NSAC LONG RANGE PLAN TOWN HALL MEETING ON NUCLEAR STRUCTURE, REACTIONS AND ASTROPHYSICS

Argonne NATIONAL LABORATORY 75 1946–2021

GAMMASPHERE

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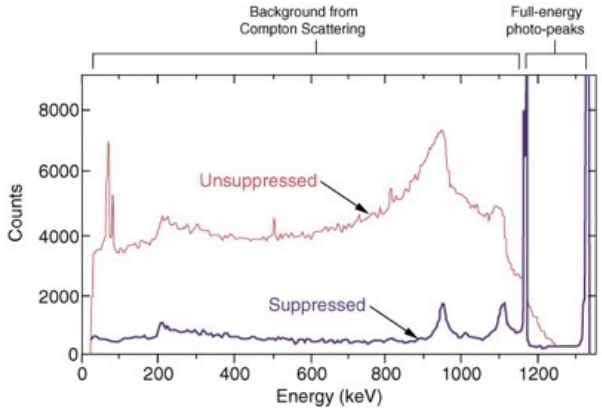
GAMMASPHERE

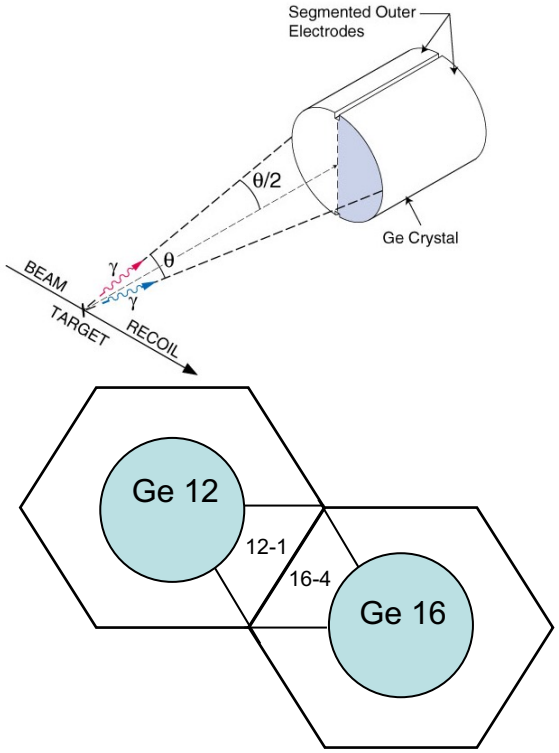
- Gamma-ray Array: high efficiency, high signal to noise
  - In operation for over 25 years
- Over 100 Compton suppressed HPGe Detectors
  - Suppression by BGO scintillators
- 25+ years premier device for nuclear structure research at high angular momentum
- Couples seamlessly with auxiliary devices
  - FMA, AGFA, Microball, Chico, Neutron Shell, Goddess, ...



FEATURES TO ENHANCE RESOLUTION AND P/T

1. Segmented Outer Contact on Ge Crystal
   - Allows for better Doppler reconstruction.
   - Allows for polarization measurement
   - Available for ~60% of detectors

2. Nearest Neighbor Suppression
   - Utilize BGO nearest neighbor for Compton suppression
   - This is a 10% improvement to P/T at 1 MeV



Electric Honeycomb

GAMMASPHERE SWITCH TO DIGITAL DAQ

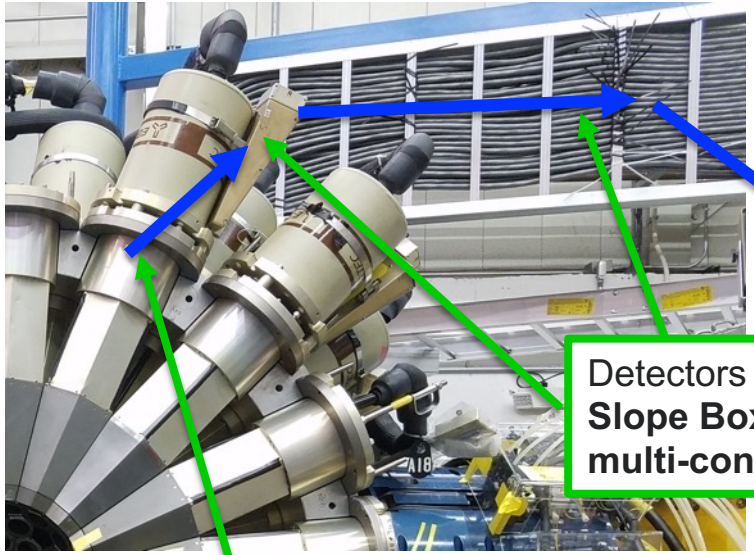
By replacing analog electronics with a digital pulse processing data acquisition system , the major limitations and liabilities of the analog system can be overcome.

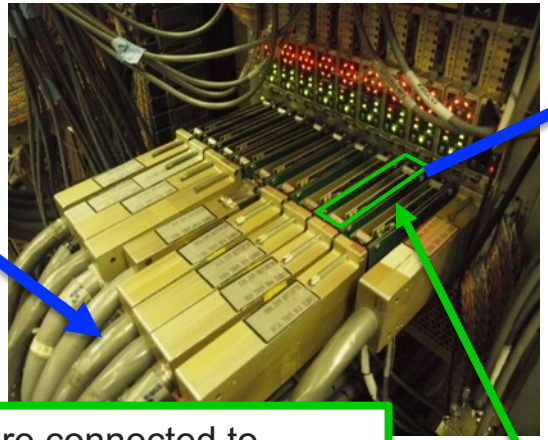
- *Gammasphere analog electronics had fixed shaping time for Ge shaper, limited rate to ~10-15k/sec.* Shaping time for digital shaper can be set depending on rate in detector e.g. decreasing processing time of Ge shaper from ~10 to ~2.5µsec should allow Ge to run at 40,000 cps with same pileup percentage as with analog system at 10,000 cps.

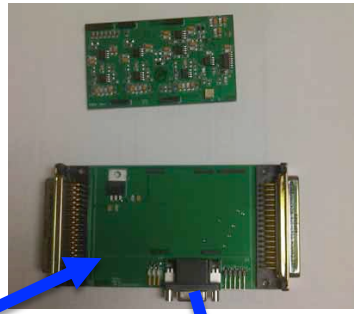
- *For analog Gammasphere, trigger took minimum of 25µsec to process event - no pipelining.* Improved trigger model increase throughput limits imposed by current trigger:
  - Singles throughput from 35,000 event/sec to 500,000 event/sec
  - High Spin throughput from ~15,000 event/sec to >100,000 event/sec

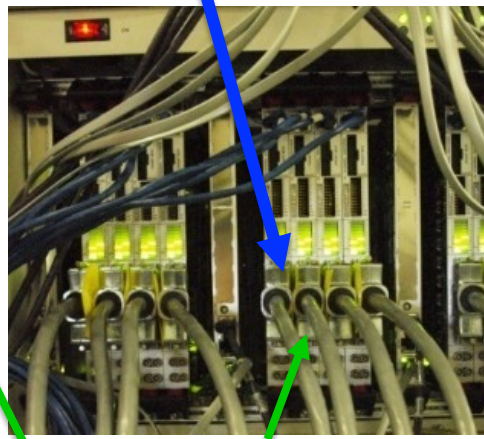
- *Replacement of analog electronics solves liability due to aging components.* For example, after digital system was commissioned, failures to analog system became to great as to allow it to operate as a DAQ.

GAMMASPHERE HYBRID ELECTRONICS CONFIGURATION









Detectors are connected to **Slope Boxes** that drive **large multi-conductor** cables.

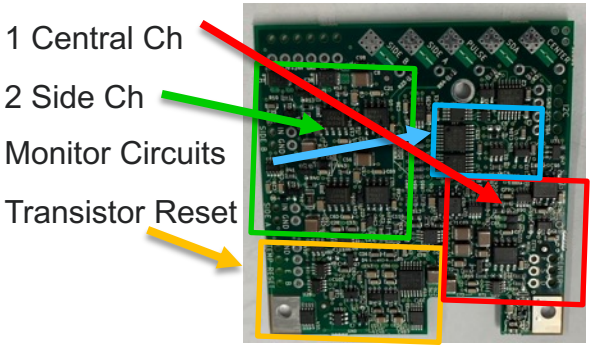
Charge-sensitive preamp in the detector drives the germanium signals to the Slope Box.

No nearest neighbor suppression

The cables connect to a **VXI system**, which convert signals from the detector into differential signals that are then sent to **VME digitizers.**

CURRENT UPGRADE PROJECT

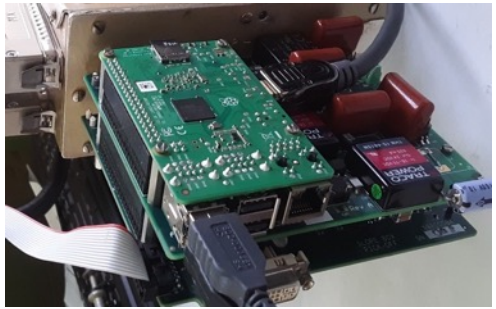
New Ge Preamp



4 QI Pulsers (Ge Center, Ge Sides, Cable Driver)
I2C Bus communicates with the Pickoff FPGA
Self-Diagnostic Capabilities:
- Identify Ge FET Failures
- Temp & Humidity in Preamp Compartment
- PT 500 Readout

140 fabricated
Replacement has begun

Slope Box Extension (SBX)



Consists of pickoff card, power board and optional Raspberry Pi (EPICS control)
Control interface: Slope Box, Preamp, Power Board
Software-Controlled DC offset and gain of detector signals
Implementation of BGO Hit Pattern
Implementation of BGO discriminators for Electric Honeycomb
Distributes differential signals over DVI-I to Collector Box
DVI-I cable replaces gray cable.

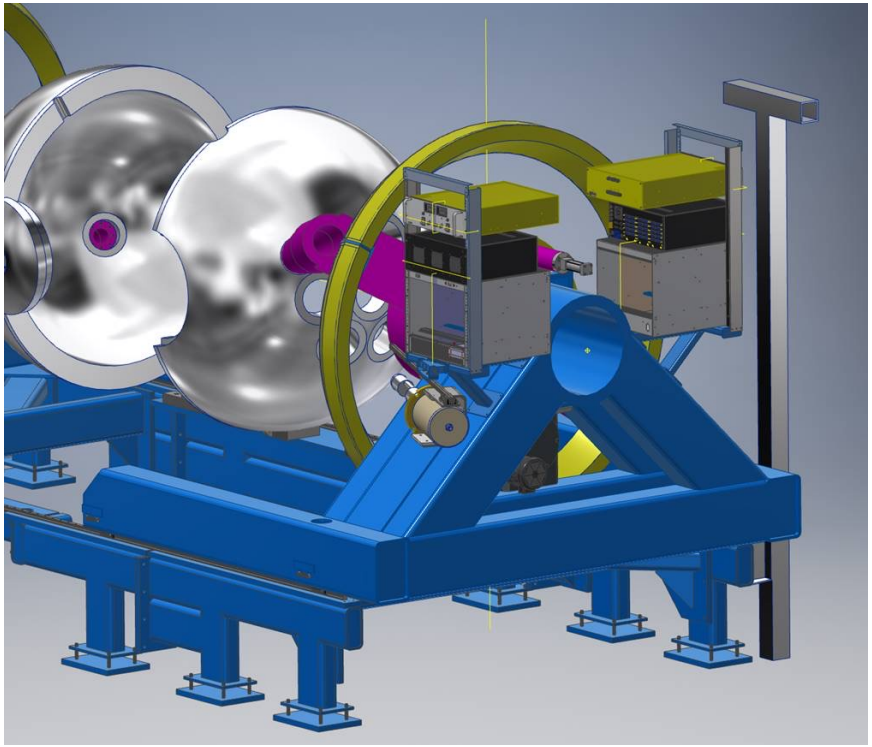
140 fabricated pick off cards
Replacement has begun

Collector Box

Raspberry-Pi connects to EPICS database of PVs for 30 GS Modules
48V Power Distribution to Individual SBX units
Ground Continuity Monitoring
FPGAs perform Serial Transactions to Control/Monitor each GS Module
Distinct FPGA implements “Electric Honeycomb”
4 preamp signals from GS modules passed to digitizers

Boxes being tested for installation
Require 4 units (30 GS modules/each)
1 installed, remaining being assembled

GAMMASPHERE UPGRADE - MOBILITY



Design for DGS Electronics Gantry: Russ Knaack

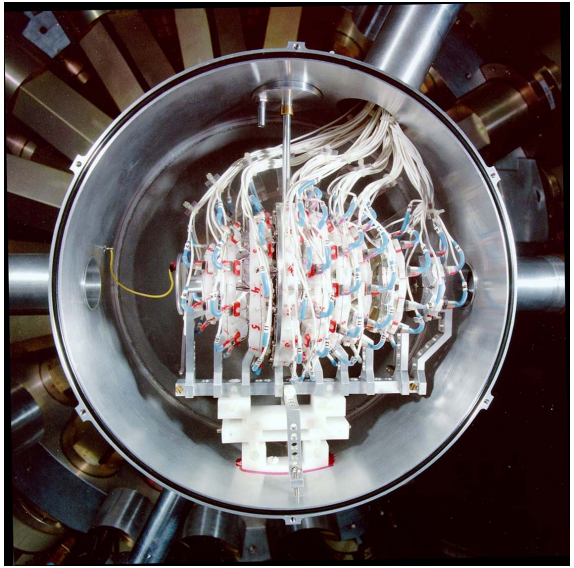
- All DAQ components moved to support structure *e.g.,* digitzer, collector box, trigger.
- Grey signal cables (60-75ft) replaced with DVI-cables (25 ft).
- Enables side channel readout (Doppler Correction) and nearest neighbor suppression (Peak-to-Total).
- New setup would allow device to be moved to another counting area *e.g.,* CARIBU Low Energy Hall.
- Project completion – end of 2022.

Final Hurdle: Repair of aging HPGe detectors

EXPERIMENTAL PROGRAM: 5 YR OUTLOOK

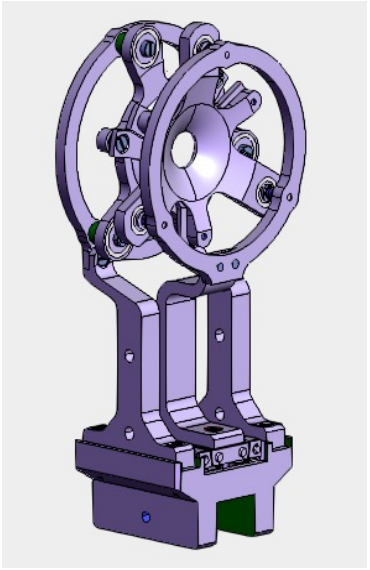
- Proton-rich nuclei between A~50 and 100 – lifetime measurements.
- Structure of heavy-nuclei Z>100 – AGFA focal plane.
- Multi-step Coulomb excitation of neutron-rich nuclides – nuCARIBU.
- Beta-decay of neutron-rich isotopes - nuCARIBU.

PROTON RICH STUDIES WITH GAMMASPHERE



Microball

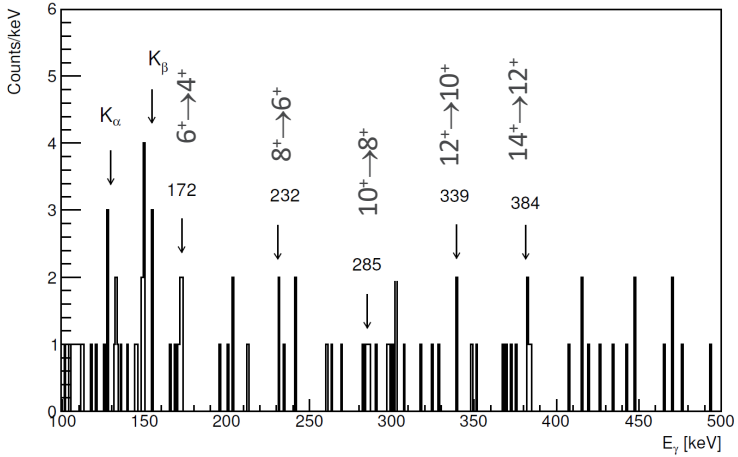
Neutron Shell

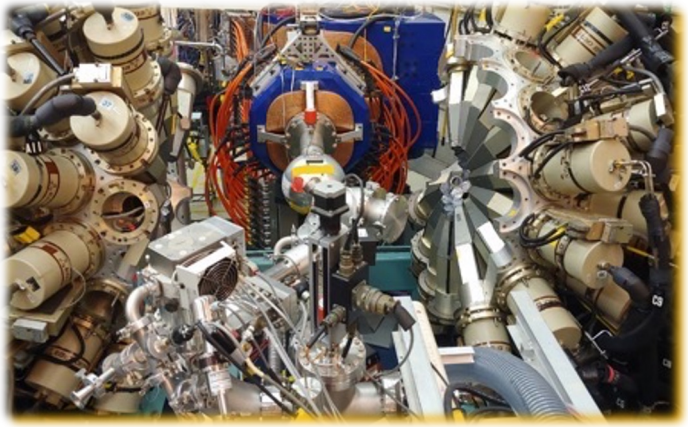


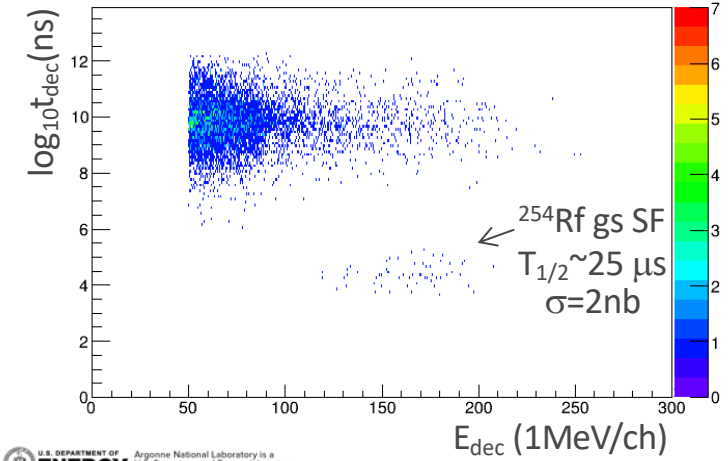
Compact Plunger

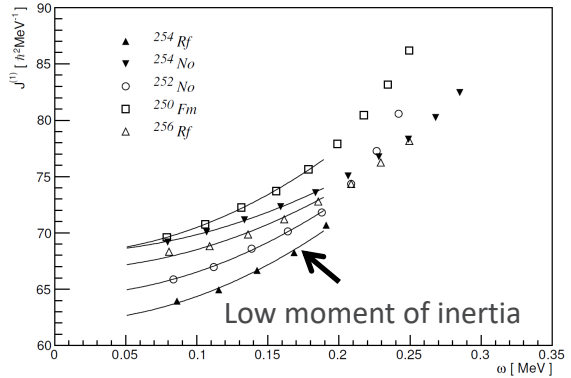
- Re-established operation of Microball and Neutron Shell and developed dedicated digital data acquisitions for both systems (MB-Gretina Dig) and (NS-XIA)
- Compact plunger can operate inside Microball allowing for lifetime measurements for nuclides previous studied with Gammasphere.

NUCLEAR STRUCTURE OF HEAVY ELEMENTS: Z>100









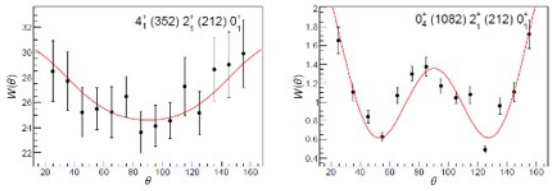
D. Seweryniak et al., PRC submitted

β-DECAY FACTORY IN AREA 1 (FY23/24)

Gammasphere Decay Station

- β–γ coincidences for proper feeding intensities
- γ–γ, γ–γ–γ for level structure determination and spin assignments from angular correlations
- Reduced summing and crystal to crystal scattering (in contrast to X-Array)
- Calorimetry provides information on excitation energy on event-by-event basis (Ge + BGO)
- Gammasphere electronics upgrade provides 3 copies of Ge central contact @ 4, 8 and 20 MeV full range

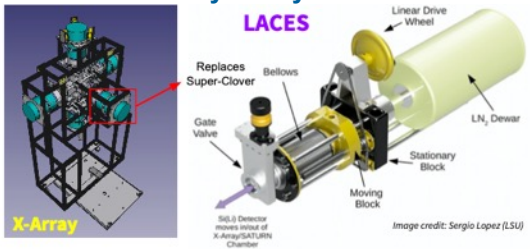
γ ray angular correlations following ^{100}Y beta decay with Gammasphere



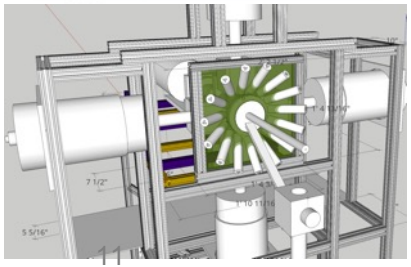
Saturn/X-Array Upgrades

- $LaBr_3$ to measure lifetimes – 2 rings, 15 1”x1” crystals each ring.
- Conversion electron measurements utilizing Laces (LSU)
- 2 BEGe detectors for low-energy gamma-ray and x-ray detection

Si(Li) detector system to couple with X-Array decay station



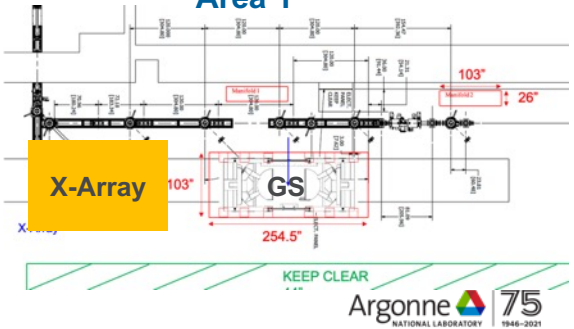
1 LaBr3 Ring @ X-Array



Beta Decay Factory

- Gammasphere upgrade project allows for relocation of device to Area 1.
- Using nuCARIBU, we estimate 2 orders of magnitude increase in implanted ions.
- Gammasphere gives multi-fold coincidences, total gamma-ray energy, angular correlations, for spin, parity, mixing rations.
- X-Array – lifetimes ($LaBr_3$), low-energy gamma detections (BEGe), conversion electron measurement (LACES).
- Campaign of six months to measure 30-50 parent decays – FY23 (Q2)

Area 1



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THE ANL TEAM WORKING ON GS UPGRADE:

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THANKS FOR YOUR ATTENTION