Searching for shape coexistence in 124Te

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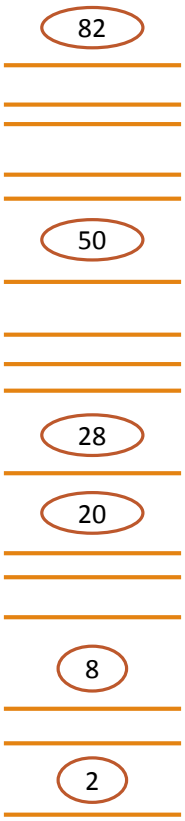
WNPPC 2019

Nuclear structure



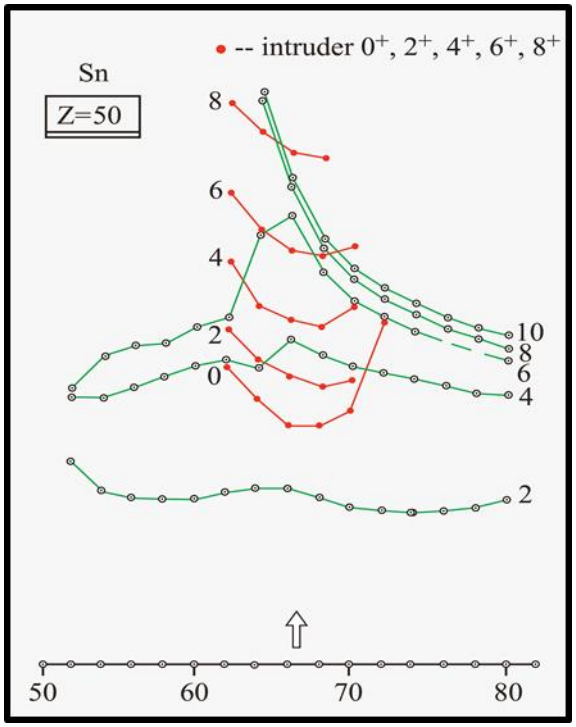
Shell model predicts shell closure at “magic” numbers of protons and neutrons

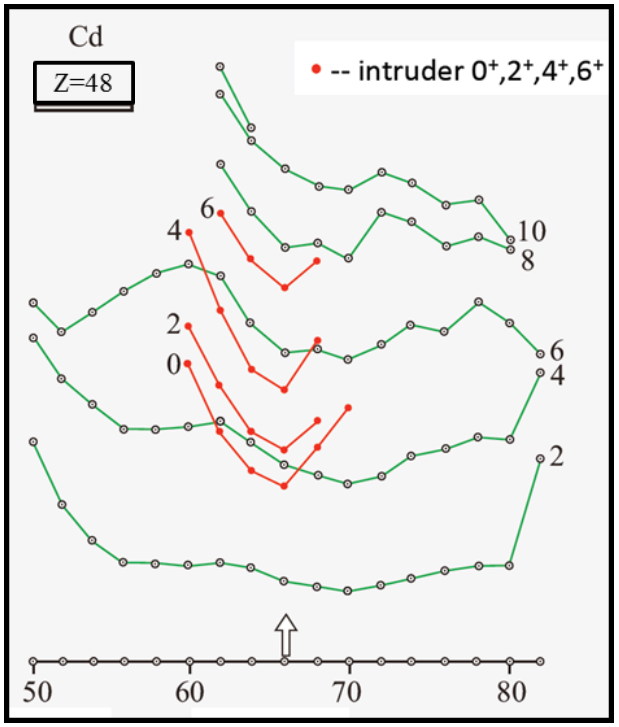
^{124}Te:

- Stable
- Z=52
  - Near closed proton shell
- N=72
  - Mid-shell for neutrons

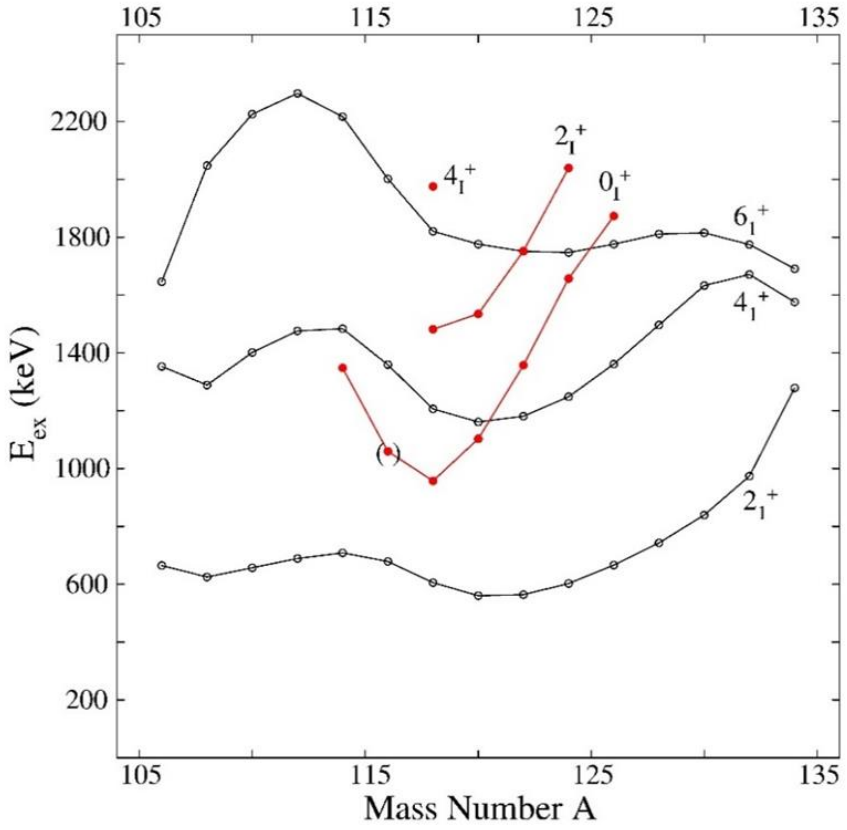
Shape coexistence

Can be characterized by absolute B(E2) values, but other indications exist:





- Parabolic energy dependence as a function of neutron number in intruder bands.
- Transition energy difference



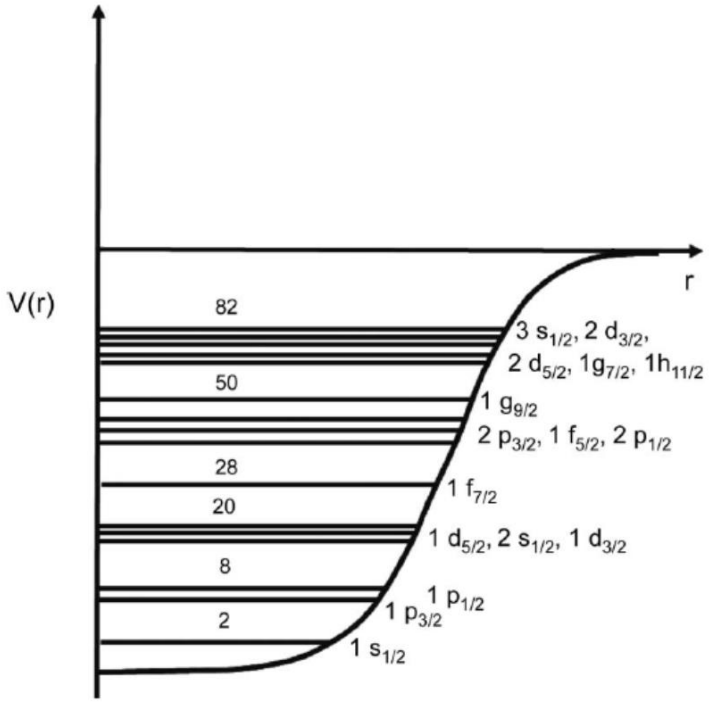
Why ^{124}Te?

- Z=52
  - Shape coexistence already established in Z=48 and Z=50 nuclei

- Lifetimes of many states are well known
  - absolute B(E2)s can be calculated once branching ratios are measured.

^{123}Te(n,gamma)

Neutron capture



- **Thermal neutrons** come in at very low energies
- Neutrons captured in compound nucleus reaction
- Daughter nucleus will be in an excited state near or at its **neutron separation energy**
  - The calculated neutron separation energy for ^{124}Te is 9.43 MeV

Why neutron capture?

- In order to investigate shape coexistence, must populate **0^+ intruder states**
- It is difficult to make a nucleus with zero angular momentum
- Neutron has a spin angular momentum of ½
  - If the target nucleus has a small angular momentum, low-spin states will be populated

123Te(n,gamma)

- Target nucleus has a ground state spin of + ½, so 0^+ states will be populated by neutron capture
- Comparatively high neutron capture cross section (418.3 b)
  - 124Te has a thermal neutron capture cross section of 6.324 b
- Long half life (>9.2×10^{16} years)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A48
A480
D1075
15
N481
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E713
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D531
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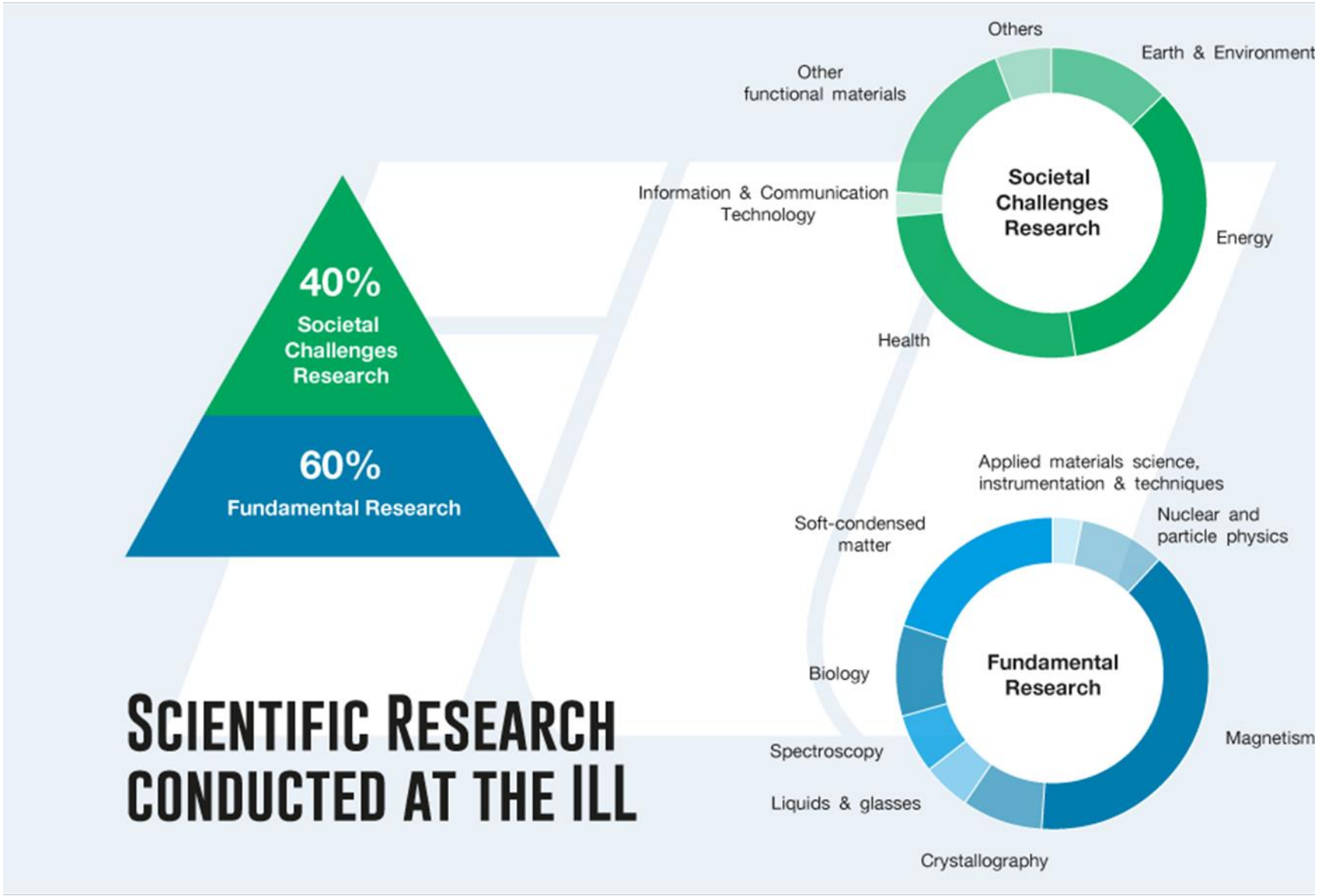
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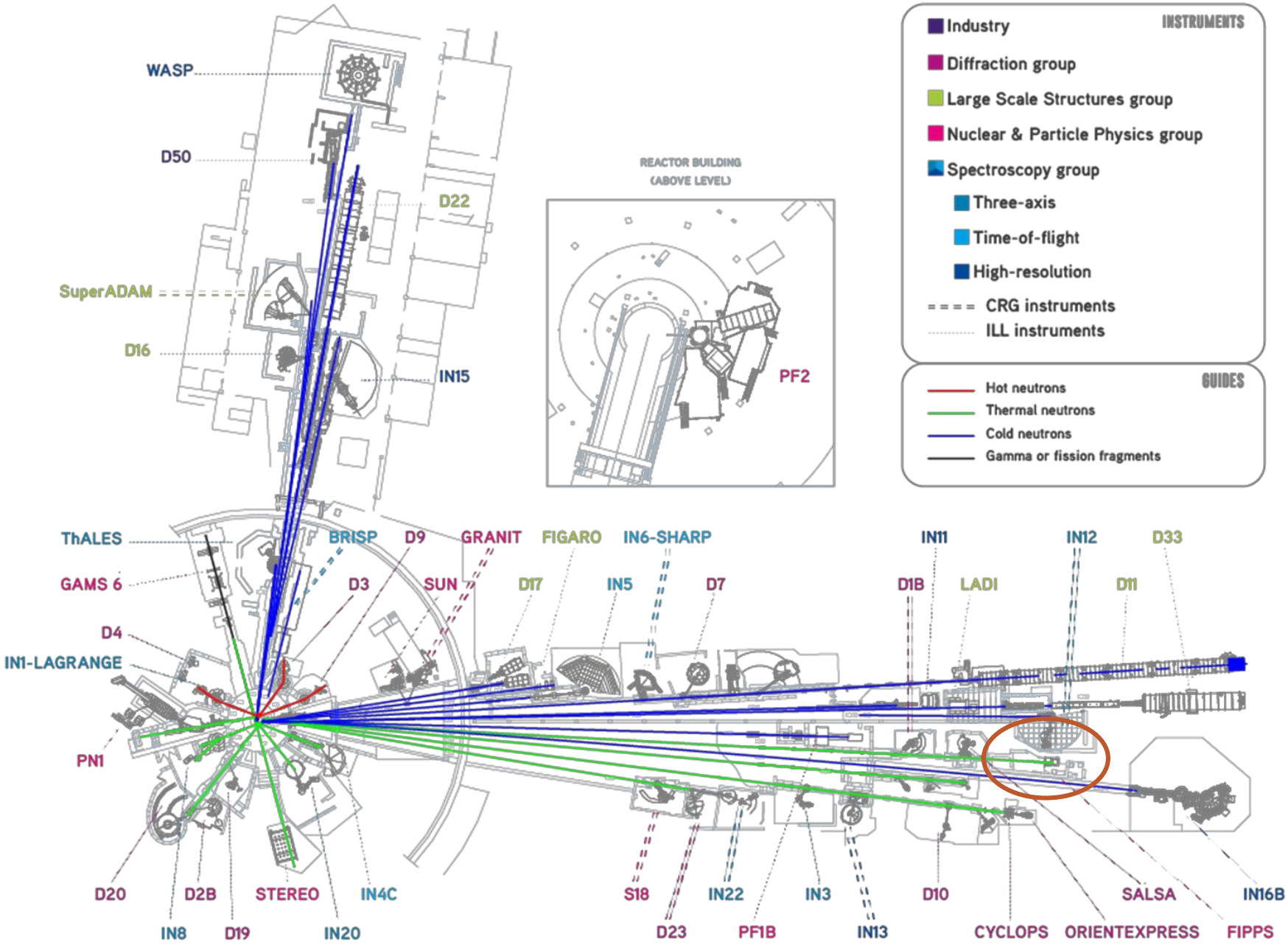
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D50
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D16
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D9
GRANIT
FIGARO
IN6-SHARP
D3
SUN
D17
IN5
D7
IN11
IN12
D33
D1B
LADI
D11
D20
D2B
STEREO
IN4C
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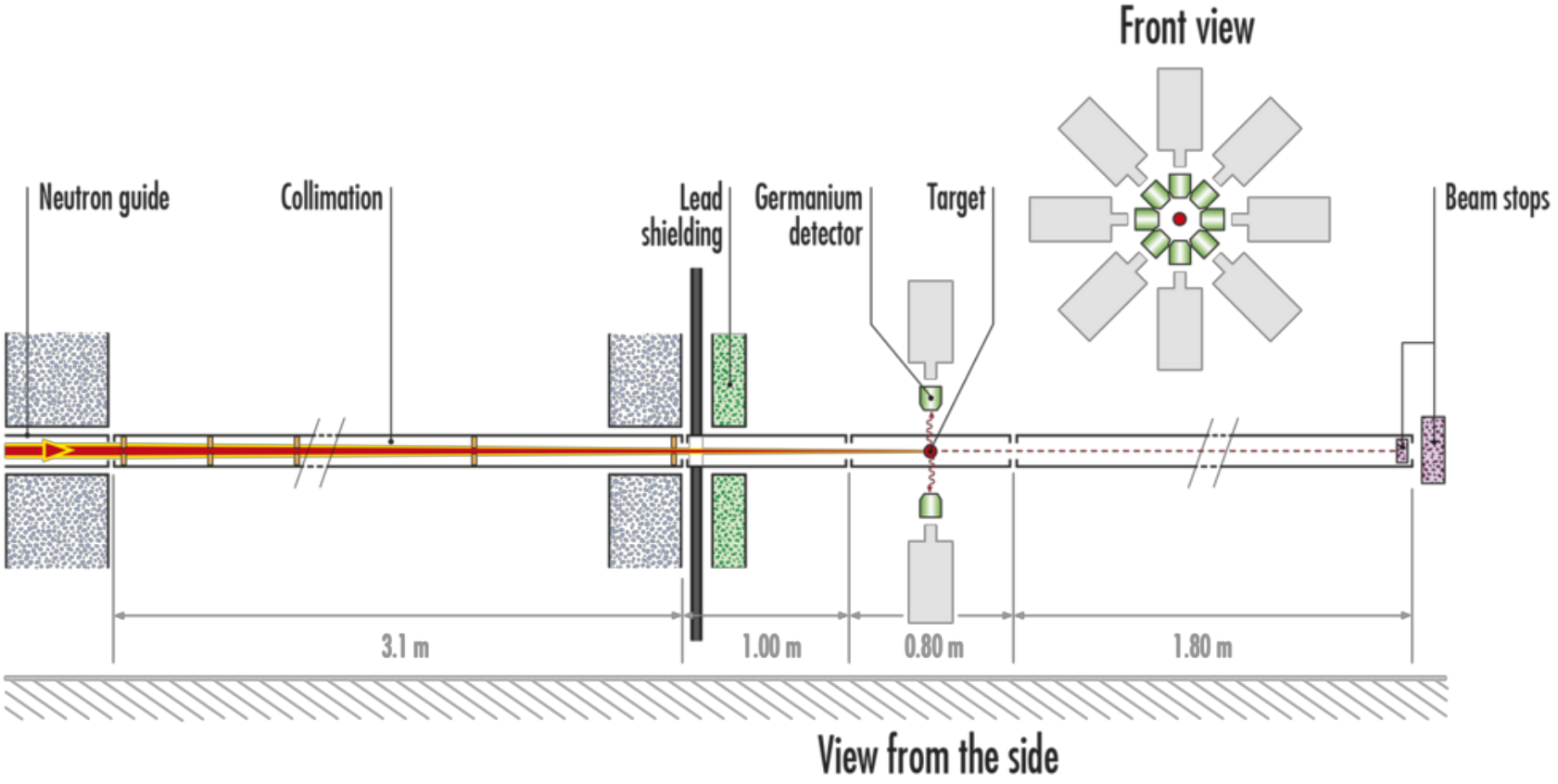
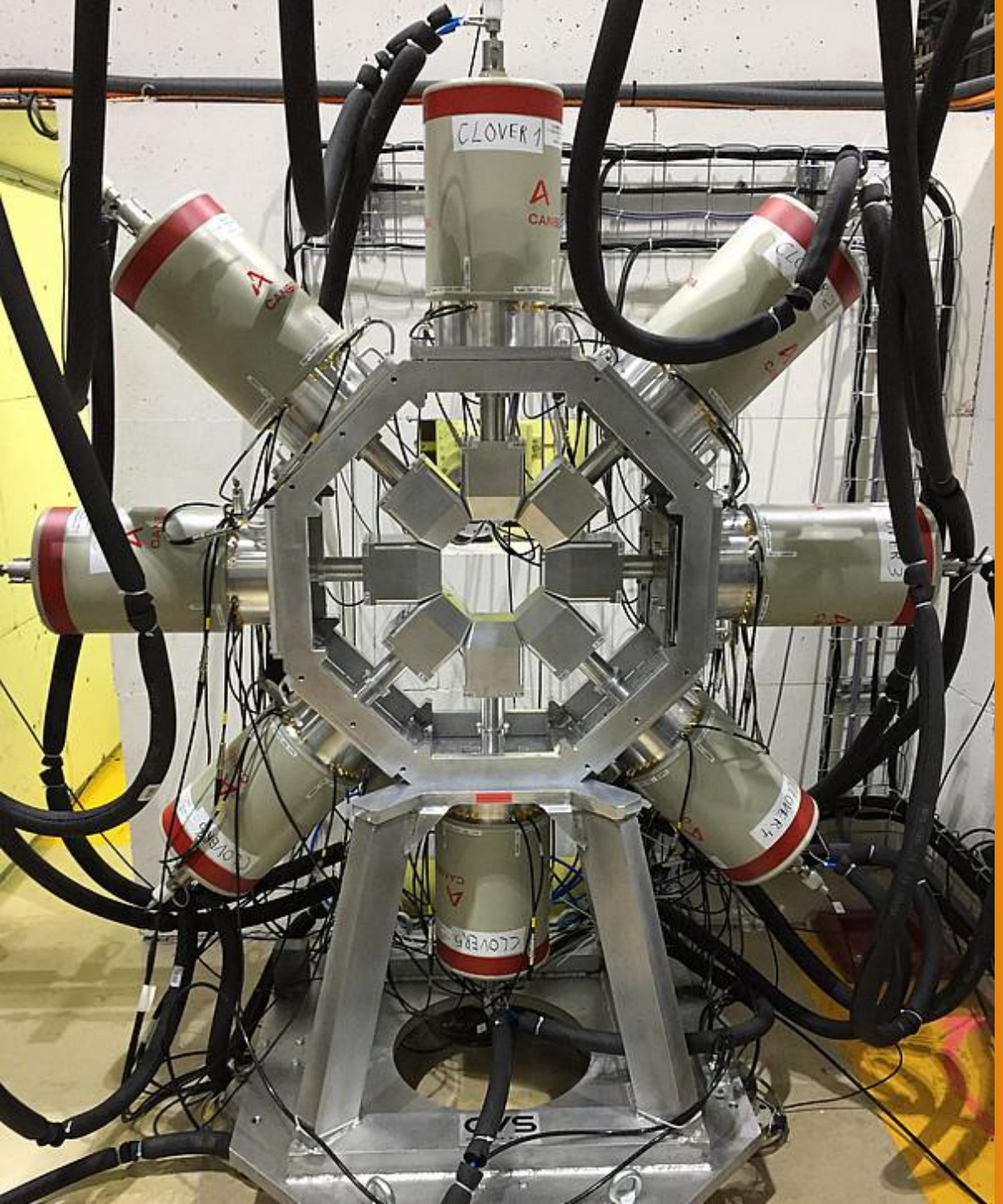

Front view
Neutron guide
Collimation
Lead shielding
Germanium detector
Target
Beam stops
3.1 m
1.00 m
0.80 m
1.80 m
View from the side



FIPPS

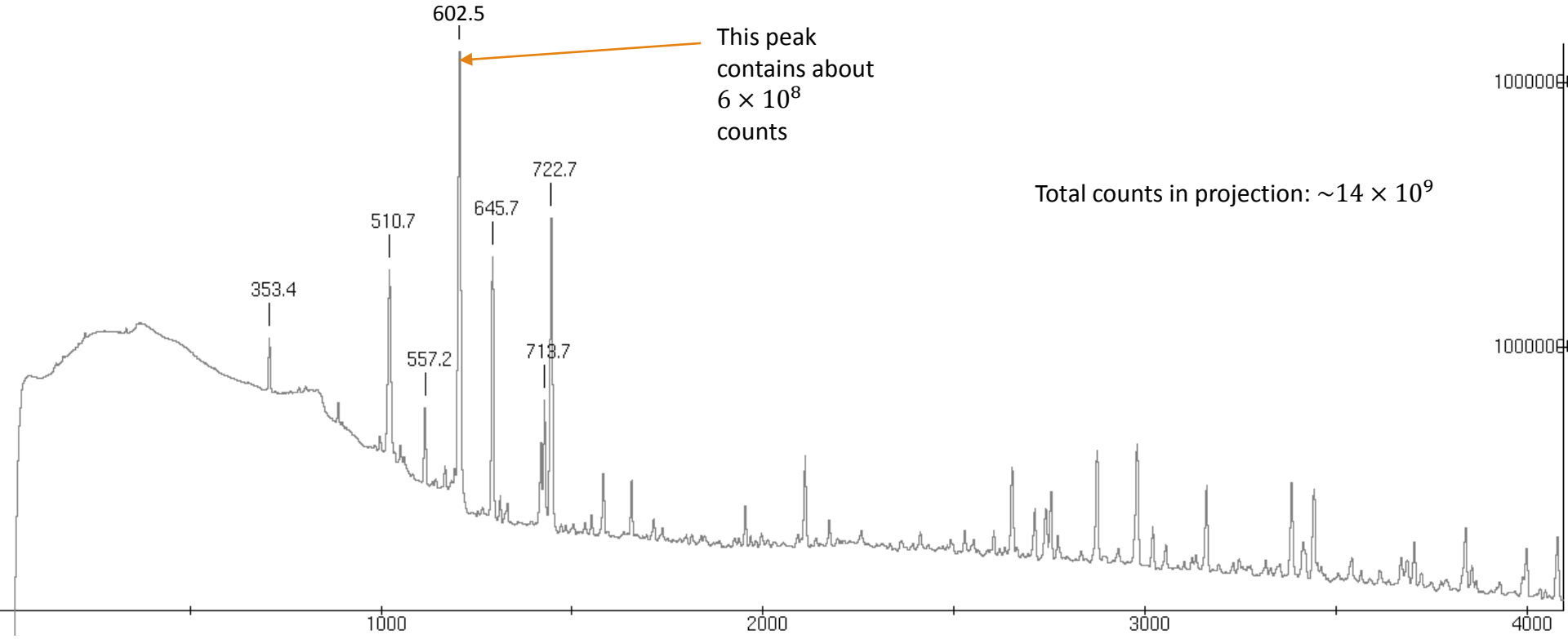
8 CLOVERS EACH CONSISTING OF 4 HPGE DETECTORS

BEAM IS A HIGHLY COLLIMATED PENCIL NEUTRON BEAM

Data acquisition and sorting

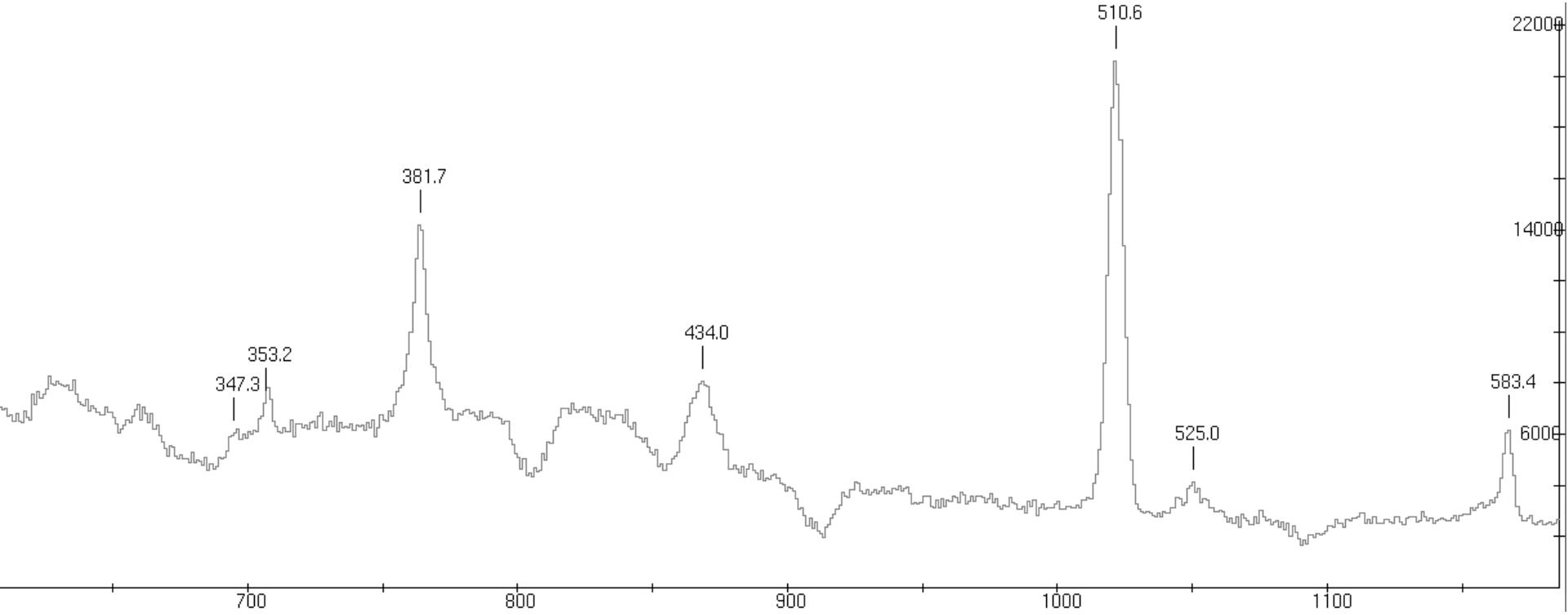
- Detectors record the time and energy of gamma rays that hit them
- We set a timing window – for every gamma ray that hits the detector, any other hits registered within the time gate are considered “in coincidence” with it
- In Coincidence: occurring one after the other in a cascade
- From this we construct a symmetric matrix of gamma ray energies – “gating” on any gamma energy gives a histogram of counts vs energy that occur in coincidence with that gamma.

Preliminary results



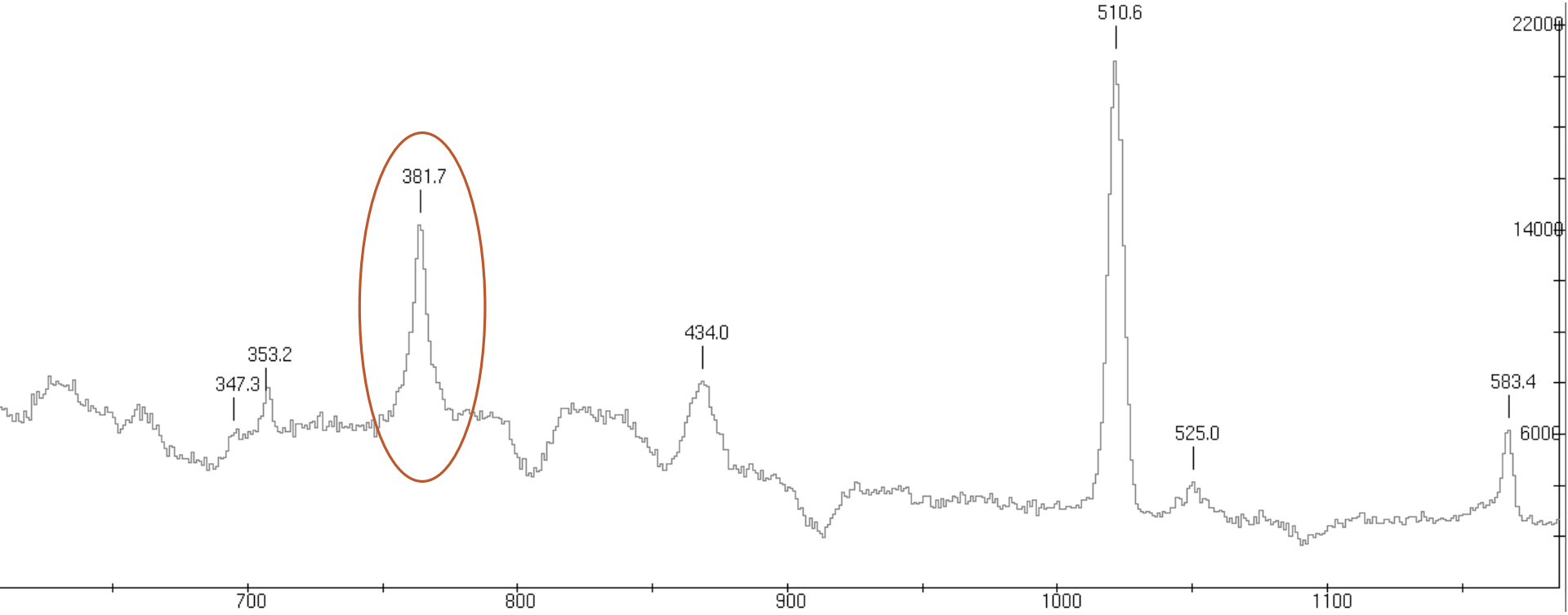
Total projection of gamma-gamma coincidence matrix (logarithmic y-axis)

Preliminary results



Portion of a slice taken on the 1055 $0^+ \rightarrow 2^+$ transition
(linear y-axis)

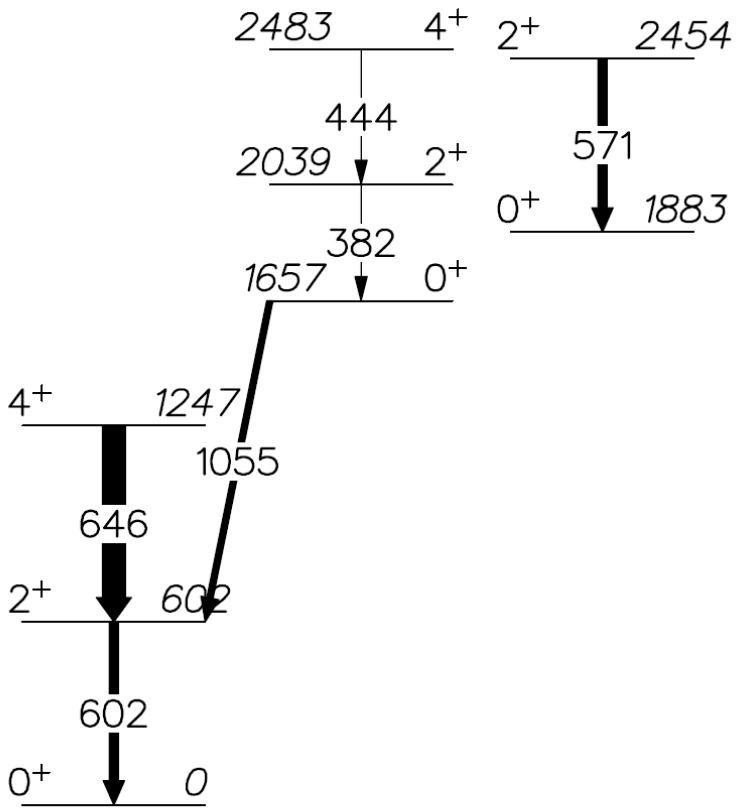
Preliminary results



Portion of a slice taken on the 1055 $0^+ \rightarrow 2^+$ transition
(linear y-axis)

Preliminary results

Large discrepancy between ground state $2^+ \rightarrow 0^+$ transition and intruder $2^+ \rightarrow 0^+$ energy



Thank you!

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