# How to approach the potential of antihyperons in nuclei at PANDA

- introduction
- how to implant antibaryons ?
- some (not all) open questions

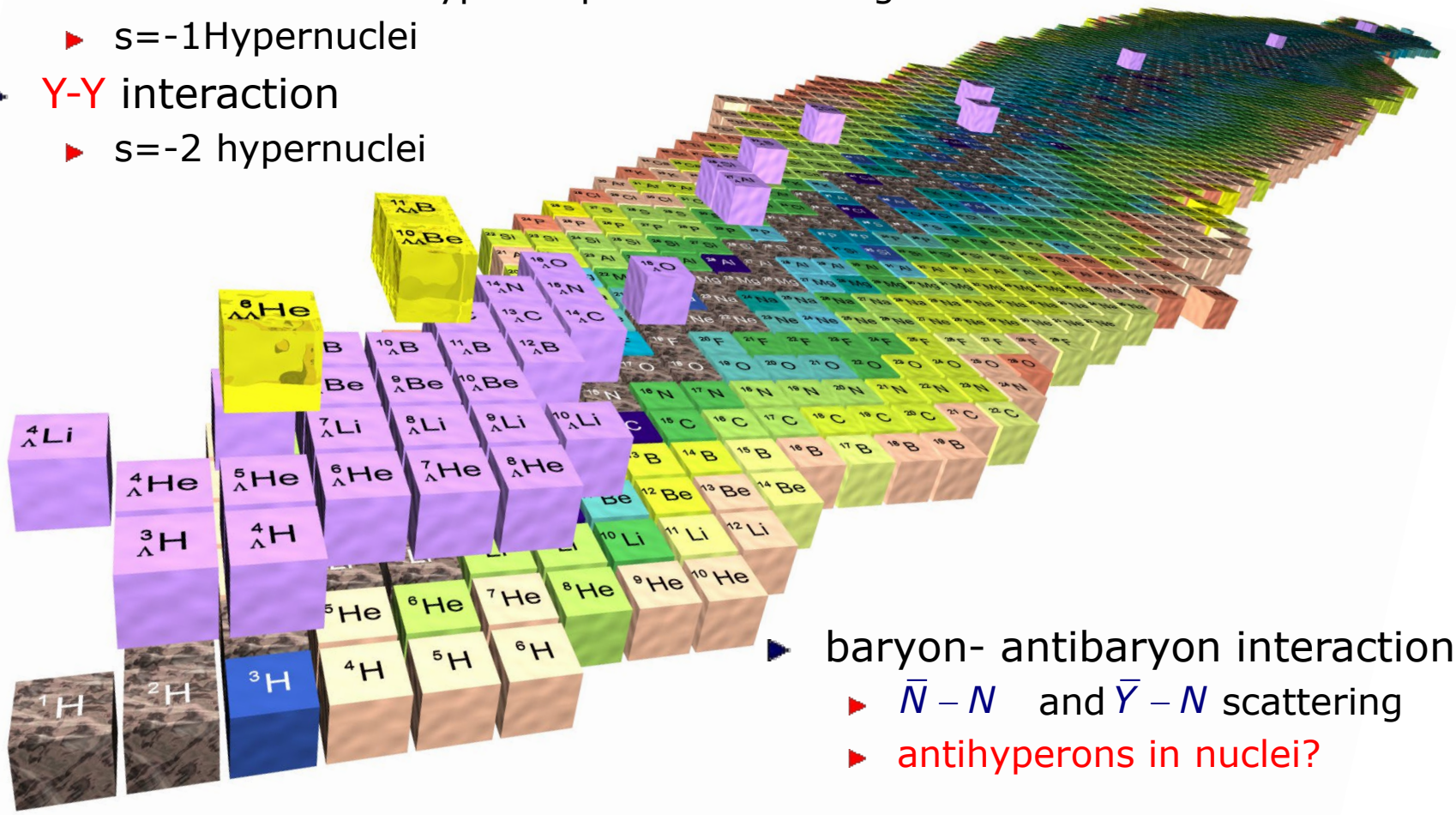
MAINZER MIKROTRON

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

SFB 443

# Baryon-baryon interaction

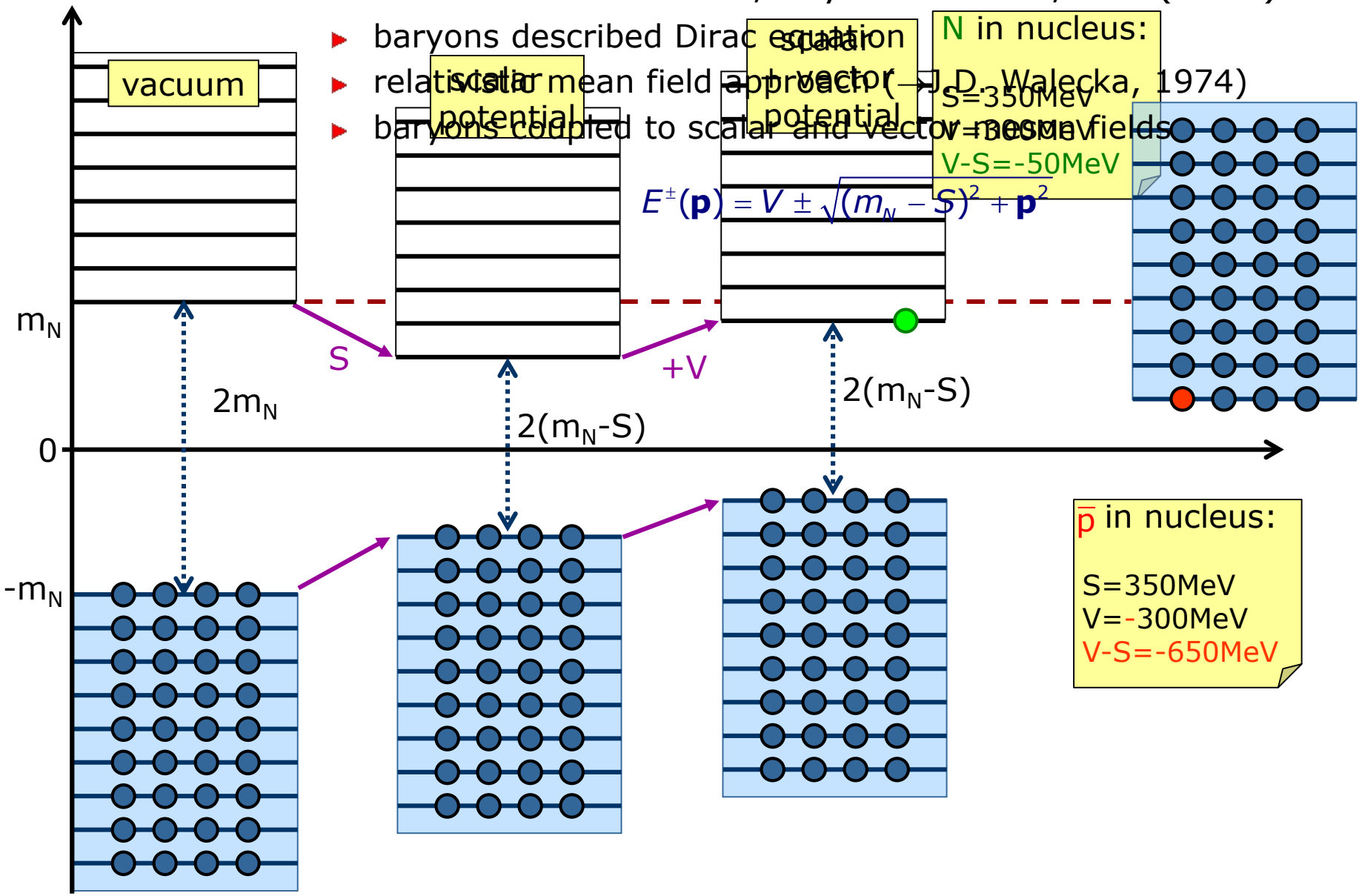
- N-N interaction
  - N-N scattering
  - ordinary nuclei
- Y-N interaction
  - low momentum hyperon-proton scattering
  - s=-1Hypernuclei
- Y-Y interaction
  - s=-2 hypernuclei



- baryon- antibaryon interaction
  - $\bar{N}-N$ and $\bar{Y}-N$ scattering
  - antihyperons in nuclei?

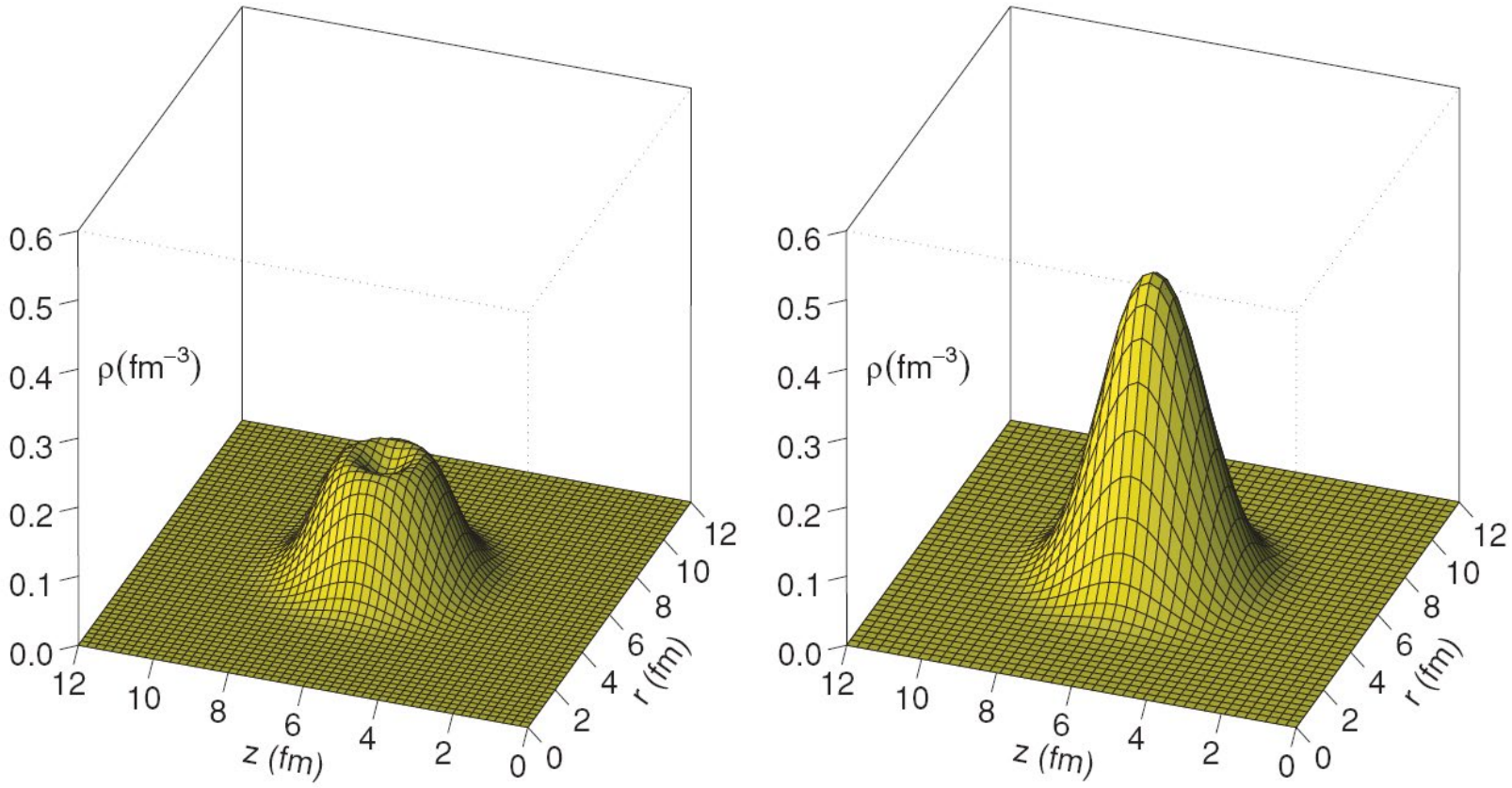
# Antibaryons in nuclei

- Hans-Peter Dürr and Edward Teller, Phys. Rev. **101**, 494 (1956)
  - baryons described Dirac equation
  - relativistic mean field approach (→ J. D. Walecka, 1974)
  - baryons coupled to scalar and vector mean fields



# Antiprotons in nuclei

- I.N. Mishustin *et al*., Phys. Rev. C 71, 035201 (2005)




- dramatic density increase

# Why do antihyperons in matter matter?

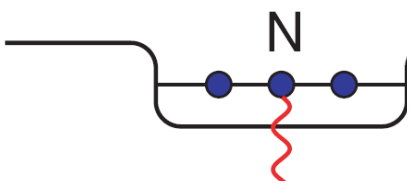
- antibaryons in nuclei allow in principle to determine S and V separately
- because of the strong cold compression color degrees of freedom might become very important
- allow to study the formation of a baryon antibaryon pair inside a nucleus $\Rightarrow$ study formation time $t \sim \hbar/E_F \sim 5\,\mathrm{fm/c}$

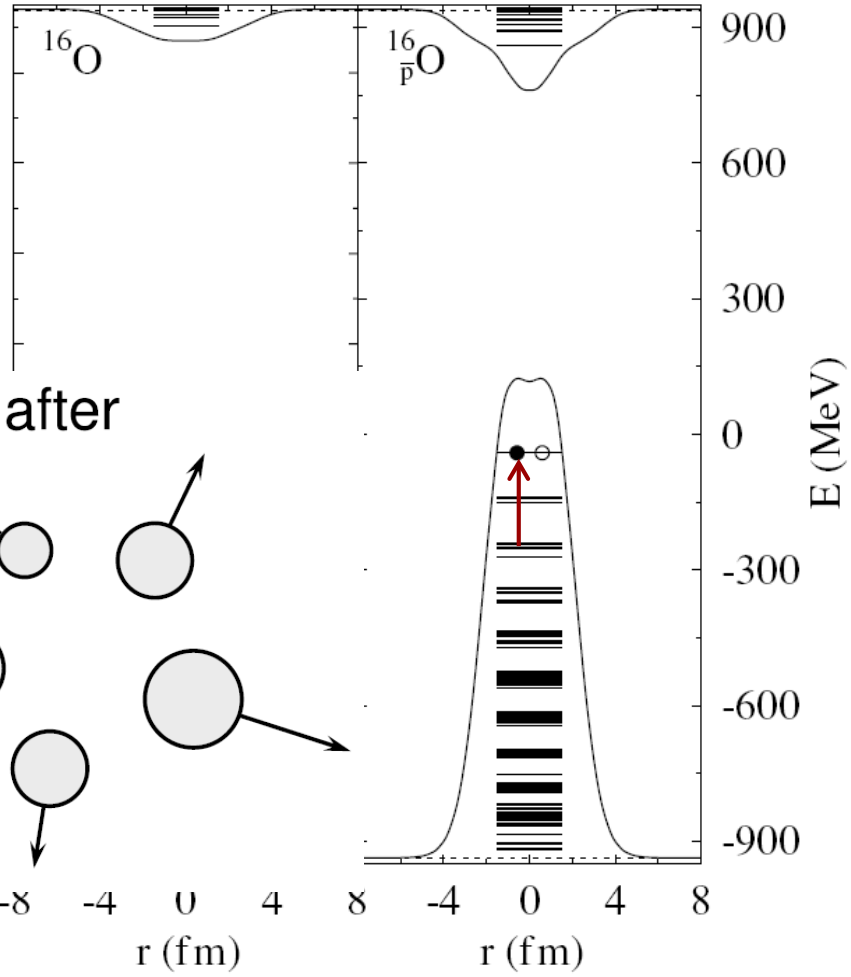
# Antihyperons stopped in Nuclei

- antibaryons stopped in nuclei

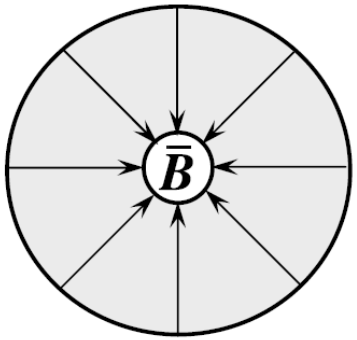
$$\bar{p} + \mathrm{A} \rightarrow {}_{\bar{B}}\mathrm{A} + X$$

  - I.N. Mishustin *et al*, Phys. Rev. C 71, 035201 (2005)
  - suggested observables
    - "Super-transitions" from Fe (mono-energetic mesons)
    - Transitions between levels of each
    - Explosio after an
    - formatic



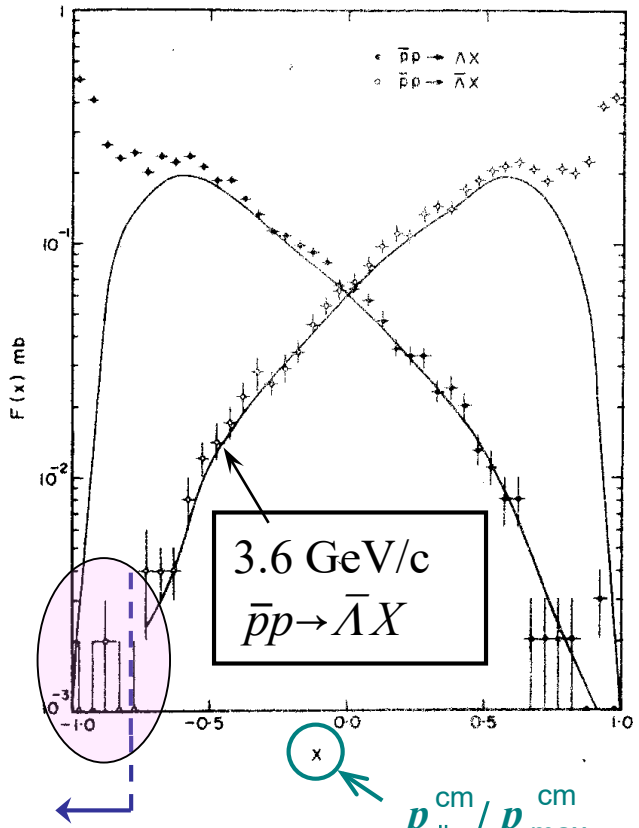




- forwa



# Difficulties

- cross section?
  - for antiprotons o.k.
  - for $\Lambda$'s unclear
- no direct observation of the antibaryon
  - background?
- both methods work possibly for antiproton and antilambda nuclei but not for anti-$\Xi$ or heavier antihyperons



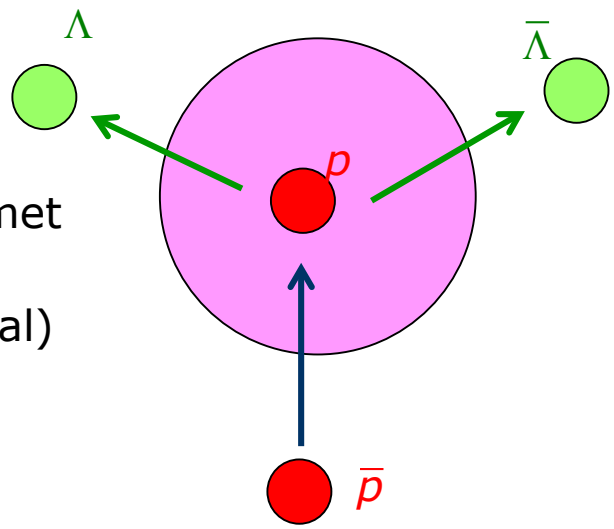

$$p_{\parallel}^{lab} \leq \Delta p = 400\,MeV/c$$

(from I. Mishustin (2005))

# Can we measure the potential for $\bar{Y}$?

- $p + \bar{p} \rightarrow \Lambda + \bar{\Lambda}$ close to threshold in complex nuclei
- Question: is the momentum of the $\Lambda$ and anti-$\Lambda$ on the average equal?
- possible answer:
  - at the point of creation inside the nucleus momentum conservation is met
  - but: $\Lambda$ and anti-$\Lambda$ have different effective mass (= different scalar potential)
  - as soon as $\Lambda$ and anti-$\Lambda$ leave the nucleus they will have different asymptotic momenta
  - the momentum difference is sensitive to the potential difference

is this correct?

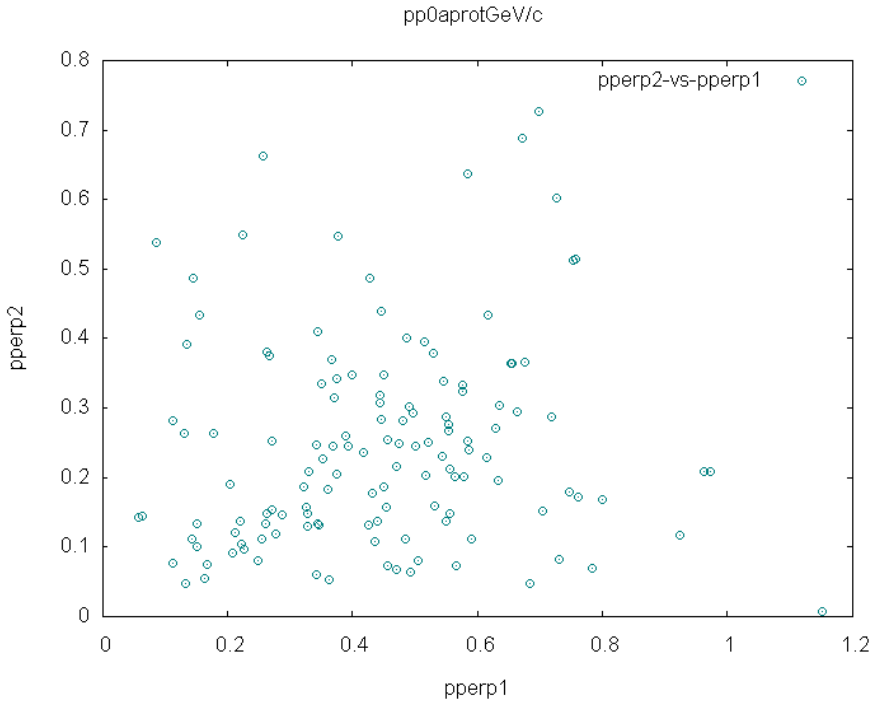



- experimental details
  - need to average over Fermi motion
  - use light nucleus to reduce rescattering
  - leading effect $\Rightarrow$ need to look at (average) transverse momentum

# Simple MC: 1.6 GeV/c pbar-C

$$E_H(\vec{p}) = V + \sqrt{(m_H - S)^2 + \vec{p}^2}$$

- proton: S=350MeV V=300MeV (V-S=-50MeV)
- antiproton: S=350MeV V=-300MeV (V-S=-650MeV)
- C target
- $\Lambda$ potential=2/3 of nucleons
- Fermi motion
- leading effect
  - lambda: 0.445 GeV/c
  - antilambda: 0.244 GeV/c



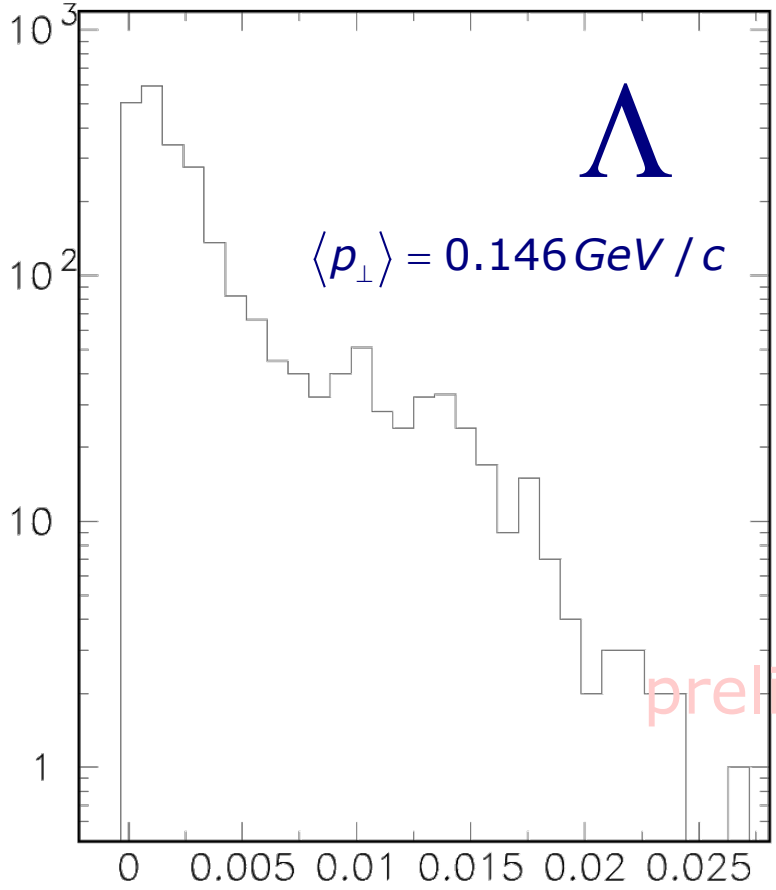

- can be extended to every hadron-antihadron production ($\Lambda_c\bar{\Lambda}_c$...)

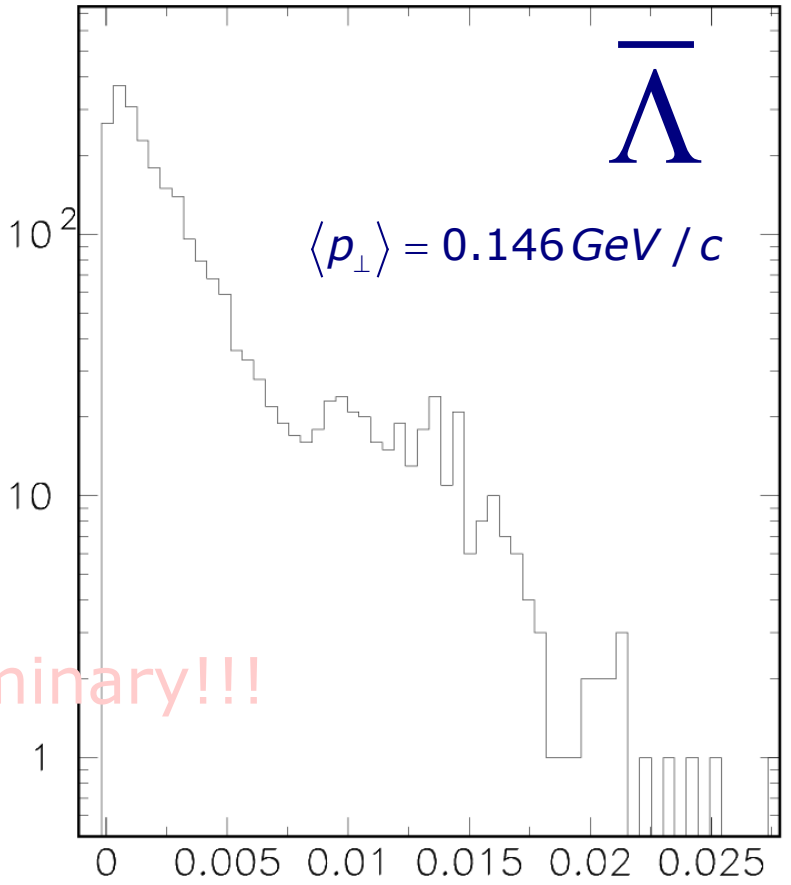
# Some open questions

- different absorption of hyperon and antihyperon
- rescattering
  - influence of nuclear mass $\Rightarrow$ use light nucleus to reduce rescattering
  - but: coherence length of $\Lambda$ anti$\Lambda$ pair: $t \sim \hbar/E_F \sim 5\,\mathrm{fm/c}$ $\Rightarrow$ need large nucleus
- use $\Lambda$ and anti-$\Lambda$ polarization to enhance anti-$\Lambda\Lambda$ pairs which did not encounter a rescattering on their way out
- if method is successful: can be extended to any hadron-antihadron production (even $\Lambda_c\overline{\Lambda}_c$…)

# Are there any data?

- perhaps
- PS185: 1.45, 1.66 and 1.77GeV/c $\bar{p}\,^{12}C \to \bar{\Lambda}\Lambda X$
- Stephan Pomp, thesis
- only polarization data published
  - $p_{miss}$<250MeV/c

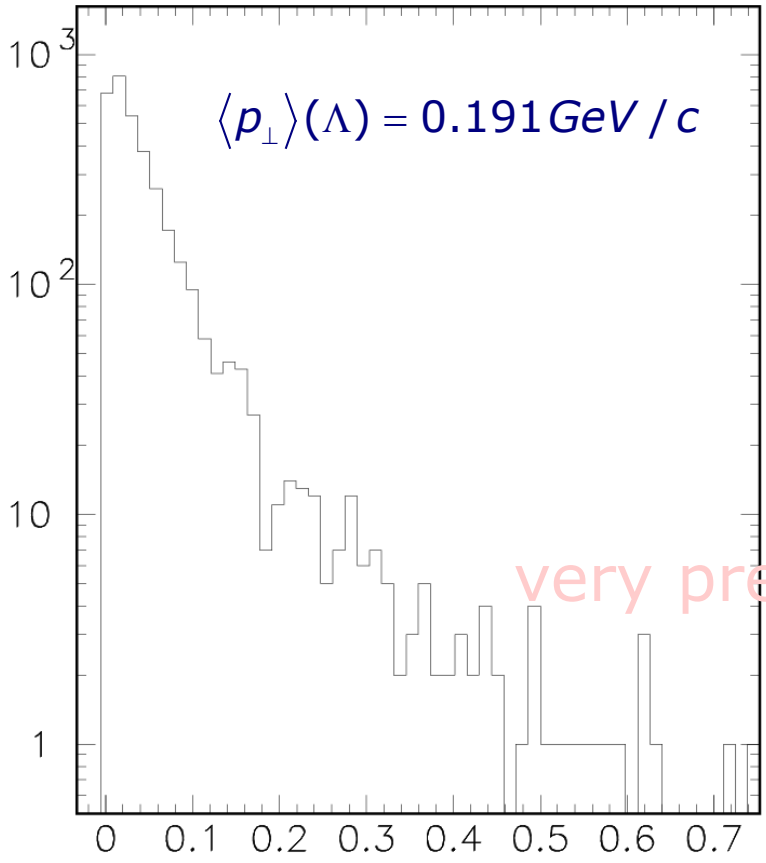


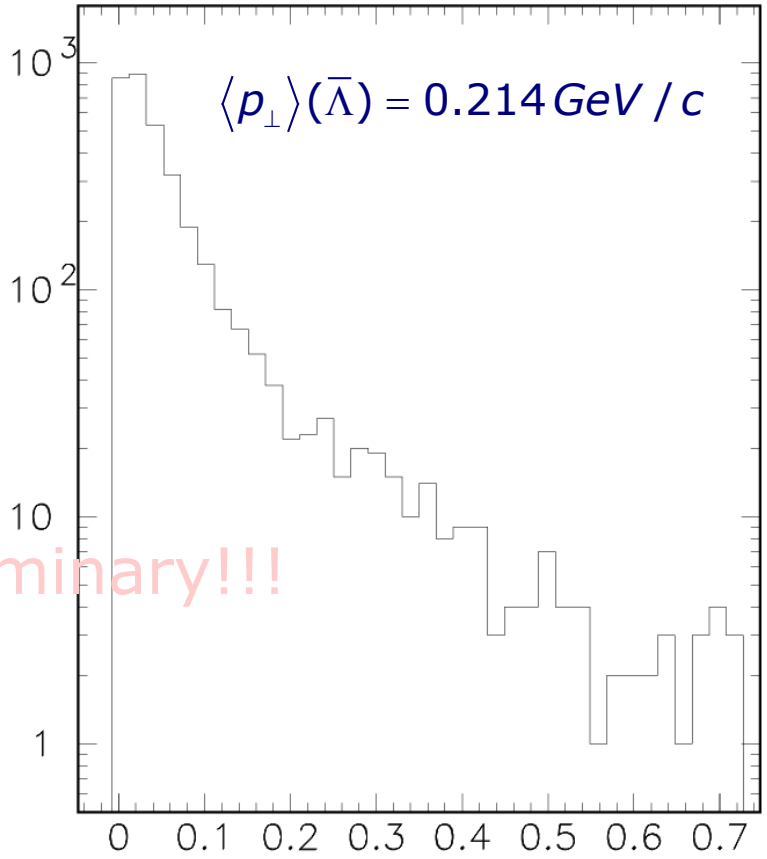




preliminary!!!

# Non Quasi Free Events

- PS185: 1.45GeV/c
  - $p_{miss}$>250 MeV/c






- different absorption…???


„Der Professor als Narr – das freut den Schüler. Aber manchmal fragt man sich schon, war es Narretei oder wieviel Wahrheit.“

Sieger Köder