REPORT ON RUN 13 FOR STAR

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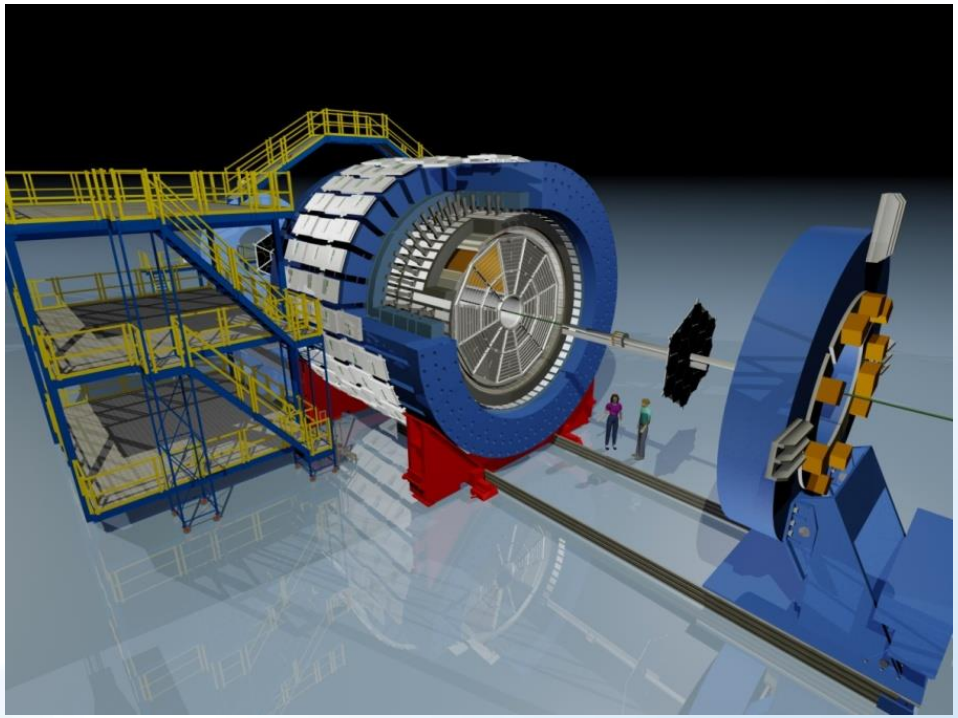
For the STAR Collaboration
June 27, 2013

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

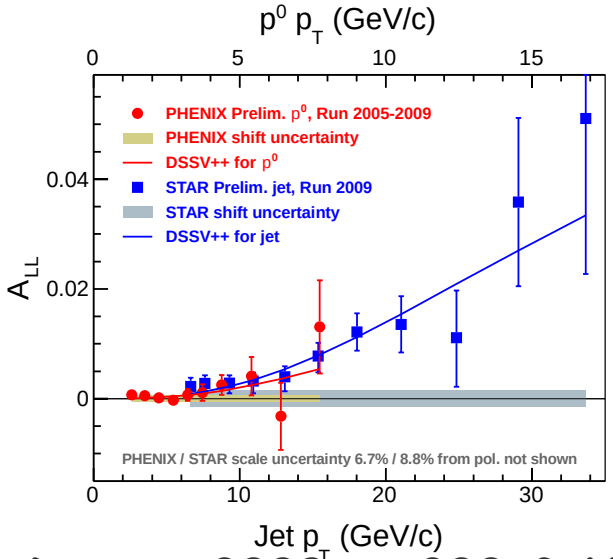
U.S. DEPARTMENT OF ENERGY | Office of Science

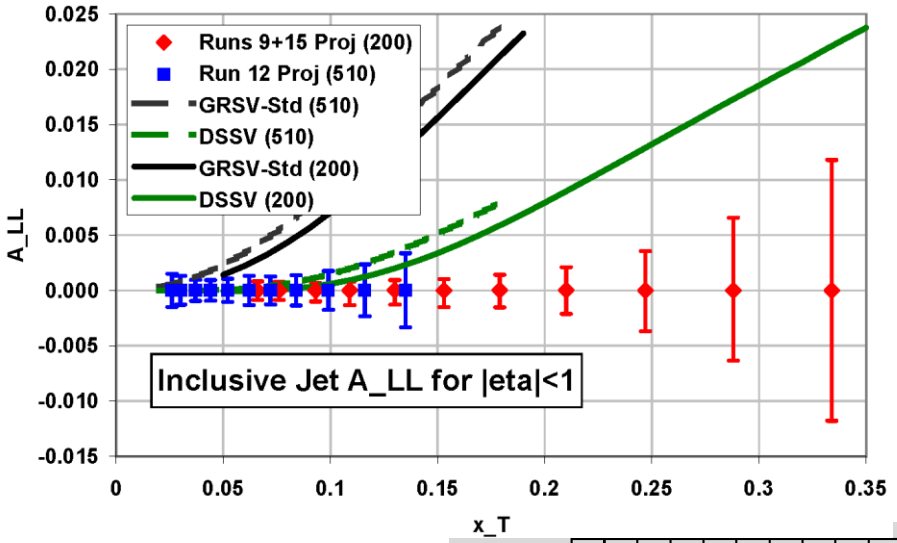
Outline

- Select Physics motivations for Run 13
- New/enhanced detector sub systems for Run 13
- STAR Running Efficiency
- Summary of data set accumulated
- Shutdown work in preparation for Run 14
- Summary



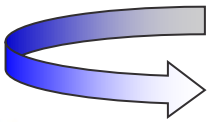
GLUON CONTRIBUTION TO THE SPIN OF THE PROTON



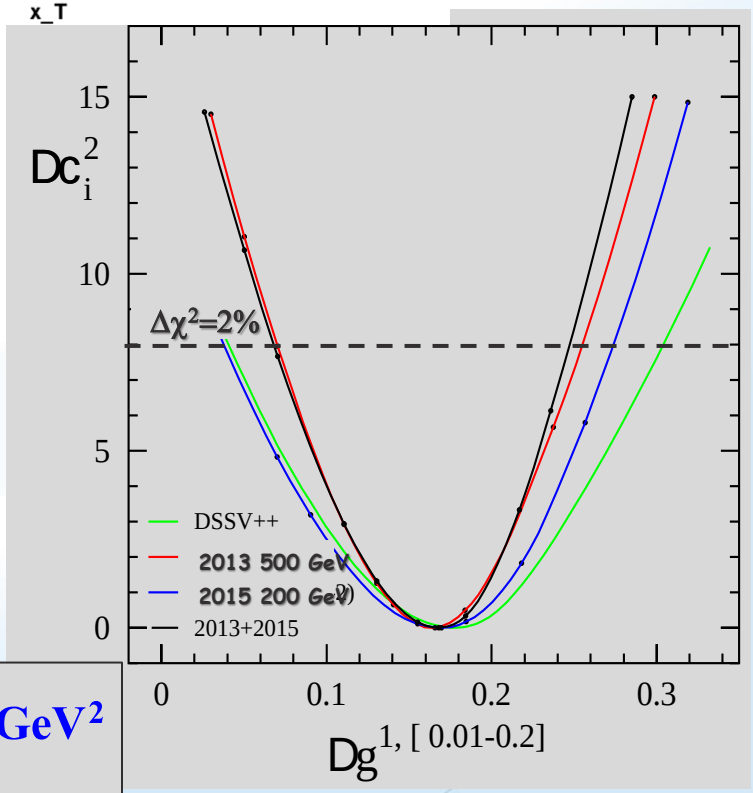


Data ≤ 2009 at 200 GeV yield
first time a significant non-zero $\Delta g(x)$

$$\int_{0.05}^{0.2} dx\Delta g \sim 0.1 \pm^{0.06}_{0.07} @\ 10\ \mathrm{GeV}^2$$



Can we improve ?
YES
add 510 GeV (12+13)
and more 200 GeV (15) data

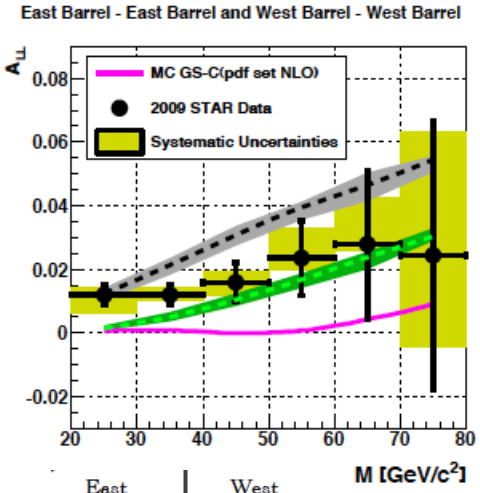


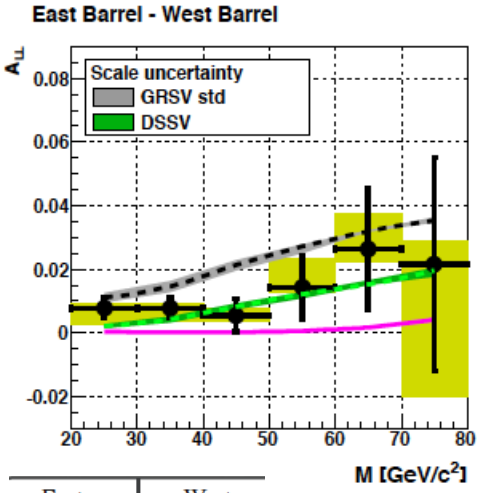
$$\int_{0.01}^{0.2} dx\Delta g \sim 0.16 \pm^{0.14\rightarrow0.090}_{0.12\rightarrow0.085} @\ 10\ \mathrm{GeV}^2$$

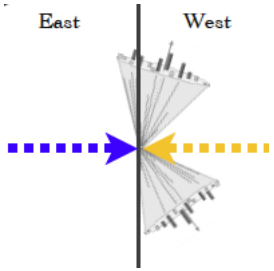
Slide courtesy of E. Aschenauer

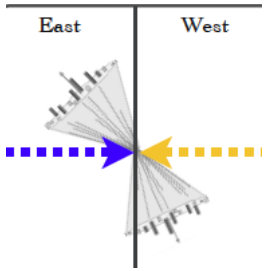
ΔG(X) THROUGH DI-JETS

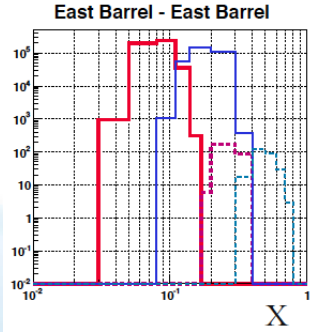
2009: √s=200 GeV p+p→ jet+jet+X

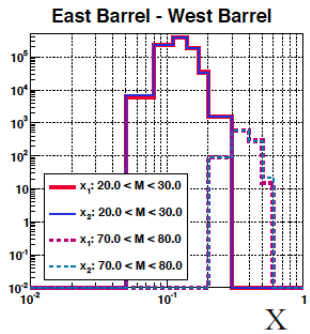












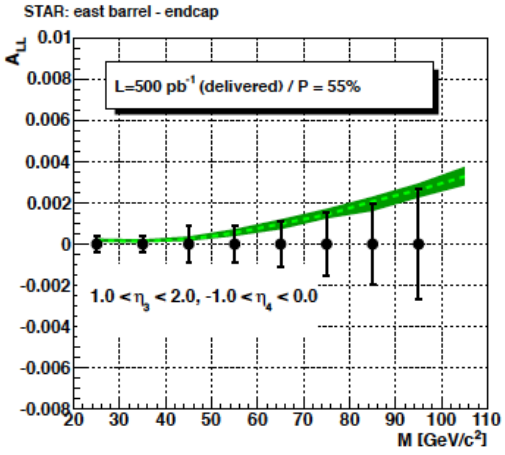
- Inclusive A_{LL} measurements at fixed p_T average over a broad range of x_{gluon}
- Reconstructing correlated probes (eg. di-jet, γ-jet) provides information on initial state partonic kinematics at LO

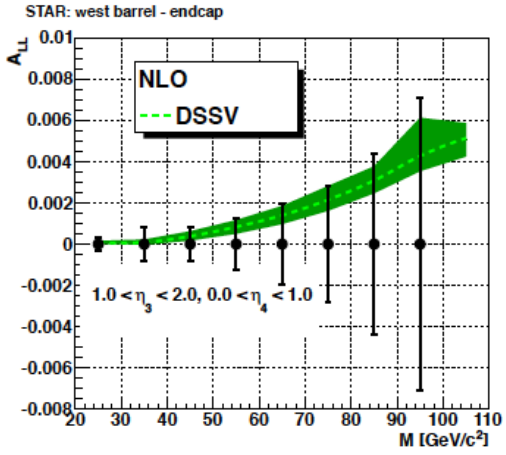
$$x_1 = \frac{1}{\sqrt{s}}(p_{t,1}e^{\eta_1} + p_{t,2}e^{\eta_2}) \qquad x_2 = \frac{1}{\sqrt{s}}(p_{t,1}e^{-\eta_1} + p_{t,2}e^{-\eta_2})$$

$$M = \sqrt{x_1 x_2 s} \qquad \eta_1 + \eta_2 = \ln\frac{x_1}{x_2}$$

- This allows for constraints on the shape of $\Delta g(x)$

2012+2013: √s=510 GeV p+p→ jet+jet+X

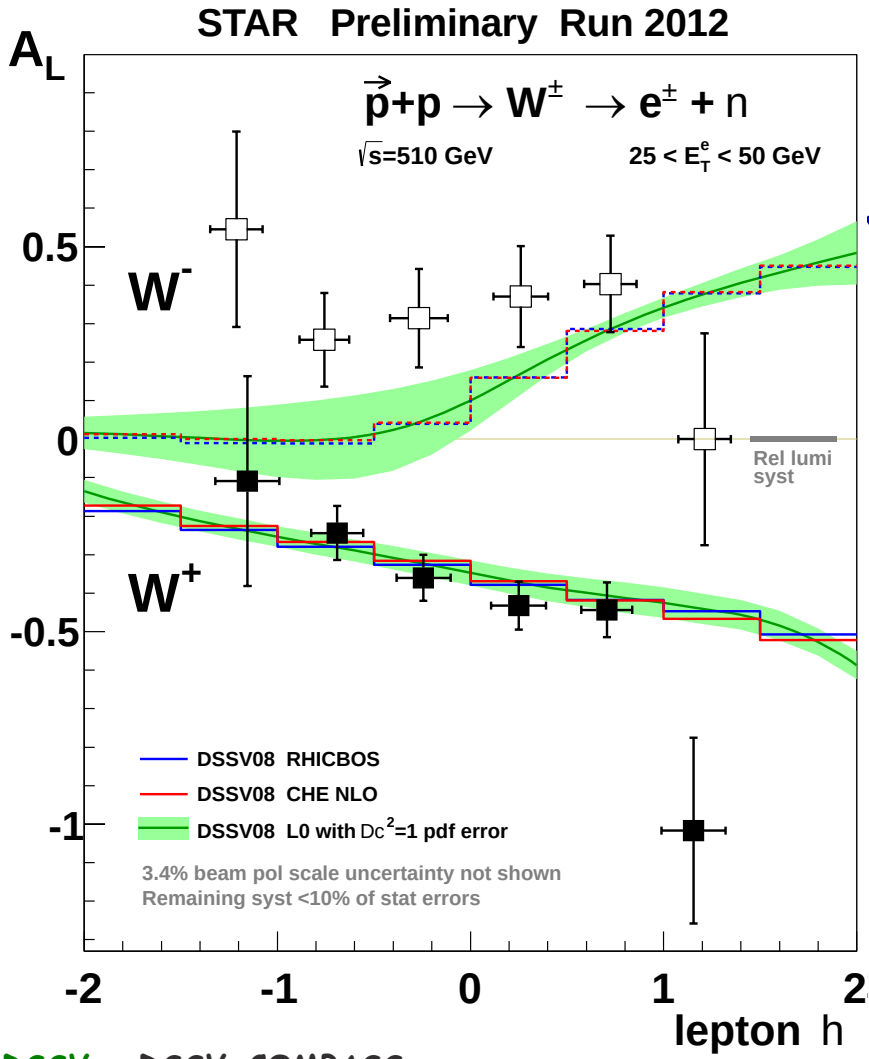




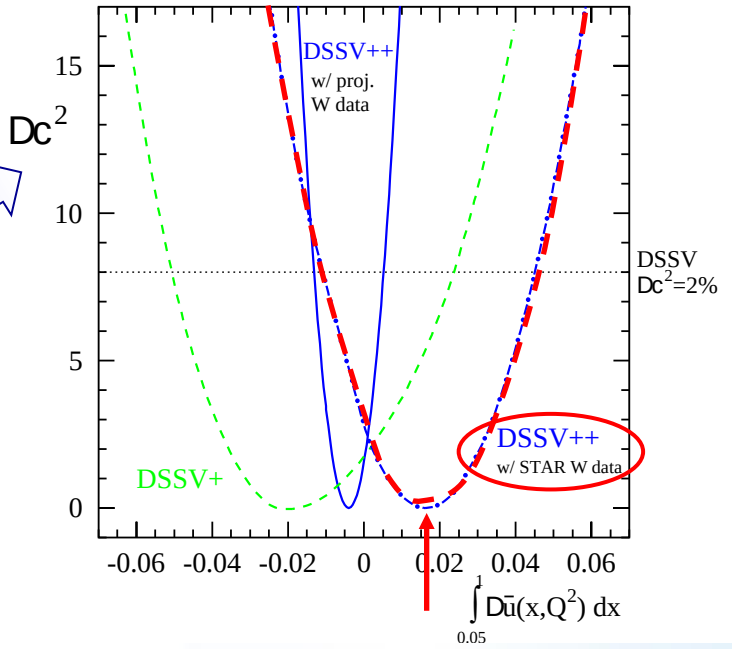
Slide courtesy of E. Aschenauer

2012 RESULTS

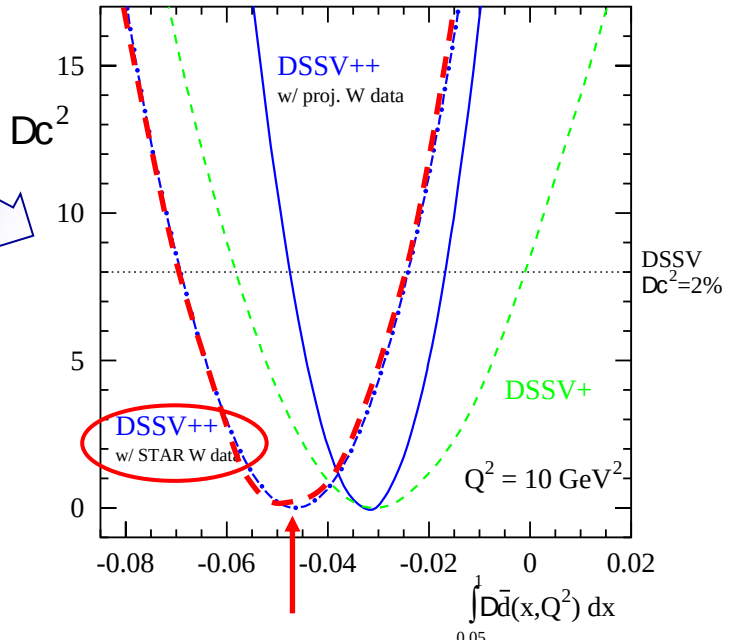
arXiv:1304.0079



$\Delta\bar{u}$



$\Delta\bar{d}$



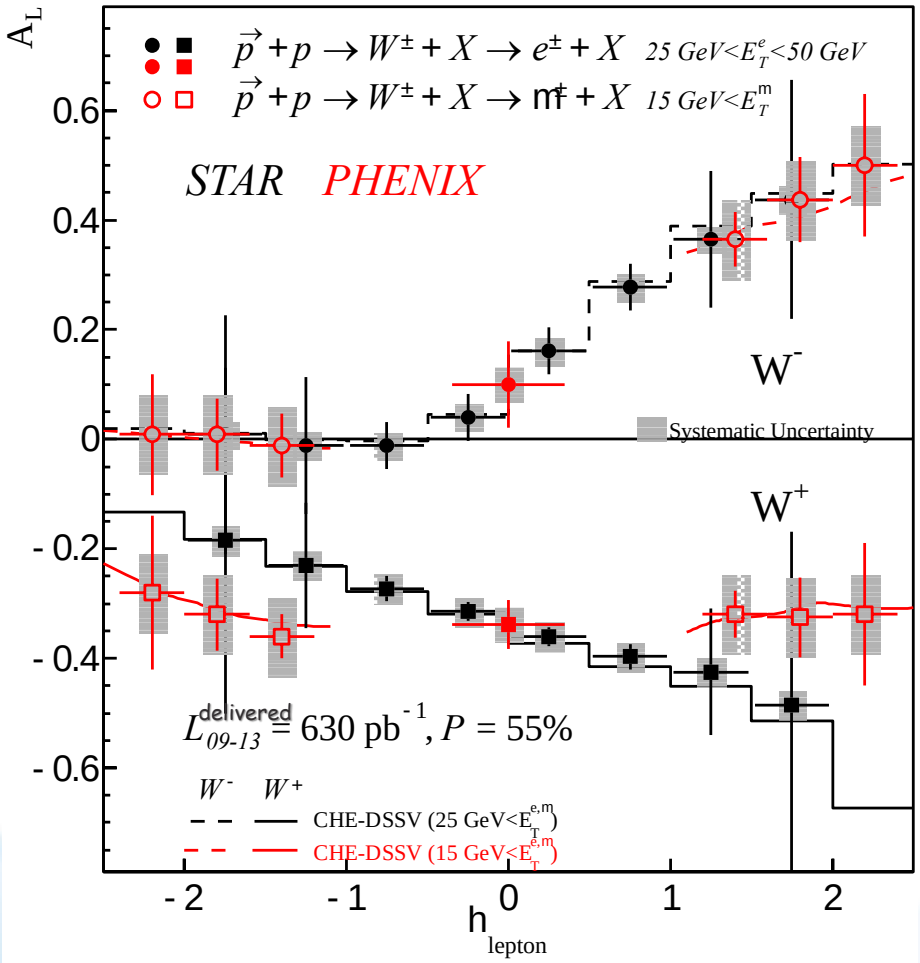
DSSV+: DSSV+COMPASS
DSSV++: DSSV+ & STAR-W 2012
DSSV++: DSSV+ & RHIC-W proj. (2009 – 2013)

Slide courtesy of E. Aschenauer

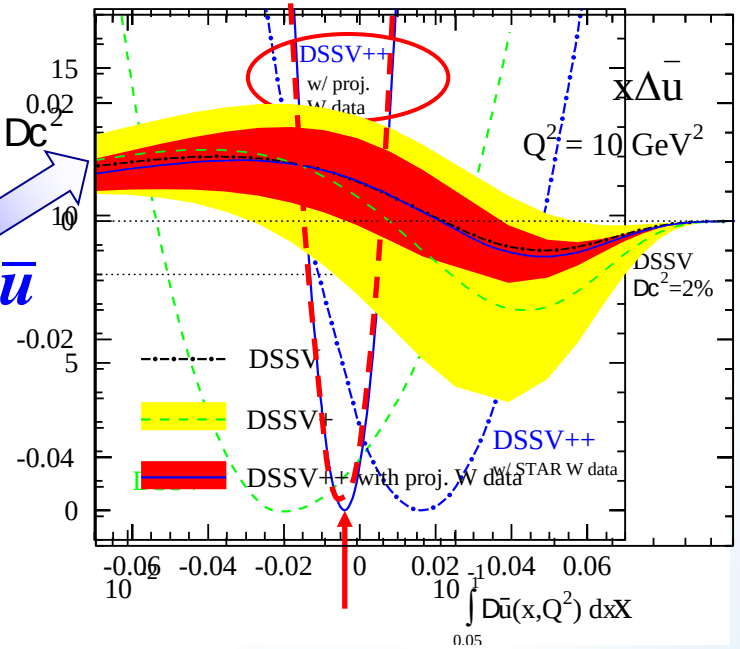
W-RESULTS: 2009-2013

RHIC: $\int L_{09-13} = (50 + 100 + 120 + 475) = 745 \text{pb}^{-1}$

pseudo-data randomized around DSSV



$\Delta\bar{u}$



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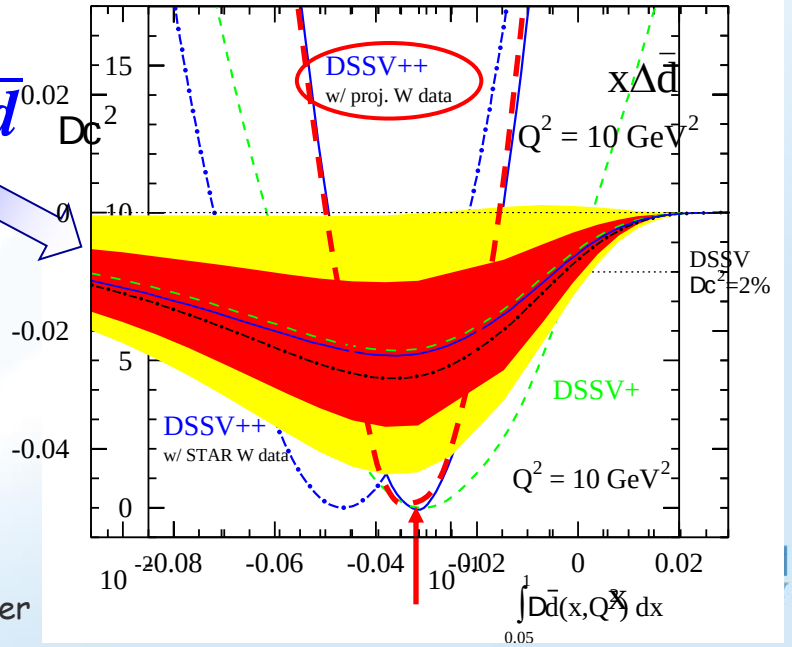


DSSV+: DSSV+COMPASS

DSSV++: DSSV+ & STAR-W 2012

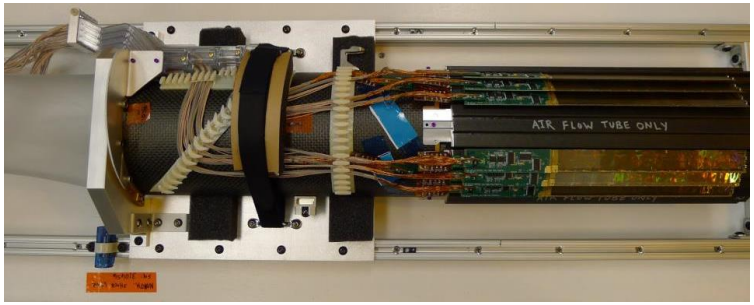
DSSV++: DSSV+ & RHIC-W proj. (2009 - 2013)

Slide courtesy of E. Aschenauer

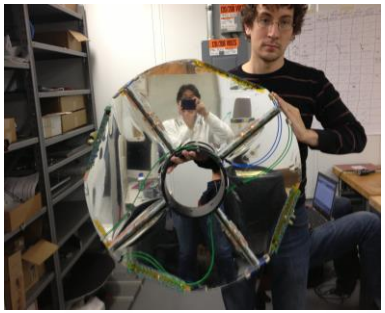
NEW AND ENHANCED SUB SYSTEMS INSTALLED FOR RUN 13

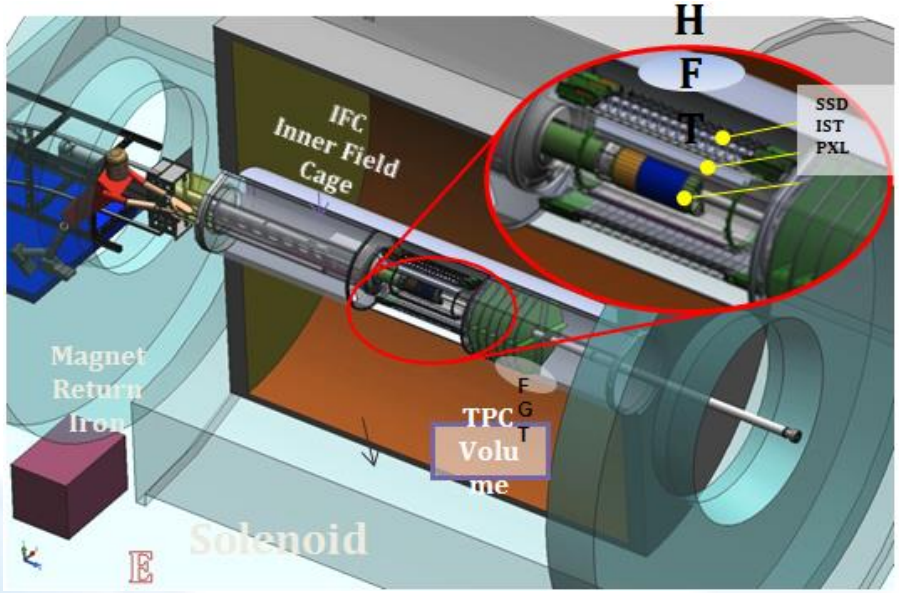
65% of MTD

3/10 of PXL

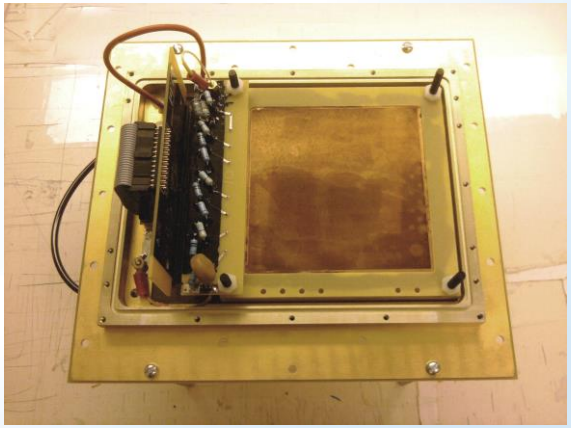


Full FGT





8 GMT modules



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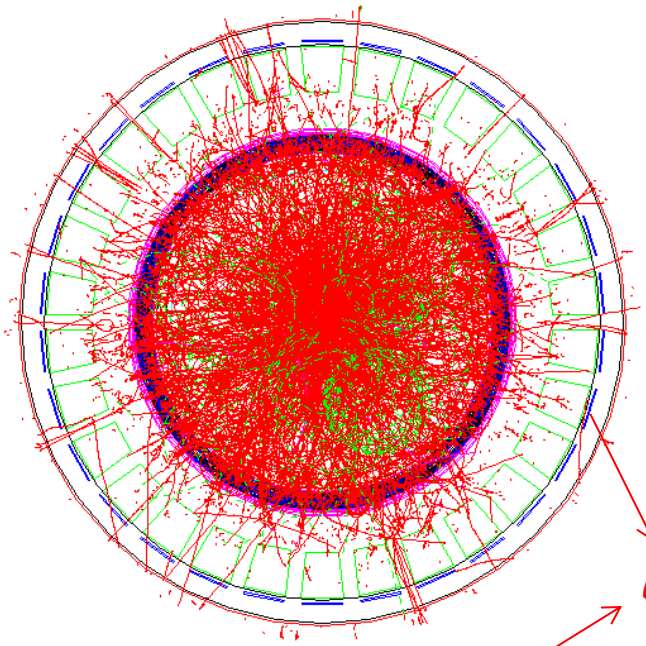
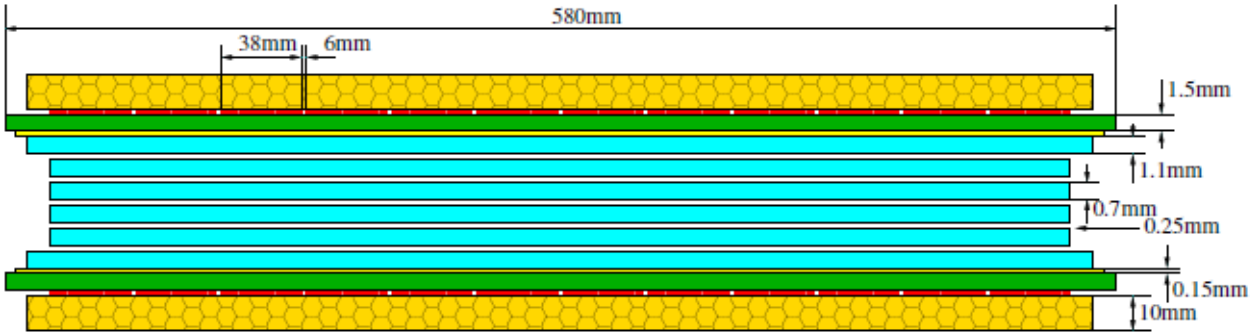
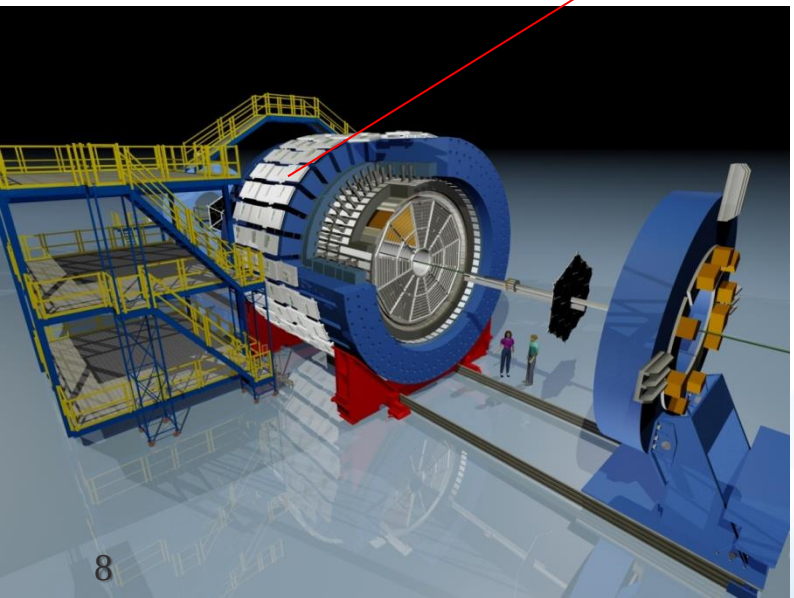
THE MTD AT STAR







Multi-gap Resistive Plate Chamber (MRPC): gas detector, avalanche mode

A detector with long-MRPCs covers the whole iron bars and leave the gaps in-between uncovered. Acceptance: 45% at $|\eta|<0.5$

118 modules, 1416 readout strips, 2832 readout channels (full system)

Long-MRPC detector technology, electronics same as used in STAR-TOF

Slide courtesy of L. Ruan

MTD for Run 13

Testing MTD modules prior to installation

By Nov. 13th, 63% of the MTD system was installed at STAR for Run 2013.

Current status:

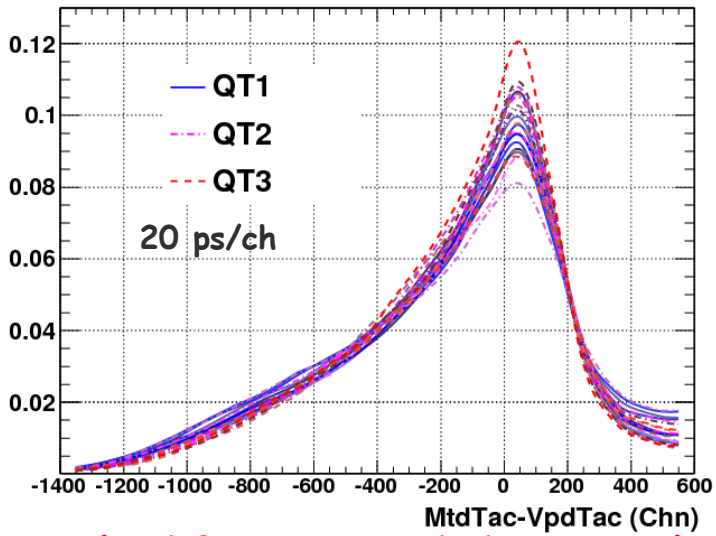
Detector works fine: among 75 trays installed, 74 work properly.

The trigger algorithm in place on May 9th:

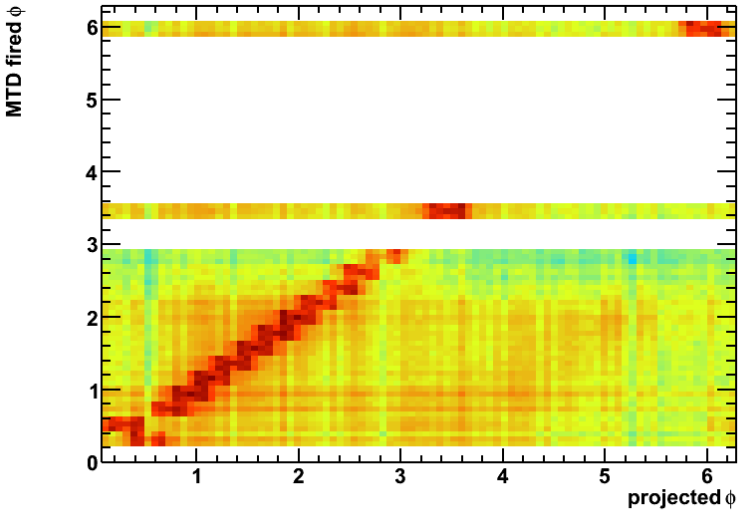
Took single-muon, electron-muon, and di-muon triggered events through rest of Run 13.

Slide courtesy of L. Ruan

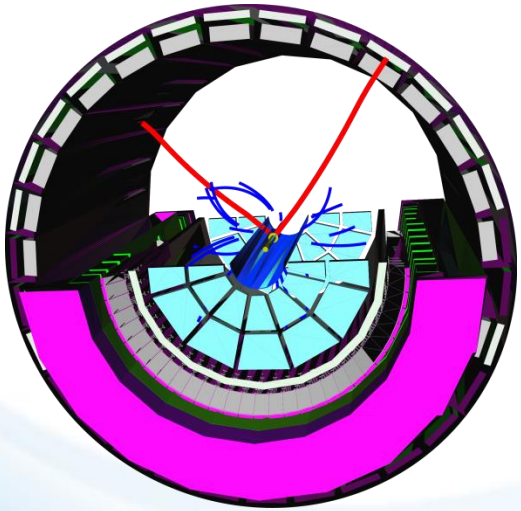
MTD Performance from Run 13



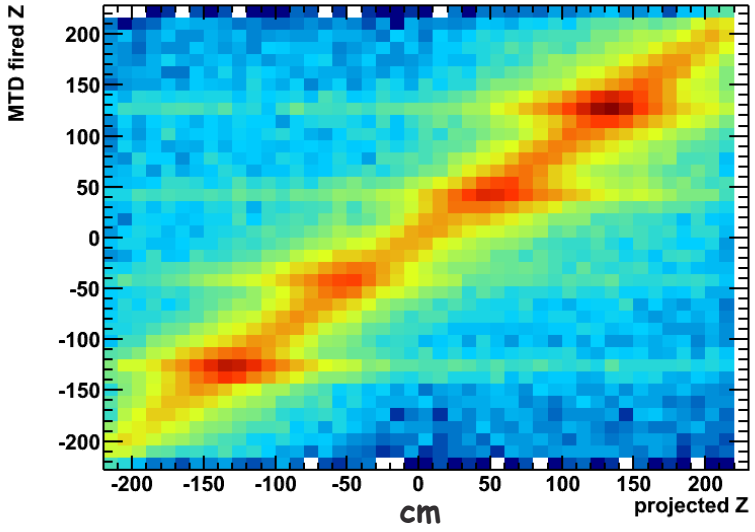
At the L0 trigger, MTD timing lined up



MTD hits matched with the TPC tracks



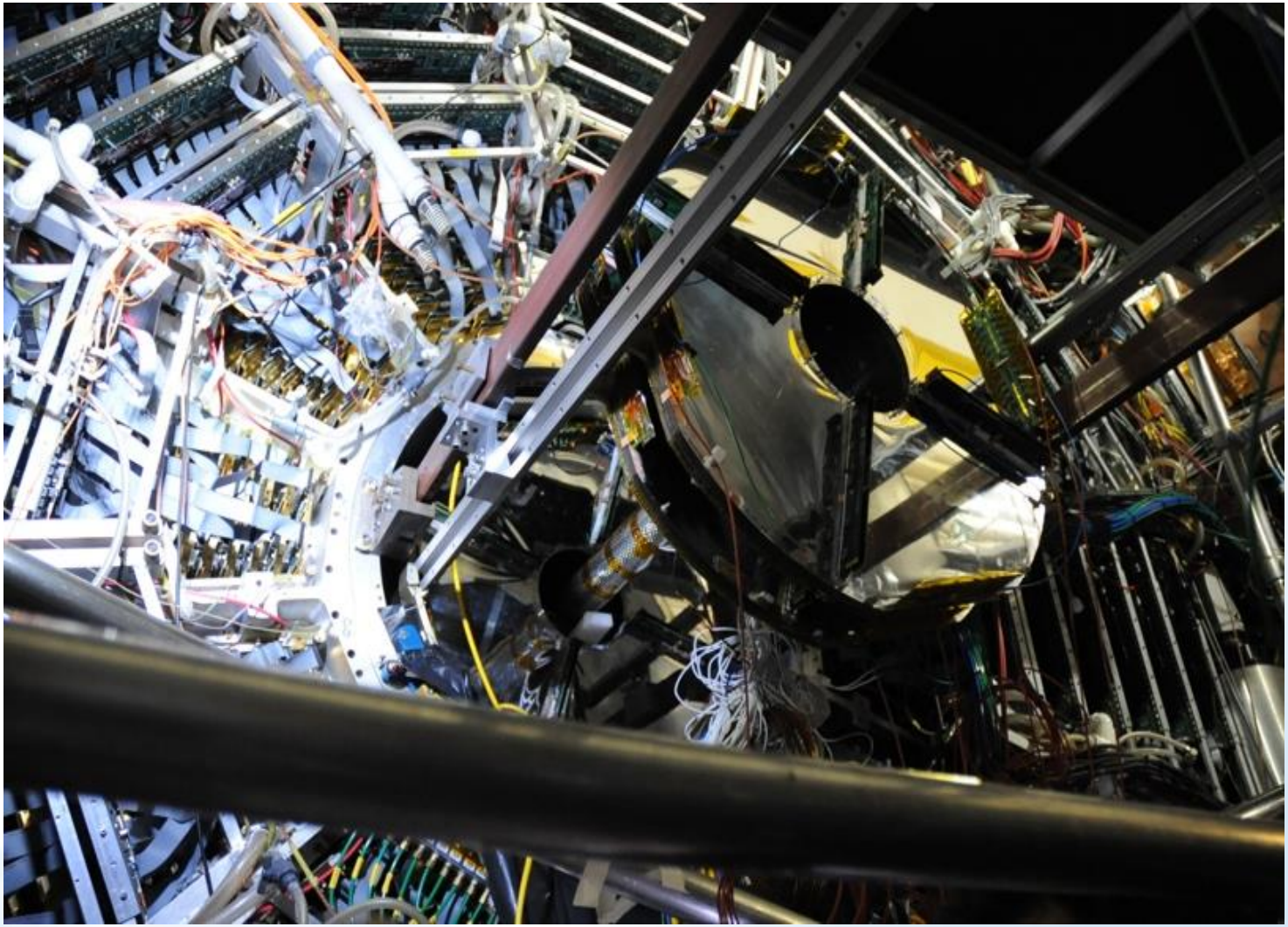
Event display for J/ψ event in p+p 510 GeV collisions



Slide courtesy of L. Ruan

Assembly/Installation of the Forward GEM Tracker (FGT)

- Photo: Closeup West - Disk 5/6

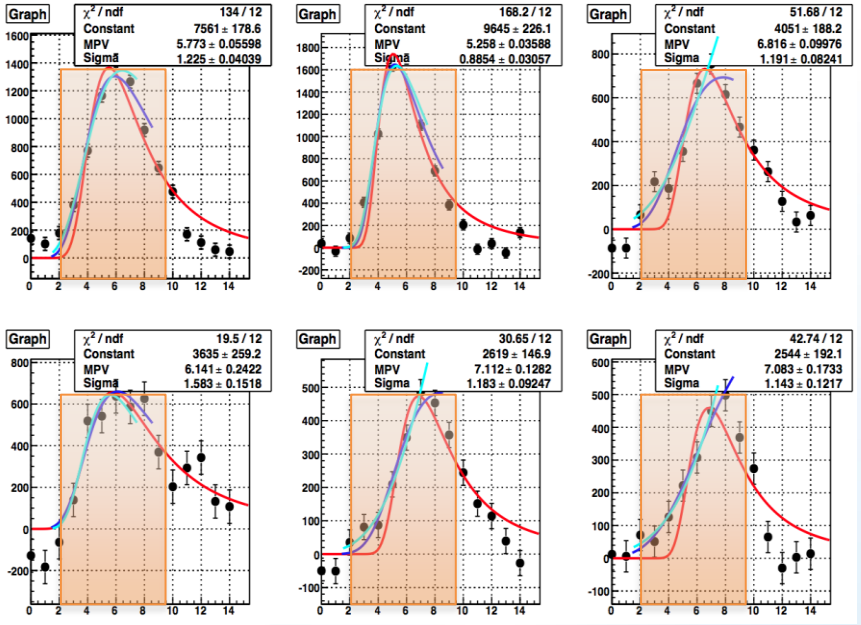


Slide courtesy of B. Surrow

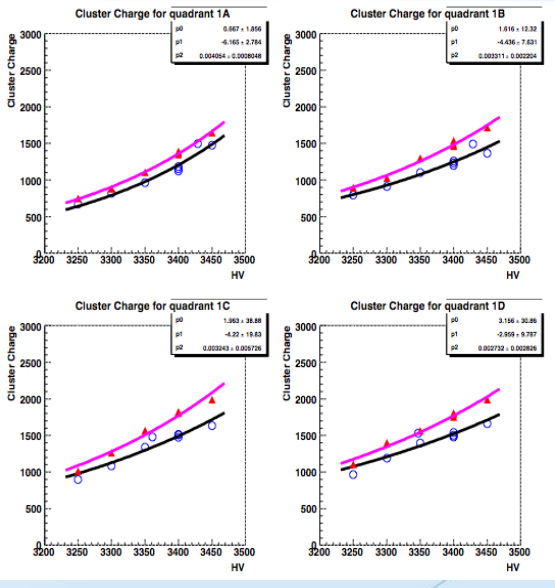
FGT Commissioning and hardware status

Overview

- The following items were adjusted and completed prior to physics mode operation:
  - Latency and Time-bin distribution
  - APV parameter scan
  - HV scan



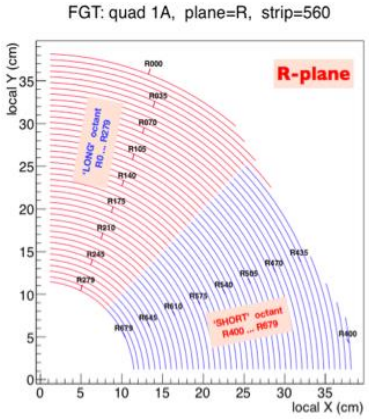
- With physics mode operation and availability of calorimeter triggers:
  - Rate studies
  - Including JP type triggers in addition to W / EEMC related triggers

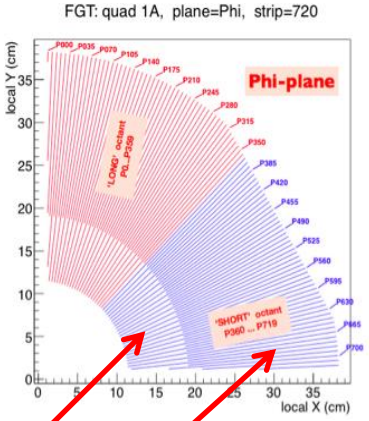


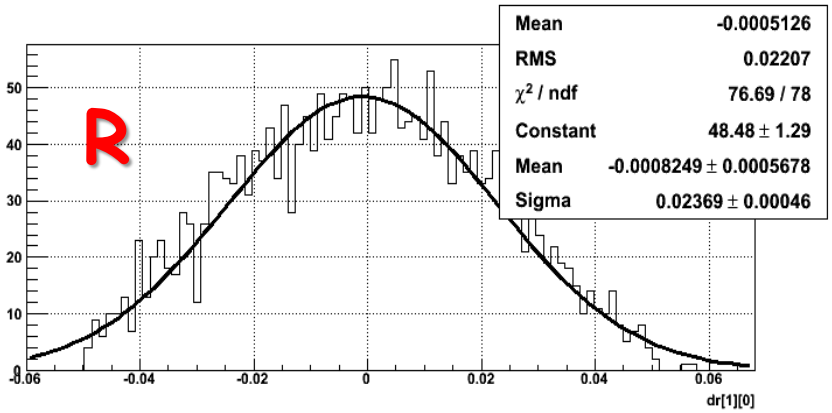
Slide courtesy of B. Surrow

FGT Performance results

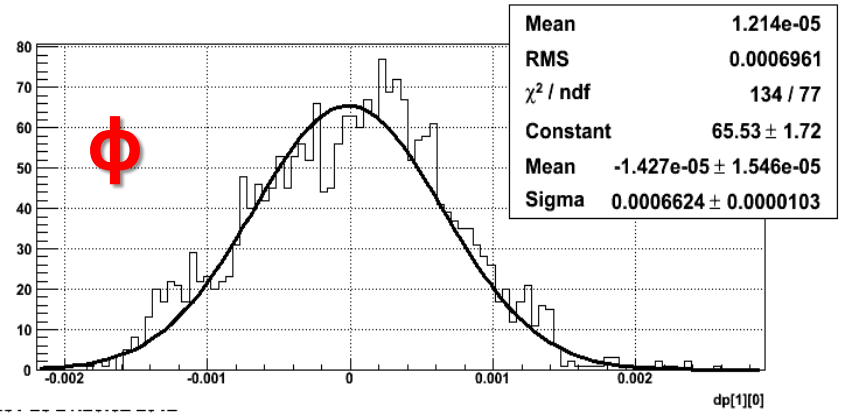
- **Cosmic-ray residuals**







Sigma = 240μm



Sigma = 0.6mrad
➜ 180μm @
R=30cm

Small R

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 @ R=30cm

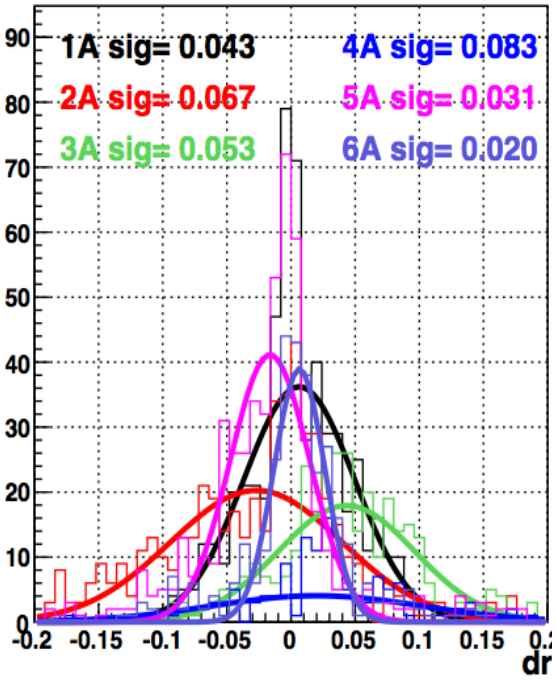
➜ 150μm resolution at each detector

Slide courtesy of B. Surrow

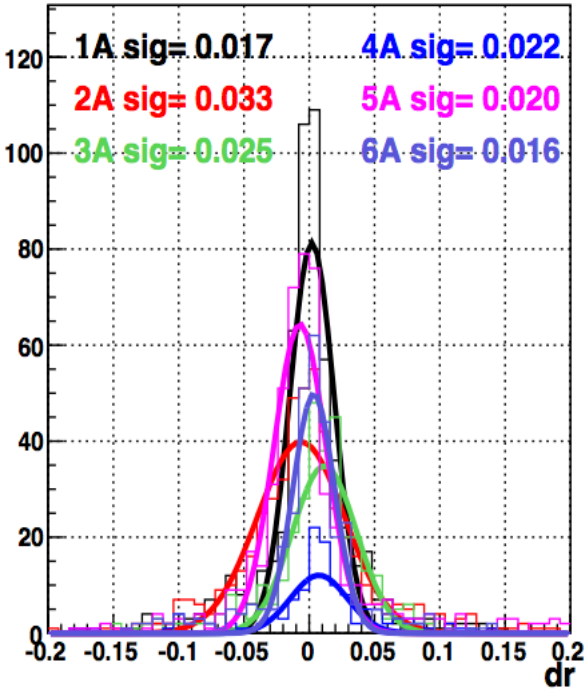
FGT Performance results

- First residual results from Run 13

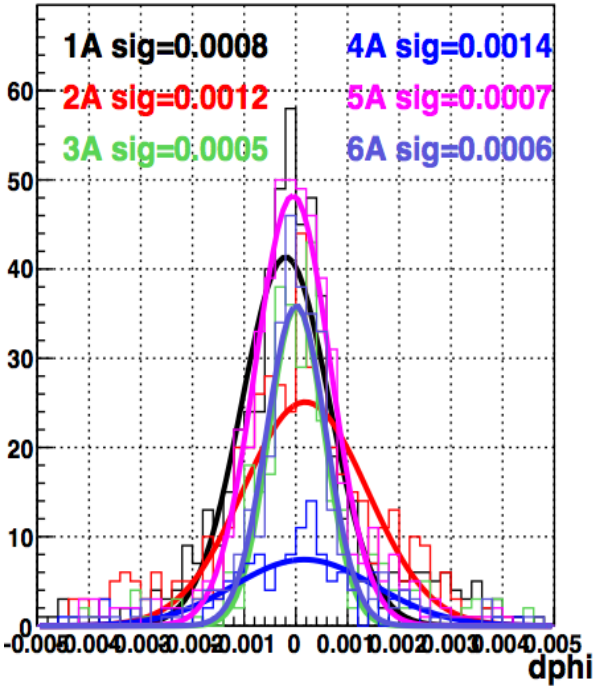
ΔR Before



ΔR After



Δφ After

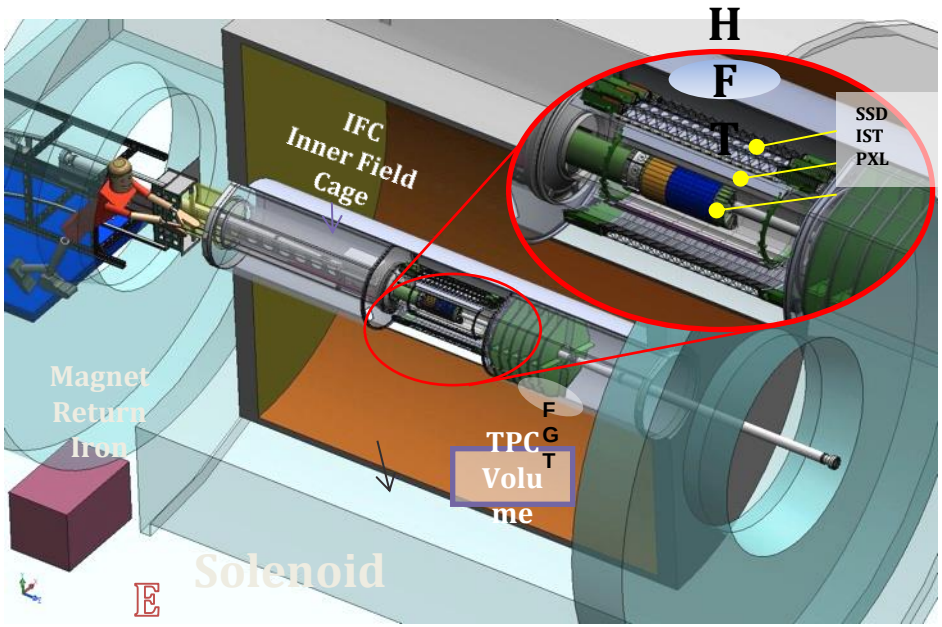


- Shift up to ~ 1mm (R) and ~0.5mrad (Phi)
- Residual sigma ~300μm (R) and ~1mrad (Phi) (0.5mrad @ 30cm = 150μm)
- Results are consistent with cosmic-ray and Cu-Au results!

FGT SUMMARY

- Performance / Plans / Goals
  - Residuals widely consistent among several measurements and in rough agreement with simulation results in proposal required for high-p_T Q-separation
  - Actual demonstration of charge-sign separation capabilities based on Run 13 data requires completion of challenging development of tracking involving vertex, FGT, TPC and EEMC SMD hit points as outlined in proposal - Key specification for FGT performance
    - Simulations require still substantial effort
    - FGT/TPC tracking integration (STV) in progress
  - Efficiency for fiducial, fully working area ~0.9 (Cosmic-ray result)
  - Acceptance loss due to FEE issues (Live FEE channels ~70%), gas & HV issues.
  - A_L measurement at backward / forward rapidity, i.e. $1<|\eta|<2$ for W^+/W^- production -

STAR HFT DETECTOR

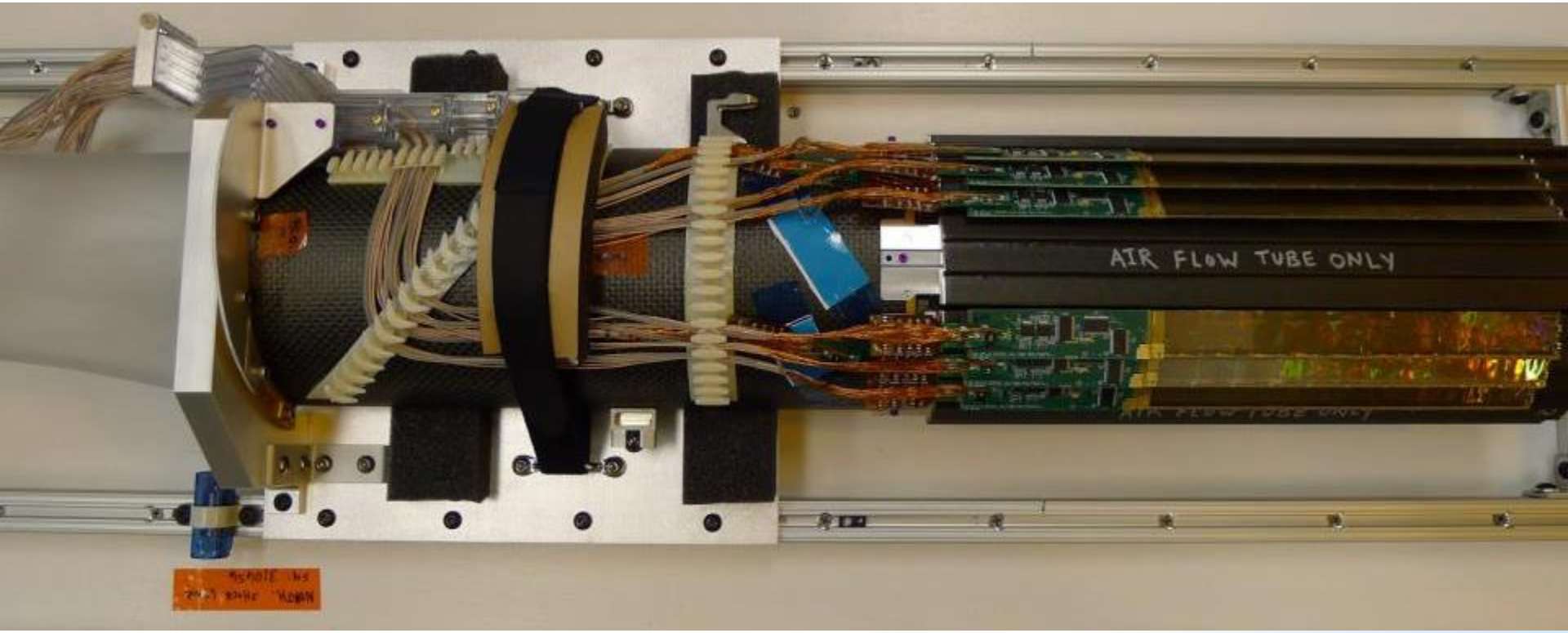


One half pixel with two sectors at test before installation

Fully Installed in Run-14 there will be 10 sectors of PXL, as well as the IST and SSD sub-systems
Each PXL sector has inner layer at 2.5 cm and outer at 8cm.
There are 40 sensors per PXL sector.
Each sensors has ~1M 18*18 microns pixel with on-board discrimination and zero suppression
Engineering run detector had 3 sectors installed on May 8, 2013

Slide courtesy of F. Videbaek

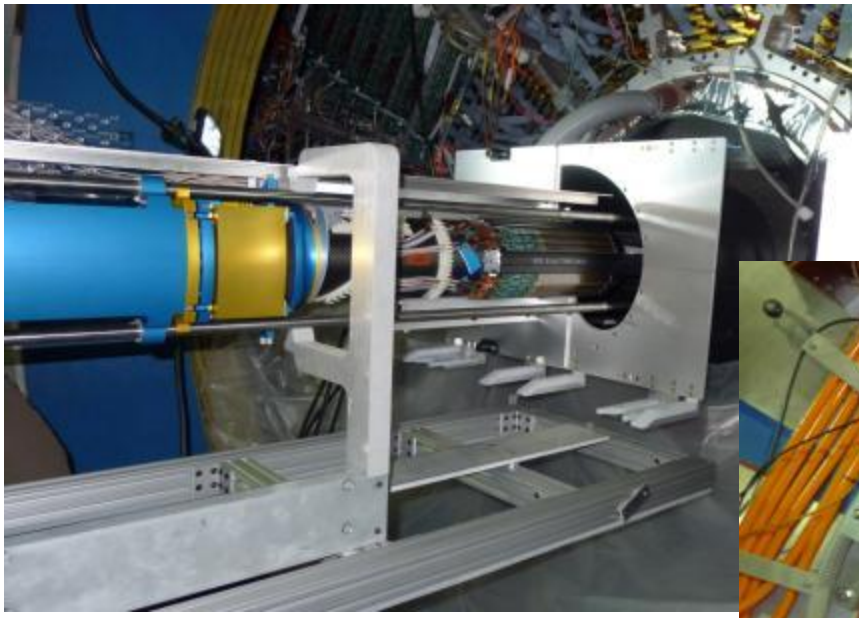
INSERTION INTO THE EXPERIMENT IN MAY 2013

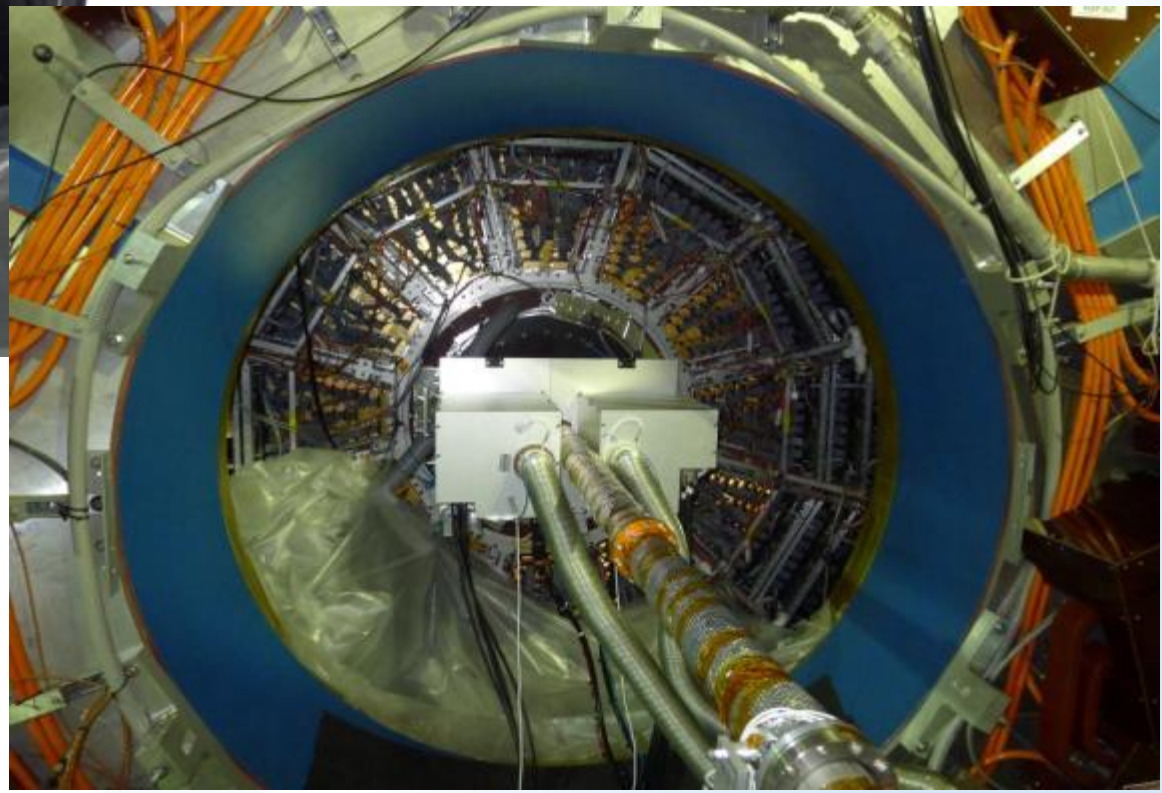


A PXL half holding two fully instrumented sectors (only the outer ladders can be seen) and three carbon (naked) sectors for smooth cooling. The other half had only one instrumented sector

Slide courtesy of S. Margetis

Insertion of HFT into the experiment in May 2013





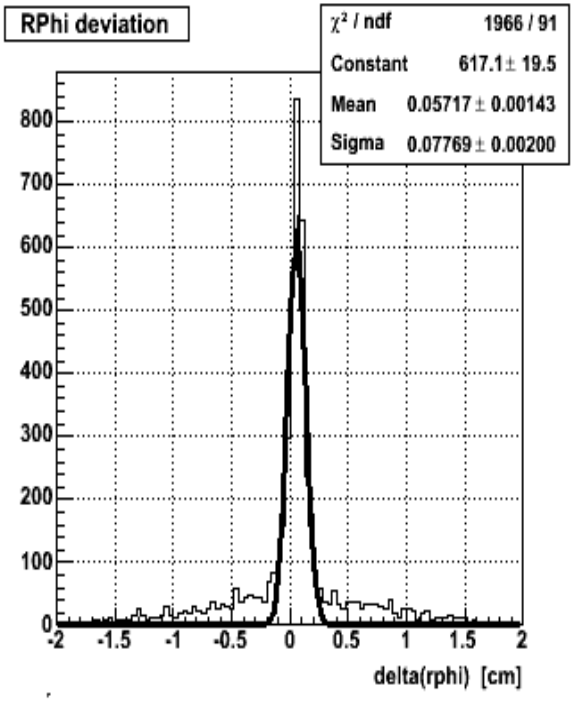
- PXL being pushed in and after installation in the East end of STAR

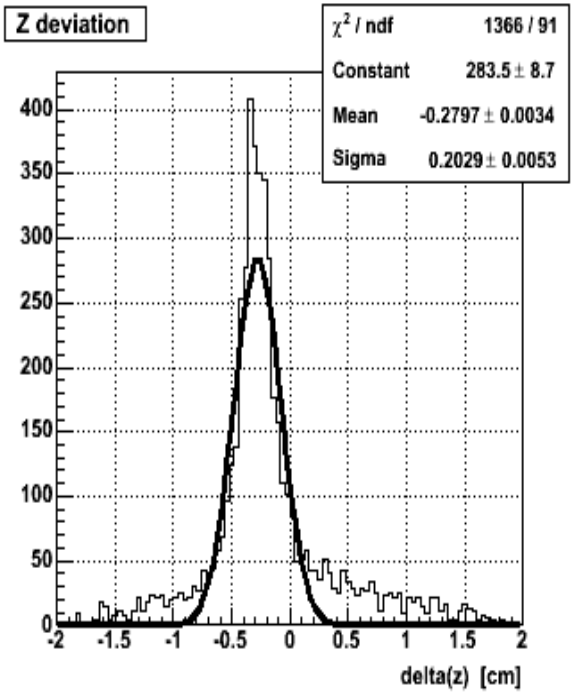
Slide courtesy of S. Margetis

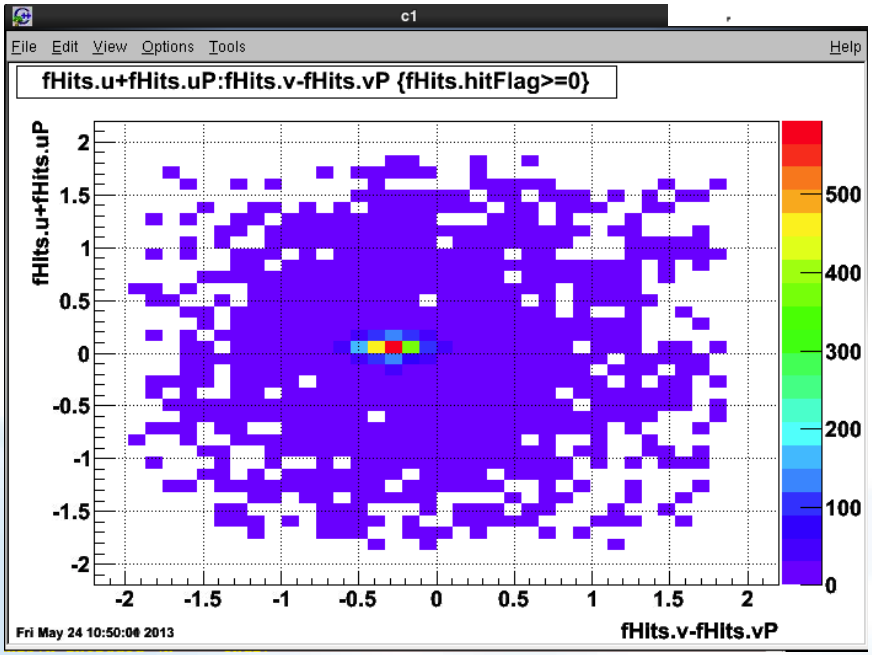
FIRST LOOK AT DATA

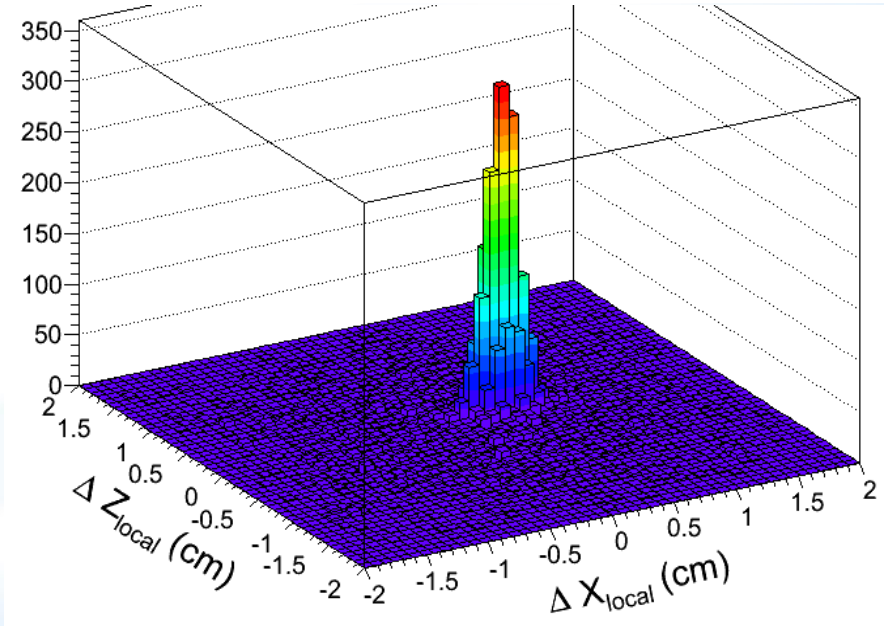
First tracking results show matching of TPC tracks to hits on sensors with residuals compatible with TPC-track resolutions on the sensors (~1-2 mm)

A beam (z) shift of ~3mm of the relative position of PXL and TPC is also observed







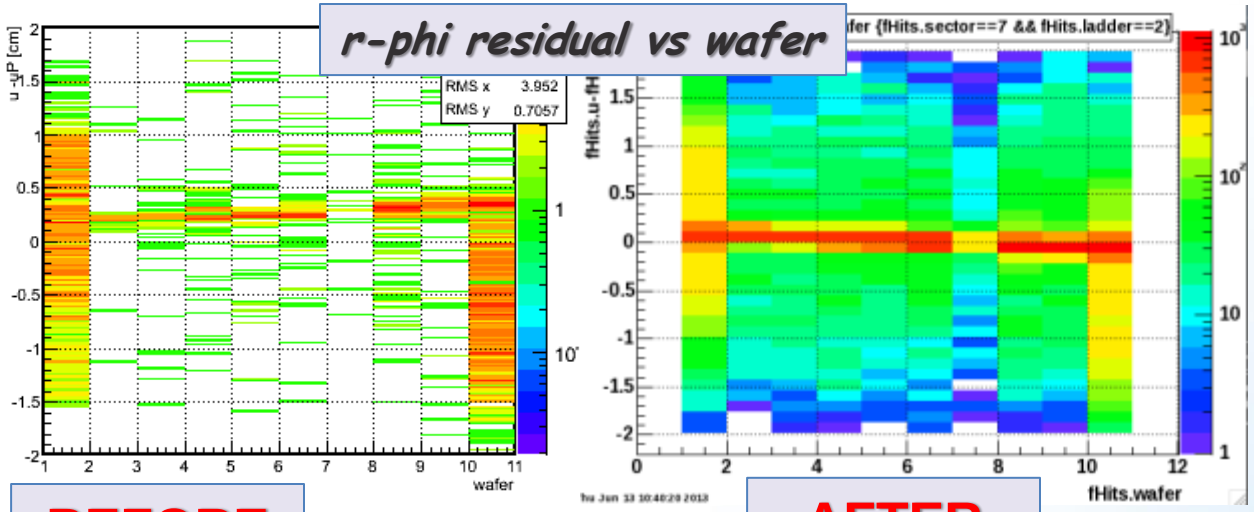


Slide courtesy of S. Margetis

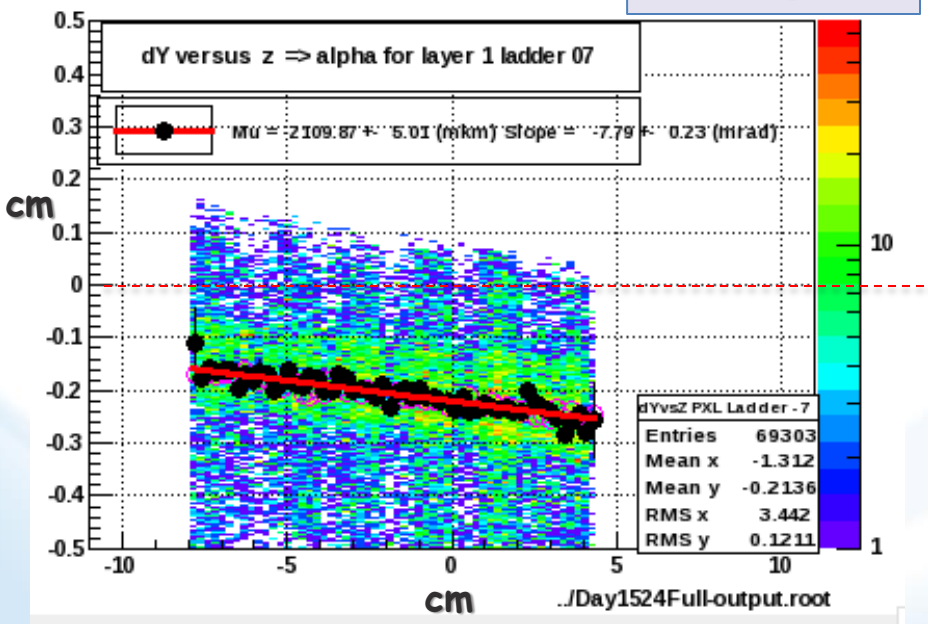
HFT FIRST LOOK AT DATA

First look at alignment showed one sector (#4) being placed in almost ideal position and one (#7) deviating a few mm with some rotations ("before" plots)

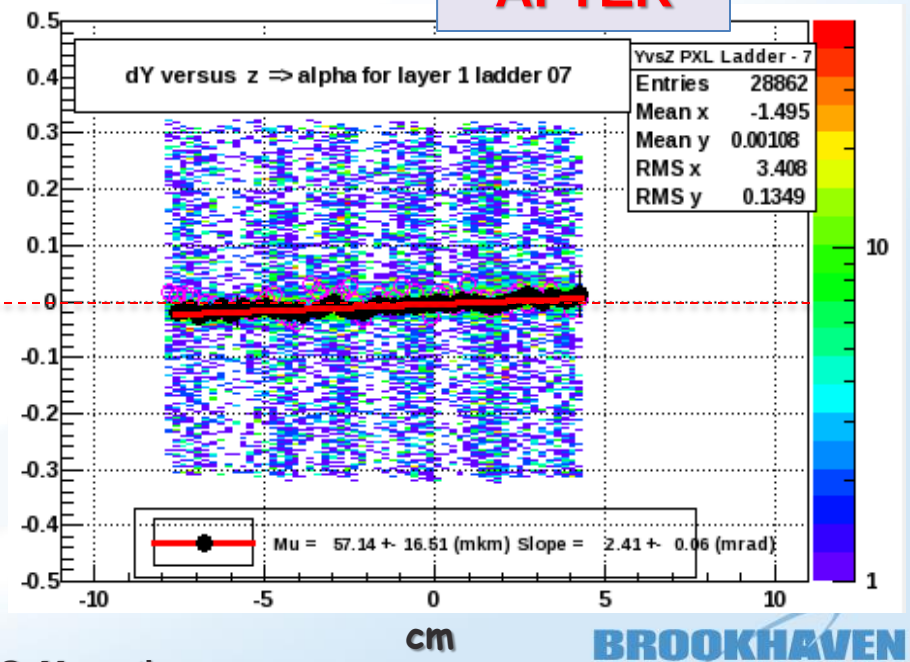
First pass corrections on sector #7 ("after" plots) seem to rectify most of the misalignment. A few iterations are expected to align sensors to <10 microns



BEFORE



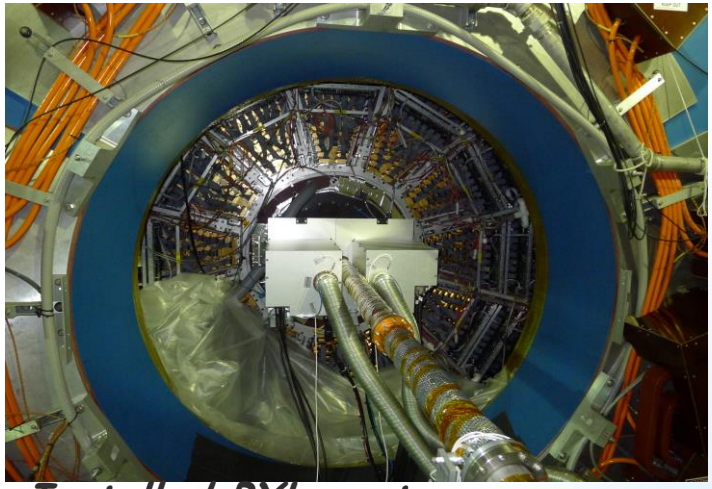
AFTER



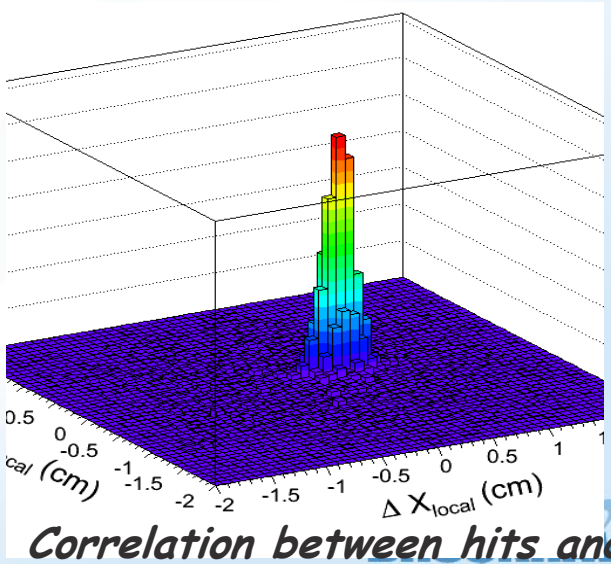
Slide courtesy of S. Margetis

PXL ENGINEERING RUN

- PXL system ,(3/10 sectors) first application of MAPS sensors, in collider environment is being commissioned
- System has been integrated with STAR DAQ and trigger.
- Valuable lessons from operating in the STAR environment has been learned on mechanical, settings, latch-up and stability. Several issues has been resolved. Will be incorporated for production pixel system.
- First tracking results shows matching of TPC tracks to hits on sensors with residual in order of the expected TPC resolutions on the sensors (~1-2 mm)



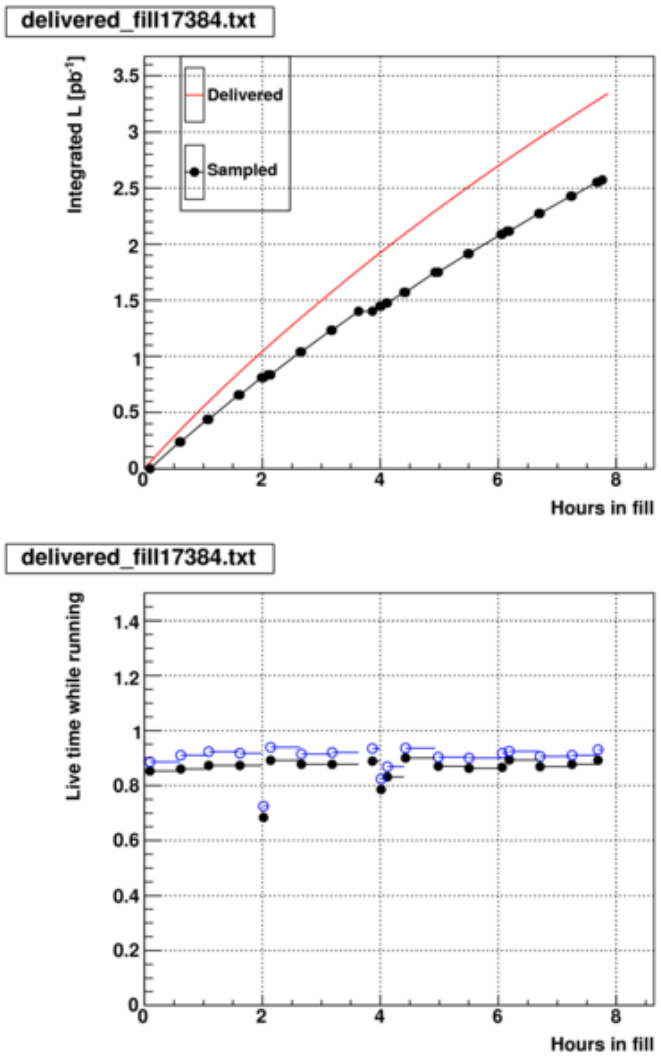
Installed PXL system as seen from East End of STAR



Correlation between hits and TPC tracks on one sector ladder

STAR'S RUNNING EFFICIENCY FOR RUN 13

Fill 17384
Started Mon Apr 15 08:09:45 2013
Ended Mon Apr 15 16:01:19 2013
7.9 Hours
Total delivered: 3.342 pb^-1
Sampled Fraction: 0.806
after correction by average TCULive/Live: 1.047
Fraction of L delivered while taking data: 0.885
Fraction of hours delivered while taking data: 0.887
Minutes lost before first run: 5.7 Frac: 0.012
Minutes lost after last run: 5.6 Frac: 0.012
Luminosity fraction lost before first run: 0.016
Luminosity fraction lost after last run: 0.009
Average Live Time while taking data: 0.870
Live Time from TCU Counters while taking data: 0.911
Luminosity fraction lost in lasers: 0.000
Hours lost in lasers: 0.0 Frac: 0.000



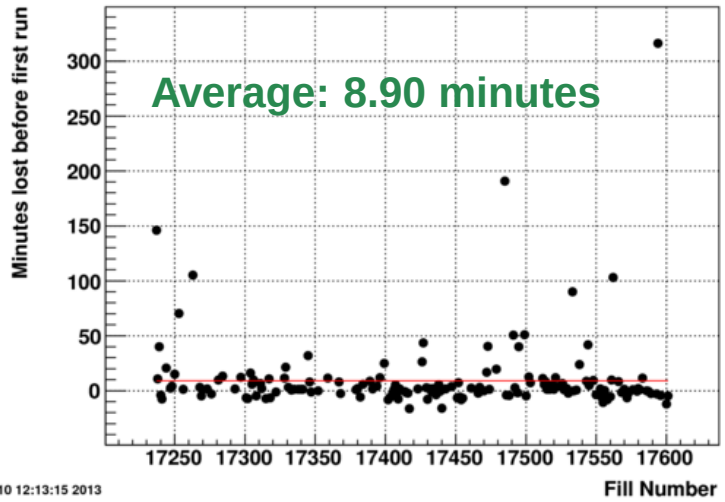
Example of how data on STAR's running efficiency is collected, calculated, and plotted for each RHIC Store.

Following slide shows these store by store calculated values plotted for the entire RHIC Run 13.

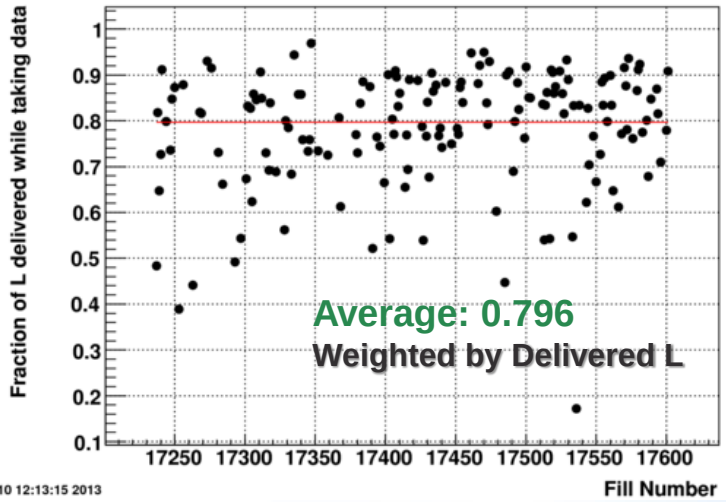
Utility and Web page done by J. Dunlop

STAR'S RUNNING EFFICIENCY FOR RUN 13

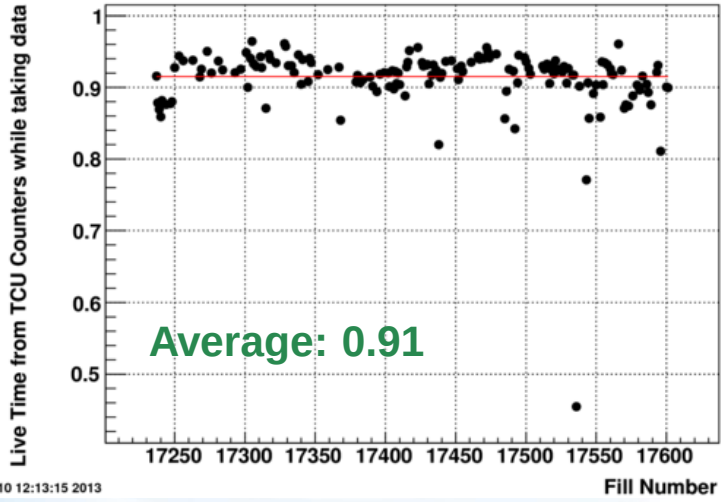
Minutes lost before first run



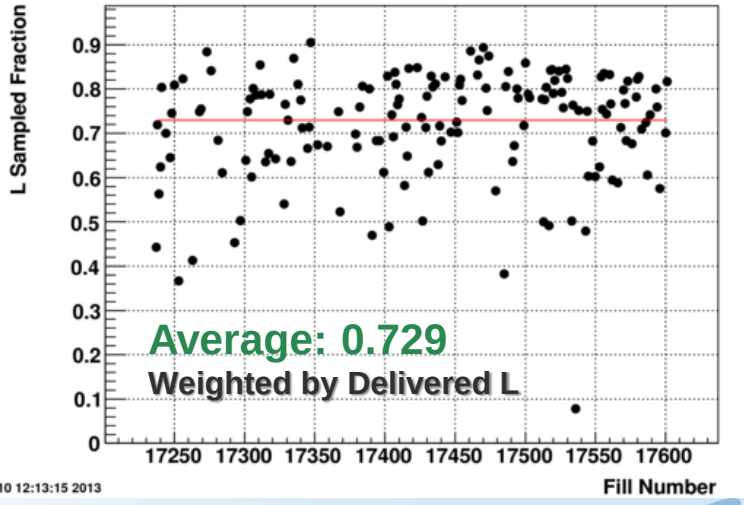
Fraction of L delivered while taking data



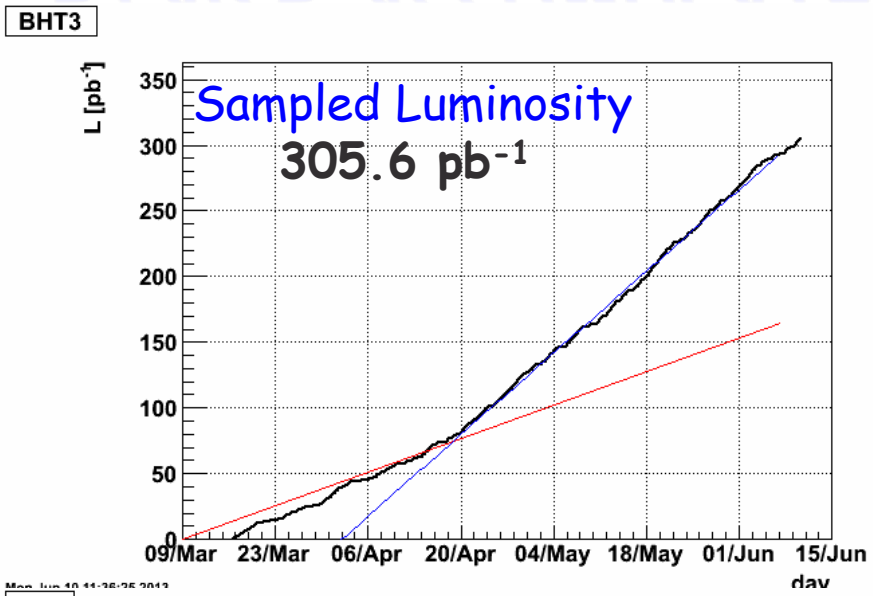
Live Time from TCU Counters while taking data

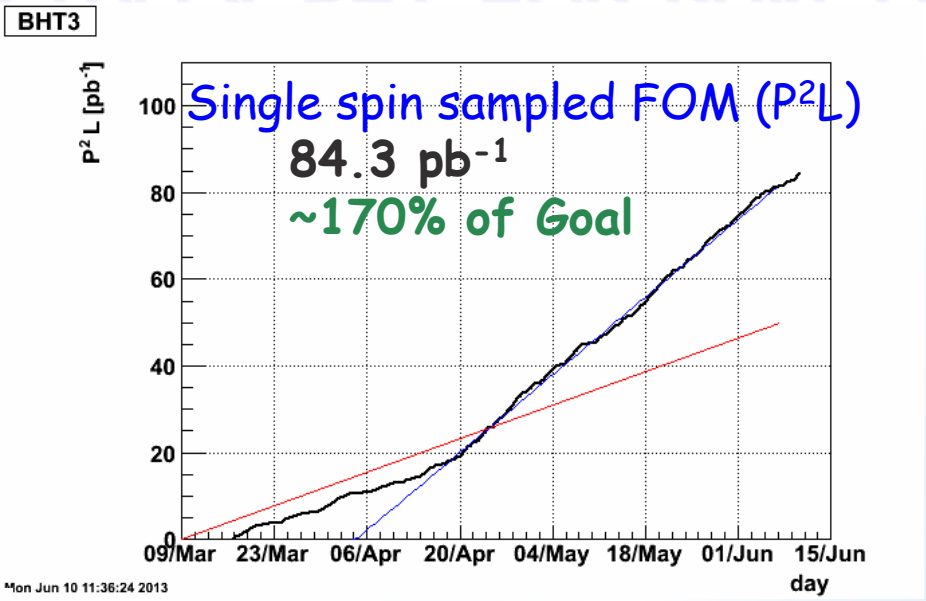


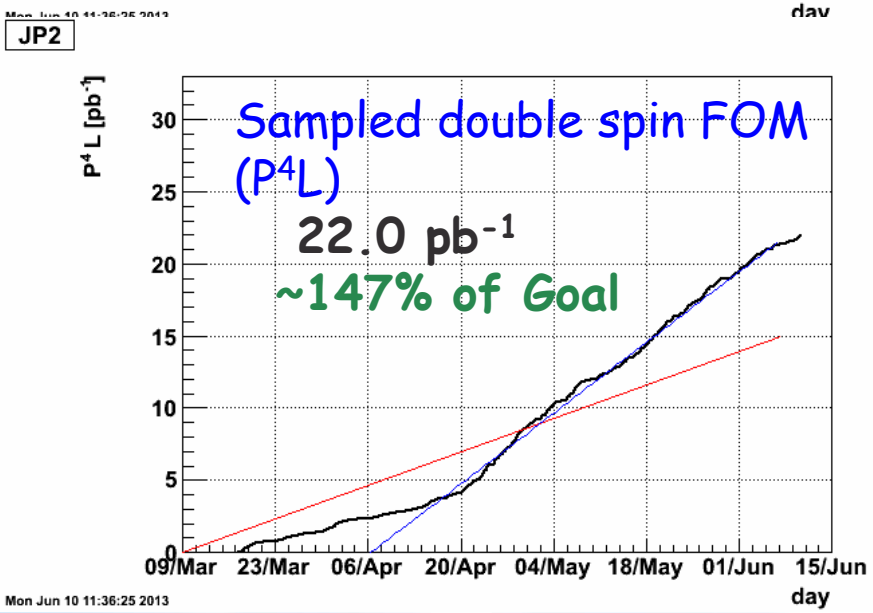
L Sampled Fraction



STAR'S ACCUMULATED DATA SET FOR RUN 13







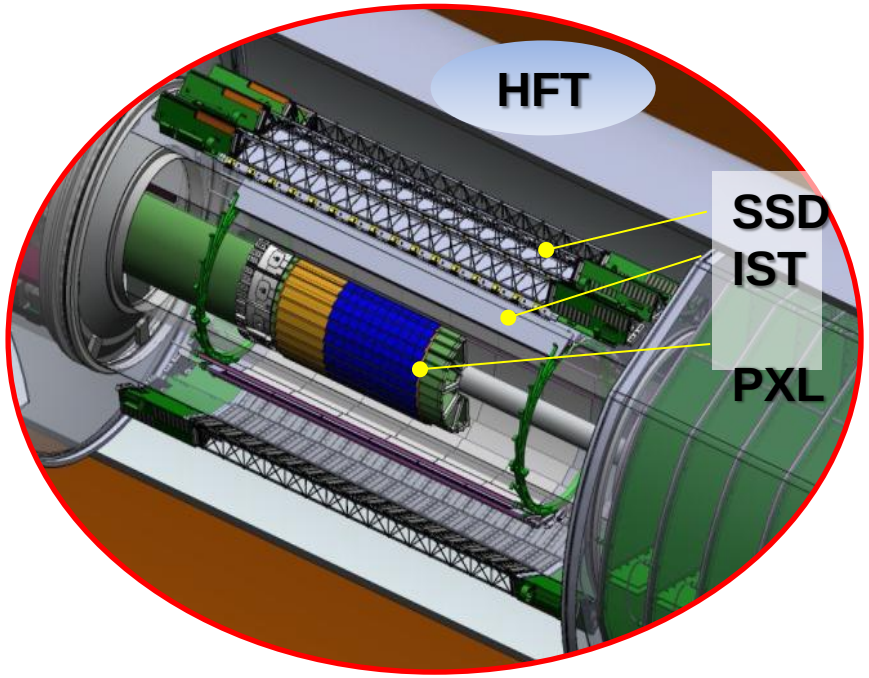
STAR Run 13 510 GeV pp Beam Use Request Goals:

Single Spin FOM P^2L = 50 pb^{-1}
Double Spin FOM P^4L = 15 pb^{-1}

Goals surpassed by a significant amount!

PLANS IN PREPARATION FOR RUN 14

- Install complete HFT



- Complete installation of MTD

- Unstack, aneal, and make repairs to Forward Meson Spectrometer in preparation for Run 15.
- Routine maintenance for all sub systems.

SUMMARY

- Installed and commissioned a number of new/extended sub systems during Run 13 (Trg Clk distribution, 65% of MTD, Full FGT, GMT, enhanced TPC electronics config. abilities, subsystem auto recovery, 3/10 PXL, new Trigger Control Unit).
- STAR Running Efficiency was very good.
- We achieved ~ 147 & 170% of our Spin data set accumulation goals.
- Plans for Run 14 include the completed MTD and the complete Heavy Flavor Tracker (PXL, IST, & SSD).


IST assembly, June 25, 2013

Last but not least, a big THANK YOU from STAR to C-AD for delivering the large delivered FOM for RHIC Run 13!