Strange hadron production in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the STAR detector

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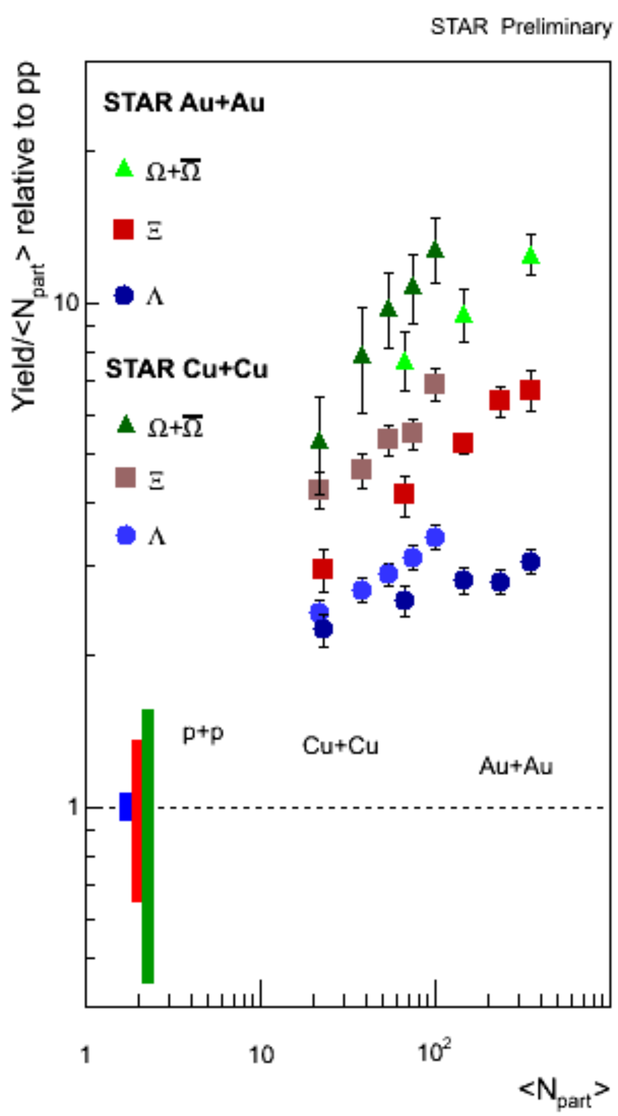
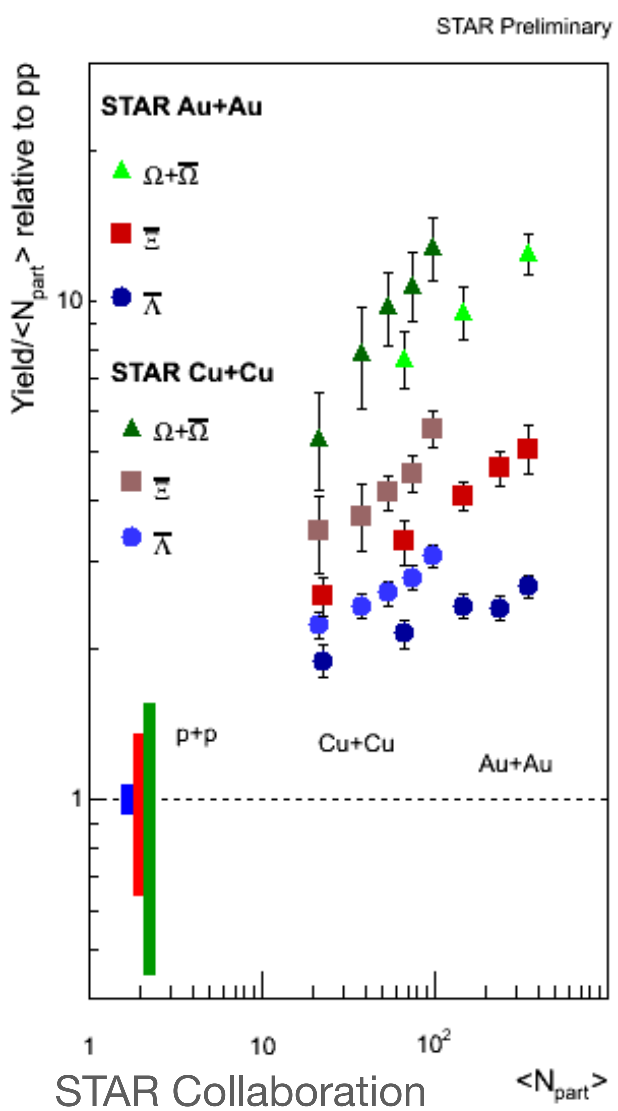
Outline :

- Motivation
- Overview of the STAR Detector
- Data Set and Particle Identification
- Analysis Technique
- Summary and Outlook

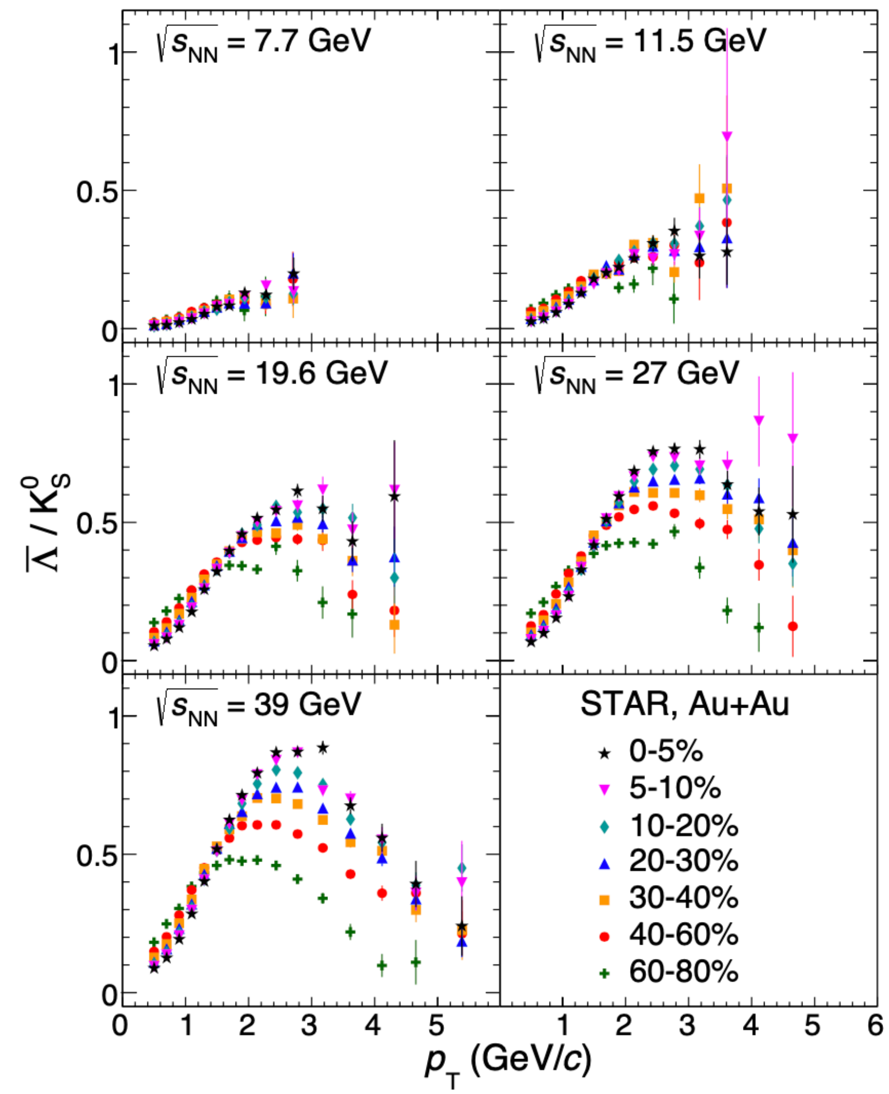
Motivation I : Strangeness as a sensitive probe

- Strangeness enhancement in A+A collisions at RHIC energy has been identified as a signature of QGP formation
- d+Au strangeness data will connect peripheral A+A with p+p





STAR Collaboration

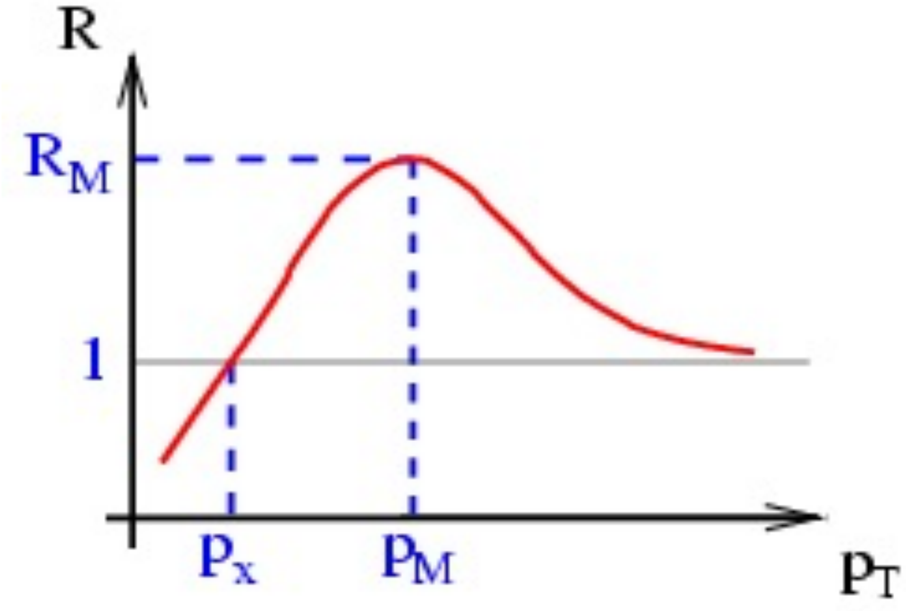


STAR Collaboration
Phys. Rev. C 102 (2020) 34909

- Baryon enhancement at intermediate p_T is due to parton recombination

Motivation II : Cronin effect

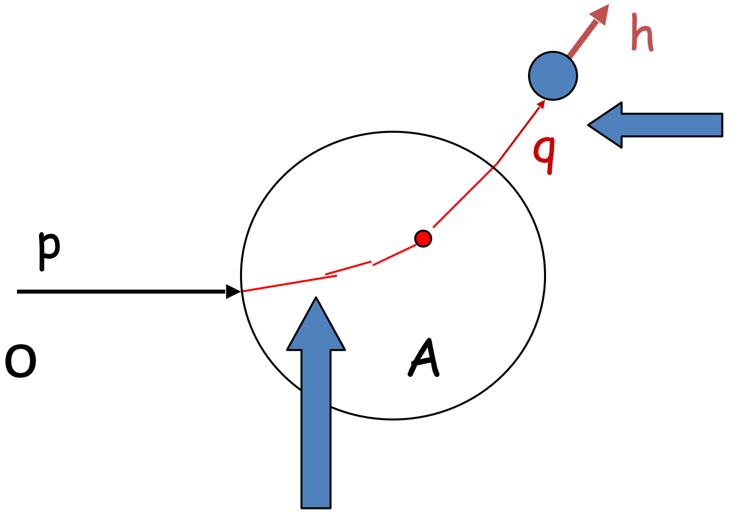
- Cronin effect in d+Au collisions is seen in nuclear modification factor R_{dAu}
  - < 1 for $p_T < P_x$
  - > 1 for $p_T > P_x$
  - approach 1 again when $p_T \rightarrow \infty$



What is the mechanism of Cronin effect?

- Traditional models: do not explicitly predict particle type dependence, but do predict centrality dependence
- Final state models: predict particle species dependence of Cronin effect

Measurements of particle type and centrality dependence of Cronin effect will help to understand the effect.



Recombination:
Dang Seog Lee
J.Phys.G36:064034,2009

Final state effect, modification of hadronization

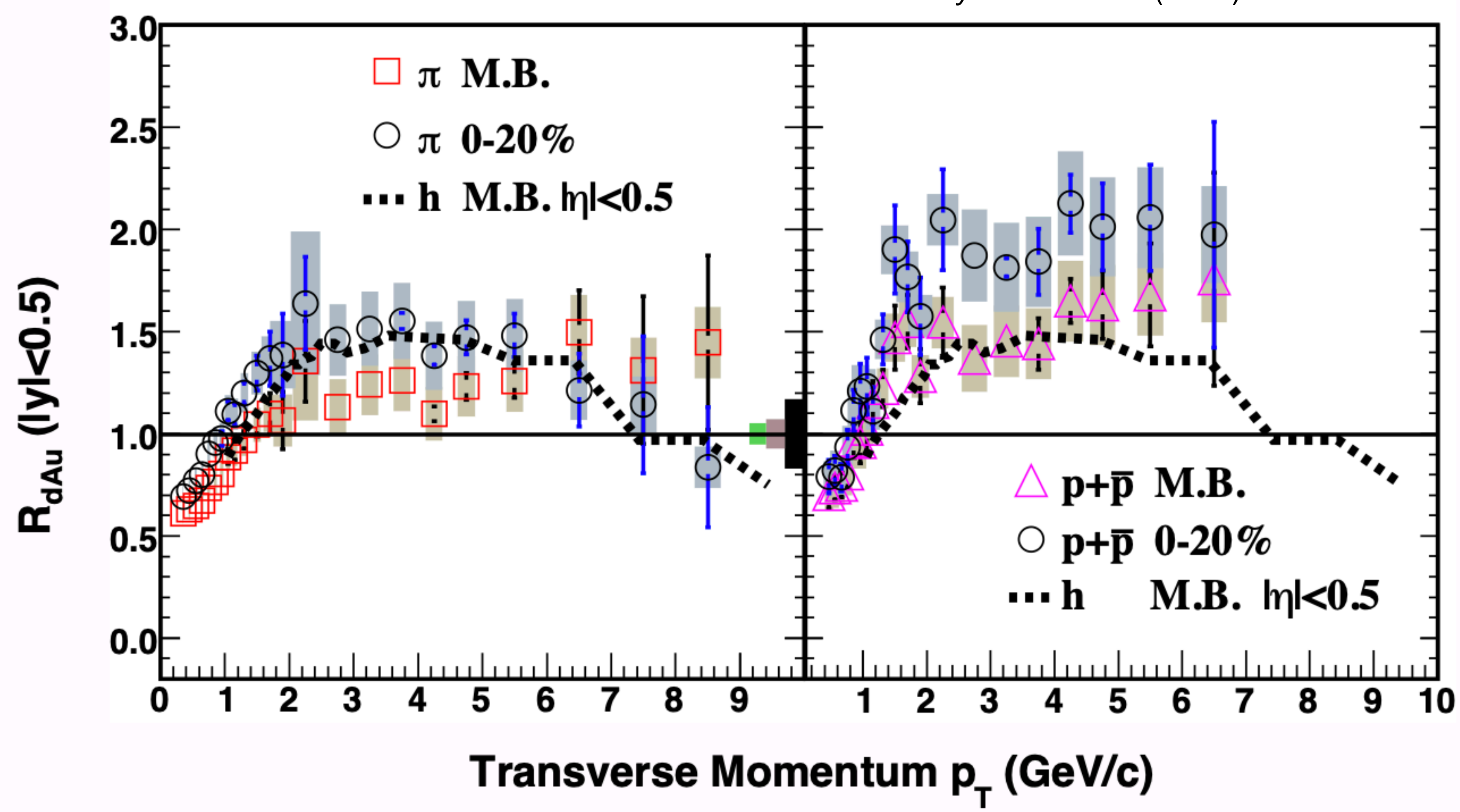
Traditional models :
A Accardi

https://arxiv.org/abs/hep-ph/0212148

Multiple parton/hardon scatterings in initial state

Cronin Effect in d+Au :

Phys.Lett.B 637 (2006) 161-169



Nuclear modification factor R_{dAu} :

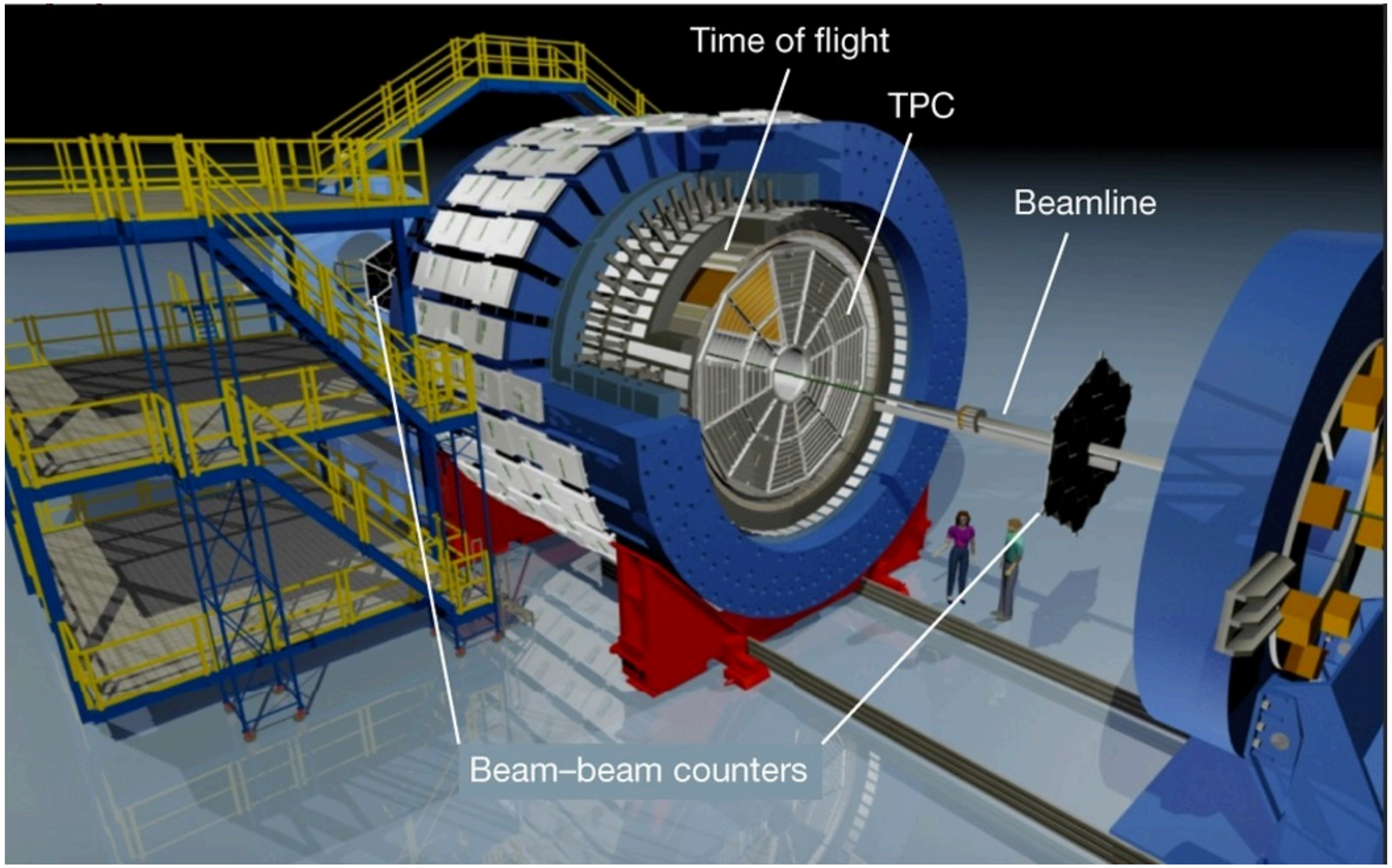
$$R_{dAu}(p_T) = \frac{d^2N/(2\pi p_T dp_T dy)}{T_{dAu} d^2\sigma^{pp}/(2\pi p_T dp_T dy)}$$

$$T_{dAu} = \langle N_{bin} \rangle / \sigma^{pp}_{inel}$$

- For $2<p_T<5$ GeV/c, R_{dAu} of proton rises faster than pions.

- With topological reconstruction, strange hadrons can be reconstructed to high p_T for the study of particle type dependence of Cronin effect.

Overview of STAR Detector :

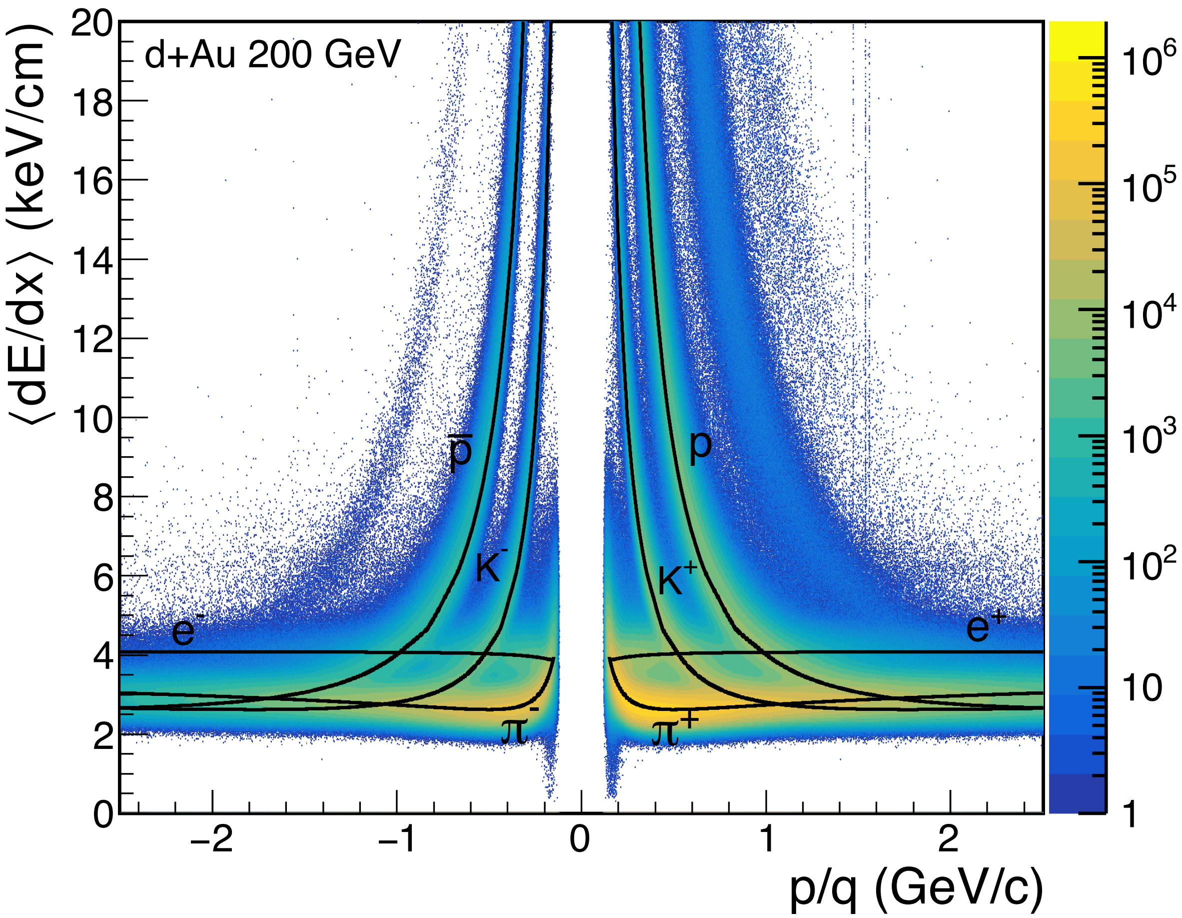


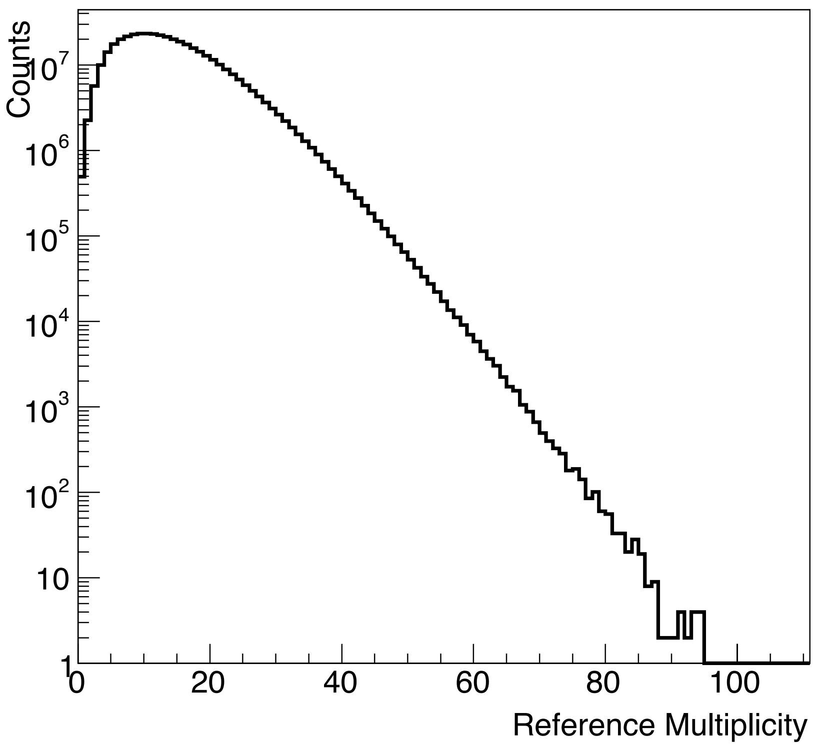
- Main goal of STAR experiment is to study the formation and characteristics of quark gluon plasma (QGP)

- The Solenoidal Tracker At RHIC (STAR) consists of several sub detectors :
  - **Tracking :** Time Projection Chamber
  - **Particle Identification :** Time Projection Chamber and Time of Flight

Data Set and Particle Identification :

- d+Au 200 GeV (Year : 2016)
- Events analyzed ~180M
- Particles studied : (${K_S}^0$, $\Lambda(\bar{\Lambda})$, $\Xi^-(\bar{\Xi}^+)$, $\Omega^-(\bar{\Omega}^+)$)

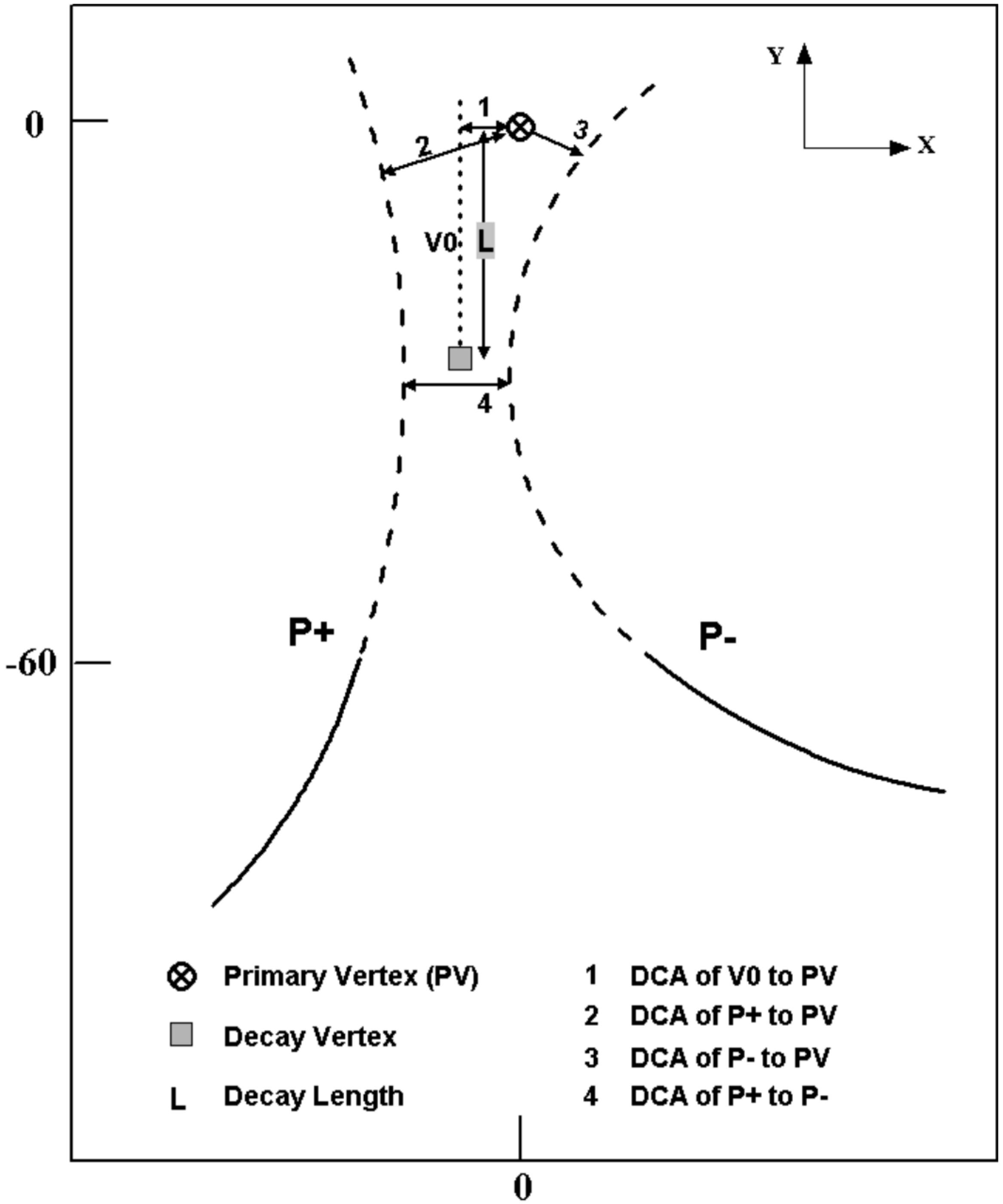




- Particle identification is done via <dE/dx> measured in TPC

$$Z = \log \frac{\langle dE/dX \rangle_{measure}}{\langle dE/dX \rangle_{Bichsel}}, \; n\sigma_p = \frac{Z}{\sigma_p}$$

Particle Reconstruction K_S^0 :



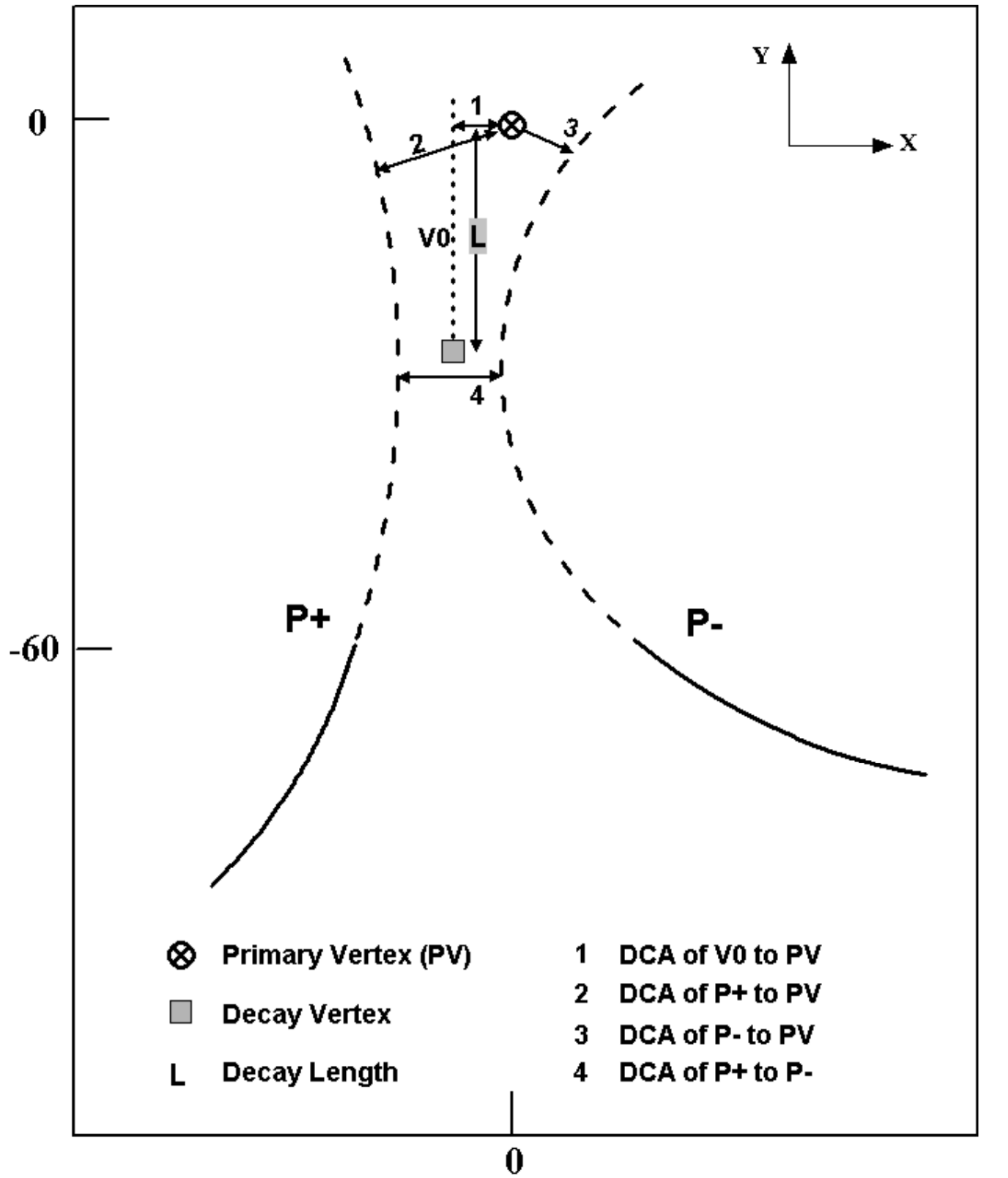
$K_s^0 \rightarrow \pi^+\pi^-,\ c\tau = 2.68\text{cm}$

Branching Ratio : 69.2%

- Cuts on daughters :
  - Number of hits in TPC >15
  - PID from TPC
- V0 reconstruction cuts :
  - DCA of P+ to P- <= 0.8 cm
  - DCA of V0 to PV < 0.8 cm
  - DCA of pion to PV > 0.7 cm
  - Decay length >= 2.5 cm

https://drupal.star.bnl.gov/STAR/files/startheses/2005/jiang_hai.pdf

Particle Reconstruction $\Lambda(\bar{\Lambda})$:



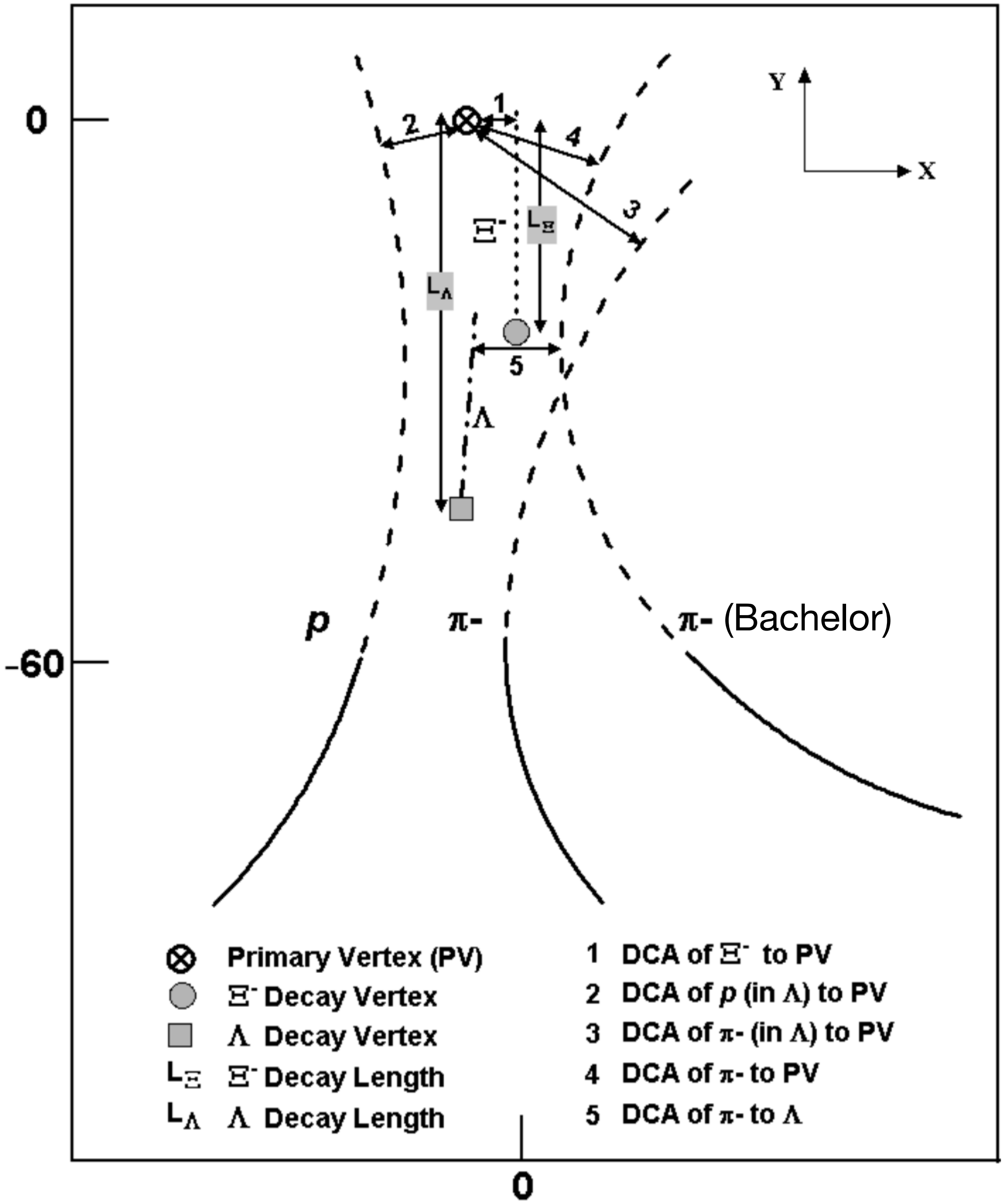
Λ-> p +π^- , $\overline{\Lambda}$ -> $\bar{\text{p}}$+π^+

Branching Ratio : 63.9%

- **Cuts on daughters :**
  - PID from TPC
- **V0 reconstruction cuts :**
  - DCA of P+ to P- <= 0.8 cm
  - DCA of V0 to PV < 0.8 cm
  - DCA of P+ to PV > 0.3 cm
  - DCA of P- to PV > 1.0 cm
  - Decay length >= 3.0 cm

https://drupal.star.bnl.gov/STAR/files/startheses/2005/jiang_hai.pdf

Particle Reconstruction $\Xi^{-}(\bar{\Xi}^{+})$:

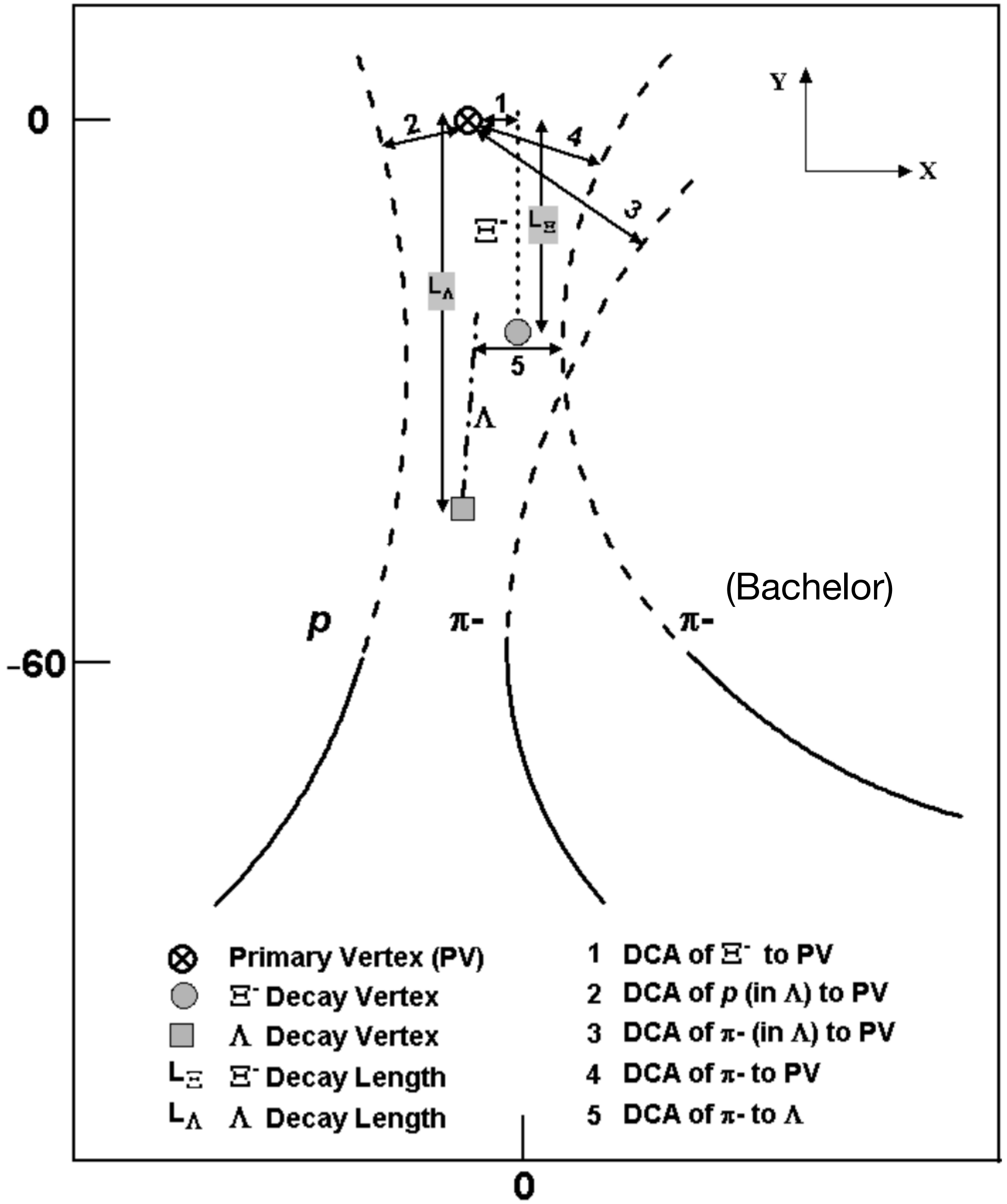


$$\Xi \rightarrow \Lambda\pi \rightarrow p\pi\pi, c\tau = 4.91\text{cm}$$

- **V0 reconstruction cuts :**
  - DCA of P+ to P- <= 0.8 cm
  - DCA of V0 to PV < 5.0 cm && > 0.2cm
  - DCA of Proton to PV > 0.5 cm
  - DCA of Pion to PV > 1.0 cm
  - Decay length >= 5.0 cm
  - $|\text{Mass- Mass}_{pdg}| < 0.0012$ GeV/c^2
- **Ξ reconstruction cuts :**
  - DCA of V0 to bachelor <= 0.8 cm
  - Decay length >= 3.4 cm
  - DCA of Ξ to PV <= 0.8 cm
  - DCA of bachelor to PV >0.8 cm

https://drupal.star.bnl.gov/STAR/files/startheses/2005/jiang_hai.pdf

Particle Reconstruction $\Omega^{-}(\bar{\Omega}^{+})$:



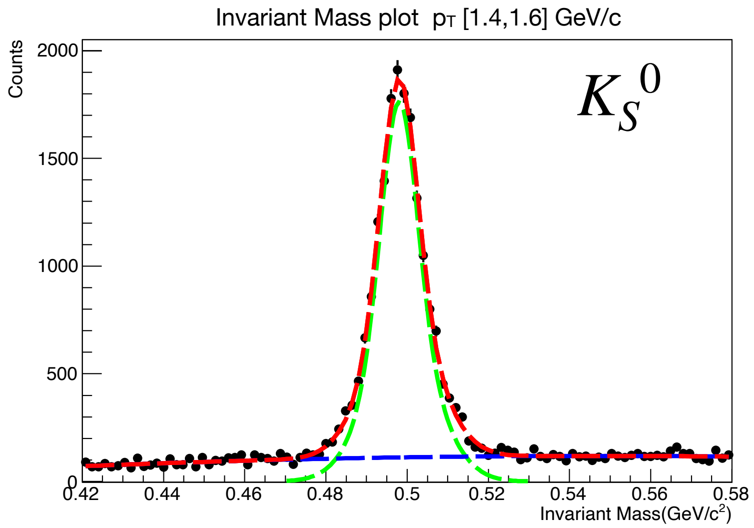
* left figure is for Ξ, and is used for illustrative purpose

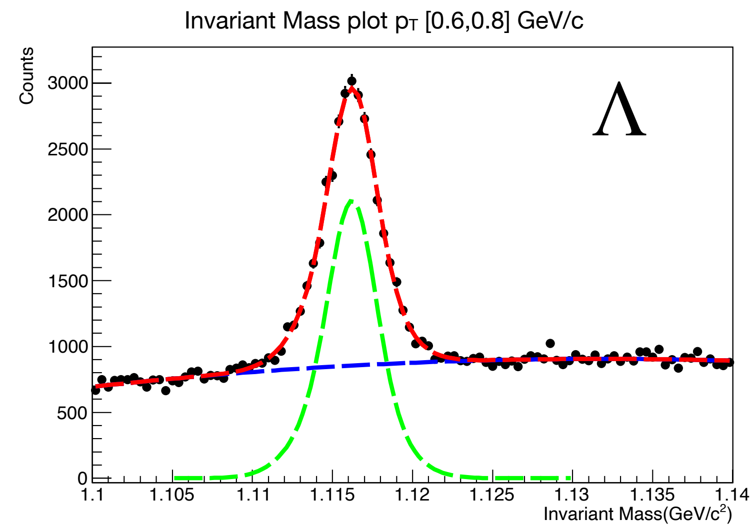
$$\Omega^{-} \rightarrow \Lambda K^{-} \rightarrow p\pi K^{-}, c\tau = 2.461\text{cm}$$

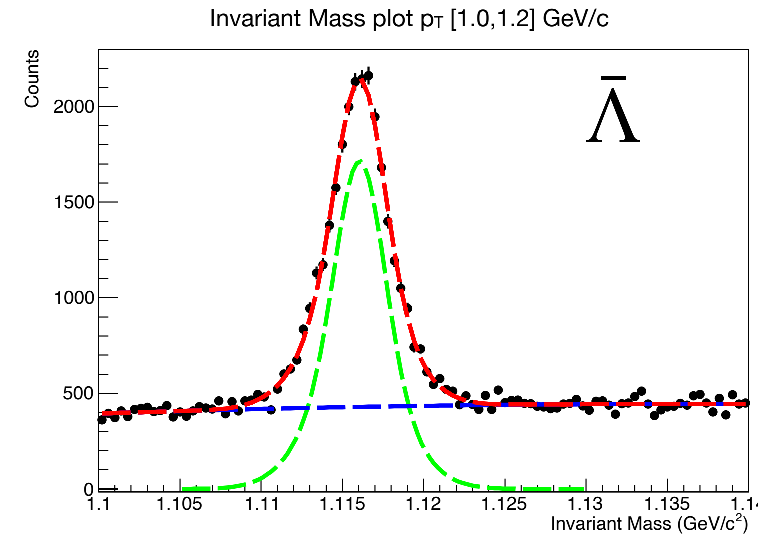
- **V0 reconstruction cuts :**
  - DCA of P+ to P- <= 0.7 cm
  - DCA of V0 to PV < 5.0 cm && > 0.4 cm
  - DCA of Proton to PV > 0.6 cm
  - DCA of Pion to PV > 2.0 cm
  - Decay length >= 5.0 cm
  - $|Mass- Mass_{pdg}| < 0.006$ GeV/c^2
- **Ω reconstruction cuts :**
  - DCA of V0 to bachelor <= 0.7 cm
  - Decay length >= 3.0 cm
  - DCA of Ω to PV <= 0.4 cm
  - DCA of bachelor to PV > 1.0 cm

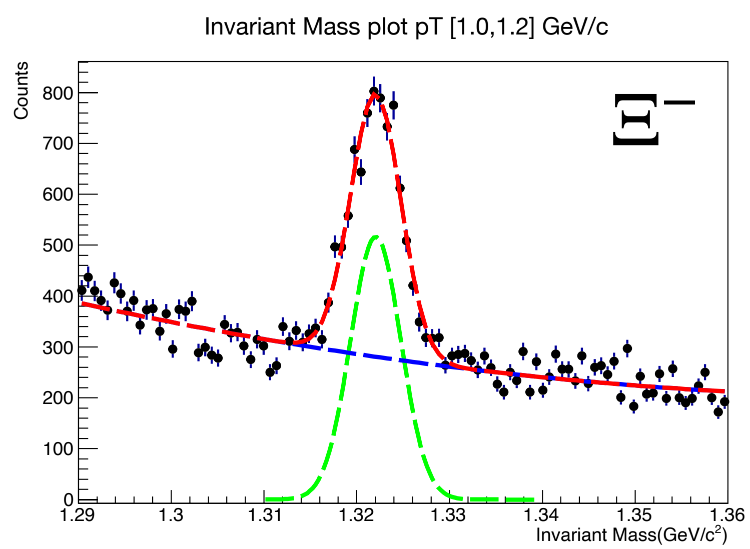
https://drupal.star.bnl.gov/STAR/files/startheses/2005/jiang_hai.pdf

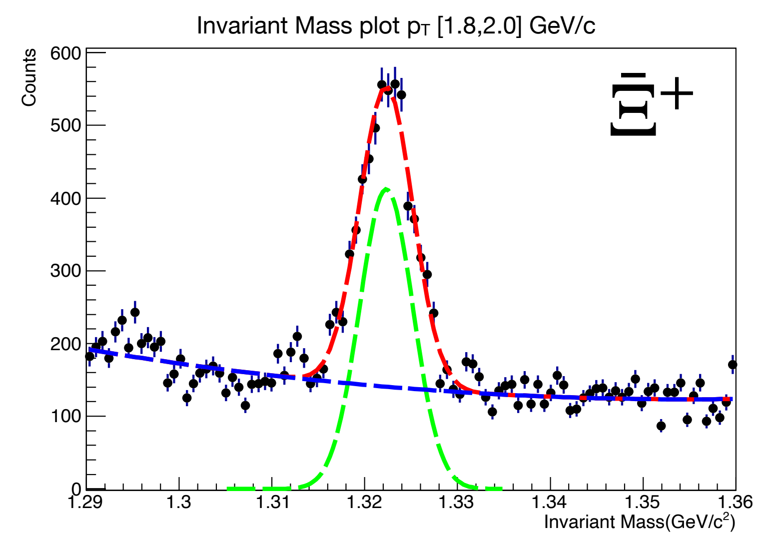
Invariant Mass Distribution :

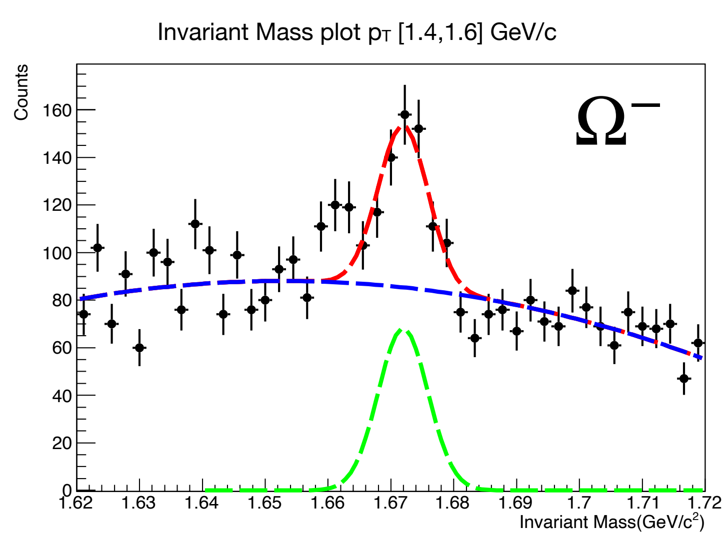


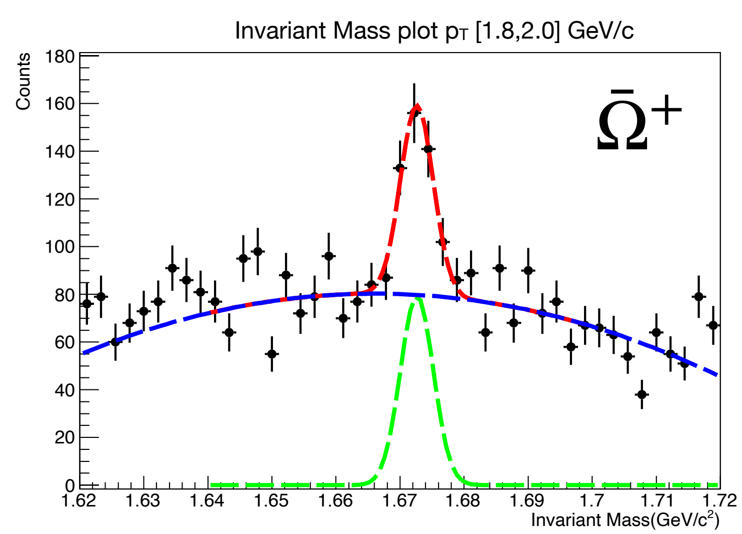












- Red line : Double gaussian + 2nd order polynomial (signal+background)
- Blue line : 2nd order polynomial (background)
- Green line : double gaussian (signal)

Summary and Outlook :

- Presented invariant mass distributions for strange particles ($K_S{}^0$, $\Lambda(\bar{\Lambda})$, $\Xi^-(\bar{\Xi}^+)$, $\Omega^-(\bar{\Omega}^+)$) in d+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

- Efficiency study is ongoing.

- Working on corrected spectra to obtain dN/dy, $<p_T>$ and nuclear modification factor (R_{dAu}).

Thank You!