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Thin-Gap RPC study for ATLAS L1Muon Upgrade

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On behalf of ATLAS Muon Collaboration

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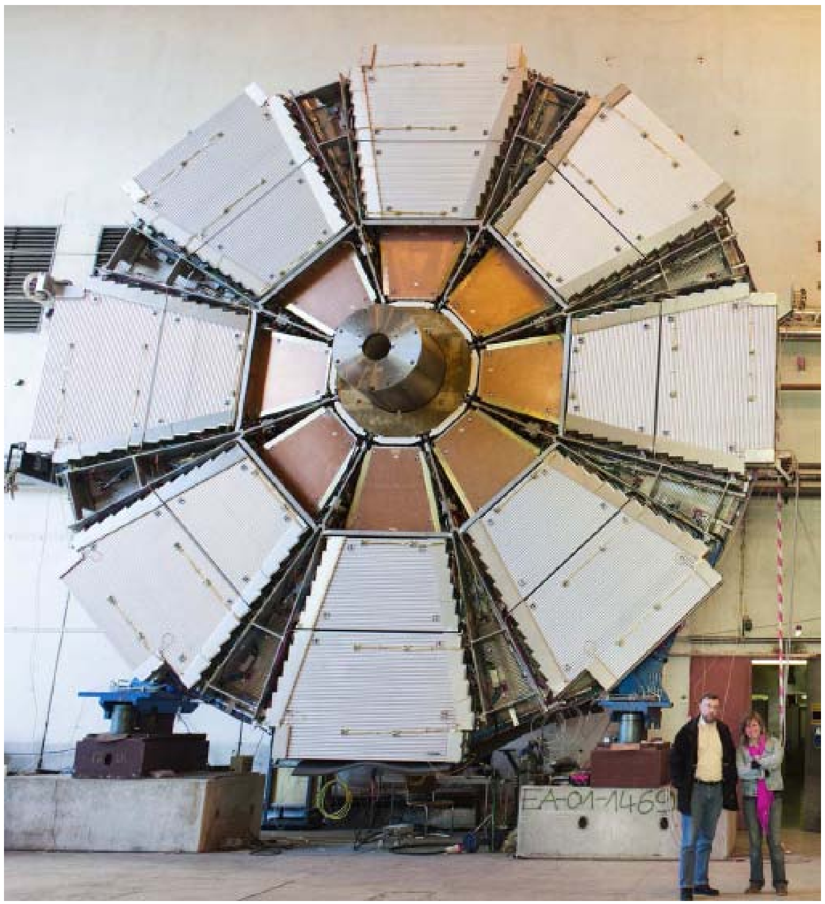
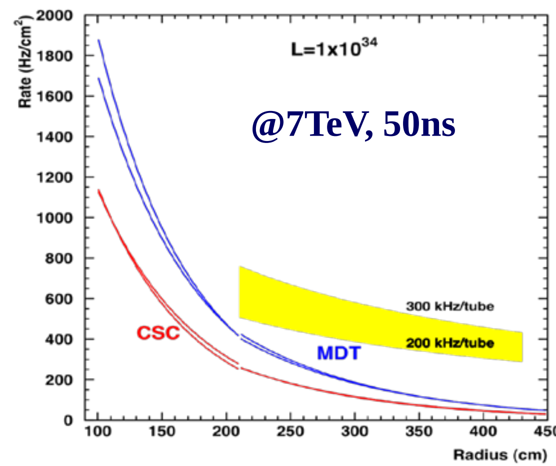
INFN Frascati, Italy

Motivation

➢ Deal with ATLAS L1Muon Trigger of Small Wheel @1e34, 14TeV, 25ns



- ~**10kHz/cm^2** events rate at innermost, most due to soft γ/n



- **<1mrad (<300μm) position resolution to improve online trigger pT cut**

- **<1ns time resolution to reject most fake hits**

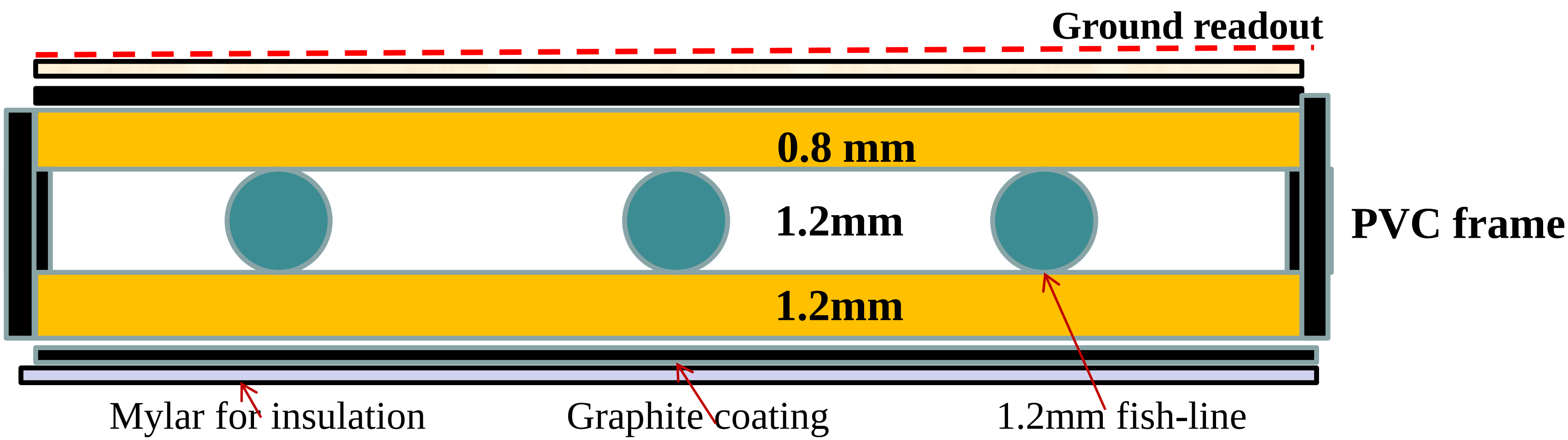
Efforts on RPC

- **Thin-Gap RPC configuration**
  - Argonne + Michigan chamber: **1mm Glass plate** & **1mm gap** & **1mm strip**
  - Aiming at Time & Position Resolution study
  - SPS H8 test, μ beam@50Hz

- **Low resistive plate study**
  - Rome2 chamber of **2mm ATLAS Bakelite plate** & **1+1mm bi-gap**
  - Aiming for good performance under high rate environment
  - GIF test, Photon rate@**7kHz/cm^2**

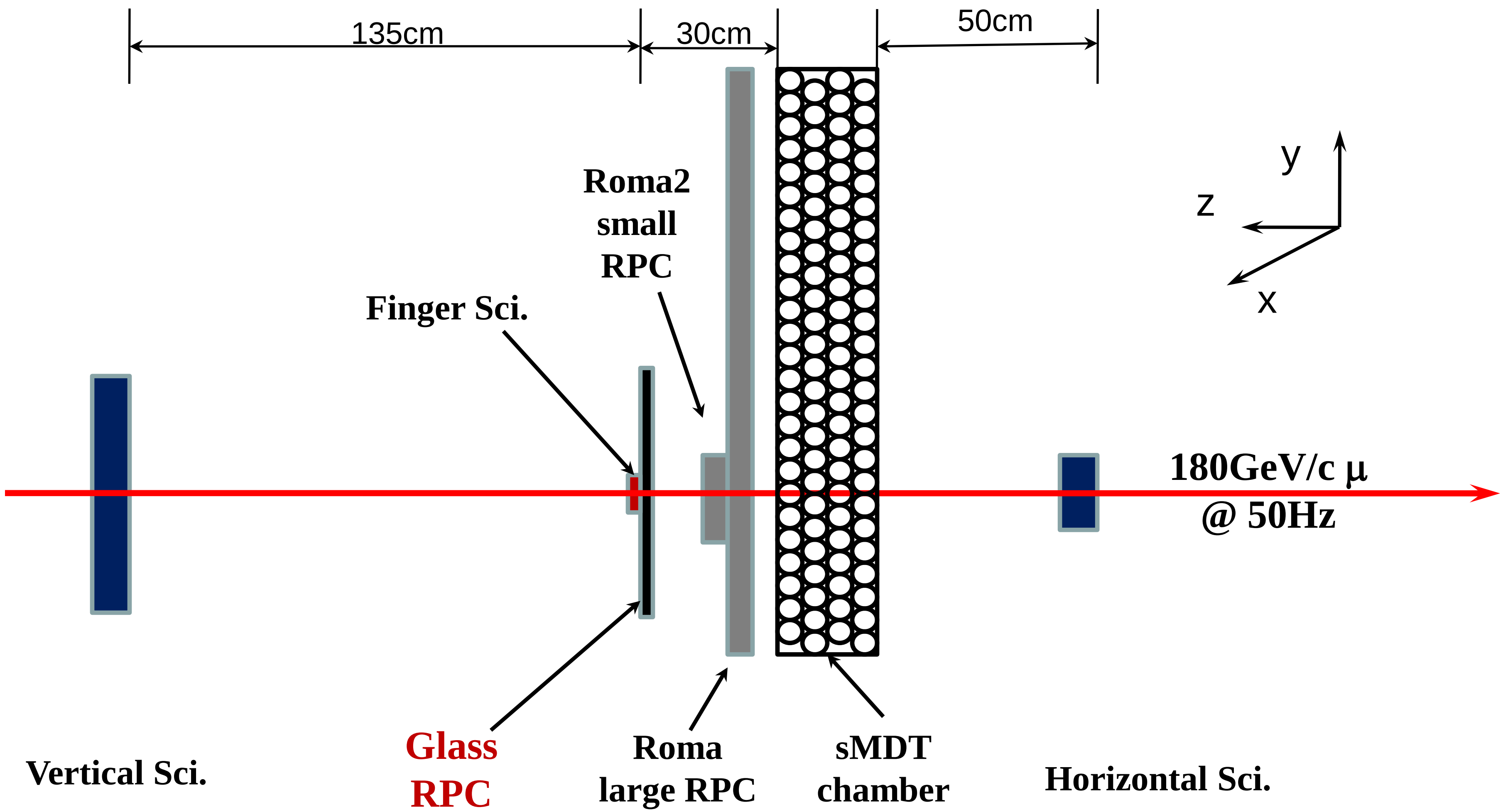
Thin-gap RPC design

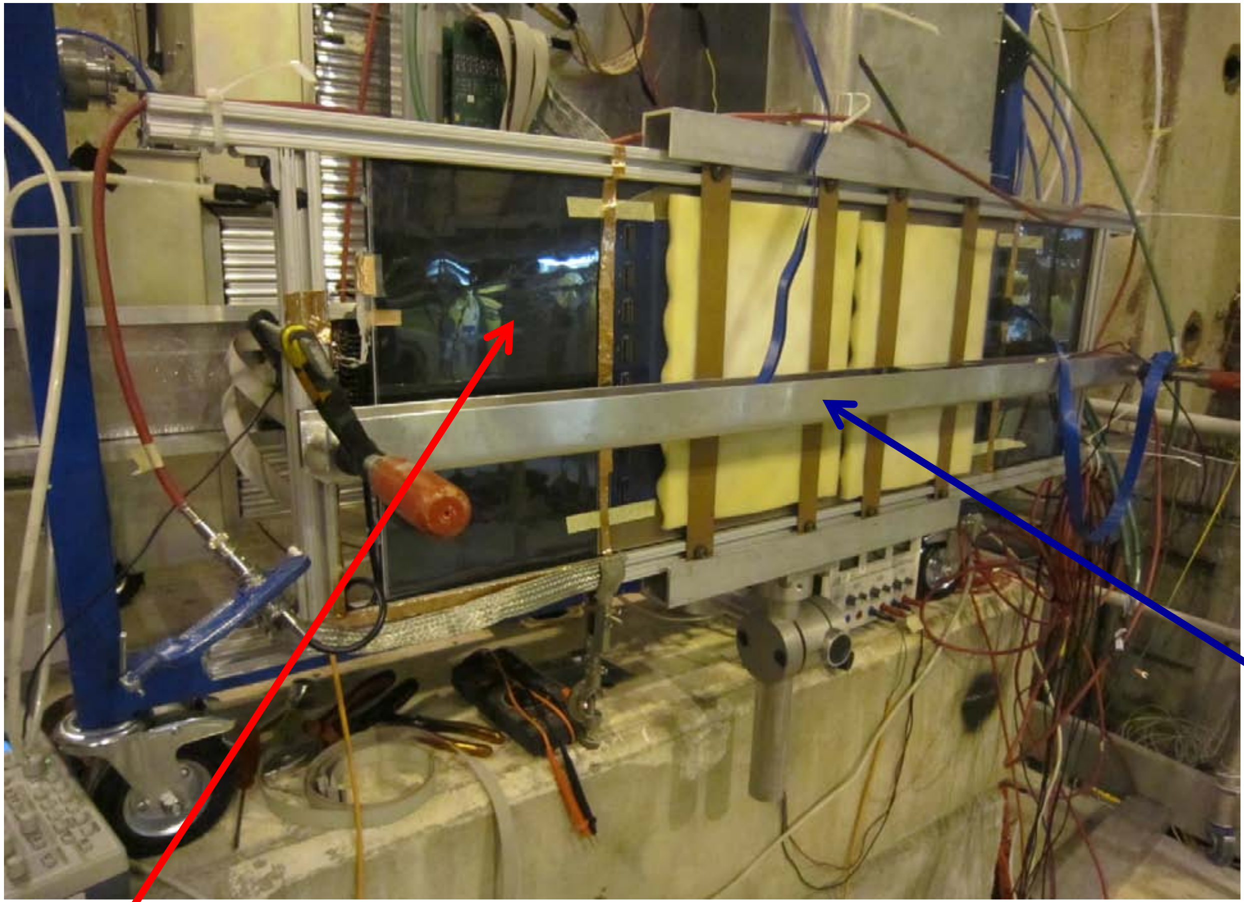
➢ **Prototype:** ANL+UM chamber



- Gas: $C_2H_2F_4$(94.7%), Iso-C_4H_{10}(5.0%), SF_6 (0.3%) → Avalanche mode
- Gap: **2 mm** → **1.2mm**
- Plate : Glass, **$5\times10^{12}\Omega\cdot$cm**, ~ **1mm**
- Readout pitch: **3cm** → **1.27mm**, strip width 1.0mm, **72** pitches
- Electronics: ATLAS Muon drift tube (**MDT**) readout, time resolution ~ 0.8ns

SPS H8 beam test setup (Nov 2011)

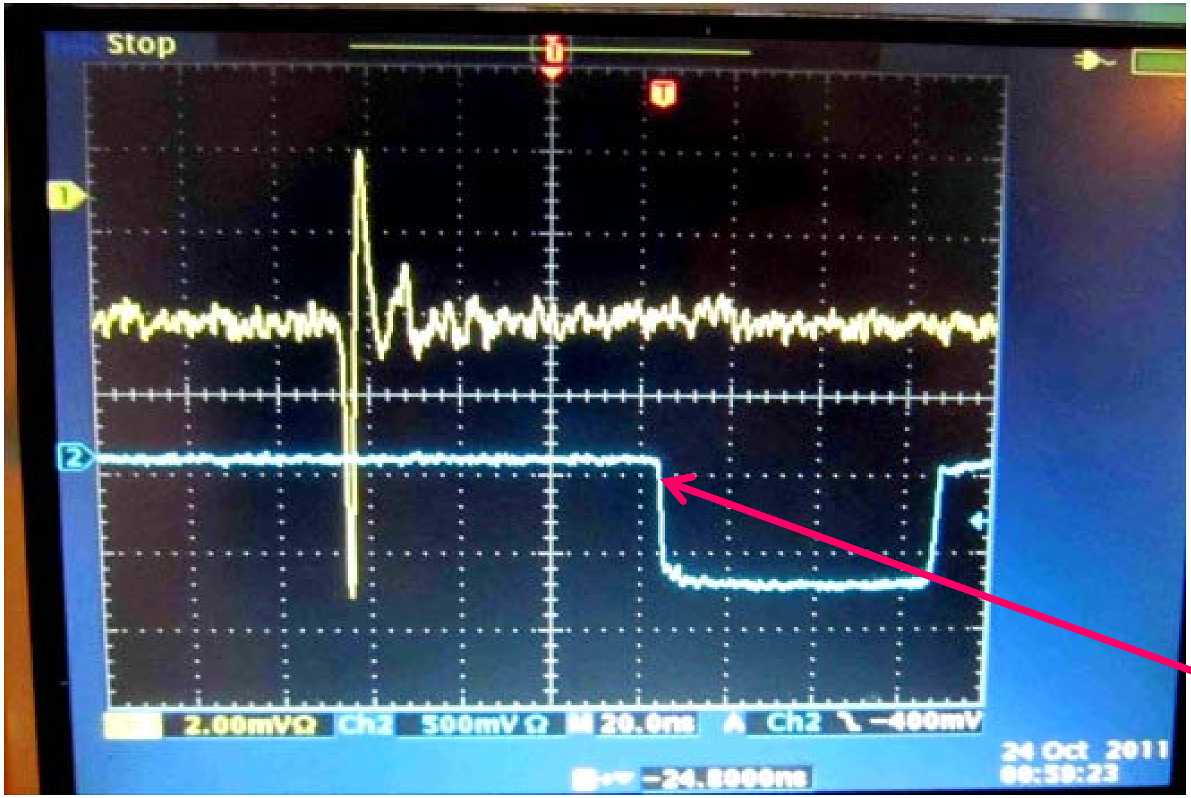




* Finger Scintillator

Glass RPC, stationed in a frame without alignment calibration

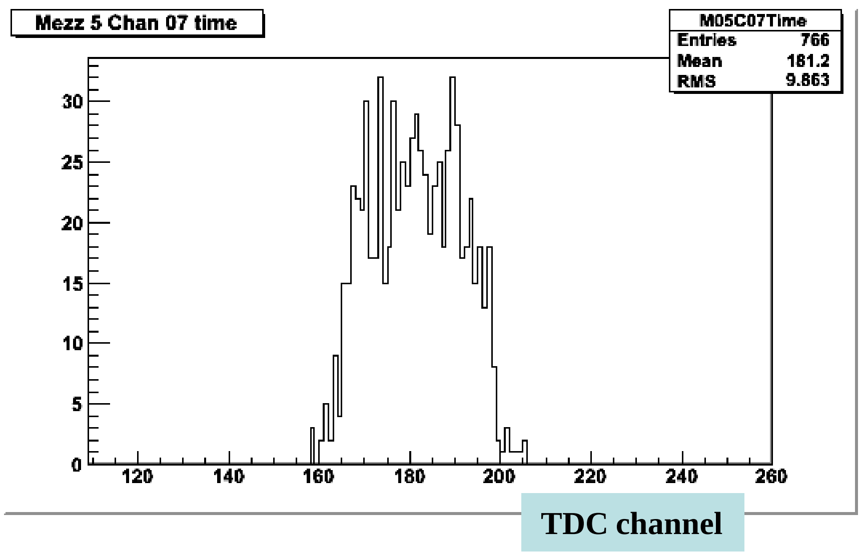
- **Event selection:** fast scintillator coincidence to trigger DAQ
- **RPC hit:** ADC>50 counts at 6600V
- **Timing:** RPC T_1 and Finger Sci. T_0 read by same MDT electronics



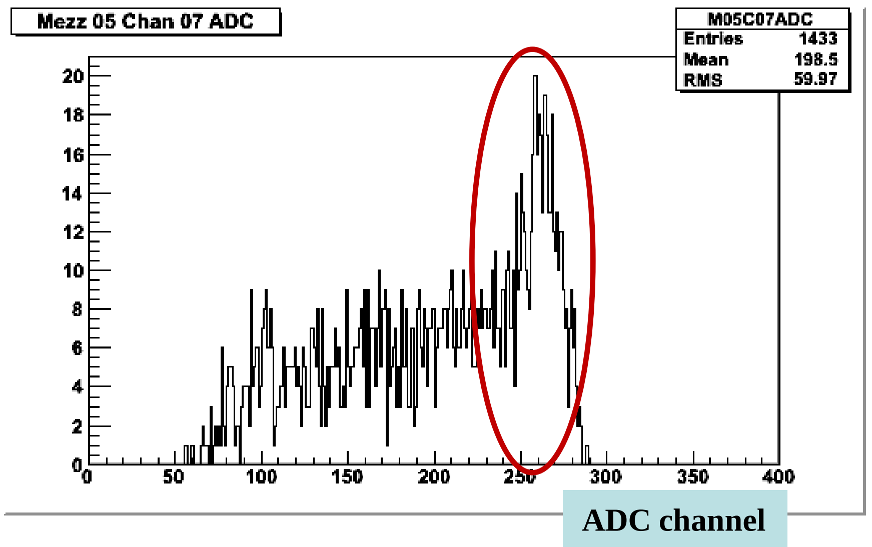
Finger Sci.
$\delta T_0 \sim 300$ps

TDC&ADC Distribution

- TDC: effective threshold -58.75mV



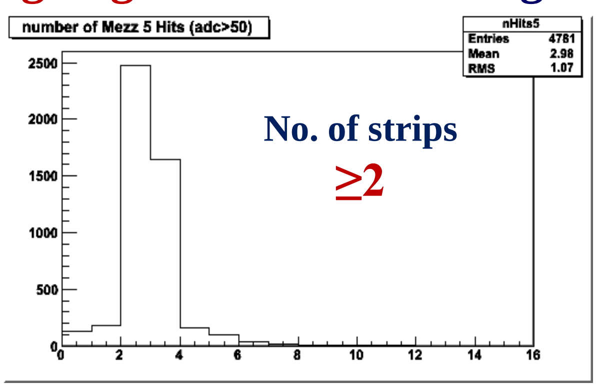
- ADC: charge integration gate 11ns



✓ No continuous spectrum → background free

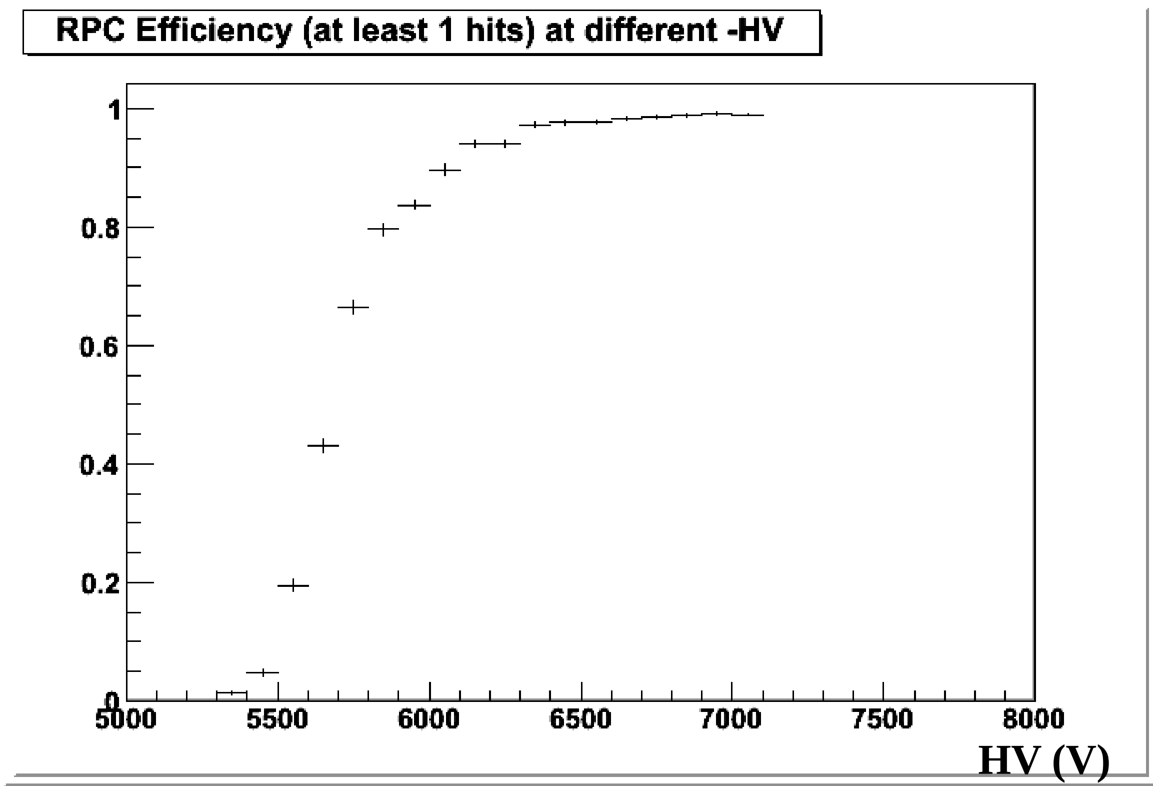
✓ T_1 distribution → 25ns beam time uniformity

✓ Large signal ADC with charge diffusion



Efficiency

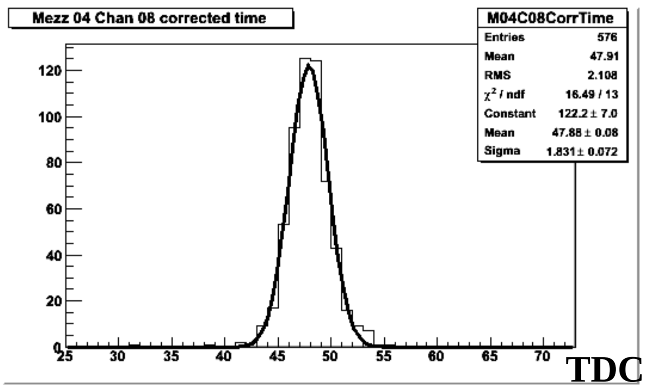
- Efficiency = (#evts of RPC fired)/(#evts of Scintillator triggered)



1mm gap → HV **6.5kV** @ **97**% efficiency

Time Resolution

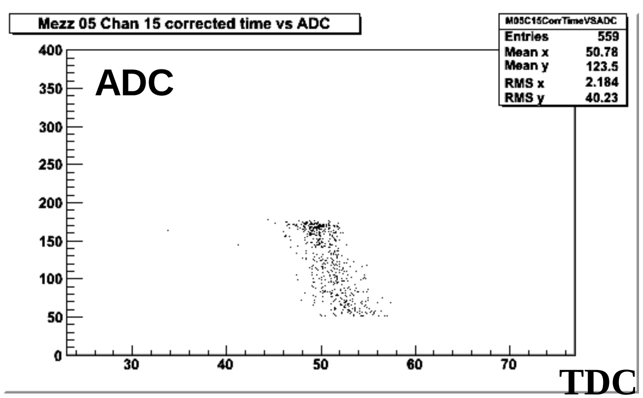
- **Time difference (T_1-T_0):**



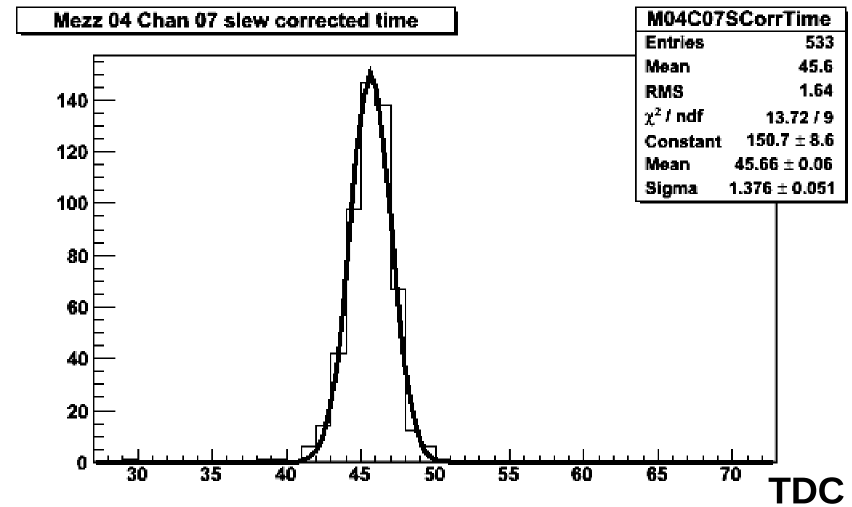
✓ **eliminate time-walk bias**

✓ **uncertainty as ~ 1.4ns**

- **TA Slew correction:**



- **After TA Slew correction**

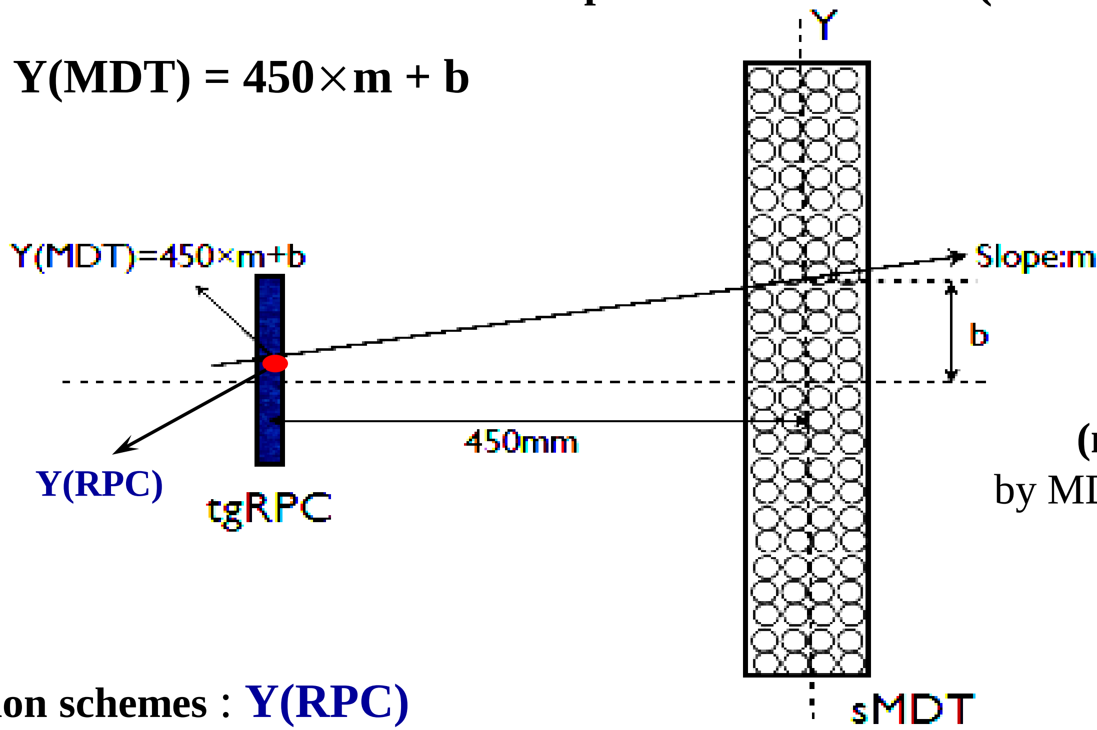


Time resolution ~ 1.1ns

Dominated by readout electronics ~0.8ns

Position Resolution

- Residual between RPC reconstruction and MDT prediction as ΔY = Y(MDT) - Y(RPC)
- MDT prediction: Y(MDT) = 450×m + b



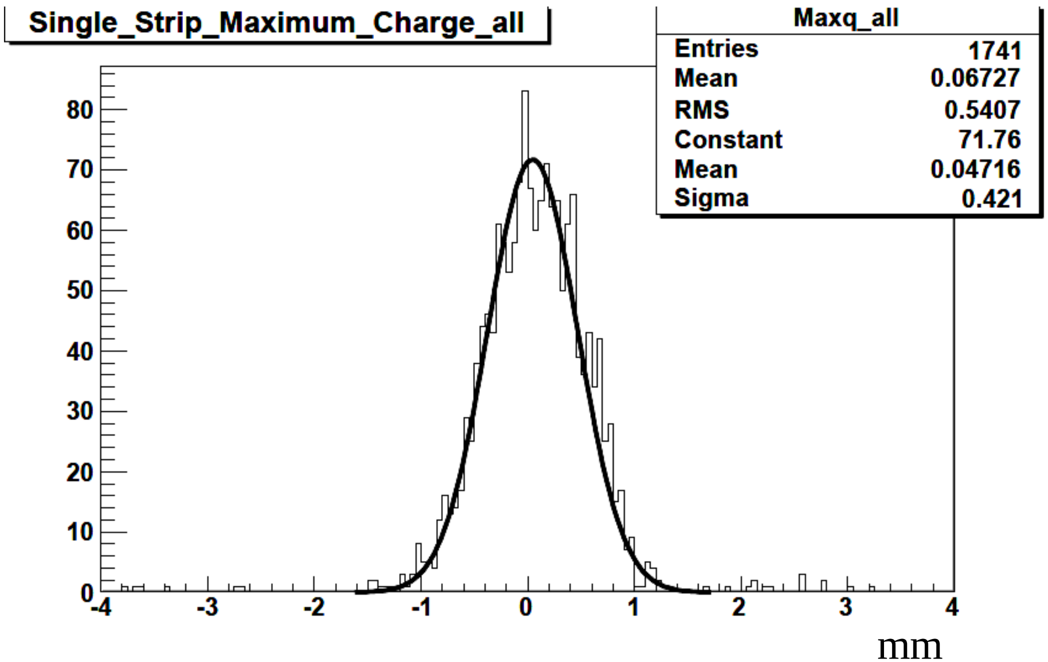
(m,b)
by MDT fitting

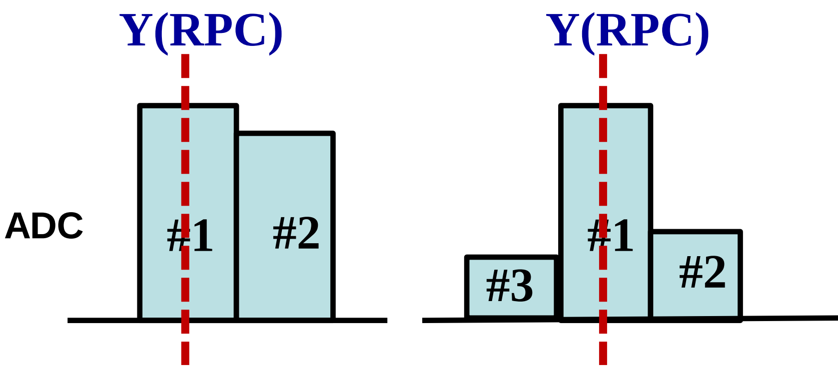
- RPC reconstruction schemes : Y(RPC)
  - **Maximum Charge Strip**
  - **First Arrival Time Strip**
  - **Centroid weighting**

@ readout pitch size **1.27mm**

Residual Distribution

• Maximum Charge Strip





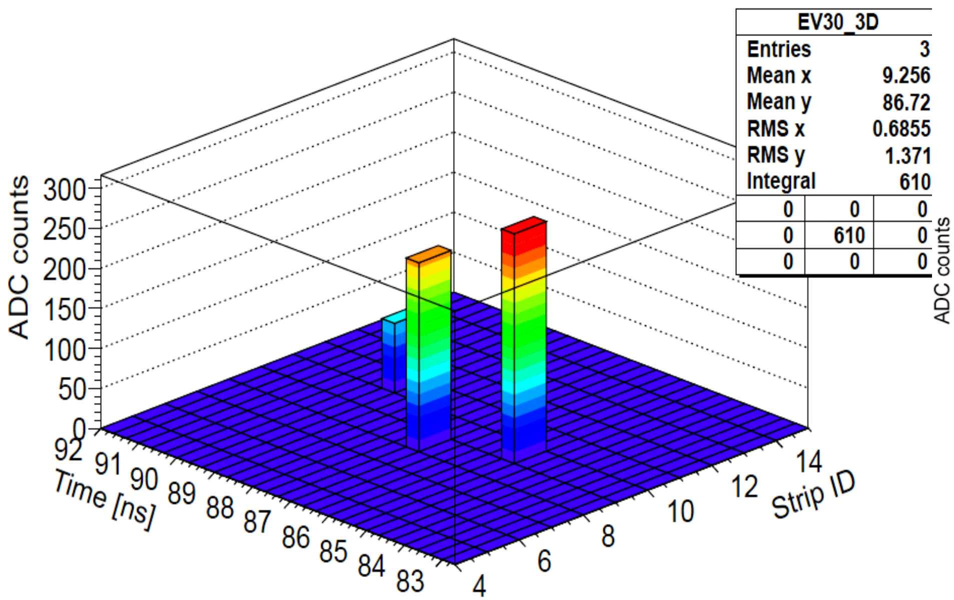
* **No global ADC calibration**, which will compromise MaxQ selection among adjacent strips

$$\sigma_{\text{MaxQ}} = \sqrt{\sigma_{RPC}^2 + \sigma_{MDT}^2} \sim \mathbf{420}\ \mu\text{m}$$

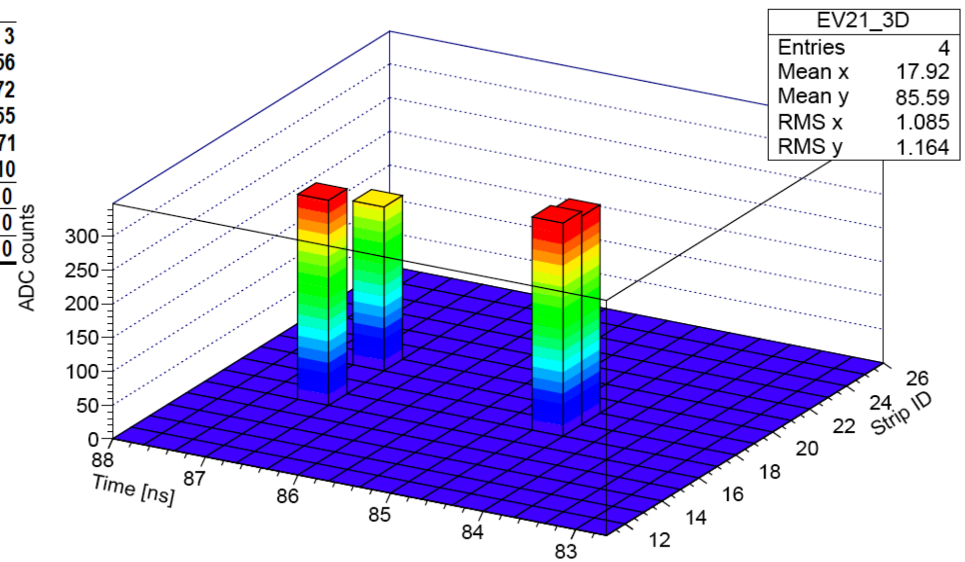
* $\sigma_{MDT} \sim$ **100μm**
* **RPC frame alignment has not been calibrated yet**

➢ 1st-Arrival vs. MaxQ:

1st Arrival ~ 80%

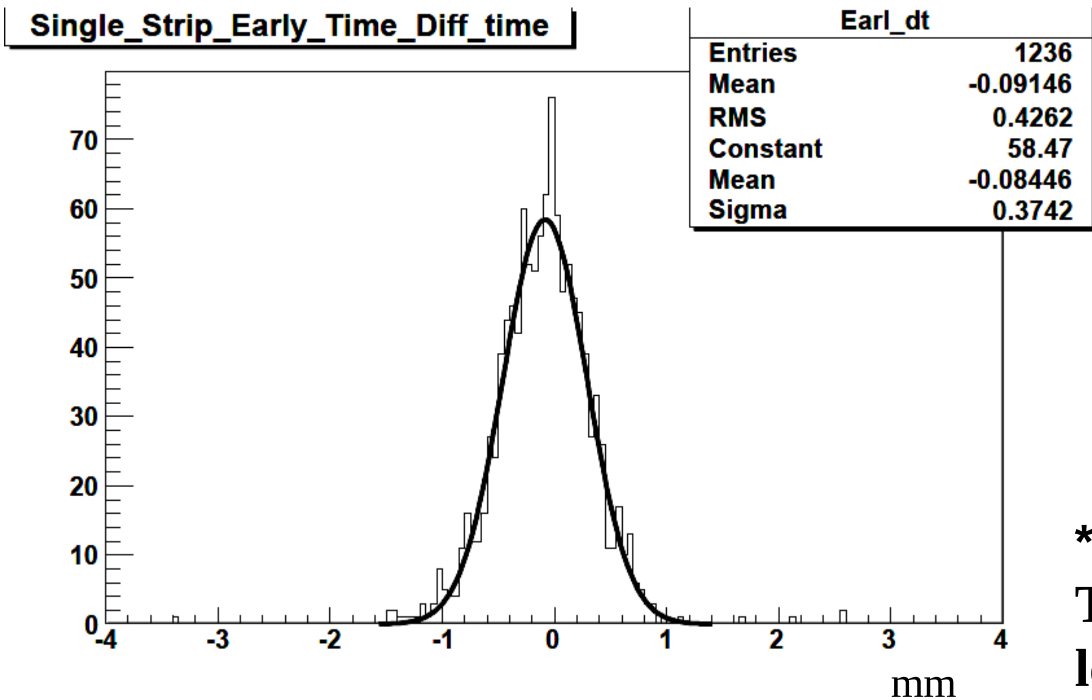


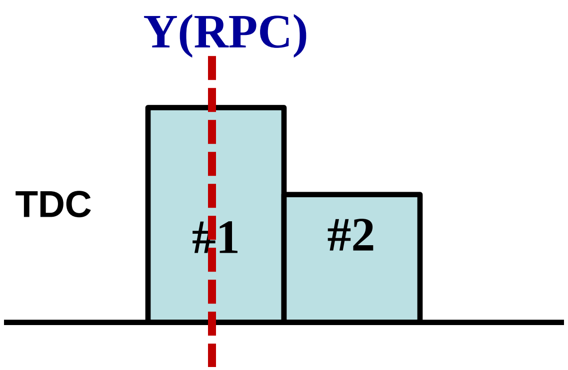
non-1st Arrival ~ 20%



- **When 1st-Arrival strips can be distinguished, most of them coincide to the MaxQ ones in the events**
- **Due to TDC resolution, fraction of events have 2 stripes with "same" arrival time, i.e. non-1st Arrival**

• **First Arrival Time: with distinguishable 1st-Arrival events only**

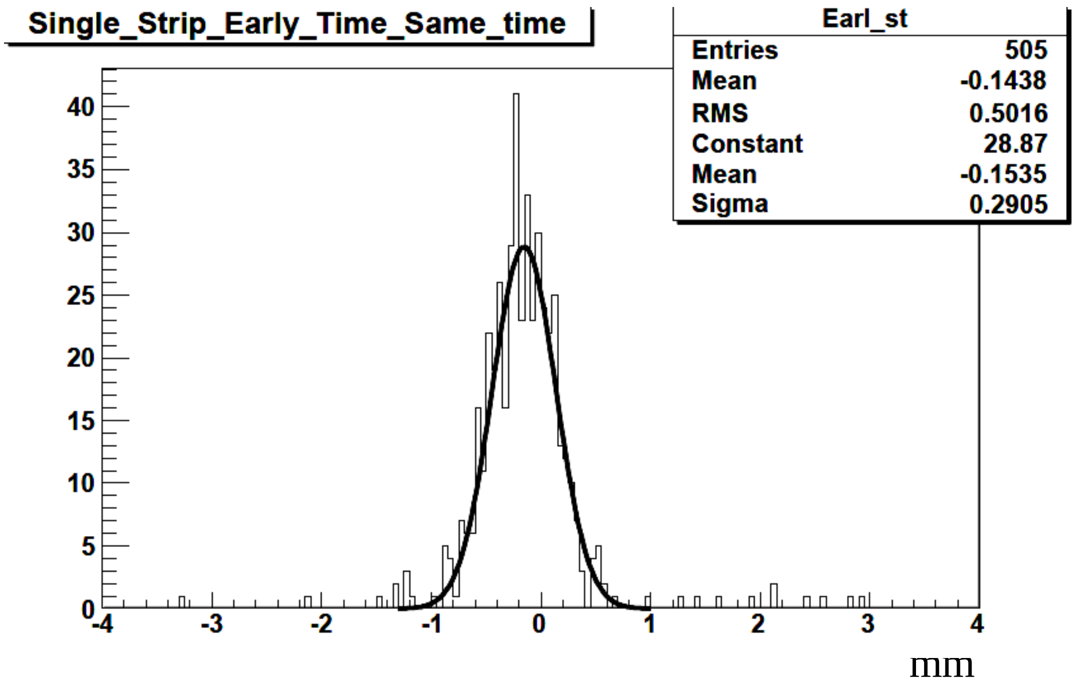


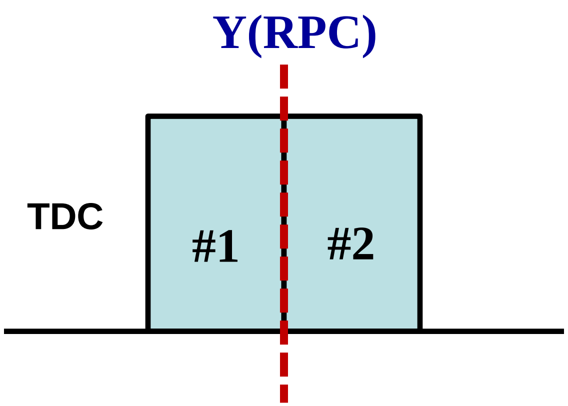


* **No global TDC calibration, but TDC fluctuations amid strips are less than ADC ones**

$$\sigma_{1Arr} \sim 370\ \mu m$$

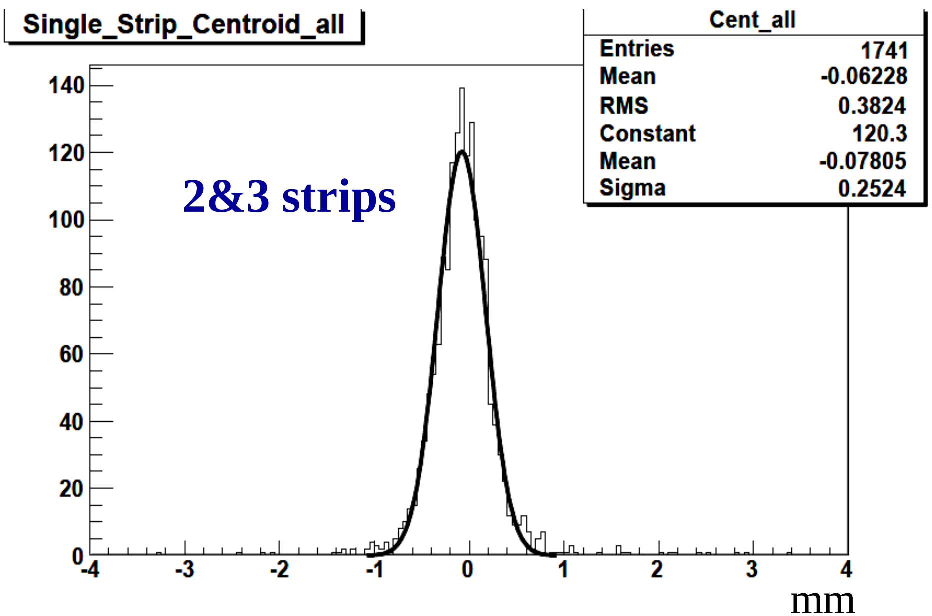
• **Same Arrival Time: non-1st Arrival events with indistinguishable earliest arrival**

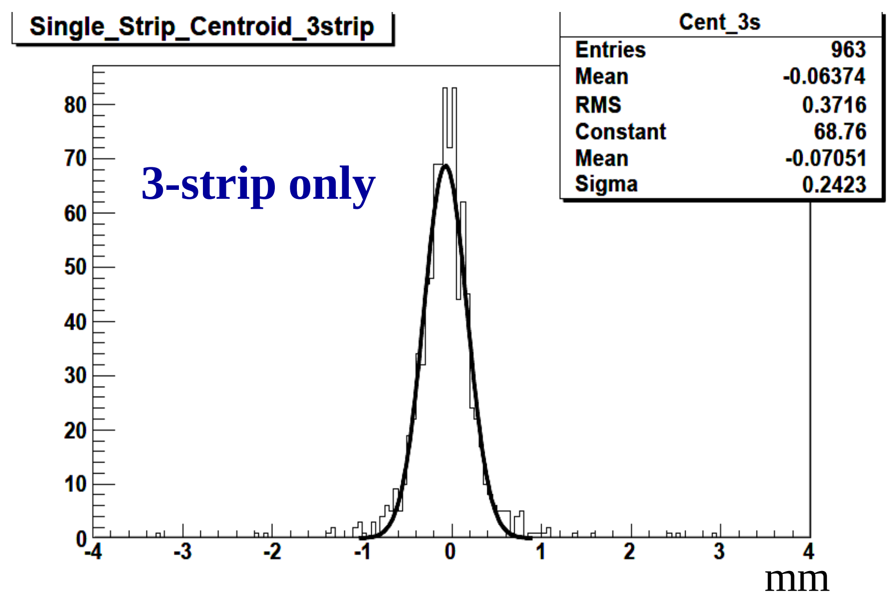




$$\sigma_{\mathrm{non1A}} \sim 290\ \mu\mathrm{m}$$

- **Centroid Finding:** $Y(RPC) = (\sum Strip_i \cdot adc_i) / (\sum adc_i) \times 1.27mm$

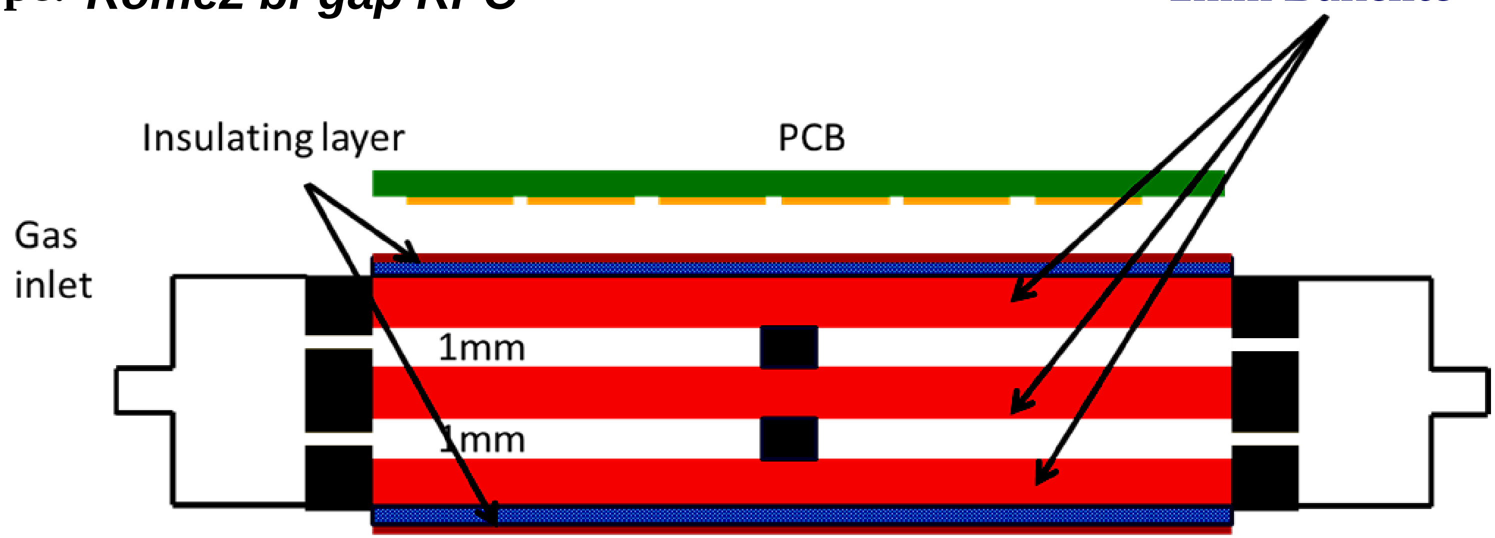




$$\sigma_{Centr} \sim 250\ \mu m$$

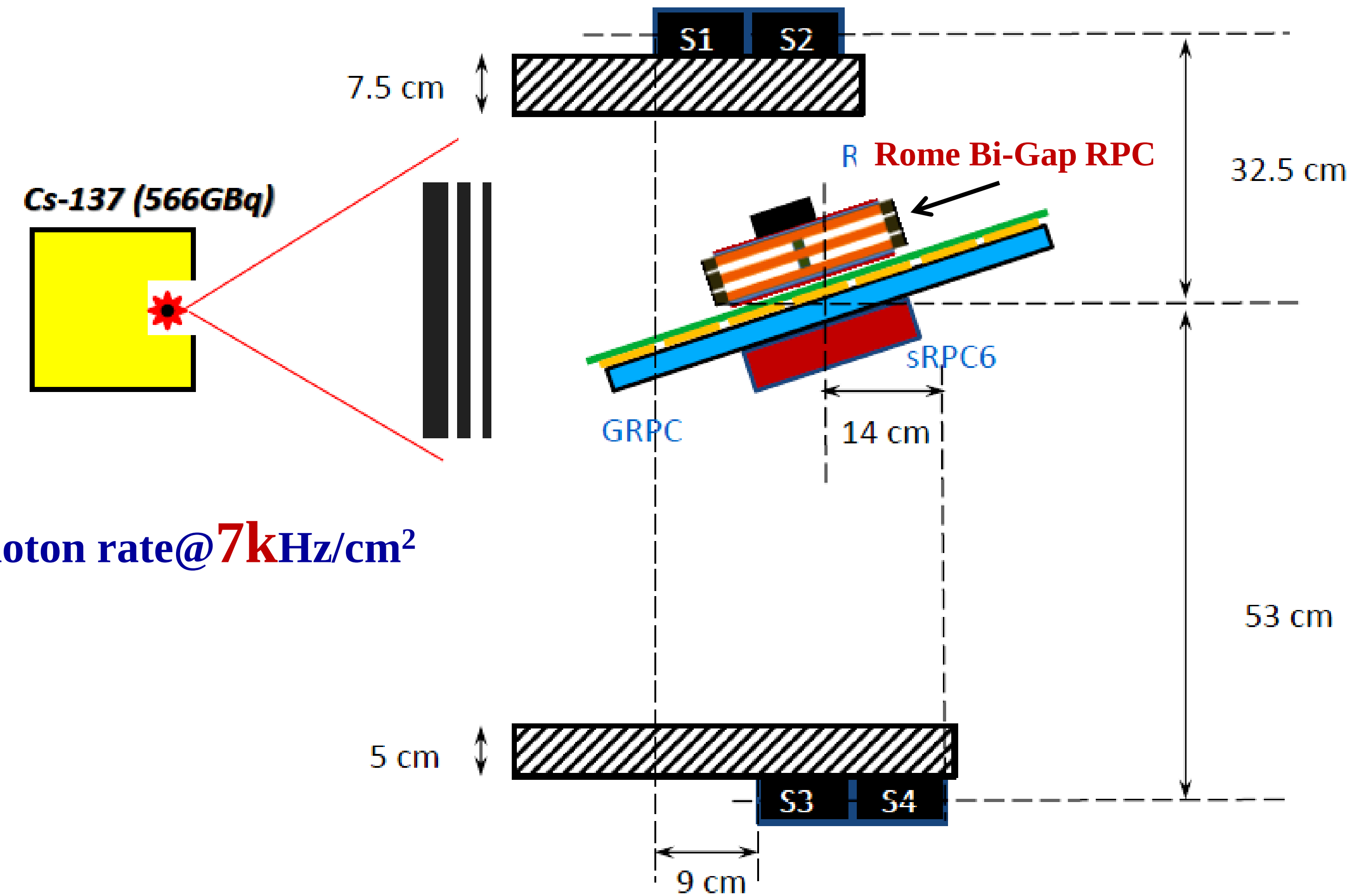
Low resistive tgRPC

- **Prototype:** ***Rome2 bi-gap RPC***



- Plate: Glass $5\times10^{12}\Omega\cdot$cm,1mm → Bakelite **$1\times10^{10}\Omega\cdot$cm, 2mm**
- Bi-gap: improve efficiency at high rate operation, HV 2×6500V → ~ **13000V**
- Electronics : new front-end, working at low gas gain to reduce operating current

GIF test setup (Jan 2012)

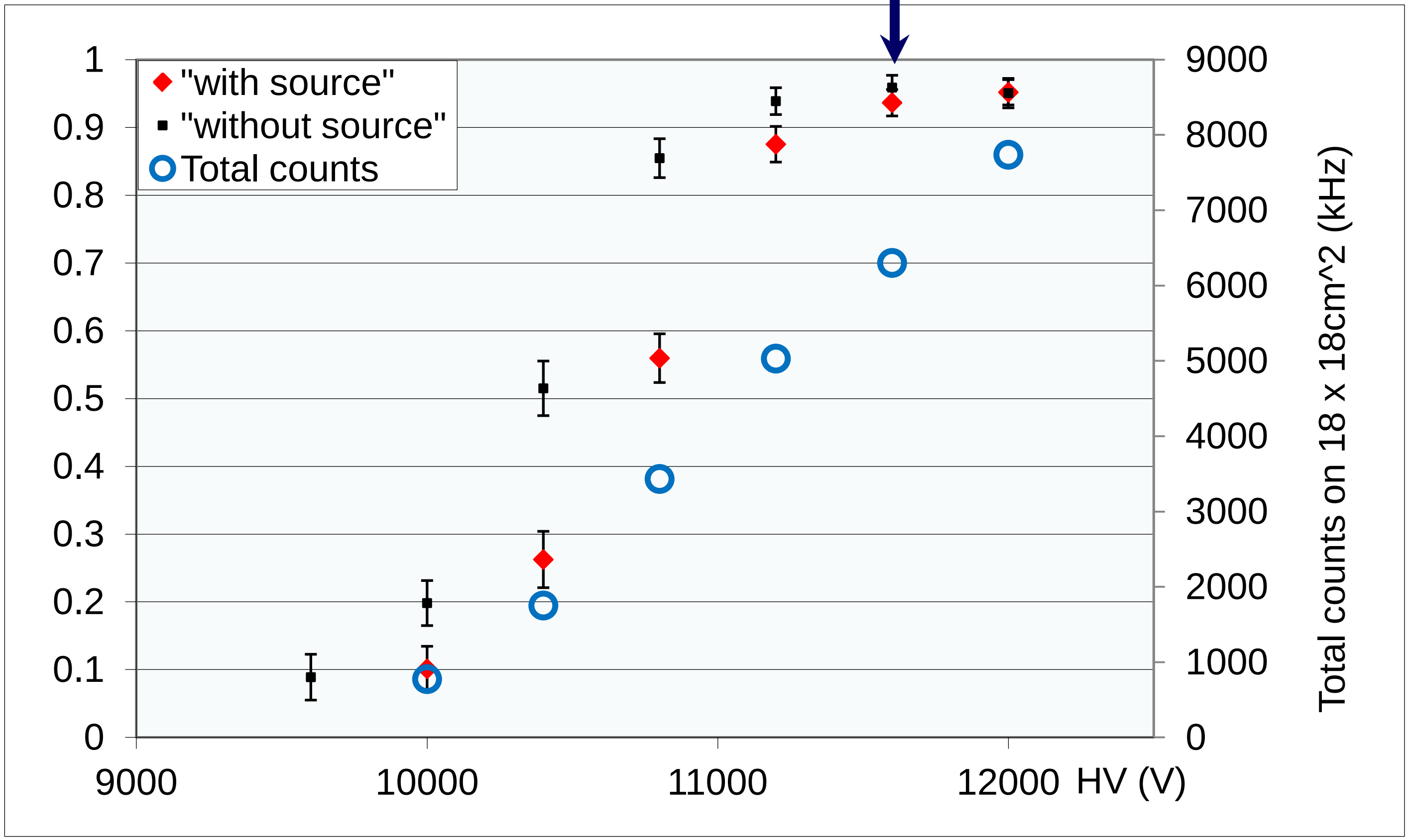


Photon rate@7kHz/cm²

Efficiency

- **Efficiency × Acceptance**

94%@11500V



- Rate test is limited by the available source flux of GIF

Conclusion

- Thin gap of **1.2mm** results in good time resolution, **<1.1ns**, dominated by readout electronics precision

- With fine readout pitch as **1.27mm**, position resolution **~300μm** can be achieved, dominated by RPC alignment uncertainty

- Bakelite **$10^{10}\Omega\cdot cm$** bi-gap chamber, fully functions in **$7kHz/cm^2$** high rate test

The design of Thin-Gap RPC could fulfill ATLAS L1Muon trigger upgrade requirement at high background rate, studies and efforts are on going in the right direction