Minimum bias physics results at LHCb

W.M.Bonivento

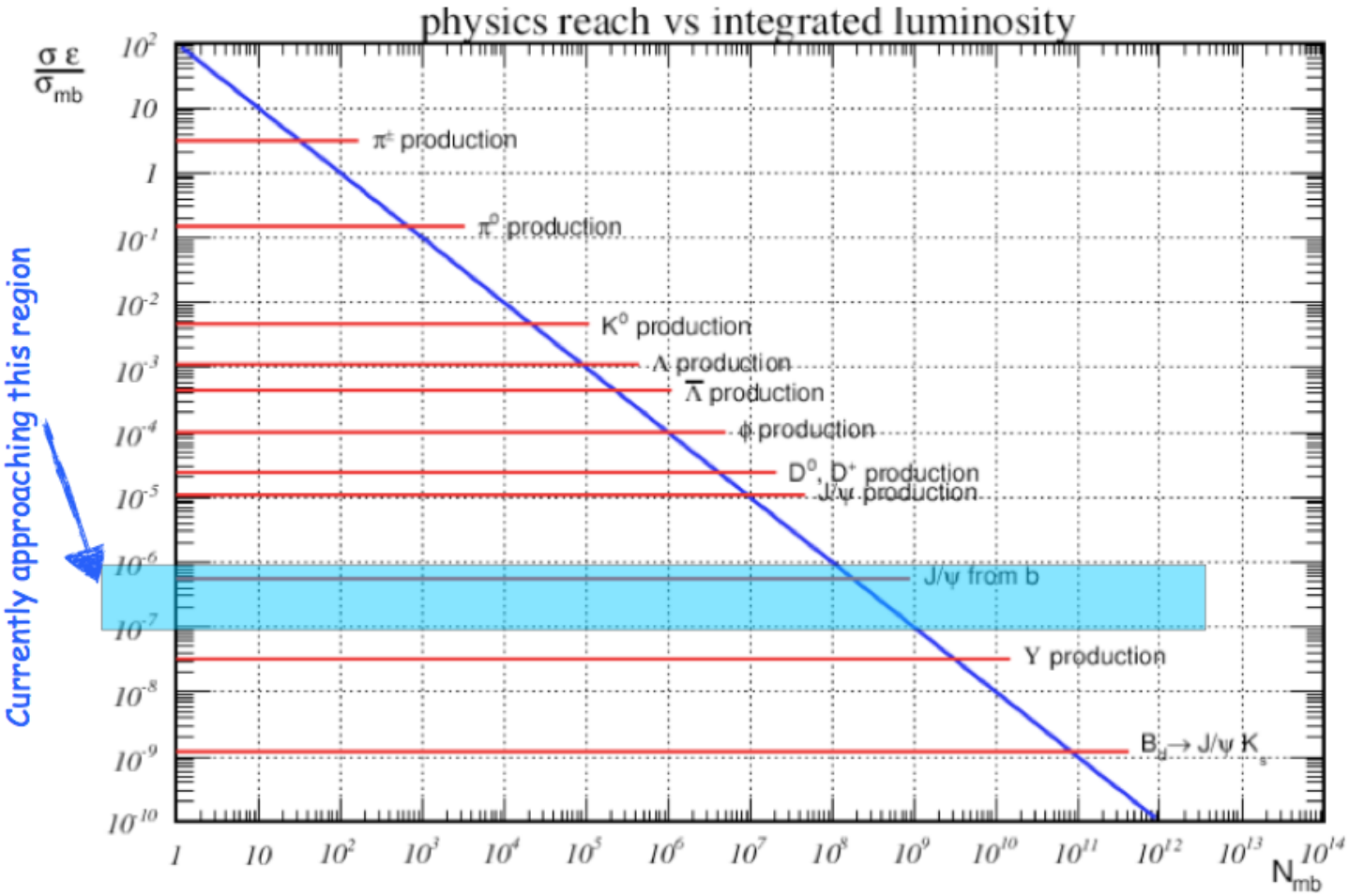
INFN – Sezione di Cagliari - Italy

On behalf of the LHCb Collaboration

Outline

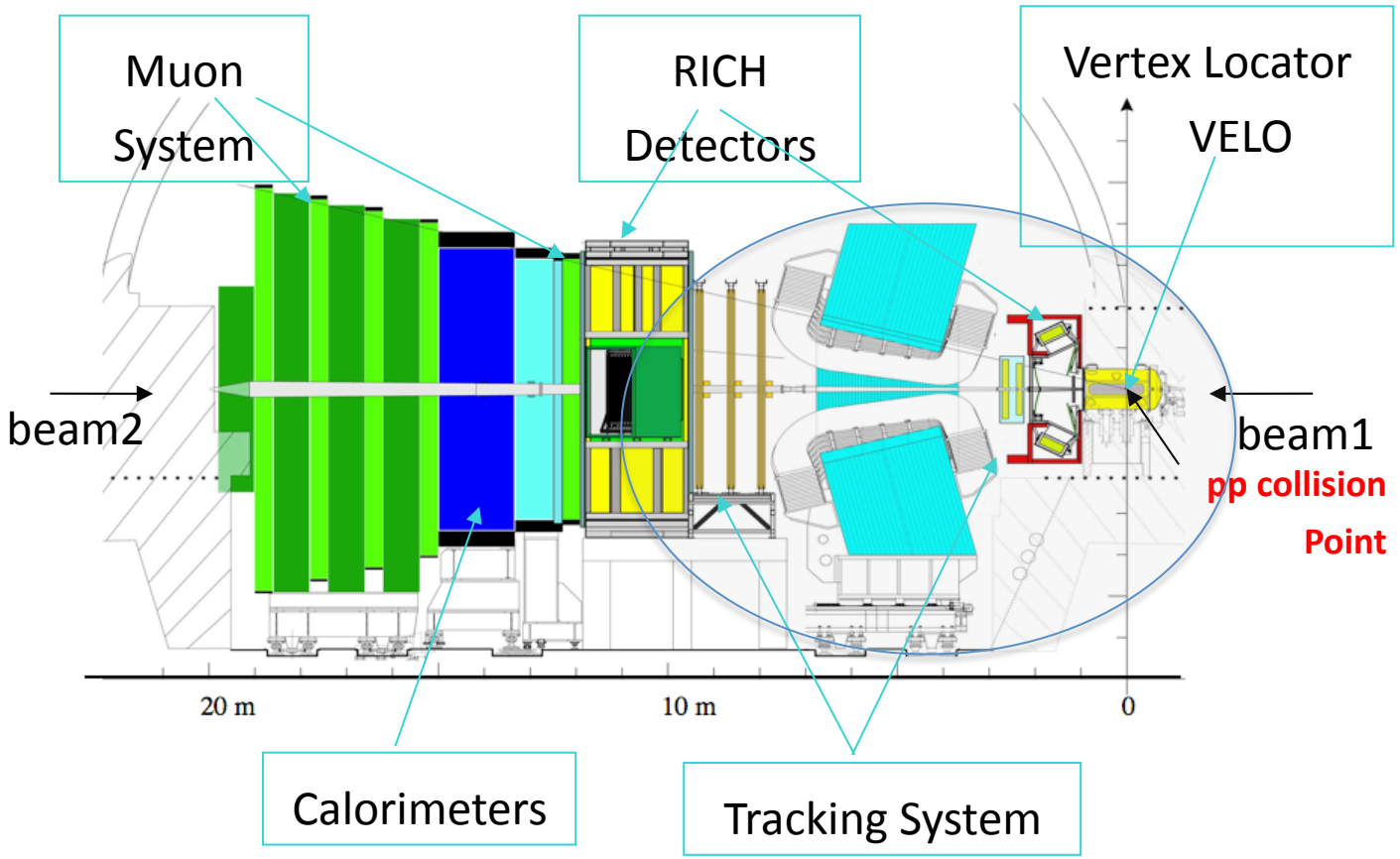
- Some “re-discovery” plots of resonances
- Prompt K_S^0 production cross-section in 2009 data @$\sqrt{s}$=0.9TeV
  - $\int\mathcal{L}=6.8\mu b^{-1}$
  - very advanced, close to finalize for publication
- Prompt antiΛ/Λ production ratio in 2010 data:
  - $\sqrt{s}$=0.9 TeV
    - $\int\mathcal{L}\approx 0.3nb^{-1}$
  - $\sqrt{s}$=7 TeV
    - $\int\mathcal{L}\lesssim 1nb^{-1}$
  - preliminary results

Setting the scale



the # of recorded minimum bias events needed to observe 100 events of the process X

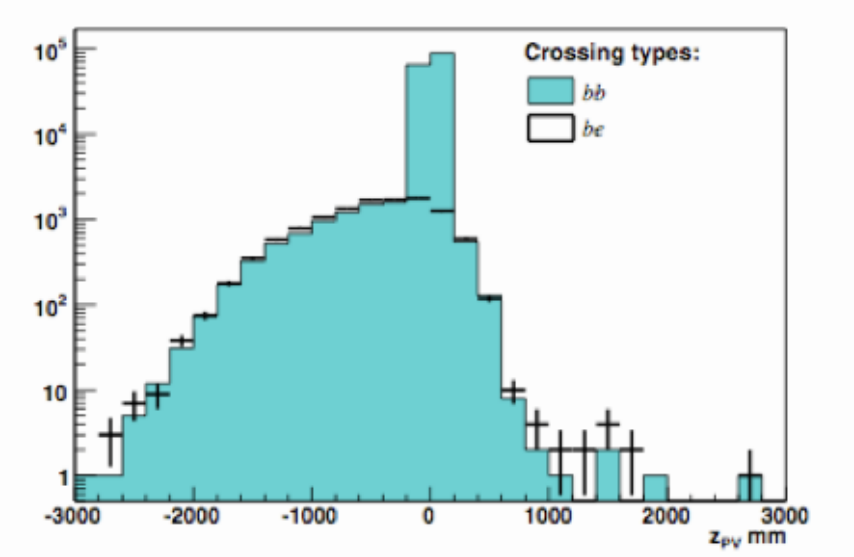
The LHCb detector



- pseudo-rapidity coverage 1.9-4.9
- possibility to reverse field polarity to check for detector asymmetries
- so far we have $\int\mathcal{L} \approx 14 nb^{-1}$ on tape

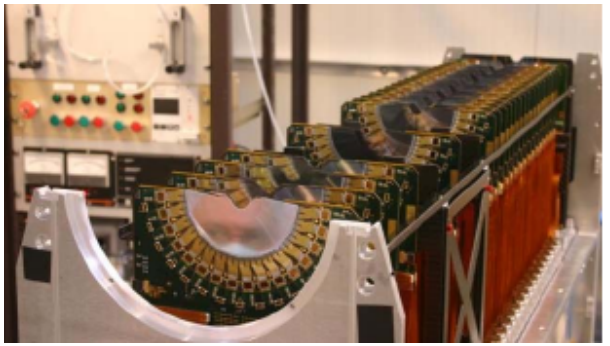
LHCb detector and trigger

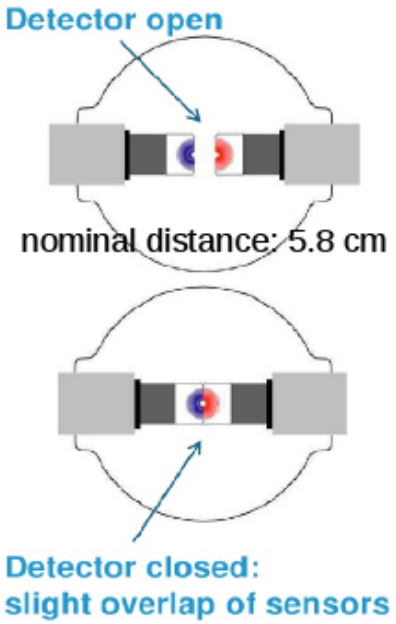
- Only first level hardware trigger used for this analysis
- trigger used for the analyses discussed in this talk:
  - minimum bias trigger based on CALO
- Beam-gas interactions were a substantial background in 2009 ➔reduced by vertex region cuts (to ≈1%) and statistically subtracted



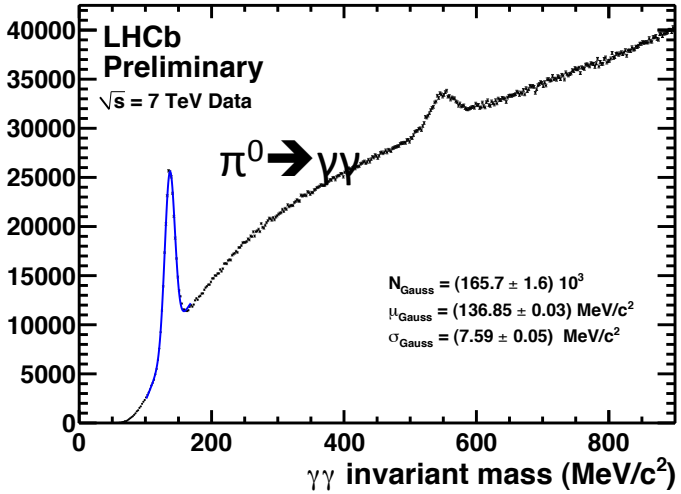
VELO position

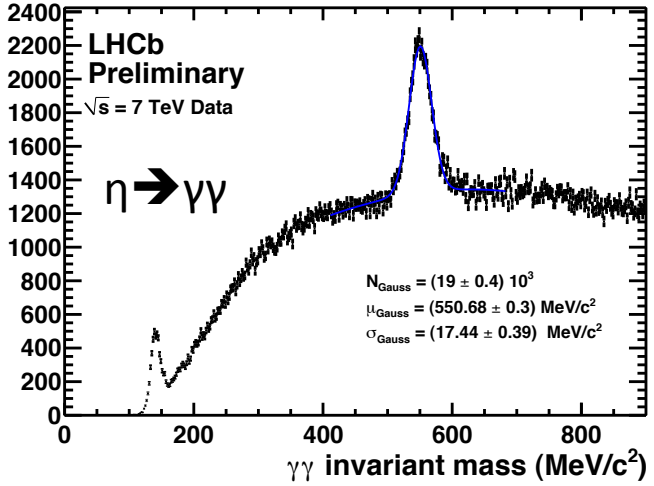
- Our vertex detector could not be closed at 0.9 TeV due to internal beam crossing angle (due to our magnet)
  - In 2009 was kept at 15mm from nominal position
  - In 2010 it was kept at 10mm
- For the 7 TeV runs the VELO was closed



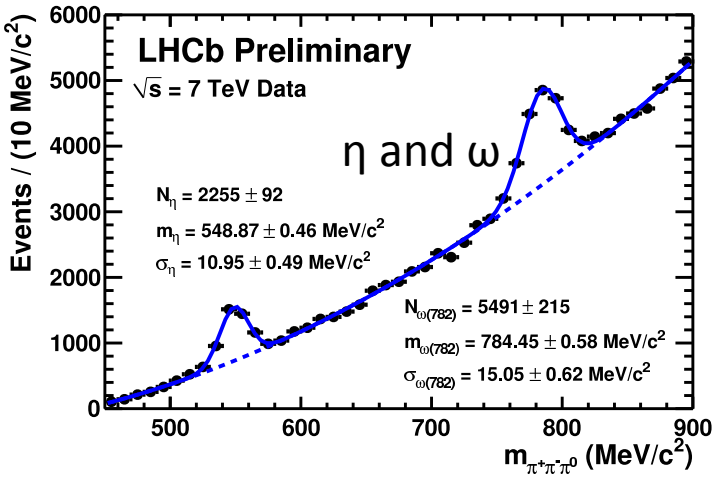


Non strange mesons

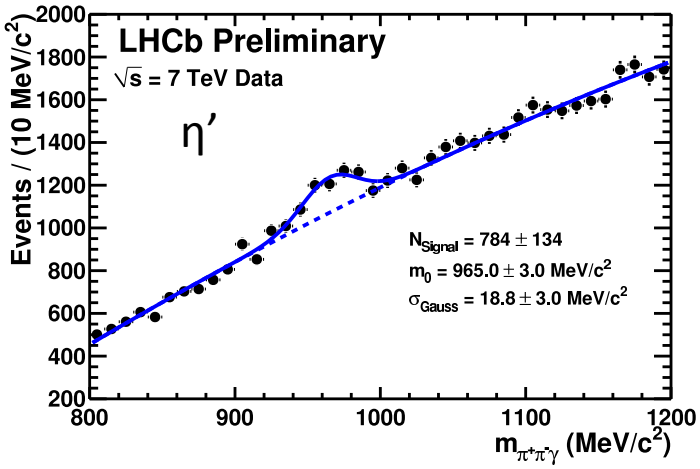




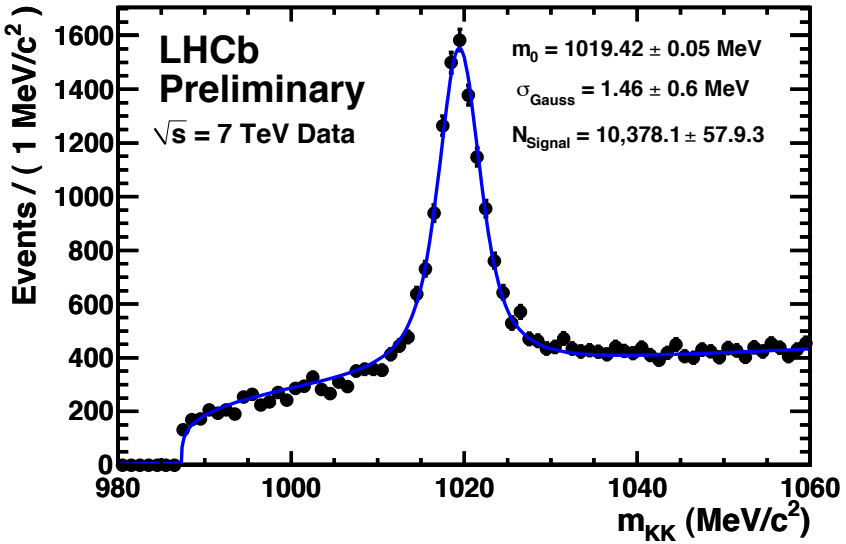
mild $p_T(\gamma)$ cuts



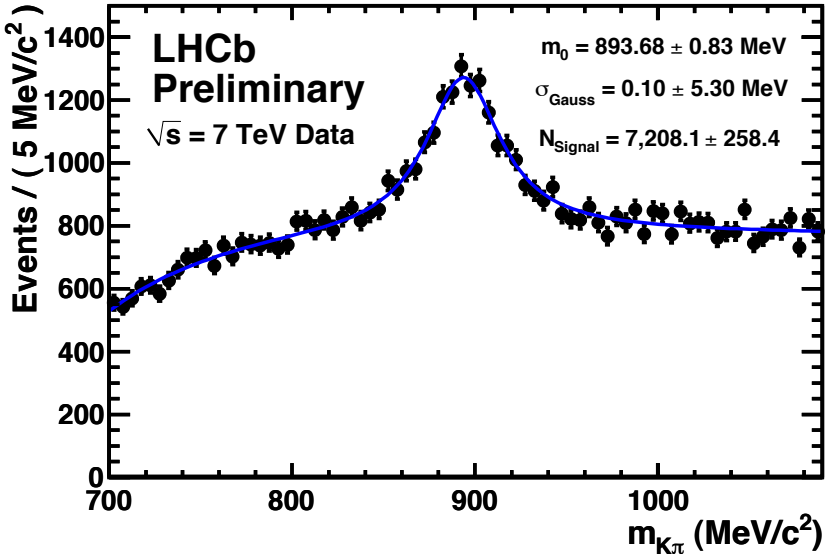
hard $p_T(\gamma)$ cuts



Strange mesons

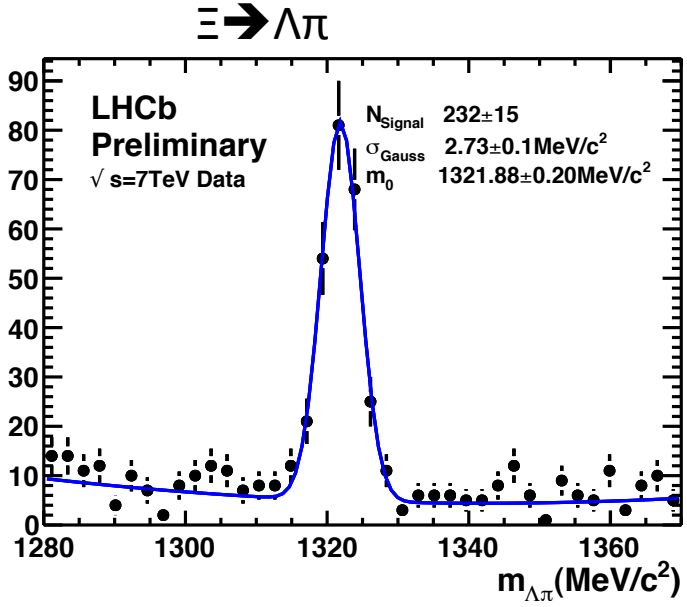


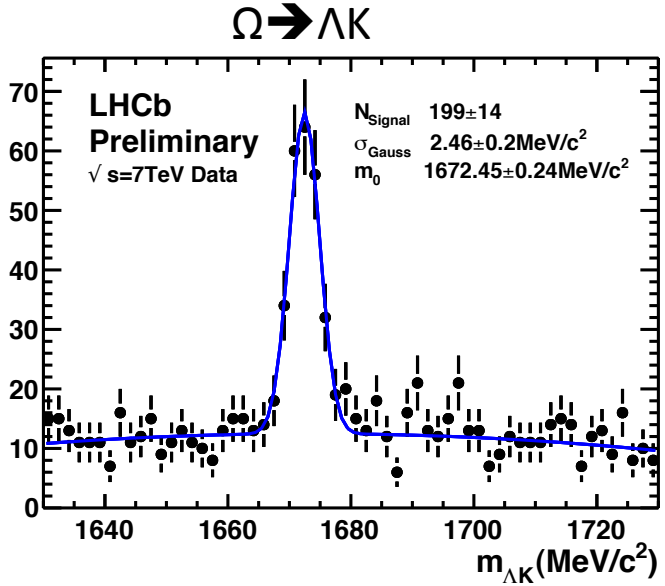
Φ➔KK



K*➔Kπ

Strange hyperons





Physics motivation of K_S^0 analysis

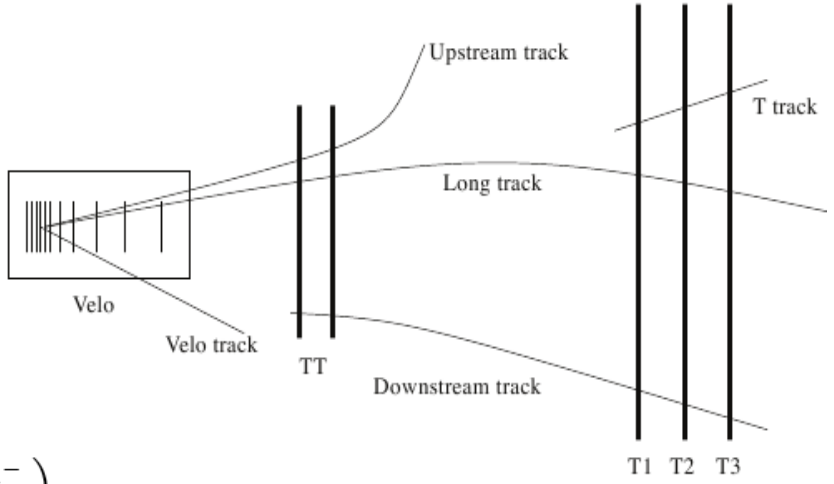
- Strangeness production very good to test fragmentation models since valence quarks are not strange
- Highest CM energy so far 1.96 TeV (but for ppbar) at Tevatron and 200 GeV at RHIC
- Models tuned for central rapidity and p_T>0.4-0.5 GeV/c
- LHCb covers the forward rapidity and can provide a measurement down to p_T=0

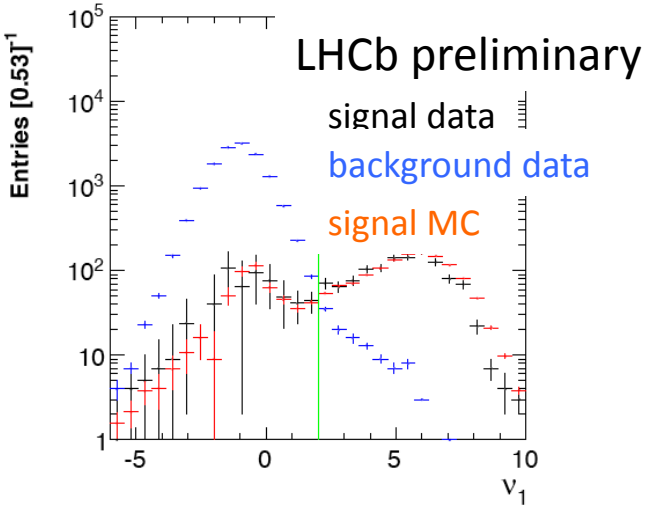
Event selection

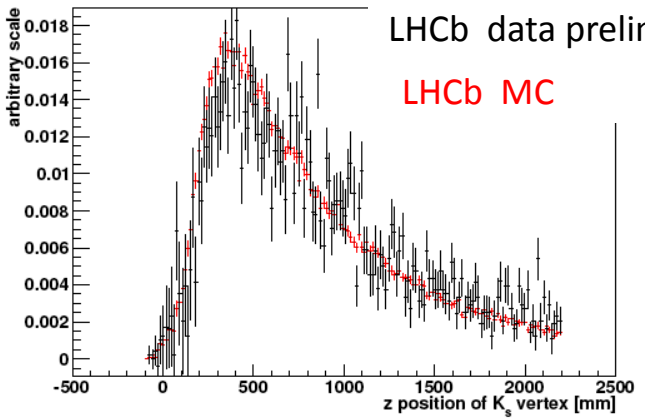
We have performed two independent analyses

1) with LONG TRACKS

- Make long tracks with VELO hits if possible
- low statistics due to VELO open but good background rejection
- Separation from combinatorial background based on $\nu_1 = \ln\left(\frac{\mathrm{IP_{d+}} \cdot \mathrm{IP_{d-}}}{\mathrm{IP_{V^0}} \cdot 1\mathrm{mm}}\right)$



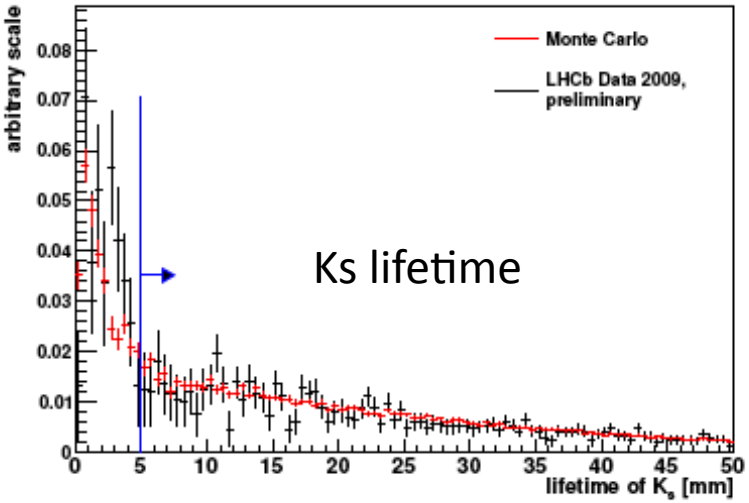




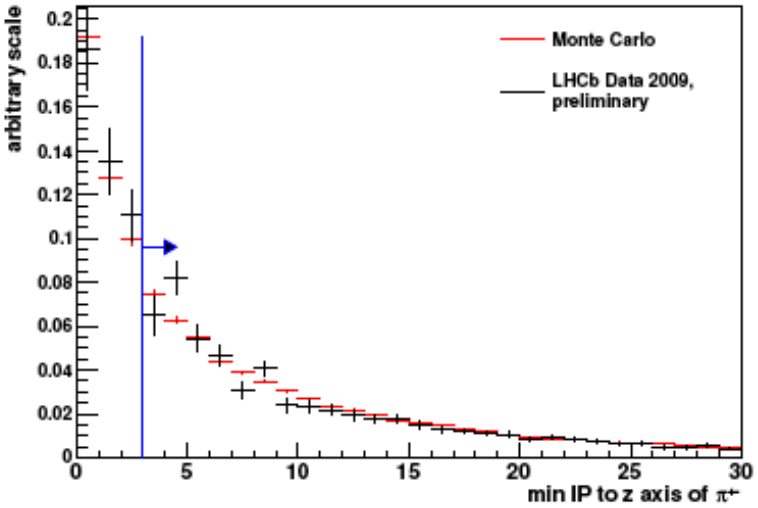
reconstructed z position of the decay vertex

Event selection

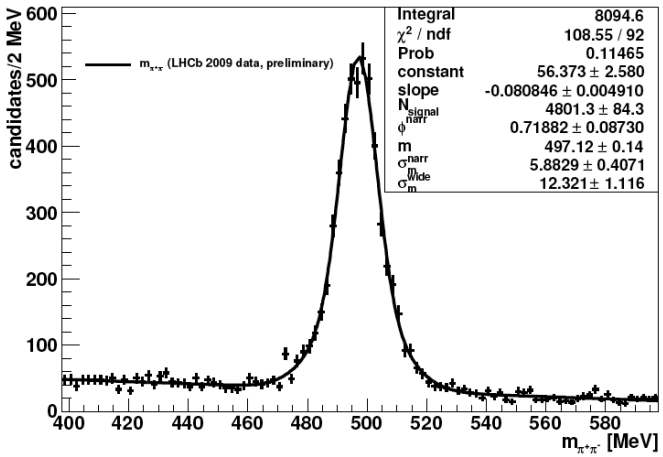
- 2) with DOWNSTREAM tracks
  - no VELO hits used in the reconstruction
  - large statistics
  - Ks required to point to the z axis



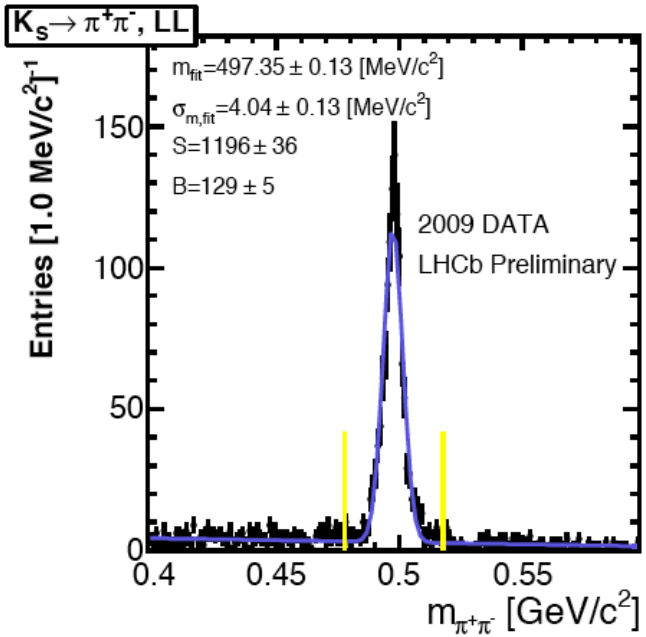
impact parameter cut of the daughters



Event selection (2)



invariant mass with downstream tracks



invariant mass with long tracks

signal extraction used both sideband subtraction and double Gaussian fit

	# events in beam-beam interactions
K^0_S long	1196
K^0_S downstream	4864

Efficiency corrections

Strategy: determine efficiencies in p_T,y bins from Monte Carlo

Use data to cross check in certain areas of phase space

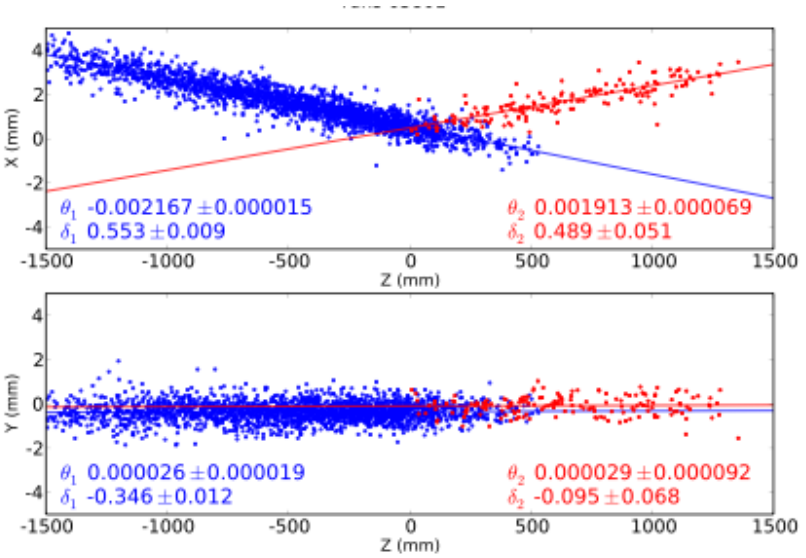
- Selection efficiency: determine ratio data/MC after a loose pre-selection
  - systematic uncertainty ≈ 4%
- Tracking efficiency:
  - MC corrected for hit finding inefficiency due to residual misalignment in data (10% effect)
  - Track efficiency measured on data splitting the track in segments: about 5% difference found in data w.r.t. MC, p_T dependent
  - systematic uncertainty ≈10% (dominant contribution after luminosity)
- Trigger efficiencies between 96.5% and 99%
  - systematic difference data-MC <1%

Luminosity measurement

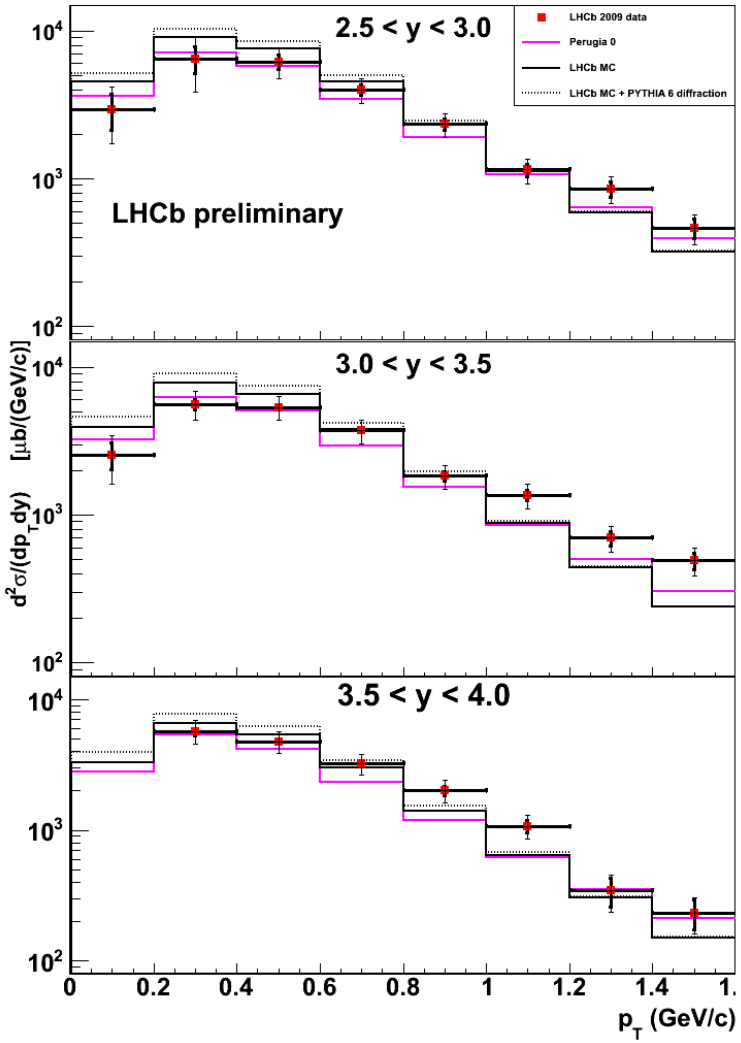
- Used a direct method based on beam currents from BeamCurrentTransformers bunch-by-bunch and reconstruction of beam transverse size (in b1-gas and b2-gas events) by the VELO

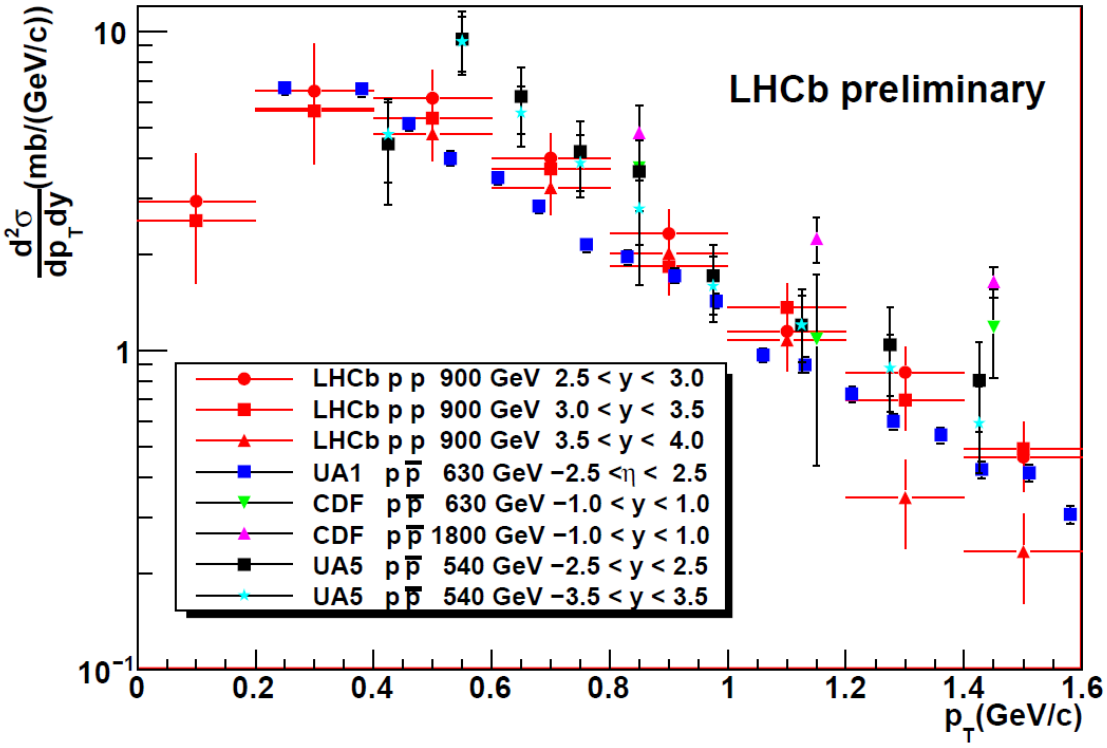
$$\mathcal{L} = f \sum_{i}^{N} \frac{n_{1i} n_{2i}}{4\pi \sigma^{x}{}_{i} \sigma^{y}{}_{i}}$$

- Need to take into account the crossing angle (2mrad) in xz plane due to LHCb B field
- Systematic on beam sizes evaluated comparing b1-gas, b2-gas and b1-b2 events
- Total systematic error ≈15% dominated by BCT current measurements



prompt $\sigma(K^0_S)$ results



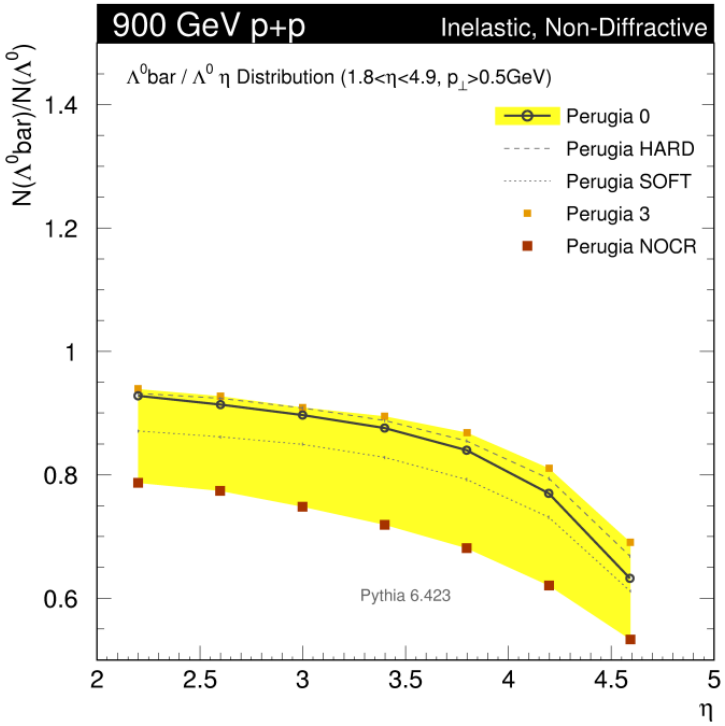


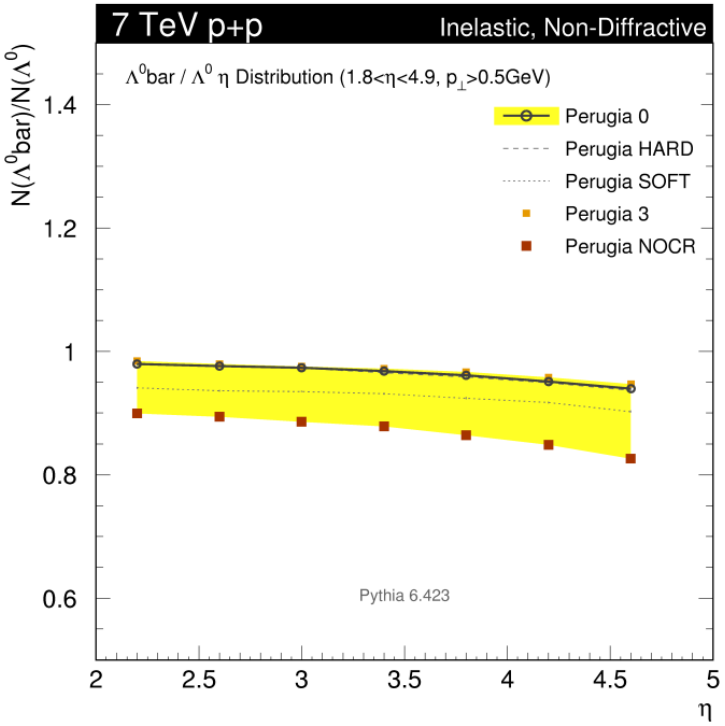
Comparison with other experiments
➔extended measurement range

Comparison to different PYTHIA tunings->data tend to be slightly harder

Physics motivation of Λbar/Λ analysis

- Study of baryon number transport
- Models tuned to lower energies; they diverge at LHC energies





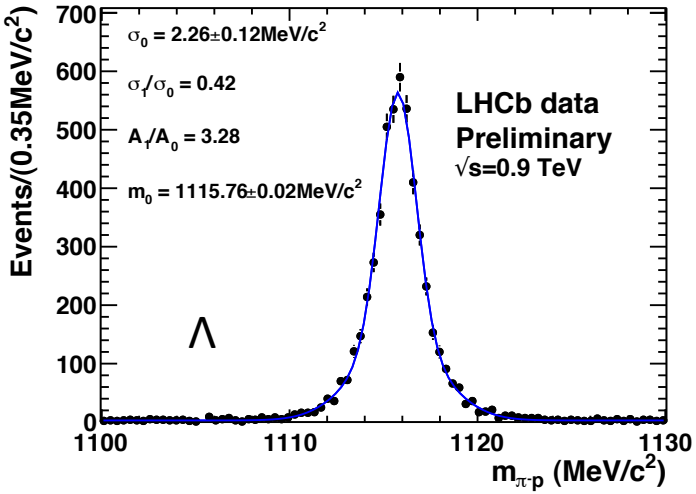
http://home.fnal.gov/~skands/leshouches-plots/

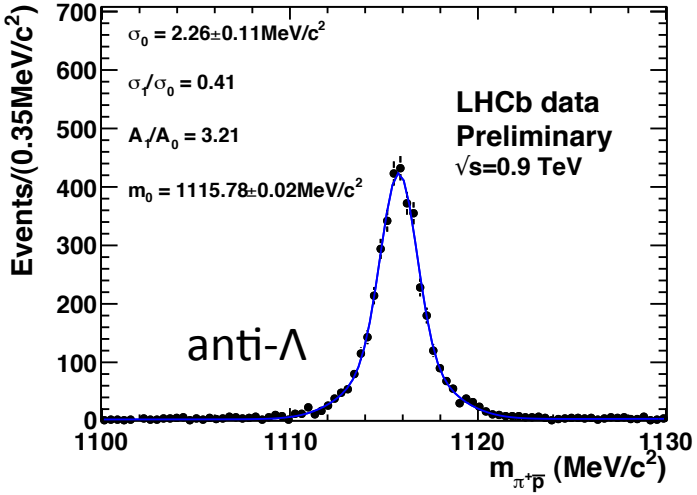
Event selection

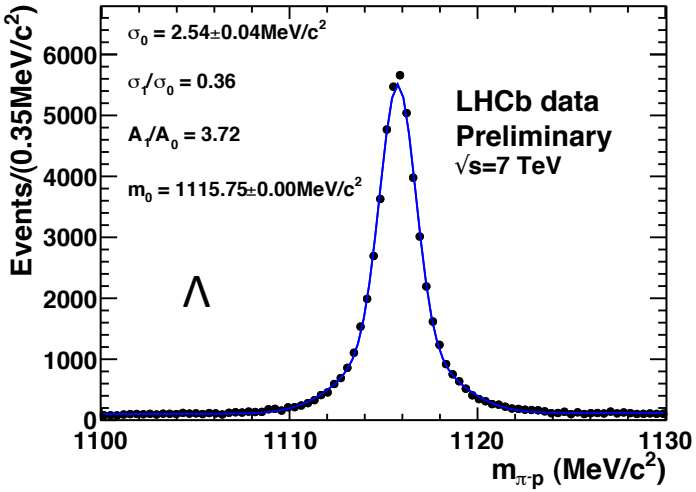
- analysis made with long tracks only
- no particle id. used: Λ and antiΛ selected by the Armenteros-Podolansky variable
- combinatorial background reduced using the same variable ν_1 as in the K^0_S analysis
- pointing of the Λ to the primary vertex required
- selected events:

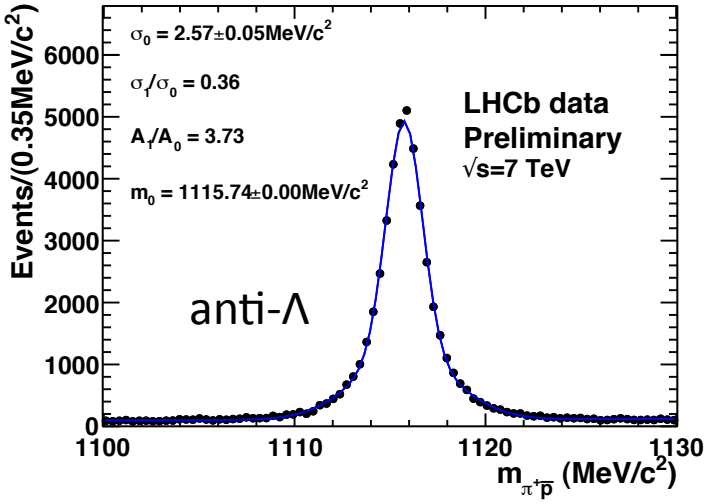
	0.9 TeV field up data	0.9 TeV field down data	7 TeV field up data	7 TeV field down data
Λ	4803	4421	20790	24815
antiΛ	3629	3173	19115	22077

Invariant mass

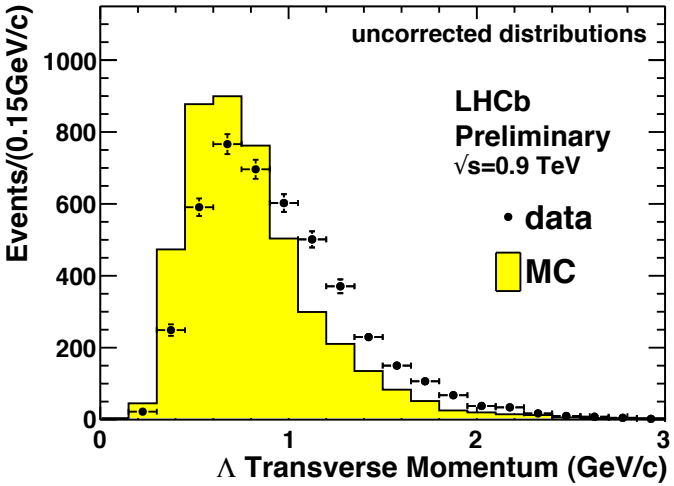


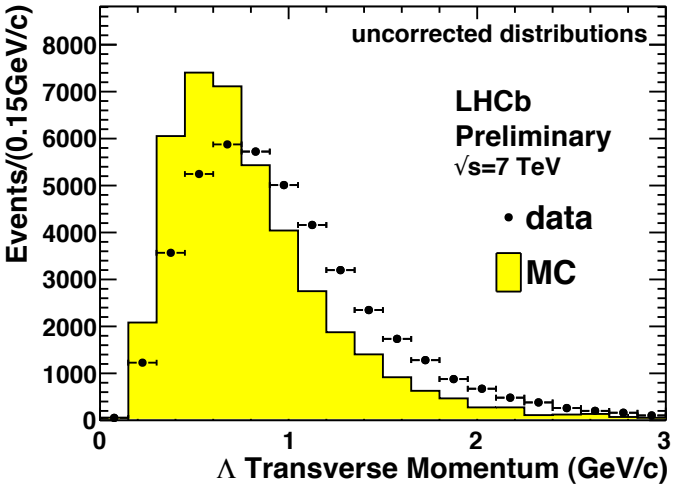




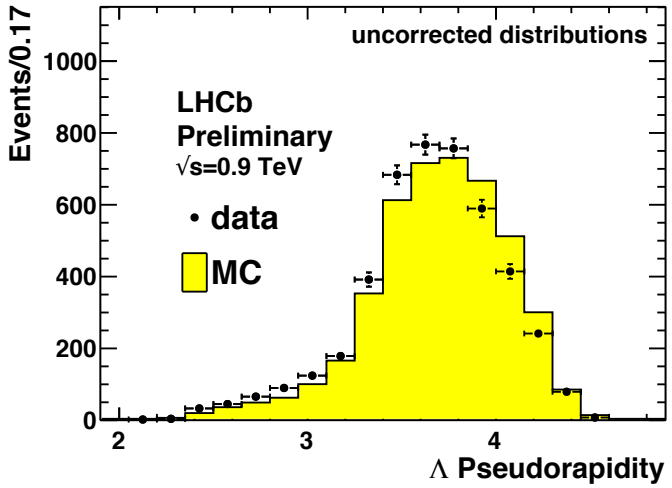


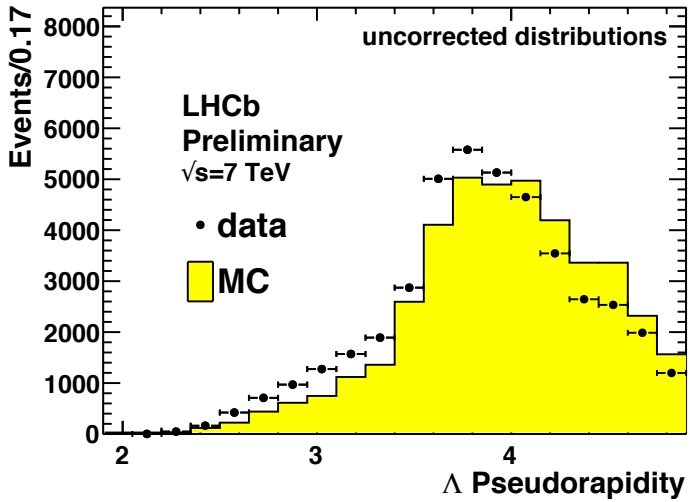
Kinematic distributions of Λ's



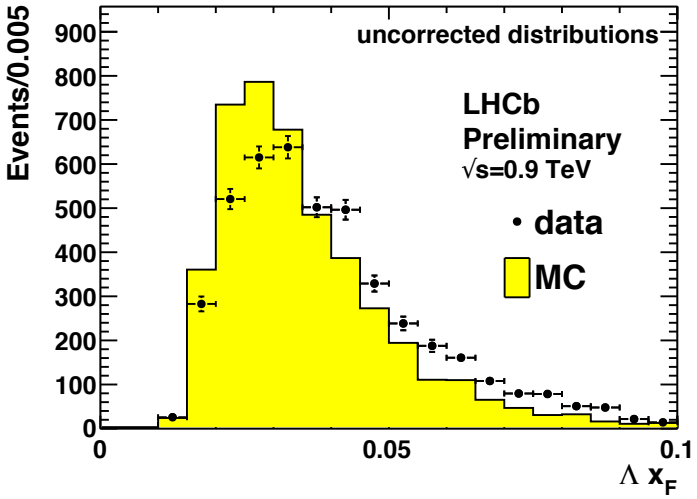


Data distributions "harder" than MC

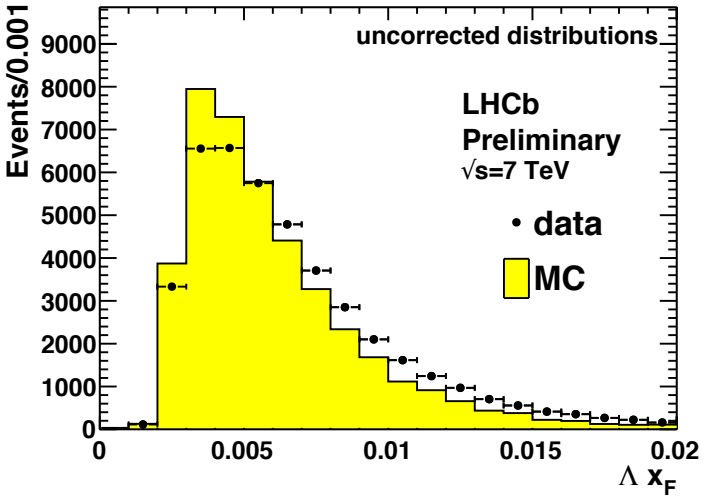




Feynman x of Λ's



0.9 TeV ➔ x_F<0.1



7 TeV ➔ x_F<0.02

very small x_F values

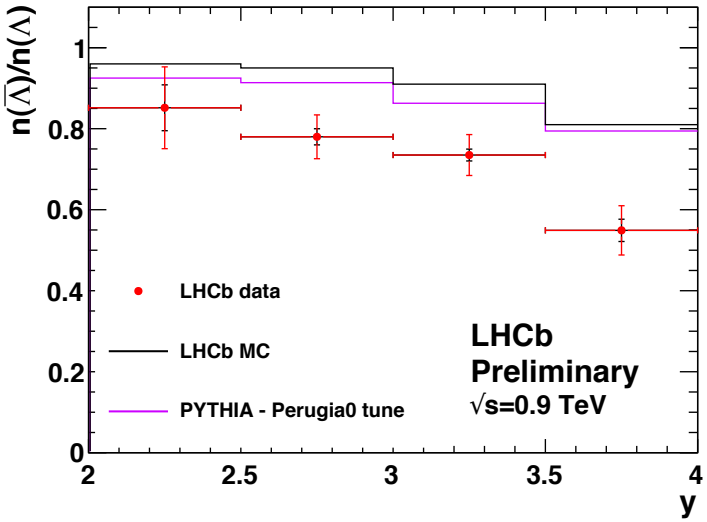
Systematic uncertainties

- In general all systematic contributions are at second order
  - e.g. variation of selection cuts
- p_T distrbutions were re-weighted to match the data distributions
  - systematic error contribution from this procedure≈0.02
- Material interactions:
  - difference between p and anti-p cross section with material ≈10% below 10GeV; reproduced also in our MC (but effect reduced by kinematic selection of Λ)
  - Material description accurate to ≈10%
  - cross section knowledge accurate to ≈10%
  - dominant systematic uncertainty ≈2%

Results for anti-Λ/Λ

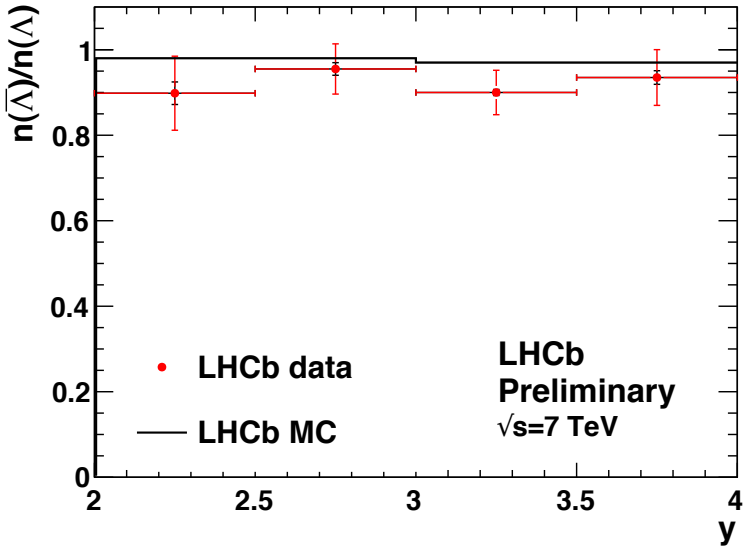
Efficiency corrected ratios for "prompt" Λ

(=production vertex <10μm from PV->after cut still about 30% of the events come from $\Sigma^{(*)}$)



Plots include both statistical and systematic error

Field up and down results were averaged being consistent with each other

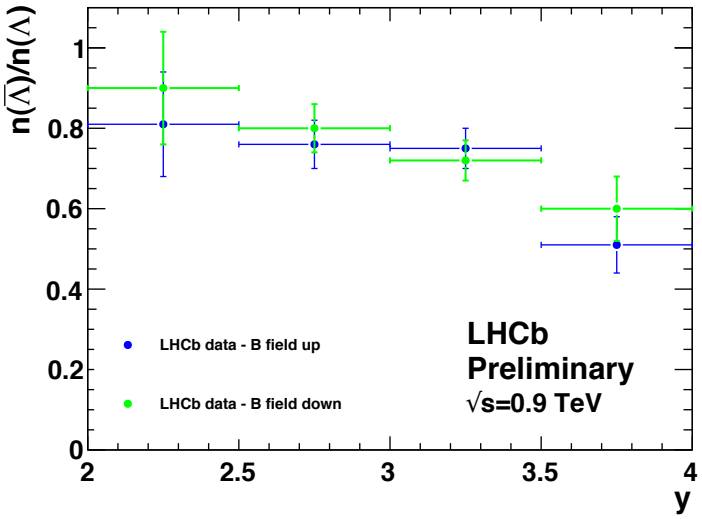


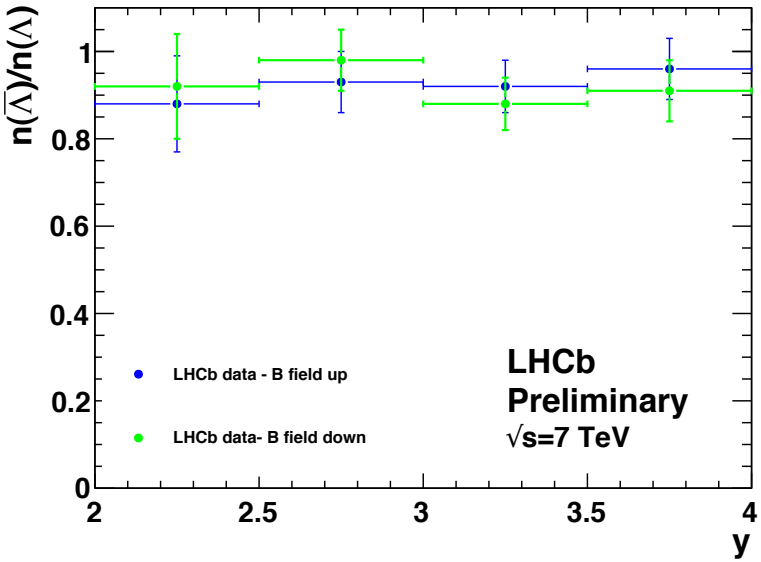
Perugia tunes do not include diffraction

LHCb tune include diffraction

(<% after selection cuts)

Comparison field up-down





Conclusion

- prompt K^0_S absolute production cross section at √s=0.9 TeV
  - p_T spectra tend to be "harder" than PYTHIA predictions
  - extended measurement range to low p_T and new y range
- prompt antiΛ/Λ ratio at √s=0.9 TeV
  - tends to be lower than PYTHIA Perugia 0 tune and LHCb tune, lower with larger y
- prompt antiΛ/Λ ratio at √s=7 TeV
  - in fair agreement with PYTHIA LHCb tune and quite flat vs. y
- study in progress of anti-baryon/baryon ratio for other baryons (anti-p/p) and of meson/baryon ratio (K^0_S/Λ)

Backup slides

Efficiency corrections

- Trigger efficiency
  - Use TriggerIndependentofSignal (TIS)_and TriggerOnSignal (TOS) events to extract efficiencies from the data and compare with MC

$$N_{BeforeTrigger} = \frac{N_{TIS} \times N_{TOS}}{N_{TIS\&TOS}} \text{ and : } \epsilon_{Trig} = \frac{N_{sel}}{N_{BeforeTrigger}}$$