Andrei Golutvin (Imperial College & CERN & ITEP)
On behalf of the LHCb collaboration

Preparation of LHCb for data taking

- ***LHCb is fully installed (except M1) and commissioned as reported to LHCC at July open session***

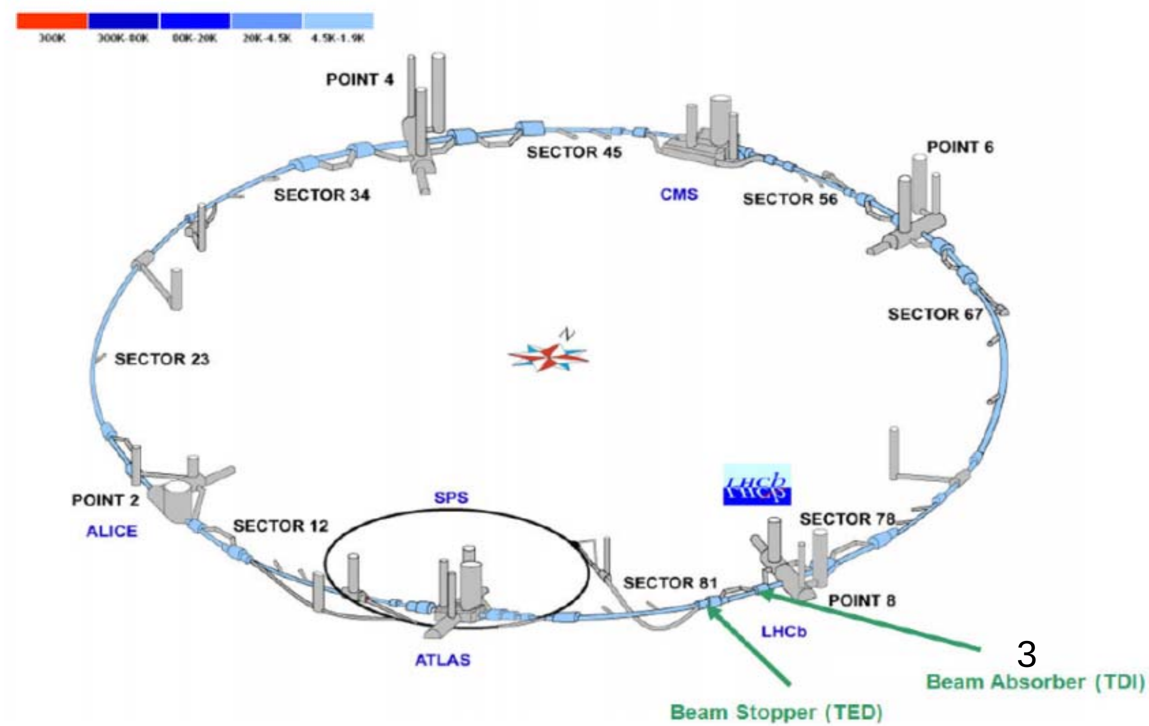
- ***Topics of this report are alignment of LHCb detector in time & space using cosmic and LHC beam induced data***

LHCb is ready for data taking

- *For all sub-detectors >95% channels are working*
- *Calo and Muon L0 is fully operational and heavily used during commissioning*
- *On line is fully operational for 2008 needs (currently readout at up to 70 kHz)*
  Completion of the installation is planned for spring 2009 to optimize cost performance
- ***LHCb has run shifts (24 hours/7 days) since middle of August:***
  Central crew of 2 persons (+ shift teams for Silicon detectors & piquet for the rest)

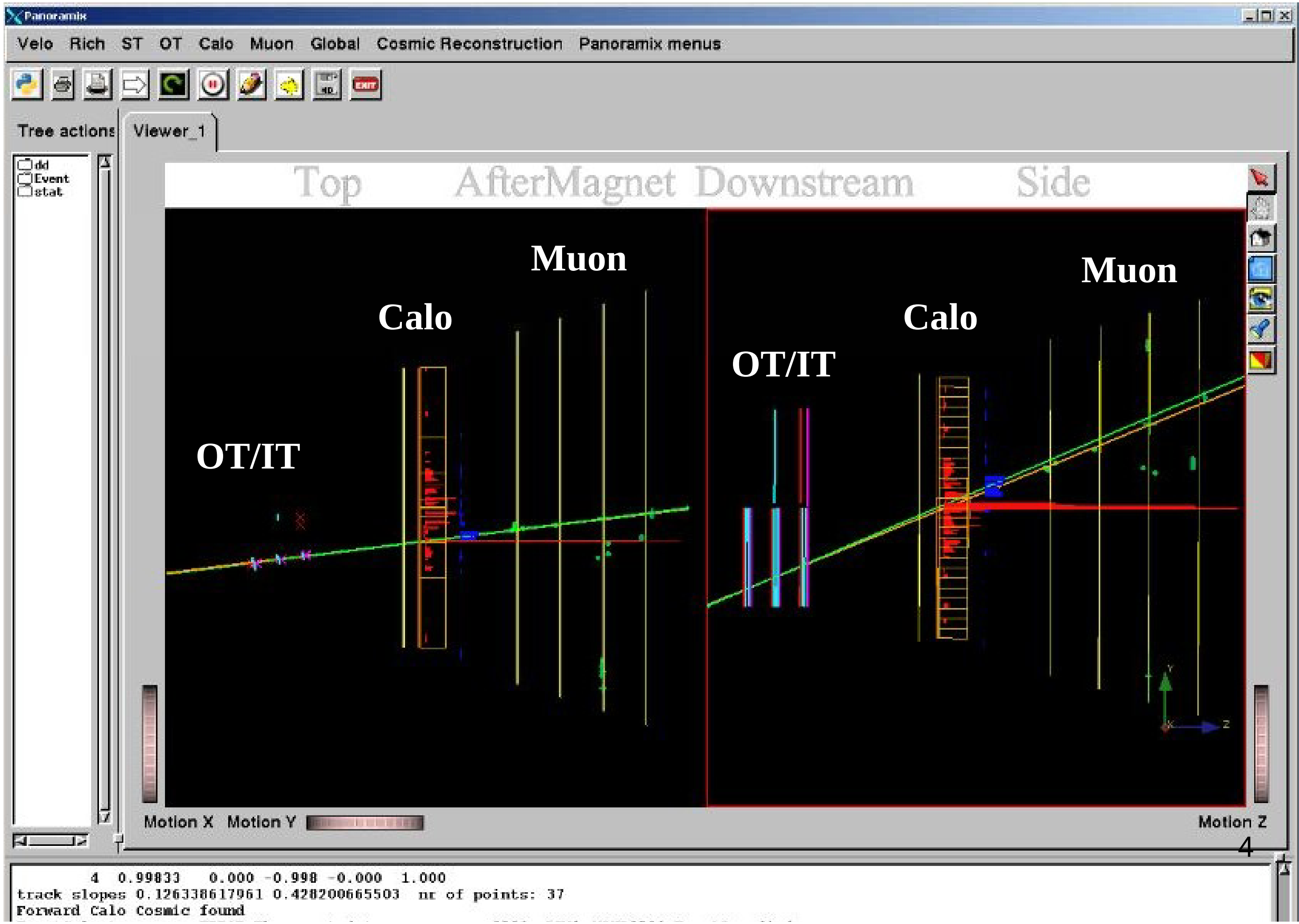
Data Samples

- ***Cosmic***
- ***TED events: muons originating from the stopping of Beam 2 (~300 m away from LHCb)***
- ***Runs taken during the circulation of Beam 1***



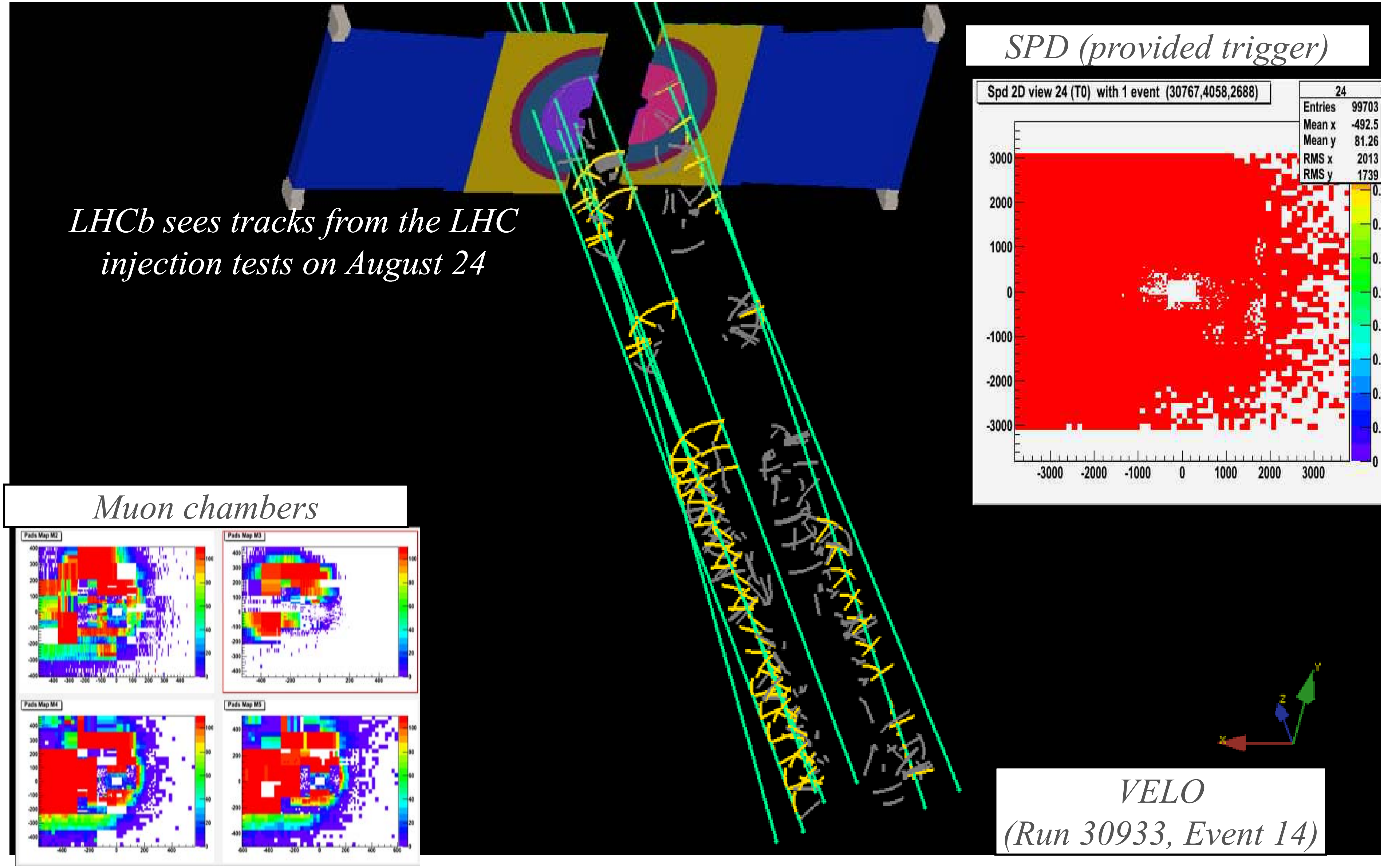
Cosmic data taking is non-trivial because of horizontal orientation of LHCb
Nevertheless nice events have been collected

Wednesday 2nd July: CALO + Muons + OT + IT + TT



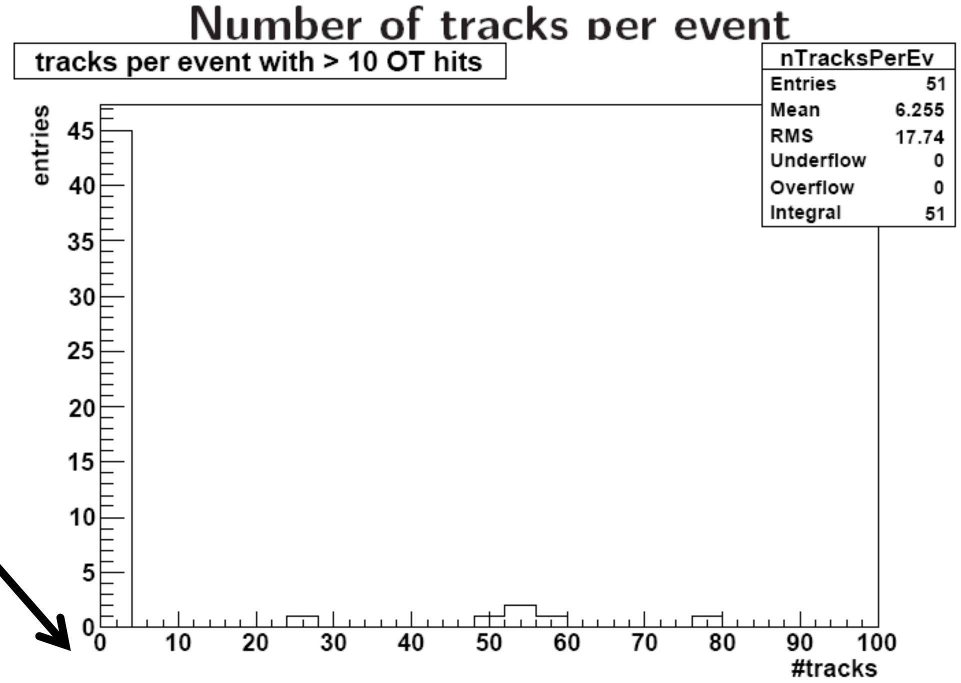
TED events (stop of Beam 2)

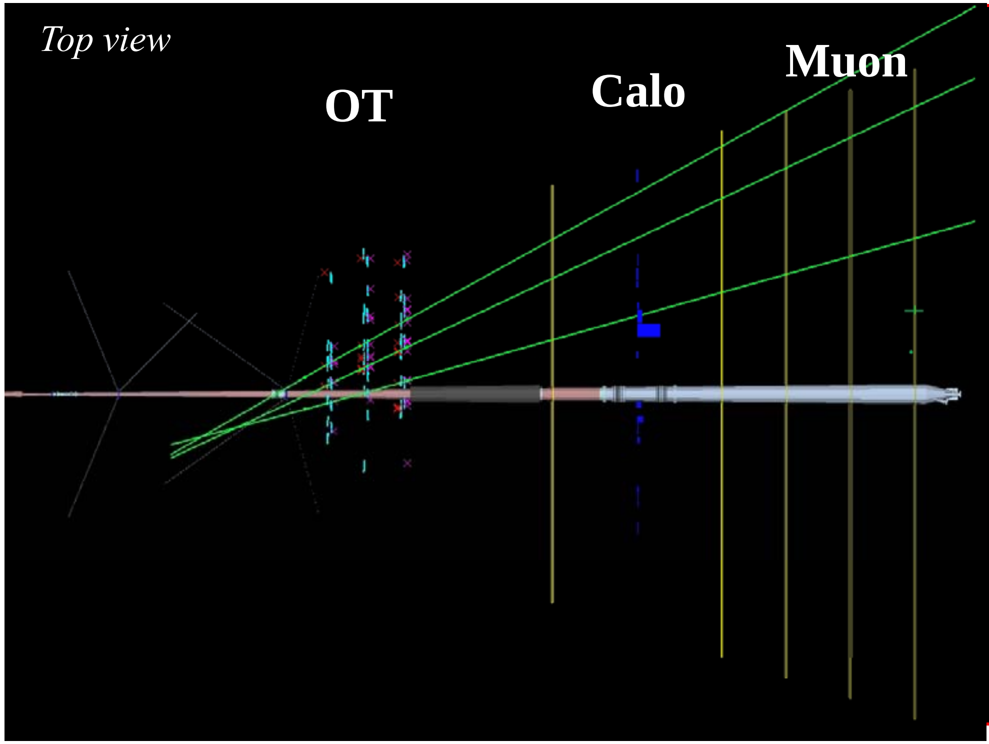
Muon tracks cross LHCb in the "wrong" direction

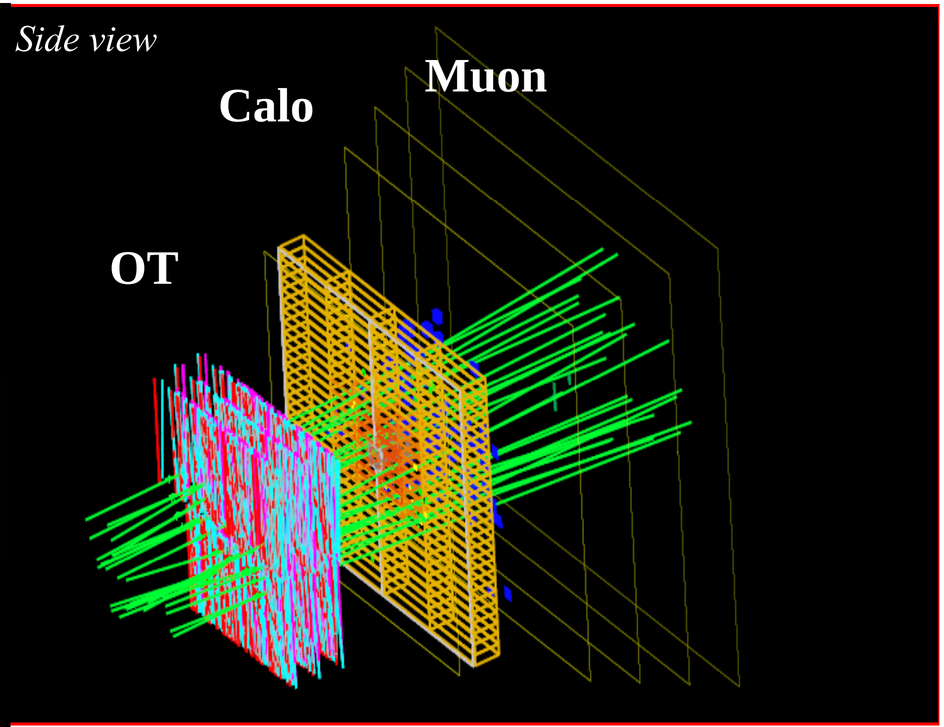


Beam 1: - 1 shot every 48 sec.
- 5×10⁹ protons per shot

Events taken during Beam 1 circulation look like either low multiplicity events, or splashes







Time alignment

methods are based on a possibility to read out 15 consecutive samples:
*N-7,..,N-1,**BX**,N+1,…,N+7*

http://lhcb-reconstruction.web.cern.ch/lhcb-reconstruction/Panoramix/PRplots/MediaDay/Beam1/beam1_ot.gif

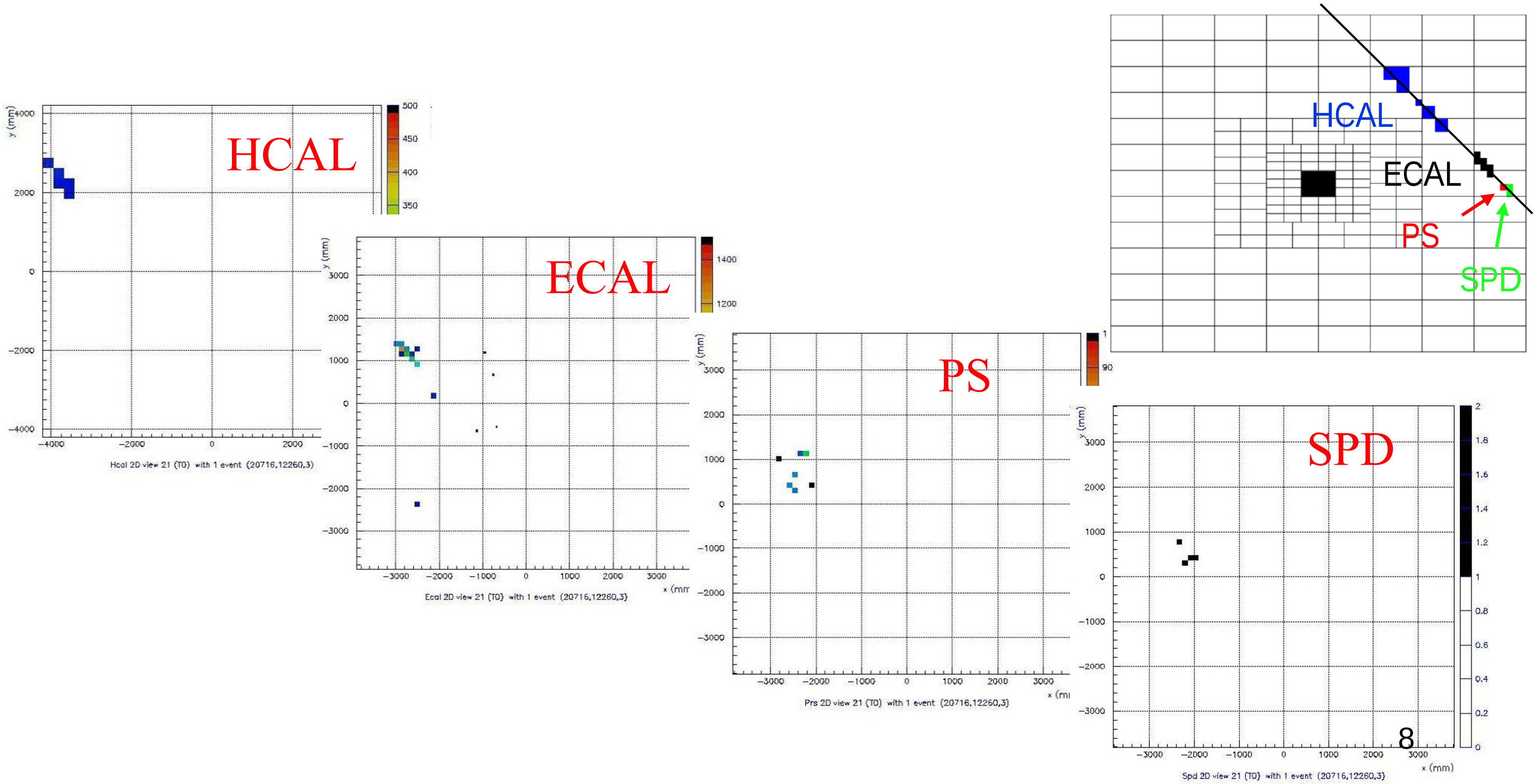
Muon	*cosmics & TED*
Calorimeters	*cosmics*
RICH	*TED*
OT	*cosmics & particles from beam 1 splashes*
ST	*cosmics & TED*
VELO	*TED*

- ***HCAL & ECAL trigger used for cosmic data***
- ***SPD multiplicity and Muon triggers for the TED and Beam-1 data***

Calorimeter time alignment *(using cosmic data)*

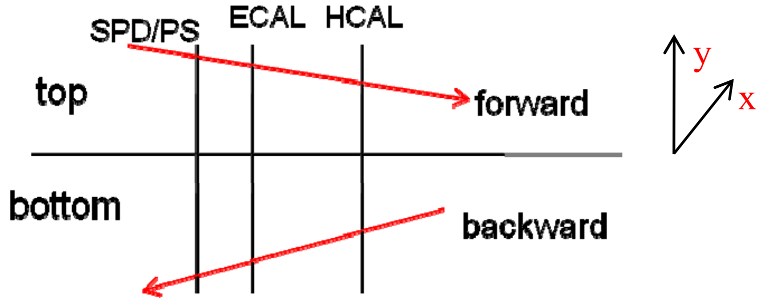
Intensive use of ECAL & HCAL for cosmic triggers since 12/07:

- *Operate ECAL/HCAL at 10**5 gain at ~10Hz / half detector rate*



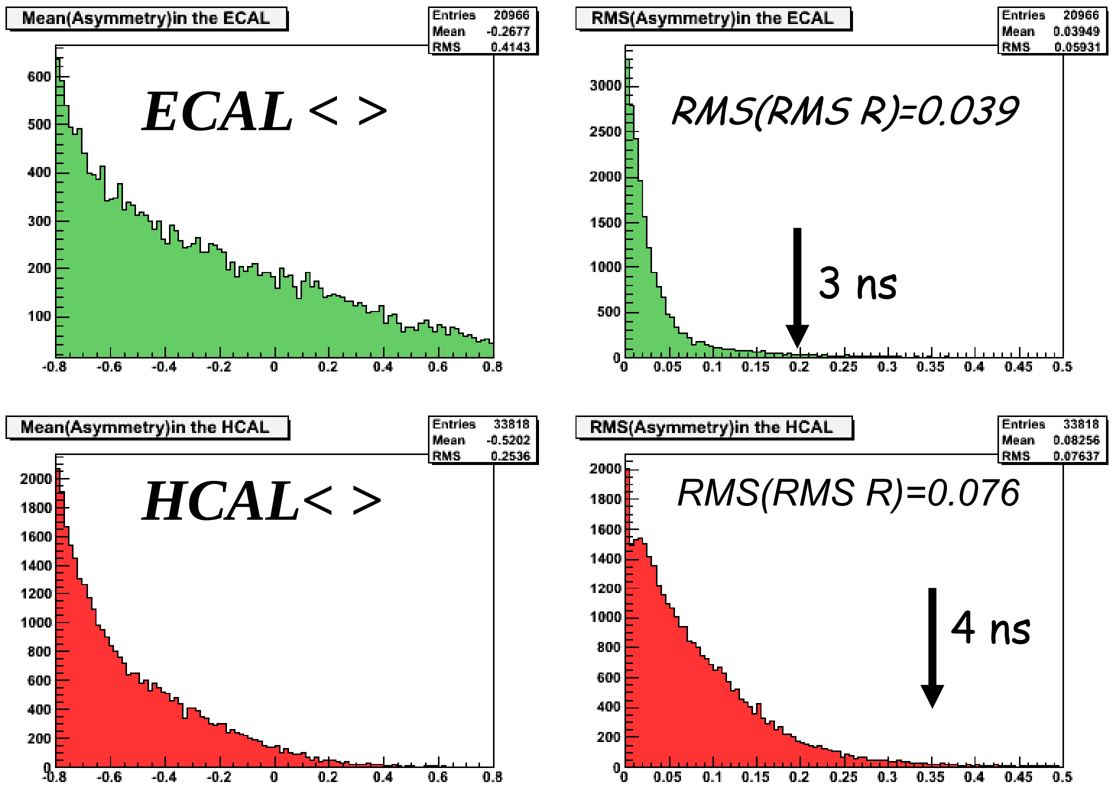
Method

- ECAL & HCAL can provide time alignment for cosmic tracks:
  - Strategy:
    - Equalize a priori timing difference among channels
    - Adjust relative detector timing (HCAL, ECAL, PS, SPD) using cosmic with the asymmetry method.
  - Method:



$$Rj = \frac{\sum_{i}^{Nevt} E_{ij}(Current) - \sum_{i}^{Nevt} E_{ij}(Next)}{\sum_{i}^{Nevt} E_{ij}(Current) + \sum_{i}^{Nevt} E_{ij}(Next)}$$

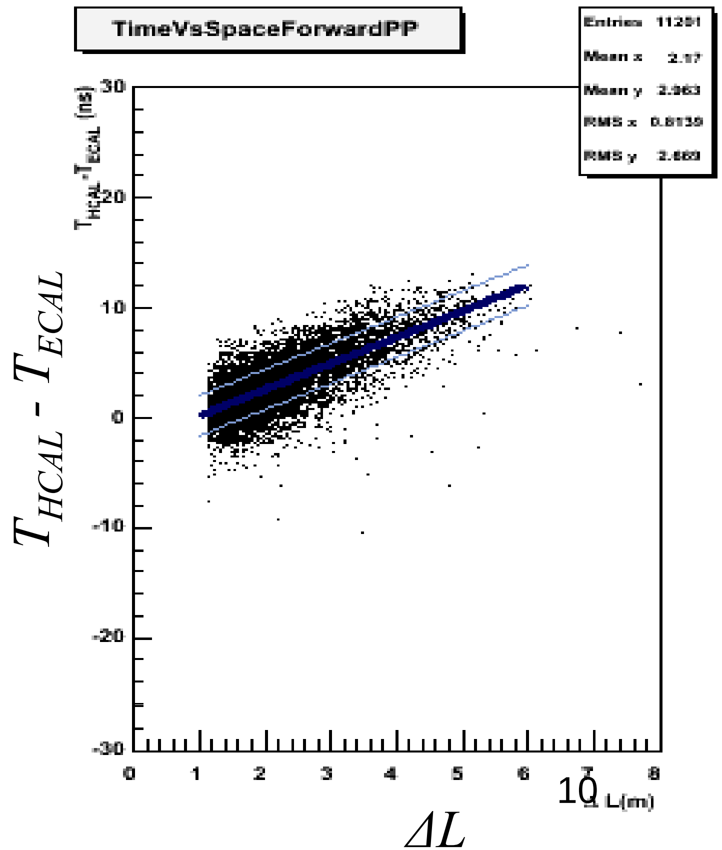
- ✓ Signal coax cables are equals for all ECAL cells and all HCAL cells (but HCAL $\neq$ ECAL)
- ✓ Calculate average X, Y in ECAL, HCAL. Decide from Y value which detector was traversed first
- ✓ From ADC values in two samples calculate asymmetry and from the average asymmetry over cells the time of passage of the cosmic
- ✓ Calculate sqrt(ΔX**2 + ΔY**2 + ΔZ**2) = ΔL =distance between the two detectors for a given event
- ✓ Plot THCAL - TECAL vs ΔL the slope should be the speed of light; the intercept should be related to timing error



$$R = \frac{N(Current) - N(Next)}{N(Current) + N(Next)}$$

87k Events

ECAL: aligned in ±3ns
HCAL: aligned in ±4ns

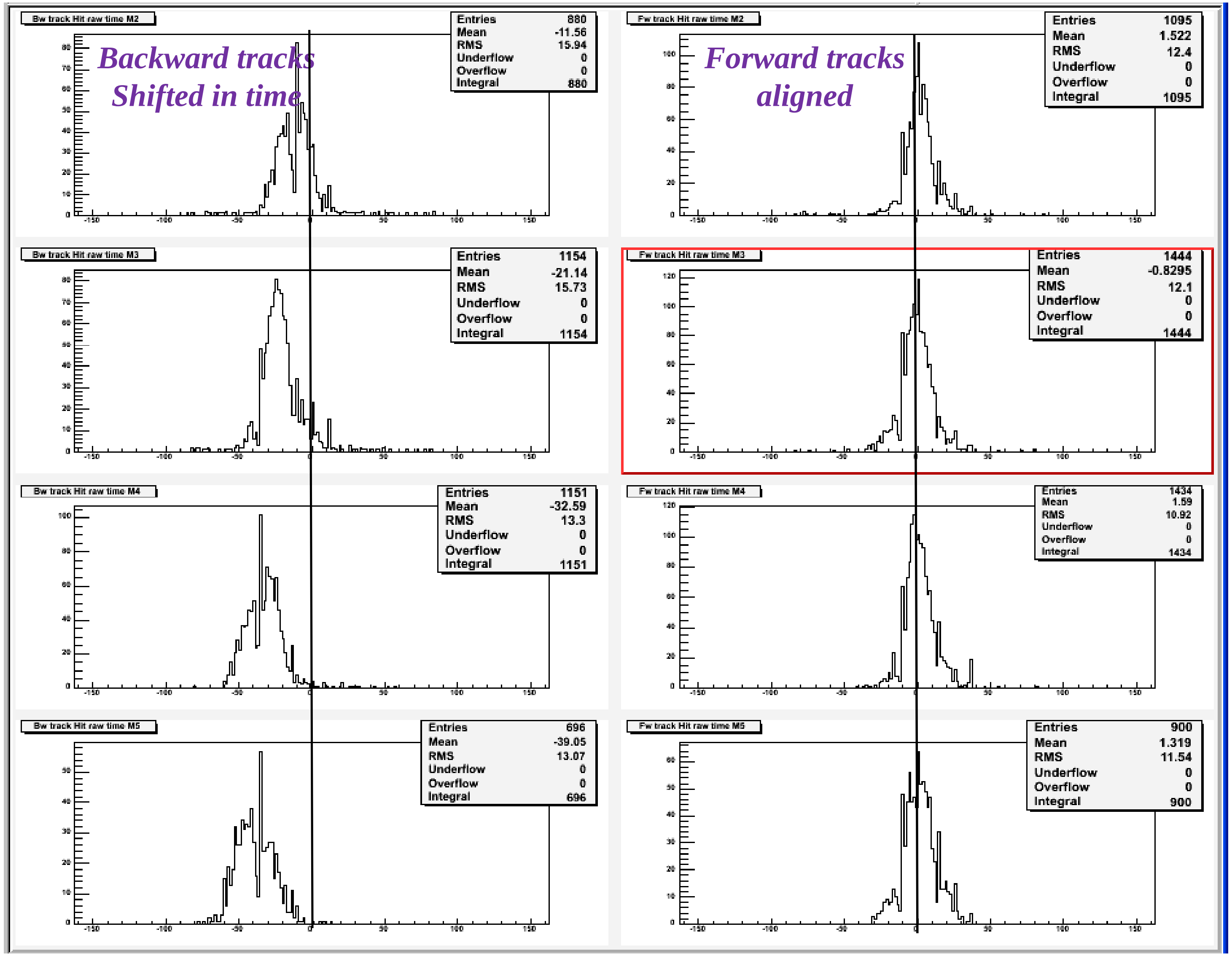


PS and SPD are aligned to ~5 ns as well

Muon time alignment *(using cosmic data taken on Sept.18)*

Calo Trigger:

Time alignment of ~3 ns observed for the forward tracks for all Muon stations

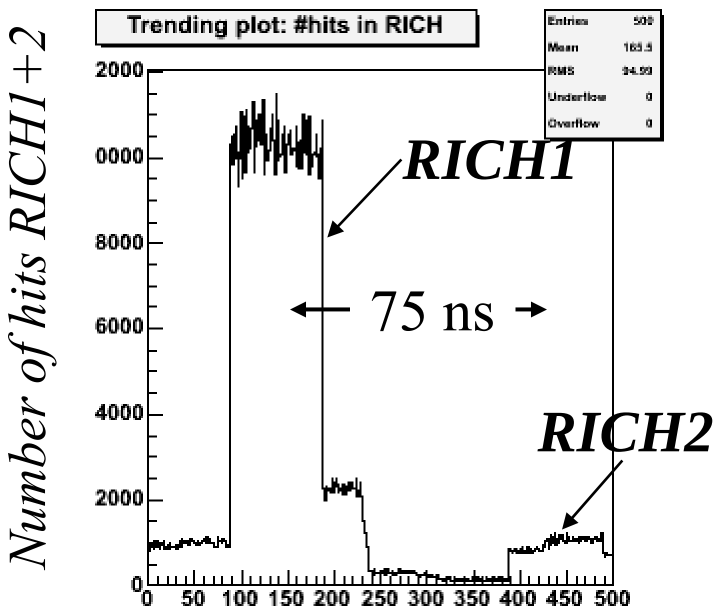


RICH time alignment

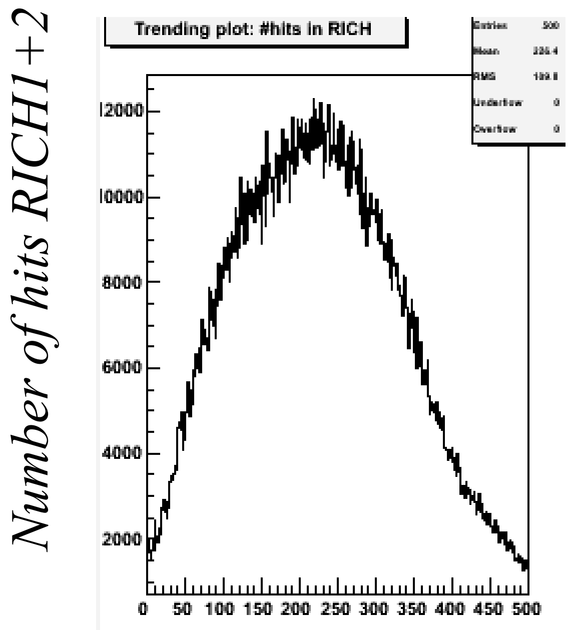
(Special procedure needed since RICH photon detectors cannot take consecutive bunches)

- *Internal timing of RICH system has been determined using pulsed laser light (<1 ns) piped onto HPDs by optical fibre*
- *≈ Uniform illumination of the HPD planes of RICH1 & 2*

1) Coarse scan *2) Fine scan (after coarse alignment)*

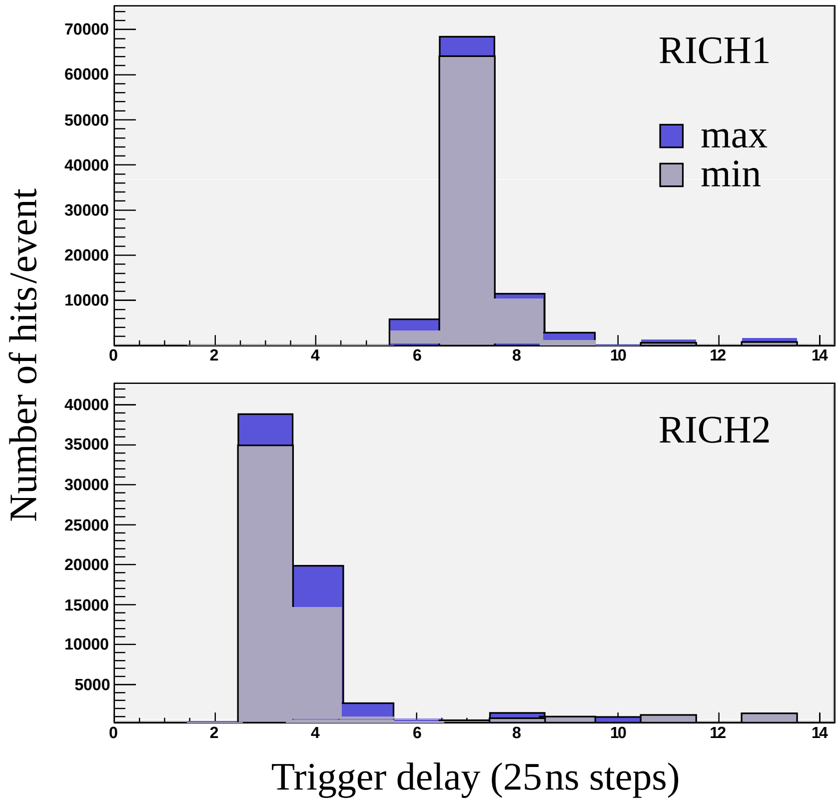


Event number in run (as timing was changed)

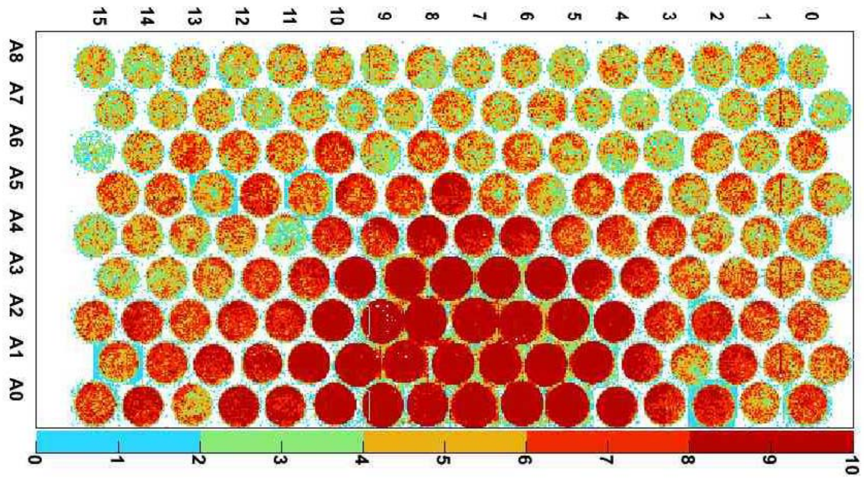


50 ns

- *Coarse time alignment to the rest of LHCb has been achieved using LHC beam dumped onto TED (i.e. Beam 2)*
- *Triggered by calorimeter system, trigger delayed in 25 ns steps*
- *For Beam 1 only RICH2 has been switched on so far*
  Timing set as determined from TED runs, and many hits seen!



Hits in one HPD plane of RICH2
(30 events from Beam 1 on collimator)



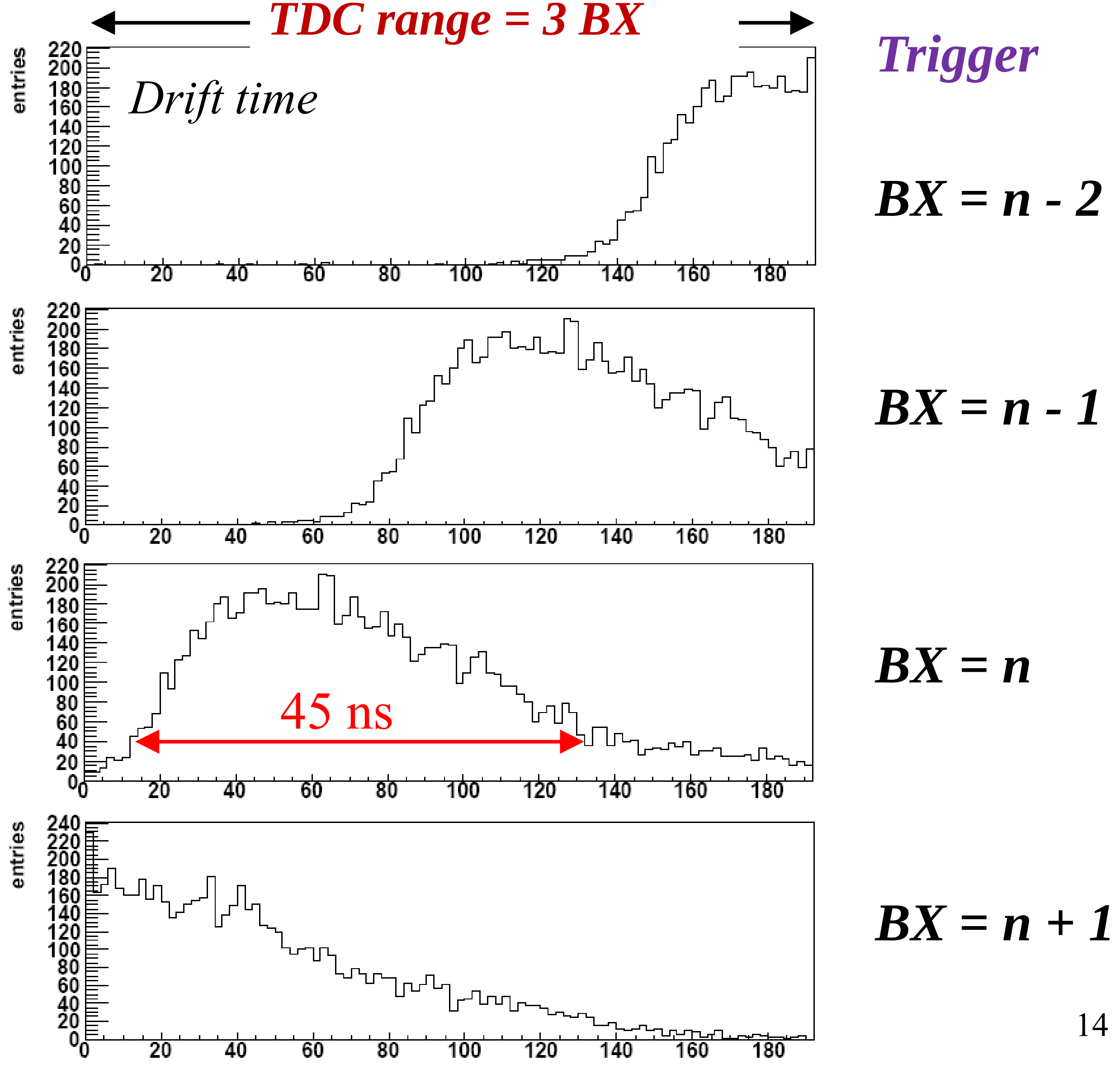
Fine alignment still to be done

Outer Tracker time alignment *(using 6 Beam1 splash events)*

Run 33062:

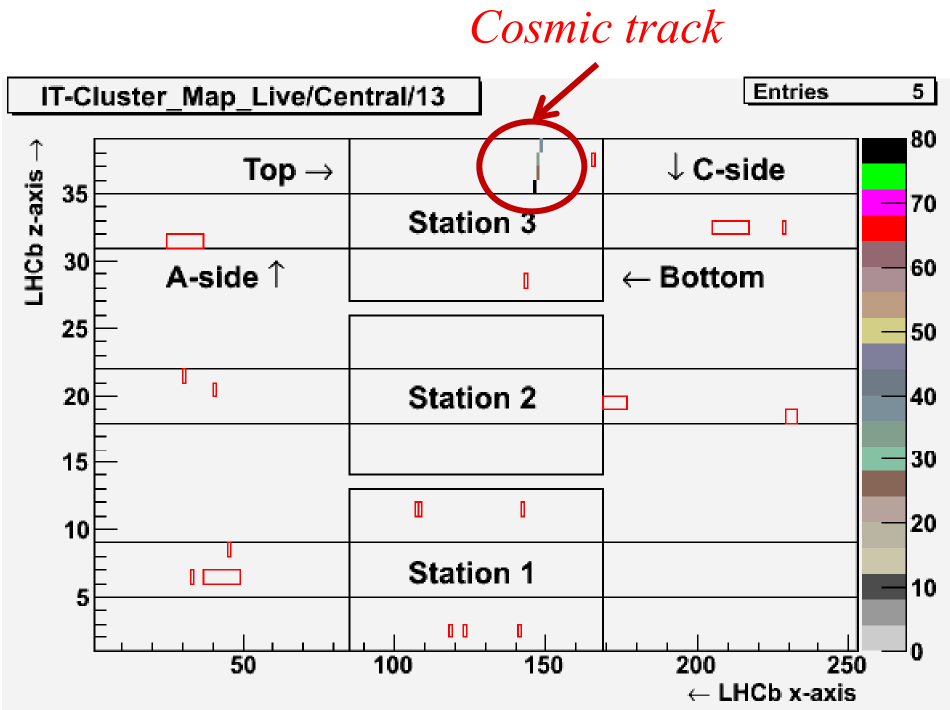
6 events with ~50 tracks/event

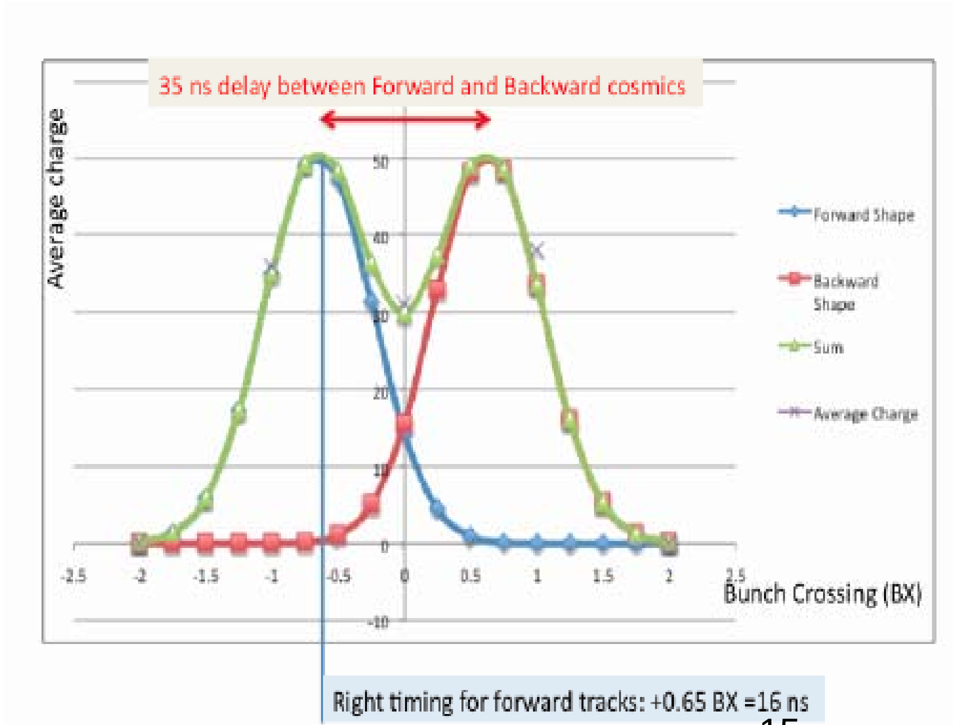
TDC spectra of all OT chambers



Silicon Tracker time alignment with cosmic data

- *IT is a large system: 4 different cable lengths, 3 different time of flights*
- *12 timing parameters to determine*
- *First global + internal time alignment made using cosmic data*

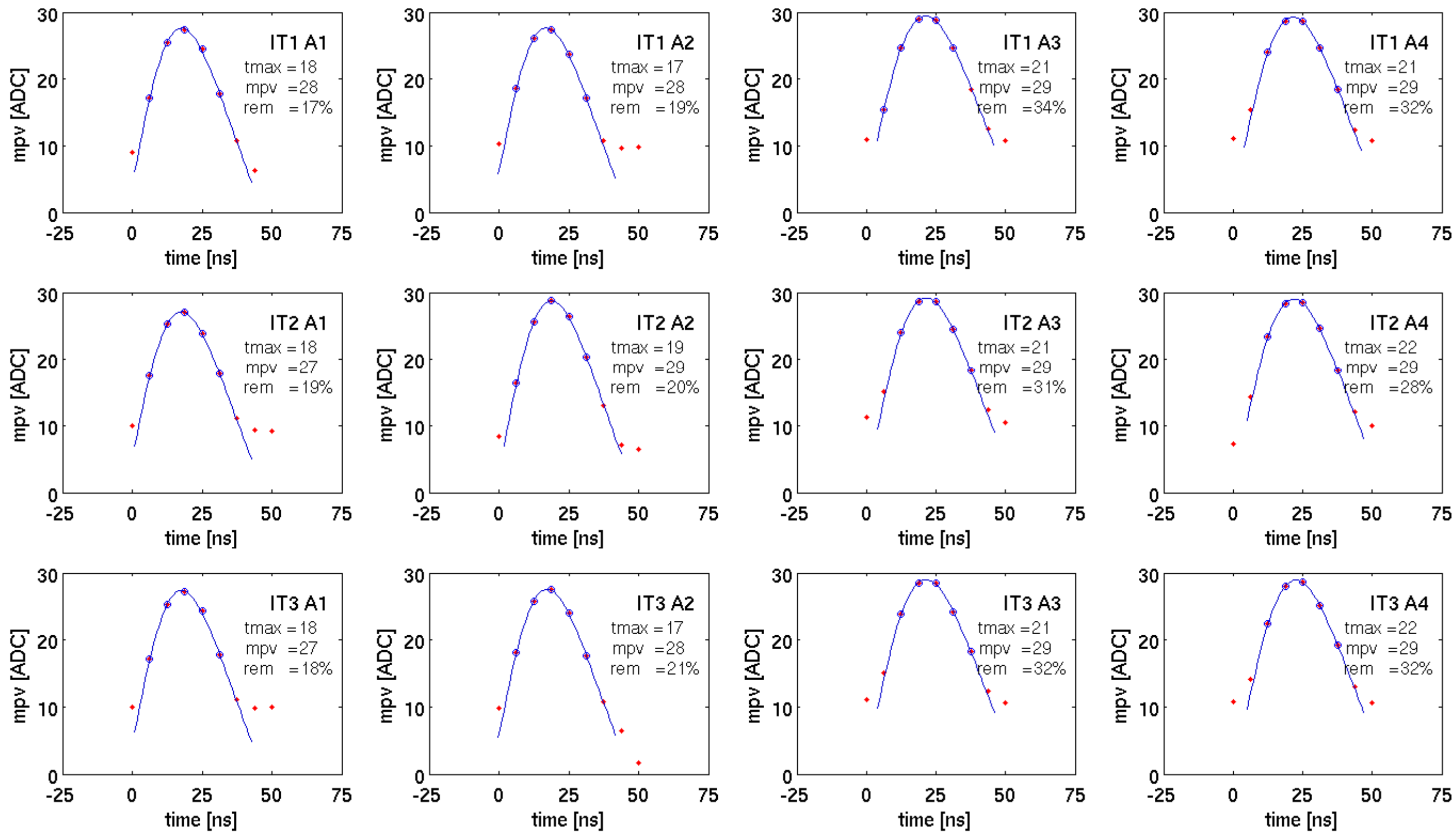




IT time alignment using TED events

(all in a very dirty environment: 10 times occupancy expected in normal running)

IT pulse shape scan from TED running (5/6 September)

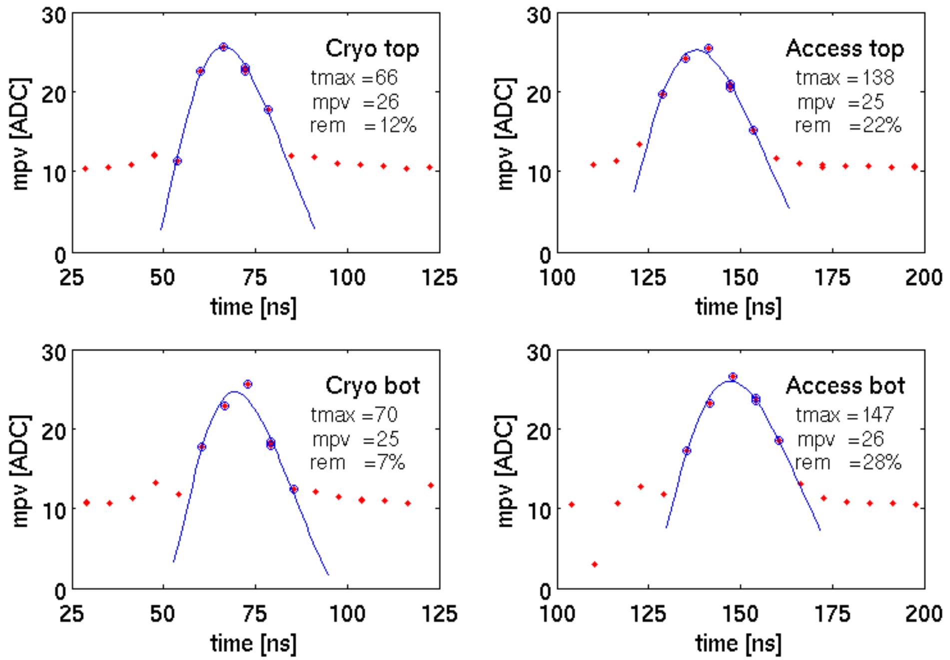


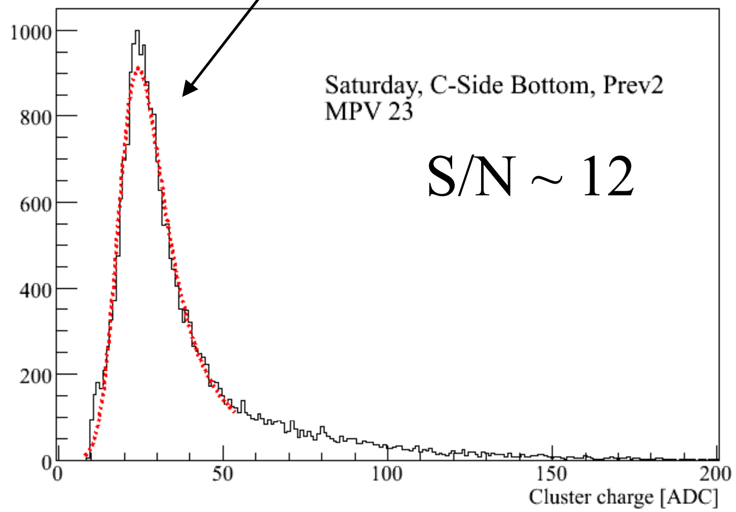
A-Side Service Boxes

Internal time alignment of IT good to few ns can be extracted

TT time alignment using TED events

TT pulse shape scan from TED running (5/6 September)



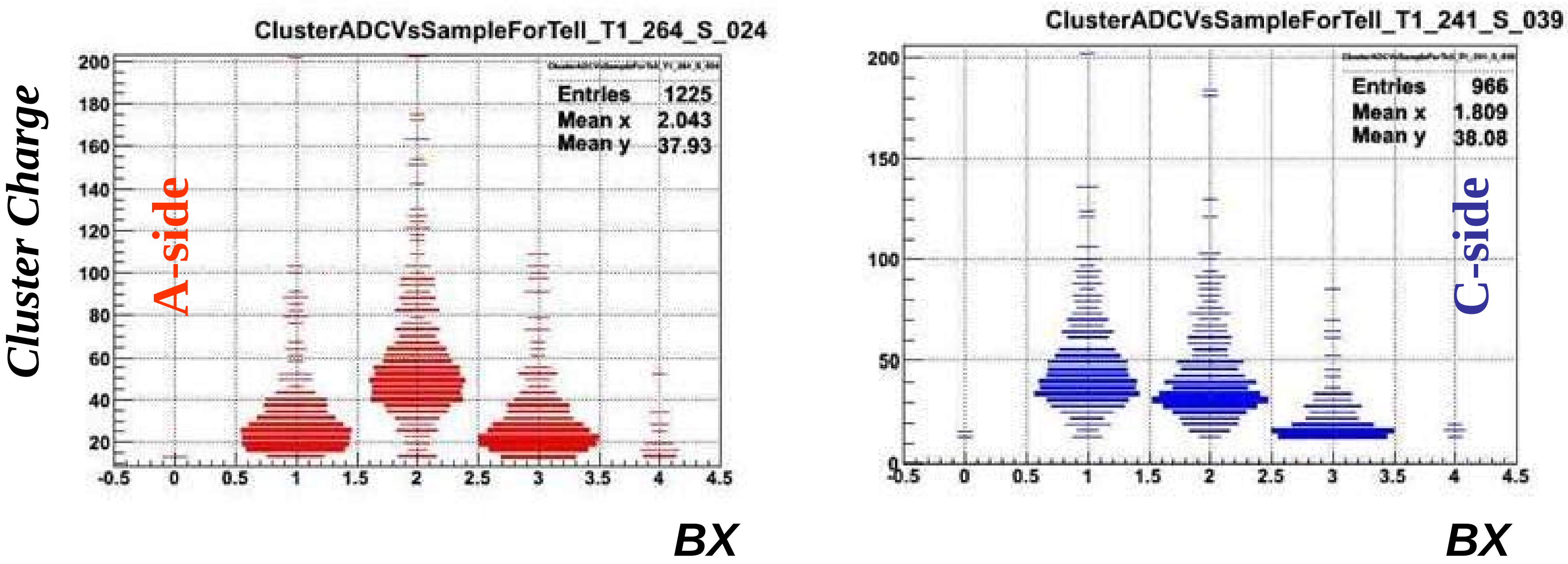


Initial timing done using known cable lengths

Internal time alignment of quadrants can be extracted from TED runs with a few ns accuracy

VELO time alignment (TED events)

- *The Coarse Time alignment was achieved during the TED runs:*



- *No large time spread over the sensors observed: peaks are between the Prev1 and the Central Trigger.*
- *The fine tuning for each sensor has to be done with the LHC beams with NZS data over a few consecutive triggers.*

Spatial alignment

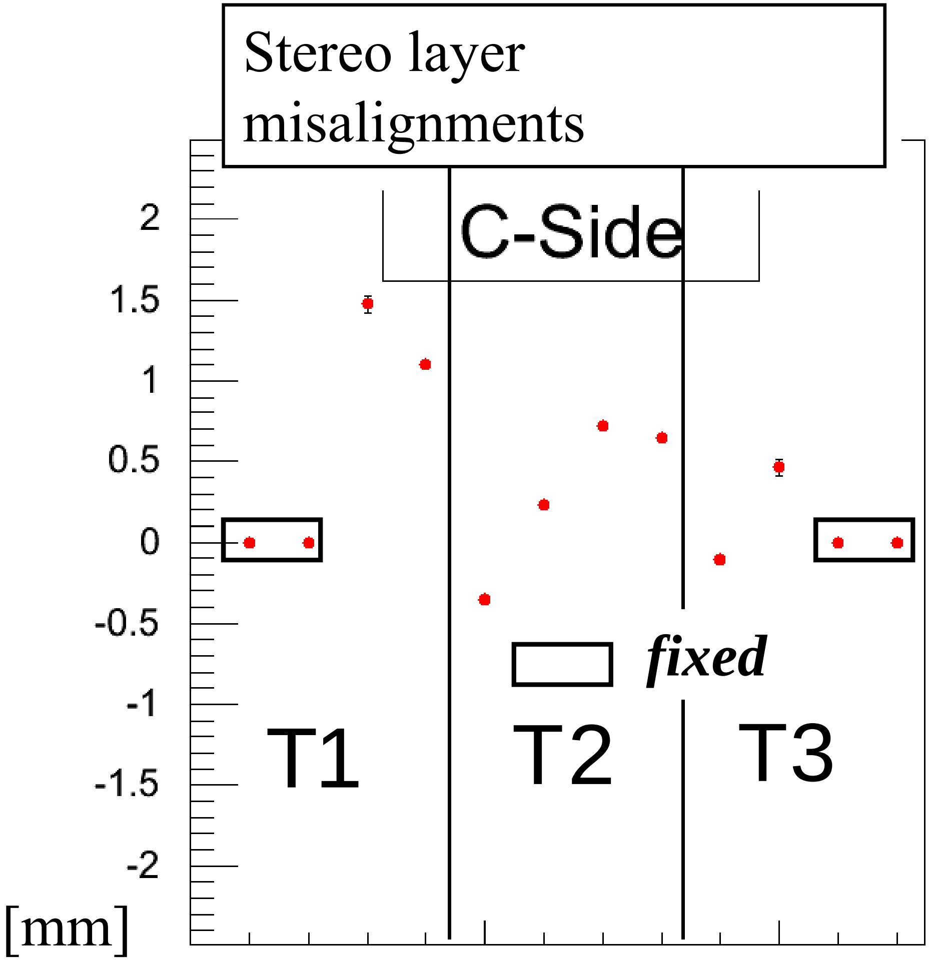
Strategy:

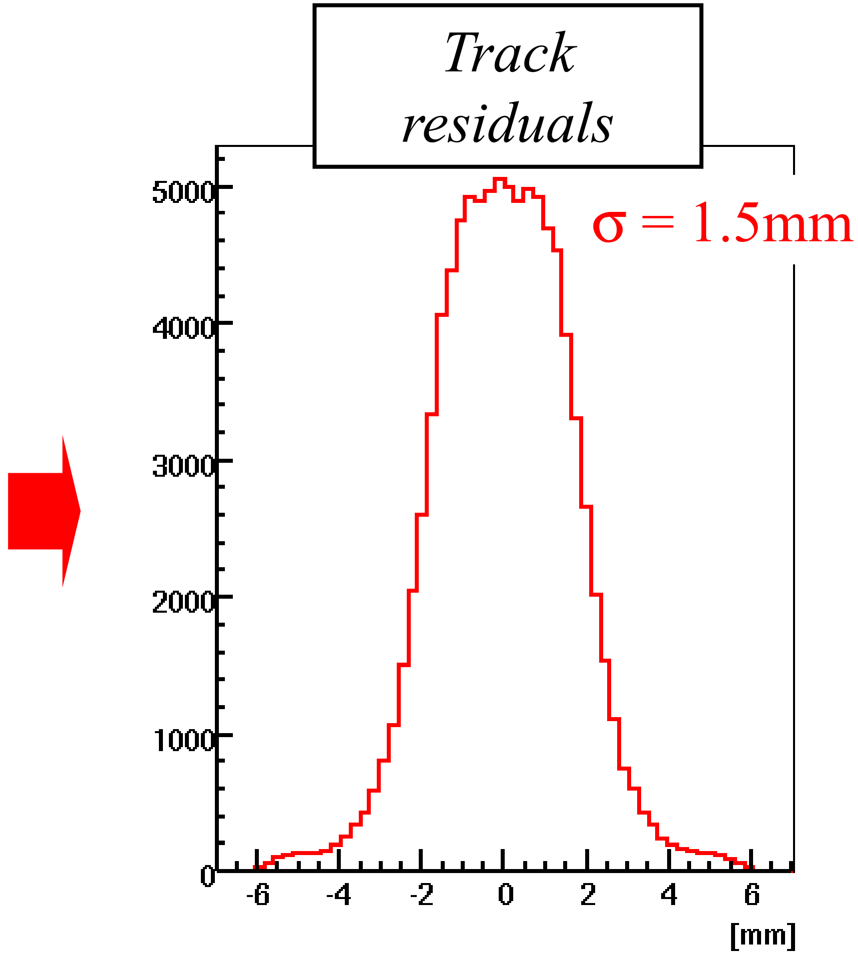
- *Use cosmic data, whenever possible, to make internal alignment of sub-detectors (example: Outer Tracker)*

- *For the final alignment use long tracks reconstructed in VELO & other tracking detectors → need collisions (first attempts have been done using TED events)*

Outer Tracker stereo layer alignment

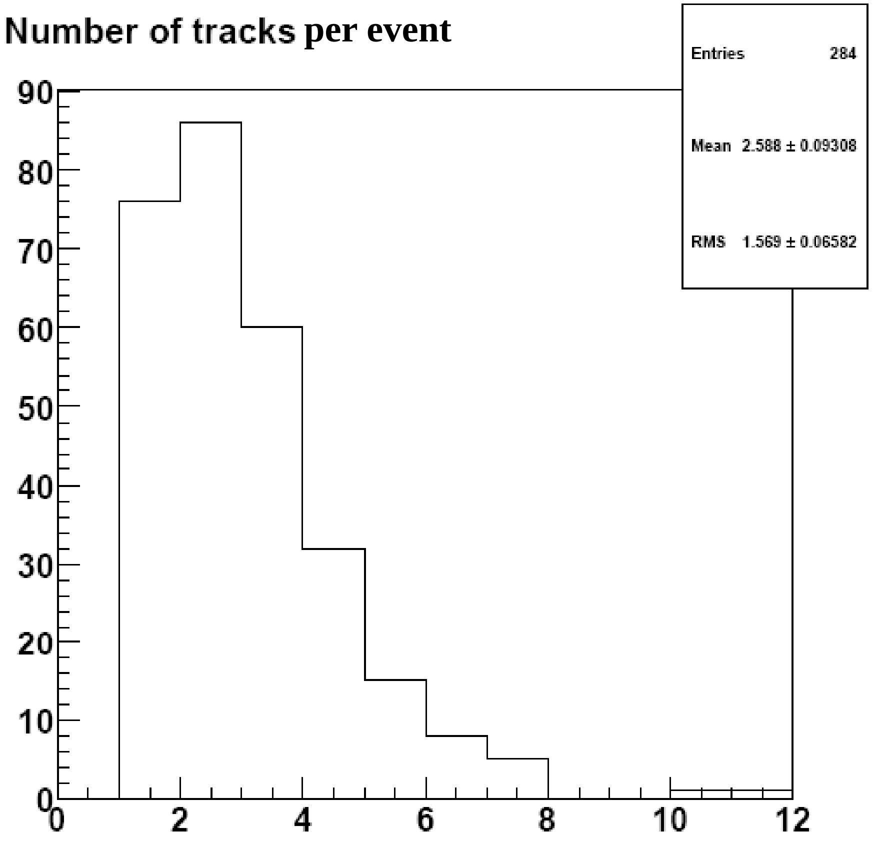
(using cosmic data)

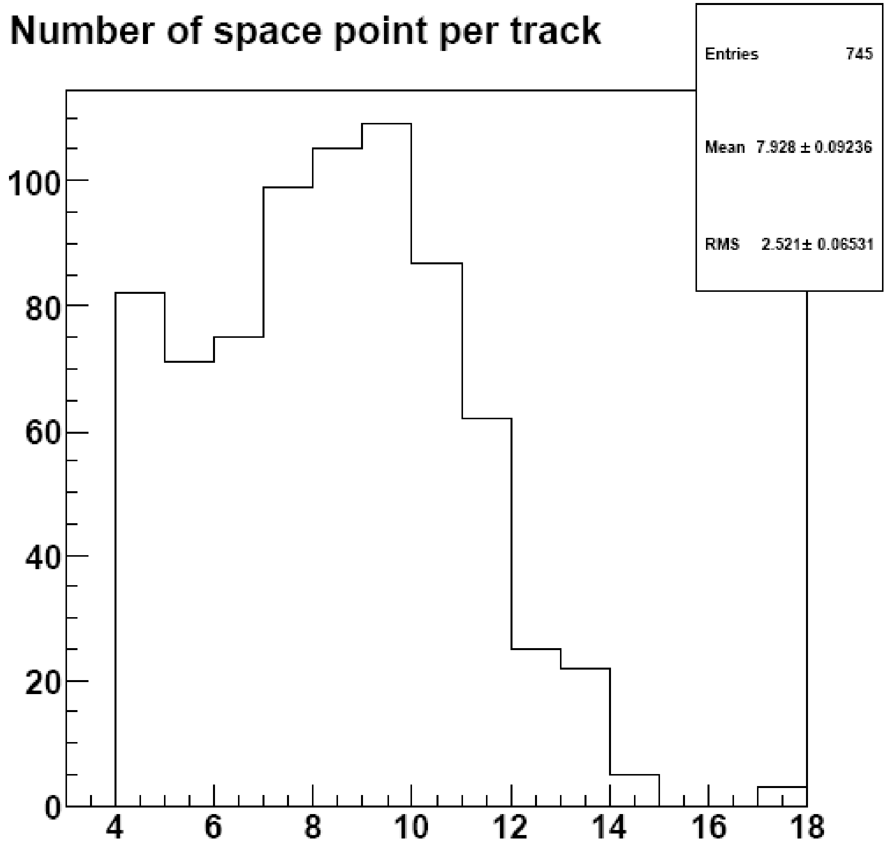




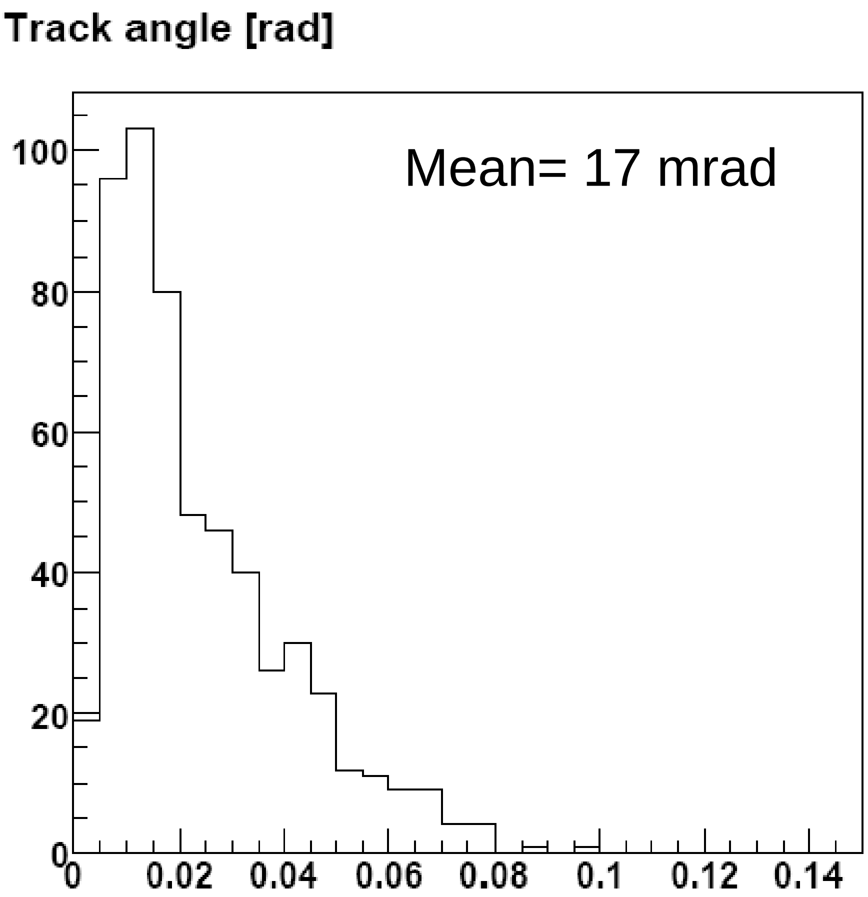
(no drift times used)

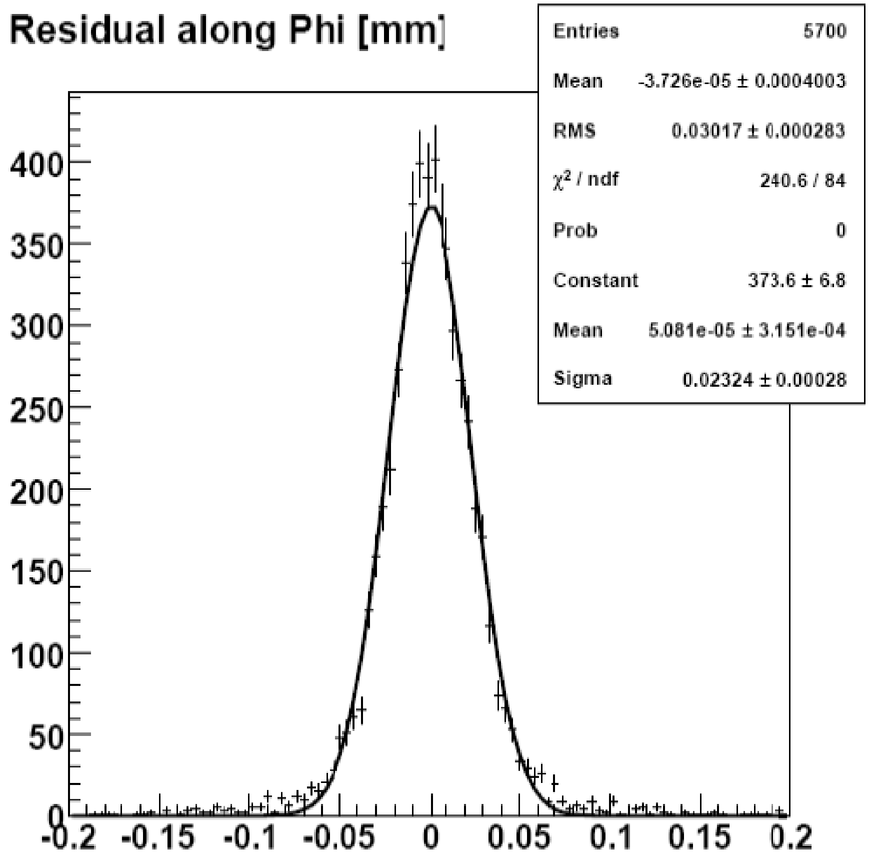
TED events
VELO: number of Tracks and space points





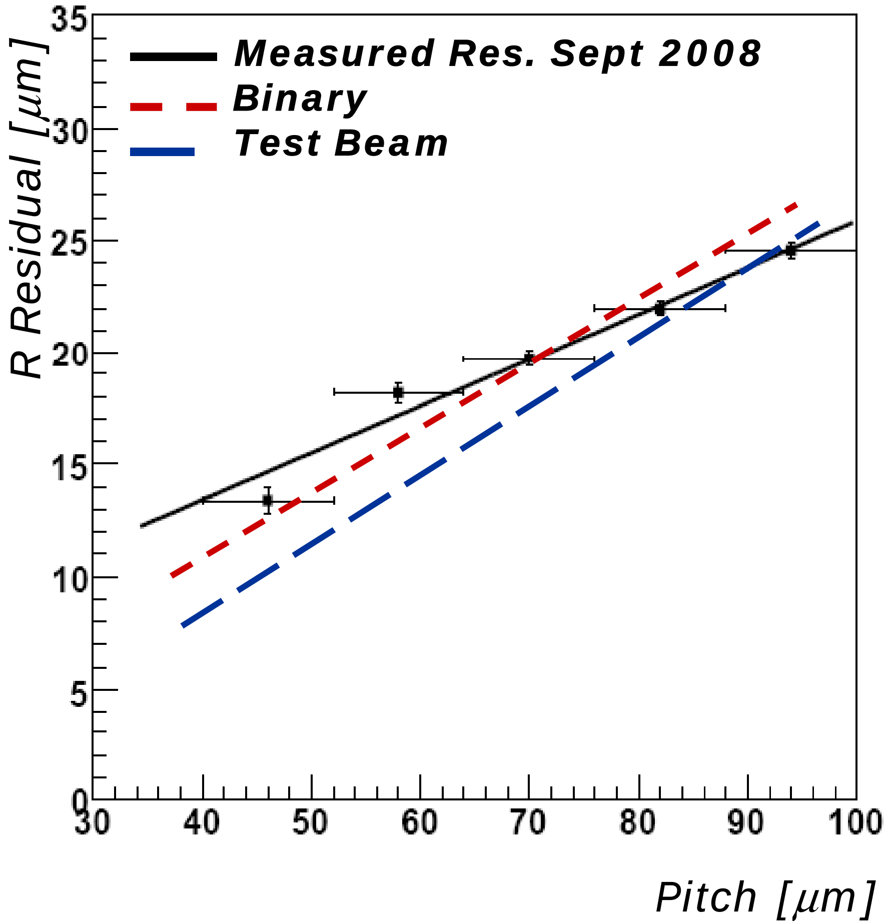
TED events: VELO track angle

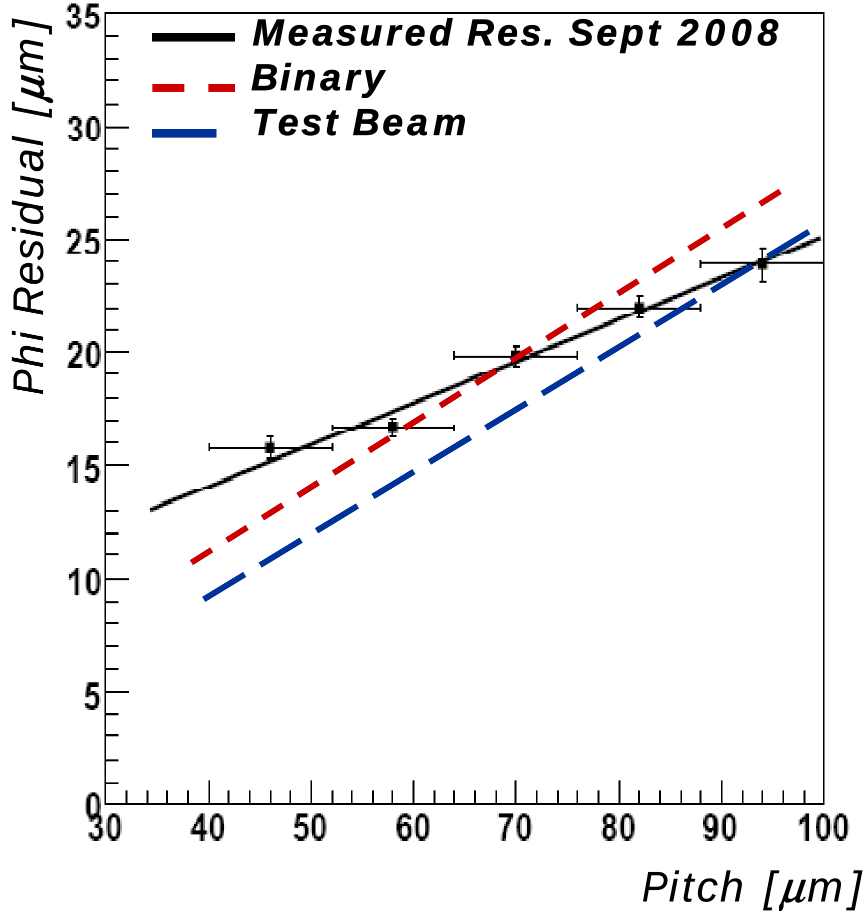




- *VELO is aligned to ~ 20 μ in R and φ*

TED events:
VELO residuals versus Pitch

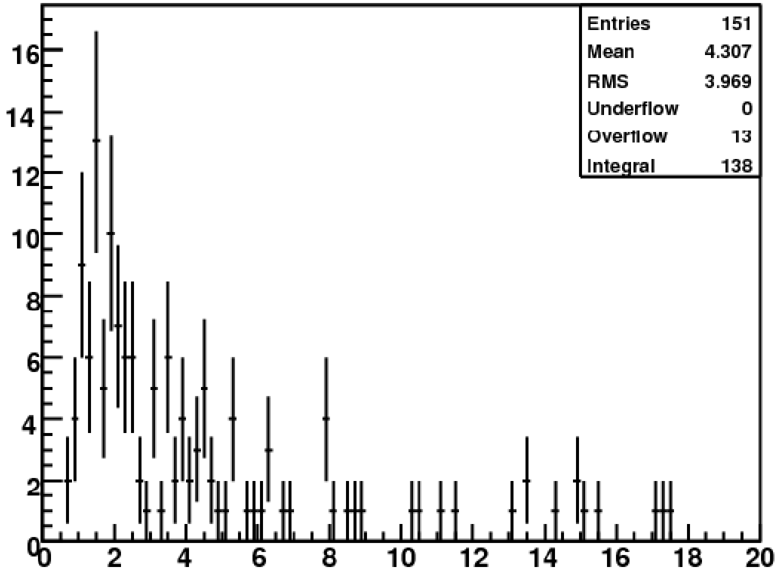




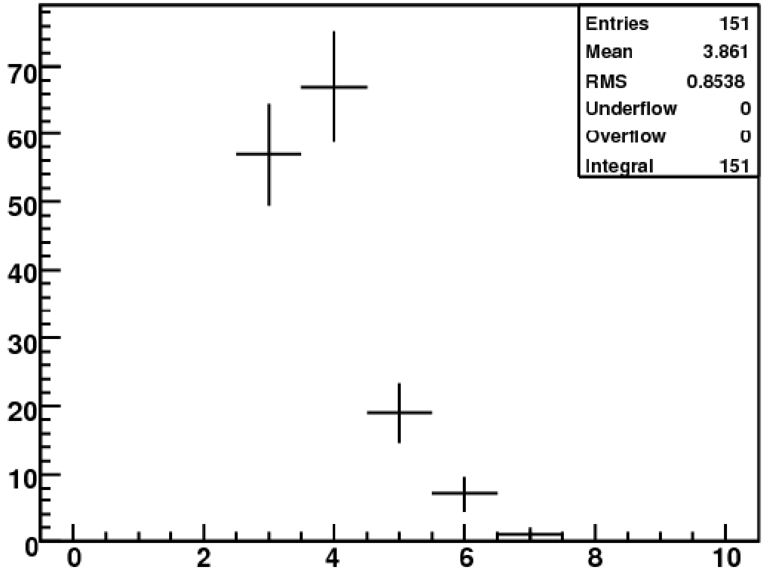
TED events:
VELO -TT tracks

Good quality of the track fit

chi2/ndof

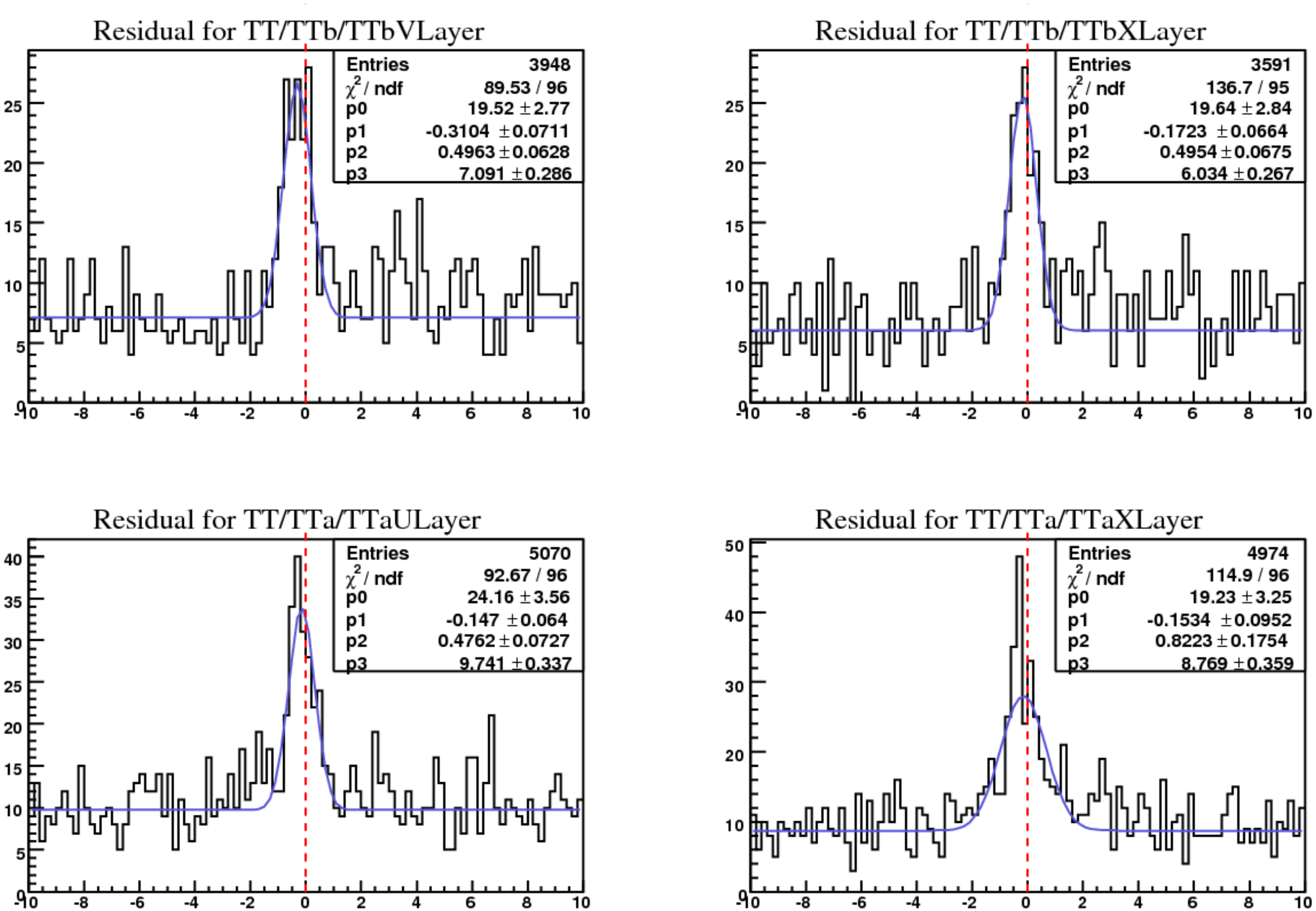


TT hits



In average 4 hits per Trigger Tracker

TED events: Residuals in TT station

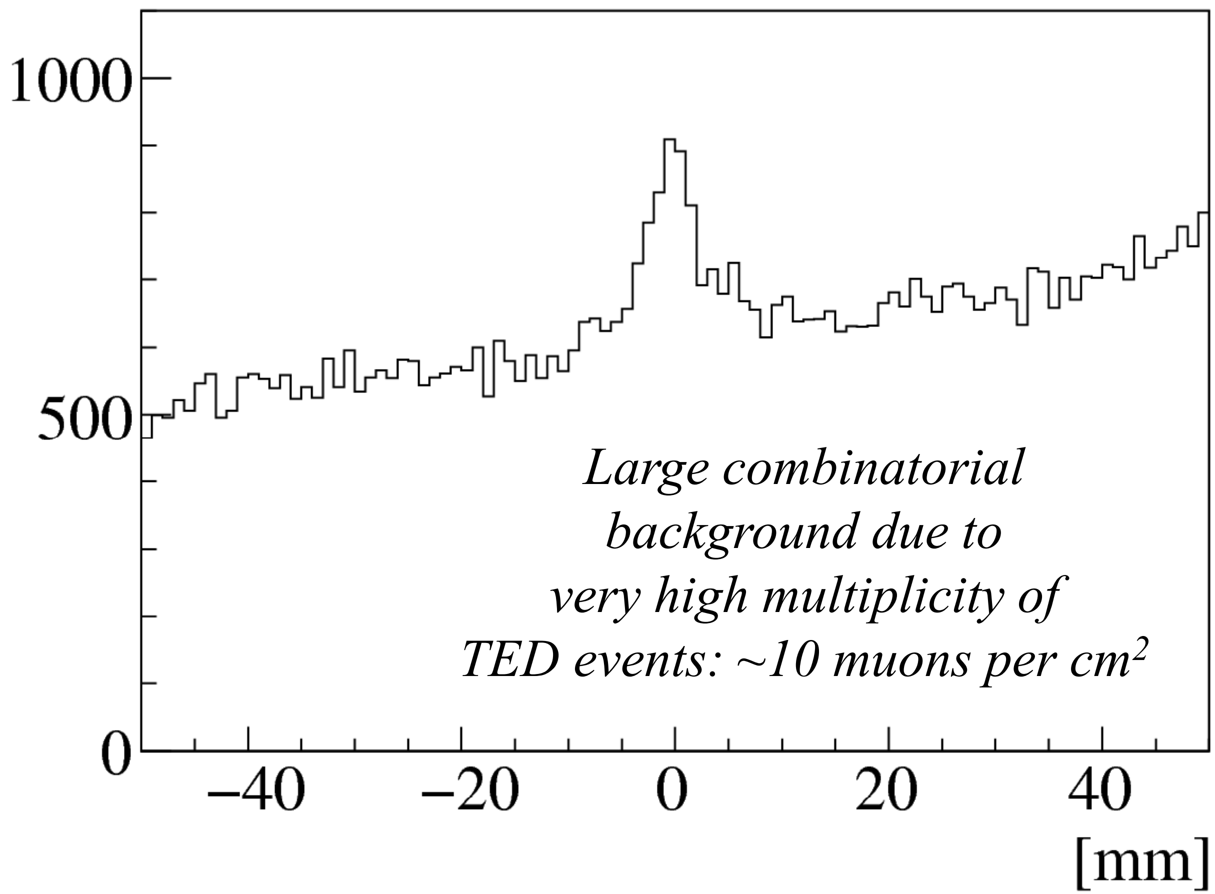


Distance of TT clusters to velo track for TT layers

within ~300 micron of expected

Extrapolation of VELO tracks to IT *(TED events)*

residual of IT hits with respect to VELO tracks



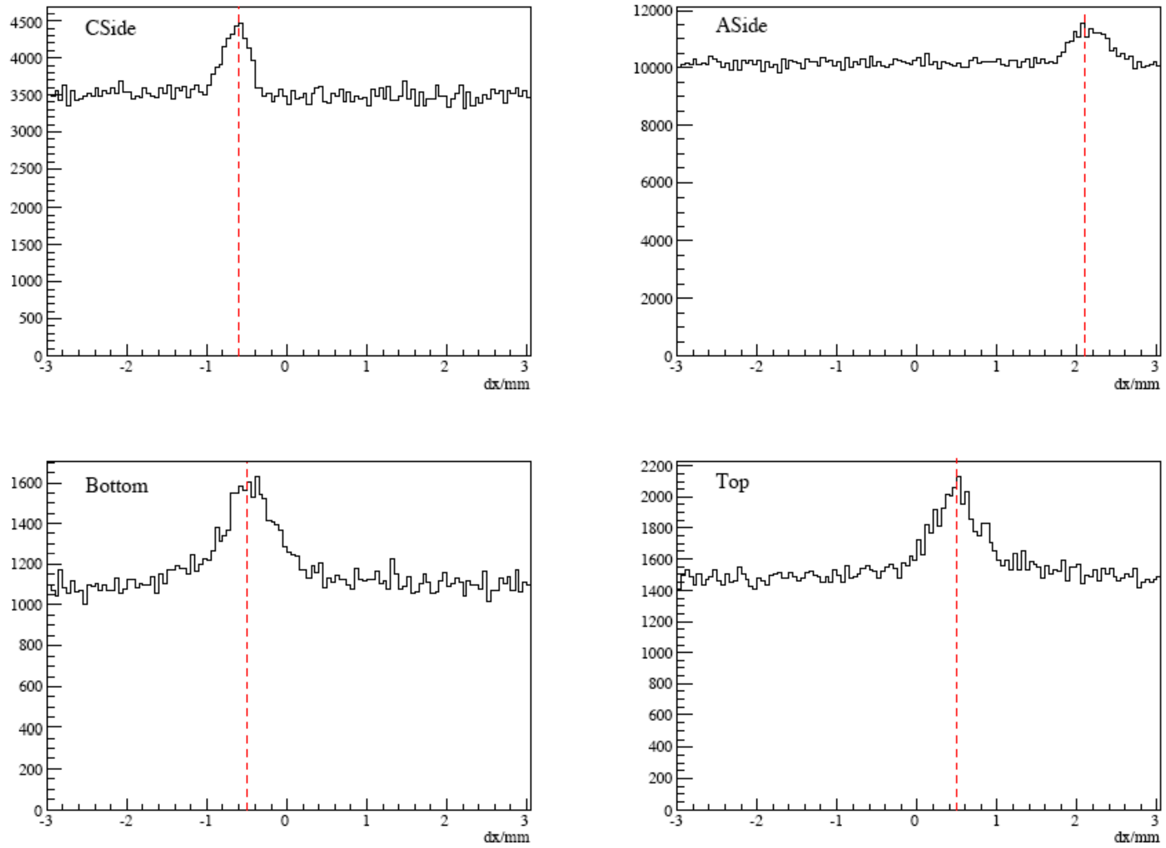
global alignment of IT good within ~mm

More TED events with reduced occupancy would be useful !!!

❑ *Internal alignment of IT using TED data*

define tracks by T1 and T3, look in T2

residual of hits in T2 with respect to tracks defined by T1 and T3



Alignment with TED events provides better sensitivity than

survey measurements

Conclusion

I'd like to thank all LHCb collaborators for their outstanding efforts to ensure that LHCb is ready for data taking

Expected LHCb sensitivity

as presented by Franz Muheim at the LHCC upgrade session Yesterday

2fb^{-1}

100 fb^{-1}

Sensitivity for $\tau \rightarrow 3\mu$ decay is under study

	Decay	Precision
γ	$B_s^0 \to D_s^{\mp} K^{\pm}$	$\sigma(\gamma) \sim 10°$
	$B^0 \to \pi^+\pi^-$	$\sigma(\gamma) \sim 5°$
	$B_s^0 \to K^+K^-$	
	$B^0 \to D^0(K^-\pi^+, K^+\pi^-)K^{*0}$	$\sigma(\gamma) \sim 6° - 10°$
	$B^0 \to D^0(K^+K^-, \pi^+\pi^-)K^{*0}$	
	$B^- \to D^0(K^-\pi^+, K^+\pi^-)K^-$	$\sigma(\gamma) \sim 6° - 10°$
	$B^- \to D^0(K^+K^-/\pi^+\pi^-)K^-$	
	$B^- \to D^0(K_S^0\pi^+\pi^-)K^-$	$\sigma(\gamma) \sim 15°$
α	$B^0 \to \pi^+\pi^-\pi^0$	$\sigma(\alpha) \sim 8.5°$
	$B^{+,0} \to \rho^+\rho^0, \rho^+\rho^-, \rho^0\rho^0$	
β	$B^0 \to J/\psi K_S^0$	$\sigma(\sin 2\beta) \sim 0.015$
Δm_s	$B_s^0 \to D_s^-\pi^+$	$\sigma(\Delta m_s) \sim 0.007$ ps^{-1}
ϕ_s	$B_s^0 \to J/\psi\phi$	$\sigma(\phi_s) \sim 0.023$ rad
	$B_s^0 \to \phi\phi$	$\sigma(\phi_s) \sim 0.11$ rad
Rare	$B_s^0 \to \mu^+\mu^-$	3σ meas. down to SM
Decays	$B^0 \to K^{*0}\mu^+\mu^-$	$\sigma(s_0)) \sim 0.46$ GeV^2
	$B^0 \to K^{*0}\gamma$	$\sigma(A_{CP}) \sim 0.01$
	$B_s^0 \to \phi\gamma$	σ (A(Δ) = 0.2

Observable		Sensitivity
$S(B_s \to \phi\phi)$		$0.01 - 0.02$
$S(B_d \to \phi K_S^0)$		$0.025 - 0.035$
$\phi_s\ (J/\psi\phi)$		0.003
$\sin(2\beta)\ (J/\psi K_S^0)$		$0.003 - 0.010$
$\gamma\ (B \to D^{(*)}K^{(*)})$		$< 1°$
$\gamma\ (B_s \to D_s K)$		$1 - 2°$
$\mathcal{B}(B_s \to \mu^+\mu^-)$		$5 - 10\%$
$\mathcal{B}(B_d \to \mu^+\mu^-)$		3σ
$A_T^{(2)}(B \to K^{*0}\mu^+\mu^-)$		$0.05 - 0.06$
$A_{FB}(B \to K^{*0}\mu^+\mu^-)\ s_0$		0.07 GeV^2
$S(B_s \to \phi\gamma)$		$0.016 - 0.025$
$A^{\Delta\Gamma_s}(B_s \to \phi\gamma)$		$0.030 - 0.050$
charm	x'^2	2×10^{-5}
mixing	y'	2.8×10^{-4}
CP	y_{CP}	1.5×10^{-4}