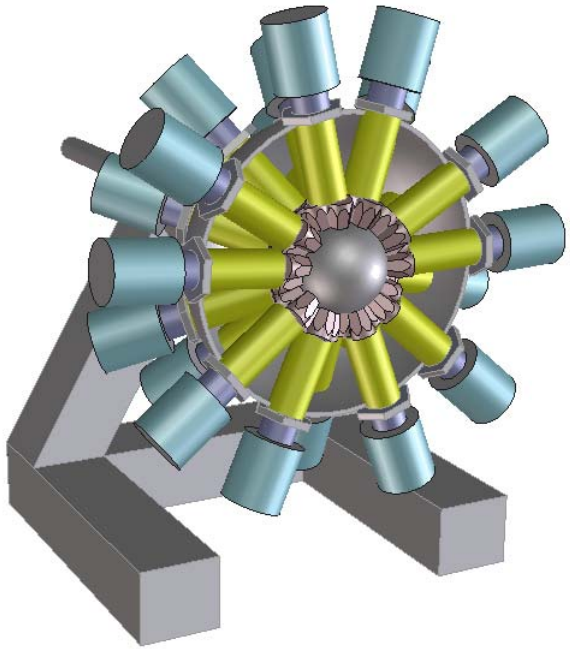
GRETA Readiness



I-Yang Lee

For the GRETA Steering Committee

NSAC Subcommittee on Categorizing Facilities

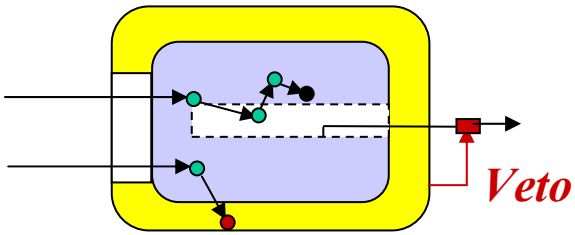
February 15, 2003, Rutgers University

Development of the U.S. gamma-ray tracking effort

- **1994 Conceptual design study**
- **1995 Duke Town meeting (1996 LRP) first discussion**
- **1997 First prototype received and tested**
- **1998 Workshop on GRETA physics (LBNL)**
- **1998 Workshop on experimental equipment for RIA (LBNL)**
- **1999 GRETA advisory committee formed**
- **1999 Second prototype received and tested**
- **2000 Workshop on GRETA physics (MSU)**
- **2000 Proposal for a GRETA module cluster submitted and reviewed, funded 2002**
- **2001 National Steering Committee formed**
- **2001 Santa Fe meeting (2002 LRP) presentation and discussion**
- **2001 Workshop on Digital Electronics in Nuclear Physics (ANL)**
- **2001 Workshop on Gamma-ray tracking detectors (Lowell)**
- **2002 Gamma Ray Tracking Coordination Committee review -*National plan for development of Gamma-ray tracking detectors in nuclear science***

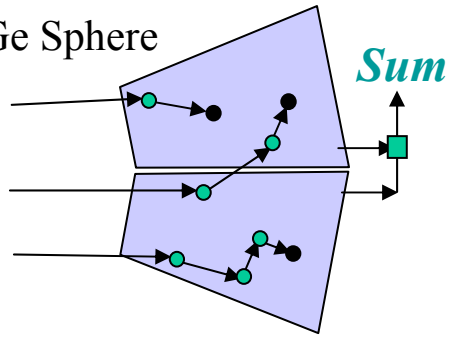
Gamma-ray Tracking Concepts

- Compton Suppressed Ge



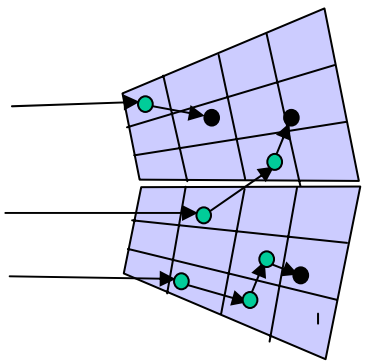
$N_{det} = 100$
Peak efficiency = 0.1
Efficiency limited

- Ge Sphere



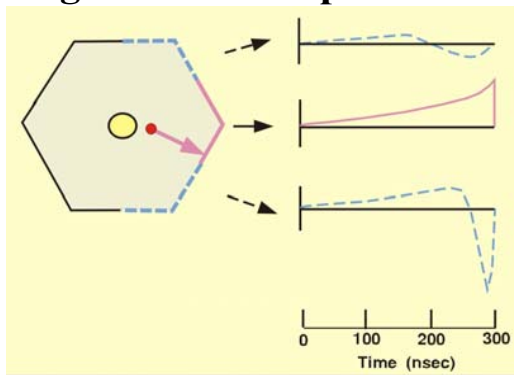
$N_{det} = 1000$ **(summing)**
Peak efficiency = 0.6
Too many detectors

- Gamma Ray Tracking

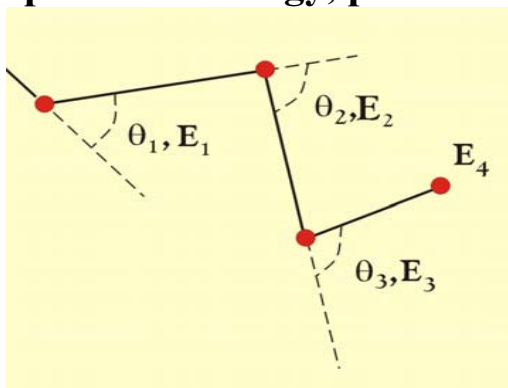


$N_{det} = 100$
Peak efficiency = 0.6
Segmentation

Pulse shape analysis in segments ➔ 3D position



Tracking of photon interaction points ➔ energy, position



GRETA R&D Efforts

Integrated Efforts Since 1994 ≅ $5 M

	Effort (FTE-yr)
• Detector	4
• Preamp	1
• Signal analysis	4
• Tracking	3
• Signal digitizer	4
• Data acquisition	1
Total	**17**

	Hardware cost
• Prototype I (12 seg.)	$ 172k
• Prototype II (36 seg.)	$ 100k (modify prototype I)
• Module cluster (3 x 36 seg.)	$ 781k
• Electronics	$ 500 k
Total	**$1,553 k**

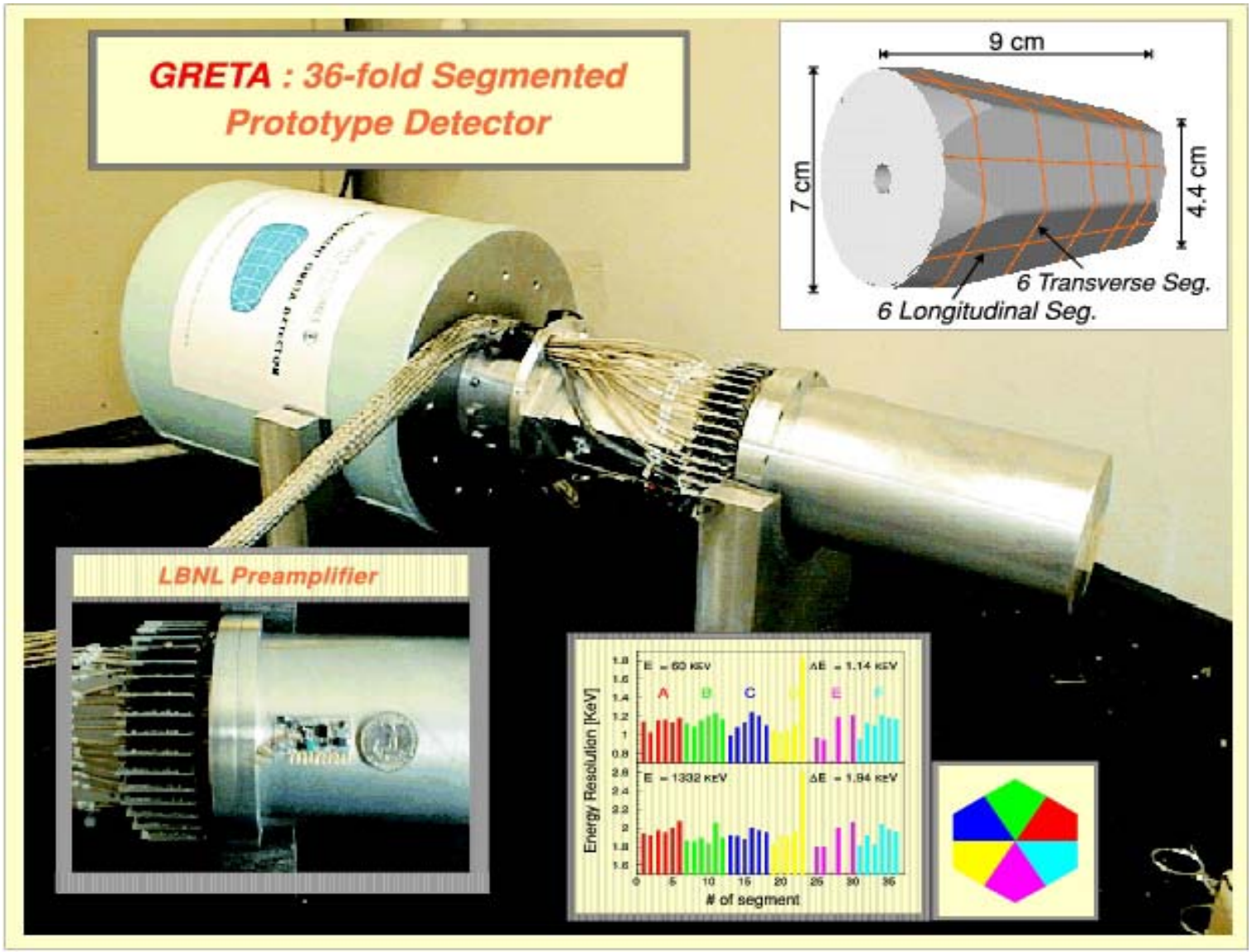
R&D Accomplishments

Proof of principle: No show stoppers

- **Segmented detectors**
  - Energy resolution: 1.2 keV at 60 keV and 1.9 keV at 1332 keV
  - Total integrated noise: < 5 keV (bandwidth 35 MHz)
  - 3-D position sensitivity: < 1 mm at 374 keV (single interaction)
- **Signal analysis**
  - Adaptive grid search: 1-2 mm
  - Least square: 1-2 mm
  - Genetic algorithm: 2 mm
  - Wavelet transformation: 5-6 mm
- **Tracking algorithms**
  - Compton tracking (150 keV < E_γ < 5 MeV) : eff = 50%, for m= 25.
  - Pair tracking (E_γ> 5 MeV) : eff = 50%

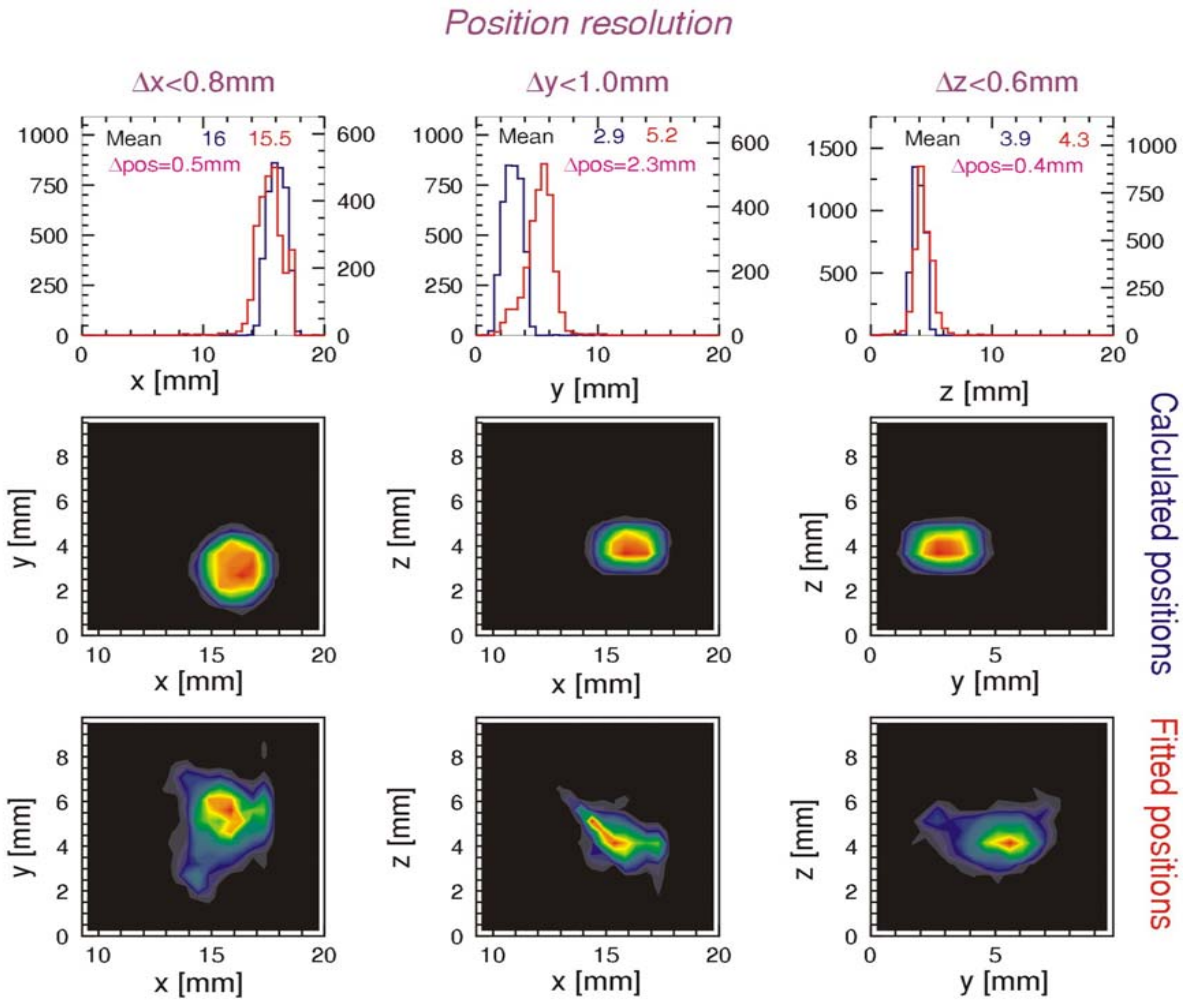
- M. A. Deleplanque et al., Nucl. Instrum. Methods Phys. Res. A430, 292(1999).
- G. J. Schmid et al., Nucl. Instrum. Methods Phys. Res. A430, 69 (1999).
- K. Vetter et al., Nucl. Instrum. Methods Phys. Res. A452, 105 (2000).
- K. Vetter et al., Nucl. Instrum. Methods Phys. Res. A452, 223 (2000).

Prototype detector II at LBNL

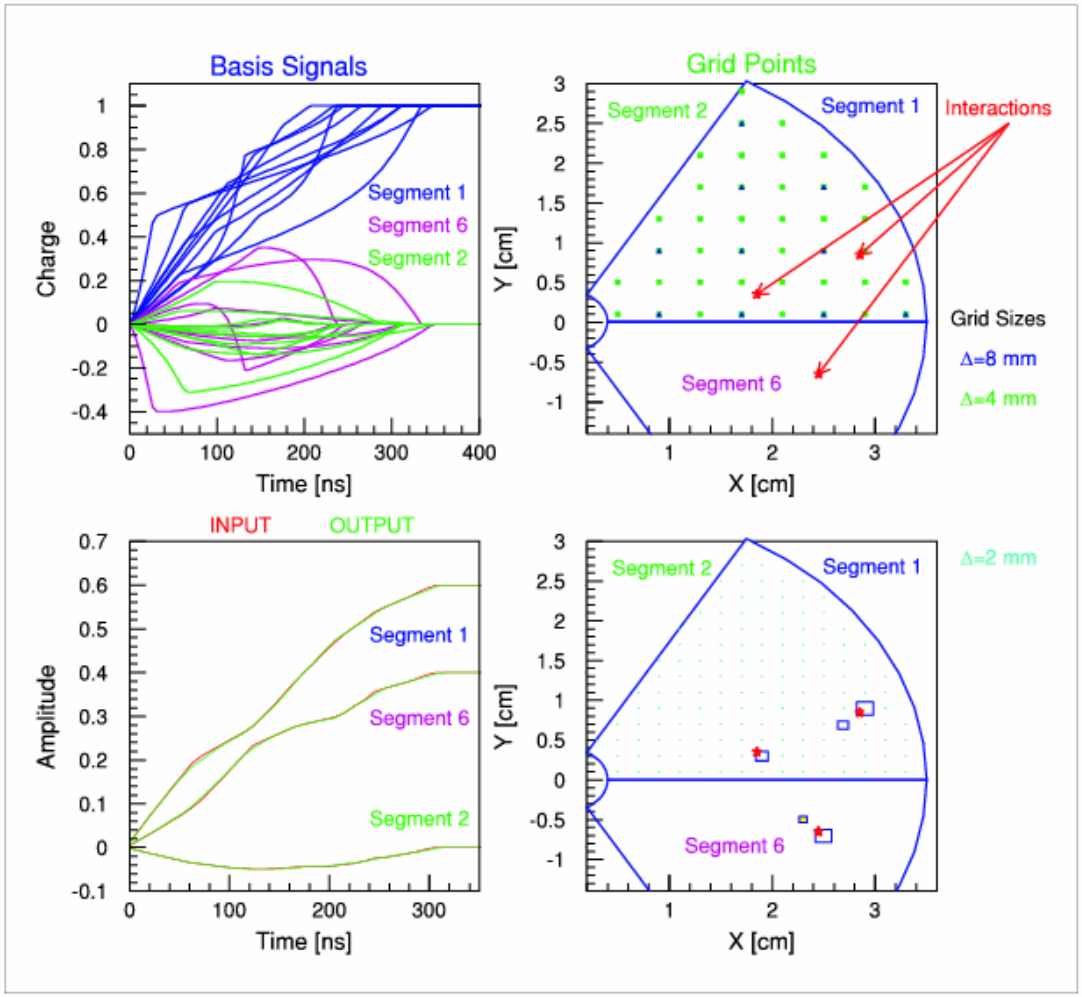


Position determination for a single interaction

K. Vetter *et al*, Nucl. Instr. Meth. A 452 (2000) 223



Signal decomposition of multiple interactions in one segment

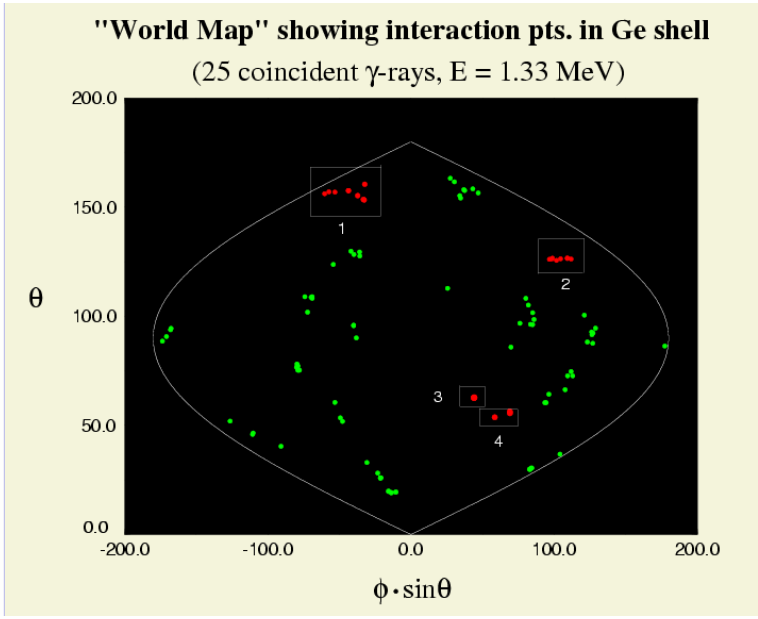


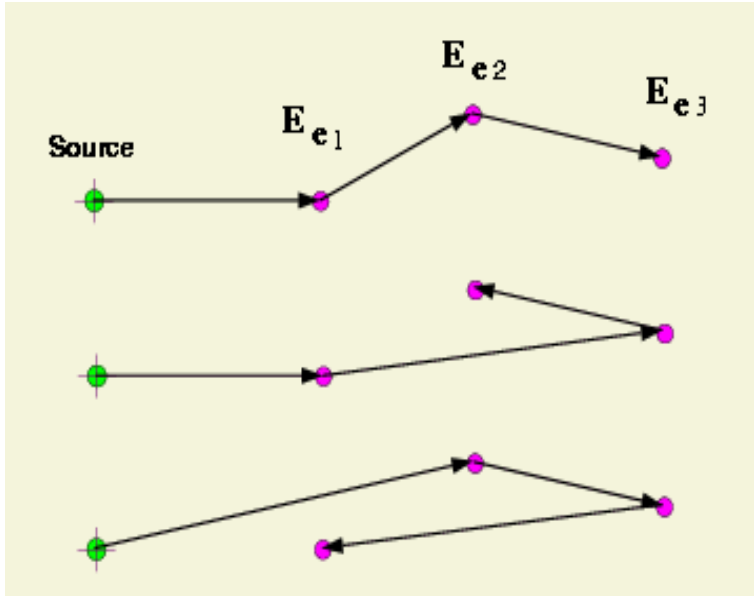
- Calculate signal in each segment for interactions on a grid ➔ base signals
- Decompose the composite signal into a linear combination of base signals
- Interpolate to improve position resolution

Tracking of Compton Scattering

First step – cluster finding

Second step – Identify sequence satisfying Compton condition





Assume:

g-ray from the source

$E_\gamma = E_{e1} + E_{e2} + E_{e3}$

Sequence with best fit

➔correct scattering sequence

➔rejects Compton and wrong direction

Tracking Results

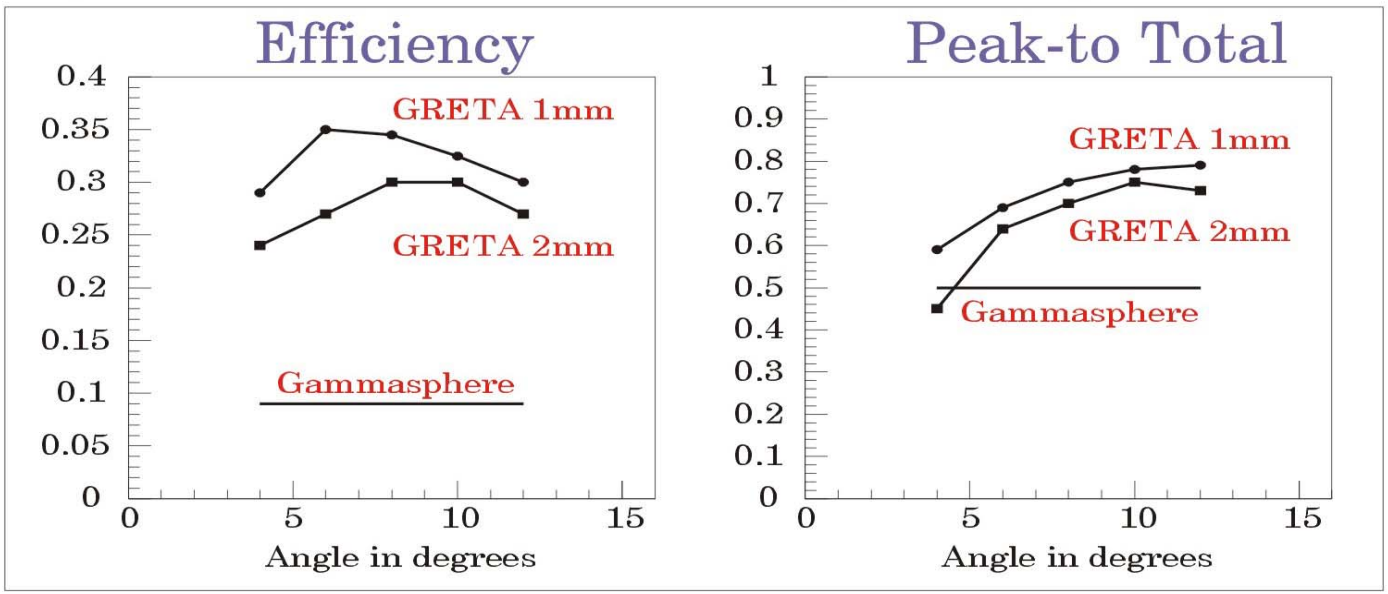
Compton Tracking

G.J. Schmid *et al*, Nucl. Instr. Meth A 430 (1999) 69

0.1 MeV < E_γ <5 MeV : Compton Effect dominant

Example: 25 gamma rays of 1.33 MeV

Cluster generation → Tracking → Split/Add/Split-add



→ *Tracking efficiency about 50%*

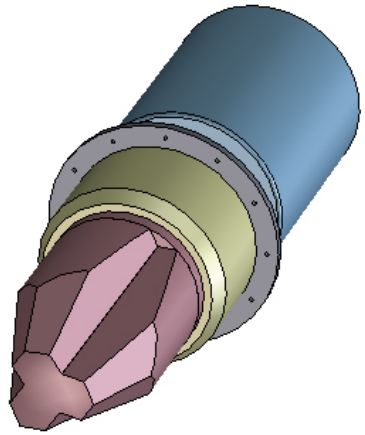
GRETA R/D plan
(FY03 – FY05)

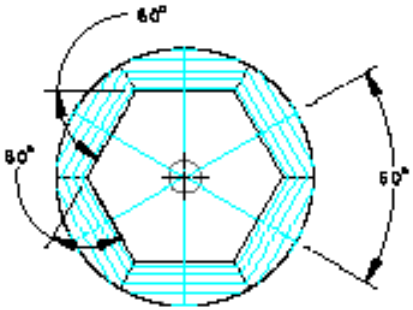
- Measurements with prototype II
- Obtain three-crystal detector modules
- Develop digital electronics
- Improve signal analysis algorithm
- Improve tracking algorithm

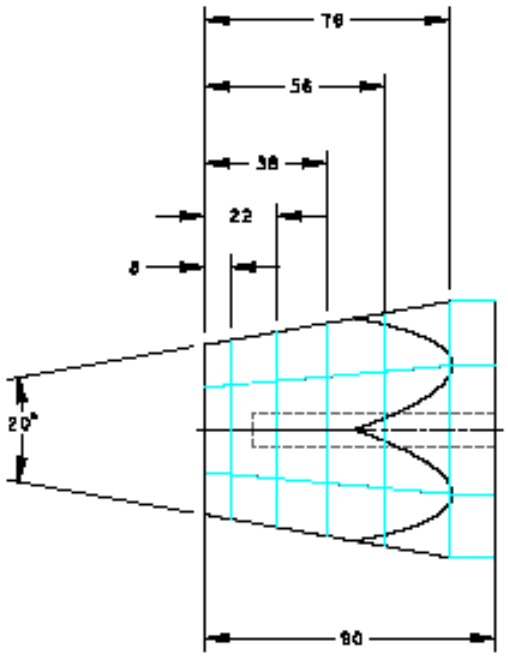
Three-crystal detector module

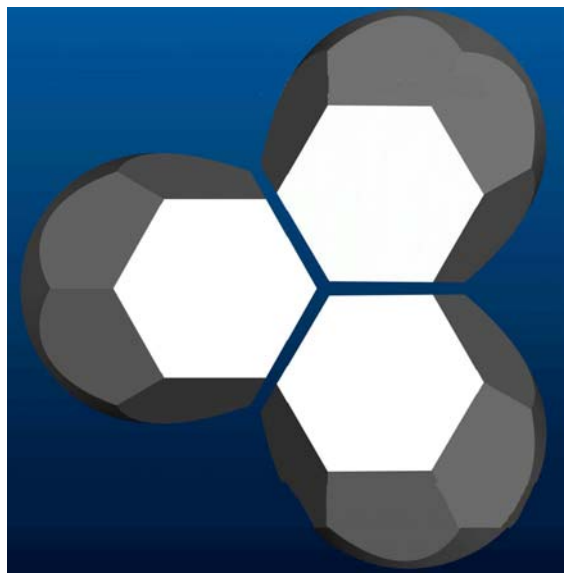
Building Block of GRETA

- **Tapered regular hexagon shape.**
- **DIA= 8 cm, L= 9 cm, 36 segments.**
- **Close packing of crystals with gap= 3.5 mm.**
- **On order and expecting delivery in Oct. 2003.**
- **Cost = $750 k ($450k for 40 units)**



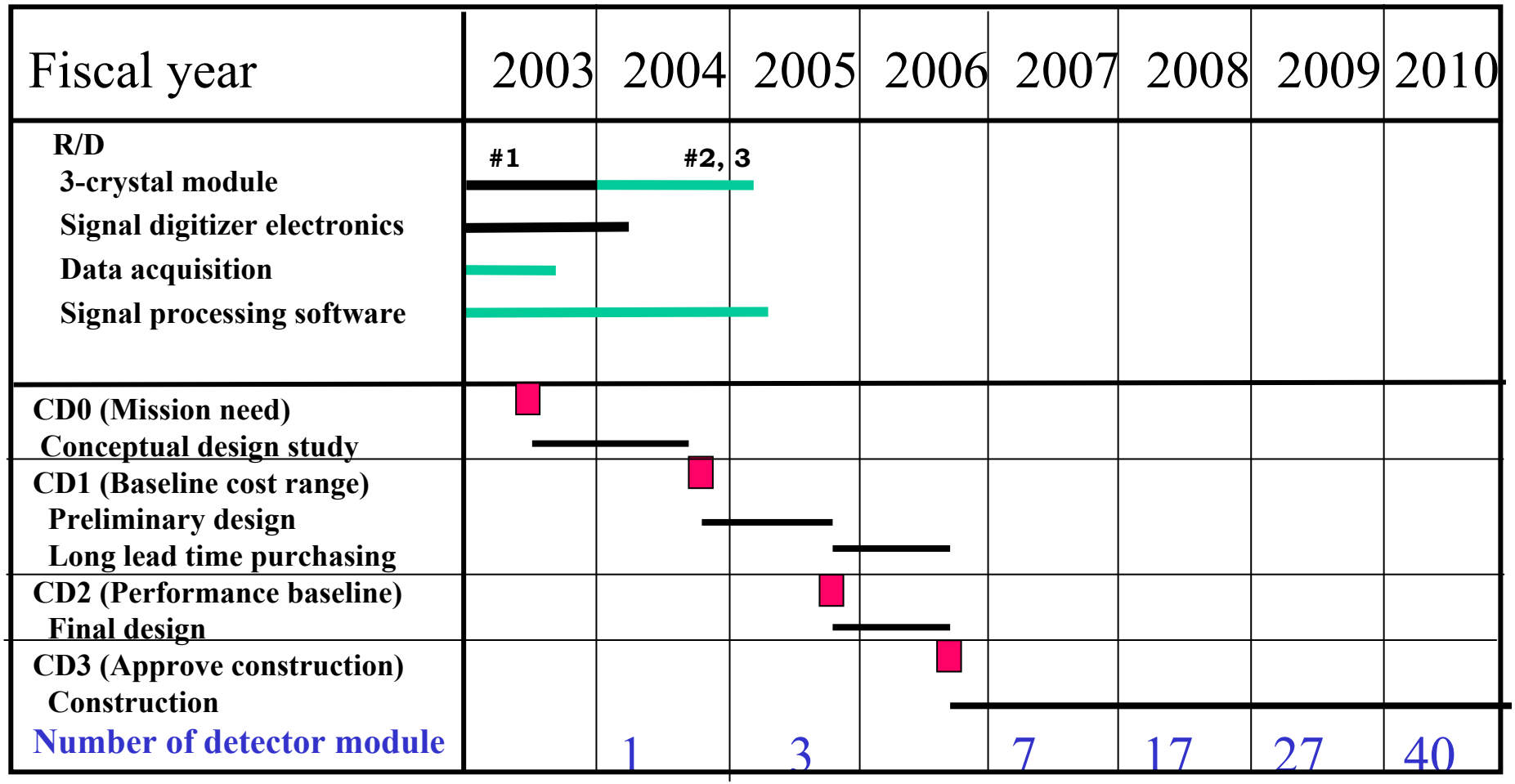






Proposed GRETA Schedule

Preliminary 1/03

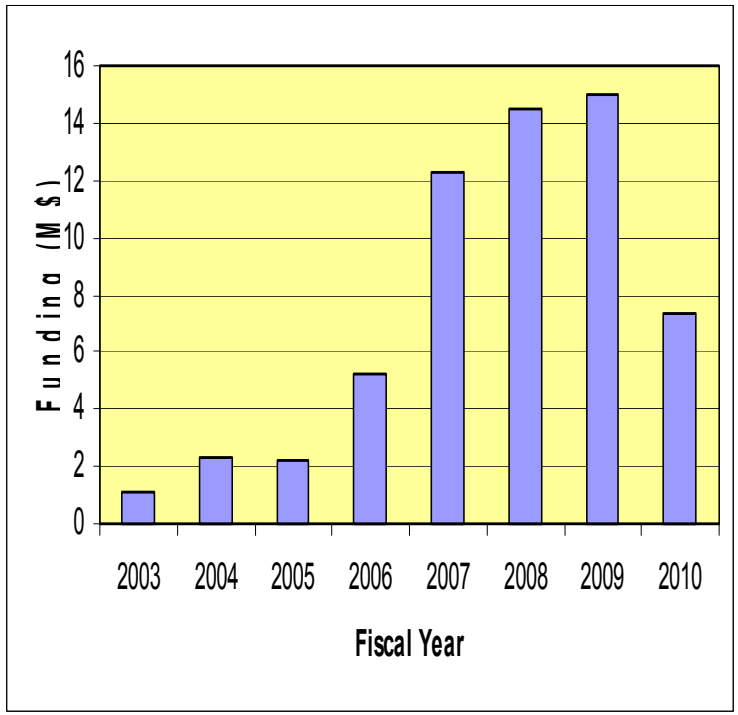


GRETA Total Cost and Cost Profile

FY02 Dollar, with overhead

Item	Purchase (M$)	Effort (FTE-yr)	
• Mechanical	0.9	5	
• LN	0.5	4	
• Detector	18.0	7	
• Electronics	3.4	10	
• Computer	1.1	13	
• Installation	0.0	6	
• Management	0.0	15	
• Safety	0.0	3	
		63	
TOTAL (M$)	**23.9**	**12.6**	**36.5**
+ escalation			**42.9**
+ contingency (27%)			**54.5 (TEC)**
+ R/D, pre-operation etc.			**60.1 (TPC)**

By: Jay Marx, Bill Edwards, Bob Minor et al.



Conclusion

- **R&D efforts have achieved the proof of principle.**
- **National effort involving Steering Committee and working groups.**
- **Cost and contingency estimates are made based on vendor price and engineering design.**
- **GRETA is ready to proceed as planned – next step is CD0.**