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V^0 particle production studies at LHCb

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Goals

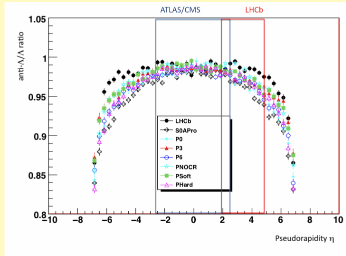
V^0 particle (K_S and Λ) production will be one of the very first measurements to be done with the LHCb detector in the early phase of LHC running. These particles are very sensitive probes of the fragmentation or hadronization process following the proton-proton interaction. Measuring V^0 production for the first time at LHC energies is very important in order to understand this process and tune the Monte Carlo generators used by all the LHC experiments. LHCb has the advantage of covering an angular range providing unique sensitivity to different fragmentation models.

Motivations: hadronization models and observables

Theoretically, the fragmentation process from partons into hadrons is still poorly understood. Different phenomenological hadronization models, tuned to SPS and Tevatron data, show divergences when extrapolated to LHC energies, especially in the pseudo-rapidity (η) range covered by the LHCb experiment. **V^0–production observables of interest include**:

- η, p_T differential production cross-sections
- relative K_S multiplicity
- meson/baryon ratio
- anti-baryon/baryon ratio vs η (**see figure**)

(See, for instance: P. Skands, arXiv/hep-ph:0905.3418)

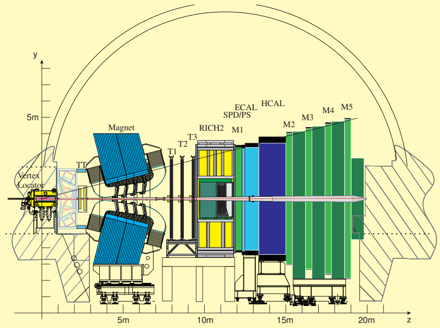


Example: $\frac{\bar{\Lambda}}{\Lambda}$ for several MC tunings. Differences between models are $\sim 1\%$ for ATLAS and CMS, $\sim 5\%$ for LHCb.

The LHCb experiment at CERN

The LHCb detector is a single-arm forward spectrometer, dedicated to the study of the CP violation and rare decays in the b-quark sector. The peaked b production at low p_T and high η justifies the detector layout. Main sub-detectors are:

- VErtex LOcator: very good vertex resolution (50–150 μm)
- TT, T1-T3: tracking stations with momentum resolution (0.3–0.5%)
- RICH: Cherenkov detectors for PID, good π-K separation in the range 2–100 GeV
- ECAL: Electromagnetic calorimeter
- HCAL: Hadronic calorimeter
- M1-M5 muon stations



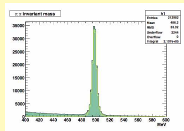
The LHCb detector is fully installed, being commissioned and ready to take data.

Data sample

We will use the first 10^8 events collected within a few LHC fills in the following conditions:

- stable colliding beams with $\sqrt{s} \geq 4$ TeV
- stable detector
- minimum bias trigger

This data sample will be also used for particle identification (PID) calibration, via high purity proton and pion samples coming from $\Lambda \to p\pi$ and $K_S \to \pi\pi$ (**figure**).



Prompt V^0 selection: Λ case

Prompt V^0 are defined as all Λ and K_S originating from:

- a primary pp interaction vertex (PV),
- a particle produced at the PV, and decaying strongly or electromagnetically into a V^0.

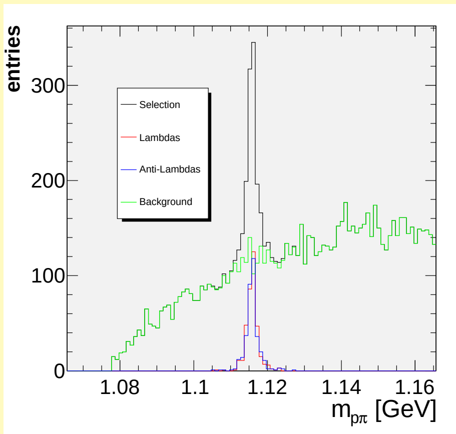
Non-prompt V^0 which are not interesting for hadronization studies, can be rejected by a cut on the impact parameter (IP) of the V^0 candidate with respect to the PV.

Selection criteria used for $\Lambda \to p\pi$ are designed to be **simple, only requiring a working tracking system**. We require:

- a pair of oppositely charged tracks seen in the Vertex Locator and traversing the whole spectrometer,
- assign them in turn the proton or pion hypothesis.

And we apply the following cuts:

- IP(π)$>$ 1mm
- IP(proton)$>$ 0.2mm
- IP(Λ)$<$ 0.4mm



The analysis of a sample of $480'000$ minimum bias events gives:

- **selection efficiency** N_{sel}/N_{rec} **of** $\sim 56\%$, depends only on the selection criteria.
- **reconstruction efficiency** N_{rec}/N_{gen} **of** 0.39% **for** Λ **and** 0.72% **for** $\bar{\Lambda}$, depends on the geometrical acceptance, and on the detector and tracking performance.

The low reconstruction efficiency is **mostly due to the reduced LHCb angular acceptance, as well as to the fact that most Λ and $\bar{\Lambda}$ are decaying outside the Vertex Locator**.

	Λ	$\bar{\Lambda}$
generated	$148'074$	$82'478$
reconstructed	621	619
selected	357	343

Signal composition

In a sample of 1876 Λ candidates in a mass window of 5 MeV around the Λ mass, we find:

true Λ	357	19%
true $\bar{\Lambda}$	343	18.3%
background	1176	62.7%

Among the 700 true Λ and $\bar{\Lambda}$, about 50% are coming from the primary vertex, and the remaining are secondary Λ particles, with eventually a non-prompt component. About 4% of our Λ sample are coming from diffractive pp events, i.e. non-relevant for hadronization processes.

Sensitivity reach

The scaling of the statistics from 480k to 10^8 events shows that **LHCb will be able to measure the ratio $\bar{\Lambda}/\Lambda$ up to a level of $\sim 1.5\%$ error, and therefore will be able to distinguish between hadronization models**. We show below the relative error on the ratio as a function of η, with a binning of 0.5, obtained with 480k events.