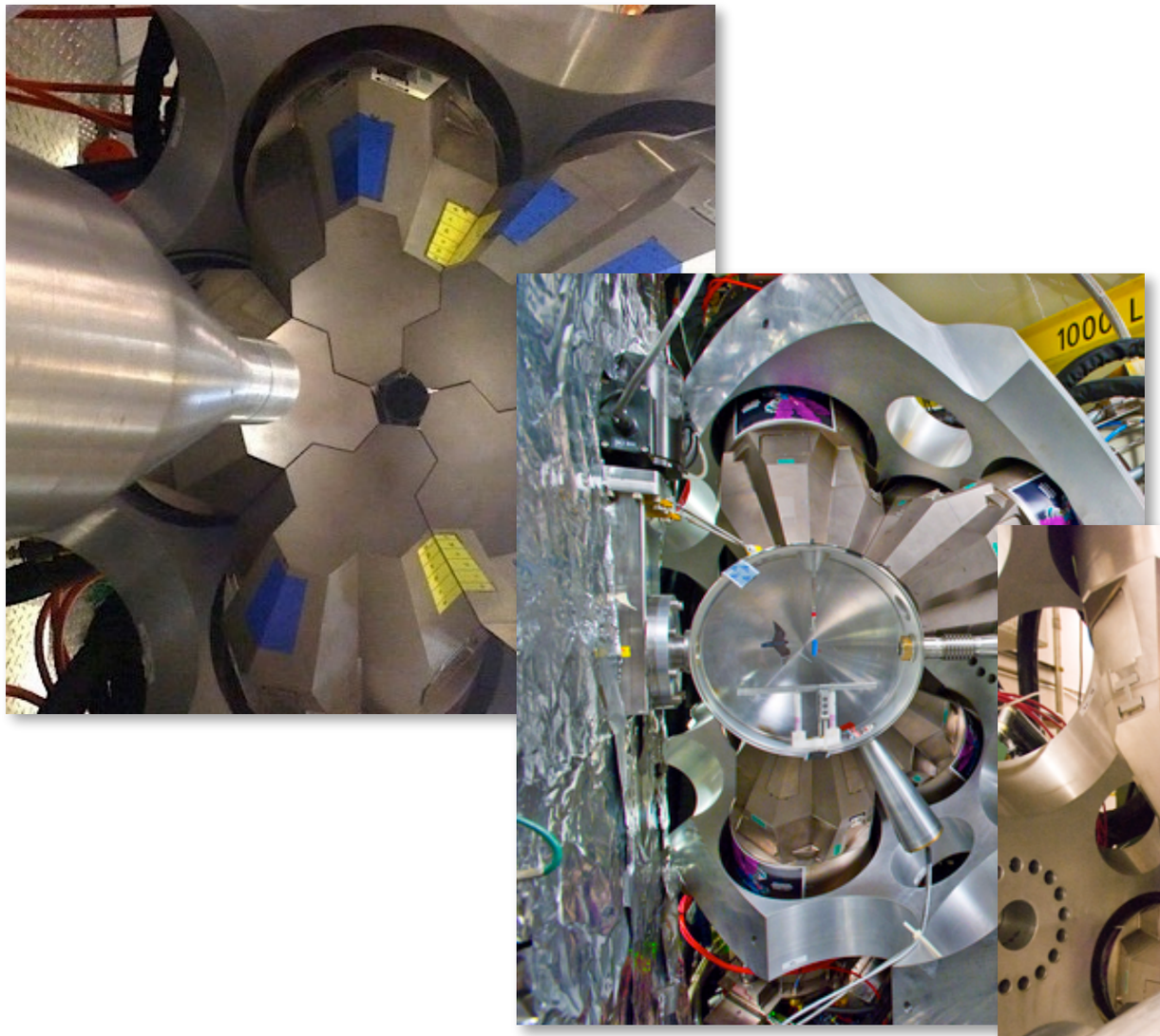
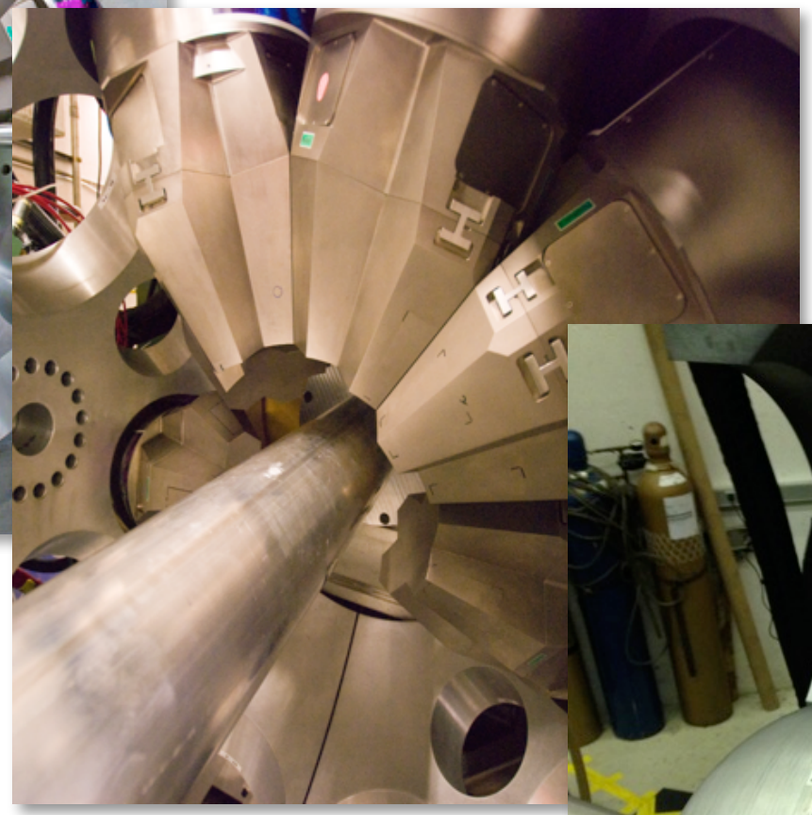
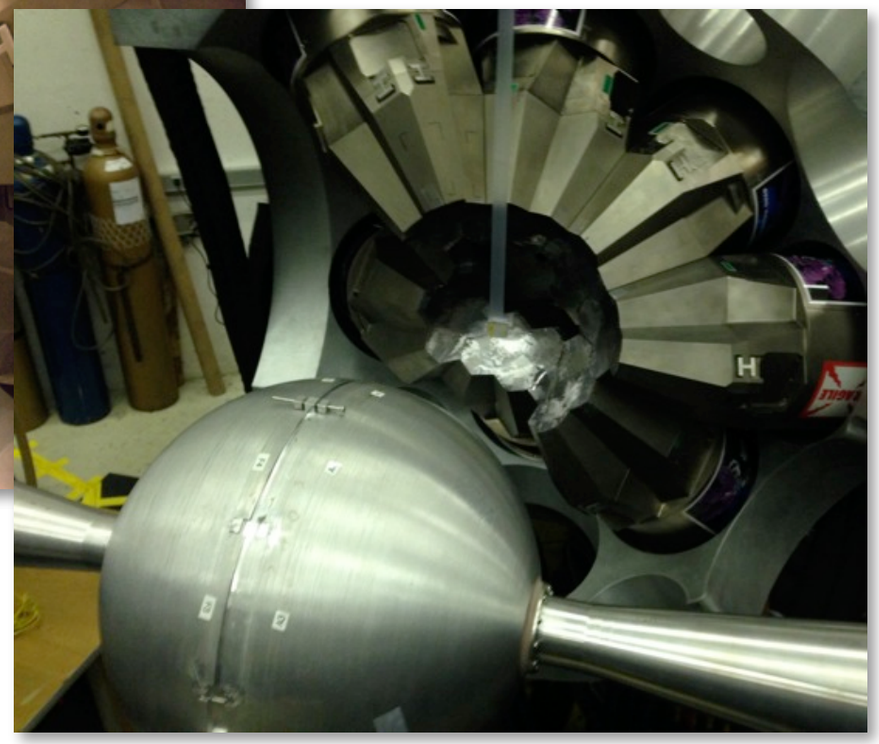






GRETINA

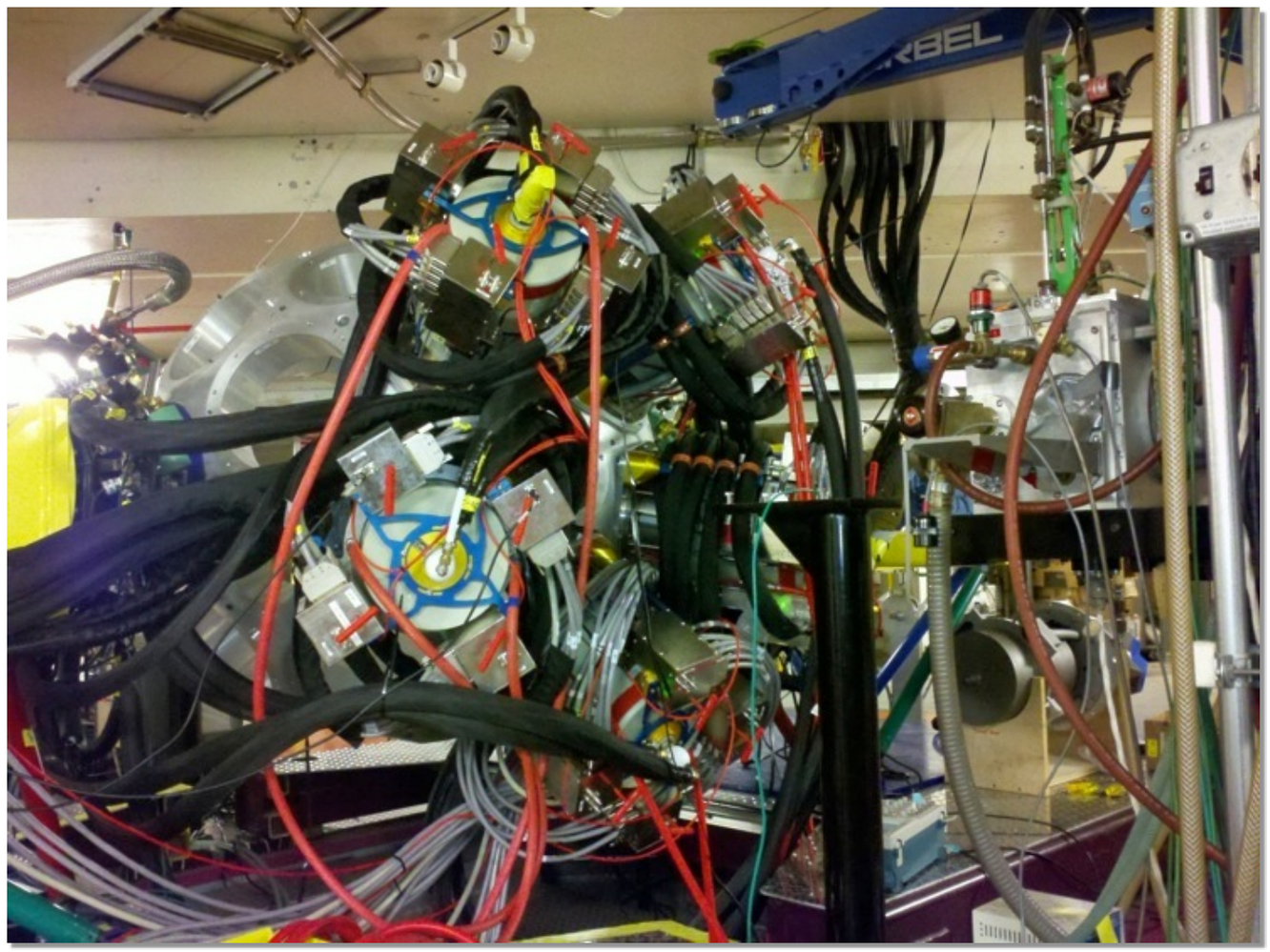
Mario Cromaz, LBNL

2014 ATLAS User's Meeting
ANL - May 15-16, 2014

Work supported under contract number DE-AC02-05CH11231.

The GRETINA Spectrometer

- first generation gamma-ray tracking array
- spherical shell of Ge covering 25% of available solid angle (scalable to full 4π coverage)
- consists of seven 4-crystal modules (quads), 36-way segmented HPGe crystals (1000 segments)
- tracking ability removes need for active suppression, scales to very high efficiencies
- physics runs now underway at ATLAS/ANL



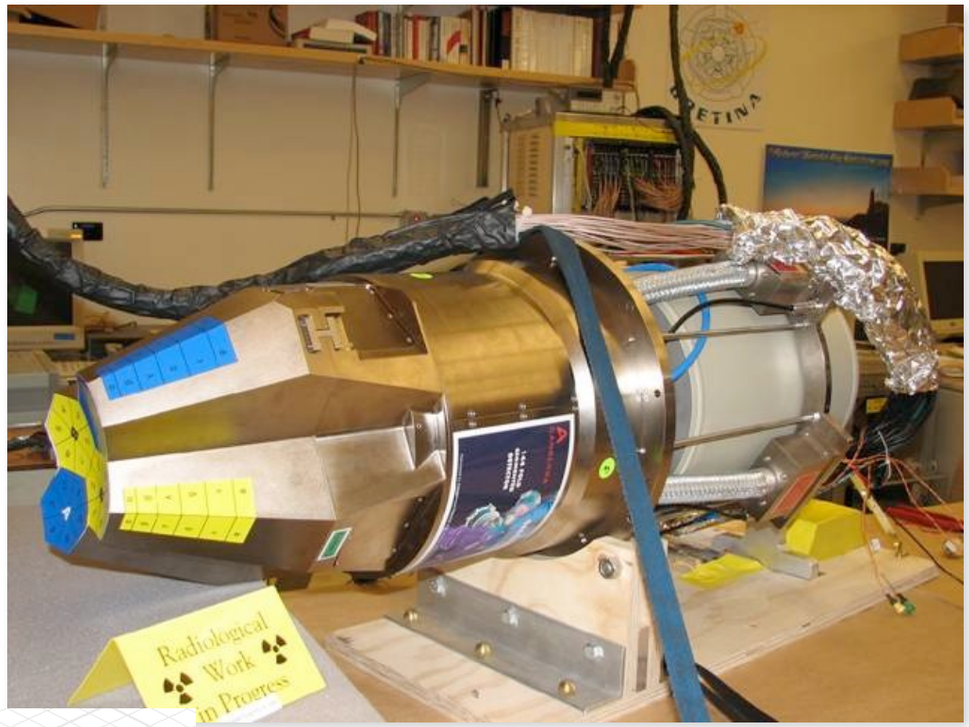
first assembly of Gretina in cave 4C at the 88” cyclotron

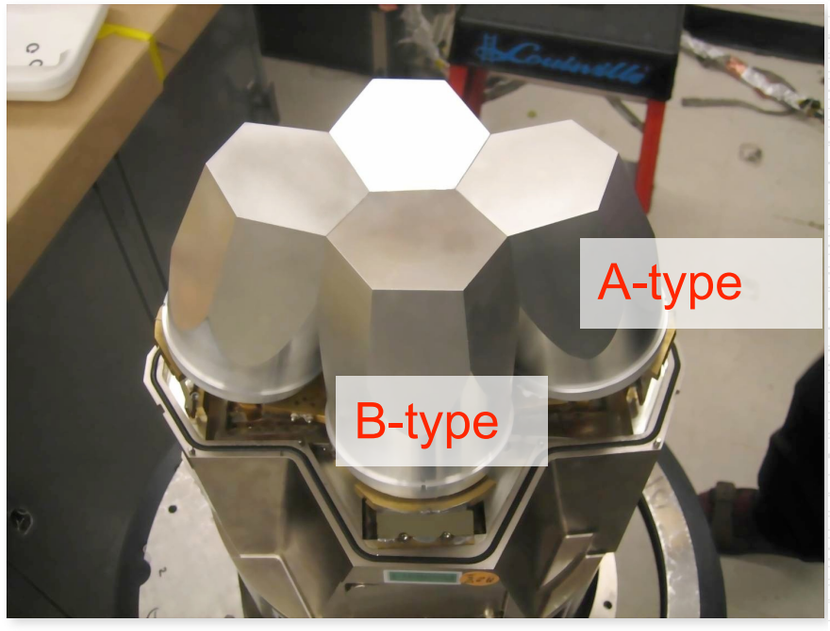
Institutions/Timeline

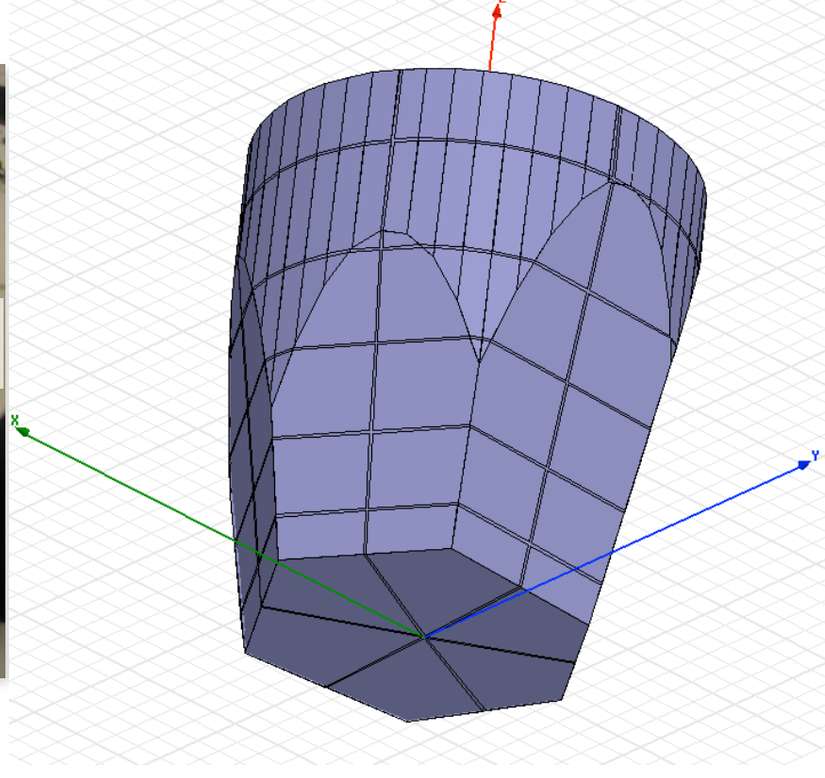
- start construction: 2005
- start operation: 2011
- engineering and commissioning runs: 2011 - 2012
- operations at NSCL: 2012 - 2013
- **operations at ATLAS: 2014**
- second NSCL campaign: 2015

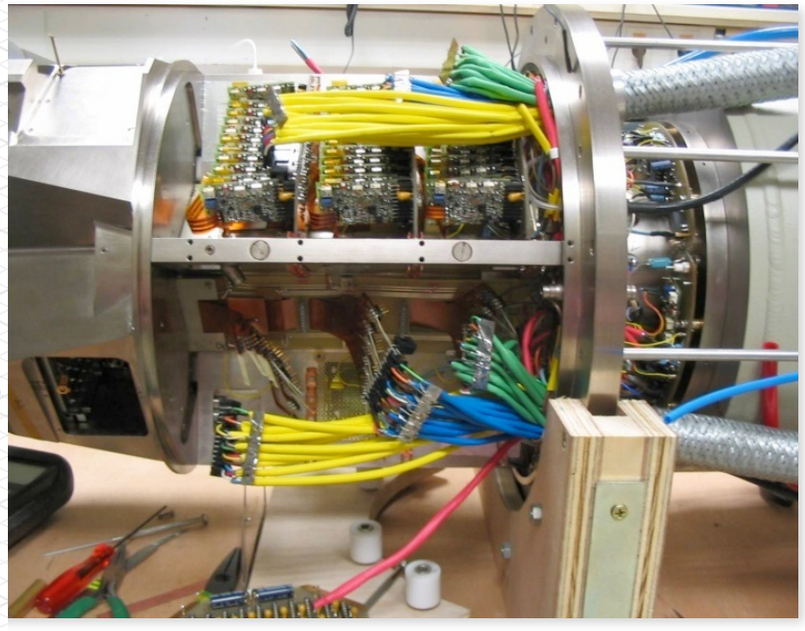
Segmented HPGe Crystals

- 4 encapsulated crystals in a single cryostat, 2 types of irregular hexagons allow for spherical packing
- segments have warm FETs, central contacts have cold FETs
- 148 pre-amps/module





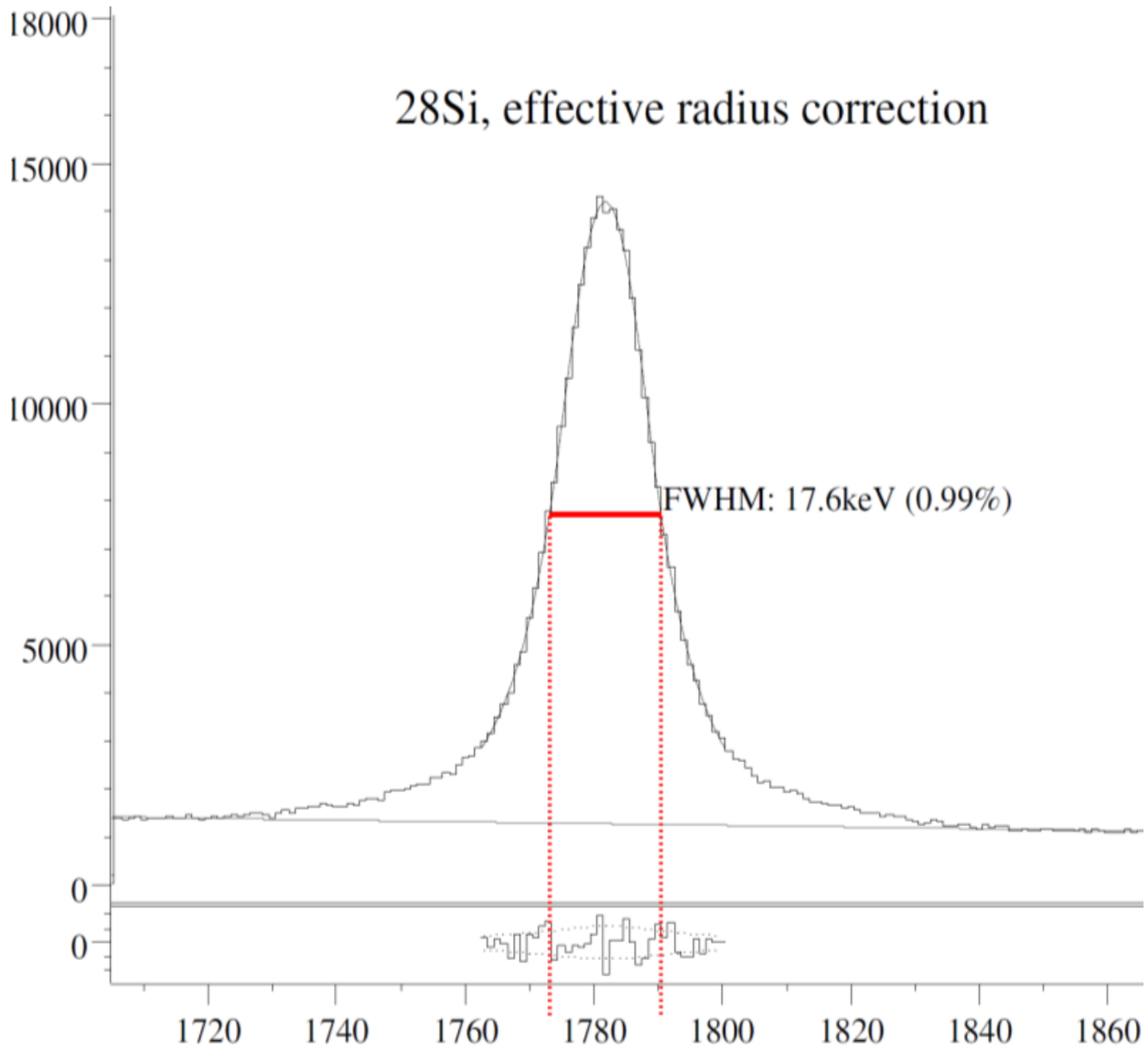




Doppler Reconstruction

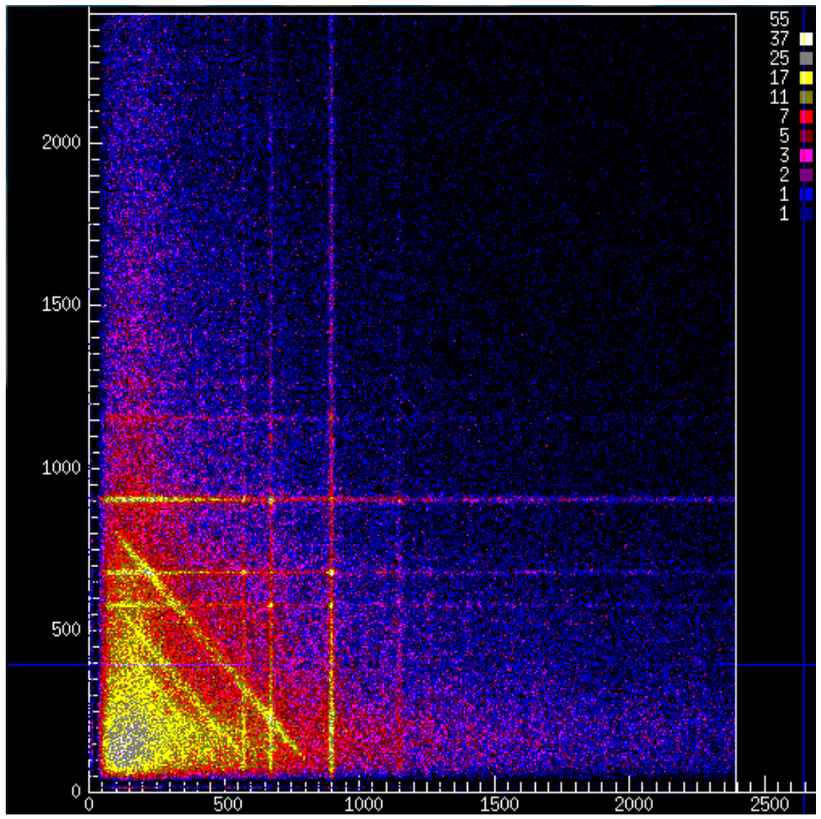
^{28}Si from ^{36}Ar on 47mg/cm^2 Be v/c=0.38

Measured FWHM of 1.00% consistent with a **spatial resolution of σ ≈ 2mm**

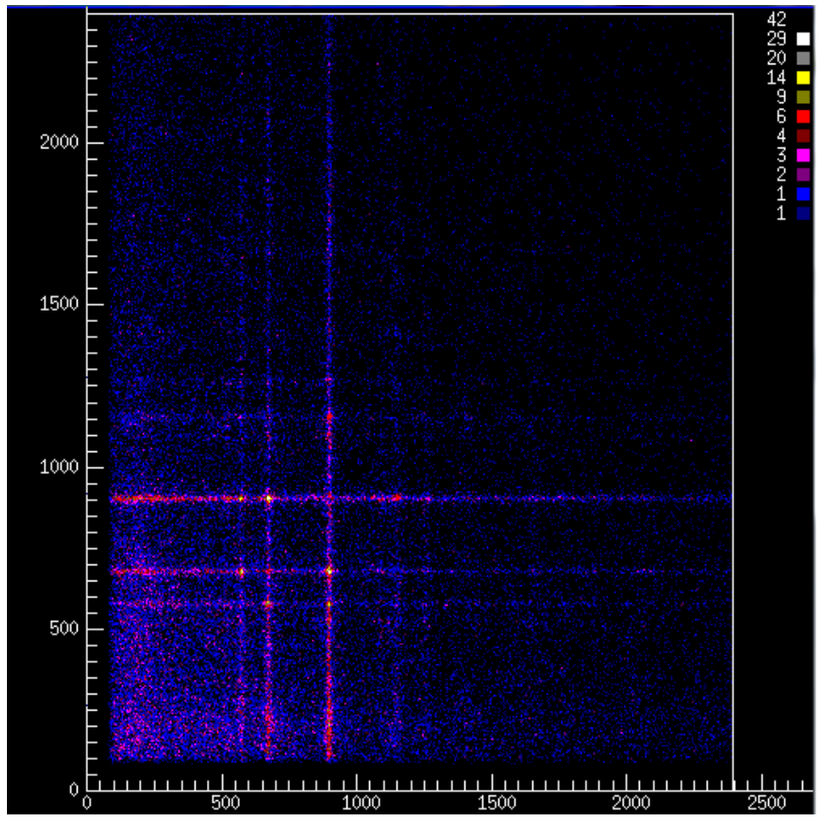


D. Weisshaar et al., GRETINA @ NSCL Commissioning

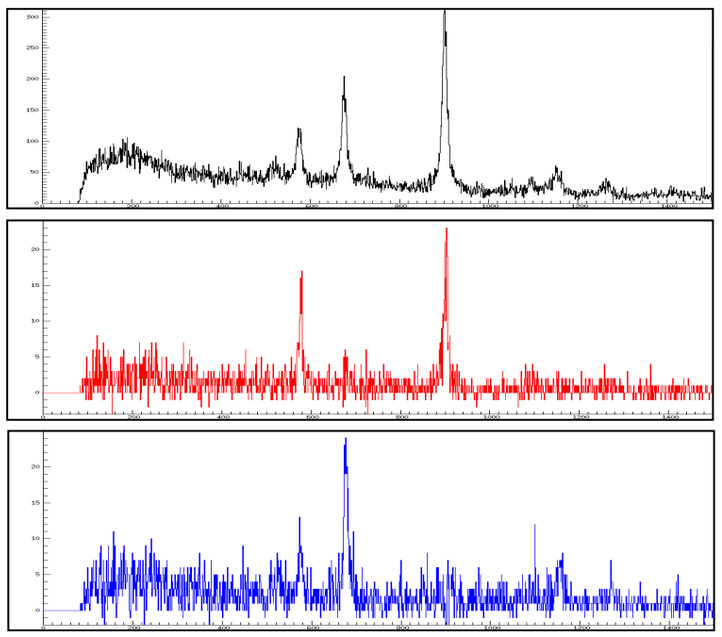
Tracking



untracked



tracked



gated

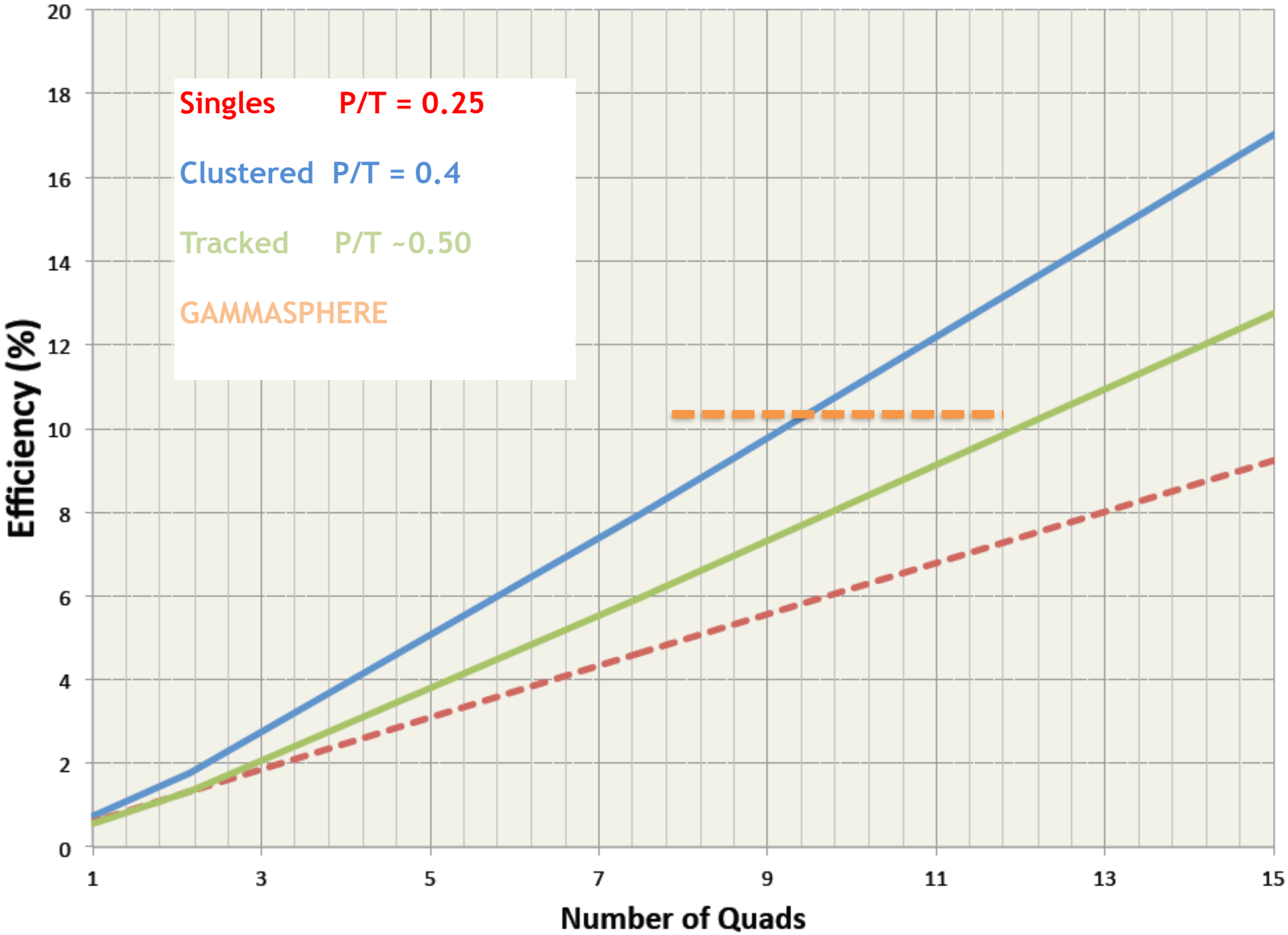
^{64}Ge populated following knockout from ^{65}Ge

Reduction of Compton background by tracking allows – for the first time – gamma spectroscopy with fast beams with spectral quality comparable to arrays with anti-Compton shields.

Performance in a Nutshell

- efficiency:
  - 6.6% calorimeter mode
  - 5.0% tracked
- P/T = 0.52 (tracked)
- energy resolution:
  - central contact: 1.7 keV @ 122 keV, 2.6 keV @ 1332 keV
  - segments: 2.5 keV @ 1332 keV
  - first-hit position resolution: 2mm
- rates:
  - ~20 kHz / crystal (pre-trigger)
  - 20k gamma/s (30k decomp/s) processing rate (post-trigger)

Efficiency


Singles P/T = 0.25
Clustered P/T = 0.4
Tracked P/T ~0.50
GAMMASPHERE
Efficiency (%)
0
2
4
6
8
10
12
14
16
18
20
1
3
5
7
9
11
13
15
Number of Quads

Detector Status

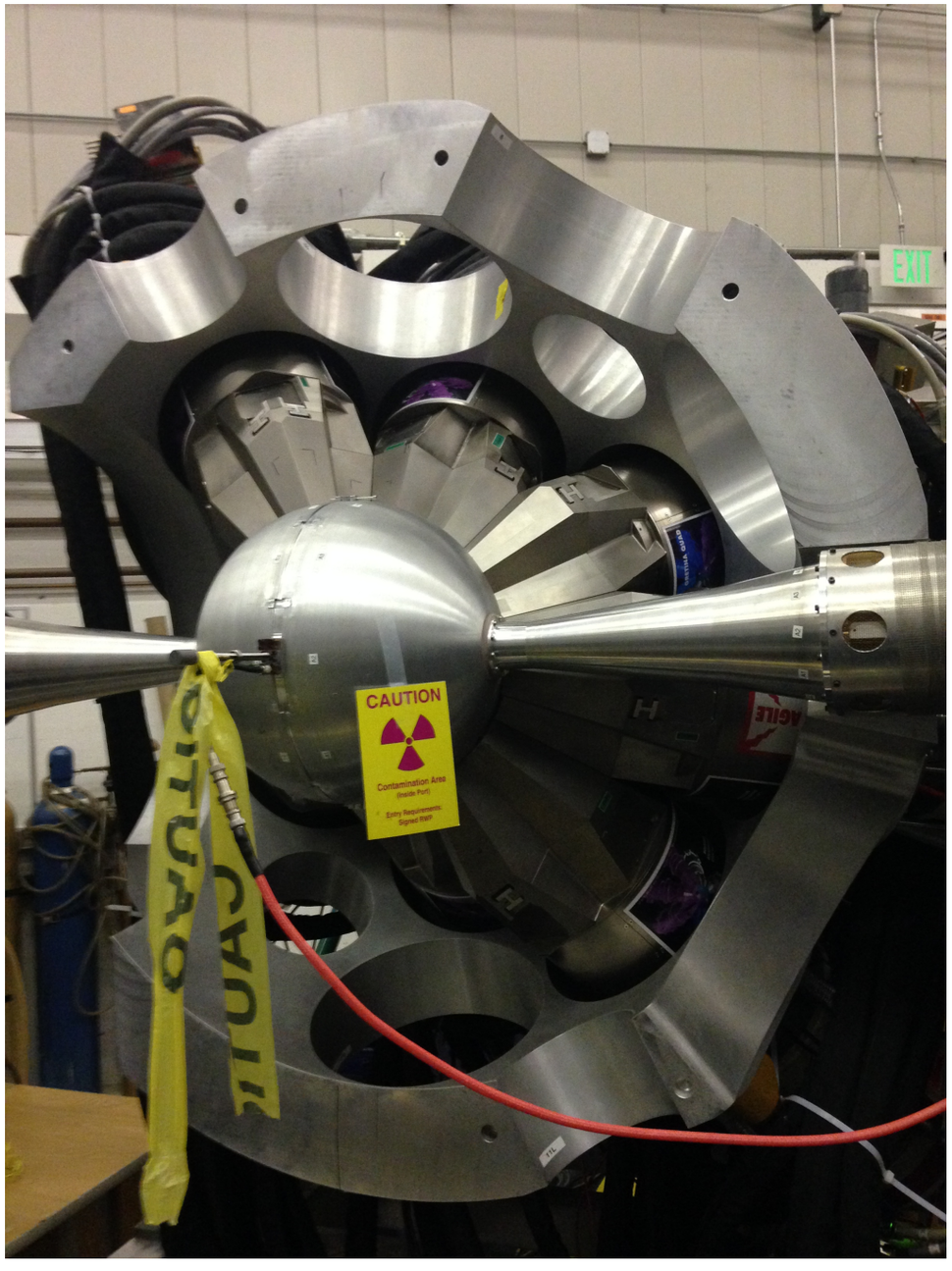
- seven quads (Q1, Q3-Q8) currently operating in the array for ATLAS campaign
- all detectors recently annealed:
  - 4 capsules rendered inoperative
  - consolidated into single quad (Q2) for repair, expected back in summer of 2014
- Q9 ordered - expected in fall of 2014
- plan to characterize, instrument, and make available Q2, Q9 for providing additional efficiency to array for the latter part of ATLAS campaign

Upgrades for ANL Campaign

- digitizer improvements:
  - replace clock distribution chip (stability)
  - adj. baseline restoration time (rate)
  - enable pipelining (deadtime)
- revised basis signal basis for all crystals, (semi-) automate process (signal decomposition)
- single interaction search (tracking)
- storage node [supernode]
  - allow for mode-3 data collection at higher rates, simplify calibrations (180 MB/s sustained) (rate)
- noise optimization (energy resolution)
- interface auxiliary detectors (CHICO2, FMA)

Auxiliary Detectors

- critical to success of large spectrometers
- GRETINA designed with auxiliary detectors in mind
- BGS, S800, CHICO interfaces successfully implemented
- GRETINA a fully timestamped system - crystals run independently
- 3 interfaces:
  - timestamp / synchronization
  - readout
  - run control
- **interested? please contact us**



GRETINA and CHICO (yesterday)

Commissioning Runs at ATLAS

- four GRETINA commissioning runs at ATLAS/ANL:
  - polarization sensitivity (1520x, A.Wiens, LBNL) ✻
    ^{nat}Mg(p,p')@ 1368MeV
  - high multiplicity performance, Doppler correction (1499x, T. Lauritsen, ANL) ✻
    ^{12}C(^{84}Kr,4n)^{92}Mo@394MeV,
    ^{122}Sn(^{40}Ar,4n)^{158}Er@170MeV
  - CHICO commissioning (1509x, M. Albers, ANL) ✻
    ^{208}Pb(^{72}Ge, ^{208}Pb(^{76}Ge, @ 302, 320 MeV respectively
  - high-energy response, pair-production tracking (1515x E. Merchan-Rodriguez, Lowell)
- analysis ongoing

✻ complete!

Polarization Sensitivity

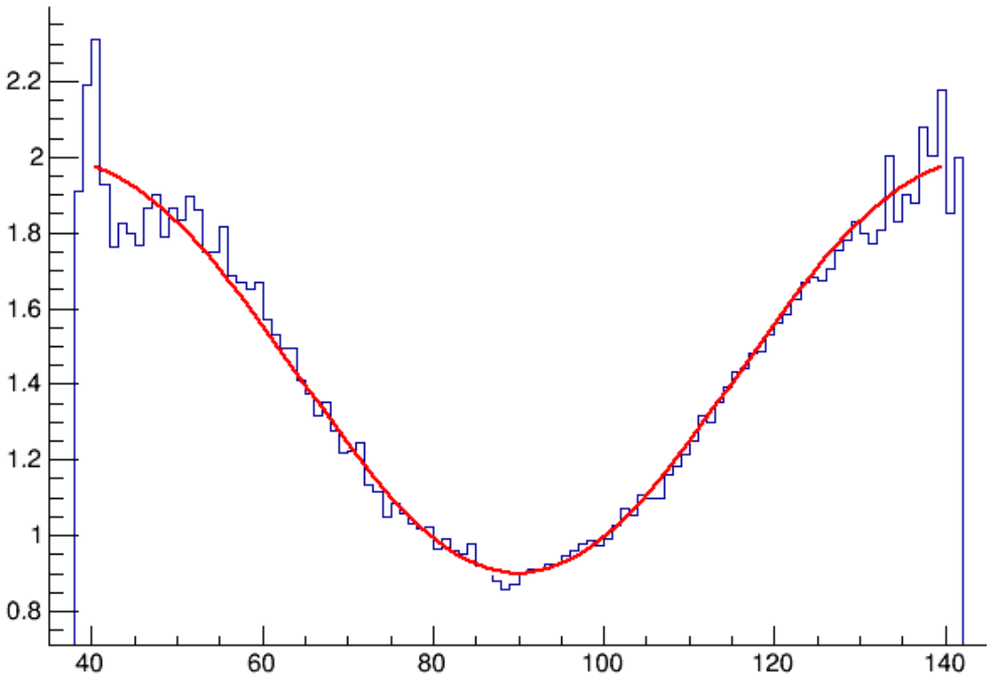
- ^{24}Mg (1368, 2754, 4238 keV) low-E proton excitation
- applied std. two-interaction decomposition, tracking
- prelim. analysis of angular distribution, azimuthal scattering

sensitive test of signal decomposition, tracking - proving ground for improved alg. and bases

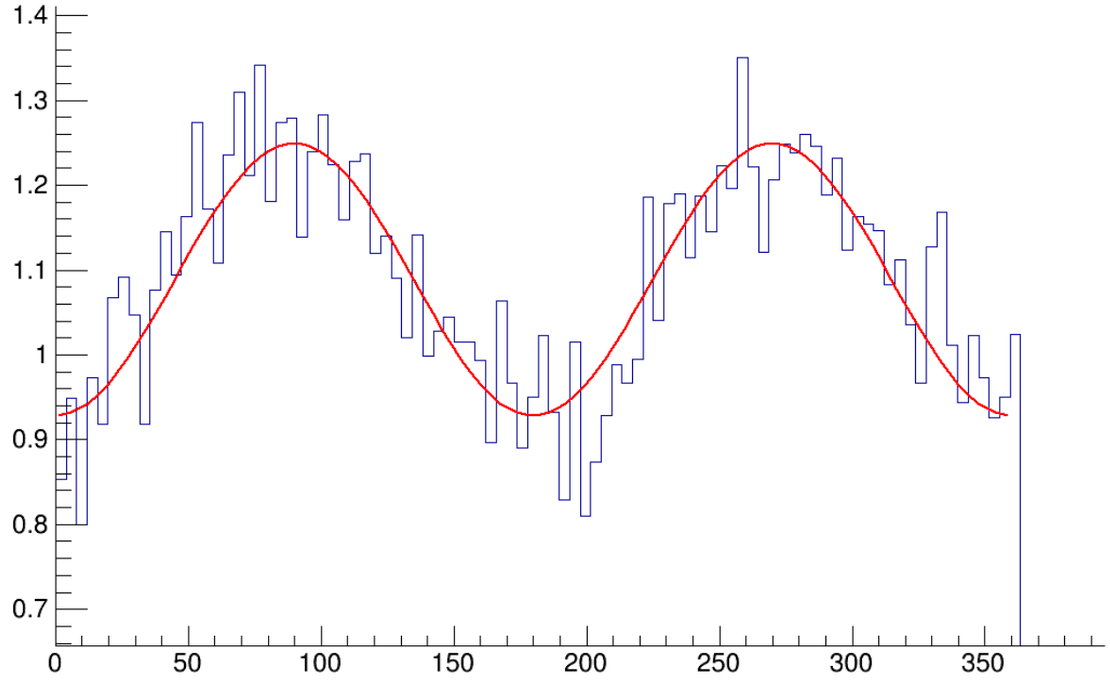
A. Wiens, LBNL

1368 keV

Angular distribution tracked



Azimuthal Compton scattering angle



Development Activities

- *additional quads (Q8, Q9, potentially Q10)*
- *signal decomposition - esp. for secondary int. points (P/T)*
  - coincidence scans
  - better modeling of crystal basis:
    - transport properties, impurity concentration
    - electronics response (differential crosstalk)
  - signal quality
- *counting rates*
  - segment summing, threshold effects (recover energy resolution)
  - digitizer firmware - pipelining
  - continuous digitization (long term)

Groups, Resources, Tools

- ***Welcome community participation!***
- GUEC, GAC - interfaces to the community
- websites, wiki(s), repositories:
  - GRETINA software working group (gswg.lbl.gov)
  - NSCL, Gretina
  - ANL, Gretina
- full complement of software tools available for data analysis, GRETINA development:
  - sorting codes
  - simulation
  - basis generation toolchain
  - offline signal decomposition
  - tracking

Summary

- GRETINA is a first-generation gamma-ray tracking detector - scalable to efficiencies well beyond conventional HPGe spectrometer arrays
- GRETINA operated successfully during a highly productive NSCL campaign at the S800
  - 1 rapid communication, 2 letters accepted, 1 in process … more to come
- physics campaign now underway at ATLAS with CARIBU/CHICO and soon FMA
- second GRETINA/S800 campaign will begin at NSCL in 2015

Acknowledgements

Construction and commissioning:

The performance of the Gamma-Ray Energy Tracking In-beam Nuclear Array GRETINA

S. Paschalis [a,*], I.Y. Lee [a,**], A.O. Macchiavelli [a], C.M. Campbell [a], M. Cromaz [a], S. Gros [a], J. Pavan [a], J. Qian [a], R.M. Clark [a], H.L. Crawford [a], D. Doering [a], P. Fallon [a], C. Lionberger [a], T. Loew [a], M. Petri [a], T. Stezelberger [a], S. Zimmermann [a], D.C. Radford [b], K. Lagergren [b], D. Weisshaar [c], R. Winkler [c], T. Glasmacher [c], J.T. Anderson [d], C.W. Beausang [e]

[a] *Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA*
[b] *Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA*
[c] *National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA*
[d] *Argonne National Laboratory, Argonne, IL 60439, USA*
[e] *Department of Physics, University of Richmond, 28 Westhampton Way, Richmond, VA 23173, USA*

Operations: ANL/NSCL/LBNL

ANL: S. Zhu, A. Ayangeakaa, M. Albers, J. Anderson, M. Carpenter, H. David, T. Lauritsen, J. Rohrer, B. Zabransky

NSCL: D. Weisshaar, A Gade, F. Recchia, T. Baugher, C. Langer, E. Lunderberg, A. Lemasson, S. Noji, M. Scott, D. Smalley, K. Wimmer, R.Zegers R. Fox (NSCL DAQ) and D. Bazin, S. Williams (S800)

ORNL: D. Radford, J. M. Allmond

LBNL: I.Y. Lee, A.O. Macchiavelli, C.M. Campbell, H. Crawford, P.Fallon, C. Lionberger, A. Wiens

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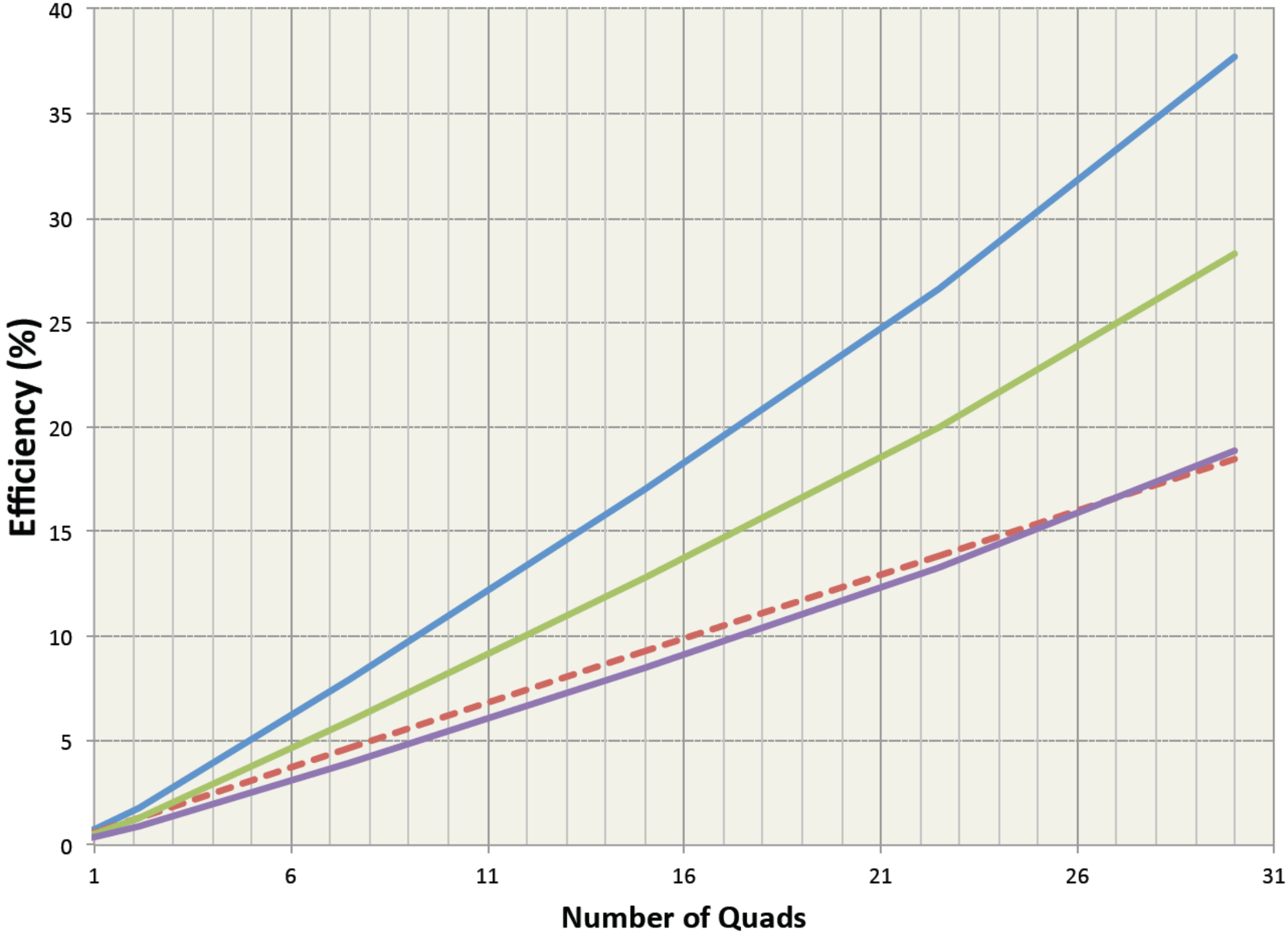
Performance Metrics

Table 2: Anticipated performance of GRETINA array

			GRETINA KPP	GRETINA Current*	GRETINA Goal*
1	Absolute Photopeak Efficiency	1332 keV, M = 1	7.2% 5.4% tracking (Extrapolated values)	6.6 % 5.0 %	6.6% 5.5%
2	Energy Resolution (FWHM)				
	Central Contact	1332 keV		2.95 keV	2.5 keV
		122 keV		2keV	1.7 keV
	Segments	1332 keV		3.2 keV	2.7 keV
		122 keV		2.1 keV	1.75keV
3	Peak-to-Total:	^{60}	40% Summing 55% Tracking	40% 49% #	40% 52%
		^{137}	N/A		58%
	Peak-to-bkgnd compared to GS	^{152} 122 344 444	N/A	 0.84 0.72 0.85	 ~ 0.9
4	Count Rate		N/A	20-30 kHz &	50 kHz
					See text

- developed technical plan to work towards these goals
  - operations (energy resolution)
  - high-rate capability (segment summing)
  - signal decomposition (underlies P/T, tracked efficiency)

Efficiency (extended)



^{152}Eu: GRETINA and Gammasphere