核探测与核电子学国家重点实验室
State Key Laboratory of Particle Detection and Electronics

Beam Test of Thin Gap RPC for trigger and precision tracking application

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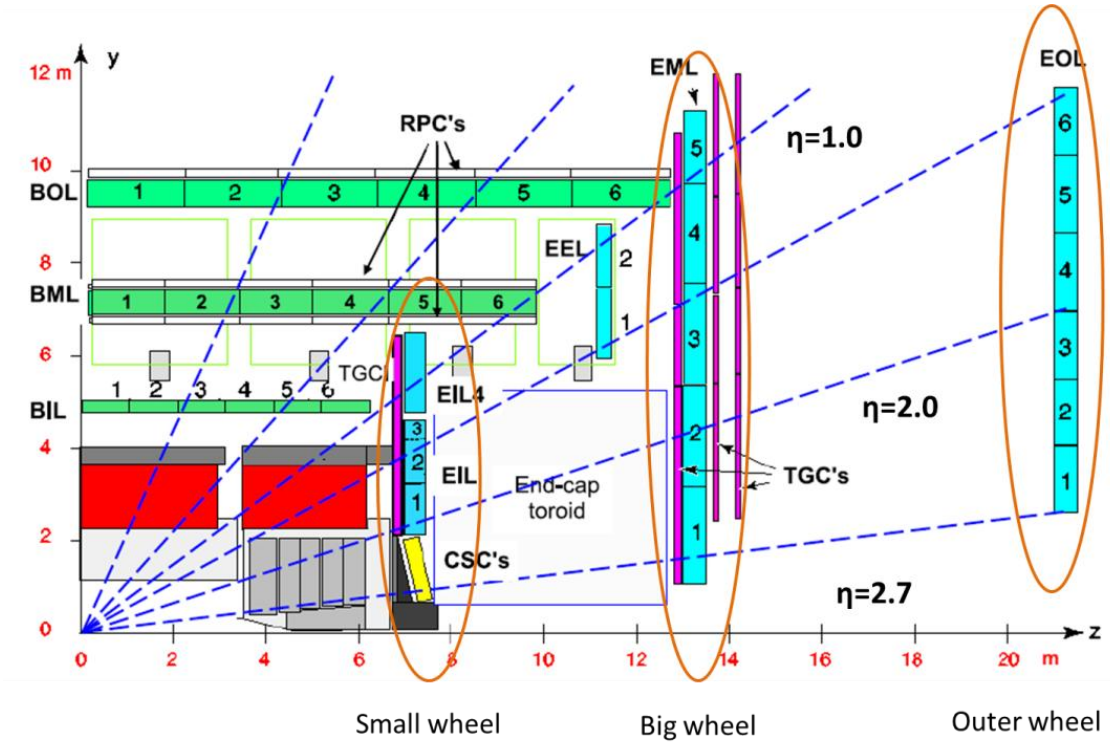
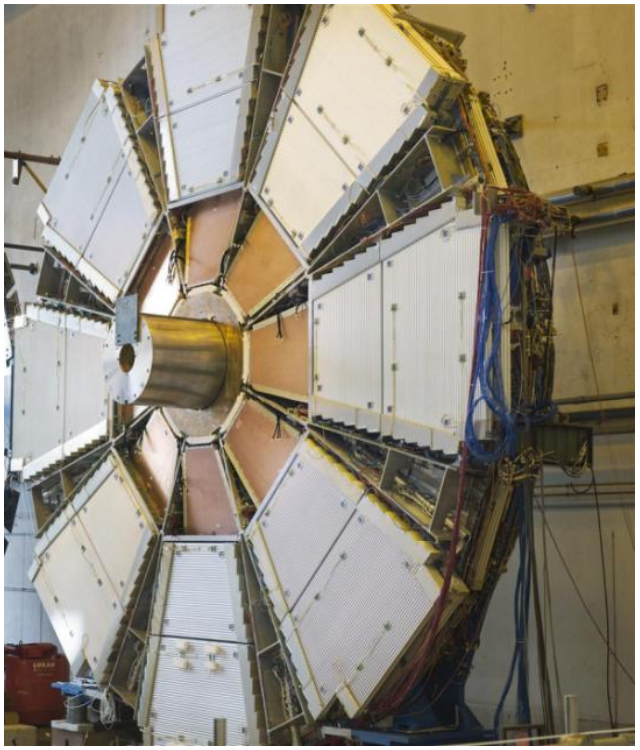
Outline

- Motivation - ATLAS Small Wheel Upgrade
- Thin Gap RPC and Beam test setup
- Efficiency
- Timing performance
- Spatial resolution study
- Conclusion

Motivation

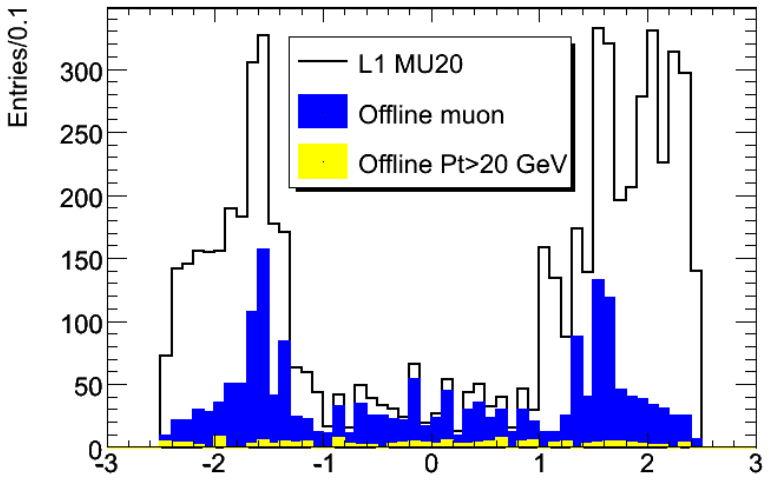
- **ATLAS Small wheel upgrade**
  - Current SW needs to be replaced to withstand the harsh environment at future Luminosity ~ 10^{34} $cm^{-2}s^{-1}$



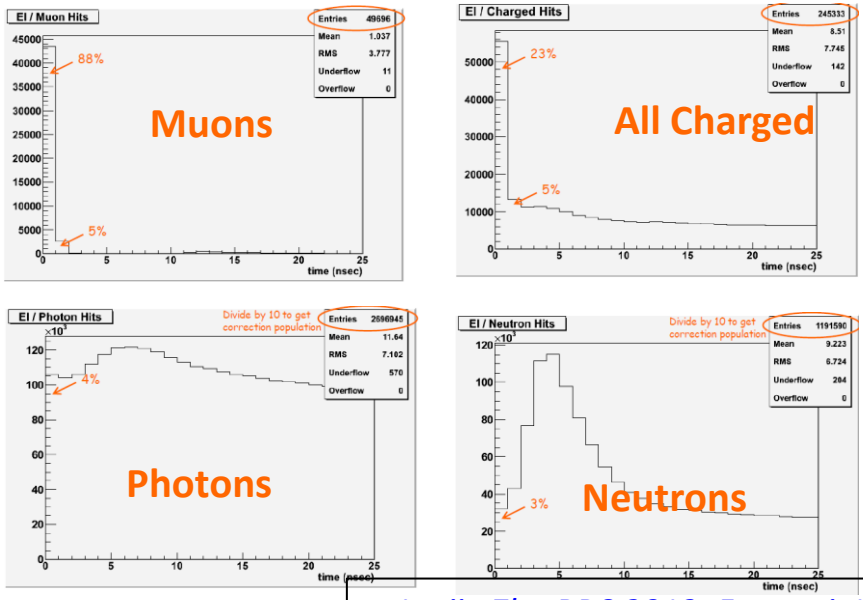


Motivation

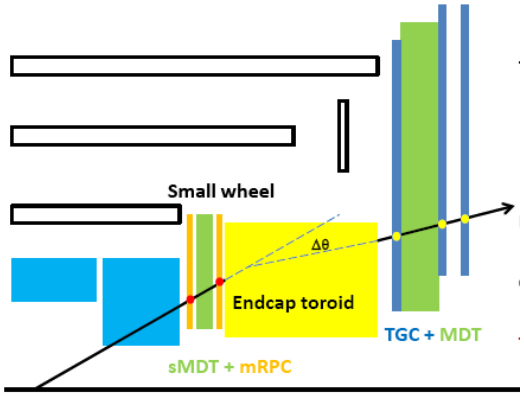
- **One of the Proposed New Small Wheel thin gap RPC+ small MDT**



S. Vlachos, External SW Evaluation Workshop, 2012



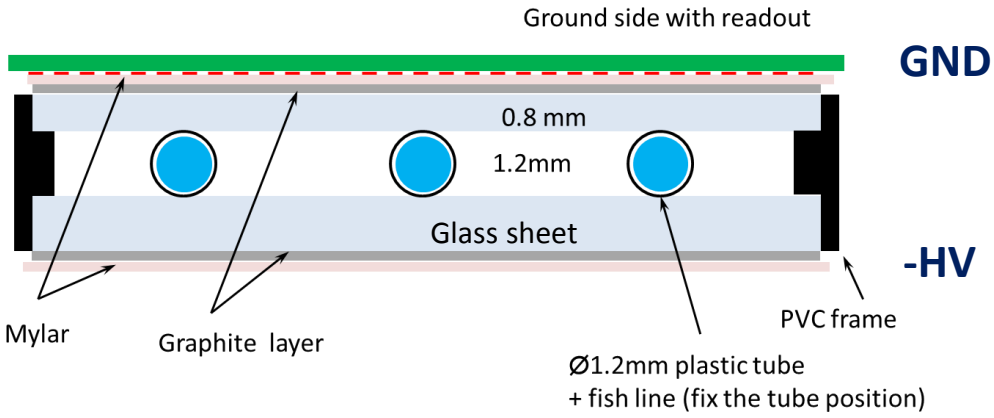
Junjie Zhu RPC 2012, Frascati, Italy



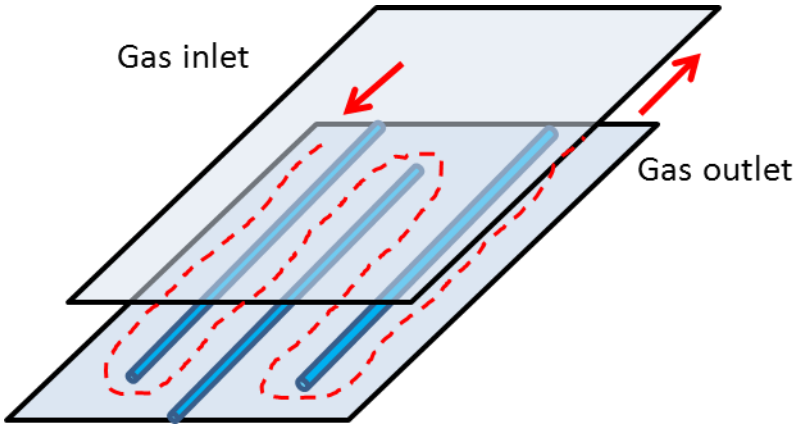
- Current L1-trigger: ~70% fakes, ~2% P_T>20 GeV (fakes are mainly coming from EndCap |η|>1.05)
- Exploit the good timing and sub mm spatial resolution from thin gap RPC to remove the carven background as soon as possible and as much as possible. (Quote R.Santonico's word)
- Related R&D work is ongoing at USTC in collaboration with University of Michigan

Thin gap Resistive Plate Chamber

X-sectional view

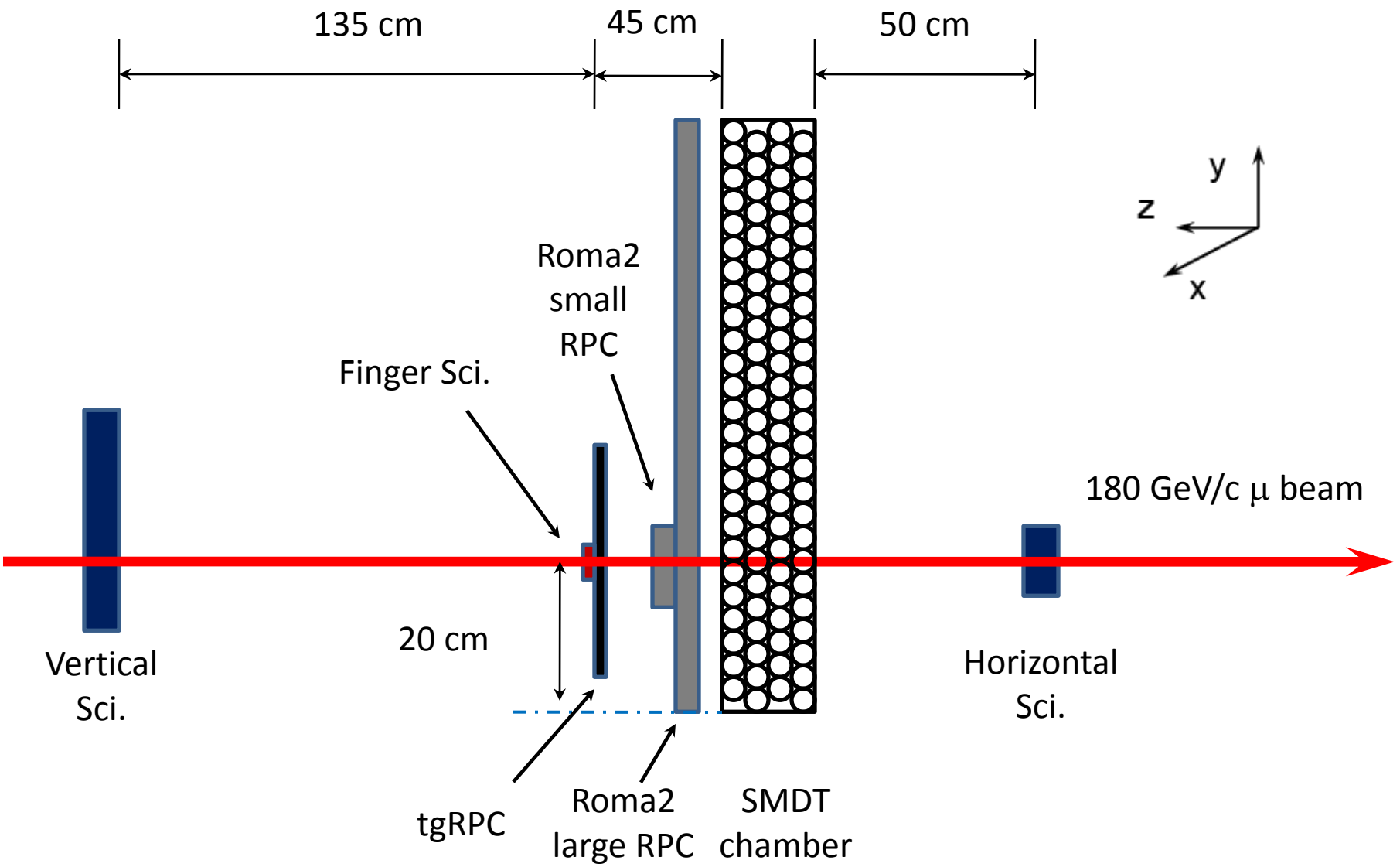


Gas flow in the chamber

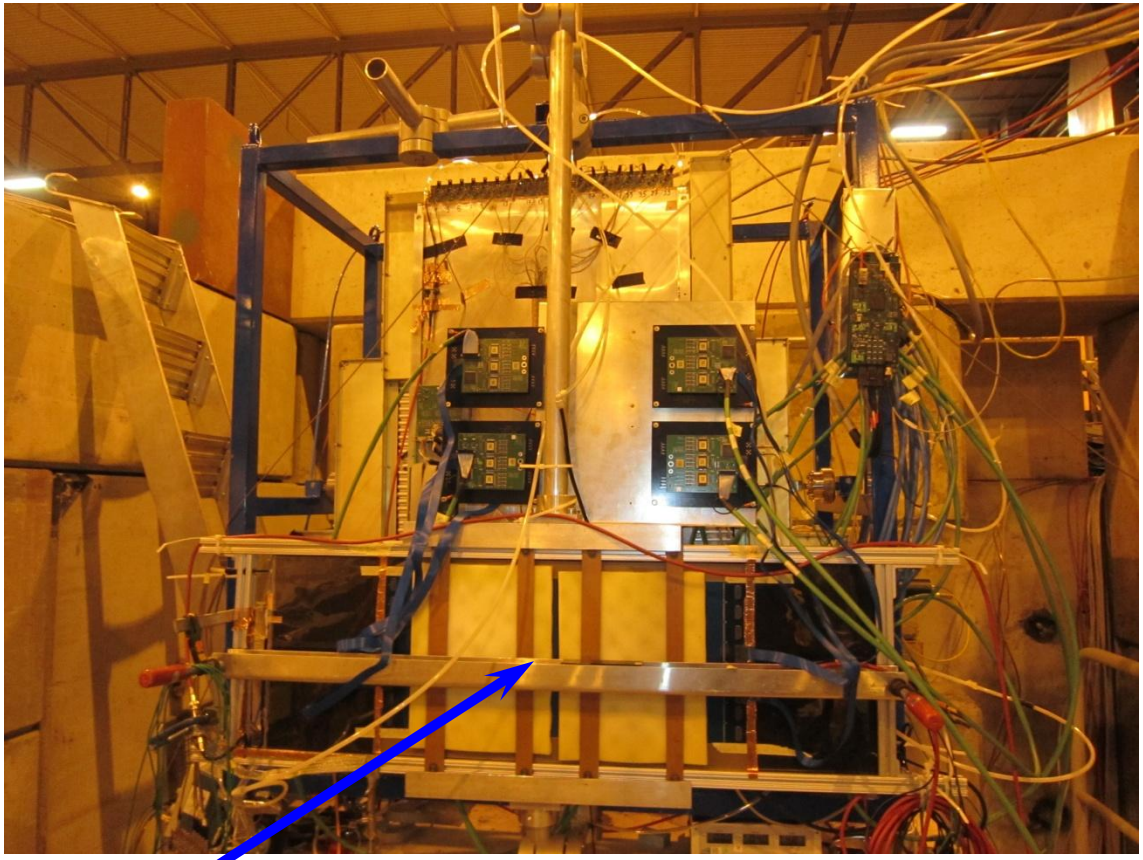


- Gas gap: 2 mm → 1.2 mm
- Resistive plate: float glass with ~1 mm thickness
- Dimension: 1 m × 0.36 m
- Gas flow zigzag through the chamber
- Gas: Freon/iC_4H_{10}/SF_6 94.7/5/0.3
- Readout Strip/Pitch: 1 mm/1.27 mm. **(read out both ends of strips)**
- Front End Electronics: ATLAS MDT mezzanine cards

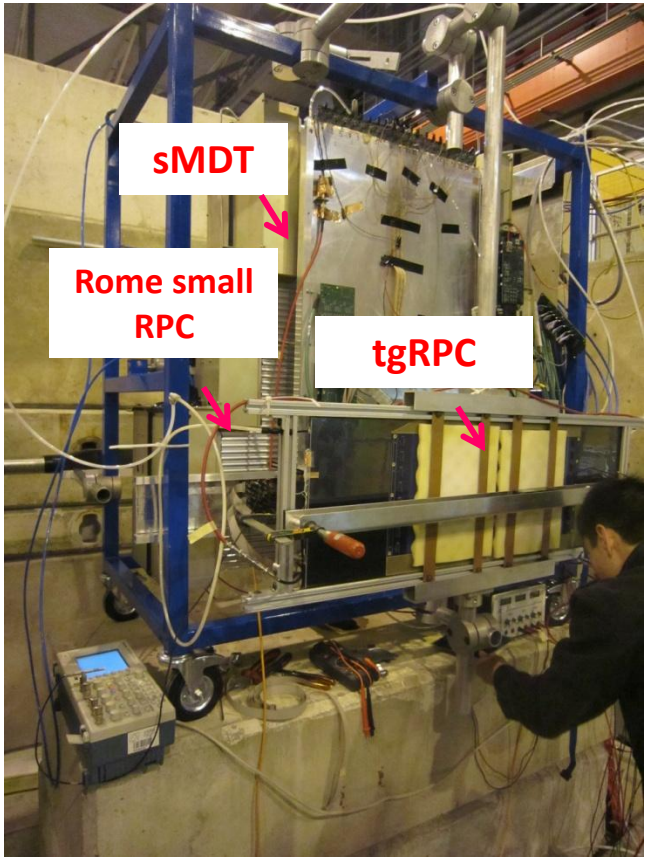
SPS H8 Beam Test Setup



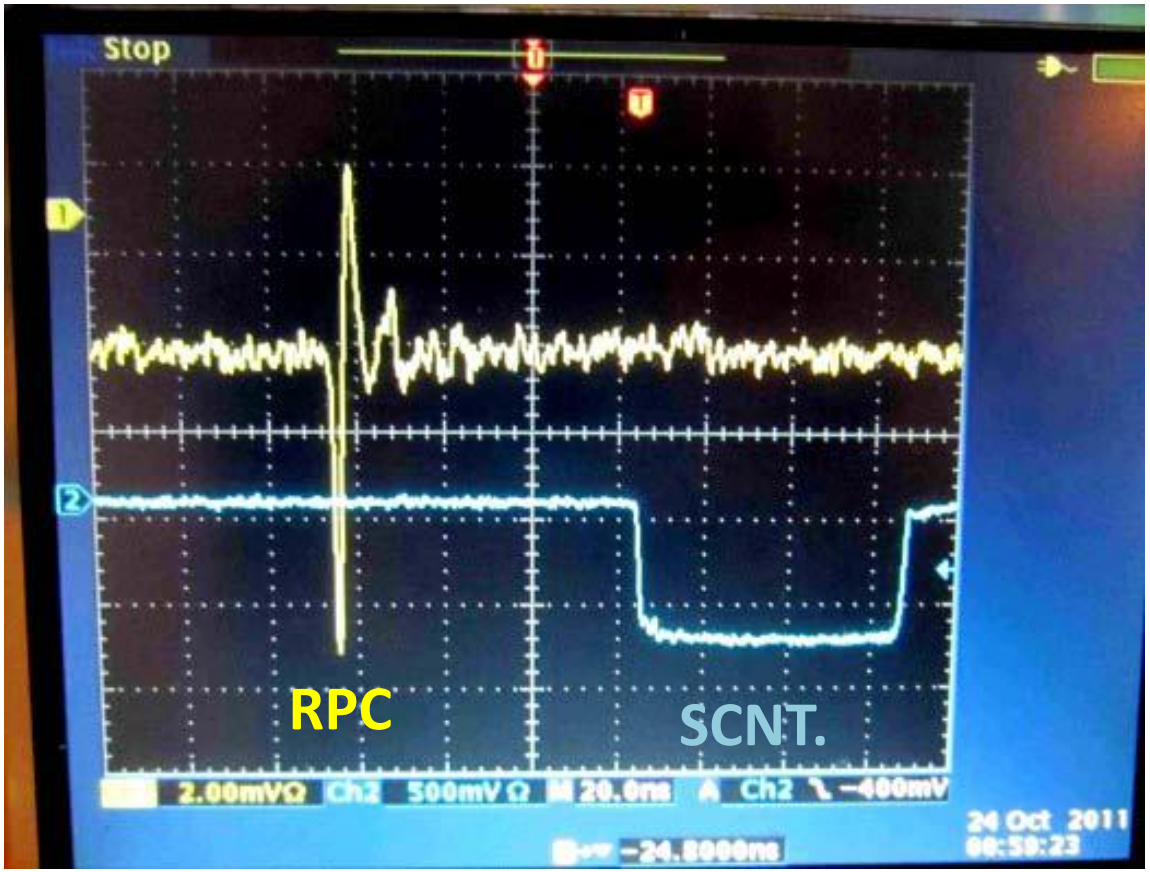
Beam Test setup



180 GeV/c μ beam



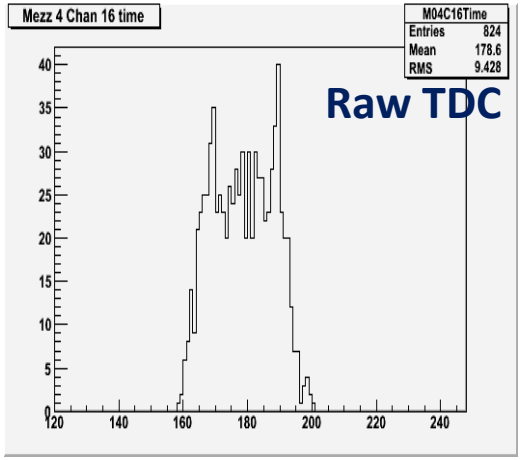
Typical Signal (Avalanche Mode)

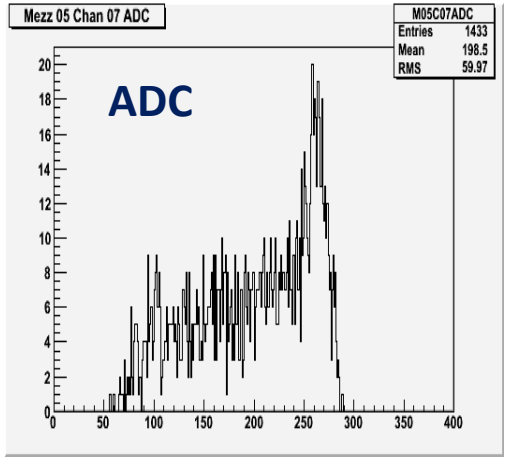


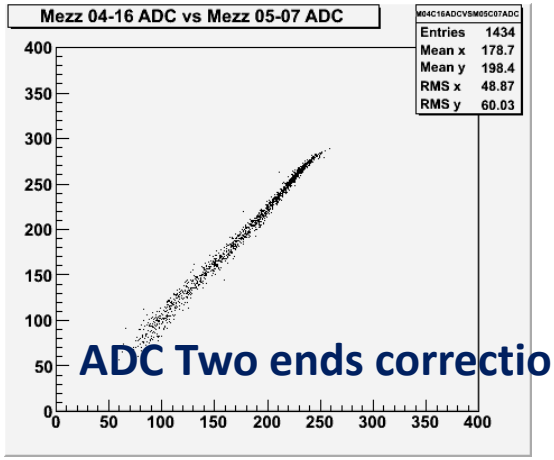
- HV=-6600V
- Signal read out from anode
- Amplitude without amplifier: few mV
- Prompt signal width < 5ns
- Prompt charge: few pC

General Performance

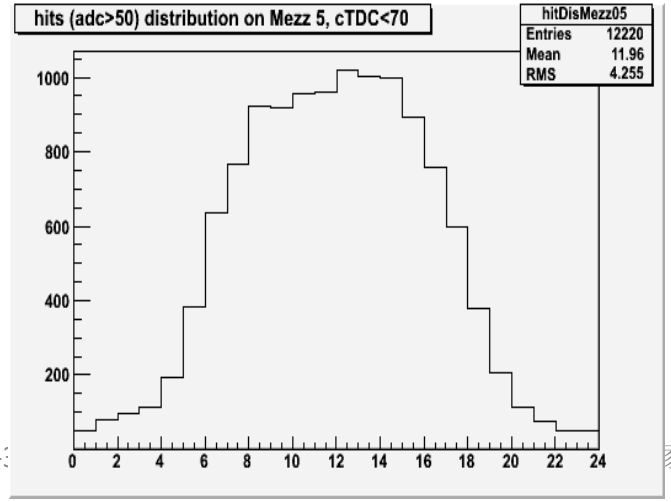
- **Raw ADC,TDC distribution**

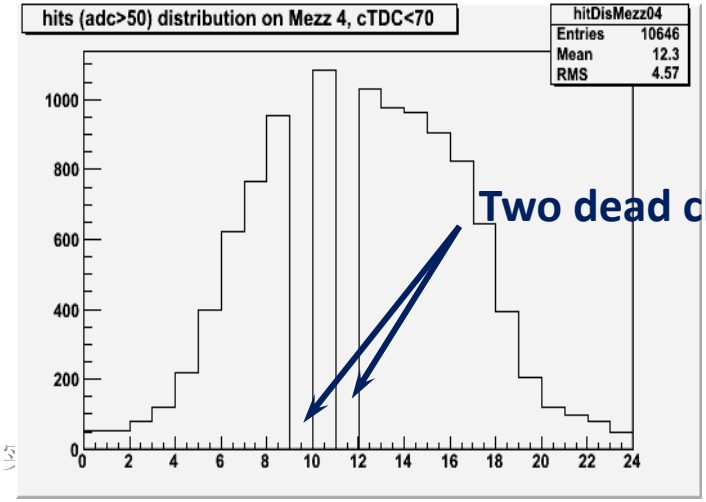






- **Hit Distribution from two ends (selected by small SCNT.)**





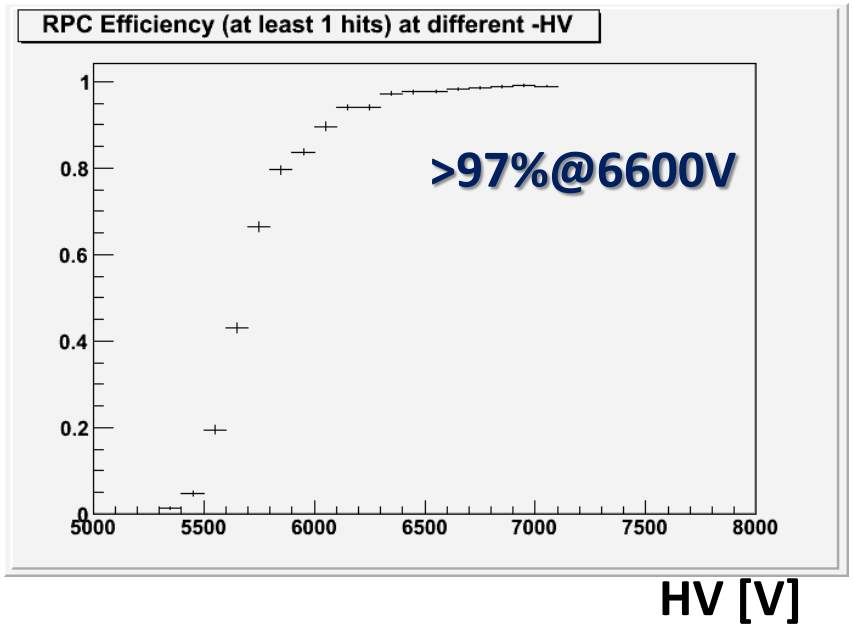
Efficiency & Hit Multiplicity

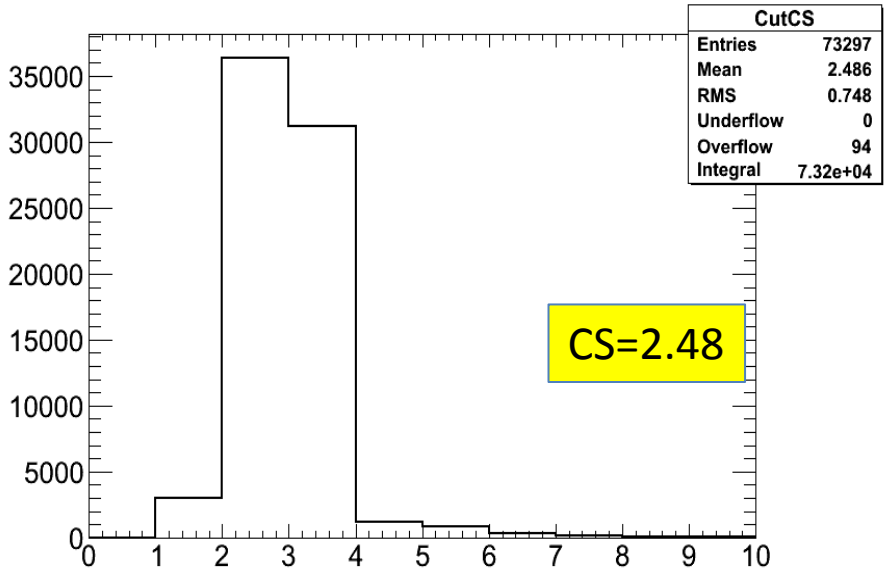
- **Efficiency:**

  # Events(hits!=0)/ # Small SCNT. Trig. Events

- **Hit Multiplicity:**

  ADC>50 && t<115

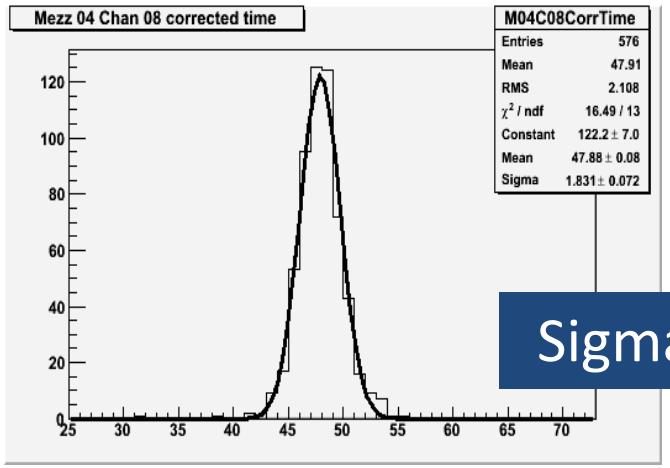


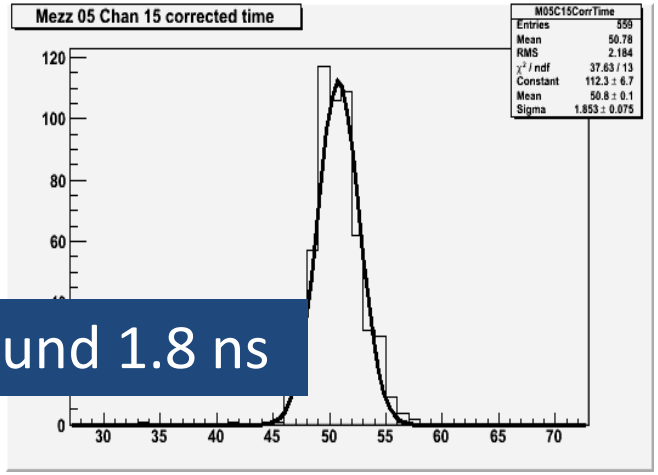


Effective Threshold	Multiplicity	Efficiency(>=1 hits)
-48.75mV	2.826	0.974 +- 0.003
-78.75mV	2.783	0.972 +- 0.002
-98.75mV	2.733	0.978 +- 0.002

Timing Performance

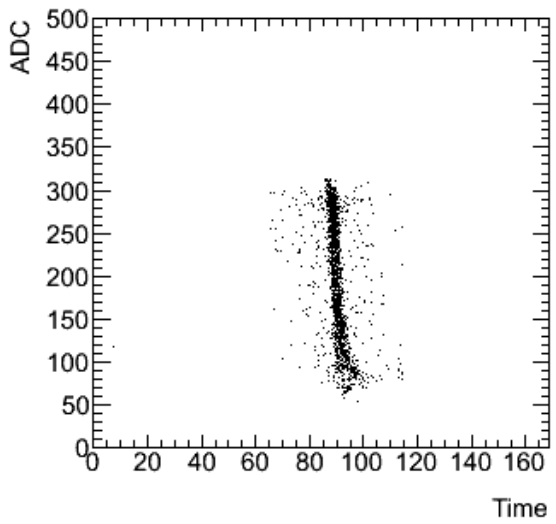
- **SCN.T Corrected Time from two ends**



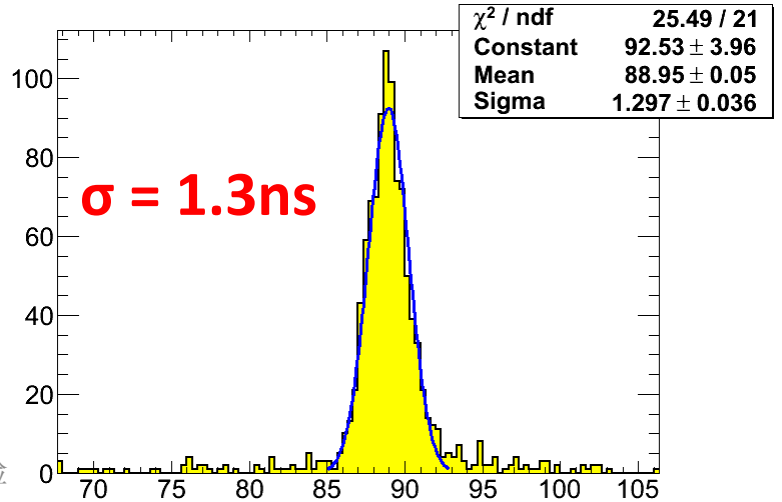


Sigma around 1.8 ns

- **T-A Correlation**

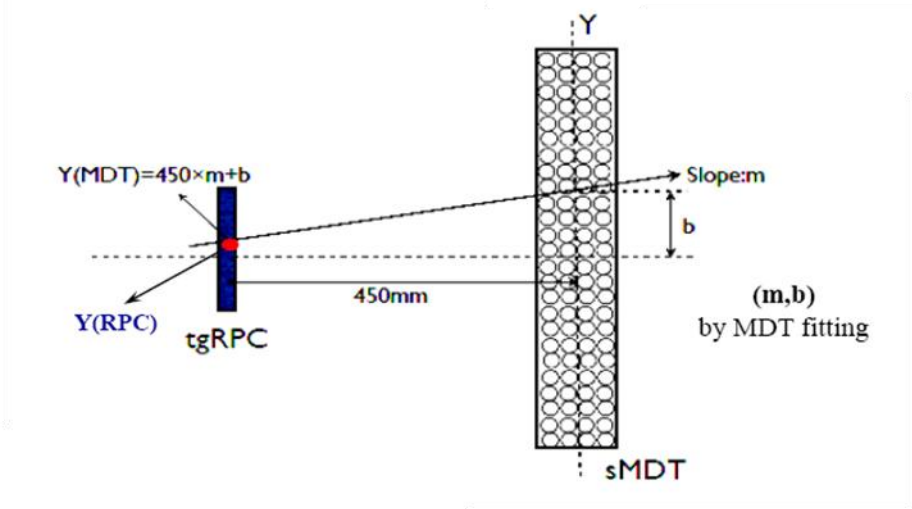


- **Timing After Slew Correction**



Spatial Resolution Study (I)

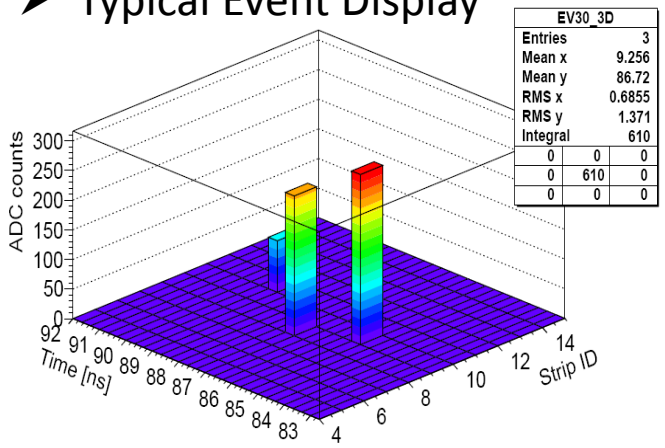
- **Residual Calculation** $\triangle Y = Y_{sMDT} - Y_{RPC}$
- **Predicted Hit position from MDT** $Y_{sMDT} = 450*m+b$

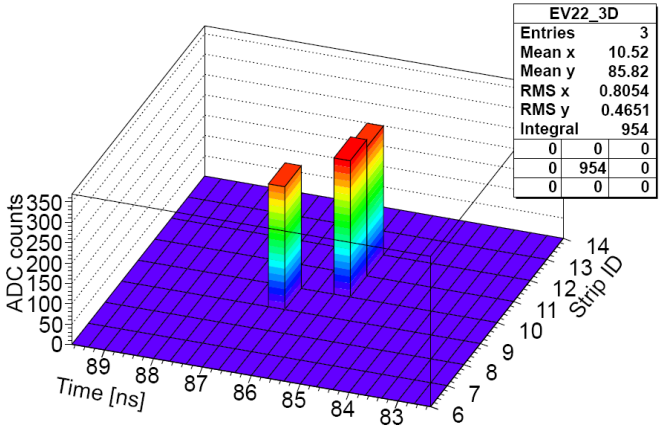


- **Three methods to reconstruct impact points on RPC**
  - Single Strip: Strip with Max. charge or Strip with Minimum time
  - Centroid Finding: $Y_{RPC} = \sum(72 - Strip_i) * adc_i * 1.27 / \sum adc_i$
  - Only use fast timing information: $Y_{RPC} = \sum(72 - Strip_i) * 1.27 / \#\ fired\ Strip$

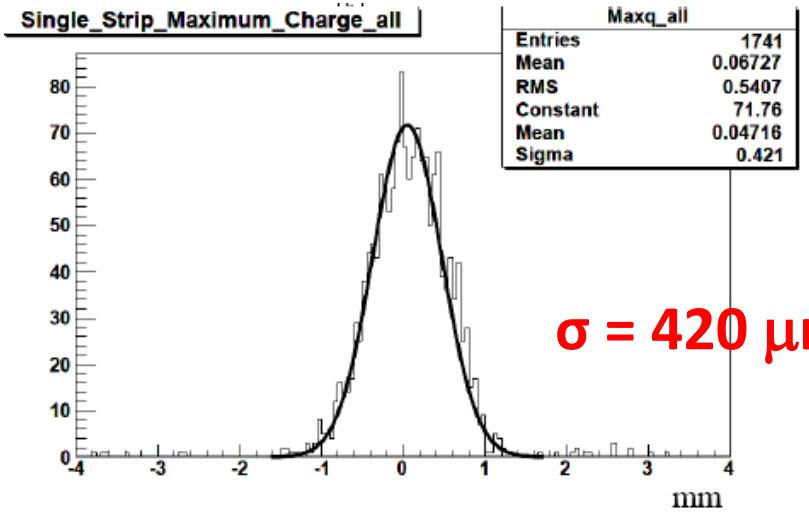
Spatial Resolution Study (II)

- Typical Event Display



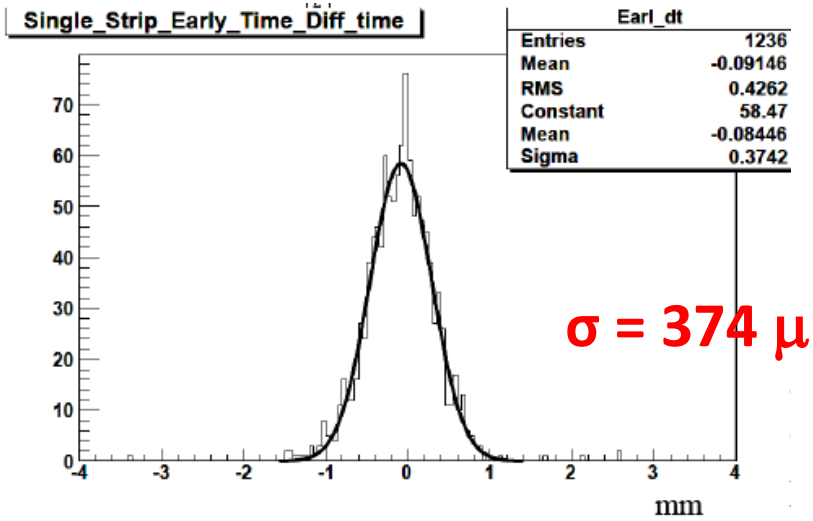


- Single Strip: MaxQ



σ = 420 μm

- Single Strip: MinT



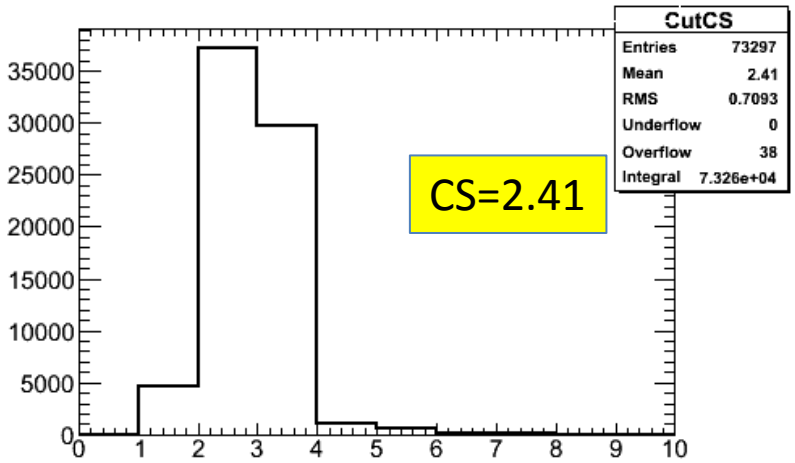
σ = 374 μm

No ADC,TDC calibration! Uncertainty from alignment and MDT precision ~100 μm included

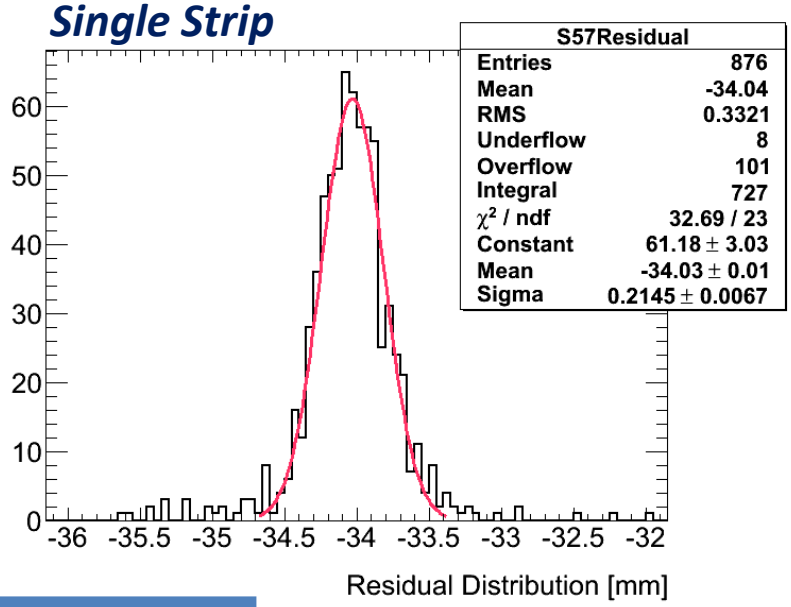
Spatial Resolution Study (III)

- Centroid

t< Minimum Hit Time+10 ns



Single Strip



Time Window [ns]	Cluster Size	Centroid Strip 57 σ [μm]	Centroid Mezz.7 (Strip49-72) σ [μm]
20	2.48	215±7	284±2
10	2.41	215±7	295±3
5	**2.36**	**236±8**	**306±3**
3	2.12	290±9	340±3
2	1.91	315±10	349±3
1	1.6	467±13	383±4

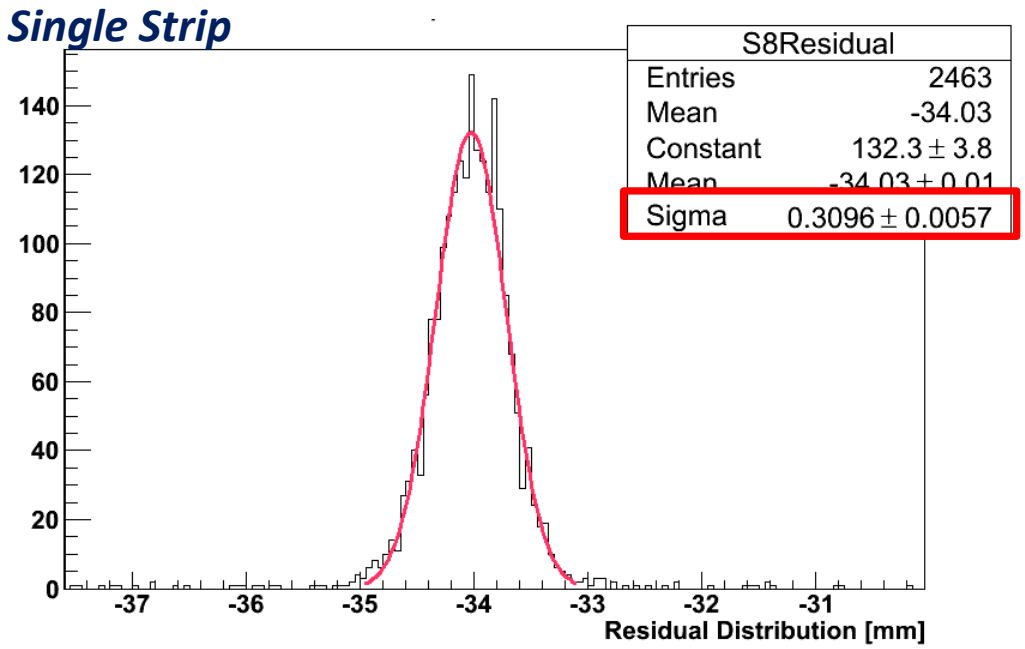
$$\sigma = \sqrt{\sigma_{RPC}^2 + \sigma_{sMDT}^2}$$

- < 200 μm Resolution for the RPC estimated from the deconvolution

Spatial Resolution Study (IV)

- Fast timing information for impact point location

  t< Minimum Hit Time+10 ns



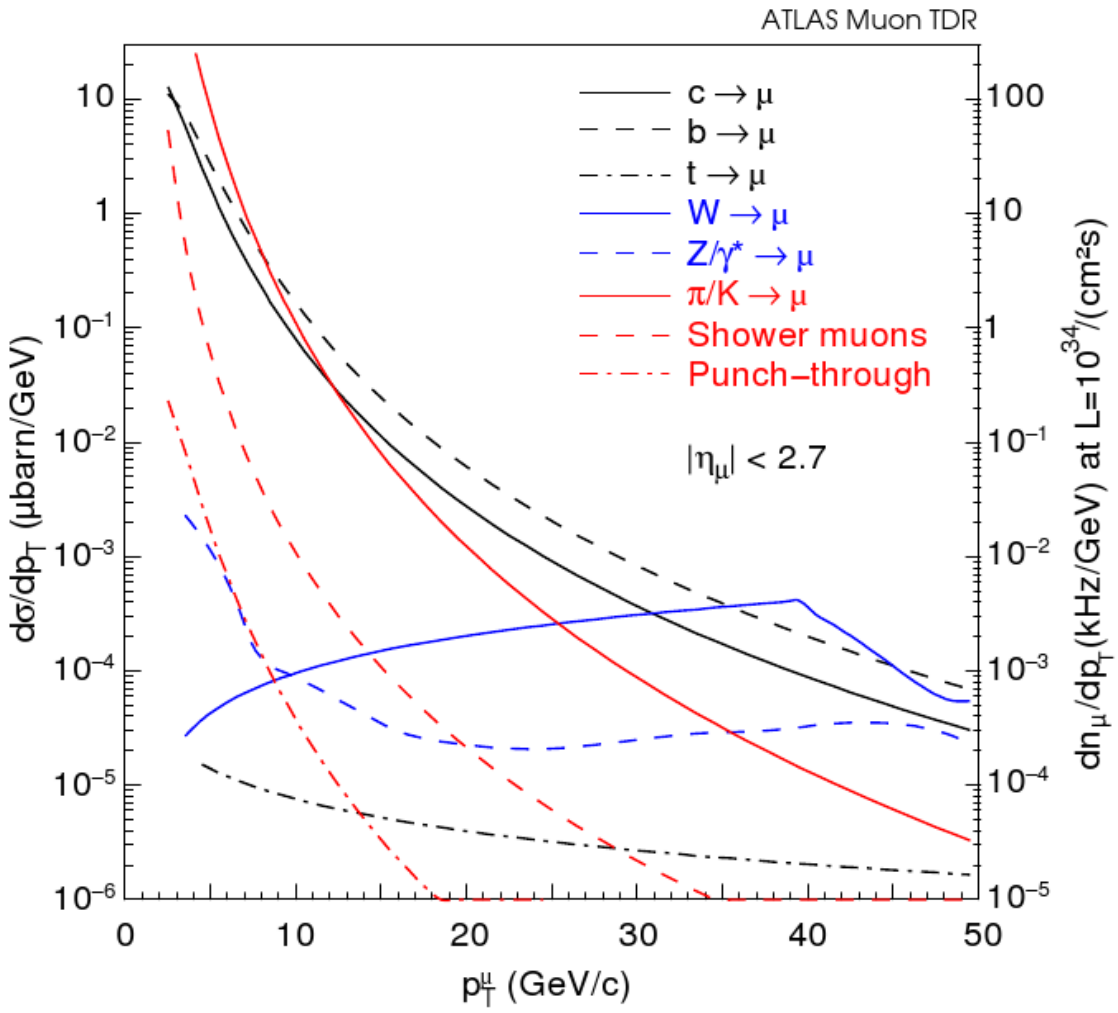
- CS=1 hit on the strip
- CS=2 hit in the middle of two
- CS=3 hit in the center strip
- Expected Resolution if CS=2 & 3 are favorable (**Strip Pitch)/2√12**

Conclusion

- Study of a thin gap RPC is motivated by the upgrade of ATLAS muon small wheel
- Beam test of the RPC with 1.2 mm gap shows good timing performance (less than 1.4 ns, measurement limited by Electronics precision)
- Low cluster size if read out from anode→ good for trigger purpose
- Spatial resolution less than 200 μm could be achieved by using centroid method with 1.27 mm readout pitch
- The good timing information could be used for trigger and online fast precision tracking (<0.3mm).
- Further study is needed: Alignment (crucial), TDC,ADC calibration …

Thank you !

backup


ATLAS Muon TDR
c → μ
b → μ
t → μ
W → μ
Z/γ* → μ
π/K → μ
Shower muons
Punch–through
|η_μ| < 2.7
dσ/dp_T (μbarn/GeV)
dn_μ/dp_T (kHz/GeV) at L=10^34/(cm²s)
p_T^μ (GeV/c)
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
100
0
10
20
30
40
50