^{18}N: a challenge to the shell model and a part of the flow path to r-process element production in Type II supernovae

May 29, 2013

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Adrien Matta **Natasha Timofeyuk**

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T-REX, MINIBALL

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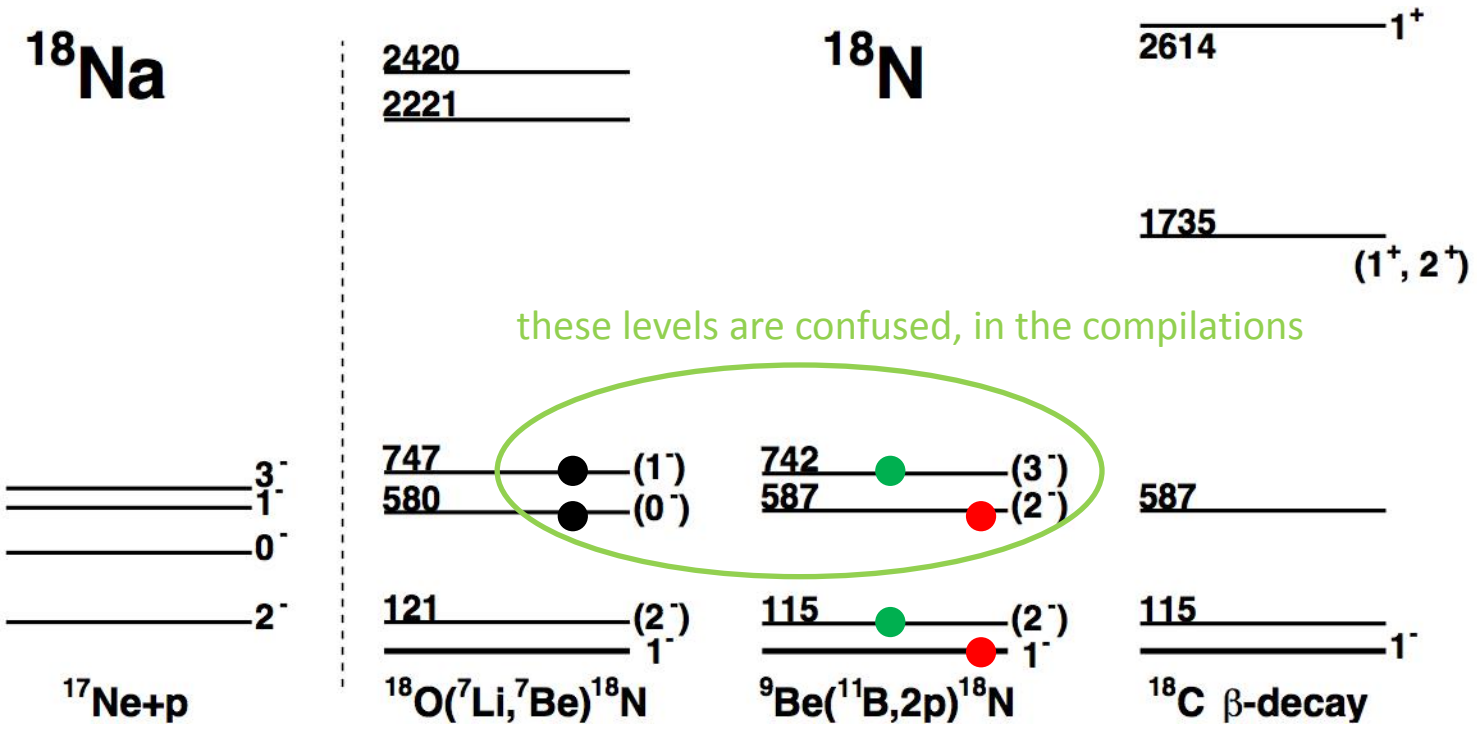
^{18}N – 7 protons, 11 neutrons

$p_{1/2}^{-1}$ $d_{5/2}^{3}$

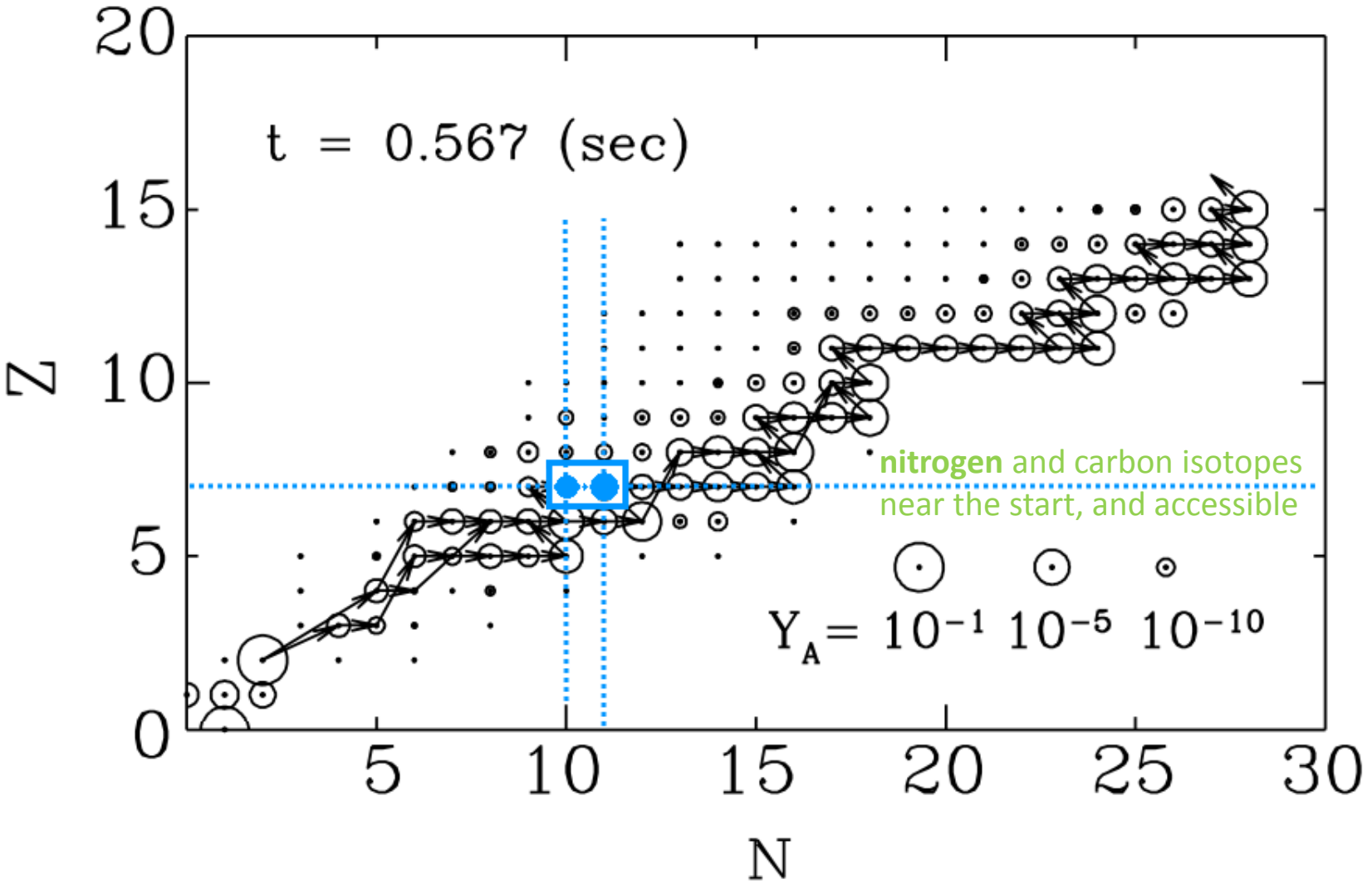


Low-lying states dominated by:

proton($p_{1/2}^{-1}$) $\otimes$ $(d_{5/2}^{3})_{J=5/2}$ or $(d_{5/2}^{3})_{J=3/2}$ or $s_{1/2}^{1}$

of which the 1^- and 2^- from the middle configuration can't be populated in (d,p)

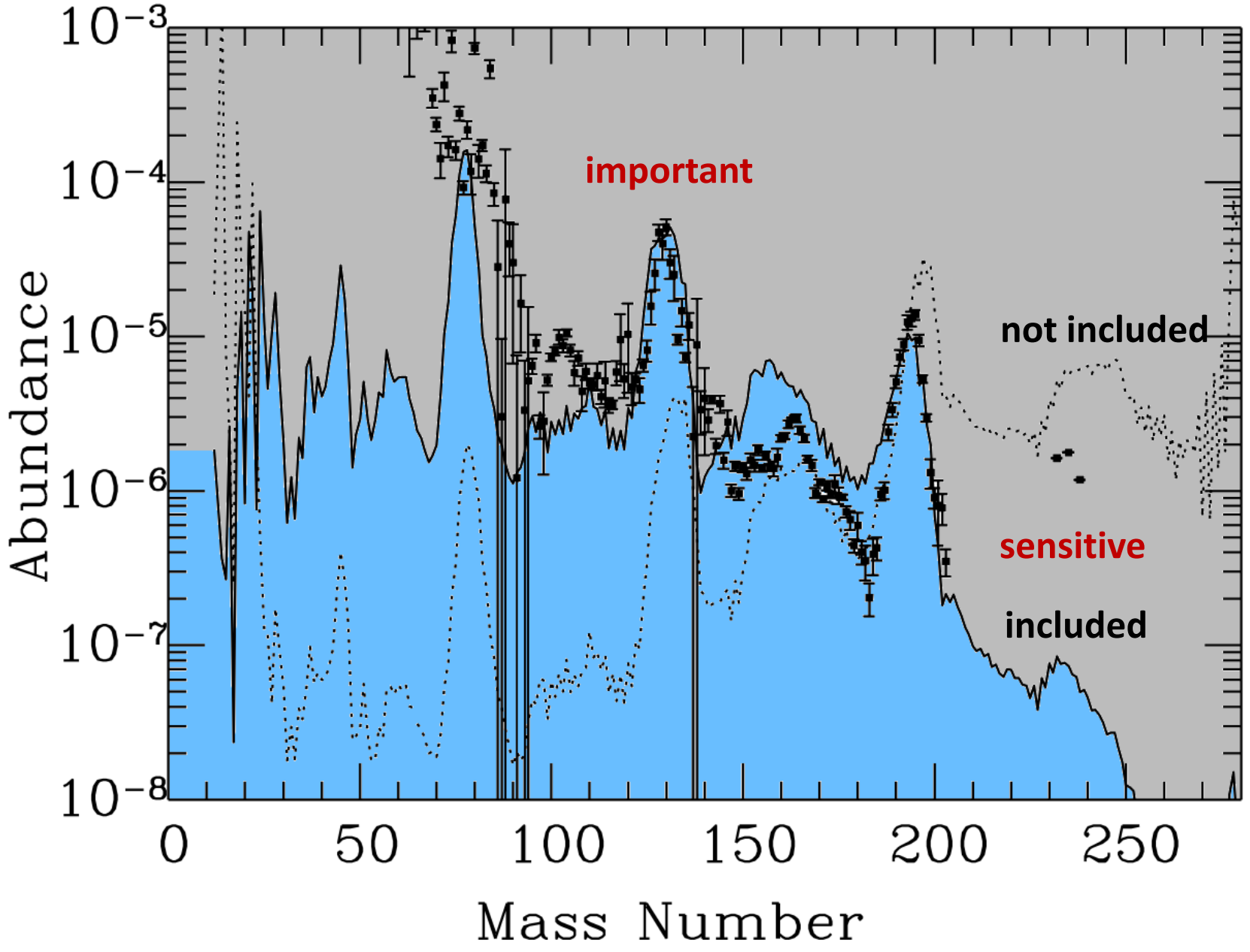
Neutron-rich pathway through light nuclei in explosive nucleosynthesis



M. Terasawa *et al.* *The Astrophysical Journal*, 562(1):470, 2001.

T. Sasaqui *et al.* *The Astrophysical Journal*, 634(2):1173, 2005.

Neutron-rich pathway through light nuclei in explosive nucleosynthesis



PREVIOUS WORK

Canberra data, Putt et al.

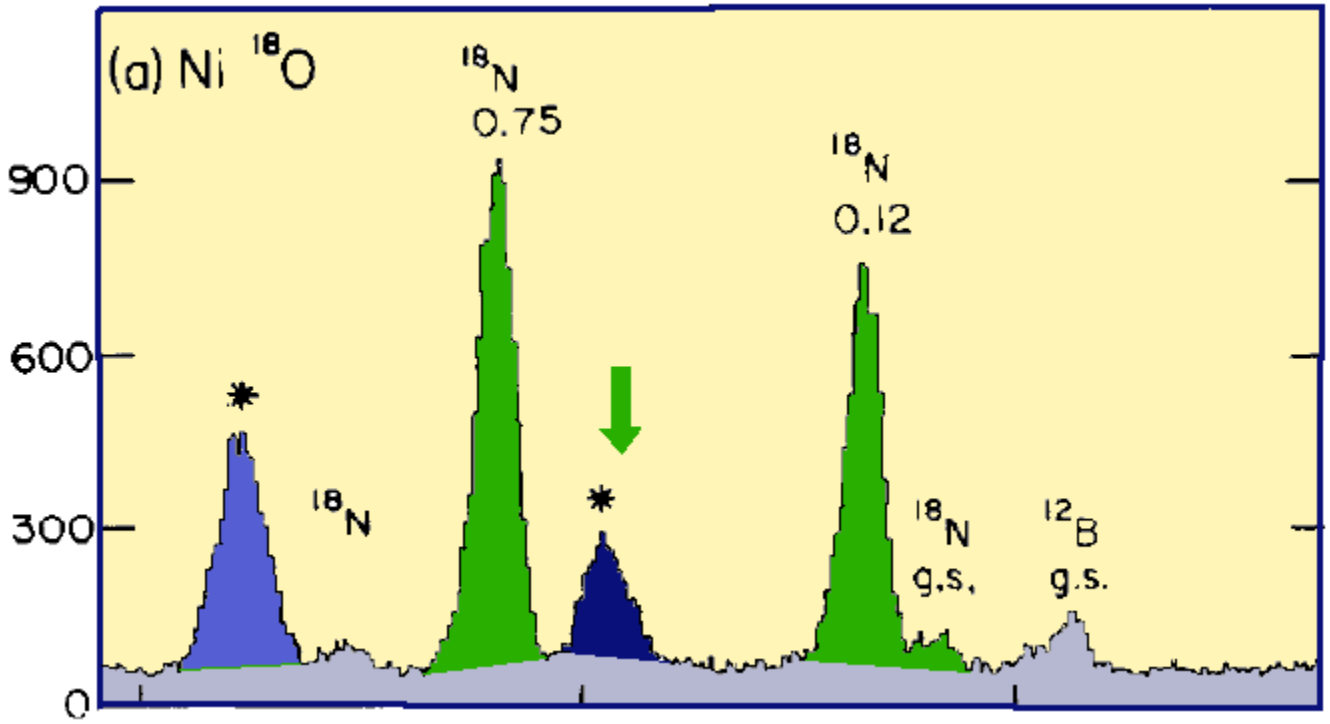
(^{7}Li,^{7}Be)

^{7}Be* at 0.48 MeV

like (d,p)

This reaction removes a proton, **adds a neutron**

Should populate 3^{-} at 0.75 MeV plus **two OTHER** states apart from g.s. and 0.12 MeV



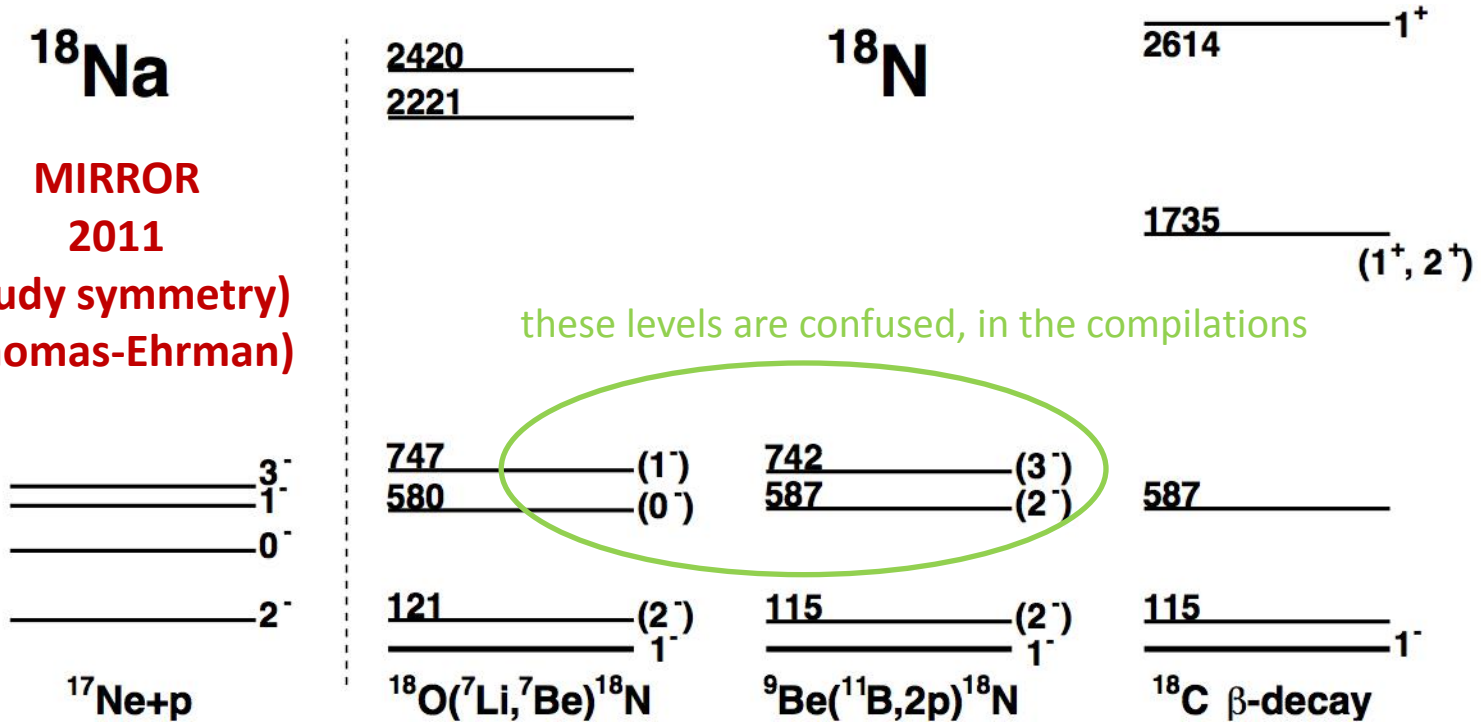
The **starred** peaks are the ones that contain at least in part the excited ^{7}Be channel.

The **missing two peaks** are the 0^{-} and 1^{-} from $s_{1/2}$ transfer.

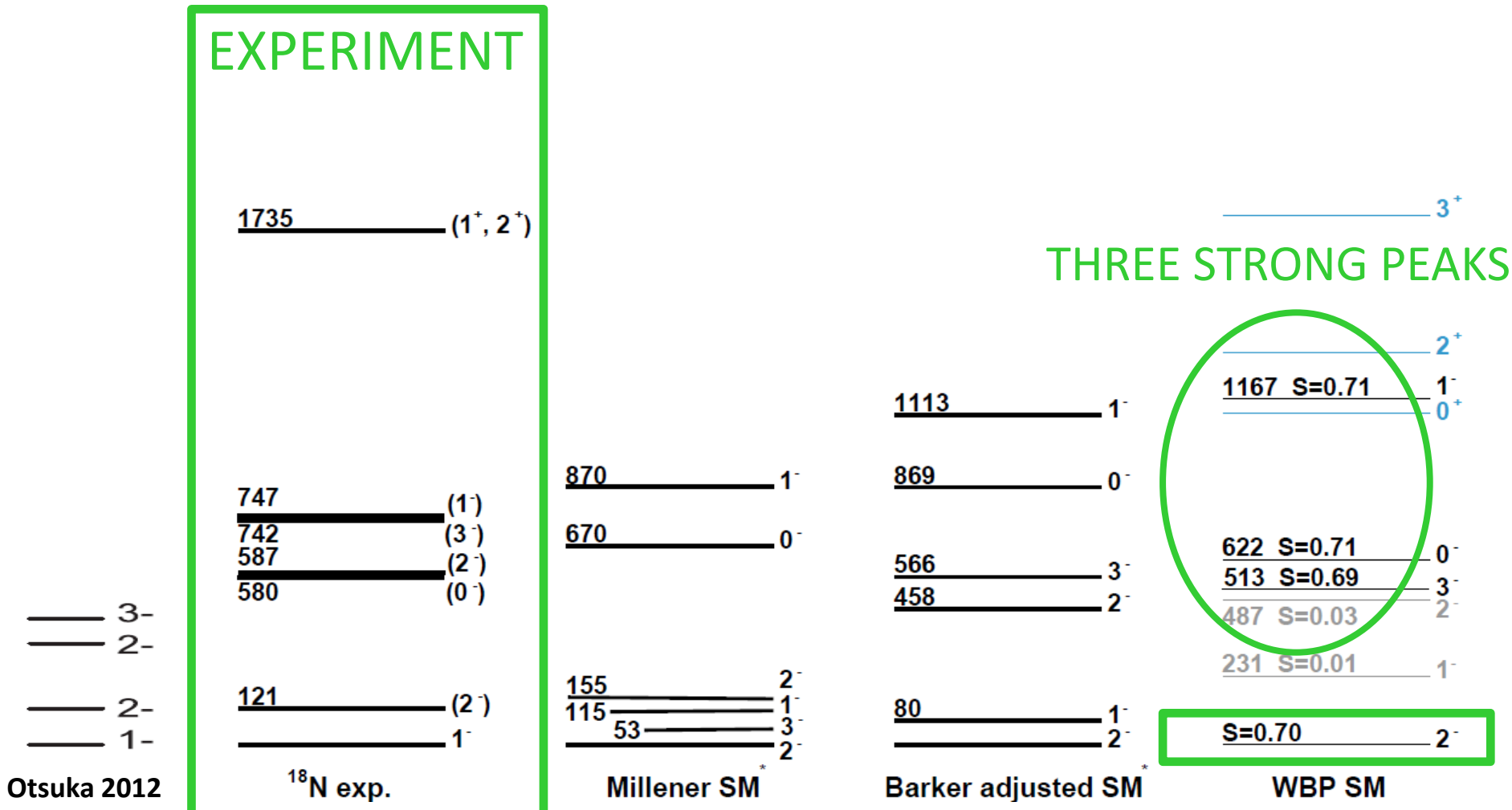
Putt et al. identify the states as being at 0.75 and at 0.58, but we say 1.23 also possible.

In the proposal, we have taken Putt et al.'s suggestion (0.58 and 0.75 peaks).

Reminder: this is what was shown earlier – current EXPERIMENTAL situation, with MIRROR



Compare current EXPERIMENTAL situation, with THEORY



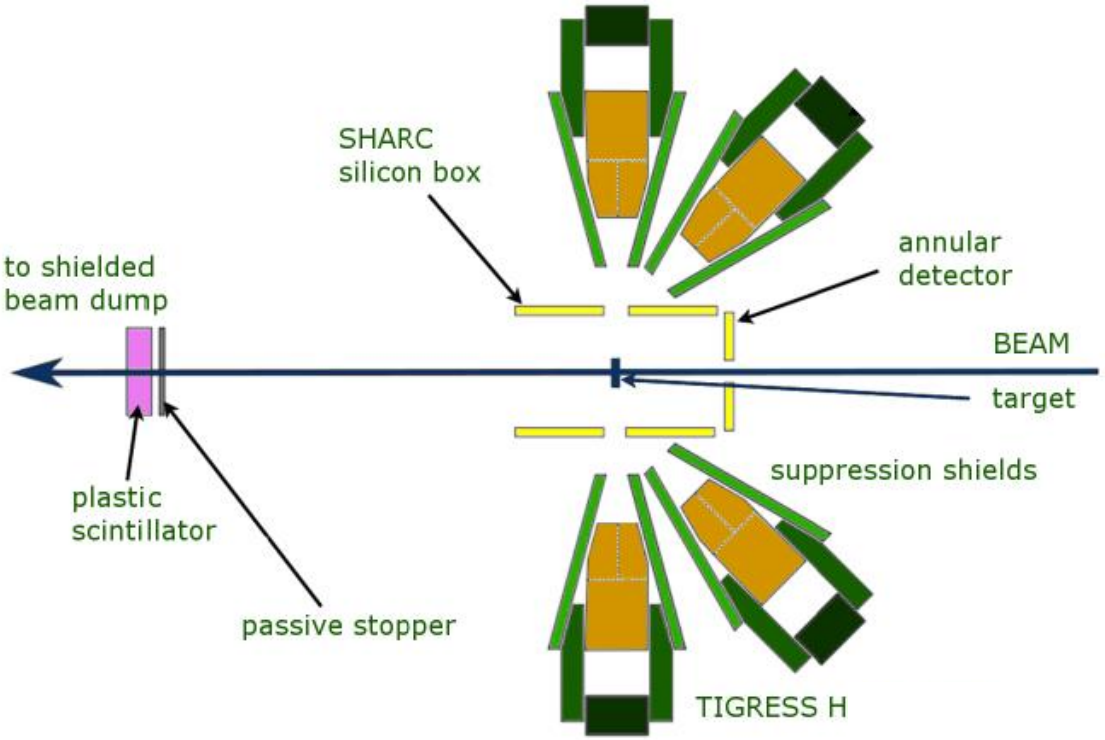
AS WELL AS THE 2^-

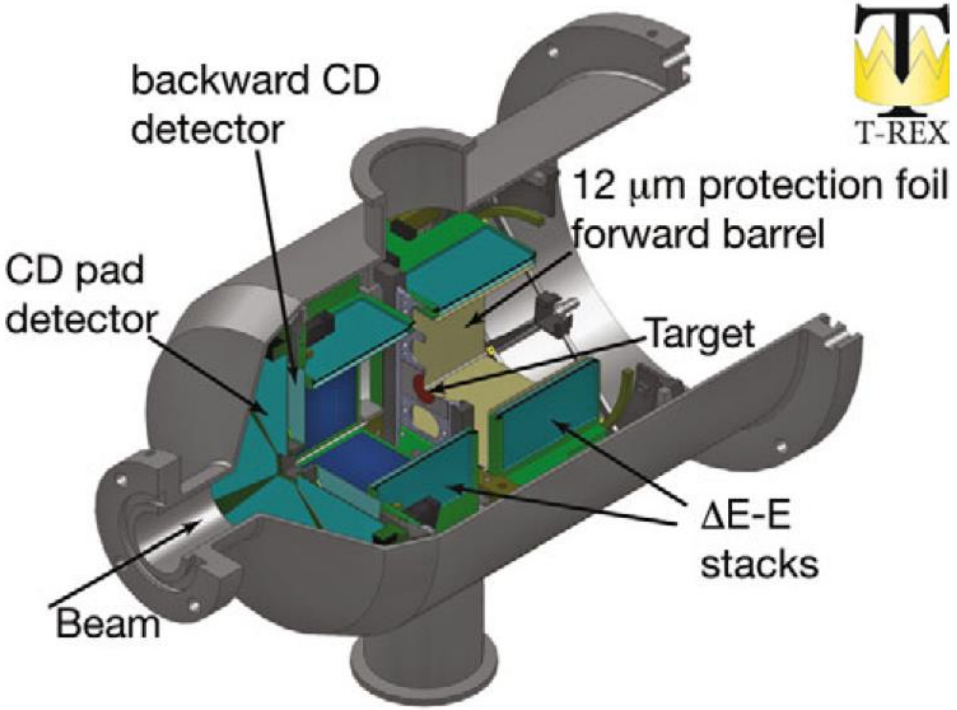
(THE 0^- AND 1^- ARE MISSING EXCEPT IN THE ANU RESULTS)

THE EXPERIMENT

HIE-ISOLDE beam of ^{17}N

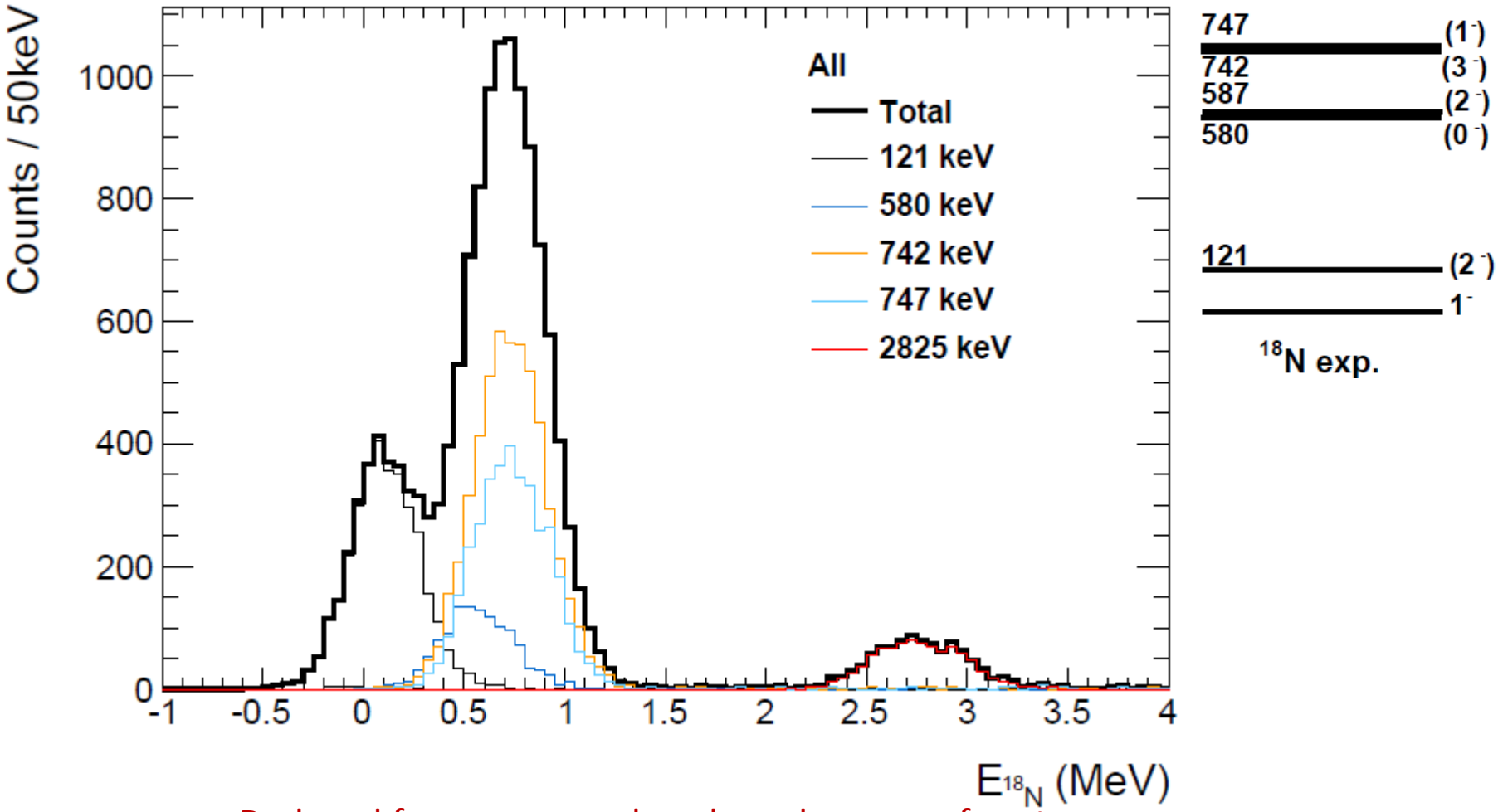
Reaction $^{17}N(d,p)^{18}N$
5.5 MeV/A
10^4 pps on target
T-REX plus MINIBALL
Gamma-ray gating
Measure E_x and SF's, ANC's





EXCITATION ENERGY RESOLUTION arising from the charged particle measurement

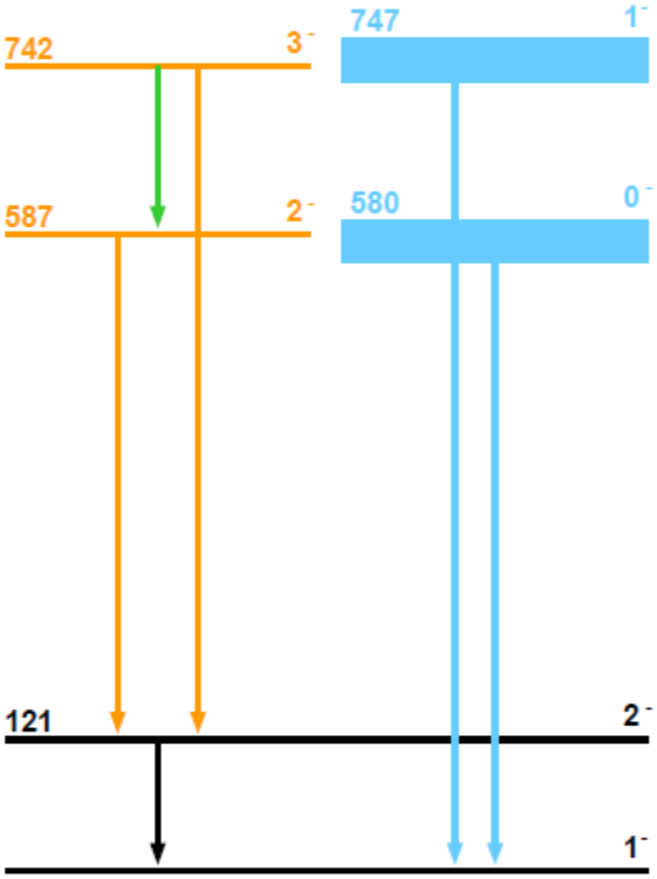
Limitations: beam spot, strip pitch, (target thickness 0.5 mg/cm^2)
Intensities: using predicted cross sections and spectroscopic factors
Includes hypothetical state at neutron **threshold**



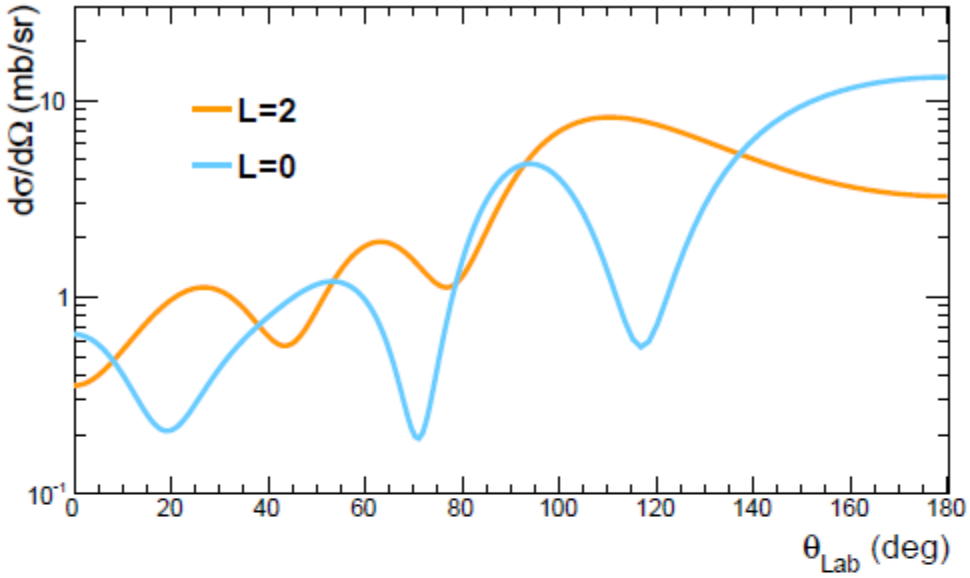
Deduced from measured angle and energy of proton

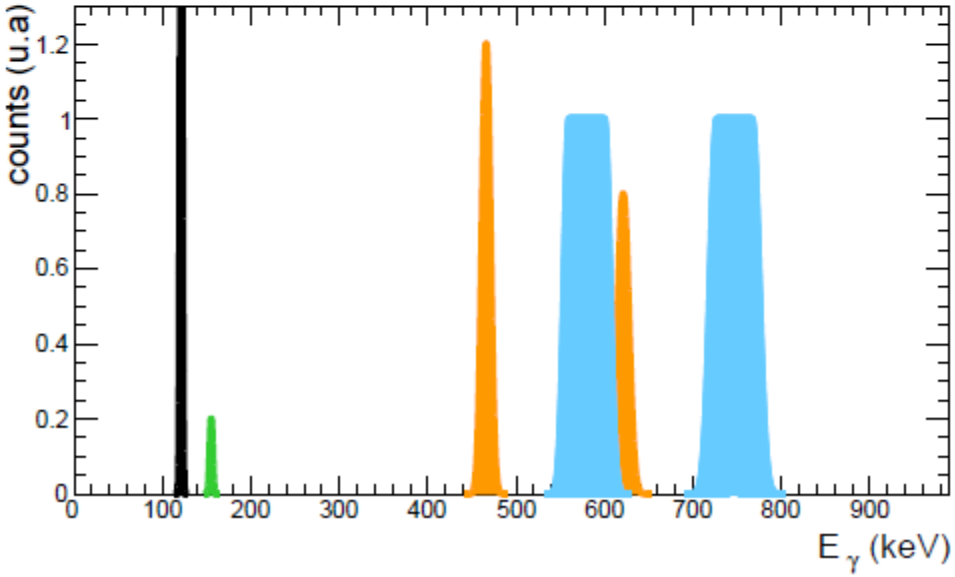
HOW GAMMA-RAYS WILL ALLOW THE NEAR-DEGENERATE STATES TO BE RESOLVED

Allows for Doppler correction using crystal segment data

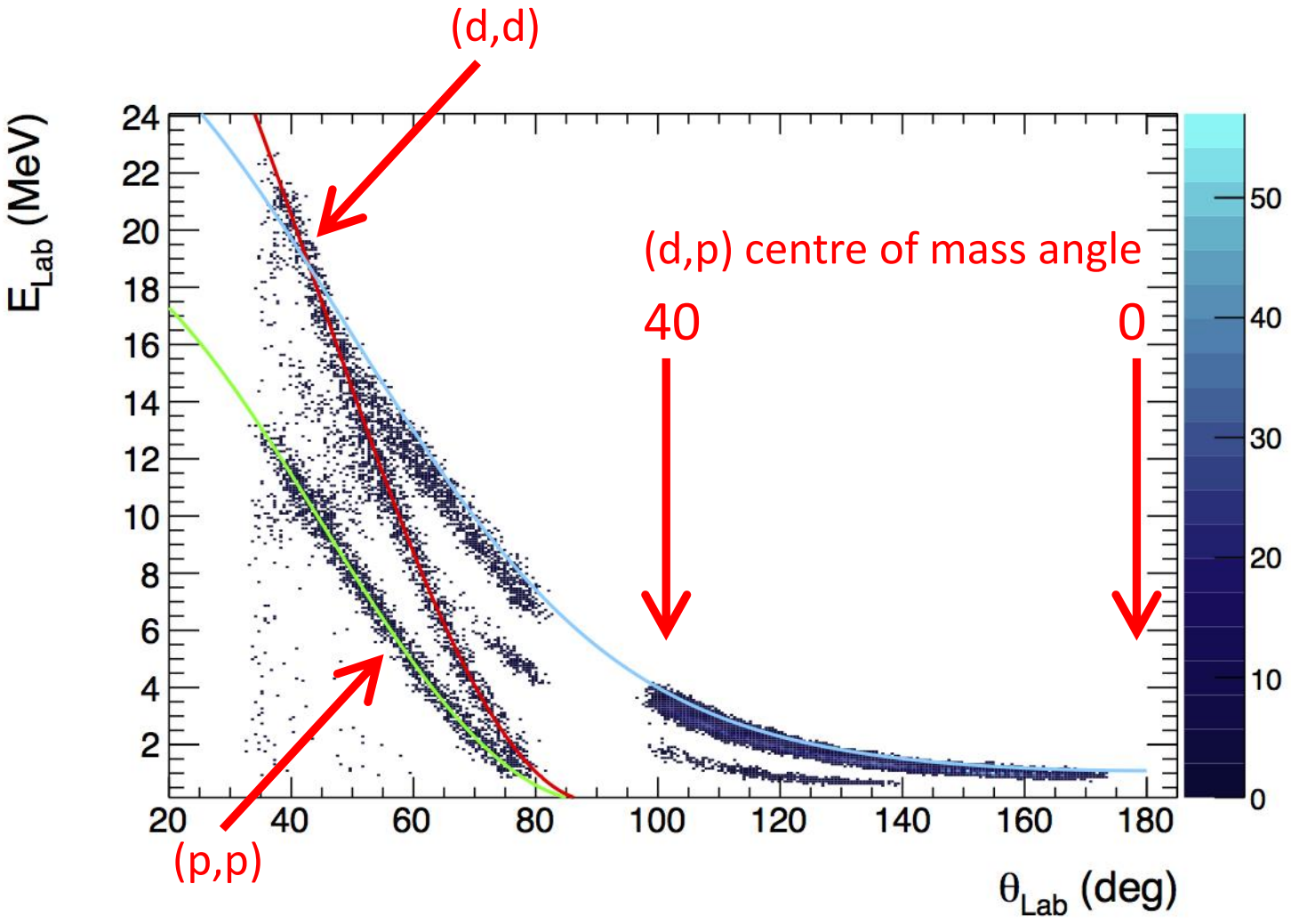


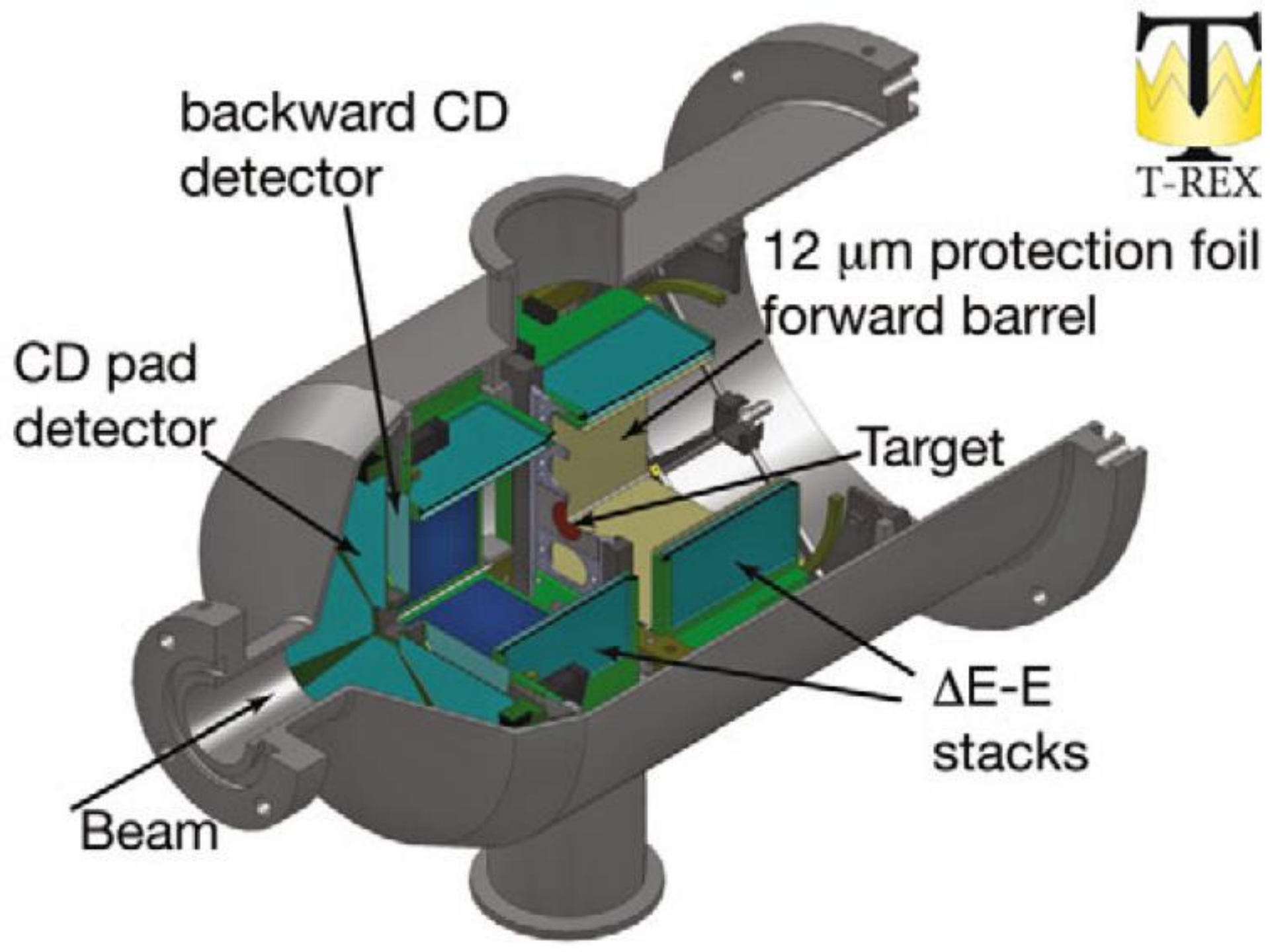
^{18}N exp.



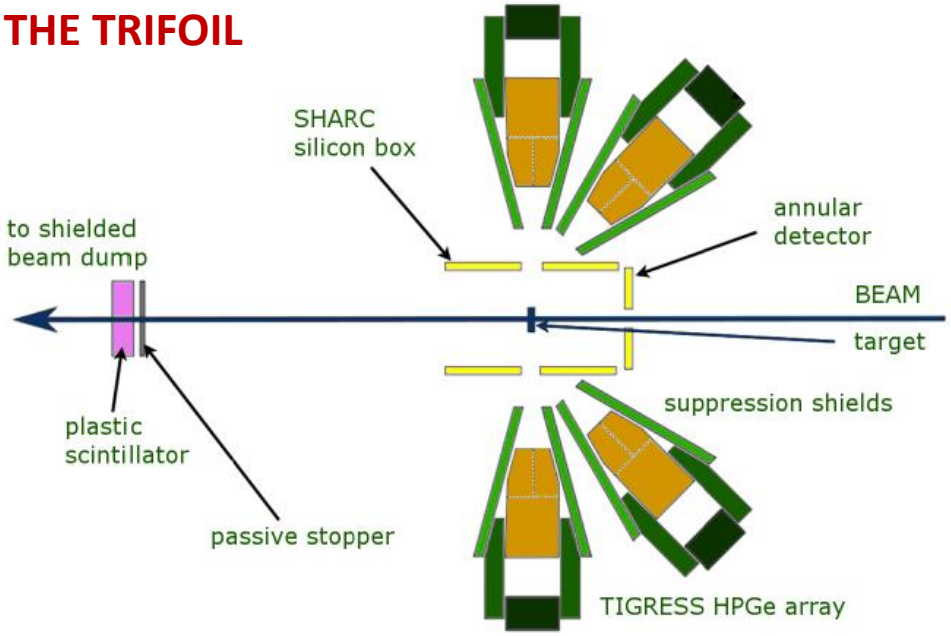


WHAT WE SHOULD OBSERVE WHEN WE PLOT THE T-REX ENERGY AGAINST LAB ANGLE

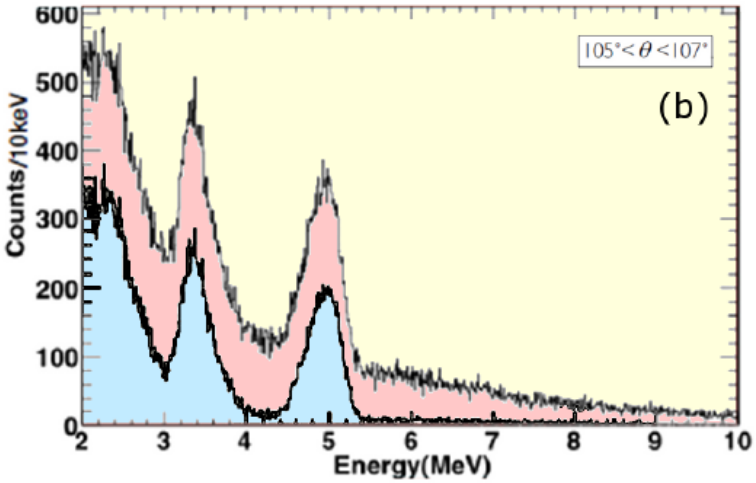



backward CD
detector
12 μm protection foil
forward barrel
CD pad
detector
Target
ΔE-E
stacks
Beam
T-REX

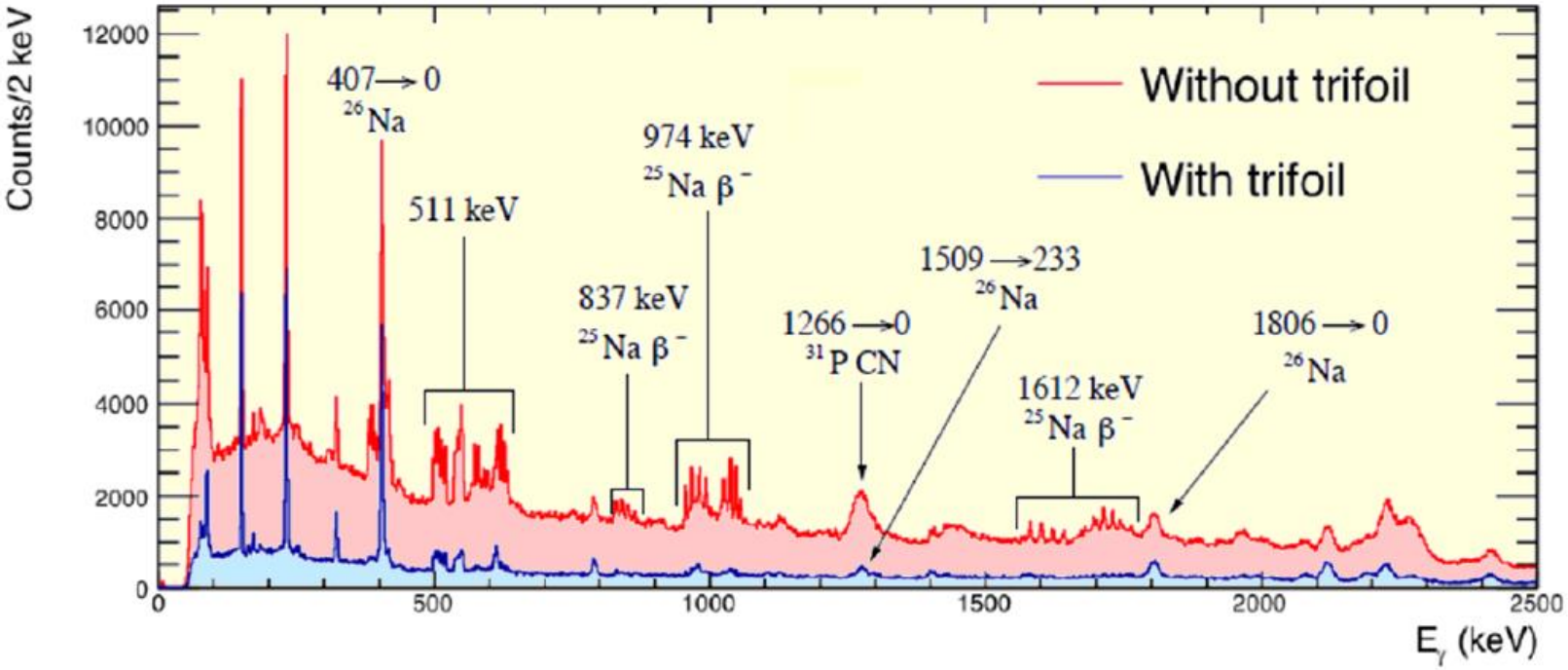
THE TRIFOIL



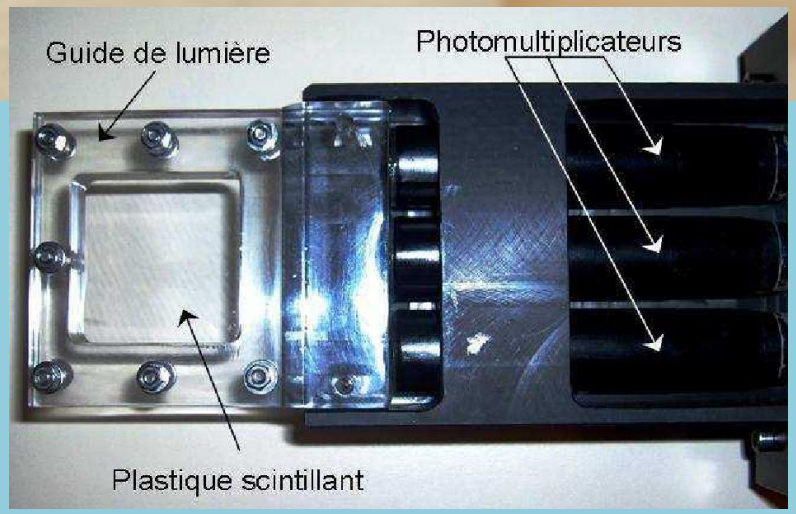
PARTICLES



GAMMA-RAYS



THE TRIFOIL

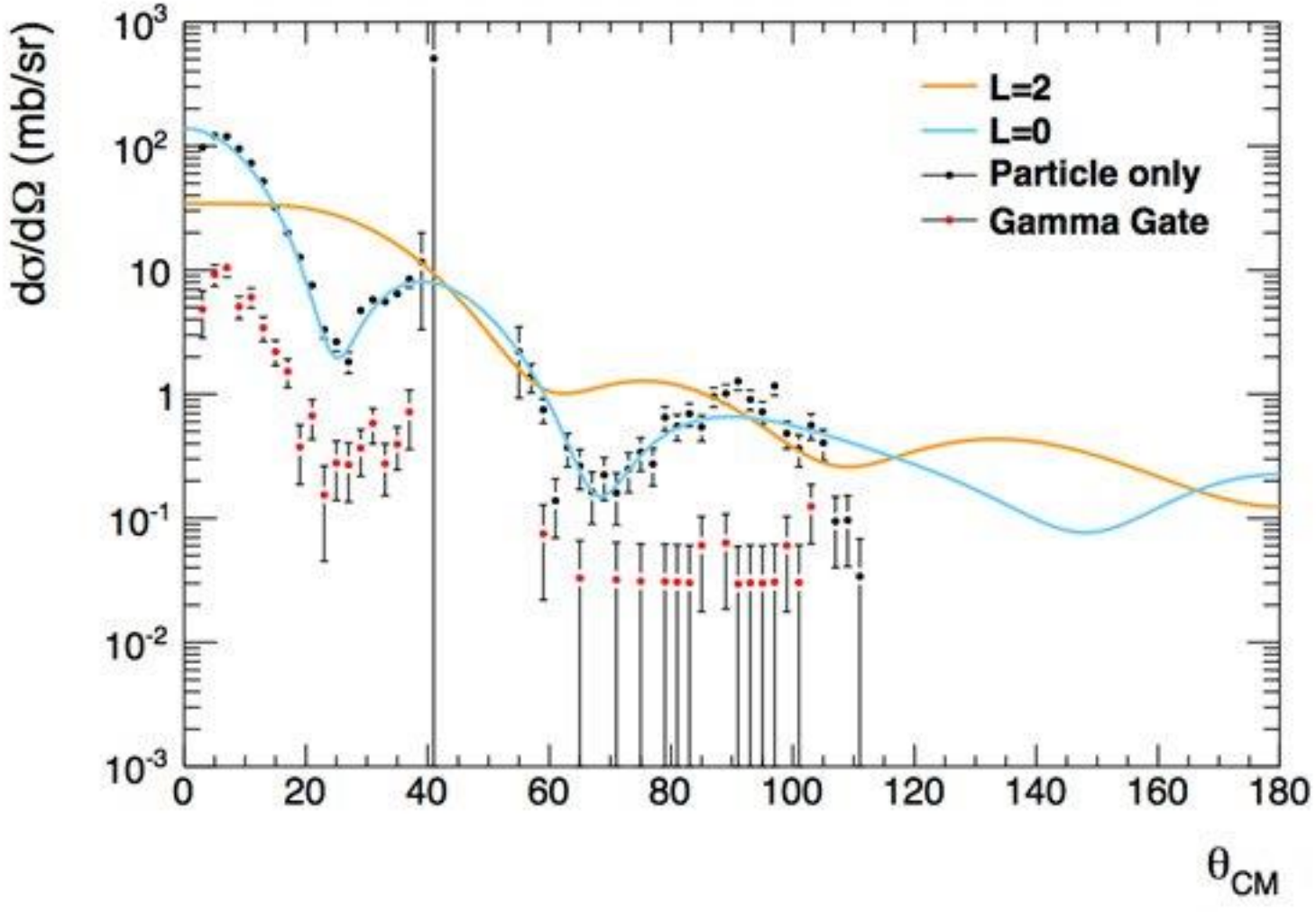


TRIFOIL DETECTOR

LPC Caen

SIMULATION OF THE DIFFERENTIAL CROSS SECTION FOR ONE OF THE NEW S-WAVE STATES

Actual predicted statistics for one week of running with 0.5 mg/cm^2 target



Angle bins: 2 degrees in c.m.

SUMMARY of REQUEST

We are requesting **27 shifts of ^{17}N beam** at 5.5 MeV/A

With this, we will **perform (d,p) with the ^{17}N beam**, and study all populated states in ^{18}N, using gamma-rays to select and identify the closely spaced levels.

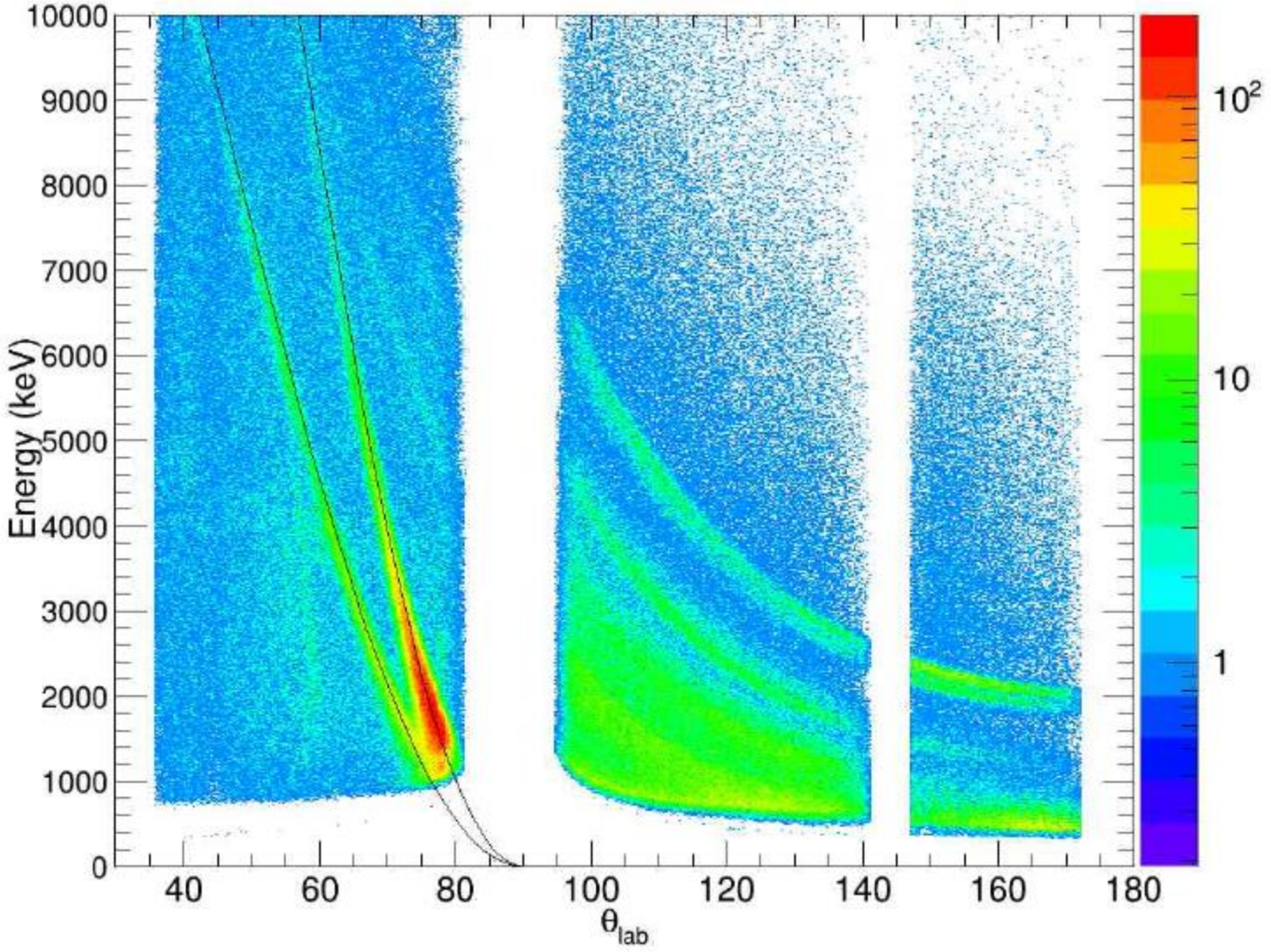
Of this, **21 shifts** are required in order to perform the **(d,p) measurement.**
We believe that we can save time by not running on a carbon target.
We would run on a carbon target (target contaminant) if time permits.

We have allowed **6 shifts** for optimising the charge state to accelerate (to minimise contaminants) (extraction will use NO^+ from nanoCaO+O_2, + plasma) and stripping methodology (what foils, and where) to eliminate ^{17}O.

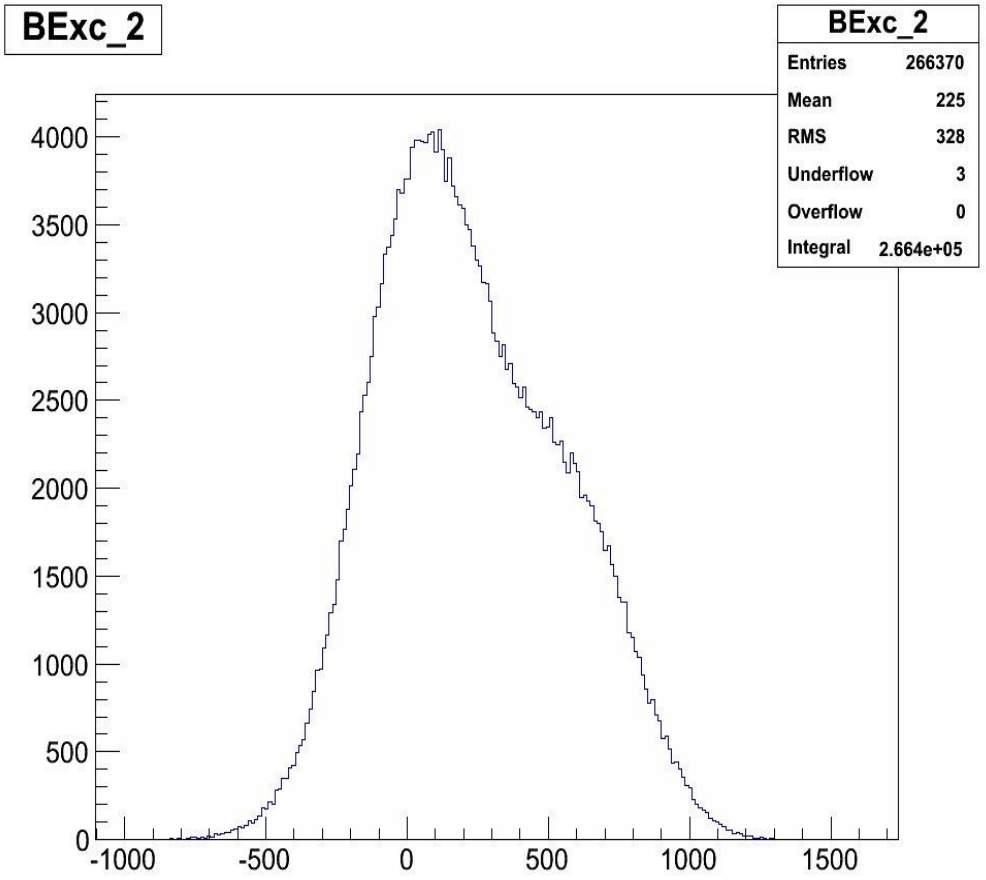
We are requesting **3 shifts** for setting up with a stable **pilot beam**, to ensure that detectors and electronics are set up correctly

We **request 10^4 pps** for the ^{17}N beam, on the reaction target.
The beam should be delivered at the **T-REX + Miniball** setup.

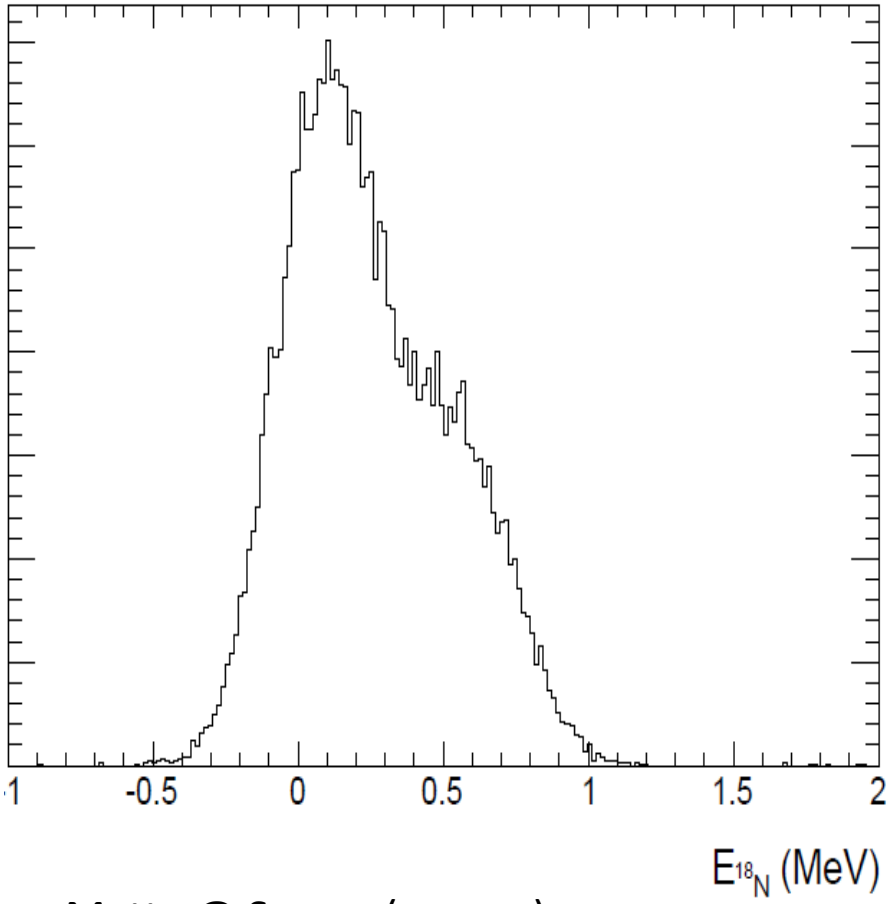
We have allowed for a 5mm diameter beam spot on target (dominates the resolution).


Energy (keV)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
40
60
80
100
120
140
160
180
θlab
10²
10
1

Reconstructed excitation energy for lowest four known states, assuming isotropic production



Klupp/Muecher @ Munich



Matta @ Surrey (approx)