

GEANT4 SIMULATIONS FOR THE R3B CALORIMETER

EURONS

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• Summary and Future work





(Facility for Antiproton and Ion Research)





R³B Experiment

(Reactions with Relativistic Radiactive Beams)

Studies of reactions in inverse full kinematics Reactions to be considered in R3B experiment:

- Elastic and quasi-elastic scattering
- Coulomb excitation
- Knockout reactions
- Total-absorption and charge-exchange reactions
- Fission and spallation
- Fragmentation and multifragmentation





Madrid, January 19th 2009





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CALIFA's Requirements





Prime mission: measure γ (50 keV – 25 MeV) with optimal energy resolution (ideally < 5%)

R³B Calorimeter Collaboration:

USC (Spain), LUND (Sweden), IEM (Spain), GSI (Germany), Chalmers (Sweden), Daresbury (UK), Univ. Complutense (Spain), KTH Stockholm (Sweden), IPN Orsay (France), JINR (Russia), TUD (Germany), TUM (Germany)

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CALIFA's Structure



Based on angular distribution of emitted γ rays and its corresponding Doppler shift (because of γ rays sources are moving with relativistic energies).

- **Barrel:** Region from $\sim 40^{\circ}$ up to 130° in polar angles
- Forward endcap: From $\sim 7^{\circ}$ up to $\sim 40^{\circ}$







Forward endcap: Phoswich?

- Contribute to **design of CALIFA's forward endcap.** In principle, we'll record:
 - \circ γ -rays in the energy region 50 keV 25MeV (~50% of total γ -rays emitted by a moving source)
 - Protons up to 300 MeV in Lab system
- Our suggestion: two new generation scintillators crystals layers in a phoswich configuration with only one common readout (crystals must be optically compatibles).
 - For **protons**: useful for particle telescope $\Delta E/E$ identification: solve ambiguity



$$-\frac{dE}{dx} = Kz^2 \frac{Z}{A} \frac{1}{\beta^2} \left[\frac{1}{2} \log \frac{2m_e c^2 \beta^2 \gamma^2 T_{\text{max}}}{I^2} - \beta^2 \right]$$

Deposited energy by a charged particle in a material according to **Bethe-Bloch equation**

• For **gammas**: energy and efficiency optimization at reduced cost



Experimental tests

• Phoswich: $LaBr_3$ (3 cm) + $LaCl_3$ (5 cm)



ST. GOBAIN PHOSWICH



HAMAMATSU R5380 PMT

Material	Energy Resolution (at 662 keV) (%)	Light yield (photons/keV γ)	Decay time (ns)
LaBr ₃	2.9	63	16
LaCl ₃	3.8	49	28

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ENERGY SPECTRUM WITH GATE A



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Crystals optimization: simulations

- Geant4 simulations purposes
 - Comparison with experimental tests in our Lab
 - Search for the best material and size of each crystal (following CALIFA's requirements)
 - Analysis of energy transfer to the neighboring crystals: very important for electronic components (coincidences and summing)

First configuration analyzed is:

- LaBr₃ in a 3x3 array.
- 20x20 mm² frontal surface of each crystal
- Total energy deposited (9 crystals)
- Gamma-rays from 500 keV up to 30 MeV
- Incidence on central crystal
- Distance source-detector = 20 cm





First crystal length

Studying first interaction depth for LaBr₃: we need to make sure that gamma particles interact in first crystal



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How long must be 2nd crystal?

Studying Photopeak efficiency



improve: a hint about total phoswich length

Energy transfer

to neighboring cristals







• Better photopeak efficiencies for 5x5 array (about 5 % for 7 cm length)

• Next tests: compare results for 5x5 with 7x7



Total Crystal's Volume



- Total Crystal's Volume: Variation with respect to inner radius analysis
- At present, inner radius in barrel is stablished to be 300 mm



 If we reduce inner radius to 200 mm, volume of detector material used is about 50 % (with the same crystal length)





- Necessary to sum more neighboring crystals (as shown 5x5 better efficiency than 3x3)
- Phoswich dimensions: two crystals 7 + 8 [cm] or one crystal 15 cm
- Transmit to the rest of collaboration:
 small reduction of inner radius = big reduction of cost (# crystals as well as # readout channels)

Future work

- Perform simulations with protons
- Introduce real dimensions of crystals
- Implementation of LITRANI code for creation and propagation of scintillation photons to obtain realistic spectra with energy resolution of crystals





MAGISOL meeting





Thank you for your attention