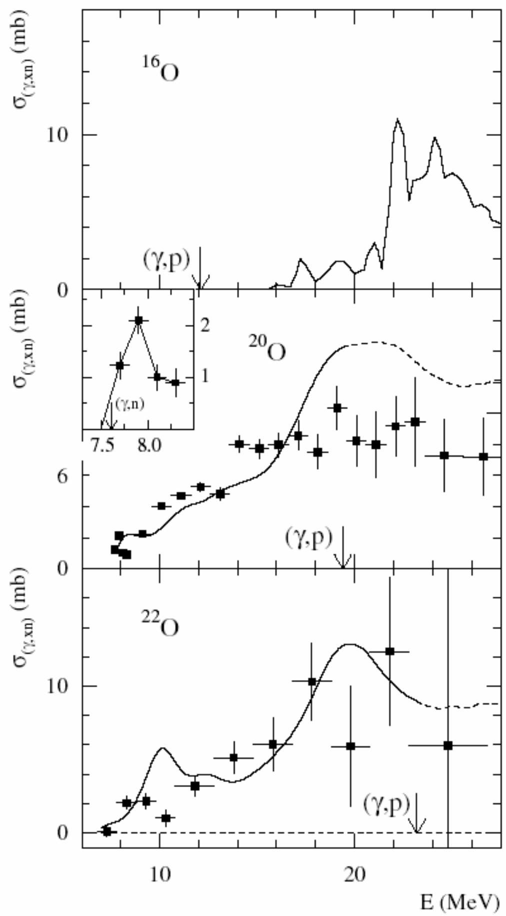
# Giant Resonance Studies with Radioactive Beams



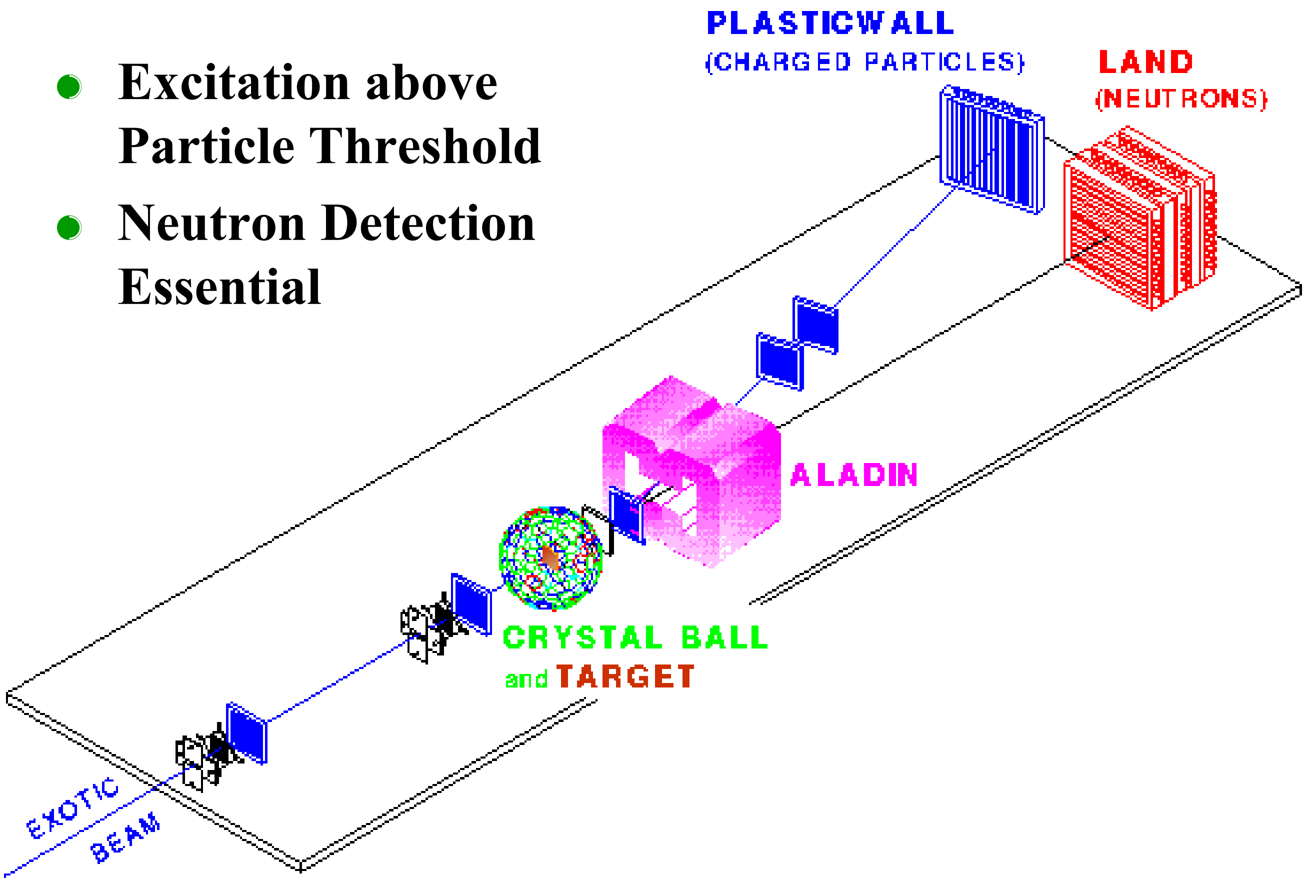
- Giant Resonances Built on the Ground State
  - Inelastic Scattering
  - Projectile Excitation
  - Double Phonon Excitation
- GDR Built on Excited States
  - Fusion Evaporation

# Ground State Giant Resonances



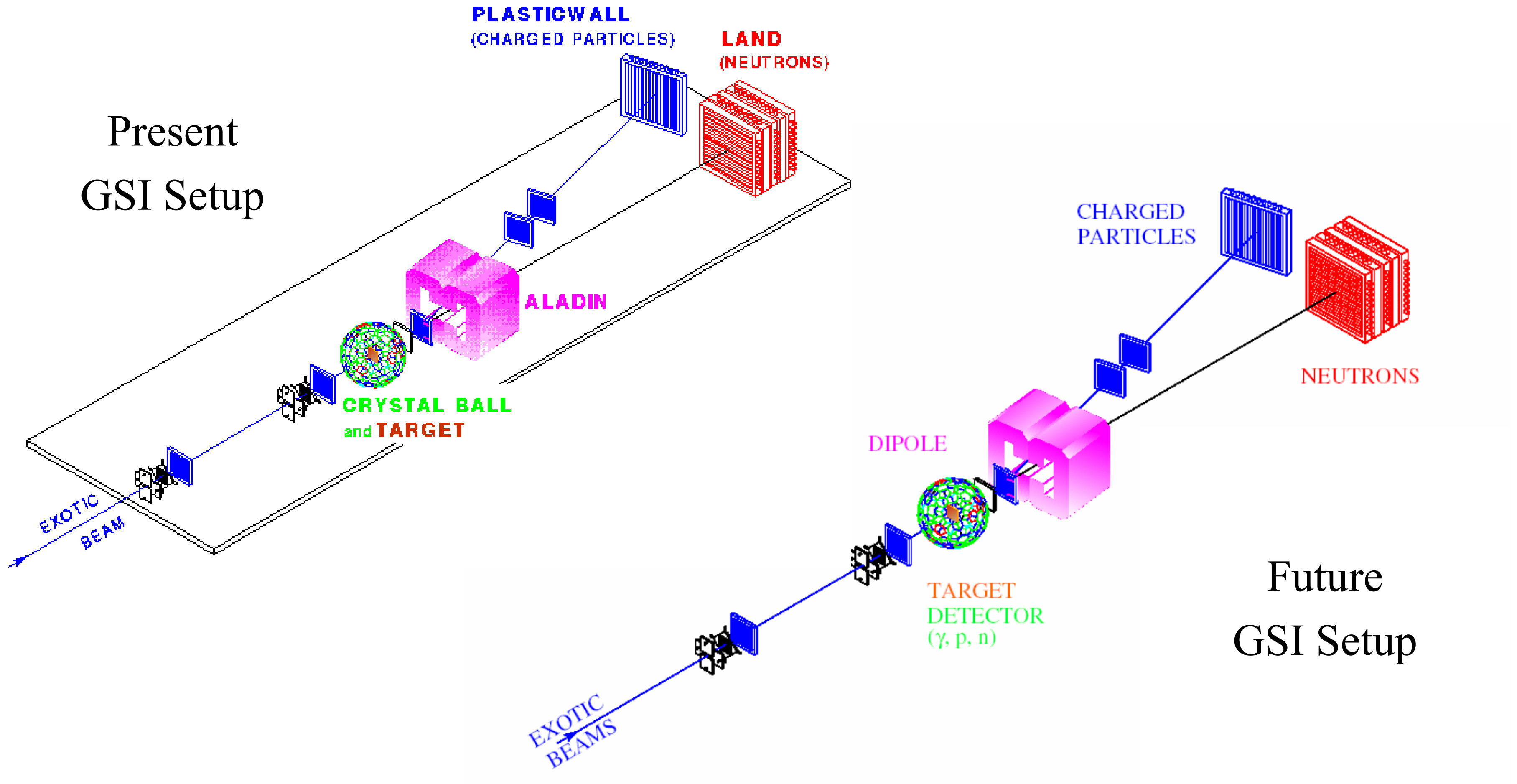



- **Excitation above Particle Threshold**
- **Neutron Detection Essential**



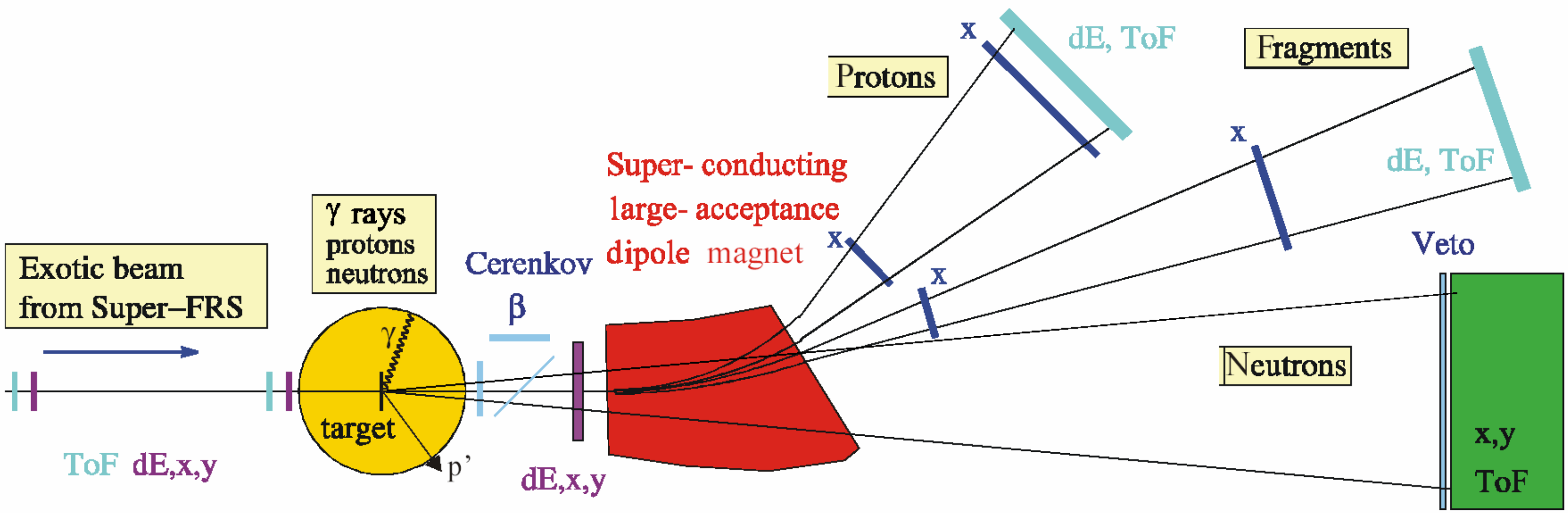

A. Leistenschneider *et al.,* Phys. Rev. Lett. **86** (2001) 5442

# Possible Future Setup

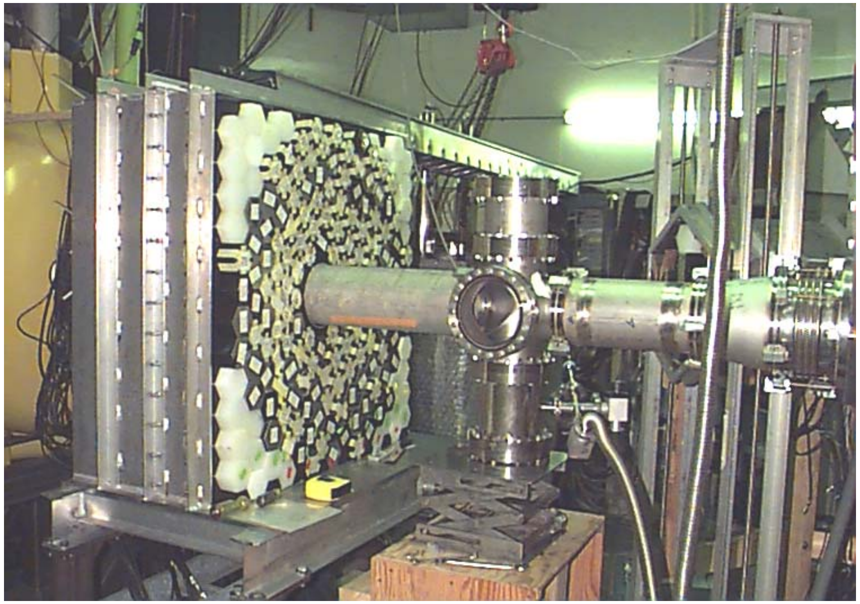


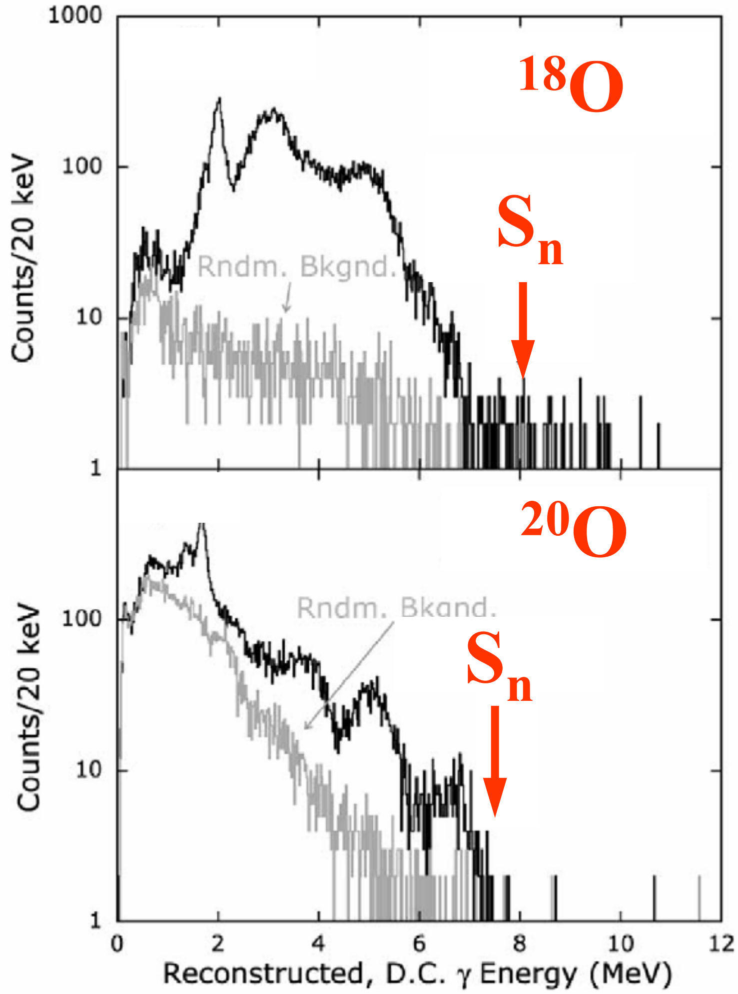
# Future GSI Setup





# Gamma-Decay Branch Very Small

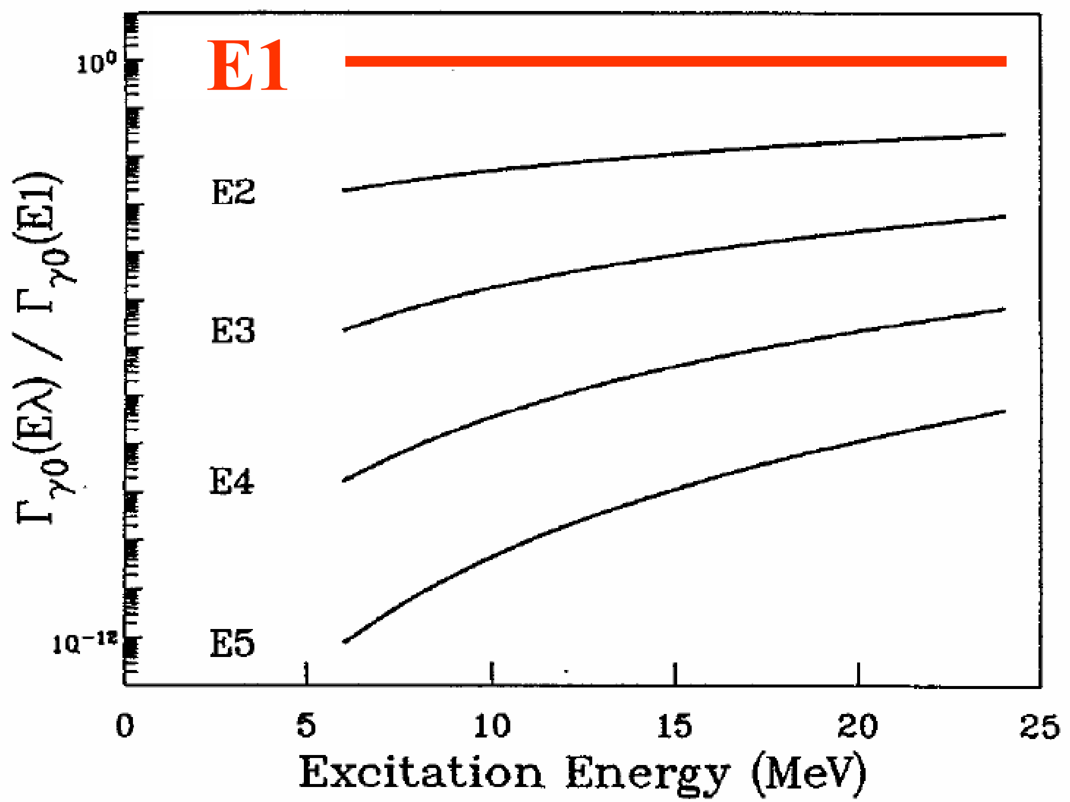





E. Tryggestad *et al.,* Phys. Lett. **B541** (2002) 52

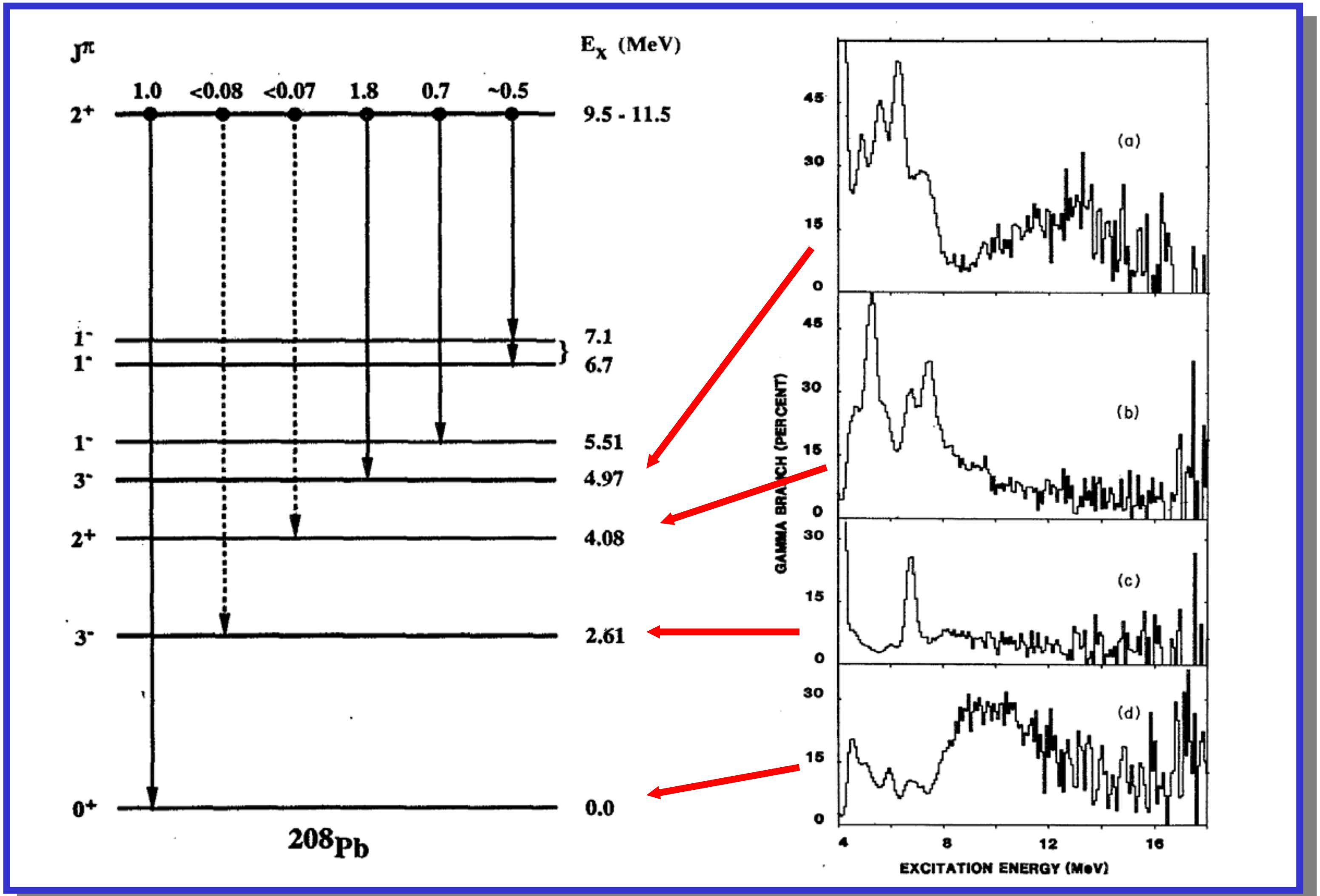
# Gamma-Rays are Multipolarity Selective





# Isolate Specific Resonance






J. R. Beene *et al.*, Phys. Rev. **C 39** (1989) 1307

# GDR $^{11}Be$

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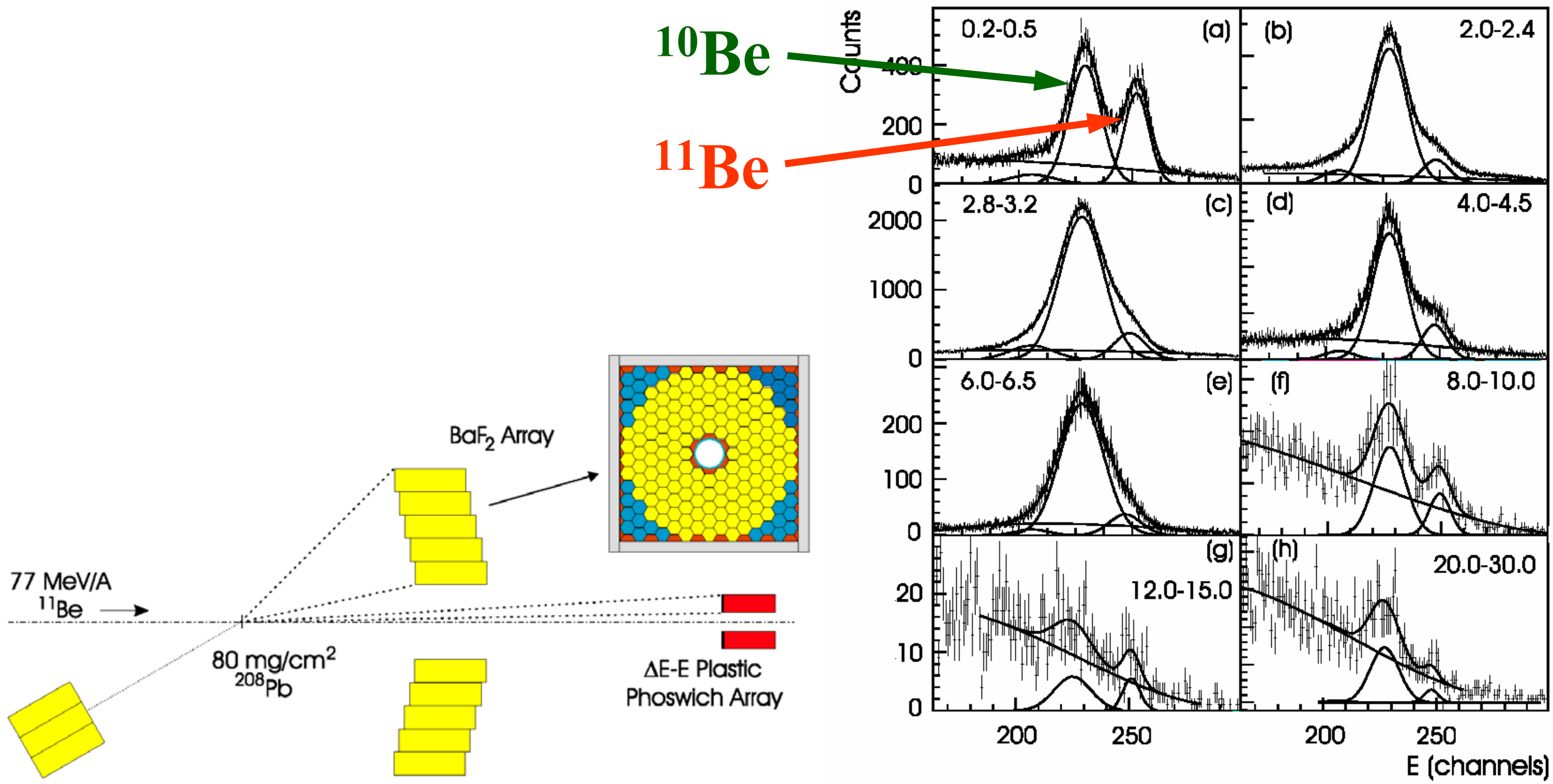


R.L. Varner *et al*., Proc. of Int. Work. On Collective Excitations in Fermi and Bose Systems, Edited by C. Bertulani, p.264 (World Scientific, 1999)

# Requirements for GS GR

- **FAST FRAGMENTATION BEAMS**
- Neutron Coincidence Measurements are more sensitive:
  - Sweeper with neutron detection at $0^0$
- Gamma Coincidences require:
  - High beam intensities (>$10^6$pps)
  - Clean particle separation and identification (Magnetic Spectrograph)
  - Forward array of segmented fast scintillator
    - High efficiency
    - Excellent neutron separation
    - Moderate energy resolution

# GDR in Hot Nuclei

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- More exclusive experiments
- Development of more efficient arrays
- Angular momentum dependence of the GDR width
- Isolate specific channels:
  - Multiplicity Gates
    A. Bracco, Phys. Rev. Lett 74, 3748 (1995)
  - Isomer Trigger
    J. P. S. van Schagen, Nucl. Phys. A581, 145 (1995)
  - $\alpha$-Scattering
    E. Ramakrishnan, Phys. Rev. Lett. 76 2025 (1996)
  - Discrete Transitions
    G. Viesti et al., Phys. Rev. C55, 1594 (1997)
  - Evaporation Residues
    V. Nanal et al. (ANL, 2000)

# Improvement of Resolution



- Large NaI: ~2%
- Ge+BaF2: 1.6%

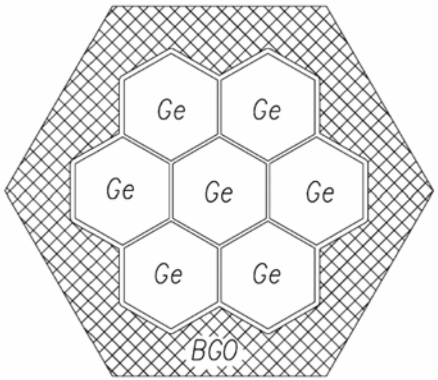
  A. Krasznahorkay et al. NIM A316, 306 (1992)
- Ge+BGO: 0.7%

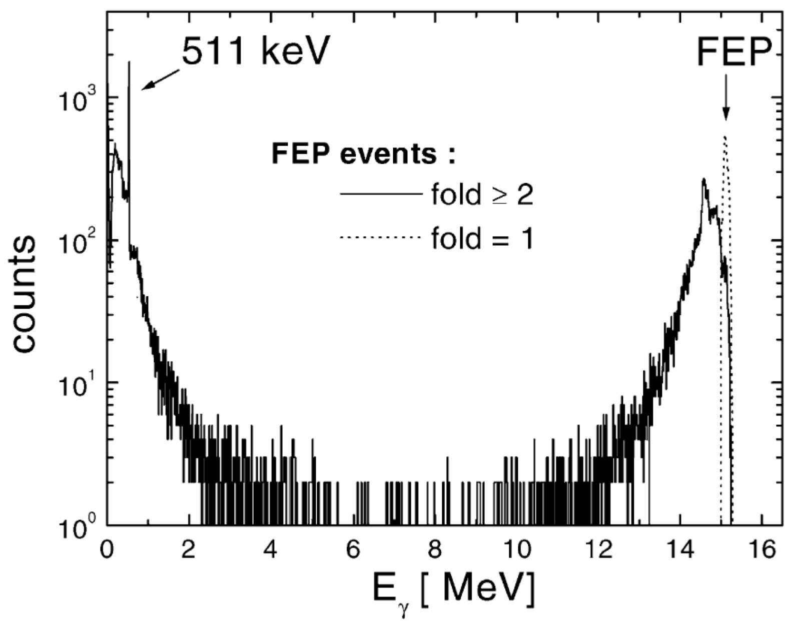
  F. Camera et al. NIM A351, 401 (1994)
- Ge Cluster: 0.4%

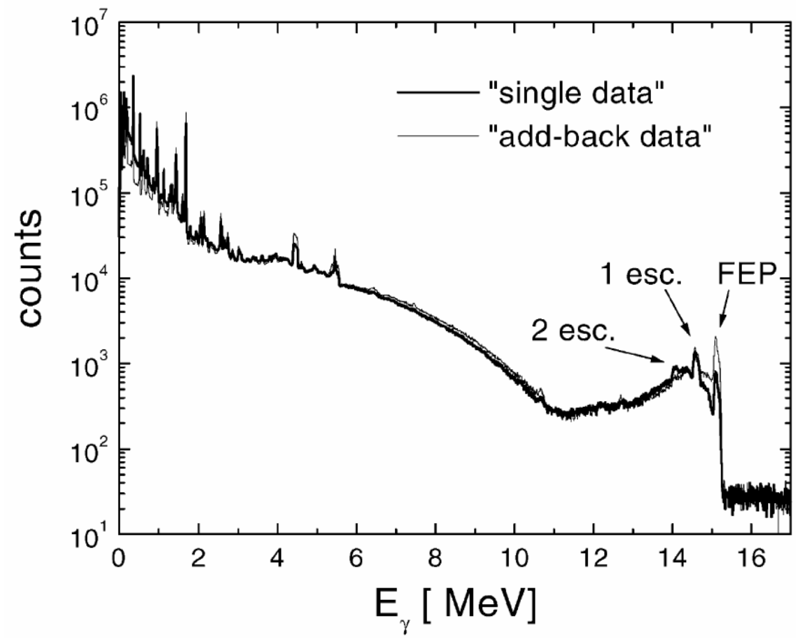
  B. Million et al. NIM A452, 422 (2000)

# High Energy Response of Ge-Clusters



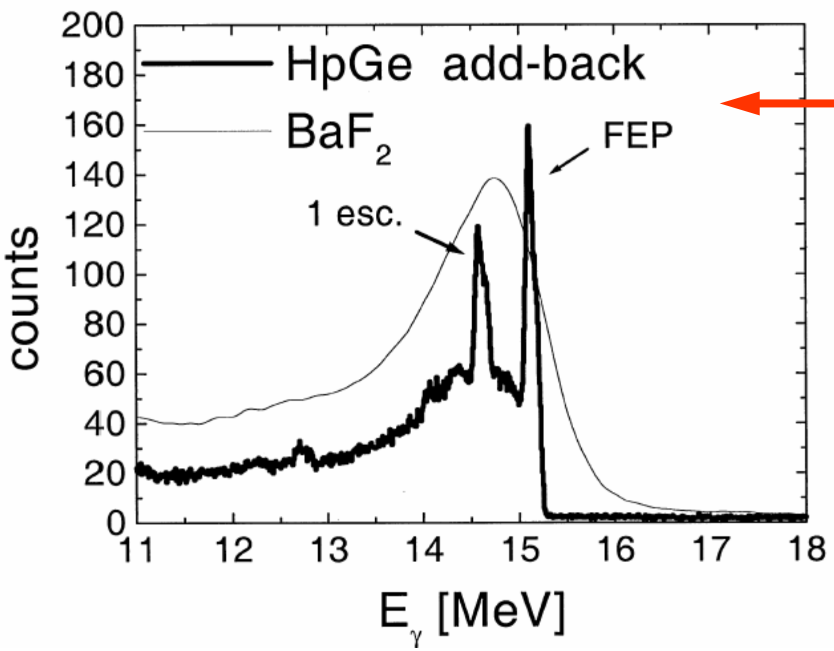


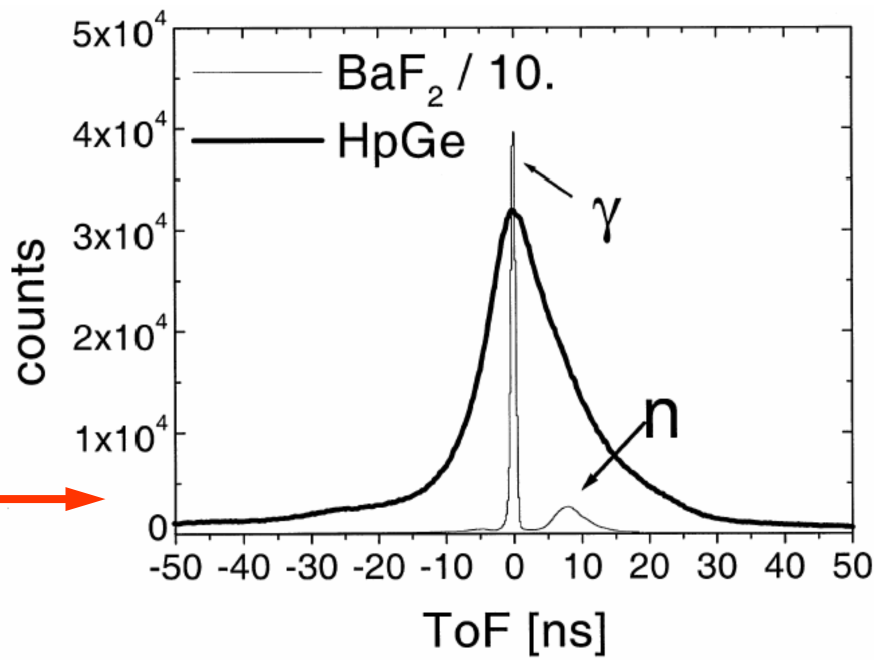




B. Million *et al*. NIM **A 452** (2000) 422

# Ge-Clusters vs $BaF_2$



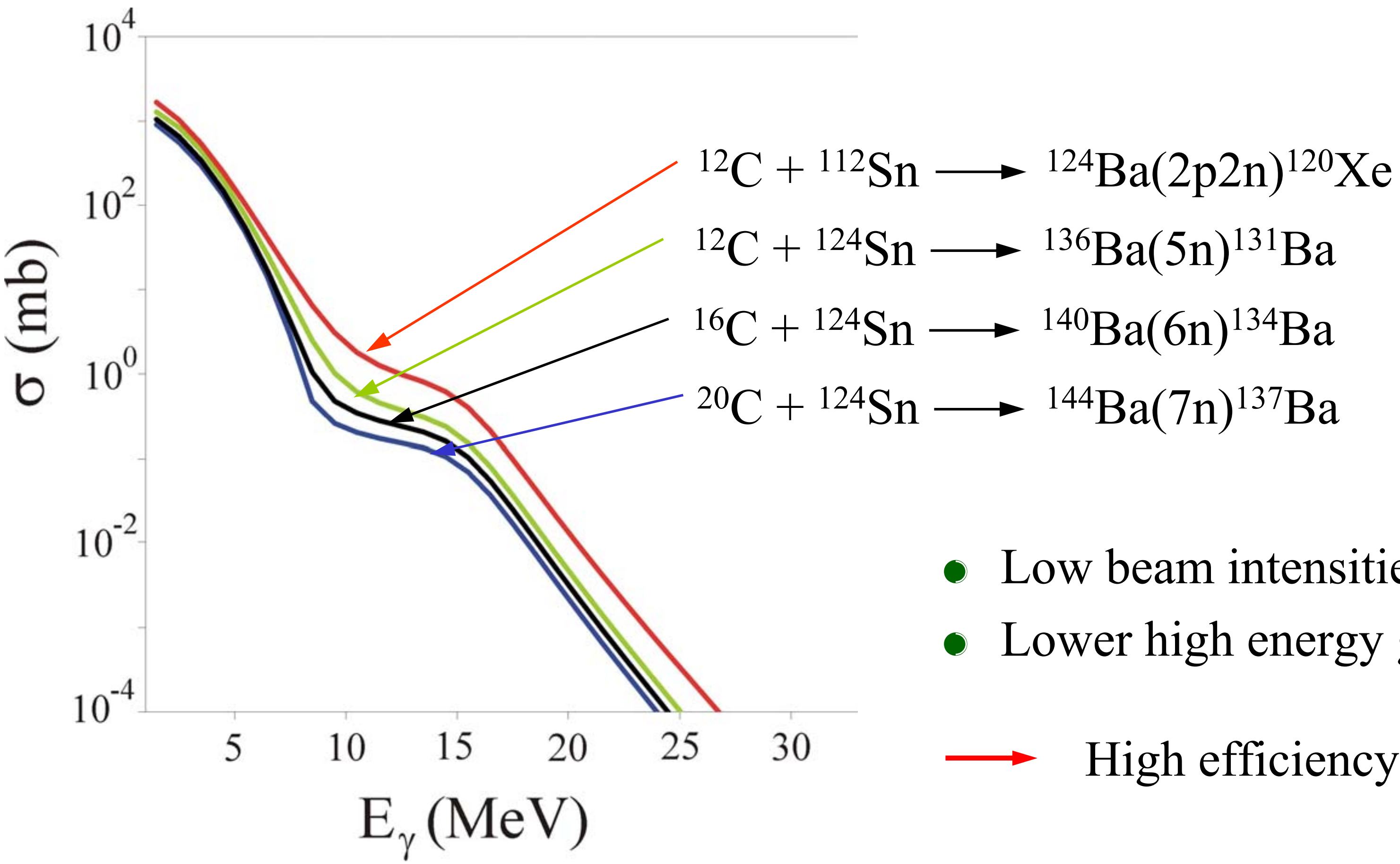

Energy Resolution




Time Resolution

B. Million *et al*. Nucl. Instrum. and Methods **A 452** (2000) 422

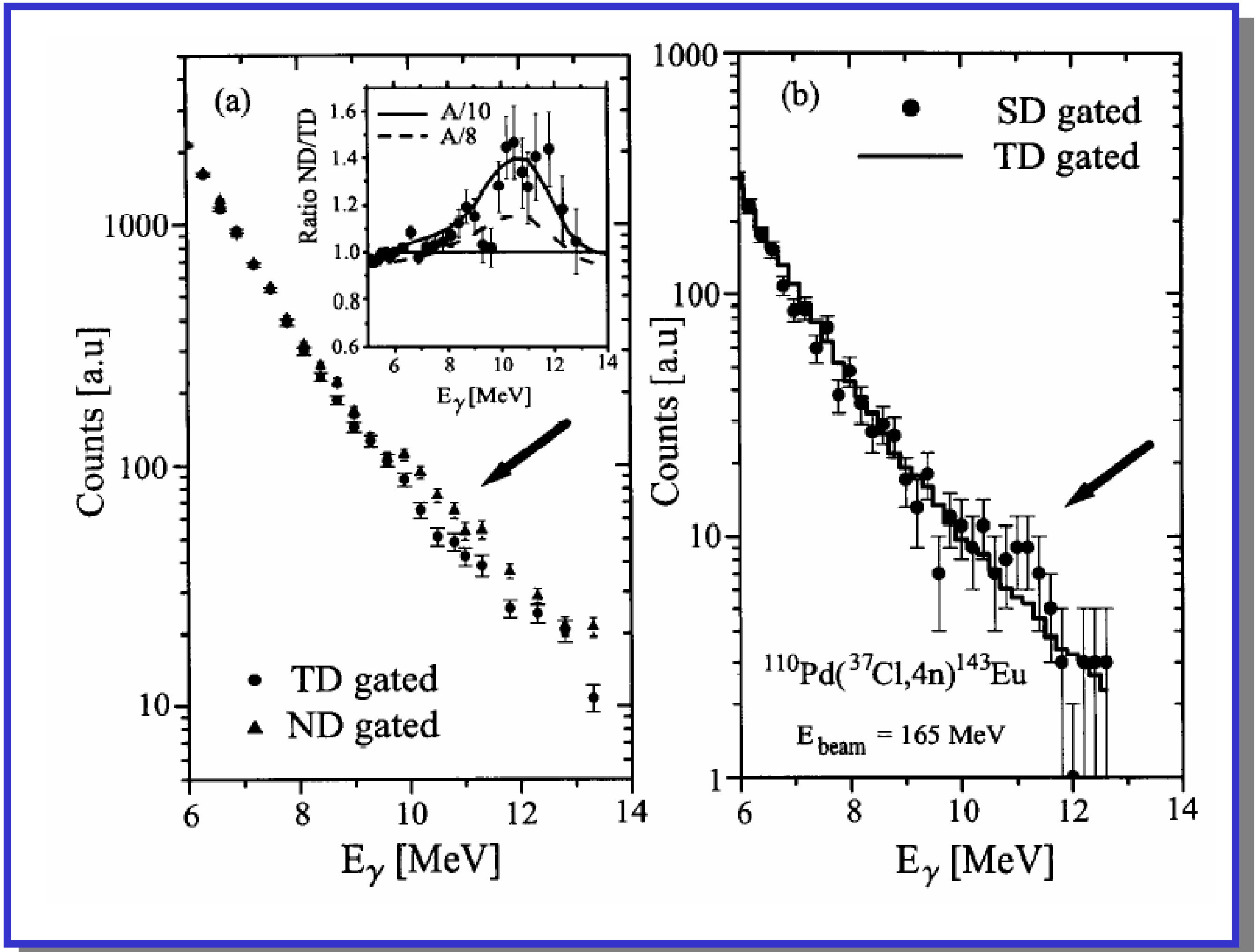
# Fusion Evaporation with RIA




- Low beam intensities
- Lower high energy gamma yields

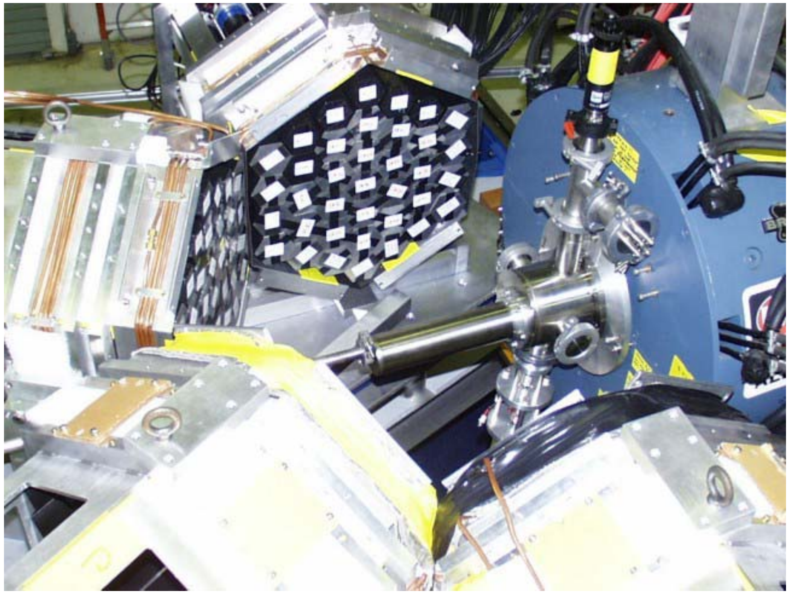
→ High efficiency is essential

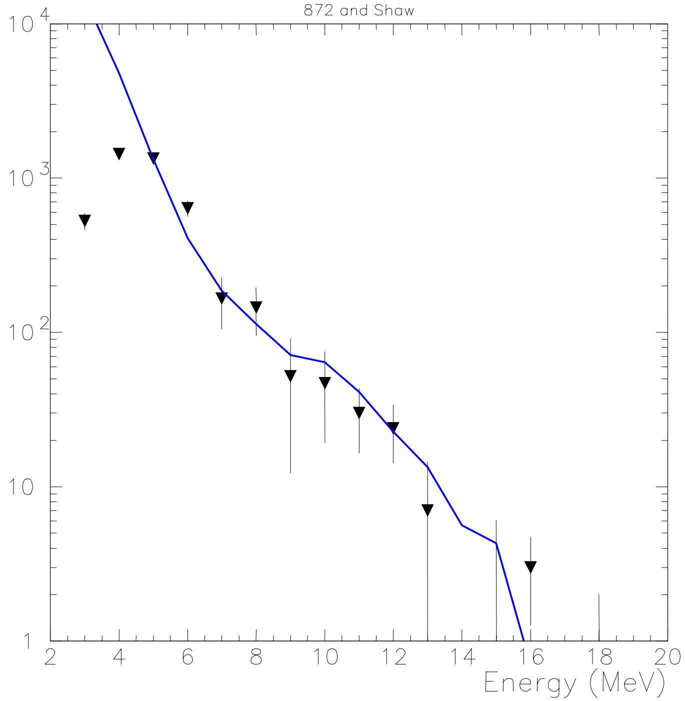
# Gating on Superdeformed States




A. Bracco, *et al*. Nucl. Phys. **A682** (2001) 449c

# Gating on Evaporation Residues






BaF$_2$ efficiency ~14%
FMA efficiency ~ 5%

$^{48}Ca + {}^{176}Yb \longrightarrow {}^{224}Th$
~500μb cross section !!

# Efficiencies

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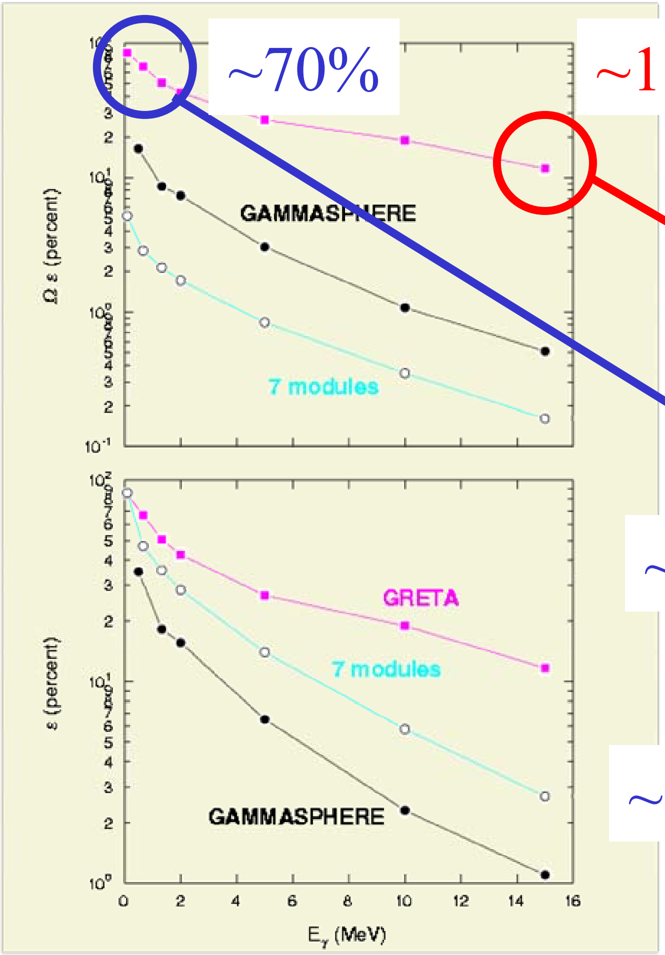
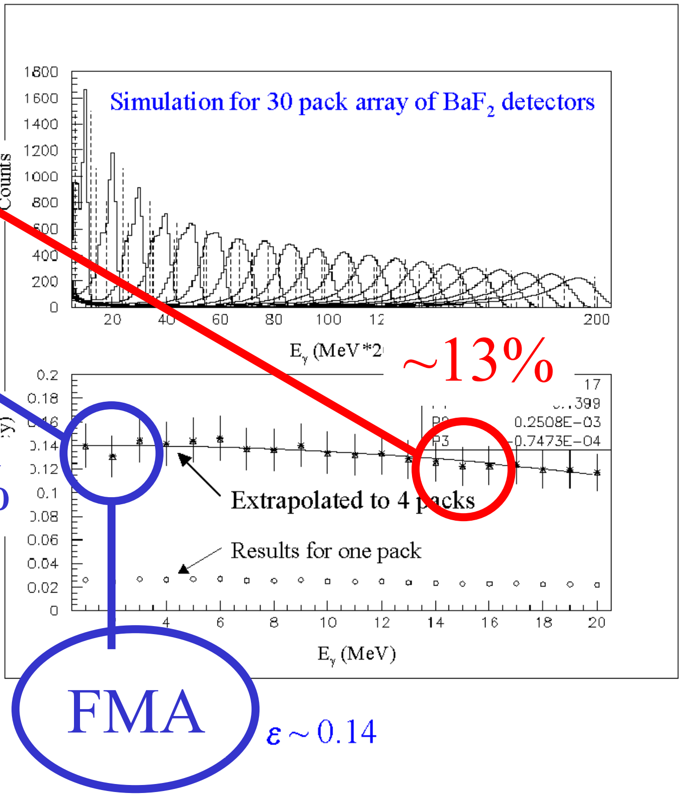
**Detector Efficiency**




BaF$_2$-Array

Geant Efficiency



# Countrate Estimates

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| | | |
|---|---|---|
| **Evap.-gated:** | Residue Cross section: | ~1mb |
| | High-Energy γ-efficiency: | ~0.13 |
| | Residue efficiency: | ~0.05 |
| | Beam Intensity: | ~3pnA ($2 \cdot 10^{10}$pps) |
| **RIA:** | Fusion Cross section: | ~1000mb |
| | High-Energy γ-efficiency: | ~0.13 |
| | Residue efficiency (Singles): | 1.00 |
| | Beam Intensity: | **~$10^6$ pps** |

# Requirements for Hot GDR



- **REACCELERATED ISOL BEAMS**
- GRETA:
  - Highly efficient even at high gamma energies
  - Gating on low energy transitions possible
  - Doppler correction for inverse kinematics
  - Limited coverage at forward angles
- Highly Efficient Fast Scintillator:
  - Excellent neutron-gamma separation
  - High count-rate capabilities

# ISOL and Fragmentation

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- **REACCELERATED ISOL BEAMS**
  - GRETA for hot GDR
  - Scintillator Array for forward angles and high countrate environments
- **FRAGMENTATION BEAMS**
  - Scintillator Array for high energy $\gamma$-rays from projectile excitations at forward angles
  - GRETA for tagging of low energy transition

# Conclusions

- GRETA? Yes, that's obvious
- Fast Scintillator Array? YES