HpGeDSSD Tracking R&D and the X-Array

DOE Germantown 13th Nov 2002

C.J. Lister Argonne National Laboratory

Strategy

Detectors Status

Current R&D Projects

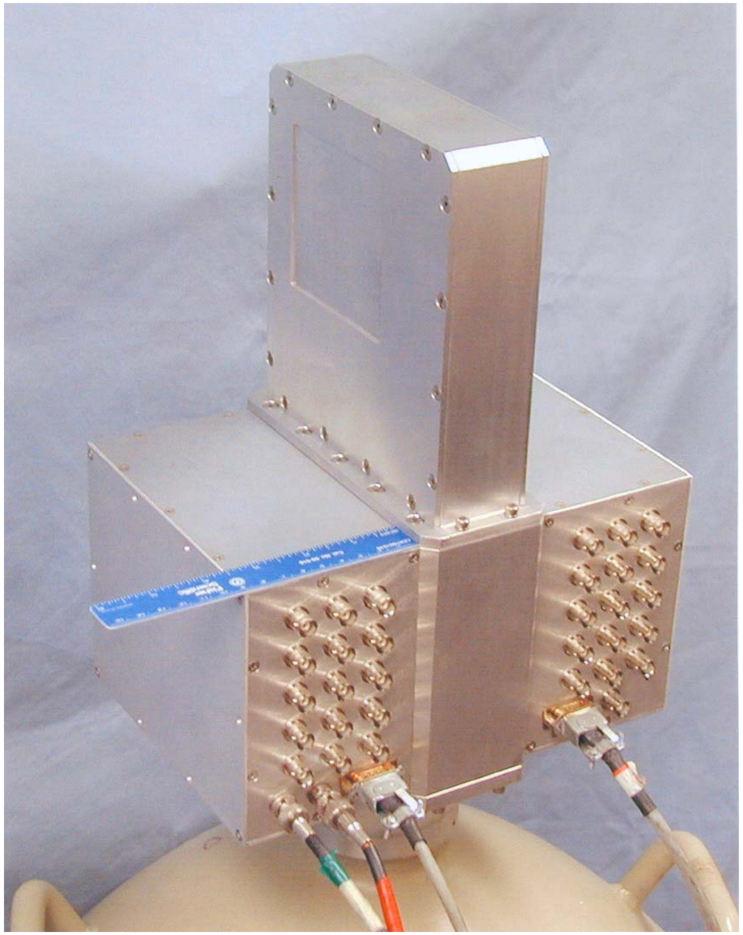
Future Procurement Plan

Current Effort Level

Plan for FY2003

Longer Term Plans

Resources Needed



Strategic Approach to γ-Ray Tracking using Planar HpGeDSSD's

4-Pronged Approach:

1) Develop Planar Germanium Detector Technology
2) Develop Digital Tracking Technologies
3) Demonstrate Scientific Usefulness of Devices for many Applications
4) Develop an Efficient Focal Plane Array for the FMA, The X-Array

Note: We co-ordinate our R&D with the detector development group at the Naval Research Laboratory, (Dr. R. Kroeger, Dr. B. Phlips) who pioneered work with HpGeDSSDs for space science and national security.

Planar Germanium Detector Status

Manufactured by Ortec, Oak Ridge, TN

"Mark 3"

Traditional p-type bulk material with Boron/ Lithium Construction….. a "LEPS"
92 x 92 x 20 mm Wafers
16 x 16 Orthogonal 5mm strips
3 mm guard ring
All Warm FET preamp
Bulky Test Cryostat

By far the best to date:	1.5 keV FWHM (Li)	16 strips
	2.1 KeV FWHM (B)	15 strips

"Mark 4" (December 2002)

All Cold FET preamps
Guard ring-less ?? (or 14 x 14 fallback)
Same Mechanical Package as "Mark 3"

Current R&D Projects

Technical

Digital Pulse Processing	(J. Amann)
Analysis of Resolution, "Addback" and "Event-loss"	(S. Freeman)
Monte Carlo Simulations	(E.F. Moore)
Two Detector (64-Channel) Analog Data. Acq.	(K. Teh)
VME Capability for Analog and Digital System.	(K. Teh)

Applications

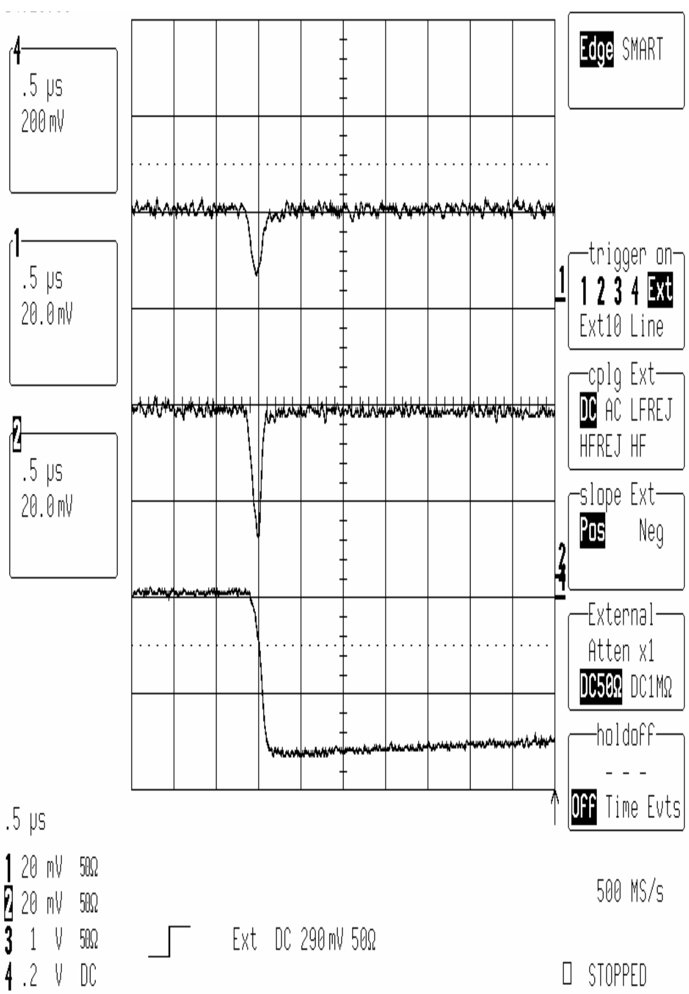
Doppler Correction "Inbeam"	(S.Fischer)
Polarization of γ-rays from α-decay sources	(N. Hammond)
SBIR project "Hunting for Fossils on Mars"	(D. Nisius)
ANL Technology Division "Compton Camera"	(F. Kondev)
The "X-Array", a FMA Focal Plane Detector	(E.F. Moore / Teng Lek Khoo)

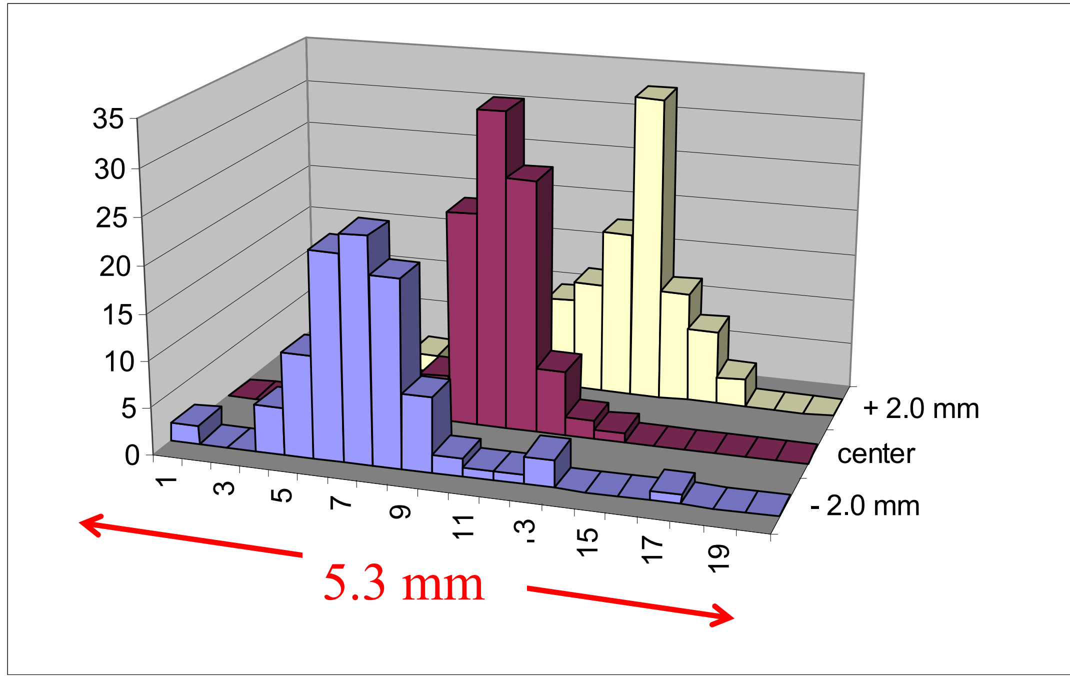
HpGeDSSD Position Sensitivity Tests

J. Amann, DePaul University

^{60}Co Interaction

Real & Induced charge





Collimated source tests:

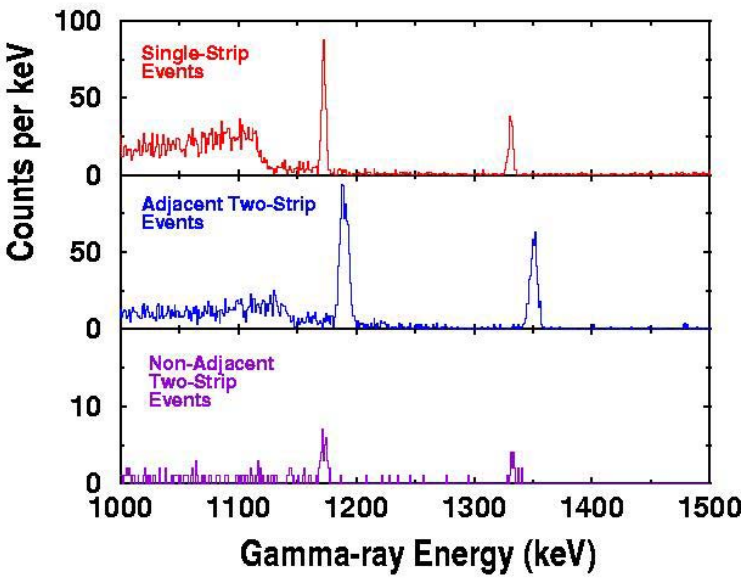
Position across single strip

Determined from difference in size of induced signal in adjacent strips

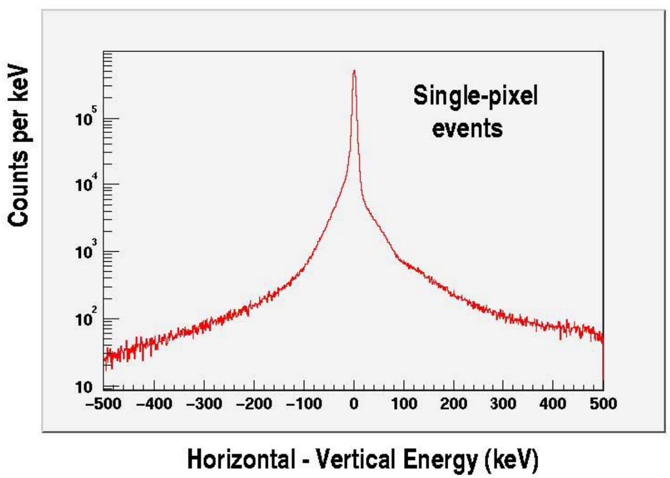
Testing HpGeDSSD Resolution and Efficiency

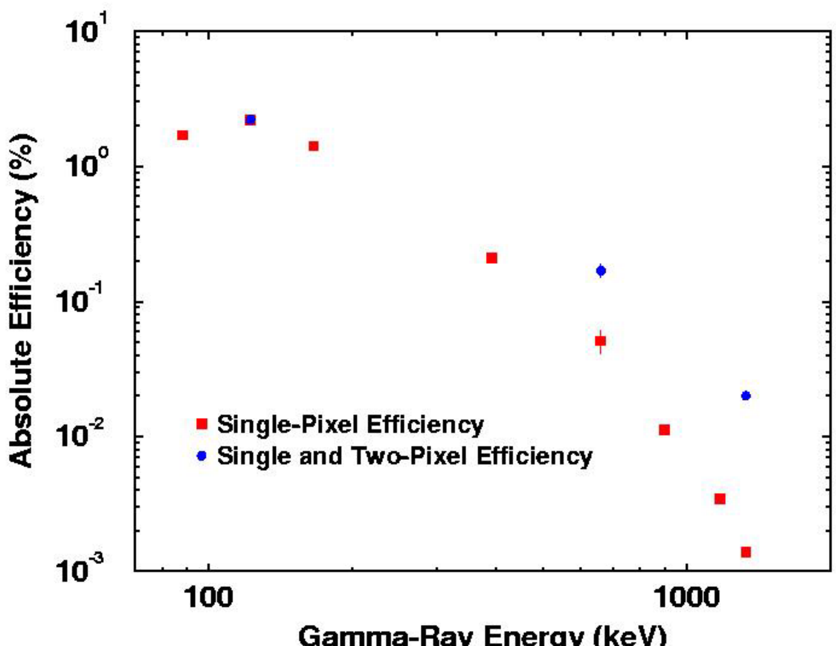
Dr. S.J. Freeman (U. of Manchester UK / ANL sabbatical visitor)

Matching expectation and reality reveals a great deal about how the detector works.



* Resolution, and gain-shifts, measures capacitive coupling.
* Front-Back charge consistency quantifies collection loss
* Surface-Maps quantify edge-losses
* Absolute Efficiency becomes a matter of definition





May 2001

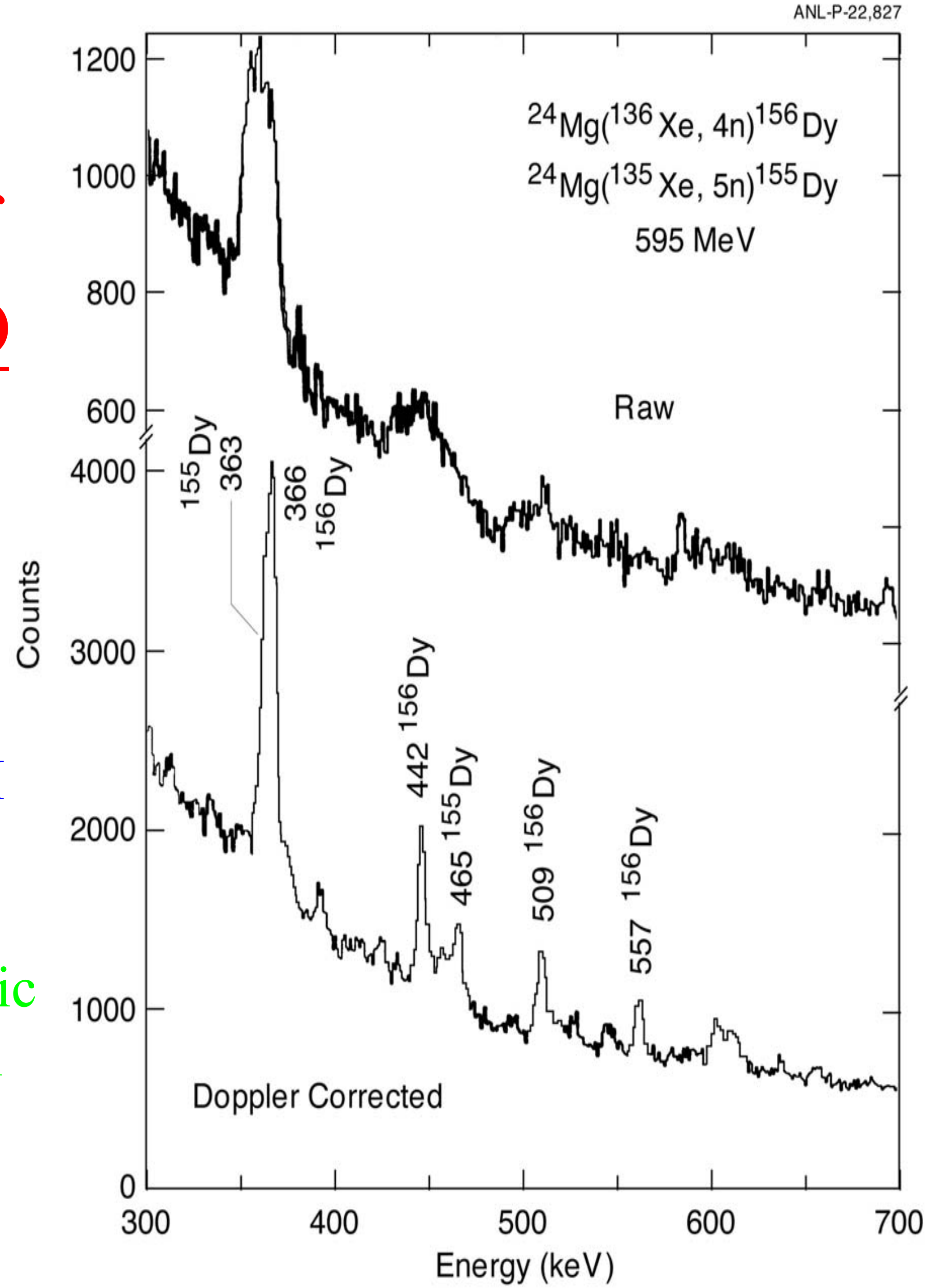
First In-Beam Test of "Mark 2" HpGeDSSD Detector

Fast Moving Ions (v/c=0.08)

Pixel-by-pixel correction

Ten-fold improvement in FWHM

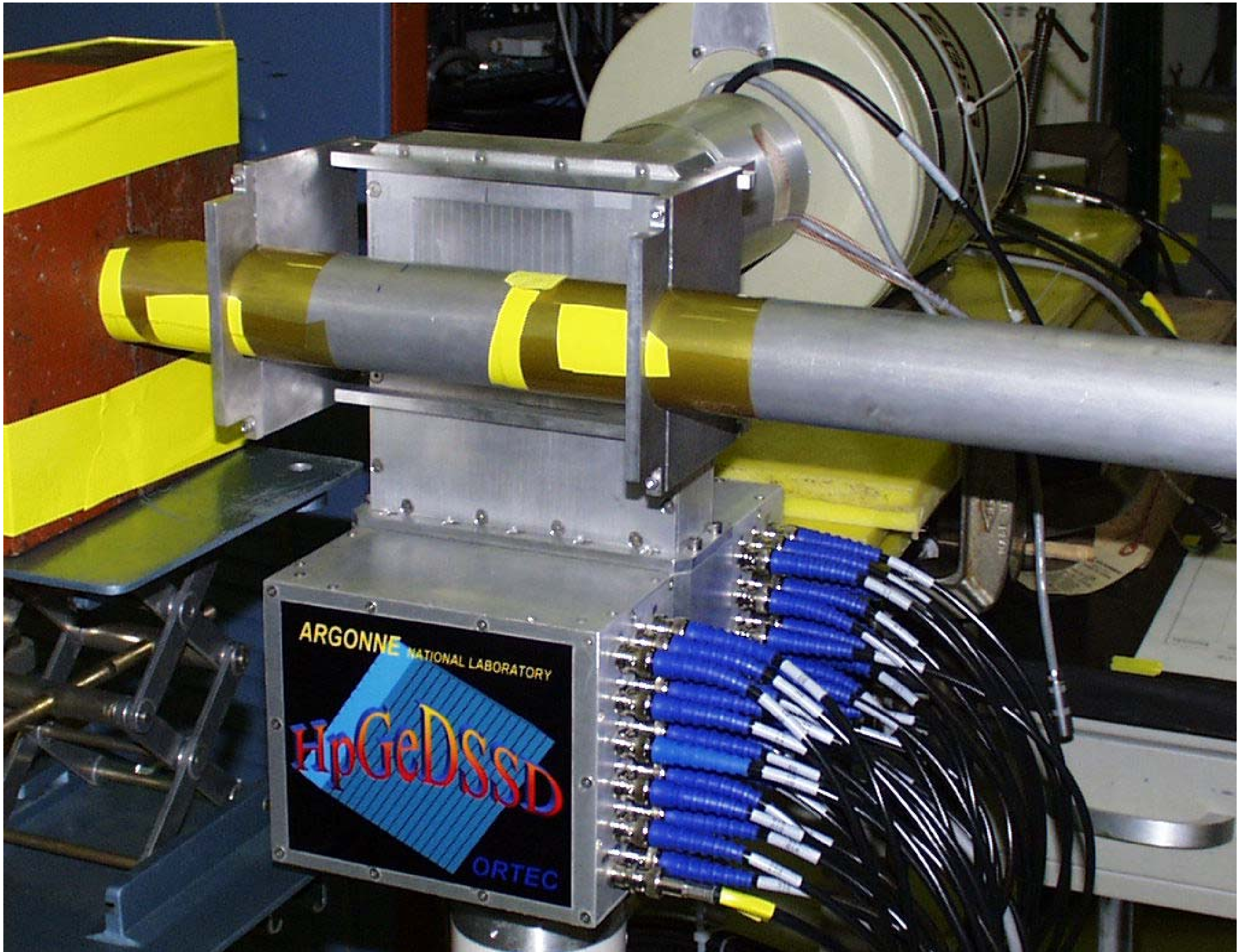
Mark 3 detector has better intrinsic energy resolution and better pixel definition: Test in August 2002

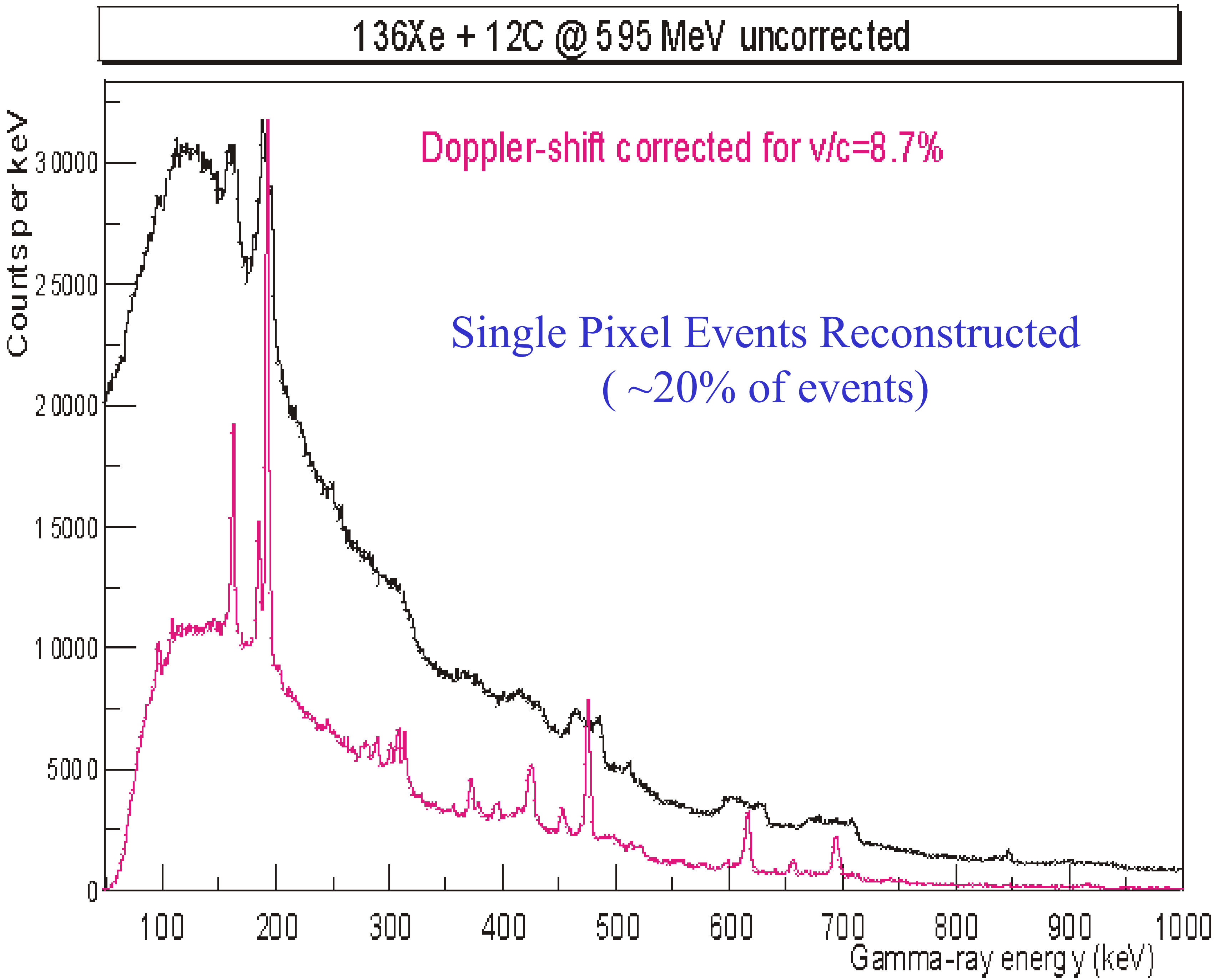


“Mark 3” HpGeDSSD In-beam Experiment at ATLAS

Test of Doppler-shift correction capability

(October 2002)



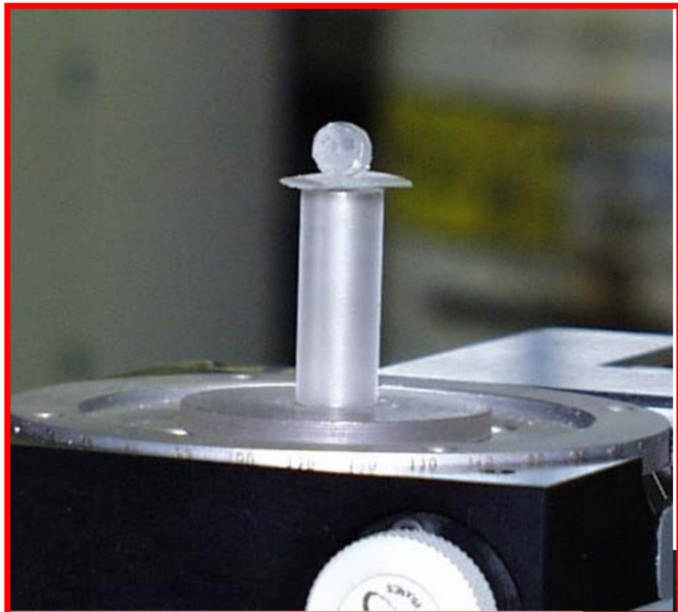


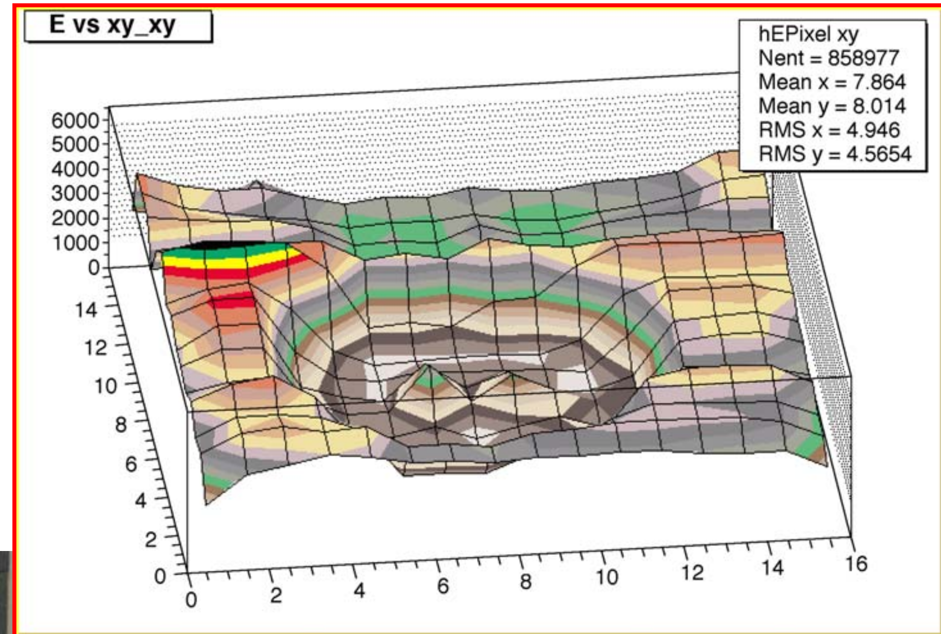
136Xe + 12C @ 595 MeV uncorrected
Doppler-shift corrected for v/c=8.7%
Single Pixel Events Reconstructed
(~20% of events)
Counts per keV
30000
25000
20000
15000
10000
5000
0
100
200
300
400
500
600
700
800
900
1000
Gamma-ray energy (keV)

Polarization Experiment

U. Liverpool / ANL Collaboration

HpGeDSSD Imaging Test



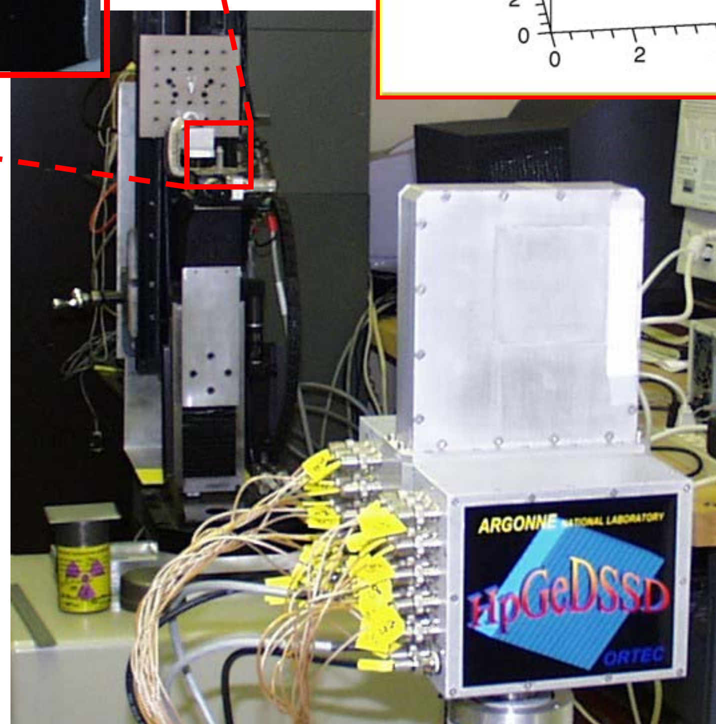


BIR sample holder

Collimated 15 mCi ^{109}Cd source

Quartz sample with 1 mm drilled holes

- Paraffin
- graphite



Information on position from strip hits only

P.I. Dr. D. Nisius,
BioImaging Research Corp.

Future HpGeDSSD Detector Procurement Plan

1) Streamlined Mechanical Envelope

Construct a practical compact cryostat for Array deployment
Thin-Contact Technology
(First Unit ~ $125K, four for $500K)

2) "Full Detector Stack"

To Construct a full tracking unit, with 4 layers of germanium

A) Phase 1 would be a test cryostat loaded with 2 wafers
B) Phase 2 would reload cryostat with 2 more wafers
(Total Estimated Prototype ~ $500K)

X-Array Physics Applications

α–γ Fine structure spectroscopy

p-γ Fine structure spectroscopy

β–γ Decay studies

e-γ Conversion electron spectroscopy

Isomer Studies

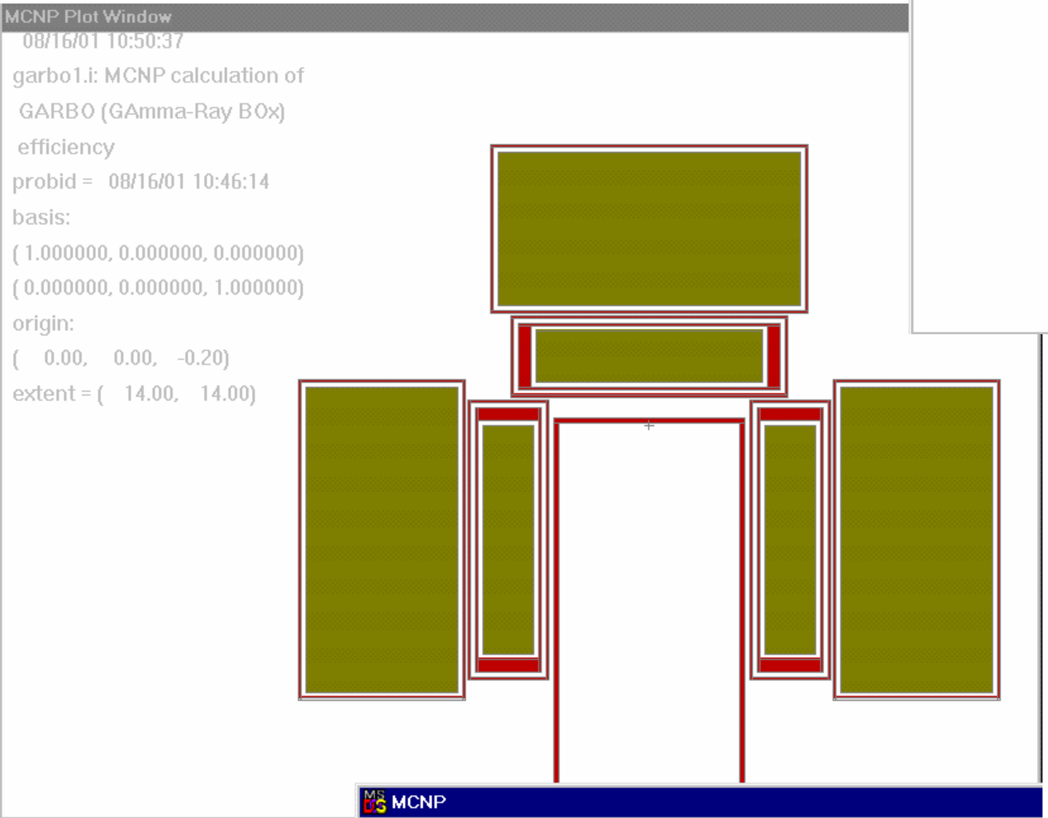
Low Energy Coulomb Excitation

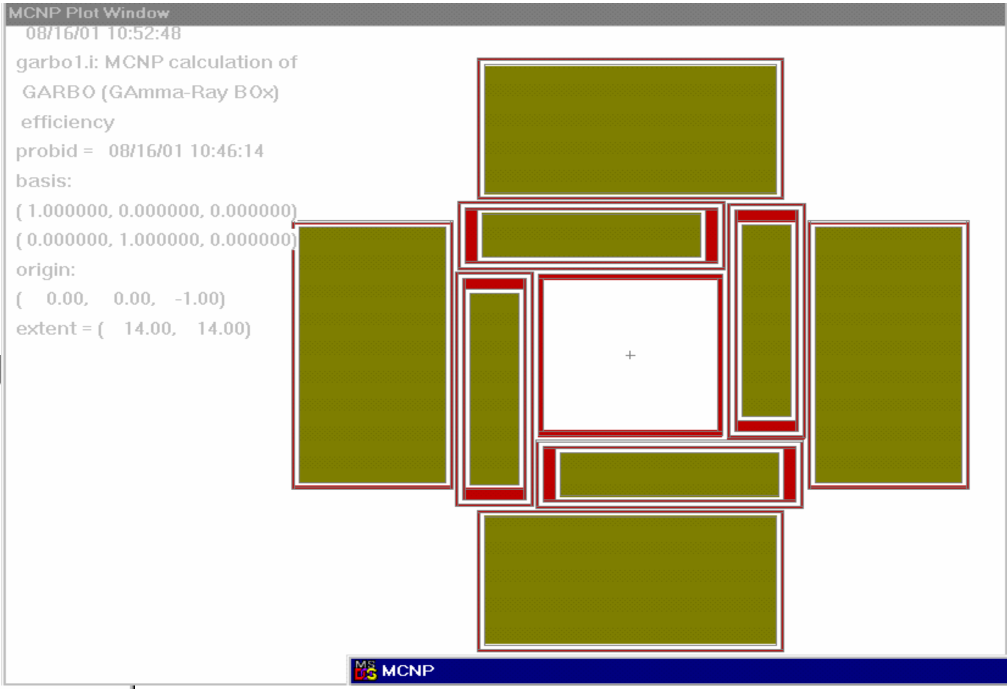
Design Optimization For:

High Efficiency, Good Energy Resolution, High Count rate Capability, Considerable Segmentation, Mechanical Flexibility, Compatibility with existing silicon arrays and is ideal for RIA in the future.

X-Array MCNP Geometry

Vertical cross section

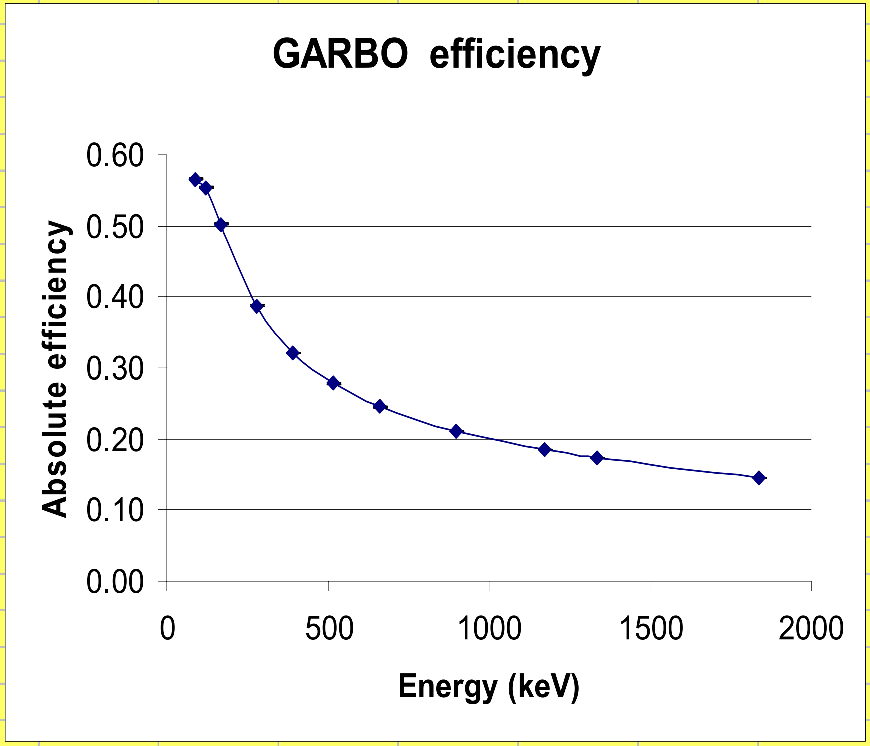




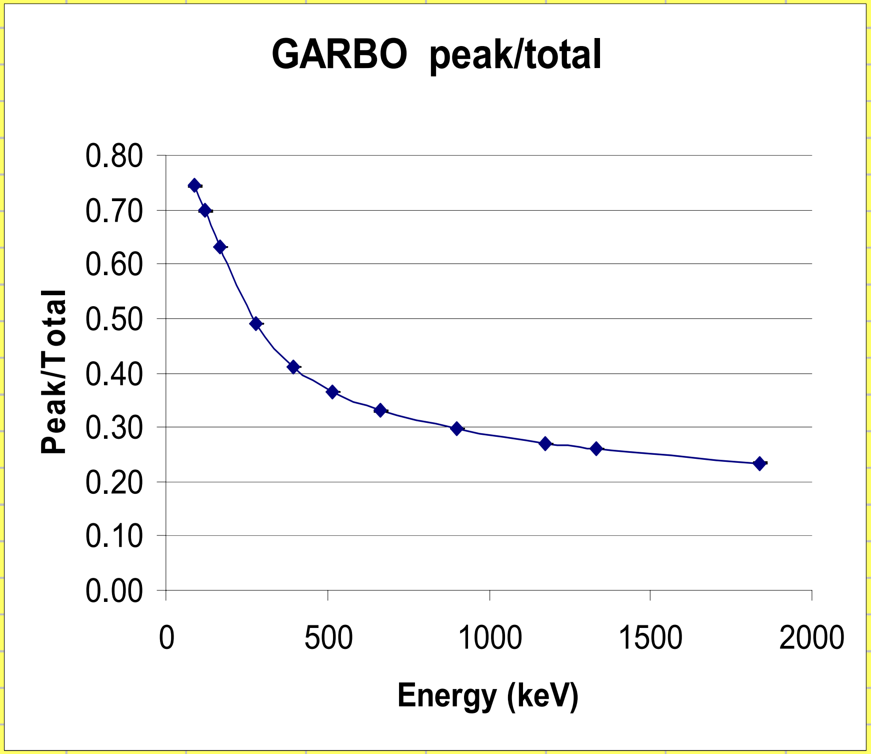
Horizontal cross section

MCNP Results

Photopeak efficiency



Peak to Total (E > 30 keV)



X-Array Status

November 2002

"Mark 3" Planar Module delivered 18th February 2002
"Mark 4" expected December 2002

Detailed Design of Focal Plane Vacuum Envelope

Simulations for different back detector sizes / geometries

Extensive Discussions with detector manufacturers concerning size and segmentation vs. cost

Proposed Preliminary X-Array Budget

November 2002

Item	$K (X-Array)	$(Tracking)
5 Big "Back" detectors	5 x 125	
4 Streamlined Planars (First counted in GARBO R&D)		4 x 125
Clover high resolution Amps, ADC's, TDCs and logic (25channels)	70	
Planar high resolution Amps, ADC's, TDCs and logic (160channels)		170
High Power NiM, CAMAC and VME Crates, High Voltage	50	
Frame	40	
Chamber	30	
LN2 System	30	
Laboratory Tax (11%)	93	73
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TOTAL	$938K	$744K

Current (CY2002) Effort Level

NAME	Institution	Effort (CY2002)
C.J. Lister	ANL (Physics)	(1.75 FTE)
M. P. Carpenter		
N. Hammond		
RVF Janssens		
E.F. Moore		
T.L. Khoo		
K. Teh		
F. Kondev	ANL (Technology)	(0.1 FTE)
Prof. S. Freeman	U. Manchester U.K.	(0.5 FTE)
Prof. S. Fischer	DePaul University	(0.25 FTE)
Dr D. Nisius	BioImaging Research Inc.	(0.25 FTE)

		~ 3.0 FTE

Plans For FY2003

1) Test and Evaluate “Mark 4”
2) Build Compton Camera.
3) Build PET scanner and start Medical Collaboration with U. Chicago Medical Center Radiology Group (Prof. R. Beck).
4) Procure “Mark 5” Streamlined Detector with thin contact technology.
5) Design / Specification of Detector Stack
6) Polarization Physics at ANL
7) “Fast Ion” physics of odd-A nuclei at MSU
8) Procurement of 2 large backing detectors; “2-sided” box evaluation of X-Array performance.

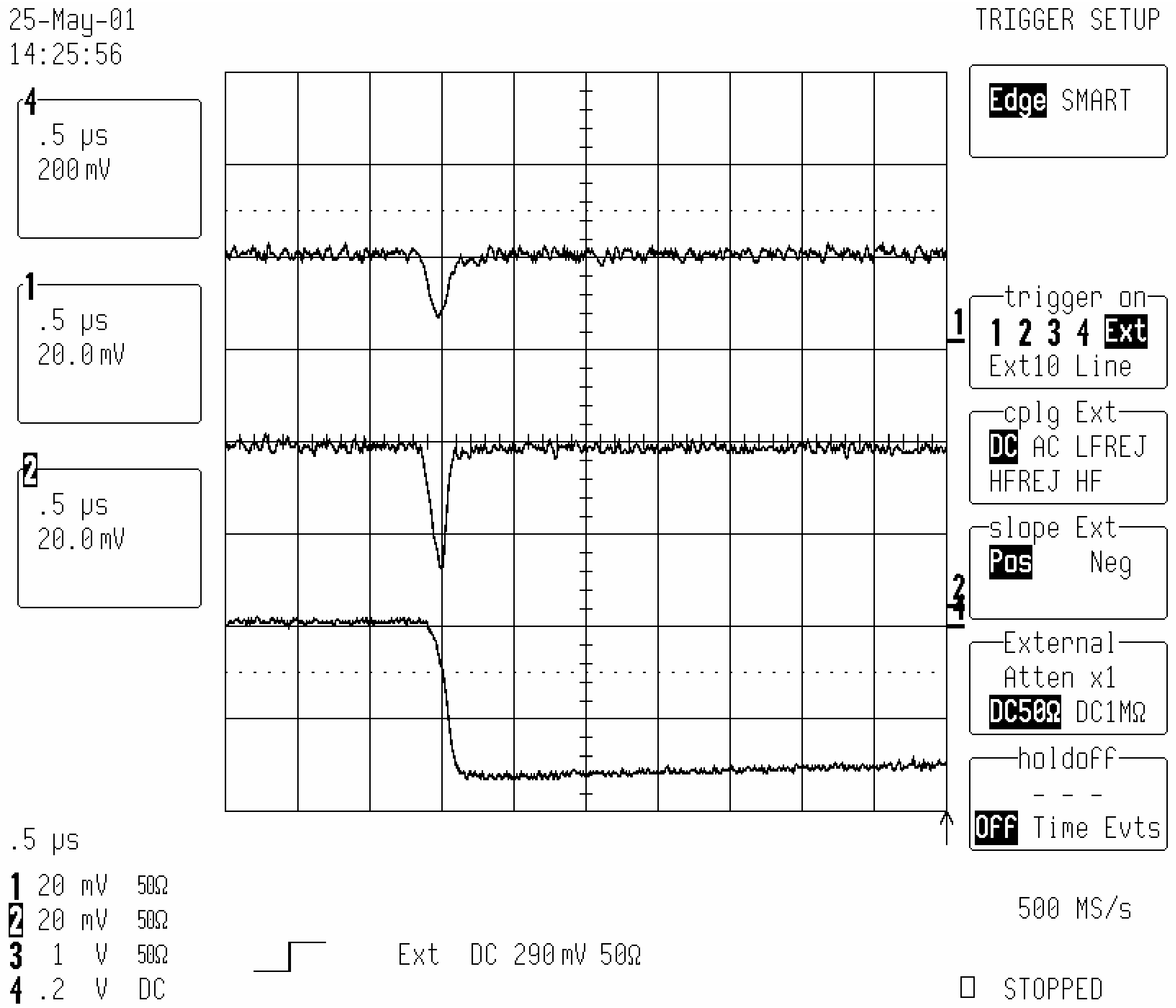
Longer Term Plans (2003-5)

1) Procure and evaluate a HpGeDSSD "4 stack"
2) Develop Signal Processing and software for Tracking
3) Build full X-Array by 2005

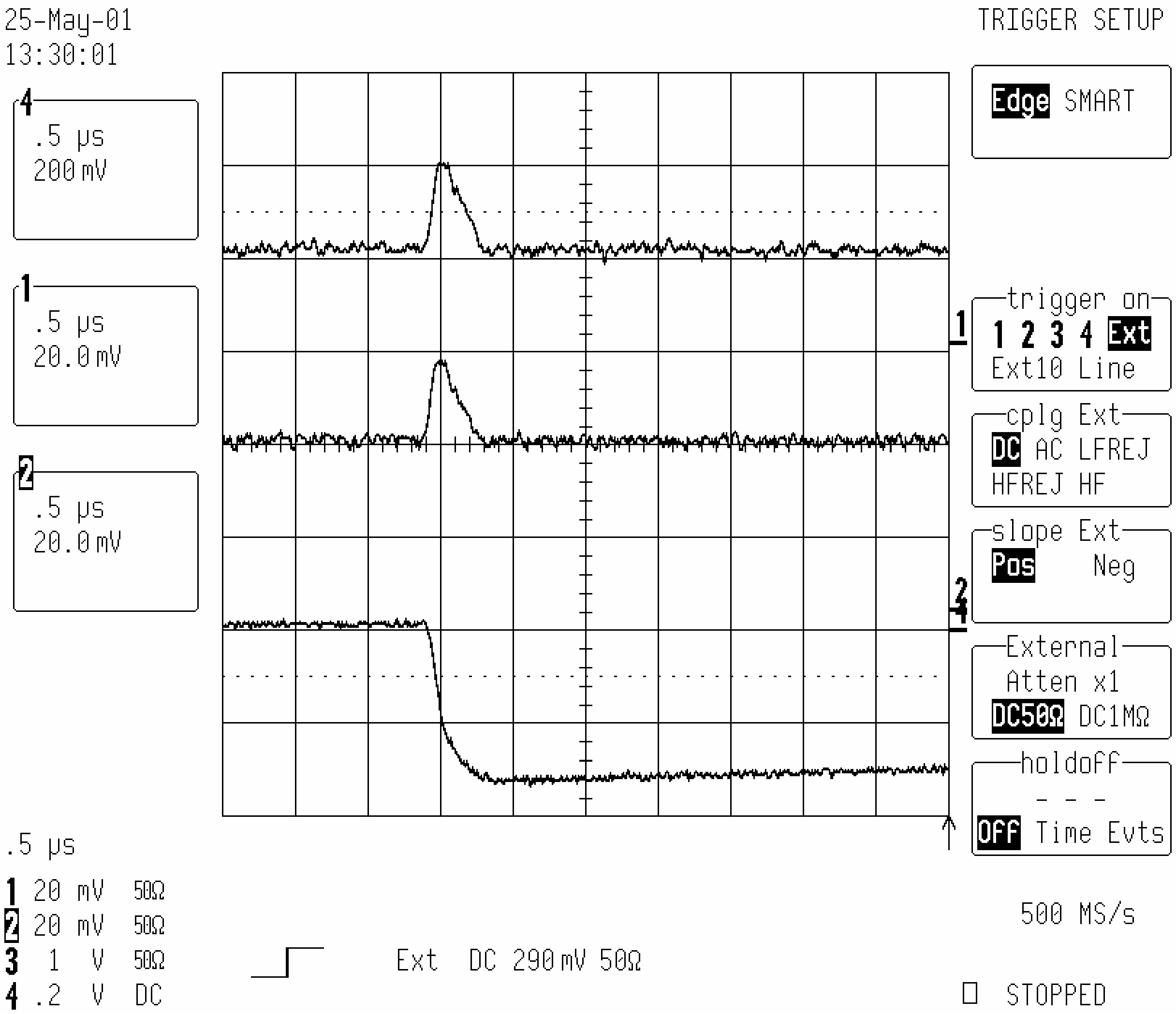
Resources Needed for Plan (2003-5)

1) Planar Detectors and Tracking Technologies $1466K
   (Inc. Wafers for X-Array and "4-Stack")
2) X-Array Infrastructure and Backing Detectors $938K

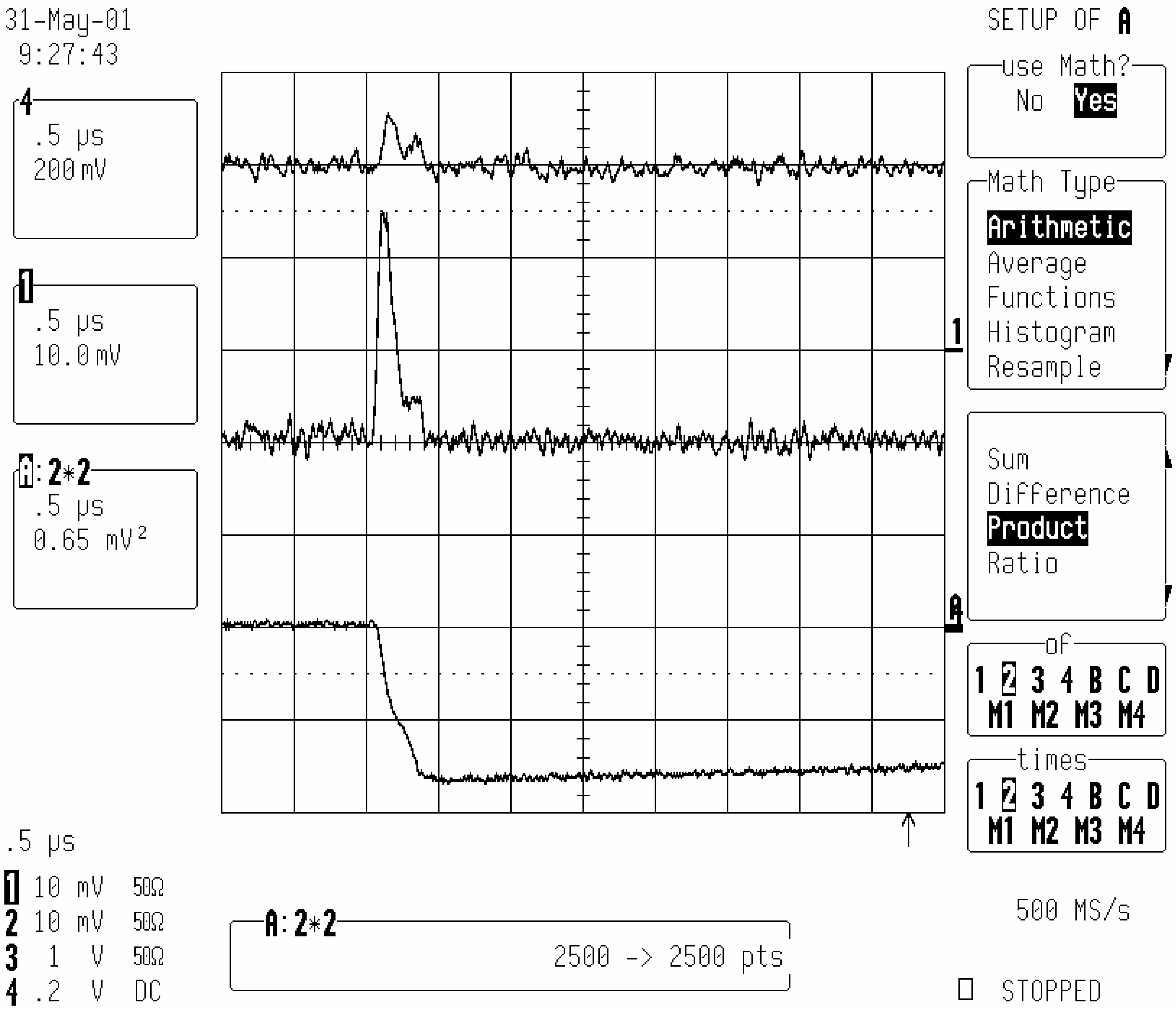
60Co “Deep” Interaction



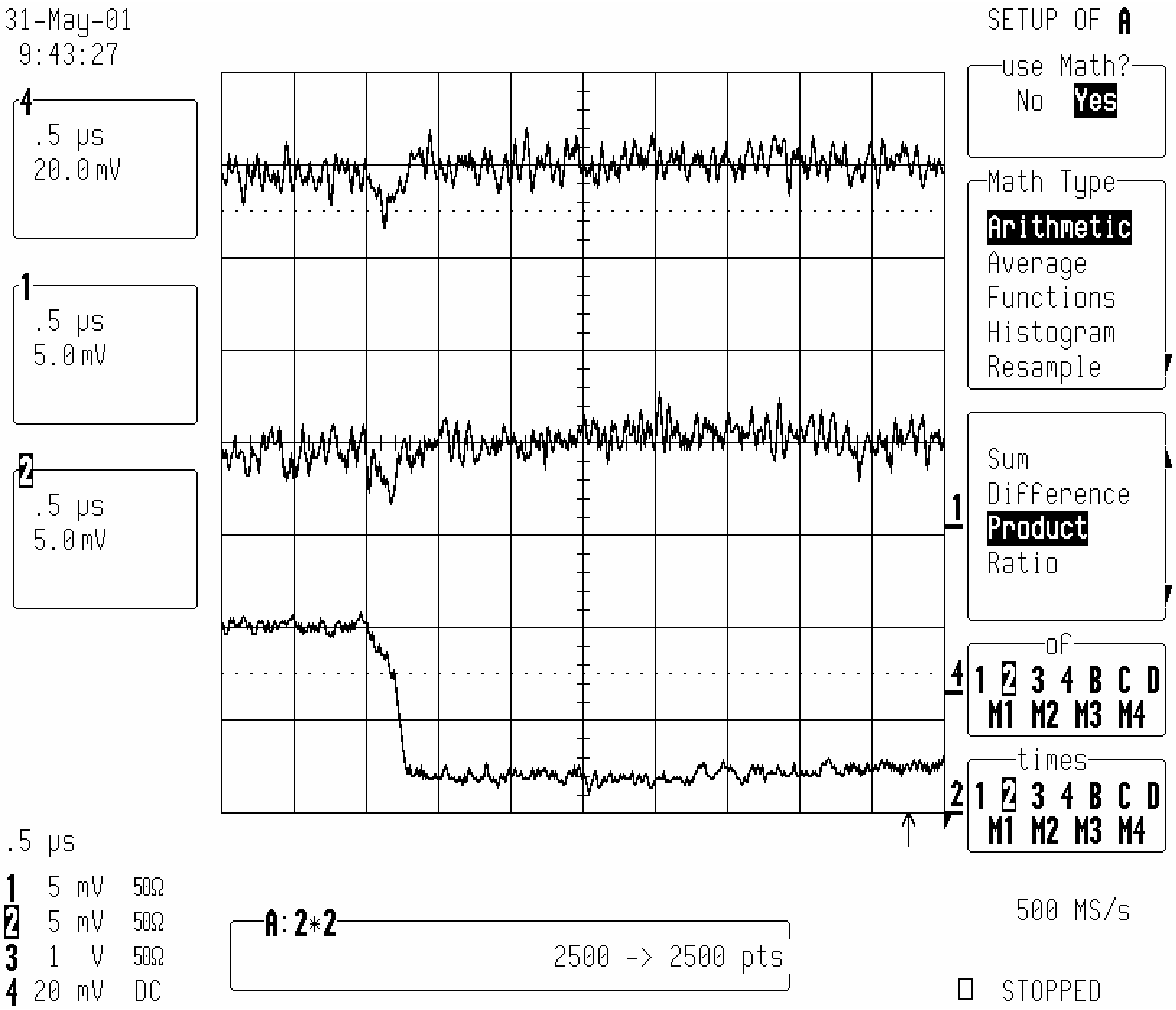
60Co “Shallow” Interaction



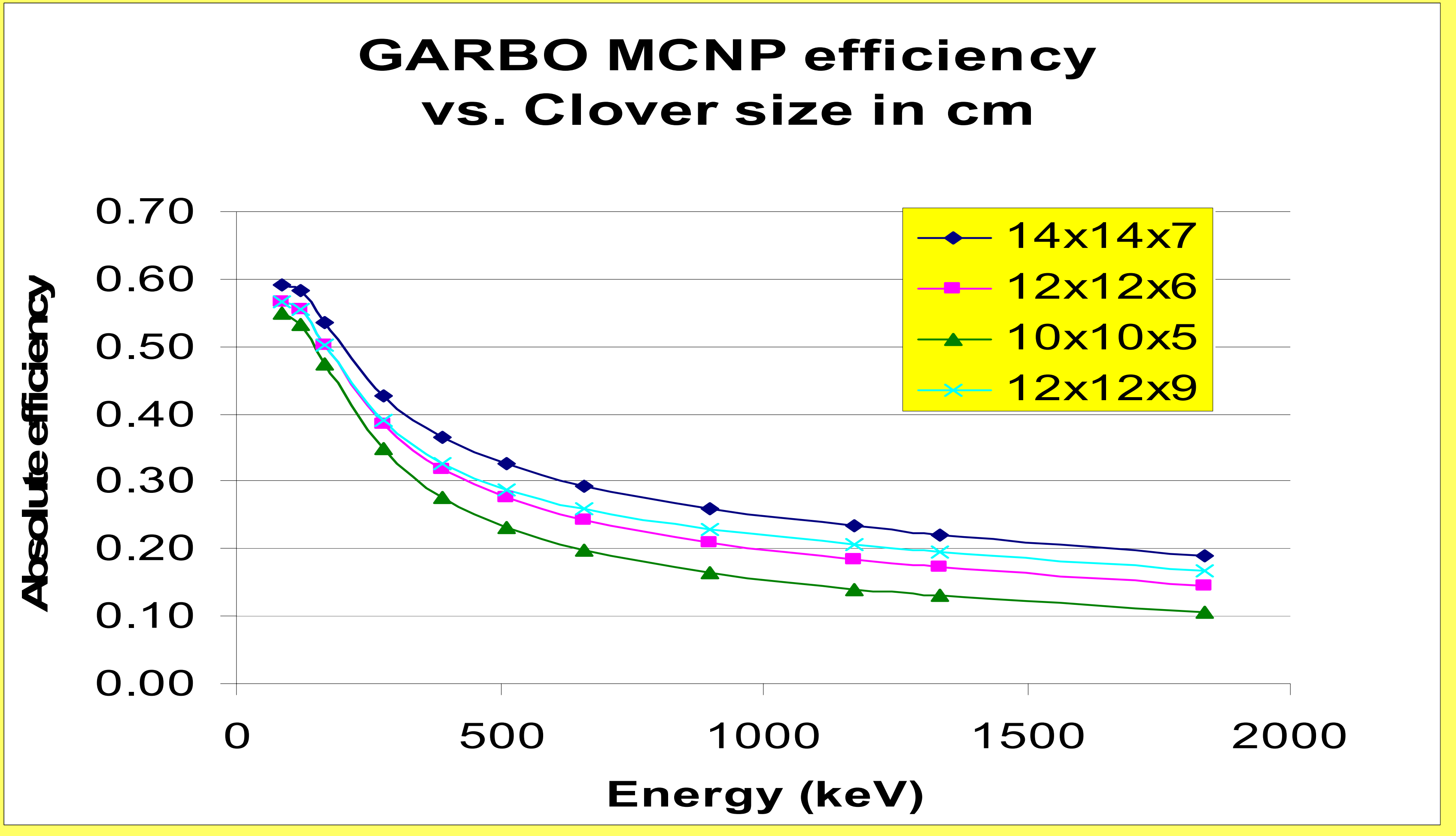
137Cs "Shallow, 2 Interactions" Interaction



57Co “Deep, Center” Interaction



MCNP Results



Post Meeting Budget Revision

Revised Budget Numbers Novervmber 14th 2002 following DOE visit.

YEAR	"TRACKING R&D"	"X-ARRAY"	
	(GRTCC Report)	(FMA Specific)	(Tracking Related*)
2003	150[a]	375	---
2004	300[b]	370	335
2005	200[b]	100	335
Tax (11%)	72	93	74
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	$722K	$938K	$744K

* The "tracking related" component of the X-Array is the inner box of planars and their associated electronics. These detectors form a key component of the X-Array, as they provide the X-ray and polarization sensitivity which makes the instrument unique. The detectors can also be used separately from the array for use as a PET scanner, Compton camera, or in many other "Tracking" applications.

a) This component is $125K for a "streamlined, thin contact HpGeDSSD" plus $25K for digital pulse processing boards for our data acquisition system.

b) Estimated cost of a "4-Stack" of planars in a single cryostat.