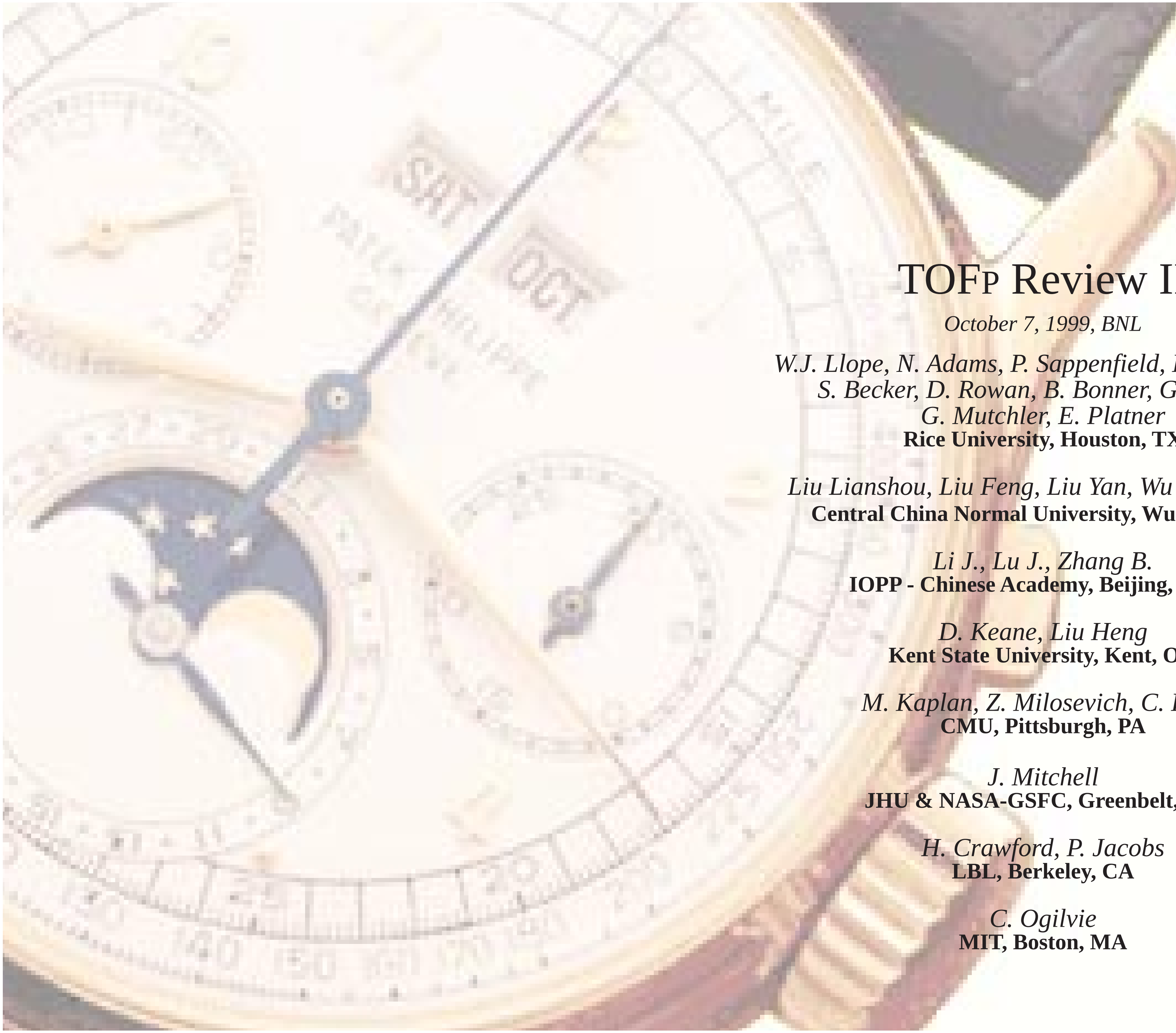

TOFp Review II

October 7, 1999, BNL

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Central China Normal University, Wuhan, China

Li J., Lu J., Zhang B.
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Kent State University, Kent, OH

M. Kaplan, Z. Milosevich, C. Kunz
CMU, Pittsburgh, PA

J. Mitchell
JHU & NASA-GSFC, Greenbelt, MD

H. Crawford, P. Jacobs
LBL, Berkeley, CA

C. Ogilvie
MIT, Boston, MA

Review][Outline:

W.J. Llope for the TOFp Group
Rice University
October 7, 1999 (BNL)

Brief reminder of
- motivation for TOFp...
- system as proposed...

In-tray Component R&D and SysTest-I

charge: build everything inside the tray,
connect it appropriately, and
show how well it works under realistic conditions

- Cabling
- Voltage System
- FEE
- Controls

Tray mechanical aspects...

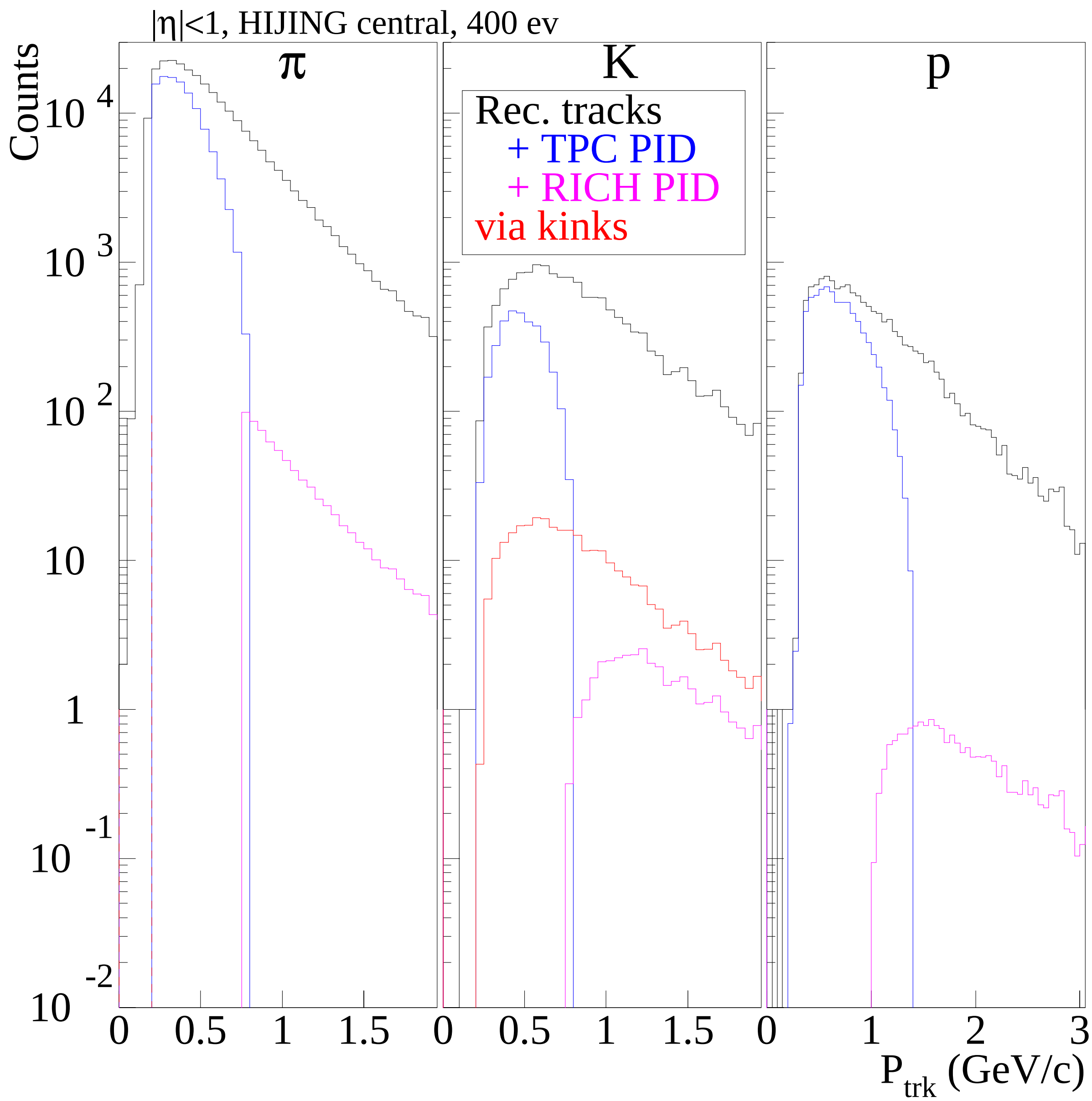
Installation...
Test Procedures...
Calibration...
pVPD...
Interfaces...

Cost, Schedule, and Manpower...

Implementation Plan...

Requirements Document...

π/K/p Identification in STAR



regions of lower efficiency & larger BGs...

π	~0.5 < P < 0.75	GeV/c
K	~0.5 < P < 0.9	GeV/c
p	P ~ 1	GeV/c

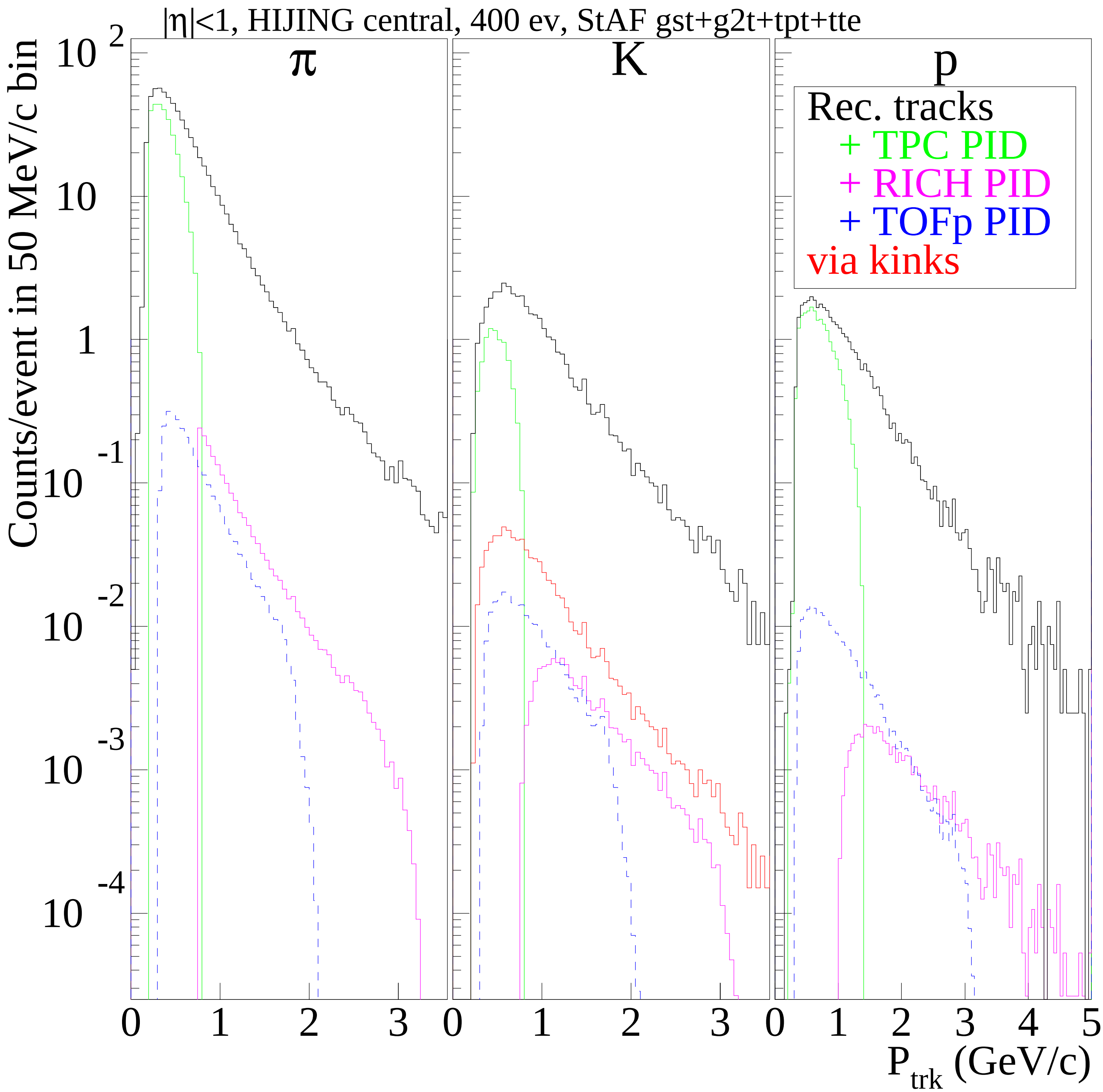
TPC/RICH PID "matching" possible, but with relatively larger uncertainties...

K kinks are important for spectra!

but not the same tracks as ID'd in RICH, so no PID matching possible...
can compare to TPC <dE/dx>, but necessarily at smaller Nhits...
not possible for protons, perhaps possible for pions...

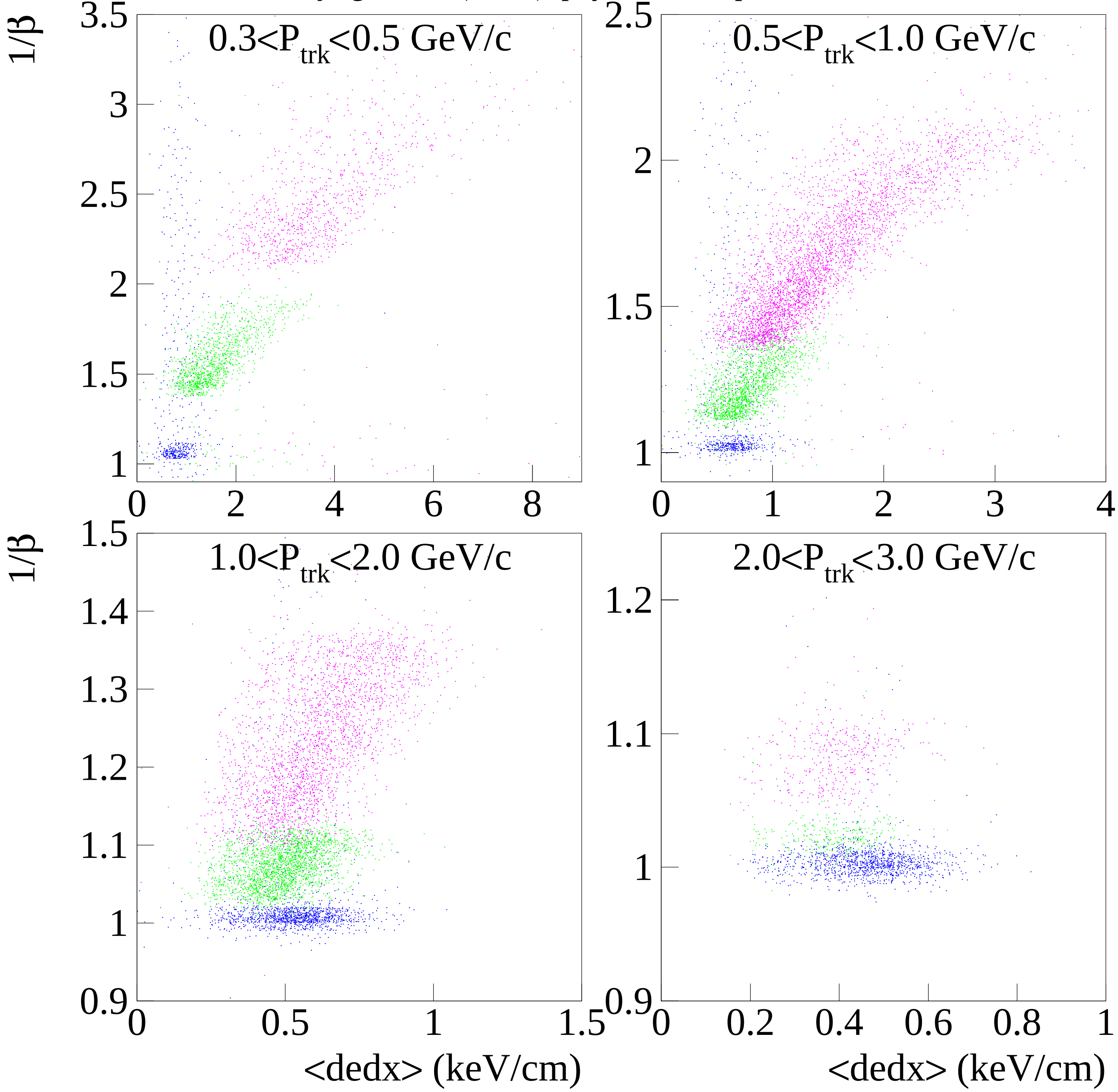
TOF bridges the inefficient regions in PID acceptance...

for TPC and SVT dE/dx, and for RICH rings, TOF PID can be used for "evaluation"
to optimize algorithms, calibrations, cuts, ...
2d plots of PID information track by track - better cuts, lower backgrounds
complementary to embed/eval simulations...

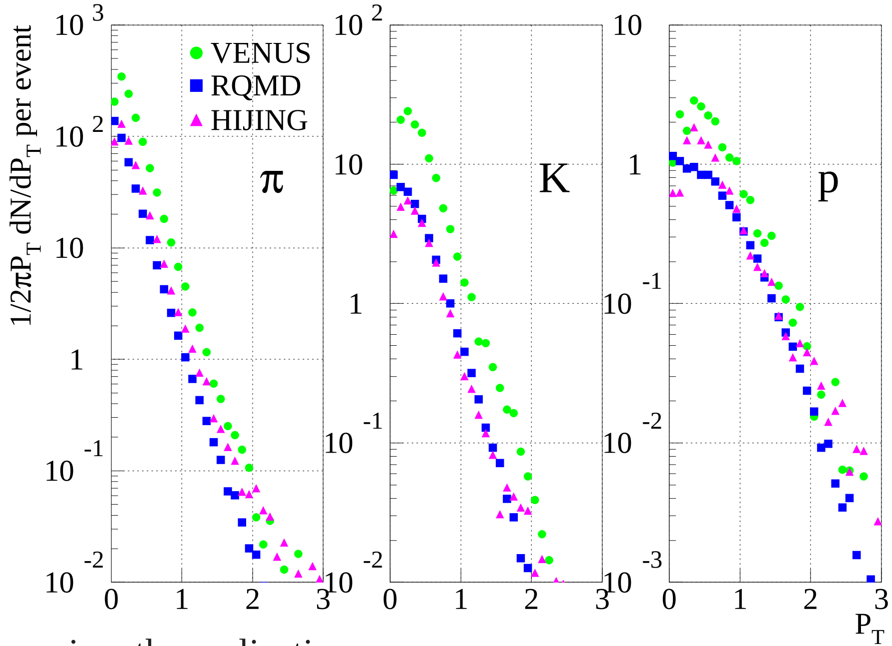


open cuts... (Nhits>10, χ2/Nhits<2.5)
not requiring track has a hit in TPC pad row 45...

400 central hijing events (13.3h), phys. on, tfs+tpt+tte_e+cts+tofana

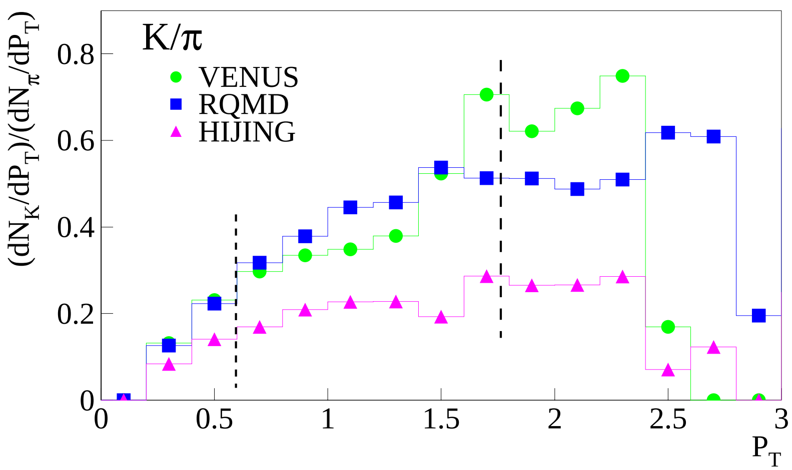


Single particle spectra



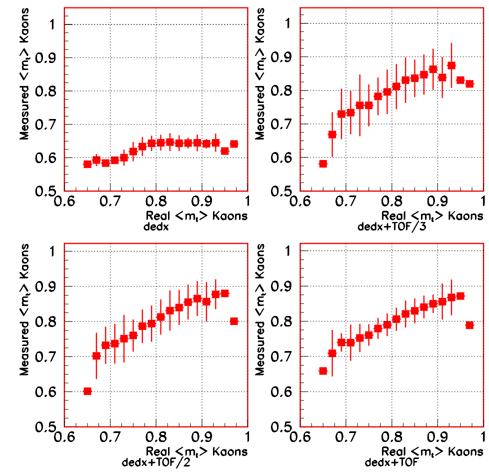
Expansion, thermalization...
Flow via fragments...
Rapidity spectra... net protons... asymmetries...
Onset of High-Pt, mini-jets, parton dE/dx, ...

Ratios, *e.g.* K+/K-, p/$\bar{p}$, d/$\bar{d}$, ...



Interferometry out to ~1.5 GeV/c (not simulated yet)

Event-by-Event Observables



Direct PID on both legs of ϕ, Ψ, ..., decays...

Is there an inexpensive approach to get at most of this?

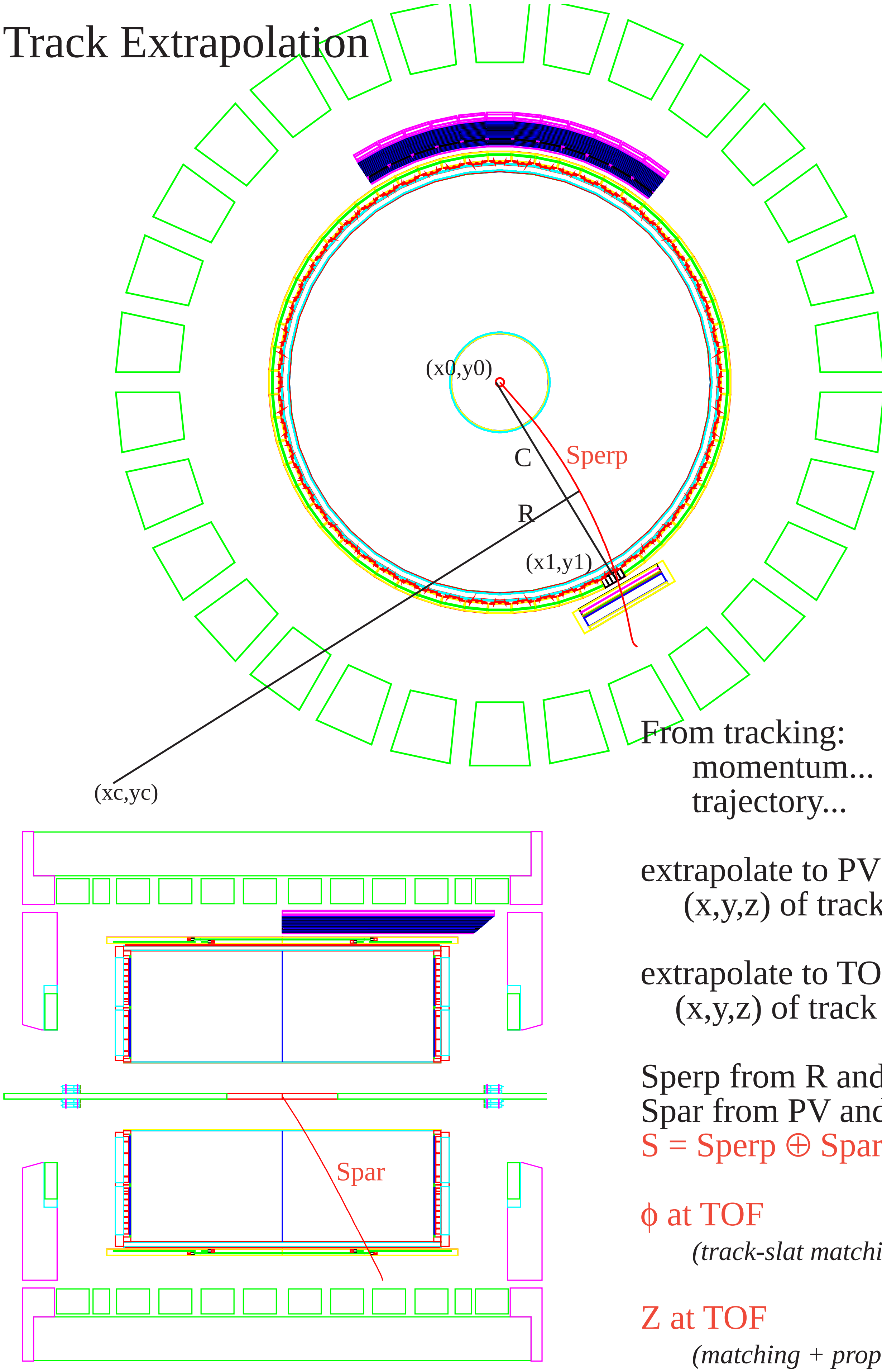
Punt on *formation* of E-by-E observables...
Punt on "two-leg" ϕ, Ψ, ... reconstruction...

Concentrate on:
- Tieing together the PID...
  - (TPC dE/dx, SVT dE/dx, RICH)...
- ratios...
- dN/dPt...
- dN/dy...

for directly-identified π, K, p, d, ...

in centrality and other EbyE-based event samples...

Track Extrapolation



From tracking:
momentum...
trajectory...

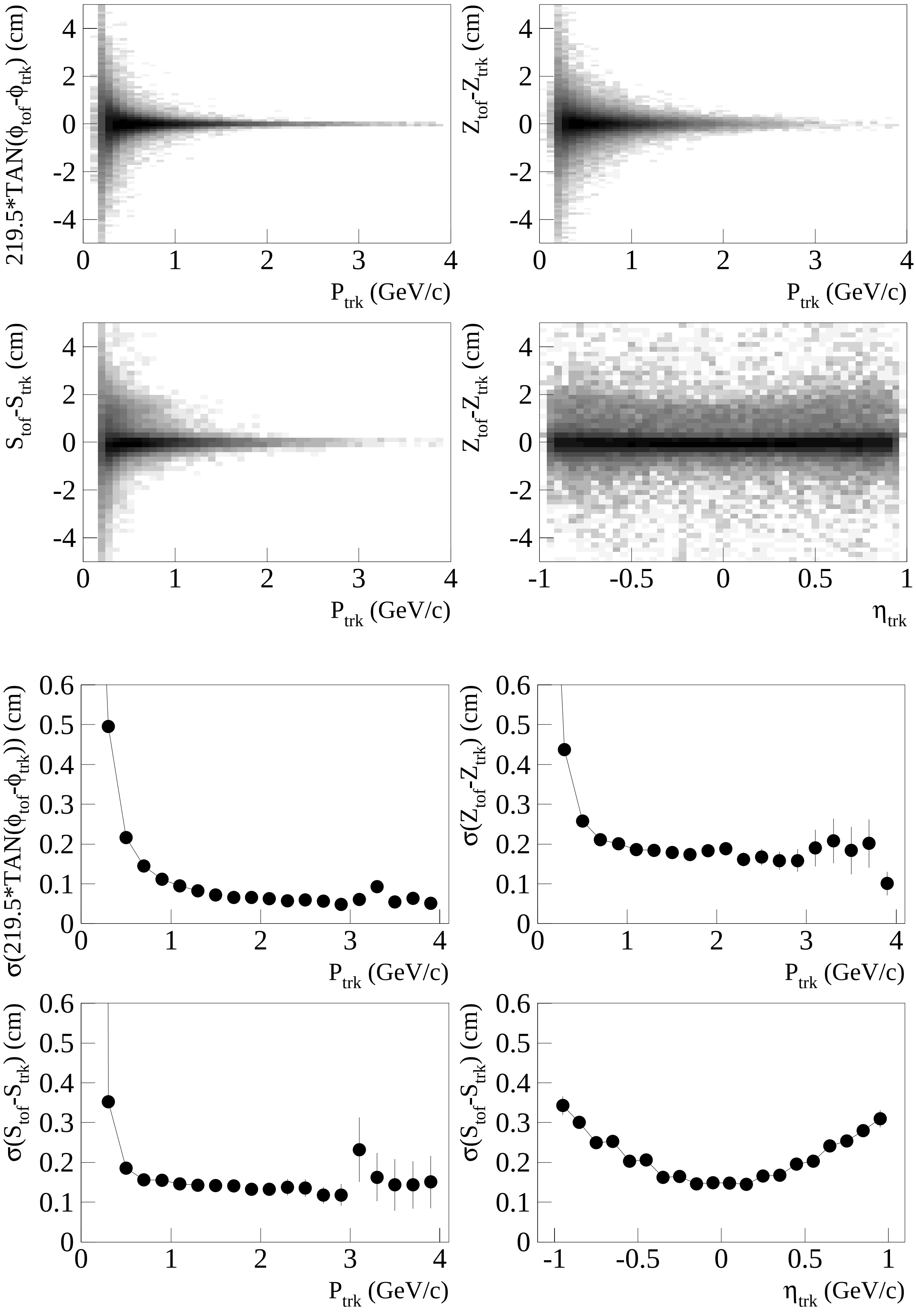
extrapolate to PV
(x,y,z) of track at PV

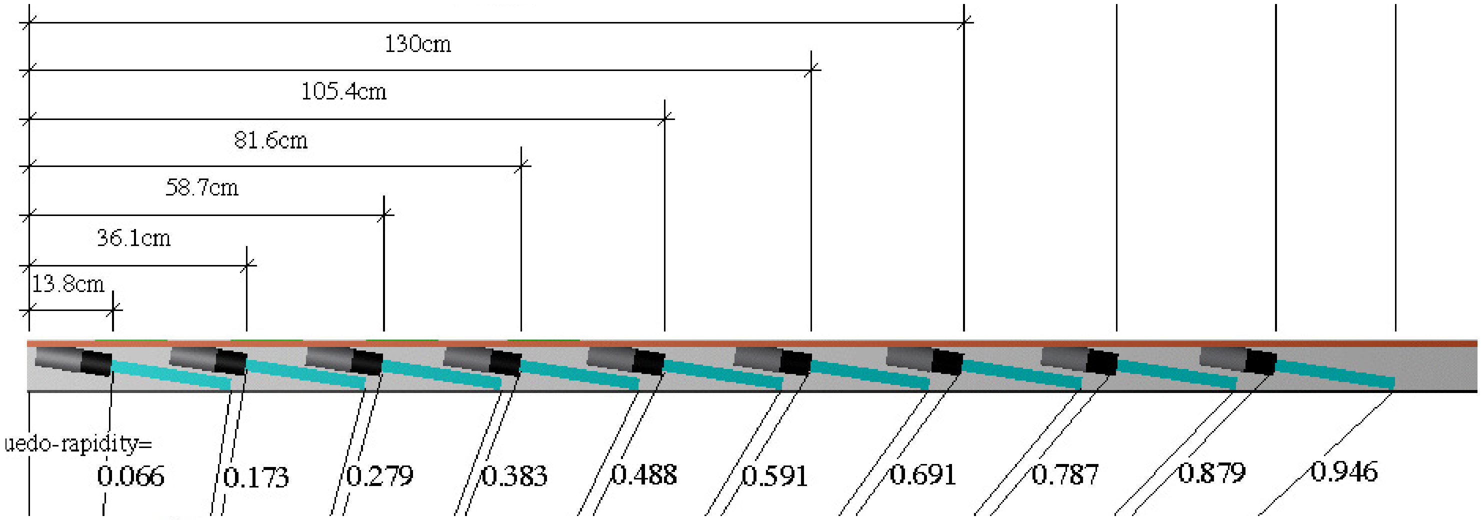
extrapolate to TOF
(x,y,z) of track at TOF

Sperp from R and C
Spar from PV and Ztof
S = Sperp ⊕ Spar

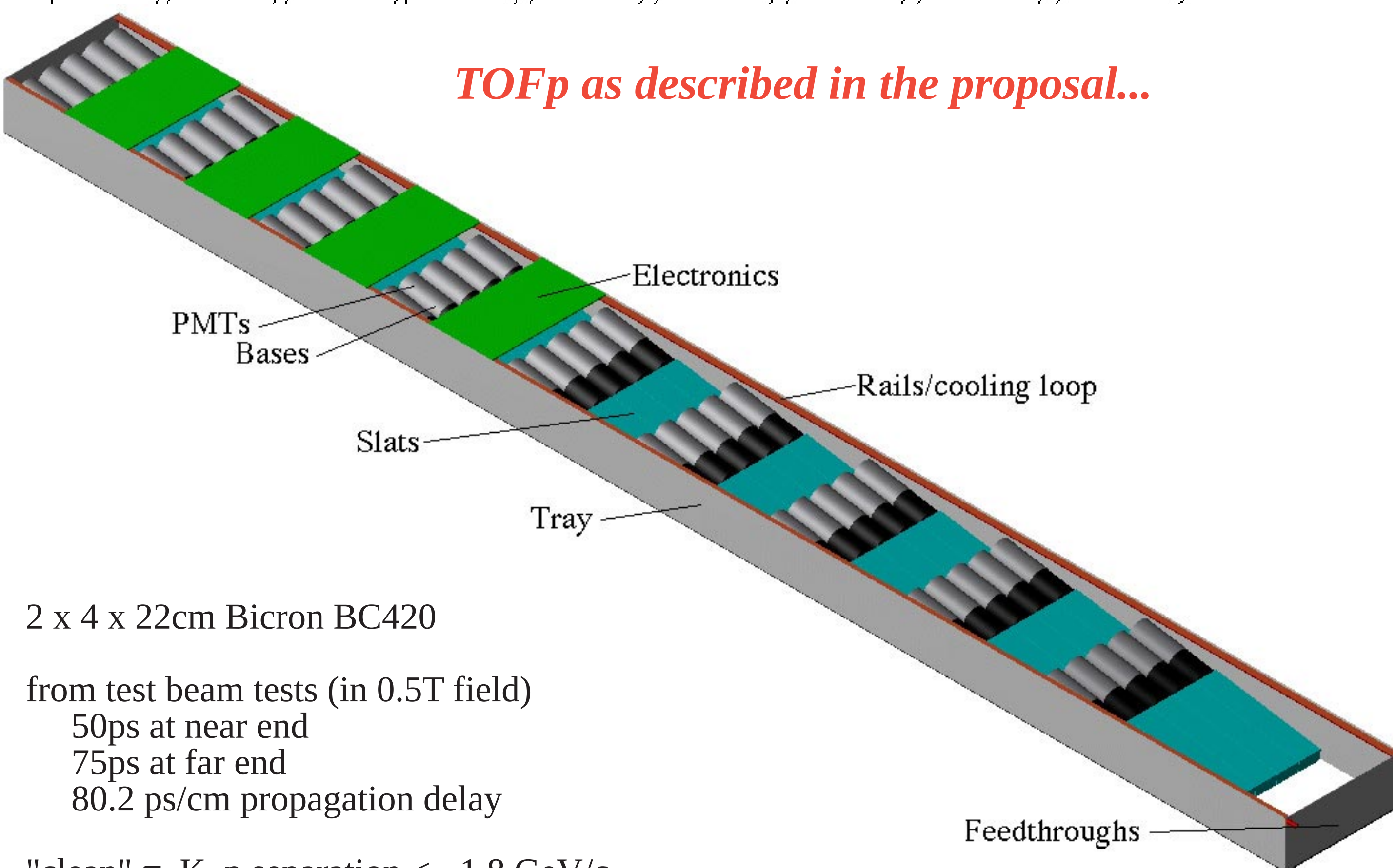
ϕ at TOF
(track-slat matching)

Z at TOF
(matching + propagation delay)


219.5*TAN(ϕtof-ϕtrk) (cm)
Ptrk (GeV/c)
Ztof-Ztrk (cm)
Ptrk (GeV/c)
Stof-Strk (cm)
Ptrk (GeV/c)
Ztof-Ztrk (cm)
ηtrk
σ(219.5*TAN(ϕtof-ϕtrk)) (cm)
Ptrk (GeV/c)
σ(Ztof-Ztrk) (cm)
Ptrk (GeV/c)
σ(Stof-Strk) (cm)
Ptrk (GeV/c)
σ(Stof-Strk) (cm)
ηtrk (GeV/c)



TOFp as described in the proposal...

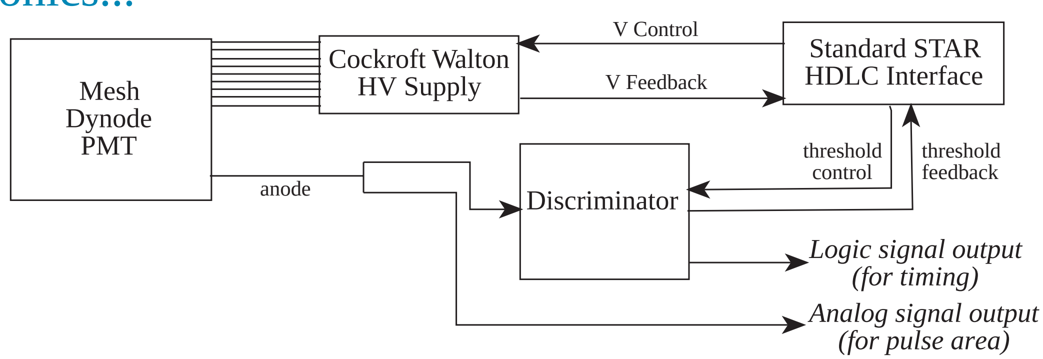


2 x 4 x 22cm Bicron BC420

from test beam tests (in 0.5T field)
- 50ps at near end
- 75ps at far end
- 80.2 ps/cm propagation delay

"clean" π, K, p separation < ~1.8 GeV/c
"clean" π/K, p separation < ~3 GeV/c

In-tray electronics...



SysTest-I

Review-I	(January 6, 99)	
Committee report available; Systest-I proposal requested	(April 13, 99)	3 mo.
SysTest-I Proposal released	(April 22, 99)	1 wk.
SysTest-I Proposal approved	(May 21, 99)	1 mo.
20k$ found in BNL funds by T. Hallman (account still being set up, funds not actually available yet)	(June 6, 99)	3 wk.

June - September, 1999 — Room 118, Herman Brown Hall, Rice University — 4 mo.

Finalize all R&D

Collect all bench data...

Review-II (October 7, 1999)

→ SysTest-I Focus:

- Measure performance of signal cables
- Produce Voltage system and measure performance
- Produce final FEE from existing prototypes and measure performance
- Measure tray+cable system performance up to CAMAC Backplane

Some notes:

Four slat assemblies built and studied, parts for 2 more, R5946's left over from CTB...

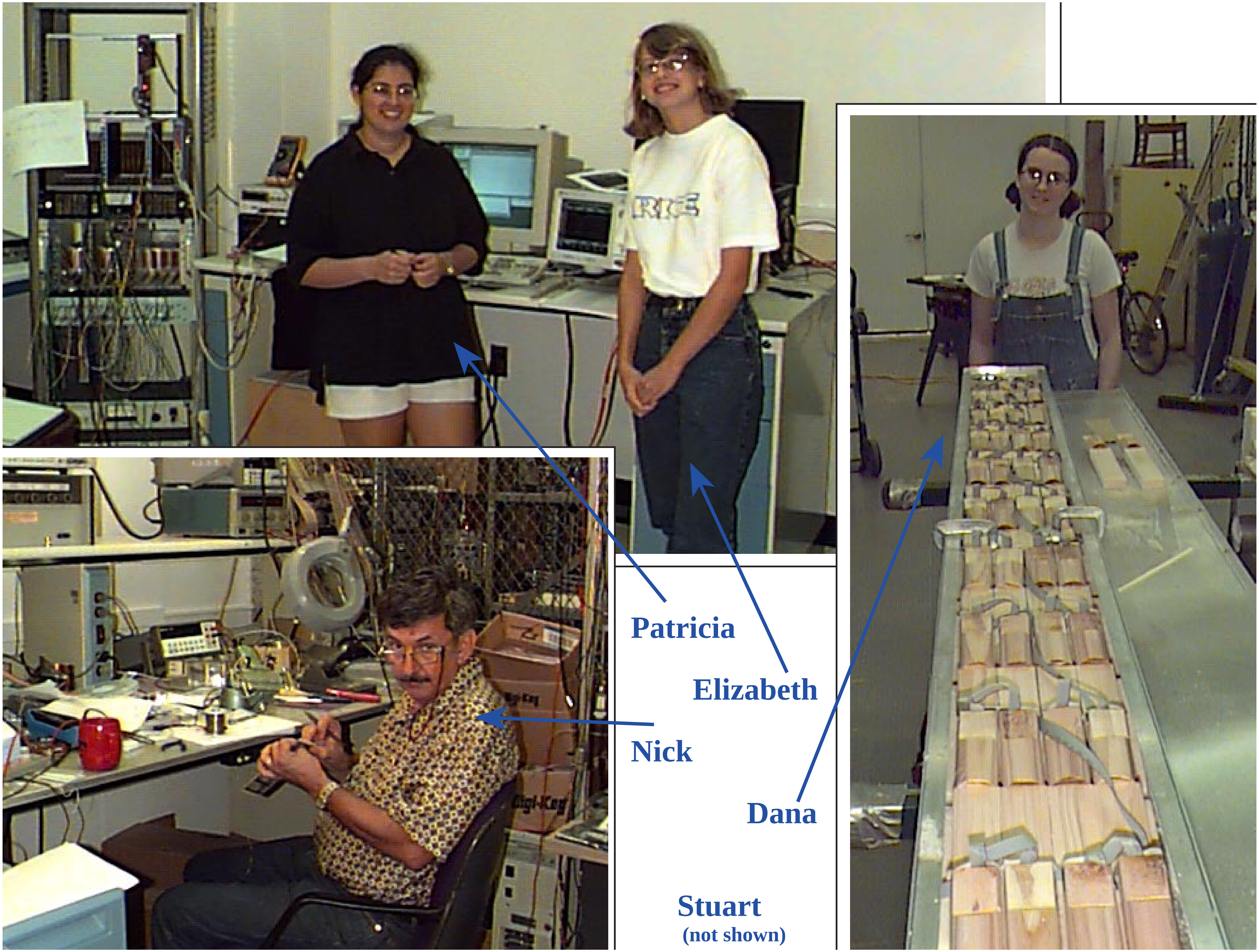
LE discrimination in-tray proposed, hence LE the primary focus of the FEE R&D...

but we also completed several product cycles for CF discriminators...

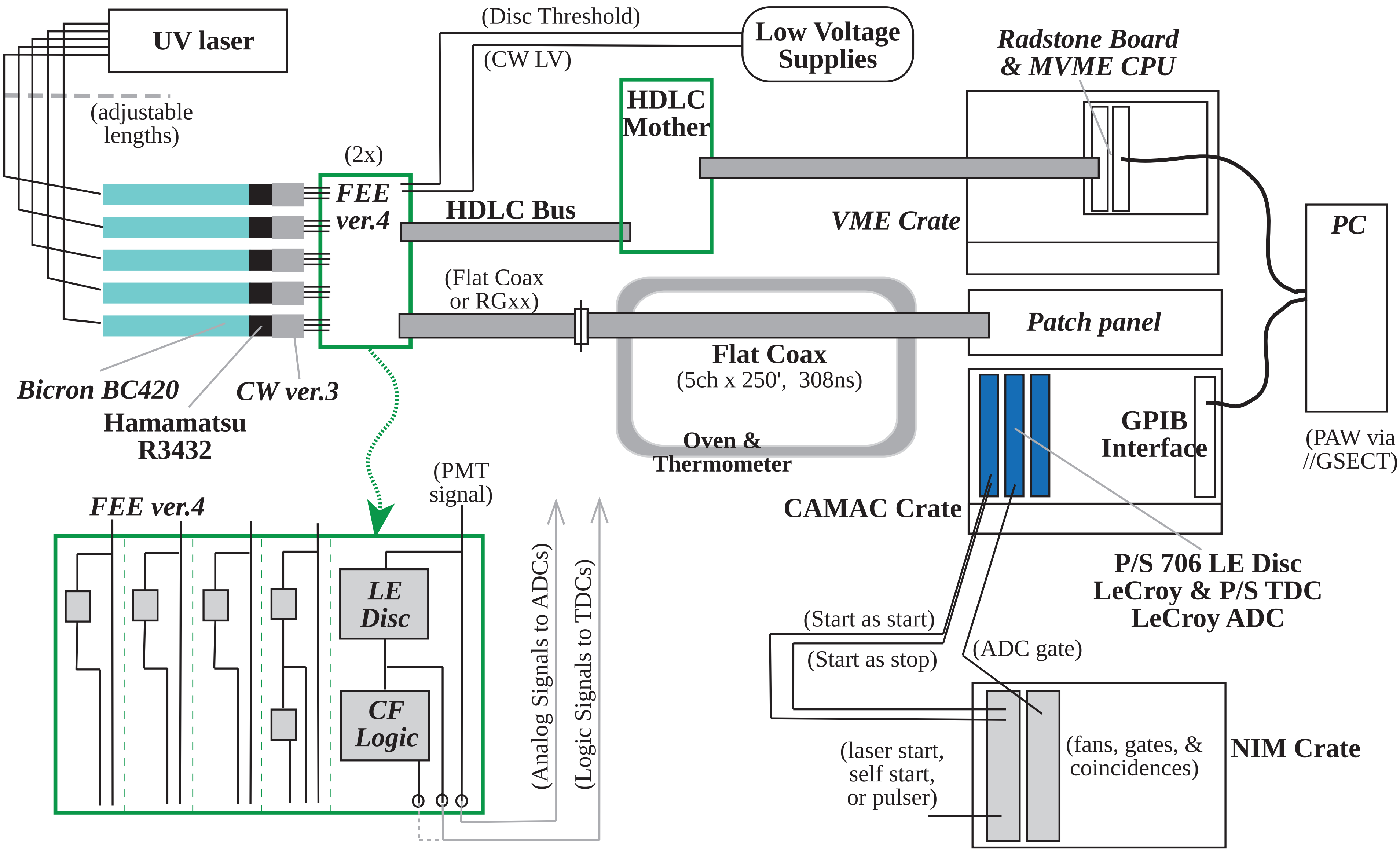
Monster pulses on the "start" detector...

Start PMT was an RCA 8575, although others tried as well, including an R5946...

TDC distributions expressed in 'TDC channels' in some plots - conversion is 50ps/ch.

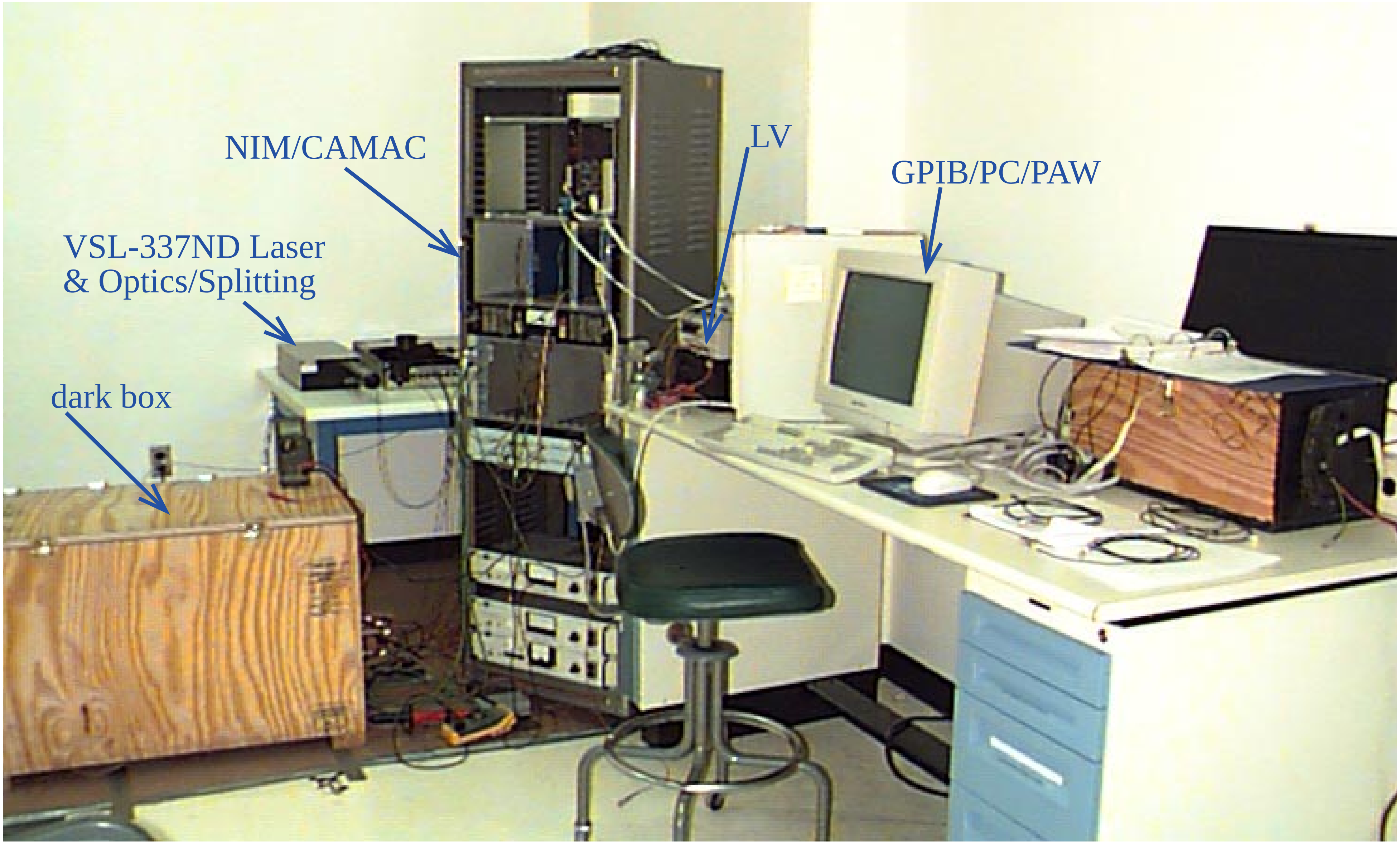

Patricia
Elizabeth
Nick
Dana
Stuart
(not shown)

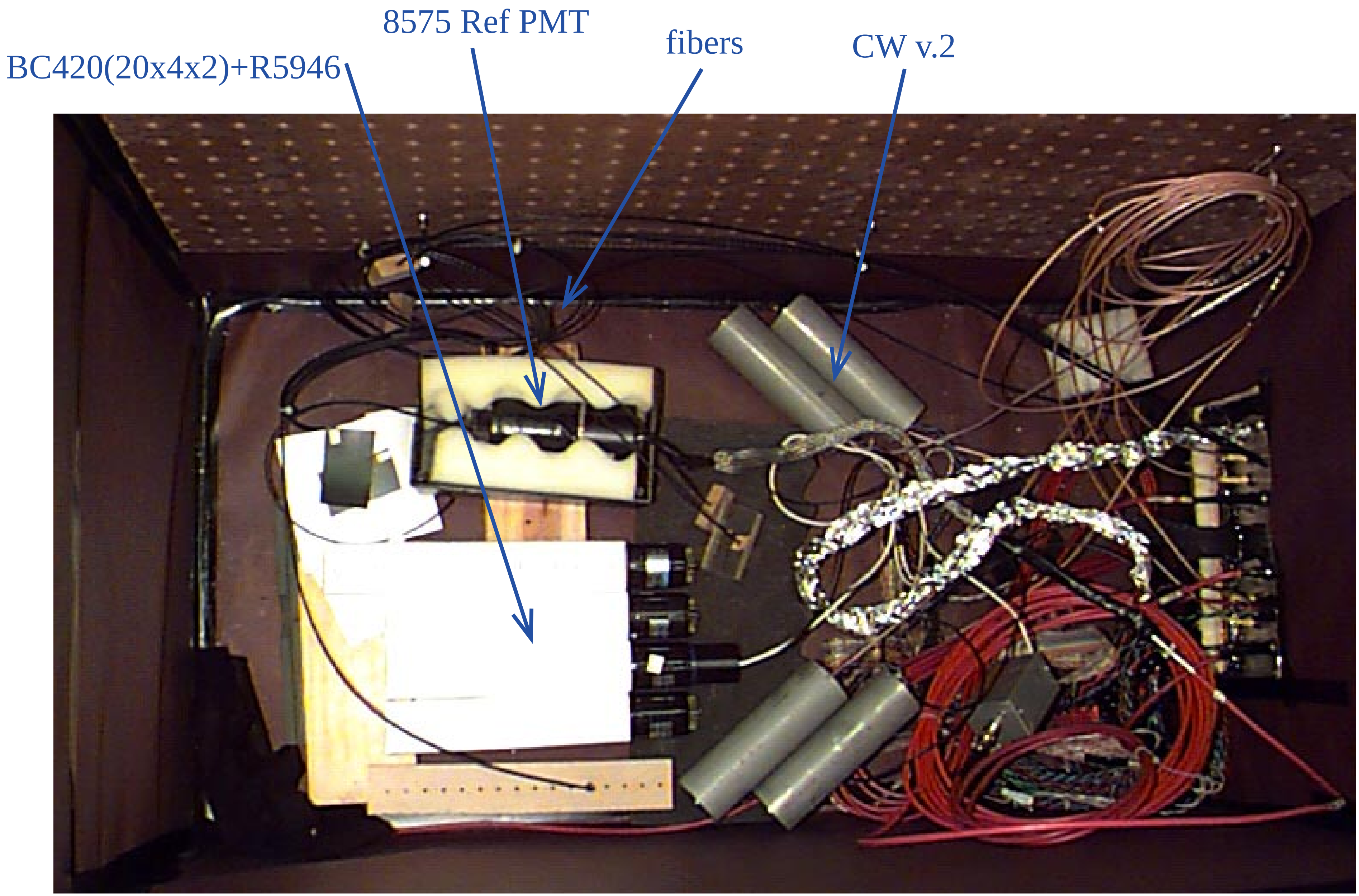
SysTest-I Schematic (shown as proposed 4/22/99)



Also on hand:

Discriminators	P/S 704 (4), 715 ... LRS 621BL and 623B ... Ortec 934cfd ... P/S 706 (∞)
ADC/TDC	LRS 2249A (4), 2228A (2), 2228 (3) ... P/S 7186 (2), **P/S 7186H (3)**
Scopes	**HP Infinium (1.5 GHz, 8 GS/s)** & Tektronix TDS640A (500 MHz, 2 GS/s)

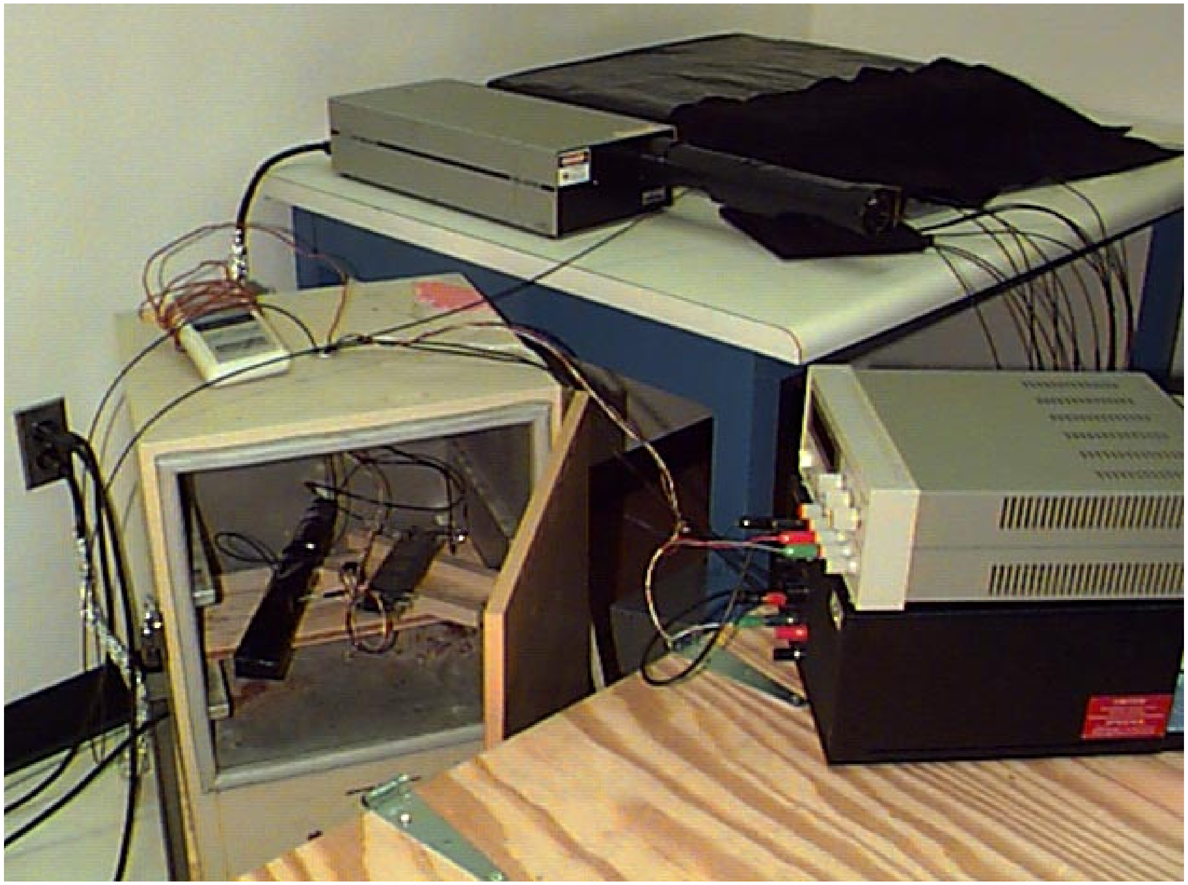

NIM/CAMAC
LV
GPIB/PC/PAW
VSL-337ND Laser
& Optics/Splitting
dark box

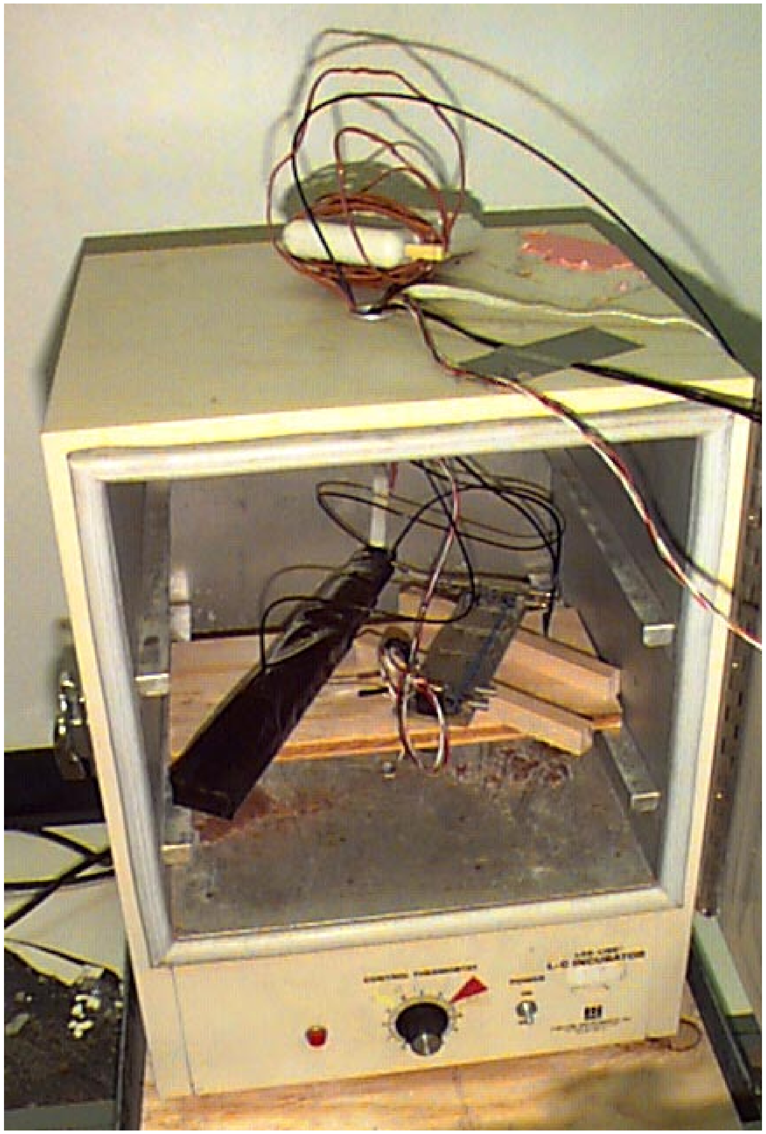

8575 Ref PMT
fibers
CW v.2
BC420(20x4x2)+R5946

HP Infinium
8 Gs/s
1.5 GHz
~12 ps time resolution
accurate direct measurements...
cross check of CAMAC DAQ...

two precision waveform generators...
attenuation & cross talk...
important “baseline” tests...

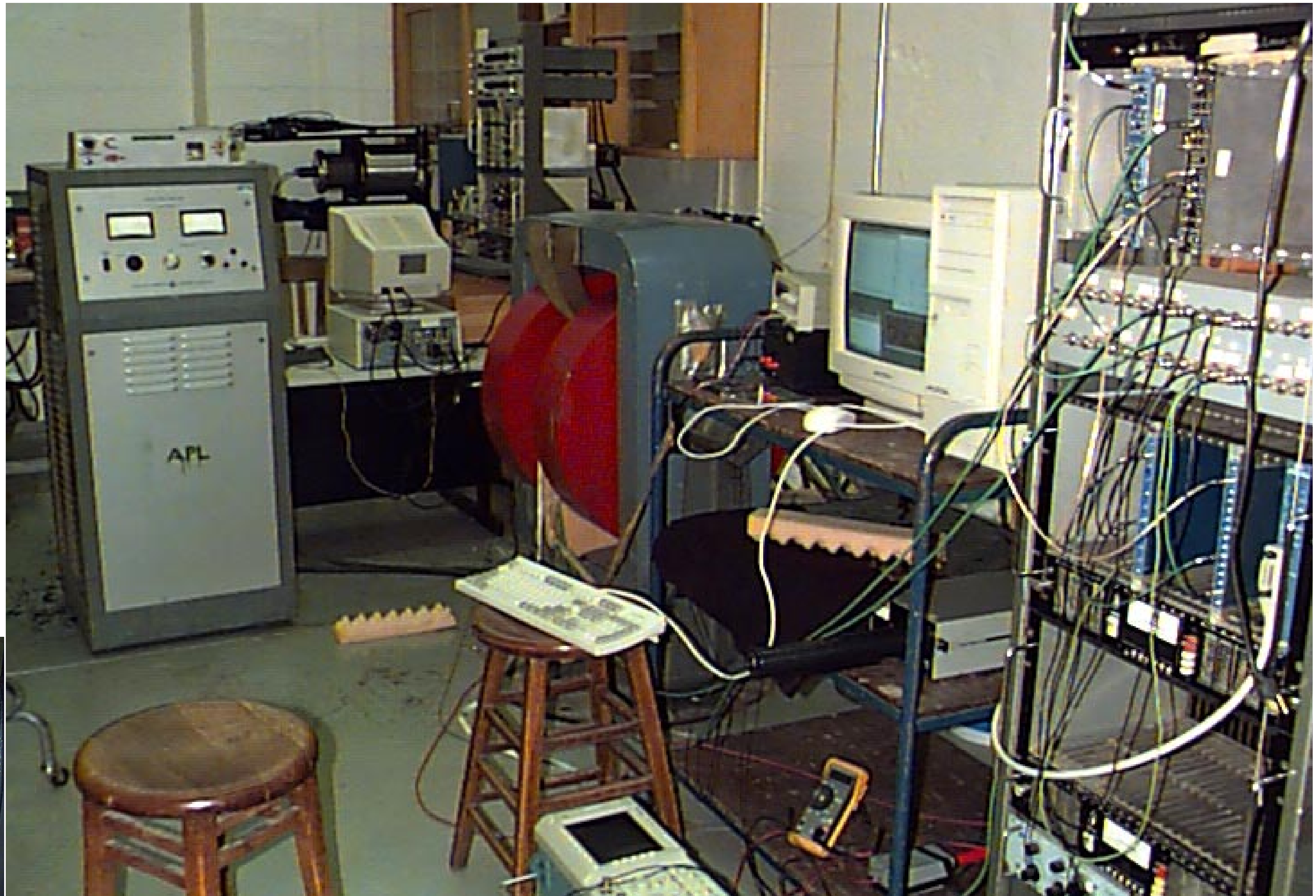
Ambient Temperature Tests...





shown is oven set up for slat assy/FEE temperature testing...
cable performance also tested in this oven...

Ambient Magnetic Field Tests...



VSL-337 Nitrogen Laser

Laser Science, Inc. introduced the first VSL-337 nitrogen laser in 1983. The laser features our patented sealed plasma cartridge, that eliminates the need for flowing nitrogen gas. Further, the VSL-337 laser is air cooled so the plumbing and expense associated with flowing water for chilling are avoided. While product improvements have been made over the years, the current VSL-337 is still the smallest and lowest priced pulsed nitrogen laser on the market. With over fifteen hundred VSL-337 nitrogen lasers in the field, it has become a standard in research and teaching.

Performance. The VSL-337 nitrogen laser provides 4 nsec pulses at 337 nm in the UV with a pulse energy of 120 μJ. Peak power is 30 kW and the average power is 2.4 mW at 20 Hz. The pulse repetition rate can be varied from 1 to 20 Hz. The laser can be triggered either internally or externally with a TTL trigger pulse. Reliable firing allows the laser to be synchronized to other timed events. Constant pulse shape and good pulse to pulse stability were designed into the VSL-337 with our fixed electrode and discharge stabilizing preionizers.

Turnkey Operation. No alignment is necessary as the resonator mirrors are mounted on the plasma cartridge and aligned in the factory. No gas or cooling connections are needed. No warm-up time is required. The user simply plugs in the VSL-337 nitrogen laser, turns it on, and starts collecting data. The first pulse is a good pulse.

Modular Design. The polymer encapsulated plasma cartridge module includes all the components which deteriorate over time. That is, the field replaceable unit incorporates the energy storage capacitors, the switching element, the plasma tube with prealigned resonator mirrors, the electrodes, and the preionizers. Once replaced, the user regains the performance of a new laser!

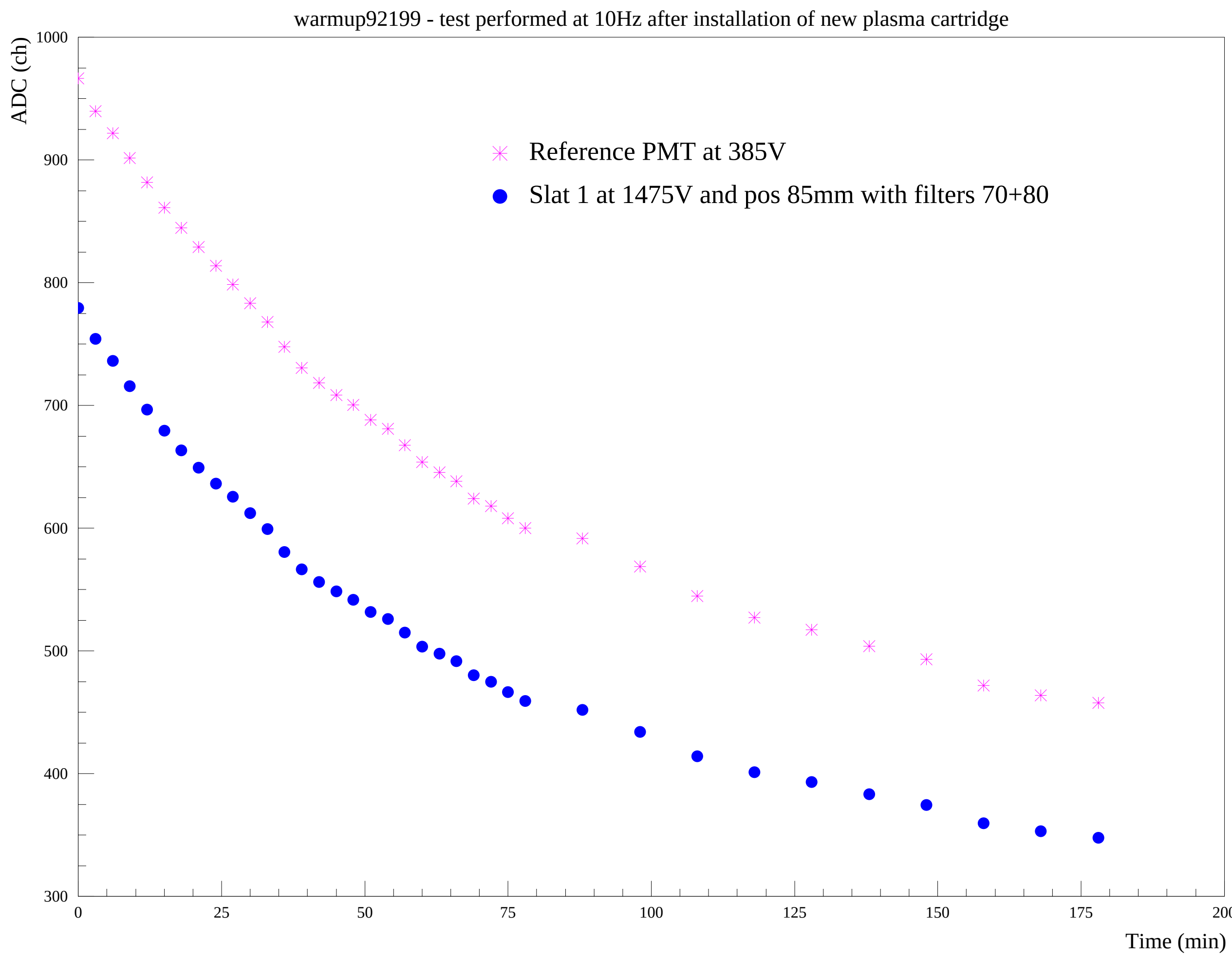
Long Life. The plasma cartridge is warranted to maintain at least 70% of its energy for twenty million pulses or two years, whichever occurs first.

Options. The VSL-337 is powered by a small external power supply. Alternatively it can be powered by a 12 volt battery, making it ideal for field applications. When very low RFI is a requirement, the VSL-337 can be fitted with a shielded housing. We supply fixed frequency and tunable dye laser modules for pulsed visible laser light, detectors, fiber optics, and laser to microscope adapters for a variety of microbeam experiments.

Specifications*

Part Number	337000-00 for 110 v, 337000-01 for 220 v
Wavelength	337.1 nm
Spectral Bandwidth	0.1 nm
Repetition Rate	1 to 20 Hz
Pulse Width, FWHM	4 nsec
Pulse Energy	>120 μJ
Pulse to Pulse Energy Stability	≤ 4% std. dev.
Peak Power	30 kW
Average Power	2.4 mW at 20 Hz
Beam Size	3 x 7 mm
Beam Divergence, Full Angle	5 x 8 mrad
External Trigger Input	TTL, rising edge
Jitter	≤ 40 nsec std. dev.
Power Consumption	1.6 A average; 3.2 A peak at 20 Hz, 12 VDC
Dimensions, l x w x h	10.6 x 4.6 x 2.7 in; 27.0 x 11.7 x 6.9 cm
Weight	5 lbs; 2.3 kg

the Laser takes *hours* to warm up...



...always allowed several hours for laser to settle before collecting any data,
...then take data as efficiently as possible
$\longrightarrow$ by now well-determined efficient test procedures are all established...

Cabling

long signal cables are necessary given path distance between tray and platform and for delay. there is also cabling inside the tray.

with appropriate choice of attenuation spec, coaxial cable is the best delay one can get:

delay/RT ratio:	best electronic delay:	**~20:1 or worse....**
	standard RG58:	**~60:1 or better...**

250-350 ft of β=0.66 coaxial signal cable, *e.g.* the RG-58 series, provides the needed delay.

A smaller diameter coaxial ribbon cable, “Flat Coax” (Amphenol Spectra-Strip), was discussed in the proposal, in case space for TOFp cable routing in-tray and out to the platform is tight.

H. Matis notes at the videocon review that there is space for RG-58, but path isn’t yet quantified...

How are specific signals are affected by 250ft of a given cable type?

In:

Pulser Sine wave	(-400 mV, frequency in the range 0.1-20 MHz)
Pulser “square” wave	(-800 mV, RT>2 ns, 10-100 ns wide)
TOFp logic signals	(-800 mV, RT from <1 to ~2.5 ns, 10-100 ns wide)
TOFp PMT signals	(-500 mV, RT~3-5 ns, FWHM~10ns, typical R5946 line shape)

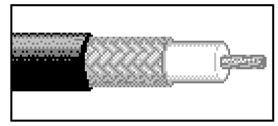
Study:

Amplitude Attenuation	(generally irrelevant)
Rise Time Attenuation	(very relevant)
Amplitude Cross Talk	(relevant)
Timing Cross Talk	(very relevant)

For:

RG-58 C/U, 50 Ω, 250 ft.	(the proven standard cable, but C/U is not the best RG-58 out there...)
FlatCoax, 93 Ω, 4ch wide, 250 ft.	

50 Ohm Transmission Cable
RG-58 C/U QPL
20 AWG



1-800-BELDEN-1

Trade Number Industry Stds.	Std. Lgth. (ft.)	Std. Units (lbs.	AWG (strand) Type (dia.) Nom. D.C.R.	Core O.D. Nom. O.D.	Shields Nom. D.C.R.	Nom. Imp. (ohms)	Vel. of Prop.	Nom. Cap.
8262	U-500 500 U-1000 1000	13.3 14.0 26.5 26.3	20 (19x33) TC 0.035in. 10.8 ohms/M'	0.116 in. 0.195 in.	95% TC Braid Inner 4.1 ohms/M'	50.0	66.0%	30.8 pF/ft
Metric	(Meters) U-152.4 152.4 U-304.9 304.9	(Kg) 6.05 6.4 12.0 12.0	.889 mm 35.4 ohms/km	2.946 mm 4.953 mm	Inner 13.4 ohms/km			101.0 pF/m

Description:		
Insulation:	Polyethylene	Coaxial MIL Spec Cable to MIL-C-17G. 20 AWG stranded tinned copper conductor with polyethylene insulation. Tinned copper braid, 95% coverage. Black non-contaminat: jacket. MIL-C-17G M17/155-00001 (RG-58 C/U) QPL Temperature Rating : 80°C Suggest Operating Temperature Range (Non-UL): -40°C to +85°C. Maximum Operating Voltage (Non-UL): 1400 Volts RMS. Un-swept version of RG-58
Jacket:	PVC-NC	
Plenum Version(s):	n/a	

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1.0	0.44	1.44
10.0	1.4	4.59
50.0	3.3	10.82
100.0	4.9	16.1
200.0	7.3	23.9
400.0	11.5	37.7
700.0	17.0	55.7
900.0	20.0	65.6

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1000.0	21.5	70.5

Top

(Select other related products with BACK or PREVIOUS.)

Home Page
Return to Belden's Home Page

Products | Trade Shows | Distributors | Links | Message Center | Financial Info | Search | FAQs

Amphenol FlatCoax

discussed in proposal as an option for the long cables...

Spectra-Strip® **Electronic Cable** online catalog **Amphenol**

HOME

Searches

- family
- application
- part

Information

- new product information
- cable assembly
- process info request
- email

Part Information | Outline Drawing | Introduction | Specifications | Ordering Information

TOP Part Information:

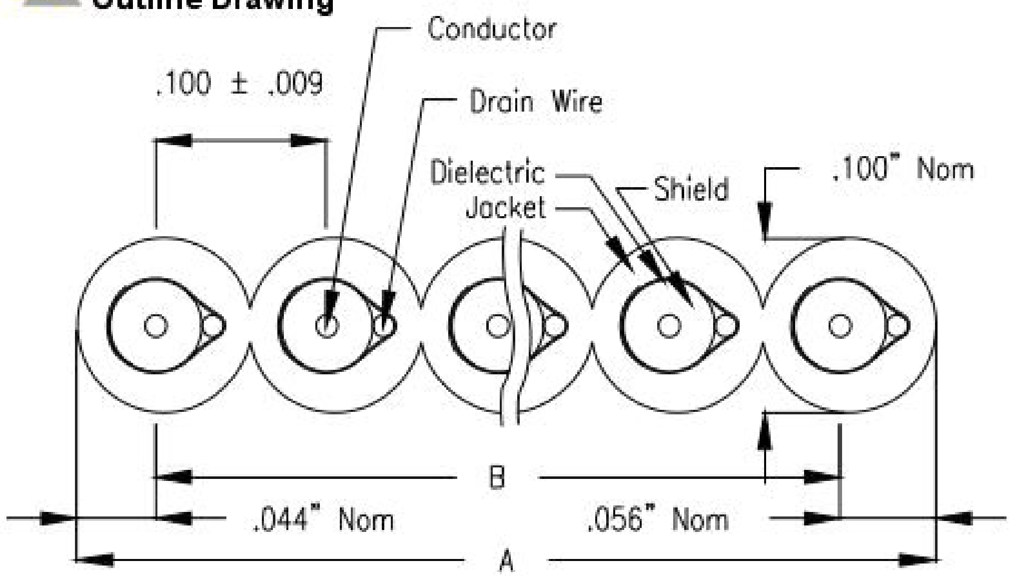
Part Number: 121-3001-002

Description: .100 pitch flat coax, 93 ohm

Family: Flat Coax

Add to Information Request

TOP Outline Drawing



TOP Introduction

Spectra-Coax planar cable is coaxial cable that can be mass terminated. Used in high speed computers and other digital equipment, coax planar cable combines economy of time and money through reliability, space and labor savings. Manufactured with controlled signal to signal centers, Spectra-Coax cable consists of individual solid conductors, each with foamed or solid polypropylene insulation, a foil shield, and an oriented drain wire. An extruded contoured outer jacket allows mass termination or separation and stripping of conductors. This standard flat cable can be cut to any length and still maintain controlled centers.

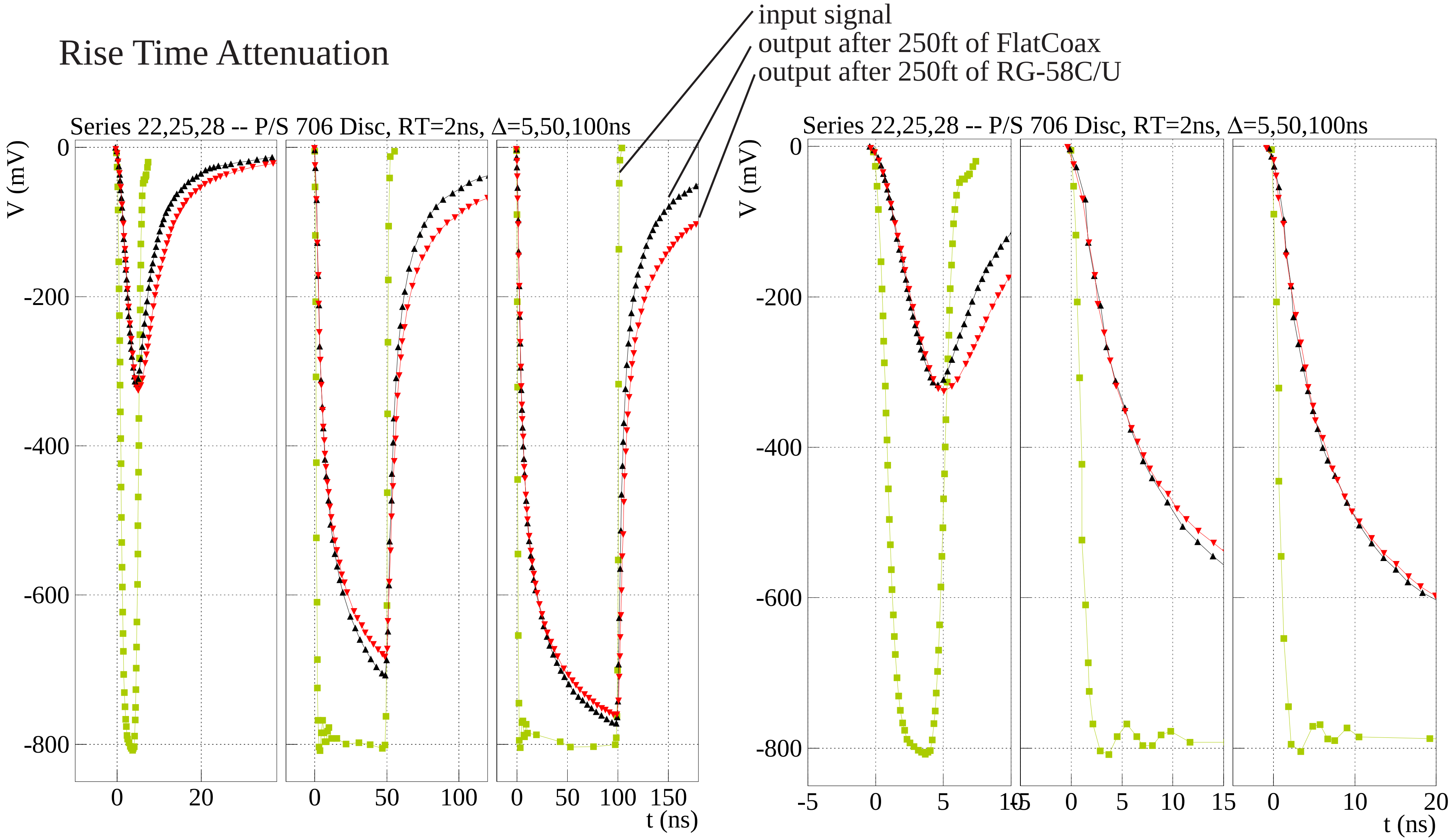
Physical	
Center conductor	30 Awg solid copper, enamel coated
Dielectric	Foamed polypropylene
Diameter	.064" ± .002"
Drain Wire	28 Awg solid tinned copper
Shield	Longitudinally wrapped aluminum / polyester foil
Jacket	Red PVC, .017" nom wall
Conductor Spacing	.100" ± .009"
Cable Thickness	.100" nom

Electrical	
Impedance	93 ± 5 ohms
Capacitance	14.2 pf / ft nom
Crosstalk	< .1% NE and FE, unbalanced, 10 ft cable length. Risetime 3 ns
Propagation delay	1.35 ns / ft nom
Risetime Degradation	<350 ps / 10 ft (20 – 80 %)
Attenuation	6 dB / 100 ft nom @ 100 MHz
UL Style	2741

Ordering Information

Part Number	No. Conds.	Width "A"		Width "B"	
		Inch	(mm)	Inch	(mm)
121-3001-002	2	.200	(05,08)	.100	(02,54)
121-3001-003	3	.300	(07,62)	.200	(05,08)
121-3001-004	4	.400	(10,16)	.300	(07,62)
121-3001-005	5	.500	(12,70)	.400	(10,16)
121-3001-006	6	.600	(15,24)	.500	(12,70)
121-3001-007	7	.700	(17,78)	.600	(15,24)

Rise Time Attenuation



Negligible difference in logic signal leading edges after 250 ft of RG58 or FlatCoax...

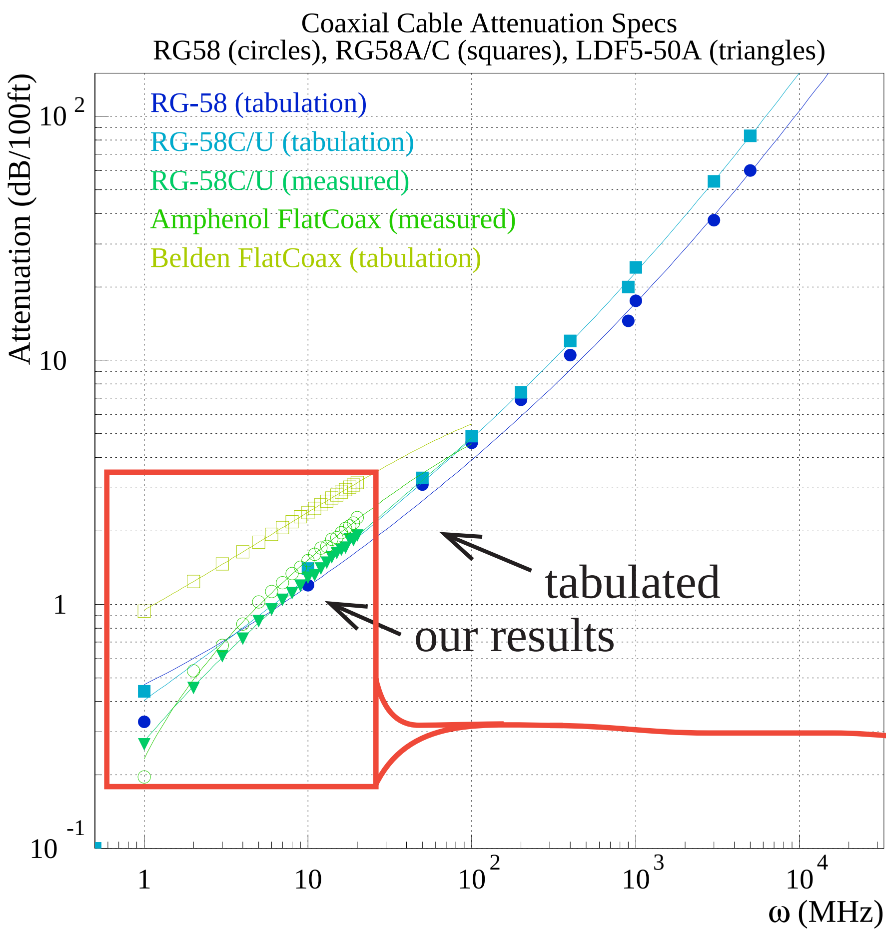
shown are P/S 706 signals... also compared many other fast RT signals...

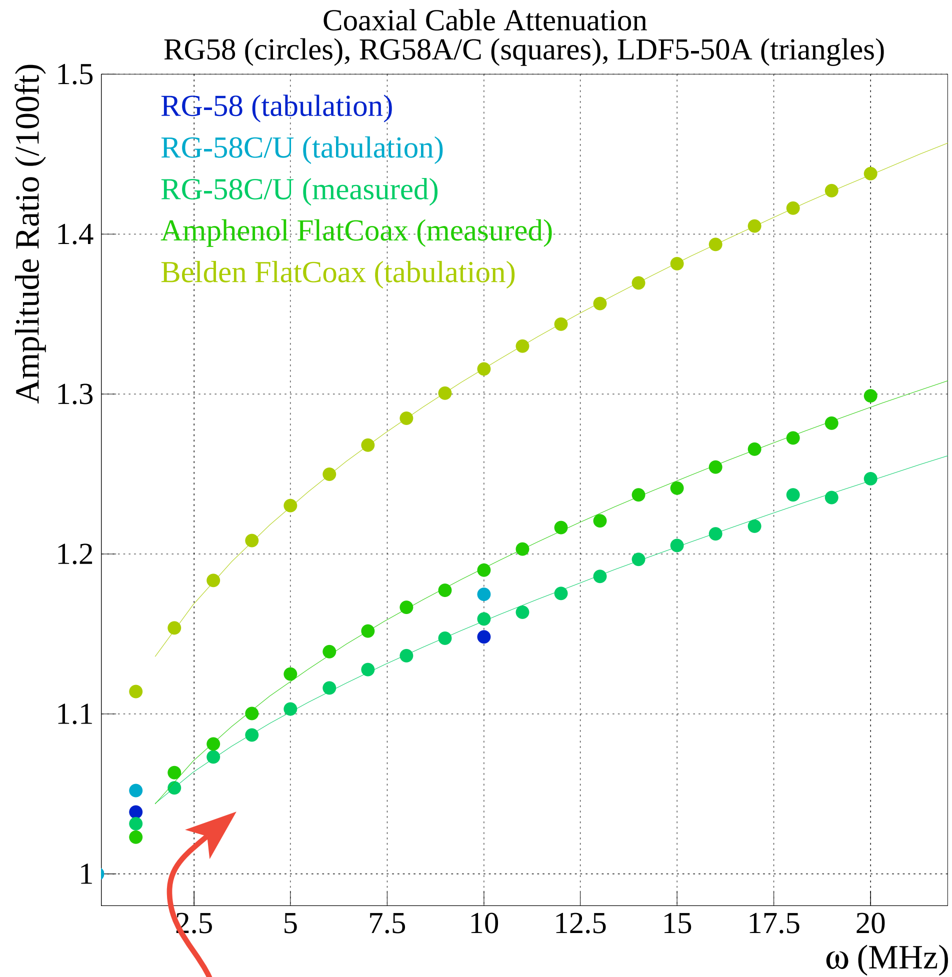
RG58 and Flat Coax must have similar attenuation (dB) vs. frequency (MHz) characteristics...

with Amp FlatCoax apparently a shade worse in attenuation than RG-58C/U...

Direct measurements of λ (dB) vs. ω (MHz)...

Sine wave attenuation
Range 0.1 - 20 MHz
Measured
250ft RG58C/U
250ft Flat Coax
Plot equiv. 100ft of cable





Yes, the attenuation performance is similar...

Good agreement with tabulations for RG58...

Belden FlatCoax not nearly as good as Amphenol's...

Signal propagation simulations...

$$\alpha^*(f,Z) = [c_0 + c_1\sqrt{2if} + c_2 f]_Z \qquad (1)$$

$$\mathcal{R}(\alpha^*) = \frac{\text{LOG}(10)}{20}\ \lambda(dB) \qquad (2)$$

where $c_0 = R_{dc}/2Z$ and c_1 and c_2 are fit parameters for a given cable type, (*e.g.* RG-58, Flat coax) and length, Z.

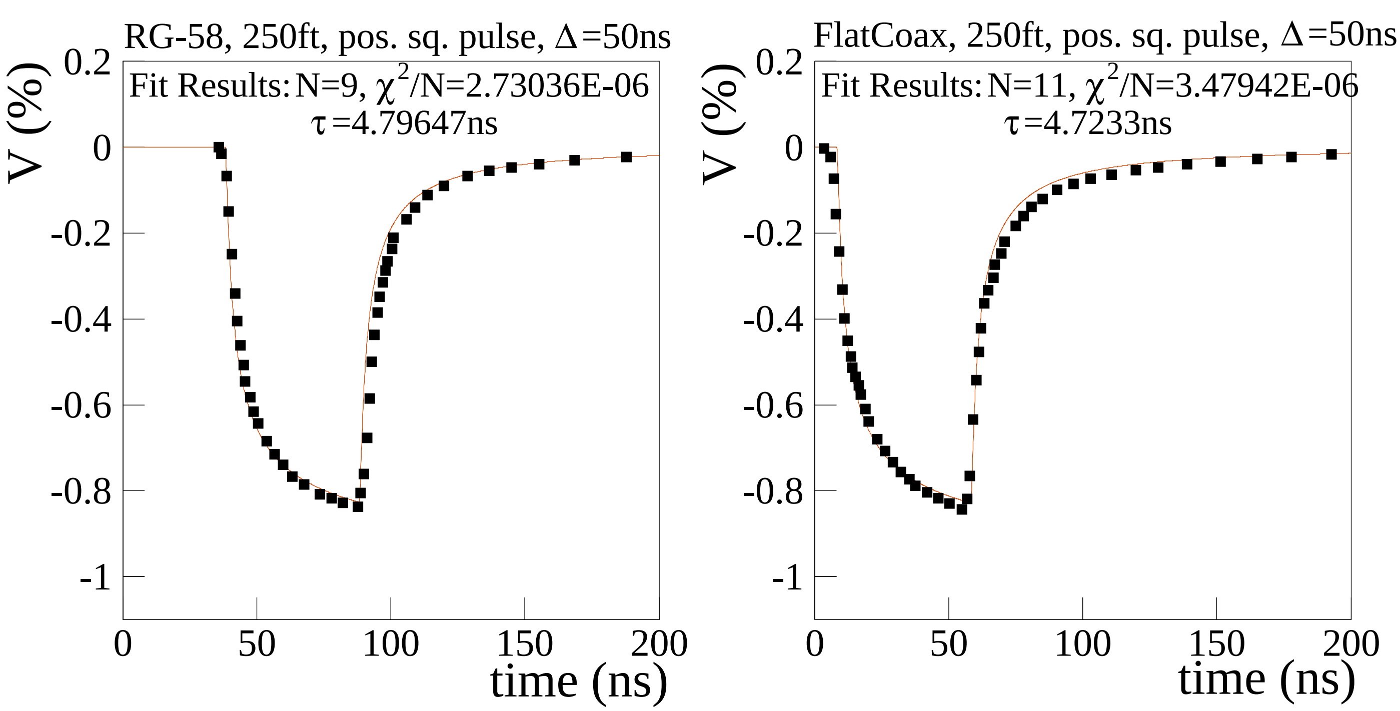
$V_{input}(0,t)$ is an arbitrary voltage waveform

$$F^*_{input}(\omega) = \int_{-\infty}^{\infty} V_{input}(0,t)\ e^{-i\omega t}\ dt \qquad (3)$$

$$F^*_{output}(Z,\omega) = F^*_{input}(\omega)\ e^{-\alpha^* Z} \qquad (4)$$

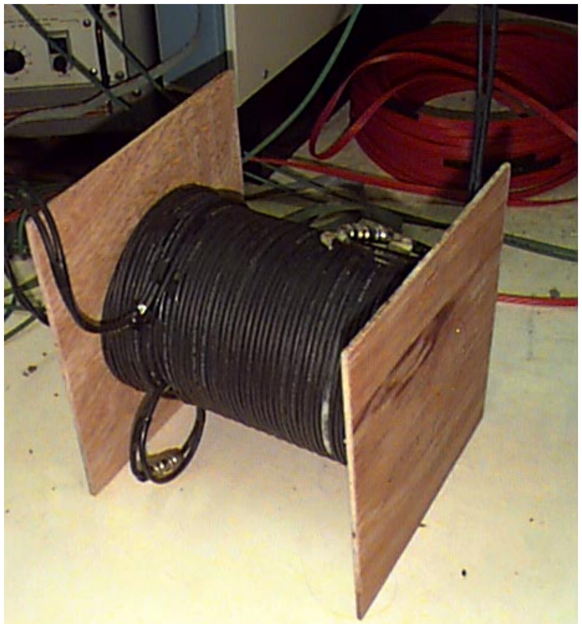
$$(\omega = 2\pi f)$$

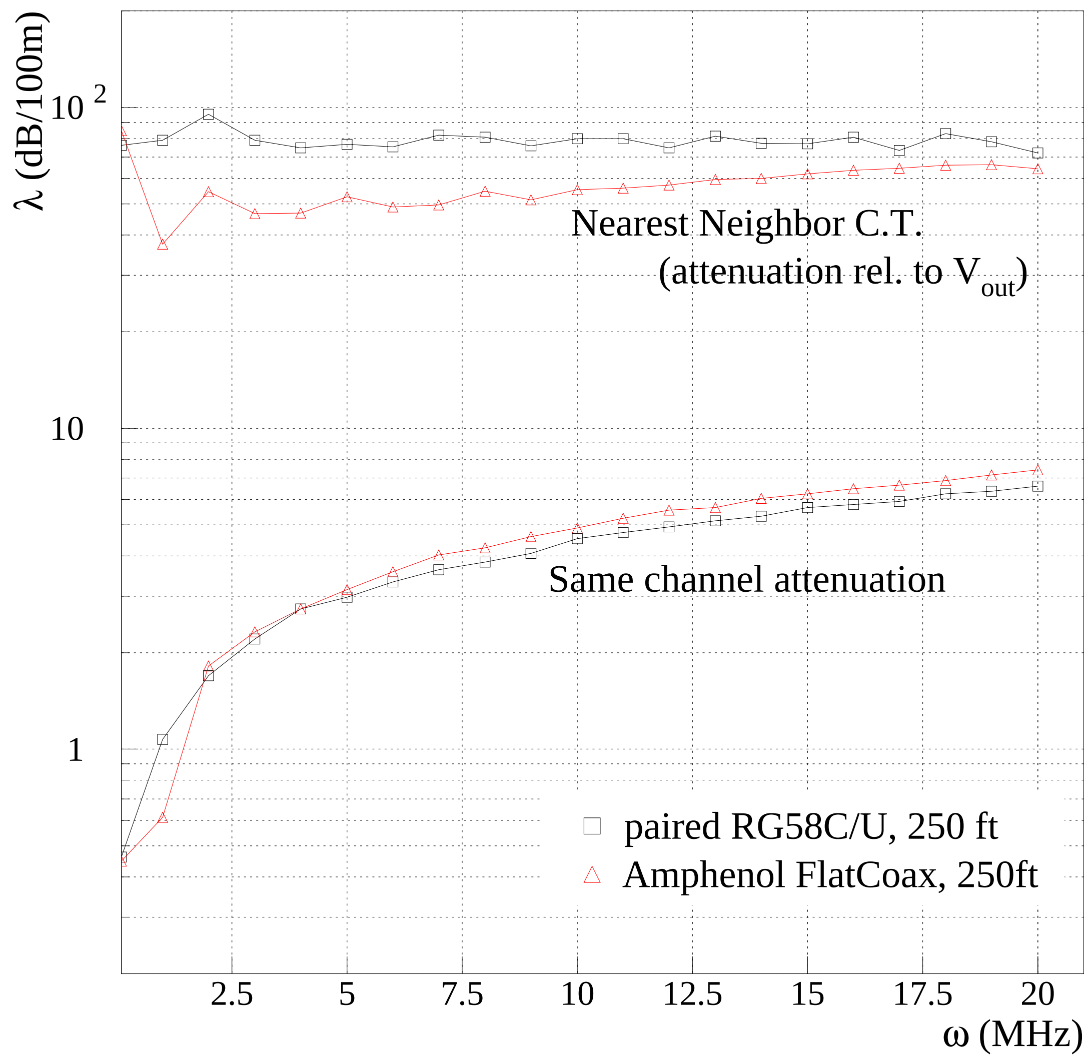
$$V_{output}(Z,t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F^*_{input}(\omega)\ e^{i\omega t}\ e^{-\alpha^* Z}\ d\omega \qquad (5)$$



Amplitude Cross Talk...

250ft long FlatCoax, 4 wide...
250ft long pair of RG58C/U...





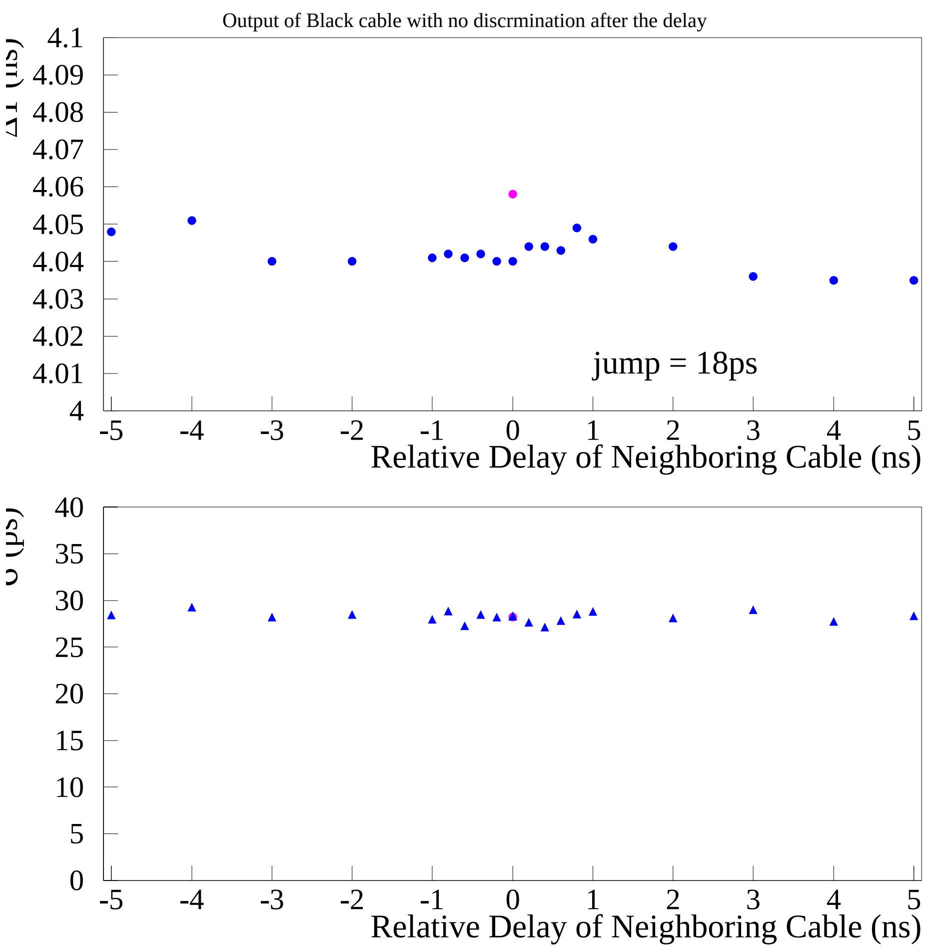
- at 20 MHz, FlatCoax cable amplitude cross talk for sine wave input is about 1%
- at same frequency, “RG58 pair” amplitude cross talk is a factor of 5-10 less.

(note though 0.1-20 MHz is only a fraction of the relevant frequency range...)

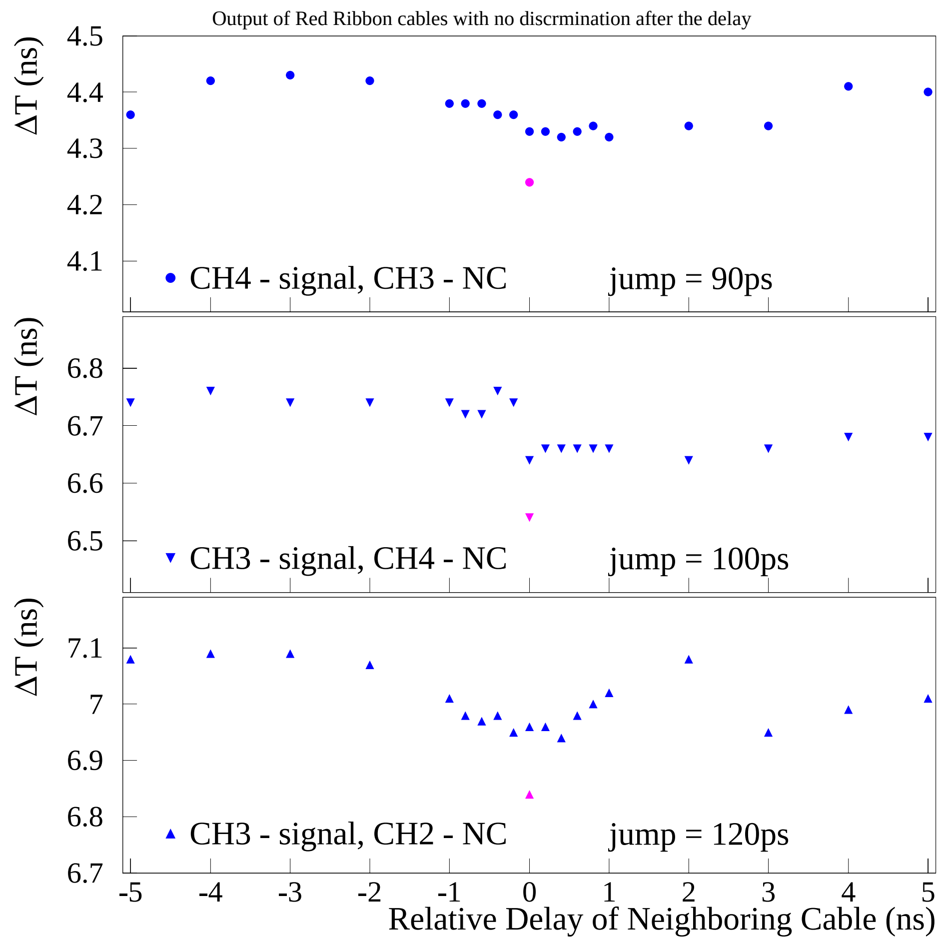
Cable timing cross talk...

- use fast pulser with 2 logic-like outputs and control over exact Δt between the two...
- study cable propagation delay in channel X in different cases of a similar signal in a neighboring cable channel Y at a controlled relative time...
- particularly simple job for the Infinium!

RG58C/U bundle



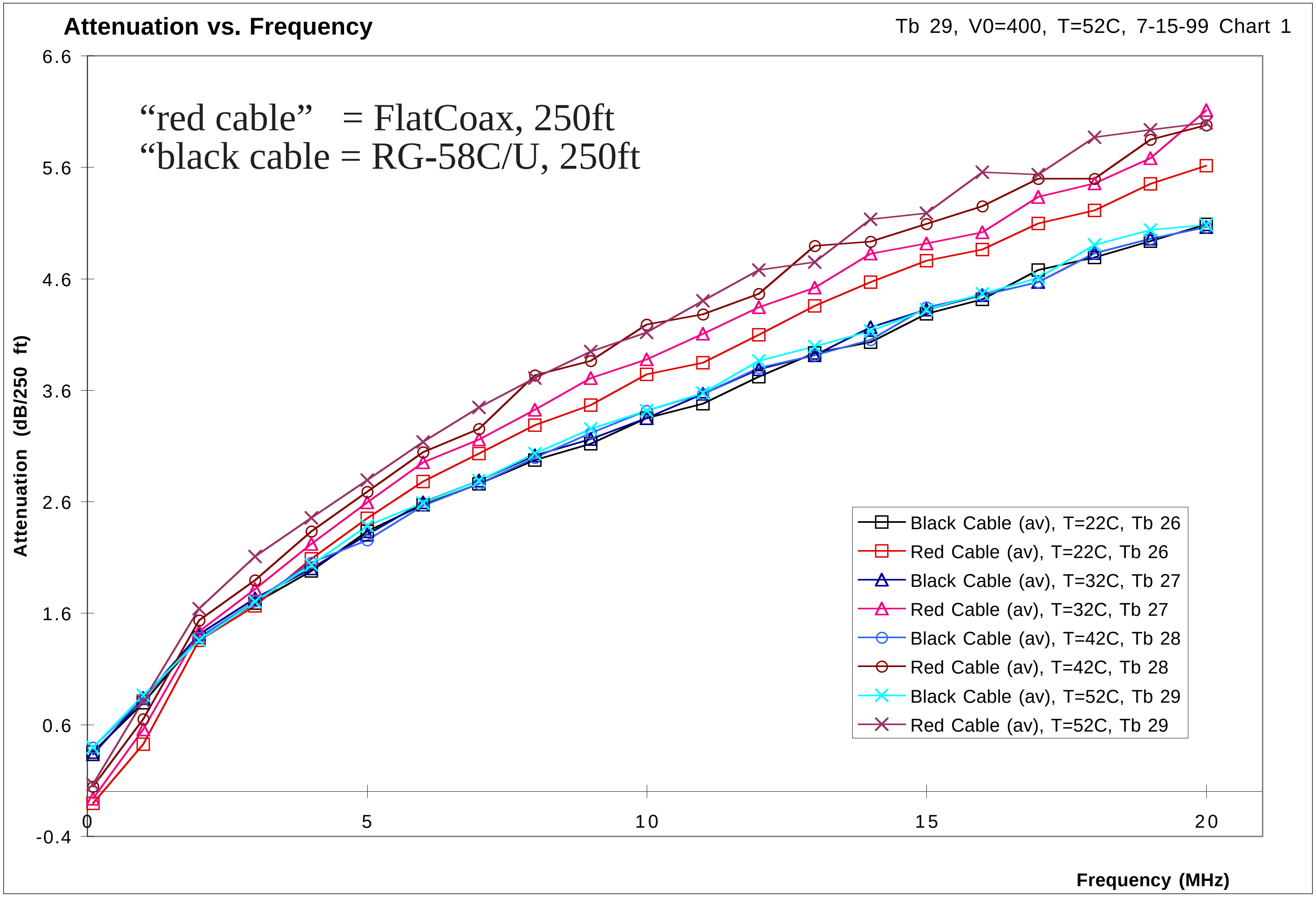
FlatCoax



time cross talk affects the propagation delay, not the dispersion...
timing cross-talk seen was:

RG-58C/U bundle:	< 20ps...
FlatCoax:	~ 100ps for numerous pairs...

Dependence of cable performance on cable temperature...



RG-58 $\rightarrow$ no dependence of performance on Temperature in range 22 to 52 °C
FlatCoax $\rightarrow$ performance depends on Temperature...
...attenuation increases roughly ~0.2 dB per 250ft per 10 °C...

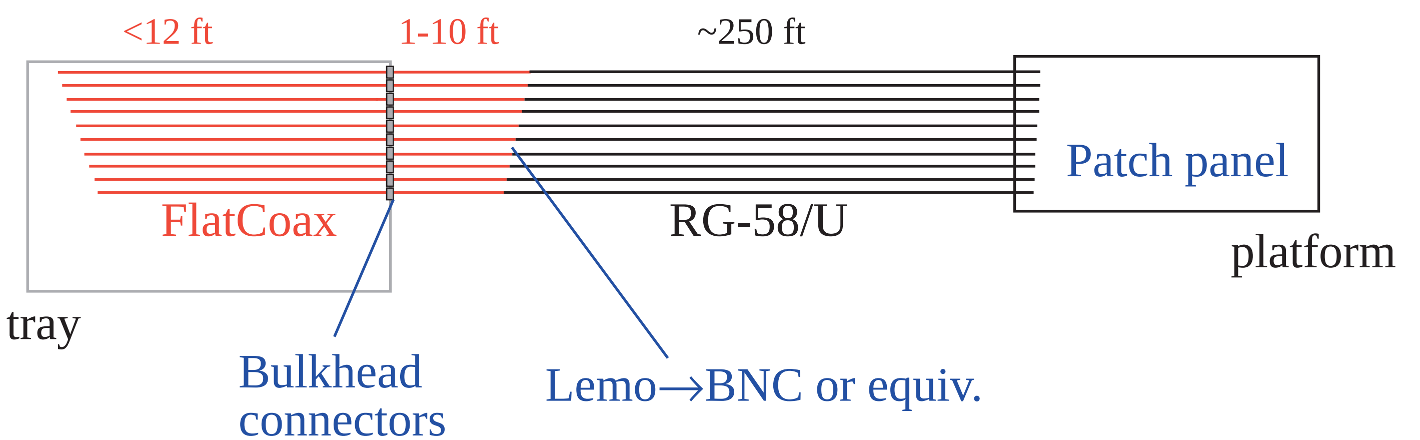
→ there *are* performance compromises if FlatCoax is chosen to be the long TOFp signal cables...

amplitude cross talk seen but tolerable...
timing cross talk seen but excessive...
dependence of attenuation on temperature...

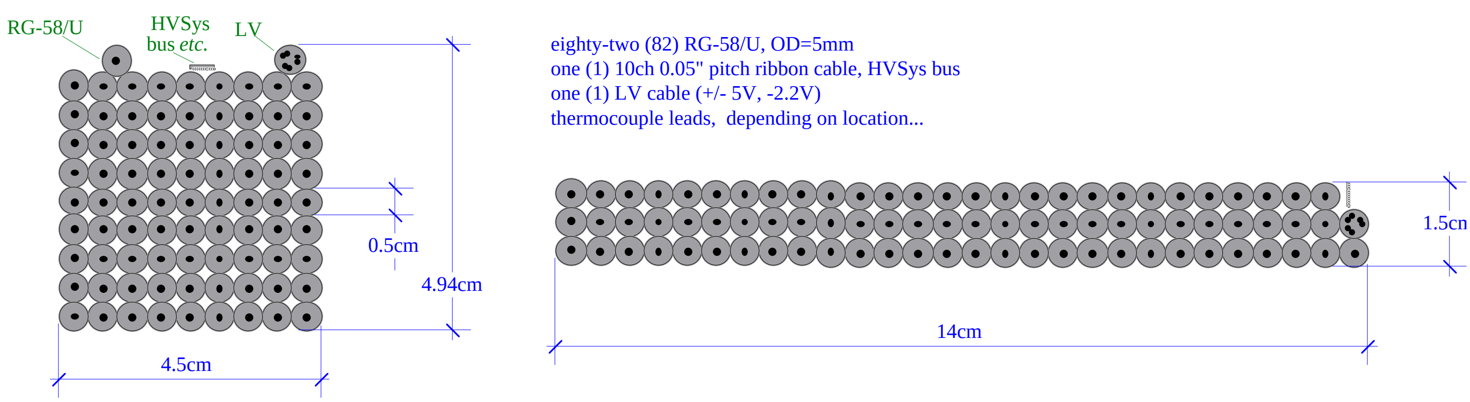
recommendation for long signal cables is RG58/U, Belden 8240

- ~18 dB/100m @ 200 MHz (note RG-58C/U used in SysTest-I is 23dB!)
- v = 0.66 c
- OD ~ 5mm
- Same cost...
- No external impedance matching needed...
- <0.2% amplitude cross talk
- <20 ps or less timing cross talk

Amphenol FlatCoax appropriate inside tray (<12 ft runs)
and perhaps for a small distance after that...
...total allowable length of FlatCoax is 25ft...

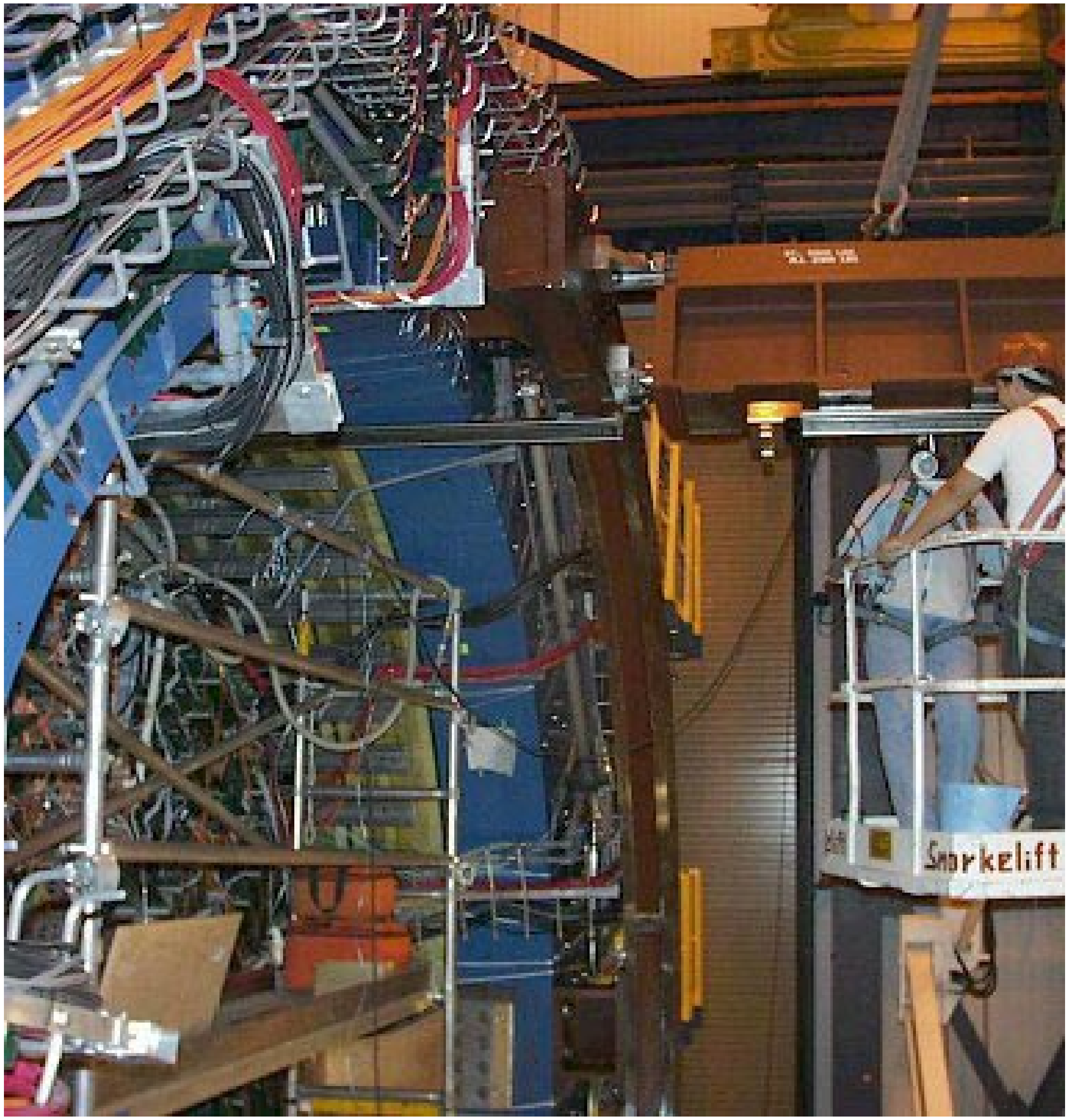


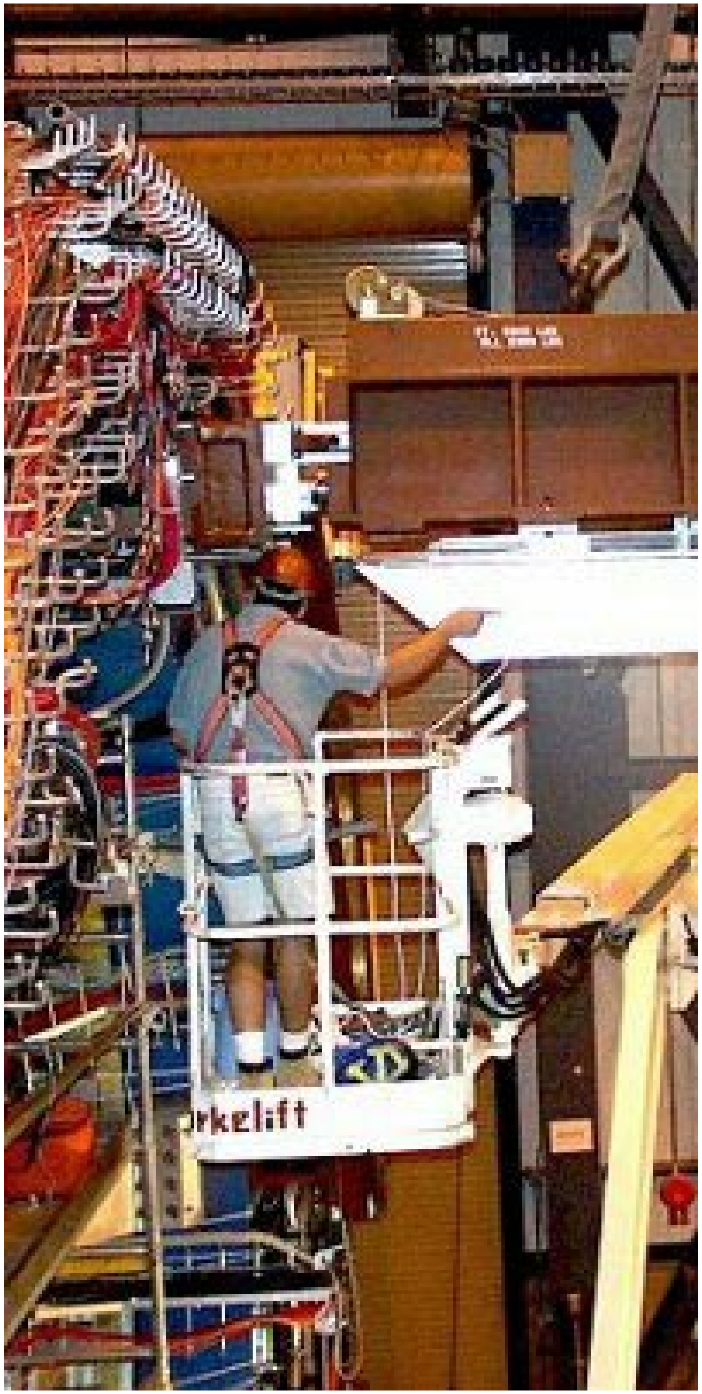
Cross sectional area needed for TOFp cable path...



TOFp cable path to be specified by integration group...
lots of room?

shown here is not the end of STAR that TOFp goes into...

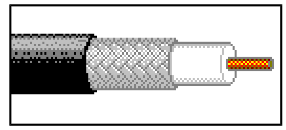




Belden

1-800-BELDEN-1

50 Ohm Transmission Cable
RG-58/U Type
20 AWG



Trade Number Industry Stds.	Std. Lgth. (ft.)	Std. Units (lbs.	AWG (strand) Type (dia.) Nom. D.C.R.	Coreo.D. Nom.o.D.	Shields Nom. D.C.R.	Nom. Imp. (ohms)	Vel. of Prop.	Nom. Cap.
8240 UL AWM: 1354 NEC: CMX CEC: CMX Brilliance	50 100 U-500 500 U-1000 1000	1.7 2.9 13.4 14.1 26.0 26.6	20 (Solid) BC 0.033in. 10.0ohms/M'	0.116in. 0.193in.	95% TC Braid Inner 4.1ohms/M'	51.5	66.0%	29.9pF/ft
Metric	(Meters) 15.2 30.5 U-152.4 152.4 U-304.9 304.8	(Kg) .77 1.3 6.1 6.4 11.8 12.1	.838mm 32.8ohms/km	2.946mm 4.902mm	Inner 13.4ohms/km			98.1pF/m

Description:		
Insulation:	Polyethylene	Brilliance® 50 Ohm, Transmission and Computer Cable. 20 AWG solid bare copper with polyethylene insulation. Tinned copper braid, 95% shield coverage. Black Temperature Rating : 80°C Voltage Rating : 30 Volts (UL) Suggested Operating T Range (Non-UL): -40°C to +80°C. Maximum Operating Voltage (Non-UL): 1400 Volts Military Specification : JAN-C-17A
Jacket:	PVC	
Plenum Version(s):	88240 82240	

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1.0	0.3	.98
10.0	1.1	3.61
50.0	2.5	8.20
100.0	3.8	12.5
200.0	5.6	18.4
400.0	8.4	27.5
700.0	11.7	38.4
900.0	13.7	44.9

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1000.0	14.5	47.5

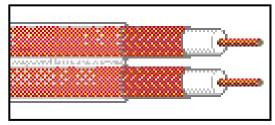
Top

(Select other related products with BACK or PREVIOUS.)

Belden

1-800-BELDEN-1

Plenum Computer, Instrumentation and B-Cast Cable
Dual RG-59/U Type
23 AWG
Plenum



Trade Number Industry Stds.	Std. Lgth. (ft.)	Std. Units (lbs.	AWG (strand) Type (dia.) Nom. D.C.R.	Core O.D. Nom. O.D.	Shields Nom. D.C.R.	Nom. Imp. (ohms)	Vel. of Prop.	Nom. Cap.
89555 NEC: CMP CEC: CMP	500 1000 2000	48.2 92.7 186.0	23 (Solid) BCCS 0.023in. 52.0ohms/M'	0.134in. 0.212in.	97% BC Braid Inner 2.6ohms/M'	75.0	69.5%	19.5pF/ft
Metric	(Meters) 152.4 304.9 609.8	(Kg) 21.91 42.1 84.5	.584mm 170.6ohms/km	3.403mm 5.385mm	Inner 8.5 ohms/km			64.0pF/m

Description:		
Insulation:	FEP	Dual Plenum, Coaxial Computer, Instrumentation and Broadcast Cable. RG-59/U, 23 AW bare copper covered steel conductor with FEP insulation. Bare copper braid, 97% c Clear FEP jacket. Zip Cord Construction Temperature Rating : 200°C. Suggested Ope Temperature Range (Non-UL): -70°C to +200°C. Maximum Operating Voltage (Non-UL): 1 Volts RMS. Spools and/or UnReel® cartons are one piece, but lengths may vary ±10% length shown.
Jacket:	FEP	
Plenum Version(s):	n/a	

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1.0	0.5	1.64
10.0	1.0	3.28
50.0	2.3	7.54
100.0	3.7	12.1
200.0	5.4	17.7
400.0	8.4	27.5
700.0	11.6	38.0
900.0	13.8	45.2

Attenuation		
Freq MHz	Nom. Atten (dB/100ft)	Nom. Atten (dB/100m)
1000.0	14.8	48.5

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(Select other related products with BACK or PREVIOUS.)

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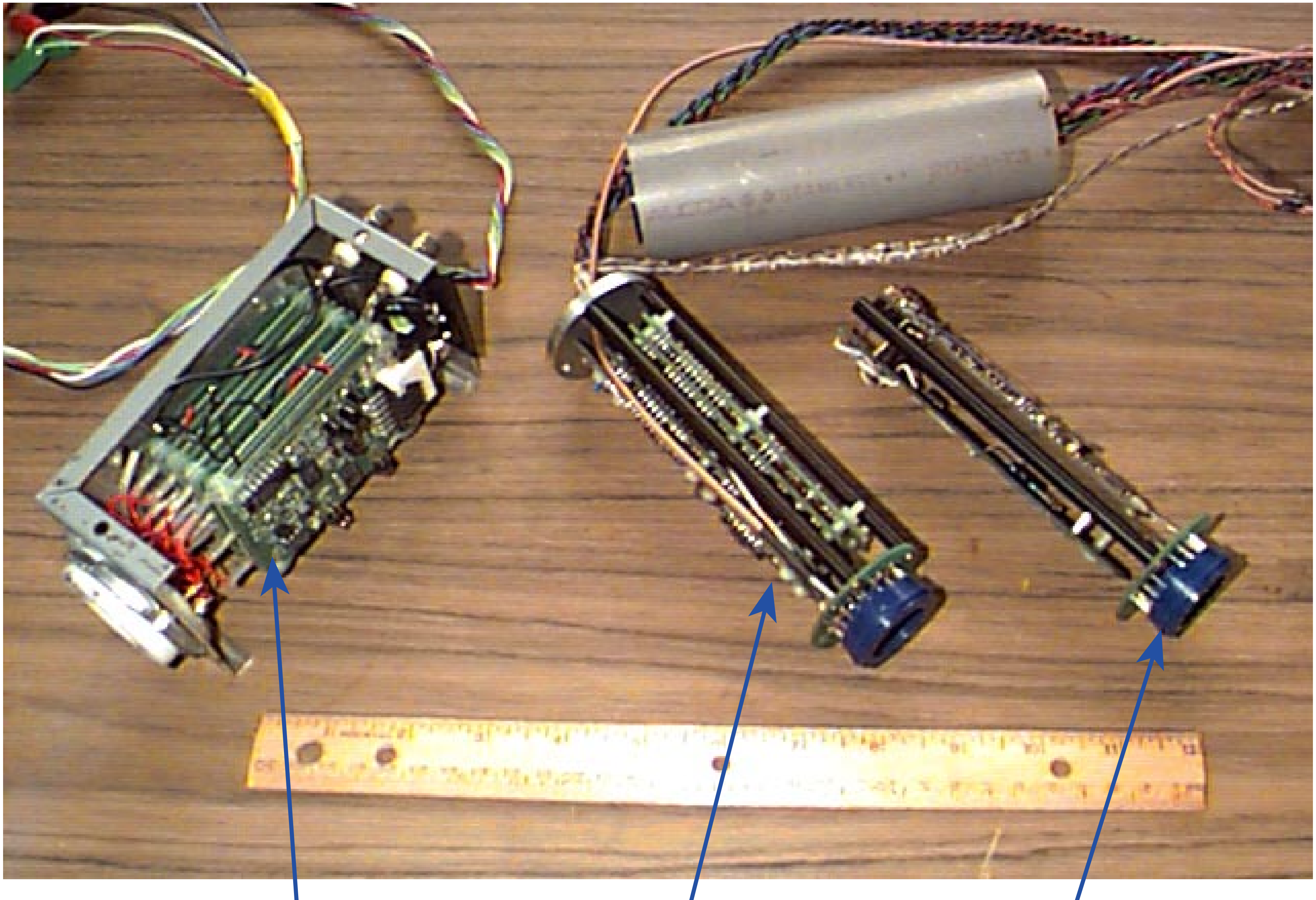
History of Rice CWs...



version 1
Mitch Wright

version 2
Harry Themann

version 3
Nick Adams

(note these were all developed for the CTB, not TOFp - there are considerably different reqs for the two!)

Voltage

TOFp proposal suggests Nick Adams' (Rice) version III CW bases
simpler than previous versions, and stable
on original schedule, would have been best approach
the present schedule cannot afford this any more...

Commercial vendors contacted:

EMCO (declined to quote for our specs)
Hamamatsu (don't work in magnetic fields)

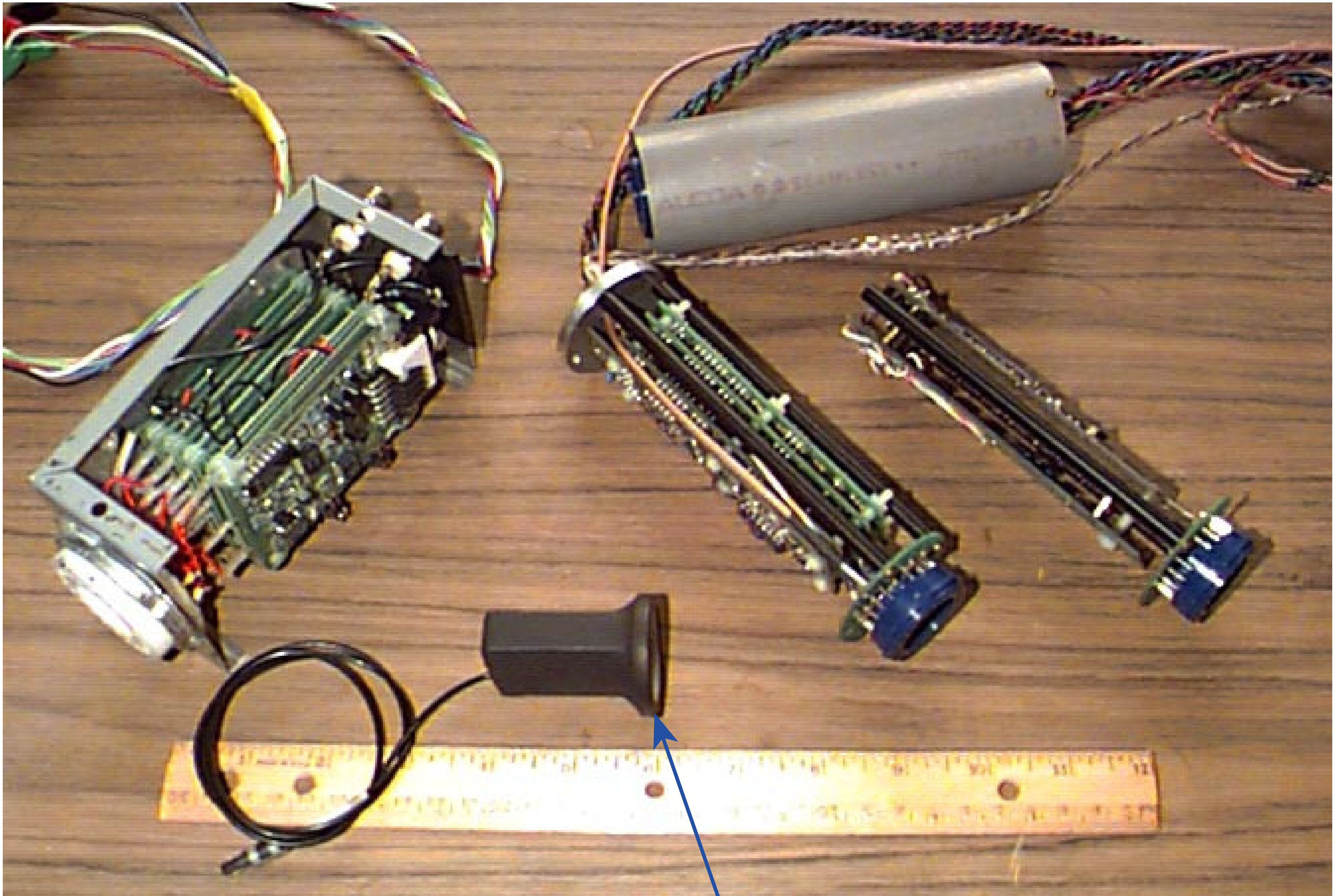
HVSys Valery Astakhov *et al.*
http://www.tsl.uu.se/~sukhanov/HVSys/Astakhov/welcome.htm

- simple control via System Module — connects only to bus, PC, & AC power
- single bus for all cells in a tray — only feedthrough is single 10 ch. ribbon
- cells are small — diameter 1.5", length ~ 2"
- power <0.5 W/cell, or <25 W/tray — practical upper limit is 50 cells/tray
- cost/cell ~80$, and can be produced quickly
- System Module (2 k$) already in hand
- DOS GUI or Terminal interface to control and read-back cells

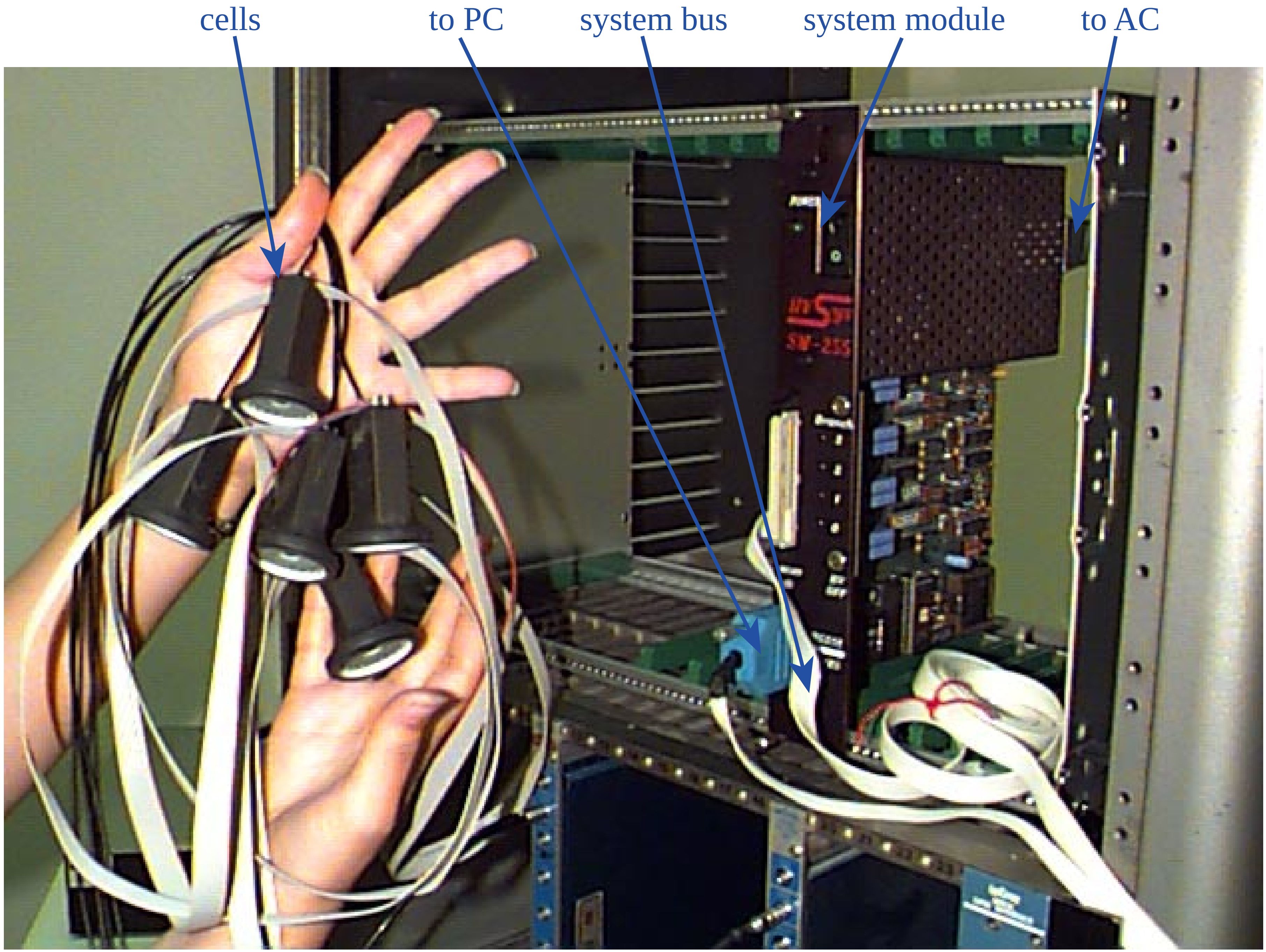
06/04/99: began discussions with Valery...
06/09/99: agrees to make 6 cells on spec...
06/19/99: design specs for TOFp finalized...
07/04/99: TOFp cells complete...
07/05/99: cells carried to Dallas by a friend...
07/08/99: cells arrive at Rice...

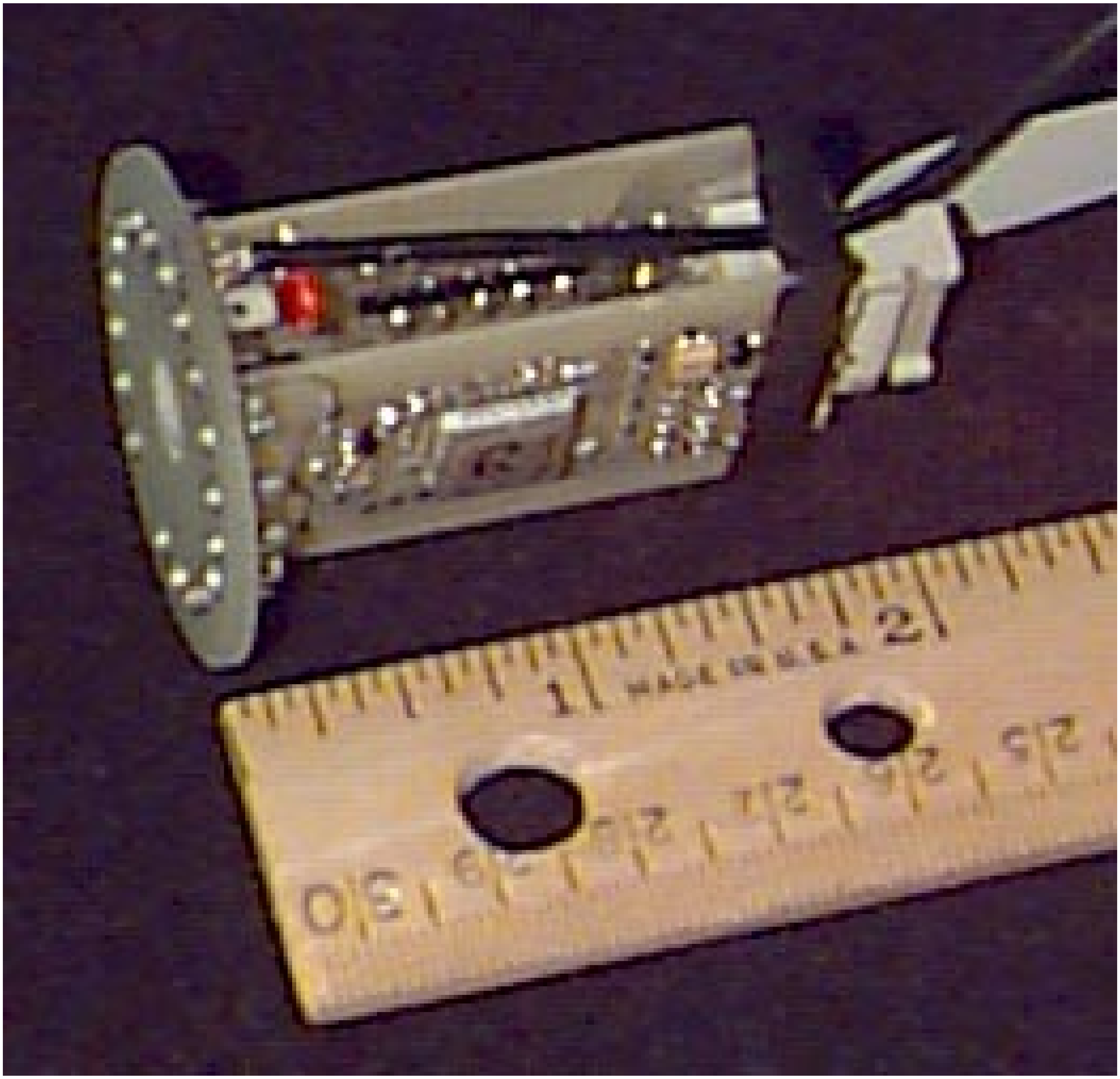
since then the system has been kept on almost all the time...

~2 months of testing of 6 HVSys cells developed specifically for TOFp...



HVSys cell...


cells
to PC
system bus
system module
to AC

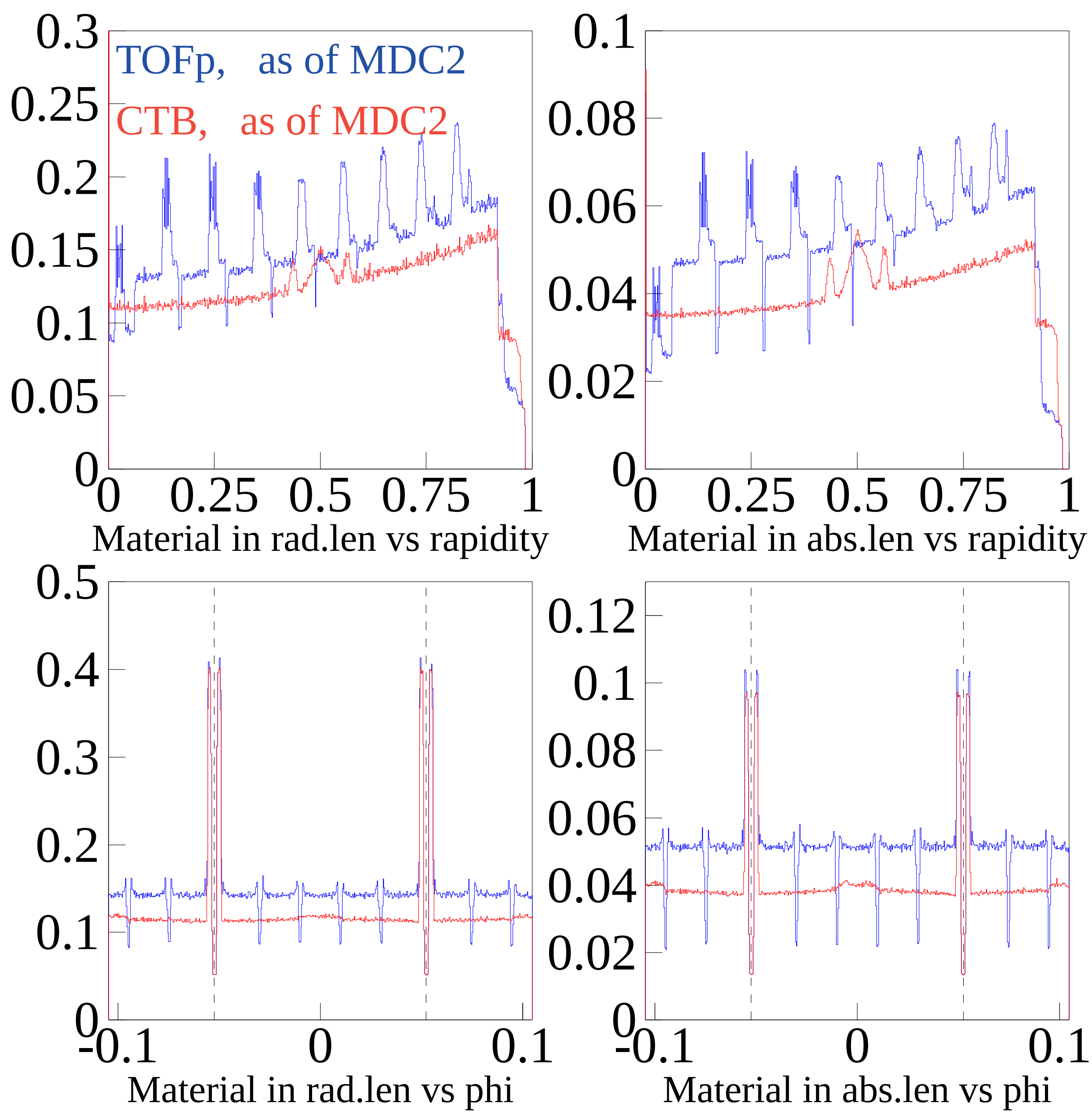


two thin boards...
thinner socket...
→ present TOFp gstar geometry file is *too ponderous*...

only connections are to HVSys bus and the signal output...
→ HDLC interface to the tray is *no longer needed*...

TOFp radiation and interaction lengths...

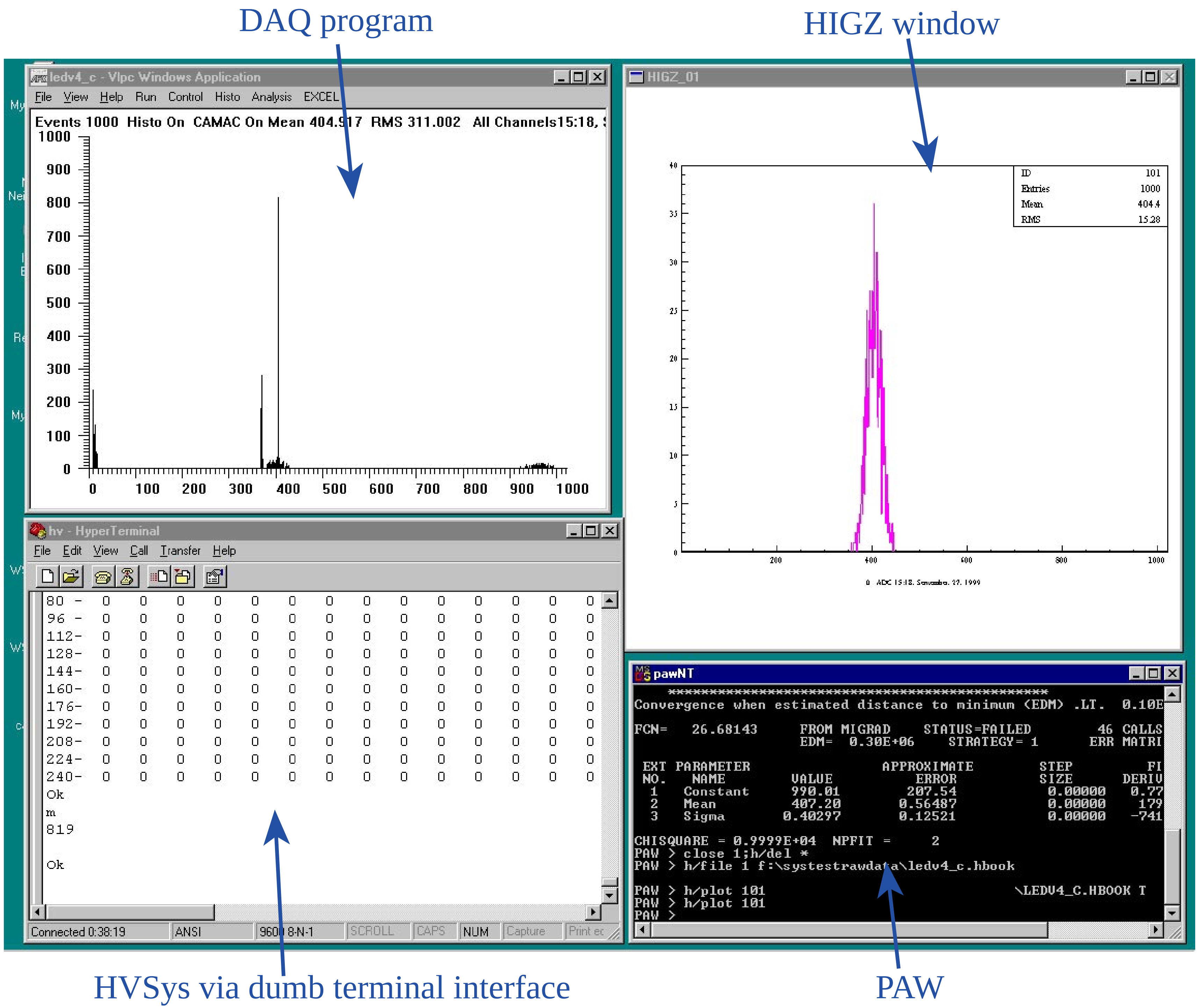
...recall results when (large & dense) Rice v.3 CW base was assumed...
(1cm plastic socket, 4 board perp to tray, Al shell)



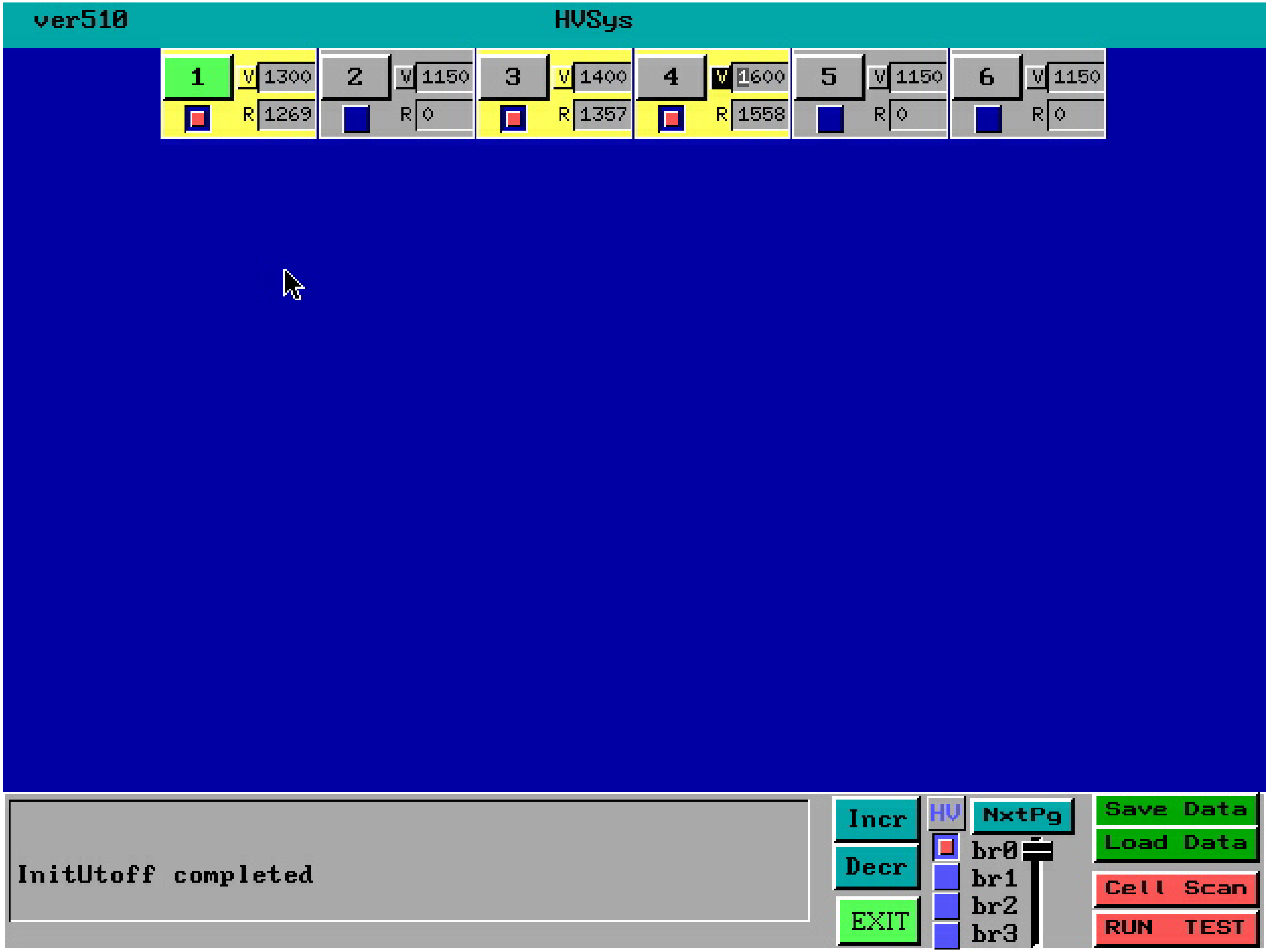
The bumps in the eta view are the Rice v.3 bases...

These bumps are thus *overestimates* when one considers the much smaller size and mass of the HVSys cells...

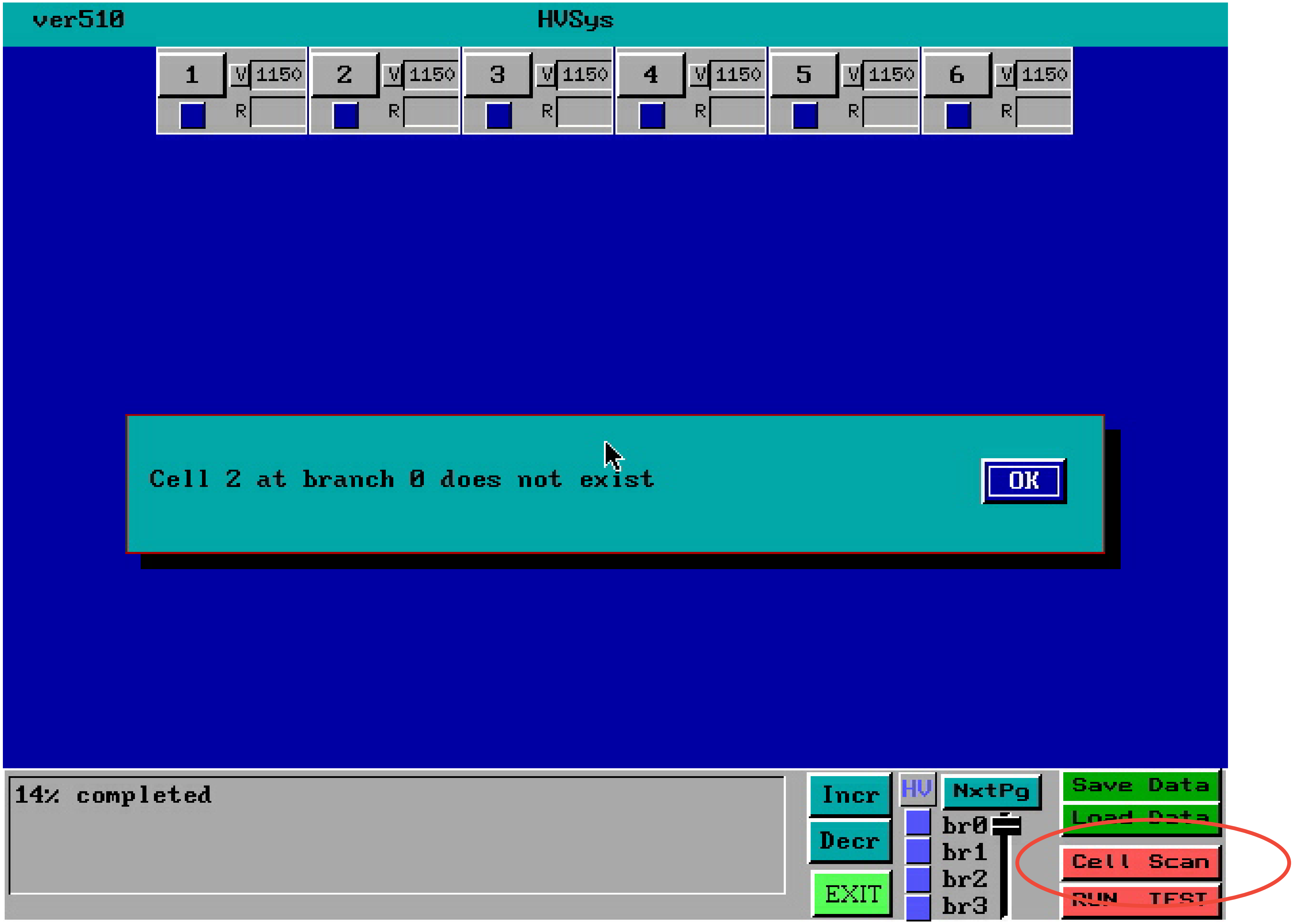
. ...obviously I need to update btofgeo.g (~1hr)...


DAQ program
HIGZ window
HVSys via dumb terminal interface
PAW
ledv4_c - Vlpc Windows Application
File View Help Run Control Histo Analysis EXCEL
Events 1000 Histo On CAMAC On Mean 404.917 RMS 311.002 All Channels15:18,
HIGZ_01
hv - HyperTerminal
File Edit View Call Transfer Help
Connected 0:38:19
pawNT
Convergence when estimated distance to minimum (EDM) .LT. 0.10E
FCN= 26.68143 FROM MIGRAD STATUS=FAILED 46 CALLS
EDM= 0.30E+06 STRATEGY= 1 ERR MATRI
CHISQUARE = 0.9999E+04 NPFIT = 2
PAW > close 1;h/del *
PAW > h/file 1 f:\systestrawdata\ledv4_c.hbook
PAW > h/plot 101
PAW > h/plot 101

DOS GUI for HVSys Control...



HVSys comes with scan and monitoring capabilities...



HVSys

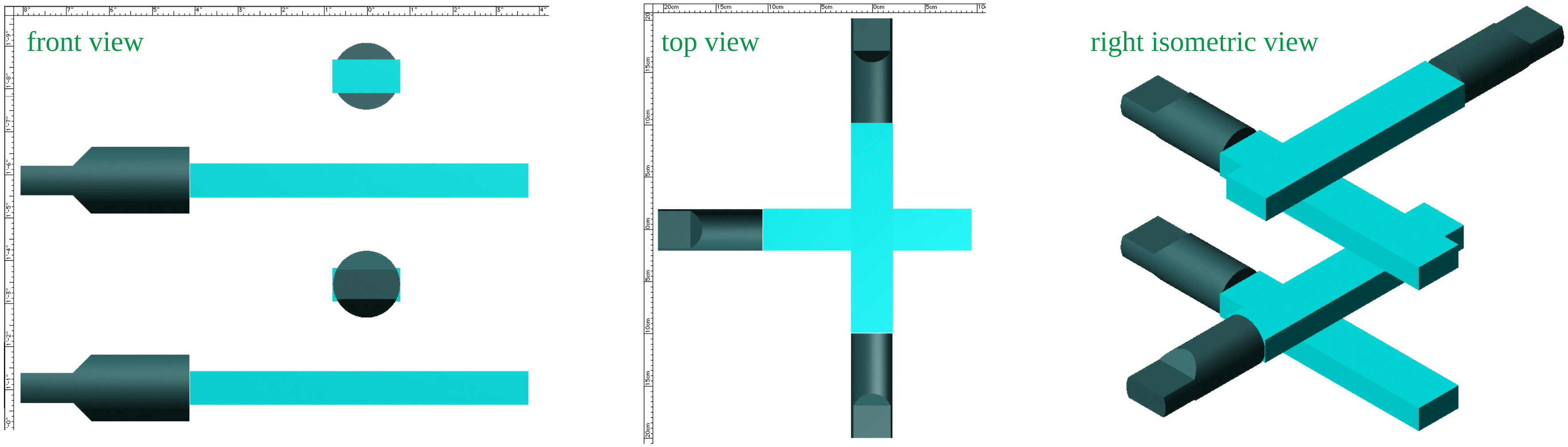
Usability:

Cells and system overall work exactly as expected...
Both control paths (terminal interface or DOS GUI) work...
HVSys voltage scale for each cell "calibrated" to resistive HV and Rice CW v.2...
No affect on ADC distributions compared to resistive HV bases...

Stability:

From HVSys readout: never greater than one count variation (~4.8V/count)...
No system crashes or resets ever seen when taking laser data...

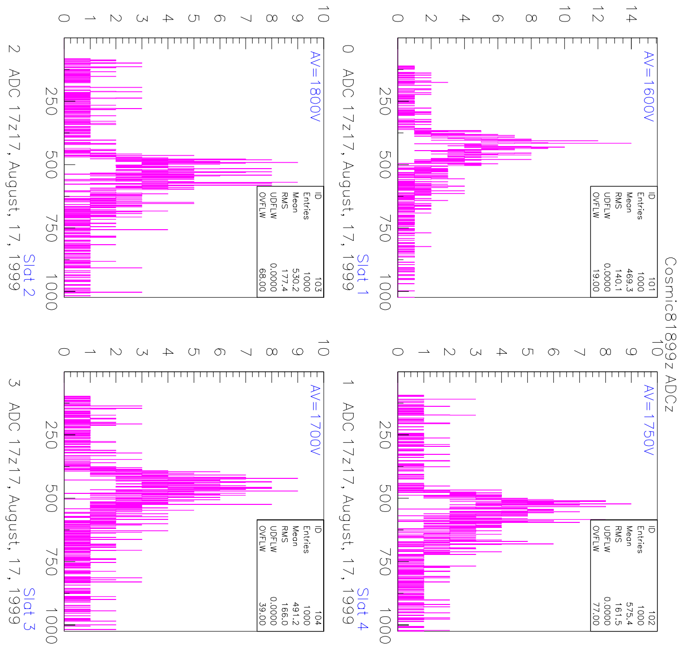
Every night take 2500 cosmic events... Each weekend take 10000 cosmic events...
→ voltage stability from positions of peaks night to night...
→ run stability by checking cosmic count rate...



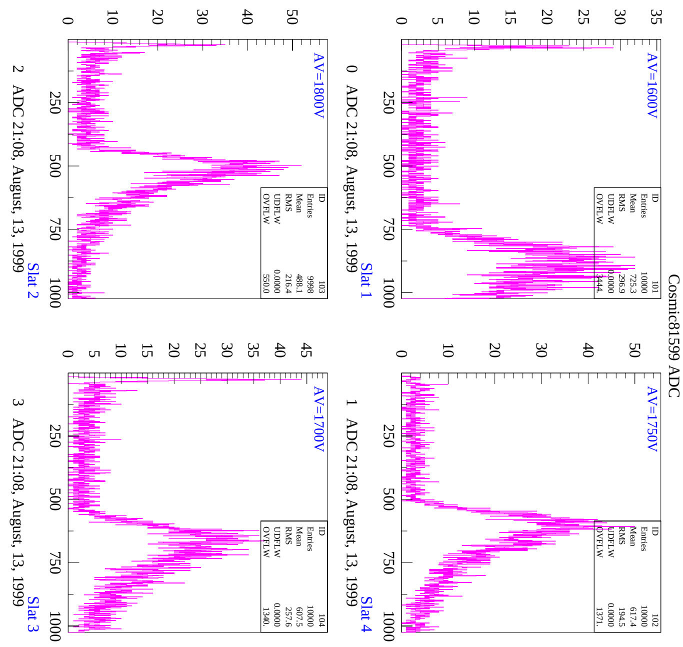
each cosmic run's data are now shown...
many early ones aren't quite right... (we were learning)

...these events also set the relevant Edep scale for all laser-related tests!!!

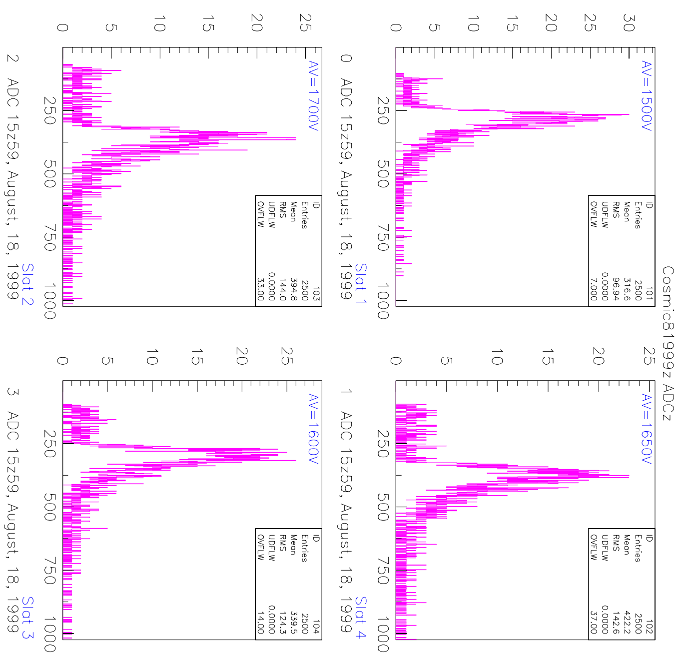
Rice CW v.2 bases



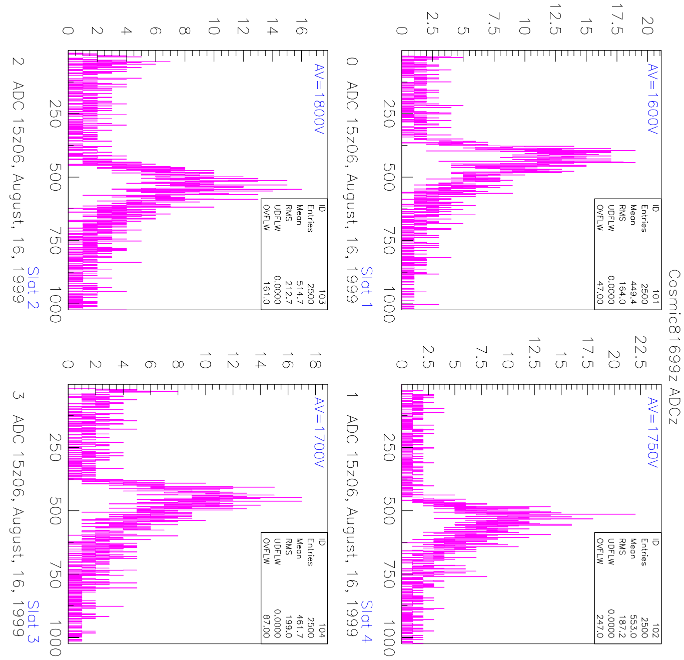
Rice CW v.2 bases



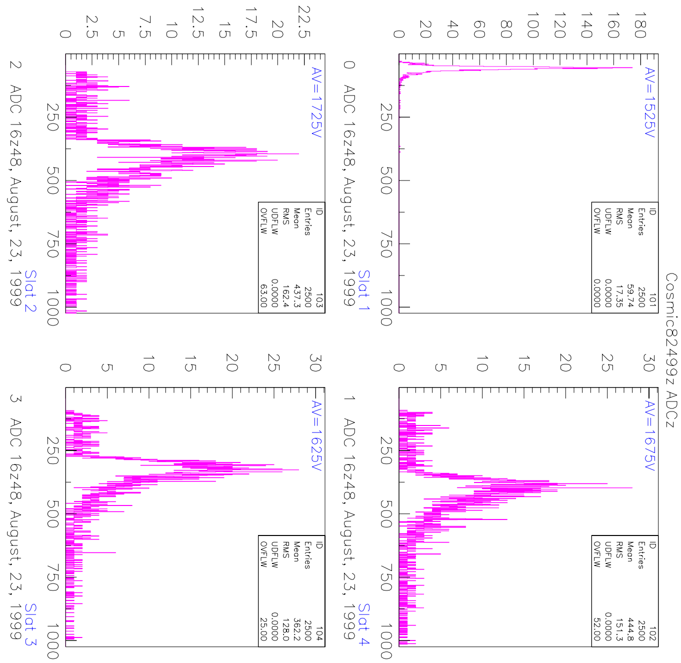
Rice CW v.2 bases, voltage change 100V



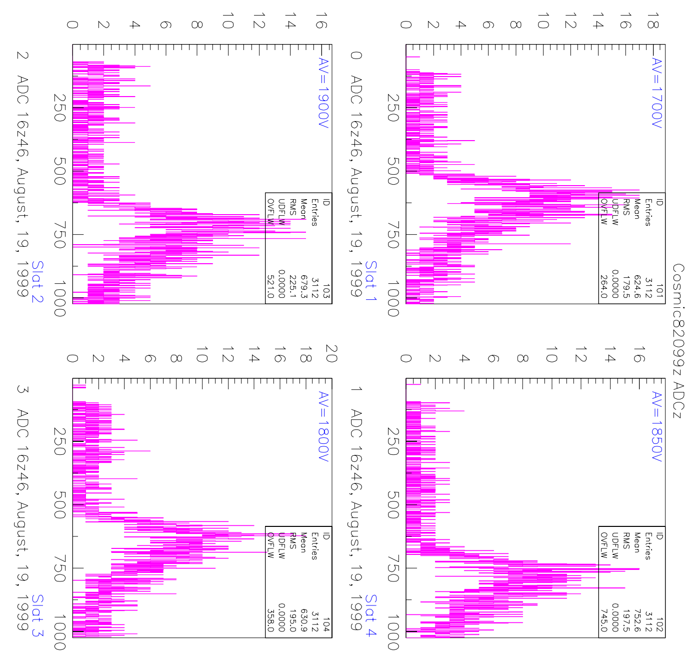
Rice CW v.2 bases, reduced voltages



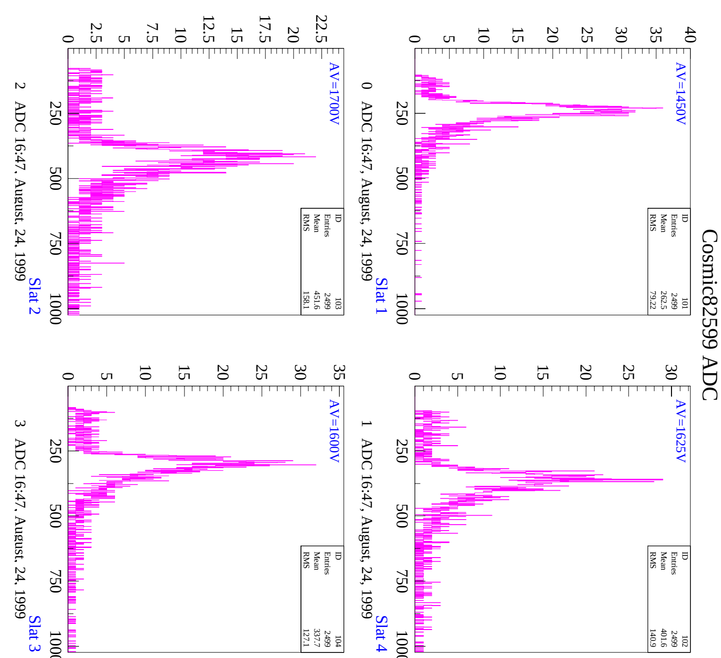
Rice CW v.2 bases again



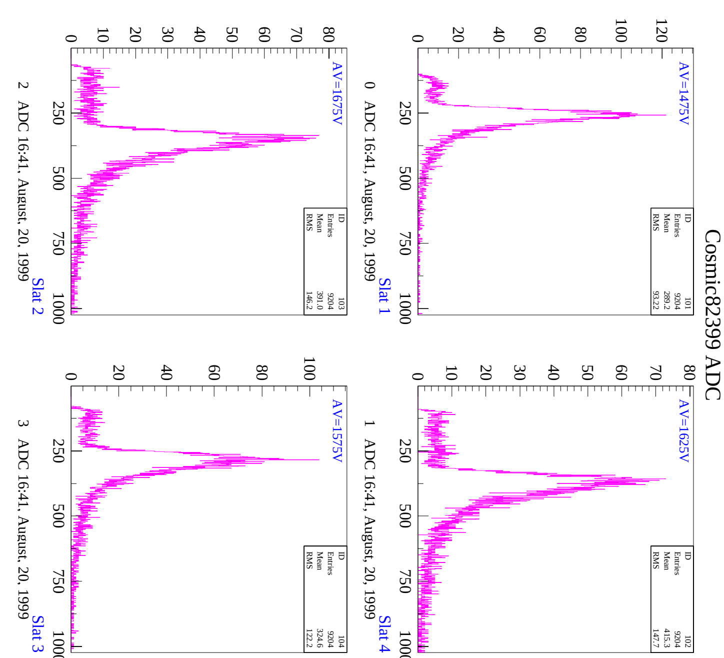
Rice CW v.2 bases, rasied voltage 200V



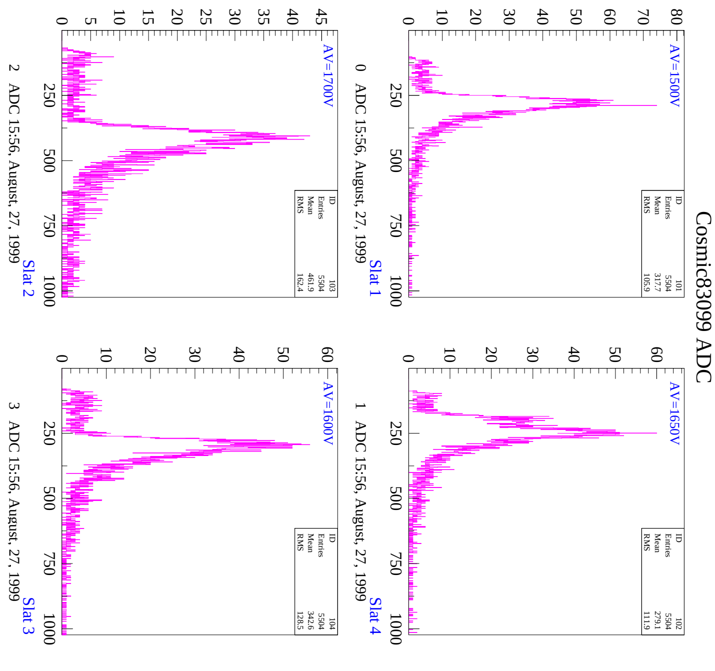
back to HVSys cells



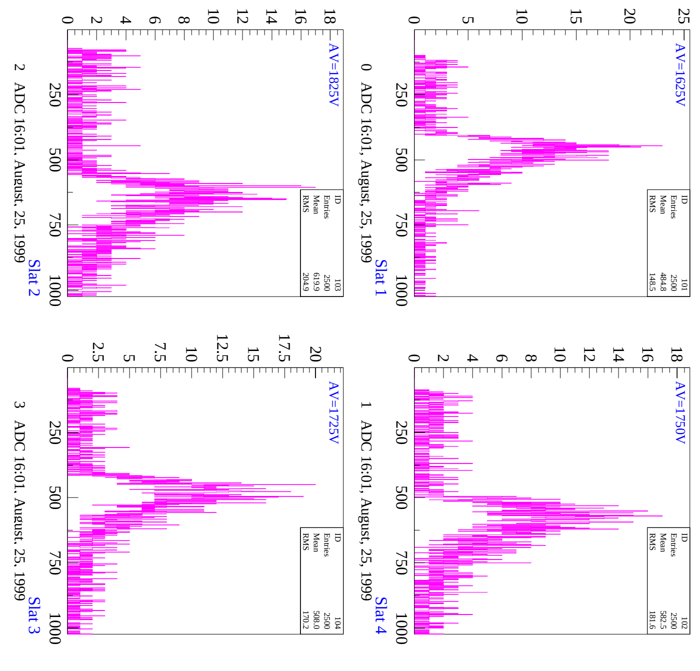
first from with HVSys cells



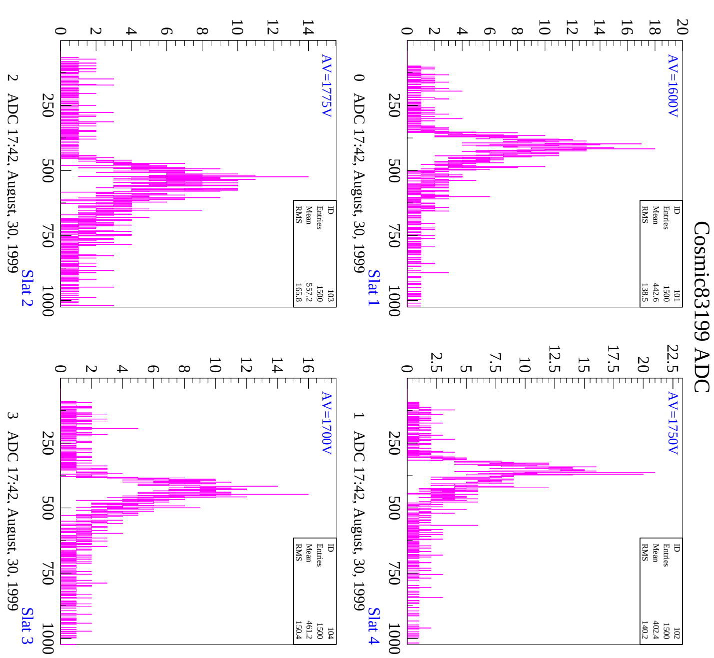
HVSys cells, using new slat stand...



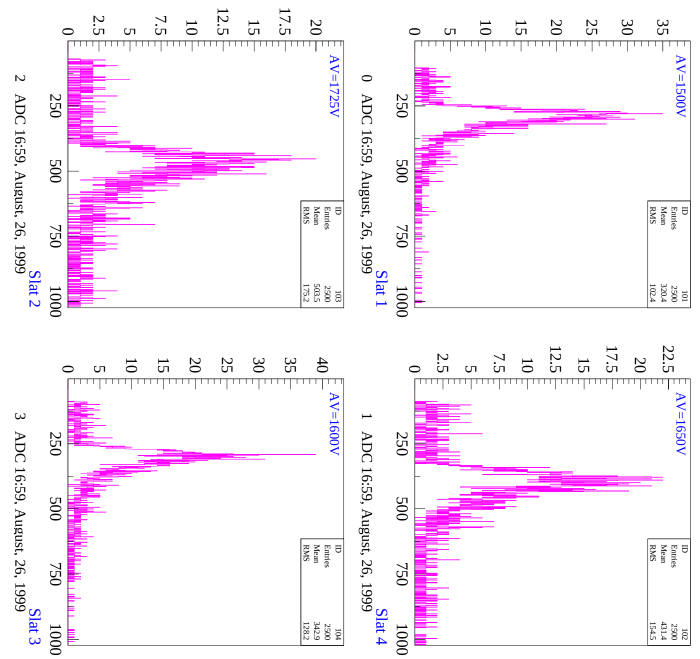
HVSys cells,voltage changes...



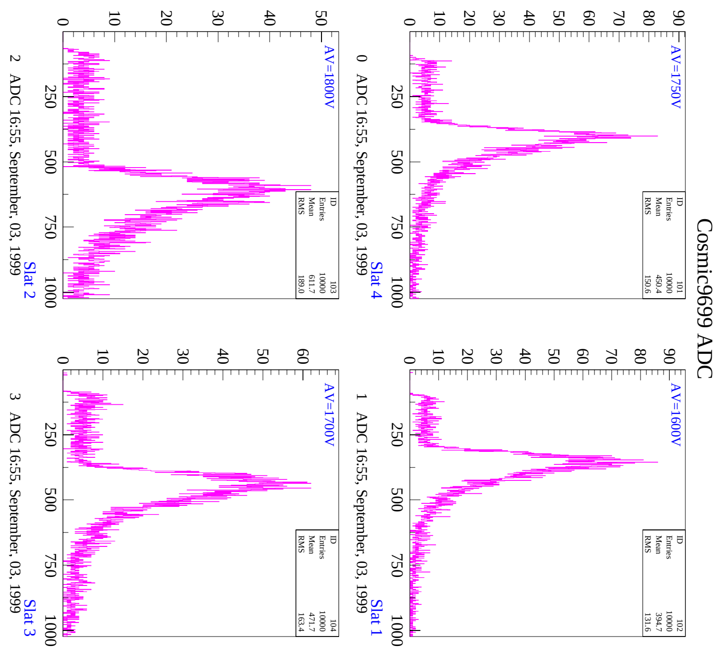
HVSys cells, voltage changes..



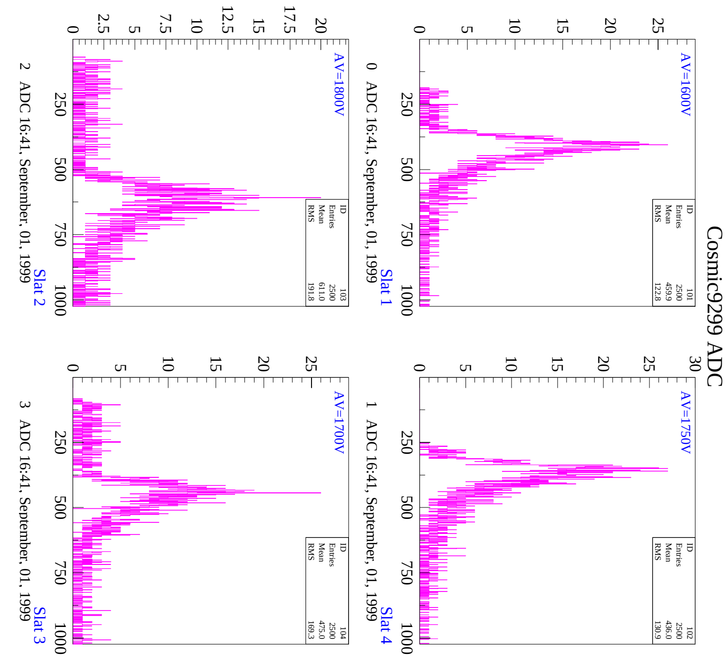
HVSys cells, voltage changes...



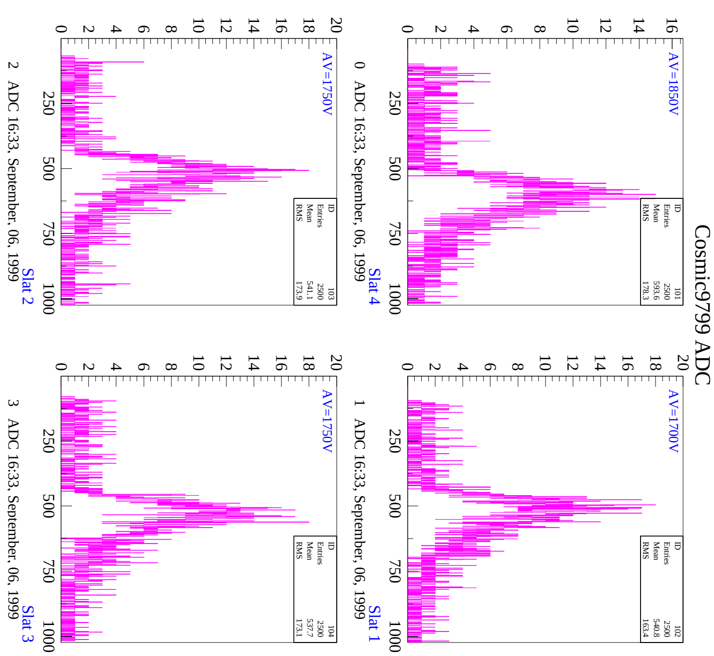
HVSys cells, slat ordering now 4,1,2,3 from top...



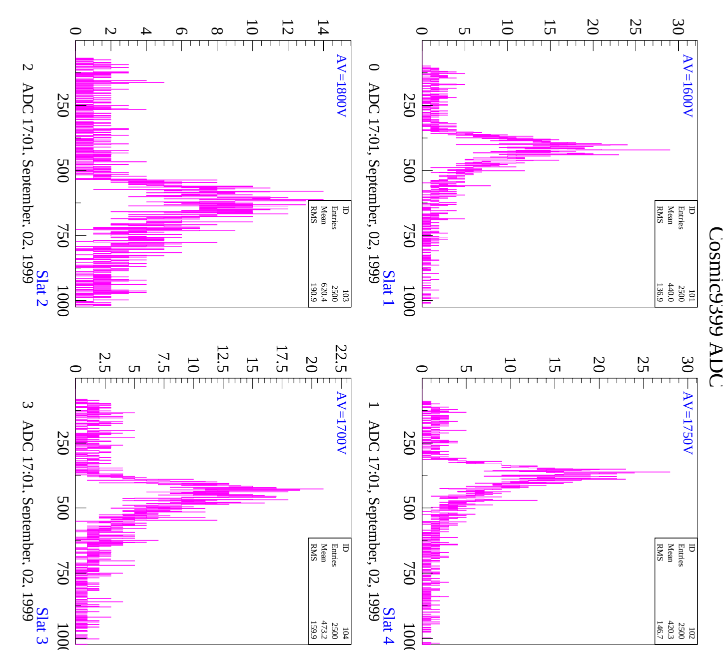
HVSys cells,back to original stand...



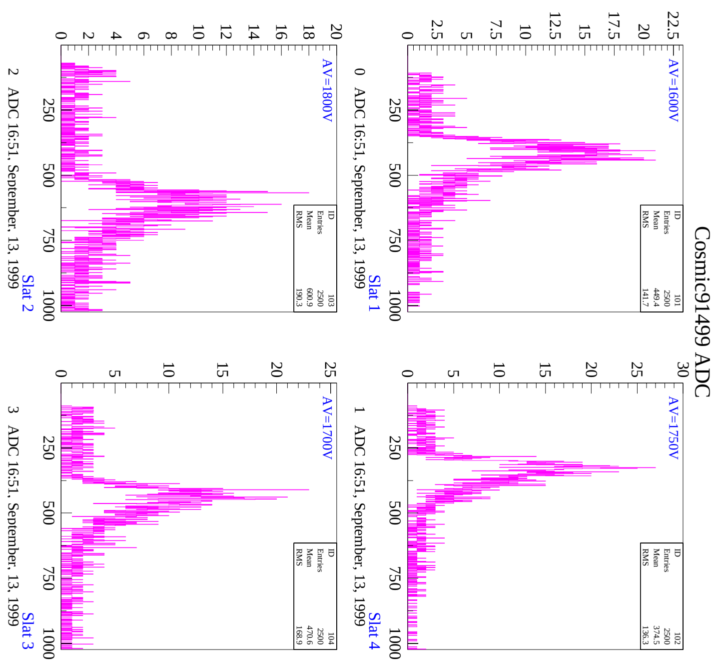
HVSys cells, voltage changes..



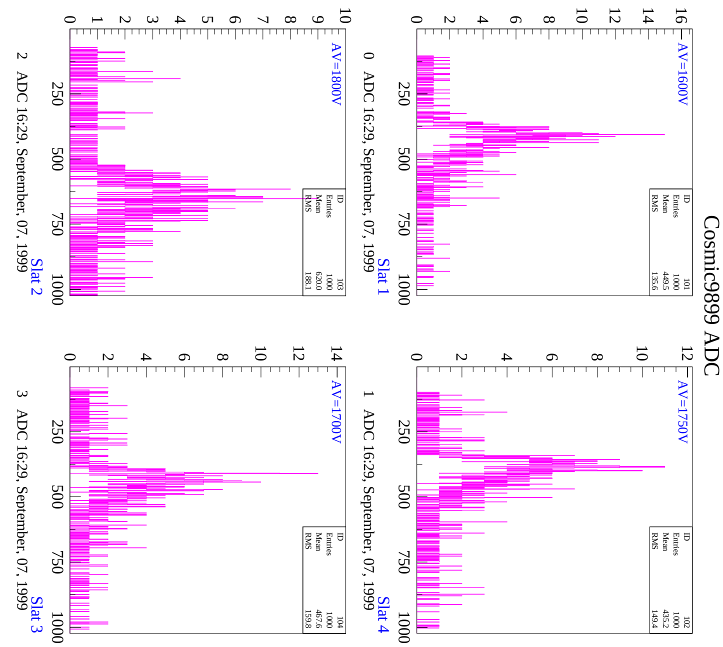
HVSys cells, lowered thresholds....



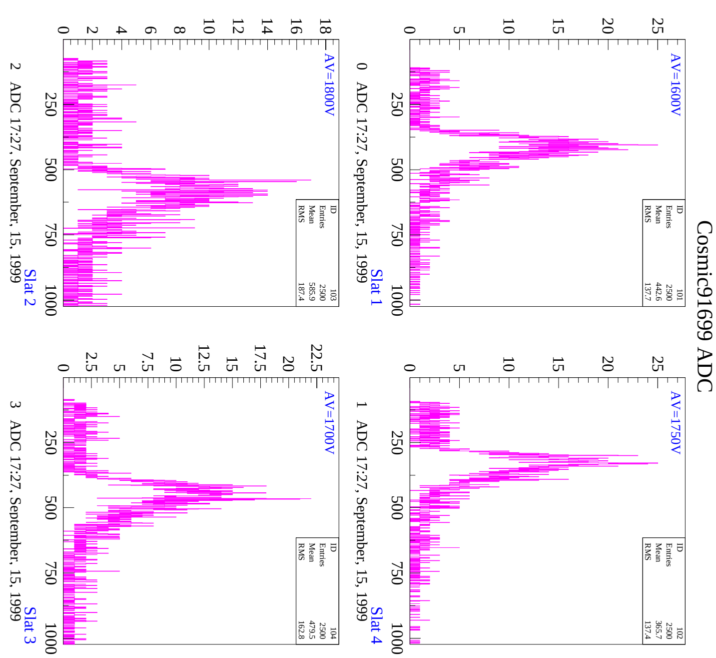
HVSys cells, major revisions...



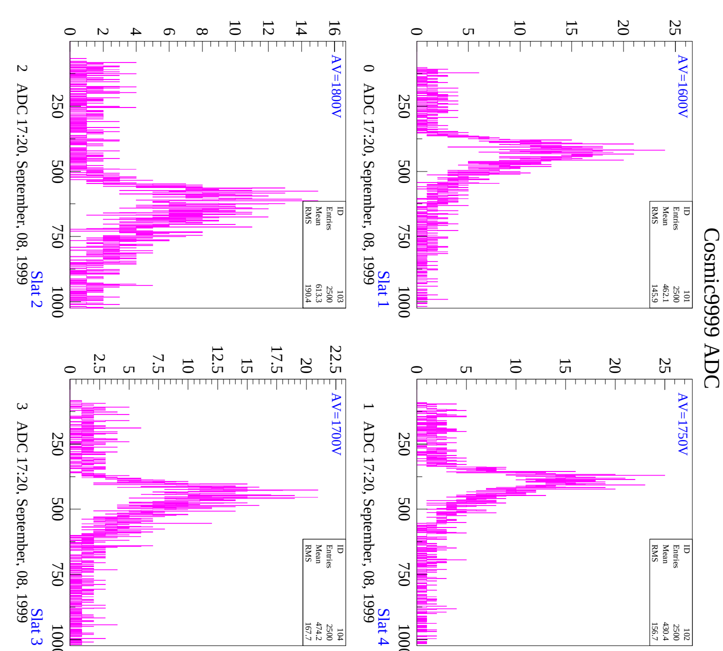
HVSys cells,back 1,4,2,3 ordering



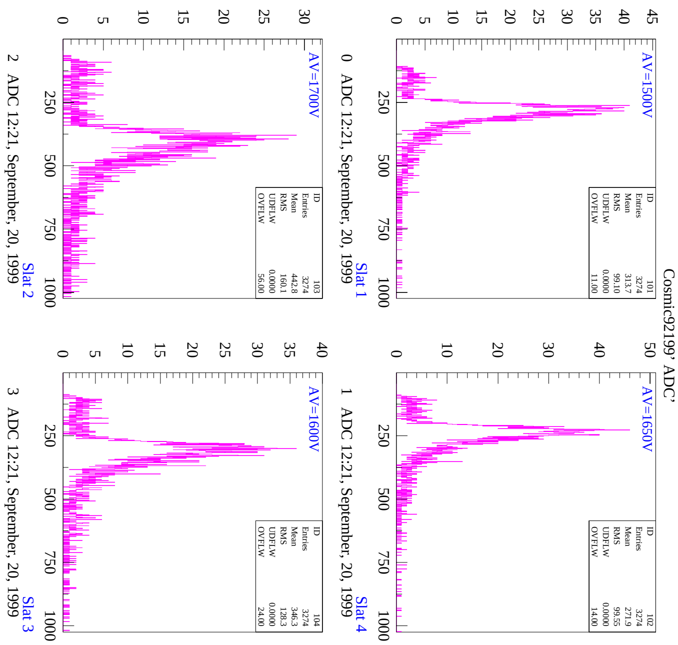
HVSys cells, no change...



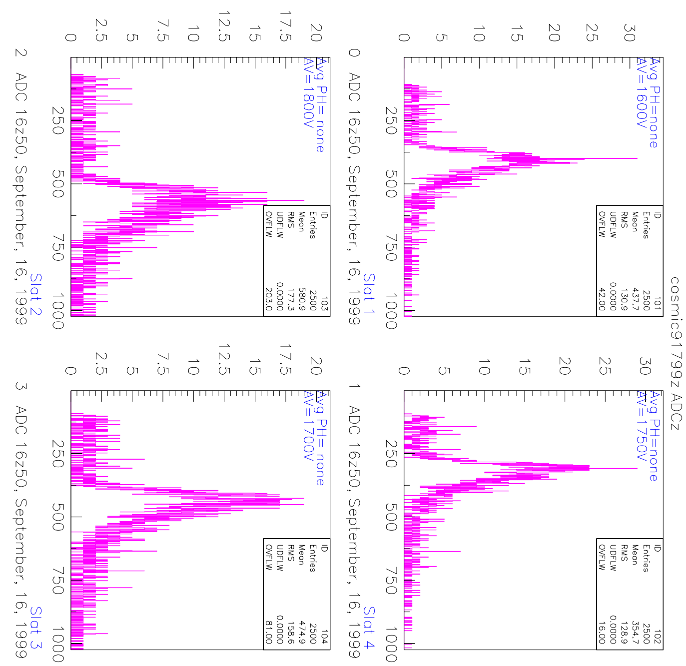
HVSys cells, no change...



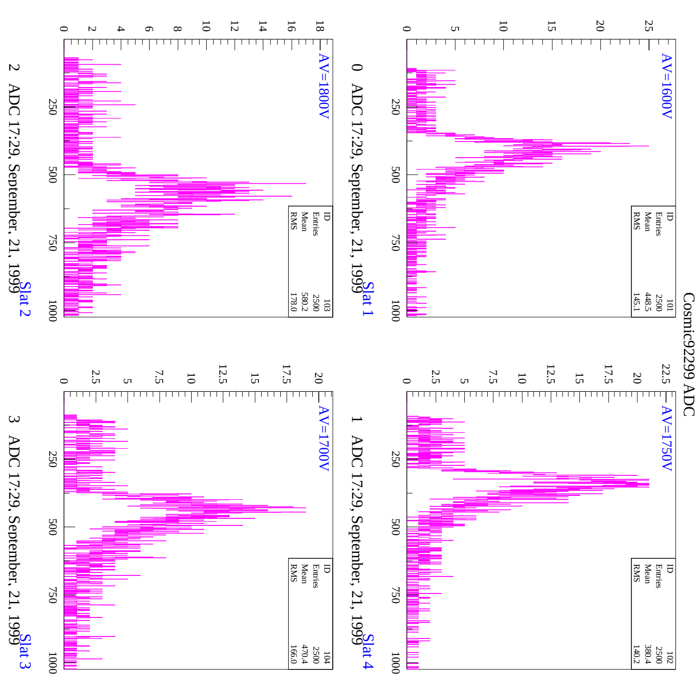
HVSys cells, no change...



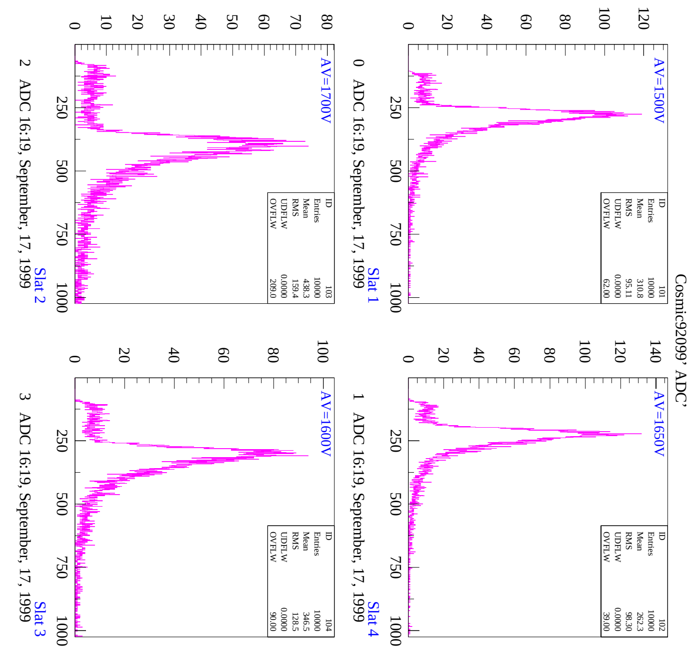
HVSys cells, no change...



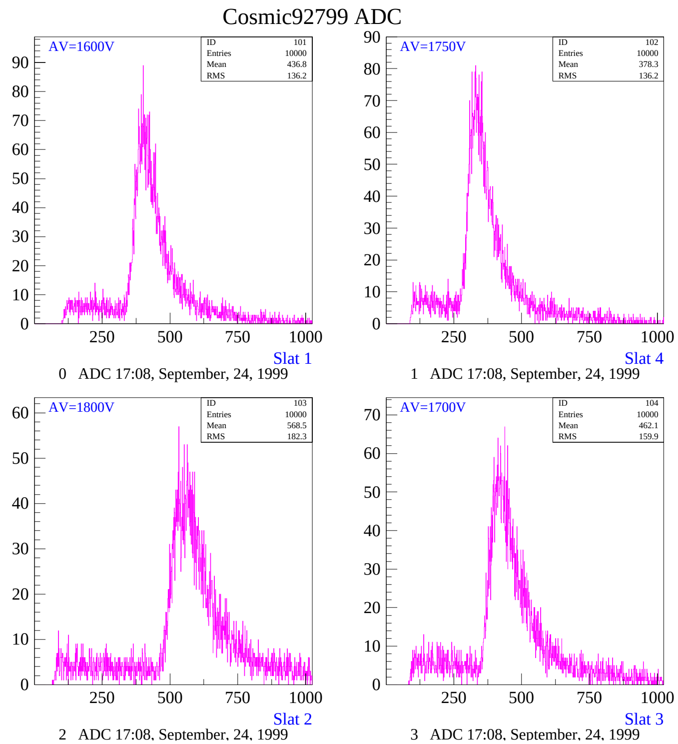
HVSys cells, voltage change...



HVSys cells, voltage change...



HVSys cells, voltage change...



Stability results using cosmics...

no system crashes or resets seen...

peaks stable to <2%

ignoring v.2 CW runs and runs before V changes:

slat	1	2	3	4
	459.9	611.0	475.0	436.0
	440.0	620.4	473.2	420.3
	449.5	620.0	467.6	435.2
	462.1	613.3	474.2	430.4
	449.4	600.9	470.6	374.5
	442.6	585.9	479.5	365.7
	437.7	580.9	474.9	354.7
	448.5	580.2	470.4	380.4
	436.8	568.5	462.1	378.3

(still taking these data)...

Slat	V
1	1600
2	1750
3	1800
4	1700

the values of the voltage&PH for the measured cosmic m.i.p.s are used to determine the appropriate filter for the laser!

several options for appropriate filters (in splitter-box or on slat).

- two transparencies, one printed at 80% gray and the other at 70% gray
- Andover filter #2...

in either case, the laser with the fiber in the slat center gives the same ADC value as for cosmics at the same hit position and PMT voltage...

...all laser results done at Edep equivalent to 1 m.i.p. to within ~10%...

Metallic Neutral Density Filters

General Specifications
VIS-NIR transmitting
UV-VIS-NIR transmitting

Neutral density filters are very useful in a number of applications such as attenuators for broadband spectral sources, partial reflectors for light balancing applications and for use as neutral beamsplitters. Metallic type neutral density filters obtain their optical density by depositing a metal alloy coating onto a specific type of substrate which is determined by the wavelength region of interest. For the Andover standard metallic neutral density filters, the substrate is either optical grade glass or fused silica. Custom substrates are available and will be quoted upon request. Please contact one of our technical sales representatives for assistance. Unlike the all-dielectric or absorption type filters, the metallic type rely on a combination of absorption, reflection and transmission to obtain their proper optical density. Since these films are partially reflecting and absorbing, they will withstand more incident energy than the totally absorbing type; however, their maximum power density is still limited by the fact that they are partially absorbing. If one intends to use these filters as attenuators in laser systems, please check with a technical sales representative for the recommended maximum power density that these filters will withstand.

Optical density (D) is defined as the logarithm to the base 10 of the reciprocal of the transmitted radiant power (T):

$$D=\log_{10}\frac{1}{T} \quad \text{or} \quad T=10^{-D}$$

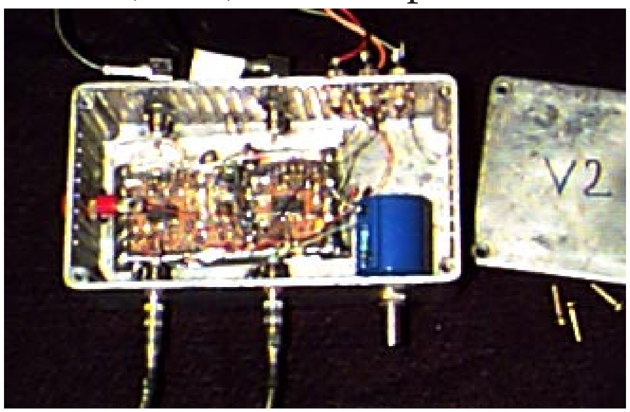
If the user requires a specific density that is not an Andover stock item, they may take advantage of the additive effect of these filters and use several filters in series. One must exercise caution in doing this because multiple reflections will occur and cause a reduction in the density value. To avoid this phenomenon, it is recommended that the filters be tilted slightly so that their films are not parallel to each other.

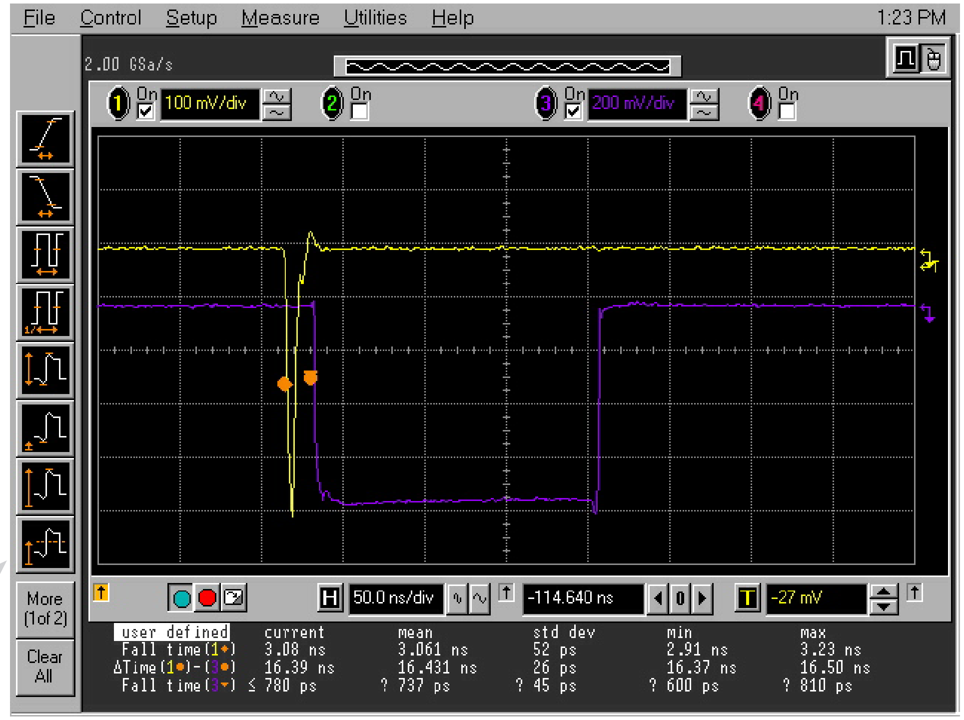
FEE Development...

as of late July,1999 (BNL collab. mtg.):

FEE version II

LE, 2ch, RT~750ps (commercially, RT~2.5 ns)



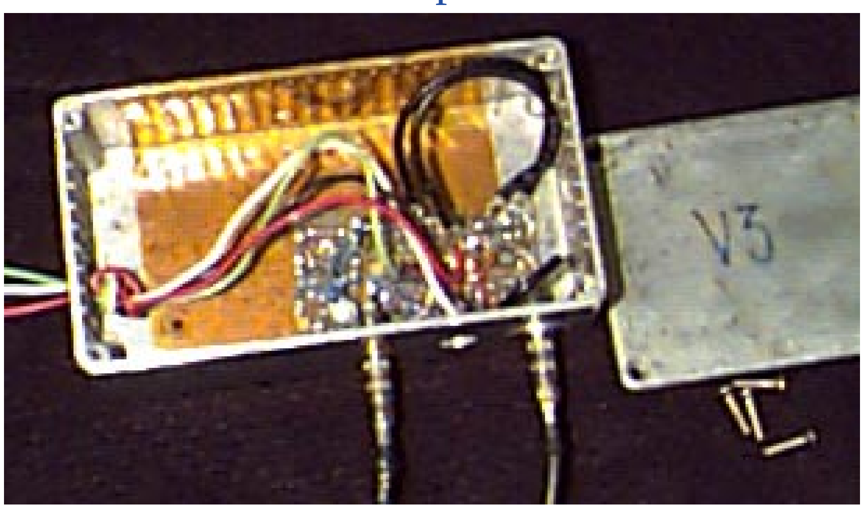


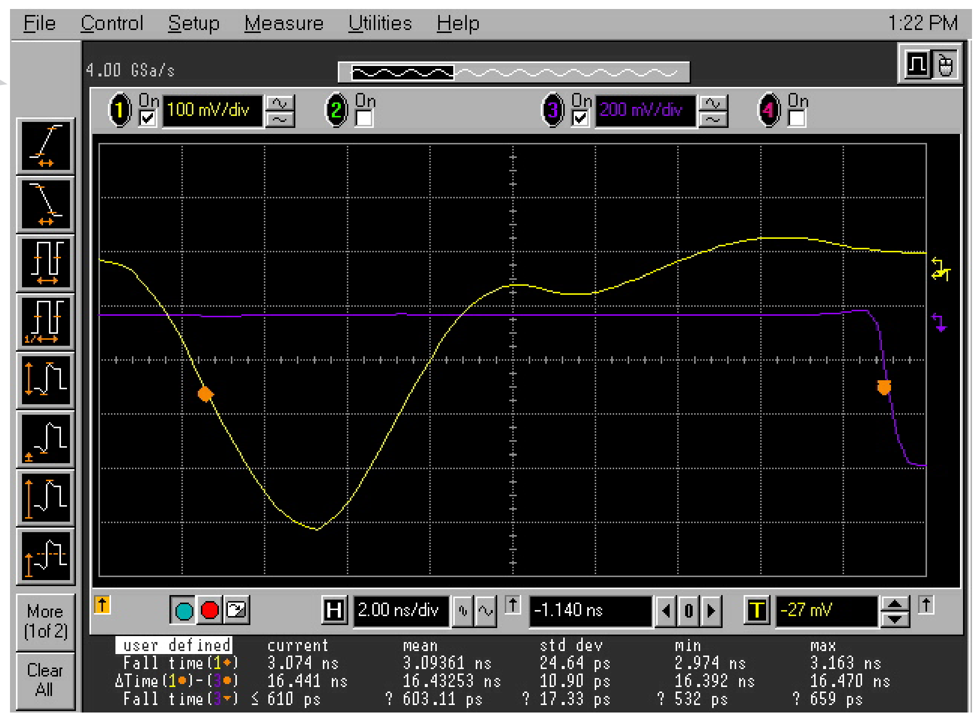
FEE version III (completed 7/22/99)

CFD, 1ch

→ RT ~ 610ps

→ resolution ~11ps

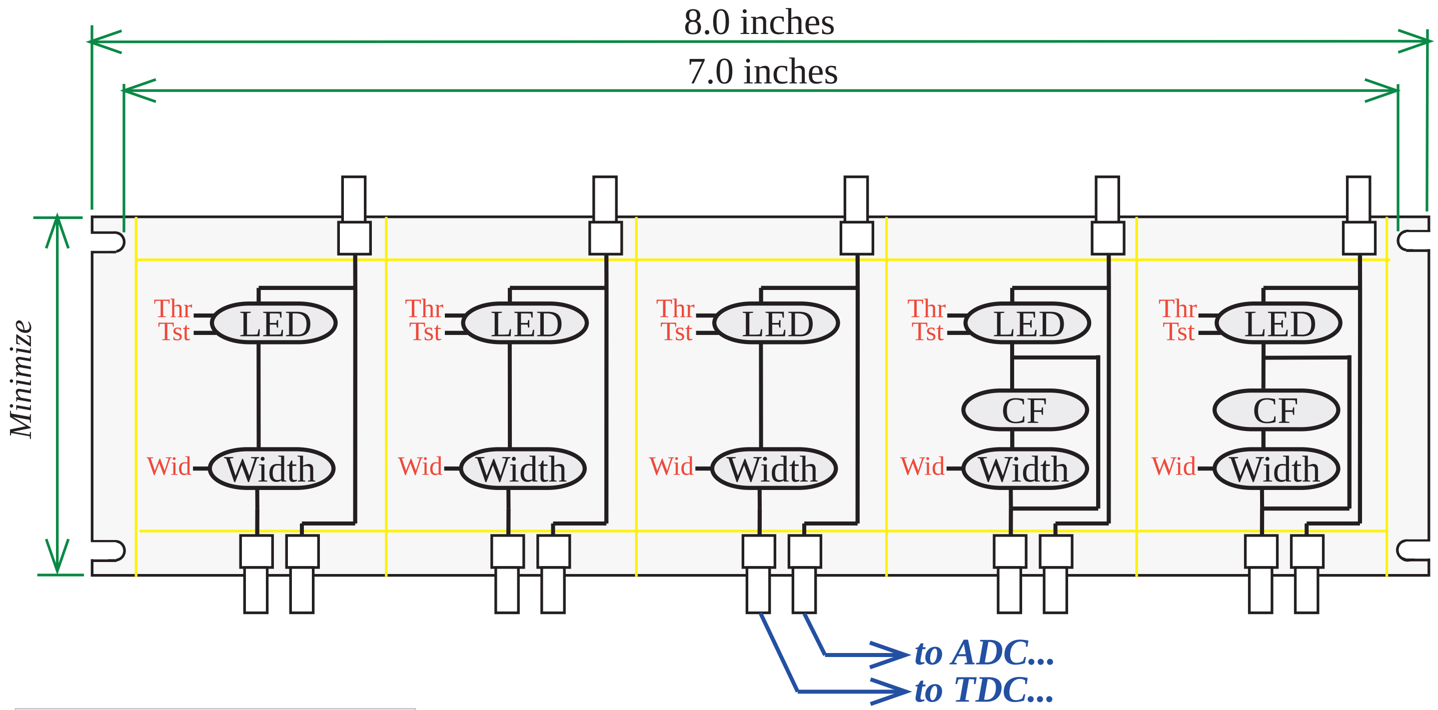




Functional Description of TOFp FEE version IV

WJL, 7/6/99 (revised 7/23/99)

History:
v. I - 1ch, first breadboard
v. II - 2ch LE, RT~0.75ns
v. III - 1ch. first version of LE+CF
v. IV - 5ch LE w/ 2ch CFD



Thr = Pot for LED threshold
Tst = Thres test point
Wid = Pot for logic width

Produce 5 channels version IV board.
All chs have LE circuit, and 2 chs have additional CF circuitry.
Produce two (2) such boards, for 10 ch total

Dimensions:
Board width to bolt onto TOFp cooling rails. *Minimize* length.

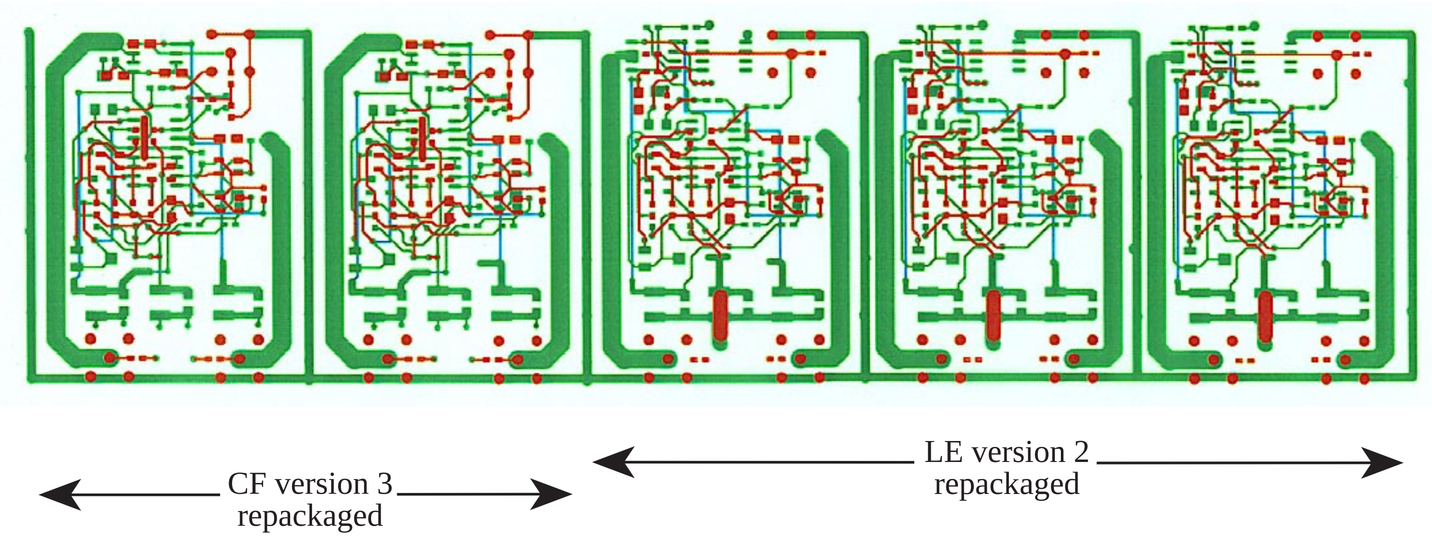
I/O specs:
LE thresholds *individually* adjustable from *50 mV to 1V*
output rise time < 1ns, and *minimized*.
output fixed flat-top voltage, NIM standard *-800 mV*
output widths *individually* adjustable in range *20ns to 100ns*
dead time = 100ns
provide board space and connections for *input protection*.

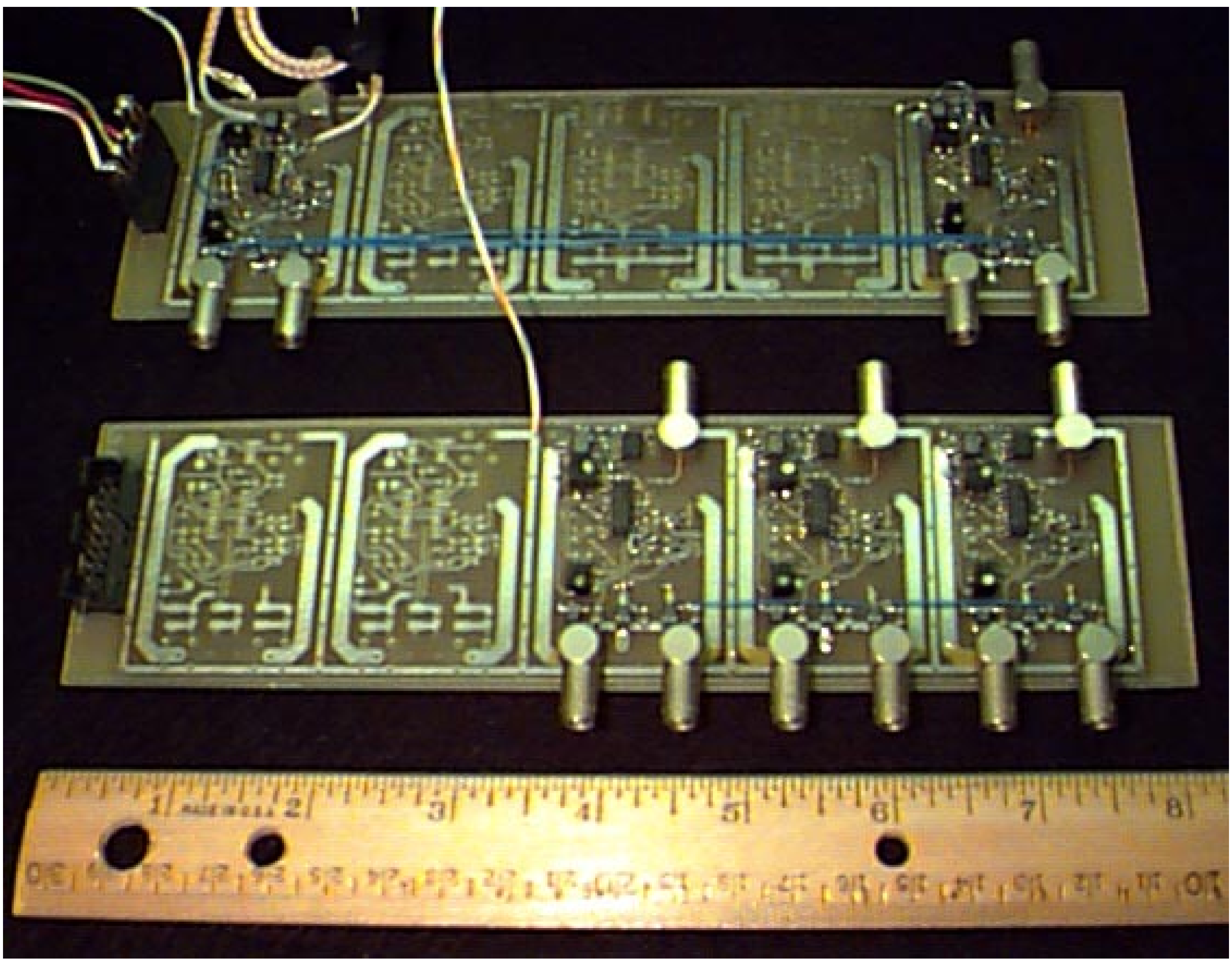
Connections:
5 lemo female on one side take 5 PMT signals
10 lemo female on other side give 5 logic & 5 PMT signals

Present Schedule:
1 week - design/construct/test v.III (complete 7/22/99)
1 week - artwork for version IV
2 days - PCB fab (shopped)
1 week - stuff/test

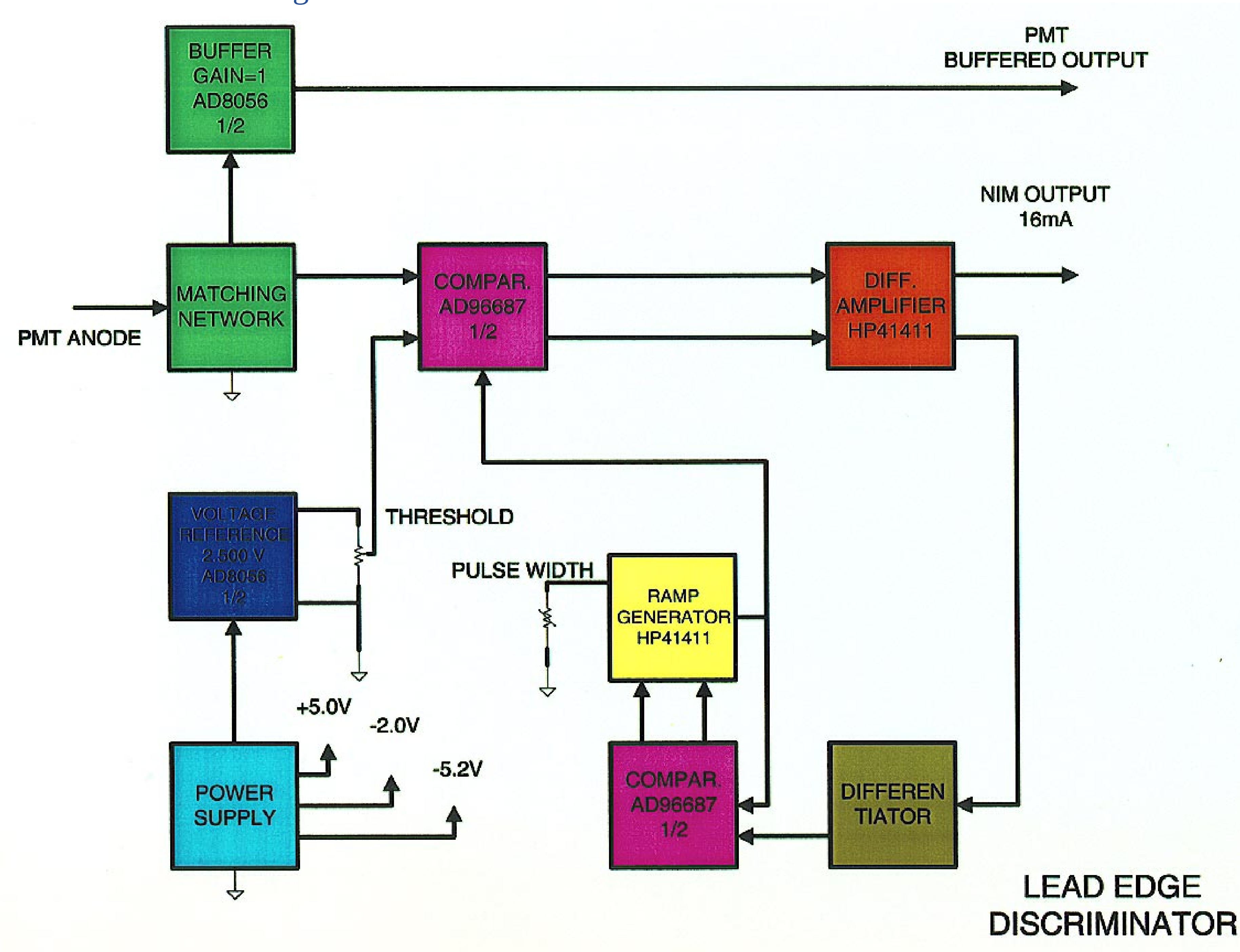
→ ***Completion of two (2) Version IV boards: Aug 7, 1999***.

FEE v.4 Final Layout





FEE v.4 LE Block Diagram



Lead Edge Discriminator

The purpose of the device is to detect the moment when a pulse amplitude passes a set threshold. Due to the characteristics of pulses (fast rise edges and small pulse width), the circuitry has to be designed with some constraints. Length of traces on the printed circuit board (pcb) has to be minimized, the traces has to be designed as transmission lines with a standard characteristic impedance Z_0. Ground planes has to be properly chosen, so to cover a maximum surface of a pcb layer, but to avoid unwanted feedback capacitances for the amplifying elements.
The LED has as components:

-Matching input resistor (network). It is necessary in order to terminate properly the coax cable carrying signals from the photomultiplier tube (PMT). The cables that we have used have Z_0 = 93 Ω.

-Comparator. It is used one of the fastest integrated circuit comparators: AD96687 (it contains two identical devices). This device will compare the amplitude of the incoming pulse to a dc negative voltage (threshold). When the pulse is larger (absolute value) than the threshold, the outputs of the comparator flip the state. The output is ECL compatible (signal low = -1.6V, signal high= -0.9V).

-Differential amplifier. It is the load of the comparator and makes the level translation ECL-NIM. Besides, this stage improves the rise and fall edges of the output signal. A 16 mA pulse will have a rise edge of 600ps, as compared with the 2ns rise edge from the comparator.

-Pulse width circuitry. The output pulse width can be adjusted in the range 15ns to 100ns. During the output pulse, the circuit also inhibits the input of the LED to detecting any other incoming pulses.

-Differentiator. This circuit will sense only the change in state of the output pulse, generating a very narrow positive pulse for the rising edge and a very narrow negative pulse for the falling edge.
-Comparator. Noninverting input is driven by the positive pulse from the differentiator. The inverting input is driven by the ramp generated by the ramp generator. The steady state of this circuit is “low”. A positive spike from the differentiator will toggle the circuit in a “high” state. That makes the ramp generator to charge the timing capacitor on the inverting input. When the voltage on this capacitor exceeds the voltage on Noninverting input, the comparator changes state back to “low”. That will stop the ramp generator to charge the capacitor. The output pulse duration is adjusted with a potentiometer.
-Ramp generator. This circuit will charge the timing capacitor with a constant current. It is started or stopped by the comparator.

-PMT signal buffer. This is a gain=1 noninverting amplifier. The output has a 50 Ω circuit trace on the pcb, to avoid reflections. A Lemo connector and a coax cable with a Z_0 = 50 Ω takes the signal to the TDC.

-Voltage reference. A LM385-2.5 at 1mA current, followed by a constant load presented by an inverting amplifier. In this configuration, the reference voltage will vary in value with only the magnitude of the wideband noise of the assembly LM385 AD8056, which is bellow 150 µV. The threshold is adjustable with a potentiometer placed as a load to AD8056.

-Power supply. The proper functioning requires a +5.0V , -2.0V, and a –5.2V supply

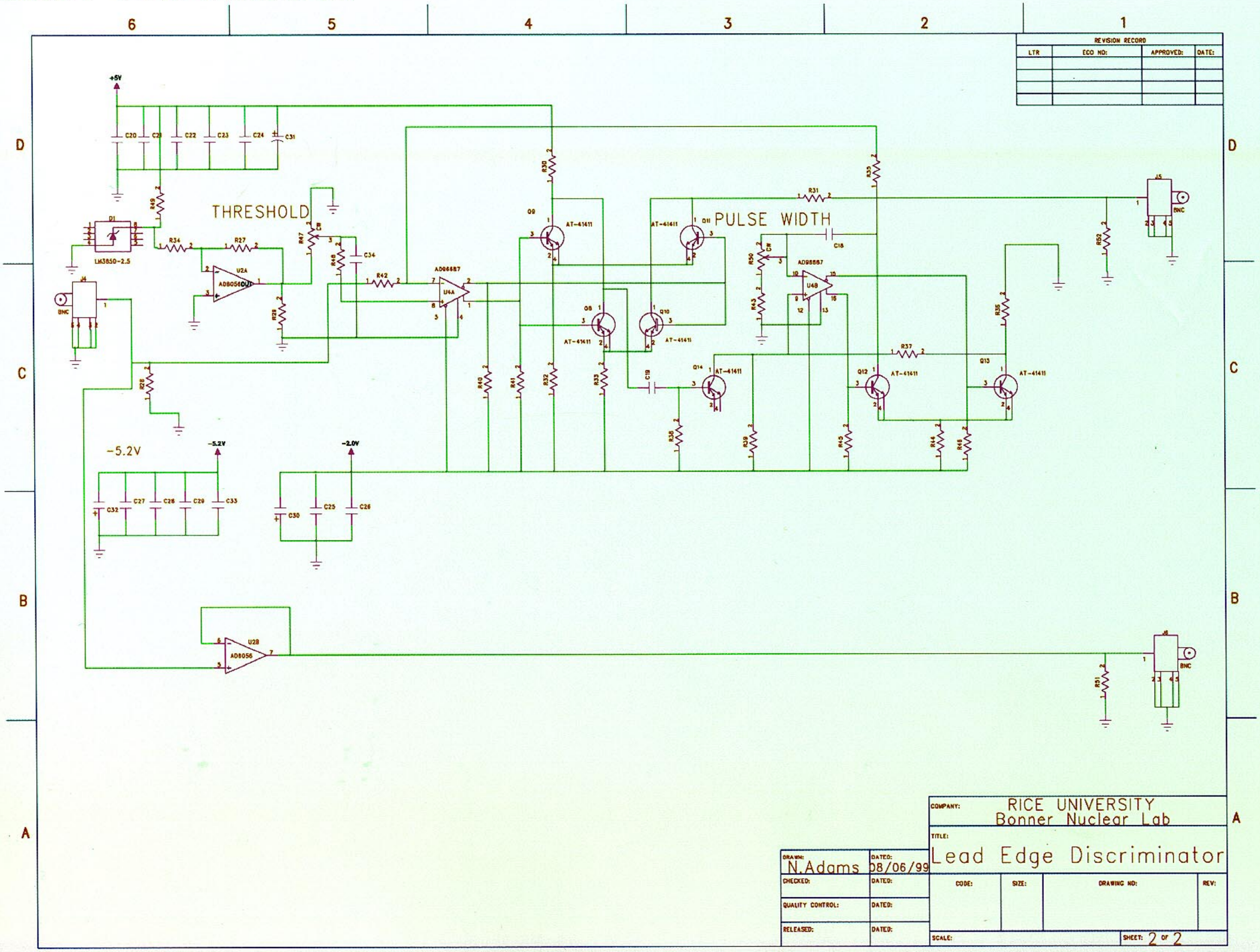
Components used:

AD96687	Dual ultra fast comparator
AD8056	Dual fast operational amplifier
AT-41411	HF transistors

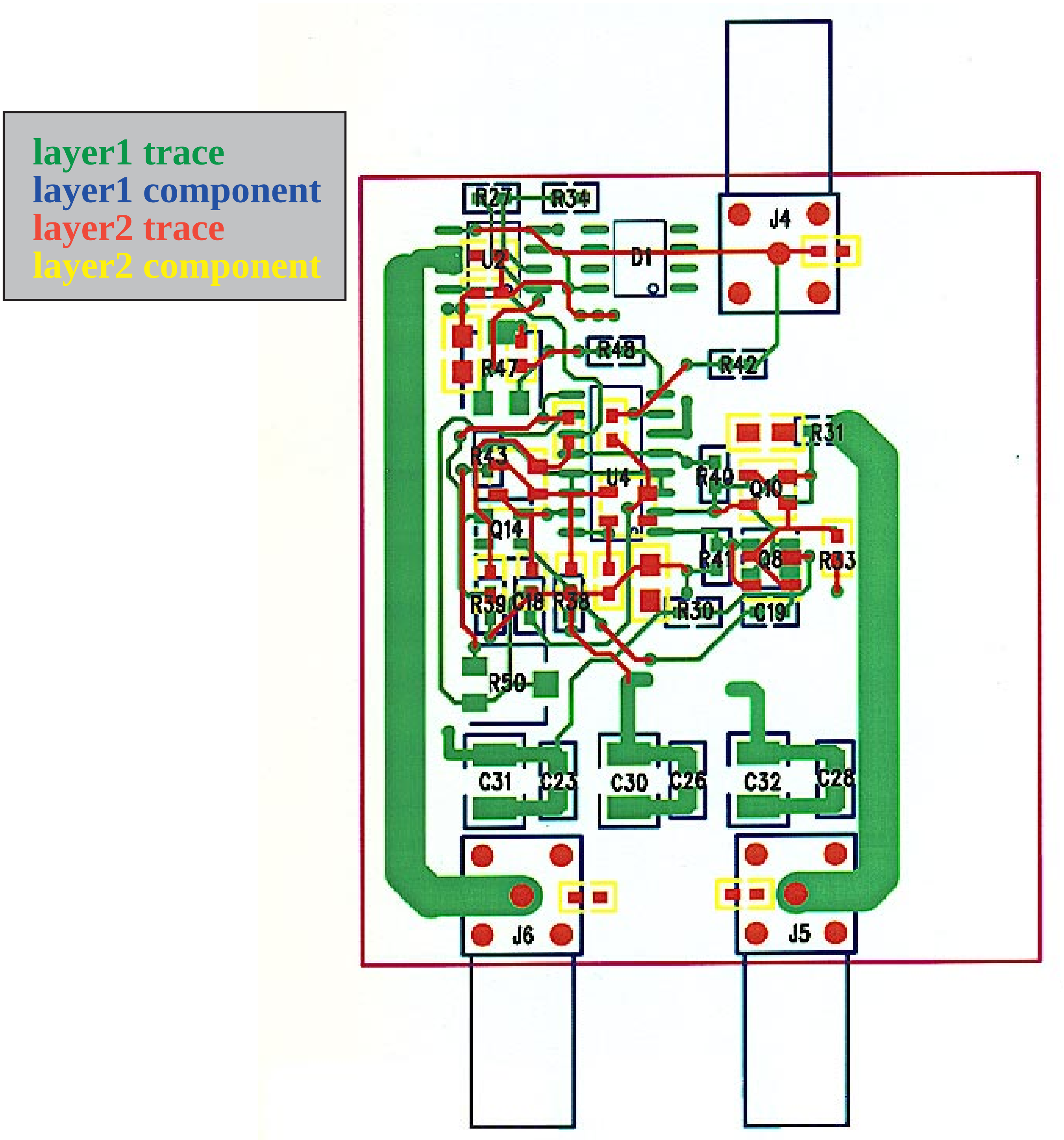
603 surface mount resistors and capacitors
50 Ω pcb embedded transmission lines
Lemo connectors

Nick Adams
10-01-1999

LED.sch-1 - Fri Oct 01 10:16:22 1999



COMPANY:	RICE UNIVERSITY Bonner Nuclear Lab
TITLE:	Lead Edge Discriminator
DRAWN: N.Adams	DATED: 08/06/99
CHECKED:	DATED:
QUALITY CONTROL:	DATED:
RELEASED:	DATED:
CODE:	SIZE:
DRAWING NO:	REV:
SCALE:	SHEET: 2 of 2



FEE v.4 LE is the final development discriminator for TOFp

→ no more FEE R&D left

FEE v.5 is same design, layout, & components
except one potentiometer is replaced by a cable

→ threshold from external LV level...

and two CFDs are paste-replaced by v.4 LE's...

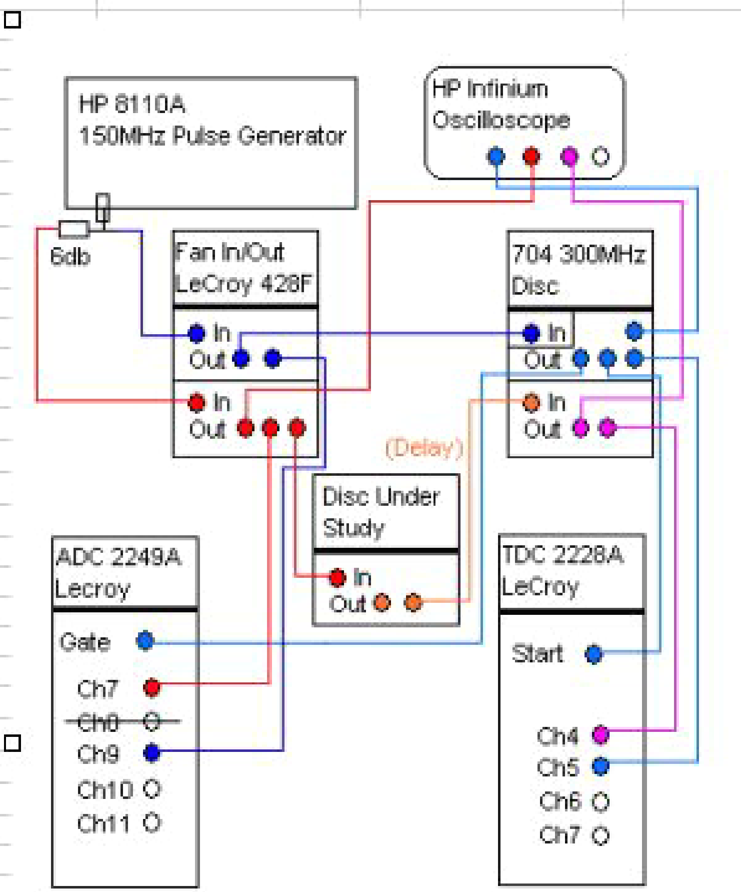
→ the 5 channels of the v.4 are intentionally 100% distinct except for LV...

Direct comparisons of TOFp v.4 FEE with PS70x series discriminators (300 MHz, 2ns RT)

please ignore data labelled CFD in these tables (setups shown here for LE+LE comparisons only!)...

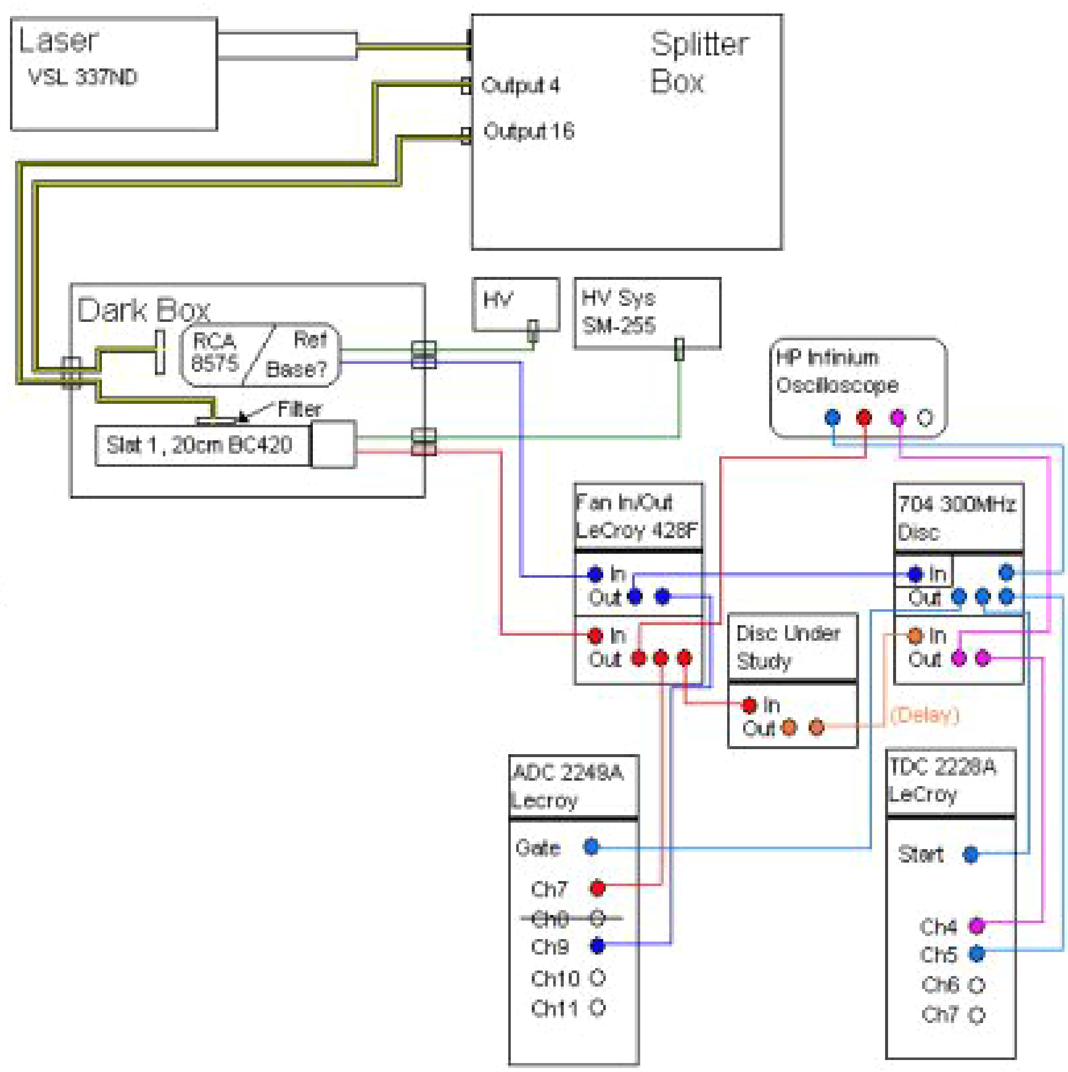
	(PH in mV)	551.6	550.5	550.2
	(ADC Slat)	426.9	429.5	427.7
2ns	(ADC Ref)	844.5	844.3	844.1
	(TDC Slat)	556.1 +/- 0.4795	685.3 +/- 0.4494	555.3 +/- 0.4625
	(TDC Ref)	907.5 +/- 0.5003	907.3 +/- 0.4720	907.3 +/- 0.4427
	Scope (ΔT)	32.98ns +/- 19.70ps	39.59ns +/- 15.23ps	32.97ns +/- 12.88ps
	Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
	Cable	100mV	Disc only	Disc only 100mV
	Short Cables	2	6	10
	(PH in mV)	544.1	543.0	542.9
	(ADC Slat)	388.5	390.9	389.0
3ns	(ADC Ref)	767.5	767.5	767.3
	(TDC Slat)	559.5 +/- 0.5674	669.2 +/- 0.5003	557.3 +/- 0.4024
	(TDC Ref)	907.4 +/- 0.4916	907.2 +/- 0.4604	907.3 +/- 0.4449
	Scope (ΔT)	33.17ns +/- 17.16ps	38.77ns +/- 16.78ps	33.07ns +/- 13.38ps
	Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
	Cable	100mV	Disc only	Disc only 100mV
	Short Cables	3	7	11
	(PH in mV)	538.7	537.9	537.8
	(ADC Slat)	349.5	351.7	350.0
4ns	(ADC Ref)	689.4	689.5	689.5
	(TDC Slat)	562.7 +/- 0.5411	662.3 +/- 0.4575	559.2 +/- 0.4327
	(TDC Ref)	907.3 +/- 0.4798	907.1 +/- 0.4749	907.3 +/- 0.4585
	Scope (ΔT)	33.33ns +/- 15.05ps	38.42ns +/- 14.33ps	33.16ns +/- 13.94ps
	Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
	Cable	100mV	Disc only	Disc only 100mV
	Short Cables	4	8	12
	(PH in mV)	497.4	498.2	498.1
	(ADC Slat)	302.3	304.2	302.6
5ns	(ADC Ref)	594.5	594.6	594.6
	(TDC Slat)	565.6 +/- 0.5441	661.7 +/- 0.6061	560.9 +/- 0.5047
	(TDC Ref)	907.3 +/- 0.4760	907.1 +/- 0.4916	907.2 +/- 0.4862
	Scope (ΔT)	33.49ns +/- 15.02ps	38.40ns +/- 14.02ps	33.25ns +/- 14.48ps

Note:
1) 'Slat' is ouput of pulser with 6db attentuation
2) 'Ref' is output with no attenuation, 1.2V pulse height
3) Rate set to 100Hz

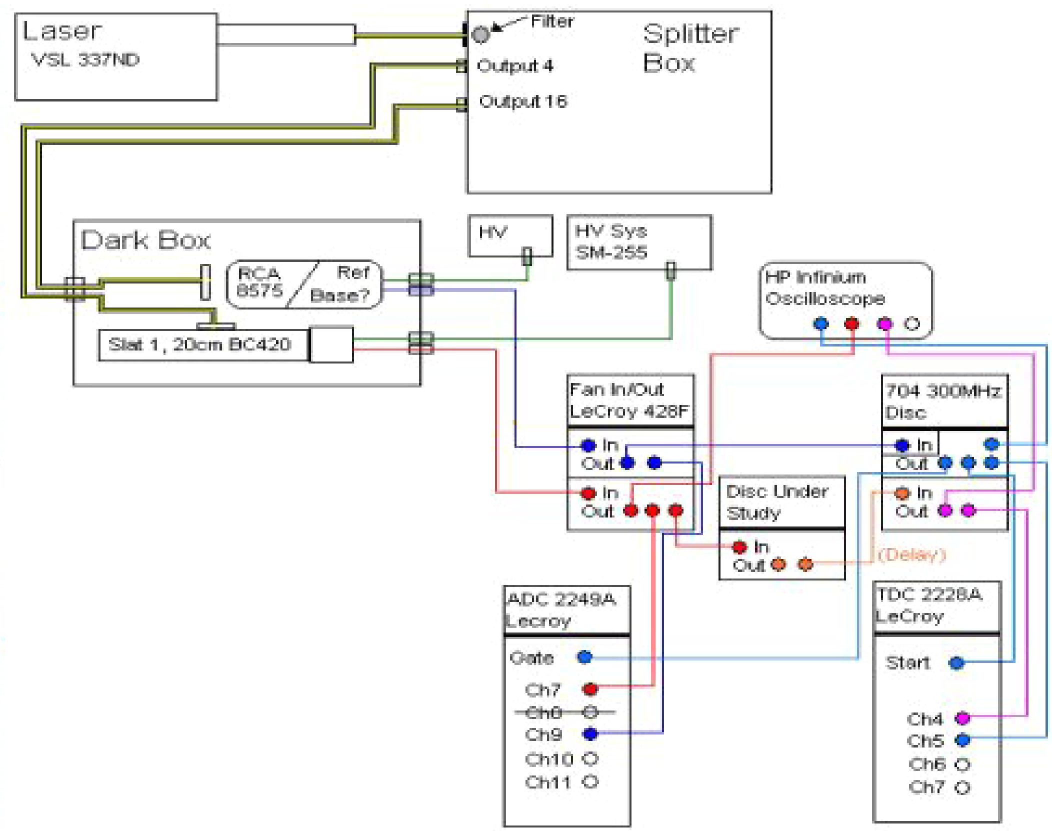


Discriminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	13	14	15
(PH in mV)	564.3	571.2	579.0
(ADC Slat)	468.7	475.8	479.5
(ADC Ref)	917.2	925.5	938.6
(TDC Slat)	535.7 +/- 1.763	661.9 +/- 3.671	526.5 +/- 1.755
(TDC Ref)	907.3 +/- 0.4365	907.3 +/- 0.4487	907.3 +/- 0.4712
Scope (ΔT)	31.97ns +/- 91.81ps	38.41ns +/- 181.2ps	31.49ns +/- 86.93ps
Note:			
1) Slat 1 at 1700V, filter 70+80			
2) Ref PMT at 500V, no filter on Ref			

Discriminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	16	17	18
(PH in mV)	587.7	566.3	560.8
(ADC Slat)	516.6	500.2	494.6
(ADC Ref)	954.0	950.3	952.7
(TDC Slat)	662.9 +/- 0.6399	769.1 +/- 1.330	654.8 +/- 0.6792
(TDC Ref)	907.2 +/- 0.4678	907.3 +/- 0.4834	907.3 +/- 0.4435
Scope (ΔT)	38.45ns +/- 26.26ps	43.87ns +/- 110.1ps	38.04ns +/- 25.98ps
Note:			
1) Slat 1 at 865V, no filter			
2) Ref at 500V, no filter on Ref			

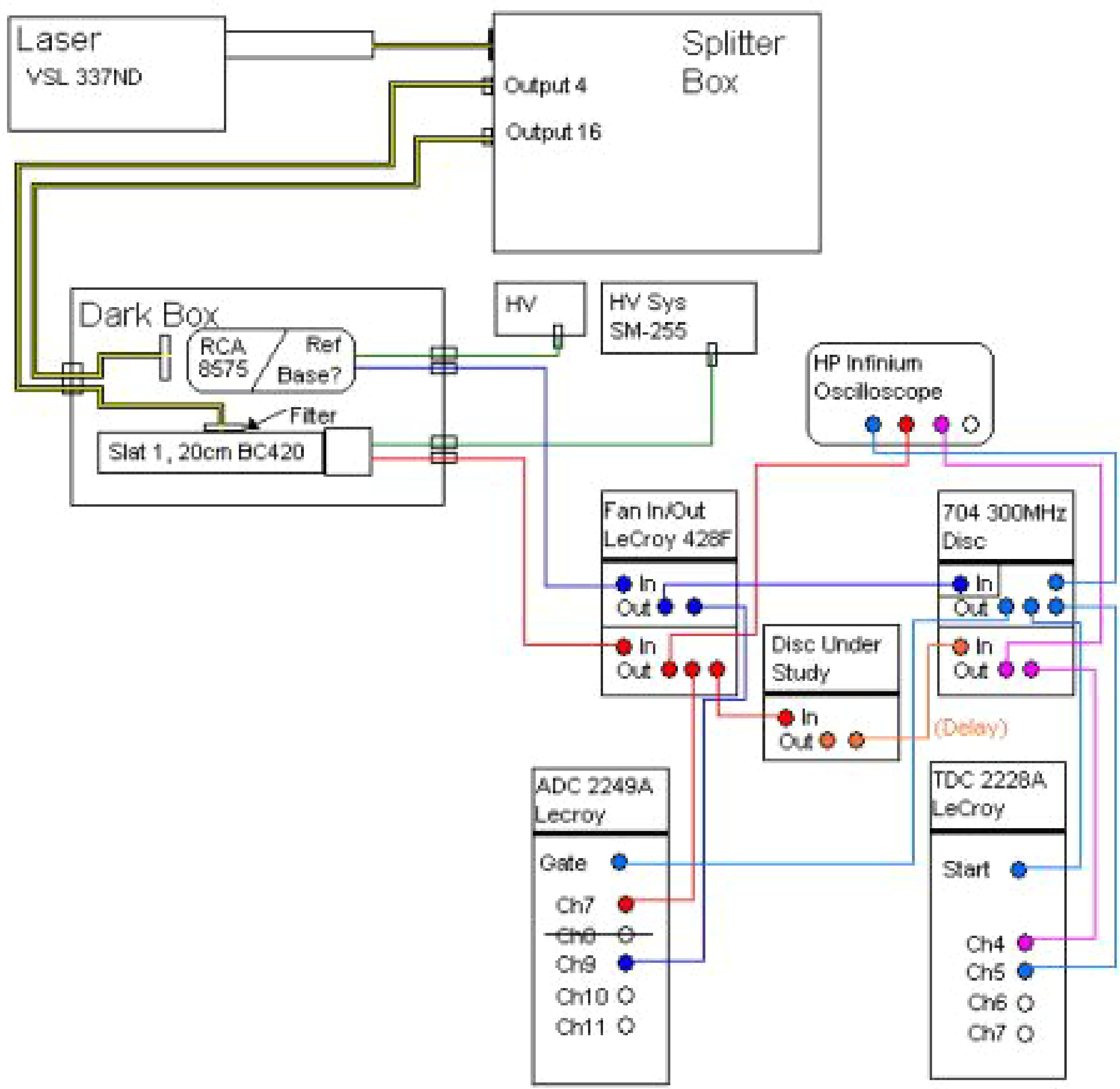


Short Cables	1	2	3
(PH in mV)	567.9	564.5	563.4
(ADC Slat)	477.7	474.8	473.4
(ADC Ref)	overflow	overflow	overflow
(TDC Slat)	852.1 +/- 1.933	977.6 +/- 3.565	841.7 +/- 1.962
(TDC Ref)	407.4 +/- 0.4962	907.4 +/- 0.4899	907.4 +/- 0.4914
Scope (ΔT)	48.12ns +/- 99.22ps	54.54ns +/- 191.0ps	47.59ns +/- 97.23ps
Note:			
1) Slat 1 at 1740V (cosmics at 1600V -> ADC ~460ch at pos 85mm), pos 55mm			
2) Ref at 1100V			
3) Filter 2			
Discriminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	4	5	6
(PH in mV)	594.8	592.5	594.2
(ADC Slat)	427.1	425.6	426.4
(ADC Ref)	overflow	overflow	overflow
(TDC Slat)	800.2 +/- 2.045	902.0 +/- 2.883	789.6 +/- 1.974
(TDC Ref)	907.1 +/- 0.5263	907.2 +/- 0.4783	907.3 +/- 0.4810
Scope (ΔT)	45.47ns +/- 104.8ps	50.68ns +/- 147.5ps	44.93ns +/- 100.8ps
Note:			
1) Slat 2 at 1780V (cosmics at 1800V -> ADC ~600ch), pos 85mm			
2) Ref at 1100V			
3) Filter 2			
Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	7	8	9
(PH in mV)	577.7	576.5	576.6
(ADC Slat)	503.4	501.3	501.7
(ADC Ref)	overflow	overflow	overflow
(TDC Slat)	885.0 +/- 2.011	1014 +/- 2.880	873.4 +/- 1.823
(TDC Ref)	907.2 +/- 0.4951	907.4+/- 0.4906	907.3 +/- 0.4218
Scope (ΔT)	49.82ns +/- 100.7ps	56.42ns +/- 148.5ps	49.22ns +/- 92.31ps
		580.0 8a	
Note:		506.1	
1) Slat 0 at 1342V, pos 85mm		overflow	
2) Ref at 1100V		551.6 +/- 2.943	
3) Filter 2		907.3 +/- 0.4796	
		32.78ns +/- 152.2ps	



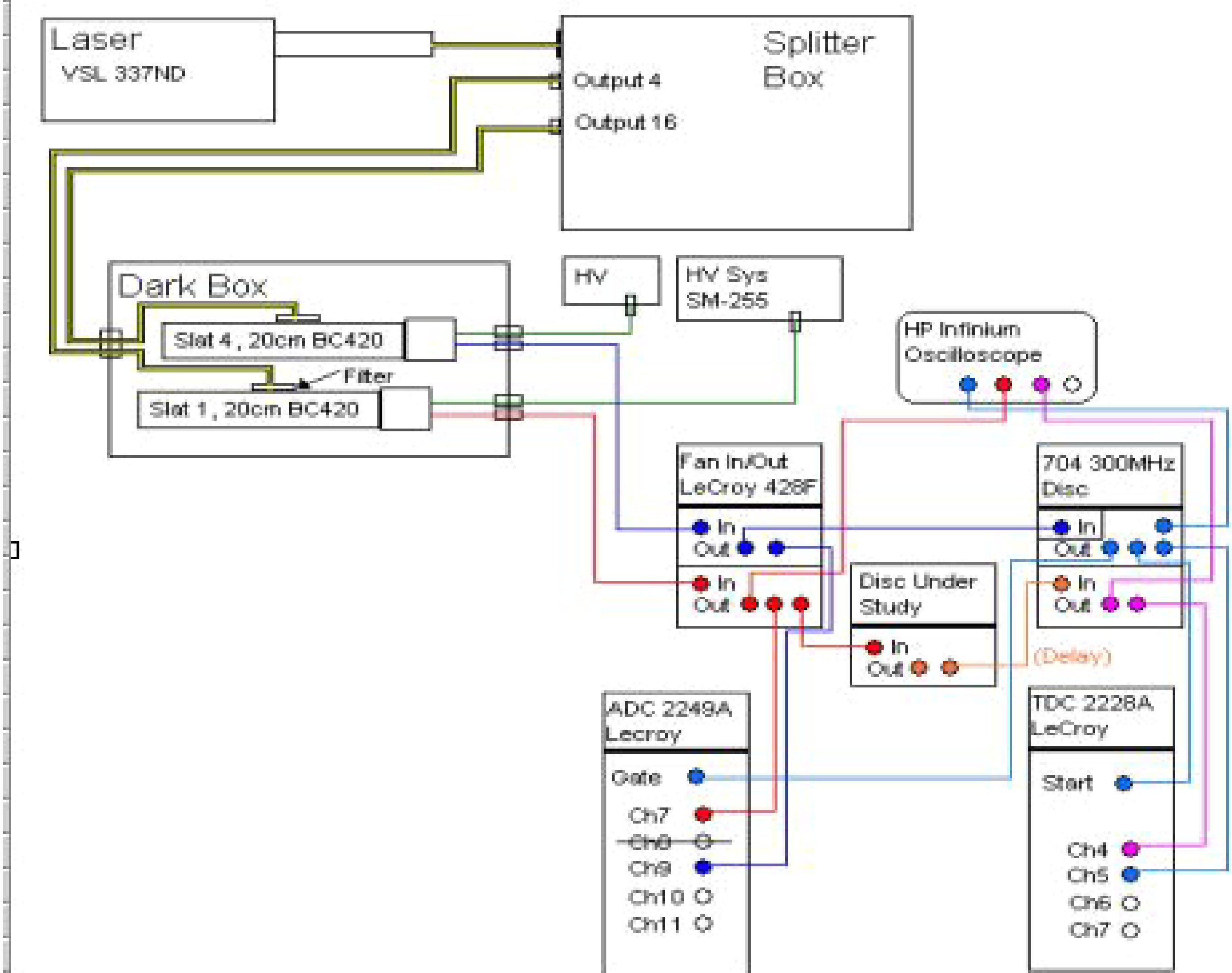
Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	10	11	12
(PH in mV)	602.2	595.9	599.1
(ADC Slat)	499.4	497.3	495.7
(ADC Ref)	807.7	801.4	796.9
(TDC Slat)	532.9 +/- 1.683	660.0 +/- 3.127	523.3 +/- 1.559
(TDC Ref)	907.4 +/- 0.4646	907.3 +/- 0.4201	907.3 +/- 0.4789
Scope (ΔT)	31.82ns +/- 84.13ps	38.32ns +/- 161.6ps	31.33ns +/- 76.64ps

Note:
1) Slat 1 at 1670V (cosmics at 1600V -> ADC ~460ch at pos 85mm), pos 55mm
2) Ref at 500V
3) Filter 2 on Slat 1, No filter on Ref



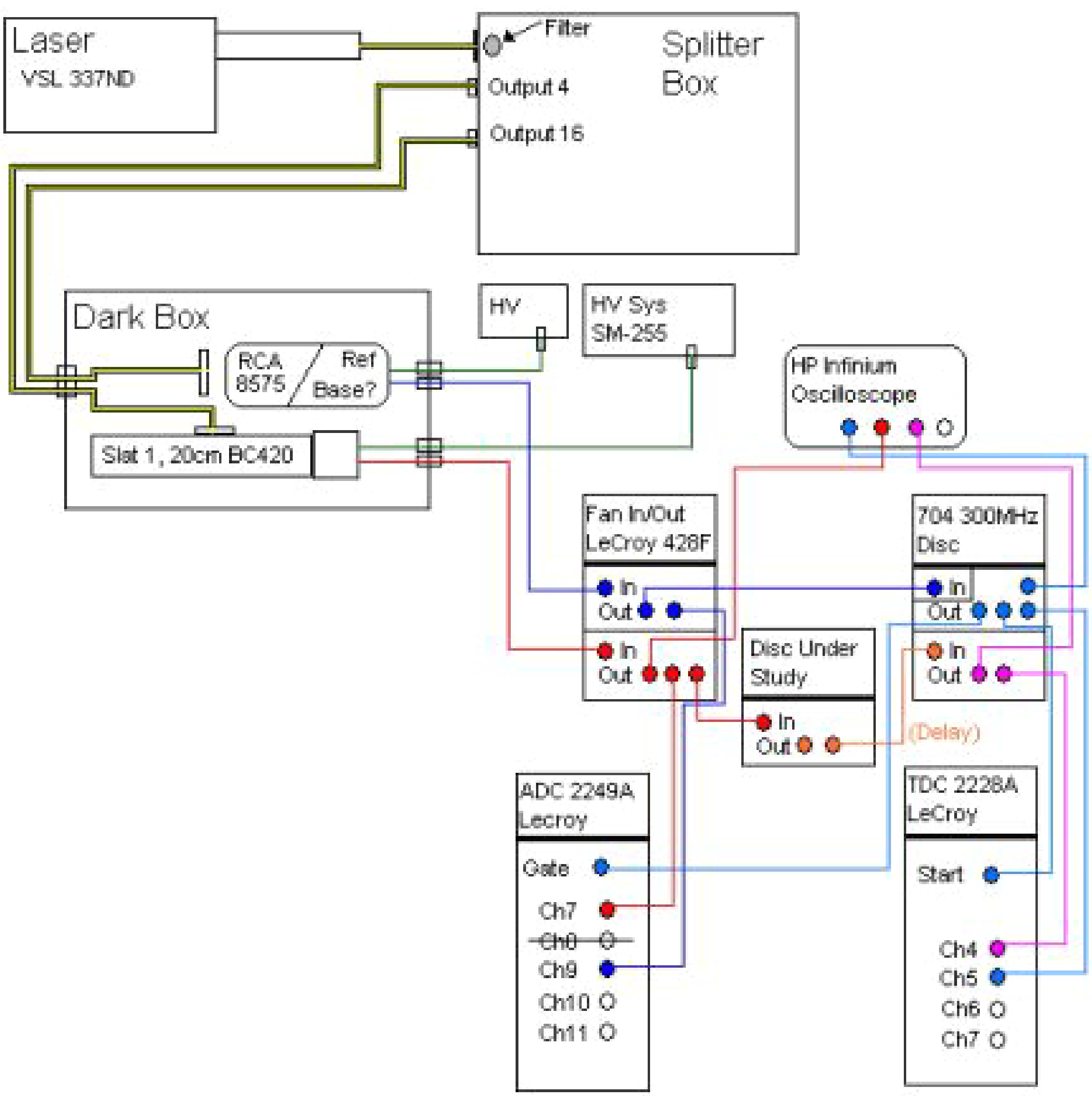
Discrminator	LED Phillips 704	CFD (new board)	LED (new board)
Cable	100mV	Disc only	Disc only 100mV
Short Cables	1	2	3
(PH in mV)	550.2	547.9	554.9
(ADC Slat)	462.0	463.8	465.9
(ADC Ref)	overflowed	overflowed	overflowed
(TDC Slat)	378.6 +/- 1.835	503.2 +/- 3.369	364.7 +/- 1.754
(TDC Ref)	907.4 +/- 0.4212	907.3 +/- 0.4751	907.3 +/- 0.4763
Scope (ΔT)	23.96ns +/- 93.17ps	30.35ns +/- 214.5ps	23.25ns +/- 88.44ps

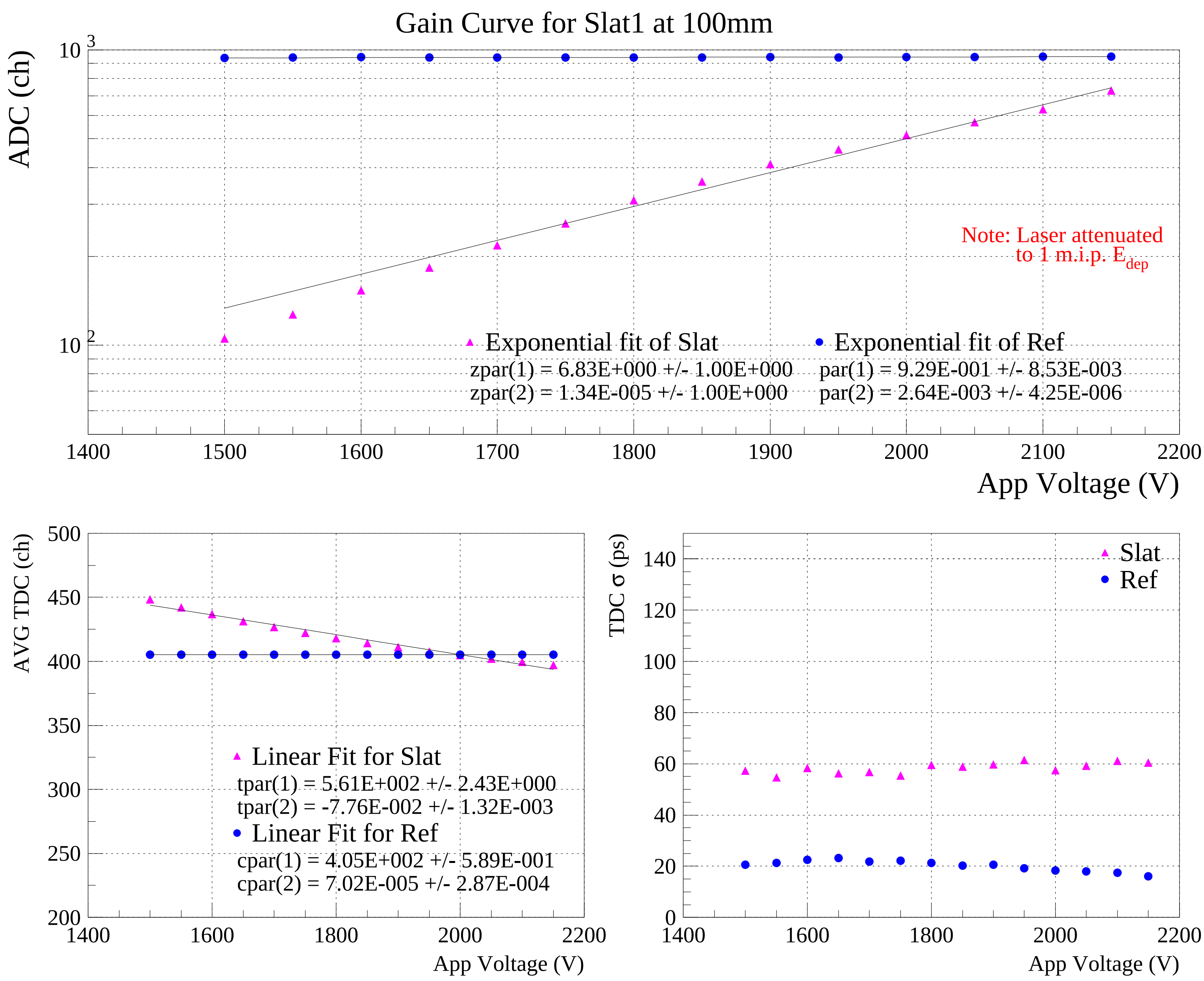
Note:
1) Slat 1 at 1700V, filter 2
2) Slat 4 used as Ref at 1375V, no filter on Ref



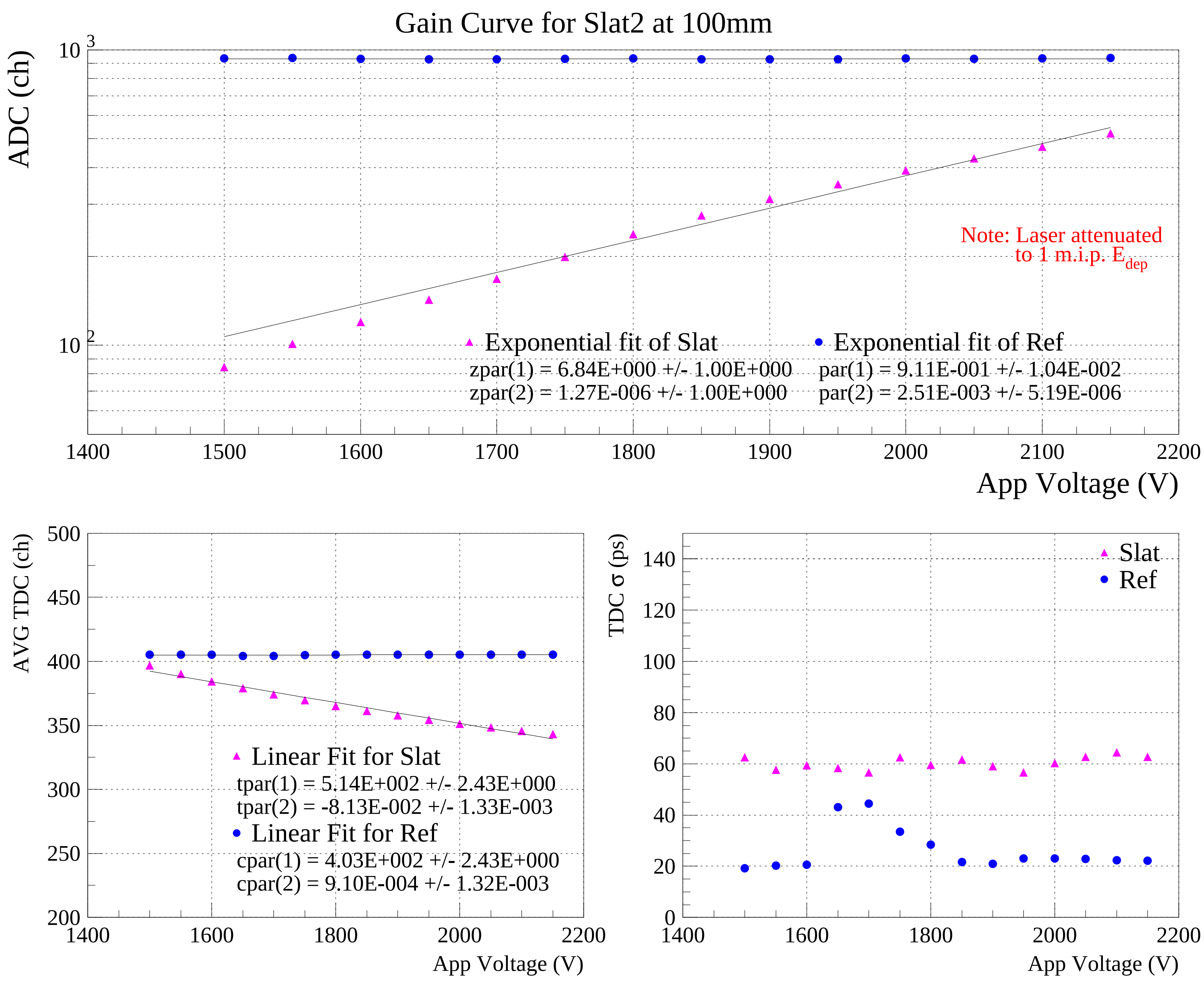
Discrminator	LED Phillips 708 (2nd disc - changing threshold) [CFD (new board) is 1st disc]			
Cable	100mV	200mV	300mV	400mV
Short Cables				
(PH in mV)	581.6	580.1	579.0	578.5
(ADC Slat)	472.9	473.2	473.1	473.3
(ADC Ref)	917.3	918.7	919.0	920.1
(TDC Slat)	448.0 +/- 1.885	449.3 +/- 1.827	450.8 +/- 1.852	456.9 +/- 1.845
(TDC Ref)	338.2 +/- 0.3825	338.0 +/- 0.5081	336.3 +/- 1.142 (fit??)	337.2 +/- 0.4357
Discrminator	LED Phillips 708 (2nd disc - changing threshold) [LED Phillips 708 is 1st disc at 100mV]			
Cable	100mV	200mV	300mV	400mV
Short Cables				
(PH in mV)	563.8	565.5	568.7	572.6
(ADC Slat)	463.0	464.2	466.6	469.5
(ADC Ref)	901.0	903.4	906.3	913.1
(TDC Slat)	492.8 +/- 1.591	495.9 +/- 1.616	498.5 +/- 1.582	500.1 +/- 1.617
(TDC Ref)	337.3 +/- 0.2935	336.3 +/- 0.7894	337.1 +/- 0.4004	337.2 +/- 0.3703

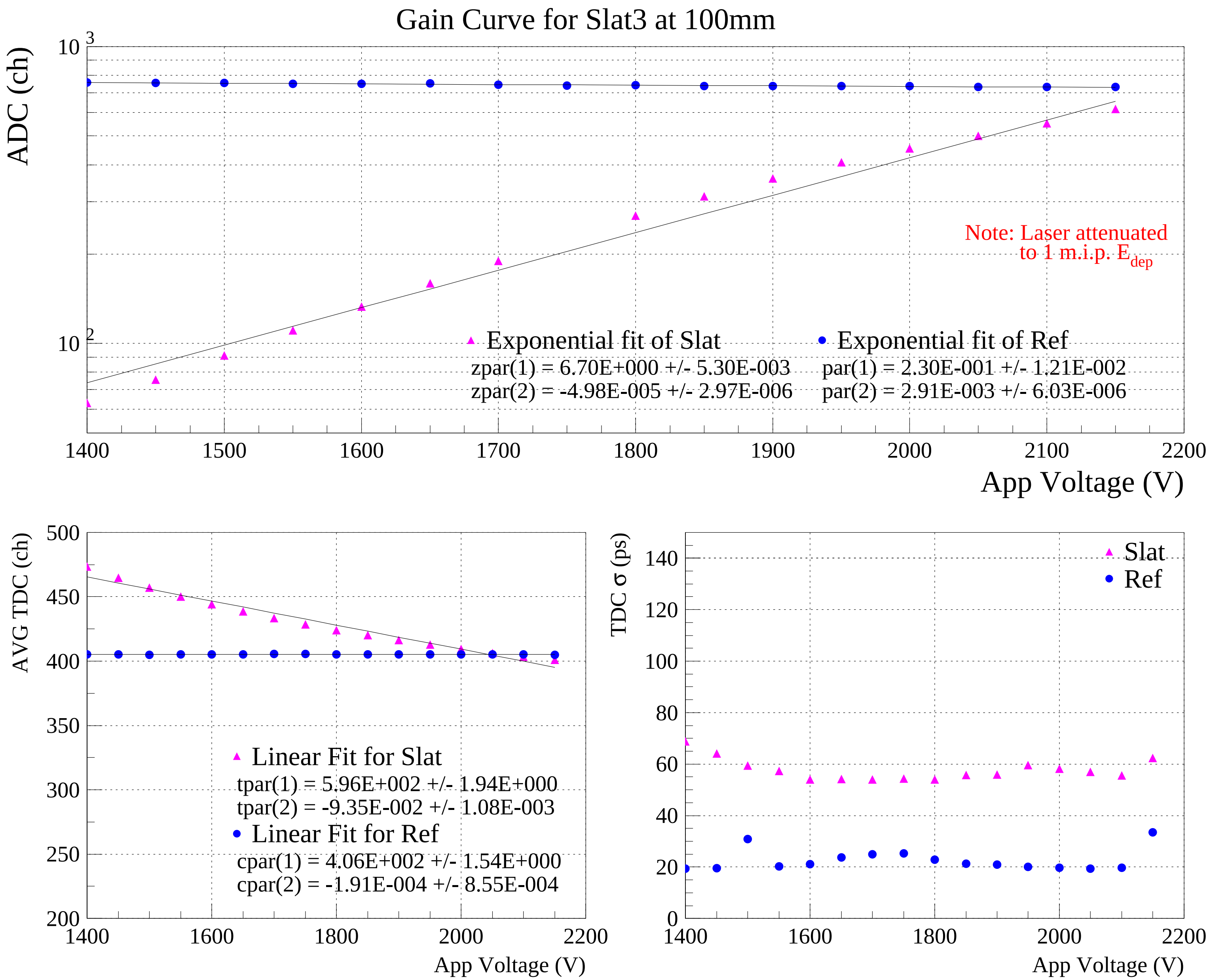
Note:
1)Slat 1 at 1650V
2)Ref at 1000V
3)Filter 2



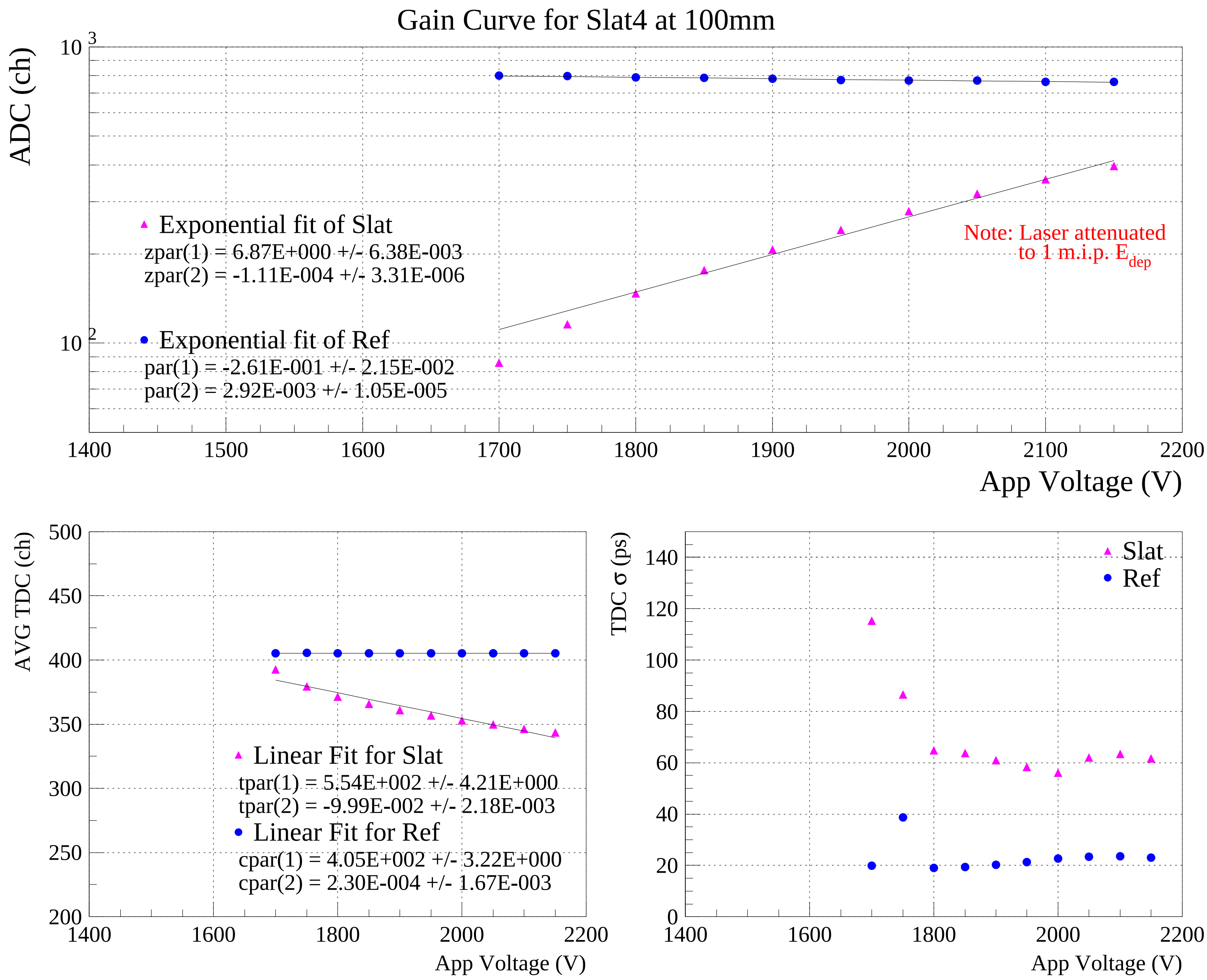


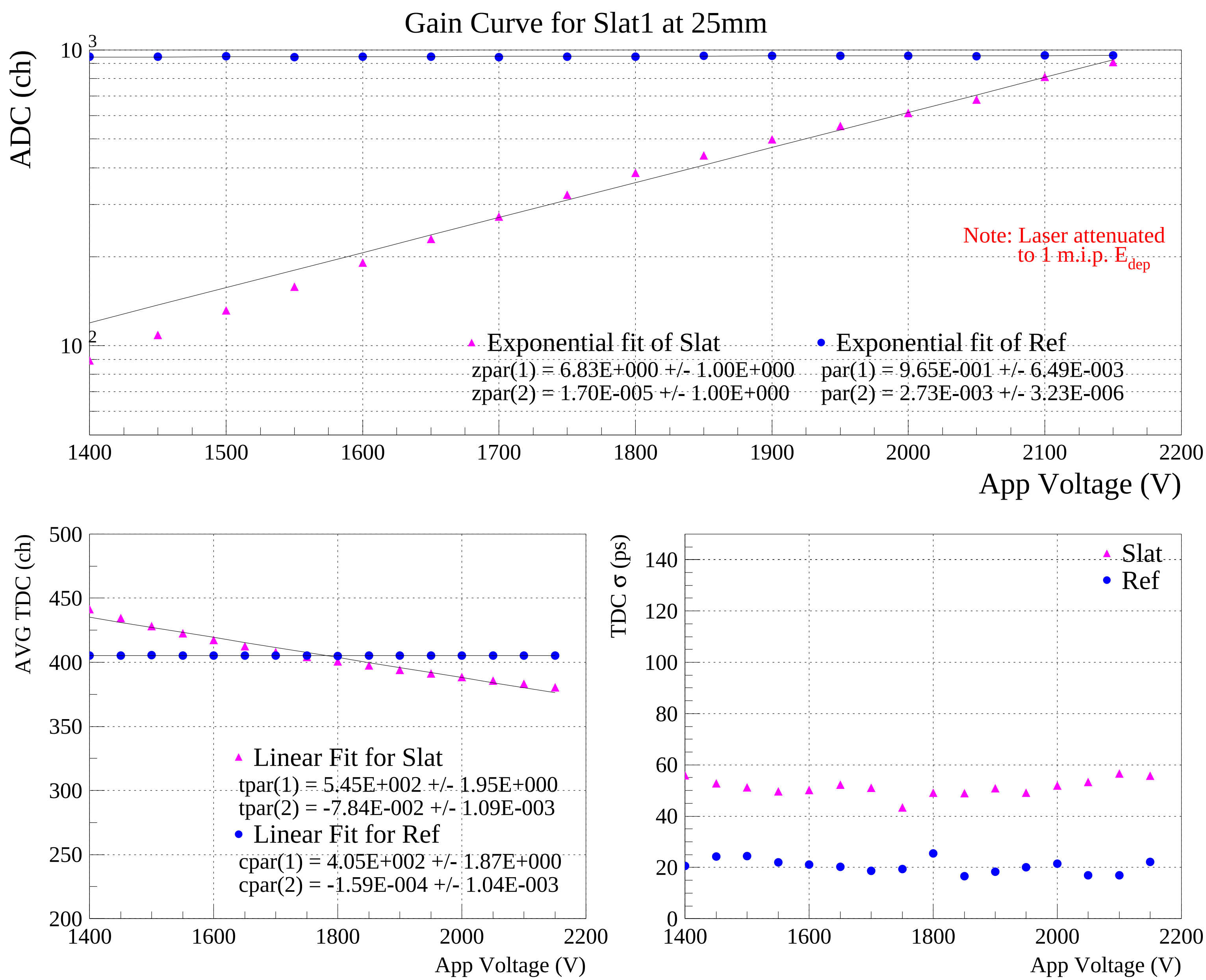
Gain Curve for Slat1 at 100mm
ADC (ch)
App Voltage (V)
Note: Laser attenuated to 1 m.i.p. E_dep
Exponential fit of Slat
zpar(1) = 6.83E+000 +/- 1.00E+000
zpar(2) = 1.34E-005 +/- 1.00E+000
Exponential fit of Ref
par(1) = 9.29E-001 +/- 8.53E-003
par(2) = 2.64E-003 +/- 4.25E-006
AVG TDC (ch)
App Voltage (V)
Linear Fit for Slat
tpar(1) = 5.61E+002 +/- 2.43E+000
tpar(2) = -7.76E-002 +/- 1.32E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 5.89E-001
cpar(2) = 7.02E-005 +/- 2.87E-004
TDC σ (ps)
App Voltage (V)
Slat
Ref


Gain Curve for Slat2 at 100mm
ADC (ch)
App Voltage (V)
Note: Laser attenuated to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.84E+000 +/- 1.00E+000
zpar(2) = 1.27E-006 +/- 1.00E+000
Exponential fit of Ref
par(1) = 9.11E-001 +/- 1.04E-002
par(2) = 2.51E-003 +/- 5.19E-006
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 5.14E+002 +/- 2.43E+000
tpar(2) = -8.13E-002 +/- 1.33E-003
Linear Fit for Ref
cpar(1) = 4.03E+002 +/- 2.43E+000
cpar(2) = 9.10E-004 +/- 1.32E-003
App Voltage (V)
TDC σ (ps)
Slat
Ref
App Voltage (V)

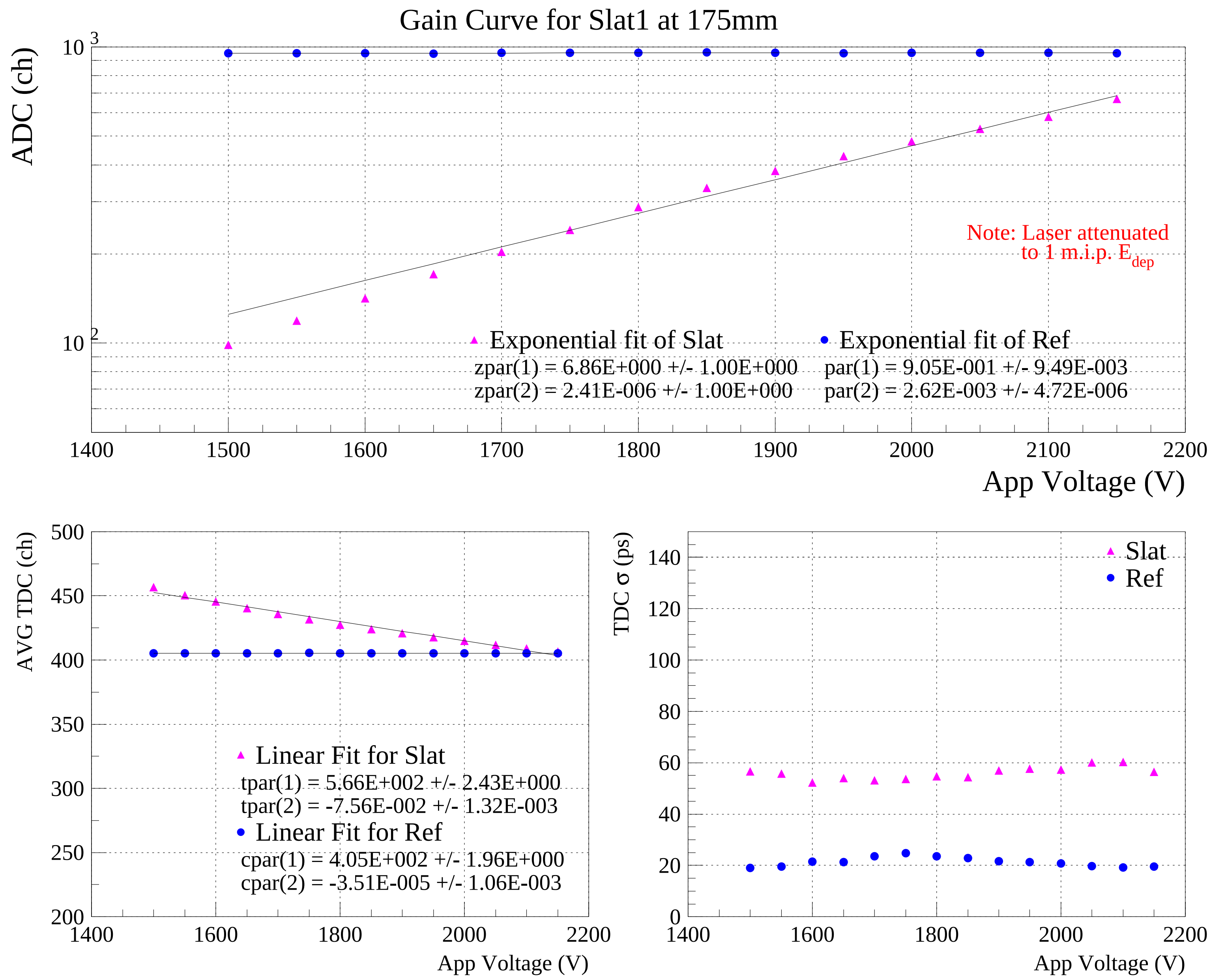


Gain Curve for Slat3 at 100mm
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.70E+000 +/- 5.30E-003
zpar(2) = -4.98E-005 +/- 2.97E-006
Exponential fit of Ref
par(1) = 2.30E-001 +/- 1.21E-002
par(2) = 2.91E-003 +/- 6.03E-006
App Voltage (V)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 5.96E+002 +/- 1.94E+000
tpar(2) = -9.35E-002 +/- 1.08E-003
Linear Fit for Ref
cpar(1) = 4.06E+002 +/- 1.54E+000
cpar(2) = -1.91E-004 +/- 8.55E-004
App Voltage (V)
TDC σ (ps)
Slat
Ref
App Voltage (V)

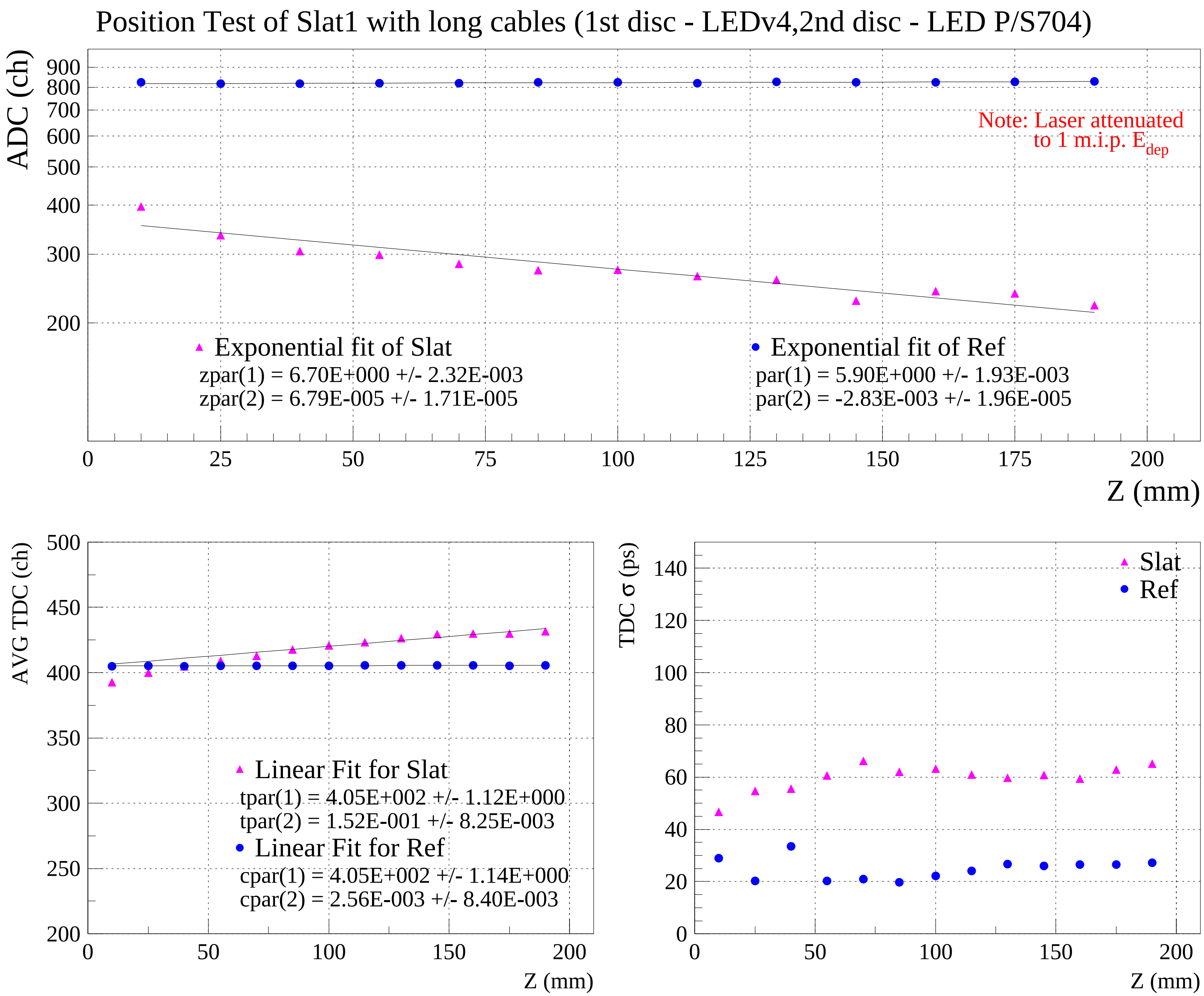

Gain Curve for Slat4 at 100mm
ADC (ch)
App Voltage (V)
Exponential fit of Slat
zpar(1) = 6.87E+000 +/- 6.38E-003
zpar(2) = -1.11E-004 +/- 3.31E-006
Exponential fit of Ref
par(1) = -2.61E-001 +/- 2.15E-002
par(2) = 2.92E-003 +/- 1.05E-005
Note: Laser attenuated to 1 m.i.p. E_{dep}
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 5.54E+002 +/- 4.21E+000
tpar(2) = -9.99E-002 +/- 2.18E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 3.22E+000
cpar(2) = 2.30E-004 +/- 1.67E-003
App Voltage (V)
TDC σ (ps)
Slat
Ref
App Voltage (V)



Gain Curve for Slat1 at 25mm
ADC (ch)
App Voltage (V)
Note: Laser attenuated to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.83E+000 +/- 1.00E+000
zpar(2) = 1.70E-005 +/- 1.00E+000
Exponential fit of Ref
par(1) = 9.65E-001 +/- 6.49E-003
par(2) = 2.73E-003 +/- 3.23E-006
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 5.45E+002 +/- 1.95E+000
tpar(2) = -7.84E-002 +/- 1.09E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 1.87E+000
cpar(2) = -1.59E-004 +/- 1.04E-003
App Voltage (V)
TDC σ (ps)
Slat
Ref
App Voltage (V)

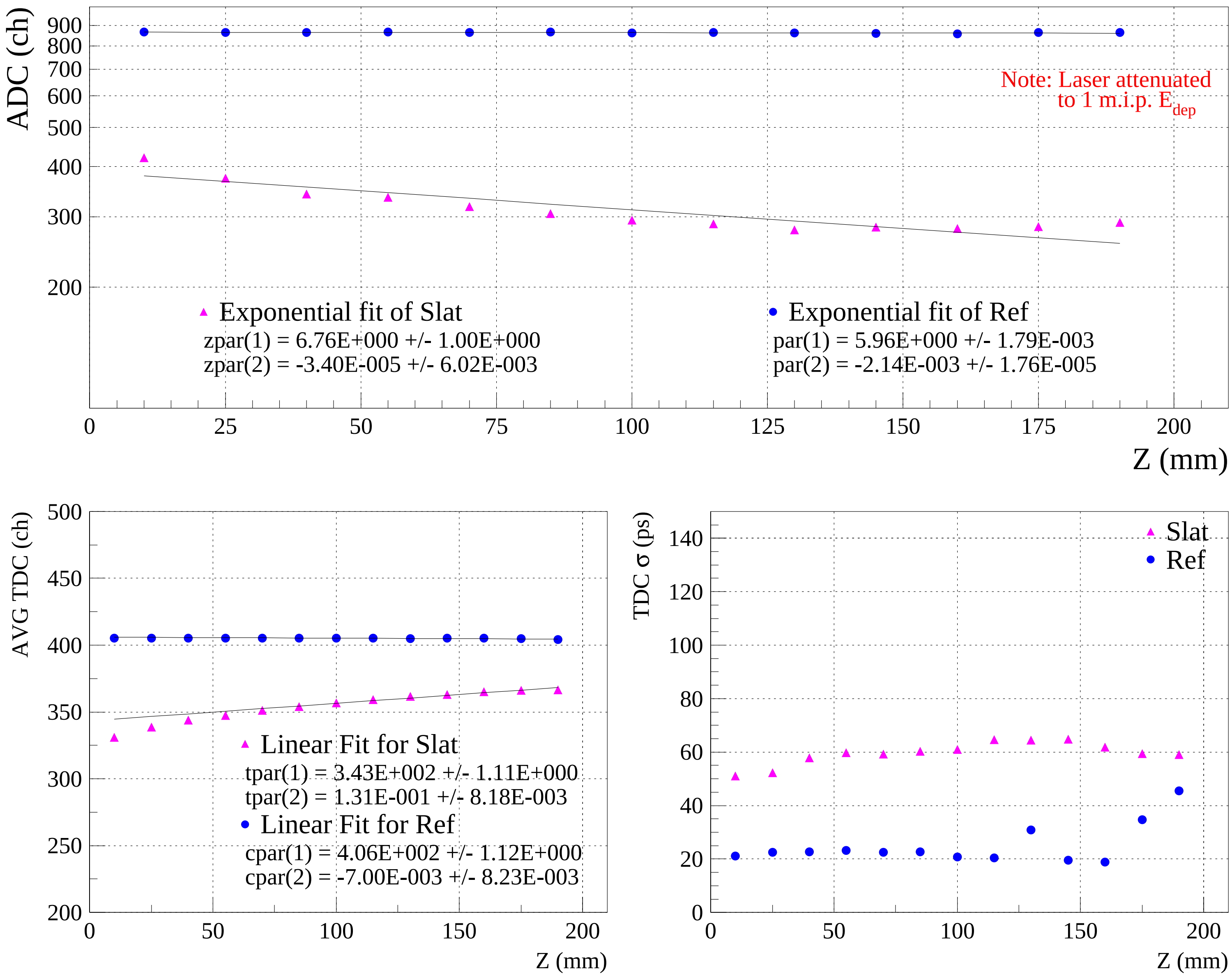


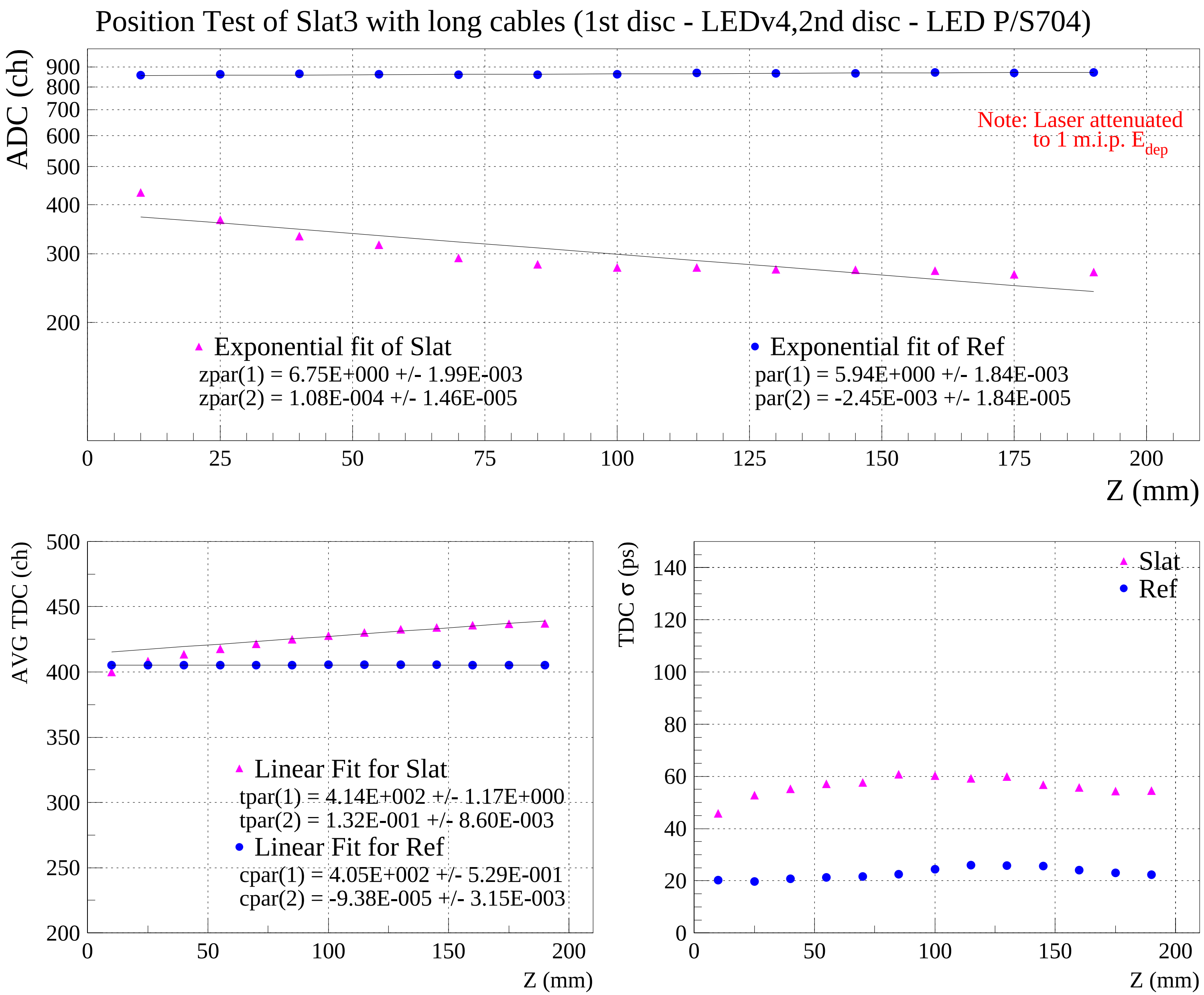
Gain Curve for Slat1 at 175mm
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.86E+000 +/- 1.00E+000
zpar(2) = 2.41E-006 +/- 1.00E+000
Exponential fit of Ref
par(1) = 9.05E-001 +/- 9.49E-003
par(2) = 2.62E-003 +/- 4.72E-006
App Voltage (V)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 5.66E+002 +/- 2.43E+000
tpar(2) = -7.56E-002 +/- 1.32E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 1.96E+000
cpar(2) = -3.51E-005 +/- 1.06E-003
App Voltage (V)
TDC σ (ps)
Slat
Ref
App Voltage (V)

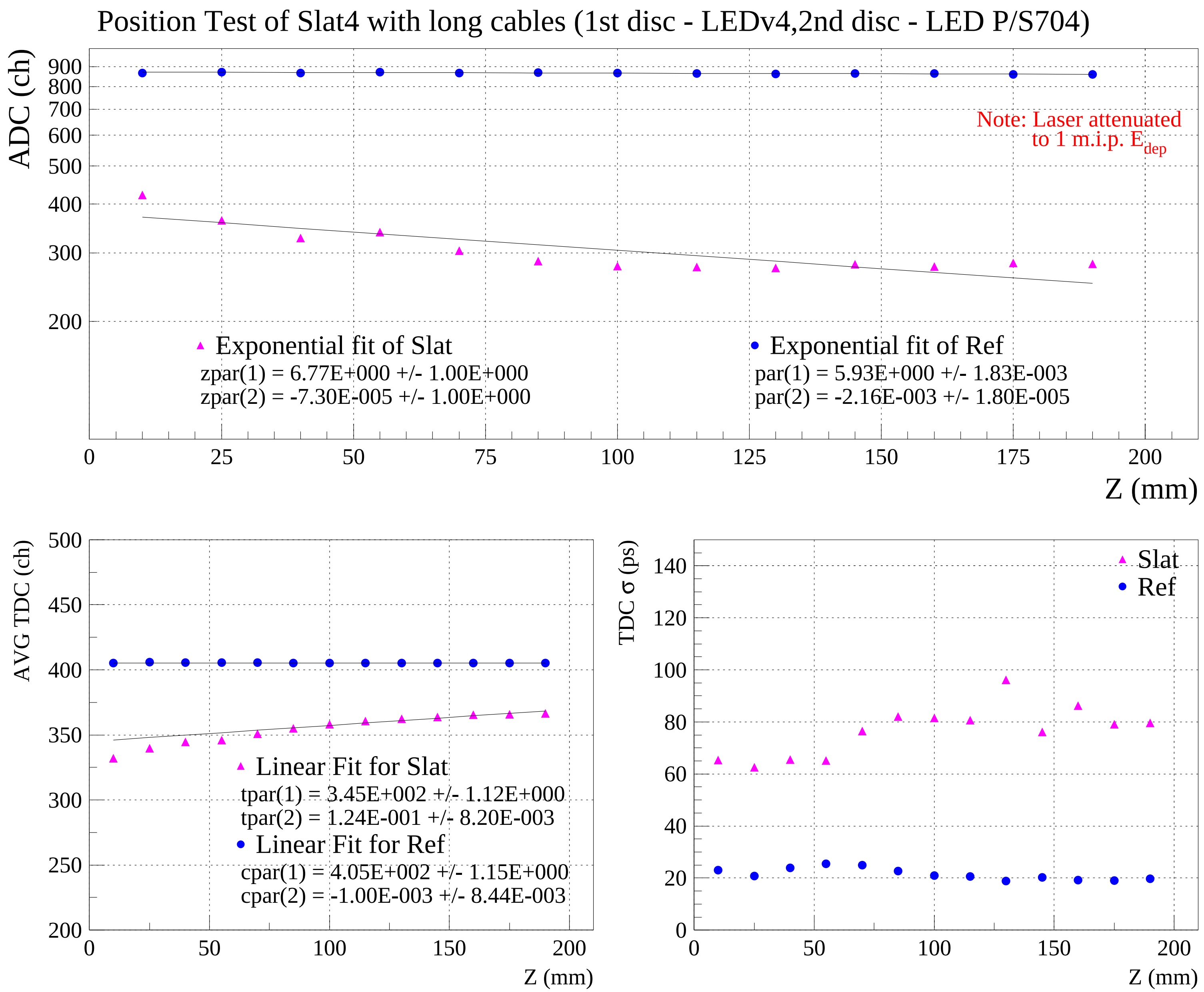


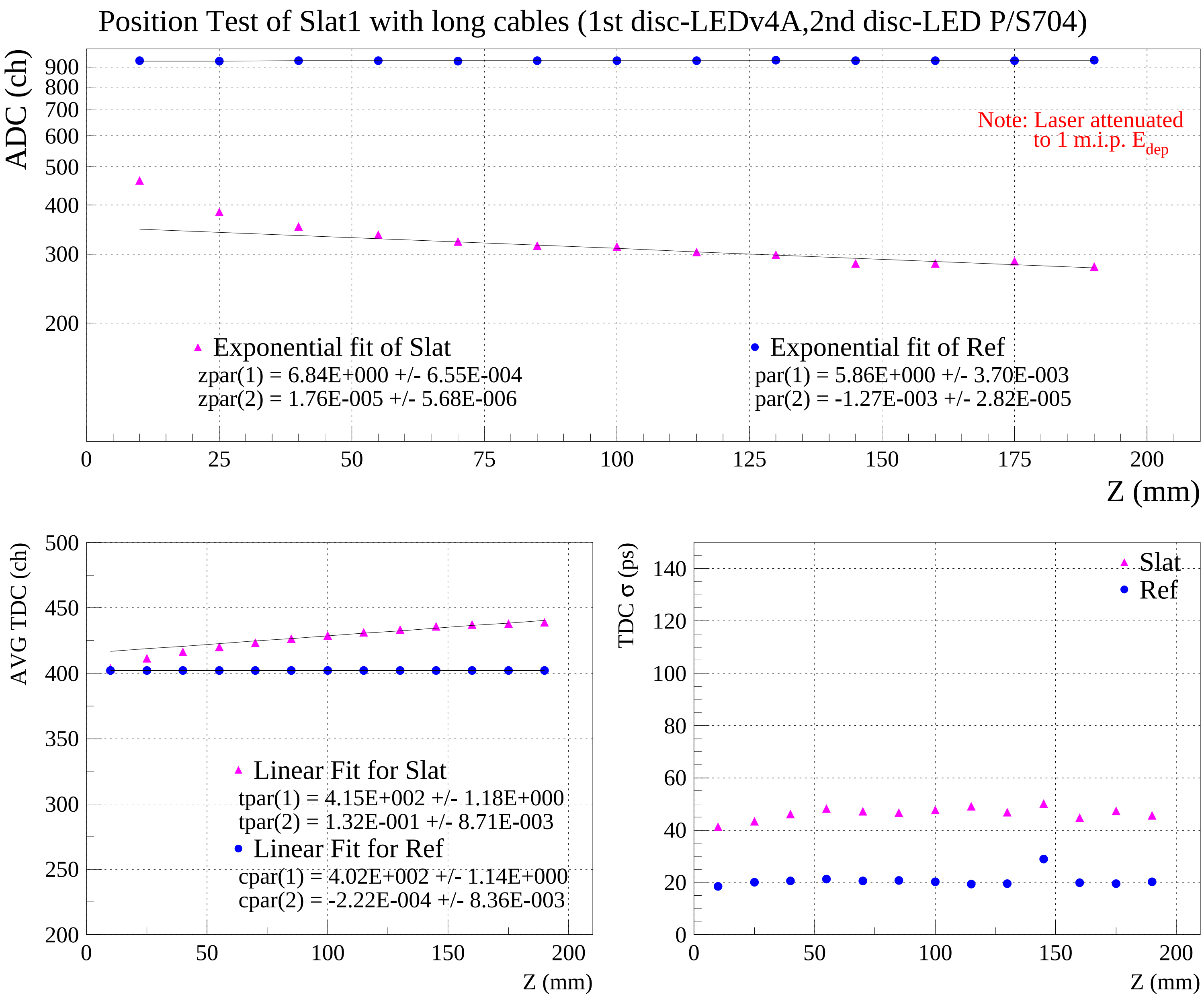
Position Test of Slat1 with long cables (1st disc - LEDv4,2nd disc - LED P/S704)
ADC (ch)
Note: Laser attenuated
to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.70E+000 +/- 2.32E-003
zpar(2) = 6.79E-005 +/- 1.71E-005
Exponential fit of Ref
par(1) = 5.90E+000 +/- 1.93E-003
par(2) = -2.83E-003 +/- 1.96E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 4.05E+002 +/- 1.12E+000
tpar(2) = 1.52E-001 +/- 8.25E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 1.14E+000
cpar(2) = 2.56E-003 +/- 8.40E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)

Position Test of Slat2 with long cables (1st disc - LEDv4,2nd disc - LED P/S704)

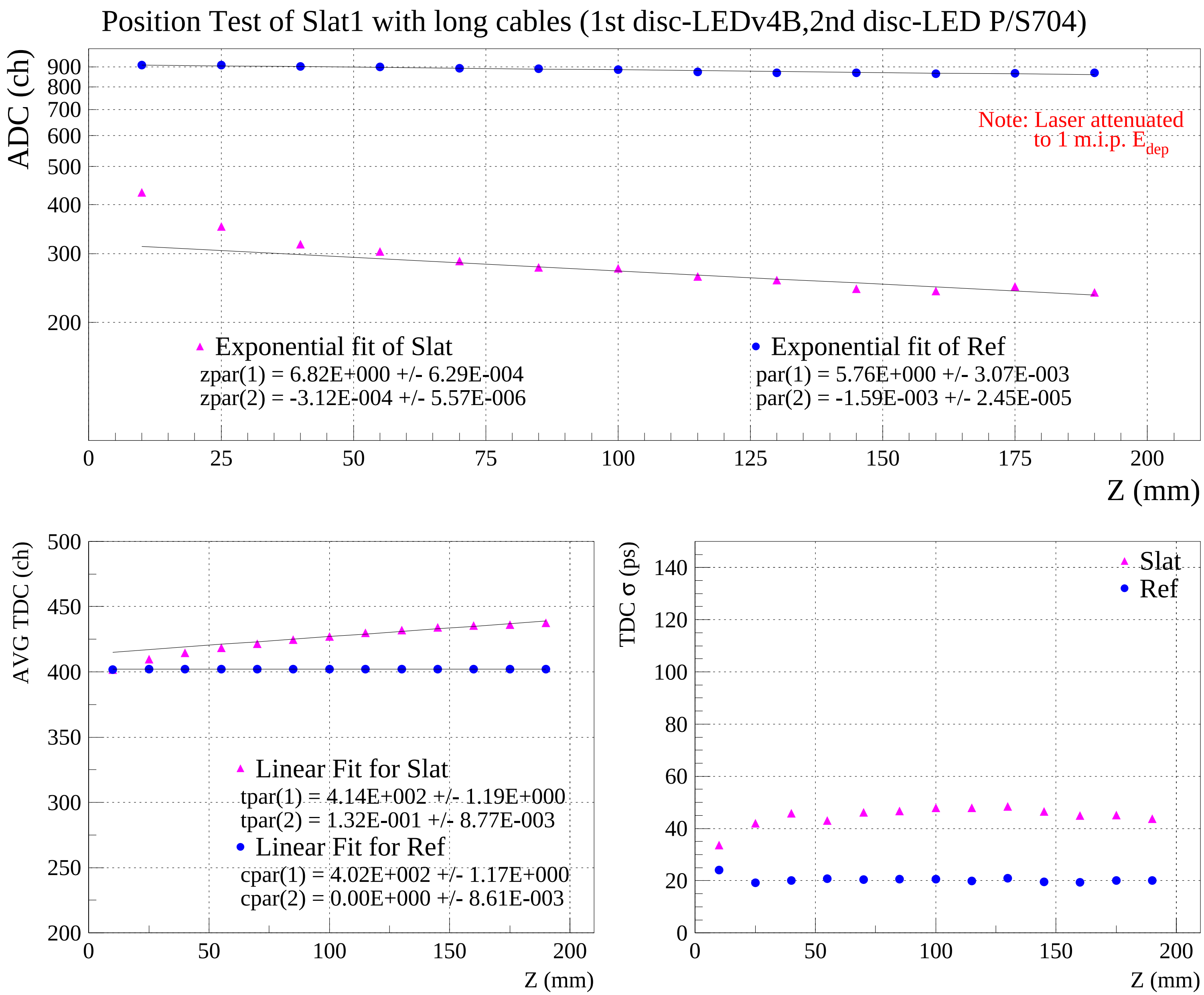


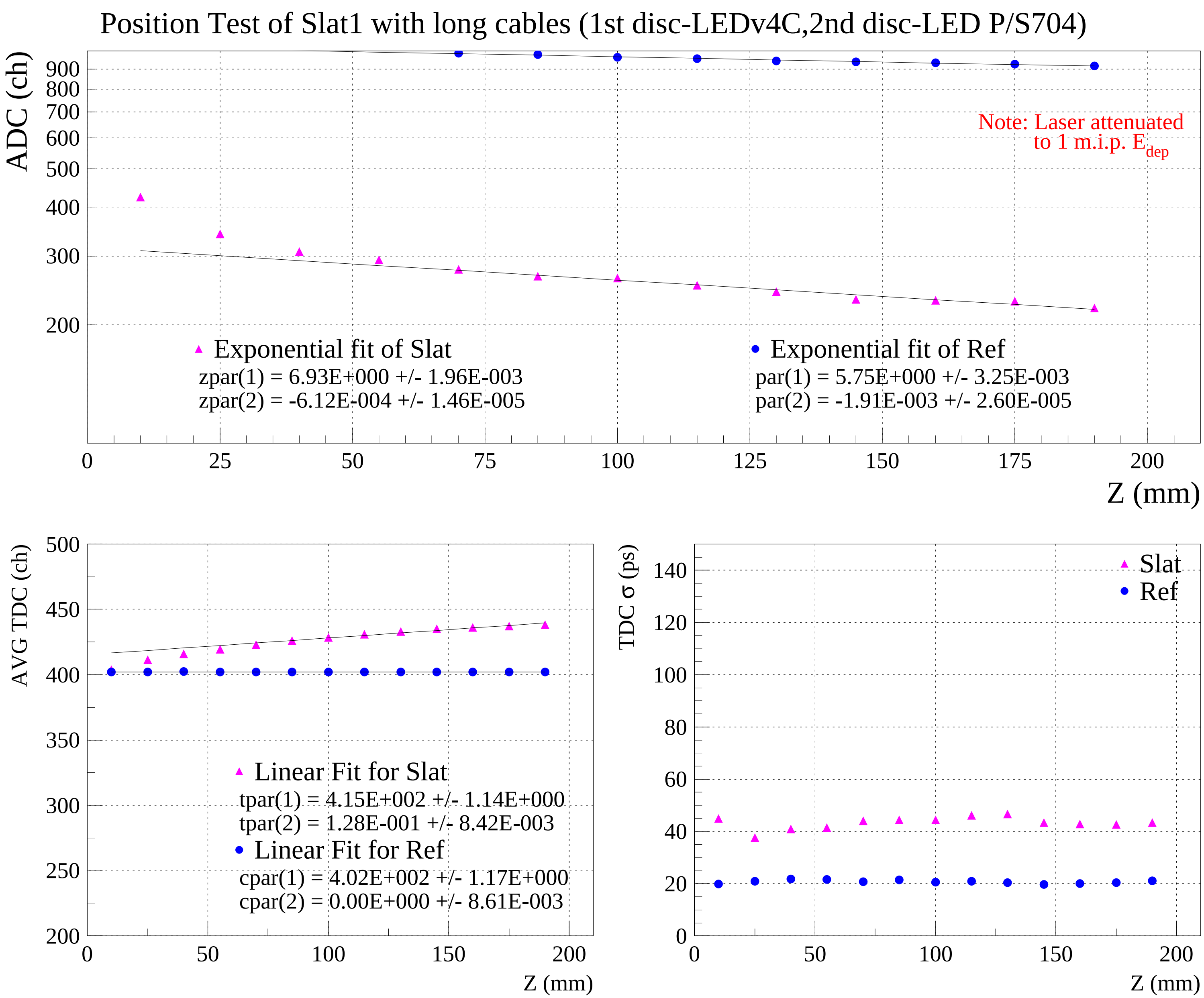

Position Test of Slat3 with long cables (1st disc - LEDv4,2nd disc - LED P/S704)
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.75E+000 +/- 1.99E-003
zpar(2) = 1.08E-004 +/- 1.46E-005
Exponential fit of Ref
par(1) = 5.94E+000 +/- 1.84E-003
par(2) = -2.45E-003 +/- 1.84E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 4.14E+002 +/- 1.17E+000
tpar(2) = 1.32E-001 +/- 8.60E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 5.29E-001
cpar(2) = -9.38E-005 +/- 3.15E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)


Position Test of Slat4 with long cables (1st disc - LEDv4,2nd disc - LED P/S704)
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E_dep
Exponential fit of Slat
zpar(1) = 6.77E+000 +/- 1.00E+000
zpar(2) = -7.30E-005 +/- 1.00E+000
Exponential fit of Ref
par(1) = 5.93E+000 +/- 1.83E-003
par(2) = -2.16E-003 +/- 1.80E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 3.45E+002 +/- 1.12E+000
tpar(2) = 1.24E-001 +/- 8.20E-003
Linear Fit for Ref
cpar(1) = 4.05E+002 +/- 1.15E+000
cpar(2) = -1.00E-003 +/- 8.44E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)



Position Test of Slat1 with long cables (1st disc-LEDv4A,2nd disc-LED P/S704)
ADC (ch)
Note: Laser attenuated
to 1 m.i.p. E_{dep}
Exponential fit of Slat
zpar(1) = 6.84E+000 +/- 6.55E-004
zpar(2) = 1.76E-005 +/- 5.68E-006
Exponential fit of Ref
par(1) = 5.86E+000 +/- 3.70E-003
par(2) = -1.27E-003 +/- 2.82E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 4.15E+002 +/- 1.18E+000
tpar(2) = 1.32E-001 +/- 8.71E-003
Linear Fit for Ref
cpar(1) = 4.02E+002 +/- 1.14E+000
cpar(2) = -2.22E-004 +/- 8.36E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)


Position Test of Slat1 with long cables (1st disc-LEDv4B,2nd disc-LED P/S704)
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E$_{dep}$
Exponential fit of Slat
zpar(1) = 6.82E+000 +/- 6.29E-004
zpar(2) = -3.12E-004 +/- 5.57E-006
Exponential fit of Ref
par(1) = 5.76E+000 +/- 3.07E-003
par(2) = -1.59E-003 +/- 2.45E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 4.14E+002 +/- 1.19E+000
tpar(2) = 1.32E-001 +/- 8.77E-003
Linear Fit for Ref
cpar(1) = 4.02E+002 +/- 1.17E+000
cpar(2) = 0.00E+000 +/- 8.61E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)



Position Test of Slat1 with long cables (1st disc-LEDv4C,2nd disc-LED P/S704)
ADC (ch)
Note: Laser attenuated to 1 m.i.p. E_dep
Exponential fit of Slat
zpar(1) = 6.93E+000 +/- 1.96E-003
zpar(2) = -6.12E-004 +/- 1.46E-005
Exponential fit of Ref
par(1) = 5.75E+000 +/- 3.25E-003
par(2) = -1.91E-003 +/- 2.60E-005
Z (mm)
AVG TDC (ch)
Linear Fit for Slat
tpar(1) = 4.15E+002 +/- 1.14E+000
tpar(2) = 1.28E-001 +/- 8.42E-003
Linear Fit for Ref
cpar(1) = 4.02E+002 +/- 1.17E+000
cpar(2) = 0.00E+000 +/- 8.61E-003
Z (mm)
TDC σ (ps)
Slat
Ref
Z (mm)

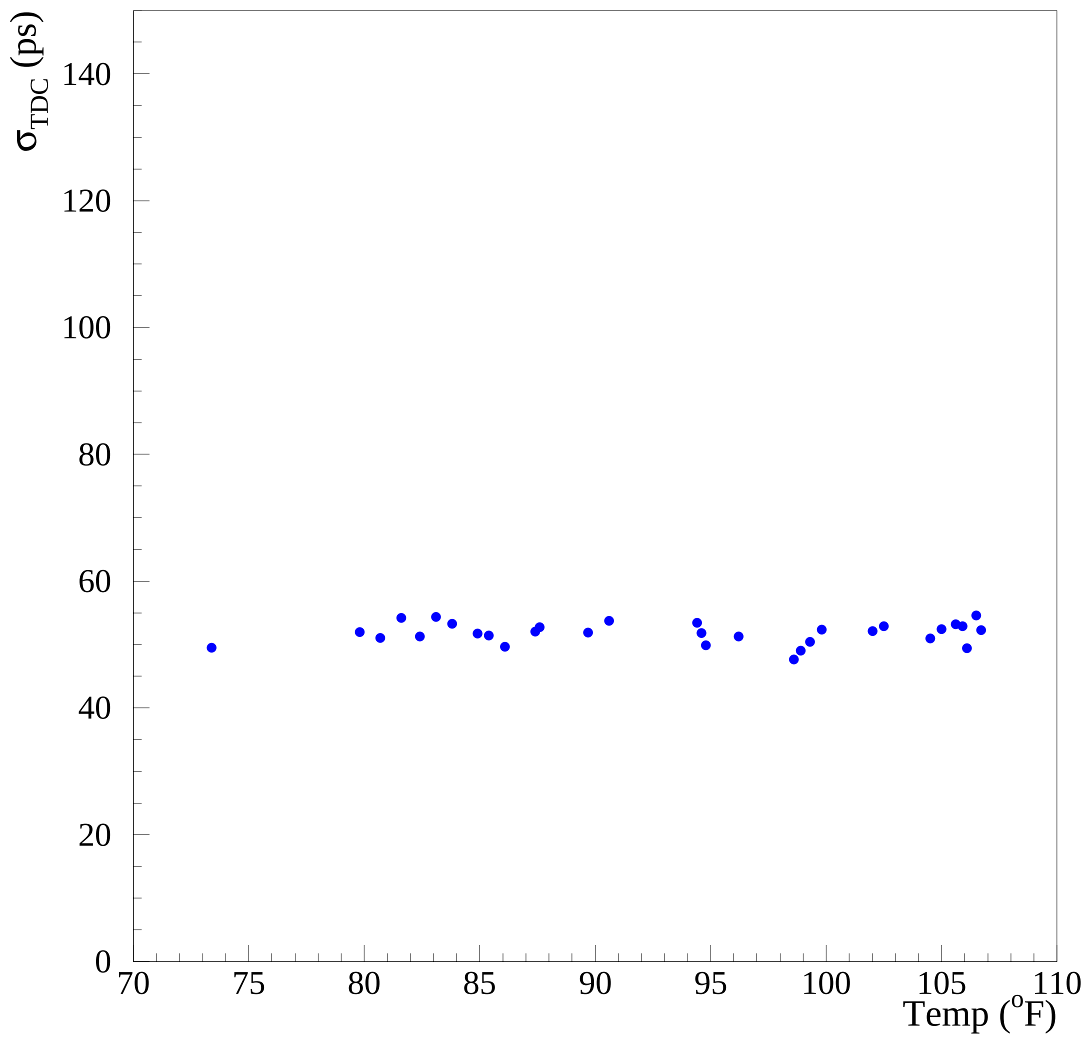
Ambient temperature dependence of performance of all In-Tray components (Slat Assy+Cell+FEE)

31 runs over ~5hr period

laser @ 1 m.i.p...
fiber on slat at 100mm...
short cables...

T from thermocouple and DVM...

Oven “nicely” unstable...



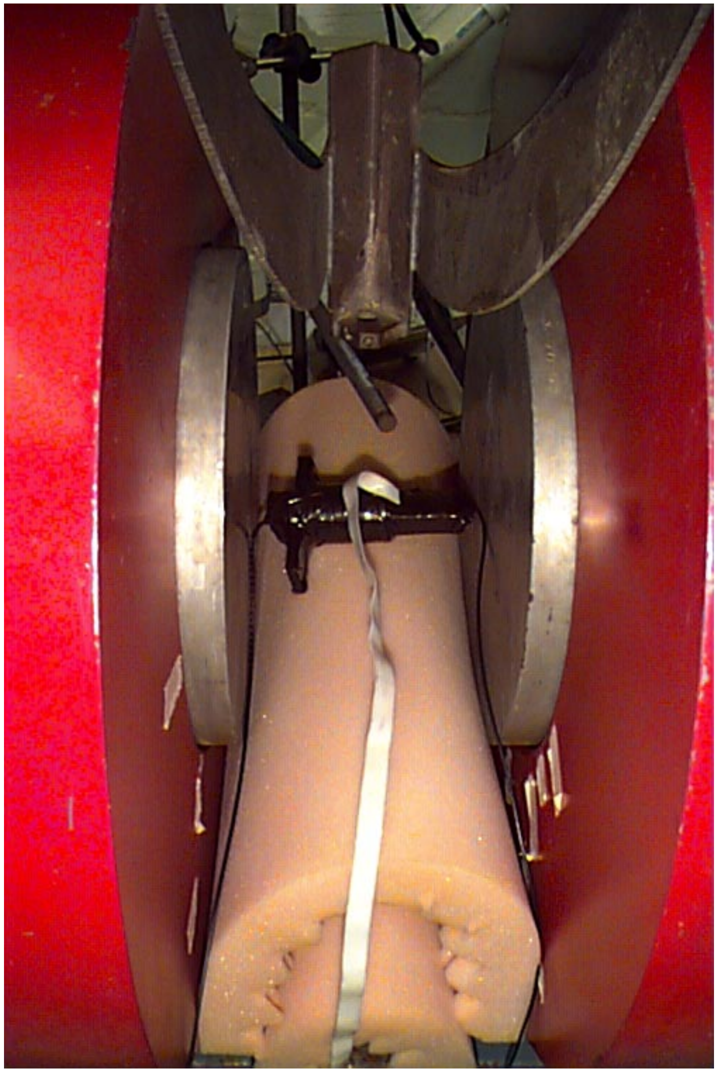
performance of the in-tray components does not depend on the temperature studied in the range from ~72 °F to ~107 °F...

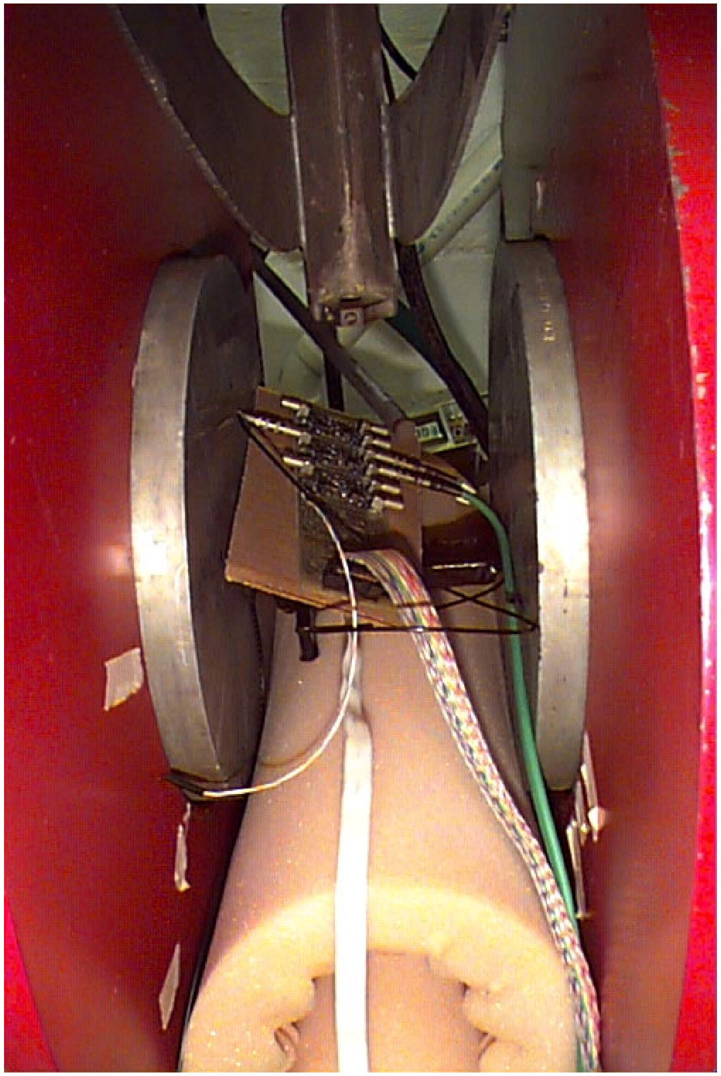
Performance of R5946+Cell+FEE v.4 in a Magnetic Field

performance of R5946 in magnetic fields already studied in detail Ahmad et al., NIM A **400**, 149 (1997)

magnet bore only ~6 inches wide, and PMT must be within 20 degrees of parallel to the field...
perform test with a v. small piece of scintillator, not a full TOFp slat...

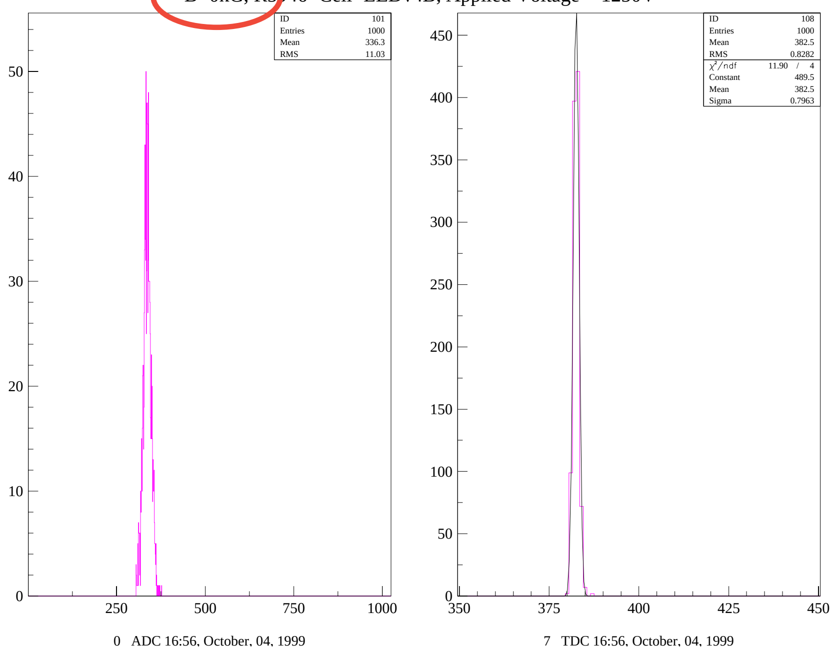
angle that symmetry axis of PMT made w.r.t. the field direction was ~10 degrees...



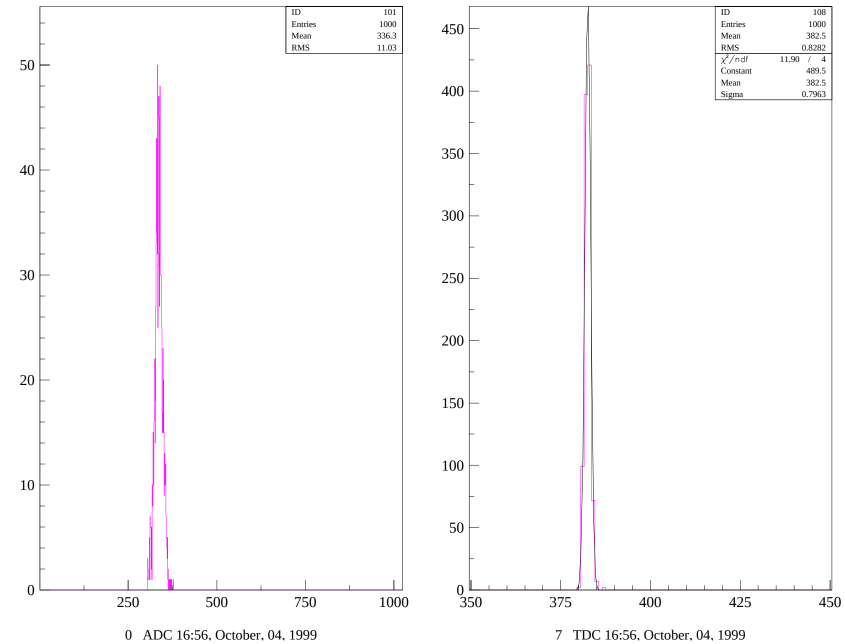


ADC and TDC distributions for various field strengths...

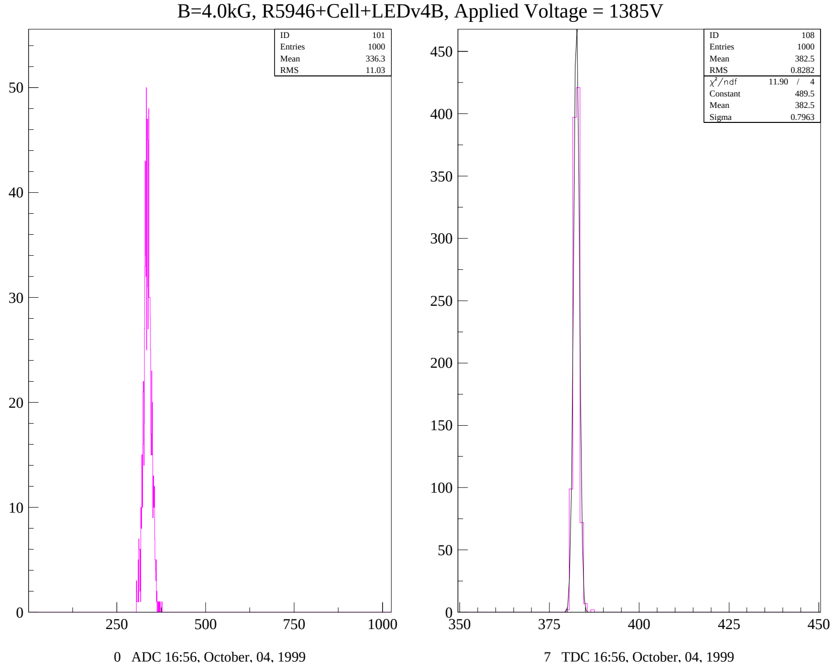
B=0kG, R5946+Cell+LEDv4B, Applied Voltage = 1250V



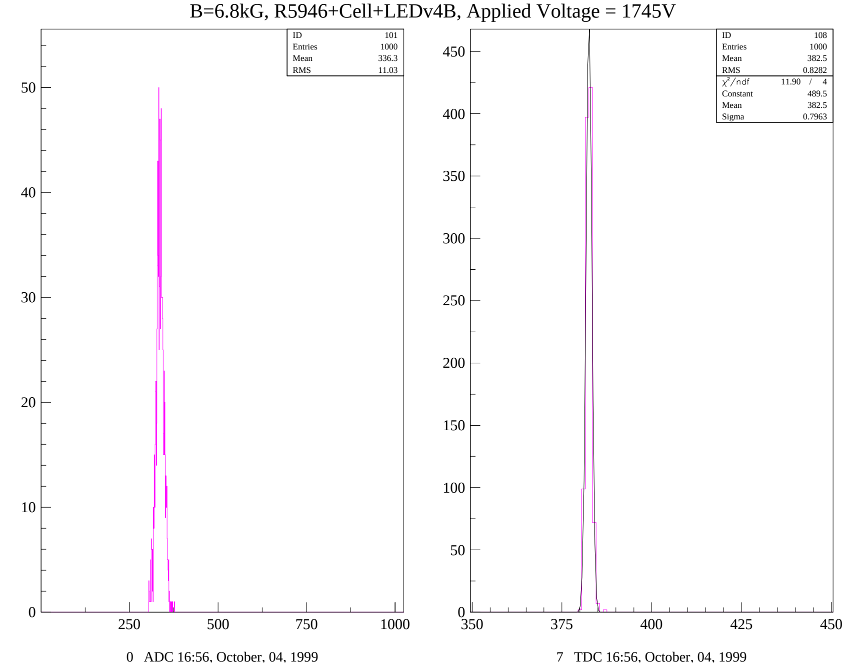
B=2.3kG, R5946+Cell+LEDv4B, Applied Voltage = 1250V



B=4.0kG, R5946+Cell+LEDv4B, Applied Voltage = 1385V

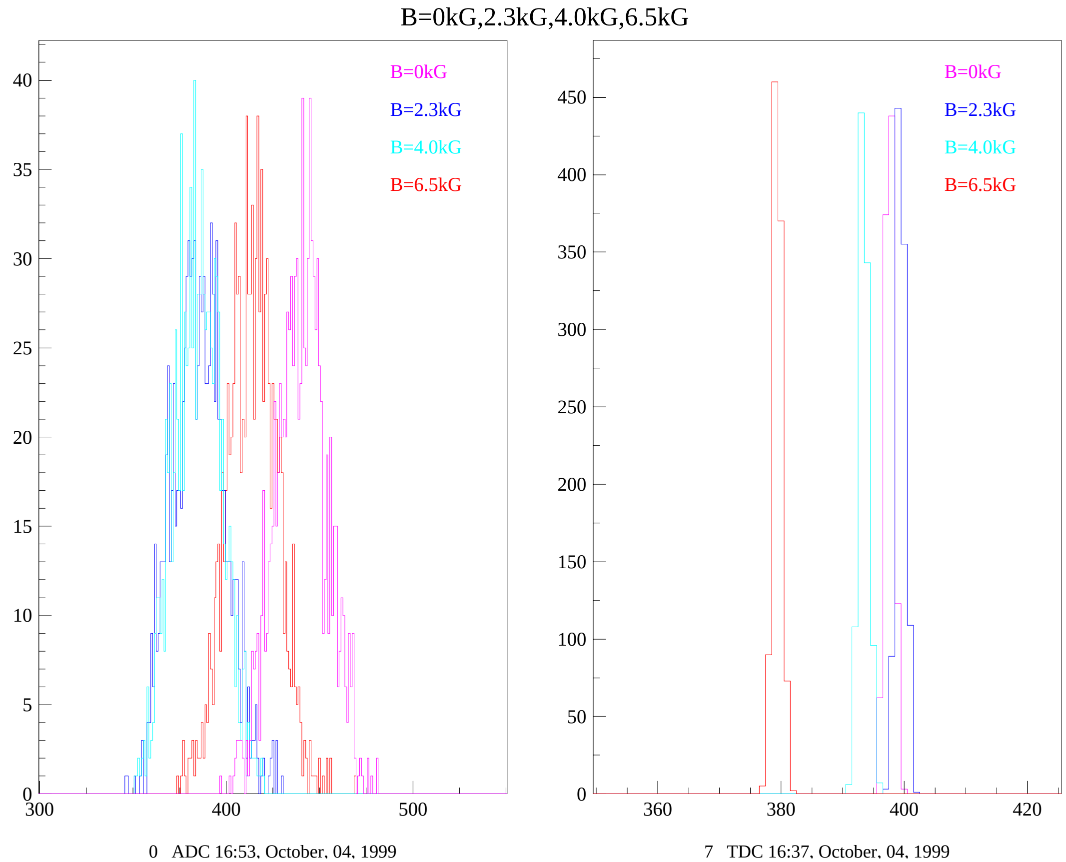


B=6.8kG, R5946+Cell+LEDv4B, Applied Voltage = 1745V



Magnet Reading in V (final reading in V)	0.003	0.522 0.457	0.993 0.951	0.936 0.911	1.529 1.522	1.497 1.492	1.564 1.562
Applied Voltage V	1250	1250	1385	1385	1385	1745	1745
Slat ADC	440.2	385.5	174.7	384.7	77.60	414.0	336.3
Ref ADC	876.0	868.5	868.6	863.5	857.0	843.3	840.6
Slat TDC	397.6 +/- 0.789	399.4 +/- 0.800	414.9 +/- 1.071	393.4 +/- 0.854	434.5 +/- 1.341	379.4 +/- 0.781	382.5 +/- 0.79
Ref TDC	595.4 +/- 0.477	595.4 +/- 0.463	595.3 +/- 0.456	595.4 +/- 0.474	595.4 +/- 0.502	595.4 +/- 0.464	595.3 +/- 0.47

R5946+Cell+FEE v.4 works fine in magnetic fields...
studied from to 0 to 6.5kG...



decreasing gain in PMT compensated for by increasing the voltage.
yet relative timing changes... PMT's leading edge slows for increasing field strength.

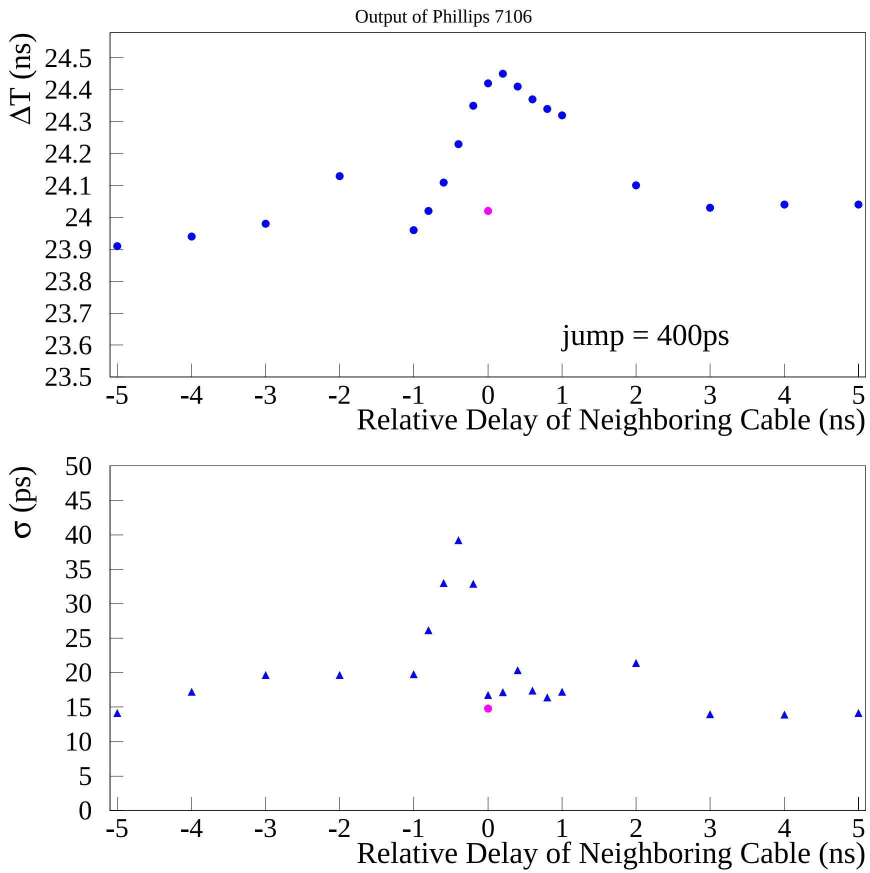
→ Timing resolution remains good in all cases...
→ Timing offsets when STAR's field is 0kG are ~0.5ns later than they are when the field is 5kG

Any modern discriminator is “fast enough” to be the TOFp ‘second discriminator’...
No cost, availability, or complexity concerns in this choice...
Rather this choice is driven entirely by a single performance spec:

“Discriminator timing cross talk”

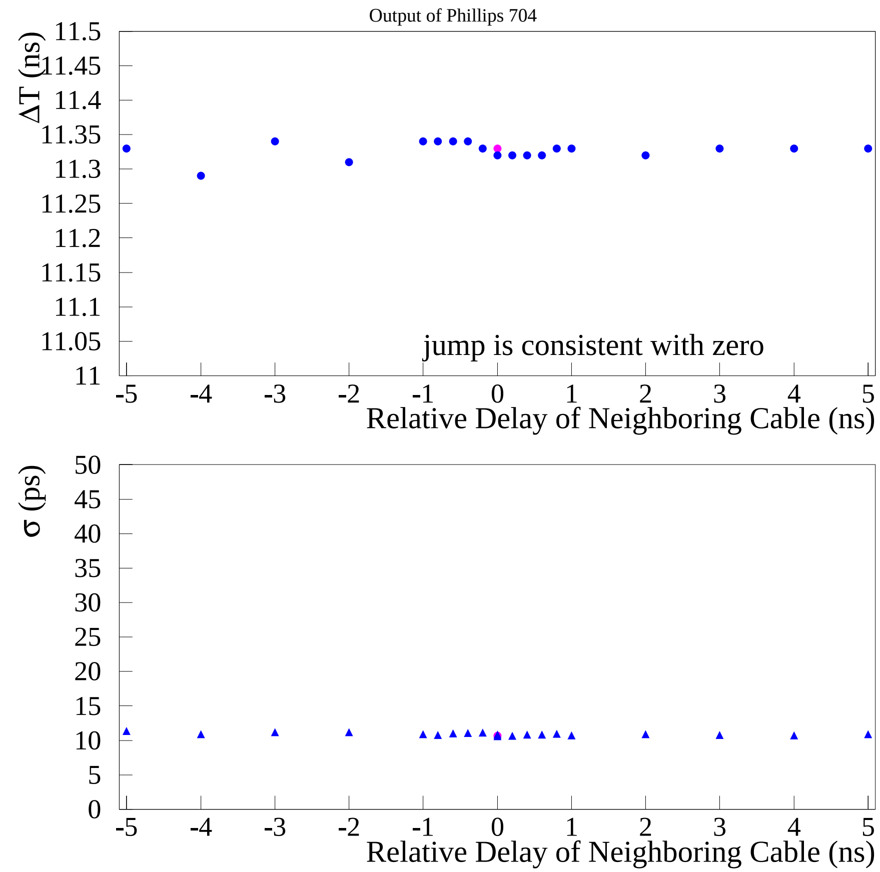
- the Proposal names the PS7106 for this discriminator based on E896, E877 and its availability...
  attractive due to mult sum output and high channel density...
- alternatives include PS 704-708 NIM and LeCroy models...

PS 7106 CAMAC



up to 400ps of timing cross talk!

PS 704 NIM



timing cross talk consistent with zero...

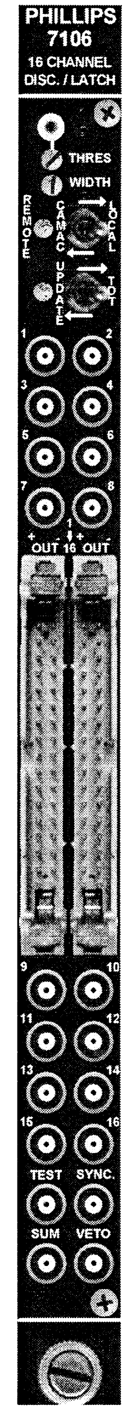
Cross-Talk Mapping of the face of a 7106...

CUS = Channel under study
NC = Neighbor channel
interpulse delay is fixed at +200ps (@ maximum effect on previous page)

CUS1	NC	DT	Diff (ps)	CUS2	NC	DT	Diff (ps)	CUS4	NC	DT	Diff (ps)	CUS5	NC	DT	Diff (ps)
Delay 200ps	**2**	**24.43**	**390**		**1**	**24.79**	**570**		1	24.48	10		1	24.12	60
	3	24.21	170		3	24.39	170		2	24.55	80		3	24.05	-10
	4	24.06	20		4	24.33	110		**3**	**24.9**	**430**		4	24.11	50
	5	24.15	110		6	24.33	110		5	24.53	60		**6**	**24.41**	**350**
	none	24.04			none	24.22			6	24.47	0		7	24.15	90
									8	24.47	0		8	24.05	-10
									none	24.47			none	24.06	

CUS1	NC	DT	Diff (ps)	CUS2	NC	DT	Diff (ps)	CUS4	NC	DT	Diff (ps)	CUS5	NC	DT	Diff (ps)
Delay -200ps	**2**	**24.36**	**340**		**1**	**24.57**	**390**		1	24.35	-90		1	24.11	70
	3	24.19	170		3	24.33	150		2	24.5	60		3	24.06	20
	4	24.05	30		4	24.32	140		**3**	**24.67**	**230**		4	24.09	50
	5	24.15	130		6	24.29	110		5	24.49	50		**6**	**24.28**	**240**
	none	24.02			none	24.18			6	24.43	-10		7	24.16	120
									8	24.44	0		8	24.03	-10
									none	24.44			none	24.04	0

CUS1	NC	DT	Diff (ps)	CUS2	NC	DT	Diff (ps)	CUS4	NC	DT	Diff (ps)	CUS5	NC	DT	Diff (ps)
Delay 200ps	**2**	**25.32**	**250**		**1**	**24.47**	**-580**		1	24.84	110		1	24.98	-20
	3	25.27	200		3	25.34	290		2	24.89	160		3	25.03	30
	4	25.13	60		4	25.2	150		**3**	**25.12**	**390**		4	25.1	100
	5	25.07	0		6	25.05	0		5	24.87	140		**6**	**25.17**	**170**
	none	25.07			none	25.05			6	24.79	60		7	25.14	140
									8	24.72	-10		8	24.99	-10
									none	24.73			none	25	



Simply awlful performance...

- Cross talk is everywhere...
- Levels can approach 600ps...
- Can extend past nearest neighbors...

Using less than fully-loaded PS7106 modules is thus also marginal for TOFp

Clearly, the PS7106 is not appropriate for the TOFp/pVPD platform discriminator...
loading only every 4th channel still marginal!

Alternative #1: do it in NIM...

- numerous PS 708 units exist in E896 TOF and are available to TOFp.
- missing now is the internal sum output feature of the PS7106...
this functionality would have to be set up w/ separate NIM logic...

Alternative #2: do it in NIM differently...

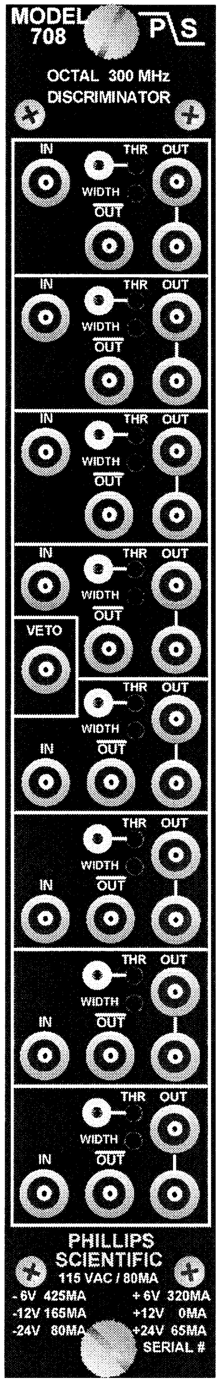
- PS 705 and 710 NIM discriminators have sum outputs...
- but these are only 75 MHz, and 150 MHz, respectively.

Alternative #3: do it in CAMAC differently...

- the LRS 3412 has sum outputs and other nice features...
- performance (resolution & cross talk) not yet studied...
- availability in equipment pools not yet investigated...

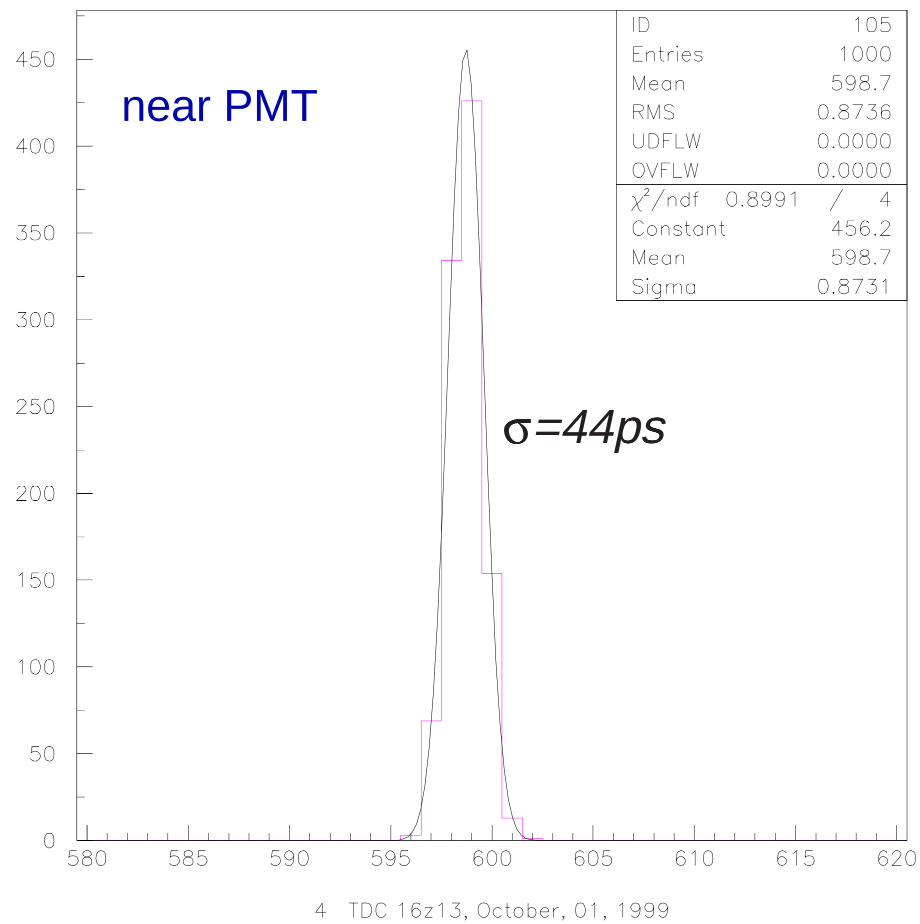
Notes:
...still intend to borrow the needed units from HEEP
...space exists in the TOFp rack for any of these options
$\rightarrow$ no cost or complexity issues here, just a choice to make...

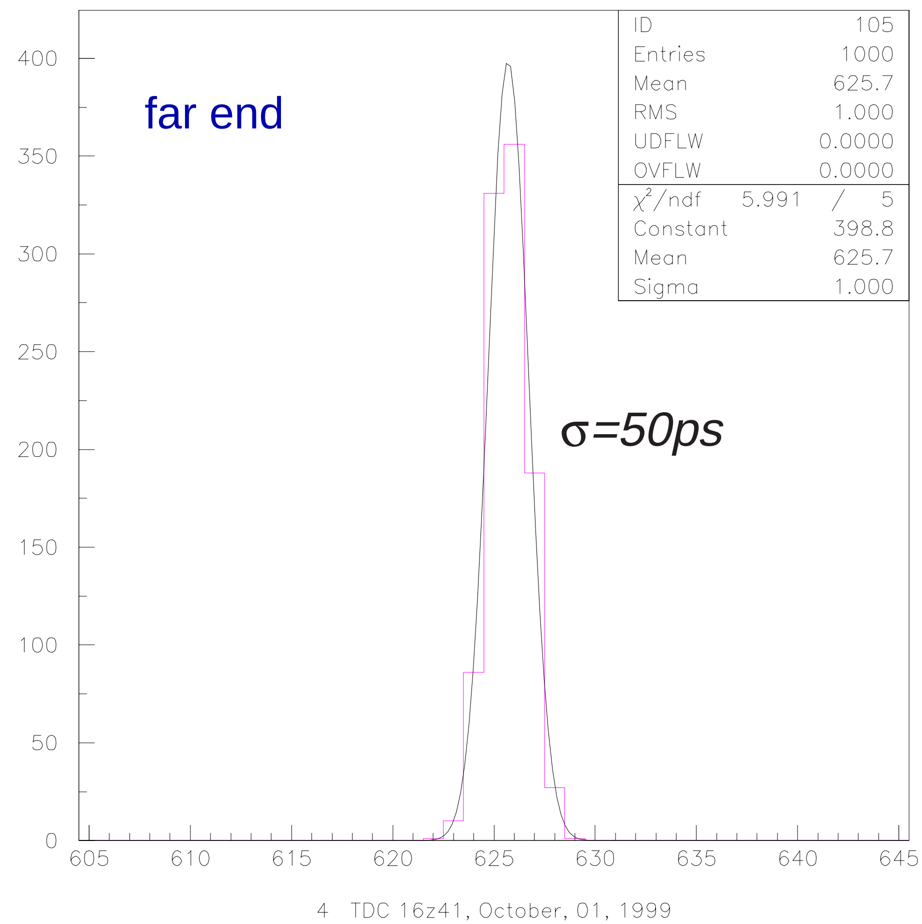
If a decision is needed now, we choose Alternative #1
(but f.y.i. we will look into Alternative #3 after this review)...



TOFp "Stop Resolution" from the big full system...

- room temperature, no magnetic field...
- laser fiber on slat attenuated to 1 MIP, Andover Filter OD=2...
- start PMT is 8575, monster light pulses...
- BC420 20x4x2cm + Epotek 301 + R5946, "Slat 1"...
- HVSys Cell 1...
- First discrimination is Rice version 4 LE...
- 250 feet RG-58C/U between 1st and 2nd discrimination...
- Second discrimination is P/S 704...
- CAMAC digitization in LRS 2228A TDC (50ps/ch)... confirmed with Infinium
- GPIB readout to PC and HBOOK/PAW...





SysTest-I Summary:

Cables:

FlatCoax is not appropriate for the long cable, O.K. near tray only...
Measured attenuation, amplitude & timing cross talk, temperature dependence...
Adopted RG-58/U for long cables. (~78% of the attenuation of the RG-58C/U or FlatCoax that were studied)
No R&D remaining.

Voltage System:

Studied HVSys - no problems, several additional advantages - Adopted.
No crashes seen, stable to percent level so far...
No need for HDLC interface in-tray.
No temperature or magnetic field dependence seen.
No R&D remaining - cell design fully specified and prototypes work.

FEE:

v.2 LE repackaged into final geometry (*a.k.a.* FEE v.4) still works great...
...outperforms best commercial units (in both resolution and output RT)
No temperature or magnetic field dependence seen.
No R&D remaining - v.5 is a trivial modification of v.4, no design changes.

Platform/Full System:

PS7106 for second discriminator is not appropriate, move this to NIM (PS708's also in hand).
Complicated patch panel no longer needed (cables and platform now Z-matched).
2228/2249 CAMAC DAQ digitization works as expected, confirmed by Infinium.
TOFp "stop resolution" with final components ranges from 40ps to 60ps...

No major surprises, no design decisions remaining...
We claim we are 100% ready to begin tray construction...

LBL DRAWING NUMBER	REV.	STAR DRAWING NUMBER	REV.	SHEET #	RHIC DRAWING NUMBER	REV.	ALL DIMENSIONS ARE
24A1401	H	SIM140-A-1	H	1of1	XXXXXXXXXX	-	INCHES / CENTIMETERS

LAWRENCE BERKELEY LABORATORY

UNIVERSITY OF CALIFORNIA - BERKELEY

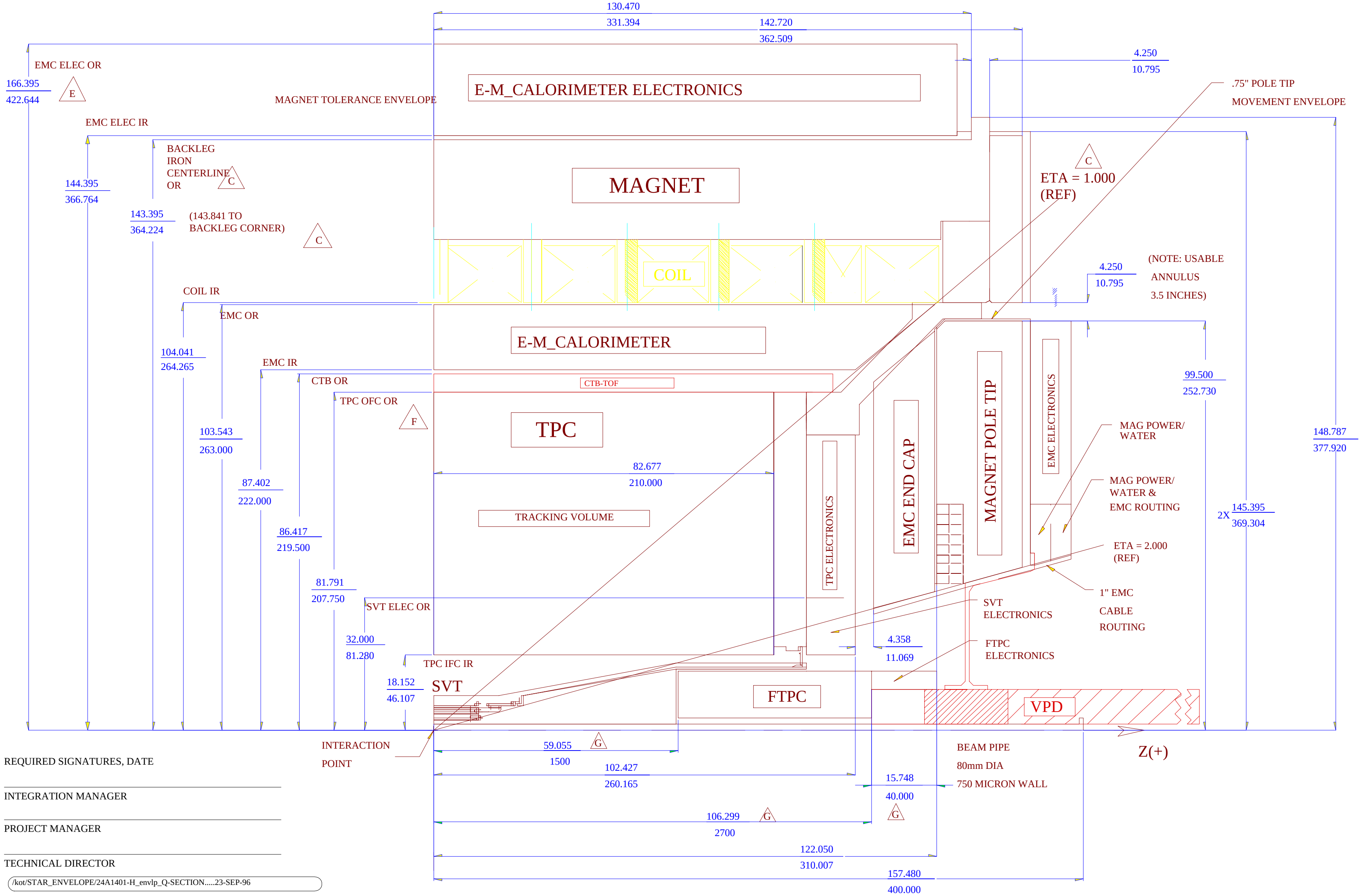
DRWN BY	DATE	COGNIZANT ENG	DATE	PRODUCTION APP	DATE	CAT.CODE/WBS
Doug Fritz	8/26/93	JER	8/26/93		x/xx/xx	SR1301

RHIC/STAR DETECTOR - S.I.

MECHANICAL COMPONENTS

QUARTER SECTION INTERFACE ENVELOPE

REV.	DWN.	CHK.	DATE	CHANGES
E	RES	DCF	10-13-95	INCREASED THE EMC B.L. ELECTRONICS AREA (OUTER RADIUS TO 166.395" WAS 159.307"), ECN EMC002
F	DCF	DCF	5-13-96	INCREASED CTB/TOF ENVELOPE IN "Z" (NOW 246 CM, WAS 240 CM) ECN TRG002
G	DCF	DCF	8-08-96	ADDED FTPC ENVELOPE, MODIFIED SVT GEOMETRY AND VPD MOVEMENT ENVELOPE, ECN SIM013
H	DCF	DCF	9-23-96	INCREASED FTPC ELECTRONICS ENVELOPE BY 10 CM IN "Z". ECN FTPC001



REQUIRED SIGNATURES, DATE

INTEGRATION MANAGER

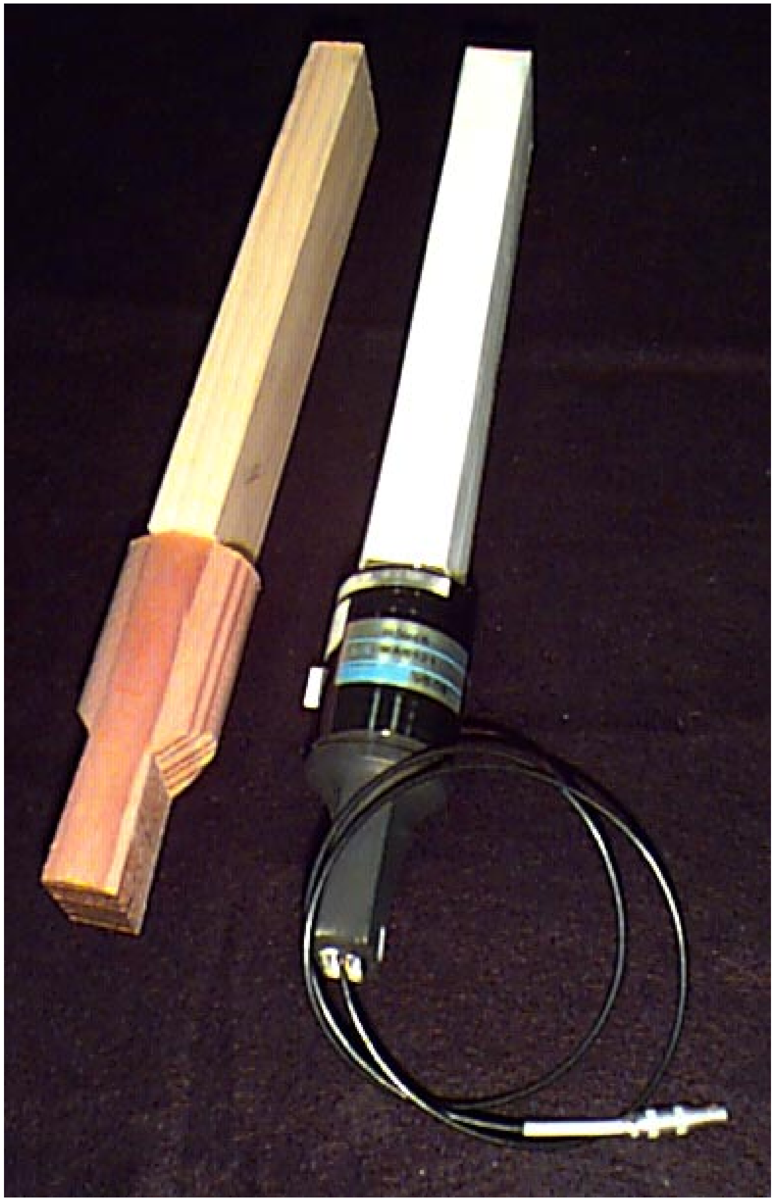
PROJECT MANAGER

TECHNICAL DIRECTOR

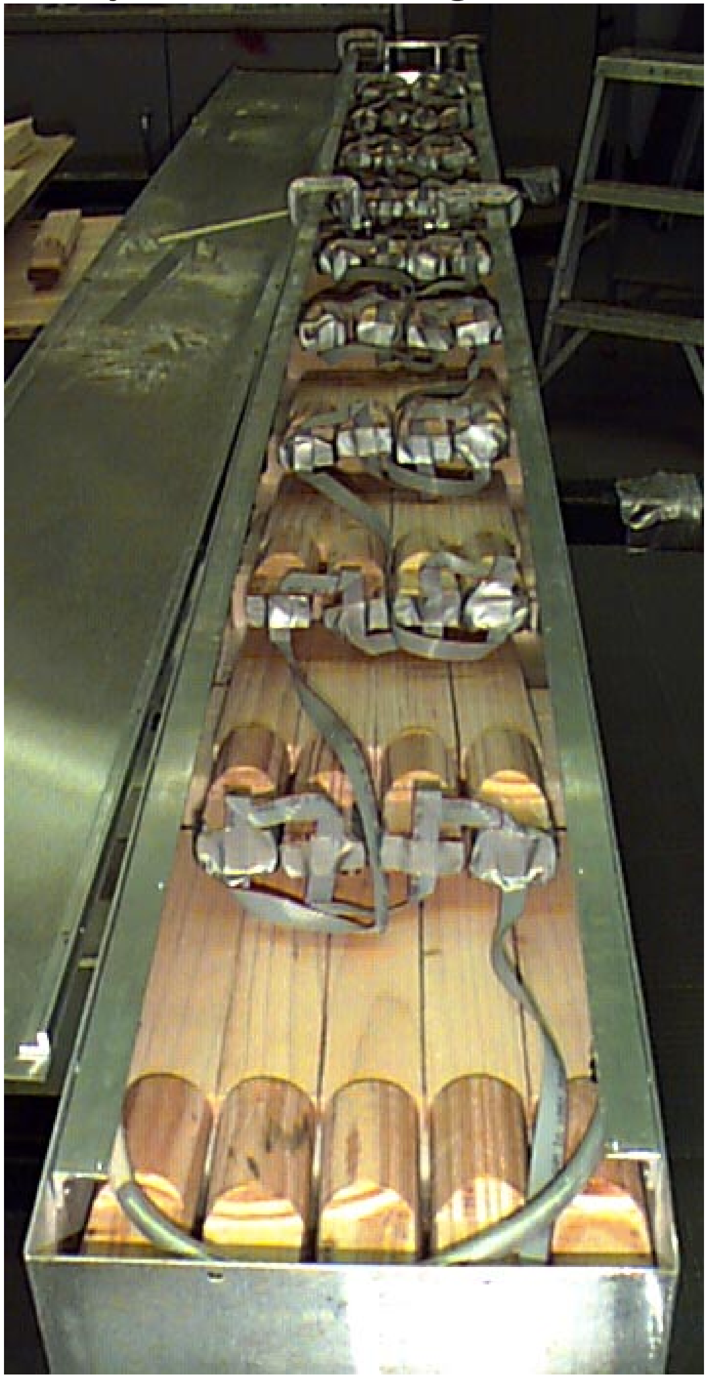
/kot/STAR_ENVELOPE/24A1401-H_envlp_Q-SECTION.....23-SEP-96

Fake TOFp

- optimize positioning and support
- define foam shapes and cooling loop...
- define cables and their routes...



HVSys Bus and routing...



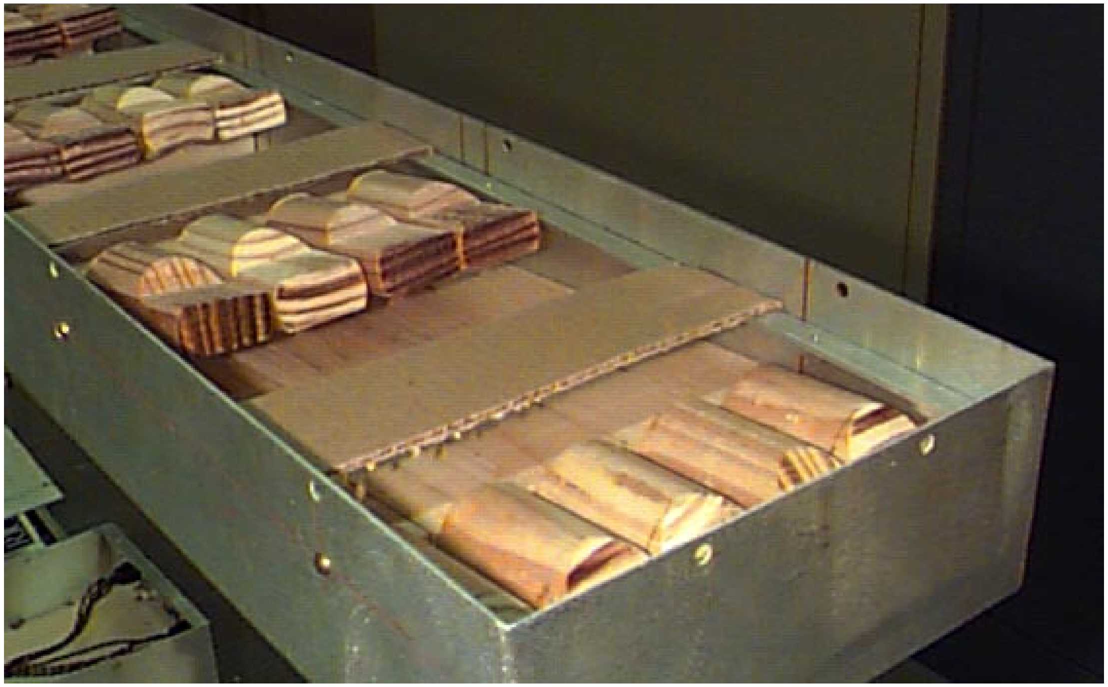
Cooling loop path and Foam/FEE Support...

η=0 end...

η=1 end...

Fake TOFp Status as of 10/2/99

final slat positioning and angles...
ten prototype “lower wedges”...
interior rails installed in final position...



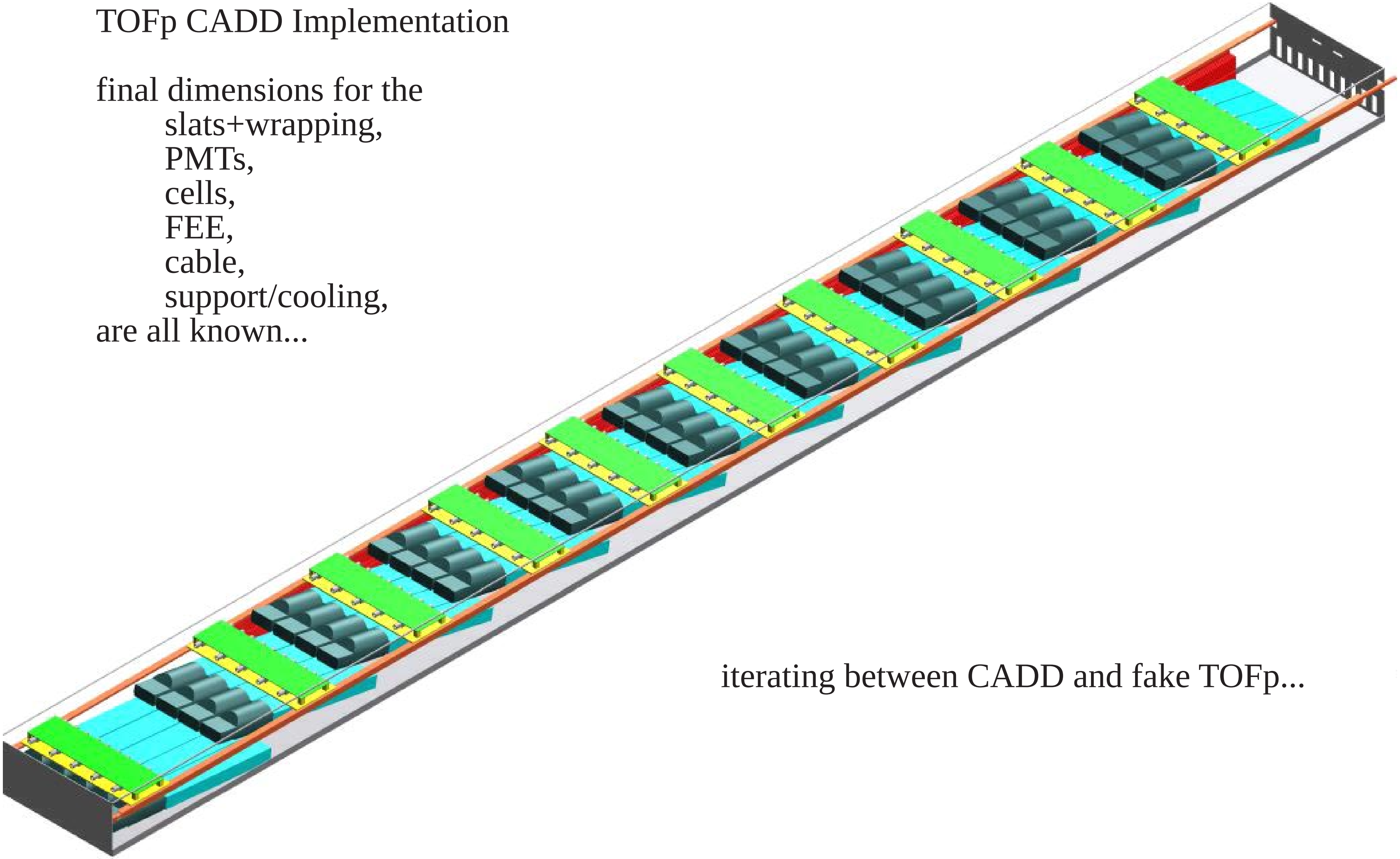
Next steps:

Prototype electronics mounts...
(these double as “upper wedge supports”)
Prototype “upper wedges”...
FEE mounts...
Tray roof mount...
Cooling loop hardware...
Cable routing revisited...
Feedthrough plate layout...

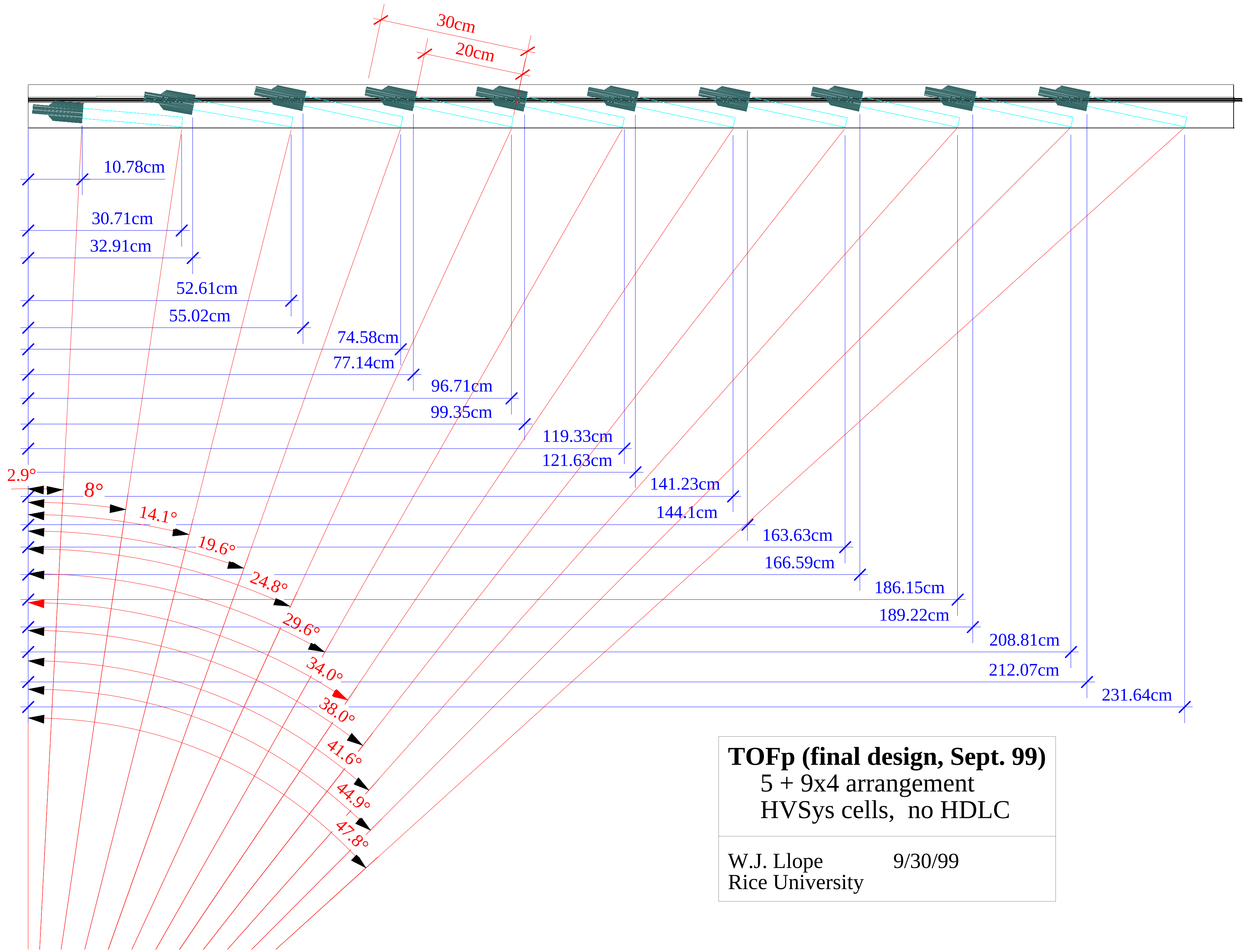
TOFp CADD Implementation

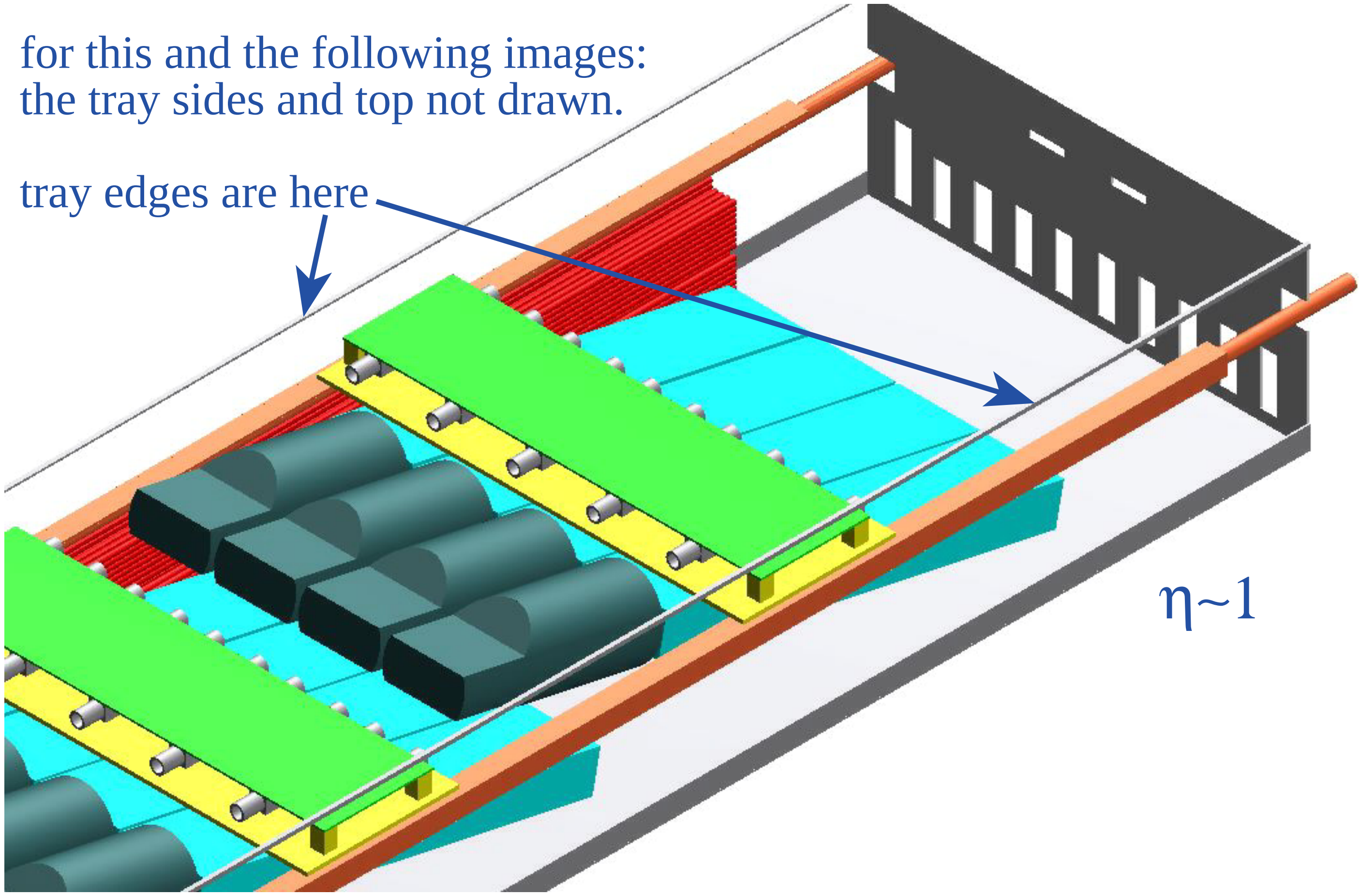
final dimensions for the
- slats+wrapping,
- PMTs,
- cells,
- FEE,
- cable,
- support/cooling,

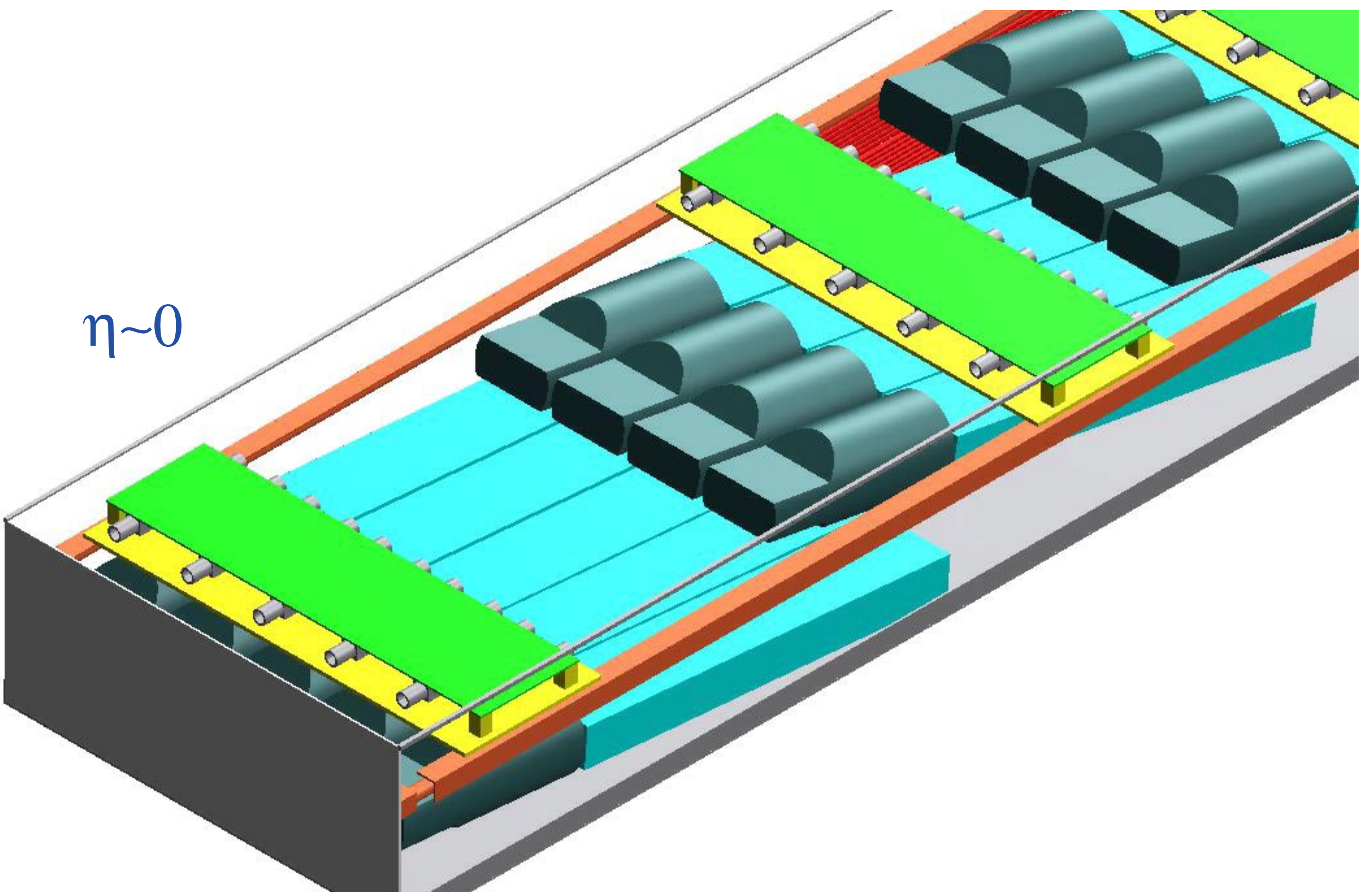
are all known...

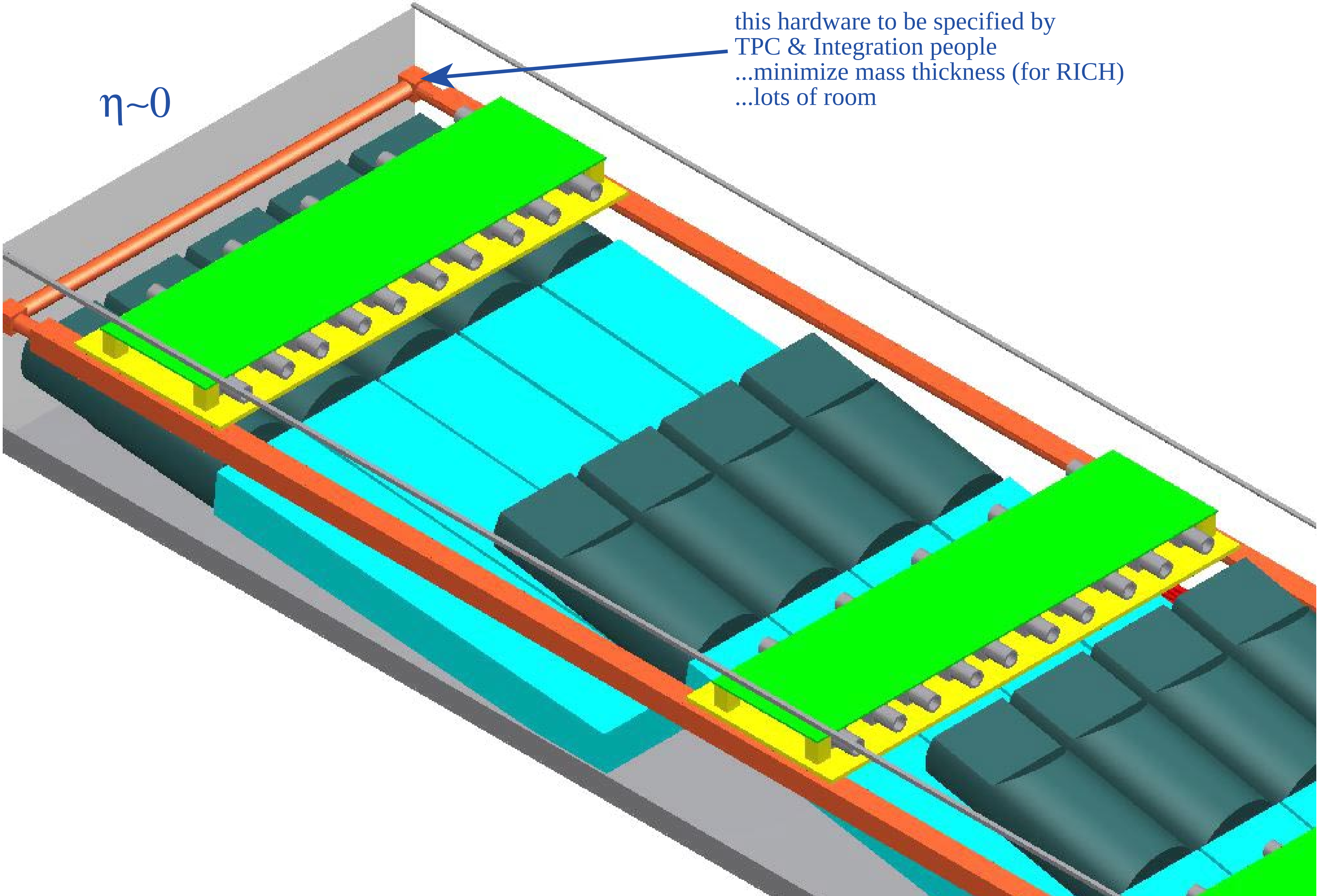


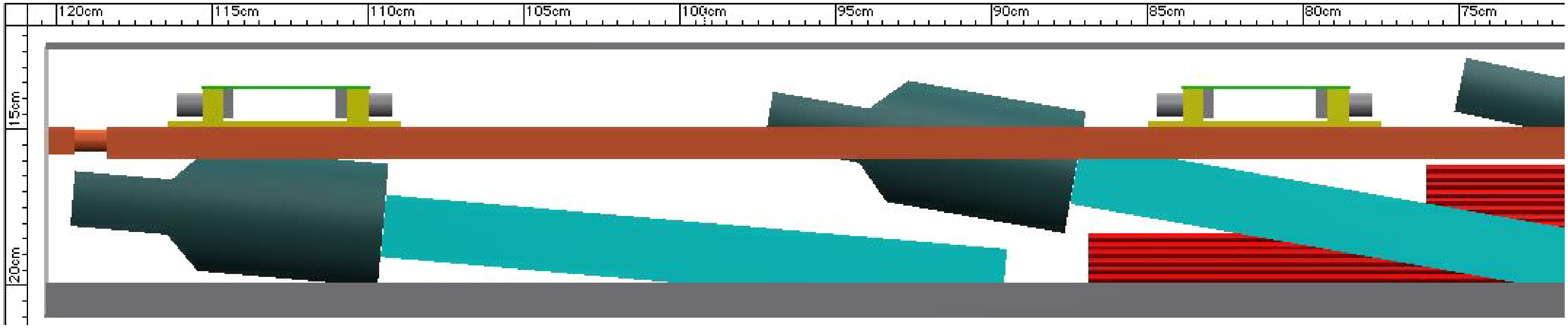
iterating between CADD and fake TOFp...


30cm
20cm
10.78cm
30.71cm
32.91cm
52.61cm
55.02cm
74.58cm
77.14cm
96.71cm
99.35cm
119.33cm
121.63cm
141.23cm
144.1cm
163.63cm
166.59cm
186.15cm
189.22cm
208.81cm
212.07cm
231.64cm
2.9°
8°
14.1°
19.6°
24.8°
29.6°
34.0°
38.0°
41.6°
44.9°
47.8°
TOFp (final design, Sept. 99)
5 + 9x4 arrangement
HVSys cells, no HDLC
W.J. Llope 9/30/99
Rice University


for this and the following images:
the tray sides and top not drawn.
tray edges are here
η~1

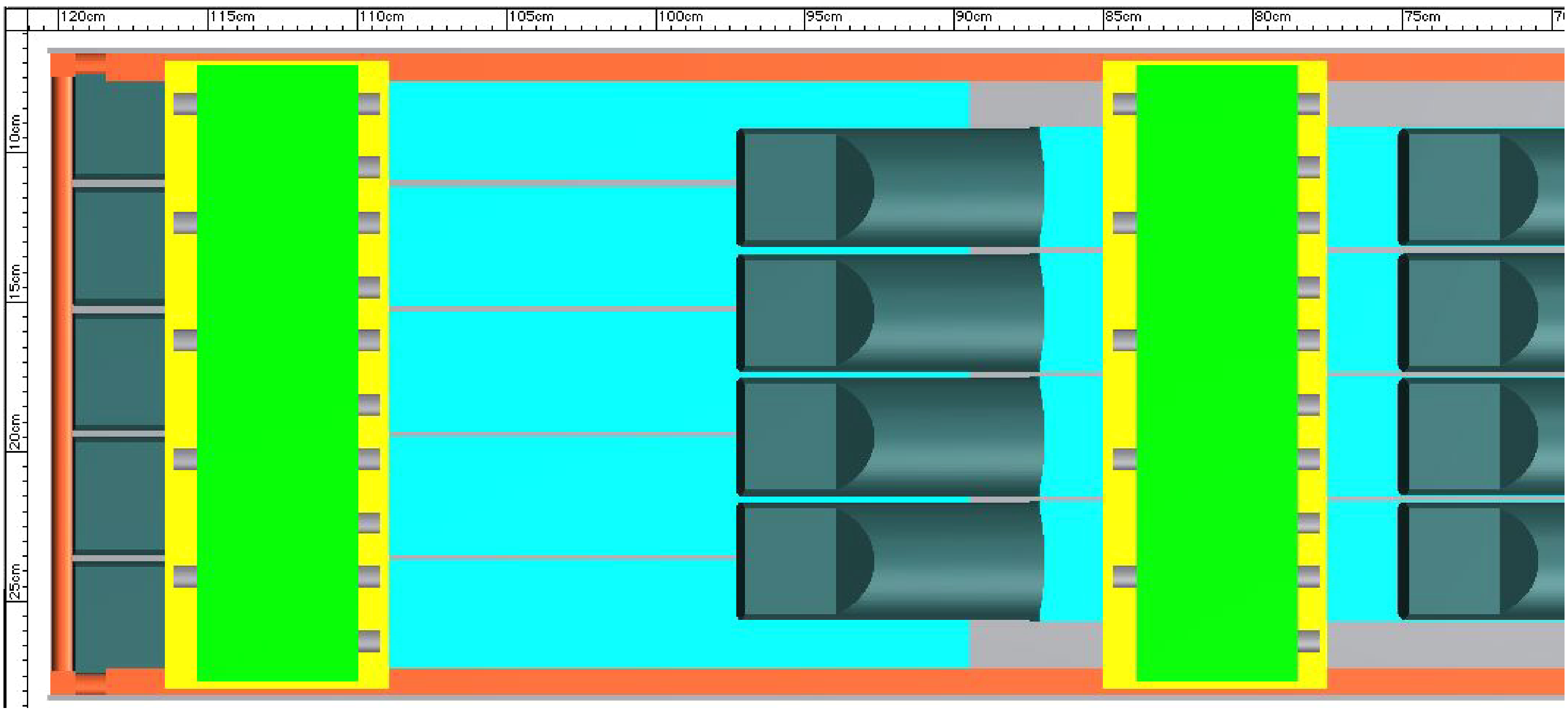

η~0


η~0
this hardware to be specified by
TPC & Integration people
...minimize mass thickness (for RICH)
...lots of room

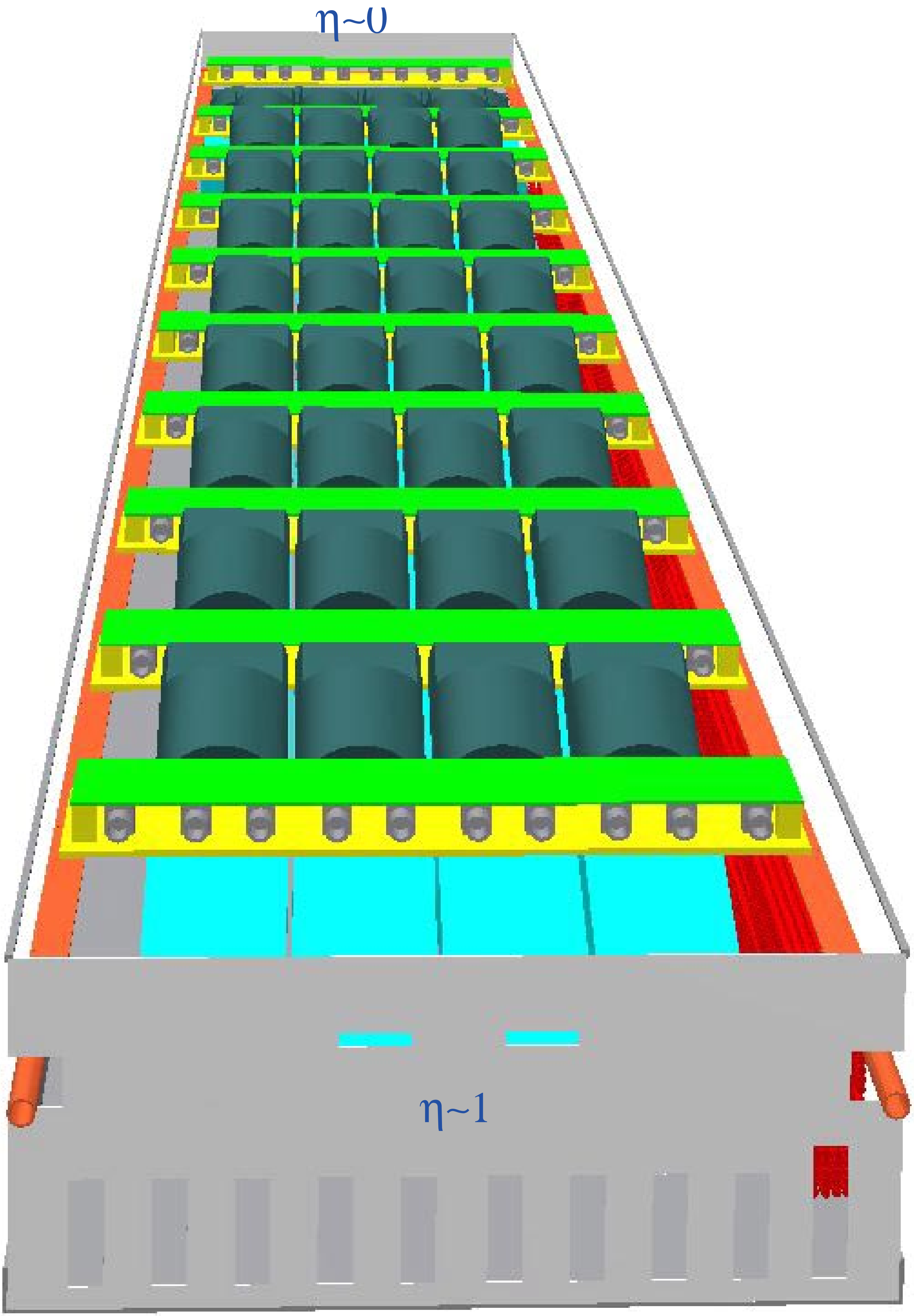


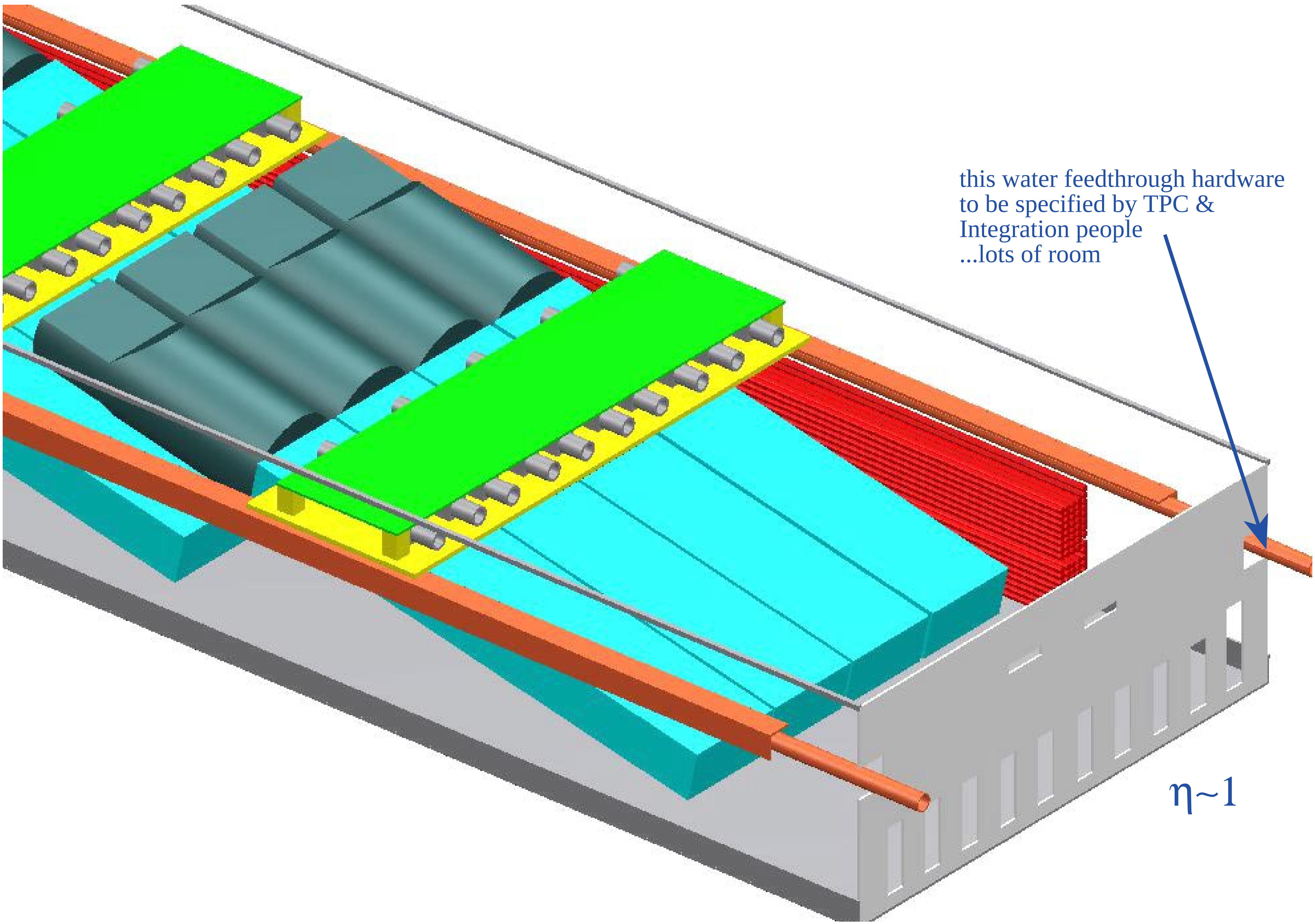
120cm
115cm
110cm
105cm
100cm
95cm
90cm
85cm
80cm
75cm
15cm
20cm

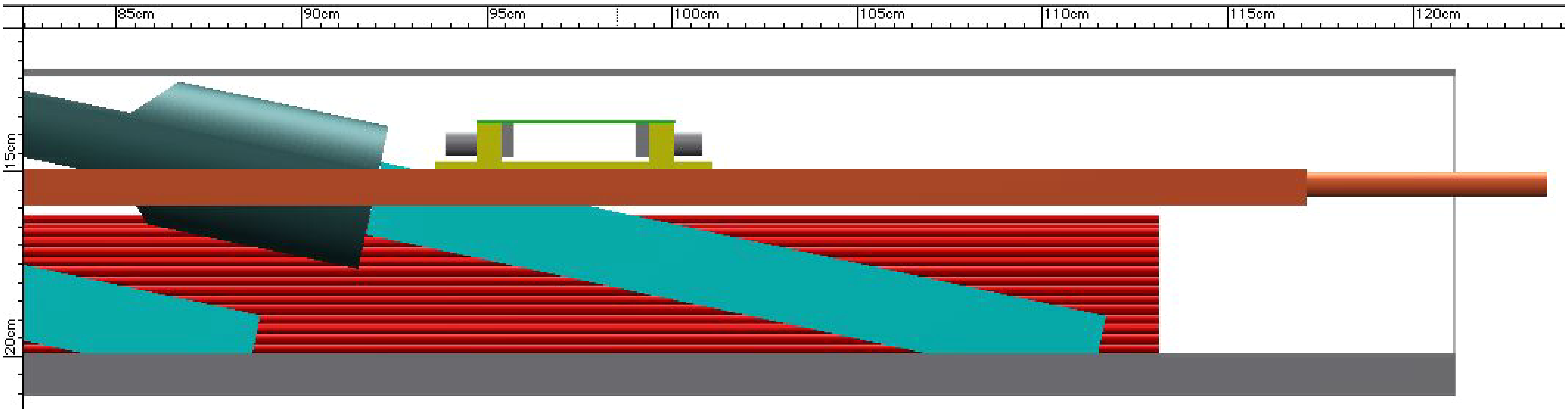
$\eta \sim 0$



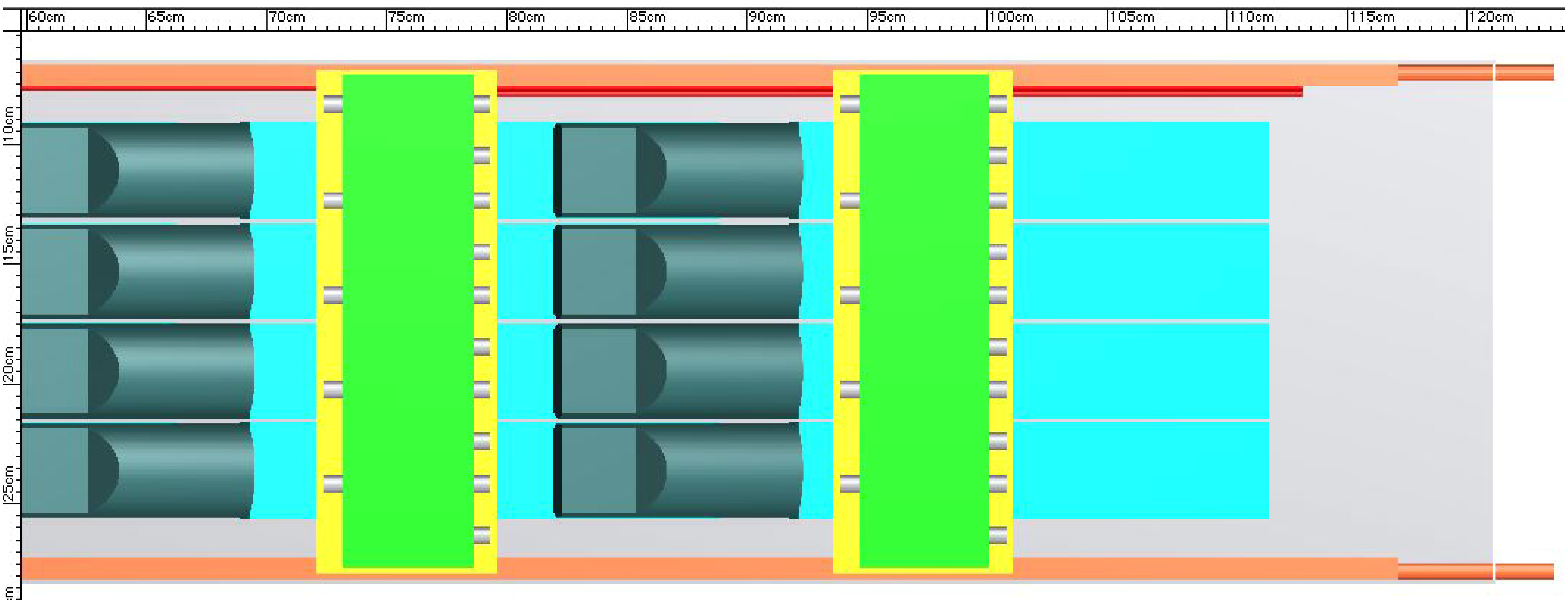
120cm
115cm
110cm
105cm
100cm
95cm
90cm
85cm
80cm
75cm
10cm
15cm
20cm
25cm


η~υ
η~1


this water feedthrough hardware
to be specified by TPC &
Integration people
...lots of room
η~1


85cm
90cm
95cm
100cm
105cm
110cm
115cm
120cm
15cm
20cm

η~1


60cm
65cm
70cm
75cm
80cm
85cm
90cm
95cm
100cm
105cm
110cm
115cm
120cm
10cm
15cm
20cm
25cm

TOFp SysTest-II

- smaller scope version of SysTest-I...
- at BNL and with final tray and electronics...

TOFp Installation

- remove 1 CTB tray, slide TOFp in...
- route cables from tray end to TOFp rack...
- connect cables at the two ends...
- “T” into TPC water loop as instructed...
- install/connect platform components needed to check the tray and cabling...
- power up cells and take cosmics... $\rightarrow$ end of detector installation
- install/connect any remaining components (*e.g.* DAQ, TRG interfaces etc.)

0$ /120 = 0$

CTB trays...

STAR Trigger Central Trigger Barrel
Tray Removal and Replacement Procedure

Leo Greiner, Geary Eppley
June 28 ,1999

The STAR Trigger CTB Trays each contain two scintillator slats with one photomultiplier tube and base per slat. If a tray needs to be replaced or repaired the following procedure should be used. We do have functional spare trays at BNL ready for use. It is recommended that these good trays be simply swapped for the malfunctioning tray and the malfunctioning tray be fixed at a STAR lab by qualified people. This procedure is written for this approach.

Before swapping trays have a tested good tray in position near the STAR detector to replace the malfunctioning tray.

Removal of tray:

1. Turn the HV off on the entire CTB via software control.
2. Turn off the HV mainframe power switch in rack 1B4 and post warning sign.
3. Set up ladders and / or rigging or man-lifts appropriate to the safe removal of the tray. This will depend on the location of the tray that needs replacing. All personnel involved should have the appropriate training for the task.
4. Remove the 6 cables (2 x HV, 2 x Signal and 2 x LED pulser) from the connectors on the end of the tray.
5. Remove the ground wire from the tray body.
6. Carefully slide the tray out keeping it parallel to the track on the TPC.
7. Remove the tray and carefully lower it to the ground.

Installation of tray:

1. If needed, install a positioning tray stop on the good tray.
2. Carefully raise the good tray into position such that it is parallel to it's track on the TPC.
3. Carefully slide the tray in keeping it parallel to the track on the TPC.
4. Re-attach the ground wire from the tray body.
5. Re-connect the 6 cables (2 x HV, 2 x Signal and 2 x LED pulser) to the correct connectors on the end of the tray.
6. Remove the ladders / rigging or manlifts.
7. Remove the sign and turn on the HV mainframe in rack 1B4.
8. Turn the HV on and test the tray.

Revisions for ***TOFp Removal***

1. & 2. → disable HVSys
3. unchanged
3.5 ← Contact experts to remove TOF connections to water
4. → remove 10 FlatCoax assemblies, 1 ribbon cable, 1 LV cable from the connectors on the tray end
5. - 7. unchanged.

For ***TOFp (re-)Installation***, undo each "removal step" in reverse order...

TOFp Test Procedures:

Four full slat assemblies were studied throughout SysTest-I

- 3 worked superbly under all conditions...
- 1 worked superbly in general, but freaked when pushed to extremes...

The test procedures must recognize basic problems of course
but also those components that may not like being pushed...

SysTest-I was the ultimate test procedure

- all relevant tests are defined...
- all hardware needed to collect the relevant test data is in hand...
- basic information on the performance specs for actual components is in hand...

we'll provide a separate document on test procedures soon.
...call this the TOFp SysTest-II Plan if you want...

Voltage Path:

- HVSys communication to System Module...
- System Module communication to cells...
- Built-in feedback and monitoring with GUI...

Signal Path: (after HVSys testing complete)

- Cosmics in powered-up slats...
- Performance of Slats, Slat/PMT junction, ADC path in FEE, and in-tray cabling ...
- Existence of stops...

FEE Performance: (after signal path testing complete)

- Laser/source tests - performance of full in-tray chain...

Digitization: (after FEE testing complete)

- Readout of ADCs and TDCs via GPIB Interface into local PC...
- Performance of platform components...

TOFp calibration Initial:

Before the TOFp tray is installed, and using the laser attenuated to 1 MIP:

• The gain scale for all slat assemblies will be already be defined
  → preset default voltages...
  → known gain curves in the region near these defaults...

• The performance of each channel of final FEE will already be spec'd
  → initial specs on pulse area performance...
  → initial specs on pulse time performance...
  → known relative timing offsets out to tray feedthroughs...

• The performance of each cable channel will already be spec'd
  → known cable delay and attenuation specs...

• Each TOFp DAQ channel will already be spec'd
  → known pC to counts conversion in ADCs...
  → known internal timing offsets in TDCs...
  → known ps to counts conversion in TDCs...

TOFp calibration Incremental:

...performed using the normal experimental data itself:
  Gain variations...
  Slewing...
  Scintillation light propagation speed...
  Temperature effects...
  → All extremely well-understood effects, standard techniques apply...

...performed using data from a separate stream:
  Pulser triggers... (STAR standard)
  TimeCalibrator runs... (can be done using local DAQ)

There is no need for in-tray calibration hardware!

i.e. in-tray LEDs, or optical fiber paths while the tray is installed...

Time of Flight means starts *and* stops... time resolution is the quadrature sum of the two...

circa TOFp proposal, our understanding was the VPD would not exist in Year 1.
- we simulated TOFp-based corrections to ZDC (~250ps)
  - → ~50ps resn. under favorable conditions, 91% efficient
  - this correction only works in highest mult collisions...
  - in peripheral Au+Au, Si+Si, p+p, → ~250ps starts?

a simple 16ch pVPD would solve the problem effectively
most of the detector/electronics can be borrowed → highly conventional and very cheap

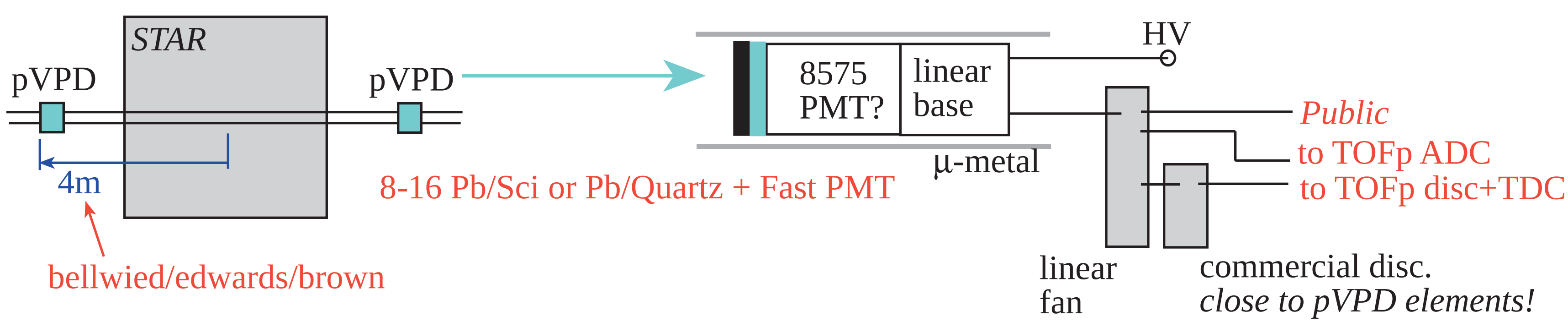
Recent interest/actual work towards a VPD or pVPD...

Bellwied/Pandey *et al.*	Bench tests of resolution of come commericial electronics
Kunz/Kaplan *et al.*	New simulations
John Mitchell	Interest in constructing detectors
Crawford *et al* and TOFp...	

*What TOFp needs from a pVPD is **not** the full functionality of the well-known VPD.*

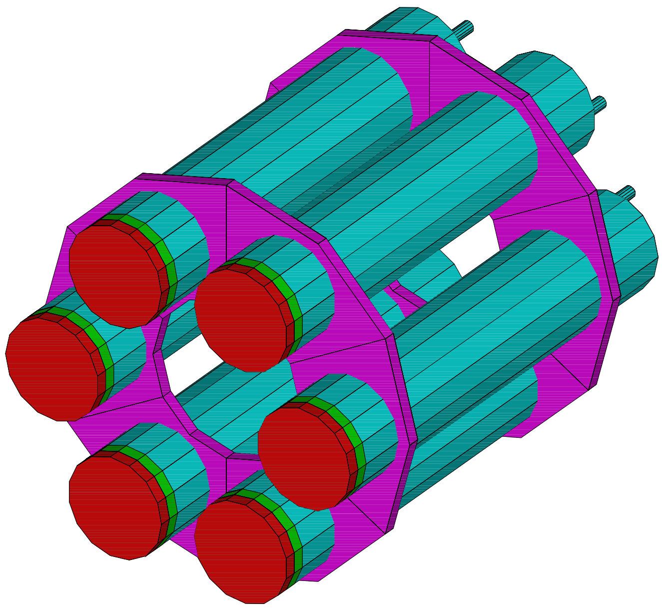
TOFp wants N_{ch}~16 (N_{ch}/2 elements per side)
- N_{ch} analog signals with pVPD PMTs → TOFp ADCs...
- N_{ch} logic signals from disc *close by* → TOFp TDCs...
- CTB or equiv pretrigger as for RICH...

...then logic local to TOFp forms TOFp master starts



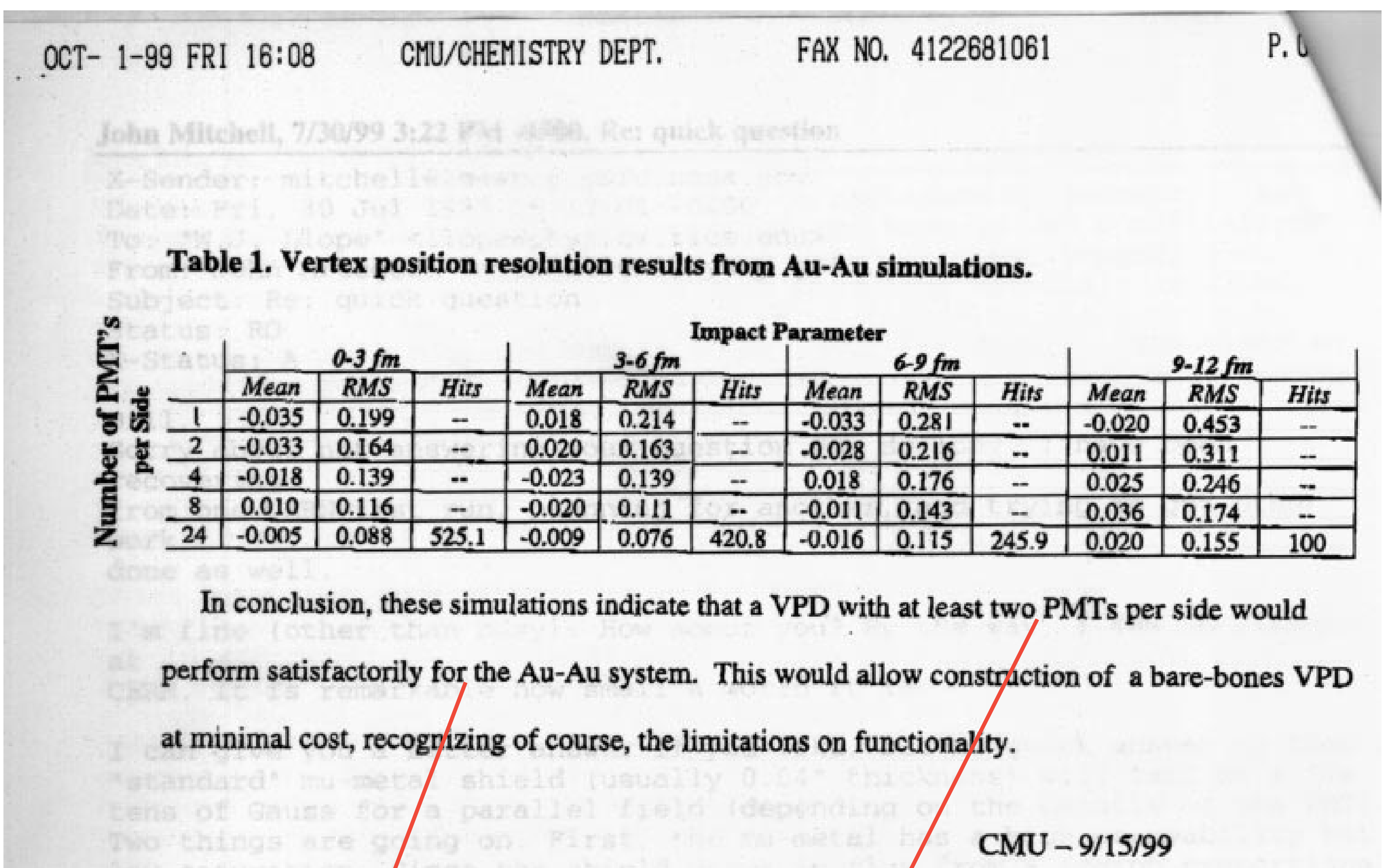
pVPD simulations...

pVPD based on library's vpddgeo.g



Au+Au, 200 GeV/N, HIJING
400cm from P.V. to either det...
Intrinsic time resn. assumed = 75ps

studied
Ndets/side = 1, 2, 4, 8, 24...
0-3, 3-6, 6-9, 9-12 fm bins...



OCT- 1-99 FRI 16:08 CMU/CHEMISTRY DEPT. FAX NO. 4122681061 P. 0

Table 1. Vertex position resolution results from Au-Au simulations.

Number of PMT's per Side	Impact Parameter 0-3 fm			3-6 fm			6-9 fm			9-12 fm		
	Mean	*RMS*	*Hits*	*Mean*	*RMS*	*Hits*	*Mean*	*RMS*	*Hits*	*Mean*	*RMS*	*Hits*
1	-0.035	0.199	--	0.018	0.214	--	-0.033	0.281	--	-0.020	0.453	--
2	-0.033	0.164	--	0.020	0.163	--	-0.028	0.216	--	0.011	0.311	--
4	-0.018	0.139	--	-0.023	0.139	--	0.018	0.176	--	0.025	0.246	--
8	0.010	0.116	--	-0.020	0.111	--	-0.011	0.143	--	0.036	0.174	--
24	-0.005	0.088	525.1	-0.009	0.076	420.8	-0.016	0.115	245.9	0.020	0.155	100

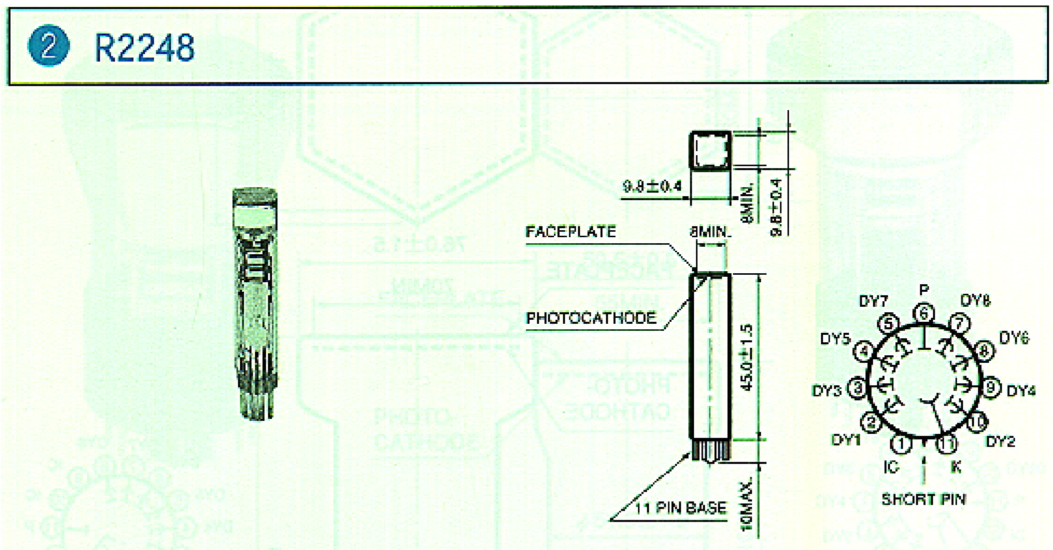
In conclusion, these simulations indicate that a VPD with at least two PMTs per side would perform satisfactorily for the Au-Au system. This would allow construction of a bare-bones VPD at minimal cost, recognizing of course, the limitations on functionality.

CMU – 9/15/99

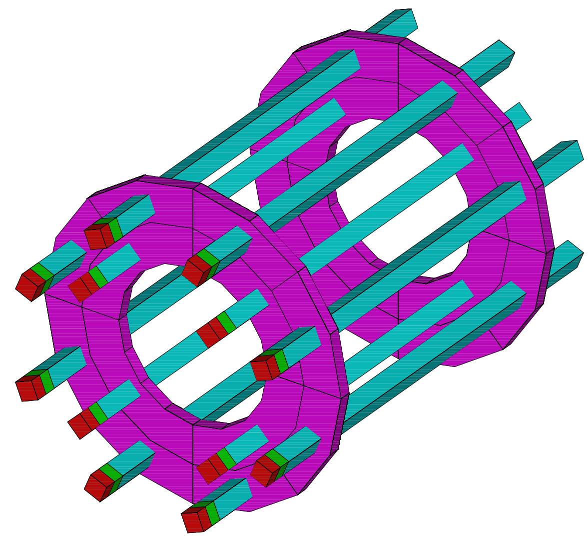
...primary vertex locating in... ...2"...

Hank's "E878 Centrality Detector" is just sitting around...

- 28-32 individual detector elements
- Pb+Quartz front faces
- Hamamatsu R2448 PMTs (3/8" square, 8 stage linear, <1250V, gain 1.1e6, 2nA dk. current, RT=0.9ns, eTT=8.5ns)
- HV Bases (bipolar Darlington current amplification)
- Shields appropriate up ~50Gauss



my pVPD geometry...



Just build:

New shields (~50$ ea): formed μ-metal + electrowelded low-carbon steel tubing

Mounting structure: machined Delran plastic

then Assemble &Install!

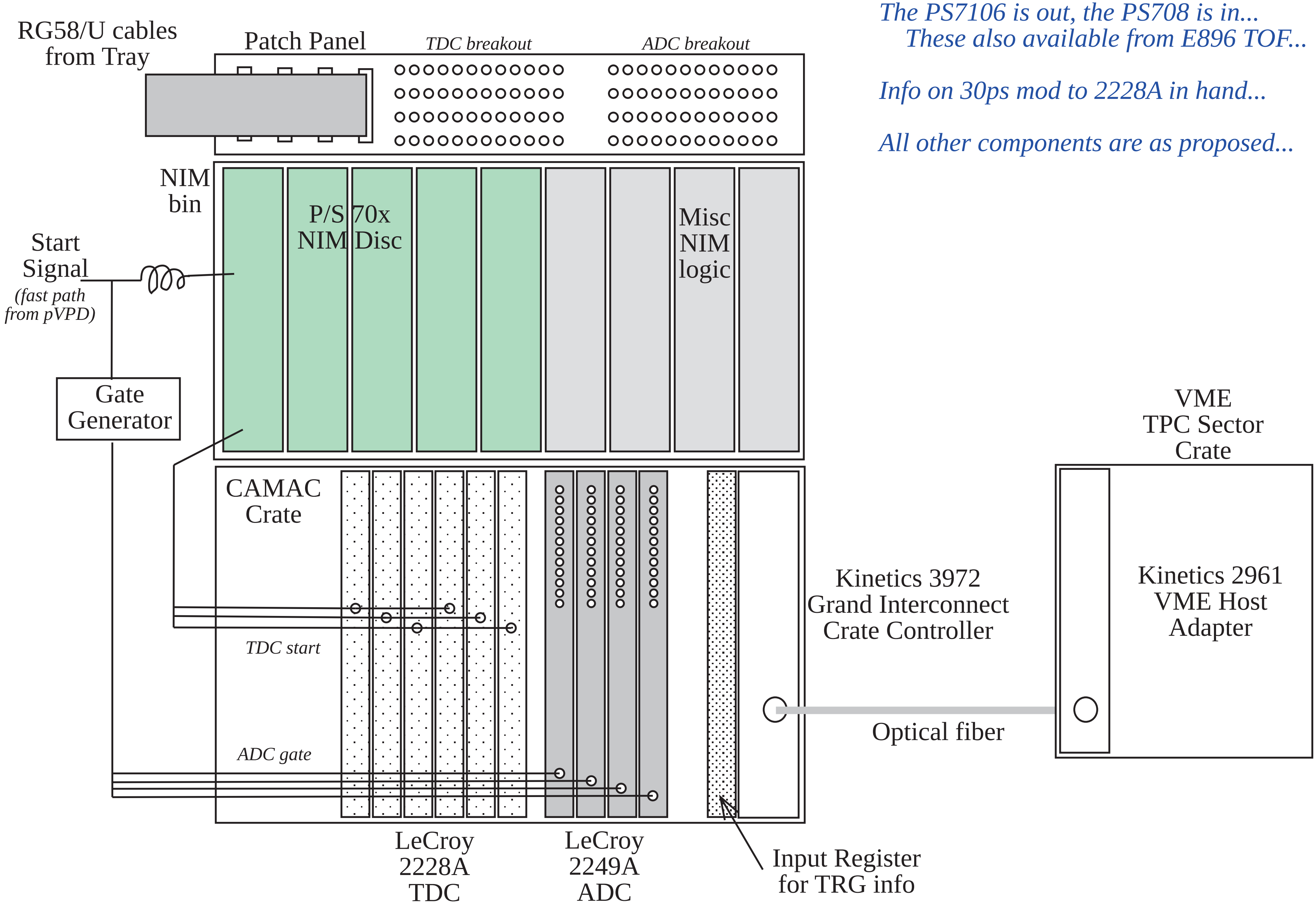
Digitization...

No impedance matching needed in panel...

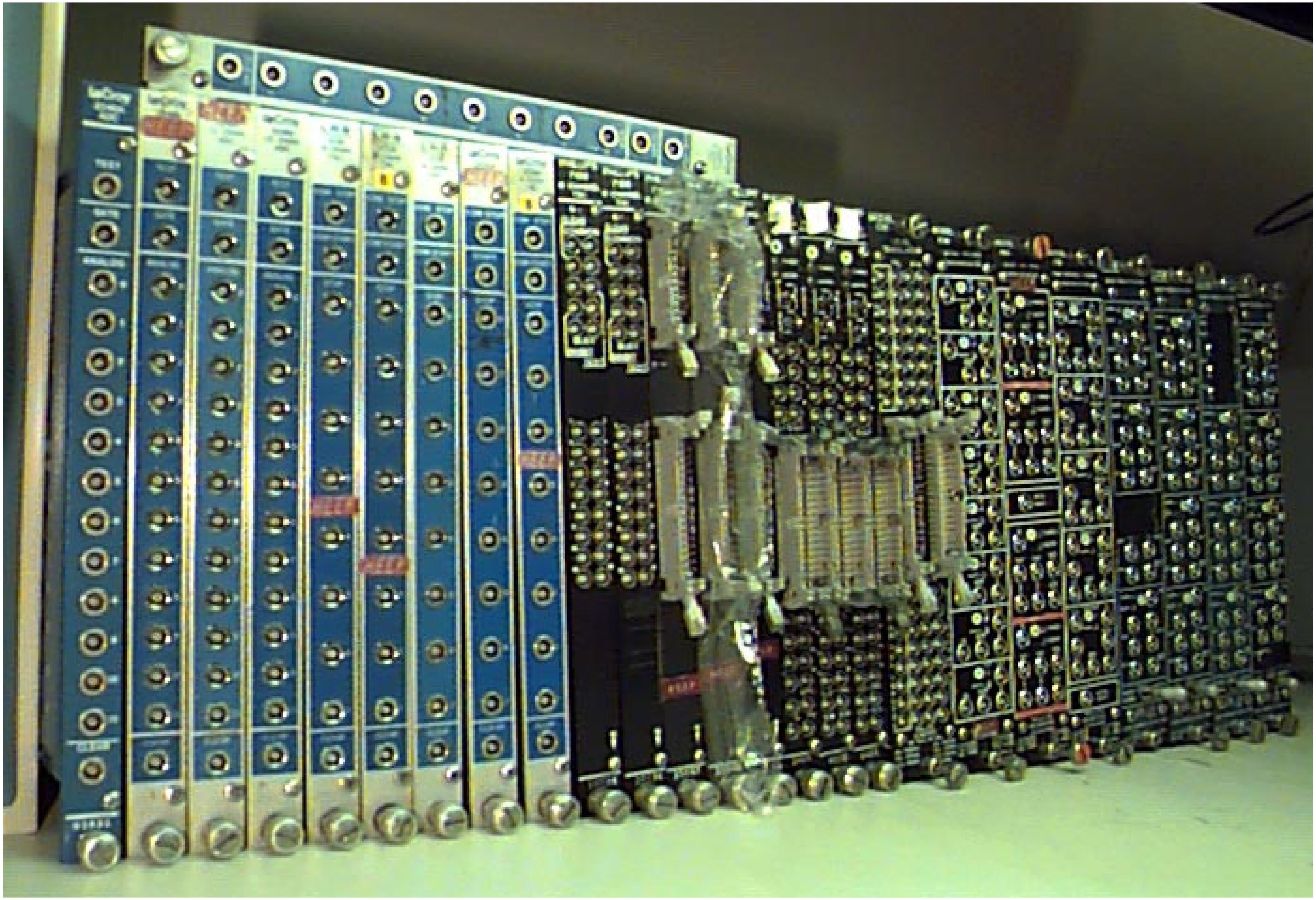
The PS7106 is out, the PS708 is in...
These also available from E896 TOF...

Info on 30ps mod to 2228A in hand...

All other components are as proposed...



Platform modules in hand...



LRS2249x LRS2228x PS7186 PS7106 PS&LRS Disc NIM
PS7186H

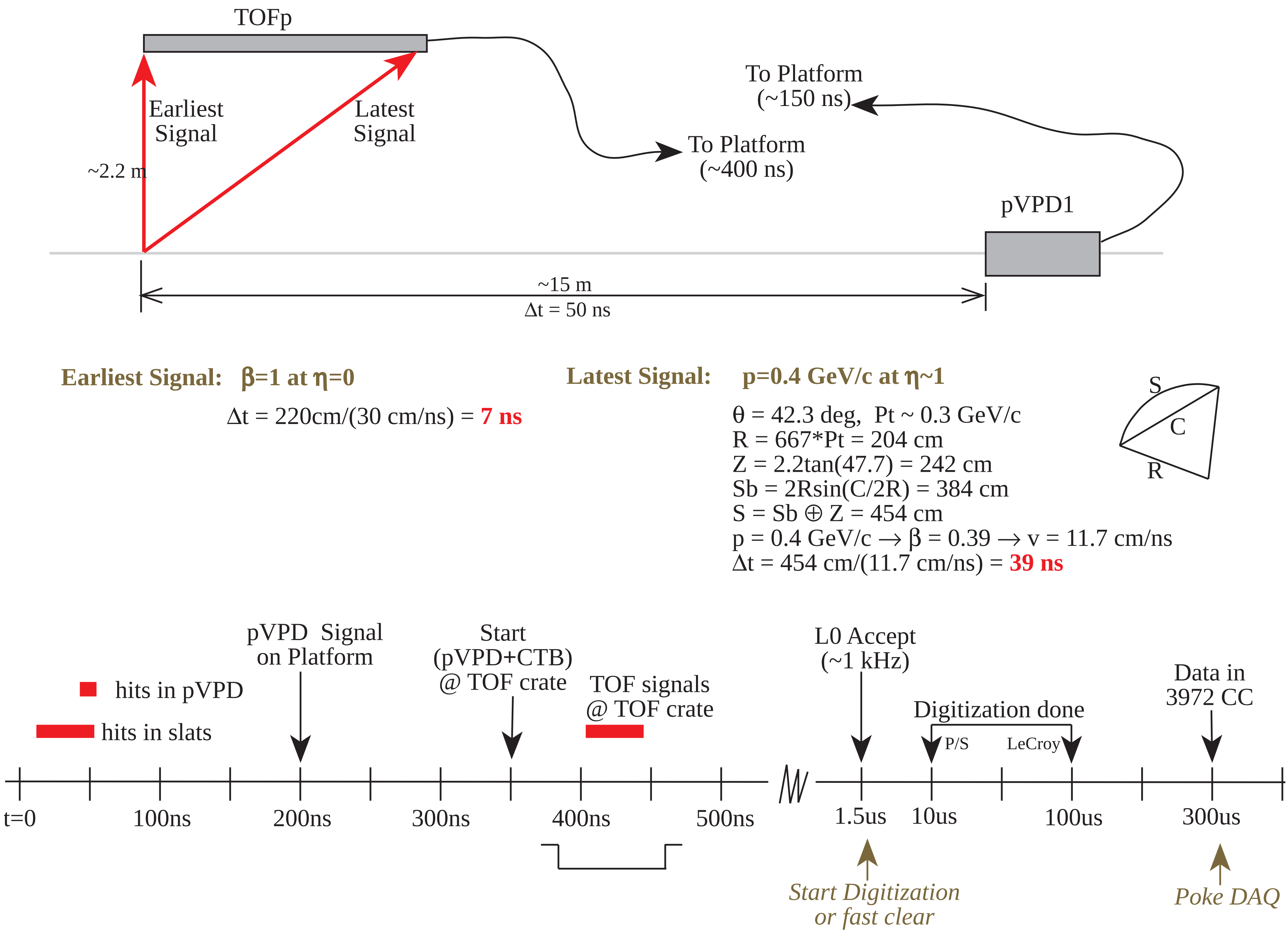
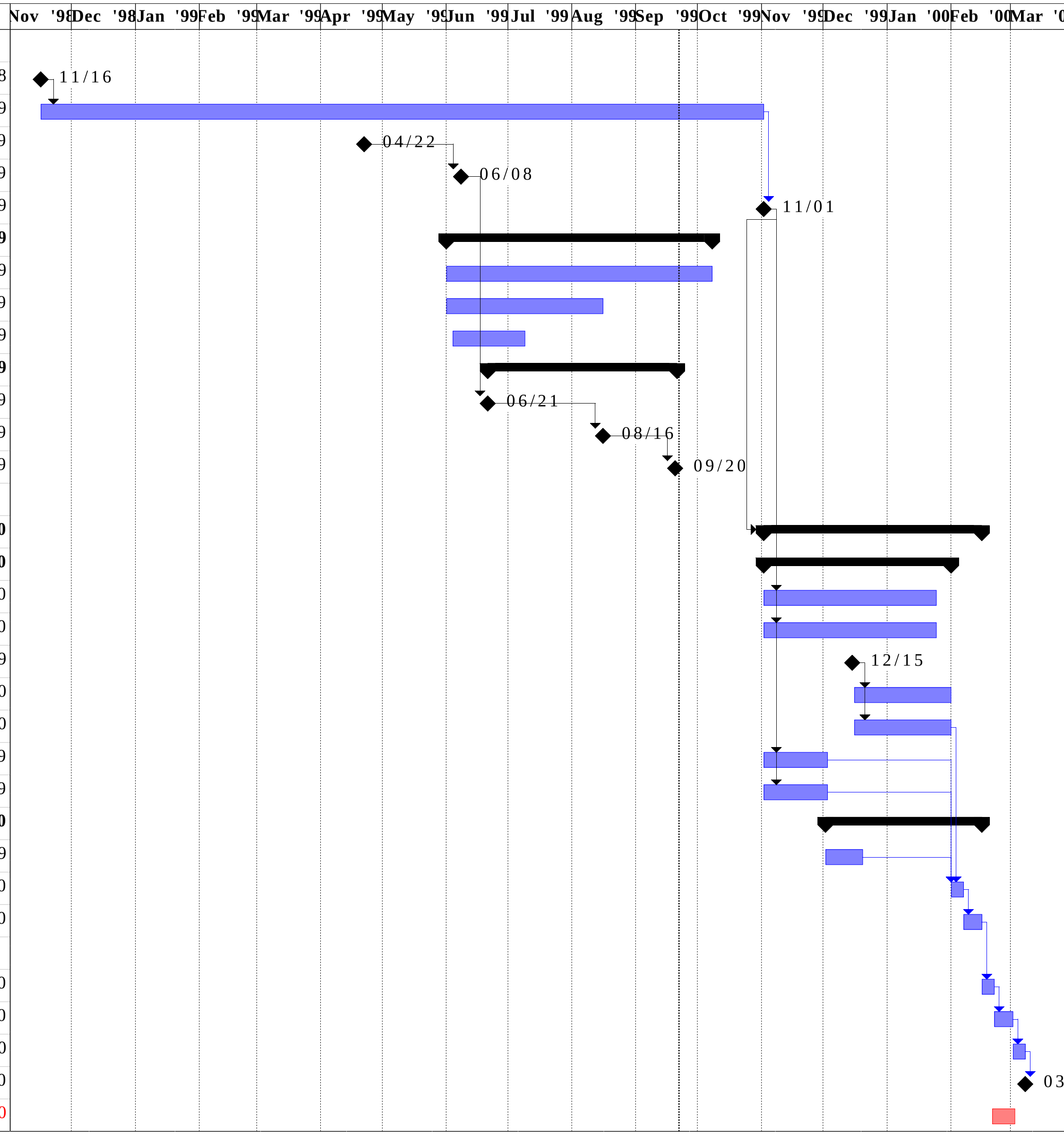

TOFp
Earliest
Signal
Latest
Signal
~2.2 m
To Platform
(~400 ns)
To Platform
(~150 ns)
pVPD1
~15 m
Δt = 50 ns
Earliest Signal: β=1 at η=0
Δt = 220cm/(30 cm/ns) = 7 ns
Latest Signal: p=0.4 GeV/c at η~1
θ = 42.3 deg, Pt ~ 0.3 GeV/c
R = 667*Pt = 204 cm
Z = 2.2tan(47.7) = 242 cm
Sb = 2Rsin(C/2R) = 384 cm
S = Sb ⊕ Z = 454 cm
p = 0.4 GeV/c → β = 0.39 → v = 11.7 cm/ns
Δt = 454 cm/(11.7 cm/ns) = 39 ns
S
C
R
hits in pVPD
hits in slats
pVPD Signal
on Platform
Start
(pVPD+CTB)
@ TOF crate
TOF signals
@ TOF crate
L0 Accept
(~1 kHz)
Digitization done
P/S
LeCroy
Data in
3972 CC
t=0
100ns
200ns
300ns
400ns
500ns
1.5us
10us
100us
300us
Start Digitization
or fast clear
Poke DAQ

Table 1: The cost for the TOFp System, including contributions from collaborating institutions. The contingency assumed for certain items is shown between parentheses. The costs shown in italics are the costs of contributed items.

ITEM	SOURCE	QUANTITY	LABOR ($)	EQUIPMENT ($)
Tray Interior				
Tray hardware	Oaks Precision	1	0	1000(25%)
BC420 slats	Bicron	45(4)	0	3465(10%)
Foam/Glue/Wrapping	various		0	875(25%)
R5946 PMTs†	Hamamatsu	25	0	*27500*
R5946 PMTs	Hamamatsu	20(4)	0	26400(20%)
FEE Boards	Rice v.5	12(2)		
Parts			0	5520(20%)
Stuff/Test§			3750(25%)	0
Cable assys	Amphenol	12(2)	0	2000(25%)
Feedthroughs	various		0	200(25%)
Cables				
RG-58/U Coaxial	Belden	80	0	6720(20%)
Low voltage	Newark	1	0	200(25%)
HVSys				
Cells	Astakhov *et al.*	45(4)	0	4500(20%)
System Module‡	Astakhov *et al.*	1	0	3000(20%)
Platform				
Patch Panel	Rice	1	0	3000(20%)
CAMAC Crate	HEEP	1	0	0
NIM Bin & logic	HEEP	1	0	0
P/S 7106 Disc	HEEP	6(2)	0	0
LRS ADC & TDC	HEEP	6(2) ea.	0	0
3470 24bit I/O†	Kinetics	1	0	*1000*
3972 Crate controller, 8MB†	Kinetics	1	0	*11000*
2961 Host adapter†	Kinetics	1	0	*9000*
2306 CPU, 32MB†	Motorola	1	0	*3000*
Trigger TCD Board	LBNL	1	0	4200(20%)
Installation				
Shipping	Rice		500(20%)	0
pVPD				
Detectors††		18(2)	0	*4000*
Mounting‡‡		2	0	*1000*
RG-58/U Coaxial‡‡	Belden	40(4)	0	*1200*
FEE	HEEP (or Rice v.5)	18(2) ch	0	0
Totals			4250	118780
Total				123030
Total, excluding contributions				65330
Total per channel,¶ excluding contributions				1452

† Contribution from IOPP/CCNU *et al.*, Wuhan and Beijing, China.
†† Contribution from Kent State University, Kent, Ohio.
‡‡ Contribution from Rice University, Houston, Texas.
‡ One HVSys System Module (to be the backup) is already in hand.
§ 25$ per hour for FEE stuff/test was assumed.
¶ 45 channels constructed was assumed, 41 of these are installed in the TOFp tray.

ID	Task Name	Duration	Start	Finish
1				
2	TOFp Proposal Submission	0 d	Mon 11/16/98	Mon 11/16/98
3	Review	251 d	Mon 11/16/98	Mon 11/01/99
4	SysTest-I Proposal Submission	1 d	Thu 04/22/99	Fri 04/23/99
5	SysTest-I Funding Available	1 d	Tue 06/08/99	Wed 06/09/99
6	Construction Funding Available	0 d	Mon 11/01/99	Mon 11/01/99
7	**SysTest-I**	**93 d**	**Tue 06/01/99**	**Thu 10/07/99**
8	Bench Data Collection	93 d	Tue 06/01/99	Thu 10/07/99
9	Signal Cable studies	54 d	Tue 06/01/99	Mon 08/16/99
10	HVSys Cell Design and Fab (6	25 d	Fri 06/04/99	Fri 07/09/99
11	**FEE Design and Fab**	**66 d**	**Mon 06/21/99**	**Tue 09/21/99**
12	Version 3, LE, 2ch	1 d	Mon 06/21/99	Tue 06/22/99
13	Version 4, CF, 1ch	1 d	Mon 08/16/99	Tue 08/17/99
14	Version 5, LE&CF, 5ch	1 d	Mon 09/20/99	Tue 09/21/99
15				
16	**Construction**	**76.13 d**	**Tue 11/02/99**	**Wed 02/16/00**
17	**Slat Assemblies**	**65.13 d**	**Tue 11/02/99**	**Tue 02/01/00**
18	Slat Fab (Bicron)	60 d	Tue 11/02/99	Mon 01/24/00
19	PMT Fab (Hamamatsu)	60 d	Tue 11/02/99	Mon 01/24/00
20	PMT Partial Delivery	1 d	Wed 12/15/99	Thu 12/16/99
21	PMT Burn/Test	33 d	Thu 12/16/99	Tue 02/01/00
22	Assy Glue/Wrap/Grade	33 d	Thu 12/16/99	Tue 02/01/00
23	HVSys Cell Fab (50)	23 d	Tue 11/02/99	Fri 12/03/99
24	FEE v5 Fab (11)	23 d	Tue 11/02/99	Fri 12/03/99
25	**TOFp Tray**	**54 d**	**Thu 12/02/99**	**Wed 02/16/00**
26	Tray Hardware Fab	12 d	Thu 12/02/99	Mon 12/20/99
27	Tray Fill	4 d	Tue 02/01/00	Mon 02/07/00
28	SysTest-II	7 d	Mon 02/07/00	Wed 02/16/00
29				
30	Ship to BNL	4 d	Wed 02/16/00	Tue 02/22/00
31	Test at BNL	7 d	Tue 02/22/00	Thu 03/02/00
32	TOFp Installation/Cabling	4 d	Thu 03/02/00	Wed 03/08/00
33	TOFp Construction Complete	0 d	Wed 03/08/00	Wed 03/08/00
34	pVPD Installation	8.88 d	Mon 02/21/00	Thu 03/02/00



Project: TOFp.MSProj
Date: Wed 09/22/99

Task | Milestone | Rolled Up Task | Rolled Up Progress
Progress | Summary | Rolled Up Milestone

TOFp Groups:

Rice University:

Construction of loaded TOFp Tray, signal cables, and patch panel...
TOFp SysTest-II...
TOFp Installation and Commisioning...
TOFp offline software...
TOFp project management...

CCNU/IOPP, Beijing and Wuhan, China: Liu Lianshou *et al.*

Construction of TOFp DAQ Interface hardware and VxWorks software...
Implementation of TRG/TOFp DAQ Interface...
Purchase 25 R5946 PMTs...
Visitors to BNL and Rice for DAQ/TRG development and operation...
Separate proposal to CNSF for larger contributions to STAR TOF (in ~1 yr)

Kent State University: Declan Keane *et al.*

Liu Heng - ramping up to ~0.5FTE on TOFp offline software...
4k$ contribution for pVPD hardware...
Others in group potentially available later...

UC-Berkeley: Hank Crawford *et al.*

Help as needed with implementation of TRG/TOFp interface...

LBNL (Jacobs), MIT (Ogilvie), and others...

Still true believers, but unable to commit significant resources at the moment...

pVPD Groups:

Johns Hopkins University: John Mitchell

pVPD Hardware and commissioning...
Interface to TOFp...

Rice University:

Interface to TOFp...
Some funds if necessary...

Carnegie Mellon University: Mort Kaplan *et al.*

pVPD Simulations and commissioning...