Multiply Strange Baryon Production in AuAu Collisions at $\sqrt{s_{NN}} = 130$ GeV

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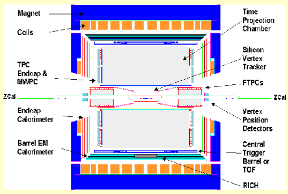
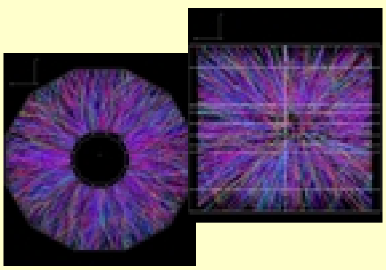
Strangeness in STAR

The STAR detector at RHIC has a large acceptance which aids in the measurement of strange particles. The figure shows the complete STAR detector. In year 1, only the TPC, CTB, and RICH detectors were installed. The large volume TPC has been used to search for the charged decay daughters of multiply strange baryons and anti-baryons.

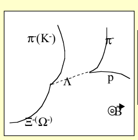


A typical central AuAu event in the STAR TPC is shown below. The search for the Ξ^- begins with the reconstruction of likely candidates from thousands of charged tracks produced in each central collision.



Ξ^- Reconstruction

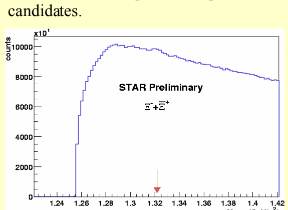
The particular decay mode that is accessible to STAR is the one most likely to occur: the Ξ^- decays into a bachelor π^- and a neutral Λ particle, which further decays into a π^- and a proton. The Ω^- also preferentially decays into a three particle final state, but with a bachelor K-.



Particle	Decay Mode	Branching Ratio (%)	cτ (cm)
Ξ^-	$\Lambda+\pi^-$	99.9	4.91
Ω^-	$\Lambda+K^-$	67.8	2.46
Λ	$p+\pi^-$	63.9	7.89

PDG Values

If a pair of charged tracks come from the same secondary decay vertex, then that vertex is tagged as a V0, or neutral vertex, candidate. In the case of the Ξ^-, the mass of the particle decaying at this vertex is calculated using proton and π^- mass hypotheses. If the reconstructed mass falls within some region of the expected Λ mass, the particle is tagged as a Λ candidate. The Λ candidate follows a straight line in the TPC. If this straight line intersects with a negative particle, then this intersection becomes a candidate for a Ξ^- decay vertex. Further extrapolation defines the candidate Ξ^- track. A similar procedure produces the anti-particle candidates.



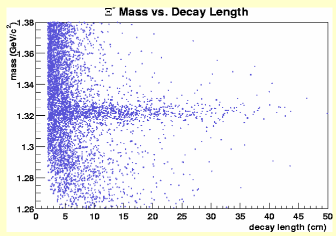
Invariant mass plot before selection cuts. The arrow indicates the PDG value.

Signal Extraction

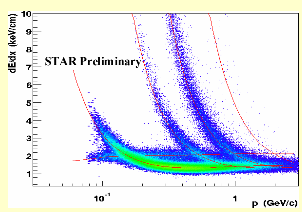
The next stage in separating real Ξ^- particles from the combinatorial background involves the use of topological and track quality cuts. The major cuts are listed below.

Ξ and Λ Distance of Closest Approach (DCA) to the primary vertex
Ξ's bachelor pion DCA to the primary vertex
Ξ and Λ decay distances
dE/dx of Λ's daughter proton

The cuts are tuned by plotting the invariant mass versus the cut parameter. There is a large contribution to the background closer to the primary vertex, so one cut of great importance is the Ξ^- decay distance. The figure below shows that the signal can be clearly distinguished from the background at distances larger than about 5 cm from the primary vertex.

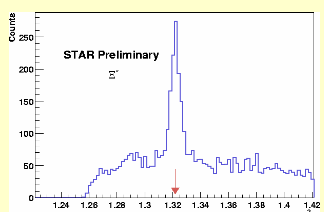


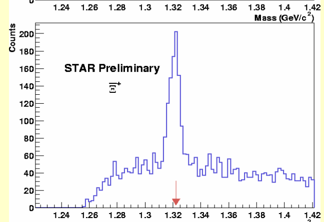
Measurement of the specific ionization (dE/dx) in the TPC makes it possible to identify different particle species. A rough cut on the dE/dx versus momentum plot, shown below, helps to exclude combinatorial background by requiring that the positive daughter of the Λ is consistent with being a proton.



Results

After applying these cuts, prominent peaks in the invariant mass histograms are found.

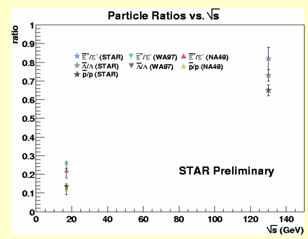




The data presented are from 338K events (15% most central). The reconstructed yield was found by fitting the Ξ invariant mass histograms to a Lorentzian on top of a polynomial background. The yields reported below were determined by integrating the Lorentzian within +/-15 MeV/c^2 about the PDG mass of 1.321 GeV/c^2. The peak signal to noise ratio came from integrating the Lorentzian within +/-5 MeV/c^2 about the PDG mass.

	Ξ^-	Anti-Ξ^+
yield/event	0.0029	0.0024
signal/noise	2.86	2.85

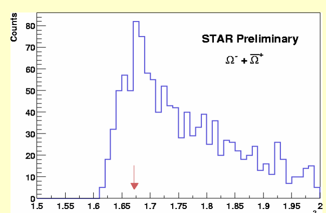
The symmetry of the STAR detector results in the same reconstruction efficiencies for a particle and its anti-particle. It is therefore possible to calculate the anti-Ξ to Ξ production ratio from the reconstructed yields. This ratio is shown below in comparison with anti-proton to proton and anti-Λ to Λ ratios measured at the SPS and RHIC. The errors shown are statistical only. The anti-particle to particle ratios at RHIC are close to one, indicating that the net baryon density at mid-rapidity is lower than at the SPS.



Future Plans

The dE/dx cuts will be changed to use the newly calibrated Bethe-Bloch values. Further work can be done to optimize the signal extraction cuts. Following this, the invariant yields will be calculated. This requires knowledge of the reconstruction efficiency, which will be obtained by embedding simulated decays into real events.

A first-pass search for Ωs in the same event sample has revealed a suggestion of a peak, as seen in the invariant mass histogram below. More statistics should allow for the anti-Ω to Ω ratio to be determined.



The requirement of more statistics will be fulfilled during the 2001/2002 running period. The addition of the SVT will increase the reconstruction efficiency for these rare multiply strange baryons by providing a high resolution tracking capability closer to the primary interaction region.

References:

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