RPC2012

INFN Istituto Nazionale di Fisica Nucleare

ATLAS RPC time-of-flight performance

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Outlook

- ATLAS RPC in p-p collisions at LHC
  - Triggering
  - Tracking
- ATLAS RPC time measurement
  - Simulation
  - Calibration
  - Resolution
- Applications
  - Background suppressions
  - Particle velocity resolution

Conclusions

ATLAS RPC: Triggering

On-line hardware trigger

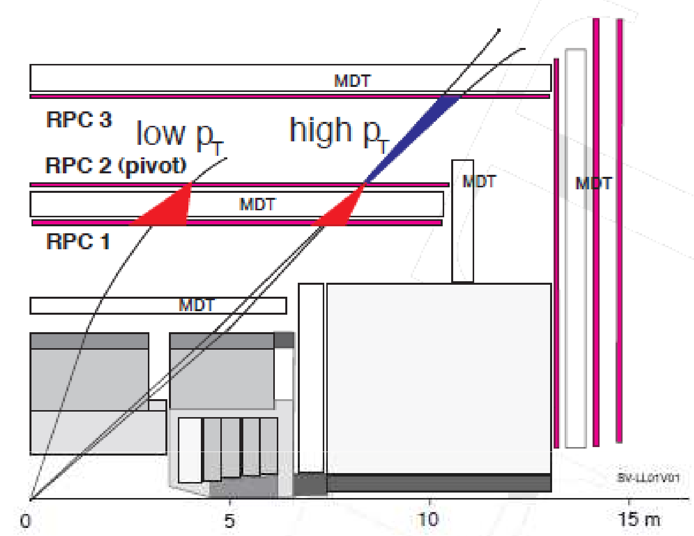
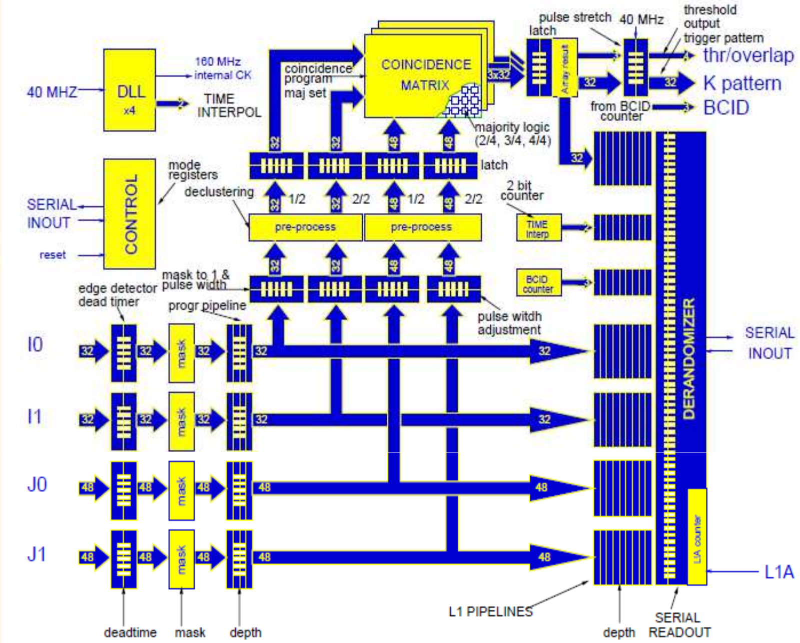


Figure 2: The Barrel Algorithm, illustrated on one quarter of the ATLAS experiment in the r-η view.

On-detector coincidence Matrix



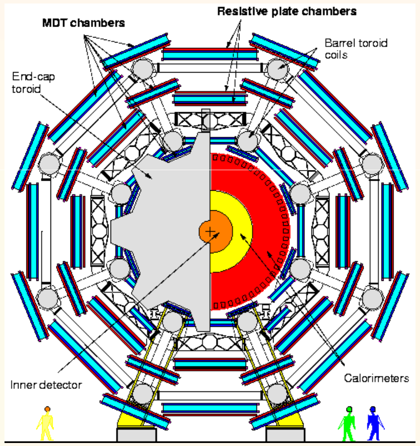
- Identify μ candidates by fast geometrical coincidence pattern in two views (trigger roads)
- Select Region of Interest $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ by eta-phi coincidence and 6 P_T thresholds per view.
- Assign bunch crossing number (25 ns)
- ϕ second non-bending coordinate (pitch ~3 cm)

- On-detector trigger/readout electronics: Coincidence Matrix ASIC's (CM)
- 320 MHz clock = 8 times LHC clock
  Time res. = 3.125ns/sqrt(12)=0.9ns
- On-line time alignment with tracks both for trigger hits and readout hits (maximize trigger efficiency)

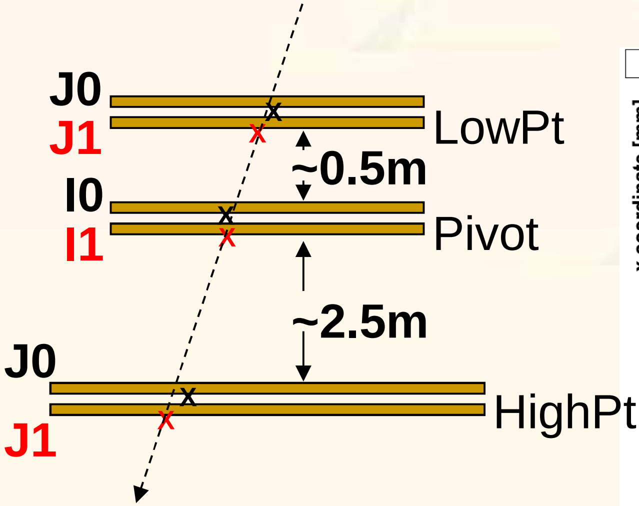
ATLAS RPC: Standalone tracking

6 space points with 1.5 average cluster size/view and 1 cm space resolution.

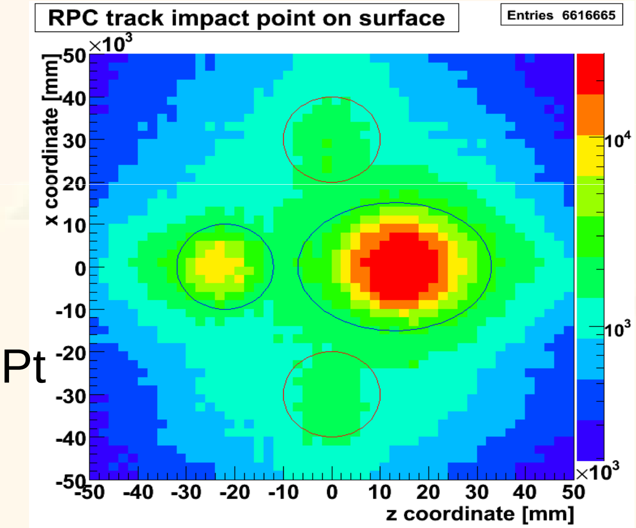
- ✓1116 RPC single units
- ✓ 26 different unit topologies
- ✓ Total surface ~ 4000 m^2



- •Straight line
- •Chi2 cut selects High Pt tracks



Cosmics reconstructed by RPC and projected on surface.
Shafts and elevator holes are clearly visible.



Time is the 4th coordinate (dt=1.5ns):

Hit Time =TimeIP+TOF+delay along strip+fixed delay (cables+optical links+…)+calib. const.

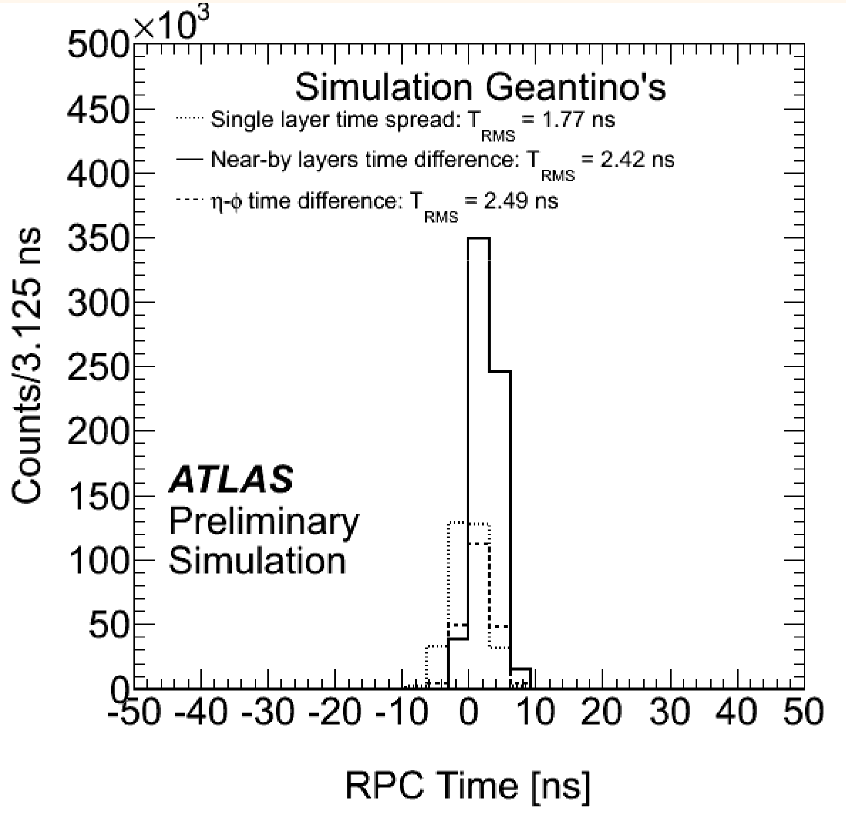
To evaluate the delay along strip the track projection on the gas volume is necessary .

RPC cluster time = minimum hit time of the adjacent hits belonging to the cluster

RPC time measurements in MC

ATLAS RPC time in simulation software:

- TOF subtracted (mimic online time calibration)
- 1,5 ns jitter (H8 test beam)
- 3.125 ns digitization (0.9 ns resolution)
- Signal delay along strip (v=208 mm/ns)



Verify simulation and reconstruction with Geantino tracks:

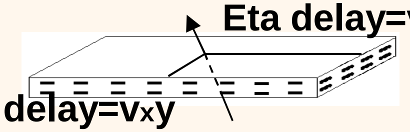
- leave hits in active volume
- no secondary interaction
- no bending in B
- No IP spread

T_{RMS}	Back-of-the-envelope calculation	Geantino
Single layer	1.5⊕0.9 =1.75 ns	1.77 ns
Near-by-layer	sqrt(2)*1.75 =2.47 ns	2.42 ns
Eta-Phi	sqrt(2)*1.75 =2.47ns	2.49 ns

All as expected!

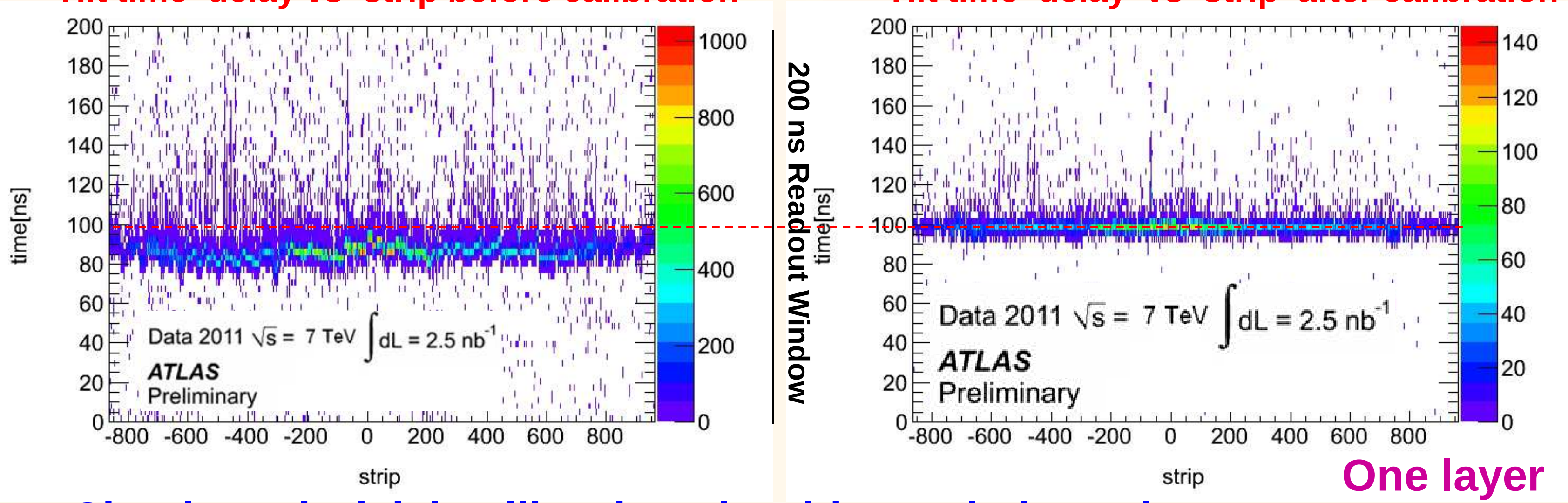
RPC time calibration

Calibration criteria: the hit time of a relativistic track leaving the IP after signal delay subtraction is in average centered in the readout window ($t_{PROMPT\ TRACK}$ =100 ns)



v=signal propagation speed along readout strip =200 mm/ns=2/3c (nominal)

Hit time–delay vs strip before calibration **Hit time–delay vs strip after calibration**



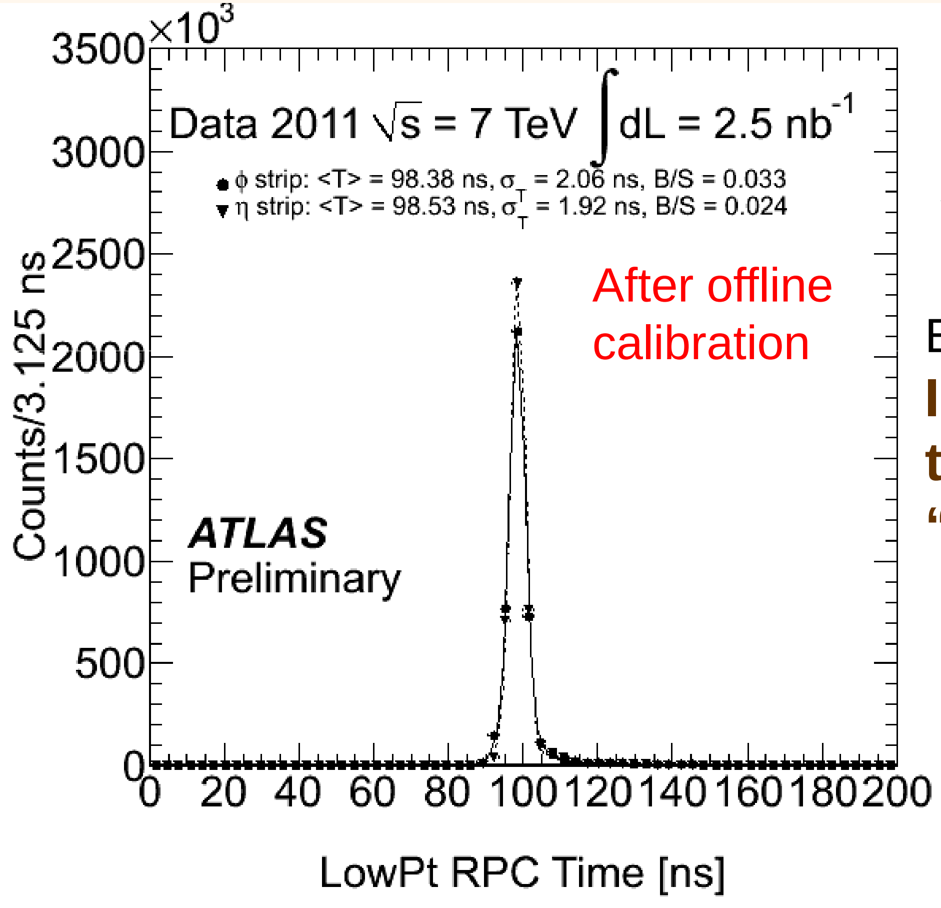
One layer out of 192

Simple and trivial calibration algorithm strip by strip:

- calibration constant per strip = max (strip time – signal delay)
- calibrated strip time = strip time + signal delay - calibration constant + 100 ns
- Real TOF = calibrated strip time + Nominal TOF - 100 ns

ATLAS RPC time resolution in pp

Data selection: Muon stream, beam stable and detectors OK, RPC clusters matched (deta,dphi<0.1) to combined muons (Inner detector+muon spectrometer)



1. **Online time resolution: 4-5 ns** (see A. Polini's slides)
2. **Signal delay subtraction: 3.5-4 ns**
3. **Off-line calibration: 1.9-2 ns**

Expected 1.75 ns :

In order to get agree we have to add in quadrature an "Extra Noise" ~ 0.9 ns

NB. Whole ATLAS, many months of data taking, small calibration sample used for calibration excluded from the plots.

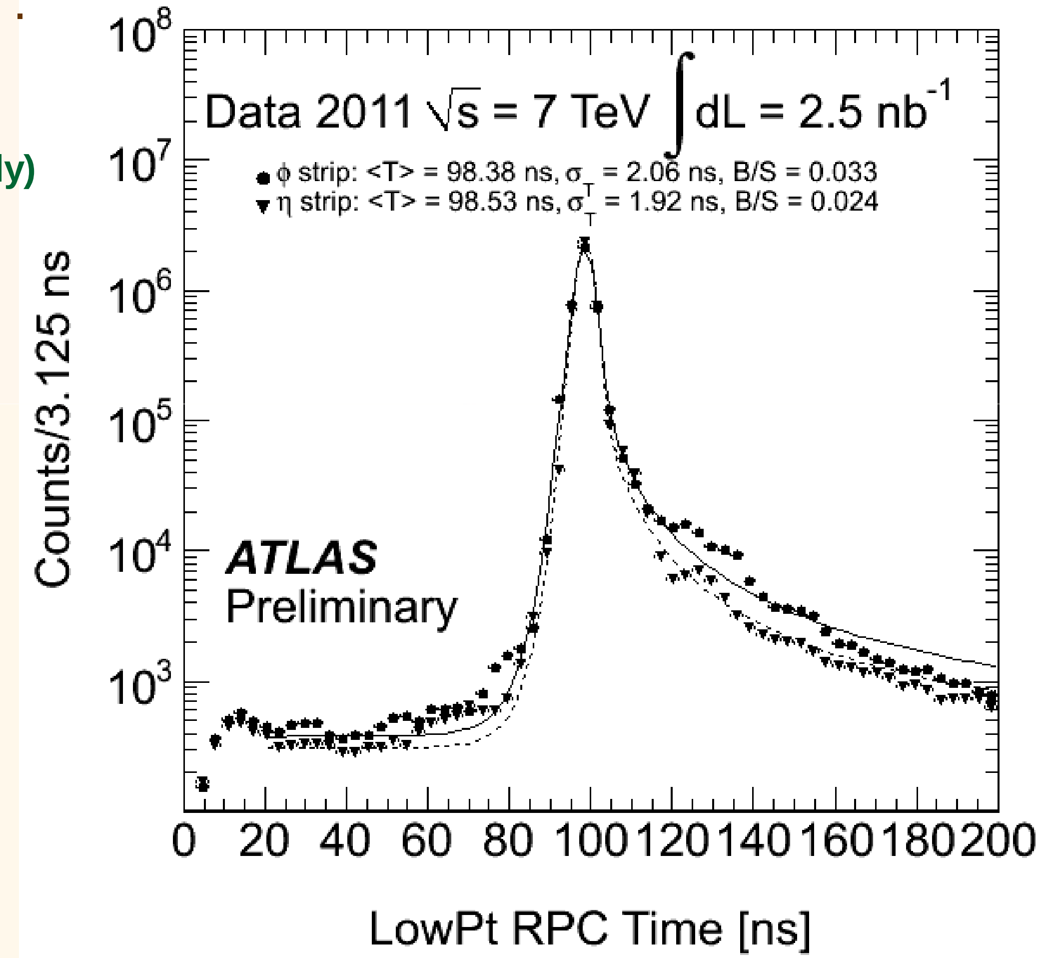
RPC time resolution function

Time resolution in data (and pp simulation very similar):

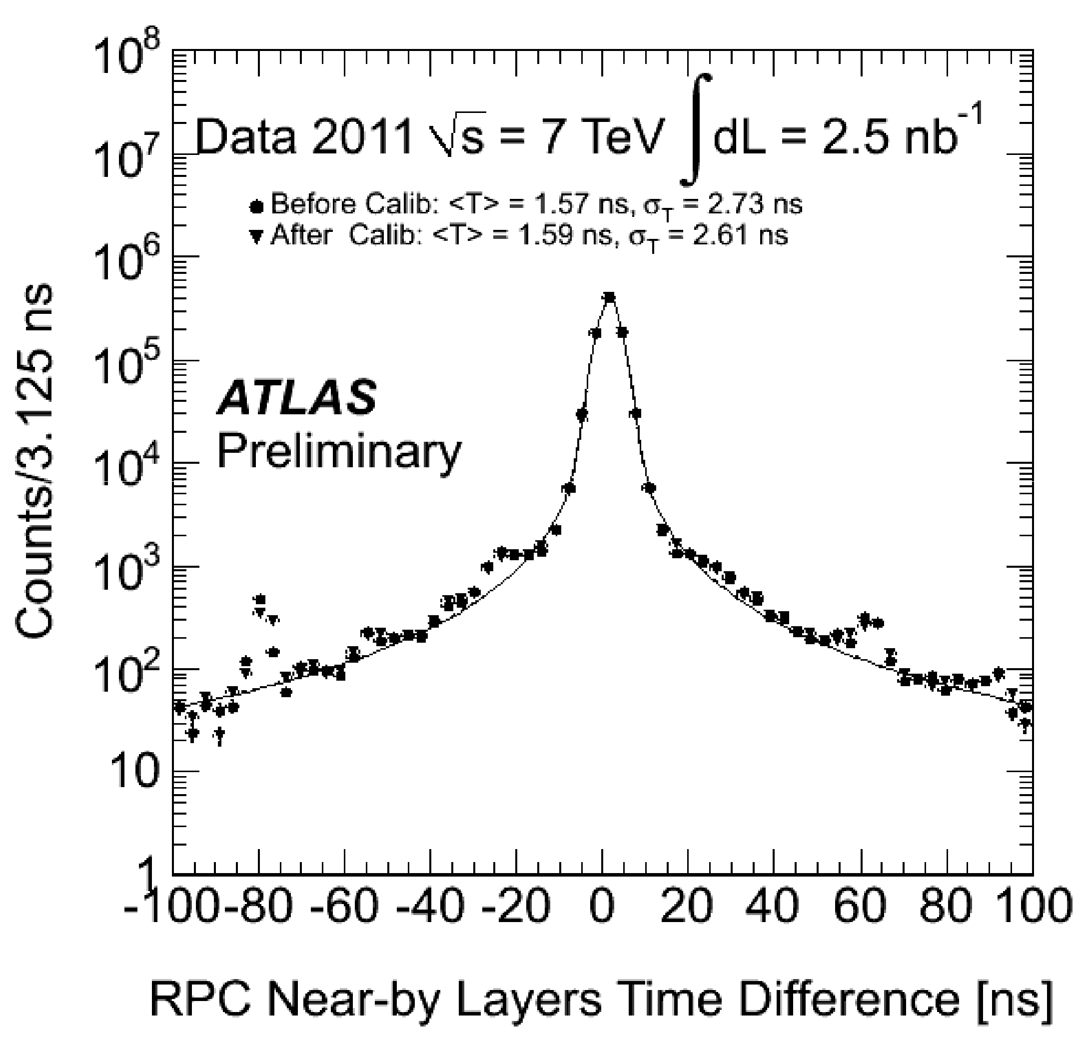
"Extra noise" ~ 0.9 ns ~ 27 cm .

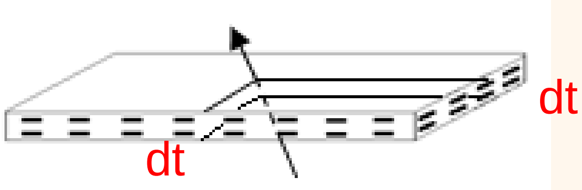
Possible sources:

- **Eta-phi "ghost" (most likely)**
- **fakes or bias in reconstructions**
- **non-Gaussian tails (asymmetric power law)**
- nominal signal velocity v=200 mm/ns
- track bending
- IP spread
- drift in time



RPC time spread b.w. layers same view



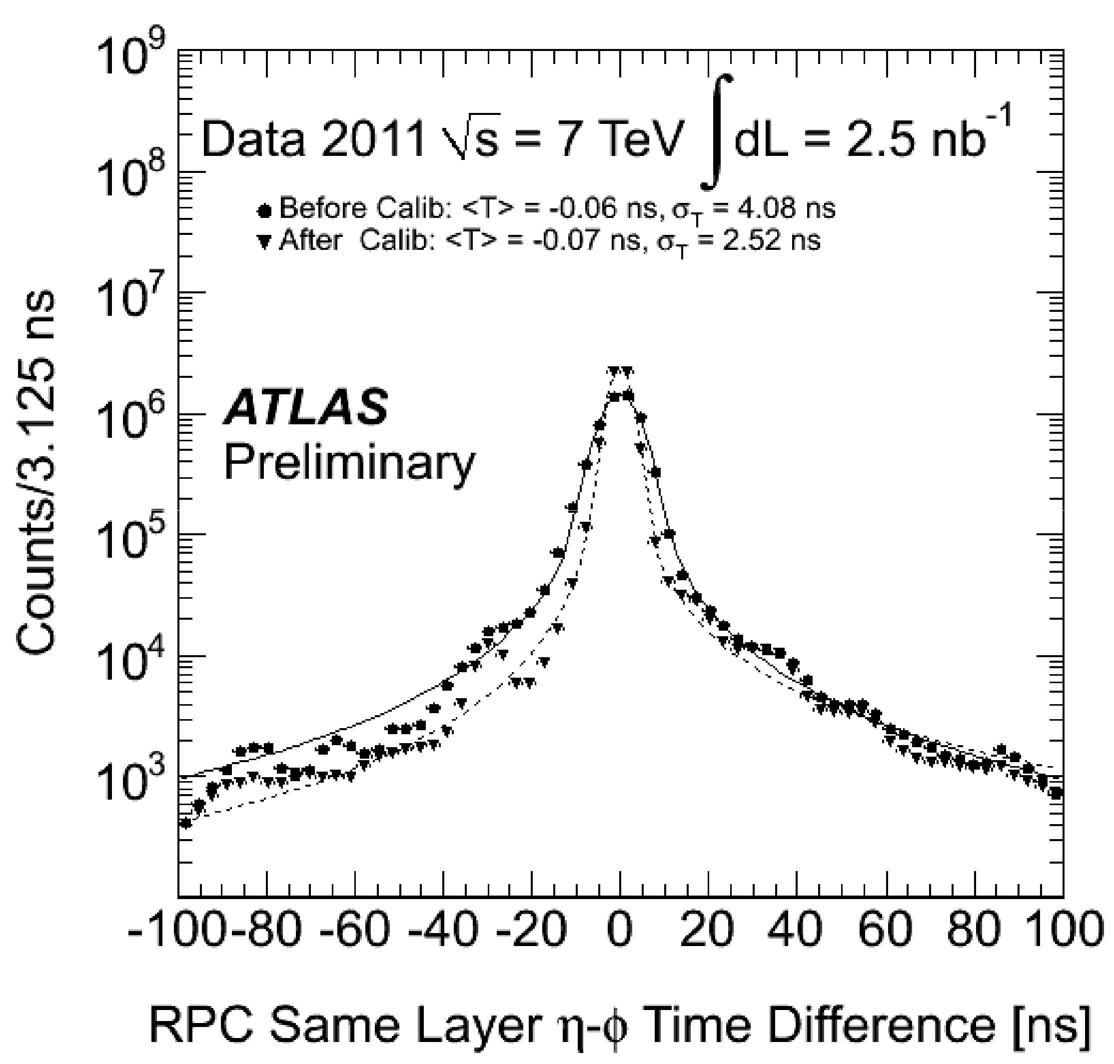


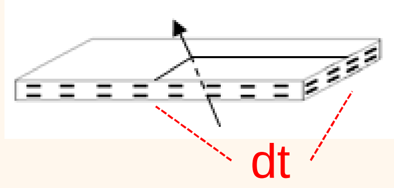
No dependence on:

- signal delay subtraction
- track bending
- IP spread

Time spread near-by layers in data = 2.61 ns.
"Extra noise" ~ 0.5 ns

RPC time spread b.w. views same layer





Dependence on:
- signal delay subtraction

No dependence on:
- track bending
- IP spread

Time spread between views same layer in data = 2.52 ns. Expected better because eta-phi time are correlated in data (signal induced from same avalanche).

RPC time resolution stability

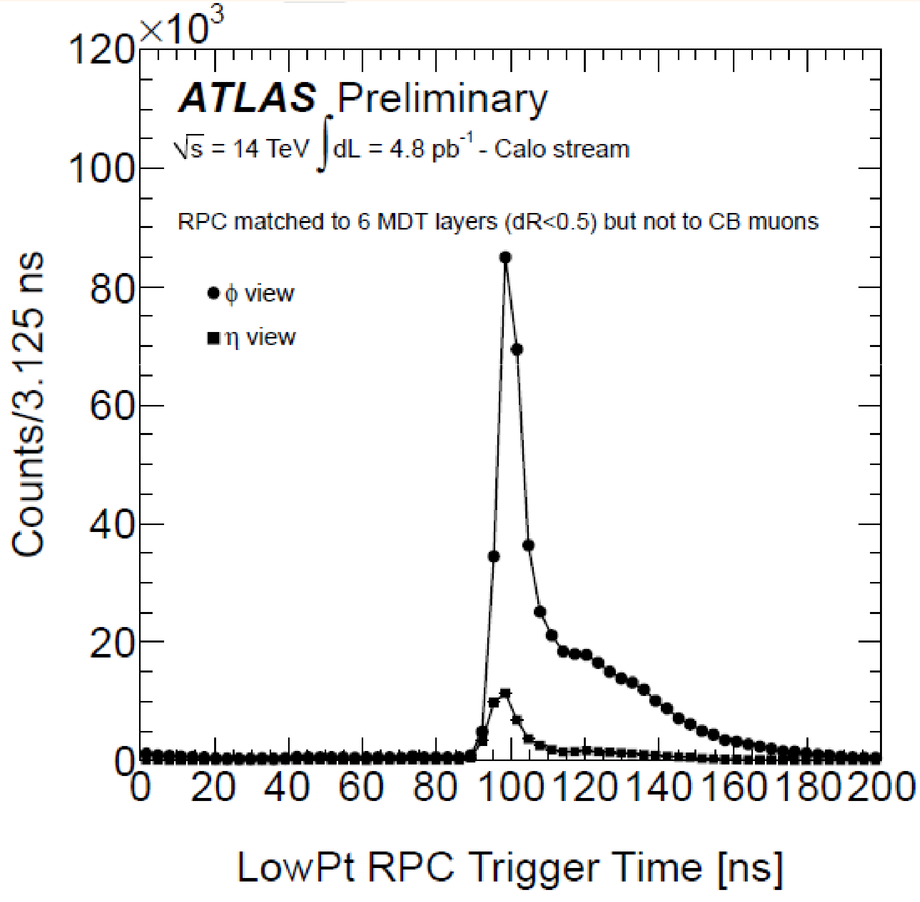
Period(End)	$\langle T_\eta \rangle$	$\langle T_\phi \rangle$	σT_η	σT_ϕ	intL
B (23 Mar)	99.97	99.78	1.92	1.90	12 pb-1
D (28 Apr)	98.42	98.23	1.92	2.10	166 pb-1
E (3 May)	98.47	98.30	1.92	2.10	50 pb-1
F(25 May)	98.50	98.31	1.92	2.10	137 pb-1
G(14 June)	98.49	98.30	1.91	2.09	518 pb-1
H(28 June)	98.28	98.48	1.90	2.10	265 pb-1
I(29 Jul)	98.67	98.50	1.92	2.06	334 pb-1
J(4 Aug)	98.38	98.18	1.93	2.09	233 pb-1
K(22 Aug	98.41	98.20	1.93	2.10	576 pb-1
L(4 Oct)	99.15	99.03	1.86	2.04	1416 pb-1
M(30 Oct)	98.45	98.23	2.29	2.40	1031 pb-1

Increasing average interactions per crossing: from about 5 to about 18

- **Off-line calibration uses run 183407 muon stream.**
- **The residual drift in time can easily be retrieved by off-line calibration.**
- **Resolution worsening in high pile-up condition is likely due to eta-phi “ghost” and fake tracks.**

Background suppression

Time distribution of all **RPC trigger hits not matched to a combined track** but having a **good match (dR<0.5) with at least 6 MDT layers** (to remove flat uncorrelated background)



Very effective in reducing correlated and un-correlated background:

- **Loopers**
- **Beam-gas, parasitic beam-beam, beam-collimator interactions**
- **Cavern background (mainly neutrons and gammas)**
- **Cosmics**

Particle velocity resolution

• Incremental distance between space points spatial averaged and ordered on the 6 layers.

• Space point time from eta and phi view average,

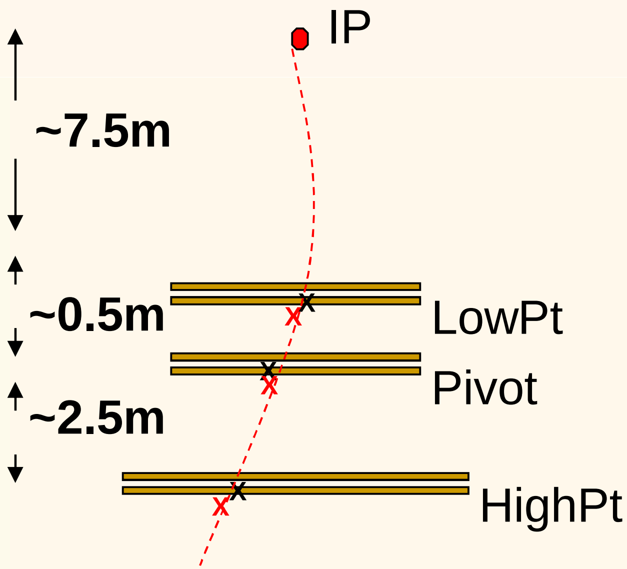
"Rule of thumb"

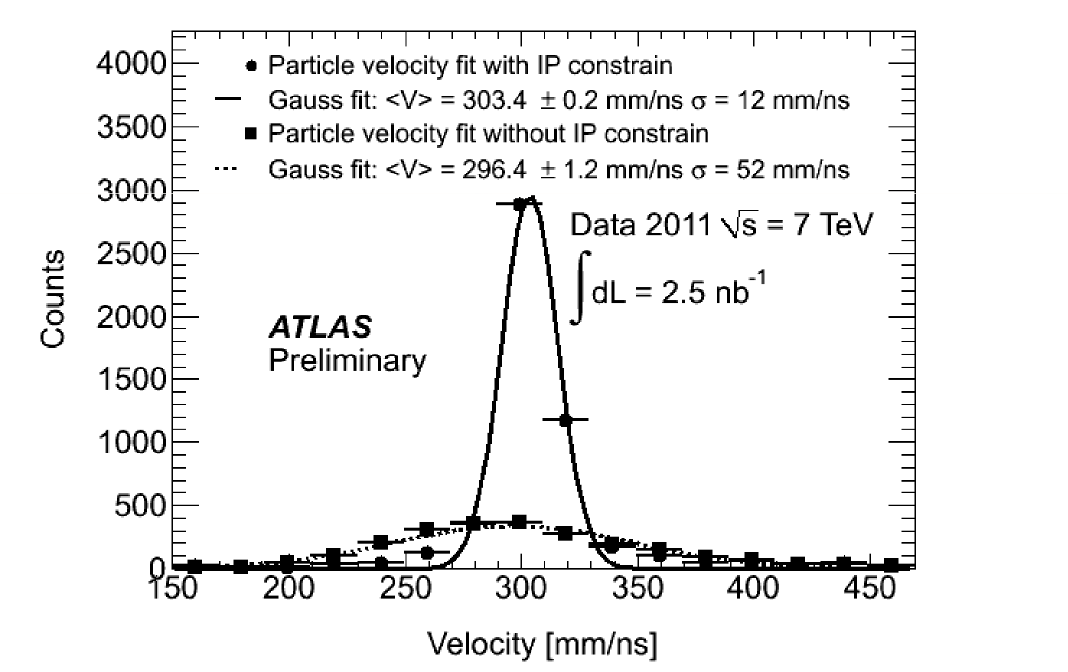
$\Delta v = c^2\, dt/L$

In Data dt=2ns/sqrt(2 HighPt layers)

with IP: L=10m and Δv about 13 mm/ns

No IP: L=2.5 m and Δv about 51 mm/ns





Using the IP constrain greatly improves resolution.

Conclusions

- The RPC time resolution is very near to the single unit resolution for the whole ATLAS and during all 2011 real data taking
  - Still space for improvement
- Simple algorithms are used for offline-calibration
  - Very easy to implement on-line
  - Possible RPC standalone but even more powerful if combined with other detectors
- Good background rejection and particle velocity measurement possible still preserving good efficiency