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# Performance test of $\mathrm{LaBr_3}$ Array using $^{27}\mathrm{Al}(p,\gamma)^{28}\mathrm{Si}$ Reactions

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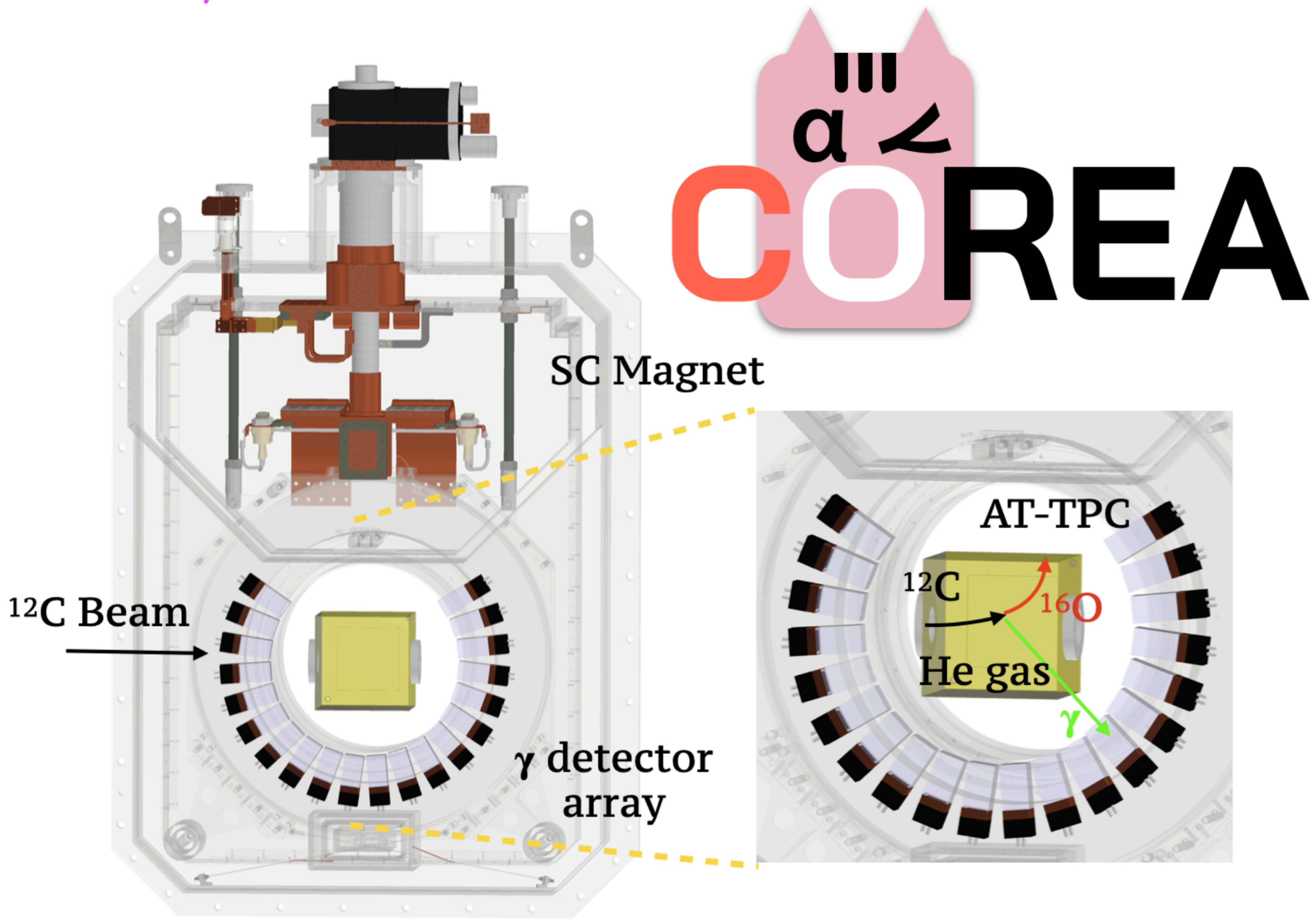
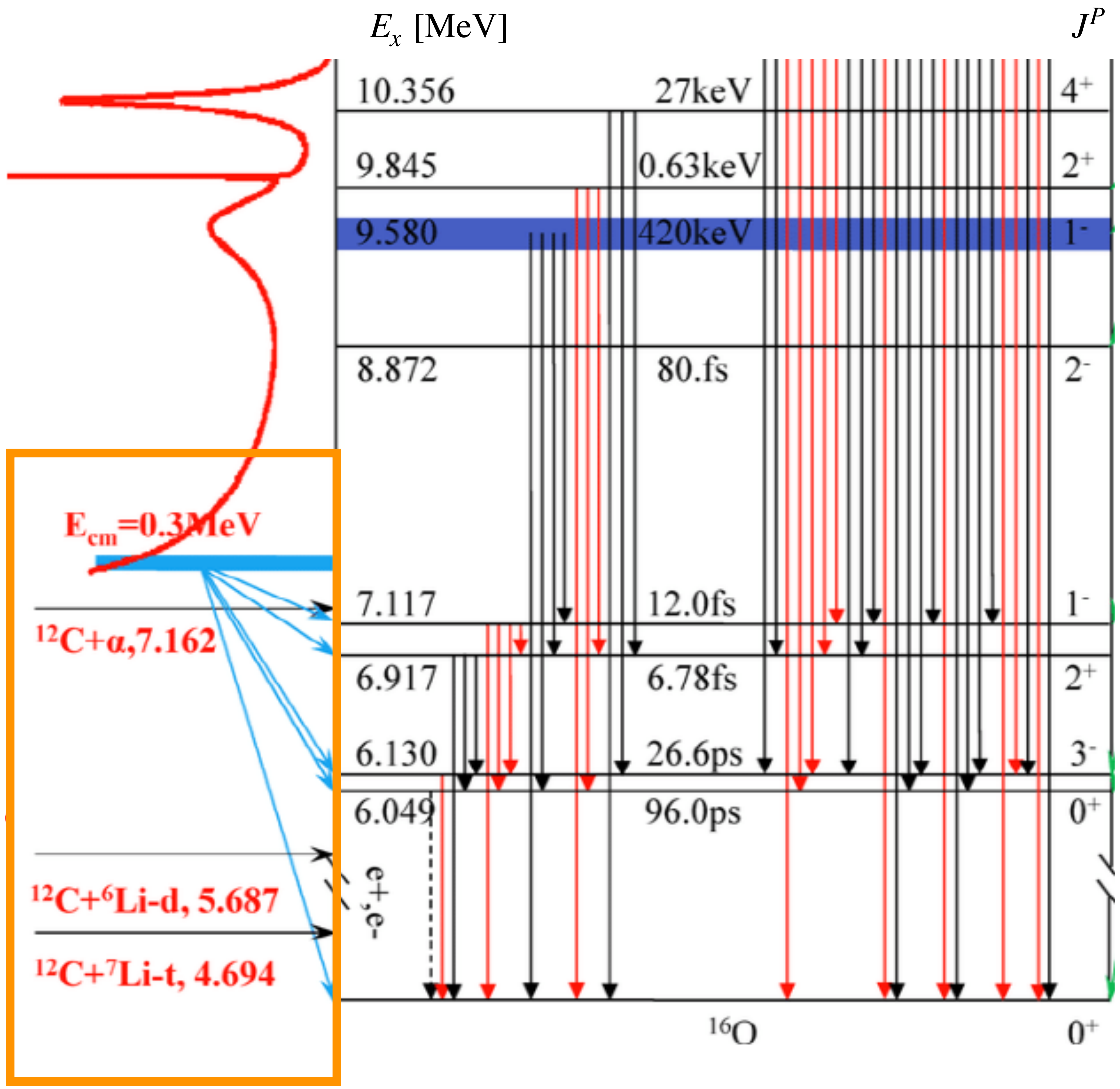
Hadron & Nuclear Physics Lab

# Carbon Oxygen Reaction Experiment with Active-target TPC (COREA)

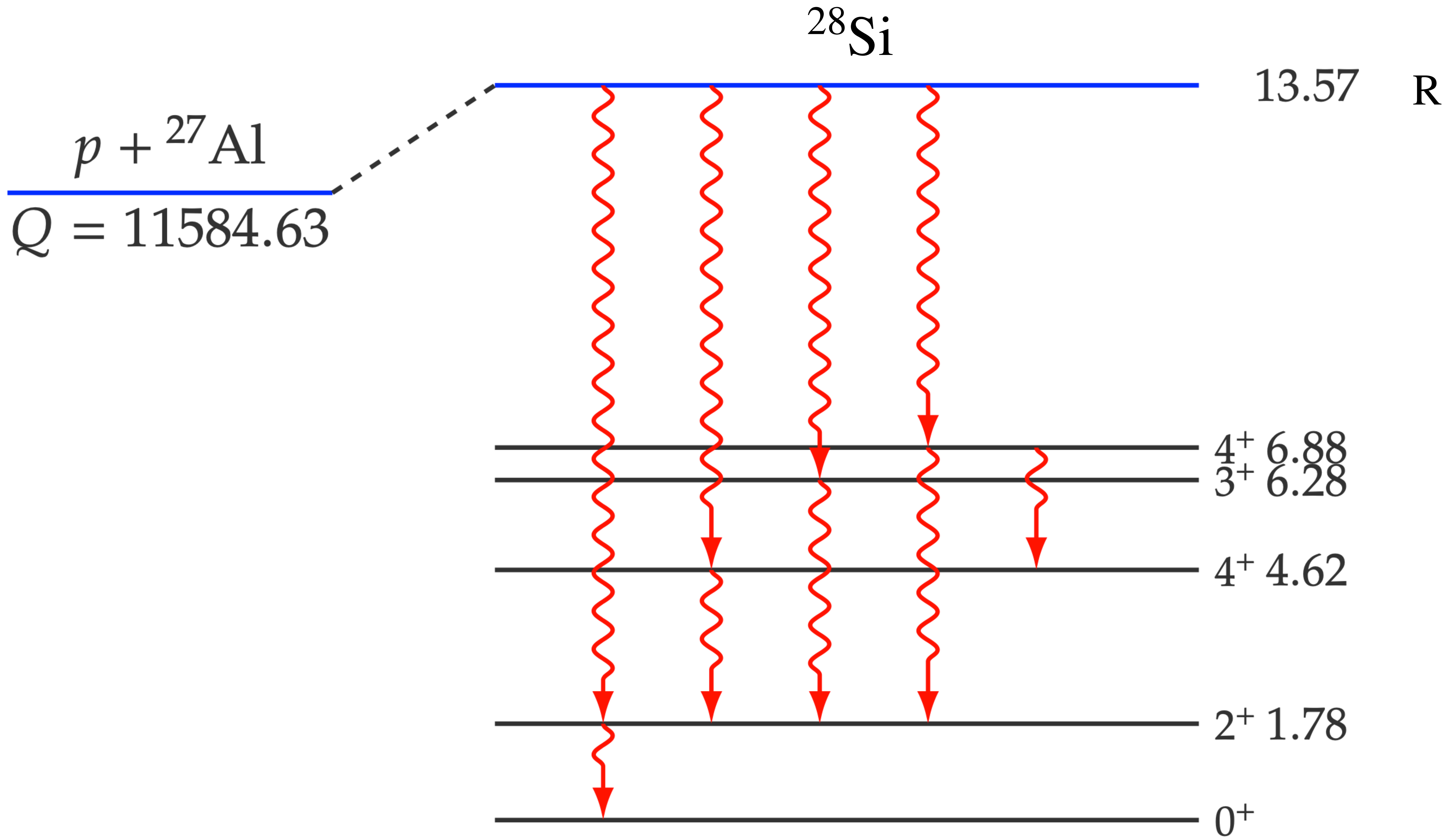
- Measurement of $^{12}C(\alpha,\gamma)^{16}O$ reaction near/below 300 keV

➡ $E_\gamma \sim 7$ MeV



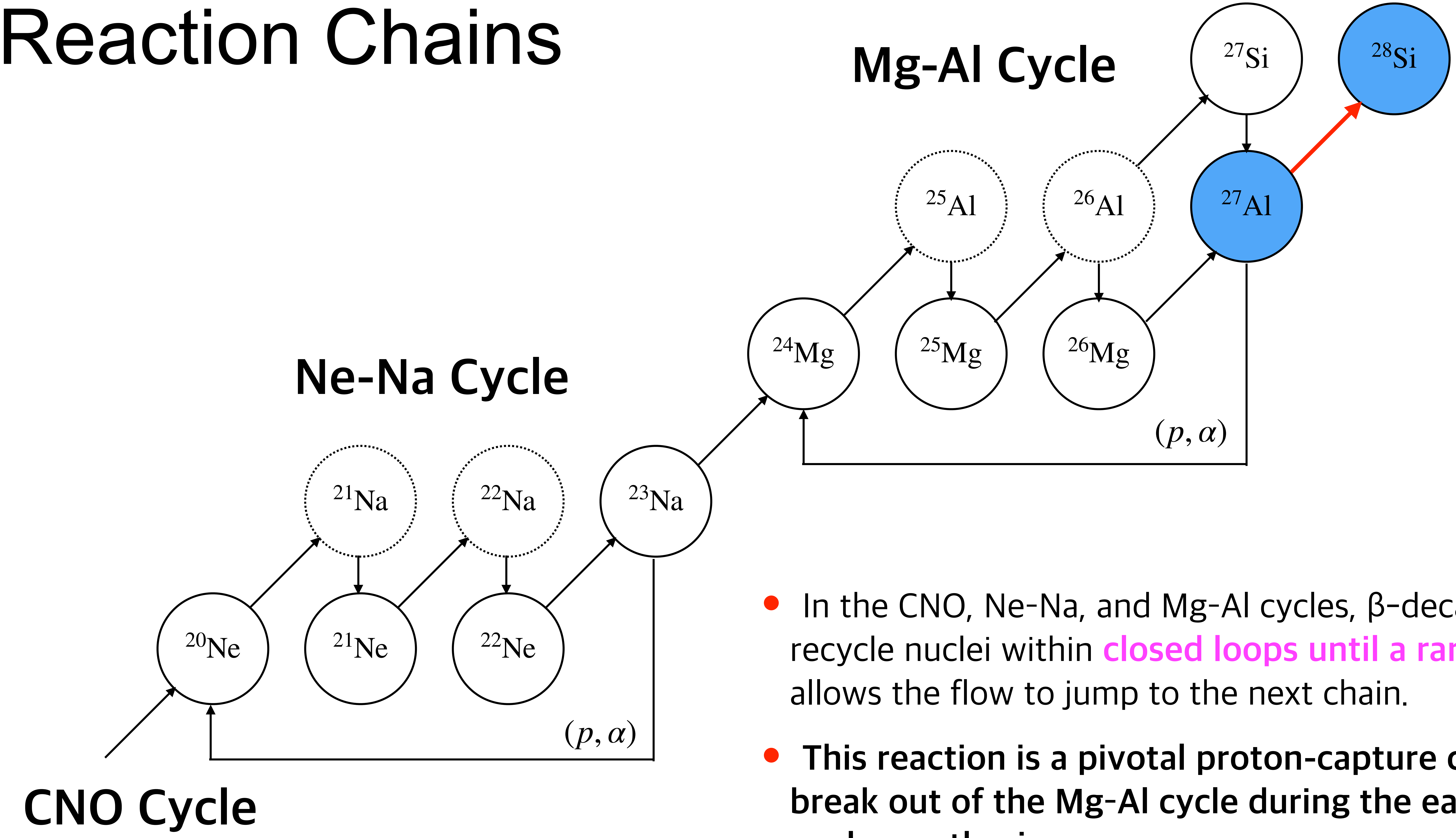
# Decay Scheme of $^{28}\mathrm{Si}$ at $E_x = 13.57$ MeV




| Energy | Transition | Fraction |
|---|---|---|
| 11.79 MeV | $R \to 2^+$ | 10% |
| 8.95 MeV | $R \to 4_1^+$ | 50% |
| 7.29 MeV | $R \to 3^+$ | 26.5% |
| 6.69 MeV | $R \to 4_2^+$ | 22.5% |
| 5.10 MeV | $4_2^+ \to 2^+$ | 20% |
| 4.50 MeV | $3^+ \to 2^+$ | 25% |
| 2.84 MeV | $4_1^+ \to 2^+$ | 50% |
| 2.26 MeV | $4_2^+ \to 4_1^+$ | 2.5% |
| 1.78 MeV | $2^+ \to 0^+$ | 100% |

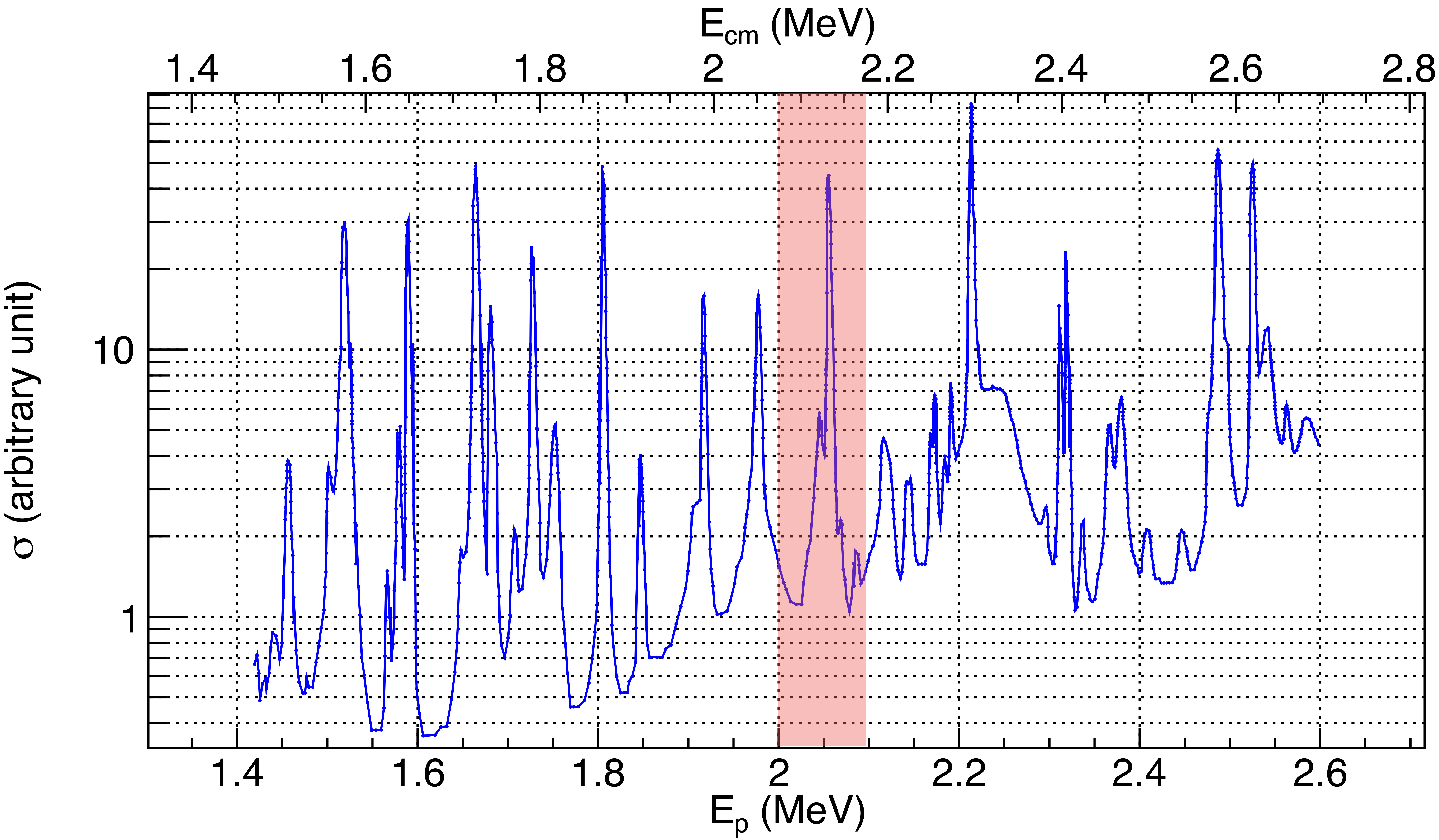
- Al target
  - ➡ Isotopic abundance of $^{27}\mathrm{Al}$ ~ 100%
  - ➡ Easy to produce
- $E_p = 2.05$ MeV
  - ➡ No other resonances nearby
  - ➡ Various gamma energies, beyond 10 MeV
    - ➡ Calibration, resolution, Detection efficiency of $\gamma$ detector

# Reaction Chains



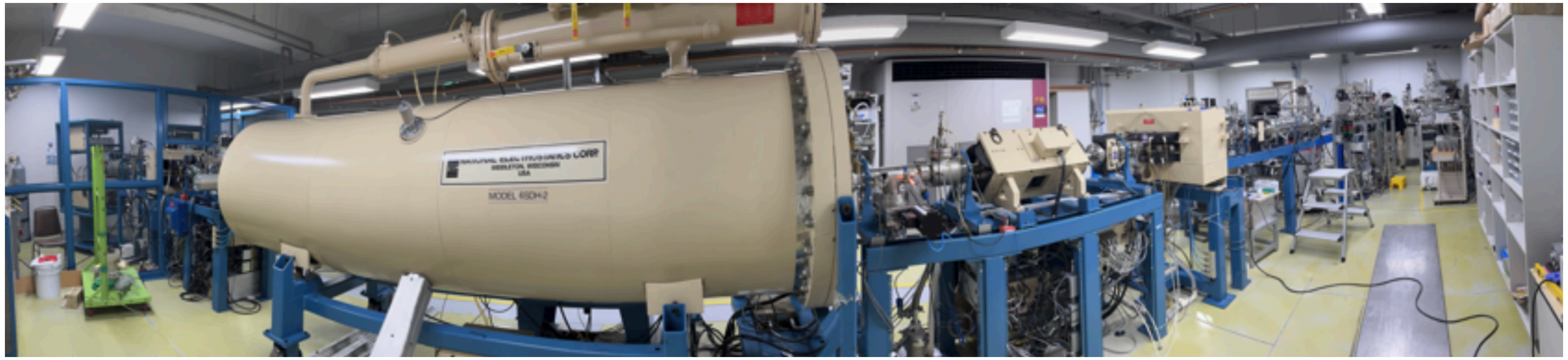

- In the CNO, Ne-Na, and Mg-Al cycles, β-decays and (p, α) captures recycle nuclei within closed loops until a rare breakout reaction allows the flow to jump to the next chain.
- **This reaction is a pivotal proton-capture channel that lets nuclei break out of the Mg-Al cycle during the earliest stages of stellar nucleosynthesis.**

# $^{28}Al(p,\gamma)^{28}Si$ Cross Section



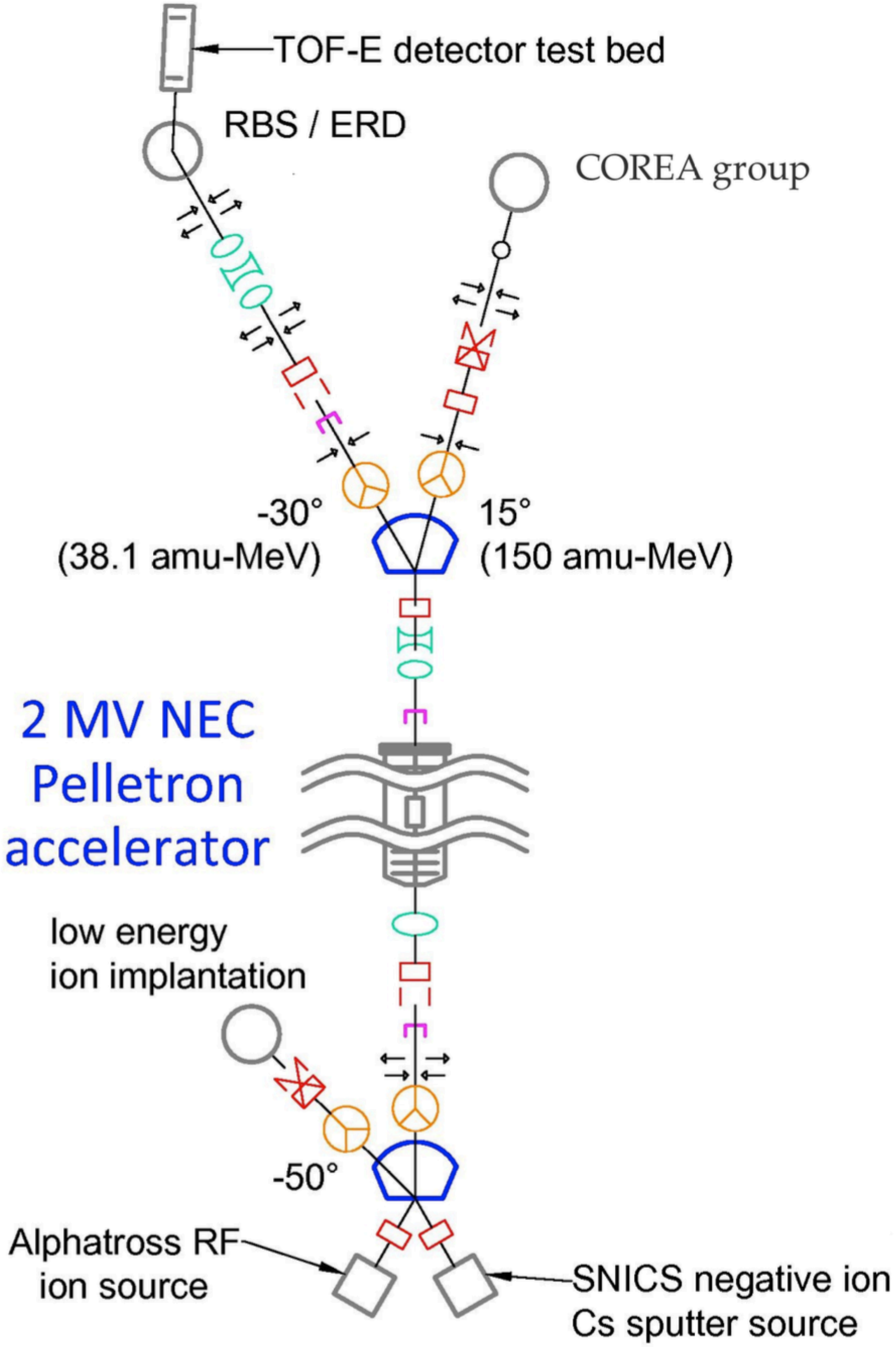
# KIST 2MV Pelletron beamline

- KIST Advanced Analysis Center (Seoul)
  (6MV Tandetron/2MV Pelletron)
  - ➡ **Very close to Korea University!**

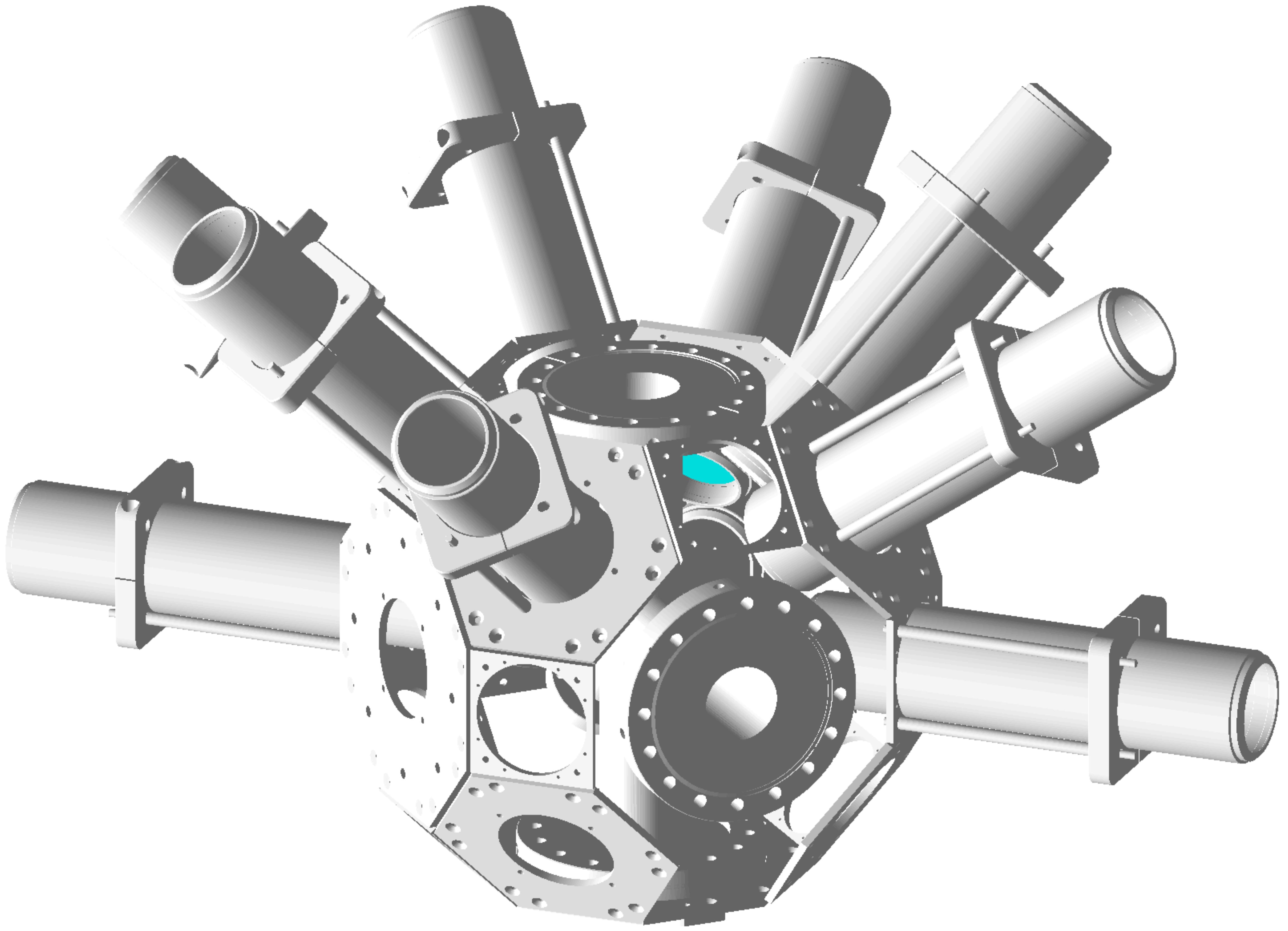


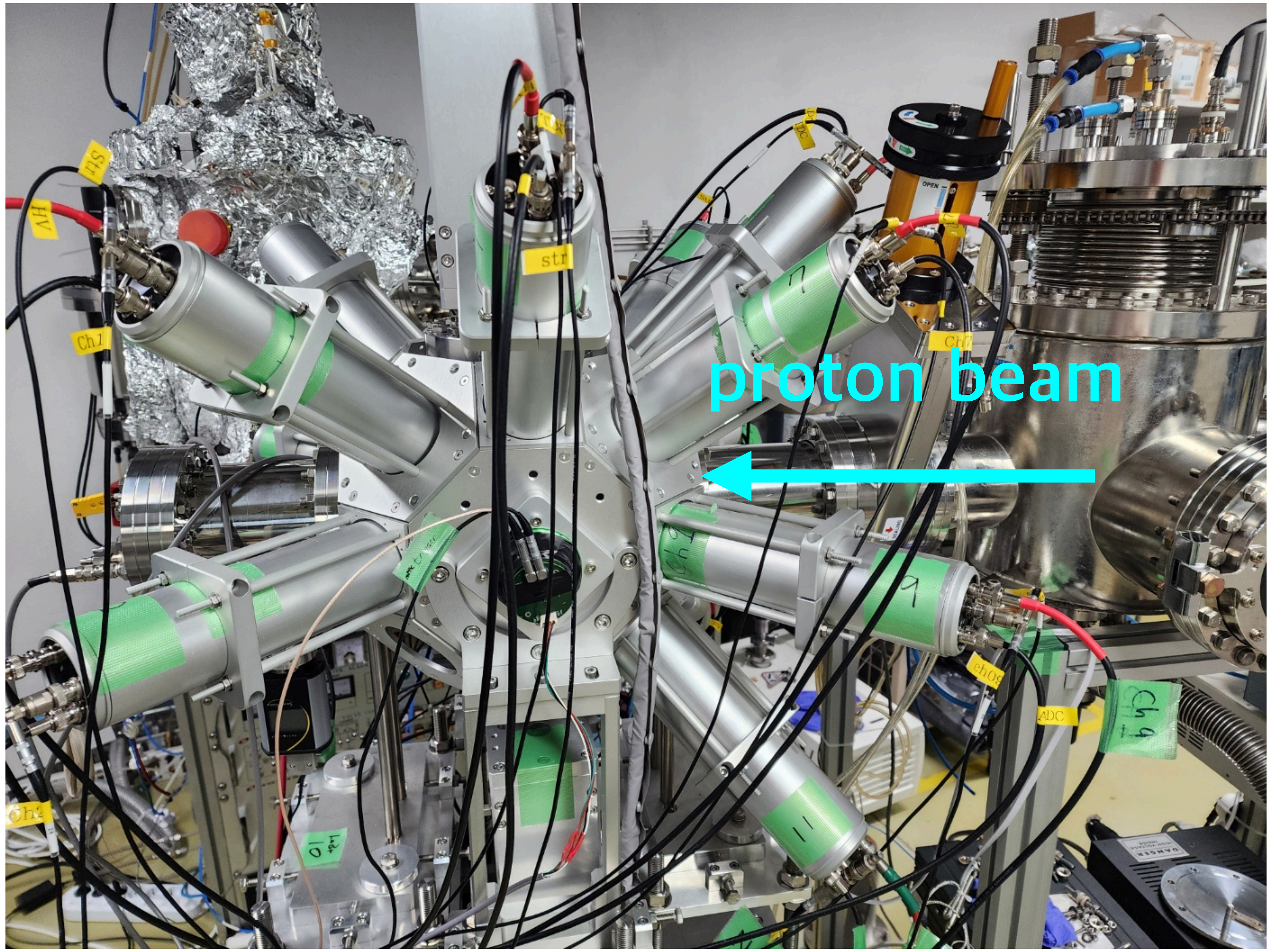
$$p,\ E = \sim 2\ \mathrm{MeV},\ I = 2\mu\mathrm{A}$$

| | | |
|---|---|---|
| ${}^{4}He^{2+}$, $E = 3.9$ MeV, $I = 1.2 - 2\ \mu A$ | | |
| ${}^{12}C^{2+}$, $E = 5.92$ MeV, $I = 3\ \mu A$ | / | ${}^{12}C^{3+}$, $E = 7.85$ MeV, $I = 10\ \mu A$ |
| ${}^{12}C^{4+}$, $E = 9.80$ MeV, $I = 3\ \mu A$ | / | ${}^{12}C^{5+}$, $E = 11.75$ MeV, $I = 50$ nA |



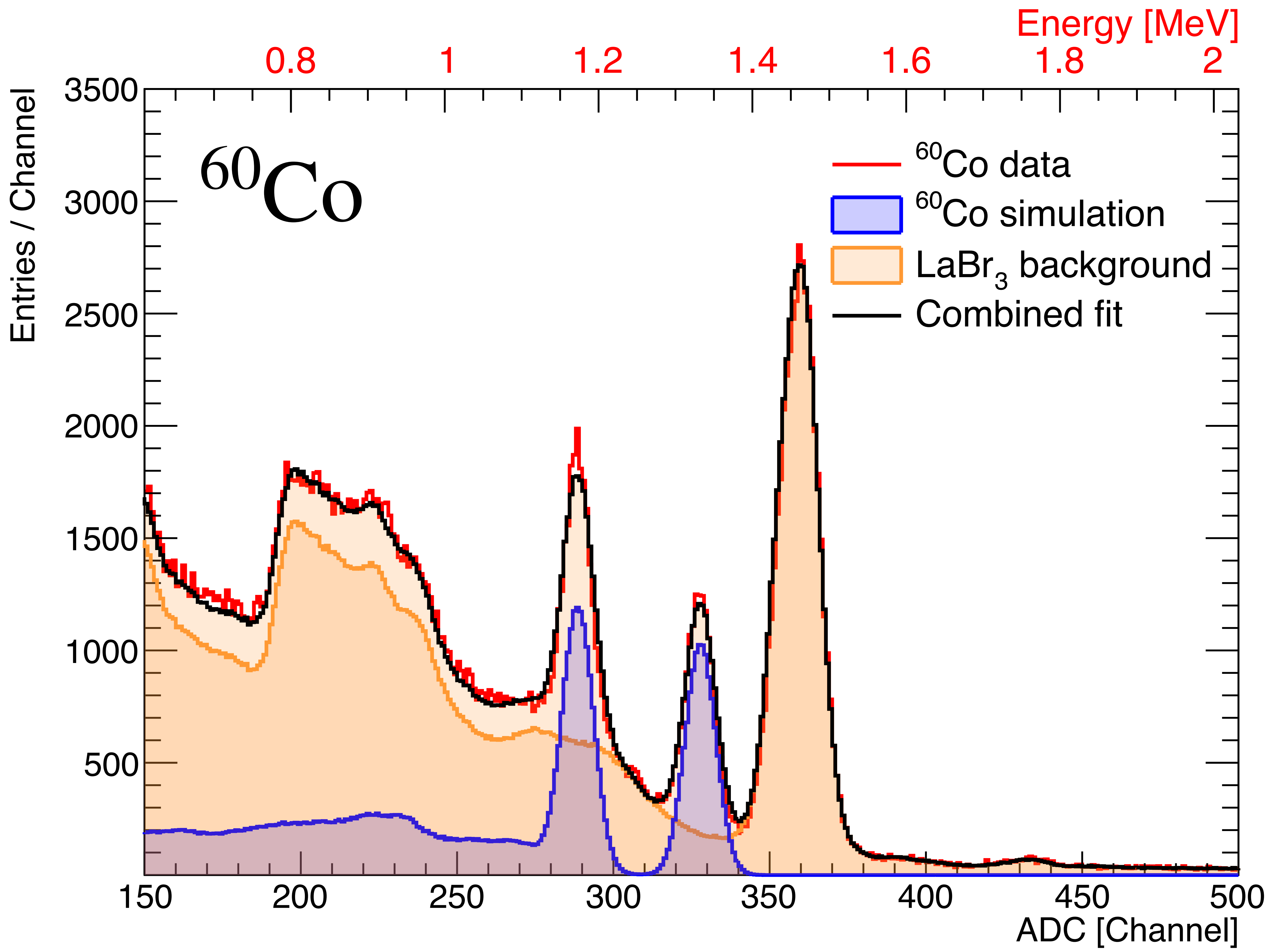
# HANUL Ball detector

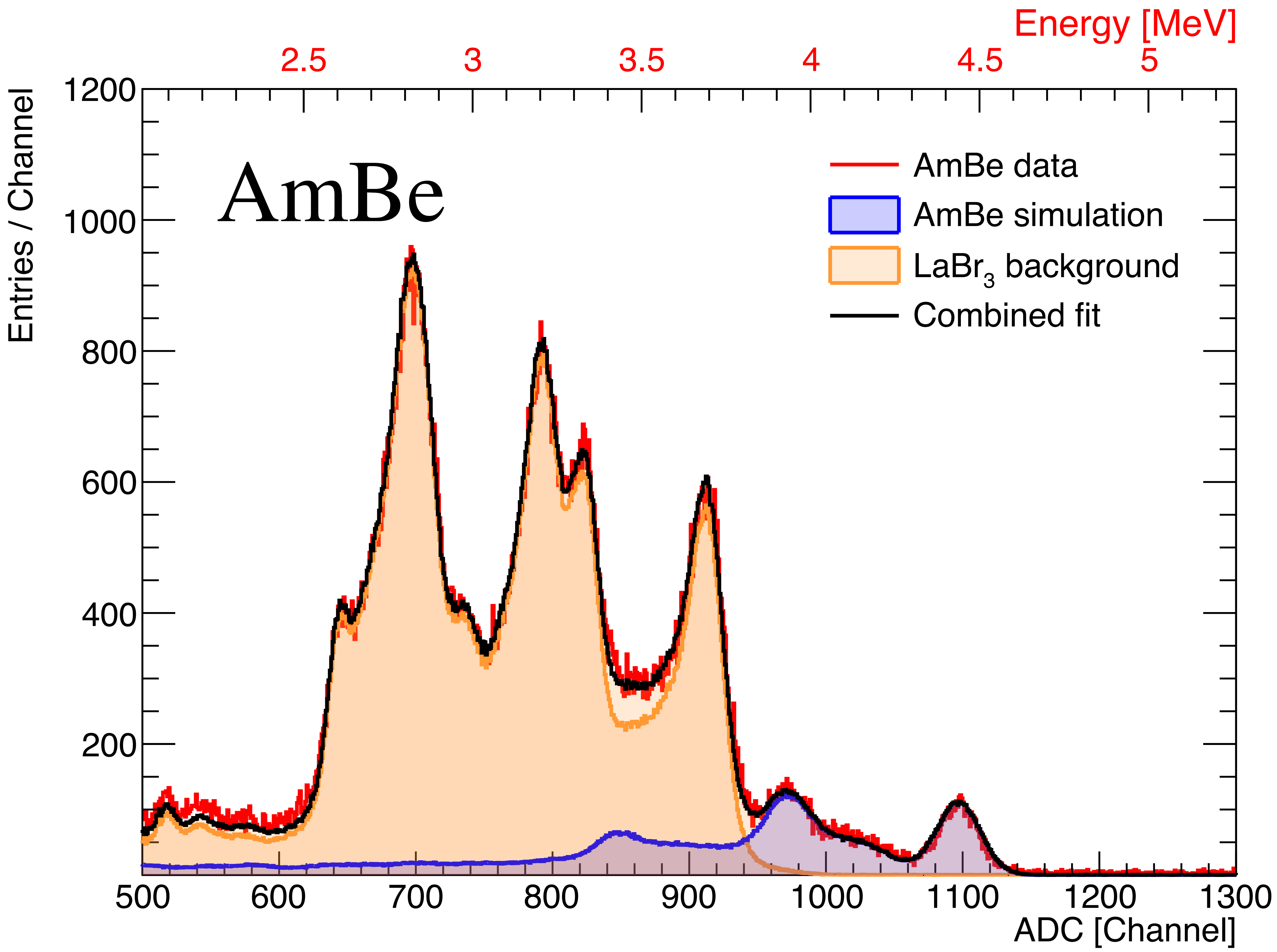





- $LaBr_3(Ce)$ detector array 12 channels
- On the faces of a truncated cuboctahedron structure
- Crystal size: $5\ \mathrm{cm}(\phi) \times 7.5\ \mathrm{cm}(\mathrm{h})$
- Detector performance such as calibration, resolution and efficiency.

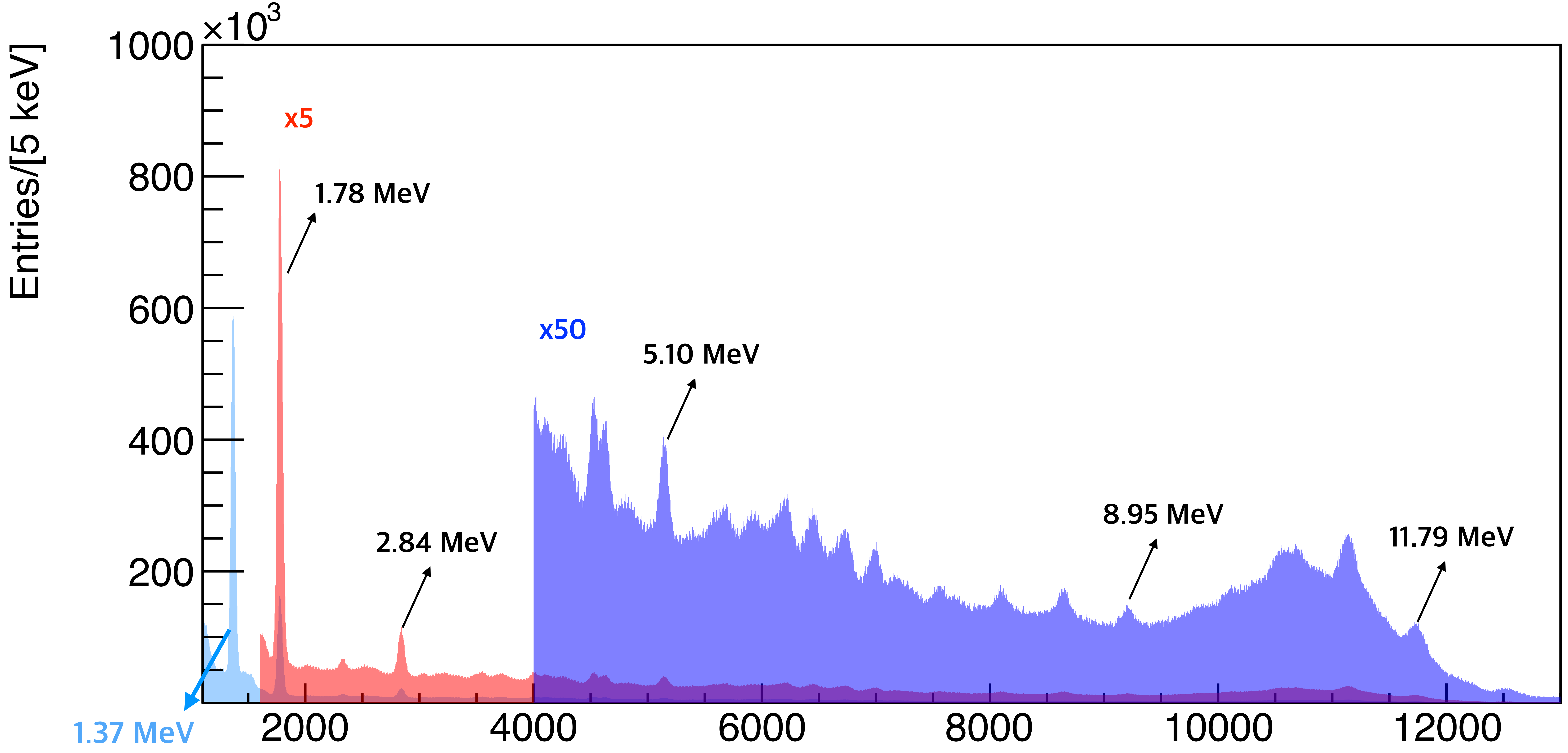
# RI Source test



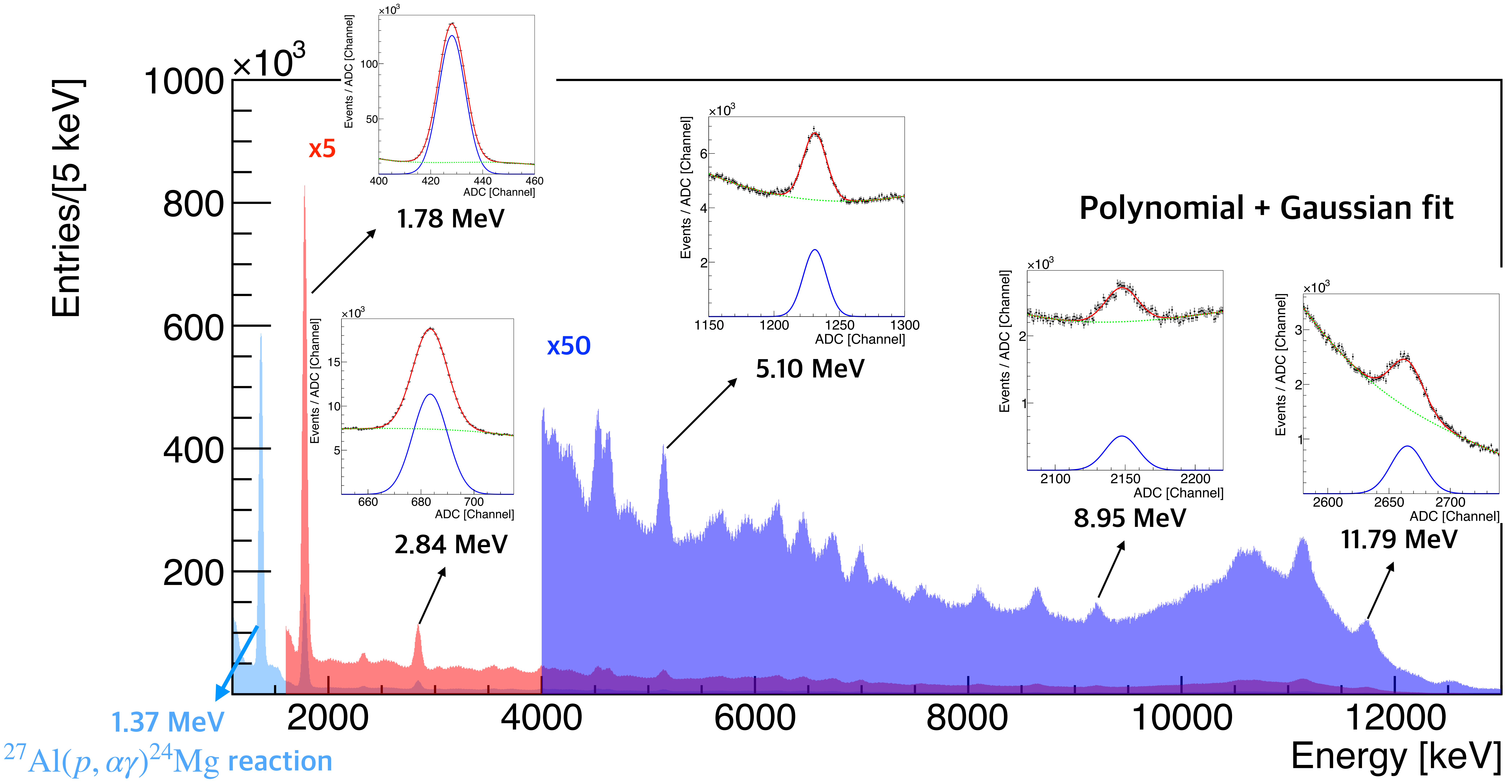

- **Combined fitting of $LaBr_3$ self-radioactive background + simulated $\gamma$ spectra**

# 0.8 $\mu$m Al foil target Energy Spectrum

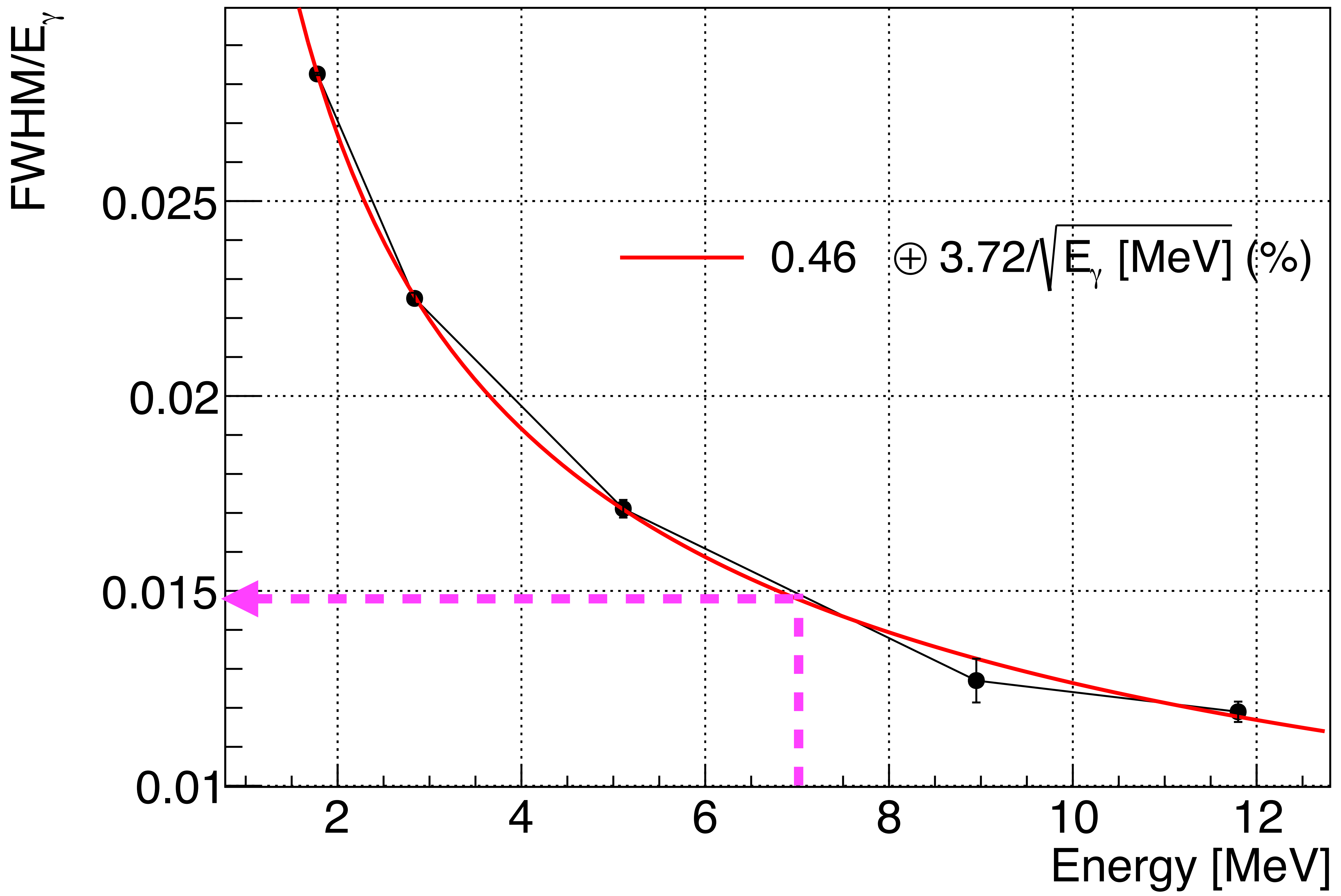


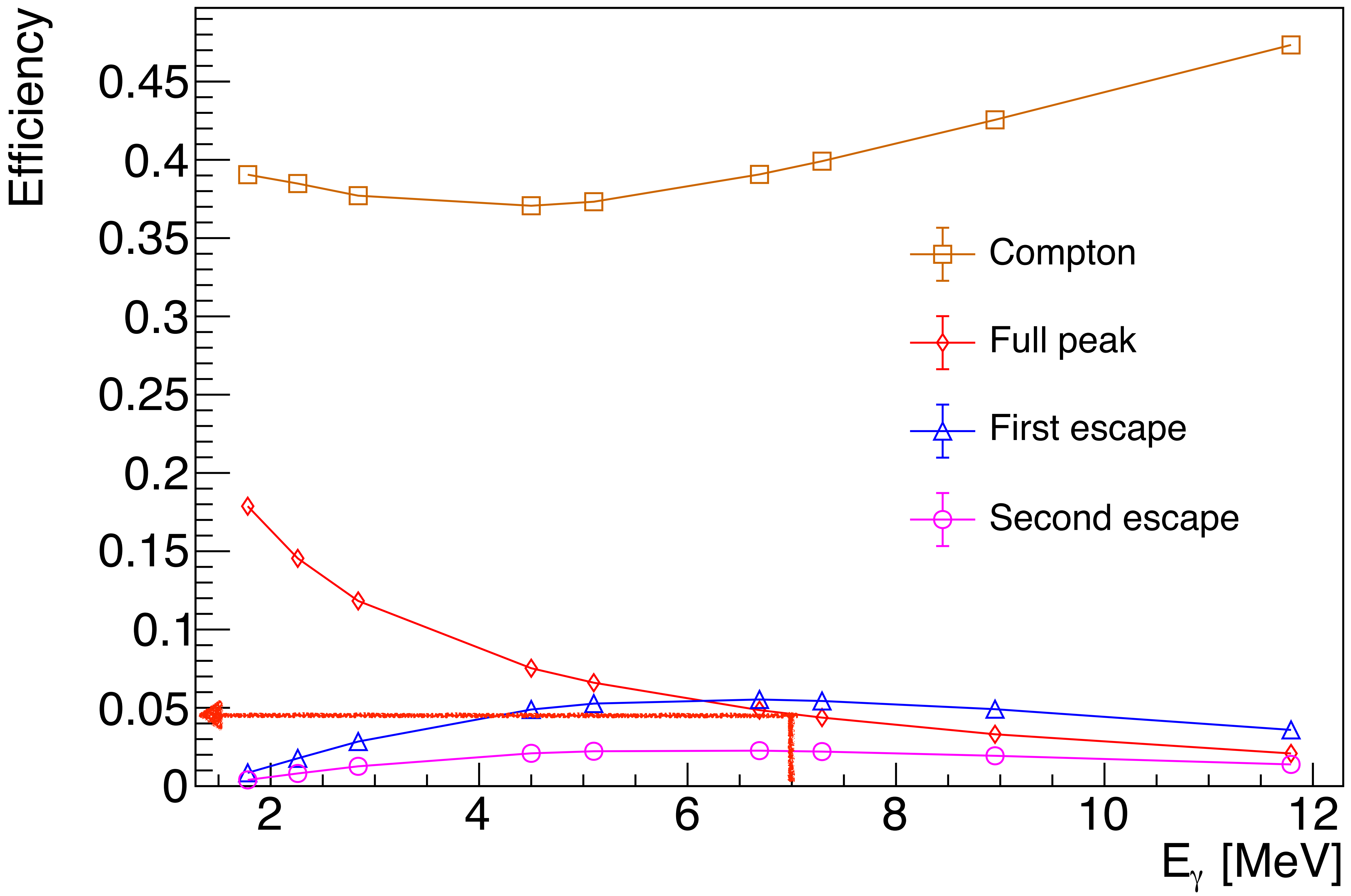

$^{27}$Al$(p, \alpha\gamma)^{24}$Mg reaction

# 0.8 $\mu$m Al foil target Energy Spectrum



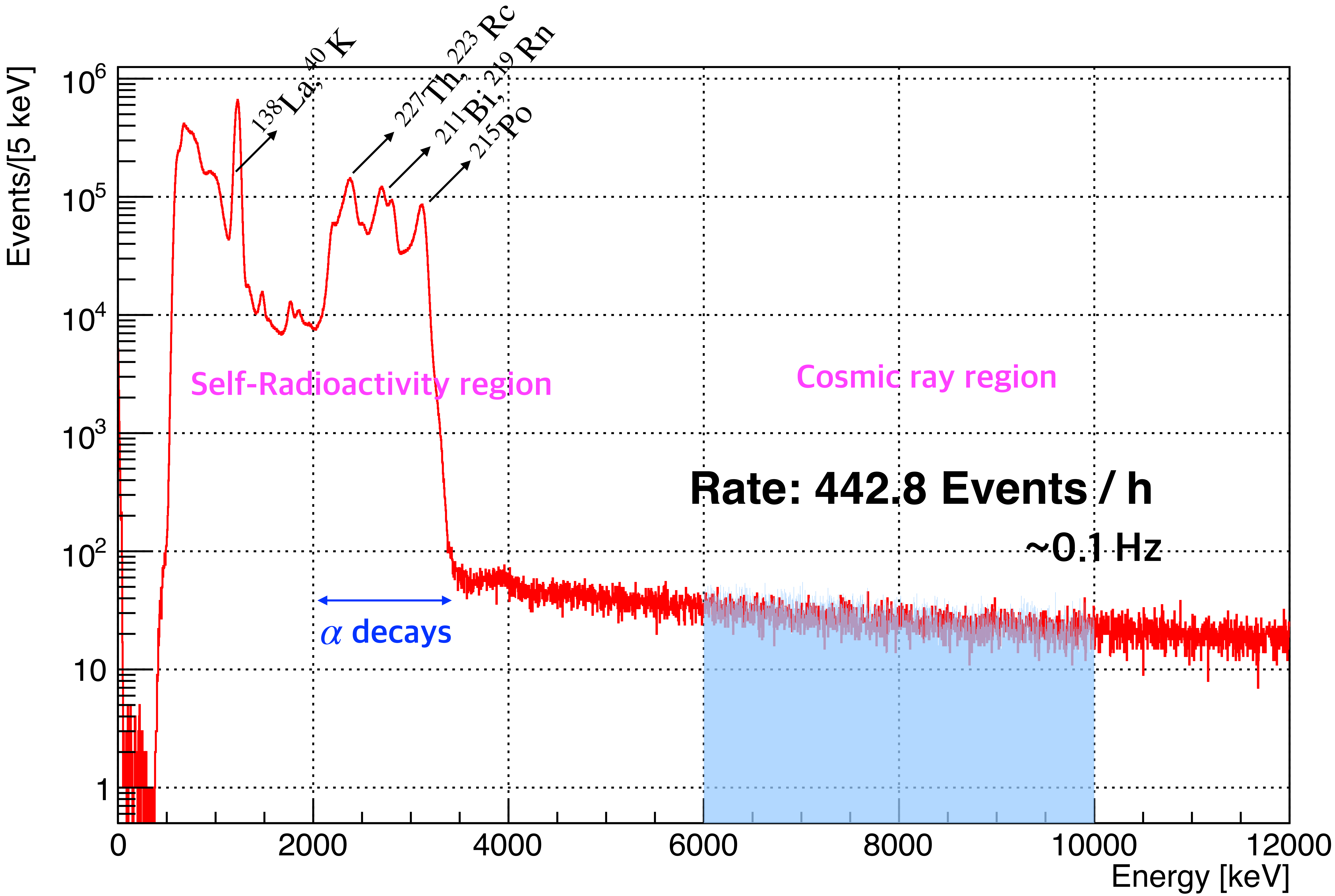
# Energy resolution and Efficiency




- 1.5 % FWHM (Al foil data) and 5% full peak efficiency (Simulation) at 7 MeV

# LaBr3(Ce) + Cosmic ray background



# Summary

- Performance test of $\mathrm{LaBr_3(Ce)}$ array for the COREA experiment
- $^{27}\mathrm{Al}(p,\gamma)^{28}\mathrm{Si}$ at $E_p = 2.05\ \mathrm{MeV}$ provides $\gamma$ ray peaks up to $13\ \mathrm{MeV}$
- Breakout reaction of Mg-Al cycle is important for early stage stellar nucleosynthesis
- RI source, $0.8\ \mu m\ \mathrm{Al}$ foil, cosmic run data
- Detector performances were studied with known $\gamma$ peaks and Geant4 simulation

  ➡**1.5% resolution (FWHM), 5% Full peak efficiency and 0.1 Hz cosmic ray**
- **The goal is the complete comprehension of the spectra**

  ➡**Overall fitting taking into account background,**
  **accidental coincidence, escape peaks and compton edge**