Probing the relative momentum of two-nucleon system in ^{6}He and ^{6}Li

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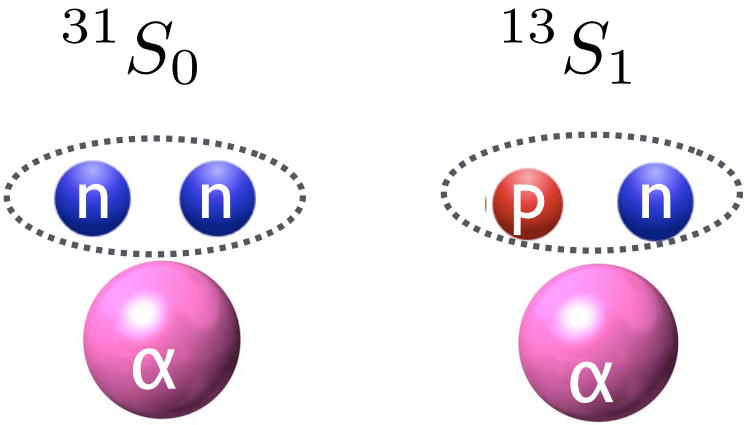
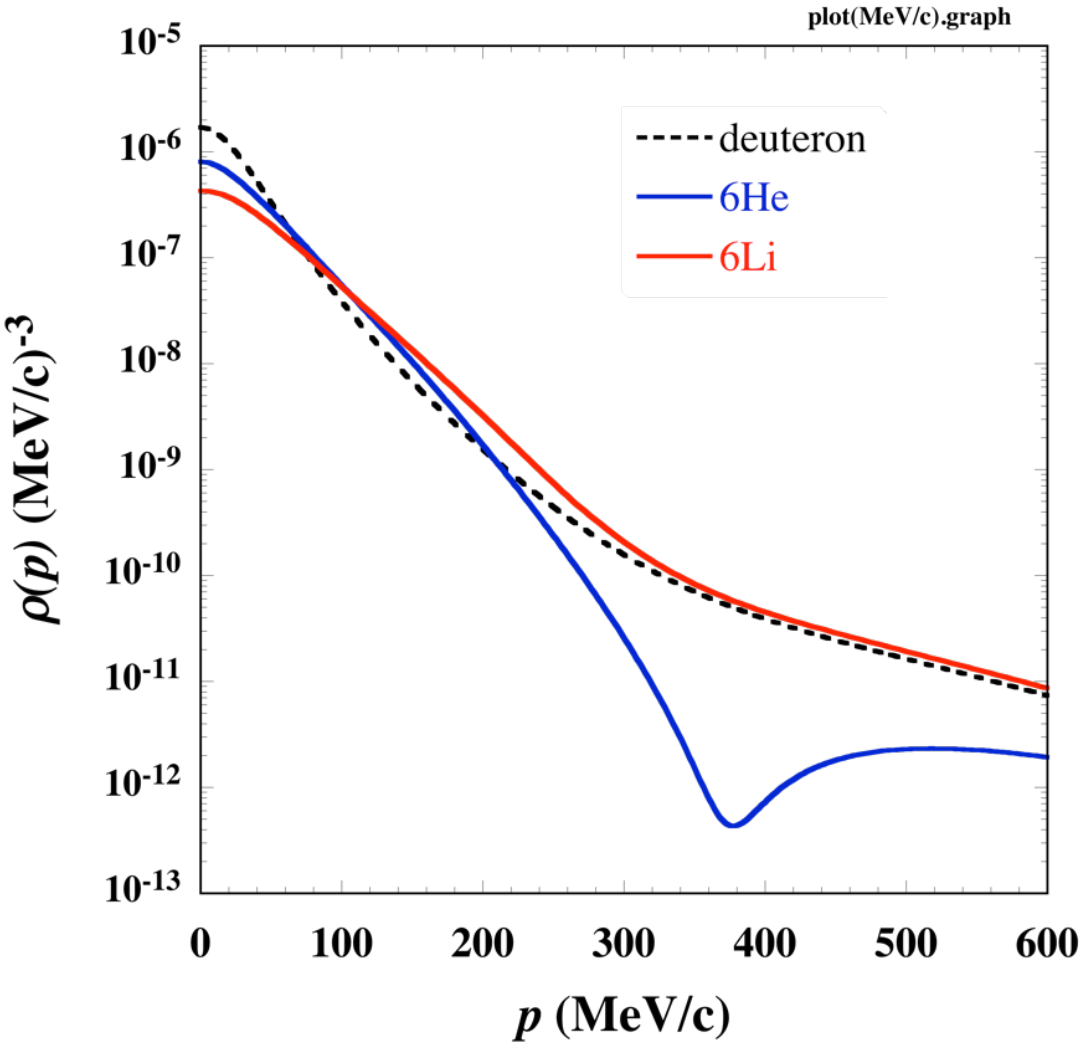
Two-nucleon system ^{6}He and ^{6}Li



^{6}He ^{6}Li



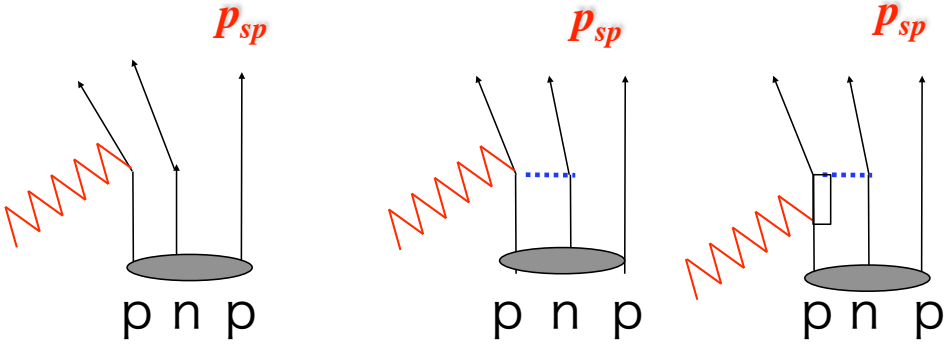
W. Horiuchi and Y. Suzuki
Phys. Rev. C76 (2007) 024311.

Photoabsorption by “np” and “pp”

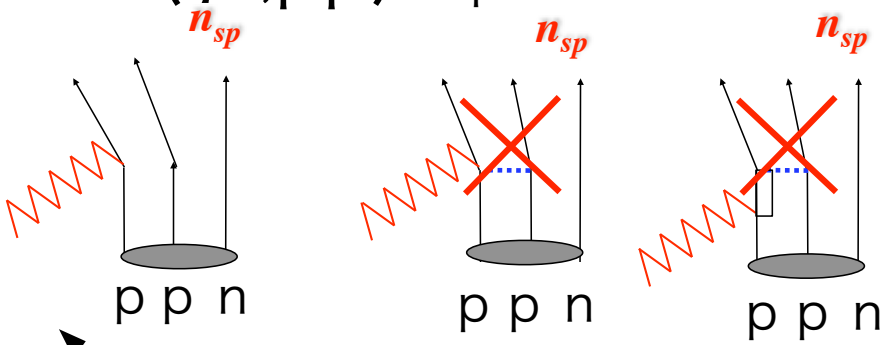
γ + ^{3}He -> ppn

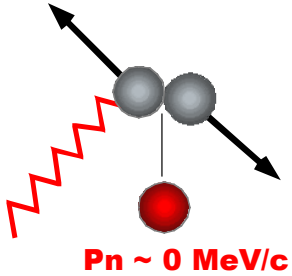
TAGX spect.: large accept.

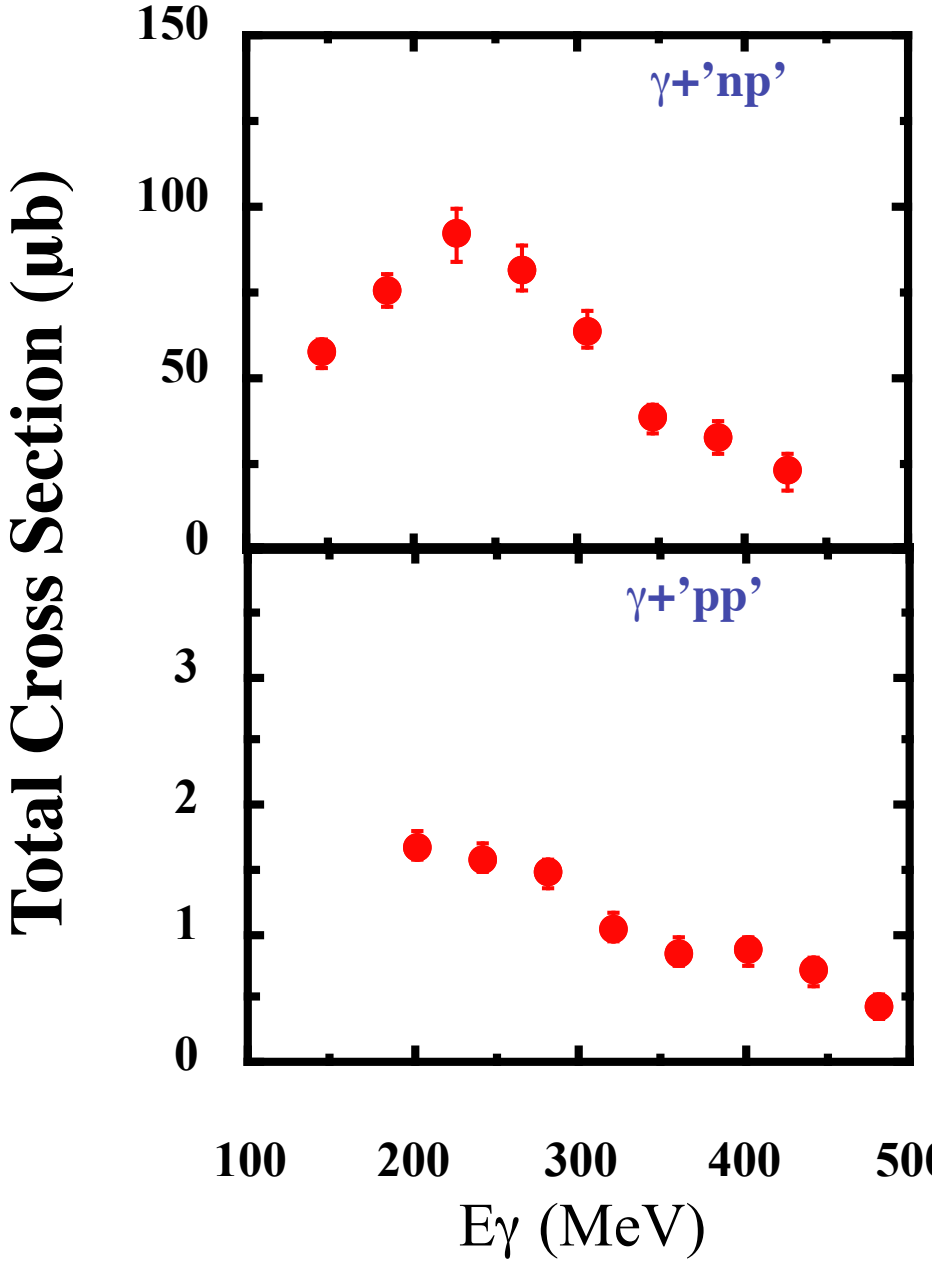
1) ^{3}He(γ,np)p$_{spectator}$



2) ^{3}He(γ,pp)n$_{spectator}$





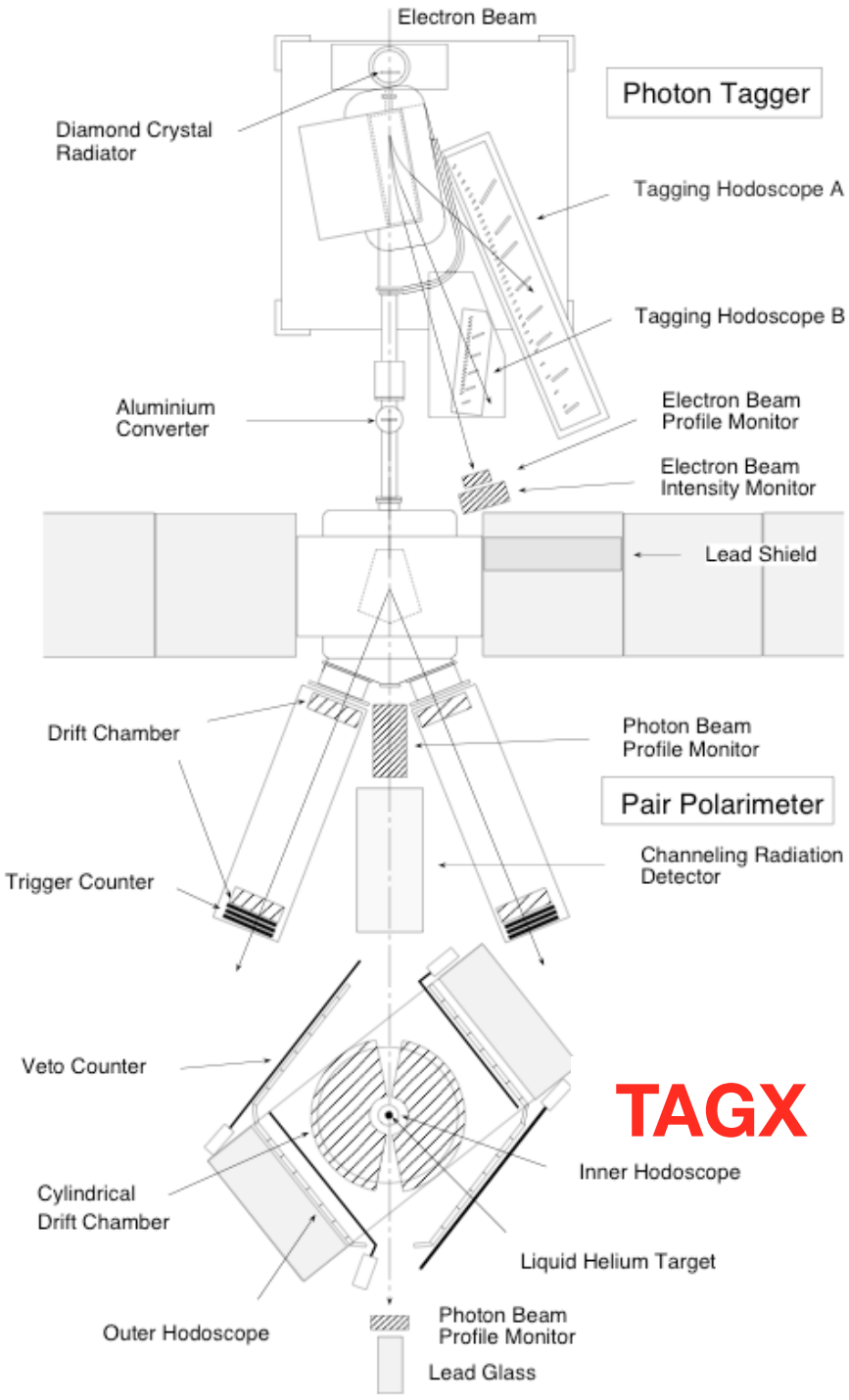


TAGX collaboration

PRL 73(94)404, PRL 74(95)1034, PRC49(94)R597

TAGX at INS, Tokyo (~1999)

HST 15 @ Osaka, JAPAN



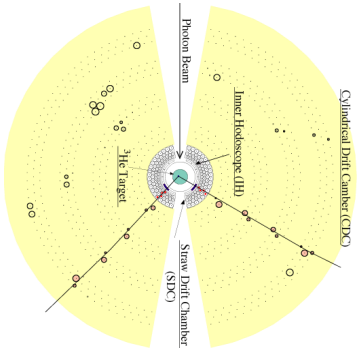
1.2 GeV electron synchrotron at INS, UT

Photon tagger

- Eγ = 100 - 1000 MeV (ΔEγ=±5MeV)
- Nγ = 1x10^6 /sec

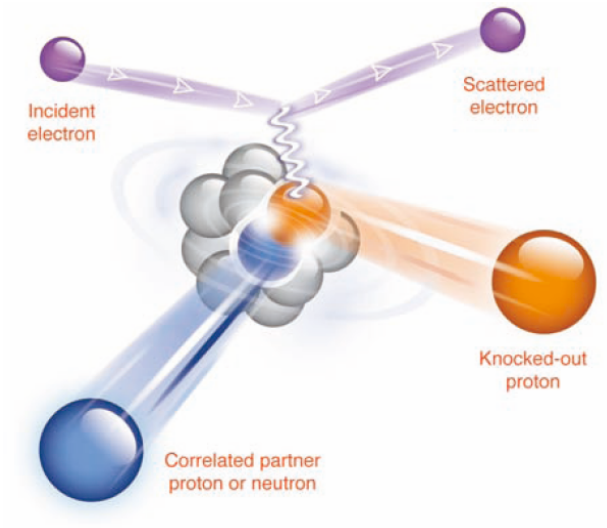
TAGX spectrometer

- large acceptance ~ 3.2 st
- neutron detection capability



Two-nucleon knockout @ JLAB

$^{12}C(e,e'pp)/^{12}C(e,e'p)$



virtual photons

longitudinal : charge

transverse : current

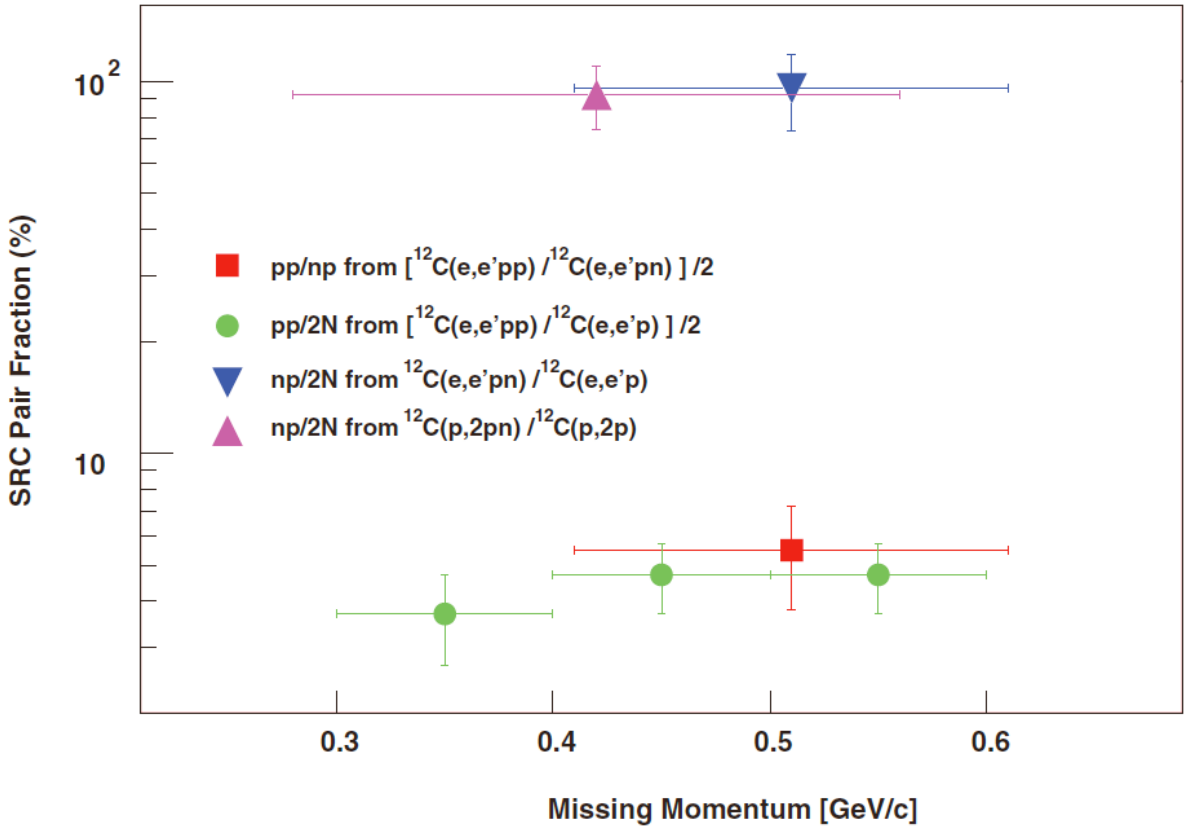
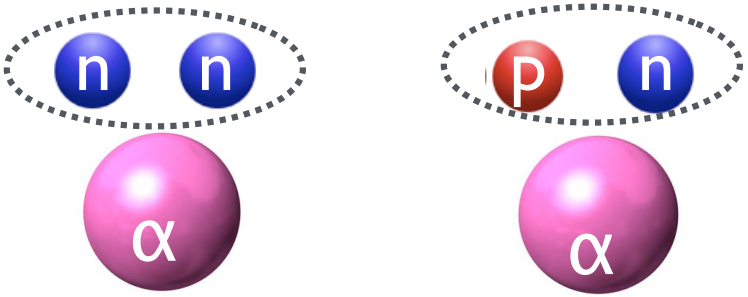


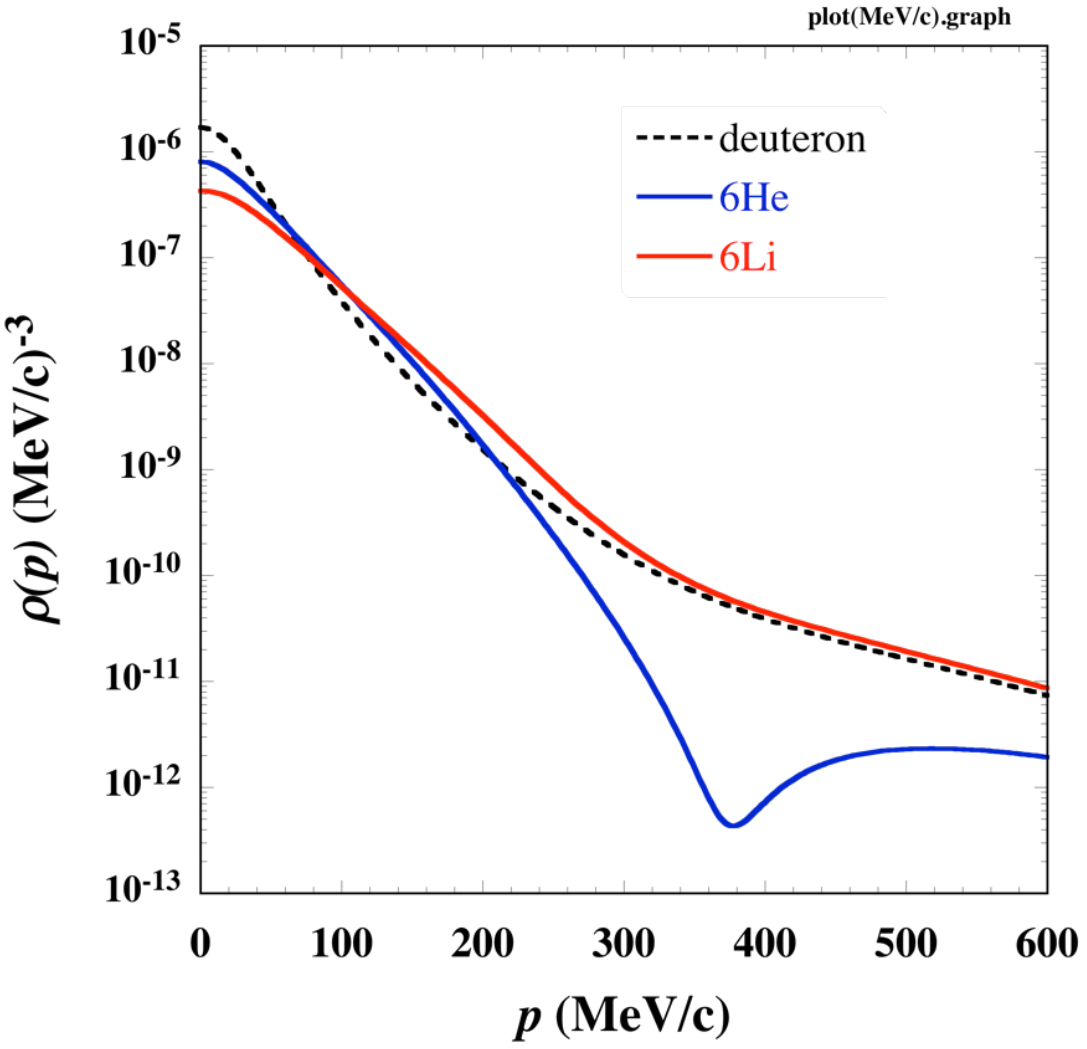
Fig. 2. The fractions of correlated pair combinations in carbon as obtained from the (e,e'pp) and (e,e'pr reactions, as well as from previous (p,2pn) data. The results and references are listed in table S1.

Two-nucleon system ^{6}He and ^{6}Li

$^{31}S_0$ $\quad$ $^{13}S_1 + {}^{13}D_1$



^{6}He $\quad$ ^{6}Li

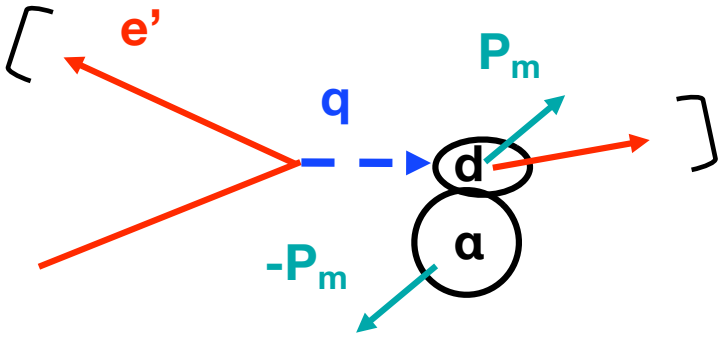


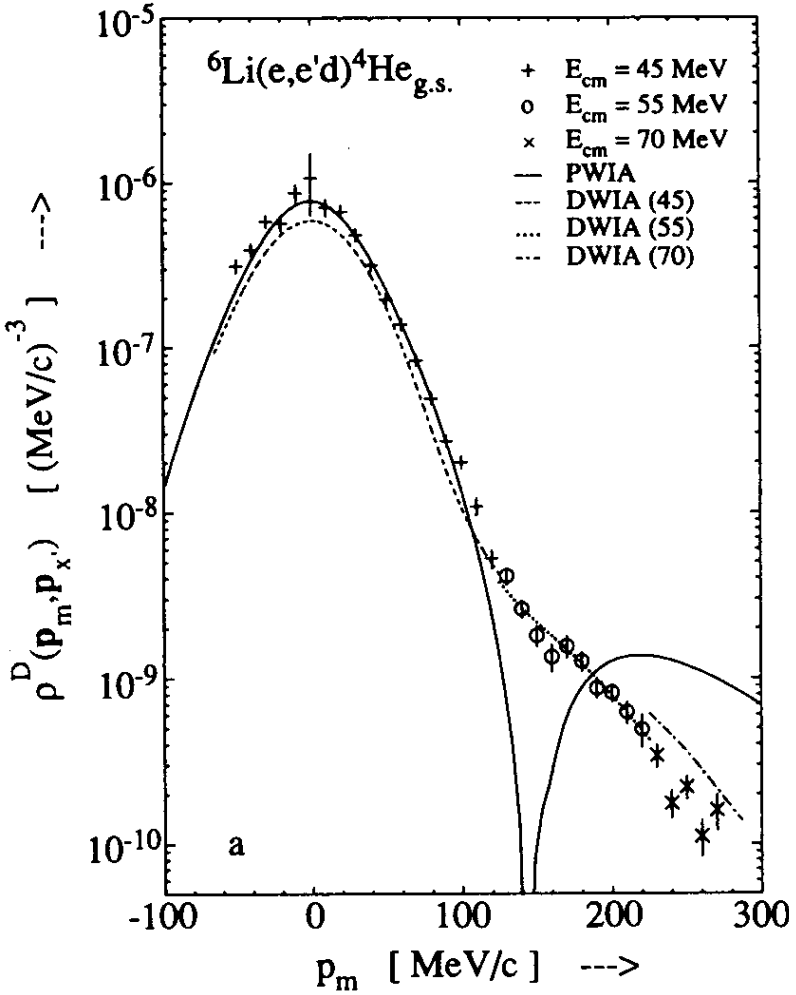
W. Horiuchi and Y. Suzuki
Phys. Rev. C76 (2007) 024311.

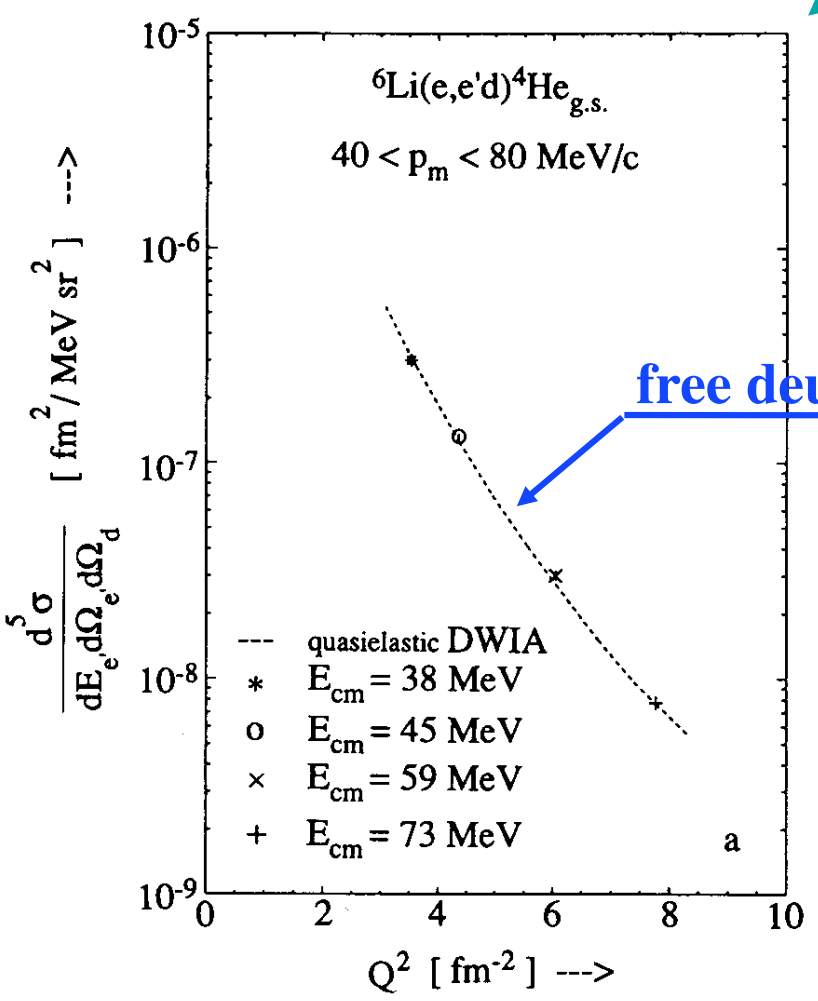
“deuteron” in ^{6}Li

^{6}Li(e,e’d)α @ NIKHEF under quasi-elastic e-d kinematics

$$\frac{d^6\sigma}{\overrightarrow{dp_e}\,\overrightarrow{dp_d}} = K\sigma_{ed}(q)\left|\phi(p_m)\right|^2$$



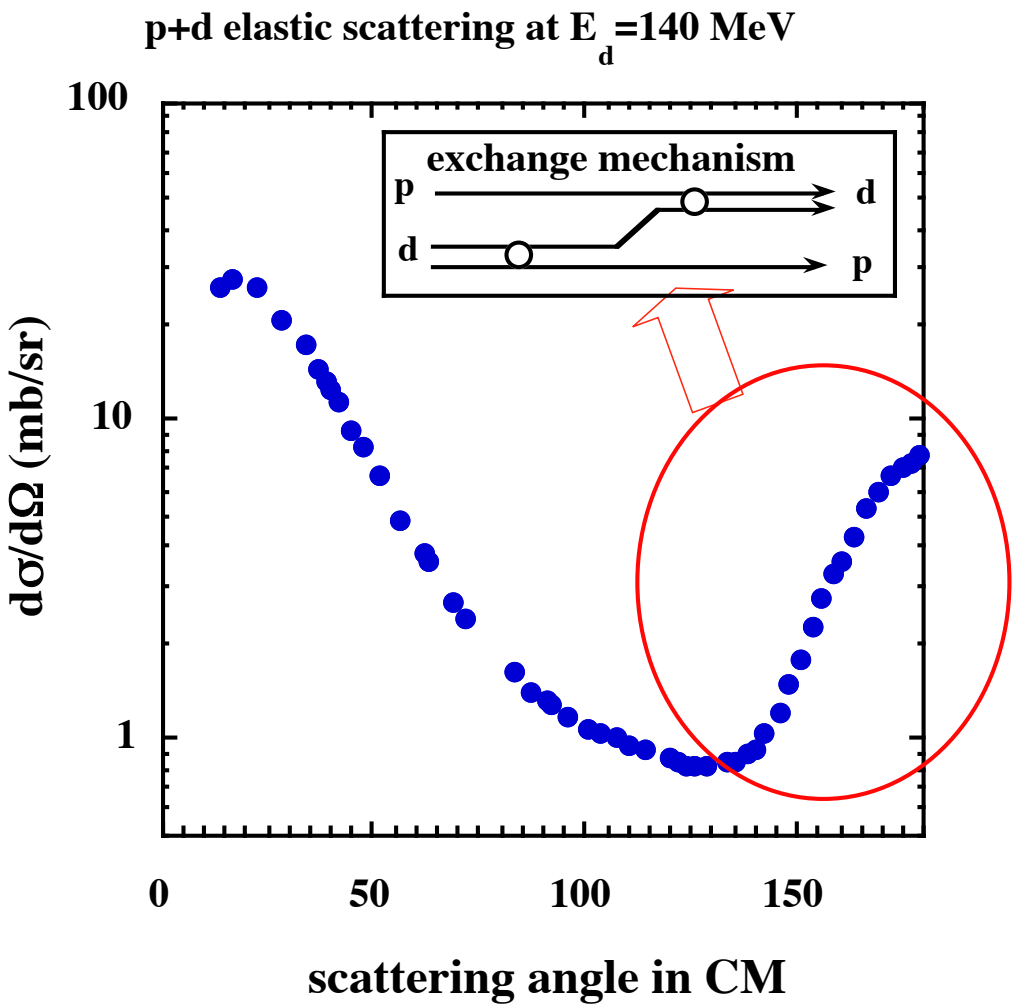




R. Ent et al.,
NPA578(’94)93.

pd elastic scattering

Backward scattering ⟺ **One Nucleon Exchange (ONE) process**



K. Sekiguchi et al.,
PRC 65,034003,2002

PWIA

$$\frac{d\sigma}{d\Omega} \propto |\rho(k)|^2$$

$$k = \frac{1}{2} p_{pd}$$

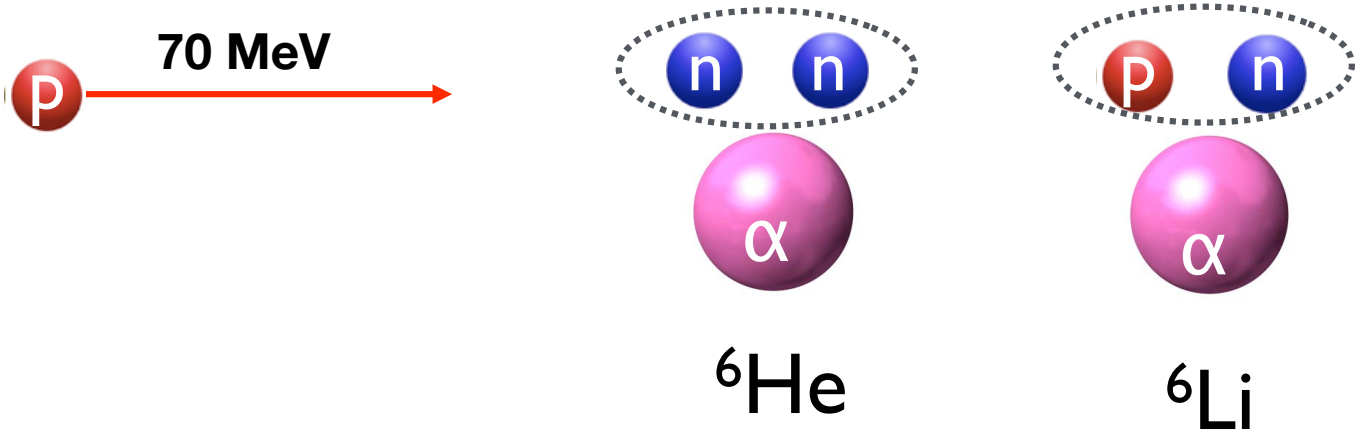
relative momentum
between *p* and *d*

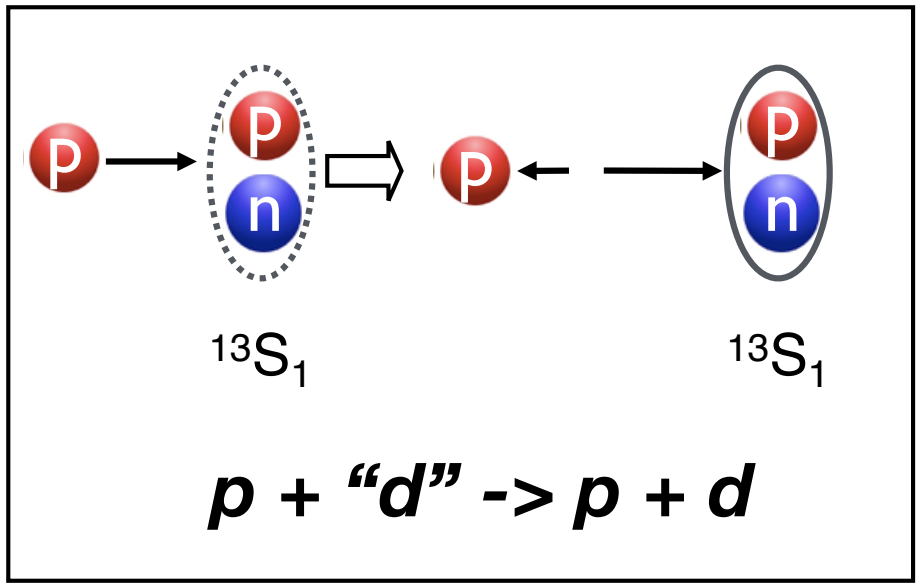
A. P. Kobushkin, J. Phys. G 12 (1986) 487

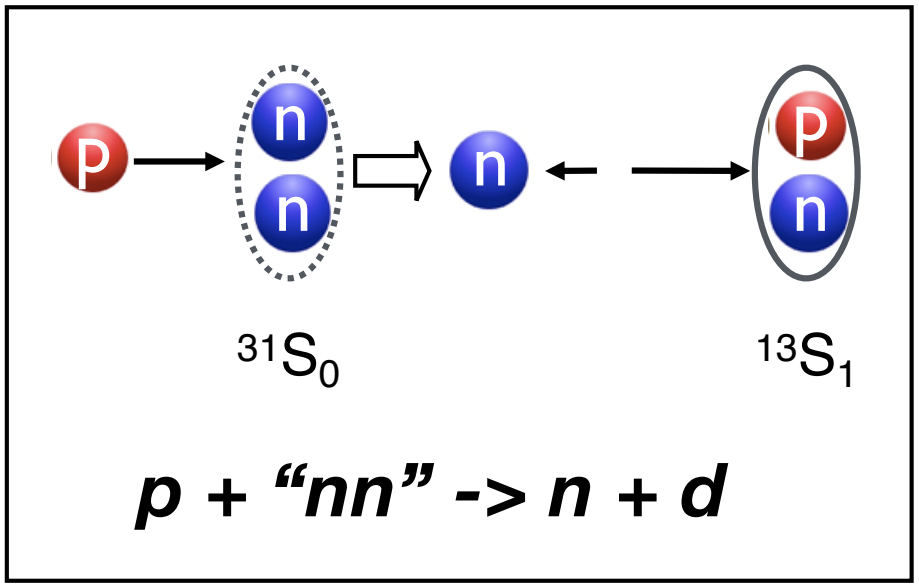
S. Ishikawa, private communication

Probing rel. mom. of 2*N* in ^{6}He and ^{6}Li

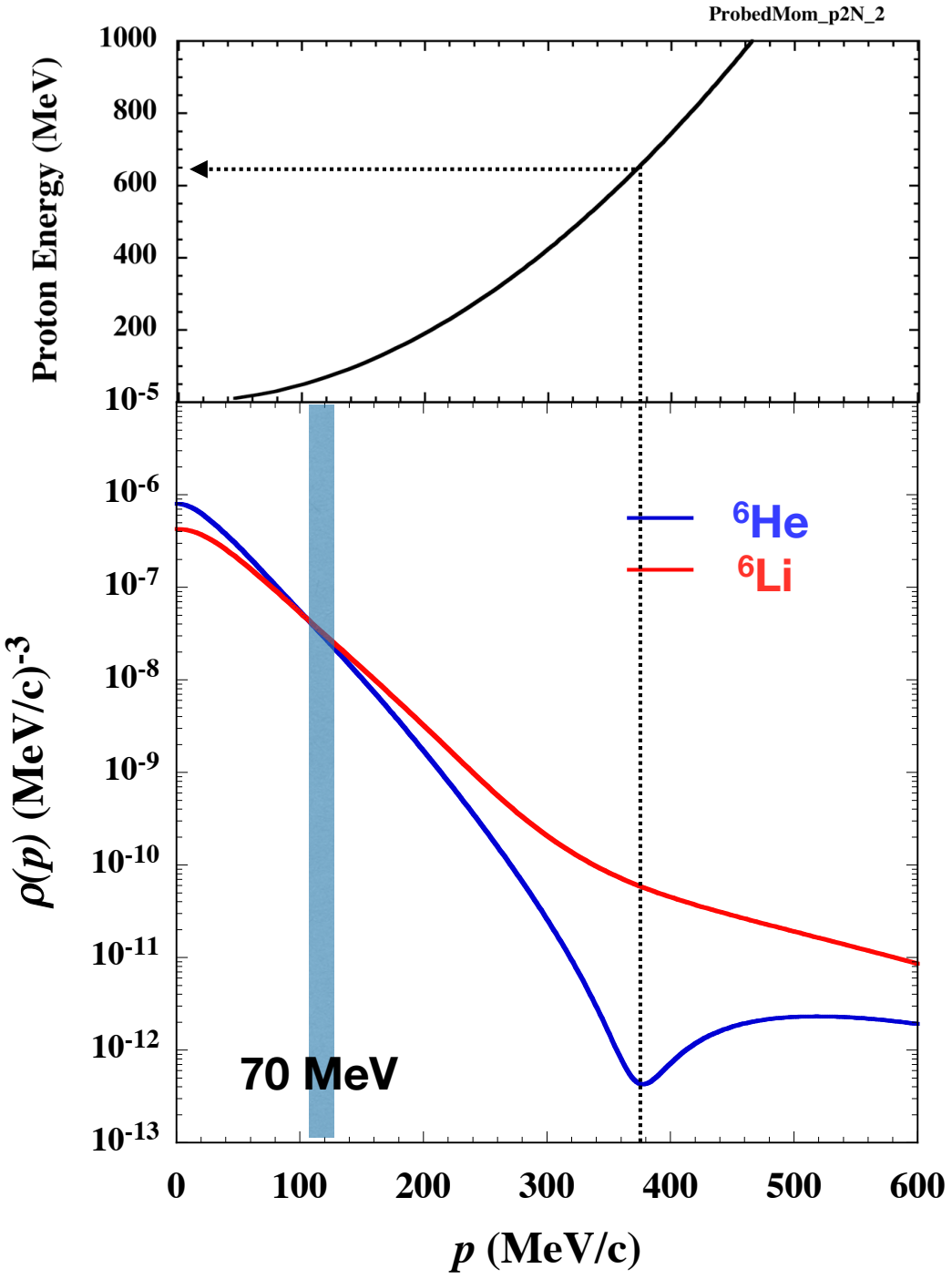
p+"2*N*" at backward for ^{6}He and ^{6}Li





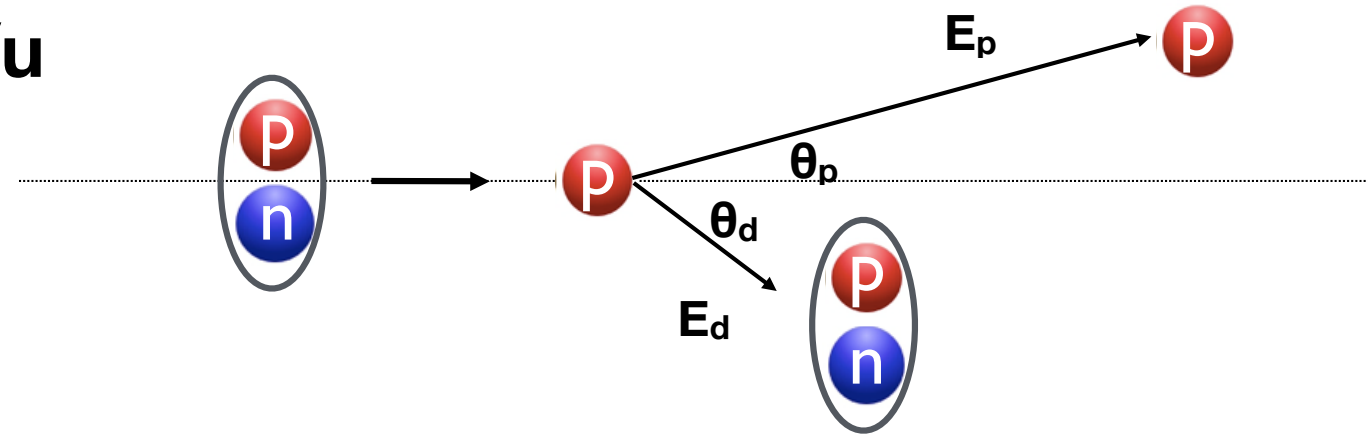


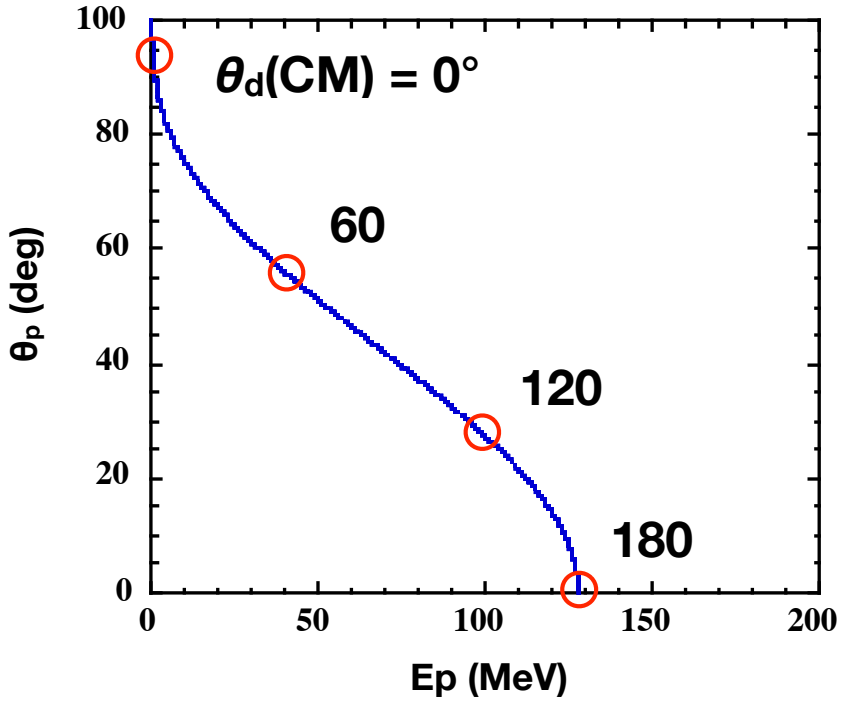
Probed relative momentum

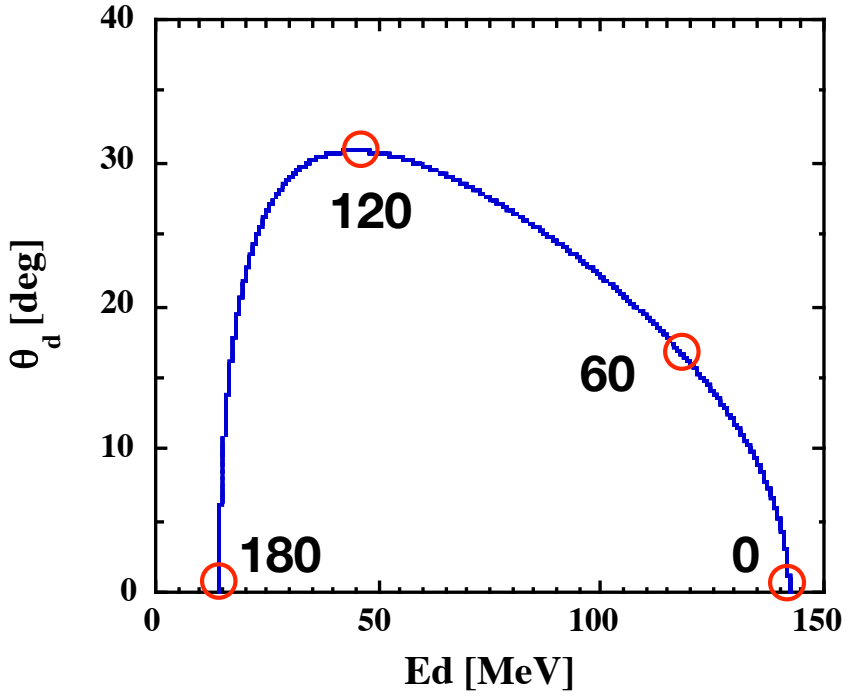


Kinematics of *p*+*d* scattering

E_d = 70 MeV/u

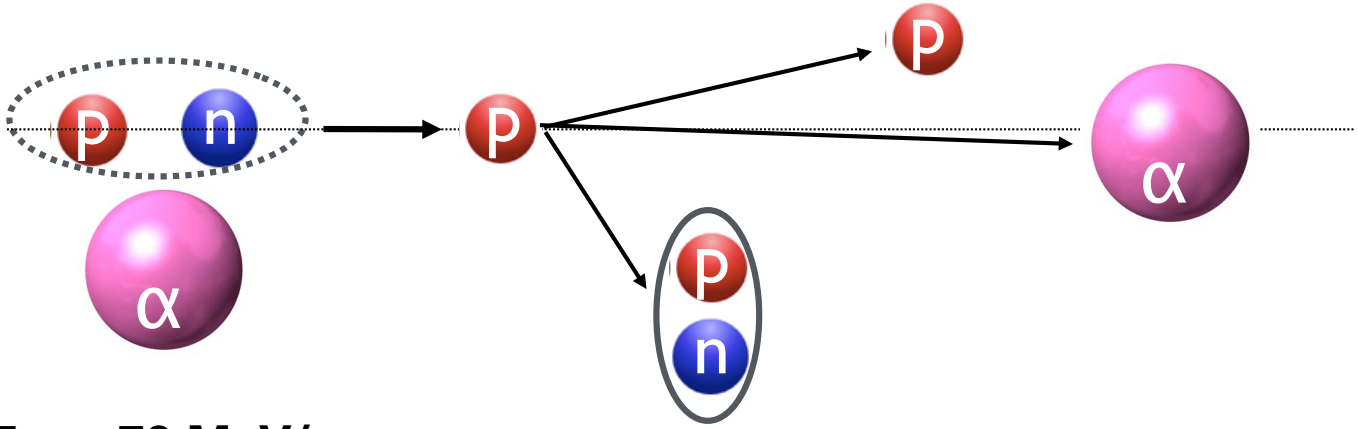




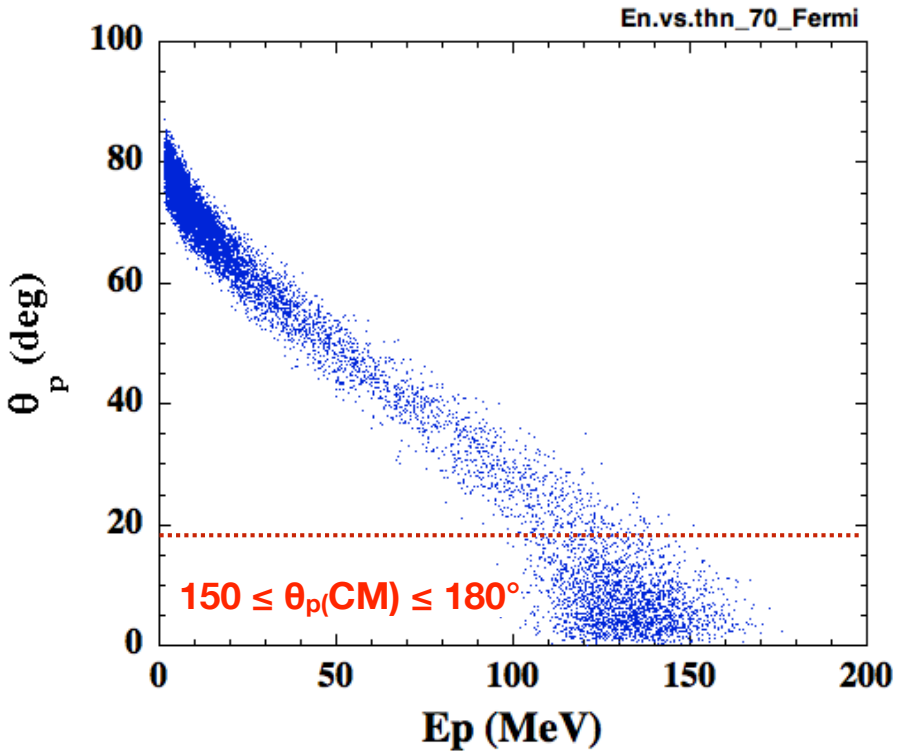


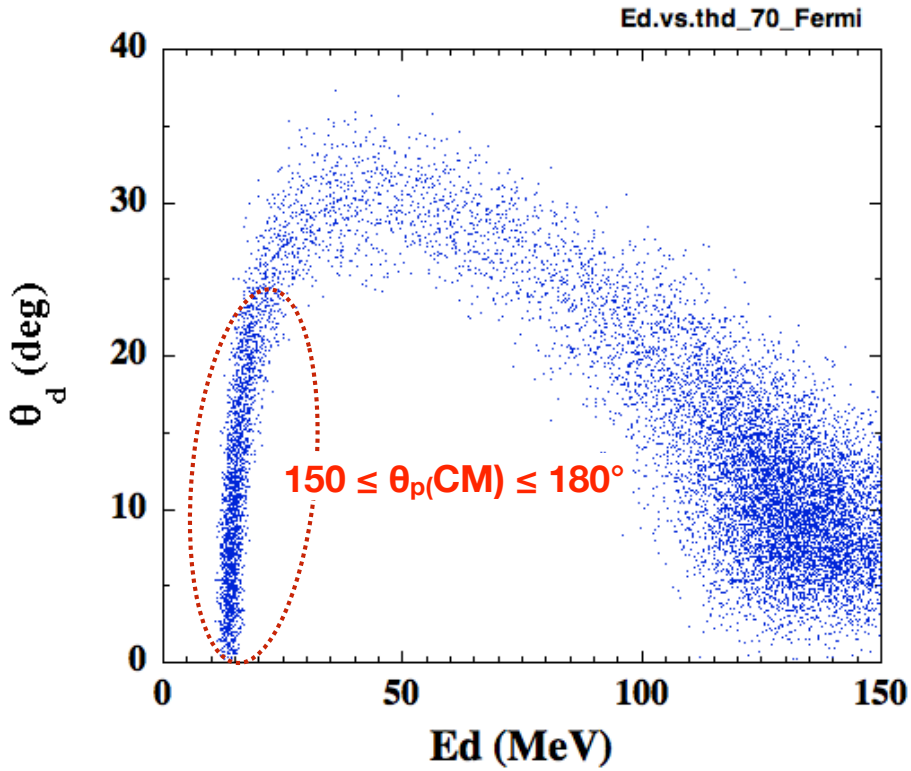
Kinematics of *p*+"2*N*" scattering

Assuming "Quasi-free" p+"d" scattering



$E_{^6Li}$ = 70 MeV/u

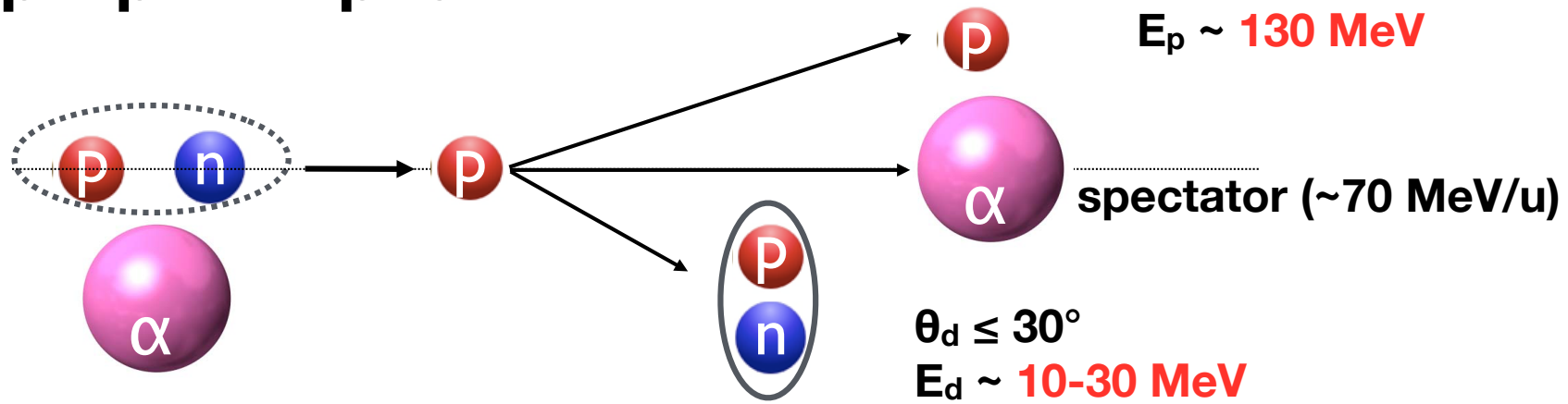




Kinematics of ONE process

Backward p+"2N" scattering events in the inverse kinematics

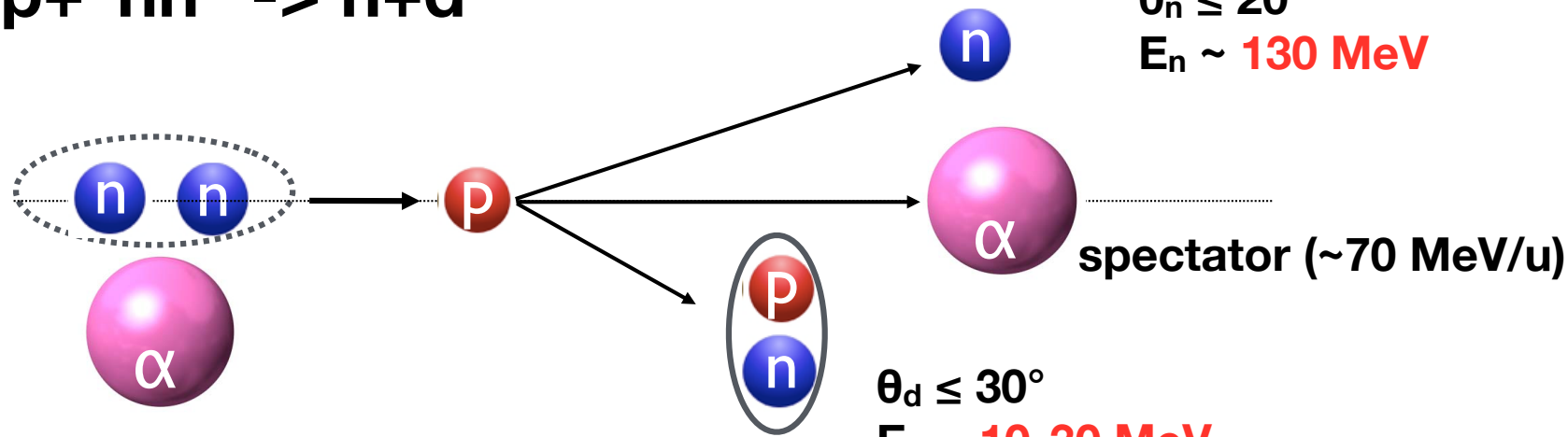
^{6}Li: p+"pn" -> p+d



$\theta_p \leq 20°$
E_p ~ 130 MeV

$\theta_d \leq 30°$
E_d ~ 10-30 MeV

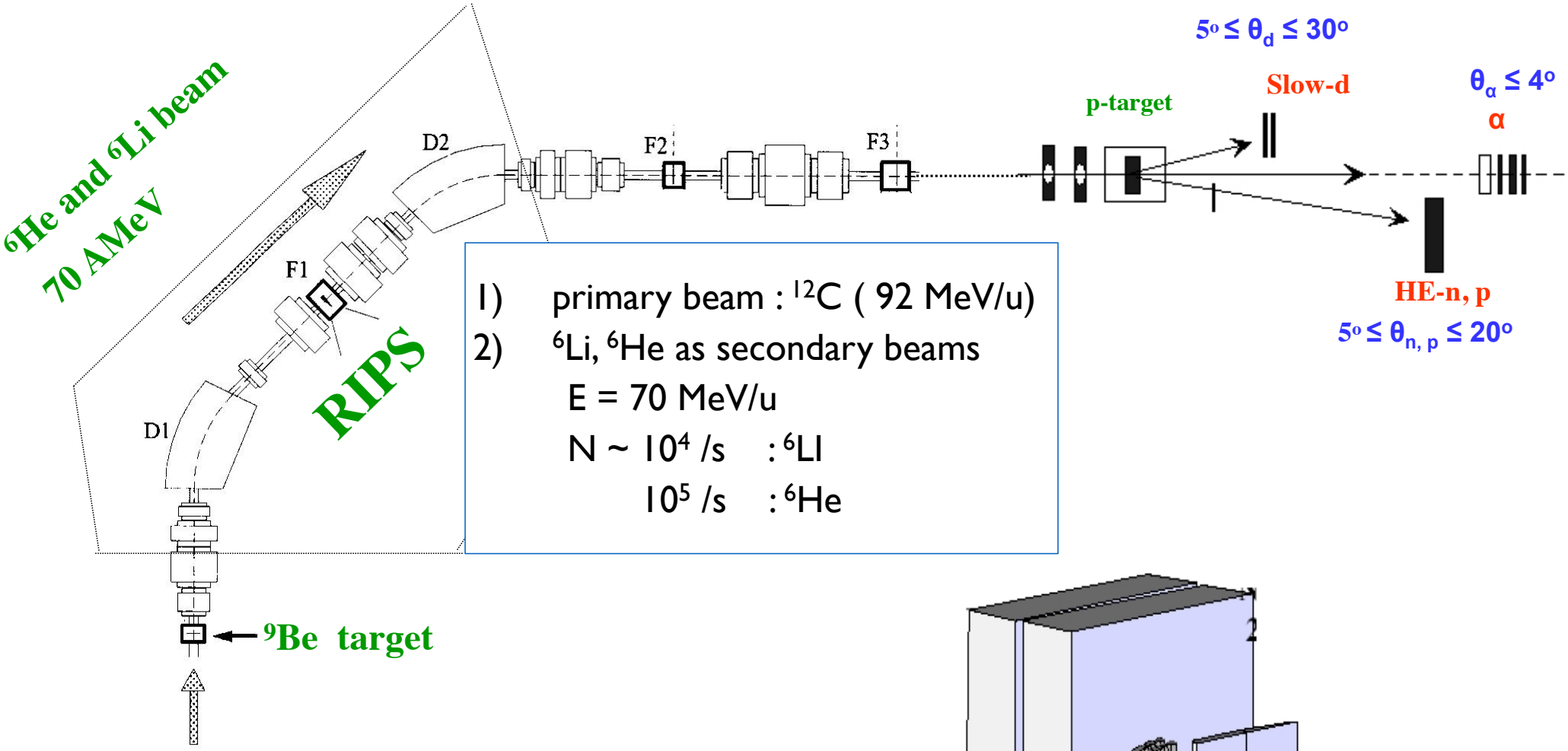
^{6}He: p+"nn" -> n+d



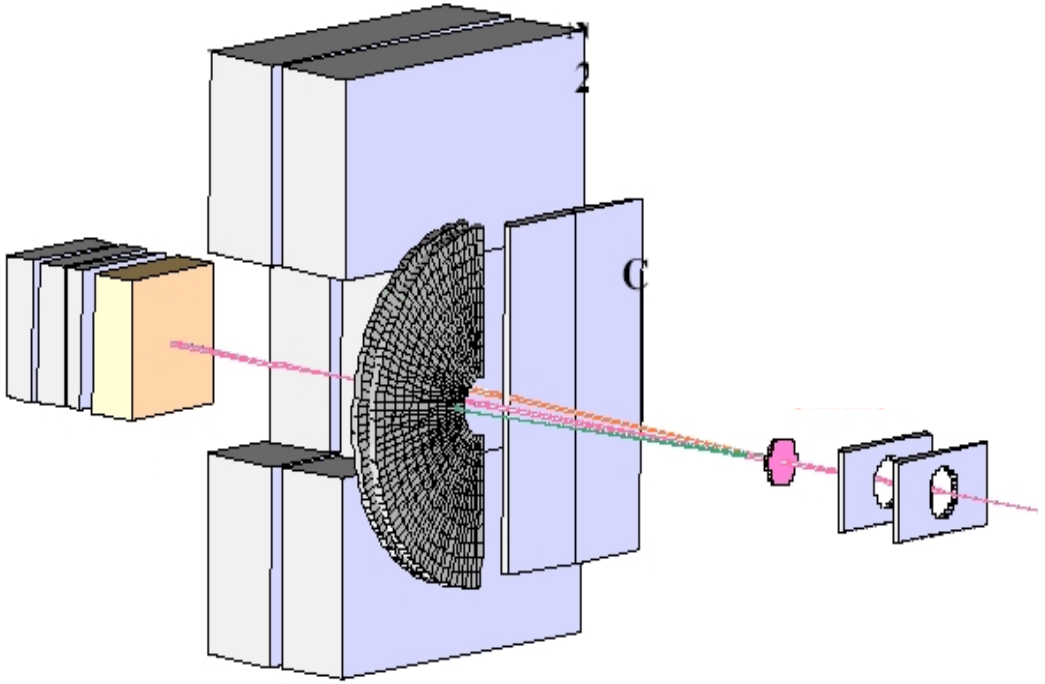
$\theta_n \leq 20°$
E_n ~ 130 MeV

$\theta_d \leq 30°$
E_d ~ 10-30 MeV

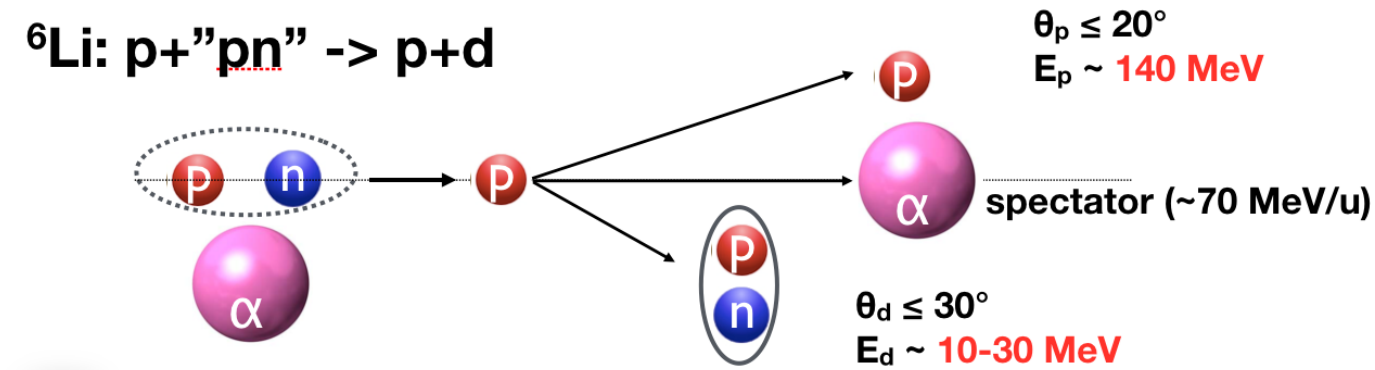
p+"2N"@backward exp. at RIPS



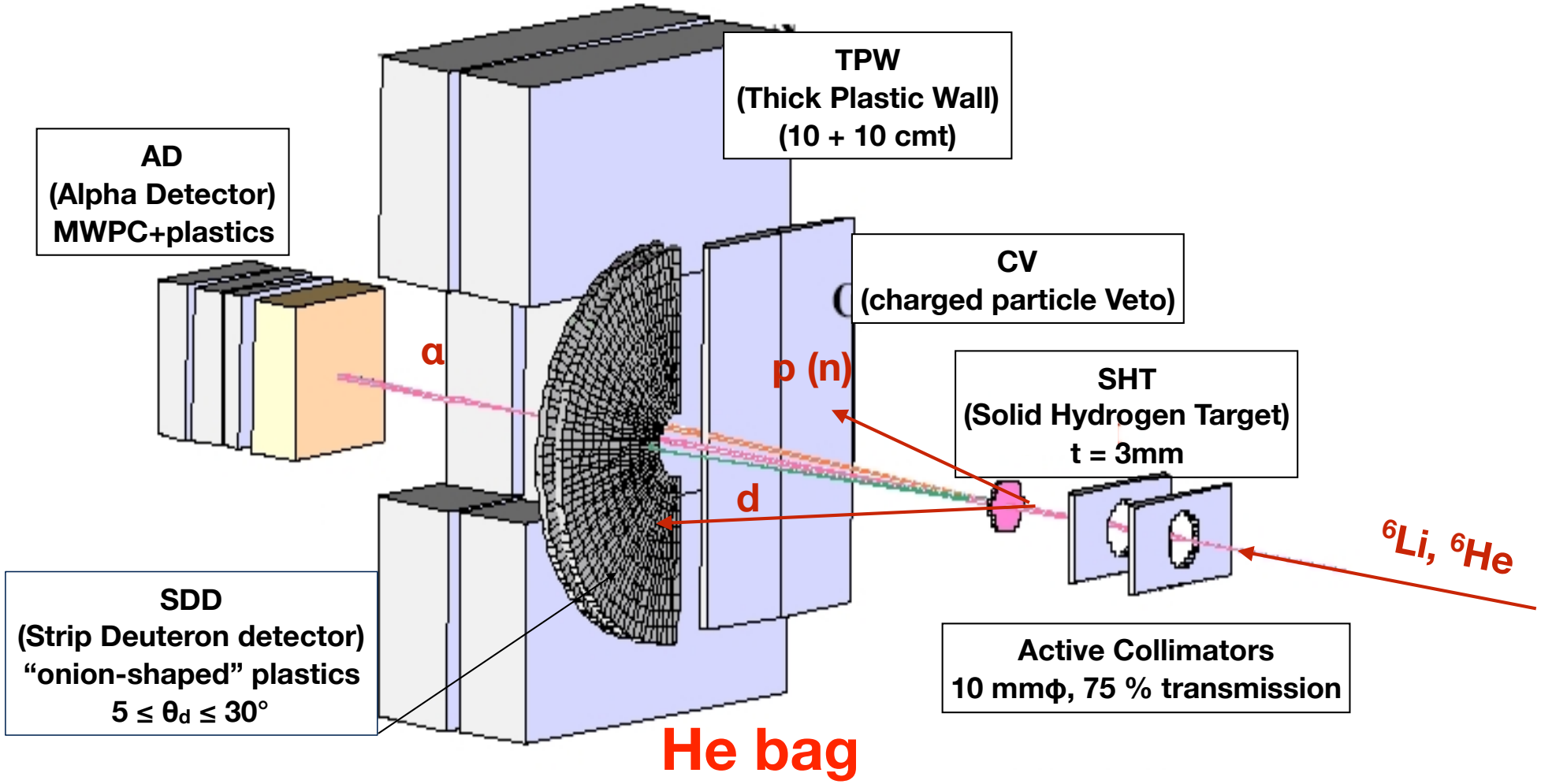
1) primary beam : ^{12}C (92 MeV/u)
2) ^{6}Li, ^{6}He as secondary beams
   E = 70 MeV/u
   N ~ 10^4 /s : ^{6}LI
   10^5 /s : ^{6}He



Detector Setup



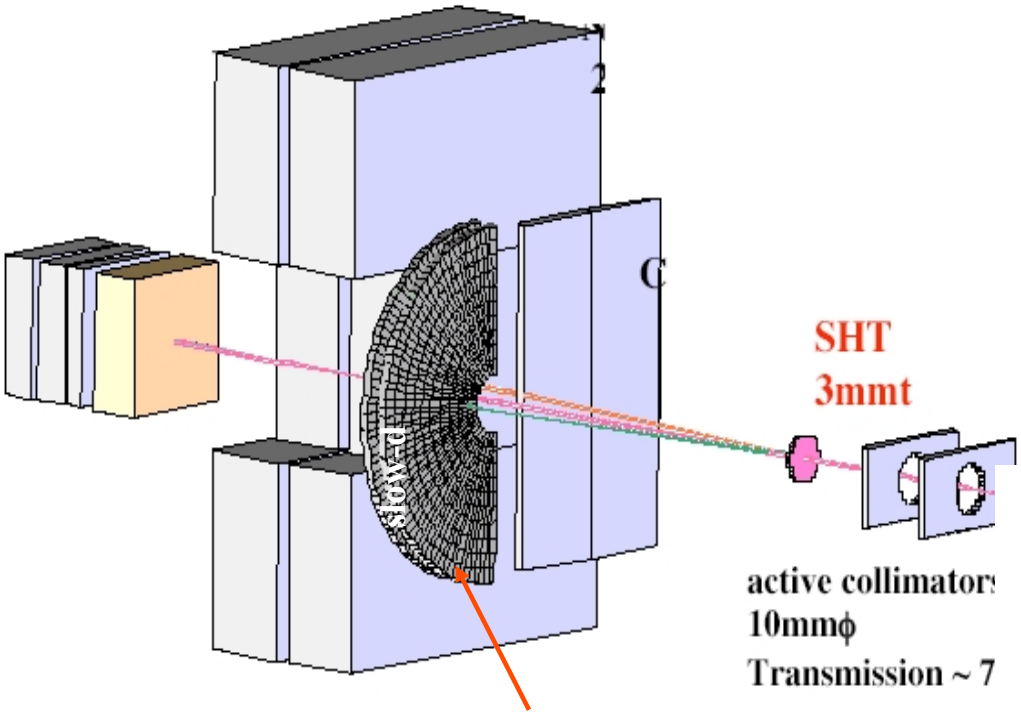
$120 \leq \theta_{CM} \leq 180°$



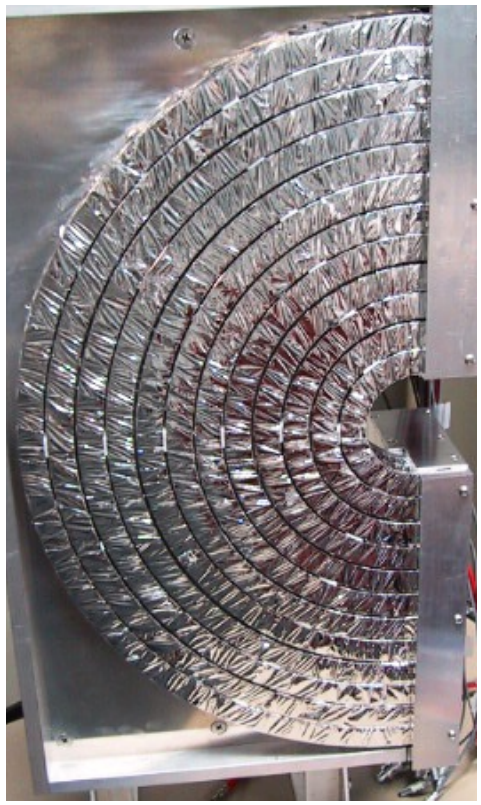
low-energy deuteron detector

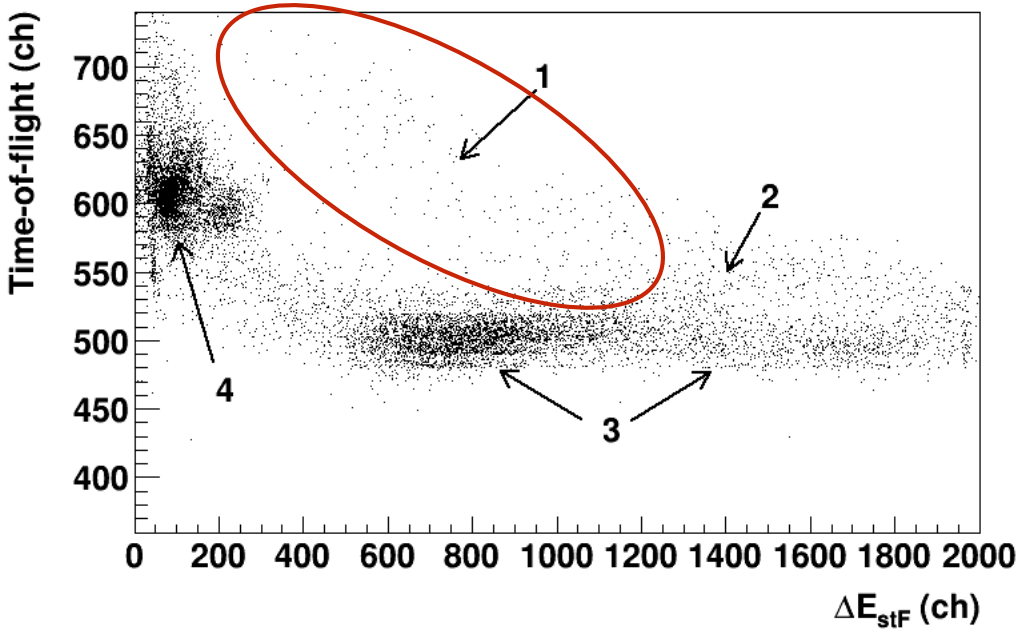
Two-layer “onion-shaped” stip detectors (2nd layer for high-E particle veto)

TOF - E



Strip detectors: 2 arrays



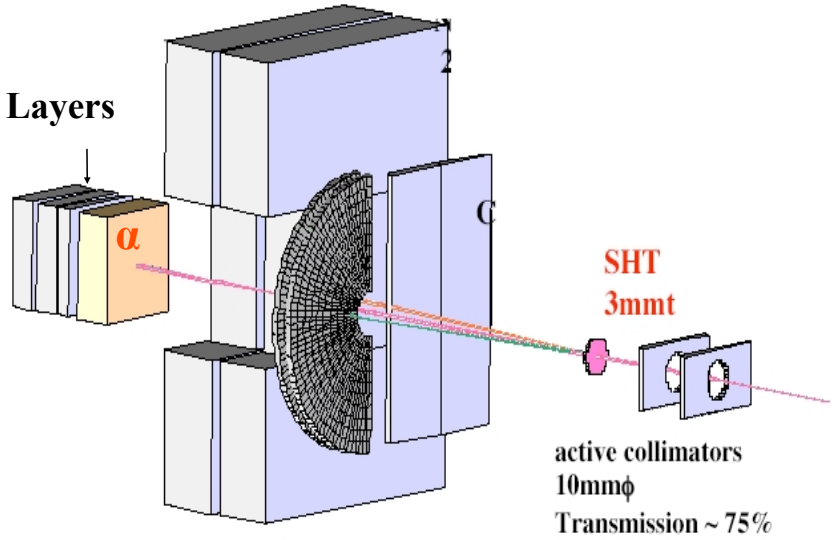


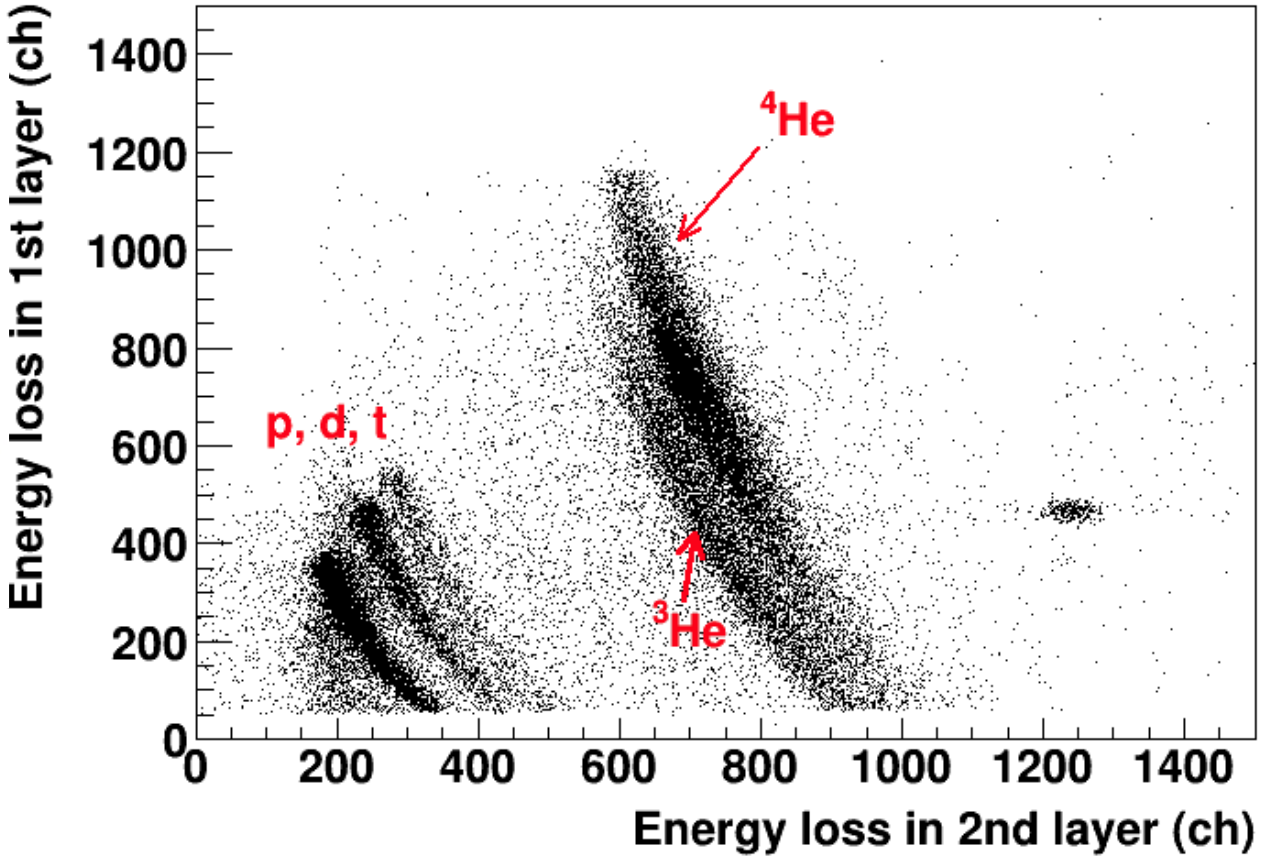
α detectors

MWPC + Range conter (ΔE-E)

thee thick plastics (3rd for veto)
θα ≤ 4°

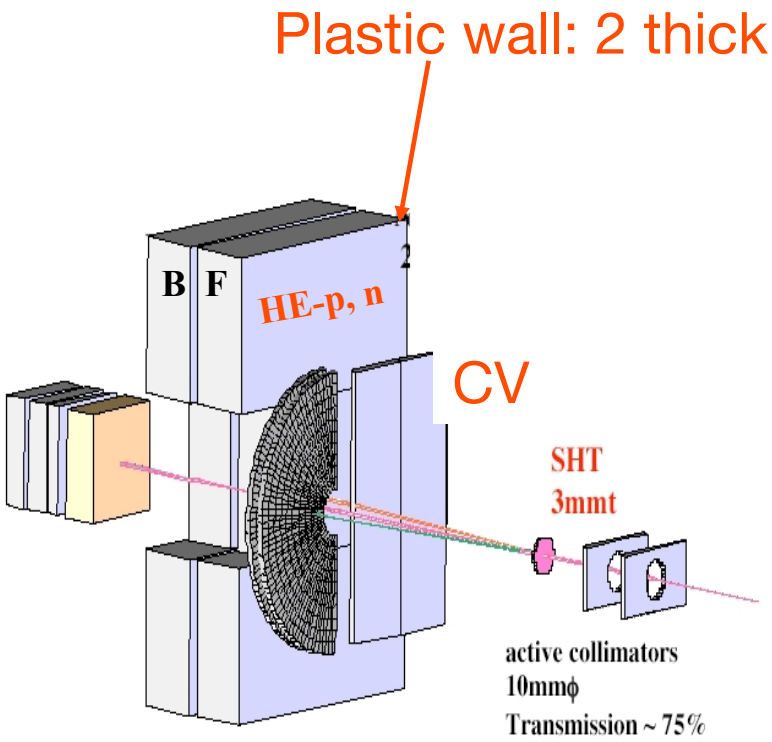
^{6}Li fragmentation (p+n+α)

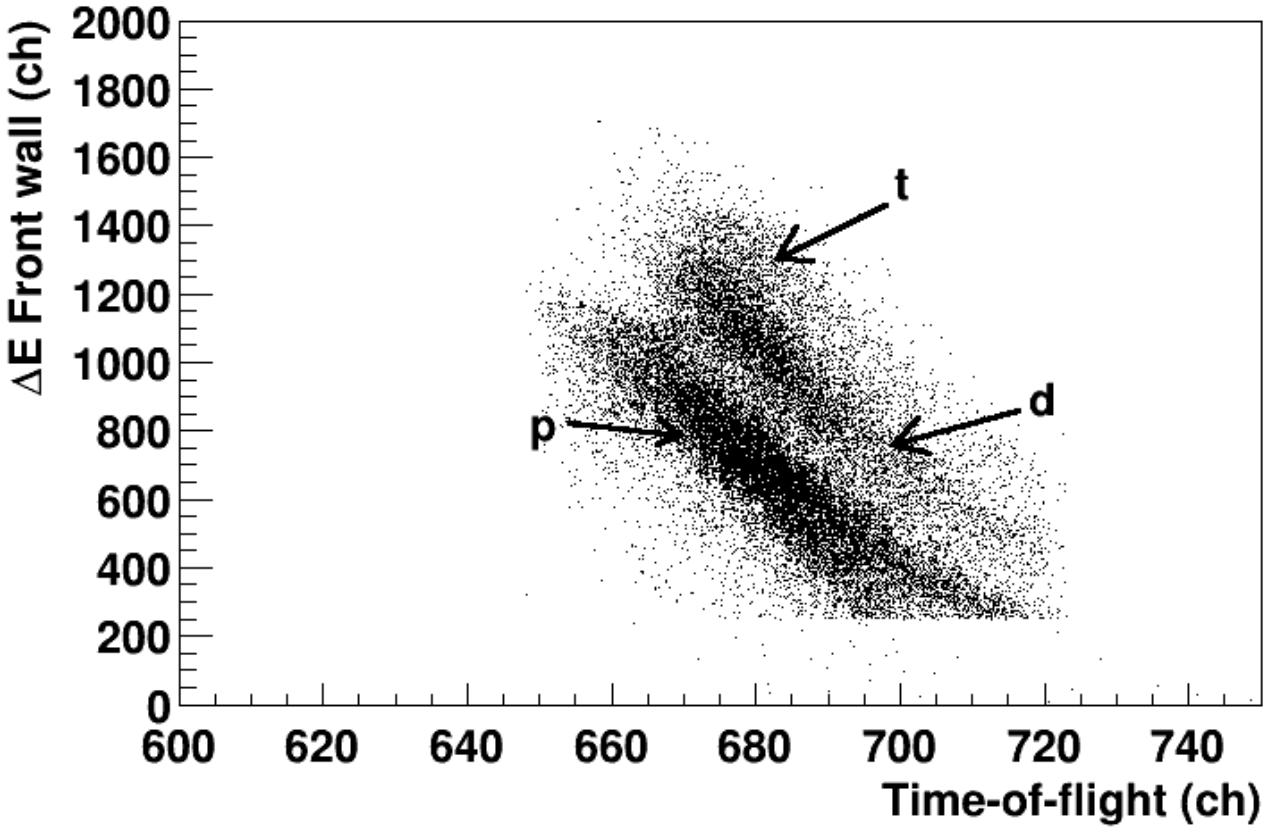




High-E proton (neutron) detector

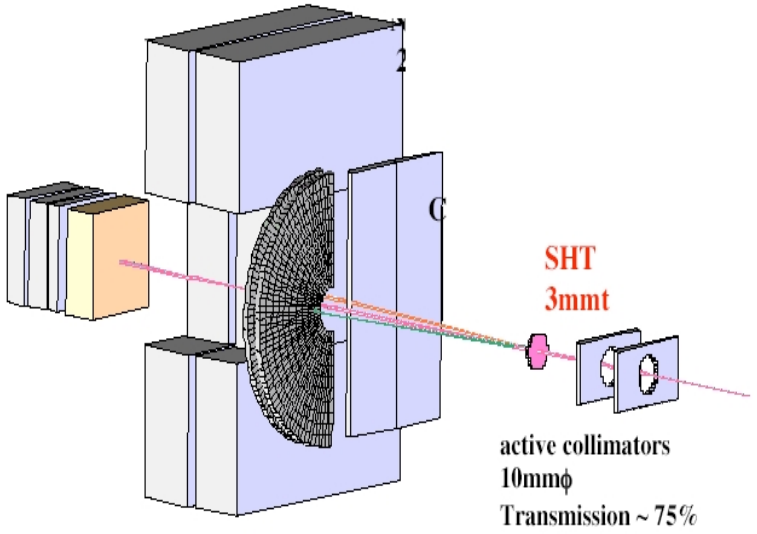
p : ΔE-E and TOF
n : TOF (flight path = 75, 85 cm)

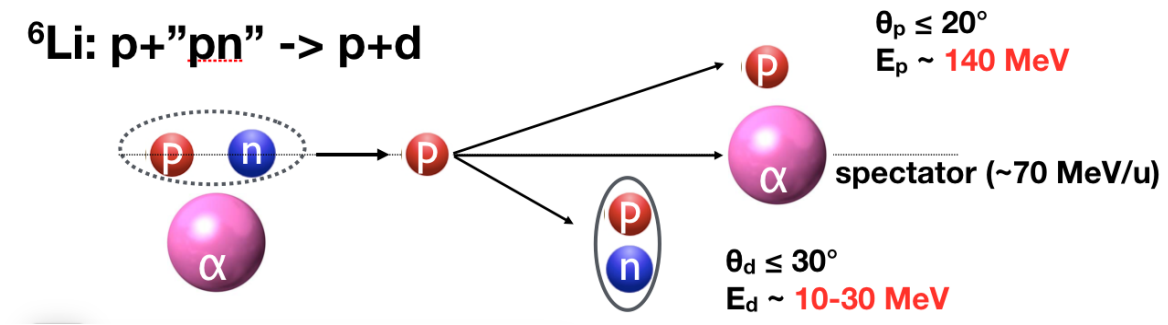


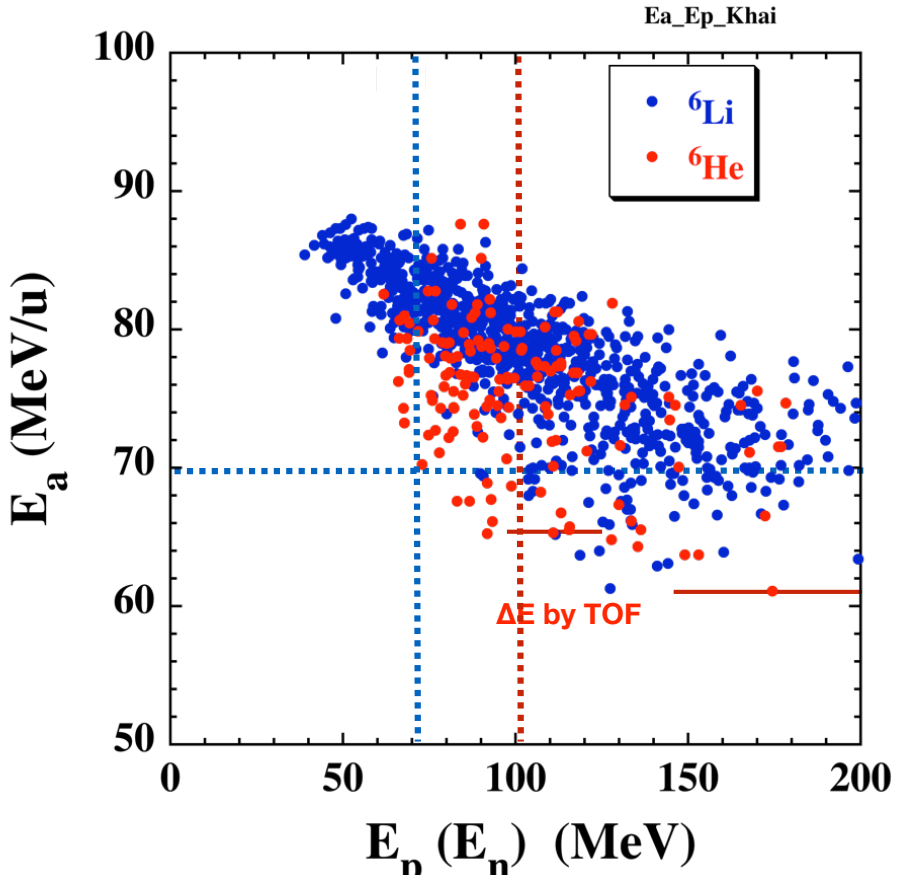


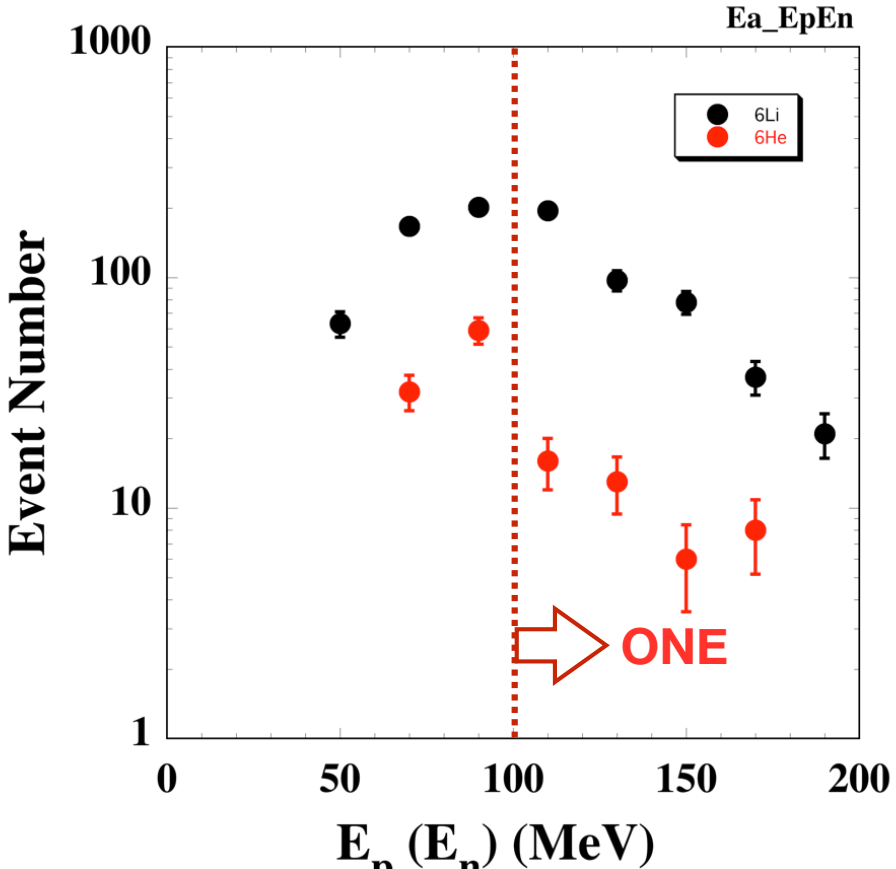
neutron detection eff. : ^{6}Li fragmentation (p+n+α)

E_α-$E_{p(n)}$ correlation

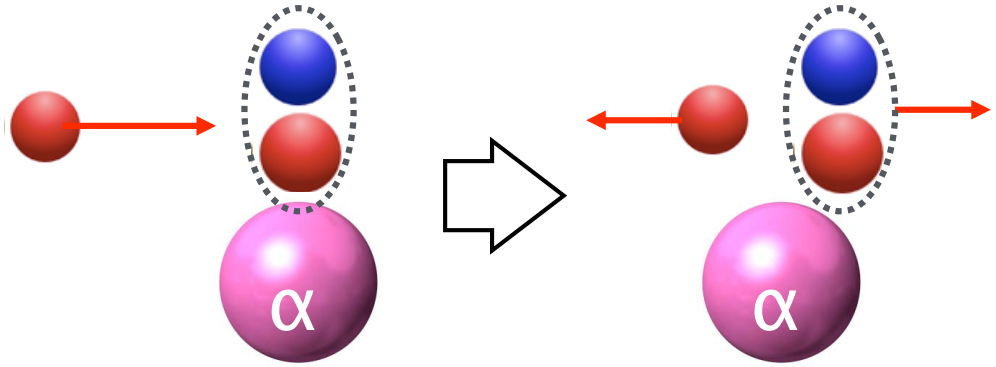




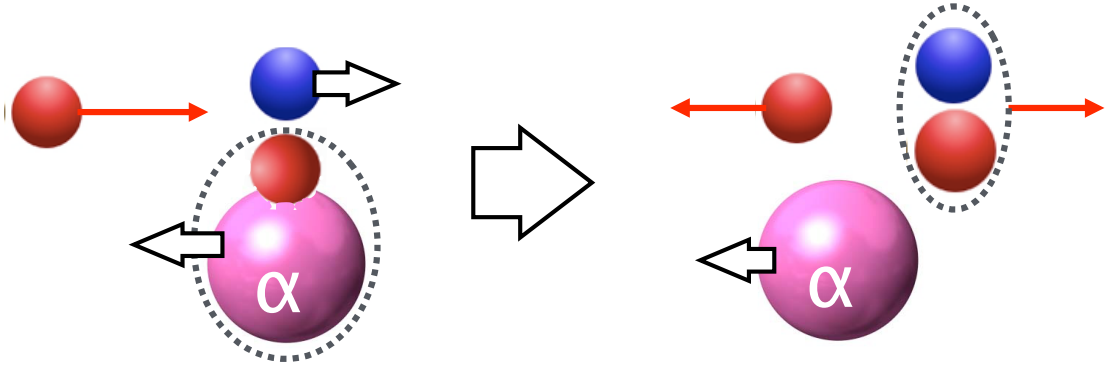




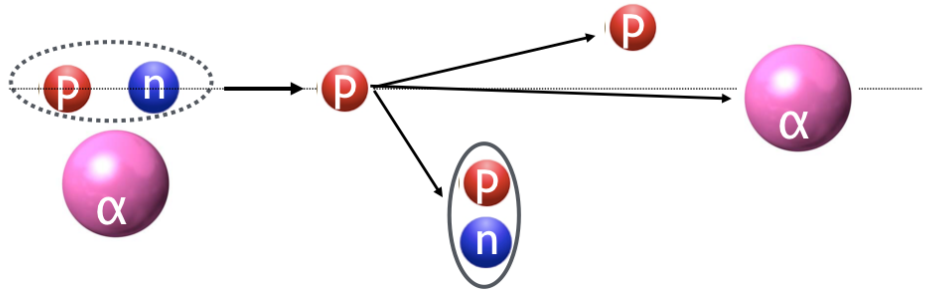
ONE process

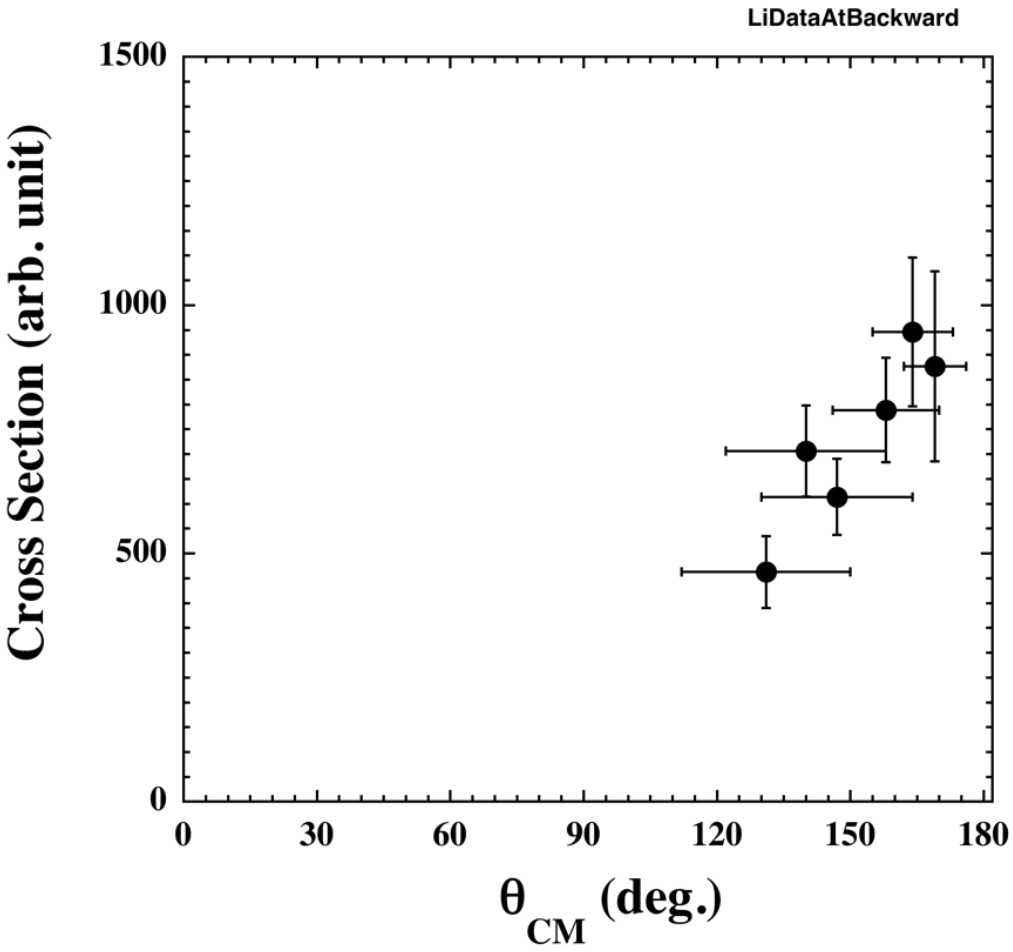


Two-step process



p + ^{6}Li -> p + d + α events





consistent with ONE for ^{6}Li events

Events for ^{6}He are smaller than expected.

detailed analysis is not possible

Cross section ratio of ONE for ^{6}Li and ^{6}He

$$\sigma_{ONE} = \frac{Y_{ONE}}{N_{target} \cdot N_{beam} \cdot \epsilon_{det}(\cdot\epsilon_n)}$$

$$R = \frac{\sigma_{ONE}(^6He)}{\sigma_{ONE}(^6Li)} = 0.045 \pm 0.007 \pm 0.010$$

stat. sys.

Cross section ratio of ONE for ^{6}Li and ^{6}He

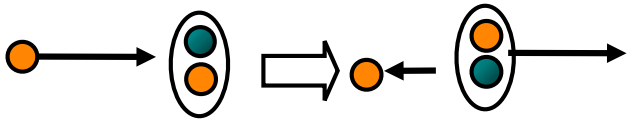
$$\frac{\sigma_{ONE}(p+'nn'\rightarrow nd)}{\sigma_{ONE}(p+'pn'\rightarrow pd)} = \frac{|<spin\cdot isospin>|^2\left[\rho_{nn}(p)\right]^2}{|<spin\cdot isospin>|^2\left[\rho_{pn}(p)\right]^2}$$

$$= \frac{|<nd|\hat{O}|p(nn)>|^2}{|<pd|\hat{O}|pd>|^2}\frac{\left[\rho_{nn}(p)\right]^2}{\left[\rho_{pn}(p)\right]^2} = 0.4444\frac{\left[\rho_{nn}(p)\right]^2}{\left[\rho_{pn}(p)\right]^2}$$

1) $\hat{O} = V(\sigma 1\cdot\sigma 2)(\tau 1\cdot\tau 2)$

2) Radial wave functions is assumed to be identical

p+'d'->p+d

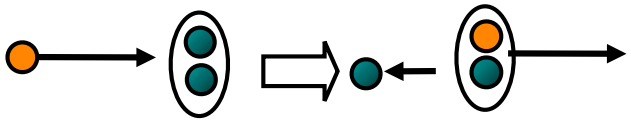


$^{13}S_1$ J=1 T=0 $^{13}S_1$ J=1 T=0

Spin $\frac{1}{2}+1\rightarrow\frac{1}{2},\frac{3}{2}\rightarrow\frac{1}{2}+1$

Isospin $\frac{1}{2}+0\rightarrow\frac{1}{2}\rightarrow\frac{1}{2}+0$

p+'nn'->n+d

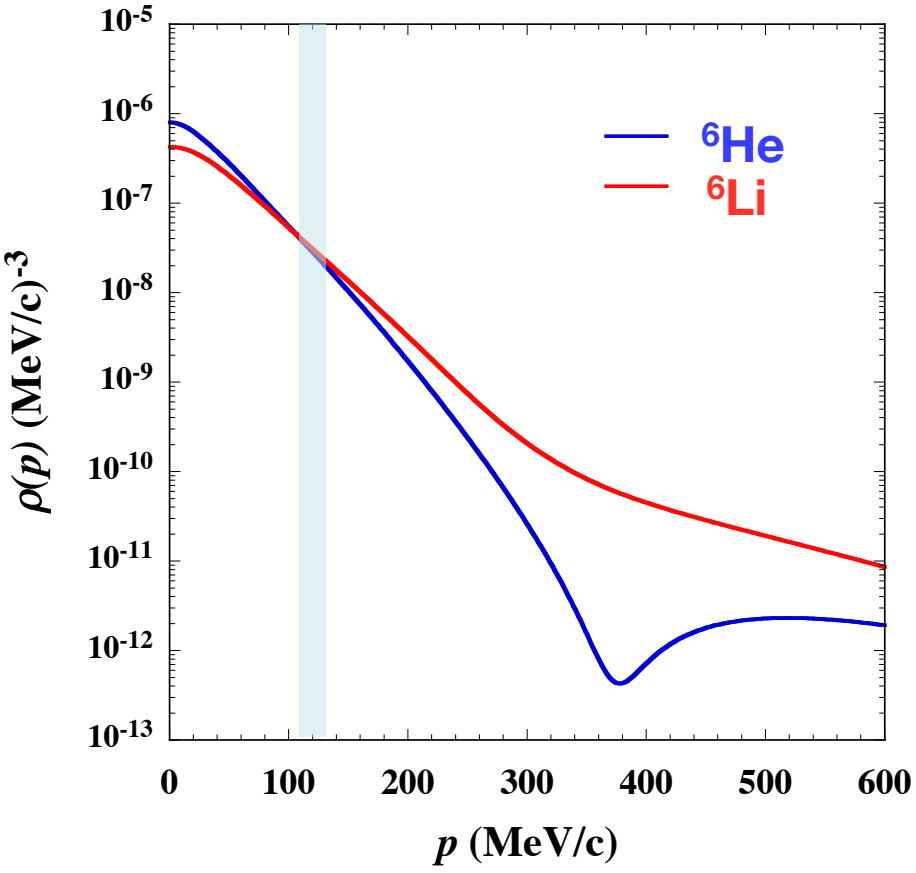


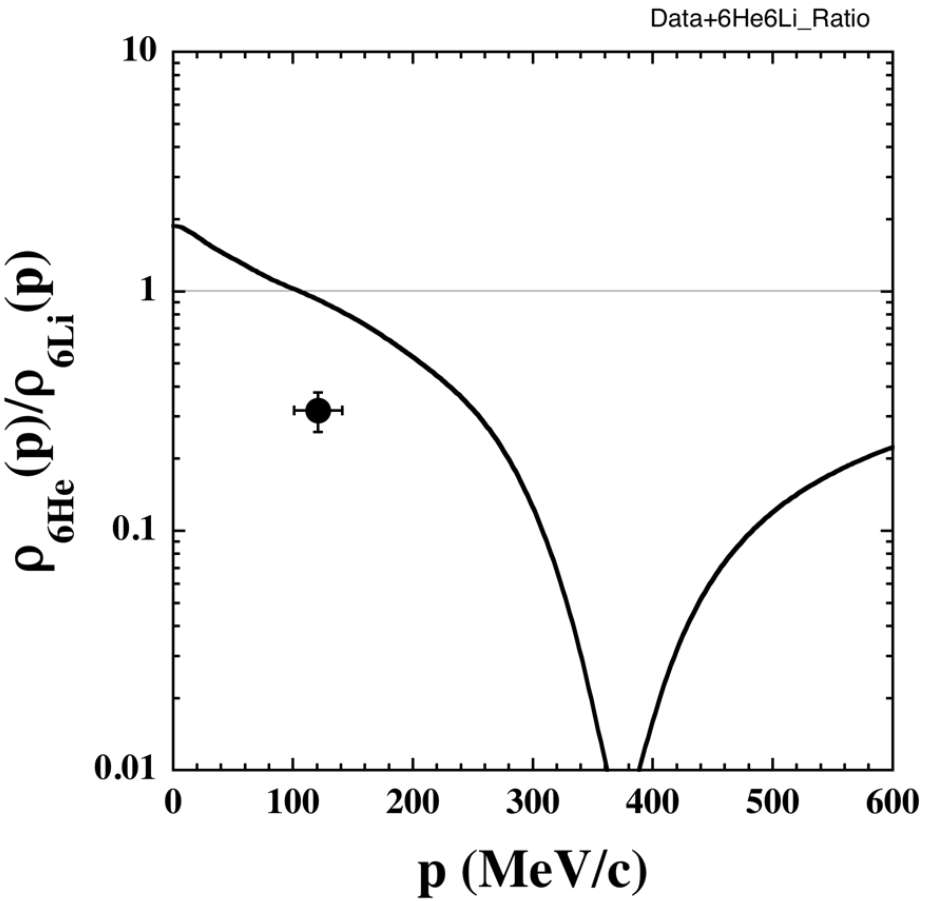
$^{31}S_0$ J=0 T=1 $^{13}S_1$ J=1 T=0

Spin $\frac{1}{2}+0\rightarrow\frac{1}{2}\rightarrow\frac{1}{2}+1$

Isospin $\frac{1}{2}+1\rightarrow\frac{1}{2},\frac{3}{2}\rightarrow\frac{1}{2}+0$

Ratio of ρ_{2N} for ^{6}Li and ^{6}He





Summary

1. p+2N backward scattering events at Ep = 70 MeV
   p+^{6}Li -> p + d + α
   p+^{6}He -> n + d + α

2. ONE (One Nucleon Exchange) events observed
   in the reaction p+^{6}Li -> p + d + α

3. Ratio of the ONE process

$$R = \frac{\sigma_{ONE}(^{6}He)}{\sigma_{ONE}(^{6}Li)} = 0.045 \pm 0.007_{\text{stat.}} \pm 0.010_{\text{sys.}}$$

4. Theoretical calculations for p+^{6}Li (^{6}He) -> p(n)+d+α reaction