NUSTAR Calorimeter WG activity report

Milan, October 2006

NUSTAR CALORIMETER Working Group

Coordinator : D. Cortina

R3B (D.Cortina) / EXL (J.A. Scarpaci)

Created in : February 2005 after the NUSTAR collaboration

Goal: Find synergies between the different calorimeters in NUSTAR (R&D, Desing phase, but also common front to negociate with providers)

List : 41 members, 21 Institutions , 10 countries,

Meetings

- February 2005 GSI, Darmstadt (Germany)
- June 2005 Valencia (Spain)
- Informal meeting , September 2005, Orsay (France)
- September 2005 Santiago de Compostela (Spain)
- February 2006, IPN Orsay (France)
- September 2006, Krakow (SPIRAL)
- October 2006, Milano (Italy)

Technical Proposal (2005)

Total absorption efficiency	80 % ($E\gamma$=15 MeV lab R3B) ($E\gamma$=2-4 MeV lab EXL)	Very large crystals
$E\gamma$ sum	$\sigma(E_{sum})/\langle E_{sum}\rangle$ <10%	
γ Multiplicity	$\sigma(N_\gamma)/\langle N_\gamma\rangle$ < 10%	
$\Delta E/E$ for γ	2-3 %	Scintillation properties Detector granularity
$\Delta E/E$ for p (up to 300 MeV) Calorimeter for p	1 %	Large crystals Dynamic range

Large dynamic range for detecting p,γ

Inner radius ~ 30 cm (house Si trackers)

UHV compatible for EXL

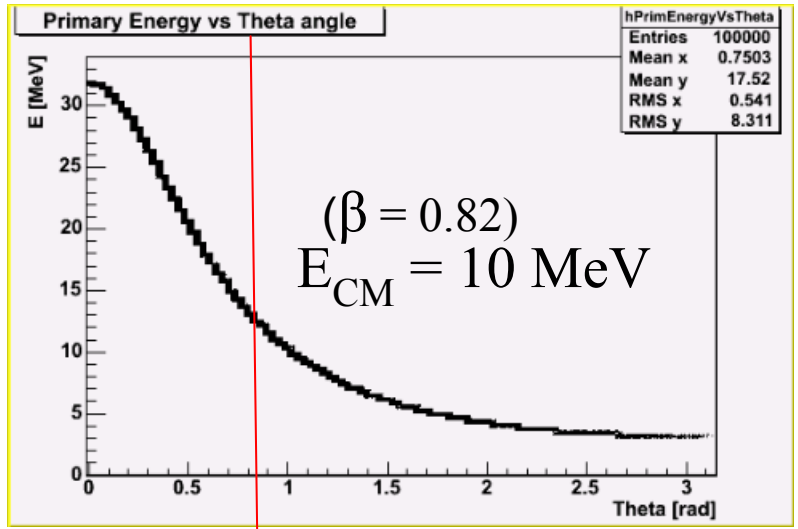
Affordable cost!!!

Experimental constraints

Gammas are emitted with energies up to

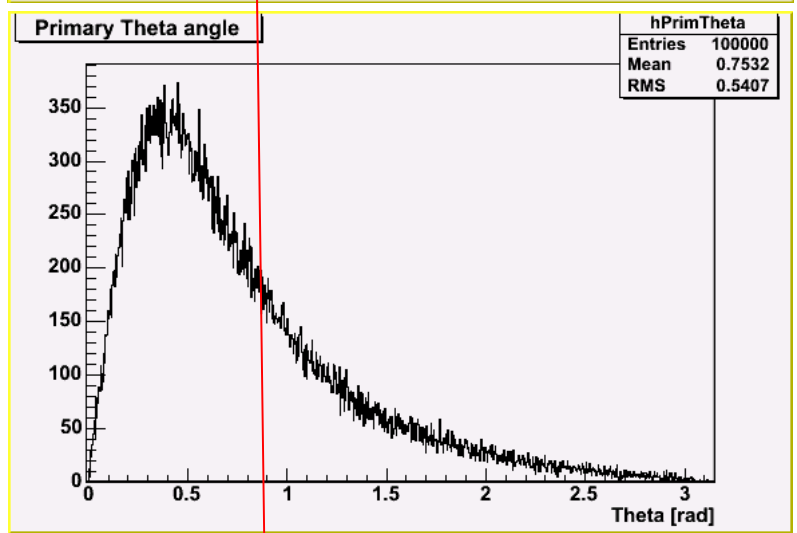
$E_{lab} = 3.2\ E_{CM}$ (for β = 0.82 ~ A. MeV700 MeV)

- A huge crystal length is required for full energy absorption



The angular distribution of the emitted gammas is peaked in the forward direction.

- allows a certain optimization of the angular coverage



The forward angular region will be the most delicate part

Crystal properties

		$LaBr_3$	$LaCl_3$	NaI(Tl)	CsI(Tl)	CsI(Na)	BGO	LYSO	PWO	CsI (pure)*
Density (g/cm^3)		5.29	3.86	3.67	4.51	4.51	7.13	7.10	8.29	4.51
Light Output (ph/MeV)		63,000	49,000	39,000	52,000	45,000	9000	32,000	100	16,800
ΔE/E (FWHM) @662 keV	PMT	<3%	3.5%	7%	6%	7.5%	10%	7.1%	>10%	7.5%
	APD	N/A	N/A		4.9 %	N/A	8.3%	N/A	N/A	4.3 %
Peak λ (nm)		380	350 430	310 ***fast*** 415	550	420	480	420	420	315
Fast Decay (ns)		25	25/213	620 ***fast*** 230	1000	630	300	41	6	35/6
Hygroscopic		yes	yes	yes	slightly	yes	no	no	no	slightly
Cost (per cm^3)		$30	$30	$2	$4.50	$4.50	$9	$25	$2	$4.50
Radiation lenght (cm)		N/A	N/A	2.9	1.86	1.86	1.1	1.2	0.85	1.86

!?

GSI, Lund,Dubna, USC, IPNO,IEM,UCM

Resolutions

CsI(Tl)+VM2000+APD/PMT+^{137}Cs

J.Peyre IPNO

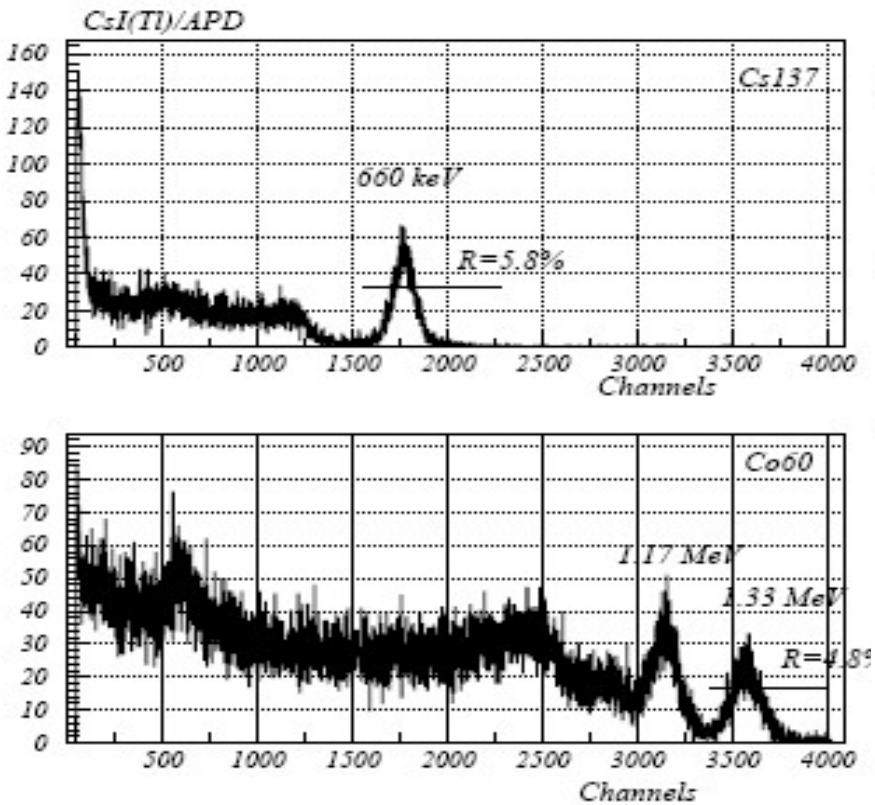
Summary of USC Crystal tests

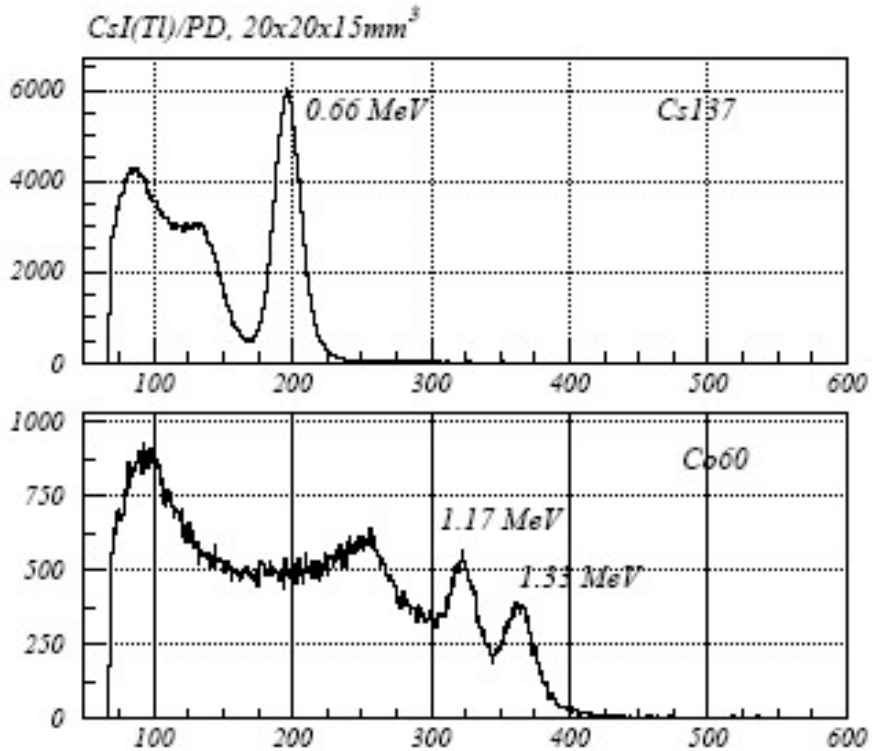
XP1918	XP1901	XP3102	S8664-10	
6.07 %	7.03%	9.06%	***5.15 %***	**1x1x1cm**
7.42%	8.45%	9.87%	***6.28%***	**1x1x5 cm**
10.71%	12.76%	15.70%	***6.31%***	**1x1x10 cm**

Energy resolution for CsI(Tl) with a ^{137}Cs (662 keV) source

Comparison of CsI/APD and CsI/PD energy resolution

Eγ=0.66 MeV	**ΔE/E=5.8%**	**ΔE/E=12.0%**
Eγ=1.33 MeV	**ΔE/E=4.8%**	**ΔE/E=7.1%**

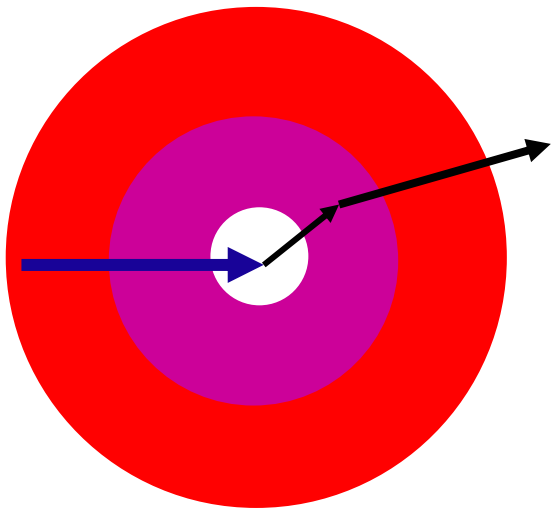




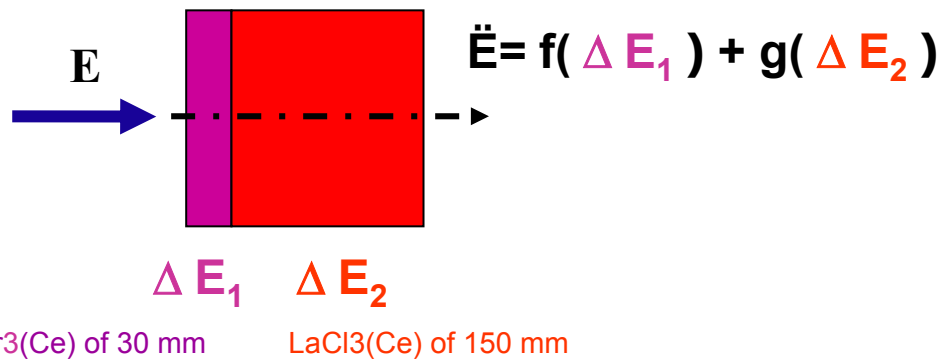
R.Wolski Dubna

Proposed scenario

- *Two layers detector*:

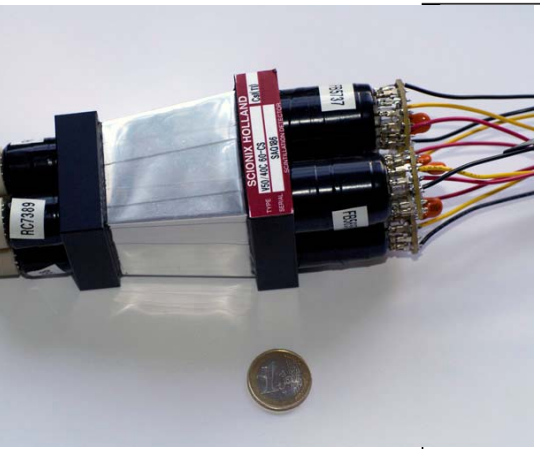


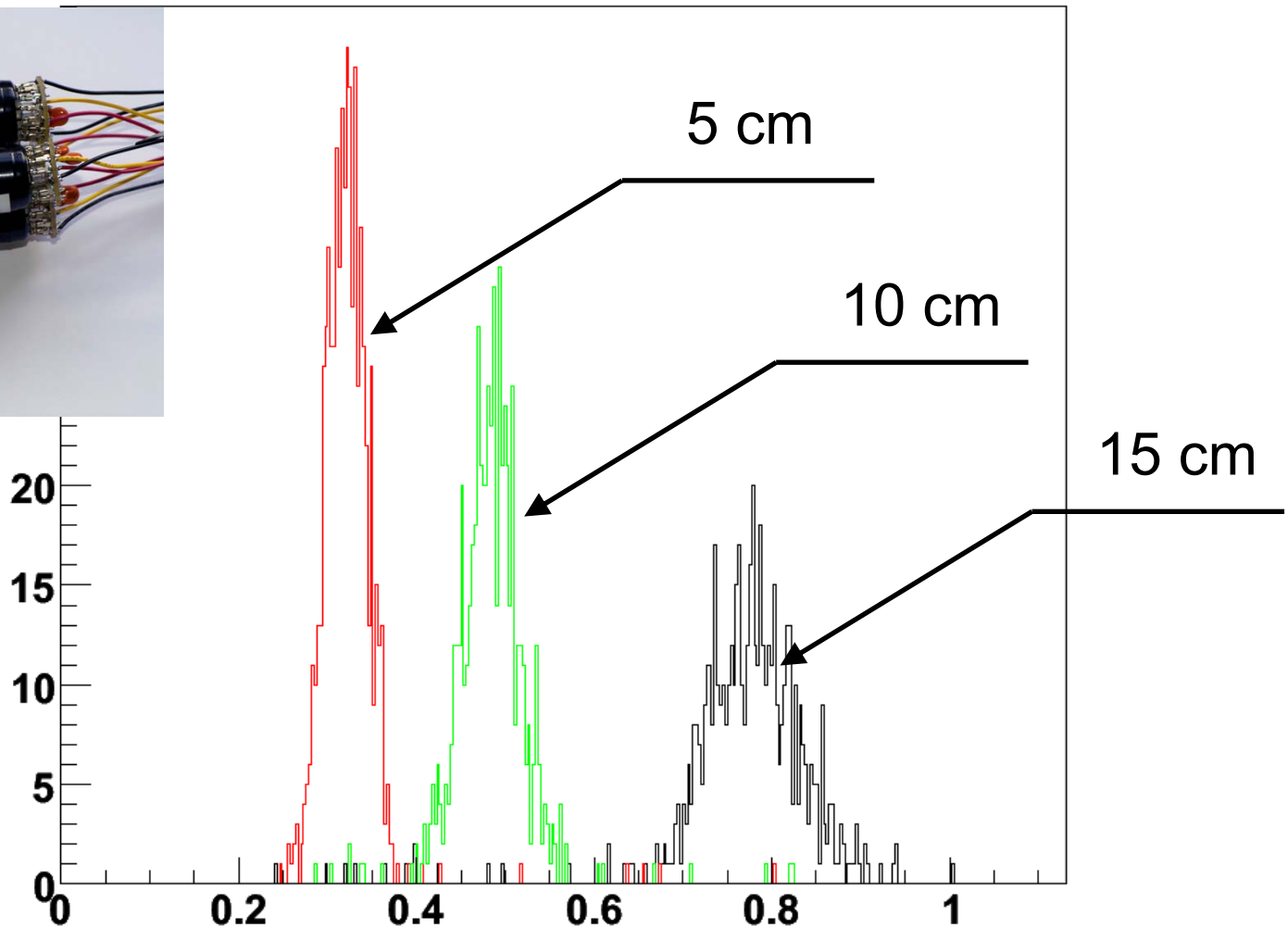
- *Simplificatio n*



the estimated final energy is proportional to the energy deposited in each layer

Position resolution (ratio of the PMT's energies)





Light division between 2 PMTs

Main conclusion from crystal+readout test

✓ For intermediate-backward angles CsI(Tl) could be a solution

best results correspond to an adequate matching between the spectral response of crystal and readout , and to an optimized ratio between the back crystal and readout areas

- CsI(Tl)+square PM
- CsI(Tl)+APD with light guides

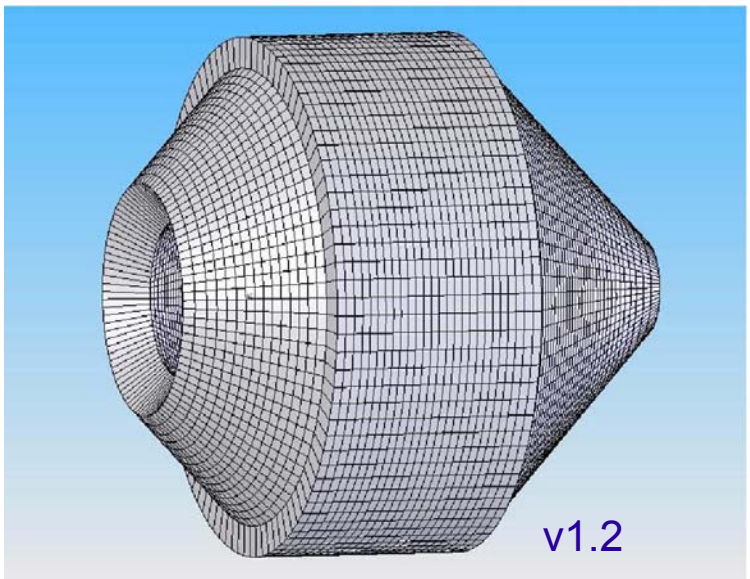
✓ For CsI, the readout with PD has to be considered

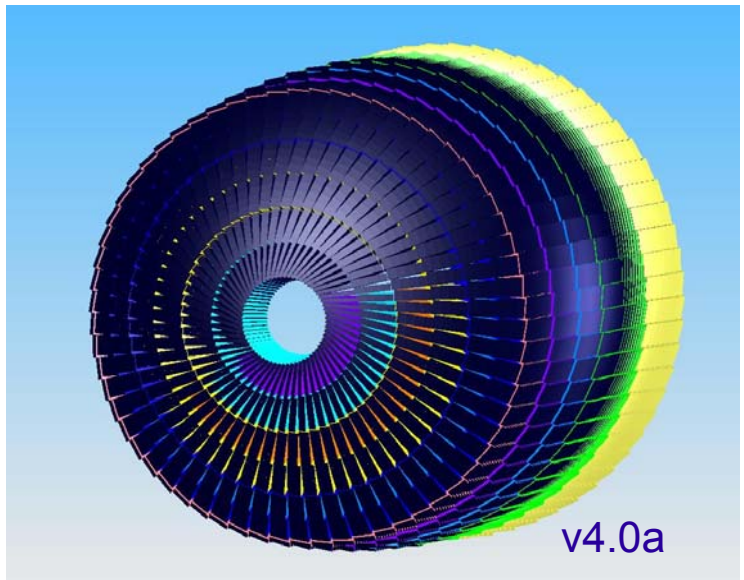
✓The forward angular region needs deeper investigation

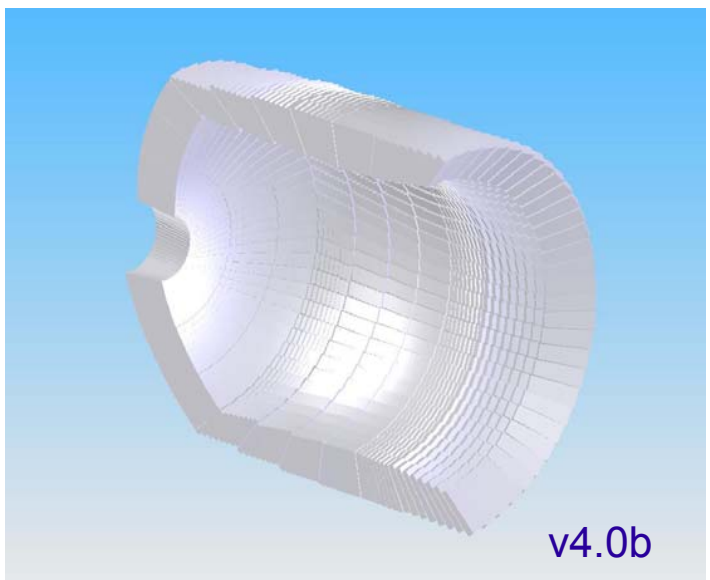
new crystal materials and new concepts

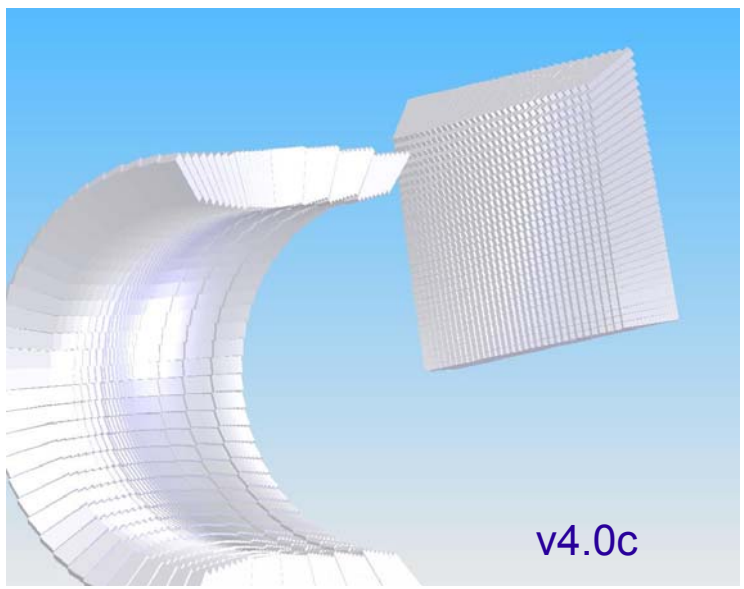
- CsI(undopped), LaCl, LaBr
- 2 step concept needs to be experimentally validated (single readout or individual readout)
- 2 sides readout test do not provide a definite answer

Calorimeter models (CAD)

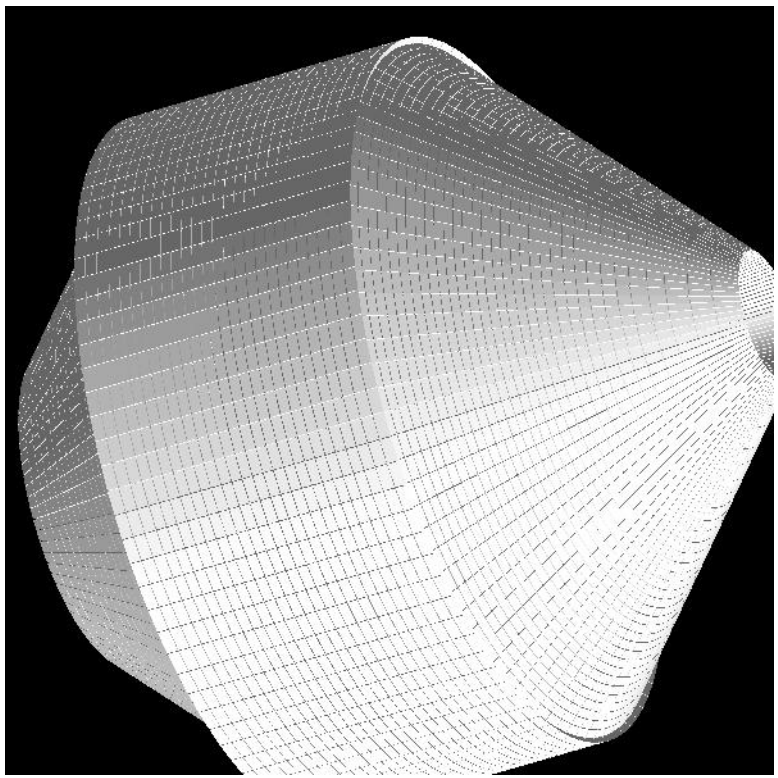




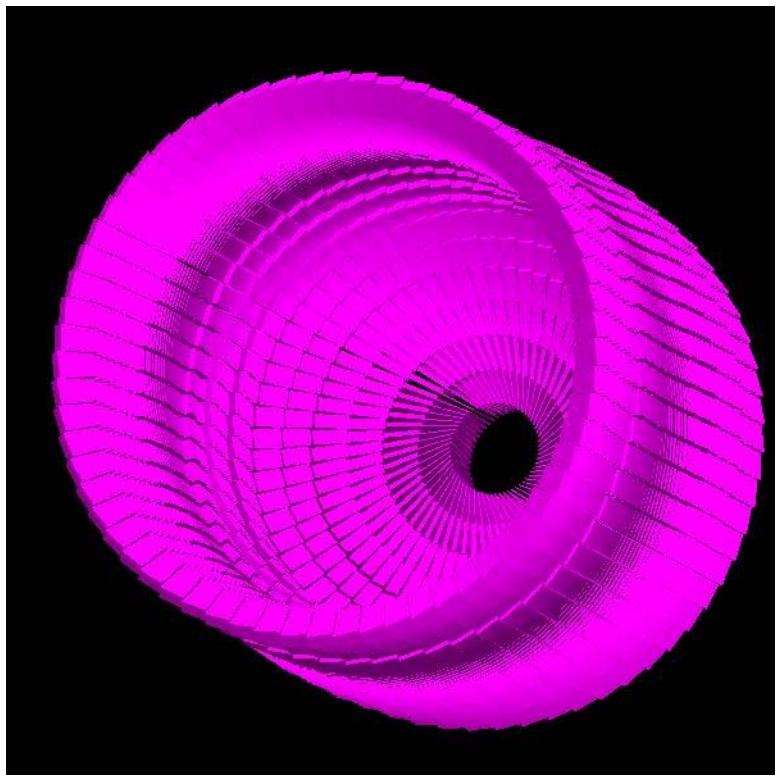




Calorimeter models (GEANT4)
Detailed simulations



v1.2



v4.0a
v4.0b

H.Alvarez USC

Main conclusions from simulations

✓Detailed mechanical study (crystal arrangement, mechanical support solution…) is needed

✓Close interaction between mechanical engineers and ¨simulators¨ are very important

✓Full simulations are very valuable source of information

- Lund group joint the G4 group (EXL)
- the response with p has to be investigated
- 2 step concept needs to be simulated and integrated in a ¨realistic¨ calorimeter

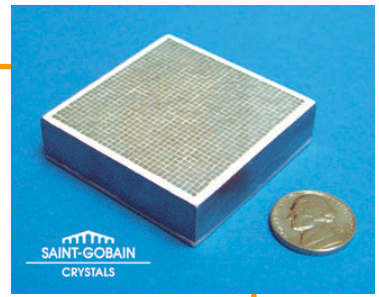
R&D Actions before our next meeting (Apr 07)

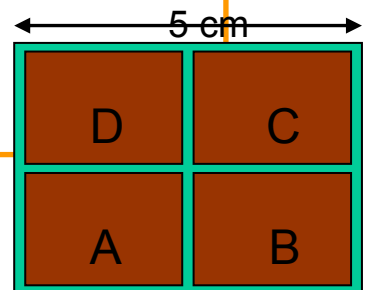
Backward CsI(Tl)

- ✓ squared PM — IPNO
- ✓ improve light collection — USC,IPN
- ✓ test readout PD/APD — USC,GSI,LUND,DUBNA
- ✓ Test CsI(Tl) from other providers
  - Monocrystal (Ukraine) — LUND,DUBNA
  - IMP, Lanzhou (China) — USC, GSI
  - others — IPNO

Forward

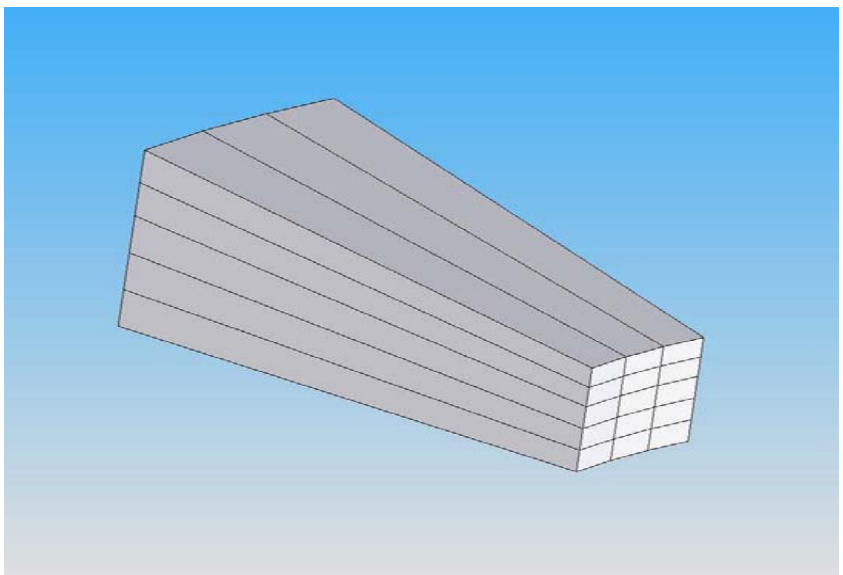
- ✓ Test of CsI(undopped) — GSI,USC
- ✓ Test of LaCl — USC,IPN
- ✓ Test of two step concept — IEM
- ✓ Test of monoblock crystal — GSI





Barrel Prototype

✓ **Beam-test of the Barrel concept with a realistic prototype:**



- ✓ 15 crystals (approx. 4.4 x 1.6 x 12 cm^3)
- ✓ APDs S8664-10 (Hamamatsu) — USC
- ✓ mechanical structure → IPNO concept
- ✓ temperature and voltage stabilisation — GSI, IPN ??
- ✓ full simulation — USC
- ✓ electronics → PANDA pre-amp
  flash ADC (PICA ,...?) — USC, ??
- ✓ DAQ → VME/MBS — GSI

- part of the ¨demonstrator¨
- construction of other prototypes

Beam-lines available for proton and gamma tests

ACULINNA: Mass separator at JINR, Dubna [A. M. Rodin et al., Nucl. Instr. Meth. B 204 (2003) 114] p, d, t, α etc

MAX-lab: New tagged photon beam-line from MAX electron synchrotron [J-O Adler et al. Nucl. Instr. Meth. A 388 (1996) 17] 10 – 230 MeV photons

TSL/GWC: Cyclotron at The Svedberg Lab., Uppsala [L-O Andersson et al., TSL Progress report 1987-1991 p. 10] p up to 180 MeV, d, t, α

+ GSI

+ Tandem UAM

B.Jakobsson Lund

05/10/2006 Milan

NUSTAR Calorimeter Working Group Meeting

Working Package definition

Time

Work package	R3B	EXL
Crystal-readout	USC, IEM,GSI	IPNO,GSI,Lund, Dubna
General design	USC	IPNO
Simulations	USC, IEM	Lund, IPNO
Mechanics		
Electronics		
Slow control		
Beam tests		

05/10/2006 Milan

NUSTAR Calorimeter Working Group Meeting

Organisative issues

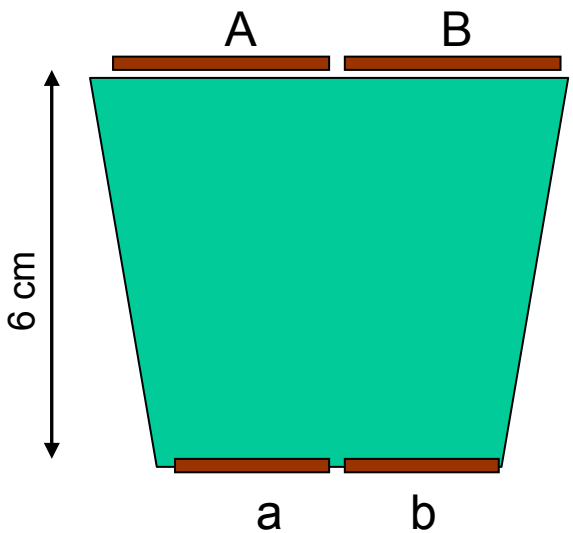
- ✓ Internal MoU (i.e. DAQ WG)

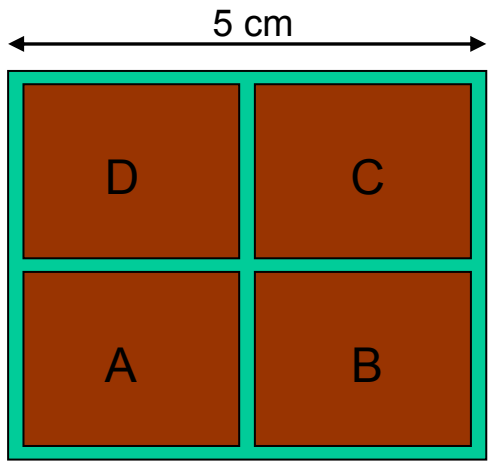
- ✓ European Money (FP7)

Name	Institution	Country
D. Cortina ,I.Durán,H.Alvarez, J.Benlliure, E.Casarejos	Santiago University	Spain
O. Tengblad, M.J.G: Borge, M. Turrión	IEM– CSIC Madrid	Spain
B. Rubio, J.L. Taín	IFIC CSIC-UV Valencia	Spain
L. M. Fraile, J.M. Udías	Complutense Uni. Madrid	Spain
J. Gerl , T. Aumann	GSI Darmstadt	Germany
O. Kisselev	Mainz University	Germany
H. Scheit	MPI Heidelberg	Germany
P. Reiter	Cologne University	Germany
D. Cullen, S. Freeman	Manchester University	UK
R.Lemmon	CCLRC Daresbury Lab.	UK
K. Spohr , M. Labiche	Paisley University	UK
P. Nolan	Liverpool University	UK
A. Maj , M. Zieblinski, M. Kmiecik	Krakow University	Poland
A.Algora	Debreecen	Hungary
L. Batist	St Petersburg	Russia
A. Artukh	JINR Dubna	Russia
V.Avdeichikov , B. Jacobsonn	Lund	Sweden
J.A. Scarpaci , Y. Blumenfeld, F. Skaza, J. Pouthas, Zerger, J. Perey	IPN Orsay	France
E. Pollacco	CEA Saclay	France
W. Zhang		China
R. Palit, I. Mazumdar	TIFR Mumbai	India

Other concepts

Large position sensitive $LaBr_3$:Ce detector

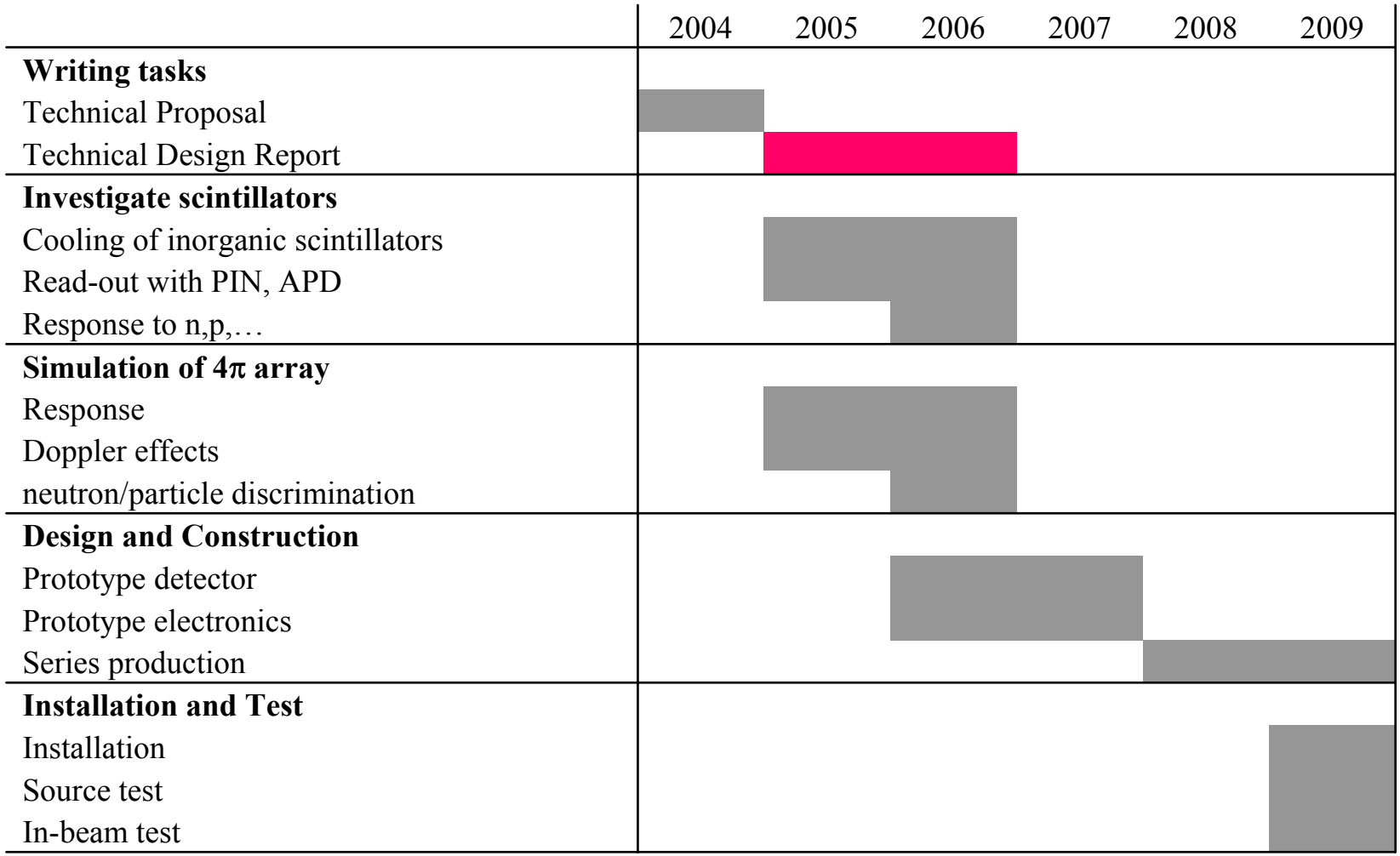




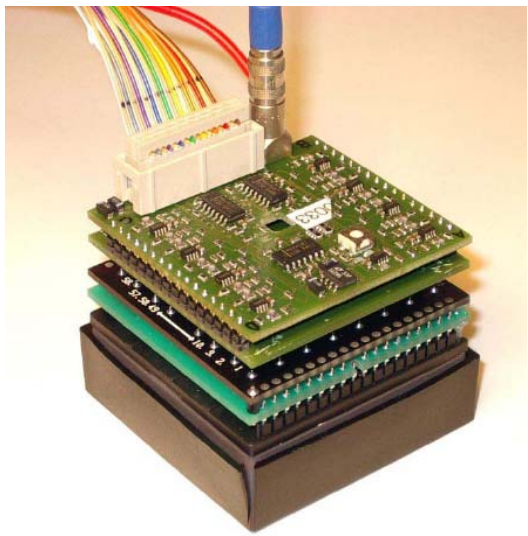
$E = \Sigma (E_a ... E_D)$

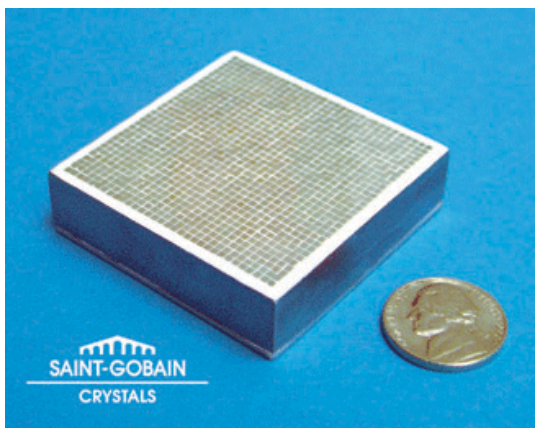
pos(x,y,z) = centroid of light distribution

Time schedule



Other concepts



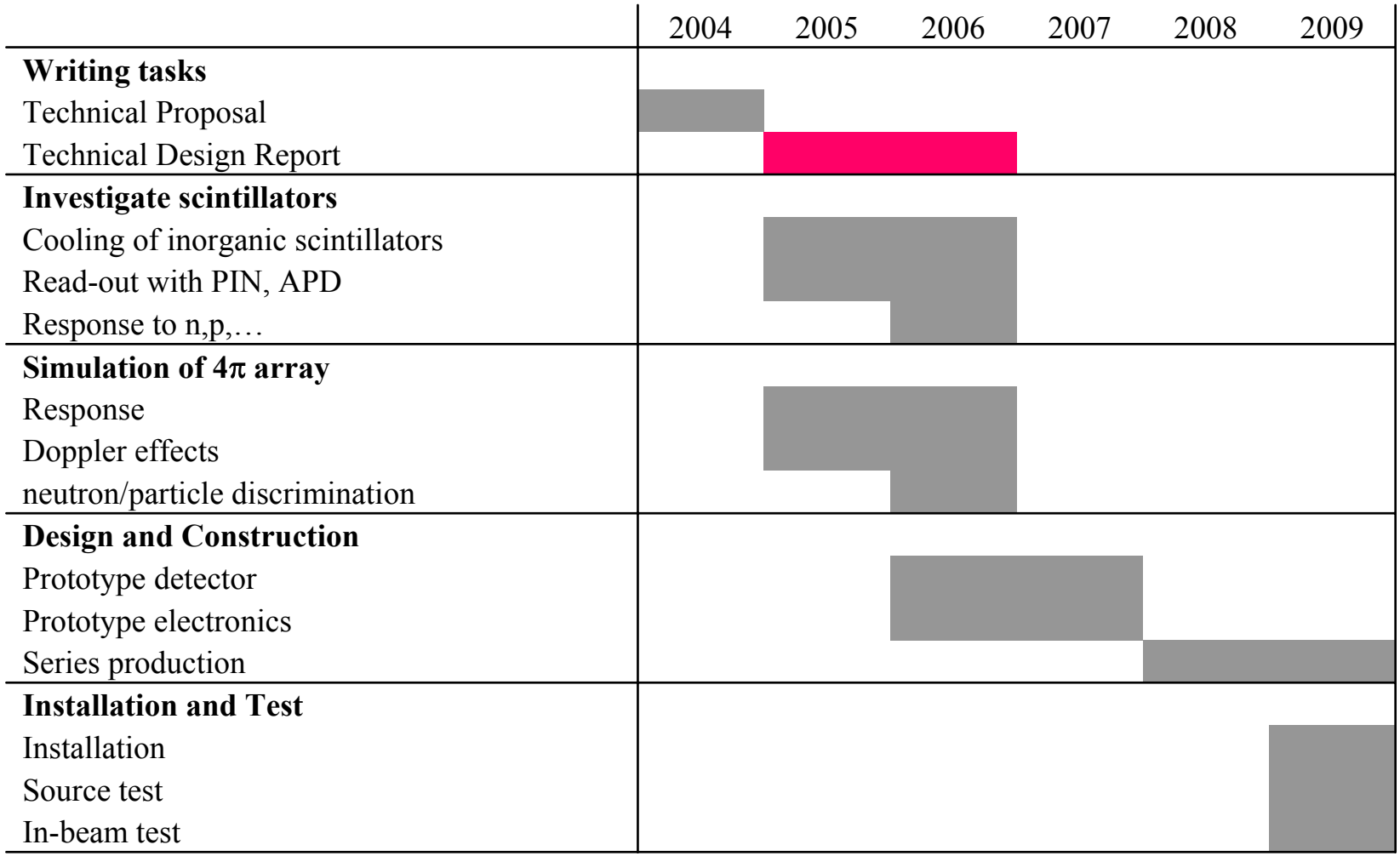


- ✓Two H8500 Flat panel Photomultiplier tube
- ✓MPET-H8500 readout interface
- ✓Two scintillating arrays:
  - Array BrilLanCe 380

    Full detection area 2"x 2", 4x4x30 mm^3, encapsulated in Al housing, 3mm glass window
  - Array PreLuDe 420

    Full detection area 2"x 2", 4x4x30 mm^3
- ✓*Spatial resolution for proton detection*
- ✓*γ absorption energy resolution*

Time schedule



What the Lund/Dubna group wishes to achieve until next annual meeting

- **produce two* close-to-final (forward) EGPA clusters**

  requires CsI(Tl) decided (alternatives?,doping conc?)

  from geometry decided (length?, square **and** rectangular.*)

  Milano: readout device decided (APD or PD?)

- **put these clusters in correct EXL recoil detector setup (dummy)**

  requires exact design of ESPA for D-section (foil, thicknesses)

  from HV or air (if HV – what wall?)

  Milano:

- **make complete GEANT4 simulations for these clusters**

  requires we agree on the input for resolution and efficiency limiting effects

  from establish direct cooperation with Orsay group, others?

  Milano:

- **test the clusters in-beam with both protons and photons**

  requires from acceptance of beamtime and beamline design

  TSL, MAX-lab (preliminarily accepted)

  and ACULINNA:

B.Jakobsson LUND