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# **Commissioning of the Transition Radiation Tracker**

**Second ATLAS Physics Workshop of the Americas  
Simon Fraser University  
17 June 2008**

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University of Pennsylvania  
on behalf of**

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Paul Keener, Godwin Mayers, Mike Reilly, Ben LeGeyt, Nandor Dressnandt  
Jim Degenhardt, Mauro Donega, Săsa Fratina, Franck Martin, Peter Wagner  
Mike Hance, John Alison, Dominick Olivito, Ryan Reece,  
Liz Hines, Josh Kunkle, Brett Jackson, Chris Lester, Jon Stahlman**

# TRT Geometry (1 quadrant of inner detector)

TRT has 350,000 straws with 4 mm diameter  
Charged particle can hit 36 straws for  $|\eta| < 1.7$   
Position resolution per straw is about 200 microns

## TRT Barrel

$z=0.00$  to  $0.74$  m

$r=0.56$  to  $1.07$  m

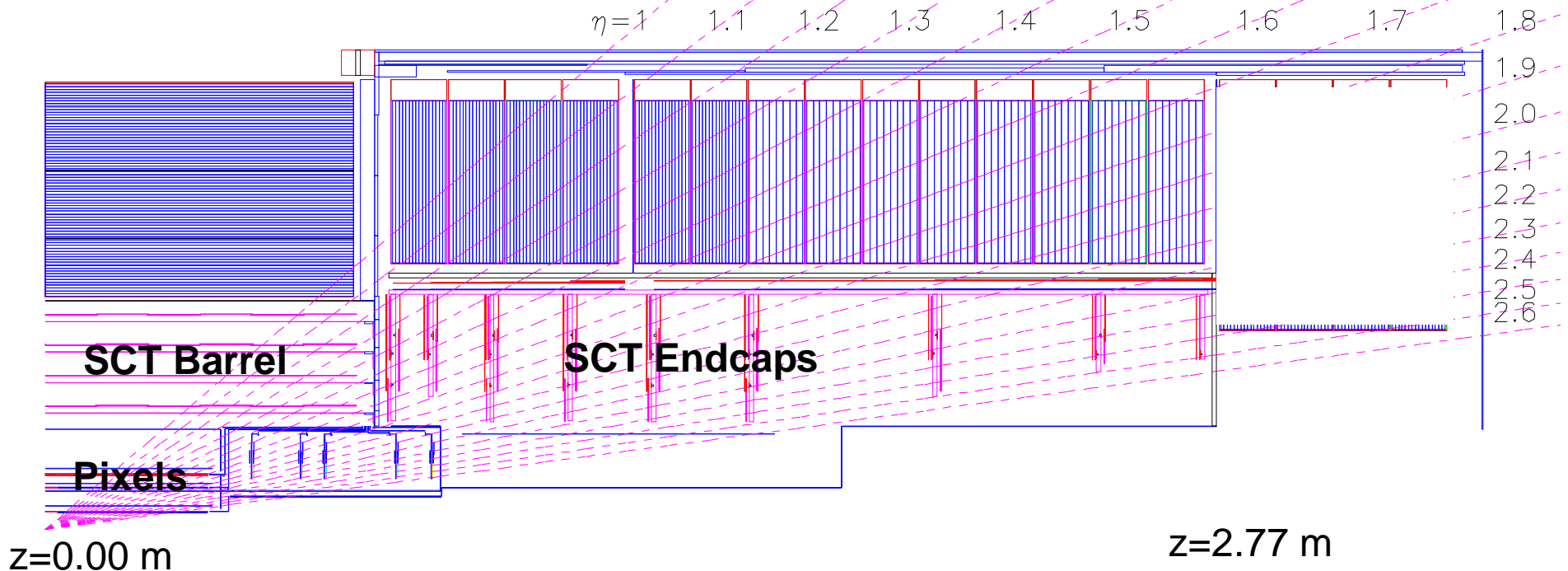
Straws along  $z$ -axis

## TRT Endcap

$z=0.83$  to  $2.77$  m

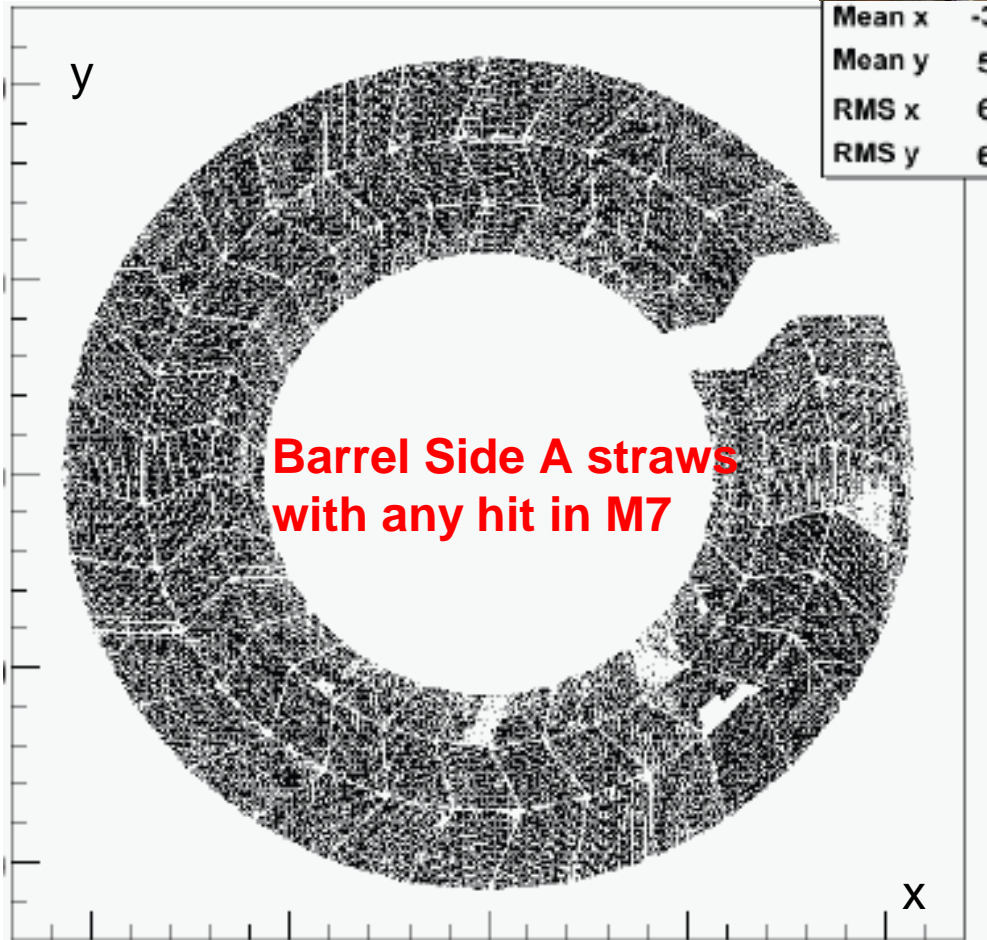
$r=0.64$  to  $1.03$  m

Straws go radially out (spokes on bicycle wheel)



# TRT M7 run: June 2008

M7 cosmic ray run:  
almost all **50,000** straws  
on side A barrel read out  
at trigger rate of 83 kHz



Installation: June 2006



# TRT Electronics System

Front-end electronics checked before and after installation

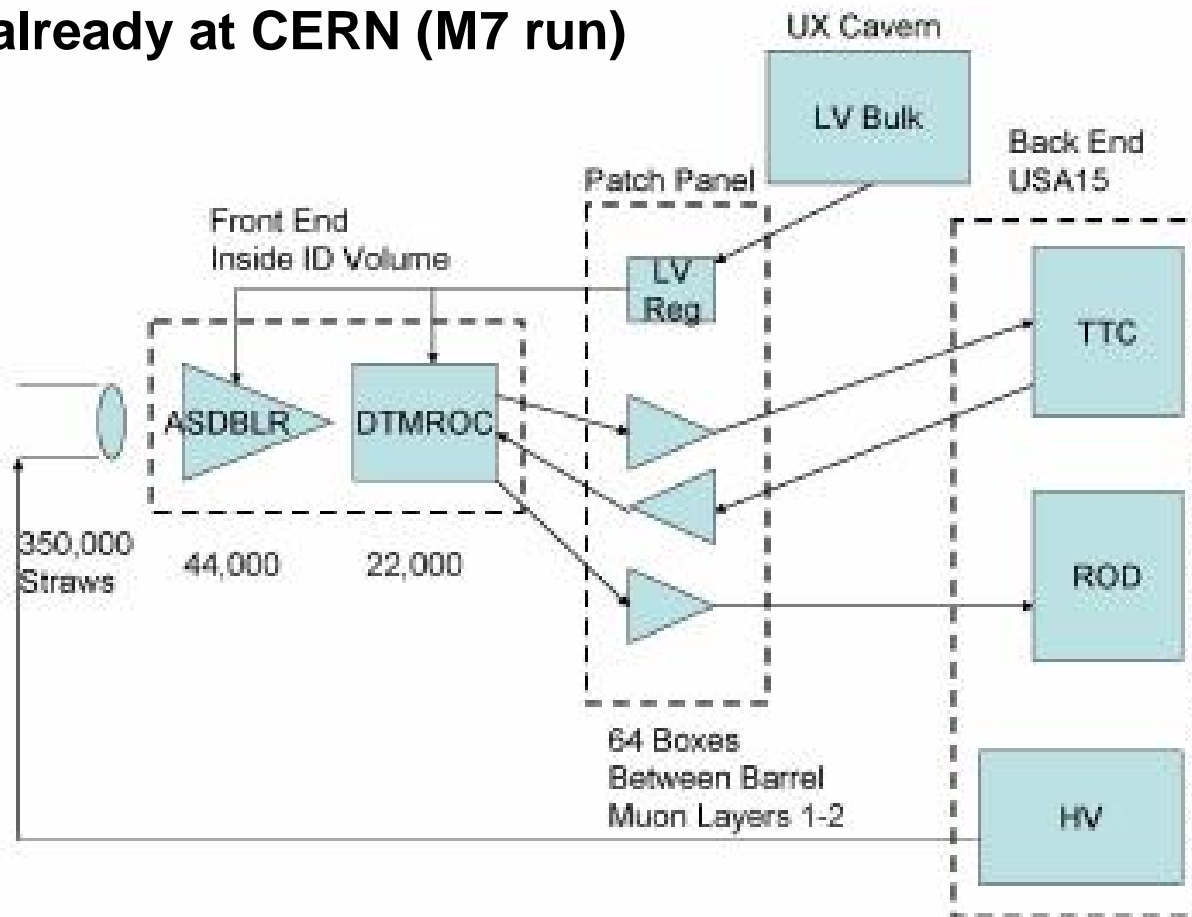
Milestone and special runs to exercise data-taking with ATLAS DAQ

§ Essential to commission detector for physics collisions

**RODs sommes prêts!**

§ 97 passed tests at UBC (96 needed)

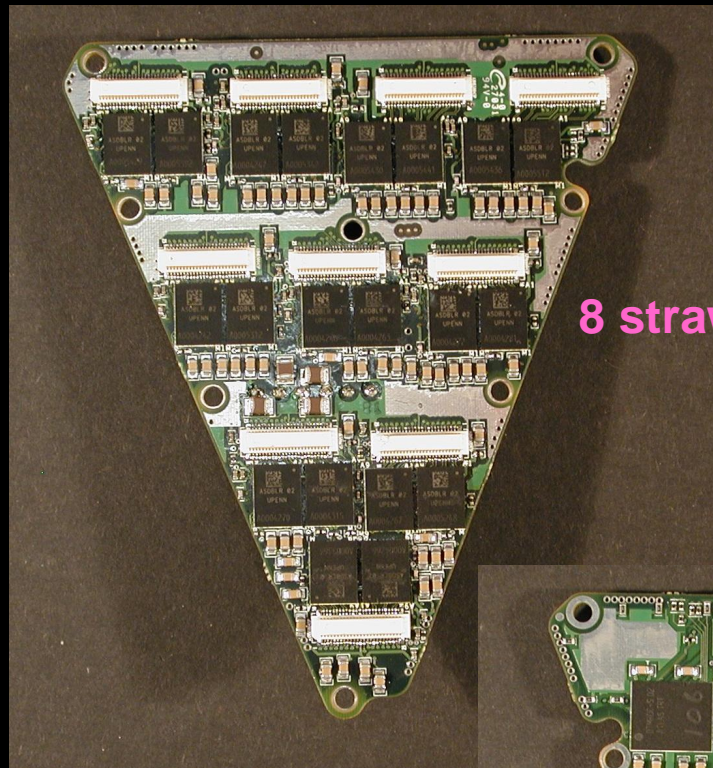
§ 56 already at CERN (M7 run)



**All RODs  
expected  
at CERN  
mid-July**

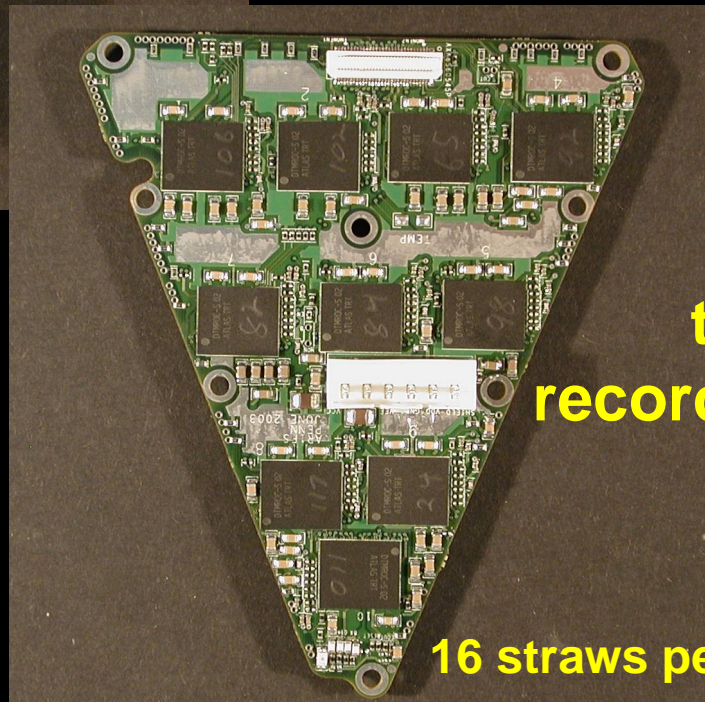
# Barrel Front-end Fast Electronics

Double-sided Electronic board



8 straws per chip

Analogue:  
amplifier  
shaper  
discriminator  
baseline restoration

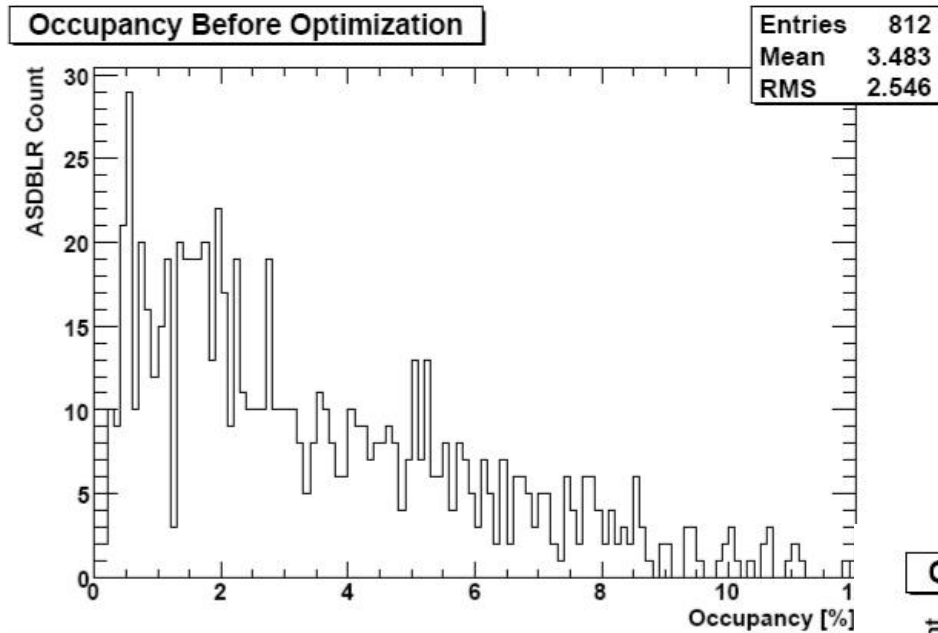


16 straws per chip

Digital:  
take 75 ns snapshot  
record above/below threshold  
low every 3.125 ns,  
high every 25 ns

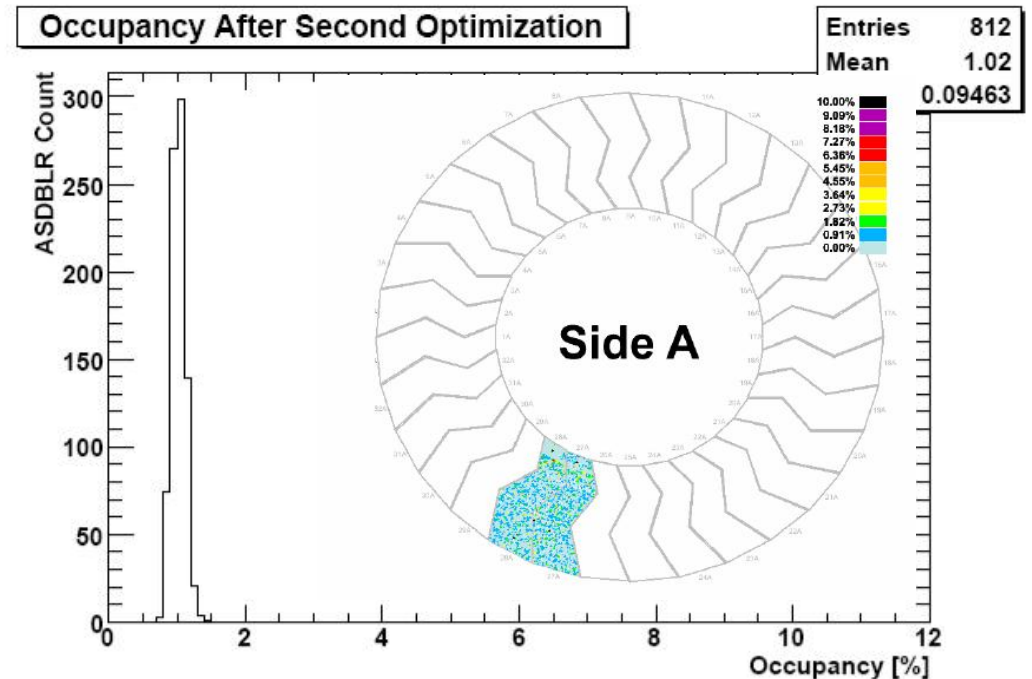
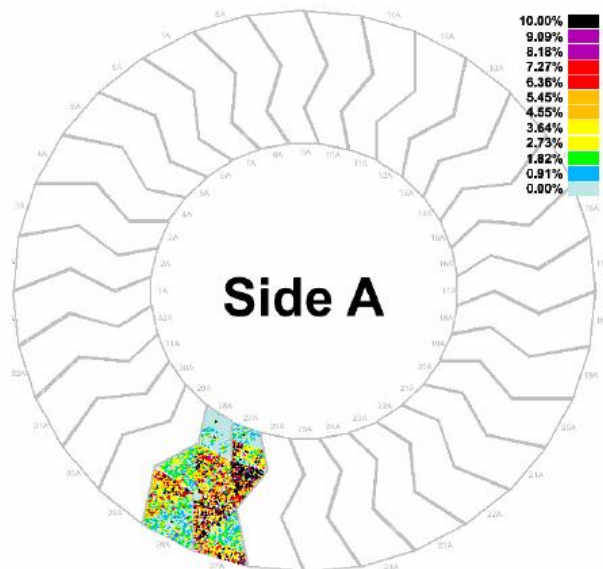
# Threshold equalization

(Ryan Reece)



Adjust level of low threshold to obtain equal occupancy over detector (quiet time calibration)

- § Throws away hottest and coldest straws on ASDBLR chip
- § Occupancy for 6 out of 8 channels on ASDBLR chip



# Timing in the detector readout

Leading edge when electrons ionized closest to wire at straw center arrive

§ position information for tracking

Trailing edge when electrons ionized furthest (2 mm) from wire at straw center arrive

§ these take 40-50 ns to drift in

§ should arrive at the same time for all straws crossed by the particle

## M7 run data

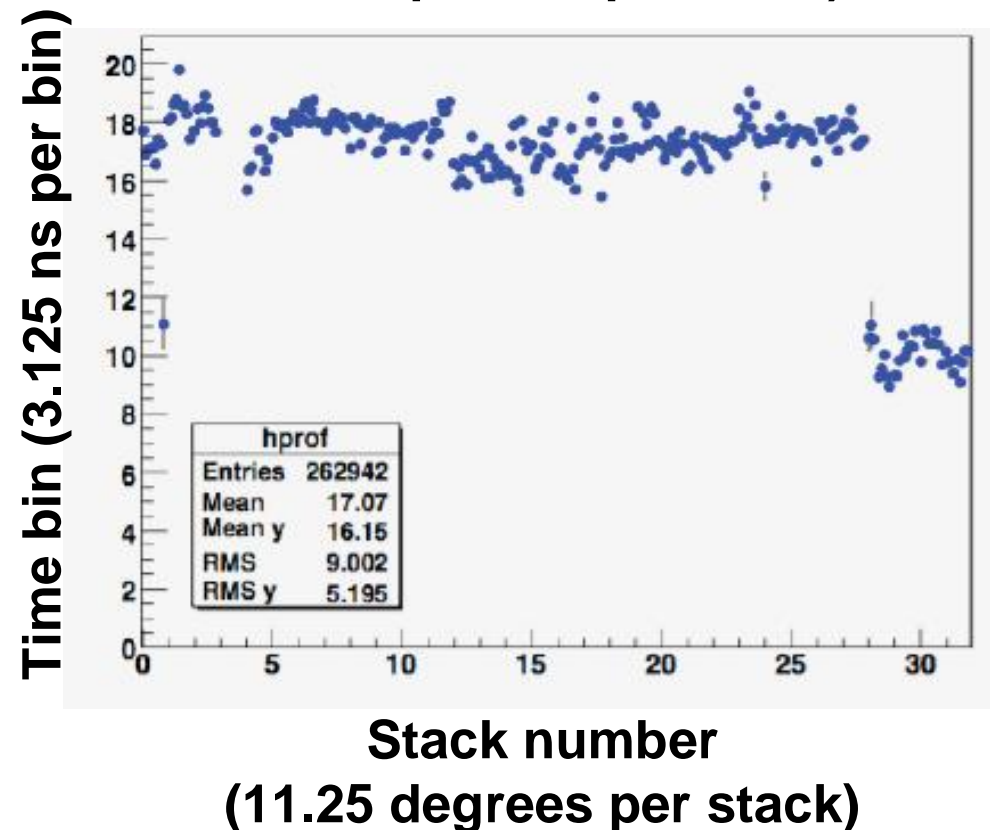
§ Shows that hardware calibration provides good alignment

§ Found offset of one bunch crossing (8 bins) for 4 stacks, easily fixed

(Mike Hance, Ben LeGeyt, Săsa Fratina)

## Average trailing edge

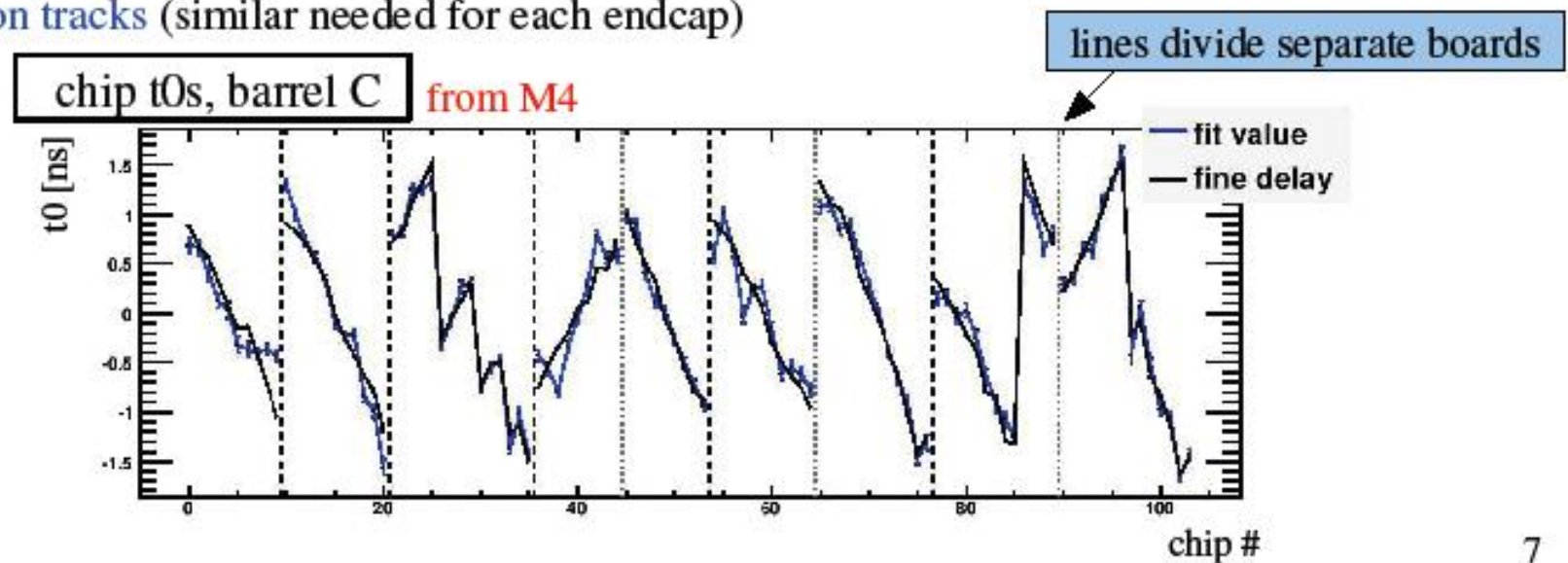
for 1600 straws in each stack  
(corrected for time of passage of cosmic ray muon and chip-to-chip offsets)



# Calibration: $t_0$ per TTC line



- We expect straw to straw  $t_0$  variations to contribute at order  $\sim 0.1$  ns
- Chip to chip variations have been shown to be the same across all phi sectors for each side of the barrel by both hardware fine delay scans and my calibration (see plot)
- Can reach  $\sim 0.1$  ns accuracy in  $t_0$  with  $\sim 1000$  hits on a detector element
- So it seems reasonable to calibrate on board level, taking chip to chip delays into account, until we get  $\sim 1000$  hits/straw, then consider switching to straw level
- board level calib for barrel:  $1000 \text{ hits} * 9 \text{ boards/phi} * 2 \text{ sides} * 32 \text{ phi} / 30 \text{ hits per track} = 18,000 \text{ tracks}$  (similar needed for each endcap)
- straw level calib for barrel:  $1000 \text{ hits} * 1642 \text{ straws/phi} * 2 \text{ sides} * 32 \text{ phi} / 30 \text{ hits per track} = 1.5 \text{ million tracks}$  (similar needed for each endcap)



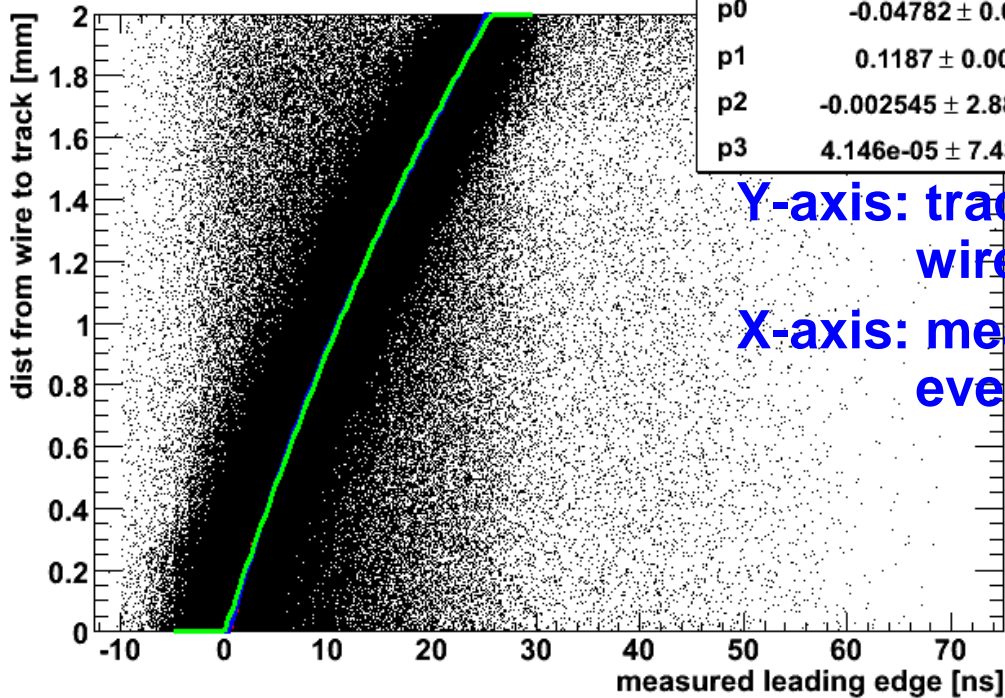
# Calibration: position(time)

rt relation

$$r = p_0 + p_1 t + p_2 t^2 + p_3 t^3$$

$\chi^2 / \text{ndf}$	1144 / 36
p0	$-0.04782 \pm 0.001051$
p1	$0.1187 \pm 0.0003256$
p2	$-0.002545 \pm 2.883e-05$
p3	$4.146e-05 \pm 7.439e-07$

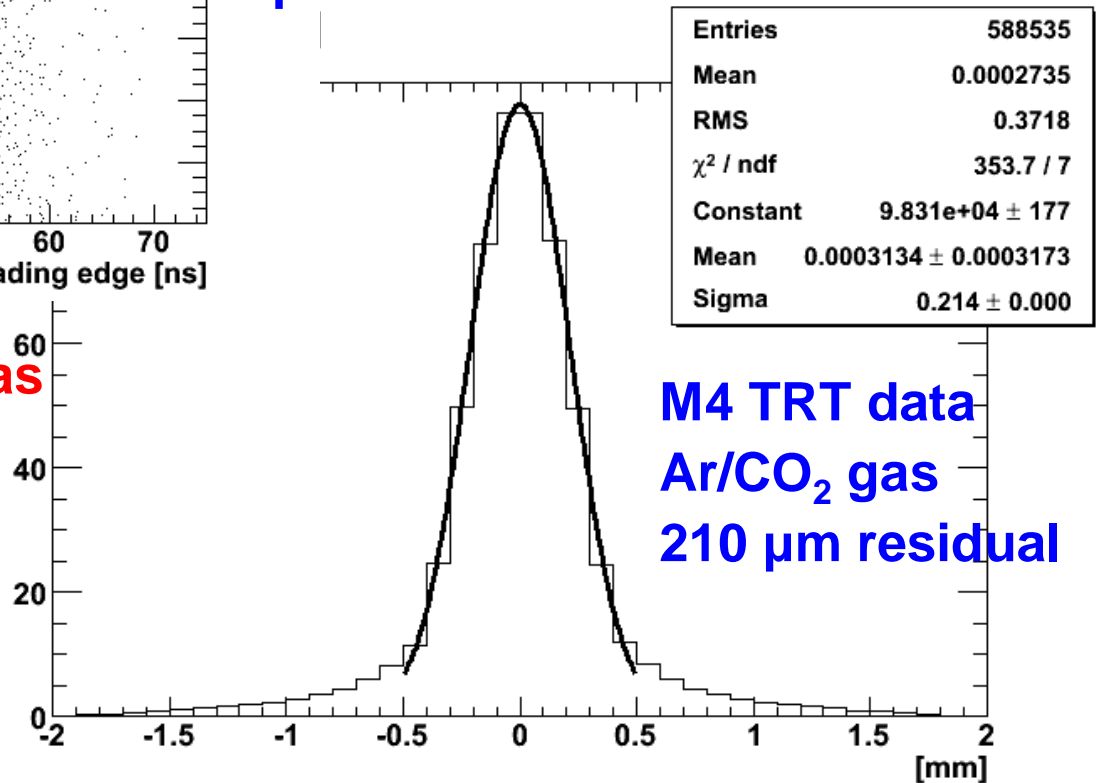
*(Dominick Olivito,  
Chafik Driouchi, NBI)*



**Y-axis:** track fit estimate of distance from wire to closest approach of particle  
**X-axis:** measured leading edge, corrected for event phase and  $t_0$

**Note: calibration depends on gas**  
 Ar/CO<sub>2</sub> drift velocity 70  $\mu\text{m}/\text{ns}$   
 Xe/CO<sub>2</sub> drift velocity 50  $\mu\text{m}/\text{ns}$   
 and magnetic field

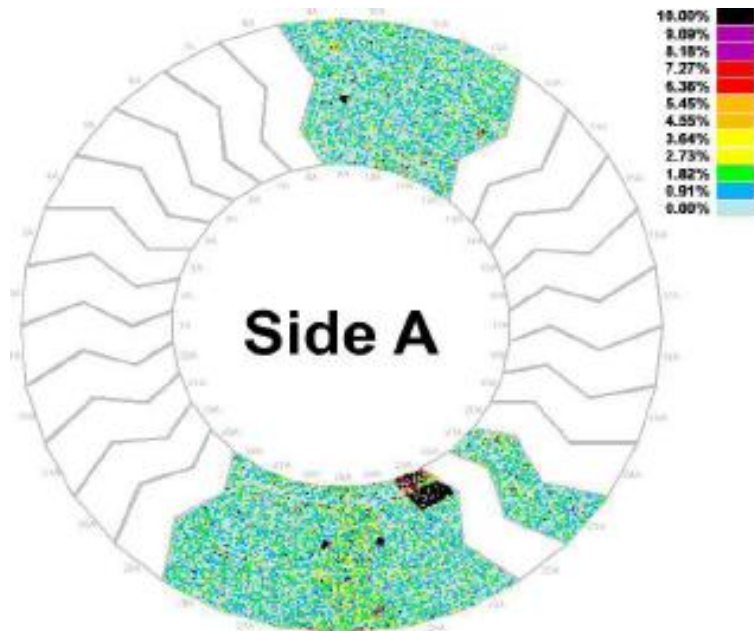
**Expect better resolution with Xe/CO<sub>2</sub>**



**M4 TRT data**  
**Ar/CO<sub>2</sub> gas**  
**210  $\mu\text{m}$  residual**

# Alignment

(John Alison,  
Andrea Bocci, Duke)

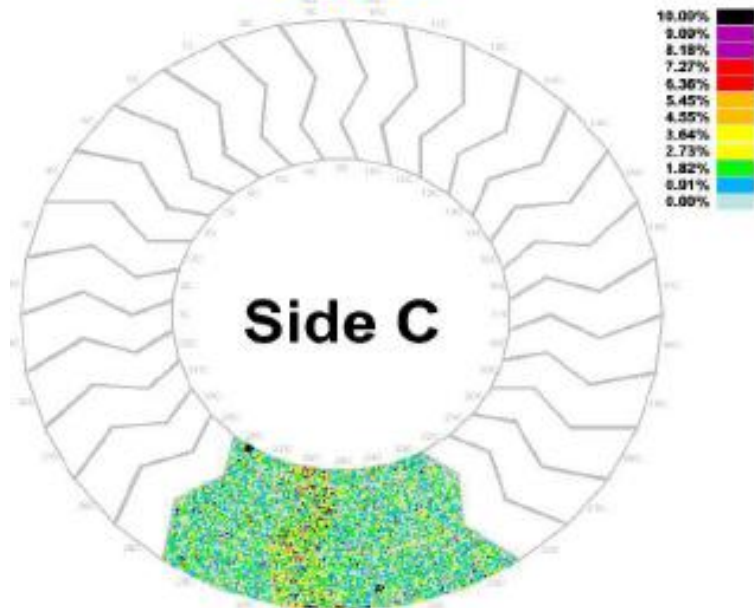


**M6 first combined SCT+TRT run since surface commissioning**

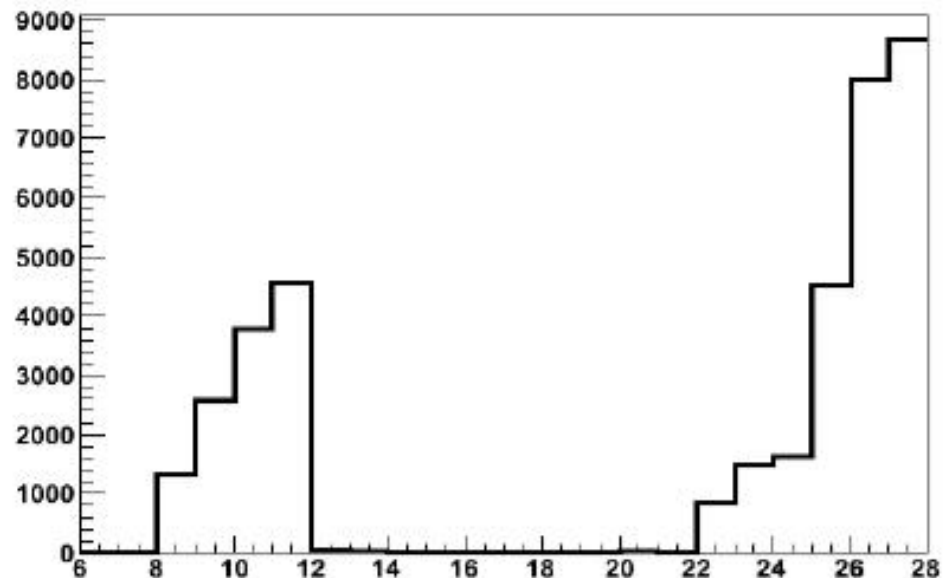
**Ran global TRT alignment on tracks**

§ **At least 5 SCT hits**

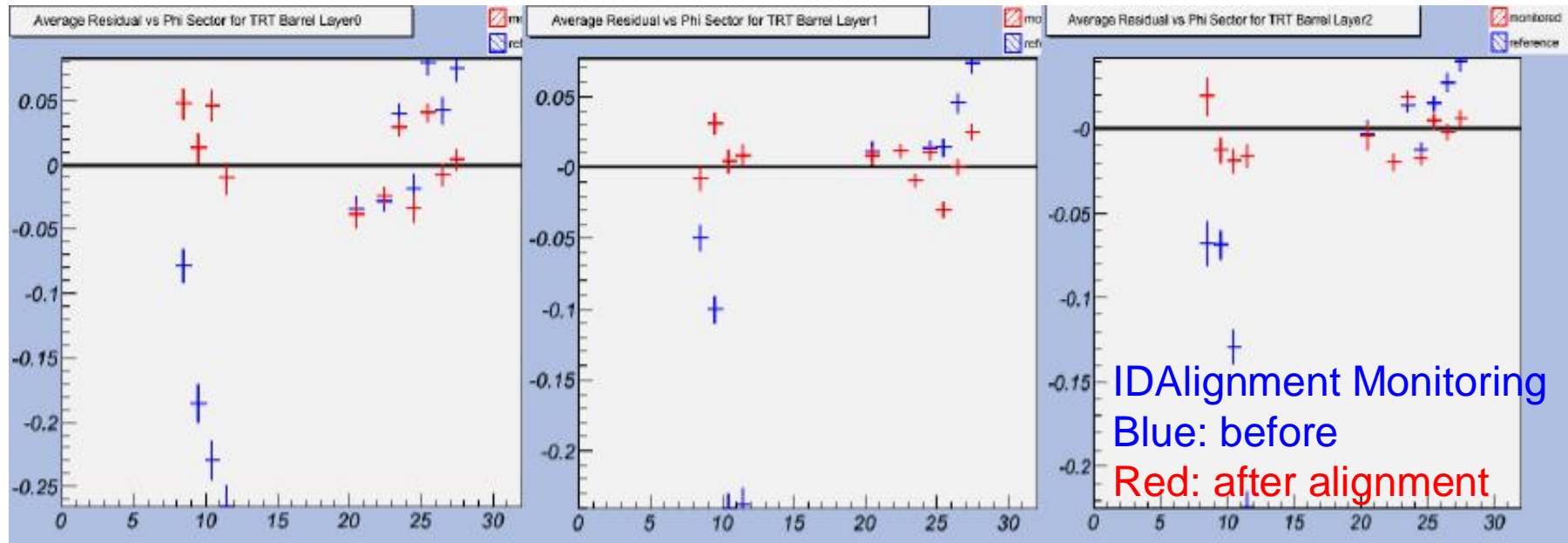
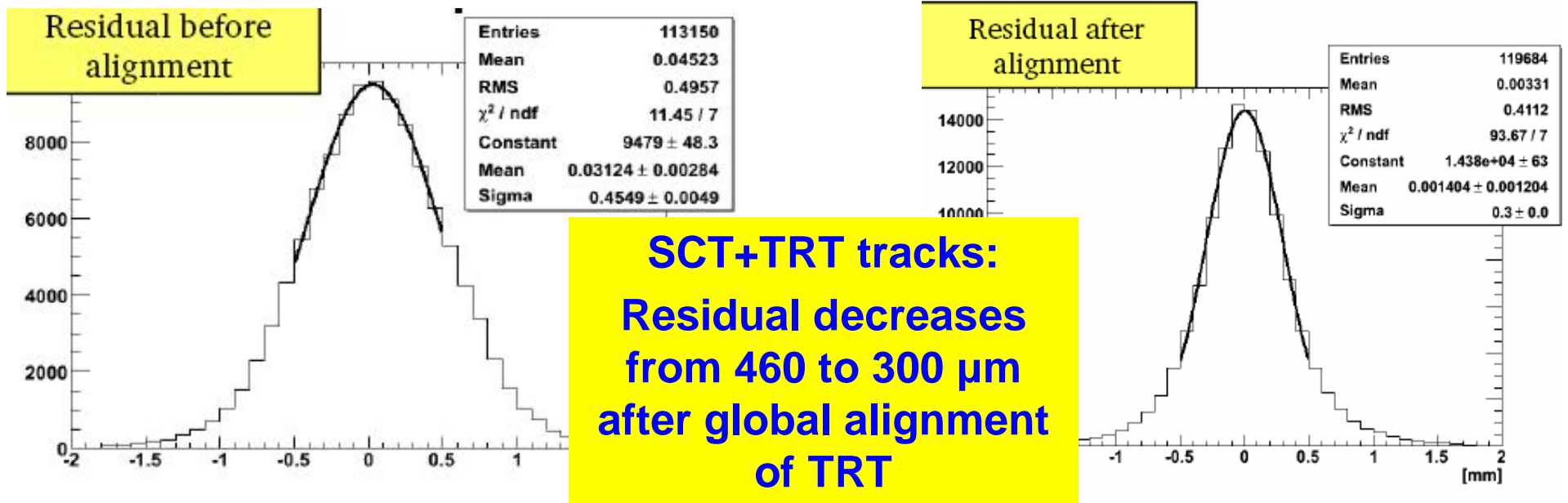
§ **At least 20 TRT hits**



**Number of hits on tracks versus phi stack**



# Alignment: residuals (John Alison, Andrea Bocci, Duke)



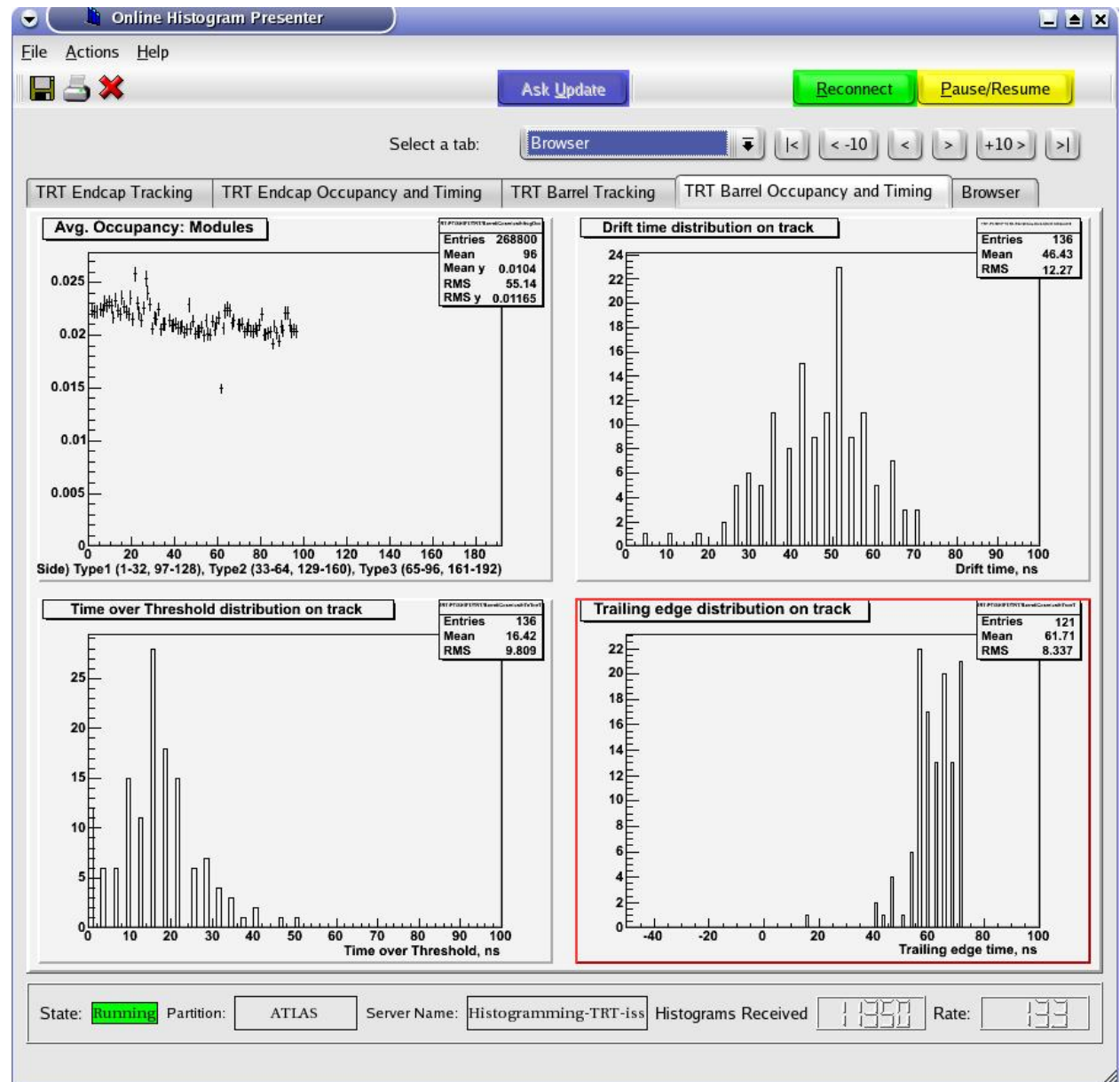
# TRT Data Quality Monitoring *(Jim Degenhardt Peter Cwetanski, IU)*

Athena code to  
analyse TRT data  
and present results  
to shifters in real  
time and offline

§ Tested in M runs

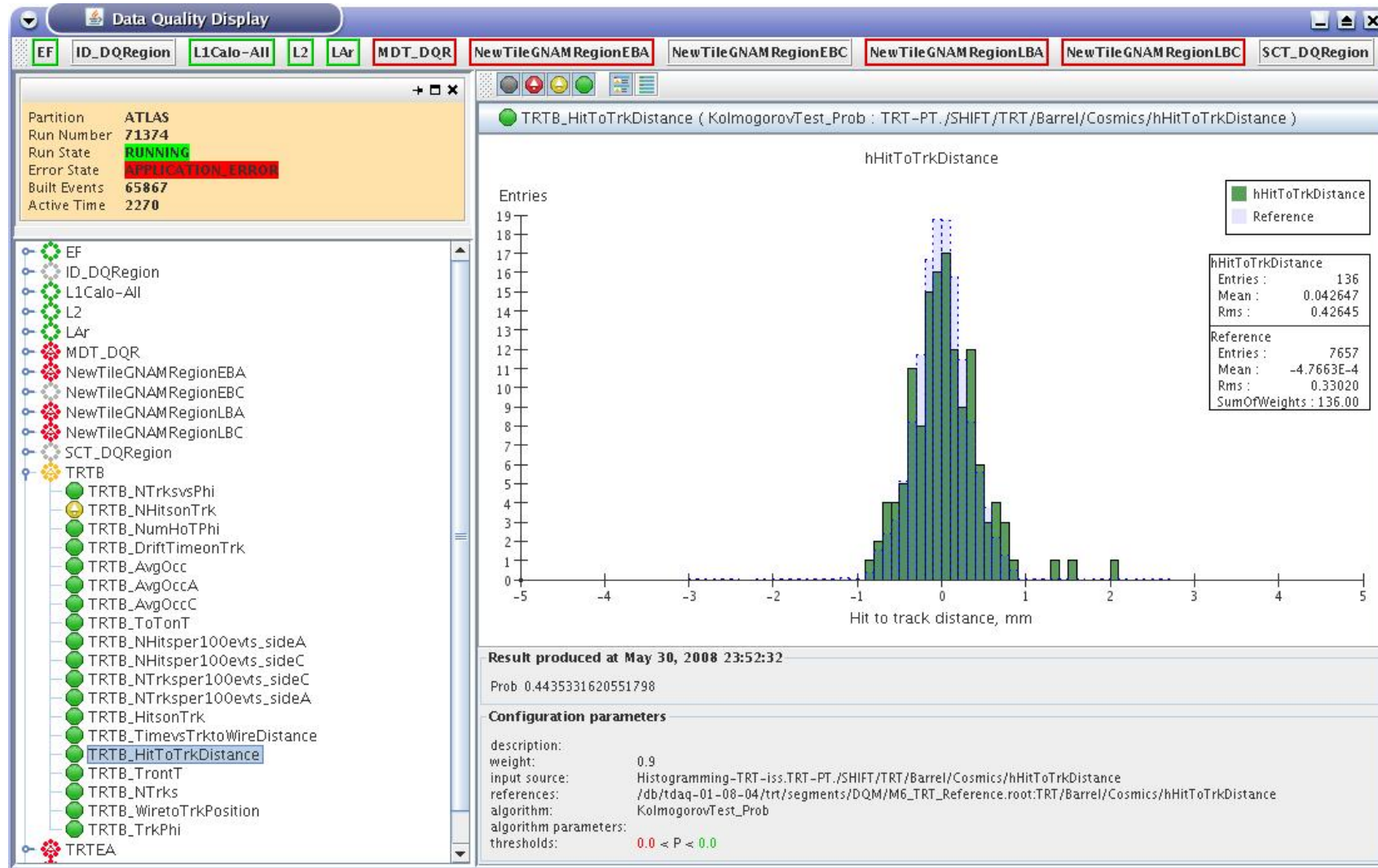
§ Tested in FDR

Output histograms  
also compatible  
with powerful  
visualization of  
TRTViewer



# TRT monitoring in DQMF *(Jim Degenhardt Peter Cwetanski, IU)*

Set up automatic checks of monitoring histograms via ATLAS Data Quality Monitoring Framework for online (event filter) and offline (Tier-0)



# Trigger: TRT only tracking at L2

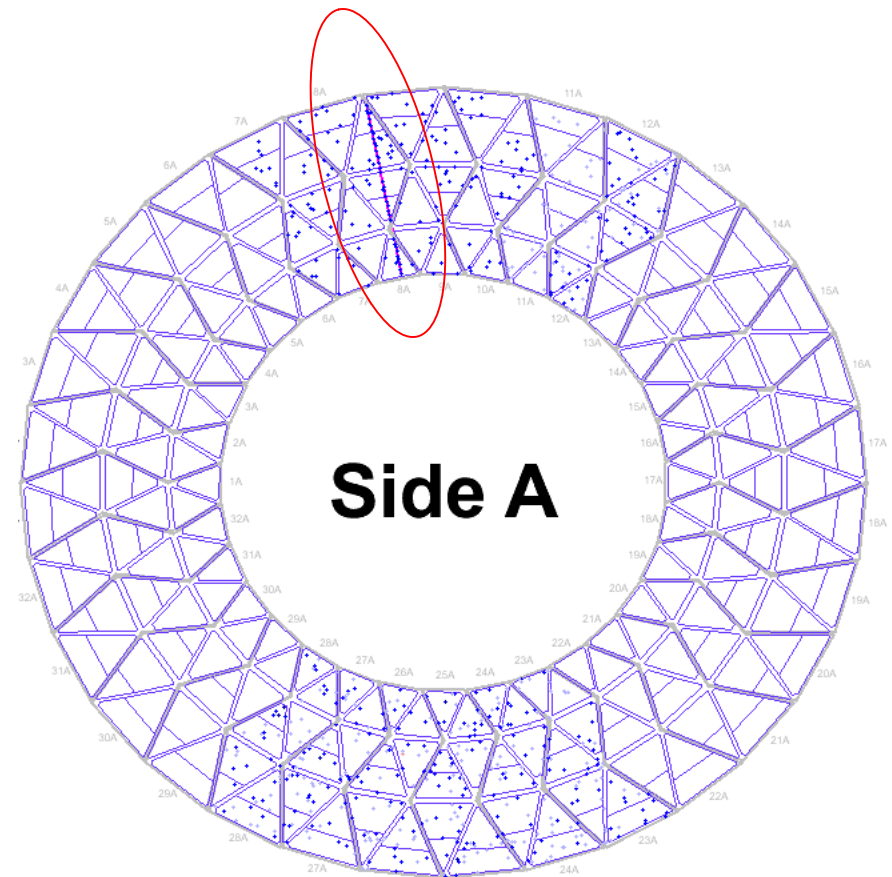
*(Săsa Fratina, Dominick Olivito, Jim Degenhardt)*

## Cosmic ray muons

- § Improved algorithm to work over entire volume of TRT, and also with magnetic field on
- § Integrated in Atlas online framework and runs in auto-accept mode in M runs since December 2007
- § Collect data to constrain weak modes in alignment

## Physics Collisions

- § Comparing performance of “new tracking” version with old version
- § Overall efficiency similar, more hits attached with new algorithm
- § Optimizing algorithm to improve efficiency and CPU time



# Summary & Plans

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## TRT commissioning is well advanced

- § Hardware operation
- § Threshold equalization
- §  $t_0$  calibration
- §  $r(t)$  calibration
- § Alignment
- § Data Quality Monitoring
- § Trigger for cosmic ray muons

## Plans as physics collisions approach

- § Trigger reconstruction for TRT-only tracks in physics collisions
- § Tracking performance
- § Threshold & hit efficiency
- § Transition radiation for electron identification (with Xenon)
- § Photon conversions to map detector material