A Novel $LaBr_3$ based γ-ray detection array for use at RIBF

P. Doornenbal[1], H. Scheit[1], N. Aoi[1], T. Motobayashi[1], H. Sakurai[1], and S. Takeuchi[1]

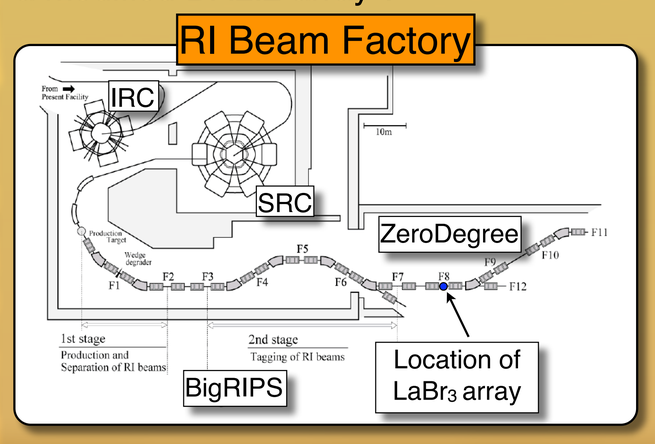
[1]RIKEN Nishina Center for Accelerator-Based Science, 2-1 Hirosawa, Wako, Saitama 0351 - 0106, Japan

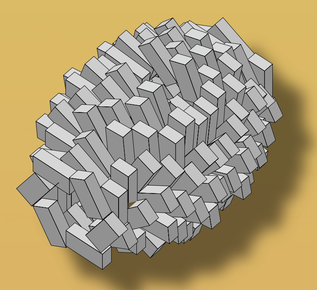
Motivation

With the Radioactive Ion Beam Factory (RIBF) at RIKEN being on the cusp to deliver the world's most intense RI beams at energies of several hundred MeV/u, a new γ-ray detection array is required to exploit the new experimental possibilities coming along with it. The material LaBr3(Ce) possesses an unprecedentedly high intrinsic energy resolution for scintillators of 2 % (FWHM) at 1332.5 keV and an excellent time resolution below 500 ps and is therefore well suited for high-resolution in-beam γ-ray experiments at relativistic energies. To minimize Doppler effects, the total array will comprise of up to one thousand individual crystals. The array will be placed around the secondary target area of the large acceptance fragment separator BigRIPS. Alternatively, the array can be used in a different configuration for stopped beam, delayed γ-ray decay experiments.

Objectives and considerations

- Construct a 4π $LaBr_3$ fast beam γ-ray detection array of up to 1000 detectors with an optimized geometry for RIBF energies of v/c = 0.6,
- Energy resolution of less than 3 % (FWHM) at E_γ = 1332.5 keV and E_{beam} = 100 MeV/u,
- Full energy peak efficiency (FEP) of 40 %,
- Simple detector geometry for a maximum of flexibility and to allow for an easy reconfiguration of the array for stopped beam experiments,
- In the first instance, the uncompleted array can be used in addition to a modified DALI2 array*.

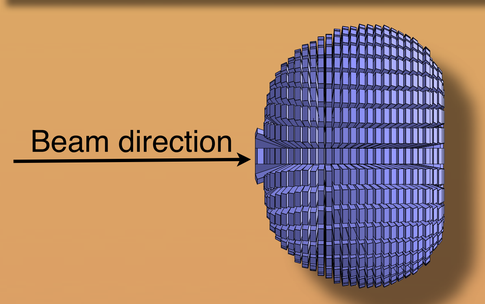


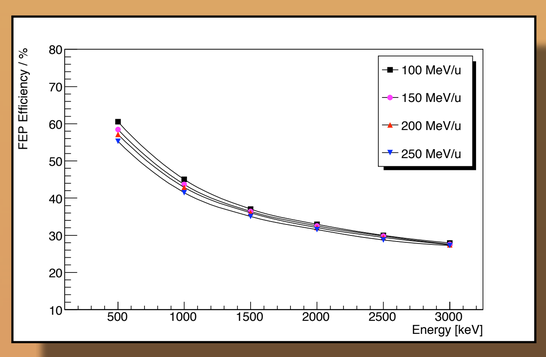


DALI2 array: 160 NaI detectors

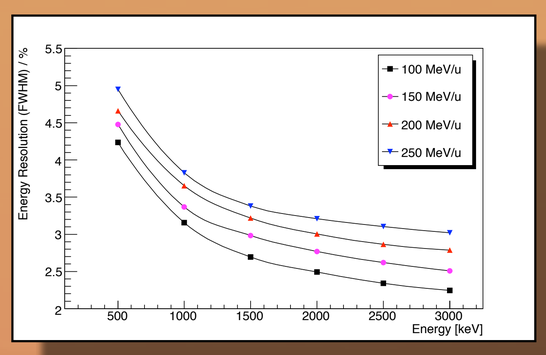
*S. Takeuchi *et al.*, RIKEN Acc. Rep. **36**, 148 (2003)

Configuration for fast beam experiments

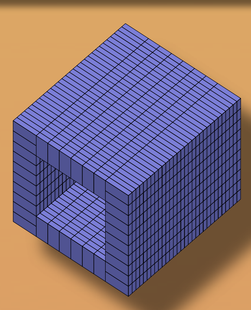


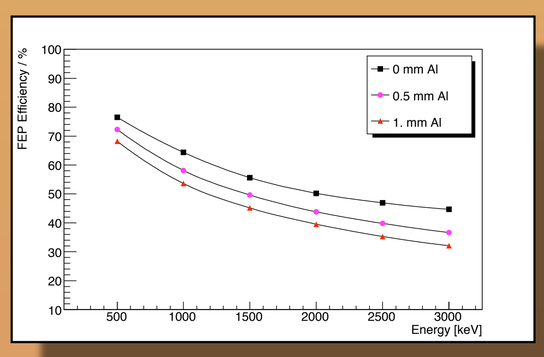


- 960 $LaBr_3$ detectors,
- Arranged in a configuration that keeps the same Doppler broadening due to the detectors' opening angle for all polar angles at v/c = 0.6,
- 15 x 40 x 80 mm^3 crystal size,
- Simulations are performed with a 0.5 mm thick Al housing.

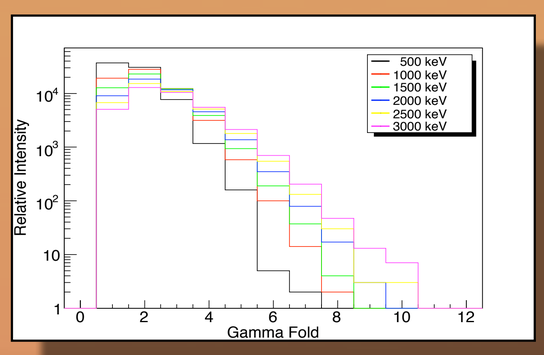


Configuration for stopped beam experiments





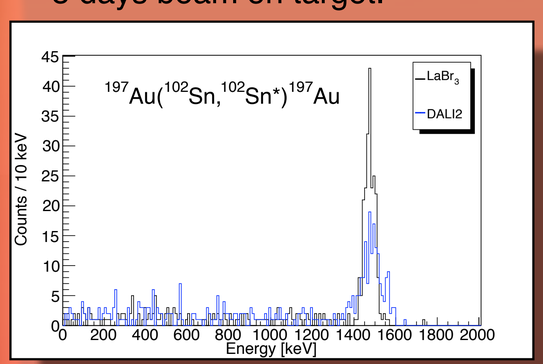
- 960 $LaBr_3$ detectors in a simple boxed shaped geometry,
- 15 x 40 x 80 mm^3 crystal size
- 12 cm distance to target,
- Simulations performed with Al housings of 0, 0.5 and 1.0 mm thickness,
- ≈ 85 % solid angle coverage,
- High granularity is kept for high energetic γ-rays.



Simulated exemplary experiments

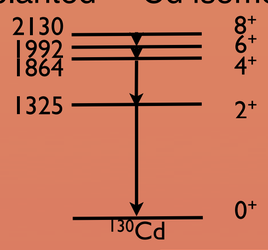
Relativistic Coulomb excitation of ^{102}Sn

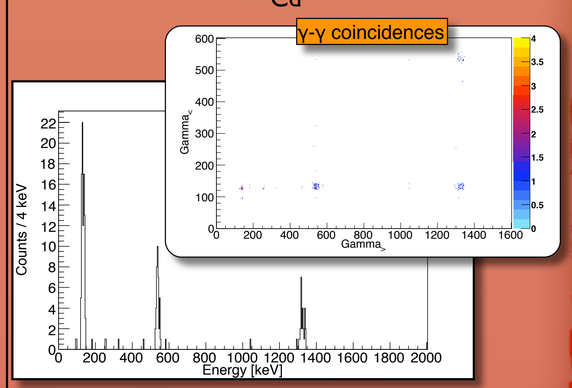
- 25 particles per second ^{102}Sn beam 150 MeV/u at secondary target,
- Secondary target thickness of 500 mg/cm^2 Au,
- B(*E2*; $0^+ \rightarrow 2^+$) = 0.044 e^2b^2 from shell model calculations*,
- 5 days beam on target.



Isomer spectroscopy at the limits

- 50 implanted ^{130}Cd isomers.





*A. Banu *et al.*, PRC **72**, 061305(R) (2005)

Conclusions

- The $LaBr_3$ array in a configuration of 960 detectors with the dimensions of 15 x 40 x 80 mm^3 fulfills the set requirements on energy resolution and photopeak efficiency at the relativistic secondary beam energies of the RIBF.
- The high granularity and efficiency of the array make it a powerful tool to study γ-γ angular correlations.
- Only few implanted isomers are necessary to reconstruct level schemes. Therefore, the array is a dedicated equipment for the spectroscopy of very weakly produced isomers.