Measuring Strangeness Production in STAR at RHIC

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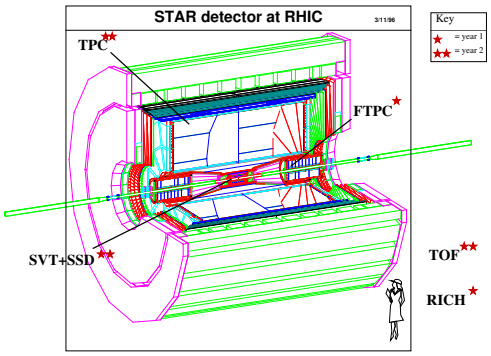
The STAR Detector and Strangeness

The STAR detector at RHIC is unique in its ability to measure a wide range of strange particles over a wide acceptance. These include both charged and neutral kaons, and the phi meson, as well as the strange baryons, Λ, Ξ and Ω. This will enable a study of integrated yields and particle ratios measured as a function of system size and energy. The transverse momentum spectra will also be studied to look for effects of collective motion, such as that arising from radial flow. Also unique to STAR, by virtue of the detector s large acceptance, is the possibility of studying the K^0K^0 two particle correlation function. It might even be possible to extended this to study ΛΛ interferometry.

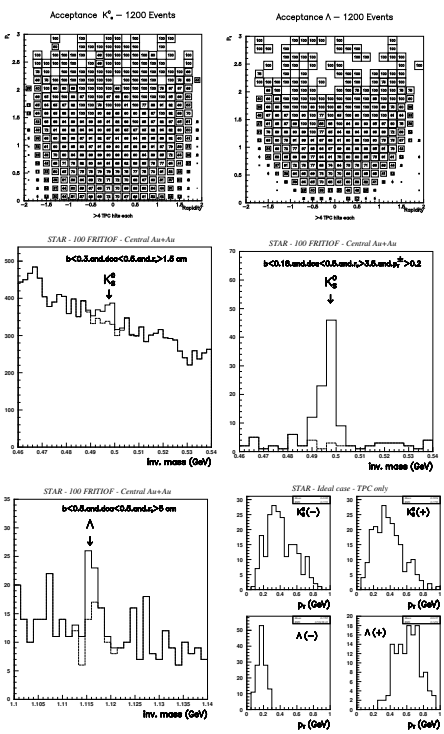


The elements of the STAR detector system which provide the capability to measure strange particle production are outlined below:

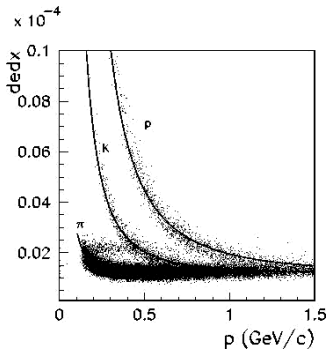
The Central Time Projection Chamber

TPC: The central Time Projection Chamber will enable K^0 and Λ production to be measured in the first year of RHIC operation, by reconstruction of their charged decay modes which give rise to the familiar v0 decay topology. Charged kaons can be identified both via their specific energy loss, *dE/dx*, and via their semi-leptonic decay, by the so-called kink analysis.

The figures below show the TPC acceptance for K^0 and Λ. The differences result from the low momentum pion daughter in the case of the Λ. K^0 and Λ invariant mas distributions are shown from 100 FRITIOF events after various selection cuts have been made. The cuts are the impact parameter of the parent at the primary interaction vertex, *b*, the distance of closest approach of the daughters at the secondary vertex, *dca*, the distance of the decay from the primary vertex, r_v, and the transverse momentum of the daughters.



The following figure shows the specific energy loss, *dE/dx*, for pions kaons and protons from *N* central Au+Au events at 100 GeV/A. Good separation for kaons may be achieved for transverse momenta, $p_T < 600$ MeV/*c*.

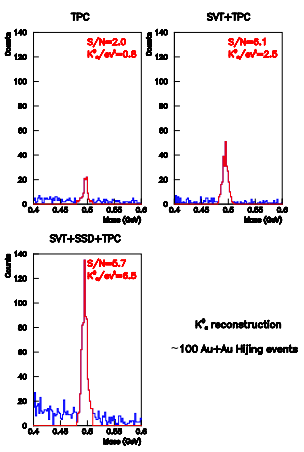


The curves are fits to the Bethe-Bloch formula. Energy loss information is also available from the Silcon Vertex Tracker (see below). Additonal particle identification capabilities will be provided by a Ring Imaging Cherenkov and a Time of Flight system, albeit over a limited geometrical acceptance. Further details of the capabilities of these detectors are given below.

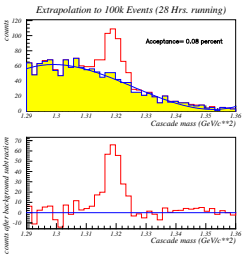
The Silicon Vertex Tracker

SVT and **SSD**: The Silicon Vertex Tracker consists of 3 layers of Silicon Drift Detectors at radii of approximately 5, 10 and 15 cm from the primary interaction vertex and covering a pseudorapidity interval of η=±1. A fourth layer of Silicon Strip Dectectors at a radius of approximately 25 cm, provides for greater acceptance for all weakly decaying strange particles, but most importantly, increases the overall reconsruction efficiency for the rarest strange baryons, Ξ- and Ω-, and their antiparticles.

The following figures show the improvement in the reconstruction efficiency for K^0 with the addition of the original 3-layer SVT and the incremental improvement provided by the addition of the SSD. The improvement shown for the addition of the SSD arises due to two main factors. First, the requirement that hits are left in all three layers of the SVT can be relaxed to three hits in four layers including the SSD. This widens the acceptance to particles with longer decay lengths. Second, the closer proximity of the SSD to the inner padrows of the TPC, enables TPC tracks to be extrapolated to the SSD in an extension of the Track Following algorithm. This, together with the three hit requirement in the SVT+SSD provides for better background suppression. The final result is that approximately 8 K^0 are reconstructed per central Au+Au event, opening up the possibility of studying K^0K^0 interferometry.

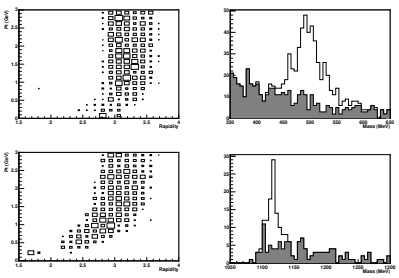


The following figure shows an early simulation of Ξ reconstruction which employed only a 3-layer SVT. The figure has been extrapolated to show the invariant mass distribution after 100k events, equivalent to 28 hours running time. New simulations to calculate the Ξ yield encorporating the SSD are underway. The expected increase in the reconstruction efficiency is reflected by the estimate given in table 1 below.



The Forward Time Projection Chambers

FTPC: The Forward TPCs are radial drift devices that cover a pseudorapidity interval of $2.5 < \eta < 4.0$. A recent feesibility study has shown that the momentum resolution for secondary decay products is sufficiently good, that K^0 and Λ may be reconstructed by a v0 invariant mass analysis similar to that performed in the central TPC.



Ring Imaging Cherenkov

RICH: In collaboration with the High Momentum Particle Identification Group at CERN, STAR will employ a prototype RICH detector developed for ALICE at the LHC. The RICH will enable kaon identification in a transverse momentum range of approximately $1.1 < p_T < 3.0$ GeV/*c*.

Time-Of-Flight patch

TOF: As a future upgrade, a Time-Of-Flight patch will replace part of the central trigger barrel which covers the outer radius of the central Time Projection Chamber and will extend the identification capability of charged kaons to $p_T < 1.5$ GeV/*c*.

Summary

In summary, STAR will measure strange particle production for a wide variety of species over a large range of transverse momentum and rapidity. Below, some strange particle reconstruction rates are given, together with estimates of the time it will take to acquire sufficient statistics for various types of measurement.

Particle	Hijing (fm)	>3 TPC hits	Reconstructed		
			TPC	TPC+SVT	TPC+SVT+SSD
K^0_s	2.14	M	1.1	1.1	1.1
Λ	4.9	3	1.1	1.1	1.1
Λ	2.8	2	1.1	1.1	1.1
Ξ	7	1.1		1.101	0.01–0.03
Ξ	7	1.1		1.101	0.01–0.03
Ω	8.11	1.111		~ 0.0003	
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Terminal

Table 1: The expected reconstructed rate of various strange particles based on Hijing central Au+Au events at 100 GeV/A.

Measurement	Required Yield
N	10–100
dN/dy,dN/dy_T	1–10k
$d^2N/dydy_T$	10–100k

Table 2: The estimated yield of strange particles required to measure the total integrated yield and single and double differential distributions.

Particle	N		dN/dy,dN/dy_T		$d^2N/dydy_T$		
K^0_s	10M	10 minutes	10k	1.3 hours	10k	13 hours	Year 1
Λ	10k	1.3 hours	10k	13 hours	100k	1 week	
Ξ	100k	2 days	1.5M	1 weeks	10M	1 months	Year 2
Ω	10M	1 months					

Table 3: The estimated number of events required to measure the total integrated yields, and single and double differential distributions of various strange particles, and the time taken to acquire them at a nominal trigger rate of 1 Hz.