David Jenkins

Department of Physics, University of York, UK

PARIS – a novel calorimeter for medium-resolution gamma-ray spectroscopy

paris.ifj.edu.pl

European Gammapool Workshop

May 27-30, 2008, Paris

Goal of the PARIS Collaboration:

Design and build high efficiency detector consisting of two shells for medium resolution spectroscopy and calorimetry of γ-rays in large energy range

Inner (hemi-)sphere, highly granular, will be made of new crystals (LaBr3(Ce), LaCl3, CeZnTe), rather short (up to 5 cm). The readout might be performed with APDs or with digital electronics which would offer the possibility of pulse shape analysis.
The inner-sphere will be used as a multiplicity filter of high resolution, sum-energy detector (calorimeter), detector for the gamma-transition up 10 MeV with relatively good resolution (better than 3%), and as an absorber for the large detectors behind. It will serve also for fast timing application.

Outer (hemi-)sphere, with lower granularity but with high volume detectors, rather long(at least 15 cm), could be made from conventional crystals (BaF2 or CsI), or using existing detectors (Chateau de Crystal or HECTOR).
The outer-sphere will measure high-energy photons or serve as an active shield for the inner one.

The PARIS collaboration (status on 8.5.2008)

IFJ PAN Kraków (Poland): P. Bednarczyk, M. Kmiecik, B. Fornal, J. Grębosz, A. Maj, W. Męczynski, K. Mazurek, S. Myalski, J. Styczeń, M. Ziębliński, M. Ciemała, A. Czermak. R. Wolski
IPN Orsay (France): F. Azaiez, J.A. Scarpaci, S. Franchoo. I. Stefan
CSNSM Orsay (France): G. Georgiev, A. Lefebvre-Schuhl
University of York (UK): D.G. Jenkins, M.A. Bentley, B.R . Fulton, R. Wadsworth, O. Roberts
IPN Lyon (France): Ch. Schmidt, O. Stezowski, N. Redon
IPHC Strasbourg (France): O. Dorvaux, S. Courtin, C. Beck, D. Curien, B. Gall, F. Haas, D. Lebhertz, M. Rousseau, M.-D. Salsac, L. Stuttgé, J. Dudek
GANIL Caen (France): J.P. Wieleczko, S. Grevy, A. Chbihi, G. Verde, J. Frankland, M. Płoszajczak, A. Navin, G. De France, M. Lewitowicz
LPC-ENSI Caen (France): O. Lopez, E. Vient
Warsaw University (Poland): M. Kicińska-Habior, J. Srebrny, M. Palacz, P. Napiórkowski
IPJ Swierk, Otwock (Poland): M. Moszyński
BARC Mumbai (India): D.R. Chakrabarty, V.M. Datar, S. Kumar, E.T. Mirgule, A. Mitra, P.C. Rout
TIFR Mumbai (India): I. Mazumdar, V. Nanal, R.G. Pillay
University of Delhi, New Delhi (India): S.K. Mandal
University of Surrey, Guildford (UK): Z. Podolyak, P.R. Regan, P. Stevenson
GSI Darmstadt (Germany): M. Górska, J. Gerl, S. Pietri
University of Oslo (Norway): S. Siem
Oak Ridge (US): N. Schunck
ATOMKI Debrecen (Hungary): Z. Dombradi, D. Sohler, A. Krasznahorkay, G. Kalinka, J.Gal, J.Molnar
INRNE, Bulgarian Academy of Sciences, Sofia (Bulgaria): D. Balabanski,
University of Sofia (Bulgaria): S. Lalkovski, K. Gladnishki, P. Detistov
NBI Copenhagen (Denmark): B. Herskind, G. Sletten
UMCS Lublin (Poland): K. Pomorski
HMI Berlin (Germany): H.J. Krappe
LBNL, Berkeley, CA (US): P. Fallon, M.-A. Deleplanque, F. Stephens, I-Y. Lee
iThemba LABS (RSA): R. Bark, P. Papka, J. Lawrie
DSM/Dapnia CEA Saclay (France): C. Simenel
INFN-LNS, Catania (Italy): D. Santonocito
Institute of Nuclear Physics, NCSR "Demokritos", Athens (Greece): S. Harissopulos, A.
Istanbul University, Instambul (Turkey): M.N. Erduran, M.Bostan, A. Tutay, M. Yalcinkaya,
Nigde University, Nigde (Turkey): S. Erturk
Erciyes University, Kayseri (Turkey): **I**.. Boztosun
Ankara University, Ankara (Turkey): A. Ataç-Nyberg
Kocaeli University, Kocaeli (Turkey): T. Güray
Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia: A. Fomichev, S. Krupko, V. Gorshkov.
Uppsala University, (Sweden): H. Mach
KVI, Groningen, (The Netherlands): M. Harakeh
INFN and University Milano (Italy): S Brambilla, F. Camera, S. Leoni, O. Wieland.
LPSC Grenoble(France): G. Simpson
The Weizmann Institute Rehovot (Israel): M. Haas
INFN Napoli (Italy): D. Pierroutsakou
STFC Daresbury (UK): J. SImpson, J. Strachan, A. Smith, M. Labiche

39 institutions from 16 countries
≈ 100 physicists, engineers and PhD students

PARIS collaboration meetings

1. Orsay kick-off meeting, January 2007
2. Krakow, May 2007
3. Caen, November 2007
4. York, May 2008 *(partially supported by SP2PP@FP7)*

+ a number of informal meetings of the PARIS „activists"

PARIS Management board

A. Maj - project spokesman; D. G. Jenkins, J.P. Wieleczko, J.A. Scarpaci - deputies

PARIS Steering *(Advisory)* Committee

F. Azaiez (F) -chairman, D. Balabanski (BG), W. Catford (UK), D. Chakrabarty (India), Z. Dombradi (H), S. Courtin (F), J. Gerl (D), D. Jenkins (UK) - deputy chairman, S. Leoni (I), A. Maj (PL), J.A. Scarpaci (F), Ch. Schmidt (F), J.P. Wieleczko (F)

Active working groups

1. Simulations (O. Stezowski et al.)
2. PARIS mechanical design scenarios (S. Courtine, D. Jenkins et al.)
3. Physics cases and theory background (Ch. Schmitt et al.)
4. Detectors (O. Dorvaux, J. Pouthas et al.)
5. Financial issues (J.P. Wieleczko et al.)
6. PARIS in FP7 projects (A. Maj, F. Azaiez et al.)

PHYSICS CASES

NUCLEAR SHAPES

a) Jacobi shape transitions
^{120}Cd, ^{98}Mo, ^{71}Zn
(A. Maj, J. Dudek et al.)

b) Studies of shape phase diagrams of hot nuclei – GDR differential methods
$^{186-193}$Os, $^{190-197}$Pt
(A. Maj, I. Mazumdar et al.)

c) Hot GDR studies in neutron rich nuclei
128<A<144
(D.R. Chakrabarty, M. Kmiecik et al.)

ISOSPIN SYMMETRY

d) Isospin mixing at finite temperature
^{68}Se, ^{80}Zr, ^{84}Mo, ^{96}Cd, ^{112}Ba
(M. Kicińska-Habior et al.)

REACTION MECHANISMS

e) Onset of the multifragmentation and the GDR
120<A<140, 180<A<200
(J.P. Wieleczko, D. Santonocito et al.)

f) Reaction dynamics by means of γ-ray measurements
$^{214-222}$Ra, $^{118-226}$Th, $^{229-234}$U
(Ch. Schmitt, O. Dorvaux et al.)

g) Heavy ion radiative capture
^{24}Mg, ^{28}Si
(S. Courtin, D.G. Jenkins et al.)

High efficiency calorimetr for high energy γ-rays +

- a) **γ-multiplicity filter** + RFD or VAMOS or AD
- b) **γ-multiplicity filter**
- c) **γ-multiplicity filter** + RFD or VAMOS
- d) **γ-multiplicity filter**
- e) INDRA or FAZIA
- f) **γ-multiplicity filter** + RFD or VAMOS or CORSET-like
- g) LISE or RFD

Further Physics cases:

Fragmentation studies at RIKEN/GSI-FAIR
Coulomb excitation
Nuclear Astrophysics
(γ,π_0) with Crystal Ball at MAMI

Specifications for the array:

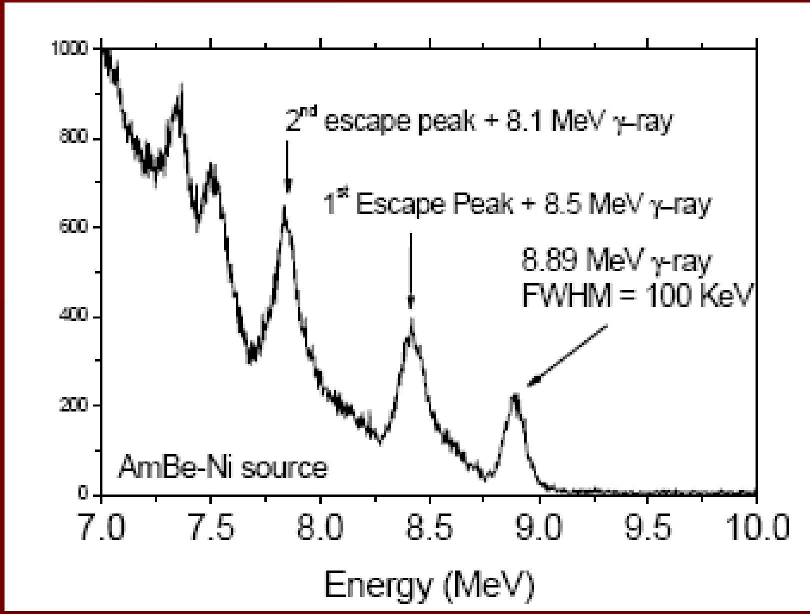
Fusion-evaporation (mainly), 5% < v/c < 10% (up to 25% - fragmentation)
But also v/c=0 and v/c=40-50% (in case we use it at FAIR)

Both shells shall be ***modular***
for easy coupling to other detectors
(e.g. **AGATA**, GASPARD, Neutron det., INDRA, FAZIA)

WG Detectors and electronics

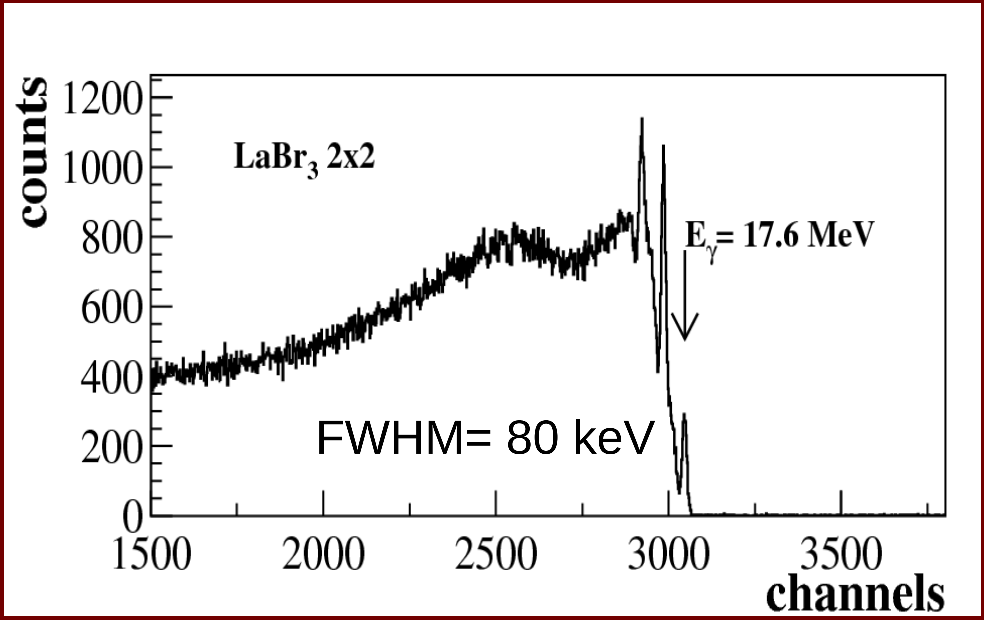
a) Tests of new LaBr3 cystals:

Milan group:
Source and 3"x3" crystal



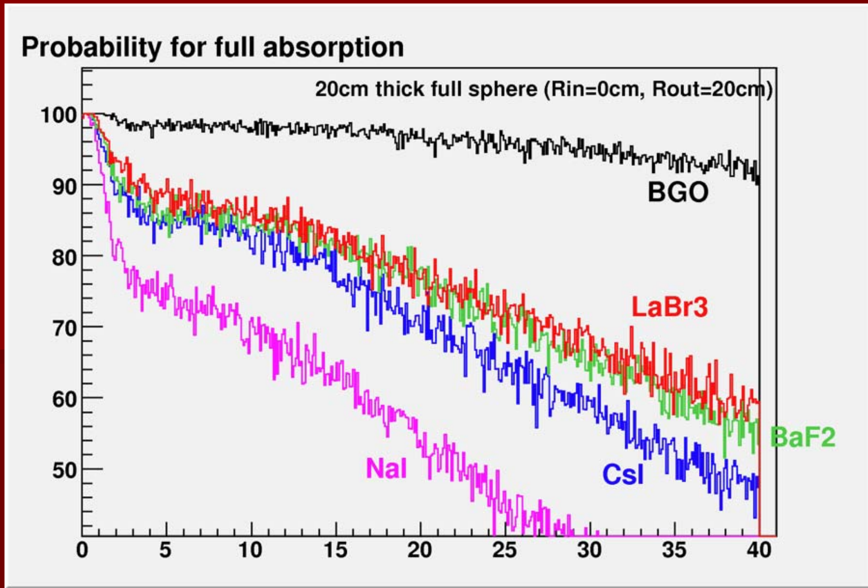
Debrecen-Sofia-Orsay-Krakow group:
(p,γ) reaction and 2"x2" crystal

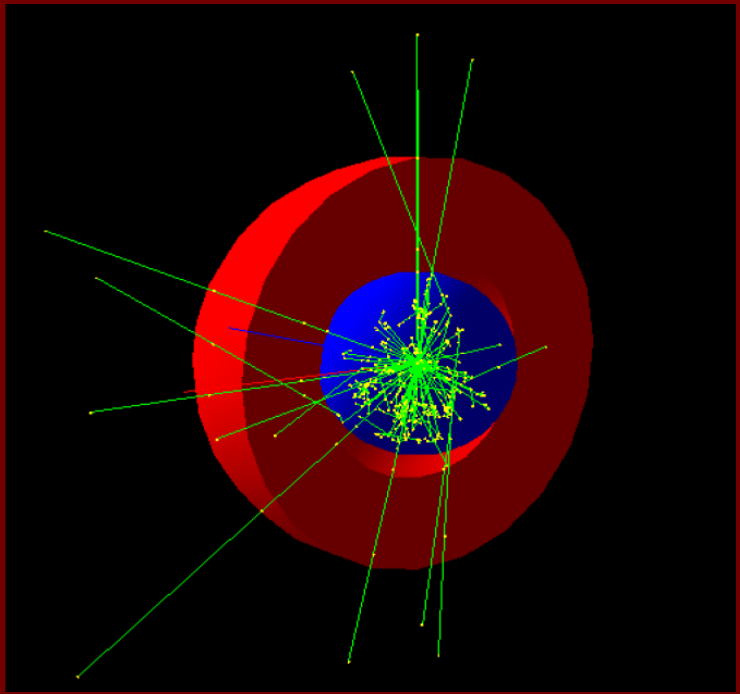
^{7}Li (p,γ) ^{8}Be, E(protons)=441 keV

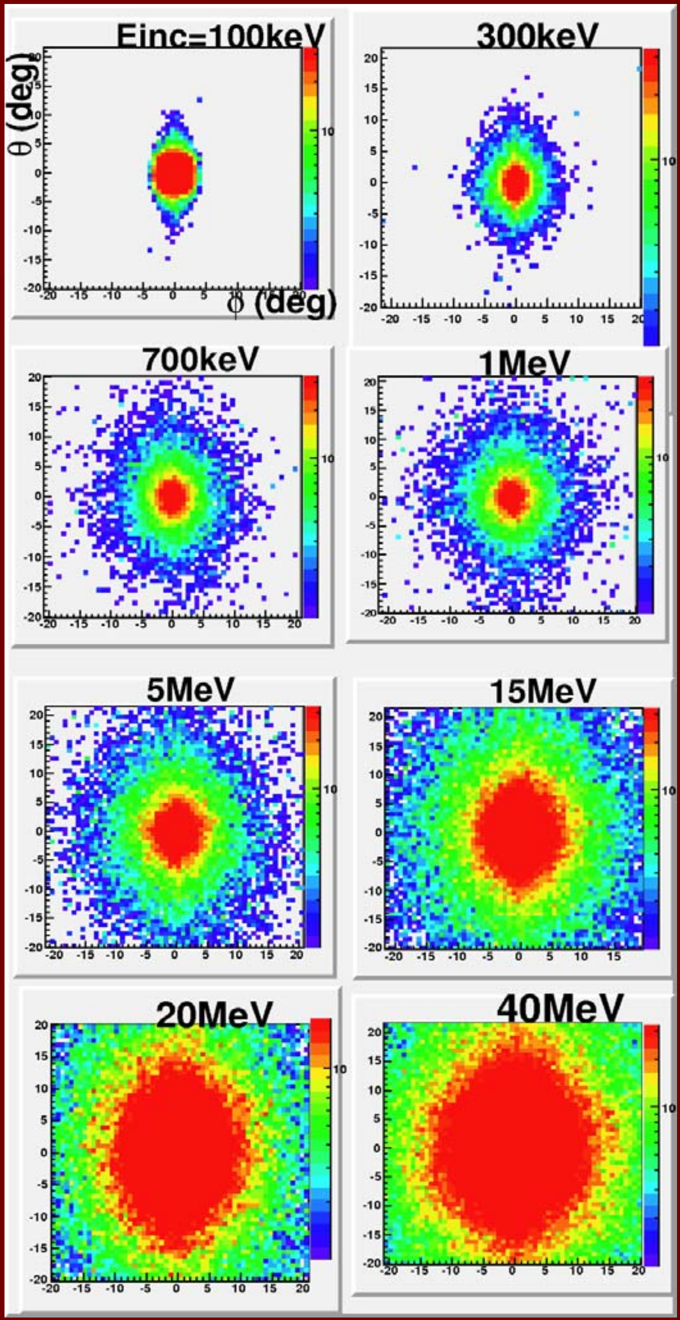


b) Tests of PM tubes and APDs:

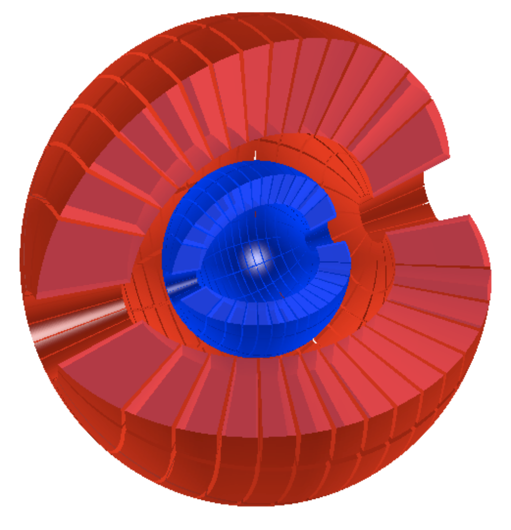
Strasbourg, GSI, Świerk, Milano


Probability for full absorption
20cm thick full sphere (Rin=0cm, Rout=20cm)
BGO
LaBr3
BaF2
NaI
CsI




Einc=100keV
θ (deg)
ϕ (deg)
300keV
700keV
1MeV
5MeV
15MeV
20MeV
40MeV

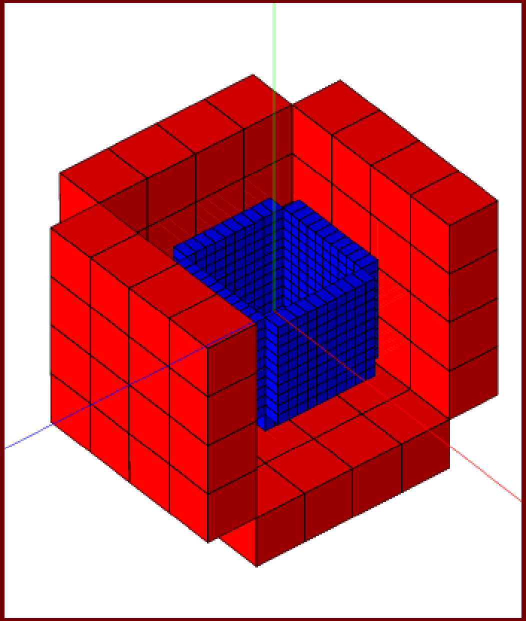
POSSIBLE GEOMETRIES of PARIS



SPHERICAL (e.g. same as AGATA modules):

+ : easy reconstruction, good line shape, compability with other spherical detectors,..

- : Limited to one distance, high cost of a segment,…



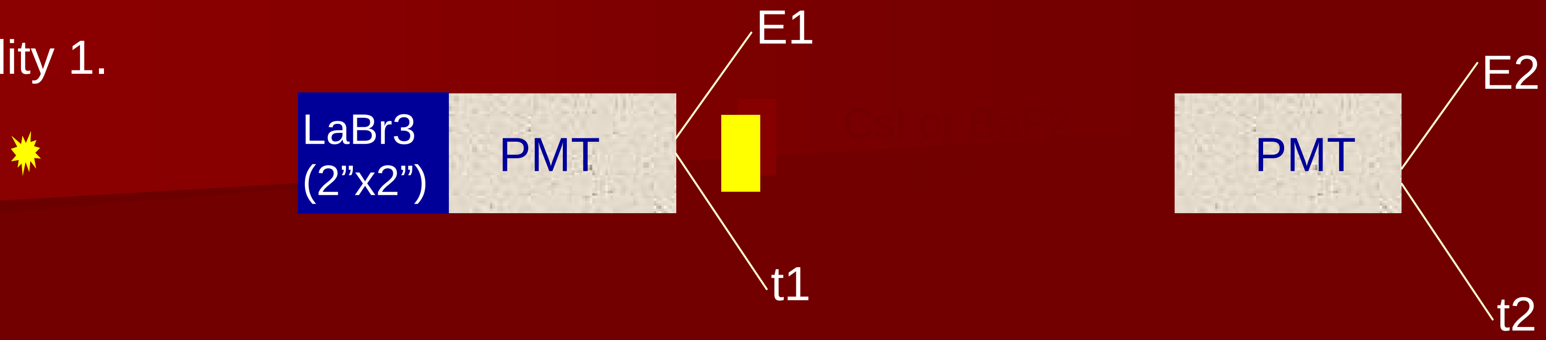
CUBIC (offering variable geometry):

+ : adjustable to different distances, compatibility with many detectors, lower cost for a segment, easier mechanical support,

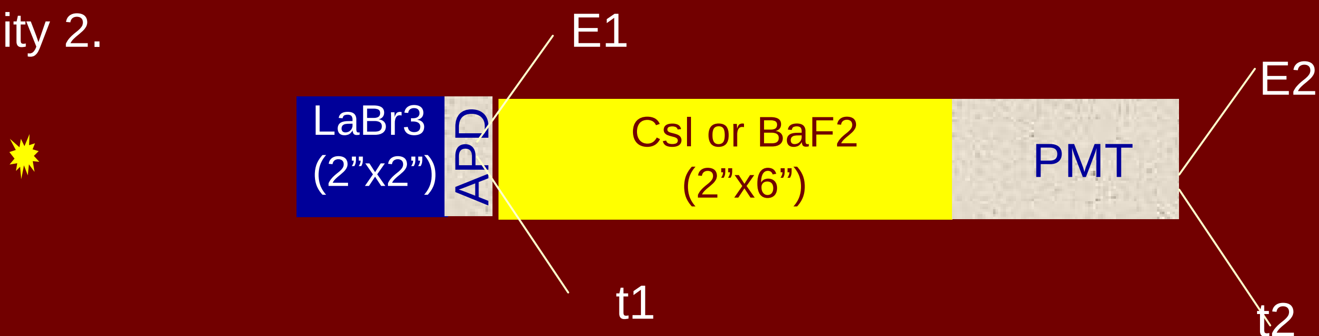
- : More complicated reconstruction, worse line shape, …

3 POSSIBILITIES FOR A „GAMMA-TELESCOPE” ELEMENT

Possibility 1.

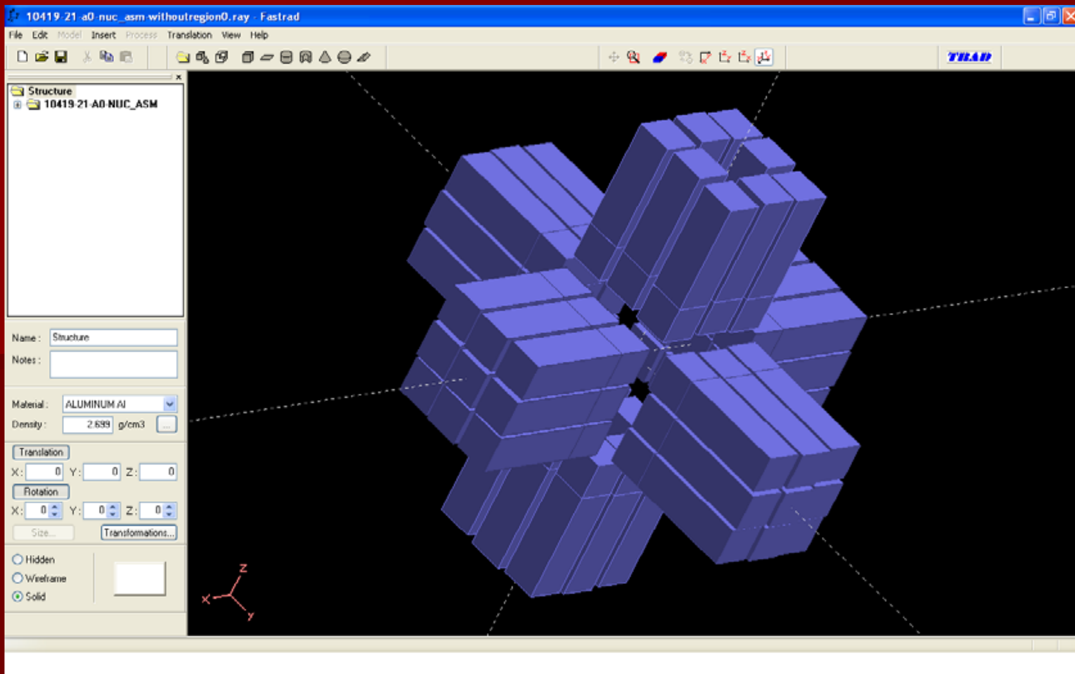


Possibility 2.



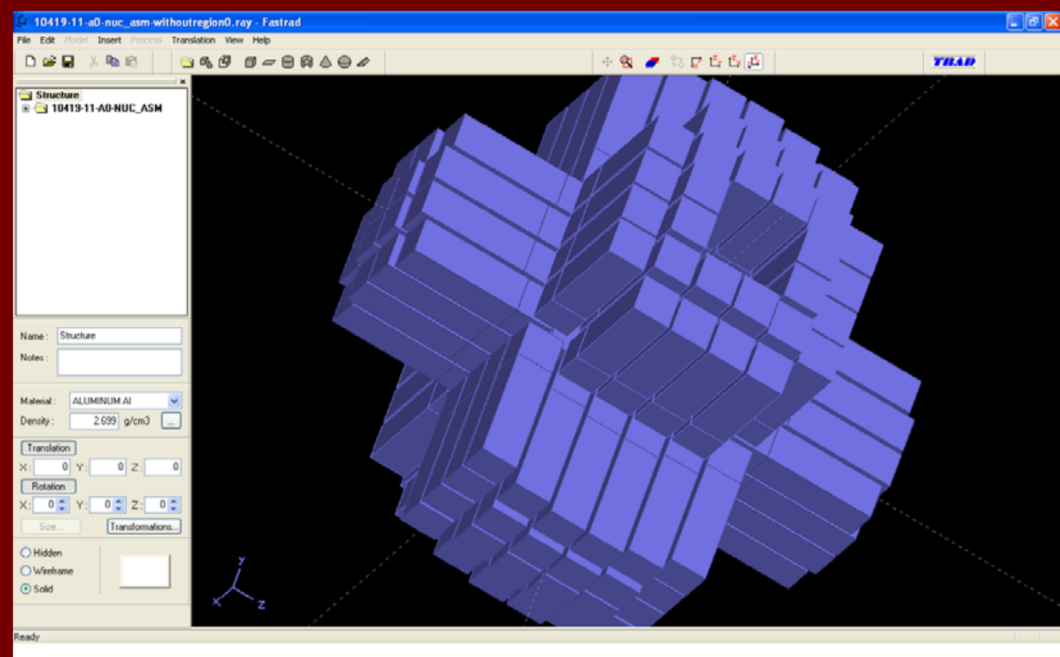
Possibility 3 – „phoswich”.


Science & Technology Facilities Council
Paris
2" cubed Lanthium Bromide crystal
2"x150mm Caesium Iodide crystal
1mm thick aluminum/ carbon fibre can
Photo Multiplier Tube Hamamatsu R580-17
0.66kg
1.75kg
Science & Technology Facilities Council
Paris
Light tight bond
Photo Multiplier tube shown at 39mm diameter by 127mm long
Light tight bond
Cable for PMT passes through this hole
Science & Technology Facilities Council
Paris
Detectors can be slid forwards and backwards



Various cubic designs exist for different inner radii and number of detectors

Detailed GEANT4 simulations in progress using realistic geometries and modelling key Physics experiments



The next steps

- Developing the Physics case (and adding to it)
- Testing the Phoswich design
- Testing for neutron response
- Continuing with realistic simulations
- Finalising the design

Please join **PARIS!**