Beam test results of thin gap RPC

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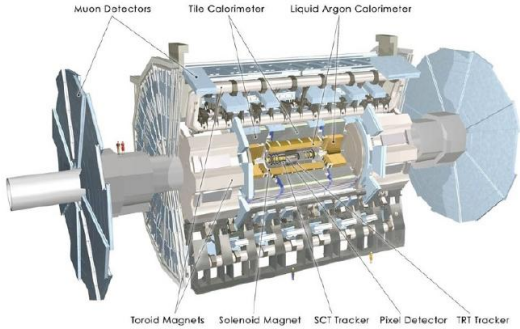
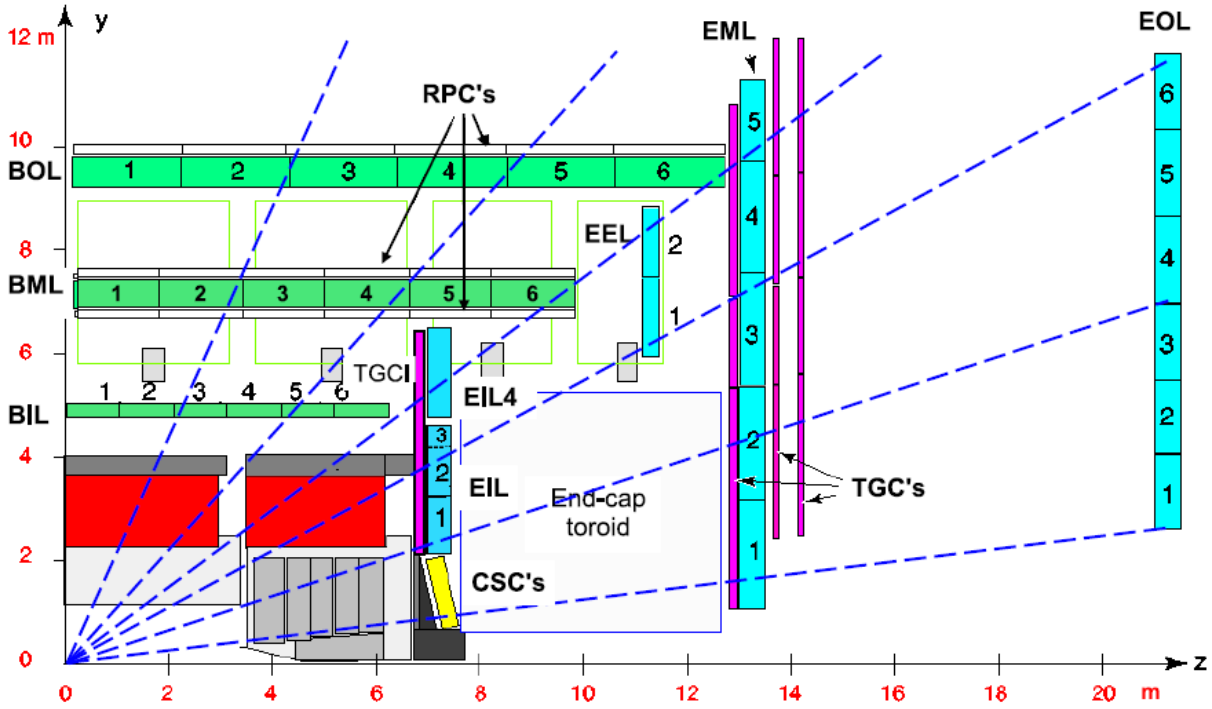
Outline

- Introduction
- Setup
- Data analysis
- Conclusion

Introduction

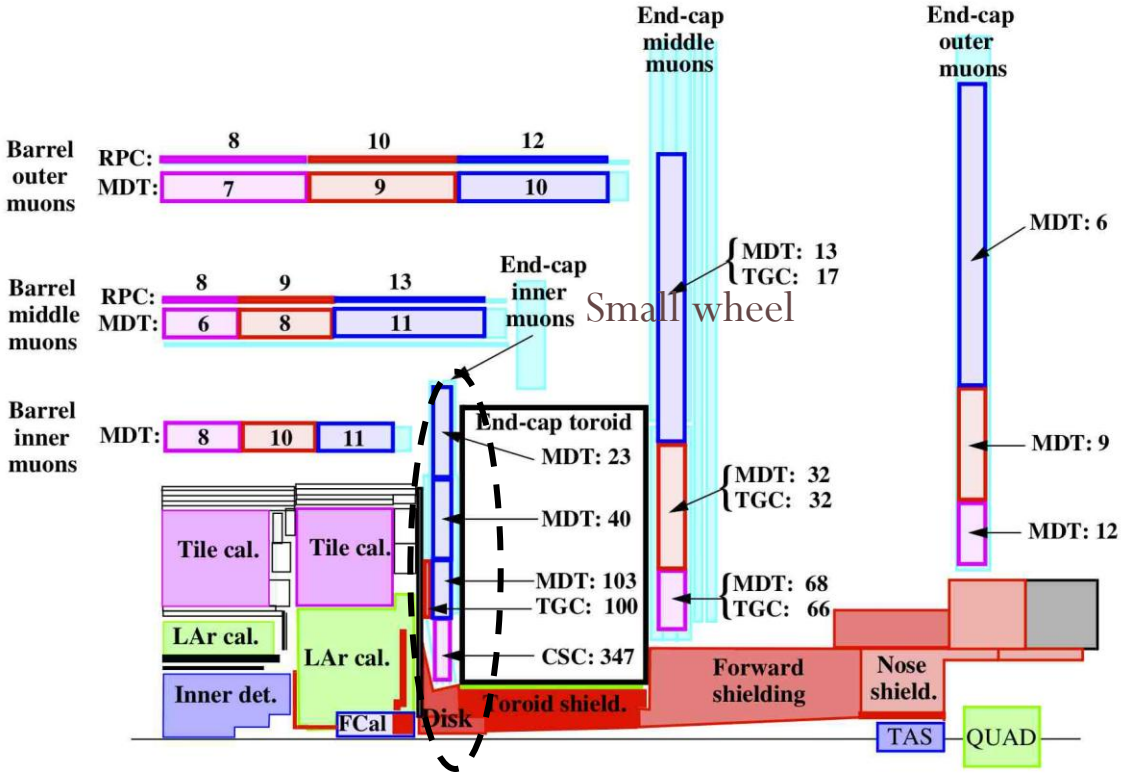
ATLAS muon spectrometer



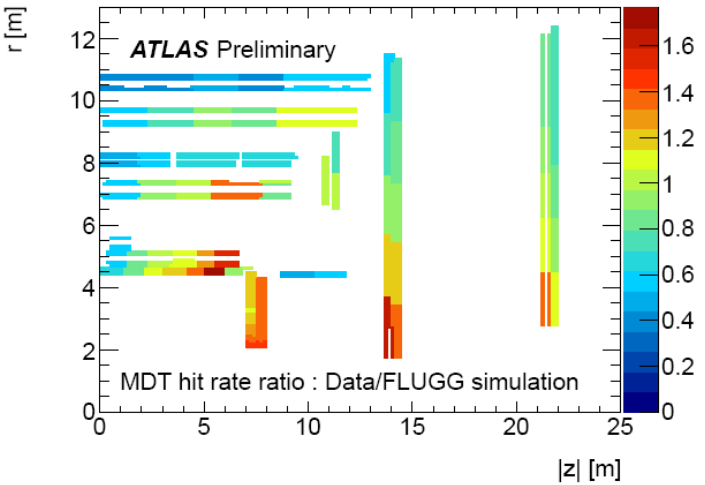


Introduction

Count rates in ATLAS for $L=10^{34}\ cm^{-2}s^{-1}$



Innermost rate close to 2kHz/cm^2

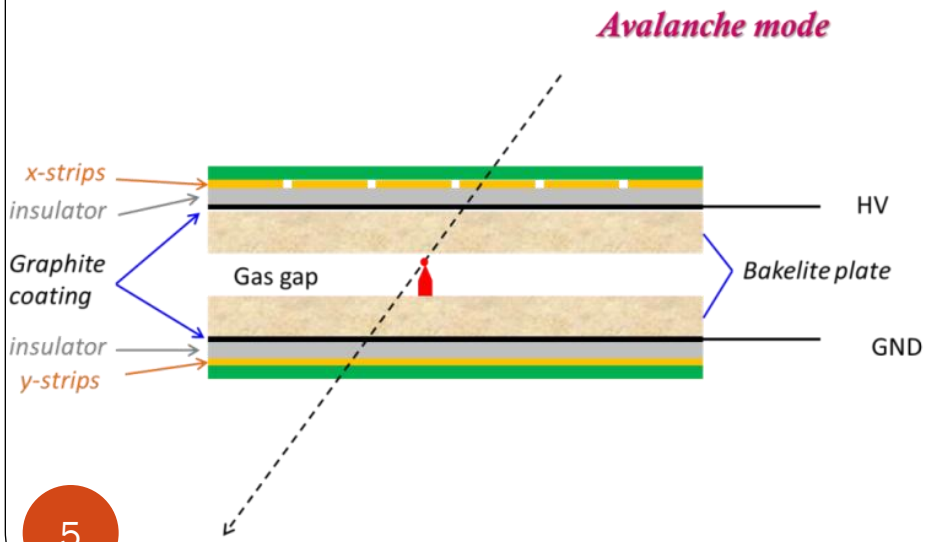


Introduction

- The prospect of reaching luminosity of greater than 10^{34} $cm^{-2}s^{-1}$ for the LHC after 2018 shutdown requires the muon system to be upgraded for L1 trigger

- Provide extra trigger within 5ns time resolution in inner station → eliminate fake trigger for high p_T (>20GeV)
- Improve p_T resolution → needs <1mrad point resolution
- Withstand the harsh environment near the beam pile

One of the proposal: tgRPC+sMDT



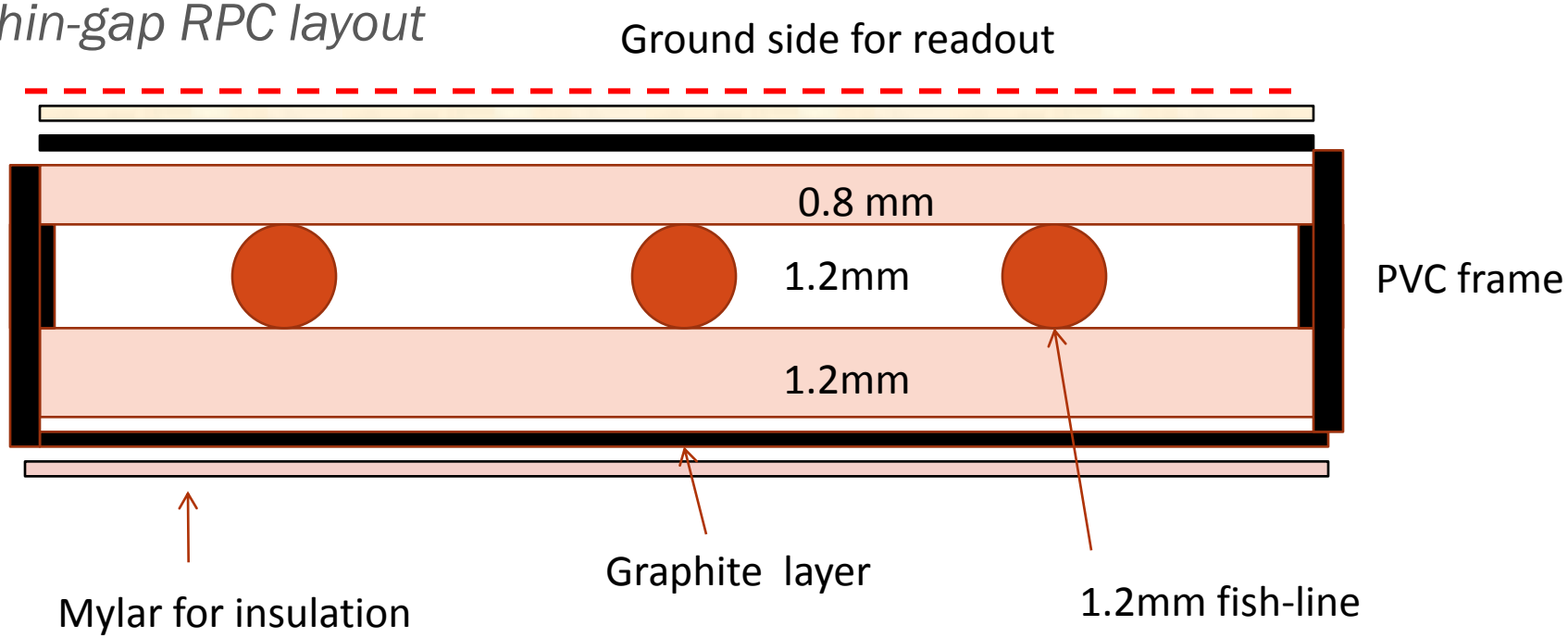
- Thin-gap RPC design:
  - Gas gap: 2 mm → 1mm
  - Graphite layer: 100 KΩ/sq → few MΩ/sq
  - r/o strip: 3cm → 1-few mm
  - Bakelite plates: 10^{12} Ω·cm,2mm → 10^{10} Ω·cm,1mm

Introduction

- Scope of the thin gap RPC beam test:
  - Test the timing performance
  - Demonstrate sub-mm spatial resolution by using fine strips
    - *Note: sub-mm position fluctuation possible for RPC. Previous Study by TsingHua University. J.Ye et al. NIM A 591 (2008)*
  - Study the efficiency and cluster size is for both HV polarization, with respect to the readout strip

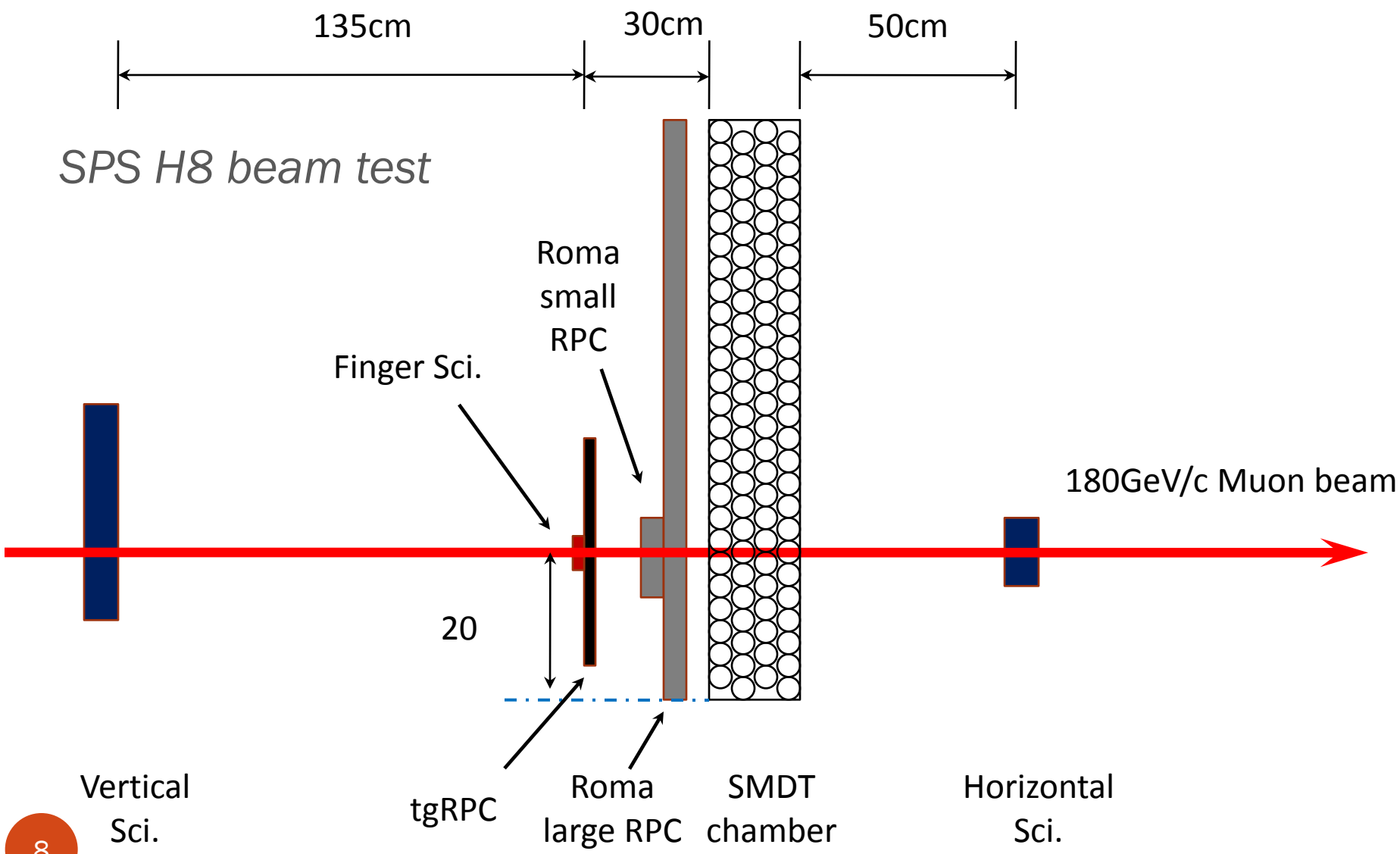
Setup

Thin-gap RPC layout



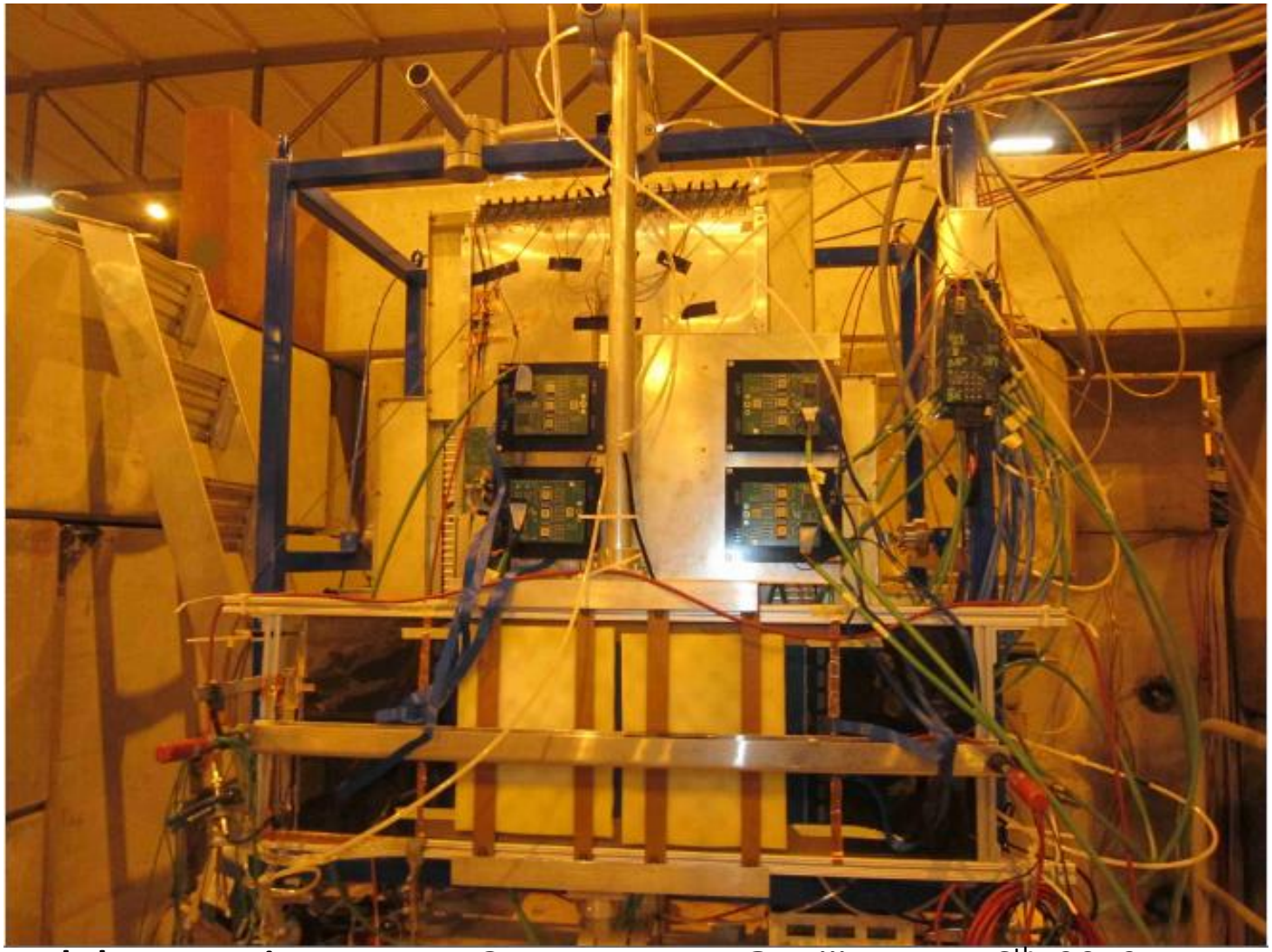
- For UM Chamber, 72 strips (length: 50cm) at the ground side connected to 3 mezzanine cards to readout from the both side
  - strip pitch 1.27mm, strip width 1.0mm
  - One mezzanine card contains 24 readout channels: 3 Octal ASD (Amplifier/Shaper/Discriminator), a single 24-channel TDC.

Setup


135cm
30cm
50cm
SPS H8 beam test
Roma
small
RPC
Finger Sci.
180GeV/c Muon beam
20
Vertical
Sci.
tgRPC
Roma
large RPC
SMDT
chamber
Horizontal
Sci.

Setup

Thin Gap RPC and MDT at H8 Test Beam



Setup

- Event and Hit Selection:
  - Small scintillator (2 layers 2cm^2 area) must be fired
  - ADC > 50 counts

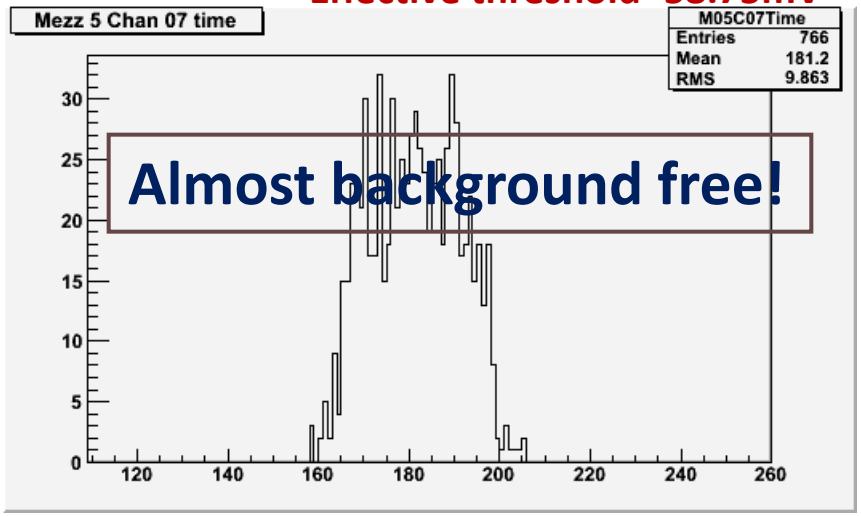
Thin-Gap RPC Signal at -6600V

Negative HV are applied to Thin-gap RPC chamber

TDC&ADC Distribution

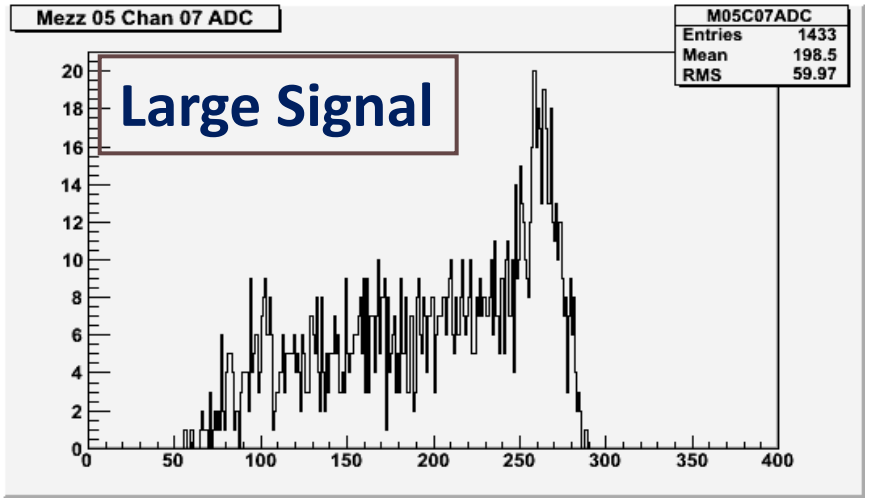
Time Distribution

Effective threshold -58.75mV

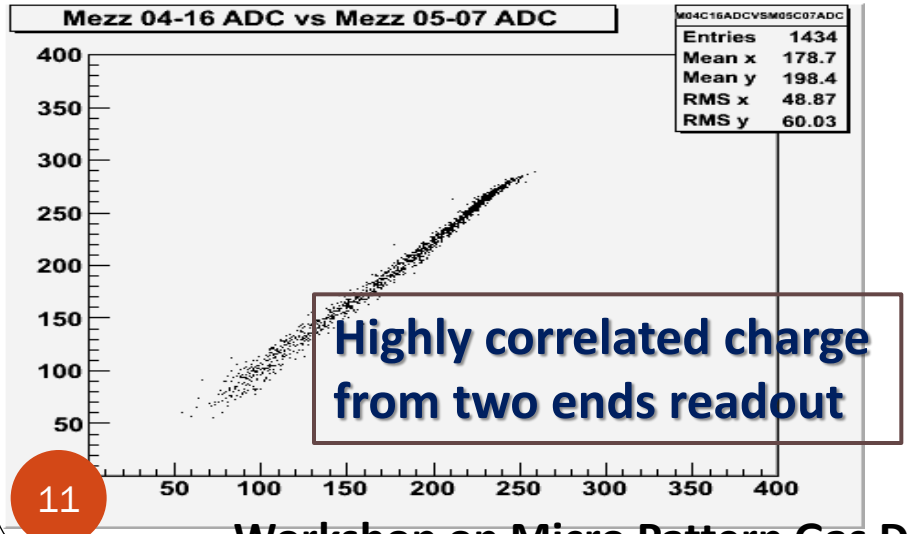


ADC Distribution

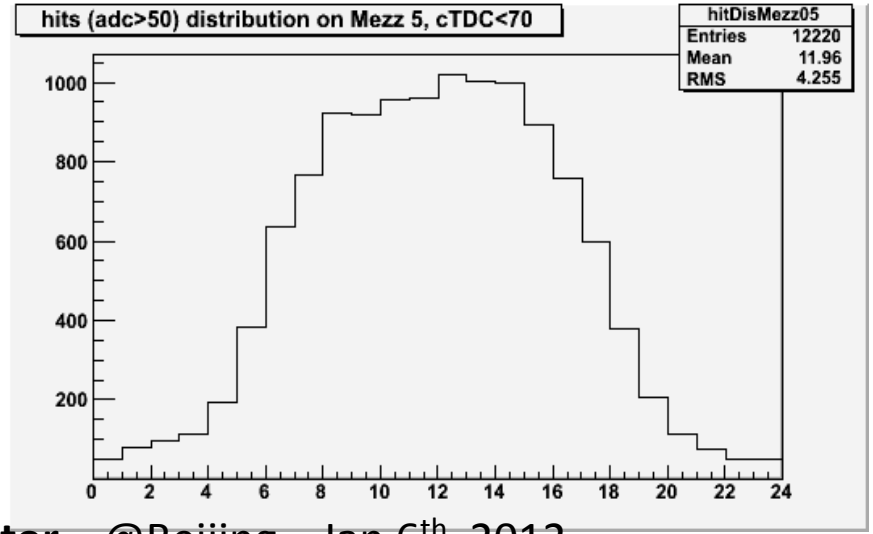
Effective threshold -108.75mV



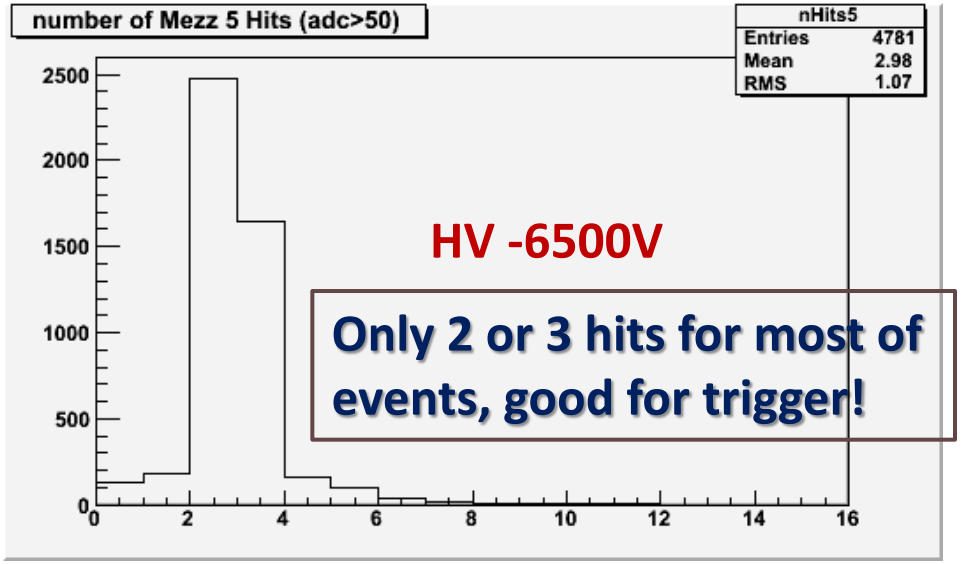
ADC Distribution from 2 ends readout



Hit Distribution in one Mezzanine card

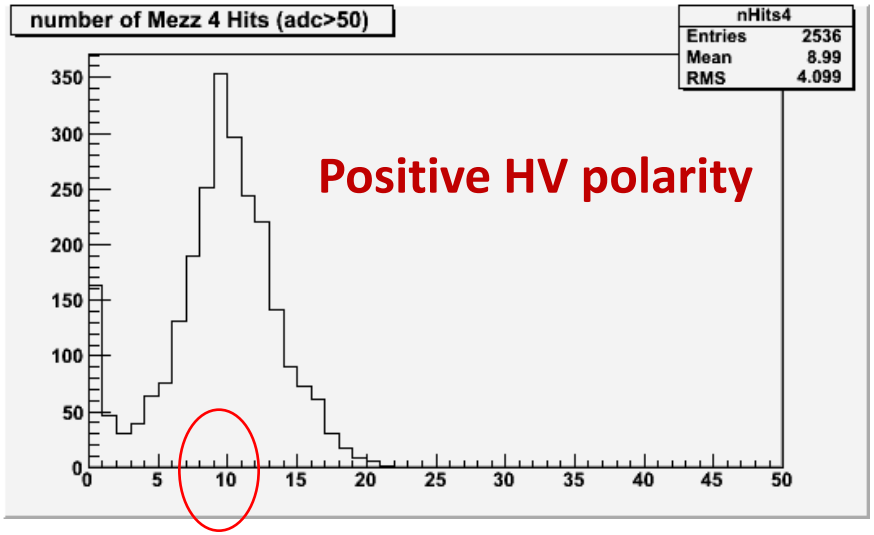


Multiplicity

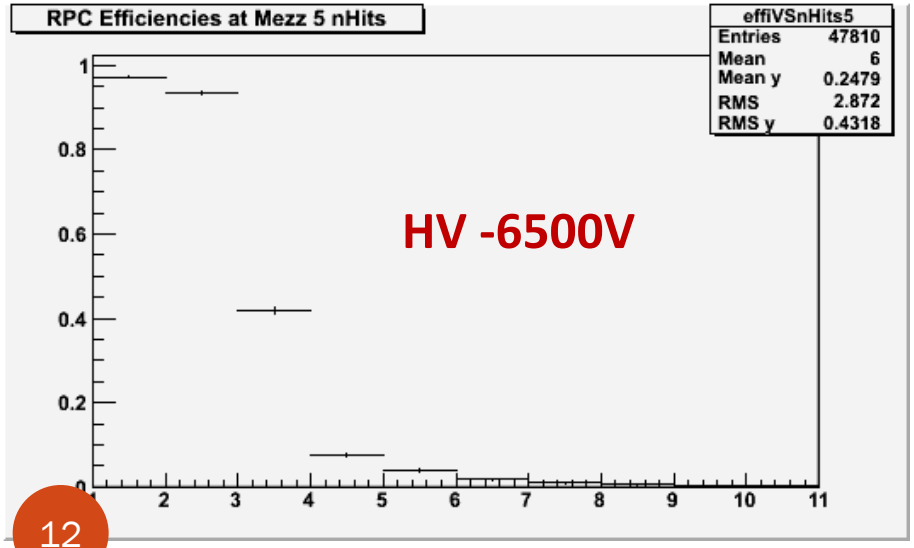


HV -6500V

Only 2 or 3 hits for most of events, good for trigger!



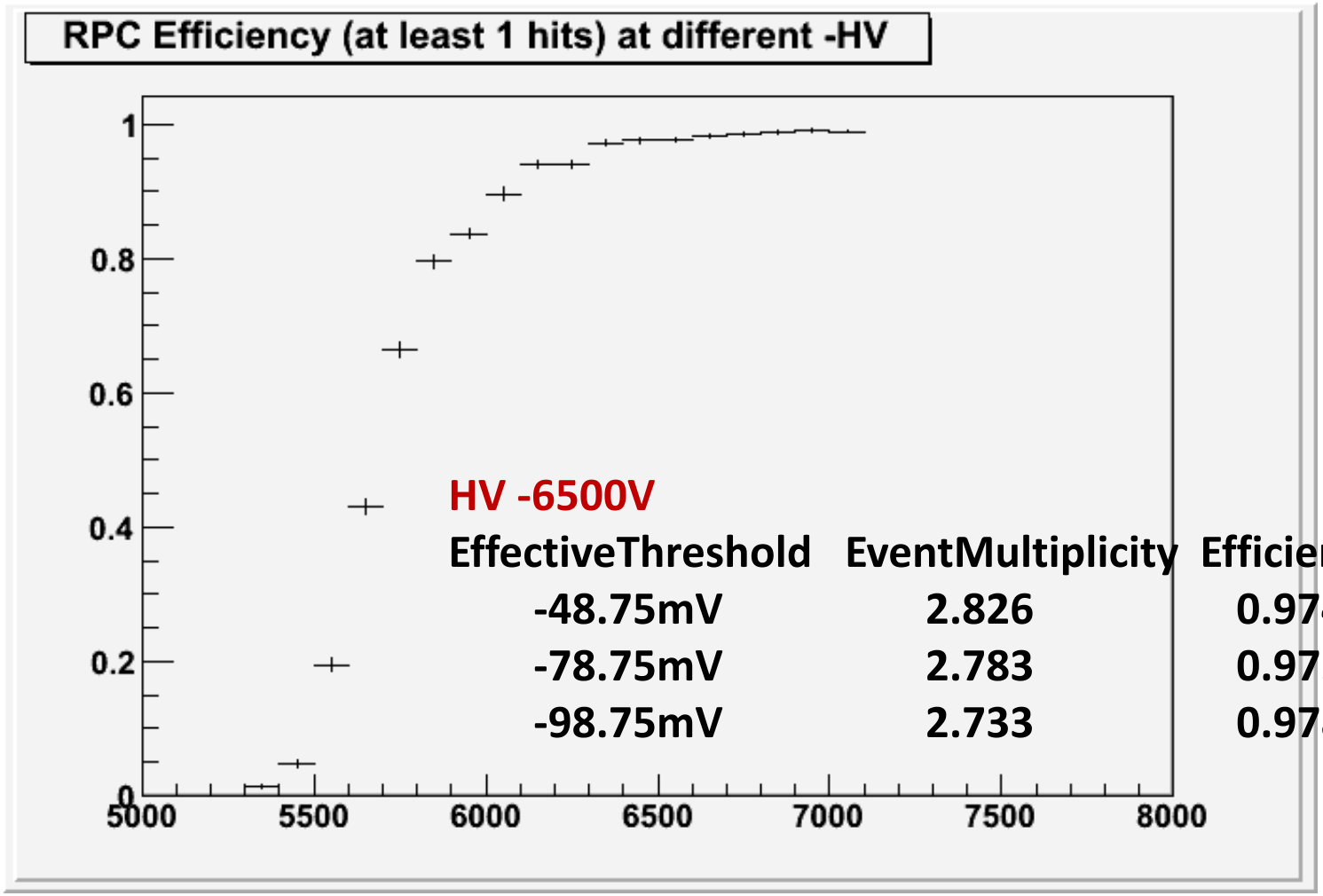
Positive HV polarity



HV -6500V

Efficiency == Fraction event with at least n RPC hits over number small scintillators are fired

Efficiency at Different Negative HV

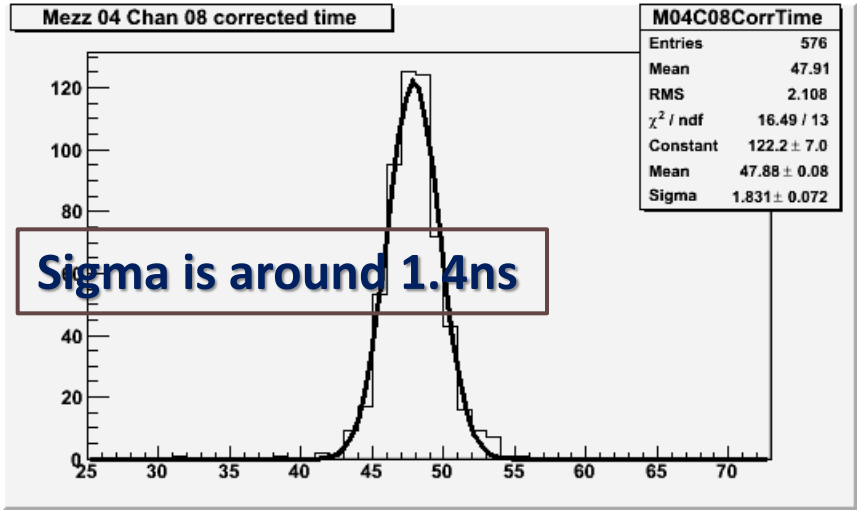


HV -6500V

EffectiveThreshold	EventMultiplicity	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

Time Resolution

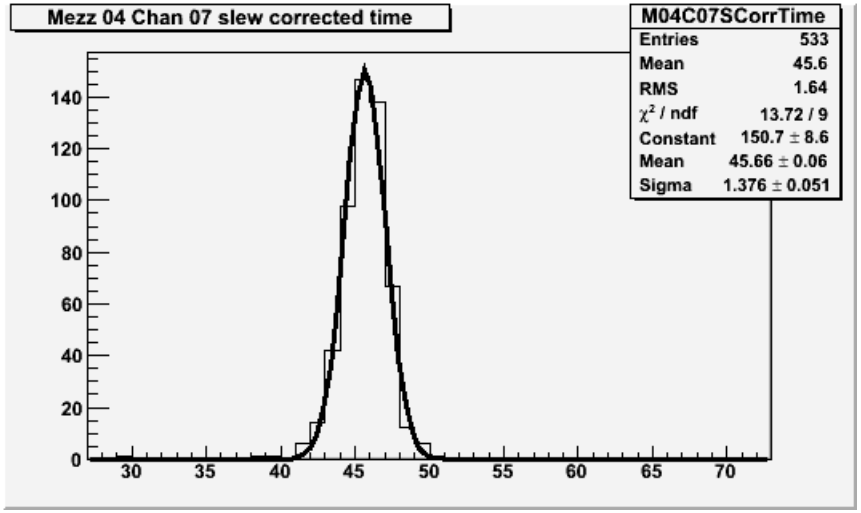
Time resolution corrected by scintillator



Sigma is around 1.4ns

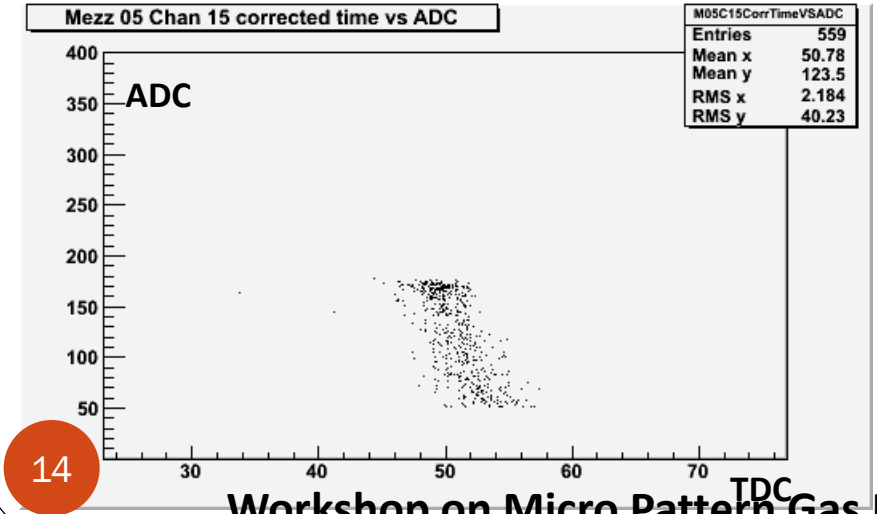
- **HV -6500V**
- **Effective threshold -48.75mV**
- **Charge integration gate 11ns**

Time resolution corrected by TA Distribution



Sigma is around 1.1ns!

T&A Distribution



Slew correction from single channel, all channels use same correction

Residual Measurement

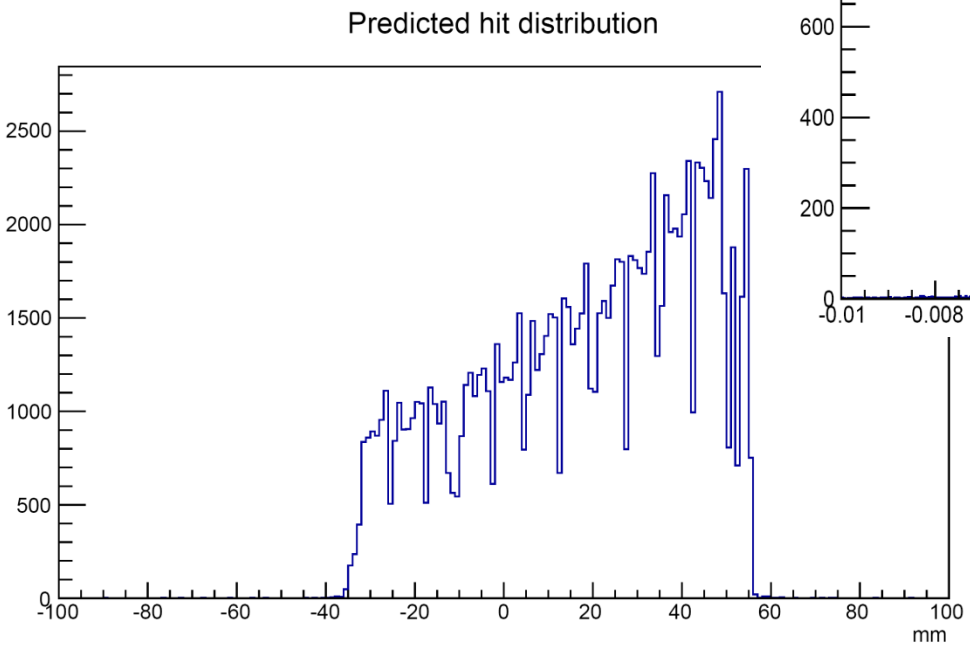
- Event selection: t<115&&adc>50&Hit(sMDT)
- Anaylsis is done w/o any adc and tdc calibration
- Calculation of Residual between UM RPC and MDT (y axis)

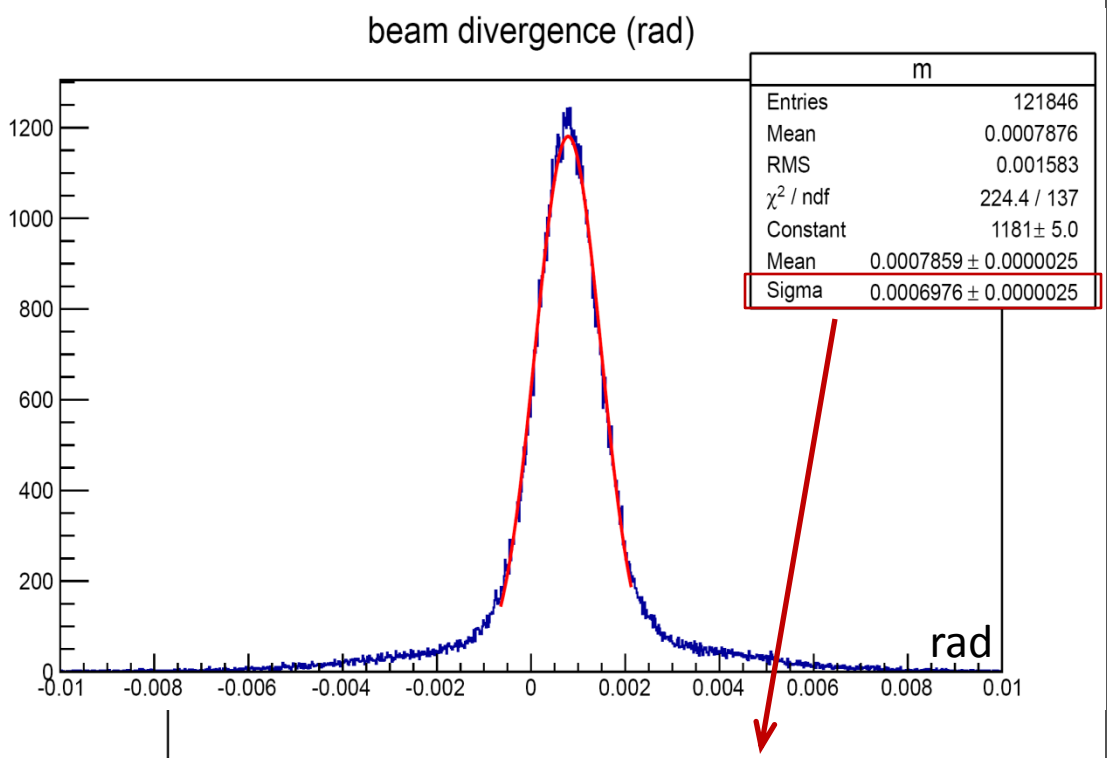
  ResidualY= PredictedY(MDT)-ReconstructedY(RPC)

- PredictedY=360*m+b
- Three kind of calculations of hit point on UM RPC chamber are performed:
  - ✓ Maximum Charge Strip finding $ReconstructedY=(72-Strip_{MaxQStrip})*1.27$
  - ✓Earliest Arrival Time finding $ReconstrucedY=(72-Strip_{early\ time})*1.27$
  - ✓ Centriod finding $ReconstrucedY=\sum(72-Strip_i)*adc_i*1.27/\sum adc_i$

Beam Profile & Divergence

Beam Profile



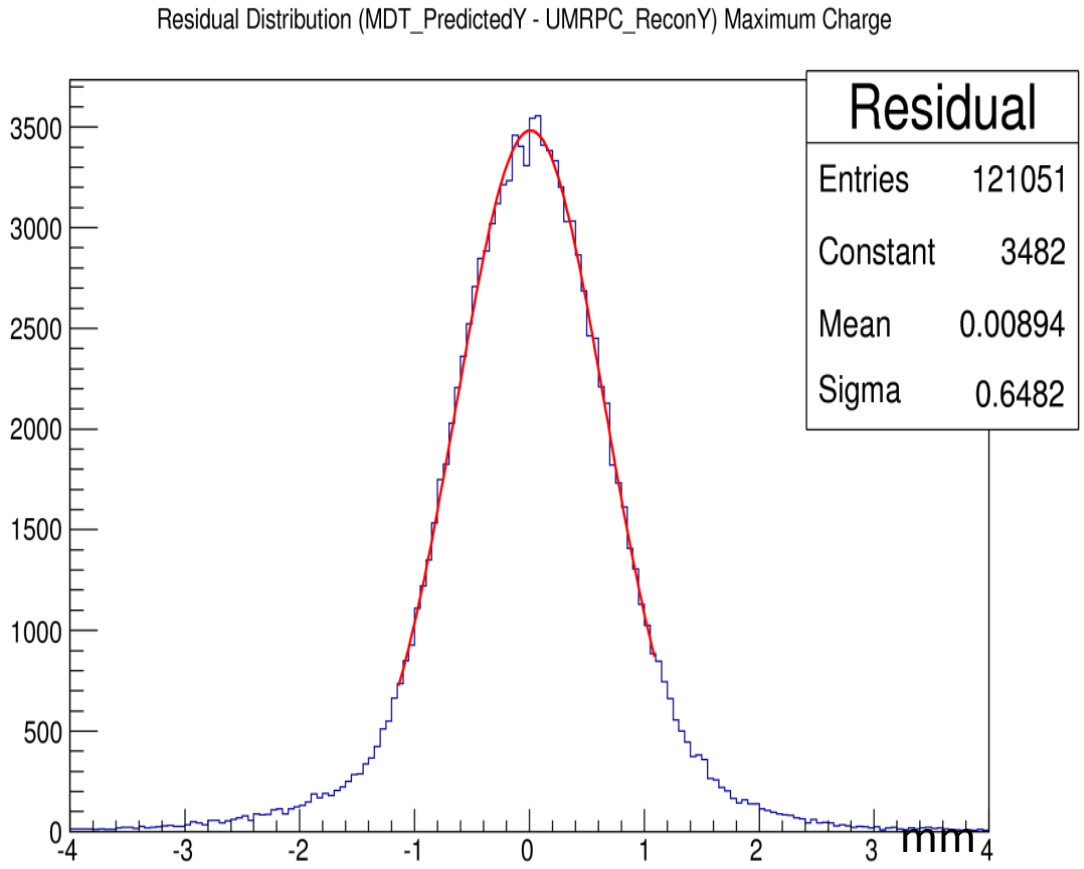


σ=0.7mrad

MDT angular resolution + beam divergence

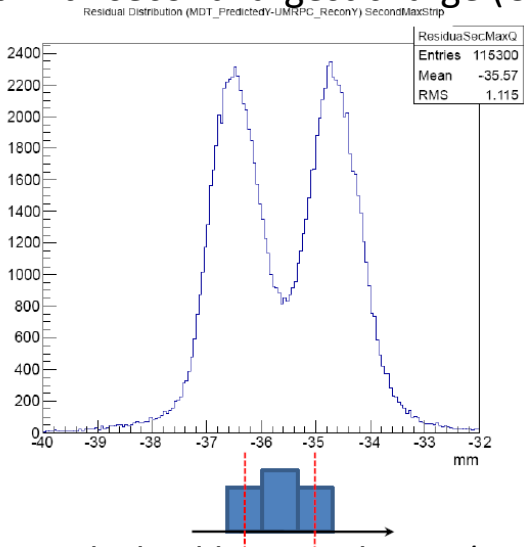
Residual Distribution I (Maximum charge)

- Strip with maximum charge is used to calculate the hit position on UM RPC

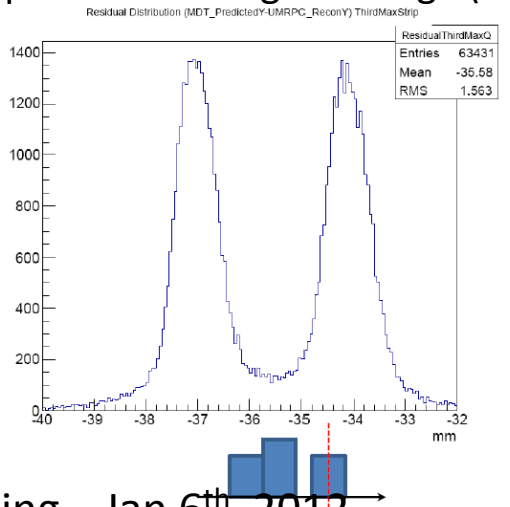


Global Residual Distribution

Strip with second largest charge (CS>=2)

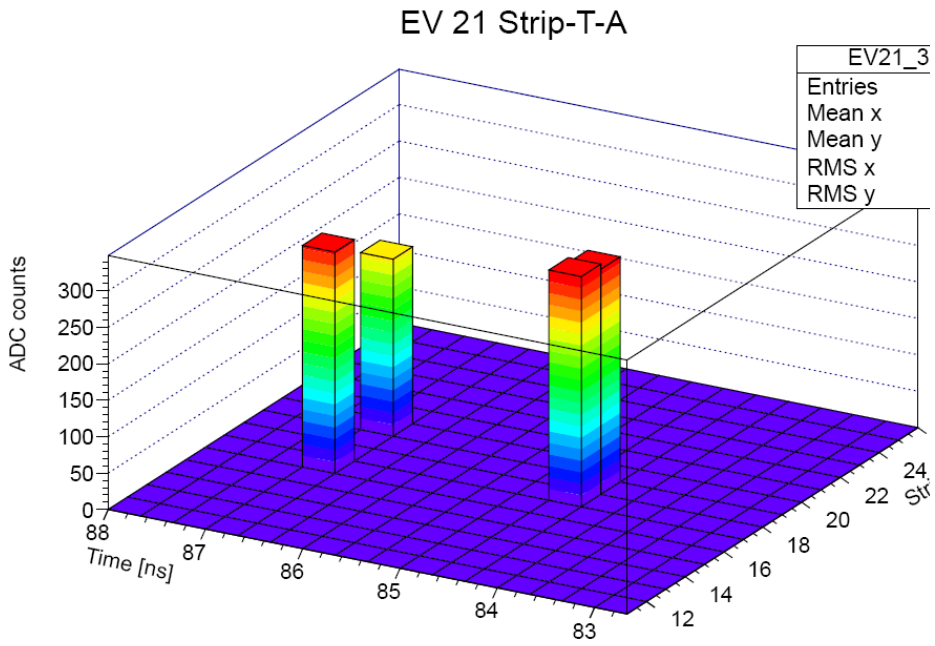


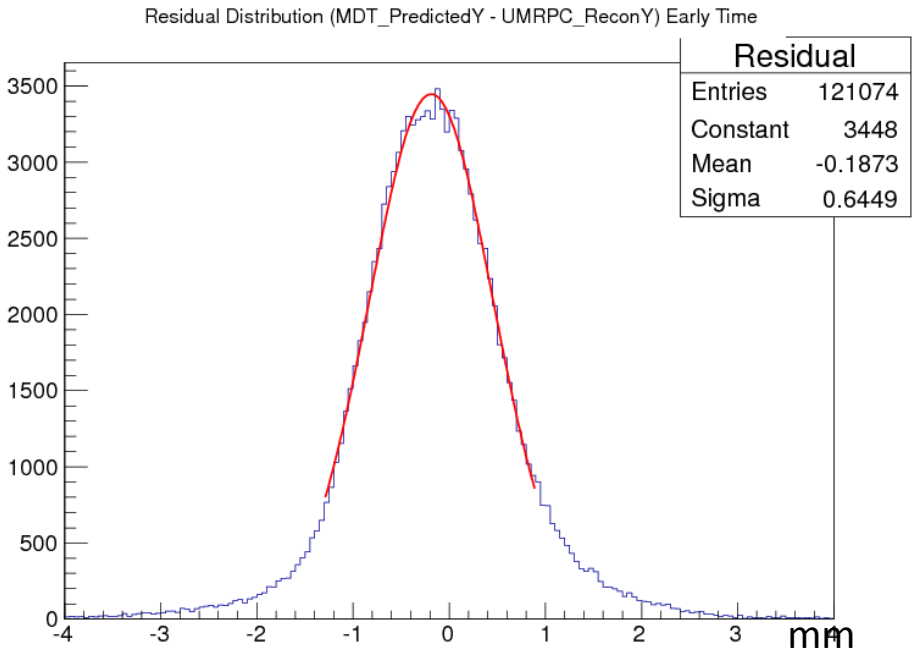
Strip with third largest charge (CS>=3)



$$\sigma_{tot} = \sqrt{\sigma^2_{UMRPC} + \sigma^2_{angular} + \sigma^2_{MDT}}$$ ~650 μm

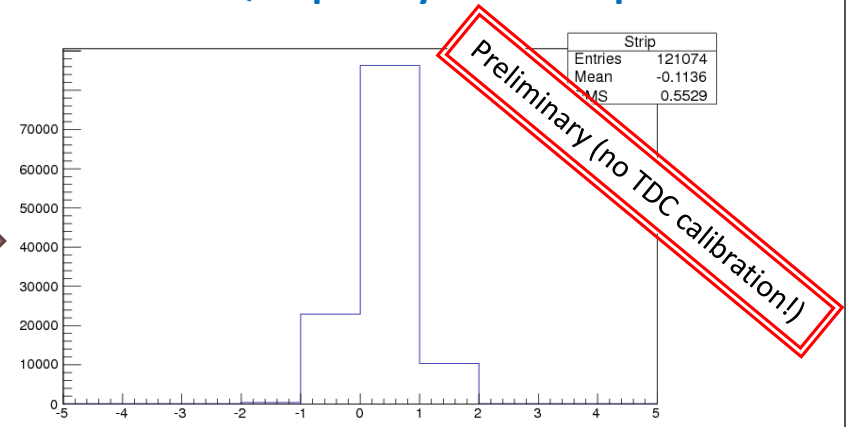
Residual Distribution II (Earliest arrival time)





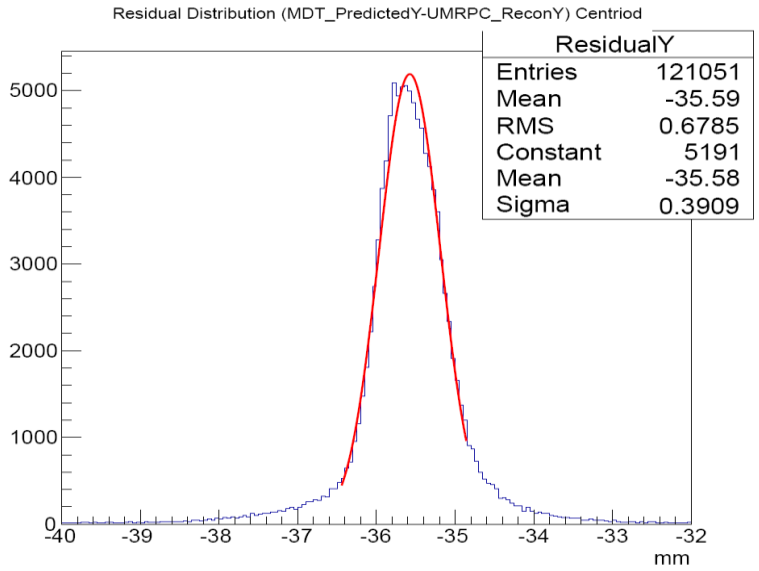
- Select Strip with Earliest signal arrival time to reconstruct the position
- Overall space resolution: **σ=645 μm**
- Check whether the strip with maximum charge are the earliest arrival one or not
  - Most of the strips with biggest charge are the same as the ones with the earliest signal arrival time

MaxQStrip-EarlyArrivalStrip

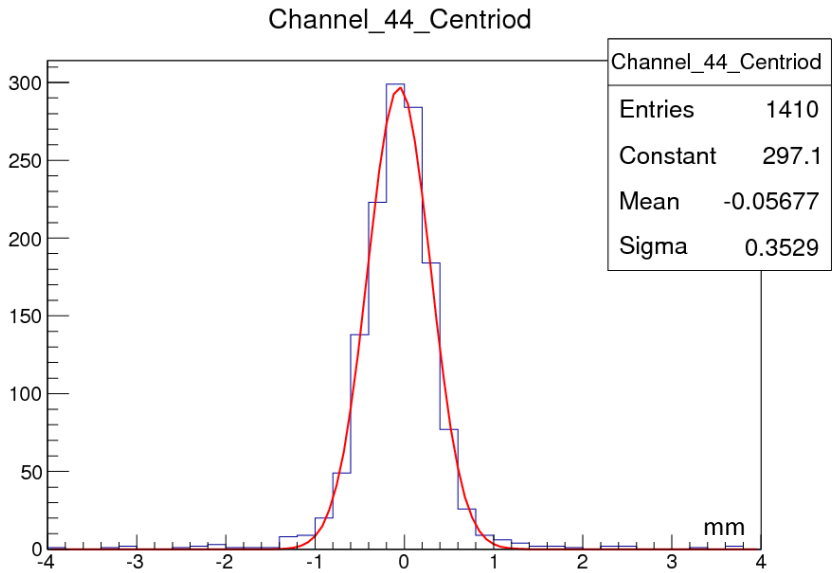


Residual Distribution III (Centriod)

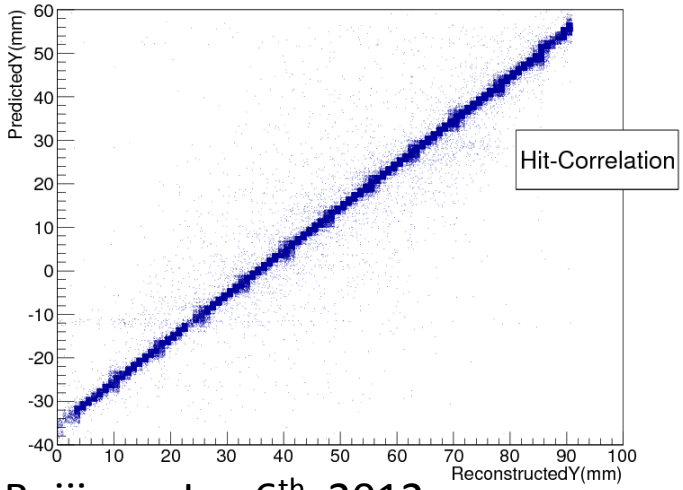
Global Residual Distribution



Local Residual (strip 44)Distribution



- Reconstructed position are calculated from the centriod of all hits
- Single strip overall space resolution: **σ=350 μm**
- Global space resolution: **σ=390μm**



Conclusion

- **UM RPC 1.2mm gas gap readout by 1.2 mm pitch strips**
  - Large signal and almost background free;
  - Highly correlated charge measurements from two ends as expected;
  - Low event multiplicity (2 or 3 hits per event)
  - Very high plan efficiency (should close to single strip efficiency), around 98% with HV -6500V;
  - Good time resolution with/without slew correction;
  - Without explicit adc and tdc calibration, global space resolution ~ 650 μm is achieved both from maximum charge finding method and earliest arrival time find method
  - Most of the strips have the earliest signal arrival time are corresponding to the ones with maximum charge (preliminarily)
  - Charge centriod method give the UM RPC spatial resolution better than at least 300 μm

Thank you