Prompt K_s production at $\sqrt{s} = 900$ GeV

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on behalf of the LHCb collaboration

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Outline

- outline of the $K_s \longrightarrow \pi\pi$ analysis
- analysis details
- preliminary results
- summary and outlook

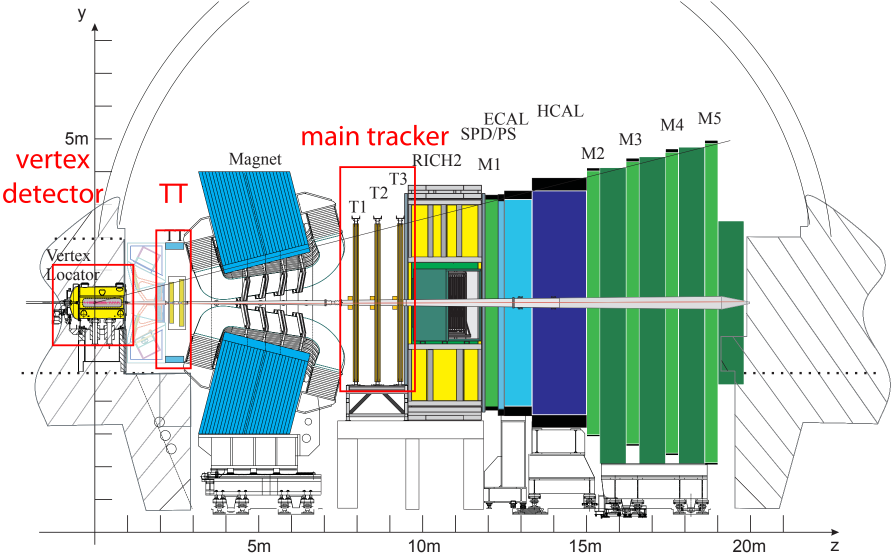
Analysis idea

- V0 production not yet measured in the LHCb y range at $\sqrt{s}$ =900 GeV
  - interesting input for tuning hadronization/fragmentation models
  - go for K_s first, it's the easiest to measure in 2009 data
- measure in bins of p_T and y

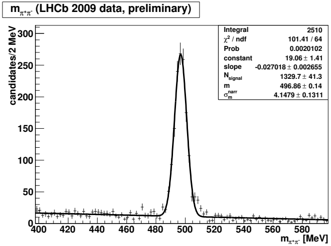
$$\mathcal{L}\,\sigma_{K_s}(p_T, y) = \varepsilon^{-1}_{rec.}(p_T, y)\,\varepsilon^{-1}_{trig}(p_T, y)\,N(p_T, y)$$

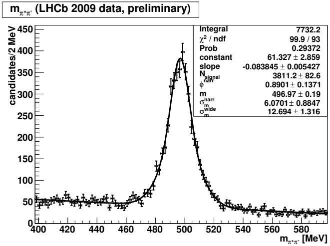
  - from data:
    - $N(p_T, y)$ (in channel $K_s \longrightarrow \pi^+\pi^-$)
    - take $\mathcal{L} = 6.8 \pm 1.0\mu\mathrm{b}^{-1}$ (preliminary)
      direct beam profile measurement by LHCb, bunch currents from machine
  - from MC: $\varepsilon_{rec}(p_T, y)$ (definition includes $BR(K_s \rightarrow \pi\pi)$)
  - from data and/or MC: $\varepsilon_{trig}(p_T, y)$
- need to make sure that MC describes data

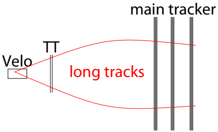
LHCb detector

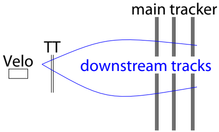


Long vs Downstream Tracks









lower statistics, higher resolution

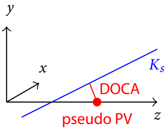
lower resolution, higher statistics

- most K_s decay after Velo $\Longrightarrow$ larger statistics with downstream tracks
- open Velo causes acceptance loss for long tracks
- long track mass resolution much better than downstream one

$\Longrightarrow$ two complementary analyses, concentrate on down-down in this talk

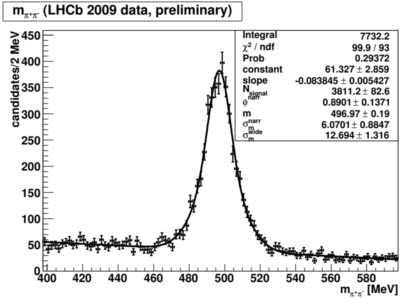
Data samples, selection

- 13 runs taken December 11-15, 2009
- only minbias events triggered by calorimeters
  - E_T(hadronic calo.) > 240 MeV
  - more than 2 preshower (SPD) hits
- selection
  - use "PV-less" selection (to be more independent of Velo)

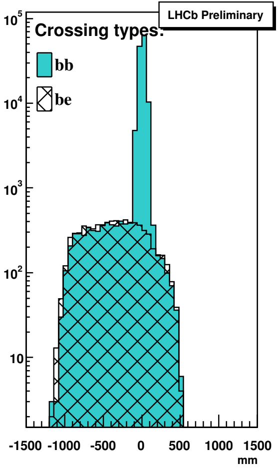


total K_s yield: 3811±83 candidates

cut	value
π p	$<$ 2 GeV
π p_T	$<$ 50 MeV
π red. track χ^2	$<$ 25
π IP	$>$ 3 mm
K_s red. vertex χ^2	$<$ 25
K_s dec. vertex z	$<$ 2200 mm
K_s IP	$<$ 150 mm
K_s DIRA	$>$ 0.99995
K_s ct	$>$ 5 mm
$\lvert\Delta m\rvert$	$<$ 50 MeV



Beamgas subtraction



PV z position

- compare shapes of PV distributions for beam-beam and beam-empty events
- determine factor β from non-collision region (z_{PV} <-200 mm)

$$N_{collisions} = N_{bb} - \beta \cdot N_{be}$$

with β =0.916±0.019, valid for the data sample used in this analysis

- not an important effect: 3% correction to K_s yields after selection
  - effect will become even smaller when the bunch currents increase this year

Updated results

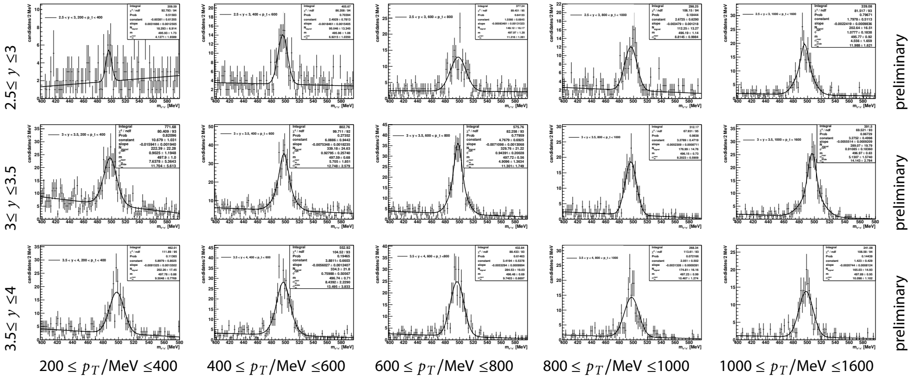
- results shown here are from March, quite a bit of refinement since then
- newer results to appear soon, but not approved yet
  - will give some indication of changes during talk

Signal extraction in bins of y and p_T

$$\mathcal{L}\,\sigma_{K_s}(p_T, y) = \varepsilon^{-1}_{rec.}(p_T, y)\,\varepsilon^{-1}_{trig}(p_T, y)\,N(p_T, y)$$

Signal extraction in bins of y and p_T

- fit model: lin. BG + double Gaussian (single for low statistics bins)
  - fit model uncertainties: 4%



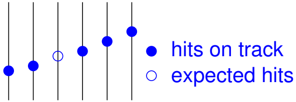
- table with numbers in backup

Tracking efficiencies

$$\mathcal{L}\,\sigma_{K_s}(p_T, y) = \varepsilon^{-1}_{rec.}(p_T, y)\,\varepsilon^{-1}_{trig}(p_T, y)\,N(p_T, y)$$

Tracking efficiencies

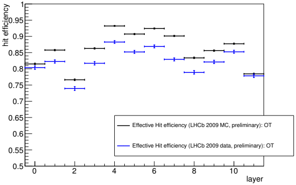
- turn off known dead channels in MC (< 1%)
- not enough: use effective hit efficiency to account for hits not picked up



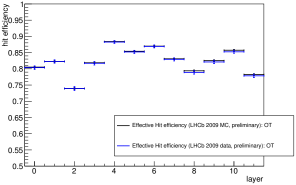
  - affected by true (hit) inefficiencies, alignment, pattern recognition
    - not real inefficiency: hits are in detector but not found due to misalignment
    - few cosmics for LHCb, so alignment efforts still ongoing
  - pattern reco does not really care for which of these reasons a hit is absent
  - reprocess MC with the "right" fraction of hits dropped

Tracking efficiencies

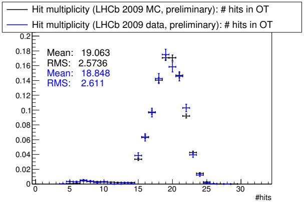
- data blue, MC black (e.g. for Outer Tracker)



drop fraction $\frac{\text{blue curve}}{\text{black curve}}$ in each layer



- check number of hits per subdetector after correction
  - for systematics, look at variation of ratio $\frac{\text{hits per track (data)}}{\text{hits per track (MC)}}$
    - in bins of p, ϕ, η, y, per quarter. . .
  - vary effective hit efficiencies by TT ±2%, IT ±5%, OT ±1%
  - ⇒ about 8% systematic uncertainties on yields



Total reconstruction efficiency

- total efficiency low (LHCb is not a 4π detector)

$p_T[MeV]/y$	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0
200 – 400	$0.9 \pm 0.1 \pm 0.1$	$5.7 \pm 0.2 \pm 0.5$	$5.8 \pm 0.2 \pm 0.6$
400 – 600	$2.8 \pm 0.2 \pm 0.3$	$9.6 \pm 0.3 \pm 0.8$	$9.2 \pm 0.3 \pm 1.2$
600 – 800	$5.1 \pm 0.3 \pm 0.7$	$12.9 \pm 0.4 \pm 1.0$	$12.0 \pm 0.5 \pm 1.3$
800 – 1000	$8.7 \pm 0.5 \pm 0.5$	$14.5 \pm 0.7 \pm 1.4$	$11.0 \pm 0.7 \pm 1.4$
1000 – 1600	$11.7 \pm 0.6 \pm 1.3$	$15.4 \pm 0.8 \pm 1.6$	$9.6 \pm 0.8 \pm 0.9$

(numbers in percent, preliminary)

- treat data and MC exactly alike

- breakdown for $600 \le p_T/MeV < 800, 3.0 \le y < 3.5$:
  $\varepsilon_{decay} = 69\%$, $\varepsilon_{acceptance} = 49\%$, $\varepsilon_{reco} = 74\%$, $\varepsilon_{sel} = 49\%$

Trigger efficiency

$$\mathcal{L}\,\sigma_{K_s}(p_T, y) = \varepsilon^{-1}_{rec.}(p_T, y)\,\varepsilon^{-1}_{trig}(p_T, y)\,N(p_T, y)$$

Trigger efficiency

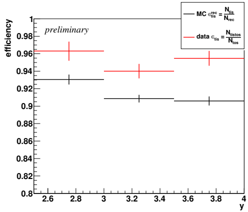
- trigger efficiency can be measured on data
  - two uncorrelated classes of events:
    - trigger on signal (TOS)
    - trigger independent of signal (TIS)

$$\varepsilon_{TIS}(p_T, y) = \frac{N_{TISTOS}(p_T, y)}{N_{TOS}(p_T, y)}$$

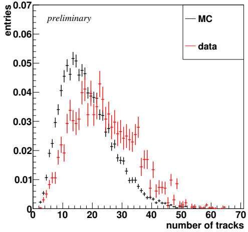
- not enough statistics for measurement in bins of p_T and y
- use trigger emulation of MC, crosscheck with data in 1D projections

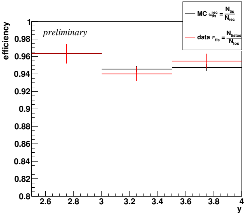
Trigger efficiency

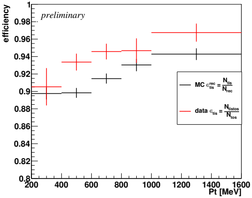
- track multiplicity different in data and MC: reweight
- trigger efficiency typically above 95% (full table in backup)
- trigger efficiency systematics: 2% (preliminary)

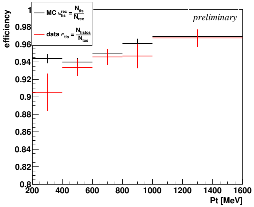


track multiplicity









Sources of uncertainties

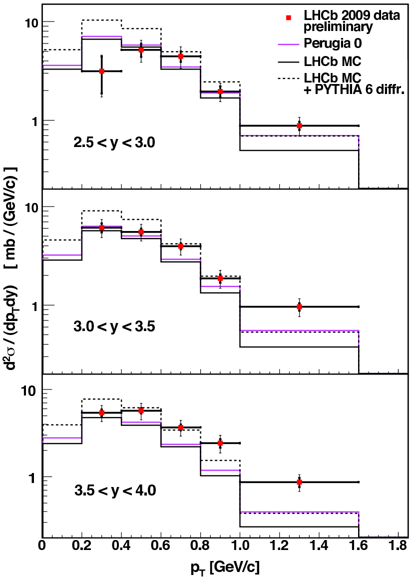
- statistical uncertainty: around 10% (depending on bin)
- systematics:

important systematics	minor effects
data/MC agreement (8%)	binning effects
fit stability (4%)	non-prompt K_s
stability of selection cuts (2.5%)	beam gas subtraction
trigger (2%)	branching ratio uncertainties

Preliminary results: K_s production in regions of rapidity

$$\mathcal{L}\,\sigma_{K_s}(p_T, y) = \varepsilon_{rec.}^{-1}(p_T, y)\,\varepsilon_{trig}^{-1}(p_T, y)\,N(p_T, y)$$

Preliminary results: K_s production in regions of rapidity



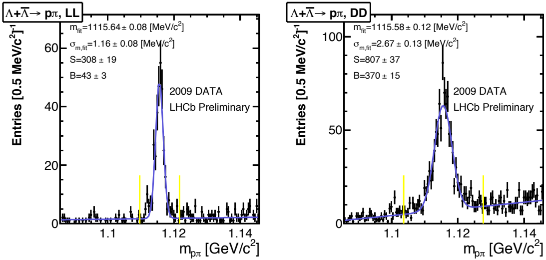
- data points: bold error bars: stat.; thin error bars: systematics (incl. 15% on lumi)
- black curve: LHCb Monte Carlo
- magenta curve: Perugia 0 Pythia tuning
- results reasonably consistent with MC

Summary/Outlook

- presented first (preliminary) physics results at LHCb: K_s production cross section
  - inelasic pp collisions, $\sqrt{s} = 900$ GeV, in range of $0.2 < p_T/\text{GeV} < 1.6$ and $2.5 < y < 4.0$
  - analysis with "minimal requirements": no PID, almost no Velo, no energy measurements
  - more infromation at http://cdsweb.cern.ch/record/1260133

Summary/Outlook

- several analyses of 2009 data ongoing
  - $\Lambda/\bar{\Lambda}$ studies ($\bar{\Lambda}/\Lambda$, $(\Lambda+\bar{\Lambda})/K_s$)



- analysis of 2010 data (at $\sqrt{s}$ =7 TeV) has begun as well
  - K_s, $\Lambda/\bar{\Lambda}$
  - D mesons
  - J/ψ production cross section, polarisation
  - other charmonium resonances
  - lots more. . .

Backup

Backup

Signal extraction: uncorrected K_s yields

- uncorrected K_s yields (preliminary)

$p_T[MeV]/y$	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0
200 – 400	18 ± 7 ± 1	222 ± 22 ± 9	202 ± 17 ± 10
400 – 600	95 ± 13 ± 6	339 ± 25 ± 5	334 ± 22 ± 5
600 – 800	149 ± 16 ± 9	330 ± 21 ± 10	285 ± 19 ± 5
800 – 1000	112 ± 13 ± 4	177 ± 15 ± 4	175 ± 16 ± 3
1000 – 1600	203 ± 17 ± 9	289 ± 20 ± 8	165 ± 15 ± 4

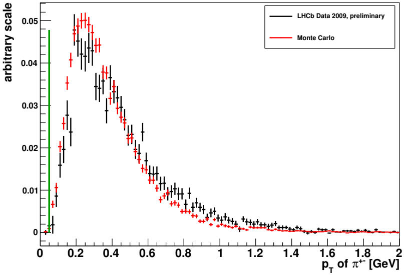
Trigger efficiencies

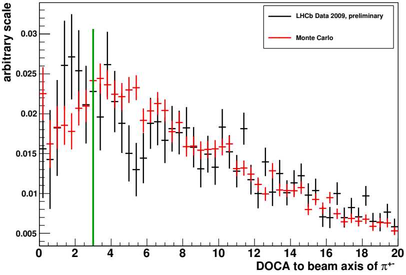
- trigger efficiencies in percent (preliminary)

$p_T[MeV]/y$	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0
200 – 400	93.5 ± 4.1 ± 2.0	93.8 ± 1.2 ± 2.0	94.7 ± 1.0 ± 2.0
400 – 600	96.4 ± 1.4 ± 2.0	93.9 ± 1.0 ± 2.0	93.5 ± 1.0 ± 2.0
600 – 800	96.6 ± 1.3 ± 2.0	95.1 ± 1.0 ± 2.0	95.1 ± 1.0 ± 2.0
800 – 1000	96.8 ± 1.4 ± 2.0	96.3 ± 1.1 ± 2.0	96.5 ± 1.3 ± 2.0
1000 – 1600	96.8 ± 1.1 ± 2.0	95.6 ± 1.3 ± 2.0	97.1 ± 1.4 ± 2.0

Selection efficiencies

- systematics of selection come from data/MC disagreement
- check every variable by releasing only that cut (n-1)
- total systematics: 2.5% (preliminary)
- two examples: p_T and (pseudo-)IP of daughter π





Preliminary results: K_s production in regions of rapidity

- K_s production in regions of rapidity

$p_T[MeV]/y$	2.5 - 3.0	3.0 - 3.5	3.5 - 4.0
200 – 400	2139 ± 870 ± 270	4152 ± 440 ± 410	3678 ± 337 ± 429
400 – 600	3520 ± 545 ± 444	3761 ± 304 ± 328	3883 ± 288 ± 517
600 – 800	3024 ± 373 ± 458	2690 ± 193 ± 231	2497 ± 198 ± 279
800 – 1000	1330 ± 173 ± 94	1268 ± 124 ± 128	1649 ± 185 ± 214
1000 – 1600	1792 ± 177 ± 218	1963 ± 172 ± 215	1770 ± 218 ± 175