Adam Maj (IFJ PAN Kraków)
for the PARIS collaboration

Brief status of the PARIS project

PARIS

paris.ifj.edu.pl

From SPIRAL2 White Book: www.ganil.fr/research/developments/spiral2/files/WB_SP2_Final.pdf

In our studies of nuclear structure there are many unanswered questions:

- What are the limits to nuclear existence? Very little is known in particular on where the neutron drip-line lies or what the upper limit is for the number of protons in a nucleus.
- What new forms of nuclear matter will be found in nuclei far from stability?
- Will new forms of collective motion be observed far from stability?
- What is the ordering of quantum levels in nuclei far from stability? Put another way: what happens to the well known shell structure seen in stable nuclei as we move away from stability?
- What will be the forms of nuclear matter at the extremes of stability? It is already known that some neutron-rich, light nuclei have a halo of neutrons. Do they develop into neutron skins in heavier nuclei?
- Do the dynamical symmetries seen in near-stable nuclei appear in exotic nuclei as well?

SPIRAL2 will produce high quality beams of exotic nuclei which will allow us to address these and many other questions that are common to much of modern science.

Shells and magic numbers, pairing and superfluidity, symmetries and their spontaneous breaking, resonances, collective motion, penetration of barriers by composite systems, level densities and the thermodynamics of small systems, entropy and phase transitions are some of the many general phenomena in physics for which the atomic nucleus provides an excellent laboratory.

To answer these questions one needs efficient detectors:

Existing: VAMOS, INDRA, AGATA, …

and new (SP2PP):

ACTAR, DESIR, S3, EXOGAM, FAZIA, GASPARD, NEDA, **PARIS**

4-5-6th October, 2005 „Future prospects for high resolution gamma spectroscopy at GANIL" - Convenors : Bob Wadsworth and Wolfram Korten

WG „Collective modes in continuum" – convenors: Silvia Leoni & Adam Maj

Spiral2

GANIL
SAC open session
October 19th, 2006

Letter of Intent for SPIRAL 2

Title: High-energy γ-rays as a probe of hot nuclei and reaction mechanisms

Spokesperson(s) *(max. 3 names, laboratory, e-mail - please underline among them one corresponding spokesperson):*
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David Jenkins, University of York (UK), dj4@york.ac.uk

GANIL contact person
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Aim:
to design and build efficient gamma calorimeter *PARIS*

COLLABORATION

Members of the Collaboration :

Give the list of participating institutions and names of collaborators.

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IPJ Swierk, Otwock (Poland): M. Moszynski

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TIFR Mumbai (India): I. Mazumdar, V. Nanal, R.G. Pillay, G. Anil Kumar

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UMCS Lublin (Poland): K. Pomorski

HMI Berlin (Germany): H.J. Krappe

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Ankara University, Ankara (Turkey): A. Ataç-Nyberg

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Flerov Laboratory of Nuclear Reactions, JINR, Dubna (Russia): A. Fomichev, S. Krupko, V. Gorshkov.

Uppsala University, Uppsala (Sweden): H. Mach

KVI, Groningen (The Netherlands): M. Harakeh

INFN Milano (Italy): S Brambilla, F. Camera, S. Leoni, O. Wieland.

LPSC Grenoble(France): G. Simpson

INFN Napoli (Italy): D. Pierroutsakou

STFC Daresbury (UK): J. Simpson, J. Strachan, M. Labiche

Nuclear Physics Group, The University of Manchester (UK): A. Smith

RIKEN Tokyo (JP): P. Doornenbal

40 institutions from 17 countries
≈ 100 physicists, engineers and PhD students

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. Courtin, D. Jenkins et al.)
3. Physics cases and theory background (Ch. Schmitt et al.)
4. Detectors (O. Dorvaux et al.)
5. Financial issues (J.P. Wieleczko et al.)
6. PARIS in FP7 projects (A. Maj, F. Azaiez et al.)
7. Electronics (P. Bednarczyk et al.)
8. PARIS-GASPARD synergy (J.A. Scarpaci et al.)

J. Pouthas – PARIS liaison to SPIRAL2 project management

PHYSICS CASE

PARIS physics cases

Early (presented in LoI)

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.)

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

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.)

New

h) Multiple Coulex of SD bands
36<A<50
(P. Napiorkowski, F, Azaiez, A. Maj et al.)

i) Relativistic Coulex (case for FAIR or RIKEN)
40<A<90
(P. Bednarczyk et al.)

j) Nuclear astrophysics (p,γ)
e.g. *^{90}Zr*
(S. Harissopulos al.)

k) Shell structure at intermediate energies (SISSI/LISE)
20<A<40
(Z. Dombradi et al.)

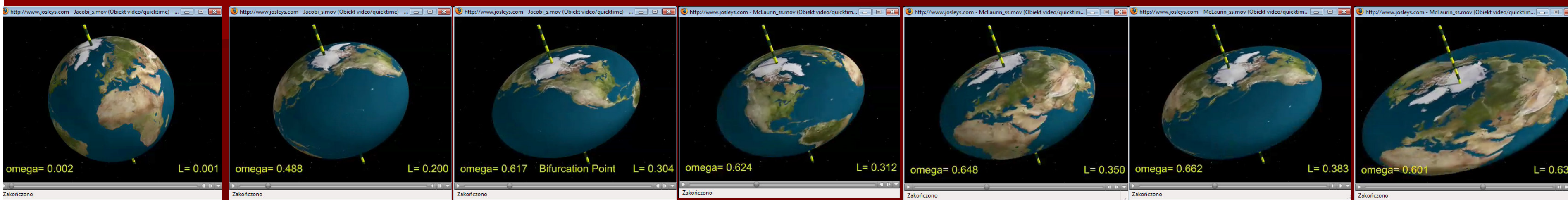
l) Shell structure at low energies (separator part of S^3)
30<A<150
(F. Azaiez, S. Franchoo et al.)

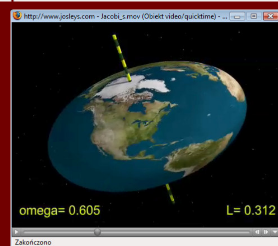
Jacobi (and Poincare?) shape transitions and Coriolis splitting of the GDR

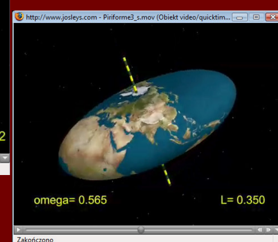
(A. Maj, J. Dudek et al.)

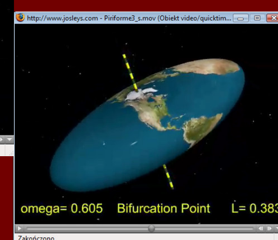
Jacobi shape transition:
Theoretical shapes of rotating gravitating body

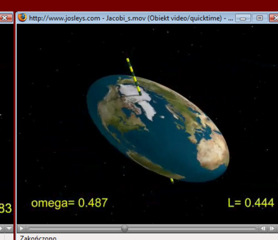
Colin MacLaurin (1742) shows that, as the angular momentum increases, the Earth will become more flat. The shape is an ellipsoid with two equal axes, rotating around the short axis. The ellipsoid becomes a disc with an ever increasing radius.

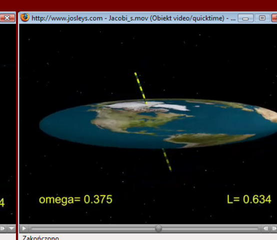






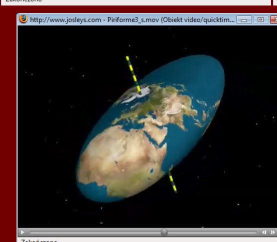


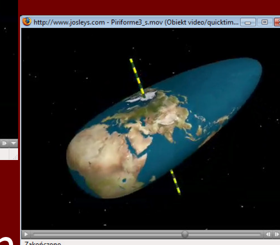




Carl Gustav Jacob Jacobi (1834):

At certain angular velocity *gravitating mass rotating synchronously* may change abruptly the shape from MacLaurins oblate shape to elongated triaxial (Jacobi bifurcation).





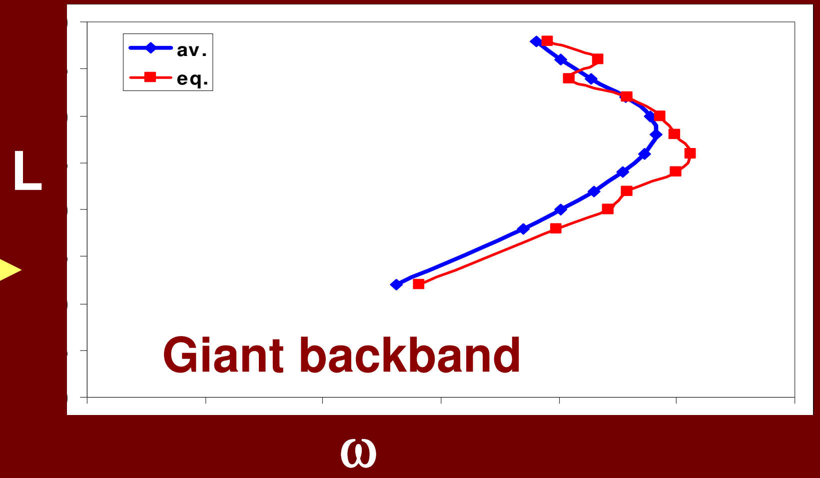
Based on talk by Prof.. Etienne Ghys of the Unité de Mathématiques Pures et Appliquées de l'E.N.S. de Lyon
www.josleys.com/show_gallery.php?galid=313
Copyright: Jos Leys/Etienne Ghys.

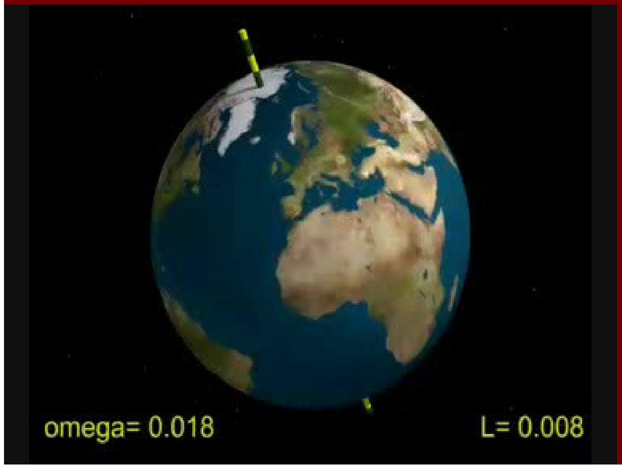
Henri Poincare (1885):

Described how the path of the Jacobi ellipsoids encounters multiple bifurcation points – elongated triaxial may change rapidly to a pear shape

McLaurin path

Jacobi path





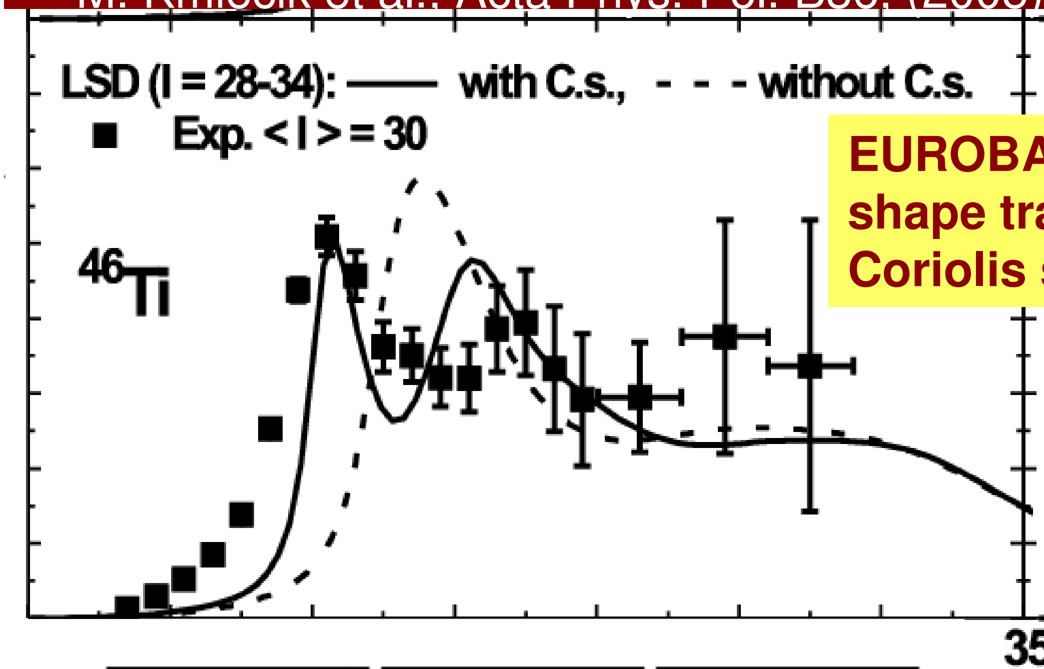
Poincare path

- **R. Beringer, W.K. Knox, *Phys. Rev.* 121 (1961) 1195:**
  Similar phenomenon might be expected in nuclei at highest spins
- **S. Cohen, F. Plasil, W.J. Swiatecki, *Ann. Phys. (N.Y.)* 82 (1974) 557:**
  Rotating liquid drop model
- **K. Pomorski, J. Dudek, *Phys. Rev.* C67 (2003) 044316:**
  LSD (Lublin-Strasbourg Drop) Model

- **M. Kicińska-Habior *et al.*, *Phys.Lett.* B308 (1993) 225:**
  ***Seattle exp.* - Possible signature of the Jacobi shape transition for ^{45}Sc in the inclusive GDR spectrum**
- **A. Maj et al, *Nucl. Phys.* A687 (2001) 192:**
  ***NBI exp.* – Possible signatures of the Jacobi shape transition for ^{46}Ti in the multiplicity gated GDR spectra and angular distributions**
- **D. Ward *et al.*, *Phys.Rev.* C66 (2002) 024312-1:**
  Giant backbend of the E2 quasicontinuum bump

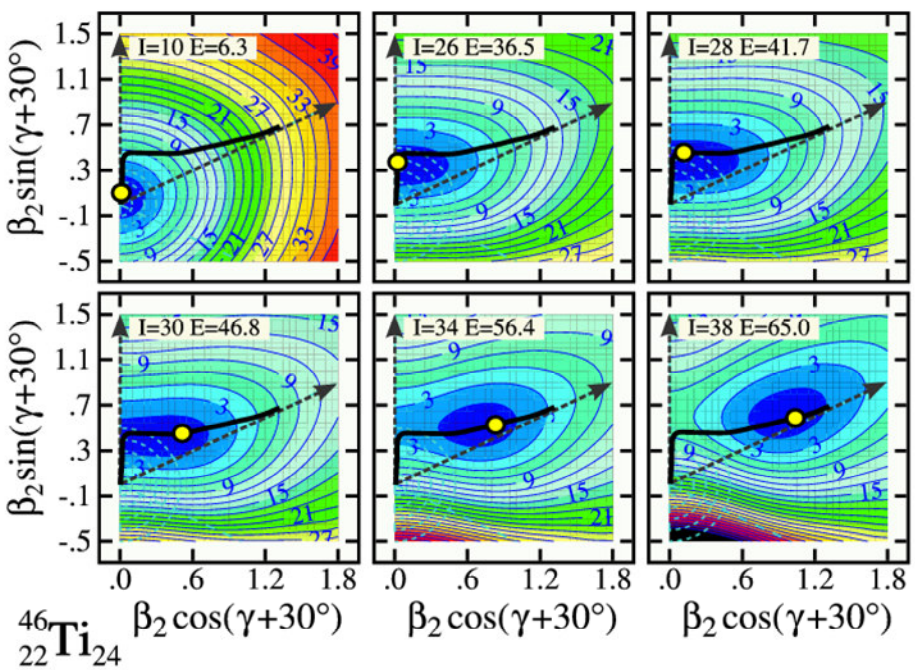
- **M. Riley, Zakopane 2008:**
  Oblate to prolate transition in N~90 nuclei for I>60$\hbar$

A. Maj et al, Nucl. Phys. A731 (2004) 319
M. Kmiecik et al., Acta Phys. Pol. B36, (2005) 1169

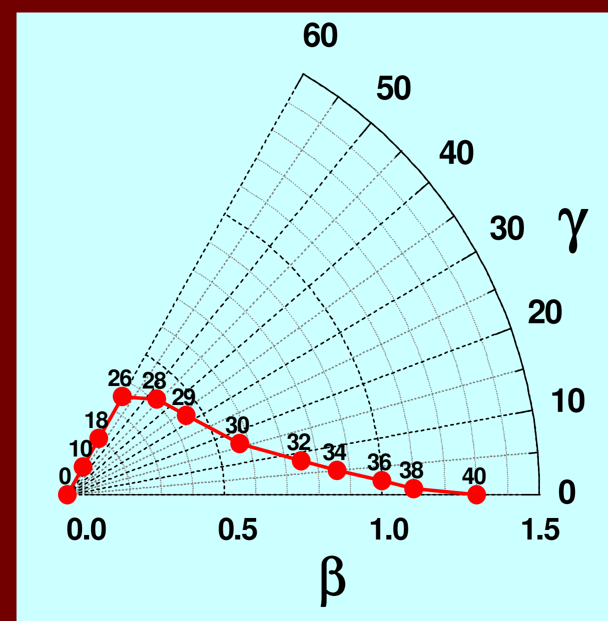


EUROBALL IV exp: Evidence for the Jacobi shape transition and (for the first time) for the Coriolis splitting in ^{46}Ti

Calculations: LSD model and thermal shape fluctuactions

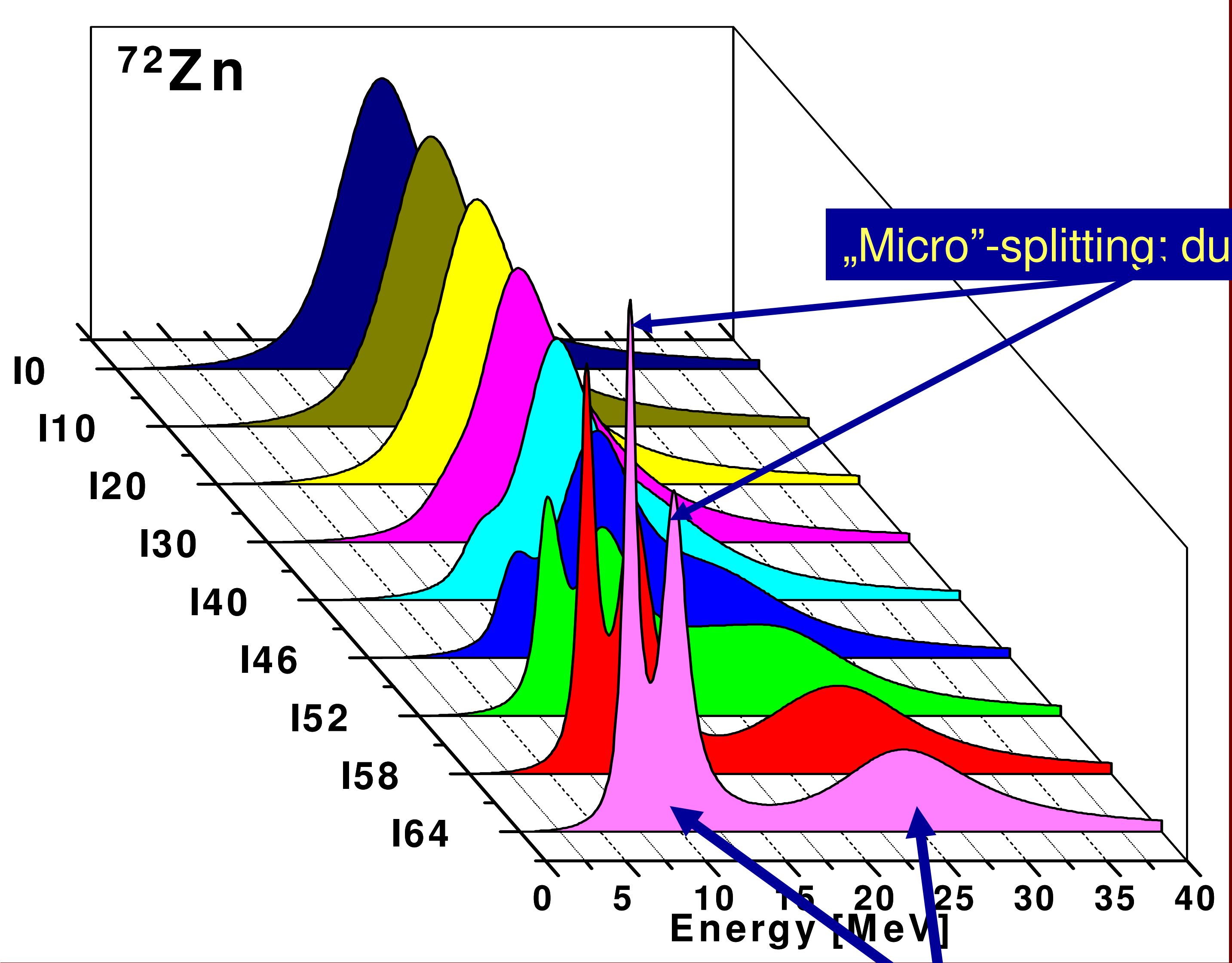


Evolution of equilibrium shape



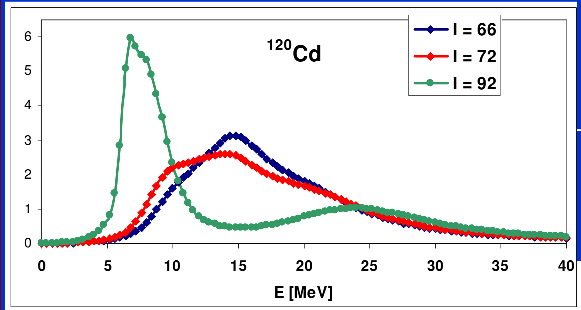
Spin evolution of the GDR line shape

„Micro”-splitting: due to Coriolis effect



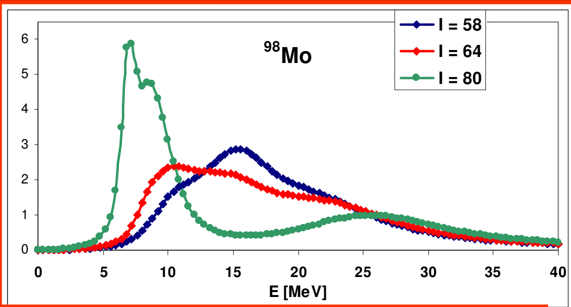
„Macro”-splitting: due to very elongated shape

Summary of the experimental programme for GANIL



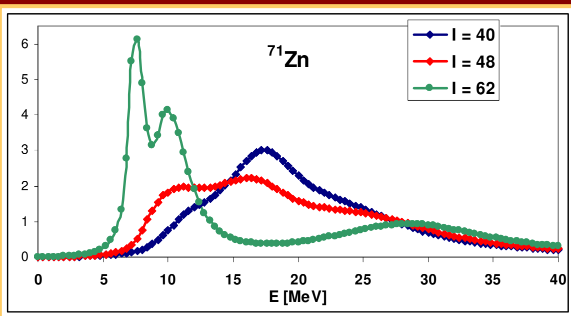
$^{94}_{36}$Kr + $^{26}_{12}$Mg → $^{120}_{48}$Cd;
10^{10} pps
E_b = 900MeV, I_{max} = 100 ħ, E* = 190 MeV

$^{40}_{20}$Ca + $^{58}_{28}$Ni → $^{98}_{48}$Cd;
stable
E_b = 250MeV, I_{max} = 78 ħ, E* = 120 MeV

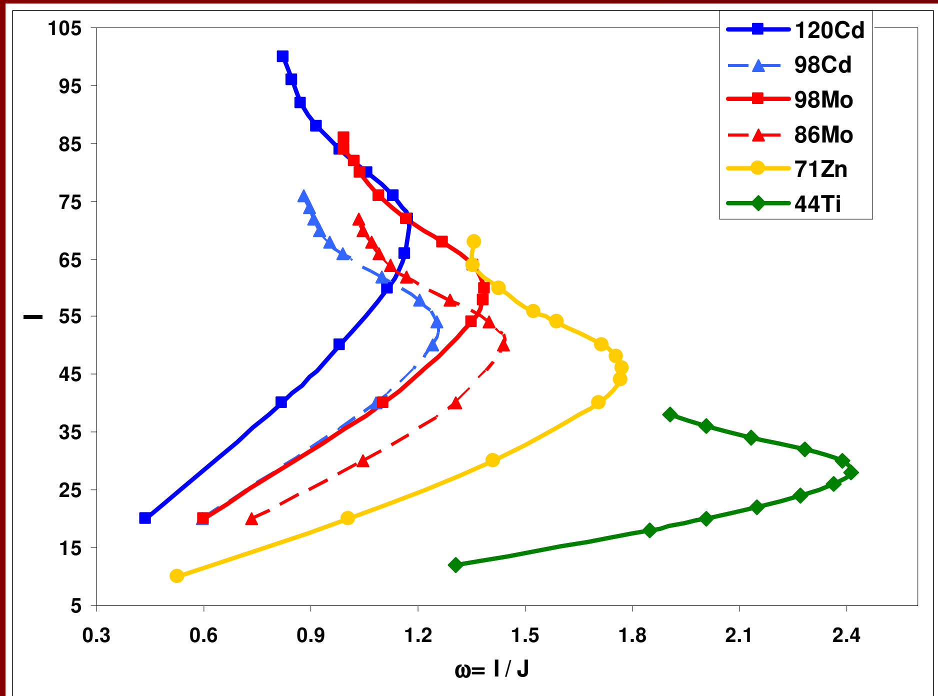


$^{68}_{28}$Ni + $^{30}_{14}$Si → $^{98}_{42}$Mo;
10^{8} pps
E_b = 500MeV, I_{max} = 85 ħ, E* = 150 MeV

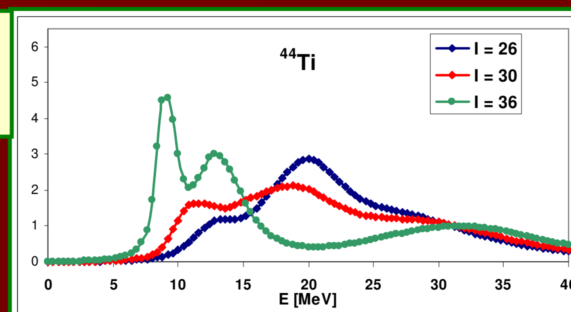
$^{58}_{28}$Ni + $^{28}_{14}$Si → $^{86}_{42}$Mo;
stable
E_b = 400MeV, I_{max} = 68 ħ, E* = 110 MeV



$^{23}_{10}$Ne + $^{48}_{20}$Ca → $^{71}_{30}$Zn;
10^{6} pps
E_b = 220MeV, I_{max} = 70 ħ, E* = 160 MeV



$^{12}_{6}$C + $^{32}_{16}$S → $^{44}_{22}$Ti
stable
E_b = 170MeV, I_{max} = 38 ħ, E* = 130 MeV



What happens at higher spins?

New theoretical results

K. Mazurek, J. Dudek, A. Maj, *tbp*

^{142}Ba

β-γ

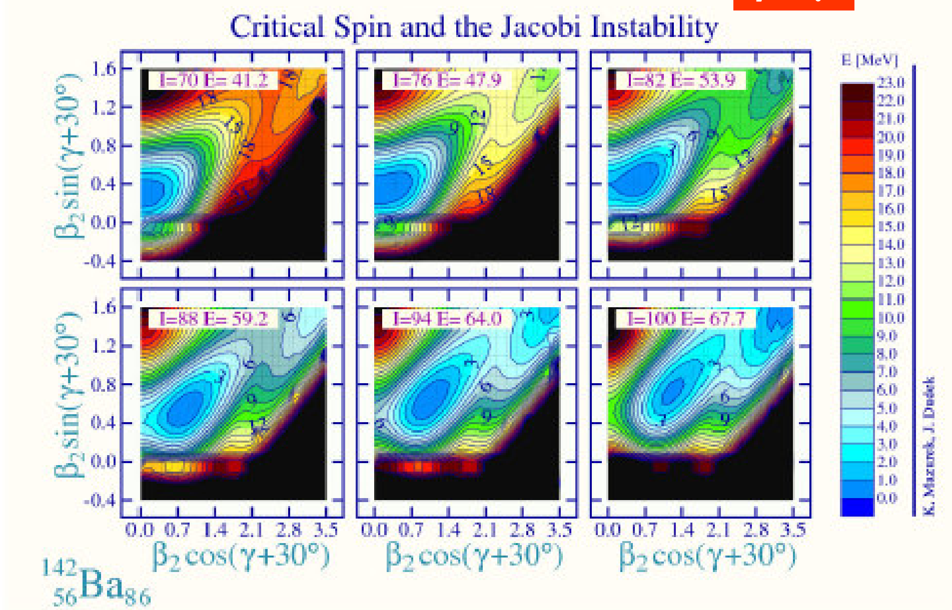


Fig. 2a: The LSD energy surfaces for ^{142}Ba for Jacobi transition, calculated for spins 70, 76, 82, 88, 94 and 100 ℏ.

α2–α3

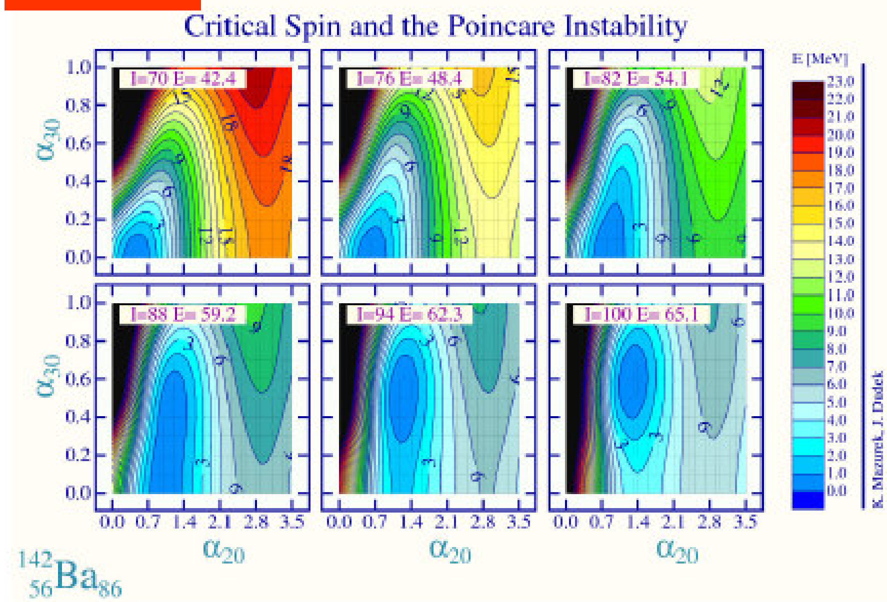


Fig. 2b: Same as in 2a, but for Poincare transition.

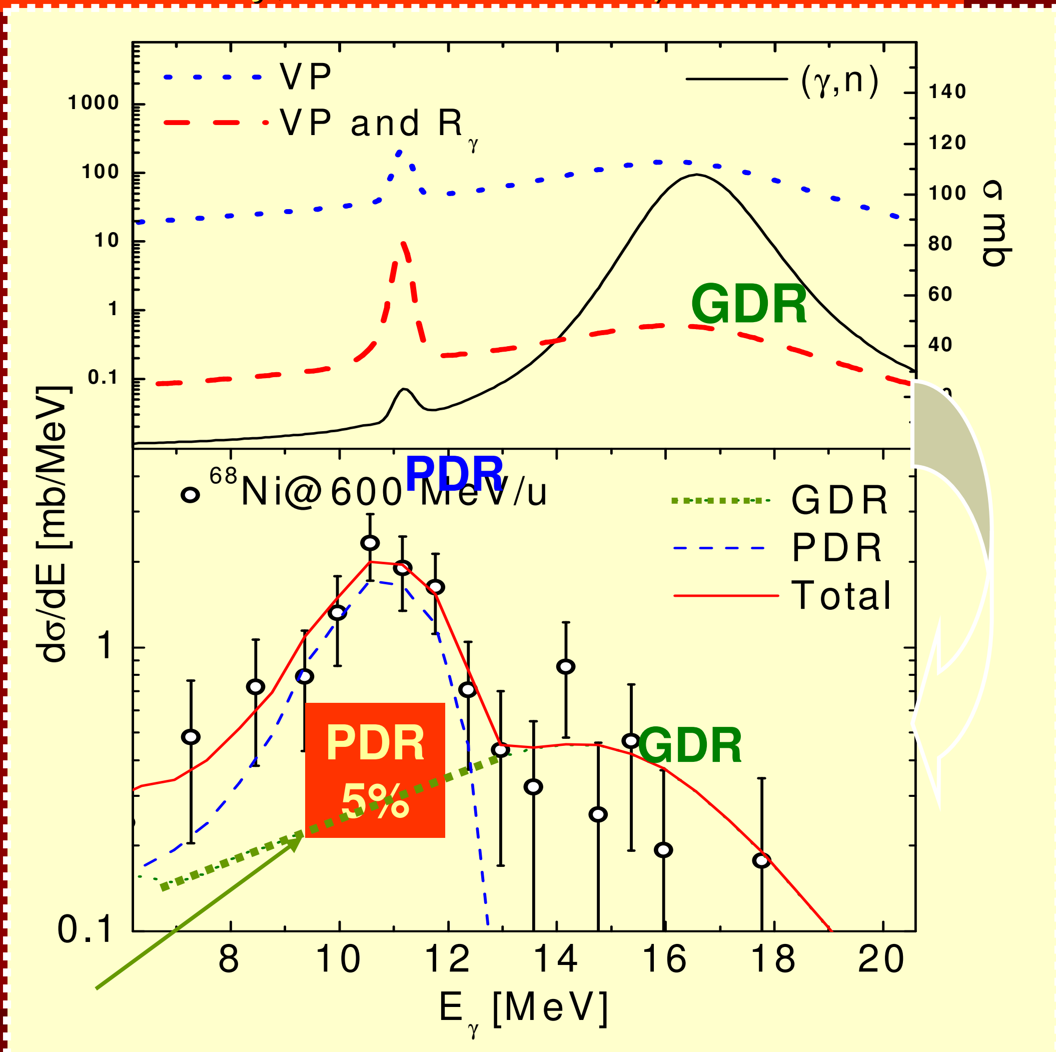
Oblate (McLaurin) → elongated triaxial (Jacobi) → elongated octupole (Poincare)

I≈76ℏ

I≈88ℏ

cf. talk of Kasia Mazurek

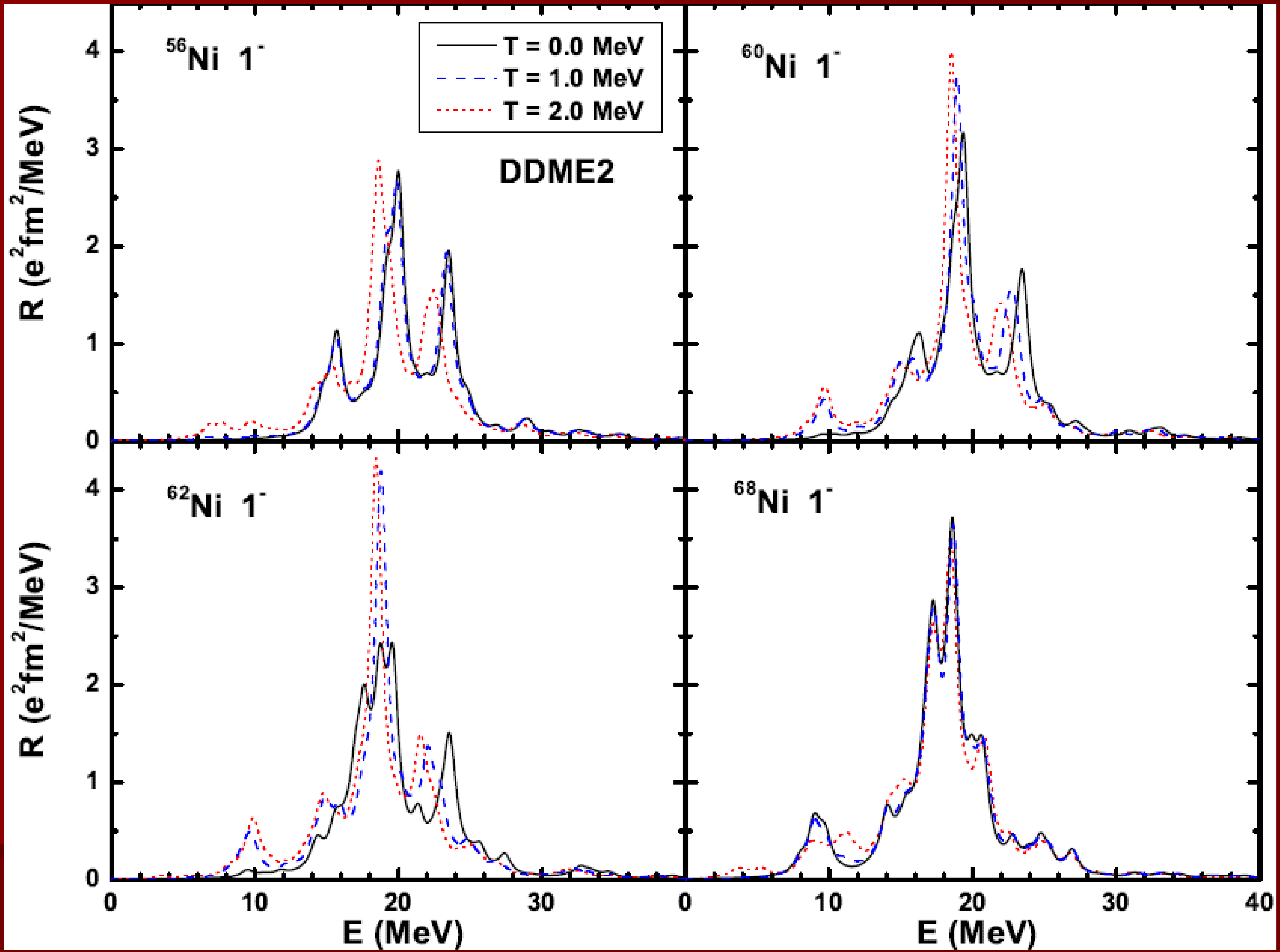
Hot GDR studies in neutron rich nuclei -
How collective properties change with isospin
(D.R. Chakrabarty, M. Kmiecik et al.)



Soft dipole mode
(Pygmy Dipole resonance)
in cold nuclei

PDR in 68Ni observed by the virtual photon scattering technique (RISING exp.)
From O. Wieland et al., PRL 102, 092502 (2009)

What happens with PDR at higher temperatures?



D. Vretenar et al, PRC in print

Soft dipole mode in hot nuclei?

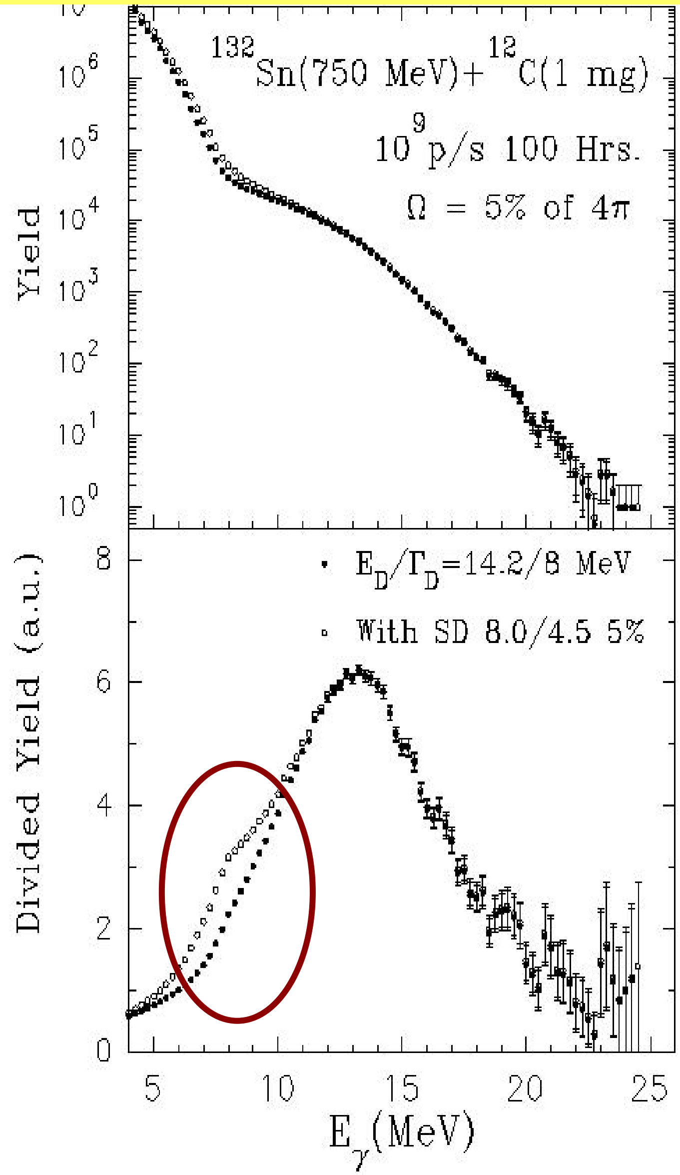
Physics to address:

- **Evolution of nuclear shape with T and J - dependence on N/Z**
- **Signature of "soft dipole" like excitation in hot nuclei**
- **Entrance channel dependence for the same compound nucleus at similar J and almost similar T**

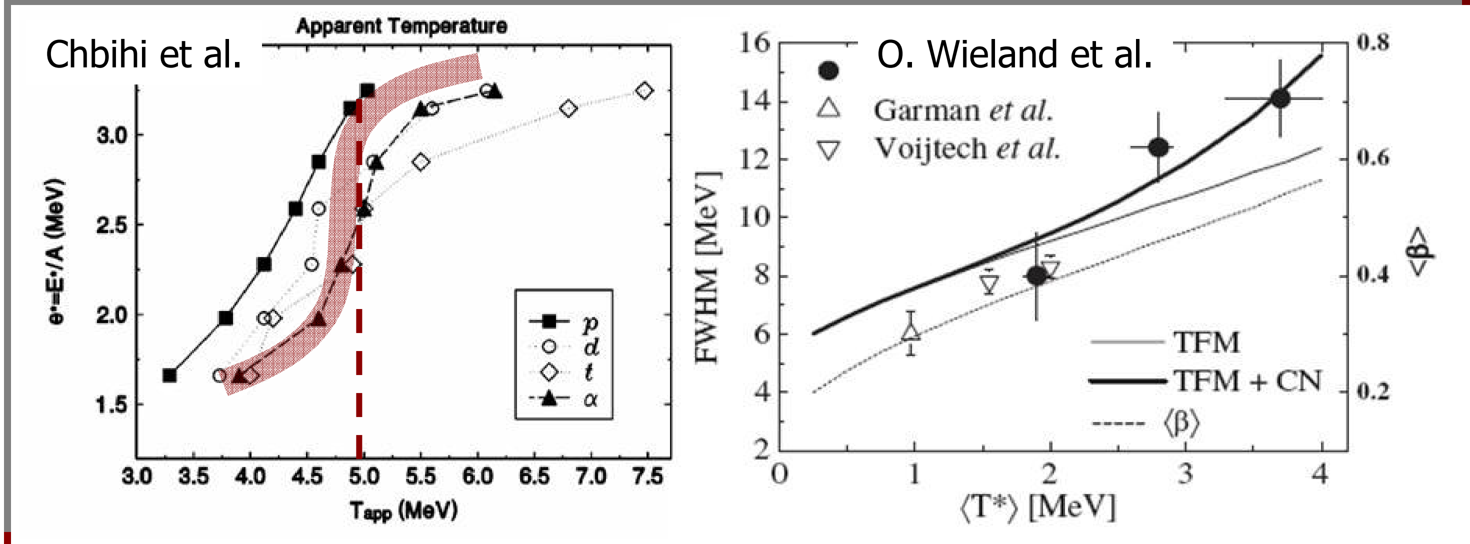
$^{128-132}Sn+^{12}C$ and $^{88-96}Kr+^{40,48}Ca$
spanning a range of
A=128 to 144, T up to ~2 MeV, J range up to ~ 70ħ
(Can be combined with stable beam reactions
$^{112-124}Sn+^{12}C$, $^{80-86}Kr+^{40,48}Ca$

extending the A-range down to 120)

CASCADE simulated spectra for hot nuclei with Soft Dipole (D.R. Chakrabarty)



Onset of the multifragmentation and the GDR
J.P. Wieleczko, D. Santonocito et al.,



Limiting temperature:
Onset of multifragmentation?

No firm evidence of the saturation of the GDR width up to 4 MeV

What we want to know is what happens to the collective motion in the excitation range where a plateau is observed

GDR data for T>4 MeV needed

INDRA (FAZIA) and/or **high-energy γ-calorimeter**

Planned reactions to study:

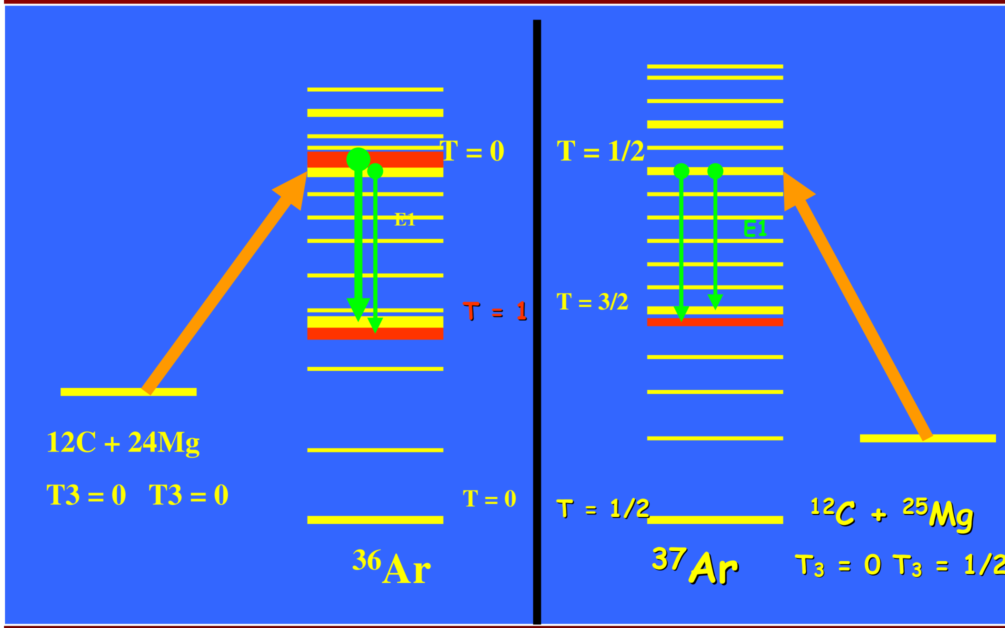
$^{64}Ni + ^{78}Zn$
$^{94}Kr + ^{50}Ti$
$^{96}Sr + ^{48}Ca$
$^{72}Kr + ^{50}Ti$

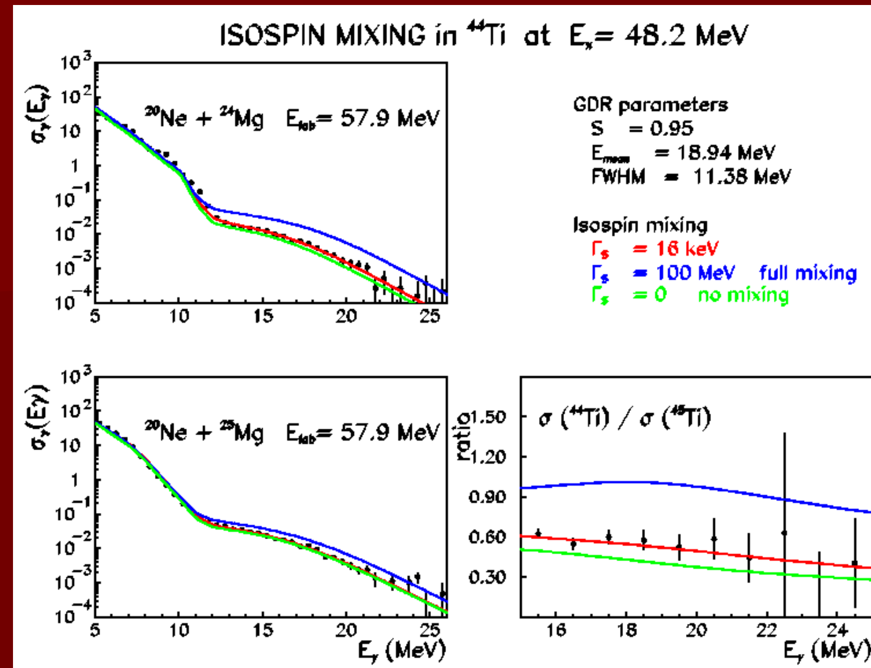
$^{122}Cd + ^{58}Ni$
$^{90}Kr + ^{90}Zr$

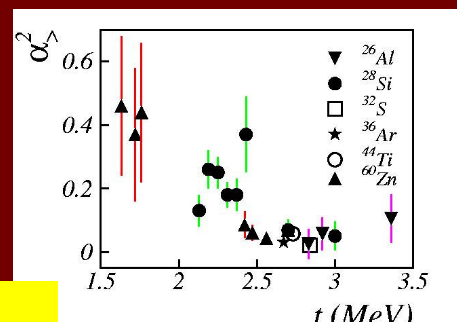
Talk of J.P. Wieleczko

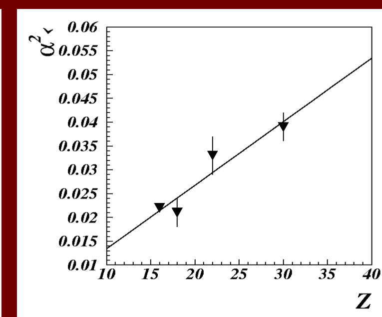
Physics case d) - contact: M. Kicińska-Habior

Isospin mixing at finite temperature









Goal:

- study isospin mixing in heavy N = Z nuclei
- test temperature dependence of isospin mixing
- test mass (A) and charge (Z) dependence of isospin mixing

High-energy γ-calorimeter + multiplicity filter

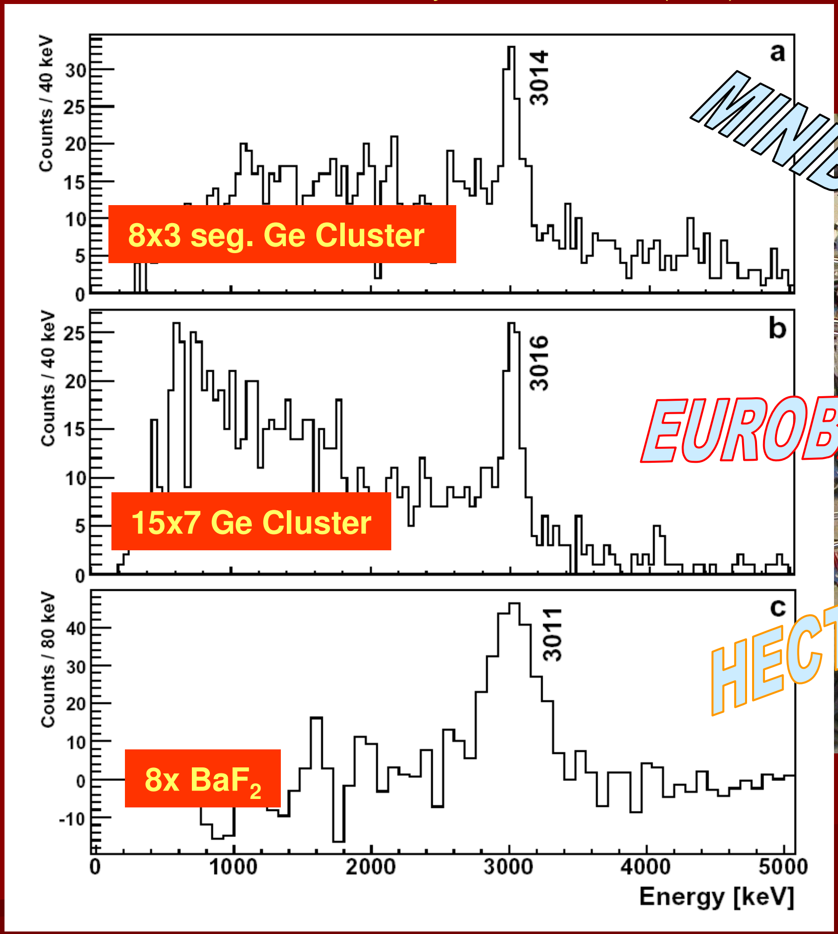
Beams to use: ^{44}Ti, ^{56}Ni, ^{72}Kr

Nuclei to study: ^{68}Se, ^{80}Zr, ^{84}Mo, ^{96}Cd, ^{112}Ba

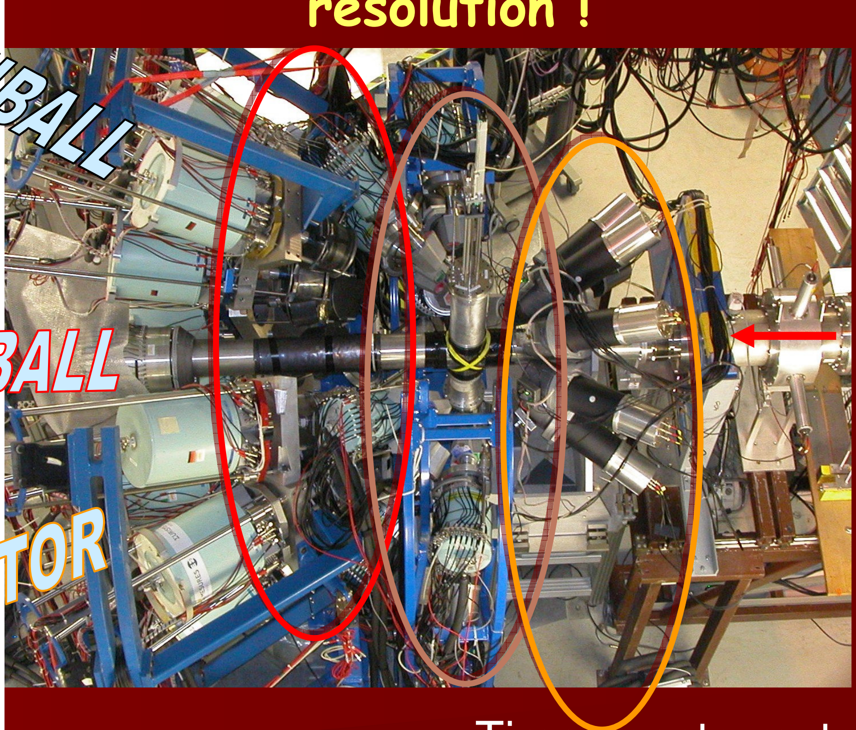
Relativistic Coulex (case for FAIR or RIKEN)
(P. Bednarczyk et al.)

RISIN|G exp.: ^{36}Ca E(2$^+$) β = 0.545 /^{48}Ca double fragm./

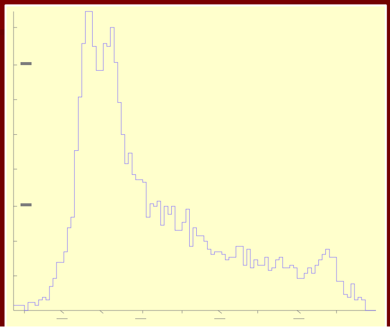
P.Doornenbal et al.,Phys.Lett. B 647, 237 (2007)



Comparable peak intensity and resolution !

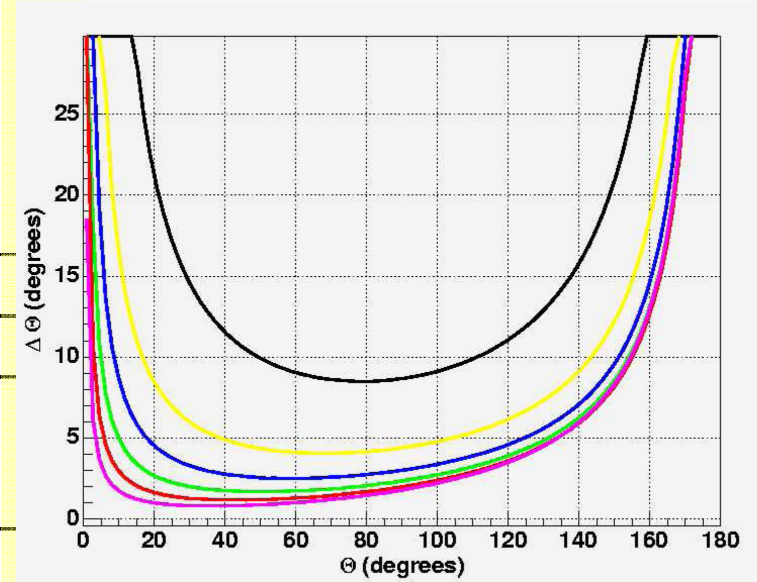


ΔE/E ~4%

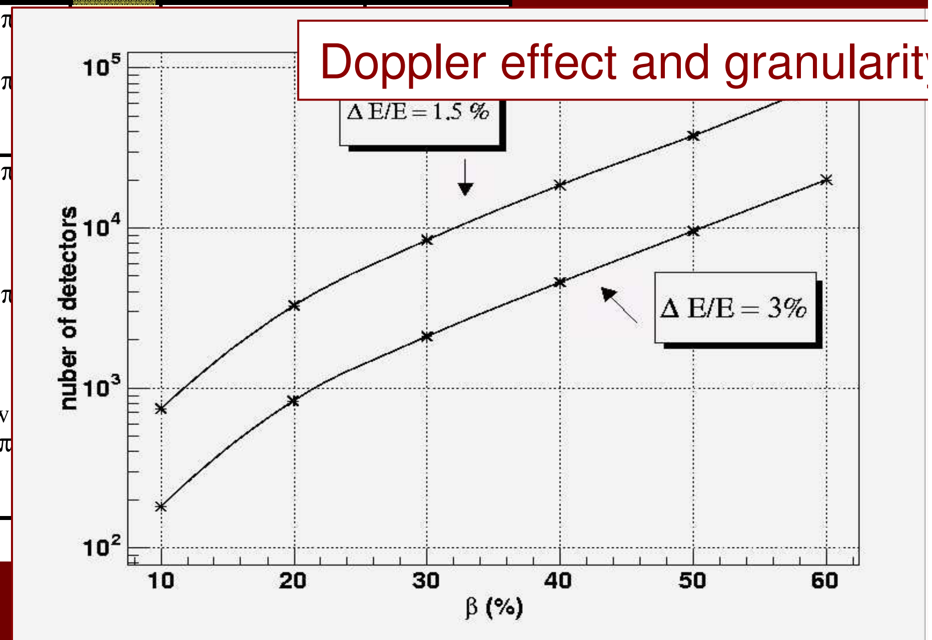


Time spectrum: to resolve gammas from target and beam stopper a resolution beter than 1 ns is required

Physics Case	Recoil mass	v/c [%]	E_γ range [MeV]	$\Delta E_\gamma/E_\gamma$ [%]	$\Delta E_{sum}/E_{sum}$ [%]	ΔM_γ	Ω coverage
Jacobi transition	40-150	<10	0.1-30	4	<5	4	2π-4π
Shape Phase Diagram	160-180	<10	0.1-30	6	<5	4	2π-4π
Hot GDR in n-rich nuclei	120-140	<11	0.1-30	6	<8	4	2π-4π
Isospin mixing	60-100	<7	5-30	6	-	-	4π
Reaction dynamics	160-220	<7	0.1-25	6-8	<8	4	2π
Collectivity vs. multi-fragmentation	120-200	<8	5-30	5	-	-	2π
Radiative capture	20-30	<3	1-30	<4	5	-	4π
Multiple Coulex	40-60	<7	2-6	5	-	-	2π
Astrophysics	16-90	0.1	0.1-6	6	5	-	4π
Shell structure at intermediate energies (SISSI/LISE)	16-40	20-40	0.5-4	3	-	-	3π
Shell structure at low energies (separator part of S^3)	30-150	10-15	0.3-3	3	-	-	3π
Relativistic Coulex	40-60	50-60	1-4	4	-	1	Forw 3π



Doppler effect and granularit



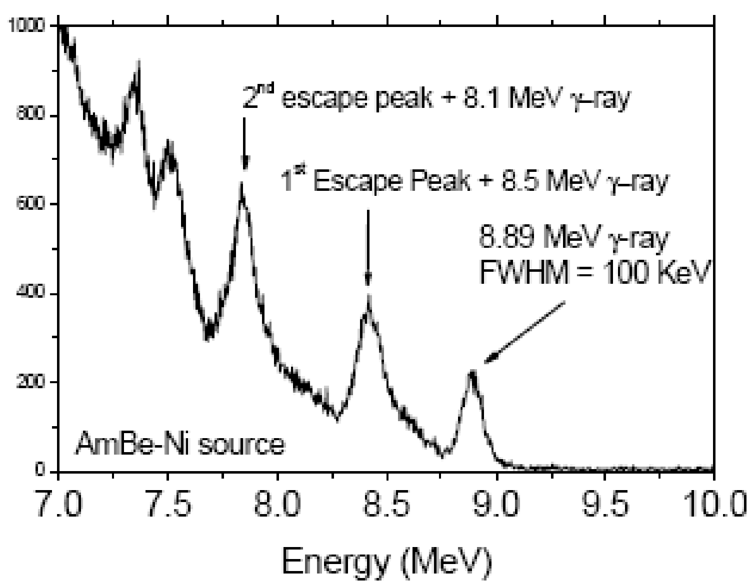
<β> ≈ 10%; ΔM/M<4 → **Granularity: 200-800**

ΔT: <1 ns; ΔEγ/Eγ: < 3%; high efficiency up to 15 MeV → **$LaBr_3$ scintillators**

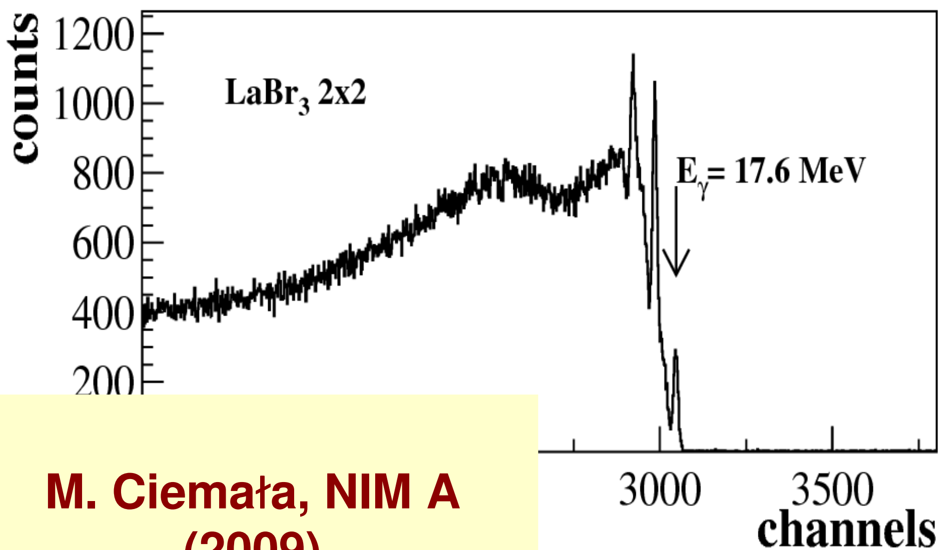
Why LaBr3?

large light output (>60000 ph/MeV)
high efficiency (>60% up to 10 MeV)
→spectroscopy far from stability
energy resolution (3% at 662 keV, 0.6% at 18 MeV)
→spectroscopy far from stability
time resolution (~250 ps)
→discrimination against neutrons
fast light pulse decay (~16 ns)
→high counting rate capability
very good temperature stability,worldwide interest, also in medical sector

Milan group: Source and 3”x3” crystal



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



M. Ciemała, NIM A (2009)

PARIS desing concepts:

Design and build high efficiency detector consisting of 2 shells *(or 1 shell)* 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), rather short (up to 5 cm). The readout might be performed with PMTs or APDs.
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 medium energy resolution (better than 3%). 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.

Array has to be mechanically compatible with AGATA
and possibly other detectors: GASPARD, Neutr. Det, INDRA/FAZIA

2008 – pricing agreement between PARIS and Saint Gobain for the PARIS crystals in R&D phase

BASIC SIMULATIONS

PARIS GEANT4 software – **O. Stezowski,** Ch. Schmitt, M. Ciemała et al.
Great work done by the Simulation WG!

Conclusions from first (rather idealistic) stage of simulations (Stezowski et al..)

•The idea of **two concentric layers seems to be rather pertinent**, as suggested by the simulations: a) the percentage of fully absorbed events in one of the 2 shells has been found rather large; b) a two-shell design is relevant provided the inner shell is not too much absorbent. In this way, the inner shell fulfils its calorimeter job, while the outer layer is devoted to the detection of high-energy photons.

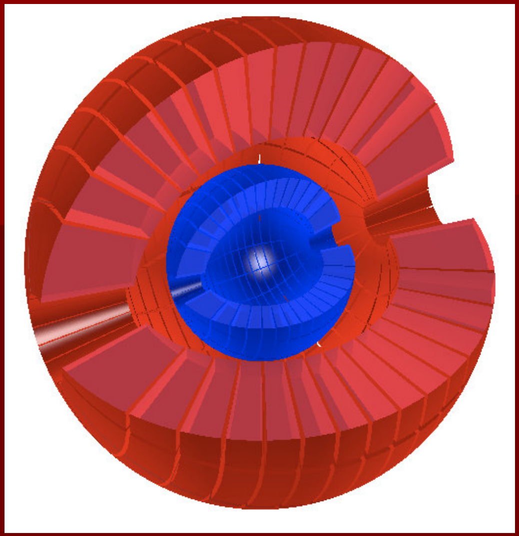
•Aside from events which are fully absorbed in either of the two shells, a sizeable percentage of fully absorbed events are γ-rays which share their energy deposit between the 2 layers. Provided we are able to properly reconstruct the energy partition, the global performances of the array can even be further enhanced. This requires further work on segmentation and reconstruction.

•The cubic geometry is worth of further investigation, as it can provide economical solution for the 2-shell calorimeter.

•It seems to be that the optimal thicknes of the inner LaBr3 shell is 2”, while the diameter of the crystals shall be between 1” and 2” (at 15 cm distance from target).

DESIGN

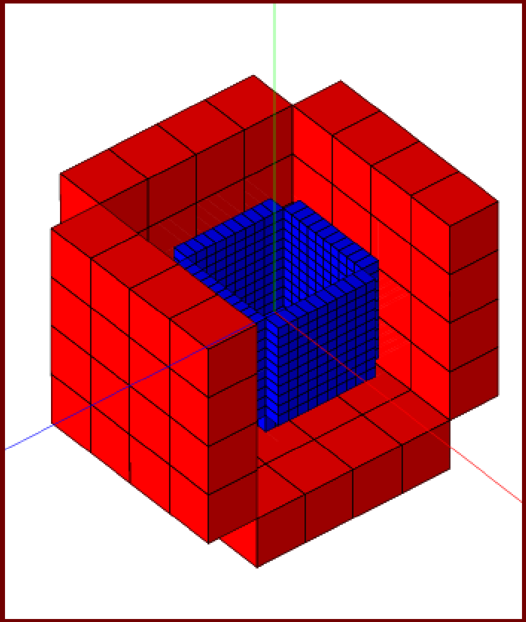
POSSIBLE GEOMETRIES of PARIS



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

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

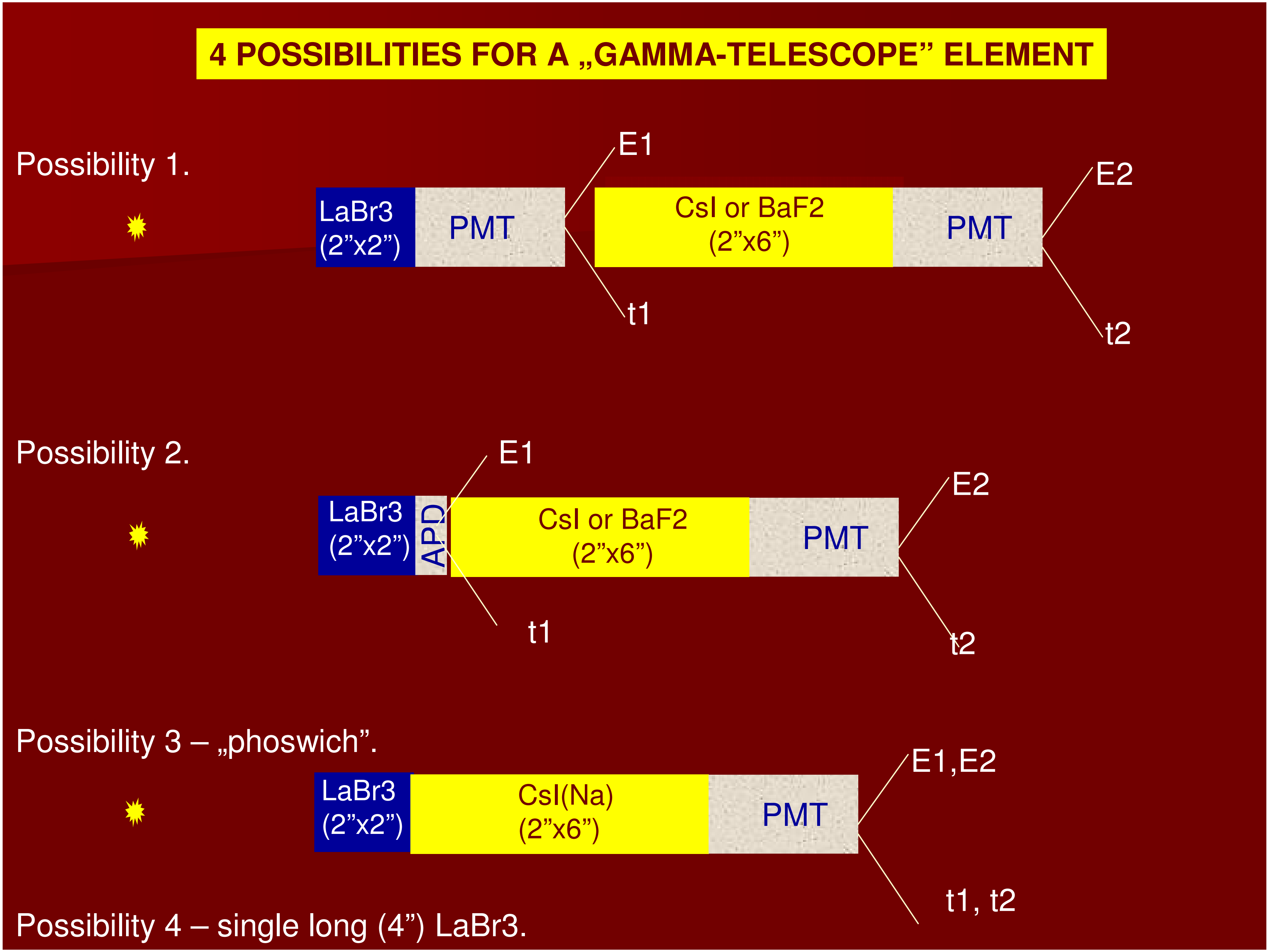
- : Limited to one distance, high cost of a segment,…



CUBIC (offering variable geometry):

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

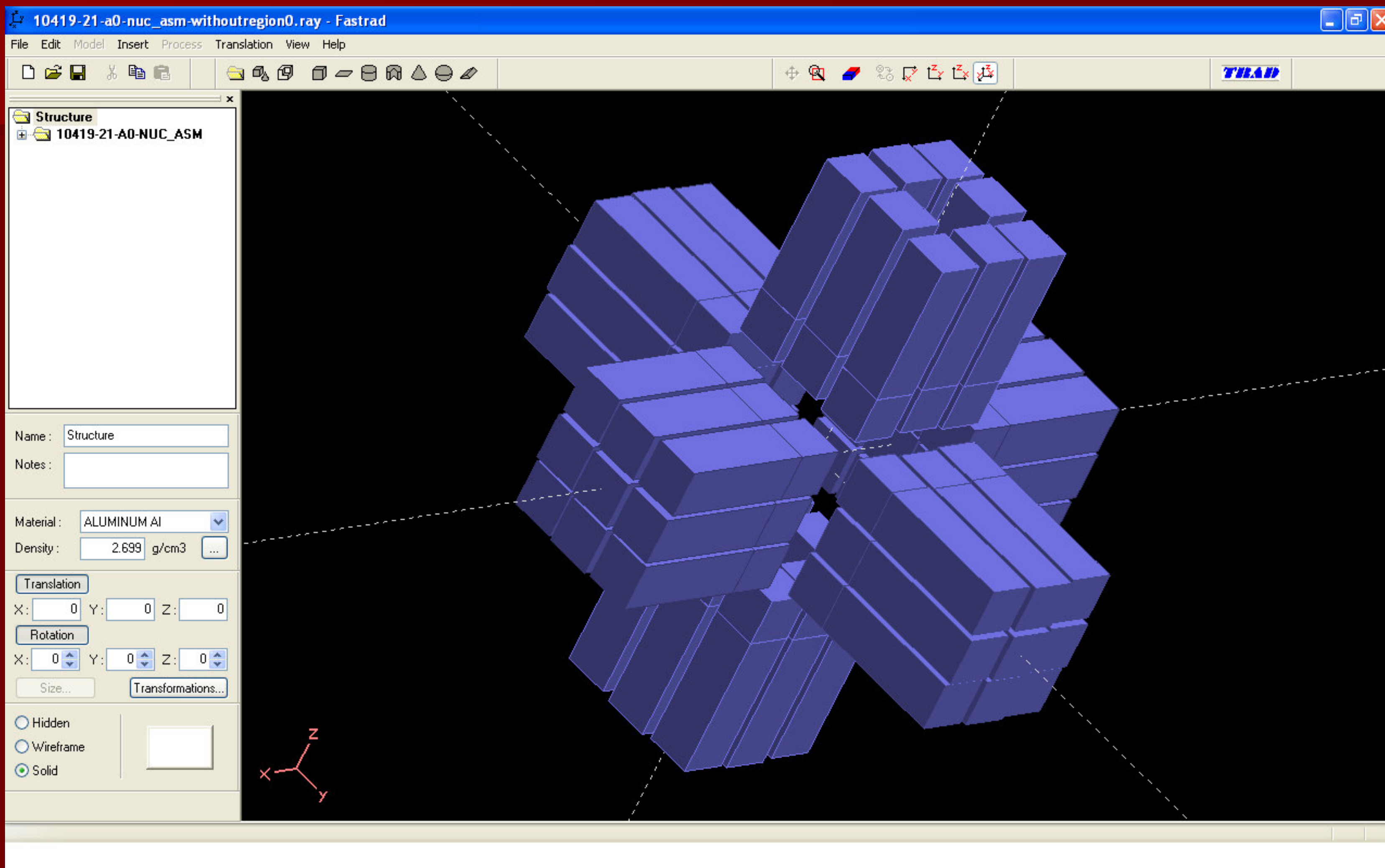
- : More complicated reconstruction, worse line shape, …



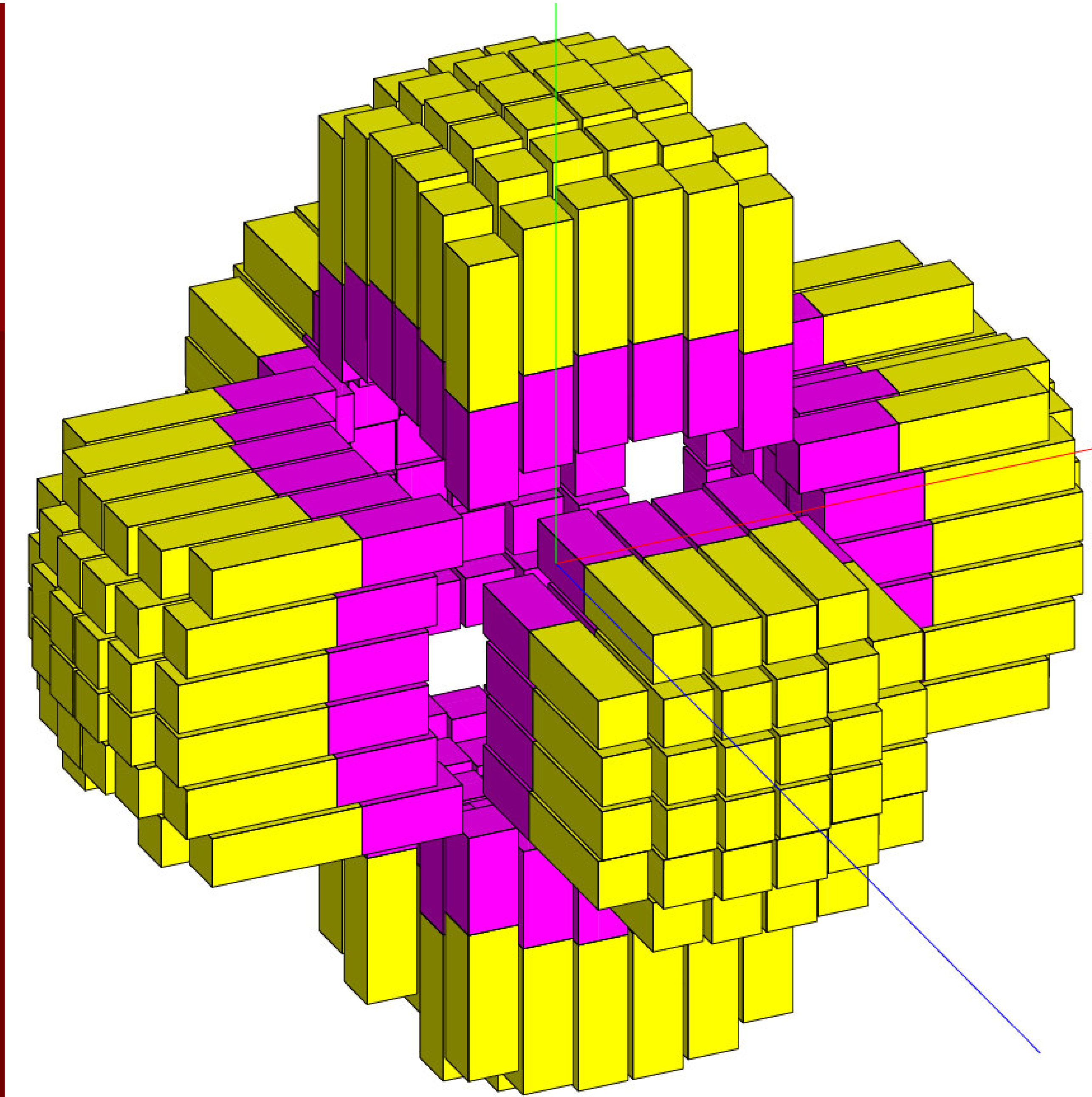
4 POSSIBILITIES FOR A „GAMMA-TELESCOPE" ELEMENT
Possibility 1.
LaBr3 (2"x2")
PMT
E1
t1
CsI or BaF2 (2"x6")
PMT
E2
t2
Possibility 2.
LaBr3 (2"x2")
APD
E1
t1
CsI or BaF2 (2"x6")
PMT
E2
t2
Possibility 3 – „phoswich".
LaBr3 (2"x2")
CsI(Na) (2"x6")
PMT
E1,E2
t1, t2
Possibility 4 – single long (4") LaBr3.

Various cubic designs exist for different inner radii and number of detectors (J. Strachan, A. Smith, S. Courtin, D. Jenkins et al.)

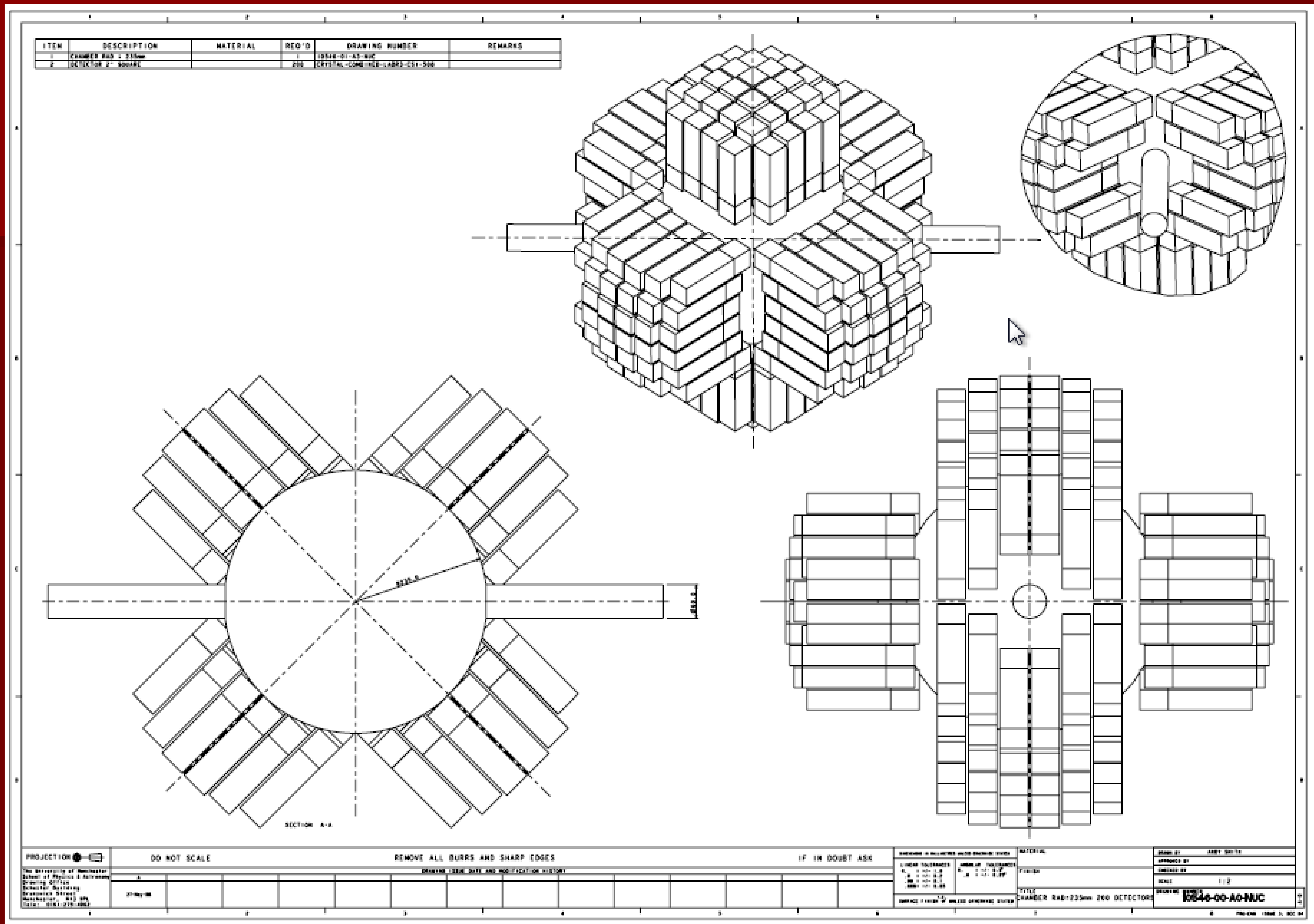
CUBIC-LIKE GEOMETRY

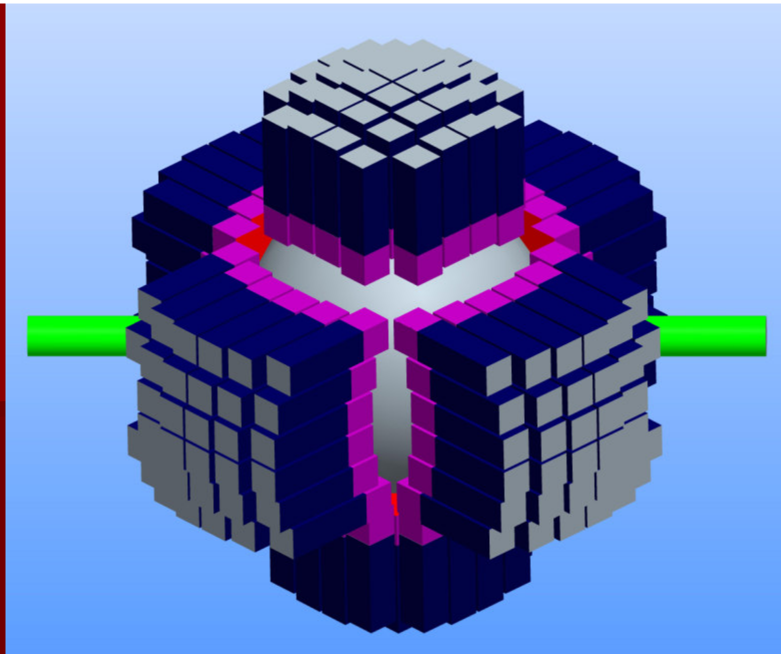


52 phoswitches - Labr3: 2”x2”x2” + CsI: 2”x2”x6” (15 cm inner radius)

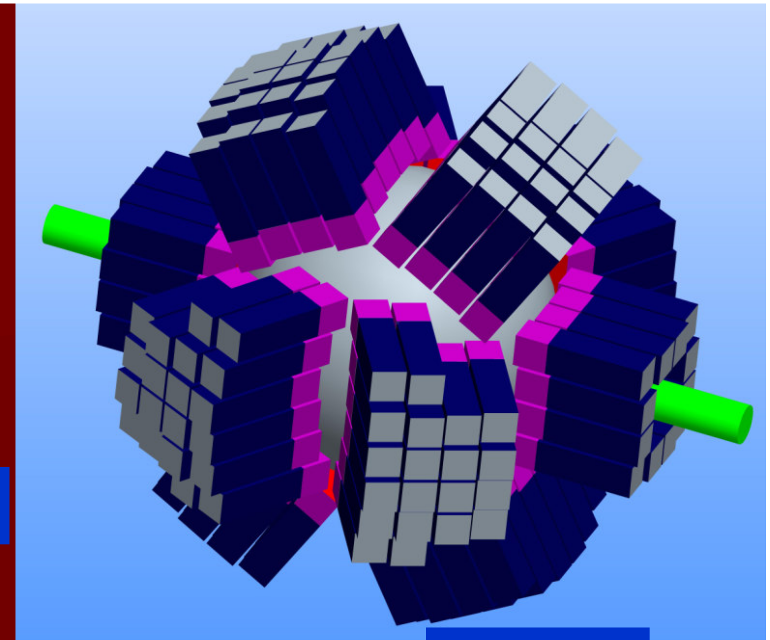


204 phoswitches - Labr3: 2”x2”x2” + CsI: 2”x2”x6” (23 cm inner radius)


ITEM
DESCRIPTION
MATERIAL
REQ'D
DRAWING NUMBER
REMARKS
DETECTOR 2" SQUARE
SECTION A-A
PROJECTION
DO NOT SCALE
REMOVE ALL BURRS AND SHARP EDGES
IF IN DOUBT ASK
DRAWING ISSUE DATE AND MODIFICATION HISTORY
MATERIAL
TITLE
CHAMBER RAD=235mm 200 DETECTORS
SCALE
1:2

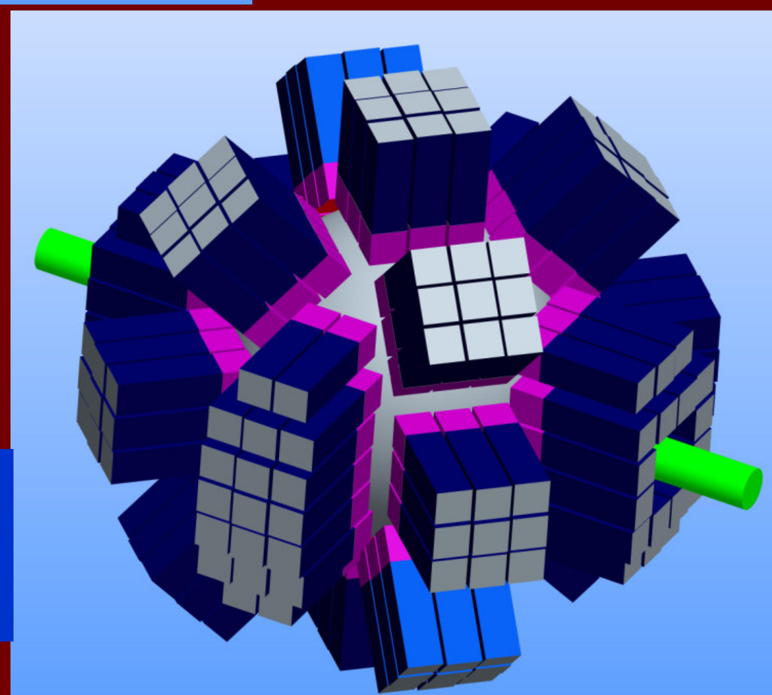


200 elements



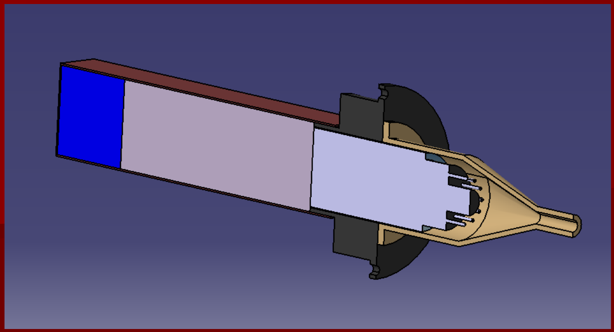
Cube
6 faces

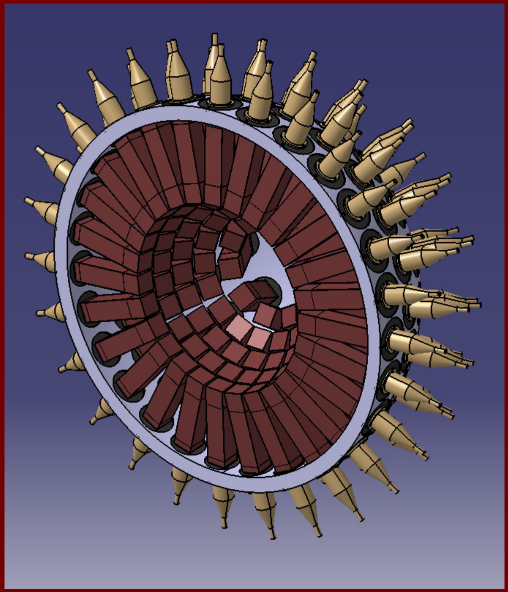
Decagon
10 faces



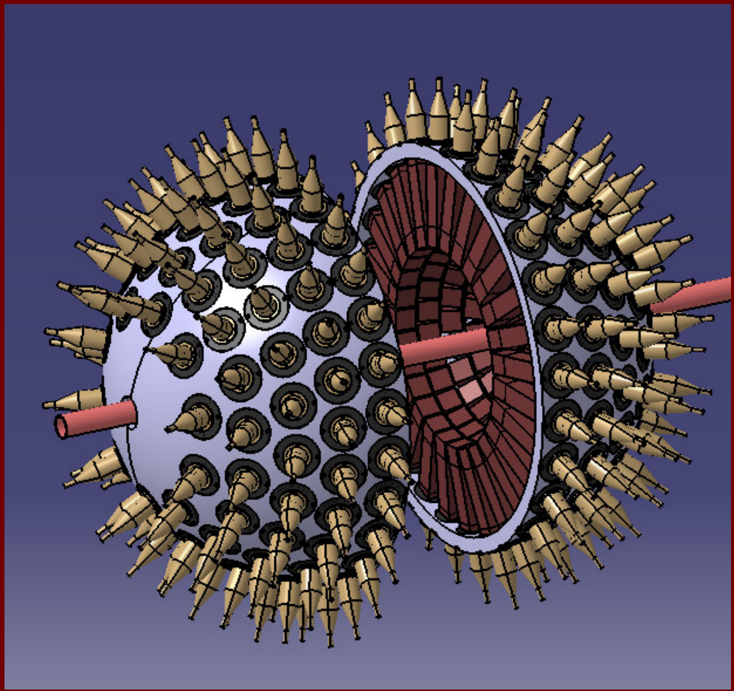
Octadegon
18 faces

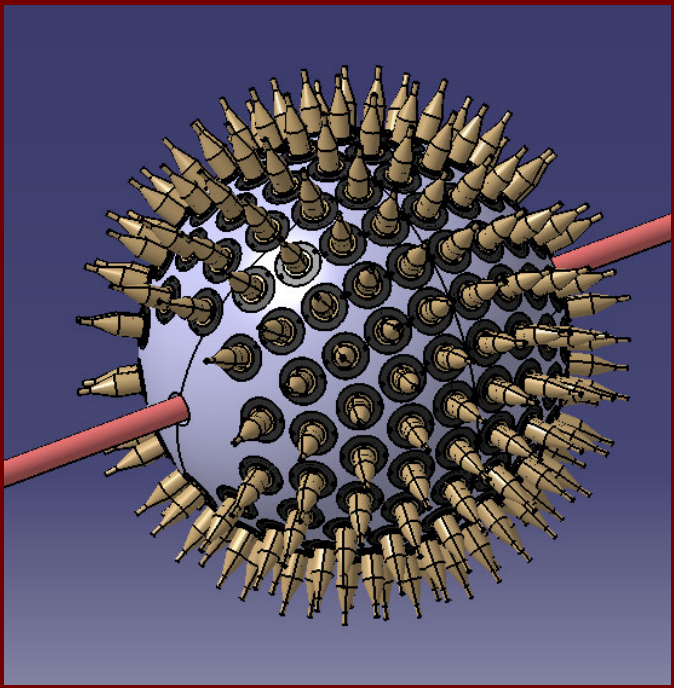
SPHERE-LIKE (RADIAL) GEOMETRY



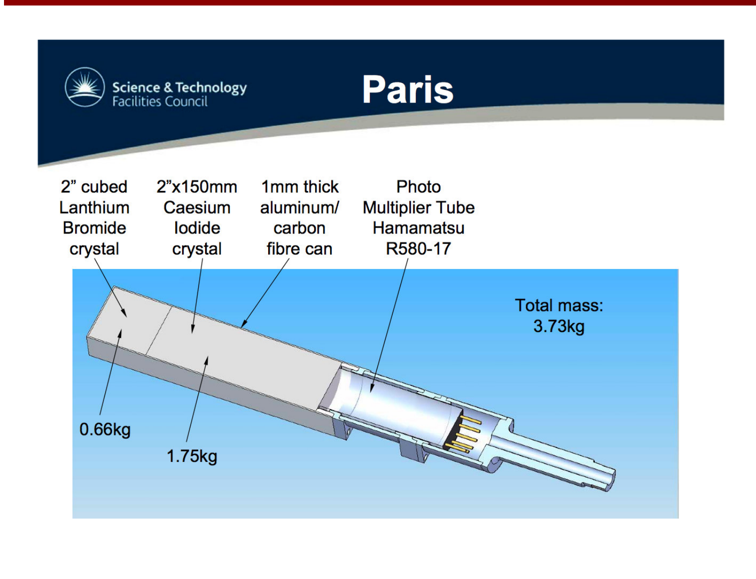


200 elements





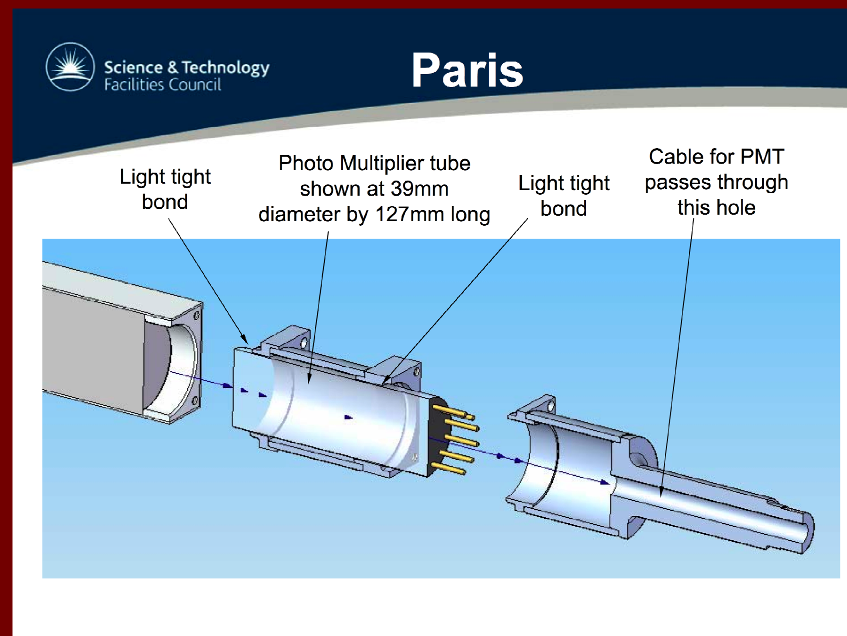
Phoswich design



Pros:

Composite detector gives sensitivity over wider range of gamma ray energies

No space lost between crystals



To test:

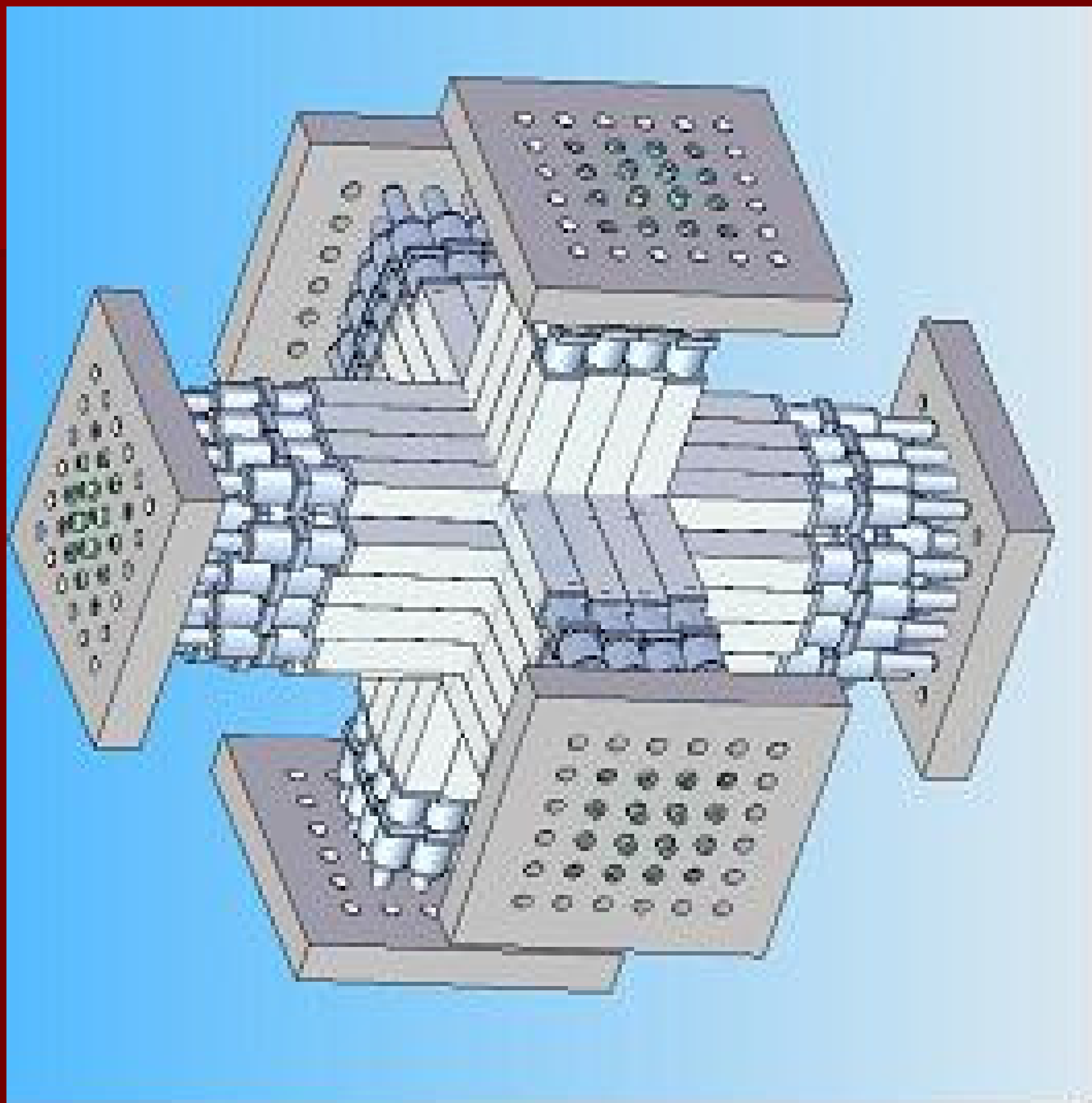
Does it work?

Is it mechanically stable?

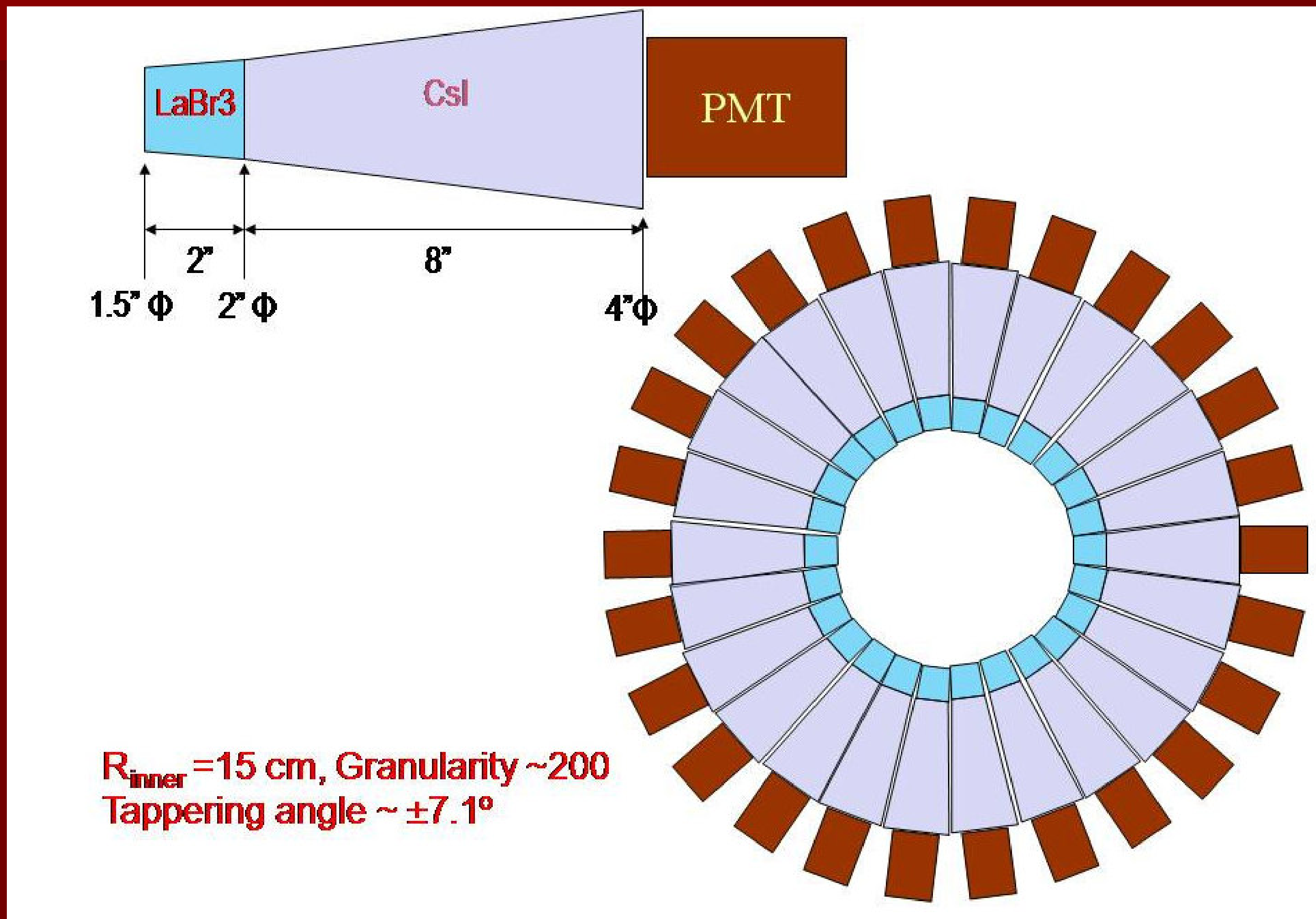
Does it provide needed energy resolution?

How does it respond to charged particles and neutrons?


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
Total mass:
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



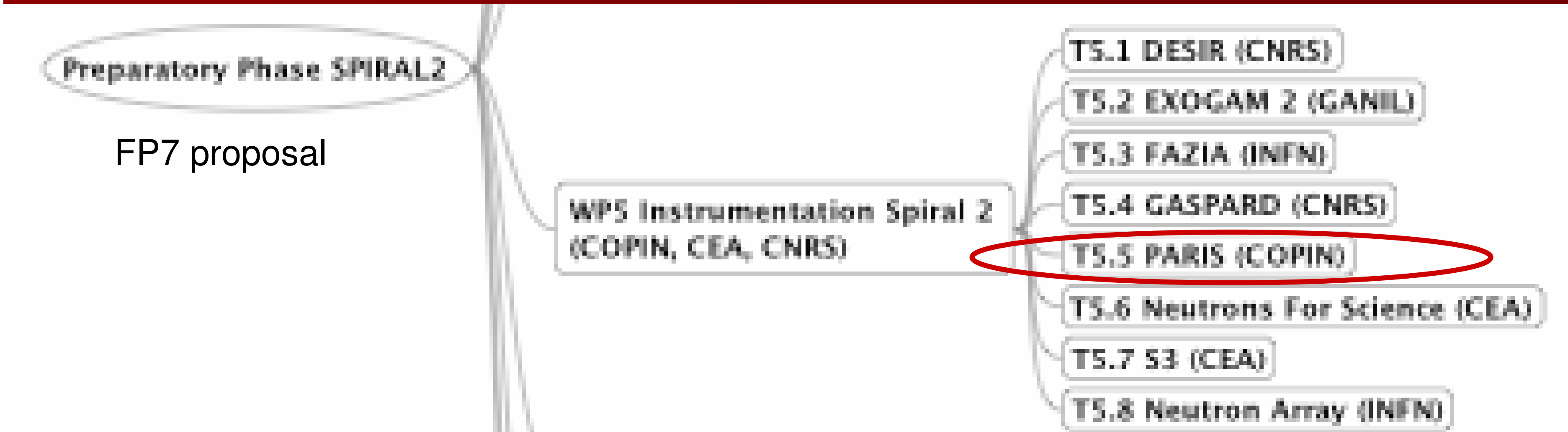
Tapered phoswich – S. Kumar (BARC Mumbai)



R_{inner} =15 cm, Granularity ~200
Tappering angle ~ ±7.1°

FOUNDING

PARIS in the FP7 SPIRAL2 Preparatory Phase project



Main goals: Design and construct PARIS prototype
Sign MoU between partners of PARIS collaboration

~200 kEuro

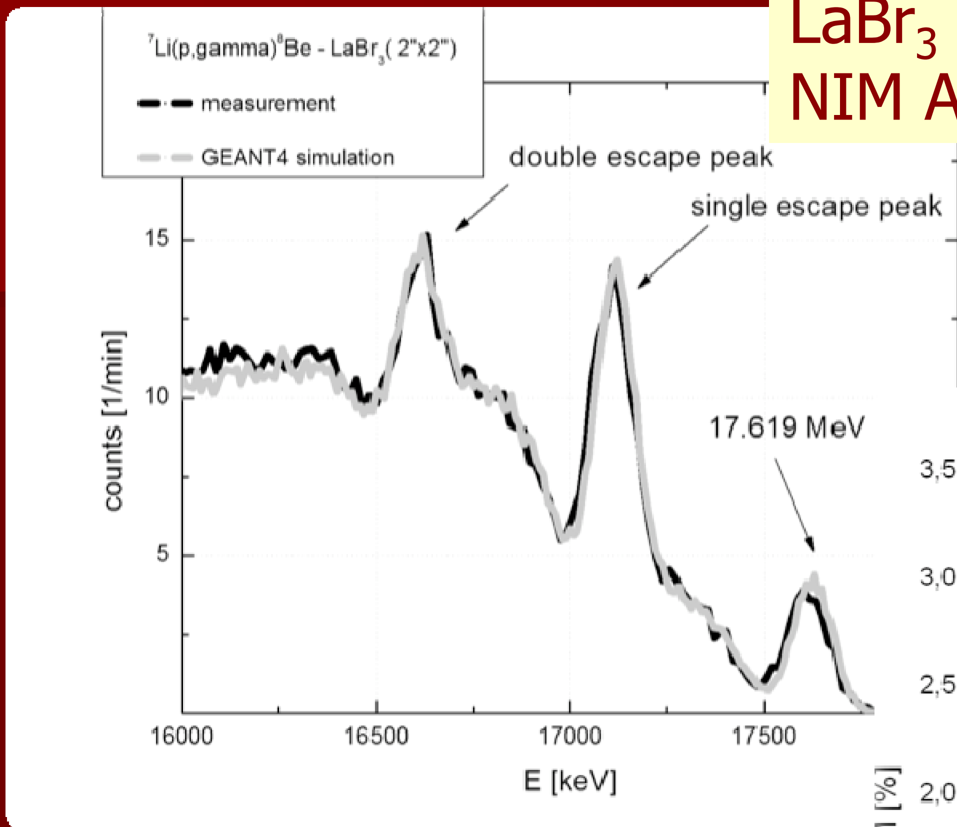
Frame for common preparation with **EXOGAM2 (+Agata Demonstrator**).

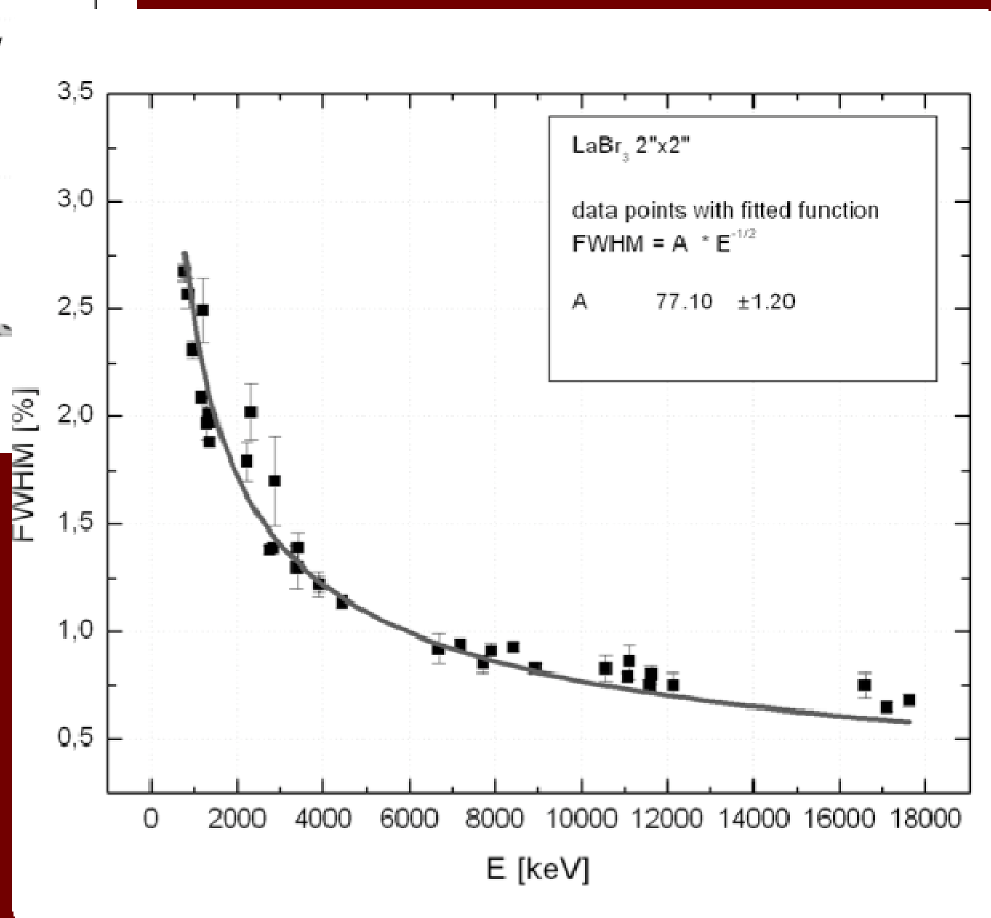
Also possibility for synergy with **Neutron Array and GASPARD**

Discussion are going on with **VAMOS** group

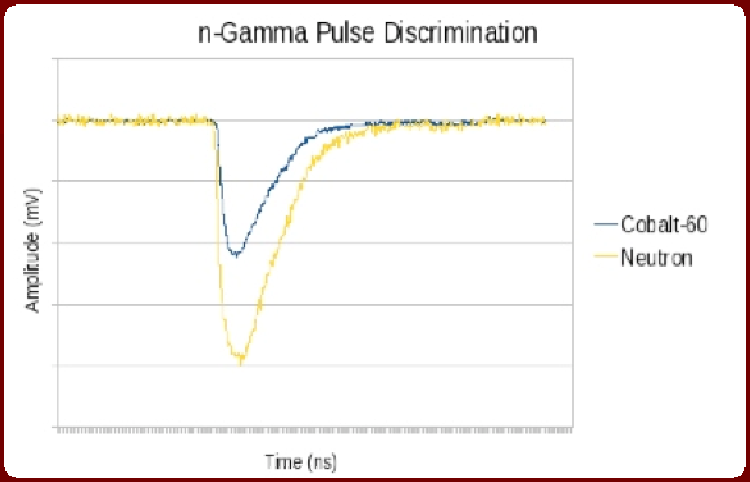
DETECTOR TESTING

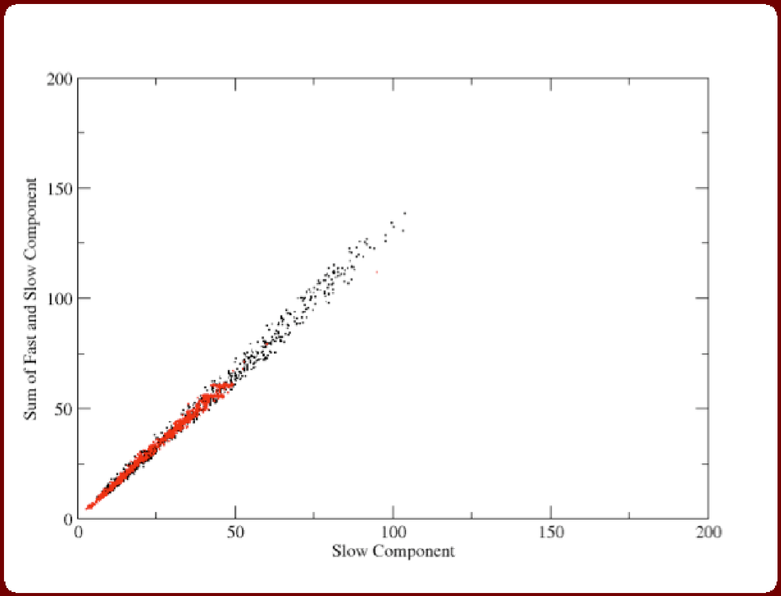
Resolution and efficiency tests for $LaBr_3$ at ATOMKI (M. Ciemała et al., NIM A608, 76 (2009))





Neutron/gamma discrimination (York group)



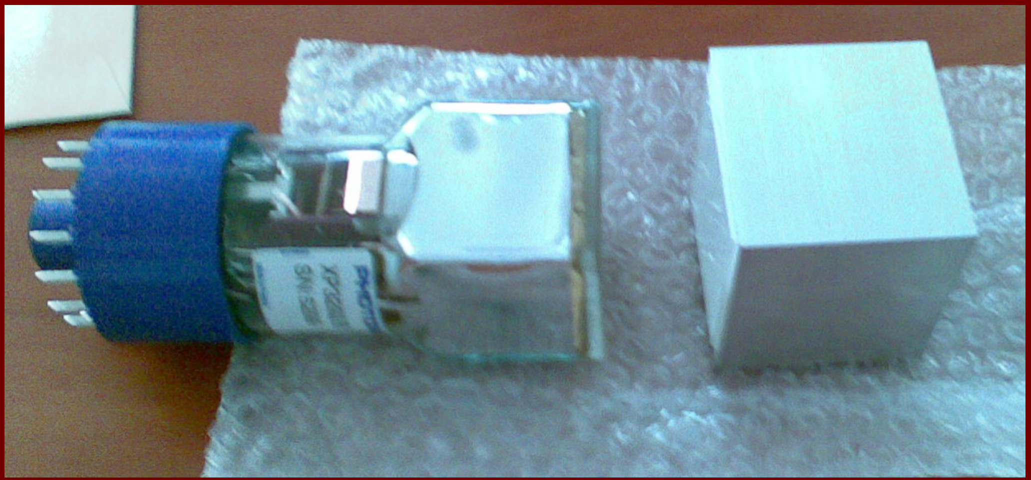


PARIS detectors tests

Orsay, Strasbourg, York, Krakow, Warsaw

We purchased from Saint Gobain, using SP2PP and PROVA funds, following detectors:

- Cubic 1″x1″x2″ LaBr3
- Cubic 2″x2″x2″ LaBr3
- Cubic 2″x2″x4″ LaBr3



Energy resolution of single cubic $LaBr_3$ the same as cylinfrical ones

Preliminary phoswich test results

- Cubic Phoswich: 1”x1”x2” LaBr3 + 1”x1”x6” CsI(Na)

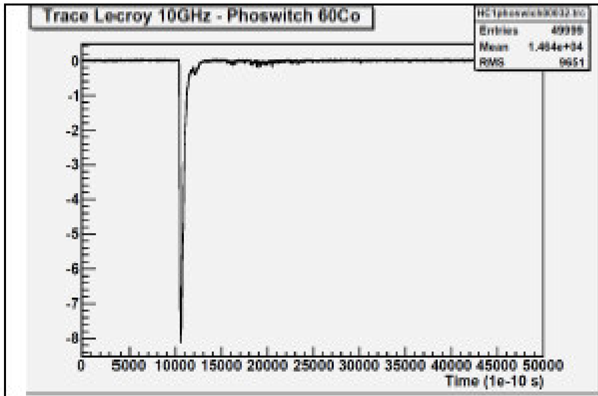


Fig. 4a: Signal corresponding to the event which deposited energy only in LaBr3

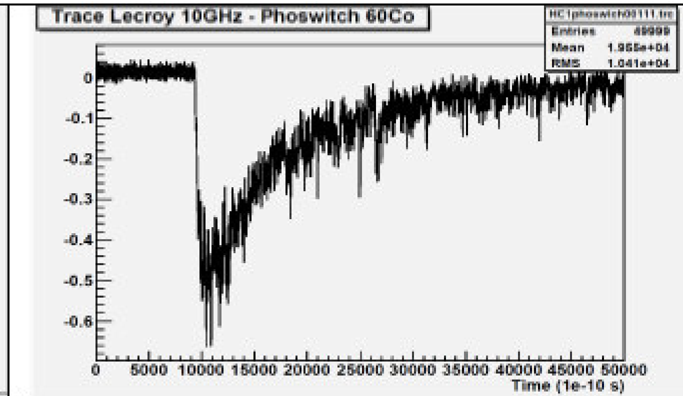


Fig. 4b: Signal corresponding to the event which deposited energy only in CsI(Na)

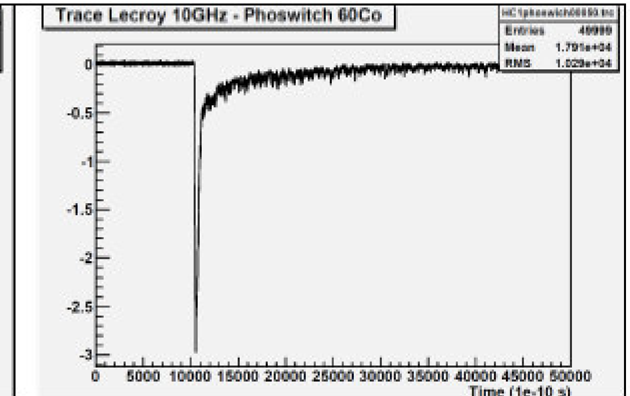


Fig. 4c: Signal corresponding to the event which deposited energy in both crystals

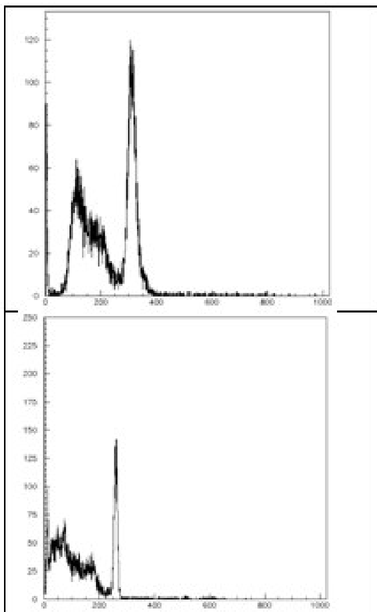


Fig. 5a: Spectra for ^{137}Cs for the events, when the whole energy is deposited in LaBr3 (bottom) and

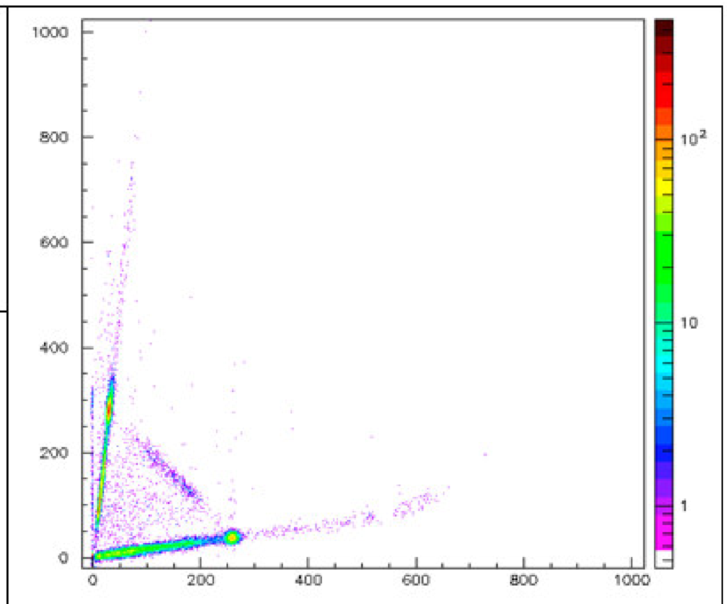
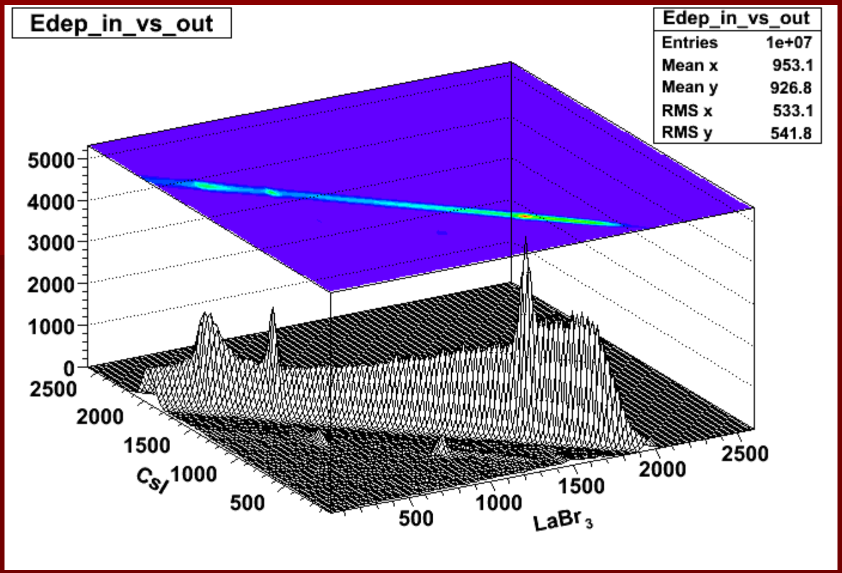
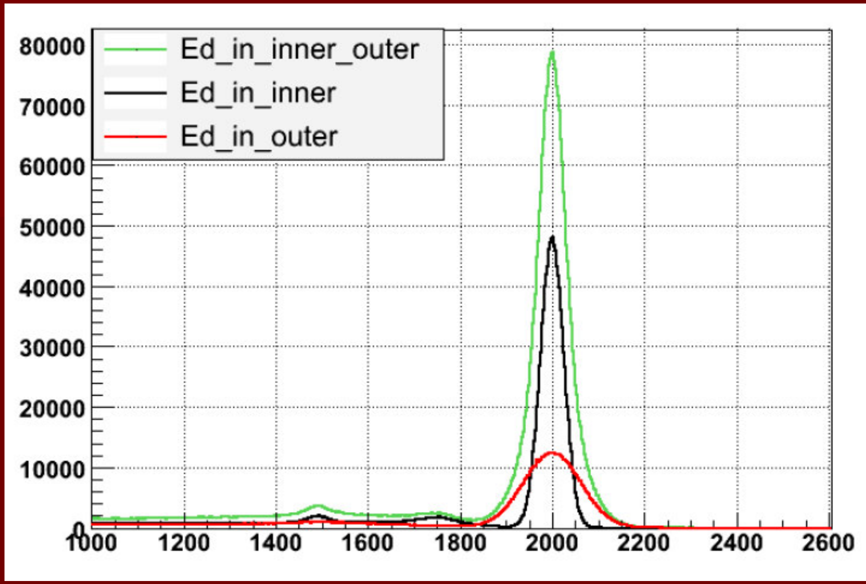


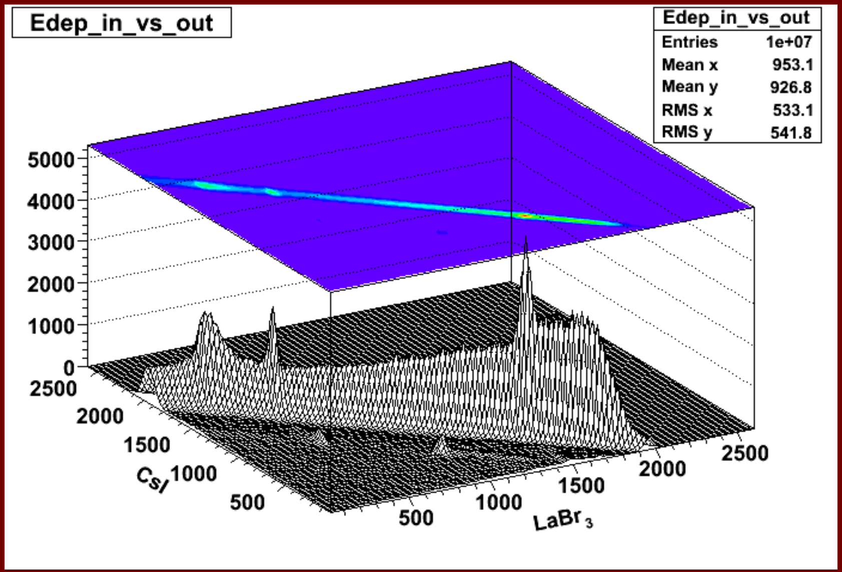
Fig.5b: Correlation plot between events deposited in LaBr3 (x-axis) and CsI (y-axis), when the detector was exposed to 661 keV gamma radiation from ^{137}Cs source

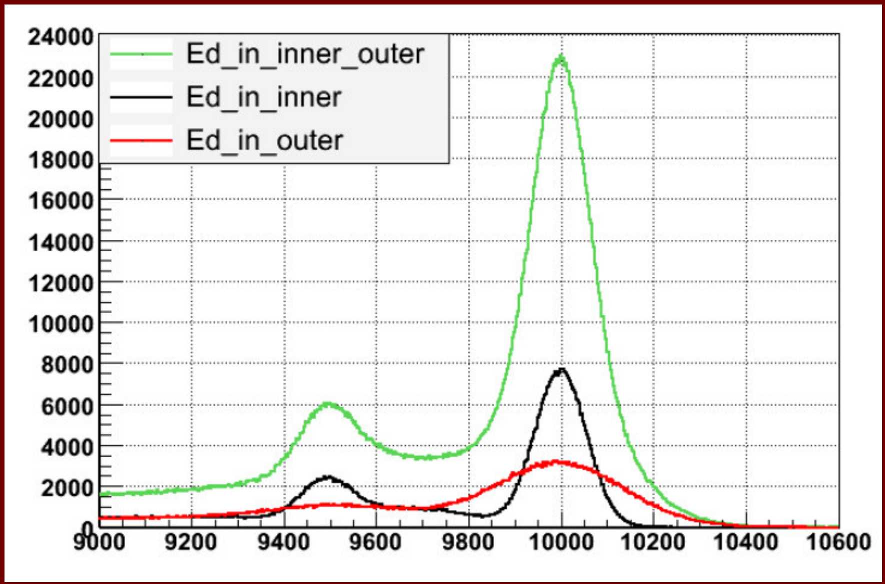
Phoswich concept seem to work

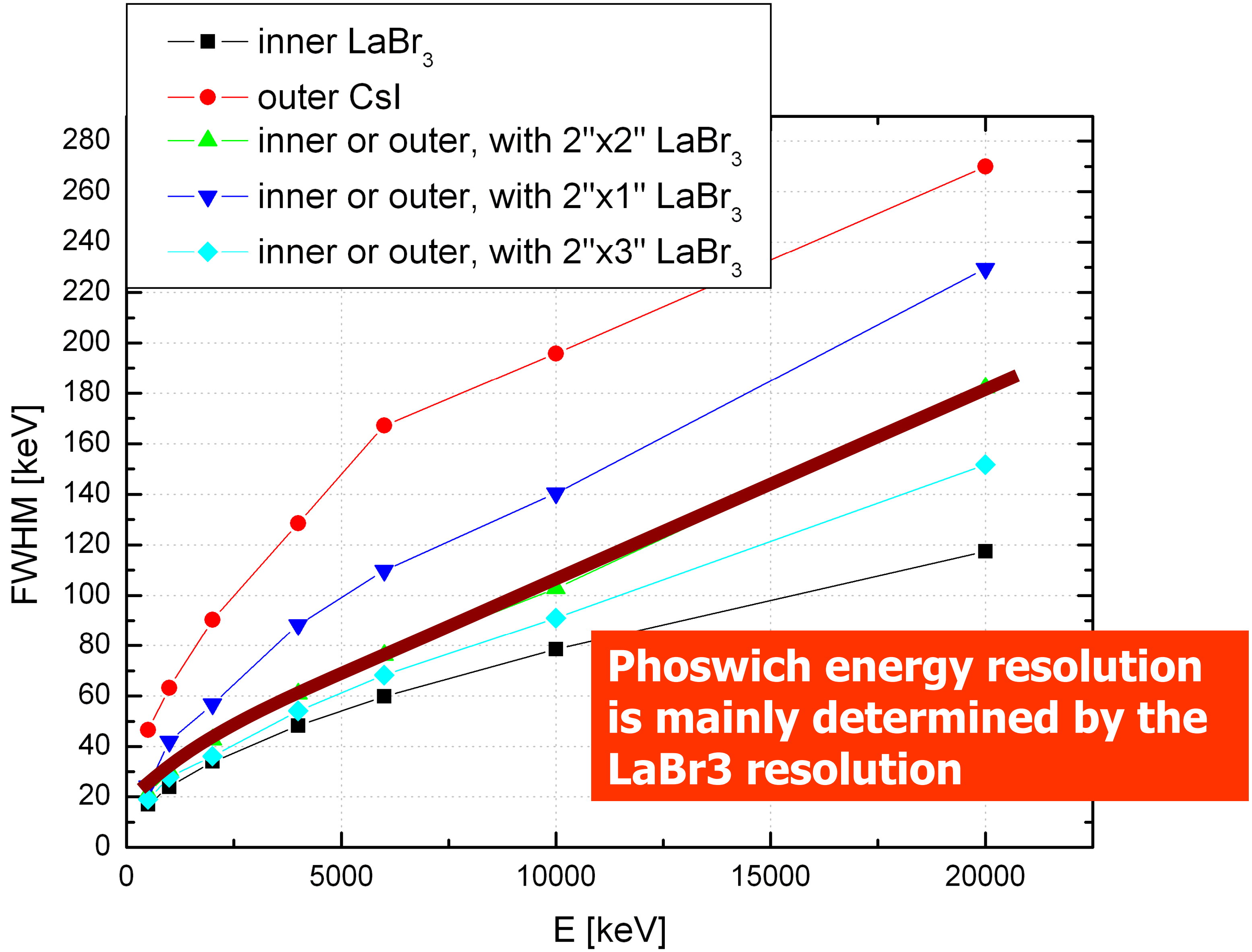
Phoswich Geant4 simulations
Krakow, Lyon, Orsay, Strasbourg







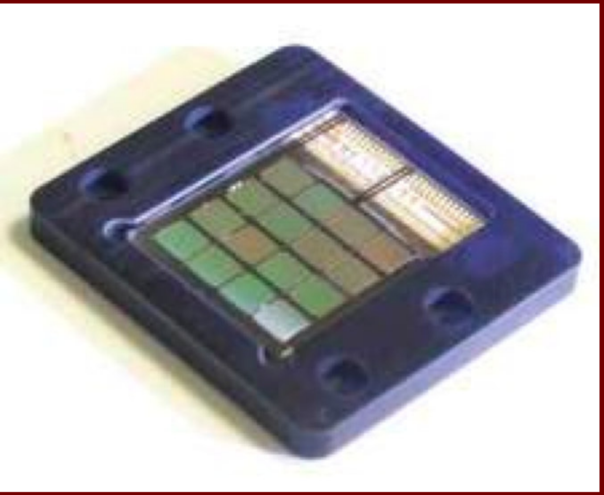



inner LaBr$_3$
outer CsI
inner or outer, with 2"x2" LaBr$_3$
inner or outer, with 2"x1" LaBr$_3$
inner or outer, with 2"x3" LaBr$_3$
FWHM [keV]
E [keV]
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
0
5000
10000
15000
20000
Phoswich energy resolution is mainly determined by the LaBr3 resolution

APD testing
(York, Strasbourg, Orsay)

SensL — THE LOW LIGHT SENSING COMPANY

SPMPlus



- Direct replacement for photomultiplier tube
- Insensitive to magnetic fields
- Can operate in vacuum
- Large sizes possible
- Attractive for simultaneous PET and MRI scanning
- Gain stabilisation as function of temperature must be achieved

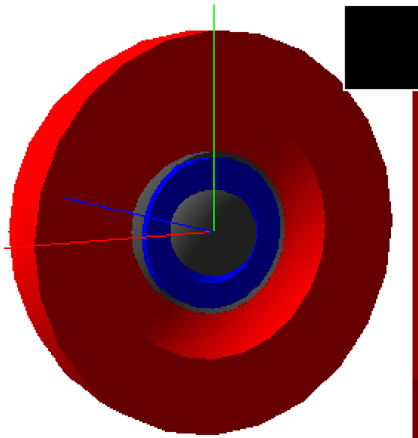
<u>Electronics</u>

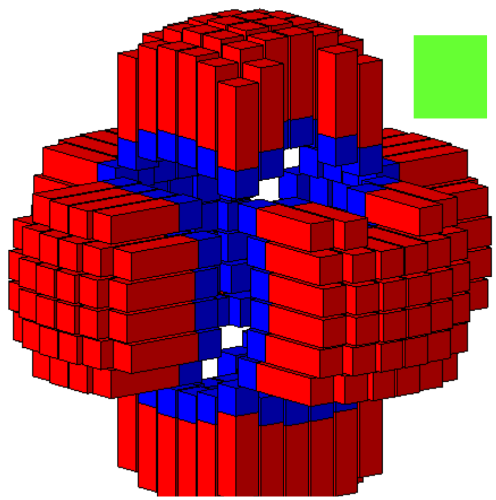
- **Designing the HV supply – Sofia**
- **Digital Electronics – Debrecen, Krakow, Orsay**
- **DAQ – Orsay, Krakow**

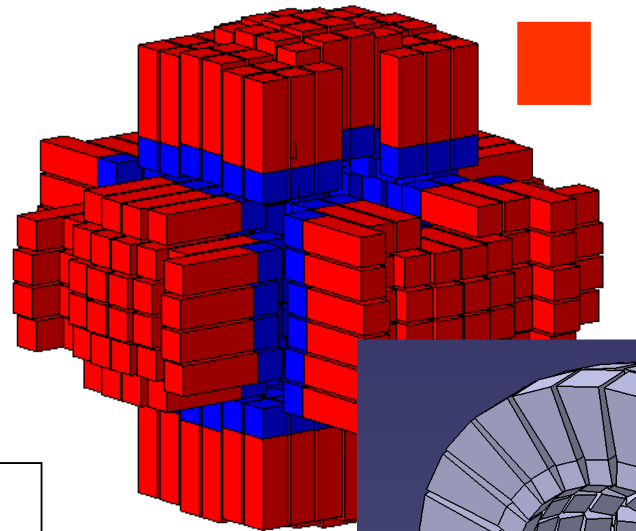
A.Czermak (Krakow) represents PARIS in the *SPIRAL2 ELECTRONICS WG*
X.Grave (Orsay) represents PARIS in the *SPIRAL2 DAQ WG*

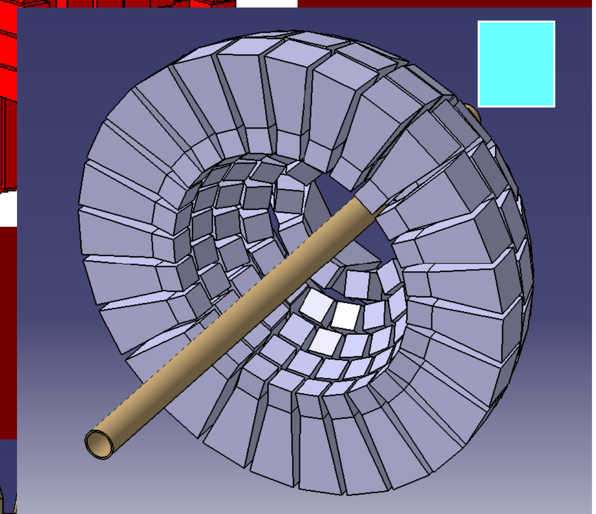
WHAT NEXT?

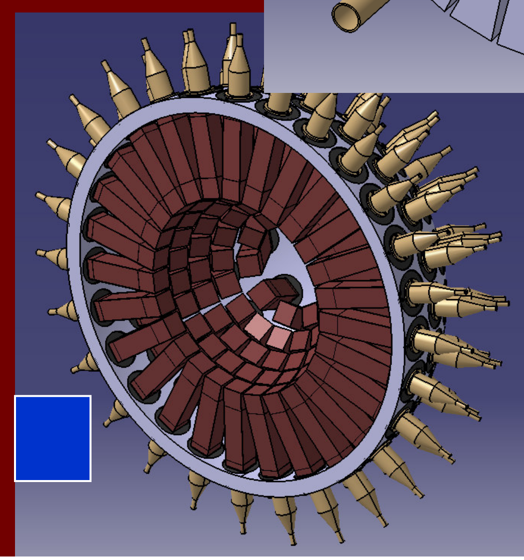
Cubic vs. Radial geometry

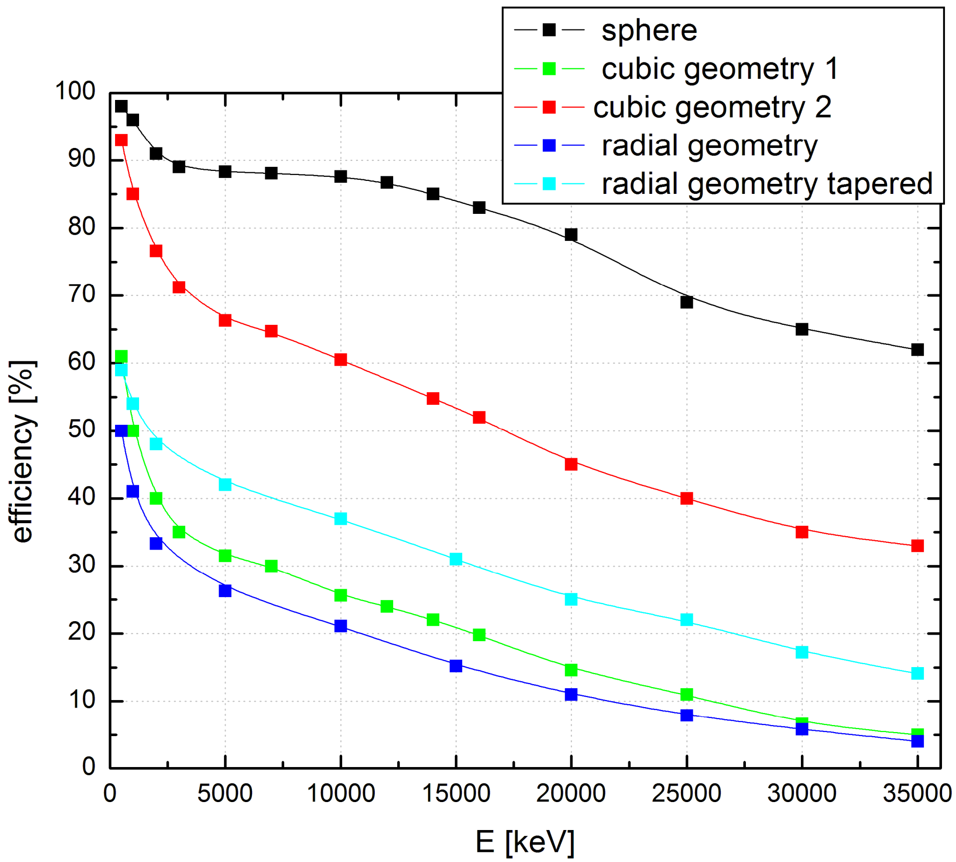






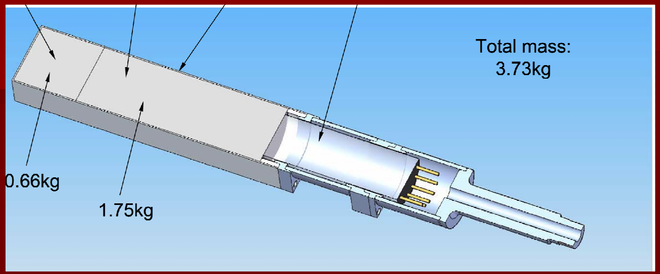




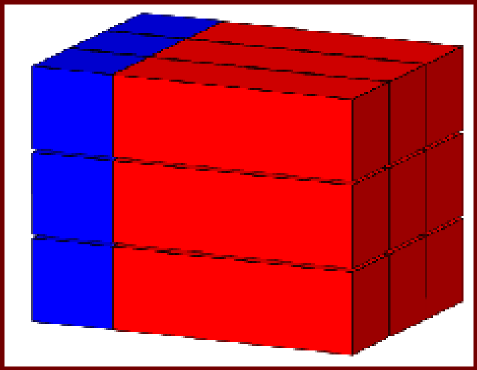


Proposed next steps
(to be decided during this meeting)

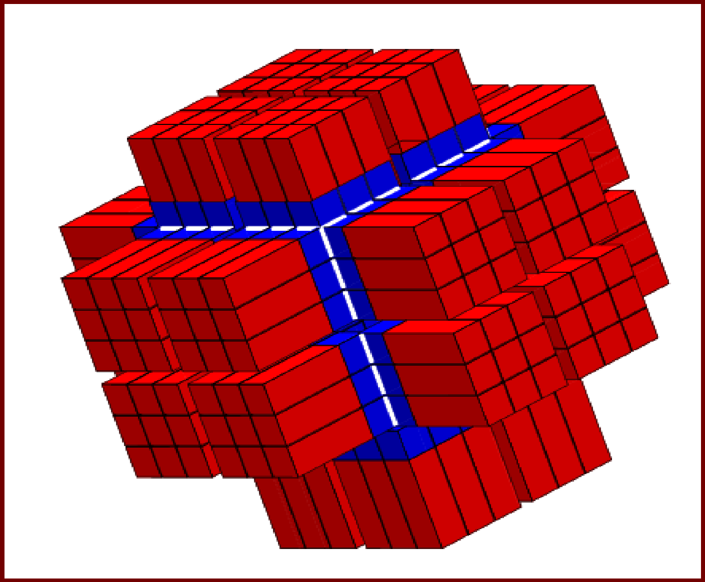
Detailed tests of phoswich

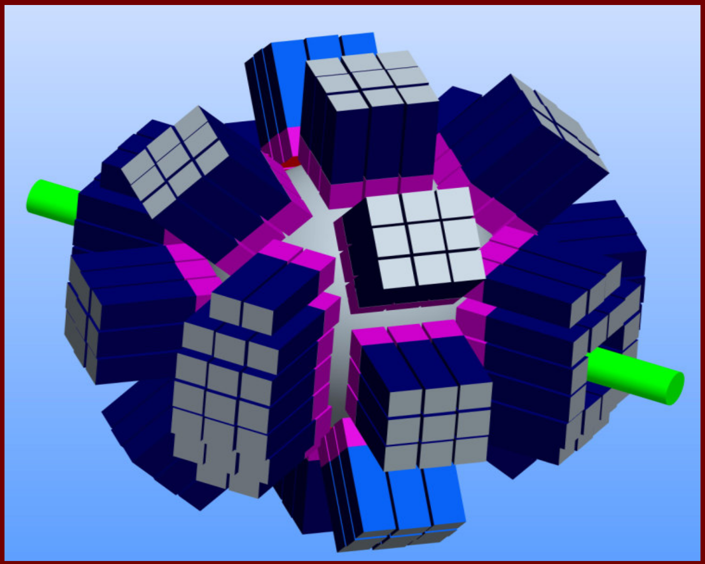


Purchasing/Assembling
CLUSTER of 9 phoswiches



MoU between partners and bulding **PARIS** with Clusters
It can be arranged either in **cubic or radial geometry**





Such arrangement will be compatible with other detectors, e.g. AGATA, GASPARD,…

14.10.2009 SAC report on PARIS status:

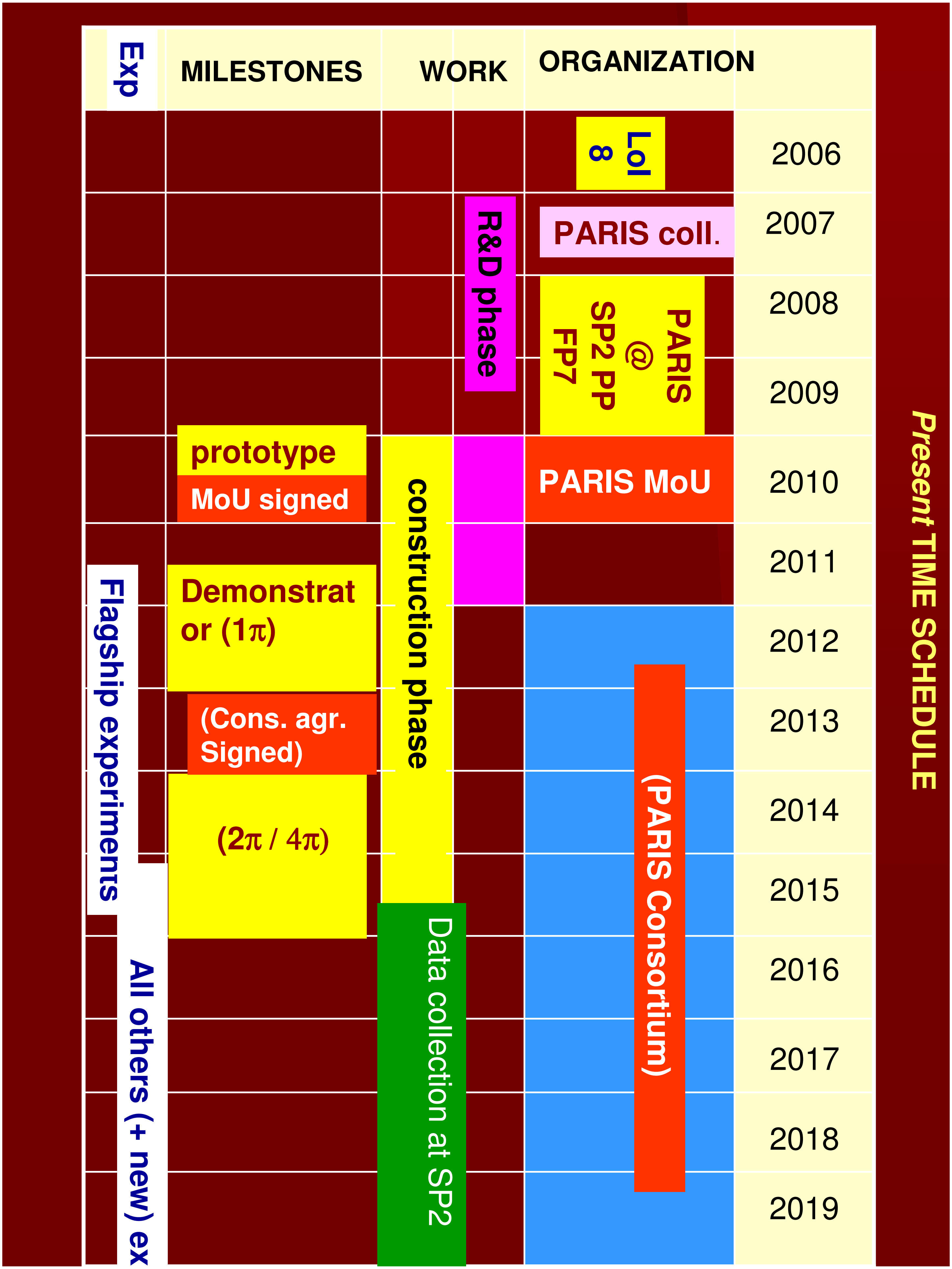
The SAC acknowledges the progress made by the PARIS collaboration in particular concerning the detector tests of the LaBr3 prototype cubic detectors which displayed excellent resolution in both configurations the 2″ -long and 4″ -long crystals. The test with the phoswich-type detector composed of LaBr3 and CsI(Na) crystals is very encouraging indeed and should be quite useful in detecting high-energy γ-rays because of the high efficiency and very reasonable resolution. The GEANT4 simulations have been performed with the phoswich-type detector and it seems that the collaboration is now at the crossroad for making a choice between the cubic-like geometry and the radial-like geometry of PARIS, both consisting of rectangular phoswich crystals. The truly spherical geometry has been abandoned because of the choice of rectangular phoswich crystals.

The SAC is pleased to hear that the final decision of the geometry will be made in October 2009.

It would be strongly recommended that in the next status report both the GASPARD and PARIS collaborations should work out one or more experiments where the integrated GASPARD and PARIS detectors are used.

The next steps

- PARIS FEE and DAQ
- PARIS & GASPARD physics case
- Testing the Phoswich design
- Testing for neutron response
- Testing PARIS prototype *(FP7 SP2PP)*
- Finalising the design(s)
- MoU between PARIS partners
- Continuing with *realistic* simulations
- Choose the final design
- Find the money and build PARIS



Present TIME SCHEDULE
Exp
MILESTONES
WORK
ORGANIZATION
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
LoI
8
PARIS coll.
PARIS
@
SP2 PP
FP7
R&D phase
PARIS MoU
prototype
MoU signed
construction phase
Demonstrat
or (1π)
(Cons. agr.
Signed)
(2π / 4π)
Data collection at SP2
(PARIS Consortium)
Flagship experiments
All others (+ new) ex

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And to

- *FP7 SP2PP project*
- *Saint Gobain*
- *French ANR project*
- *Polish MNiSW Grant*

We are pleased to announce that the forthcoming

ZAKOPANE CONFERENCE ON NUCLEAR PHYSICS

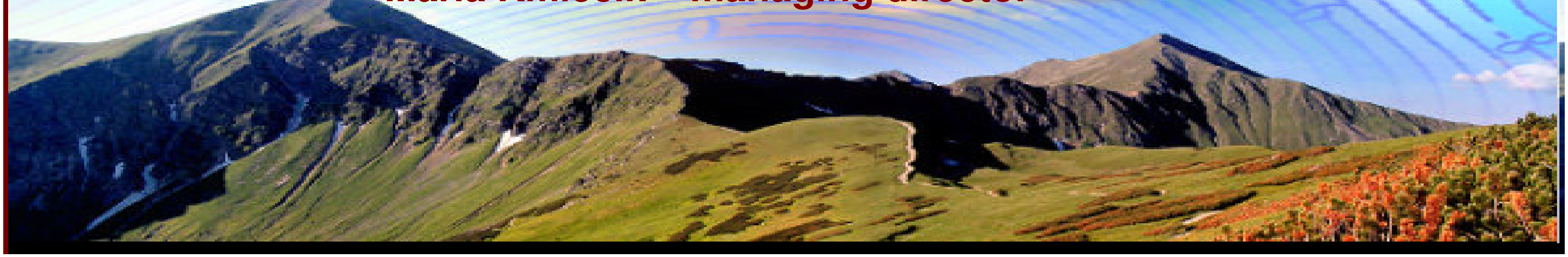
45th in the series of Zakopane School of Physics
will be held in Zakopane, Poland, on
August 30 – September 5, 2010

Organized by
The Henryk Niewodniczański Institute of Nuclear Physics,
Polish Academy of Sciences, Krakow

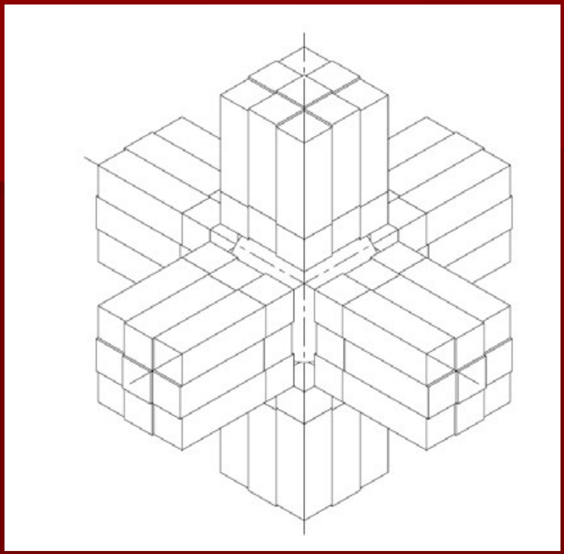
zakopane2010.ifj.edu.pl

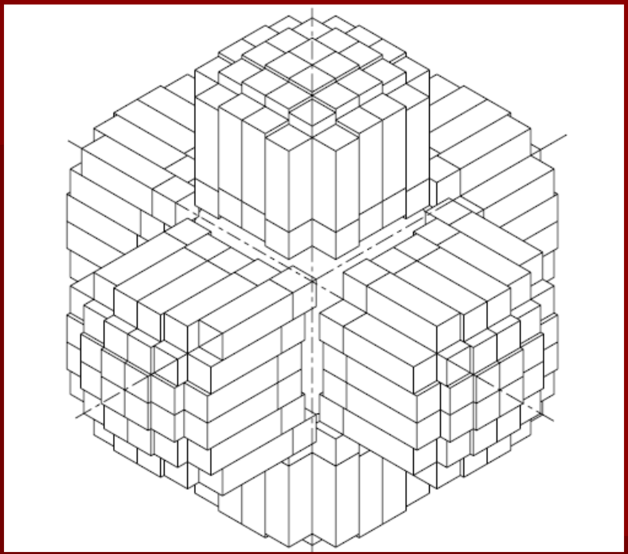
You are cordially invited to come!

Adam Maj – chair
Piotr Bednarczyk – scientific secretary
Maria Kmiecik – managing director



Cost estimate for some possible scenarios of PARIS





a) Low granularity (Demonstrator ?):

54 phoswitches
LaBr3: 2”x2”x2”
CsI(Na): 2”x2”x6”
(15 cm from target)

54*14 k€ = **0.75 M€**
+ cost of 216 channel electronic

b) Medium granularity:

200 phoswitches
LaBr3: 2”x2”x2”
CsI(Na): 2”x2”x6”
(20 cm from target)

200*14 k€ = **2.8 M€**
+ cost of 800 channel electronic

c) High granularity:

800 phoswitches
LaBr3: 1”x1”x2”
CsI(Na): 1”12”x6”
(20 cm from target)

800*6 k€ = **4.8 M€**
+ cost of 3200 channel electronic