LHCb Status Report

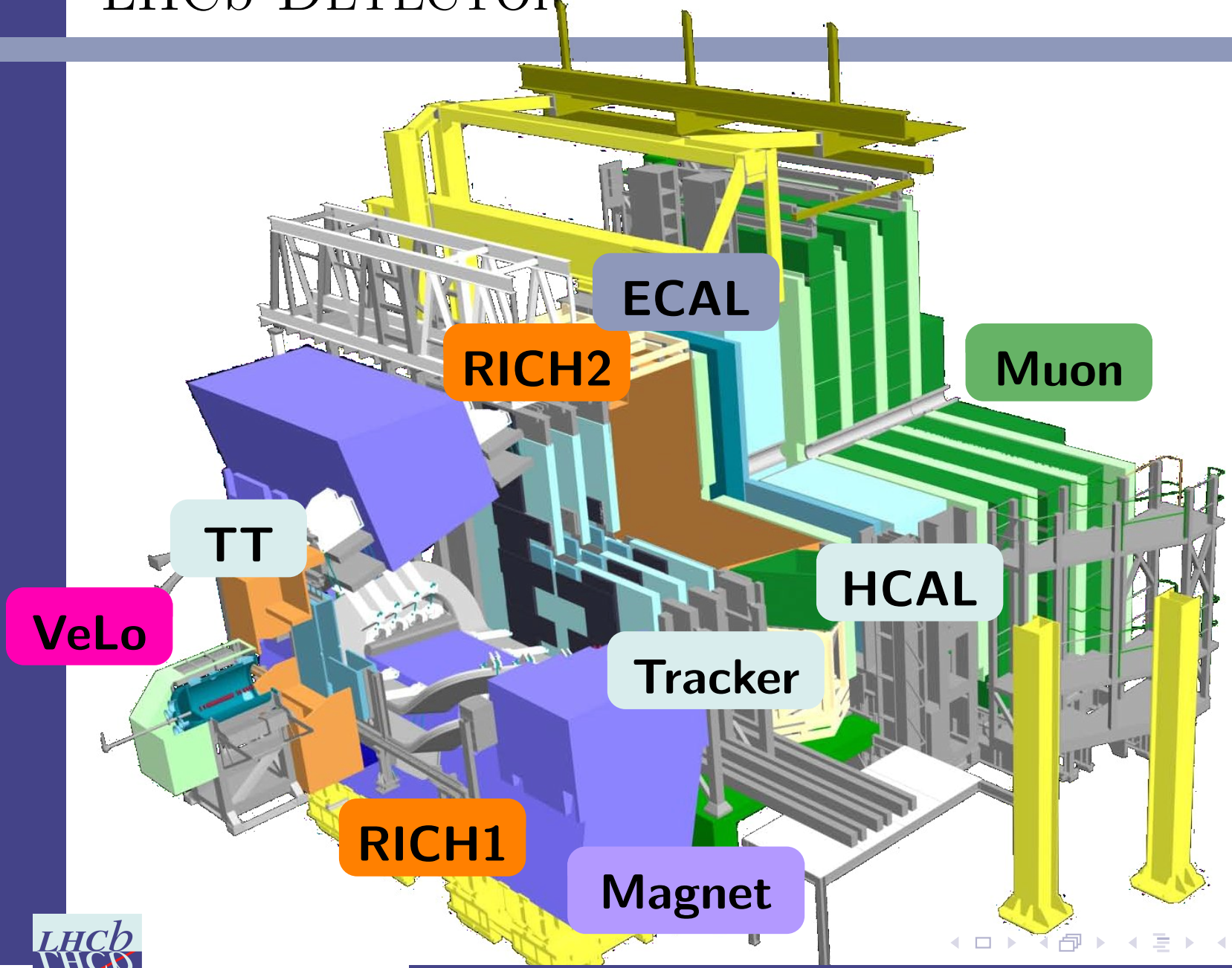
- LHCb
- Luminosity, Trigger
- Tracking
- PID
- Zoology
- Future

101st LHCC — 5 May 2010

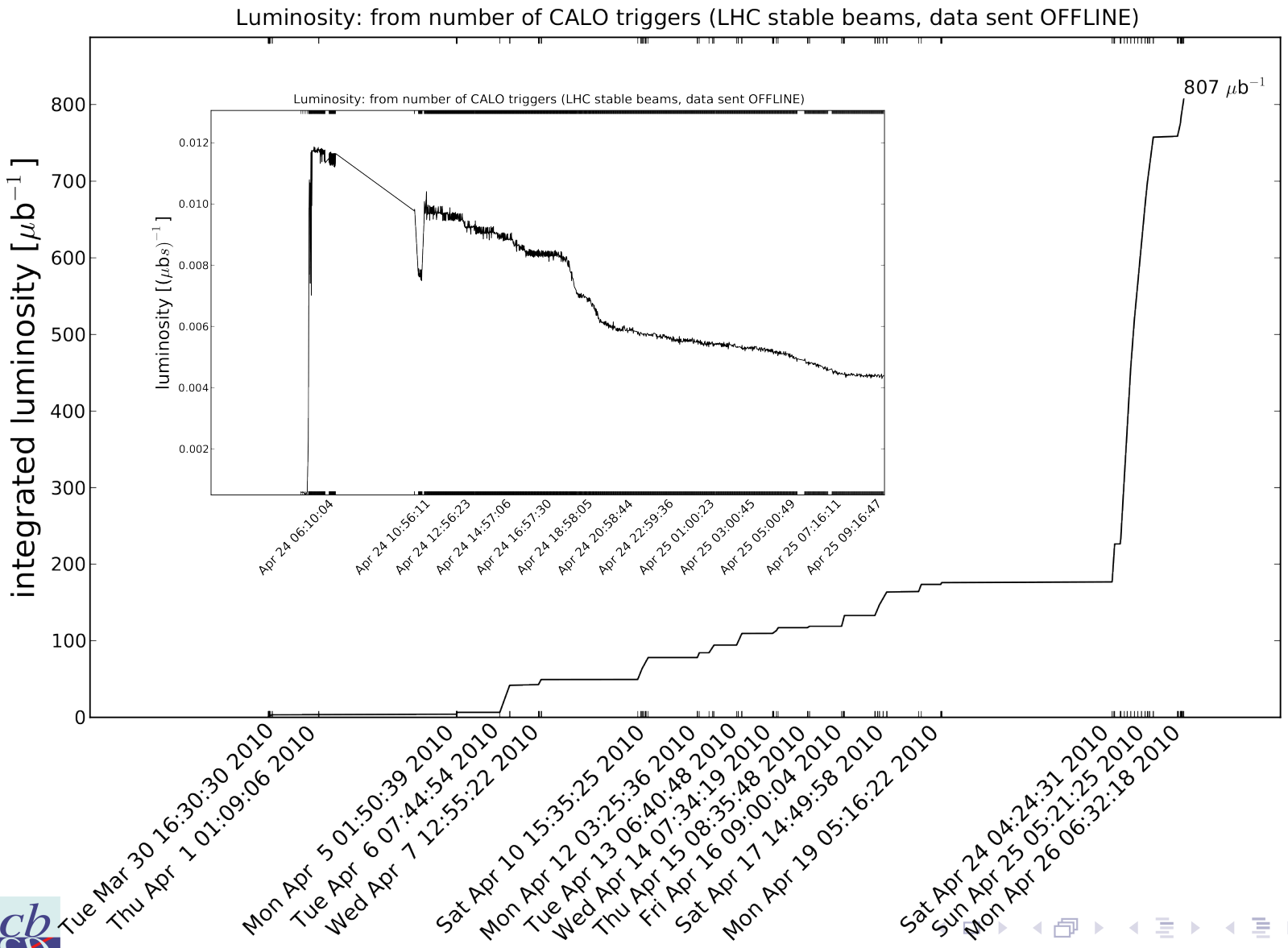
Patrick Koppenburg
On behalf of the
LHCb Collaboration

NIKHEF

LHCb Detector



Luminosity at 3.5 TeV



Trigger Strategy

L0: Based on Calo, Muon and Pile-up

MB triggers: HCAL, SPD, CALO, MUON, Pile-Up ...

c,b triggers: Electron, Photon, Hadron, Muon, Di-Muon, π^0

Luminosity: Muon, Di-Muon, Beam-Gas

Readout Supervisor: Passes on L0 decision and adds random triggers

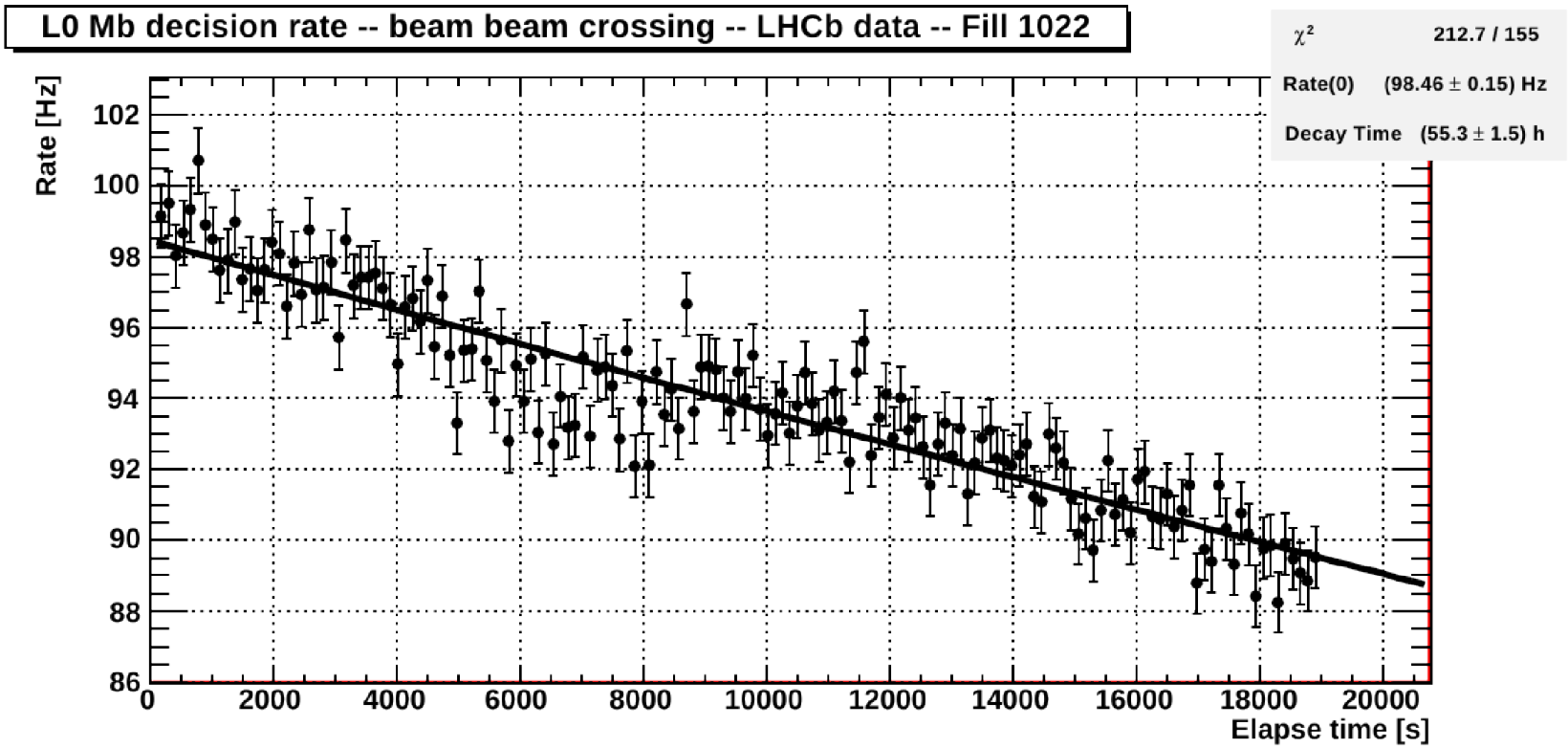
- Knows about bunch structure.

HLT: software based on "everything"

Micro-Bias: At least one track in velo (RZ), or T stations

No-Bias: 100 Hz of random

Trigger Operations



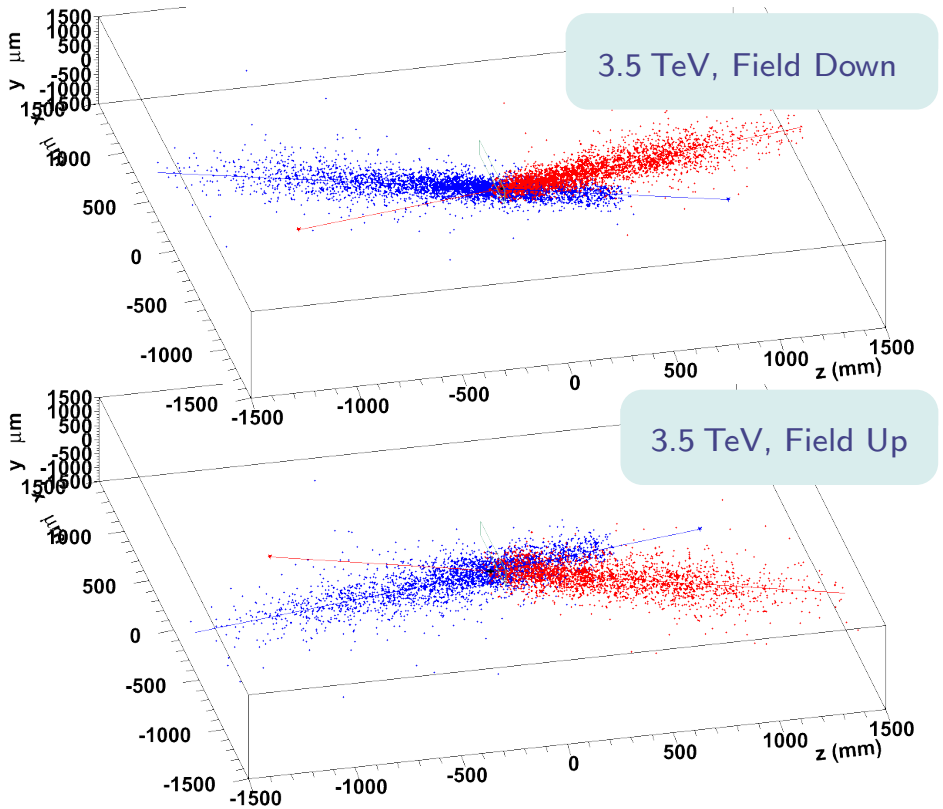
Minimum bias: We can take minimum bias at full rate at the moment

No bias: 100 Hz of no bias events (including 1 Hz beam-gas)

Hlt1: Standard selections in parallel with pass-all

Magnet Polarity

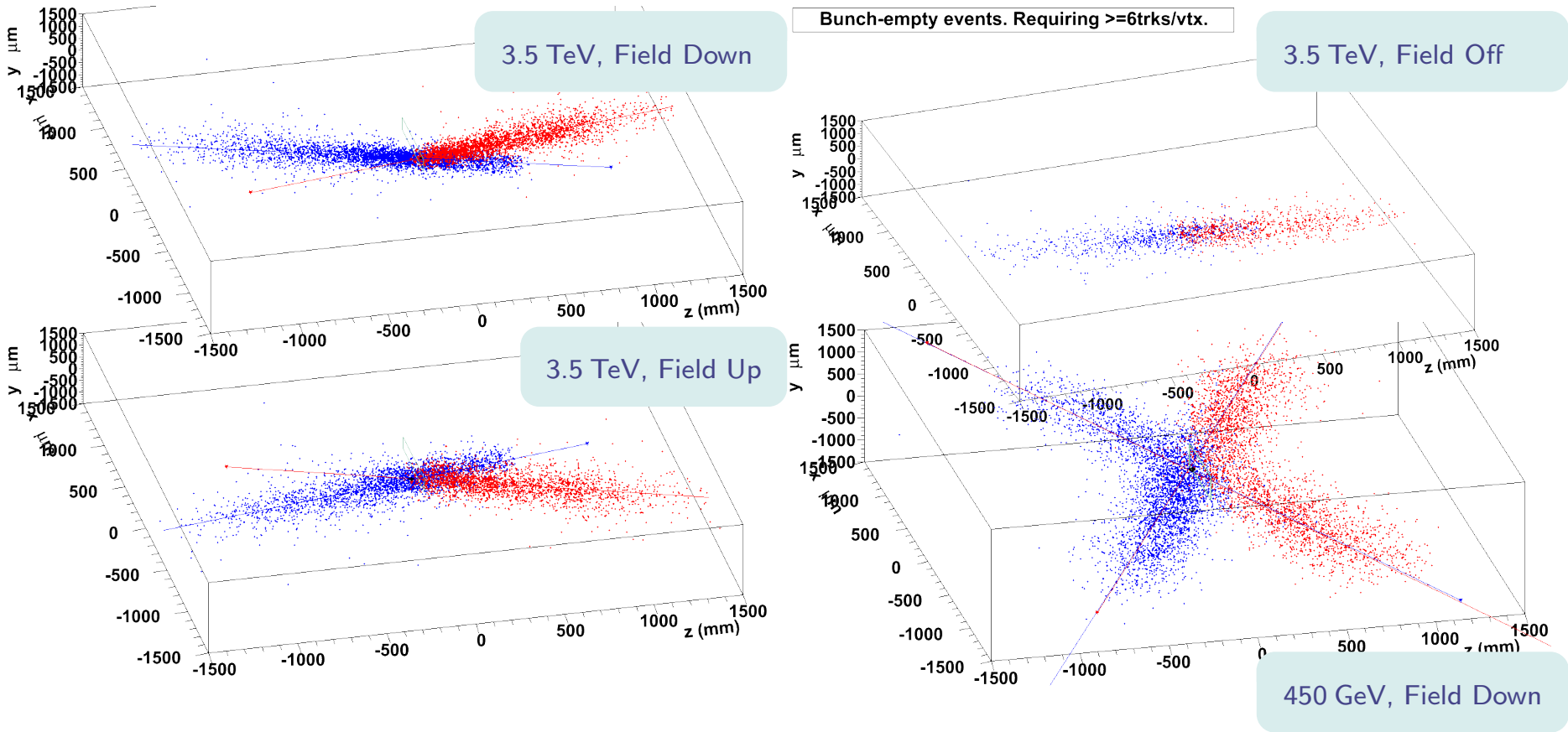
- We can swap the magnet polarity
  - ➜ Important for systematic studies of CP effects
    - So far have taken 10% data with field Up. Will catch up soon



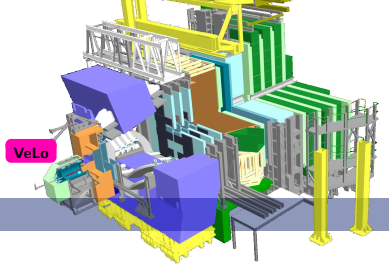
- Primary vertex in Beam Gas events for Beam1 and Beam2
  - z coverage due to velo acceptance
  - Crossing angle due to B field
- Beam profiles used to determine luminous region
  - ➜ Luminosity

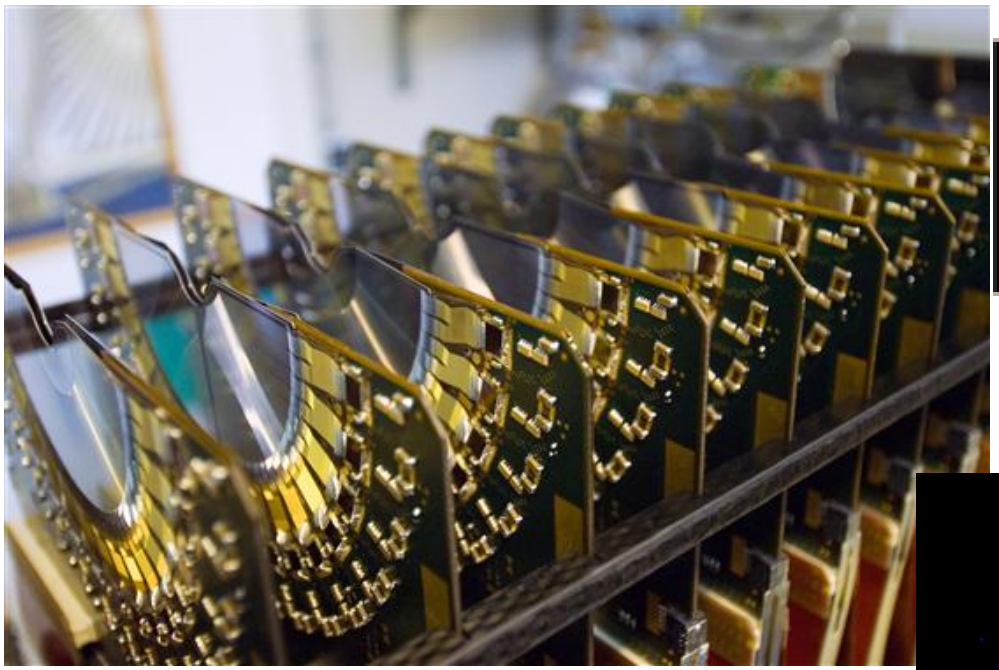
Magnet Polarity

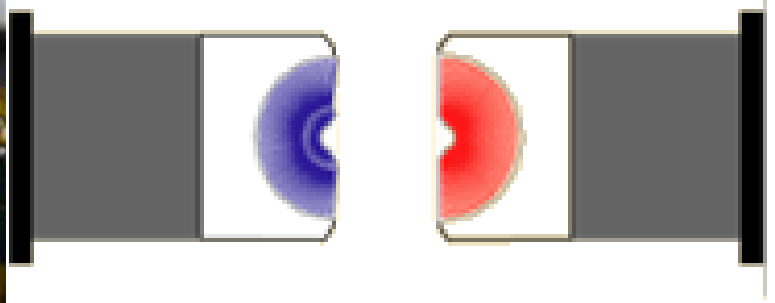
- We can swap the magnet polarity
  - ➜ Important for systematic studies of CP effects
    - So far have taken 10% data with field Up. Will catch up soon

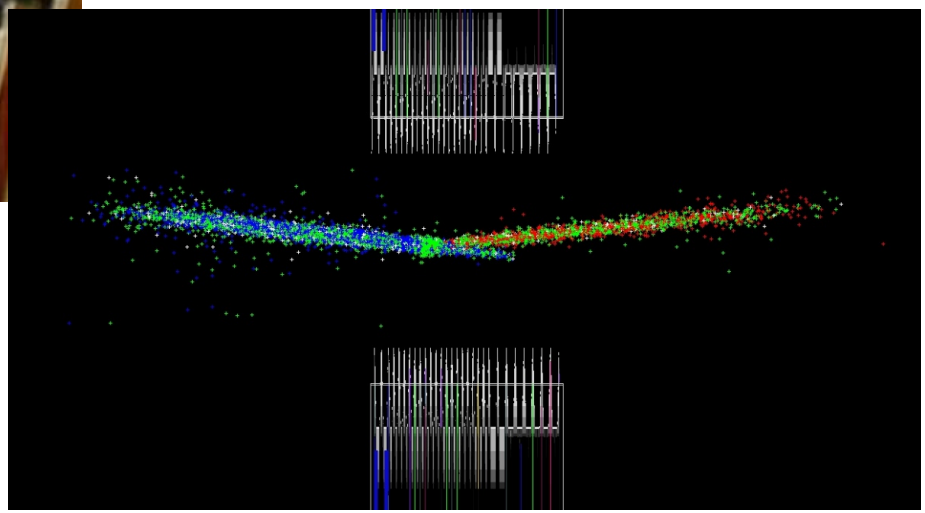


Velo



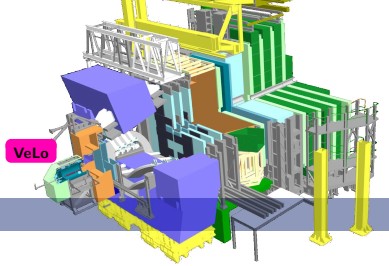


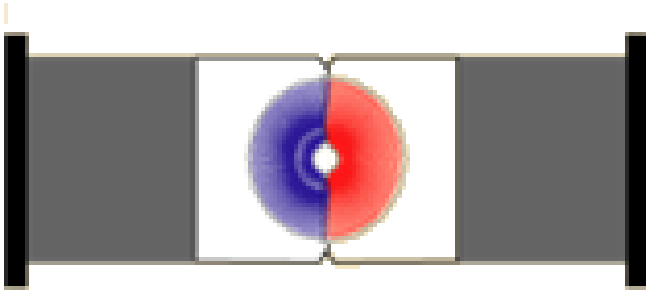




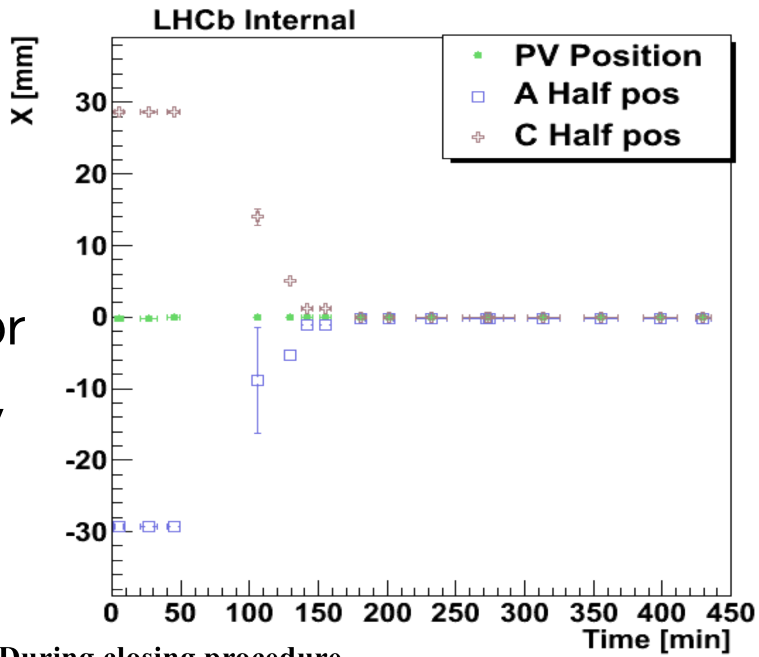
- Velo sensors all powered
- 99.3% are operational
- With 450 GeV beams we could not fully close the Velo
- . . . but we see where the beams are

VELO



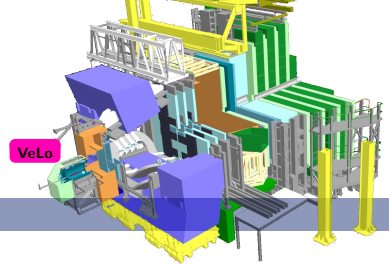


- Velo closed for the first time on 1. Apr
- Closing procedure now takes routinely < 15 minutes
- Stability in (X, Y, Z) : $(10, 4, 10)\ \mu\mathrm{m}$

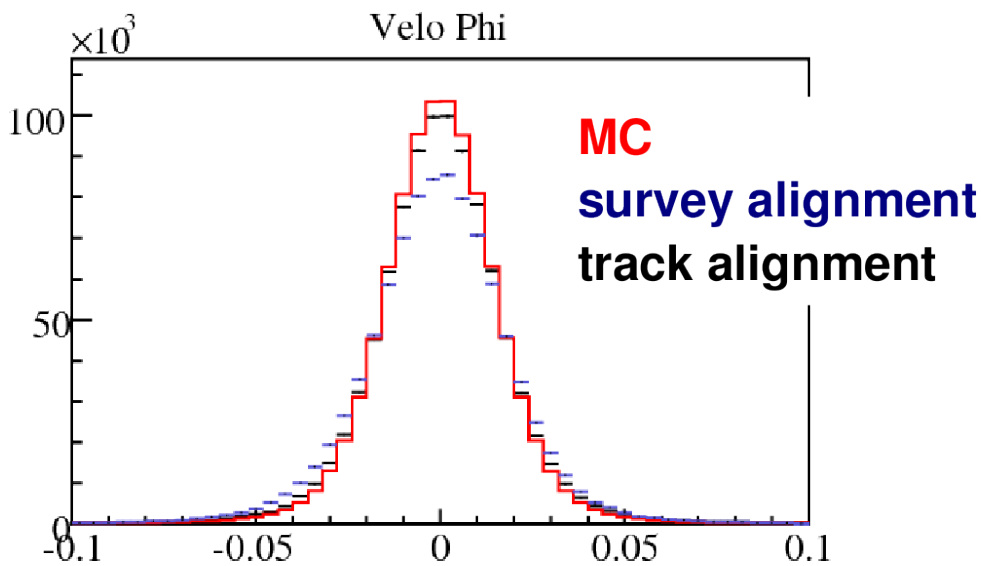


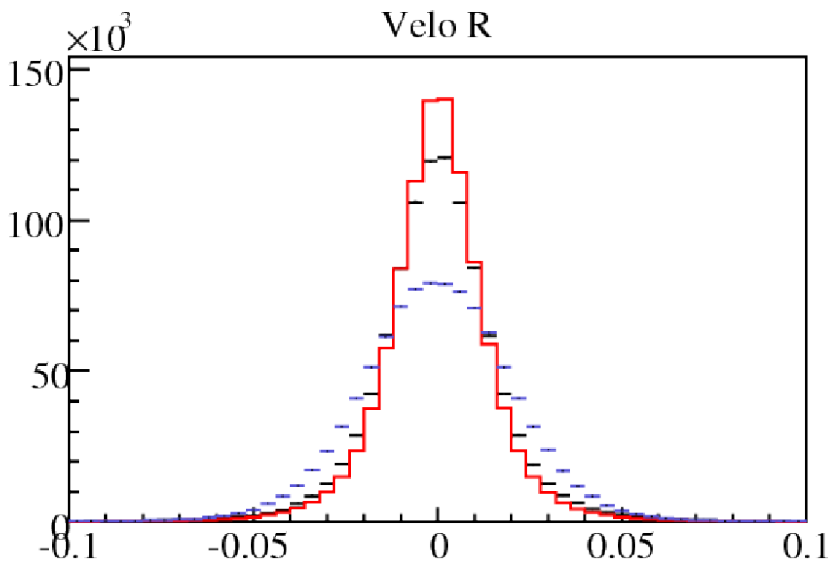
During closing procedure

Velo

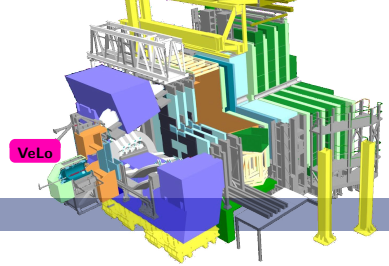


- ✔ Hit residuals as expected

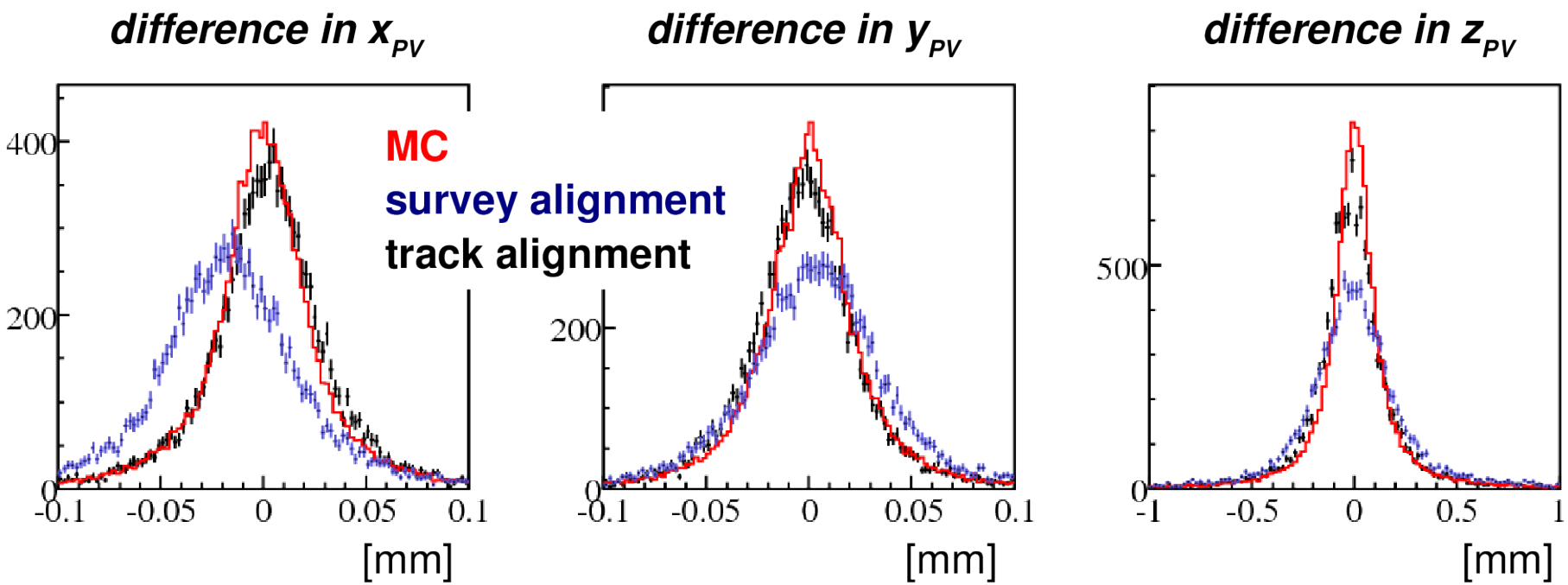




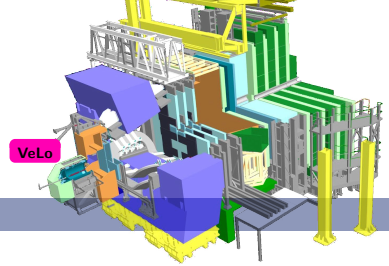
Velo



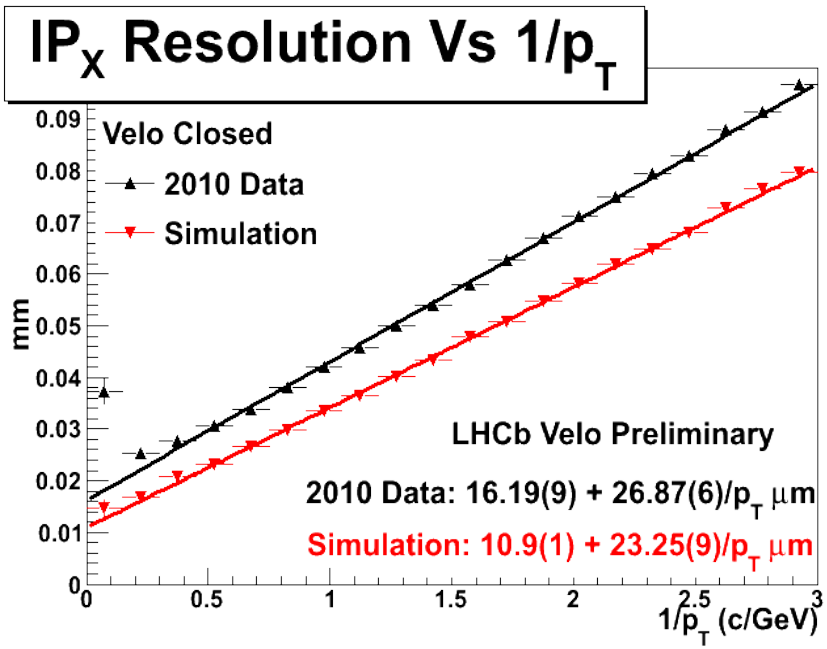
- ✔ Hit residuals as expected
- ✔ Align Velo halves using Primary Vertex from each side

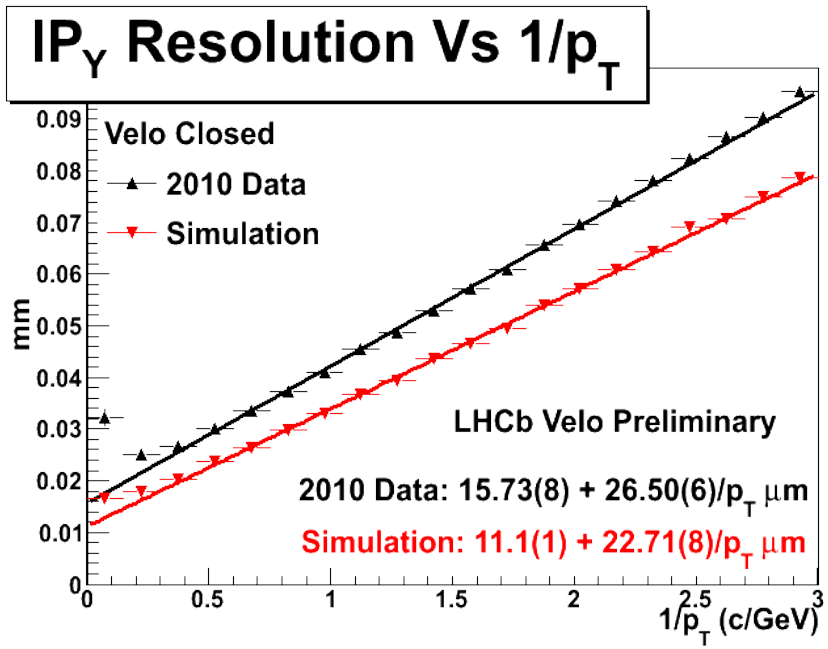


Velo

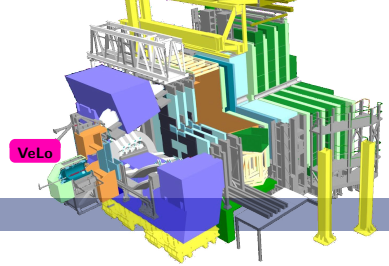


- ✔ Hit residuals as expected
- ✔ Align Velo halves using Primary Vertex from each side
- ✔ Impact parameter resolution $\propto 1/p_T$

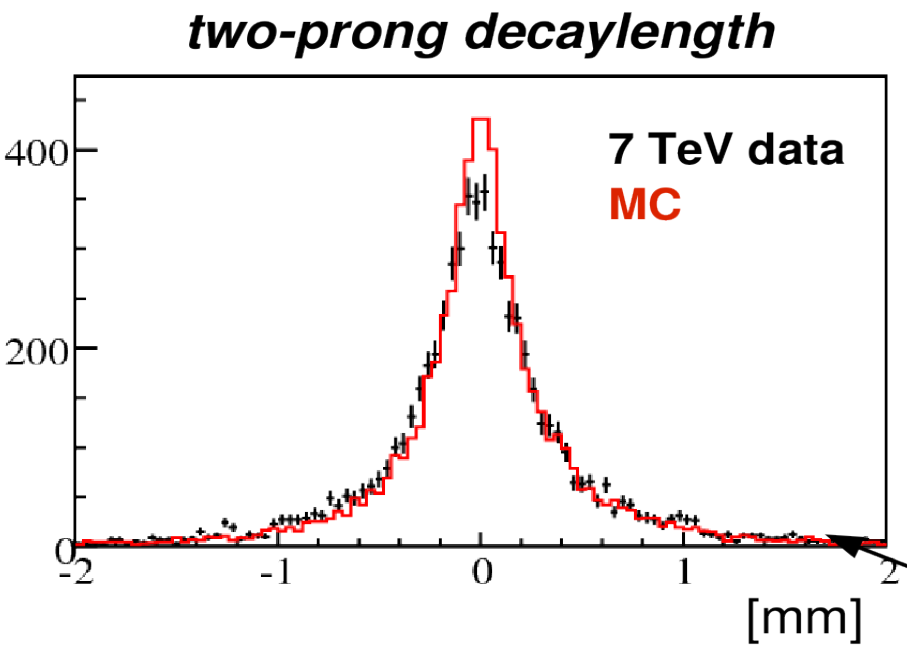


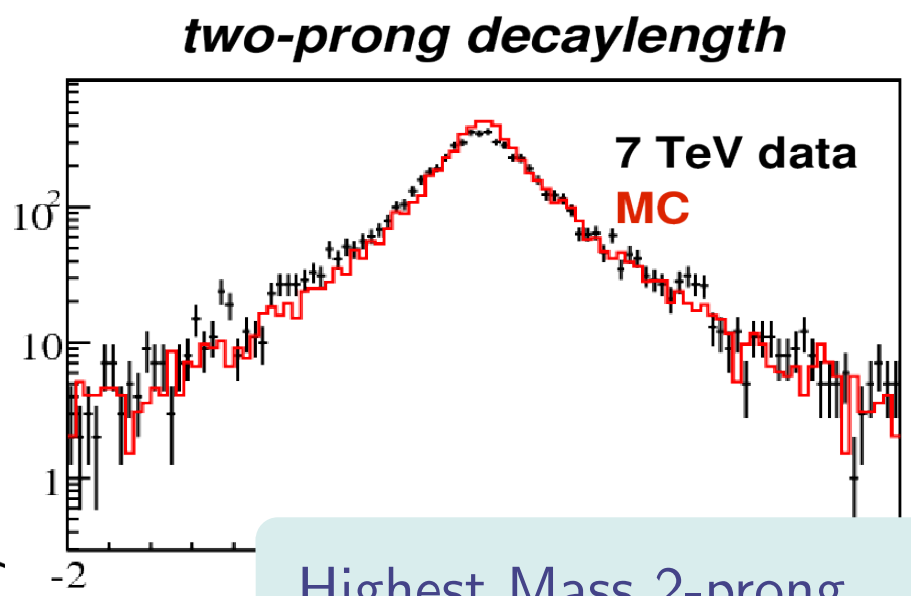


Velo



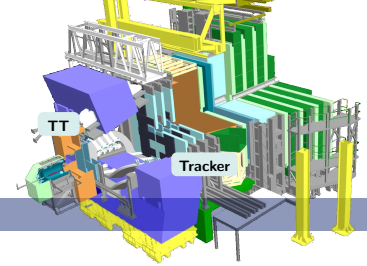
- ✔ Hit residuals as expected
- ✔ Align Velo halves using Primary Vertex from each side
- ✔ Impact parameter resolution $\propto 1/p_T$
- ✔ Decay length as expected



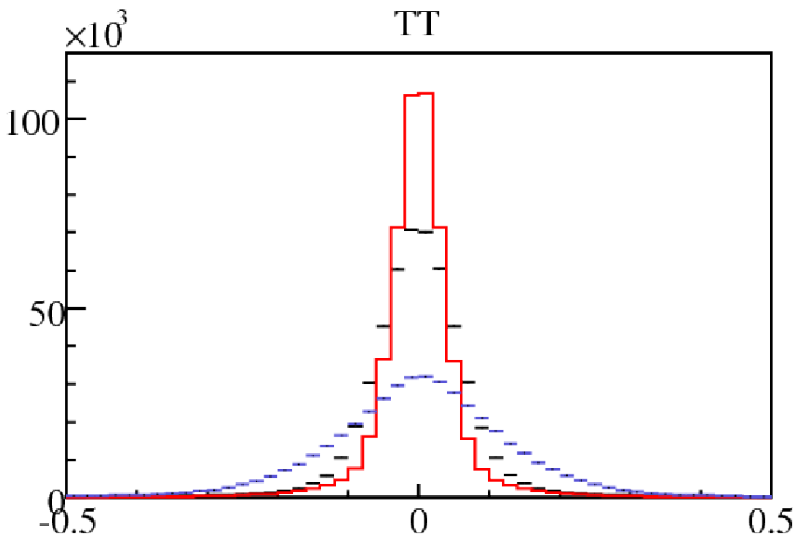


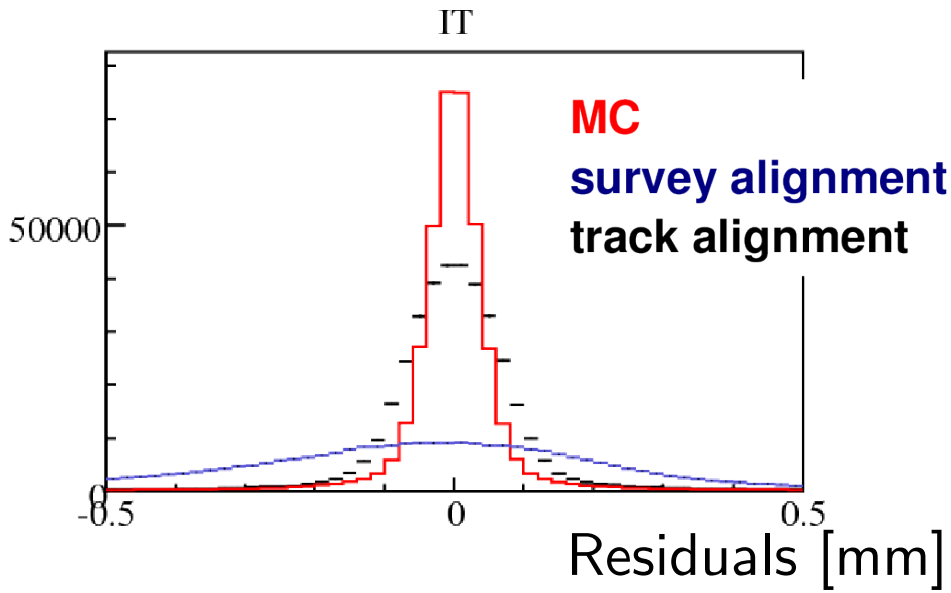
Highest Mass 2-prong

Silicon Trackers

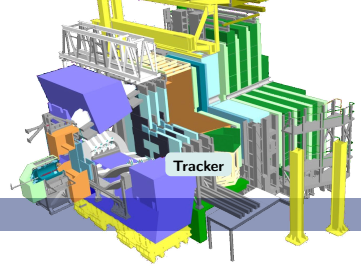


- >99.5% TT and IT channels operational.
- Signal to noise ratio as expected
- Alignment ongoing.
  - Still something to gain:
  - Residual width is 65 μm. MC expectation is 50 μm

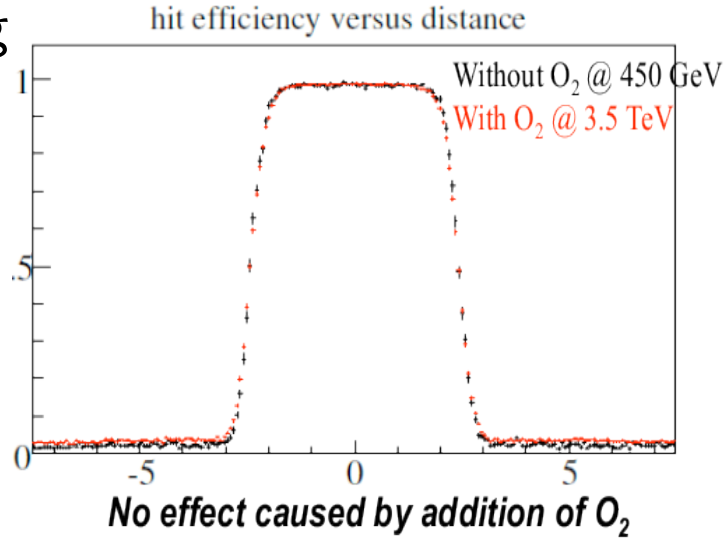


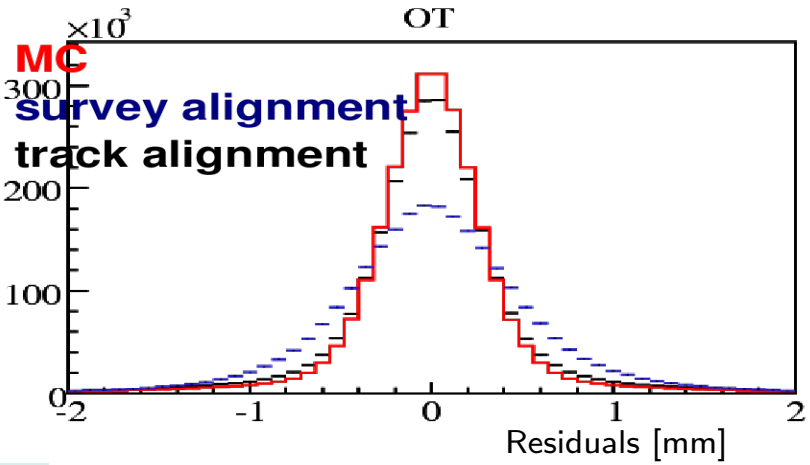


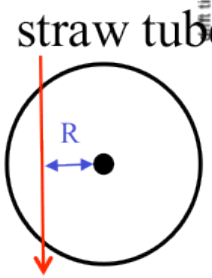
Outer Tracker

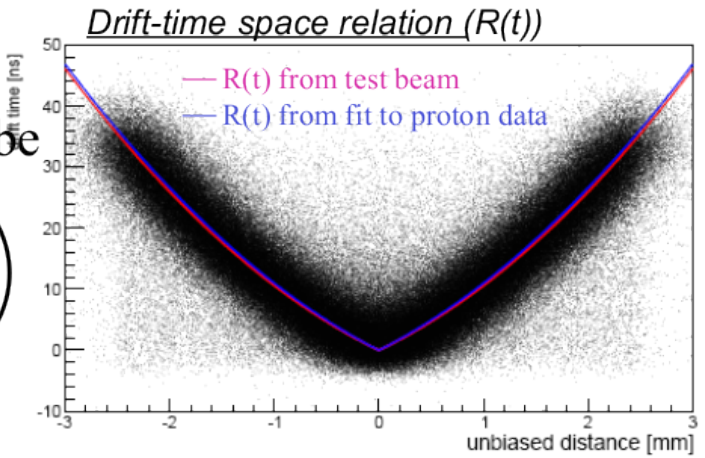


- Detector is 100% efficient and running at nominal threshold with low noise
- O_2 was added to the gas mixture in order to mitigate ageing effects. No effect on hit efficiency is observed.
- Space vs drift-time relation fits expectation from test beam
- Alignment is getting close to MC

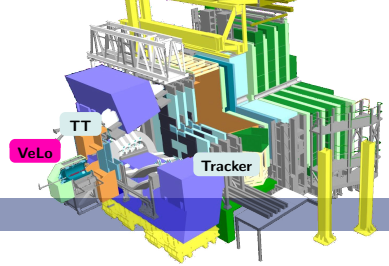


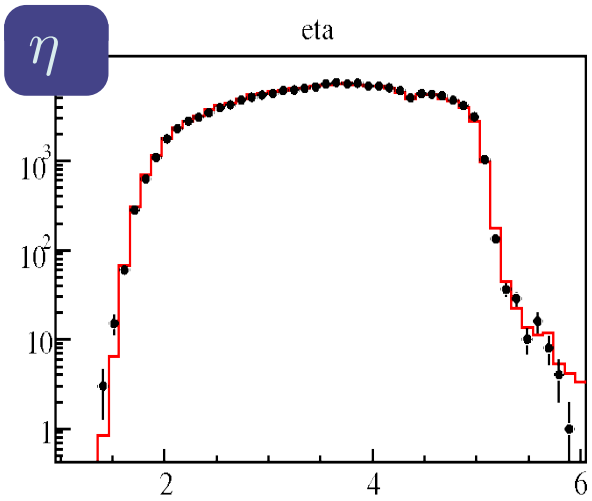


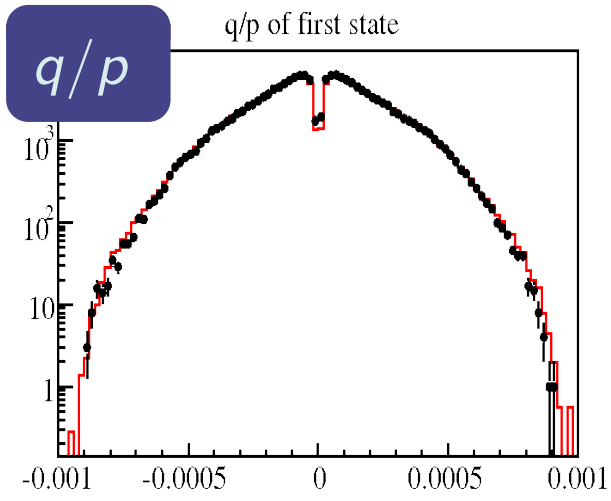


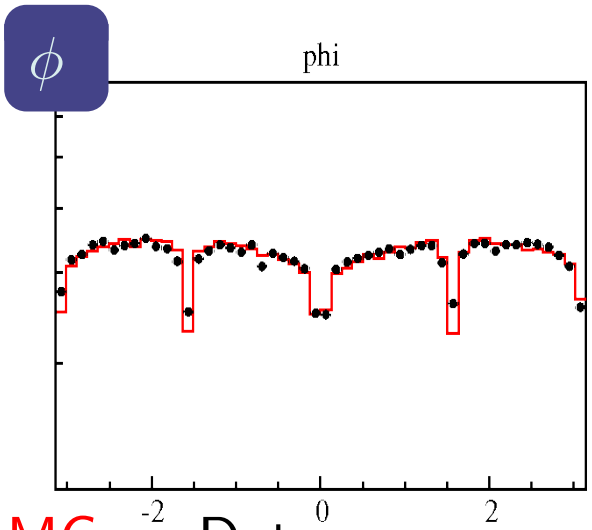


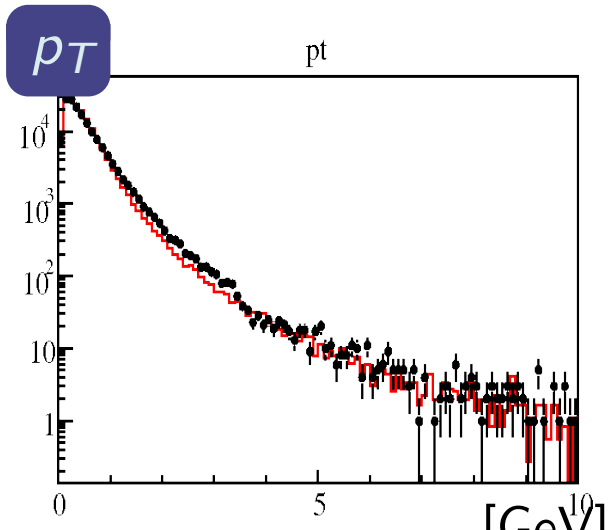
Long Tracks (Velo & T stations)







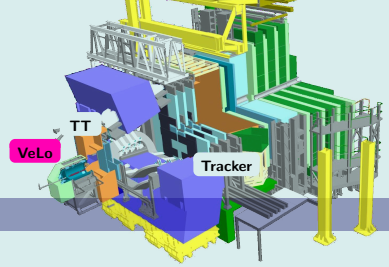




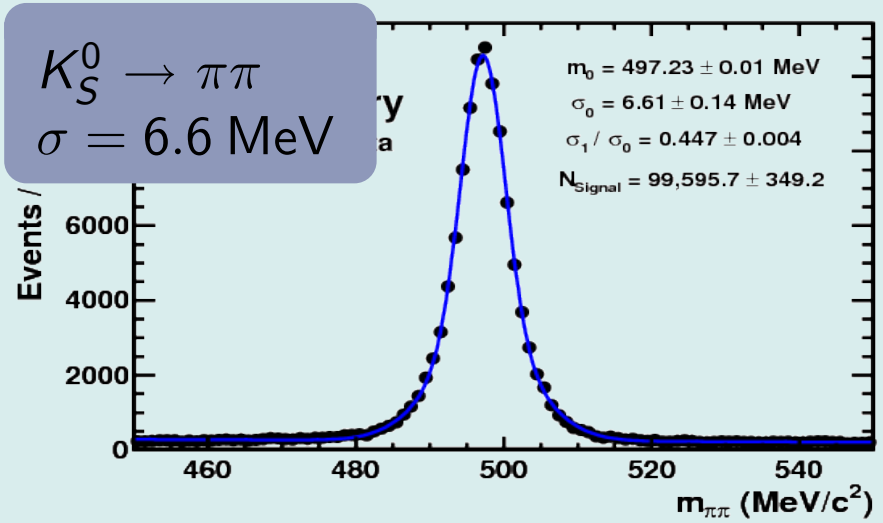
MC — Data

- Good agreement between data and MC

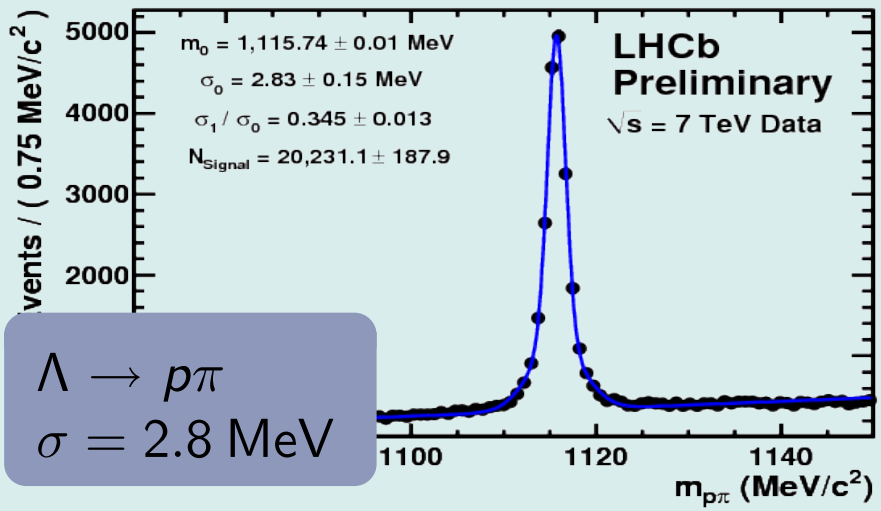
Zoology 1 — K^0_S, Λ, Ξ, Ω



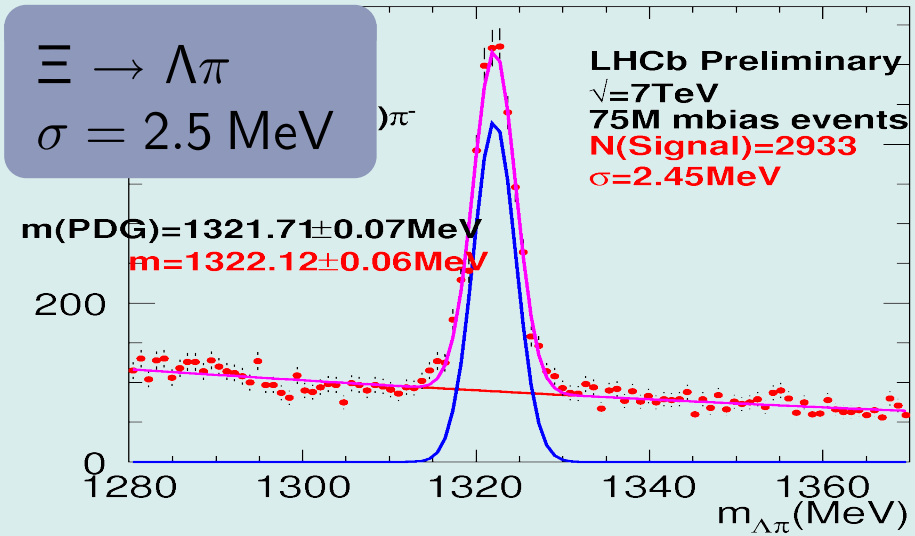
$K^0_S \to \pi\pi$
$\sigma = 6.6$ MeV



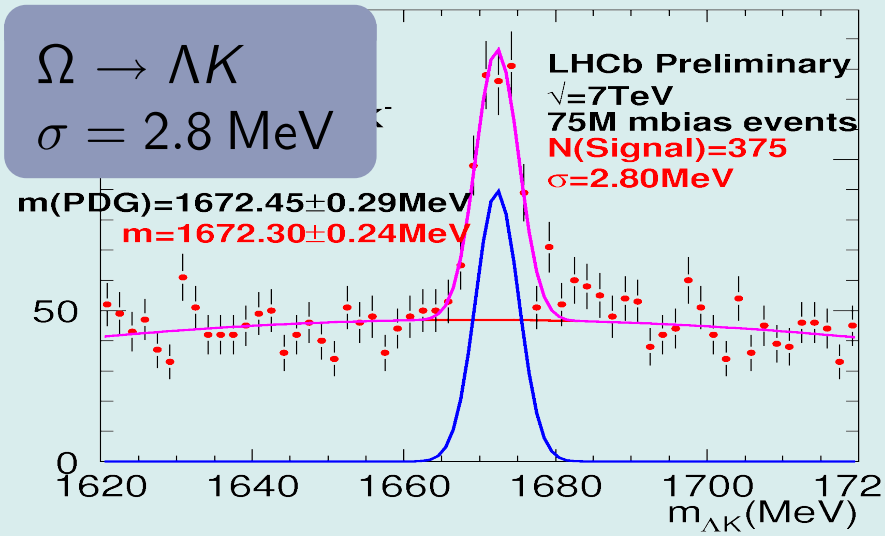
$\Lambda \to p\pi$
$\sigma = 2.8$ MeV



$\Xi \to \Lambda\pi$
$\sigma = 2.5$ MeV

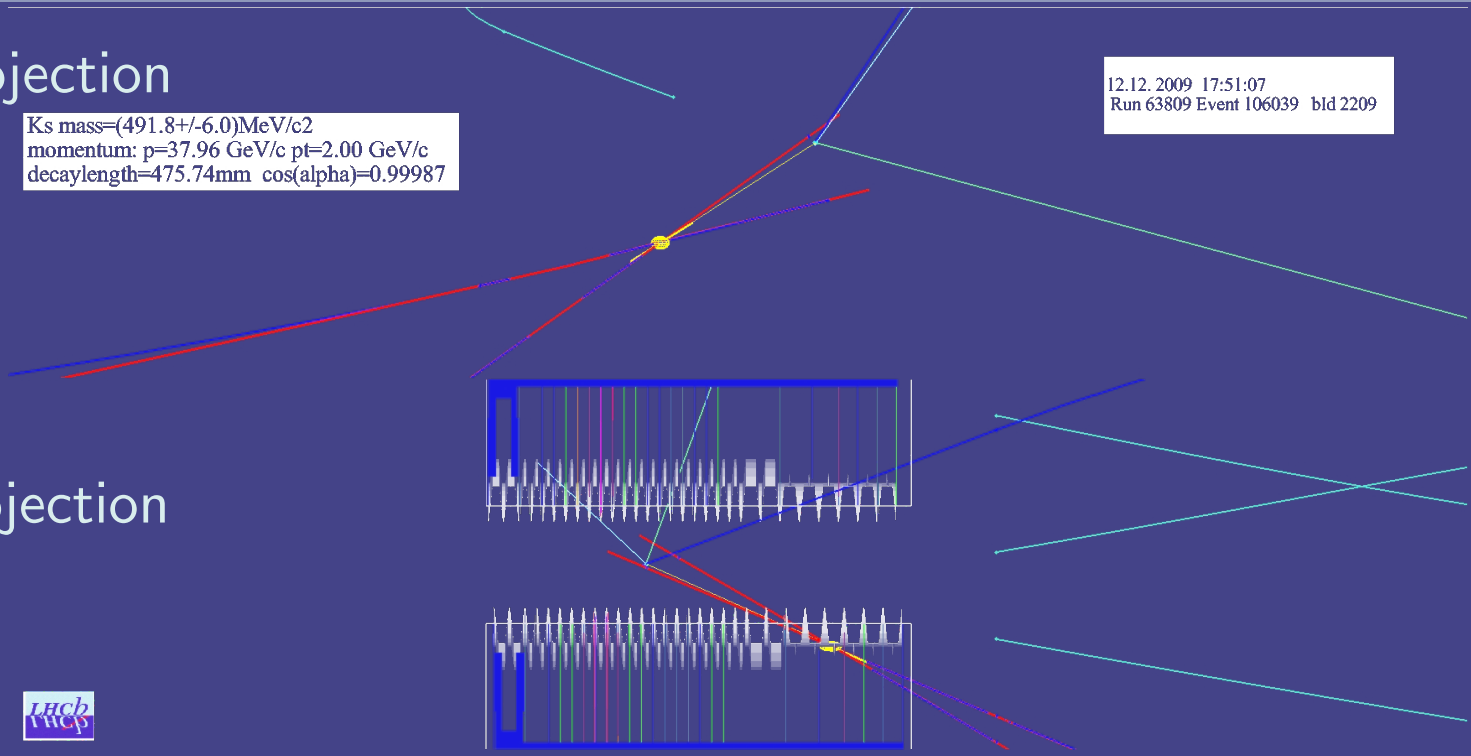


$\Omega \to \Lambda K$
$\sigma = 2.8$ MeV



2009 data — Open Velo

XY projection

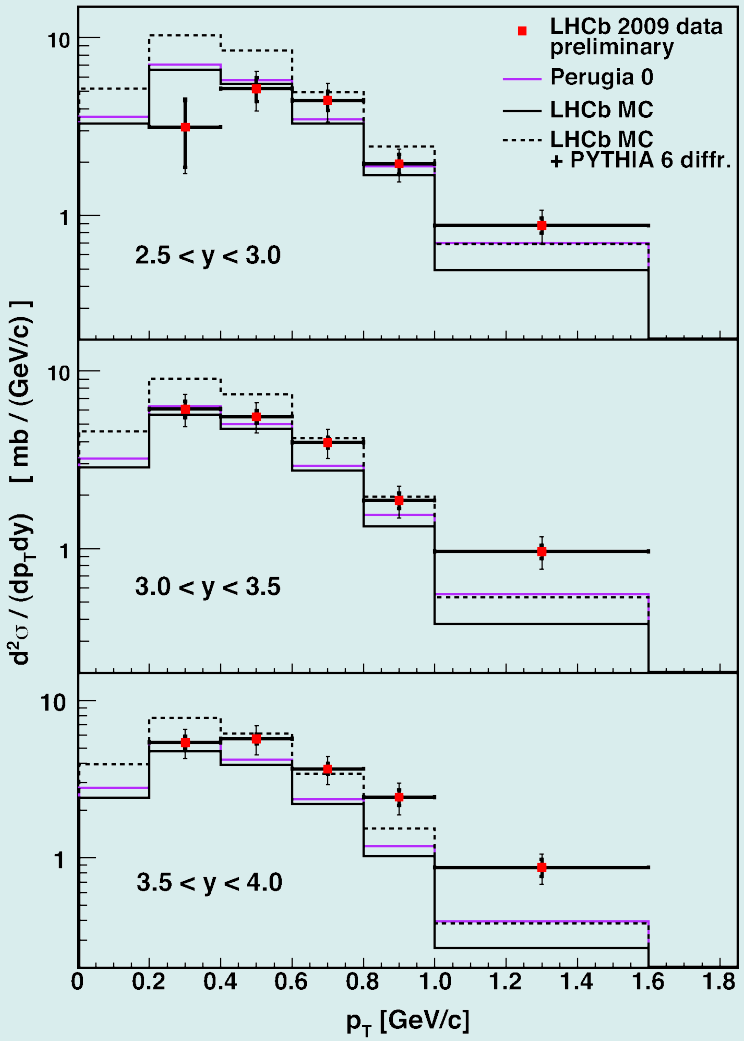


YZ projection

- $6.8 \pm 1.0\,\mu\mathrm{b}^{-1}$ at $\sqrt{s} = 900$ GeV with Velo 15 mm from nominal position
- We have taken $\mathcal{O}\left(300\,\mu\mathrm{b}^{-1}\right)$ this week-end with Velo 10 mm from nominal position and both magnet polarities

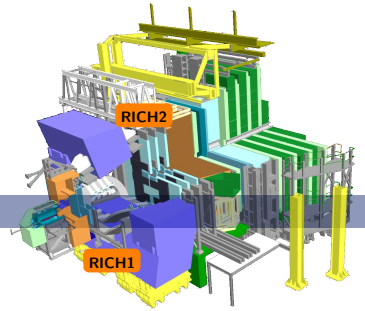
K^0_S Production at $\sqrt{s} = 900$ GeV

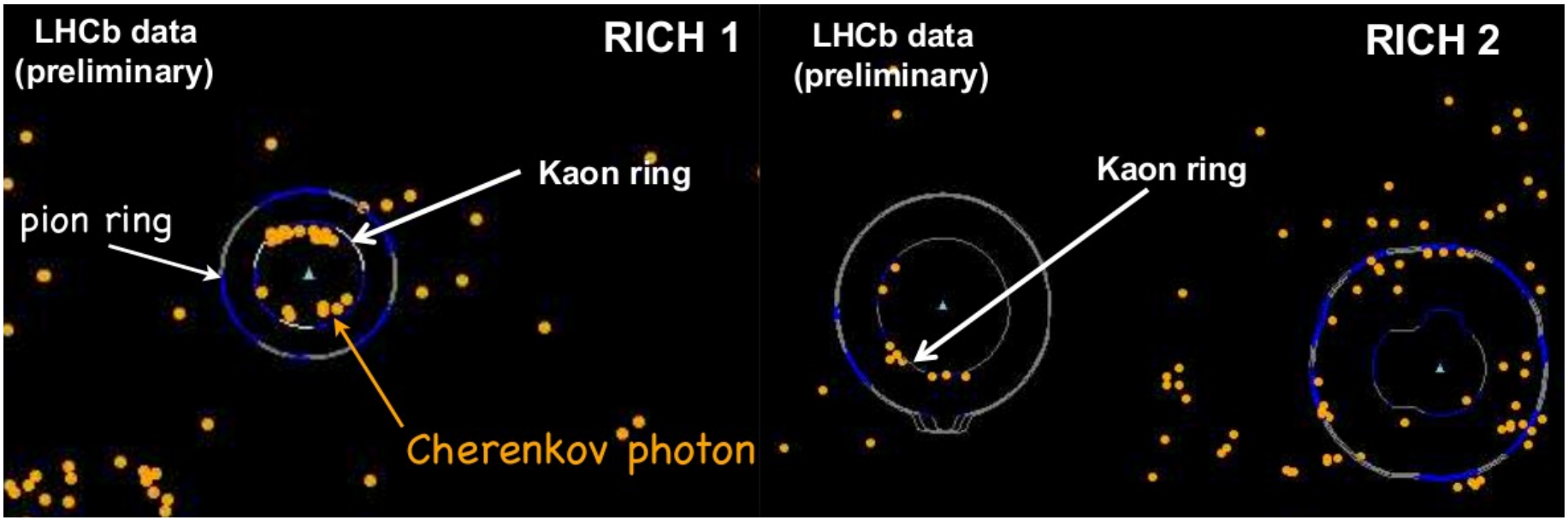
First Public LHCb Result



- Measure K^0_S without using VeLo
- ➜ K^0_S p_T distributions in 3 rapidity bins
- Compare to `Pythia 6.4` with `Perugia0` tuning
- Luminosity determined through LHCb measurement of beam-beam and beam-gas profile
  - ➜ Achieved 15% precision (dominant uncertainty LHC currents)
- **Λ, $\overline{\Lambda}$ and p, $\overline{p}$ also in the pipeline**

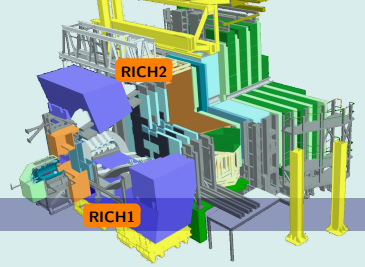
RICH

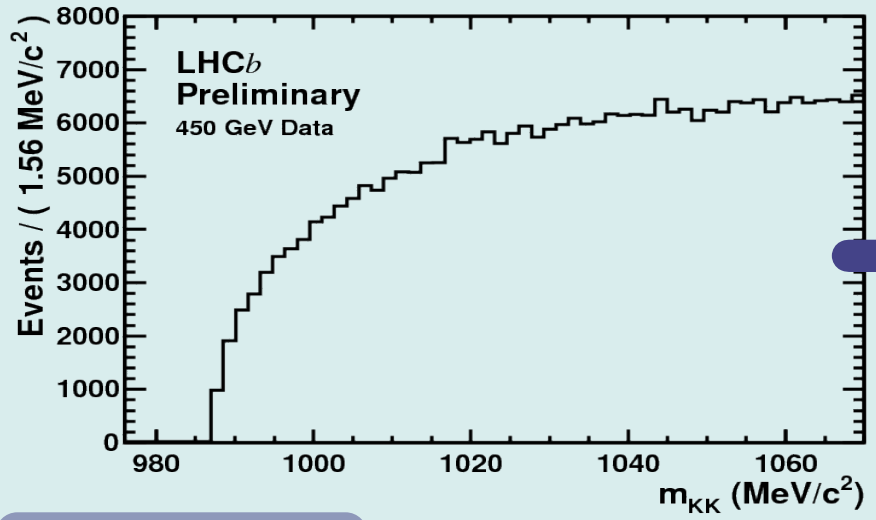




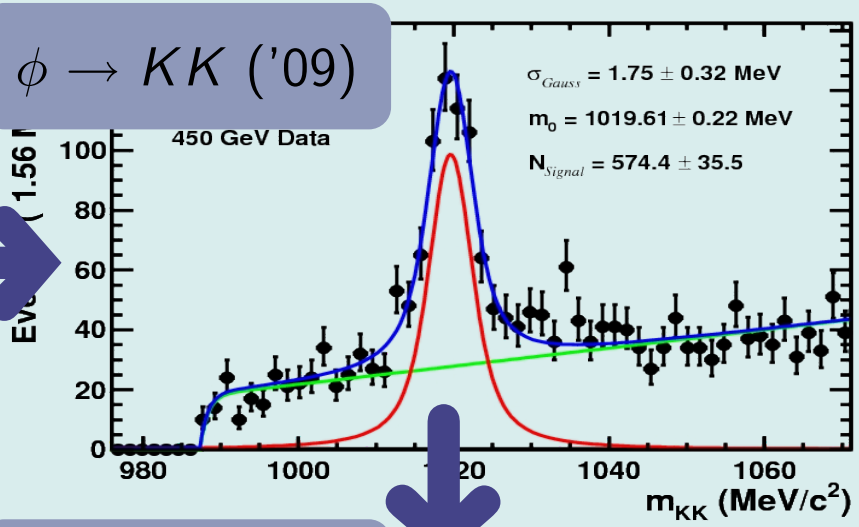
- RICH1 and RICH2 being aligned wrt tracking system
- Nice kaon and pion rings seen in both systems

Zoology 2: ϕ and K^*

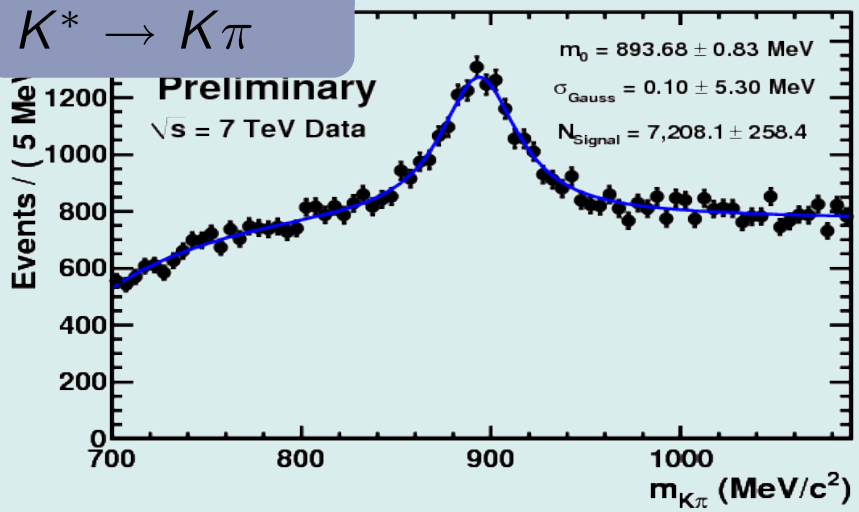




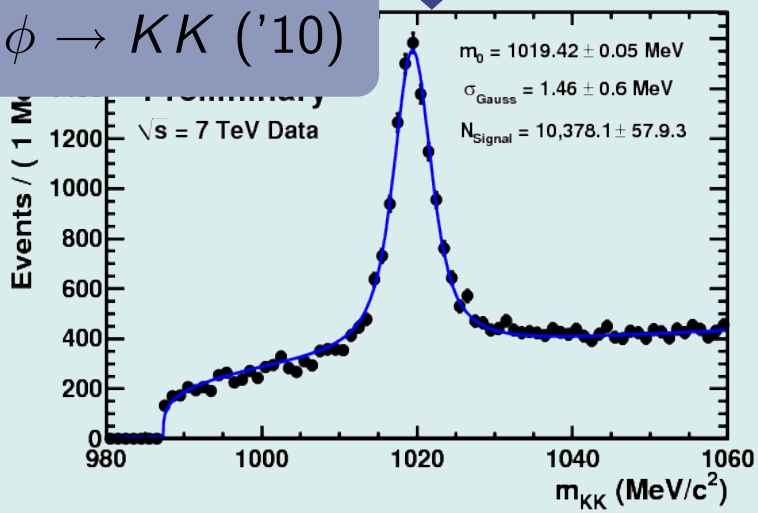
$\phi \to KK$ ('09)



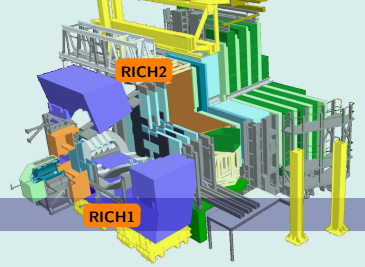
$K^* \to K\pi$



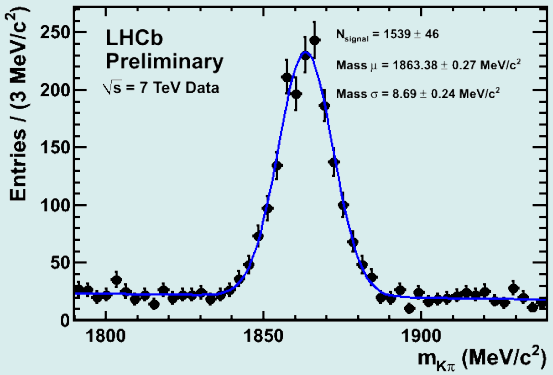
$\phi \to KK$ ('10)



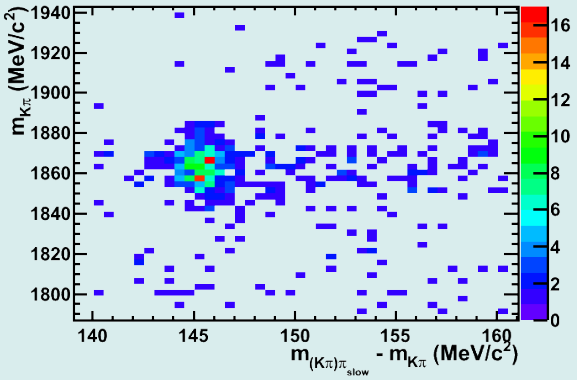
Zoology 3: $D \to K\pi$ and D^*



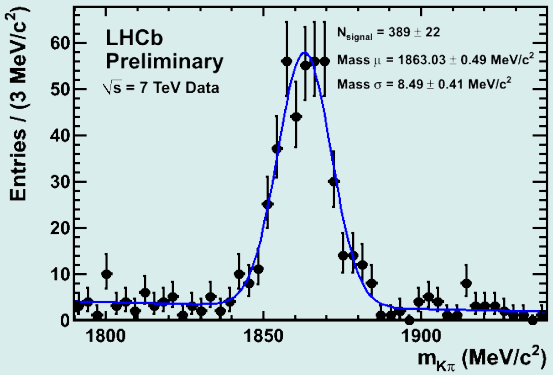
Untagged $K\pi$ mass



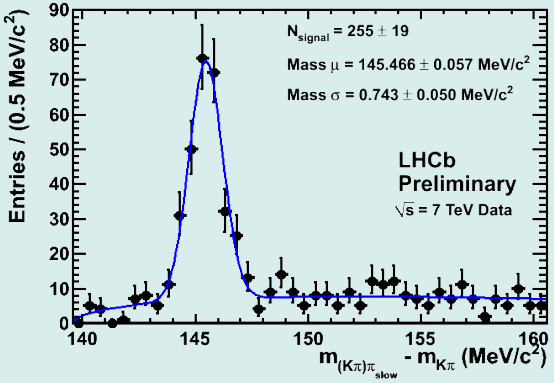
$m_{K\pi}$ vs Δm



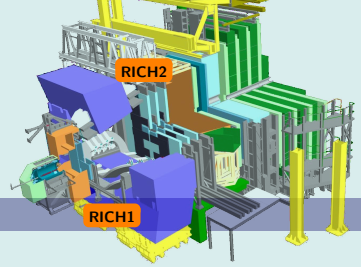
Tagged $K\pi$ mass



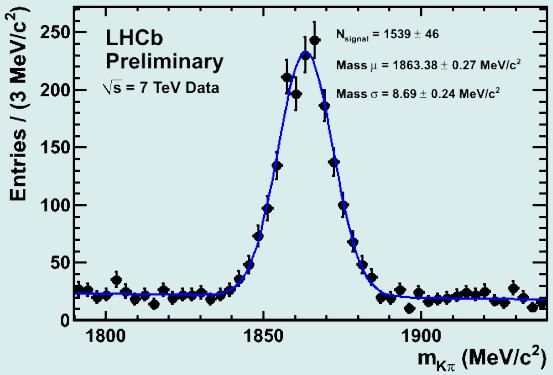
Δm



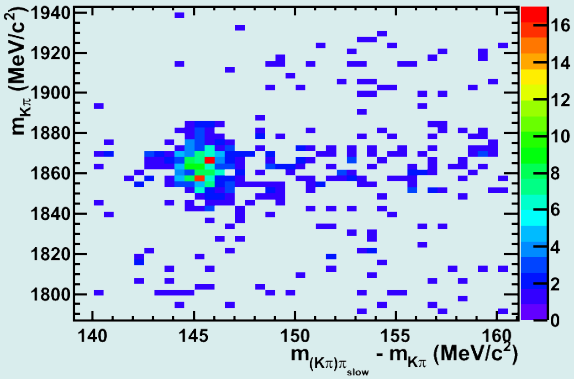
Zoology 3: $D \to K\pi$ and D^*



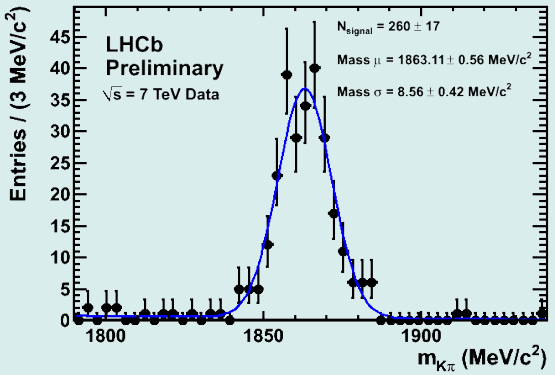
Untagged $K\pi$ mass



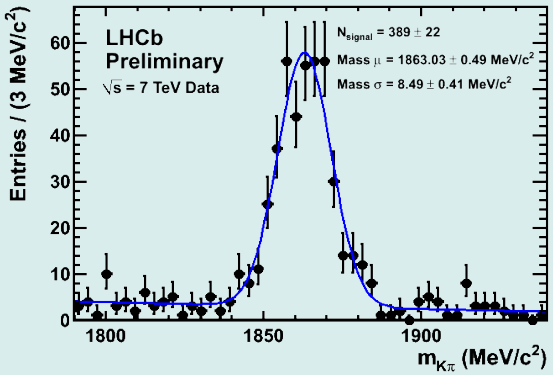
$m_{K\pi}$ vs Δm



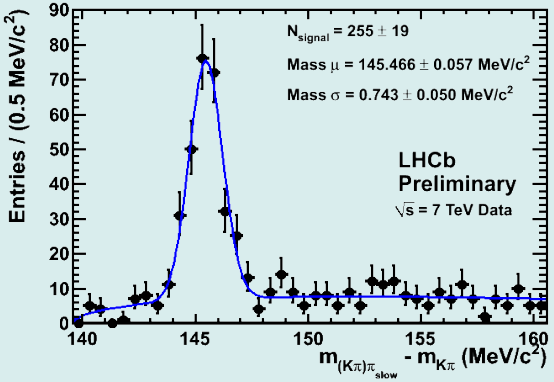
$m_{K\pi}$ with Δm cut



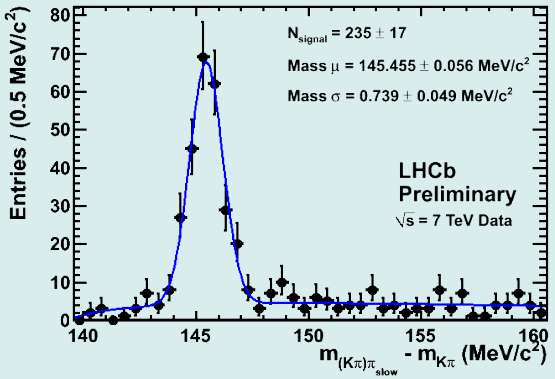
Tagged $K\pi$ mass



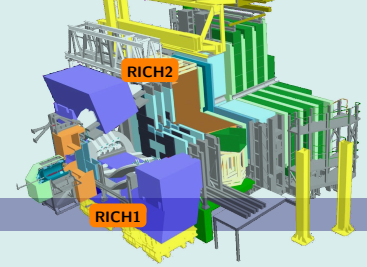
Δm



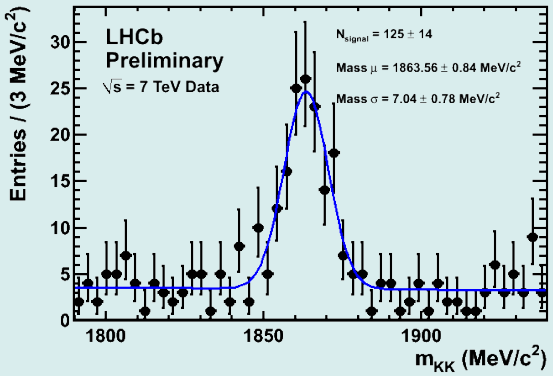
Δm with $m_{K\pi}$ cut



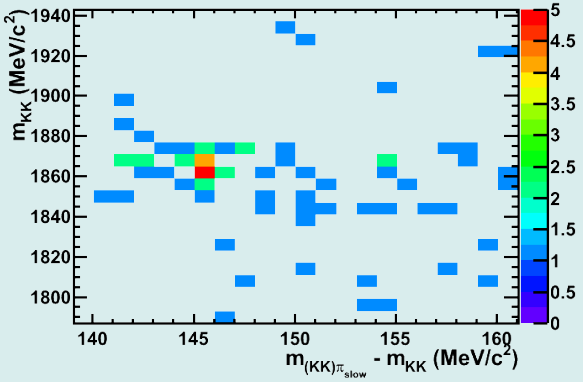
Zoology 3: $D \to KK$ and D^*



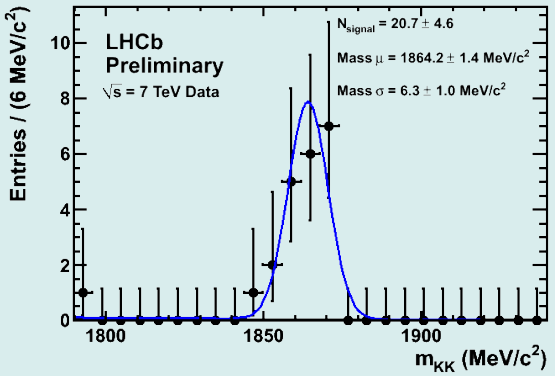
Untagged KK mass



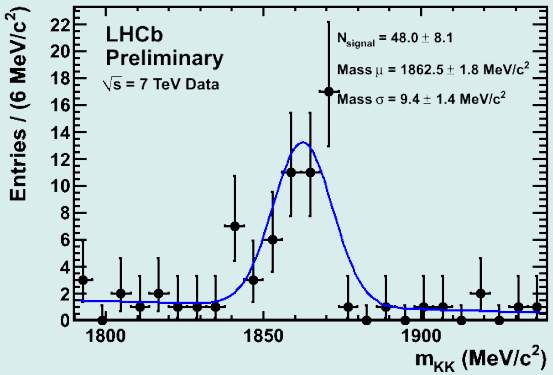
m_{KK} vs Δm



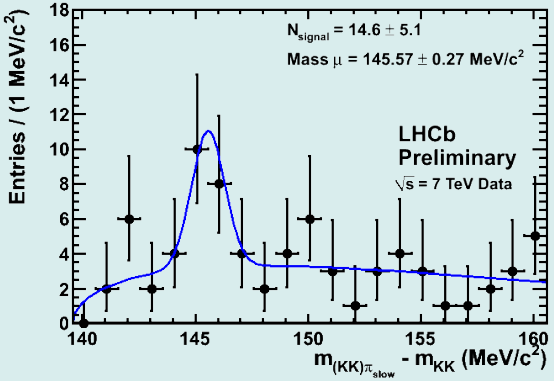
m_{KK} with Δm cut



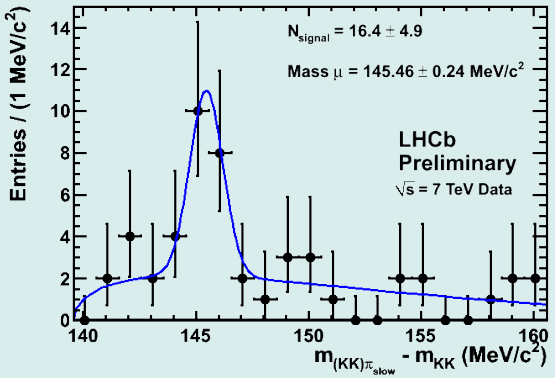
Tagged KK mass



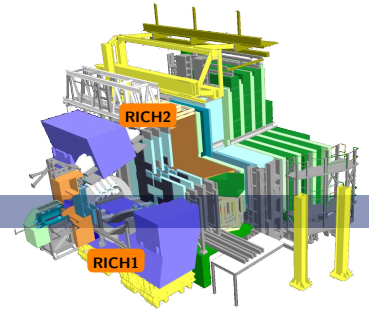
Δm



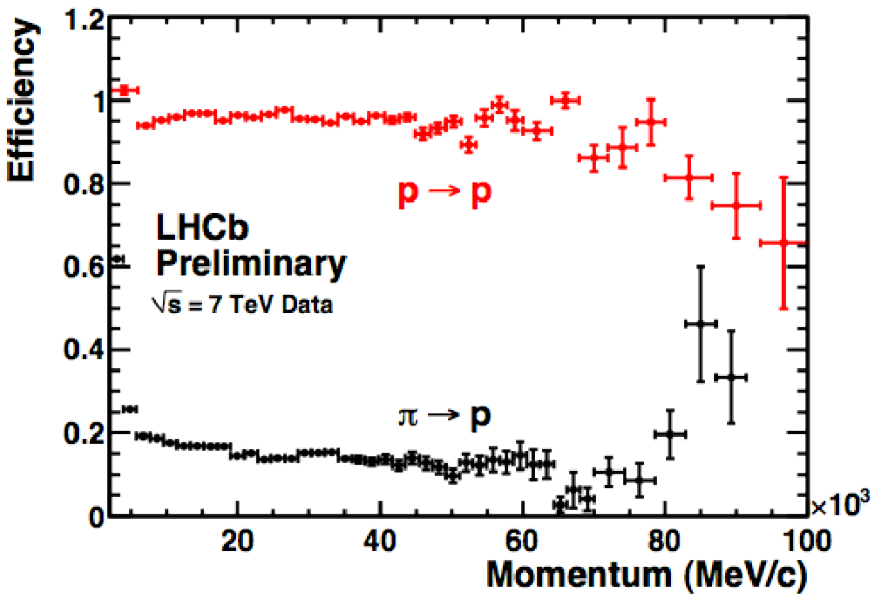
Δm with m_{KK} cut



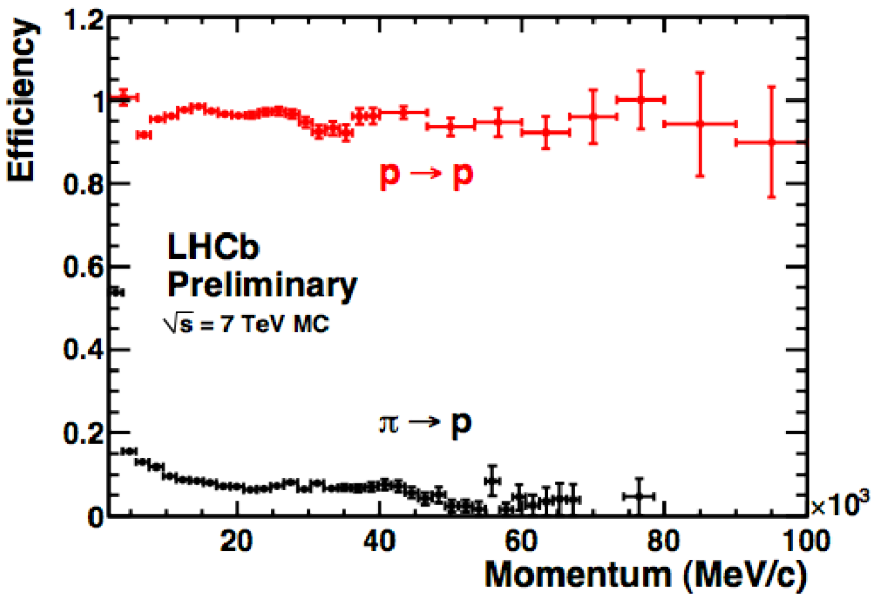
RICH-ID



Data



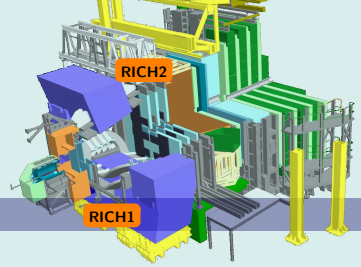
Monte Carlo



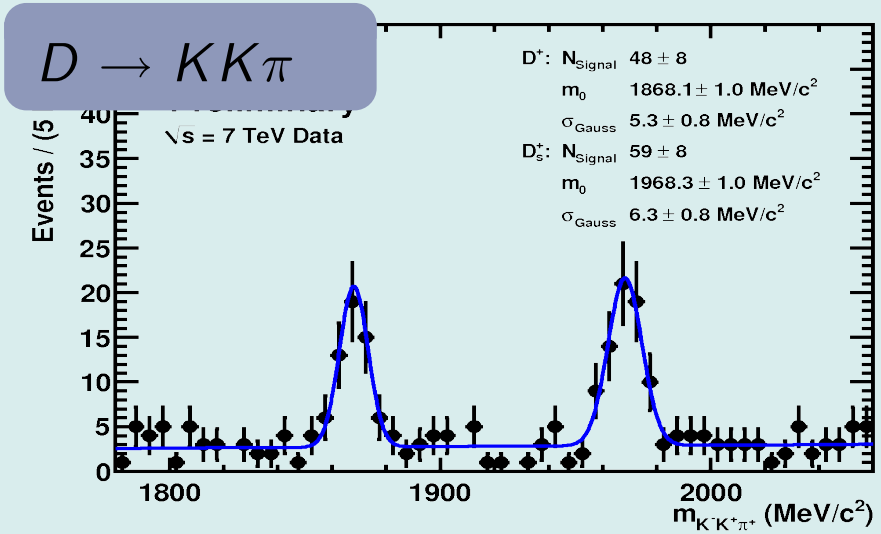
$$\Delta\log\mathcal{L}(\mathrm{p}-\pi) > 0$$

- Proton-ID efficiency and mis-ID using protons from Λ
- We will use tagged $D \longrightarrow K\pi$ decays to calibration kaon-ID : work ongoing

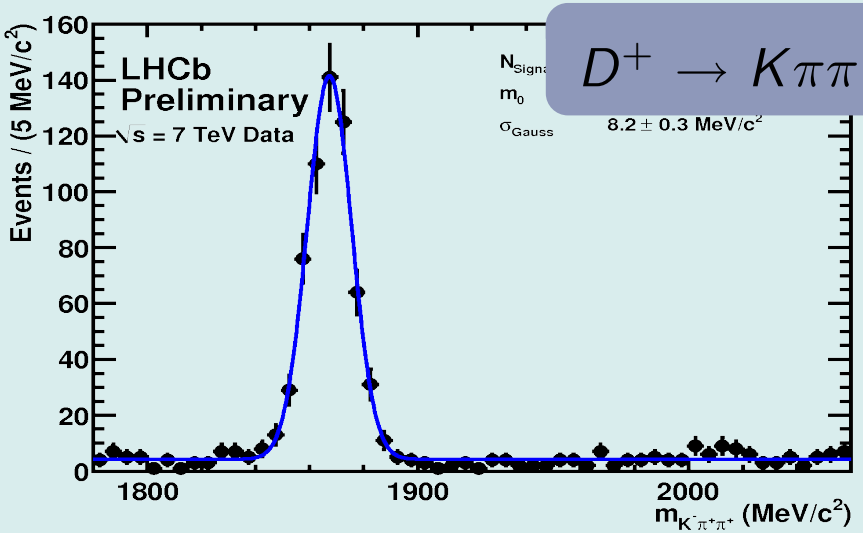
Zoology 4: D^+, D_s^+, Λ_c



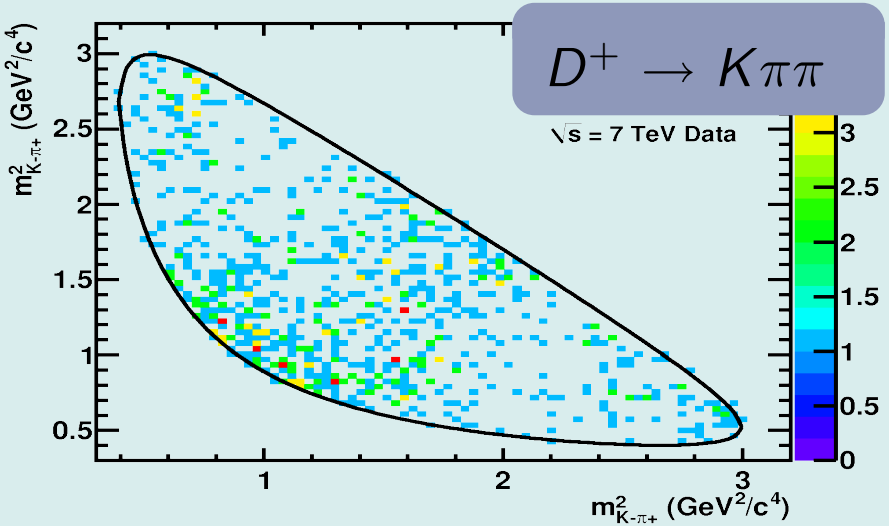
$D \to KK\pi$



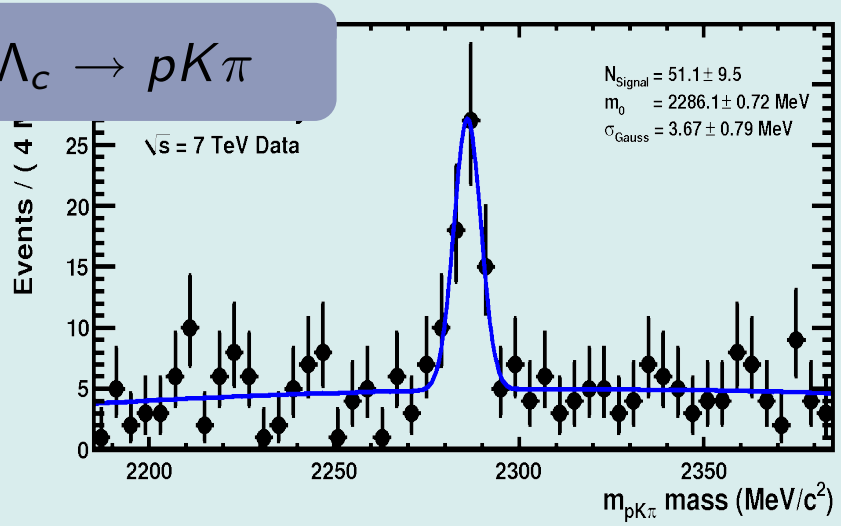
$D^+ \to K\pi\pi$



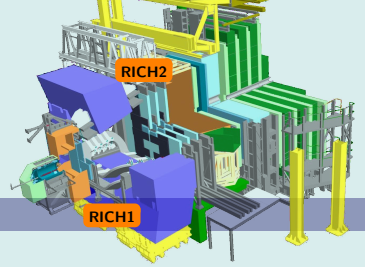
$D^+ \to K\pi\pi$



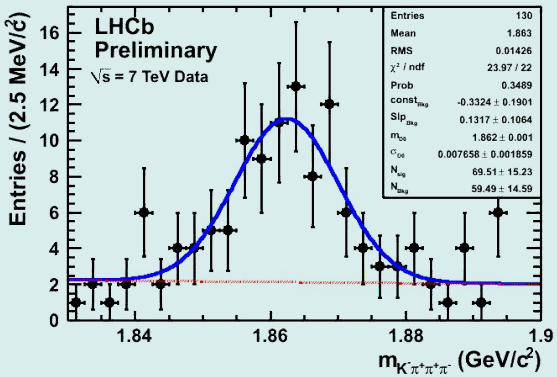
$\Lambda_c \to pK\pi$



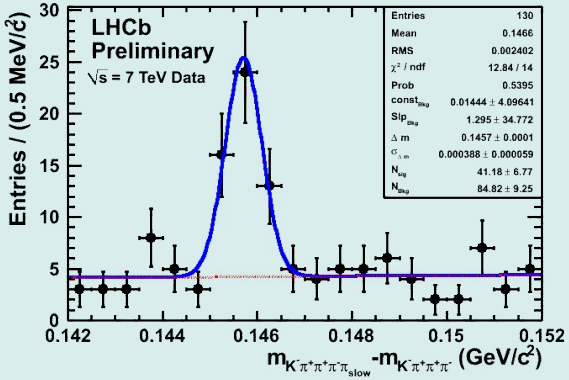
Zoology 5: $D^0 \to K\pi\pi\pi$



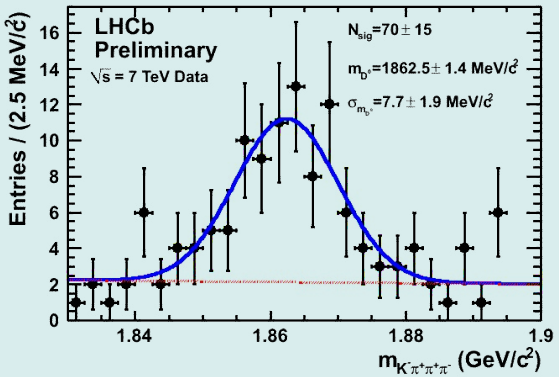
Untagged $K\pi\pi\pi$



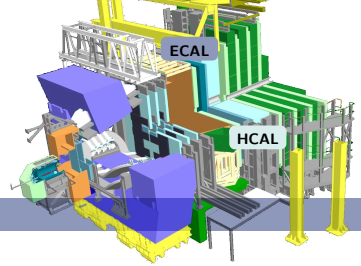
Δm



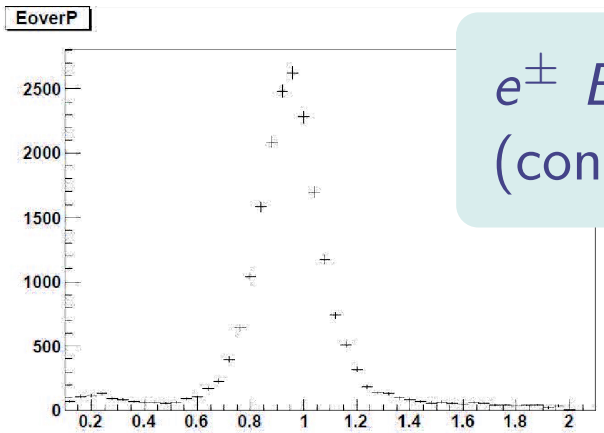
$m_{K\pi\pi\pi}$ with Δm cut



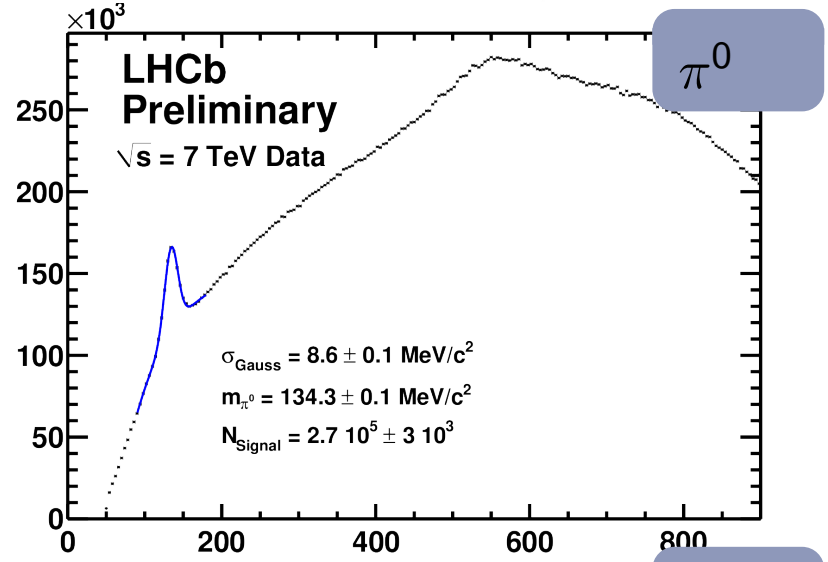
Calorimetry

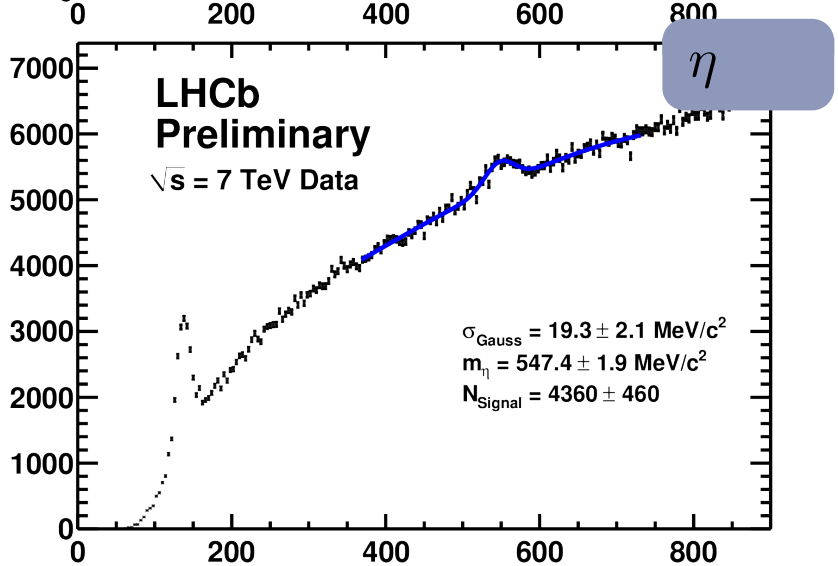


- The calorimeters systems work very effectively, providing the principal trigger at LHCb
- Time alignment now 1 ns
- PS/SPD calibration using MIPs
- ECAL Energy calibration ongoing. Need 50M events to achieve 1% with π^0

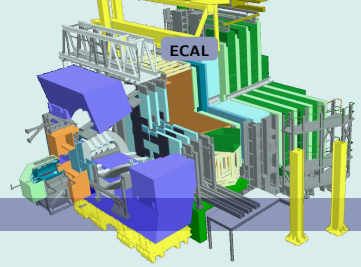


$e^{\pm}$ E/p (conversions)

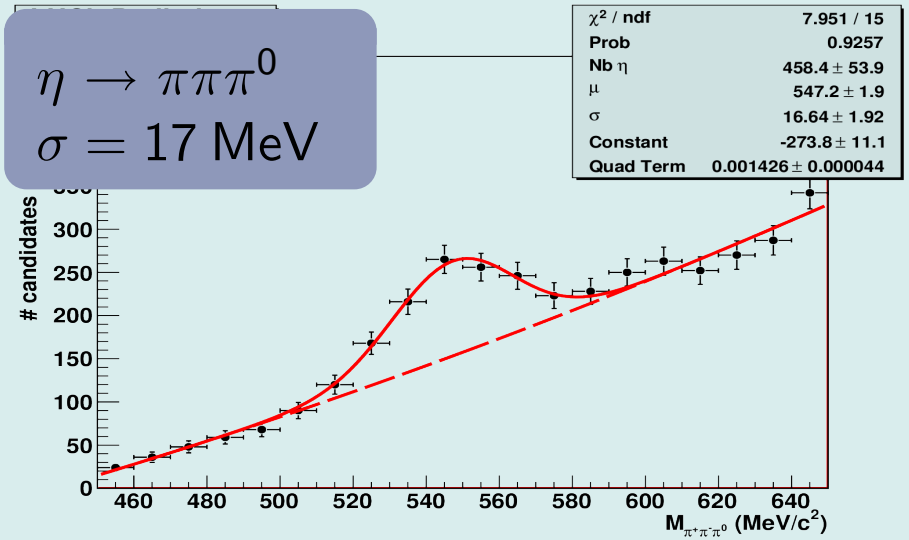




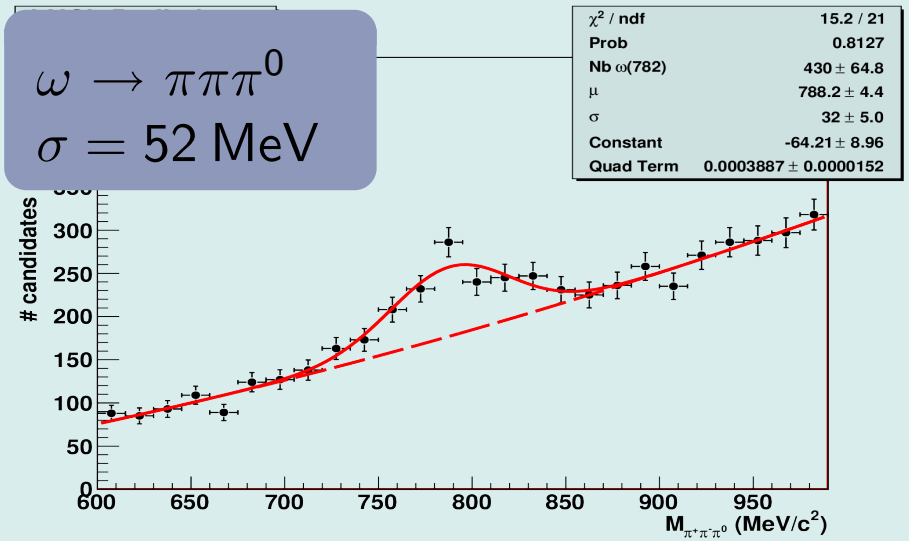
Zoology 6: Using π^0

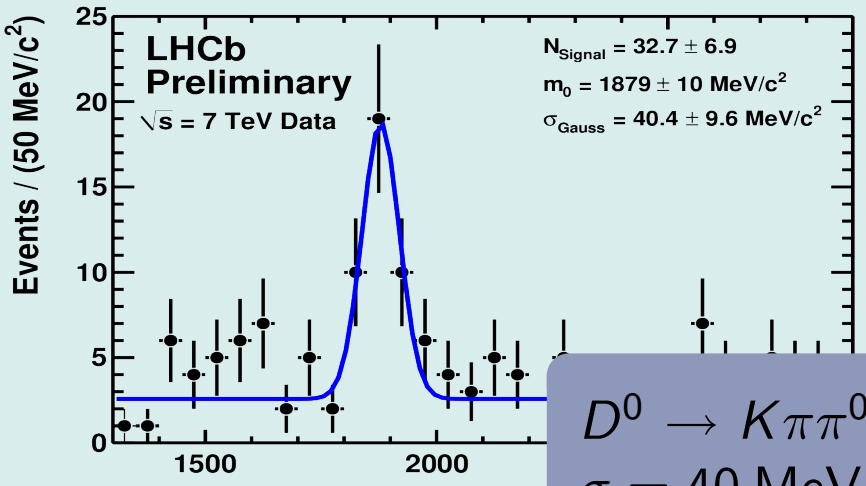


$\eta \longrightarrow \pi\pi\pi^0$
$\sigma = 17$ MeV



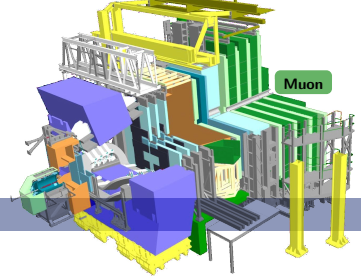
$\omega \longrightarrow \pi\pi\pi^0$
$\sigma = 52$ MeV





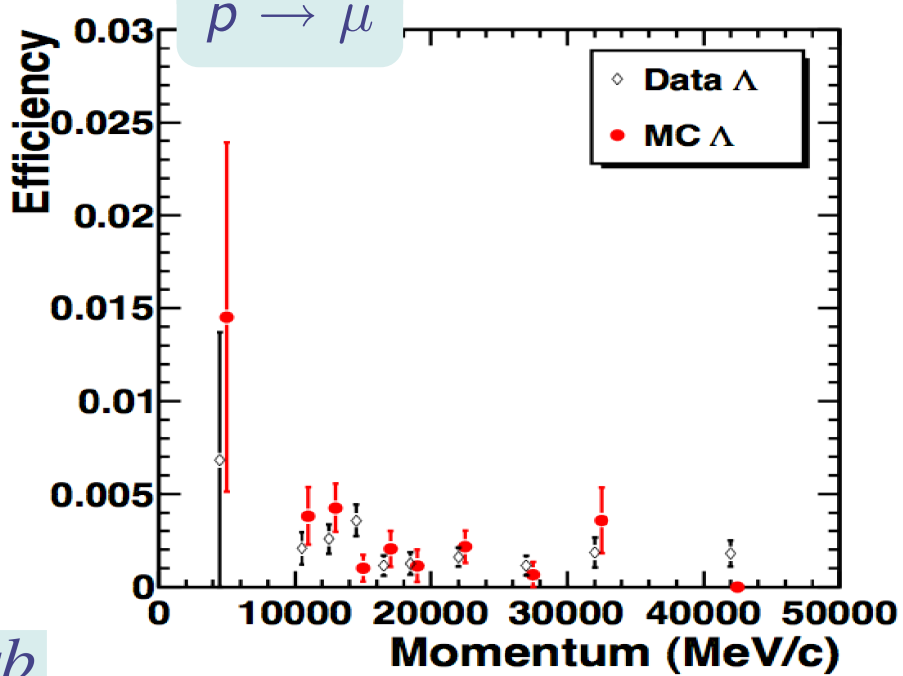
$D^0 \longrightarrow K\pi\pi^0$
$\sigma = 40$ MeV

Muon

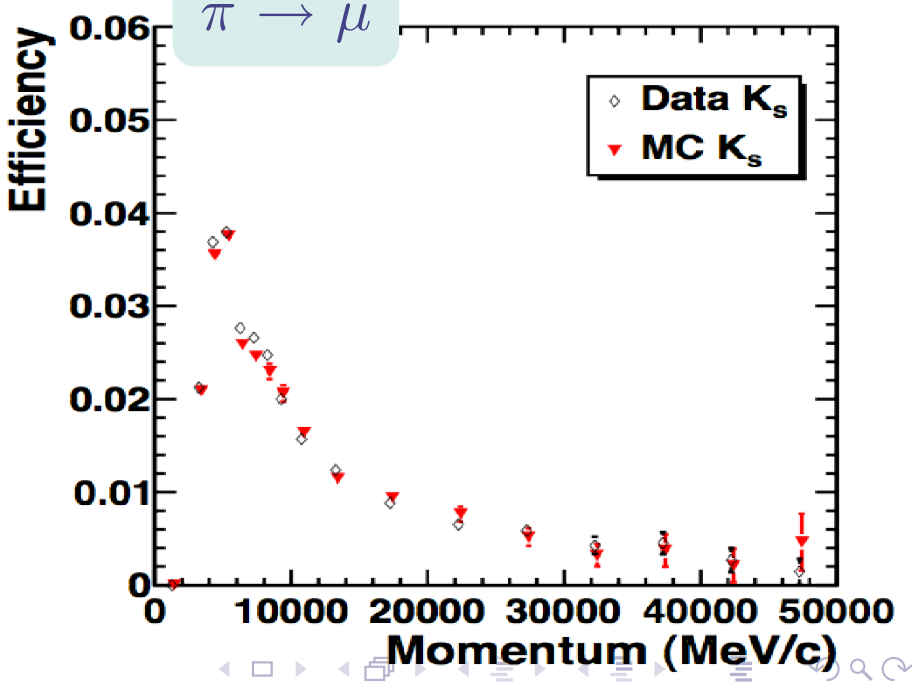


- Muon system works very well. Now tuning muon-ID
- Not enough J/ψ to measure μ-ID efficiency
- K^0_S and Λ used as a clean samples of p and π
- Proton Mis-ID : $(0.18 \pm 0.02)\%$. MC: $(0.21 \pm 0.04)\%$.
- Pion Mis-ID: $(2.38 \pm 0.02)\%$. MC: $(2.34 \pm 0.02)\%$.

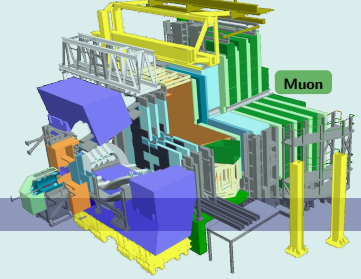
$p \longrightarrow \mu$

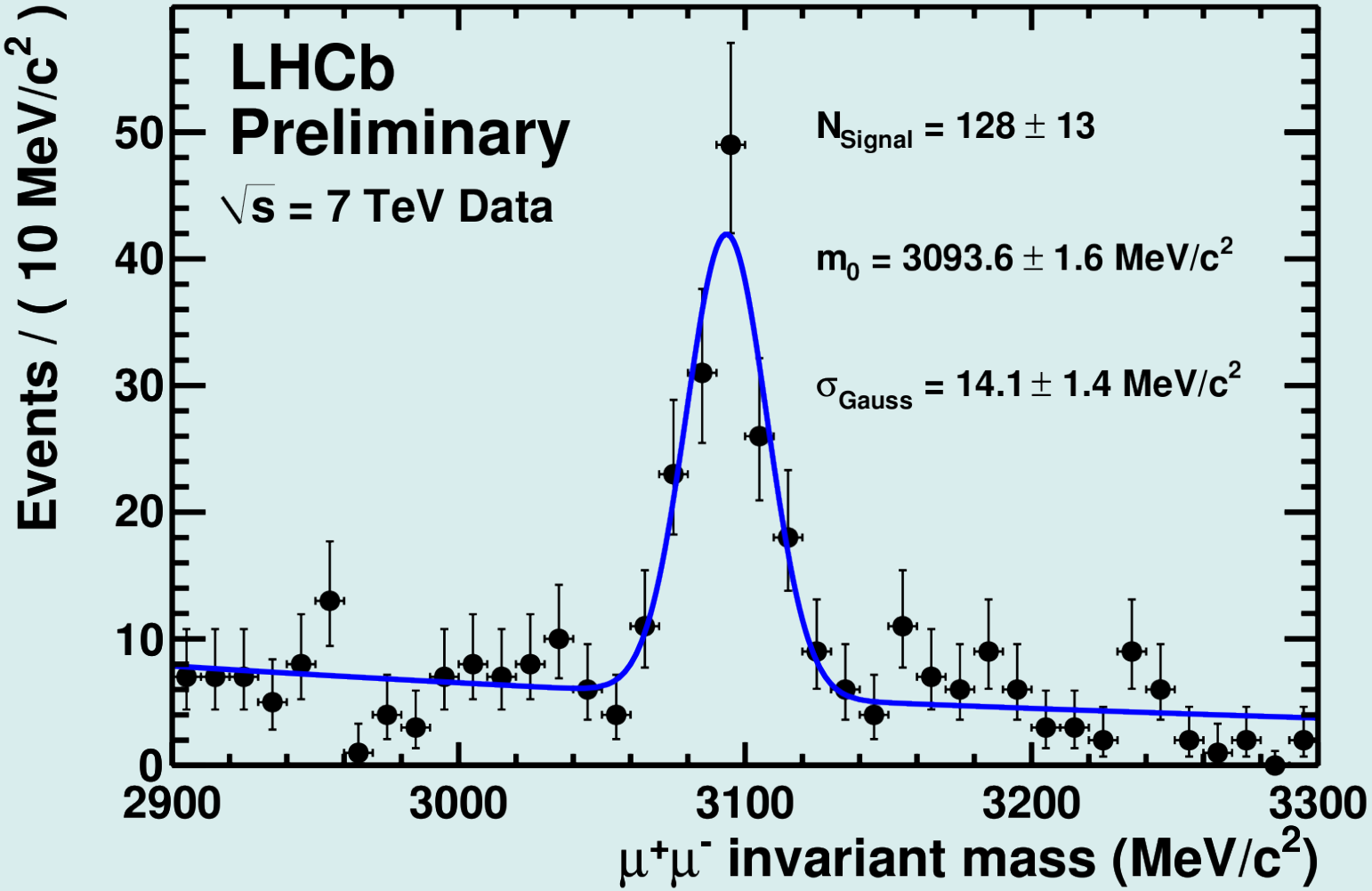


$\pi \longrightarrow \mu$

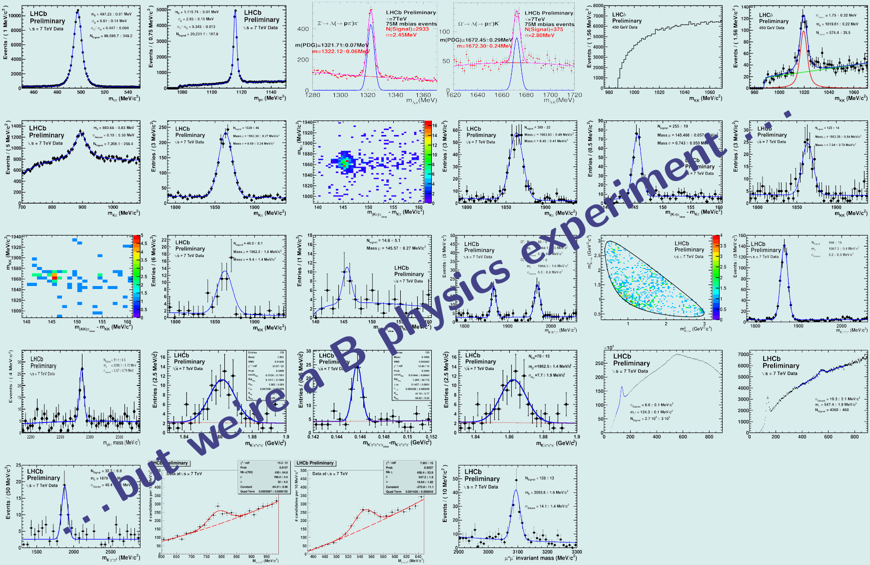


Zoology 7 : $J/\psi \to \mu\mu$

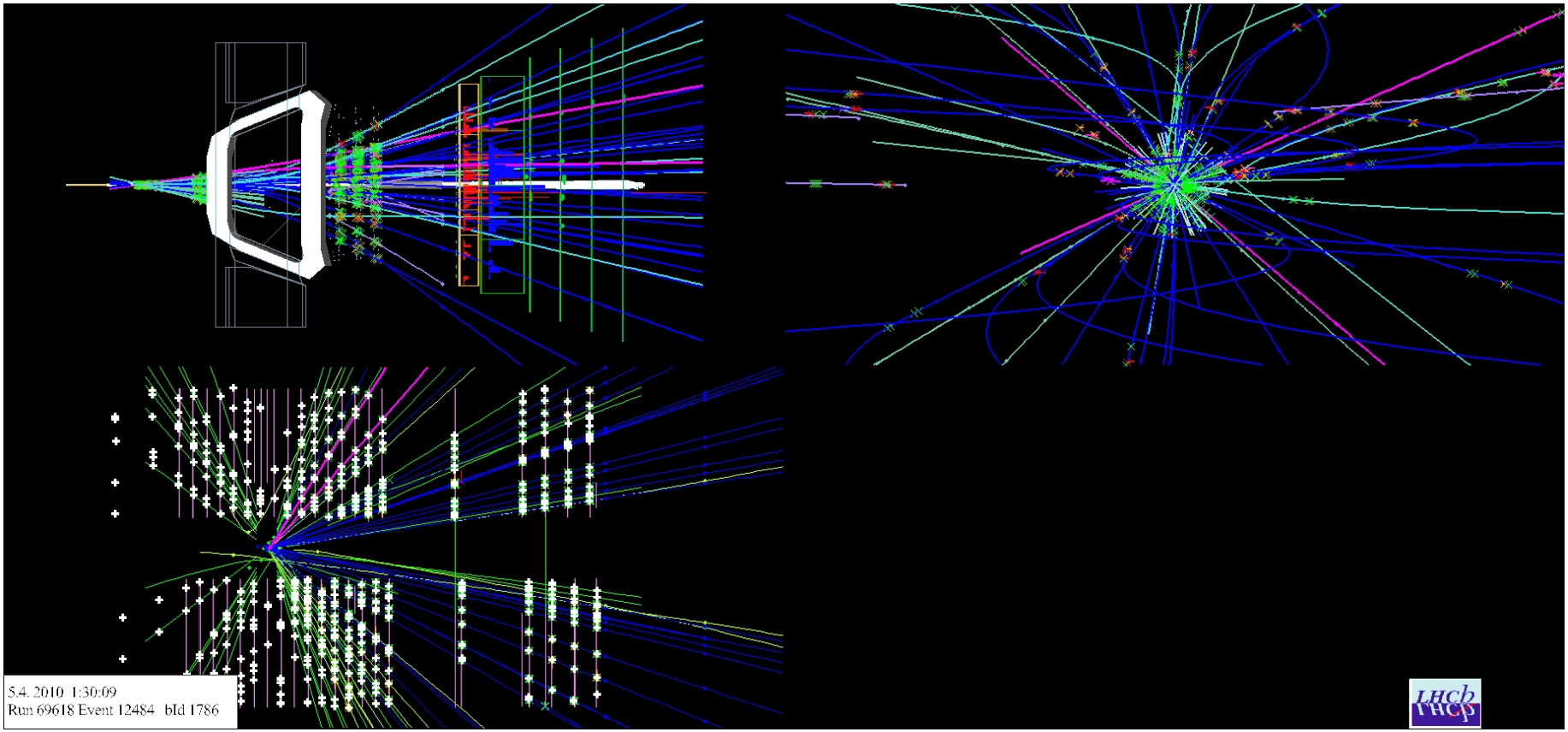




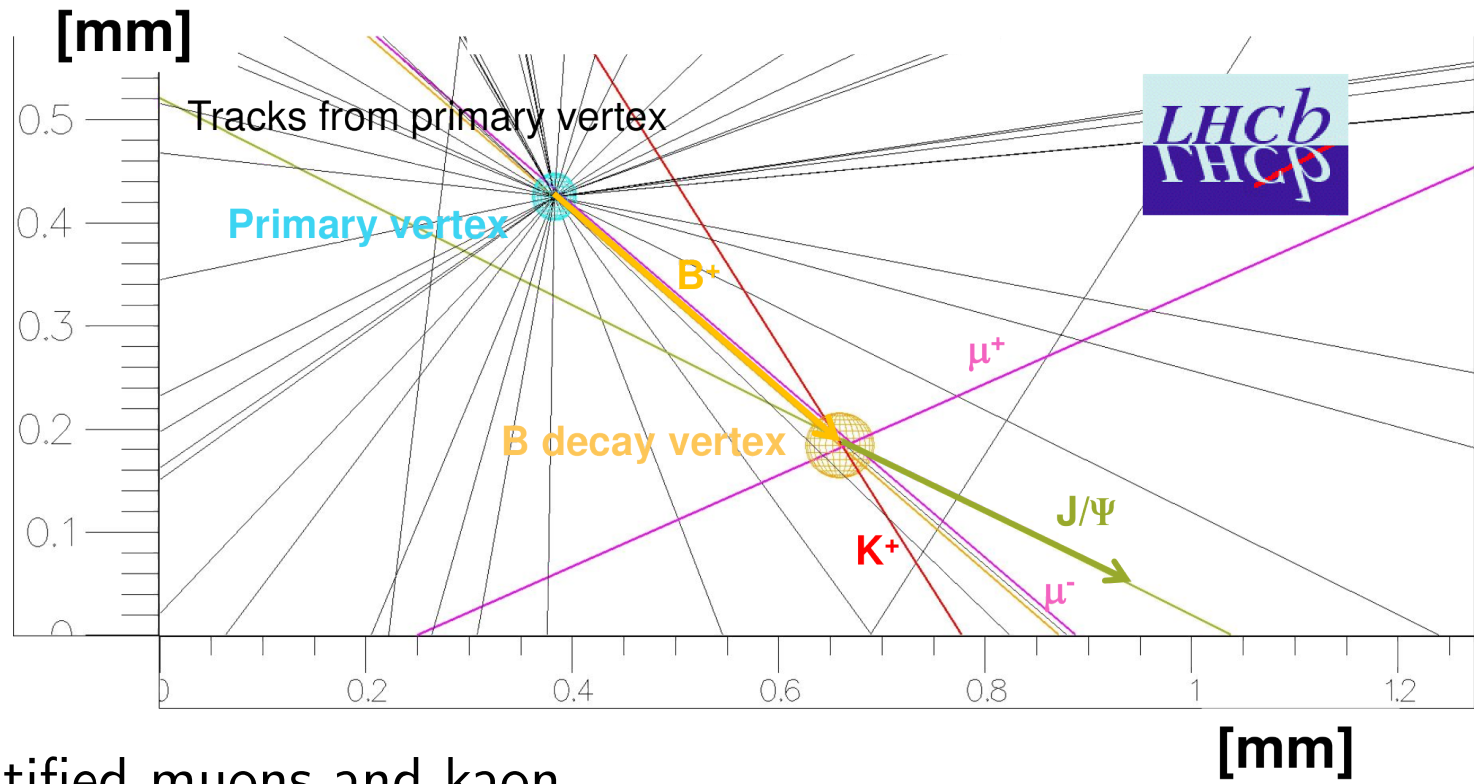
Very Nice Peaks!



B^+ Candidate

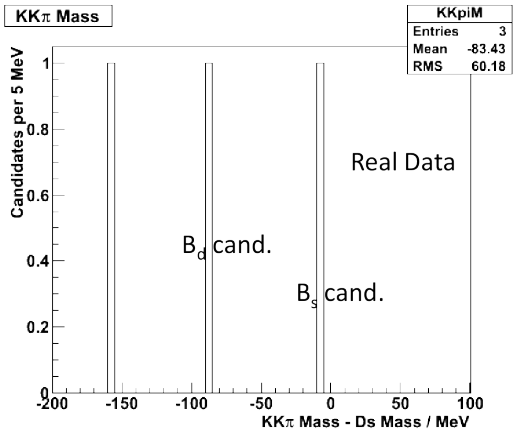


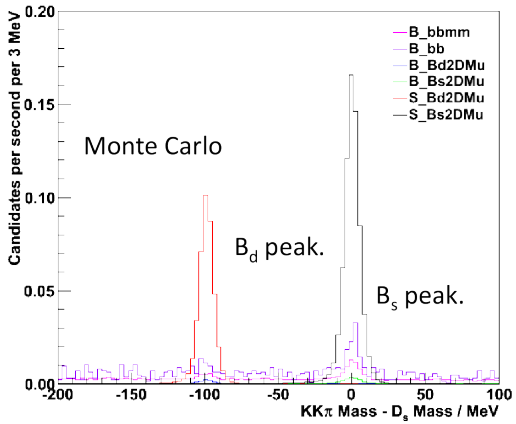
B^+ Candidate



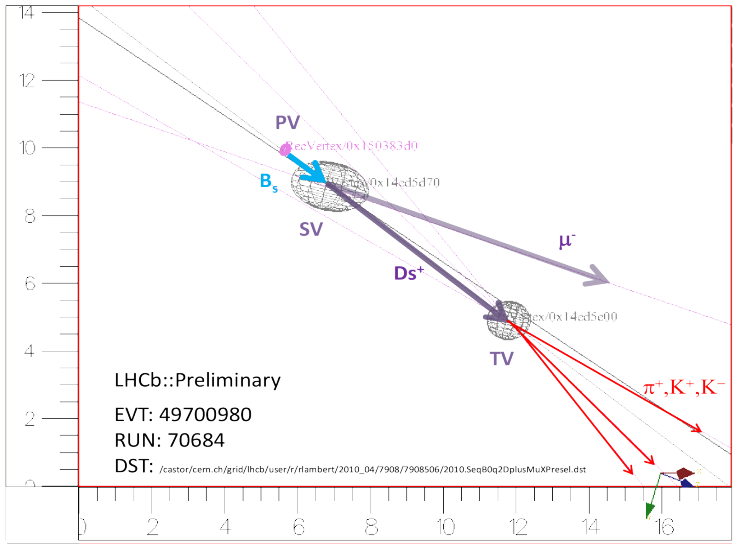
- Well identified muons and kaon.
- $m_{J/\psi} = 3097.90$ MeV, $m_{B^+} = 5319.90$ MeV
- Proper time $= 0.6\,\mathrm{ps}$ ($26\,\sigma$ from PV)
- Angle of flight and momentum of $B^+ = 0.7°$

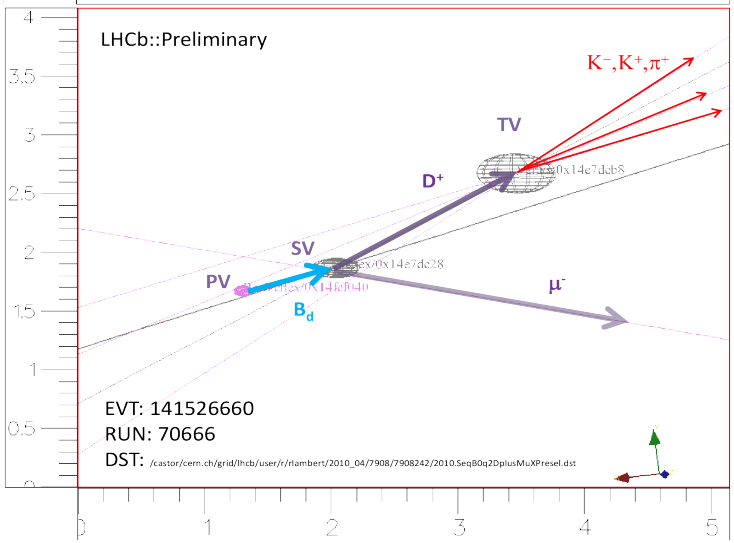
Semileptonic Candidates





LHCb::Preliminary

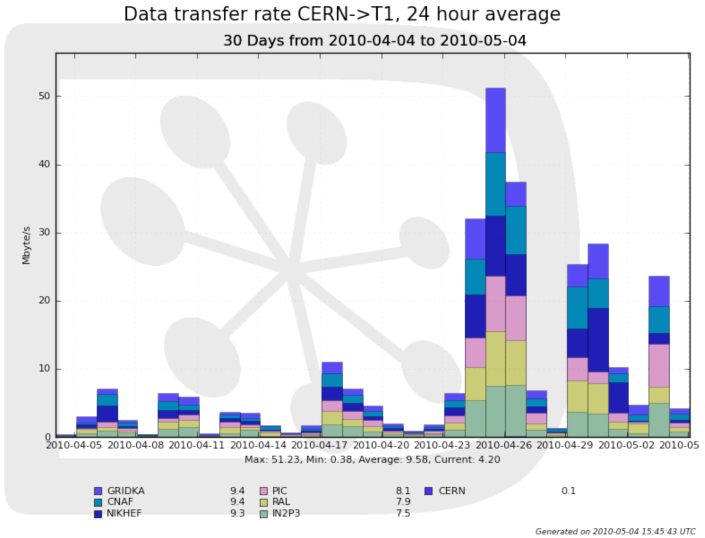


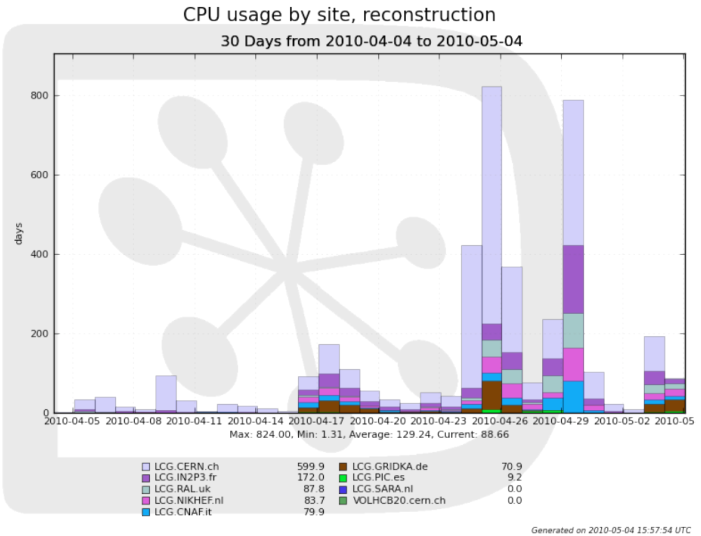


- Looking at $D \longrightarrow KK\pi$ with a μ tag forming a secondary vertex
- Classify by $KK\pi$ mass
- 3 Candidates:
  - One background
  - One $B_d \longrightarrow D^+\mu\nu$
  - One $B_s \longrightarrow D_s\mu\nu$

Offline Computing

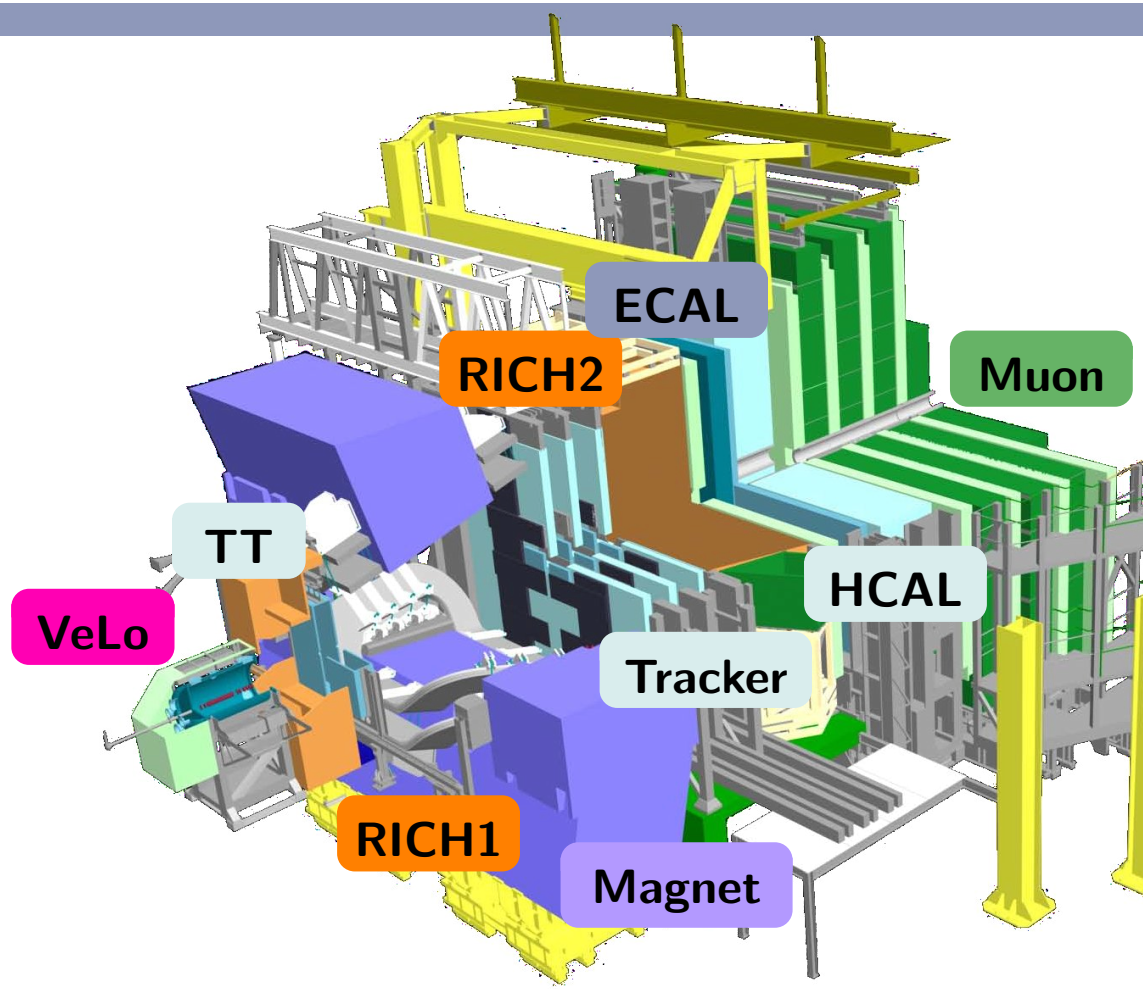
- Data processing chain works well. Several reprocessings already done.
- New data is distributed to the Tier1s
- Some issues with Tier1 stability regarding storage
  - So far CERN had highest share of CPU
- 2010 Simulation campaign will start soon





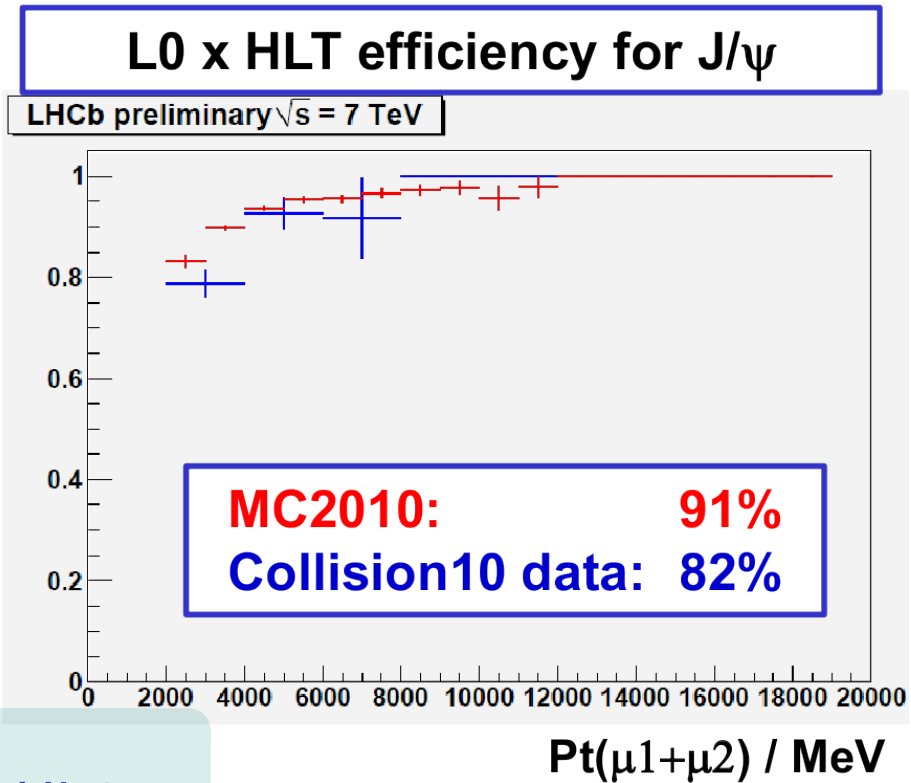
LHCb Trigger (2010)

- ✔ Hardware-based L0 trigger: moderate p_T cuts: 40 MHz ➜ 300 kHz
  - The whole data is sent at up to 300 kHz to a farm of $\mathcal{O}(500)$ CPUs
  - HLT1 tries to confirm a L0 decision by matching the L0 candidates to tracks.
    ➜ $\mathcal{O}(10\,\text{kHz})$
  - HLT2 does the full reconstruction and loose selection of B and D candidates ➜ 2 kHz
    - This is less than the $b\bar{b}$ rate



Trigger Outlook

- Can write up to 2 kHz. Did not yet have to cut...
- Soon will need to switch on Hlt1
  - IP resolution under control
  - μ efficiency being monitored
  - L0xHt1 efficiency on unbiased D^* $(60 \pm 4)\%$ (MC: 66%)
- Then will need Hlt2



Collisions	L0	Hlt1	Hlt2
< 2 kHz	"MB trigger"		
< 25 kHz	≤ 25 kHz	2 kHz	
< 300 kHz	≤ 300 kHz	10 kHz	2 kHz

Conclusion

- LHCb in a good shape
- Some more work needed to iron out small problems
- We see all the particles we expect to see
  - Including B mesons!
  - V0 analyses on their way to publication
- Future prospects for B and c-physics : See Guy Wilkinson's talk this afternoon.