The p(n,γ) Reaction
The Biggest of Them All*

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The p(n,γ) Reaction A new member of the Big Three Family

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ECT*, Key Reactions in Nuclear Astrophysics, February 21, 2025

The Anthropic Principle

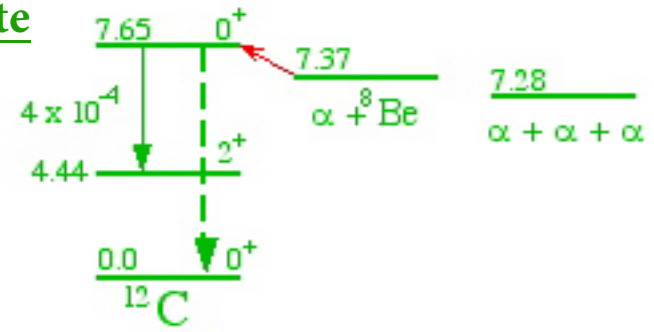
The laws of Physics are fine tuned for life to exist. We observe the laws, hence, they exist.

Brandon Carter, Krakow, 1973
(unlike the Copernican Principle)

The Anthropic Principle

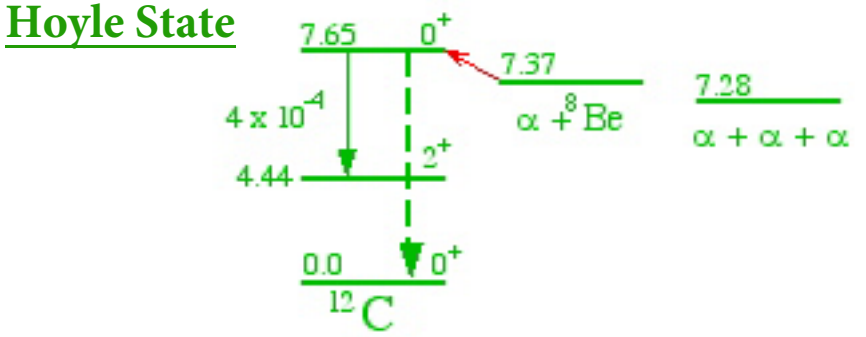
The Hoyle Sate:
E = 280 keV

Hoyle State

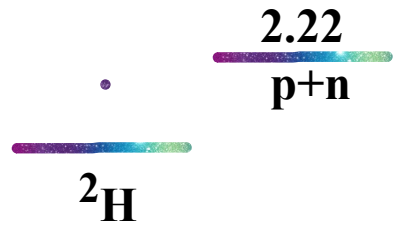


The Anthropic Principle

The Hoyle Sate:
E = 280 keV



BE(^{2}H) = 2.22 MeV
BE/u = 1.11 MeV
Tensor N-N Interaction (S_{12})



The Anthropic Principle

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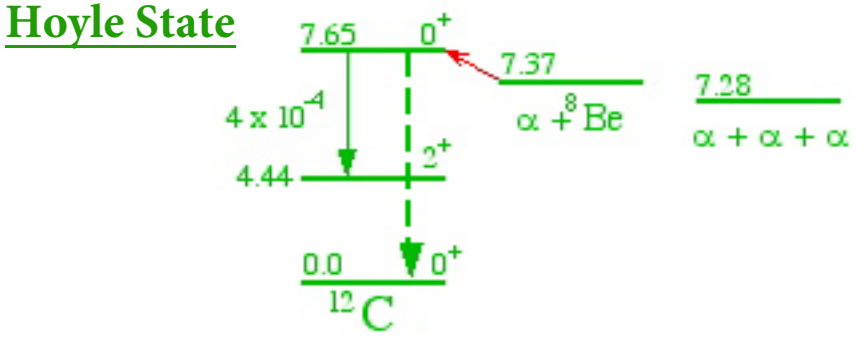

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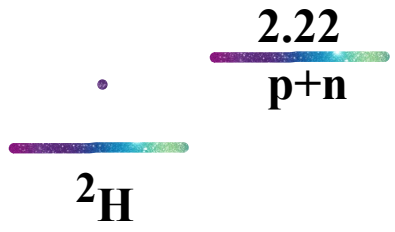


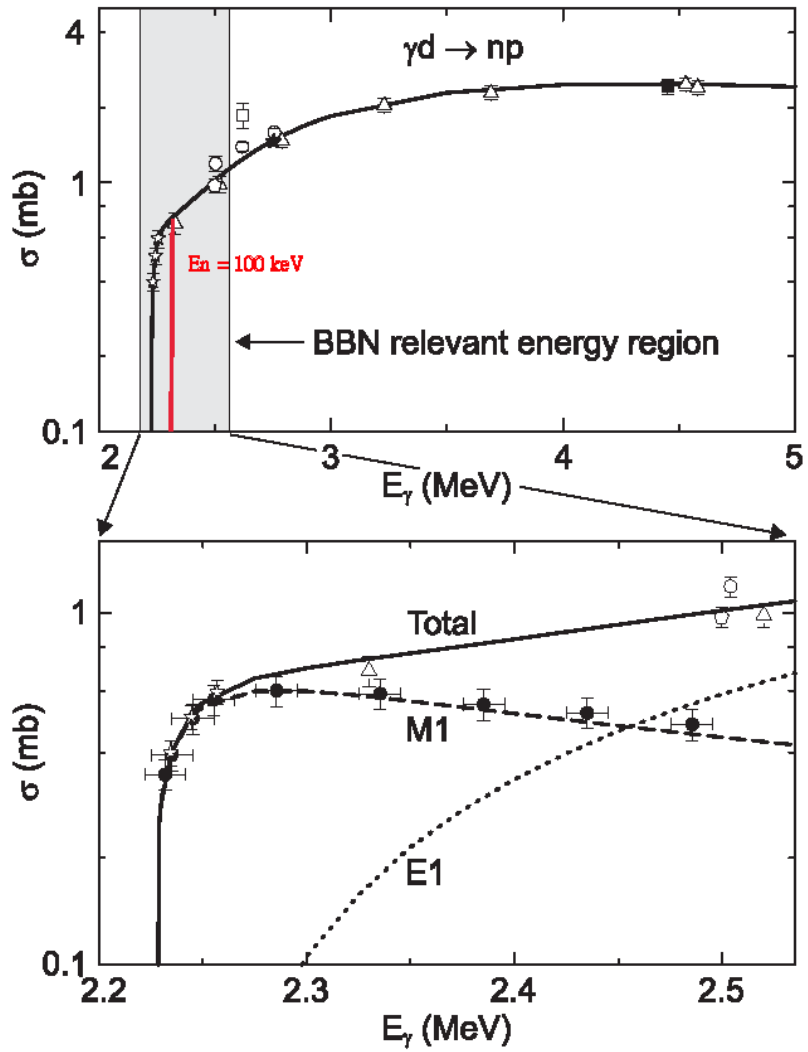
We exist due to: 1) Fine tuned N-N interaction 2) Fine tuned Hoyle Sate

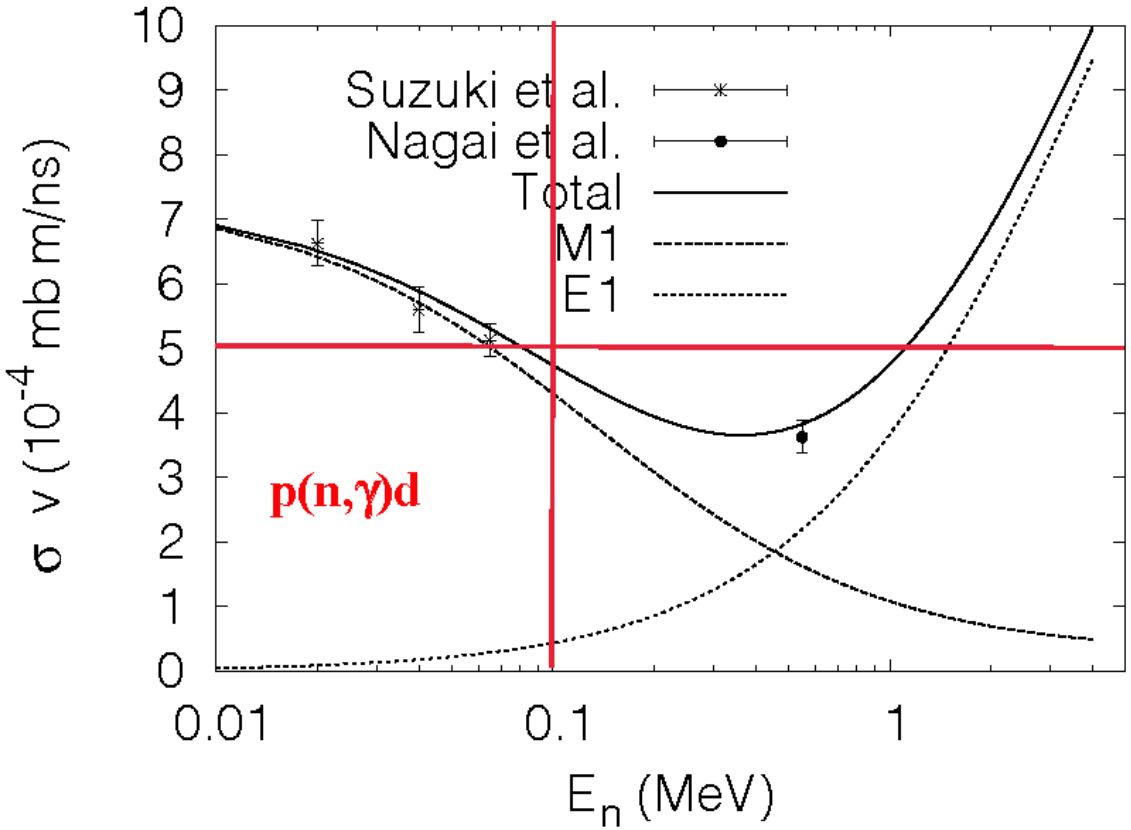
My message to our field:

1) $^{12}C(\alpha,\gamma)$ **must be measured** $(\pm 5\%)$

2) **p(n,γ) must be measured** $(\pm 1\%)$

N. Ryezayeva et al. PRL**100**(2008)172501: Results from potential model calculations and from pionless nuclear effective field theory are in excellent agreement with the data (**10% test of EFT**)



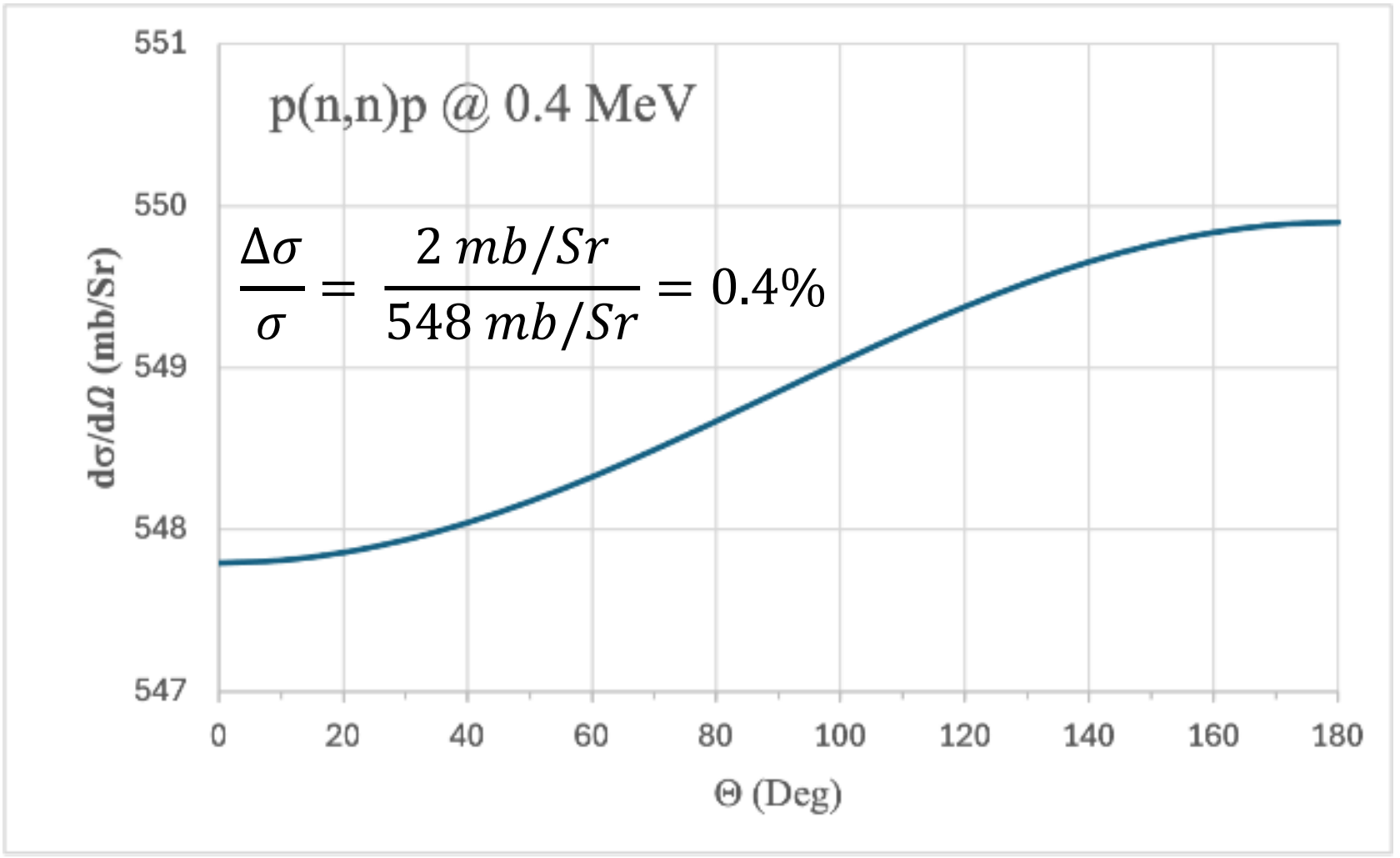


0.1 mb

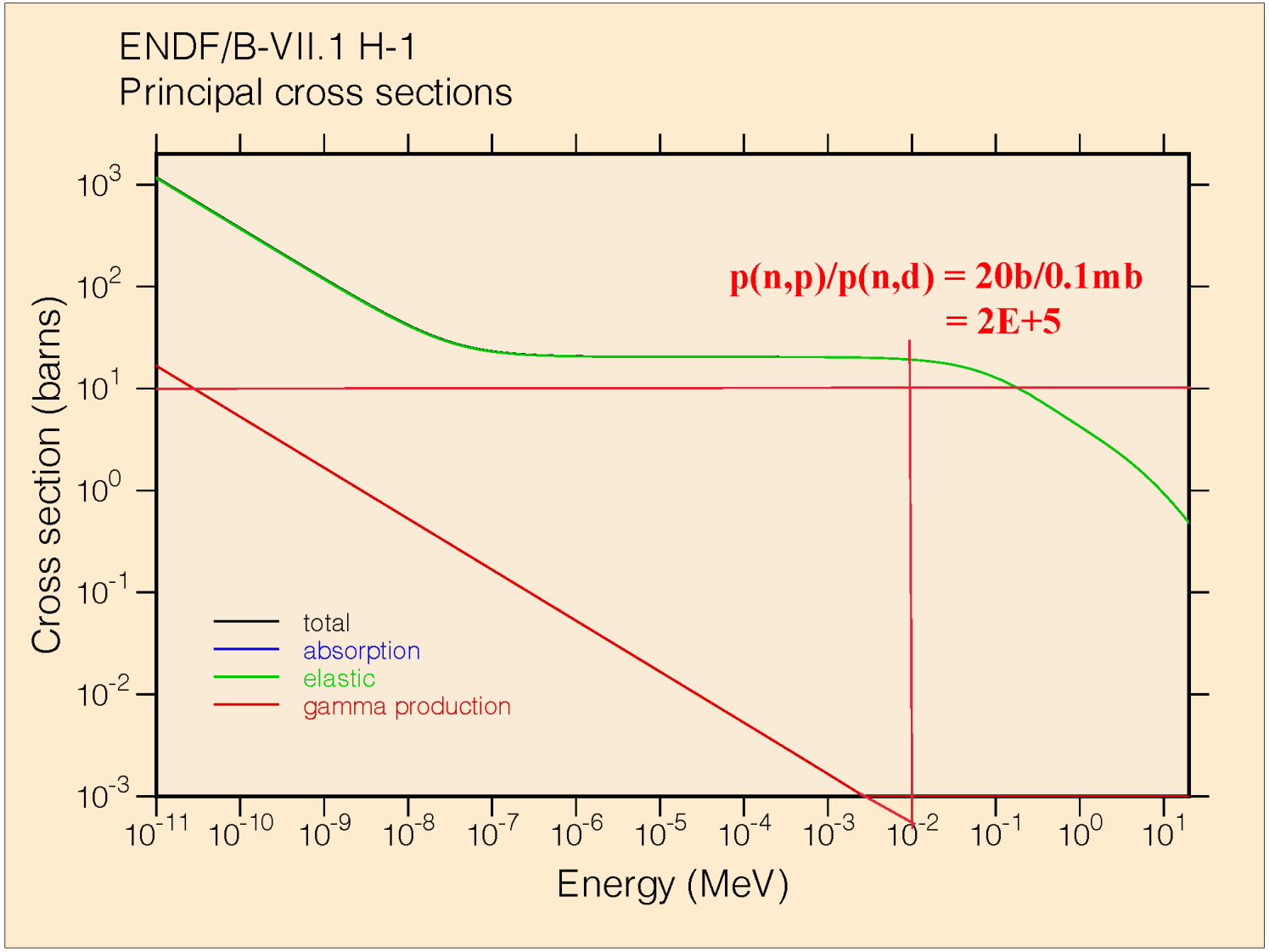
BBN use the cross section of the p(n,γ) reaction calculated by theory

E (MeV)	Cross section (mb)				
	MCMC	Prev. Meth.	Rupak[14]	Nakamura[29]	Hale[30]
1.265×10^{-8}	333.8(15)	333.7(15)	334.2(0)	335.0	332.6(7)
5×10^{-4}	1.667(8)	1.666(8)	1.668(0)	1.674	1.661(7)
1×10^{-3}	1.171(5)	1.171(5)	1.172(0)	1.176	1.167(2)
5×10^{-3}	0.4979(23)	0.4976(21)	0.4982(0)	0.4999	0.4953(11)
1×10^{-2}	0.3322(15)	0.3319(14)	0.3324(0)	0.3335	0.3298(9)
5×10^{-2}	0.1079(5)	0.1079(4)	0.1081(0)	0.1084	0.1052(9)
0.100	0.0634(3)	0.0634(2)	0.06352(5)	0.06366	0.0605(10)
0.500	0.0341(2)	0.0343(1)	0.0341(2)	0.03416	0.0338(8)
1.00	0.0349(3)	0.0352(1)	0.0349(3)	0.03495	0.0365(8)

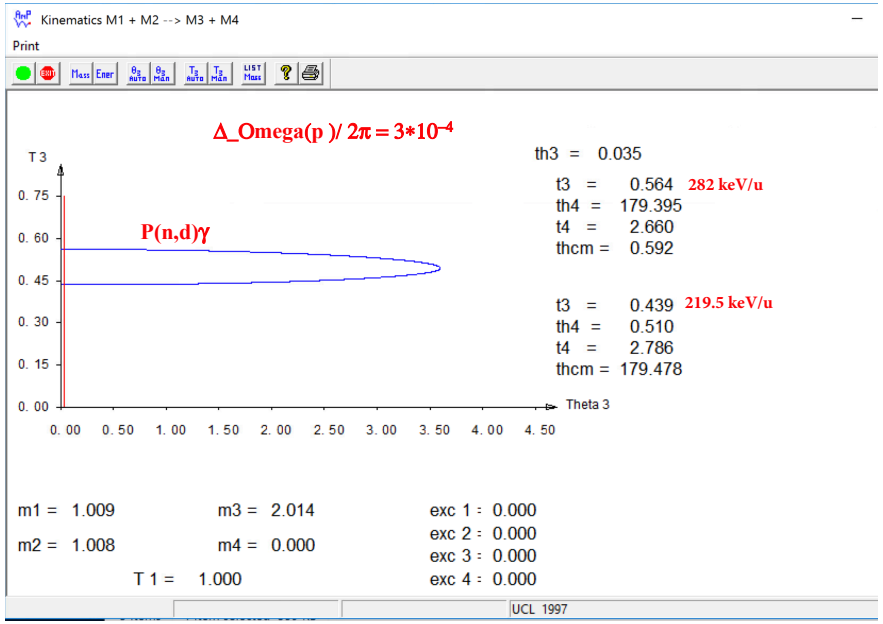
Measure: $\frac{\sigma(n,g)}{\sigma(n,n)}$ **Measure:** $\frac{\sigma(n,d)}{\sigma(n,p)}$ **Both d & p measured in the TPC**

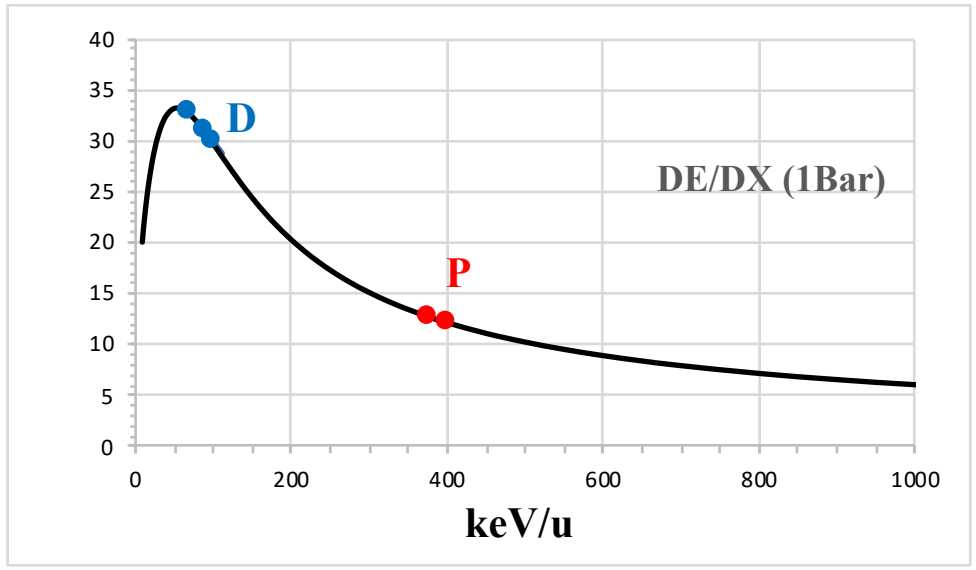


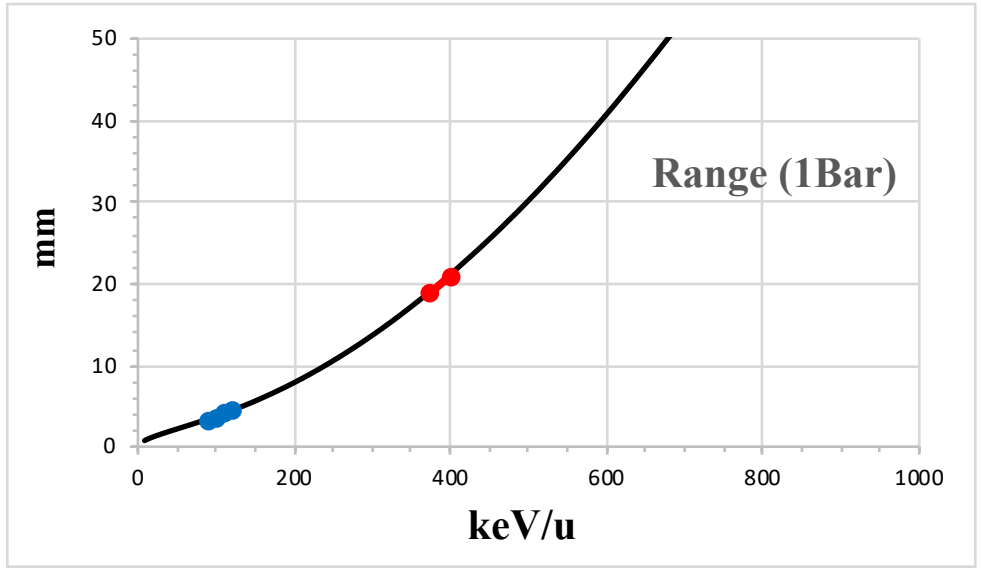
HANDBOOK ON NUCLEAR ACTIVATION DATA, Boedy, IAEA, Vienna, page 29, 1987


ENDF/B-VII.1 H-1
Principal cross sections
Cross section (barns)
Energy (MeV)
total
absorption
elastic
gamma production
p(n,p)/p(n,d) = 20b/0.1mb
= 2E+5

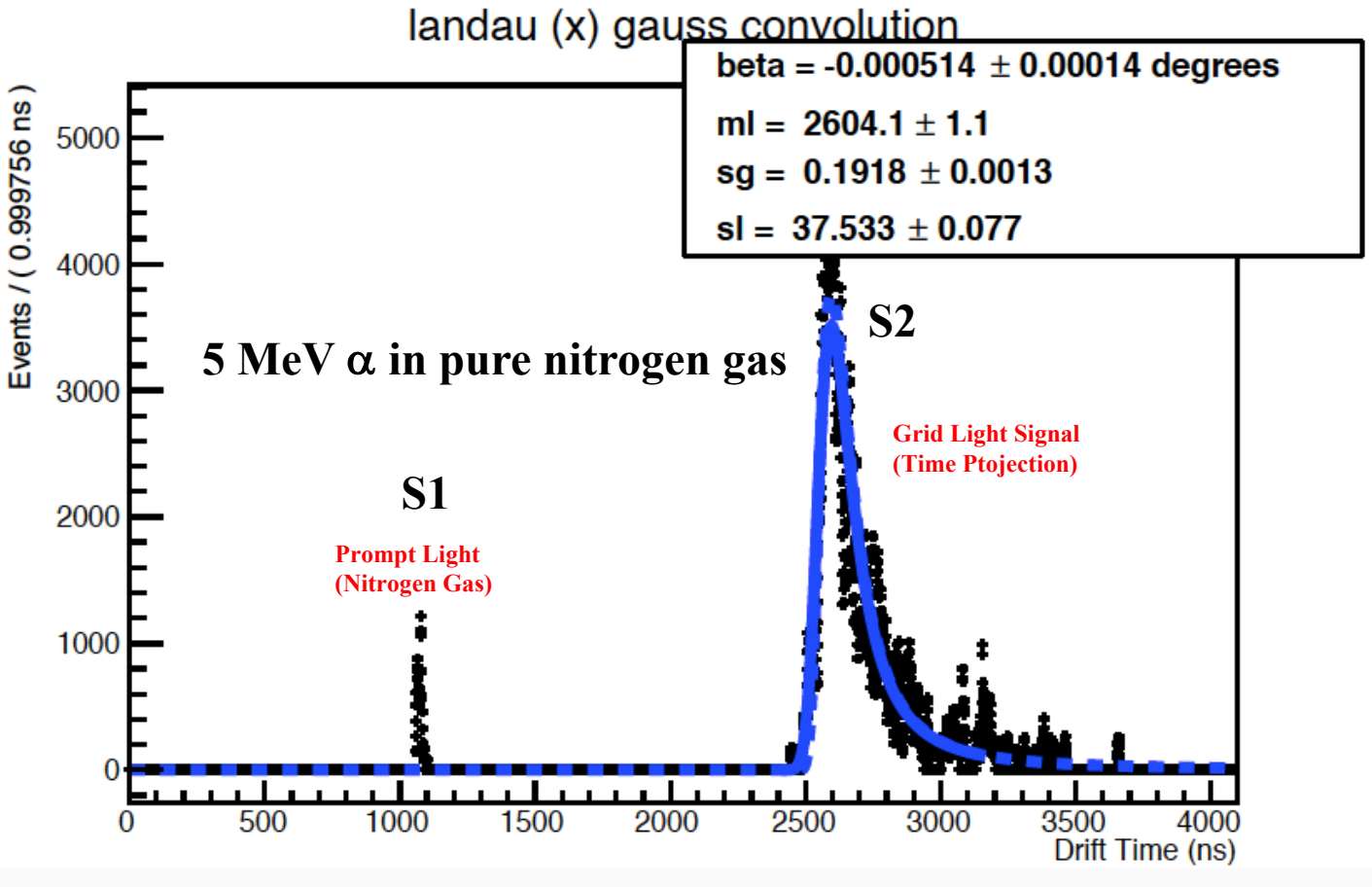
En = 1.0 MeV

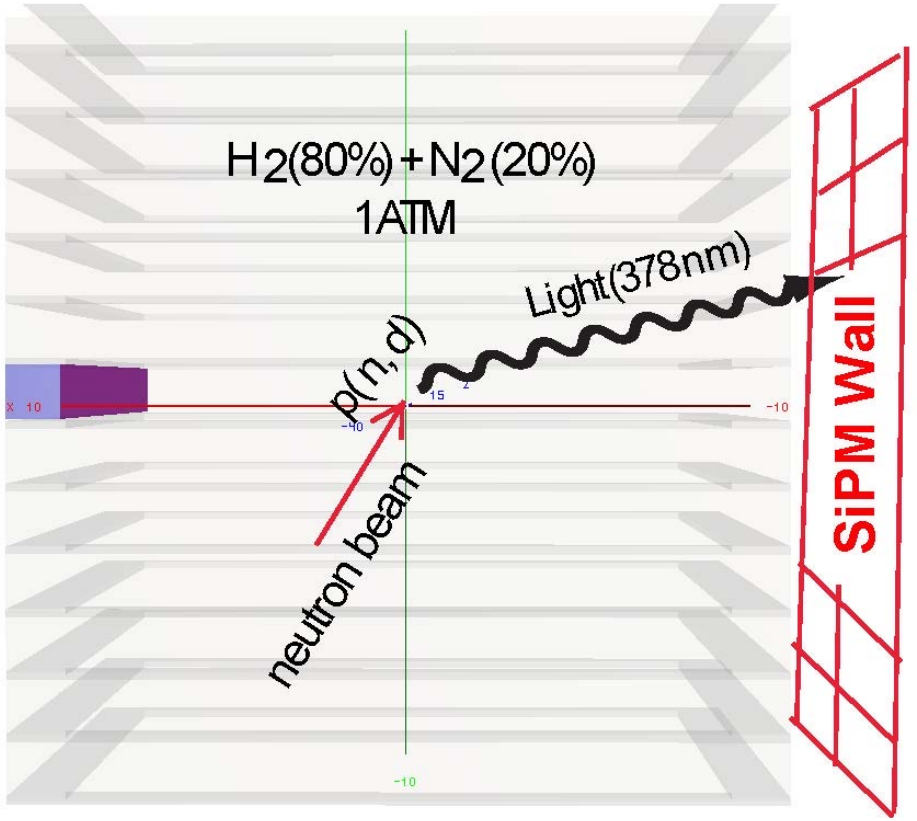

Kinematics M1 + M2 --> M3 + M4
Print
Δ_Omega(p)/ 2π = 3*10⁻⁴
P(n,d)γ
Theta 3
th3 = 0.035
t3 = 0.564 282 keV/u
th4 = 179.395
t4 = 2.660
thcm = 0.592
t3 = 0.439 219.5 keV/u
th4 = 0.510
t4 = 2.786
thcm = 179.478
m1 = 1.009
m2 = 1.008
m3 = 2.014
m4 = 0.000
T 1 = 1.000
exc 1 : 0.000
exc 2 : 0.000
exc 3 : 0.000
exc 4 : 0.000
UCL 1997


40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
D
P
DE/DX (1Bar)
keV/u


50
40
30
20
10
0
0
200
400
600
800
1000
mm
Range (1Bar)
keV/u

Alte/Noi Technology: Fast Timing TPC, TOF, Prompt Light Emission





Thank you

Thank you Aurora, Carlos, Josè, Livius and Roland From All of Us

Grazie mille