The JUROGAM Array

(Also JUROGAM II)

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for GREAT / JUROGAM /SAGE collaboration

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Contents

- JUROGAM gamma-ray array
- Experimental methods

- Status of Campaigns
- JUROGAM Physics

- Milestones

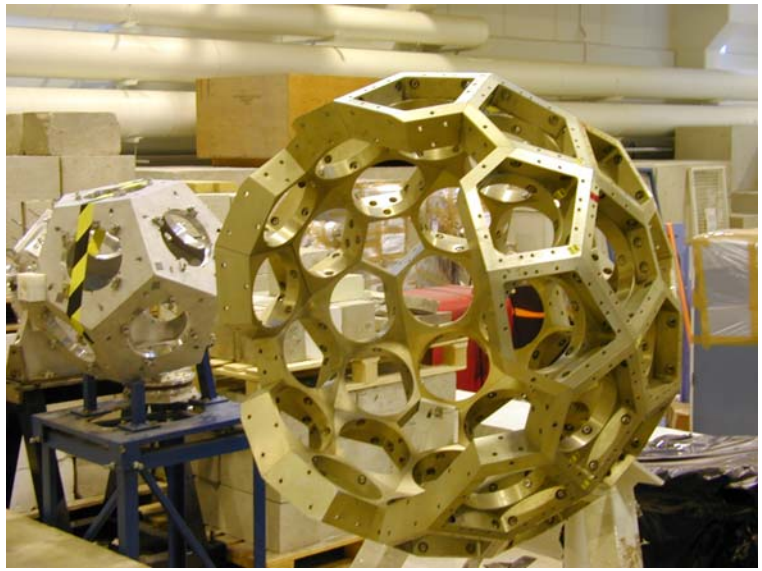
- Applications and the Resource

- JUROGAM II

- SAGE / LISA

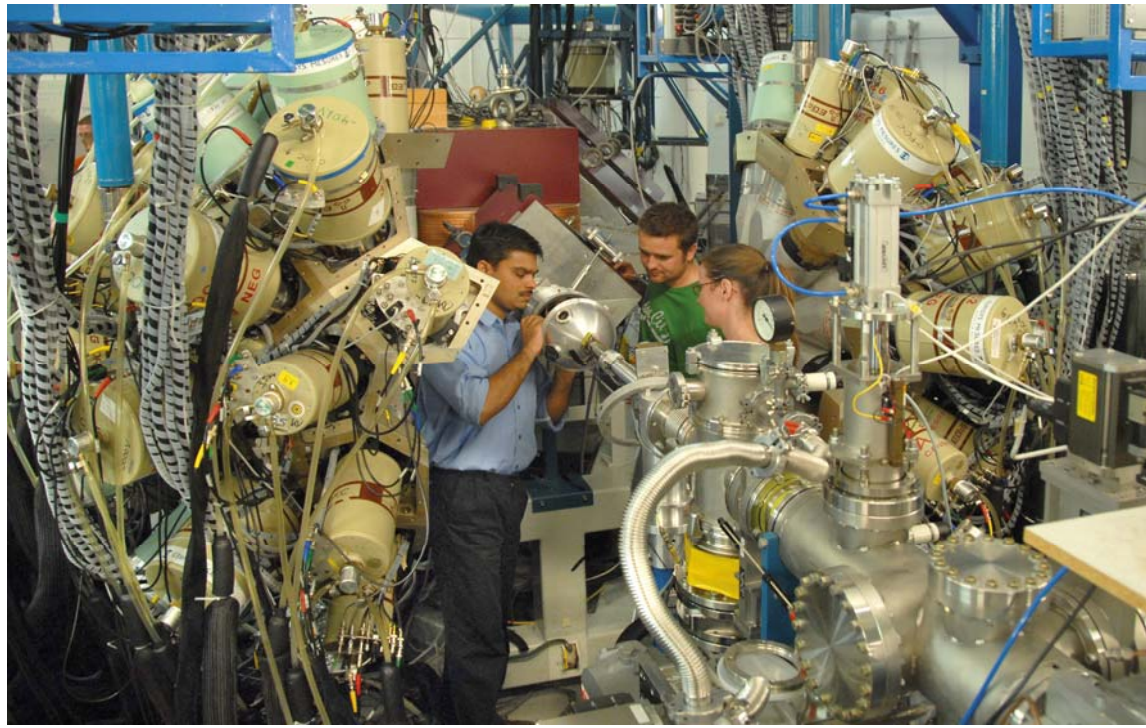
- Future developments

JUROGAM…
Remember this?

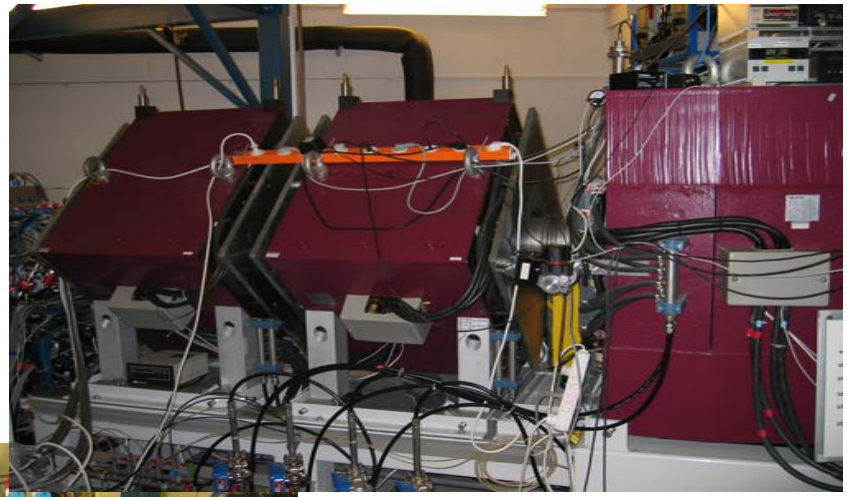


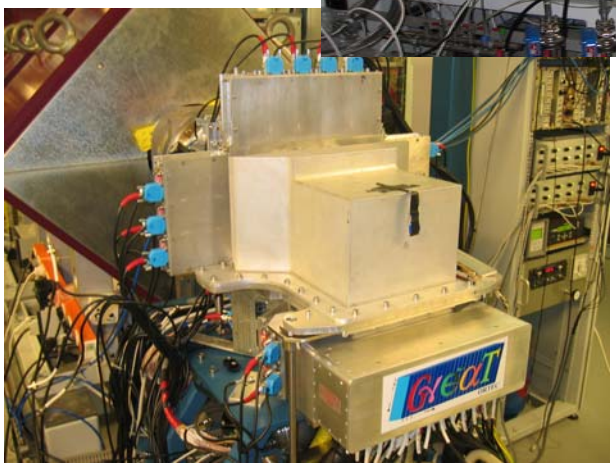
JUROGAM (2003-2008)

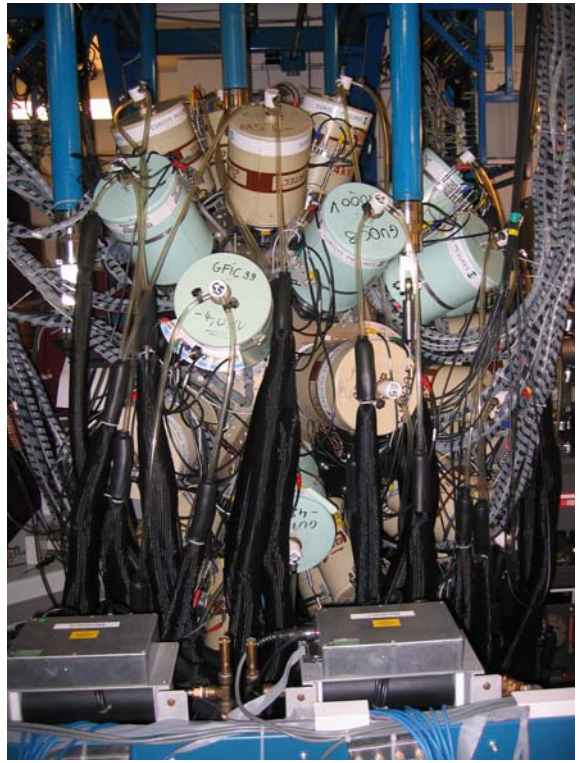
- 43 Anti-Compton suppressed HP-Ge detectors (ε_{ph} = 4.2% / 1.3 MeV)
- JYFL “Host Laboratory” for ex-EUROBALL detectors 2003-2008
- Comprises of all EB Phase I + GASP detectors.
- UK-France loan pool completes the array



How to do what we do…

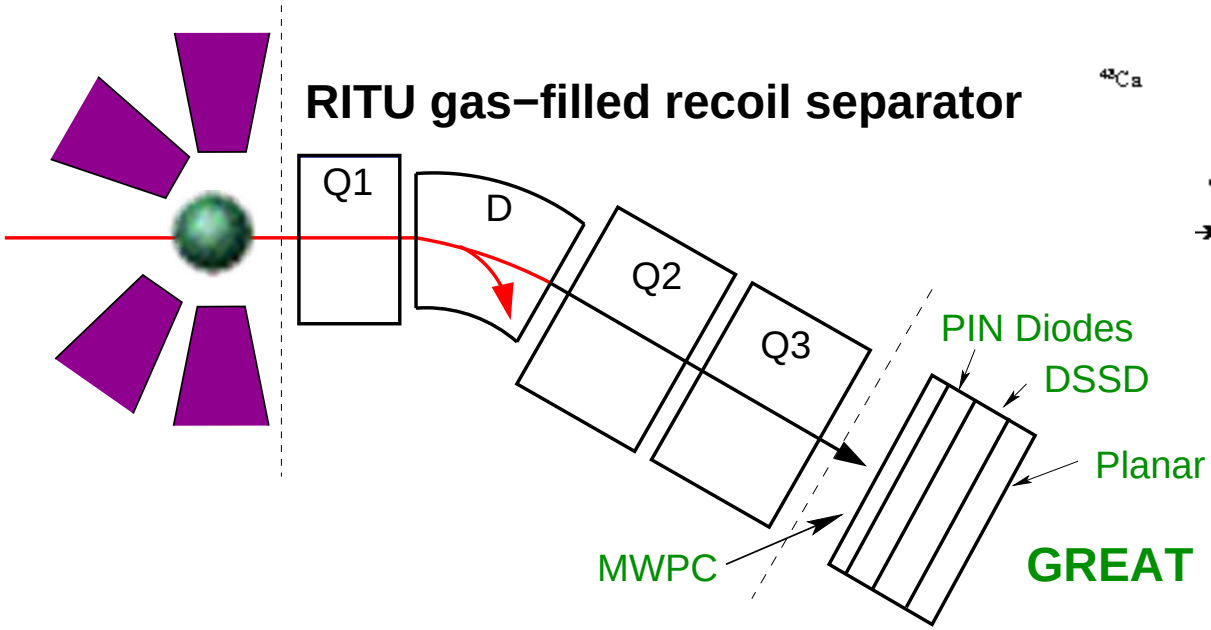


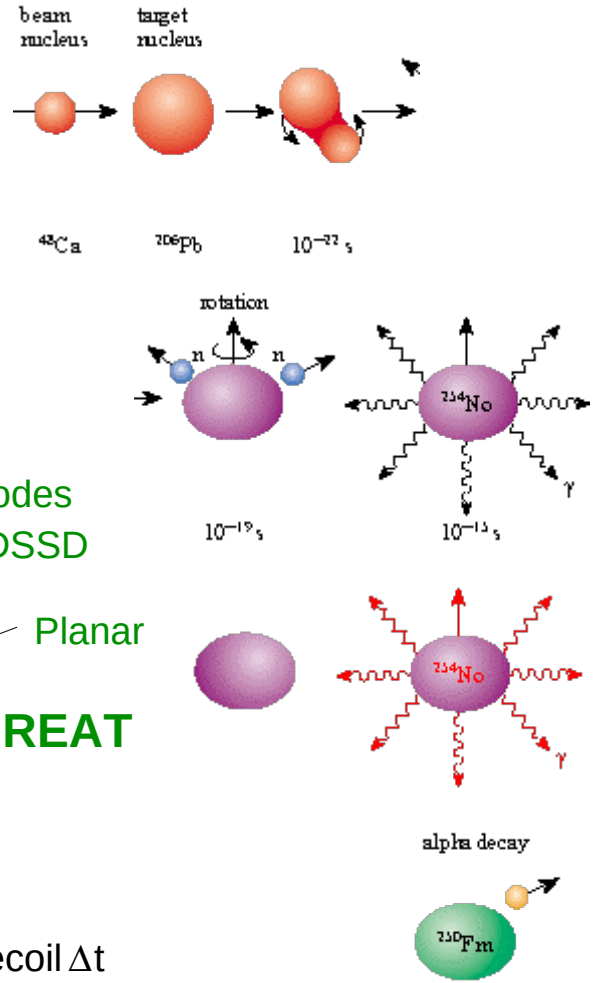




“Complete Spectroscopy”

Jurogam Array



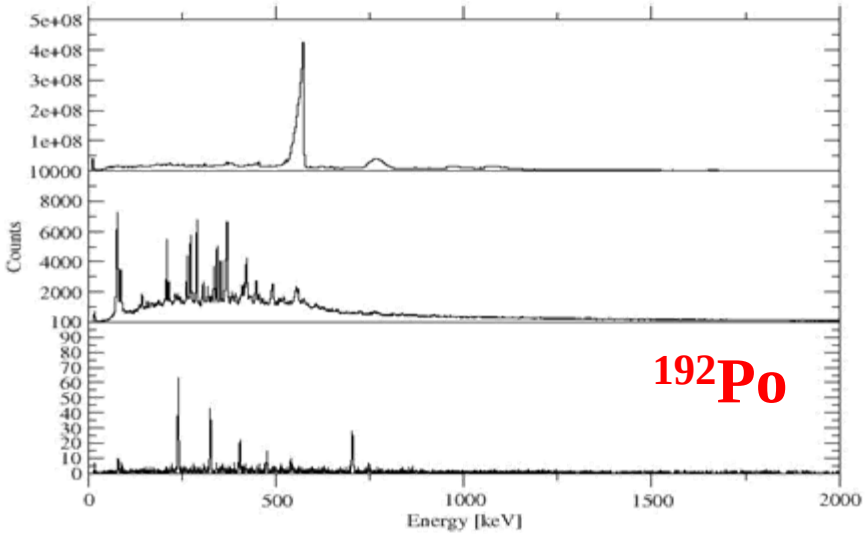


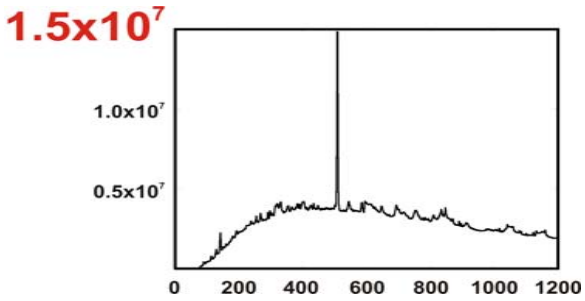
Approx 1 μs

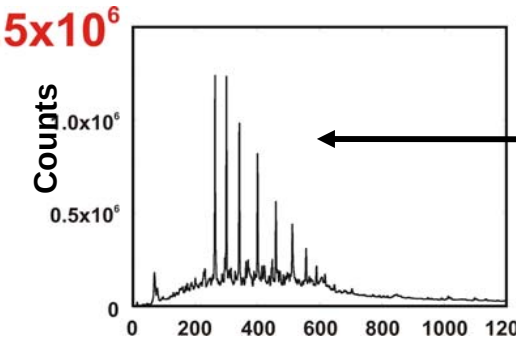
Ge (prompt) Recoil Δt

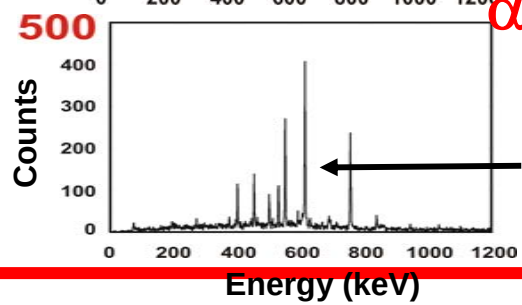
Ge (delayed) Recoil Δt

Efficiency & Selectivity



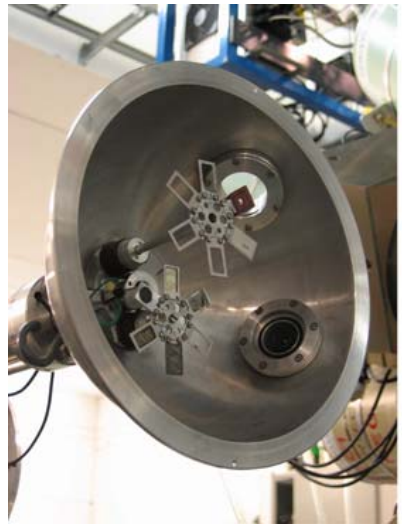


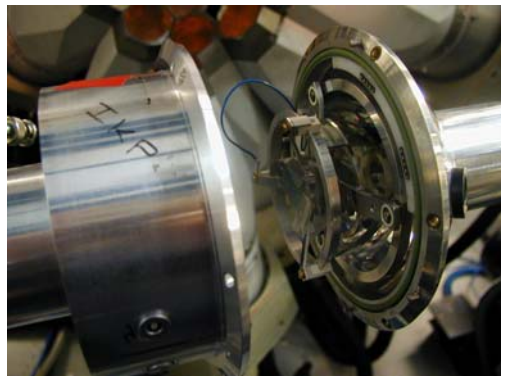


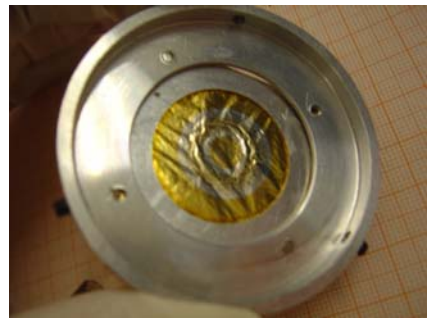


→Gamma-detection efficiency
→Tagging techniques
- Isomer tagging
- Beta-decay tagging
- Prompt selection

JUROGAM Target Systems

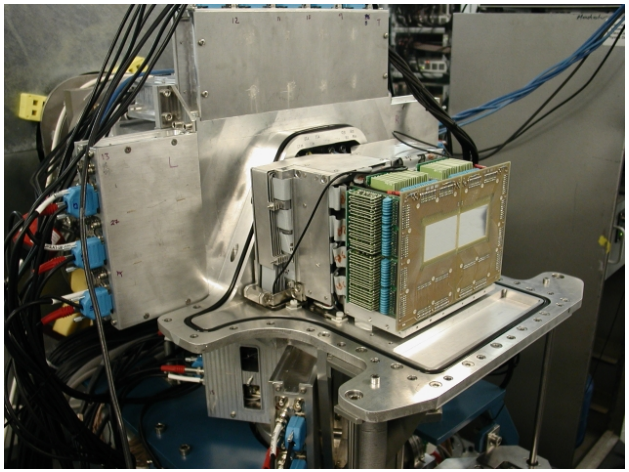


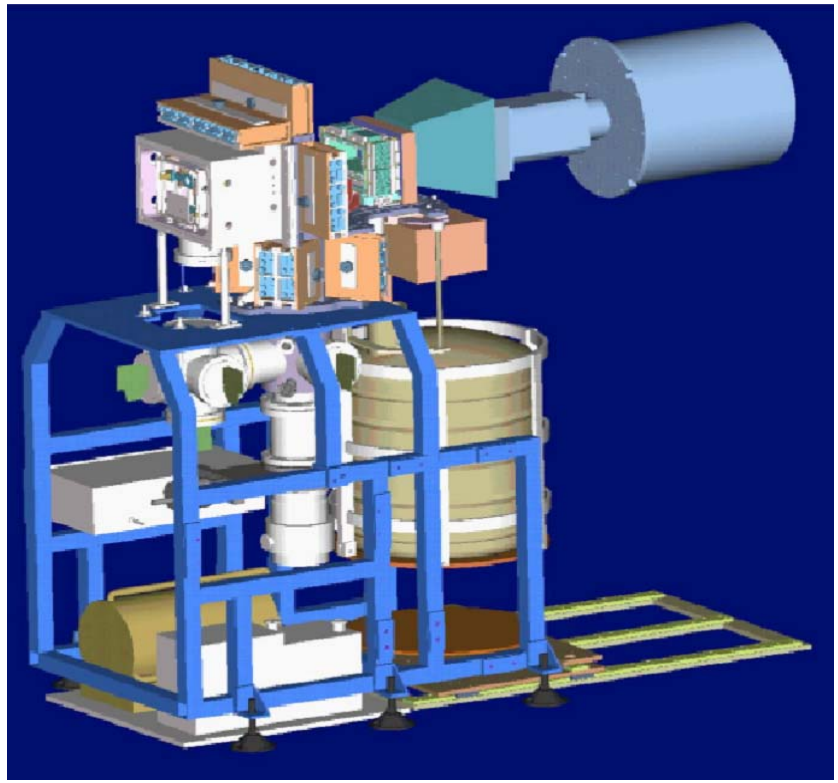




The GREAT Spectrometer

- 2 x 60mm x 40mm DSSD
- 28 x 40mm x 40mm PIN Diodes
- 24 x 12 Segmented Planar Ge
- Compton-Suppressed Segmented Ge Clover
- Position-Sensitive MWPC





TDR : Total Data Readout

- Triggerless Data Acquisition System
- Rates up to 1500 kHz without deadtime
- 380+ channels timestamped data
- 10 ns resolution
- Time-of-Day clock with 32 day rollover
- Successful correlation over 36 hours
- Flexible + Easily Scalable

- *Distributable 100MHz Clock*

JUROGAM Physics Programme and Methodology

- Multiple Shape Coexistence
- Spectroscopy of Heavy Nuclei
- Study of Nuclei Near Proton Drip Line
- Study of Isomeric States
- Lifetime measurements
- Beta-Decay Tagging
- Study of Octupole Deformation

JUROGAM Campaigns 2003-2008

Campaign 1	**4/2003 – 12/2004 : 9 months**	**14 experiments**
Campaign 2	**4/04-6/04 10/04-3/5 : 9 months**	**14 experiments**
Campaign 3	**9/2005 – 9/2006 : 12 months**	**21 experiments**
Campaign 4	**1/2007 – 9/2007 : 9 months**	**12 experiments**
Campaign 5	**4/2008 – 5/2007 : 2+2 months**	**6 experiments**

Next PAC September 2008

JUROGAM PUBLICATIONS (so far...)

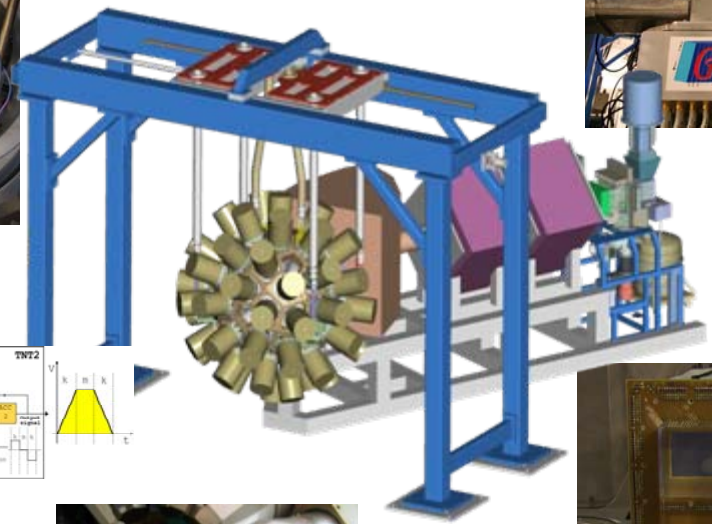
PhD Theses Training

JUROGAM Publications 2005-2008

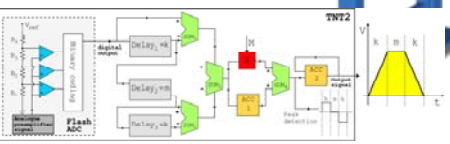
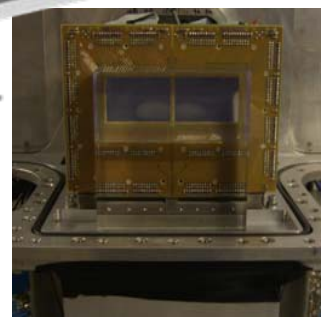
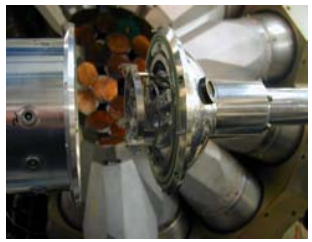
1. *"Lifetimes of intruder states in ^{186}Pb, ^{188}Pb and ^{194}Po."*
   T.Grahn, et al. – Nucl. Phys. **A801**, 83 (2008)
2. *"Excited states in the neutron-deficient nuclei $^{197,199,201}Rn$."*
   K.Andgren, et al. – Phys. Rev. **C77**, 054303 (2008)
3. *"Identification of excited states in the $T_z = 1$ nucleus ^{110}Xe: Evidence for enhanced collectivity near the $N = Z = 50$ double shell closure."*
   M. Sandzelius, et al. – Phys. Rev. Lett. **99**, 022501 (2007)
4. *"Coulomb shifts and shape changes in the mass 70 region."*
   B.S. Nara Singh, et al. – Phys. Rev. **C75**, 061301(R) (2007)
5. *"First identification of excited startes in ^{169}Ir."*
   M. Sandzelius, et al. – Phys. Rev. **C75**, 054321 (2007)
6. *"Observation of a Rotational Band in the Odd-Z Transfermium Nucleus ^{251}Md."*
   A. Chattilon, et al. – Phys. Rev. Lett. **08**, 132503 (2007)
7. *"Investigation of nuclear collectivity in the neutron mid-shell nucleus ^{186}Pb."*
   J. Pakarinen, et al. – Phys. Rev. **C75**, 014302 (2007)
8. *"Recoil-beta tagging: A novel technique for studying proton-drip-line nuclei."*
   A.N. Steer, et al. – Nucl. Instr. Meth. **A565**, 630 (2006)
9. *"Yrast states and band crossings in the neutron-deficient platinum isotopes $^{169-173}Pt$."*
   D.T. Joss, et al. – Phys. Rev. **C74**, 014302 (2006)
10. *"High-spin states in the proton-unbound nucleus ^{161}Re."*
    K. Lagergren, et al. – Phys. Rev. **C74**, 024316 (2006)
11. *"Collectivity and Configuration Mixing in $^{186,188}Pb$ and ^{194}Po."*
    T. Grahn, et al. – Phys. Rev. Lett. **97**, 062501 (2006)
12. *"Evidence for oblate structure in ^{186}Pb."*
    J. Pakarinen, et al. – Phys. Rev. **C72**, 011304(R) (2005)
13. *"First identification of excited states in ^{106}Te and evidence for isoscalar-enhanced vibrational collectivity."*
    B. Hadinia, et al. – Phys. Rev. **C72**, 041303(R) (2005)
14. *"Evidence for non-yrast states in ^{254}No."*
    S. Eeckhaudt, et al. – Eur. Phys. J. **A**, DOI 10.1140 (2005)
15. *"First identification of γ-ray transition in ^{107}Te."*
    B. Hadinia, et al. – Phys. Rev. **C70**, 064312 (2004)
16. *"Recoil decay tagging of rays in the extremely neutron-deficient nucleus ^{162}Os."*
    D.T. Joss, et al. – Phys. Rev. **C70**, 017302 (2004)

Pete Jones
University of Jyväskylä

JUROGAM & Friends



R. Julin

S. Ketelhut

N.S. Bondili

T. Grahn

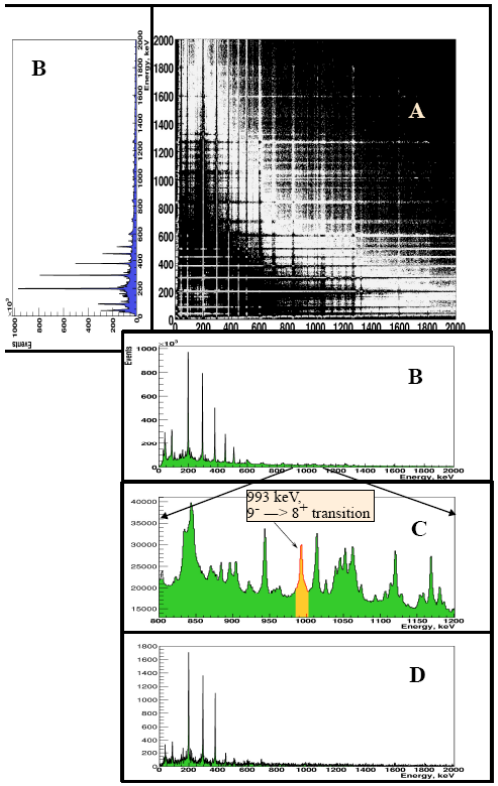
P. Mason

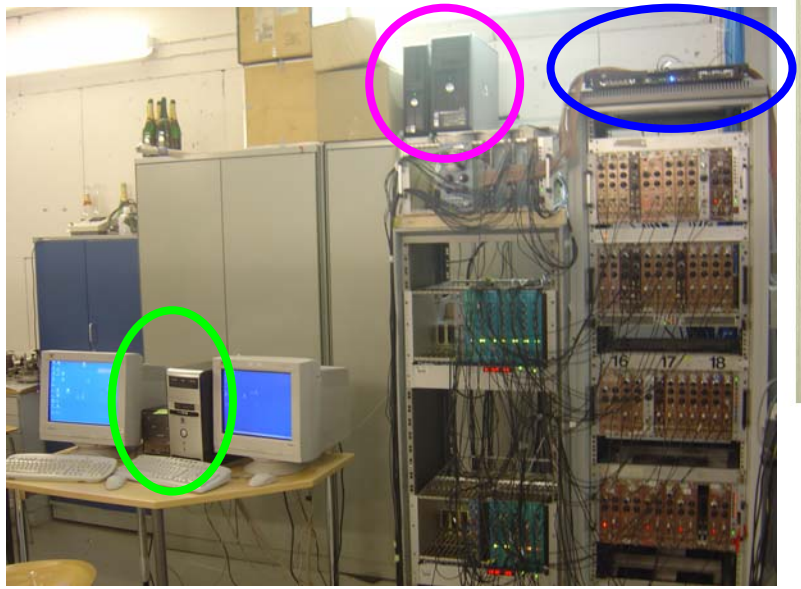
D.T. Joss

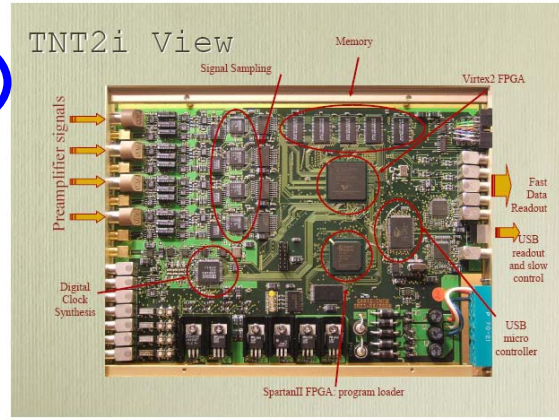
P. Peura

Pauli Peura

JUROGAM Milestone 2007
Fully Instrumented Digital Electronics

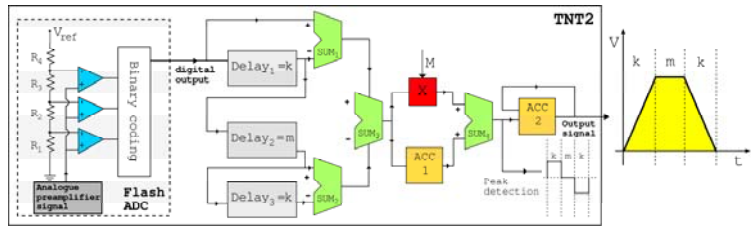




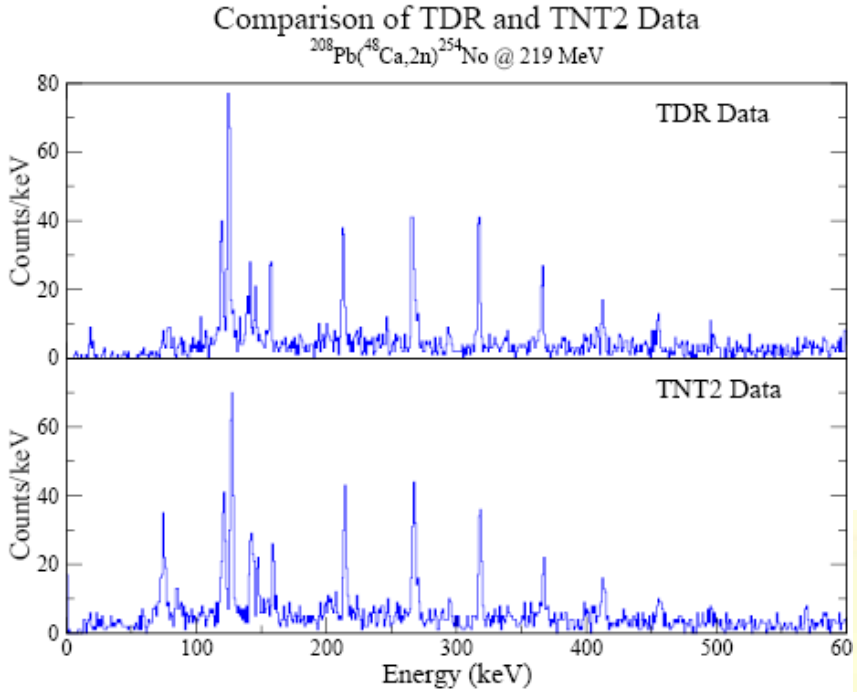


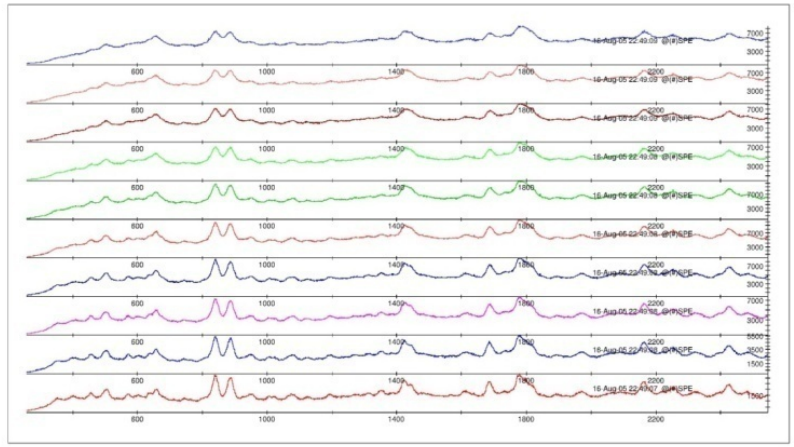
IPHC / Orsay Collaboration

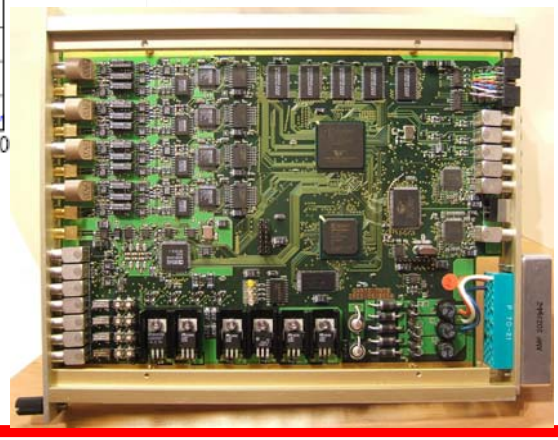
Spring 2008

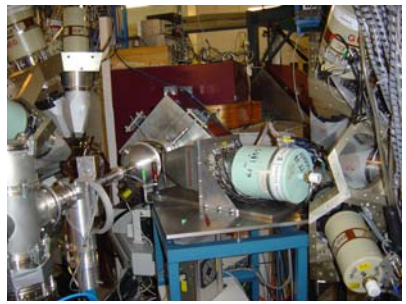


Heavy Element Spectroscopy



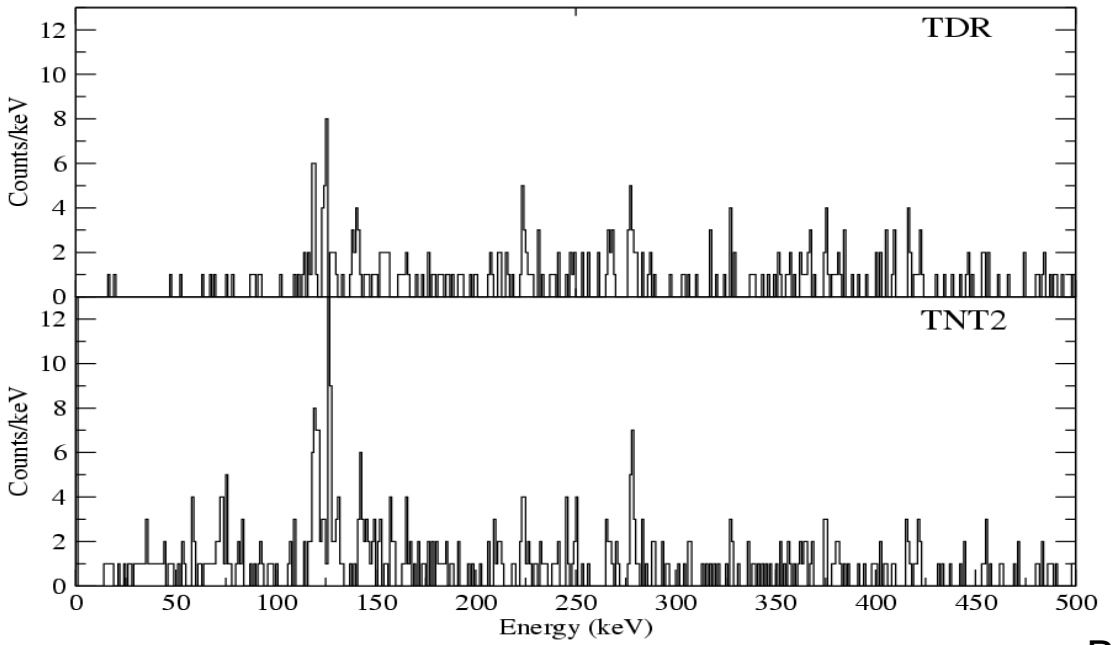


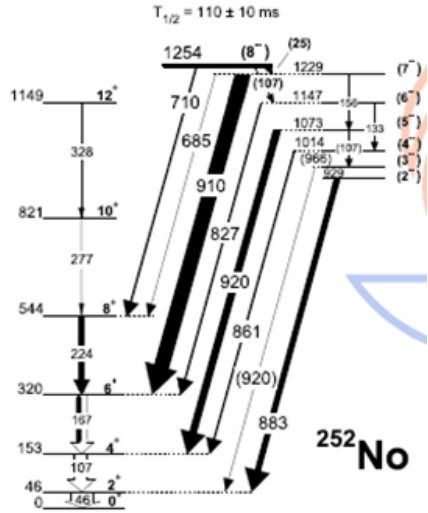




→Detection efficiency
→Throughput

Heavy Element Spectroscopy



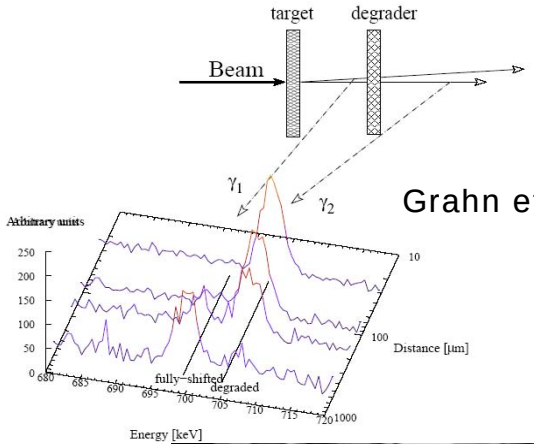


B. Sulignaro, et. al: JR80 2008
Investigation of high-K states in ^{252}No

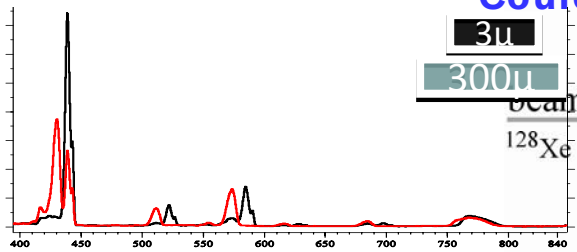
→Detection efficiency
→Throughput

Plunger and selection devices

Differential plunger inside JUROGAM

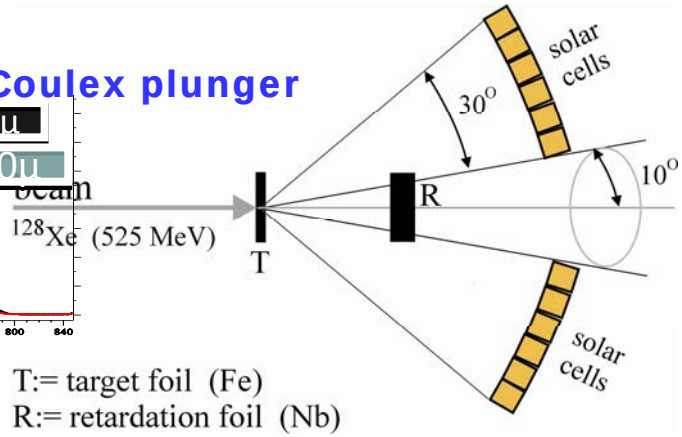


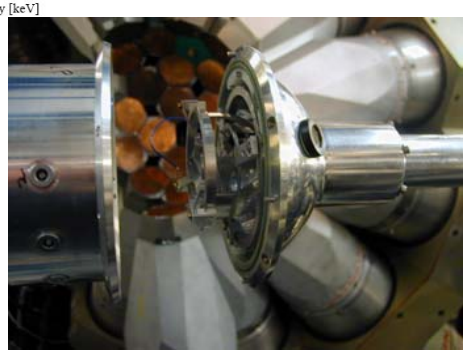
Grahn et. al

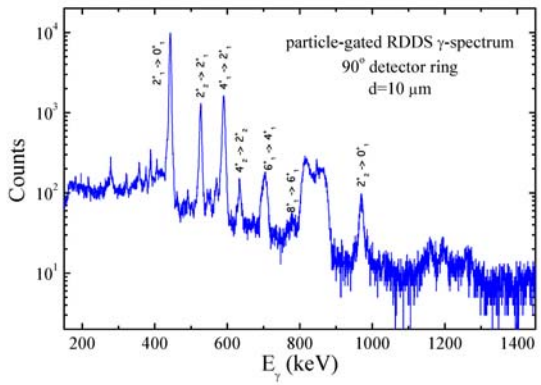


Harissopulos et. al

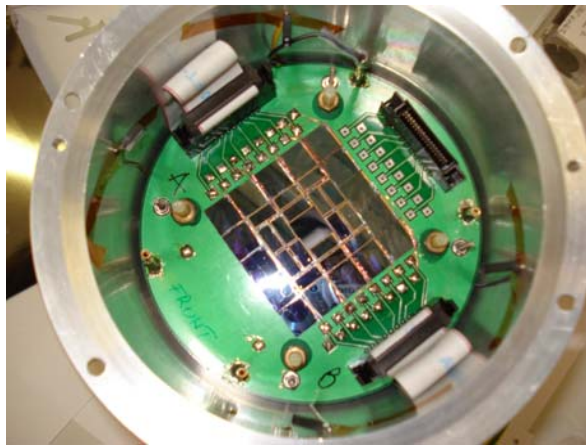
Coulex plunger







E(5) X(5) symmetries in ^{128}Xe



→ Versatile array design

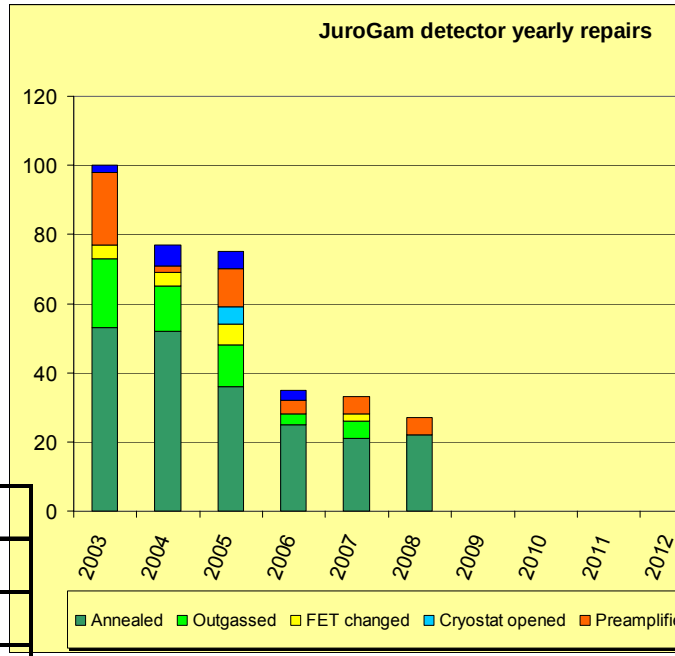
JUROGAM Statistics

Campaign 1	4/2003 – 12/2004 : 9 months	14 experiments
Campaign 2	4/04-6/04 10/04-3/5 : 9 months	14 experiments
Campaign 3	9/2005 – 9/2006 : 12 months	21 experiments
Campaign 4	1/2007 – 9/2007 : 9 months	12 experiments
Campaign 5	4/2008 – 5/2007 : 2+2 months	6 experiments

11000 hours of beamtime

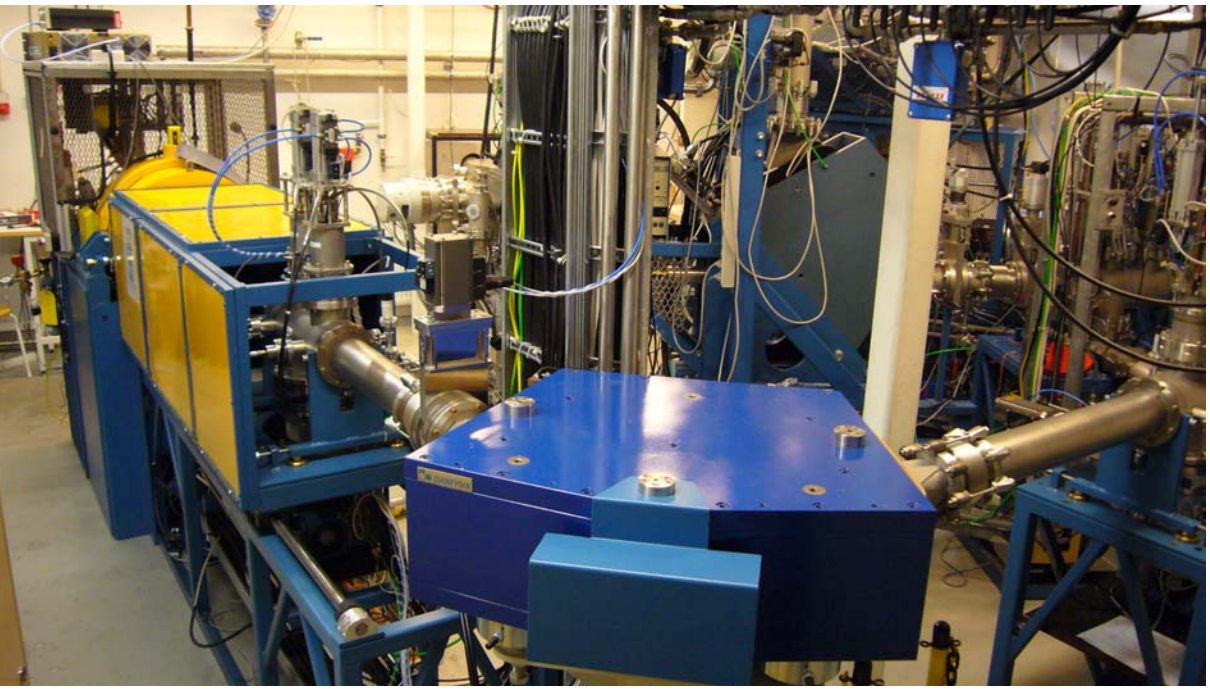
250000l LN_2 / year

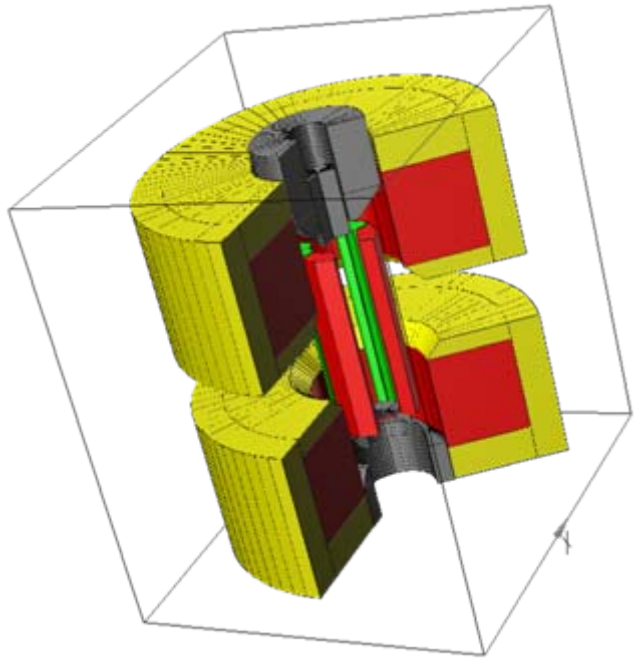
- Running Costs shared between users
  - –5000 € / week
  - –LN2 ~ 70k€
  - –Detector Repair ~ 20k€
  - –Detector Rent ~ 18k€



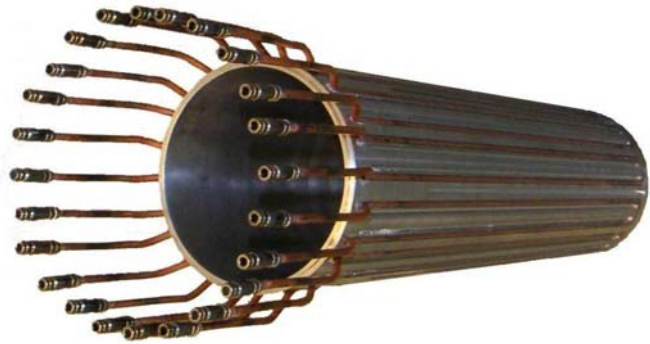
Year	Investment	
2003	46033	
2004	83441	
2005	77415	
2006	105360	
2007	123850	
2008	49000	Est - LN2

Applications





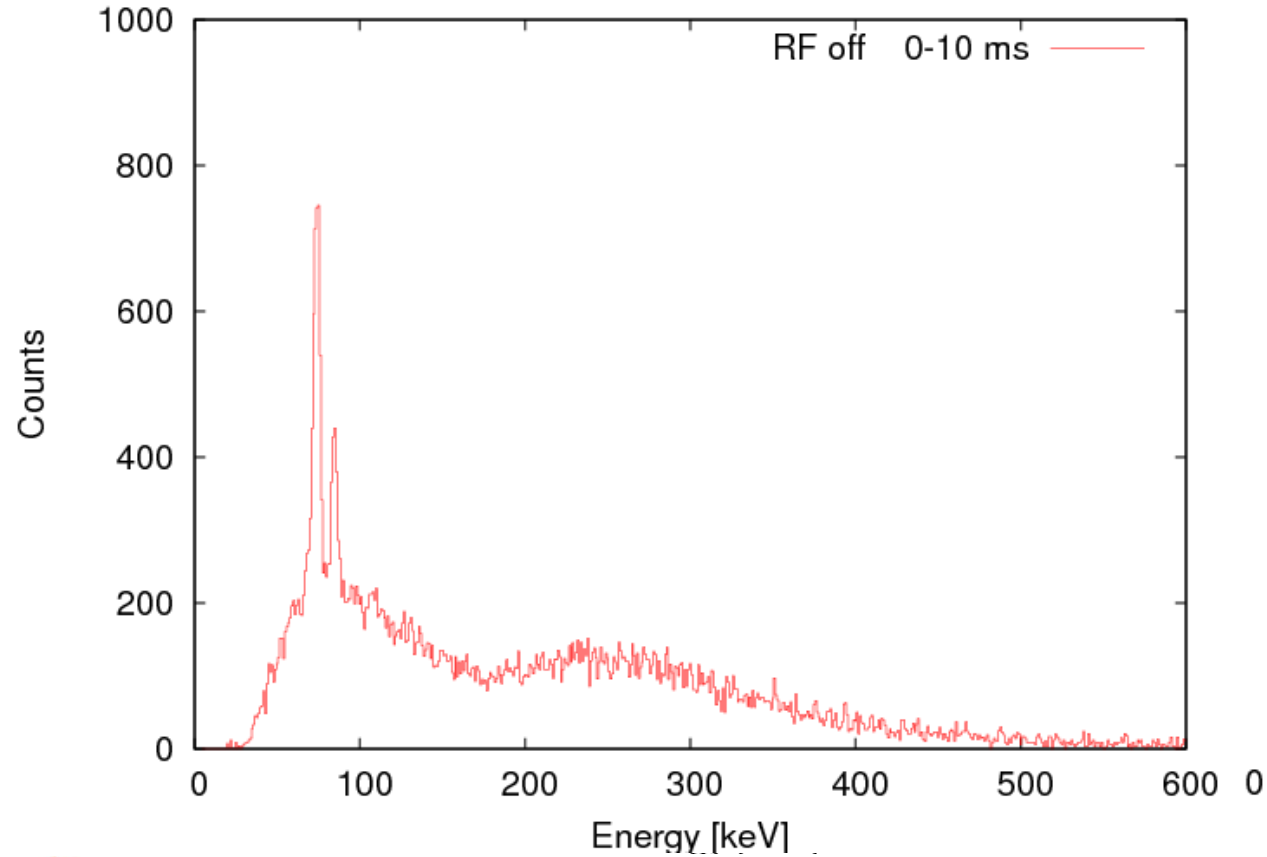
T. Ropponen - JYFL

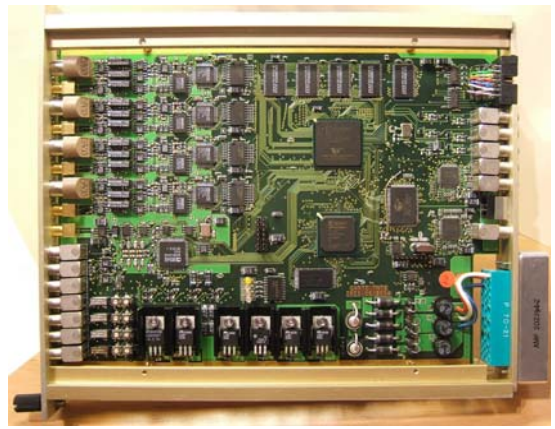


We need to understand the electron heating mechanism in order to solve the problem with excessive bremsstrahlung

- Simulations
- Time evolution measurements of bremsstrahlung
  - **So far this has not been done in the ECR community**

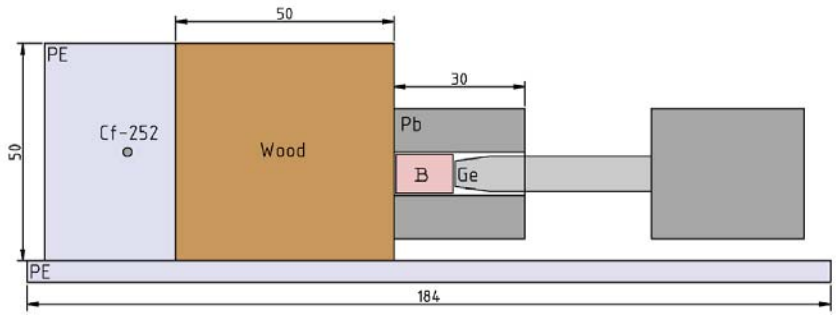
ECR Plasma Time evolution

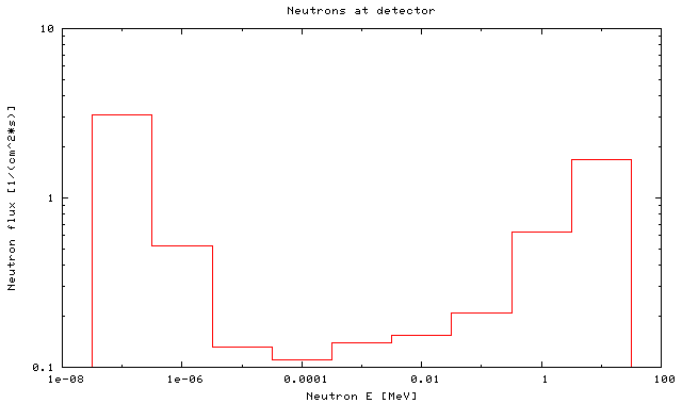


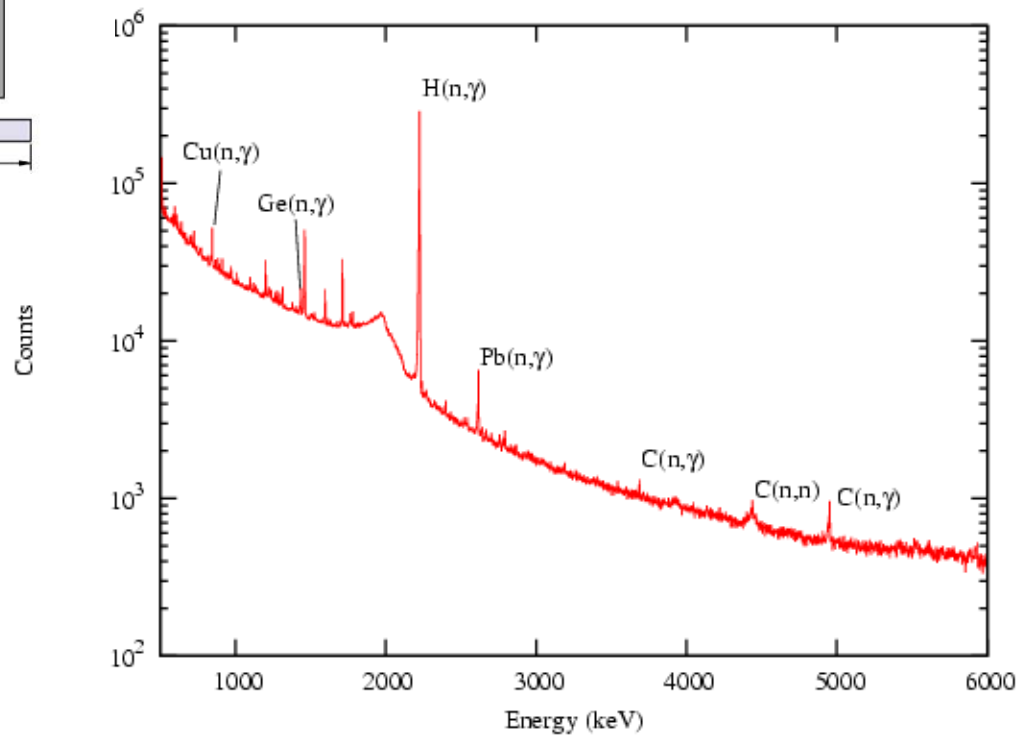


Measurement of Wood Properties

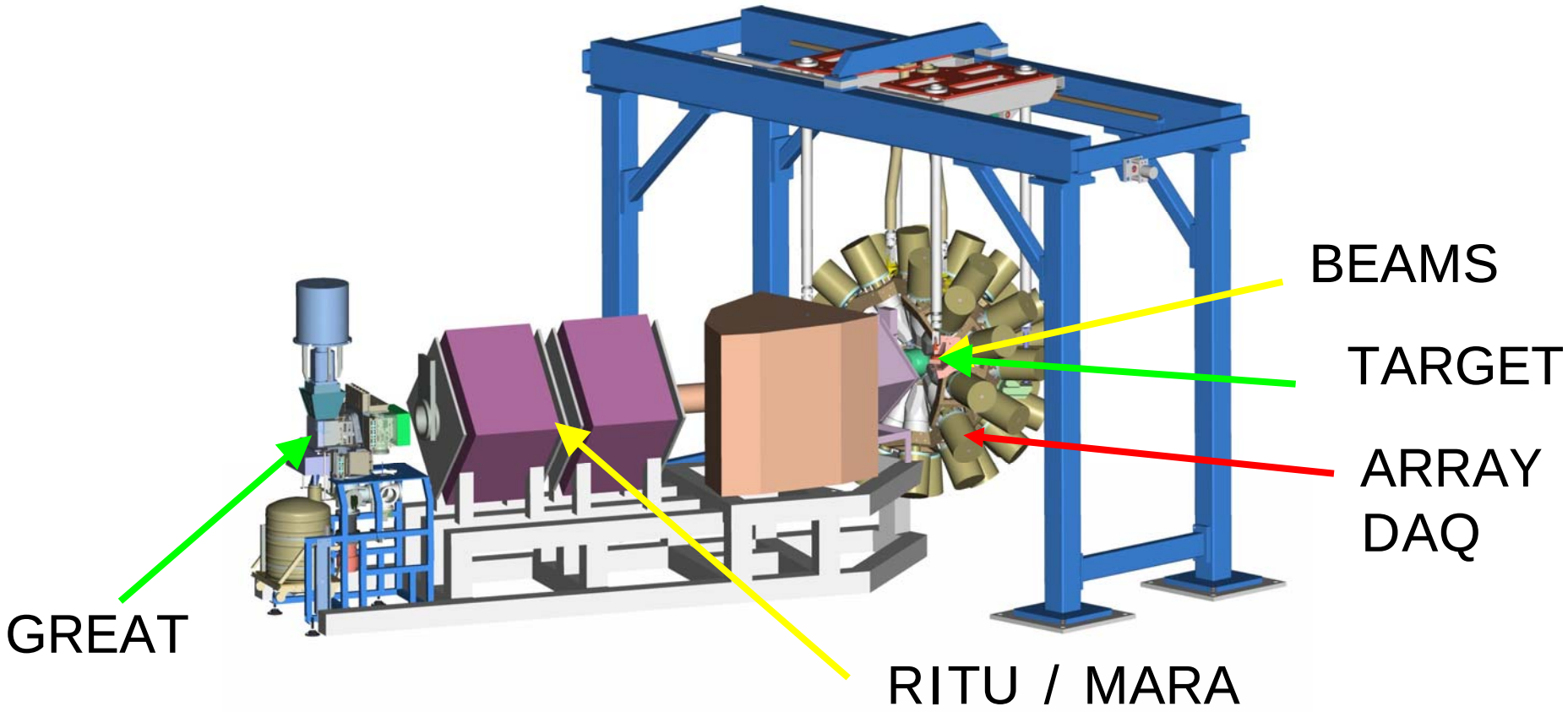
T. Kalvas - JYFL



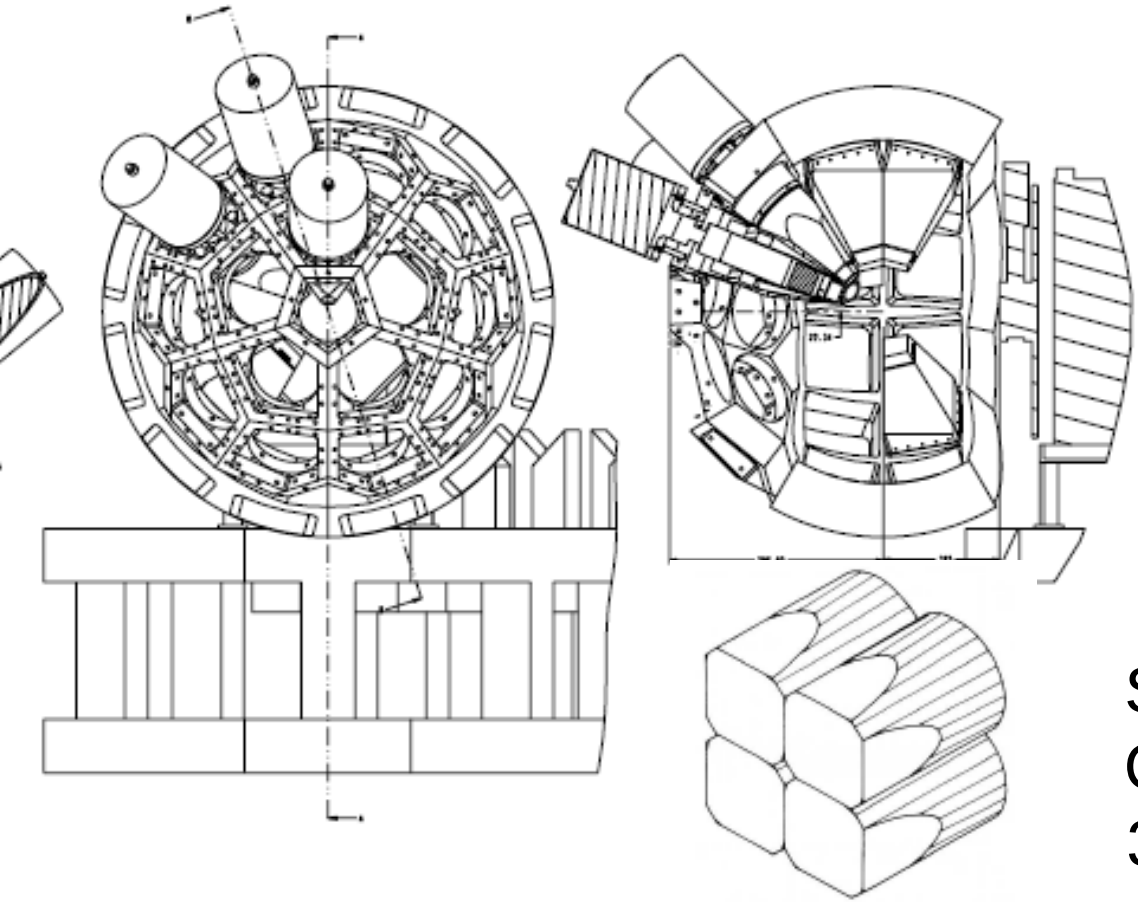


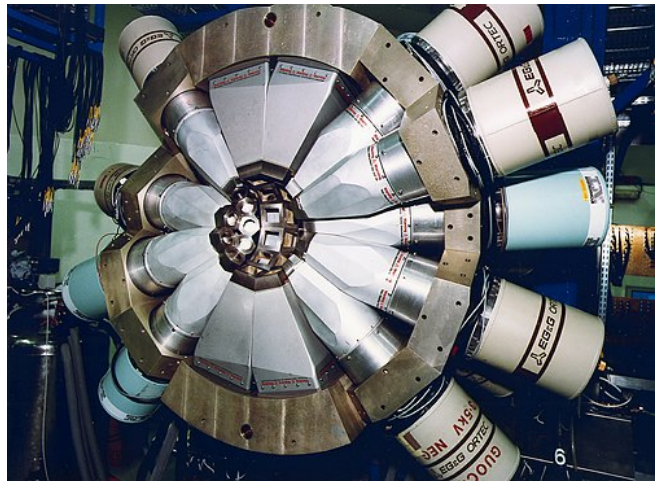


The next step…



JUROGAM II : 2008



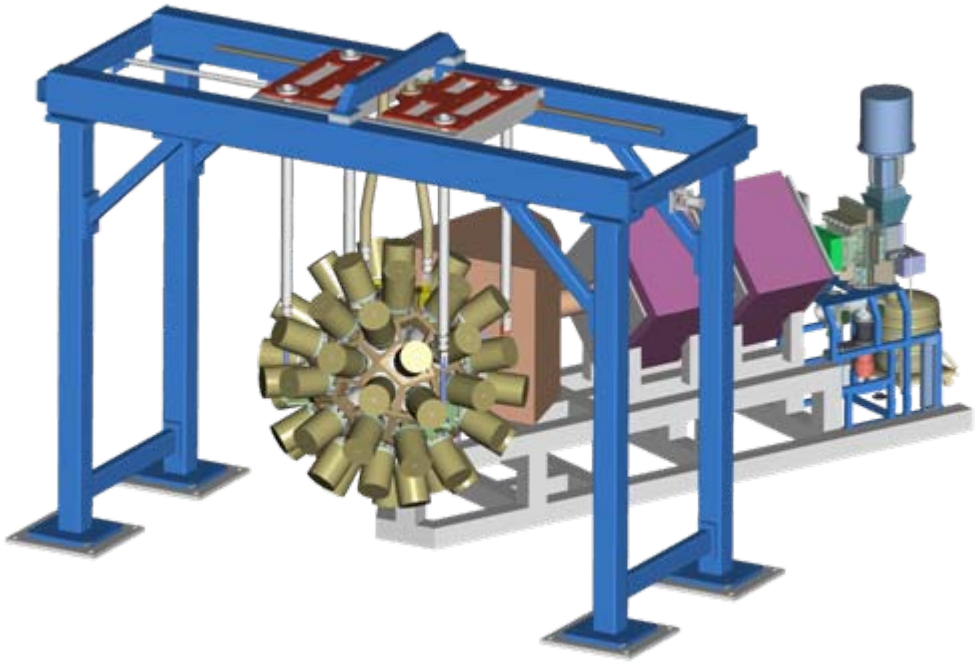


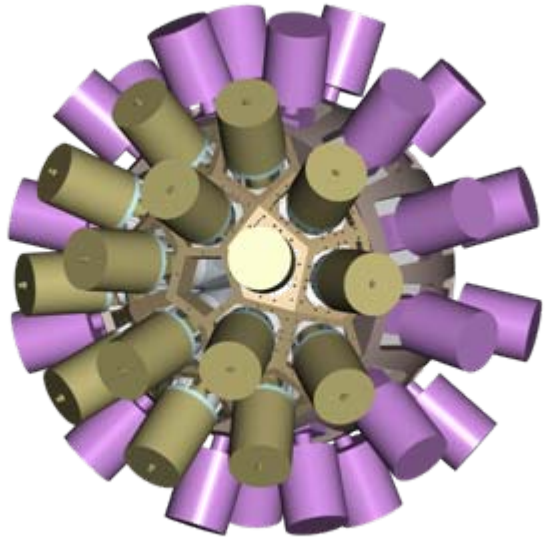
ε_{ph} 4.2 → 6%

Singles efficiency
Coincidence efficiency
3 x detector elements

- Efficient and versatile spectrometer

JUROGAM -> JUROGAM II





UNIVERSITA' DEGLI STUDI DI PADOVA
Dipartimento di Fisica "Galileo Galilei"

ISTITUTO NAZIONALE DI FISICA NUCLEARE
Sezione di Padova

Padova, November 28th 2006

Dr. Pete Jones
JUROGAM Project Manager
Department of Physics
P.O. Box 35 (YFL)
FIN-40014 University of Jyväskylä
FINLAND

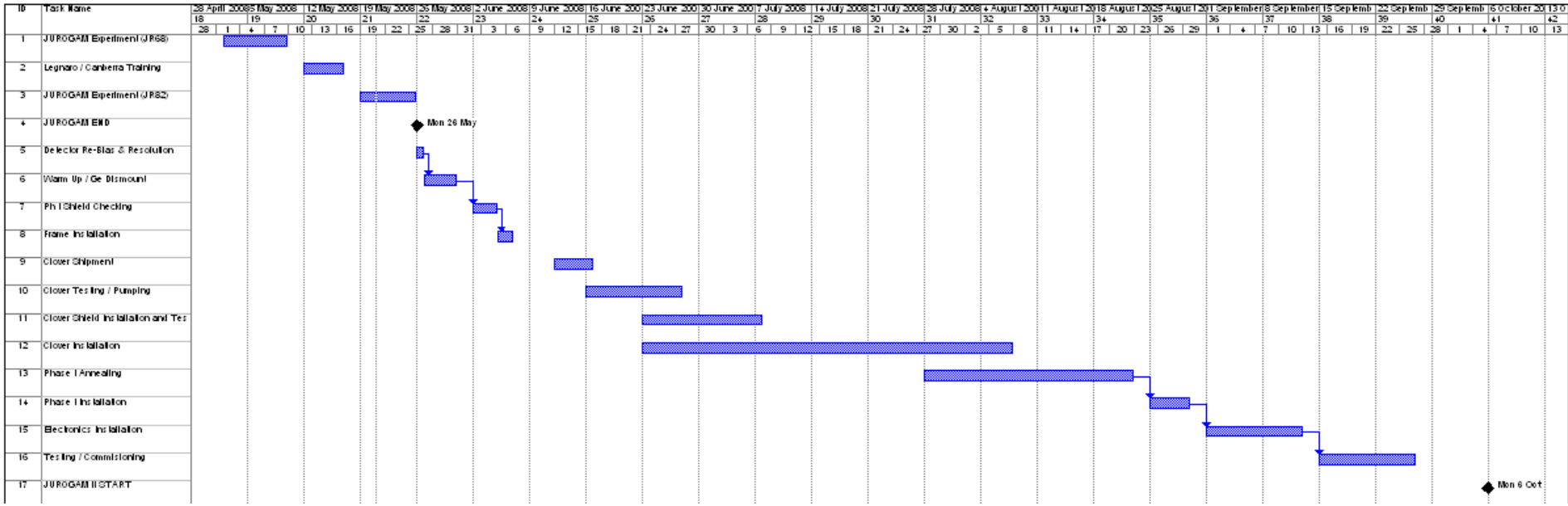
After considering the resource implications of all requests it was decided to approve the JUROGAM II resource requests as follows: 15+3 Phase I detectors and 15 ACS, 24+4 Clover detectors and 24 ACS. JUROGAM II is encouraged to invest in electronics and ACS for the Clover detectors. The request for 2010 is treated as a letter of intent. The loan is approved until 31/12/09.

Sincerely yours,

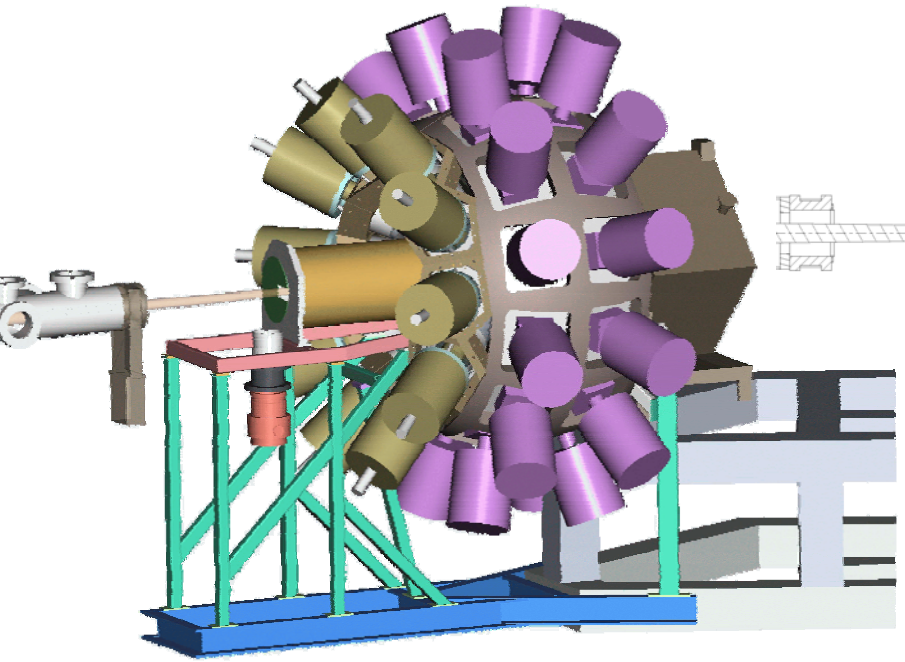
Silvia M. Lenzi
Chair of the EOC

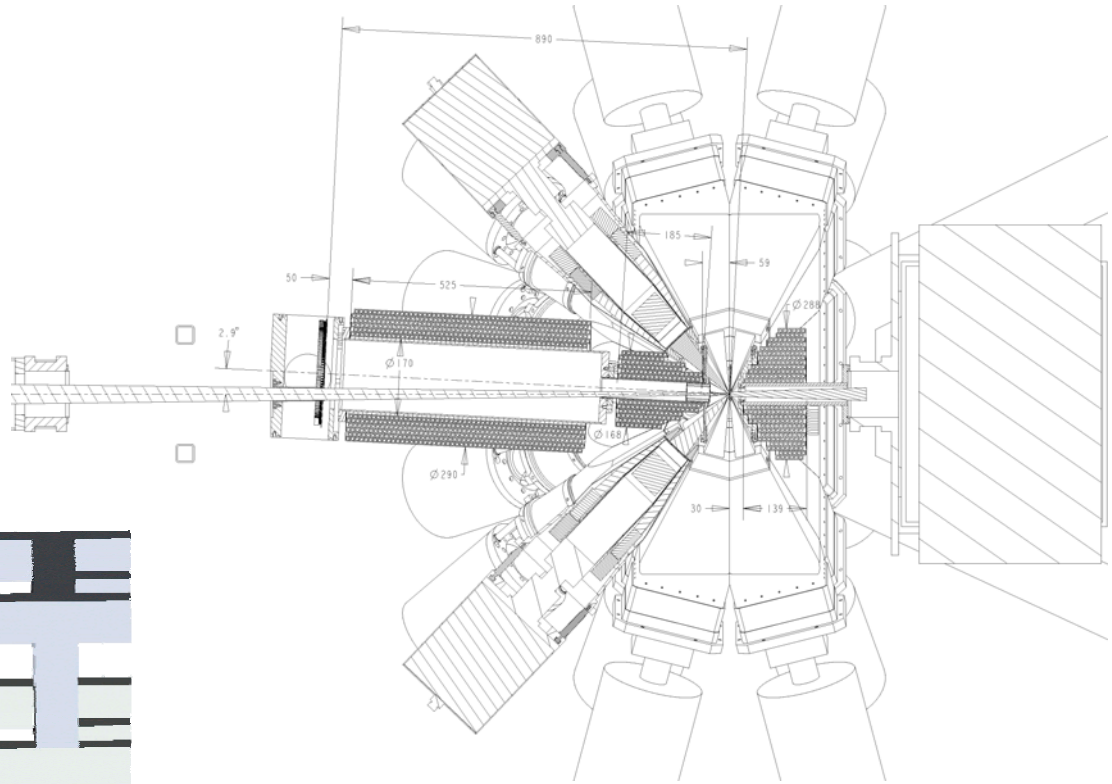
JUROGAM II Planning

JUROGAM end 26 May 2008
Infrastructure June
Equipment exchange mid June
Electronics tests September
Start October 2008



SAGE : 2008+

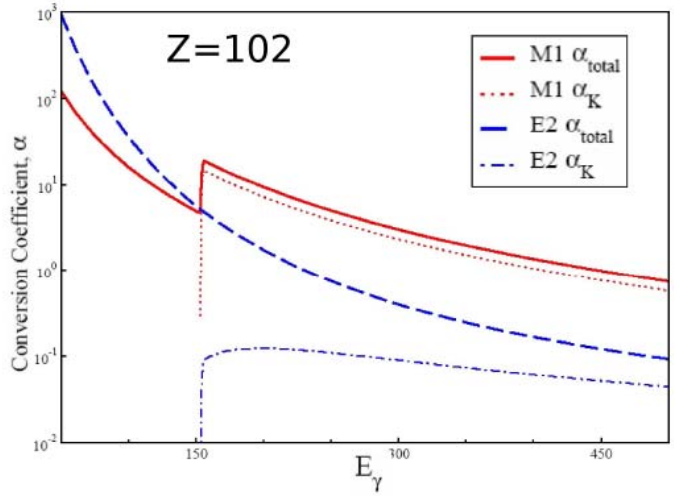




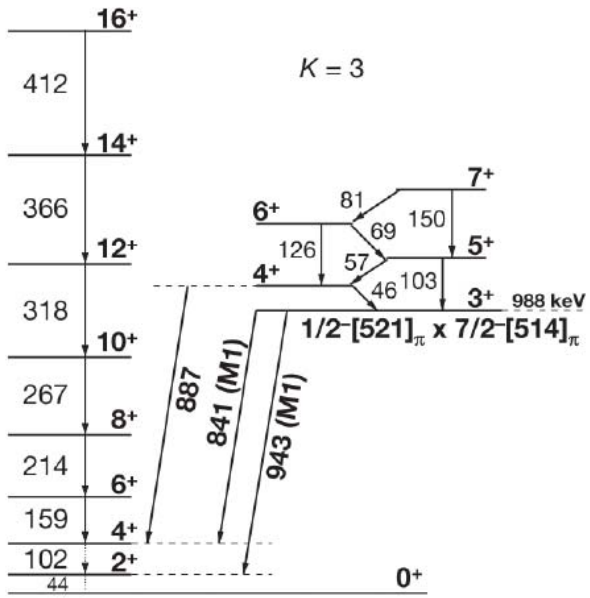
- Simultaneous Gamma and CE studies

SAGE Fundamentals

- Internal conversion becomes dominant decay mode when Z is high and E_γ is low



- In-beam γ-ray OR e^- measurements can provide only partial information
  $\Rightarrow$ γ-e^- cross-coincidences are needed

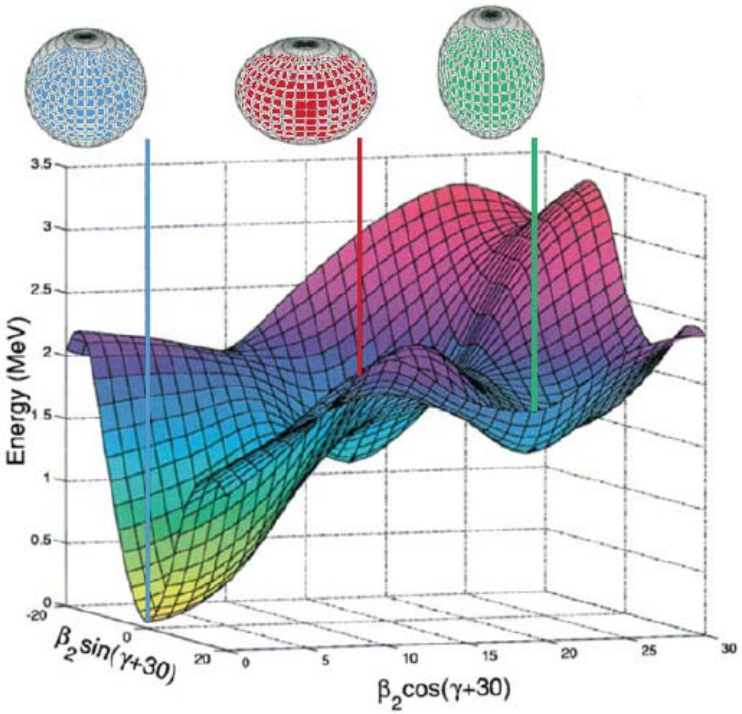


^{254}No

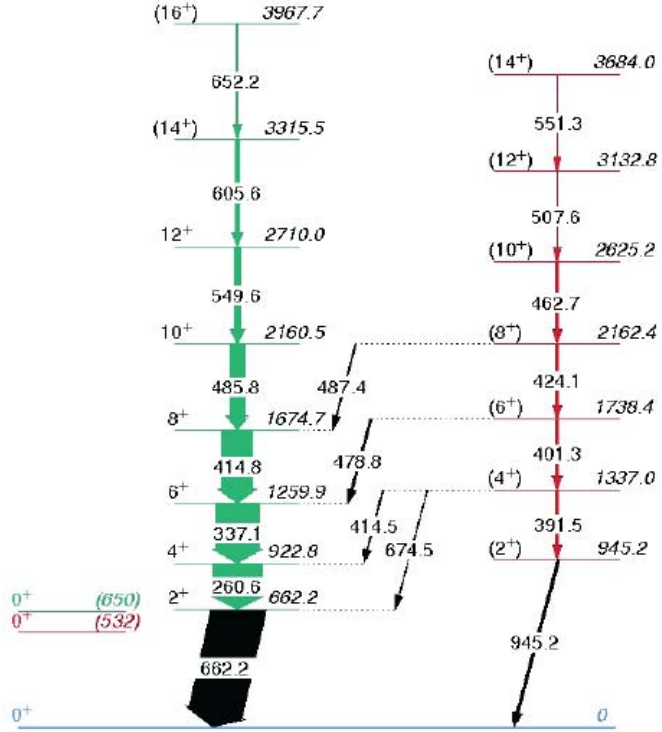
R.-D. Herzberg *et al.* Nature **442**, 896 (2006).

SAGE Fundamentals

- Internal conversion is the only decay mode for E0 transitions



A.N. Andreyev *et al.* Nature **405**, 430 (2000).

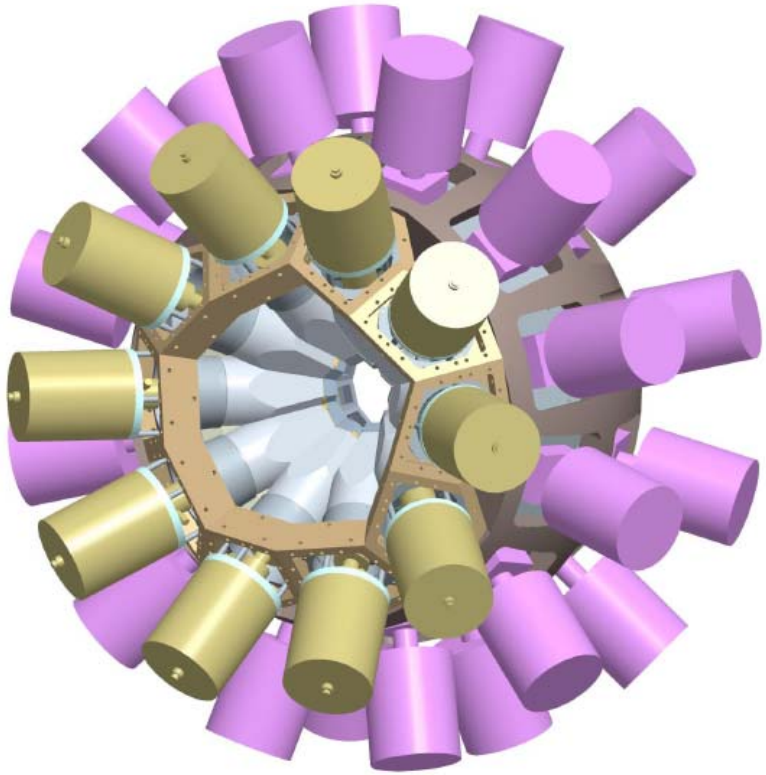


^{186}Pb

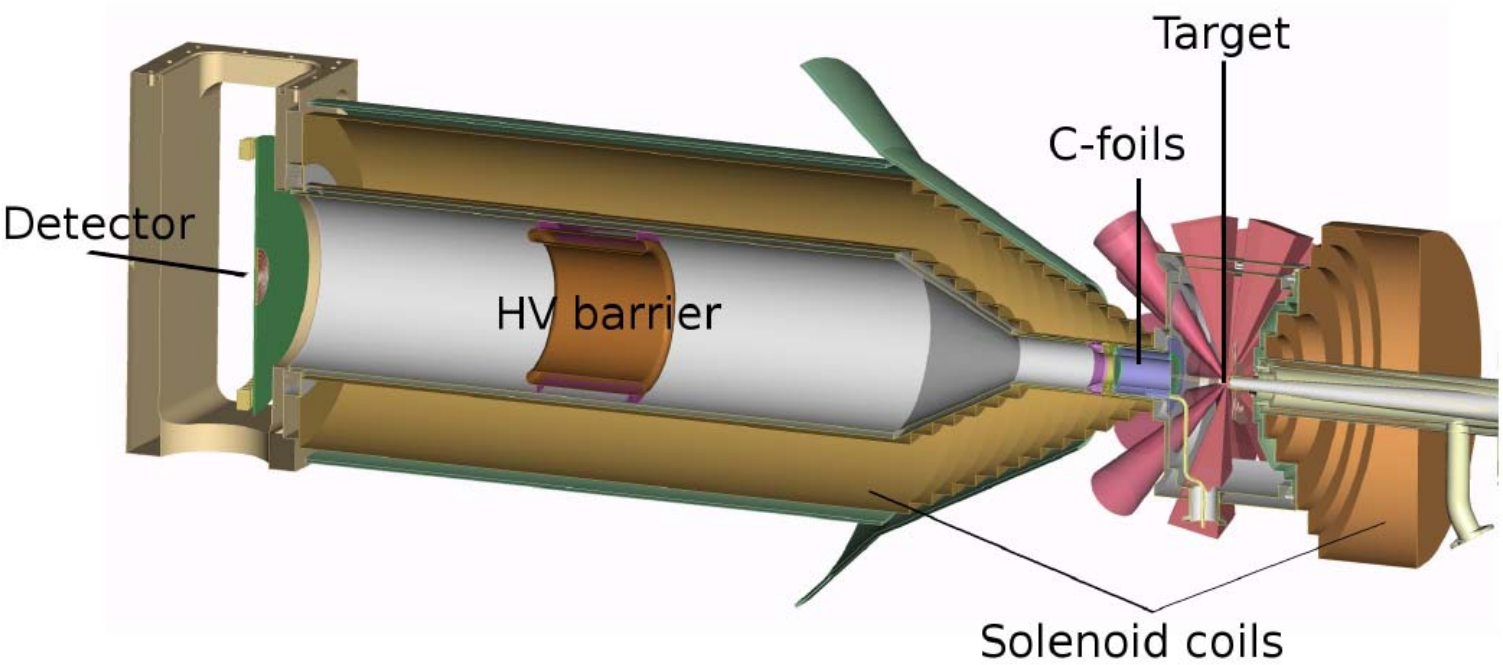
J. Pakarinen *et al.*, Phys. Rev. C **72**, 011304(R) (2005).

SAGE Integration

- EUROGAM II frame without rings at 22°, 46° and 158°
- 24 Clover and 10 Phase I Compton-suppressed Ge-detectors
- 5.5% efficiency at 1332 keV
- 111 channels in total

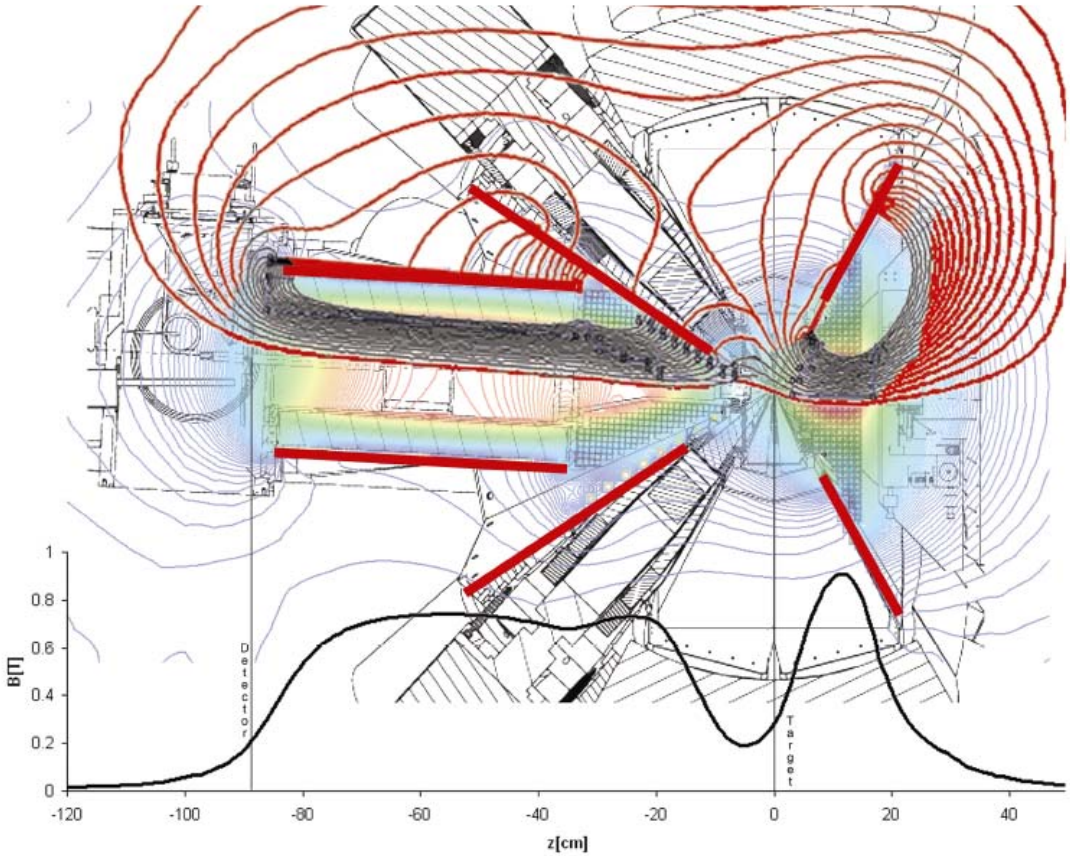


SAGE Realisation

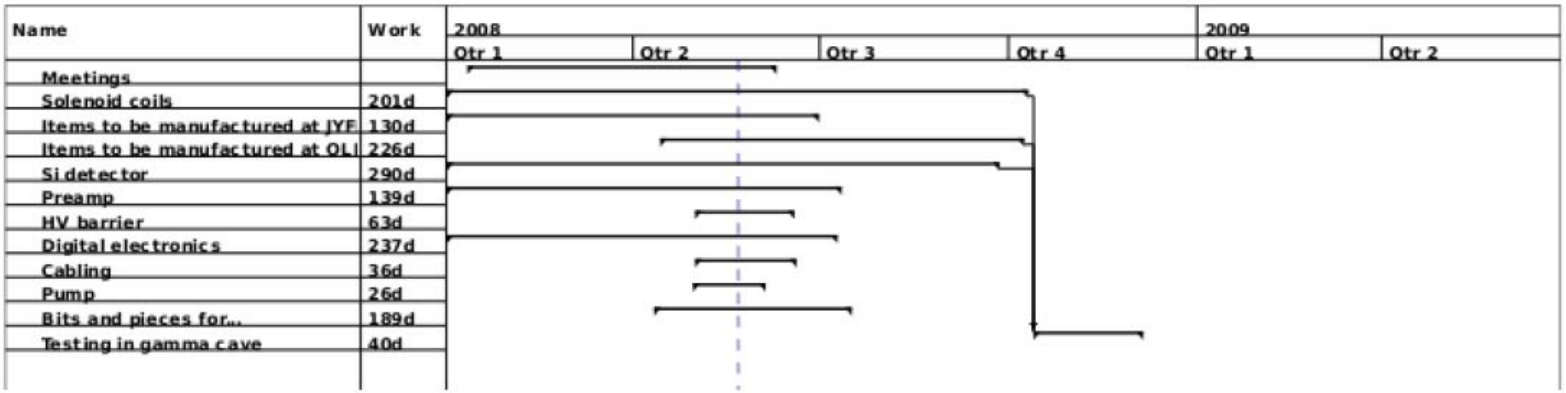


SAGE Simulations

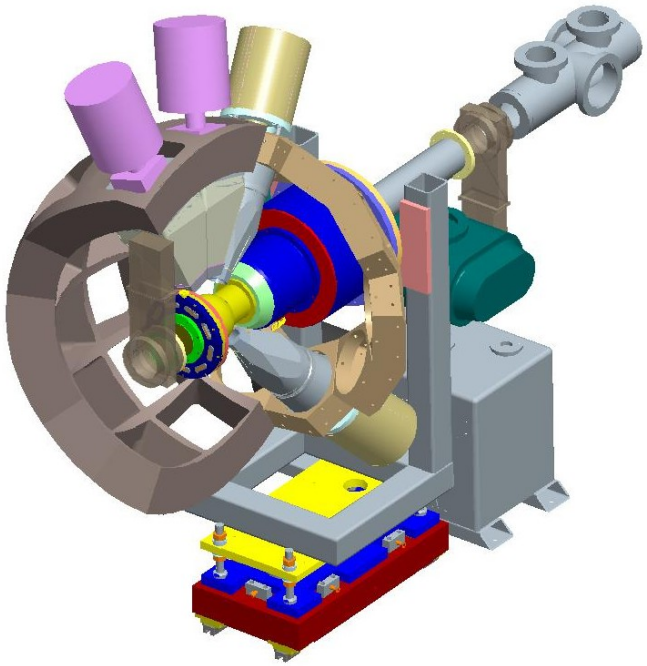
- JUROGAM II cross section
- Magnetic field profile
- Shielding needed for PMT
- Effect of shielding on B
- B on solenoid axis

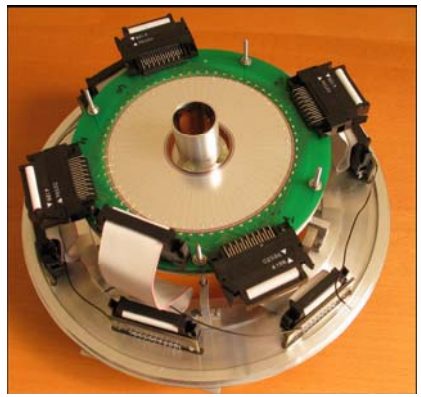


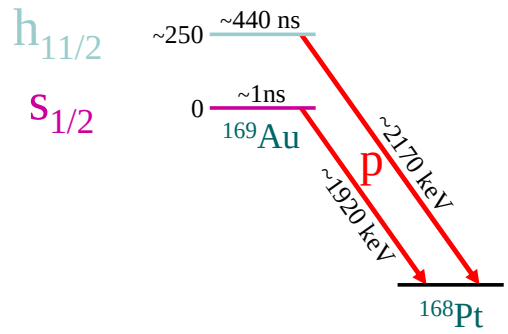
SAGE Planning

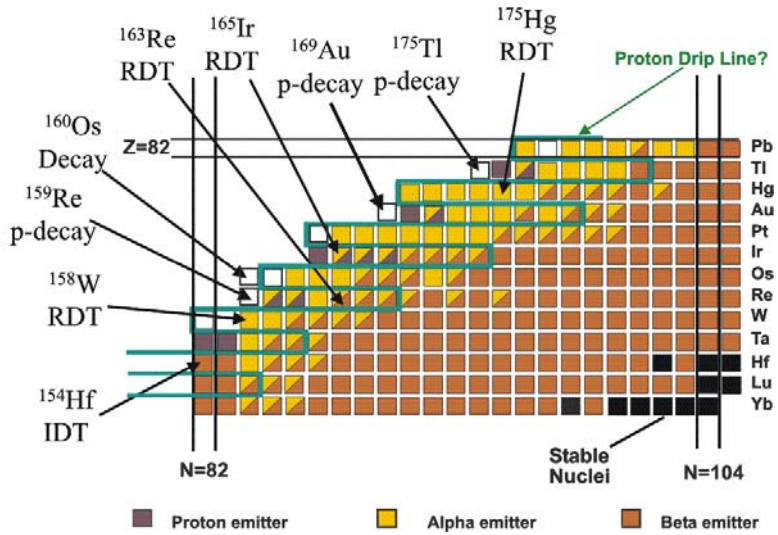


LISA : 2008+









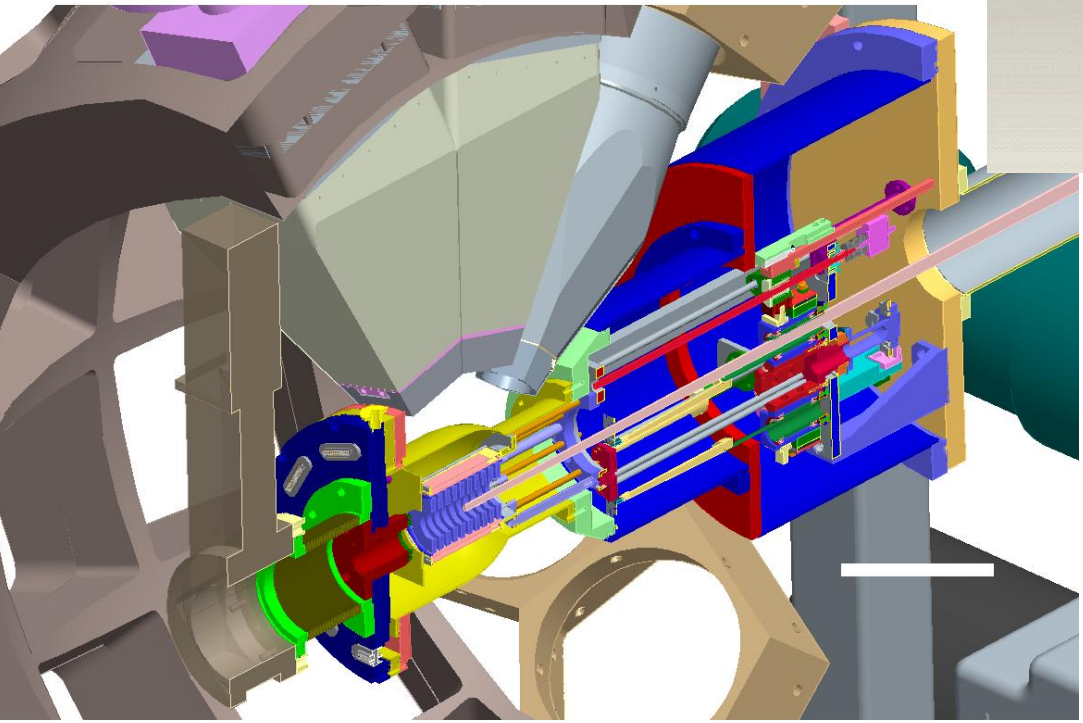
- Fast charged particle decay modes for tagging

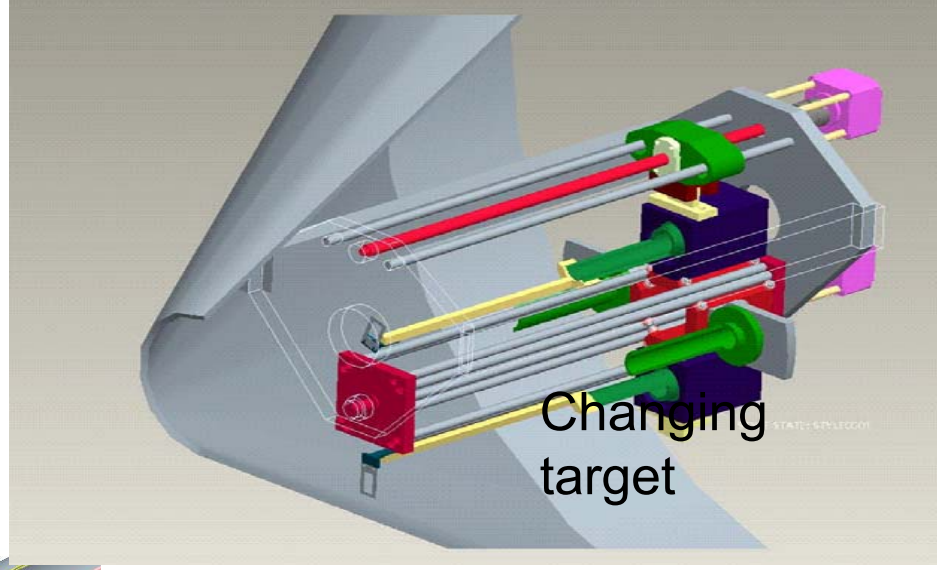
Pete Jones
University of Jyväskylä

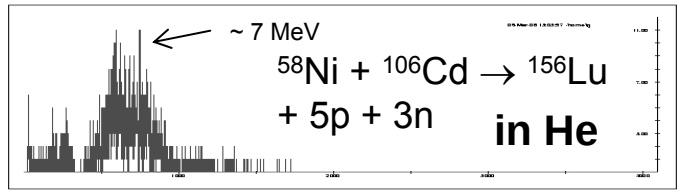
Gammapool Meeting 2008
Paris, France

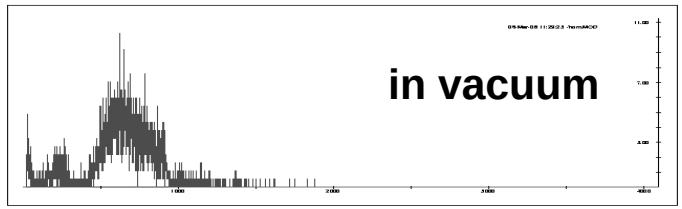
27-30 May 2008

LISA 2008+

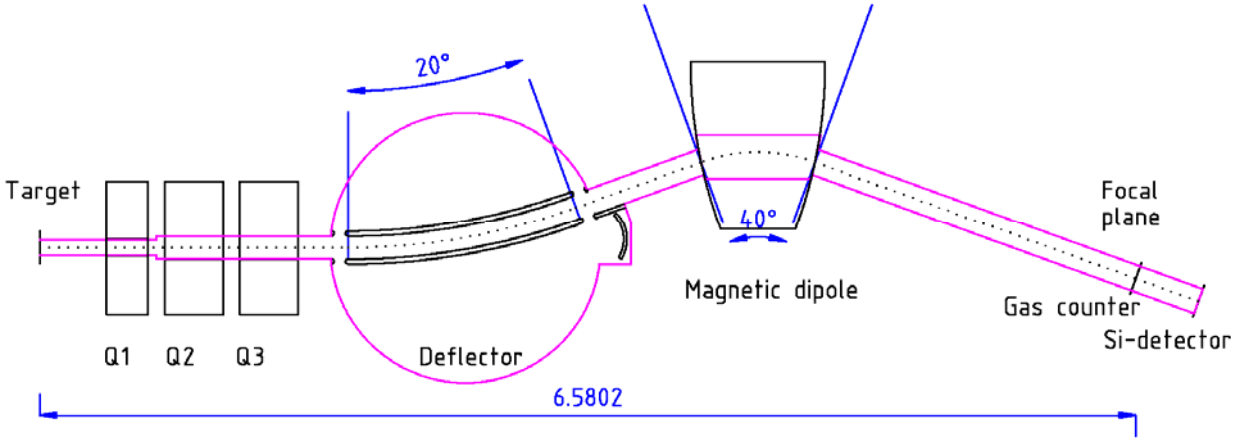


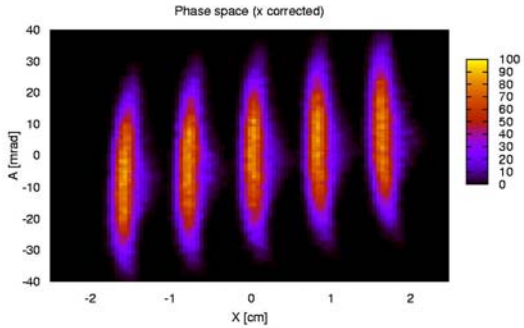


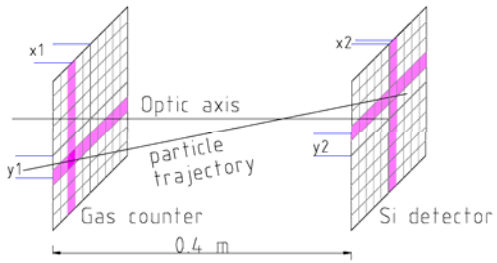




MARA Vacuum Separator







What kind of research work can be done were the RITU separator is not feasible:

Probing the N ≈ Z line up to ^{112}Ba

- **decay spectroscopy (proton and α-particle decay) at the ^{100}Sn region**
- **rp-process**
- **proton-neutron pairing interaction**
- **mirror nuclei**
  - **o study of isospin symmetry breaking**
  - **o proton skins (N < Z nuclei)**
- **superdeformation and hyperdeformation (N ≈ Z ≈ 40)**

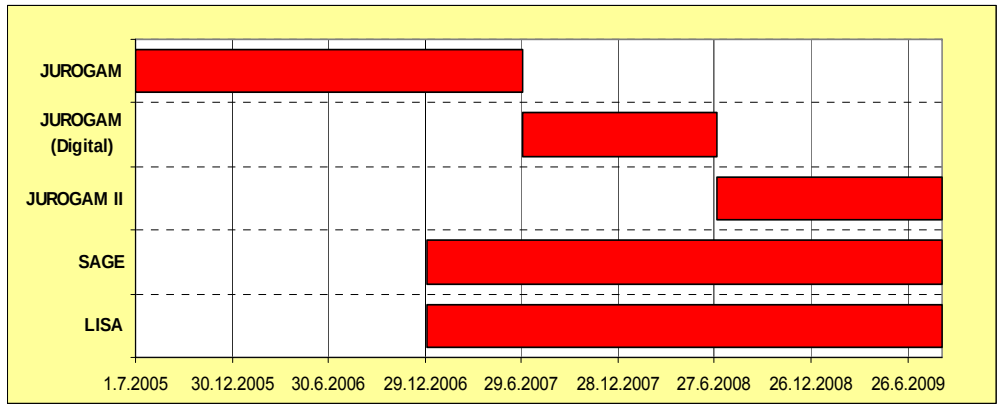
- Vacuum mode complementary to RITU

Preparations for JUROGAM II

- **9th or 10th of June 2008** : Loading in Strasbourg (boxes for Clover detectors)
- **11st or 12th of June 2008** : Loading in Legnaro (25 Clover detectors + anti-Compton shields)
- **16th of June 2008** : Delivery in Jyväskylä
- **19th of June 2008** : Delivery in Paris (have to be confirmed)
- **19th or 20th of June 2008** : Delivery in Strasbourg (IPHC)

Future Plans & Milestones

- JUROGAM II Upgrade 2008
  - Free resources
  - Needs extra digital instrumentation
- SAGE & LISA exploitation 2008+
- JUROGAM II 2008 : *A Versatile Array : October 2008*
- MARA
- Future Advances



Summary

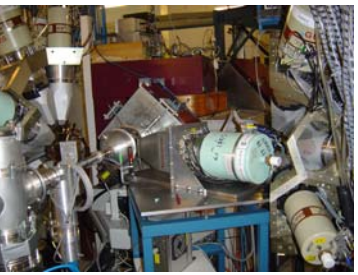
- 5 Campaigns of 67 experiments
- ~3000 hours per year

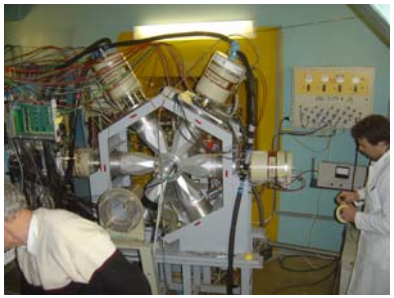
- Array working well
- Flexible array with different target chambers
- Experiments running very smoothly

- Applications for use of Resource
- LISA & SAGE
- MARA Plans

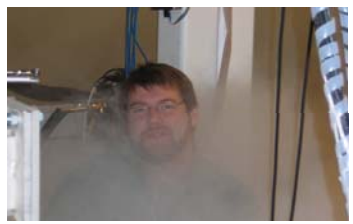
- JUROGAM II: October 2008

Thanks…







Have a
Good Summer 2008