

FAST-TIMING CAPABILITIES OF GRIFFIN



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for the GRIFFIN collaboration
University of Guelph, ON, Canada

Nu-ball workshop, Orsay, France
19 May 2016

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GRIFFIN

- **TRIUMF**
- **GRIFFIN**
- **Fast timing**
- **Future plans**
- **Approved experiments**

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TRIUMF is Canada's national laboratory for particle and nuclear physics and accelerator-based science

Located in Vancouver, BC

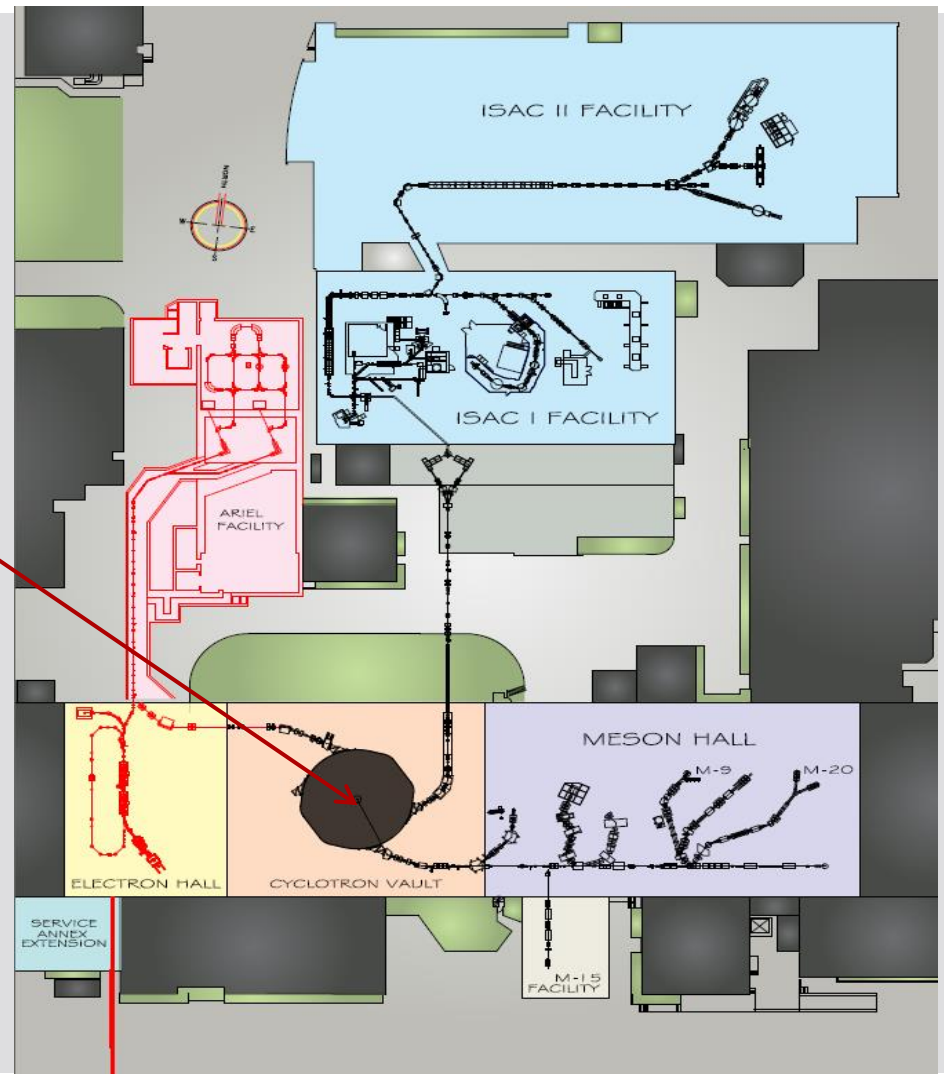


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CANADA V6T 2A3

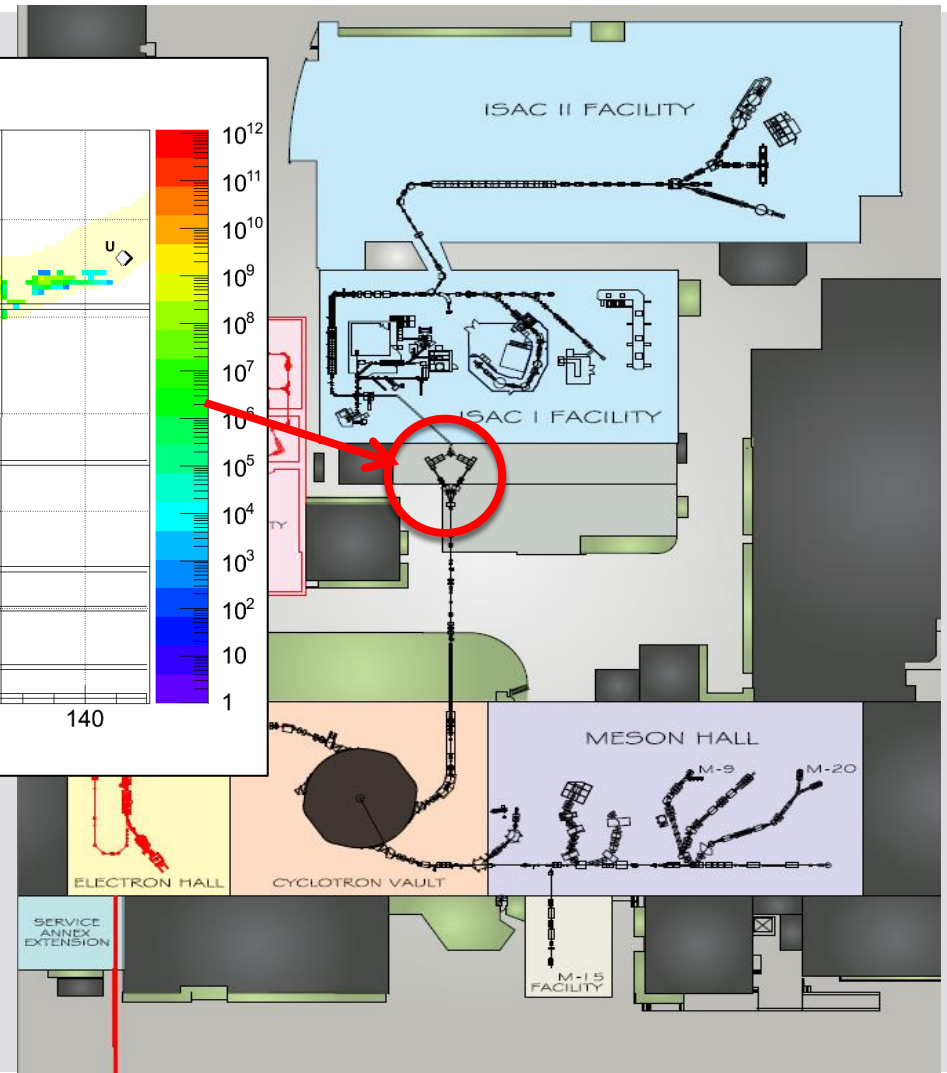
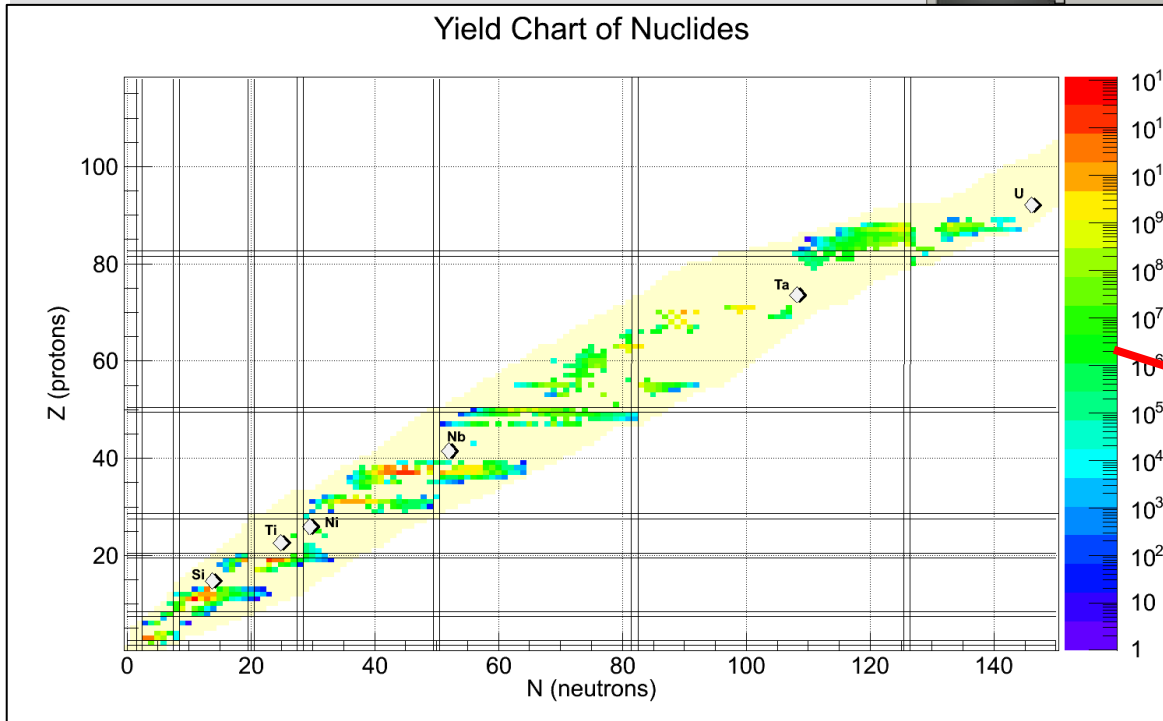
TRIUMF ISOTOPE SEPARATOR AND ACCELERATOR



- 18 m diameter cyclotron
- 500 MeV protons
- Up to 100 μA intensity
- Continuous beam

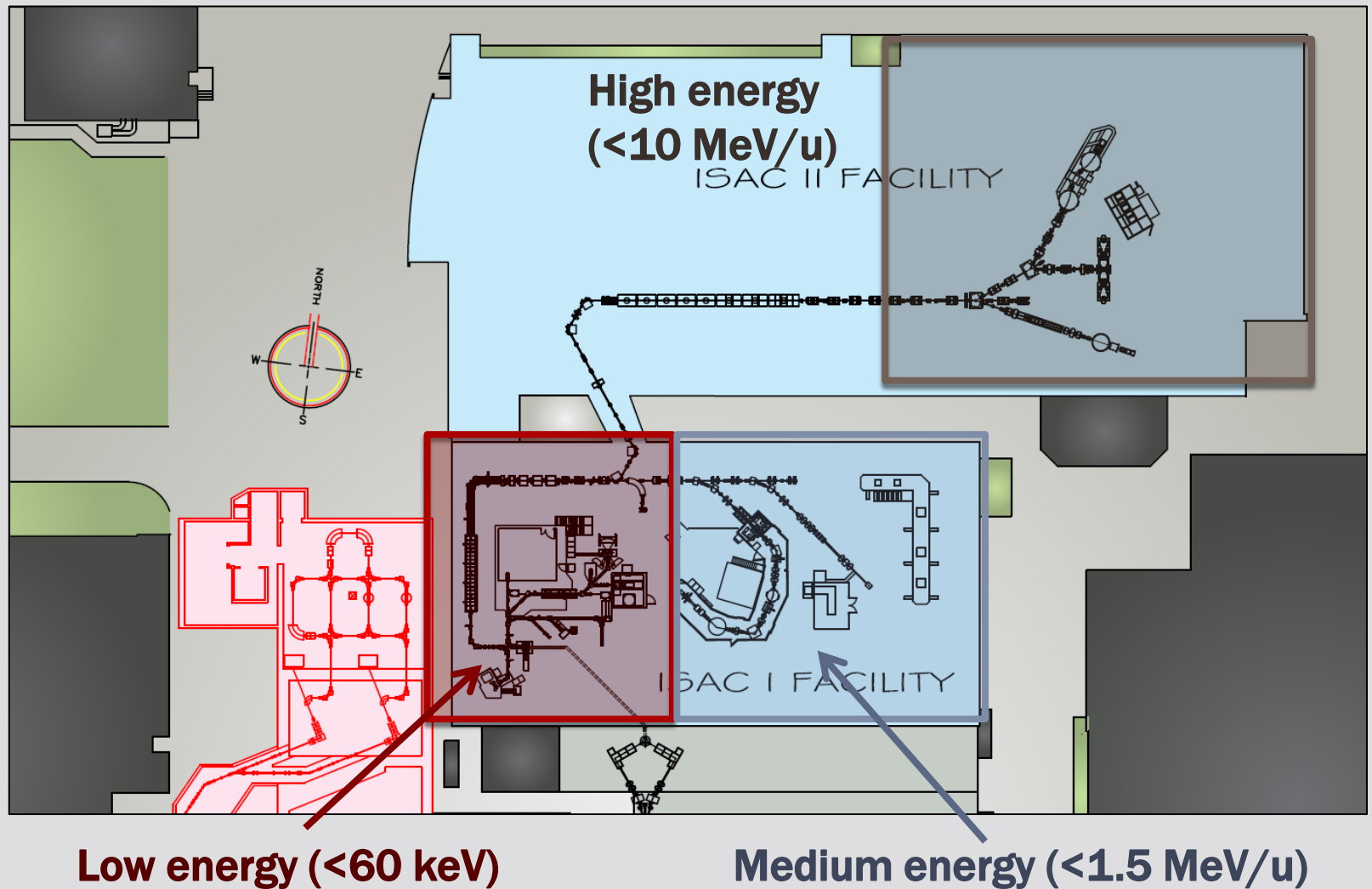


TRIUMF ISOTOPE SEPARATOR AND ACCELERATOR

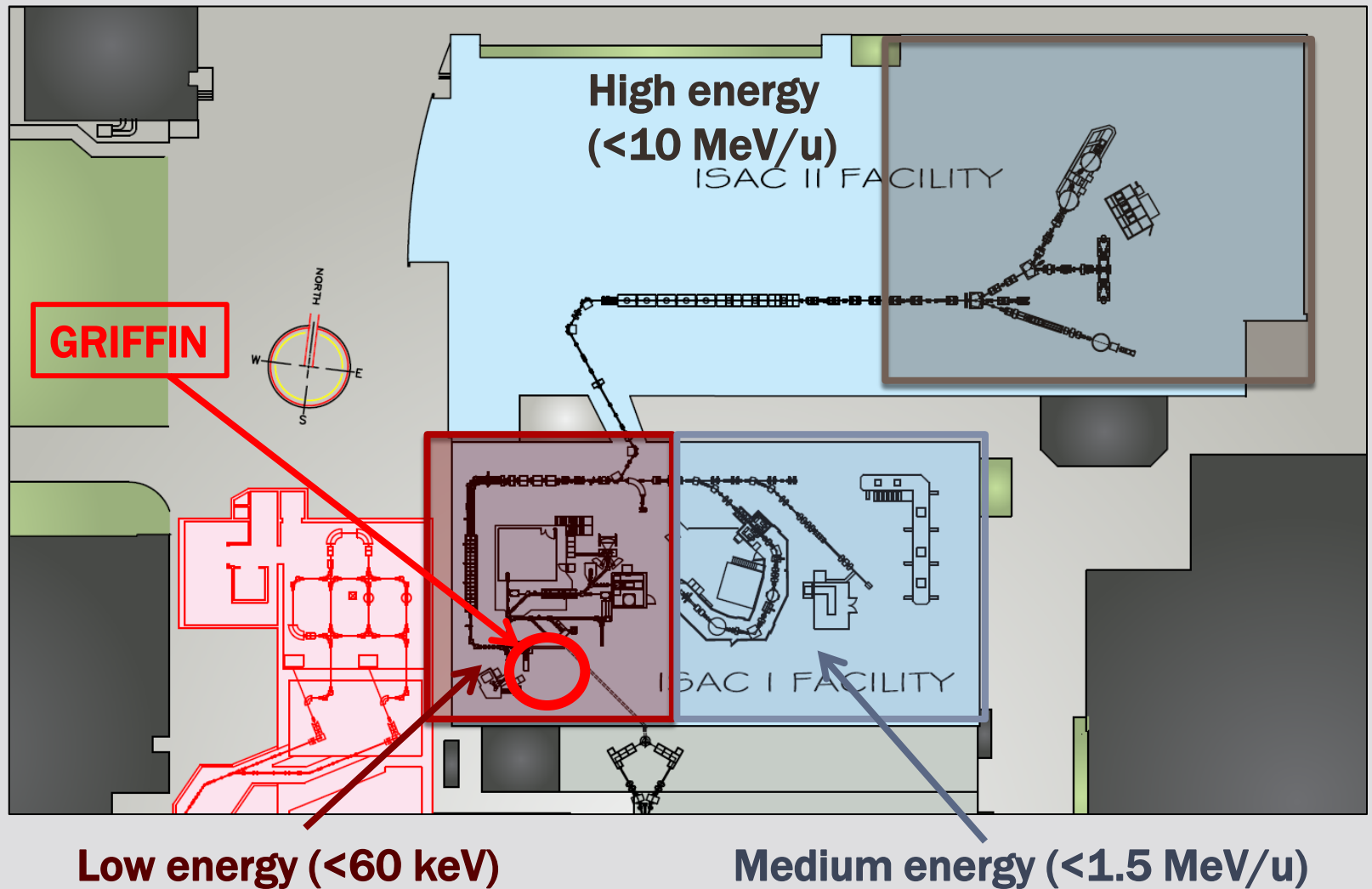


- SiC, NiO, Nb, ZrC, Ta, UC_x Targets
- Surface, FEBIAD, TRILIS ion sources
- ISOL technique
- Mass separation $1/10000$

TRIUMF ISOTOPE SEPARATOR AND ACCELERATOR



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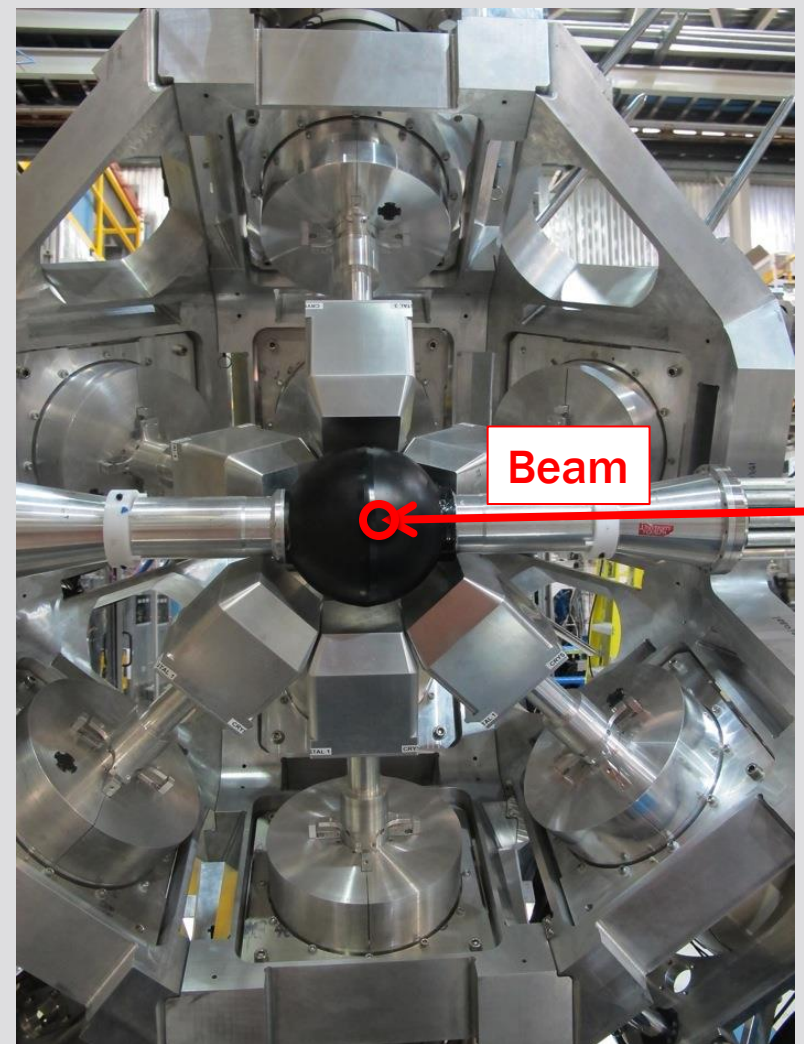
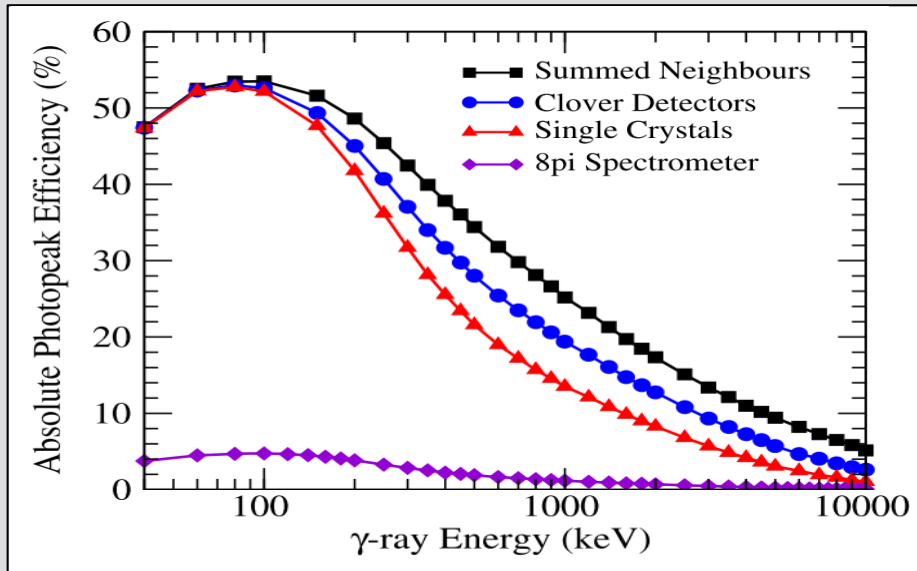
GRIFFIN HPGE CLOVER DETECTORS

Gamma-Ray Infrastructure For Fundamental Investigations of Nuclei (GRIFFIN)

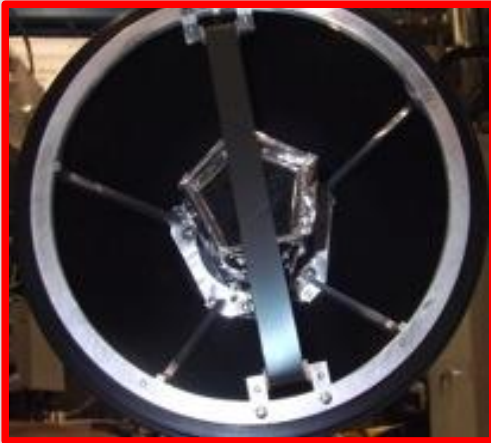
A close-packed array of
16 large-volume HPGe
Clover detectors, 64 crystals

Sensitivity down to 0.1 pps ^{132}Cd Aug-2015

Sensitivity down to 0.1 pps ^{132}Cd Aug-2015



GRIFFIN ancillary detectors



SCEPTAR:
10+10 plastic
scintillators
High efficiency
 *β particle
tagging*
*Up to 80%
efficiency*



PACES:
5 Cooled Si(Li)s
Internal Conversion
*Electrons and
alphas/protons*
5% solid angle



DESCANT
*70 deuterated benzene array to detect
neutrons. Capacity to online differentiate
photons and neutrons*
~27% solid angle

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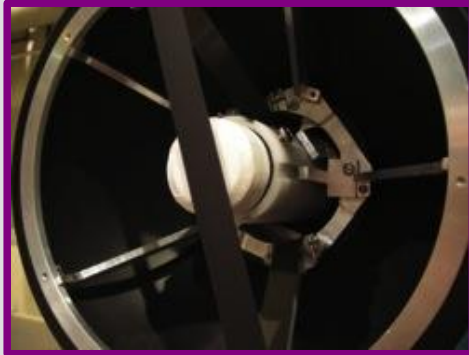


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FAST-TIMING WITH GRIFFIN

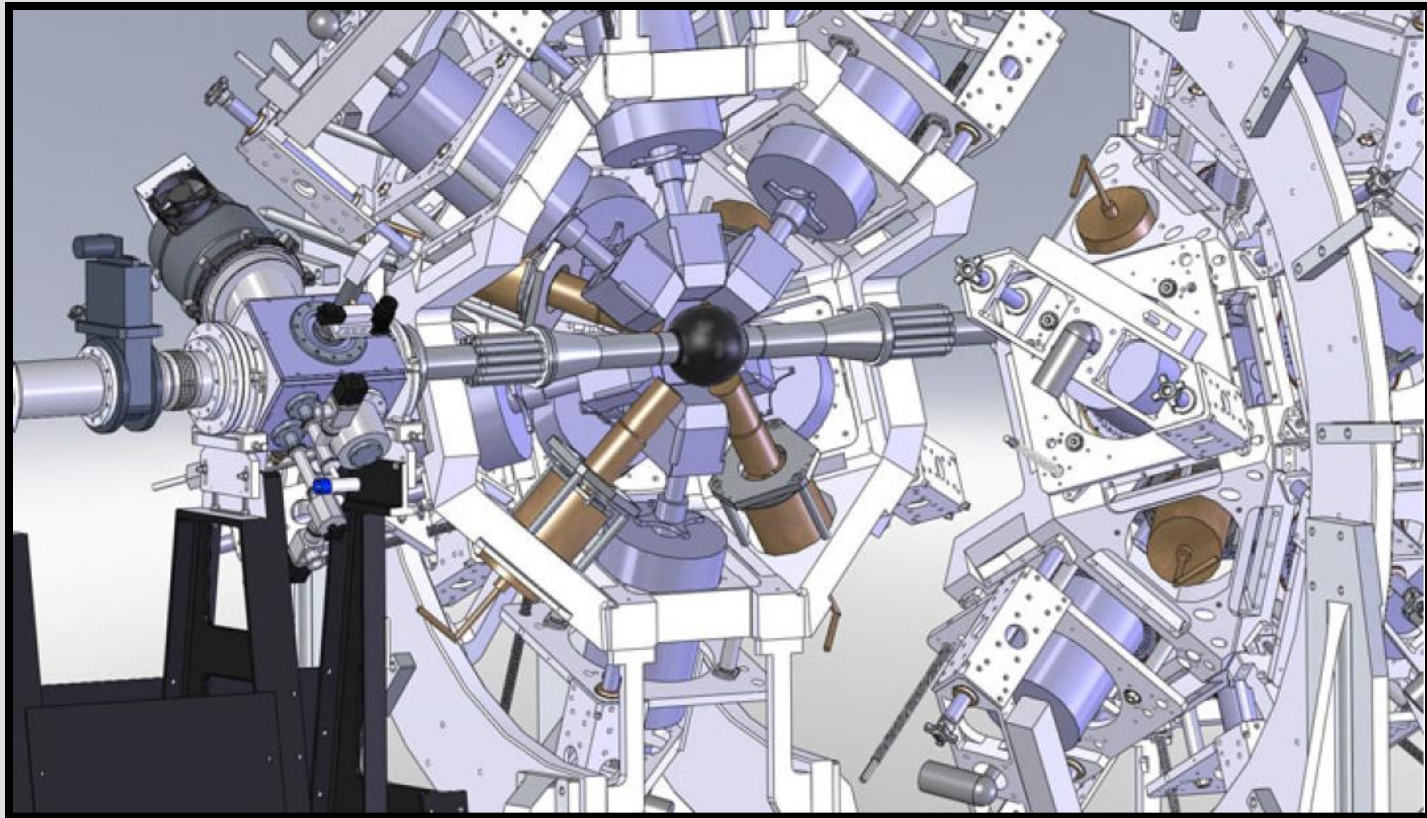


- Zero-Degree Fast scintillator
- Fast-timing plastic for β particles
- 25% efficiency

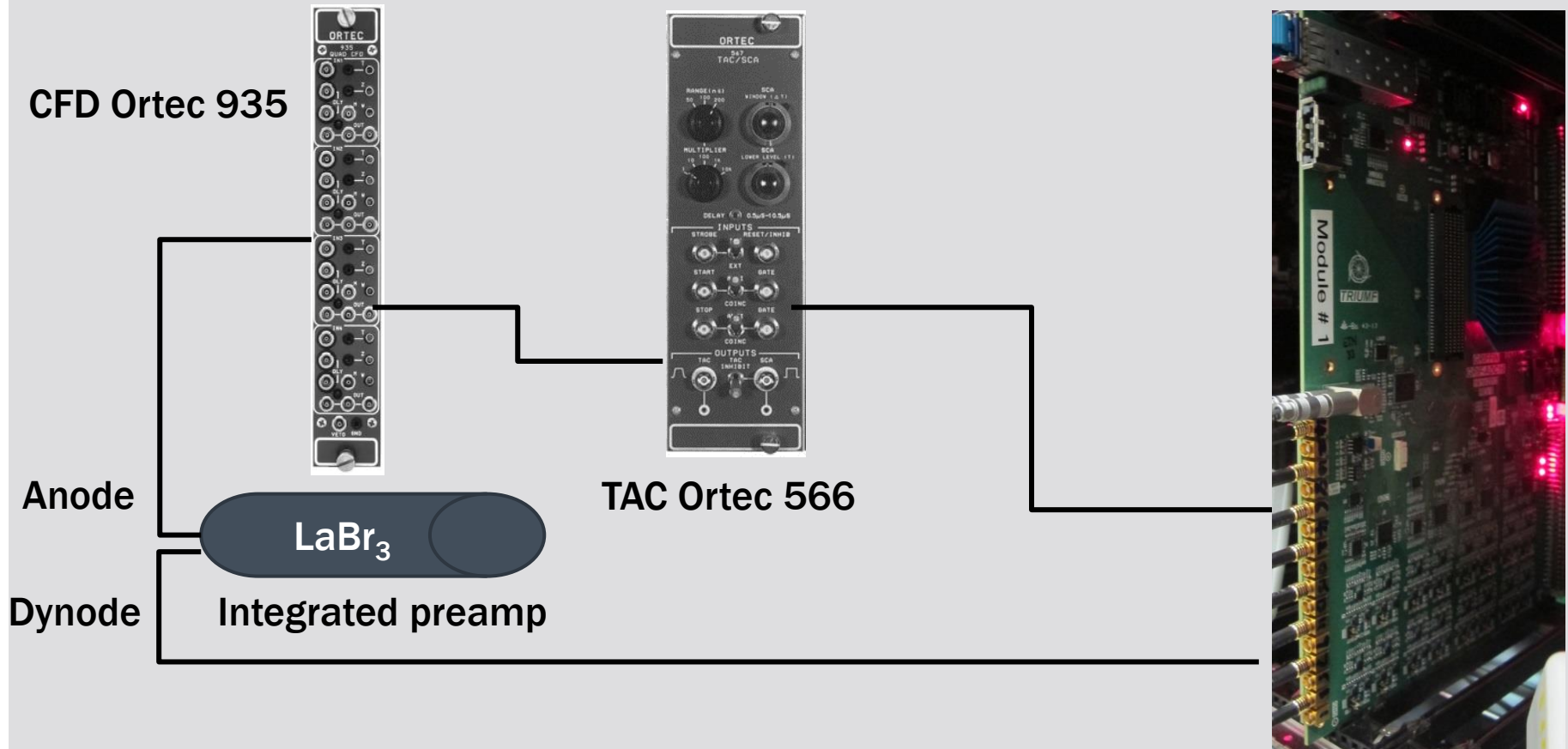


- 8 x LaBr₃(Ce) detectors
- 2" x 2" cylindrical crystals
- Photonis BrillanCe 380
- 5% Ce dopping
- Hamamatsu R2083 PMT
- Integrated pre-amp
- Sealed aluminum casing

TIMING WITH GRIFFIN



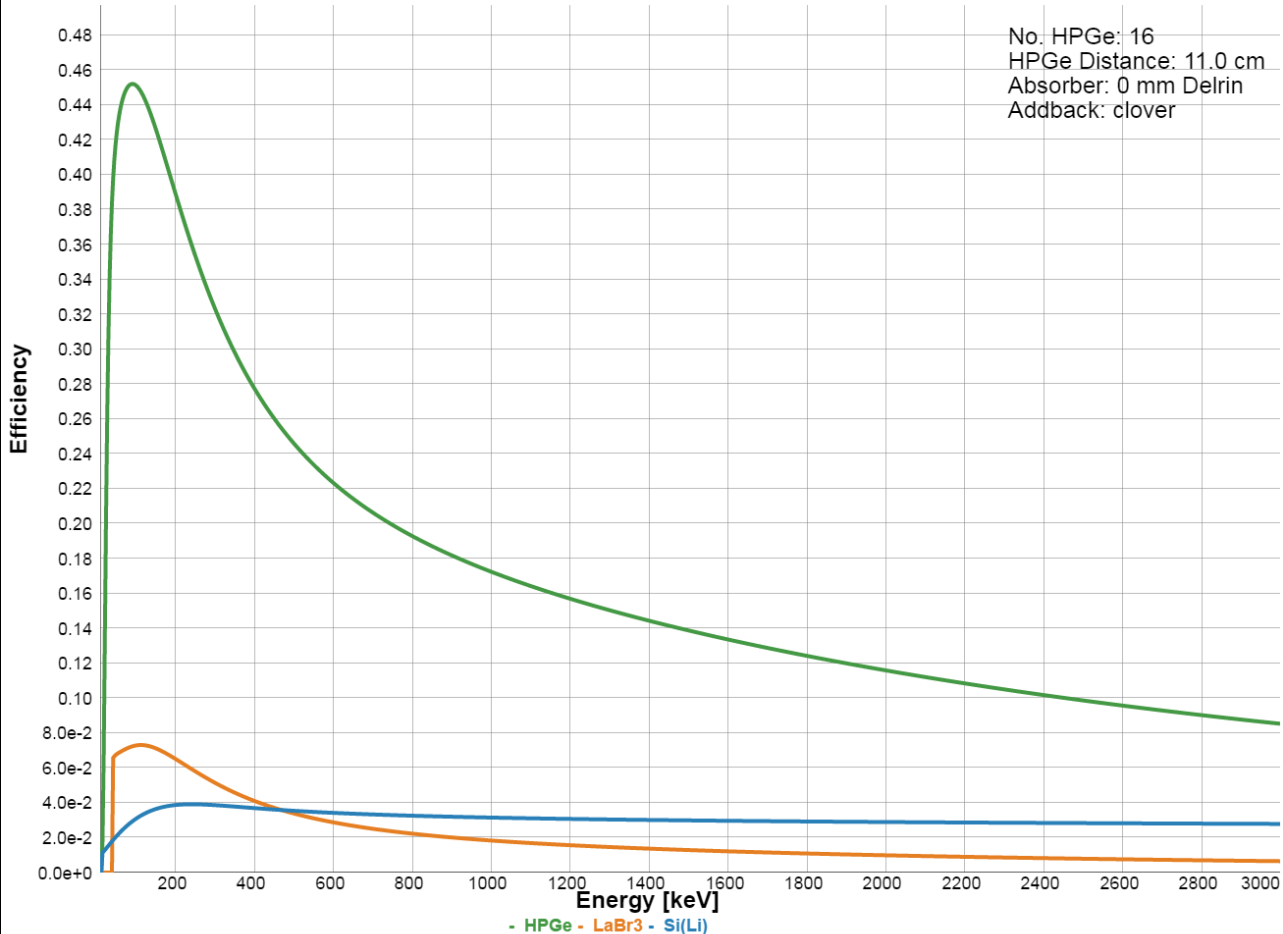
Analog electronics



GRIF16 16-channel, 14-bit, 100MHz sampling ADC module. They can handle up to 50 kcps per channel. Custom-made by TRIUMF

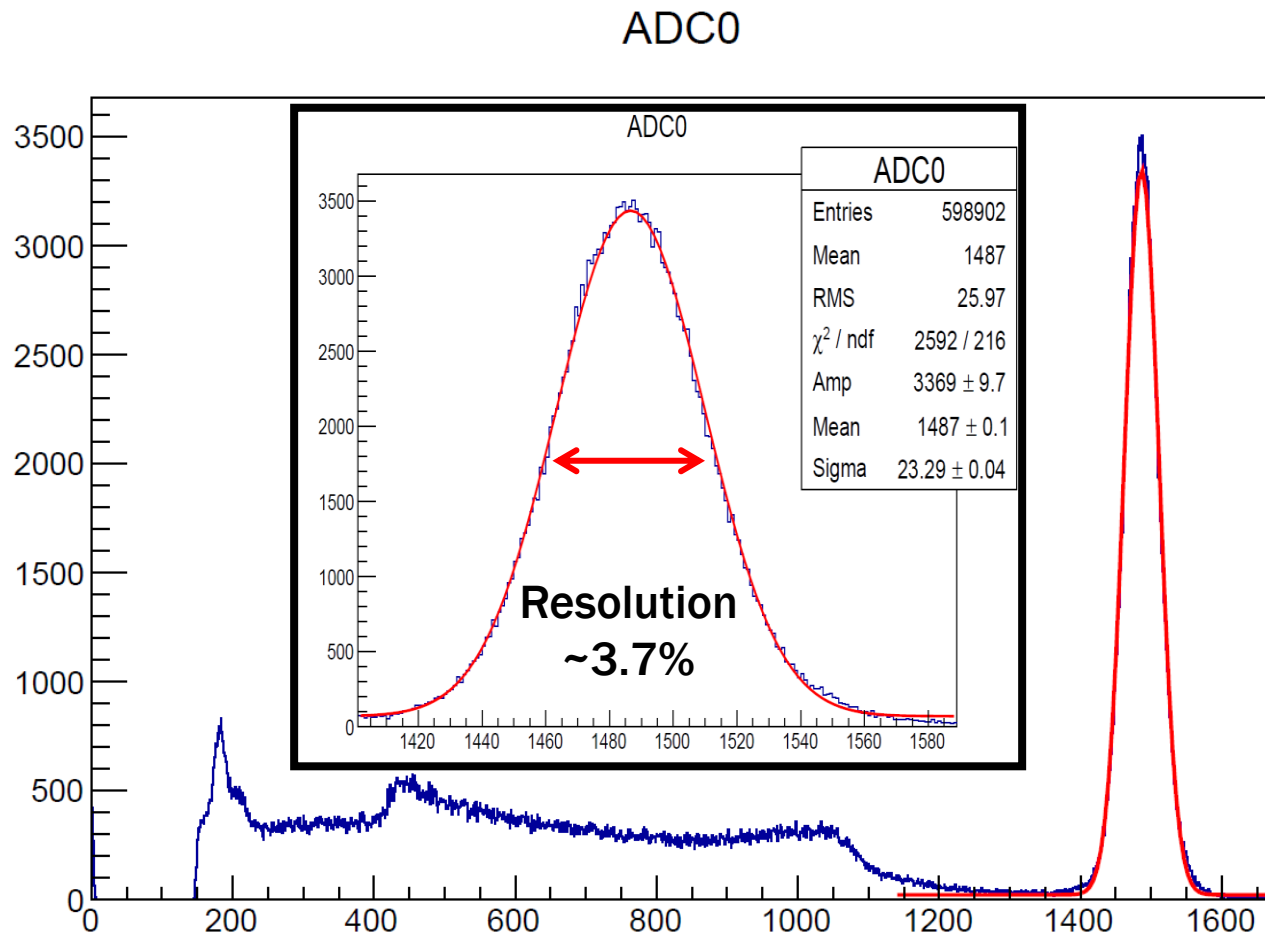
LaBr₃ total efficiency

Simulated Efficiency v. Energy



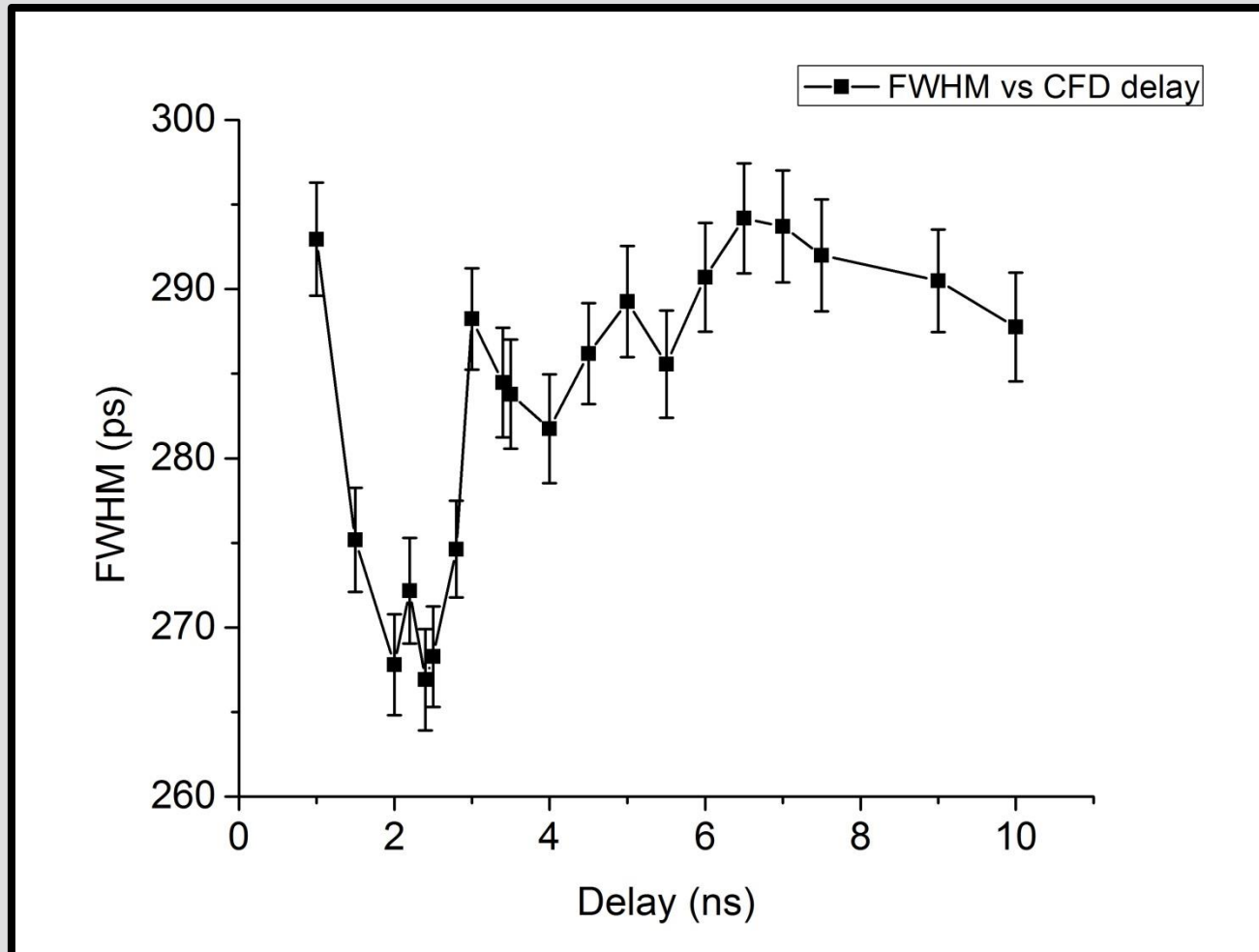
- **7.5% absolute efficiency at ~150 keV**
- **~2% at 1 MeV**
- **Simulated in Geant4**
- **Full array of 8 LaBr₃ at 11 cm from deposition point**

ENERGY RESOLUTION

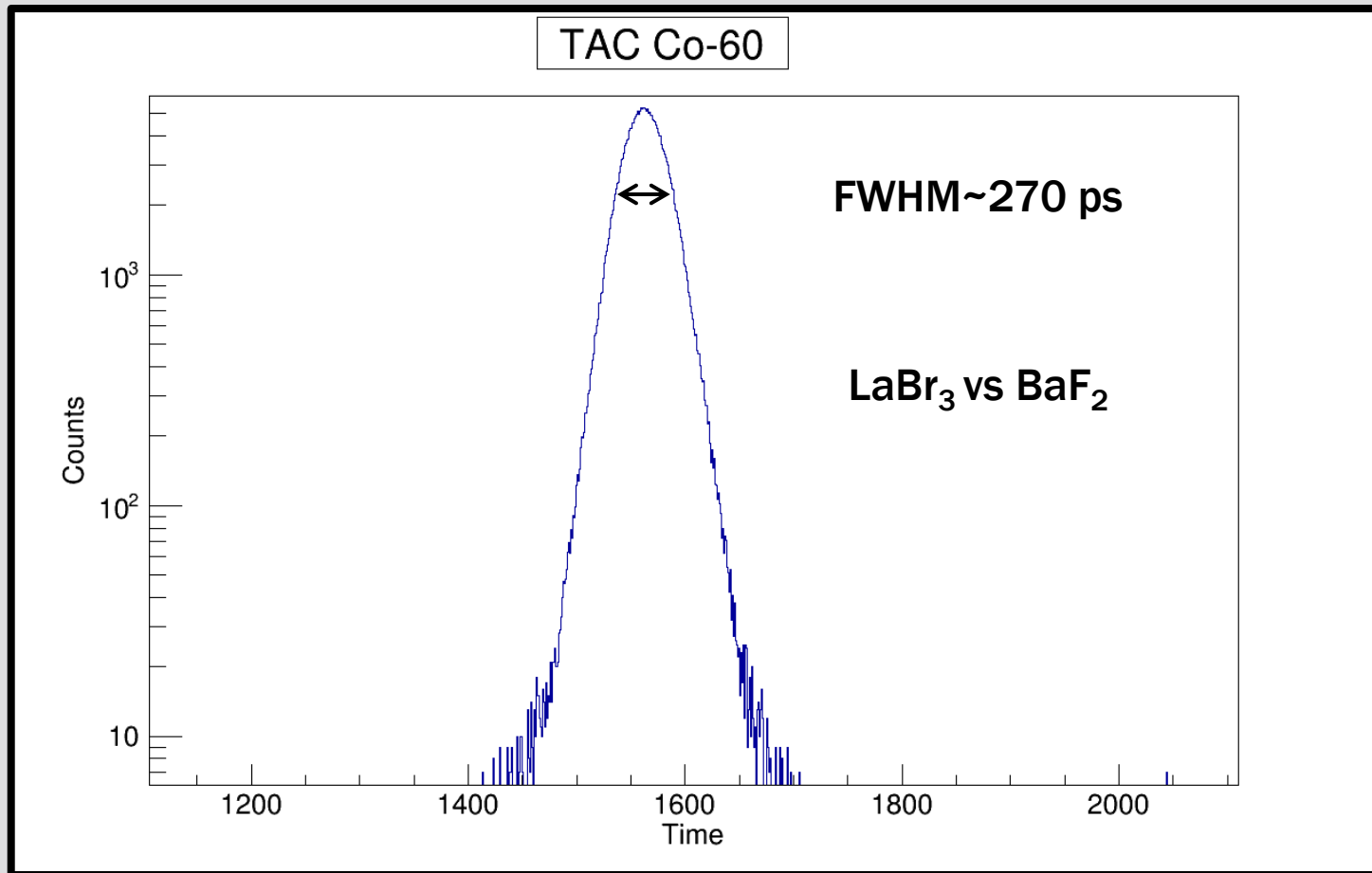


Saint Gobain claims a 3.5% energy resolution at ^{137}Cs energy (662 keV)

FWHM vs CFD delay

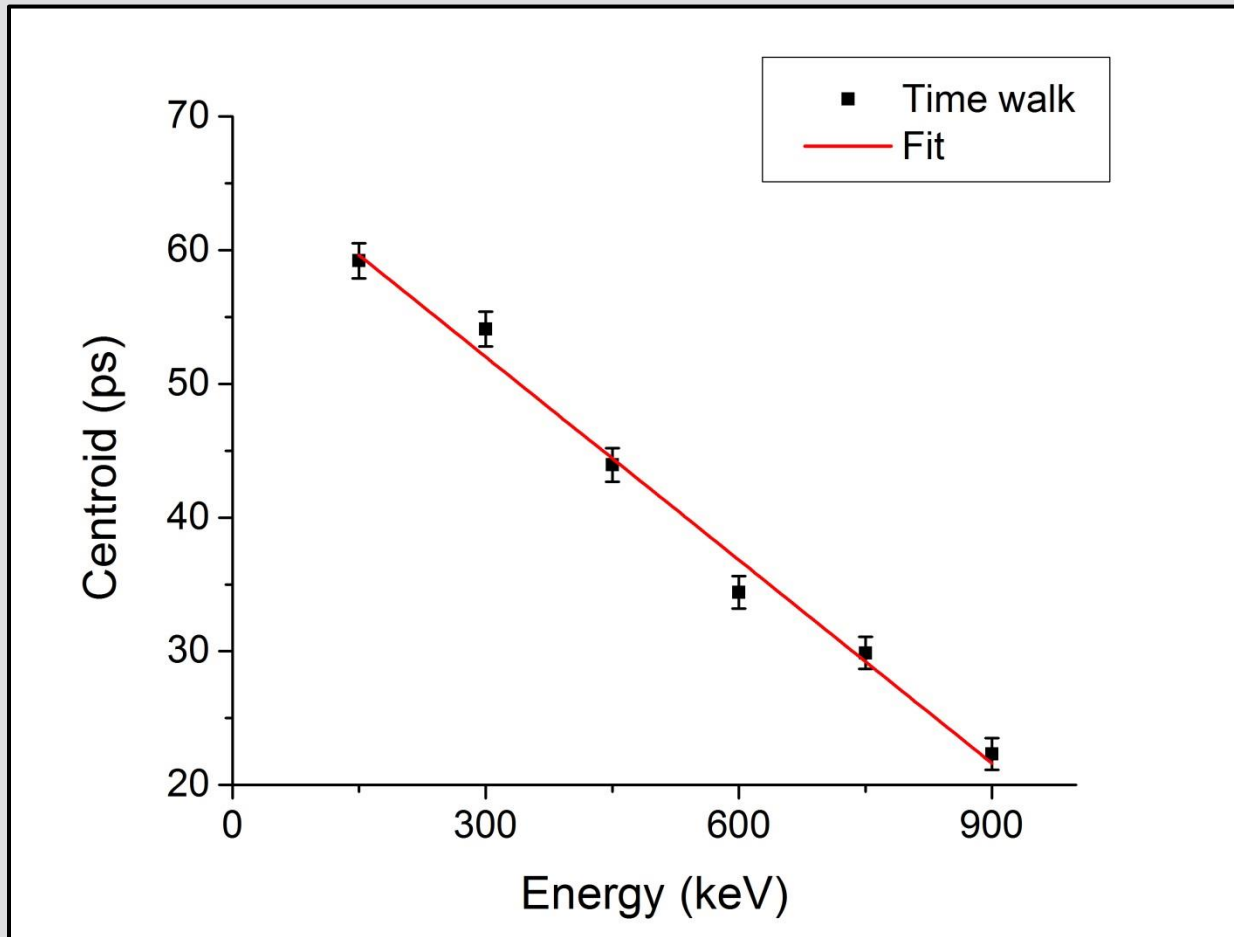


OPTIMUM FWHM



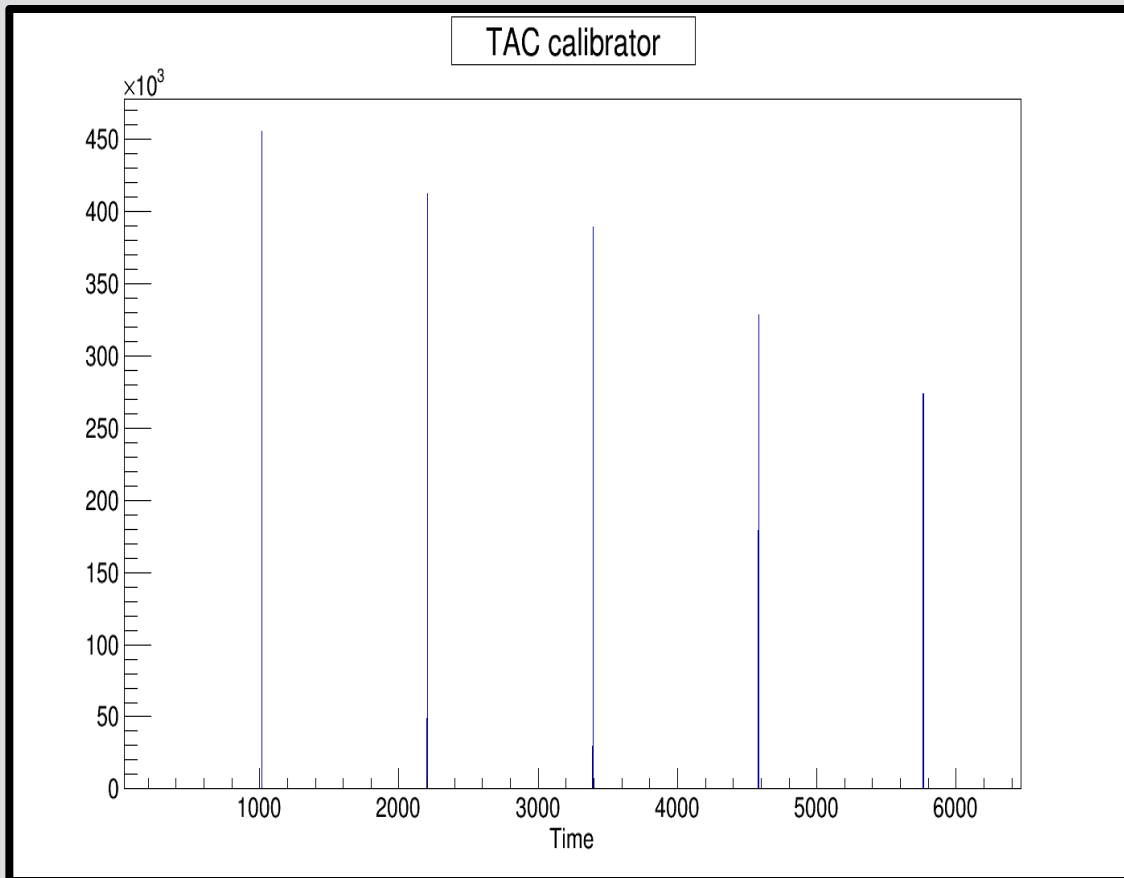
TIME WALK

Time walks as good as ± 30 ps over 1 MeV range



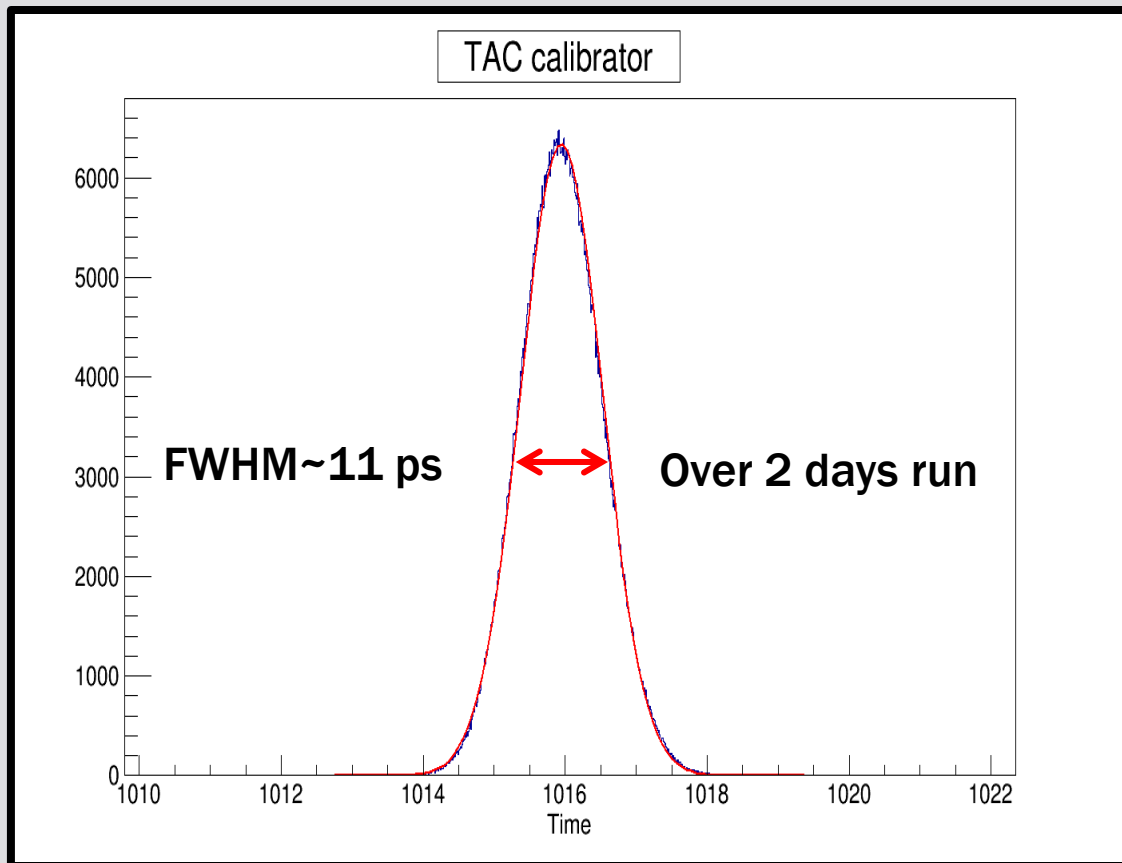
CFD delay 8 ns
FWHM~290 ps @ 1.3 MeV

DAQ system



- System is linear down to **1/1000**
- DAQ and analog electronics are located in a temperature-controlled shack

DAQ system



- System is linear down to **1/1000**
- DAQ and analog electronics are located in a temperature-controlled shack
- No TAC drifts in controlled environment

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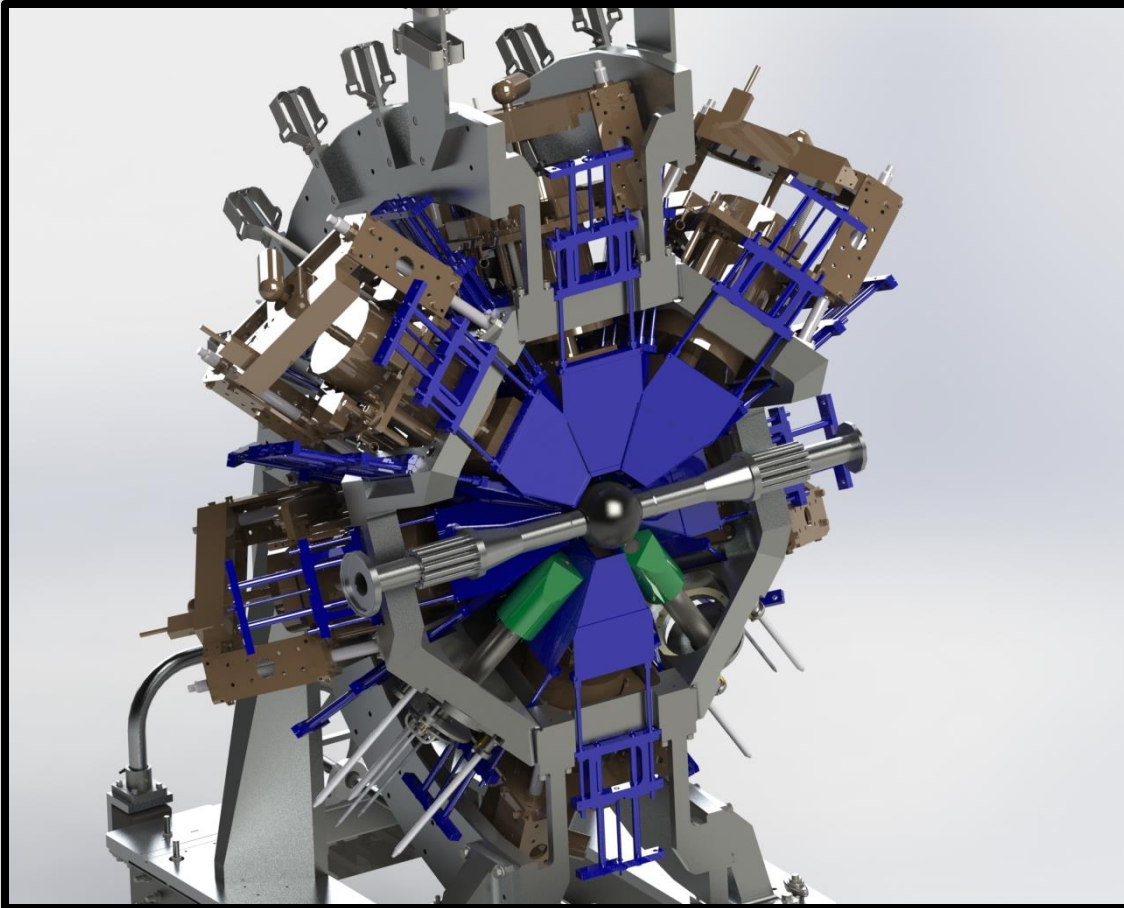


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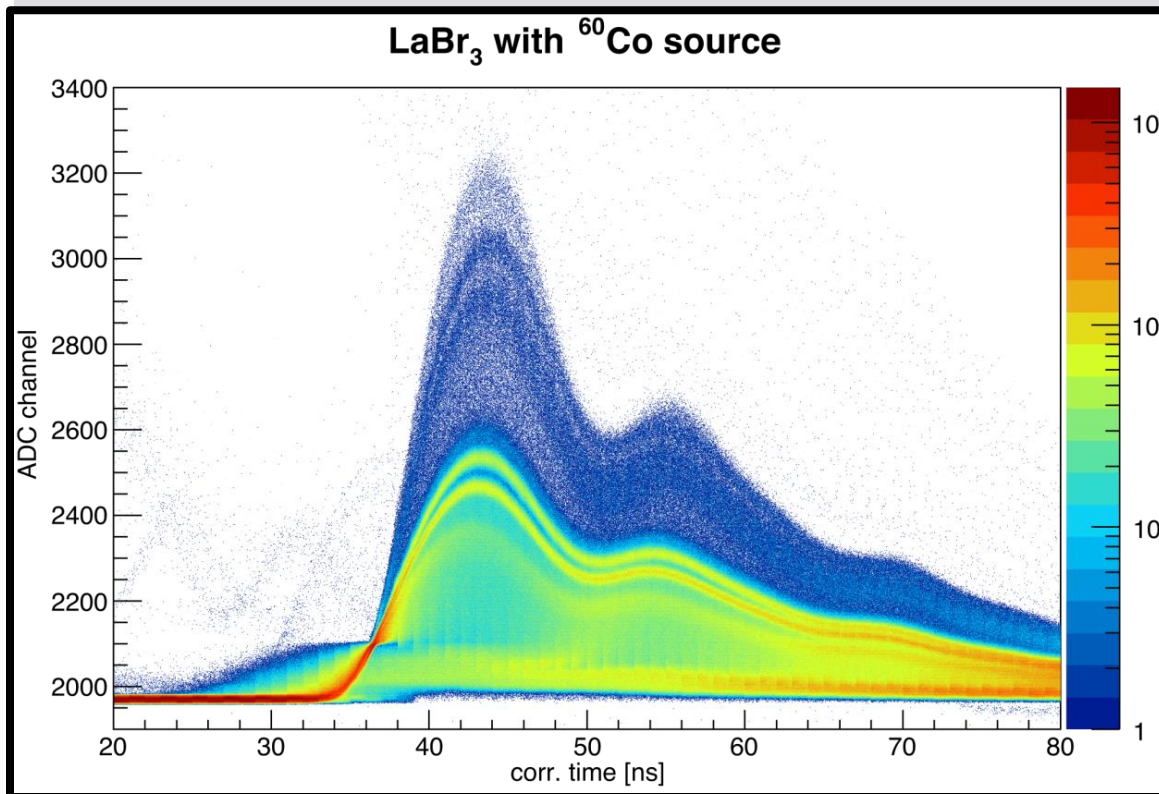
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BGO shielding



- Funding approved
- BGO shielding for both HPGe and LaBr₃ array
- BGO shield will greatly improve peak-to-background ratio
- Background is one of the sources of uncertainties in fast timing
- Will greatly increase our timing sensitivity

1 GHz electronic cards



- Custom-built DAQ cards
- The signal is taken directly from the anode
- Sample at 1 GHz frequency
- Interpolated in 1/256 steps
- We expect a system time resolution of ~25 ps

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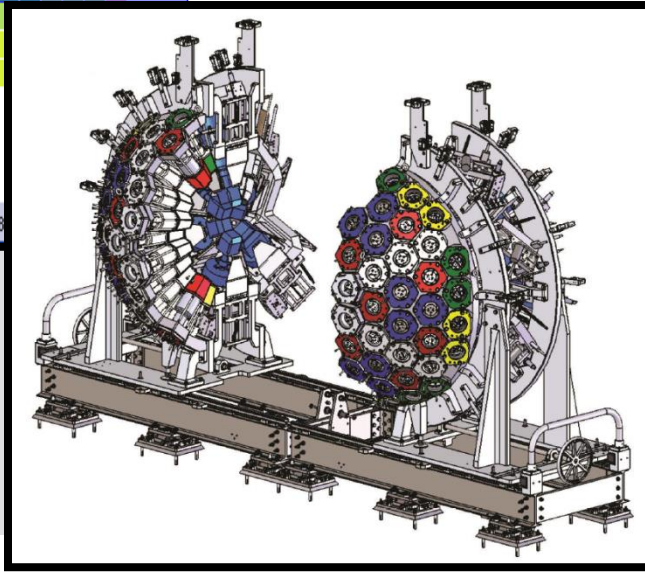
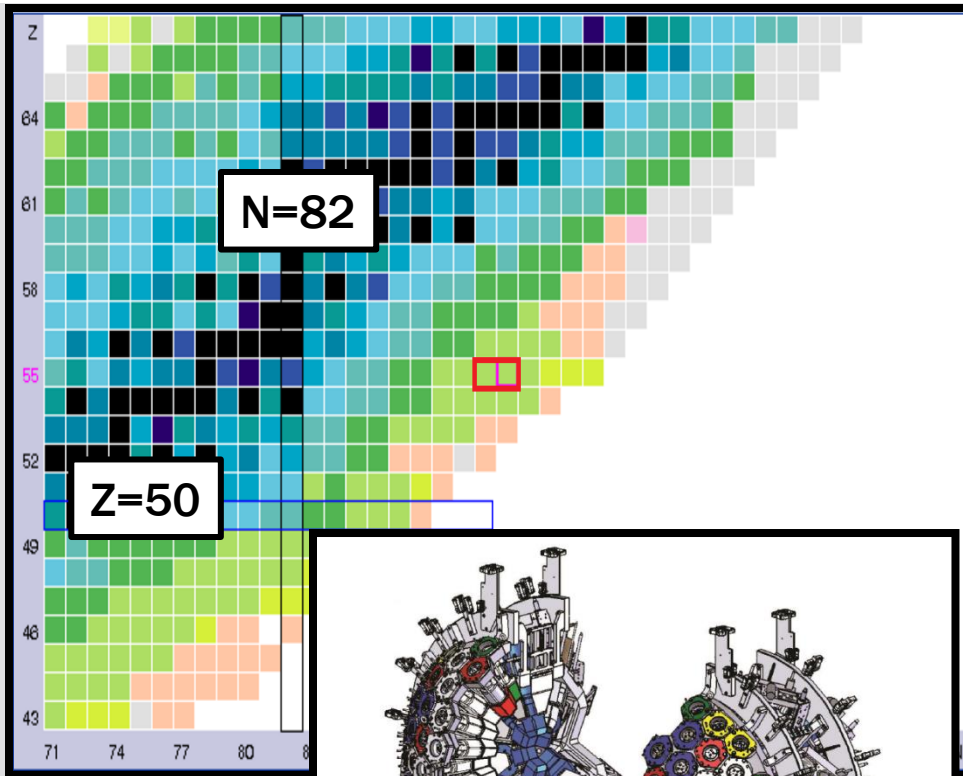
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$^{145,146}\text{Cs}$ decay

P. E. Garrett S1468

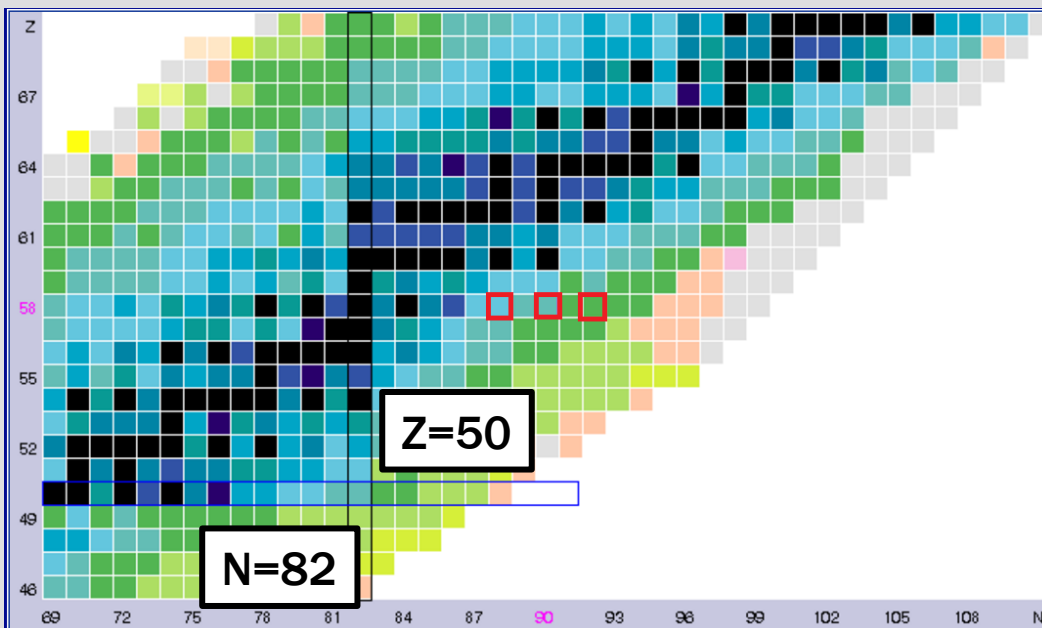


- Commissioning of DESCANT
- First experiment with LaBr_3 crystals
- Part of a wider campaign to study up to $A=149$ for the first time
- Main goal is neutron-spectroscopy
- Search for octupole bands
- Several lifetimes in the sub-nanosecond range, precision can be improved
- To be run this August

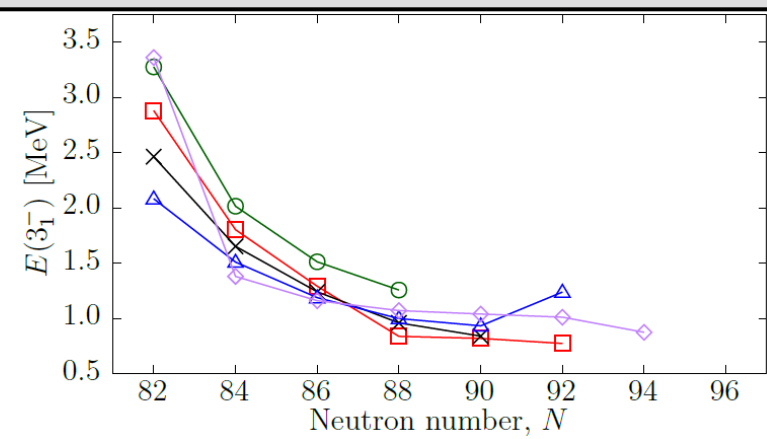
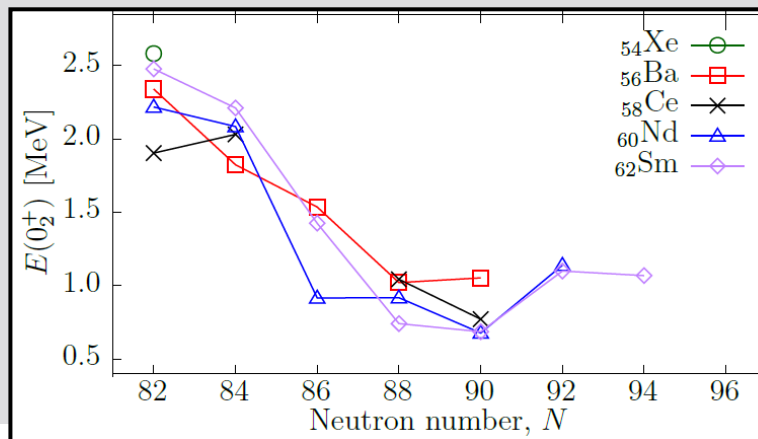
Isotope	E (keV)	J^π	T1/2 (ps)
^{145}Ba	112.6	$(7/2)^-$	220(120)
^{146}Ba	181	2^+	860(30)
	513.5	4^+	18(15)
	738.8	1^-	160(10)
	820.9	3^-	237(8)
	1052.5	0^+	<26

Neutron-rich Ce isotopes

L. P. Gaffney S1626

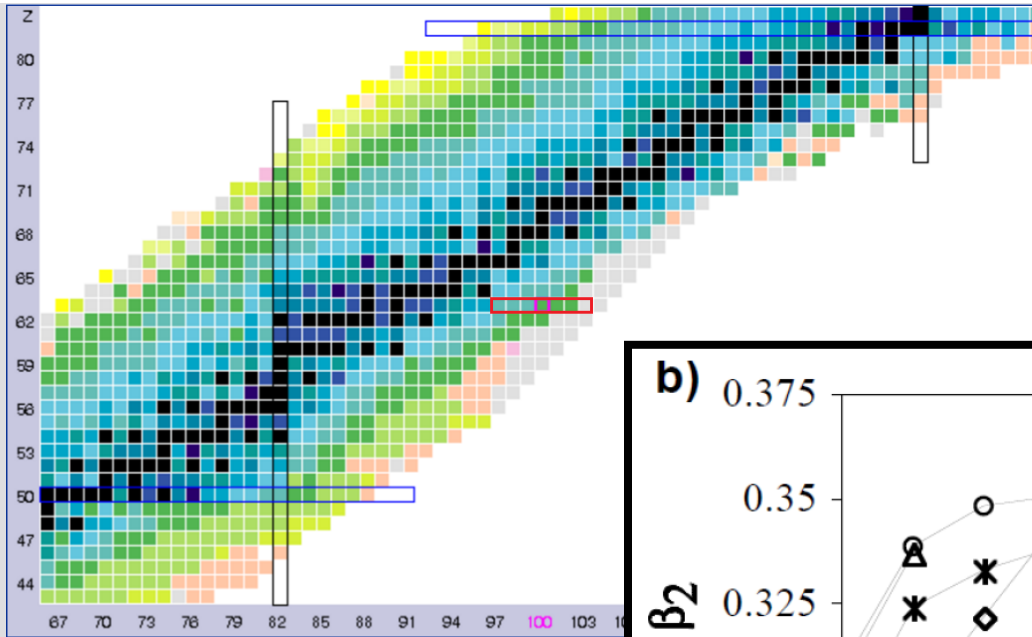


- La decay to $^{146, 148, 150}\text{Ce}$
- γ and e^- spectroscopy to investigate the β -vibrational and shape-coexistence descriptions
- Search for 3^- states to investigate the octupole correlation around $Z=56, N=88$
- Unpublished ns lifetimes in Ce
- $B(E3)$ and $\rho^2(0^+_2 \rightarrow 0^+_1)$



Decay spectroscopy of n-rich Eu isotopes

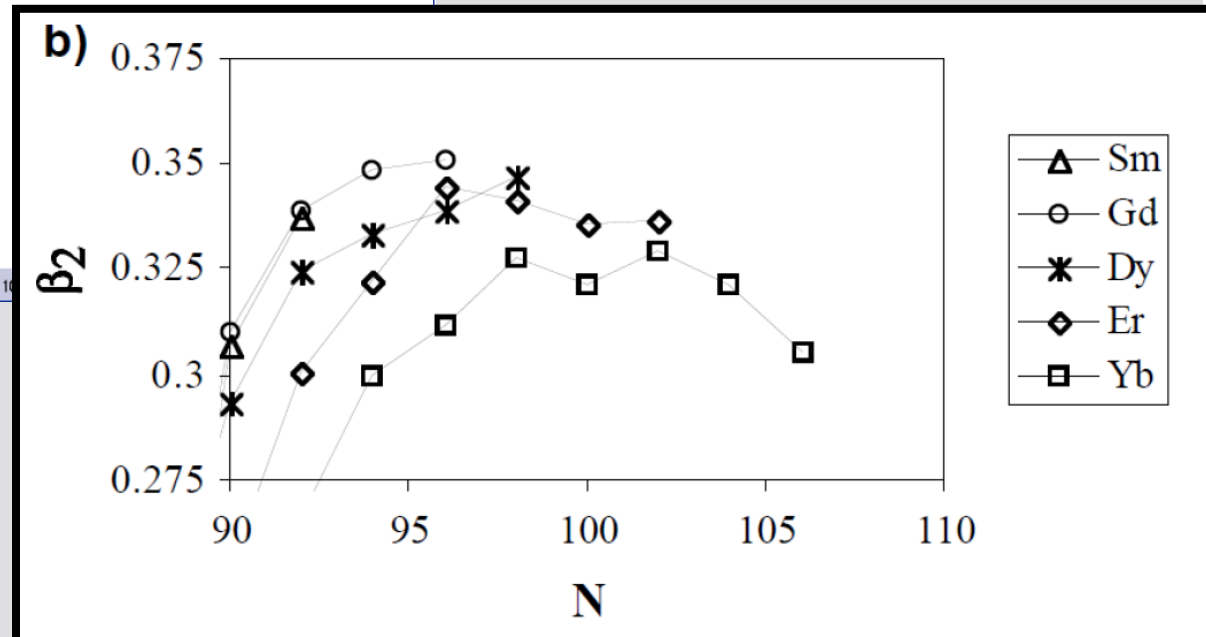
I. Dillmann, P.E. Garrett S1625



- Investigation of the rare-earth peak $A \sim 165$ in the r-process
- Eu decay into $^{160-166}\text{Gd}$
- Does deformation saturates at ^{170}Dy in the region?

	2+	4+
^{160}Gd	measured	180 ps
^{162}Gd	2.8 ns	240 ps
^{164}Gd	2.8 ns	230 ps
^{166}Gd	2.9 ns	270 ps

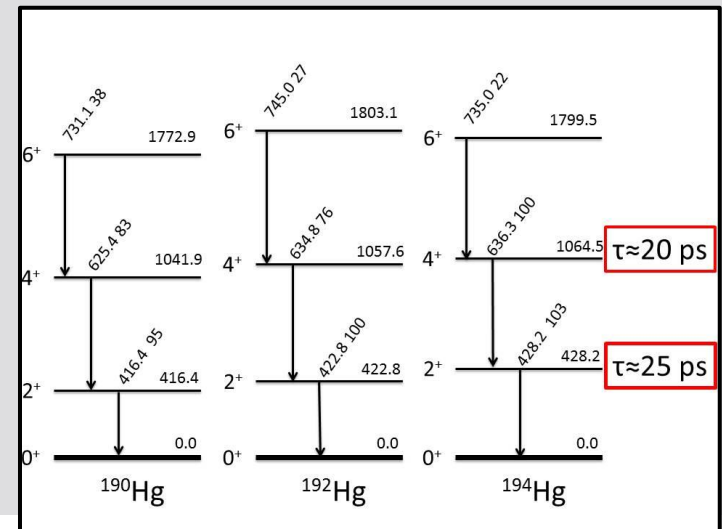
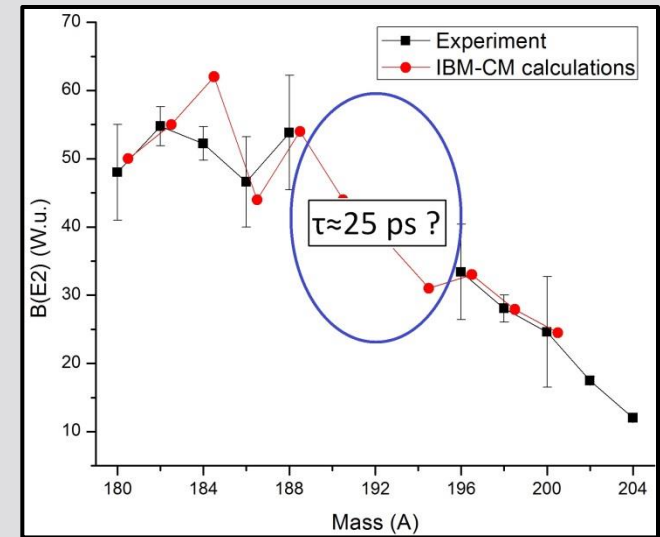
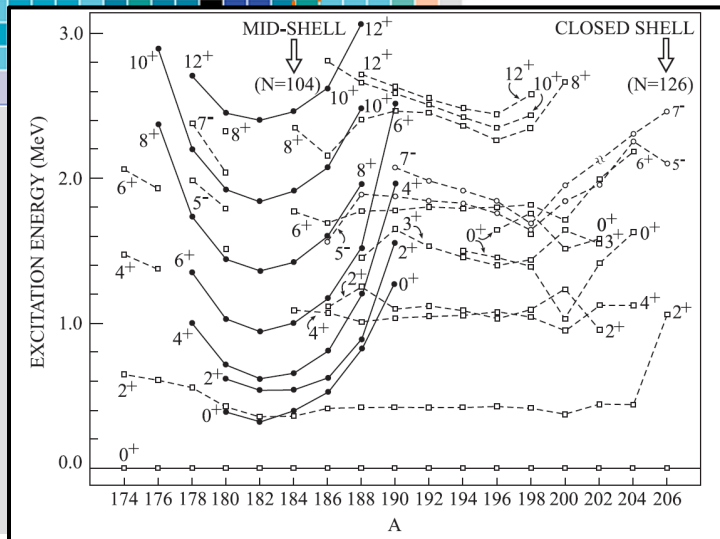
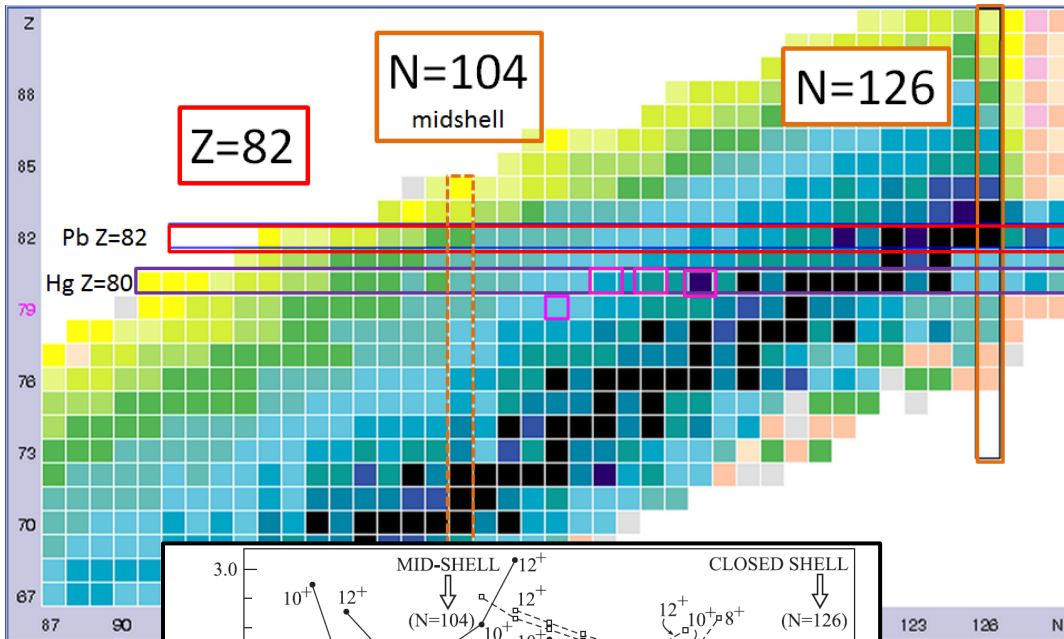
Calculated $\tau(2^+)$ and $\tau(4^+)$



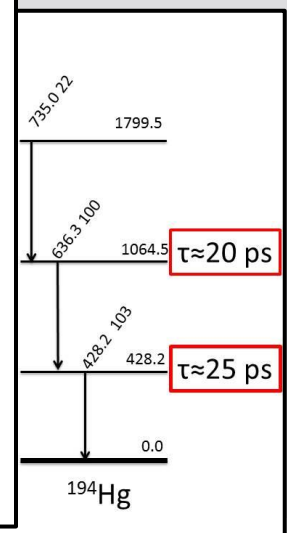
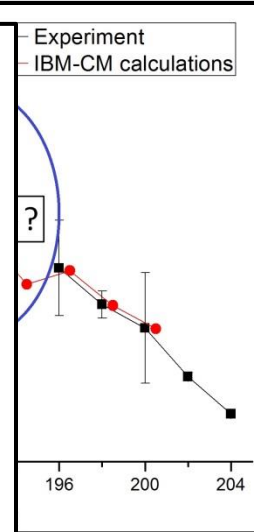
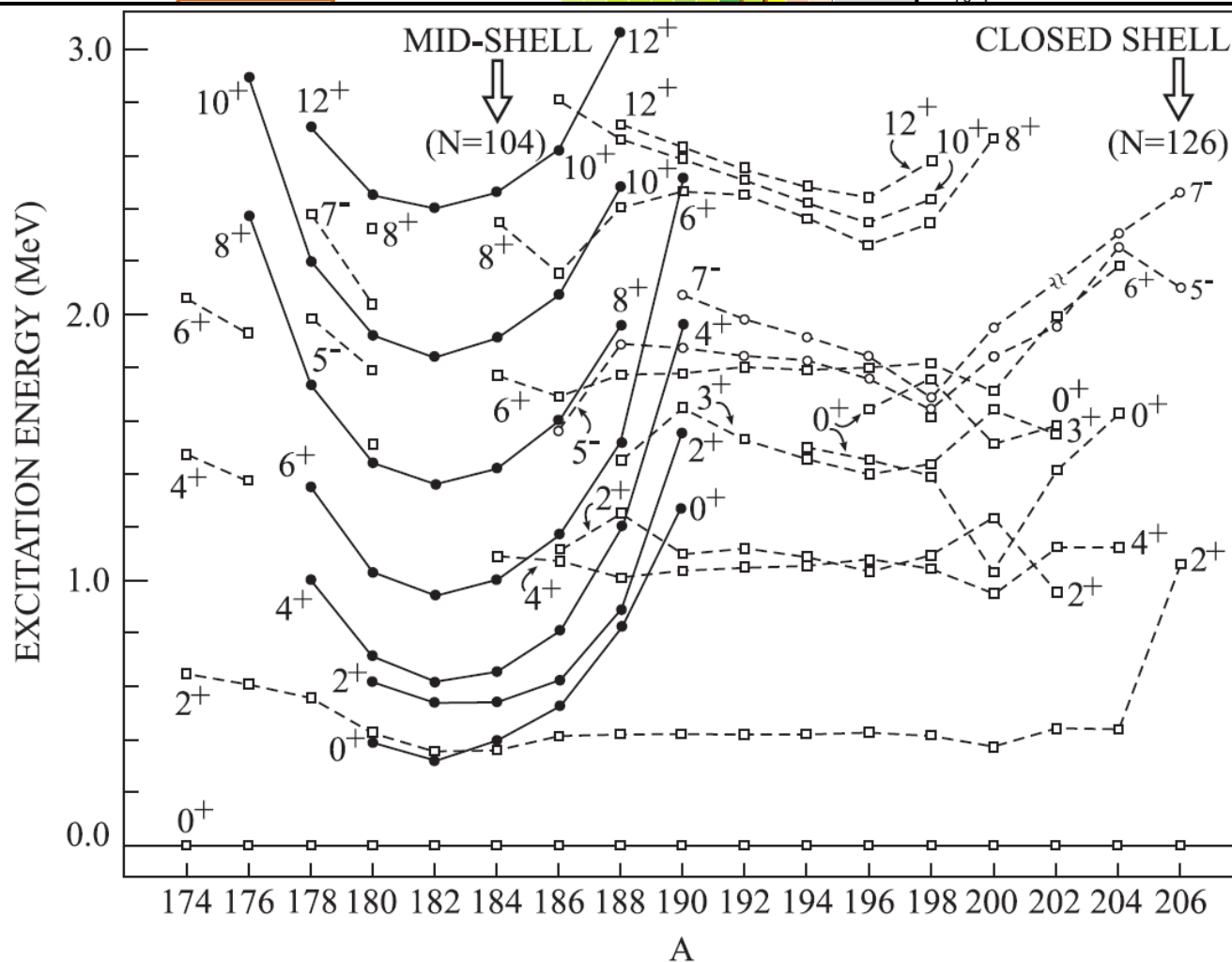
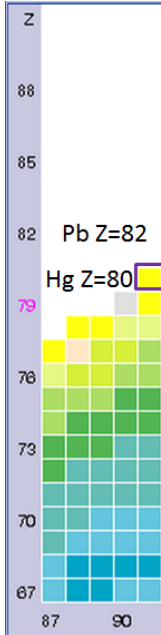
G.s. deformation in the region

Hg neutron deficient

B. Olaizola S1607

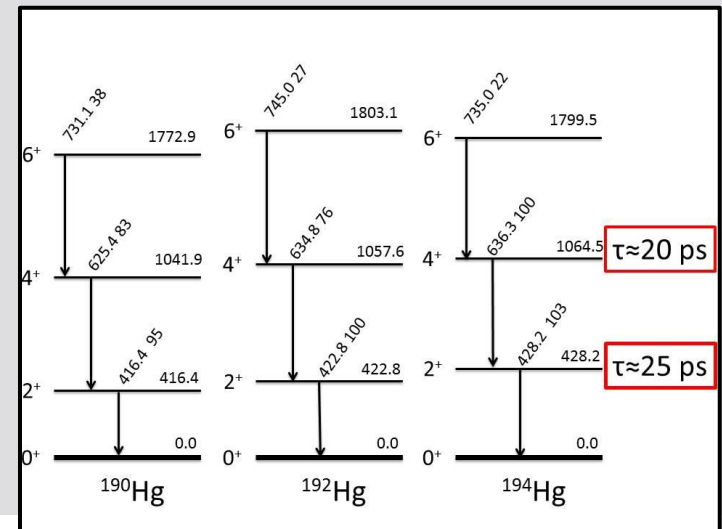
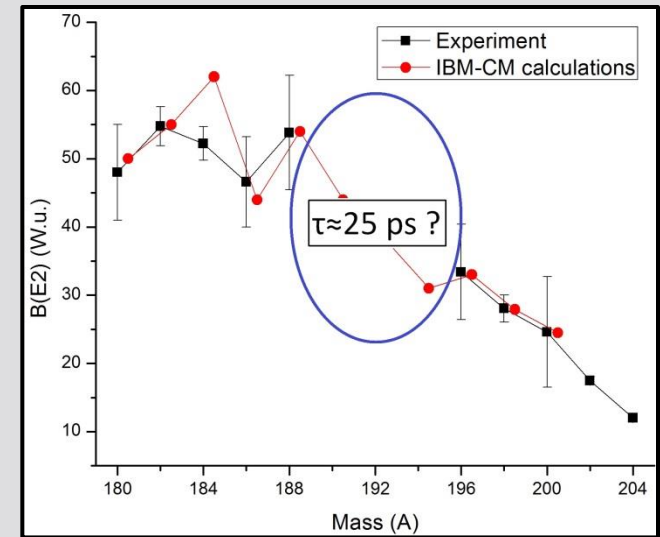
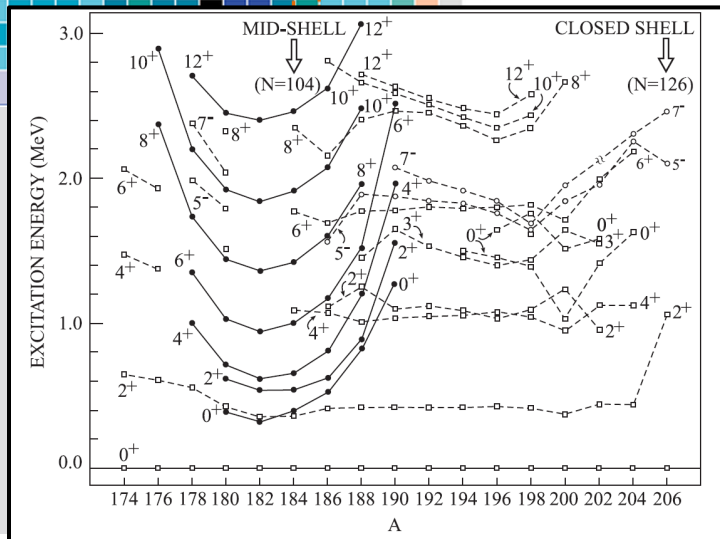
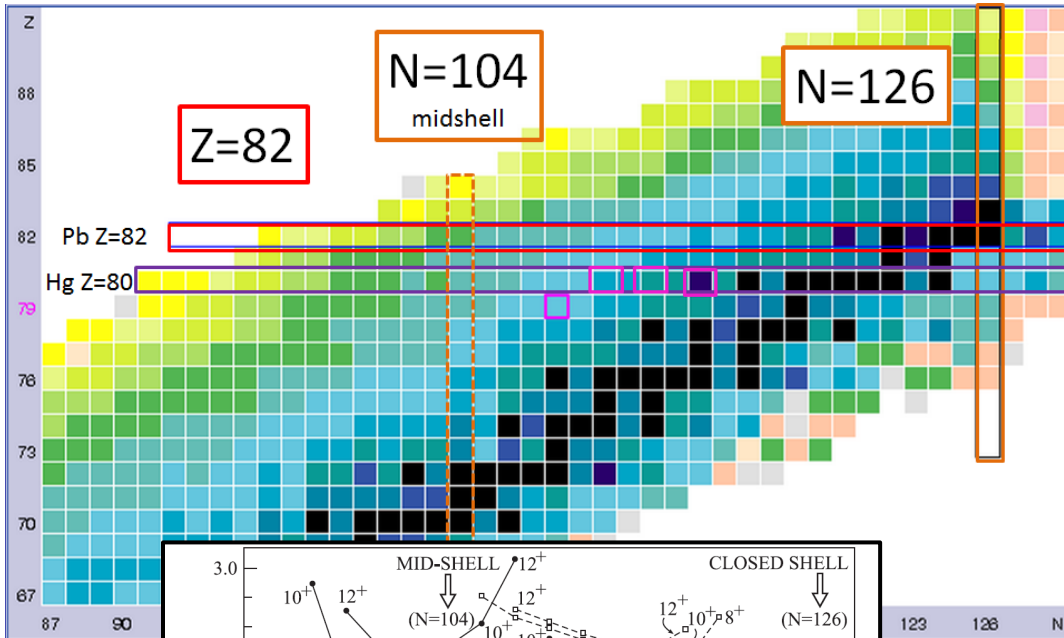


Hg neutron deficient B. Olaizola S1607



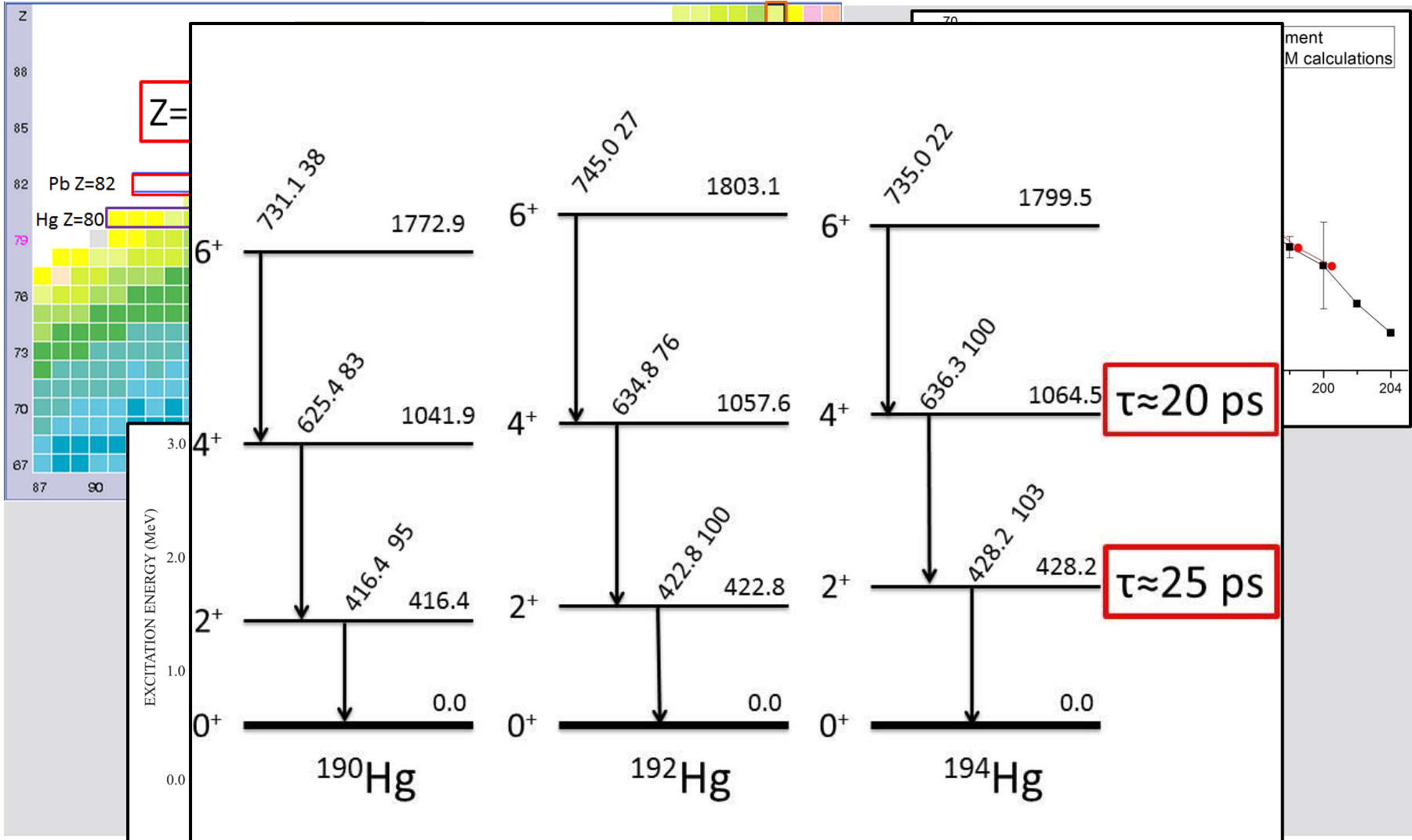
Hg neutron deficient

B. Olaizola S1607



Hg neutron deficient

B. Olaizola S1607



THANKS TO COLLABORATORS



H. Bidaman, V. Bildstein, P. Boubel, C. Burbadge, G. Deng, A. Diaz Varela, R.A. Dunlop, M. Dunlop, P.E. Garrett, B. Hadina, B. Jigmeddorj, D. Kisliuk, A. Laffoley, A. MacLean, E. McGee, D. Muecher, B. Olaizola, A. Radich, E.T. Rand, C.E. Svensson, J. Turko, T. Zidar, *University of Guelph, Canada;*

G.C. Ball, T. Ballast, C. Bartlett, P. Bender, N. Bernier, D. Bishop, M. Bowry, D. Brennan, T. Bruhn, R. Caballero, A. Cheeseman, R. Churchman, S. Ciccone, B. Davids, L. Evitts, I. Dillmann, A.B. Garnsworthy, S. Georges, G. Hackman, S. Hallam, J. Henderson, R. Kokke, R. Kruecken, Y. Linn, C. Lim, L. MacConnachie, D. Miller, W.J. Mills, L.N. Morrison, M. Moukaddam, C.A. Ohlmann, O. Paetkau, J. Park, C.J. Pearson, M.M. Rajabali, P. Ruotsalainen, B. Shaw, J. Smallcombe, J. K. Smith, D. Southall, C. Unsworth, Z.M. Wang, S. Wong, *TRIUMF, Canada;*

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Colorado School of Mines, USA

and the other members of the GRIFFIN collaboration



