LHCb Status

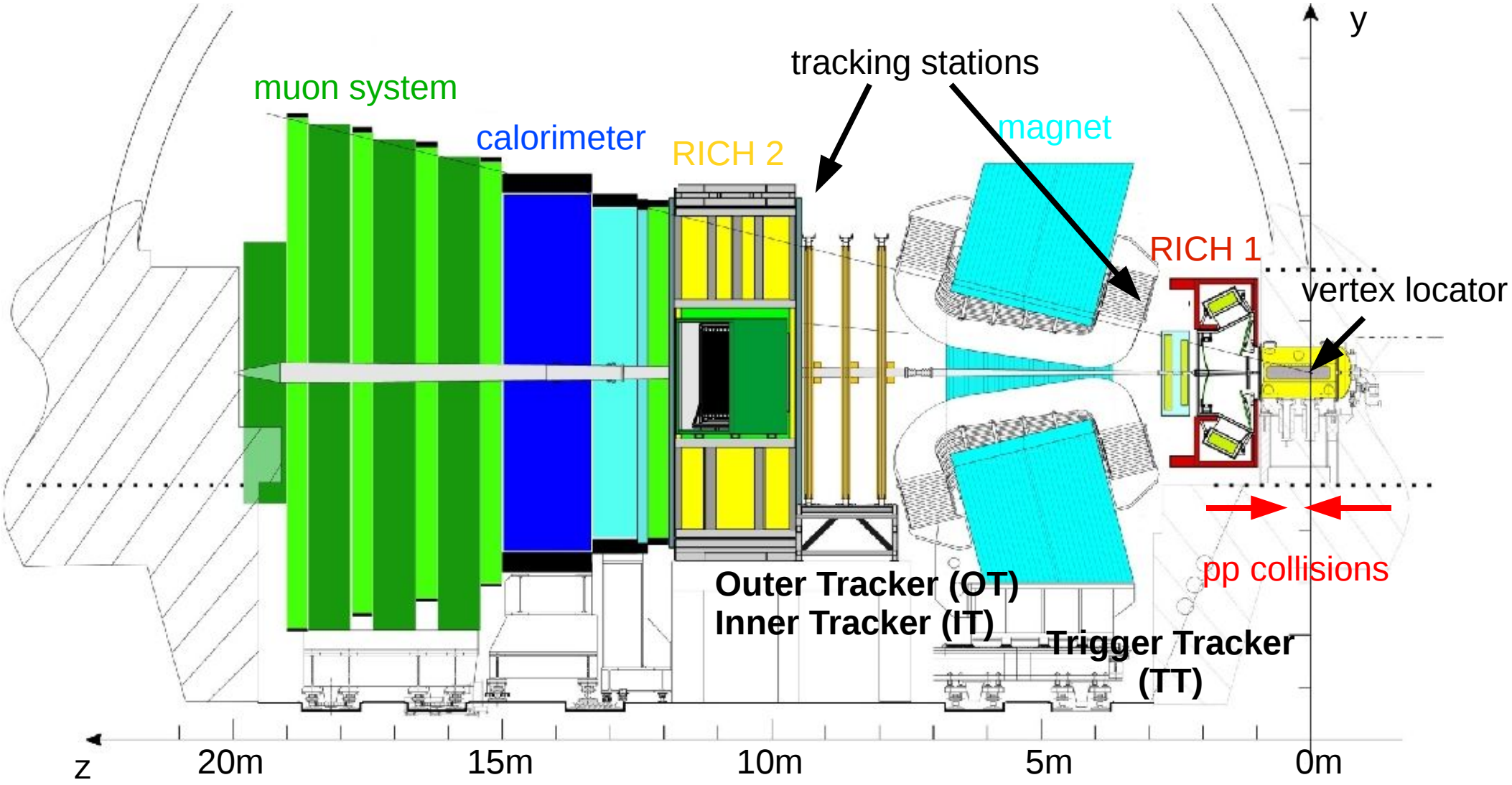
102nd LHCC meeting
07.07.2010

- data taking and detector status
- appetizer for summer conference physics results

Stephanie Hansmann-Menzemer
PI Heidelberg

for the LHCb collaboration

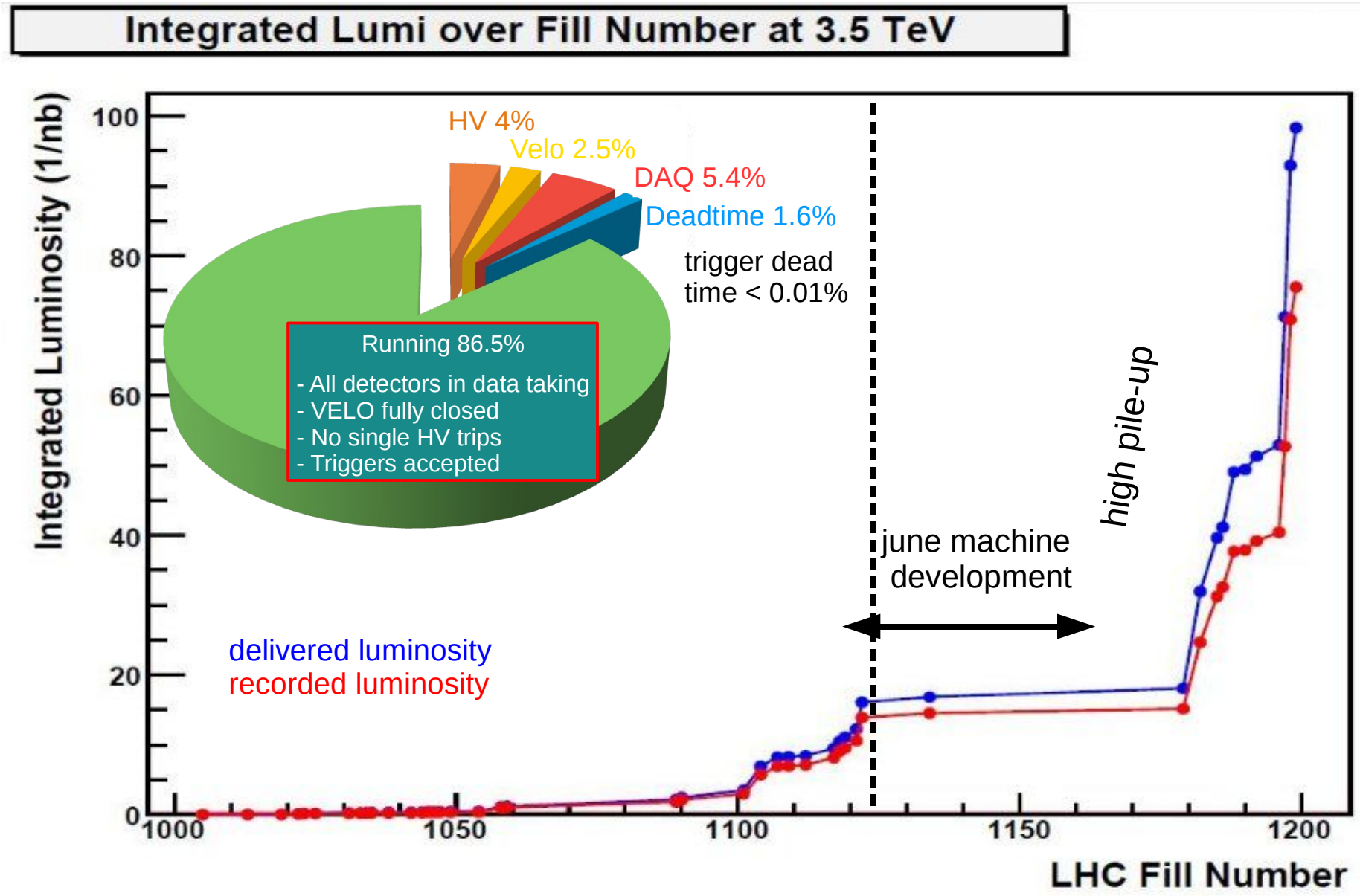
LHCb: Precision B Physics Experiment



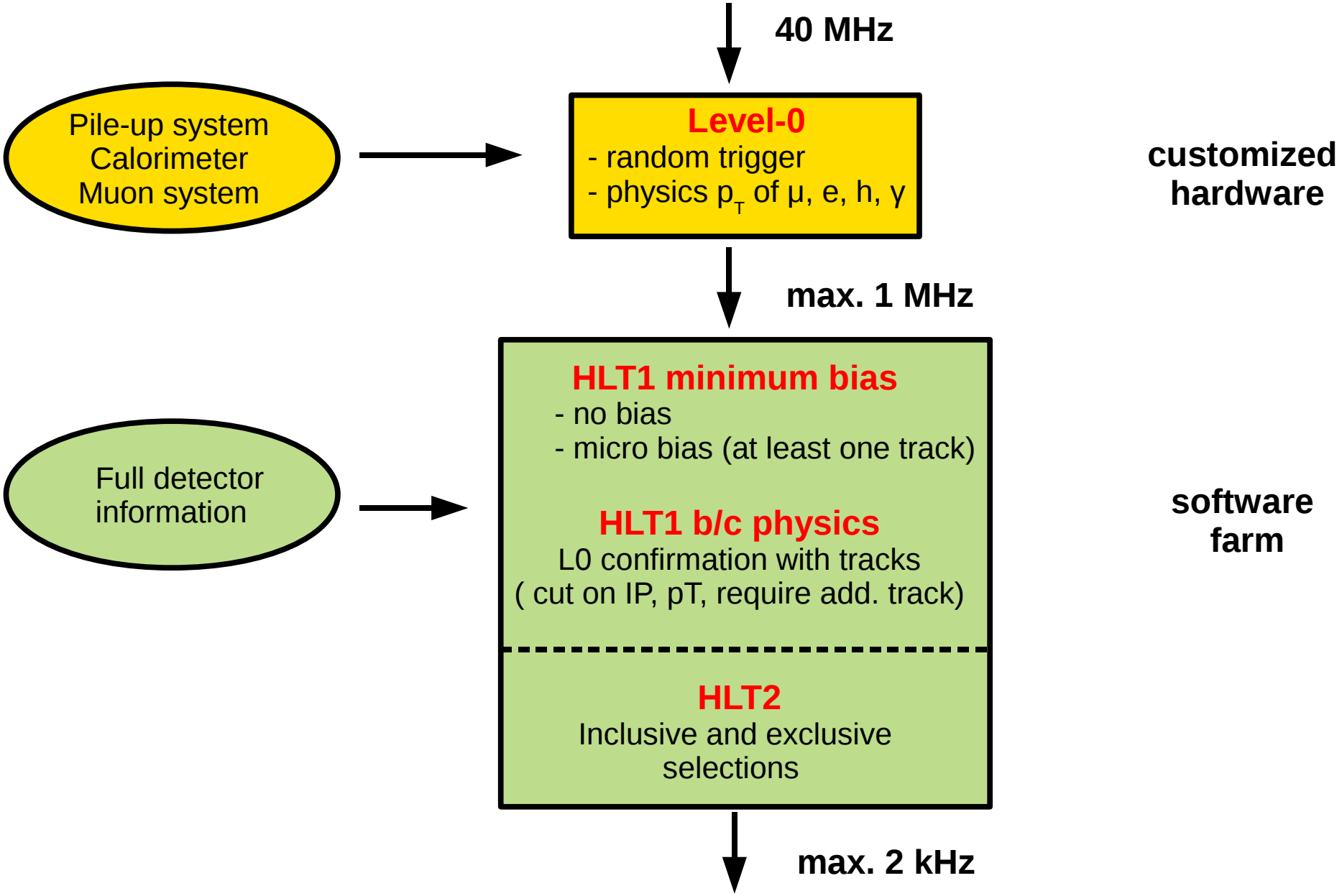
+ dedicated hardware and software trigger
+ large and clean data sets

Trigger and Data Taking

Luminosity

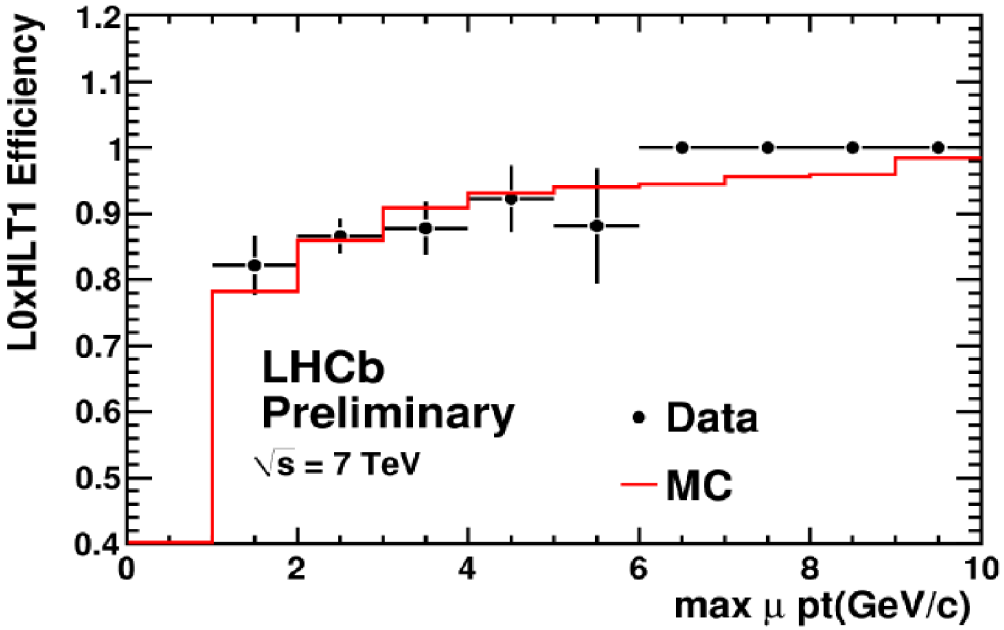

Integrated Lumi over Fill Number at 3.5 TeV
Integrated Luminosity (1/nb)
LHC Fill Number
HV 4%
Velo 2.5%
DAQ 5.4%
Deadtime 1.6%
trigger dead time < 0.01%
Running 86.5%
- All detectors in data taking
- VELO fully closed
- No single HV trips
- Triggers accepted
june machine development
high pile-up
delivered luminosity
recorded luminosity

Trigger System



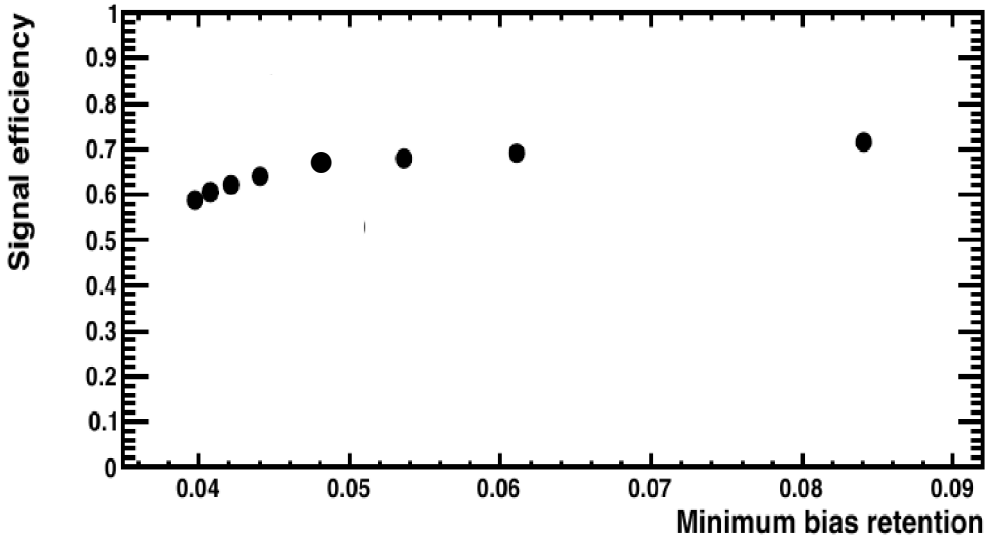
L0+HLT Efficiency

L0 + HLT1 single muon line
(tested on reconstructed J/ψ in mb sample)



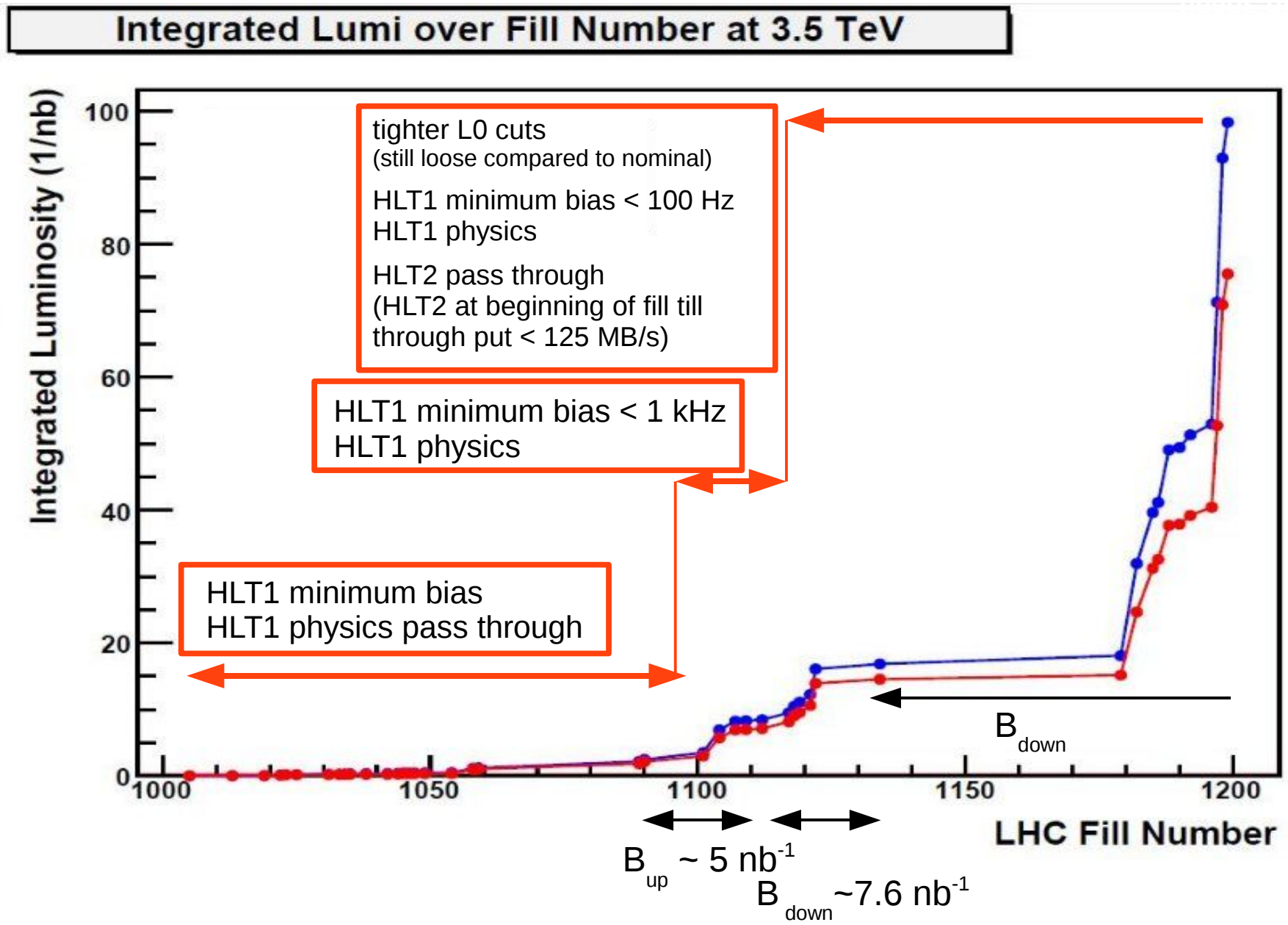
HLT1 di hadron line
(tested on reconstructed charm in mb sample)

vertex displacement X^2 cut



very good agreement between data and MC

Trigger Settings

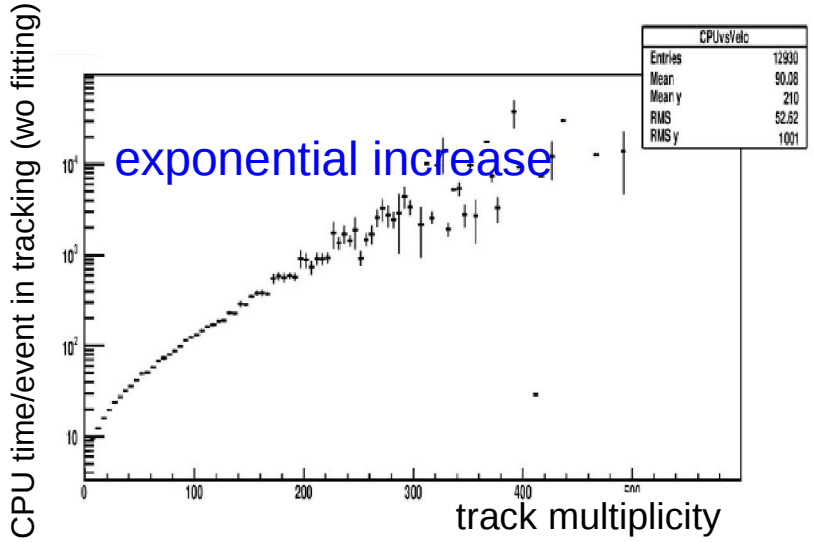


High Luminosity Running

- extreme case: observed up to 2.3 pile-up (ν =1.9) in recorded events at beginning of fill,
  LHCb designed to run at ν = 0.7 (@ 14 TeV)

take the opportunity of low bunch rate, to gain luminosity – try it now or never

- very high occupancy,
  e.g. Outer Tracker occupancy goes up to 20%
  larger event size (85kB, before 35kB)
- significantly slower for HLT & offline processing and stripping
- ghost/fakes rates,
  efficiency needs to be studied
  (initial MC studies indicated decent behaviour)



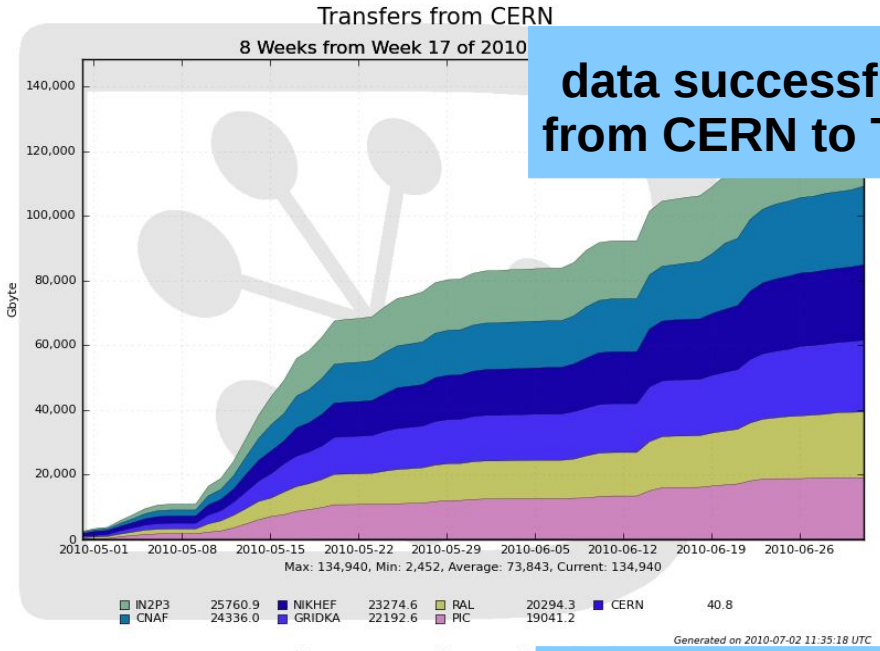
- optimal compromise between quantity and quality of physics data need to be found taking short and longterm physics goals into account.

- We have the flexibility to choose our working point!

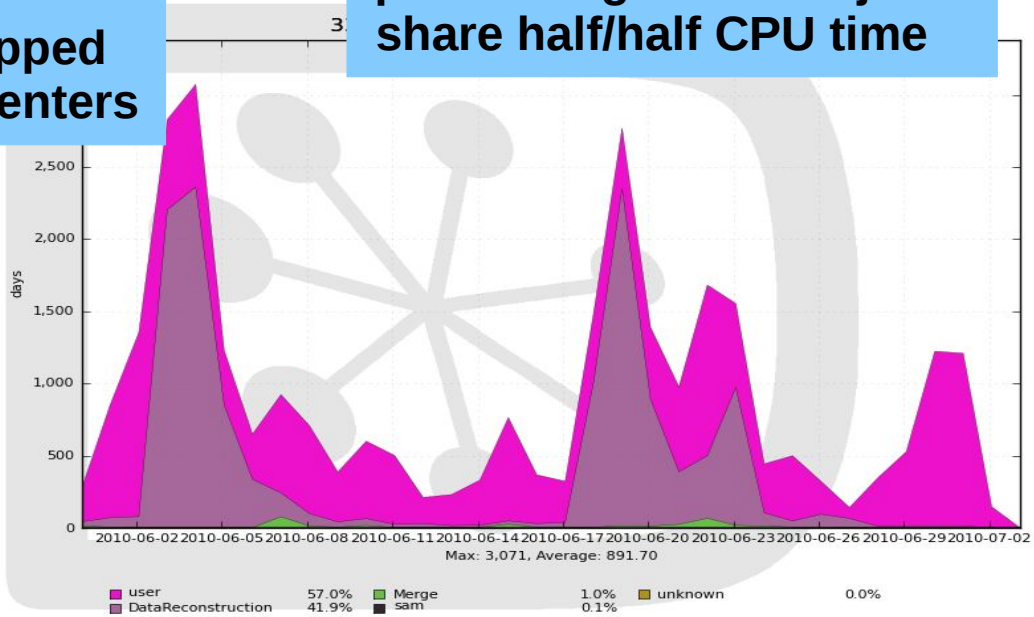
- several potential options (if needed):
  - cut on track multiplicity early at HLT 1 and/or tighter (nominal) cut at L0
  - need more testing/commissioning: beam offset in vertical plane/bunches of lower intensity
  - longer term solution: larger β* for LHCb

GRID-Computing

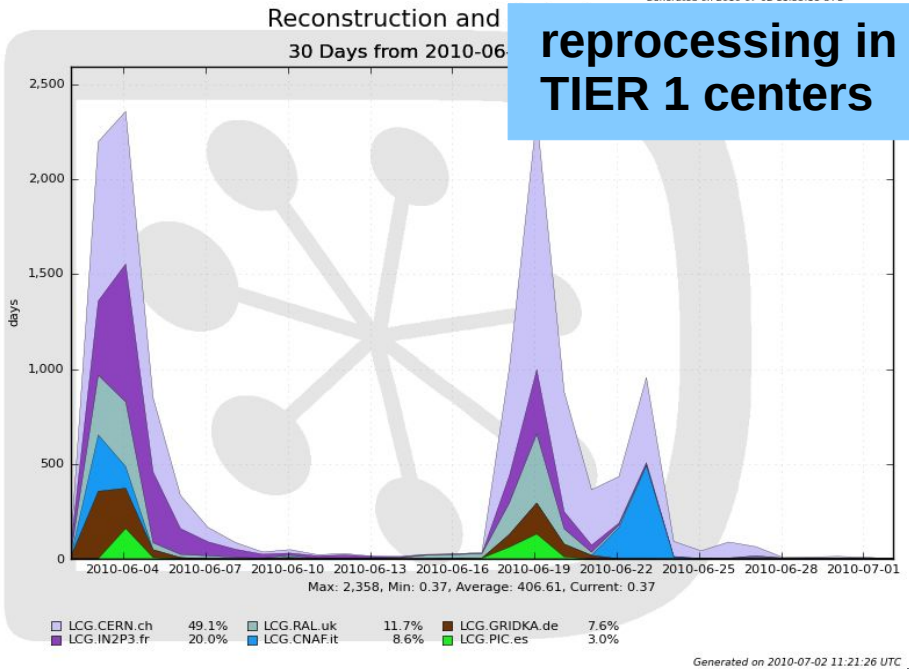
data successfully shipped from CERN to TIER1 centers



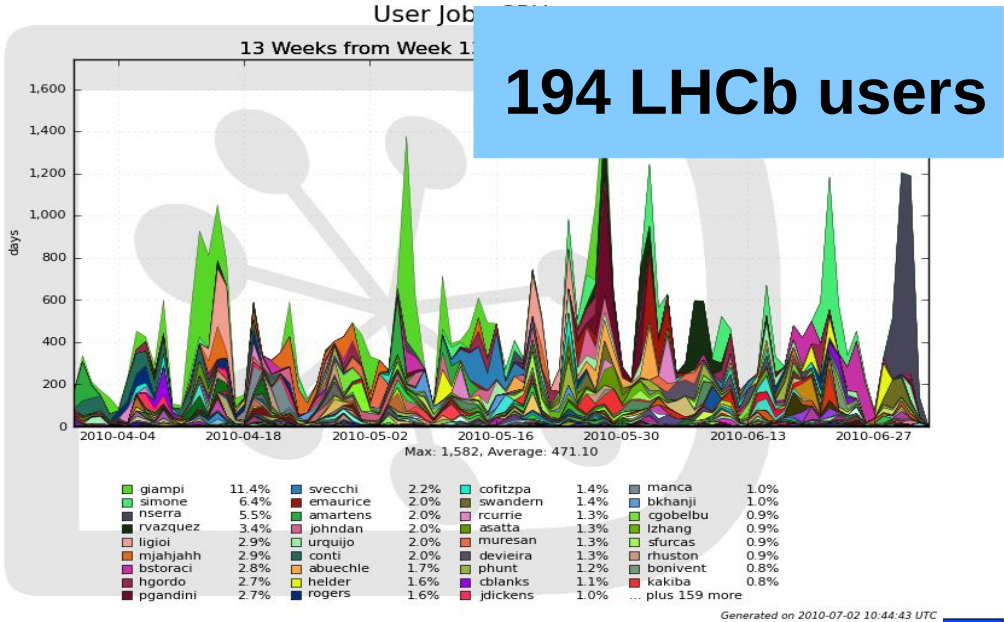
processing and user jobs share half/half CPU time



reprocessing in 6 TIER 1 centers



194 LHCb users

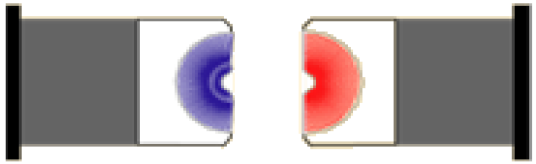


Vertex Locator:
impact parameter, vertex and proper time resolution

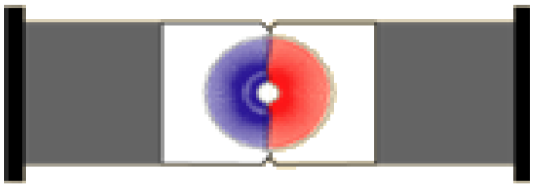
Vertex Locator
precision measurements at the IA point

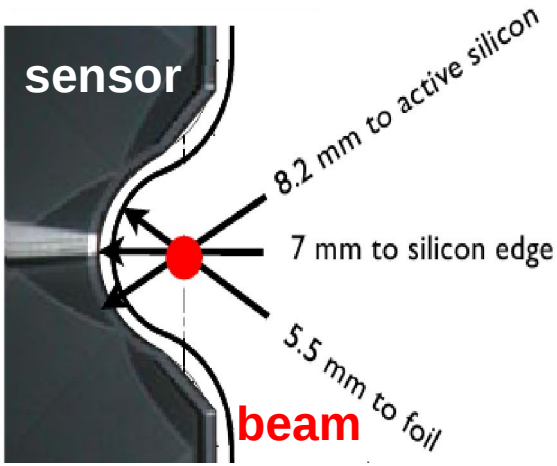
- Velo sensors all powered
- cluster finding efficiency 99.8 %

- Velo halves are open at begin of each run

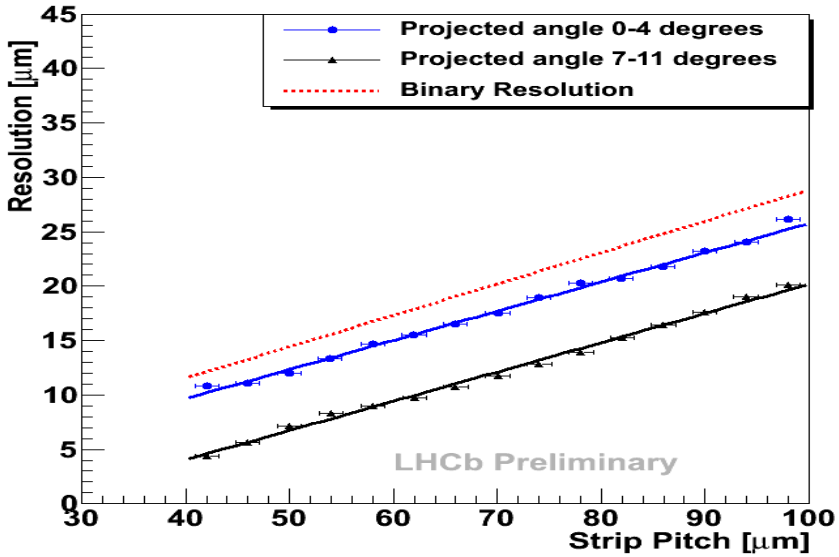


- fully closed at 7 TeV stable running





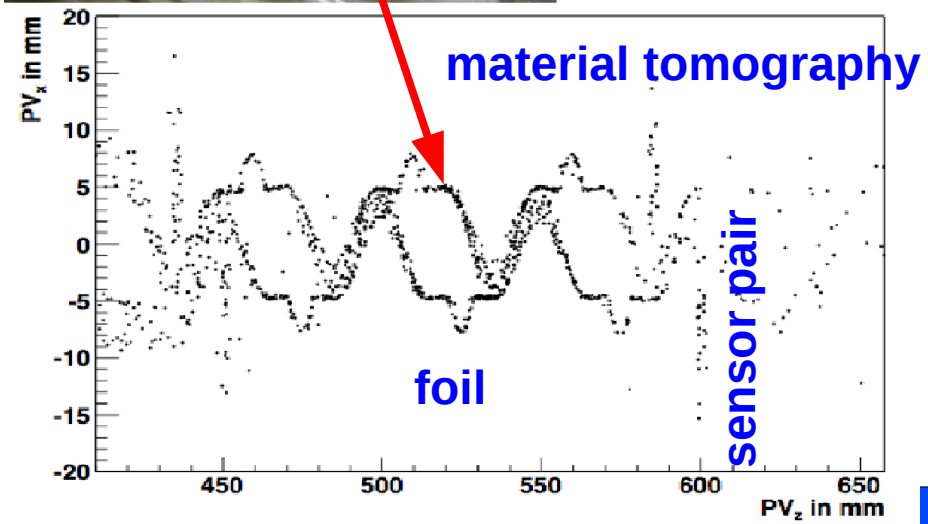
best single hit resolution ~ 4 µm



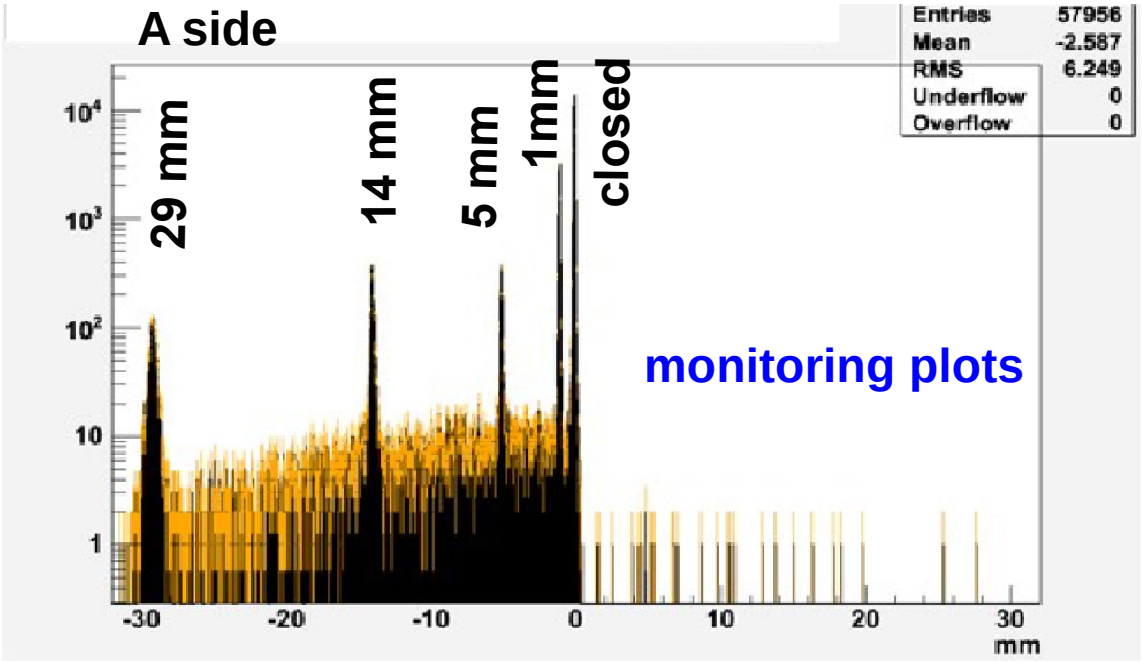
Semi-Automatic Closing Procedure

- stop 4 times to control position
- current closing procedure takes 6 min
- run-by-run variation (x,y,z):
  (10,5,25) µm

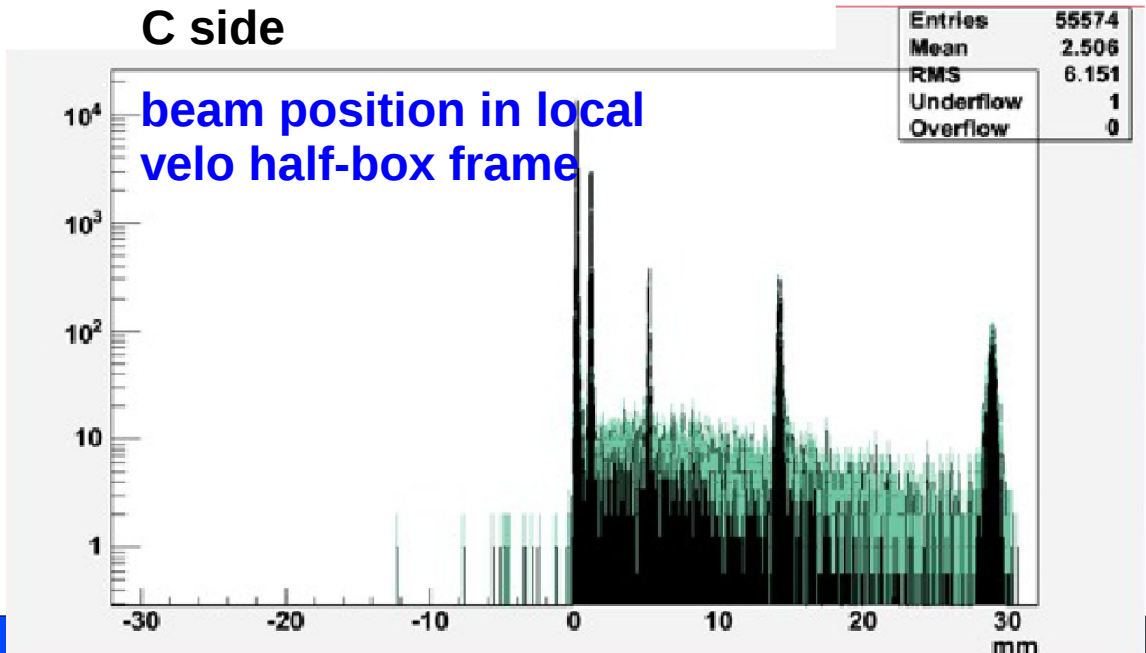
RF foil of both halves are almost touching



A side



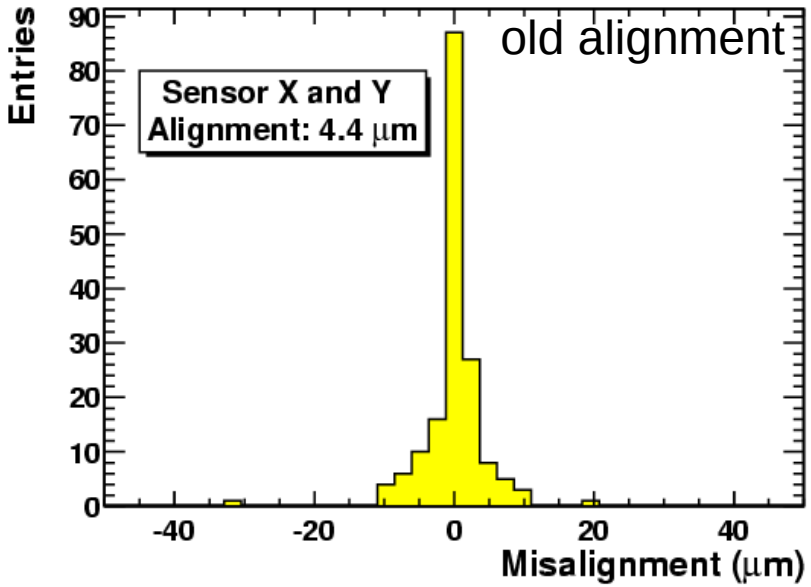
C side

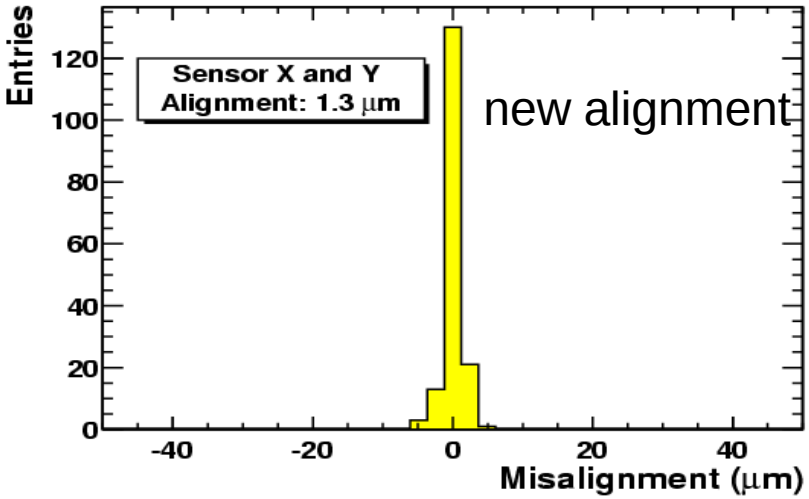


Vertex Resolution

new alignment including z translation

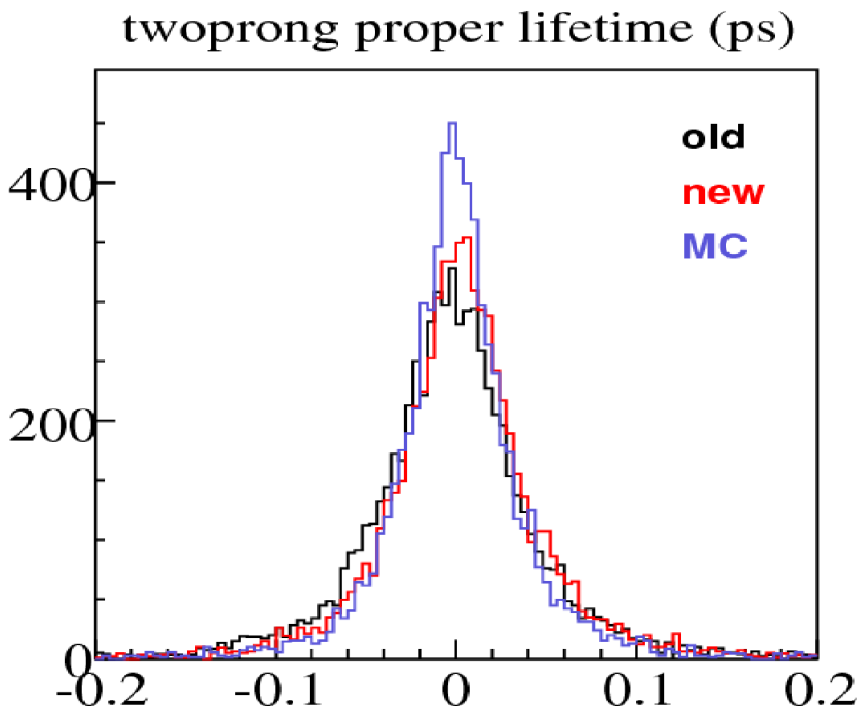
(not yet in standard production)
big improvement in alignment
monitoring offset In x and y





impact parameter resolution:

$\sigma(IP_x) \sim 16.2 + 24.6/p_T$ μm
$\sigma(IP_y) \sim 15.7 + 24.6/p_T$ μm



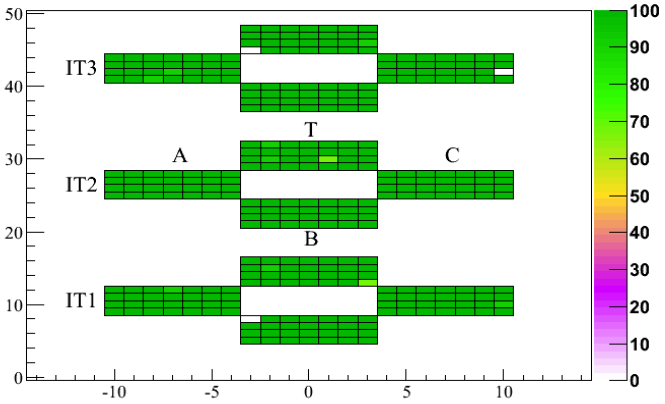
New alignment results in significantly improved proper time resolution!

(Note that this will however have little effect on resolving fast B_s mixing)

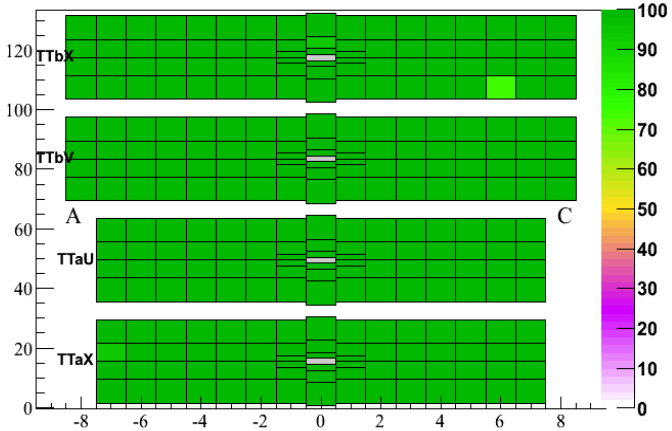
Tracking Stations & Magnet:
mass and momentum resolution, tracking efficiencies

Silicon Tracker

IT 98.6% of channels working

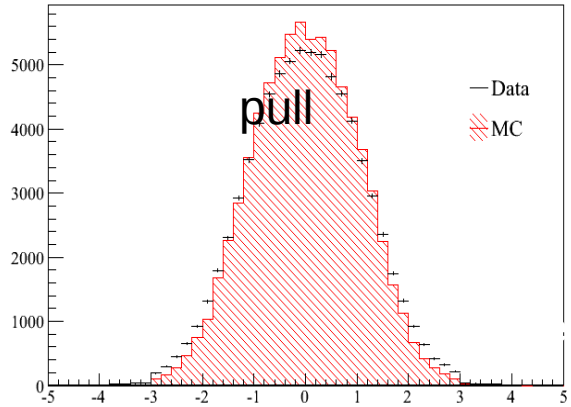


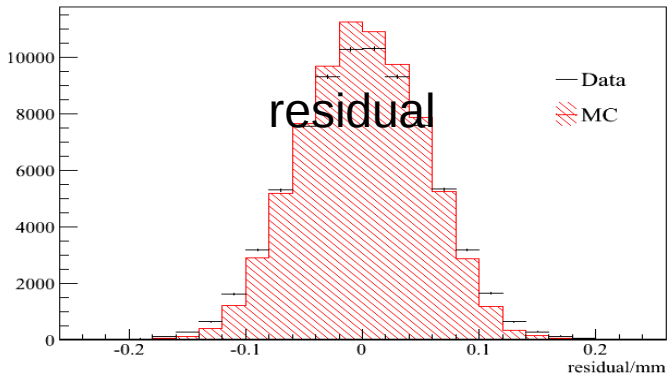
TT 99.6% of channels working

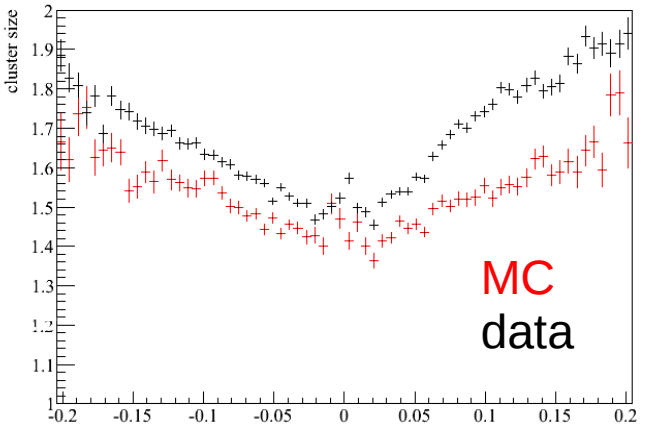


hit resolution [μm]	IT	TT
- old MC, inspired by test beam:	40	40
- data:	55	65
- **hit resolution:**	54	55
- **misalignment:**	10	35

→ **retuned hit resolution in MC**
(not yet in standard production)







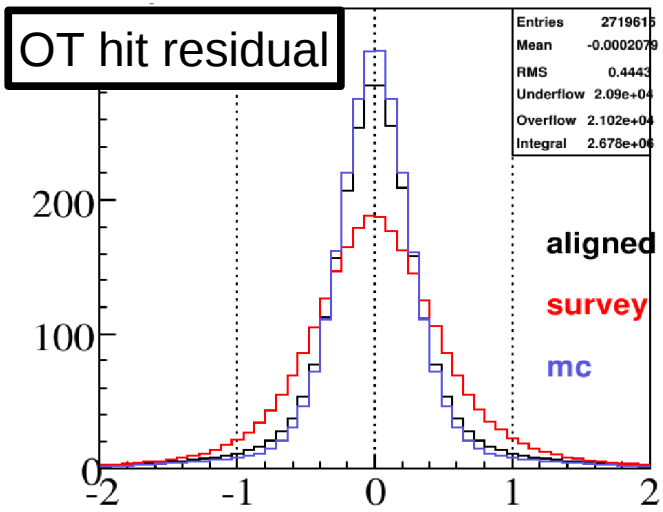
slope of track

remaining difference will be improved by tuning the gain

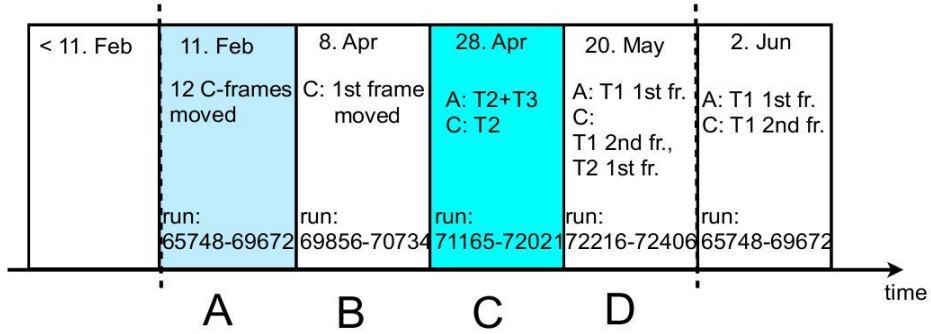
Outer Tracker

99.3 % channel working

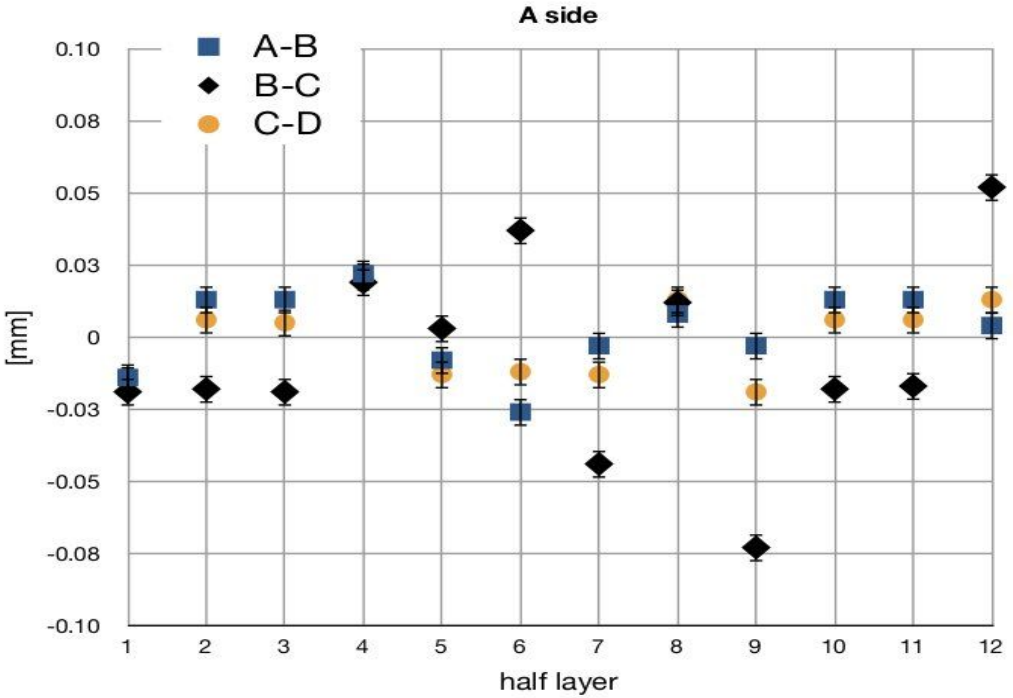
outer tracker resolution
± 270 µm, close to nominal



compare 4 time intervals



However, LHCb outer tracker C frames are moved in and out for maintenance work

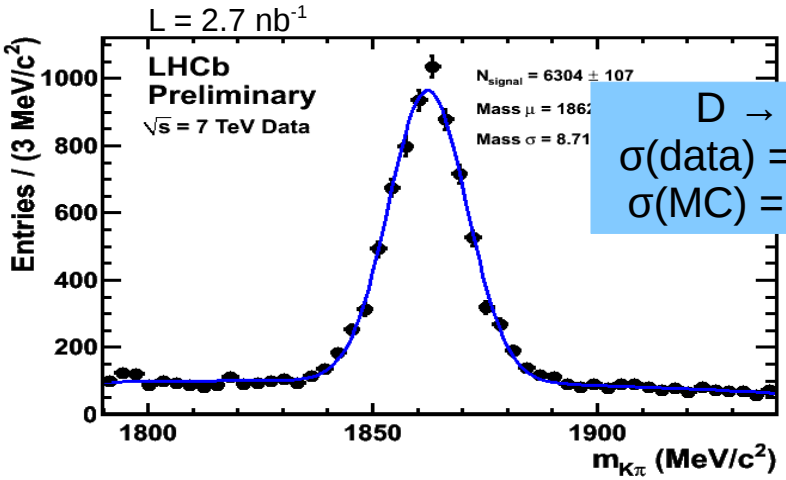


within ± 30 µm

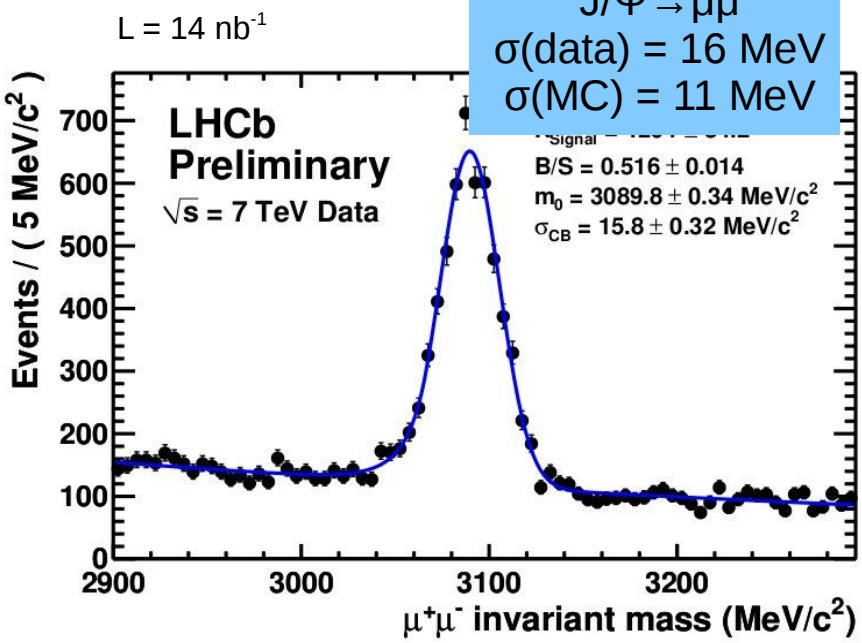
OT/IT relative alignment sensitive to movements in this order
→ **new alignment constants for every interval**

Invariant Mass Resolution

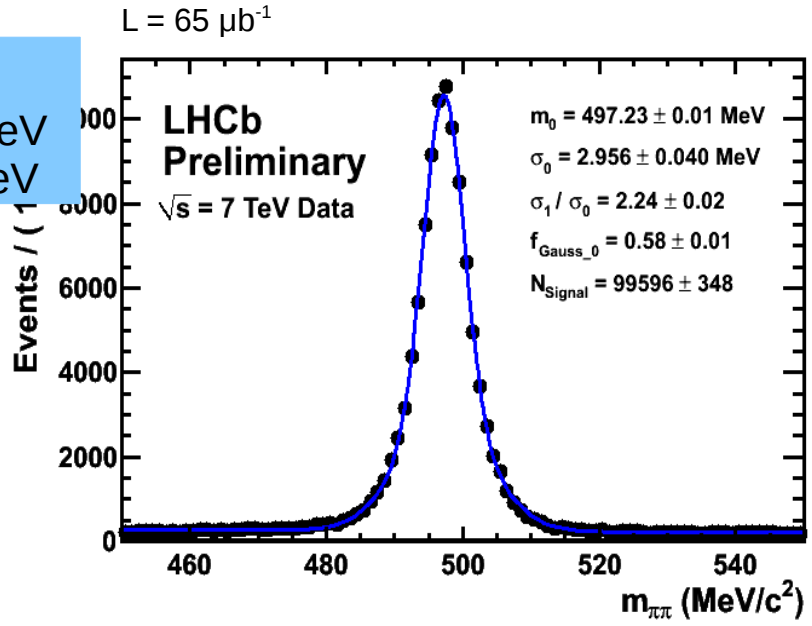
Very precise momentum and mass resolution!
aim for Δp/p ~ 0.4-0.55 % (MC),
not yet quite there



D → Kπ
σ(data) = 9 MeV
σ(MC) = 7 MeV



J/Ψ → μμ
σ(data) = 16 MeV
σ(MC) = 11 MeV

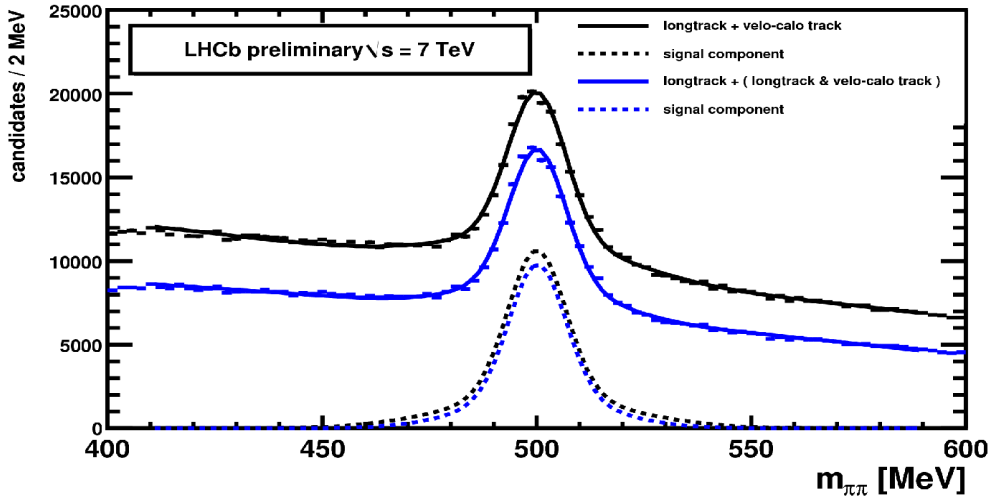


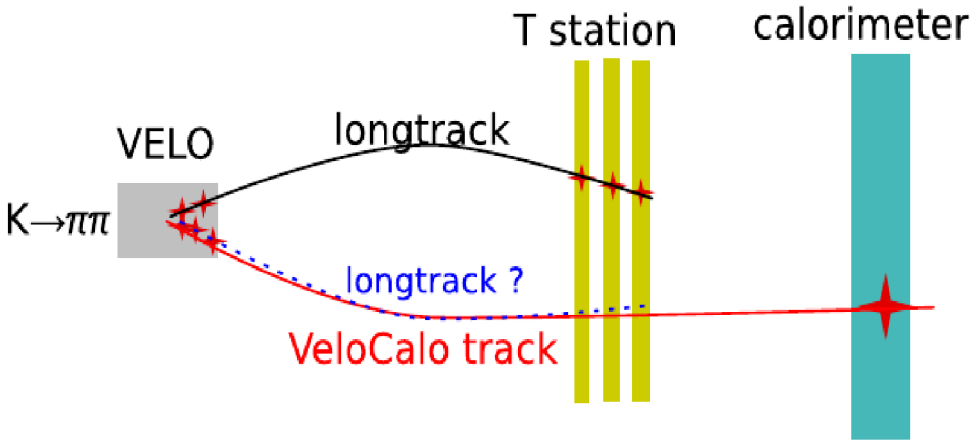
$K_s \rightarrow \pi\pi$
σ(data) = 3.3 MeV
σ(MC) = 2.6 MeV

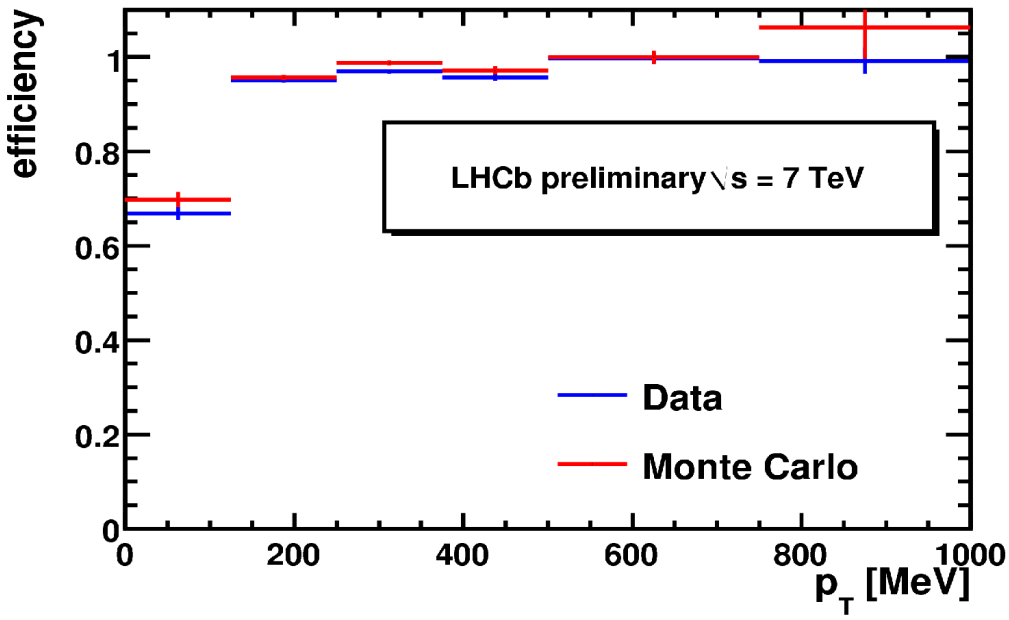
large samples of J/ψ & Υ(1S) will help to resolve this

Tracking Efficiencies

- **Tag and Prob method using K_s and J/Ψ**







slightly lower efficiency in data than in MC
(related to residual misalignment, ..)

- **4% systematic uncertainties per track** (for all phase space)

- aim for correction + 1-2% uncertainty

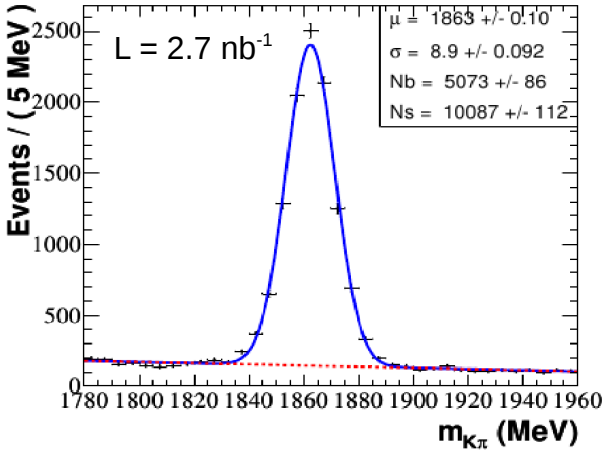
Tracking Efficiencies

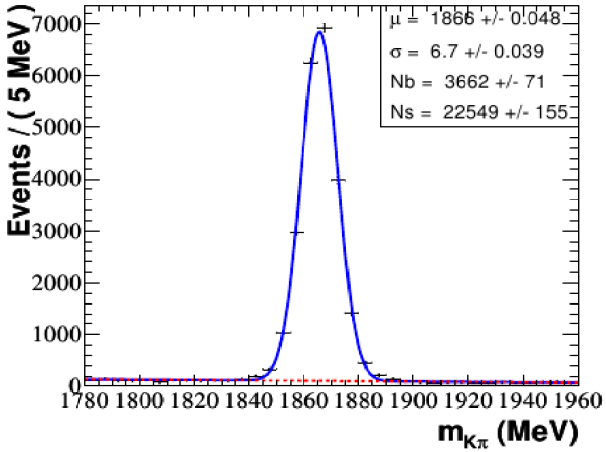
$\varepsilon(\text{track})^2 \sim N(K\pi\pi\pi)/N(K\pi) * BR(K\pi)/BR(K\pi\pi\pi)$

precisely known ± 2%

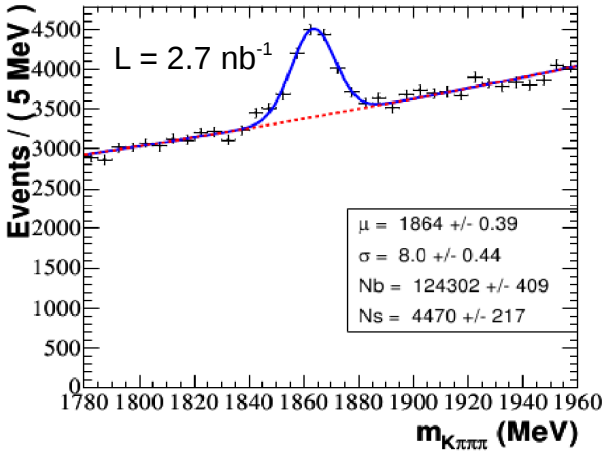
data | **Monte Carlo**

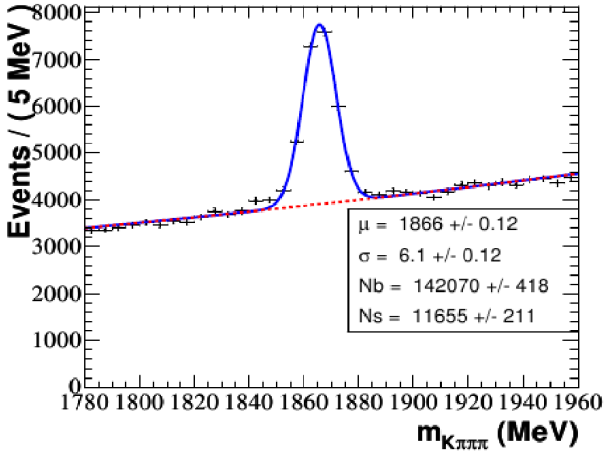
$D \to K\pi$





$D \to K\pi\pi\pi$





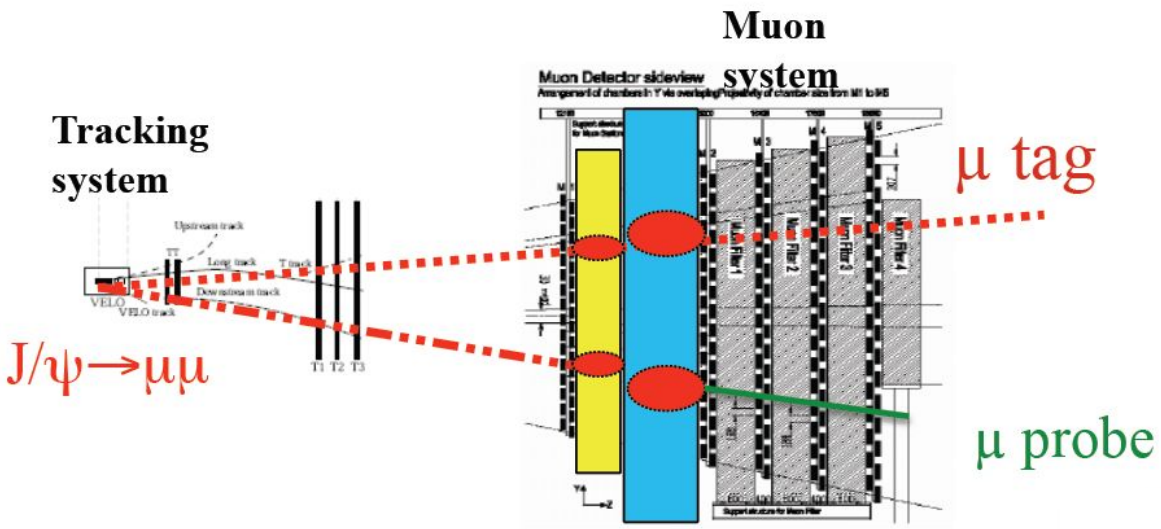
$\varepsilon(\text{data})/\varepsilon(\text{Monte Carlo}) = 1.00 \pm 0.03$

Particle Identification:

trigger, flavour tagging & B candidate selection

Muon ID Performance

MuonID efficiency can be estimated from data with J/ψ with the "tag and probe" method



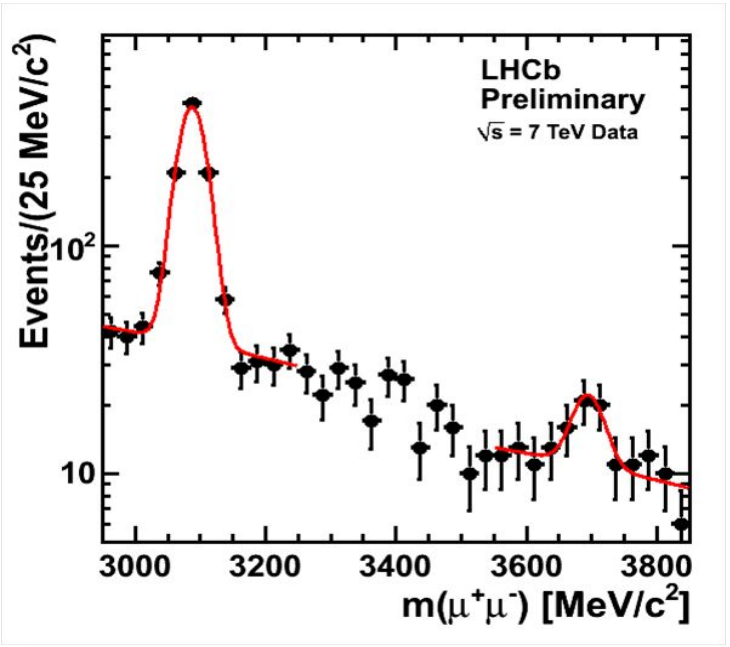
mis-ID tested using $K_s \to \pi\pi$, $\Lambda \to p\pi$ and $\Phi \to KK$

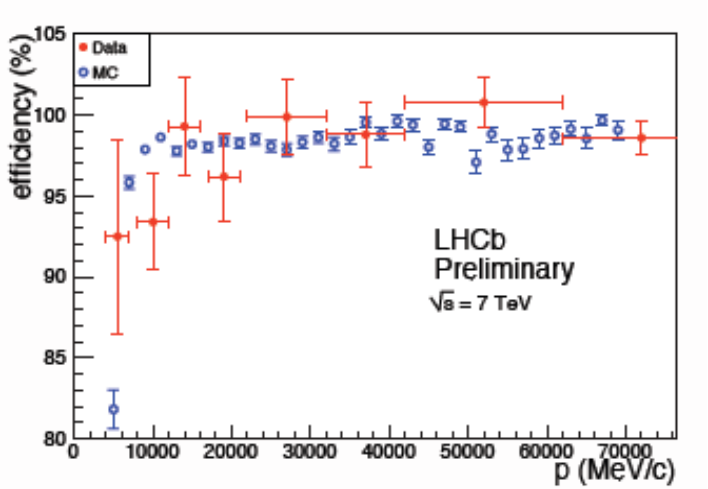
P(π→μ): 2.35 ± 0.04 (stat) %
P(p→μ): 3.1 ± 0.2 (stat) %
P(K→μ): 1.67 ± 0.06 (stat) %

(in good data/MC agreement)

→ **ready for J/ψ cross-section analysis**

L = 14 nb^{-1}

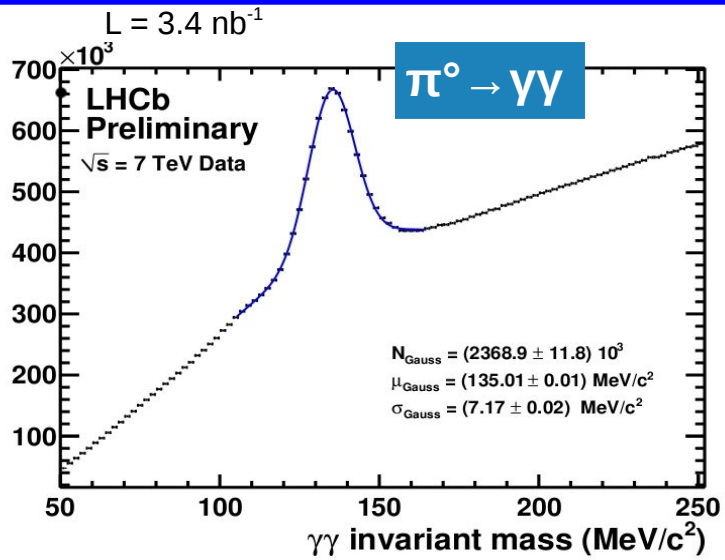


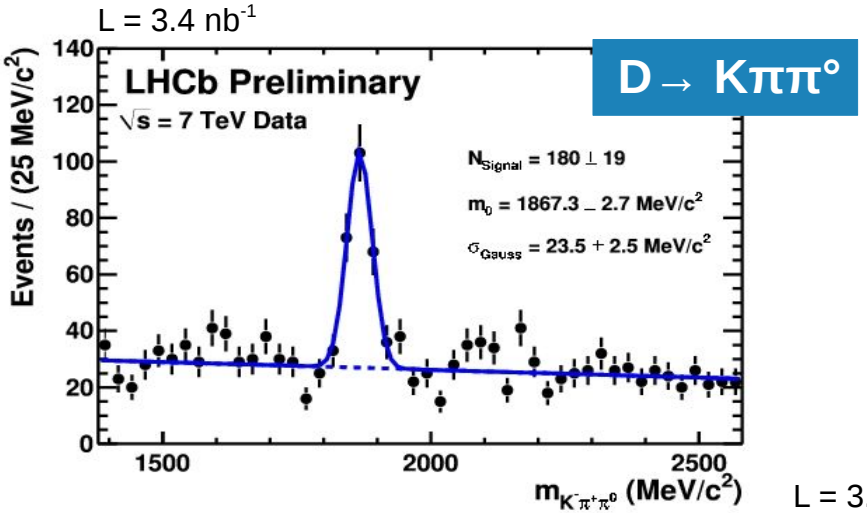


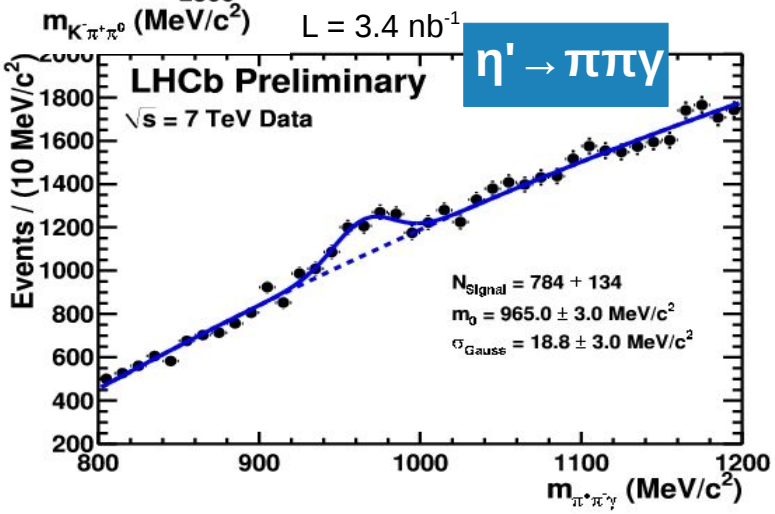
ε(μ) = 97.3 ± 1.2 (stat)%
very good agreement!

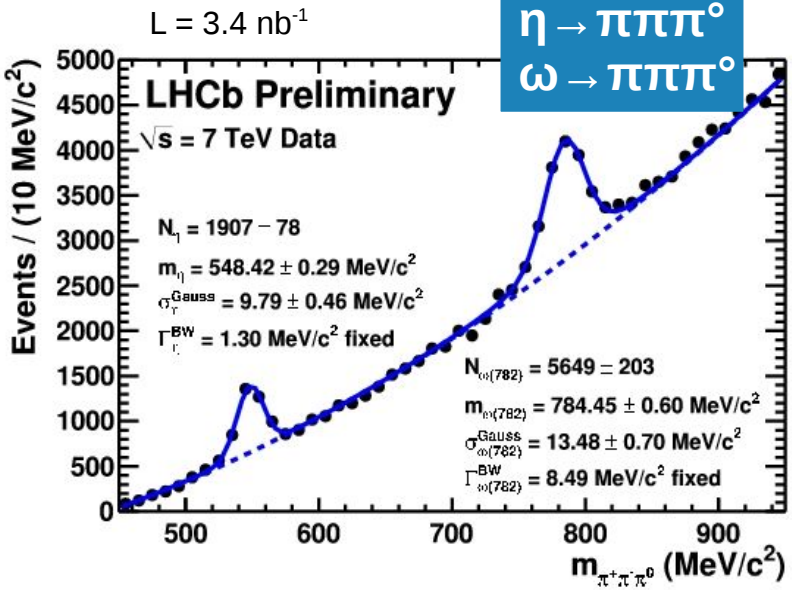
Reconstruction of Photons

- **achieved 2-2.5% inter calibration with π^0**
- many resonances observed
- mass resolution within expected range (sometimes even better than in MC)

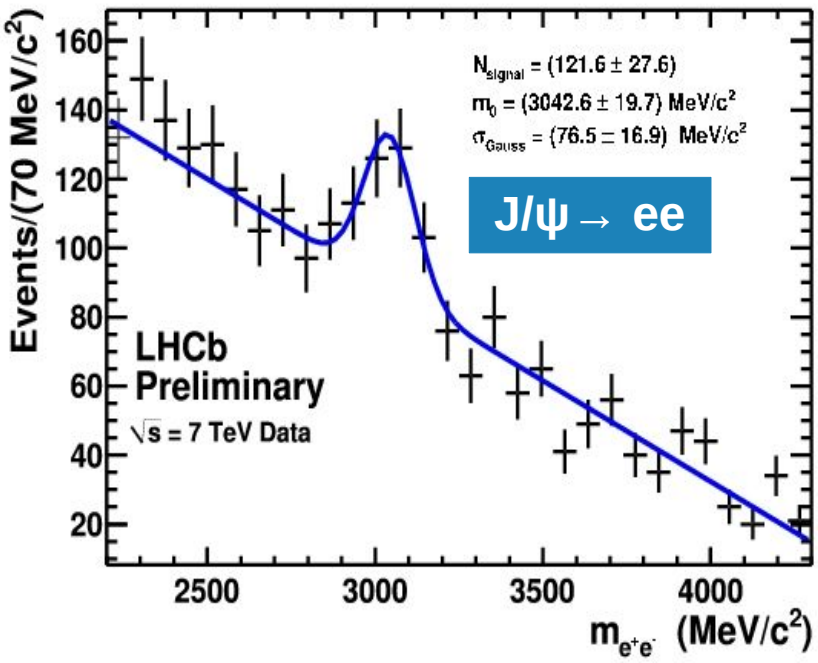




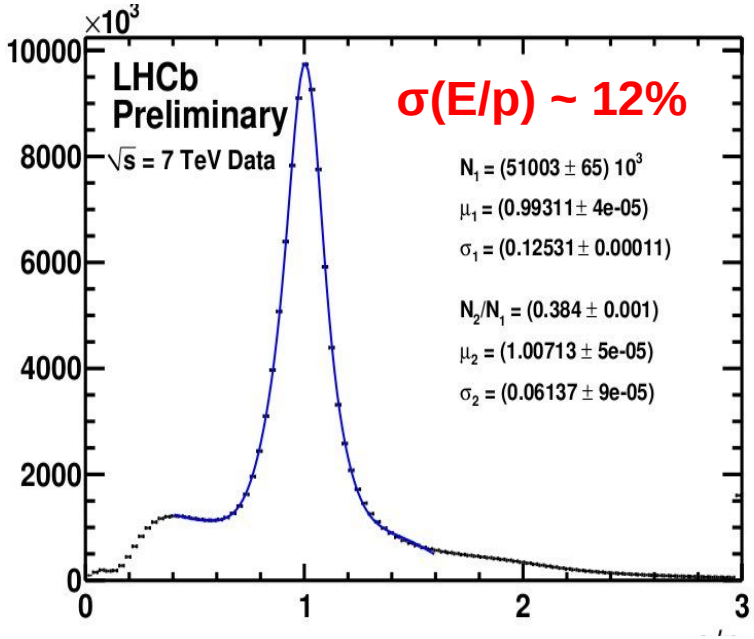




Electron Identification

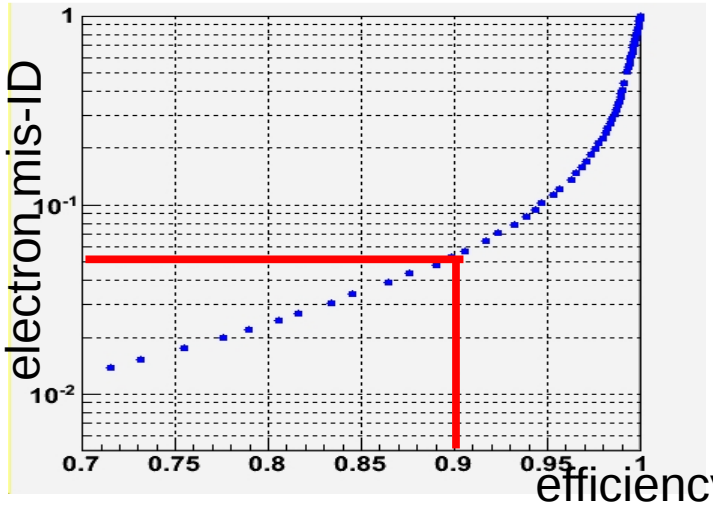


energy resolution



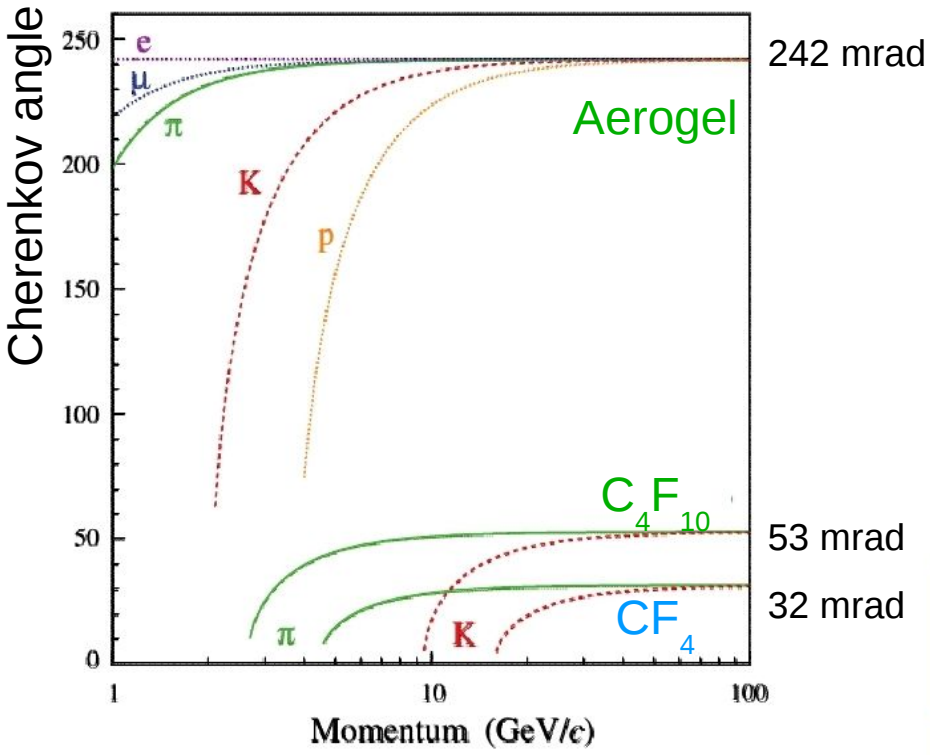
5 % mis-ID rate for 90 % efficiency

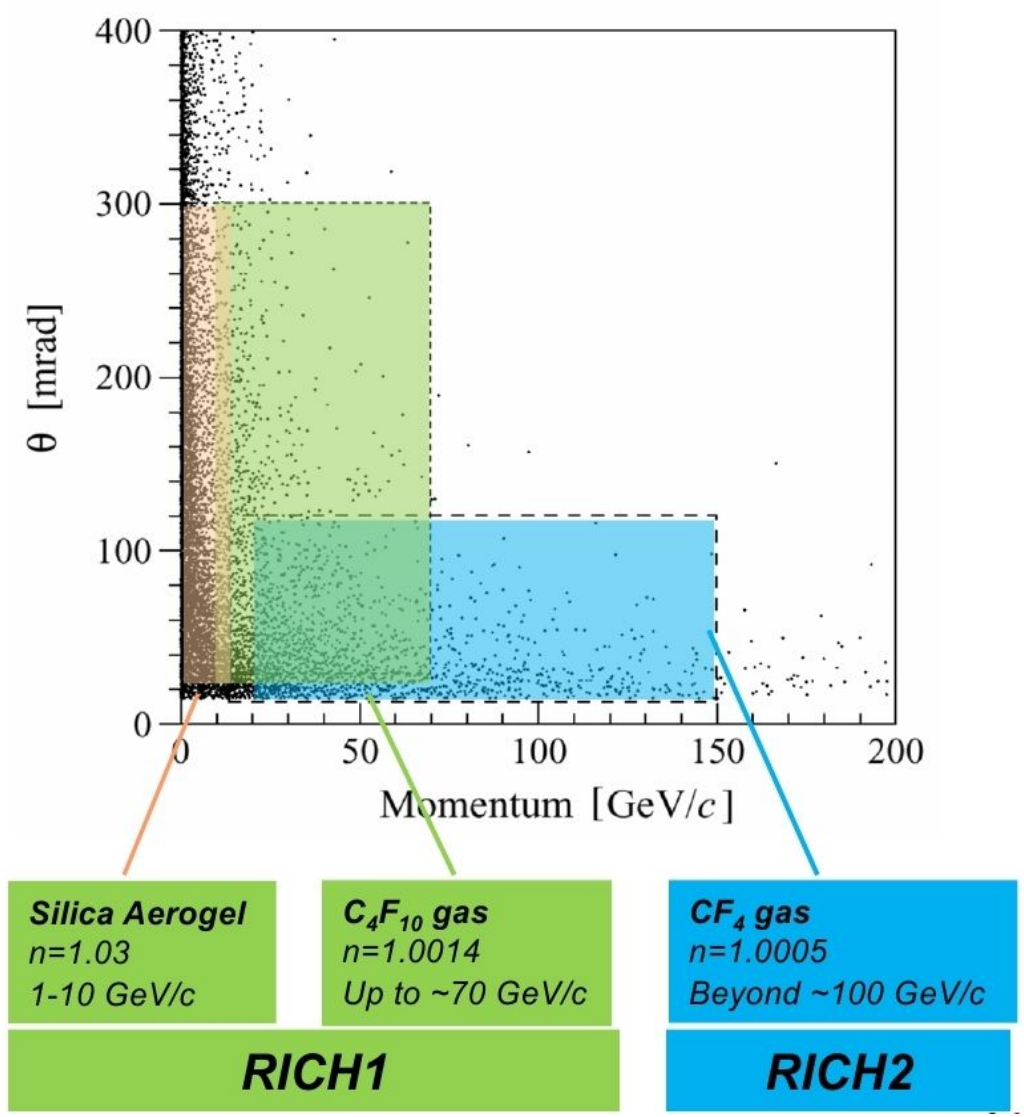
4.5 % for MC at same efficiency
very good agreement!



RICH Detectors

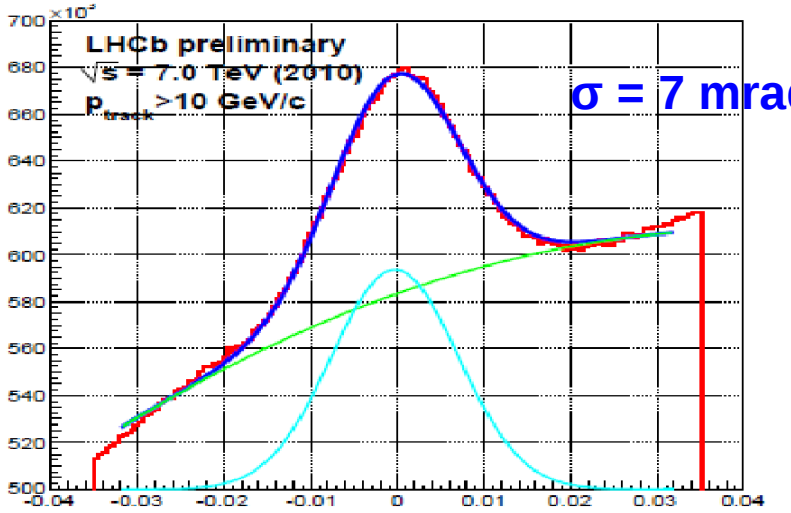
- *3 radiators*
- *1-100 GeV coverage*



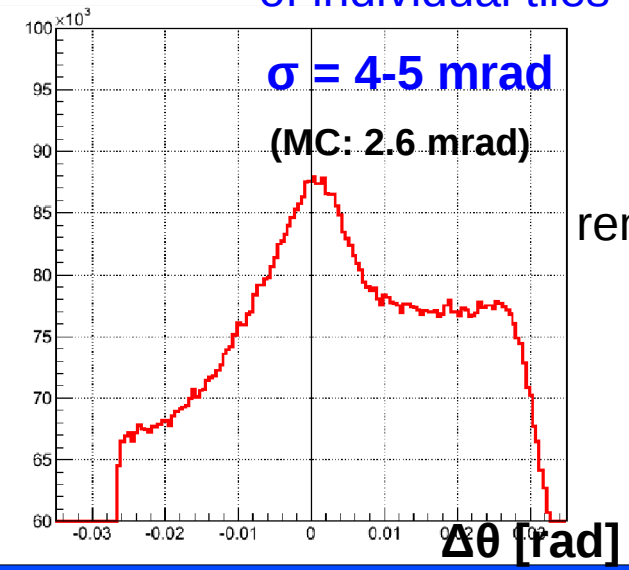


Single Photon Resolution

RICH 1: aerogel

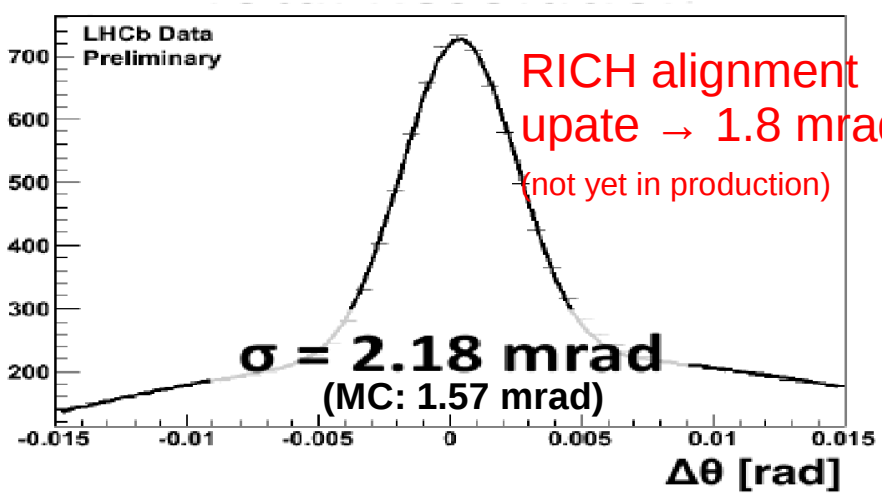


preliminary calibration of individual tiles

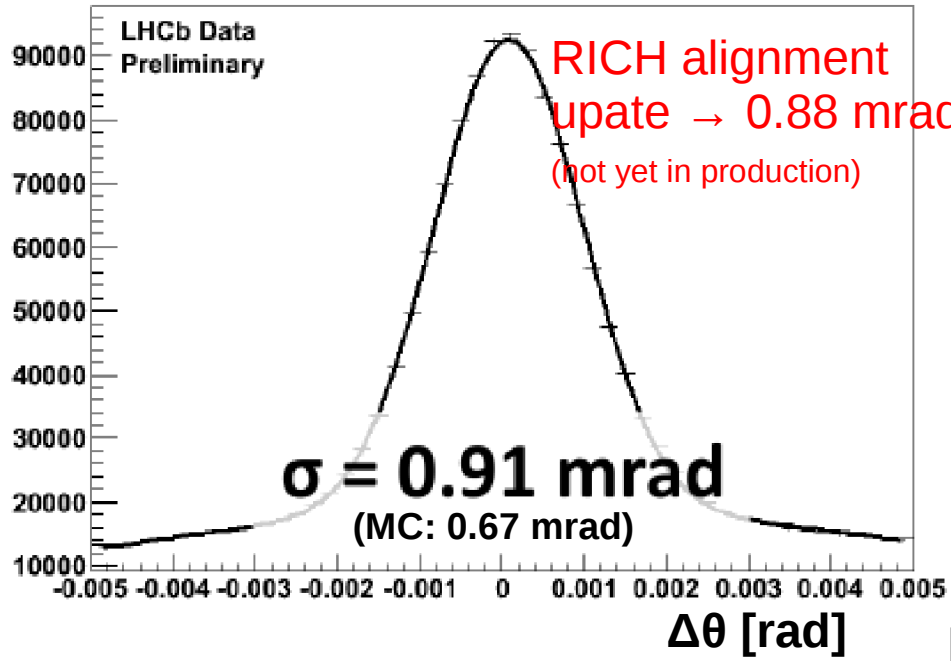


remaining difference due to C_4F_{10} contamination

RICH 1: C_4F_{10}



RICH 2: CF_4



Particle ID Performance

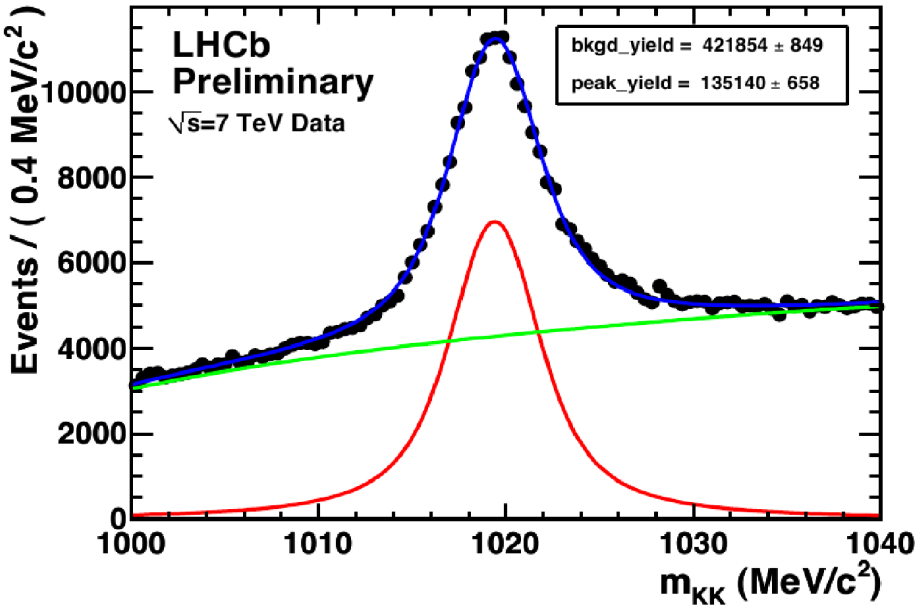
calibration sample:

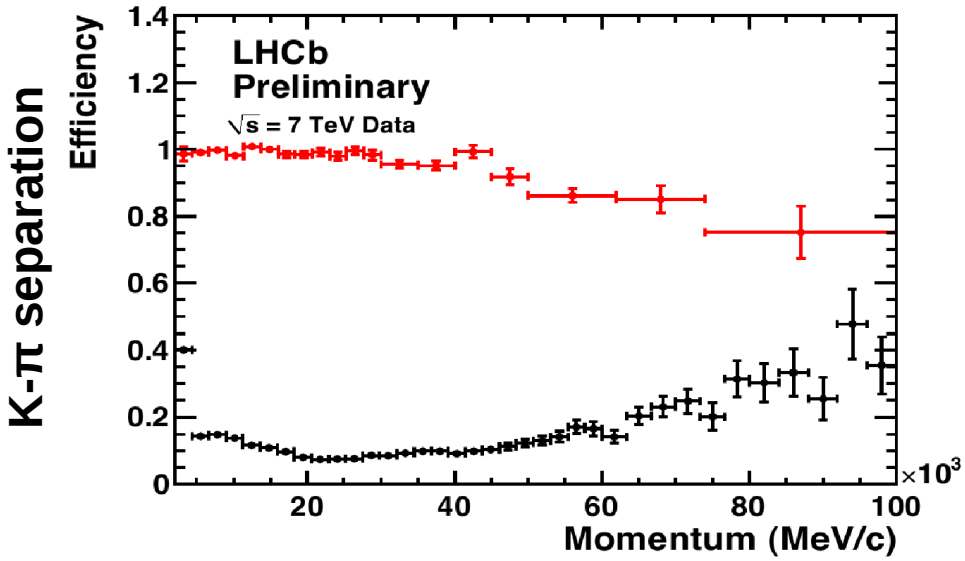
$\Lambda \rightarrow p\pi$

$K_s \rightarrow \pi\pi$

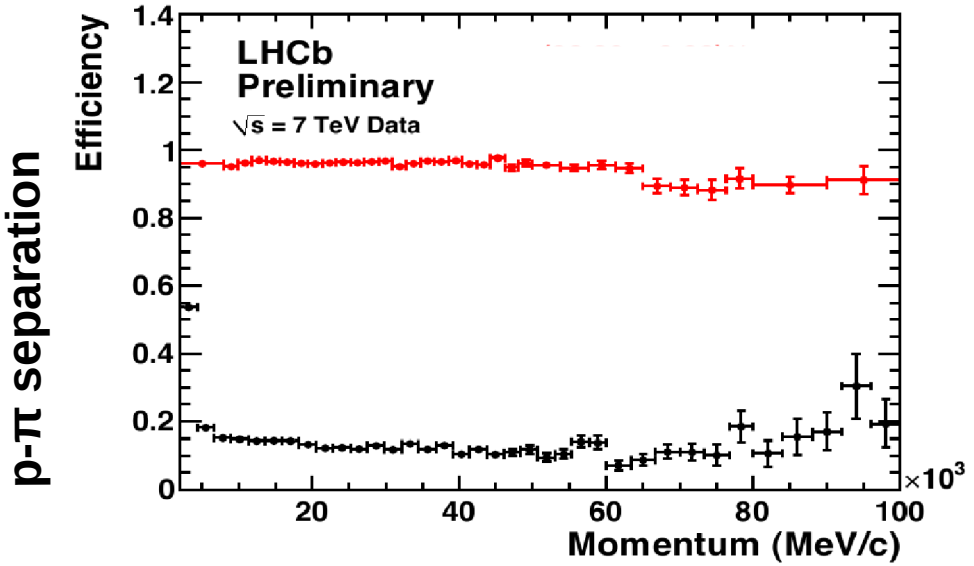
$\Phi \rightarrow KK$

(for one leg use Rich PID)





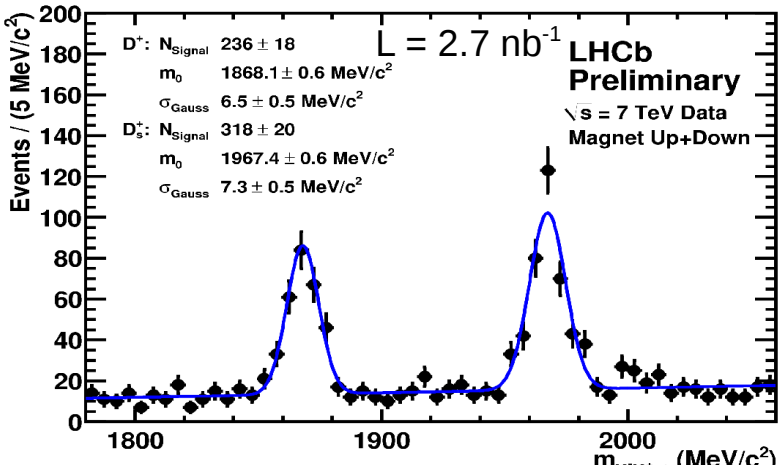
crucial for flavour tagging



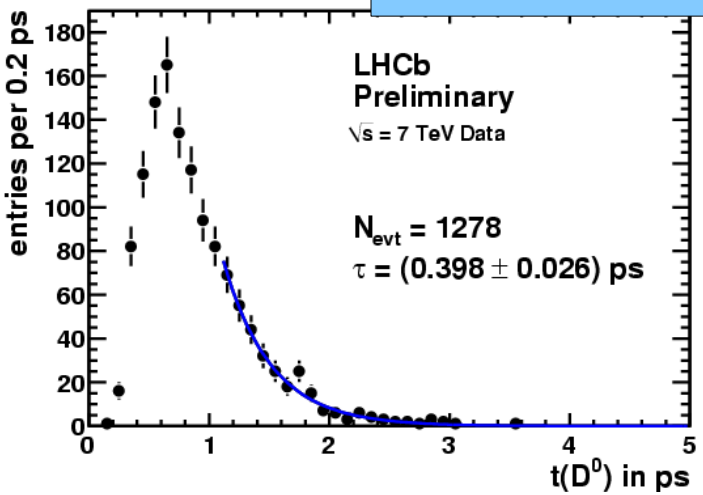
key ingredient for $\bar{p}/p$ ratio analysis for summer conferences

RICH Particle Zoo

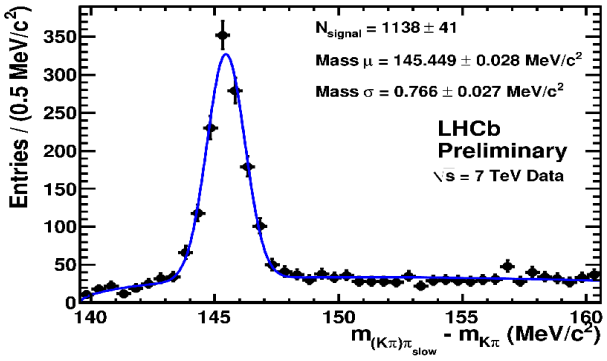
$D_s/D^+ \to KK\pi$

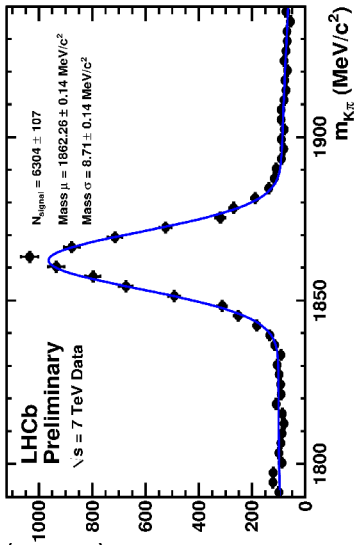


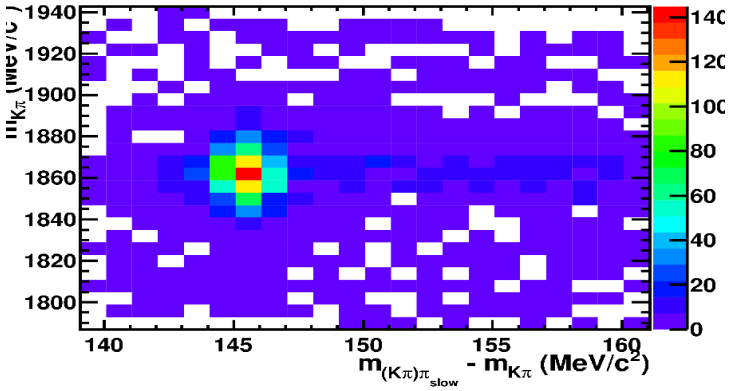
$D^0 \to (K\pi)$ lifetime

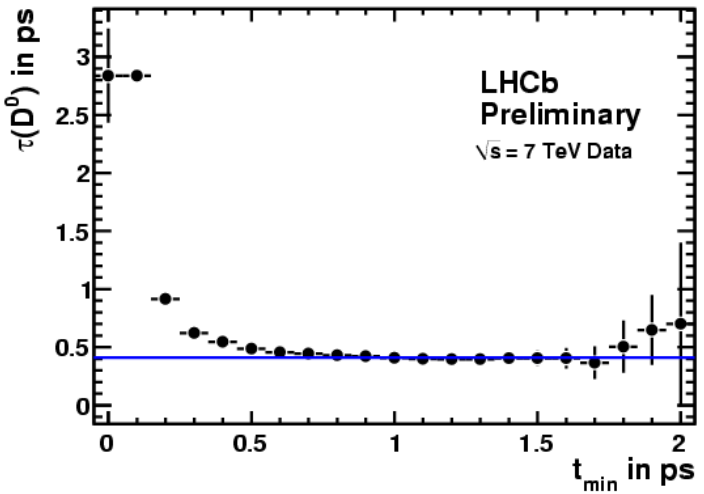


$D^* \to D^0(K\pi)\pi$









RICH very important for LHCb charm physics programme!

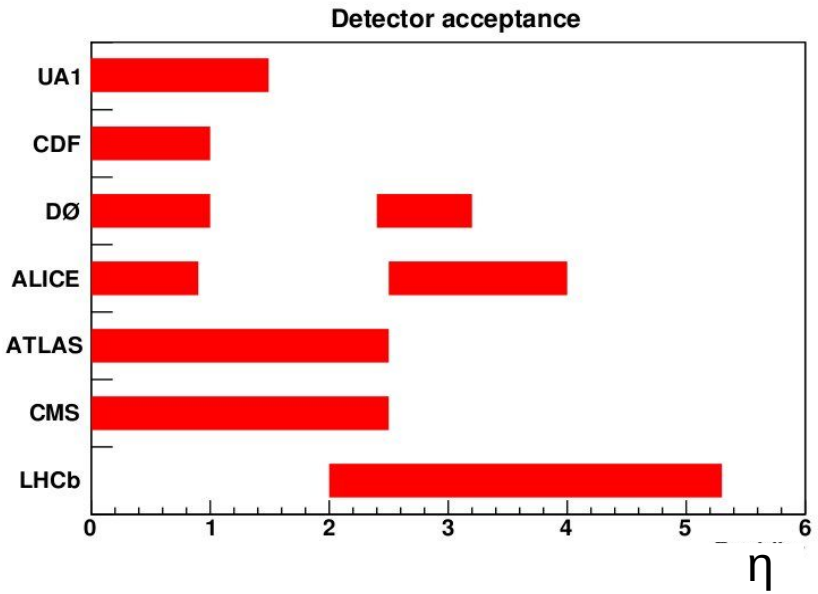
All Pieces Come Together ....

early physics results = cross section measurements & particle multiplicities/ratios

- K_s cross section (2009 data; $\sqrt{s}$ = 900 GeV)
  (first LHCb paper circulating in the collaboration)

2010 data (preliminary results ahead):

- J/ψ cross section (prompt & from b)
- $b\bar{b}$ cross section
- $D^+/D^0/D^*/D_s$ production cross section
- $\bar{p}/p$ ratio
- $\bar{\Lambda}/\Lambda$ ratio



exploit unique coverage of phase space

Common ingredients/systematics to all analysis:
luminosity, tracking efficiency, PID-misID/efficiency

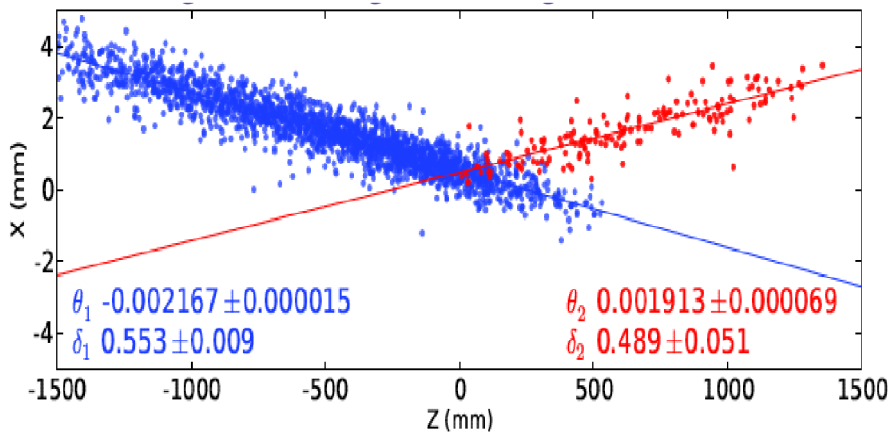
Luminosity Measurement

$$L = f \sum_{i=1}^{N} \frac{n_{1i} n_{2i}}{4\pi \sigma_{xi} \sigma_{yi}}$$

N	: number of colliding bunches
σ_{xi}, σ_{yi}	: transverse bunch size
n_{1i}, n_{2i}	: number of protons per bunch
f	: frequency

(some modifications needed for crossing angle, offset, ...)

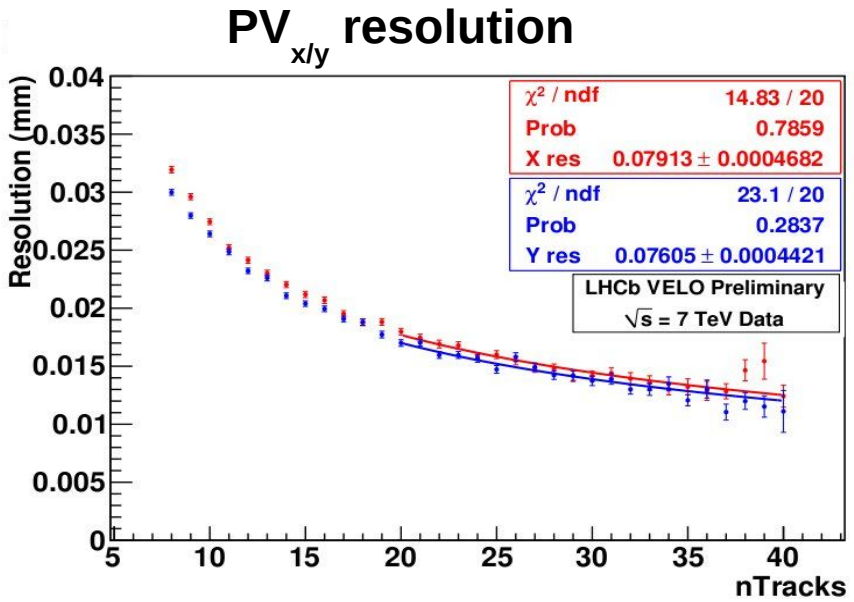
measurement of beam parameters with vertices in beam-gas events



2009 measurement dominated by systematics:

L = 6.8 ± 1.0 μb^{-1}

Currents	Widths	Positions	Angles
12%	5%	3%	1%



aim for 5% uncertainties till end of 2010

(parallel ongoing: van der Meer scan, currently ~10%)

K_s Cross Section @ $\sqrt{s}$ = 900 GeV

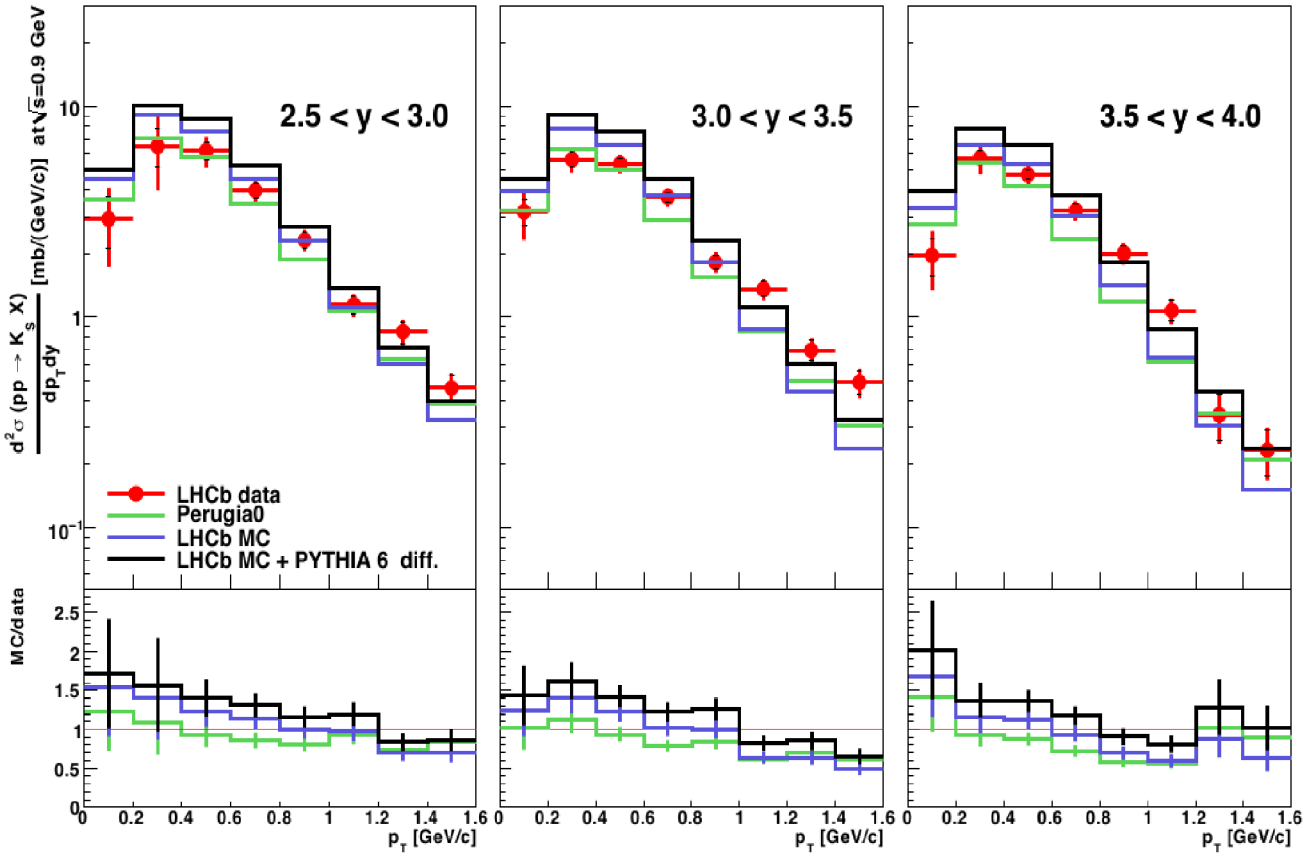
- **LHCb 1st physics paper**
  at the same time **new luminosity method applied** and extensive usage/**evaluation of all components of the tracking system**

- **two independent analysis performed** (using different tracking detectors)

- **covered range:**
  $0 < p_T < 1600$ MeV
  $2.5 < y < 4.0$
  $\sqrt{900}$ GeV ($6.8 \pm 1.0\ \mu b^{-1}$)

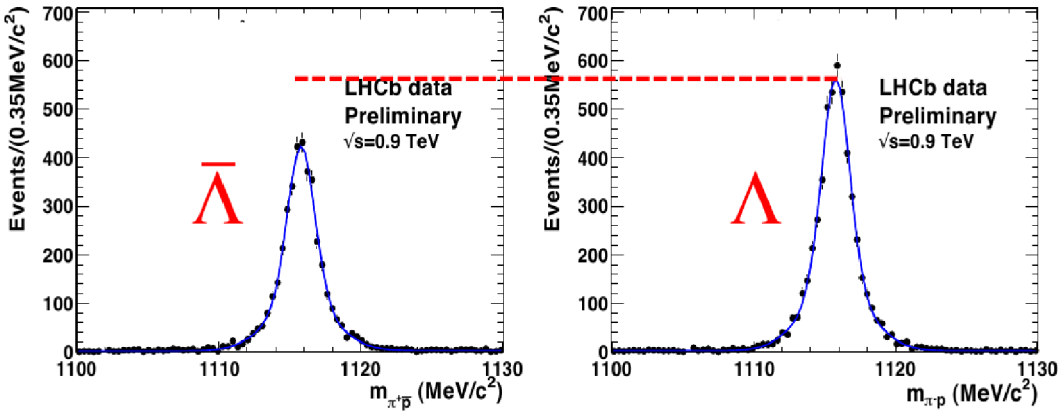
- **main systematic uncertainties:**
  - 10% statistical
  - 13% luminosity
  - 10% tracking uncertainties

- **data tends to higher p_T values**

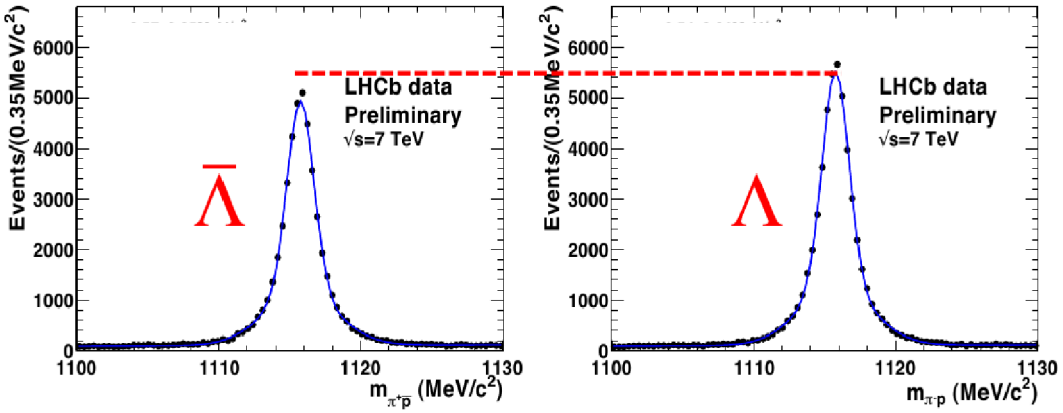


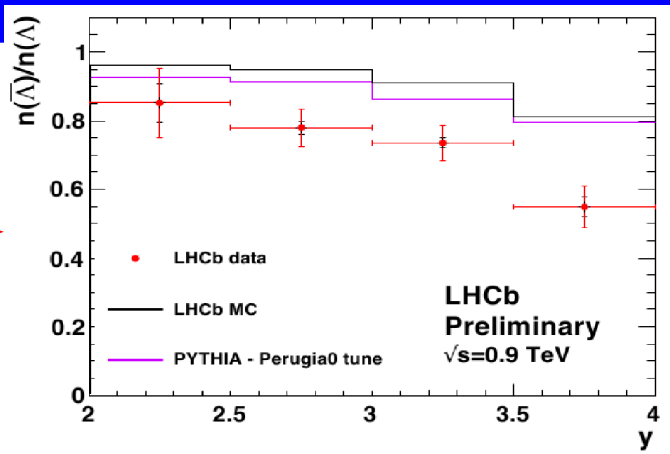
Strange Hadron Ratios

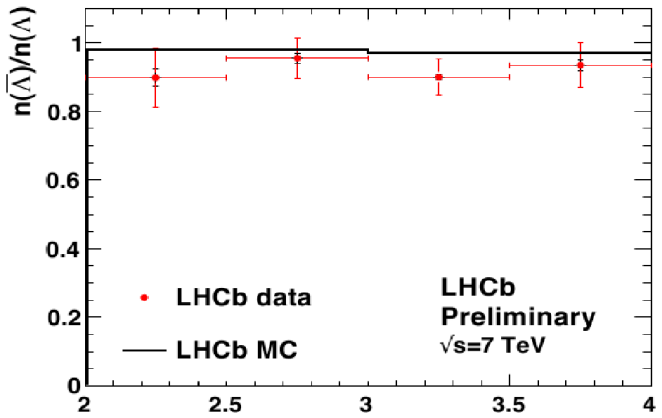
900 GeV

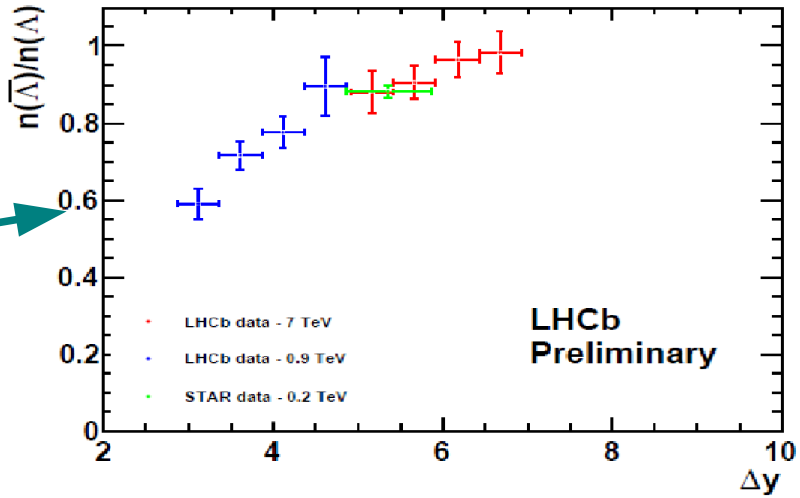


7 TeV









- **asymmetry in 900 GeV data larger than predicted by reference PYTHIA sample**
- **900 GeV and 7 TeV sample in good agreement**
- valuable input to baryon number transport
- Λ/K_s , $\bar{p}/p$ to come soon

J/ψ Cross Section

measure:

$d\sigma/dp_T$(all J/ψ)

σ(prompt J/ψ)

σ(J/ψ from b)

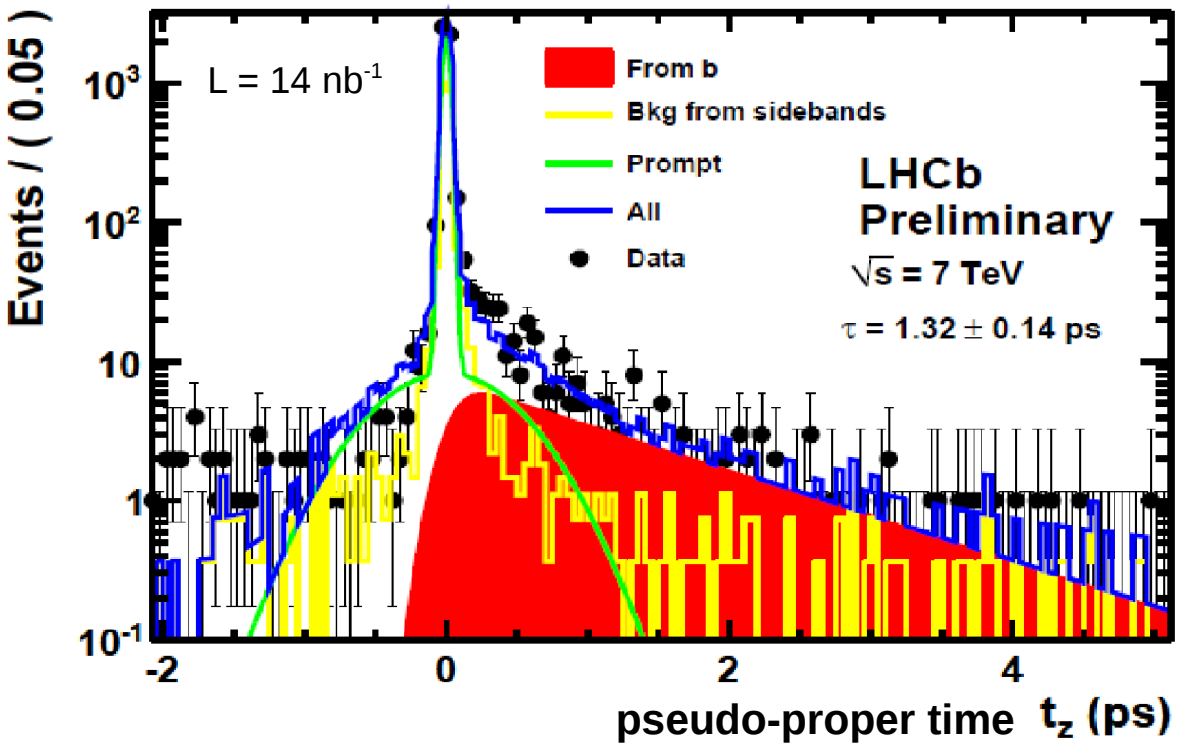
polarization

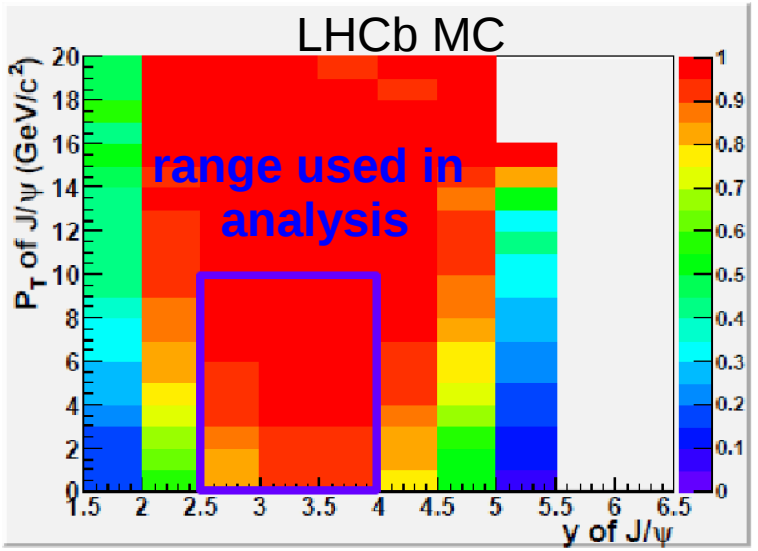
- detector acceptance generates artifical polarization

- analyse cross section with different polarization hypothesis (causes 4-25% difference)

next step:

- fit for transversal and longitudinal polarization using templates from MC





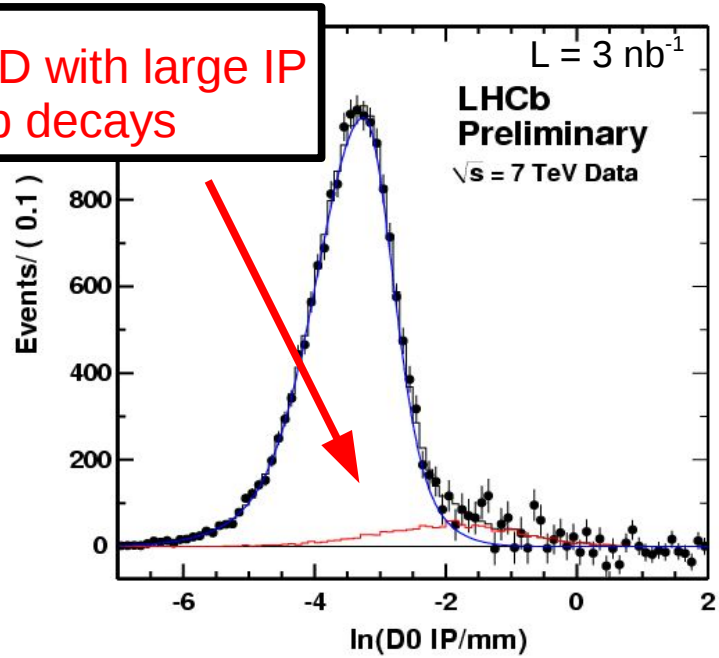
$b\bar{b}$ Cross Section

- **clear contribution from D from b visible in standard D→ Kπ selection**

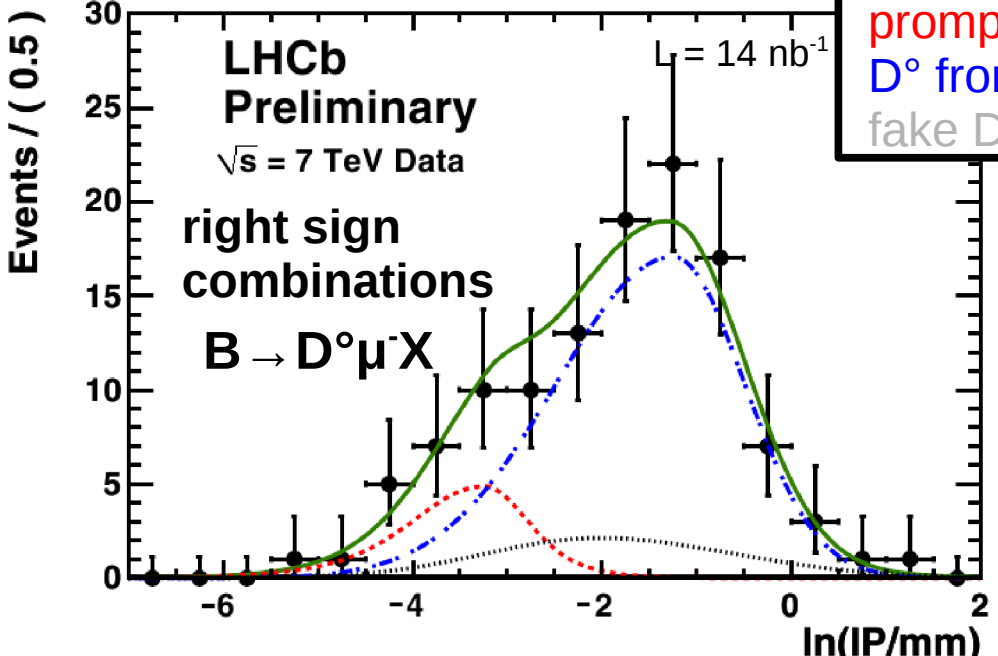
- combine D with μ
  use well known
  BR(b→ D°μX) = 6.82 ± 0.35 % (PDG)

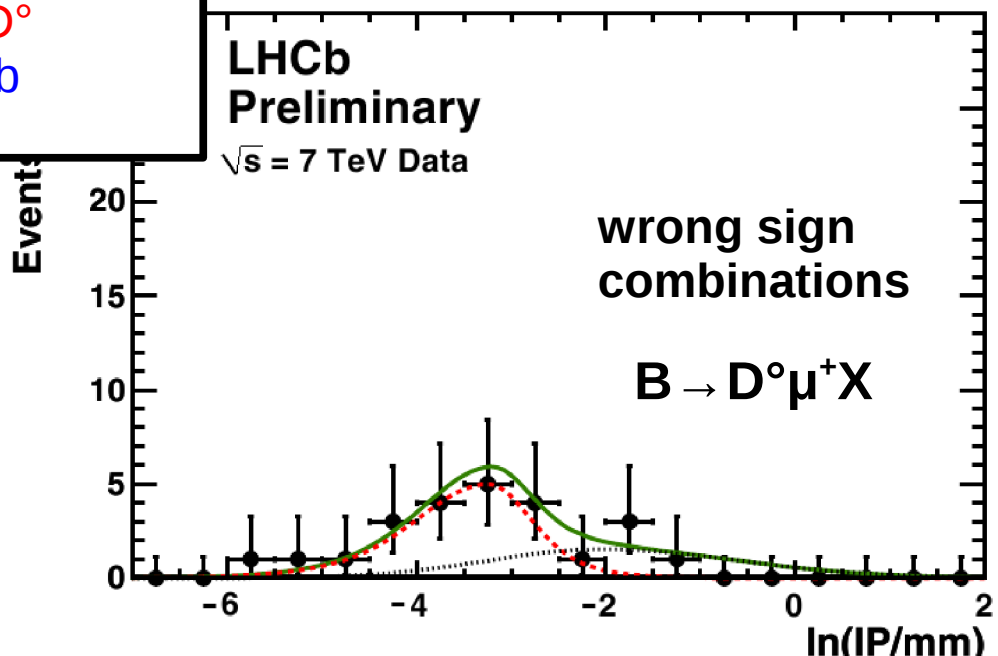
- use **ln(IP(D°)) to separate prompt D and D from b**
  smear PV and SV resolution to agree between data and MC
  hardly any impact on D from b template

~1300 D with large IP from b decays



all D° candidates
prompt D°
D° from b
fake D°

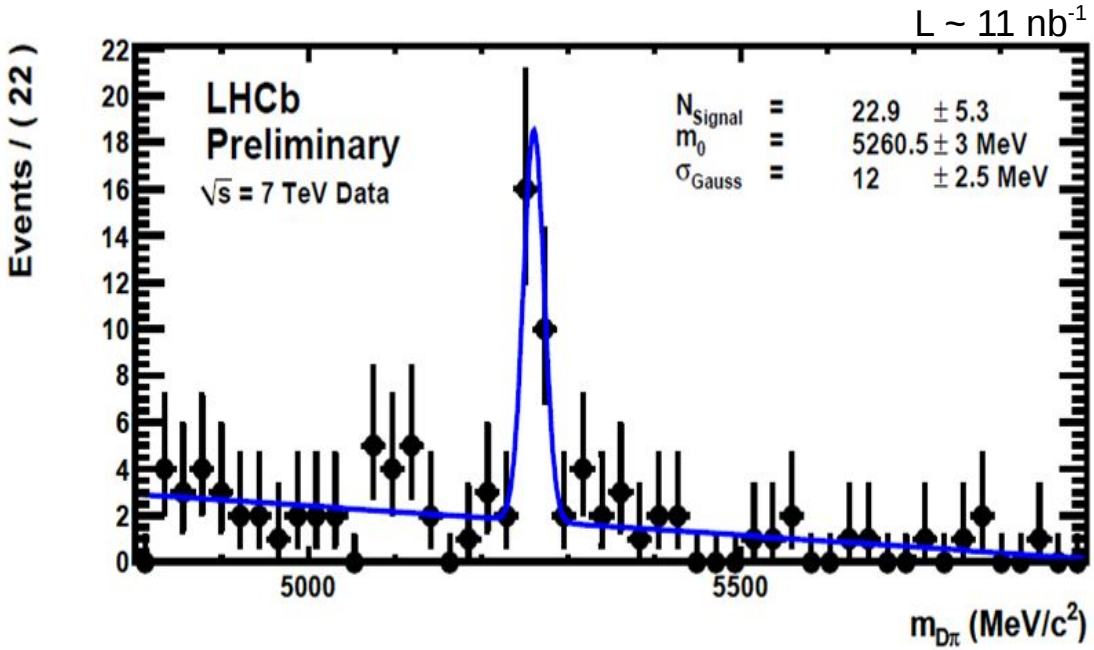




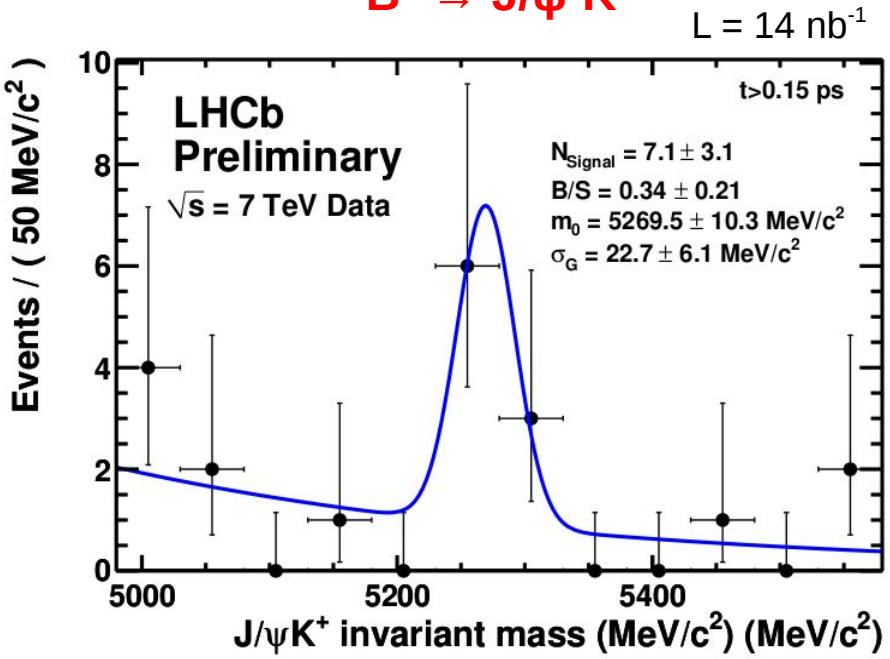
Outlook in Even More Beautiful Future ...

First fully reconstructed B signals

$B^0 \to D^0\pi$ + $B^+ \to D^+\pi$



$B^+ \to J/\psi K$



many more to come very soon ...

Conclusion

LHCb in very good shape!

- detector performance and understanding steadily improving

- several physics analysis are on their way to ICHEP:
- minimum bias physics
- b, open charm, J/ψ cross sections

- waiting for many more B data to start core physics programme

- task for the summer:
"Which running conditions are best for our short and longterm physics goals?"