Level density and γ strength function in $^{118,119}Sn$

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Senter for Akseleratorbasert
Forskning og Energifysikk

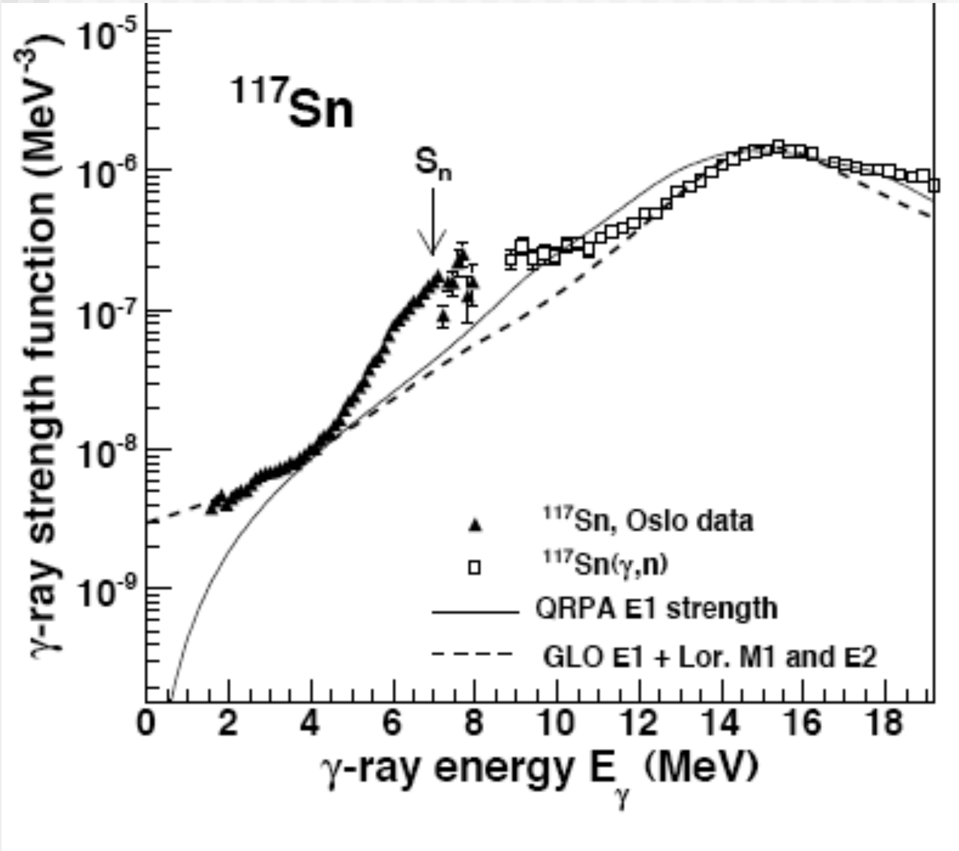
Outline

1. Motivation
2. Experimental setup
3. Preliminary analysis
4. Further investigations

Motivation

- $E\gamma$: Energy of γ from disintegration of excited product nucleus.
- Energy level density: Number of energy levels of excited nucleus per MeV.
- γ strength function: Probability function for $E\gamma$ independent of level density.
- Earlier found: New, small resonance in γ strength function for $^{116,117}Sn$.
  - Enhanced γ emission.
  - Resonances are interesting because they indicate collective oscillations in the nucleus.

New resonance in $^{116,117}Sn$



- Detects $E\gamma < S_n$.
- Small enhancement. "Pygmy".
- $E\gamma \approx 8$ MeV.
- On the tail of GEDR (Giant Electric Dipole Resonance).

Resonances´ origins

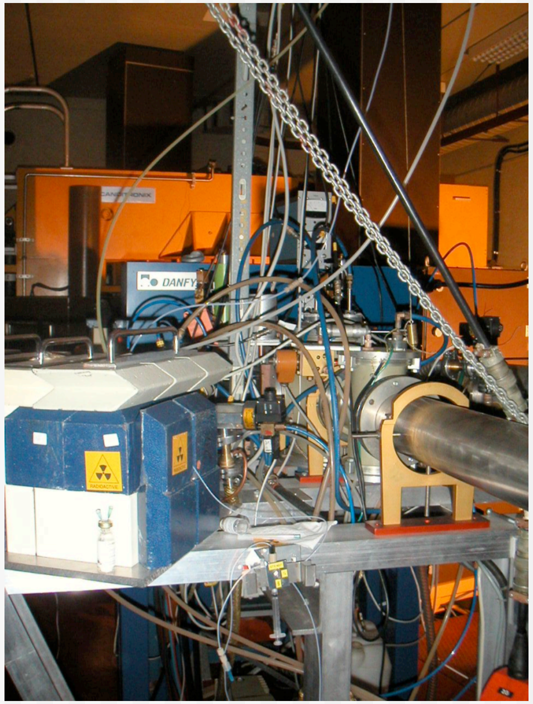
- GEDR: Out of phase oscillation of clouds of all (?) protons and neutrons.
  - Many nucleons involved ⇒ High γ strength.
  - Variation of a large charge distribution along an axis.
    - Emission of electric dipole radiation (E1 mode).
  - High frequency oscillation ⇒ Centroid $\hbar\omega \approx 15$ MeV.
- Pygmy: Origin unknown.
  - Theory prediction of small resonances at 8 MeV: M1 (GMDR) or E1 (neutron skin oscillations).
  - Neutron skin oscillations: Non-moving core of Z protons and $N \approx Z$ neutrons, while excessive neutrons ($\approx A\text{-}2Z$) oscillate in nucleus´ skin.

Motivation for $^{118,119}Sn$

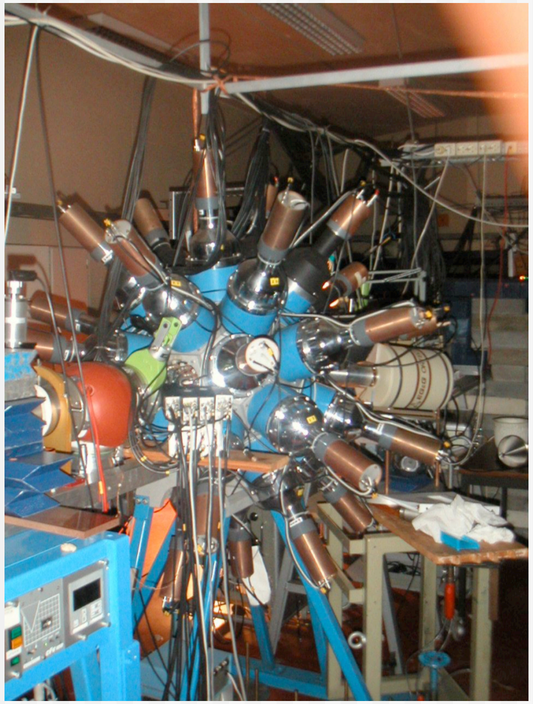
- Confirm pygmy.
- More excess neutrons in skin.
- Expect stronger pygmy, if skin oscillations.
  - Possibly scaled to number of excess neutrons.

Oslo cyclotron laboratory

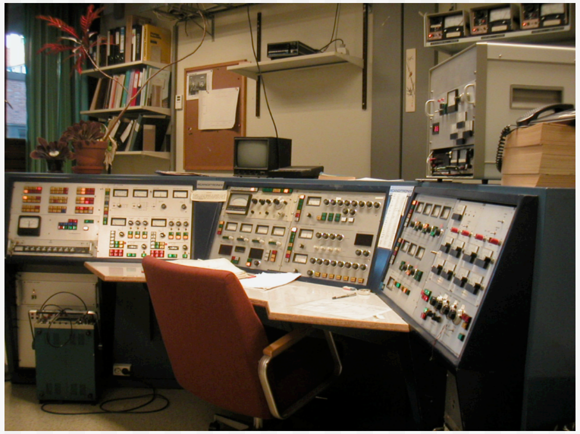
- Norway´s only nuclear particle research accelerator.
- Makes radioactivity for research and industry.



Cyclotron

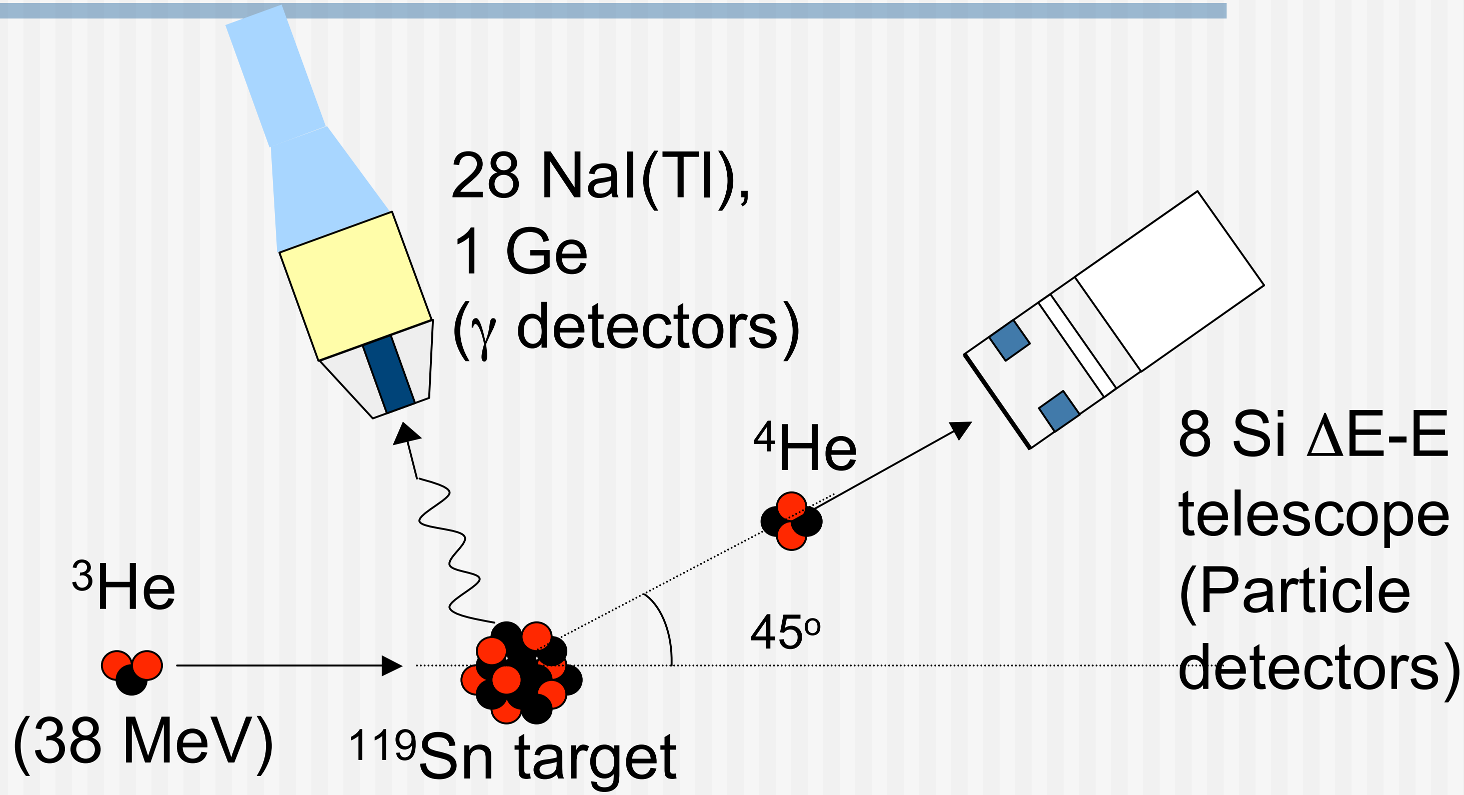


Cactus



Control room

Experimental setup



Analysis overview

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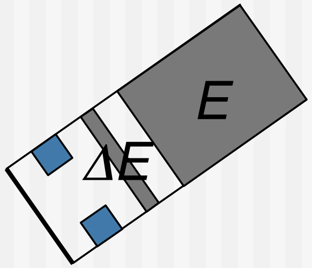
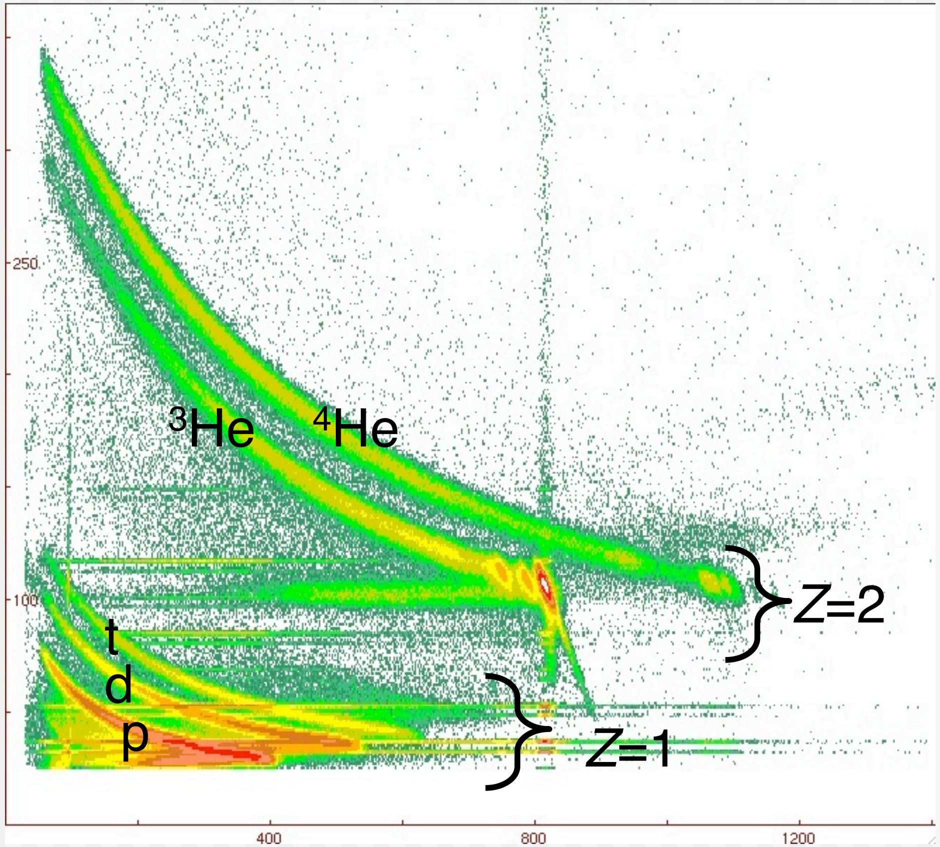
- Interested in particle and γ coincidences.
  - Pick-up reaction: $^{119}Sn(^{3}He,^{4}He\ \gamma)^{118}Sn$.
  - Inelastic scattering: $^{119}Sn(^{3}He,^{3}He'\ \gamma)^{119}Sn$.
- Particle detectors:
  - Measure particle energy ⇒ Estimate E_x.
  - Particle identification.
- γ detectors: Measure $E\gamma$.
- Keep only first generation γ. Matrix (E_x, $E\gamma$).
- Estimate level density and γ strength function.
  - Nucleus properties.

Spectrum ΔE vs. E



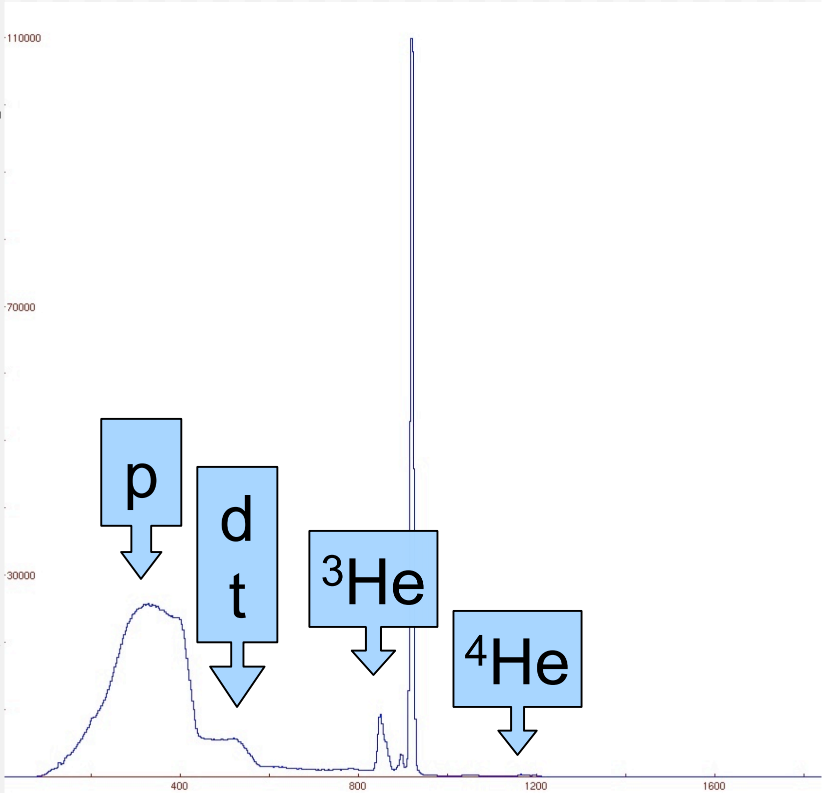
- ΔE and E energy distribution depend on charge (Z), mass (A) and particle velocity.
- Distinguish ^{4}He, ^{3}He, t, d and p.



ΔE vs. E

Spectrum of added ΔE + E

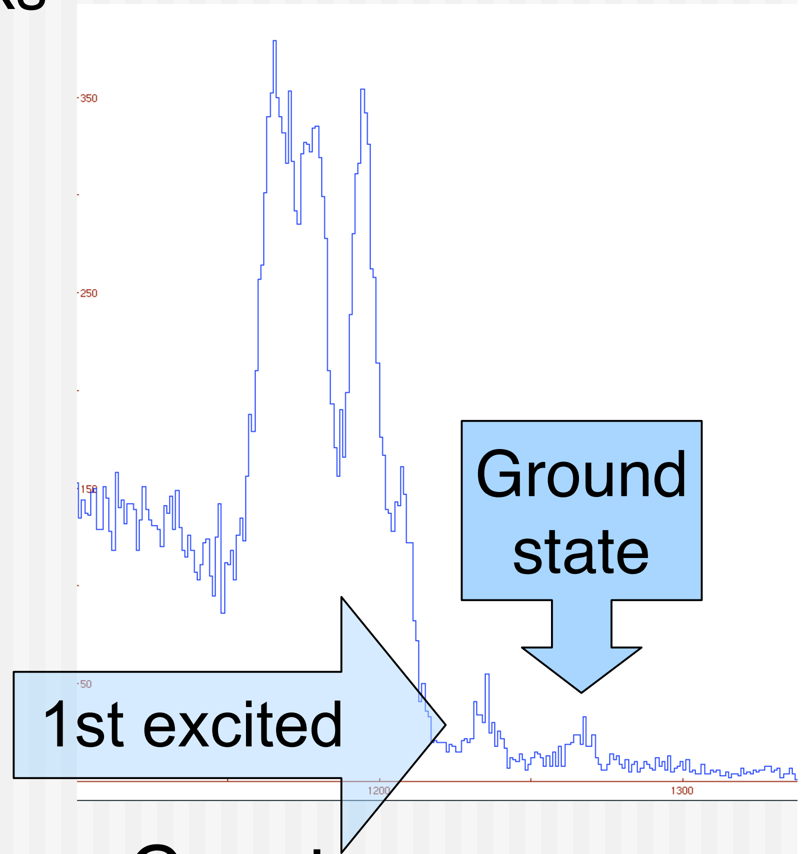
- *ΔE* detects some particle energy, *E* detects remainder.
  - Add up to total energy.
- Better resolution than partial energy in each telescope.
  - Statistical fluctuations.
- High-energetic p and d do not stop in *E*.
  - Increasing particle energy ⇒ Less total energy detection.
  - Sharp cut-off in right flank.
- Particle overlap.



Counts vs. total energy

Spectrum of ^{4}He area (zoomed)

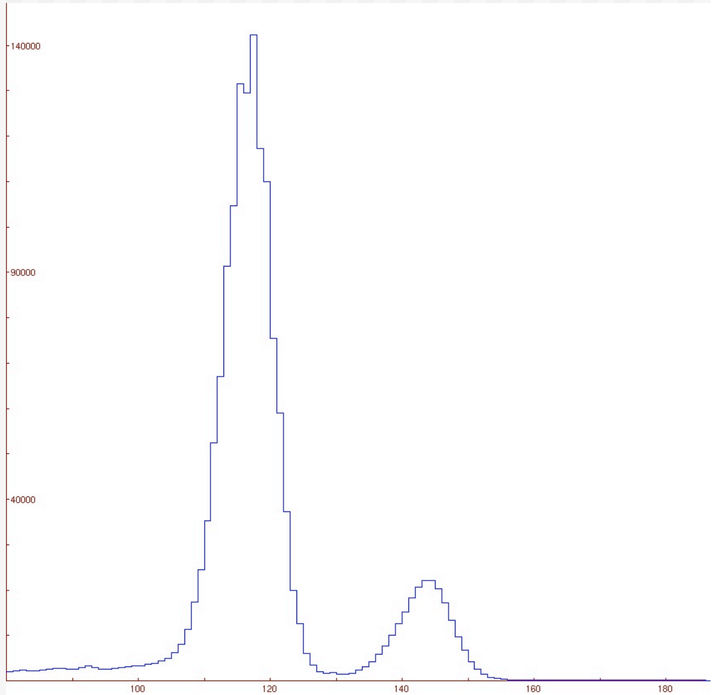
- Energy difference of ^{4}He peaks $\Rightarrow$ Must match ^{118}Sn energy difference in excitation levels (literature).
- Identify: Most energetic ^{4}He peak $\Leftrightarrow$ ^{118}Sn ground state.
- Low cross section for ^{118}Sn ground state.
  - Favour of high l neutron pick-ups.
  - High Q value.



Counts vs. energy

Spectrum *ΔE* telesc. thickness

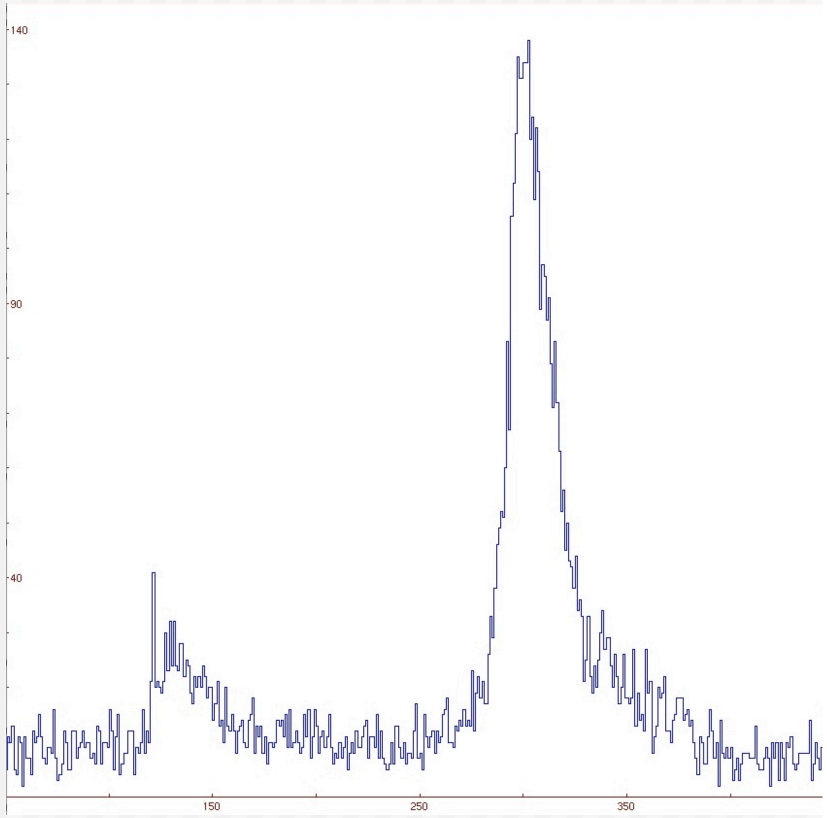
- ^{4}He and ^{3}He overlap in total energy. How to easily gate reactions?
- Function range R(*E*) for ^{4}He in Si is known.
- Calculate *ΔE* thickness for ^{4}He: $t = R(E+\Delta E) - R(E)$.
- Thickness:
  - Separates particles.
  - Criterion for gating on ^{4}He or ^{3}He particles.



Counts vs. μm Si

Time spectrum

- *Δt*: Time from particle detection to γ detection.
- Gated on: ^{4}He particles.
- Peak: γ´s from ^{4}He reactions.
- Narrow. (FWHM: 15-20 ns)
- Rest: Background of random coincidences.
  - For substraction.



Counts vs. *Δt* (ns)

Future work

- Estimate γ strength function and energy level density.
- Compare results to earlier work on $^{116,117}Sn$.
- Neutron skin oscillations?

[redacted]

Further investigations

- Matrix of E_x vs. $E\gamma$.
- Unfolding of NaI spectra with NaI response functions.
- Spectra of first γ emission from excited nucleus (first generation method).
- Decompose matrix $P = \rho \times T$.
- Normalisation of ρ and T. Make γ strength function.

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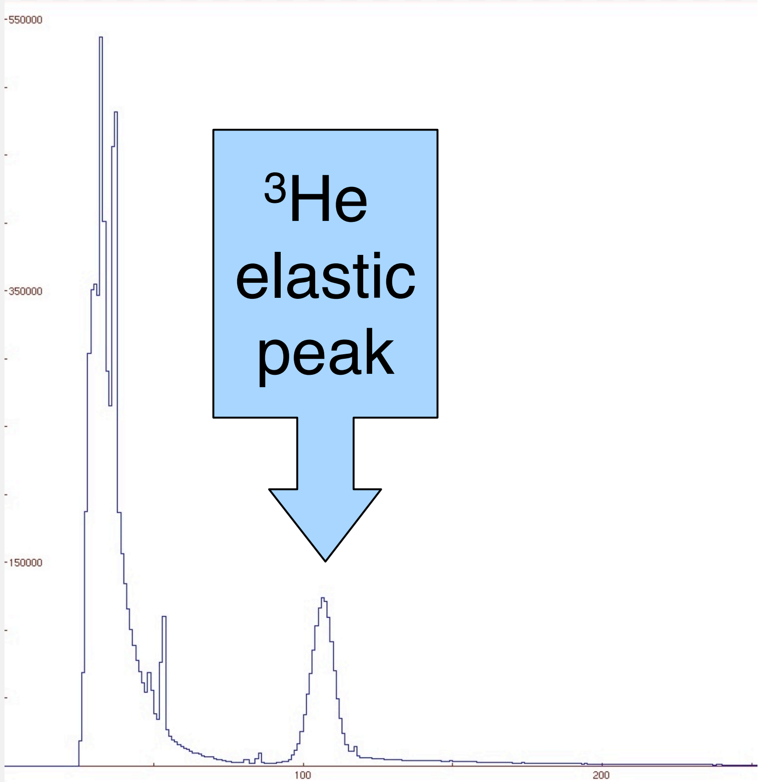
Spectrum ΔE

- ^{3}He elastic peak.
- **Også inelastic område???**
- No ^{4}He peak since high-energetic.
- **Hvorfor ikke 4He her?**
- **Er dette noe å vise?**



vs energy

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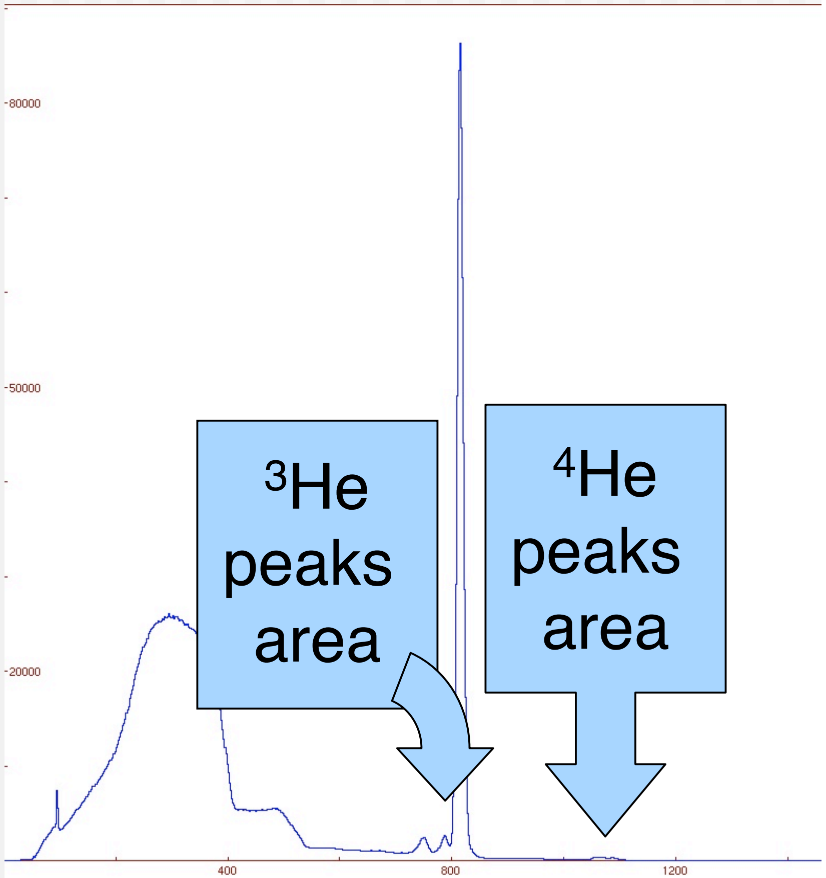
Spectrum E

- E telescope stops particles.
- Lower-energy peak: Elastic ^3He.
- Higher-energy peaks: ^4He.



vs energy