Bundesministerium
für Bildung
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Strangeness production studies at LHCb

DIS 2011, 11.-15. April 2011, Newport News

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on behalf of the LHCb collaboration

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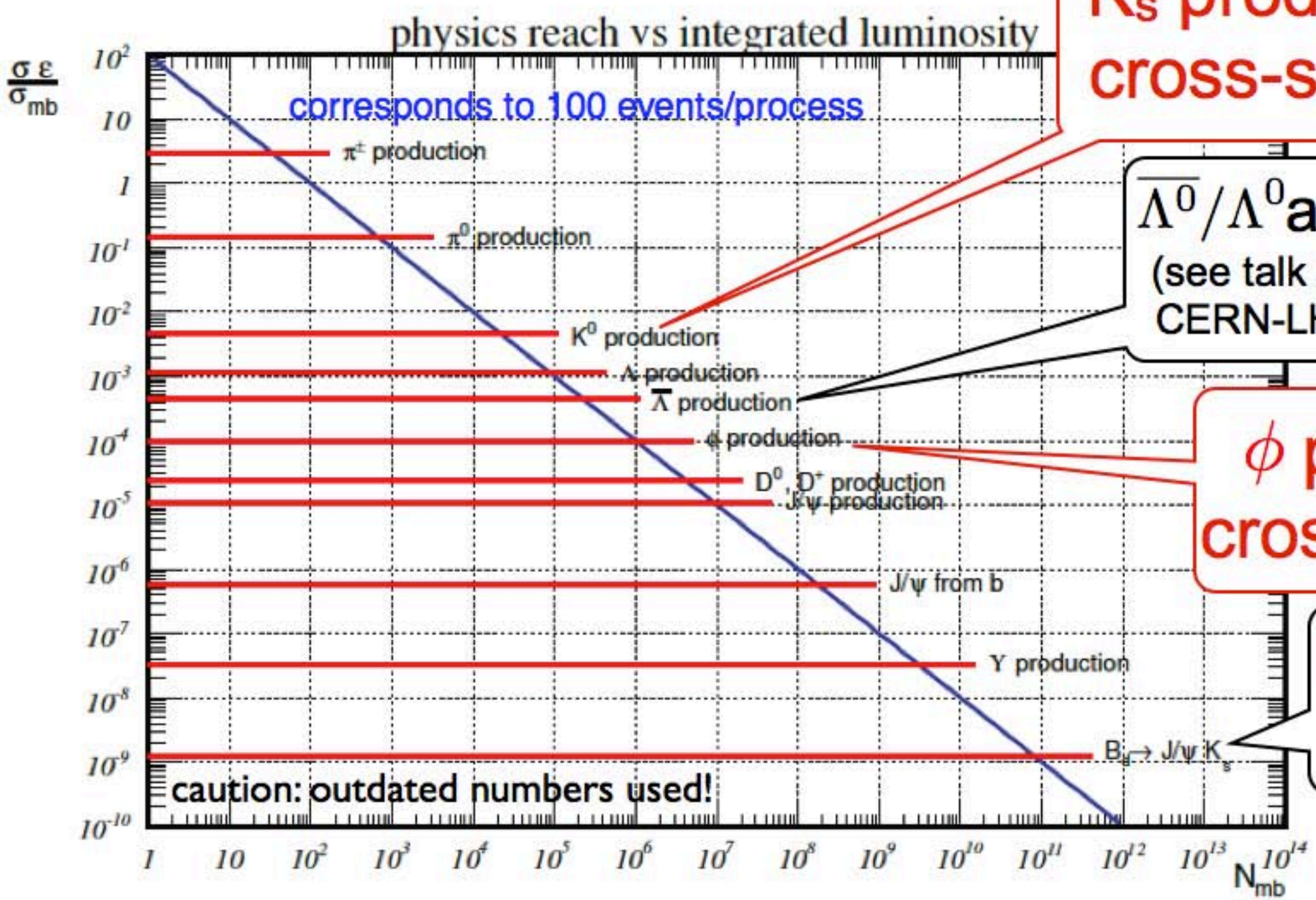
Outline



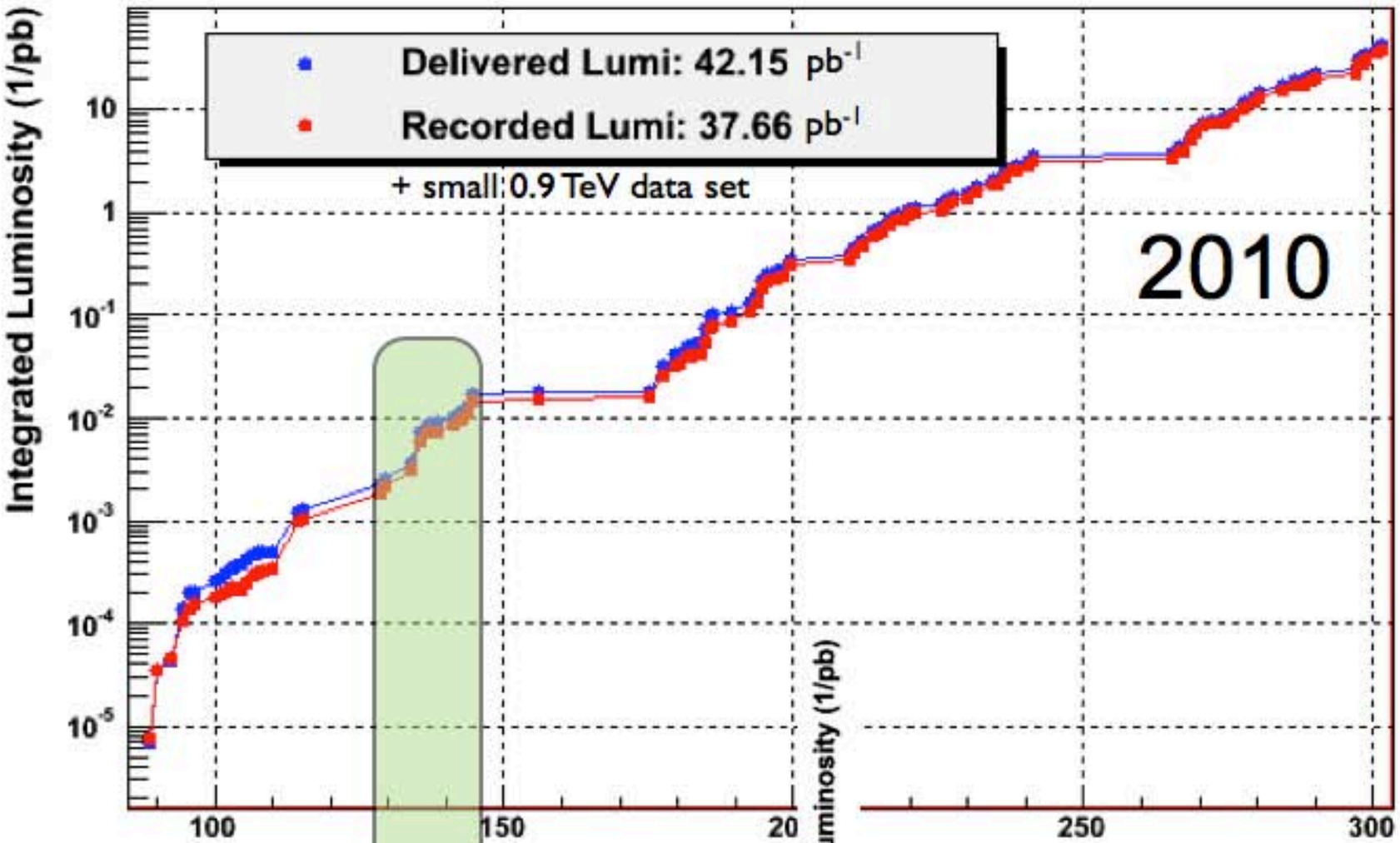
K_s production cross-section

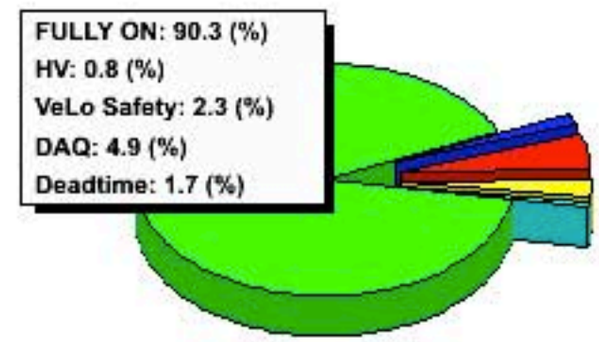
$\overline{\Lambda^0}/\Lambda^0$ and $\overline{\Lambda^0}/K_s$ ratios
(see talk by M.Adinolfi DIS2011, CERN-LHCb-CONF-2010-011)

ϕ production cross-section

Beauty 2011
(CERN-LHCb-CONF-2011-004)

LHC Luminosity

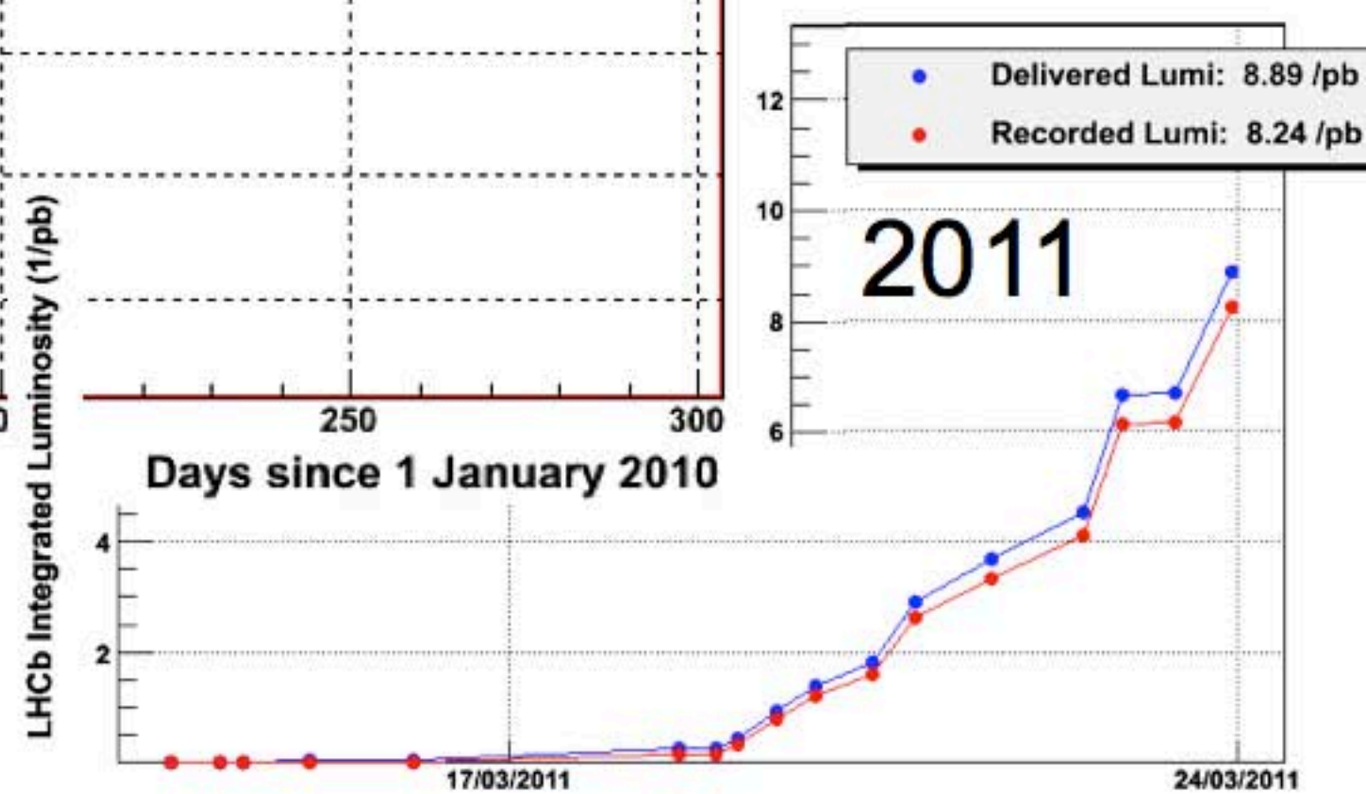




2009

7 μb^{-1} @ 0.9 TeV

14 nb^{-1} @ 7 TeV



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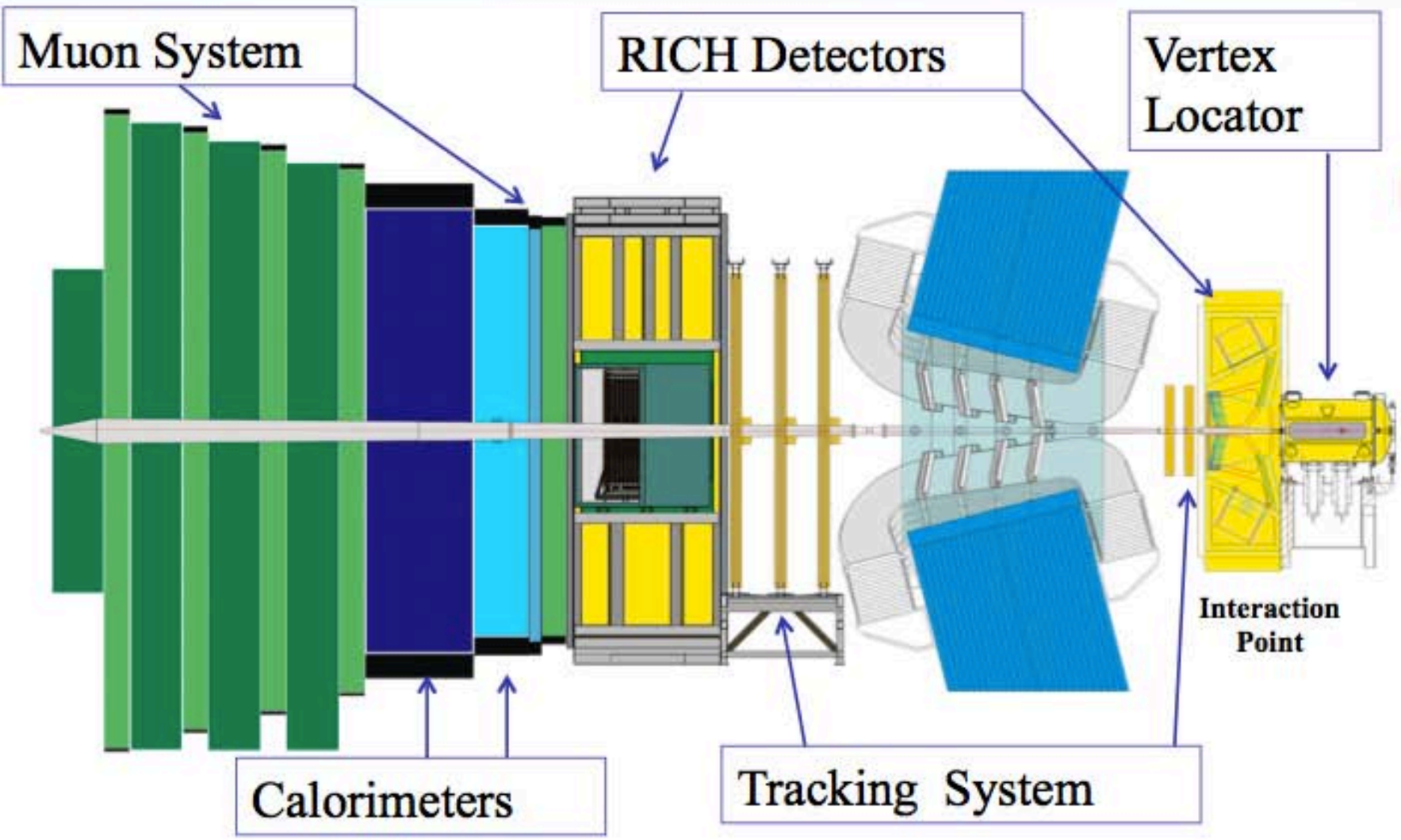
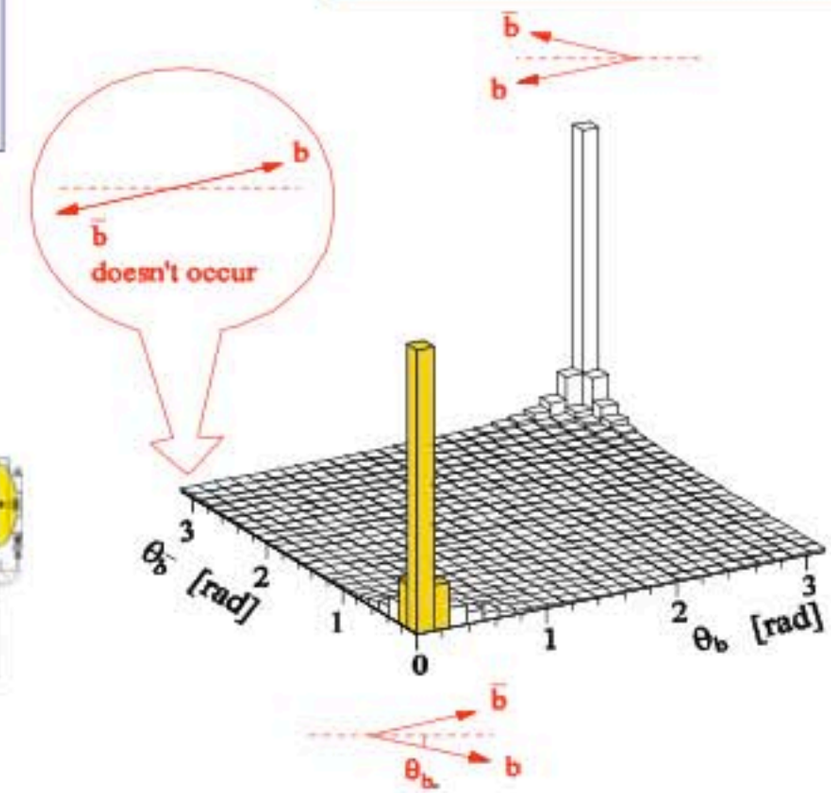
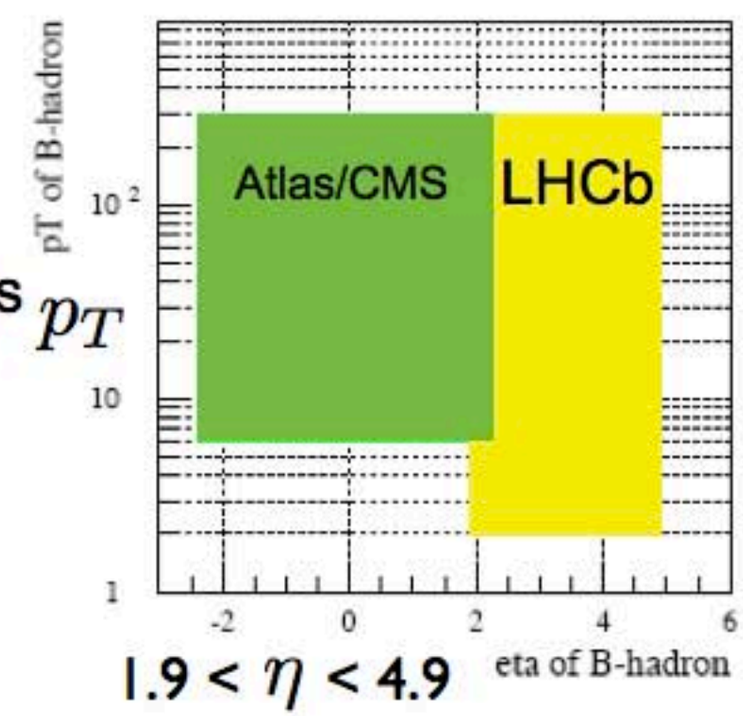
The LHCb



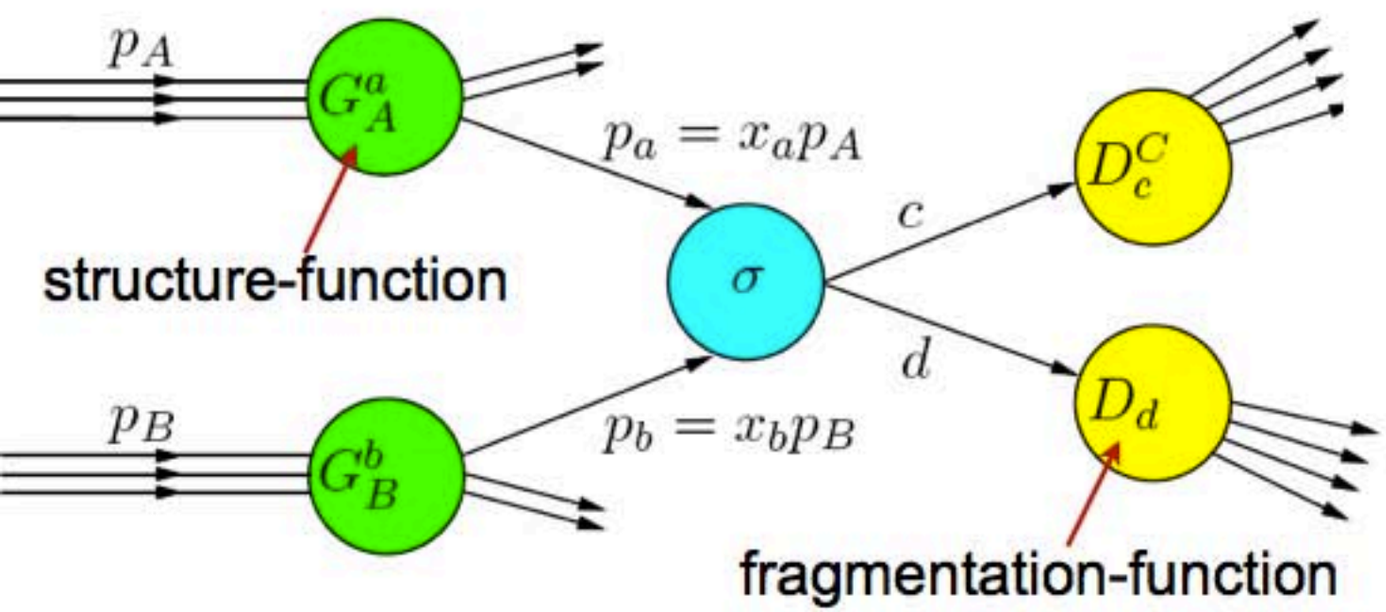




- Dedicated for precision measurements of CP violation in b-physics
- Excellent lifetime resolution (VErtex LOcator, movable device, 5mm distance to beams)
- Excellent particle identification system

Strangeness

- No valence strange quarks in initial state
- Strangeness probes fragmentation
- LEP data still has large impact on fragmentation models
- Models tuned for central rapidity and $p_T \approx 0\,\mathrm{GeV/c}$
- LHCb covers forward rapidity, and (in principle) down to $p_T > 0.4\,\mathrm{GeV/c}$



Compare to PYTHIA 6.4 simulations

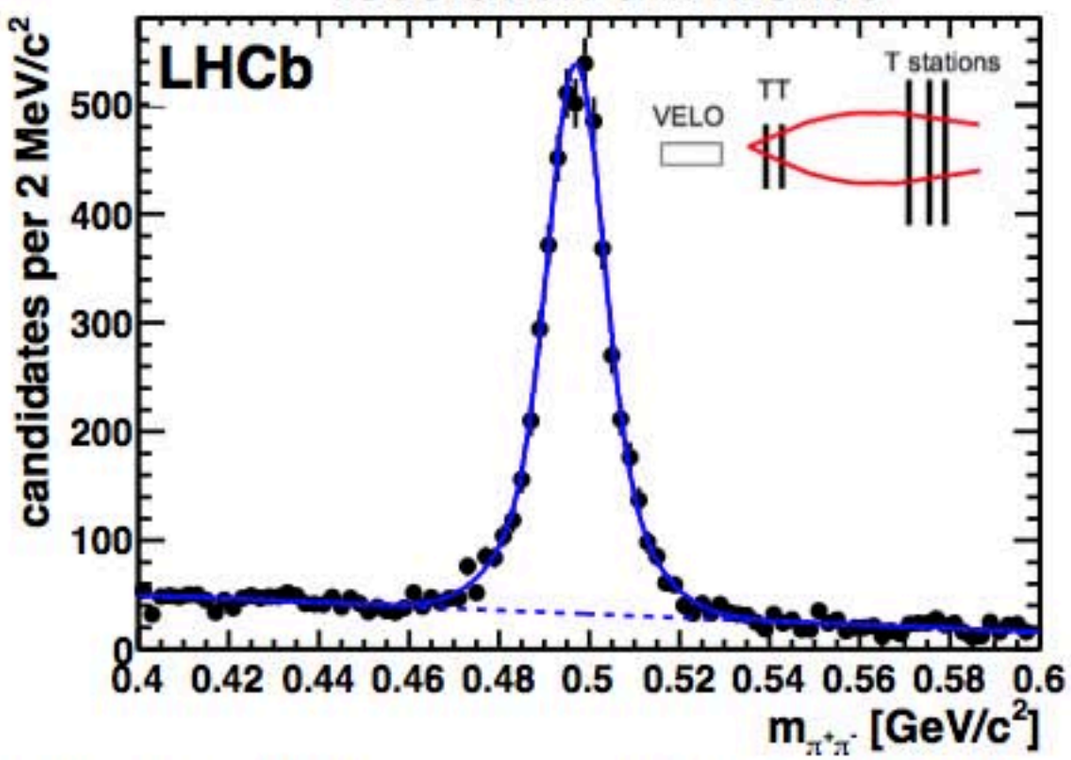
- LHCb MC [CERN-LHCb-PROC-2010-056]
- Perugia tunes [Phys. Rev. D, 82(7):074018 (2010)]

K_s production

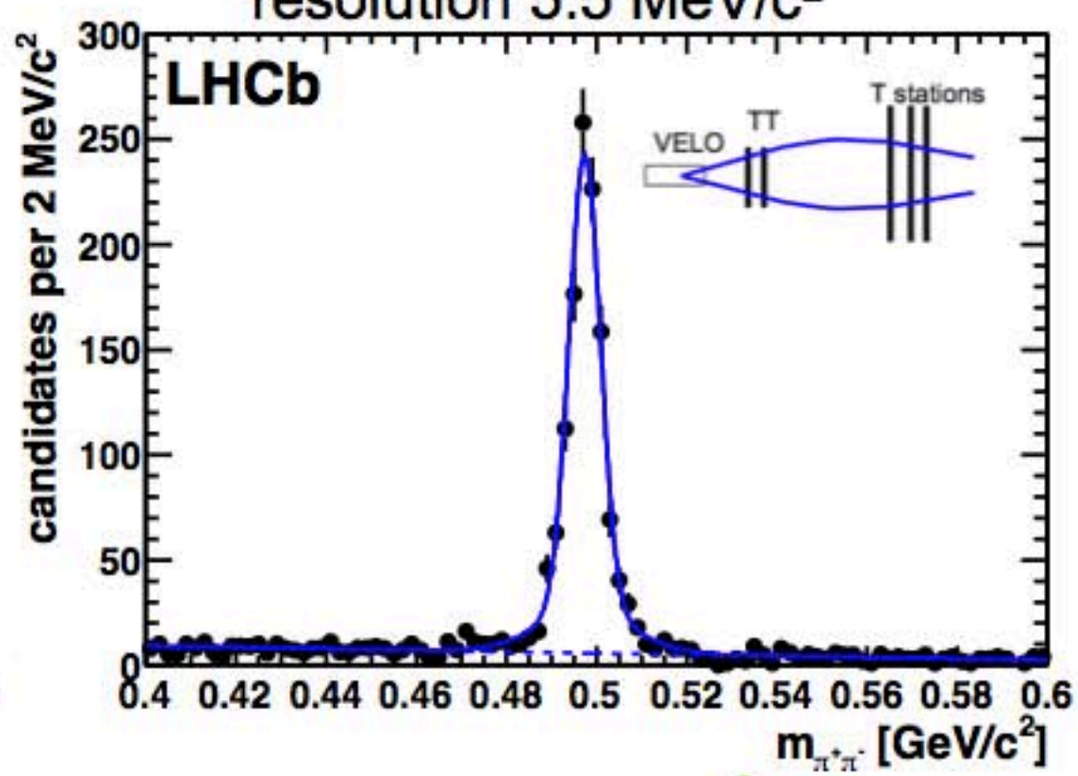
Phys. Lett. B 693 (2010) 69
arXiv:1008.3105v2

- 7 μb^{-1} @ 0.9 TeV in 2009
- Minimum Bias trigger: activity in the calorimeter
- K_s reconstructed in $K_s^0 \to \pi^+\pi^-$
- low requirements on reconstruction
- testing ground for detector understanding/calibration

downstream tracks
resolution 9.2 MeV/c^2



long tracks
resolution 5.5 MeV/c^2



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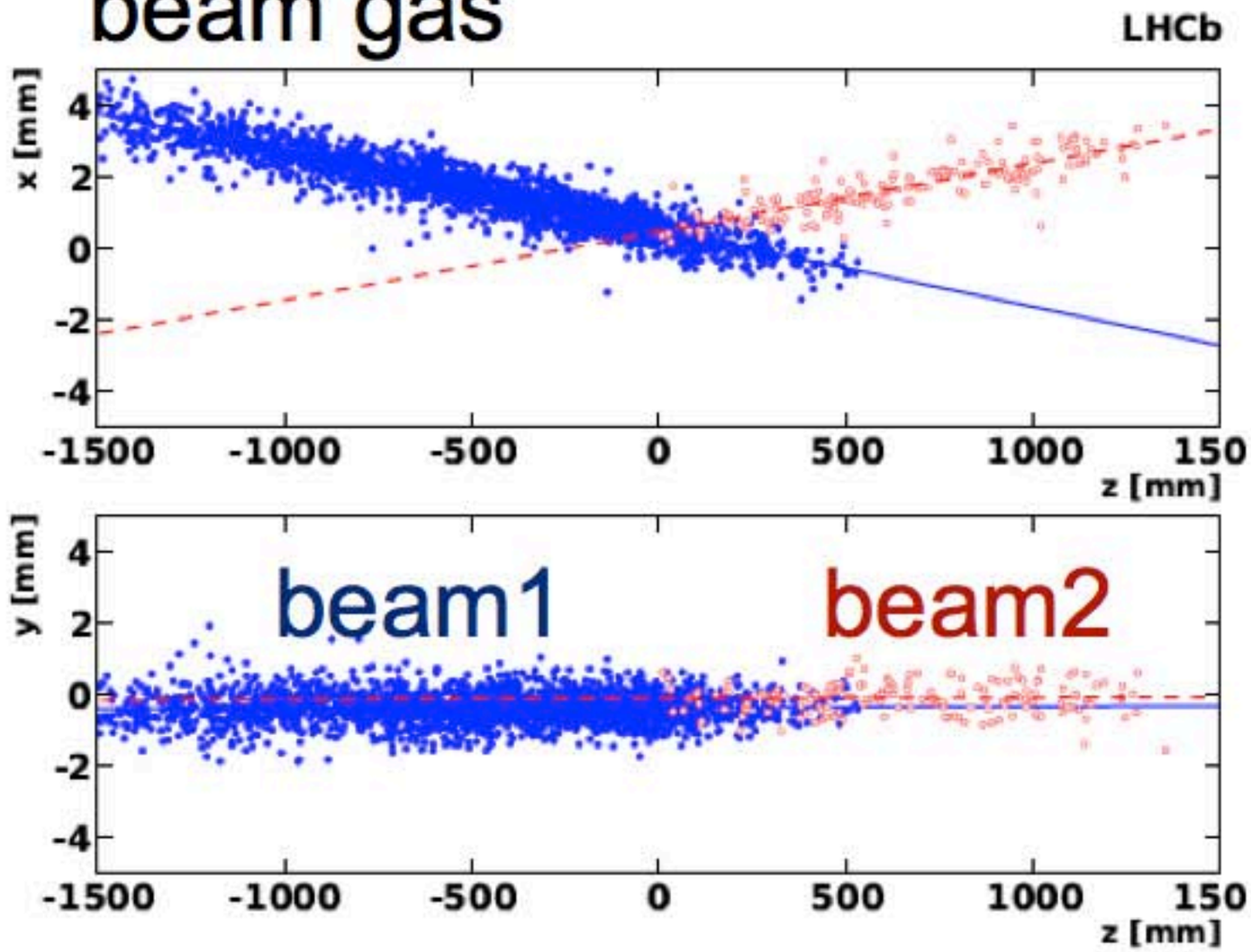
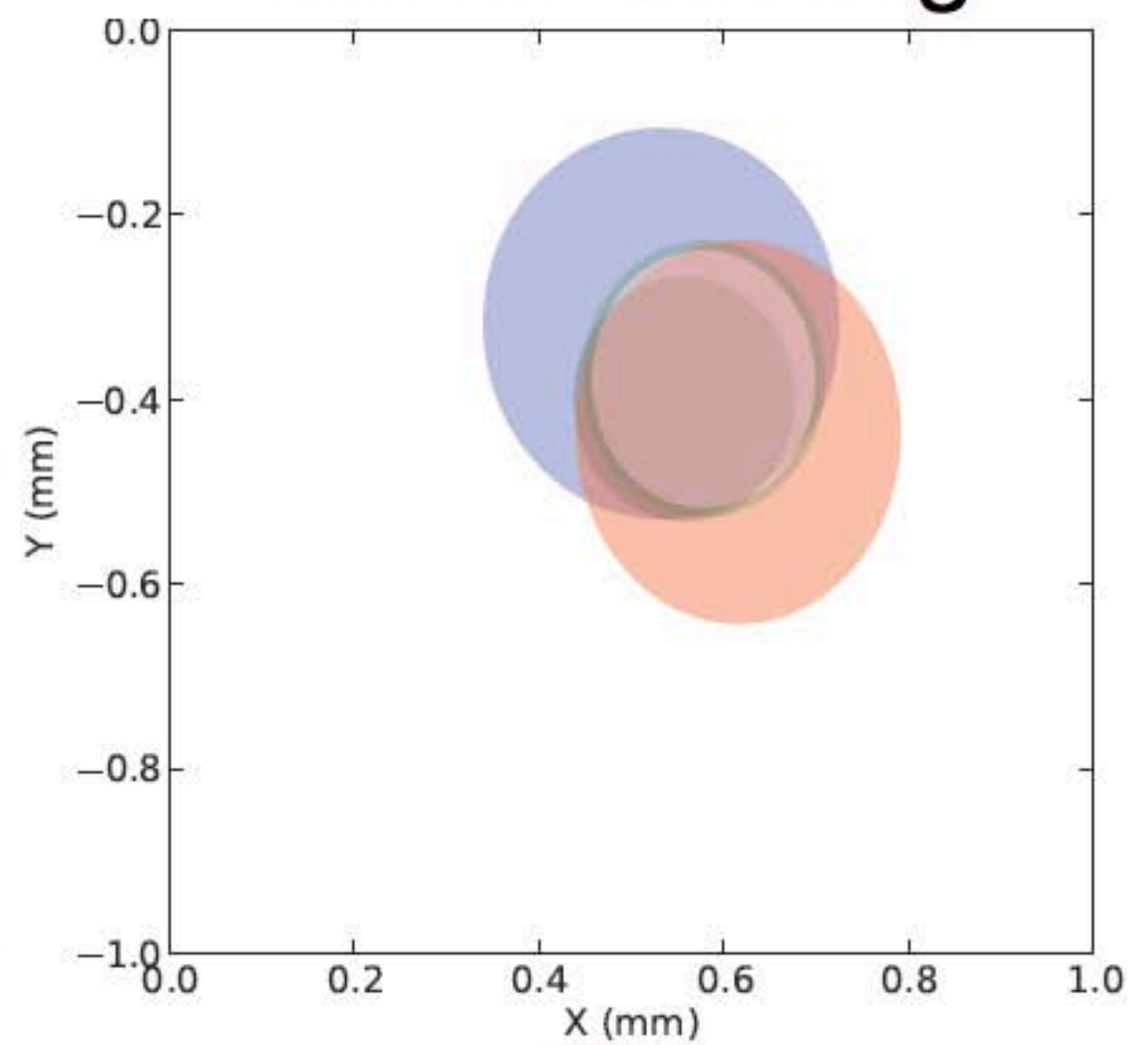
Luminosity determination for K_S production measurement

Novel absolute direct luminosity measurement from beam profiles, beam gas interaction and beam current

beam gas



beam crossing



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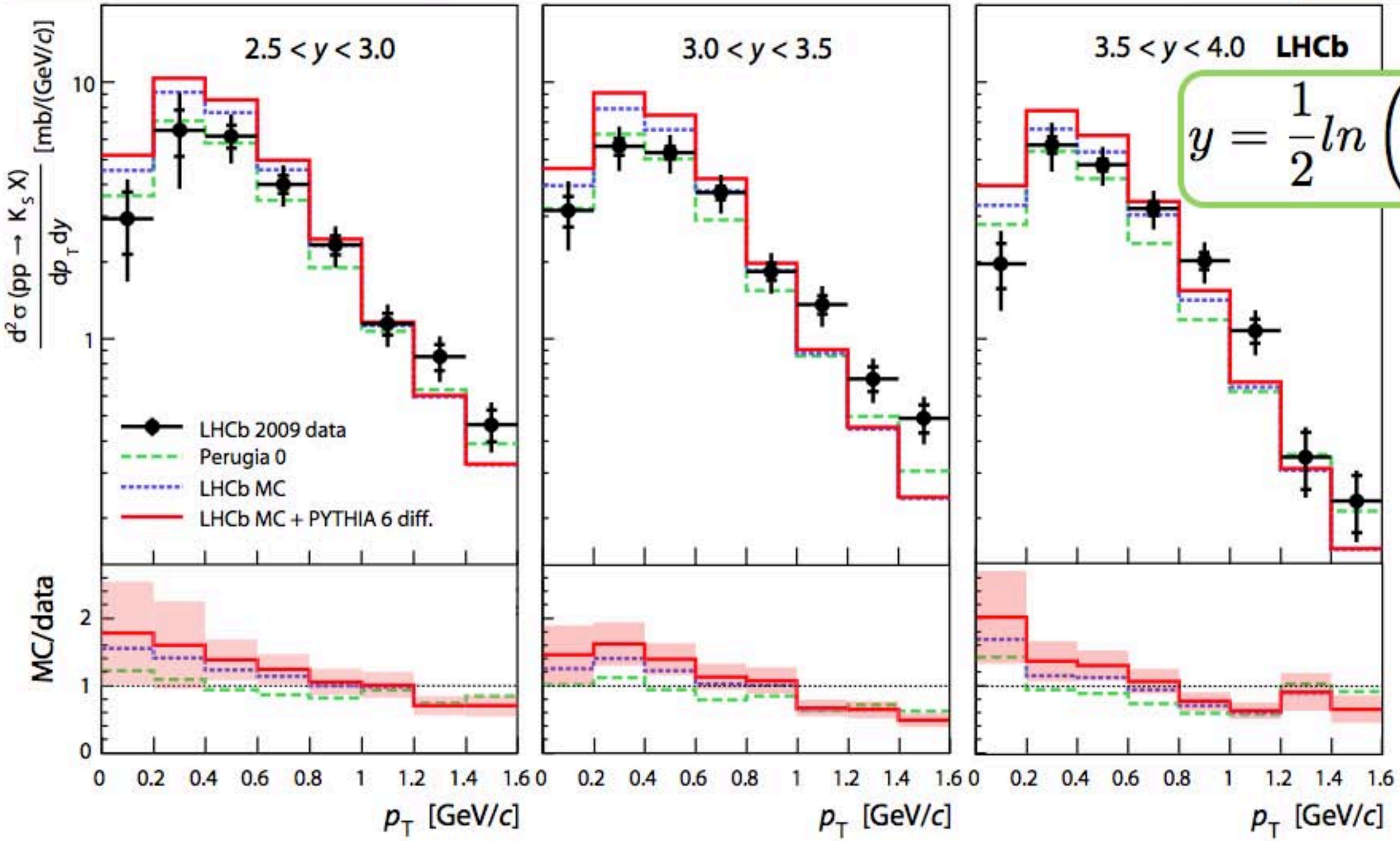
K_S spectra at $\sqrt{s} = 900\,\mathrm{GeV}$



$$y = \frac{1}{2} ln \left(\frac{E + p_z}{E - p_z} \right)$$

- harder p_T spectrum in data than MC

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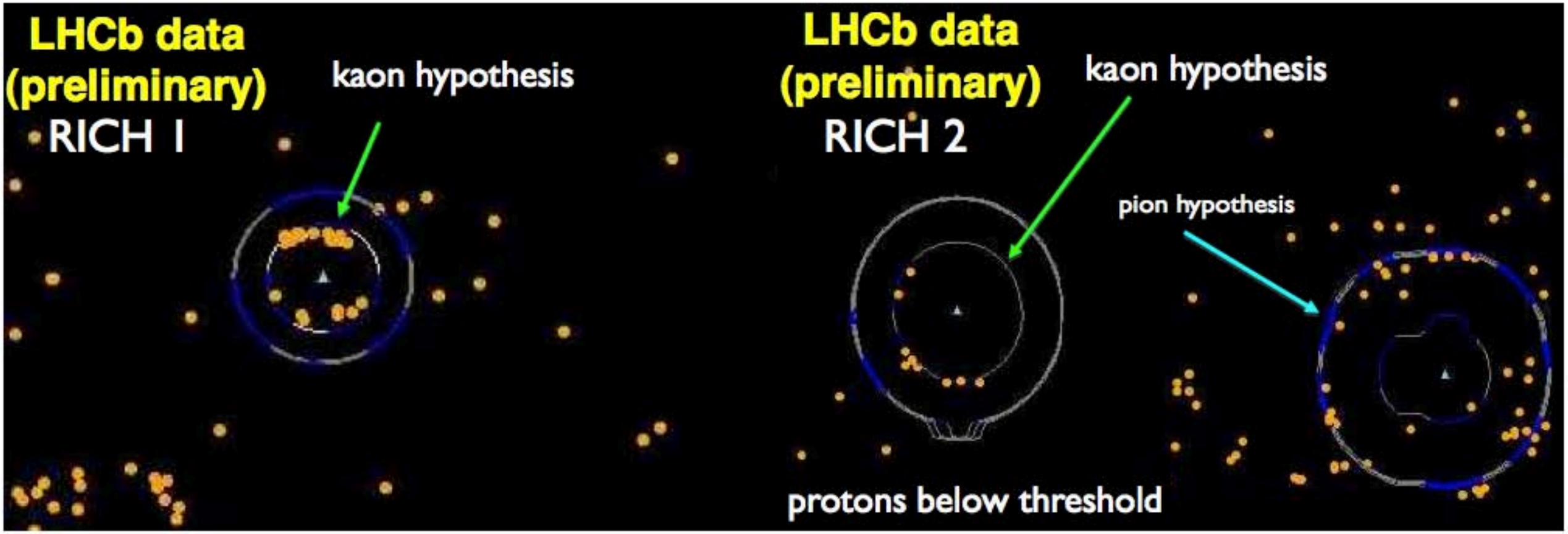
ϕ production cross-section

CERN-LHCb-CONF-2010-014

- Test for strangeness production at $\sqrt{s} = 7\,\mathrm{TeV}$
- Study RICH PID system



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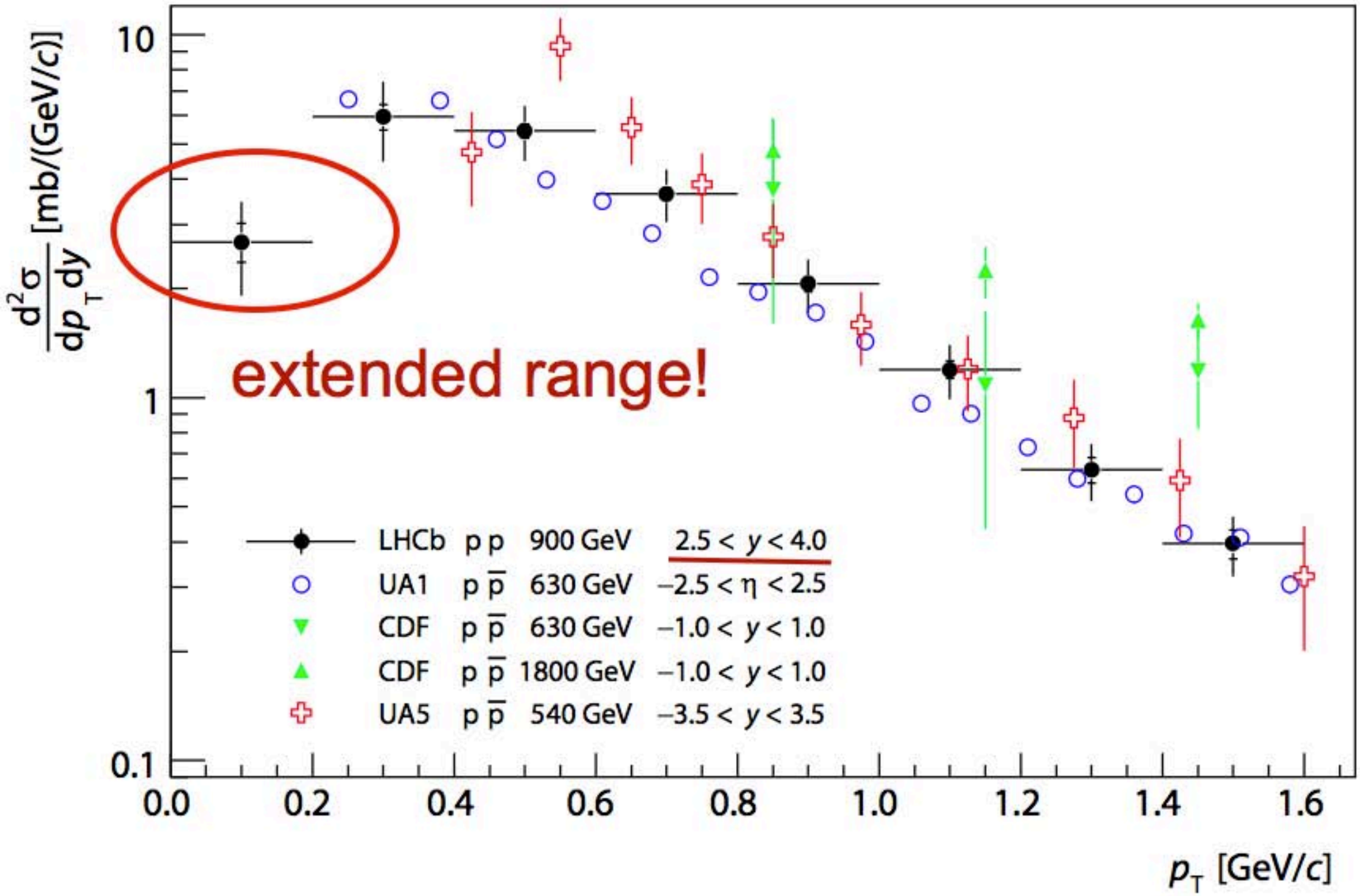
Comparison K_s production with other experiments



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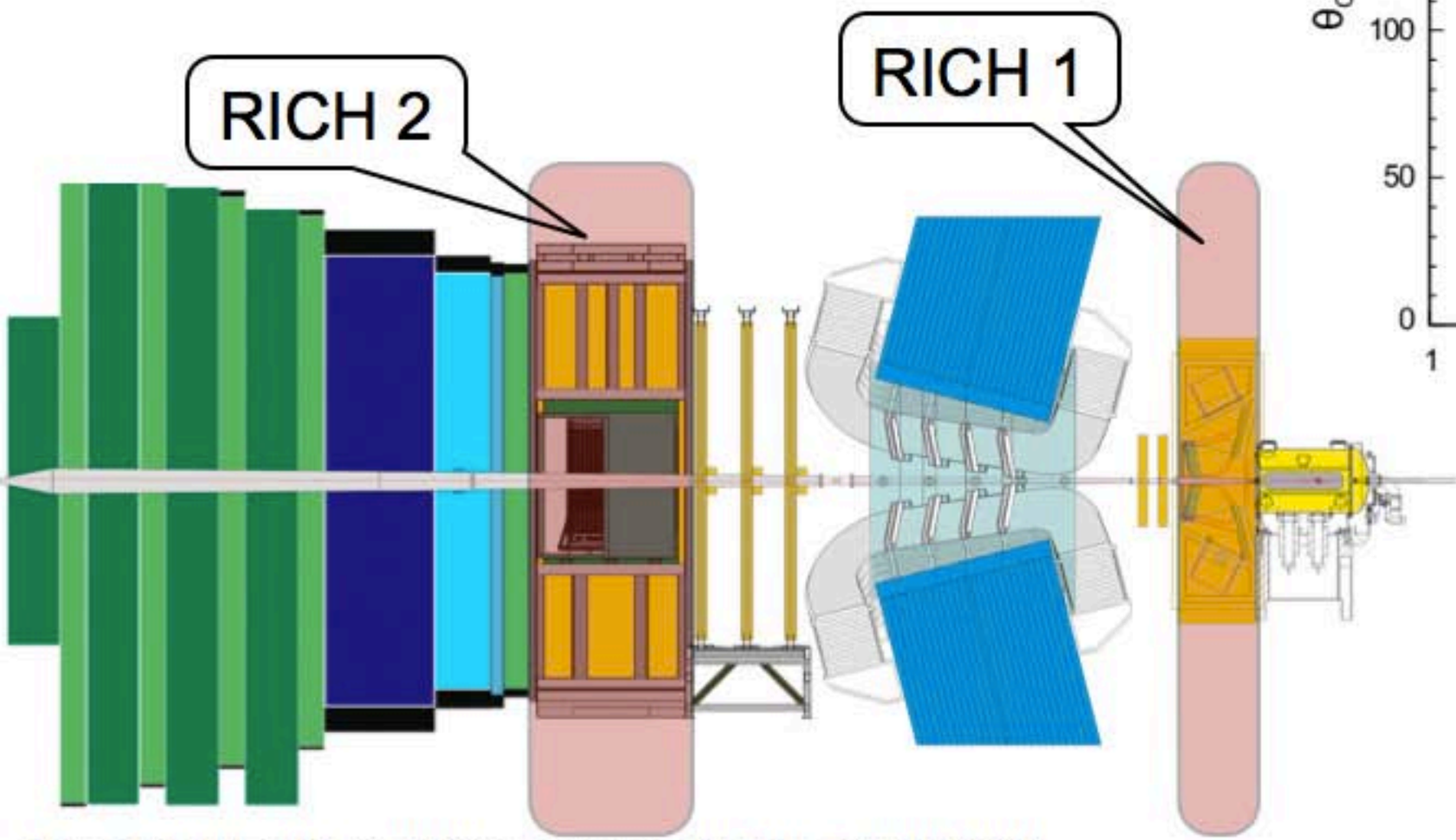
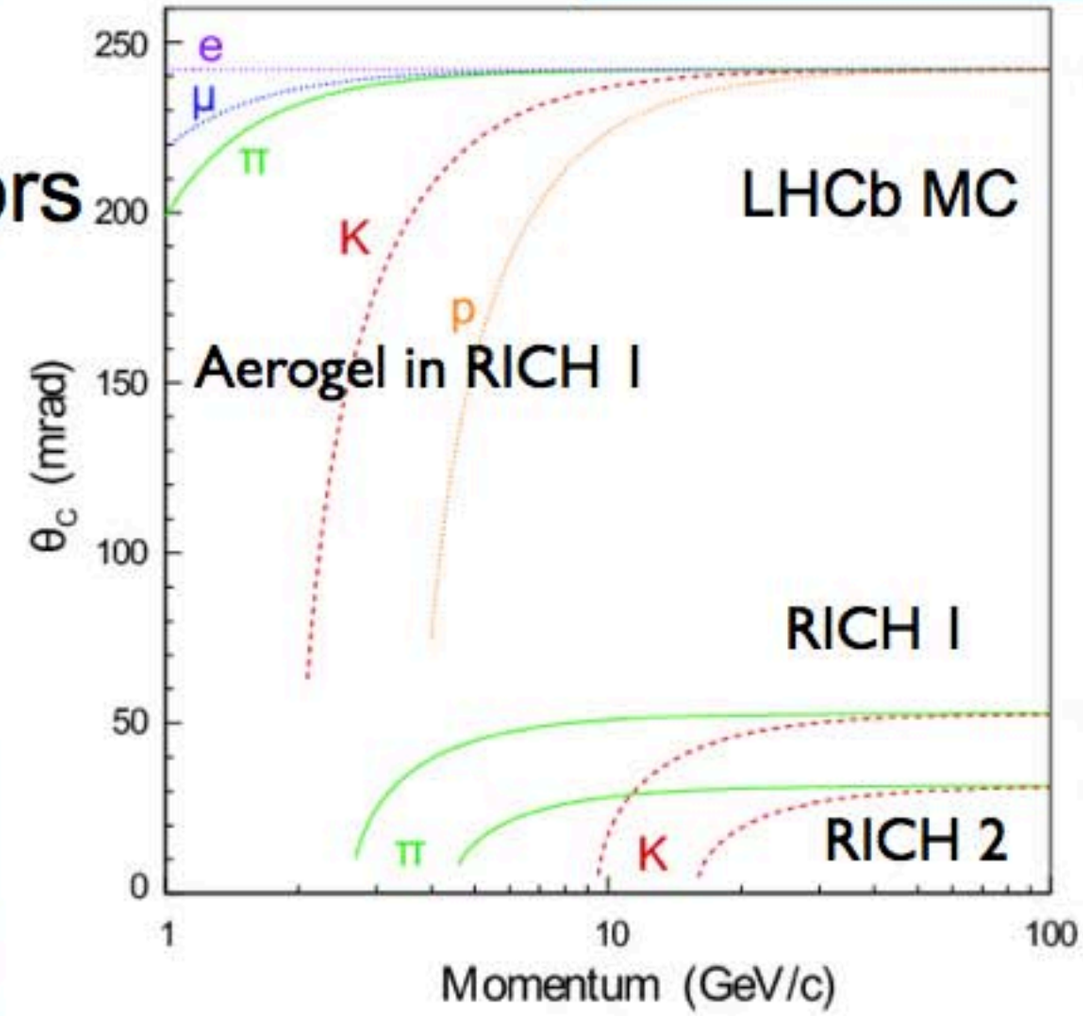
Particle Identification

- 2 Ring Imaging Cherenkov Detectors
- 3 radiators covering wide momentum range





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ϕ analysis strategy

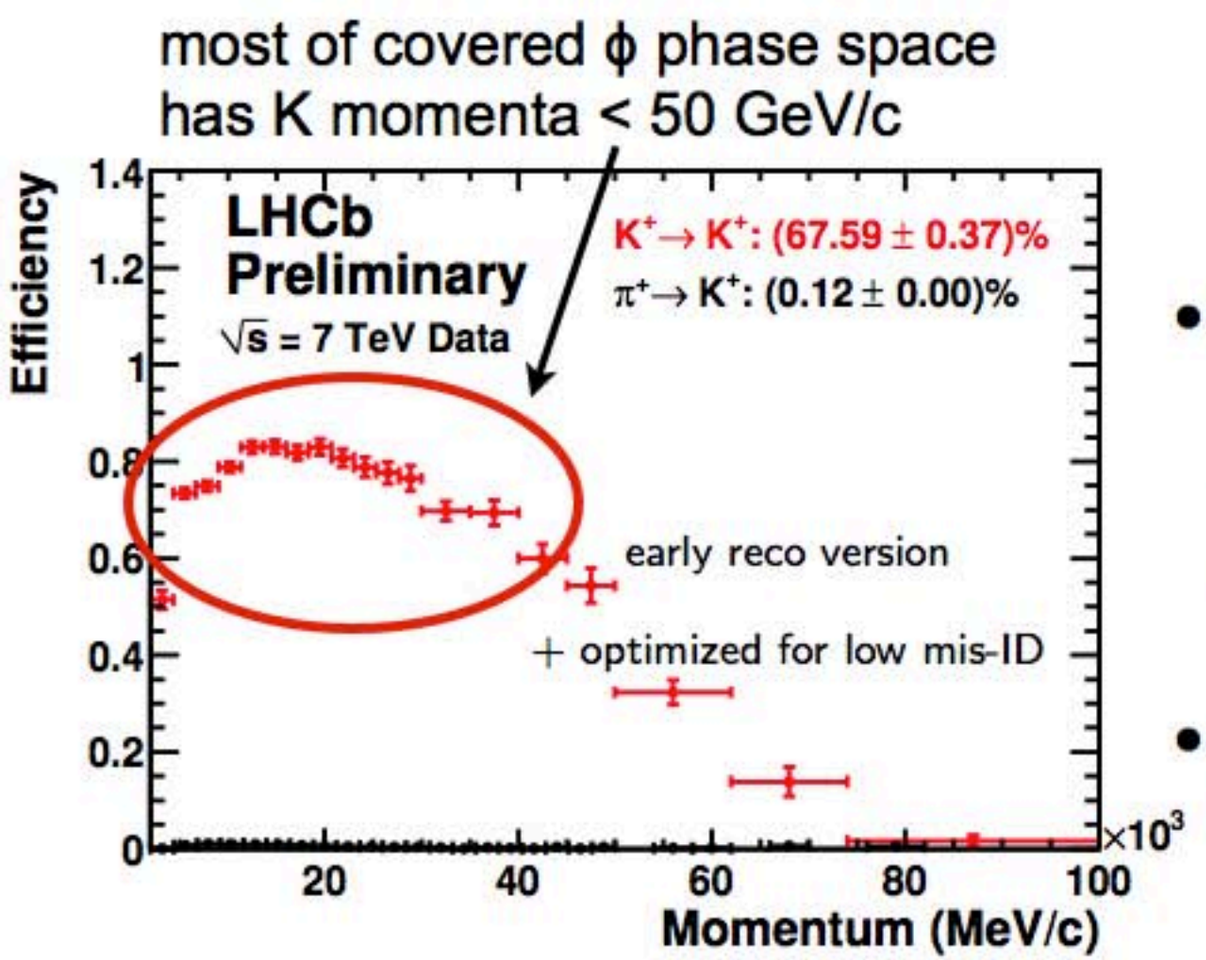
Measure ϕ production cross section in bins of rapidity y and p_T (15x15):

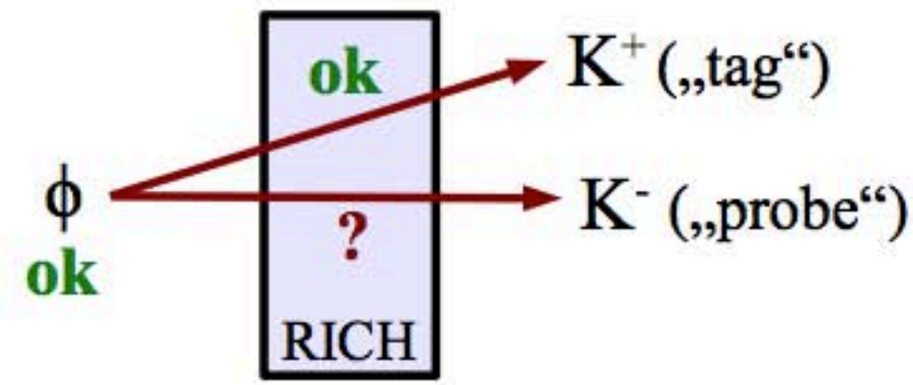
$$\sigma = \frac{N}{\mathcal{L} \cdot \epsilon \cdot \mathcal{B}(\phi \to K^+K^-)}$$

- Minimum Bias trigger: requires 1 VELO track
- Low-bias selection: long tracks + PID
- Separate reconstruction eff. (MC) from PID eff. (data)
- Signal extraction with maximum likelihood fit

PID efficiency

Determine PID efficiency on data with tag and probe





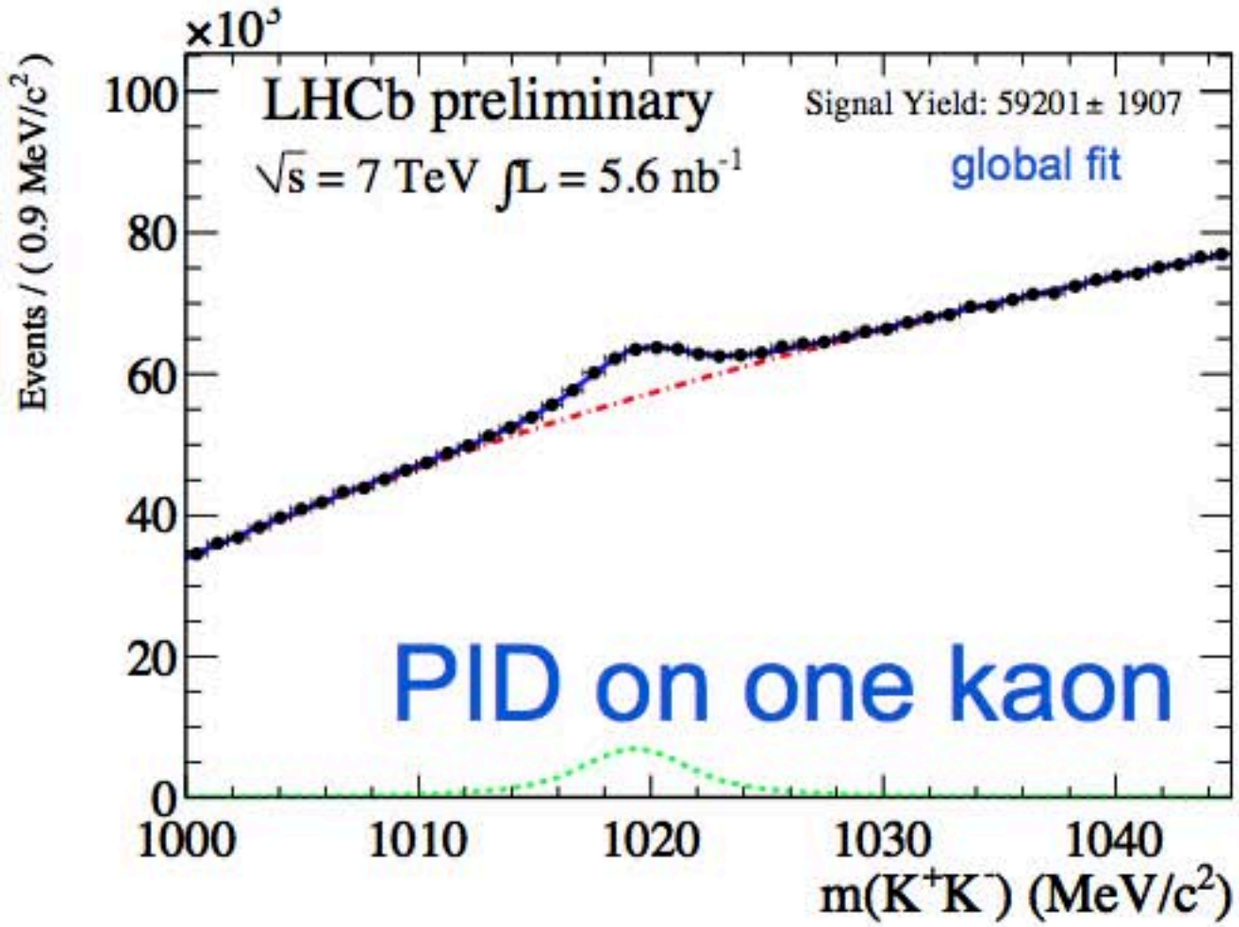
- tag: apply PID on at least one kaon

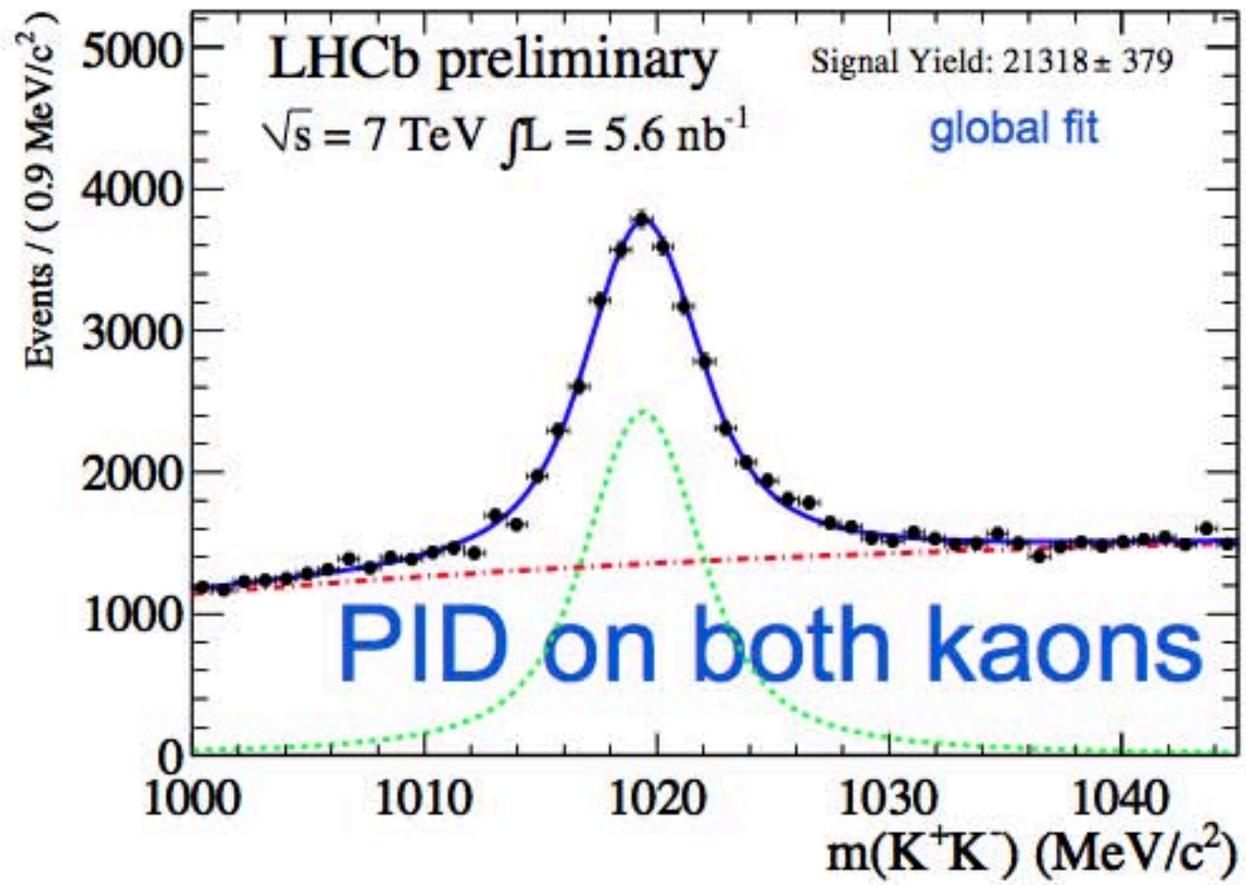
  probe: apply PID on both kaons

- fit both tag and probe samples

$$\varepsilon^i_{\text{pid}} = 1 - \left(\frac{N^i_{\text{tag}} - N^i_{\text{probe}}}{N^i_{\text{tag}} + N^i_{\text{probe}}} \right)^2$$

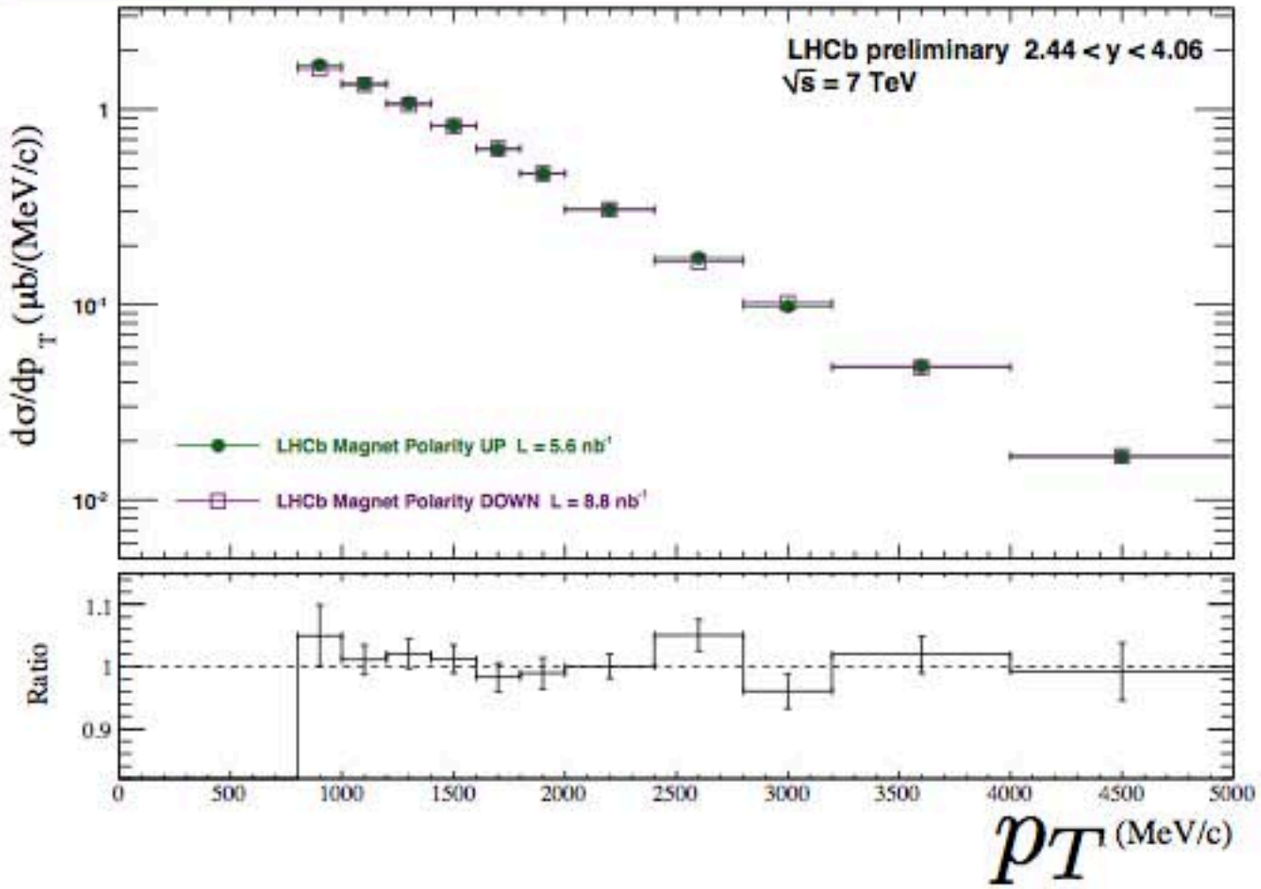
Signal extraction

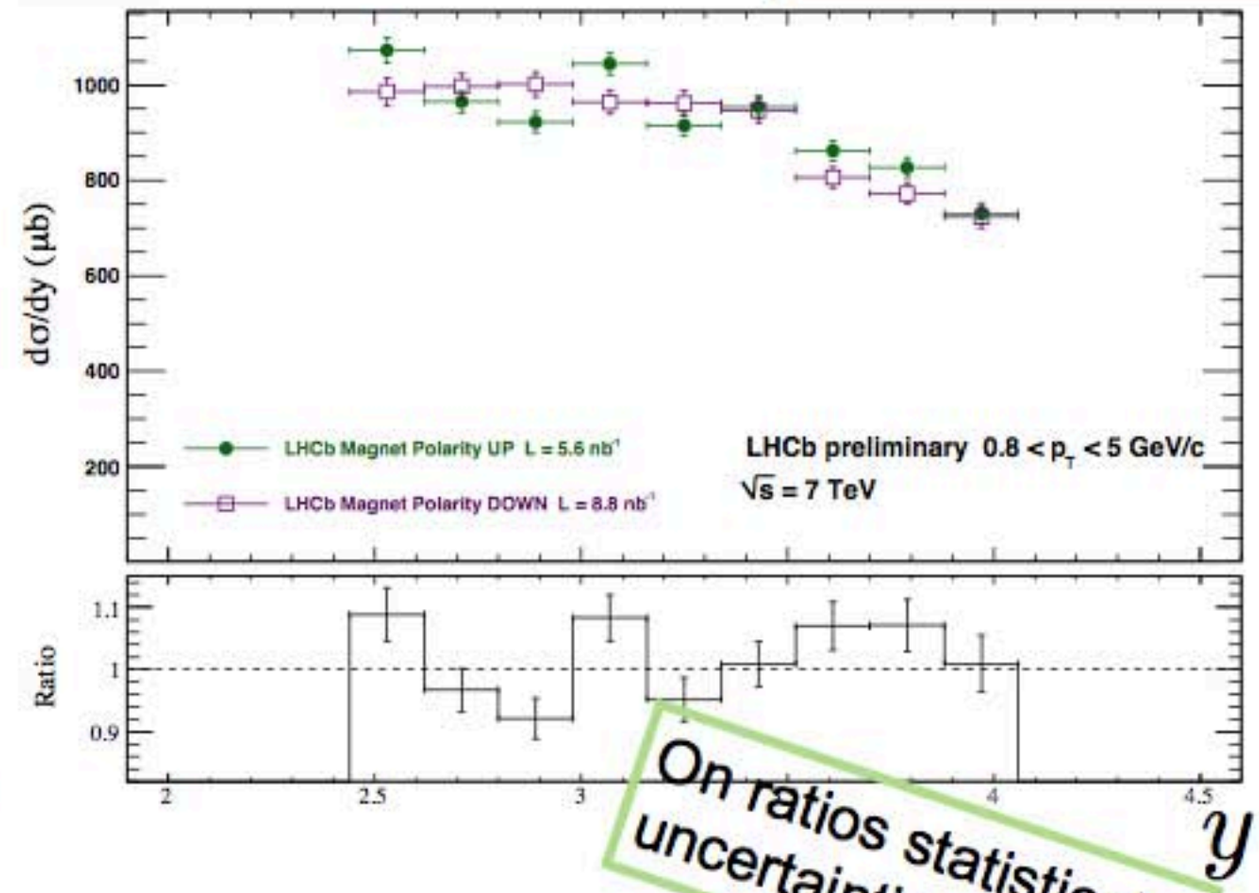




- Signal: Breit-Wigner shape ⊗ Gaussian resolution
- Background: 3rd grade polynomial

ϕ analysis: magnet polarities





On ratios statistical uncertainties only

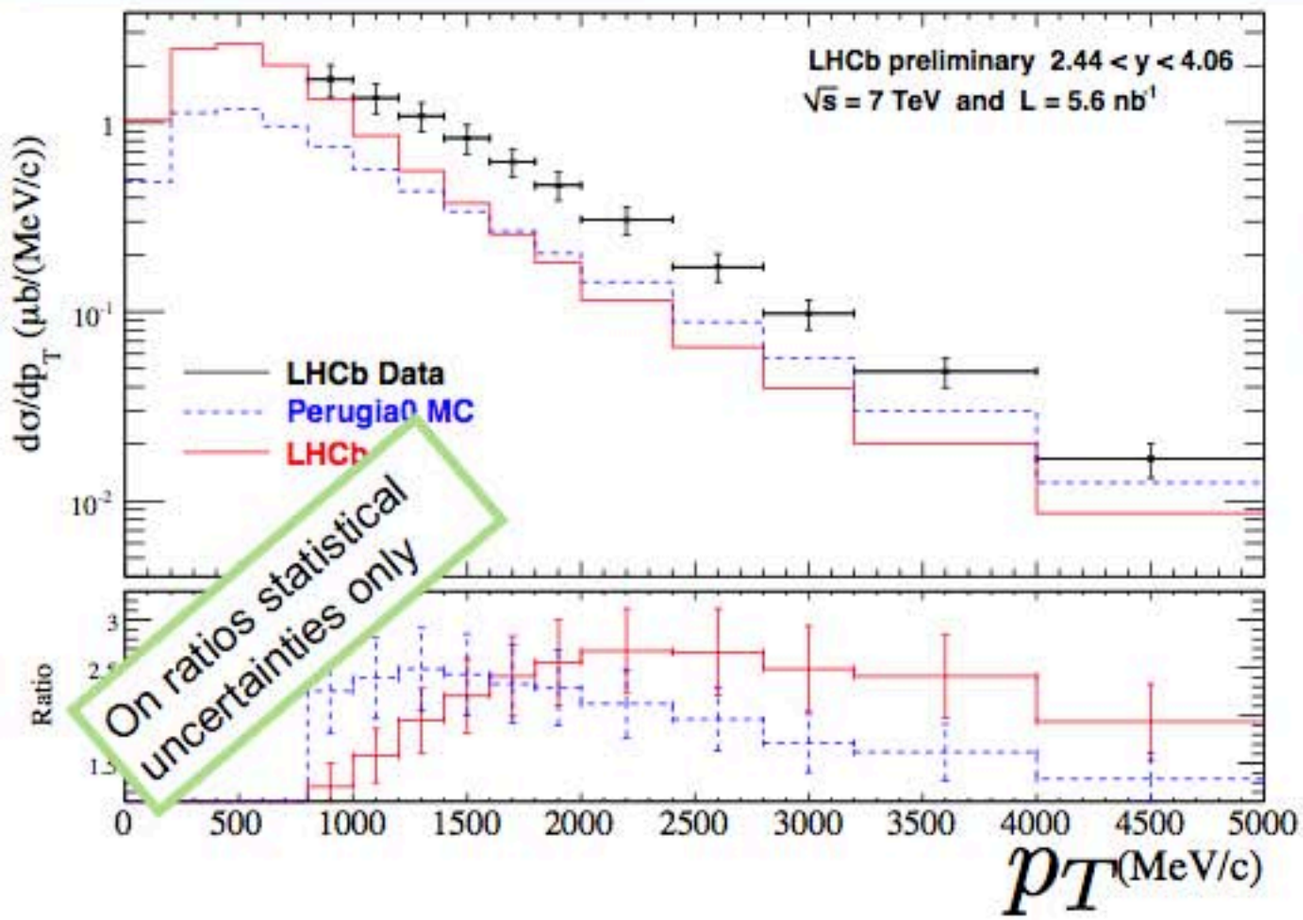
- LHCb magnet polarity can be inverted
- PID needs to be calibrated independently
- Analysis is done independently on both data sets
- The results agree well: PID calibration is well understood

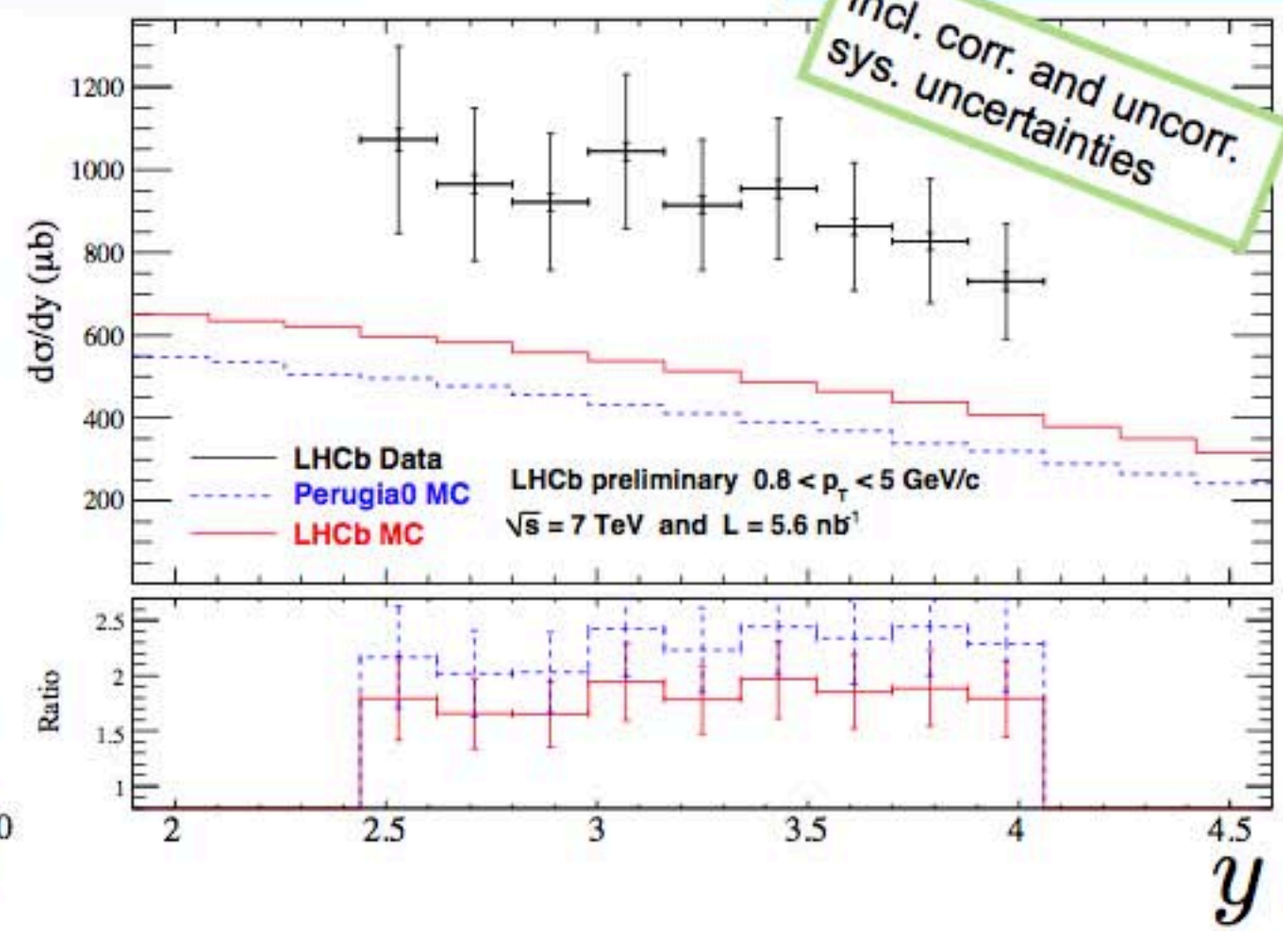
Systematics

Source		(%)	range (%)
Luminosity (normalization)		10.0	
Tracking efficiency		8.0	
Track multiplicity		5.0	
Monte Carlo association		2.0	
PID	binned	≈ 3	1–14
Reconstruction	binned	≈ 2	1–6
Branching ratio		1.2	
Doubly identified candidates		1.0	
Total		14.4	14–20

Measurement is systematically limited

preliminary Results





- summed cross section:

bin-dependent global

$$\sigma(pp \to \phi X) = (1493 \pm 12(\text{stat}) \pm 12(\text{uncorr.syst}) \pm 209(\text{corr.syst}))\ \mu\text{b}$$

- MC generator underestimates ϕ production

$y \in [2.44, 4.06]$

$p_T \in [0.8, 5.0]\ \text{GeV/c}$

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Conclusion

LHCb investigates the strangeness production in pp collisions in a unique rapidity range with first data:

- K_s production at $\sqrt{s} = 900\,\mathrm{GeV}$
- ϕ production at $\sqrt{s} = 7\,\mathrm{TeV}$

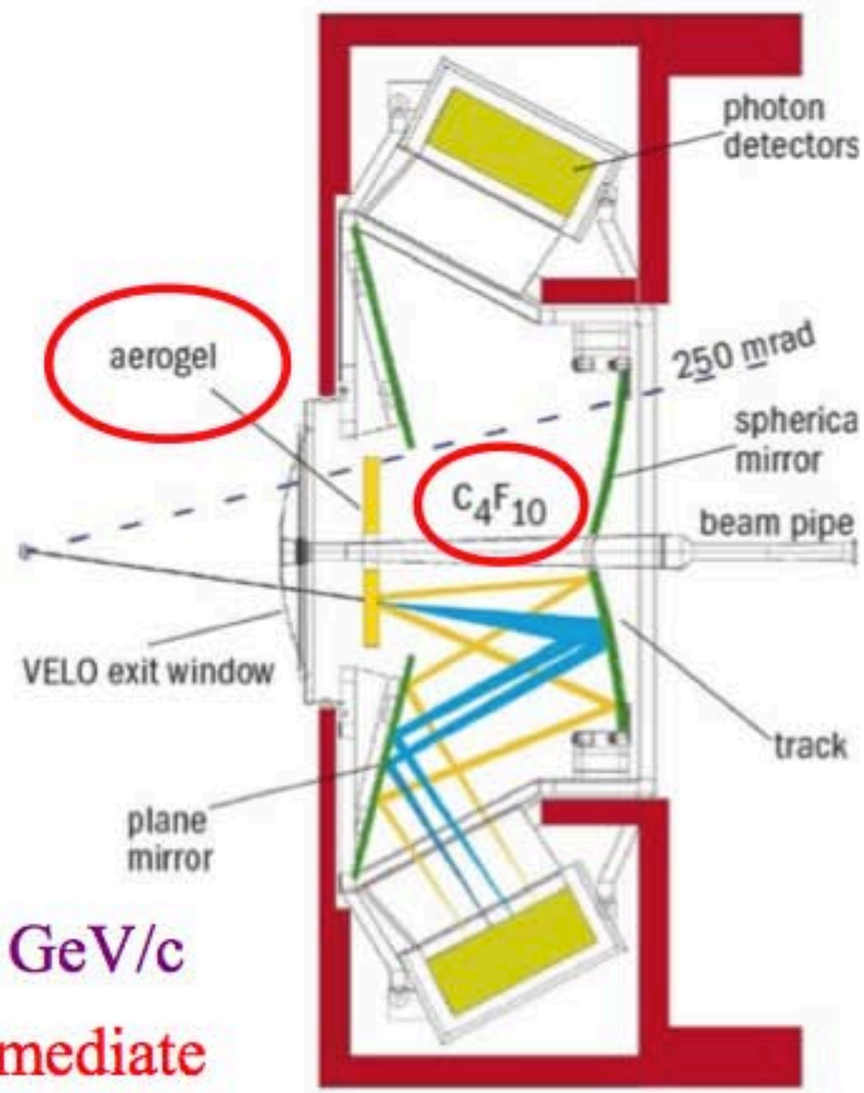
- p_T spectra for K_s production tend to be harder than predicted
- MC generator underestimates ϕ production in the considered kinematic range
- Input for QCD models and MC tuning

Backup RICH 1+2

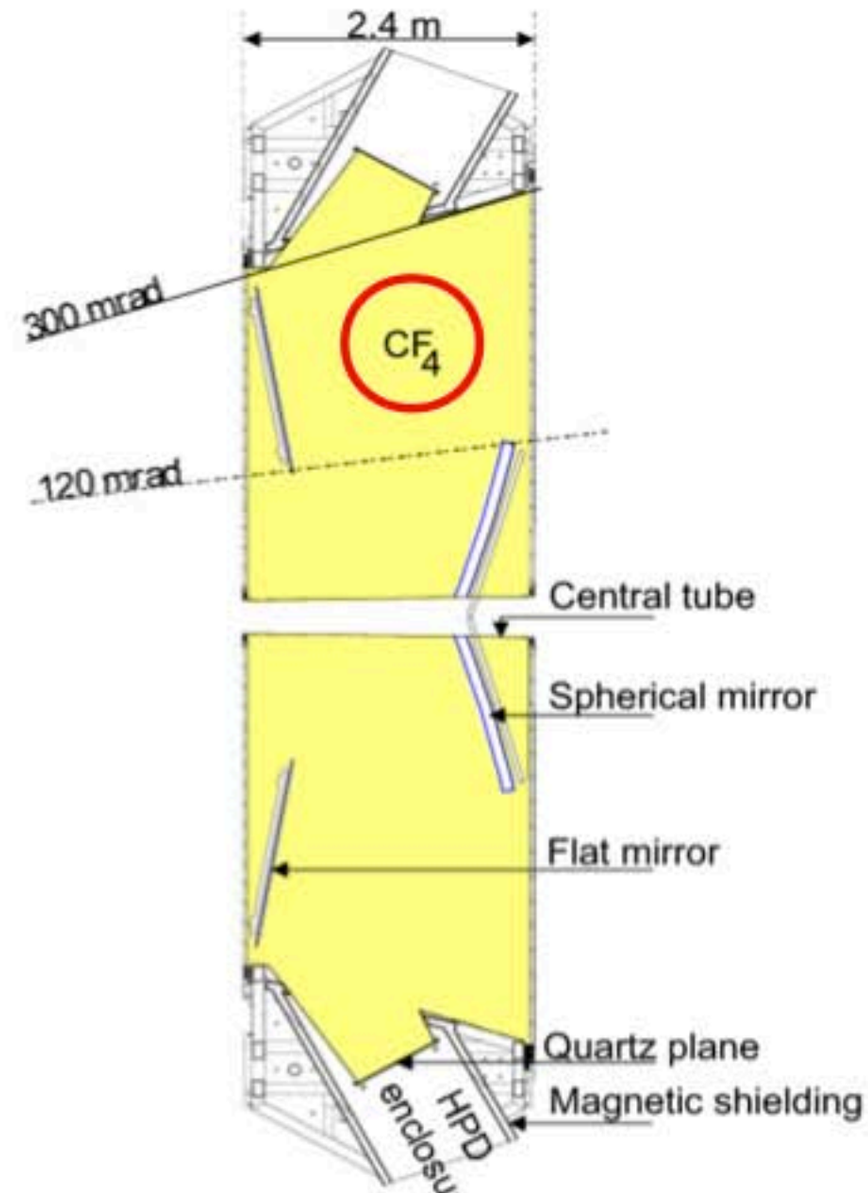
$$\cos\theta_c = \frac{1}{\beta n}$$

- Aerogel, n = 1.03, p < 10 GeV/c
- C4F10, n = 1.0014, p intermediate
- CF4, n = 1.0005, p > 20 GeV/c

[comparison: Air, n = 1.0003]



RICH 1
(side view)

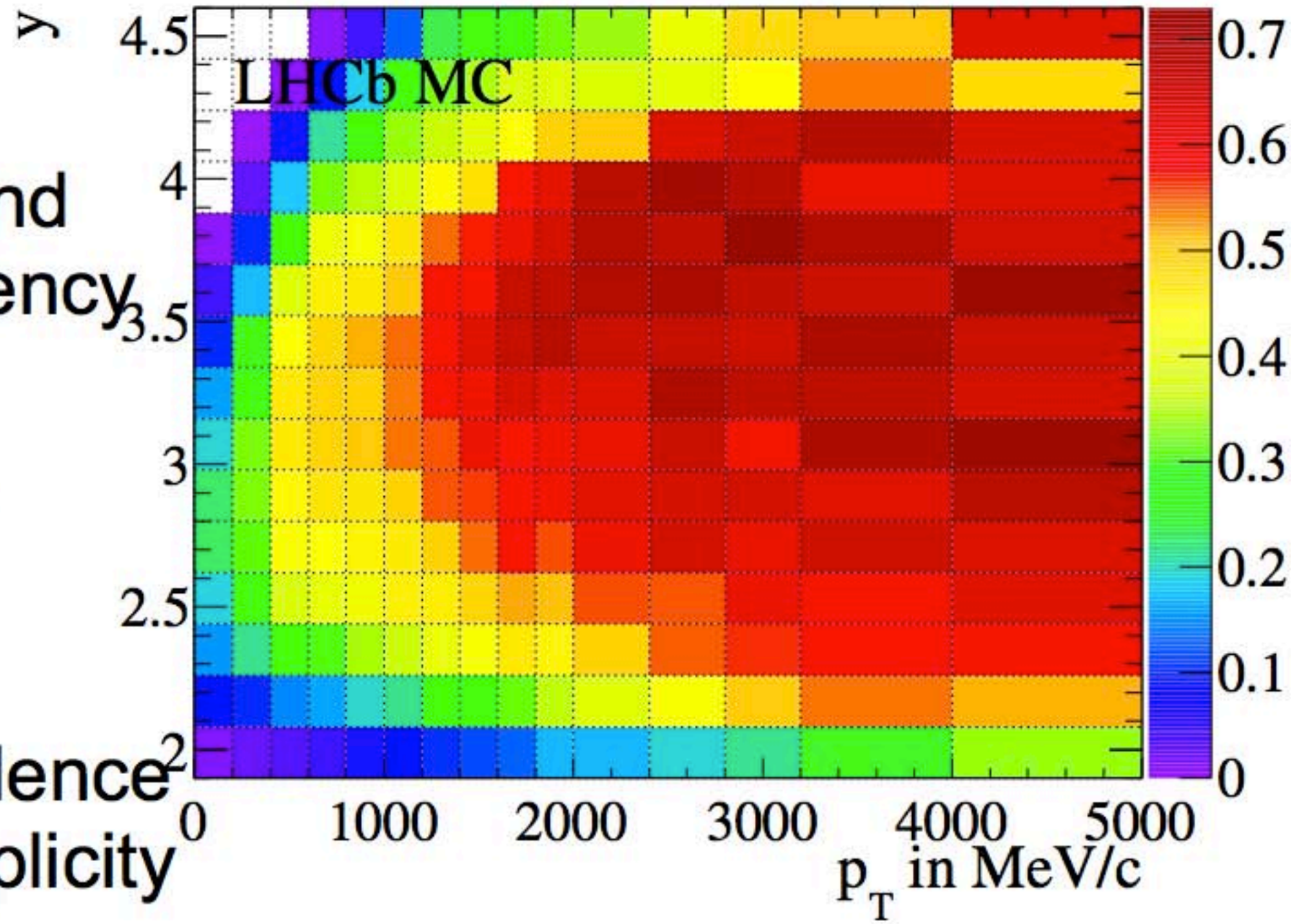


RICH 2
(top view)

Reconstruction efficiency

- Detector acceptance and tracking efficiency from MC:

$$\varepsilon^i_{\text{reco}} = \frac{N^i_{\text{sel,true}}}{N^i_{\text{gen}}}$$



- Weak dependence on track multiplicity

Backup MC parameters

- LHCb MC is based on PYTHIA 6.421

parameter	value	parameter	value
CKIN(41)	3.0	PARP(86)	0.66
MSTP(2)	2	PARP(89)	14000
MSTP(33)	3	PARP(90)	0.238
MSTP(81)	21	PARP(91)	1.0
MSTP(82)	3	PARP(149)	0.02
MSTP(52)	2	PARP(150)	0.085
MSTP(51)	10042	PARJ(11)	0.5
MSTP(142)	2	PARJ(12)	0.4
PARP(67)	1	PARJ(13)	0.79
PARP(82)	4.28	PARJ(14)	0.0
PARP(85)	0.33	PARJ(15)	0.018
MSTJ(26)	0	PARJ(16)	0.054
PARJ(33)	0.4	PARJ(17)	0.131

Enabled processes in LHCb MC:

process number	description
11	$f + f' \to f + f'$ (QCD)
12	$f + \bar{f} \to f + \bar{f}'$
13	$f + \bar{f} \to g + g$
28	$f + g \to f + g$
53	$g + g \to f + \bar{f}$
68	$g + g \to g + g$
91	Elastic scattering
92	Single diffractive (AB $\to$ XB)
93	Single diffractive (AB $\to$ AX)
94	Double diffractive
95	Low-pT scattering
421 439	Prompt charmonium
461 479	Prompt bottomonium