Confirmation of the molecular structure of excited bands in ^{21}Ne

AGATA with TRACE

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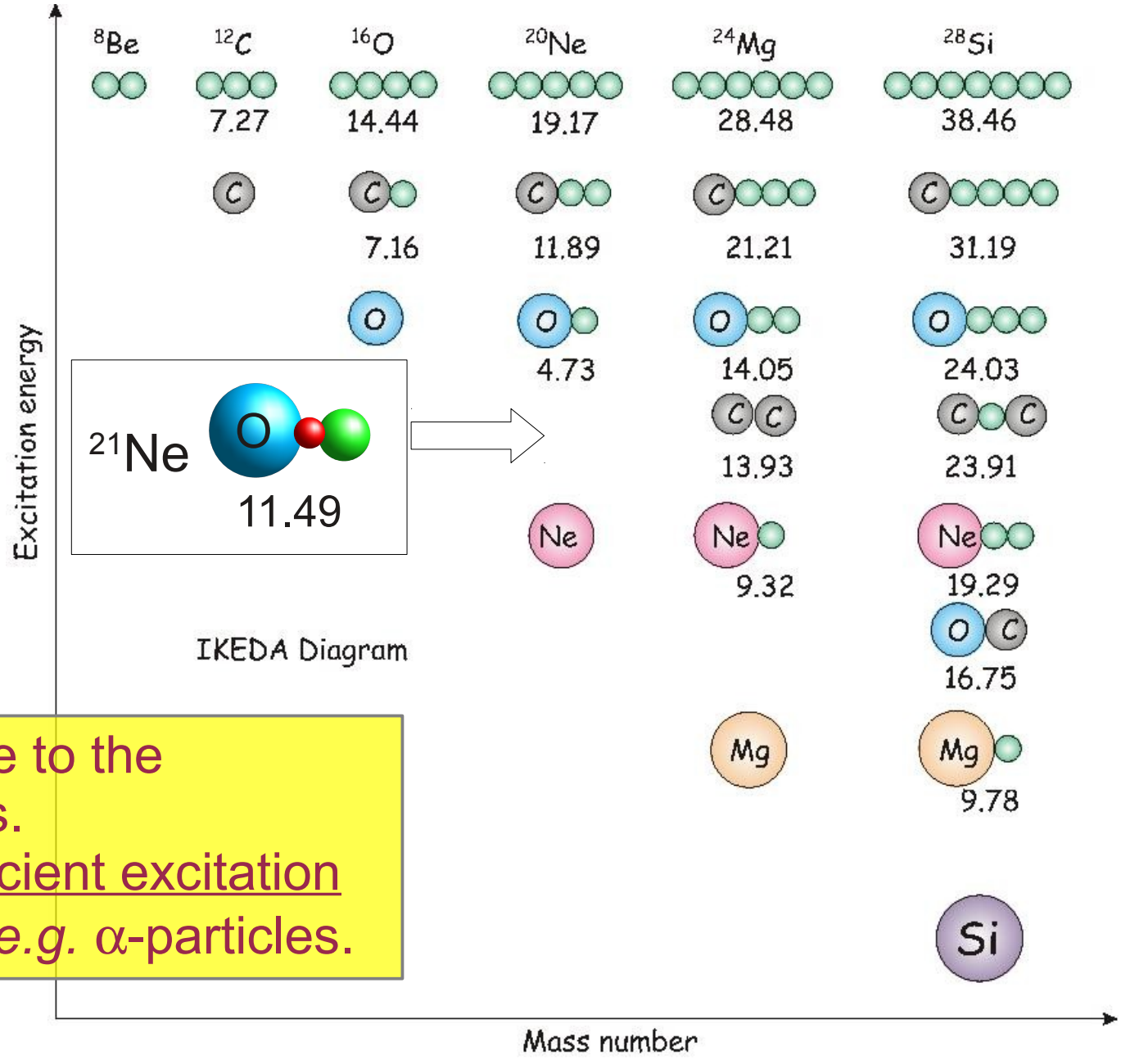
Clustering: a threshold effect

Cluster-decay thresholds in MeV

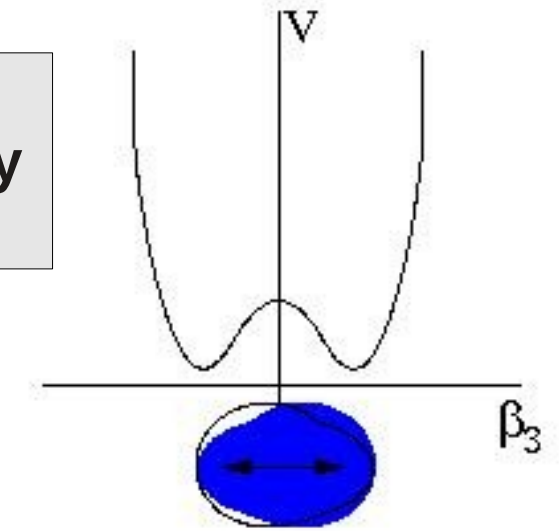


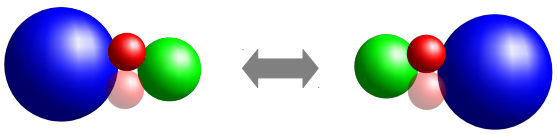
Clustering appears close to the cluster-decay thresholds.
The nucleus needs <u>sufficient excitation energy to dissolve</u> into, *e.g.* α-particles.

Tunnelling & octupole deformation in ^{21}Ne

Tunnelling: **large energy splitting**

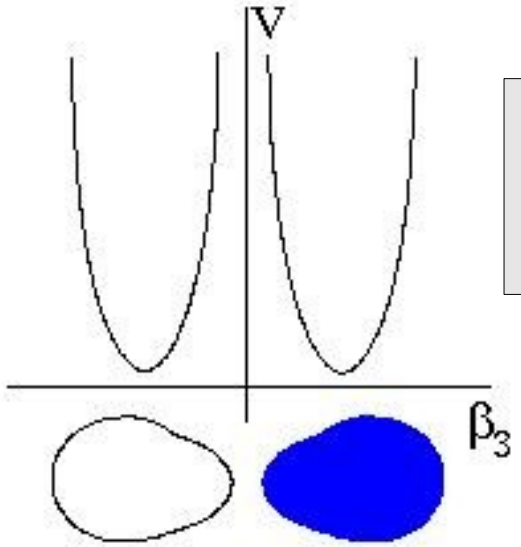
^{21}Ne: *K*=3/2 doublet

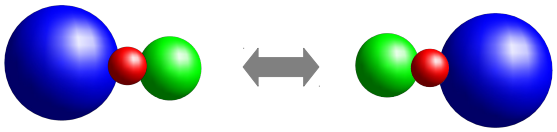




π-bond: *n*-distribution **away** from axis

^{21}Ne: *K*=1/2 doublet





σ-bond: *n*-distribution **on** the axis

No tunnelling: **degenerate levels**

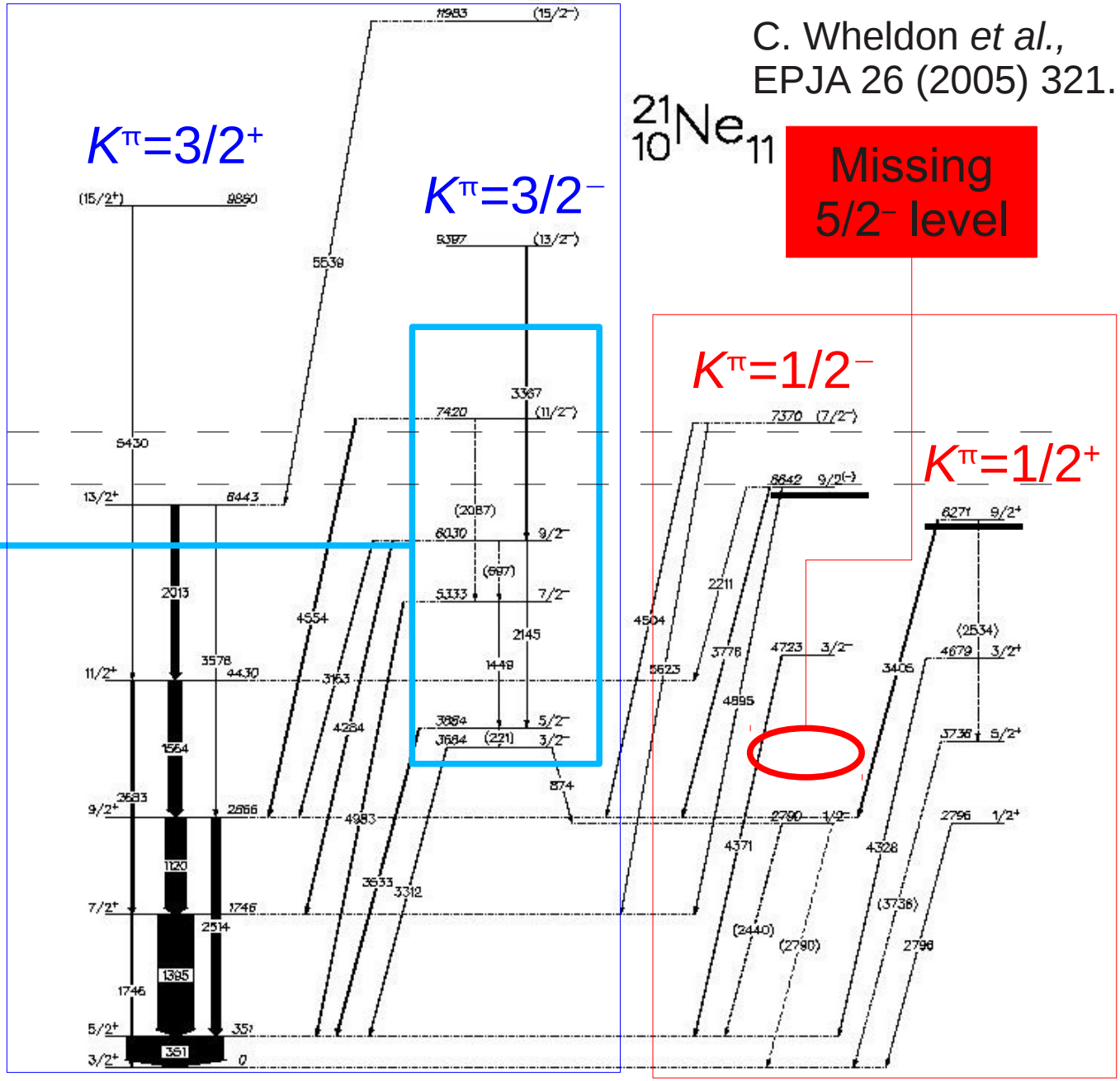
Results from GASP+ISIS

Neon-21 was the contaminant channel

In-band transitions

Both parity-doublet pairs are observed → the reaction populates the states of interest.

$^{16}O(^{7}Li, n\,p)^{21}Ne$



C. Wheldon *et al.*, EPJA 26 (2005) 321.

What makes a rotational band?

Gamma-ray spectroscopist	Particle spectroscopist
• Enhanced in-band transitions	• Common cluster decay widths
• Rotational energy dependence	• Rotational energy dependence
• In-band branching ratios	• Decays to similar daughter states

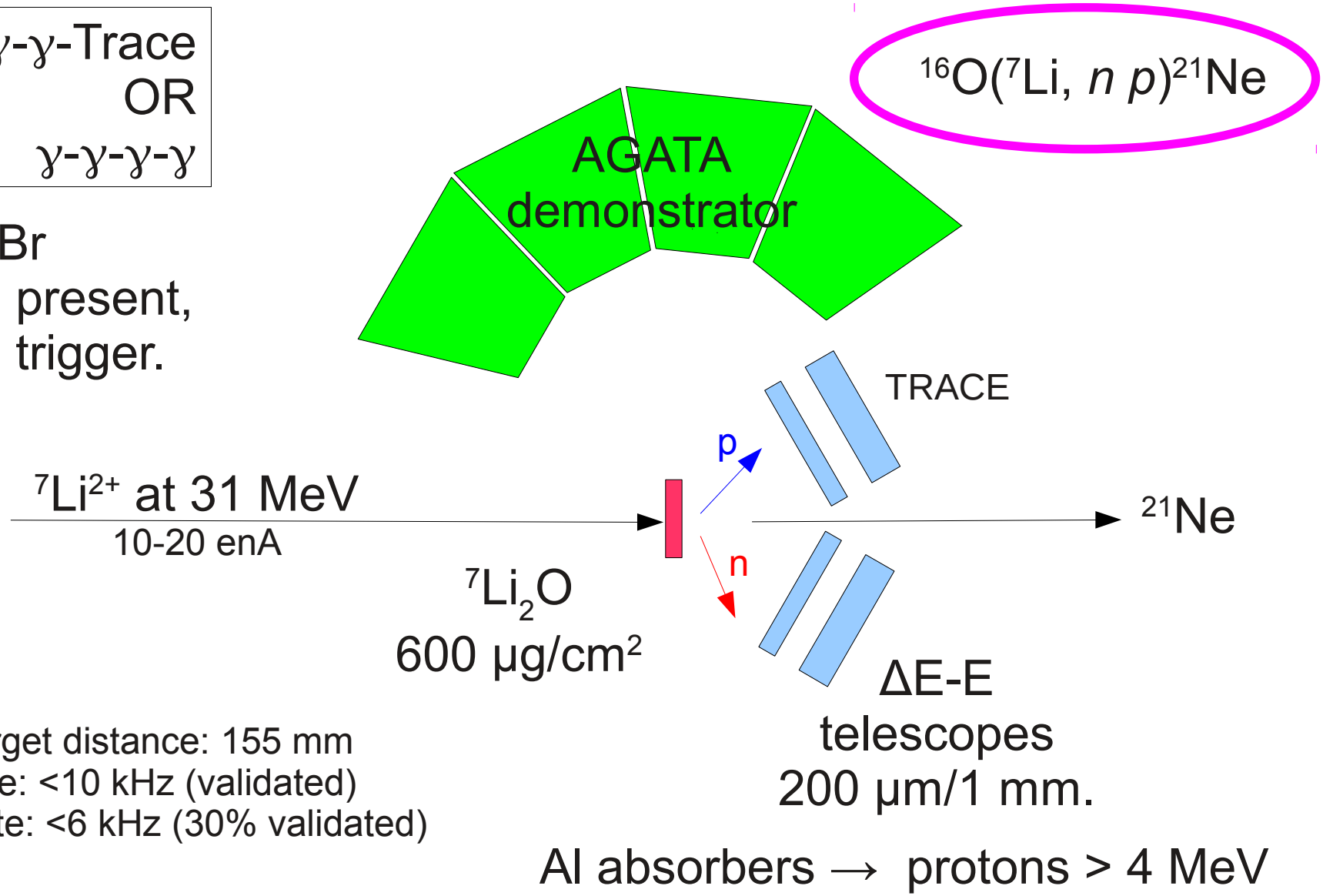
Usually, without the in-band transitions, some degree of uncertainty over band structures remains. This is true for many cluster bands in light nuclei.

Neon-21 is UNIQUE. The structures can be assigned and studied unambiguously.
Level lifetimes are known → need branching ratios to measure transition probabilities.

Experimental set-up

Trigger: γ-γ-Trace
OR
γ-γ-γ-γ

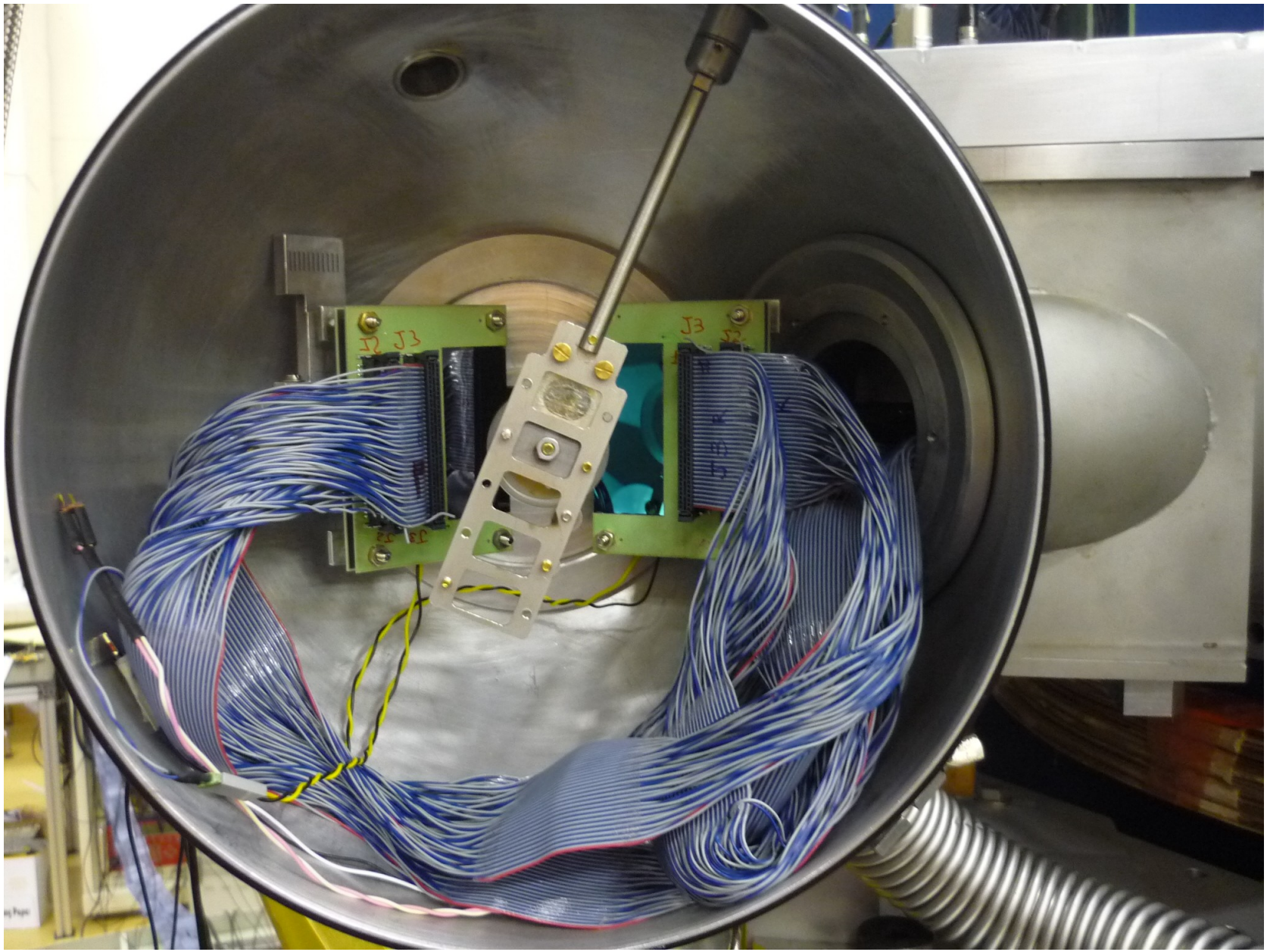
Some LaBr detectors present, but not in trigger.



AGATA-target distance: 155 mm
AGATA rate: <10 kHz (validated)
TRACE rate: <6 kHz (30% validated)

Al absorbers → protons > 4 MeV

Experimental set-up



Experiment – status and progress

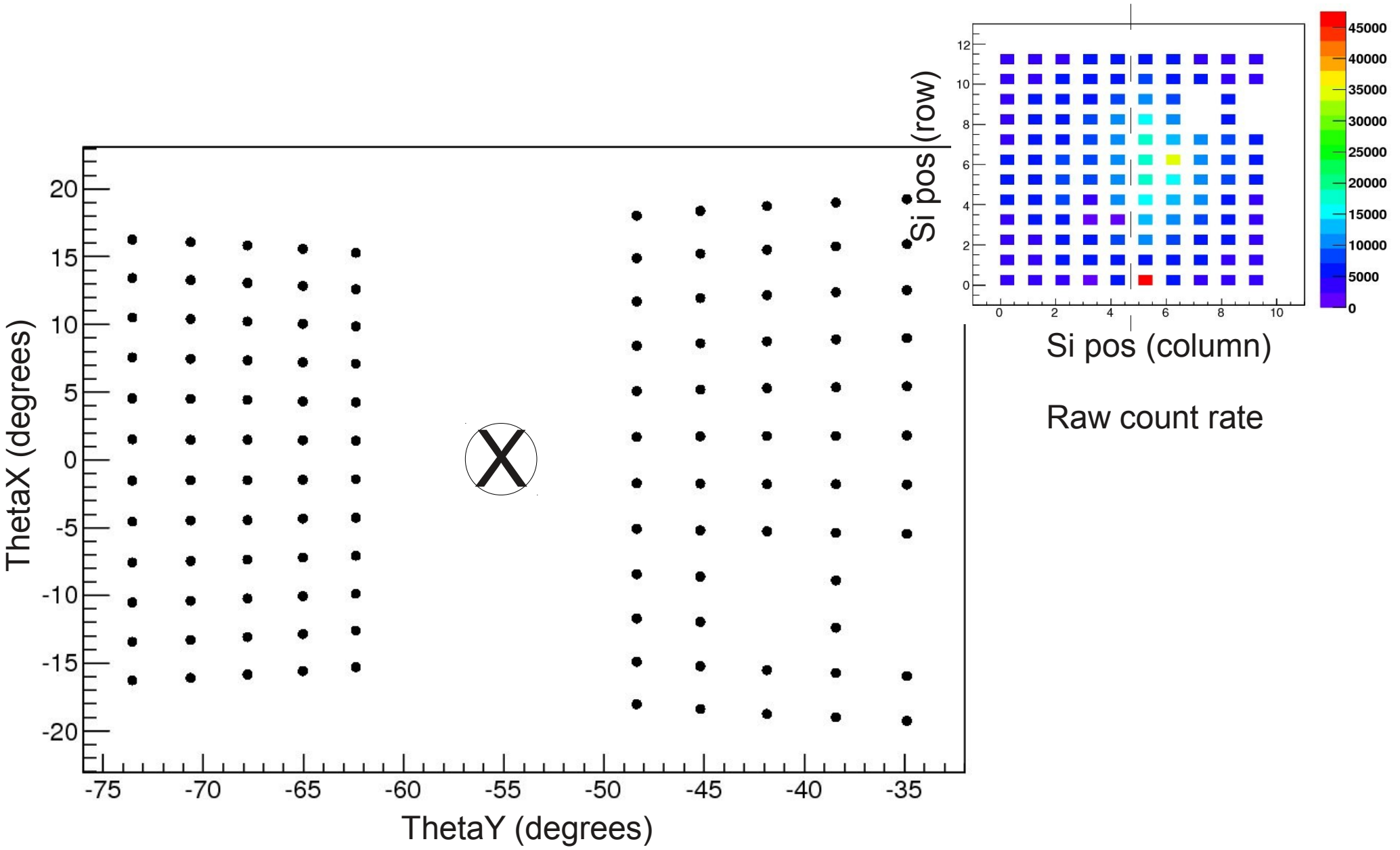
Status June 2011:

- Five days of beam time.
- No significant issues; stable beam conditions.
- Energy and initial efficiency calibration made with ^{152}Eu.
- Due to accelerator problems for making the ^{56}Co source, still awaiting high-energy efficiency calibration.

Status June 2012:

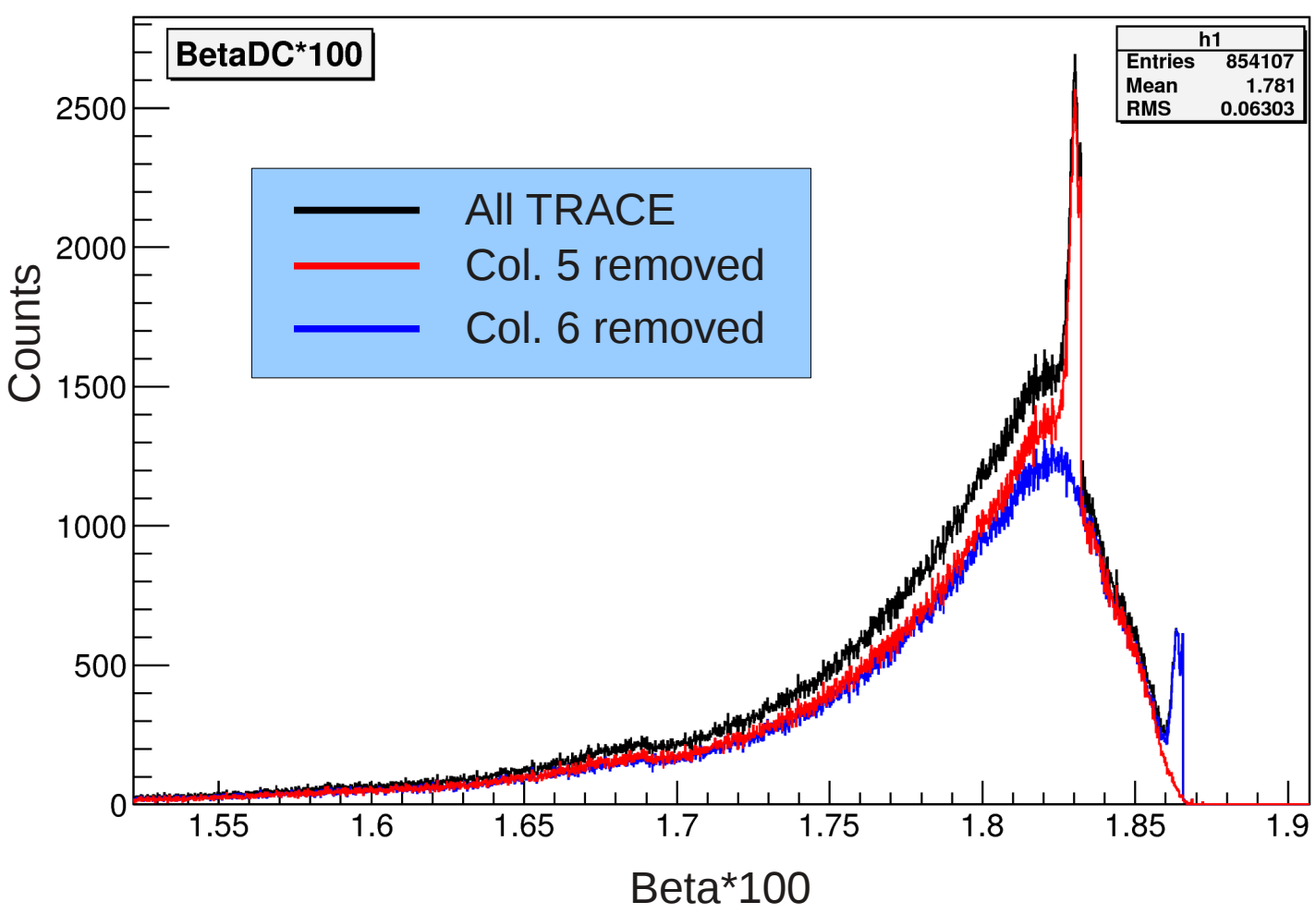
- Co-56 source production July 2011, followed in August by calibration for efficiency at high energy (>3.5 MeV).
- Calibration of AGATA completed – alignment of all segments for every run.
- Calibration of TRACE silicon detectors (E and ΔE).
- Reconstruction of missing segments via the replay of all the data (10 TB). (Copy of raw data in several locations.)
- Initial Doppler correction with TRACE positioning under-way.
- Energy-loss correction for protons through Al absorbers applied.

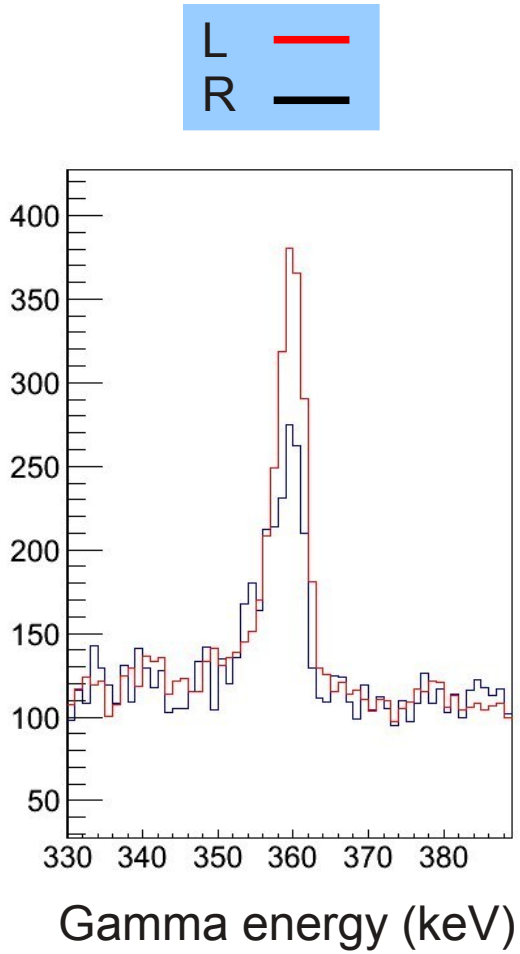
TRACE positioning



Doppler correction: beta

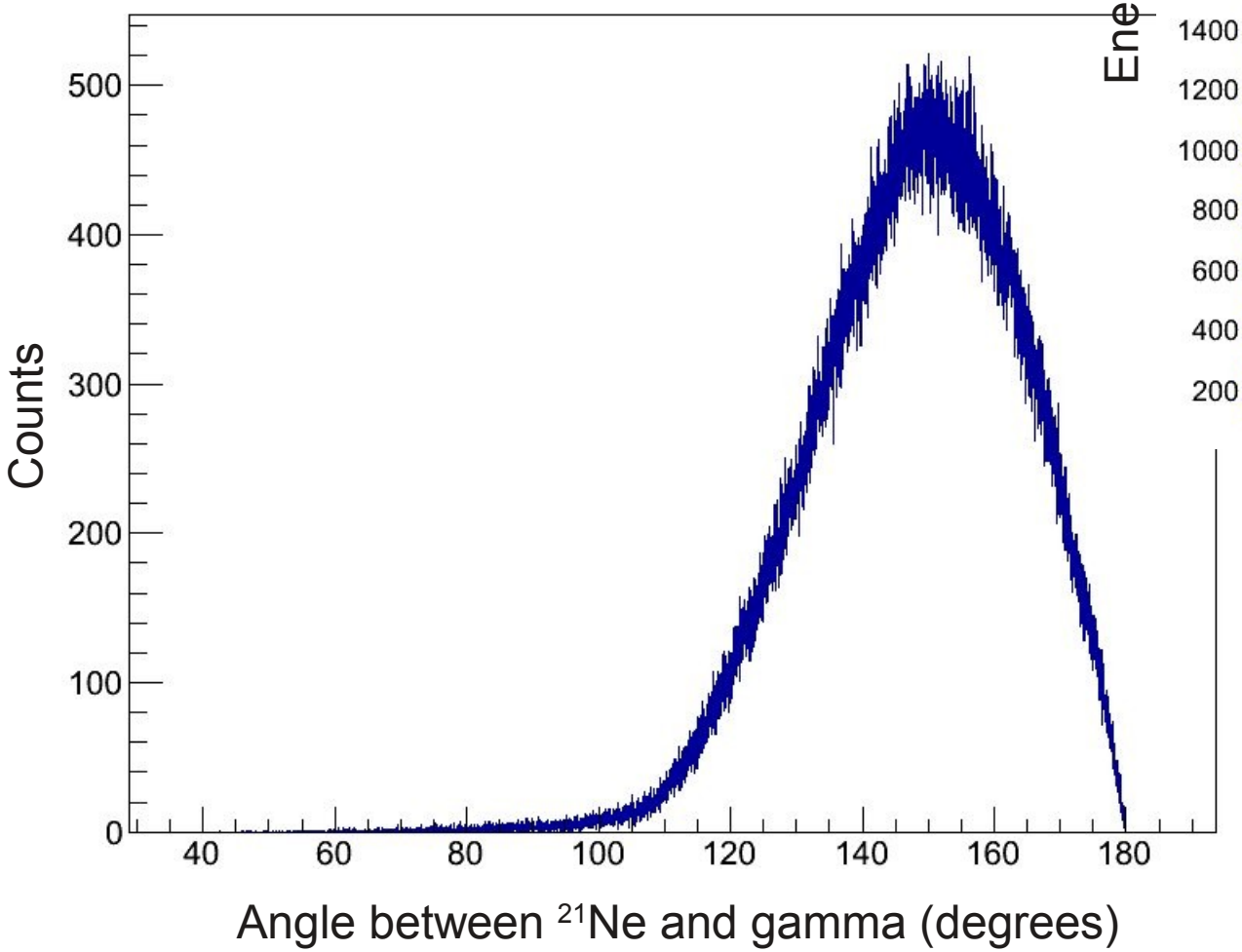
Beta for ^{21}Ne obtained from the energy and position of particles in TRACE.
The spikes are caused by noise in the the inner columns of the right ΔE pad.

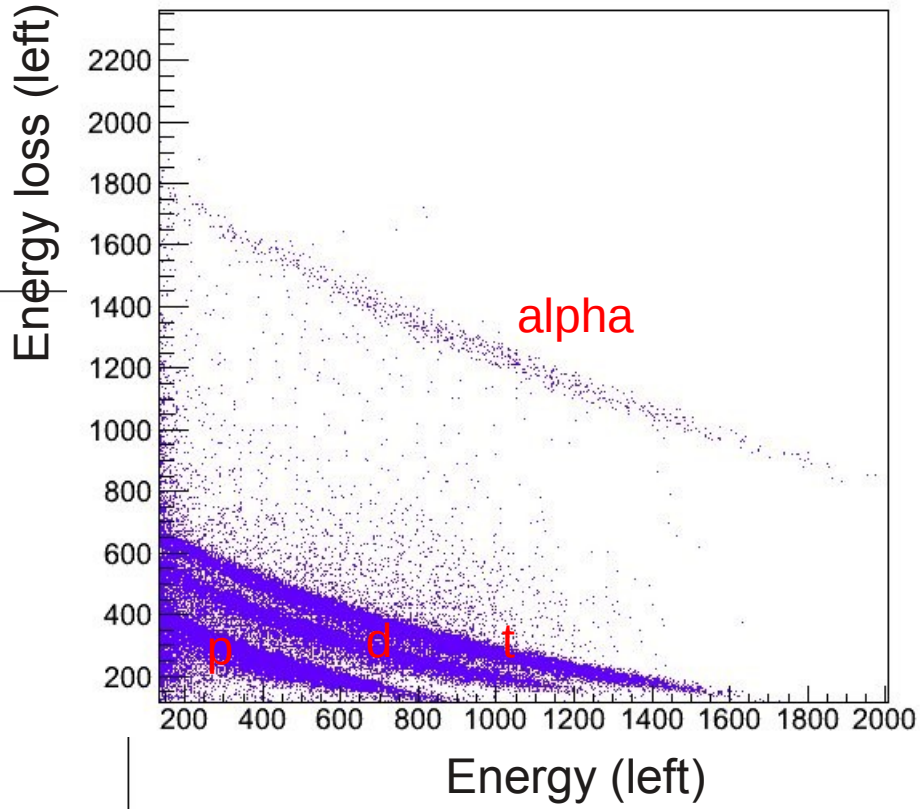




Particle id and angles

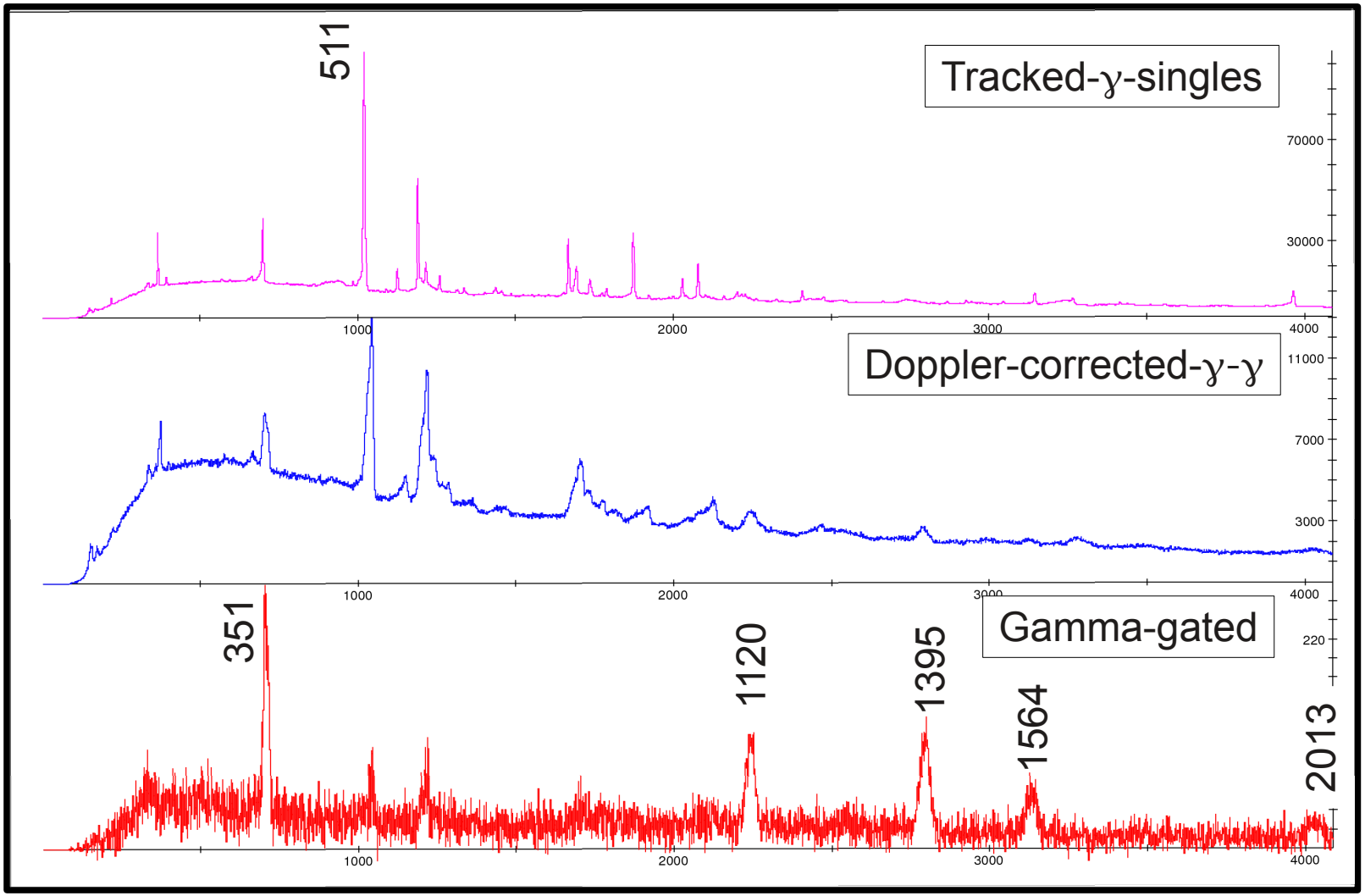
Protons, deuterons, tritons and alpha-particles are clearly distinguishable in TRACE.

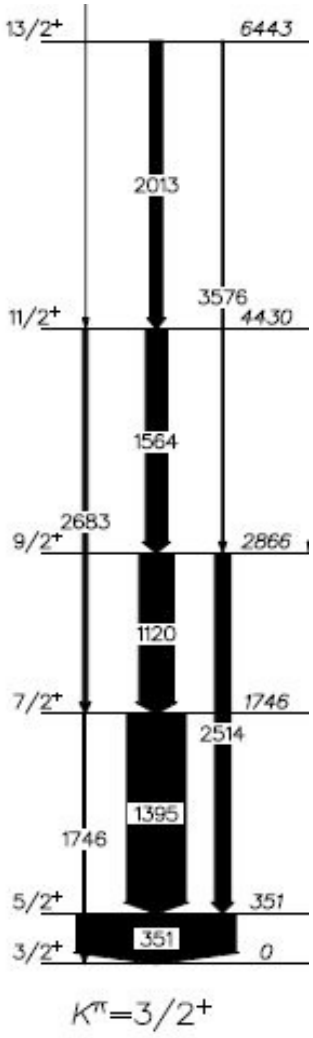




Spectra from near-line analysis

Doppler correction with average beta (no proton angle considered).





Disclaimer: different collection times/runs (near-line analysis)!

Summary and outlook

- Successful beam time.
- Gamma- and particle-coincidences are working
- Full replay completed.
- Missing segments recovered and errant segments gain-matched for every run.
- Initial Doppler correction implemented in analysis code.
- Energy-loss correction in 136 μm Al absorbers is done.
- Work to do improving on the TRACE positioning coupled with beta optimisation.
- Require sorting of full statistics for optimisation.

Acknowledgements

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Collaborators

Birmingham: Tz. Kokalova, N. Ashwood, M. Barr, N. Curtis, J. Malcolm

Krakow: N. Cieplicka

Legnaro: G. De Angelis, D. Bortolato, A. Gottardo, V. Modamio, A. Pipidis, E. Sahin, J.J. Valiente-Dobon

Manchester: D. Cullen

Milano: S. Brambilla, C. Boiano, A. Bracco, S. Leoni, R. Nicolini, S. Riboldi

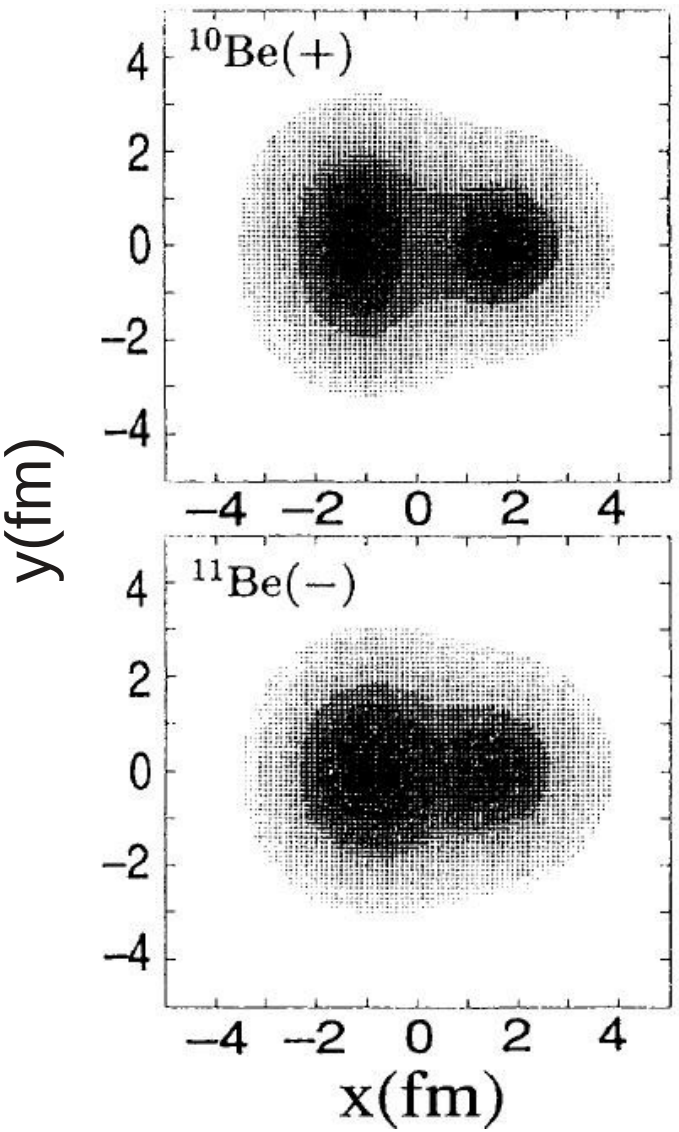
Padova: D. Bazzacco, E. Farnea, C. Michelagnoli, F. Recchia, C. Ur

UWS: L. Capponi, D. Mengoni

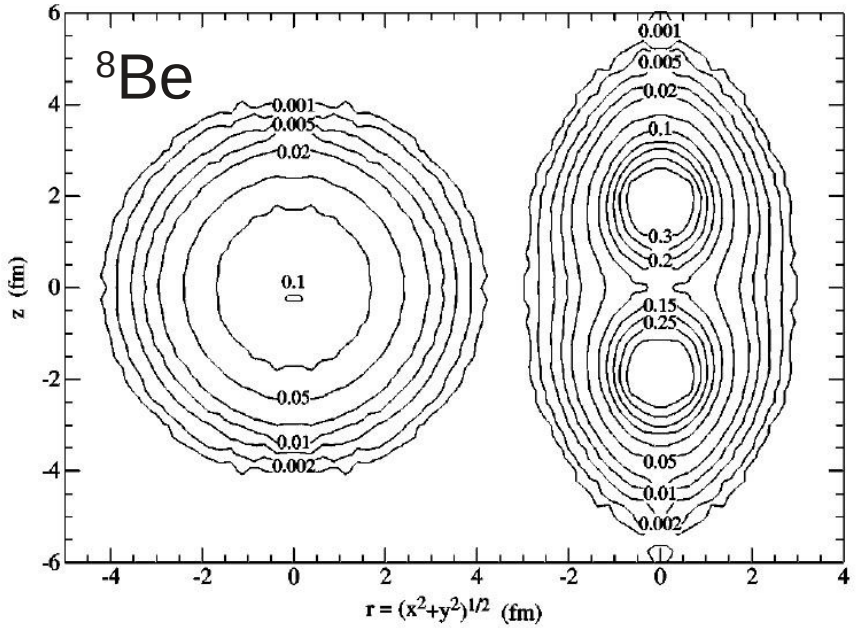
and the **AGATA Collaboration**.

Clustering in ab initio models

AMD[1]



GFMC[2]



Results from *ab initio* calculations:
anti-symmetrised molecular dynamics (AMD)
and Green's function Monte Carlo (GFMC).

[1]Y. Kanada-En'yo *et al.*, Phys. Rev. C52 (1995) 628.
[2]R.B. Wiringa et al., Phys. Rev. C62 (2000) 014001.