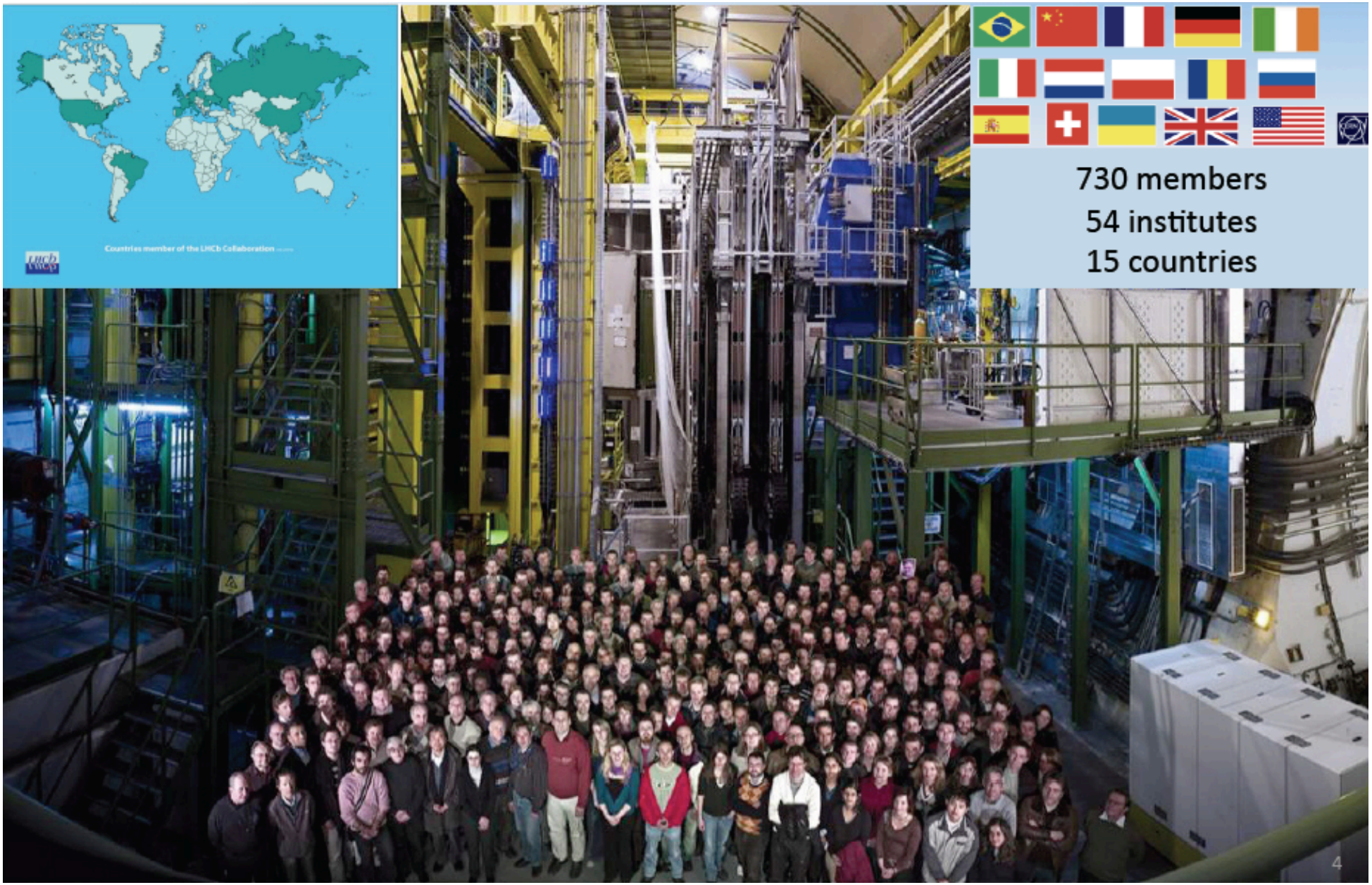
Light hadron production studies in pp collisions at $\sqrt{s}$ = 0.9 and 7 TeV with the LHCb detector

Amhis Yasmine

EPFL

Outline

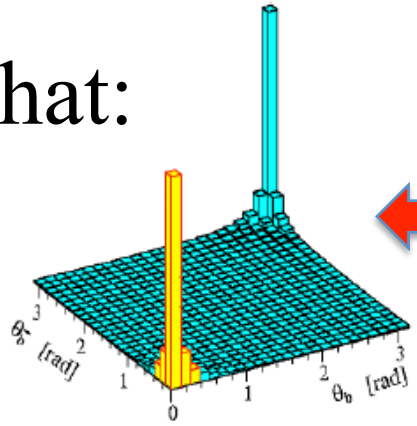
- Introduction to LHCb
- K_s production cross-section.
- Strange V^0s production ratios
- Proton ratio production.

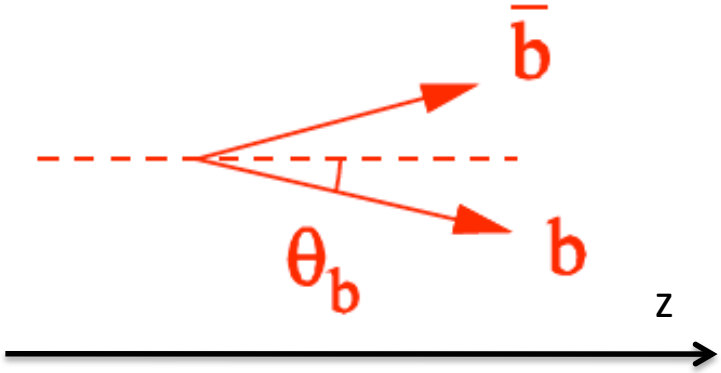

Countries member of the LHCb Collaboration
730 members
54 institutes
15 countries

Who are we?

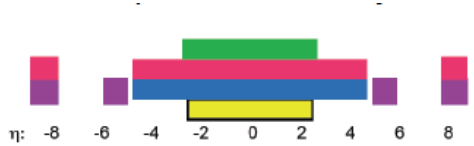
The eye of LHCb

We know that:

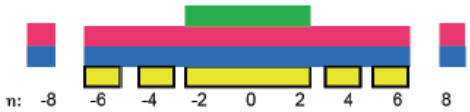




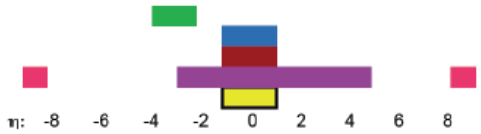
So we built:



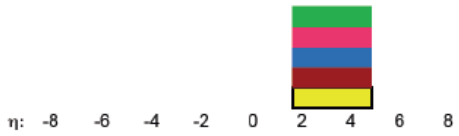
ATLAS



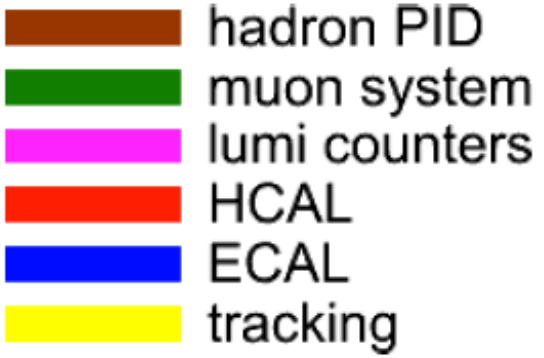
CMS&TOTEM



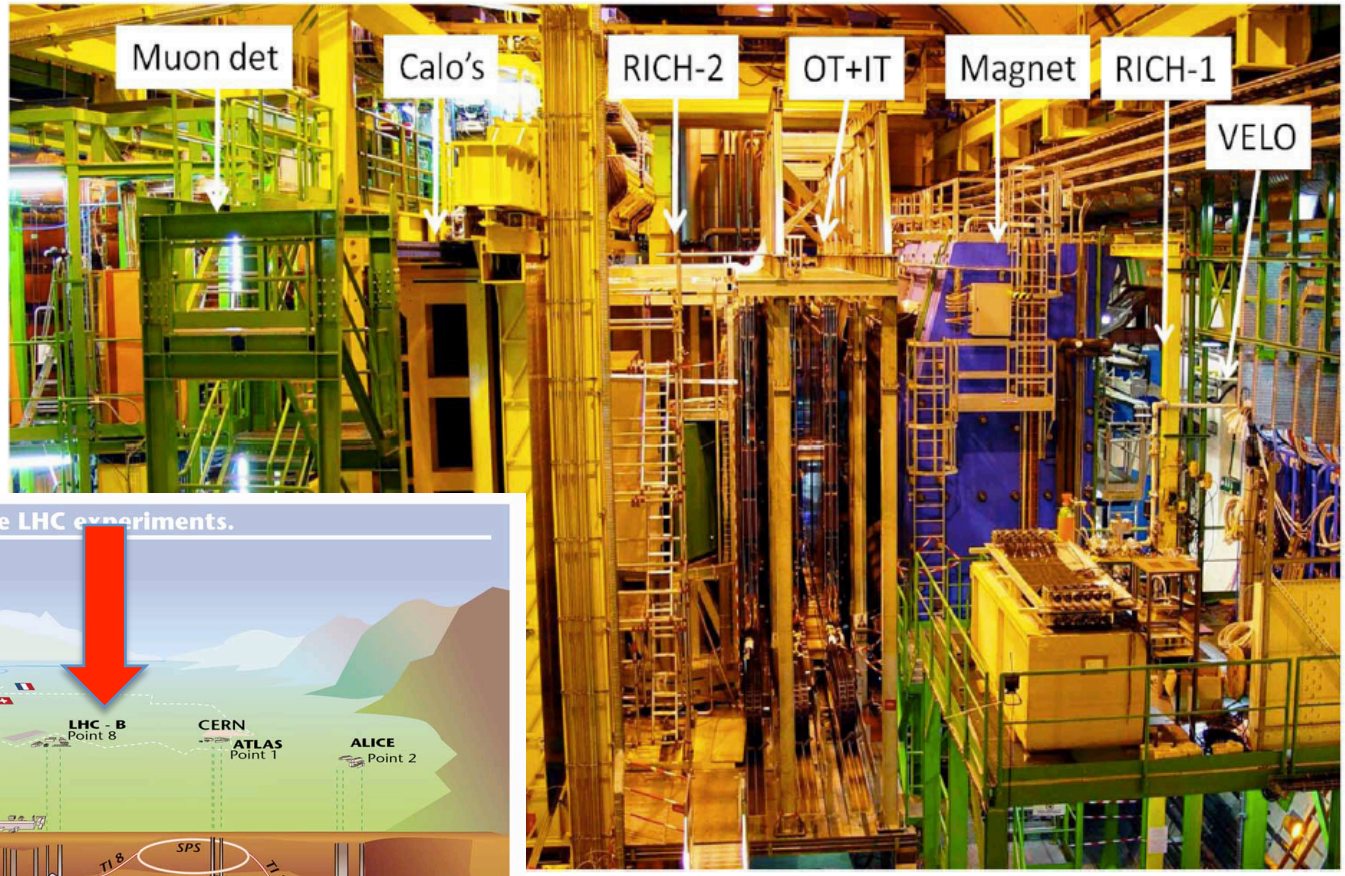
ALICE

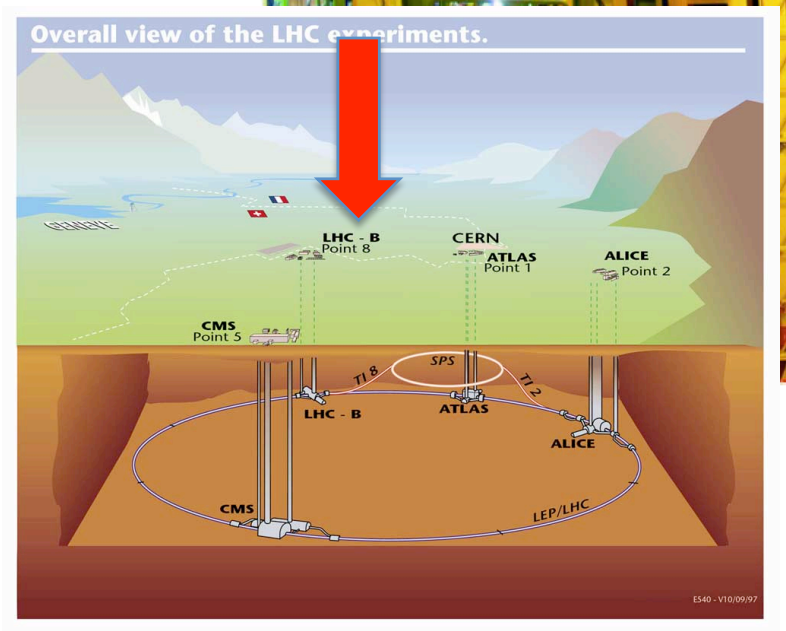


LHCb



Down in the pit where the action happens





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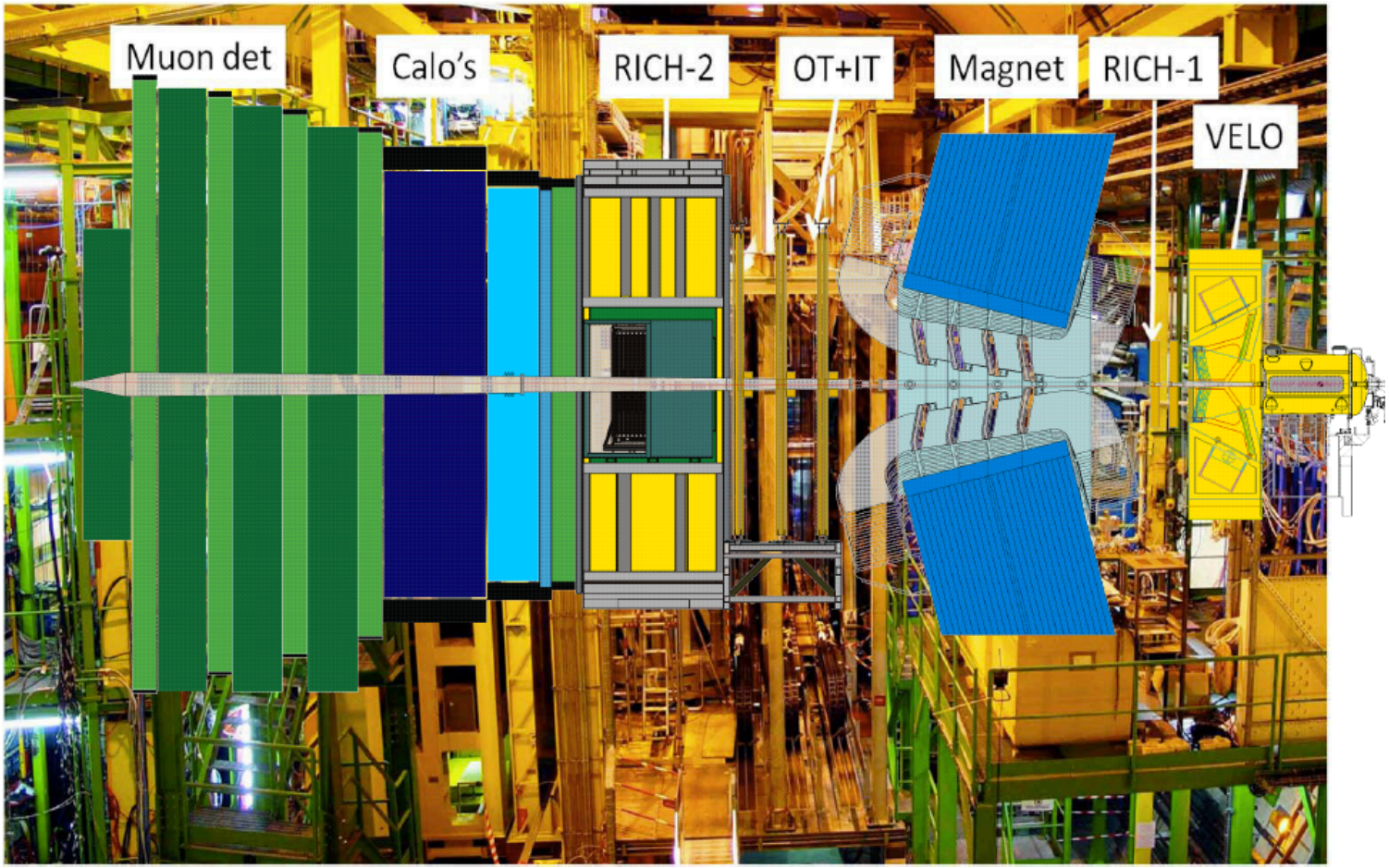
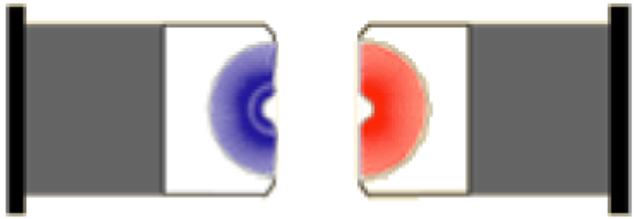


The LHCb detector at LHC, JINST **3 (2008) S08005**

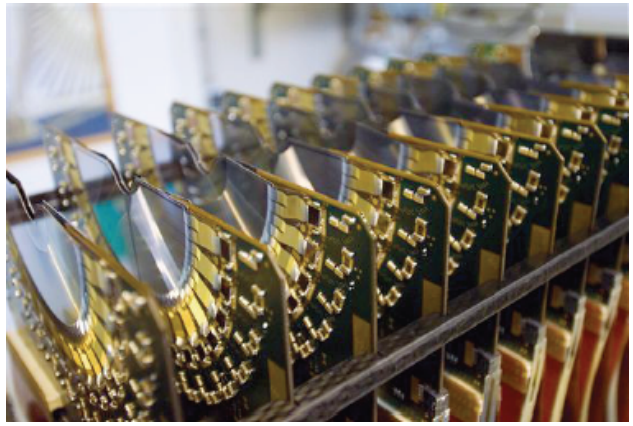
Tracking @LHCb

Velo Open

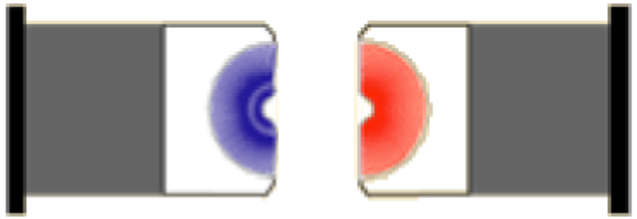


– Two halves with 21 stations.
– Each station has 2 micro-strip silicon sensors providing R and φ measurement
– Separated from beam vacuum by 300 μm Al foil (serves also as RF shield)

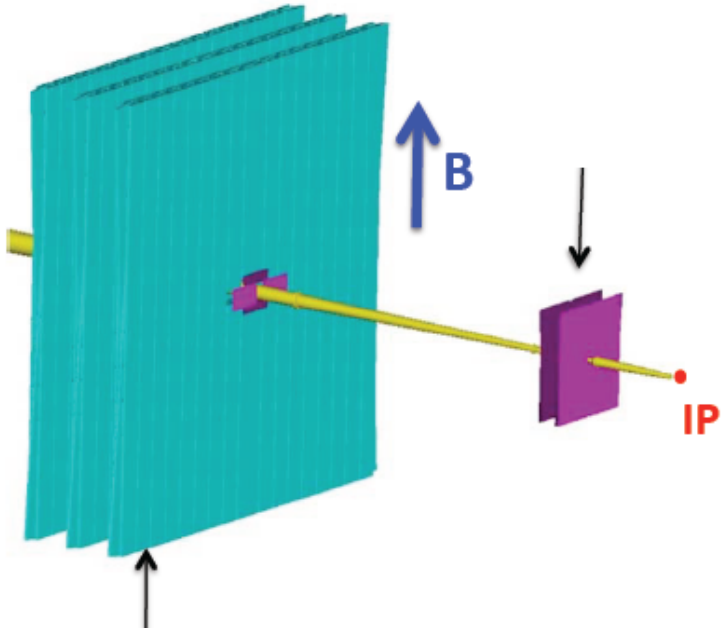
Tracking @LHCb



Velo Open

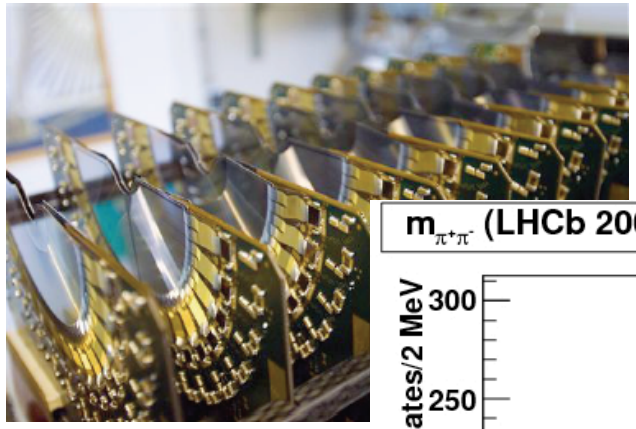


Tracker Turicensis (TT)
Silicon strip detector

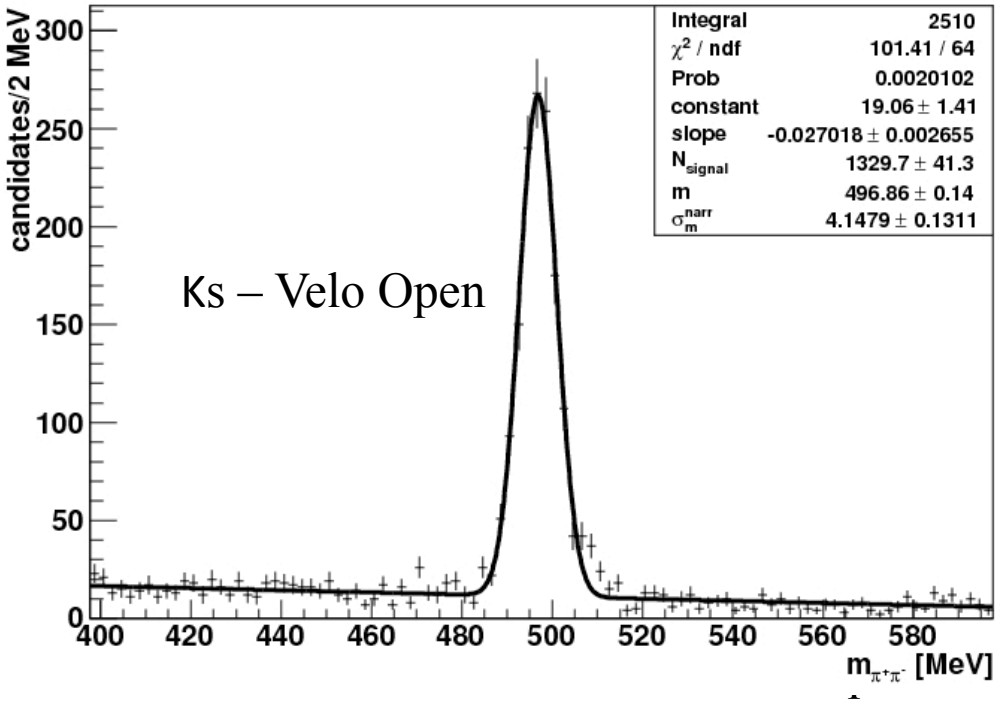


Three tracking stations
downstream of magnet
- Inner part: Silicon strip detectors
- Outer part: Straw tubes

Tracking @LHCb

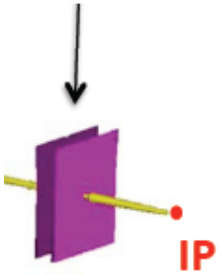


Velo Open



Ks – Velo Open

Tracker Turicensis (TT)
Silicon strip detector

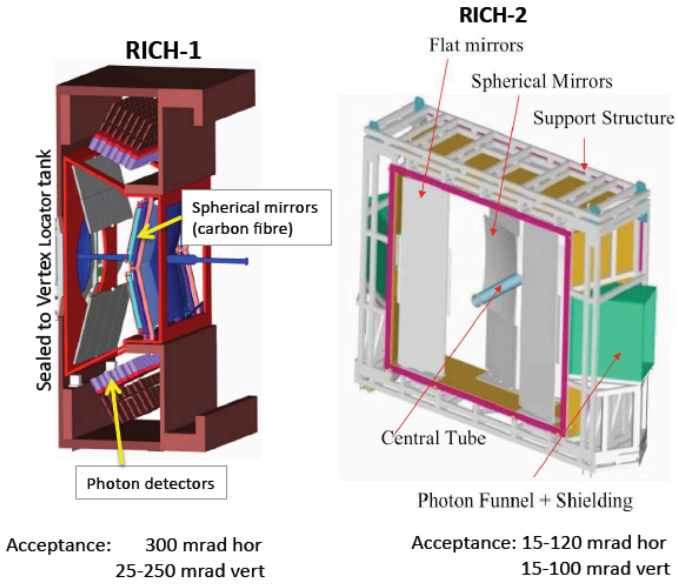


ns
ıet
strip detectors

- Outer part: Straw tubes

PID@LHCb

See Clara M. Talk

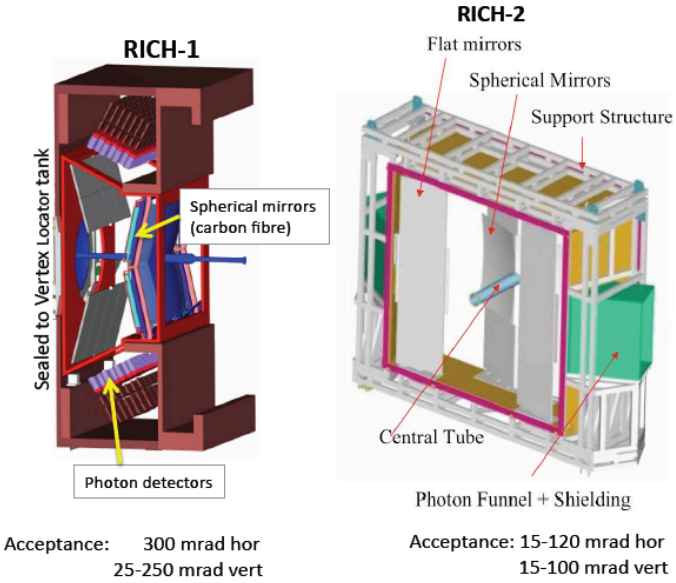


Acceptance: 300 mrad hor
25-250 mrad vert

Acceptance: 15-120 mrad hor
15-100 mrad vert

-Coverage: 1-100 GeV
- Resolusion for gas radiators close to MC after alignment of mirrors and photon detectors
- Aerogel being improved

PID@LHCb



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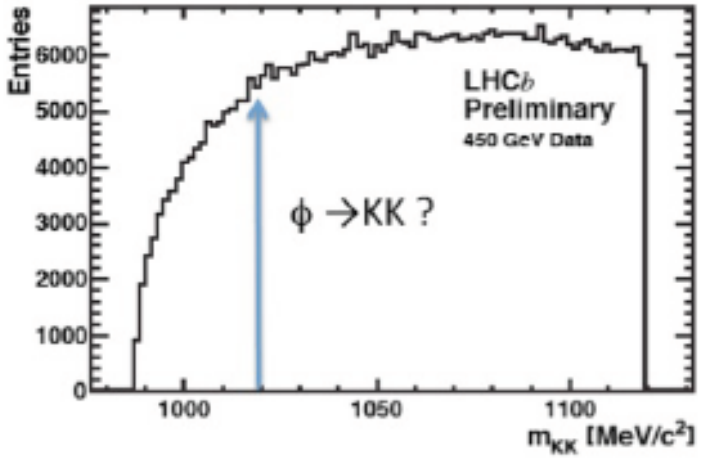
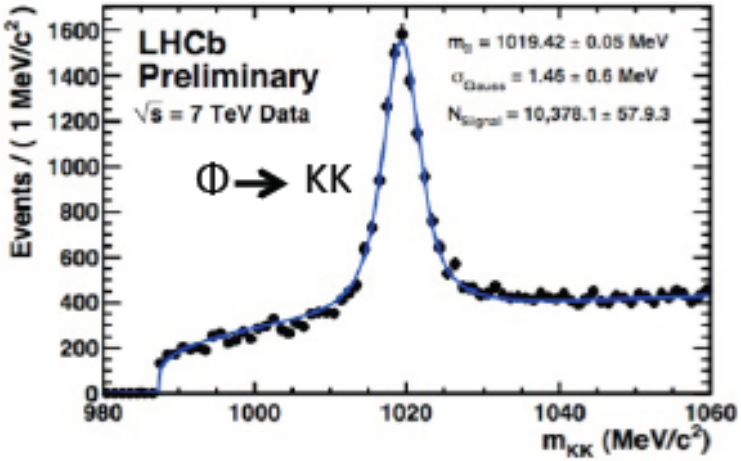
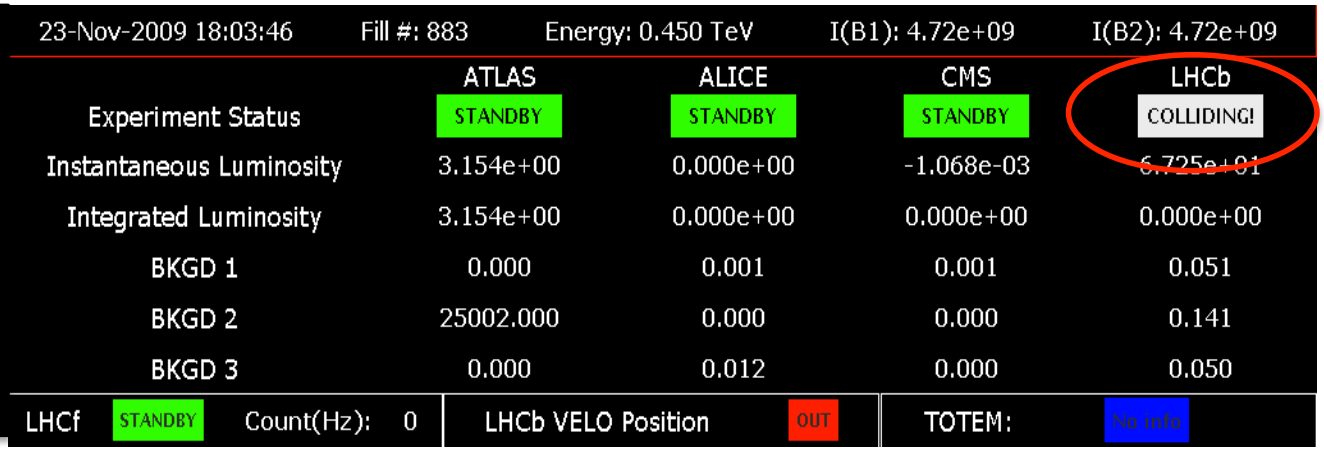


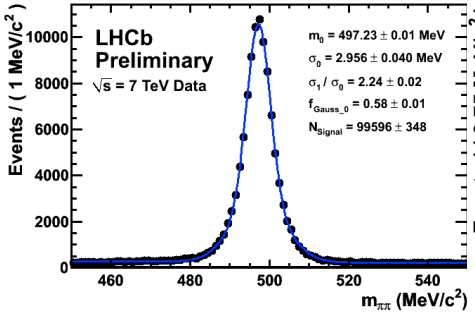


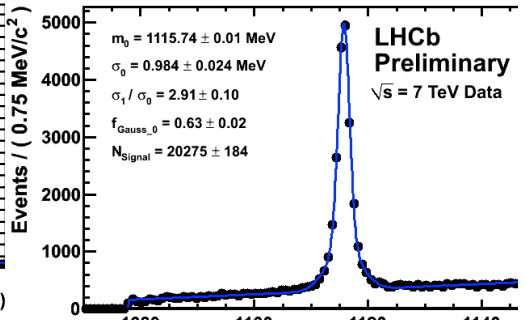
About a year after….

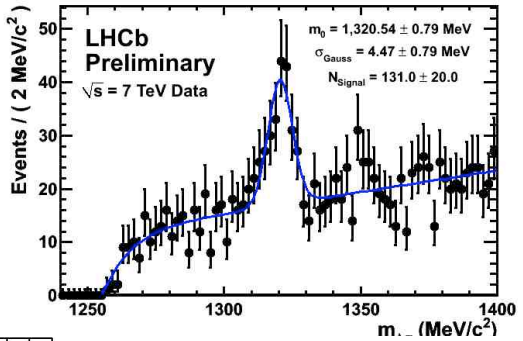


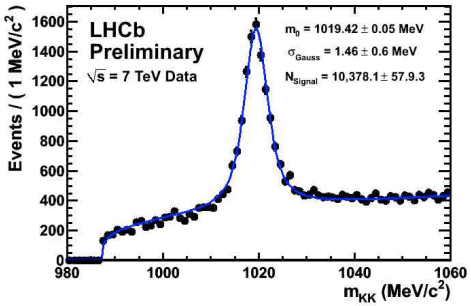
About a year after….

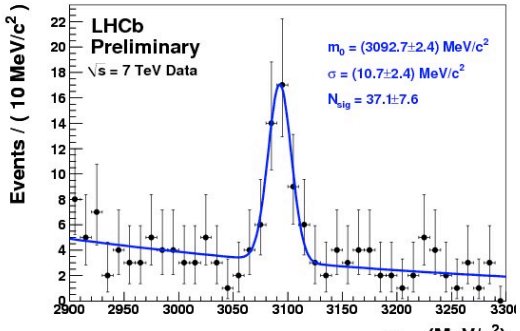
23-Nov-2009 18:03:46	Fill #: 883	Energy: 0.450 TeV	I(B1): 4.72e+09	I(B2): 4.72e+09
	ATLAS	ALICE	CMS	LHCb
Experiment Status	STANDBY	STANDBY	STANDBY	COLLIDING!
Instantaneous Luminosity	3.154e+00	0.000e+00	-1.068e-03	6.725e+01
Integrated Luminosity	3.154e+00	0.000e+00	0.000e+00	0.000e+00
BKGD 1	0.000	0.001	0.001	0.051
BKGD 2	25002.000	0.000	0.000	0.141
BKGD 3	0.000	0.012	0.000	0.050
LHCf STANDBY	Count(Hz): 0	LHCb VELO Position OUT	TOTEM: No info	

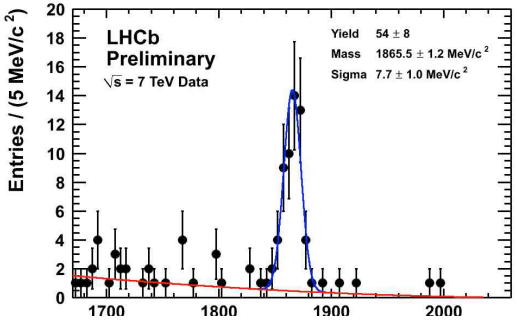


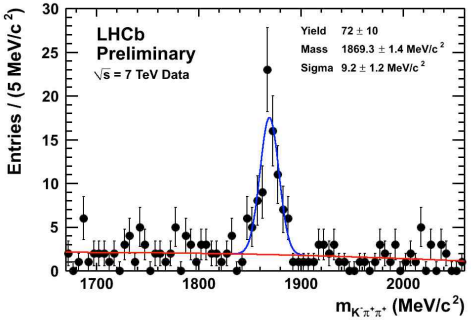


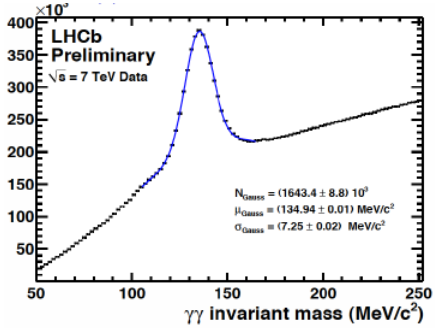






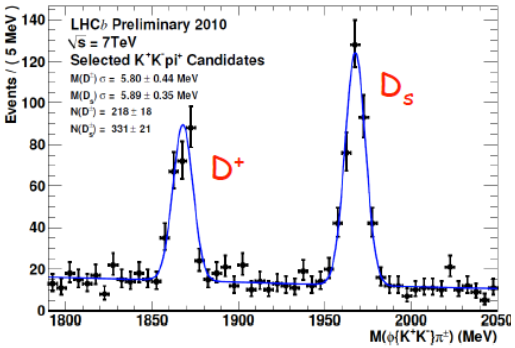


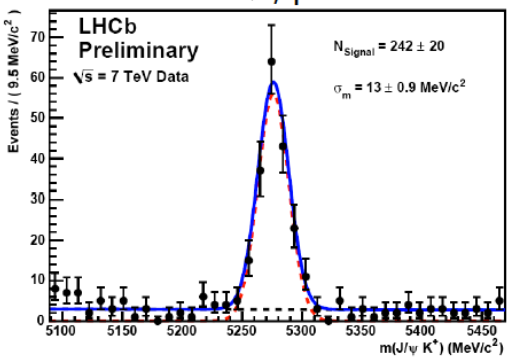


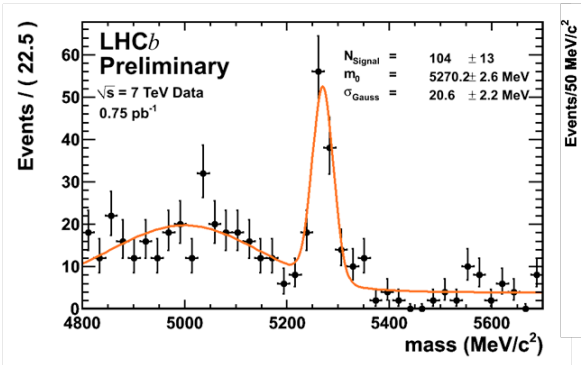


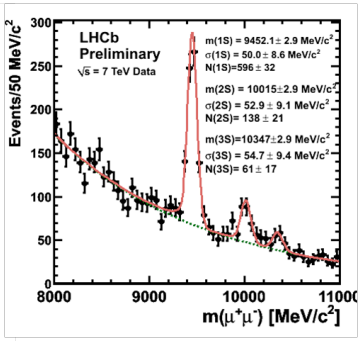
t > 0.30 ps

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

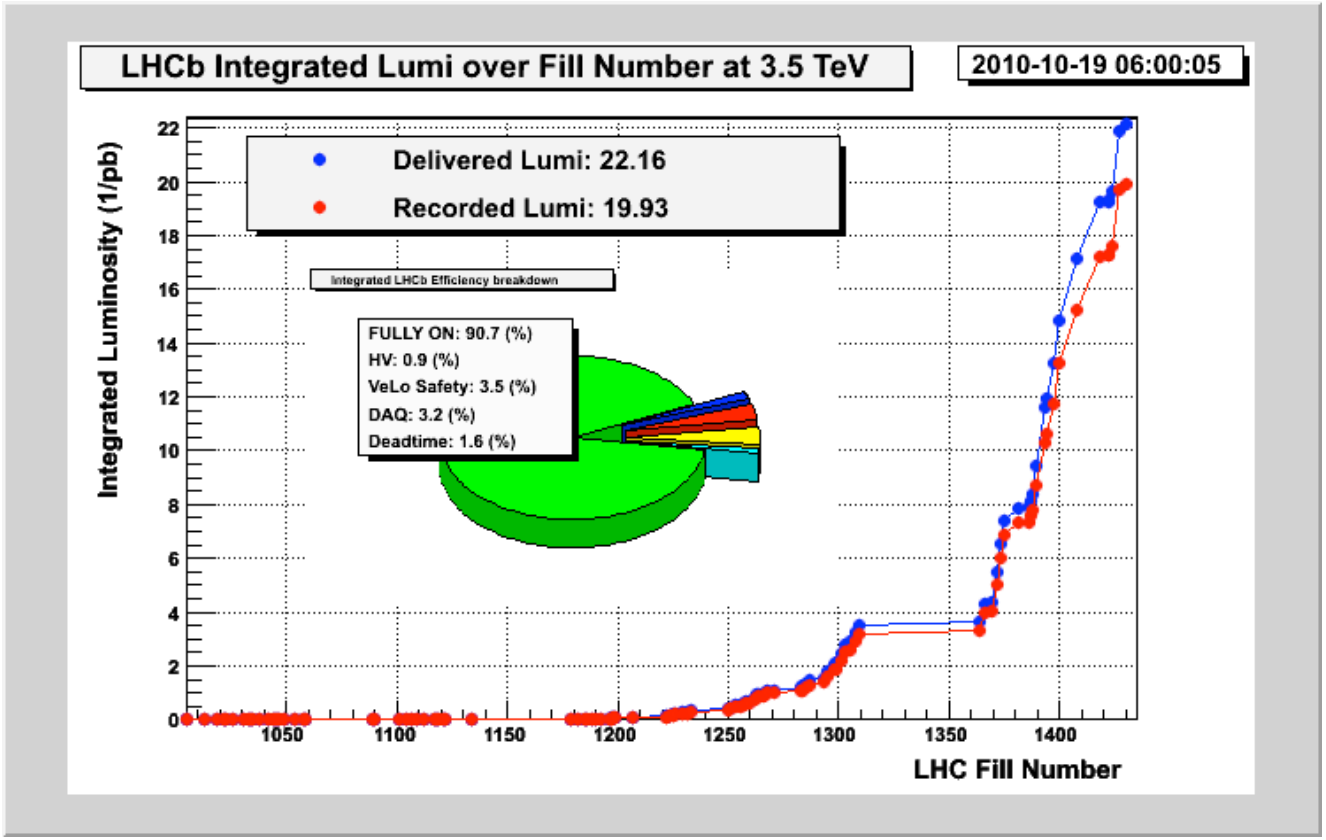








Data Samples available today

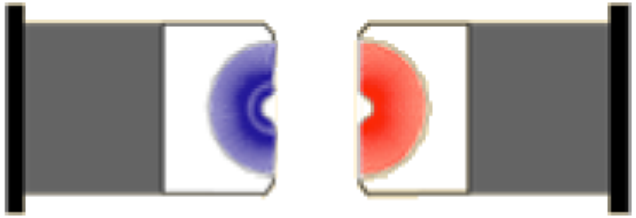


But we'll focus on Early Data where we had an open trigger

450 + 450 GeV:

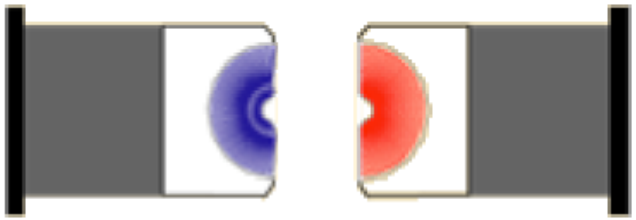
6.8 μb^{-1} in the pilot run of 2009 and 0.31 nb^{-1} in 2010

K_s production @ $\sqrt{s} = 0.9$ TeV



Velo open at $\sqrt{s} = 0.9$ TeV

K_s production @ $\sqrt{s} = 0.9$ TeV



Velo open at $\sqrt{s} = 0.9$ TeV

-Using 6.8 μb^{-1} from pilot run

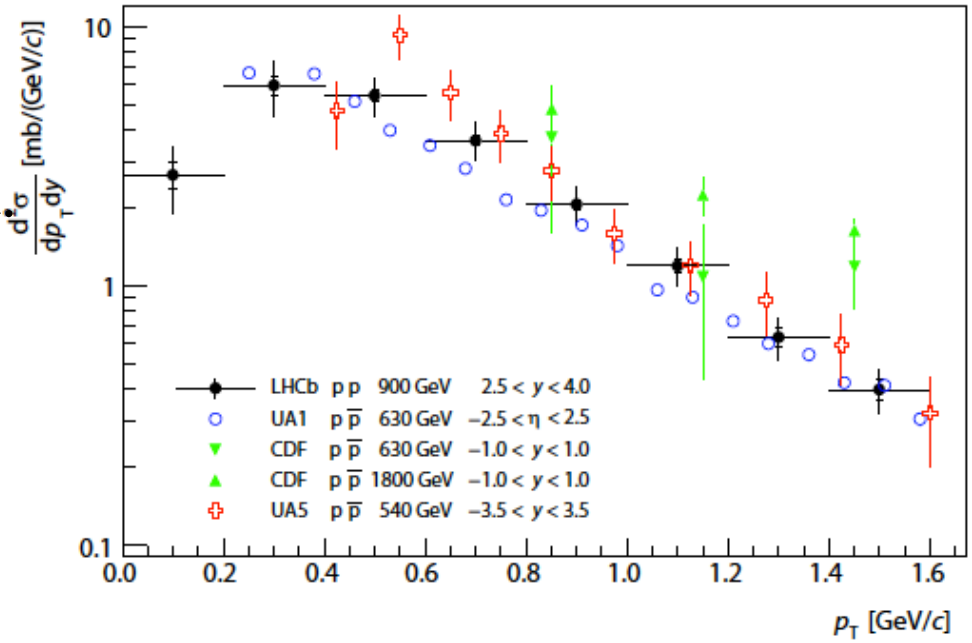
-K_s cross-section not measured before at this energy.

-The P_T and y range were extended.

-Main systematic from

Luminosity: 12 %

Tracking efficiency:10 %



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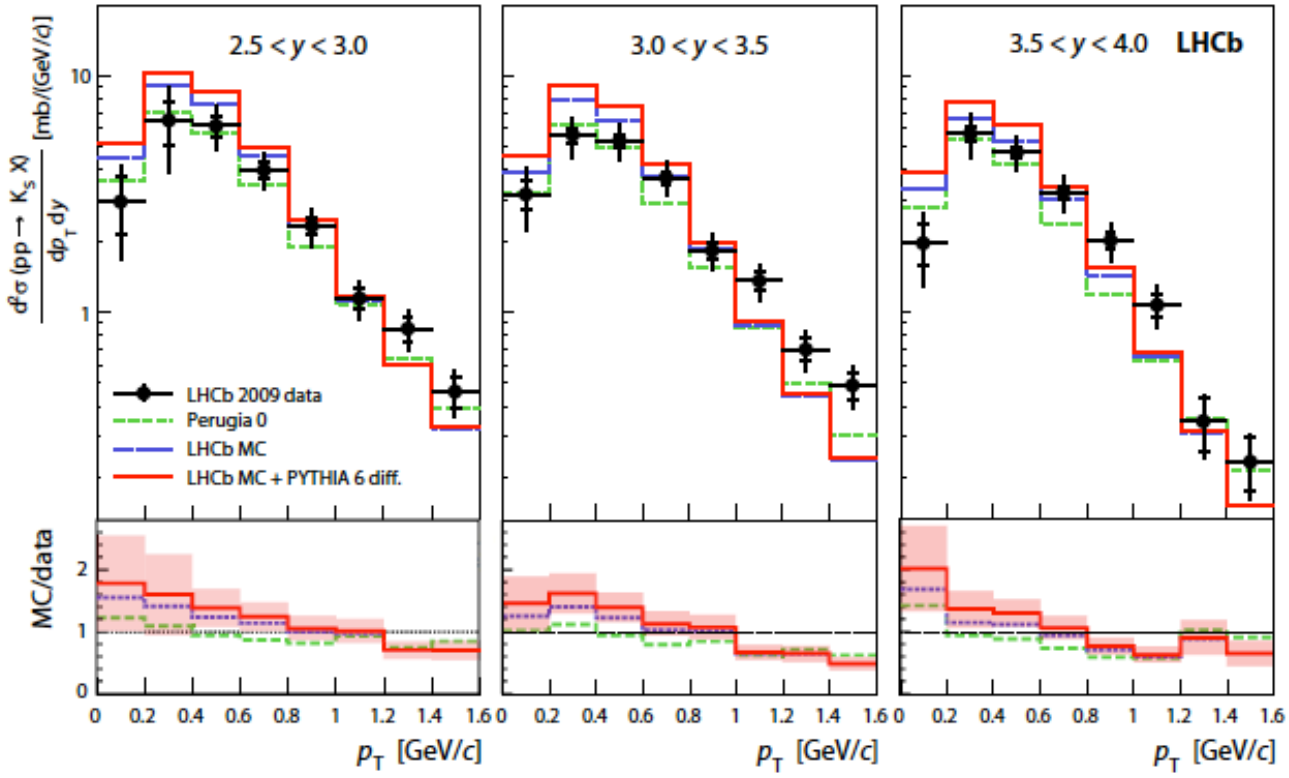
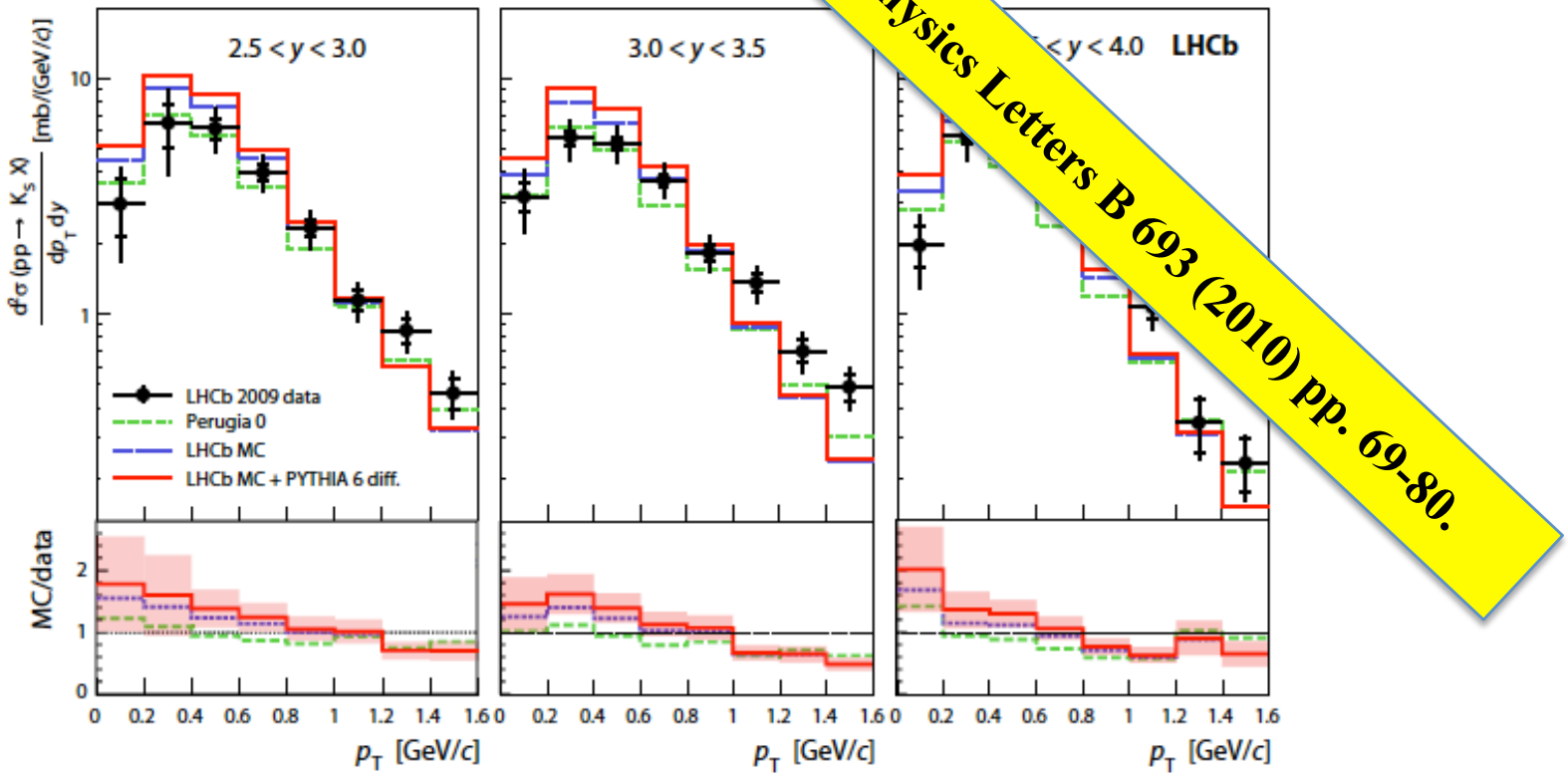


Important input for hadronization models, measured in bins of y and P_T and compared to LHCb MC and Perugia 0.

K_s production @ $\sqrt{s}$ = 0.9 TeV



Physics Letters B 693 (2010) pp. 69-80.

Important input for hadronization models, measured in bins of y and pT and compared to LHCb MC and Perugia 0 (**arXiv:1005.3457**).

V^0 measurements a couple of technicalities

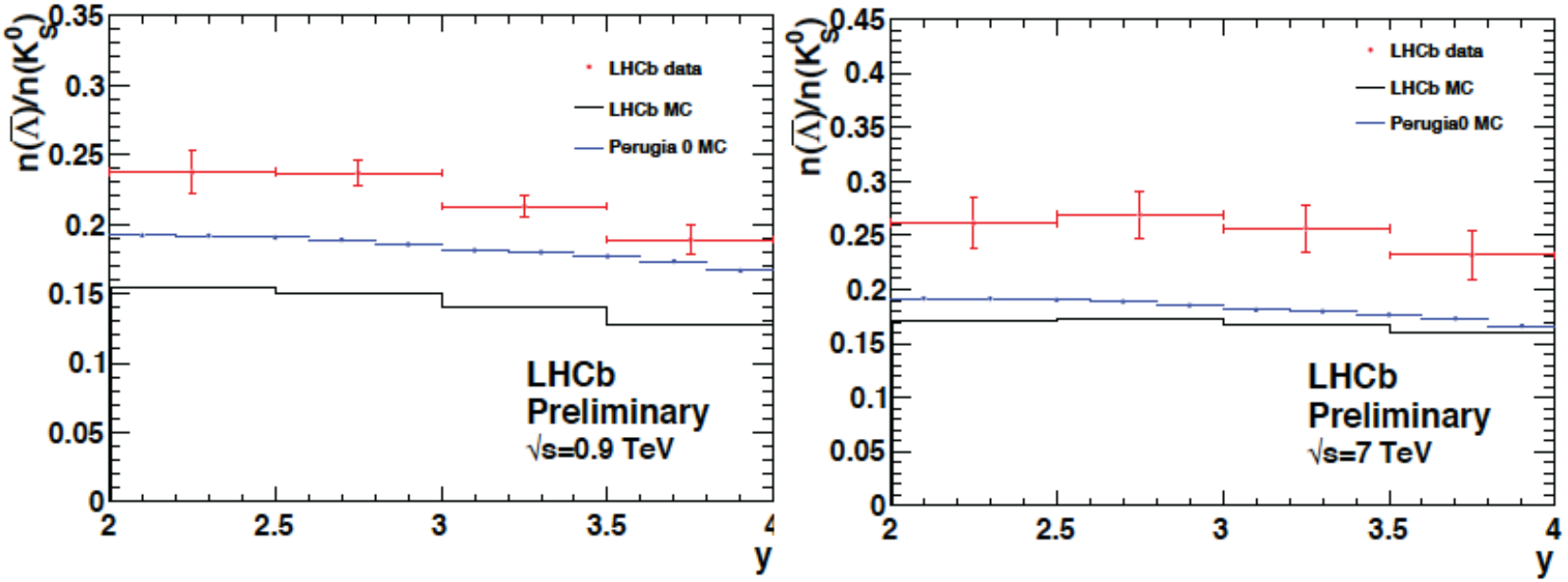
High-purity, prompt K_s and Λ samples selected based on a combined impact parameters.

PV requirement ensures that only the V^0s coming from non-diffractive events are kept (model based definition PYTHIA 6 & PYTHIA 8).

- Efficiency from LHCb-MC (PYTHIA & EvtGen) and GEANT simulation for prompt, non-diffractive events.

0. 31 nb^{-1} @ 0.9 TeV and 0.2 nb^{-1} @ 7 TeV as V^0s abound in minimum bias data: 5 K_s and 1 Λ selected per 100 triggers in data @ 7 TeV.

Baryon suppression with $\overline{\Lambda}/K_s$



Observation: The ratio $\overline{\Lambda}/K_s$ is higher than expected at both energies.

Might be consistent with indications on the ratio of to K_s production at Tevatron (http://home.fnal.gov/skands/leshouches-plots).

Baryon number transport with $\overline{\Lambda}/\Lambda$

Baryon number conservation requires the destroyed beam particles in inelastic non-diffractive collisions must be balanced by creation of baryons else where.

Question: How close are the baryon and anti-baryon produced in the phase space?

Baryon number transport with $\overline{\Lambda}/\Lambda$

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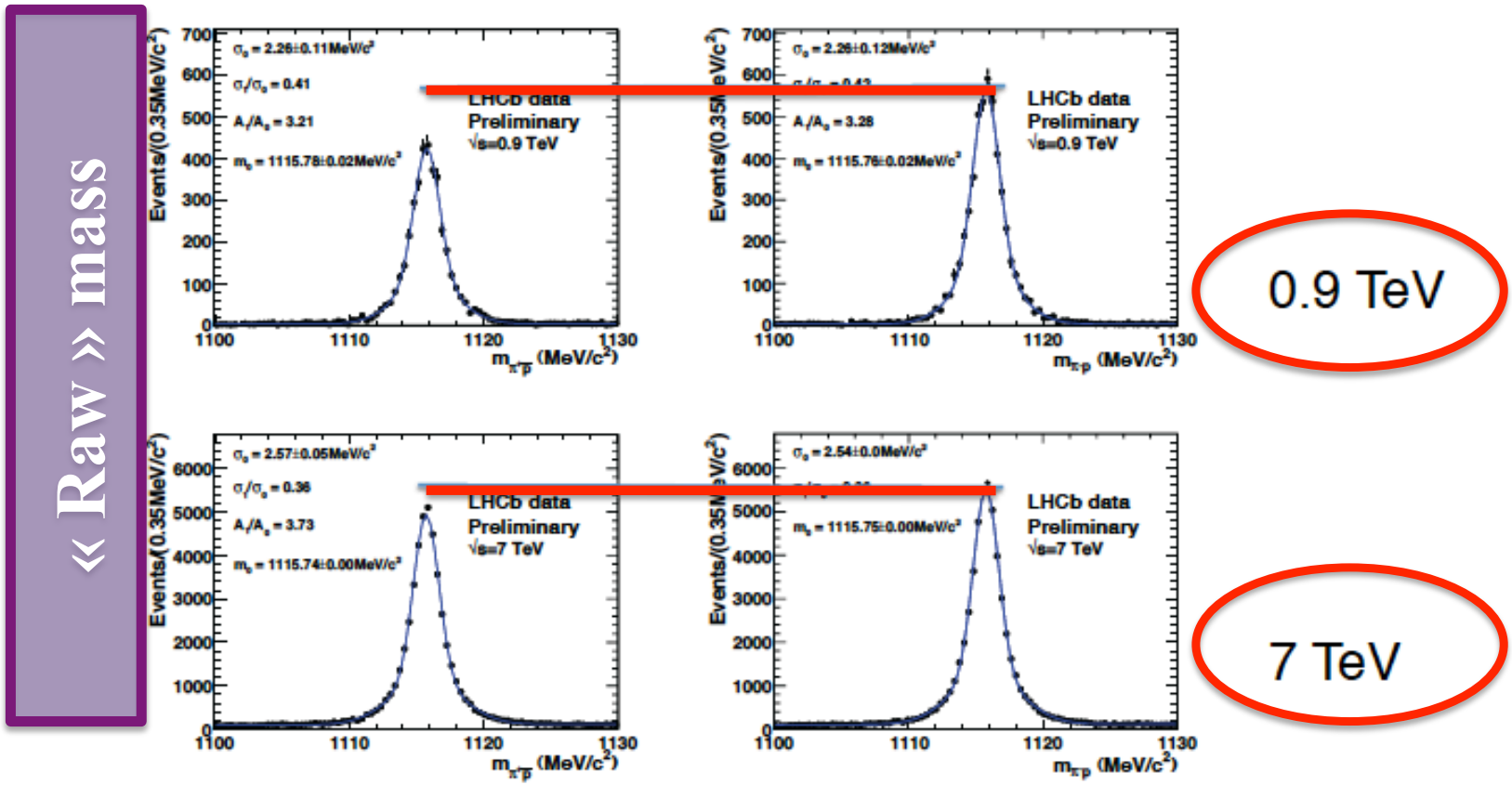
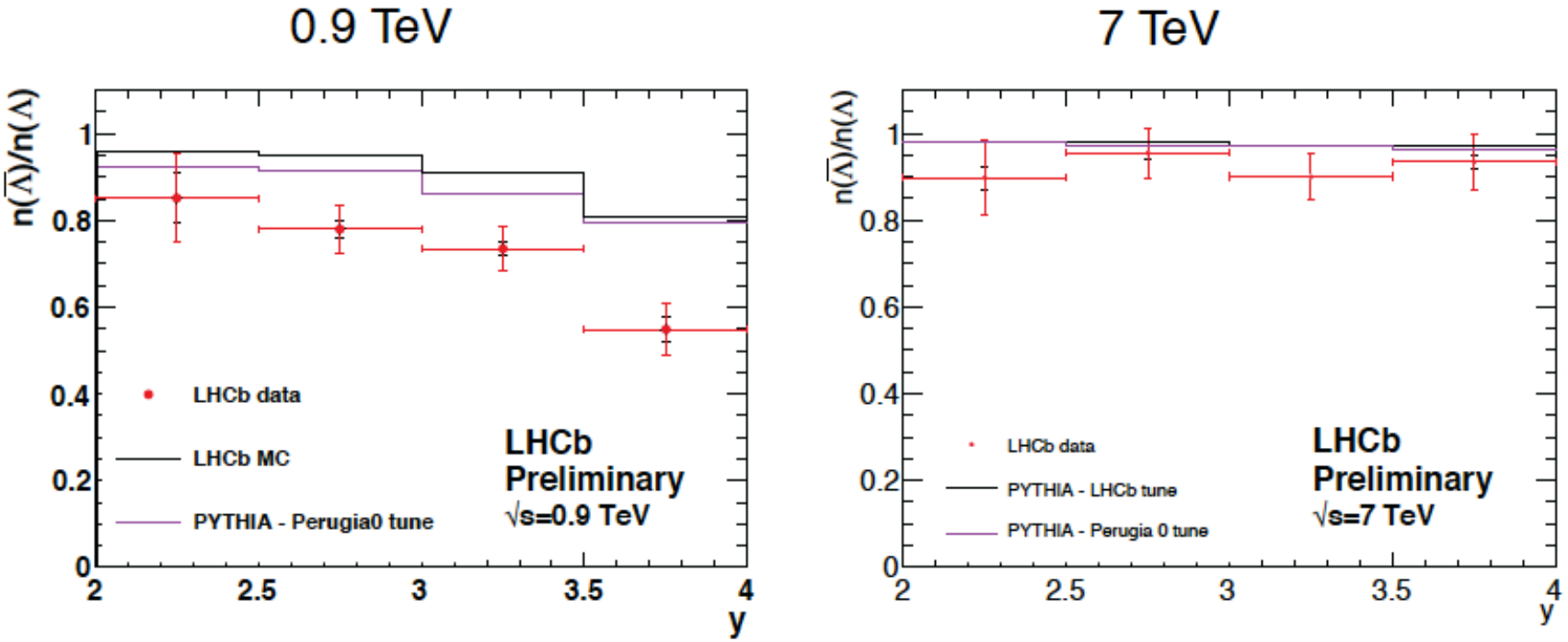
« Raw » mass

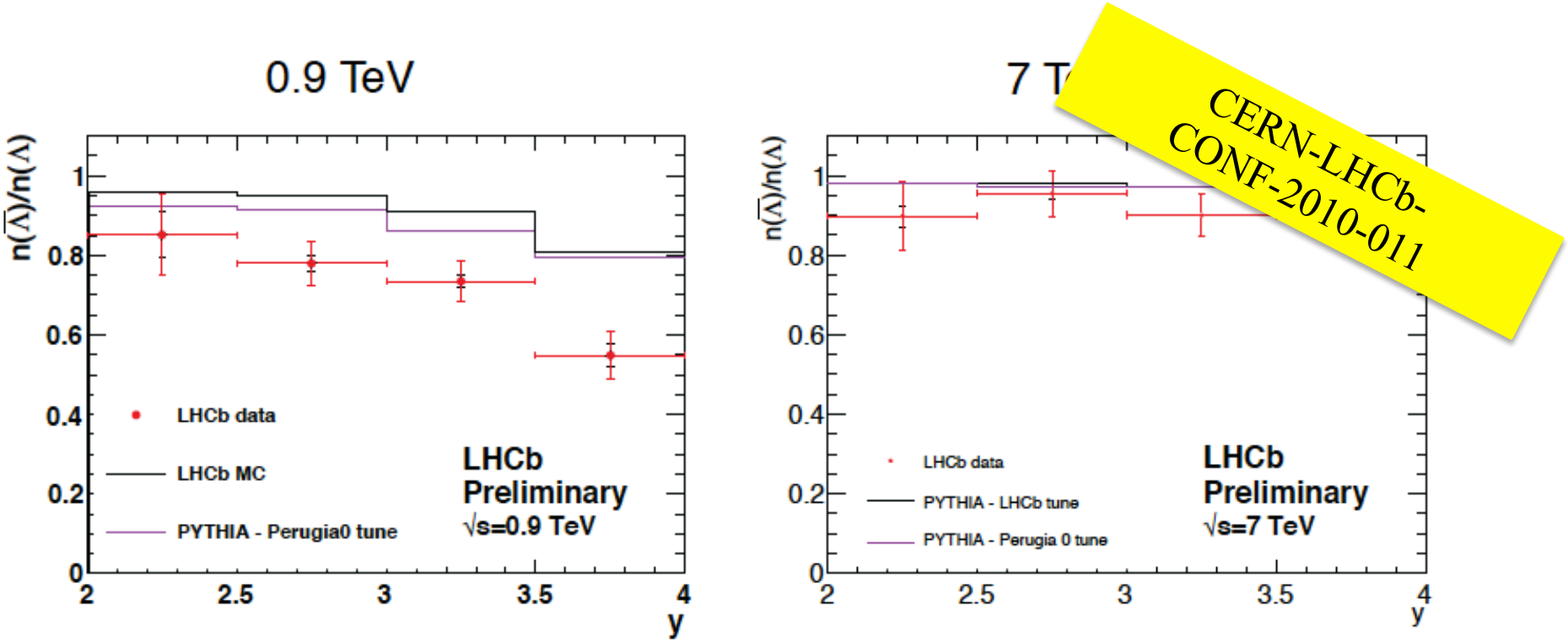


Baryon number transport with $\overline{\Lambda}/\Lambda$



Observation : Measurements lie significantly under MC predictions at 0.9 TeV; Reasonable agreement farther from the beam (in y), at 7 TeV, where the ratio must be very close to the unity.

Baryon number transport with $\overline{\Lambda}/\Lambda$



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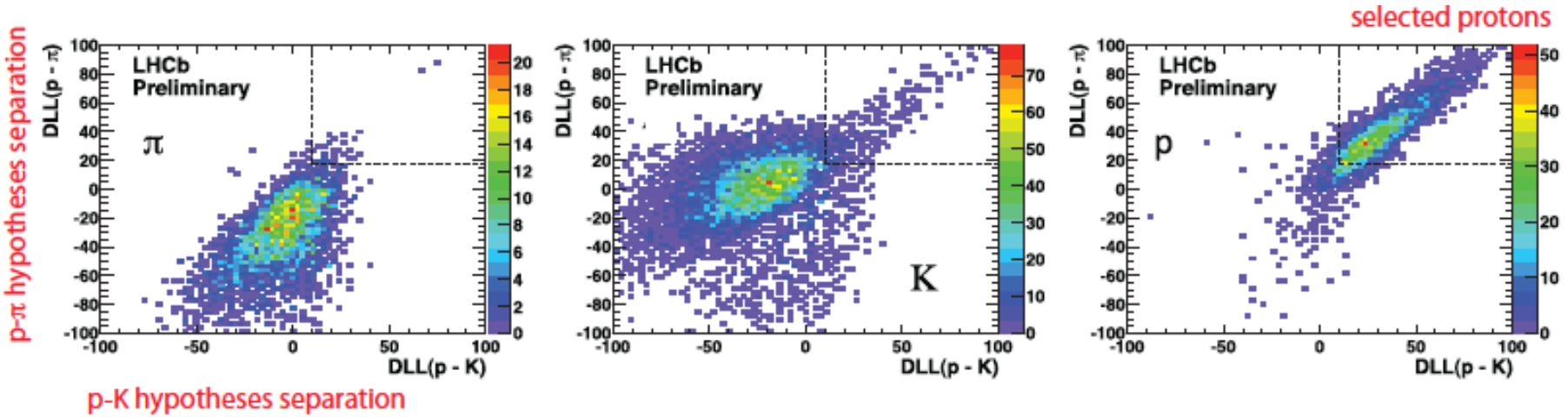
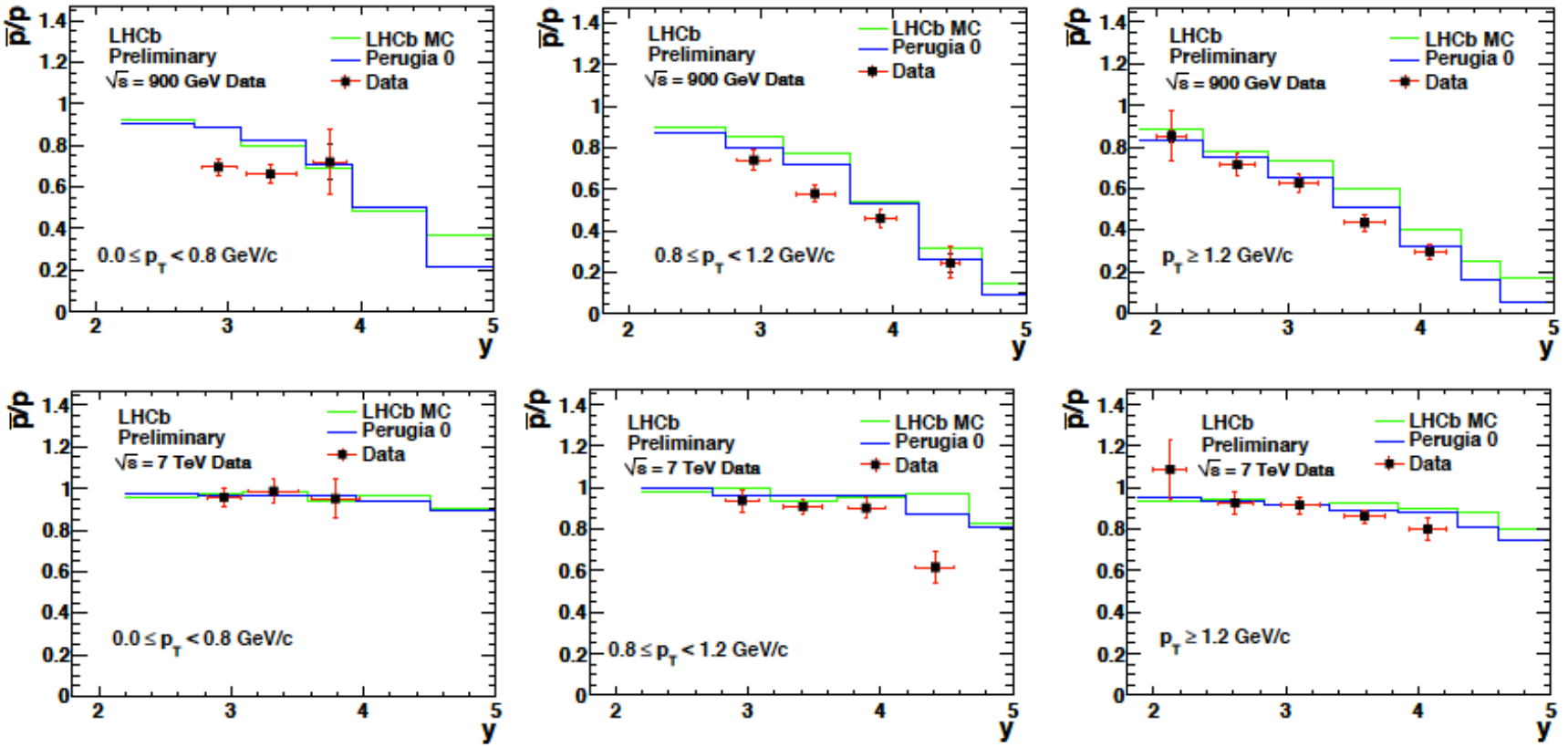
Proton production



High purity (anti)proton samples of 90-95% obtained over full LHCb acceptance.

15 MEvts @ 0.9 TeV and 13 MEvts @ 7 TeV for the $\bar{p}$/p.

Baryon number transport $\overline{p}/p$



Observation:

Big deviation in ratio from unity at low energy.

Much less so at 7 TeV. Reasonable agreement observed with Perugia 0.

Preliminary systematics in ratios

Most of the systematics cancel in the ratios. Remaining systematics relate mainly to MC, data comparisons.

Uncertainties	Errors
p,π interaction cross-sections	$\sim$ 10%
V^0production & interaction cross-sections	$\sim$10%
LHCb material description	<10%
Λ transverse polarisation	<1%
Selection cuts (dominated by PID)	1-14%
Ghost tracks	<2%
Acceptance asymmetries	$\sim$ 2%
Non-prompt contamination	<1%

Ratio	Total
$\bar{\Lambda}/\Lambda$	$\sim$2%
$\bar{\Lambda}/K^0_S$	2-12%
$\bar{p}/p$	3-14%

Baryon number transport with $\overline{\Lambda}/\Lambda$

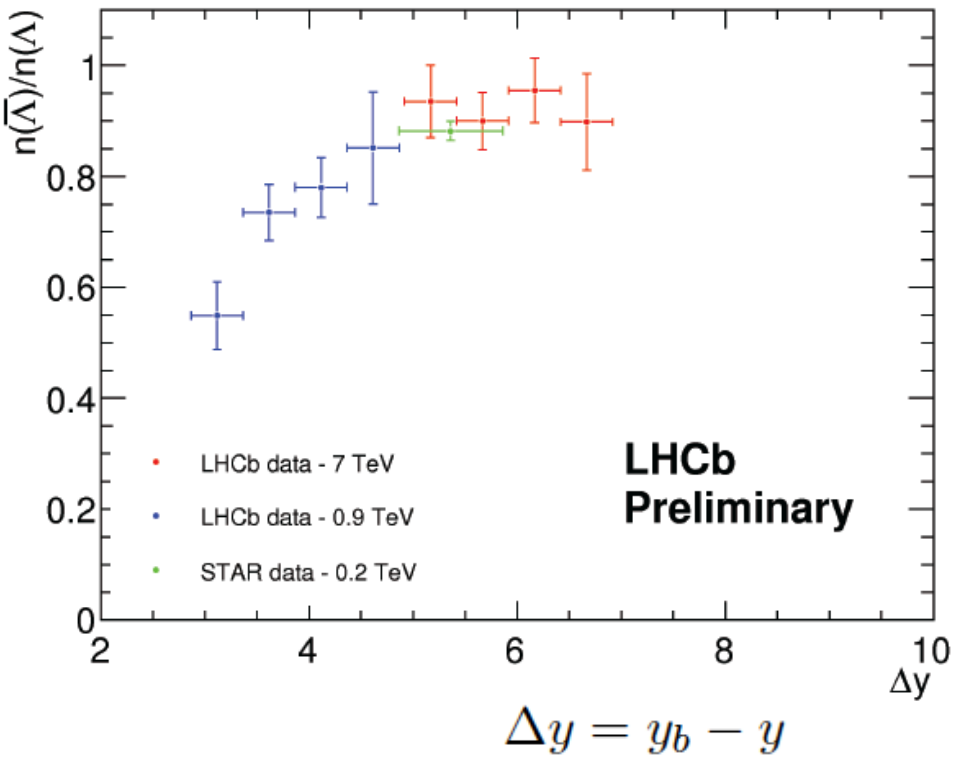
Comparing rapidity bins equally away from the beam

Probes scaling violations.

$$y_1 = y_2 + \ln\left(\frac{E_{b1}}{E_{b2}}\right)$$

Observation:

Consistency between the two Energy measurements and previous result.



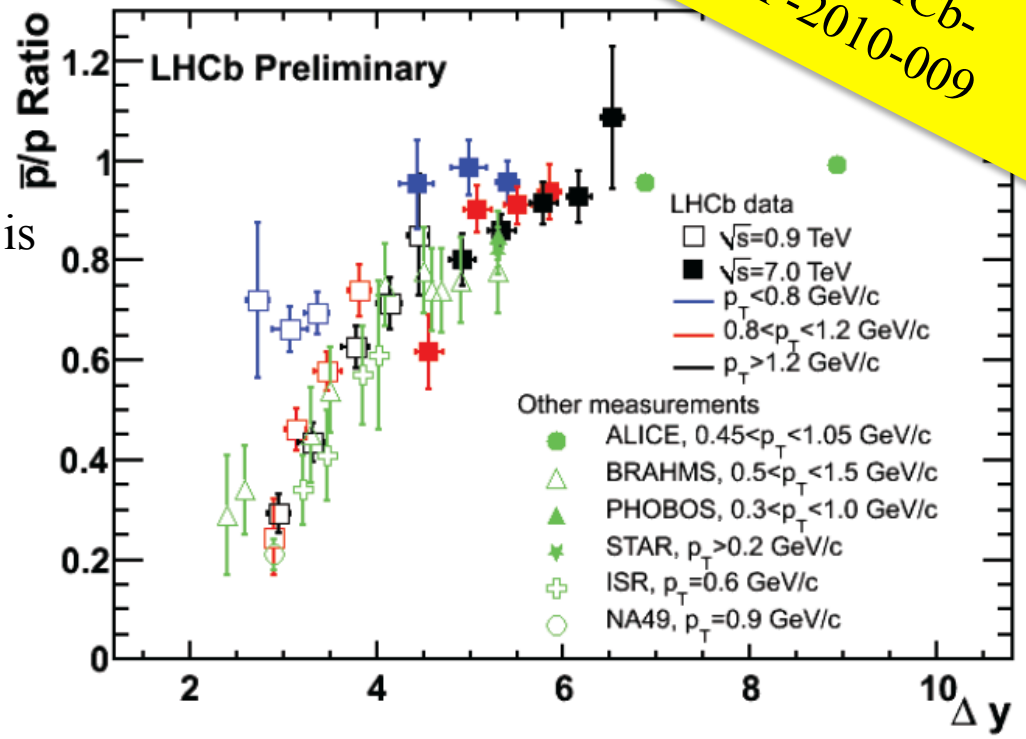
$$\Delta y = y_b - y$$

Baryon number transport with $\overline{p}/p$

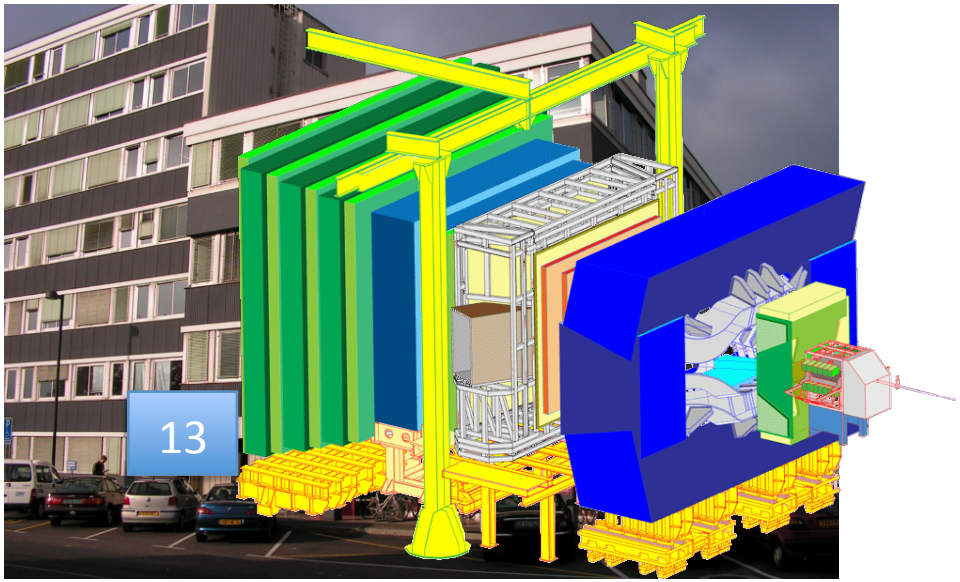
CERN-LHCb-CONF-2010-009

Observation:

Good agreement if the same P_T range is covered (high P_T).



Roma non fu fatta in un giorno ….And neither was LHCb….but….



- LHCb produced unique minimum bias physics results exploiting the unique rapidity and transverse momentum acceptance of the experiment.

- Stay tuned for coming papers:

  → Mutliplicity studies.

  → Φ production.

➜ *scaling variable for forward physics*

- Feynman's x_F

$$x_F = \frac{2p_z}{\sqrt{s}}$$

➜ *variables factorizing the Lorentz-invariant phase space element*

- transverse momentum, assuming the beam-direction along z

$$p_T = \sqrt{p_x^2 + p_y^2}$$

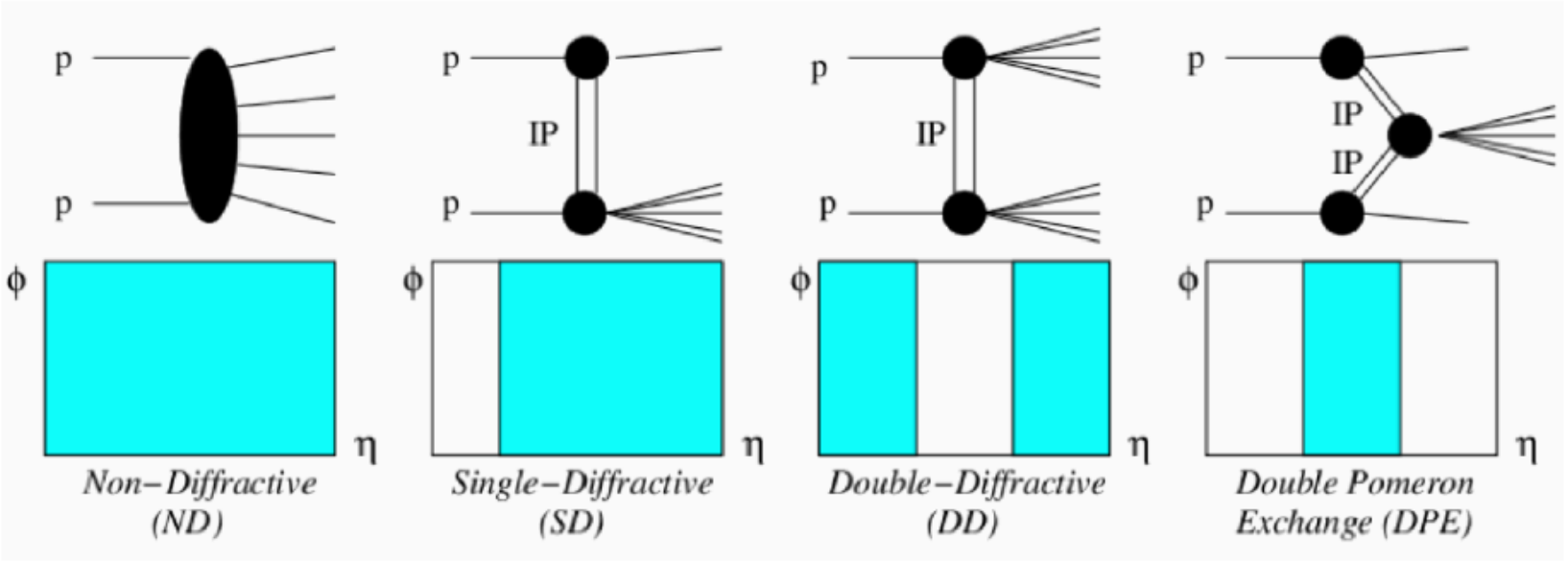
- rapidity: longitudinal variable for identified particles

$$y = \frac{1}{2} \ln \frac{E + p_z}{E - p_z}$$

- pseudorapidity: if the particle type is not known

$$\eta = \frac{1}{2} \ln \frac{p + p_z}{p - p_z} = -\ln \tan \frac{\theta}{2}$$

  ➜ kinematic dip ("seagull") in particle density around $\eta = 0$


p
p
ϕ
η
Non−Diffractive
(ND)
p
IP
p
ϕ
η
Single−Diffractive
(SD)
p
IP
p
ϕ
η
Double−Diffractive
(DD)
p
IP
IP
p
ϕ
η
Double Pomeron
Exchange (DPE)