Contents

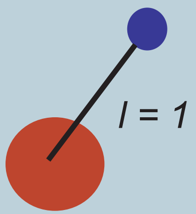
^{5}H in the *t+n+n* system

Why ^{5}H ?

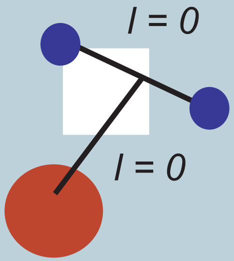
^{4}H

E~ 3 MeV

Γ ~ 3 MeV



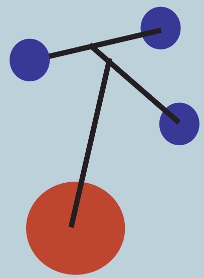
Γ ~ 10 MeV



^{6}H

E~ 2.7 MeV

Γ ~ 1-2 MeV



[1] D.R. Tilley et al, Nucl. Phys. **A708** (2002) 3

^{5}H in the *t+n+n* system

Previous knowledge of ^{5}H

Most recent Experimental results

"Narrow"

[1] ^{6}He(p,2p); E= 1.7(3), Γ = 1.9(4) MeV

[2] ^{3}He(t,p); E= 1.7(3), Γ < 0.5 MeV

"Broad"

[3] ^{9}Be(π^-,pt) and ^{9}Be(π^-,dd);
E= 5(1), Γ = 3 MeV

[1] A.A Korsheninnikov et al., Phys. Rev. Lett. **87** (2001) 092501

[2] G.M Ter-Akopian *VII International School Seminar, May 27 - June 1, 2002, Dubna,* Book of Avbstract (2002) p. 87

[3] M.G. Gornov et al., *LII meeting on Nuclear Spectroscopy and Nuclear Structure, June 18-22, 2002, Moscow,* Book of Abstracts (2002) p. 70

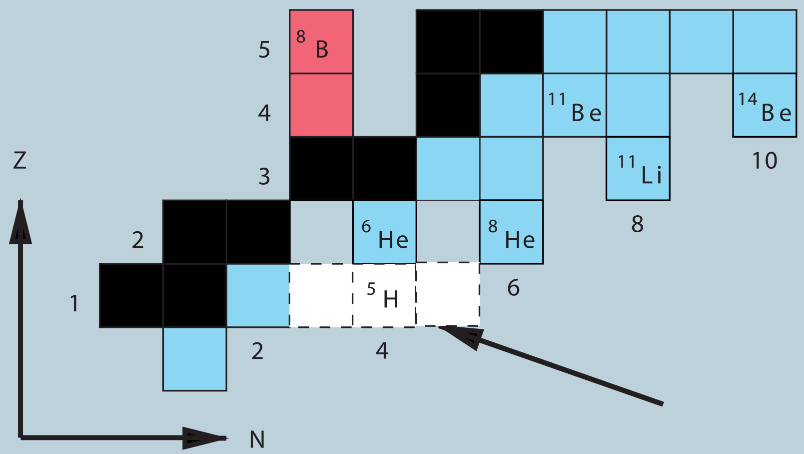
Most recent Theoretical predictions

[4] Three body microscopic calculations;
E= 2.5 - 3.0, Γ = 3 - 4 MeV

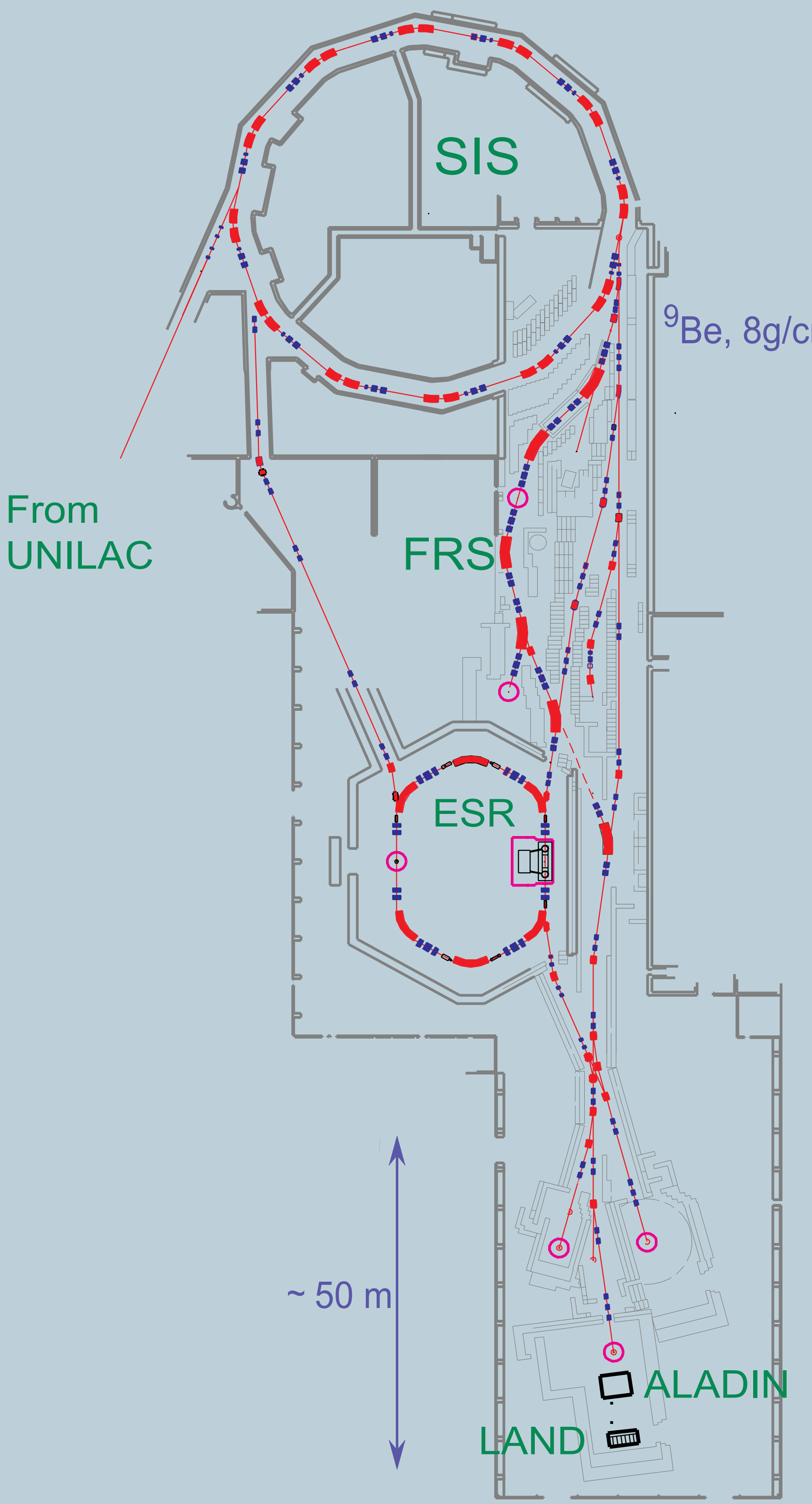
[5] Generator coordinate method;
E= 3 , Γ_n= 1 - 4 MeV

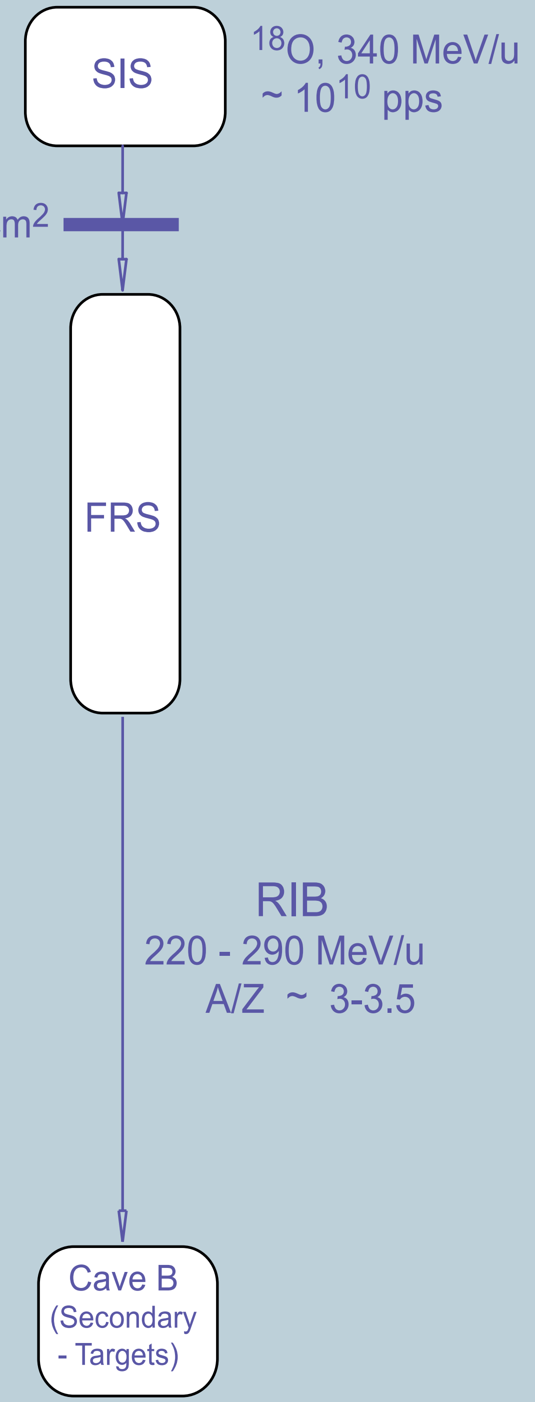
[4] N.B Shulgina et al., Phys. Rev. **C62** (2000) 014312

[5] P. Descouvemont, A. Kharbach, Phys. Rev. **C63** (2001) 027001



^{5}H in the $t+n+n$ system

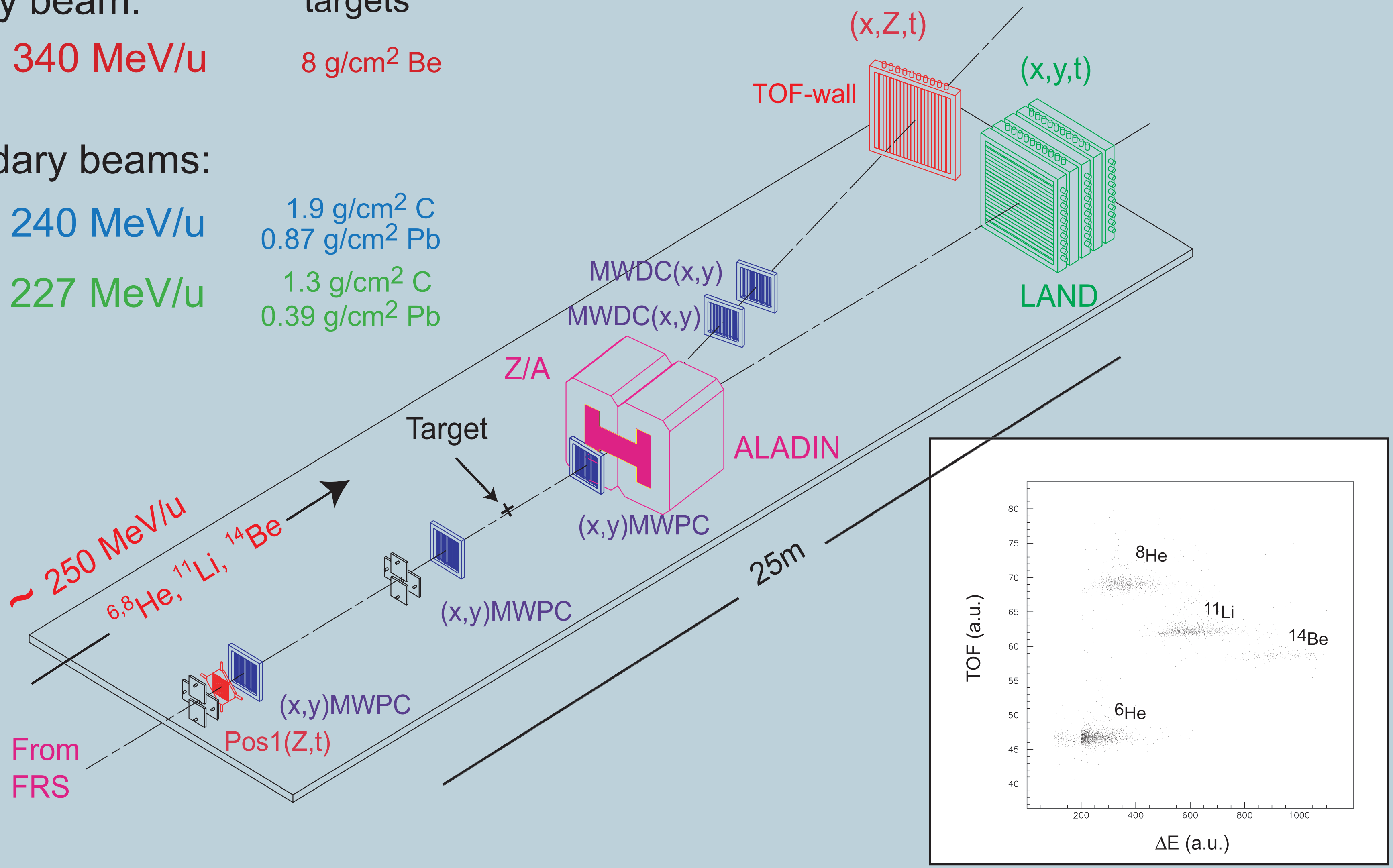




ALADIN/LAND set-up in Cave B

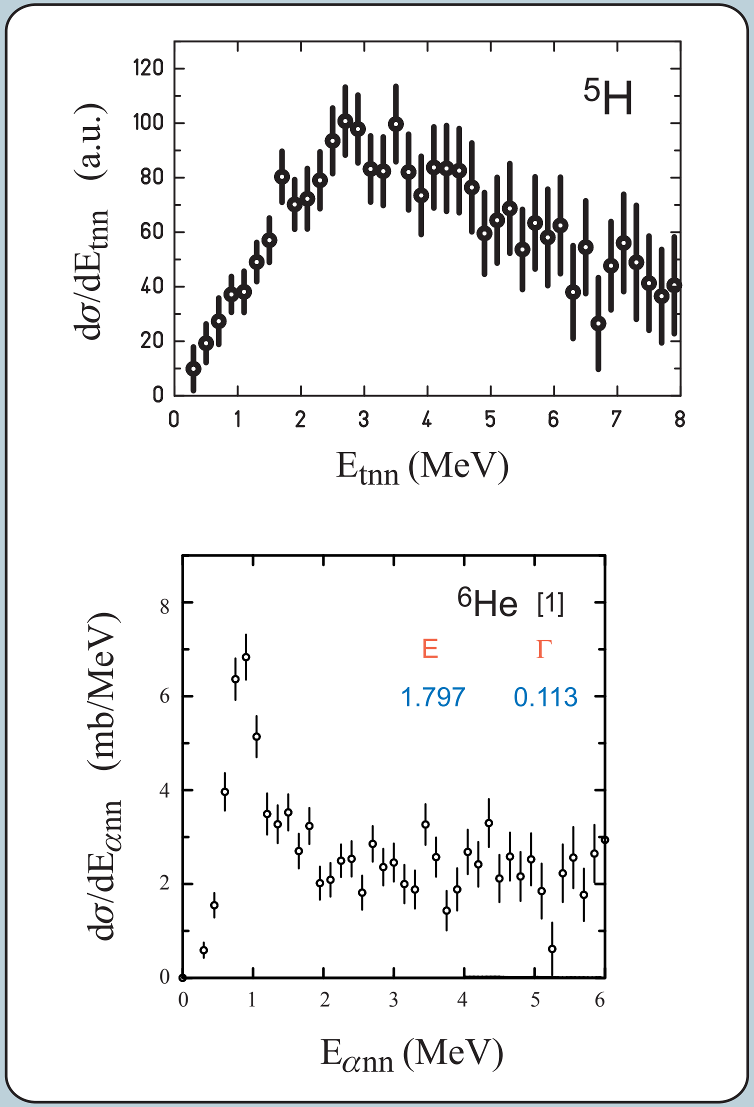
Primary beam:	targets
^{18}O @ 340 MeV/u	8 g/cm^2 Be

Secondary beams:	
^{6}He @ 240 MeV/u	1.9 g/cm^2 C 0.87 g/cm^2 Pb
^{8}He @ 227 MeV/u	1.3 g/cm^2 C 0.39 g/cm^2 Pb



M. Meister

Relative Energy Spectra



Invariant mass spectroscopy:

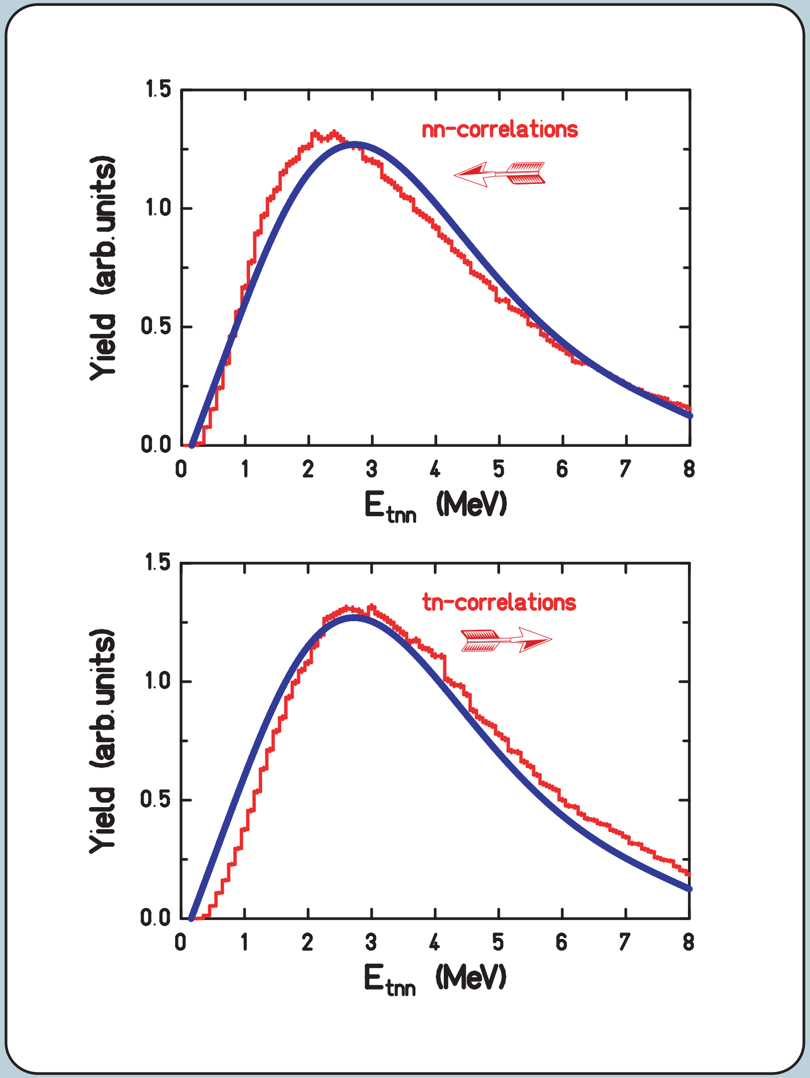
$$(M_{inv}c^2)^2 = (c\Sigma P_j)^2 = (M_{proj}c^2 + E^*)^2$$

6He → α + *Xn*, 8 % 2*n* events

6He → *t* + *Xn*, 23 % 2*n* events

[1] T. Aumann et al., Phys. Rev. C59, (1999) 1252

Combinatorial spectra



Invariant Mass = f ($\mathbf{p}_{n1}$, $\mathbf{p}_{n2}$, $\mathbf{p}_t$)

We can create three types of mixed event spectra

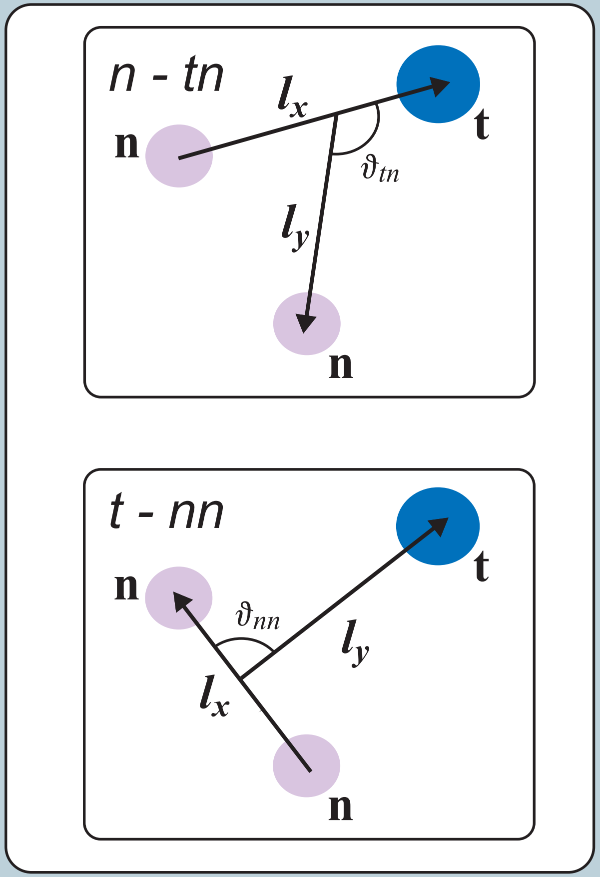
I. All particles mixed (blue)

II. Triton events mixed, both neutrons from the same event

III. Triton and one neutron from the same event

- *nn* correlation at low energy
- *tn* correlation at high energy

Jacobi - Coordinates

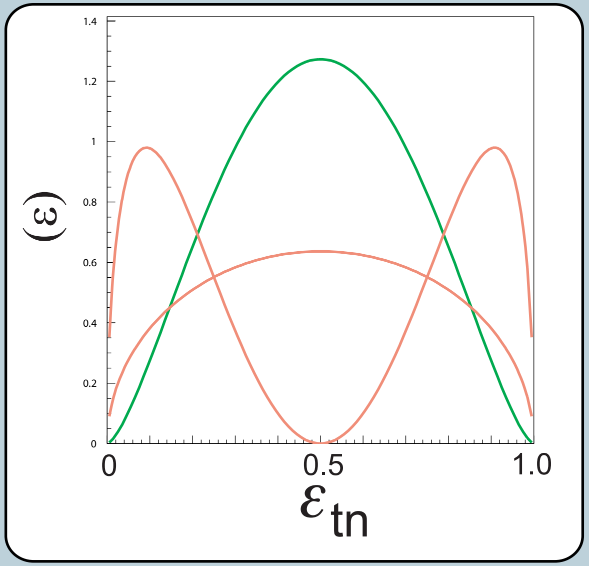


Hyperspherical Harmonics method [1,2]

$$(\varepsilon,\vartheta) = 4/\pi \sqrt{(\varepsilon(1-\varepsilon))} \Big\{ 8\varepsilon(1-\varepsilon) \quad {}^2\vartheta|A_{1211}|^2 + |A_{0000} + 2(2\varepsilon-1)A_{0200} + 4\sqrt{(\varepsilon(1-\varepsilon))} \quad \vartheta A_{0211}|^2 \Big\}$$

Expansion with lowest harmonics K=0,2

$K = l_x + l_y + 2n$ (n=0,1,2...)

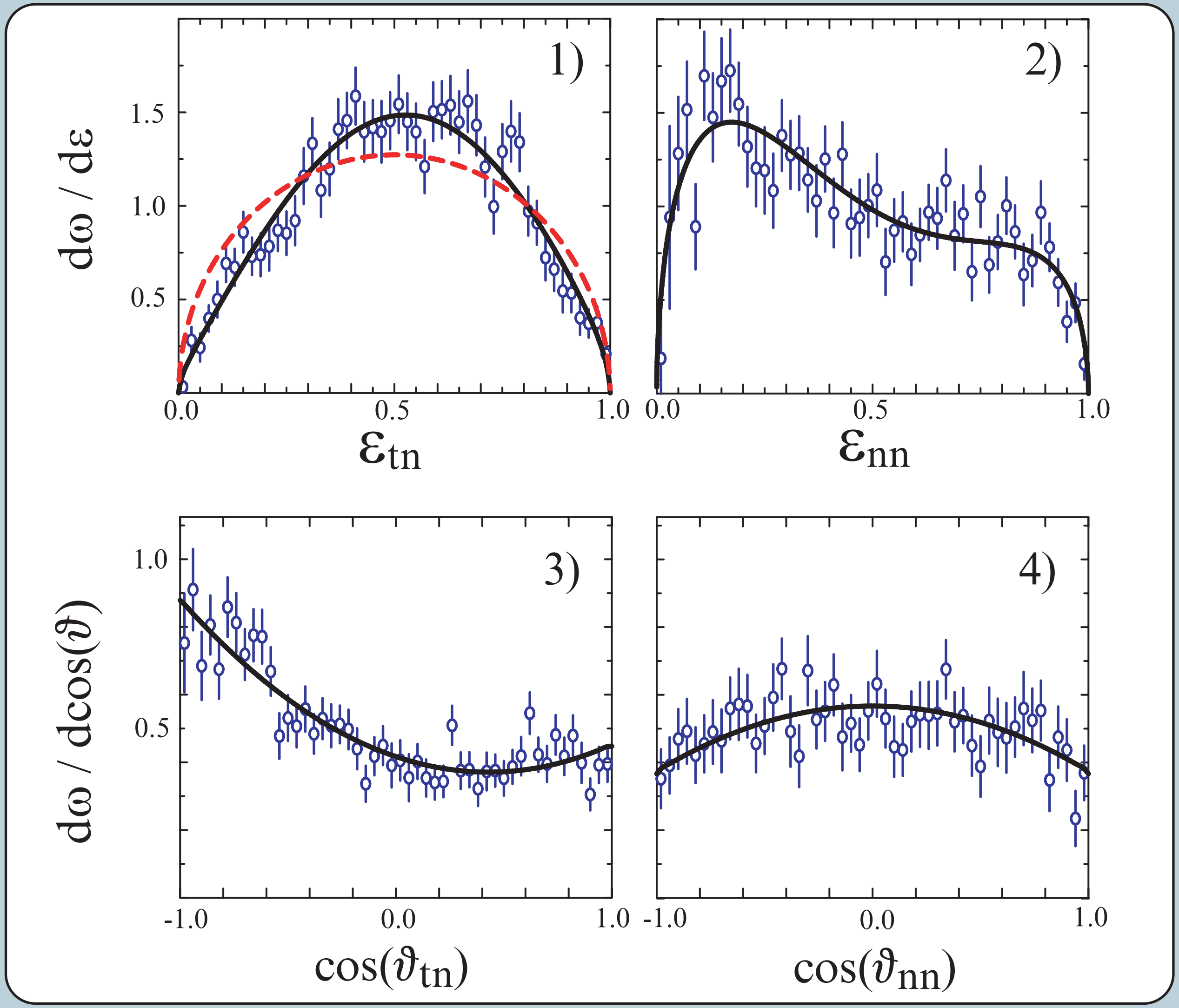


S	K	l_x	l_y
0	2	0	0
0	0	0	0
0	2	1	1

[1] L.M. Delves, Nucl. Phys. **20** (1960) 275

[2] O.V. Bochkarev et al, Nucl. Phys. **A505** (1989) 215

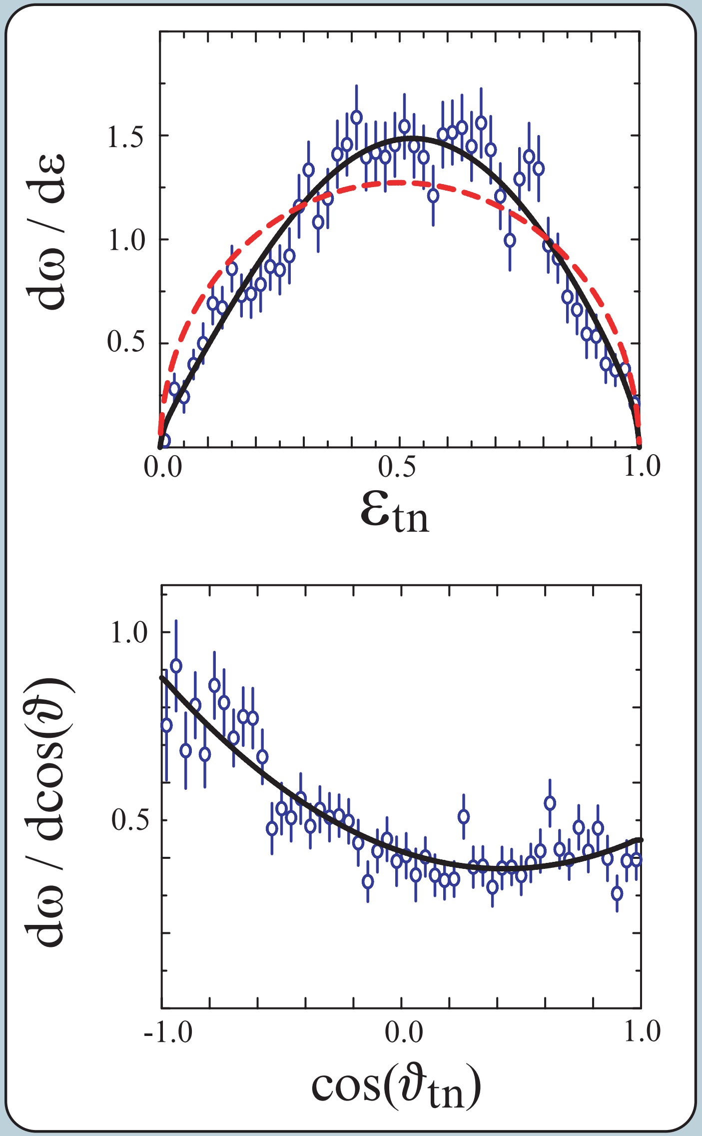
Energy and Angular correlations

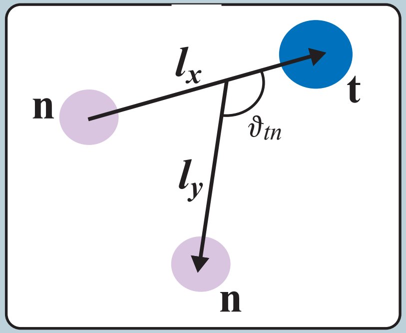


Simultaneous fit of all 4 spectra

^{5}H in the *t+n+n* system

Energy and angular correlations in the *n - tn* system





$$\varepsilon_{\mathrm{tn}} = E_{tn} / E_{tnn}$$

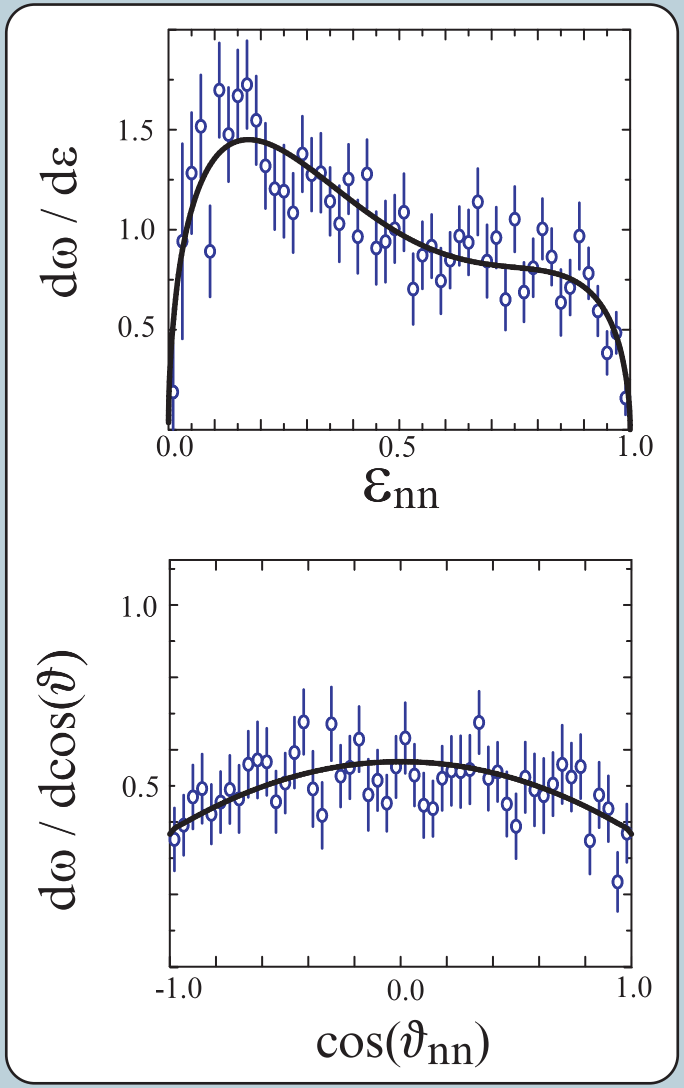
$$d\sigma / d\varepsilon \sim \varepsilon^{l_x+1/2}(1-\varepsilon)^{l_y+1/2} \quad [1]$$

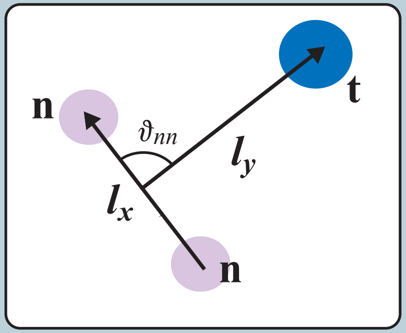
- Interference effects
- Strong *neutron - neutron* correlation

[1] L.M. Delves, Nucl. Phys. **20** (1960) 275

^{5}H in the *t+n+n* system

Energy and angular correlations in the *t - nn* system





$\varepsilon_{nn} = E_{nn} / E_{tnn}$

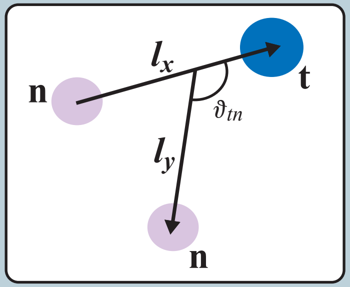
- Strong *neutron - neutron* correlation

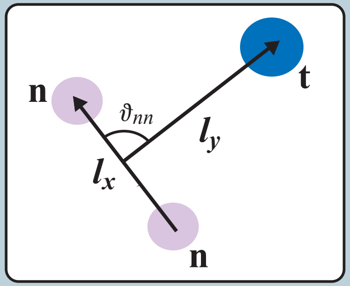
Extracted weights $C_{SKl_xl_y}$ in the t-nn system

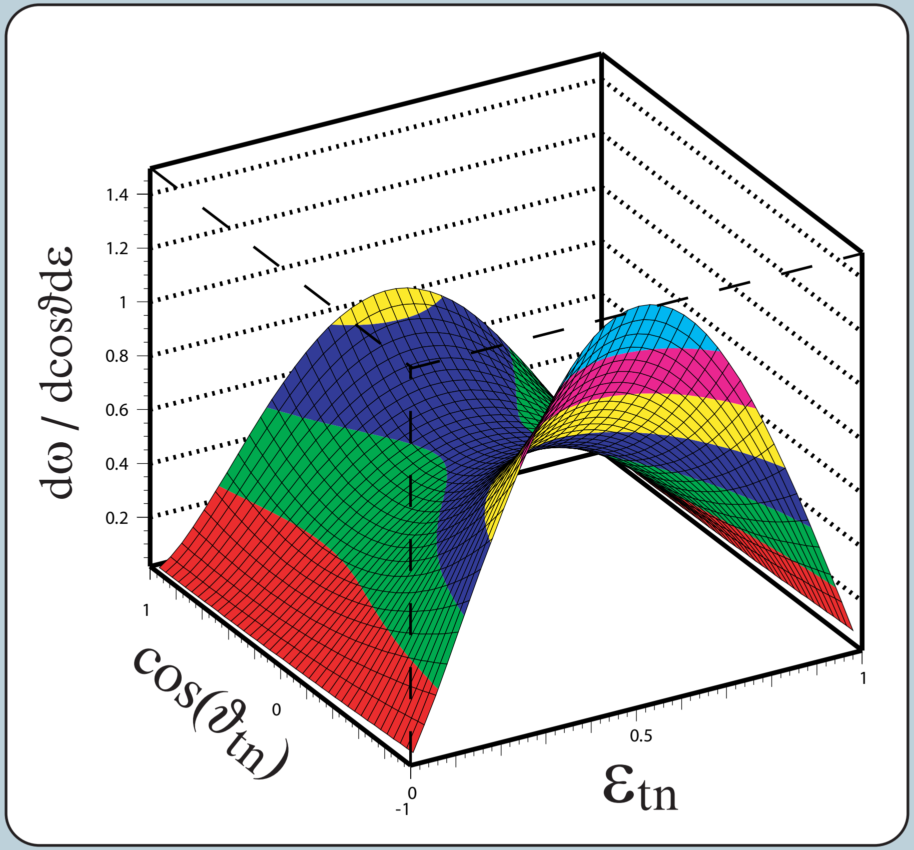
0000	*0200*	*1211*
18(3)%	*45(3)%*	*37(4)%*

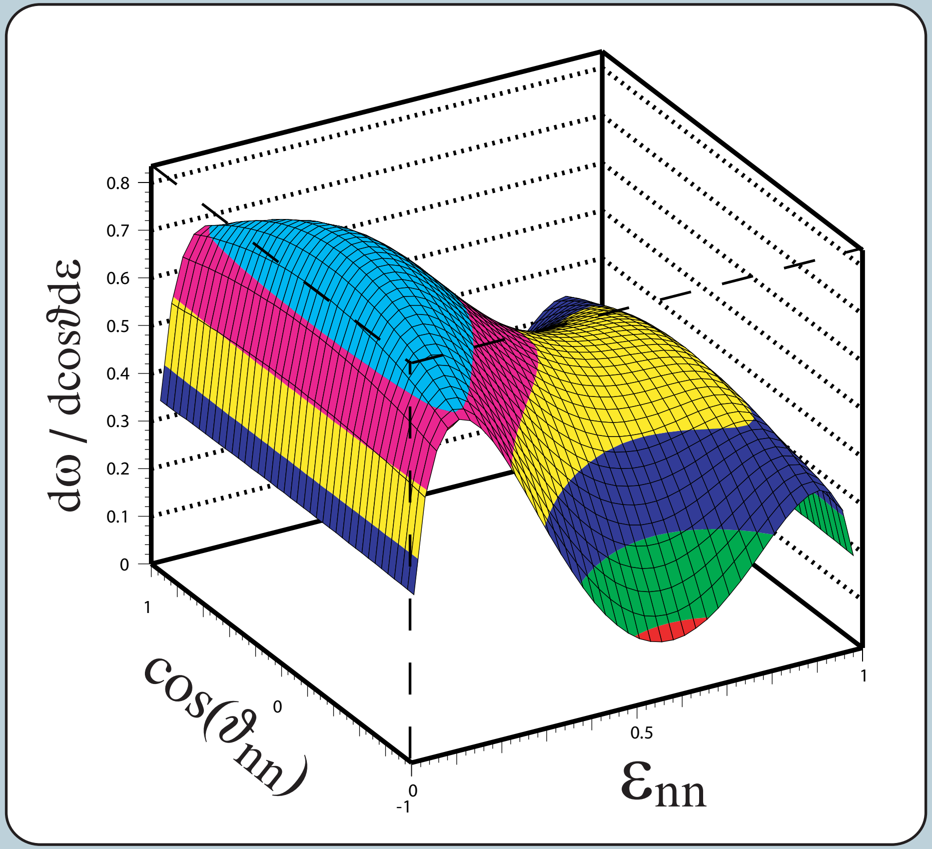
^5H in the $t+n+n$ system

Energy and Angular Correlations in two dimensions









Comparison with nuclei close by

Weights of the HH components in the *t-nn* configuration

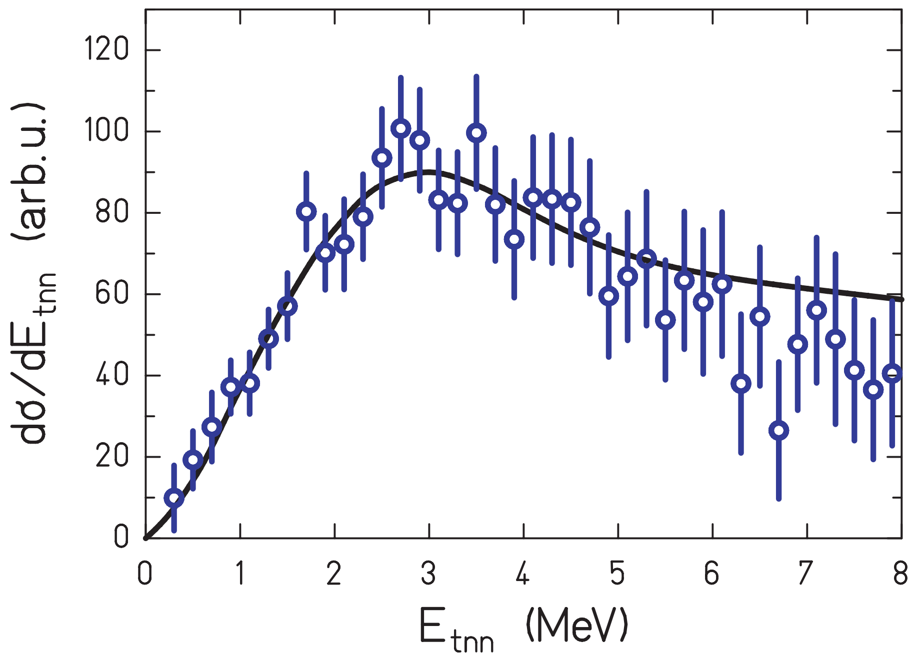
Config	0000(%)	0200(%)	1211(%)	Ref.
^{6}He	4	78	15	[1] *the.*
^{6}Be	6(5)	44(12)	50(17)	[2] *exp.*
^{5}H	18(3)	45(3)	37(4)	Present

- Strong evidence for population of the $1/2^+$ ground state in ^{5}H

[1] B.V. Danilin et al., Nucl. Phys. **A632** (1998) 383
[2] O.V. Bochkarev et al, Nucl. Phys. **A505** (1989) 215

^{5}H in the *t+n+n* system

Interpretation of the relative energy spectrum



- Distribution described well by microscopic dynamical calculations for the $1/2^+$ ground state [1], solid line.
- di-neutron decay dominates at low energy
- sequential neutron emission determines the spectrum at higher energy

[1] N.B Shulgina et al., Phys. Rev. **C62** (2000) 014312

Conclusions

- Broad distribution centered at 3 MeV, width ~ 5 MeV
- Described well by microscopic dynamical calculations and

  in reasonable agreement with recent experiments
- *nn, nt* correlations responsible for different parts of the relative energy spectrum
- No narrow resonances in the *t* + *n*+ *n* system!

Collaborators

D. Aleksandrov, T. Aumann, M.J.G. Borge, L.V. Chulkov,
Th. W. Elze, H. Emling, H. Geissel, A. Grunschloß, M. Hellström
J. Holeczek, B. Jonson, J.V. Kratz, R. Kulessa, A. Leistenschneider,
K. Markenroth, M.Meister, G. Munzenberg, F. Nickel, T. Nilsson, G. Nyman,
M. Pfutzner, V. Pribora, A. Richter, K. Riisager, C. Scheidenberger,
G. Schrieder, H. Simon, J. Stroth, O. Tengblad, M.V. Zhukov