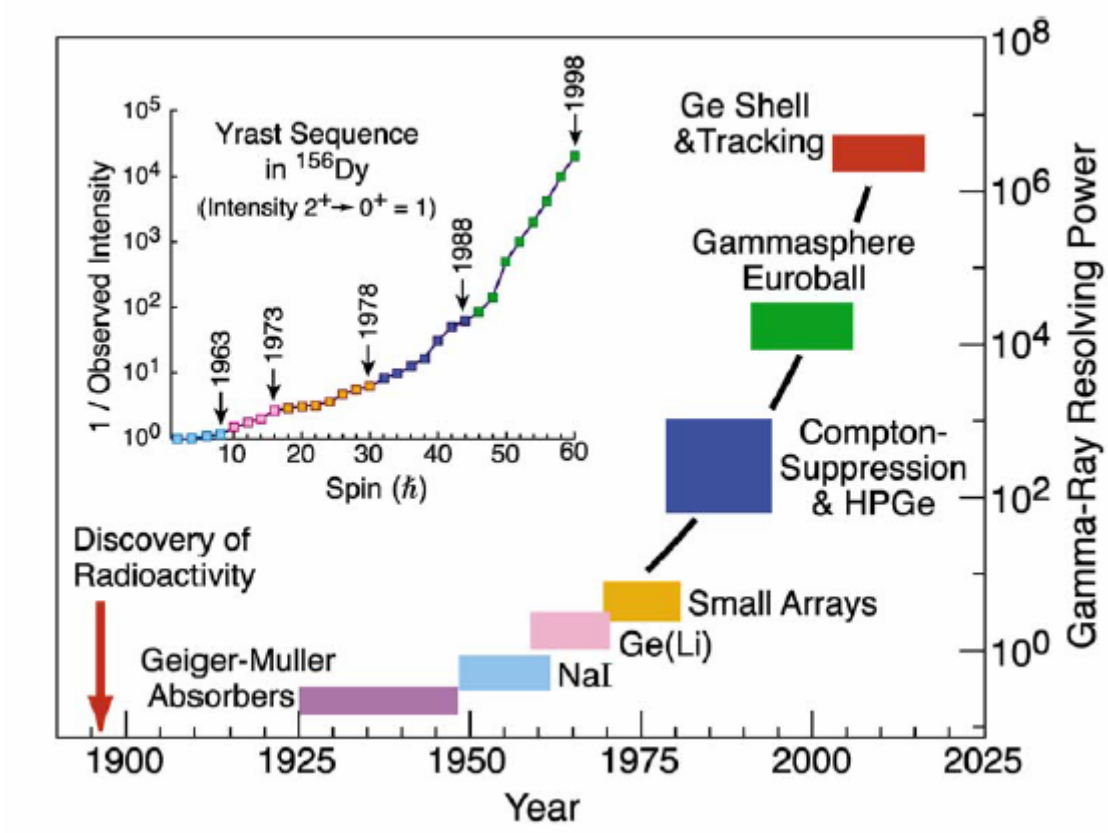
A NATIONAL PLAN FOR DEVELOPMENT OF GAMMA-RAY TRACKING DETECTORS IN NUCLEAR SCIENCE

BY

THE GAMMA-RAY TRACKING COORDINATING COMMITTEE

19 July 2002

www.pas.rochester.edu/~cline/


Yrast Sequence
in 156Dy
(Intensity 2+→ 0+ = 1)
1 / Observed Intensity
Spin (ħ)
1963
1973
1978
1988
1998
Ge Shell
&Tracking
Gammasphere
Euroball
Compton-
Suppression
& HPGe
Small Arrays
Ge(Li)
NaI
Geiger-Muller
Absorbers
Discovery of
Radioactivity
Year
Gamma-Ray Resolving Power
1900
1925
1950
1975
2000
2025

GAMMASPHERE

Commissioned:	**1995**
Scientific community:	**~400 from 94 Institutions**
Large university component	**55 Ph.D. Theses**
Scientific output [April 02]:	
Refereed publications	**~386**
Phys. Rev. Lett. + Phys. Lett.	**~ 81**

2002 Long Range Plan for Nuclear Science

New Initiatives: 4π Gamma-Ray Tracking Array

The detection of gamma-ray emissions from excited nuclei plays a vital and ubiquitous role in nuclear science. The physics justification for a 4π tracking array that would build upon the success of Gammasphere is extremely compelling, spanning a wide range of fundamental questions in nuclear structure, nuclear astrophysics, and weak interactions. This new array would be a national resource that could be used at several existing stable and radioactive-beam facilities as well as RIA.

CURRENT EFFORTS IN GAMMA-RAY TRACKING

Coaxial detectors:

GRETA	**LBNL**
SeGA	**MSU**
AGATA	**Europe**

Planar detectors:

GARBO	**ANL**
Astrophysics and other applications	**NRL, NASA, LBNL, LLNL**

Gamma-ray Tracking Coordinating Committee

Promote, coordinate and advise on the development of gamma-ray tracking detector technology in nuclear structure research.

Membership:

Cyrus Baktash	Oak Ridge National Laboratory
Doug Cline (Chair)	University of Rochester
Teng Lek Khoo	Argonne National Laboratory
Richard Kroeger	Naval Research Laboratory
Augusto Macchiavelli	Lawrence Berkeley National Laboratory
Mark Riley	Florida State University
Michael Thoennessen	Michigan State University
Kai Vetter	Lawrence Livermore National Laboratory

Charge:

- Develop the various physics justifications for gamma-ray tracking and establish the performance goals that are required in each area.
- Formulate a national R&D plan for gamma-ray tracking detectors.
- Examine the currents efforts in gamma-ray tracking that are underway in the United States and provide the Department of Energy with advice about how they should proceed.

Attendees of GRTCC Fact-finding Meeting

Argonne National Laboratory, 29-30 March 2002

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Khoo, Teng Lek	ANL	Argonne, IL 60439
Kroeger, Richard	Naval Research Lab.	Washington, DC 20375
Lee, I-Yang	LBNL	Berkeley, CA 94720
Lister, Kim	ANL	Argonne, IL 60439
Macchiavelli, Augusto	LBNL	Berkeley, CA 94720
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Reviol, Walter	Washington Univ.	St. Louis, MO 63130
Riley, Mark	Florida State Univ.	Tallahassee, FL 32306
Sarantites, Demetrios	Washington Univ.	St. Louis, MO 63130
Tabor, Sam	Florida State Univ.	Tallahassee, FL 32306
Thoennessen, Michael	MSU/NSCL	East Lansing, MI 48824
Vetter, Kai	LLNL	Livermore, CA 94550

RECOMMENDATION 1

A 4π Gamma-Ray tracking facility is an important new initiative within the 2002 NSAC Long Range Plan. This committee unanimously recommends a shell of closely packed coaxial Ge-detectors as outlined in the GRETA conceptual design for this 4π γ-ray tracking facility. We strongly recommend that DOE support this effort with highest priority

- **Gamma-ray tracking is a new concept that advances the detection sensitivity by up to three orders of magnitude.**
- **A 4π-tracking array is crucial to address exciting physics opportunities at current stable and exotic beam facilities as well as future facilities.**
- **Currently a 4π shell of closely packed coaxial Ge tracking detectors is the only practical approach for implementation of a major tracking array.**

RECOMMENDATION 2

R&D necessary to demonstrate the full functionality of this detector was identified and has to be addressed immediately. We note that a substantial fraction of this R&D effort is manpower that must be supported.

- **No known show stoppers to gamma-ray tracking detector technology**

- **National R&D Plan:**
  - **Test three-crystal cluster module now on order**
  - **Purchase and test arrays of two and three cluster modules**
  - **Continue development of digital electronics**
  - **Refine signal analysis techniques**
  - **Refine tracking algorithms**

RECOMMENDATION 3

The R&D phase, the subsequent final design, and the construction of GRETA should continue to be a community effort; in particular, it should involve significant participation by the low energy nuclear physics national laboratories and universities.

GRETA will be a National Facility

RECOMMENDATION 4

Tracking with planar detectors is of interest to the nuclear science community and has a wide range of applications outside of nuclear physics. R&D efforts in this direction should be supported as part of the drive to develop tracking, as most of the electronics and software challenges are common to all tracking detectors.

Planar detectors have applications to nuclear science that complement those provided by coaxial detectors used for the GRETA 4π array

Planar detectors have applications in space science, medicine, environmental surveying and security

R&D:

- **Develop compact detector packaging**
- **Develop stacked planar detectors**

RECOMMENDATION 5

Gammasphere continues to be the premier national γ-ray facility until GRETA becomes operational. This research facility must be supported to sustain the vitality of the field.

OBSERVATIONS

1 GRETA construction costs

The GRTCC finds that there are compelling scientific arguments for GRETA, and strongly recommends rapid implementation of this project. It is important to proceed with procurement of the GRETA module and subsequent testing in order to better identify program cost and risk analysis. In addition the GRTCC encourages the GRETA Steering Committee to continue to study ways to reduce the projected cost.

Second vendor for GRETA detector modules

Forge collaborations for development

Seek manpower contributions from universities, national laboratories and other agencies

2 Other applications of Gamma-ray Tracking

Tracking has important applications for science, technology, medicine, and societal issues such as homeland security. This report has focused on coordination for applications of tracking detectors in nuclear physics. However, it will be useful to coordinate development of γ-ray tracking in this much broader venue

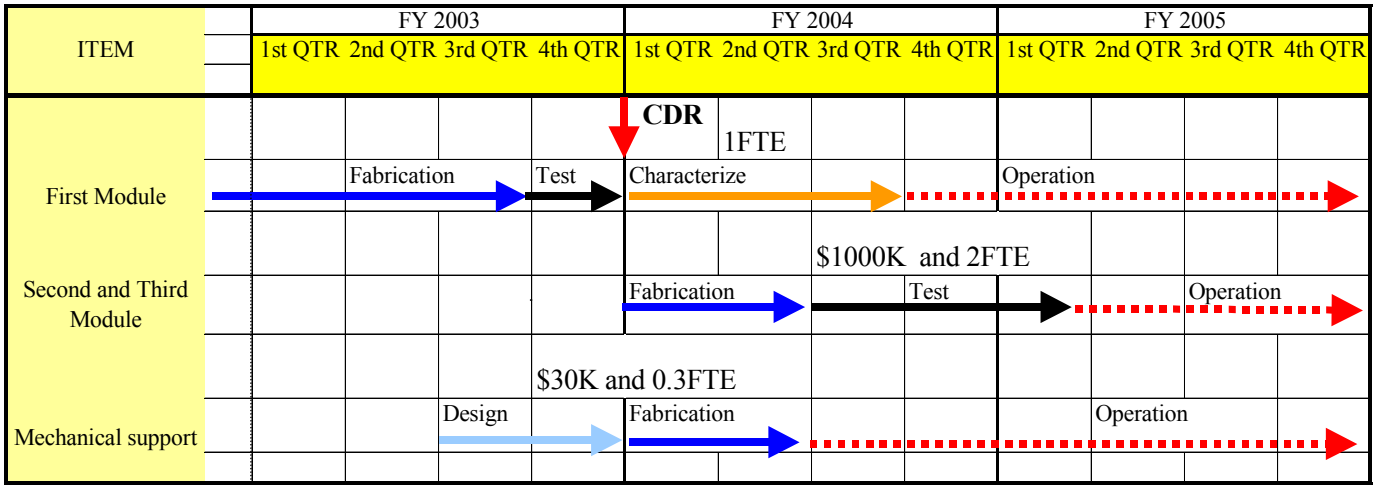
Astrophysics (Compton telescopes)

Diagnostic medical uses (Compton imaging)

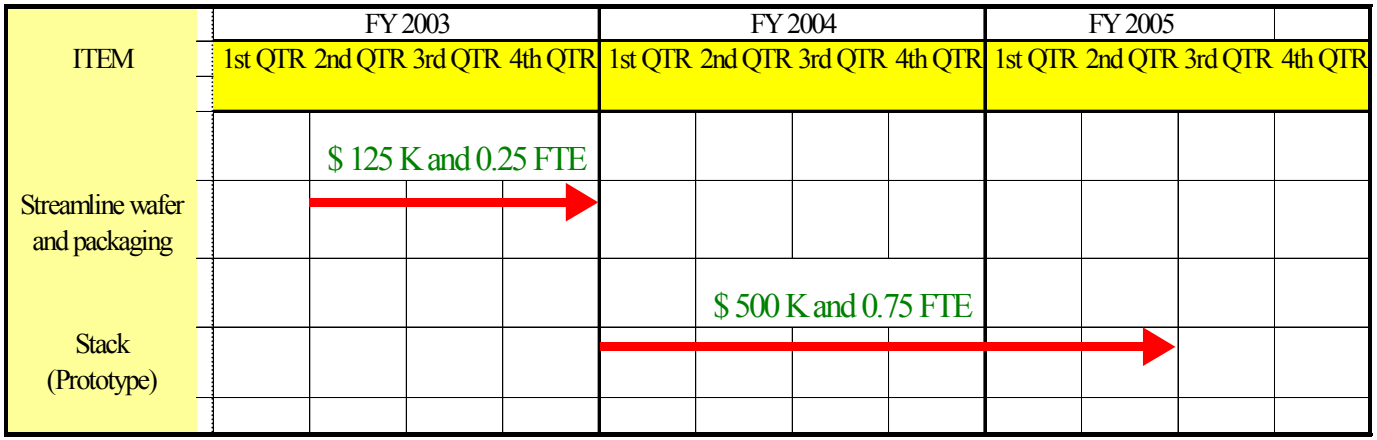
Homeland security (Detection of nuclear materials)

NATIONAL R&D PLAN FOR TRACKING DETECTORS (1)

Coaxial detectors:

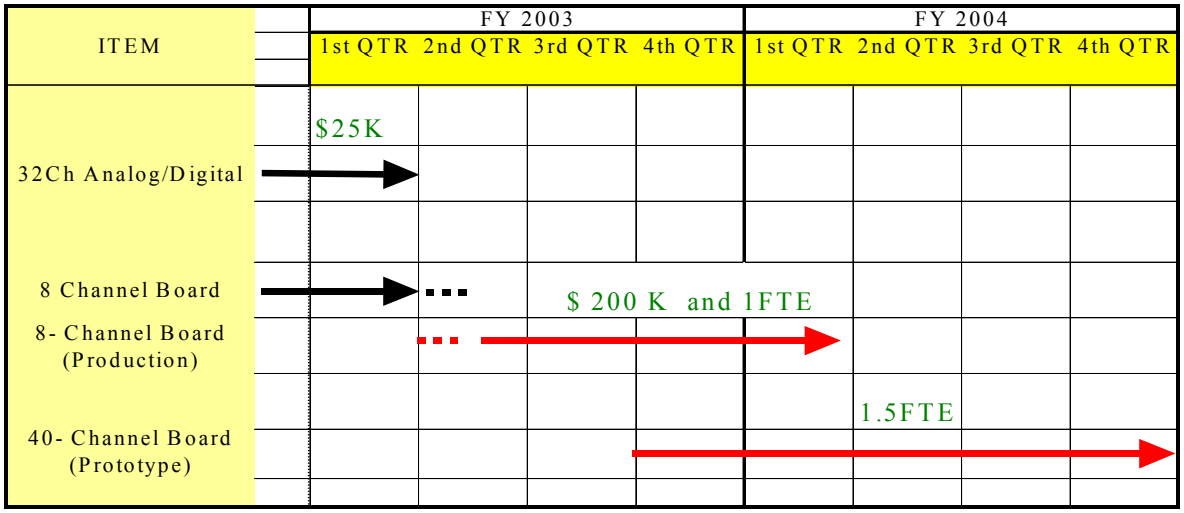


Planar detectors:

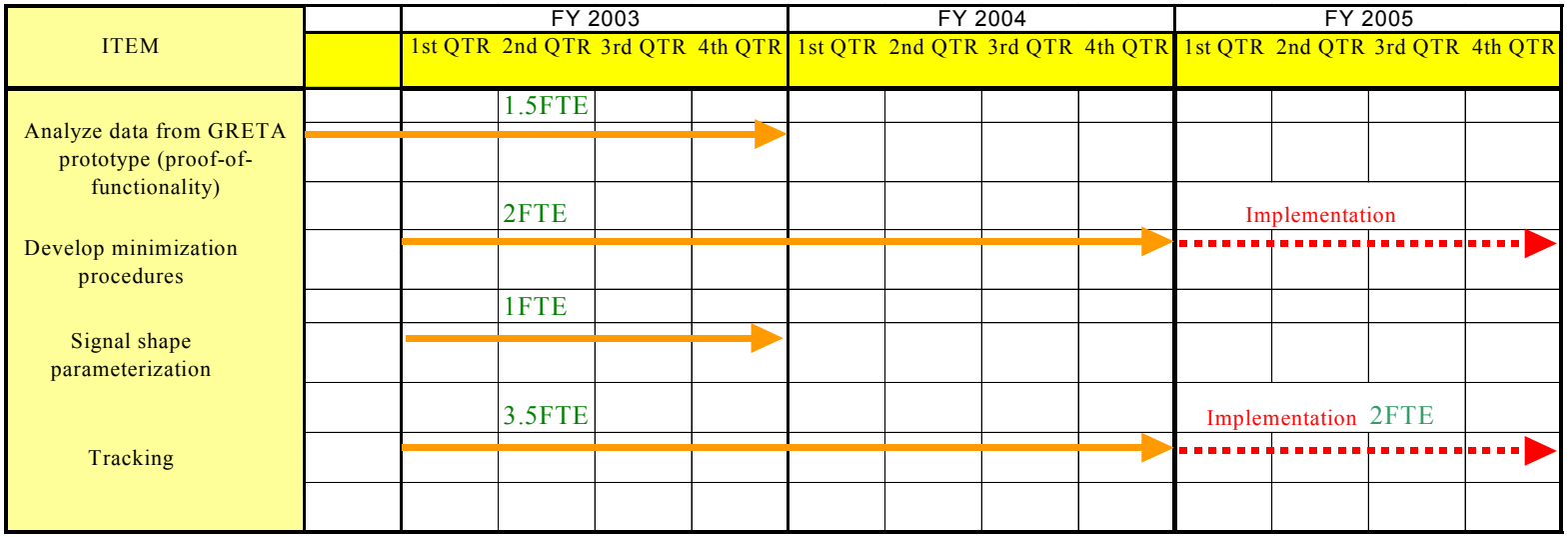


NATIONAL R&D PLAN FOR TRACKING DETECTORS (2)

Digital electronics:



Signal processing and tracking:



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4 **Tracking with planar detectors is of interest to the nuclear science community and has a wide range of applications outside of nuclear physics. R&D efforts in this direction should be supported as part of the drive to develop tracking, as most of the electronics and software challenges are common to all tracking detectors.**

5 **Gammasphere continues to be the premier national γ-ray facility until GRETA becomes operational. This research facility must be supported to sustain the vitality of the field.**

COMMUNITY SUPPORT OF RECOMMENDATIONS

Survey of Gammasphere Users Group to sample opinion.

"Please send to Cline@NSRL.Rochester.edu your selection as to which of the following best represents your opinion regarding the GRTCC recommendations:"

Strong support:	**64**
Weak support:	**0**
Weak opposition:	**0**
Strong opposition:	**0**

There is strong and unanimous support within the nuclear structure community for the development and implementation of gamma-ray tracking detectors.