TIMING, or TAGGING

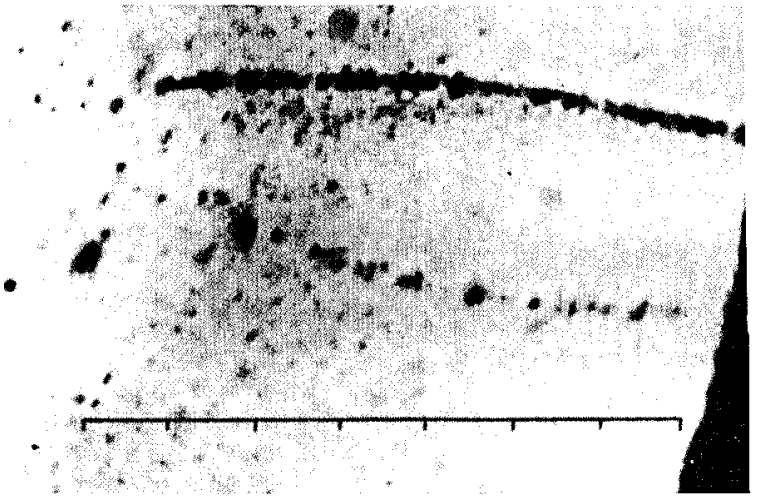
The Muon Telescope Detector

W.J. Llope, Rice University

Wikipedia: “Muons were discovered by Carl D. Anderson & Seth Neddermeyer at Caltech in 1936”

“Who ordered that?!?” – I.I. Rabi, 1937

Actually seems to have been first observed in a cloud chamber in Rostock Germany in 1933!



"The other double trace of the same type (figure 5) shows closely together the thin trace of an electron of 37 MeV, and a much more strongly ionizing positive particle whith a much larger bending radius. The nature of this particle is unknown; for a proton it does not ionize enough and for a positive electron the ionization is too strong. The present double trace is probably a segment from a "shower" of particles as they have been observed by Blackett and Occhialini, i.e. the result of a nuclear explosion".

Kunze, P., Z. Phys. 83, (1933) 1

The MTD "basic idea"

With a large area muon detector at mid-rapidity…

Physics:

- di-muon pairs from QGP thermal radiation, quarkonia, light vector mesons, resonances in QGP, and Drell-Yan production
  excellent mass resolution would separate different upsilon states

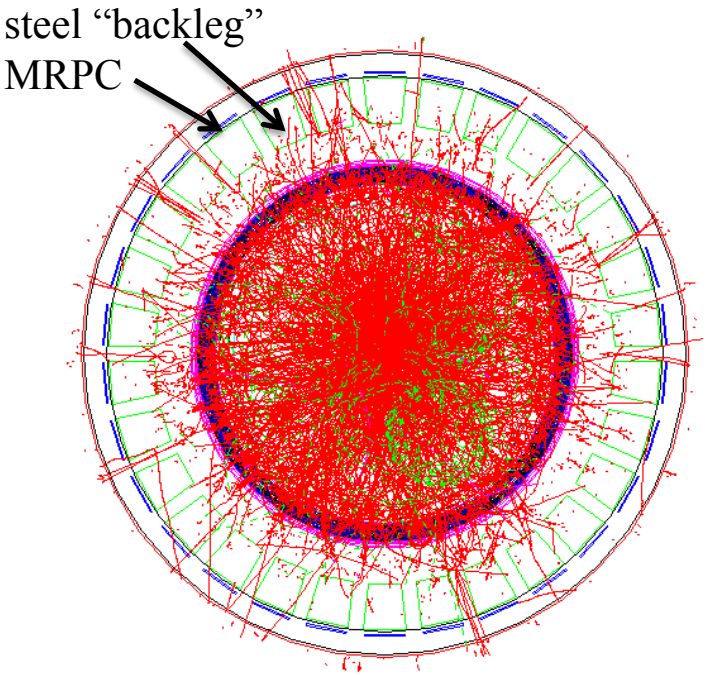
- single muons from the semi-leptonic decays of heavy flavor hadrons… e+muon correlation to distinguish heavy flavor production from initial lepton pair production

- advantages over electrons:
  - no γ conversion
  - much less Dalitz decay contribution
  - less affected by radiative losses in the detector materials

How could this be achieved?

- Hadron shielding is magnet backlegs and BEMC (~$7X_0$)
- Precise timing! start from upVPD, fast TOF hit + fast MTD hit, TPC + HFT matching
- Low-level trigger capability!

MTD conceptual design

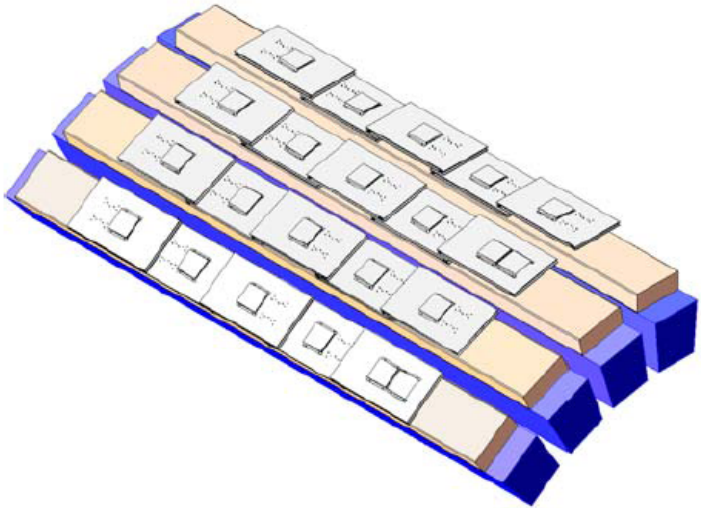


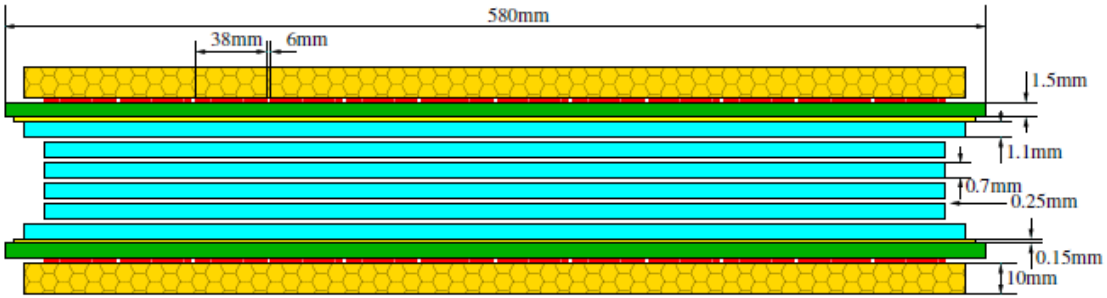
Multi-gap Resistive Plate Chamber (MRPC):
- gas detector, avalanche mode
- inexpensive, eay to build, but precise timing

The detectors cover the steel magnet backlegs and leave the φ-gaps uncovered.
- Acceptance: ~45% at $|\eta|<0.5$

118 modules, 1416 readout strips, 2832 channels

Proven detector technologies
- MRPC detectors & STAR-TOF electronics





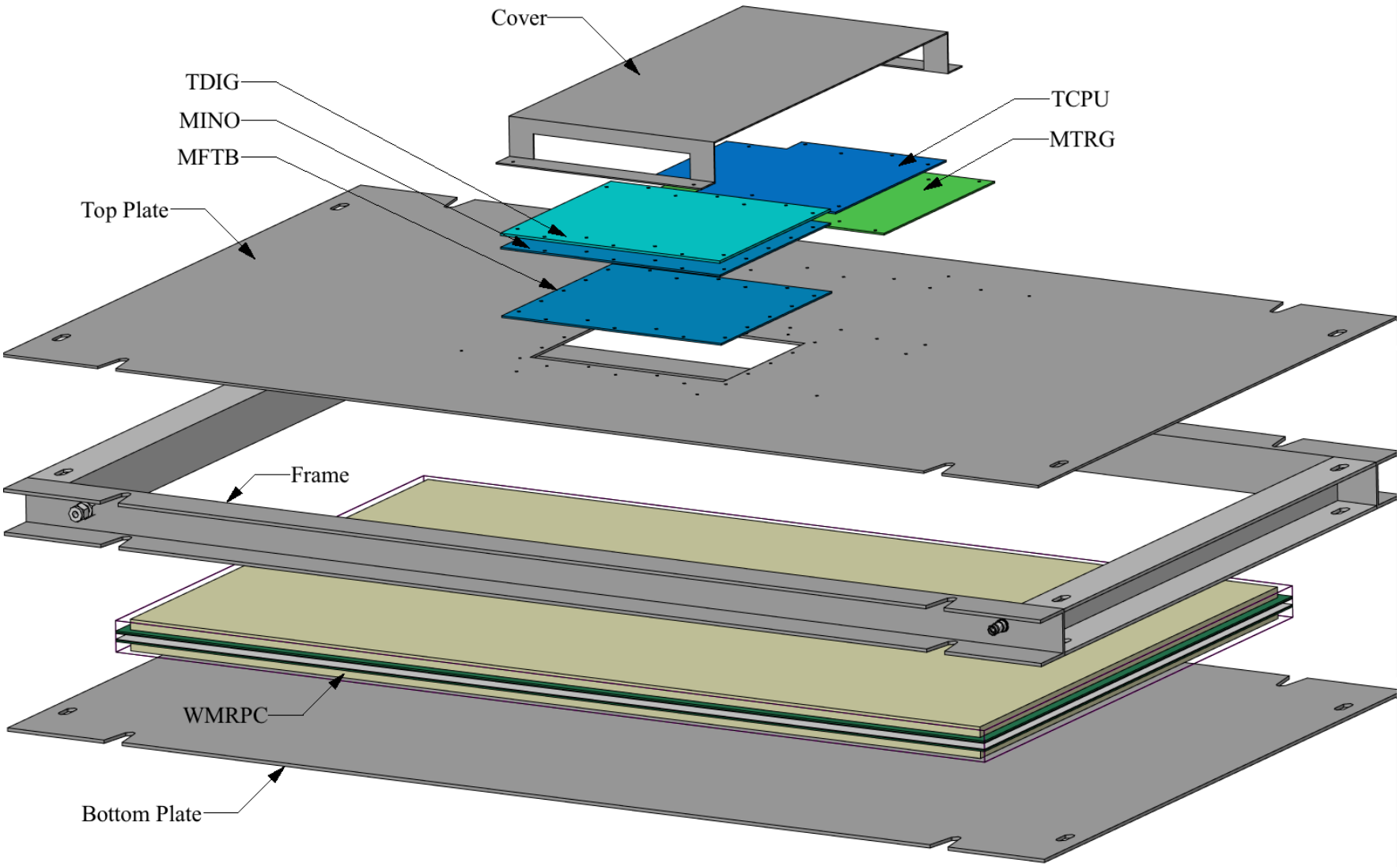
Design, Installation, and Operations

System	MRPCs	"Tray" Design	Electronics	Installation
STAR TOF	excellent	complicated	new & complicated	simple
STAR MTD	excellent	simple	commodity	complicated

Outline:

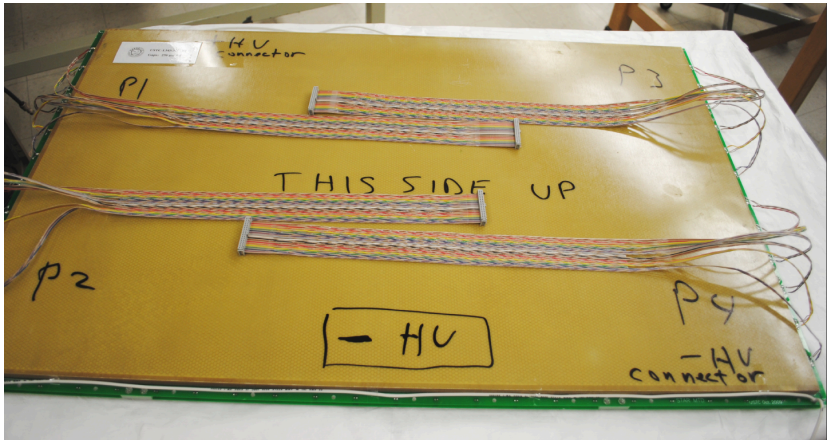
- MRPCs and "trays"
- Prototypes in runs 9-11
- The full system
- Run 12, 13, and 14 installations
- Some surprises from Run-13
- Summary

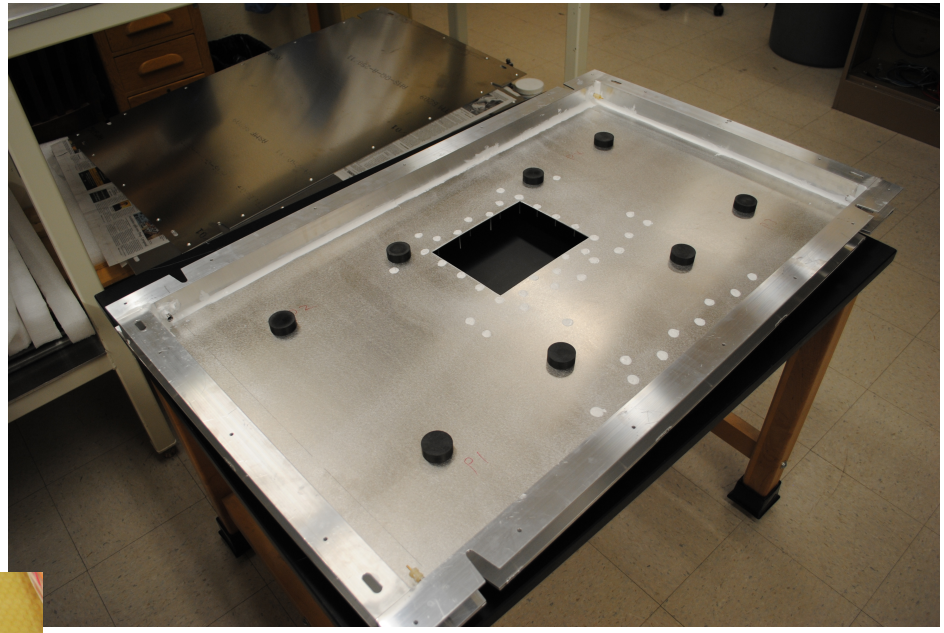
Tray Design (Exploded View)

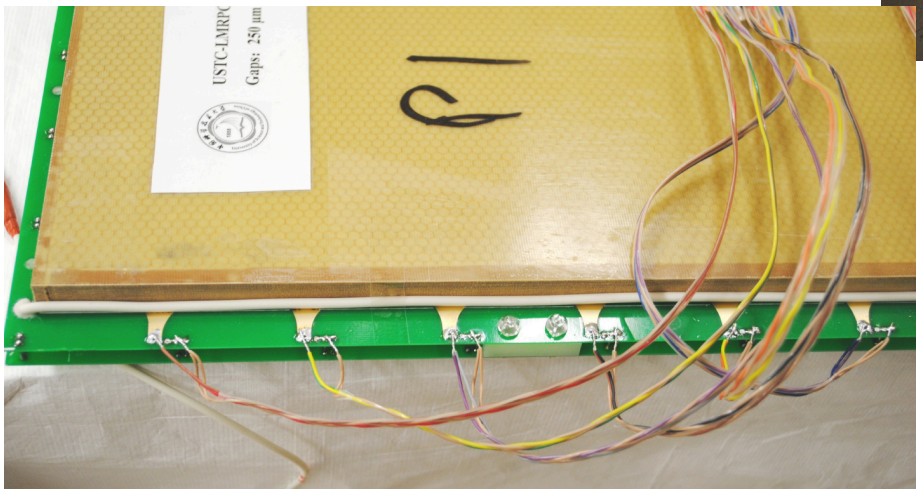


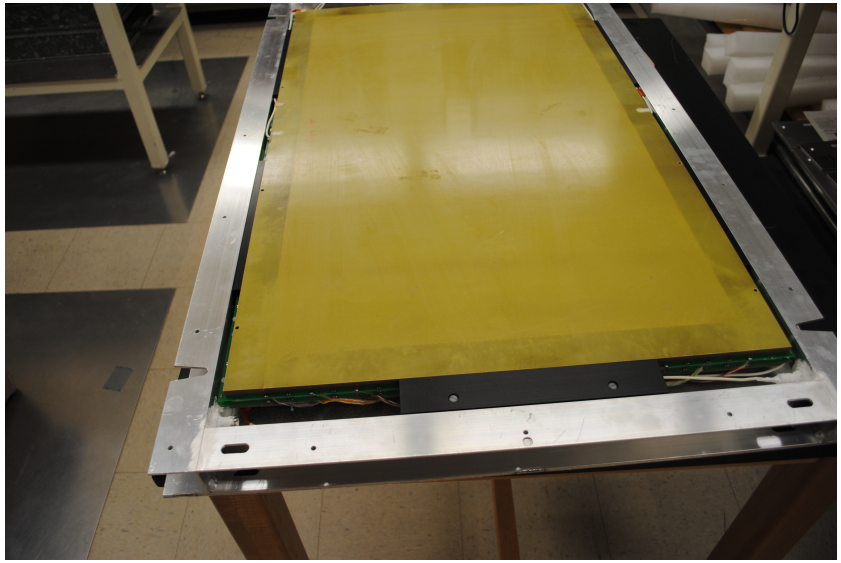
MRPCs fabricated at USTC, Tsinghua, and VECC

MTD Tray Assembly





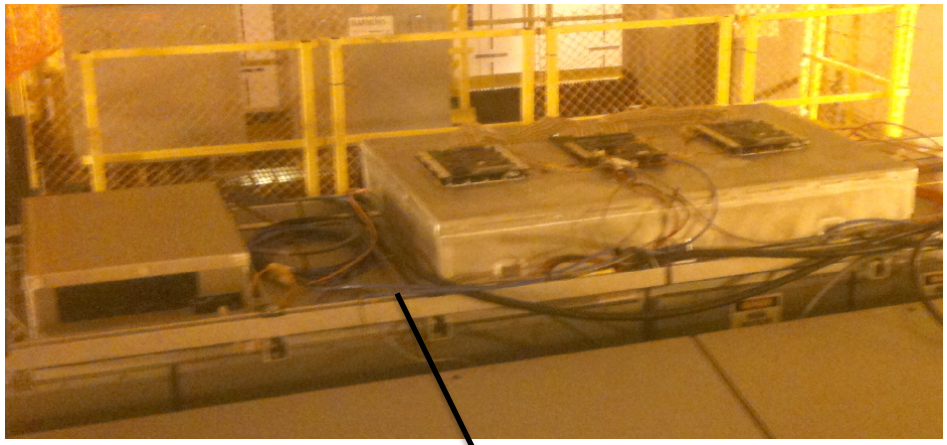


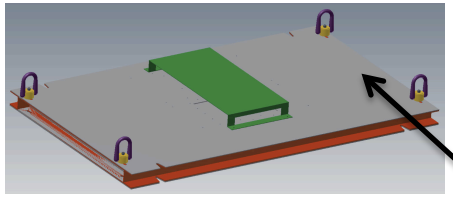


Tray Mechanics built in Houston & Austin
Tray Assembly at UT-Austin

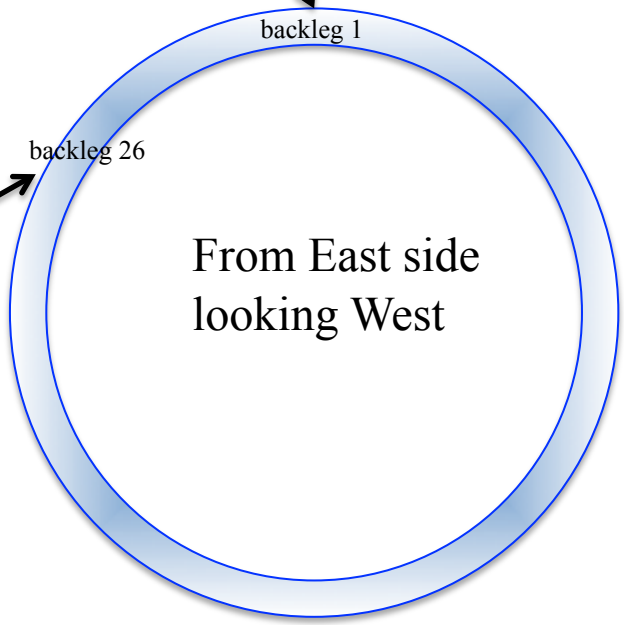
MTD9 and MTD11 Trays at BNL, December 2010

MTD9 & MTD THUB

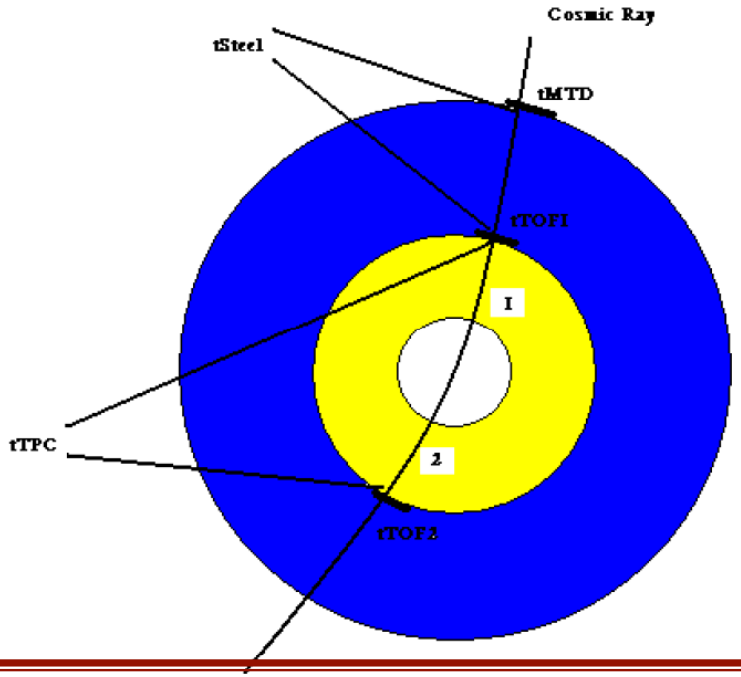




Three MTD11 trays (craned into place)



Run 9-11 prototype performance for cosmics



Cosmic ray trigger

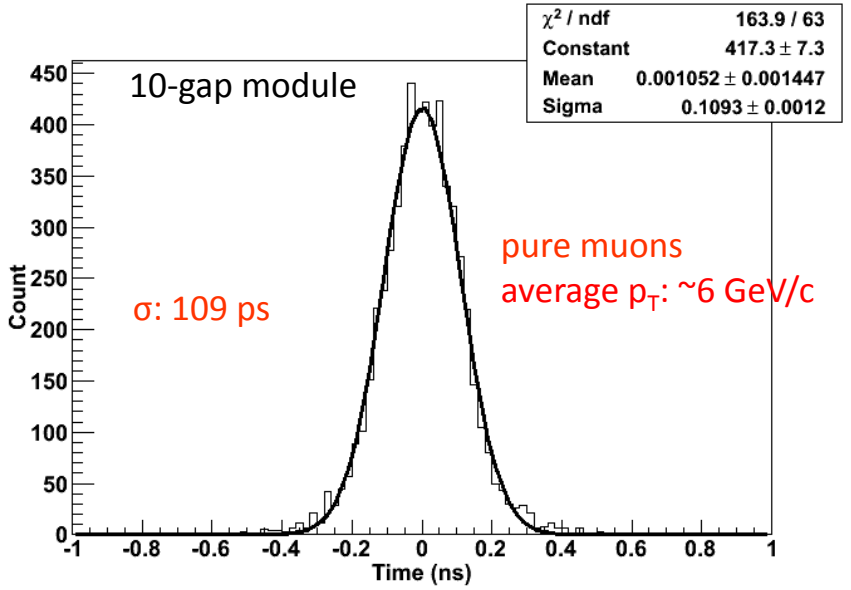
Total resolution: 109 ps

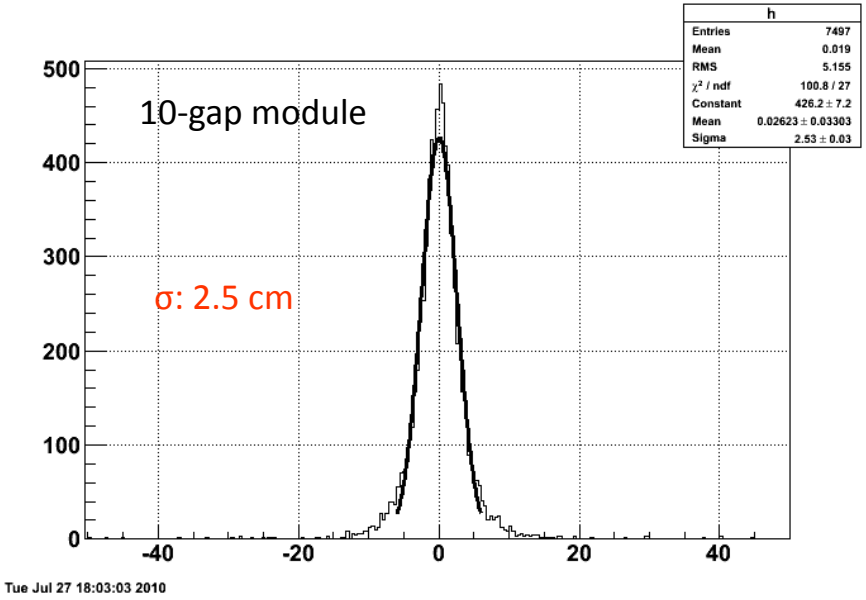
Start resolution (2 TOF hits): 46 ps

Multiple scattering: 25 ps

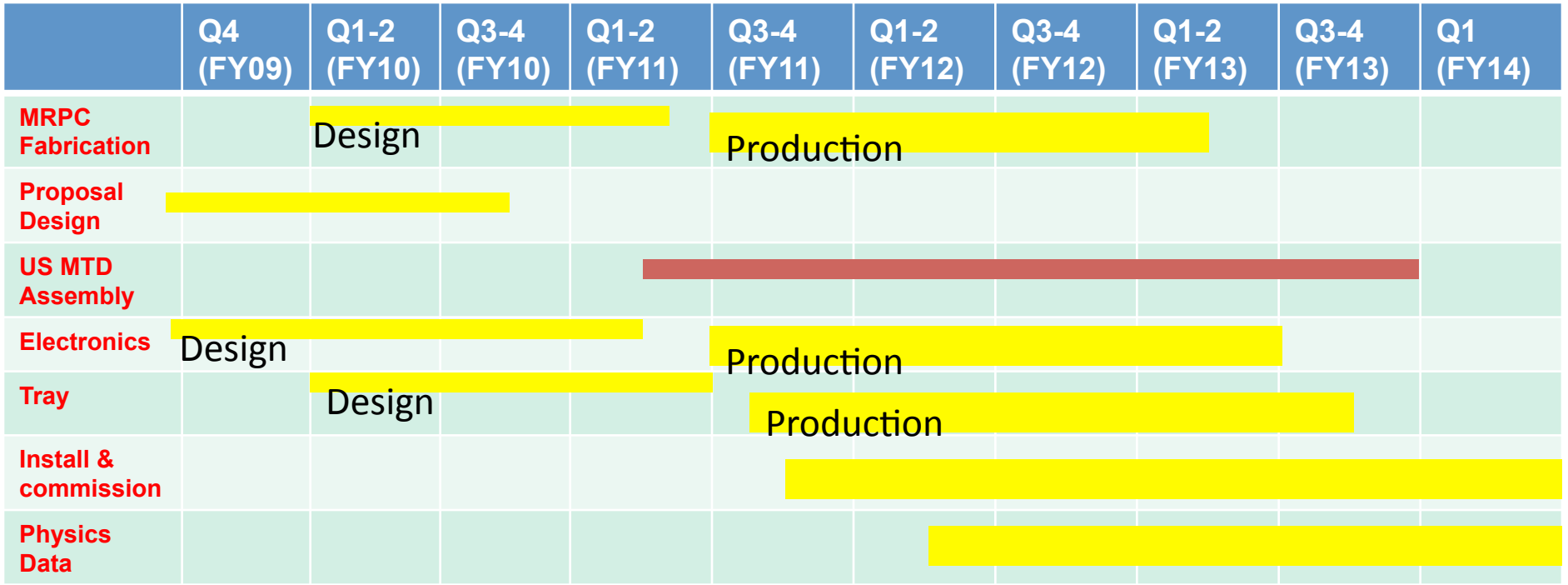
MTD intrinsic resolution: 96 ps

System spatial resolution: 2.5 cm, dominated by multiple scattering





Project Schedule and Institutions



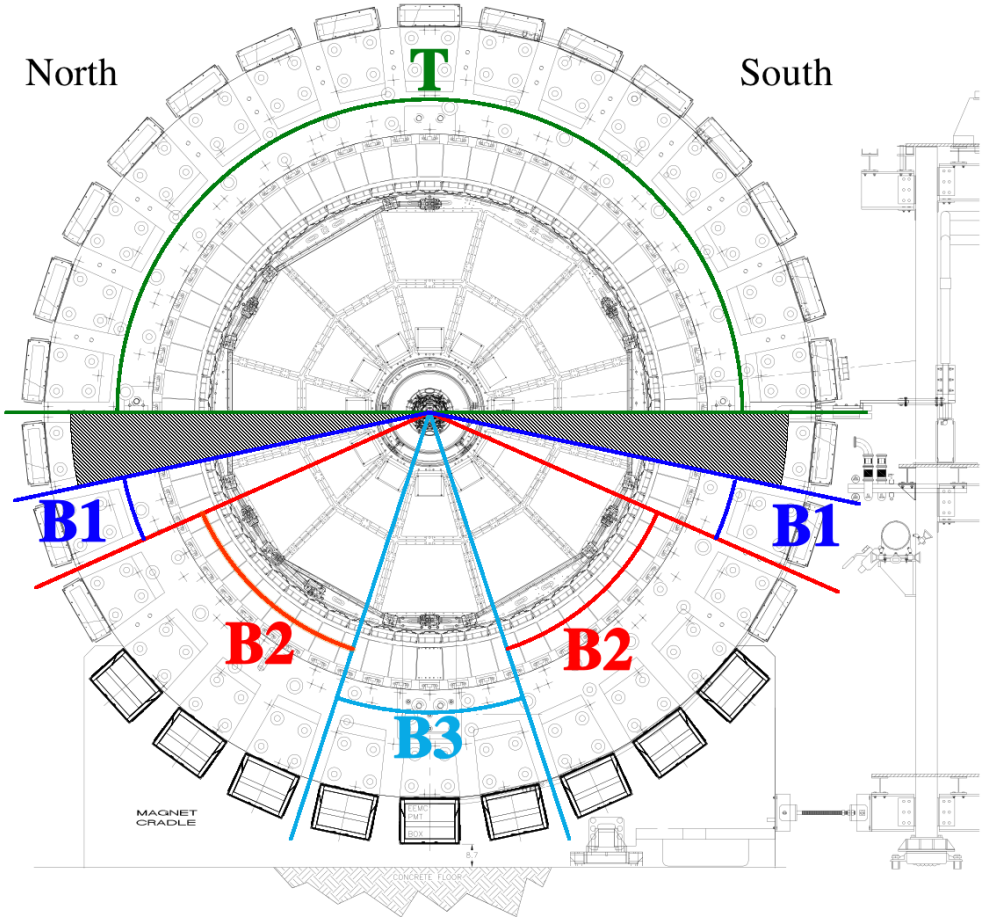
10% installation for Run12, 43% for Run13, 80% for Run 14.
Finish the project by Mar, 2014

MTD institutions: Brookhaven National Laboratory, University of California-Berkeley, University of California-Davis, Rice University, University of Science & Technology of China, Texas A&M University, University of Texas-Austin, Tsinghua University, Variable Energy Cyclotron Centre

US institutions: the electronics, the assembly of the trays and the operation of the detector

Chinese and Indian institutions: the fabrication of the MRPC modules

Geometry of the Full System



also see http://wjllope.rice.edu/~MTD/MTDintegration.pdf

US DOE Proposal:

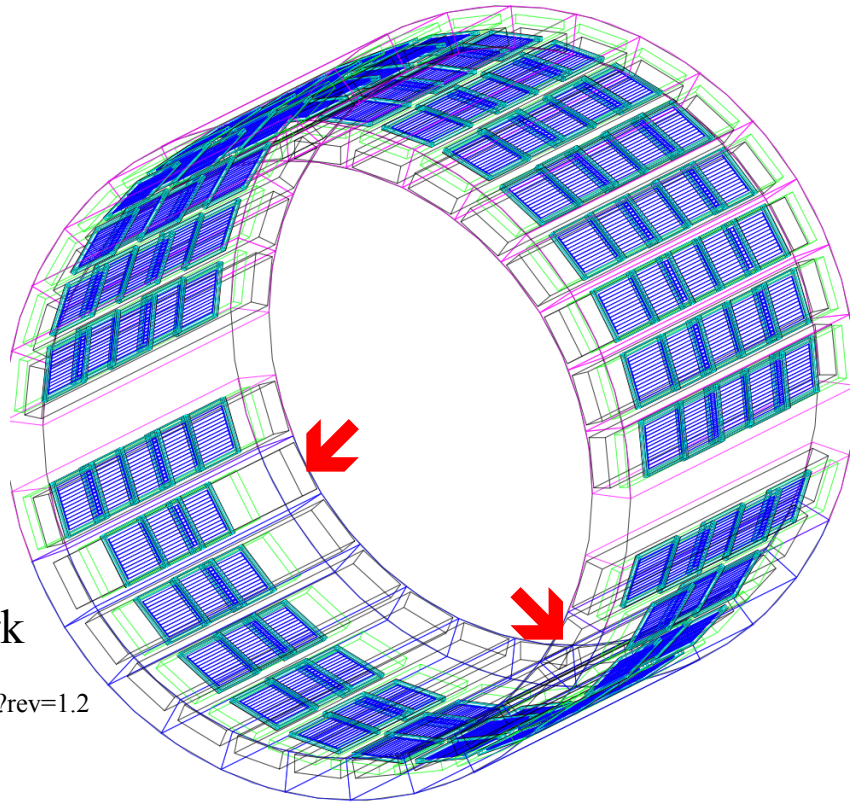
15 “5-packs” over the top

2 “5-packs” just under equator

11 “3-packs” below

…118 MTD trays total

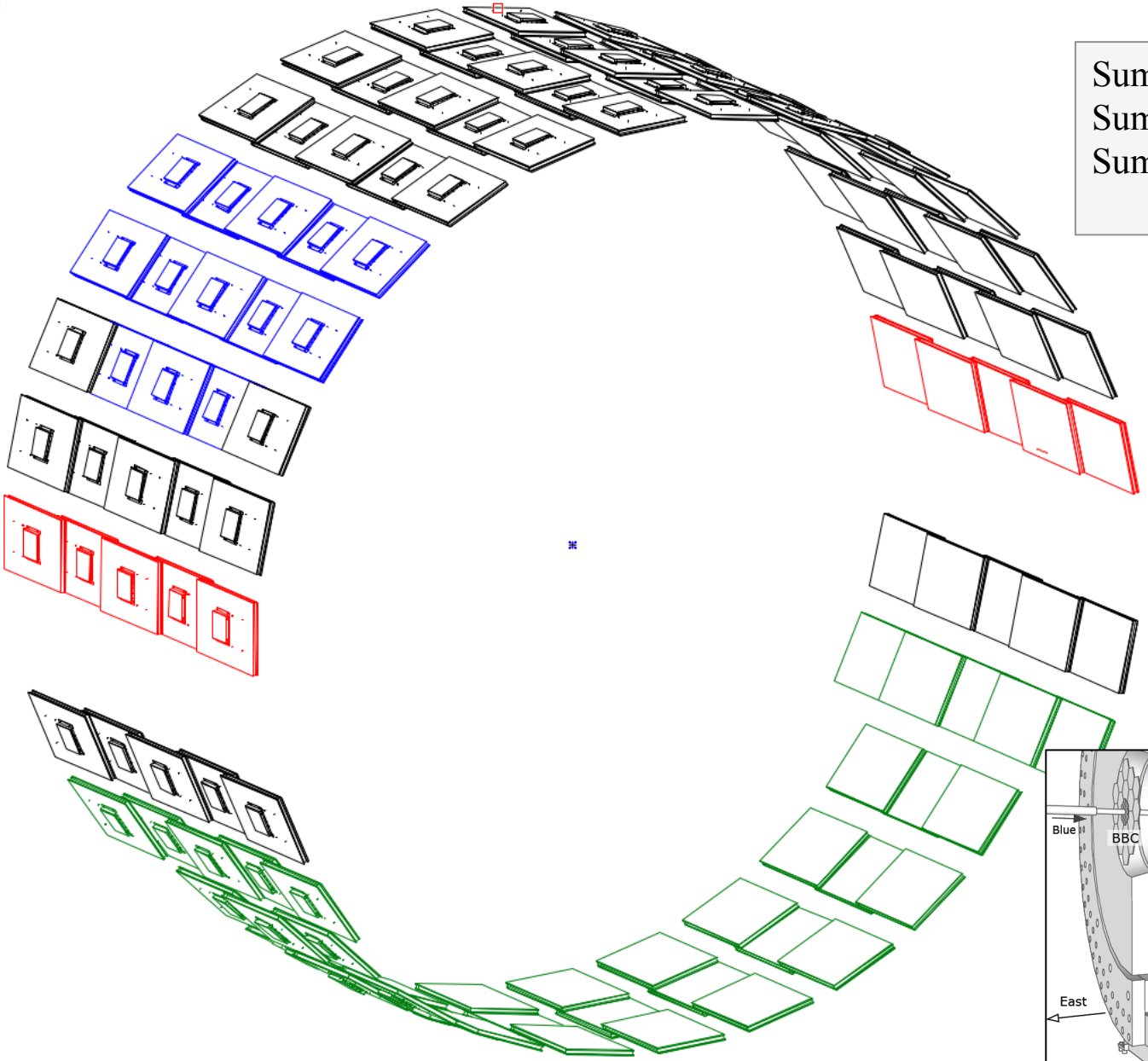
…N/S & E/W symmetric



implemented in STAR geant simulations framework

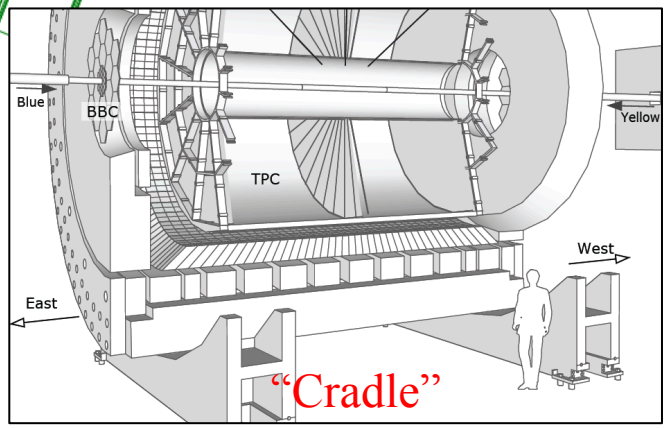
http://www.star.bnl.gov/cgi-bin/protected/cvsweb.cgi/pams/geometry/mutdgeo/mutdgeo4.g?rev=1.2

Installation stages

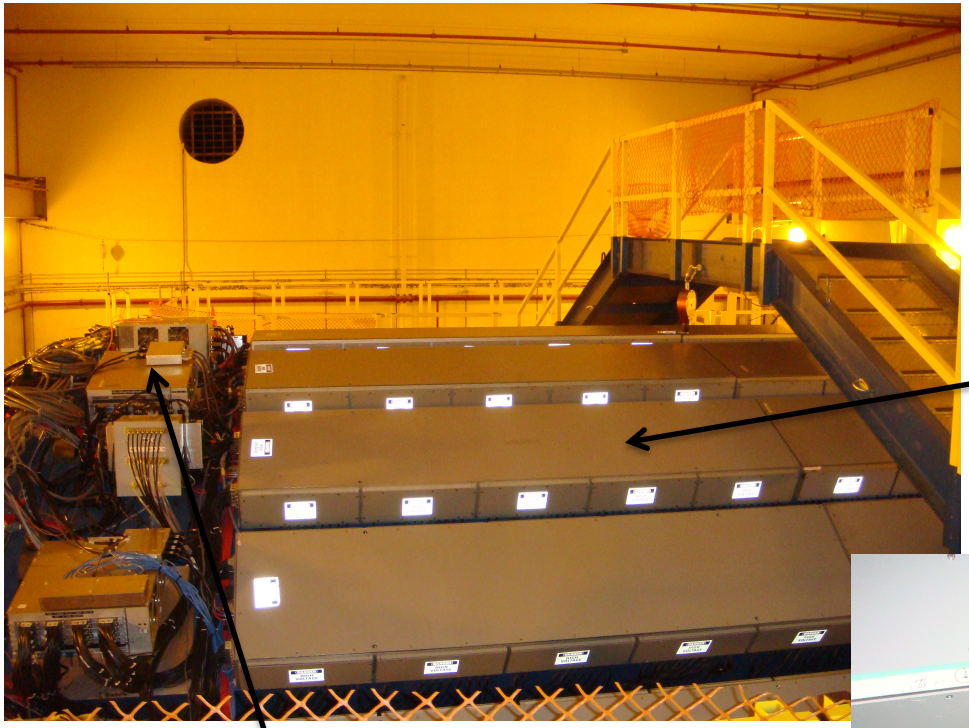


Summer 2011: 3 BLs, 13 trays
Summer 2012: 15 BLs, 75 trays
Summer 2013: 11 BLs, 37 trays
\+ 2 BLs, 10 trays

Proposal: 118 trays
Target now: 122 trays



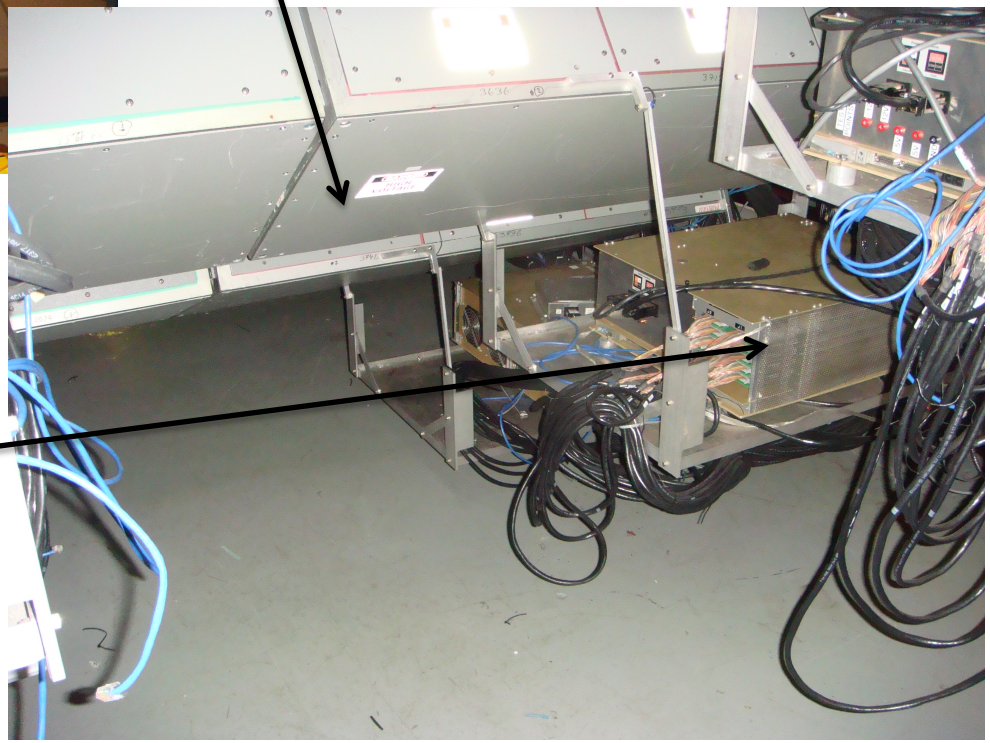
Full System Installation Locations



above STAR

BEMC PMT boxes

below STAR



BEMC crates

Run-12 Installation

Trays on 3 backlegs installed by STSG

Then all cabling added afterwards.
This took ~1.5 man-months (!)

- Anthony Kesich
- Chengming Du
- Chi Yang
- WJL

Thirteen MRPCs…

```
28: tsu,tsu,tsu,tsu,tsu
27: ust,tsu,tsu,tsu,ust
26: xxx,ust,ust,ust,xxx
```

USTC and Tsinghua modules grouped together on single HV supply channels

http://www.star.bnl.gov/HyperNews-star/get/startof/2604.html

System ran fine throughout Run-12.

(One problem w/ 28-3 HV polarity fixed mid-run)

Run-12 Installation

Run-13, as installed

L-R: John, Bob, **Bill**, Matt, Tim, Chris, Chi, Hui, Wangmei, Alex, Anthony
Not shown: Bingchu and Shuai

By Nov. 13th, 63% of the MTD system was installed at STAR for Run 2013, electronics commissioning is on-going.
Superseded the milestone (43%) for Run 2013.

new gas distribution system, new monitoring and controls station, MTD trigger development
…MTD standing on its own… (less an extension of TOF)

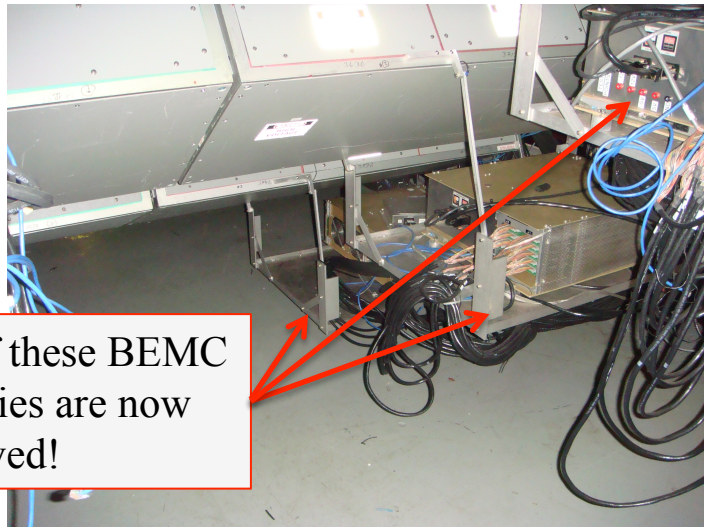
Run-14 installation

Installation of the trays "below STAR" is in progress now!

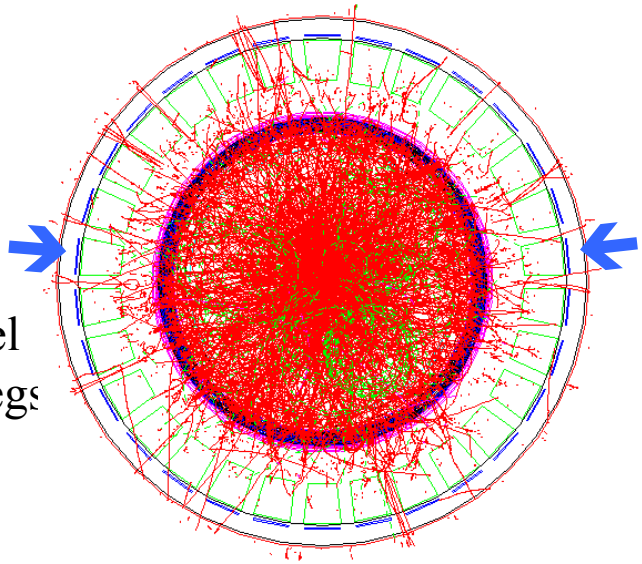
Nine BLs inside the "cradle"
Lowest 3 of these must be installed when STAR is in the Assembly Building, and require special hardware

Two BLs just outside the cradle (BLs 11 and 21) require ~5" radial standoffs…

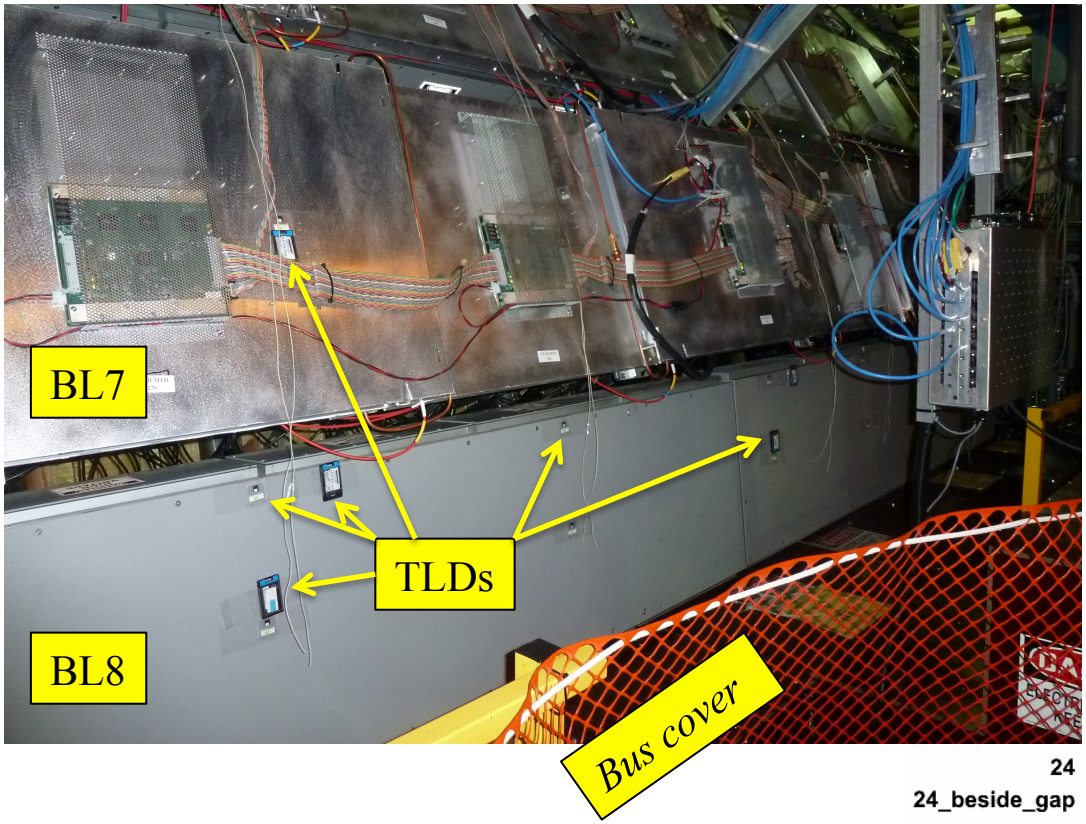
Installation is generally going well...



For BLs 8 and 24, special hardware will be needed to avoid the magnet bus covers.
This hardware is not yet designed...
These trays cannot be "centered" on the magnet backleg steel
i.e. some of the active area is in the gap between backlegs
Will the higher fluxes there make these trays inoperable?

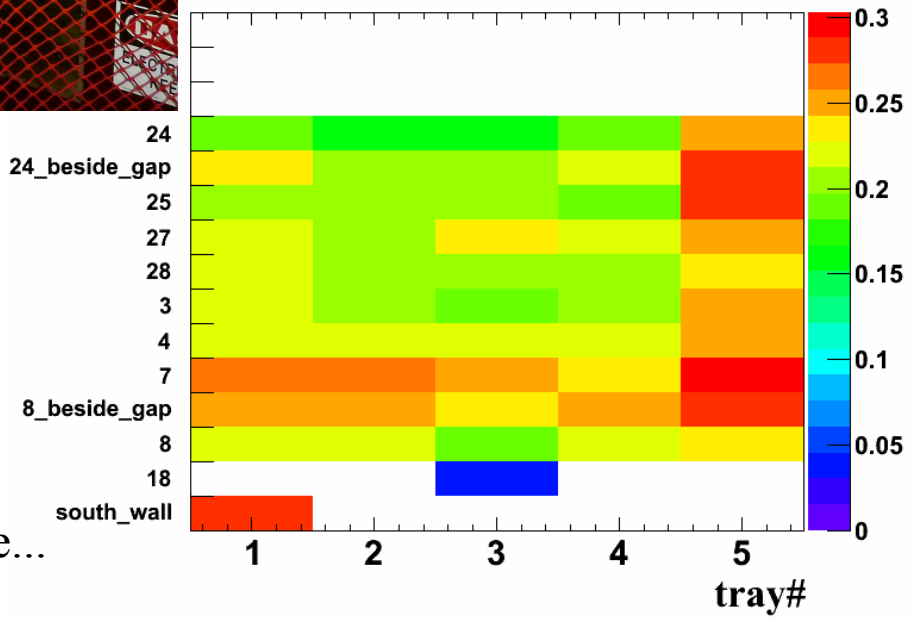


Dosimetry



68 TLDs of two types were installed all over the WAH on May 22, 2013

Are fluxes near phi-gaps hugely larger than behind the BL steel?

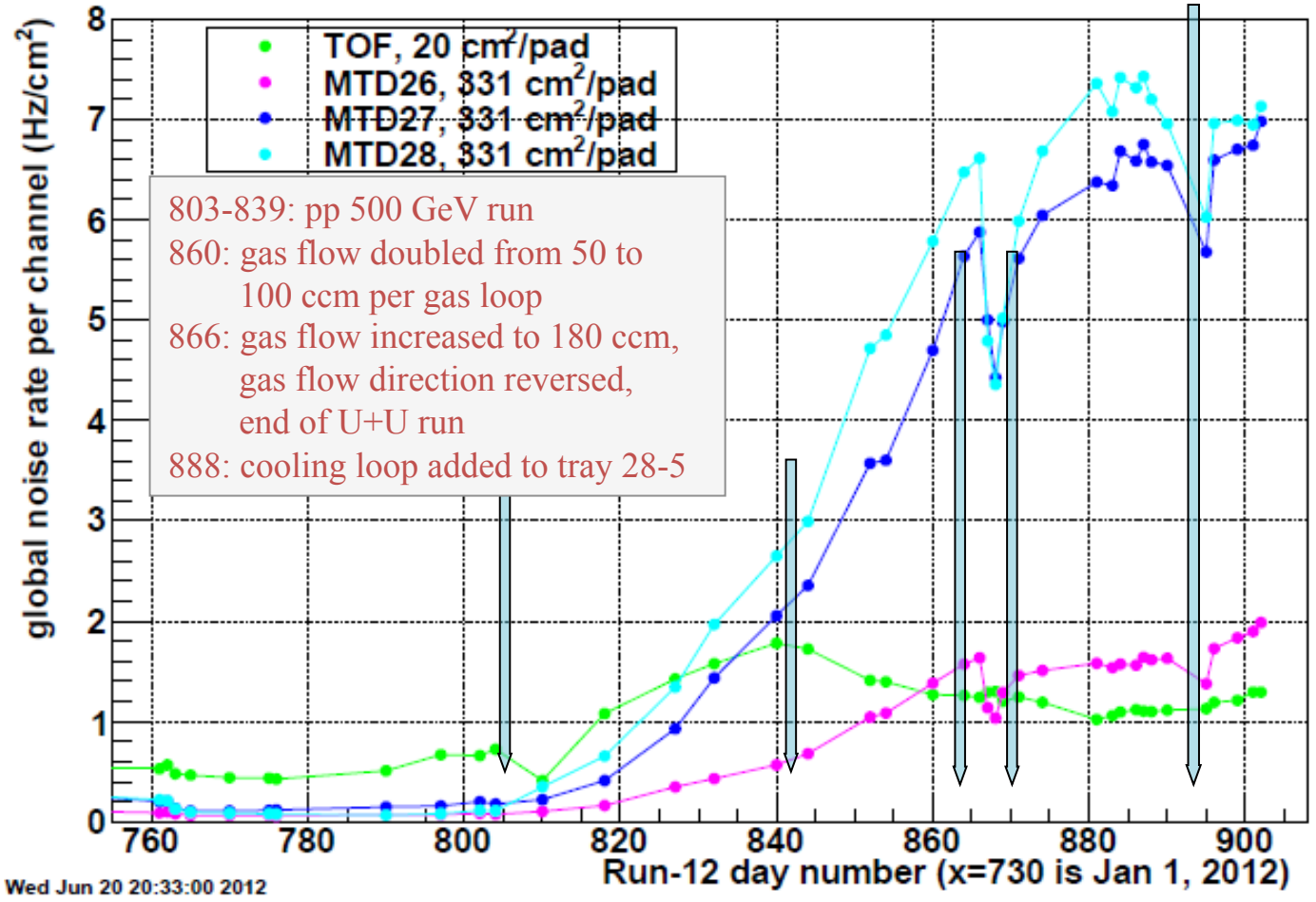


Results indicate that the fluxes in the gaps are not significantly larger than those behind the steel...

So MTD trays can go on 8 and 24 once we determine a mechanical mounting scheme...

Run-12 Noise rates

We were quite worried about the very high noise rates seen during Run-12.



7 Hz/cm² !!

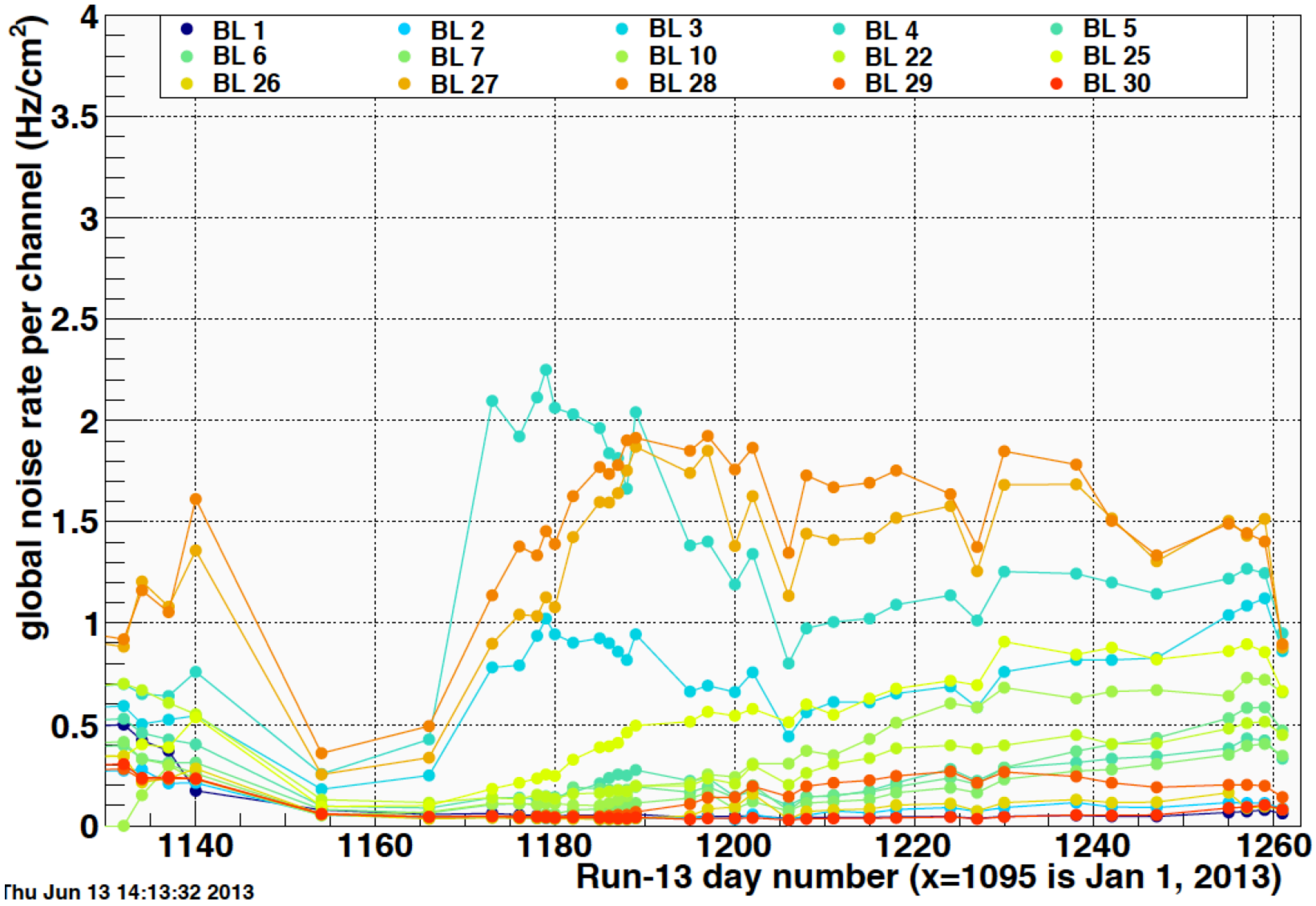
Began adding "H-foam" to the trays during the assembly at UT, & before Run-13,

Lots of new shielding in the east and west tunnels added by C-AD...

New reversible-flow gas distribution system with precise control...

Run-13 Noise Rates

These changes appear to have helped!



The "Event"

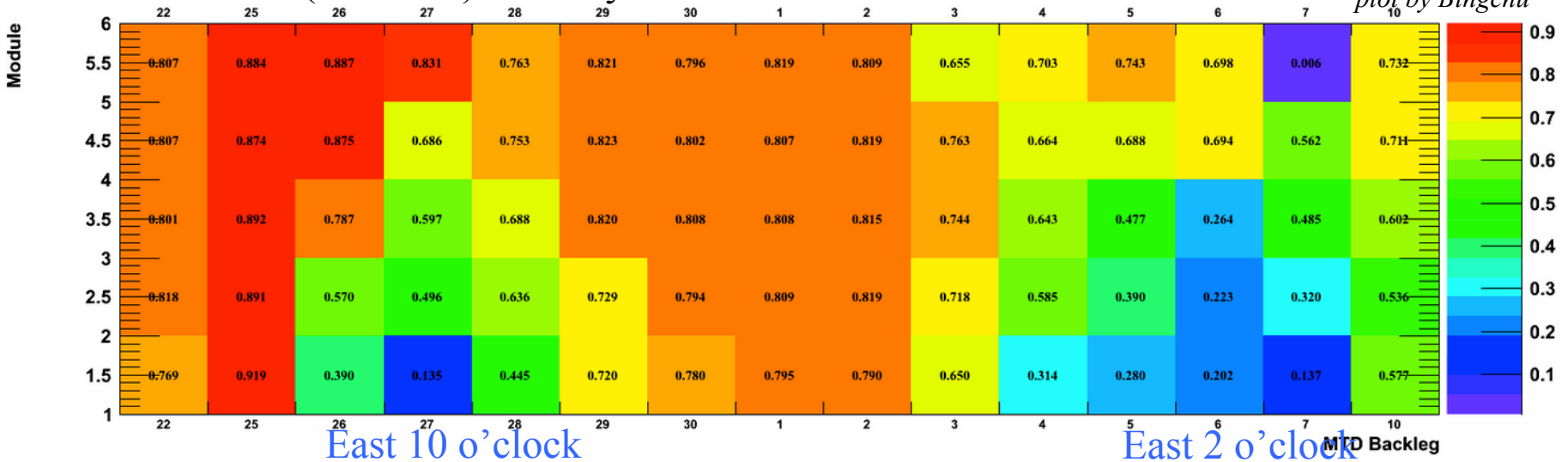
During run-13, there was a catastrophic beam-loss event that tripped all of STAR.

April 9, 2013
17:52 EST

17:52 General	Run 14099090 - 17:50 Beam was lost. General Detector trips - Nikolai Smirnov
18:19 TPC	Run 14099090 - For losting the beam, all the sections of TPC is Trip, and what I did is just click the clear button to clean the trip. - Rensheng
18:20 MTD	Run 14099090 - HV on MTD tripped during unexpected beam dump. Brought HV to Standby, and all but BL10(inner) ramped down. Alarm handler continued to give red alarm for MTD HV, so I called the expert. Turned HV OFF and expert turned it back on. Alarm handler cleared and all HV are back to standby.

We would learn over the following ~months that this event took out more than half of the MTD electronics ("MINO") in the system!

plot by Bingchu



During this shutdown, all of the MINO boards on installed trays were removed, and these plus all MINOs on new trays were modified to double the number of electrostatic discharge protection devices.

Summary and Conclusions

Fabrication of MRPCs at USTC and Tsinghua is complete
- They work well
- ~10 MRPCs at VECC (Kolkata) in progress

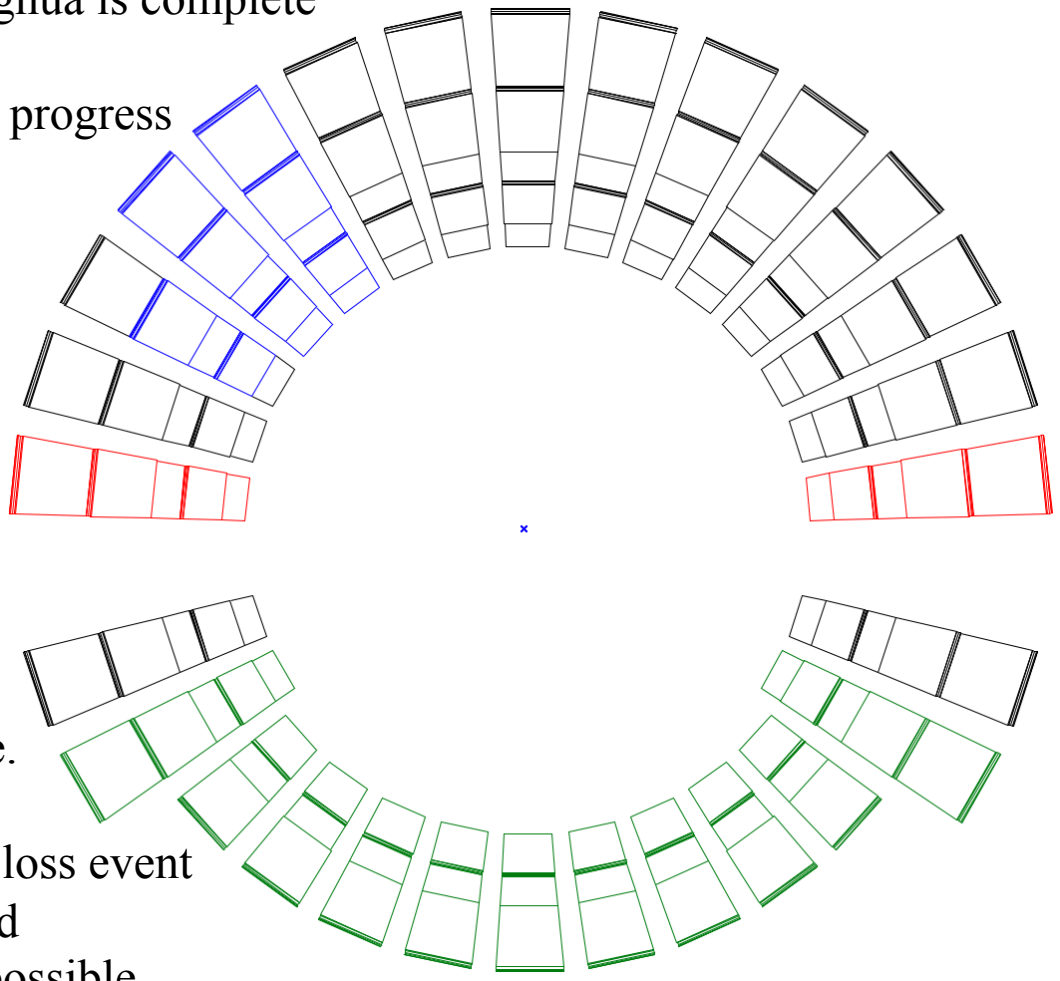
Run-13 was a serious commissioning run
~64% of the full system installed
- DAQ autorecovery implemented
- Slow controls interfaces
- Development of timing triggers

Installation is going well
- Top of STAR is done
- Bottom of STAR is underway now

Project is on-track for completion on time.

Dealing with damage from a major beam loss event
- All electronics removed and revised

Dosimetry indicates BLs 8 & 24 will be possible



谢谢您的款待