

ATLAS RPC CHAMBERS

Cosmic Ray Test in ATLAS

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INFN Lecce

On behalf of ATLAS LV1 Muon Barrel and RPC group

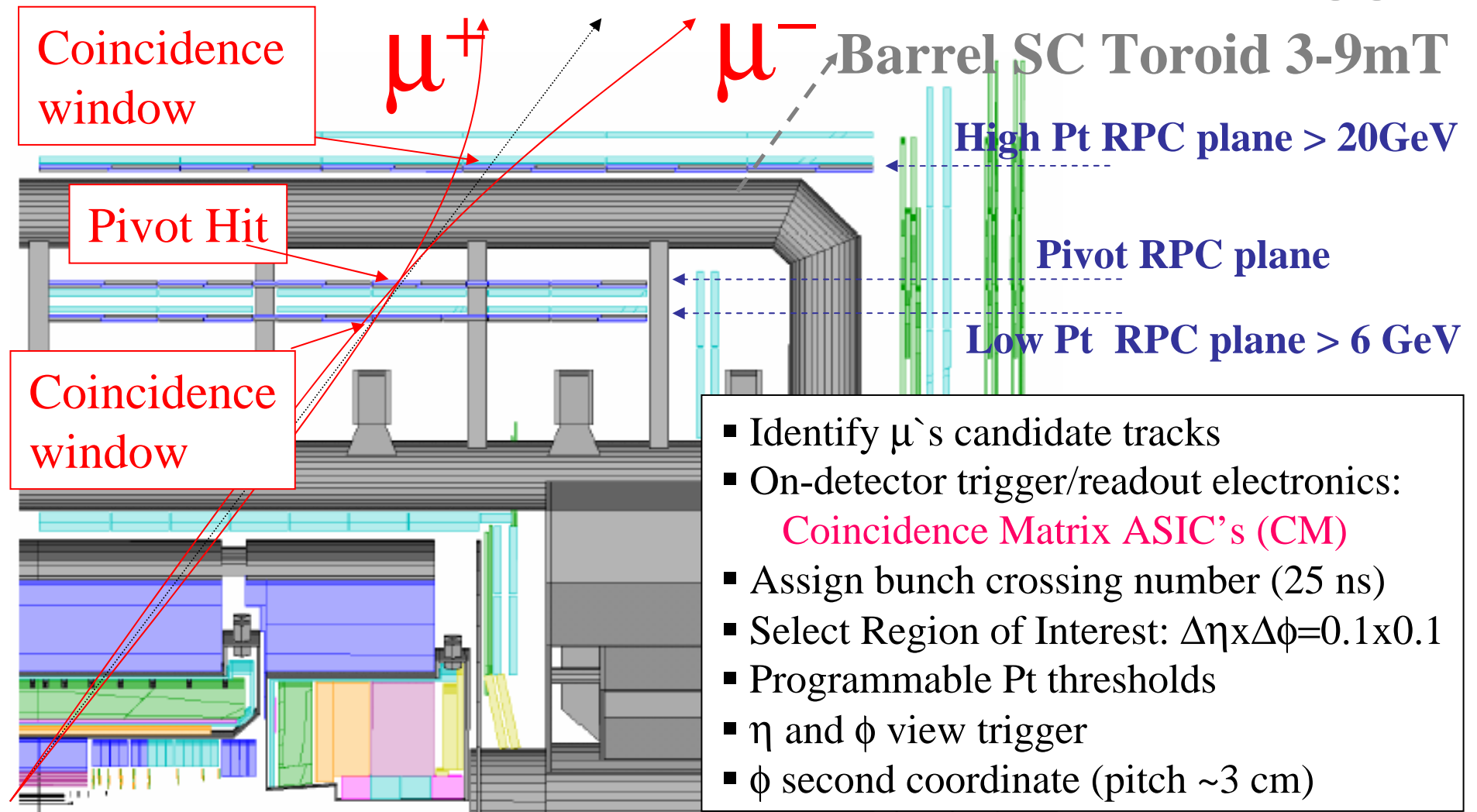
VCI-2007

Summary

- ❑ ATLAS RPC chambers
- ❑ Quality Assurance with cosmic rays
 - RPC Single Unit
 - RPC+MDT Muon Chamber Integration
- ❑ RPC pre-commissioning with cosmic rays
 - “Sector 13” setup
 - Trigger rate and profiles
 - Timing calibration
 - RPC stand-alone tracking
 - RPC efficiency and noise measurements
- ❑ Conclusions

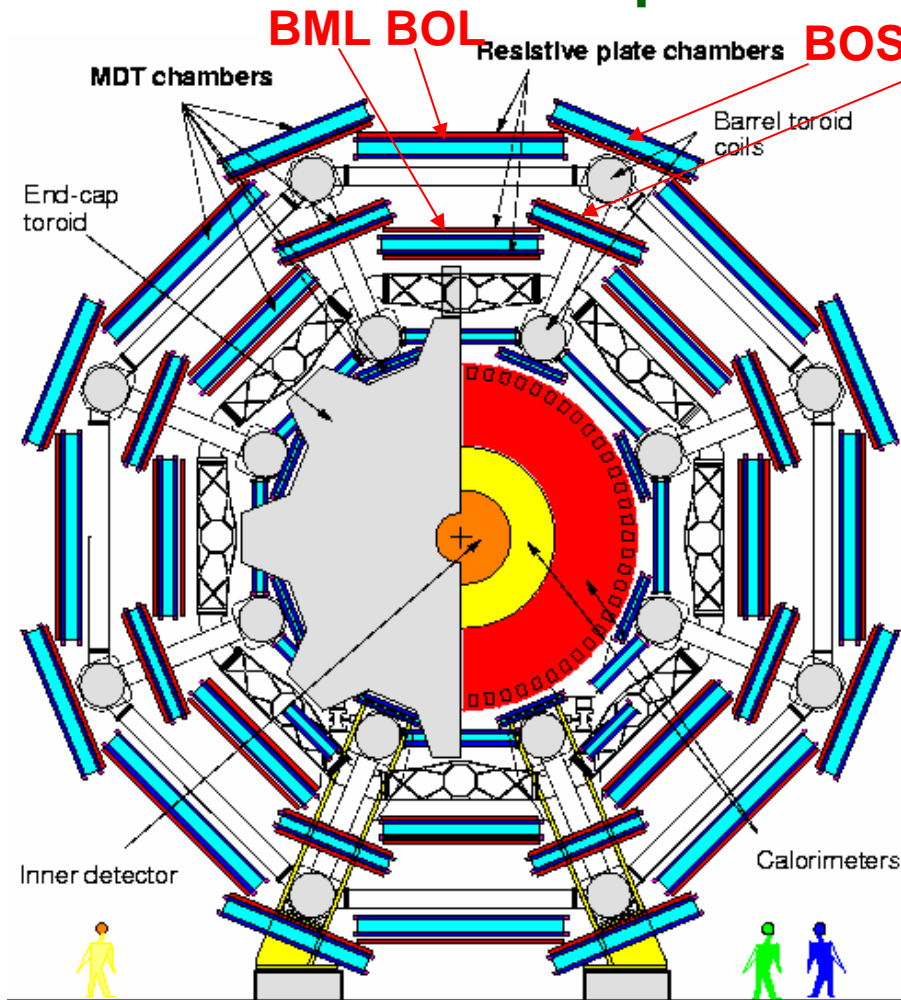
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Muon Barrel Spectrometer: LV1 RPC trigger



ATLAS RPC CHAMBERS

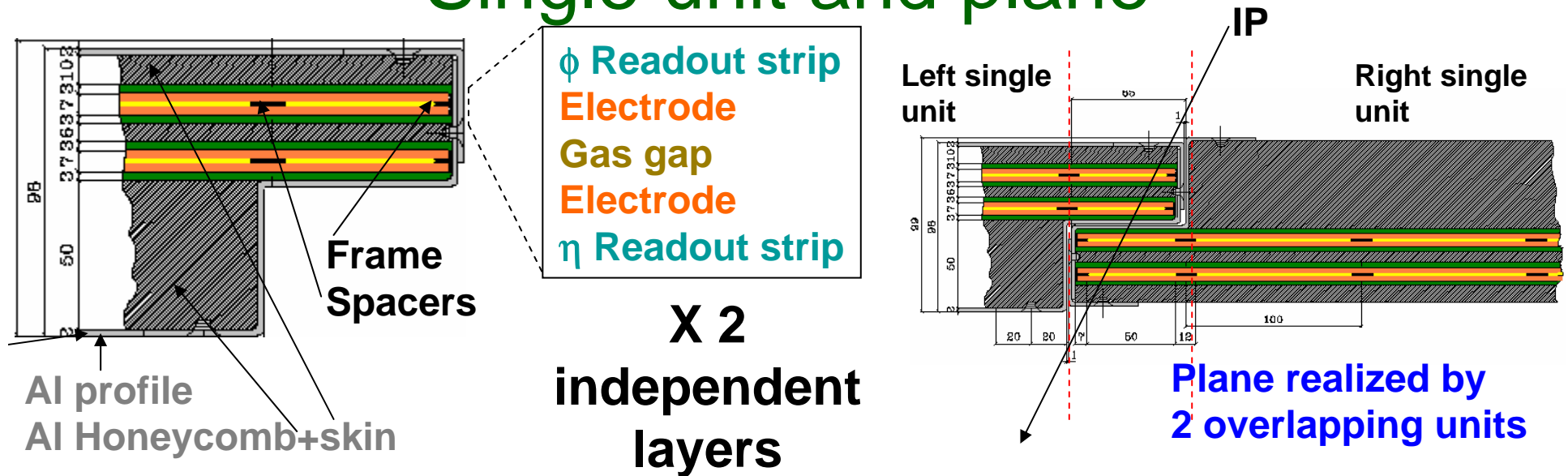
Muon Barrel Spectrometer: RPC Chambers



- ✓ **BMS, BOS, BML, BOL stations with RPC:**
 - ✓ **S = Small:** inside coils
 - ✓ **L = Large:** between coils
 - ✓ **M = Medium:** 2 RPC planes
 - ✓ **O = Outer:** 1 RPC plane
- ✓ **RPC plane = 2 (some 1) mechanically independent RPC single units**
- ✓ **1116 RPC single units**
- ✓ **26 different unit typologies**
- ✓ **Total surface ~ 4000 m²**

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Single unit and plane

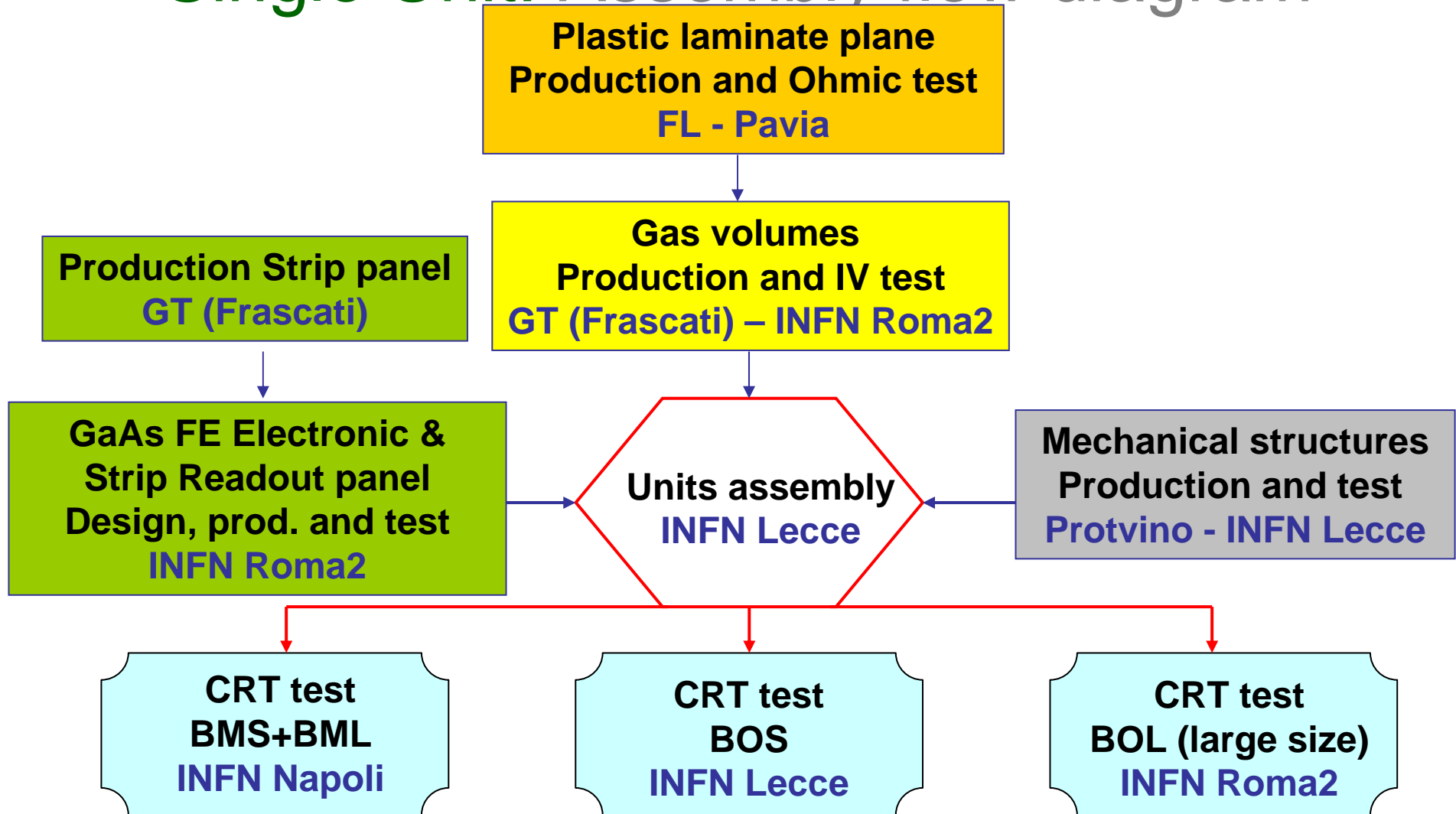


- Pick-up readout panel with copper strips and built-in 8-ch custom made GaAs FE electronics chips.
- Electrodes: graphite layer +2 mm thick plastic laminated ($\rho \sim 1 \div 4 \times 10^{10} \Omega\text{cm}$) + polymerized linseed oil.
- Gap gas: $d = 2 \text{ mm}$, surface = $1.72 \times 0.75\text{m}^2 \div 2.96 \times 1.2\text{m}^2$.
- Saturated avalanche regime $\text{C}_2\text{H}_2\text{F}_4(94.7\%)\text{C}_4\text{H}_{10}(5\%)\text{SF}_6(0.3\%)$, HV ~10 KV ($E_{\text{gas}} \sim 5\text{KV/mm}$)

Rate Capability ~ $1\text{kHz/cm}^2 @ Q_{\text{integrated}}=0$
 $> 0.3\text{kHz/cm}^2 @ Q_{\text{integrated}}=210\text{mC/cm}^2 = 7\text{y LHC} \times 5$ (Safety Factor)

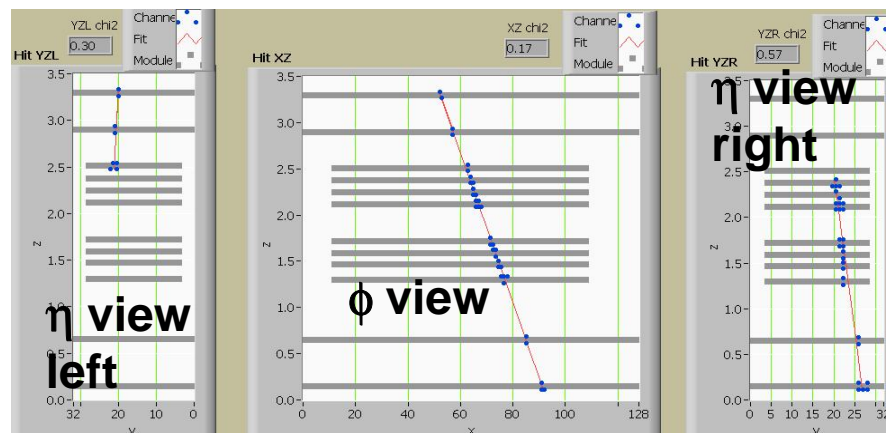
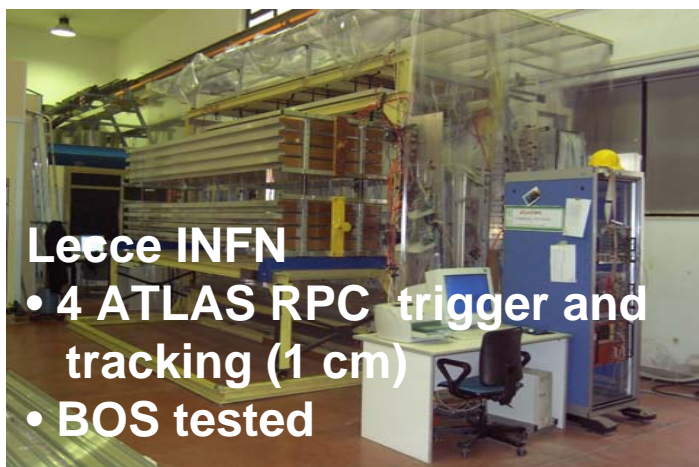
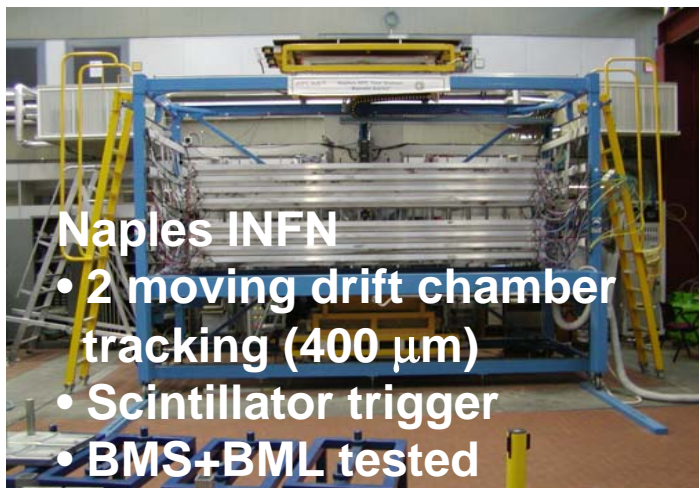
Quality Assurance

Single Unit: Assembly flow diagram



Quality Assurance

Single Unit CRT's: Three INFN Sites



4 RPC ref. + 8 RPC under test: Event Display

Quality Assurance

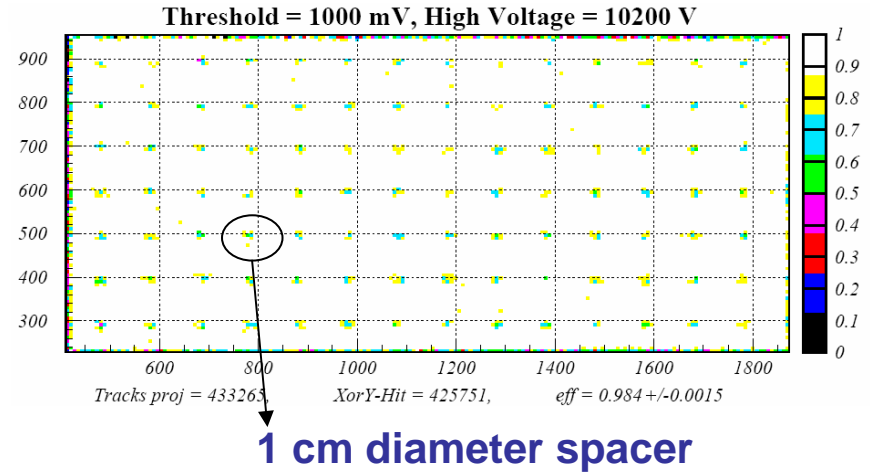
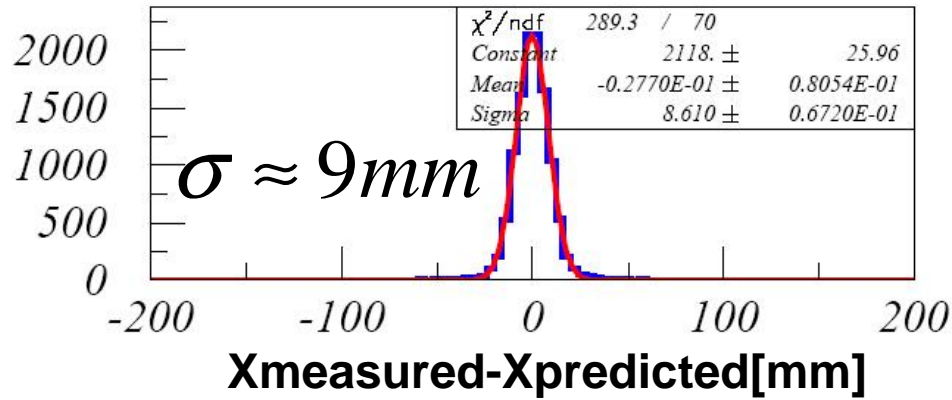
Single Unit CRT's: Acceptance criteria

- Gas volume leak test
 - ✓ Pressure drop $< 10^{-3} \text{mbar} \cdot \text{l/h} = 6 \mu\text{l/s} = \text{instrument sensitivity}$
- V-I characteristics (no anomalies in ohmic and exponential part)
 - ✓ $< 4 \mu\text{A/m}^2$ & electrical isolation $> 100 \text{ G}\Omega$
- No anomalies during HV and V_{th} scan in efficiency and noise rate
- Plateau strip panel efficiency
 - ✓ $> 95\%$
- Average cluster size
 - ✓ < 1.5 (HV=10 kV @ $V_{\text{th}}=1 \text{V}$)
- Noise rate
 - ✓ $< 1 \text{ Hz/cm}^2$ (HV=10 kV @ $V_{\text{th}}=1 \text{V}$)
- 2D Gap efficiency (tomography)
 - ✓ No local inefficiency

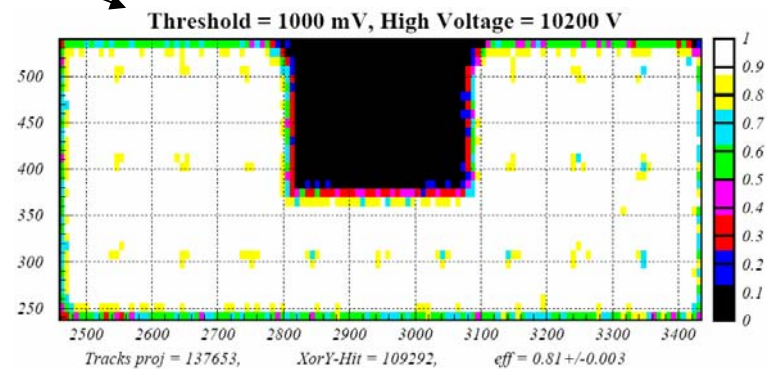
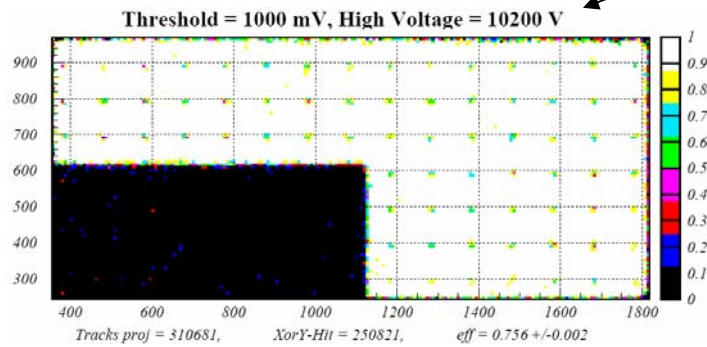
Quality Assurance

Gas volume 2D-tomography

Tracking with RPC



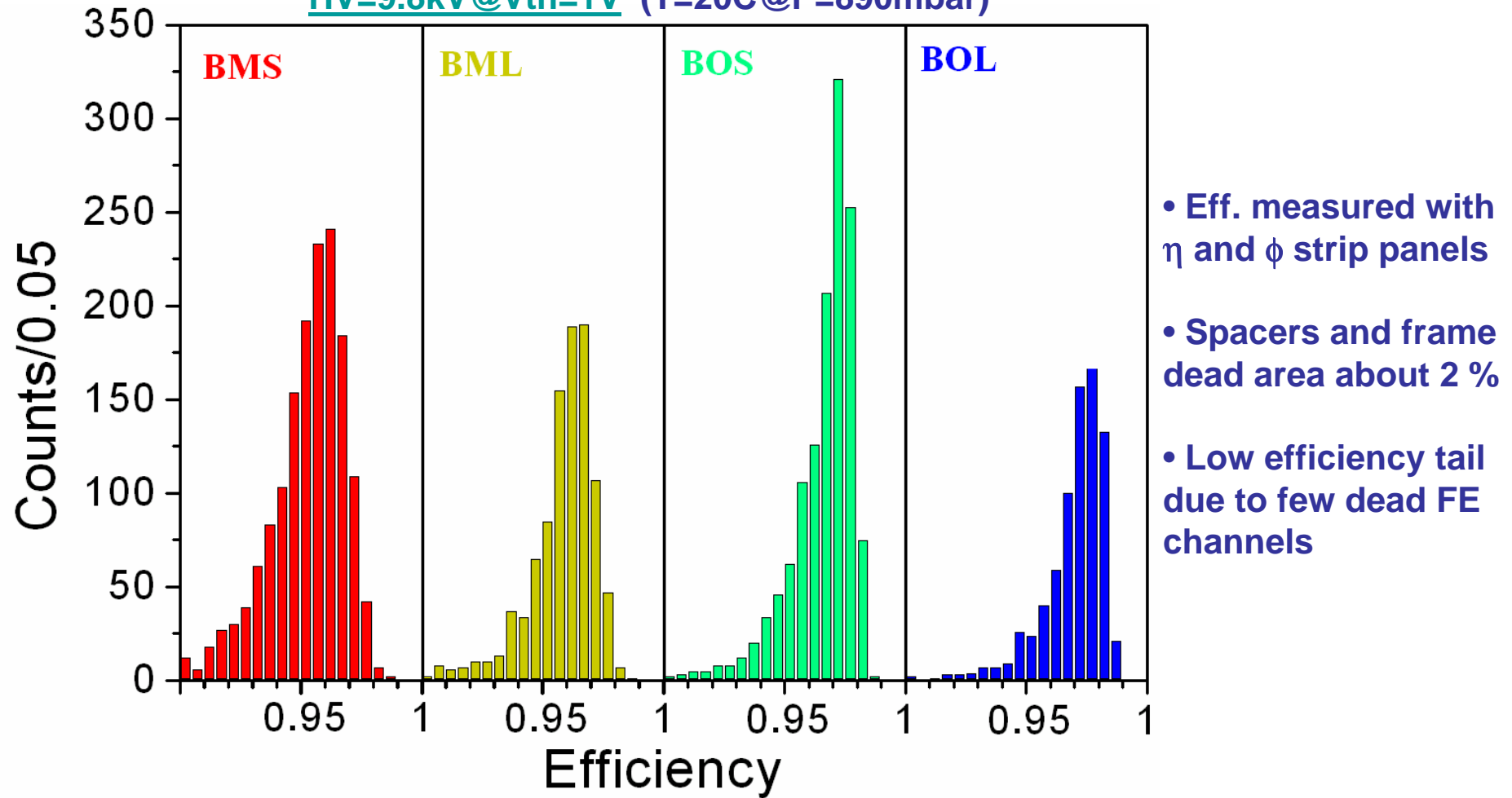
Tomography of gas volume with cut-out



Quality Assurance

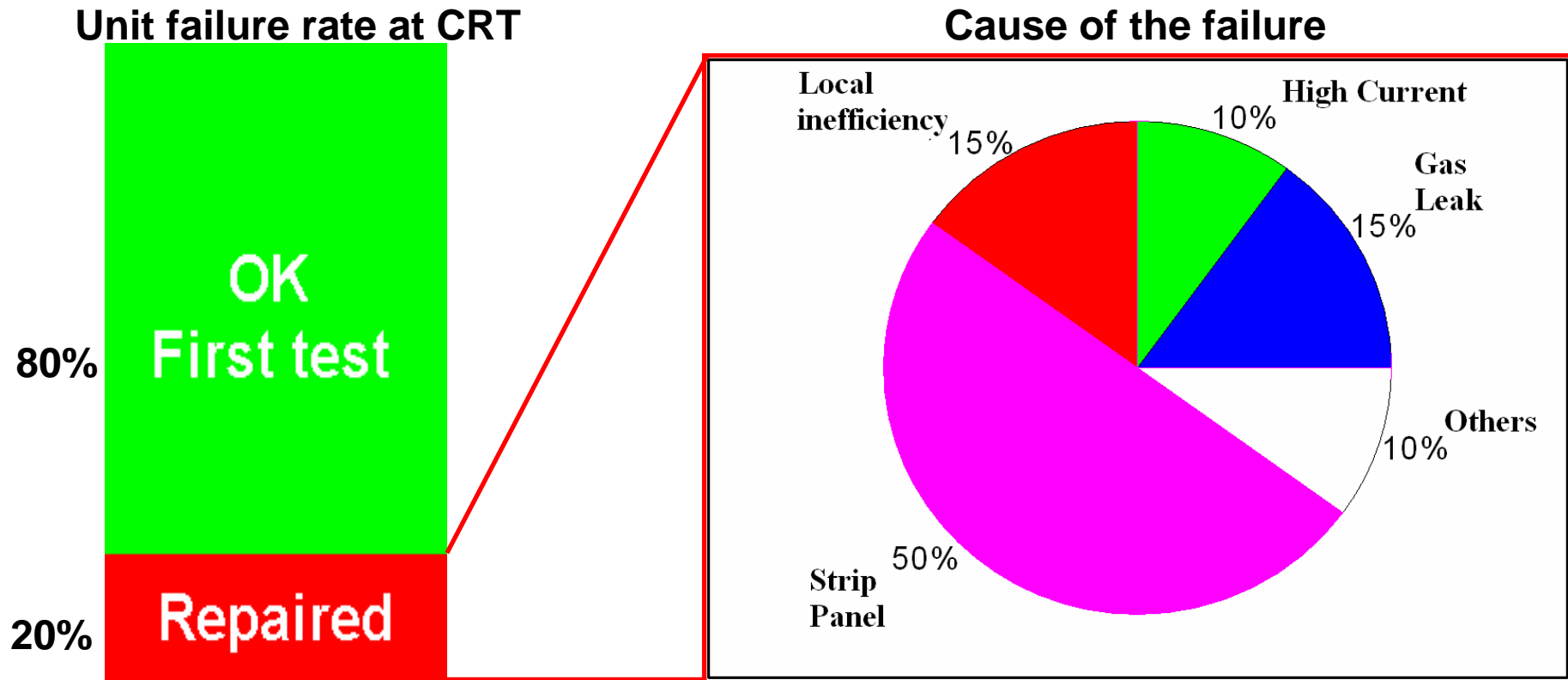
Single Unit statistics: Detection efficiency

HV=9.8kV@Vth=1V (T=20C@P=890mbar)



Quality Assurance

Single Unit statistics: Failure rate



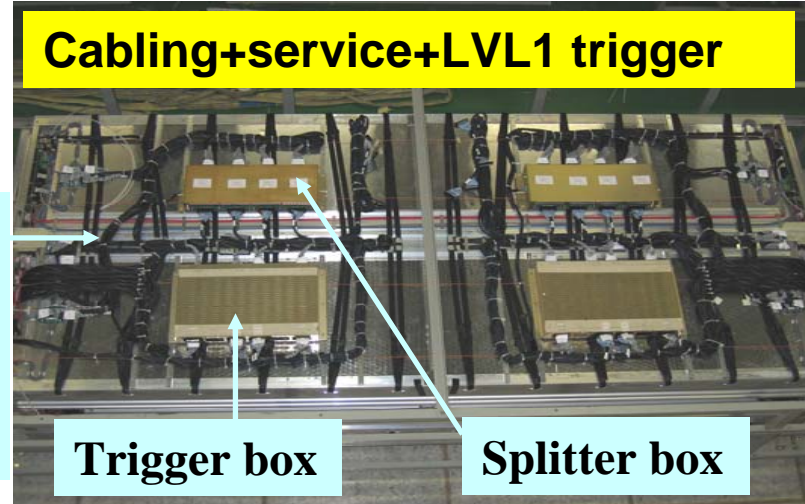
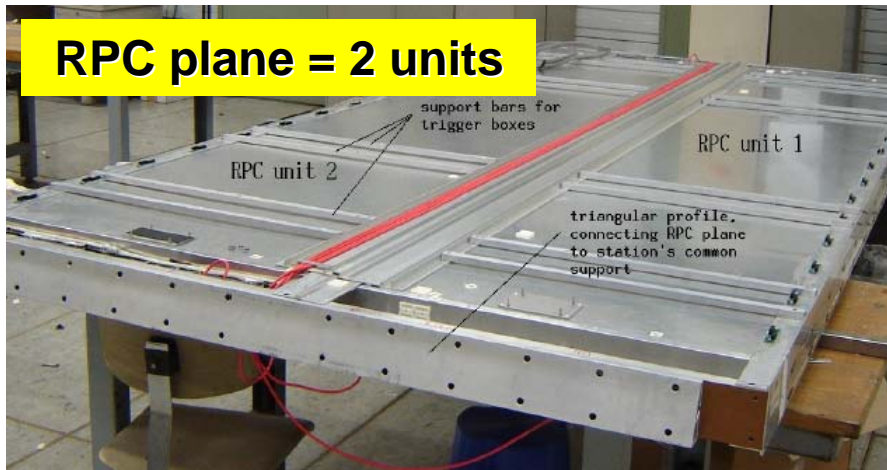
1 unit = 8 strip panels + 4 gas volumes

- Strip panel failure rate due to transportation+handling+assembly = 1.25 %
- Gas volume failure rate due to transportation+handling+assembly = 1.25%
- Gas volume failure rate detectable only with CRT = 0.75 %

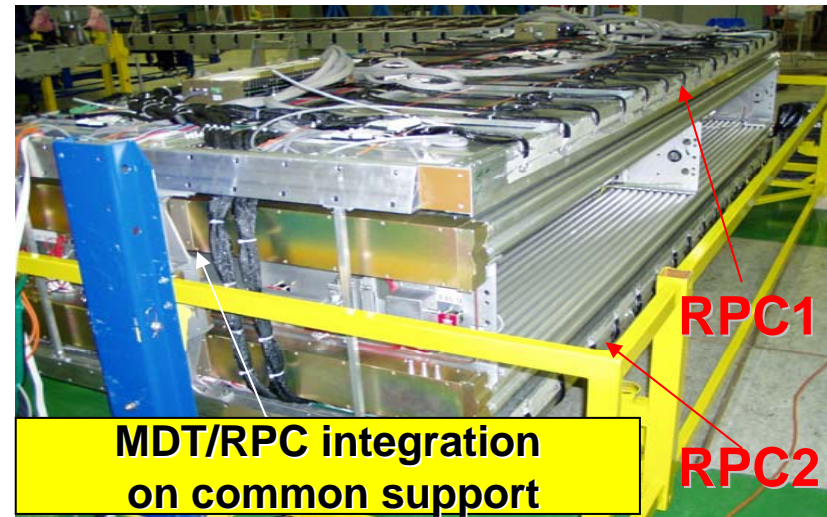
Quality Assurance

MDT+RPC integrated muon station

μ -station preparation at CERN-BB5

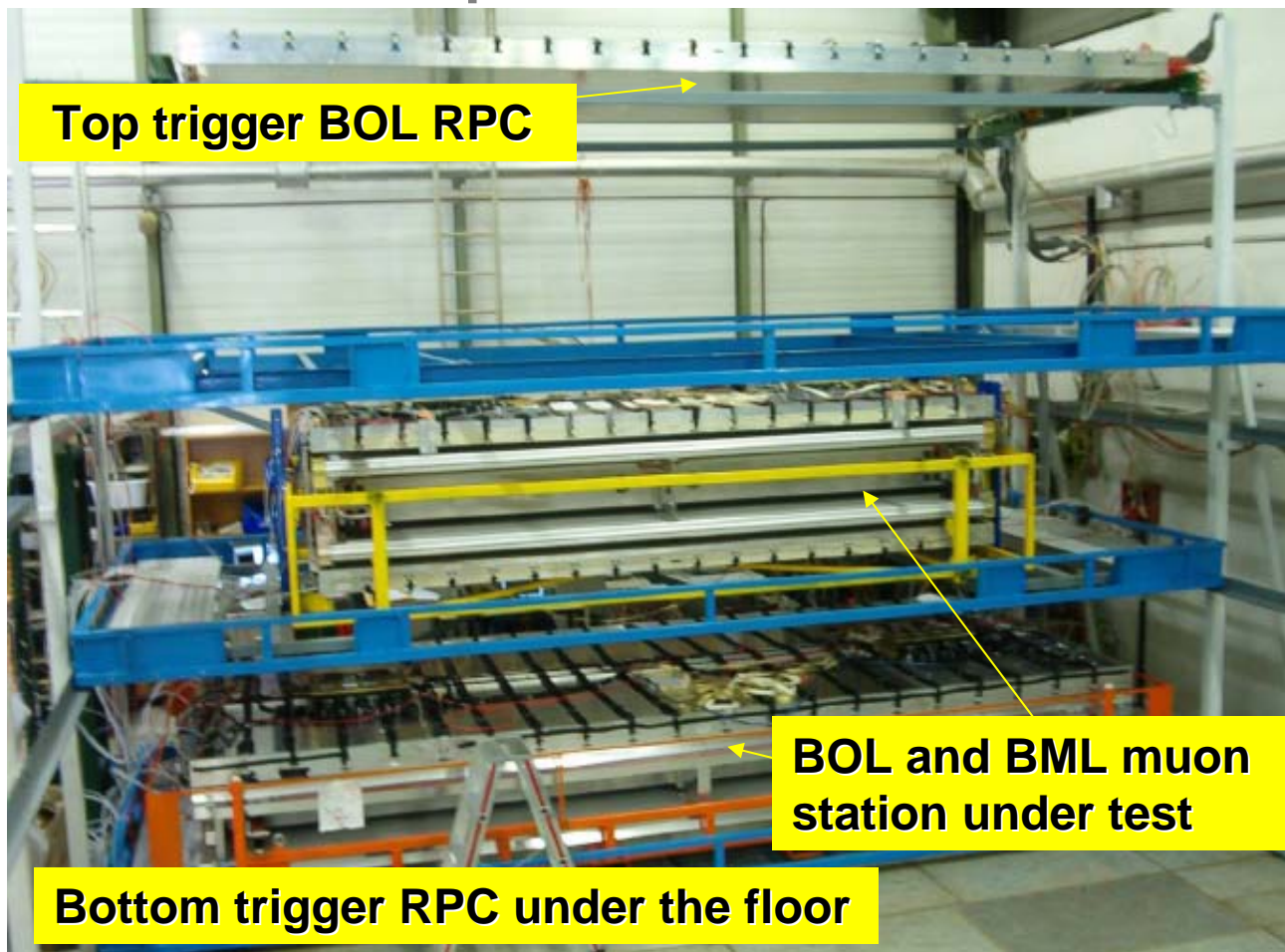


MDT/RPC stations	Total stations	RPC units
BMS/F	84	280
BML	94	298
BOS/F/G	106	202
BOL	96	192
TOTAL	380	972



Quality Assurance

MDT+RPC integrated muon station: RPC pretests and CRT with MDT



Before integration:

- Sanity check
- RPC electrical stability
- RPC IV and gas leak

After integration

- 1/2 a day of CRT
- RPC cosmic profiles
- RPC trigger cabling map checks
- about 1% dead FE channels

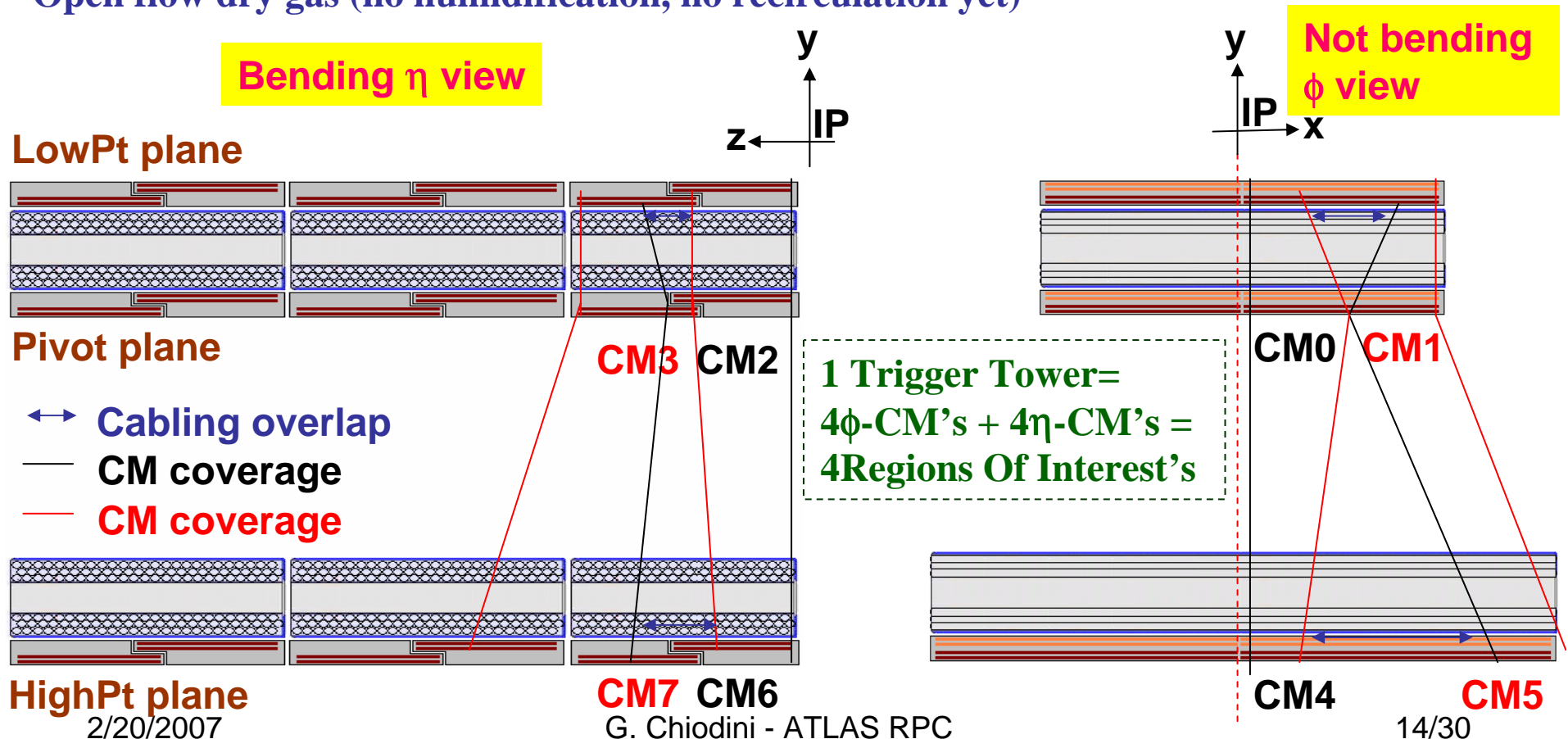
At UX1 surface level before installation:

- Sanity check
- RPC electrical stability
- RPC gas leak

ATLAS RPC pre-commissioning

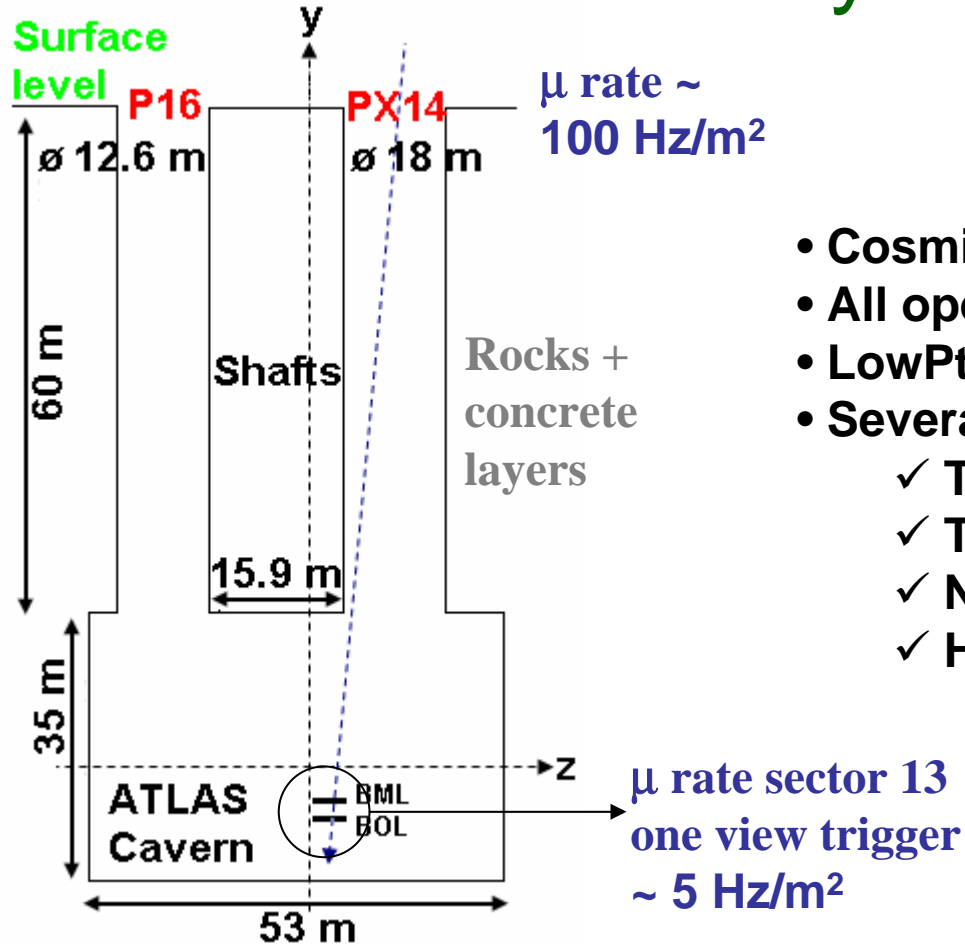
'Sector 13' setup

- 6 μ stations with RPC: 6 trigger towers (one shown in details)
- Final Sector Logic board (trigger+readout)
- Final cabling and service
- Open flow dry gas (no humidification, no recirculation yet)



ATLAS RPC pre-commissioning

Cosmic rays in 'sector 13'

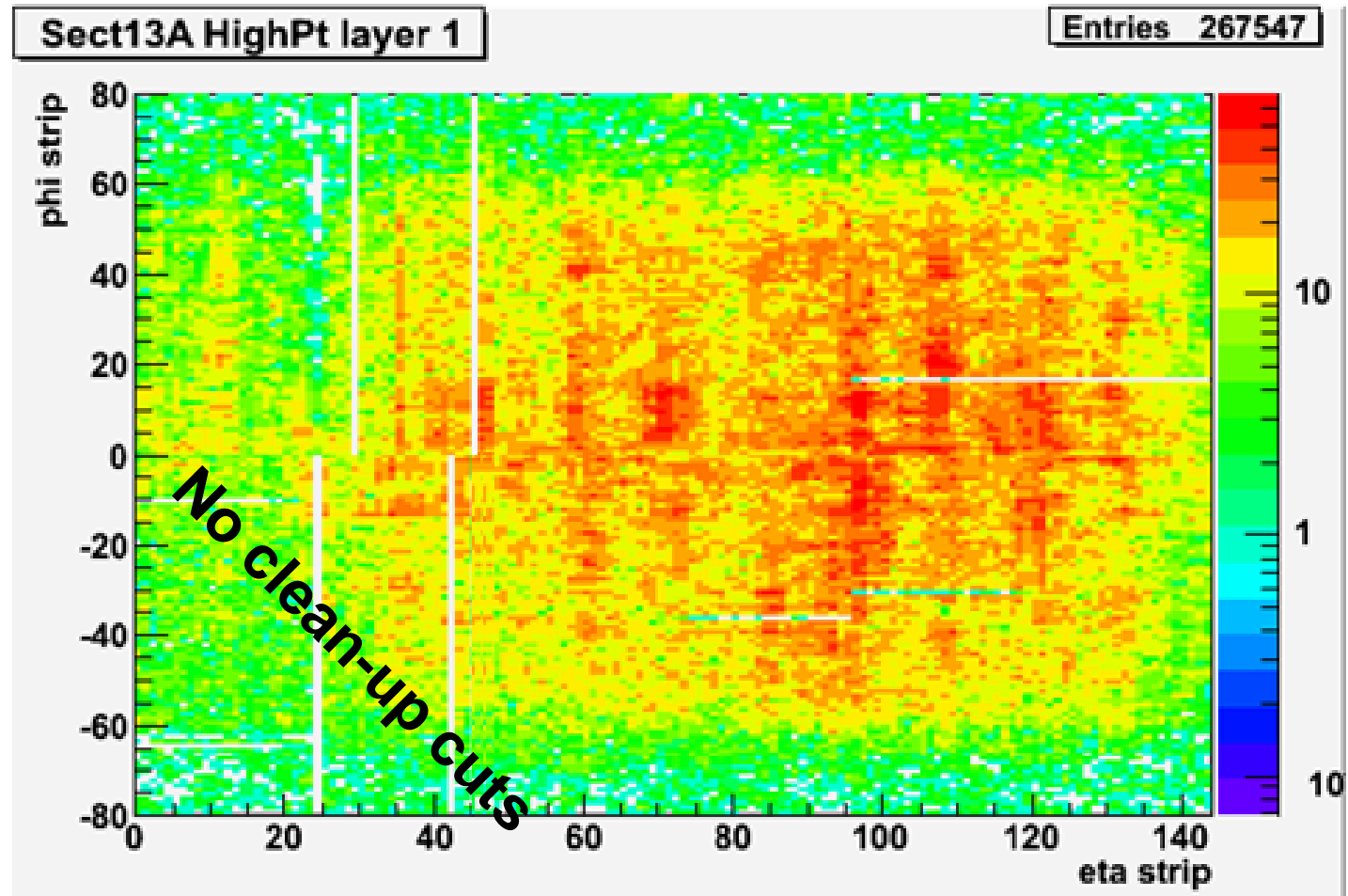


- Cosmic rays mainly form the shafts
- All open coincidence windows
- LowPt trigger 2 layers out of 4 within 25 ns
- Several trigger configuration loaded:
 - ✓ Trigger on ϕ (or η) view
 - ✓ Trigger on both view
 - ✓ Narrow coincidence windows (“roads”)
 - ✓ High Pt triggers

ATLAS RPC pre-commissioning

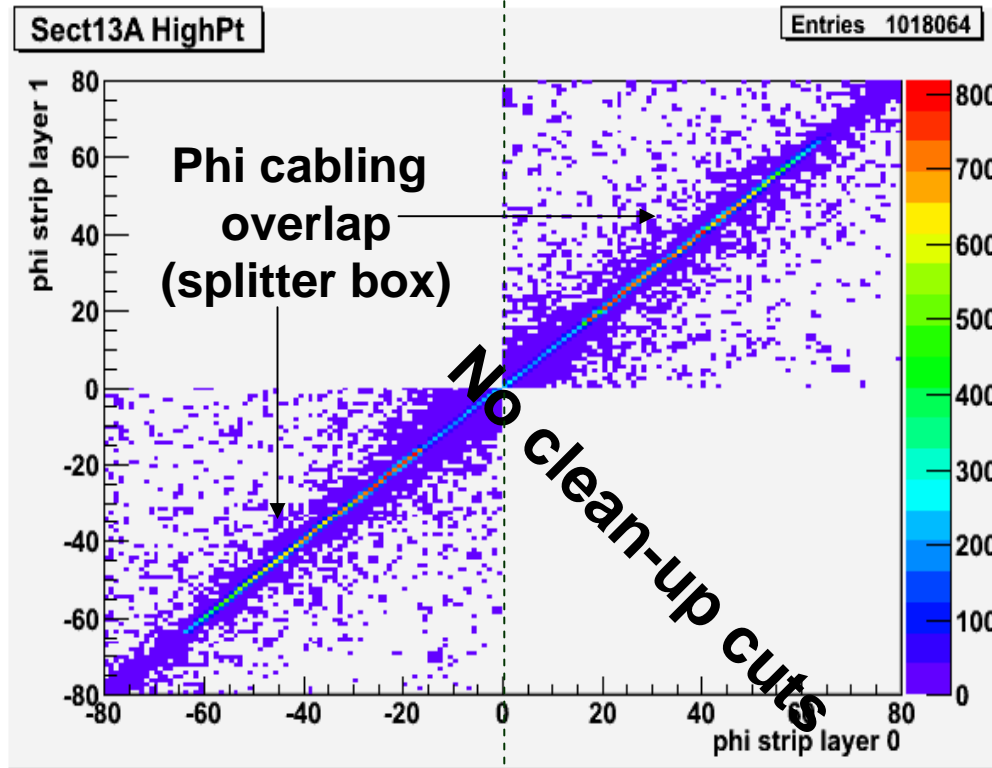
η - ϕ spatial correlations

- Raw data
- No Clustering
- Cabling overlap removed
- Cosmic mostly form the right (Atlas shaft)



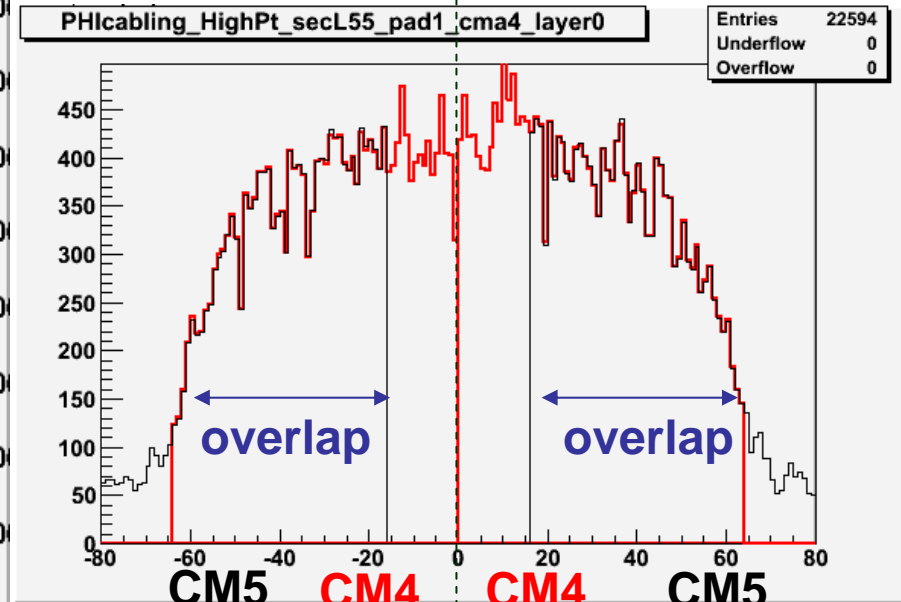
ATLAS RPC pre-commissioning

$\eta_0-\eta_1$ & $\phi_0-\phi_1$ spatial correlations



CM5 CM4
Tower 2 left

CM4 CM5
Tower 2 right

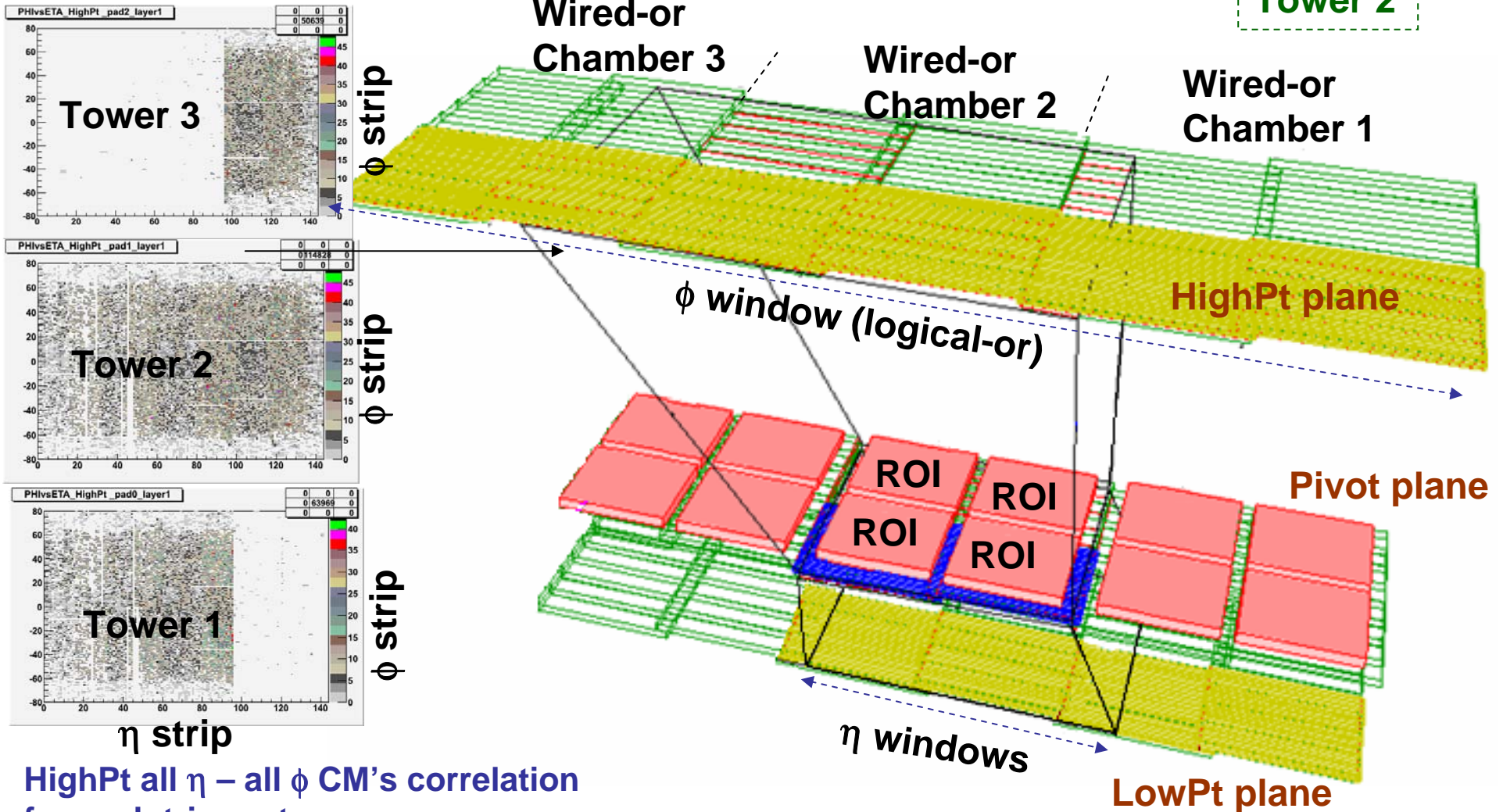


Tower 2 left Tower 2 right

ATLAS RPC pre-commissioning

ϕ logical-or (splitter-box)

Cabling Tower 2



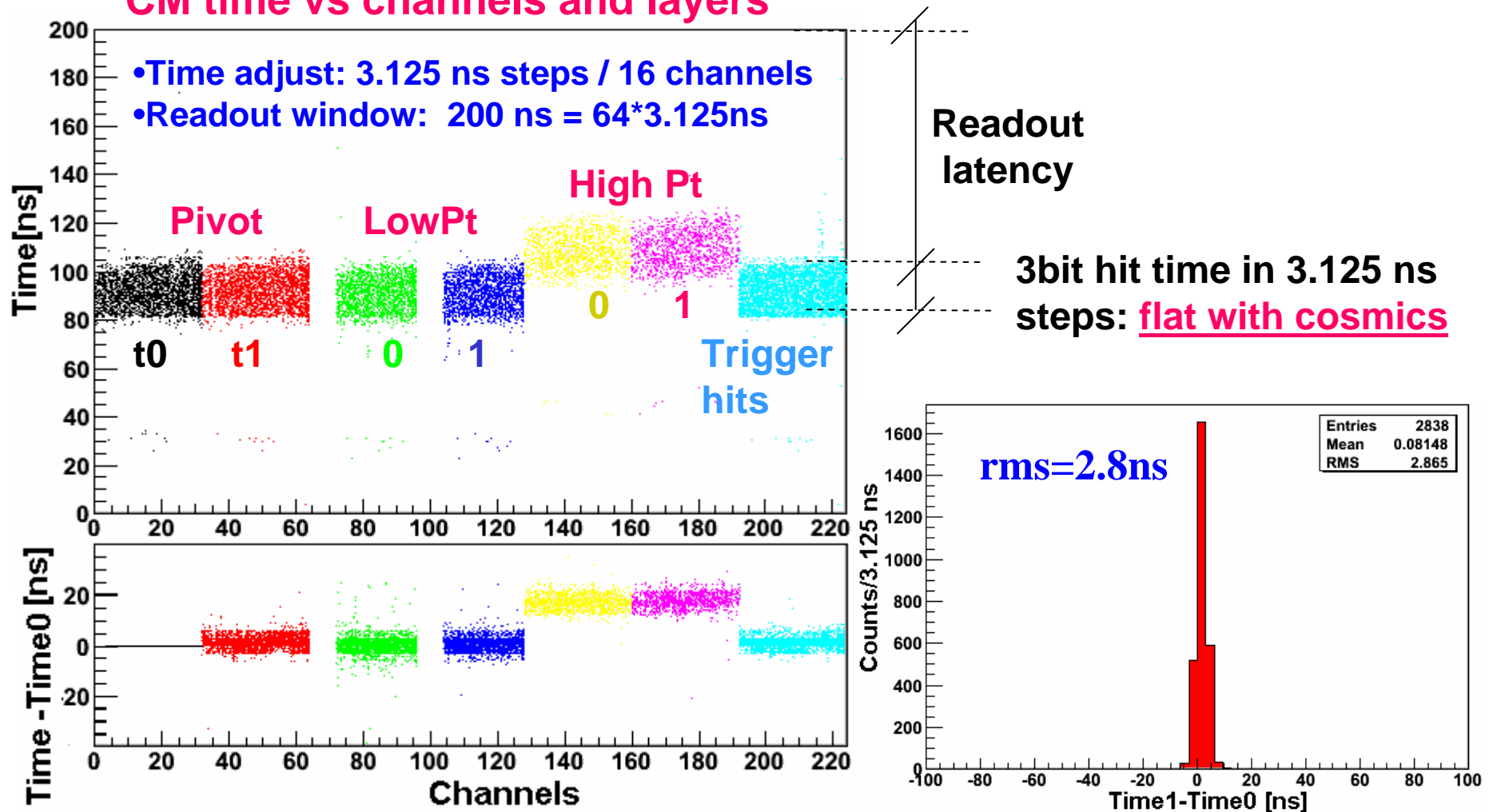
HighPt all η – all ϕ CM's correlation for each trigger towers

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ATLAS RPC pre-commissioning

Time calibration: CM raw time

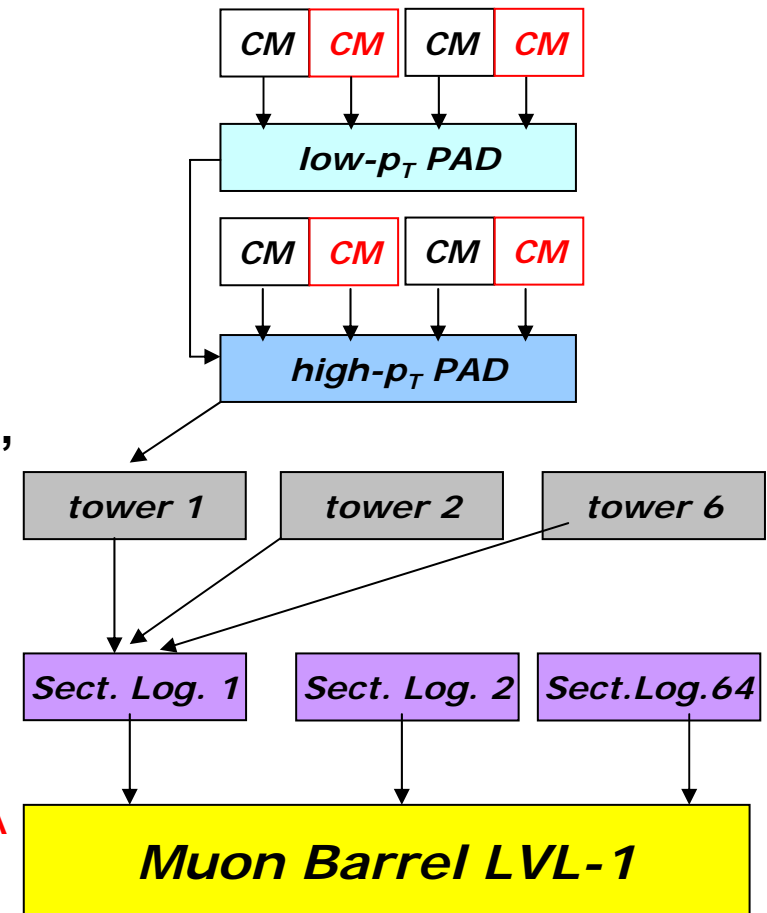
CM time vs channels and layers



ATLAS RPC pre-commissioning

Time calibration: Strategy

- Timing misalignment
 - Cable lengths
 - Optical fibres lengths
 - Trigger algorithm processing time
- Alignment strategy. Bottom-up approach, following the trigger structure
 - Within CMA (2/2 triggers inside planes)
 - Within Trigger tower (η triggers, ϕ triggers, η and ϕ triggers)
 - Within Trigger sector (Overlap regions)
 - Within Muon Barrel

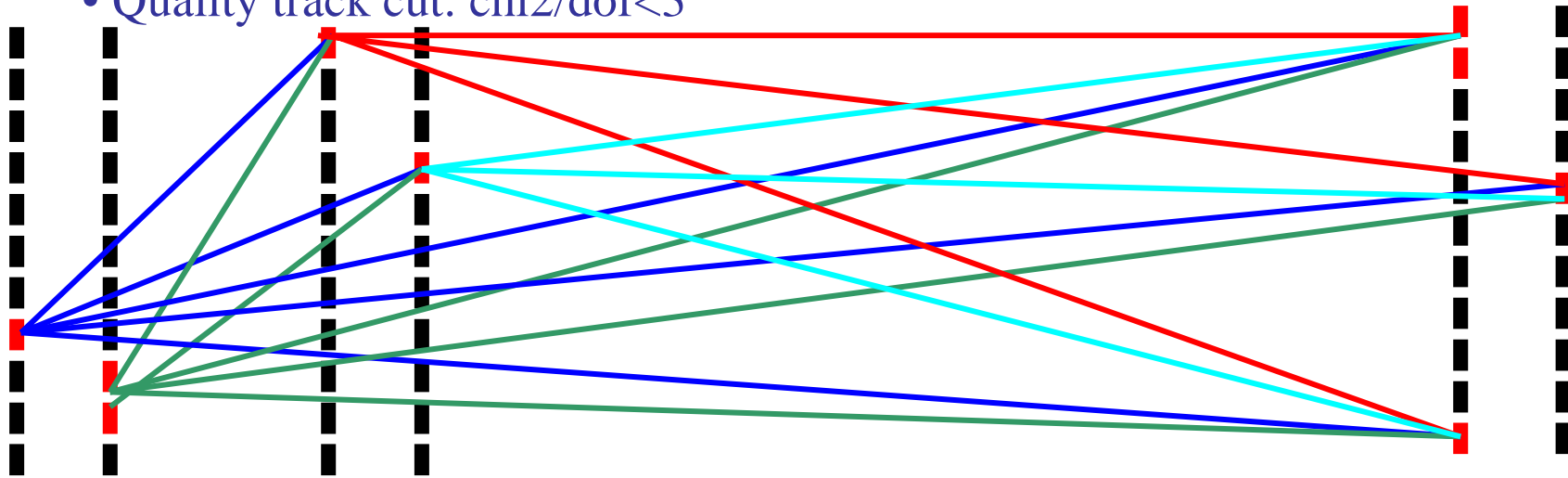


**POSTER SESSION: THE ATLAS LV1 TRIGGER:
STATUS AND RESULTS WITH COSMIC-RAY DATA**
D. Berge on behalf of ATLAS LV1

ATLAS RPC pre-commissioning

RPC stand-alone tracking

- Two cluster hits of different planes define a segment
- Segment's slope (α) and intercept (β) fill a bin of a 2D histogram
- "True" tracks given by bins with more than one entry
- Quality track cut: $\chi^2/\text{dof} < 3$

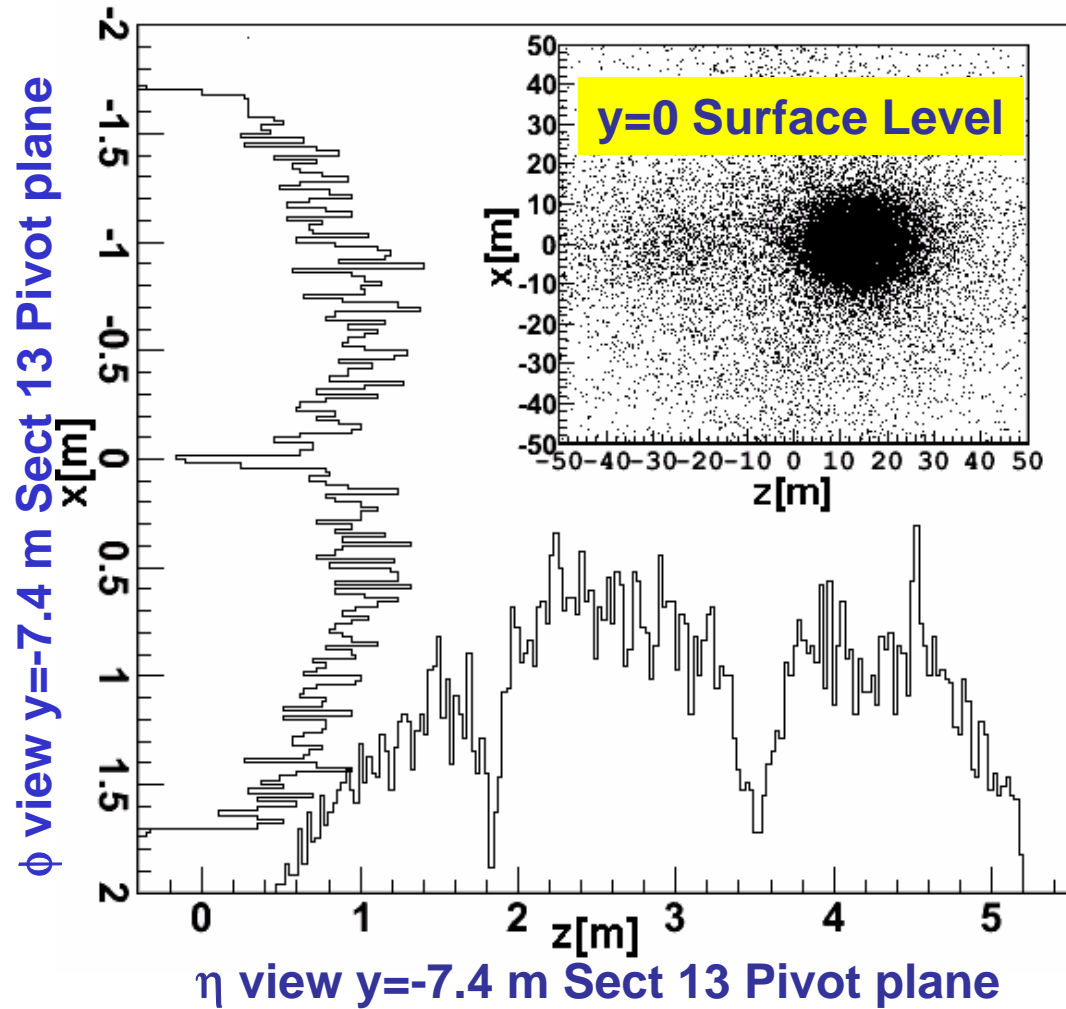


Combination of two cluster hit segments between 3 RPC planes

- RPC 3D tracking
- Long interpolation distance (about 3 m)
- Combined analysis with MDT is underway

ATLAS RPC pre-commissioning

Cosmic ray rates and profiles

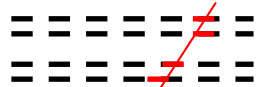


- 6 measuring point per view
- Dips due to pointing geometry opposite to the main shaft

ATLAS RPC pre-commissioning

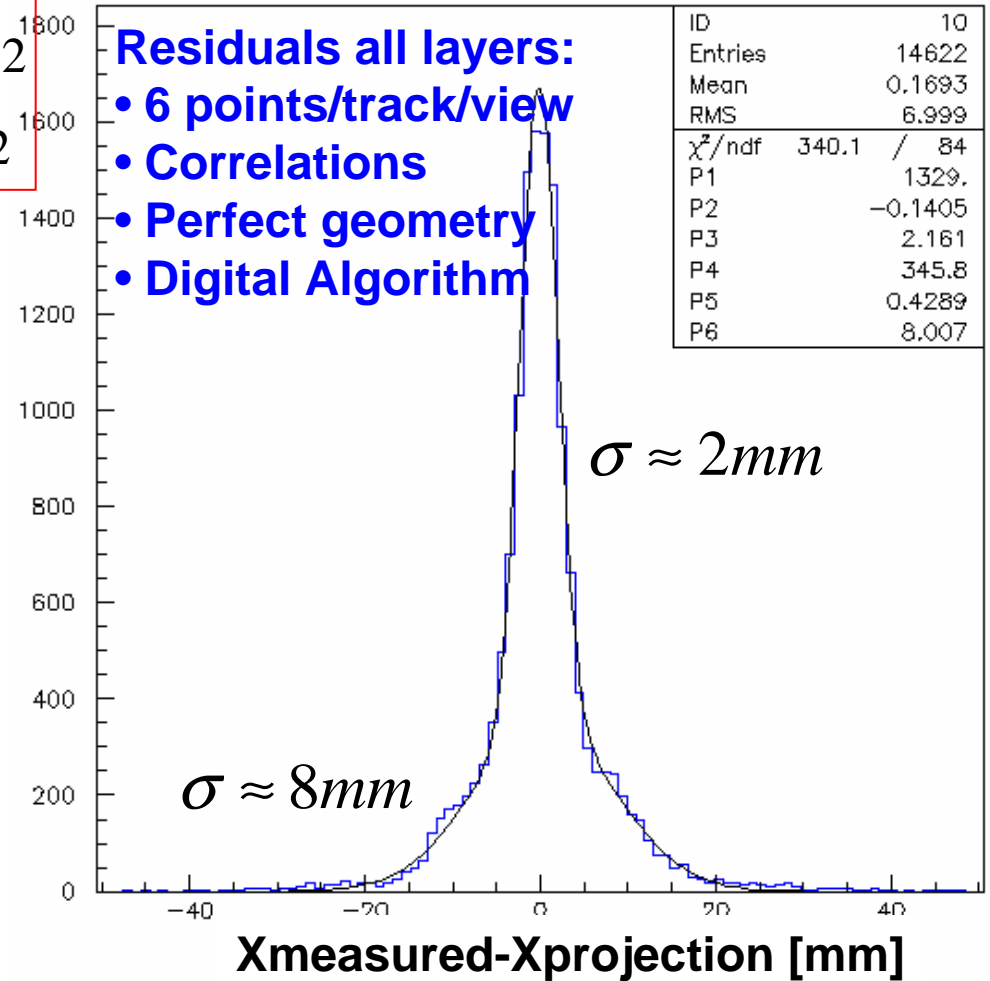
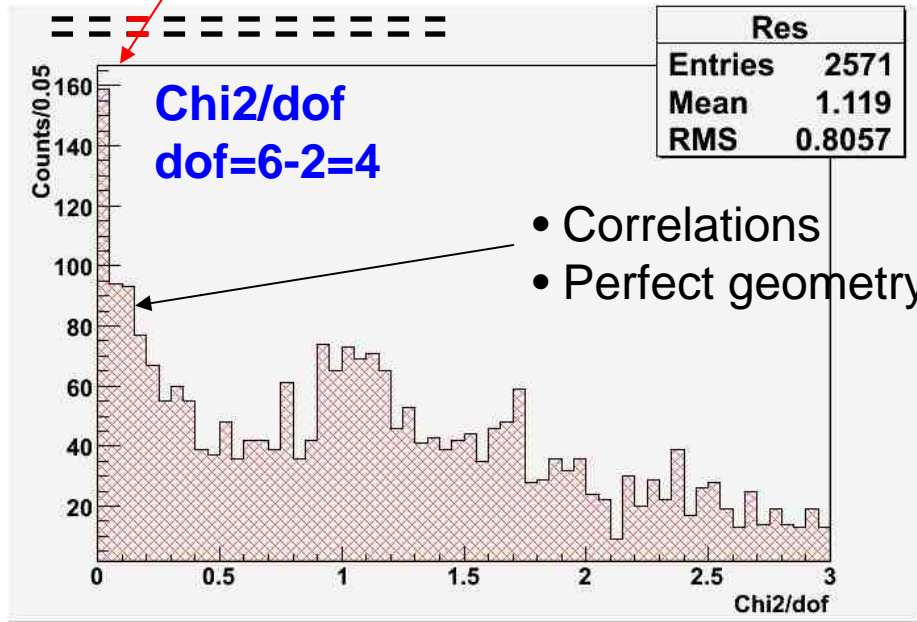
RPC stand-alone tracking

3D Tracking
 η and ϕ views



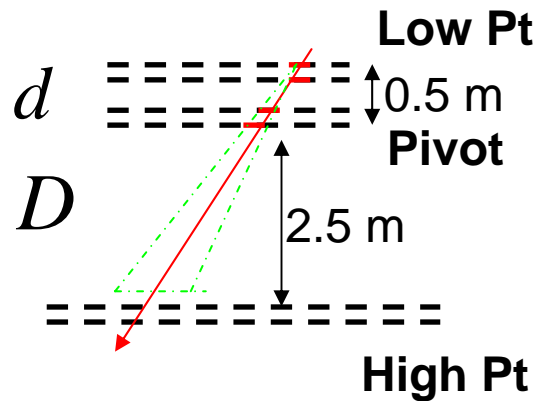
$$\sigma_{CS} = \begin{cases} \frac{f_{CS} \cdot \text{Pitch}}{\sqrt{12}} & \text{CS} = 1, 2 \\ 1.5 \text{ cm} & \text{CS} > 2 \end{cases}$$

f_{CS} = CS fraction



ATLAS RPC pre-commissioning

RPC stand-alone tracking: Extrapolation error

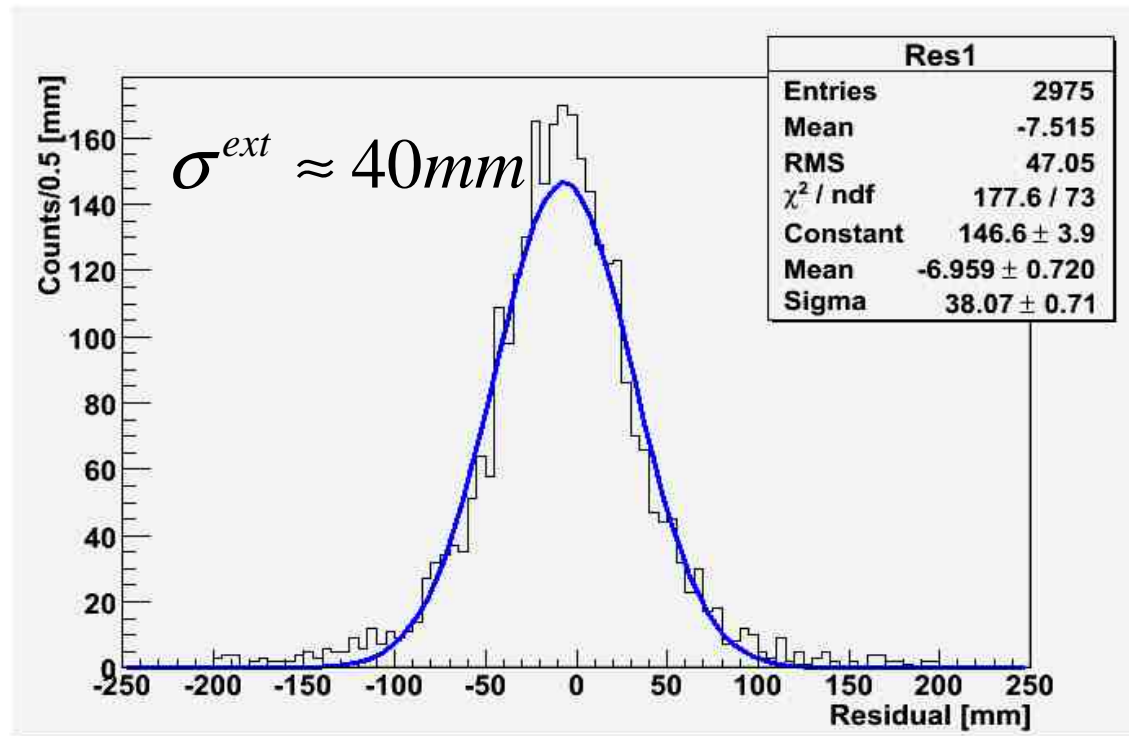


$$\sigma_{extrapolation} \approx \sigma \frac{D}{d}$$

$$\frac{\text{Pitch}}{\sqrt{12}} \frac{D}{d} \approx 40\text{mm}$$

Tracking with only LowPt and Pivot planes:

- 4 points/track/view between 0.5 m
- Extrapolation distance about 2.5 m on High Pt plane



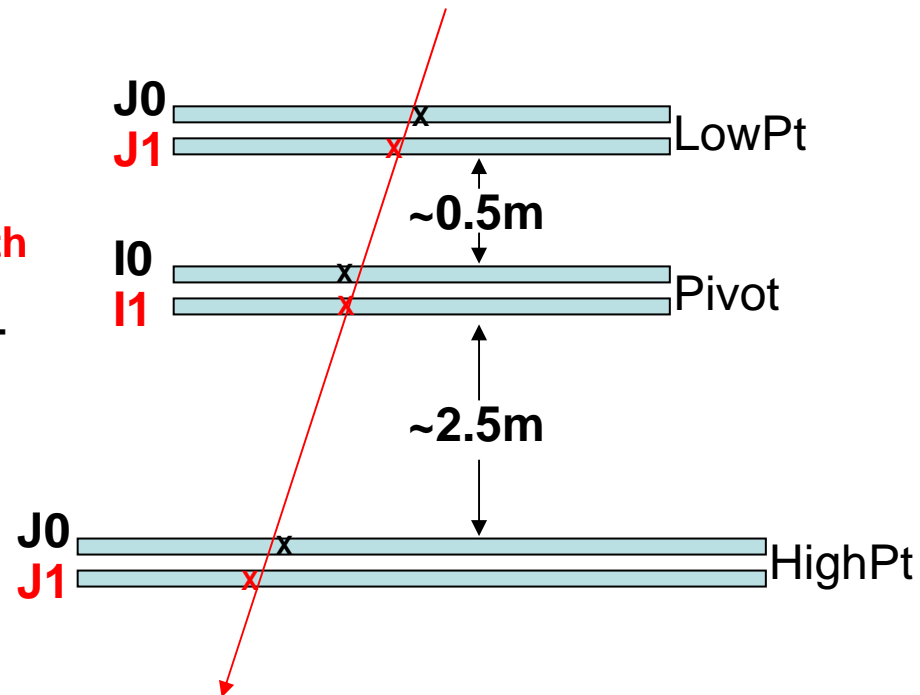
ATLAS RPC pre-commissioning

RPC efficiency measurements

2 trigger setup to measure unbiased efficiency:

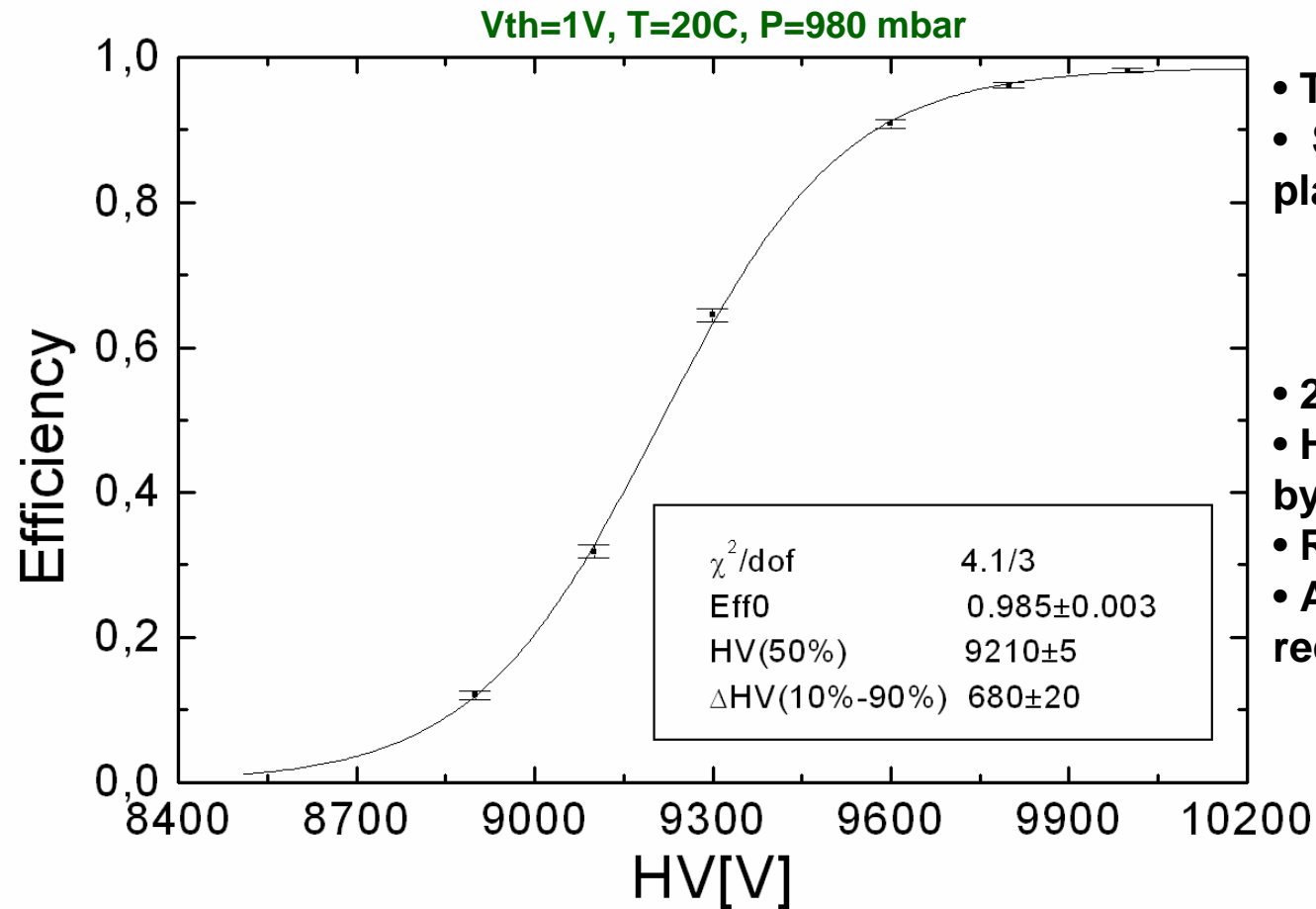
- Trigger with Layer0's and Device Under Test are the Layer1's
- Trigger with Layer1's and Device Under Test are the Layer0's

- Tracks reconstructed with only layer 1(0) hits
- Layers 0(1) UNDER TEST
- 3 points track, dof=1



ATLAS RPC pre-commissioning

RPC efficiency: Plateau curve



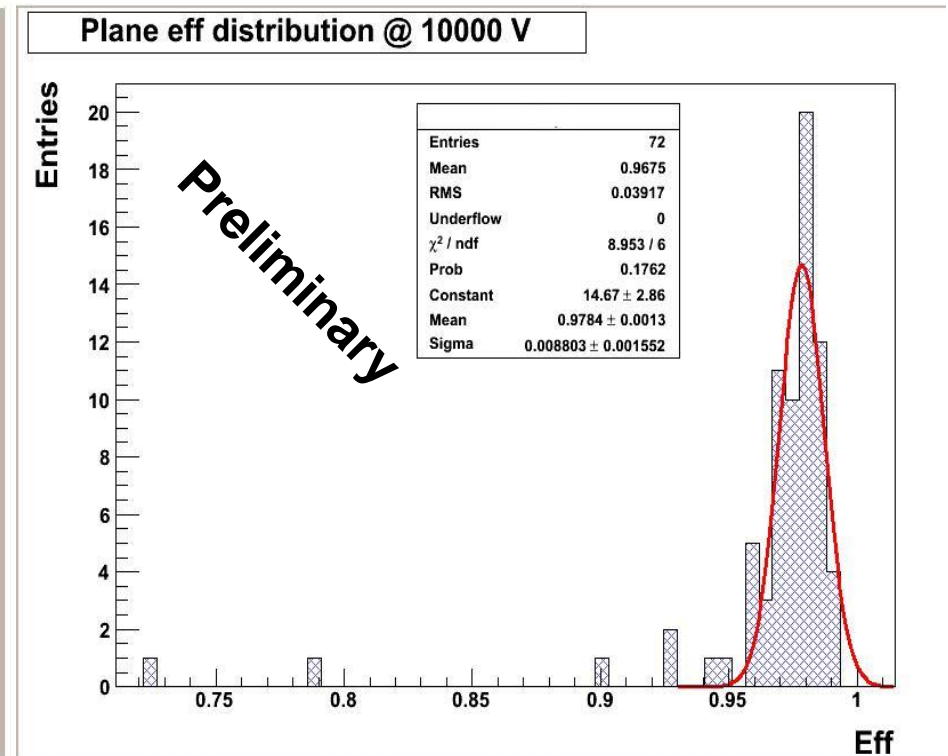
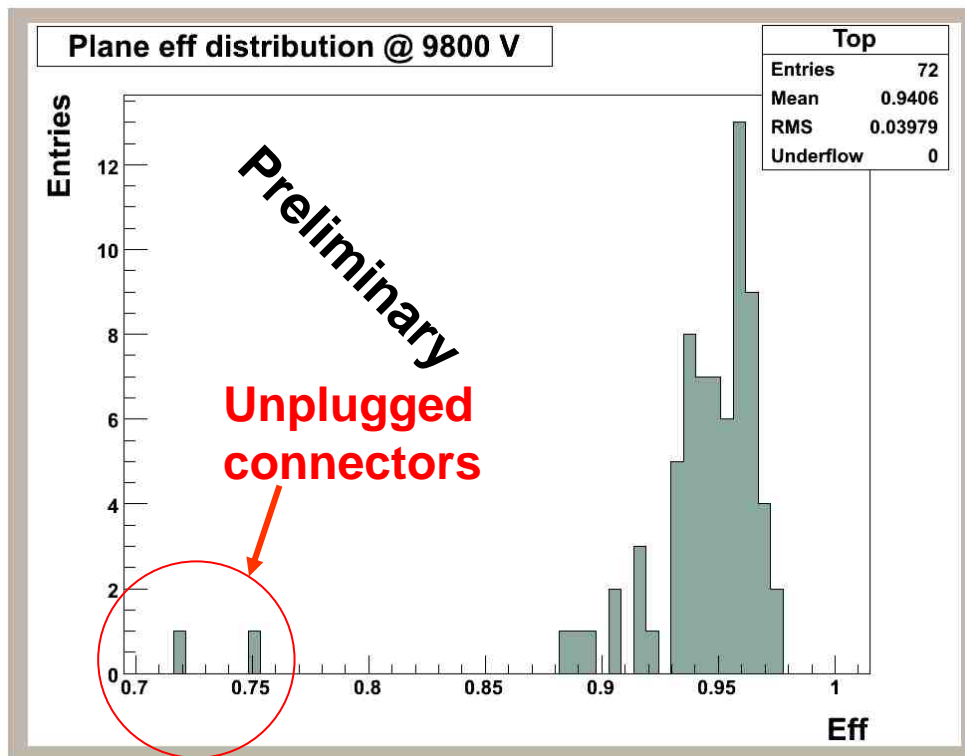
- Typical plateau curve
- Similar to single units plateau curve

- 2/4 LowPt trig. in ϕ view
- High Pt point required by software
- Runs of 50000 evts
- About 5000 tracks reconstructed/layer/tower

ATLAS RPC pre-commissioning

RPC efficiency: Distribution

HV= 9800V $\xrightarrow{V_{th}=1V, T=20C, P=980 \text{ mbar}}$ HV=10000V



- RPC efficiency with η and ϕ view per layer and tower
- Adj. HV of 200 volts the eff. increase noticeably

**FEW KNOWN PROBLEMS TO BE FIXED:
SECTOR 13 NOT COMMISSIONED YET!!!**

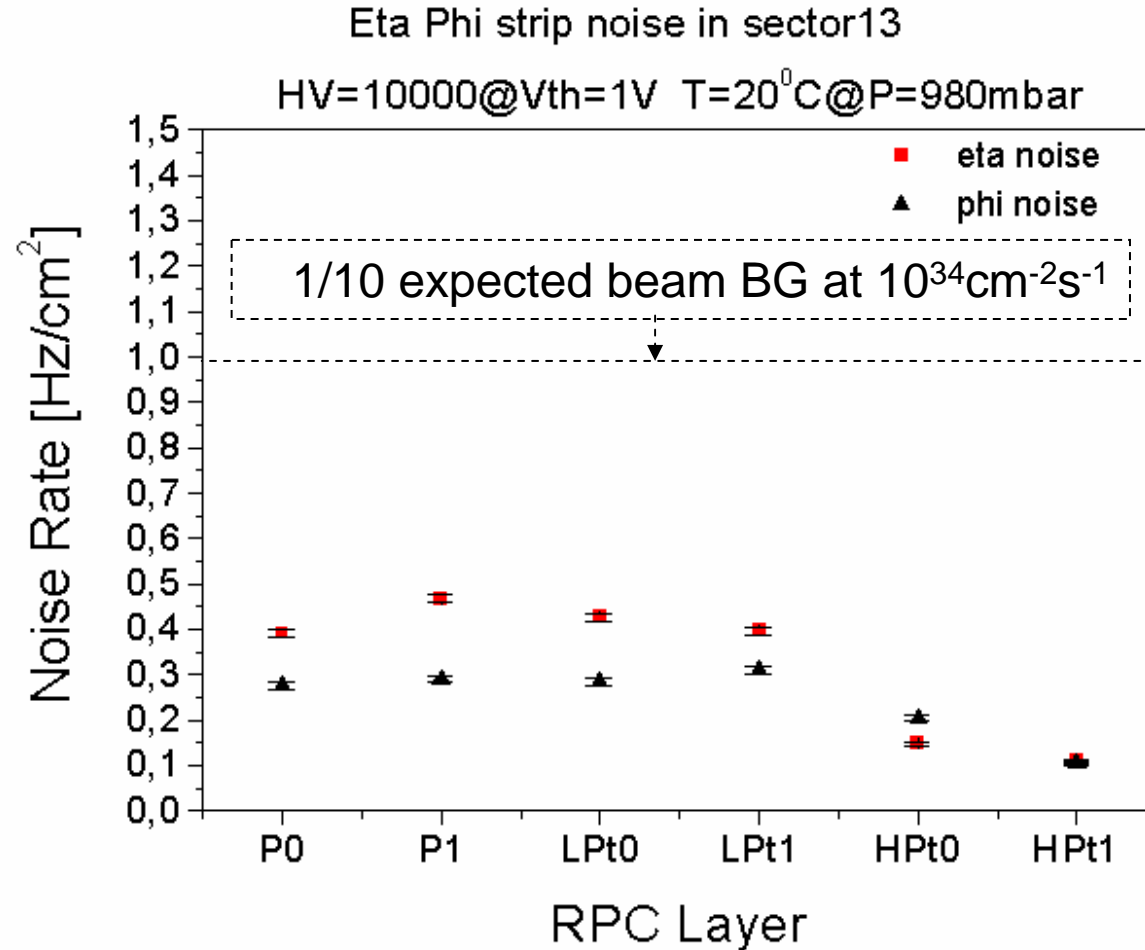
ATLAS RPC pre-commissioning

RPC noise rate

Noise rate measured by opening a 200 ns readout window every 5 ms .

Noise an order of magnitude less than expected BG at LHC design luminosity.

Systematic errors not evaluated. η and ϕ noise measured with different techniques.



ATLAS RPC pre-commissioning

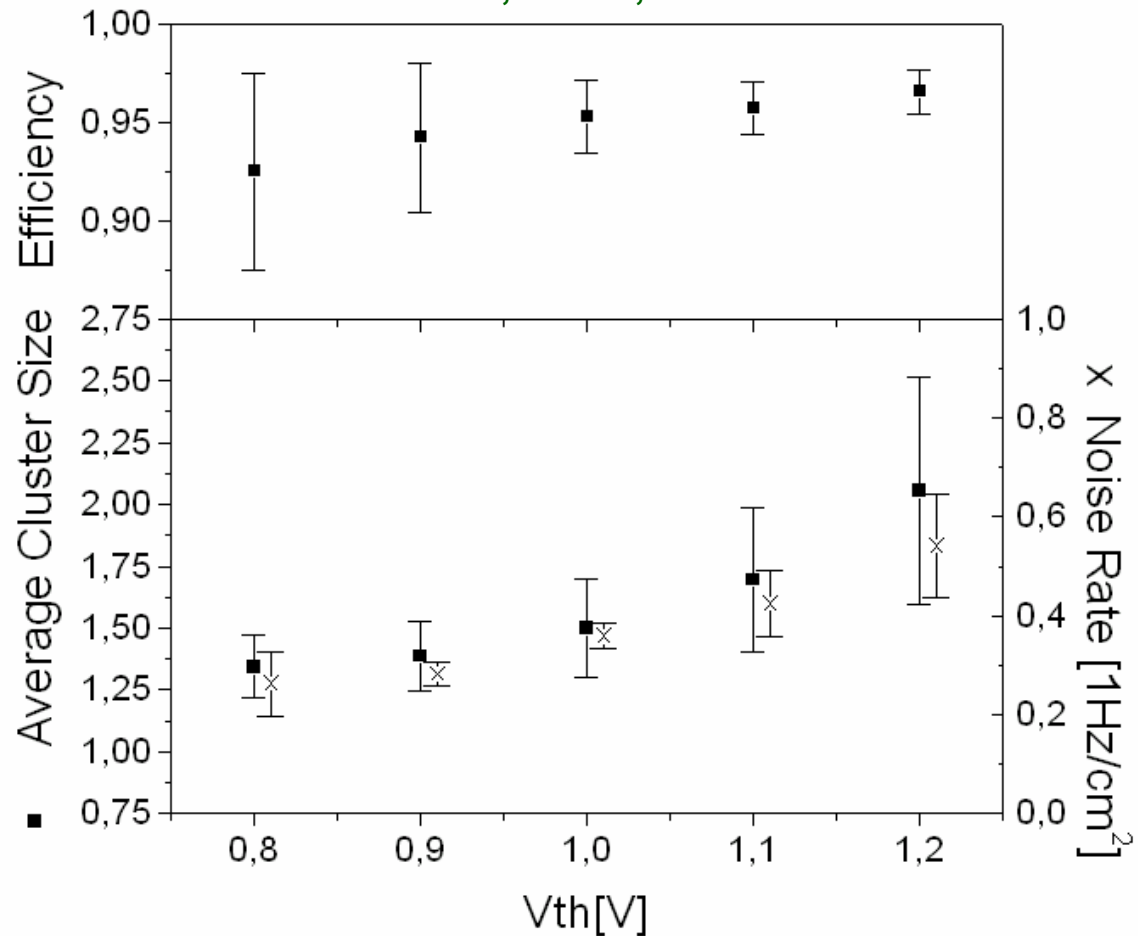
FE Voltage Threshold scan

HV=9800V, T=20C, P=980 mbar

FE voltage threshold
Vth separated for each strip
panel up to the crates.

More LV module available,
more fine tuning of the
working point possible.

- Average cluster size,
noise rate and efficiency of
all layers vs Vth.
- Error bars are the rms
spread between readout
strip panels



Conclusions

- ❑ Extensive tests with cosmic rays were performed with ATLAS RPC trigger chamber on 6 stations installed in the experiment
- ❑ A preliminary analysis of the data indicates that detector performance meet the ATLAS experiment requirements.
- ❑ Quality assurance tests either on RPC single units and MDT+RPC integrated muon station were important in order to accomplish that
- ❑ After “sector 13” exercise we are looking forward to face the final ATLAS RPC LV1 trigger commissioning sector by sector (this is NOW!!!)