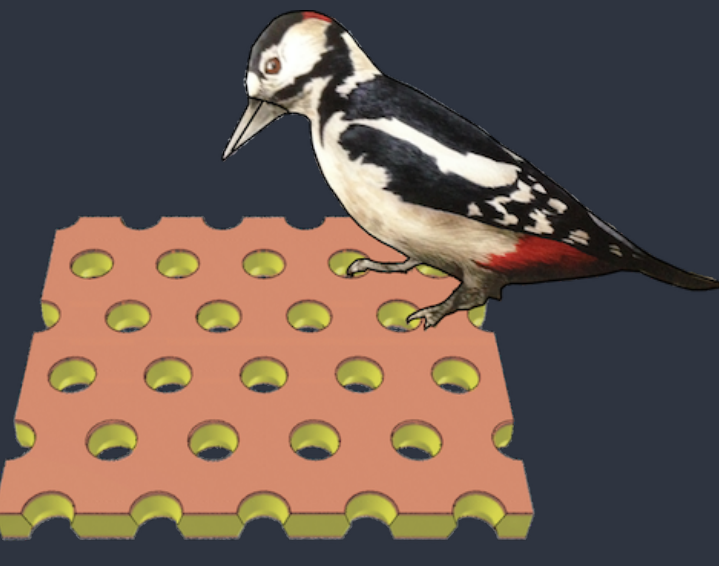# ELITPC - an active target TPC for studying nuclear reactions at astrophysical energies

M. Fila[1], M. Ćwiok[1], W. Dominik[1], Z. Janas[1], A. Kalinowski[1], M. Kuich[1], C. Mazzocchi[1], M. Zaremba[1], M. Gai[2]

[1]Faculty of Physics, University of Warsaw, Poland
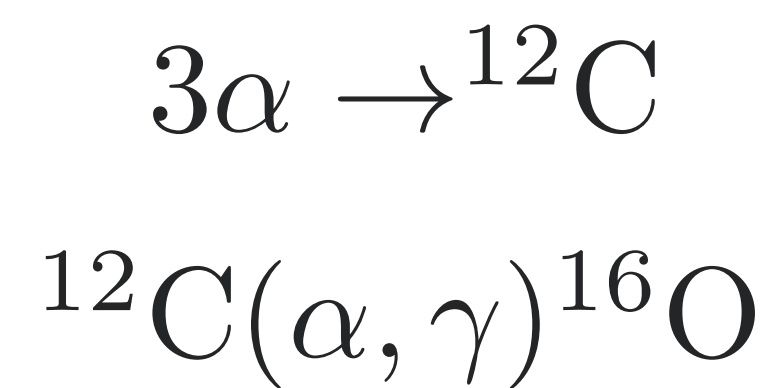[2]University of Connecticut, USA

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ELITPC
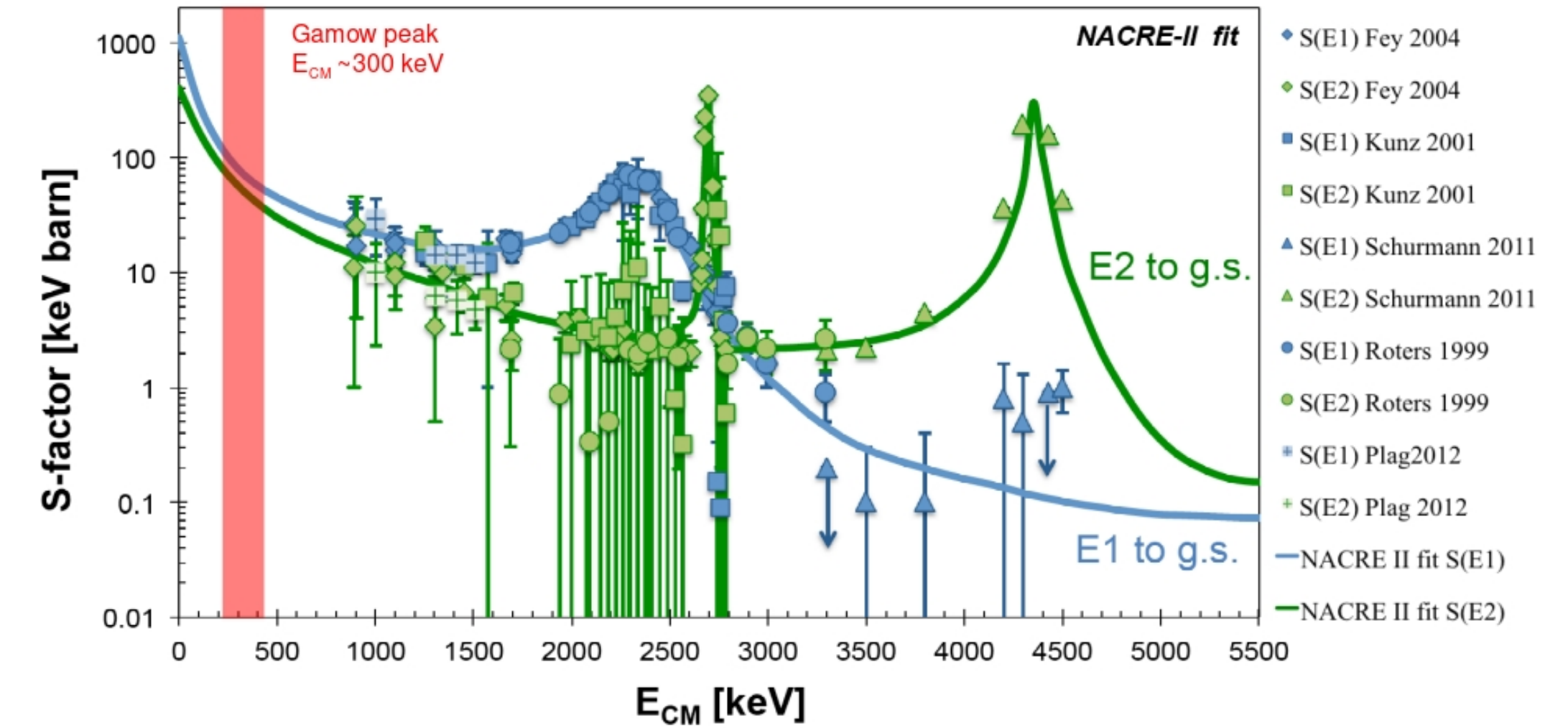
"It is little wonder that the determination of the ratio $^{12}C/^{16}O$ produced in helium burning is a problem of paramount importance in Nuclear Astrophysics."

W. A. Fowler, Rev. Mod. Phys 56, 149 (1984)

The ratio is regulated by two reactions:

$$3\alpha \rightarrow {}^{12}C$$
$$^{12}C(\alpha,\gamma)^{16}O$$

The cross section of $^{12}C(\alpha,\gamma)^{16}O$ at the stellar relevant Gamow peak is too small to measure in present day experiments.

Nacre II, Y. Xu et al., Nuclear Physics A 918 (2013)

Extrapolated astrophysical S-factors at Gamow peak in red giant stars (~300 keV) have uncertainty of 40-80%.
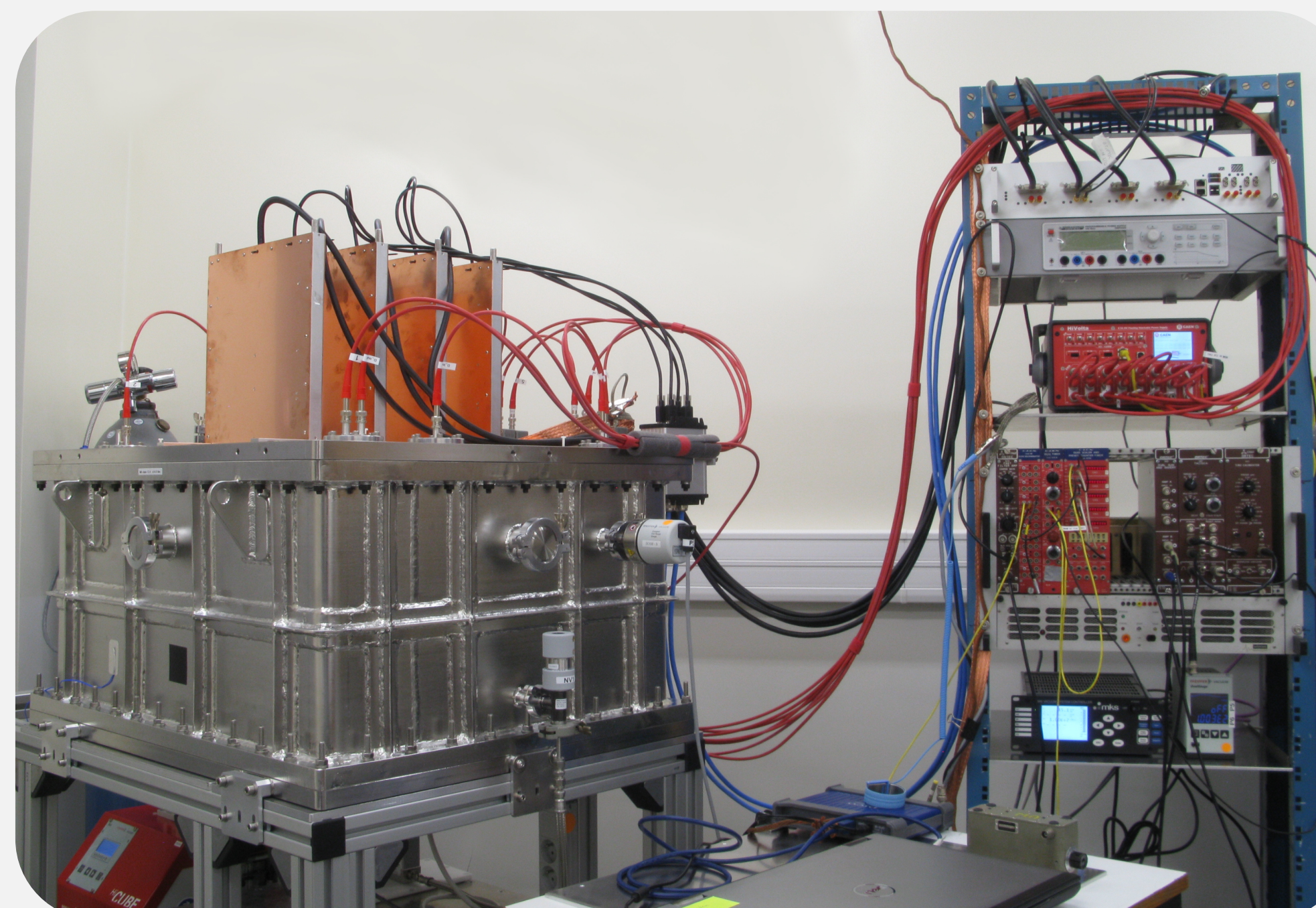

The cross sections of α-capture reaction and time-reversal photodisintegration are related by the principle of detailed balance:

$$^{12}C(\alpha,\gamma)^{16}O \rightleftharpoons {}^{16}O(\gamma,\alpha)^{12}C$$

$$\sigma_{\alpha,\gamma} = \sigma_{\gamma,\alpha} \frac{2J_O + 1}{(2J_\alpha + 1)(2J_C + 1)} \frac{E_\gamma^2}{E_{CM}} \frac{1}{\mu_{\alpha C}c^2}$$

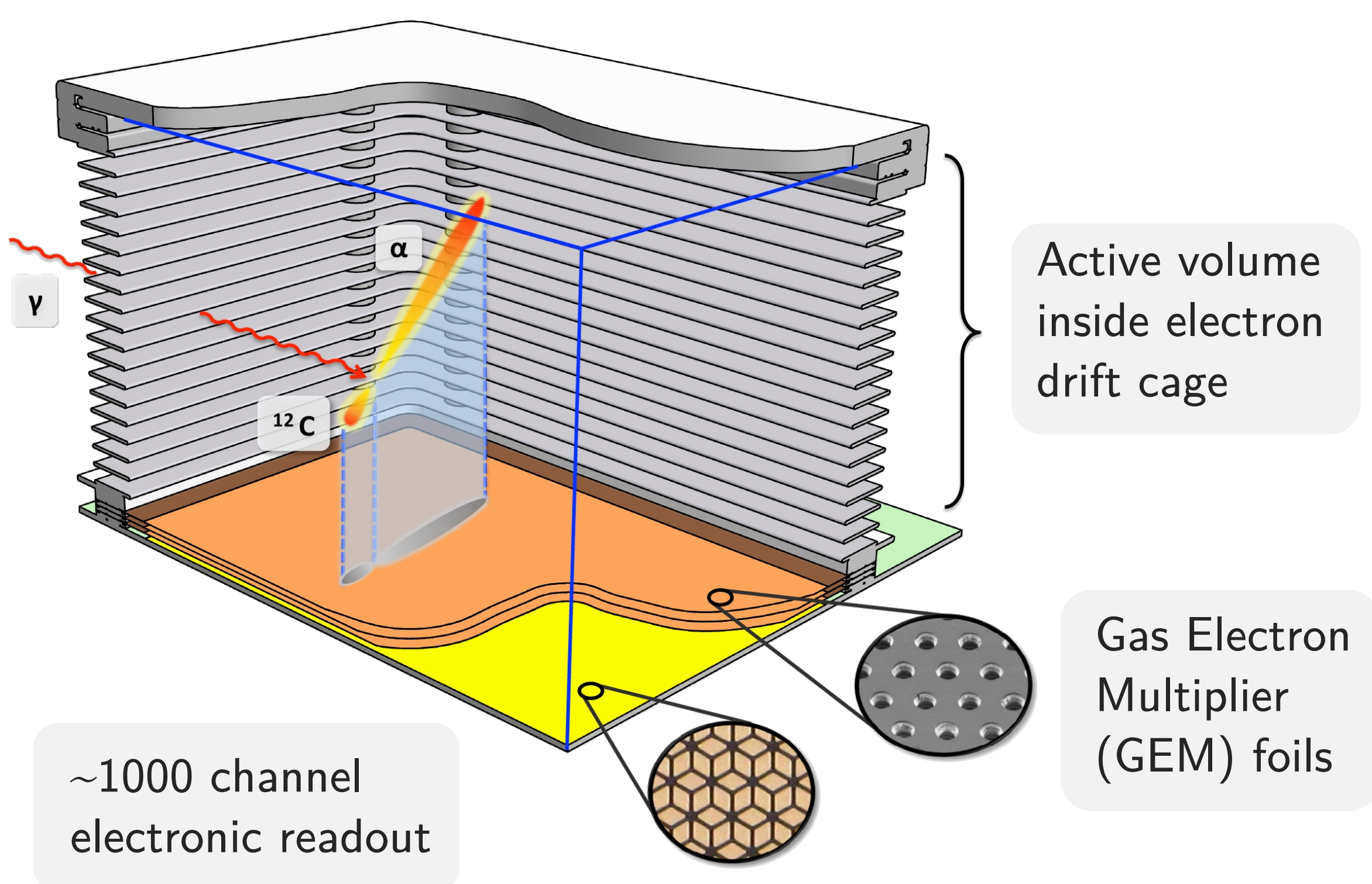The high intensity monochromatic γ-ray beams required for photodesintegration are available at facilities:

- ELI-NP, Romania (under construction)
- HIγS, USA
- NewSUBARU, Japan

Full-scale prototype detector next to its setup.

Goals:

- study (α,γ) and (p,γ) reactions of astrophysical interest,

- measure energies and angular distributions of photodesintegration reactions products,

- measure the cross sections of $^{16}O(\gamma,\alpha)^{12}C$ reaction down to 1 MeV,

- reduce the uncertainty of $^{12}C(\alpha,\gamma)^{16}O$ S-factors at Gamow peak to 10%.

Active volume inside electron drift cage

Gas Electron Multiplier (GEM) foils

~1000 channel electronic readout

**Time projection chamber:**

- low pressure (~100 mbar) gas mixture acts as both ionisation medium and target,

- detector volume: 33×20 cm^2 (planar readout) × 20 cm (drif length),

- three 50-μm thick Gas Electron Multiplier (GEM) foils for charge amplification,

- General Electronics for TPC (GET) for signal amplification & digitization,

- self or external triggering,

Multi-layer readout PCB

Virtual pixel
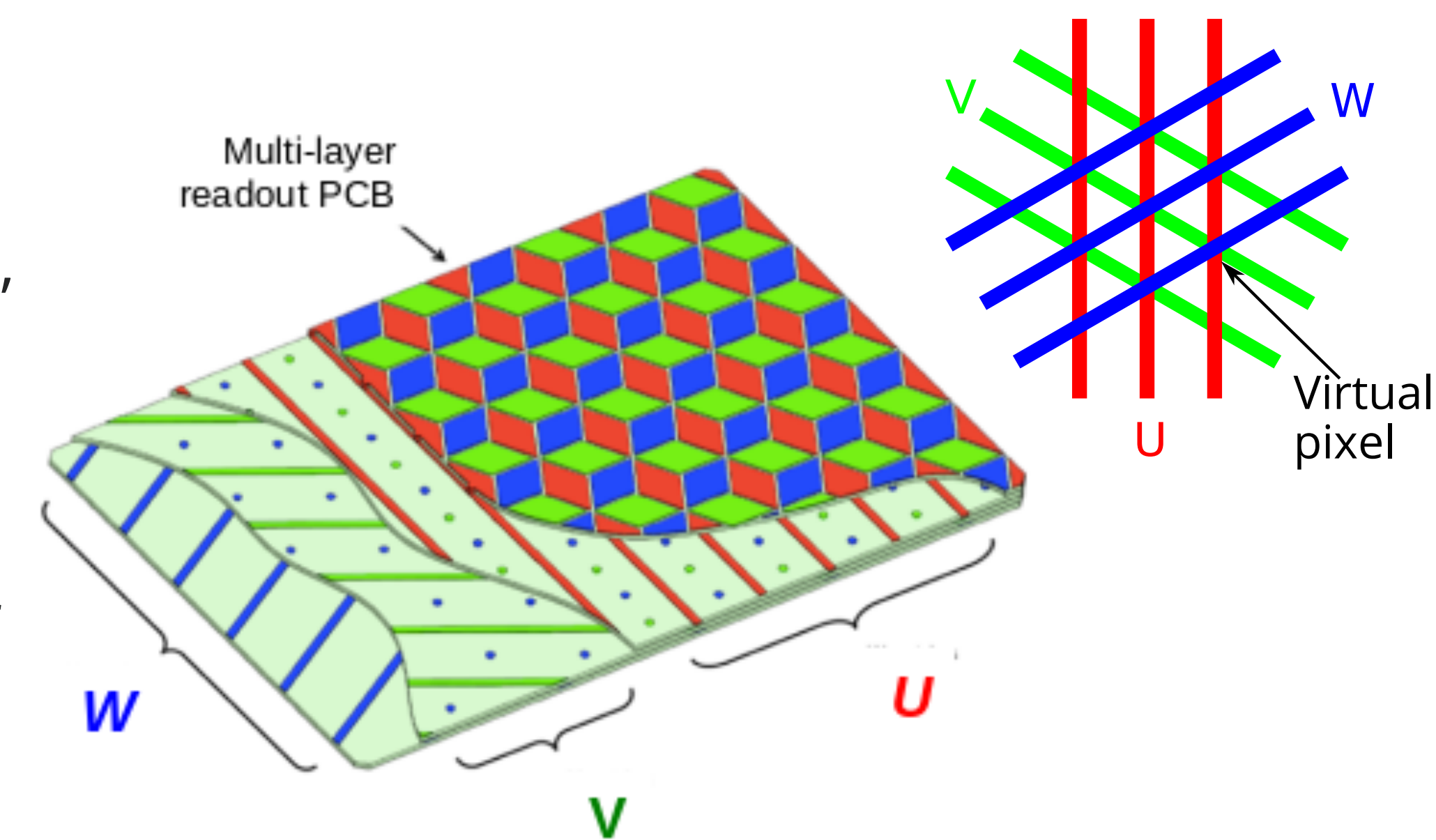
- 3-coordinate, redundant, planar strip readout suited for measuring a few particles per event.

Event reconstruction algorithms and data analysis tools are being developed. Test dataset includes data from an experiment with model detector filled with 100 mbar CO_2 and neutron beam at the 3MV Tandem IFIN-HH, Romania.
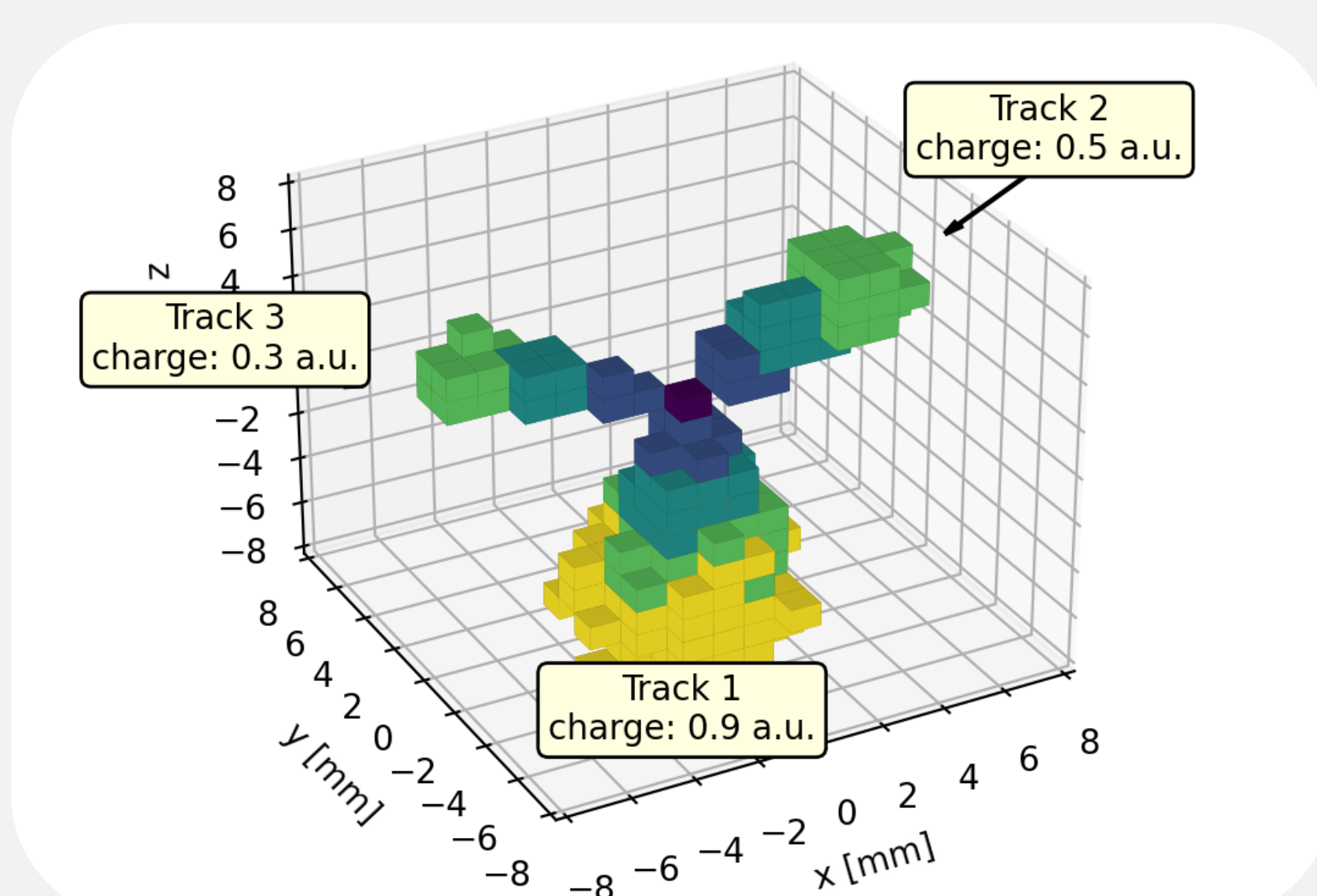
Visualisation of a $^{12}C(n,n')3\alpha$ reaction-products ionisation tracks.
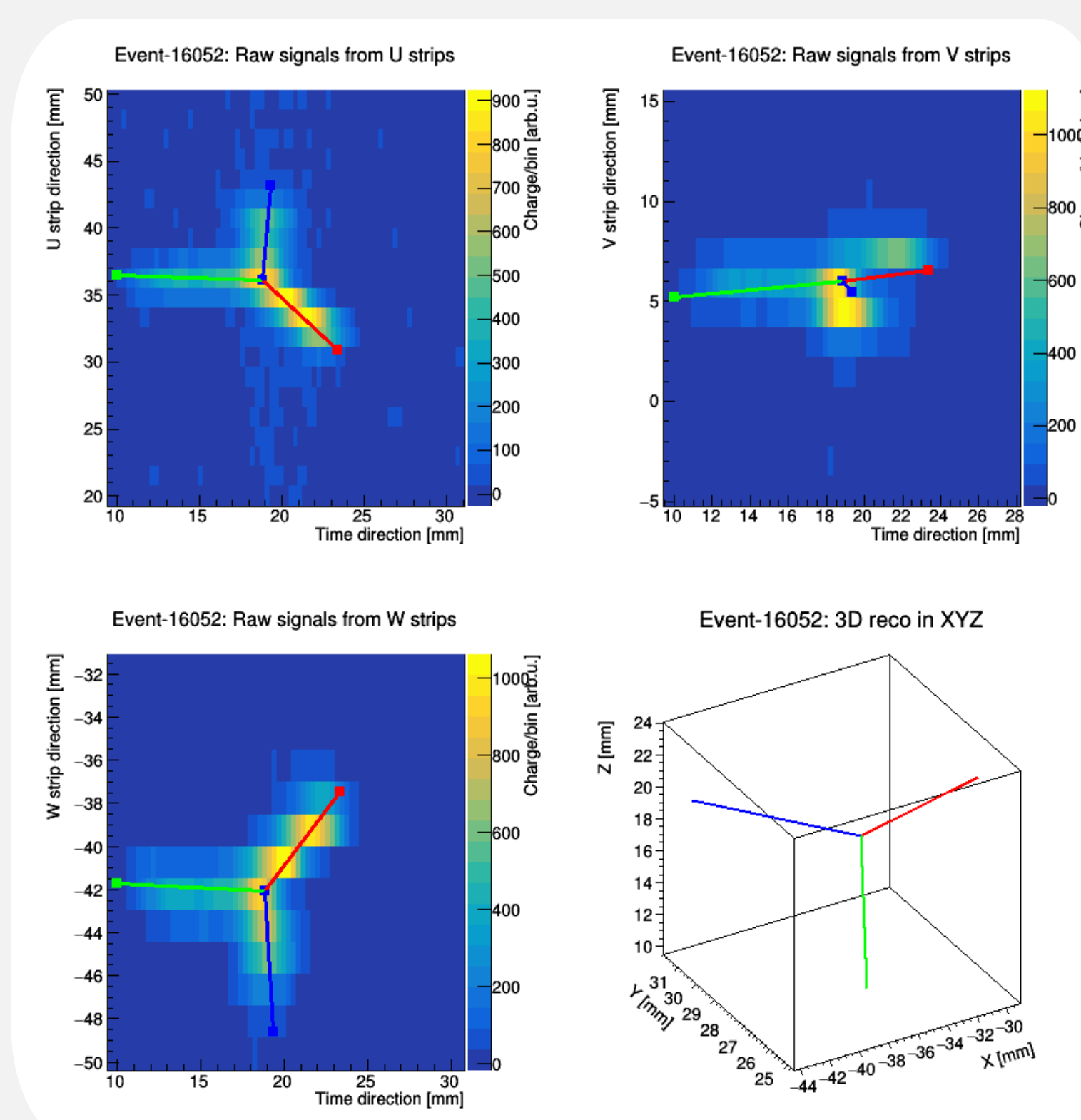
Reconstruction of the same 3α particles event registered by model detector.

Outlook:

- approved experiments at IFJ-PAN, Poland and HIgS, USA,

- DAY-1 experiment at ELI-NP, Romania.