TOF Detectors & Mechanical

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D.O.E. Review
August 2-3, 2007, BNL

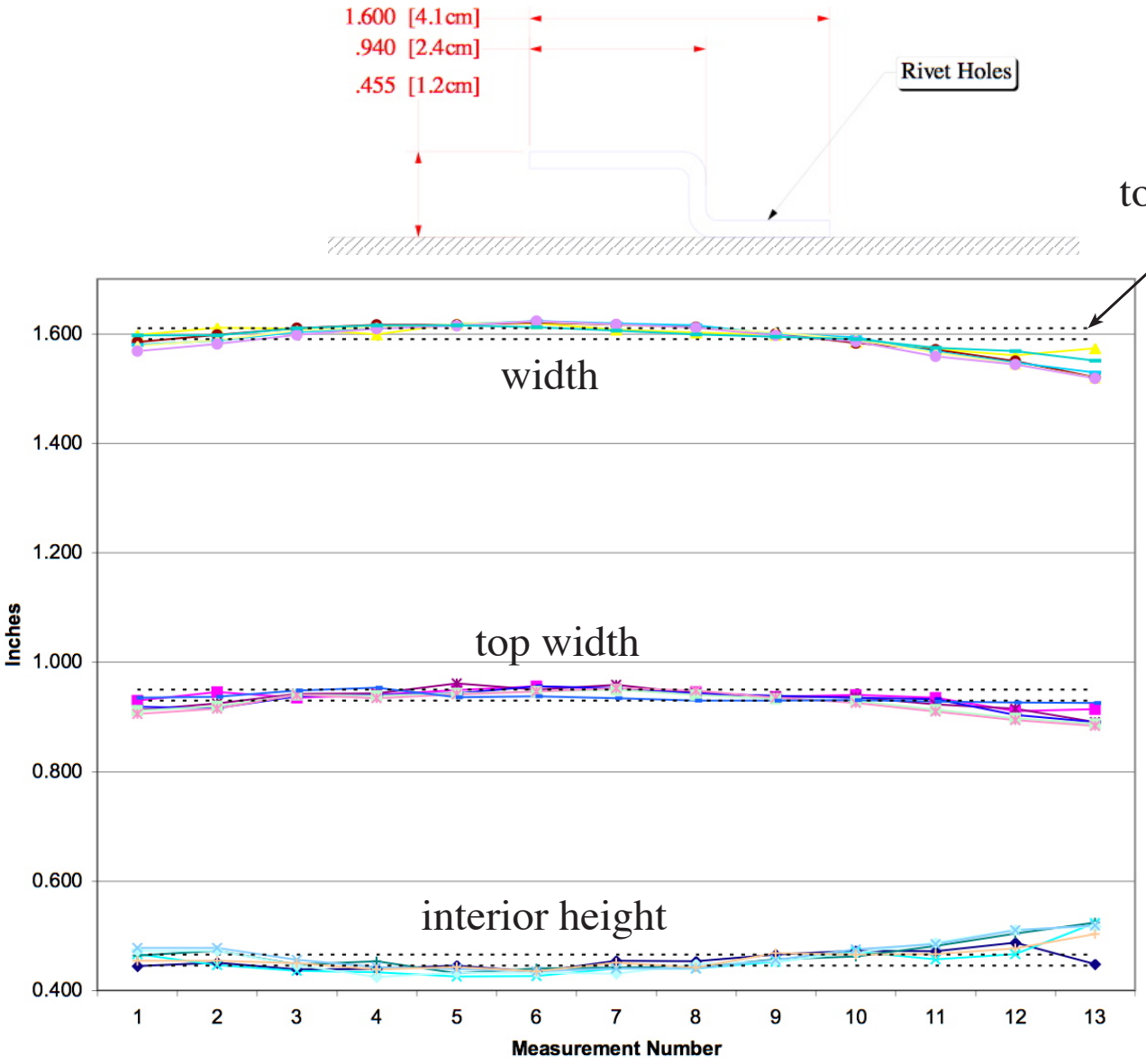
Outline:

Tray Mechanical, Assy, Fixtures
Tray Power, Heat, & Cooling
Gas System
HV & LV Systems
Start Detector
Timing Performance in ☆
Summary & Joblist

Tray Mechanical Components

- bottom, top, cover, feet, & brackets from Oaks Precision Fabricating, Houston
- inner sides, cooling loop, shims, & strain-relief plate from UT RLM machine shop

Prototype Batch of 7 “final” trays produced late 2006



→ bottom & top to spec

→ feet definitely not to spec
some dims off >100mils
length dependence

Oaks replaced defective rails

Four trays delivered to UT

Three now fully loaded
(trays “A”, “B”, “C”)

Tray #A has “bad” rails

Final Tray Order

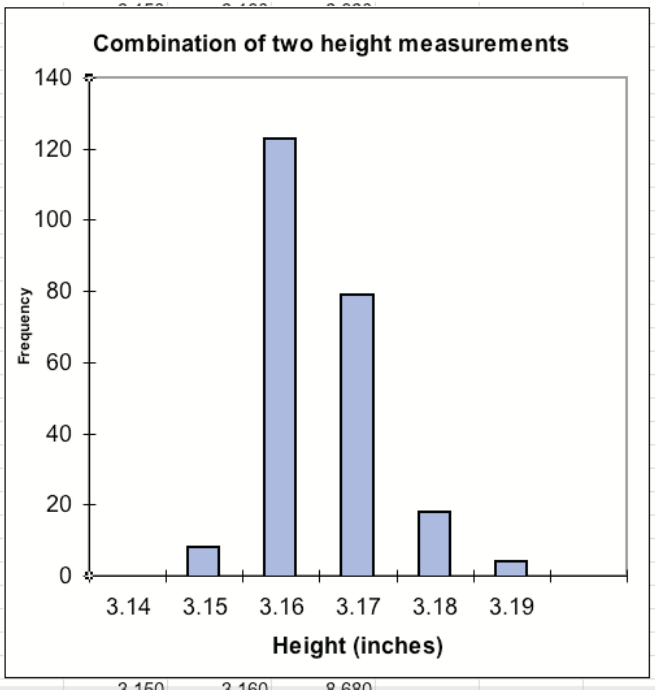
~5 small tweaks w.r.t. prototype batch

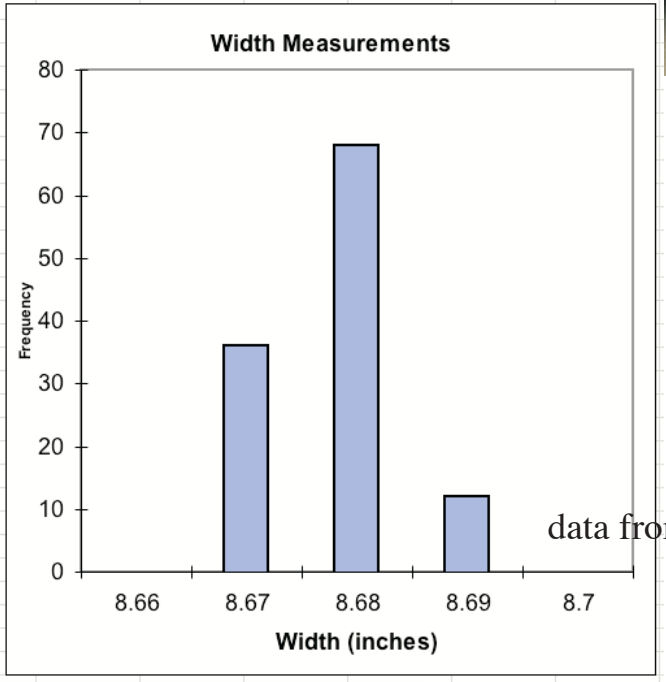
special upper bracket at closed end, wider pem studs
removed a few upper and lower brackets & pem studs
longer pem studs near strain-relief plate
cover thickness decreased from 63 mils to 50 mils

see yellow revision clouds in final cadd file:
http://wjllope.rice.edu/~TOF/TOF/Documents/TOF.pdf

order complete february 2007

118 delivered directly to UT
2 at rice until needed at UT





height and interior width
controlled to ~ 10 mils

data from D. Oldag *et al.* (UT)

Rail Strength Tests (D. Austin Belknap & WJL)

TOF trays register onto TPC rails using "feet" which are riveted to the tray bottom
shear strength ~ 150 lbs
pull strength ~ 100 lbs

1 tray from prototype batch used to insure strength of rivets-to-bottom connections

fully-loaded TOF tray weight ~ 75 lbs

Lead blocks put into tray box, then tray lifted via feet and held for some hours

single rail, 150 lbs of Pb

two rails, 150 lbs of Pb

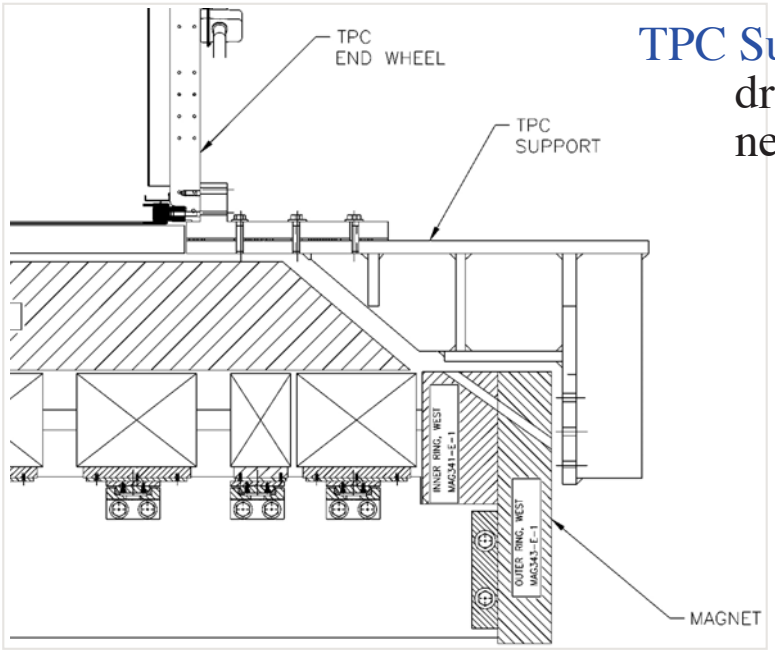
two rails, 100lbs and rail at tray end

→ No rivet failures

→ feet dimensions measured before and after each test
deformations < ~10mils

Installation Fixtures

TPC support fixture (needed to hold TPC when support arm removed for trays at 3 and 9 o'clock)
Tray insertion fixture (support tray weight, line up an external TPC rail to slide trays into STAR)

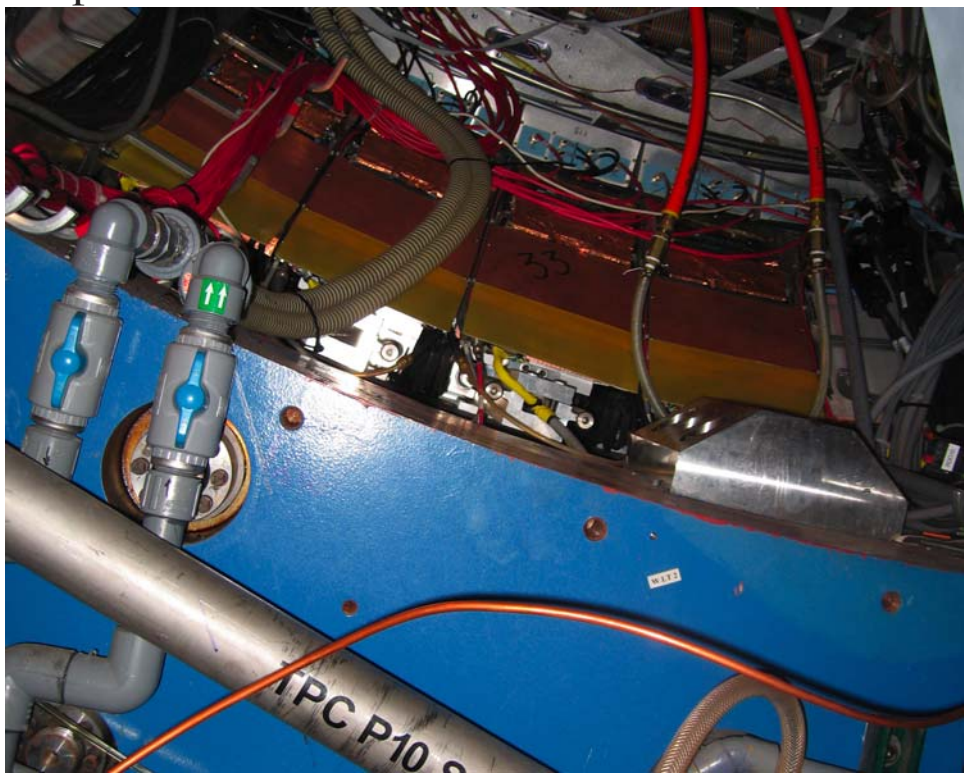


TPC Support Fixture

draft design exists (J. Scheblein)...
needed during shutdown before run-10 when tray "120" goes in...

Tray Insertion Fixture

TPC rails exist at Rice
design light structure, mounts to TPC end-ring
holds tray on perfect plane to slide neatly into ☆
6-10 positions available, then move fixture
push to make available in ~5 months



Tray assembly procedure is well-defined but
is difficult to describe fully in words.....

Final Assy of Tray 3 filmed,
edited with subtitles, and
mastered to a DVD as teaching tool (copies available to committee)

Will be extended to include
tray testing at UT
tray installation in STAR.....

- Final Trays delivered
- Assy Fixtures in place
- Assy procedure now optimized, still optimizing QA checklist & database. insure consistency
- Trays built so far "work"
  reasonable HV currents and detector noise rates once gas & HV have been up ~1 week
  zero dead channels

D&M not "done" yet though

First TCPUs just recently arrived, they fit...

Revisions to connectors & components near tray feedthrough end above top assy

Very new addition of "TTRG" interface to STAR Trigger system
positioned directly on top of Top (w/ nonconducting layer in between)

Tray Insertion and TPC Support Fixtures - design and construct

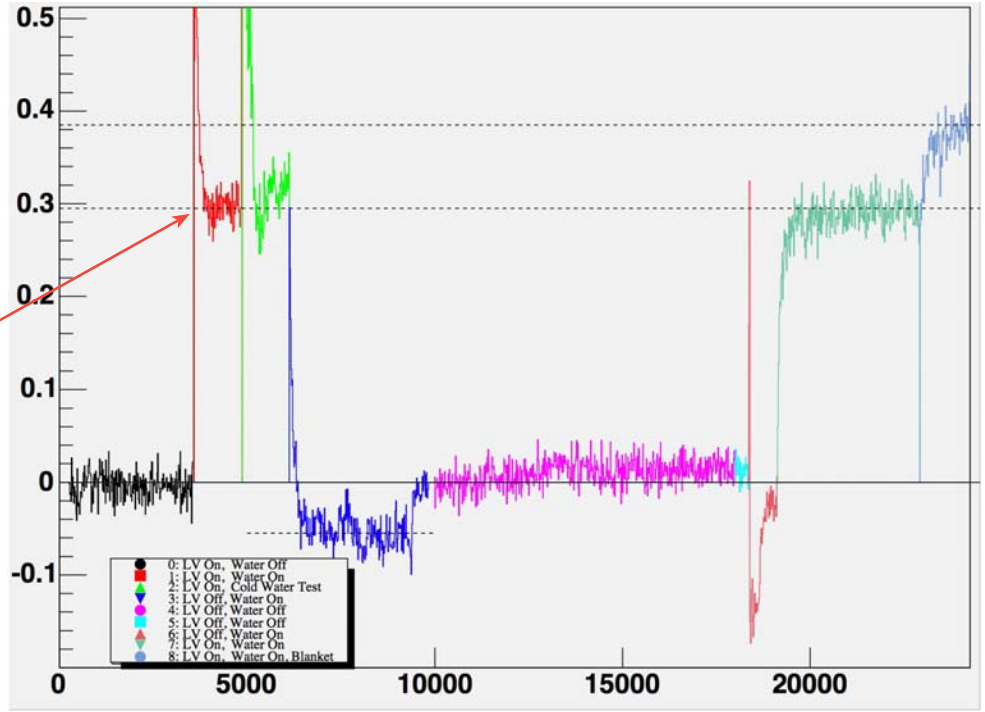
Commissioning in Run-8++

Water System -- copper water loop running between TINO & TDIG

Power tests of TOFr5
- 140W total
- square loop + shims
- perforated tray cover

water T_{input} ~ 31 deg C
flow rate ~ 1.36 Gpm
water ΔT ~ 0.295 deg C

P(water) ~ 105 W
P(radiative) ~ 35 W
P(convective) < 1 W



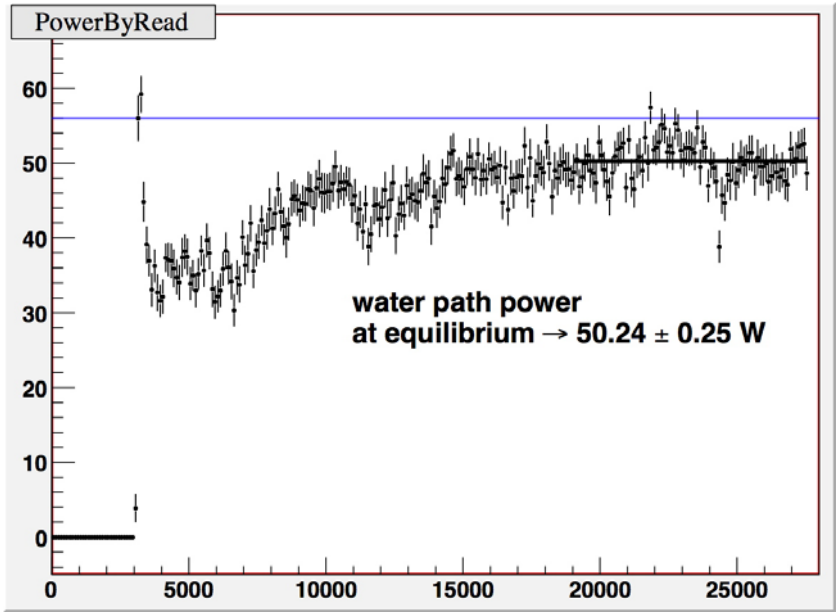
http://wjllope.rice.edu/~TOF/TOFr5/Ttests/TOFr5_T_tests.htm

Power tests w/ early TDIG-Ds
- 55W total
- rectangular loop + thinner shims
- solid tray cover

water T_{input} ~ 31 deg C

ΔT ~ 0.07 deg C

P(water) ~ 50 W



Need to repeat w/ fully configured TDIG-E's → improved ΔT → define N(trays) daisy-chained
Water test set-ups exist at both Rice and UT

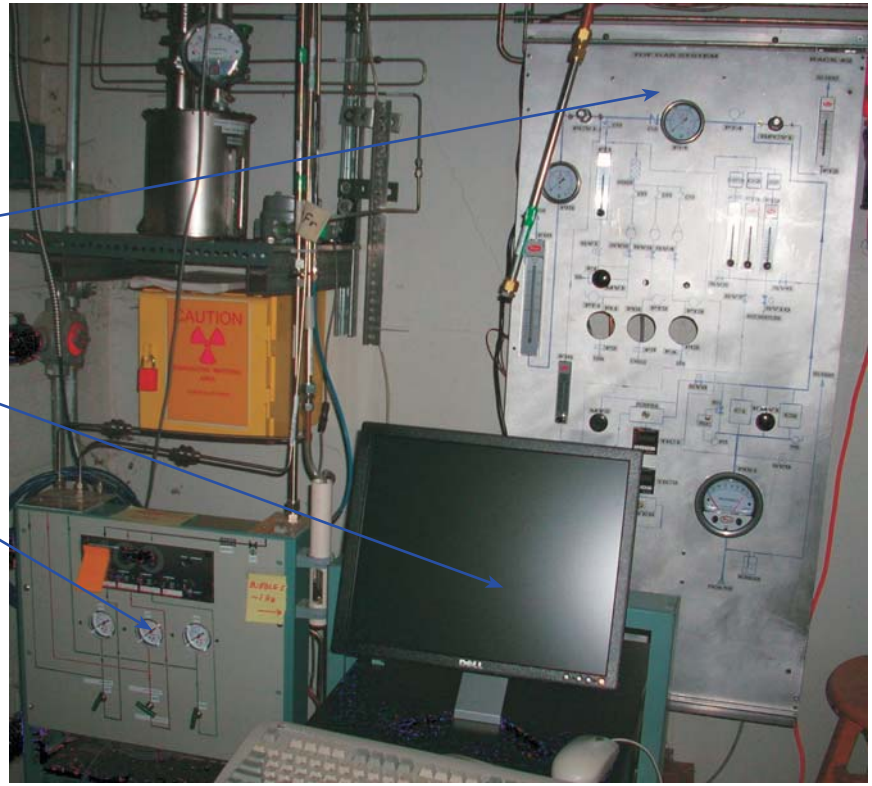
Gas System (PNPI, Russia, BNL Contract #123090)

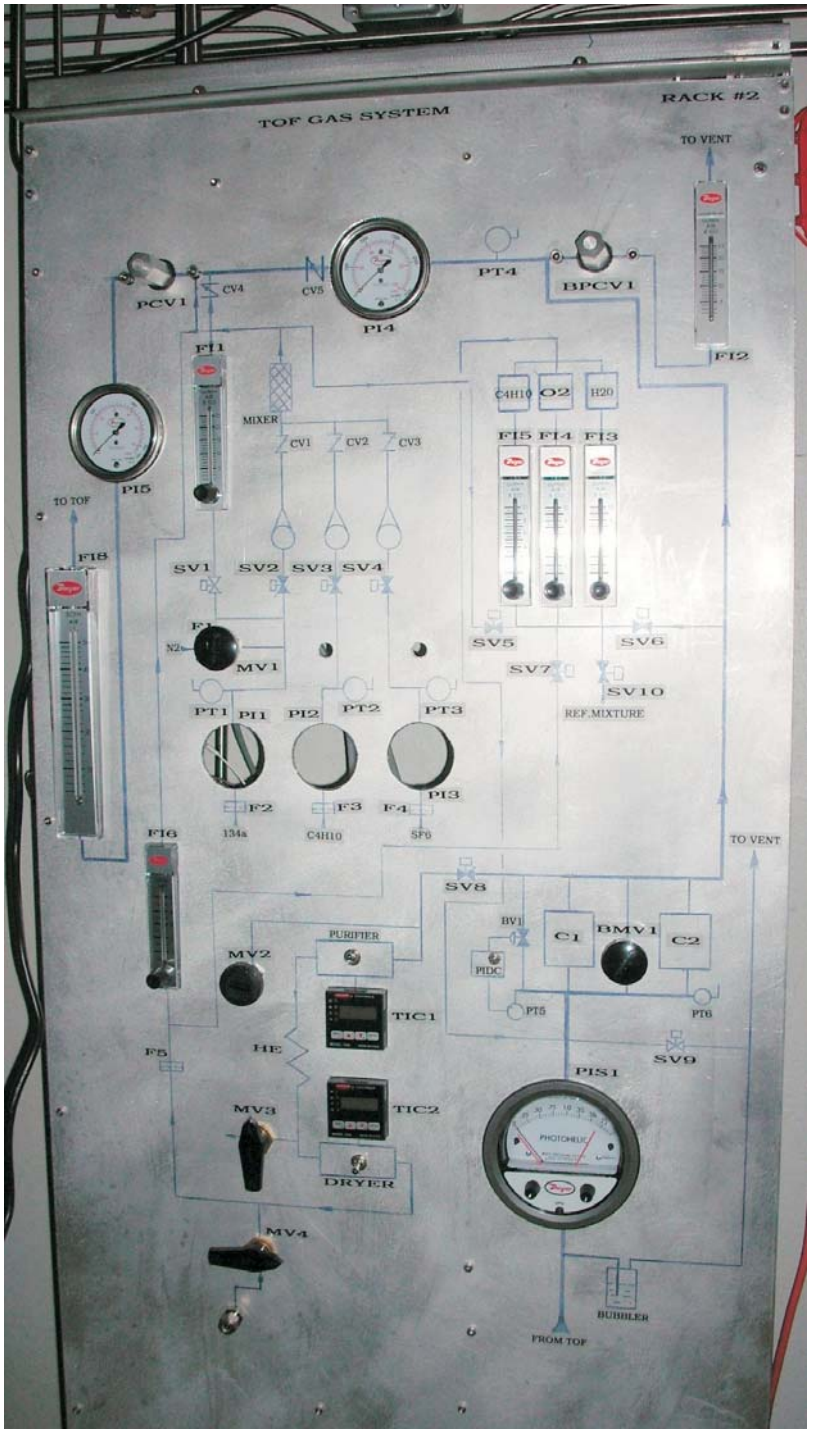
recirculate & remove O_2 and H_20
reviewed April 2006

new control PC in place
new mixing panel in place
1" SS tubing to connect to ☆ located (not yet connected)

to do:

define distribution network on detector (4 trays in series)
define "splitter" locations
complete connections
special bubbler and oil vapor filter
install windows control code





new gas panel

Low Voltage System

- Low Voltage system was reviewed by the BNL safety and approved with no change to the original design [some modification to the PL512 outputs had already been incorporated and the remaining minor modification (i.e., internal connection between chassis ground and return using 10k resistors will be implemented in the remaining models]

Subsequently:

- Low voltage system based on one Wiener PL512 12-channel unit was implemented in STAR for run 7. This constitutes 10% of the total low voltage system [this system was tested for a period of several weeks at full load (110 watts) before shipment to BNL.
- Cabling for 10% of low voltage system was purchased and for run 7 five low voltage cables were installed [for THUB and TSTART electronics].
- Slow control system was also used to control the PL512 for run 7.
- One channel of the PL512 (Ch 0) failed within first two week of the run and some firmware problems in PL512 caused communication problems which were not observed during the testing at UCLA.
- PL512 was shipped back to Wiener for further studies and repairs after the end of run 7.

[Manpower: 80% FTE, 50% Graduate student, 20% Technician for 2006-2007]

High Voltage System

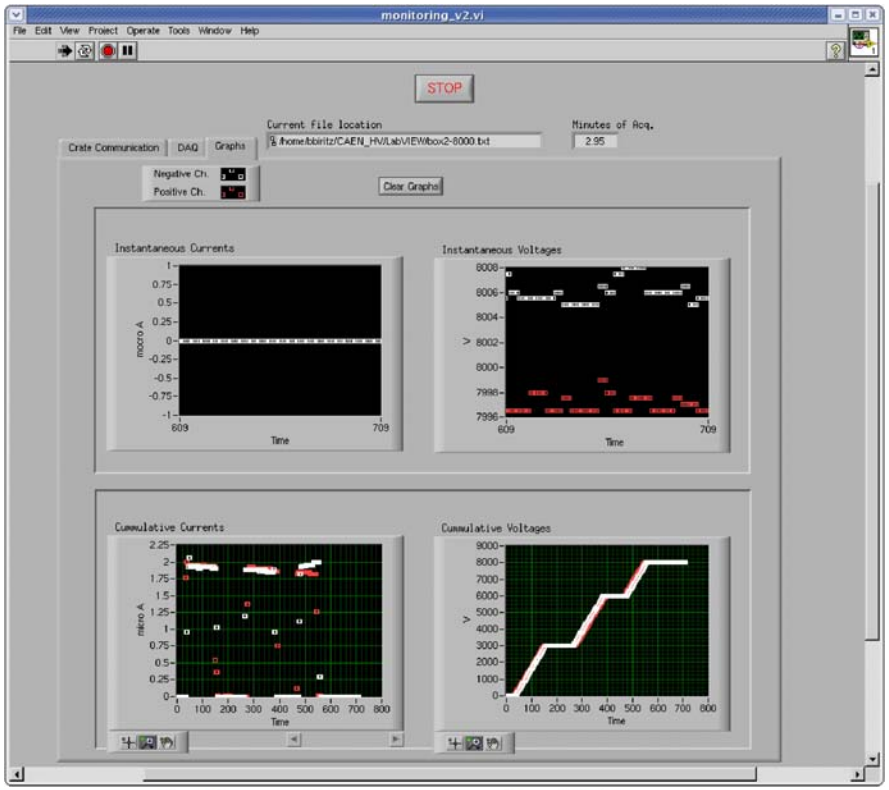
- A CAEN SY1527LC mainframe along with two six channel A1534P (pos. 8kV) and two A1534N (neg. 8kV) modules were purchased in fall of 2006. It was purchased to allow development and testing of slow controls. This HV mainframe supplies 100% of the TOF HV supply needs and includes spare channels [two pairs out of the available 12 pairs are spares].
- We have designed and built 10 12-channel distribution boxes. These will allow 12 pairs of outputs from the HV modules to supply positive and negative HV to 120 TOF trays. In addition these boxes include current limiting and filtering circuitry.
- The following tests were performed: PCBs were tested at 20 kV, all cables were tested at 16 kV, assembled PC board were tested at 15 kV [component rating limitation], and assembled boxes are being tested at ± 8 kV [CAEN limitation].
- HV cabling was produced for 15 TOF trays. Currently these cables along with one distribution box are being used for tray testing at UT Austin.
- EPICS based slow control developed last year is functional but needs on site testing.
- LabVIEW program [faster response than EPICS] monitoring the power supply during the distribution box tests.

LV Plans for 2007/08

- Cables have been ordered and received at BNL for 100% of TOF system.
- 10 PL512s were ordered in April 2007. Delivery expected in August 2007. The new units will have all BNL safety required modifications and new firmware.
- These supplies will be extensively tested at UCLA in Fall 2007 and will be shipped to BNL for installation in summer 2008 (or earlier if opportunity rises).
- The current version of the slow control software written in LabVIEW needs to be rewritten in EPICS [the version of firmware internal to PL512 was not compatible with EPICS]. This is needed to make TOF compatible with the rest of STAR so it can be incorporated in the run control/logging.
- Installation of PL512's and cables will be done by D. Padrazo (BNL STAR support group).

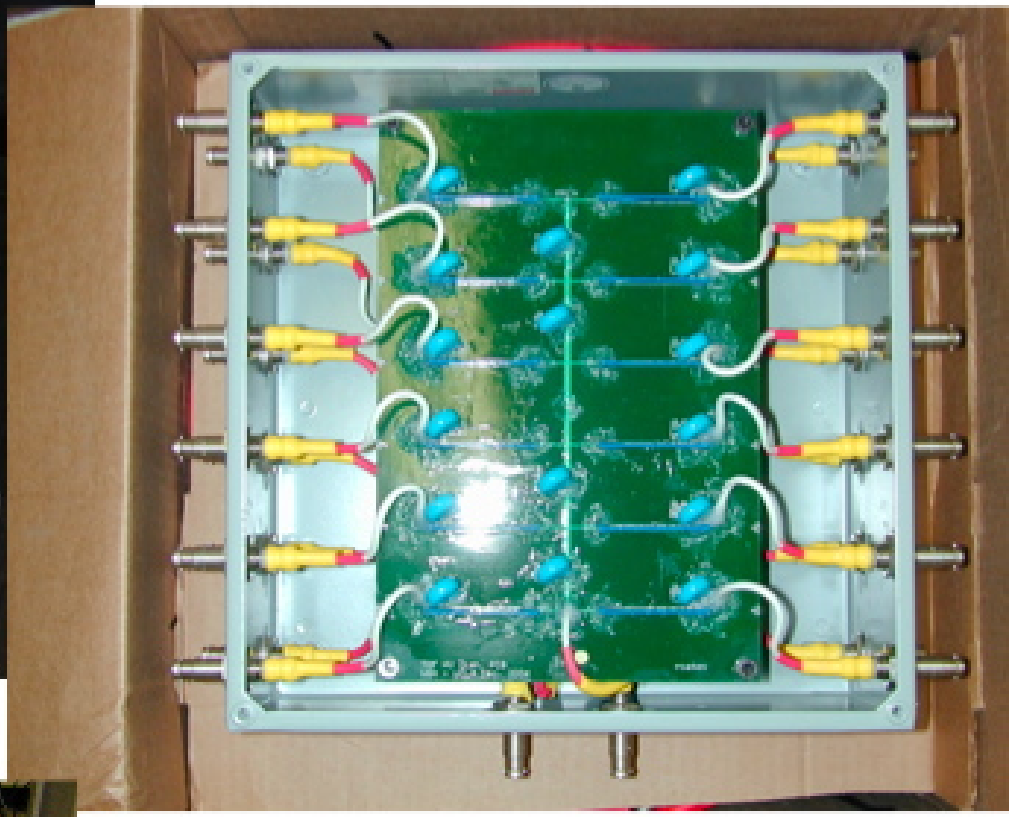
HV Plans for 2007/08

- High voltage cables for the remainder of TOF system will be ordered in August 2007.
- High voltage distribution boxes will be shipped to BNL in August for installation in STAR.
- Cables and control software will be installed for run 8. All cables are planned to be installed by the beginning of run 9.



- The design and development of the hardware was done by Vahe Ghazikhanian
- The slow control software was developed by Bertrand Biritz (UCLA graduate student).
- The fabrication of the boxes, assembly and testing of the PC boards and HV distribution boxes was performed by UCLA machine and electronic shop personnel.
- We expect to have one FTE @ 60% and one graduate student at 20% to work on the remaining aspects of the HV and LV systems.

HV Dist. Boxes



Start Detector ("upVPD")

19 detectors/side (east & west)
Pb+Scint+R5946 (recycled from TOFp)
careful electrostatic shielding, no Steel or μ-metal

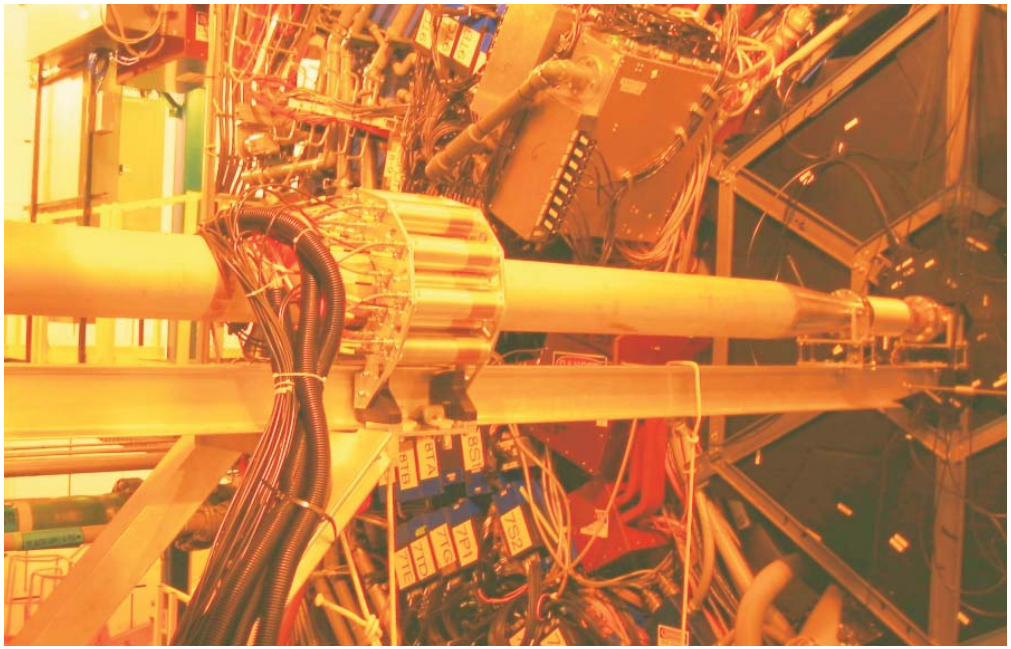
HV cables and bases from UCLA (vahe)
Mechanics from UT machine shop, Rice design
Detectors & final Assy at Rice (J. Zhou & WJL)

relative to "pVPD" (used during Runs 2 - 5).....

- factor √6 improvement in σ(start) in A+A
- factor 3.5 improvement in eff(start) in p+p (~35%)
- lighter weight, less shadowing/det

first used in Run-6 with mosfet bases.... 2 weeks of data collection (collected 10M evts, rates up to 4kevts/sec!), then uninstalled
immediately noticed base failures at ~1 base/day
start-side data unusable for fast-timing
stop-side data (TOFr5 reinstalled w/out changes) usuable but 2 weeks of p+p insufficient to track and calibrate

replaced bases before Run-7
linear bases optimized for high-rates
simple grounding mistake in some chs
braid used to fix issue during run



stable throughout Run-7, no failures

16 of 19 channels/side sent to STAR Trigger
digitized there and used at Level-0
long cables between detectors & digitizers

3 west channels read out by TOF at very end of run

still need to determine upVPD detector resolution
(& better yet as digitized by TOF electronics)

Gains

initial set done at Rice with a source (mip calibration)

gains improved using $TRGD data using correlation of upVPD ADC & CTB ADC sum (Lijuan)

Offsets determined then “installed” in hardware (Lijuan and Jack Engelage)

→ Trigger type “mb-vpd”:

READY **8176007** *2007ProductionMinBias* [PHYSICS]

Destination: "RCF"

Started: Mon Jun 25 01:26:18 2007 *[00:20:13 hr ago...]*

Stopped: Mon Jun 25 01:46:30 2007 *[00:20:12 hr]*

Last Status: Stop OK

Trigger	DAQ Input	DAQ Rate (Hz)	L0 Input	L0 Rate (Hz)	Scaler Rate(Hz)	Built	Xpress	Aborted	Rls'd (GB/L2.5)	Error
zdcpre	6 [0.0%]	0 [0.0%]	6	0	0.0	6 [0.0%]	0 [0.0%]	0 [0.0%]	0/0	0 [0.0%]
vpd0	3 [0.0%]	0 [0.0%]	3	0	889.7	3 [0.0%]	0 [0.0%]	0 [0.0%]	0/0	0 [0.0%]
mb-zdc	131 [0.1%]	0 [0.0%]	131	0	22474.1	129 [0.1%]	0 [0.0%]	0 [0.0%]	0/0	2 [1.5%]
vpd1	17 [0.0%]	0 [0.0%]	17	0	4457.1	17 [0.0%]	0 [0.0%]	0 [0.0%]	0/0	0 [0.0%]
z	116 [0.1%]	0 [0.0%]	116	0	1.0	113 [0.1%]	0 [0.0%]	0 [0.0%]	0/0	3 [2.6%]
mb-vpd	99757 [99.8%]	0 [0.0%]	99757	0	829.8	96821 [99.8%]	0 [0.0%]	0 [0.0%]	0/0	2936 [2.9%]
All	100001 [100.0%]	1 [100.0%]	100000	0	9384831.3	97060 [100.0%]	0 [0.0%]	0 [0.0%]	0/0	2941 [2.9%]

use earliest east hit and earliest west hit to define Zvtx

no slewing correction

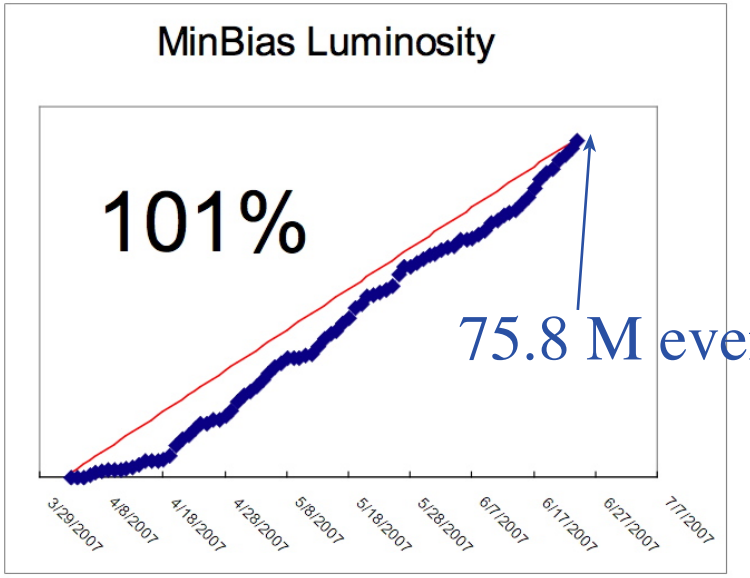
offsets applied at hardware level

flat dist of earliest ch IDs

Two gates on the east-west time difference defined

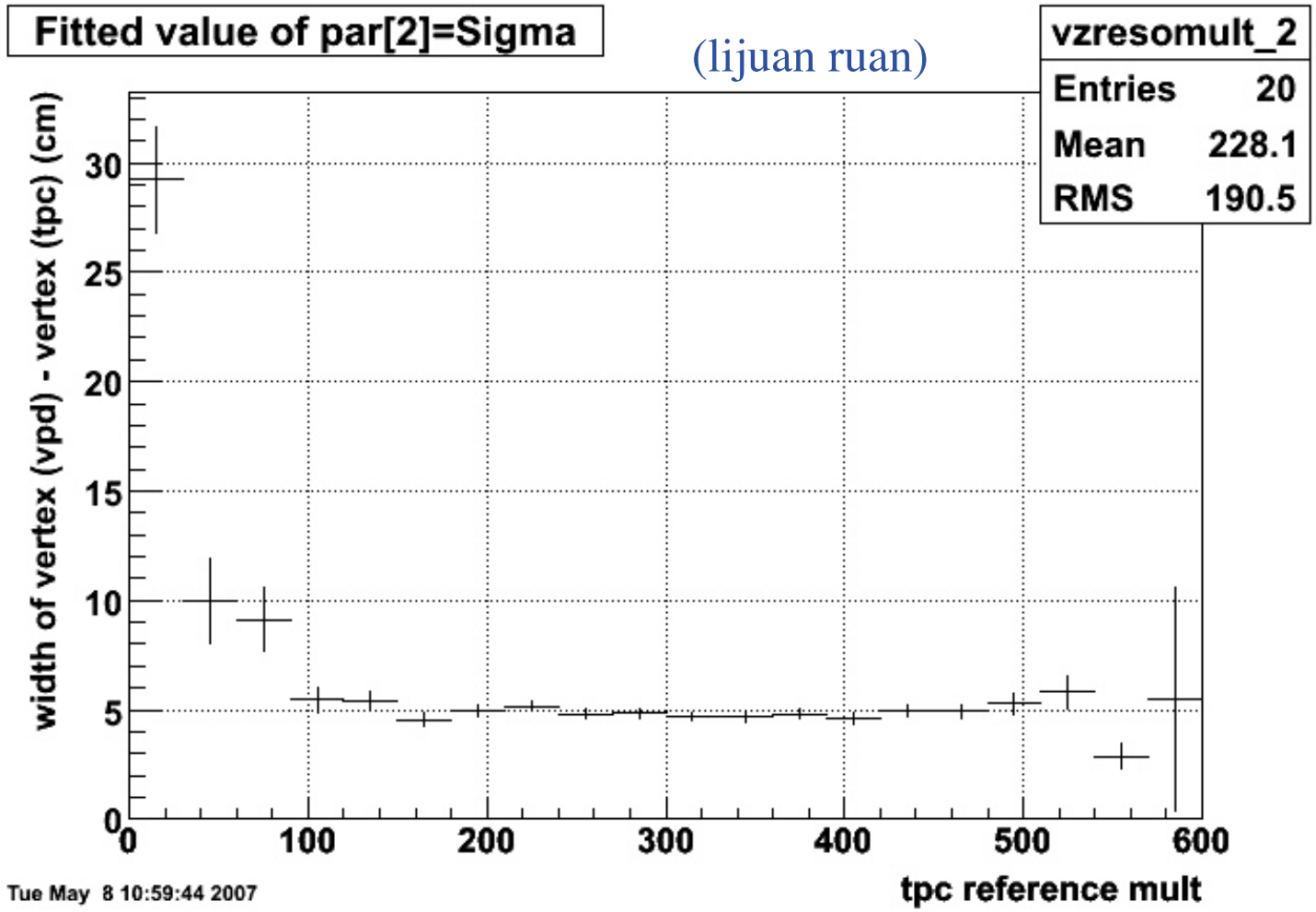
“vpd0”: 14 TAC chs wide → |Zvtx| < ~6cm

“vpd1”: 84 TAC chs wide → |Zvtx| < ~36cm



upVPD vertex Z-resn using Trigger data

form difference of Zvtx from TPC tracking (fast offline!) and Zvtx from upVPD east-west timing....
plot standard deviation of this quantity versus TPC track reference multiplicity:



Zvtx difference resolution, σ_z, is ~5cm in top ~5/6th of the refmult distribution...

$\sigma_z = \sigma_z(\text{TPC}) \oplus \sigma_z(\Delta t)$

assuming $\sigma_z(\text{TPC}) << \sigma_z(\Delta t)$:

$\sigma_z \sim 5\text{cm} \rightarrow$ TOF $\sigma(\text{side}) = \sigma(1) \sim 235$ ps

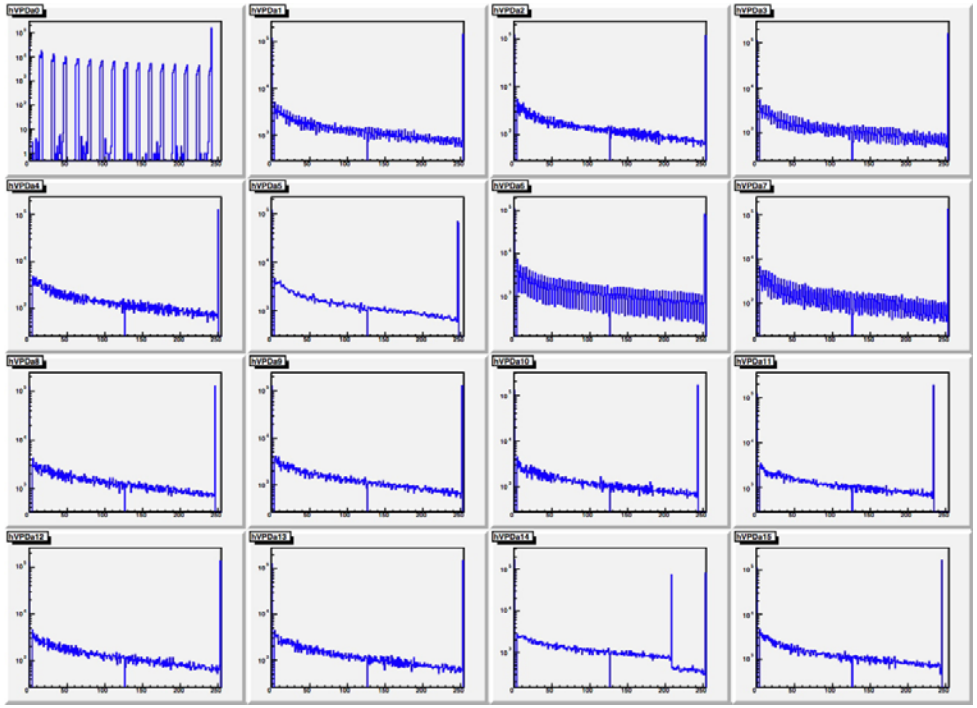
Closer look at $TRGD data

data files from staruser@startrg.starp.bnl.gov:/$TRGD
converted to TTree using locally modified version of Trg2Ntp program (Mats, Eleanor, ...)

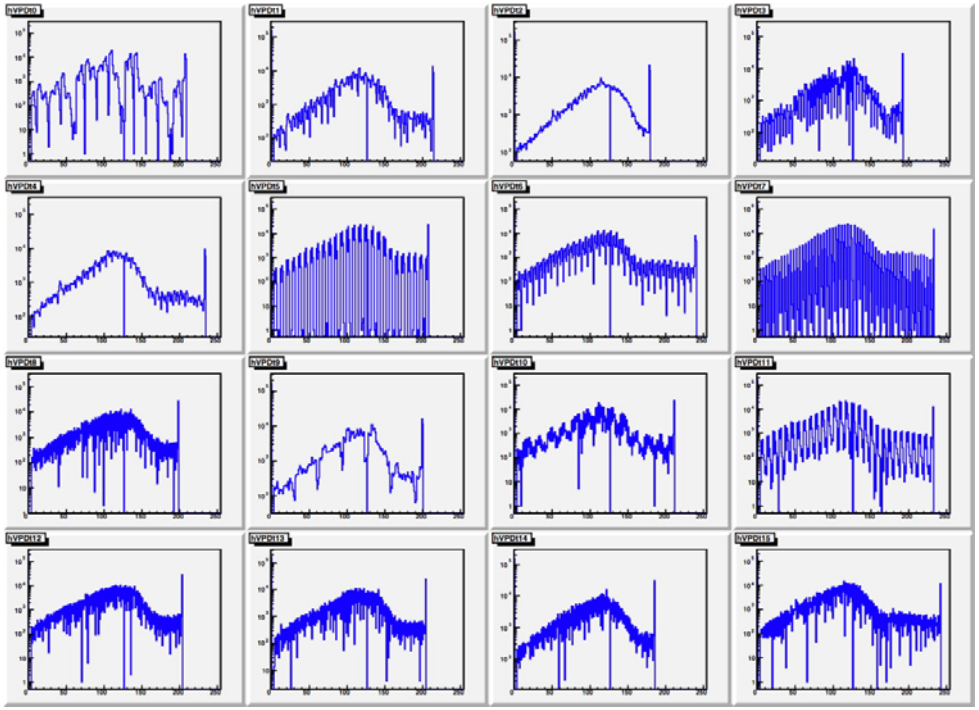
16 channels per side of upVPD digitized by Trigger
- long cables between detector and digitizers
- 8 bit ADC
- 8 bit TAC, 59ps per TACbin, “common stop” from RHIC clock

data shown here from days 88-90, default min. bias triggers, ~590k events total

ADC singles distributions, East upVPD

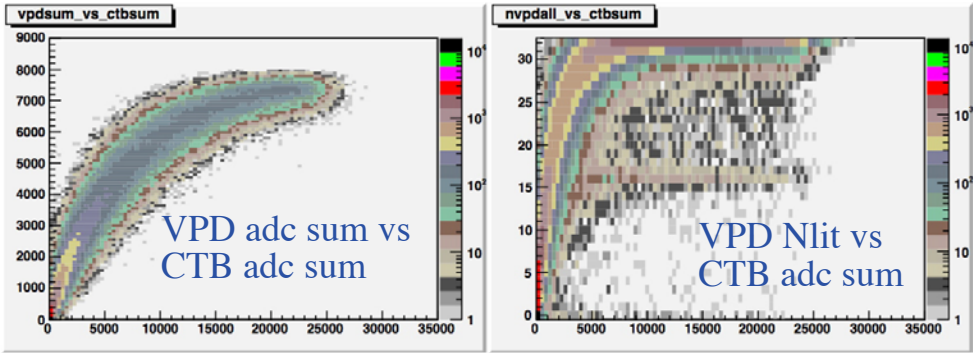


TAC singles distributions, East upVPD

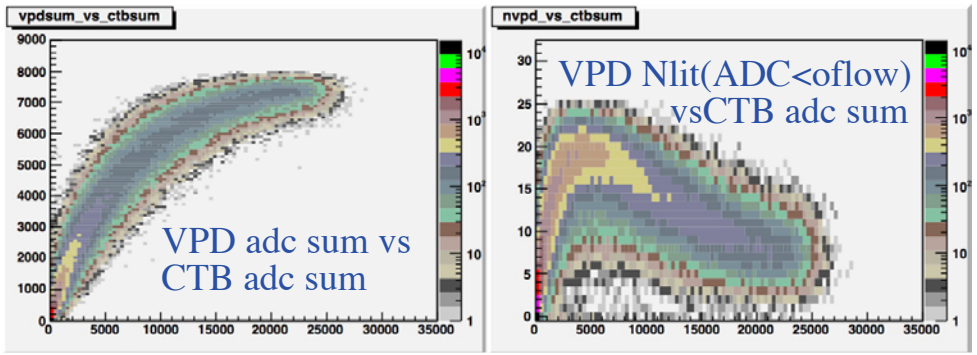


all channels work...
“stuck bits” in the digitization...

as expected (Au+Au), the start detector is getting pummelled (in a good way!)

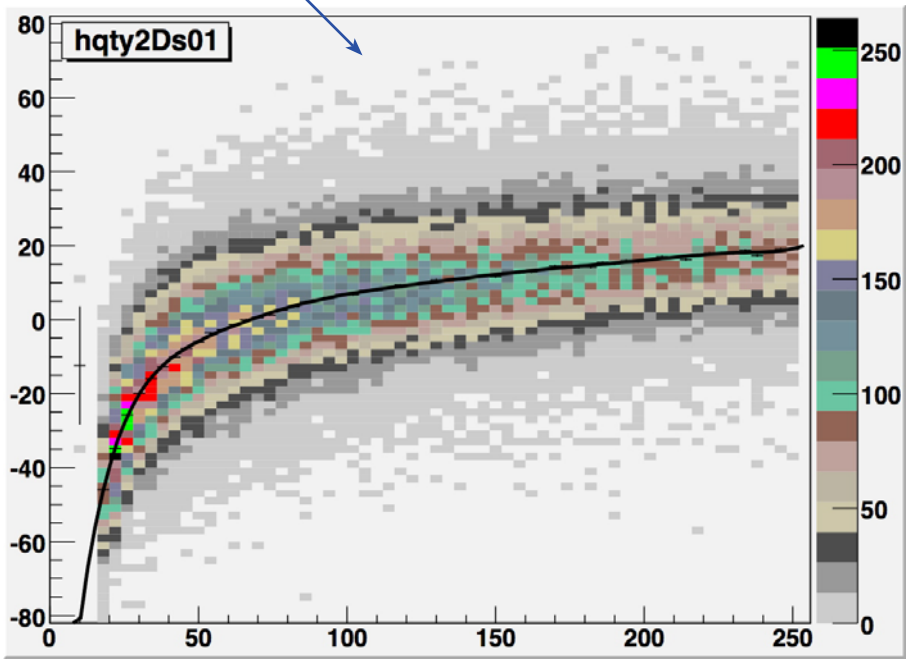


but, with centrality, most of the detectors overflow their ADCs



Slewing/Offsets Calibration:

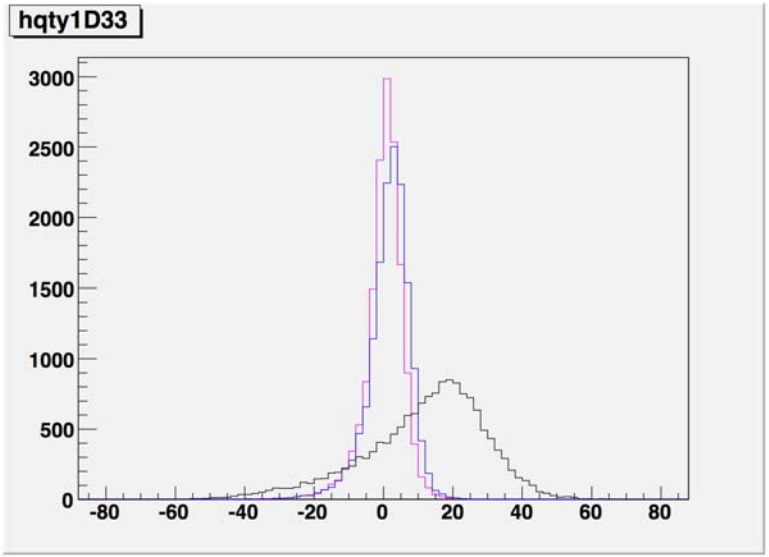
- plot chX time minus average of times of other lit channels on the same side versus ADC value for chX
- number of other channels used in average is a user parameter
- after each pass through data, fit with polynomial
- use fit pars in subsequent passes to improve ch X
- do each side (east and west) separately in each pass
- first 16 passes touch each channel for the first time
- ~64 passes total, additional passes don't help



system is common-stop (slew curves inverted)...

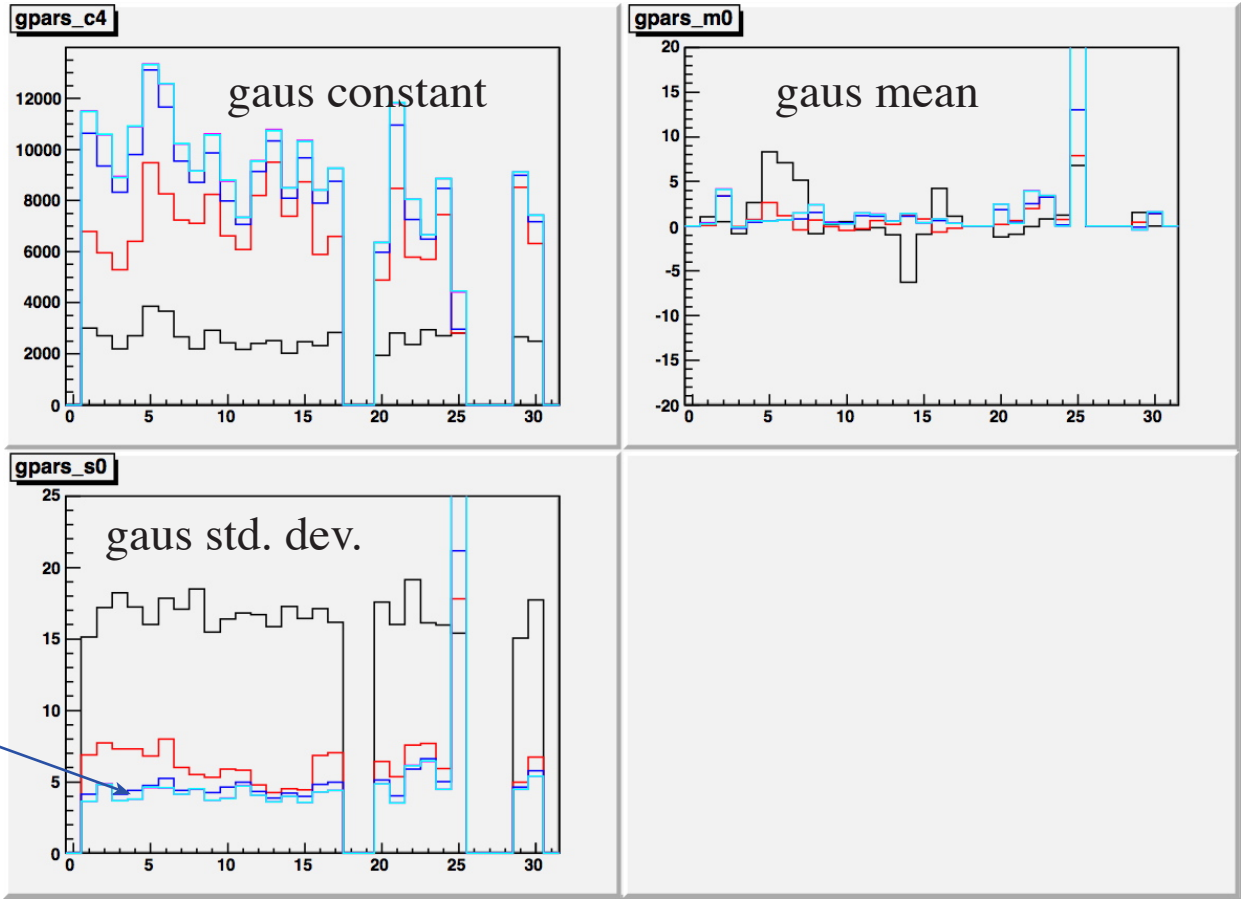
resolution of RHIC clock itself
(the common stop for the TACs) is irrelevant

Project this quantity to
evaluate single detector resolution



Fit parameters versus
upVPD channel number

black: pass<16
red: pass<32
blue: pass<48
cyan: pass<64



resulting single-detector resolution
~ 4 TAC bins
~ 240 ps

Run-7 data from Start-Side as digitized by TOF electronics

canbus read-out

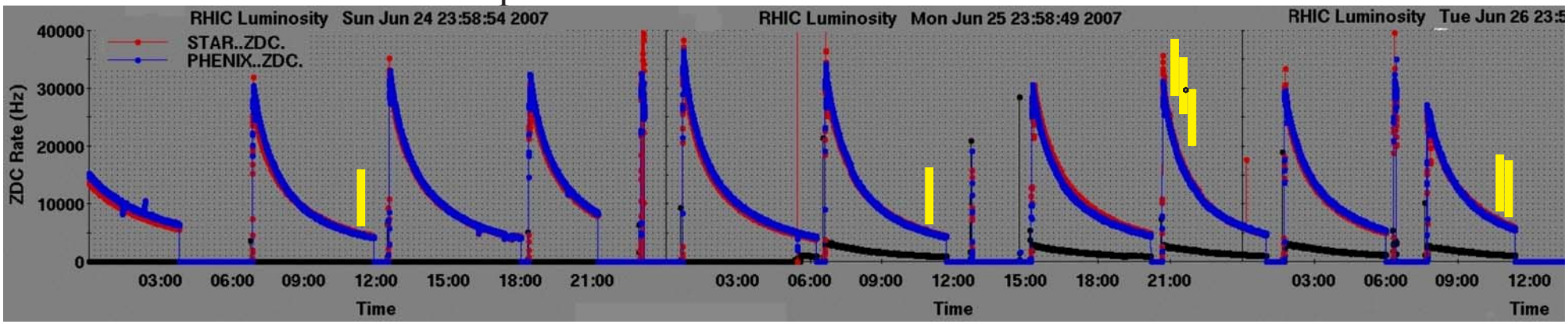
not STAR-triggered data, just flat file of all time stamps seen in widest matching window

no “event” structure

other STAR detectors like CTB & TPC not available (and cannot be made available)

simultaneous read-out of east and west not possible

all data collected within last 10 spills of Run-7



Need to define “events out” of this stream of stamps

read in “200” LE stamps, unpack and apply INL, histogram times with coarse (μs) bins

find peaks in this distribution

collect time stamps within 3 microseconds of each peak

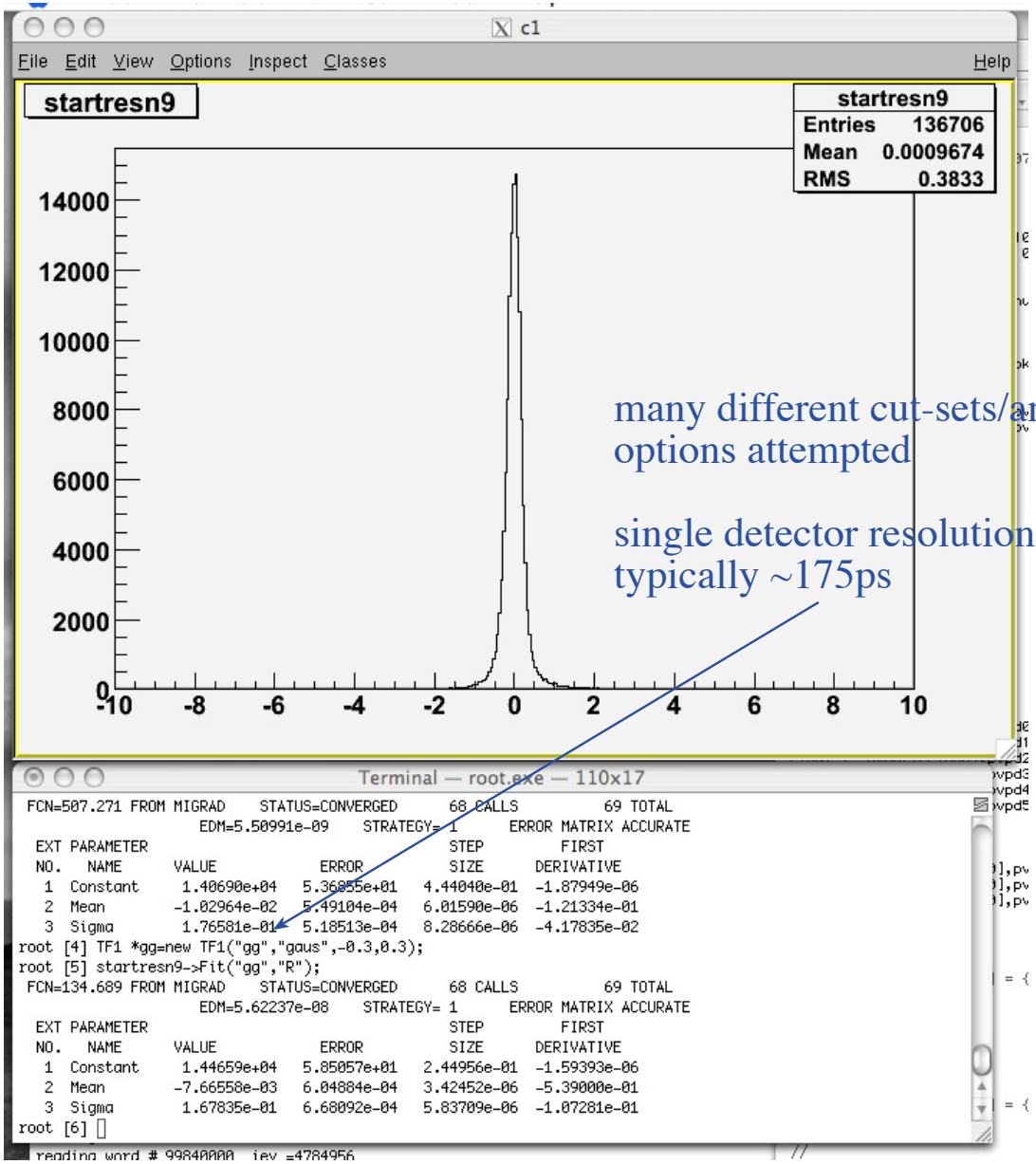
require first & last stamp IDs, and number of stamps, in peak within sanity limits

call each set of collected stamps an “event”

take earliest LE stamp in each detector channel in each event, calculate appropriate ToT

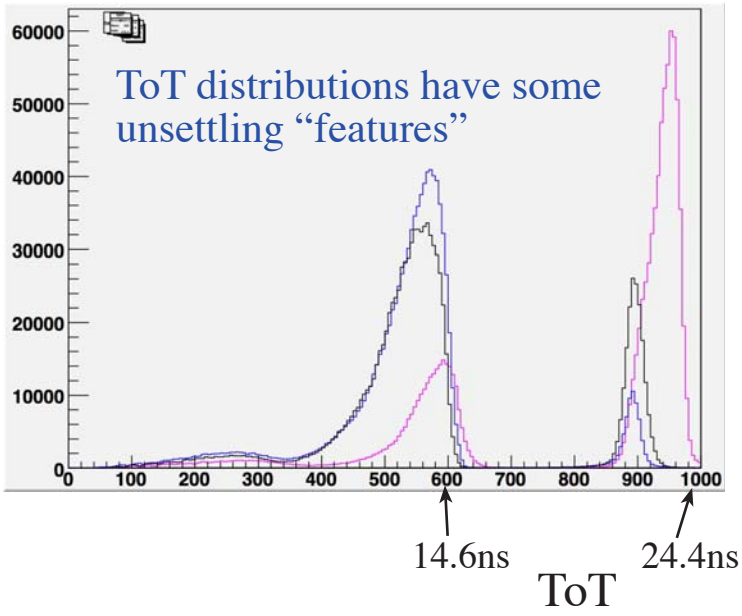
require all three detectors are struck

then calibrate using standard techniques....



many different cut-sets/analysis options attempted

single detector resolution seen typically ~175ps



TRG data (long cables) -- ~240ps
TOF data (short cables) -- ~175ps

would have expected better results.

we need to understand cause
- ToT mismatch and/or grounding?
- cabling and/or untriggered data?
- stuck bits and/or TOF electronics?

No usable data in Run-6
Some data in Run-7 but nowhere near the quality of the Run-5 data

Very badly need signficant set of STAR data in Run-8, on both start and stop sides

Summary

Final tray fabrication complete, tray mechanical looks good
Assembly space, fixtures, and an extremely competent team all in place at UT
- Assembly procedure generally well-defined but of course it is being tweaked...
- Assembly line in operation (9 trays built at UT so far)
- Excellent web area with tray and test result databases, photographs, discussion areas...

Tray assembly rate assumed in project (~2-3 trays/week) is comfortably achievable

Start detector "done", but clearly requires some tweaking
- provided Zvtx information for main STAR minimum bias trigger over entire run, no detector failures
- we still have not proven the (recycled TOFp) PMTs have met the performance specs.

LV system implemented in run-7, now fix problems and expand system
HV system nearly complete, first implementation in run-8, then expand

Gas system - good recent progress

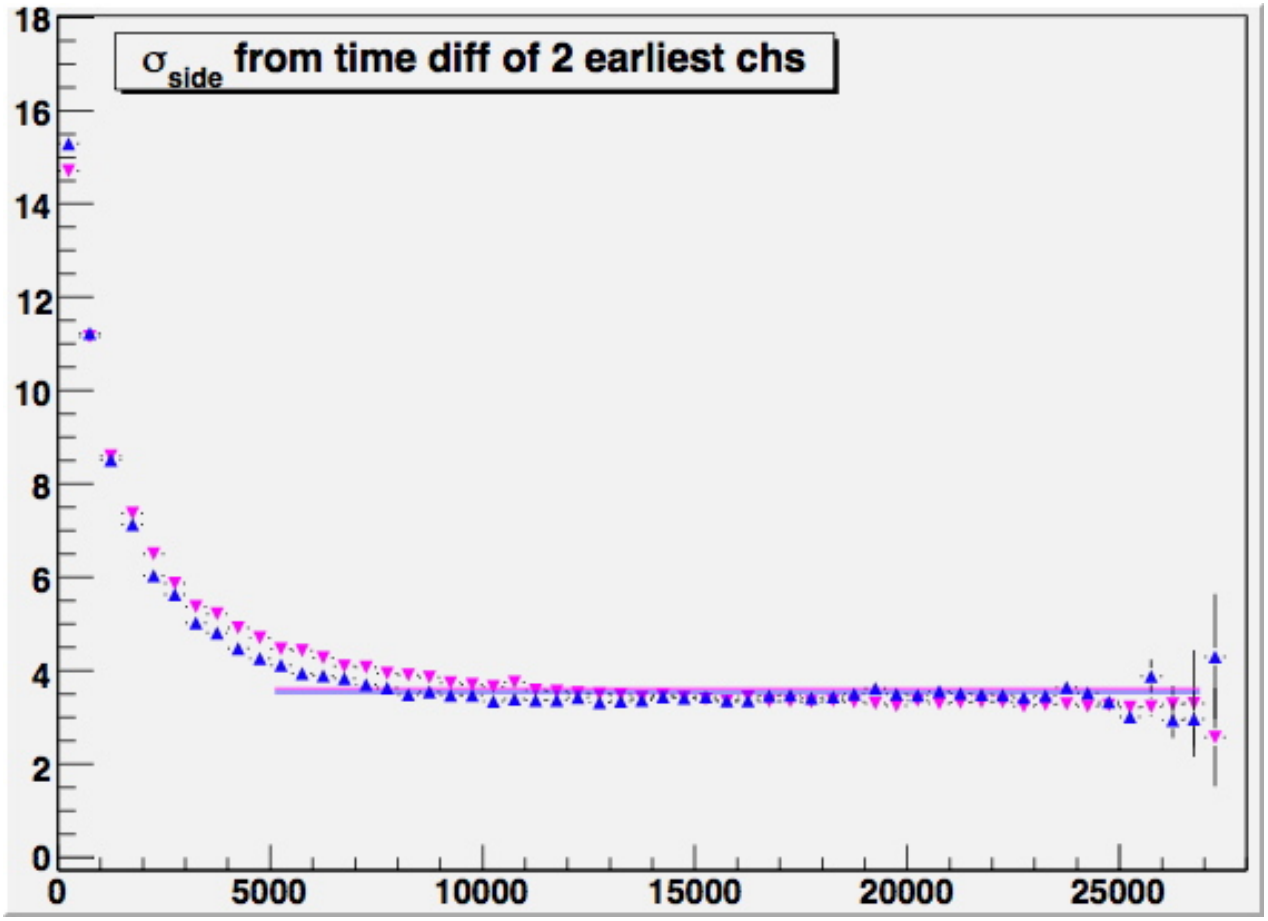
Near-Term Goals (besides continued construction & testing!)

(trays)	continue to develop "fast" MRPC testing stands and full tray cosmics stands at UT
(trays)	finalize TTRG & TCPU electronics and cable-routing/strain-relief at tray feedthrough end
(water)	repeat heat/power test with fully configured on-board electronics estimate water temperature rise per tray, and then define water distribution system
(integration)	design and fabricate TPC Support fixture (needed before run-10) Tray Insertion fixture (needed before run-9, but push to have for run-8 to gain experience)
(LV/HV)	understand cause of channel failure, and firmware instability, in LV supply complete migration from LabView to EPICs control & monitoring code continue component location as systems expand
(Start Det)	test upVPD detectors with latest TDIG electronics on the bench at Rice fix simple grounding issue in some channels, check ToT distributions
(Gas Sys)	complete gas system mechanical and control software identify on-detector gas splitter locations pursue means to leak-test all "in-detector" components

(BACKUP SLIDE)

take earliest hits on each side, no slewing correction → σ(Zvtx)~5cm → σ(1) ~ 240ps

use all hits, and do full slewing correction → σ(1) ~ 240ps



select 2 earliest channels
in each event
on each side separately
skip slewing correction

form difference
plot difference vs. CTB sum as 2D
fit Gaussians in y-slices
plot σ(1-1) vs CTB sum

σ(1) = σ(1-1)/sqrt(2)

provides another estimate of σ(1) in uncorrected $TRGD data

σ(1 east) ~ σ(1 west) ~ 3.7 TACbins ~ 220 ps