Detector Design & Construction

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☆ TOF Review, BNL

January 26-27, 2006

Outline:

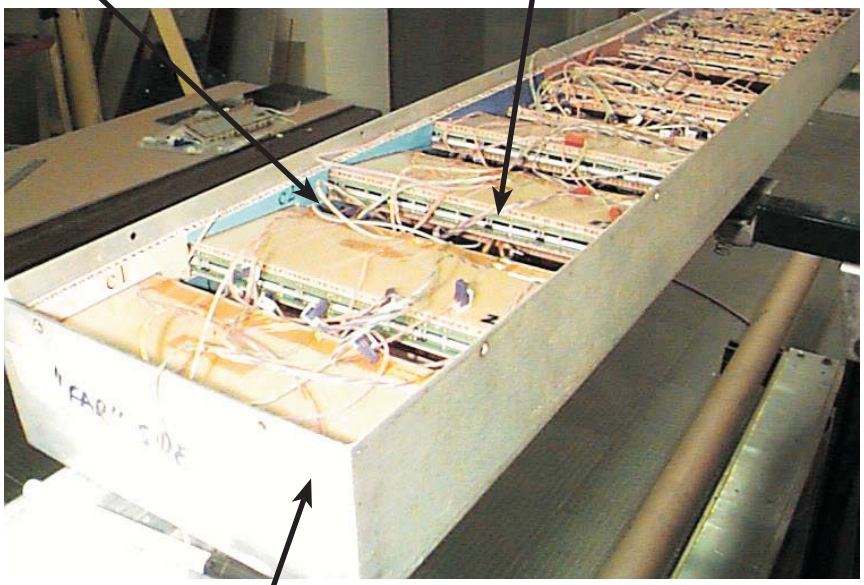
- Tray mechanical design
  - TOFr, TOFr', TOFr5, &TOFrX
- Impact of full system on STAR
  - weight
  - power & temperature
  - secondary production
  - gas containment
- Tray Fabrication
  - space and fixtures
  - detailed procedure
  - 126 tray production plan
- Start detector
  - simulations
  - new base development & tests
  - Run-6 prototype

D&M: TOFr (Run-3)

first implementation of the MRPC technology in a collider experiment
readout uses (TOFp's extremely well-understood) CAMAC DAQ
→ do these detectors work at all for us?

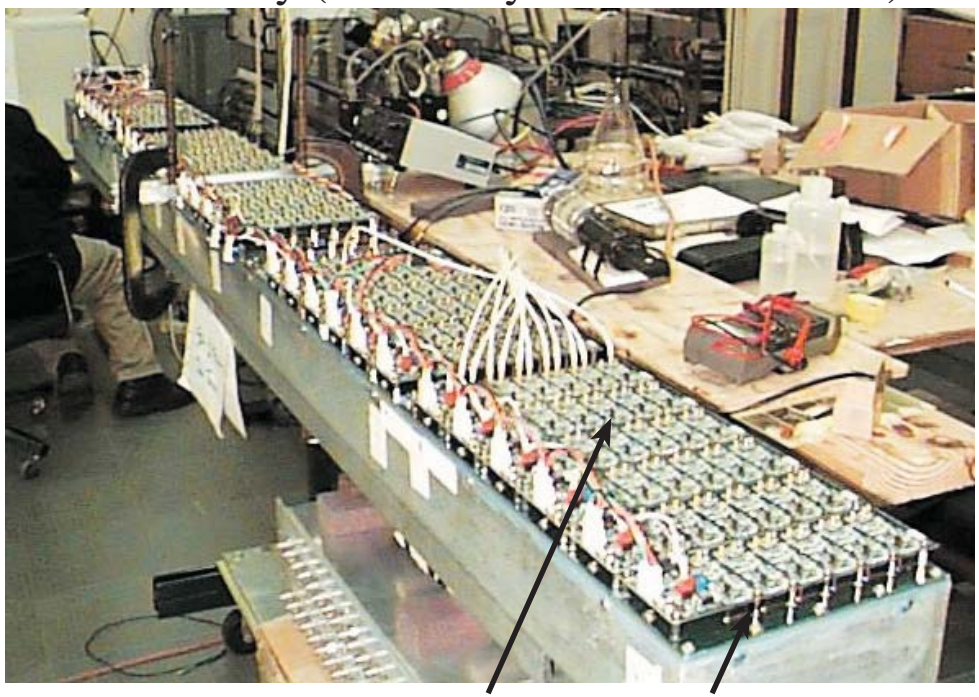
welded/tapped rail assembly
(glued gaskets also)

"sawtooths" USTC & CERN MRPCs



standard CTB tray

final TOFr tray (note many cables not shown!)



FEE layer F/T layer

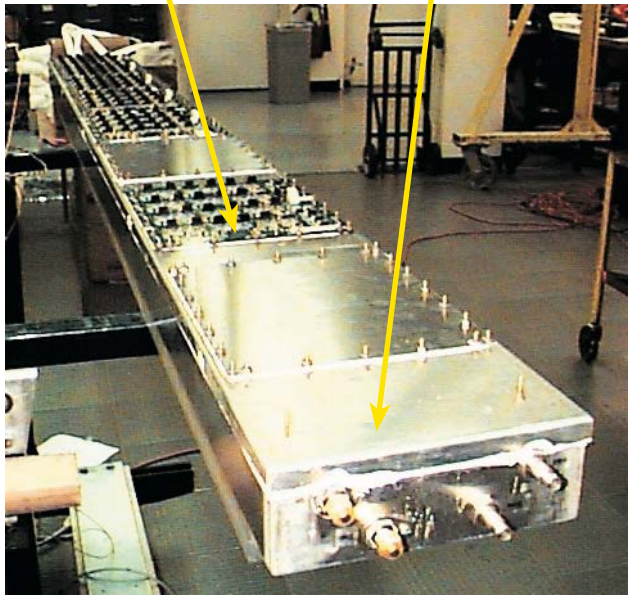
- fabrication extremely labor intensive...
  sawtooths, rail assy
- complicated gas sealing...
  gaskets, sealant (was also *wrong* sealant)
- MRPC placement w/in box too imprecise...
  each sawtooth placed individually
- overall, too tall

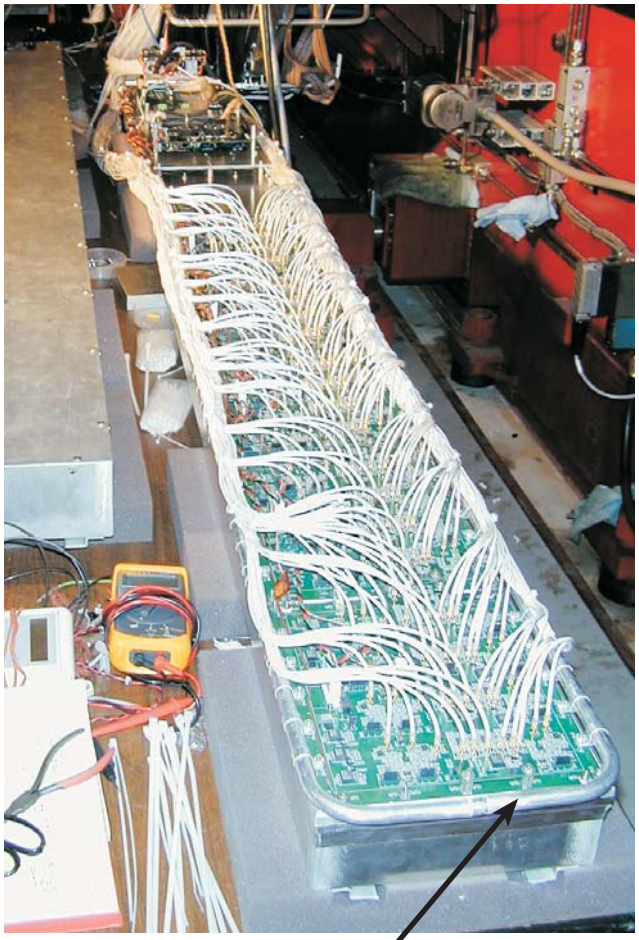
D&M: TOFr' (Run-4)

completely new tray and electronics
first system to use a TOF-specific box, not a recycled CTB box
one FEE layer, which also closes the gas volume
new batches of MRPCs (USTC, Tsinghua)

TFEE

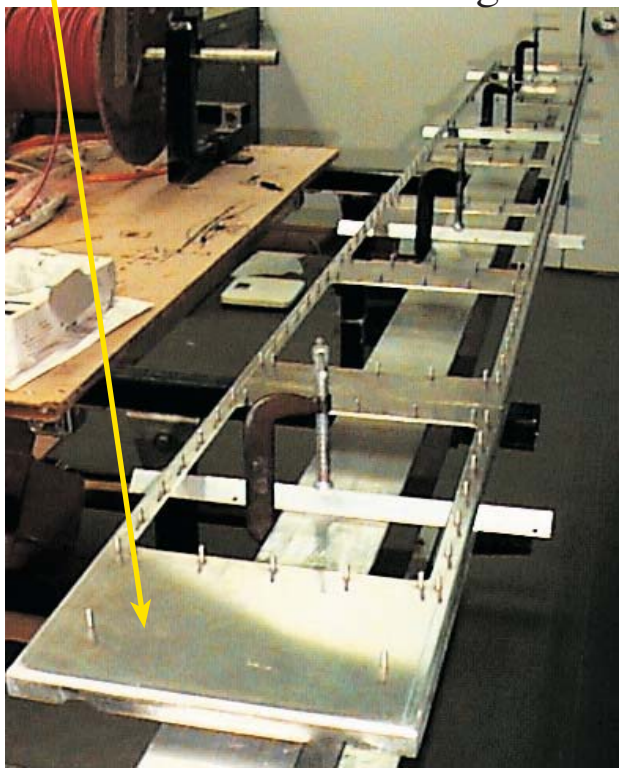
"Shoebox" top





"last minute" cooling loop

top assy now fabbed out of house
stamped, braked, welded
PEM studs
positioned to few mils
no tapping
much easier to gas-seal



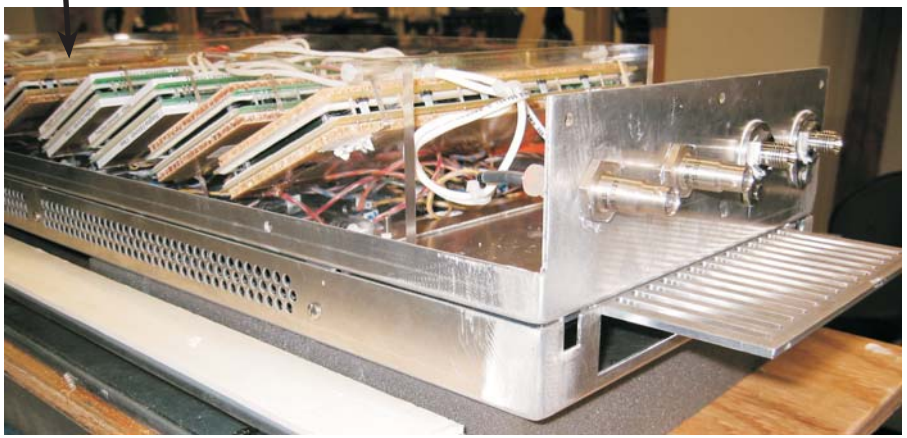
- fabrication ~~extremely~~ labor intensive...
  sawtooths, ~~rail assy~~
- ~~complicated gas sealing~~...
  ~~gaskets~~, *less* sealant (but the correct sealant this time)
- MRPC placement w/in box too imprecise...
  each sawtooth placed individually
- overall, too tall

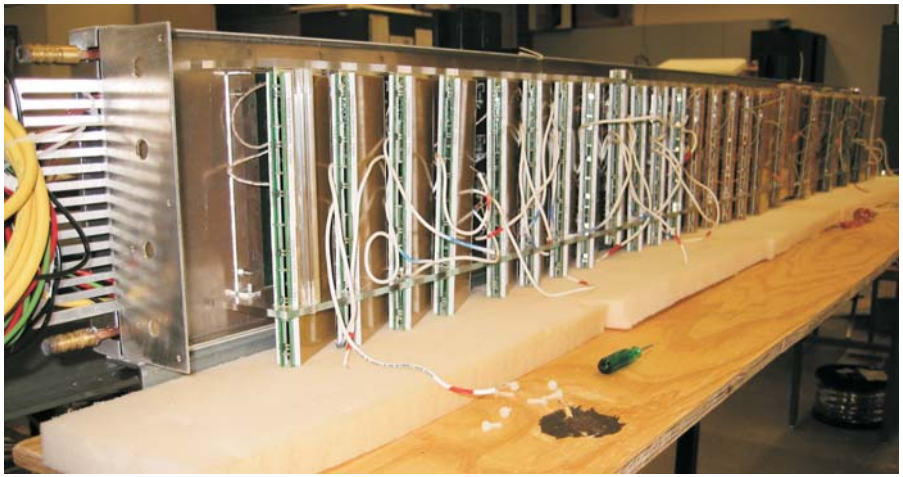
FEE dumped a lot of heat into the box
increased MRPC current draw, & noise rates...
timing seemed o.k. but...

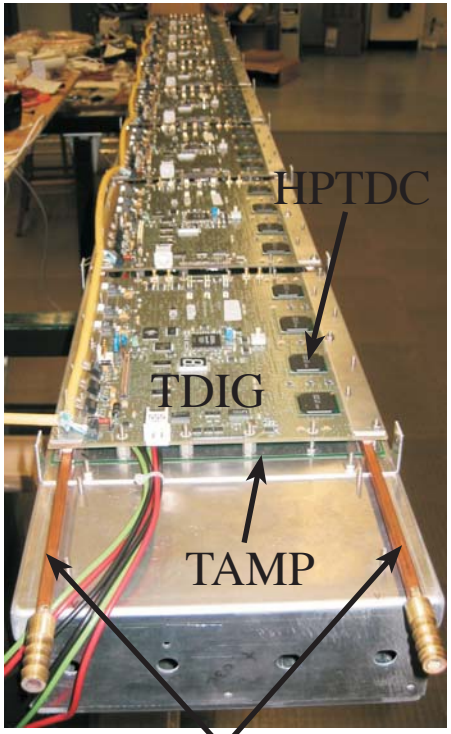
D&M: TOFr5 (Run-5)

First attempt at on-board digitization
Back to two layers of on-board electronics
Integrated cooling loop
new batches of MRPCs (USTC & Tsinghua)

"Inner Sides" instead of sawtooths...
lexan machined on hurco machine to few mils
MRPCs held in reveals cut into the inner sides
Inner sides bolt to underside of top assy







perf. cover assy

cooling loop

- ~~fabrication extremely labor intensive~~...
  ~~sawtooths, rail assy~~
- ~~complicated gas sealing~~...
  ~~gaskets~~, *less* sealant
- ~~MRPC placement w/in box too imprecise~~...
  ~~each sawtooth placed individually~~
- ~~overall, too tall~~

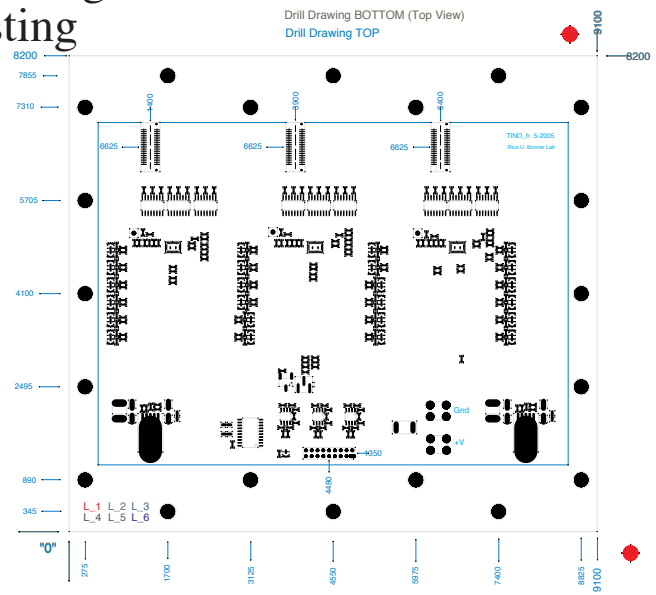
small tweaks to box & inner sides design
integration of TINO, TDIG version 2, & cooling

TOFr5 cooling loop tests & efficiency/power estimates:
http://wjllope.rice.edu/~TOF/TOFr5/Ttests/TOFr5_T_tests.htm

Mechanical Design Summary

3 generations of TOFr trays
(all rebuilt from the ground up)
all met the physics goals

subsequent trays (TOFr6, ...) will be
simple variants of the TOFr5 design:
- simple, quick, & repeatable to assemble
- very precise detector positioning
- open-box MRPC→FEE testing



Overview of TOFr5 Design

Effects on other STAR subsystems

- weight
- power, cooling, & temperature
- interaction and radiation lengths
- gas containment

4th Generation Prototype (TOFr6)

simpler cooling loop design
1/4” square → 1/4”x3/8” rectangular

only small tweaks to mechanical design
TINO
new cooling loop

tweaks to tray fabrication
bowing from welded feet
(moving back to pop-rivets)

TINO
lower power
no ringing
fully differential
multiplicity outputs
now only need positive LV!

TDIGb
accepts signals from TINO
(remove discriminators)
address timing cross-talk
multiplicity

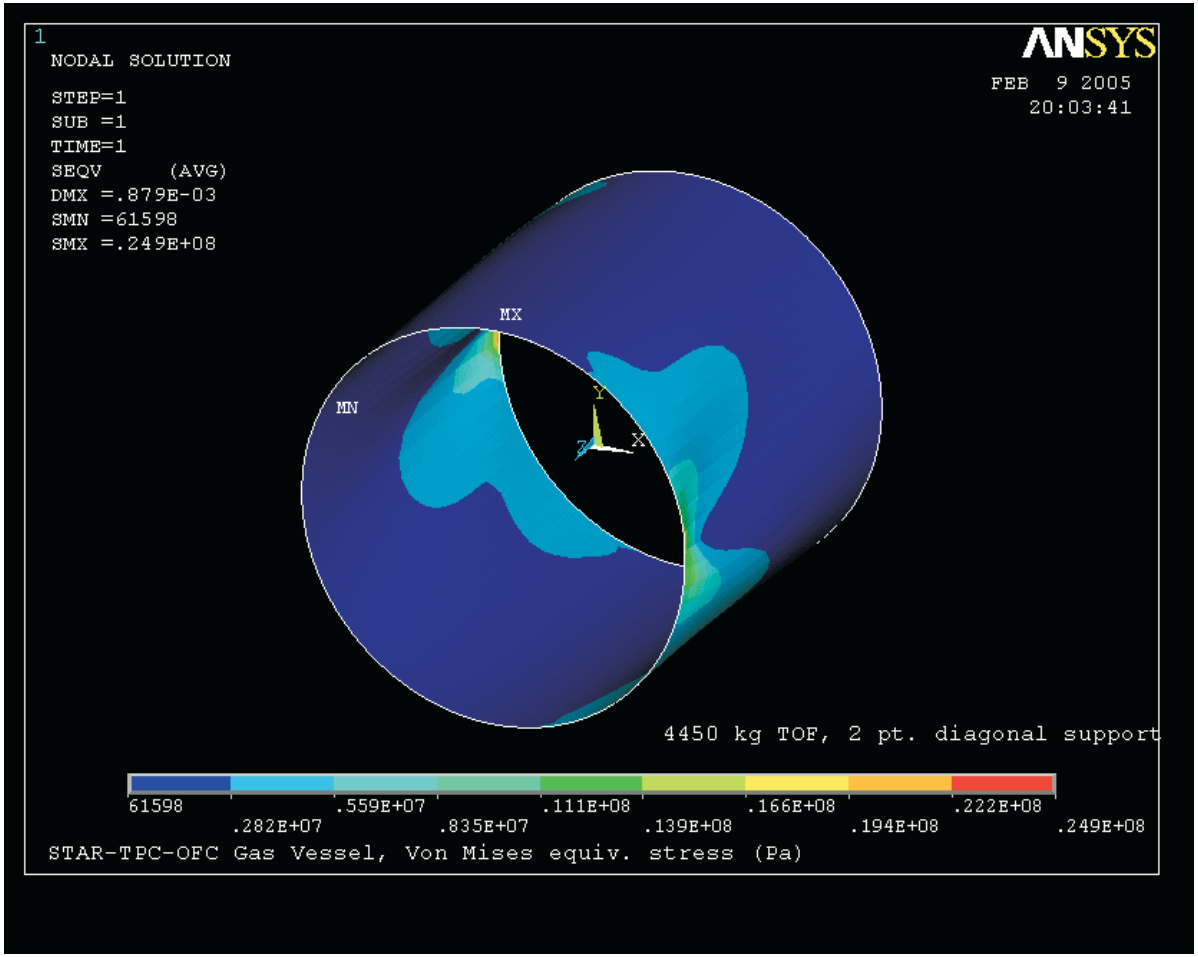
Weight issues

each TOF tray is ~75 lbs, 9,000 lbs total
what are the mechanical safety factors for:

1. "Rails" to TPC OFC epoxy joints
2. TPC support arms and end-structures
3. OFC itself

new ANSys simulations by Derek Shuman for a 10,000 lb TOF

2. assume 4-point support and 2-point support (one arm misaligned).
3. assume specific model for skin composition (glued-on rails stiffen the structure).



results for 1.
tof rails can support
3.2 klb peel
1.6 Mlb shear
2.2 Mlb tension
→ 1 klb trays would not defeat the epoxy

results for 2.
4-support max stress ~ 12.6 MPa
2-support max stress ~ 24.9 MPa

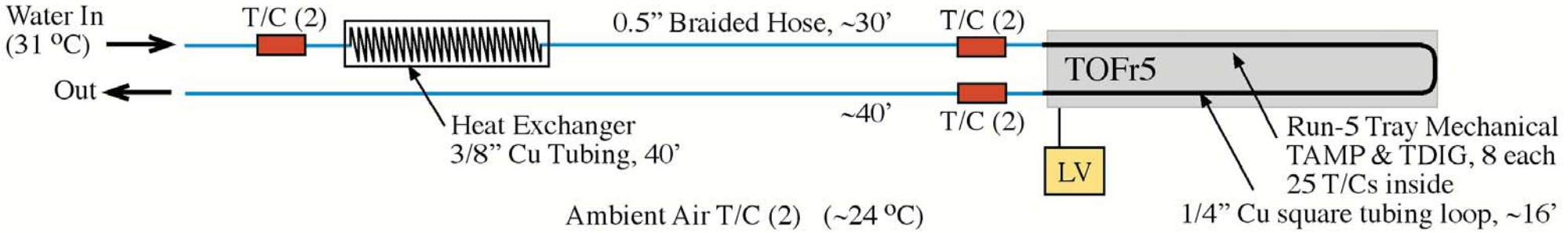
"well under yield point 214 MPa
for the H5052-H34 Al used..."

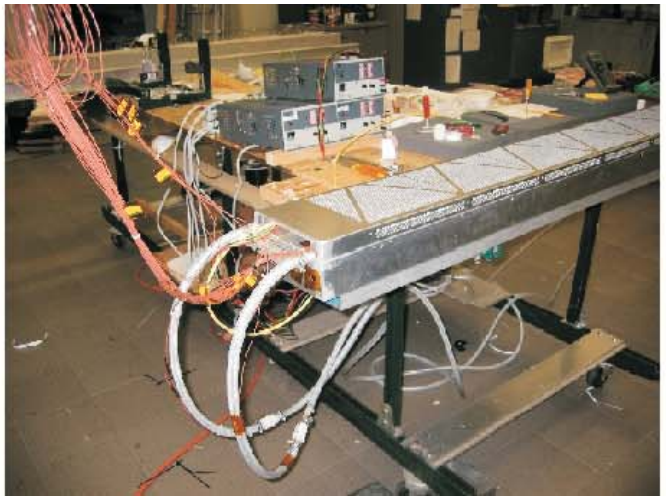
results for 3.
Tangential direction normal stresses
"are only 6.5 MPa localized near
the support in the 2-arm configuration"

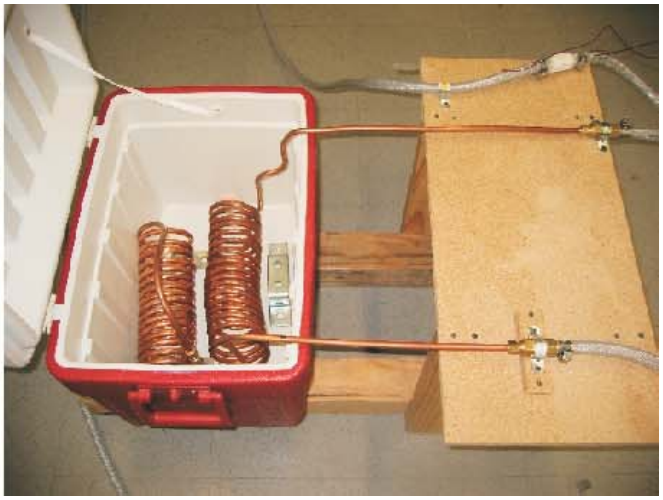
Power, Cooling, & Temperature Issues

TOFr5 electronics drop 140 +/- 10 W (TOFr6 < 100W?)

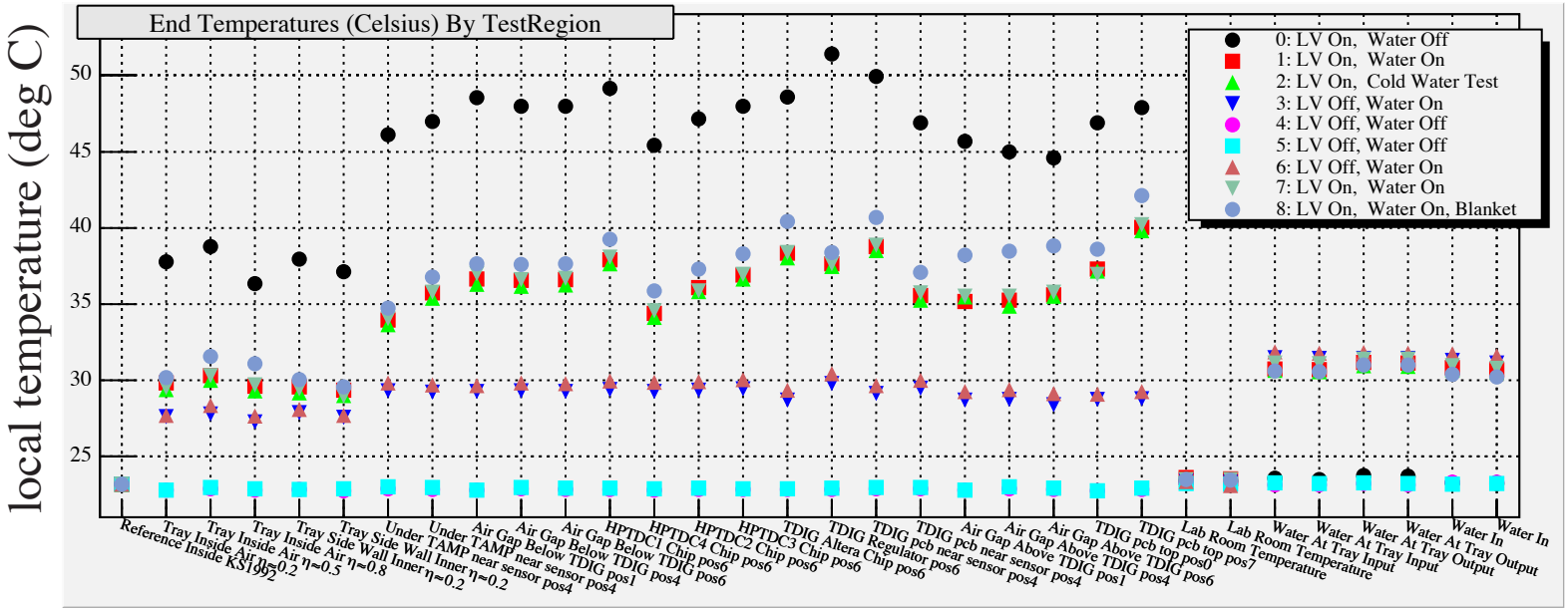
Efficiency of TOFr5's embedded 1/4"-square Cu cooling loop measured at RICE
- 32 Type-T thermocouples inside tray, on electronics, plus ambient, water in&out, etc.
- Kinetics 1992/3516 T/C readout via CAMAC to PC
  - measurement error <0.2 deg C
- full complement of TAMP & TDIG electronics installed and powered up
- water flow unfortunately 31 deg C (is <25 deg C in STAR)
- perforated top assembly!







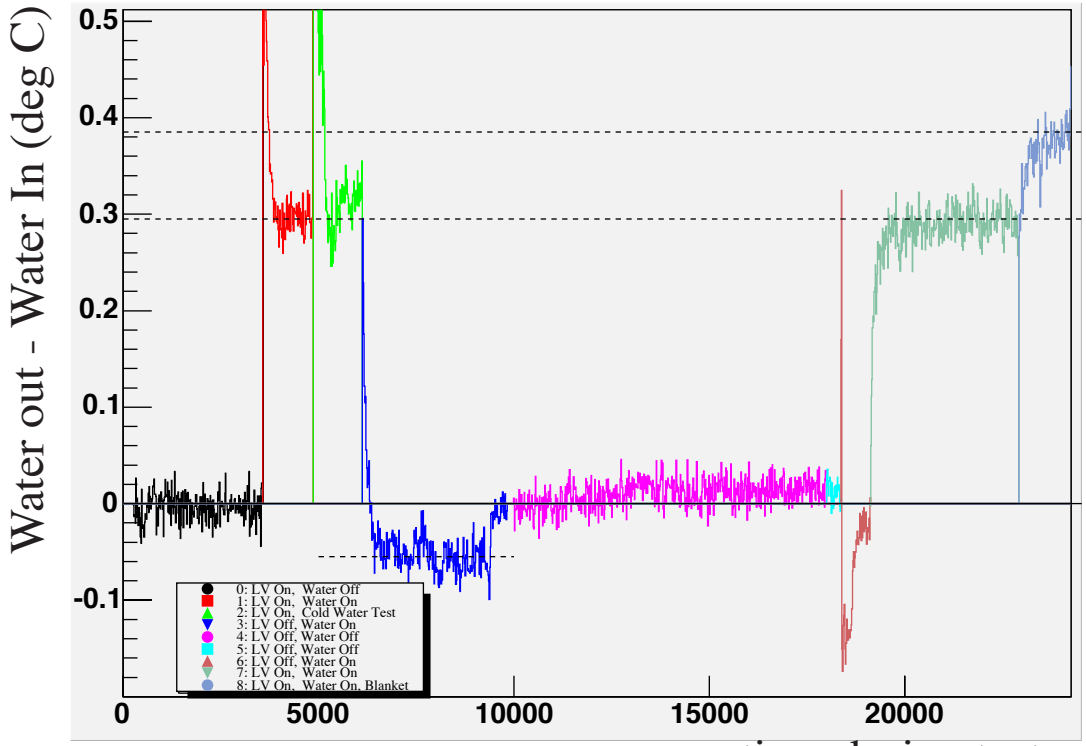
http://wjllope.rice.edu/~TOF/TOFr5/Ttests/TOFr5_T_tests.htm



max T, water flow off
~52 deg C

HPTDC spec
<60 deg C
regulators spec
<80 deg C

max T w/ warm water
~40 deg C



Power estimates

105 W removed by (warm) water!
(~3/4 of 140W total dropped)

remainder is estimated to be:

convective	~0W
radiative (skin)	~3W
radiative (FEE)	~30W

these calculations suggest radiative power could be ~halved with a solid cover...
TINO also drops total power to <100 W

will repeat these tests using TOFr6 trays
both solid and perforated cover assys
both square and rectangular loops
(improved thermal efficiency)

Secondary production

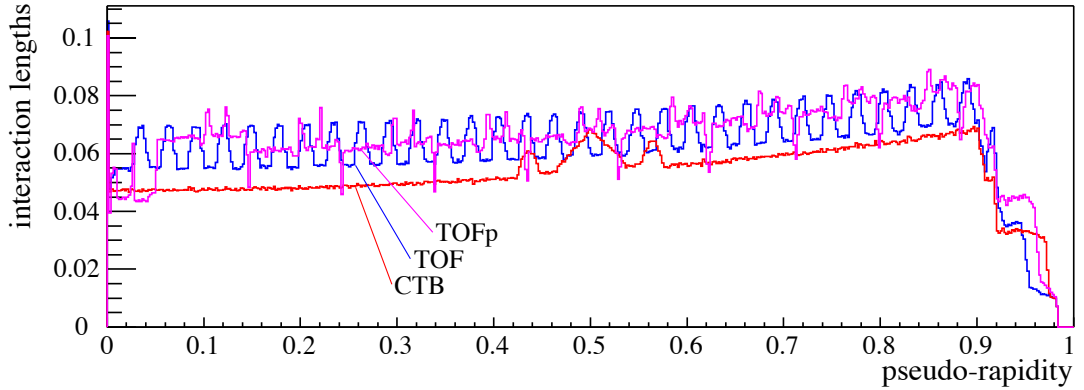
estimates from AGI+gstar simulations

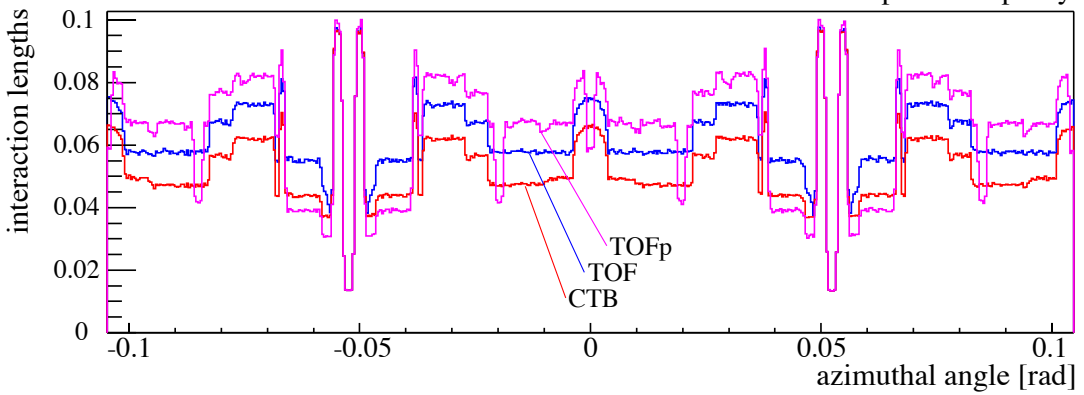
full description of MRPCs

TOF: ~6.5% of λ_0

CTB: ~4.9%

→ 32% more than CTB

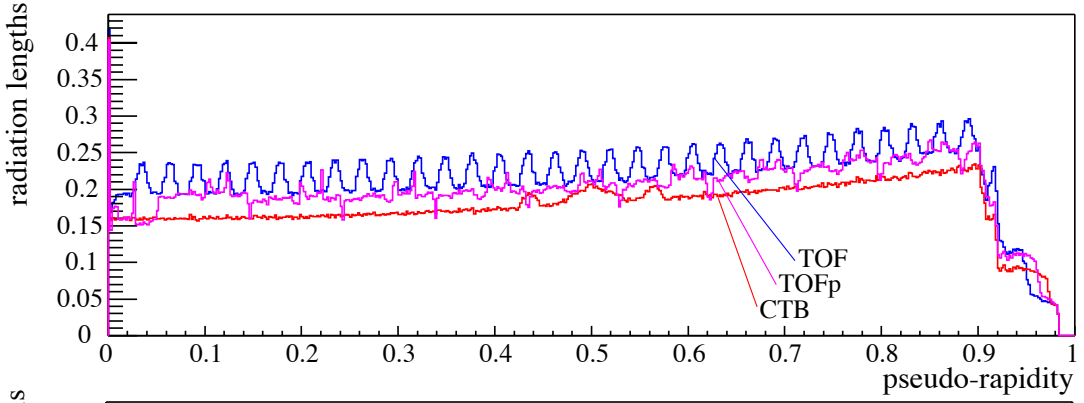


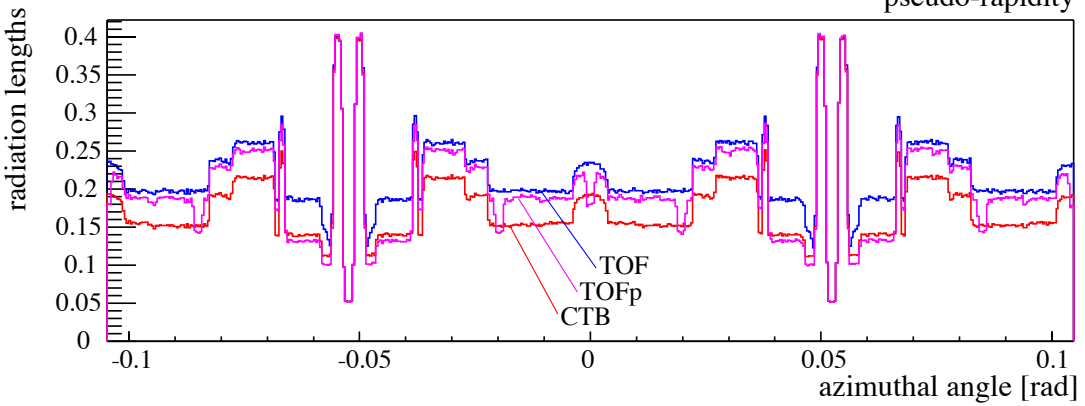


TOF: ~20% of X_0

CTB: ~15%

→ 33% more than CTB





Gas Containment

best MRPC performance obtained with 90% Freon, 5% iso-butane, & 5% SF6
most early papers on MRPC just call this “the standard mixture”

concern is the detrimental effects that SF6 would have on the TPC performance
Alice result: http://rjd.home.cern.ch/rjd/Alice/frac_SF6.html
“...if an electron is to have a 50 % probability to survive 2.5 m drift,
the SF6 level should not exceed 2 ppb.”

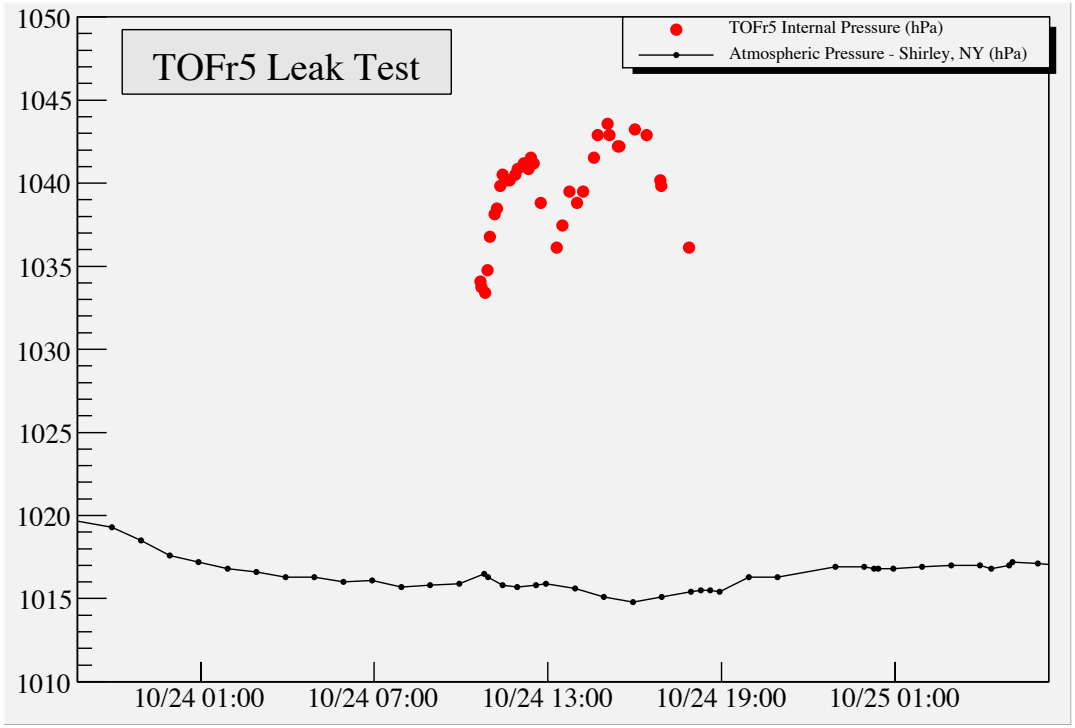
Thus, we have used only 95% Freon & 5% iso-butane during Runs 3 through 5...

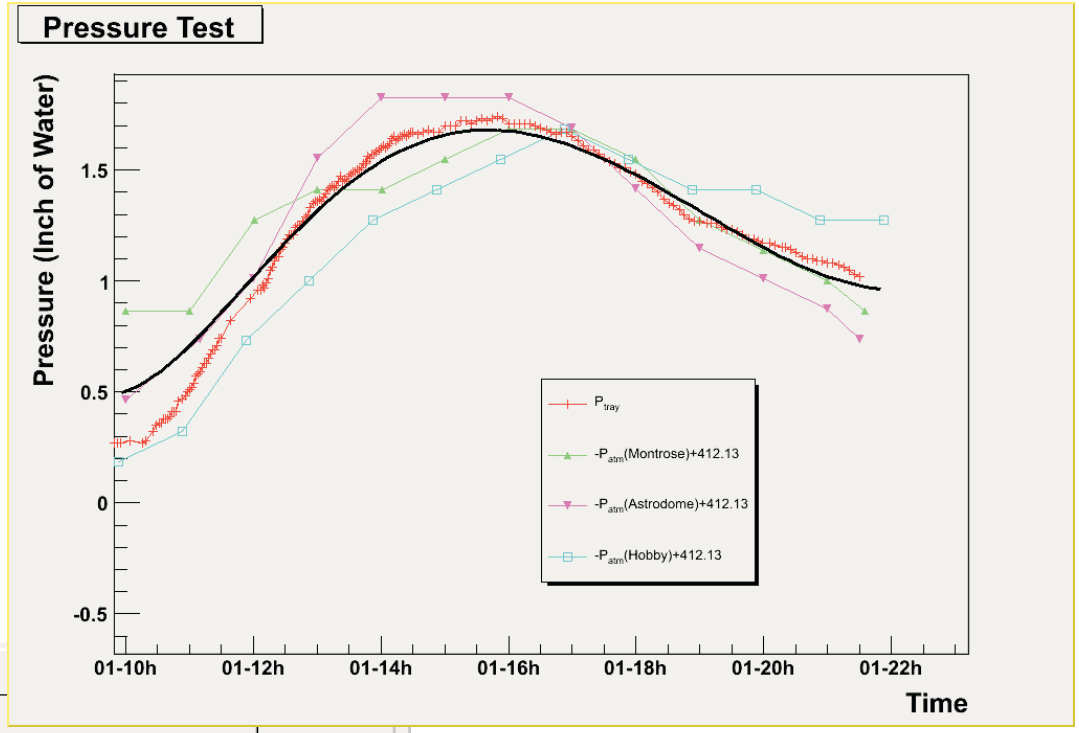
measured leak rates for 3 TOFr prototypes so far

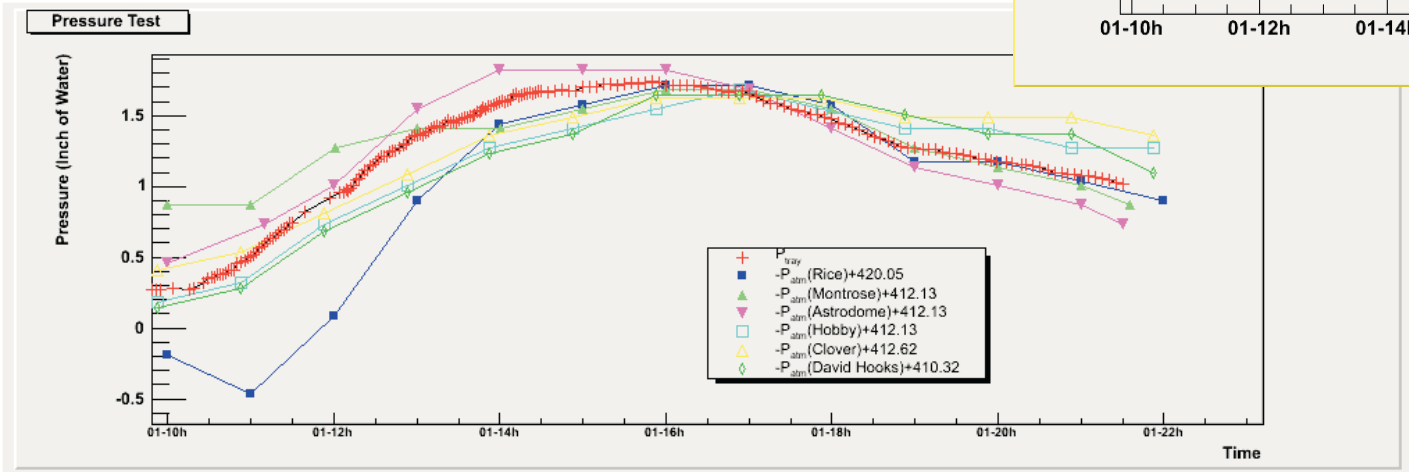
tray pressurized to ~1” above atmospheric
pressure vs time measured w/ sensitive gauge
HV connectors need to be terminated!
FEE should be off and cool or on and hot!

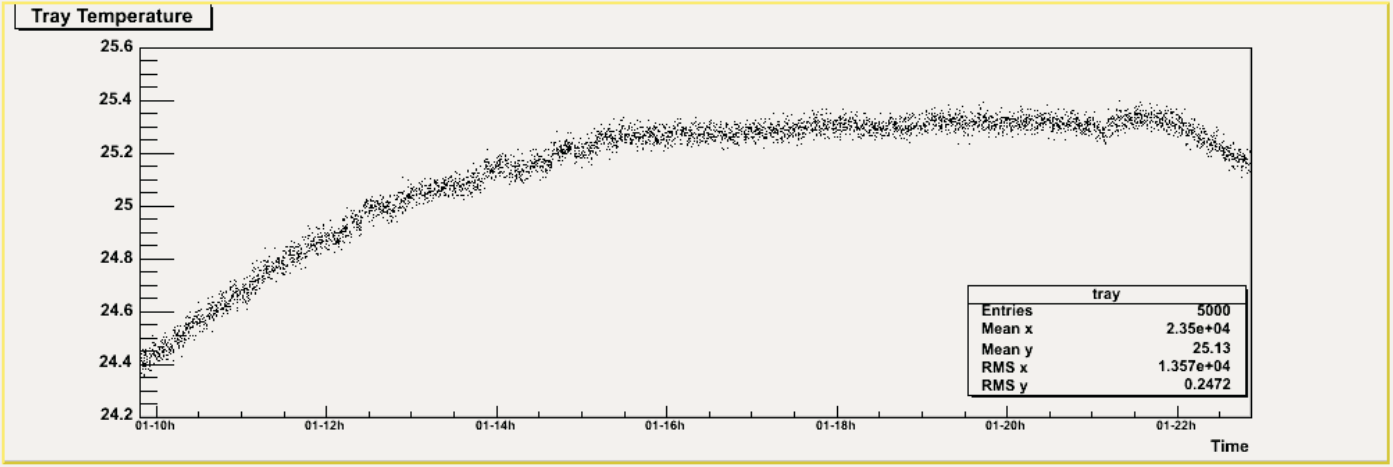
→ finite leak rate measured for TOFr (Run-3) -
modified CTB box
welded rail assy
glued gaskets

→ no measurable leaking for TOFr’ and TOFr5
TOFr-specific “shoe-box” style gas box
FEE sealed directly to tray aluminum




Pressure Test
Pressure (Inch of Water)
1.5
1
0.5
0
-0.5
01-10h
01-12h
01-14h
01-16h
01-18h
01-20h
01-22h
Time
P tray
-P atm (Montrose)+412.13
-P atm (Astrodome)+412.13
-P atm (Hobby)+412.13


Pressure Test
Pressure (Inch of Water)
1.5
1
0.5
0
-0.5
01-10h
01-12h
01-14h
01-16h
01-18h
01-20h
01-22h
Time
P tray
-P atm (Rice)+420.05
-P atm (Montrose)+412.13
-P atm (Astrodome)+412.13
-P atm (Hobby)+412.13
-P atm (Clover)+412.62
-P atm (David Hooks)+410.32


Tray Temperature
25.6
25.4
25.2
25
24.8
24.6
24.4
24.2
01-10h
01-12h
01-14h
01-16h
01-18h
01-20h
01-22h
Time
tray
Entries 5000
Mean x 2.35e+04
Mean y 25.13
RMS x 1.357e+04
RMS y 0.2472

Tray Fabrication Assumptions:

- tray structures produced in Houston at Oaks Precision
  QA/QC of fit & finish and size tolerances at RICE
- electronics produced in Houston (RICE, Blue Sky)
  TINO on tray fabrication critical path, and must undergo stricter pre-install testing
- tray Assembly and testing at UT-Austin
  MRPCs shipped to UT at rate of 160/month
    bench tests of each MRPC in china and documented on WWW
    no gas-box tests of MRPCs at UT before insertion into trays (except first few hundred)
    size tolerance testing only
- tray retesting (HV current draw & noise rates) at BNL

Final tray fabrication follows TOFr5 model...
  requires special table that can hold top+cover assembly flat and at a 90 deg angle

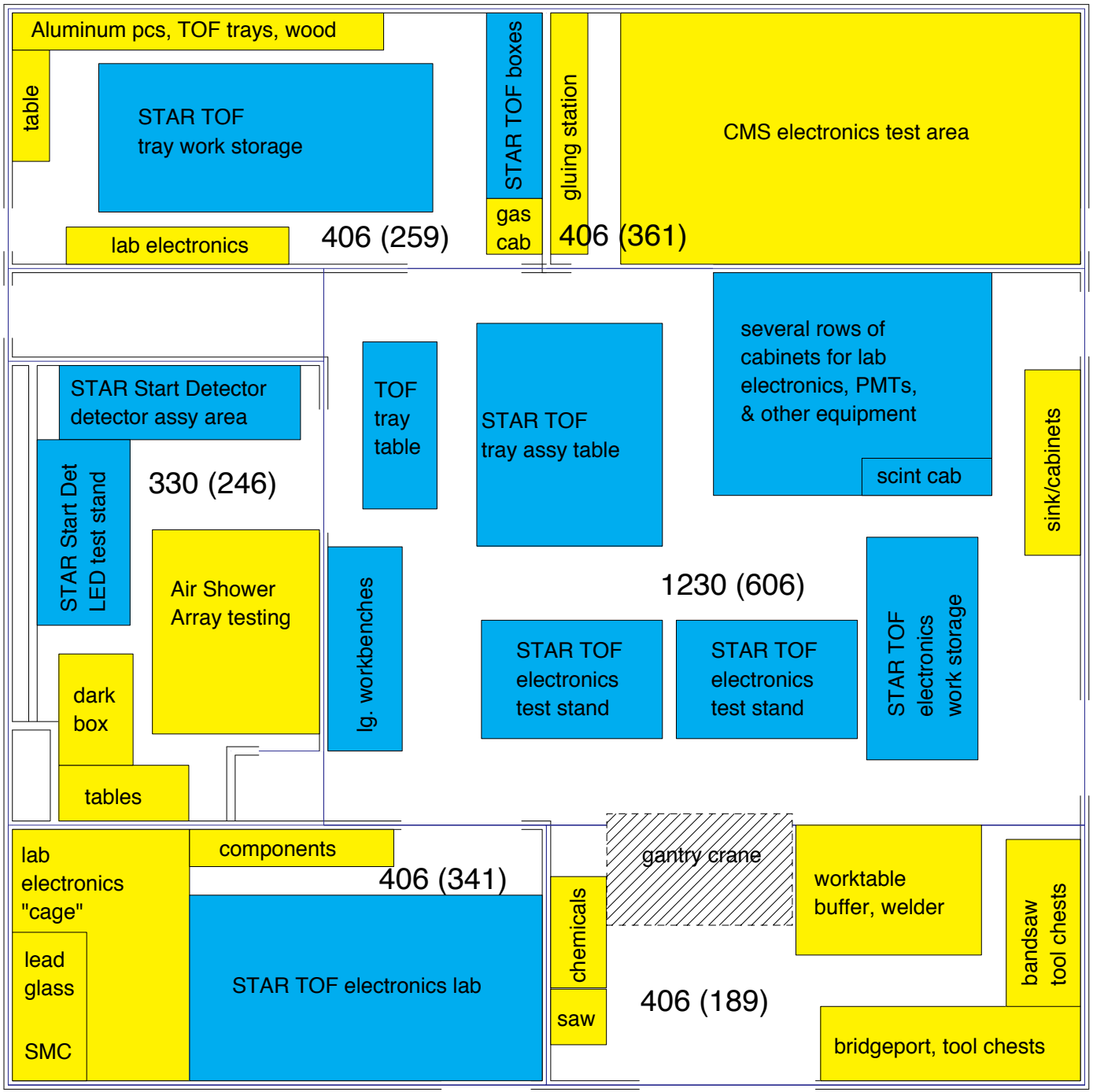
Working now within the group to set up the size and skewness specs & tolerances for MRPCs & Trays

manpower assumed is 2.5yr Mechanical Technician and 1 FTE undergraduate for 2yrs at UT
assumes also UT Postdoc (0.5 FTE) for Fabricated Tray testing
Rice Postdoc (0.5 FTE) for Electronics testing

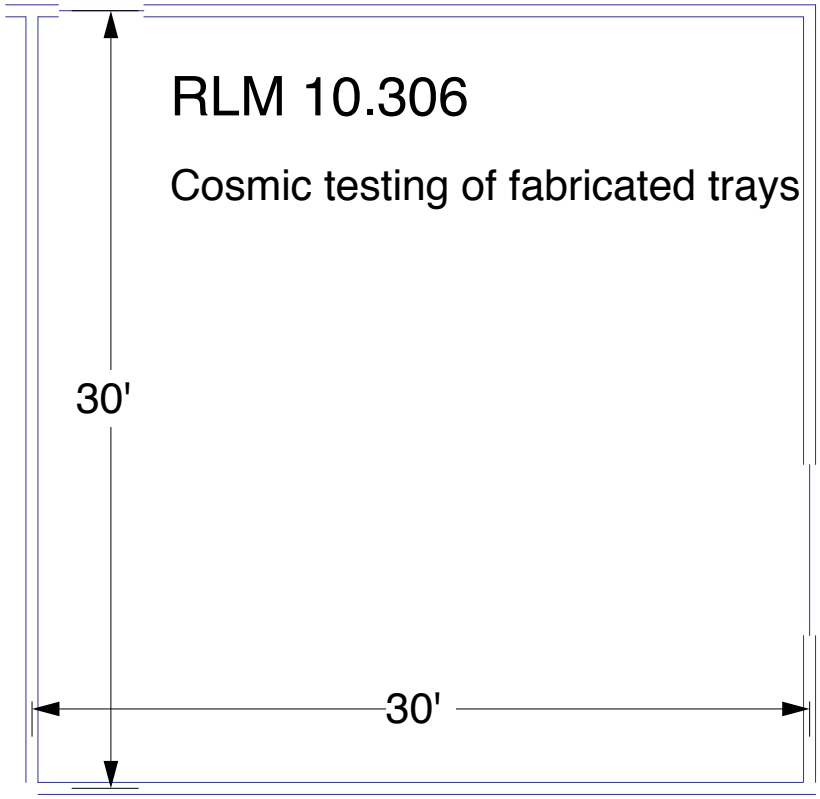
UT machine shop fabricates inner sides and cooling loops
  labor is contributed...
  raw mtls costs only...

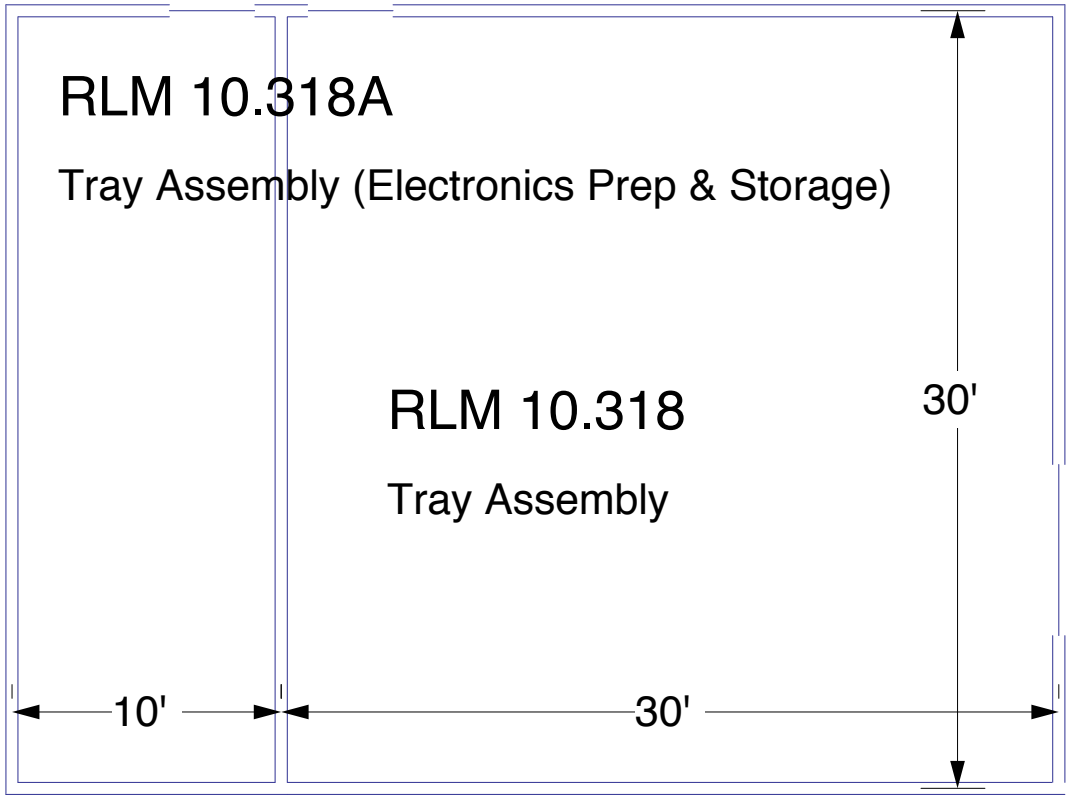
tray fabrication workflow and fabbed tray documentation system is under development.

Space @ RICE


Aluminum pcs, TOF trays, wood
table
STAR TOF
tray work storage
lab electronics
406 (259)
STAR TOF boxes
gas
cab
gluing station
406 (361)
CMS electronics test area
several rows of
cabinets for lab
electronics, PMTs,
& other equipment
scint cab
sink/cabinets
STAR Start Detector
detector assy area
STAR Start Det
LED test stand
330 (246)
TOF
tray
table
STAR TOF
tray assy table
Air Shower
Array testing
lg. workbenches
1230 (606)
STAR TOF
electronics
test stand
STAR TOF
electronics
test stand
STAR TOF
electronics
work storage
dark
box
tables
lab
electronics
"cage"
components
406 (341)
lead
glass
SMC
STAR TOF electronics lab
chemicals
saw
gantry crane
406 (189)
worktable
buffer, welder
bandsaw
tool chests
bridgeport, tool chests

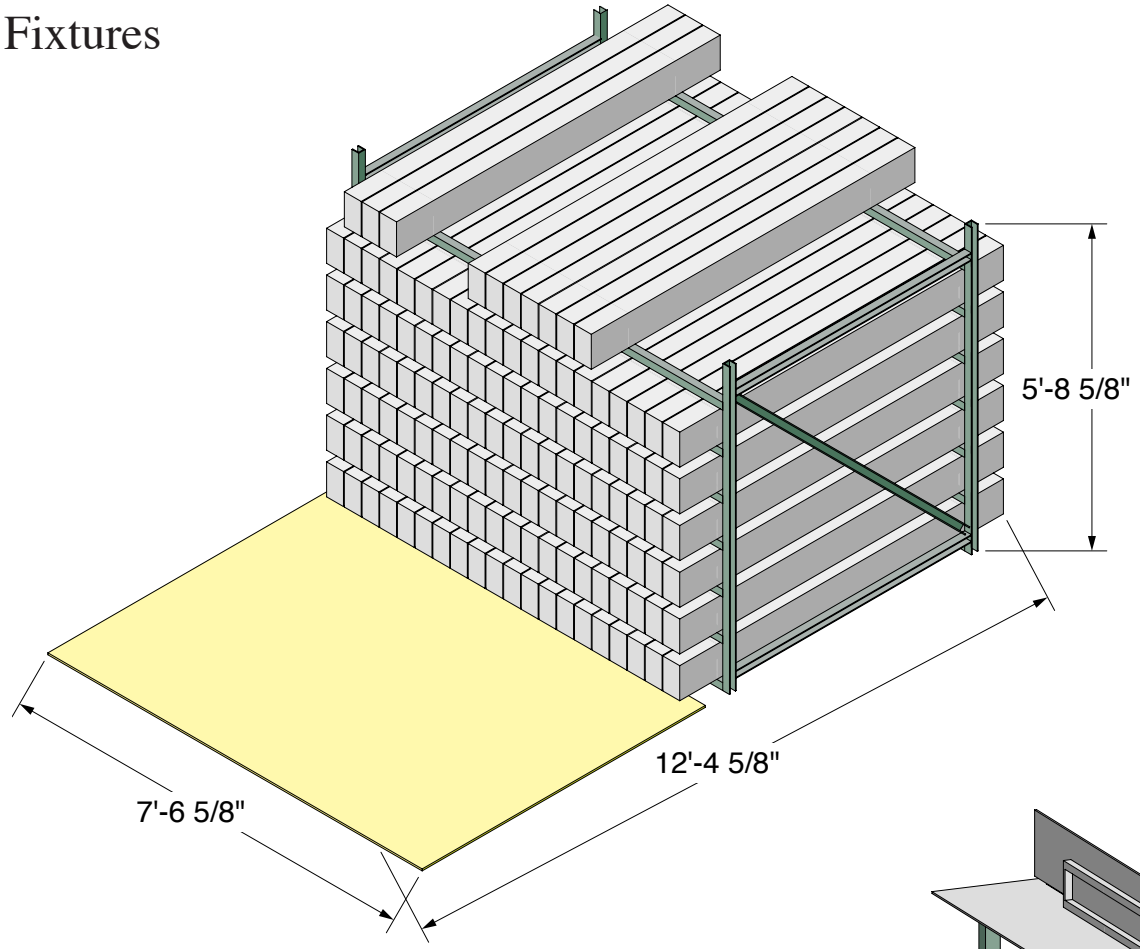
Space @ UT





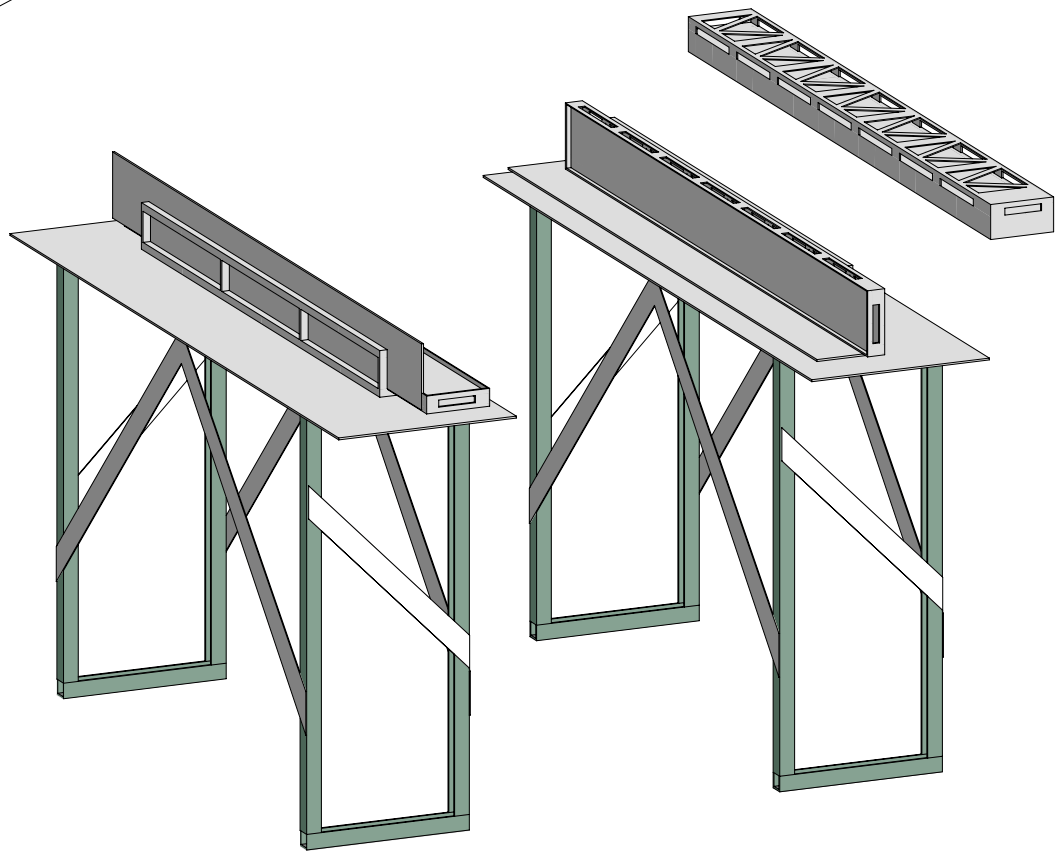
Fabricated Tray Storage and Shipping:
arbitrarily large space in
HE Physics Laboratory, ENS Bldg
(next to RLM)

Fixtures



Tray Storage Structure

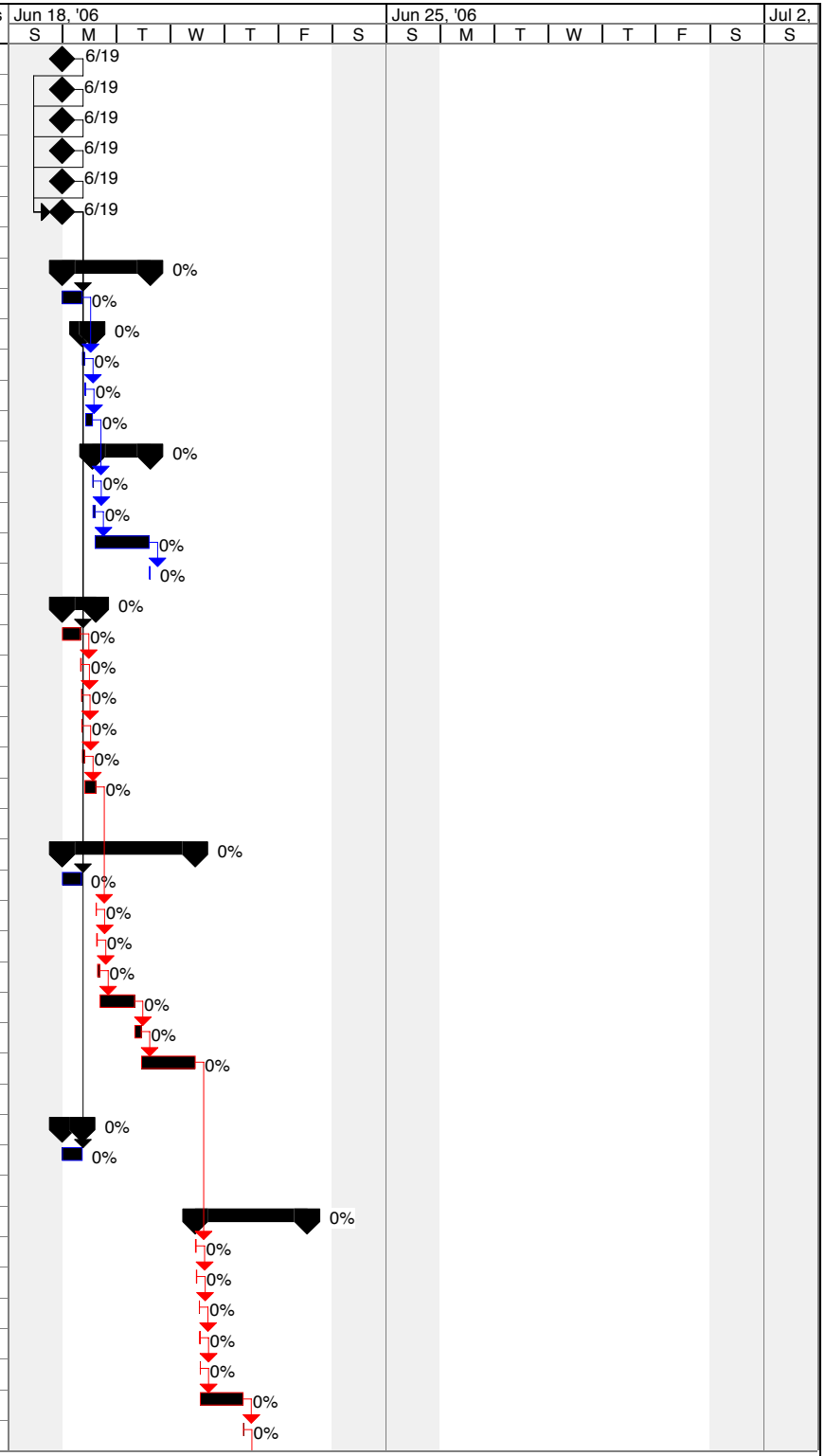
Tray Assembly Fixture



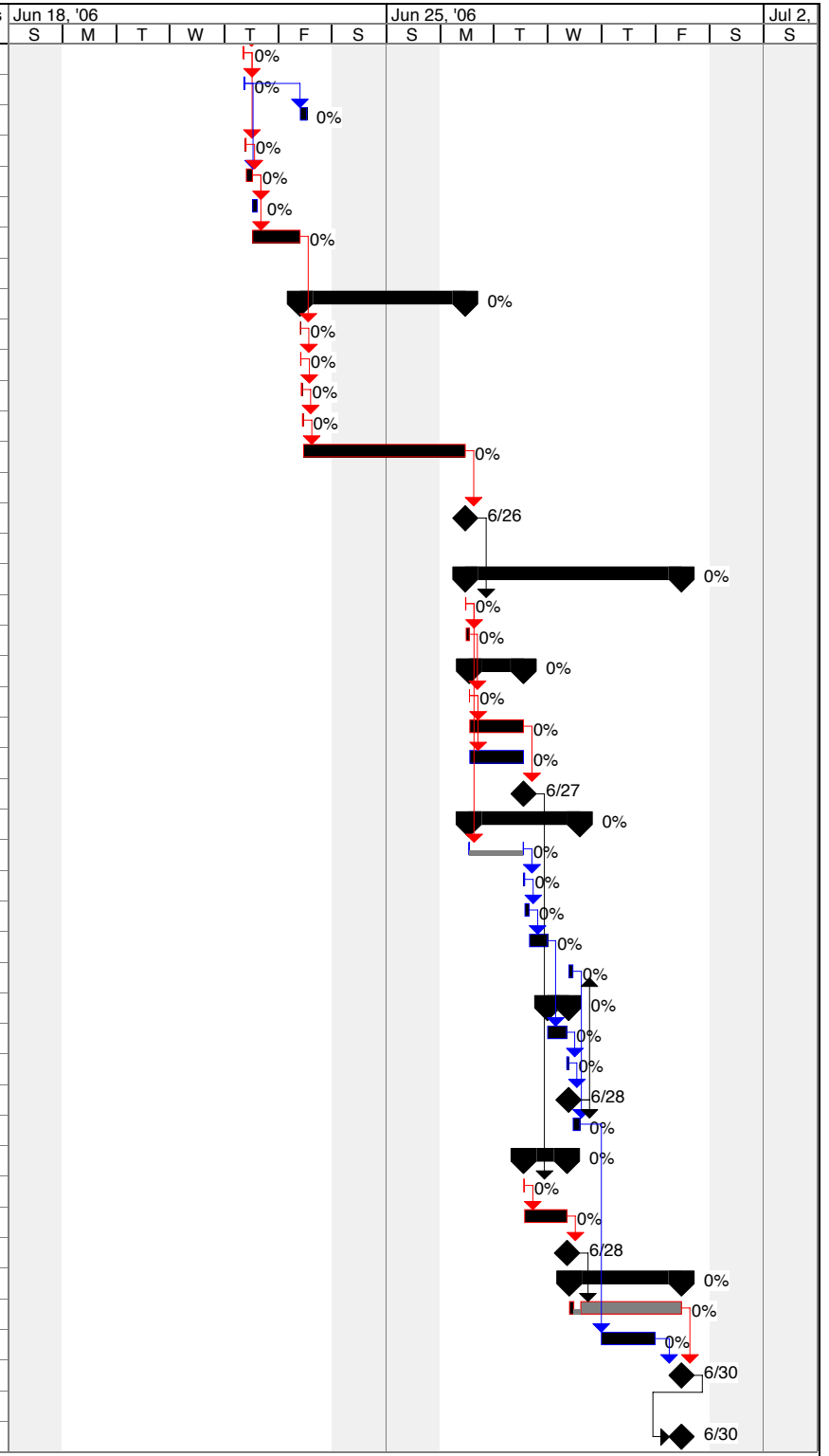
general thinking is that these storage fixtures are constructed at UT during the initial ‘gear-up’ phase of the project

i.e. during tray parts fab at Oaks...

ID	Task Name	Duration	Start	Finish	Predecess
1	Inner Sides available	0 days	Mon 6/19/06	Mon 6/19/06	
2	Cooling Loop available	0 days	Mon 6/19/06	Mon 6/19/06	
3	Tray Structures and Hardware available	0 days	Mon 6/19/06	Mon 6/19/06	
4	TINO & TDIG in Hand	0 days	Mon 6/19/06	Mon 6/19/06	
5	Wire and Cabling available	0 days	Mon 6/19/06	Mon 6/19/06	
6	All Parts in Hand	0 hrs	Mon 6/19/06	Mon 6/19/06	1,2,3,4,5
7					
8	Tray Structure Prep	14.25 hrs	Mon 6/19/06	Tue 6/20/06	
9	inspection & documentation	1 hr	Mon 6/19/06	Mon 6/19/06	6
10	clean bottom, top, cover & brackets	3.5 hrs	Mon 6/19/06	Mon 6/19/06	
11	dip	1 hr	Mon 6/19/06	Mon 6/19/06	9
12	dry	0.5 hrs	Mon 6/19/06	Mon 6/19/06	11
13	isopropyl scrub	2 hrs	Mon 6/19/06	Mon 6/19/06	12
14	bottom assy prep	9.75 hrs	Mon 6/19/06	Tue 6/20/06	
15	move bottom assy to bottom prep area	0.25 hrs	Mon 6/19/06	Mon 6/19/06	13
16	seal inner corners and welds	1 hr	Mon 6/19/06	Mon 6/19/06	15
17	curing (bottom assy inner)	1 day	Mon 6/19/06	Tue 6/20/06	16
18	add kapton layer	0.5 hrs	Tue 6/20/06	Tue 6/20/06	17
19	top assy prep	6 hrs	Mon 6/19/06	Mon 6/19/06	
20	move top assy to fixture (top topside up)	0.25 hrs	Mon 6/19/06	Mon 6/19/06	6
21	install upper brackets	0.25 hrs	Mon 6/19/06	Mon 6/19/06	20
22	install cover assy	0.25 hrs	Mon 6/19/06	Mon 6/19/06	21
23	invert top+cover assy (top topside down)	0.25 hrs	Mon 6/19/06	Mon 6/19/06	22
24	seal PEM studs on underside of top assy	1 hr	Mon 6/19/06	Mon 6/19/06	23
25	curing (top assy inner)	4 hrs	Mon 6/19/06	Mon 6/19/06	24
26					
27	TAMP to top assy	19.25 hrs	Mon 6/19/06	Wed 6/21/06	
28	TAMP inspection & documentation	0.5 hrs	Mon 6/19/06	Mon 6/19/06	6
29	invert top+cover assy (top topside up)	0.25 hrs	Mon 6/19/06	Mon 6/19/06	25
30	remove cover assy and upper brackets	0.5 hrs	Mon 6/19/06	Mon 6/19/06	29
31	reclean near big holes	1 hr	Mon 6/19/06	Mon 6/19/06	30
32	install ground washers	0.5 hrs	Mon 6/19/06	Tue 6/20/06	31
33	seal and bolt down TAMPs to top assy	3 hrs	Tue 6/20/06	Tue 6/20/06	32
34	curing (TAMP to top assy)	1 day	Tue 6/20/06	Wed 6/21/06	33
35					
36	MRPCs	1 hr	Mon 6/19/06	Mon 6/19/06	
37	inspection & documentation	1 hr	Mon 6/19/06	Mon 6/19/06	6
38					
39	Loading the Inverted Top Assy	16.77 hrs	Wed 6/21/06	Fri 6/23/06	
40	install upper brackets and cover assy	0.5 hrs	Wed 6/21/06	Wed 6/21/06	34
41	invert top+cover assy (top topside down)	0.25 hrs	Wed 6/21/06	Wed 6/21/06	40
42	install lower brackets	0.25 hrs	Wed 6/21/06	Wed 6/21/06	41
43	install "closer" inner side	0.25 hrs	Wed 6/21/06	Wed 6/21/06	42
44	rotate fuxture (top on side, closer inner side horizontal)	0.02 hrs	Wed 6/21/06	Wed 6/21/06	43
45	install MRPCs inc connections to TAMP	4 hrs	Wed 6/21/06	Thu 6/22/06	44
46	install cross-pieces and "other" inner side	0.25 hrs	Thu 6/22/06	Thu 6/22/06	45



ID	Task Name	Duration	Start	Finish	Predecess
47	rotate fixture (top topside down)	0.25 hrs	Thu 6/22/06	Thu 6/22/06	46
48	install reynolds connectors with sealant	0.5 hrs	Thu 6/22/06	Thu 6/22/06	47
49	install HV bus wiring to each MRPC	2 hrs	Fri 6/23/06	Fri 6/23/06	48
50	install gas feedthroughs & interior tubing	0.5 hrs	Thu 6/22/06	Thu 6/22/06	47
51	curing (F/T connectors on top assy)	2 hrs	Thu 6/22/06	Thu 6/22/06	48,50
52	HV tests	2 hrs	Thu 6/22/06	Thu 6/22/06	51
53	MRPC connectivity tests	6 hrs	Thu 6/22/06	Fri 6/23/06	51
54					
55	Tray Closing	9.5 hrs	Fri 6/23/06	Mon 6/26/06	
56	test fit bottom assy onto top assy	0.25 hrs	Fri 6/23/06	Fri 6/23/06	53
57	scribe	0.25 hrs	Fri 6/23/06	Fri 6/23/06	56
58	remove bottom assy and apply sealant	0.5 hrs	Fri 6/23/06	Fri 6/23/06	57
59	install bottom assy, install machine screws	0.5 hrs	Fri 6/23/06	Fri 6/23/06	58
60	curing (bottom assy onto top assy)	1 day	Fri 6/23/06	Mon 6/26/06	59
61					
62	Tray Closed	0 hrs	Mon 6/26/06	Mon 6/26/06	60
63					
64	Electronics installation and Testing	32.25 hrs	Mon 6/26/06	Fri 6/30/06	
65	rotate tray (top topside up)	0.25 hrs	Mon 6/26/06	Mon 6/26/06	62
66	move completed tray to tray test area	0.5 hrs	Mon 6/26/06	Mon 6/26/06	65
67	Gas flow for testing	8.25 hrs	Mon 6/26/06	Tue 6/27/06	
68	connect tray to gas system	0.25 hrs	Mon 6/26/06	Mon 6/26/06	66
69	gas flow started	1 day	Mon 6/26/06	Tue 6/27/06	68
70	Gas Leak testing wtih sniffer	1 day	Mon 6/26/06	Tue 6/27/06	68
71	Gas Quality Acceptable for HV tests	0 hrs	Tue 6/27/06	Tue 6/27/06	69
72	TDIG Installation	17.5 hrs	Mon 6/26/06	Wed 6/28/06	
73	remove cover assy and upper brackets	0.5 hrs	Mon 6/26/06	Tue 6/27/06	65
74	install cooling loop	0.5 hrs	Tue 6/27/06	Tue 6/27/06	73
75	install TDIG boards	2 hrs	Tue 6/27/06	Tue 6/27/06	74
76	install LV bus (lugs on-tray to boards)	1 hr	Tue 6/27/06	Tue 6/27/06	75
77	Install TDIG cabling (canbus etc)	2 hrs	Wed 6/28/06	Wed 6/28/06	81
78	LV power test	1.5 hrs	Wed 6/28/06	Wed 6/28/06	
79	install LV test cables (supply to lugs on-tray)	0.5 hrs	Wed 6/28/06	Wed 6/28/06	76
80	LV power-up and documentation	1 hr	Wed 6/28/06	Wed 6/28/06	79
81	LV test passed	0 hrs	Wed 6/28/06	Wed 6/28/06	80
82	Firmware and other electronics setup	2 hrs	Wed 6/28/06	Wed 6/28/06	77,81
83	HV Performance	4.25 hrs	Tue 6/27/06	Wed 6/28/06	
84	connect HV cables	0.25 hrs	Tue 6/27/06	Tue 6/27/06	71
85	ramp HV and collect V/I data	4 hrs	Tue 6/27/06	Wed 6/28/06	84
86	Tray Stable at Full Voltage	0 days	Wed 6/28/06	Wed 6/28/06	85
87	DAQ Performance	18 hrs	Wed 6/28/06	Fri 6/30/06	
88	Noise rate tests, dead channel identification	2 days	Wed 6/28/06	Fri 6/30/06	86
89	INL Calibration	1 day	Thu 6/29/06	Thu 6/29/06	82
90	Final test documentation	0 hrs	Fri 6/30/06	Fri 6/30/06	88,89
91					
92	Tray complete & Ready for Cosmics Testing	0 hrs	Fri 6/30/06	Fri 6/30/06	90



The procedure is generally

a series of several “few minute”operations per tray

punctuated by several ~24 hrs periods of waiting per tray (sealant curing, gas flow, etc...)

Fabrication model:

at the end of each week

two trays emerge from the tray prep area

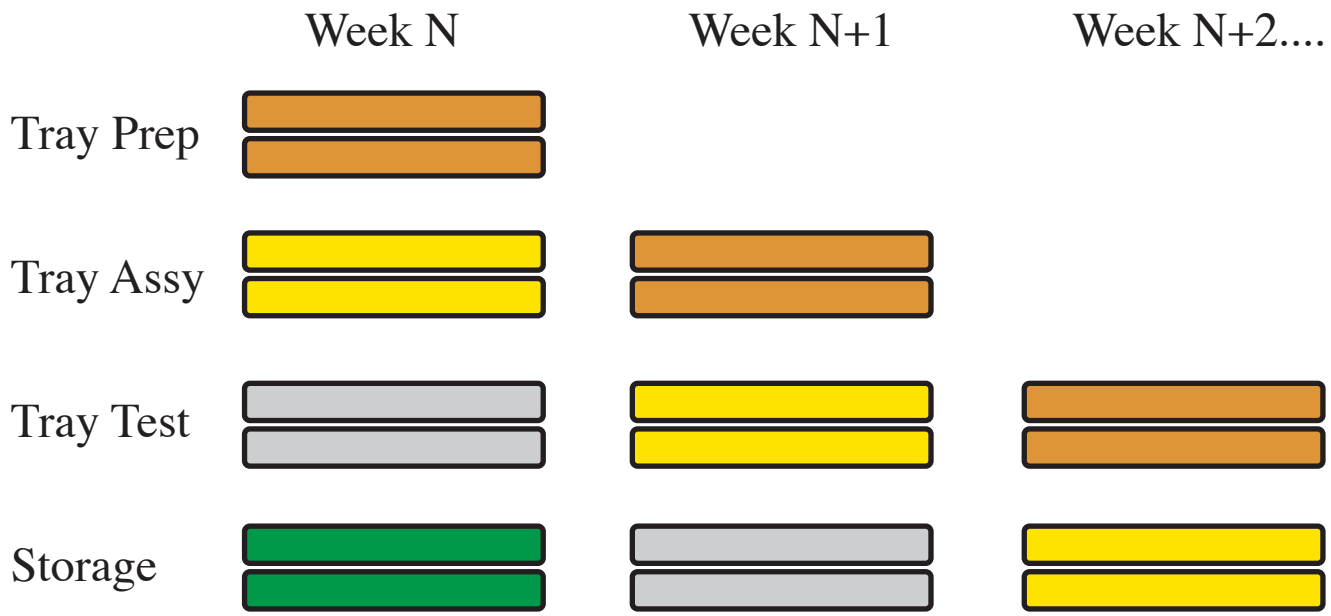
next week these will be in the tray assembly area

& two trays emerge from the tray assembly area

next week these will be in the tray testing area (gas flow, INL, noise rates, HV draw, etc)

Assumed manpower (1 FTE Tech + 2 FTE UG) and floor space sufficient

Gives some headroom in fabrication/testing schedule w.r.t. MRPC and FEE production



Tray Fabrication Milestones (4/year)

Date	No. Trays	No./week
10/06	4 trays	0.5 trays/week
01/07	10	0.8
04/07	10	0.8
07/07	14	1.1
10/07	14	1.1
01/08	16	1.3
04/08	18	1.5
07/08	20	1.7
09/08	20	1.7

installation plan:

"Skill-of-the-Craft"

can install either in AB or WAH

Both US & Chinese institutions participate in installation and commissioning

installation of trays behind the TPC support arms (3 & 9 o'clock, East & West) requires a fixture to hold the TPC while one support arm is removed.

Start-Side Status and Plans

pVPD detectors still in place (4th run now) and seem to be doing as well as always...
But an increased coverage within a similar integration volume is needed

Implement prototype for Run-6, final start detector installed before FY08 with new PMTs...

Basic idea

pVPD 2" linear PMTs + significant shielding → 1.5" mesh PMTs + no shielding...
increase number of detector channels on each side within same integration volume...

same Z-location as pVPD (Runs-2 to -5) but smaller radial extent...
total weight practically unchanged

Electronics for Run-6 prototype presumably exactly the same boards as on pVPD in Run-5

HV for prototype and final system from BBC's LeCroy 1440 supply

PMTs for prototype detector will be R5946 PMTs from decommissioned TOFp
already separated from the TOFp slats, and gain & dark current tested.
Pb converter + Scint (a few chs on each side will use quartz or lead glass instead)

New PMTs for the final detector are costed
purchase FY07, to be installed in final structures and ready for FY08 run...

Main R&D developments:

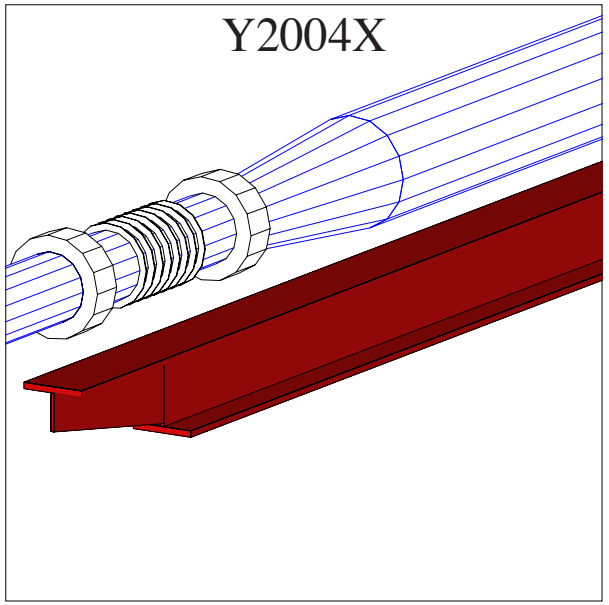
Detector design, based on full simulations
PMT base design, need high stability and high rate capability

http://wjllope.rice.edu/~TOF/upVPD/ForwardSimulations/

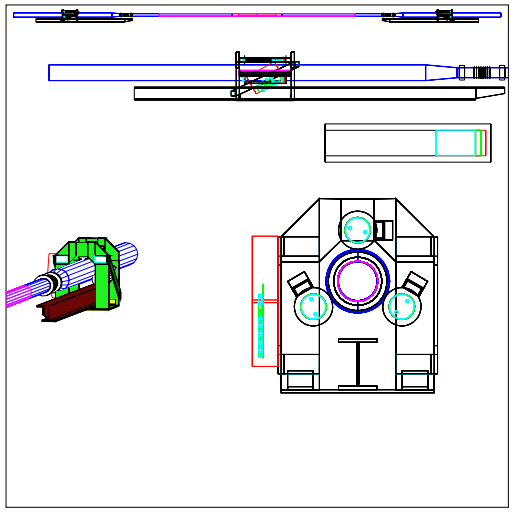
Simulations of the Upgraded pVPD (Geometry)

- Strict comparison btw starsim geometry and CADD files from STSG (discrepancies found!)
- First definition of many pipe & I-beam support structure pieces missing from starsim geometry
- Definition of several possible geometries for upVPD
- Performance of the different designs in p+p and Au+Au evts

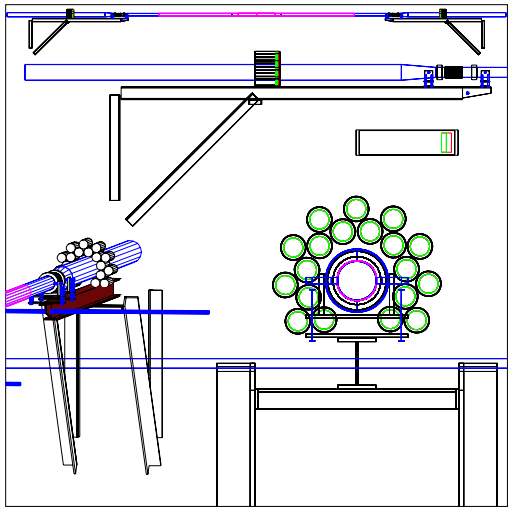
Y2004X



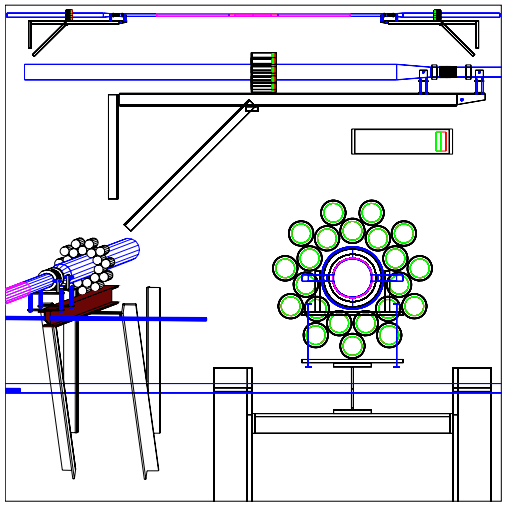
Y2004X



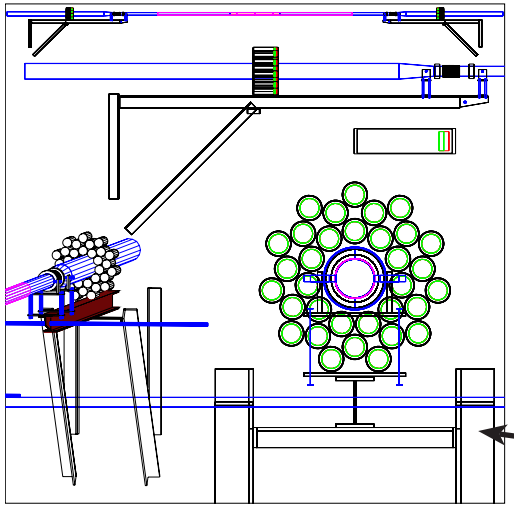
Y2006A



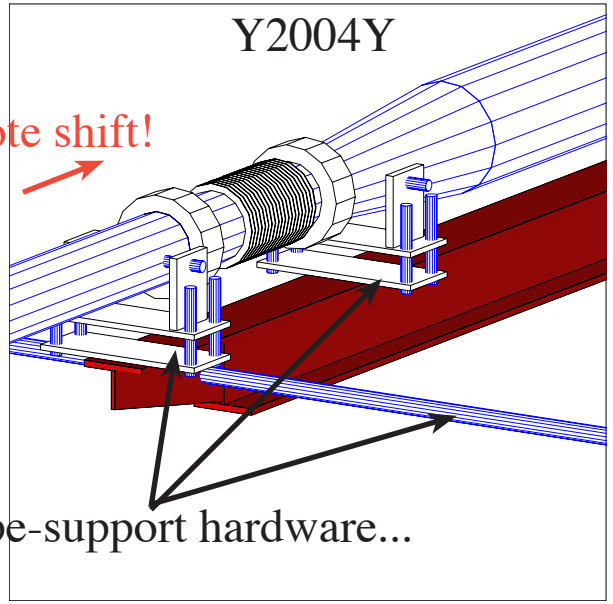
Y2006B



Y2006C

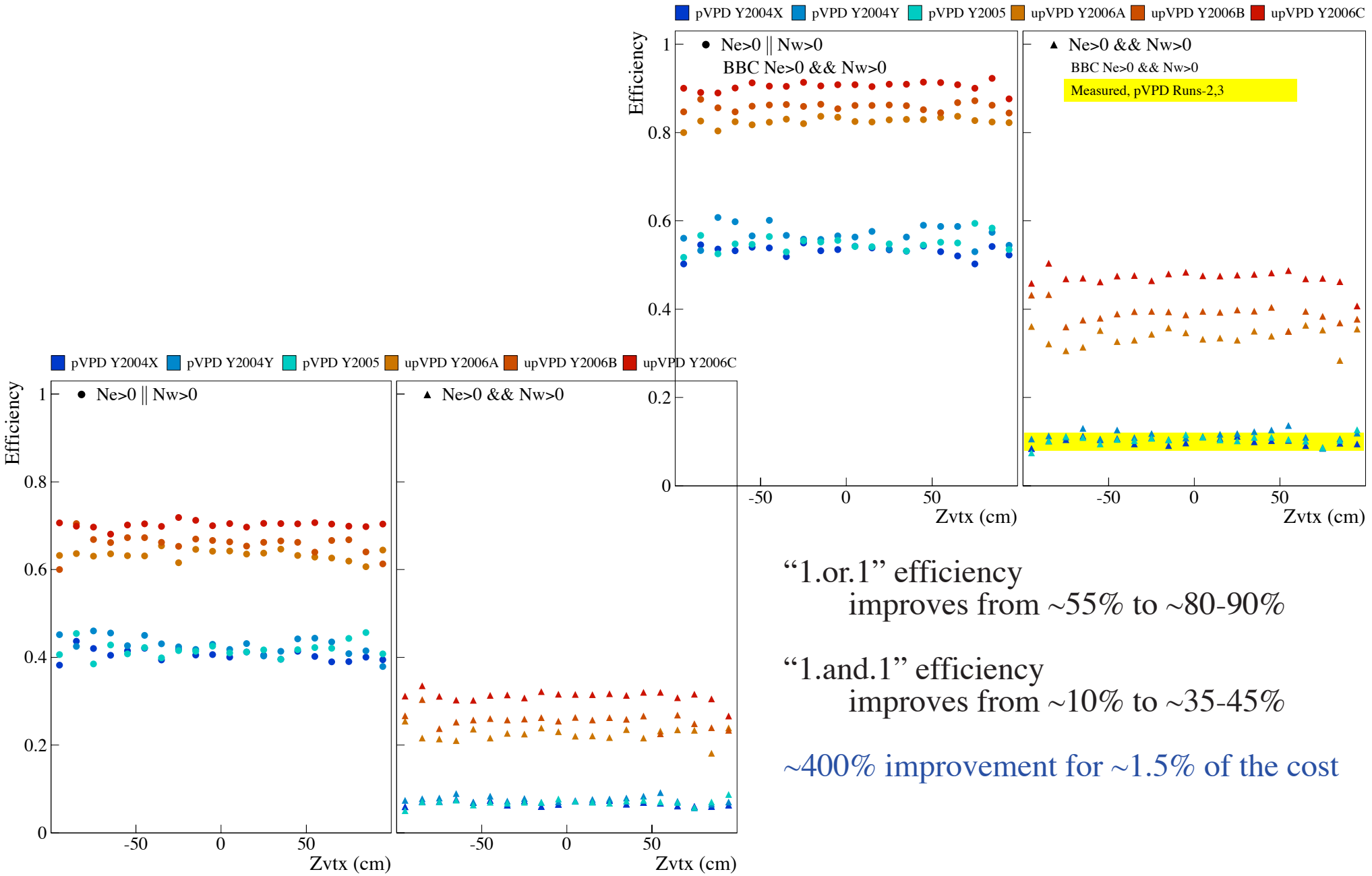


Y2004Y



Simulations of the Upgraded pVPD (Performance)

- concentrate on minimum bias p+p collisions (pythia, MSEL=2)
- study efficiency by which detector can produce start times for the different detector geometries



"1.or.1" efficiency
improves from ~55% to ~80-90%

"1.and.1" efficiency
improves from ~10% to ~35-45%

~400% improvement for ~1.5% of the cost

New Bases for the Upgraded pVPD

(Vahe Ghazikhanian, J. Mitchell, WJL)

Intended for low-power & high-rate operation with R5946 mesh PMTs

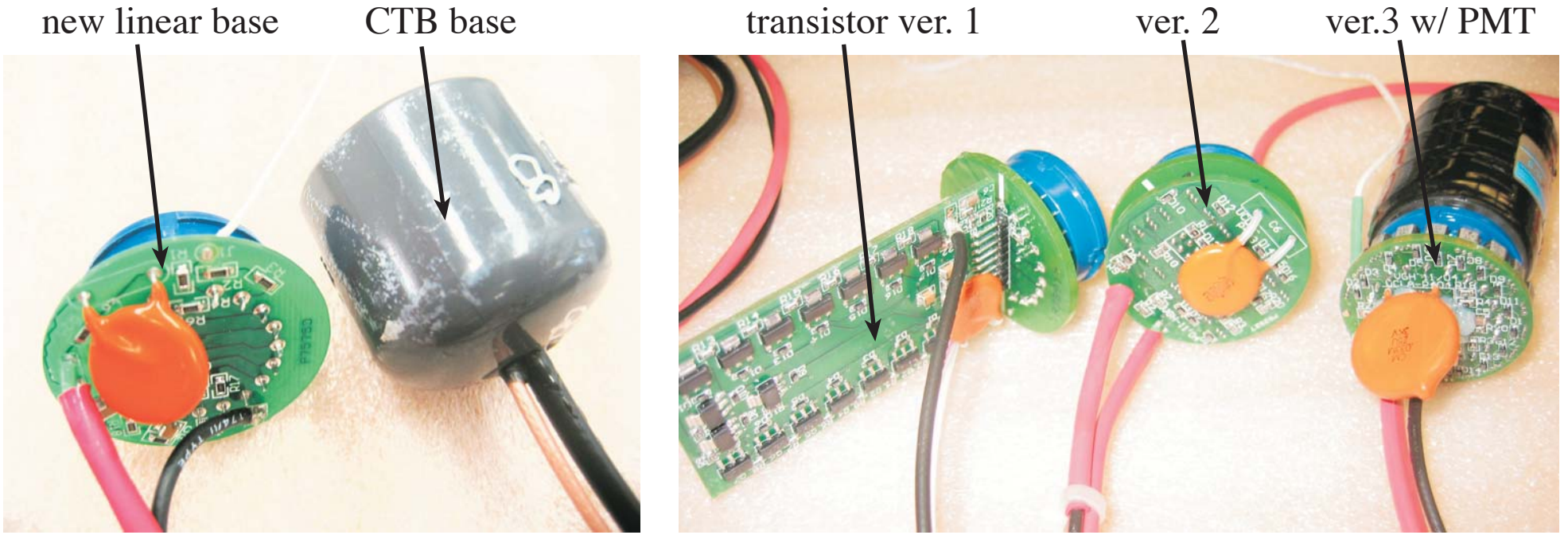
Developed one Linear base, but higher rate than std. Hamamatsu design

Linear base drops ~2W at 2kV → >50 ºC inside detector assembly...

Developed 3 versions of transistor bases

MOSFETs are primary voltage divider, current 1/10th of that for the linear base...

additional factor 10 current drop possible with different bias supply to MOSFETs (resistor chge)...



Burned-in for ~1 wk at UCLA, then LED rate-tested at Rice

Can't see any rate-dependent sag in any of the new bases (several nC pulses, 10's of kHz)

Parts available for ~3 more of latest design transistor base, will build more before Run-6

HV trests of new bases

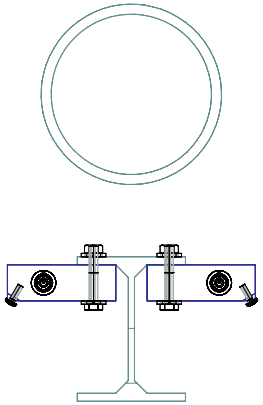
Run-6 prototype

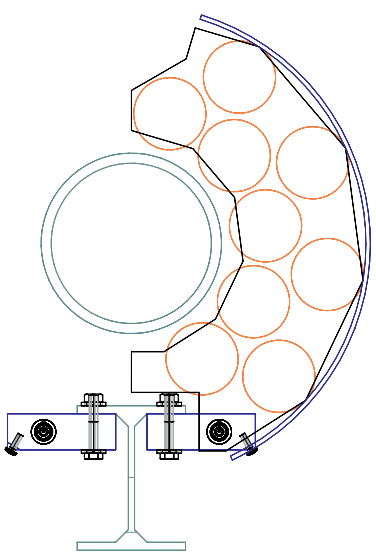
19 detectors/side

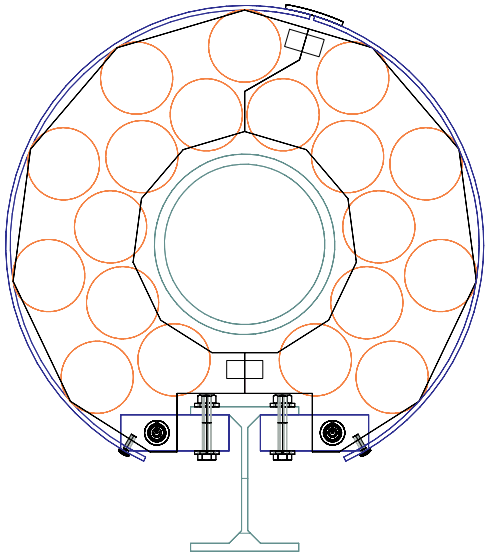
test scintillator, quartz, and lead-glass as optical element

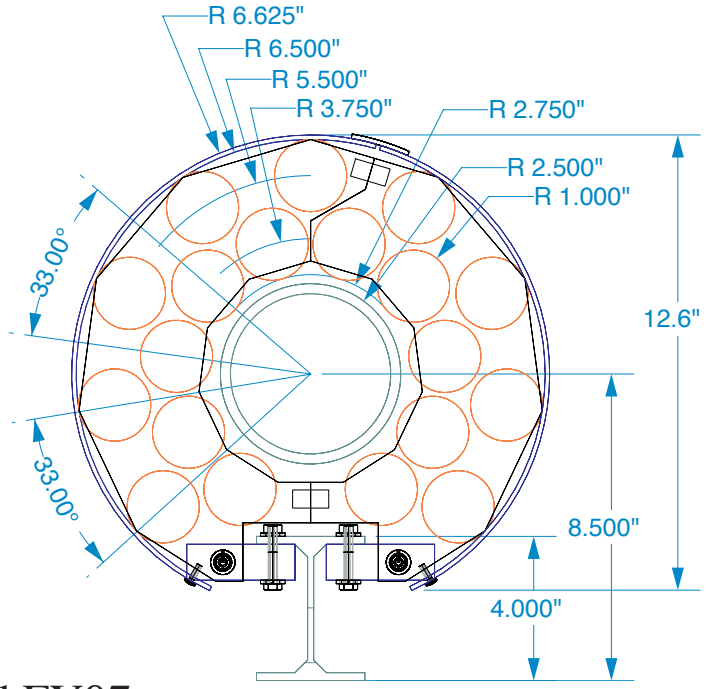
R5946 PMTs from TOFp

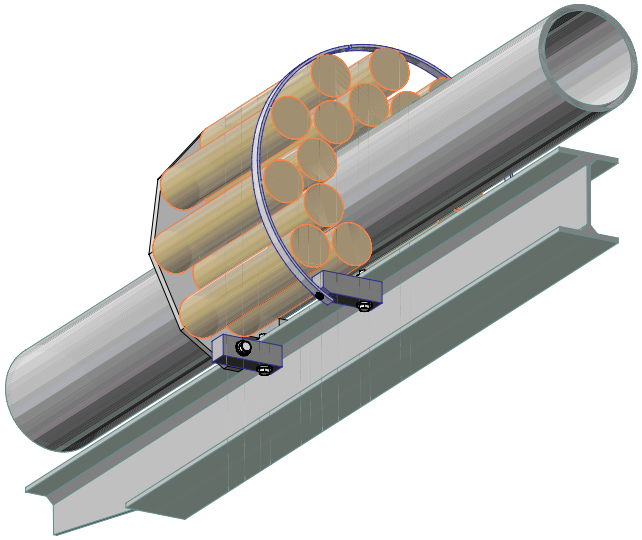
electronics from Run-5









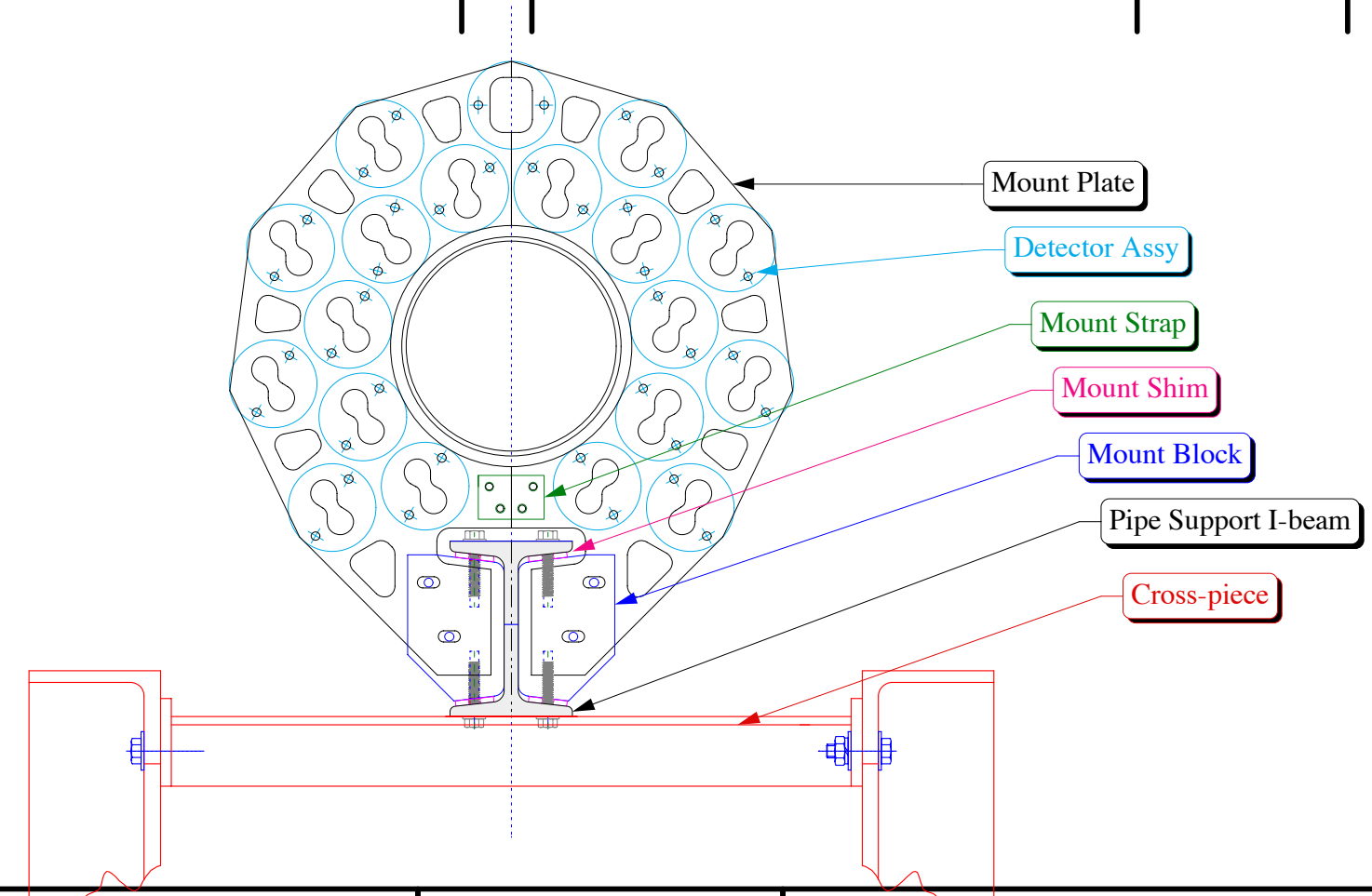


Run-8++ “final” detector

24 chs/side

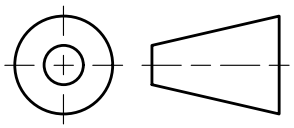
new PMTs purchased FY07

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED
1	first version	12/29/2005	WJL



UNLESS OTHERWISE SPECIFIED
DIM ARE IN INCHES
TOL ON ANGLE ±.01°
2 PL ±.01 3 PL ±.002
INTERPRET DIM AND TOL PER
ASME Y14.5M-1994

THIRD ANGLE PROJECTION



DESIGNED BY: W.J. Llope
DRAWN BY: W.J. Llope
CHECKED BY: J. Hoffmann
APPROVED BY: W.J. Llope
OTHER APPROVALS: TBD
CAD FILE NAME: TOF_107_A_1_MountAssyFront

RICE

TITLE

STAR TOF SYSTEM
Start Detector
Mount Assembly, Front View

SIZE	CAGE CODE	DRAWING NO.	REV
A	N/A	TBD	1

SCALE 1:4 | EST. WGT | SHEET 1 OF 1