V0 particle production studies at LHCb
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Goals

V0 particle (Ks 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 V0 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. V0-production observables of interest include:

- η, pT differential production cross-sections
- relative KS multiplicity
- meson/baryon ratio
- anti-baryon/baryon ratio vs η (see figure)

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

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 s-quark sector. The peak b production at low pT and high η justifies the detector layout. Main sub-detectors are:

- V̅Ertex L̅Ocator: very good vertex resolution (50–150 μm)
- TT, T1-T3: tracking stations with momentum resolution (0.3–0.5%)
- RIC: 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.

Prompt V0 selection: Λ case

Prompt V0 are defined as all Λ and Ks originating from:

- a primary pp interaction vertex (PV),
- a particle produced at the PV, and decaying strongly or electromagnetically into a V0.

Non-prompt V0 which are not interesting for hadronization studies, can be rejected by a cut on the impact parameter (IP) of the V0 candidate with respect to the PV.

Selection criteria used for Λ → pπ 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 Nsel/Nrec of ∼ 56% depends only on the selection criteria.
- reconstruction efficiency Nrec/Ngen of 0.59% for Λ and 0.72% for Λ, 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 Λ are decaying outside the Vertex Locator.

<table>
<thead>
<tr>
<th></th>
<th>Λ</th>
<th>̅Λ</th>
</tr>
</thead>
<tbody>
<tr>
<td>generated</td>
<td>148,674</td>
<td>82,478</td>
</tr>
<tr>
<td>reconstructed</td>
<td>621</td>
<td>619</td>
</tr>
<tr>
<td>selected</td>
<td>357</td>
<td>343</td>
</tr>
</tbody>
</table>

Data sample

We will use the first 108 events collected within a few LHC fills in the following conditions:

- stable colliding beams with √s ≥ 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 Λ → pπ and Ks → ππ (figure).

Signal composition

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

<table>
<thead>
<tr>
<th></th>
<th>true Λ</th>
<th>background</th>
</tr>
</thead>
<tbody>
<tr>
<td>true Λ</td>
<td>357</td>
<td>1176</td>
</tr>
<tr>
<td>non-prompt Λ</td>
<td>343</td>
<td>62.7%</td>
</tr>
</tbody>
</table>

Among the 700 true Λ and ̅Λ, 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 108 events shows that LHCb will be able to measure the ratio Λ/Λ up to a level of ∼ 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.