Proposal for a revisit of antiproton nucleus collision experiment with PANDA

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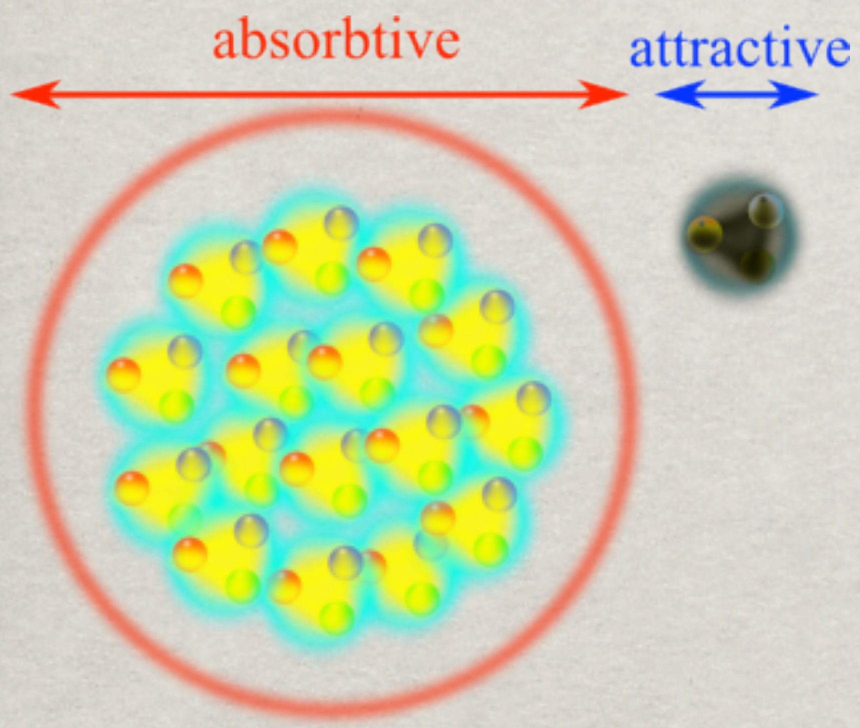
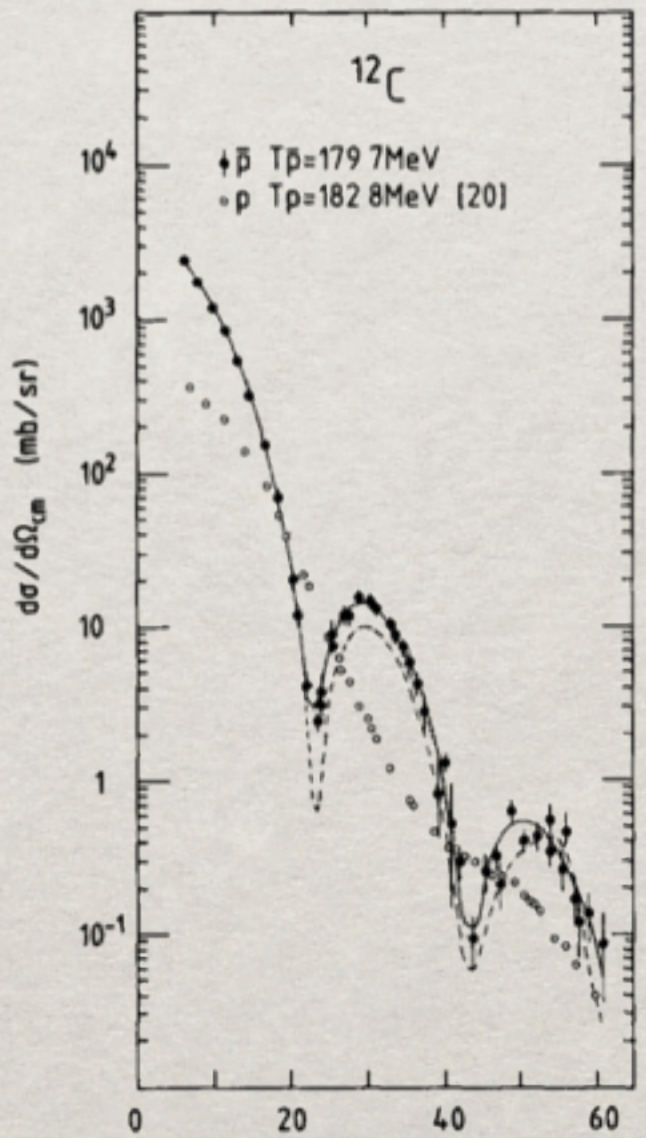
Outline

1. Introduction
2. pbar A collision:
   2.1. Determination of pbar A potential;
   2.2. Formation of extreme matter
3. Summary

Once upon a time

$$V_{opt} \simeq -\frac{V_0}{exp(\frac{r-R_R}{a_R})+1} - \frac{iW_0}{exp(\frac{r-R_I}{a_I})+1}$$





Fitting results for pbar nucleus elastic scattering data:

V_0=30MeV

W_0=118~174MeV

D. Garreta, et al., Phys. Lett. 149B, p.64, (1984)

Antiprotonic atom data

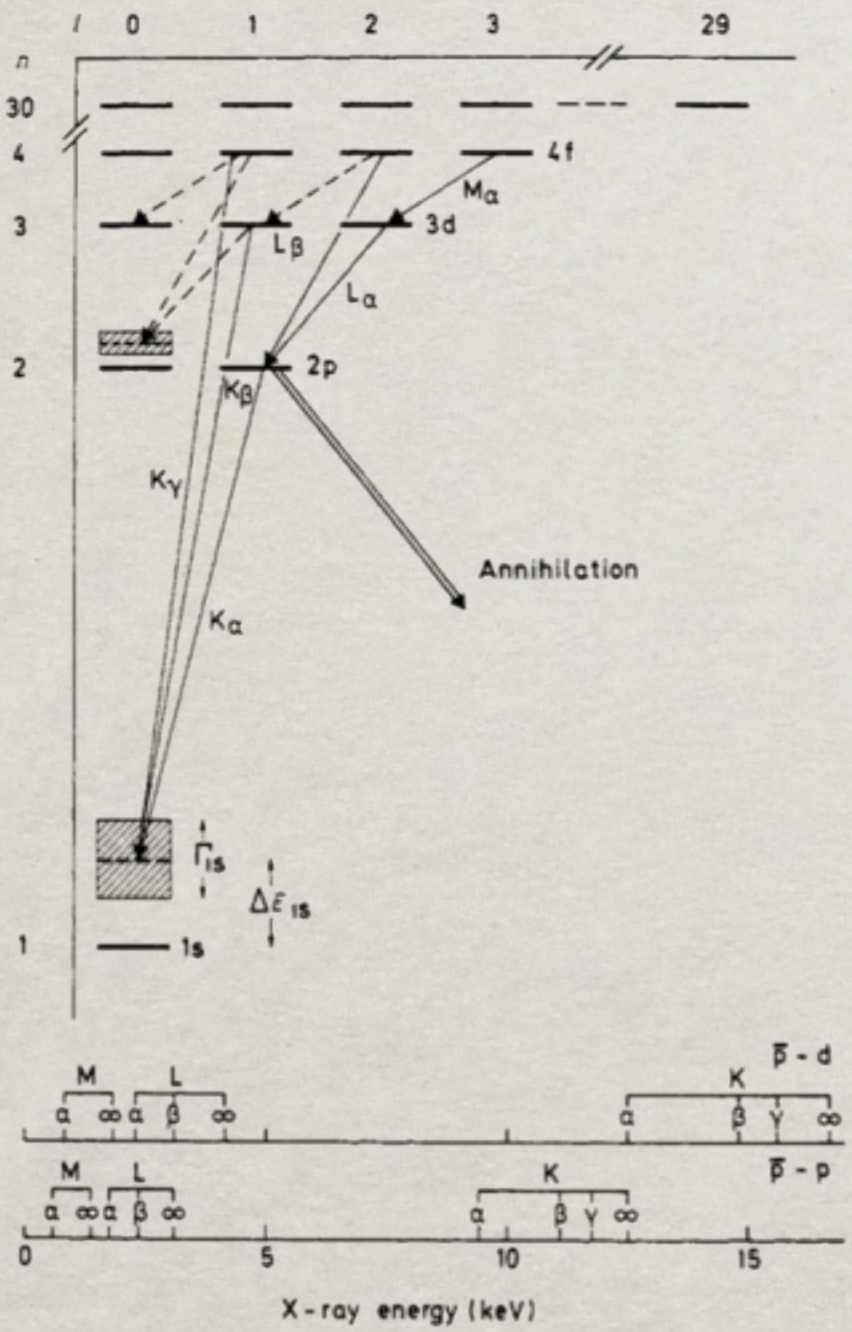
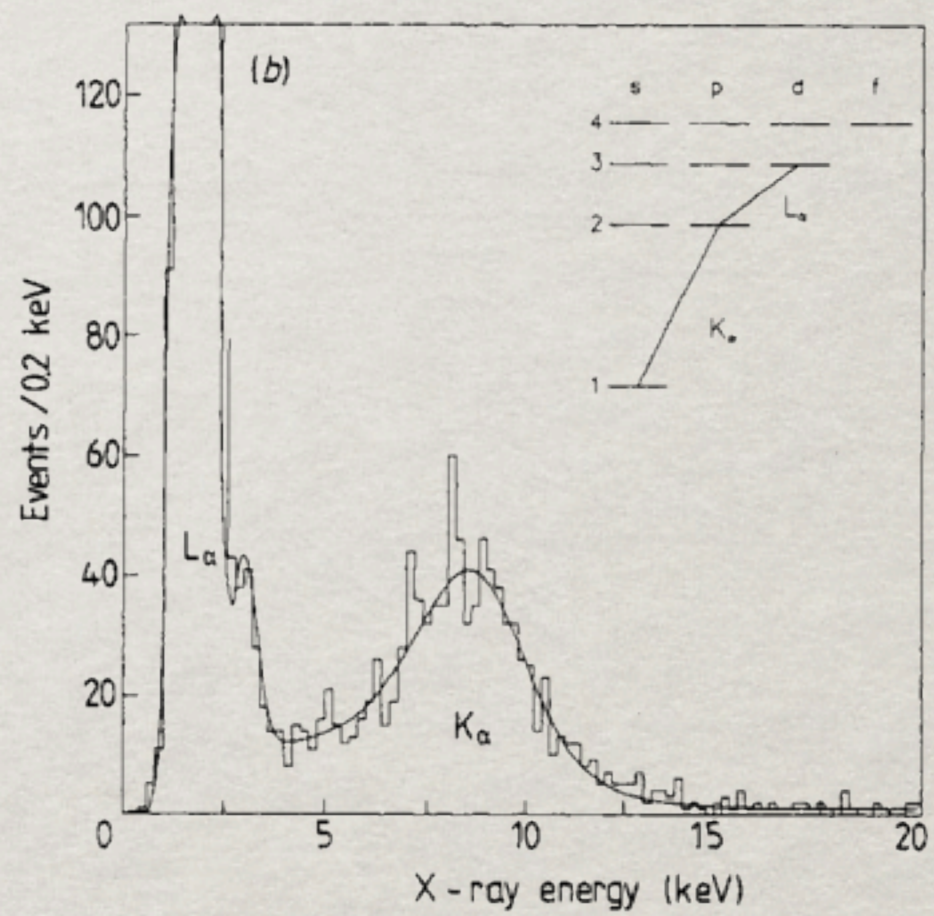


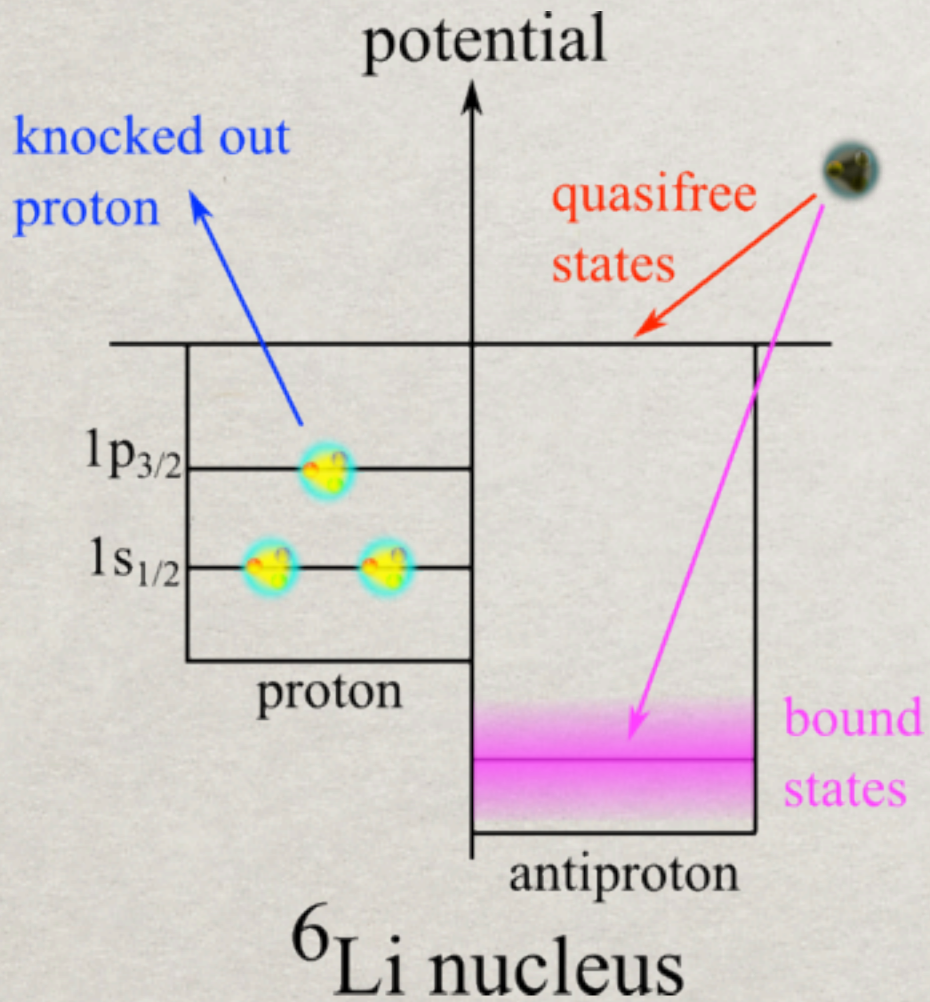
Figure 1. Level scheme for p̄–p and p̄–d atoms showing possible x-ray transitions and their electromagnetic energies.

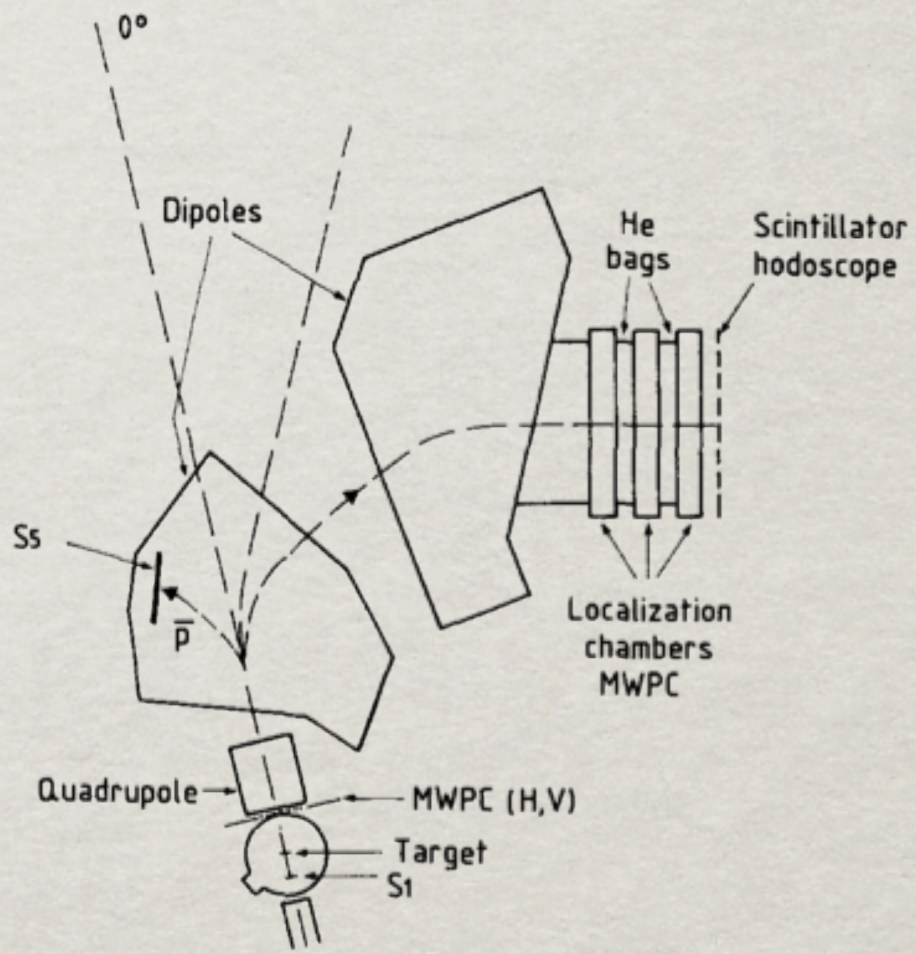


Fitting results for antiprotonic atom data:
V_0=110MeV
W_0=160MeV

E. Friedman et al., Nucl. Phys. A (761) p283 (2005)
C. J. Batty, Rep. Prog. Phys. (52) p.1165 (1989)

proton konck-out experiment





LEAR experiment in 1980s: ${}_{A}{}^{Z}T$(pbar, p)X

pbar beam@600MeV/c

Target: ^{2}H, ^{6}Li, ^{12}C, ^{63}Cu, ^{208}Pb, ^{209}Bi

E. Aslanides et al, Nucl. Phys. A 470, p.445 (1987)

proton knock-out data

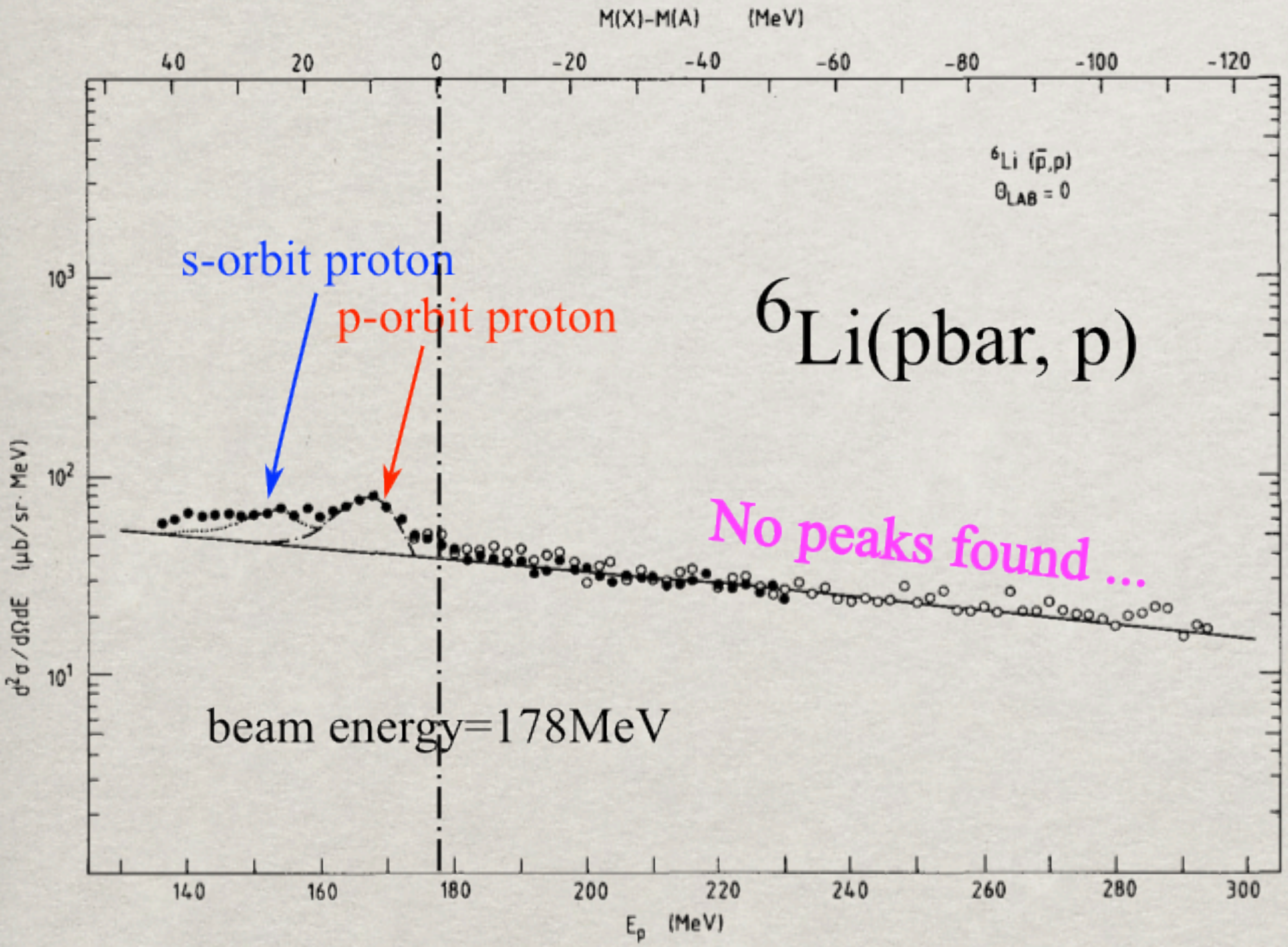


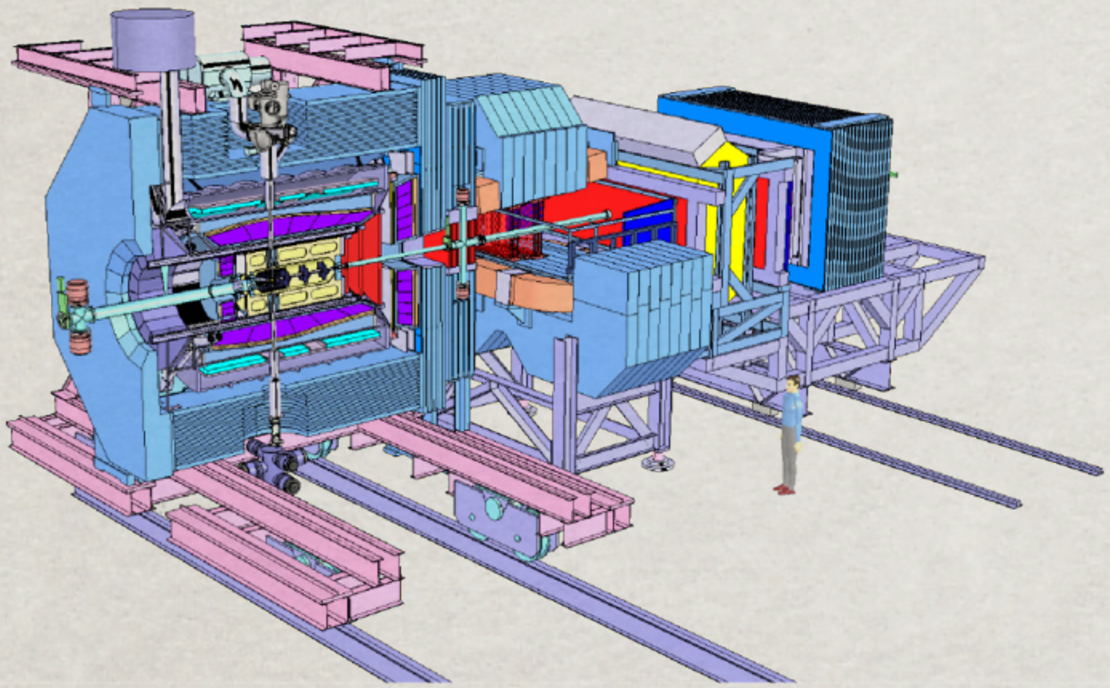
Fig. 2. Double differential cross sections for the ^{6}Li($\bar{p}$, p)X reaction at $E_{\bar{p}} = 177.9$ MeV. The full line corresponds to an average temperature $T = 101$ MeV. The dash-dotted line is the result of a quasi-free scattering calculation corresponding to an effective proton number $N_{eff} = 0.15$. The dotted line represents the contribution of the quasi-free scattering on 1s-shell protons with an effective proton number 0.09.

No peak found with higher energy!

1. beyond acceptance?
   unlikely...
2. pbar absorbed on the surface of target?
   higher beam energy...
3. "peak" too broad to be identified?
   main topic of the present talk

E. Aslanides et al, Nucl. Phys. A 470, p.445 (1987)

pbar A collision at PANDA



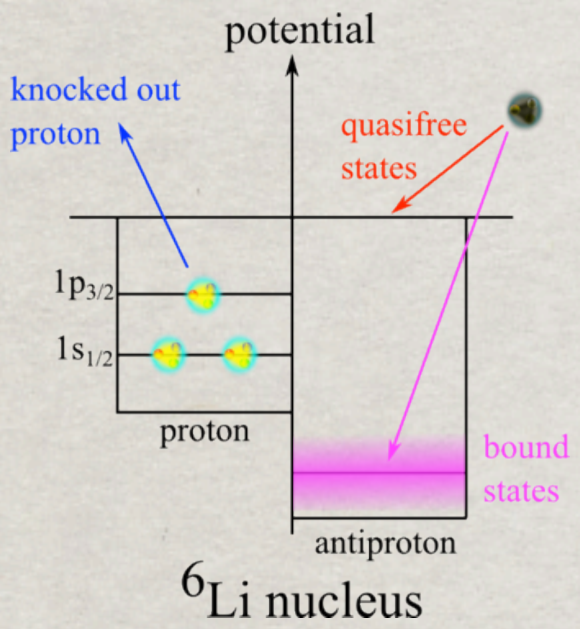
Tracking leptons among large sample of hadronic events

- Good tracking capability;
- High luminosity L ~$10^{32}cm^{-2}s^{-1}$;
- Wide momentum range:
  1.5 GeV/c ~ 15 GeV/c

For rare events

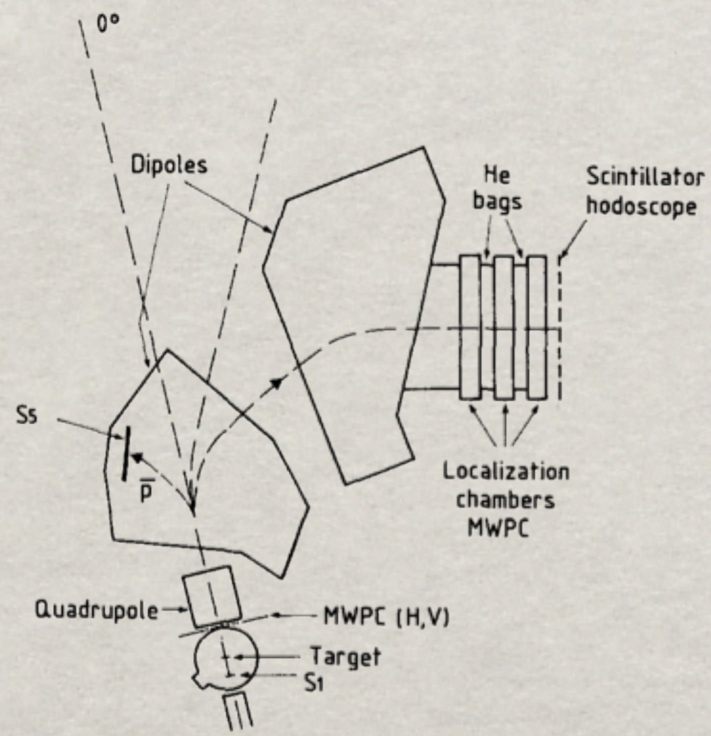
Almost 4-pi coverage for exclusive measurement

pbar A collision at PANDA

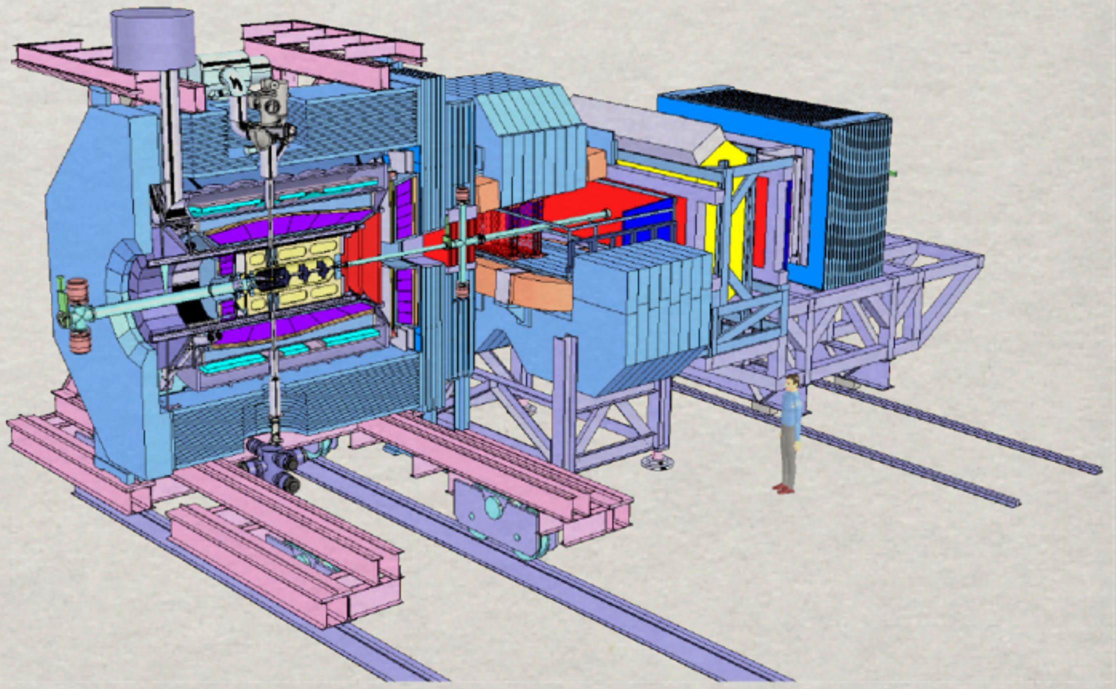


Upgrade

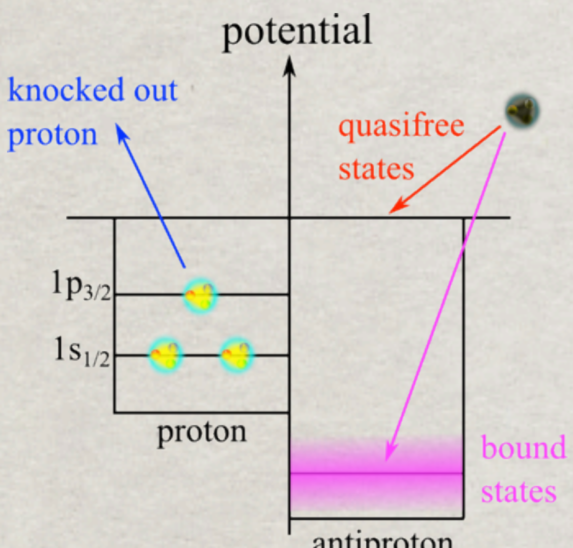
A revisit of proton knock-out experiment with exclusive measurement.



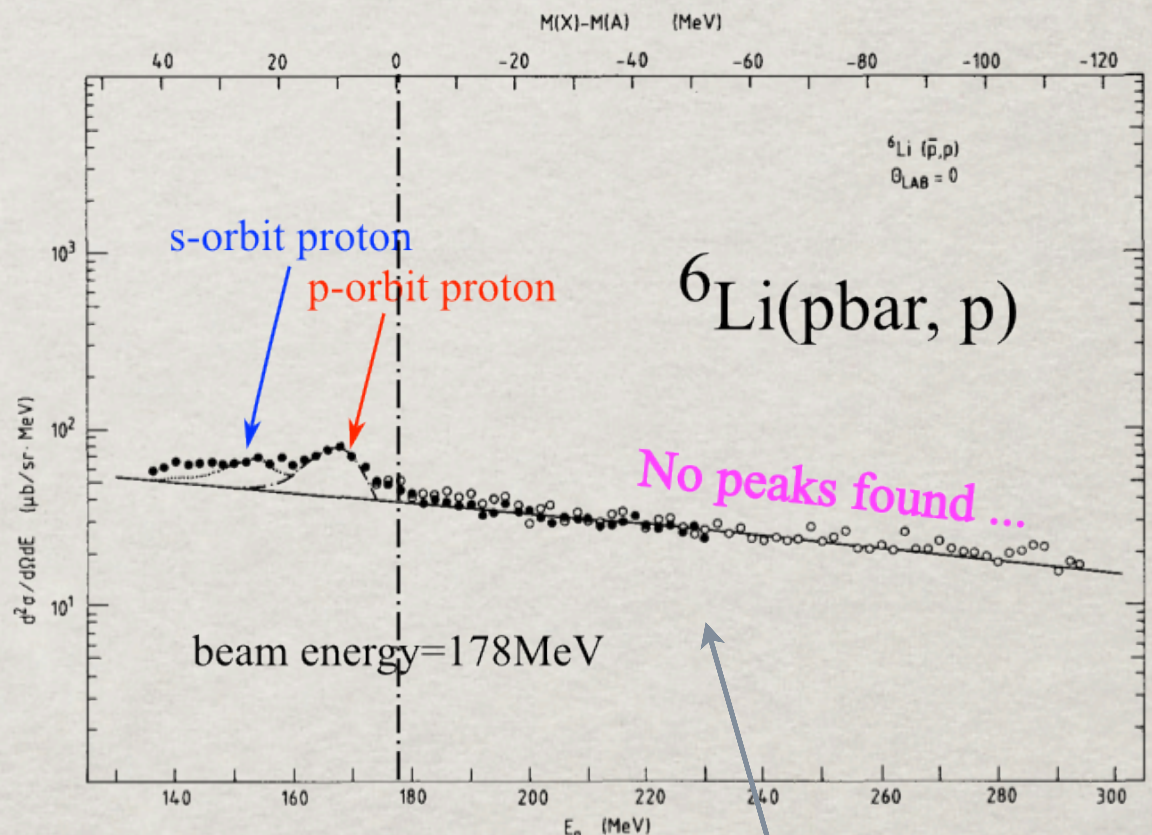
Upgrade



What's the difference we can make?



^{6}Li nucleus



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Keyword: event selection
(background suppression)

Background events:
protons with higher kinetic energy

Where is this extra energy from?

Where is the energy from?

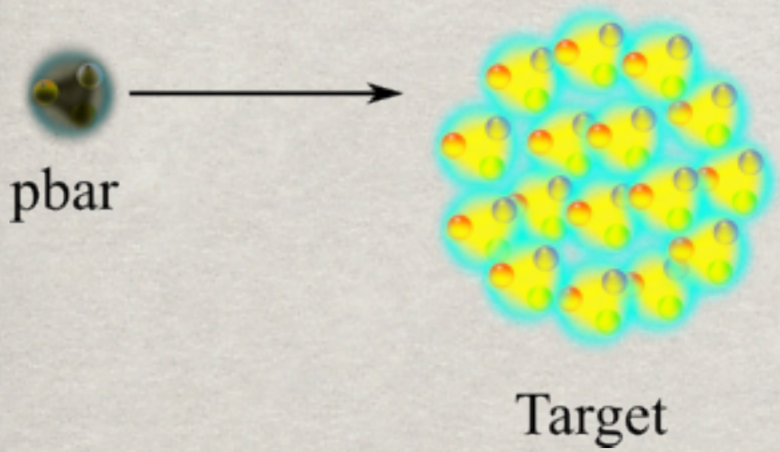
Knocked out proton with higher kinetic energy than the beam: where is the energy from?

1. from binding energy difference between proton and antiproton($E_p = E_{beam} + B_{pbar} - B_p$): symmetry in p_z of decay products
2. from light meson carrying large kinetic energy released from annihilation: asymmetry in p_z of decay products

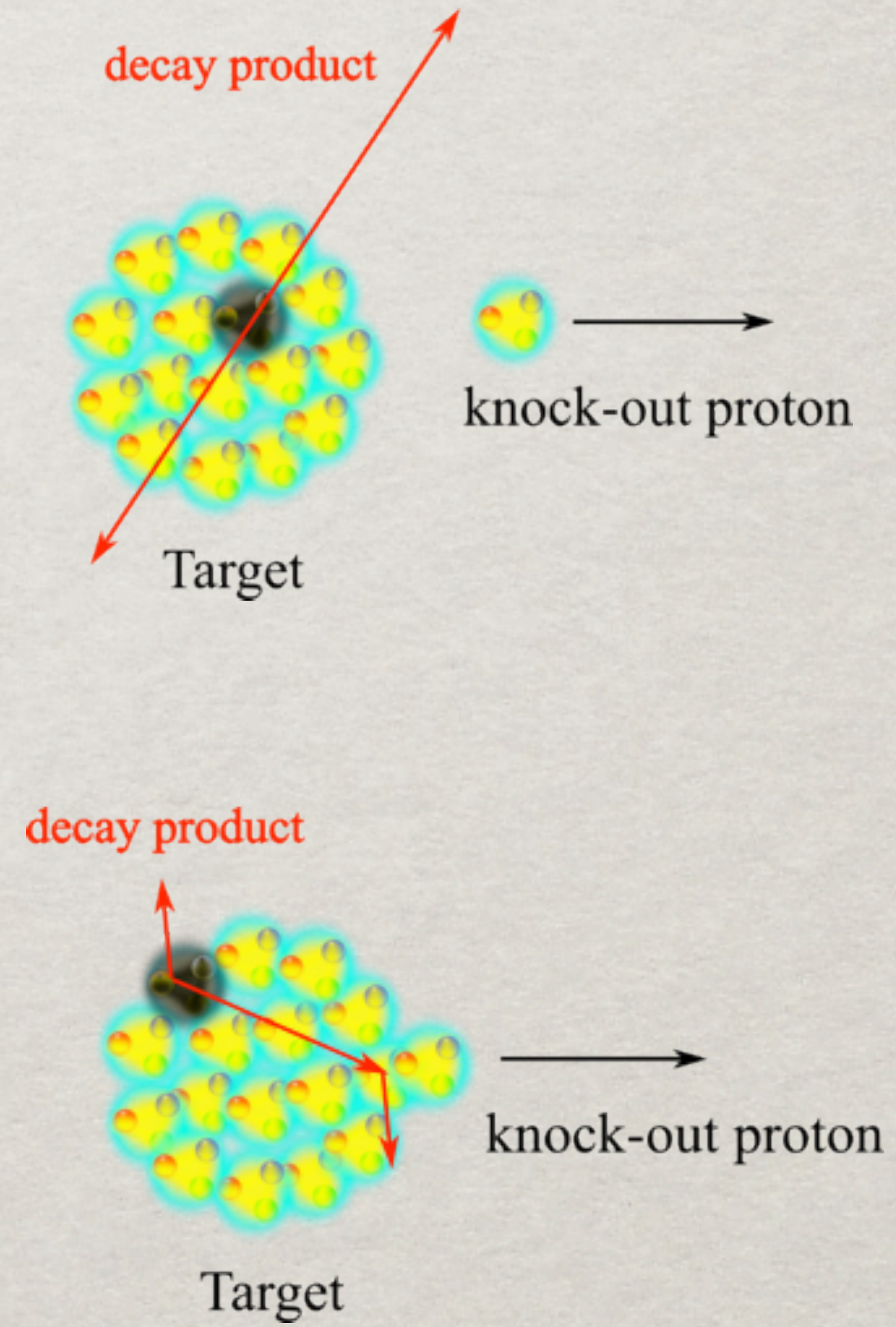
Events

Background

Possible events



Initial state: |i>



Final state: |f>

Possible experimental approach

- Hadronic decay channels
- Select events with back-to-back decay product
- Measure the knocked out proton at 0° in Lab

Example: Kaon pairs with invariant mass ~ 2 GeV.

- In-flight decay into lepton pairs
- A existence of V_0=150 will cause a decrease of invariant mass by the same order.

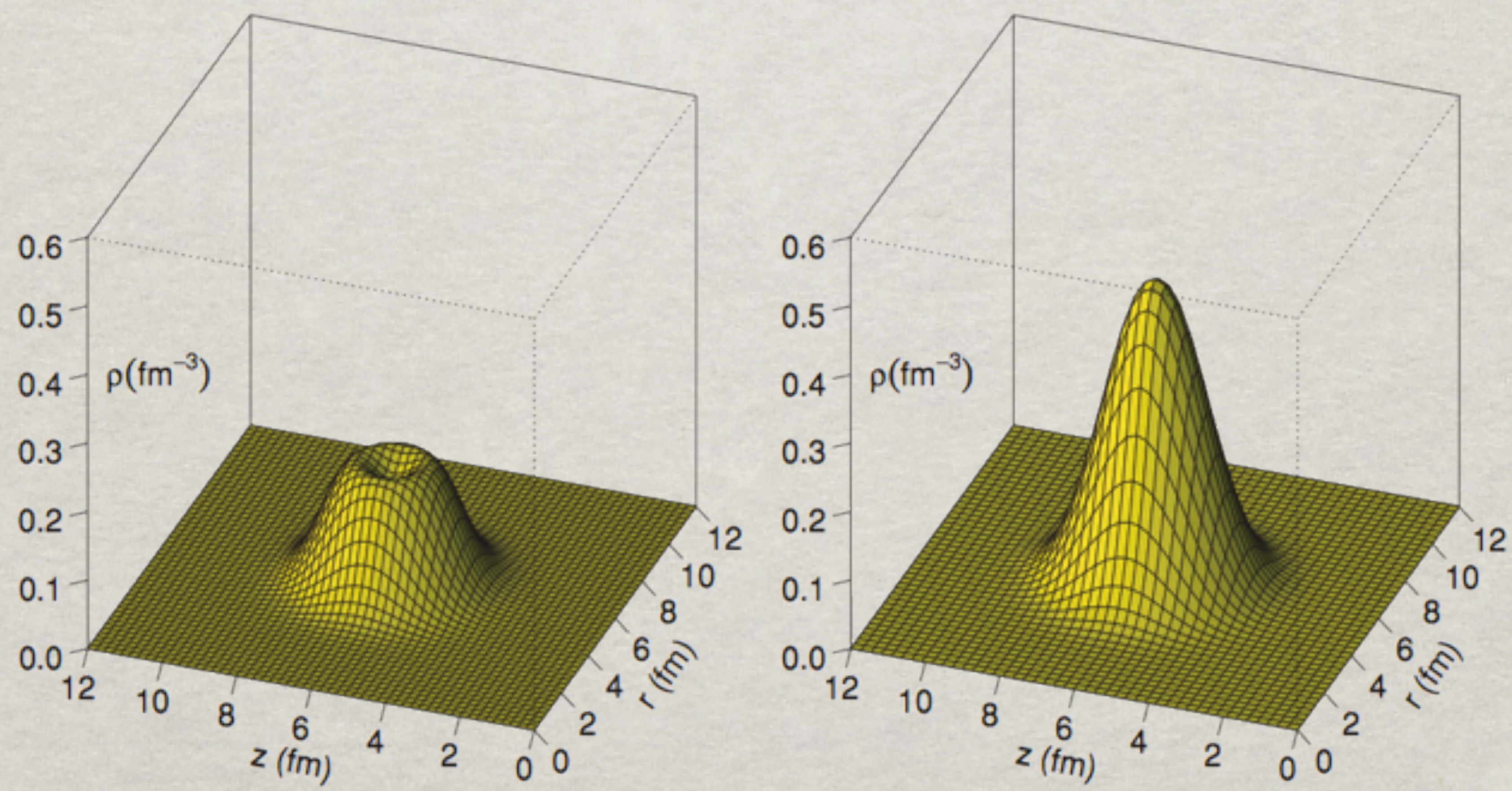
Example: electron-positron pair invariant mass measurement.

What's next?

- Provided an experimental determination of pbar potential inside nucleus
- Some extreme state of matter could be formed as predicted by Frankfurt and Giessen groups

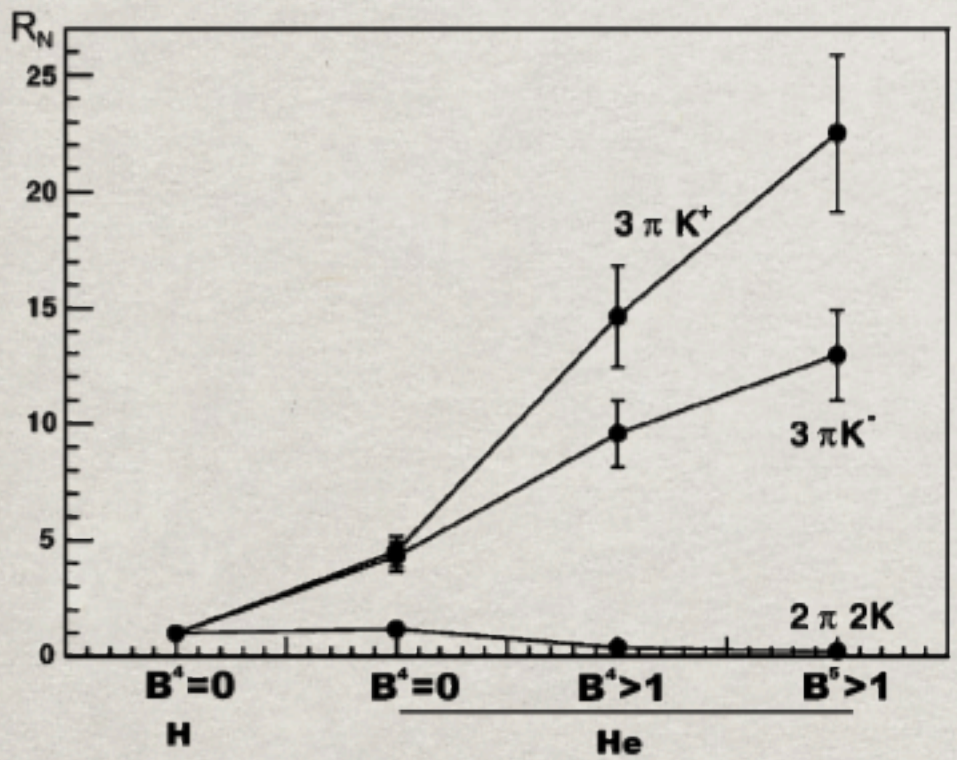
Twice higher density?

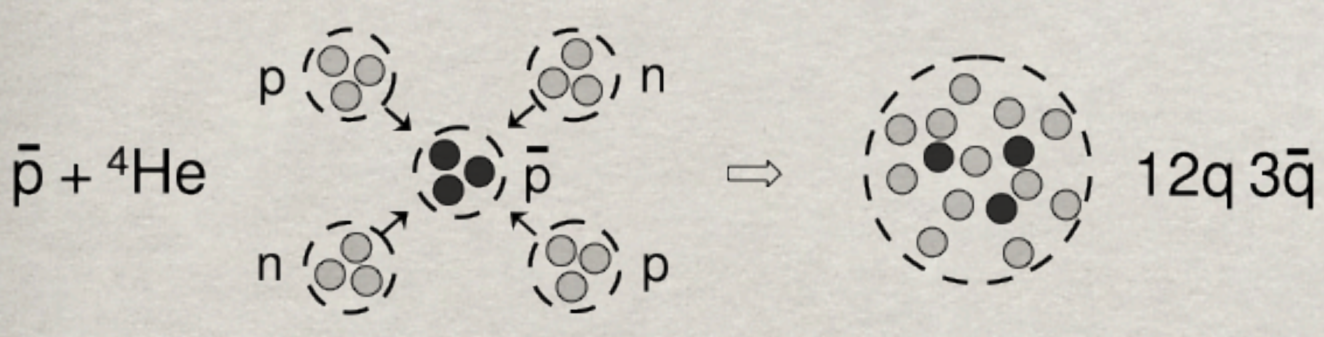
- Possibility for the formation of cold compressed matter up to twice higher density
- Mainly depends on pbar lifetime inside nucleus

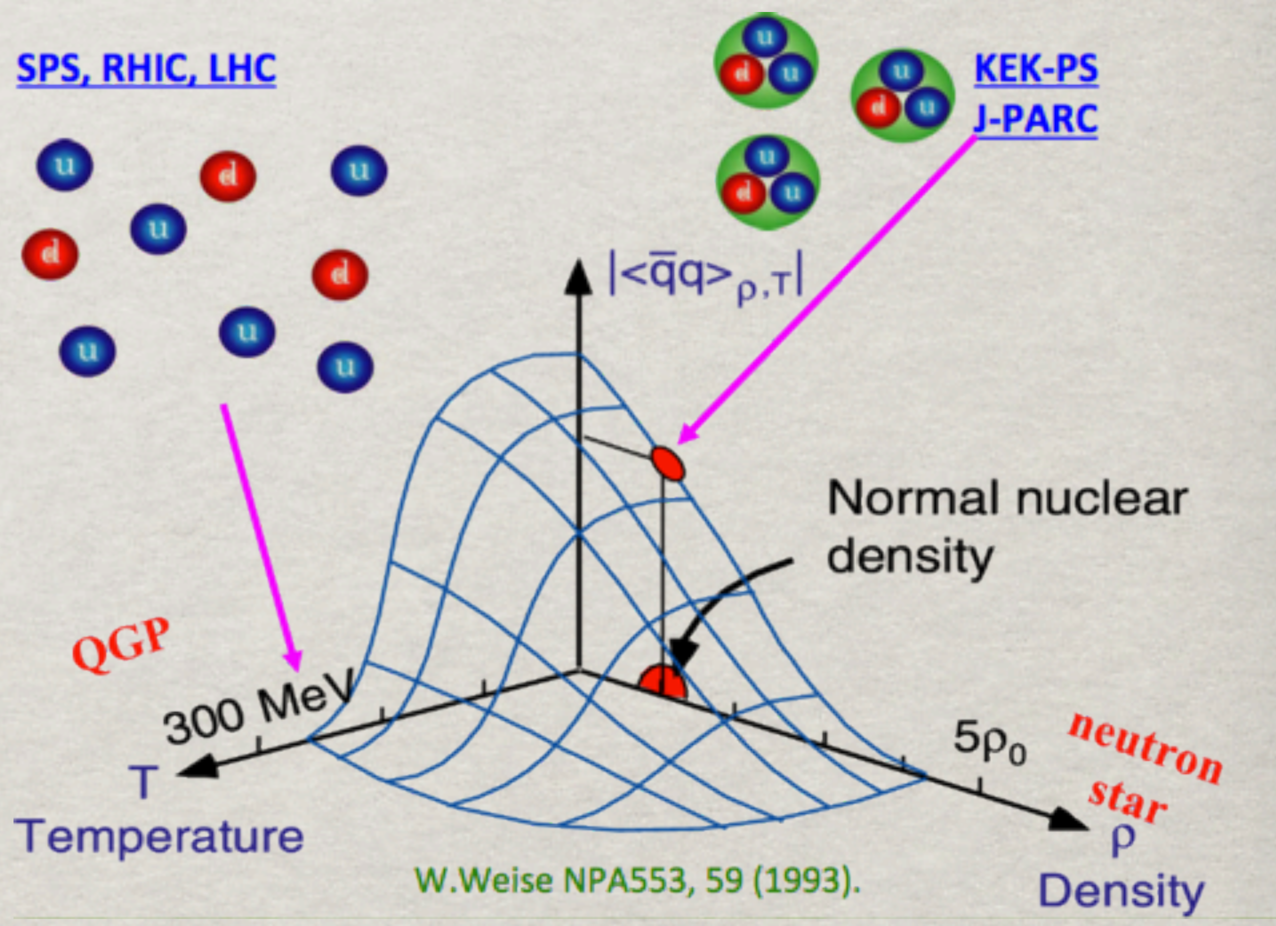


I.N. Mishustin, et al., Phys. Rev. C 71, p.035201, (2005)

More impact?







C. Bendiscioli, et al., Nucl. Phys. A 815, p.67, (2009)
I.N. Mishustin, et al., Phys. Rev. C 71, p.035201, (2005)

Summary

- PANDA is an ideal facility to revisit proton knock-out experiment
- A first time measurement for the strength of antimatter-matter interaction is possible
- Many homework need to be done