Search for hyper-triton in Ni+Ni collisions at 1.91A GeV

Yapeng Zhang

FOPI collaboration, Heidelberg University

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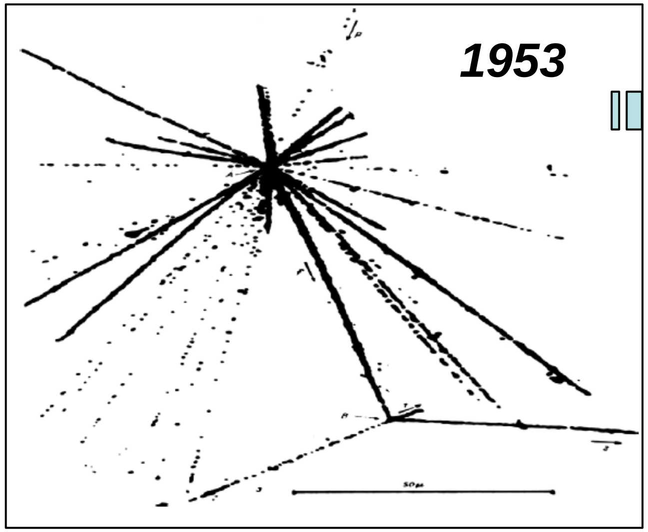
Outline

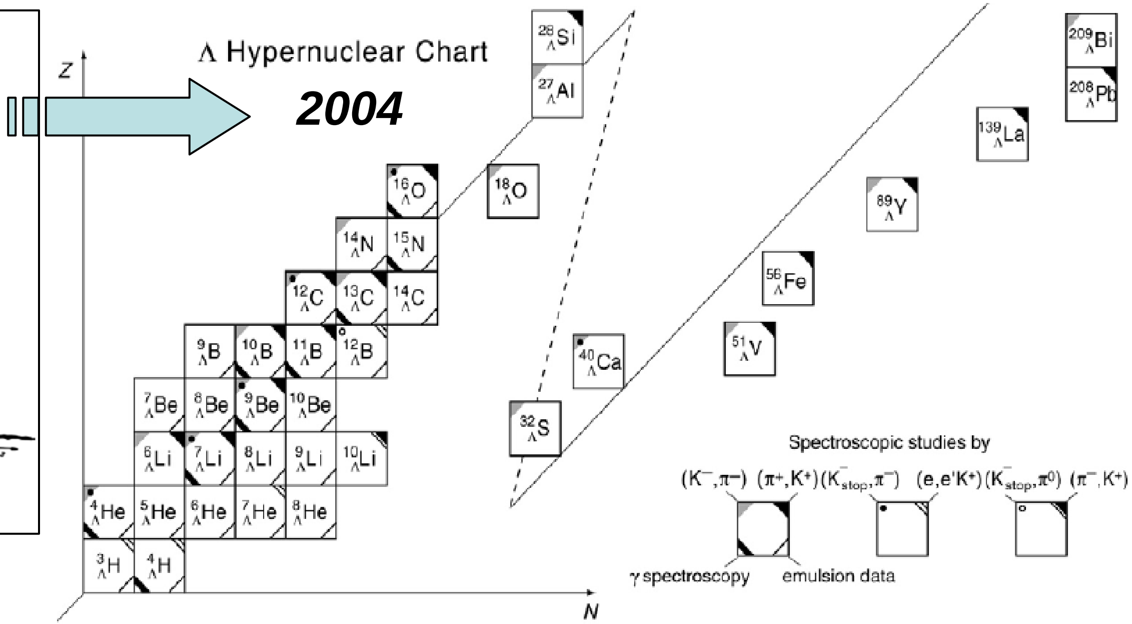
- 1. Introduction
- 2. FOPI detector
- 3. Cut quantities and evaluation results.
- 4. Background and signal simulation

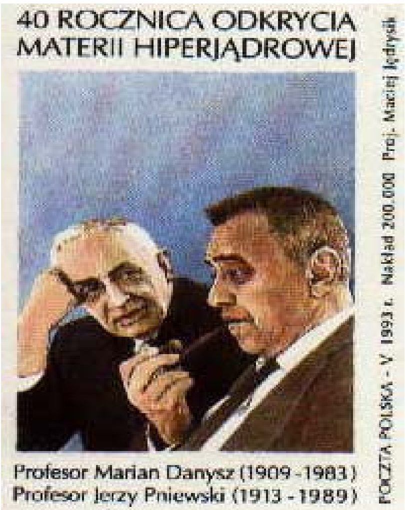
  for ${}_{\Lambda}t \rightarrow \pi^{-} + {}^{3}He$ in Ni+Ni at 1.91A GeV.
- 5. Yield ratios of ${}_{\Lambda}t^{*}/t$ and ${}_{\Lambda}t^{*}/{}^{3}He$ in certain phase space region.
- 6. Summary and outlook.

1. Introduction

Nucleus which contains at least one hyperon (Λ , Σ , Ξ , Ω).







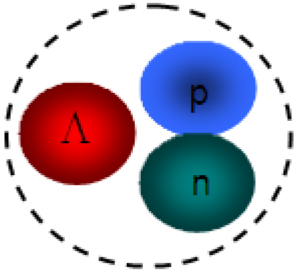
(pi$^+$,K$^+$), (K$^-$,pi$^-$), (e,e'K$^+$)

O.Hashimoto, H.Tamra, Progress in Particle and Nuclear physics 57, 564

The first observation of the decay of a hypernucleus

M. Danysz and J. Pniewski, Phil. Mag. 44 (1953) 348

Hypertriton ($_\Lambda t$) production in HIC



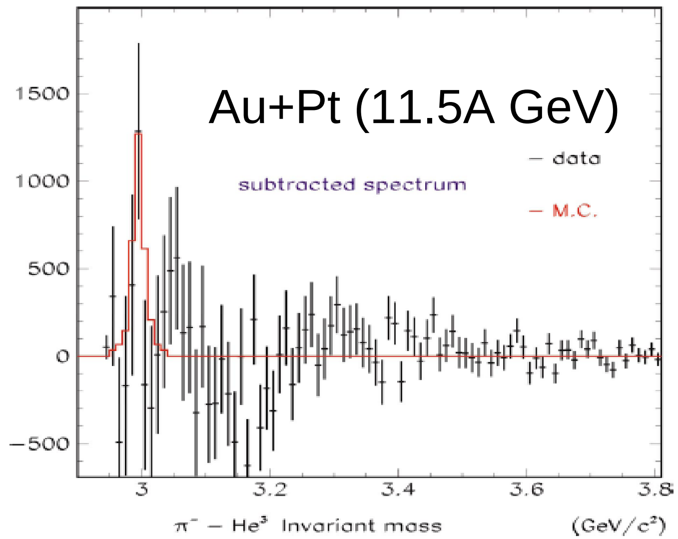
$$_\Lambda t(n+p+\Lambda)$$

(B_Λ: 0.13±0.05 MeV)

M. Juric et al. Nucl. Phys. B 52 (1973), p. 1

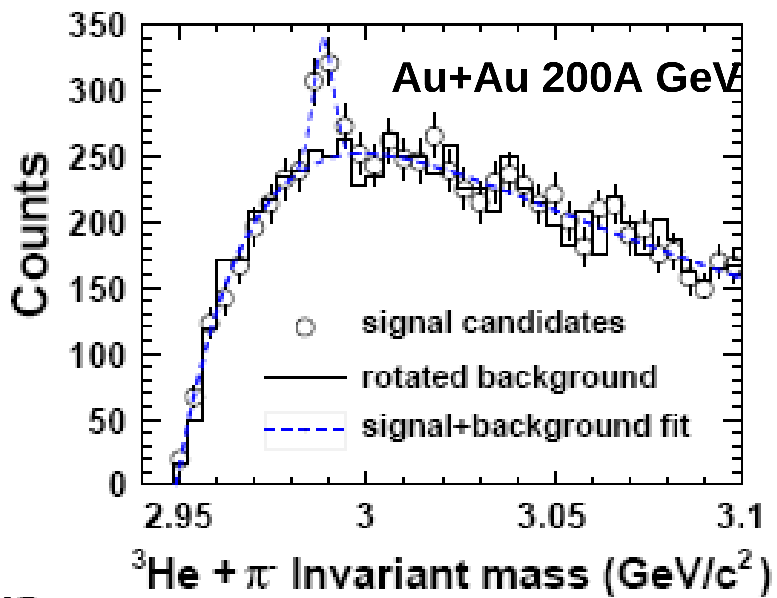
Weak mesonic decay	B.R.
$_\Lambda t \rightarrow {}^3He + \pi^-$	~35%
$_\Lambda t \rightarrow d + p + \pi^-$	~55%

M.Derrick et al. PRD,1,66 (1970);
H.Kamada et al. PRC57,1595 (1998);



Signal at 2 σ level,1.35x10⁹ central collisions

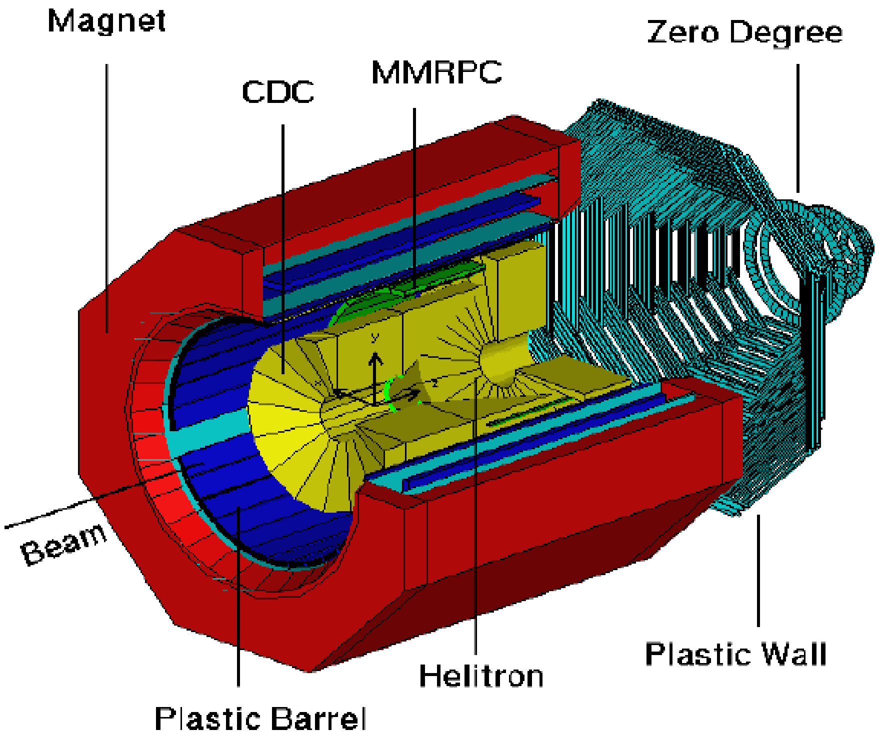
E864:T.A.Armstrong et al. PRC70, 024902(2004)

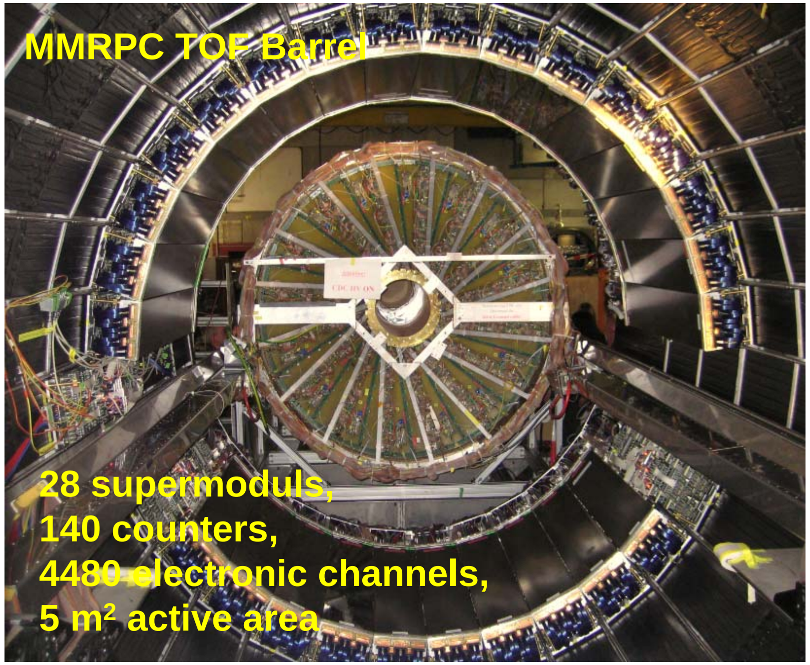


Signal at 5.2 σ level, 157 candidates
110x10⁶ central collisions

arXiv:1003.2030 [nucl-ex] (Star – collaboration)

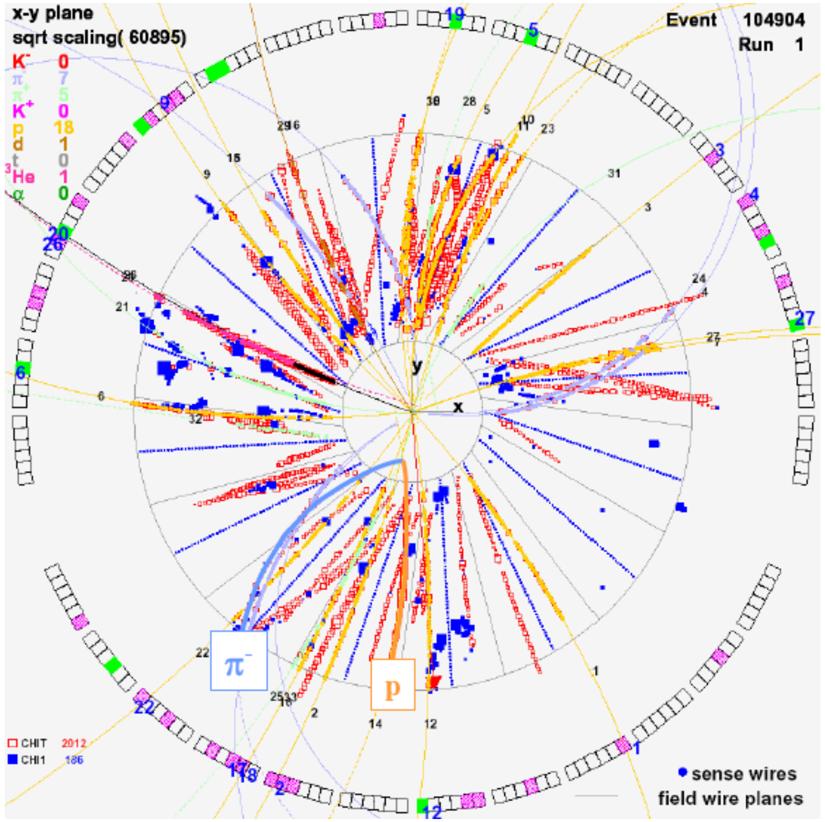
2. FOPI detector

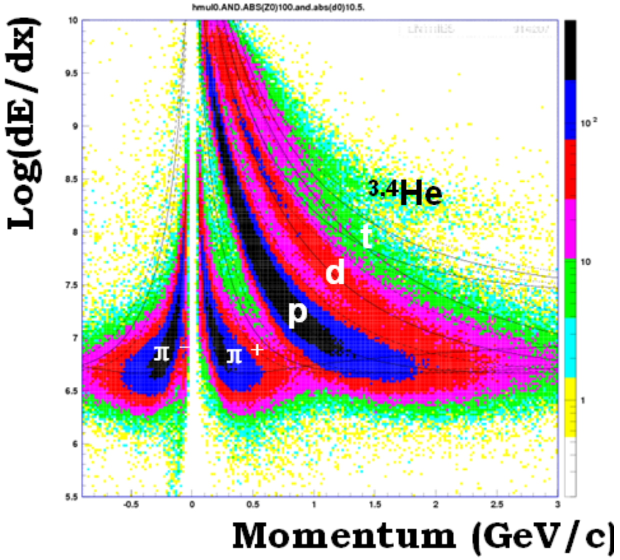


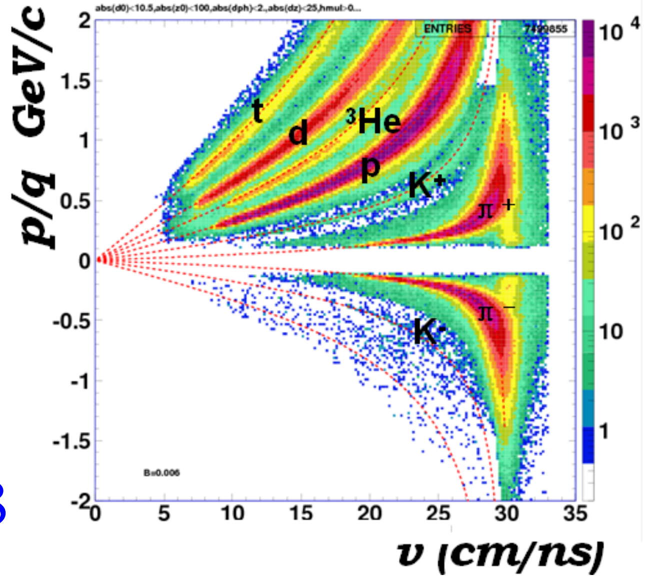


- Angular coverage close to 4 π .
- Over-all time resolution of RPC barrel : 88ps (RPC=68ps).
- Identification of p, d, t, ^{3}He, ^{4}He, $\pi^{\pm}$, $K^{\pm}$.
- Reconstruction of strange resonances (ϕ, K^{*}, Λ , Σ^{*}).

Detector performance



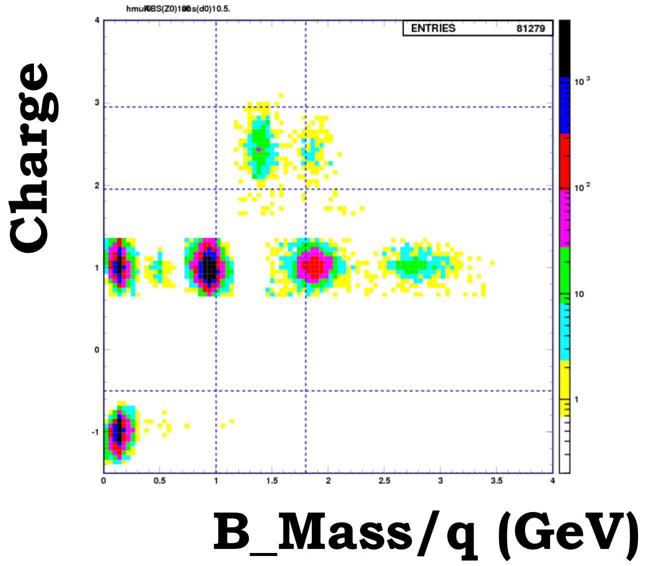


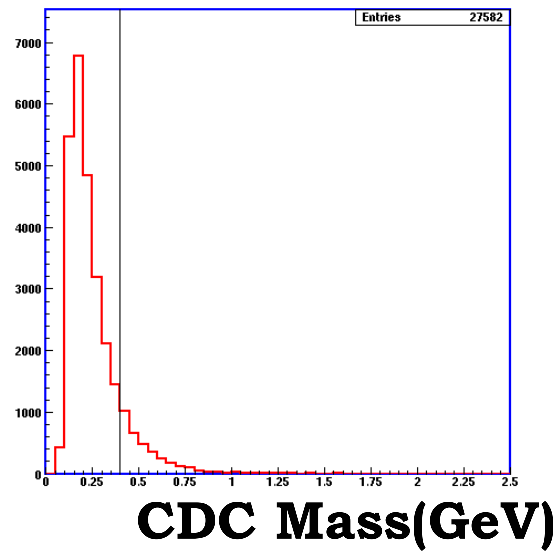


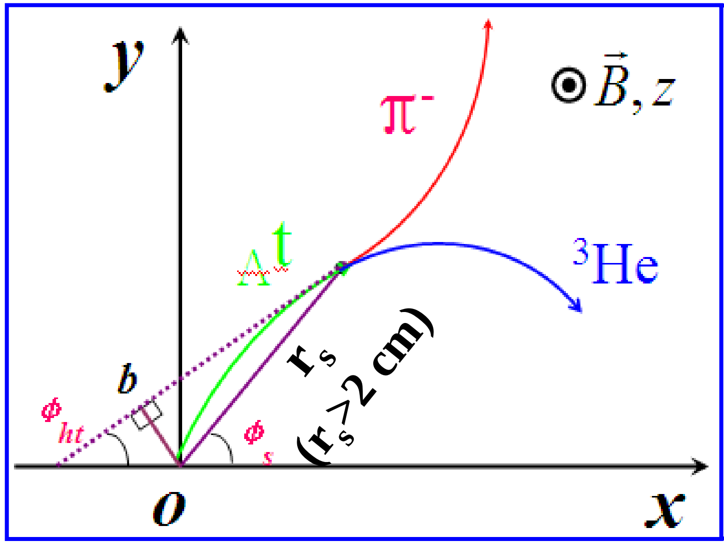
Ni+Ni @ 1.91AGeV (~60M)

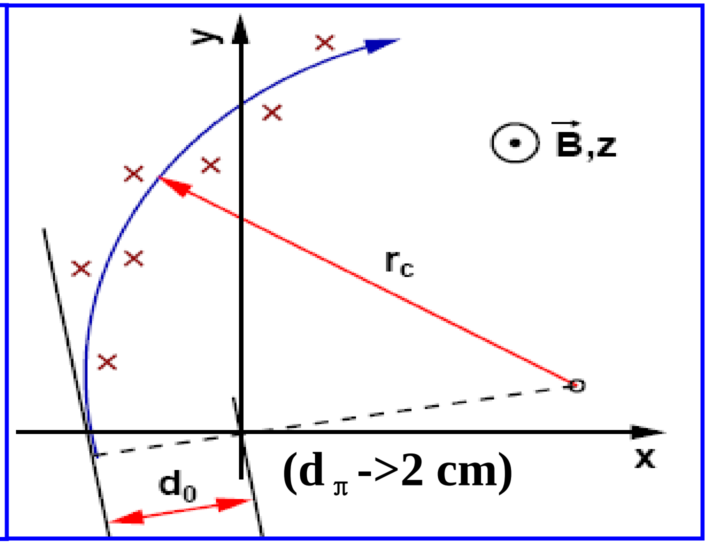
S325e, SIS18 of GSI, 03. 2008

3. Cut quantities for $_{\Lambda}t \rightarrow \pi^{-} + {}^{3}He$

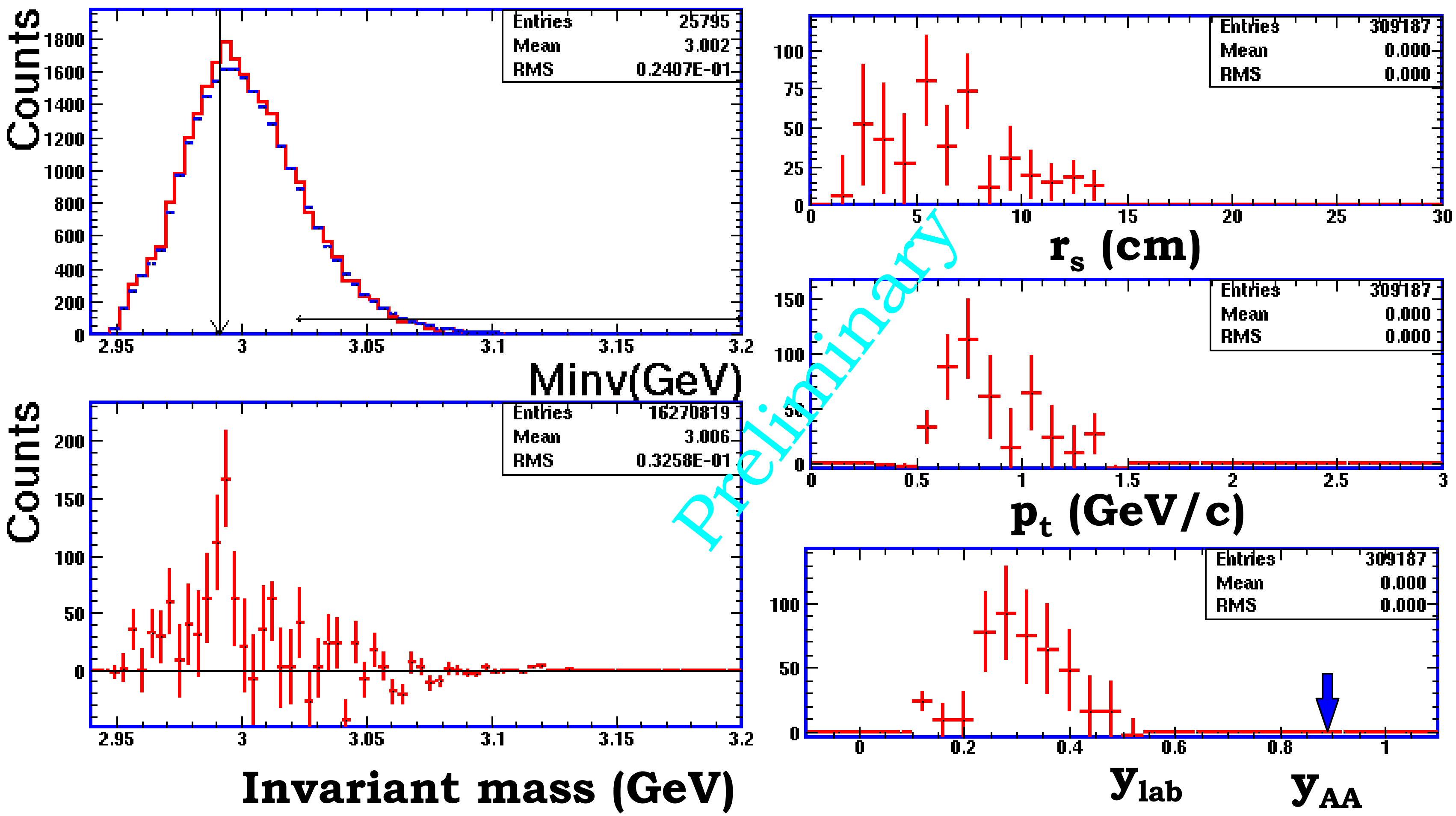




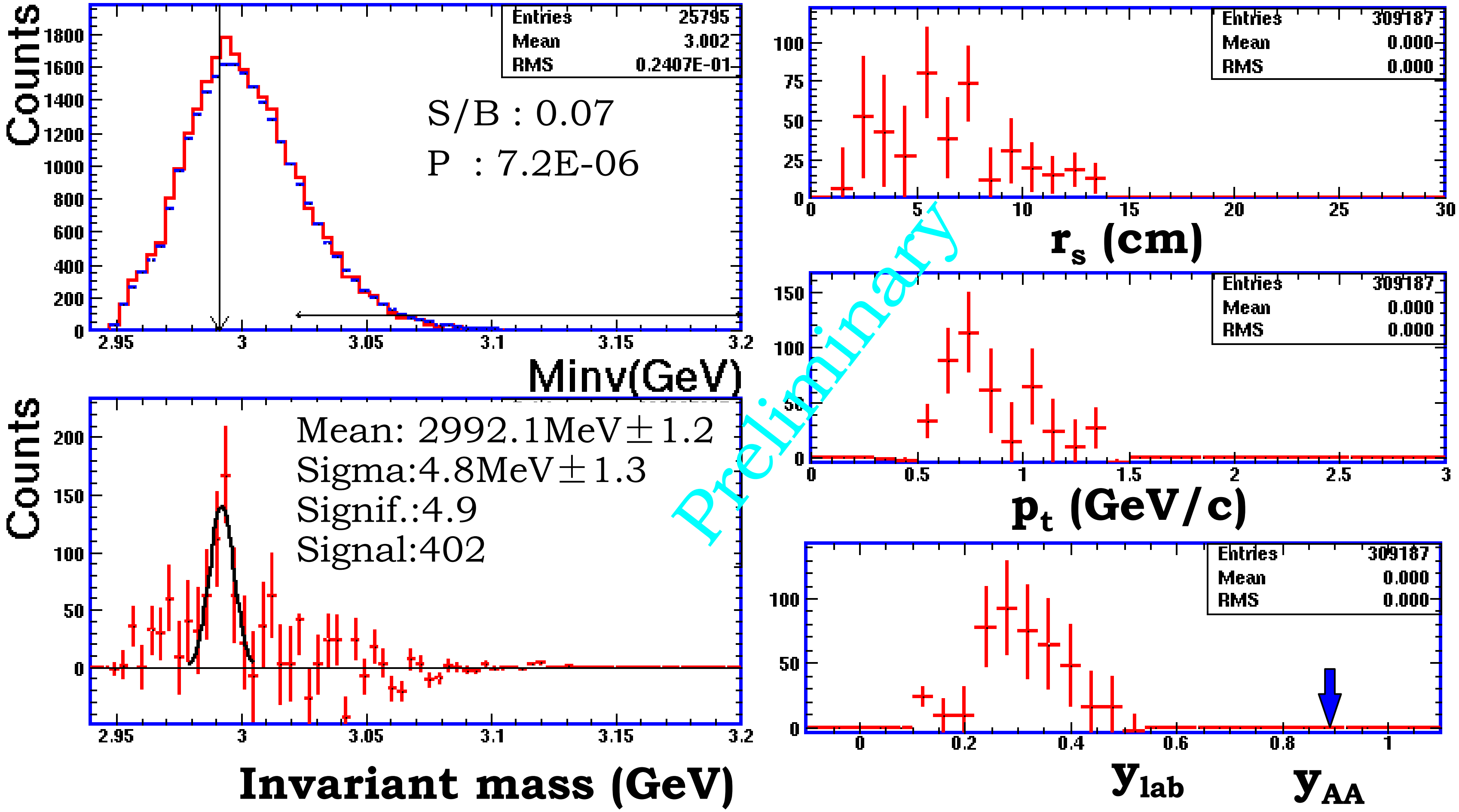




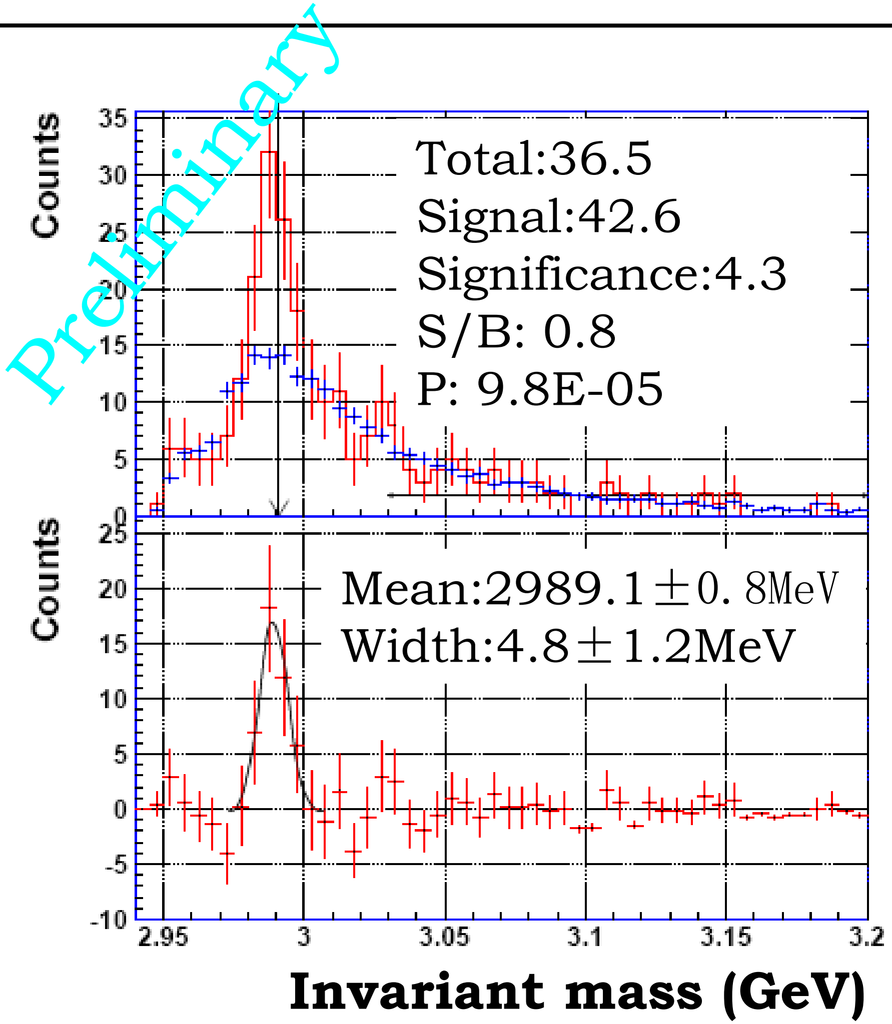
Π^--^{3}He invariant mass reconstruction



Π^--^{3}He invariant mass reconstruction



Π^{-}-^{3}He invariant mass reconstruction

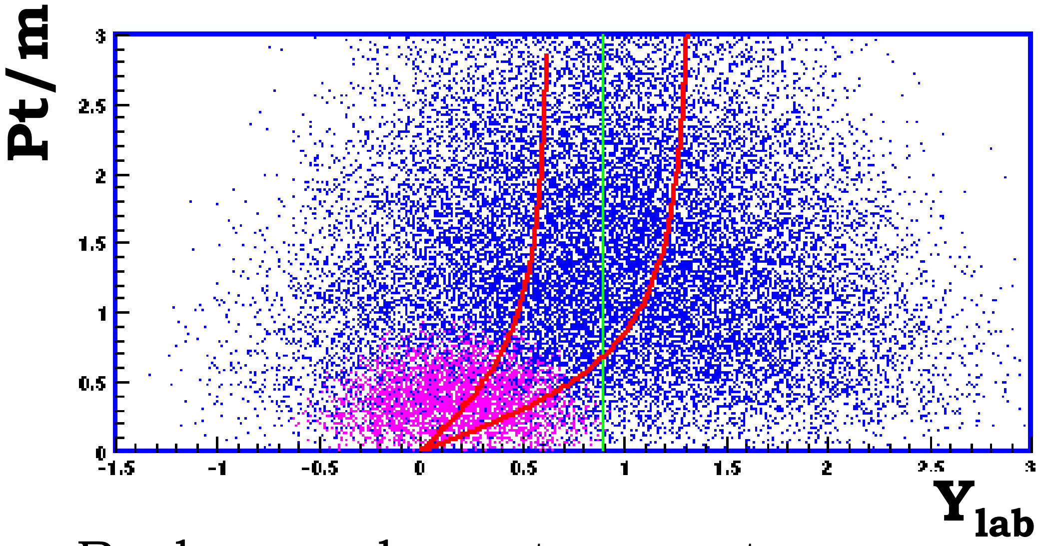


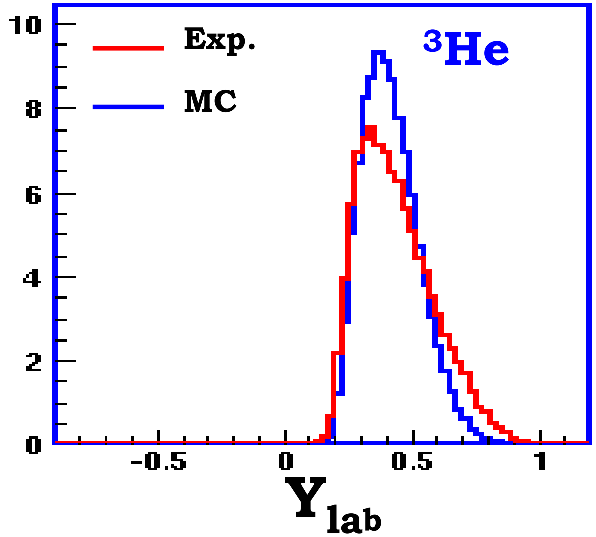
Reconstructed invariant mass of Π^{-}-^{3}He pairs from K^{+} candidate tagged events in Ni+Ni collisions at 1.91AGeV

S/B can be improved by a factor of ~10.

However, K^{+} identification is necessary over large portion of phase space.

4. $_{\Lambda}t \rightarrow \pi^{-} + {}^{3}He$ background simulation





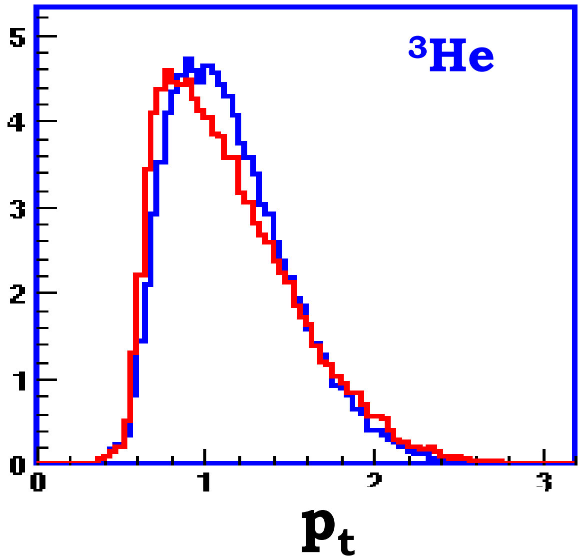
Background event generator:

1) QMD, Ni+Ni 1.93A GeV.

2) Thermal ^{3}He:

Temperature =110 MeV, Beta=0.35

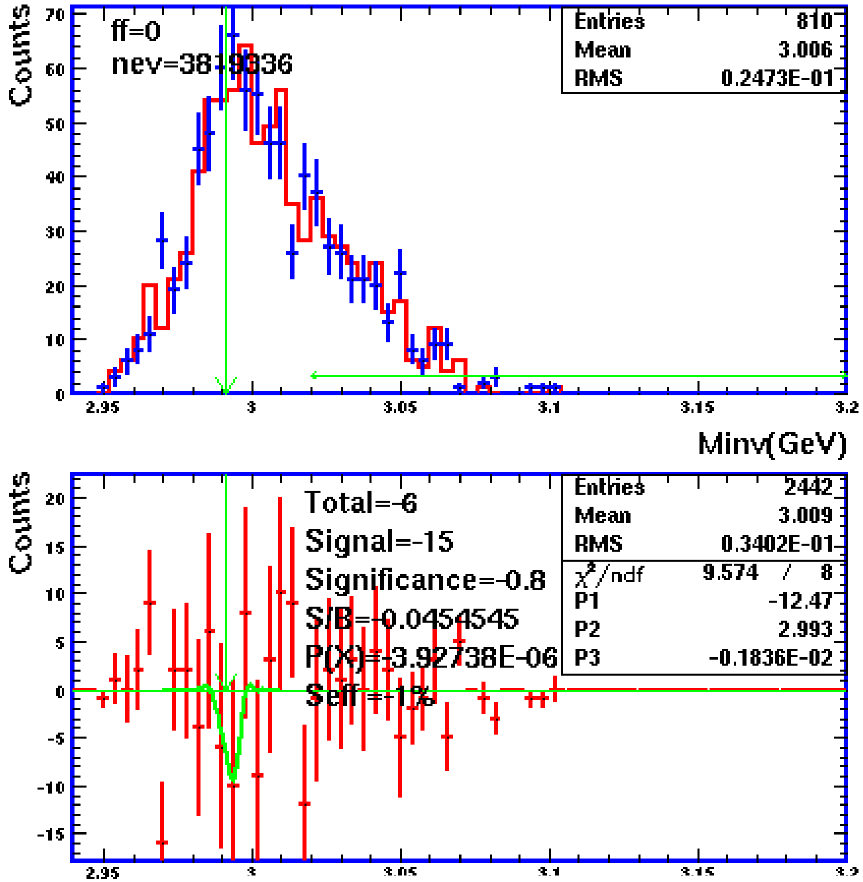
y_{source}= 0.18



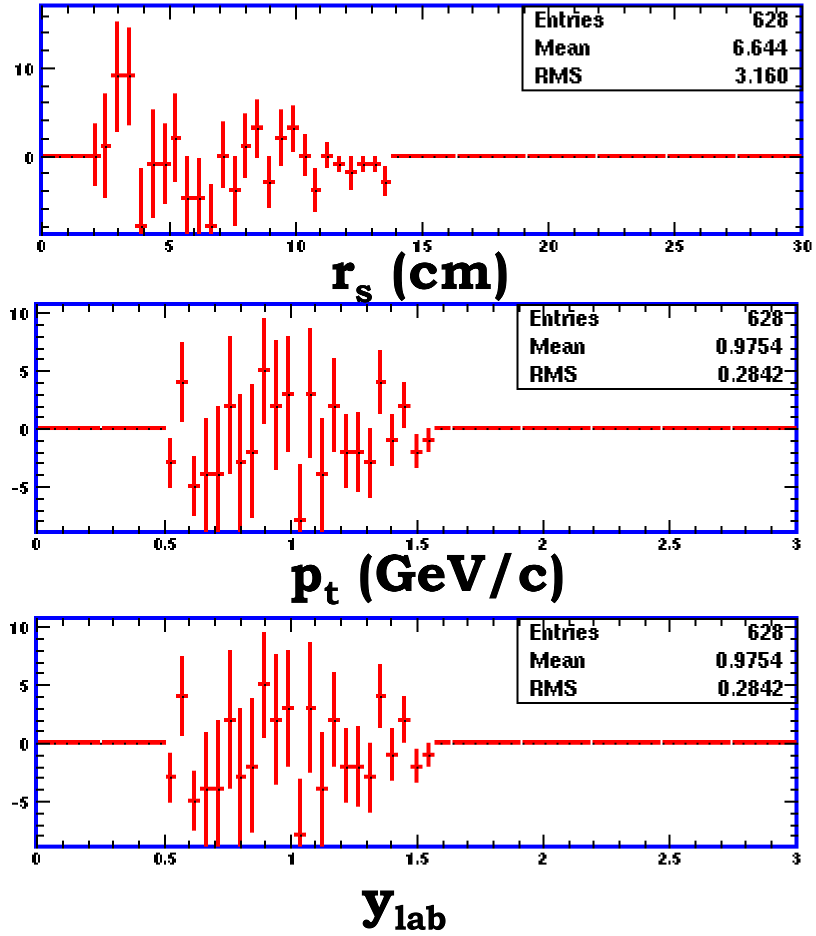
Exp(^{3}He*/ π^{-}) = 0.012

MC (^{3}He*/ π^{-}) = 0.018

MC background with selection cuts as used for data analysis



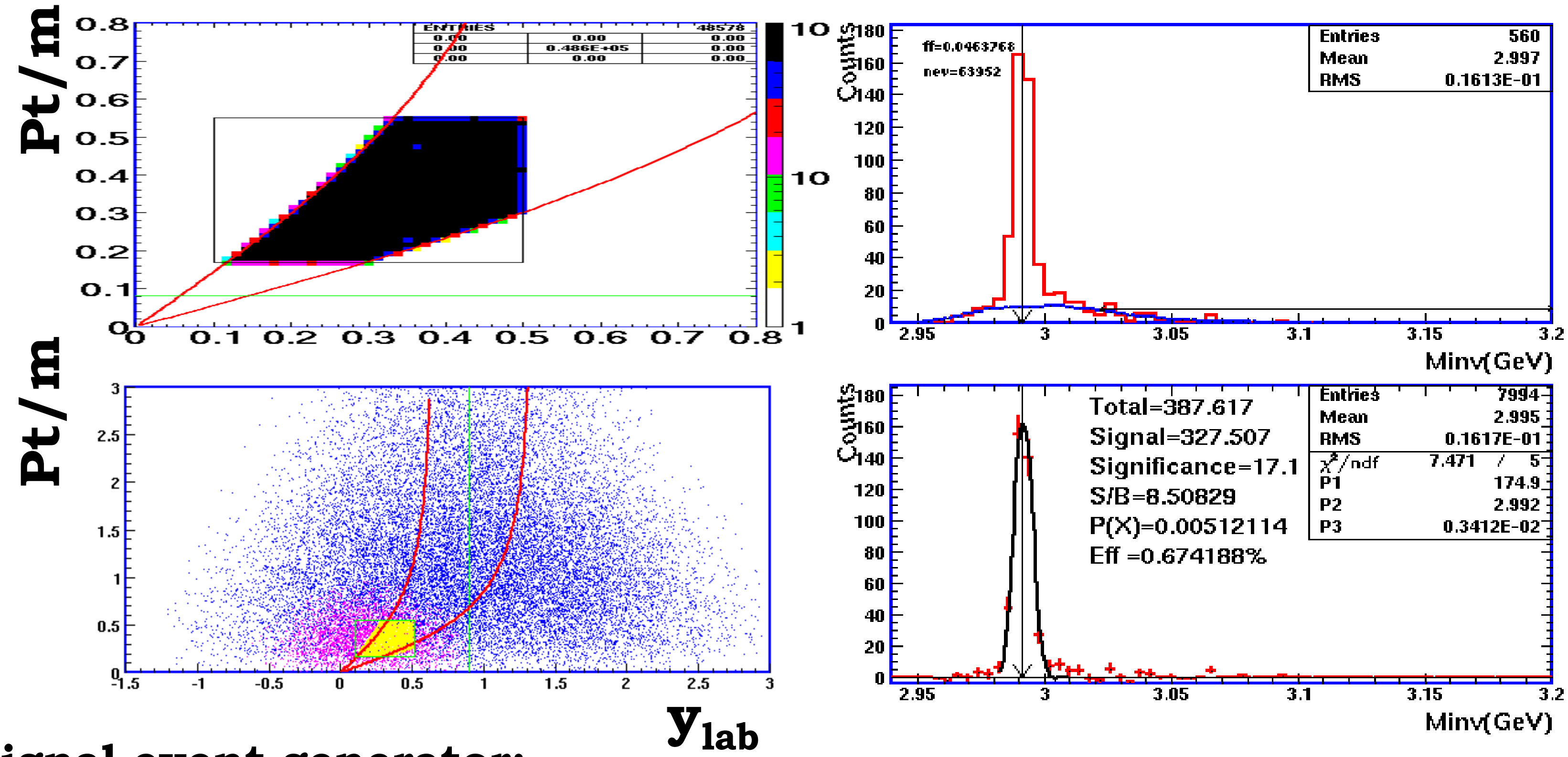
Invariant mass (GeV)



QMD+^{3}He, (4.1M), Exp. (60M)

No artificial excess created.

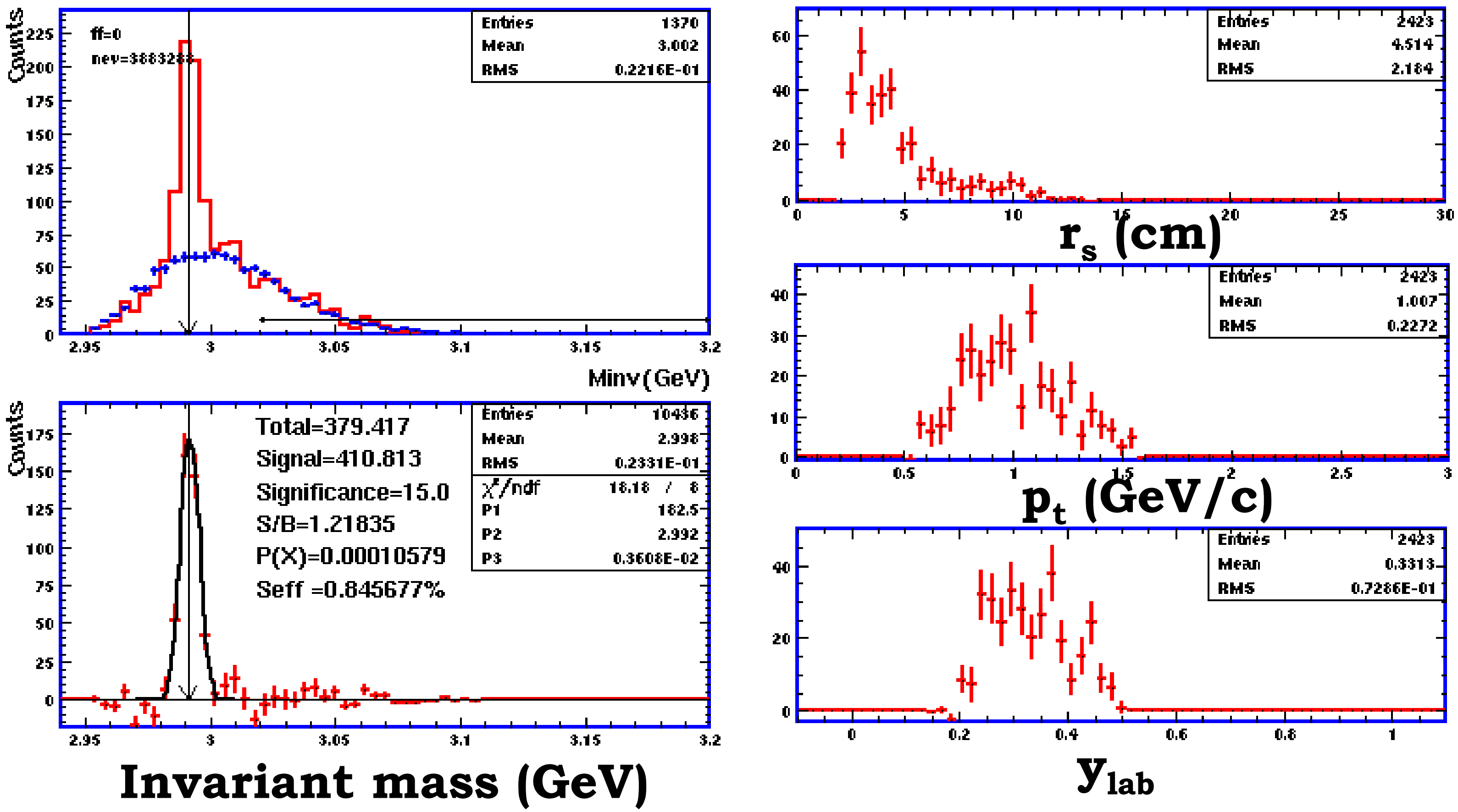
Signal event simulation



Signal event generator:

1) **QMD, Ni+Ni 1.93A GeV.**
2) **Thermal ^{3}He. (Temperature=110 MeV, Beta=0.35, y_{source}=0.18)**
   MC (^{3}He / π^-)= 0.018.
3) **$_\Lambda$t flat pt-y distribution: $p_t \in$[0.5, 1.5] GeV/c, $y_{lab} \in$[0.1, 0.5],**
   Mass=2.991 GeV, lifetime=245 ps.

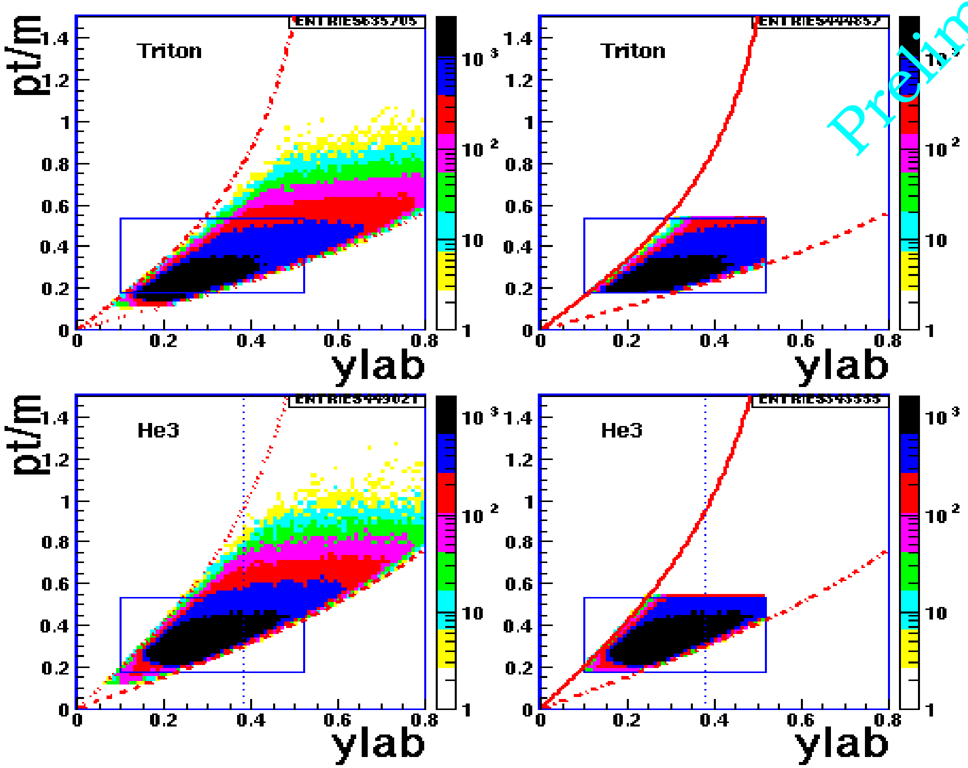
MC with selection cuts as used for data analysis



Signal events: $_{\Lambda}t$ + QMD+^{3}He, 6.4x10^4,
Backgrounds: QMD+^{3}He, 4.1x10^6,
Reconstructed: ~ 410

Eff ≈ 0.85%

5. Yield ratios of $_{\Lambda}t^*/t$ and $_{\Lambda}t^*/{}^3He$



Efficiency ≈ 65%

Preliminary

Ni + Ni @ 1.91A GeV

$p_t \in [0.5,1.5]$ GeV/c, $y_{lab} \in [0.1,0.5]$

$_{\Lambda}t^*/t = 1.6\text{x}10^{-4}/0.0085*0.65$

$= 1.2\text{x}10^{-2}$

$_{\Lambda}t^*/{}^3He = 2.25\text{x}10^{-4}/0.0085*0.65$

$= 1.7\text{x}10^{-2}$

Thermal calculation: Ni+Ni

T=60 MeV, μ_b=783.3 MeV

$_{\Lambda}t/t = 2\text{x}10^{-3}$ (BR,~0.35)

$_{\Lambda}t/{}^3He = 2.2\text{x}10^{-3}$ (BR,~0.35)

(Anton Andronic)

6. Summary

1) Invariant mass of π^--^{3}He pairs shows an excess near the mass of $_\Lambda$t under specific selection criteria.

2) Reconstruction of hypertriton was investigated using full GEANT simulation with QMD and thermal ^{3}He as background event generator. No artificial excess was found.

3) Reconstruction efficiency of $_\Lambda$t was determined by signal MC to about 0.85%.

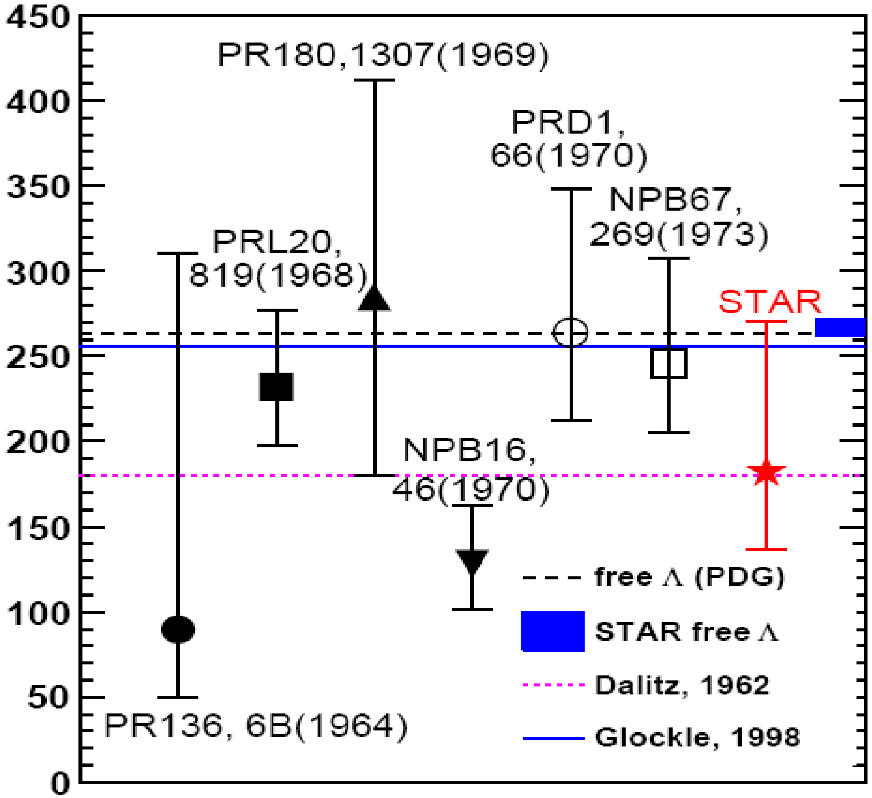
4) Yield ratio of $_\Lambda t^*/t$ and $_\Lambda t^*/^3He$ in Ni+Ni at 1.91A GeV is estimated in the phase space region:
$p_t \in [0.5, 1.5]$ GeV/c, $y_{lab} \in [0.1, 0.5]$, we get
$_\Lambda t/t = 1.2 \times 10^{-2}$, $_\Lambda t/^3He = 1.7 \times 10^{-2}$.

Outlook

1) Extend analysis to full solid angle for ^{3}He.
2) Understand reconstruction efficiency by MC in detail.
3) Extend analysis to other data sets,
   Ni+Ni@1.93AGeV (S261),
   Ni+Ni@1.91AGeV (S325),
   Ni+Pb@1.91AGeV (S338),
   Ru+Ru@1.91AGeV (S338).
4) Determine the lifetime of $_\Lambda t$.
5) Investigate three body decay: $_\Lambda t \rightarrow \pi^- + d + p$.
6) Look for heavier hypernuclei: $^4_\Lambda H$, $^4_\Lambda He$, $^5_\Lambda He$.

Thanks for your attention!

Lifetime of $_{\Lambda}t$



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