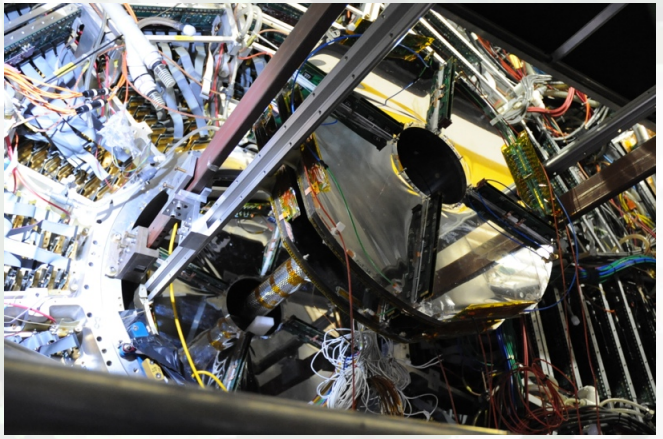
Status / Plans
Forward GEM Tracker Project

Bernd Surrow

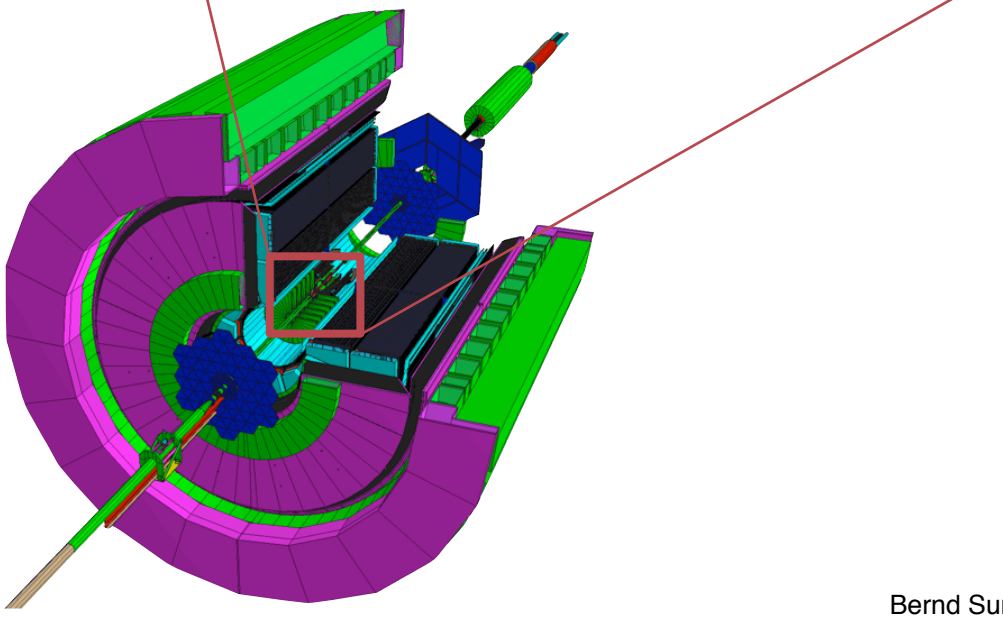
TEMPLE UNIVERSITY

On behalf of the STAR FGT group



Outline

- Motivation - Physics Program / Run 13
- Overview - FGT
- Commissioning and hardware status:
  - Installation
  - DAQ
  - Triggers
  - Run 13 QA
  - Working point adjustment
    - Latency / Time-bins
    - HV
    - APV parameters
  - Performance results
- Plans (Software / Shutdown / Physics)

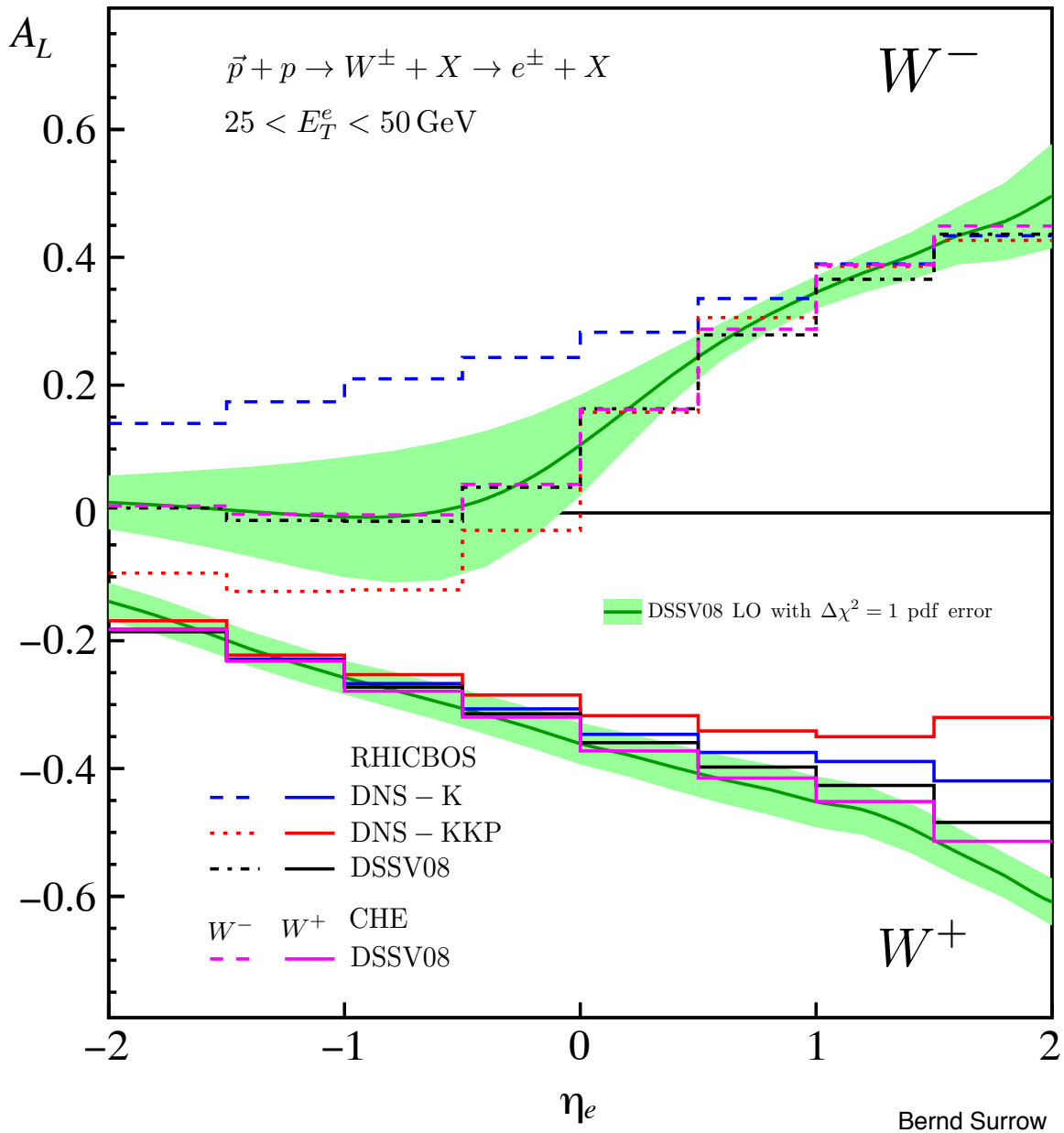


Motivation - Physics Program / Run 13

- STAR A_L results / projections

Motivation - Physics Program / Run 13

- STAR A_L results / projections

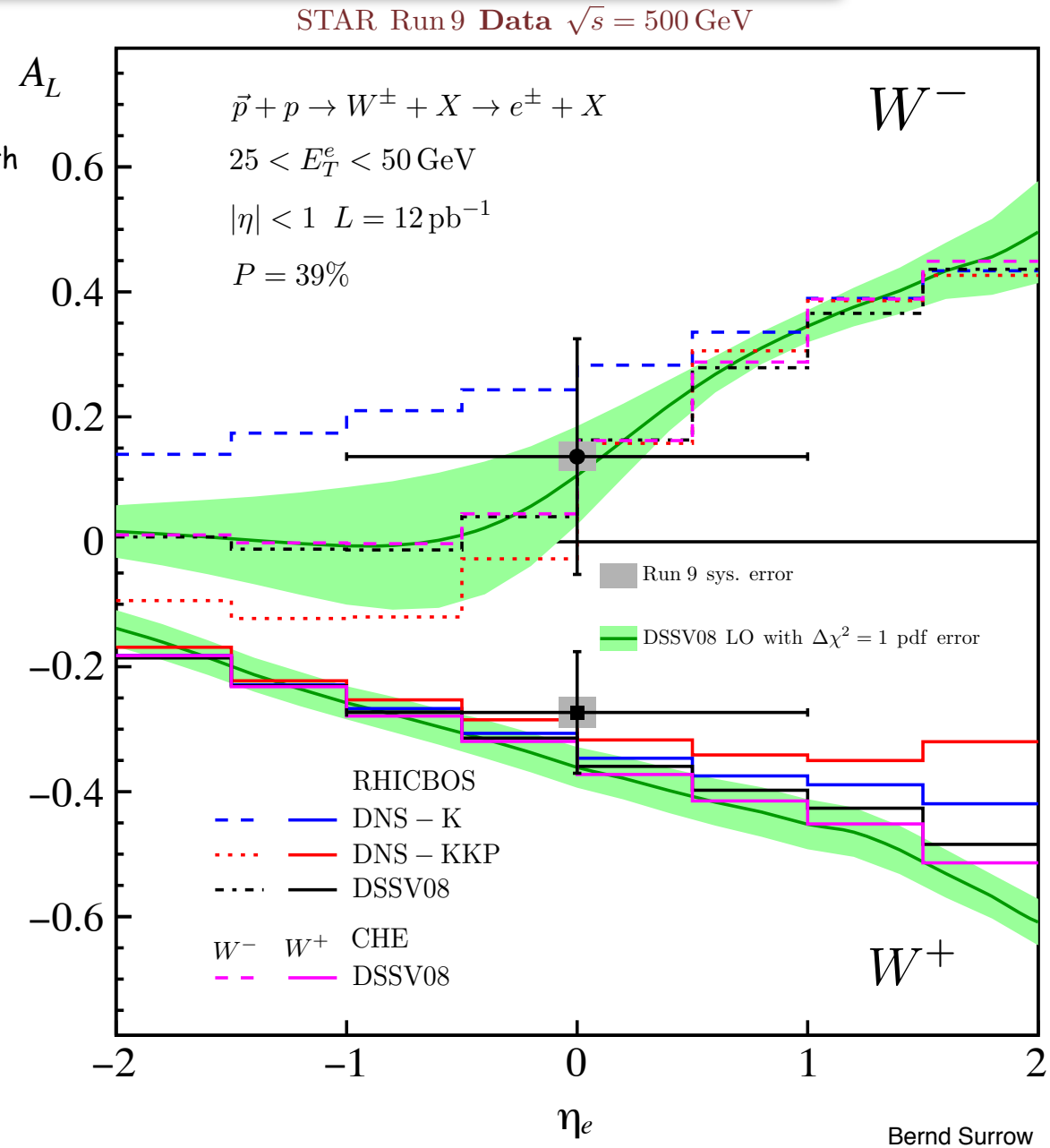


Motivation - Physics Program / Run 13

- STAR A_L results / projections

Measured asymmetries (Run 9) are in agreement with theory evaluations using polarized pdf's (DSSV) constrained by polarized DIS data

⇒ Universality of helicity distr. functions!



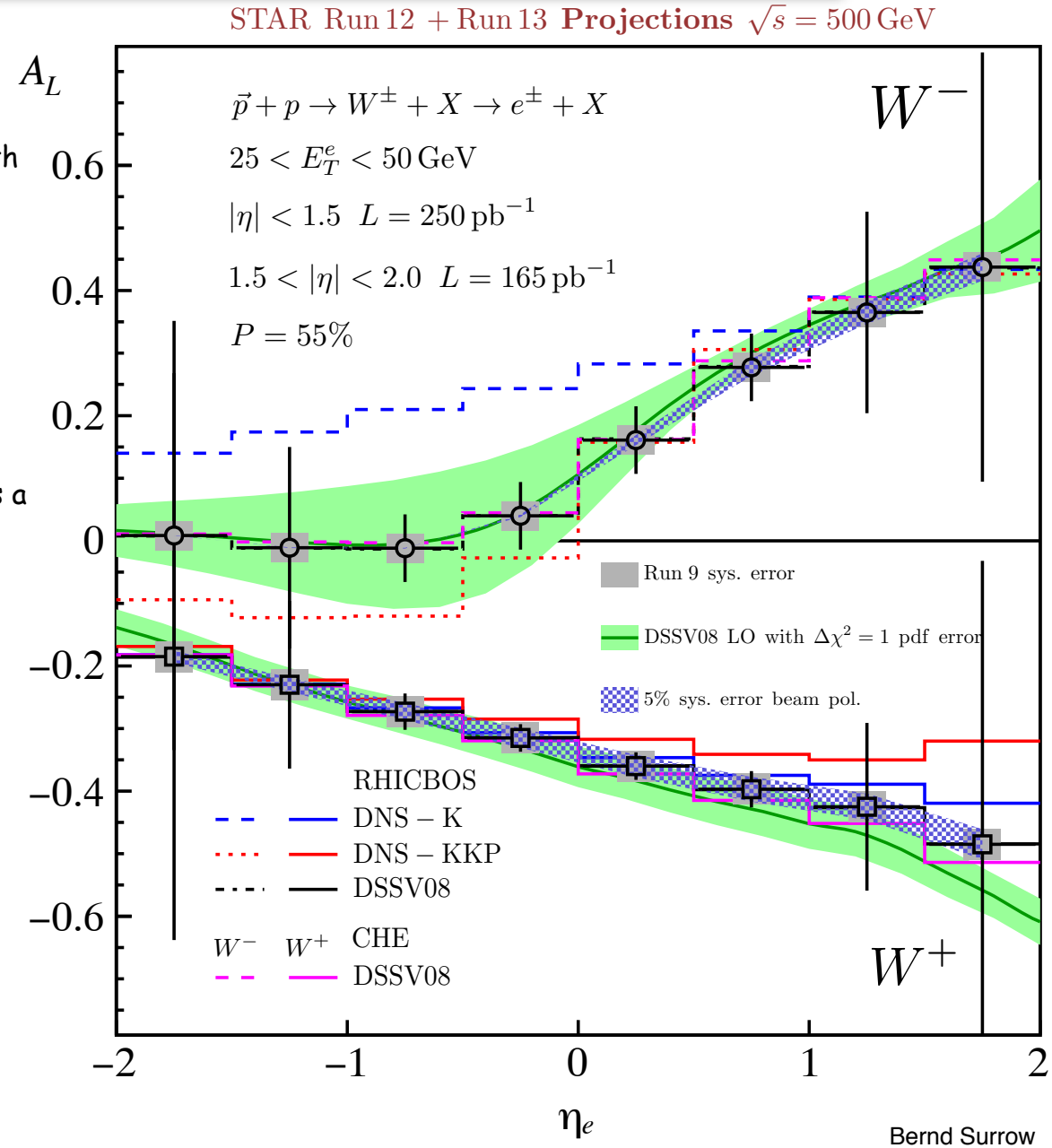
Motivation - Physics Program / Run 13

- STAR A_L results / projections

Measured asymmetries (Run 9) are in agreement with theory evaluations using polarized pdf's (DSSV) constrained by polarized DIS data

⇒ Universality of helicity distr. functions!

Critical: Measurement of W^+ and W^- asymmetries as a function η_e



Motivation - Physics Program / Run 13

- STAR A_L results / projections

Measured asymmetries (Run 9) are in agreement wit theory evaluations using polarized pdf's (DSSV) constrained by polarized DIS data

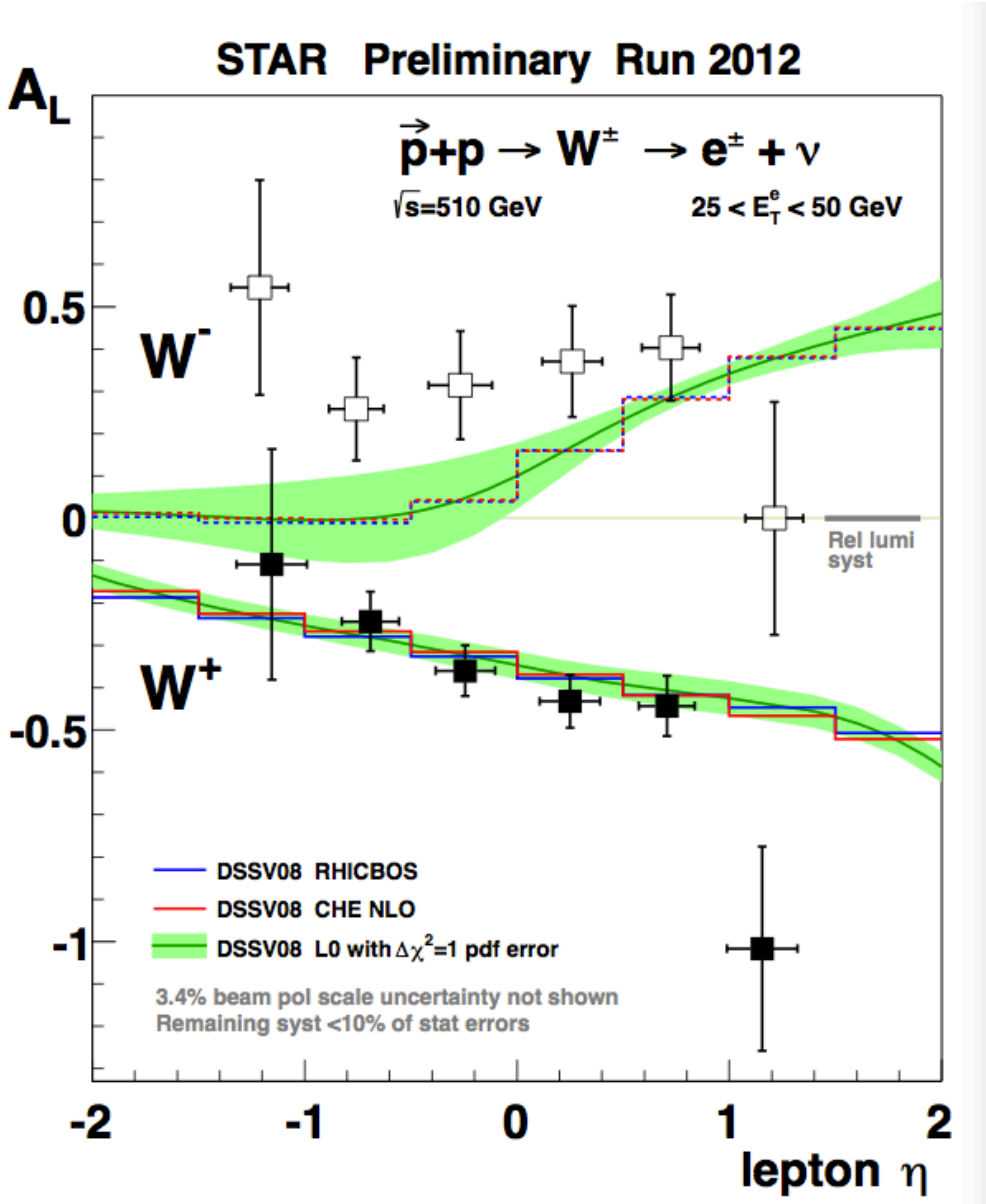
⇒ Universality of helicity distr. functions!

Critical: Measurement of W^+ and W^- asymmetries as a function η_e

Major step forward in Run 12: Large A_L (W^-) asymmetry suggests large anti-u quark polarization

Extension of backward / forward η_e acceptance enhances sensitivity to anti-u / anti-d quark polarization

⇒ STAR Forward GEM Tracker ($1<|\eta_e|<2$)

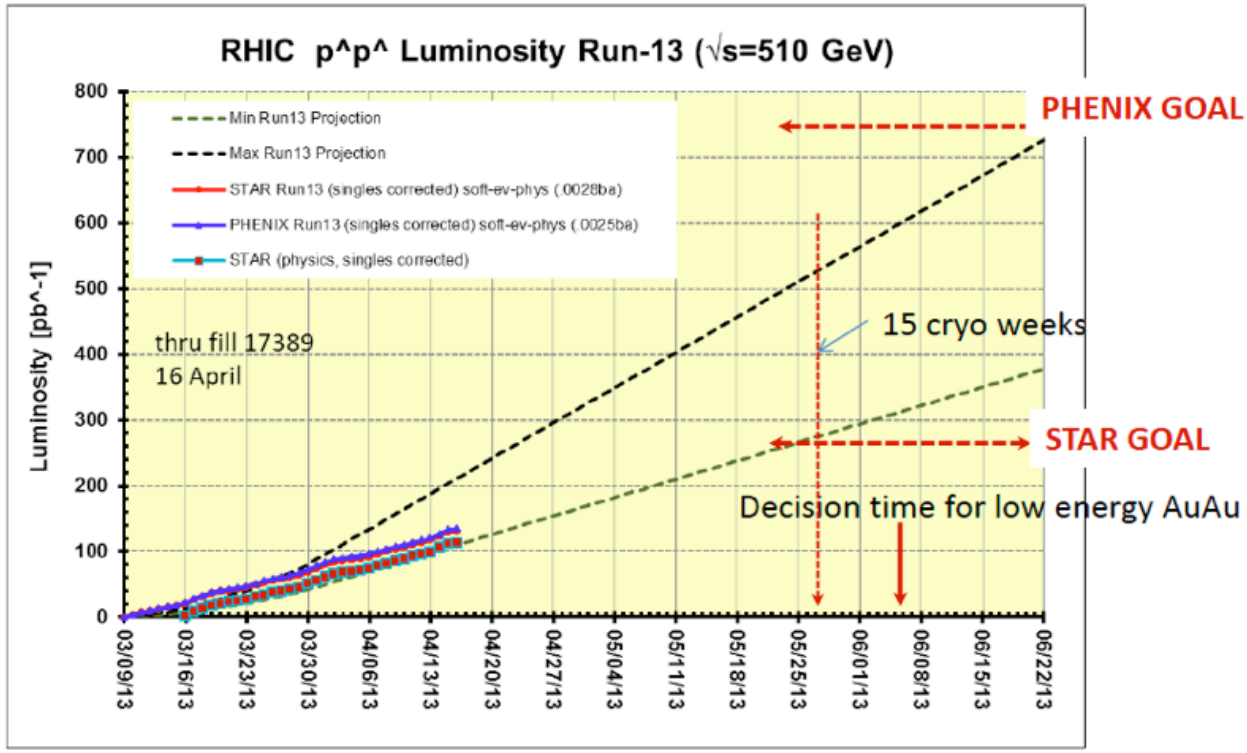


Motivation - Physics Program / Run 13

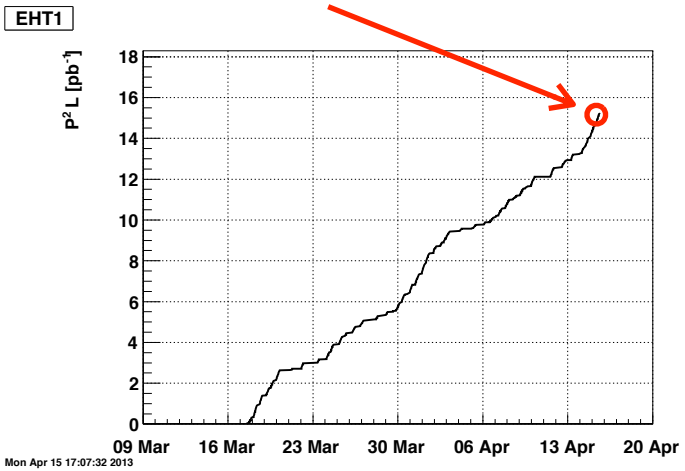
RHIC luminosity projections

PHENIX Goal, 250 pb^{-1} recorded, 750 pb^{-1} delivered, ≥ 55% polarization

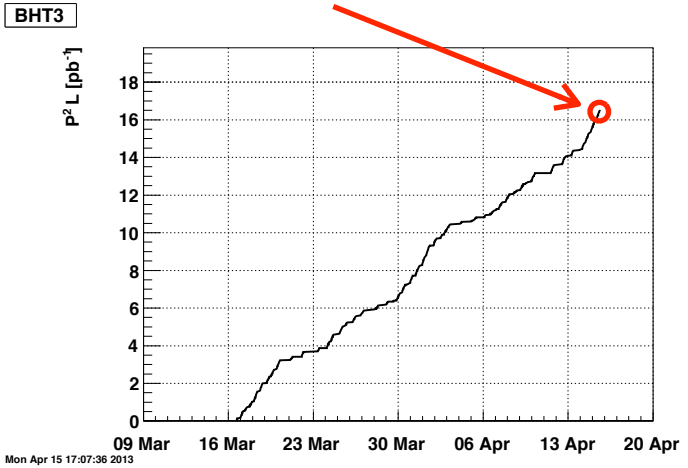
STAR Goal, 165 pb^{-1} recorded, 275 pb^{-1} delivered, ≥ 55% polarization



FOM (Forward W trigger EHT1): ~ 15pb^{-1}



FOM (Barrel W trigger BHT3): ~ 16pb^{-1}



- Run 12 mid-rapidity W A_L analysis: FOM = 20pb^{-1}
- STAR BUR goal for Run 13: FOM = $P^2 \cdot L = 0.55^2 \cdot 165 pb^{-1} = 50 pb^{-1}$

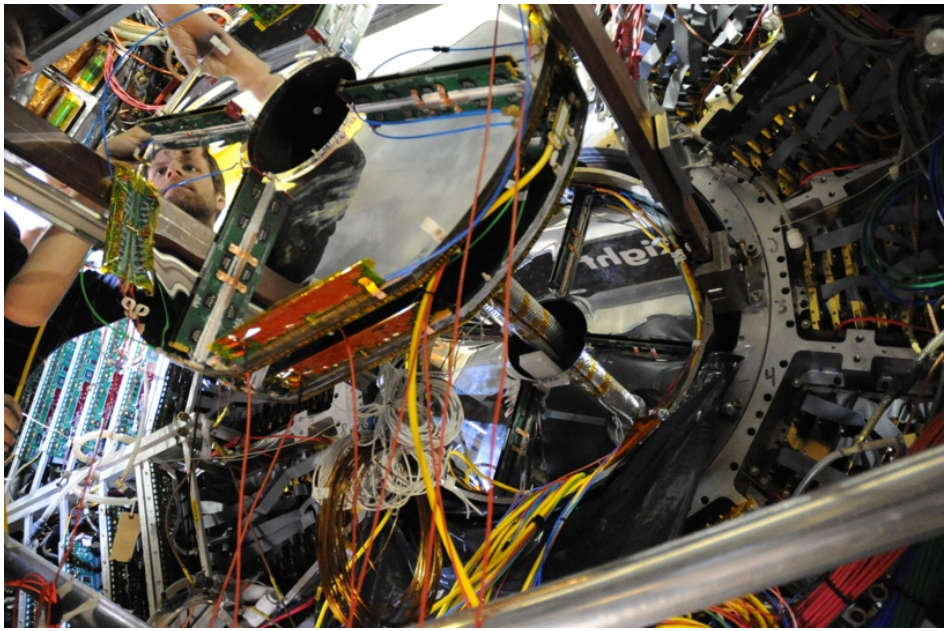
Overview - FGT

Executive summary

- Successful assembly and installation of all six disks, i.e. 24 quarter sections with 4 quarter sections on each disk
- Individual characterization and 55Fe scope test of each old and new quadrant at MIT Bates prior to installation
- Cosmic-ray testing of quadrants
- First results of analysis of cosmic-ray test data (residual / efficiency) presented
- Run 12 data analysis (Residual) and Run 13 data analysis (Residual) consistent with cosmic-ray data
- Successful testing of gas and pedestal performance prior to installation of WSC inside STAR
- Hardware status:
  - Commissioning, i.e. working point adjustment (HV, Latency, APV parameter) completed with beginning of STAR physics-mode running
  - Generally smooth operational performance of FGT
  - DAQ: Limitation of data taking rate (~200Hz) with original control module (ARC-I) / Upgrade underway with new ARC-II for Run 13
  - Satisfactory performance for all quarter sections on Disk 1 and 2 in terms of readout and actual detector behavior
  - 3/24 quarter sections disabled: 2: Gas line blockage during installation (Disk 4C/4D) / 1: Excessive leakage current (Disk 6C)
  - FEE: Issues (*) largely with APV chip communication / programming for some of the chips in particular on disk 3, 4, 5 and 6
  - Summer 2013 shutdown (*): Replacement of APV chip modules and test in preparation at Temple University GEM lab (Technical engineering support from MIT Bates required - Under discussion!)

Installation - FGT

- Status
  - 24+4 quarter sections were assembled
  - Installation of 14/24 quarter sections in Run 12
  - Installation of remaining 10 remaining prior to Run 13
  - Installation periods:
    - September 2012: Disk 1-4
    - November 2012: Disk 5-6

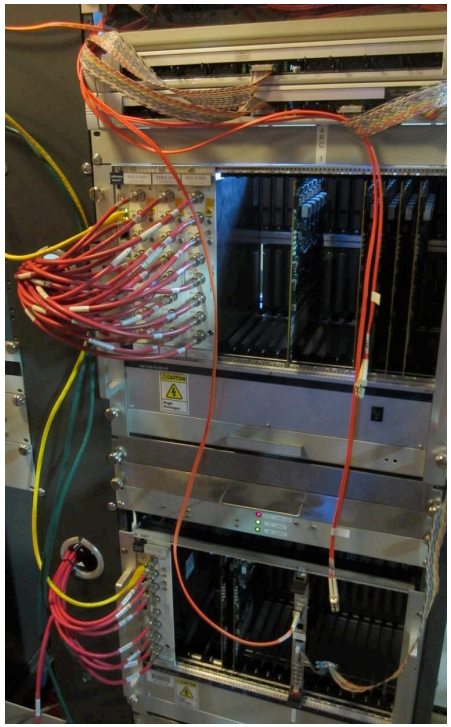


DAQ - FGT

2012 installation

- Completed final assembly and test of 6 ARM modules [total 18], and installed 2 to complete the FGT
- Resolved "6th ARM" firmware bug and data header/reader issues, and implemented variable number of timebins readout and full set of APV control registers from configuration file
- Fixed defective FEE power cable and TCD cable, each of which was set aside / not needed in Run 12
- Implemented software zero suppression in DAQ front-end PC (Tonko Ljubicic)

FGT (top) and GMT readout rack



Operational status

- No defective hardware in Run 13 FGT readout/DAQ
- Production runs typically 200 Hz with deadtime ~1-2 %
- Busy hole due to incorrect conceptual design of ARC-I module
- Some runs end early due to FGT errors: Data is fine, but inefficient operation
- Upgrade of ARC module (ARC-II): Target date, May 01, 2013

http://online.star.bnl.gov/daq/export/daq/

STAR DAQ **RUNNING [to RCF]**

pp500_production_2013 [PHYSICS]

Det	State	Dead	CPU%	Evts	Hz	kB/s	Err
TOF	RUNNING	4 %	14	1307728	1204	6778	0
BTOW	RUNNING	2 %	13	1306574	1220	11945	0
Trigger	RUNNING	0 %	0	1311950	1224	4696	0
HLT	DEAD	0 %	0	0/0	0	0	0
ETOW	RUNNING	2 %	13	1307256	1217	2554	0
FGT	RUNNING	1 %	17	175302	185	18380	0

Triggers - FGT

- Trigger list overview and rates
  - Completed FGT commissioning prior to readiness of STAR calorimeter triggers
  - Trigger overview:

RUN 14105038				
3:24 PM	3:50 PM	1514s		
TRIGGER	**Id**	**PSCL**	**EVT**	**RATE**
MBbase	17	371976	10714	7.1
ZEROBIAS	9300	10	2321	1.5
BBCMB	430015	398142	10642	7
VPDMB	430031	398142	2485	1.6
EHT0	430302	1	46284	30.6
EHT1	430303	1	16951	11.2
EHT0*EJP1*L2Egamma	430304	1	31721	21
EHT1*L2EW	430305	1	3473	2.3
EEMC-dijet	430408	1	166559	110
JP0	430411	97	37408	24.7
JP1	430412	20	37337	24.7
Total FGT rate:				241.7
Comments Shift log:	All detectors in except MTD. Good run (1.9M events).			

Run 14105038 from Monday, April 15, 2013

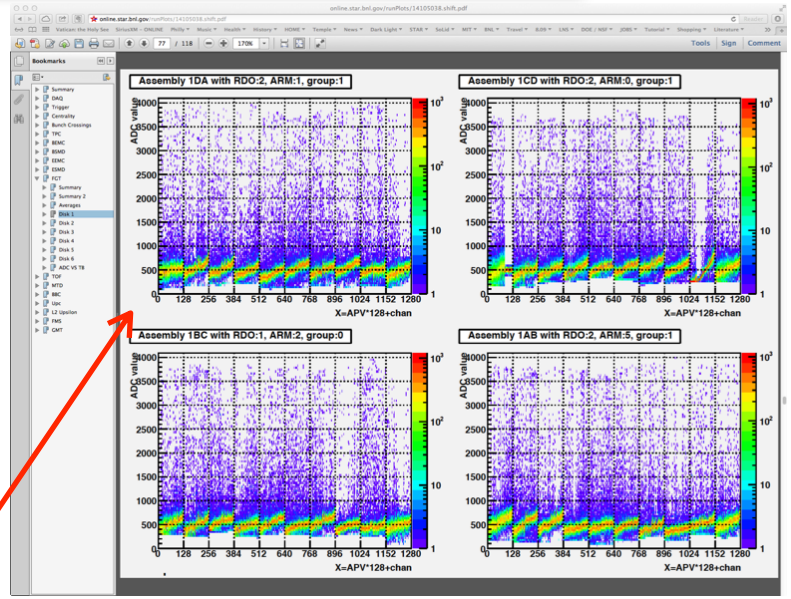
Rate for main L2 W trigger

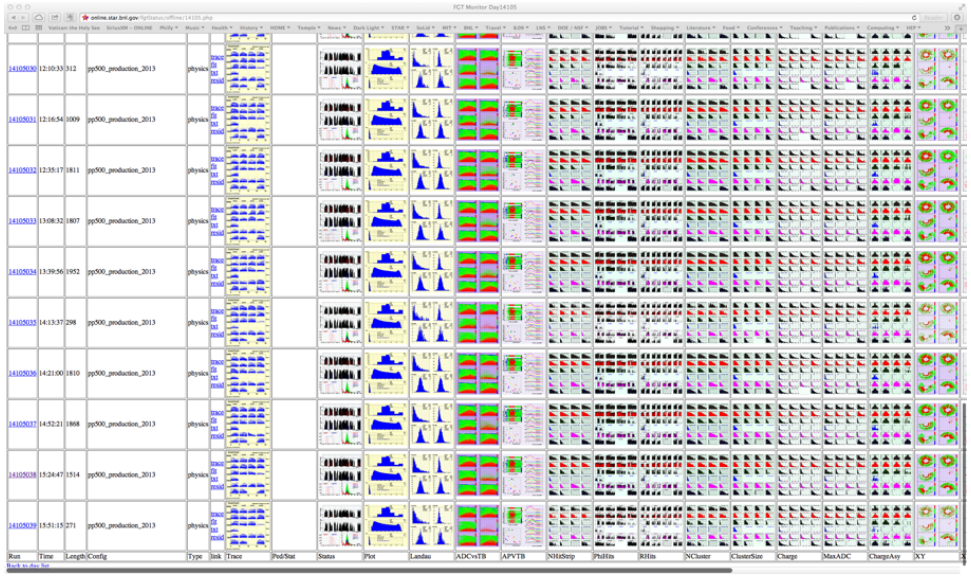
Main L2 W trigger

Total FGT rate!

Run 13 QA - FGT

- QA tools
  - Online:
    - Run monitoring tools ('JPLOT') with daily logs provided by student
    - Online FGT monitor: http://online.star.bnl.gov/fgtStatus
  - Offline:
    - Detailed non-track and track-based tools (Straight-line tracking) monitoring offline performance with daily logs provided by student: http://online.star.bnl.gov/fgtStatus/offline/



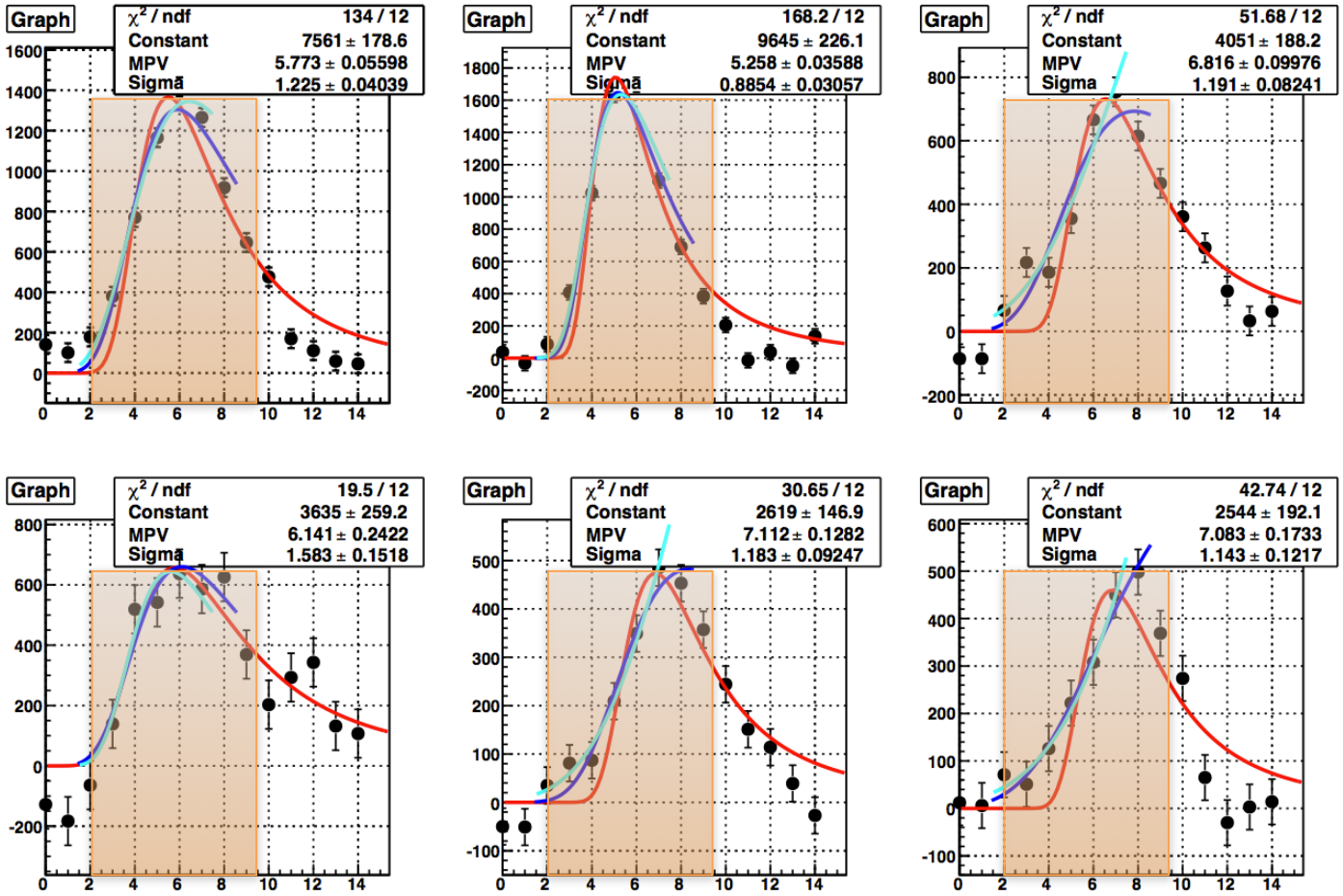


Working point adjustment - FGT

- Overview
  - The following items were adjusted and completed prior to physics mode operation:
    - Latency and Time-bin distribution
    - APV parameter scan
    - HV scan
  - With physics mode operation and availability of calorimeter triggers:
    - Rate studies
    - Including JP type triggers in addition to W / EEMC related triggers

Working point adjustment - FGT

- Time-bin distribution



Pulses from

15 time-bins readout

during commissioning:

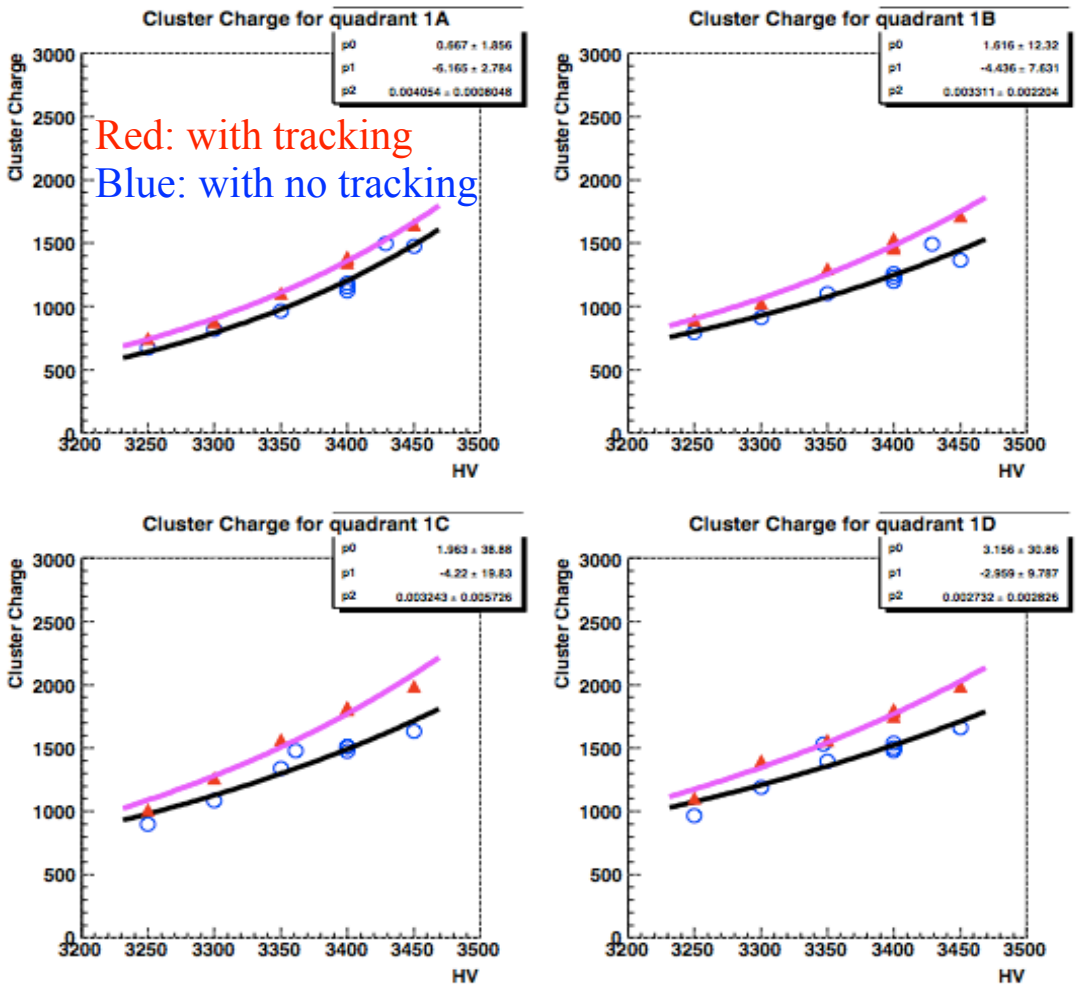
Fit (Landau distr.) with:

- 15 time-bins
- 7 time-bins
- 6 time-bins
- 8 time-bins readout (Compromise agains deadtime!)

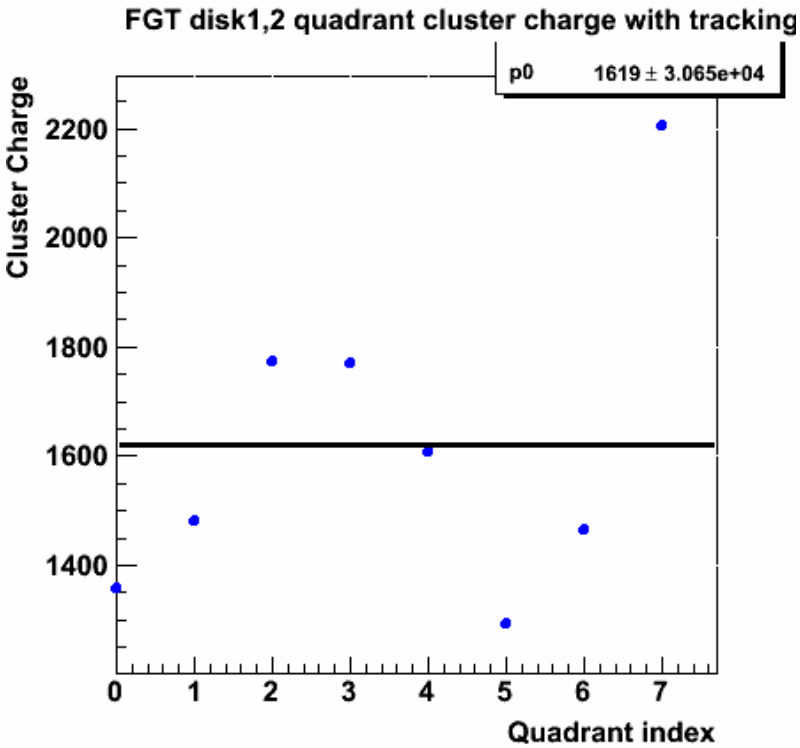
Working point adjustment - FGT

- HV

FGT disk1 cluster charge versus HV

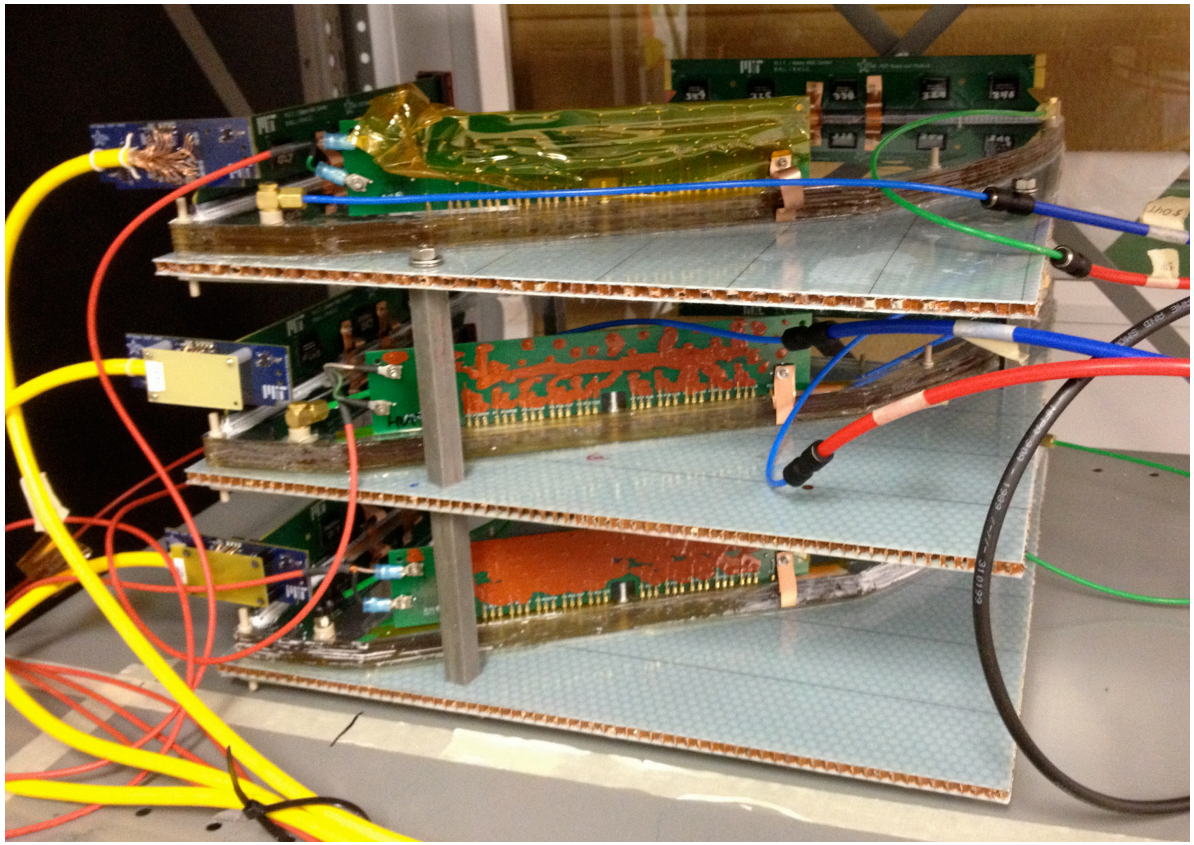


- Get gain curve for all 6 disks
- Adjust to average value of Disk 1 and 2
- Actual chosen HV value set to avoid large currents!



Performance results

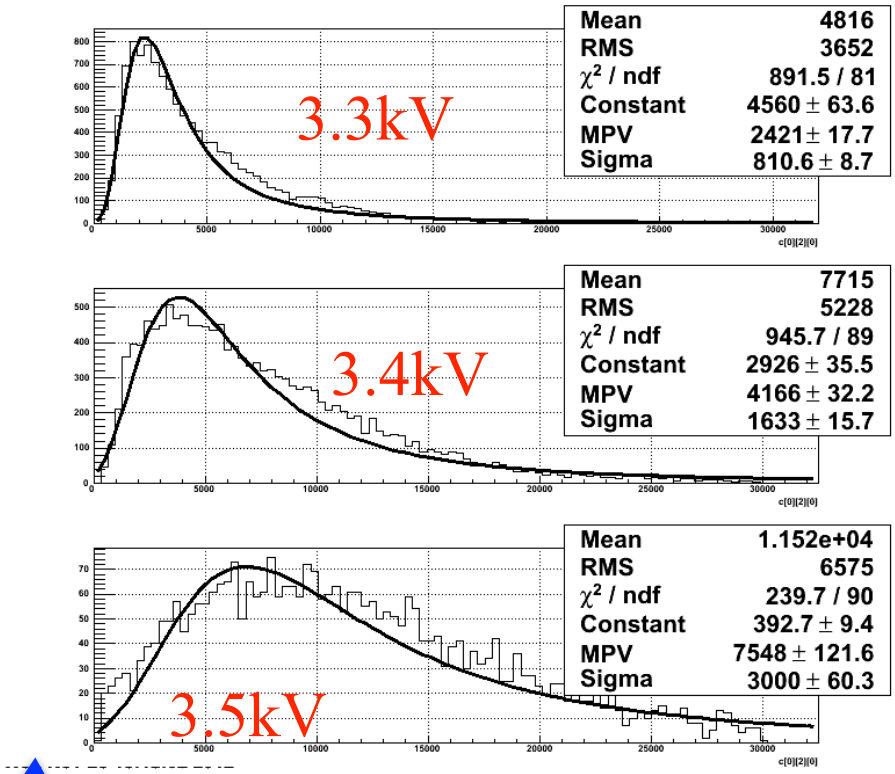
- Cosmic-ray setup

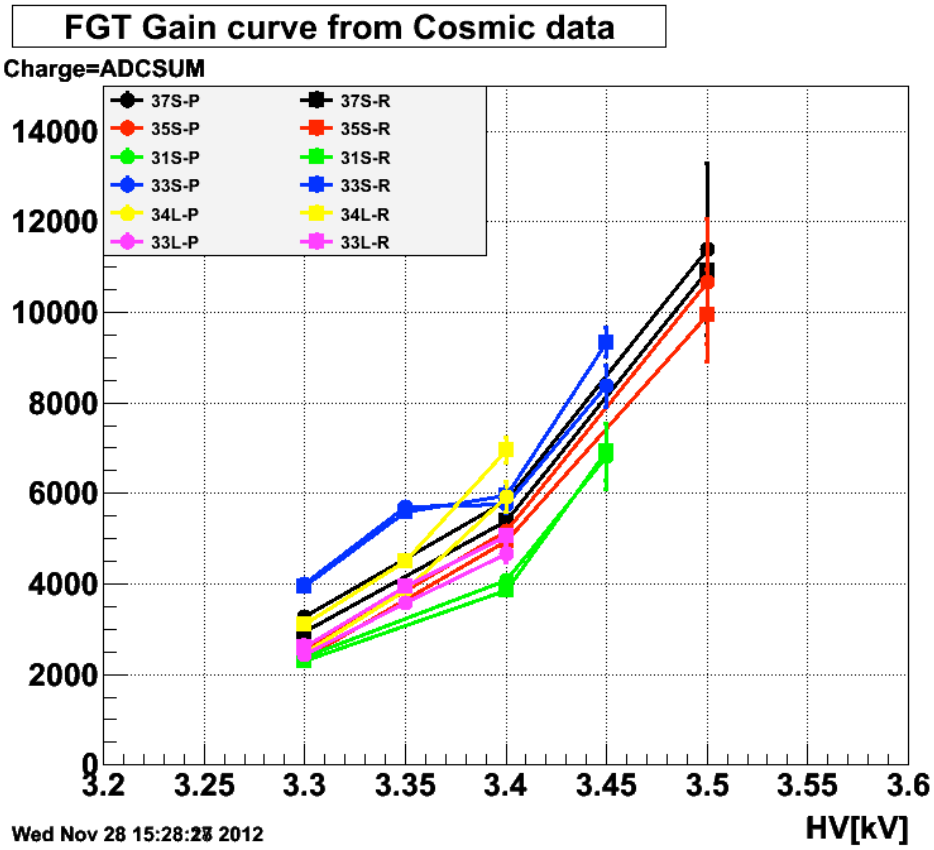


3 FGT Quads + Trigger Scintillator counter above and below

Performance results

- Gain vs. HV



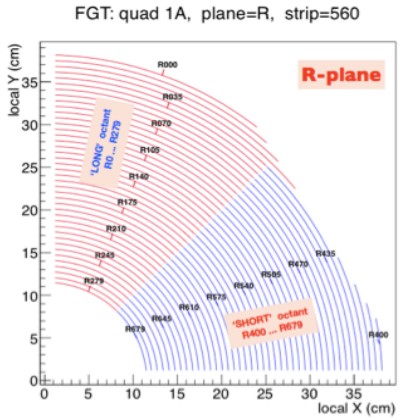


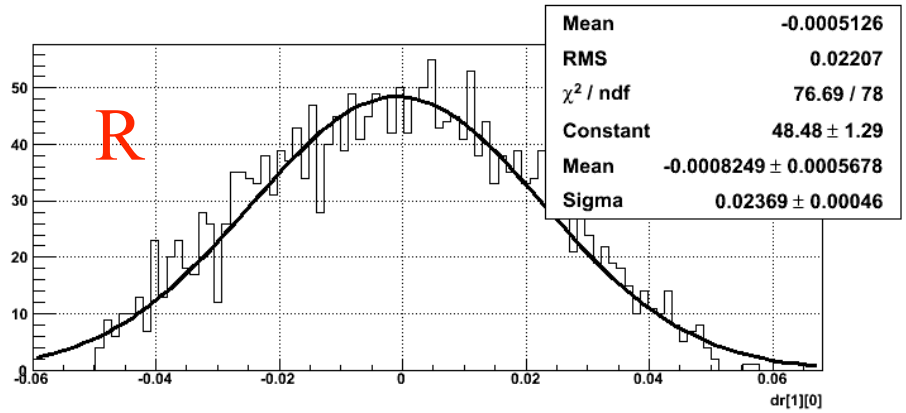
Cluster threshold = 4*PedRMS(~40)*3timebin ~ 500

ADC saturate at peak time-bin of peak strip for
~10% of pulses at 3.4kV
~50% of pulses at 3.5kV (but no visible effect on residual yet)

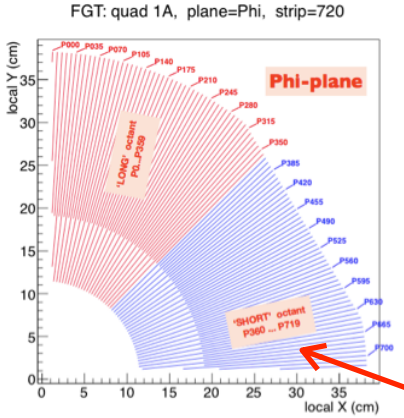
Performance results

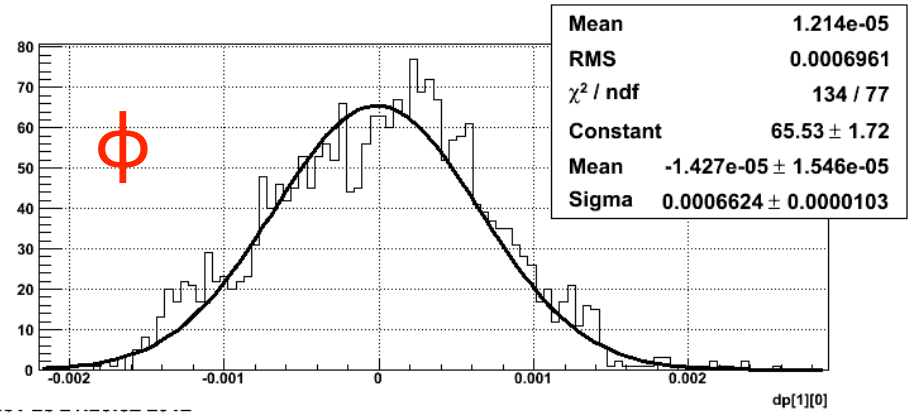
Cosmic-ray residuals





Sigma = 240um





Sigma = 0.6mrad

=> 180um @ R=30cm

NOTE: At 30cm with wider pitch compared to small R region!

Assuming all quadrants have same resolution:

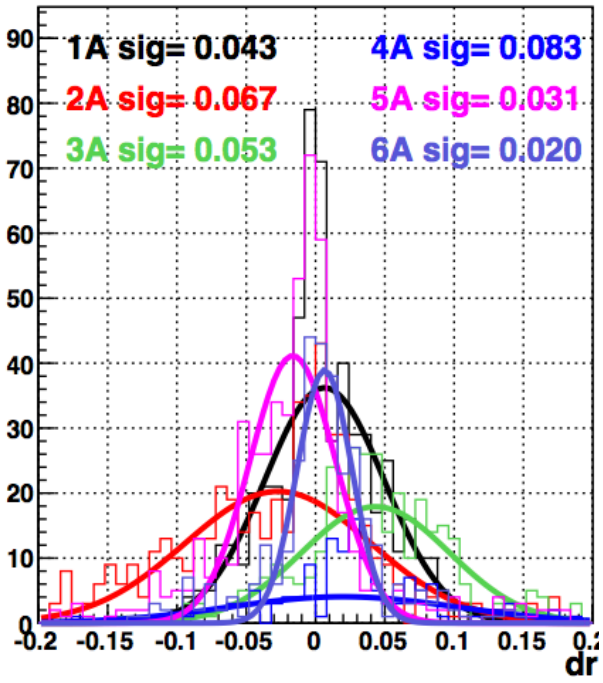
Single detector position resolution = Residual at middle quad/1.22 (from simple geometry)

180μm residual @ Middle => 150μm resolution at each detector

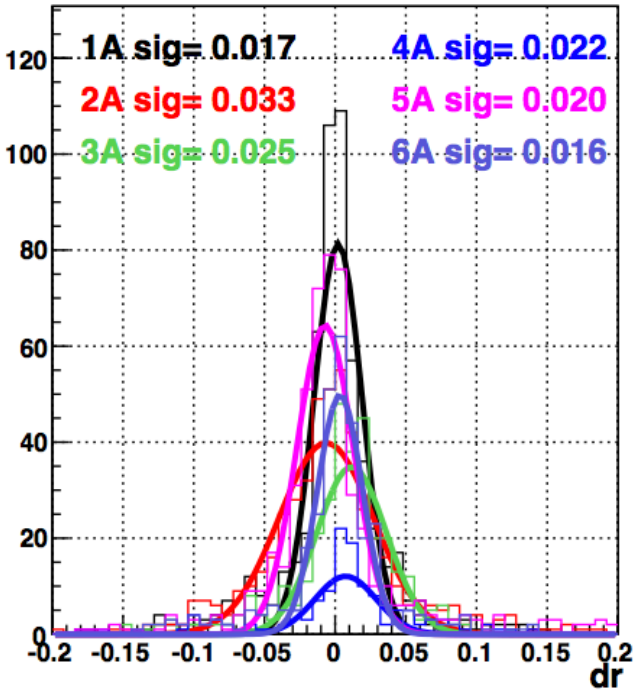
Performance results

- First residual results from Run 13

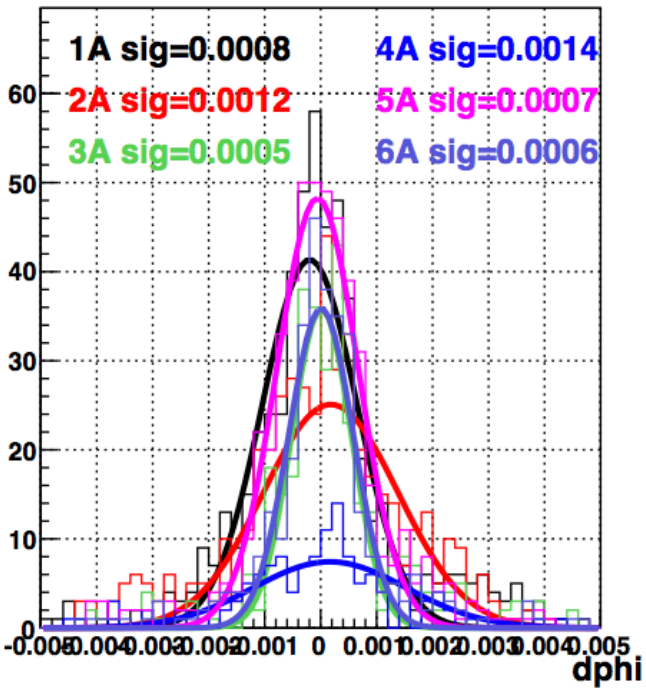
ΔR Before



ΔR After



Δϕ After



- Shift up to ~ 1mm (R) and ~0.5mrad (Phi)
- Residual sigma ~300u (R) and ~1mrad (Phi) (0.5mrad @ 30cm = 150μm)
- Results are consistent with cosmic-ray and Cu-Au results!

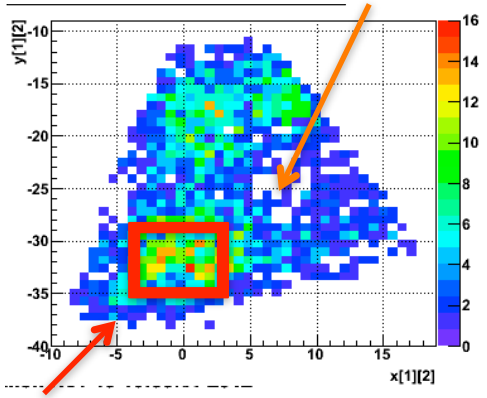
Performance results

Efficiency

Using 2 quad only "tracking" to get efficiency on 3rd quad
"Golden event" = 2 quads has 1 and only 1 cluster each in R & Phi
-> Sensitive to noise at higher HV & low Thr

FGT31-Short "Golden event" Hit Map

Less "good track" due to dead area in FGT37

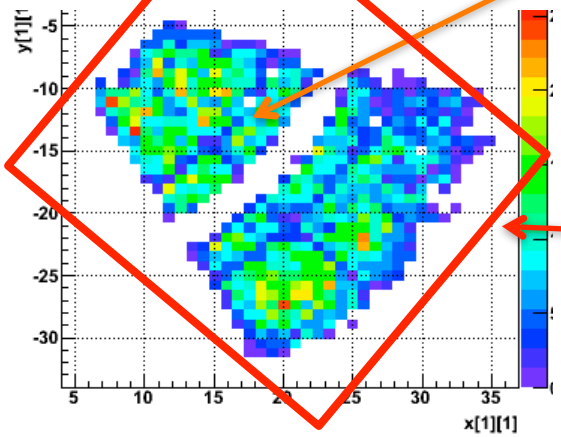


Efficiency calculated in this area only

	FGT037	FGT035	FGT031
3.3kV	73%	83%	81% → higher thr 76%
3.4kV	83%	88%	78% → higher thr 86%
3.5kV	87%	95%	61% → higher thr 86%

Default Thr= 4*PedRMS(~40)*3timebin ~ 500
Higher Thr = 7 * PedRMS(~40)*3timebin ~ 850

FGT35-Long "Golden event" Hit Map



Dead HV sector 4 (happened after data above)

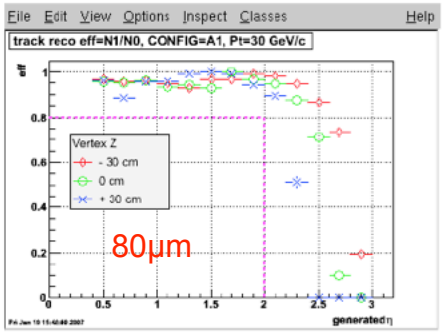
	FGT037	FGT035	FGT031
3.4kV	72%	60%	70%

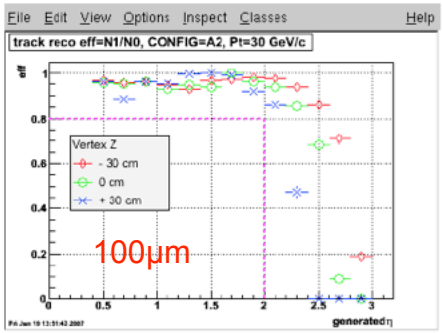
Efficiency calculated in whole octant incl. dead sector!

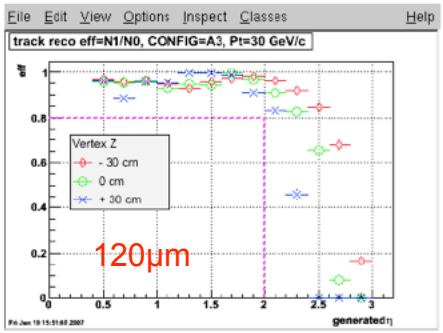
Performance results

- Contrast performance to proposal
  - Note: Consistent estimate of hit resolution of 150μm is at R=30cm which is expected to decrease by design towards smaller R with smaller pitch
  - FGT proposal simulation shows no impact on track reconstruction efficiency and charge-sign discrimination efficiency with varying FGT hit resolution for 80μm, 100μm and 120μm
  - Simulations assume combined tracking of beam line constrain, TPC hits, FGT hits and EEMC-SMD constrain
  - Full simulation / reconstruction of all elements under development!

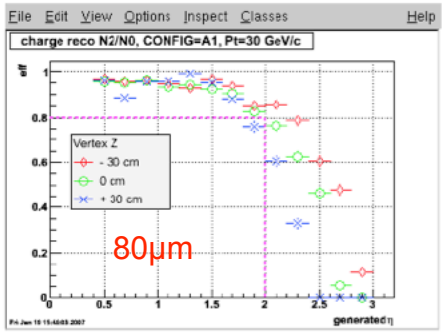
Track reconstruction efficiency

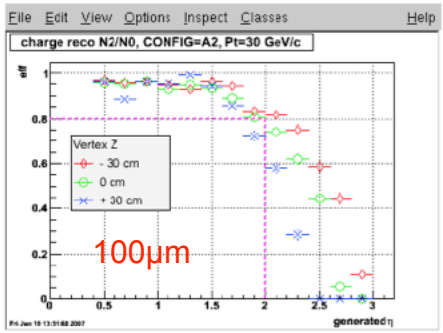


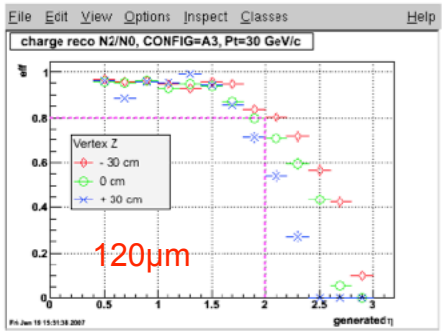




Charge-sign reconstruction efficiency





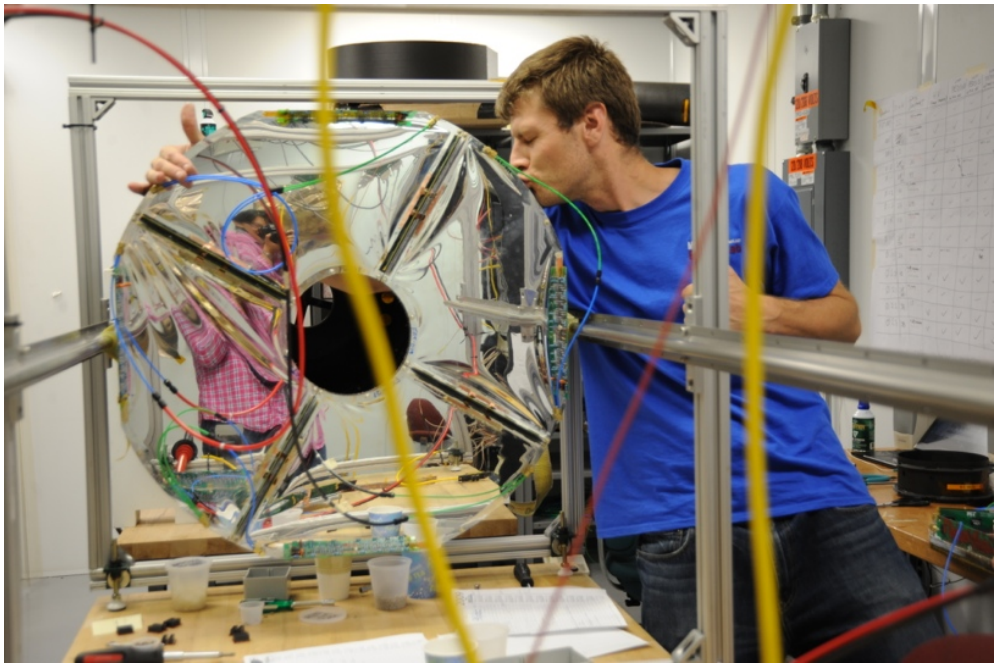


Plans

- Performance:
  - Satisfactory performance for all quarter sections on Disk 1 and 2 in terms of readout and actual detector behavior
  - 3/24 quarter sections disabled: 2: Gas line blockage during installation (Disk 4C/4D) / 1: Excessive leakage current (Disk 6C)
  - FEE: Issues largely with APV chip communication / programming for some of the chips in particular on disk 4
  - DAQ: Limitation of data taking rate (~200Hz) with original control module (ARC-I) / Upgrade underway with new ARC-II for Run 13
  - Residual consistent with previous results!
- Software:
  - Complete QA software (online / offline) in place
  - Simulations require still substantial effort
  - FGT/TPC tracking integration (STV) in progress
- Shutdown: Diagnose and repair of FEE APV modules / Replace at least one quarter section (6C)
- Physics: One A_L bin (backward / forward) - Completely statics limited (Limited detector acceptance and FOM)

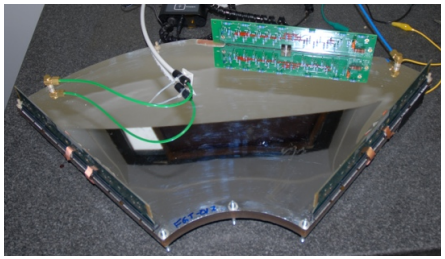
THANKS

- DOE
- BNL and STAR
- MIT and Temple University College of Science & Technology
- Special thanks : Final installation / testing and commissioning at BNL:
  - Jason, Ross and Xuan
  - Akio, Anselm, Gerrit, Ramiro and Renee
  - Gerard and Maxence
  - TU grad students: Danny / Devika

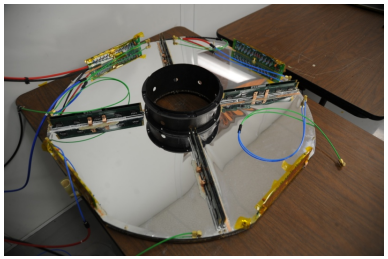


Backup (Overview - FGT)

Forward GEM Tracker - Layout

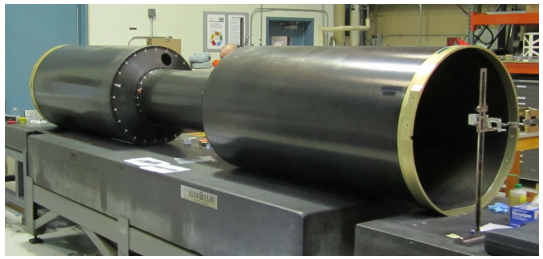


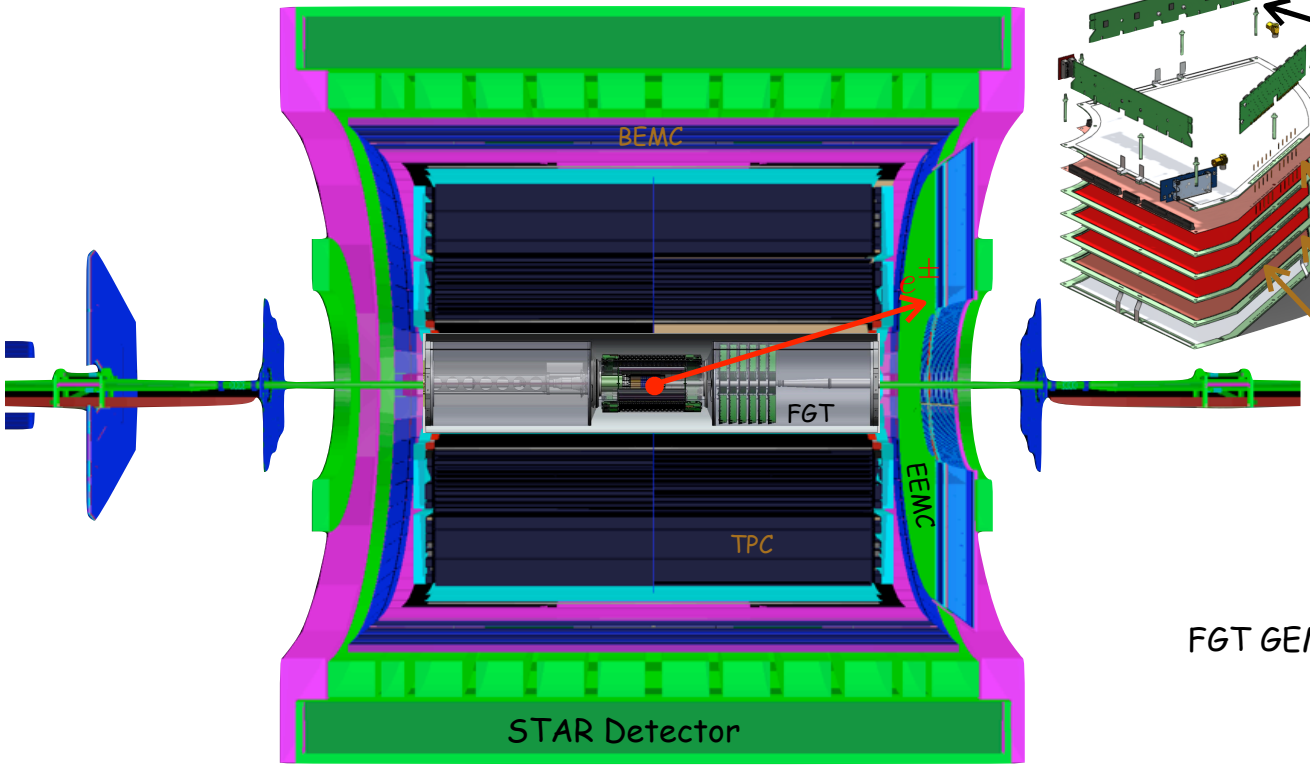
Quarter section

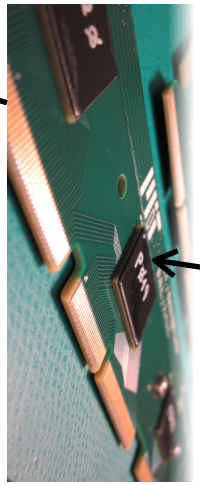


Disk

Quarter section







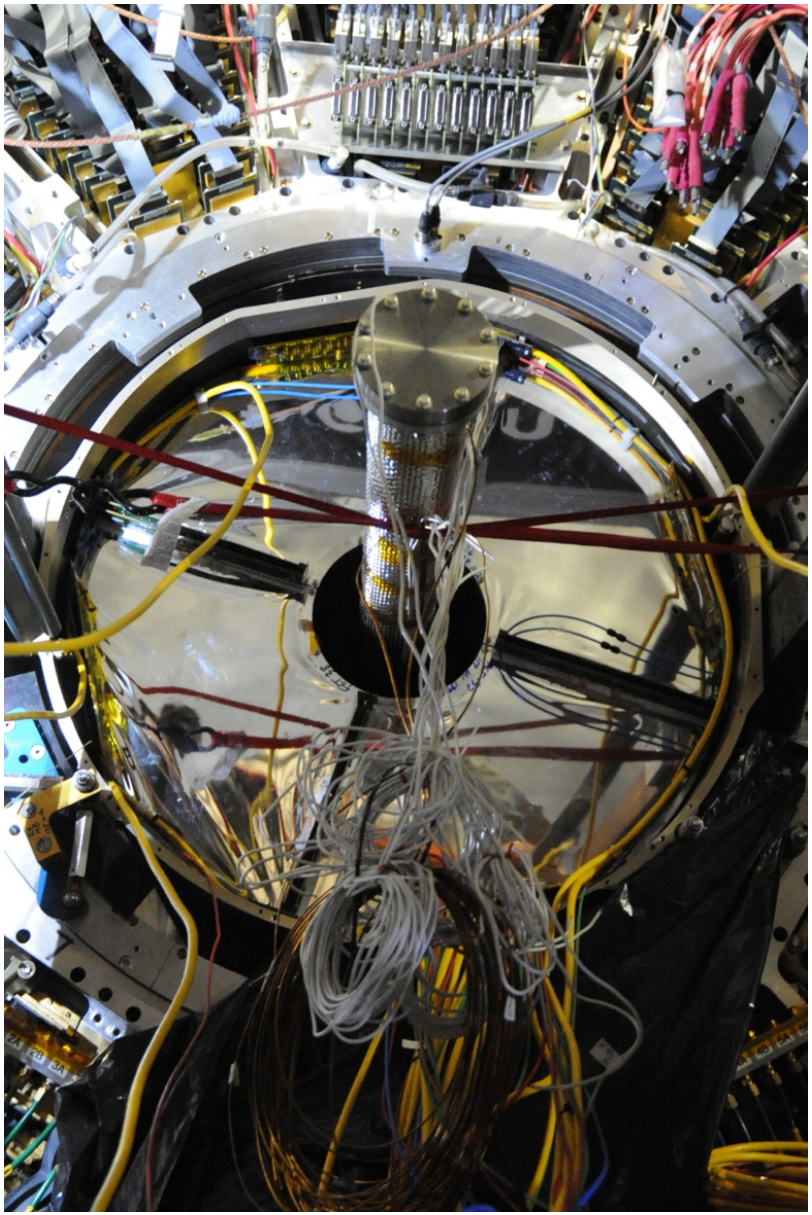
APV module

Packaged APV chip

FGT GEM foil

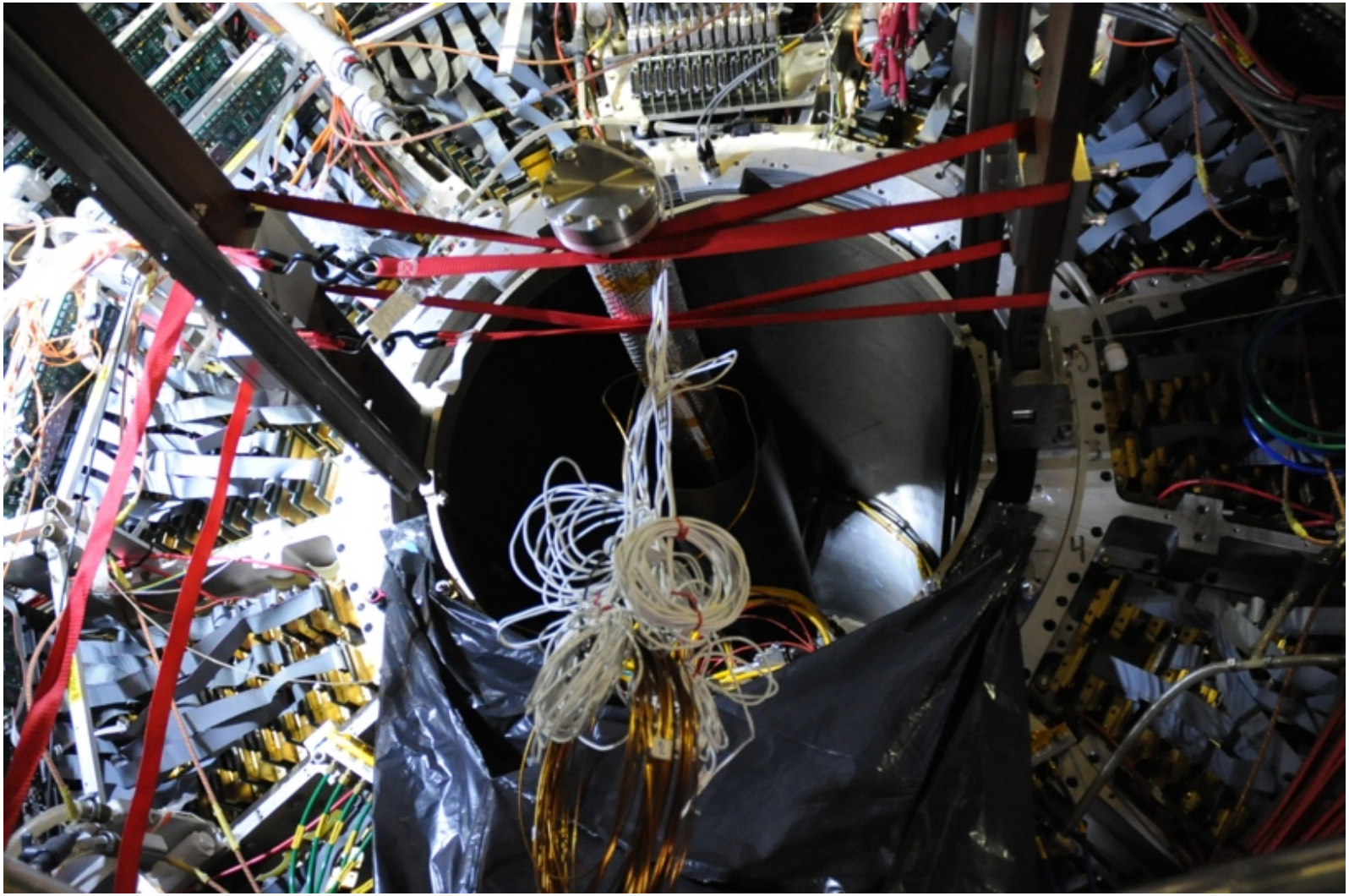
Backup (Installation - FGT)

- Photo: FGT inserted



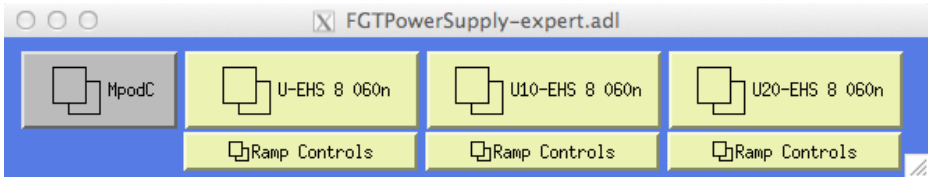
Backup (Installation - FGT)

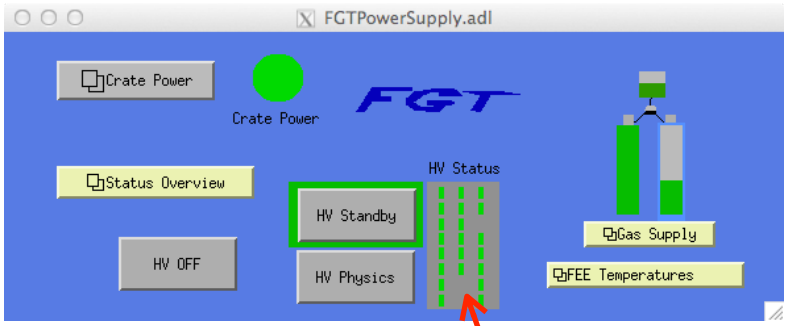
- Photo: FGT inserted with cooling tube and support of beam pipe

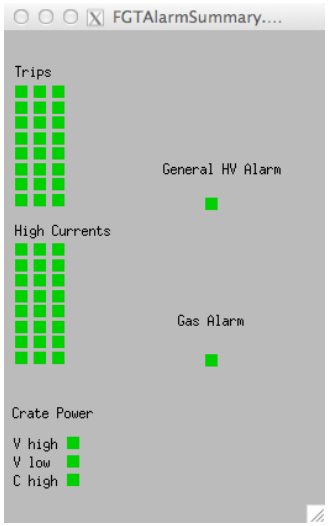


Backup (HV - FGT)

Control GUI







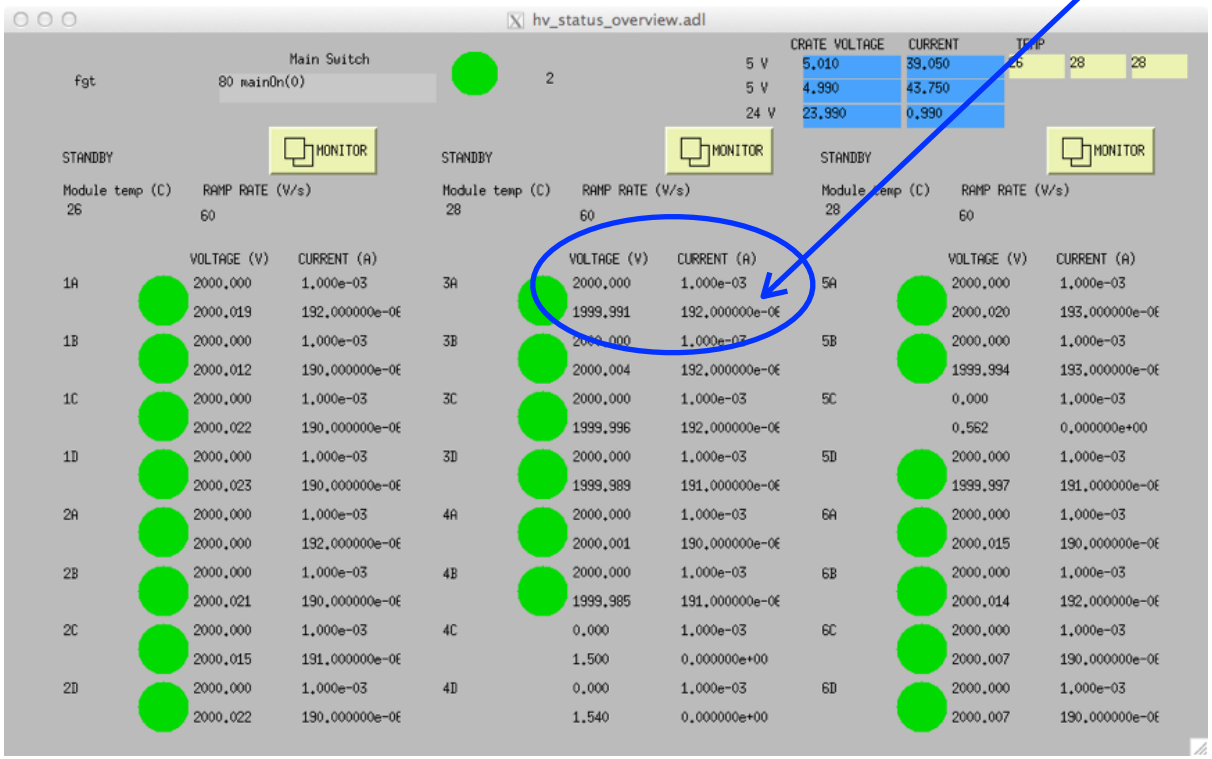
HV status for 3 modules with 8 channels each (3 ch. disabled):

Module 1: 8 channels

Module 2: 6 channels

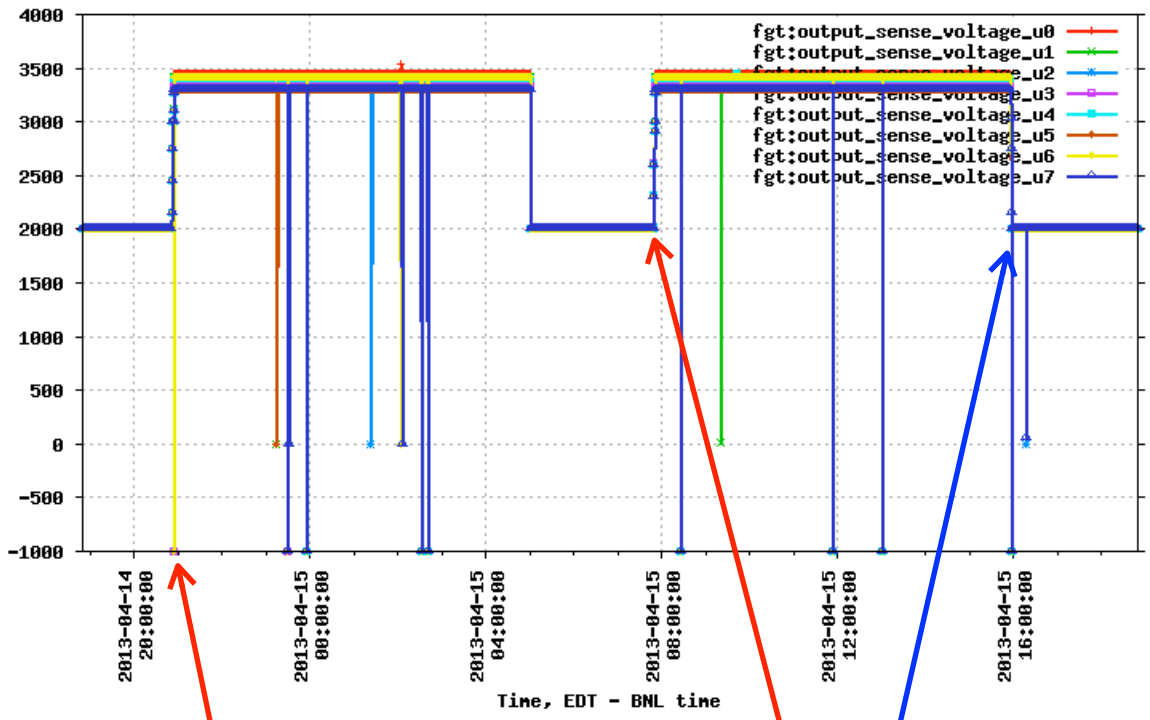
Module 3: 7 channels

- Generally: Smooth performance of actual HV operation of individual quarter sections
- Some communication / alarm errors under investigation
- Currents: Resistive currents of HV chain stable (I=V/10.46MΩ - Here: I = 2000V / 10.46MΩ ~ 191μA)

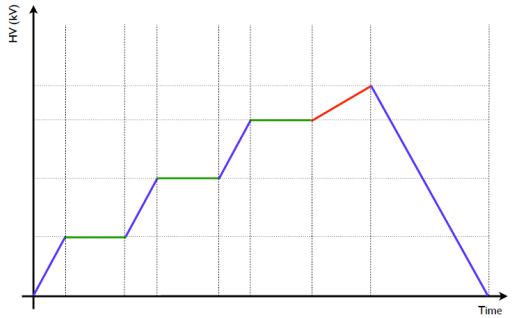


Backup (HV - FGT)

- Status
  - Fully functional control of voltage ramp / Control power to crate / Individual channels ramp / Setting of trip levels
  - Issues:
    - Frequent network communication errors
    - Continuing to tune alarm settings and training of shift crew to respond
  - Fixes, tests and updates:
    - New firmware from Wiener
    - Further testing of control software



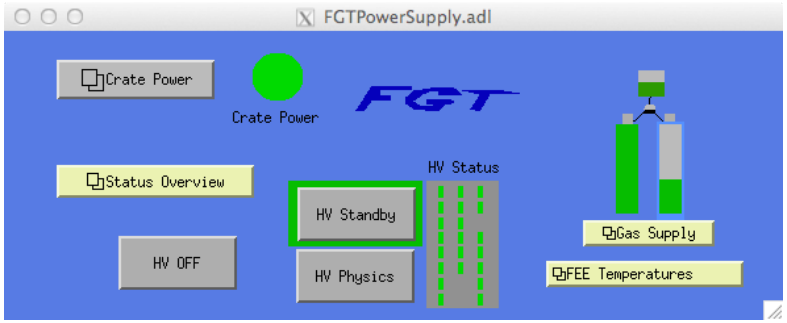
Communication errors



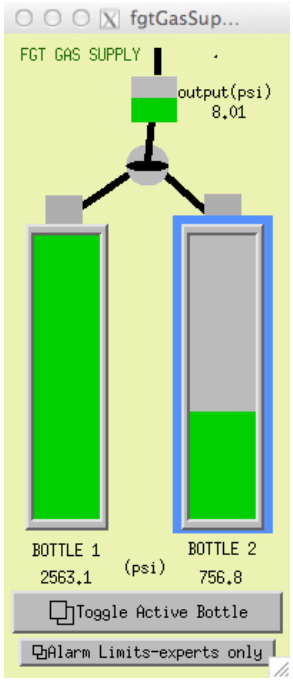
Typical ramp-up / ramp-down sequence at beginning of physics and end of physics

Backup (Gas - FGT)

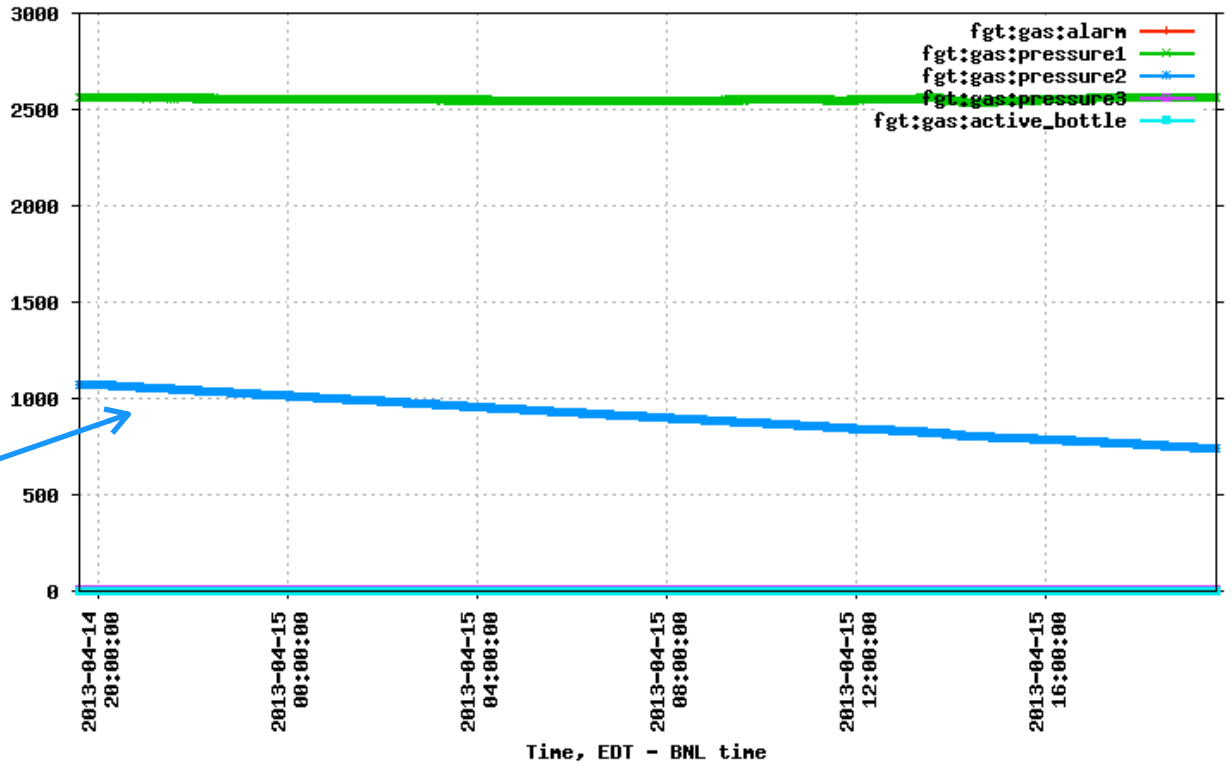
Status



- Smooth performance
- Two $ArCO_2$ (90/10) gas bottles connected to gas system
  (Gas consumption: ~350psi / day ⇒ 1 bottle / week)
- No issues!



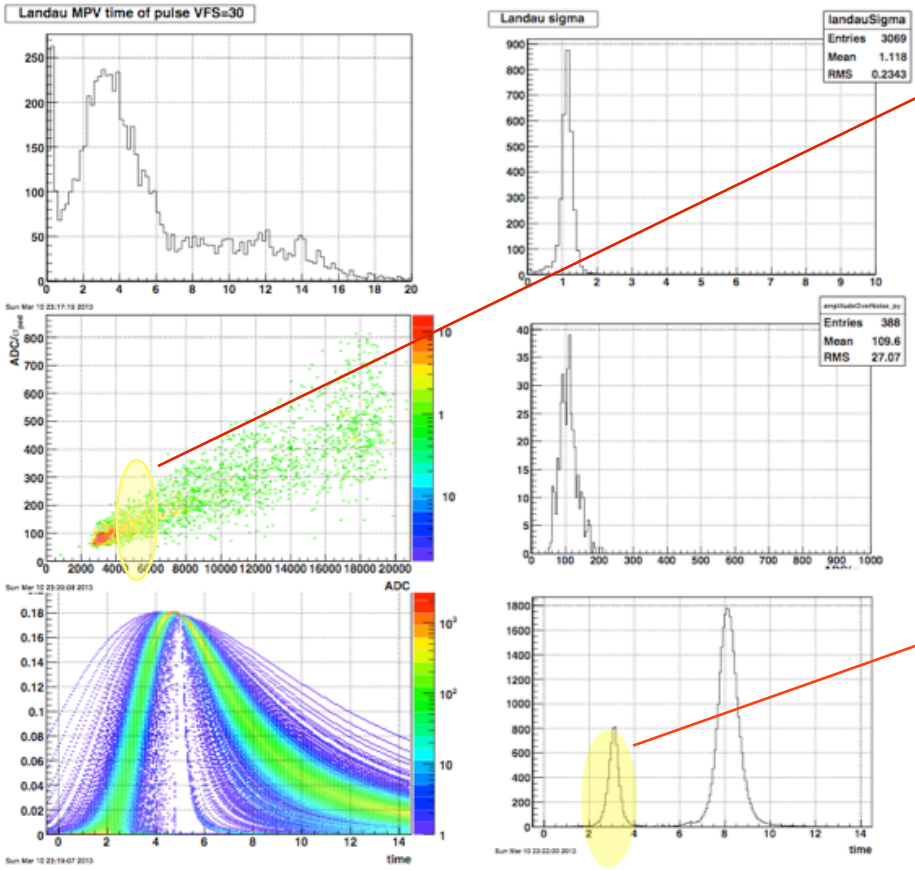
Active bottle 2

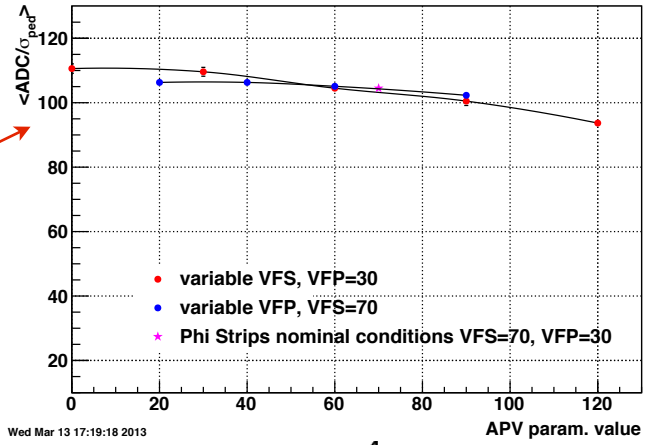


Backup (Working point adjustment - FGT)

- APV parameter: Tuned VFS (Rise time) and VFP (Decay time)

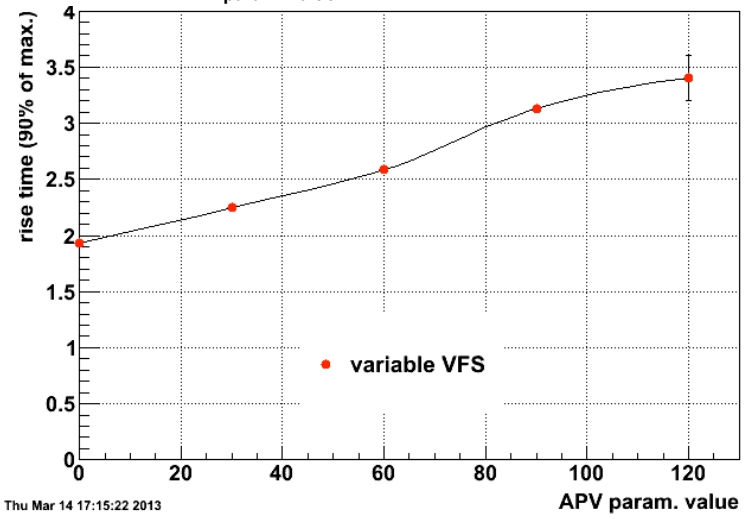
VFS = 30





Signal/noise at different pulse shapes (filtering), No big variation, improves at low VFS

rise time jitter 0.31 <>:3.08



Landau distribution fits to strip pulses

Selected VFS=10 to better fit the low number of time bins in read-out

Backup (Software - FGT)

Offline Software

- FGT reconstruction software operational and in dev
- Point Making uses simple algorithm (Mainly needed for tracking seeds!)
- All other parts of reconstruction chain stable
- FGT Hits are written to mDsts (zero suppression supported) but did not test fast offline output yet
- Points are not yet in mDSTs pending filed ticket resolution
- Simulation still needs work: GEANT completed / Slow simulator and testing not finished (Data/MC comparison!)

Online Software

- Jplots and extensive online QA plot suite running for each run

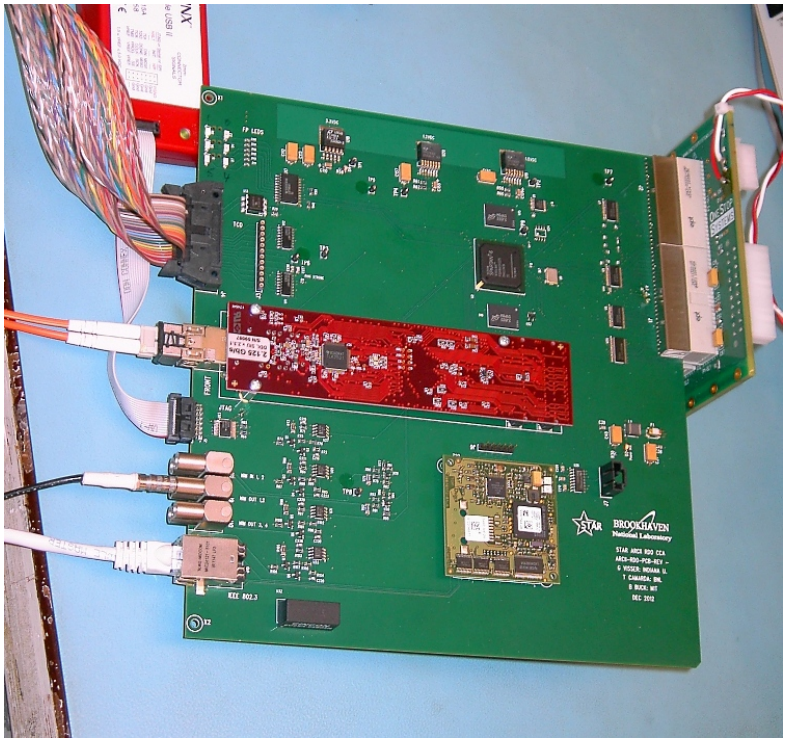
STV Tracking:

- FGT / TPC tracking: STAR S&C Team (Victor, Jason et al.) together with Akio from FGT group
- Work has progressed significantly over last weeks
- Connecting TPC tracks to FGT / seed finding in progress
- Proof of principle, straight line, 6 hits in FGT recently made to work

Backup (DAQ - FGT)

- ARC module upgrade: module ARC-II
  - Schematic entry, PCB layout, and production efforts by Tim Camarda (STSG)
  - Engineering (HW & firmware) by Gerard Visser (IU) and Ben Buck (MIT)
  - ARC-II with much larger main data buffer (1 GB vs. 128 MB) than original ARC-I, and more importantly, allows for proper coverage of this buffer with an "RDO" term in the detector busy
  - Increases data bandwidth for ARM module readout from 132 MB/s to 264 MB/s: Reduce busy term due to front-end buffer (ARM)
  - Improves run-configuration time from ~20 seconds to <1 second.
  - Converts auxiliary (ethernet-based) monitoring to use "standardized" linux module which is widely used in other STAR subsystems.
- Status
  - PCB works (Two patches needed)
  - DAQ and trigger interface tested
  - ARM interface ~70% done
  - Target: May 01, 2013

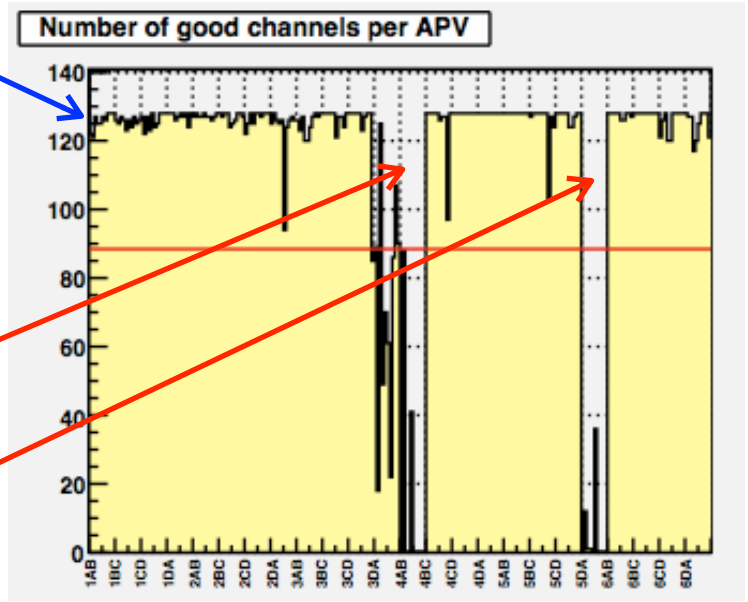
ARC-II under firmware development @ Indiana University



Backup (Run 13 QA - FGT)

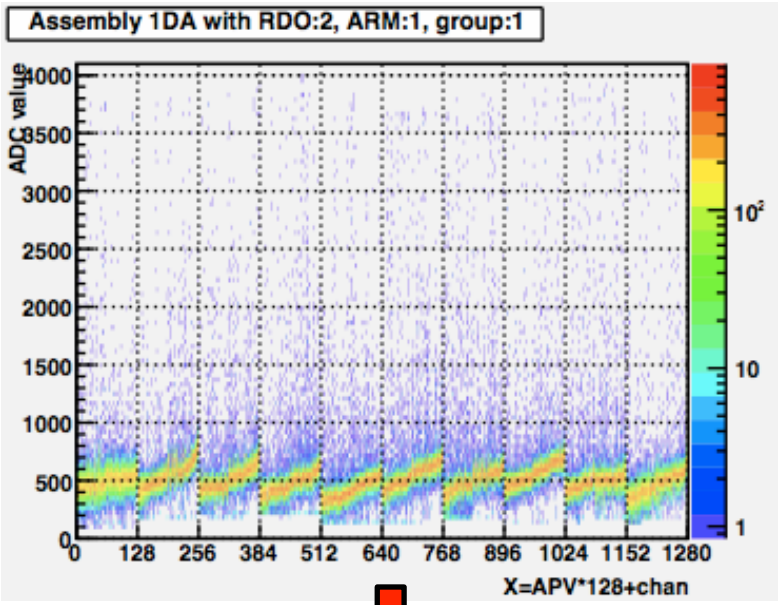
- Online

Complete FGT

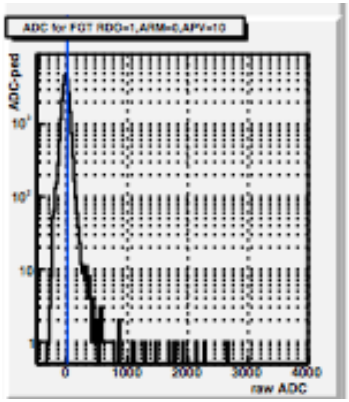


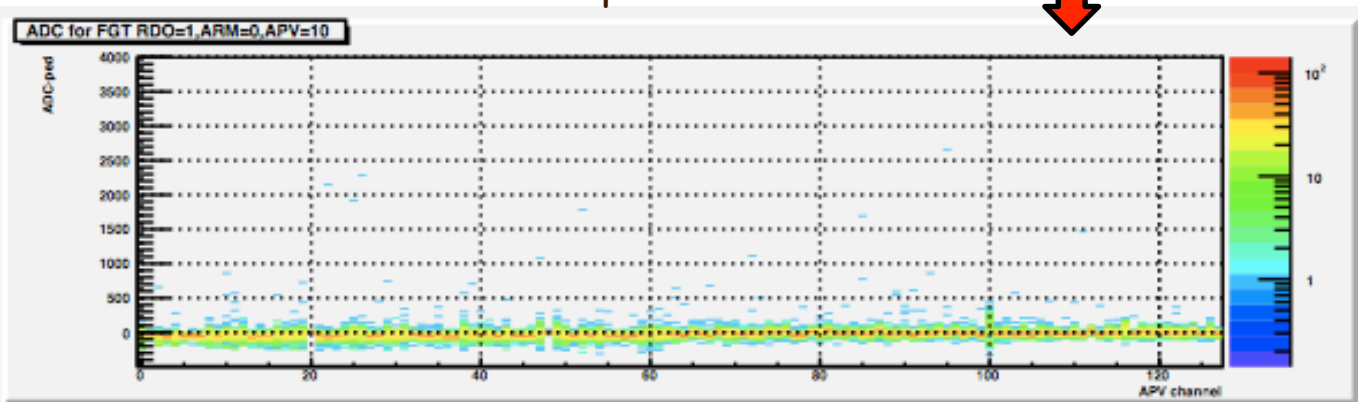
Note: 2 Disk 4 quarter section and 1 Disk 6 quarter section disabled!

One Assembly readout: 10 APV chips



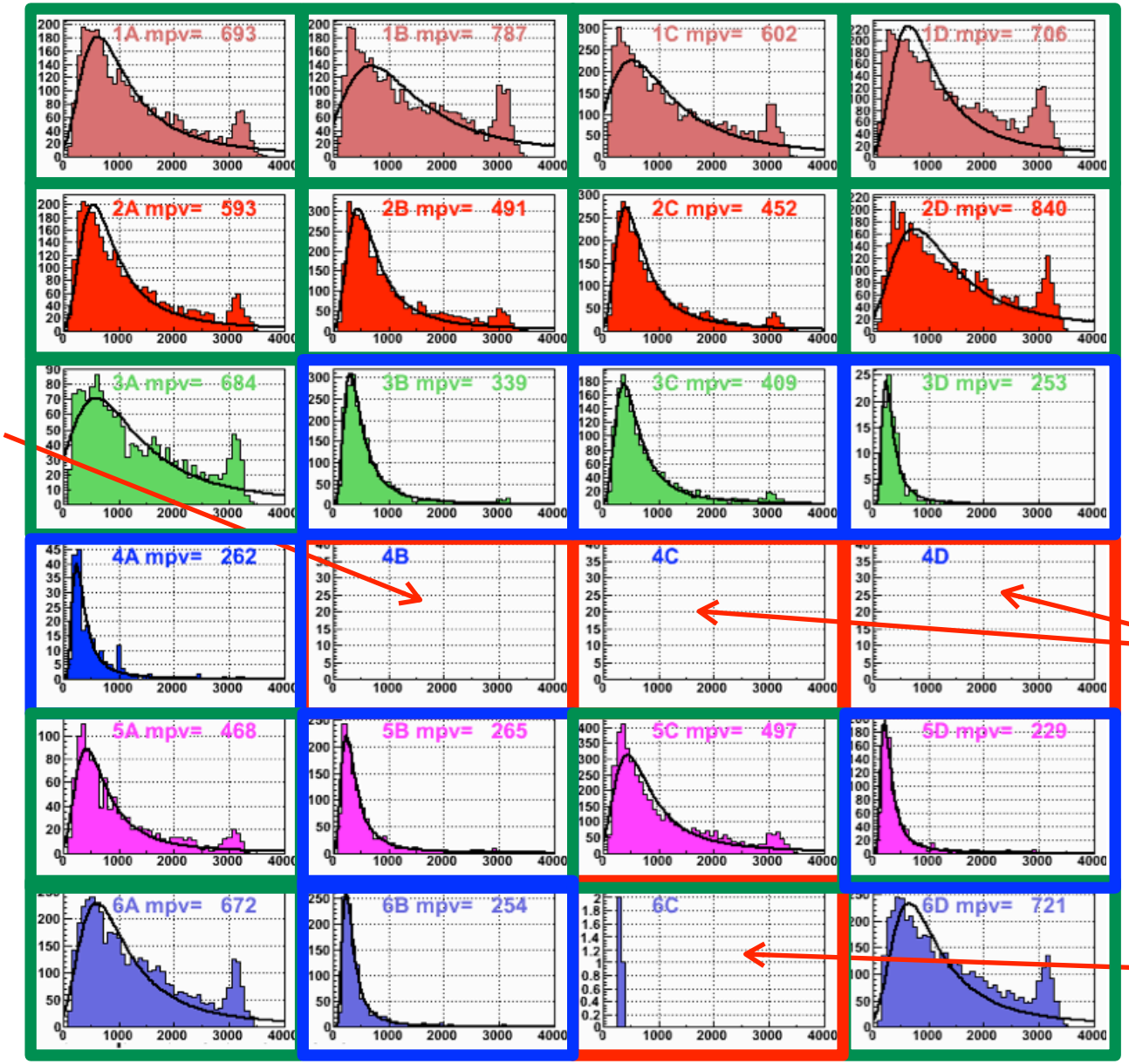
One APV chip





Backup (Run 13 QA - FGT)

- Offline



FEE problems

4C / 4D disabled: blocked gas line

6C disabled: excessive leakage current