CEDAR Conversion Electron Detection ARray

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TRIUMF/UVic

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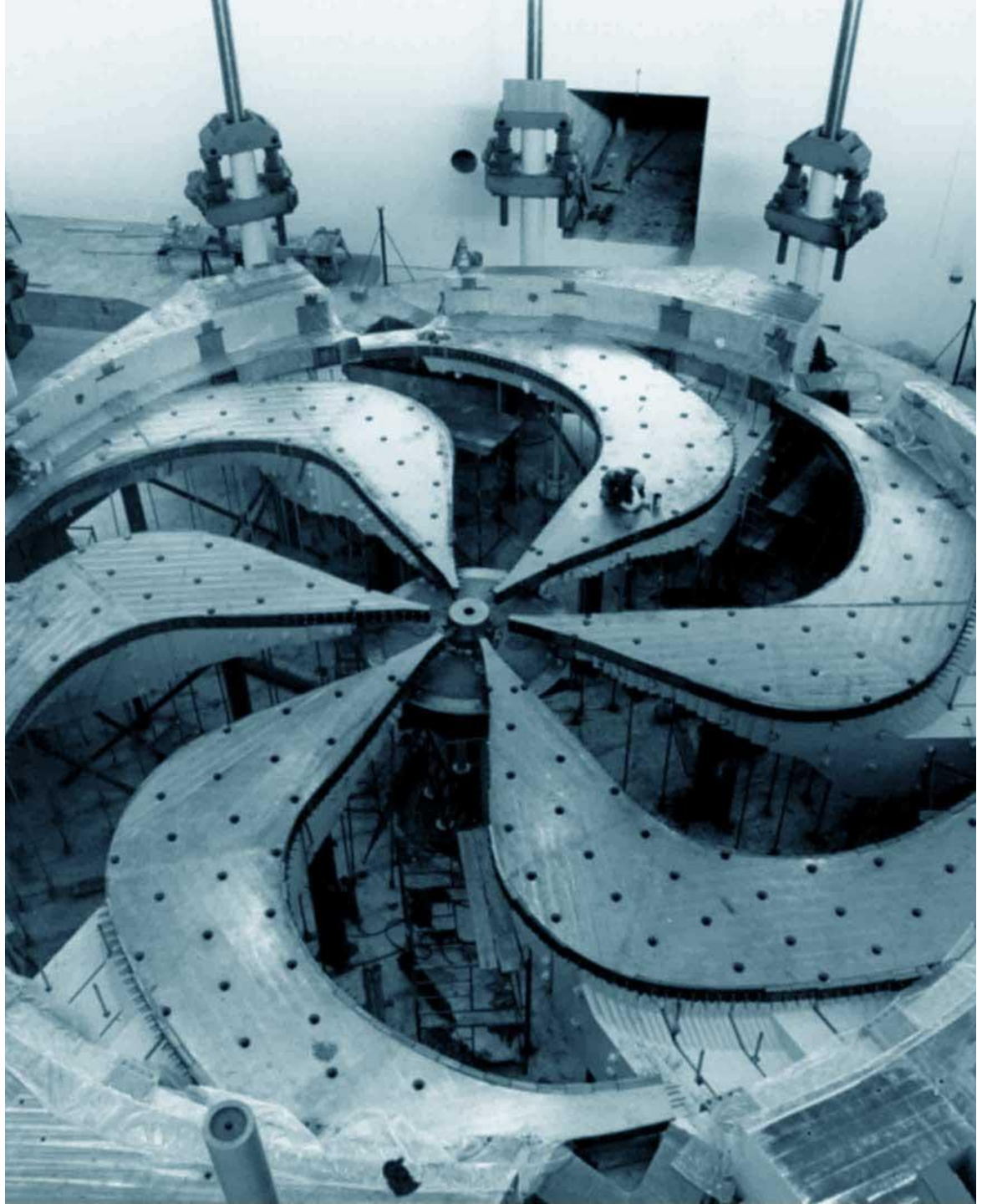
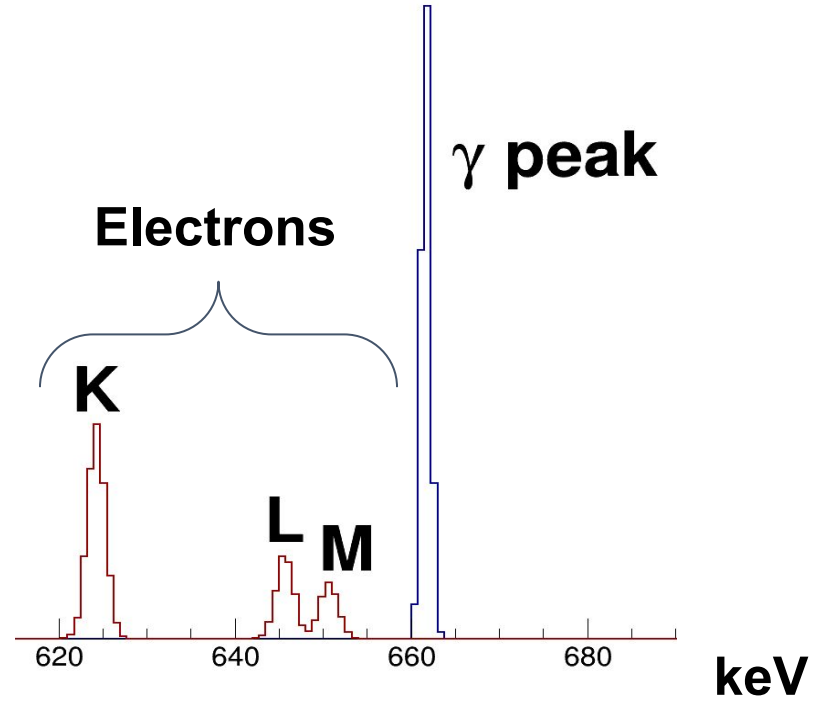
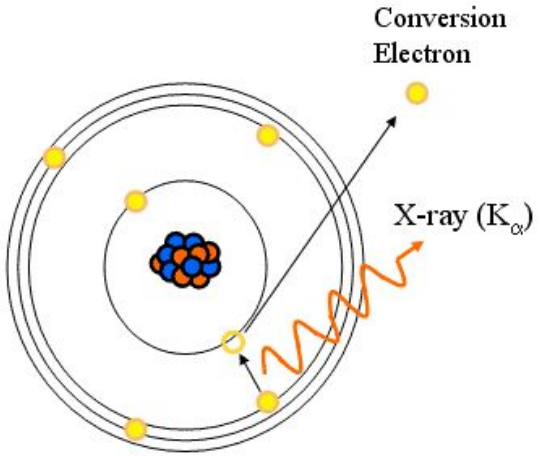


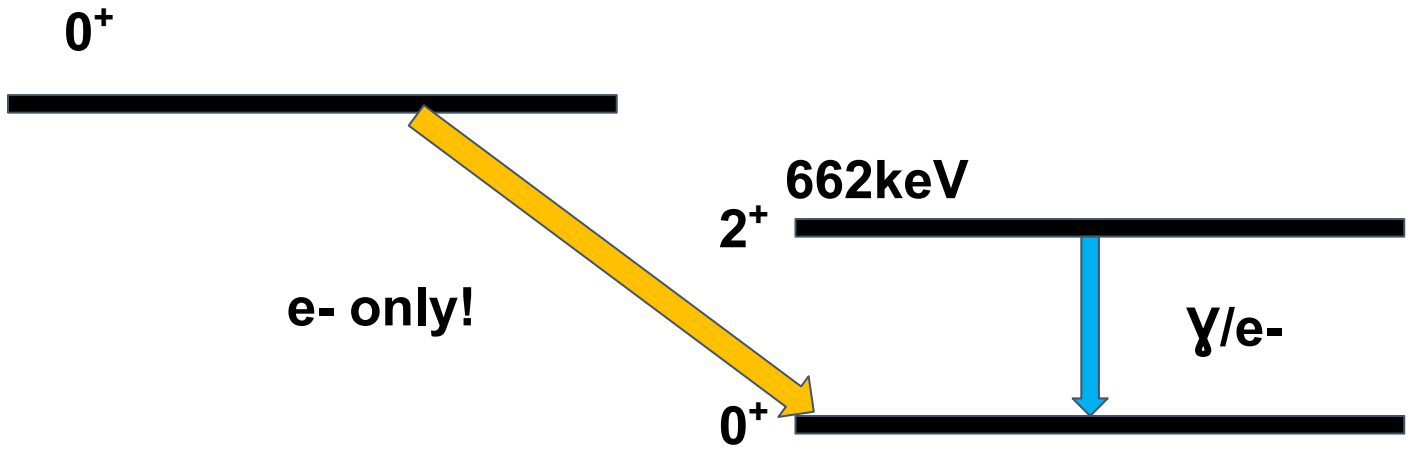
Discovery, accelerated

Internal Conversion

- Emission of an orbital electron
- Competing process of gamma-ray emission
- $T_e = \Delta E - B$, ΔE: Transition energy, B: Electron binding energy
- Labeled according to electron shell; K,L,M
- 0+ -> 0+ transition

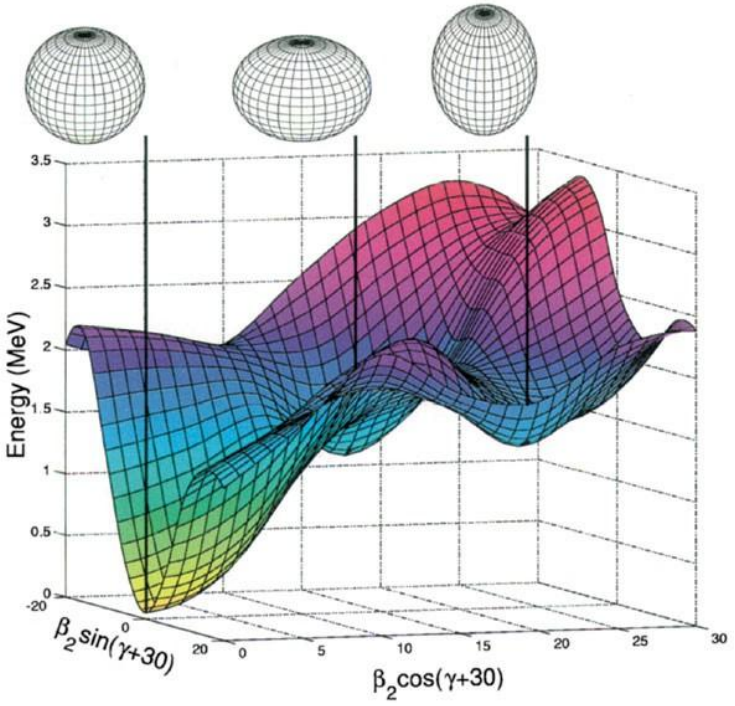




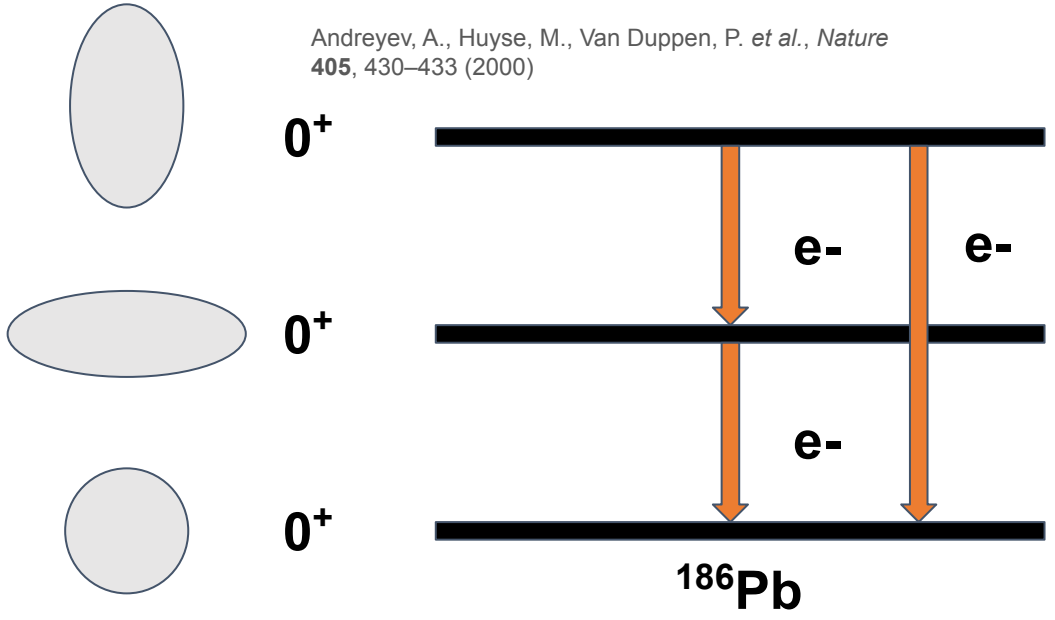


Shape Coexistence

- Most nuclei have deformation, some nuclei displays multiple shapes
- Enhanced E0 transition strength is a key signature of configuration mixing/shape mixing
- Study of conversion spectrum is crucial for our understanding of shape-coexistence

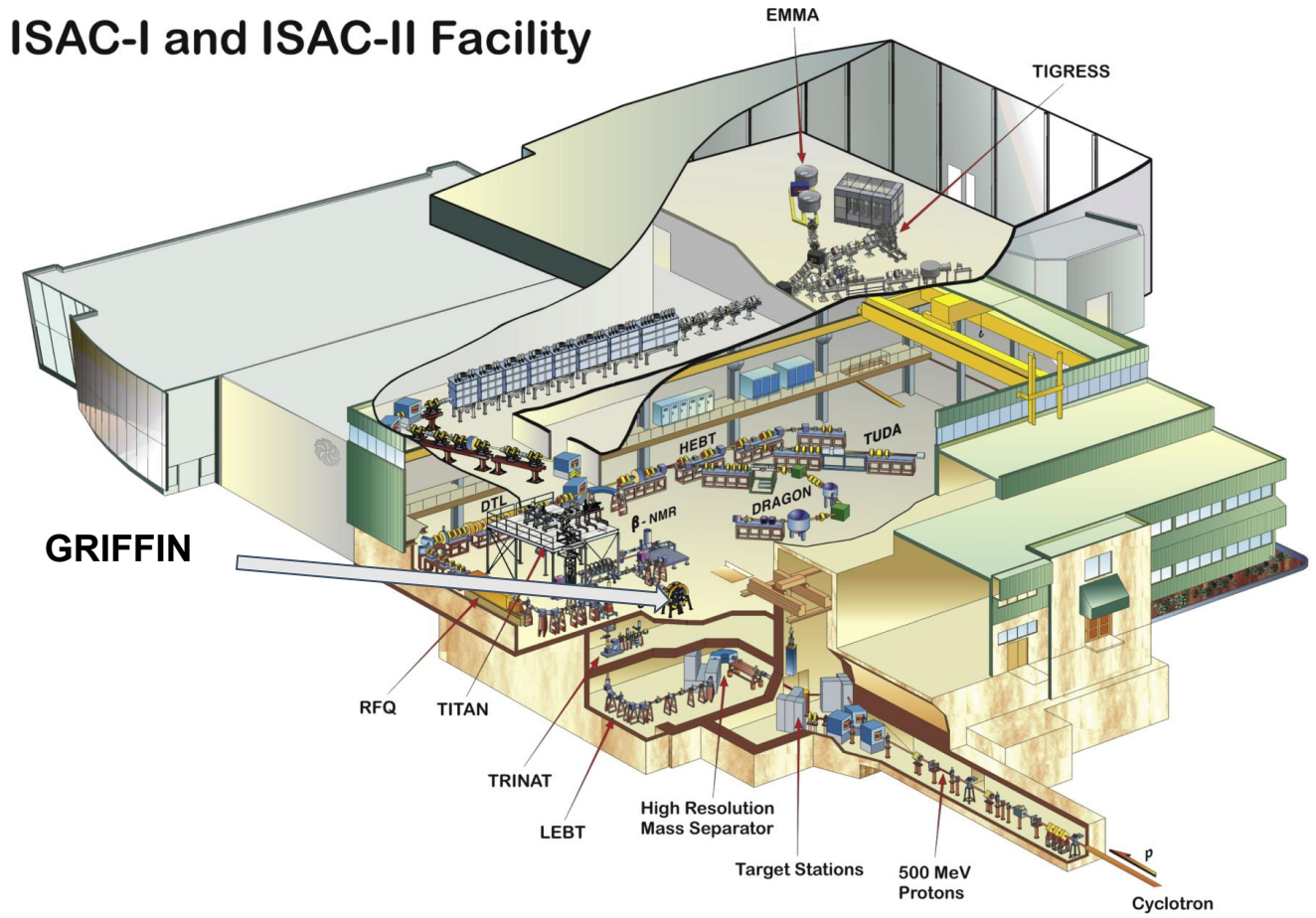


Andreyev, A., Huyse, M., Van Duppen, P. *et al.*, *Nature* **405**, 430–433 (2000)



TRIUMF ISAC (Isotope Separator and ACcelerator)

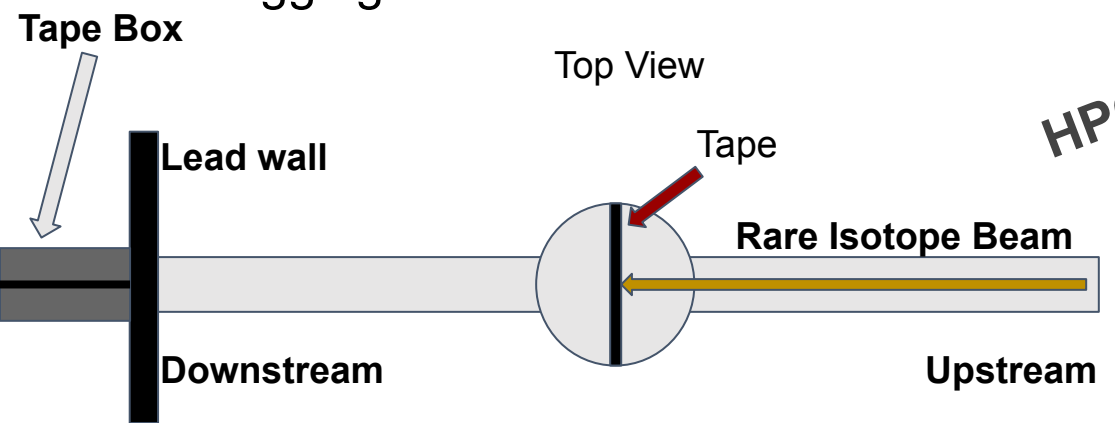
- Located in Vancouver B.C.
- Cyclotron accelerating H- ion up to 520MeV
- Delivery of protons to ISAC target station
- production of radioactive isotopes
- High resolution mass separator and laser ionization
- High purity rare isotope beam delivery to GRIFFIN at ISAC 1

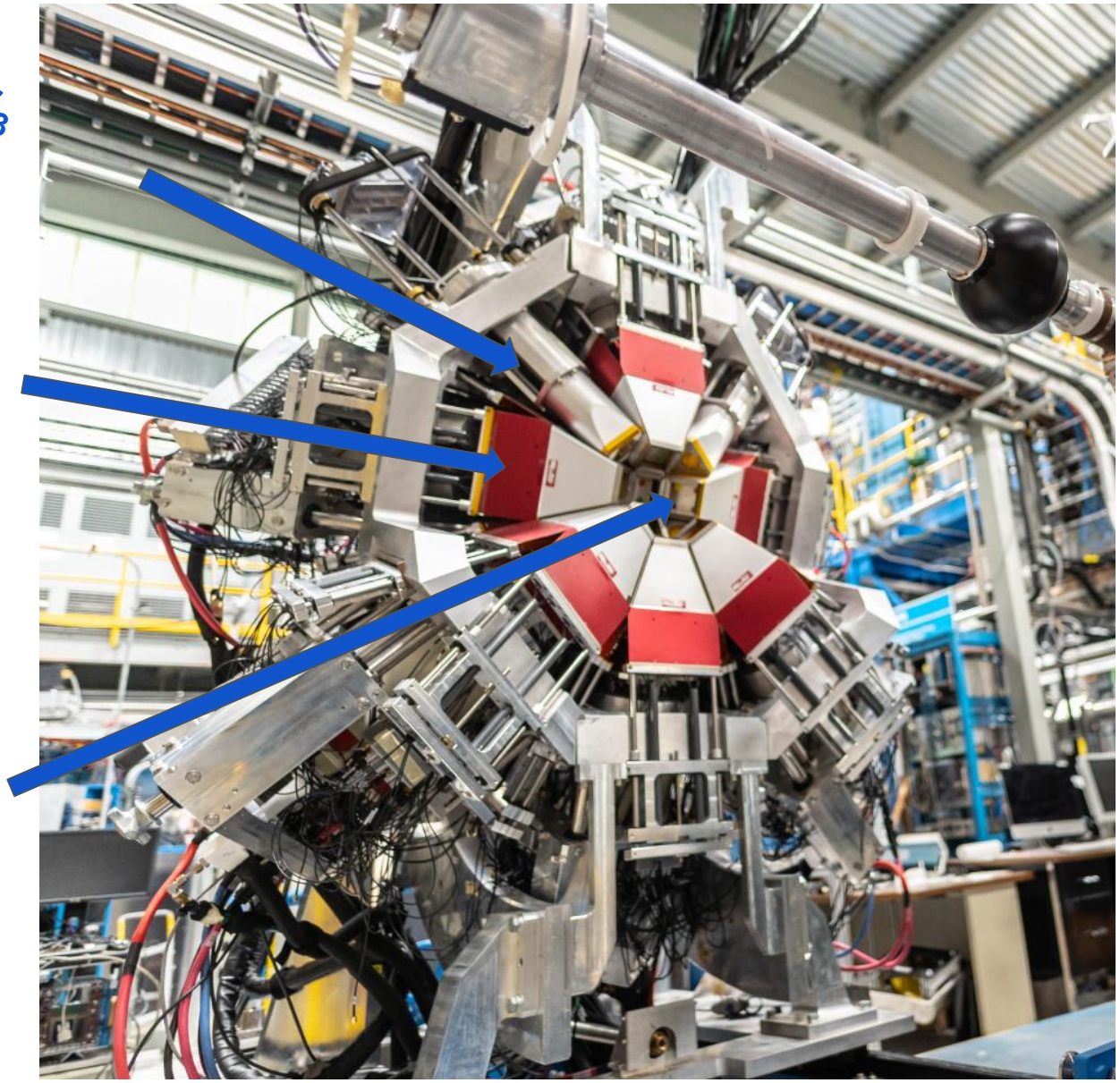


TRIUMF

GRIFFIN (Gamma Ray Infrastructure For Fundamental Investigations of Nuclei)

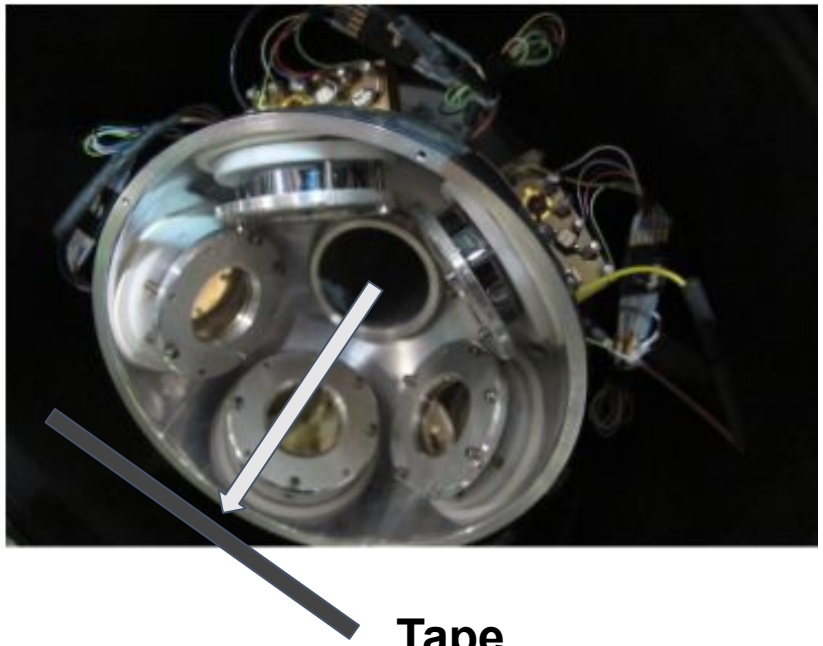
- Nuclear structure studies through beta decay
- 16 clovers with each clover consists of 4 **HPGe** crystals and **BGOs** for compton escape suppression
- **8 $LaBr_3$ fast scintillators**
- upstream using PACES, downstream with ZDS(Zero Degree Scintillators) for beta tagging



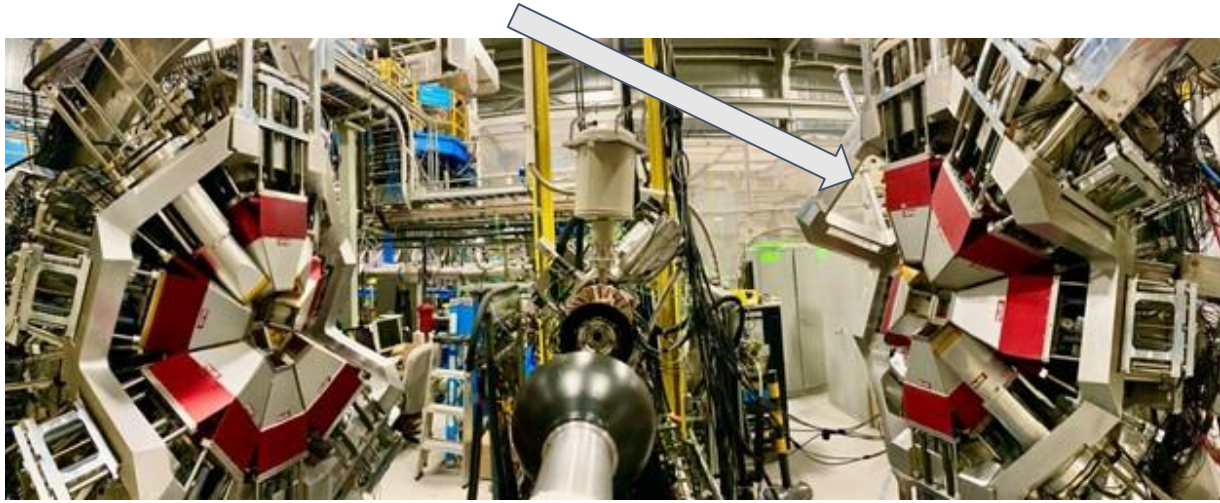


PACES (Pentagonal Array of Conversion Electron Spectrometers)

- Five 200 mm^2, 5 mm thick Lithium-drifted Silicon Si(Li) crystals near 2-3 keV FWHM at 500 keV
- 32mm from implantation spot to crystal surface
- Originally designed for 8Pi, used extensively over past 20 years
- Si(Li) requires cooling

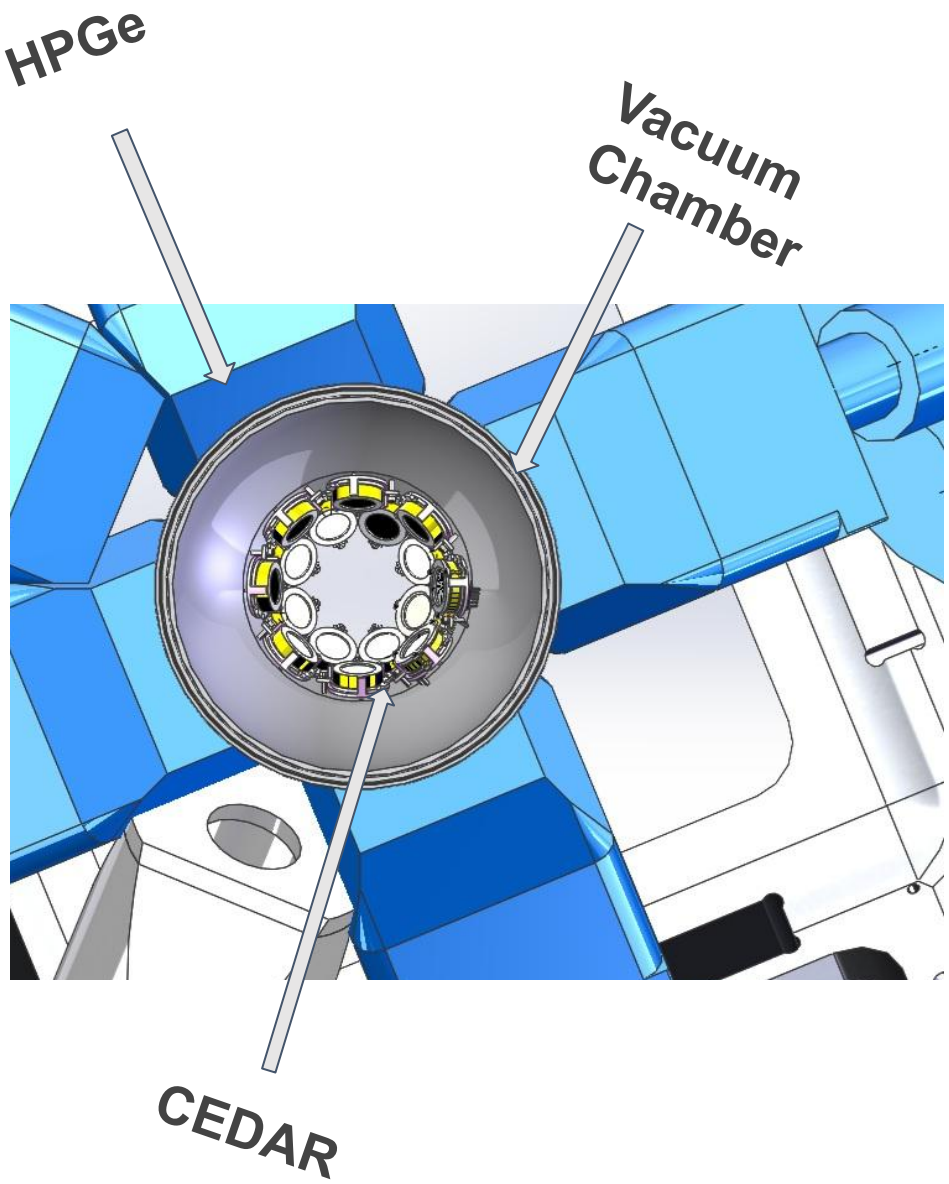


- Not optimized for GRIFFIN
- Installation of LN2 dewar requires removal of one GRIFFIN clover
- Cooling down requires 8 hours
- The Si(Li) count rate limits maximum source activity at GRIFFIN



CEDAR(Conversion Electron Detection ARray)

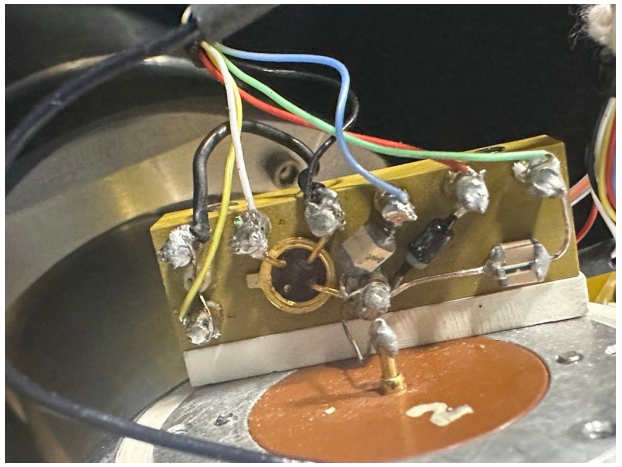
- Optimized geometry for maximum GRIFFIN photo-efficiency
- Standardize the angular differences between SiLi and HPGe
- Up to 16 SiLi crystals at distance of 40.5mm
- Maximum rare isotope beam rate at this distance is 1.6*PACES setup from solid angle calculation
- Mechanical cooling using compressor enables full 16 Clovers -> less than 2 hours cool down time



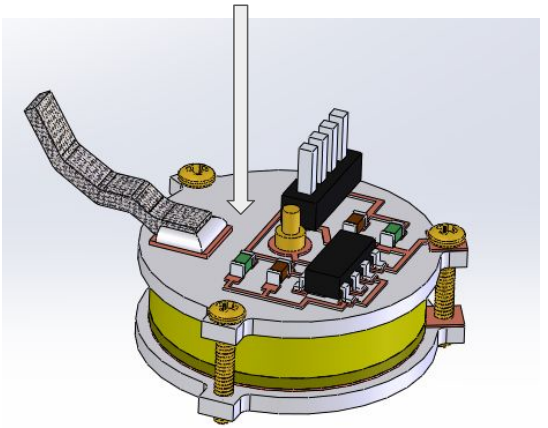
Mechanical Design

- Minimize material inside chamber
- Aluminum Nitride acting as front-end
- Electronics board and also cold finger connection
- Electrically isolated
- Thermal conductivity of 170W/mK compared to Cu of 400W/mK
- Surface mount electronic elements minimize microphonics noise

PACES front-end board

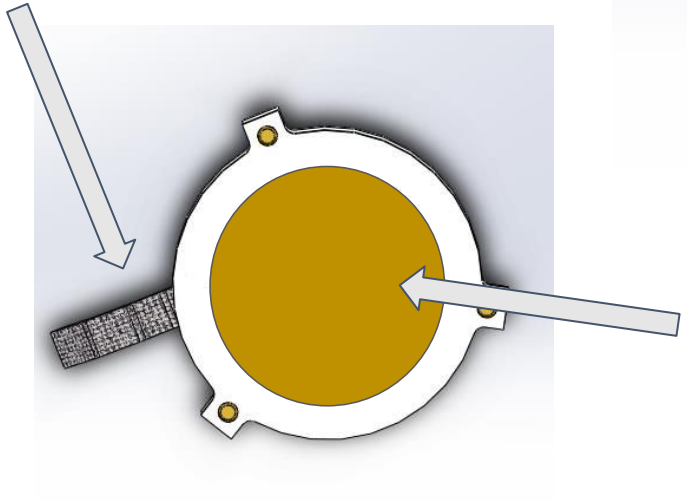


Front-end Electronics board



Back View

Al/Cu braid as cold finger connection

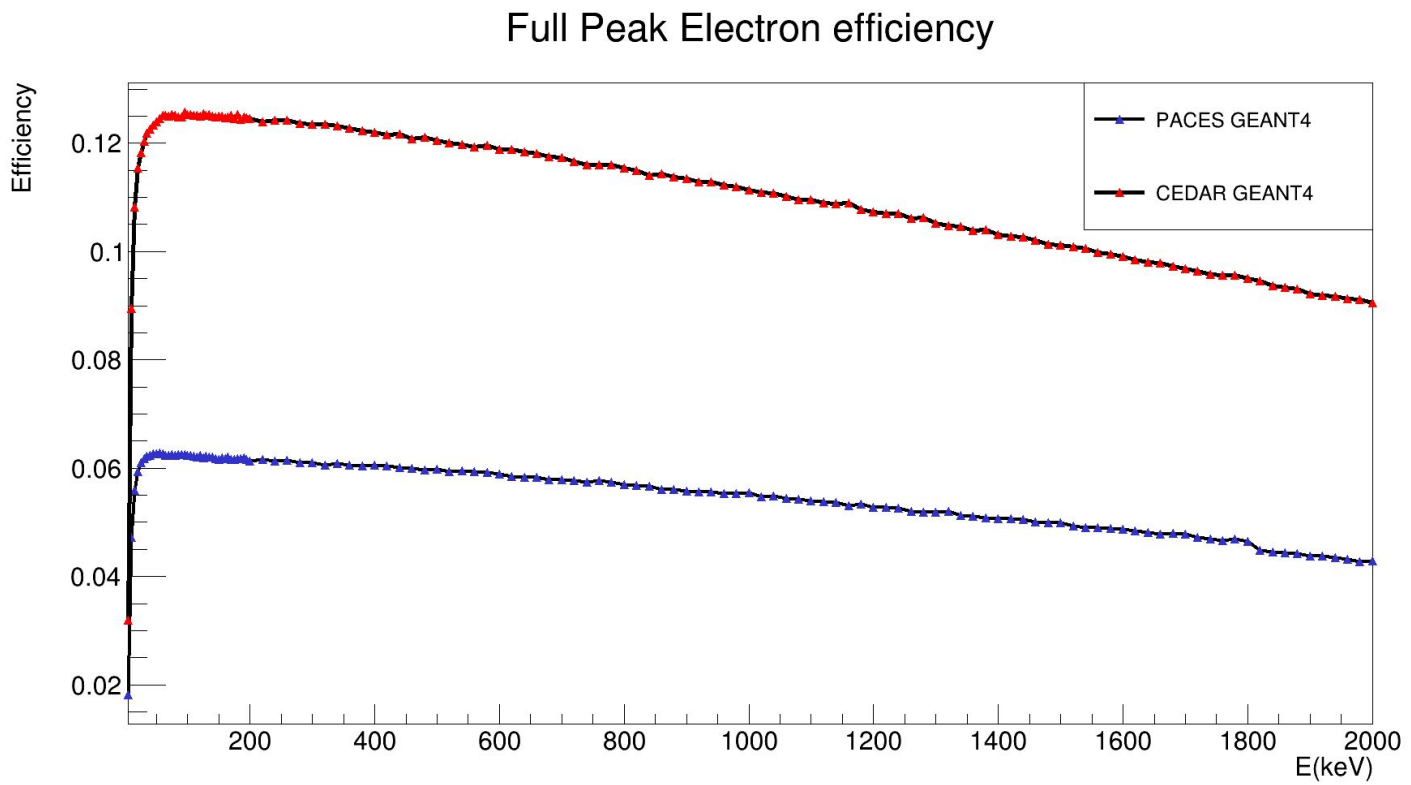


Si(Li)

Front View

Electron Full Peak Efficiency

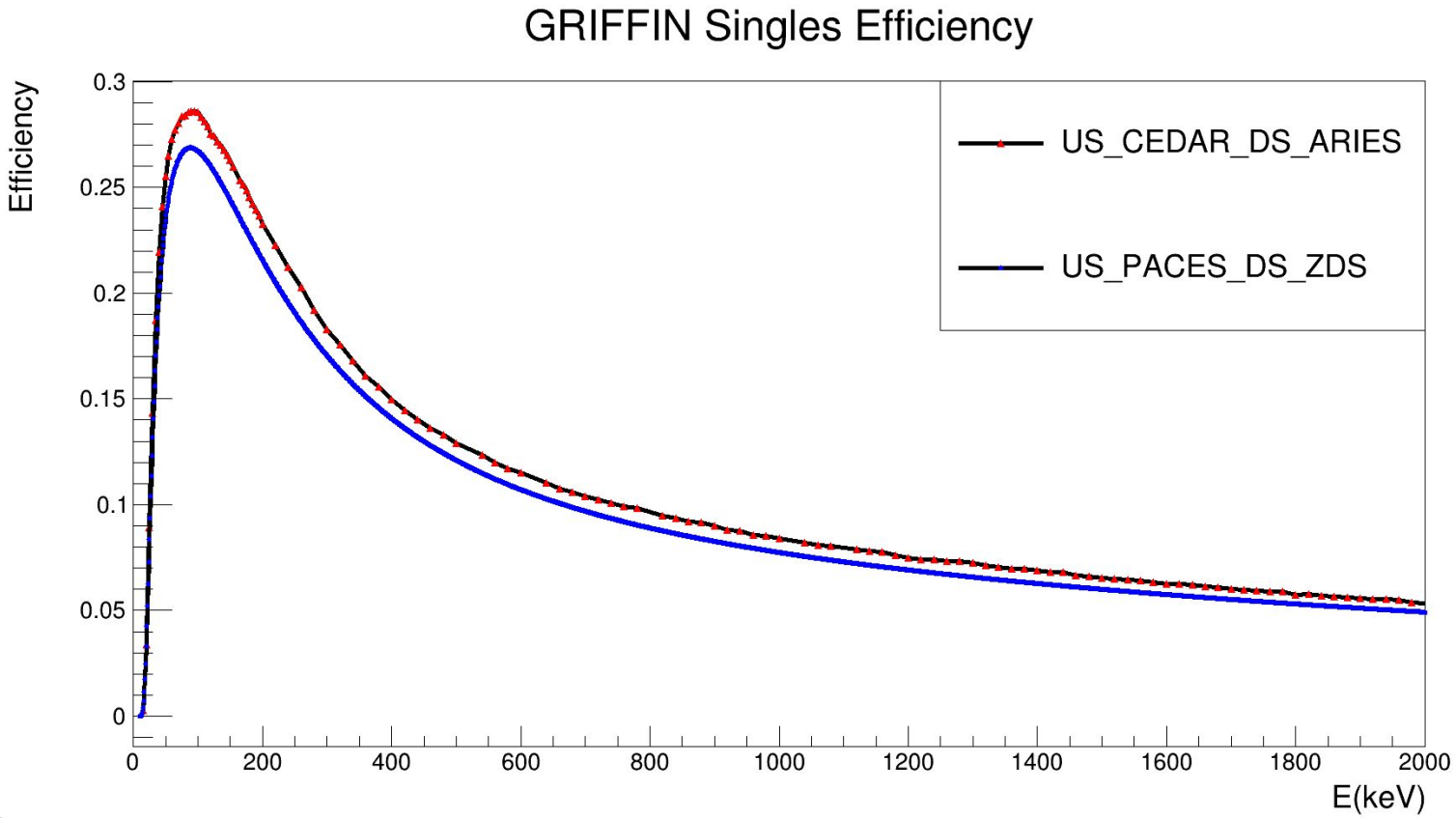
- GEANT4 Simulations
- Improvement of electron efficiency -> increased solid angle coverage
- 2 × higher efficiency
- (Reduced scattering events due to new crystal holder with less material)



Energy(keV)	Eff PACES(%)	Eff CEDAR(%)	Difference in Eff(%)
200	6.1	12.5	6.4
800	5.7	11.5	5.8
1400	5.0	10.4	5.4

GRIFFIN Photo-Efficiency

- All 16 GRIFFIN clovers
- Support structure minimized gamma-ray attenuation
- SiLi crystals placement to minimize shadowing on HPGe and LaBr3
- Improvement on GRIFFIN photo-efficiency compared to previous PACES setup



Energy(keV)	Eff PACES-ZDS(%)	Eff CEDAR-ARIES(%)	Difference in Eff(%)
200	21.8	23.3	1.5
800	8.9	9.7	0.8
1400	6.3	6.9	0.6

Current Phase and Plans for CEDAR

- ✔ Concept design
- ✔ Chamber fabricated
- ❑ Production of in crystal support structure in progress
- ❑ Front-end electronics under development
- ❑ Signal test starts end of 2026
- ❑ To be deployed at GRIFFIN late 2027

Concept designed, design fabrication	Detailed design complete,signal test	8 Crystal Assembly	in beam test	ready for experiment	Full 16 crystals
Feb2026	Oct2026	Dec2026	May2027	July2027	2028

TRIUMF

NSERC CRSNG

Thank you
Merci

- Adam Garnsworthy
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- Heather Robertson
- Carl Svensson
- Diba Toyserkani

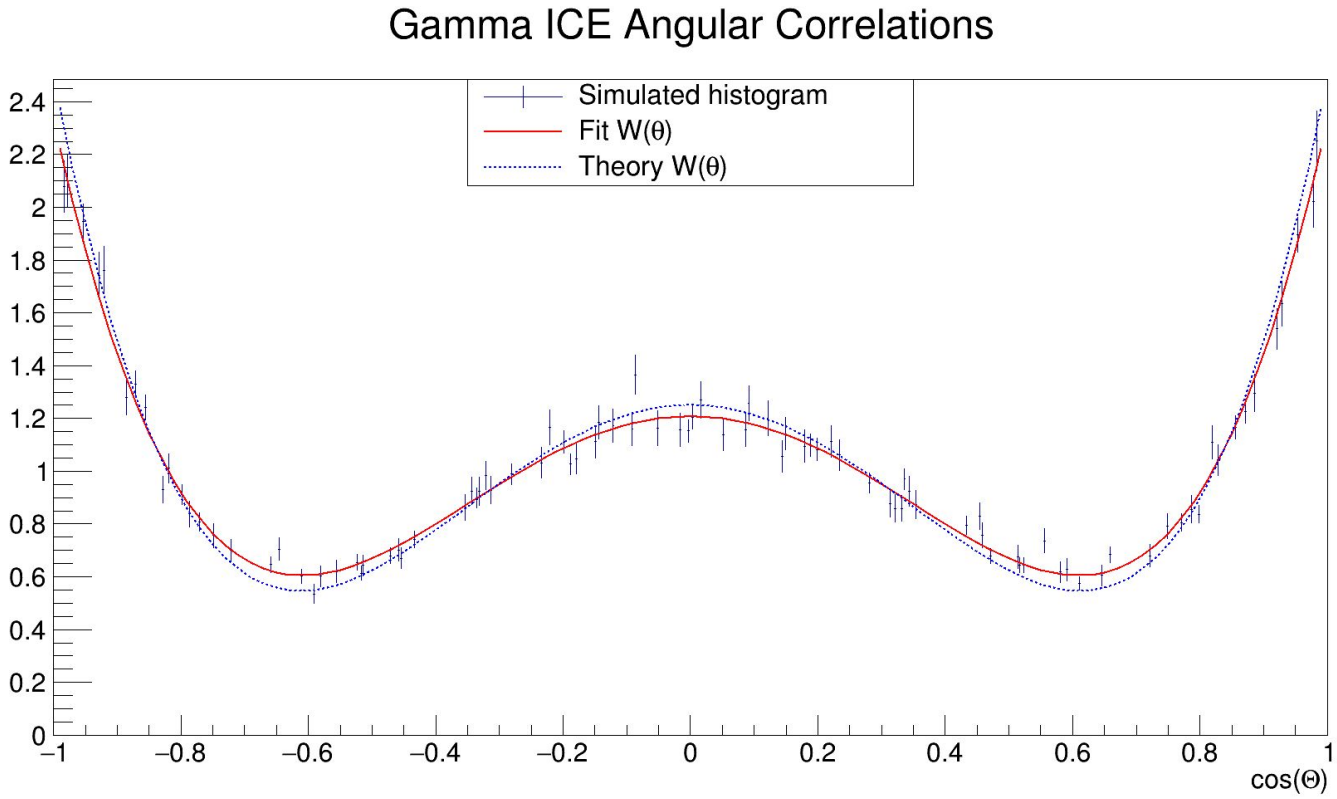
TRIUMF is located on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) People, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site.

Discovery, accelerated

Backup

ICE-Gamma Angular Correlations

- High granularity of CEDAR provides opportunity for angular correlation studies
- Gamma-ICE angular correlations and ICE-ICE directional angular correlations
- Finite detector size correction
- Sensitivities to angular momentum and parities of levels involved
- In addition, it's also sensitive to E0 components of the transition



$$A_2(e_1^K) = b_2^K(E1,E1)F_2(1,1,5,4) - 2\delta_{1e} b_2^K(E1,M2)F_2(1,2,5,4) + \delta_{1e}^2 b_2^K(M2,M2)F_2(2,2,5,4)$$

CEDAR Hardware

- Helium compressor from Cryomech, does not require clover removal of GRIFFIN
- Fast cool down, cold finger reaches 25K
- Two heaters, aluminum housed and Kapton Layered near the detector end
- Photo inside the chamber