Σ^0 reconstruction in Ag+Ag collisions at 1.58 AGeV with HADES

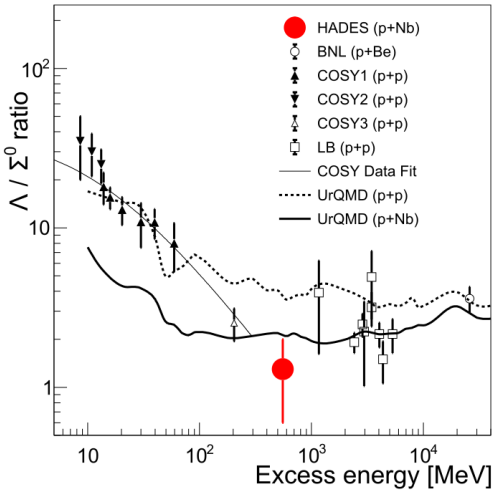
Marten Becker

Justus-Liebig-Univiersität Giessen, for the HADES collaboration

Abstract: HADES investigates the moderate temperature and high density regime of the QCD phase diagram. Strangeness can give a direct insight into the created dense matter, in particular close to the nucleon nucleon production threshold. In 2019 HADES collected Ag+Ag collisions at 1.58A GeV kinetic beam energy. A newly installed electromagnetic calorimeter allows for photon detection. Furthermore the RICH detector was upgraded, which strongly improves electron identification and the detection of conversion-pairs. In this contribution preliminary results on the search for the Σ^0 baryon, decaying electromagnetically into $\Lambda + \gamma$ will be presented. Detailed simulations prove the feasibility of this measurement using photon detection in the electromagnetic calorimeter or by employing photon conversion method based on the reconstruction of low momentum electrons in the RICH. Using the photon detected in the electromagnetic calorimeter an estimate of the Λ/Σ^0 ratio will be extracted.

Motivation

- Strangeness production used as common tool to describe medium effects and overall hadron production
- Strangness production enhanced in AA collisions, special effects below threshold
- Ag+Ag collision at 1.58 AGeV ($\sqrt{s_{NN}} = 2.55$ AGeV) right at the threshold for Λ production.
- Λ well measured from sub threshold up to LHC energies, Λ measurement always includes Σ^0
- No experimental measurements of Σ^0 baryon production in AA collisions near threshold
- Theoretical models e.g statistical models, profit from distinguishing Λ and $\Sigma^0 \rightarrow$ additional information on $\Sigma^{\pm}$



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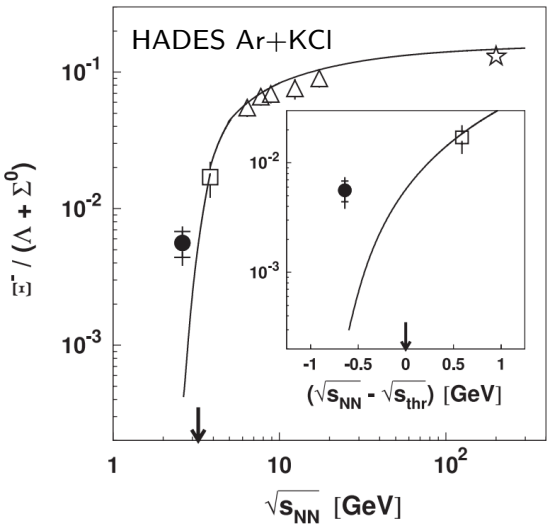


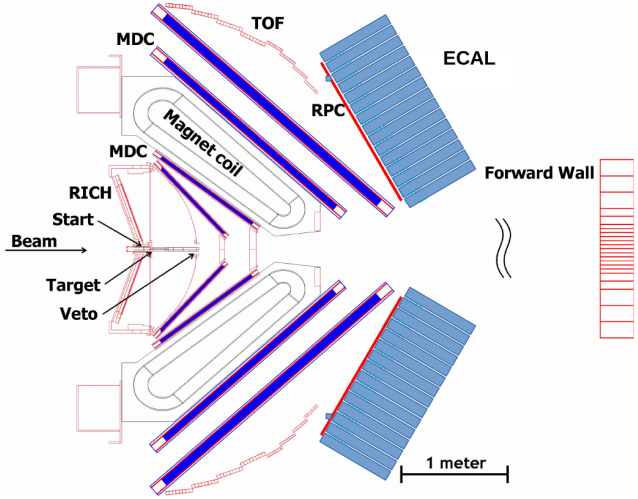
PRL 103, 132301 (2009)

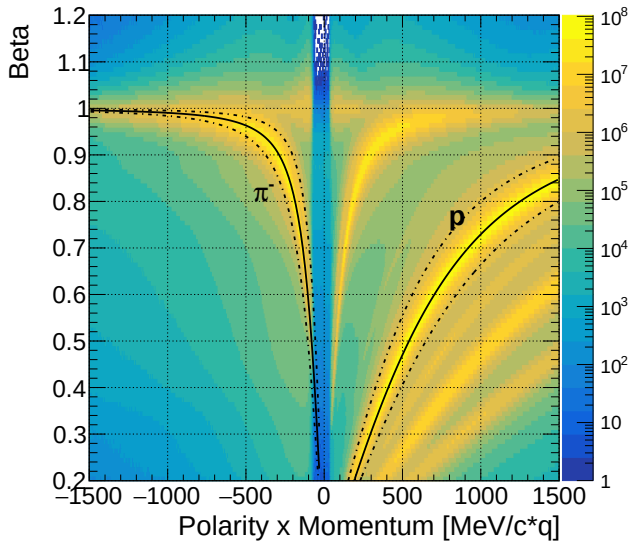
HADES - **H**igh **A**cceptance **DiE**lectron **S**pectrometer

Setup for Ag+Ag beamtime at 1.58 AGeV kinetic beam energy in march 2019:

- Optimized for the intermediate energy regime of a few AGeV kinetic beam energies
- Exploring the high baryon density region at low temperatures of the QCD phase diagram
- 4 layers of Multiwire drift chambers (MDC) for tracking & momentum reconstruction
- Magnet coil between MDC layers 2 and 3
- RPC and TOF for β information
- Upgraded RICH and new ECAL
- RICH for lepton identification
- ECal especially for photon reconstruction,

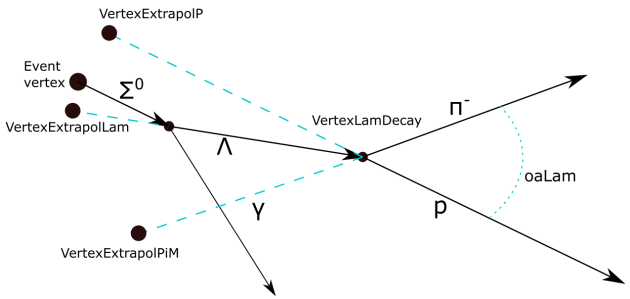
- $4.75 \cdot 10^9$ events available after quality selection (0-40 % most central Ag+Ag events)
- Particle identification based on calculated effective mass.





Σ^0 decay particle reconstruction

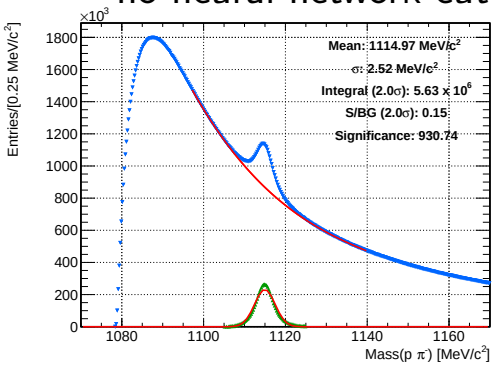
The Σ^0 decay topology:



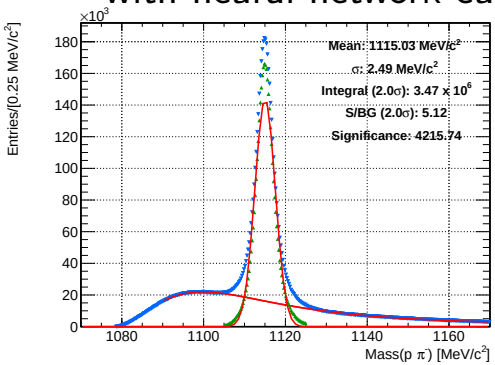
- $\Sigma^0 \rightarrow \Lambda + \gamma \rightarrow p + \pi^- + \gamma$
- $\Sigma^0 \rightarrow \Lambda + \gamma \rightarrow p + \pi^- + e^+ e^-$
- Final state consists of $e^{\pm}$ or γ and can be detected by either RICH or ECal.
- $\tau(\Sigma^0) \approx 7.4 \cdot 10^{-20}\, s$
- $\tau(\Lambda) \approx 2.6 \cdot 10^{-10}\, s$
- $\tau(\Lambda)$ + high resolution in tracking allows Off-Vertex reconstruction of the Λ
- $m_\Sigma - m_\Lambda \approx 77\, MeV/c^2$

The Λ reconstruction:

no neural network cut



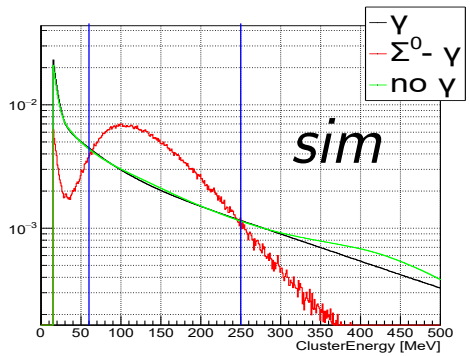
with neural network cut



- loose precuts before the MLP from TMVA evaluates a Λ probability
- additional cuts on energy loss and π^- velocity

The γ / $e^{\pm}$ reconstruction:

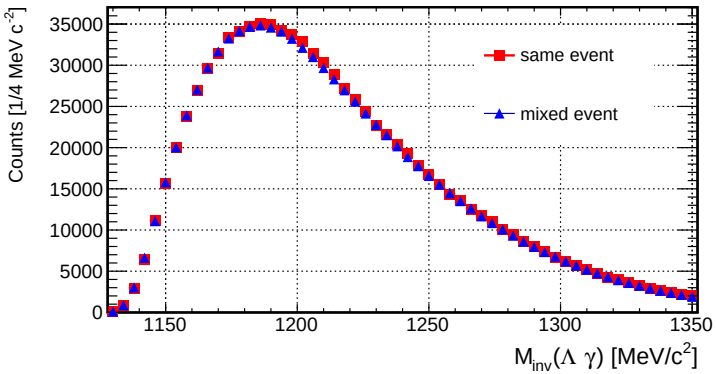
- Technically the most difficult aspect since the γ / $e^{\pm}$ from Σ^0 decay have momenta
- ECal: difficult recosntruction of low energy γs (timing & energy resolution)
- RICH: for the $e^{\pm}$ pair, tracking of both leptons is impossible since at least one partner is bend out of acceptance in the magnetic field
- RICH: neglecting the lower energetic lepton allows us to reconstruct a converted γ with $E_\gamma < 100\,\text{MeV}$

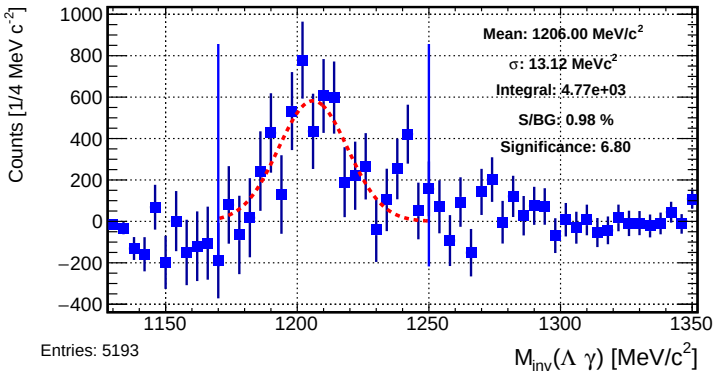


Signal extraction

Experimental $\Lambda\gamma$ results:

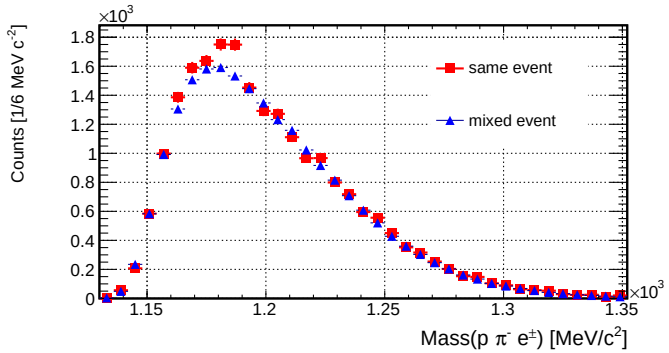
- Precise background description from event mixing technique; normalization to sidebands
- First Σ^0 reconstruction in AA collisions near production threshold

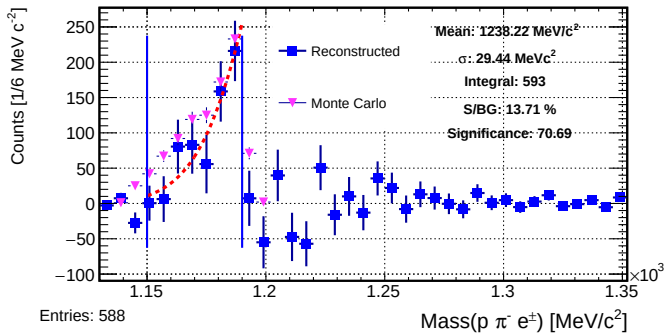




Simulated $\Lambda e^{\pm}$ results:

- Use only one fully reconstructed e^+ or e^-
- Reconstructed $\Lambda e^{\pm}$ signal in agreement with Monte Carlo signal
- Roughly 500 entries from $75{\cdot}10^6$ embedded Σ^0 reconstructed in feasibility studies
- Data: statistics too low due to small conversion probability





Outlook: Establish full efficiency correction for Λ/Σ^0 ratio