

Beta-delayed spectroscopy at the proton Drip Line with RCMP at TRIUMF

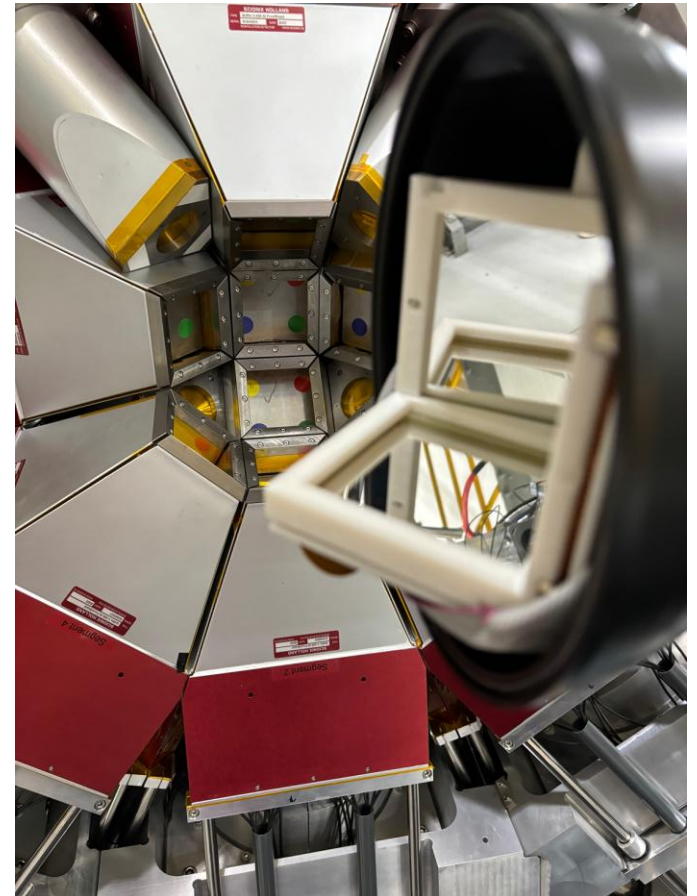
Emile Cantacuzène,
under the supervision of Gwen Grinyer



University
of Regina



GRIFFIN



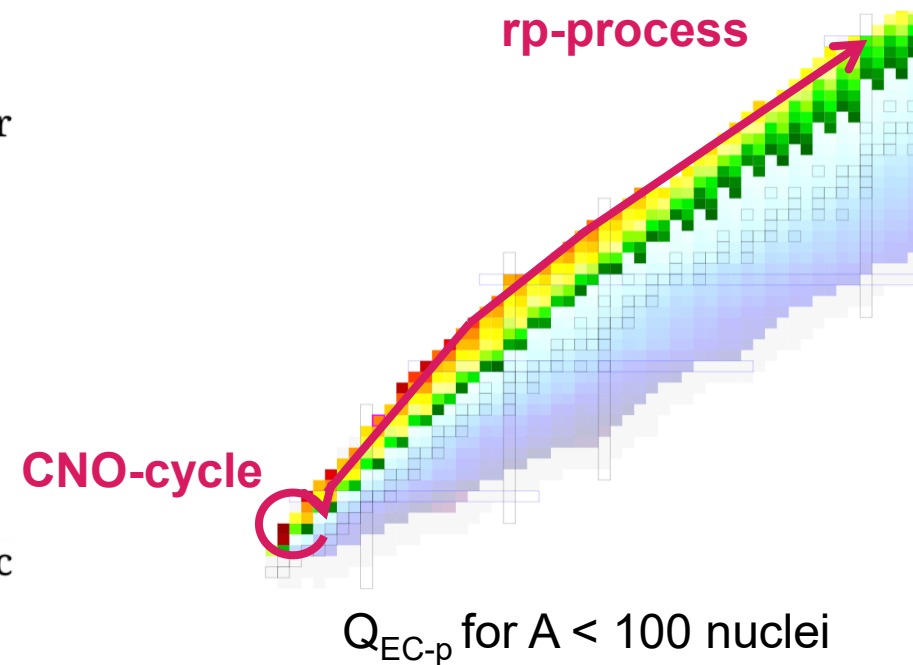
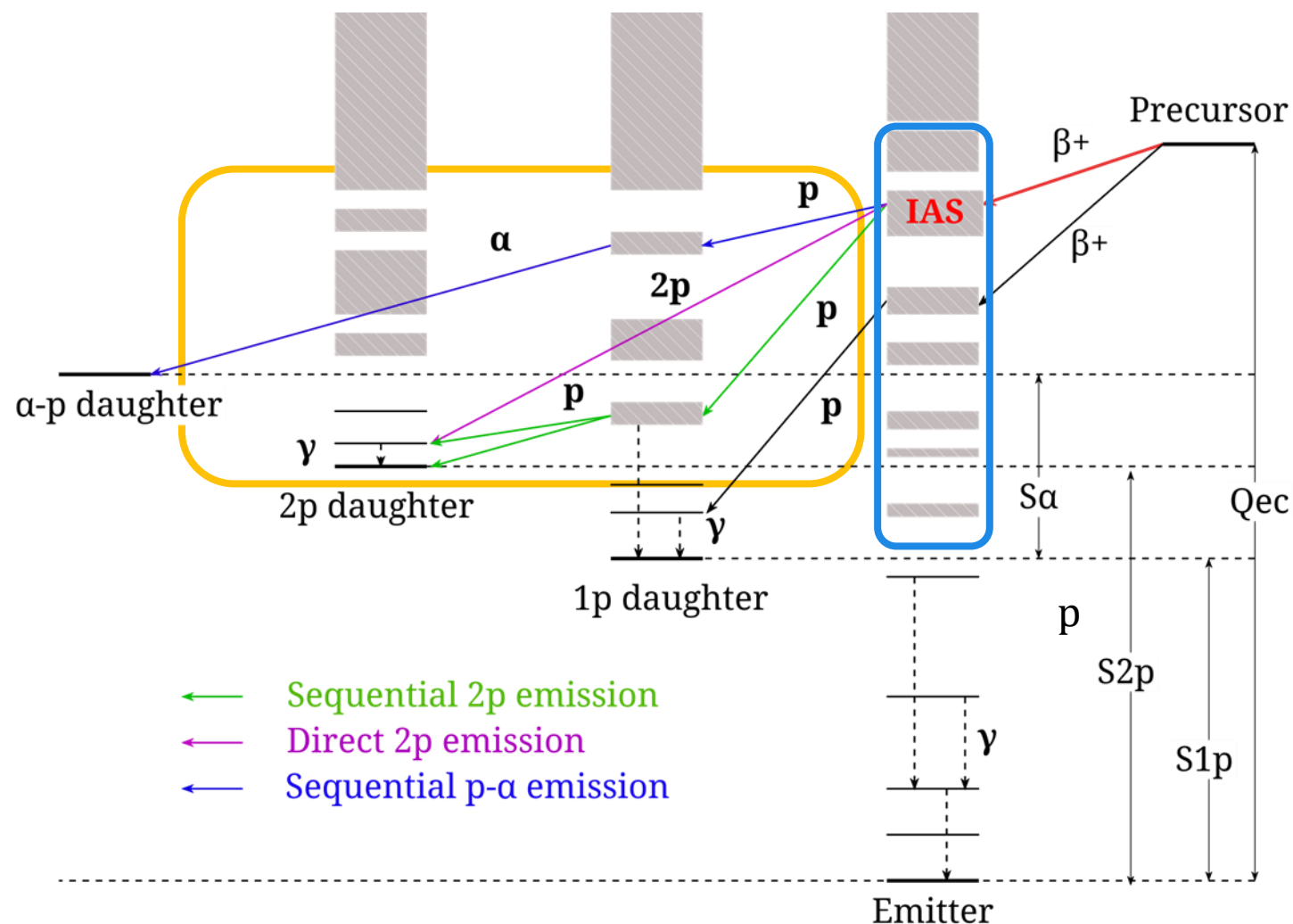
1. Introduction

2. The Regina Cube for Multiple Particles

3. Preliminary ^{20}Mg β -delayed spectroscopy

4. Conclusion

Beta-delayed charged particle emission



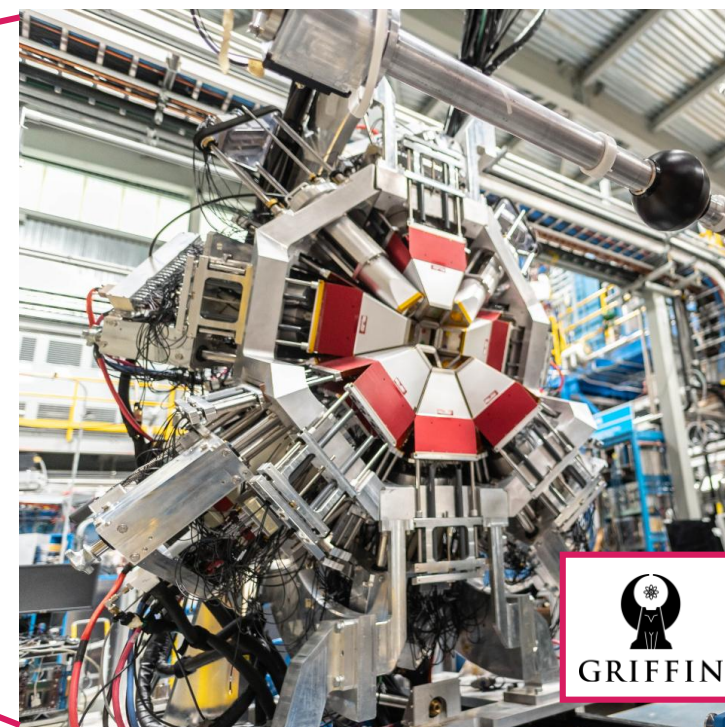
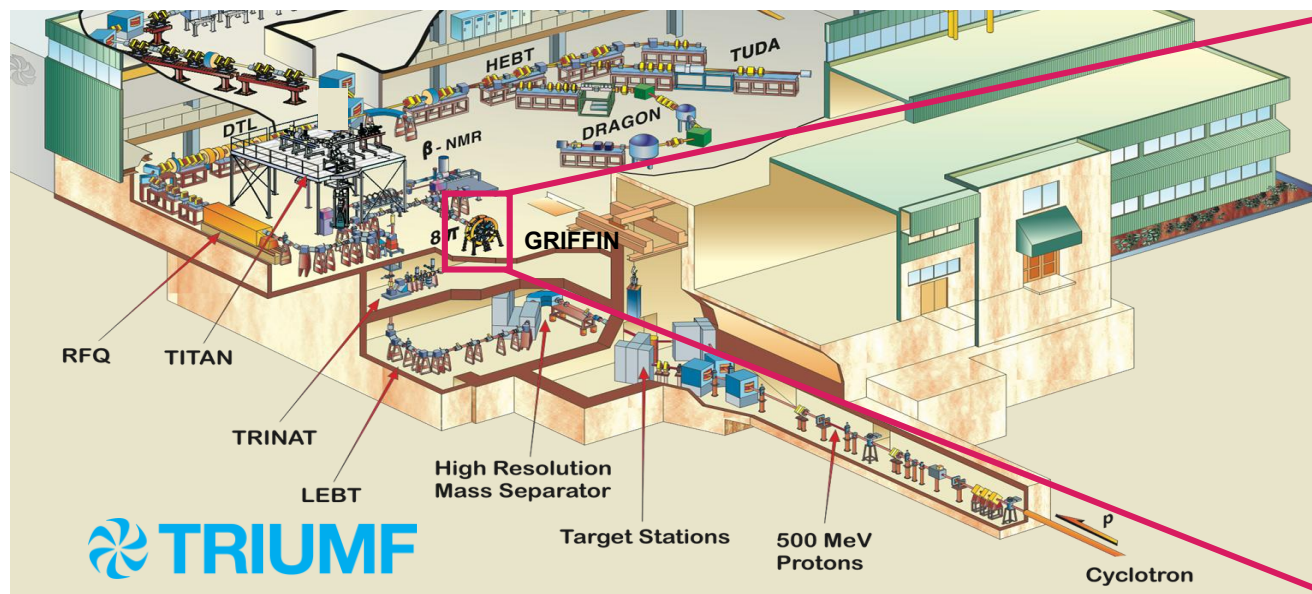
- Spectroscopy above S_p
- Particle emission mechanism
- Astrophysical processes
- Fundamental symmetries

B. Blank and M.J.G. Borge *PNPP* 60 403-483 (2008)

TRIUMF's ISAC-I Facility and GRIFFIN

A.B.Garnsworthy et al. NIMA 918 (2019)

An ISOL facility



- 500 MeV protons at 100 μ A current produced by TRIUMF cyclotron
- Thick production target
- Ion source
- Mass separation

West hemisphere of GRIFFIN

- GRIFFIN:** High efficiency γ -ray spectrometer dedicated to decay studies
- 16 HPGe clover detectors (4 crystals per clover)
 - Compton suppression and addback capabilities
 - Several ancillary detectors

Characteristics and sensitivity of RCMP

Regina Cube for Multiple Particles: 6 DSSD (Micron BB7)

- 1 mm thickness
- 64 x 64 mm² active area
- 32 front + 32 back strips = 64 channels per DSSD
- 2 mm strip pitch (0.5° angular resolution)
- Thin mylar foil to collect the beam (500 nm)

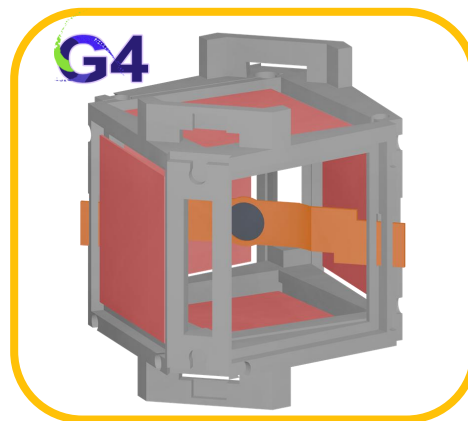
Cubic geometry

Mylar foil

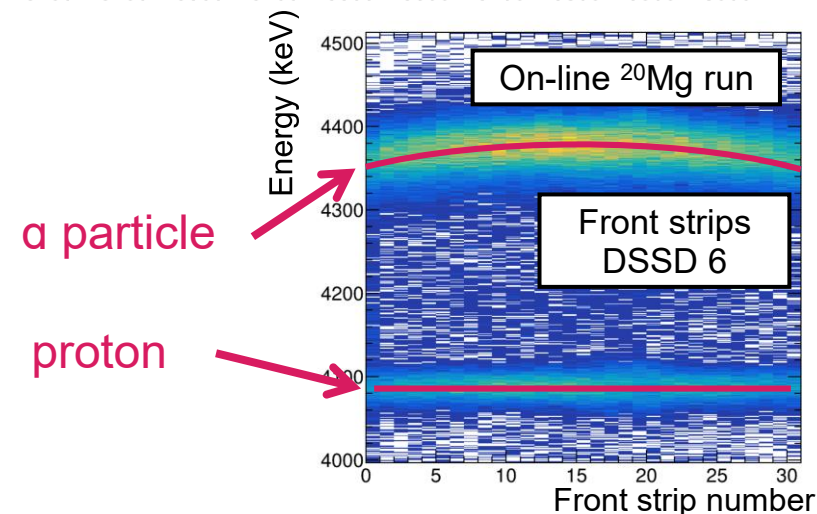
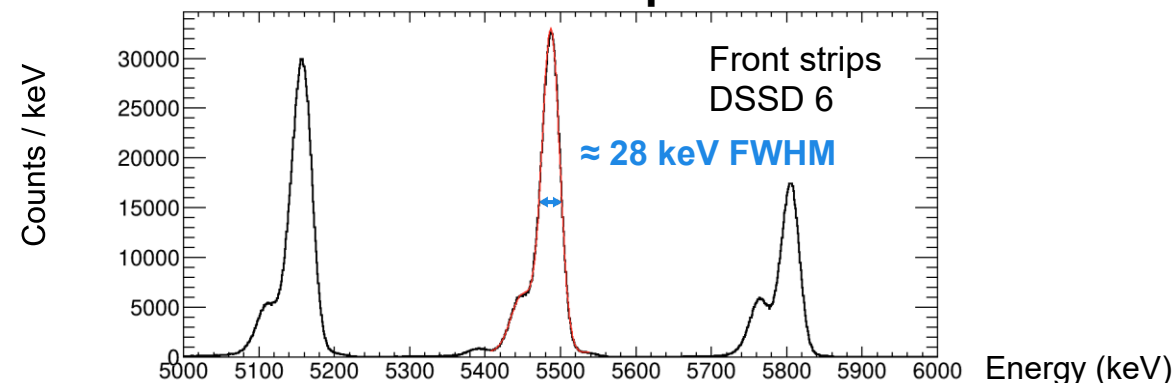
PLA holder

Resin frame

Downstream half of RCMP

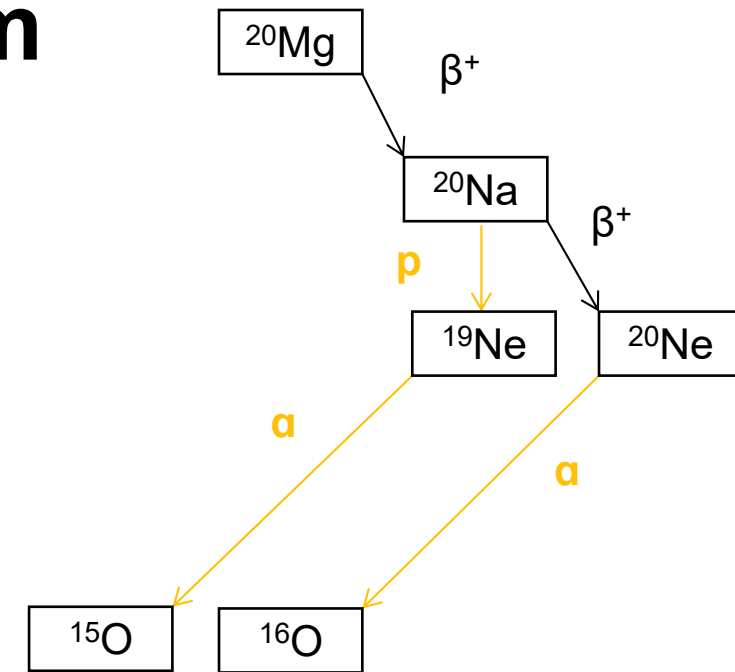
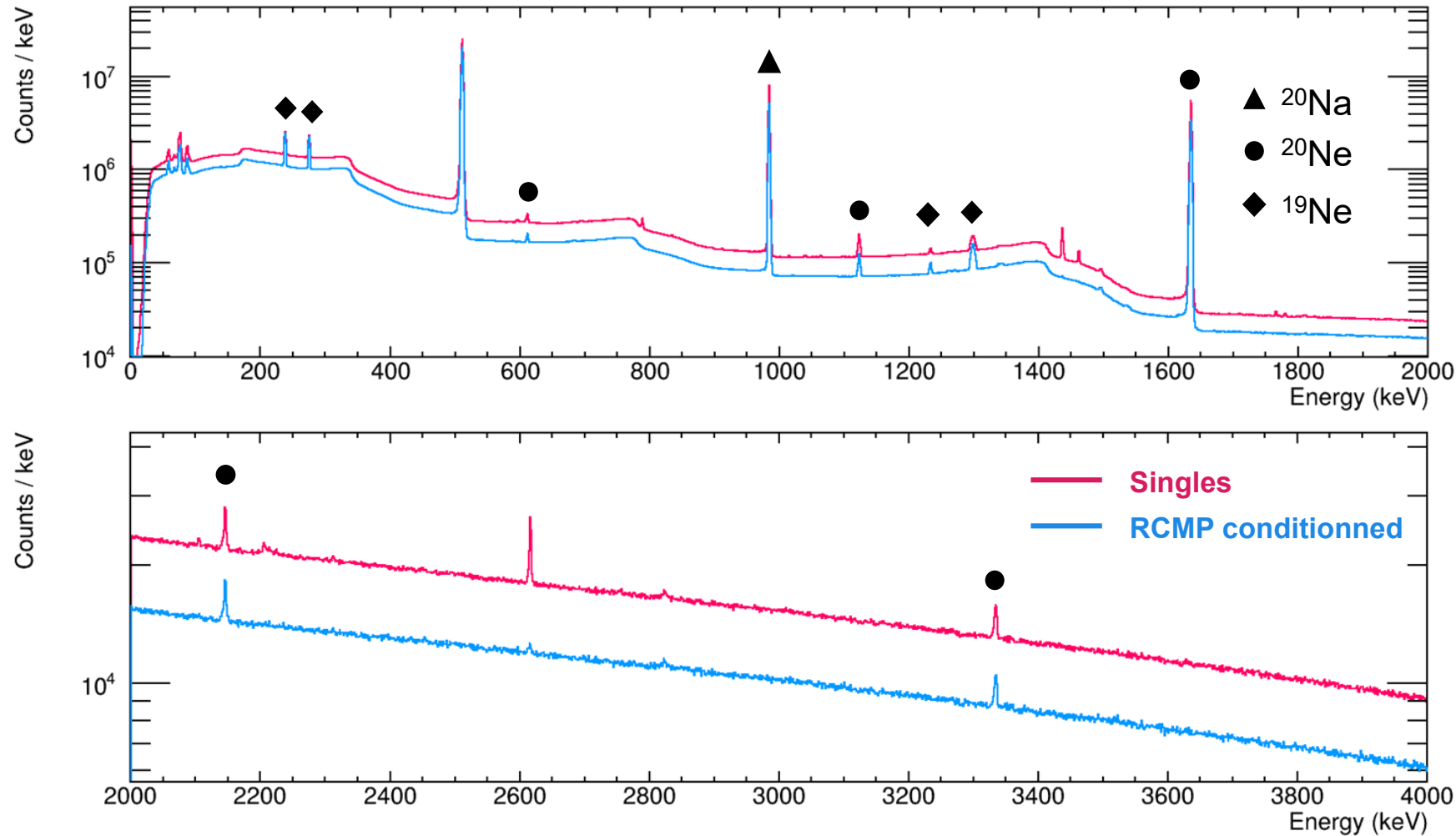


Triple α -source



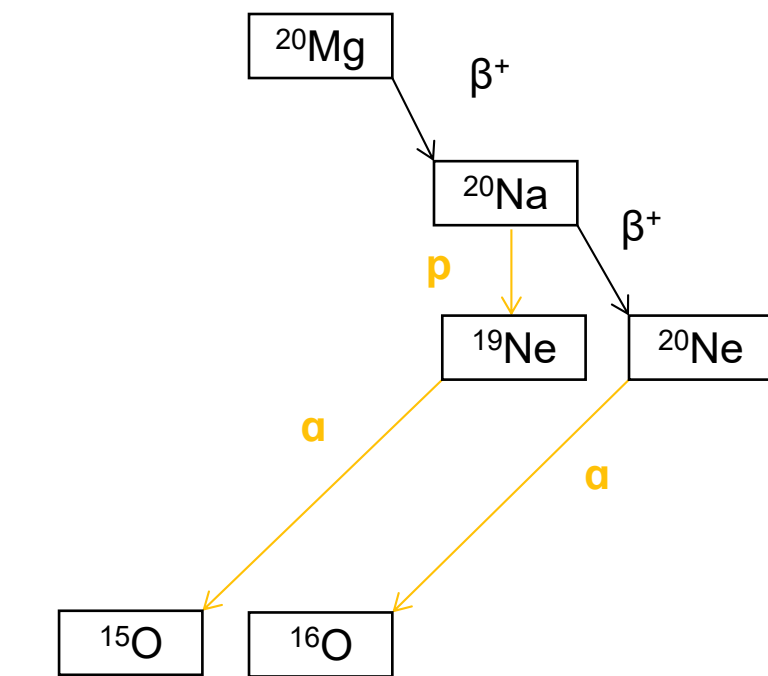
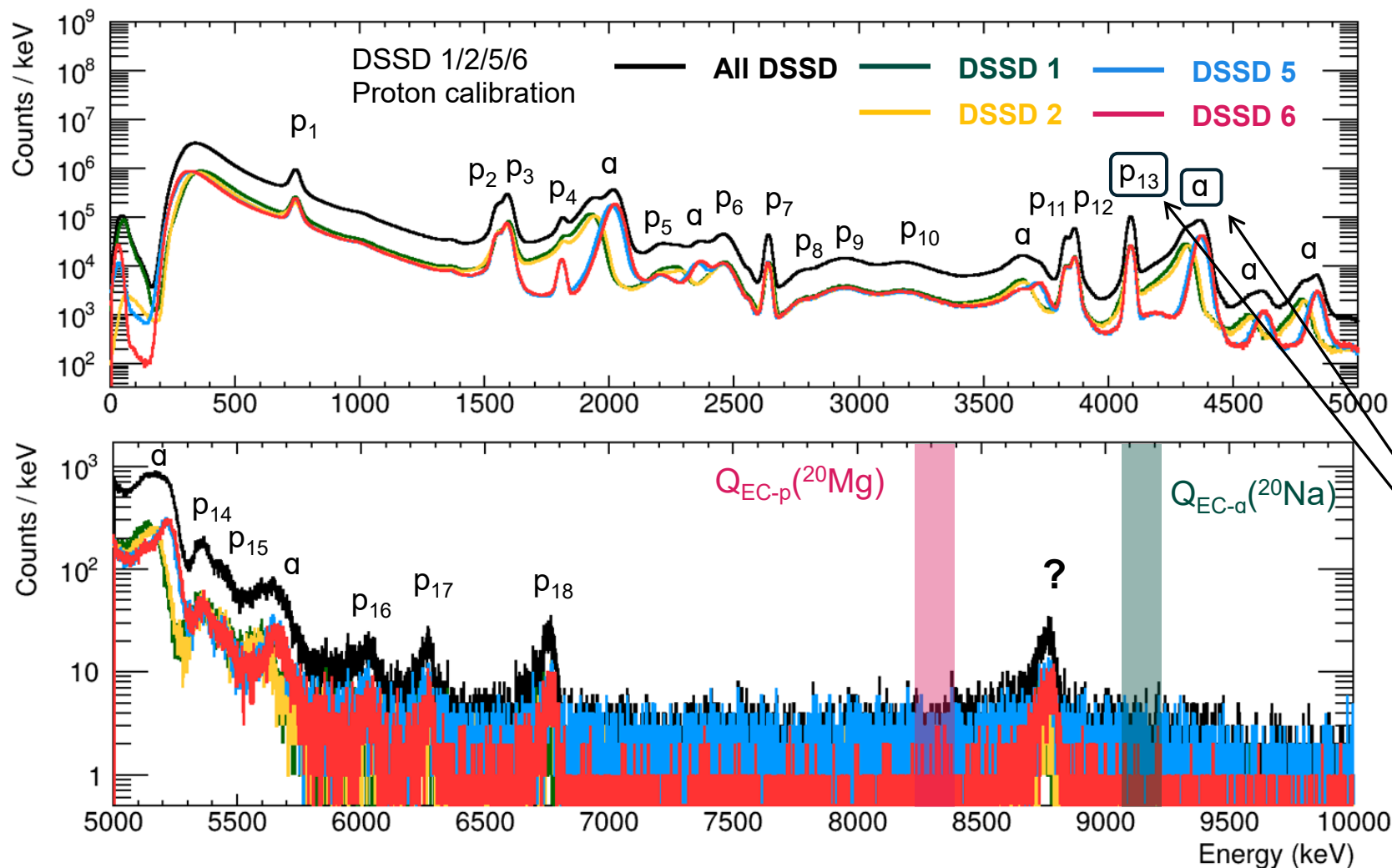
- **Energy resolution:** 28.4 (2) keV FWHM @ 5.486 MeV
- **Solid angle:** 63.4% of 4 π
- **Particle identification** using dead layers

^{20}Mg decay: GRIFFIN Energy spectrum



- 55s collection / 5s decay cycles
- ~ 44h of data @ $1\text{e}4$ pps
- ~ 1×10^9 ^{20}Mg ions implanted in total

^{20}Mg decay: RCMP Energy spectrum



α particles: energy shift due to the mylar foil

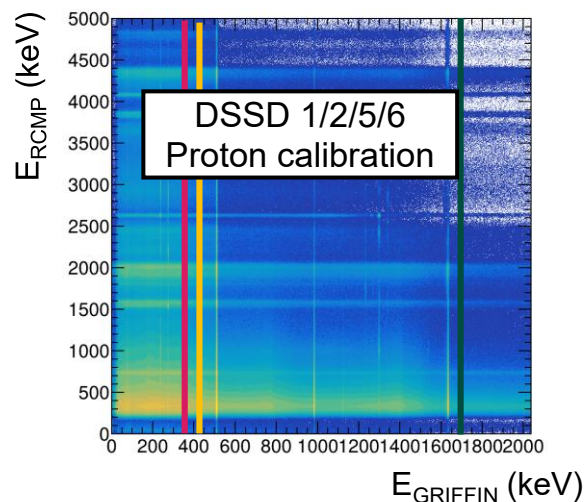
Protons: no energy shift (IAS to GS transition here)

- New proton transitions observed
- γ rays needed to perform detailed spectroscopy

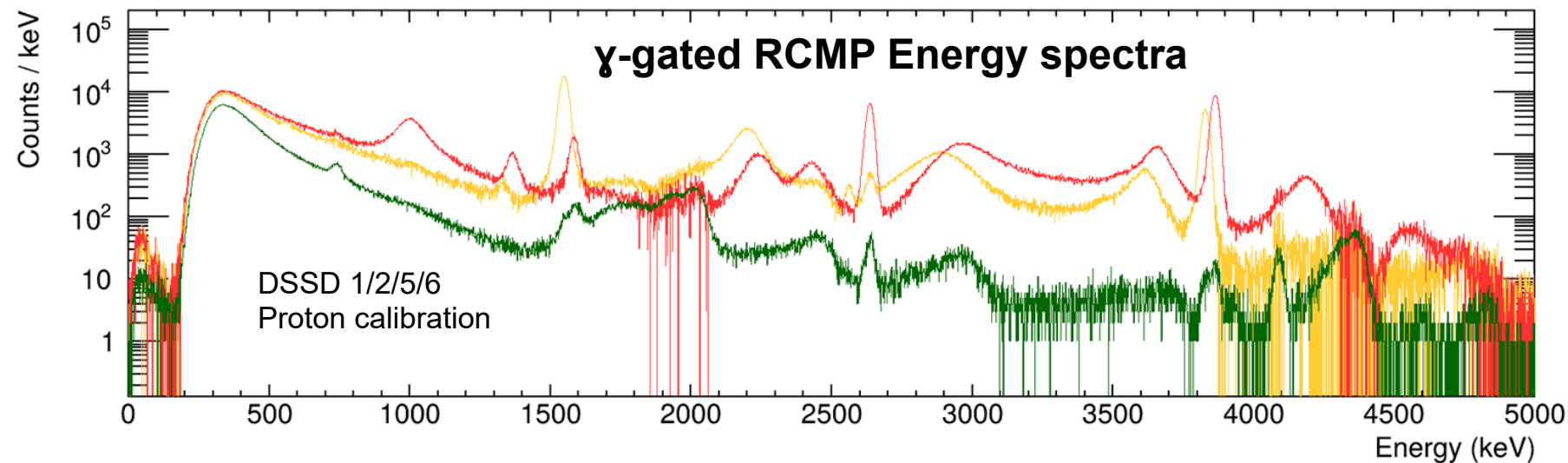
^{20}Mg decay: p- γ coincidences

- Gate on 3 main γ rays
- Background subtracted

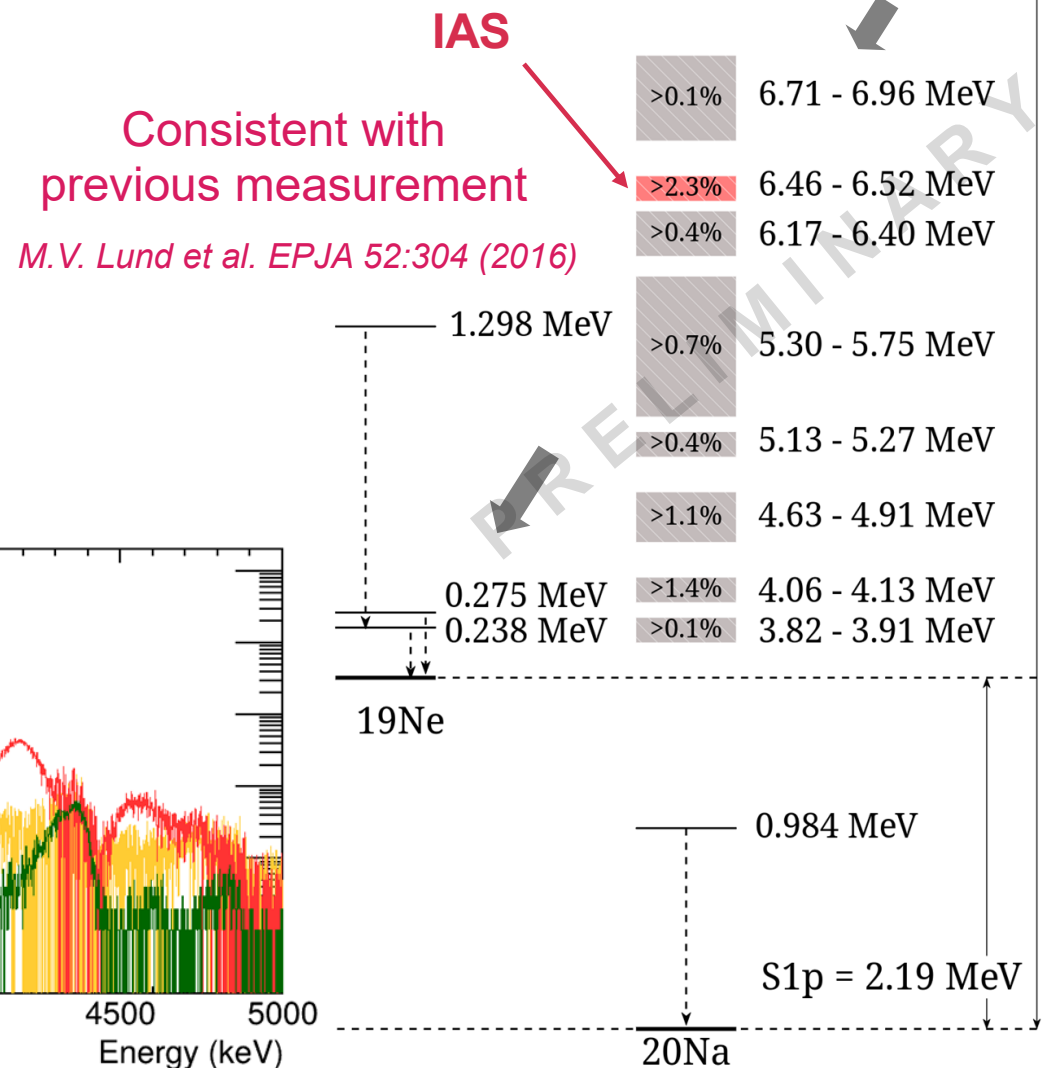
— 238 keV gate
— 275 keV gate
— 1298 keV gate



γ -gated RCMP Energy spectra



Preliminary level scheme above S_p



Summary

- **β -delayed charged particle emission** is a great tool to study a wide range of topics in nuclear physics.
- The **Regina Cube for Multiple Particles** is a new ancillary charged-particle detector for GRIFFIN, combining high efficiency, energy resolution and granularity.
- The RCMP was commissioned with a beam of **$^{20,21}\text{Mg}$ at TRIUMF** where the **highest yields ever achieved** for these isotopes was produced.
- The analysis methods for the RCMP are currently under development and the preliminary results from the commissioning data look very promising, giving us the opportunity to extend our knowledge of **nuclear structure** near the **proton drip line**.

Next steps

- Finish characterizing the RCMP
- Finish developing the data correction methods and apply them to the commissioning data
- Perform the full spectroscopy of $^{20,21}\text{Mg}$ above S_p
- Look into the multiple particle branches: p- α and 2p
- Perform new experiments with the RCMP

Thank you !

S2232 Collaborators

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Regina Group

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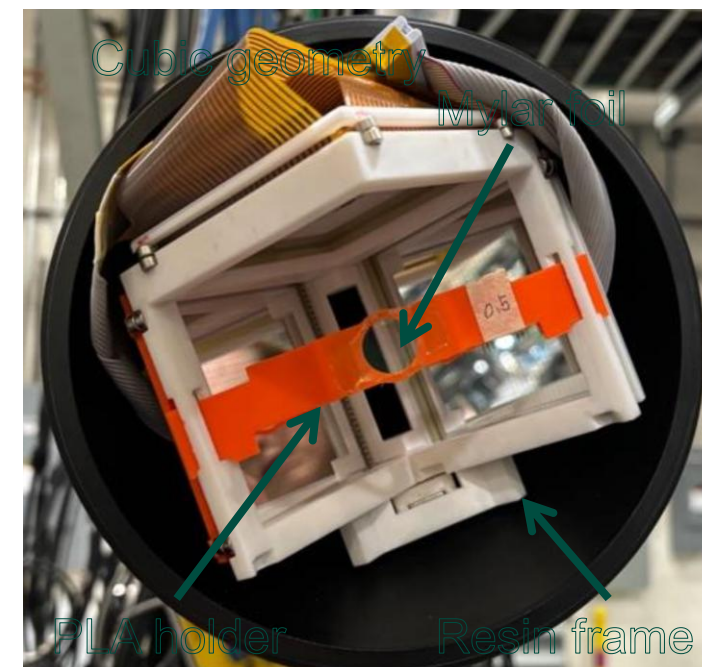
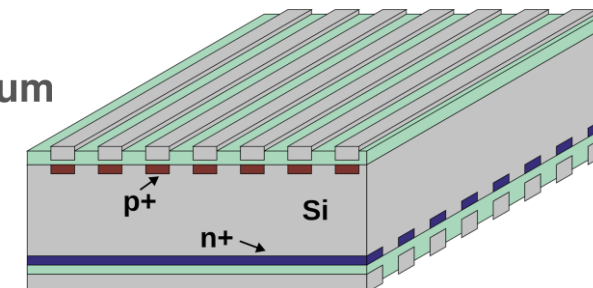
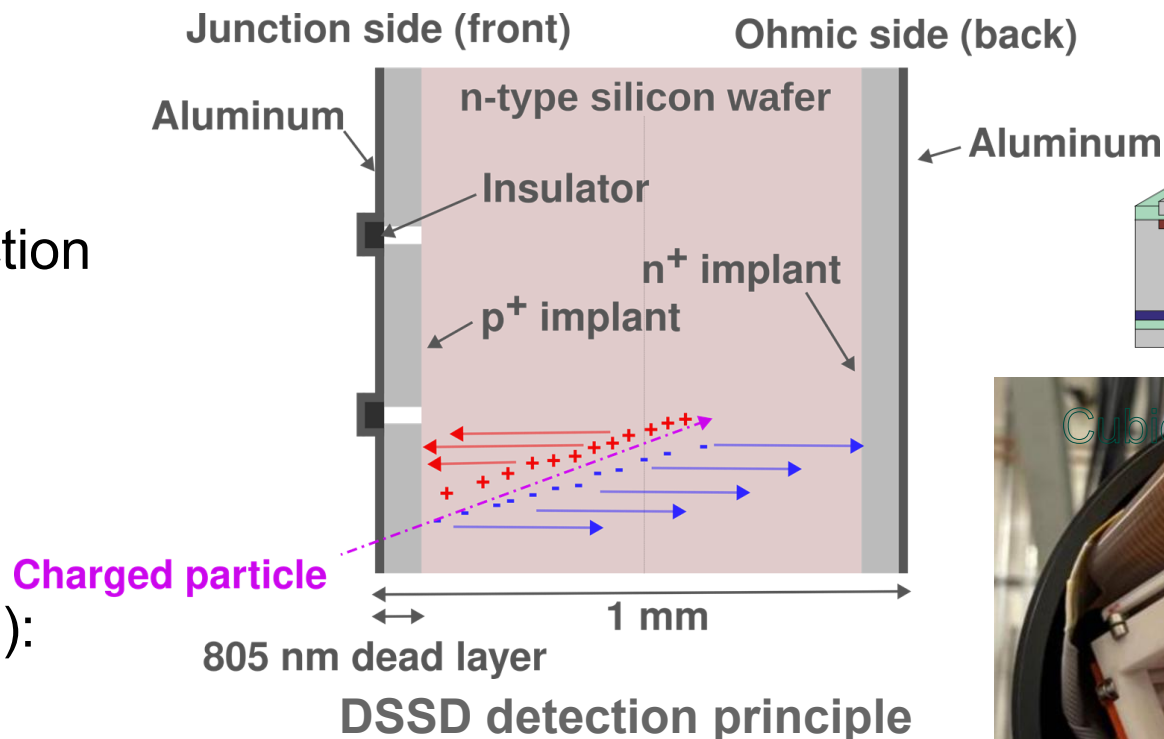
Detection principle and Characteristics of RCMP

Needs:

- . β , α and proton detection
- .Energy resolution
- .Efficiency
- .Granularity

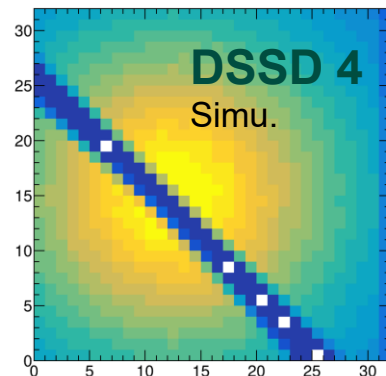
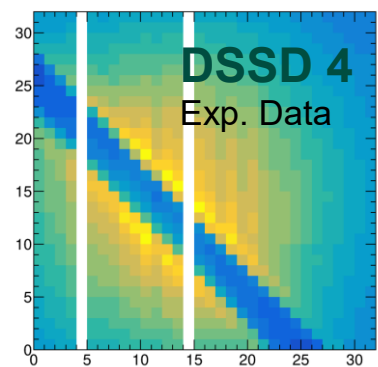
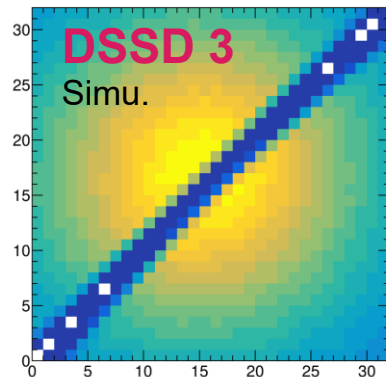
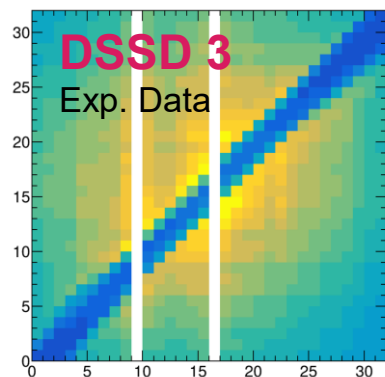
RCMP: 6 DSSD (Micron BB7):

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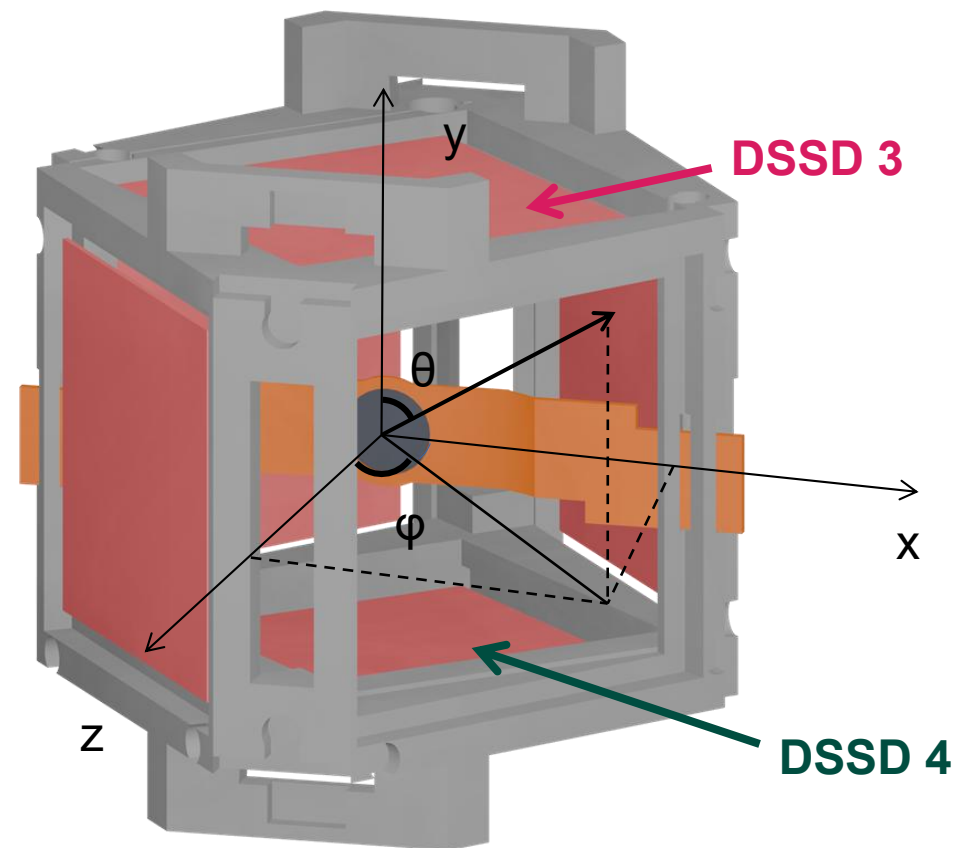


Downstream half of RCMP

Geant4 simulations



DSSD 3 and 4 heatmaps
Experimental Data VS Simulation

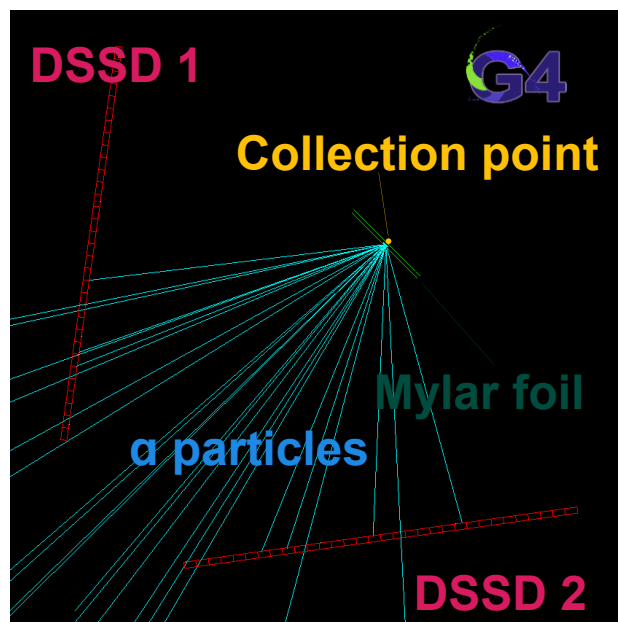


- α , β and p efficiency measurement
- ϕ and θ angles measurement for the 6144 pixels
- Measurement of DSSD 3 and 4 position

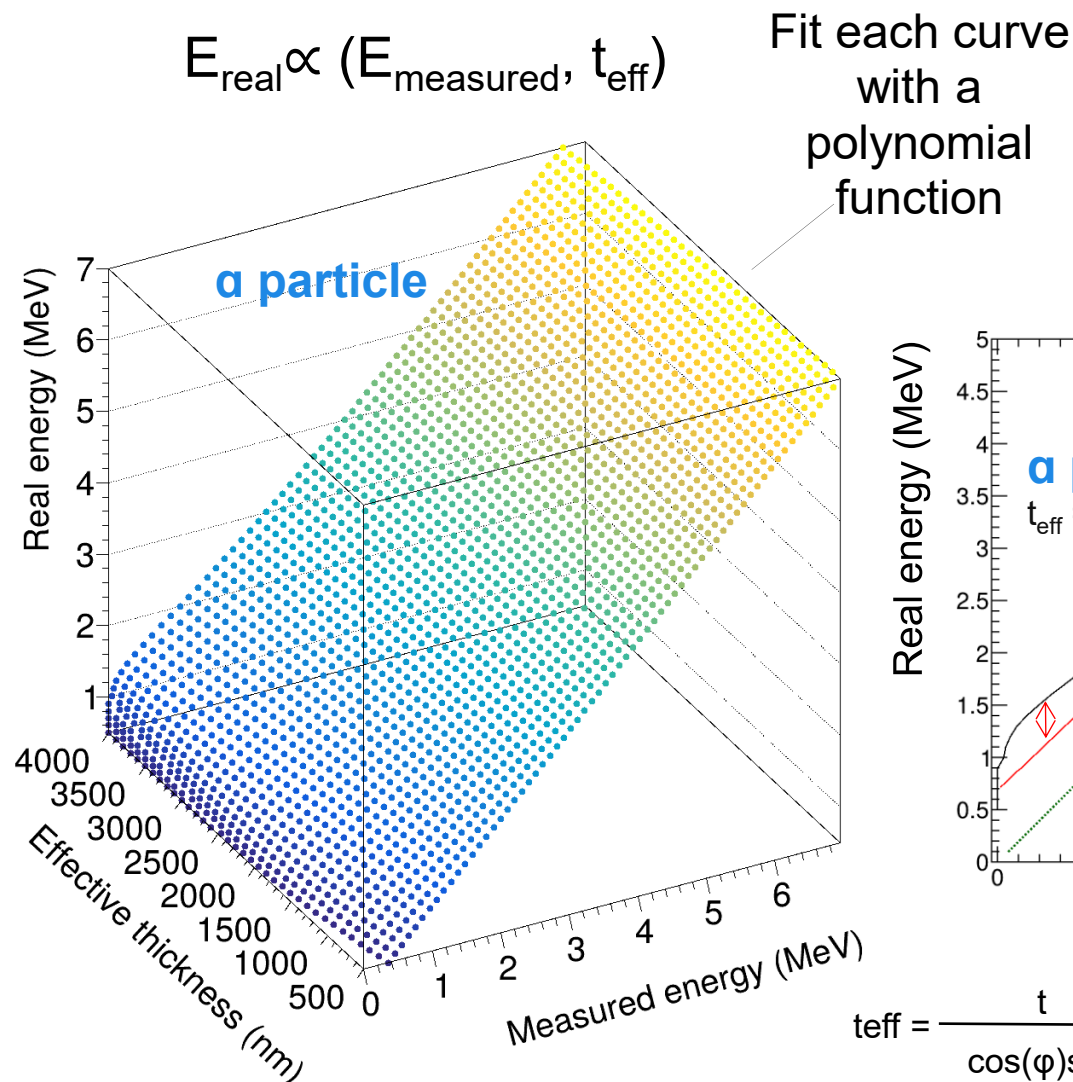
Data corrections

Energy loss correction

Non-linear effects from mylar foil



Mostly affects **alpha particles**

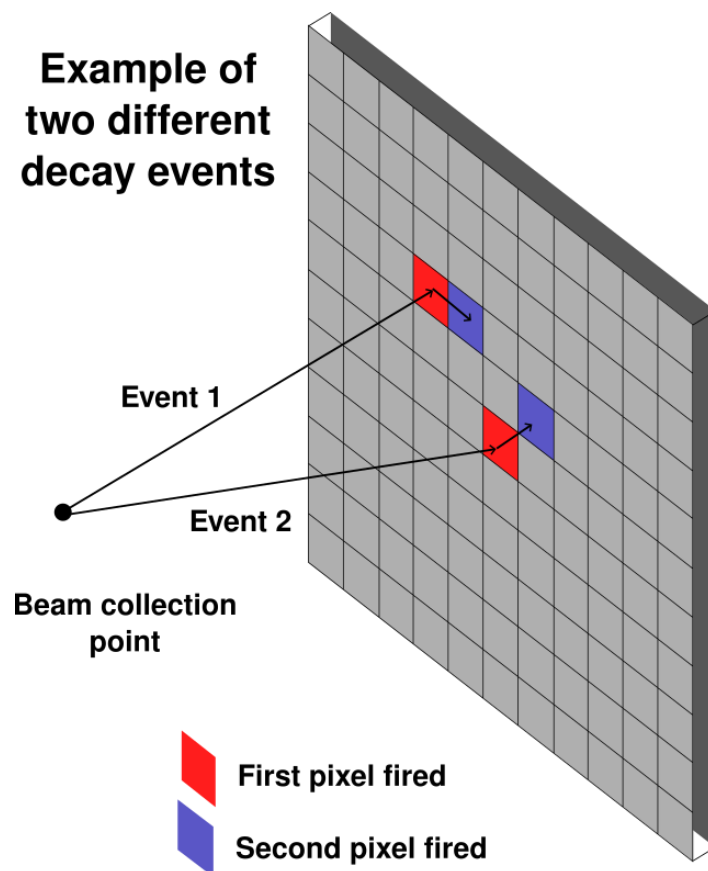


pixel hit $\rightarrow (\theta, \varphi) \rightarrow t_{\text{eff}} \rightarrow$ correction

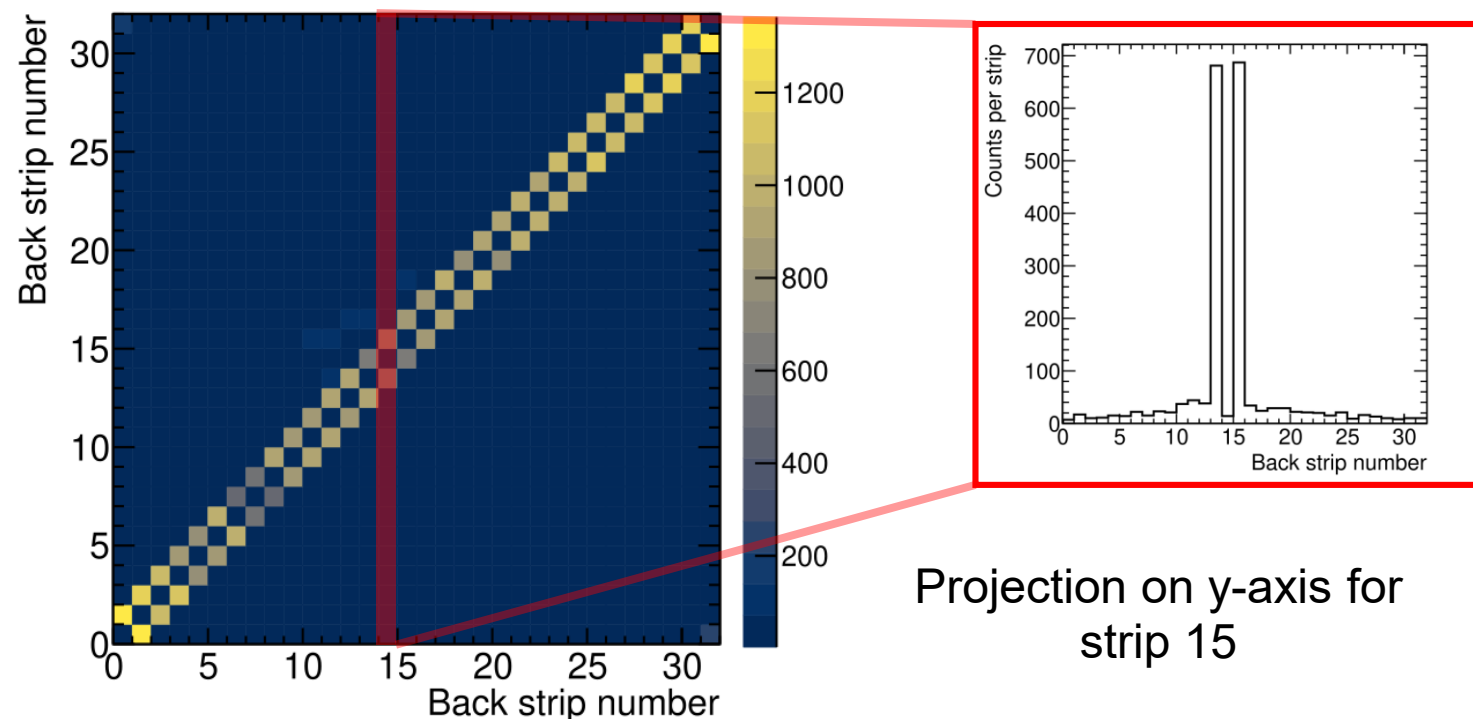
Data corrections

Energy addback procedure

Example of
two different
decay events



Back – Back correlation matrix



.Add energy deposited in neighbour strips fired in coincidence.

.Make sure the final front and back energy match.

.Take into account higher multiplicities