Kaon identification for tagging the Double - Λ- hypernuclei production at PANDA

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- General Motivation
- Introduction to Experimental concept
- Detection Strategies
- Background Suppression Methods
- Outlook

panda

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mami MAINZER MIKROTRON

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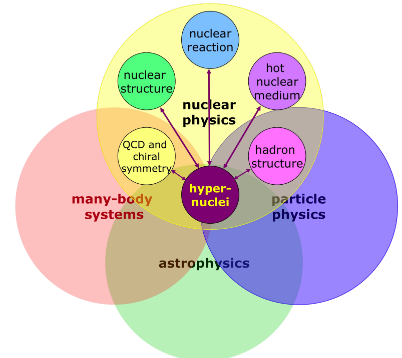
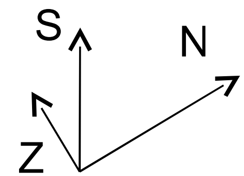
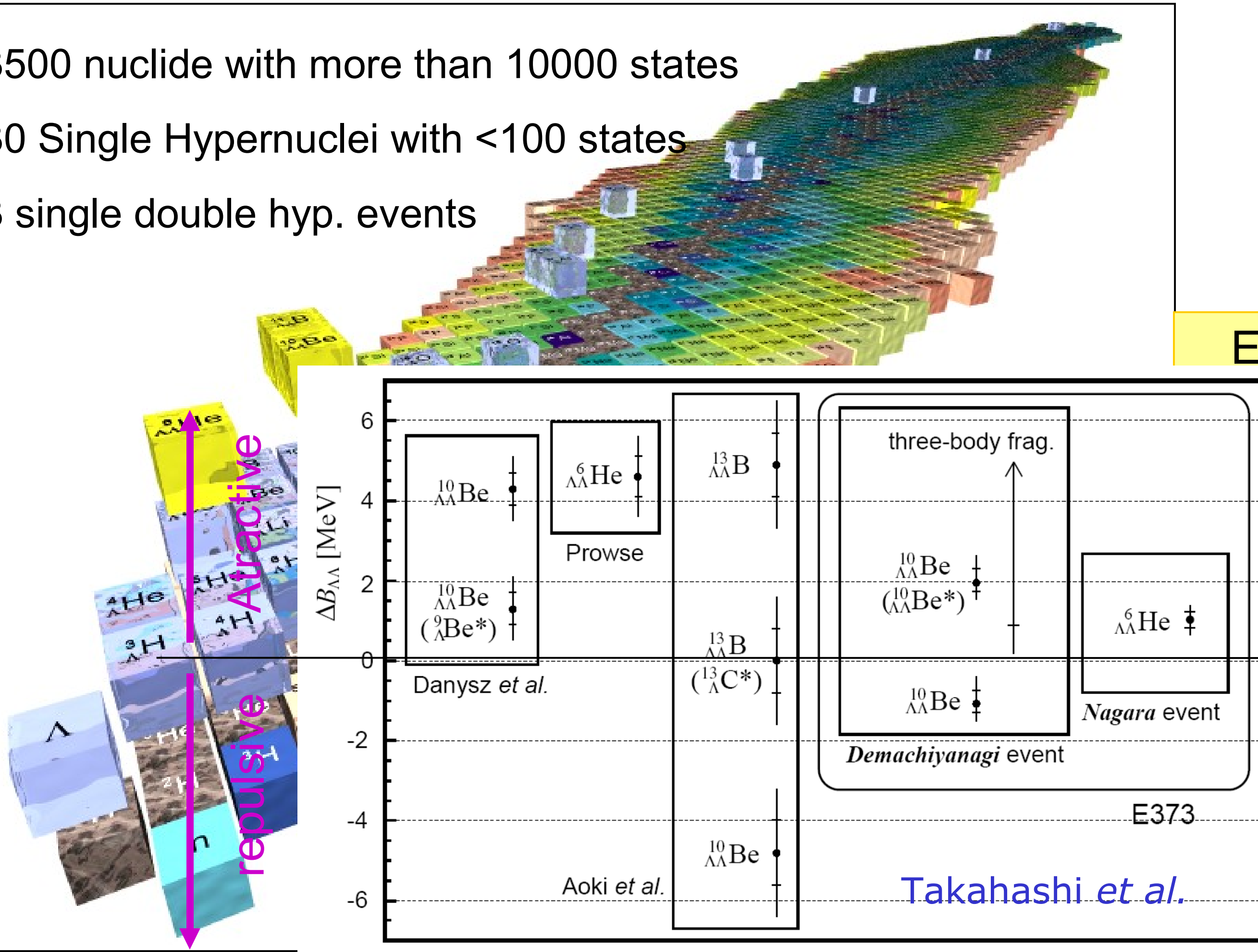
Motivation



- Study of Y-Y interaction (ΛΛ Hypernuclei) offers additional information about the B-B interaction



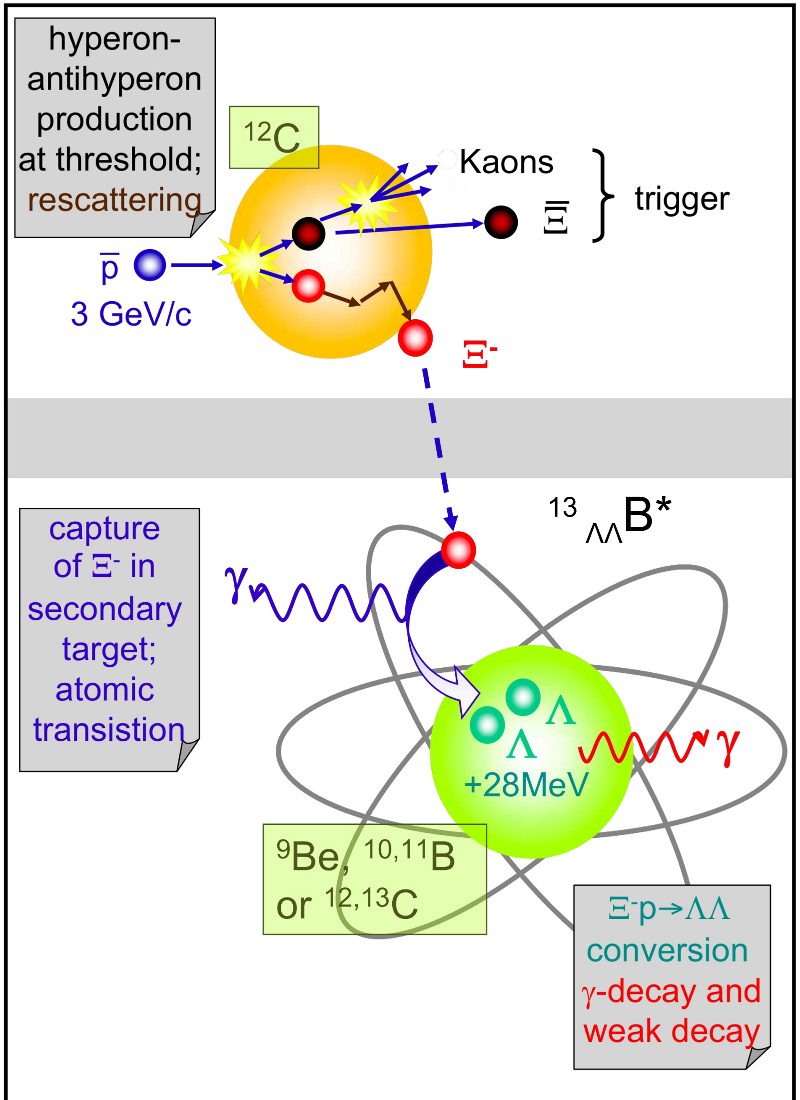
- ~3500 nuclide with more than 10000 states
- ~30 Single Hypernuclei with <100 states
- <3 single double hyp. events



Element = Proton Number

B
Y
Z

Gamma Spectroscopy of double hypernuclei at PANDA

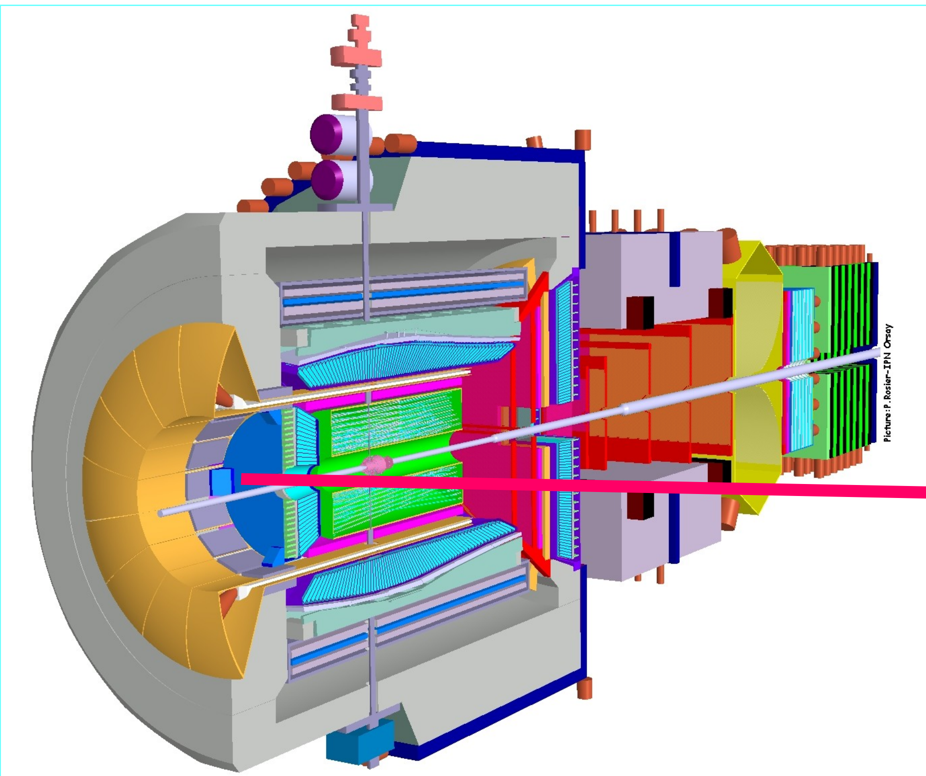


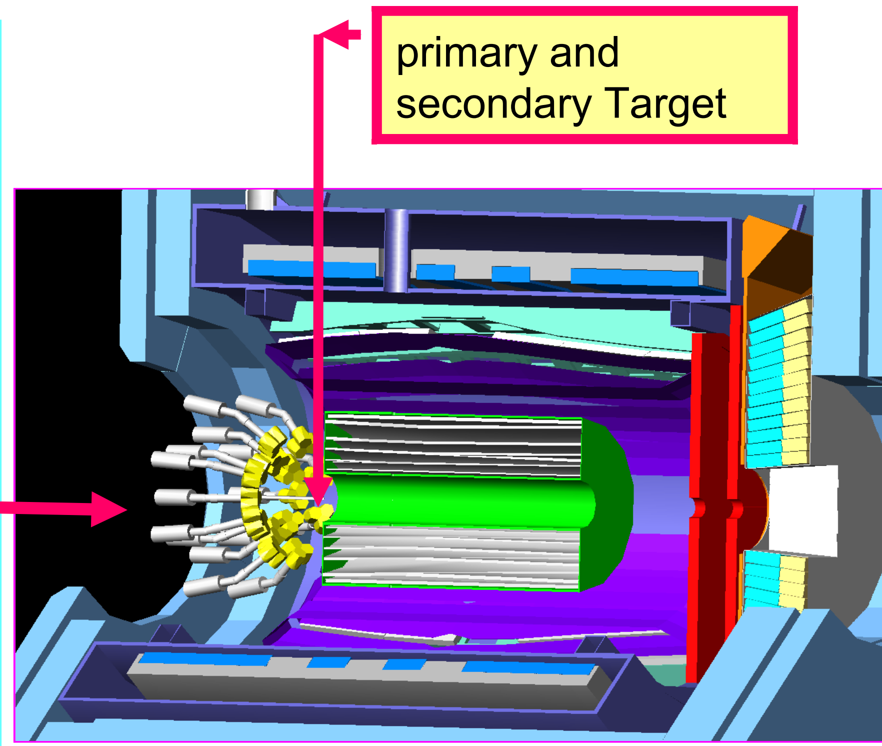
- p +Nucleus->Ξ^- +Ξ^+ at 3GeV/c
  Other Exp. E906 AGS-BNL, JPARC
  (K^- + p -> K^+ + Ξ^-)
- Cross section 2μb
- Luminosity 10^{32} cm^{-2}/s to
  7.10^5 Ξ^- +Ξ^+ hour
- Ξ^- p -> ΛΛ + 28 MeV
- energy release may give rise to the emission of excited hyperfragments ($^{13}_{\Lambda\Lambda}B^*$)
- Two-step production mechanism requires a devoted setup

Integration in the PANDA Detektor

- $\theta_{lab} < 45°$, Ξ^{+}, K trigger (PANDA)
- $\theta_{lab} = 45°\text{-}90°$,
  1. Primary target : $p + {}^{12}C \rightarrow \Xi + \Xi^{-}$,
  2. Secondary target, Ξ^{-} Capture , Hyp. Production
- $\theta_{lab} > 90°$, γ - detection at backward

Neutrons Background (16000 n s^{-1} per Crystal)





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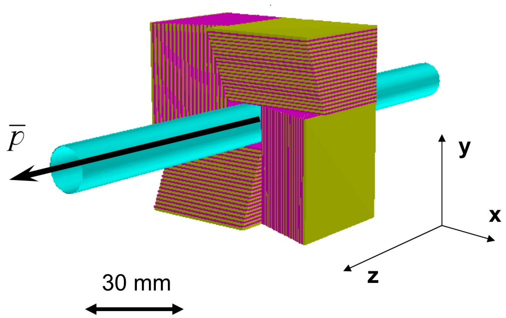
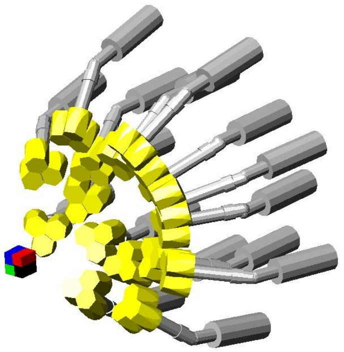
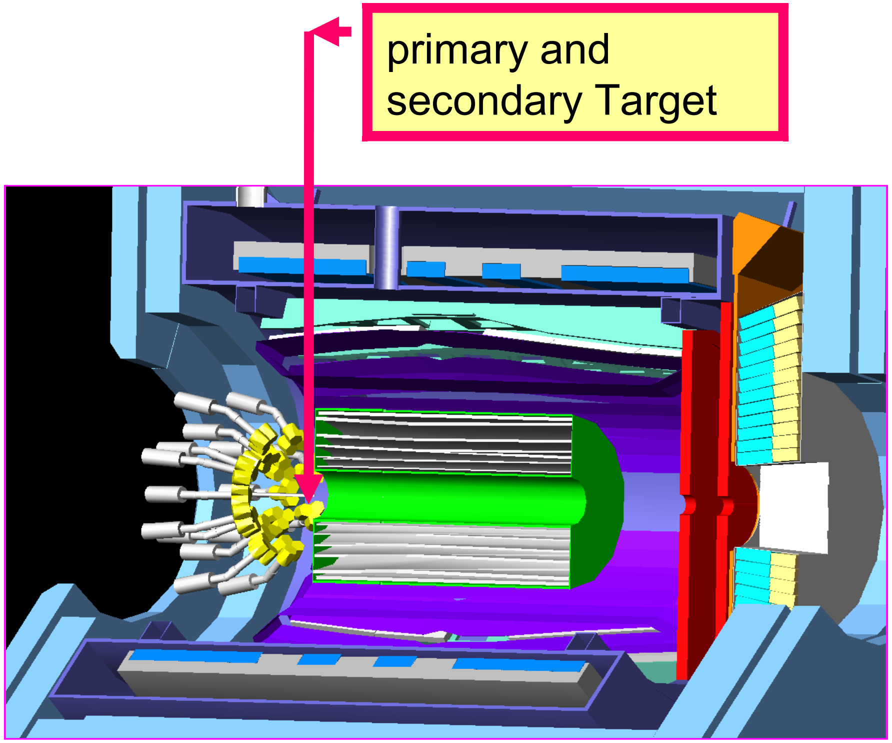




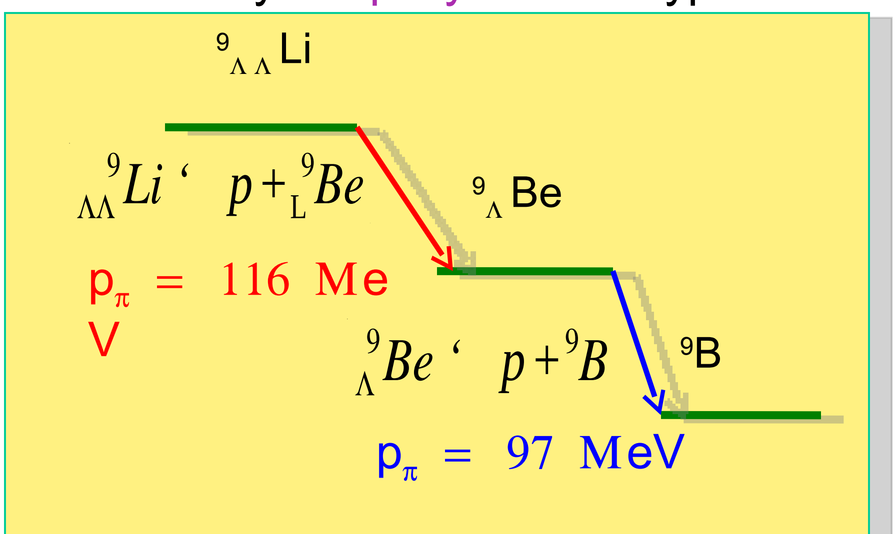


Detection strategy: Signal

- Use different light nuclear targets, (^{9}Be, ^{10}B, ^{11}B, ^{12}C and ^{13}C) to study the population of individual excited states.

- Identification of $\Lambda\Lambda$ hypernucleus through sequential weak decay via π^- emission:
    1. in light nuclei the pionic weak decay dominates
    2. the pion kinetic energy is proportional to $\Delta B_{\Lambda\Lambda}$
    3. the pion momentum is monoenergetic
    4. coincidences between two pions help to trace

5. Combination of gamma spectroscopy and sequential pionic decay as to identify uniquely double hypernuclei.



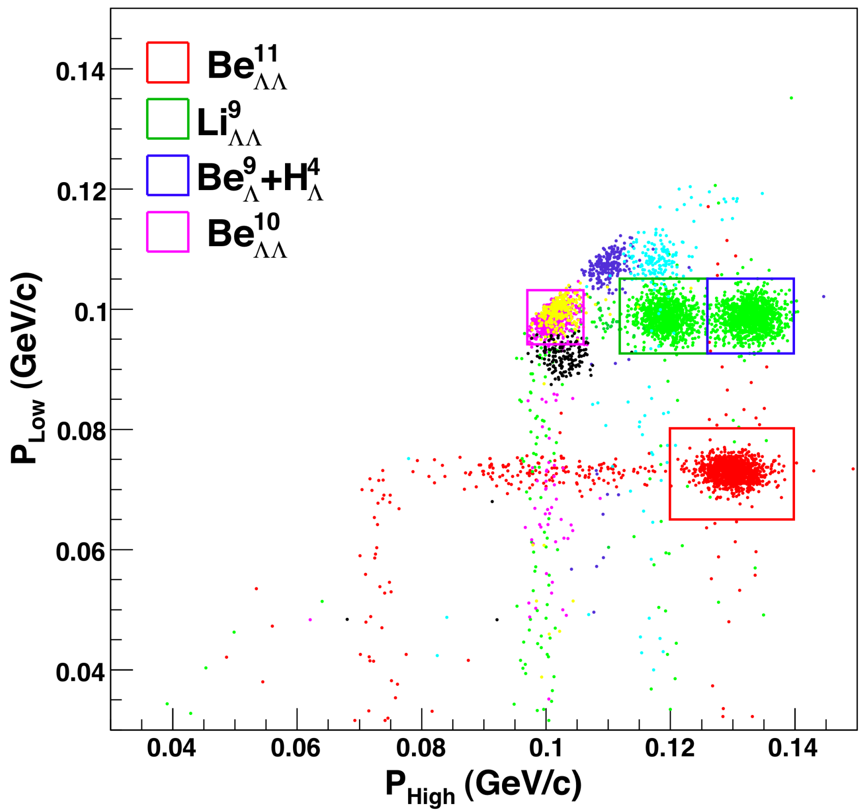
- π momentum is monoenergetic: used as fingerprint

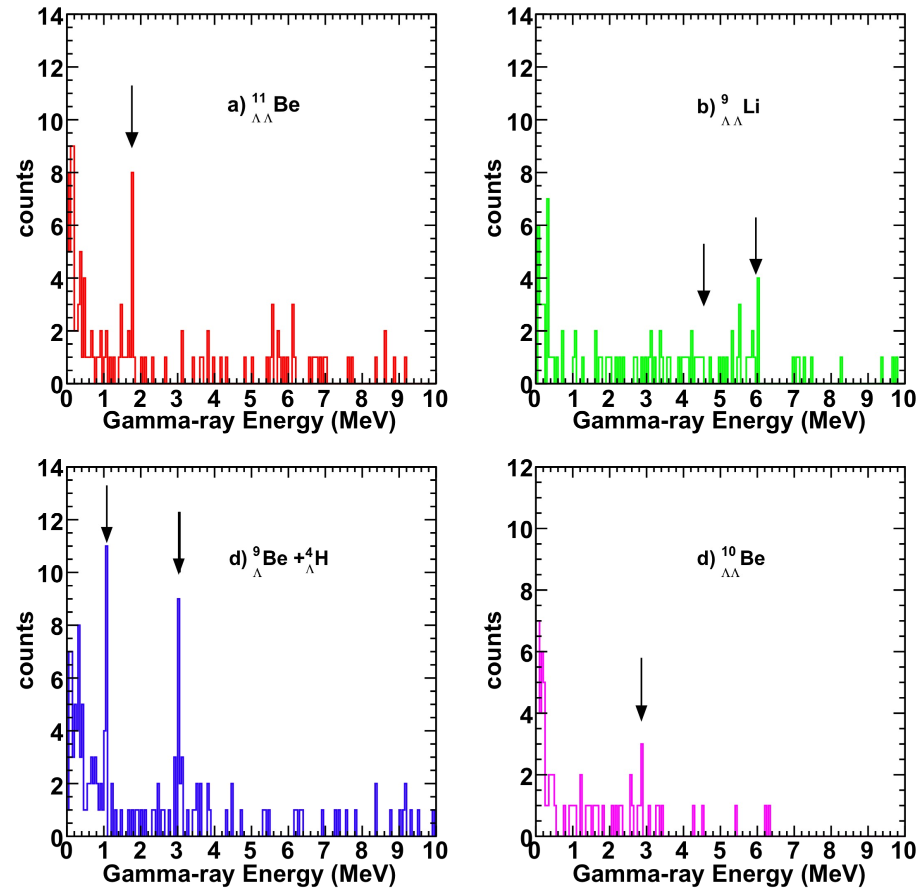
- $^{A}_{\Lambda\Lambda}Z \to \pi_H + ^{A}_{\Lambda}(Z+1)$

2. $^{A}_{\Lambda}(Z+1) \to \pi_L + ^{A}(Z+2)$

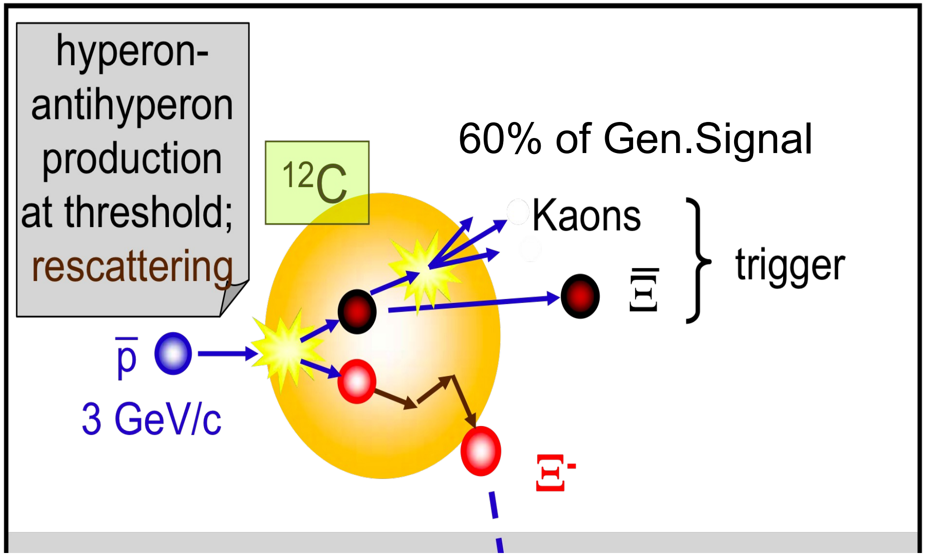
Identification of double hypernuclei: γ + weak decay

1. Mesonic weak decay of the order of 10%
2. Sequential mesonic decay of DHP releasing 2 pions





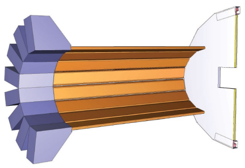
Background Suppression Strategy: Low Momenta Kaon identification



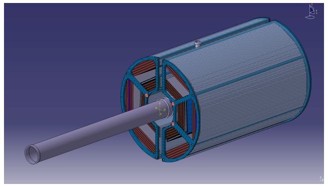
- p +Nucleus->Ξ^- +Ξ^+ at 3GeV/c
- Cross section 2μb
- p + p , total cross section 50 mb
- Exp.Challenge: $\frac{\sigma(\Xi^- \bar{\Xi}^+)}{\sigma(\bar{p}p)} \approx 4 \times 10^{-4}$

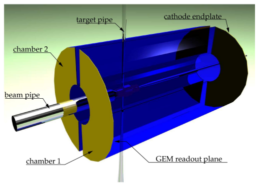
- Background reactions are a factor 25000 larger than Ξ^- +Ξ^+ prod.
- Background suppression is mandatory
- kaon (Ξ^+ annihilation) identification can be used to tag the Ξ^- +Ξ^+ prod.
- Pion-Pion Correlation technique(sequential pionic decay) and
- Gamma Spectroscopy .(arXiv:0903.3905v1 [hep:exp])

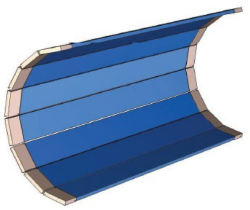
Detection Options:



- ➢ DIRC : not for low momentum particles
- ➢TPC/STT Use of (dE/dx) for PID
- ➢TPC/STT + TOF detector system :





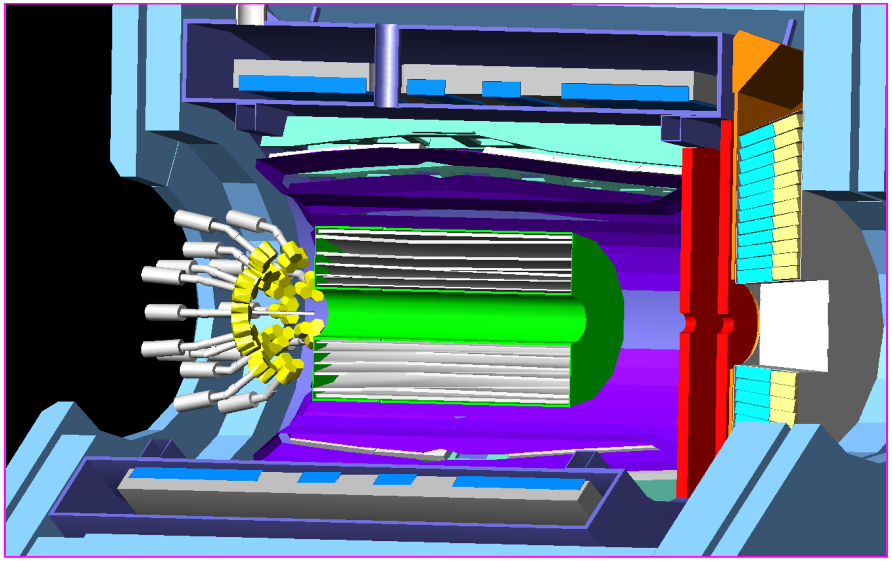


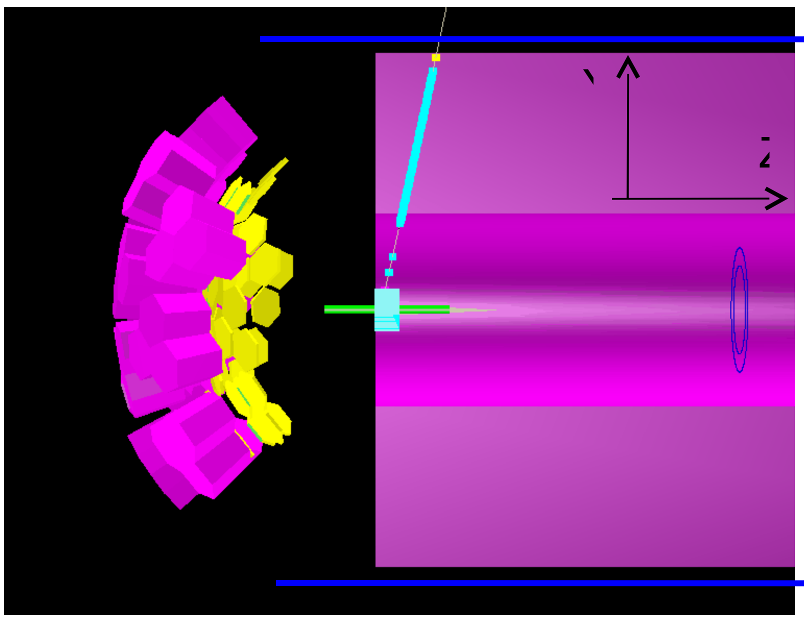
- ➢Start detector: CVD Diamond

(*Timing use, E. Bederman et al, Proc. IEEE(2009*)

- ➢Stop detector : Scint. tof barrel ~16 Slabs ~6 bars or RPC.

Diamond+TPC + TOF





•Tof barrel (STOP)

Time resolution ~ 80ps

•CVD Diamond Detector (START)

Time resolution ~ 80 ps

•TPC : tracking system

Track Length + P

P/Mass = $\beta * \gamma$

• Geo. Acceptance:

Hyp IP :15°--90°

TS IP : 144° -- 22°

STRATEGY : identification of at least one kaon per event.
(kaon multiplicity trigger)

MC Simulation :

Extended UqmdSmm (A.Galoyan)
Event Generator :

Signal : 200,000 $\Xi^- + \Xi^+$ events

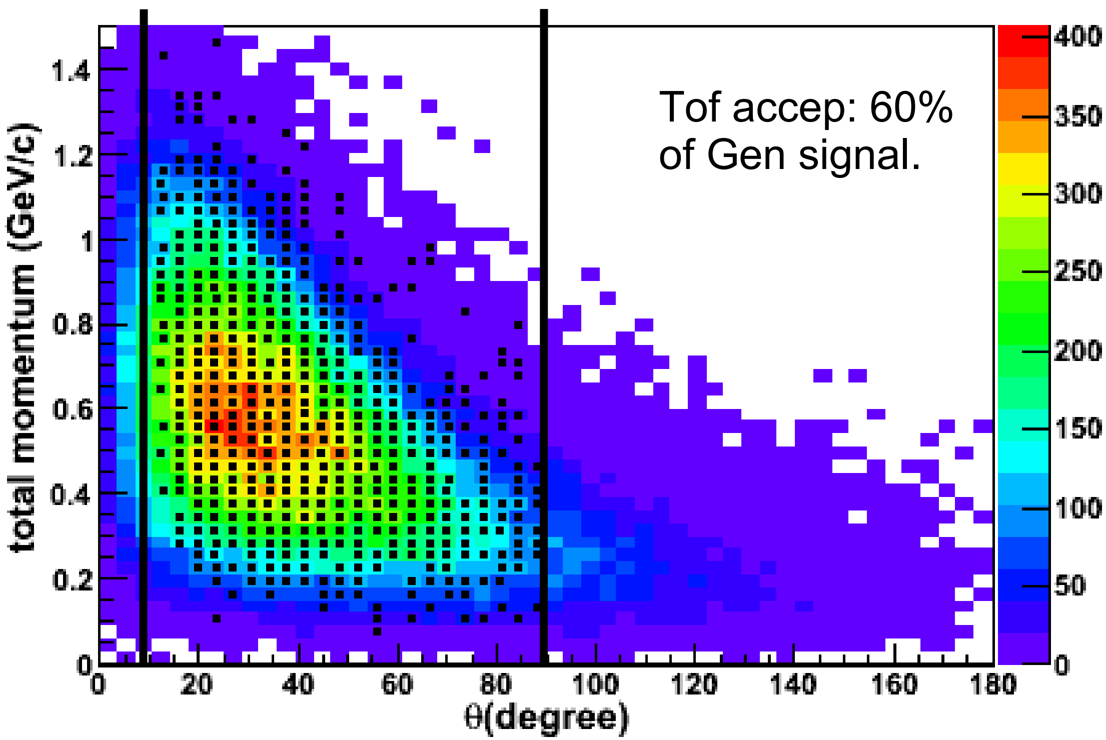
Background : 100,000 p +Nucleus

Calculations performed at
B = 1T and 0.5 T.

Tracking:
Ideal track finder algorithm

Track Fitting:
RiemannTrack at PndTools
Package

associated positive kaon distribution
at generation vertex



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(kaon multiplicity trigger)

Requirements :

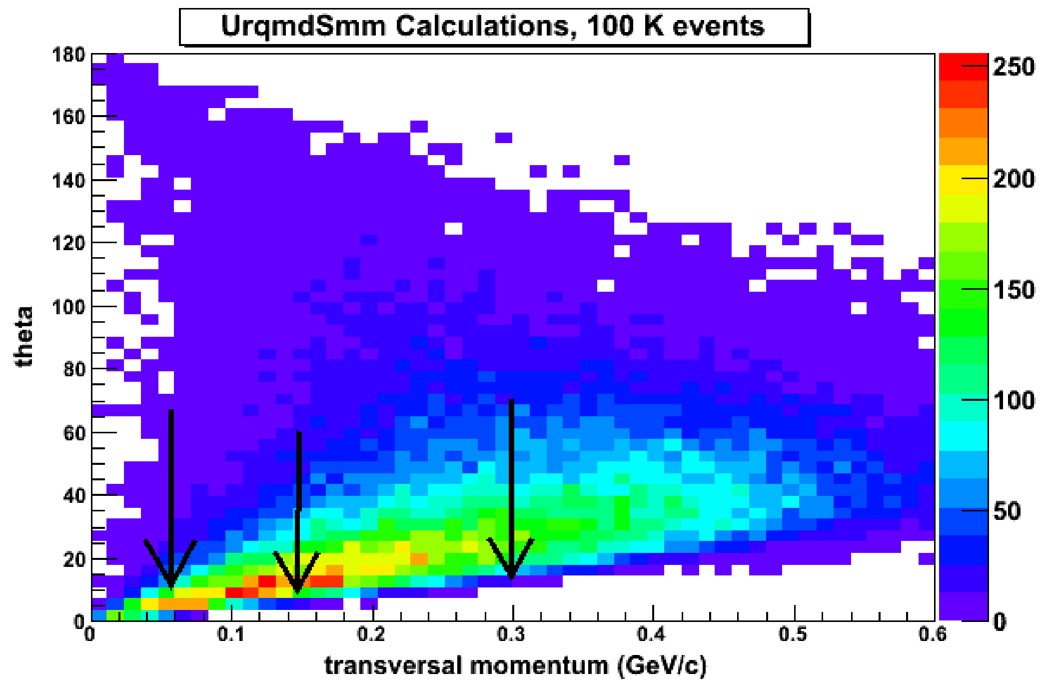
Central Tracker + Tof radius ≈ 0.5 m

$P_T = 0.3*Q*B*Radius$

B = 2 T, kaon Pt ≈ 0.3 GeV/c

B = 1T, kaon Pt = 0.150 GeV/c
(*FINUDA, ALICE, CDF*)

B = 0.5 , kaon Pt = 0.075 GeV/c
(*ALICE*)



associated positive kaon distribution
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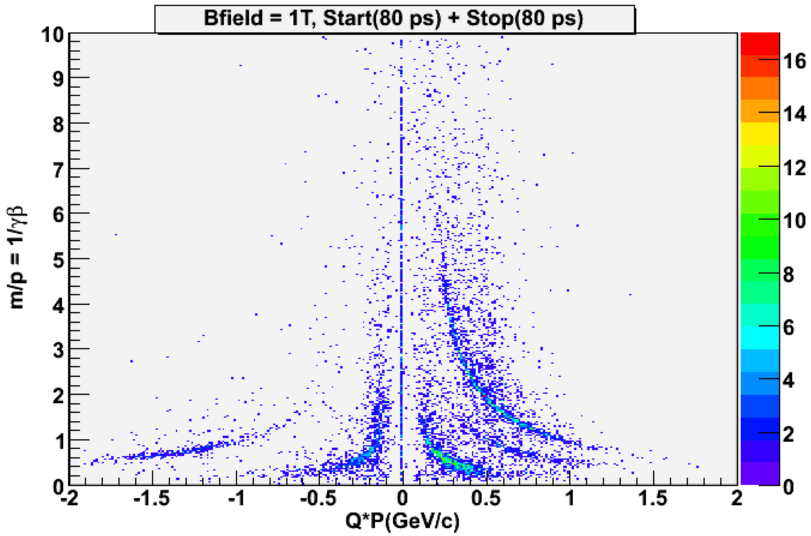
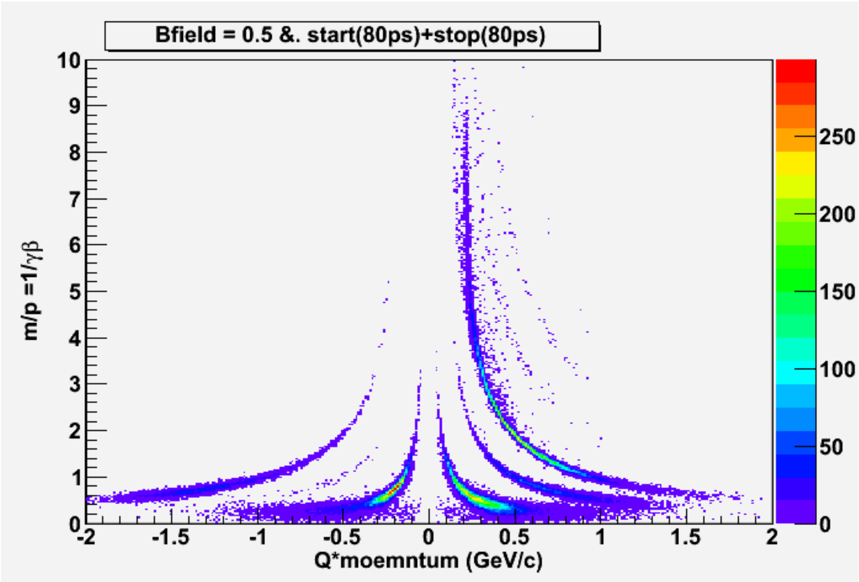
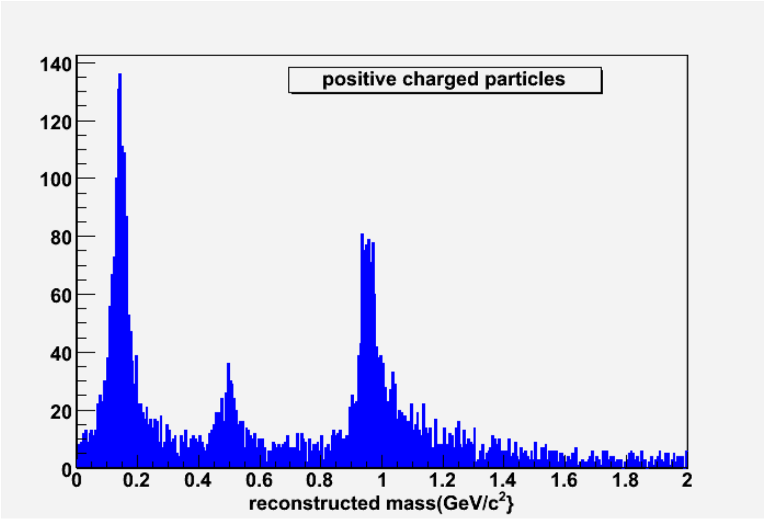
Tof Studies at different magnetic field values

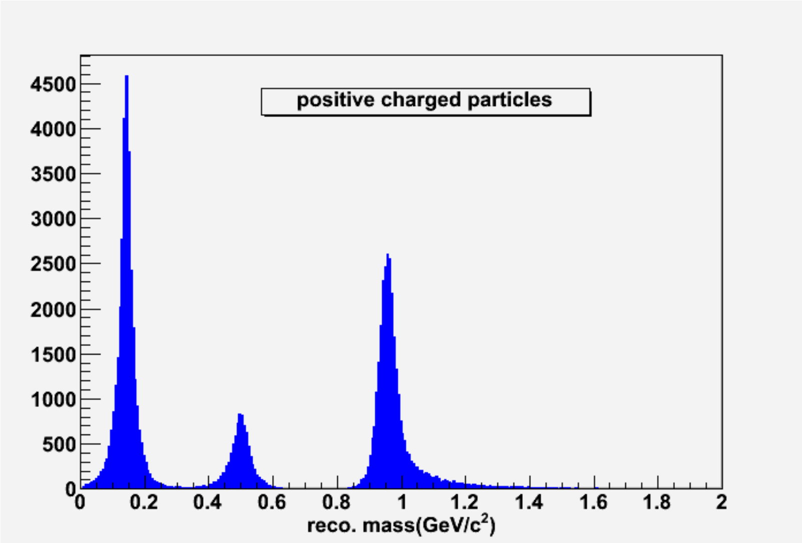




550 reco. kaons

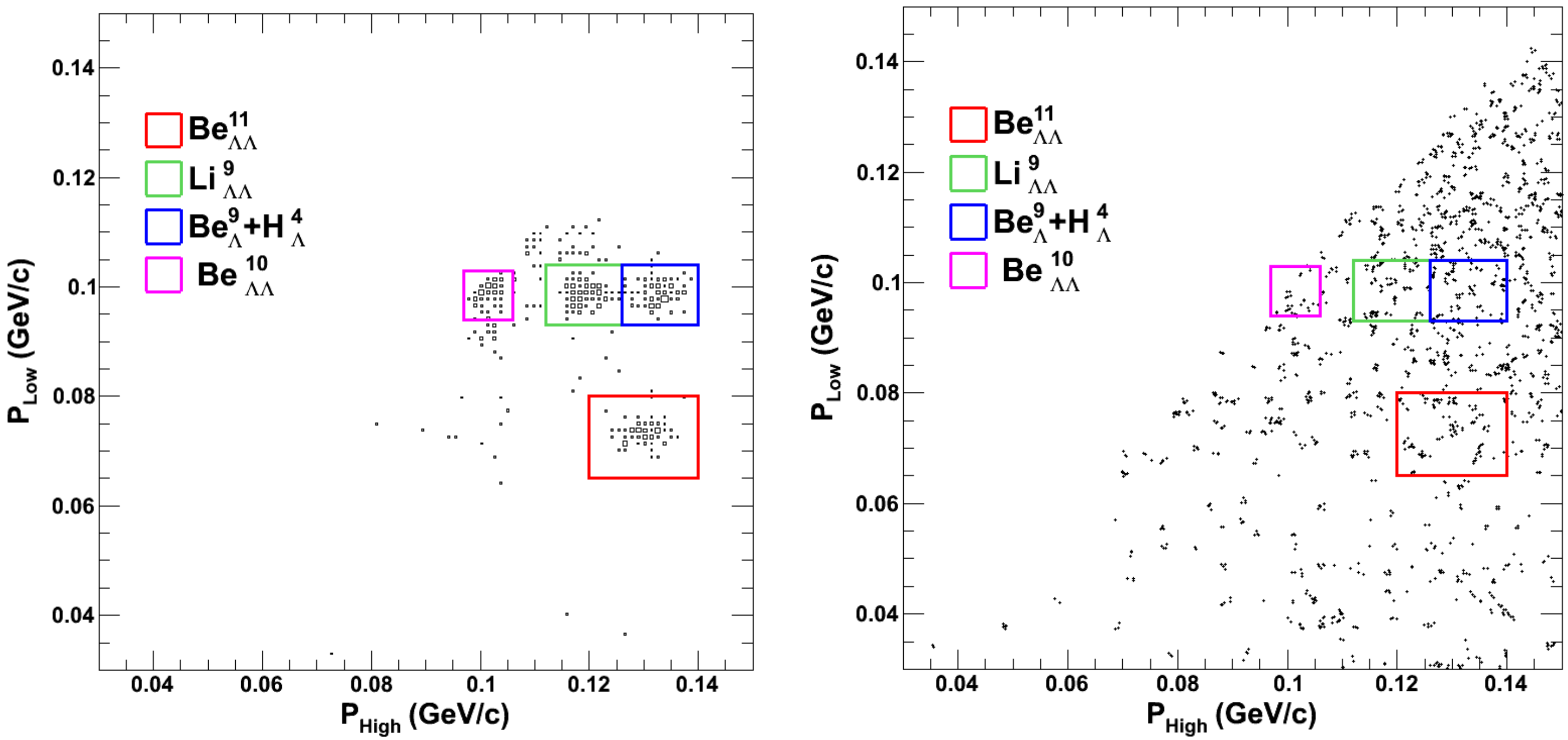
8760 reco. kaons





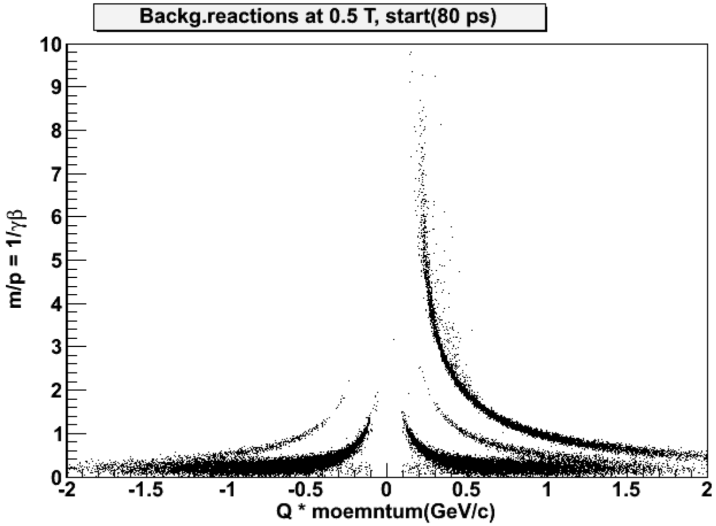
Cut on accepted kaon candidates at B=0.5 T

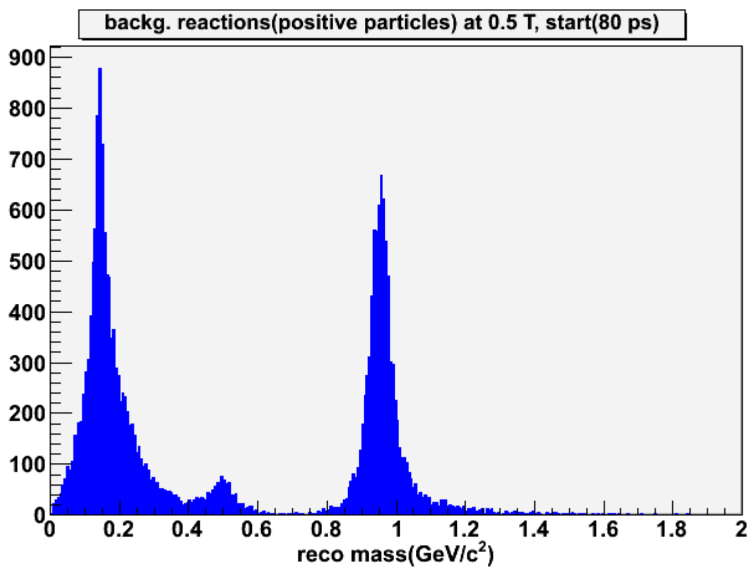
- Tagging on at least one kaon : 764 absorbed Ξ^- events
- Secondary target: 15000 Ξ^- absorbed
- Event Generator : 200,000 Ξ^- +Ξ^+ events
- S/N = 3:1 gamma energy spectra



p + Nucleus background contribution

(Urqmd+Smm, A. Galoyan et al)





- magnetic field value 0.5T
- start(80 ps)
- 100,000 p+Nucleus reactions

- 3206 rec. kaons
- No signal

p + Nucleus background contribution

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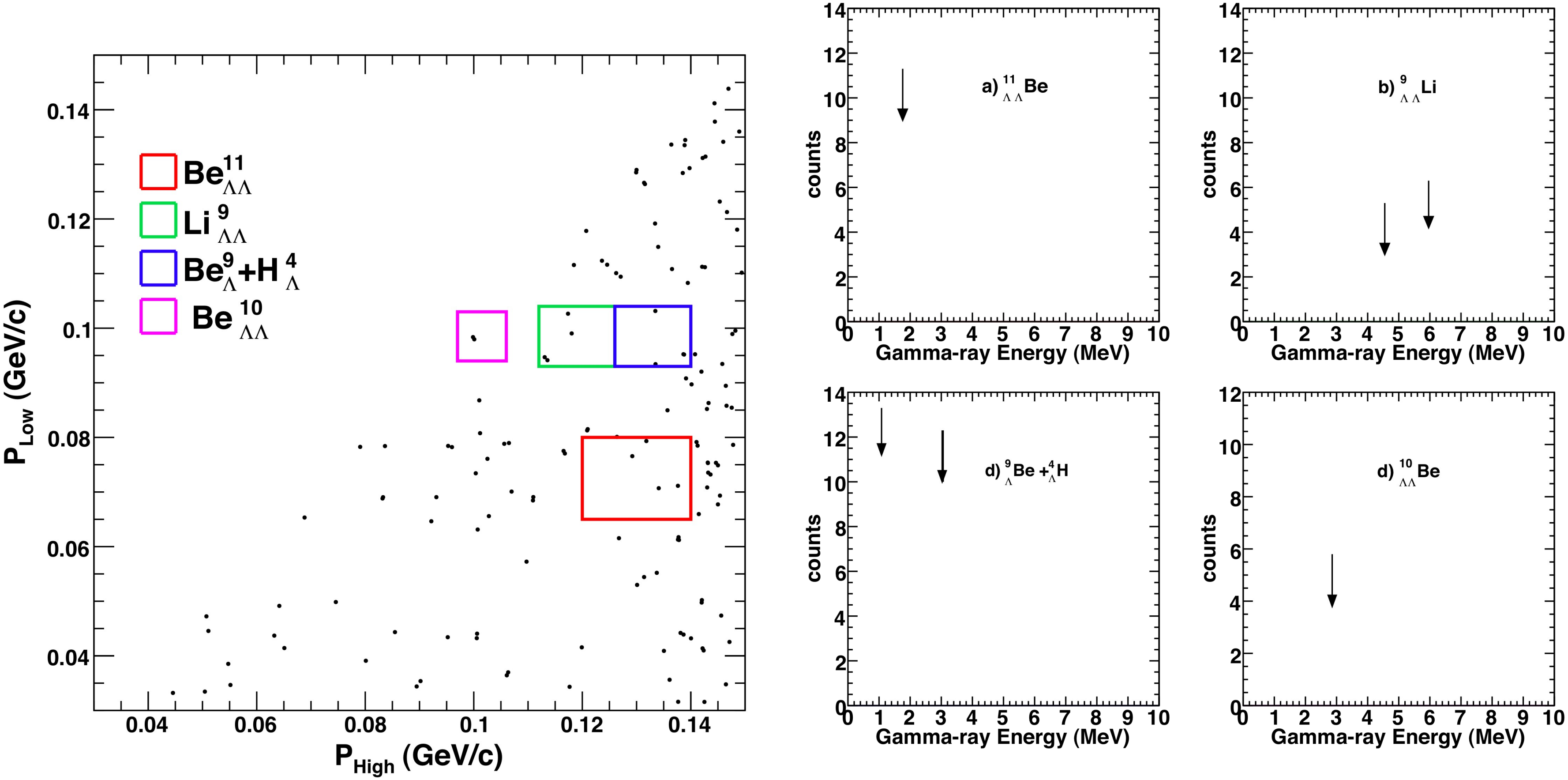
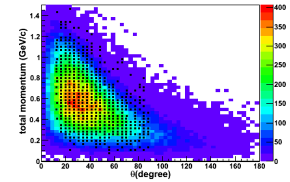
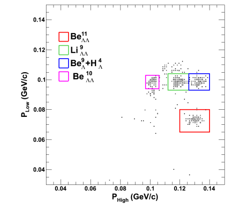


More statistic is needed

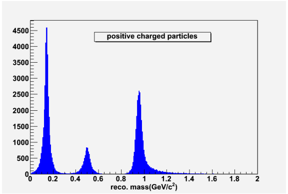
Conclusions:

1. Multiplicity kaon trigger based on TOF helps for background suppresion but statistic regarding p+Nucleus should be improved.



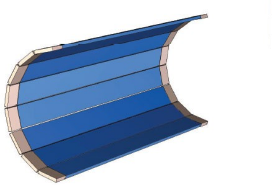


- Tracking information from Sec. Target has to be used complementary.

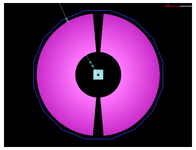


- B = 0.5 T increases the kaon identification acceptance

- A possible start detector solution: diamond detector with a time resolution of about 90 ps, example. HADES)



- The use of a TOF barrel detector will help in the identification of Double –Lambda Hypernuclei at PANDA.



Radiation hardness study

- Sim. 2.3 10^4 n+p/s at av. 25 MeV
- Rad. Damage:
  - electron irrad. vs (NIEL) of p/n
  - had. damage ~64 times stronger
  - annealing will not help
  - 12 days at 5 10^6 collions/s

ADC spectra from SiPMT before and after radiation with 3 10^8 electrons

by S. Sanchez Majos