PARIS — Photon Array for studies with Radioactive Ion and Stable beams

Overview of the PARIS Project

O. Stézowski

- IPN Lyon -

on behalf of the PARIS collaboration

27/06/2011

EGAN — European Gamma and Ancillary detectors Network

More informations ☛ http://paris.ifj.edu.pl

The PARIS Project

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

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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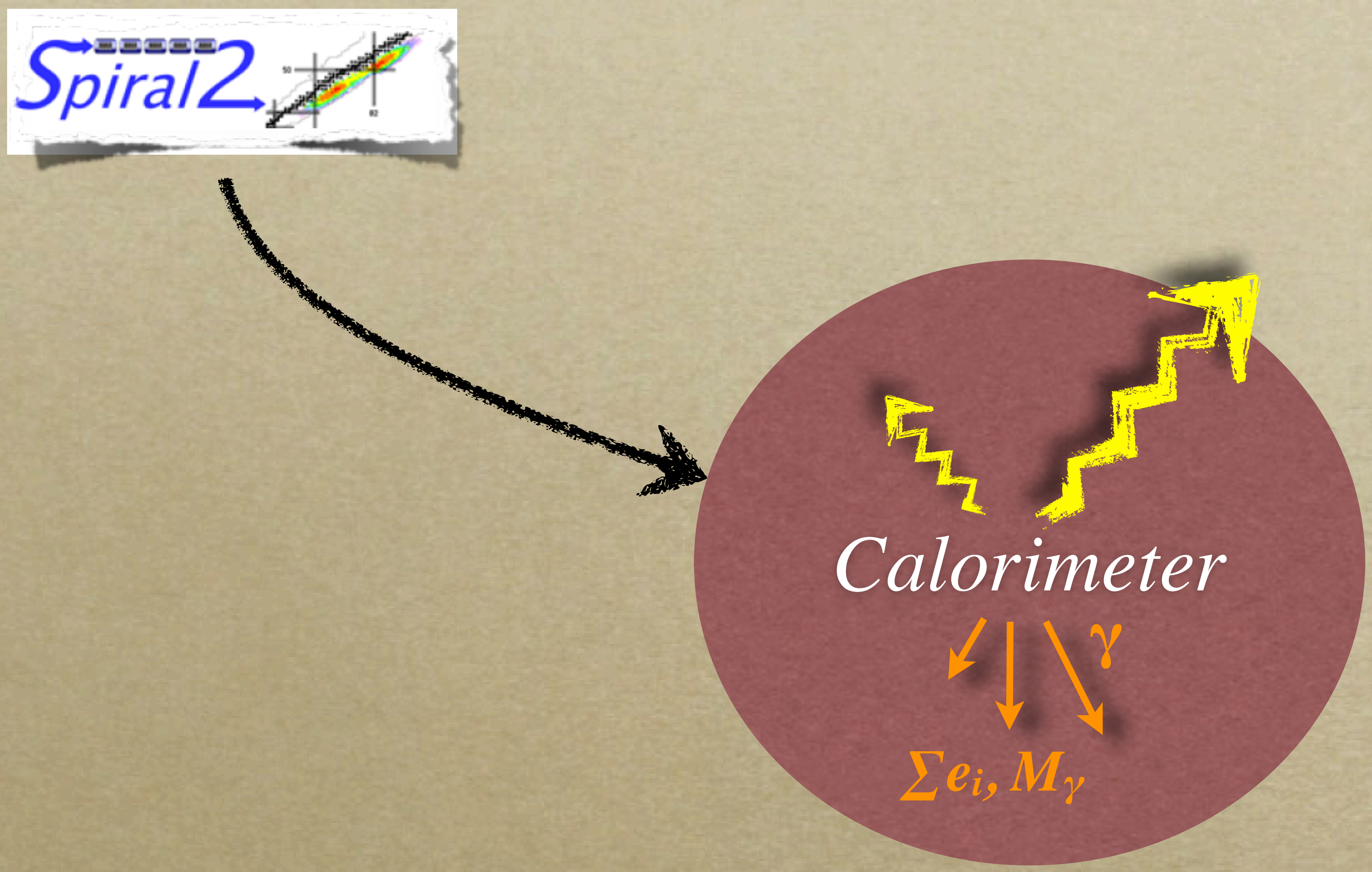
Jean-Antoine Scarpaci, IPN Orsay, scarpaci@ipno.in2p3.fr *(EXL and R3B contact)*
David Jenkins, University of York (UK), dj4@york.ac.uk

GANIL contact person
Jean-Pierre Wieleczko, GANIL, wieleczko@ganil.fr

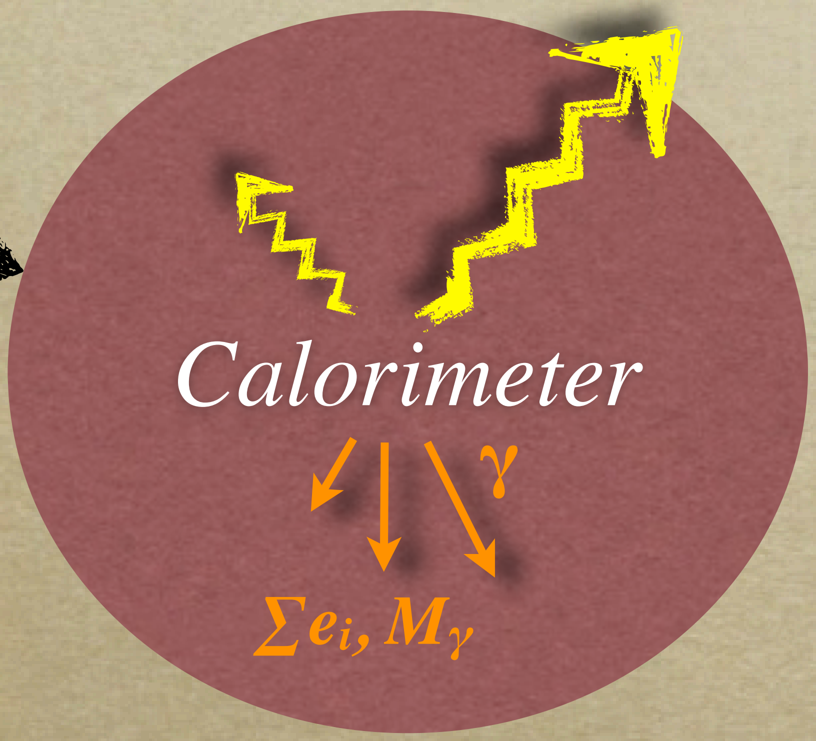
Letter of Intent

The PARIS Project



The PARIS Project

- ***High energy γ-ray***
  GDR, radiative capture
- ***Sum-spin spectrometer***
- *Discrete γ-ray*
  low multiplicity



The PARIS Project

Spiral2

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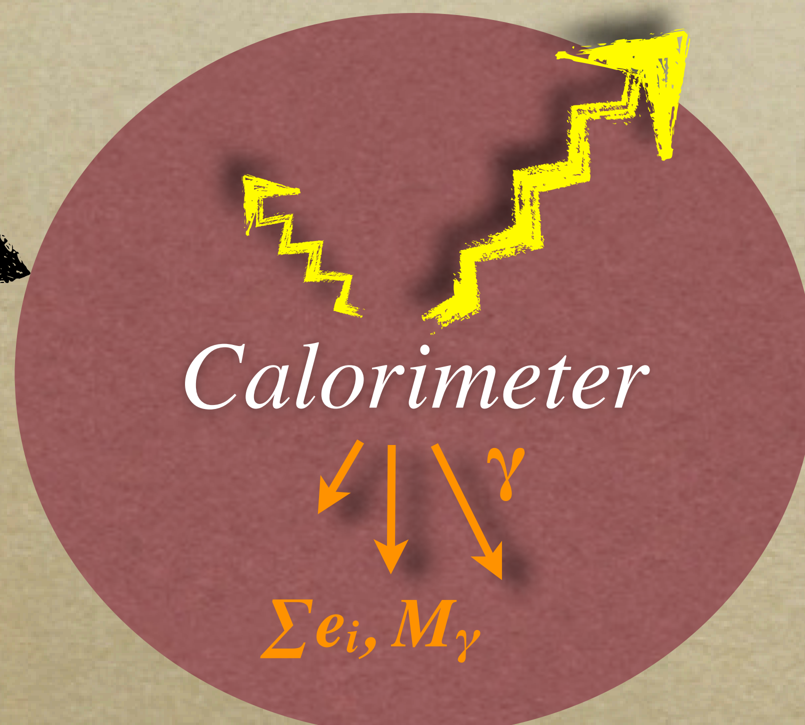

BrilLanCe®380

SAINT-GOBAIN CRYSTALS

The PARIS Project

- ***High energy γ-ray***
  GDR, radiative capture
- ***Sum-spin spectrometer***
- *Discrete γ-ray*
  low multiplicity

Calorimeter

γ

$\sum e_i, M_\gamma$

general design

Keep interesting
LaBr3 characteristics !??

BrilLanCe®380

SAINT-GOBAIN CRYSTALS

The PARIS Project

Spiral2

- **High energy γ-ray**
  GDR, radiative capture
- **Sum-spin spectrometer**
- Discrete γ-ray
  low multiplicity

Calorimeter

γ

$\Sigma e_i, M_\gamma$

signal processing

general design

BrilLanCe® 380

SAINT-GOBAIN CRYSTALS

Keep interesting LaBr3 characteristics !??

The PARIS Project

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  GDR, radiative capture
- ***Sum-spin spectrometer***
- *Discrete γ-ray*
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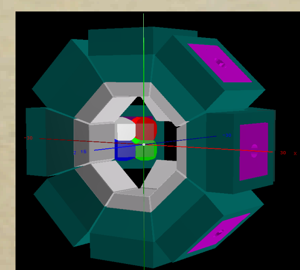
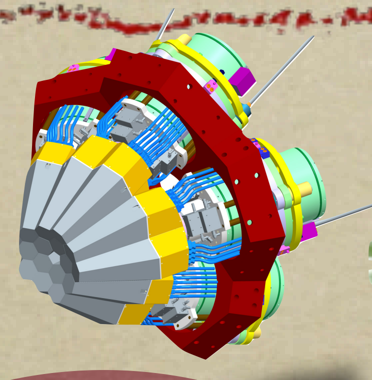
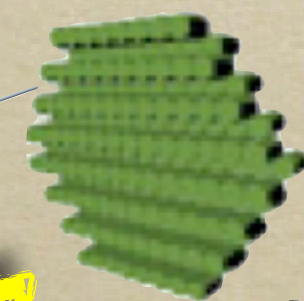


Compatible with :

- ***EXOGAM2***
- ***AGATA***
- ***NEDA***
- ***GASPARD***
- ***S3***

Calorimeter

γ

$\Sigma e_i, M_\gamma$

signal processing

general design

BrilLanCe®380

SAINT-GOBAIN CRYSTALS

Keep interesting LaBr3 characteristics !??

➥ PARIS collaboration

PARIS Management board

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

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. Electronics (P. Bednarczyk et al.)
6. PARIS-GASPARD synergy (J.A. Scarpaci et al.)
7. Financial issues (J.P. Wieleczko et al.)
8. PARIS in FP7 projects (A. Maj, F. Azaiez et al.)

PARIS *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. Schmitt (F), J.P. Wieleczko (F)

J. Pouthas – PARIS liaison to SPIRAL2 project management

➥ PARIS collaboration

PARIS Manageme
A. Maj - project … J.A. Scarpaci - deputies

Working gr
1.Simula
2.PARIS … D. Jenkins et al.)
3.Physic … itt et al.)
4.Detect
5.Electr
6.PARIS
7.Finan
8.PARIS

PARIS *Advisory*
F. Azaiez (F) -c … UK), D. Chakrabarty (India),
Z. Dombradi (H … UK) - deputy chairman,
S. Leoni (I), A. …), J.P. Wieleczko (F)

J. P … ect management

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HMI Berlin (Germany): H.J. Krappe
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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, 17 countries
≈ 100 physicists, engineers, PhD students

Physics cases, some numbers

List of requirements related to the different physics cases to be addressed at PARIS

Physics Case	Recoil mass	v/c [%]	E_g range [MeV]	DE_g/E_g [%]	DE_{sum}/E_{sum} [%]	DM_g	W coverage	DT [ns]	Ancillaries	Comments
Jacobi transition	40-150	<10	0.1-30	4	<5	4	2p-4p	<1	AGATA HI det.	High eff. Beam rej.
Shape Phase Diagram	160-180	<10	0.1-30	6	<5	4	2p-4p	<1	HI det.	High eff. Differential method Beam rej.
Hot GDR in n-rich nuclei	120-140	<11	0.1-30	6	<8	4	2p-4p	<1	HI det.	Beam re.
Isospin mixing	60-100	<7	5-30	6	-	-	4p	<1	HI det.	High eff. Beam rej.
Reaction dynamics	160-220	<7	0.1-25	6-8	<8	4	2p	<1	n-det. FF det.	Complex coupling
Collectivity vs. multi-fragmentation	120-200	<8	5-30	5	-	-	2p	<1	LCP det. HI det.	Complex coupling
Radiative capture	20-30	<3	1-30	<4	5	-	4p	<1	HI det.	High eff.
Multiple Coulex	40-60	<7	2-6	5	-	-	2p	<5	AGATA CD det.	Complex coupling
Astrophysics	16-90	0.1	0.1-6	6	5	-	4p	<1	Outer PARIS shell as active shield	High eff. Back-ground
Shell structure at intermediate energies (SISSI/LISE)	16-40	20-40	0.5-4	3	-	-	3p	<<1	SPEG or VAMOS	High eff. Low I_{beam} g-g coinc
Shell structure at low energies (separator part of S^3)	30-150	10-15	0.3-3	3	-	-	3p	<<1	Spectrometer part of S^3	High eff. Low I_{beam} g-g coinc
Relativistic Coulex	40-60	50-60	1-4	4	-	1	Forward 3p	<<1	AGATA HI analyzer	Ang. Distr. Lorentz boost

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Not especially design for high recoil velocities !!!

Physics cases, some numbers

1-40MeV

~4%

good $\Delta\Sigma e_i$, ΔM_γ

< 1ns

List of requirements related to the different physics cases to be addressed at PARIS

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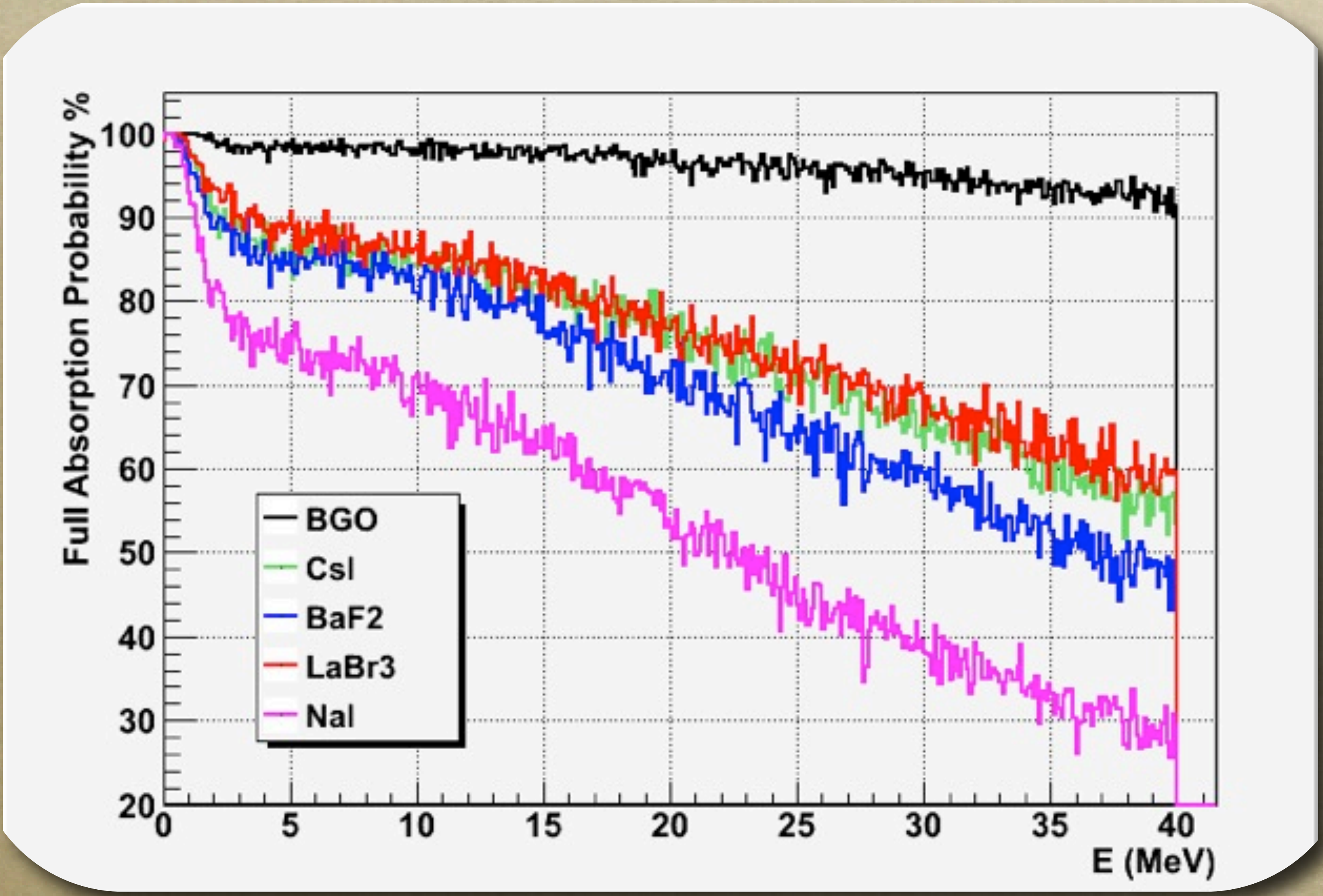
Calorimeter based on LaBr3

Geant4 simulations



Calorimeter based on LaBr3

Geant4 simulations

Resolution @ 662 keV

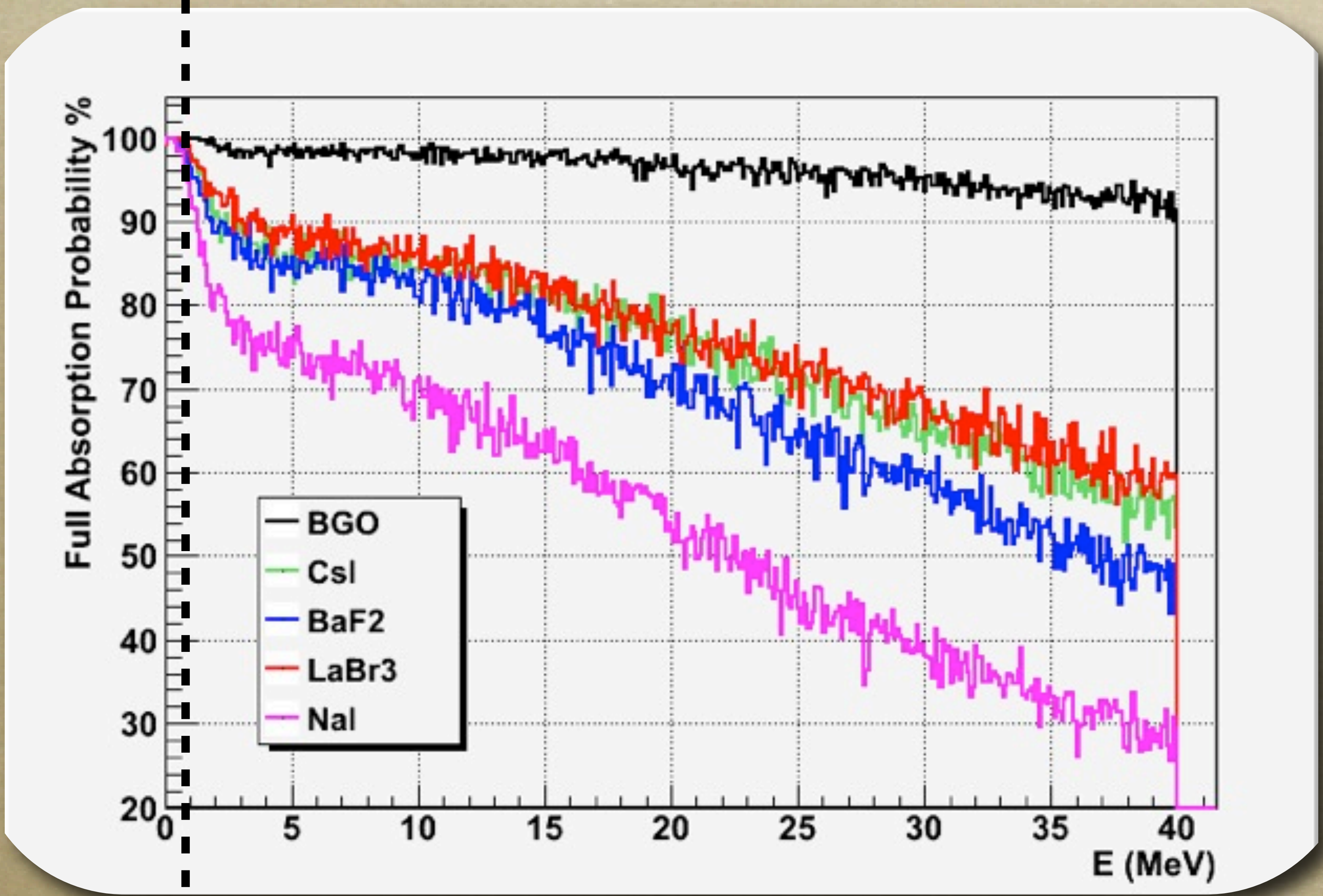
~12%

~3%

~8%

~10%

~7%



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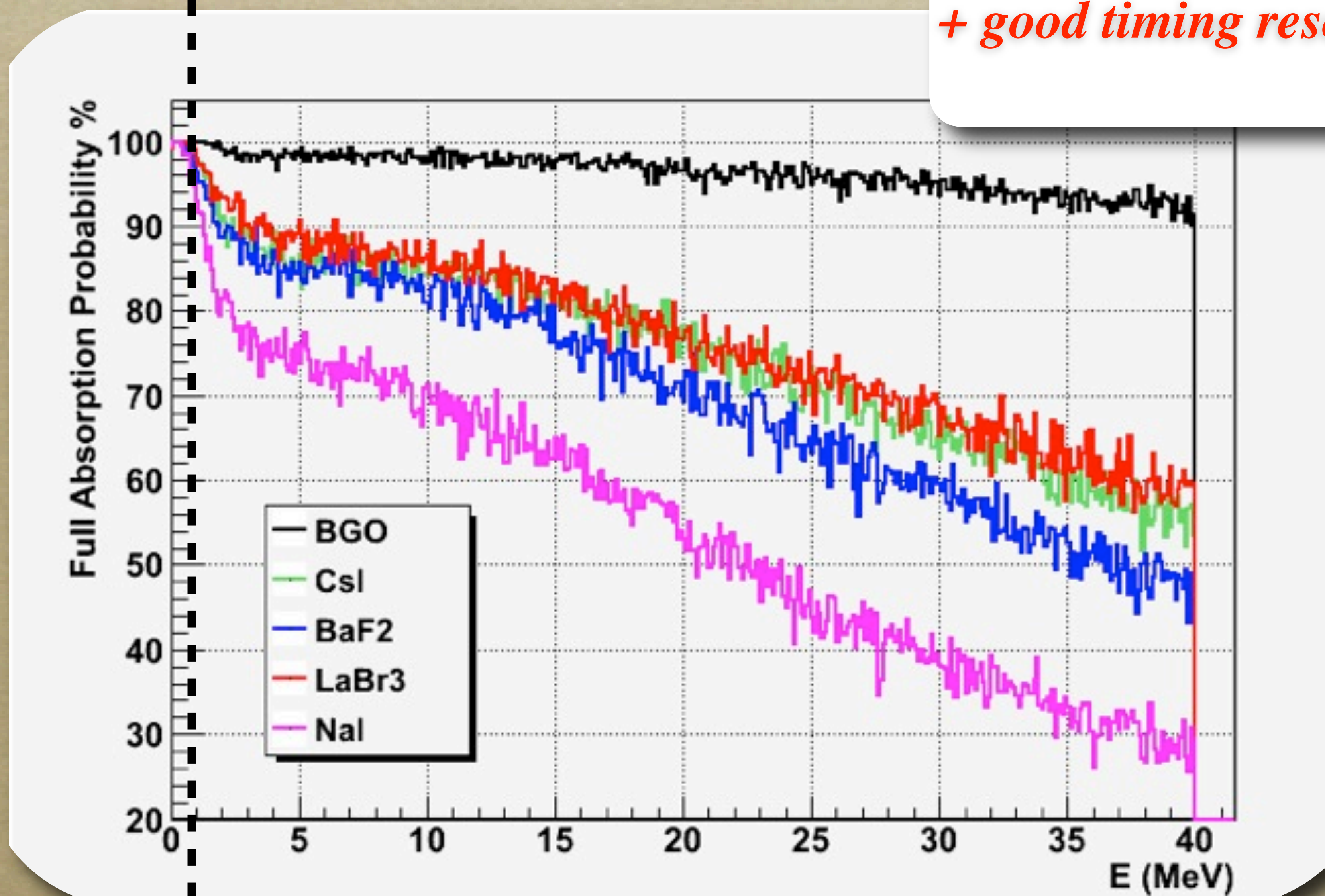


+ fast decay time (~ 16ns)
+ good timing resolution (~ 250ps)

Calorimeter based on LaBr3

Geant4 simulations

E_γ

Resolution @ 662 keV

+ fast decay time (~ 16ns)
+ good timing resolution (~ 250ps)

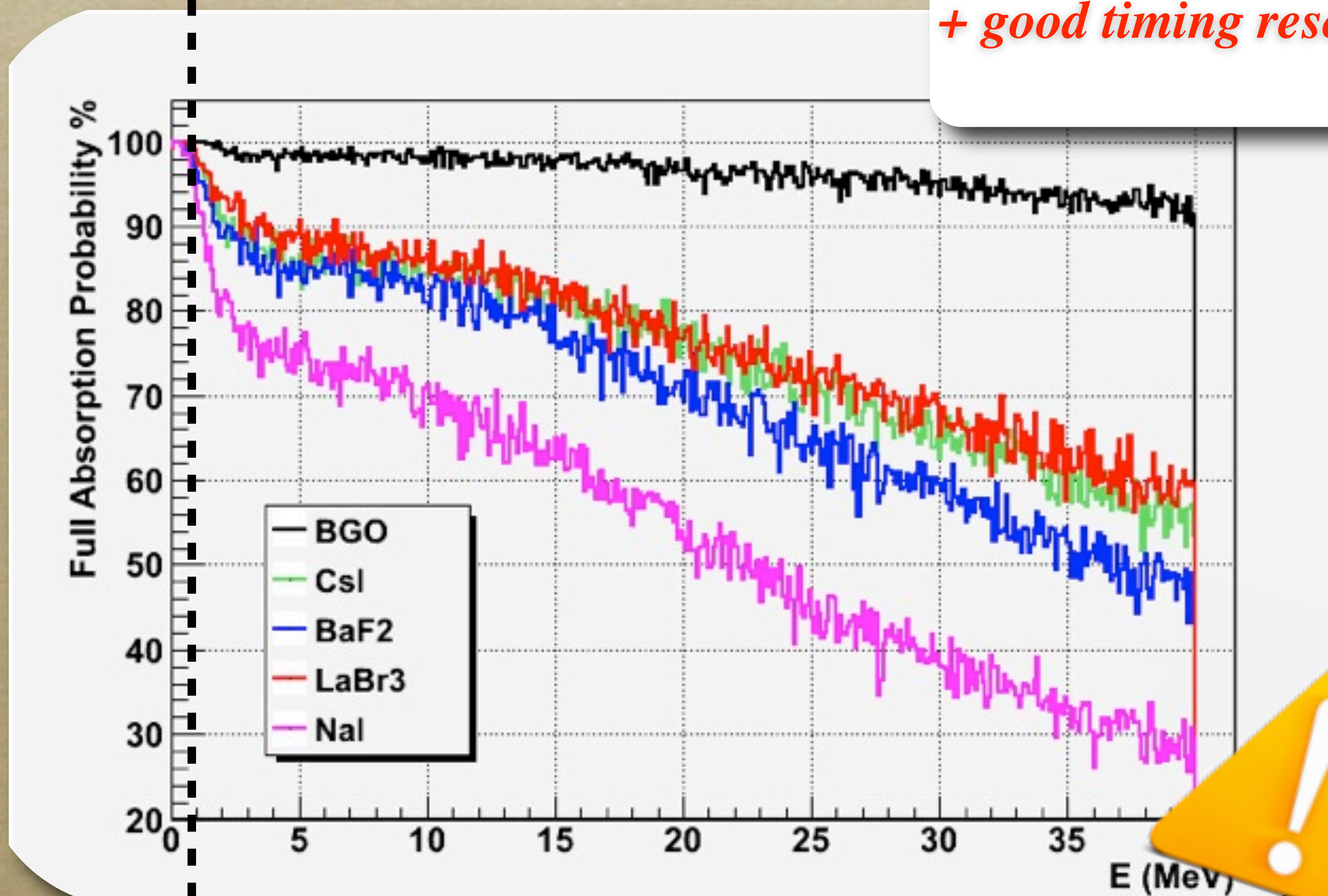
~12%

~3%

~8%

~10%

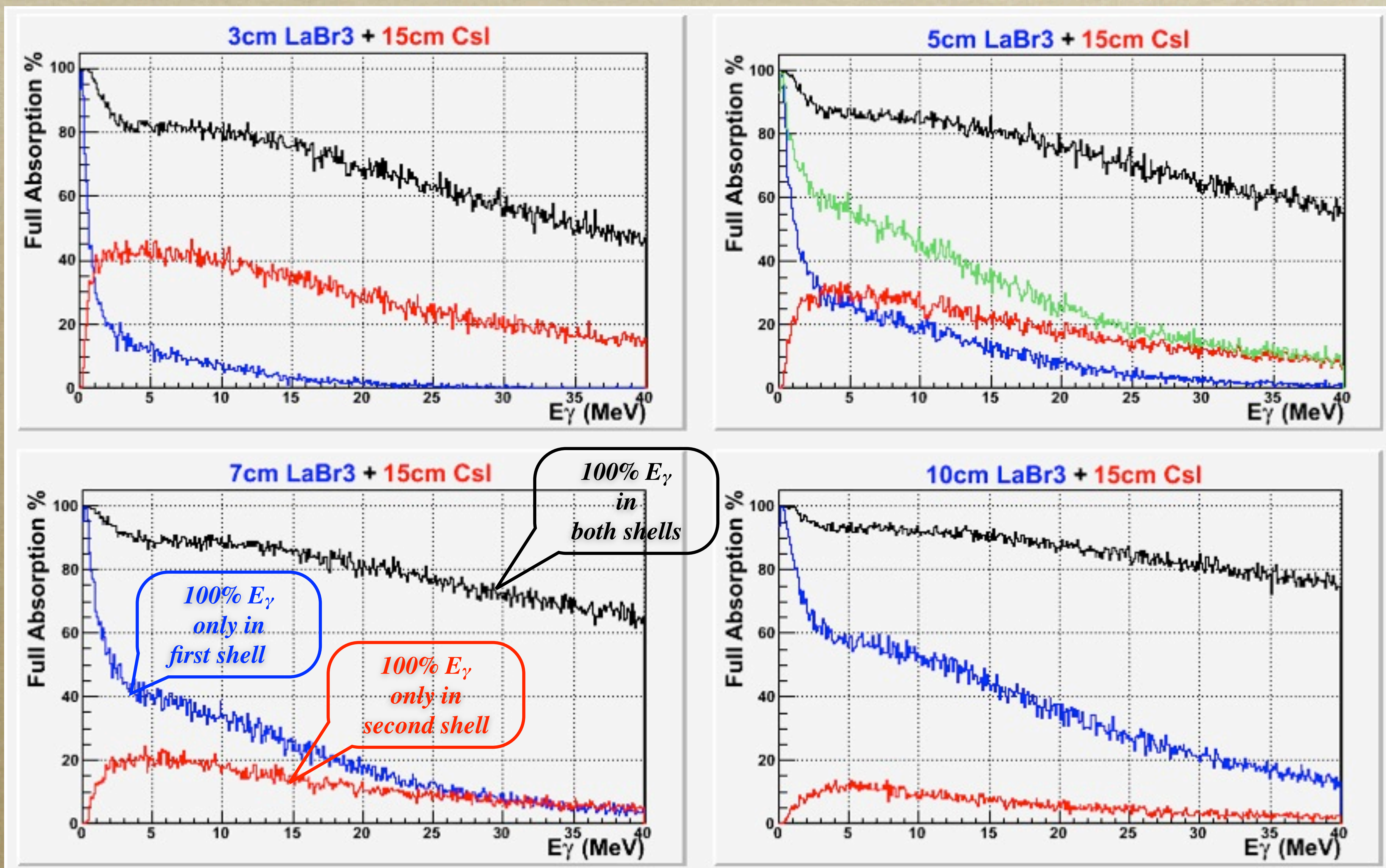
~7%



PRICE !

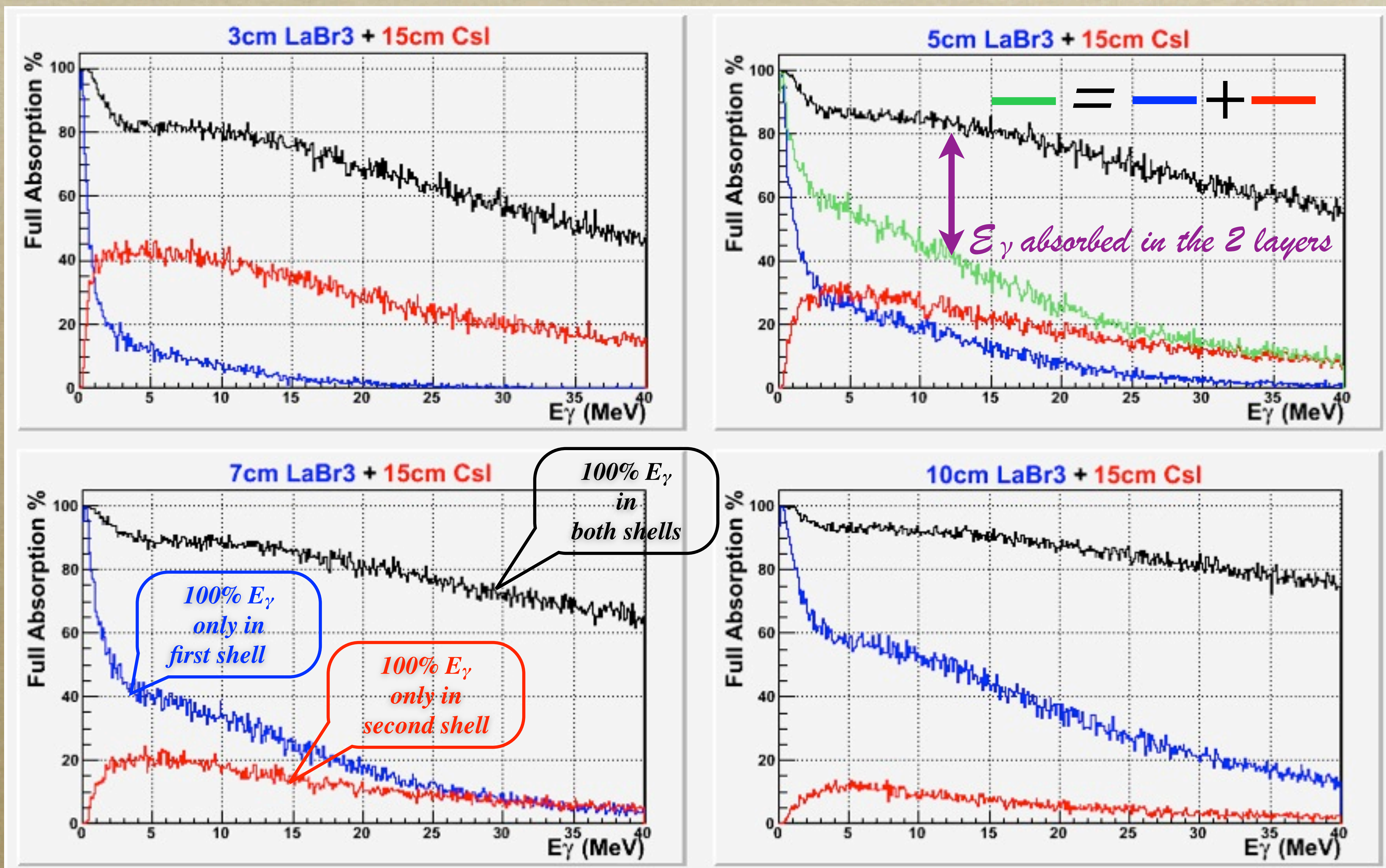
Two layers : LaBr3 + ... ???

Geant4 simulations



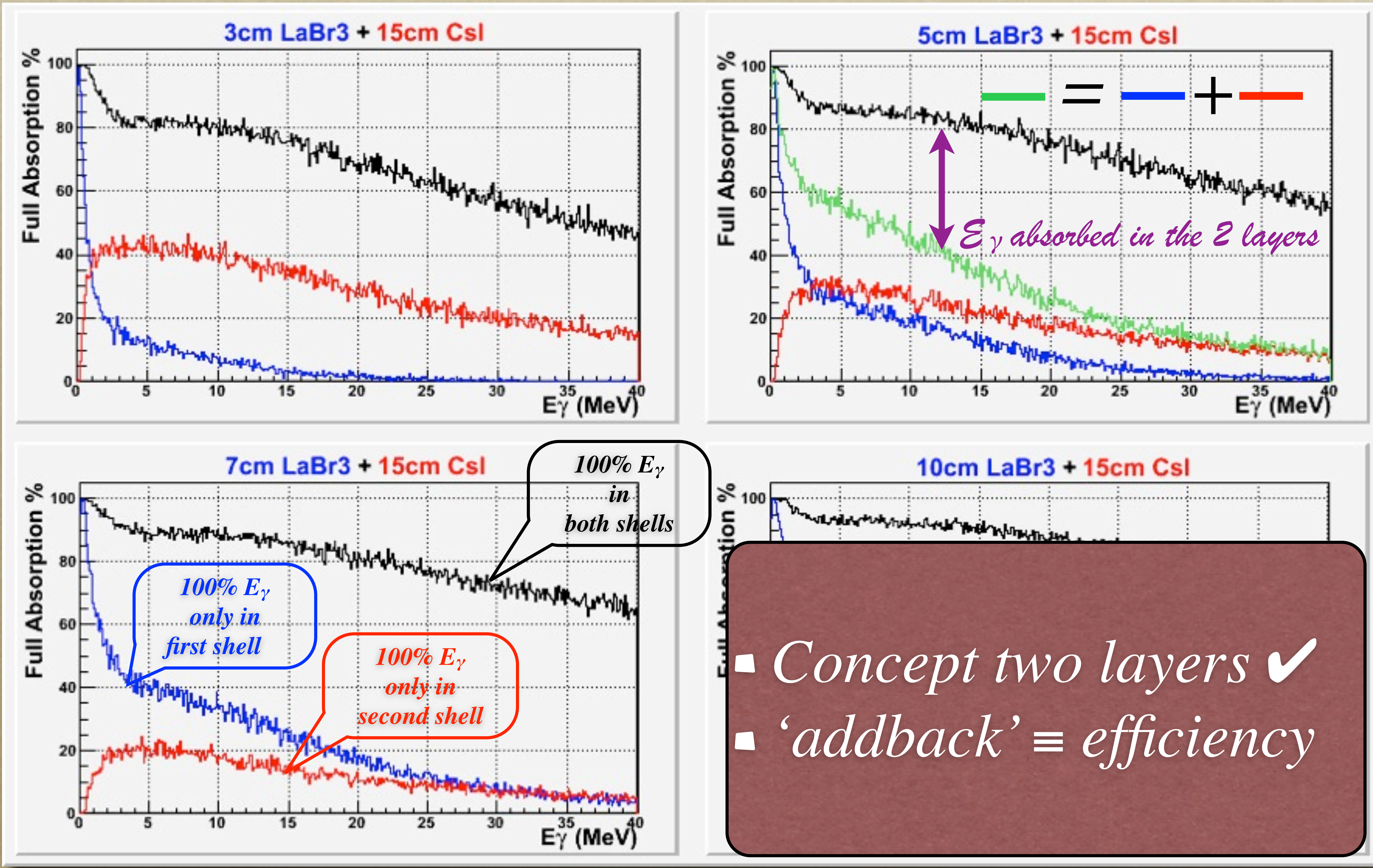
Two layers : LaBr3 + ... ???

Geant4 simulations



Two layers : LaBr3 + … ???

Geant4 simulations



- Concept two layers ✔
- 'addback' ≡ efficiency

Segmentation

pile up

Doppler

absorption

calorimeter

Geant4 simulations

Segmentation

pile up

cells 2”

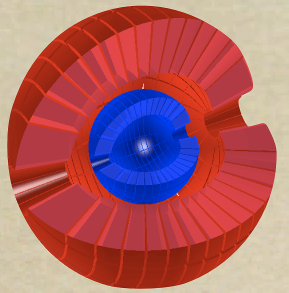
Doppler

absorption

calorimeter

Geant4 simulations

Segmentation



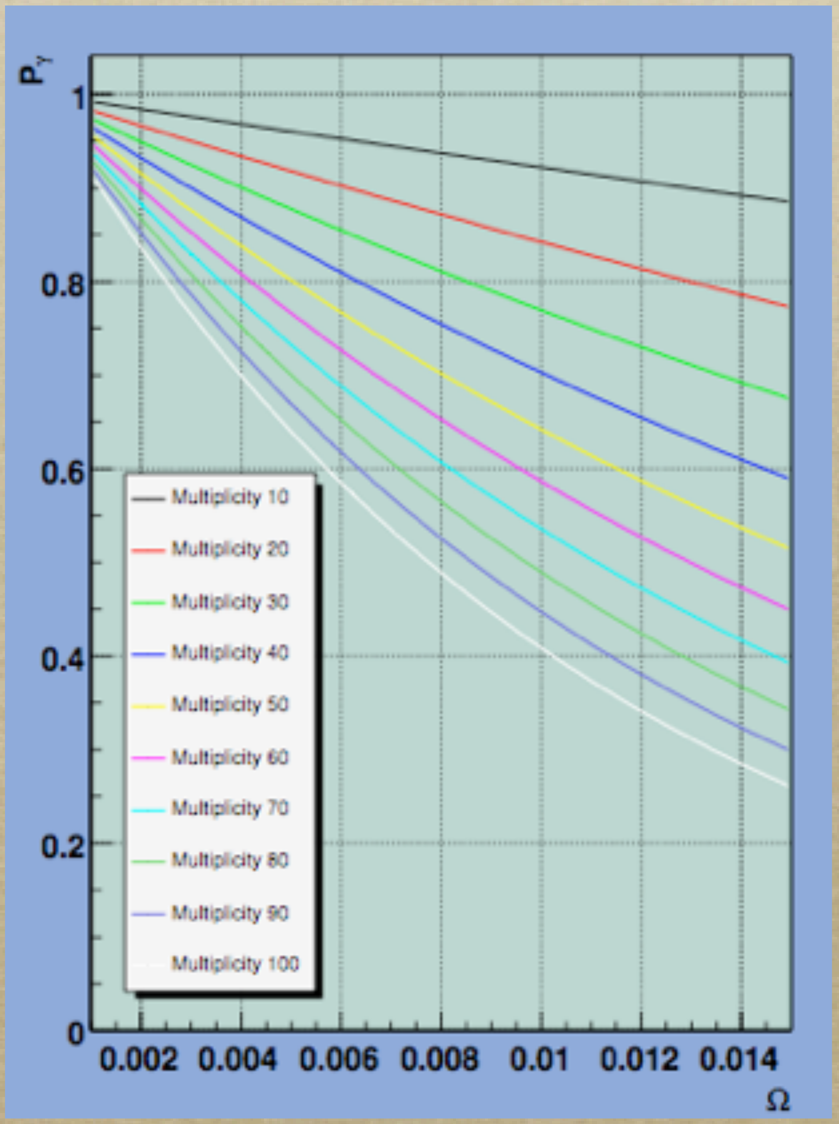
pile up

cells 2”

Doppler

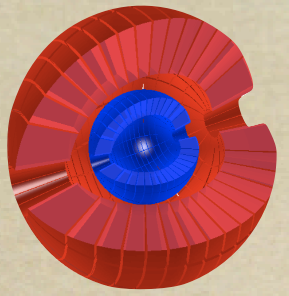
absorption

calorimeter



Geant4 simulations

Segmentation

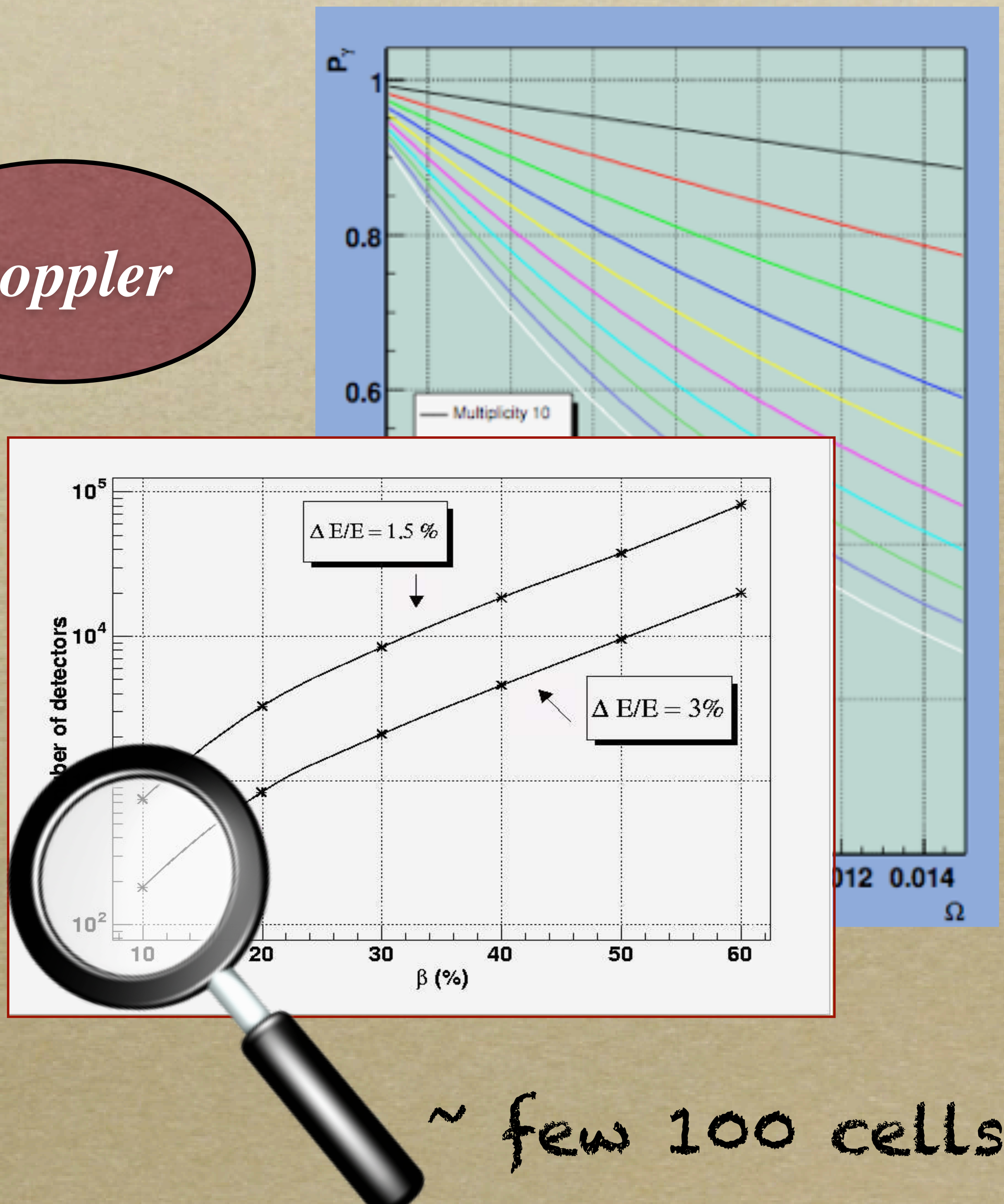


pile up

cells 2”

Doppler

absorption

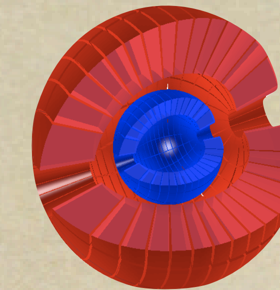


calorimeter

~ few 100 cells

Geant4 simulations

Segmentation

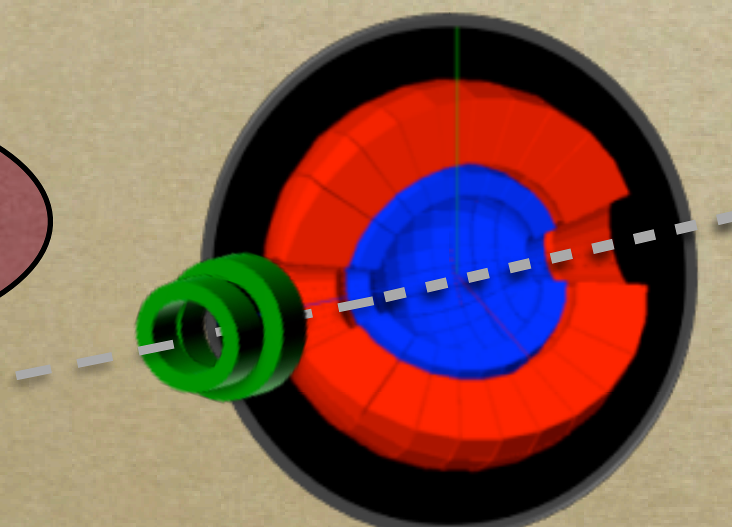


pile up

cells 2”

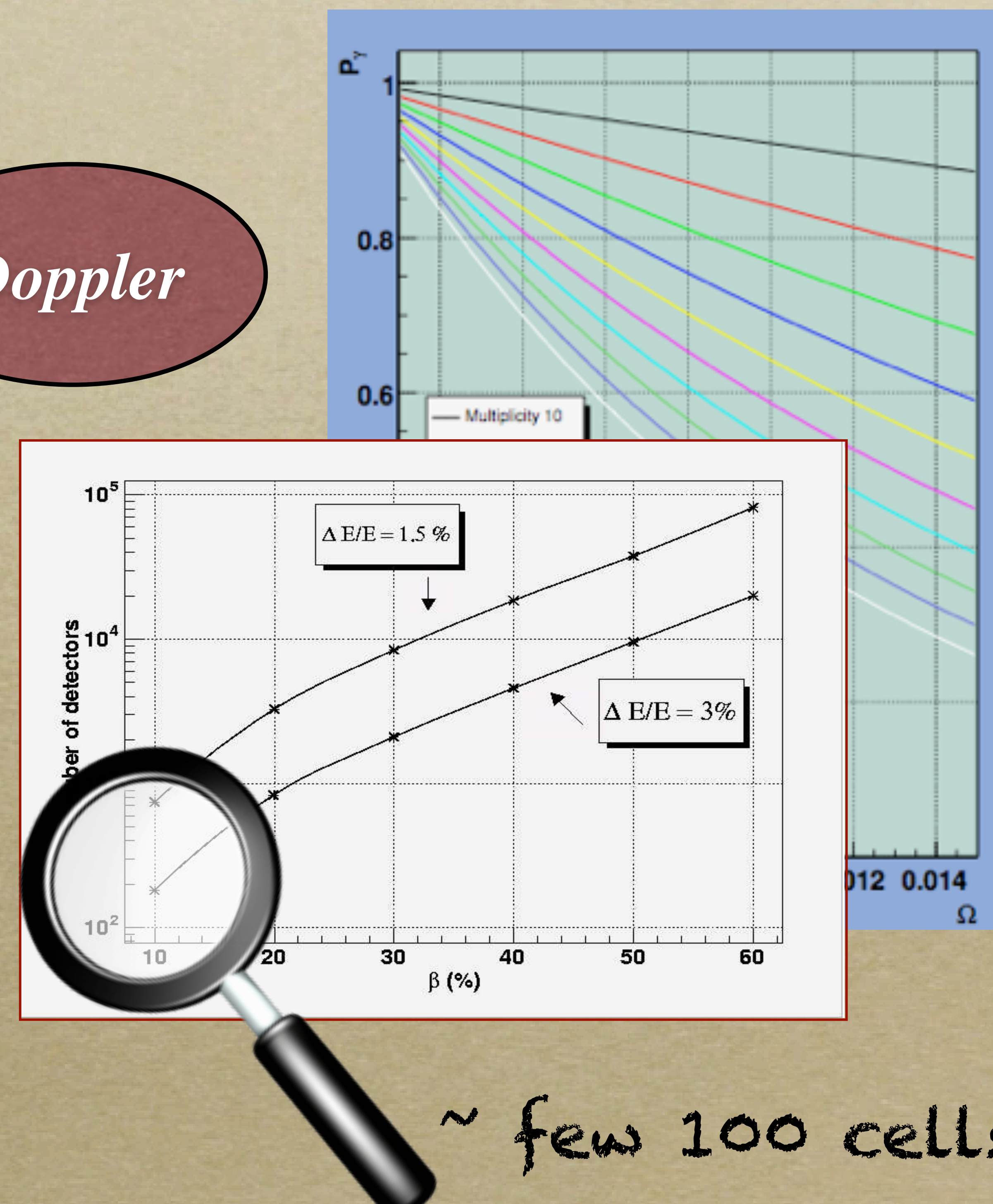
Doppler

absorption



almost 4π

calorimeter



~ few 100 cells

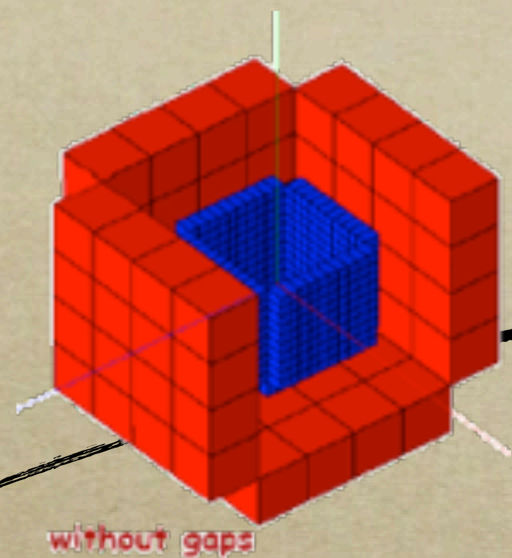
Geant4 simulations

Evolution of PARIS

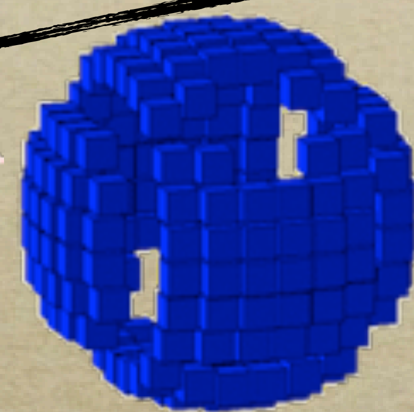
'Ideal'

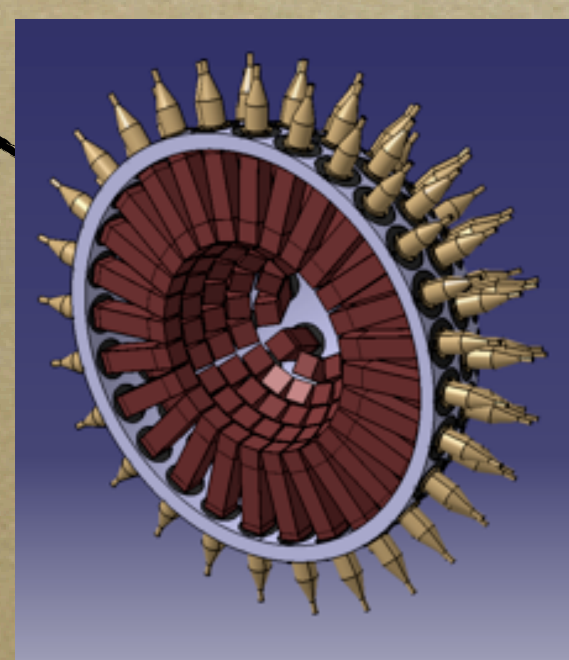
Evolution of PARIS

'Ideal'



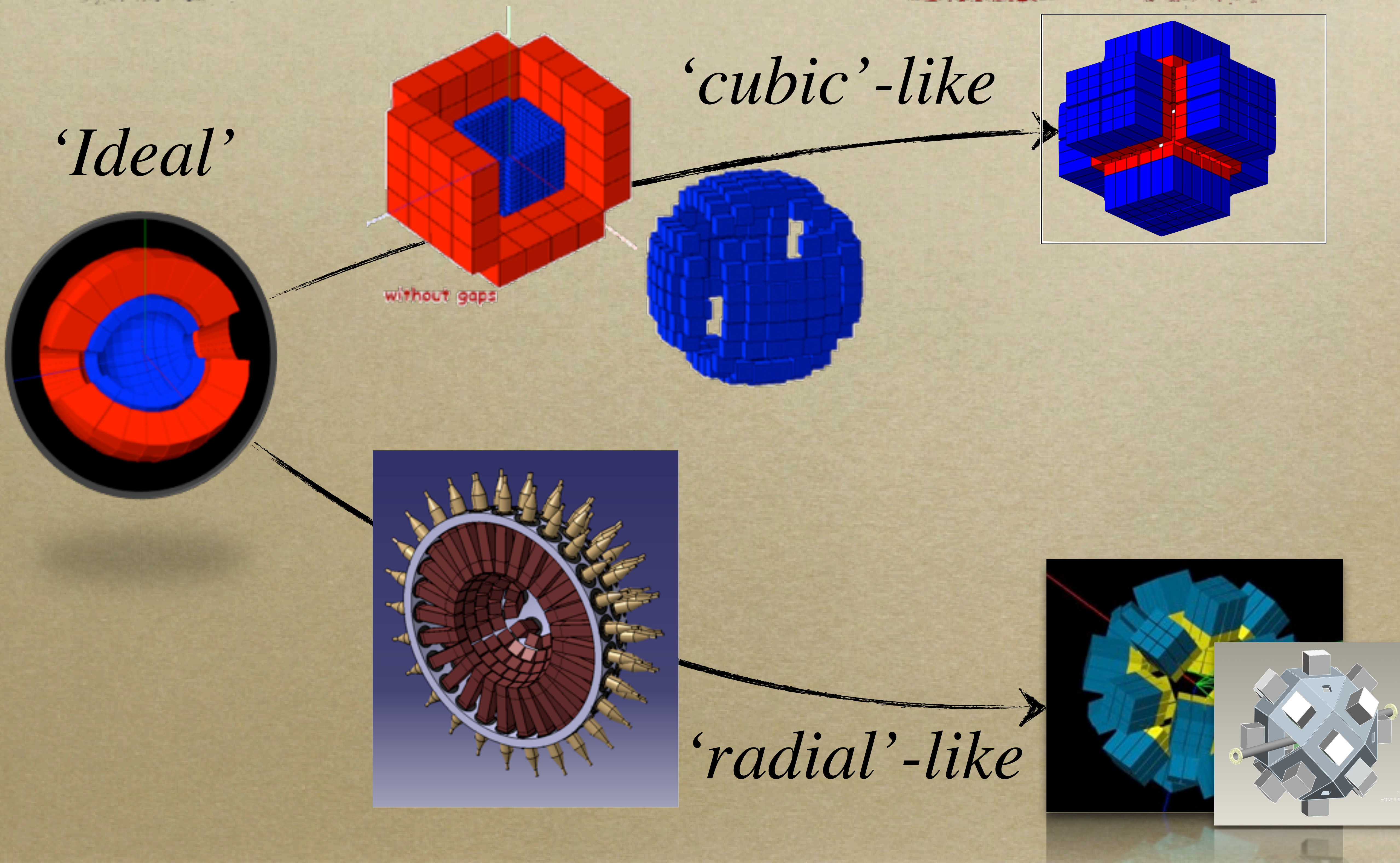
'cubic'-like





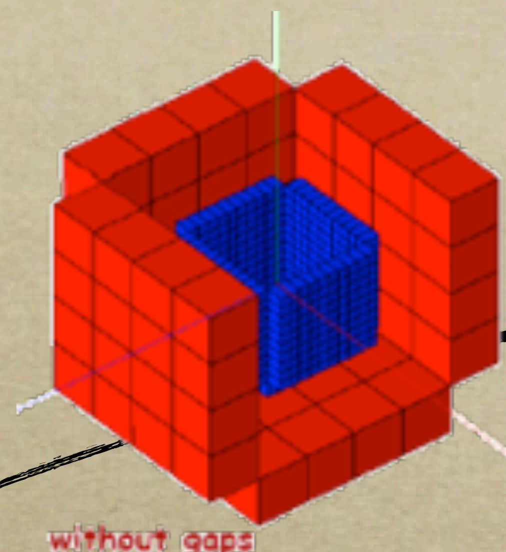
'radial'-like

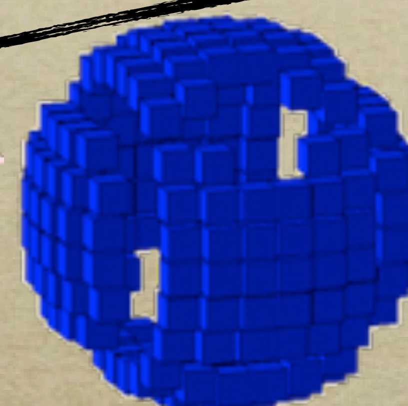
Evolution of PARIS



Evolution of PARIS

'Ideal'





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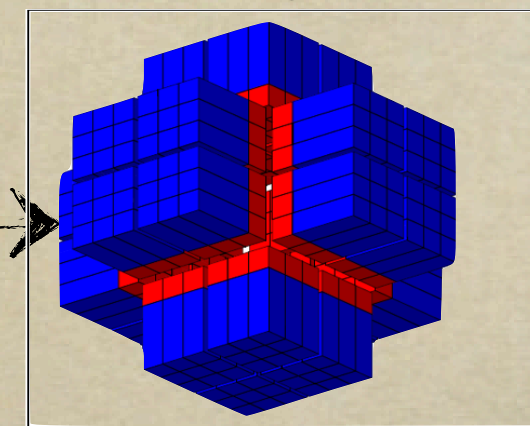
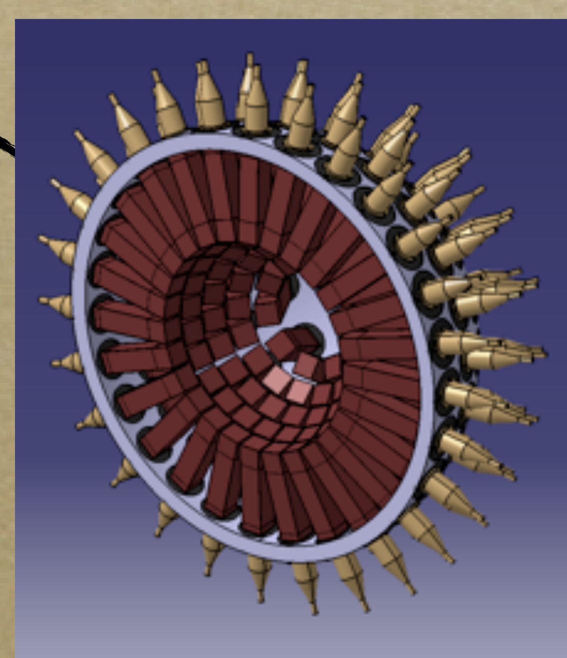
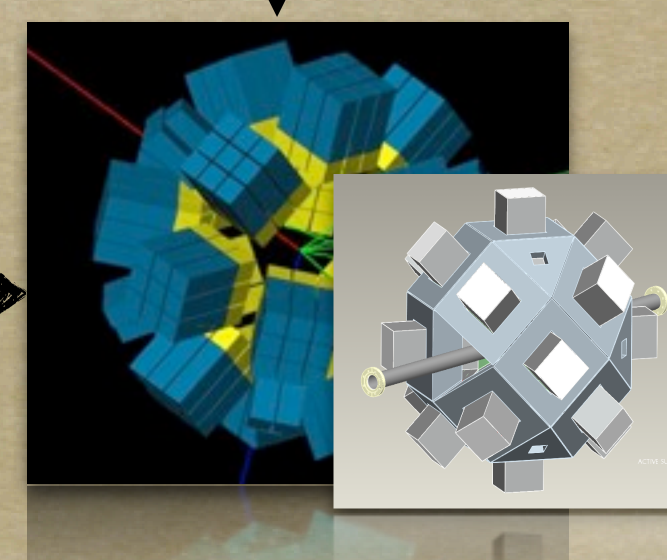


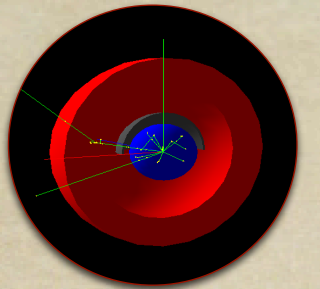
Both based
on
CLUSTERS !



'radial'-like



Characterisation of the arrays



Done, current & next steps

Characterisation of the ≠ configuration

- ☛ *full absorption efficiency @ $M_\gamma = 1$*
- *First studies on reconstructions*
- *... ...*

More on algorithms

More realistic simulations

- *Neutrons*
- *Radioactivity*
- *Coupling (AGATA, ...)*
- *Physics generator*

Characterisation of the arrays

Done, current & next steps

Characterisation of the ≠ configuration

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... ...

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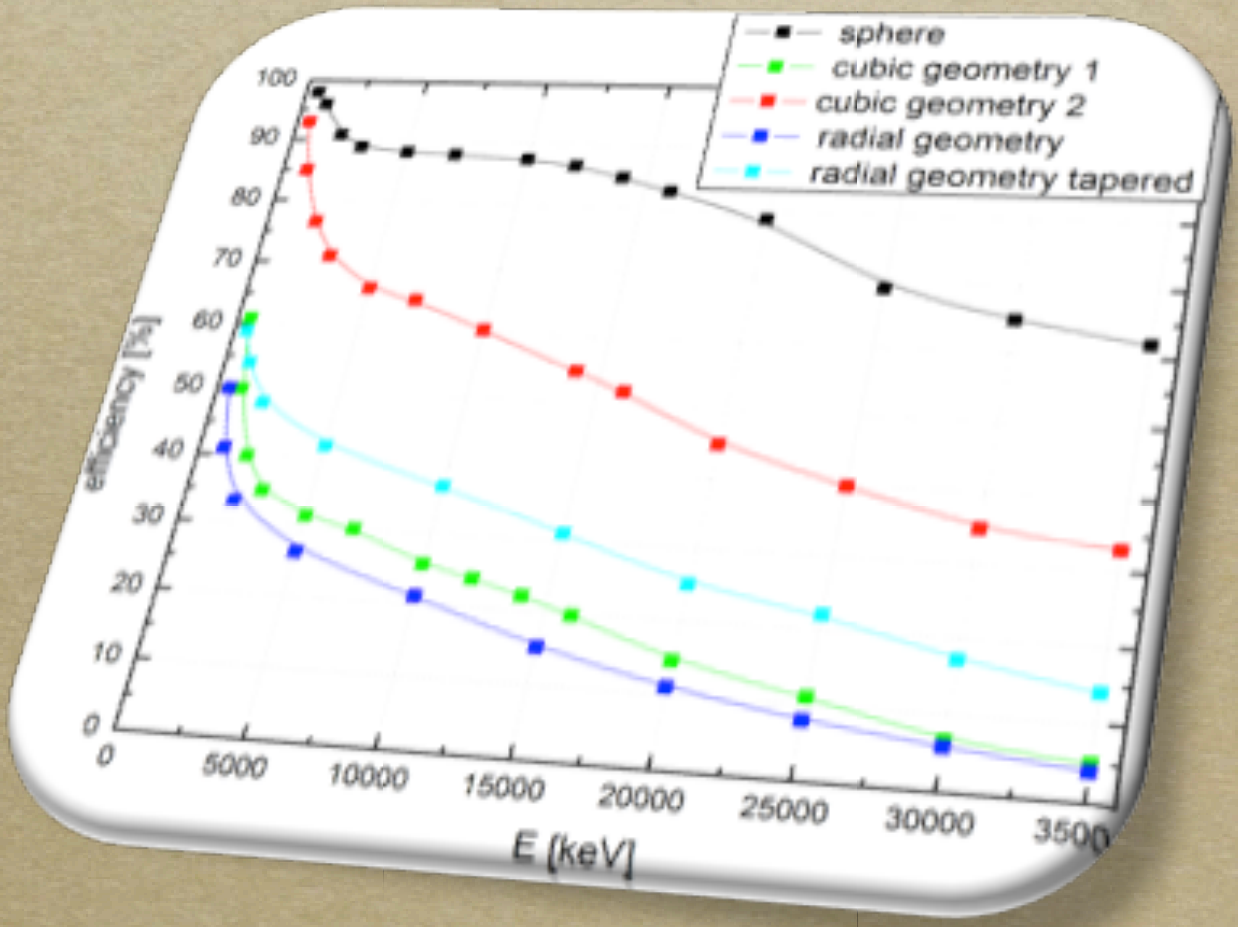

Characterisation of the arrays

Done, current & next steps

Characterisation of the ≠ configuration

full absorption efficiency @ M_γ = 1

☛ *First studies on reconstructions*

... ...

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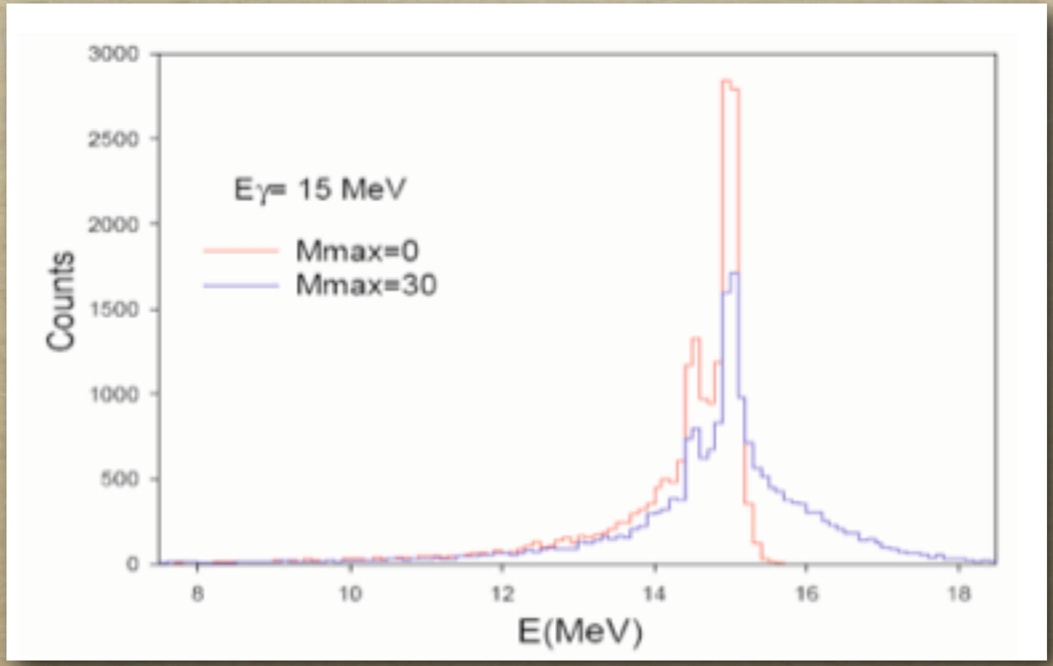
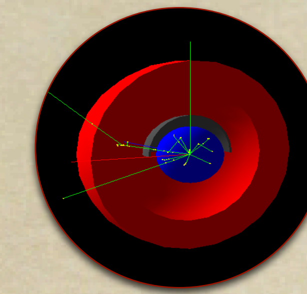


Separation high energy

&

Σ low energy needed !!!

Characterisation of the arrays



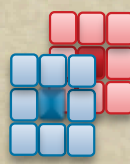
Done, current & next steps

Characterisation of the ≠ configuration

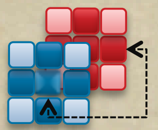
full absorption efficiency @ $M_\gamma = 1$

First studies on reconstructions

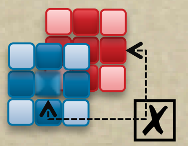
... ...



1 cell ≡ 1 γ



addback 'closest'



anti-Compton

☛ *More on algorithms*

More realistic simulations

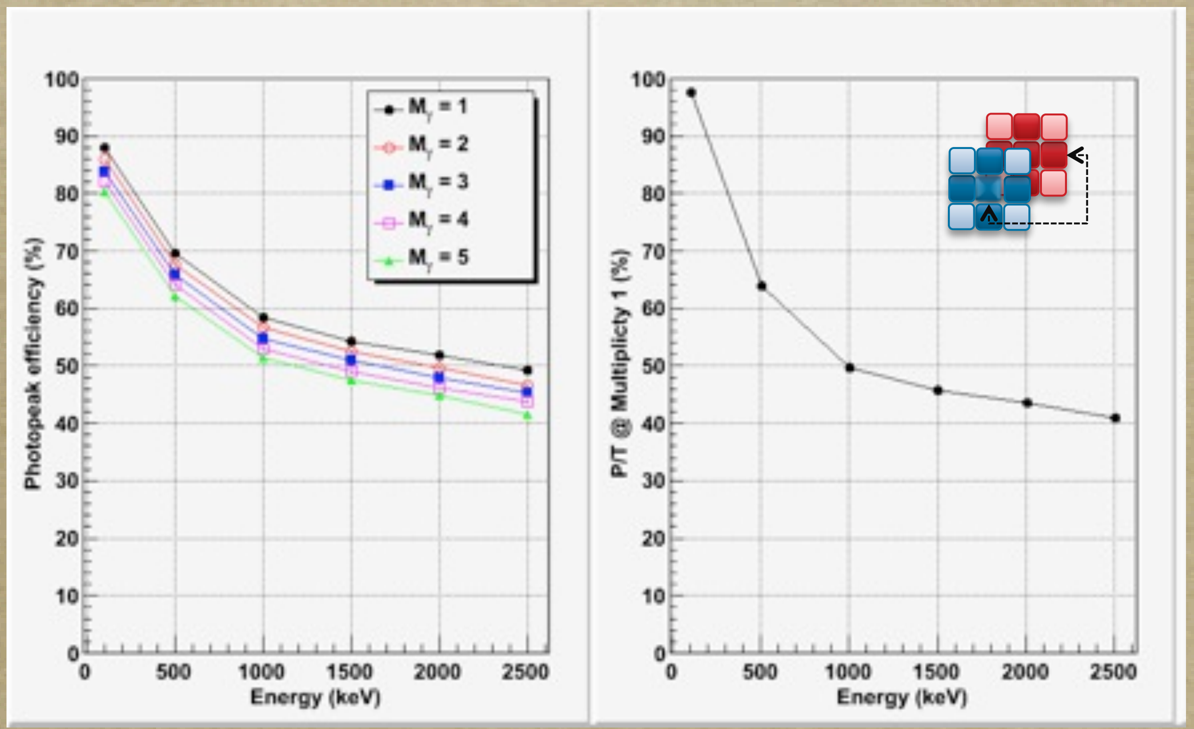
Neutrons

Radioactivity

Coupling (AGATA, ...)

Physics generator

Photopeak, P/T



Characterisation of the arrays

Done, current & next steps

Characterisation of the ≠ configuration

- *full absorption efficiency @ $M_\gamma = 1$*
- *First studies on reconstructions*
- *... ...*

☛ *More on algorithms*

More realistic simulations

- *Neutrons*
- *Radioactivity*
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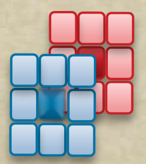

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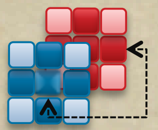

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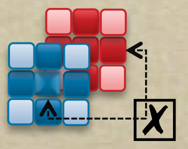
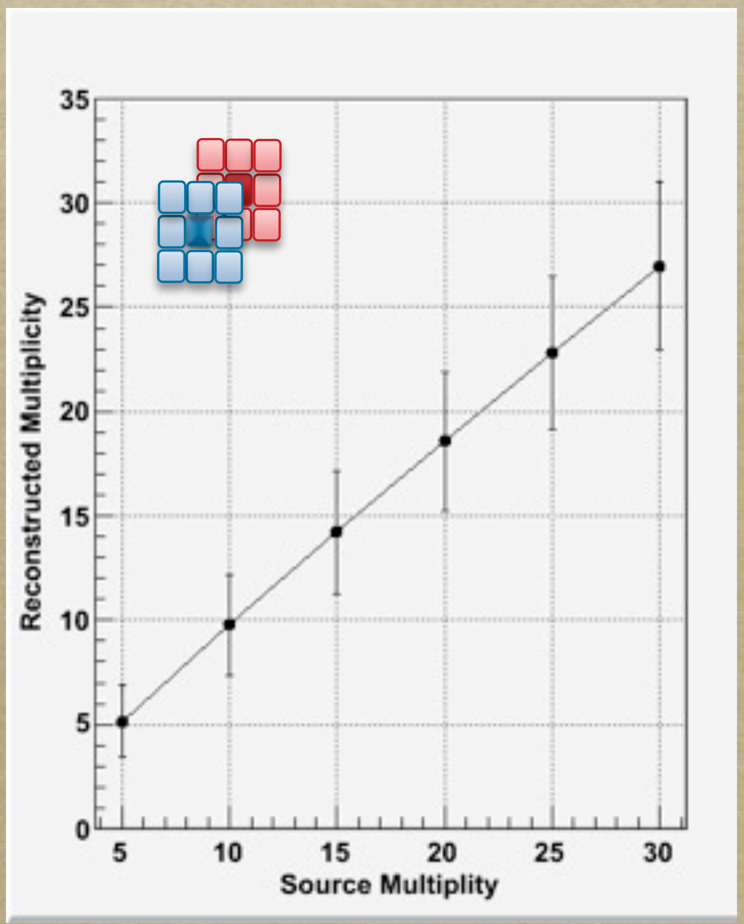


anti-Compton



Characterisation of the arrays

Done, current & next steps

Characterisation of the ≠ configuration

- *full absorption efficiency @ $M_\gamma = 1$*
- *First studies on reconstructions*
- *… …*

More on algorithms

More realistic simulations

- *Neutrons*
- *Radioactivity*
- *Coupling (AGATA, …)*
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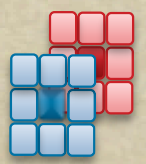
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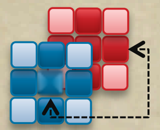
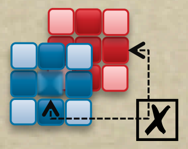
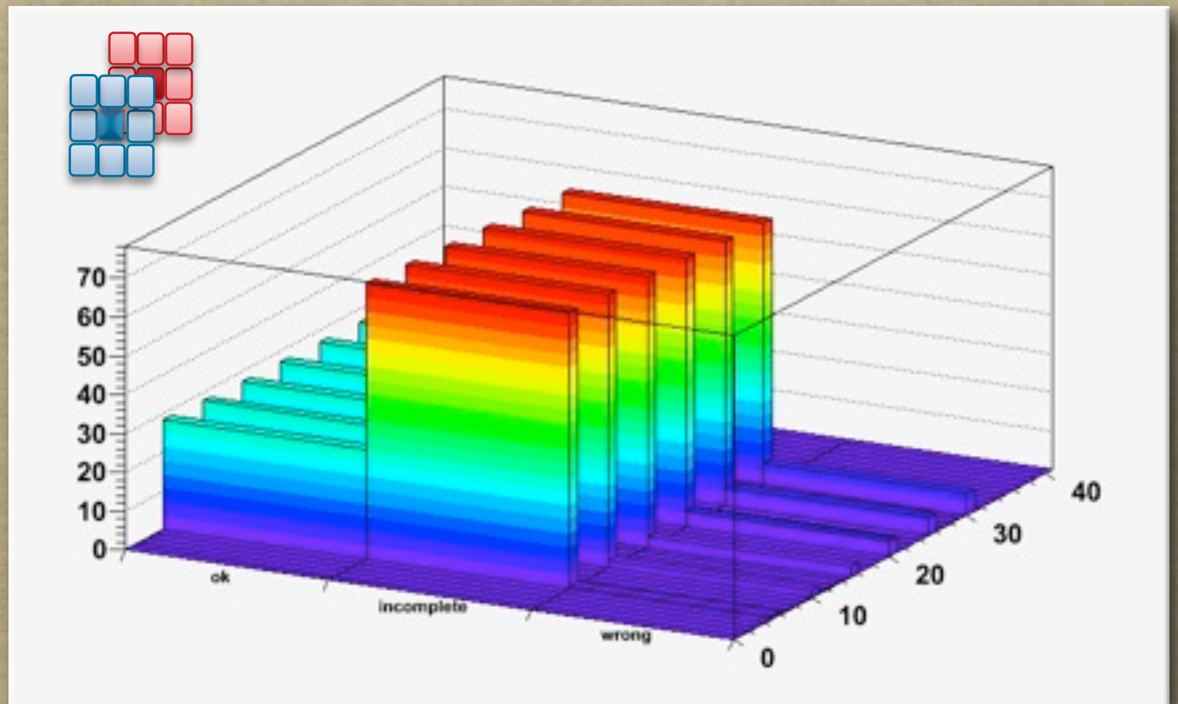

addback 'closest'


anti-Compton

Cluster 'Quality'



Characterisation of the arrays

Done, current & next steps

- E dependency
- Others
  - neuronal networks … etc

Characterisa… …tion

full absorp… …1

First studi…s on reconstructions

… …

☛ *More on algorithms*

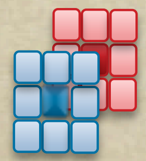
More realistic simulations

Neutrons

Radioactivity

Coupling (AGATA, …)

Physics generator



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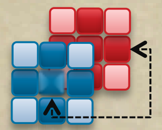

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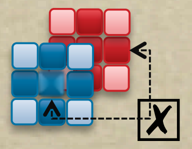
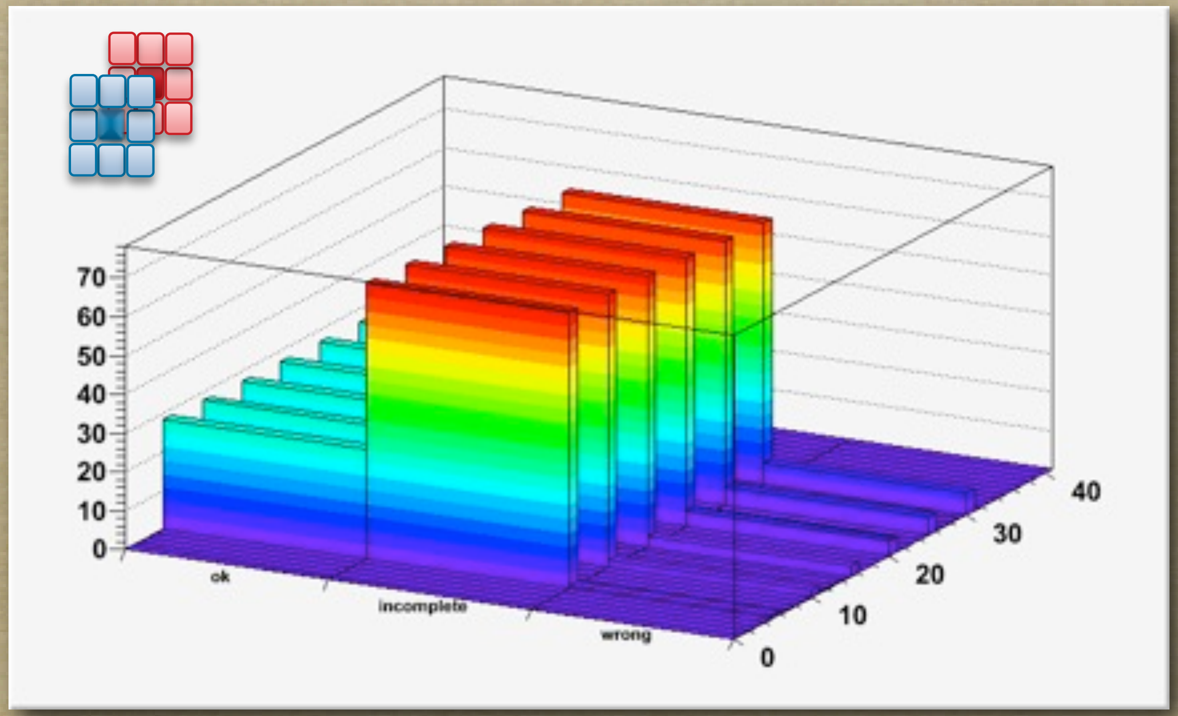
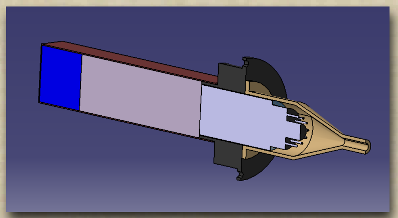


anti-Compton

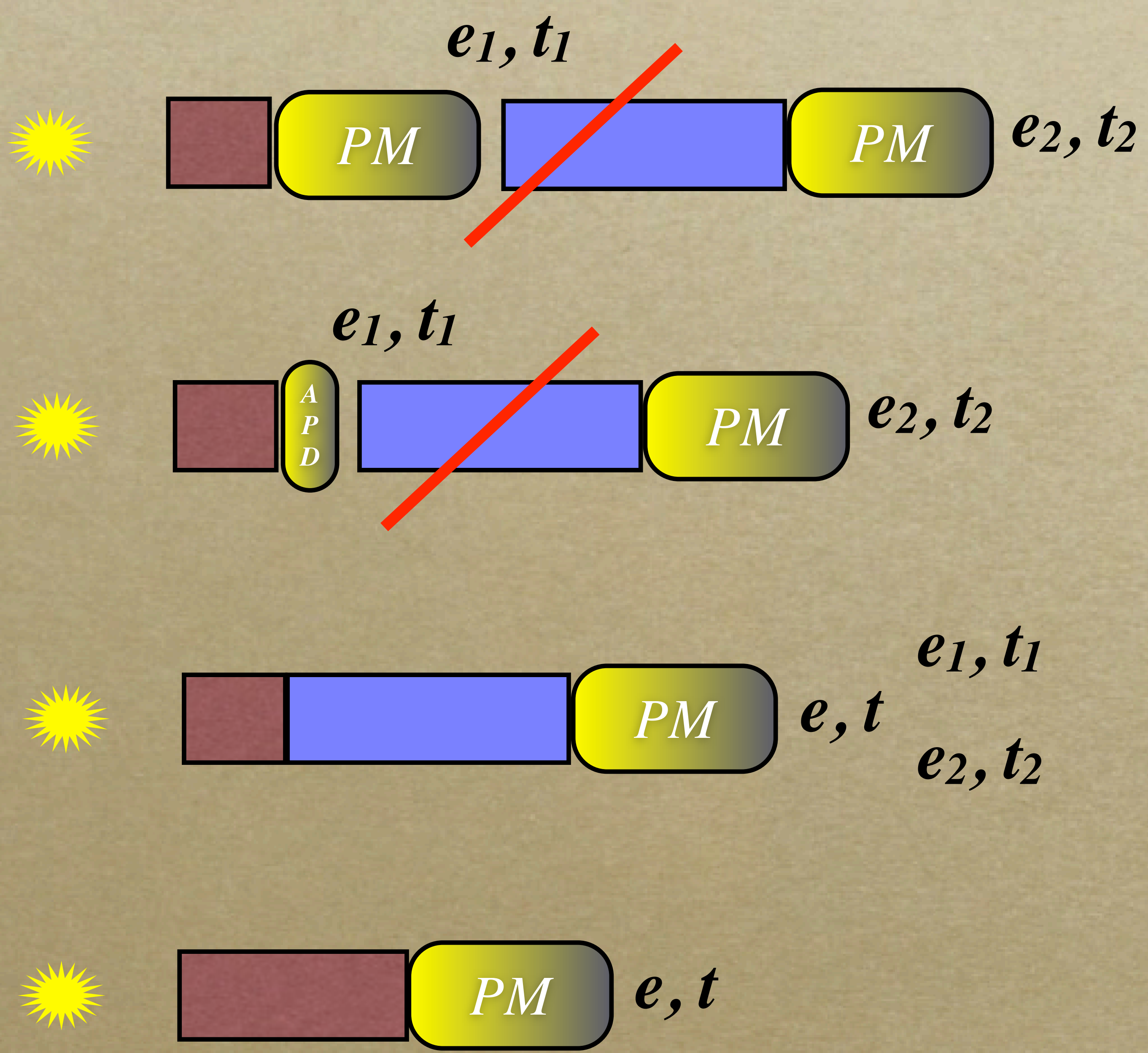
Cluster ‘Quality’



Signals



Possibilities for the PARIS modules



Cubic 1″x1″x2″ LaBr3(Ce)
Cubic 2″x2″x2″ LaBr3(Ce)
Cubic 2″x2″x4″ LaBr3(Ce)

SP2PP & PROVA funds

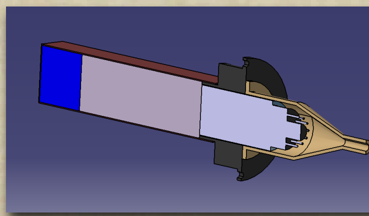
Cylindrical phoswich 1″x2″ LaBr3(Ce) + 1″x6″ CsI
Cylindrical phoswich 1″x2″ LaBr3(Ce) + 1″x6″ NaI

Photomultipliers
R5505-70, R7723-100, R6236-100, R2083, R7899-01, R6236-01, X..., + ...

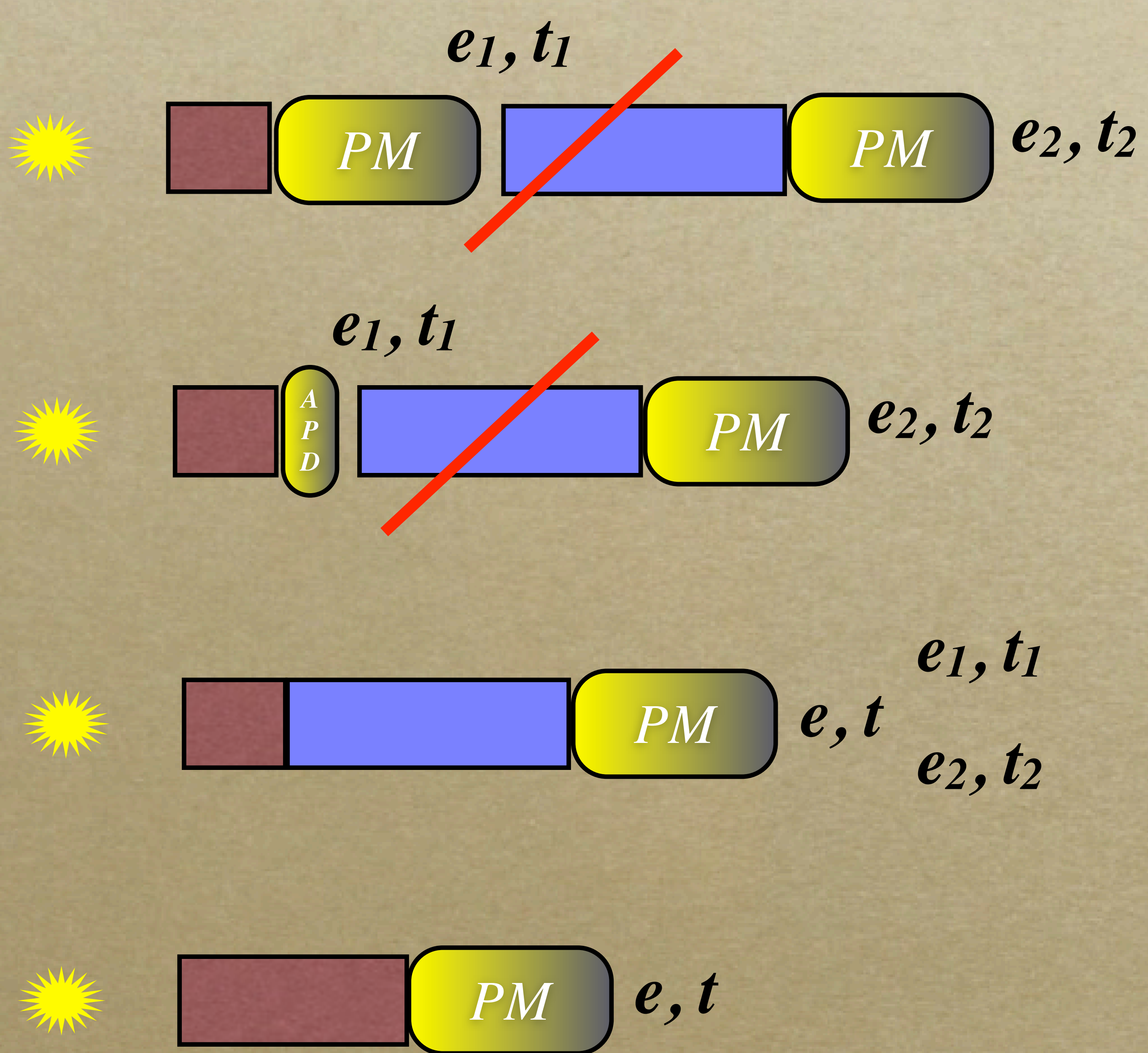
Cubic phoswich 2″x2″x2″ LaBr3(Ce) + 2″x2″x6″ NaI
- 2 ANR Prova (Orsay, Strasbourg) ☑
- 3 SP2PP (Krakow - september)
- 4 to be ordered by Mumbai

☛ CLUSTER 3x3

Signals



Possibilities for the PARIS modules



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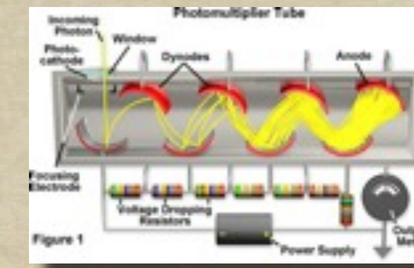
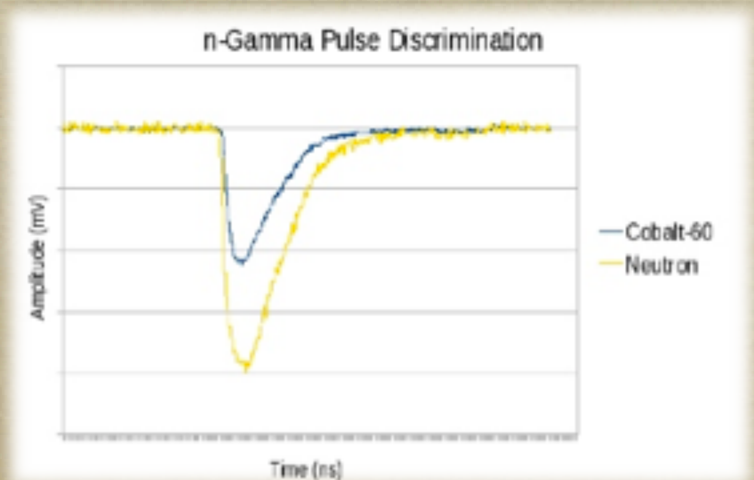
NEW !!!!

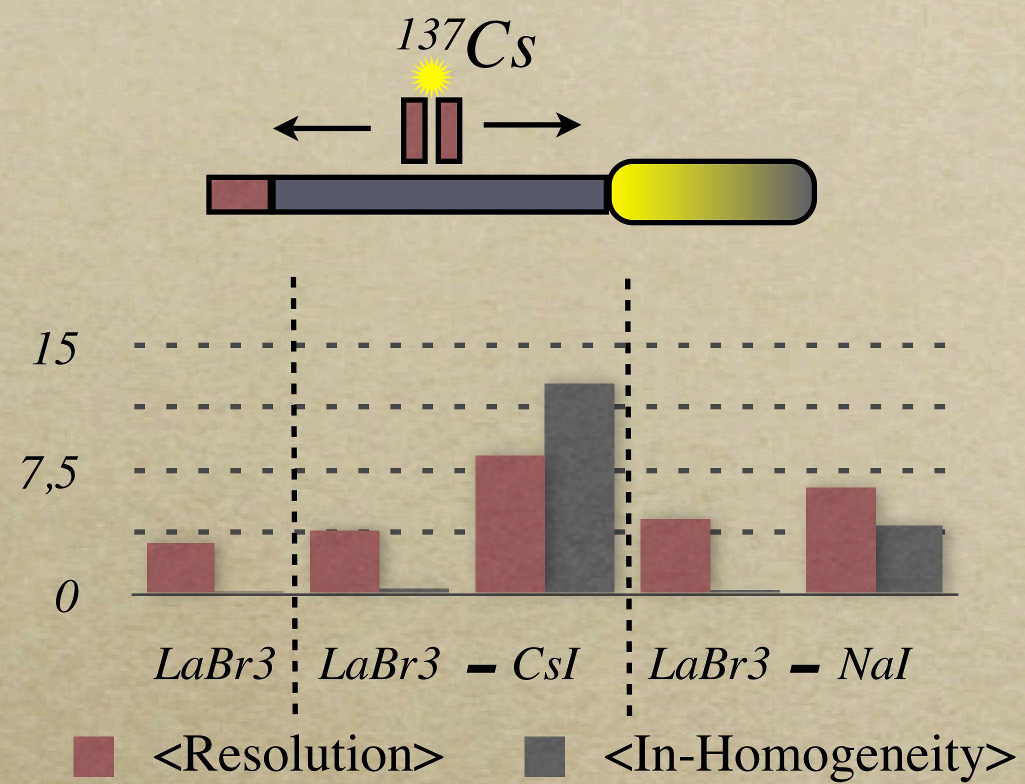
☛ CLUSTER 3x3

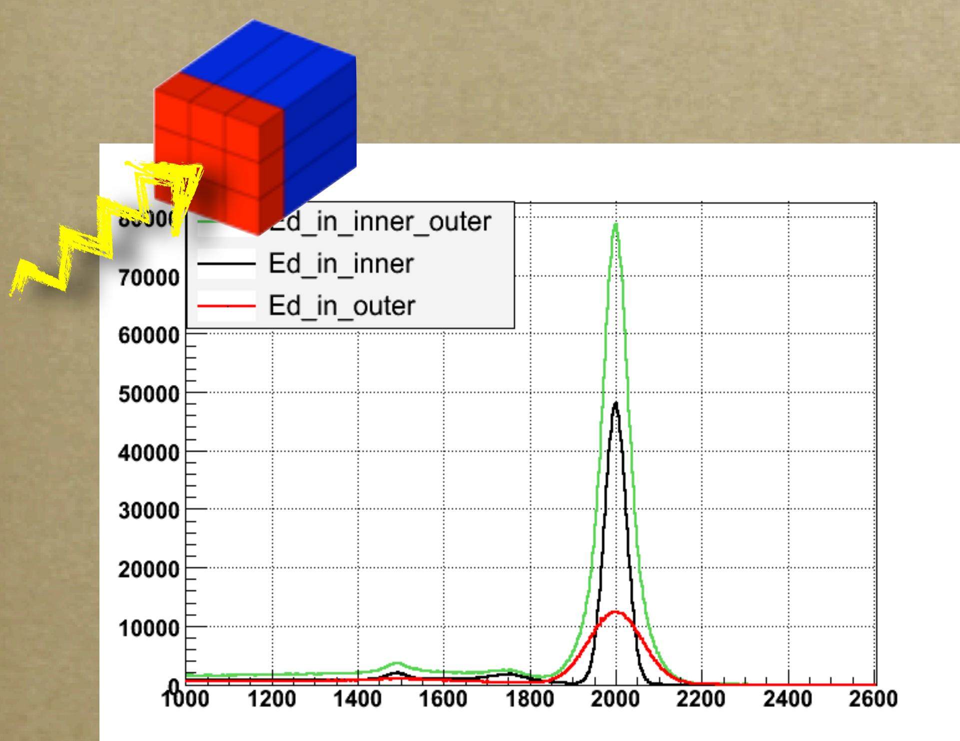
Signal collection



Discrimination γ-n ...

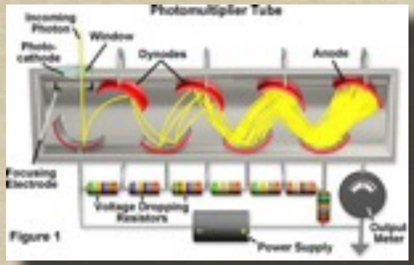




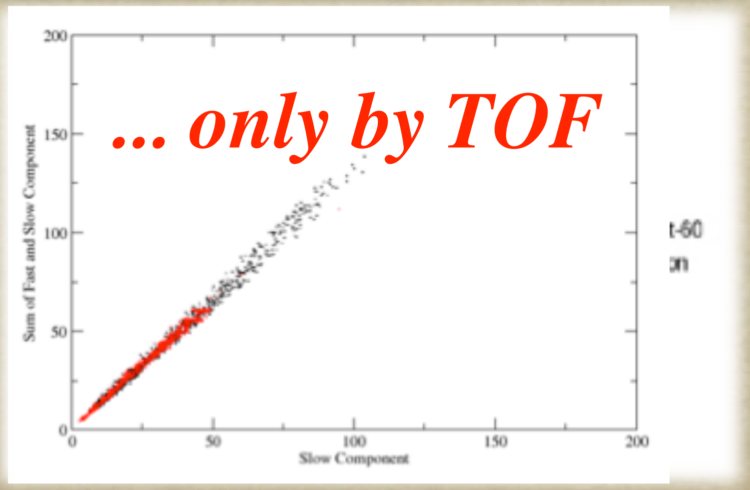


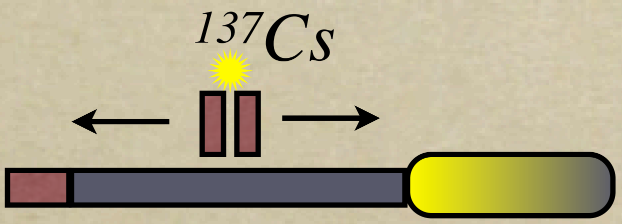
Energy sharing between the two layers ^{simu}

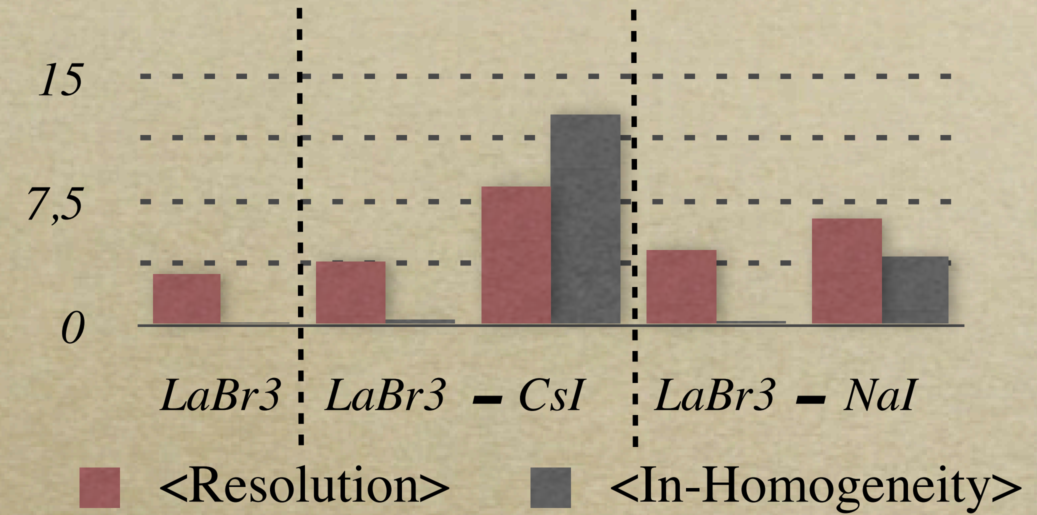
Signal collection

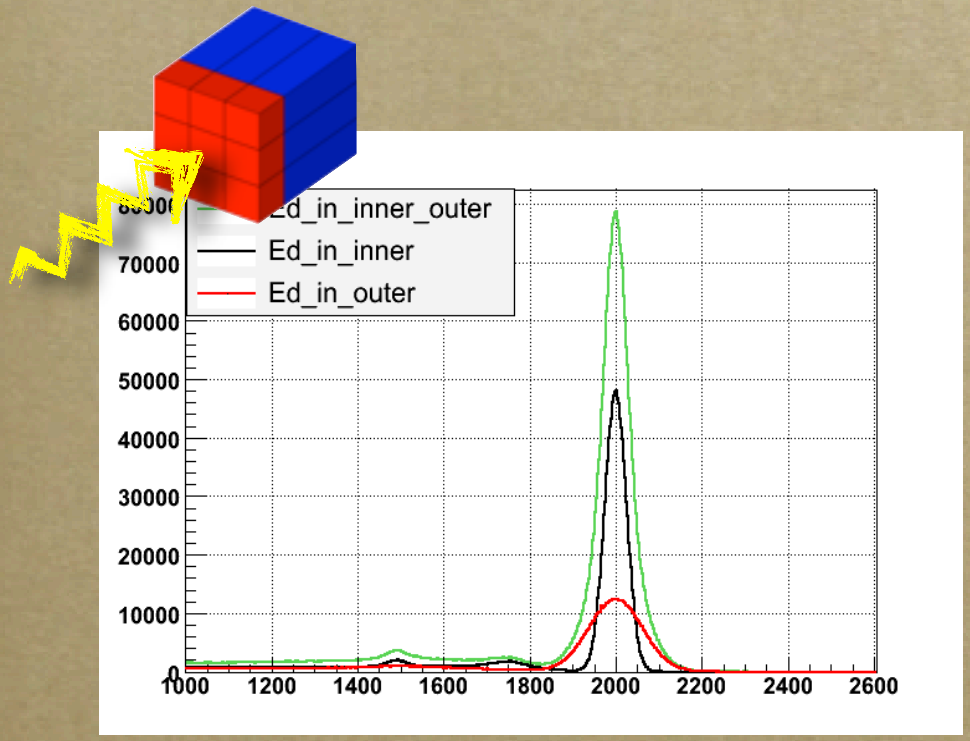


Discrimination γ-n …



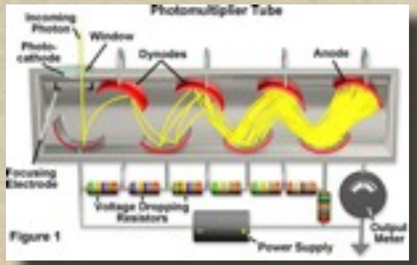




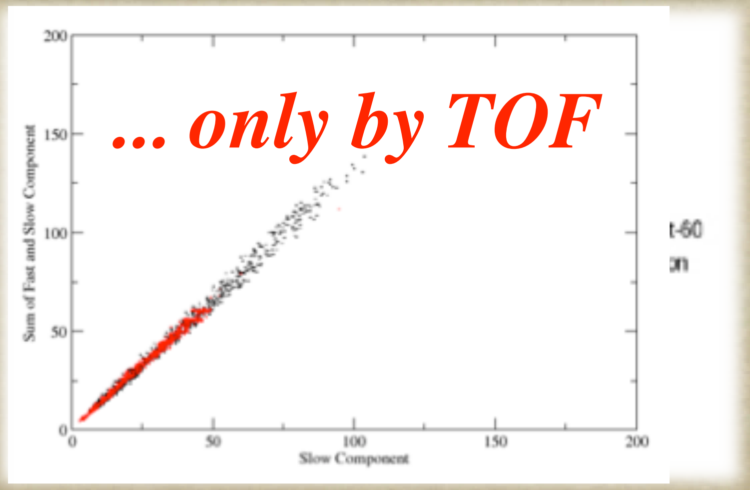


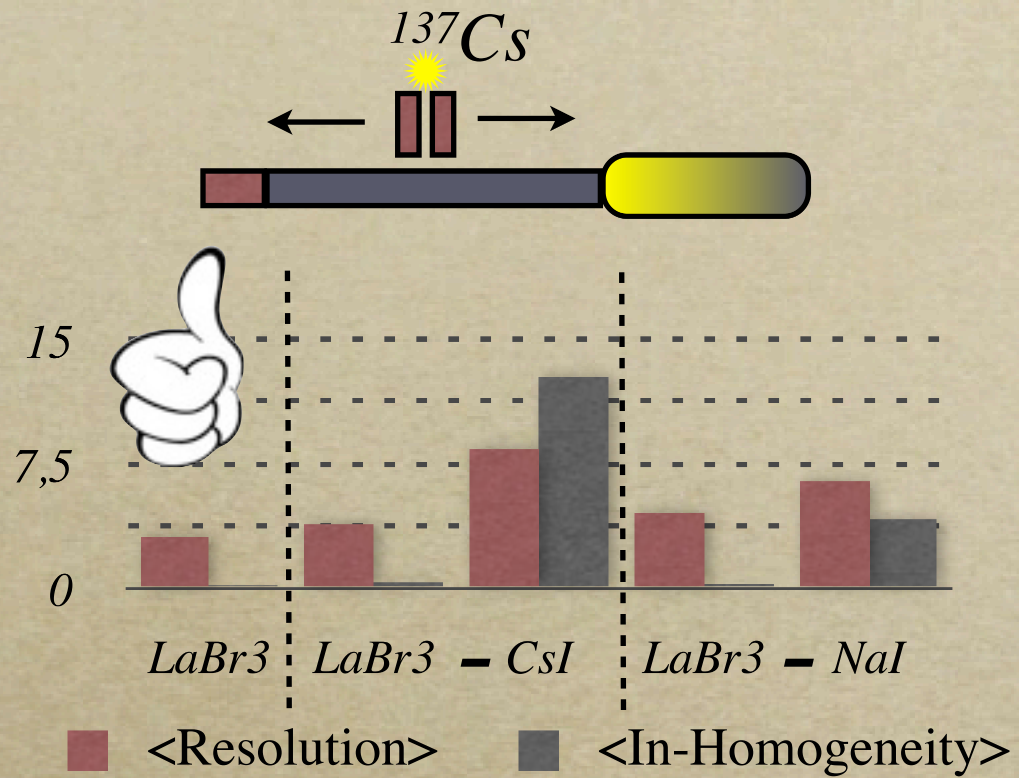
Energy sharing between the two layers *simu*

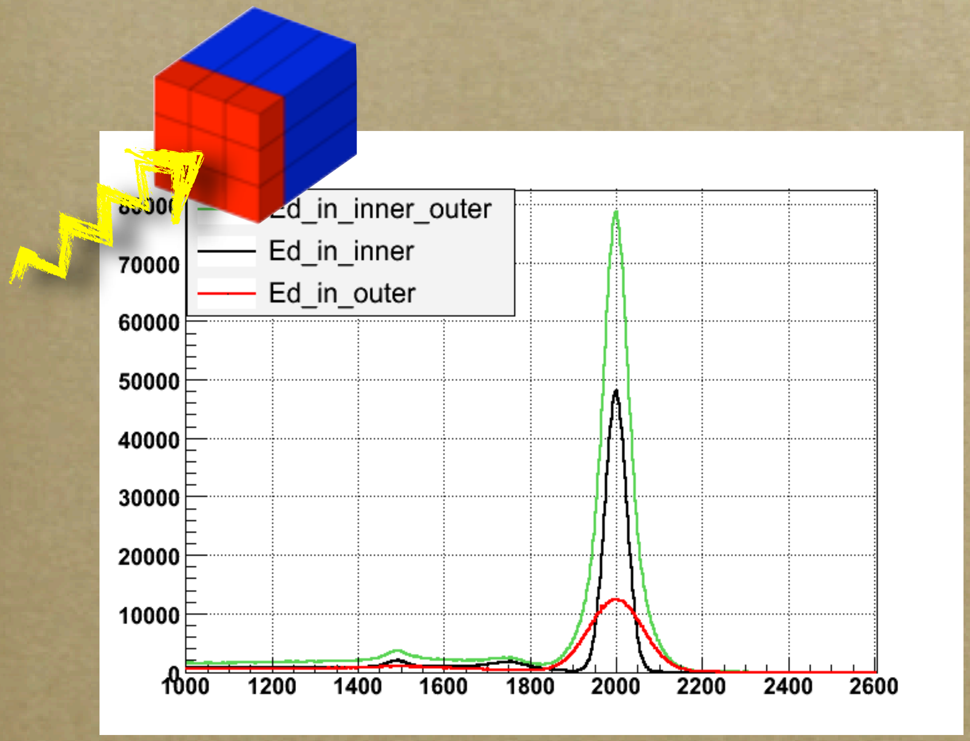
Signal collection



Discrimination γ-n …

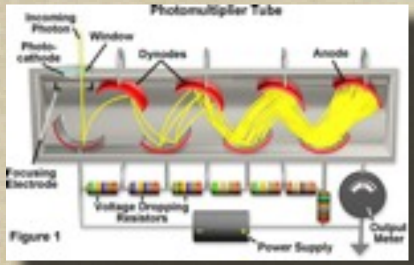




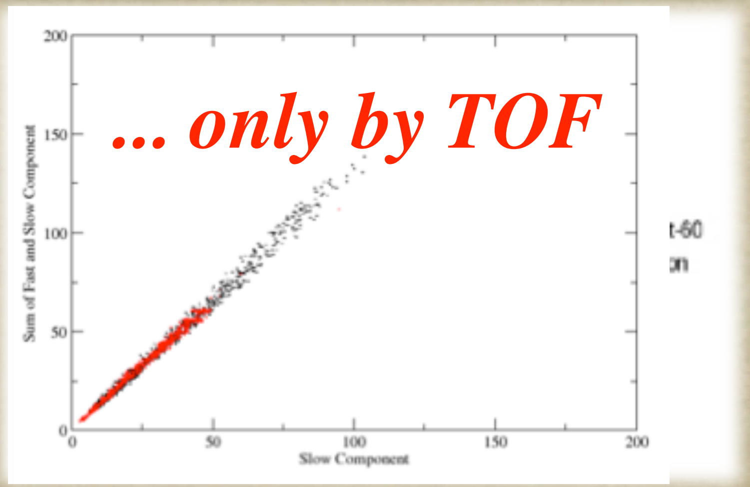


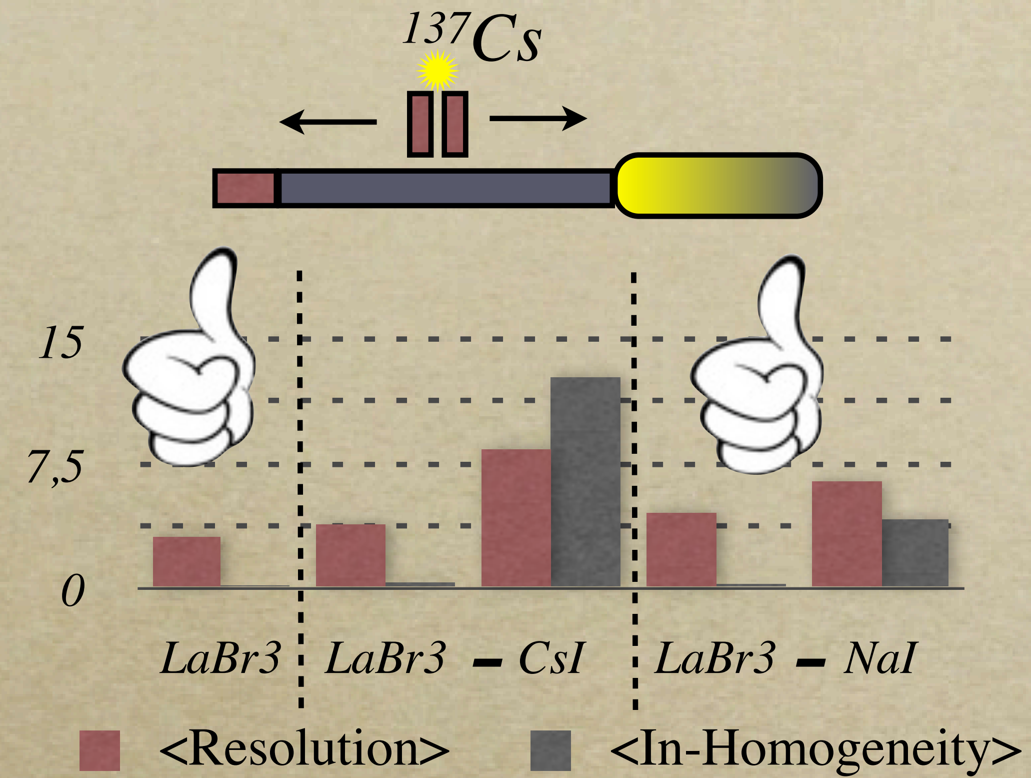
Energy sharing between the two layers ^{simu}

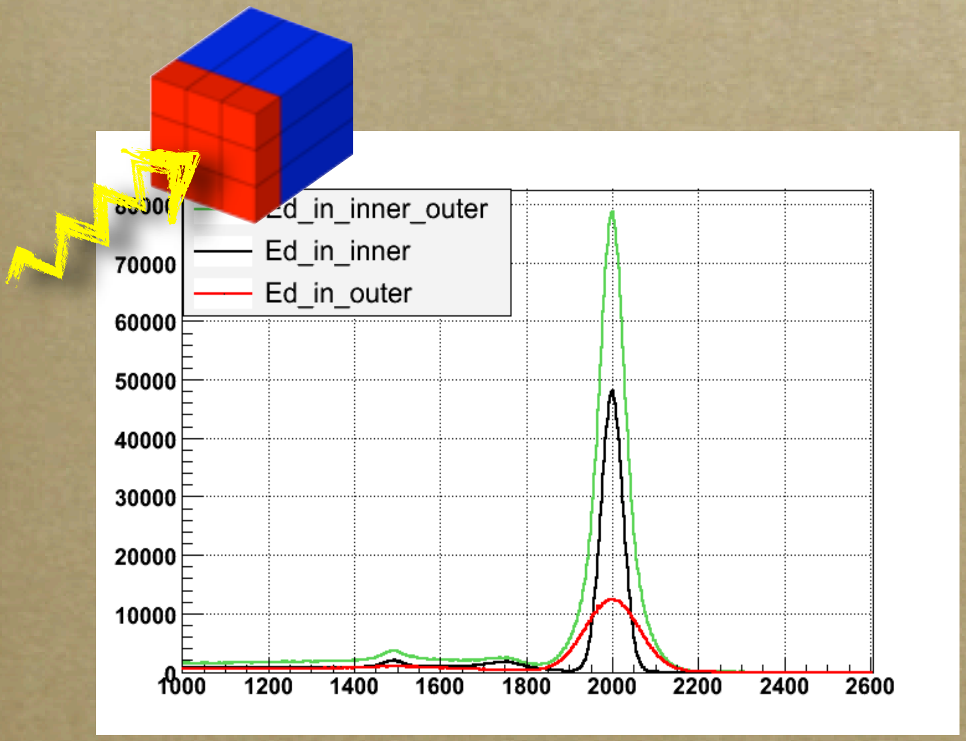
Signal collection



Discrimination γ-n ...

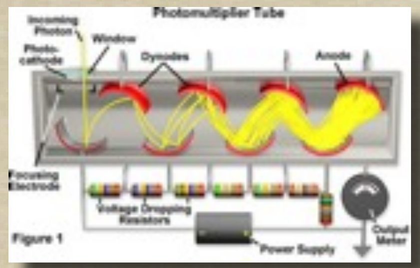




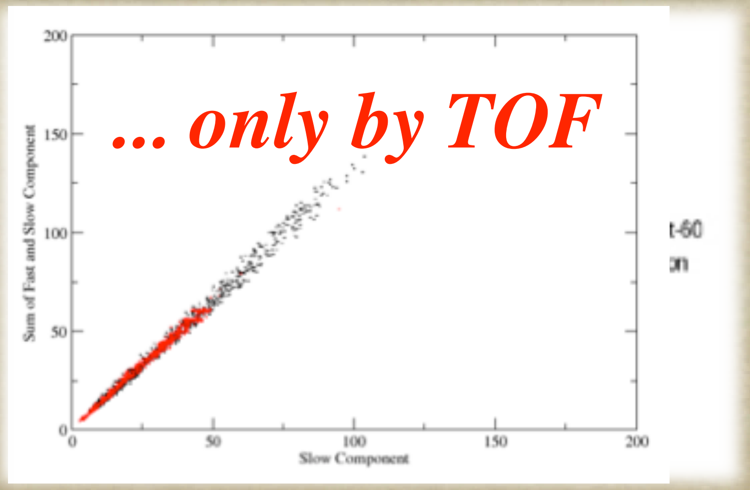


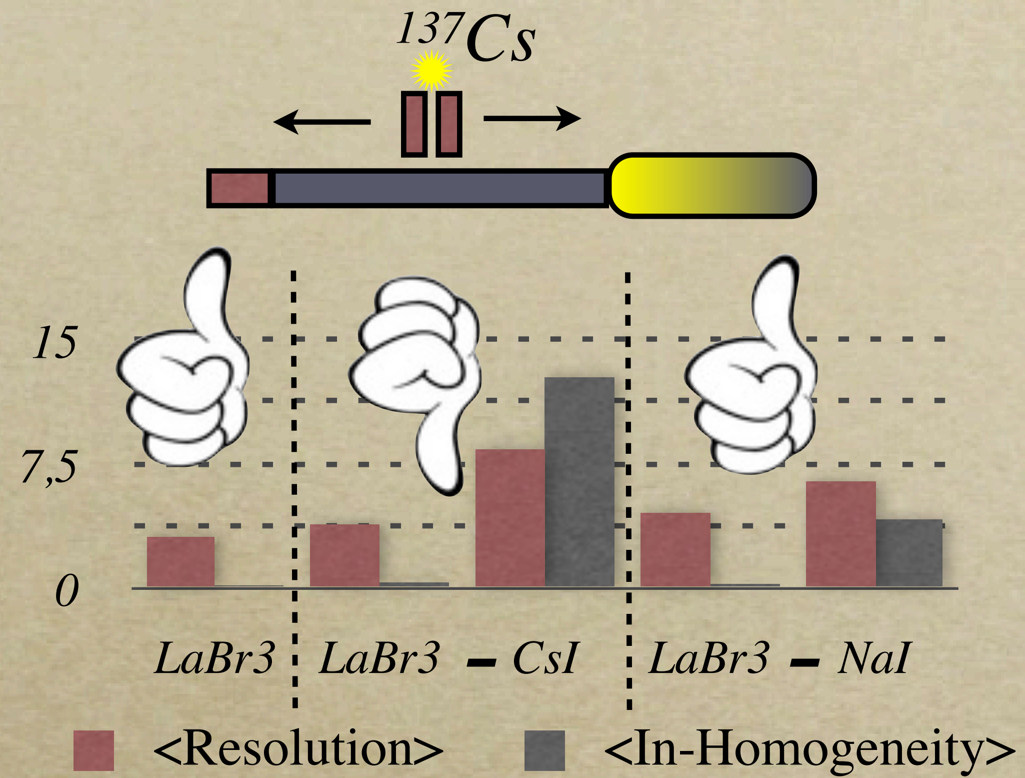
Energy sharing between the two layers ^{simu}

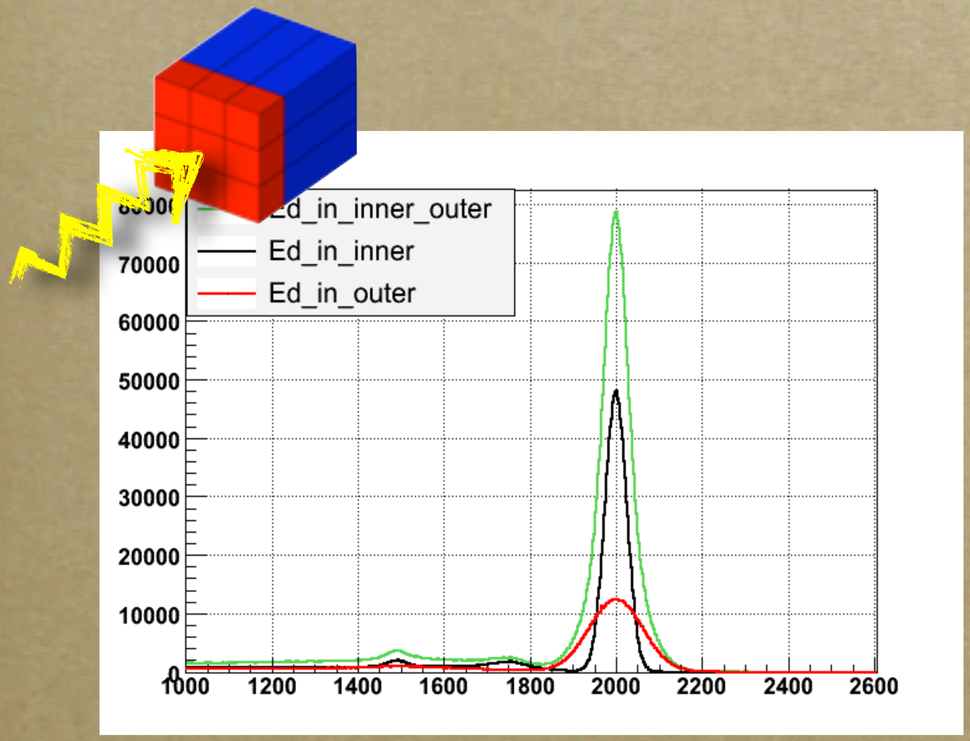
Signal collection



Discrimination γ-n …

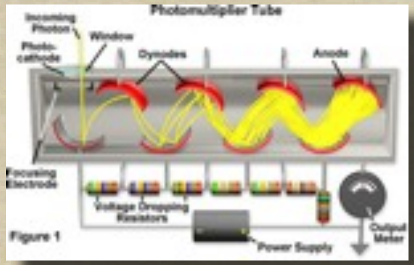




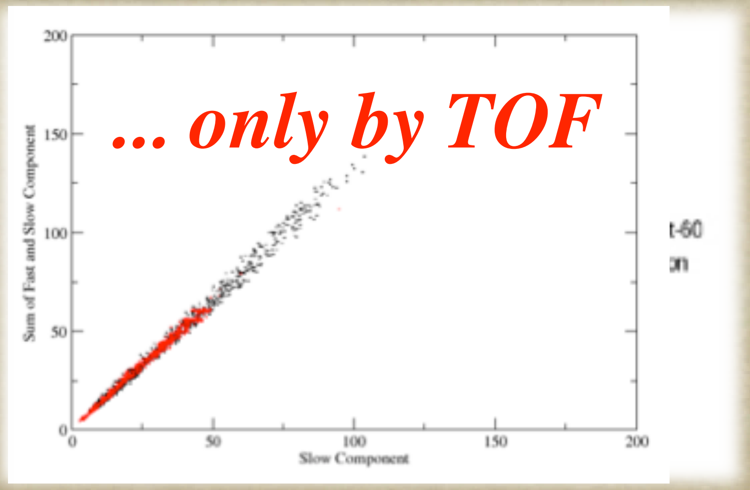


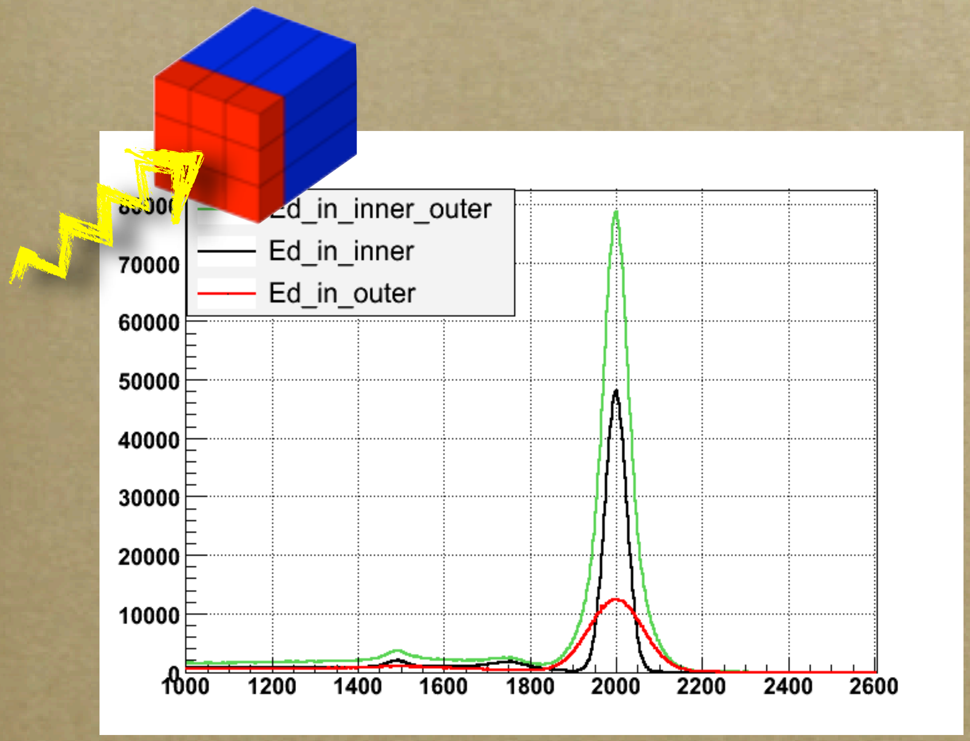
Energy sharing between the two layers ^{simu}

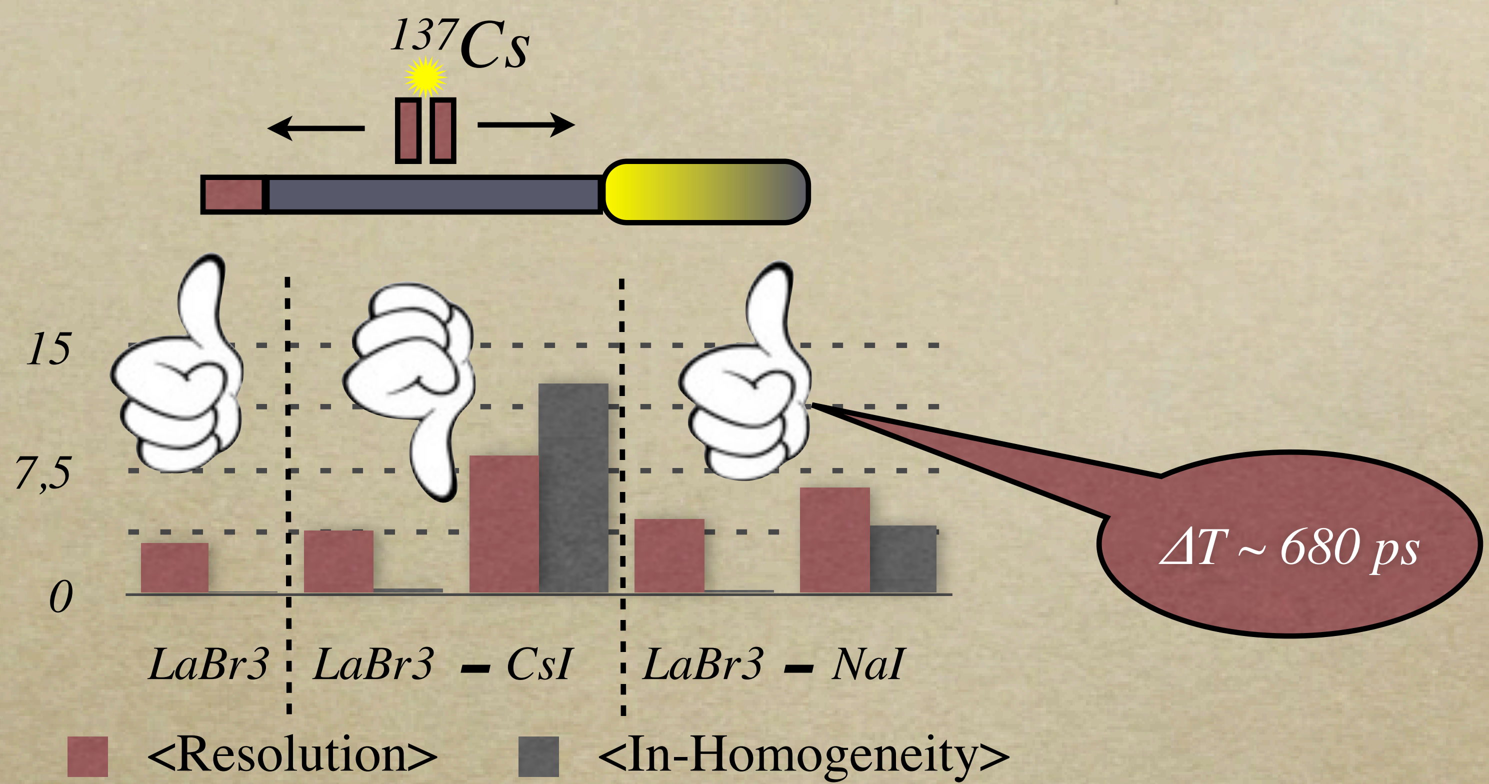
Signal collection



Discrimination γ-n ...

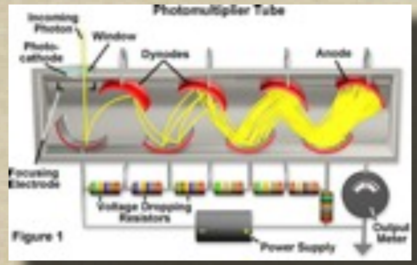




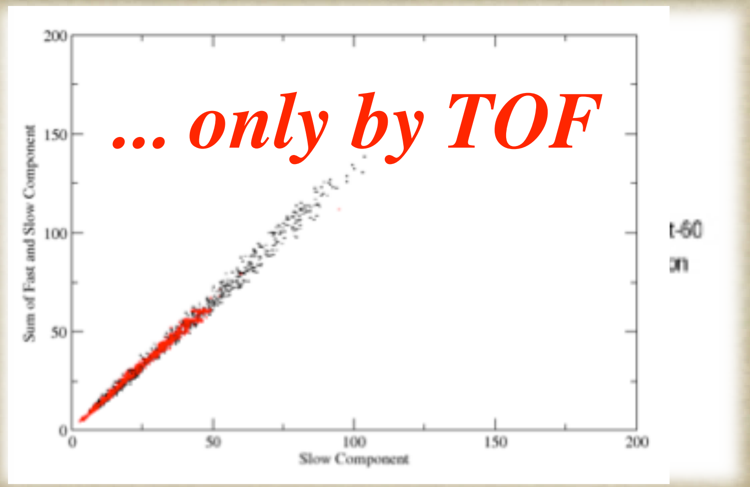


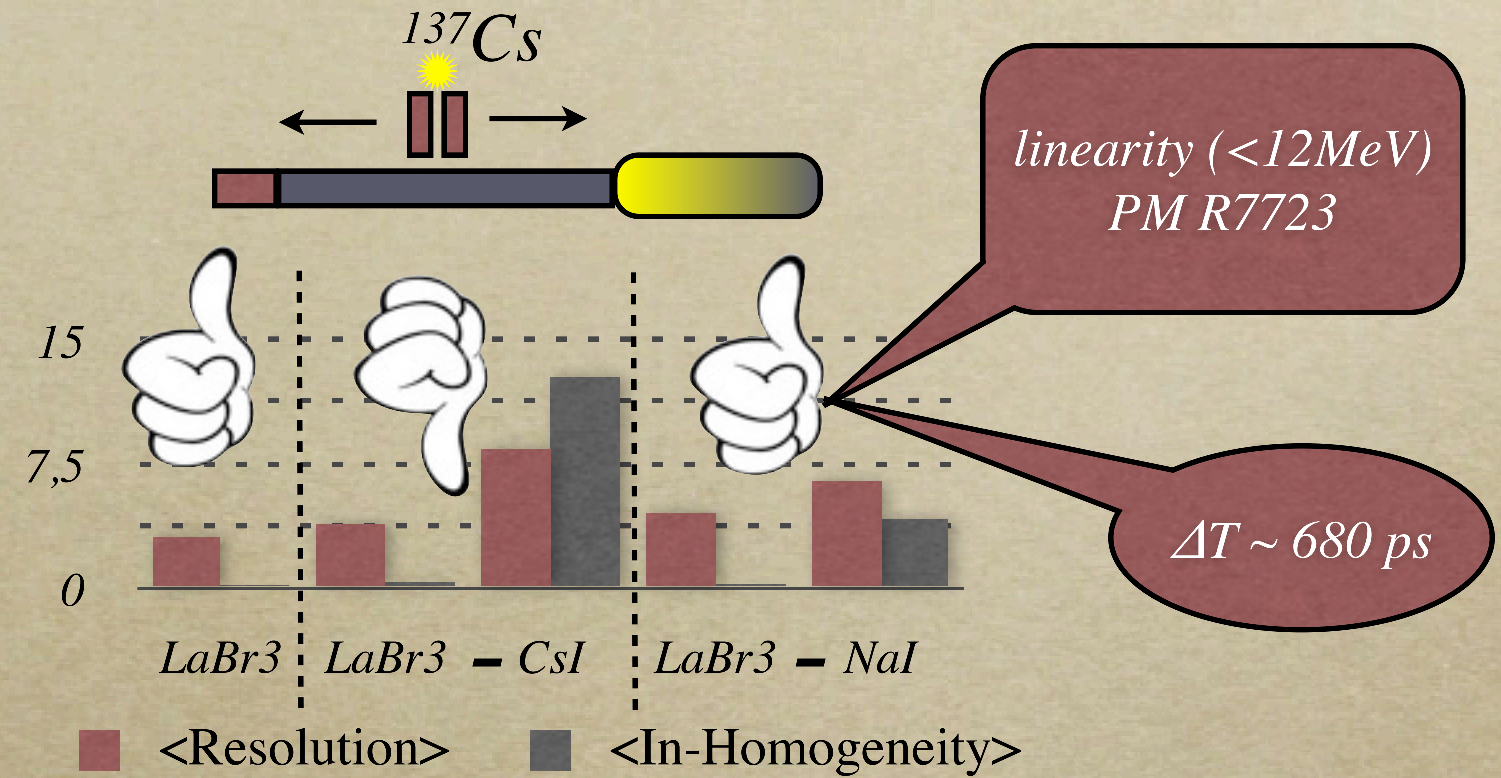
Energy sharing between the two layers [simu]

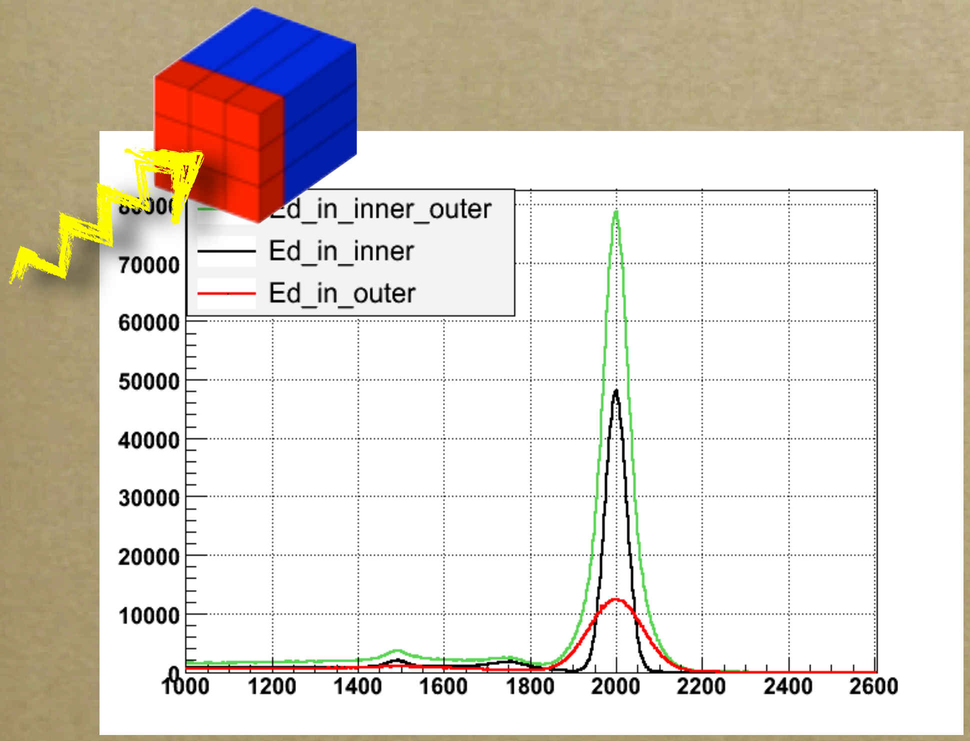
Signal collection



Discrimination γ-n …

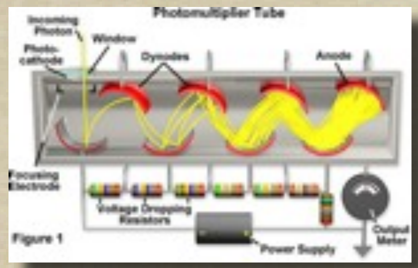




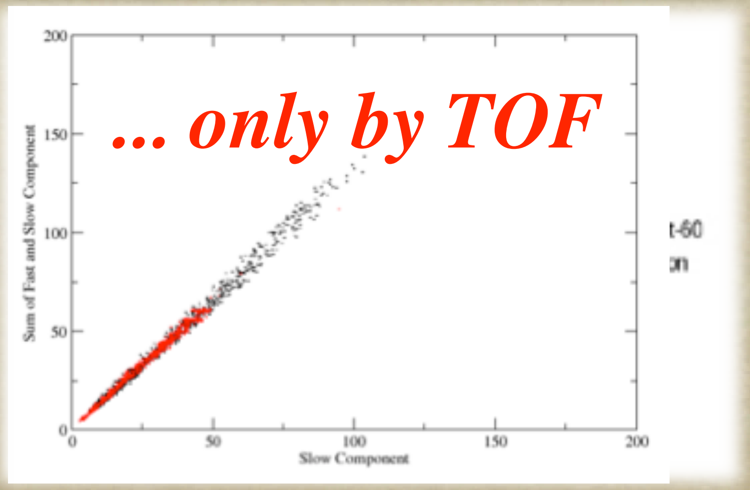


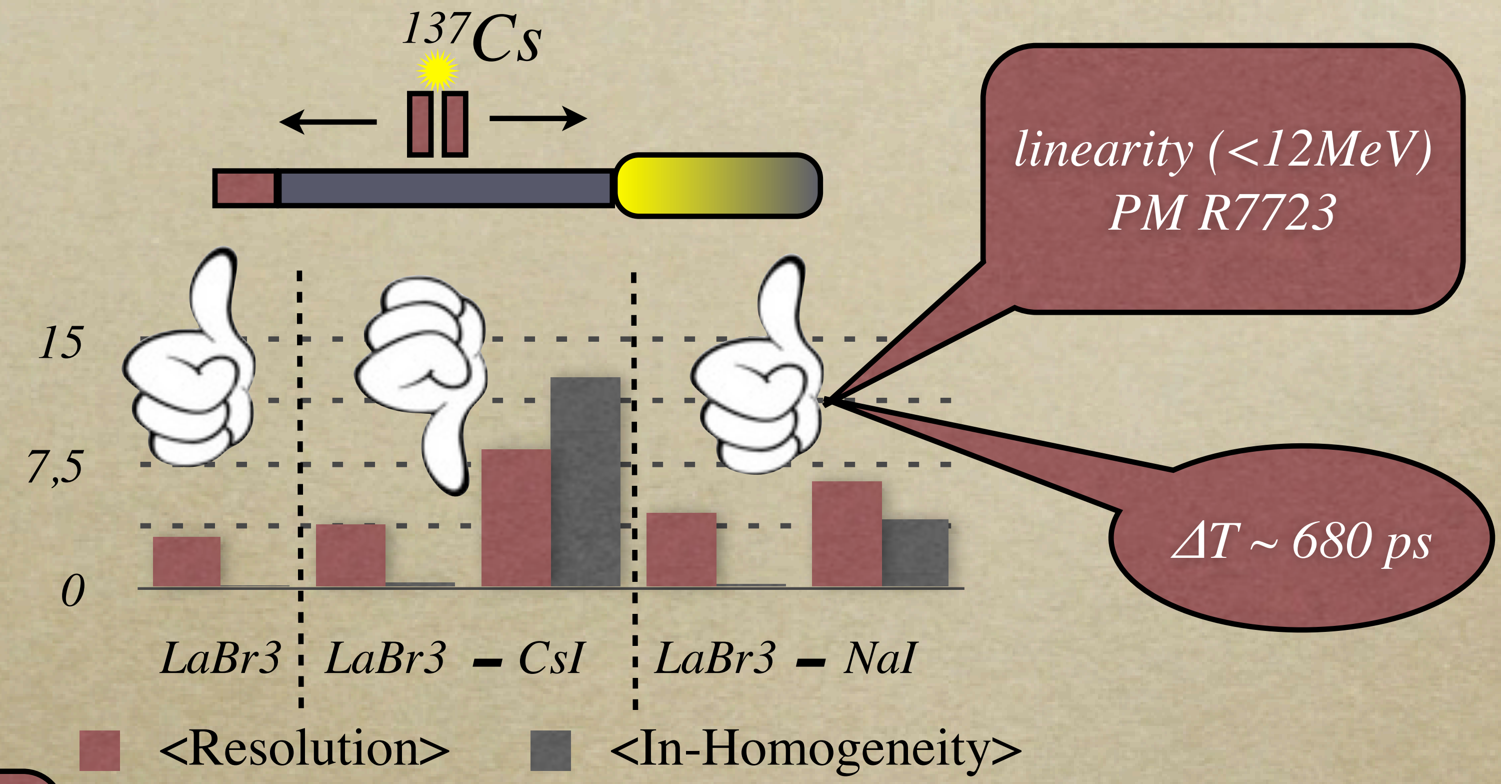
Energy sharing between the two layers ^{simu}

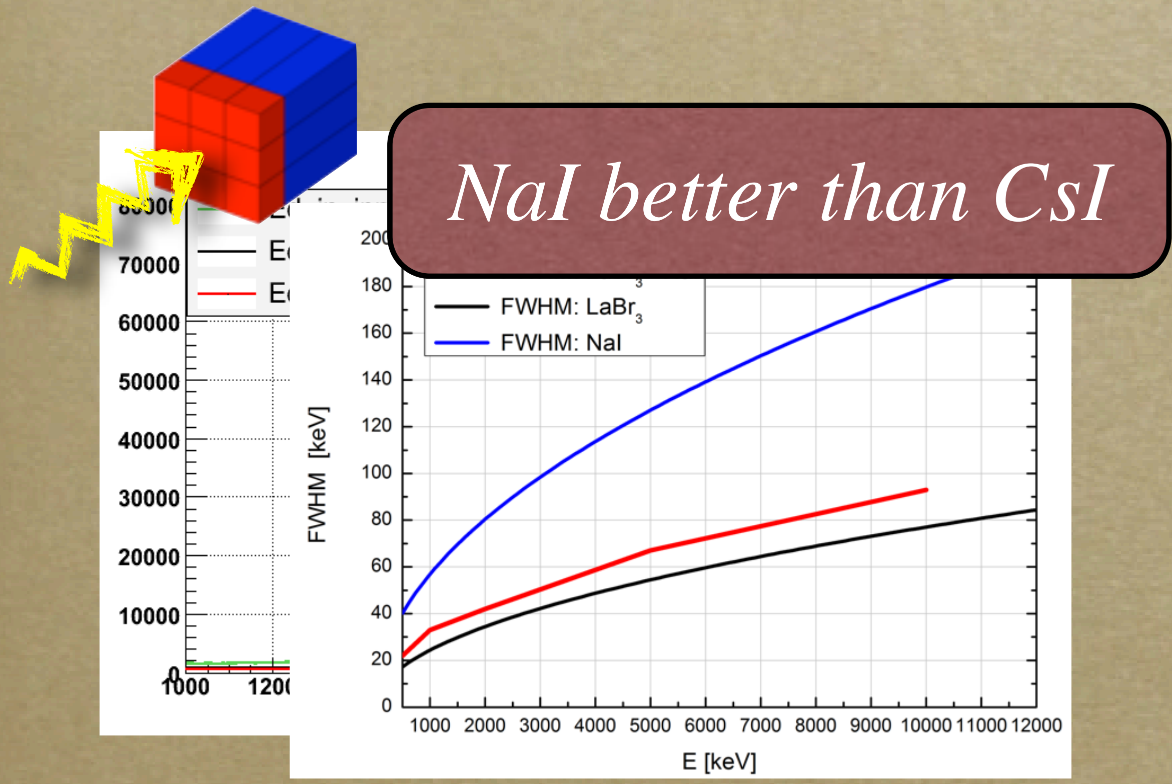
Signal collection



Discrimination γ-n ...

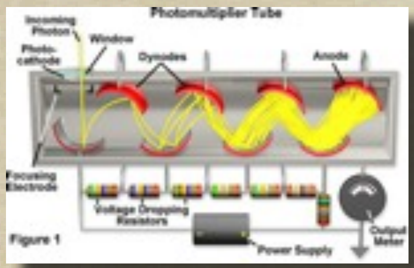




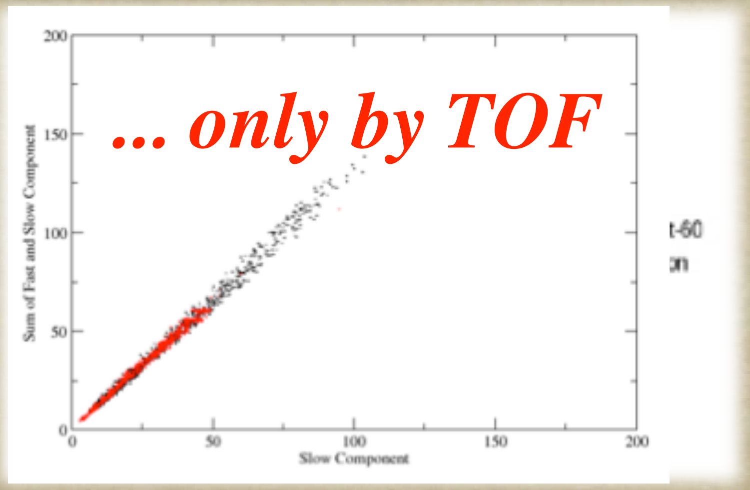


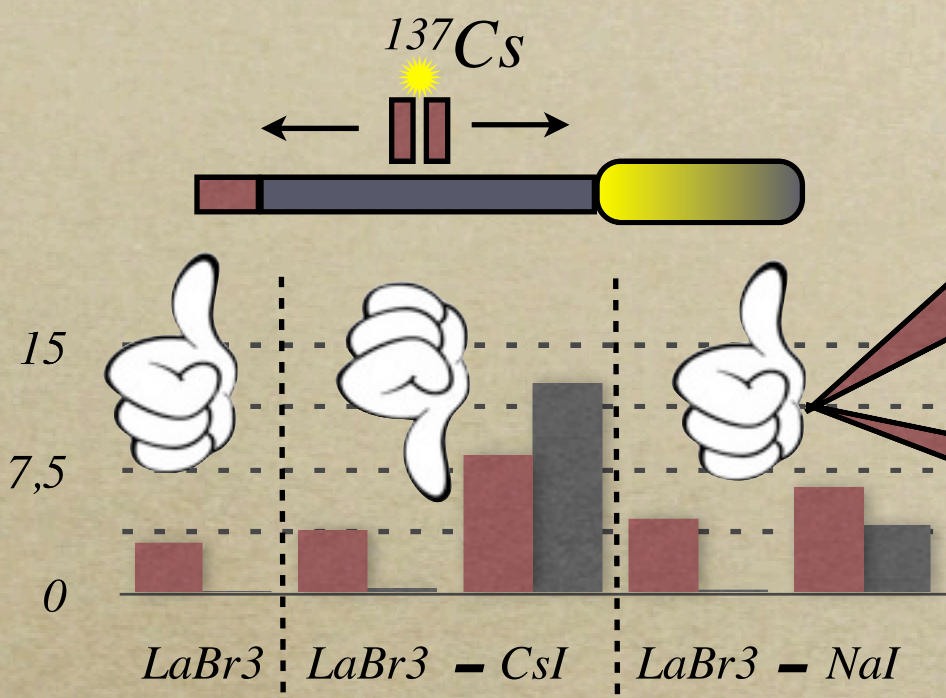
Energy sharing between the two layers ^{simu}

Signal collection



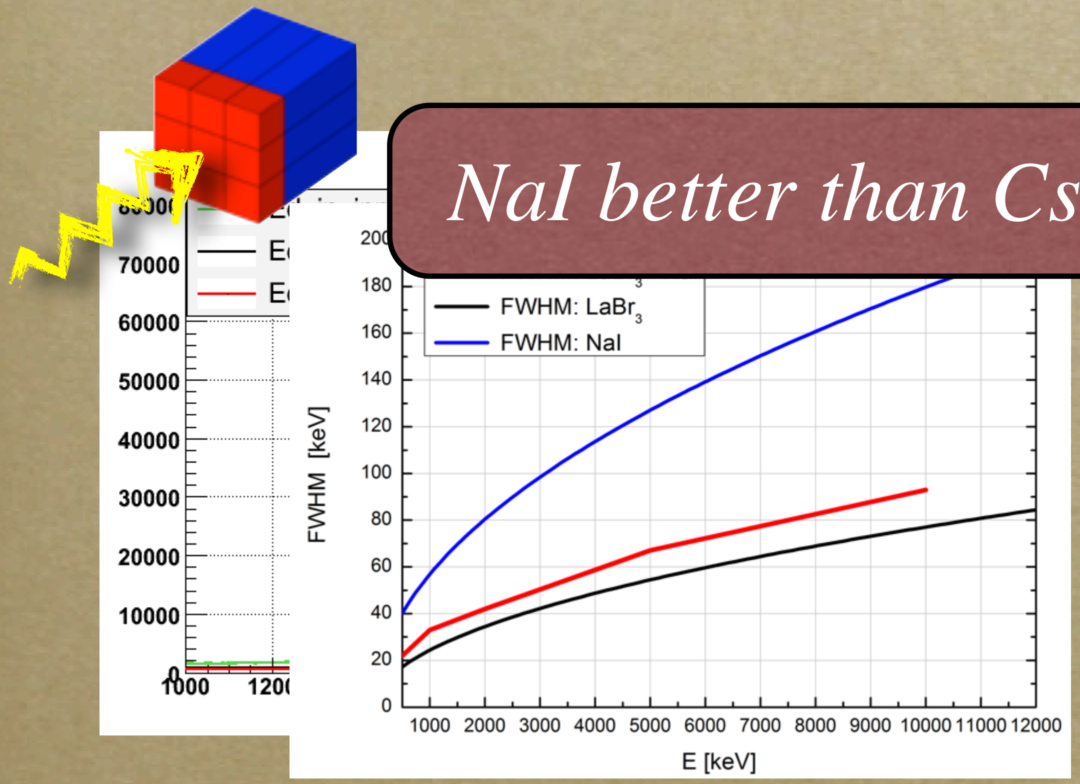
Discrimination γ-n ...





linearity (<12MeV)
PM R7723

ΔT ~ 680 ps



NaI better than CsI

Energy sharing between the two layers ^{simu}

Pure LaBr3 or LaBr3::NaI

☛ ***9 phoswich ordered***

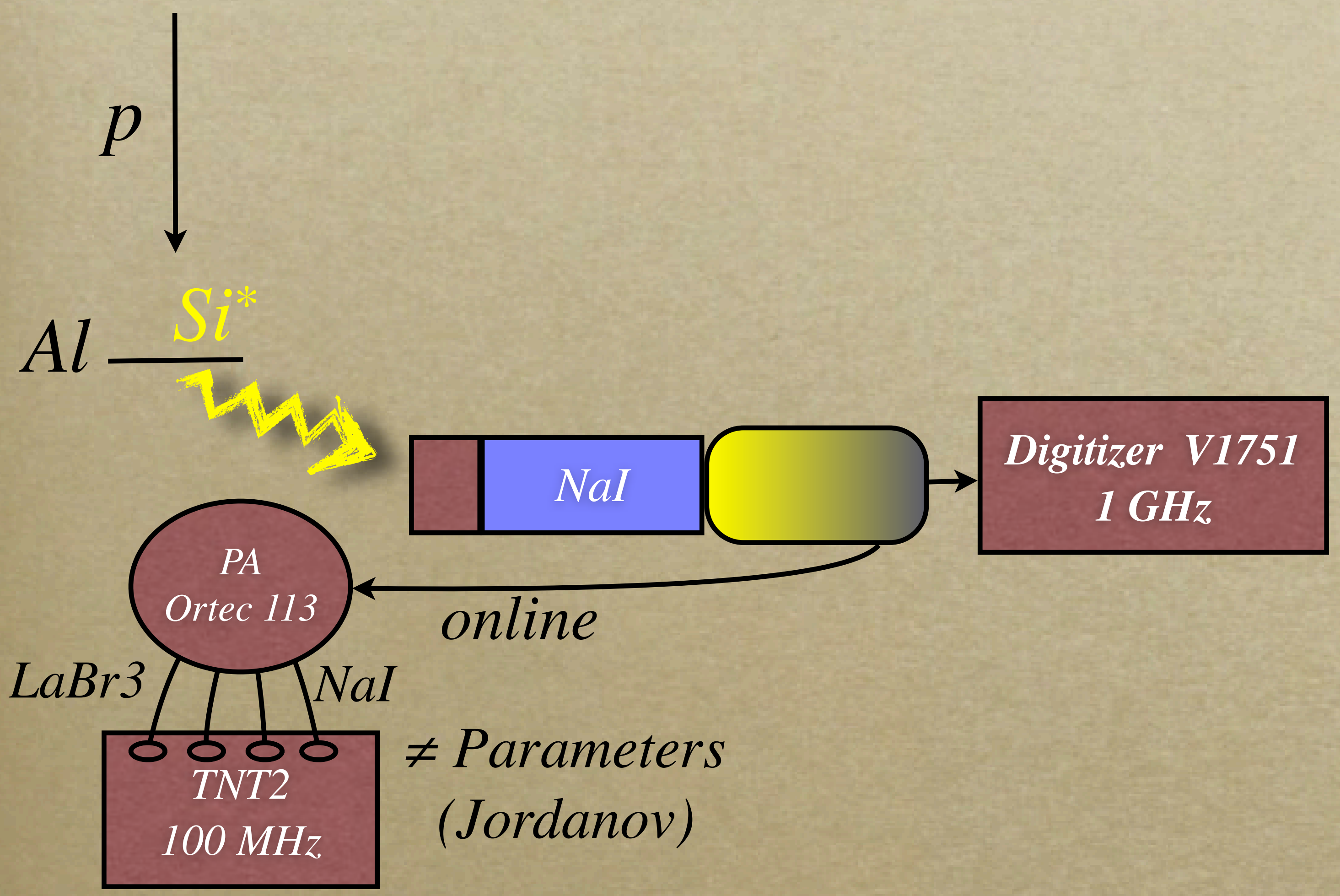
To be done *:*

full Δe-Δt measurements (source+beam)

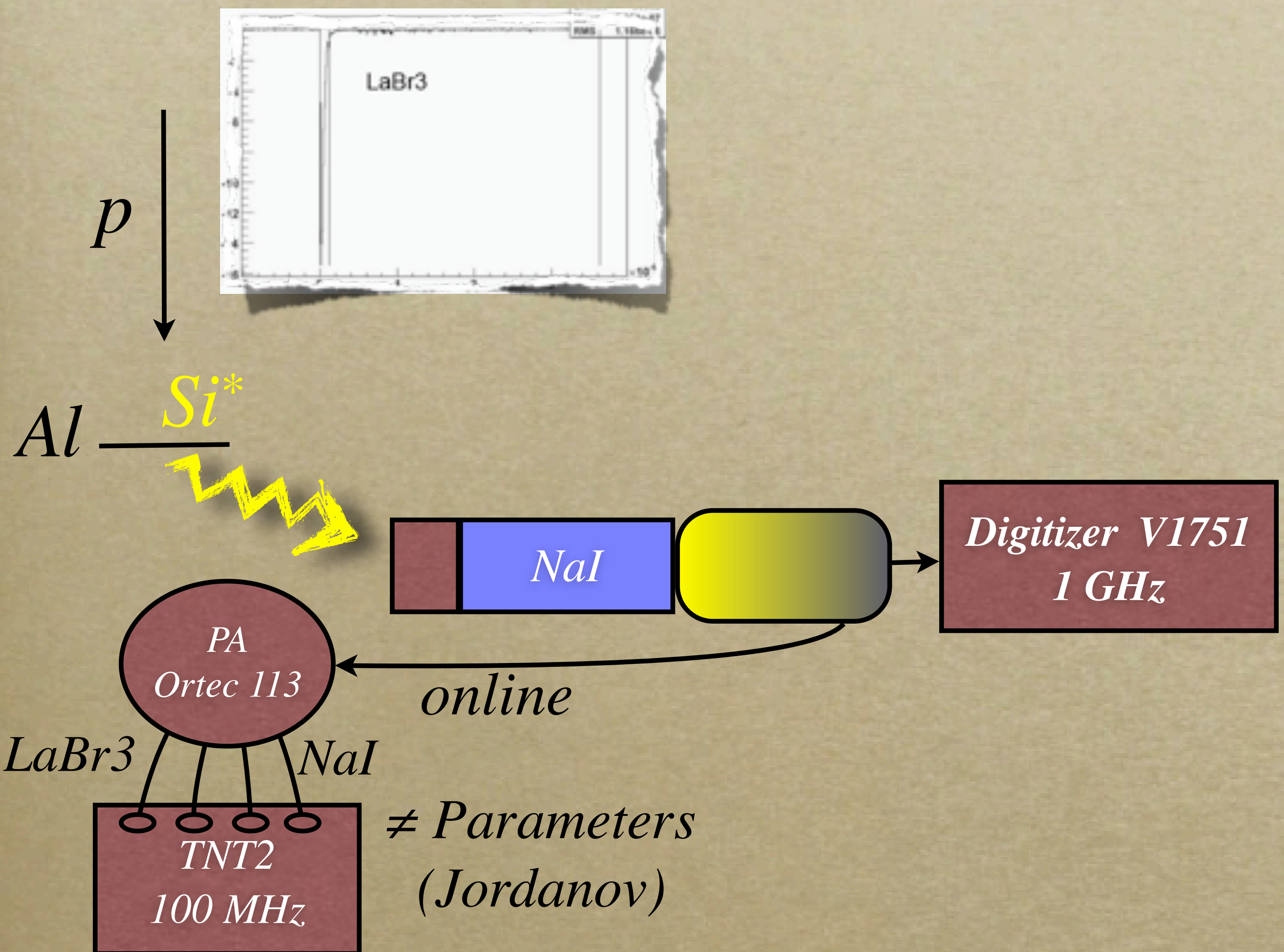
choice of the best PM

resolution, linearity, efficiency, addback

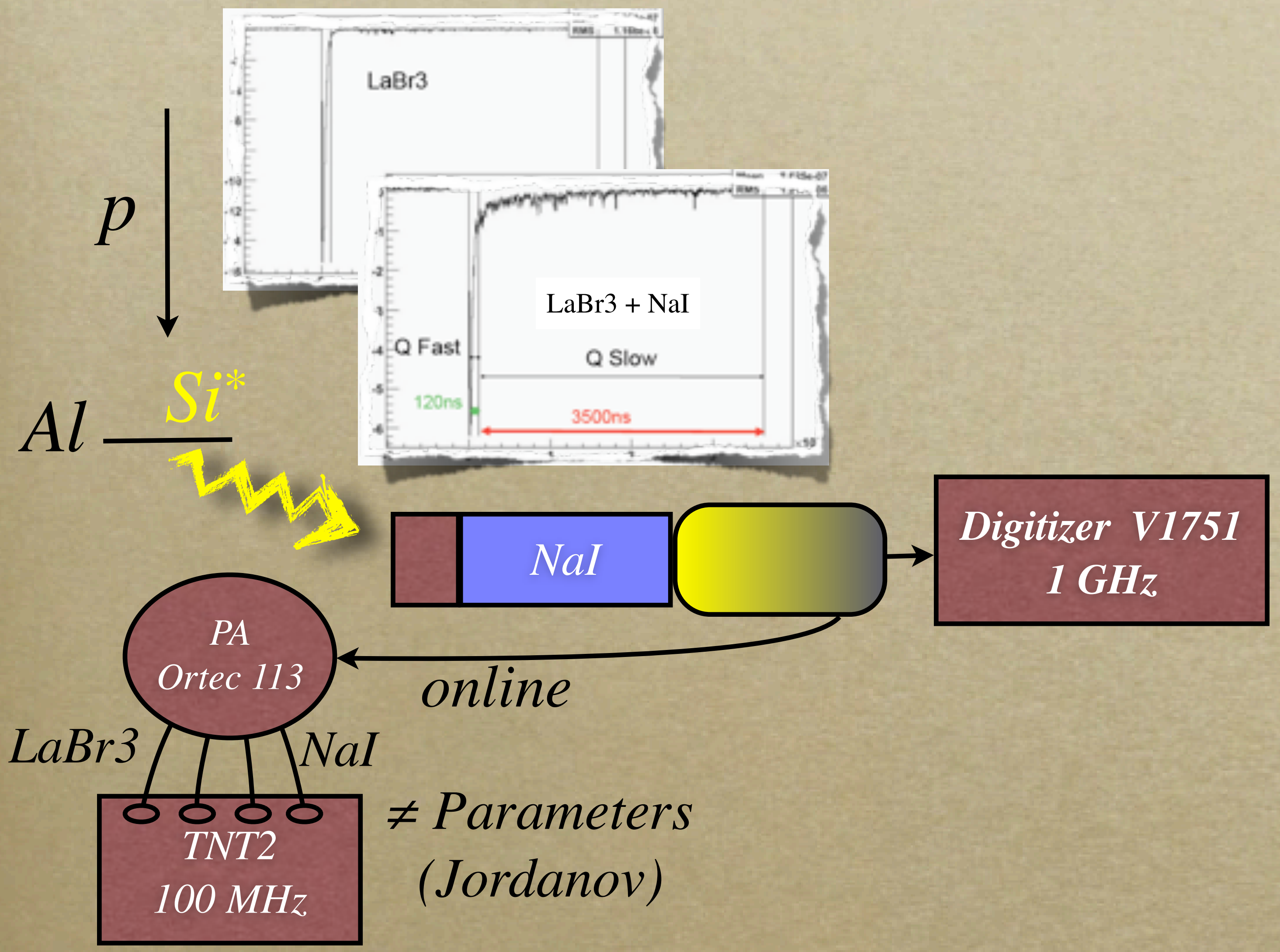
Signal processing



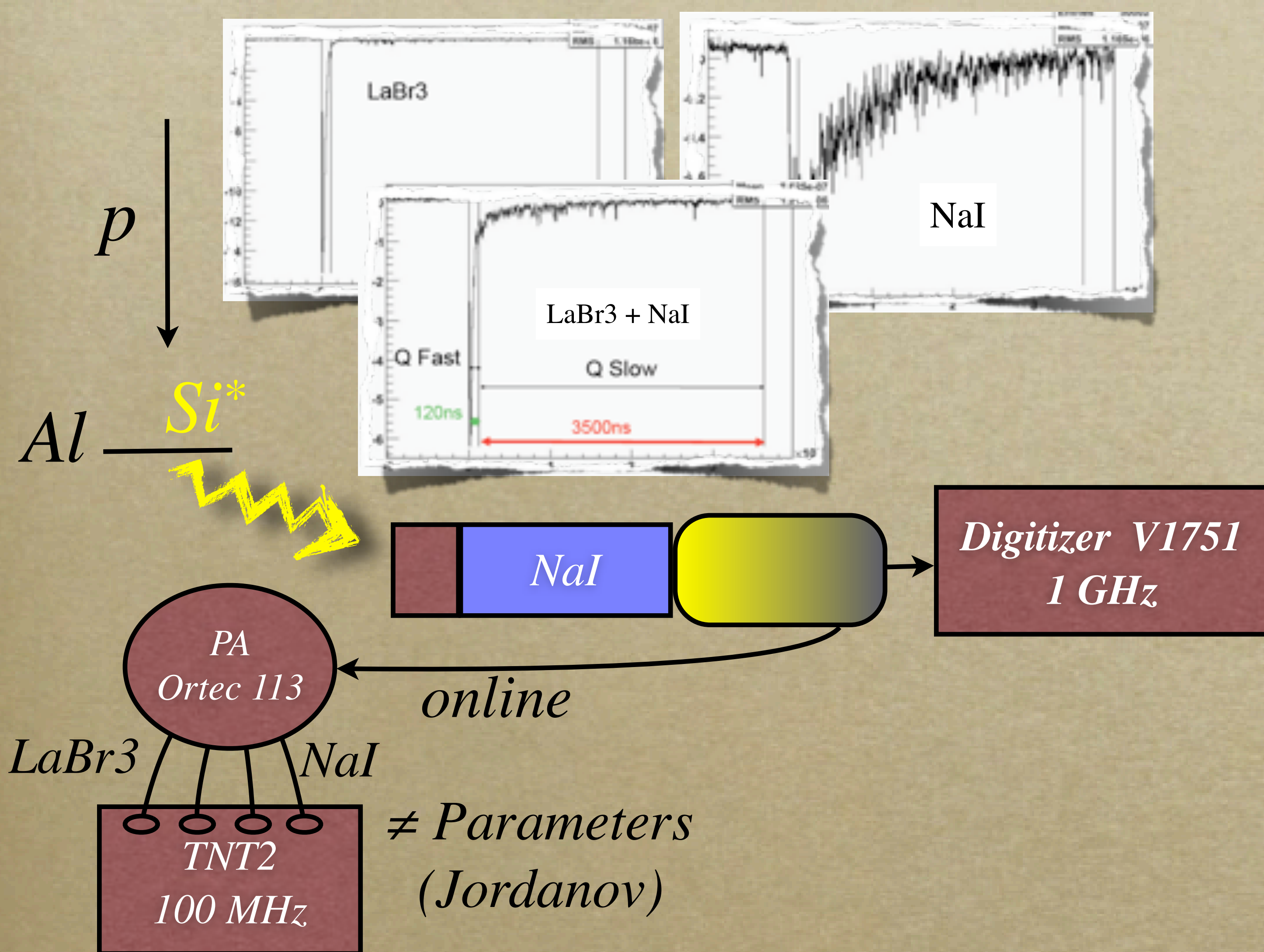
Signal processing



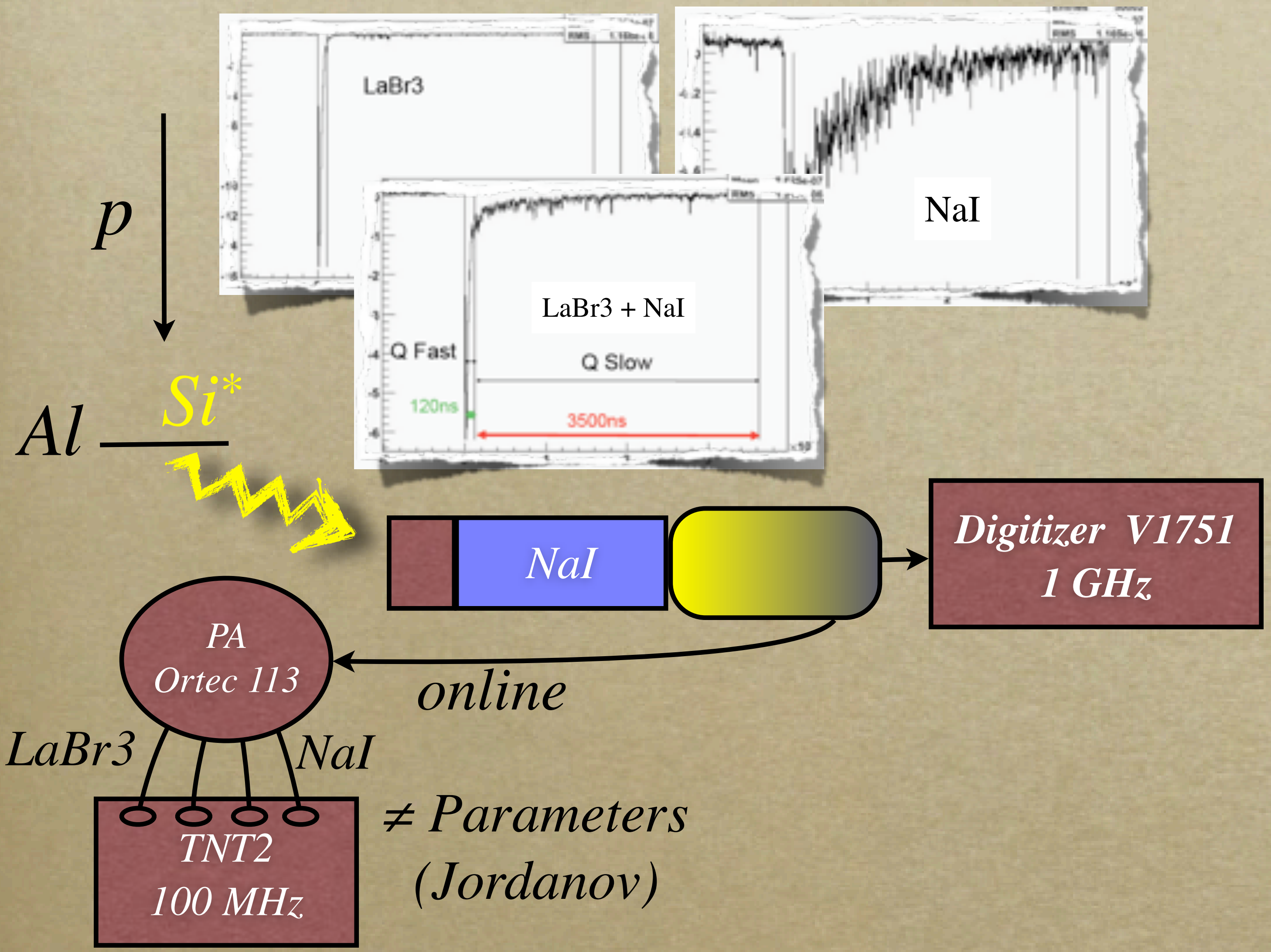
Signal processing



Signal processing



Signal processing



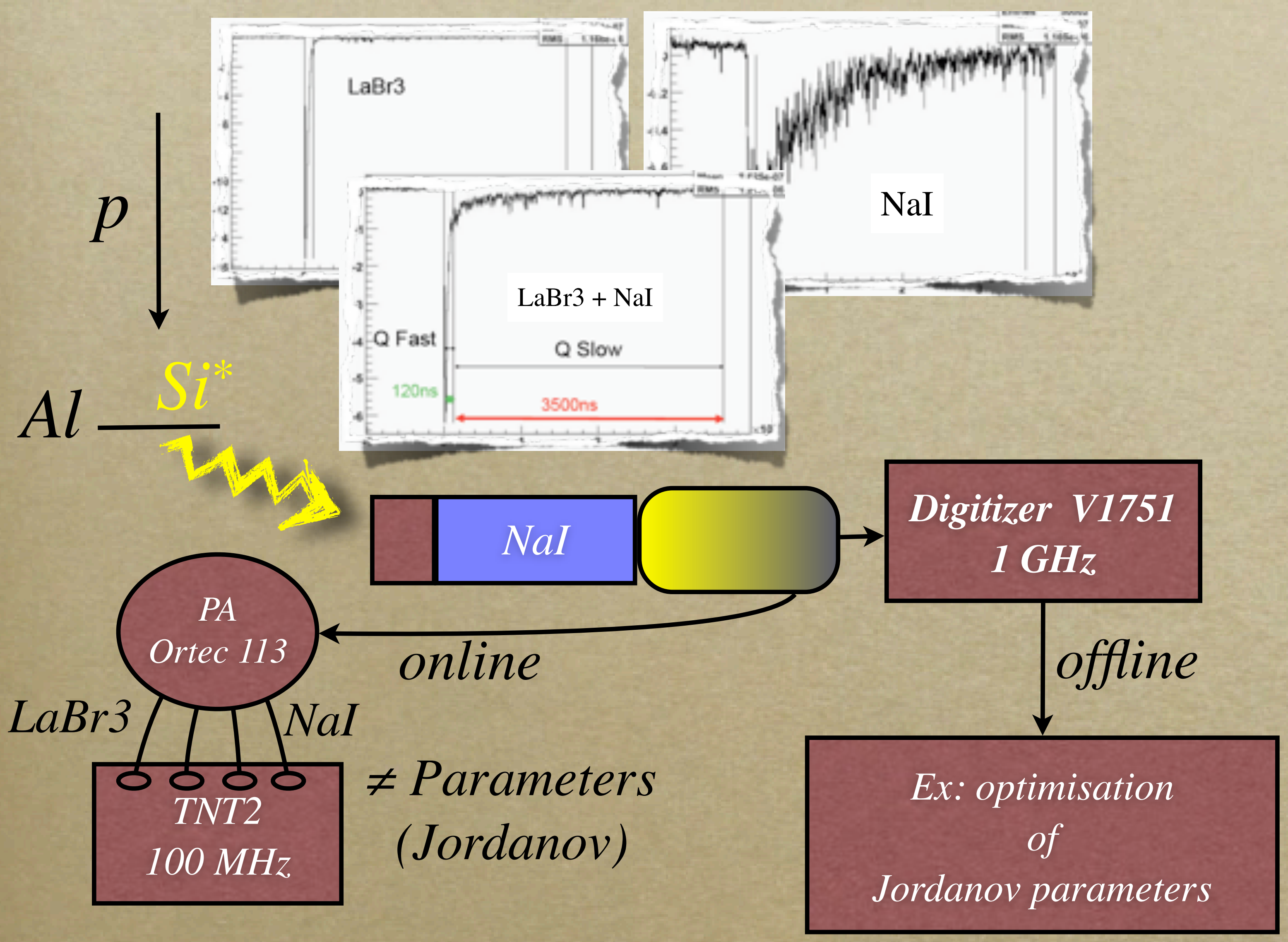
LaBr3

$R_{511\ keV} = 5.3\%$

$R_{1778\ keV} = 2.7\%$

$R_{10762\ keV} = 1\%$

Signal processing



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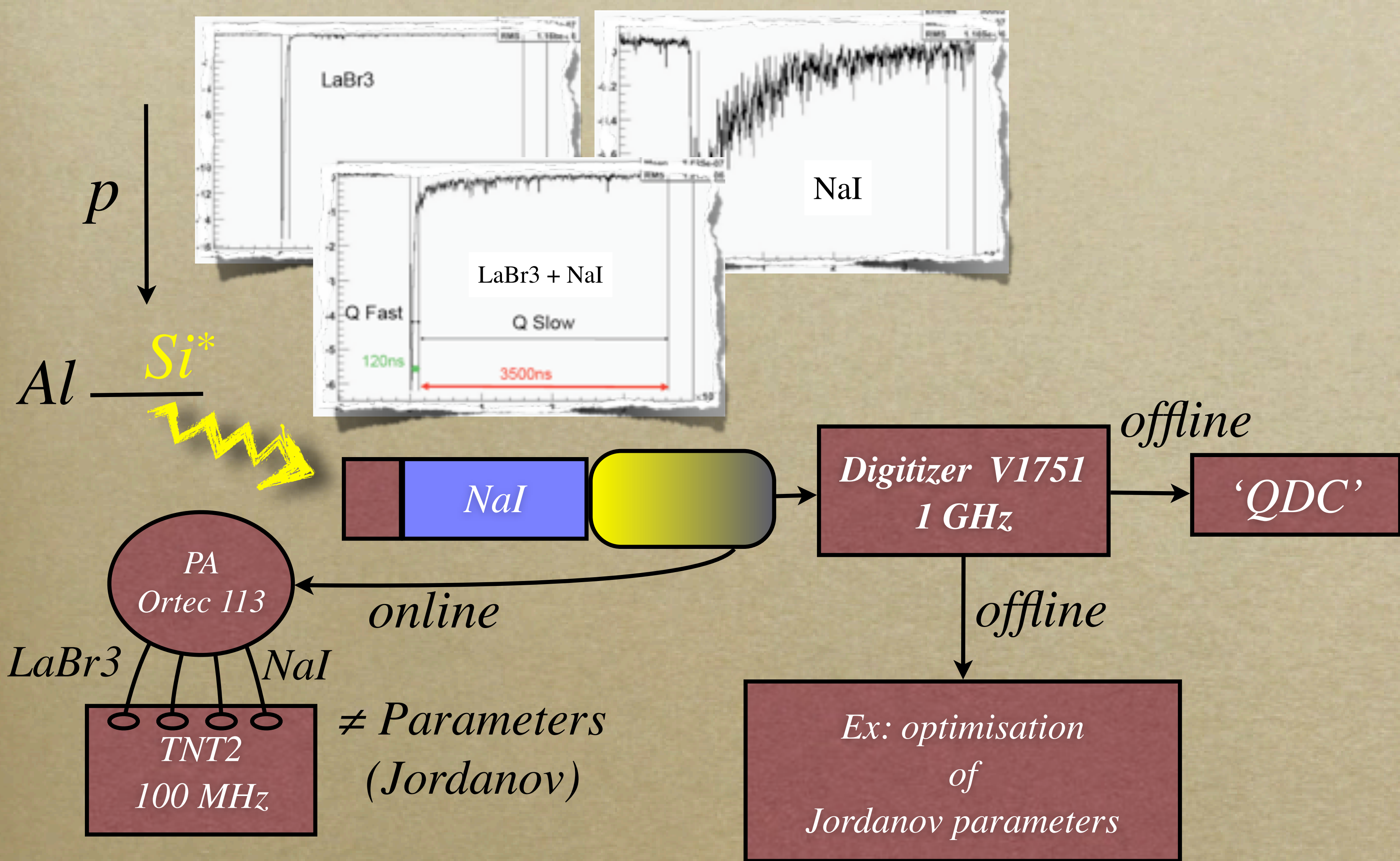

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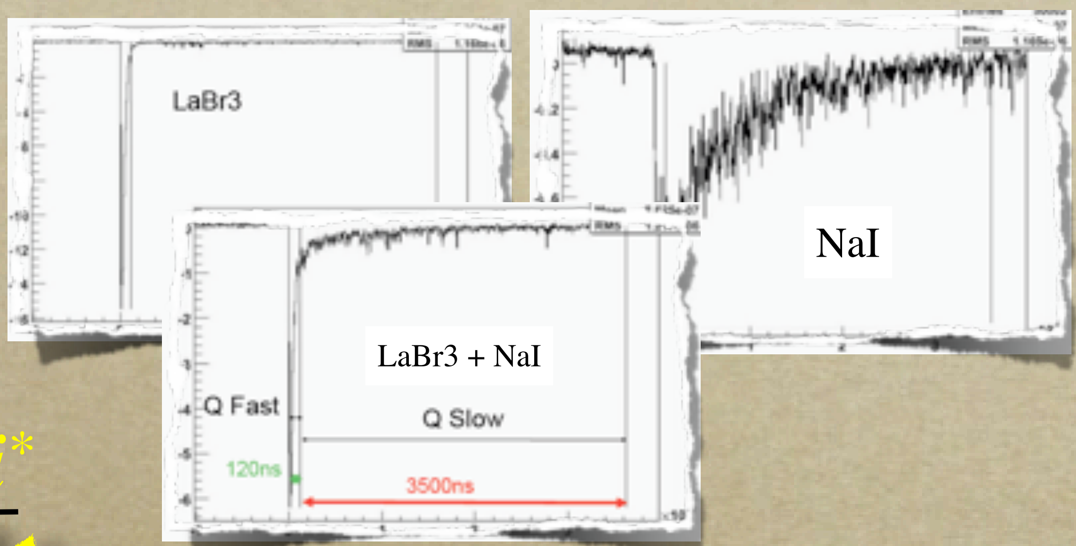

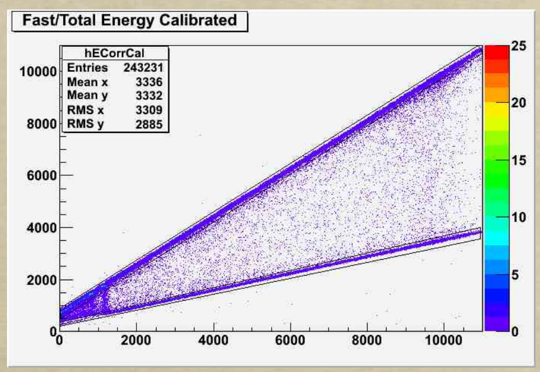

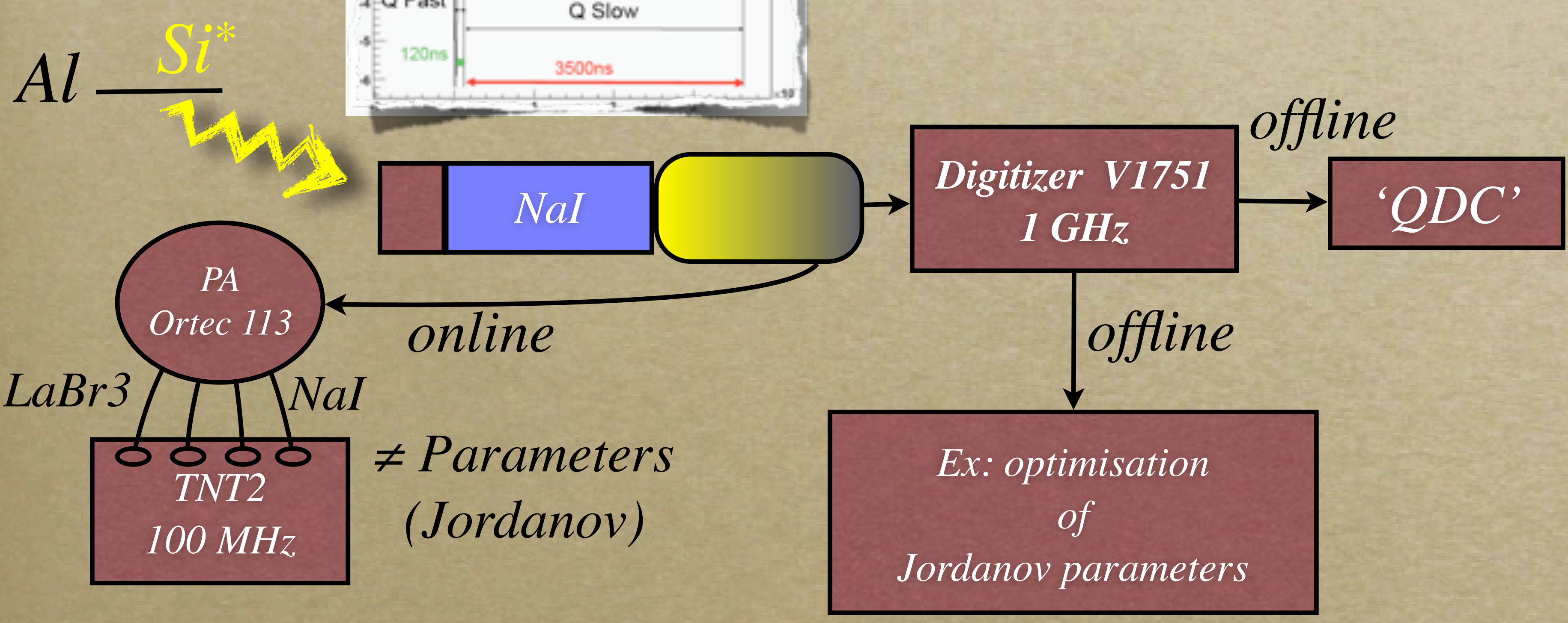

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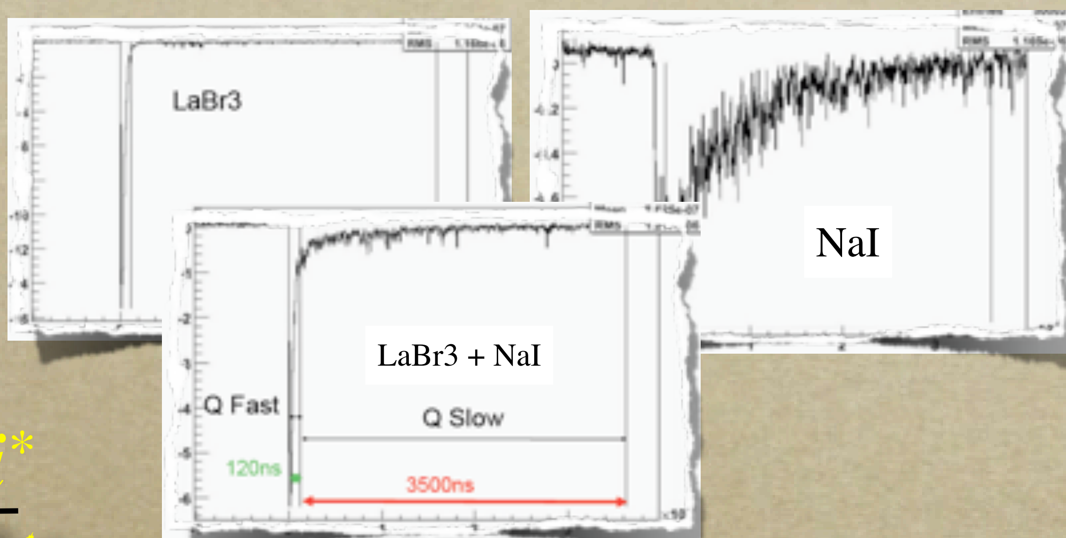
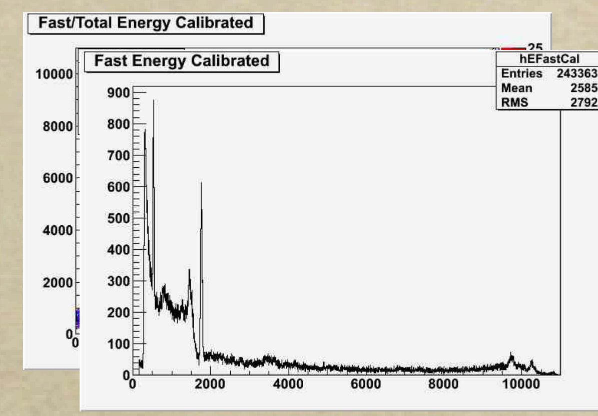
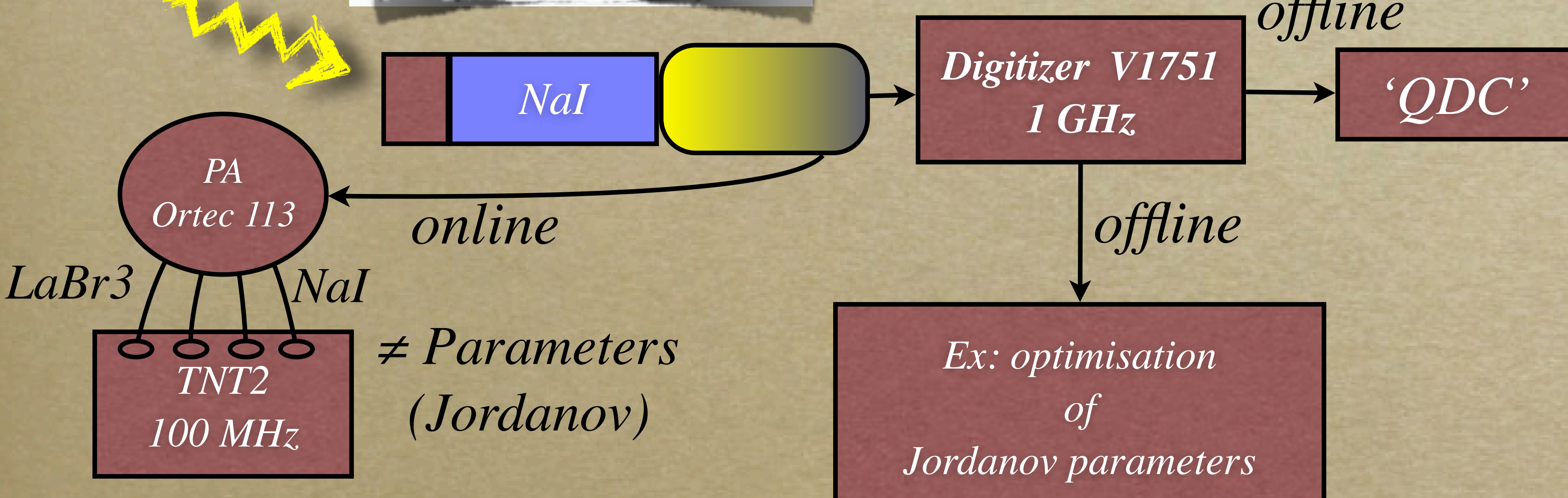
Signal processing







<u>LaBr3</u>

$R_{511\ keV} = 5.3\%$

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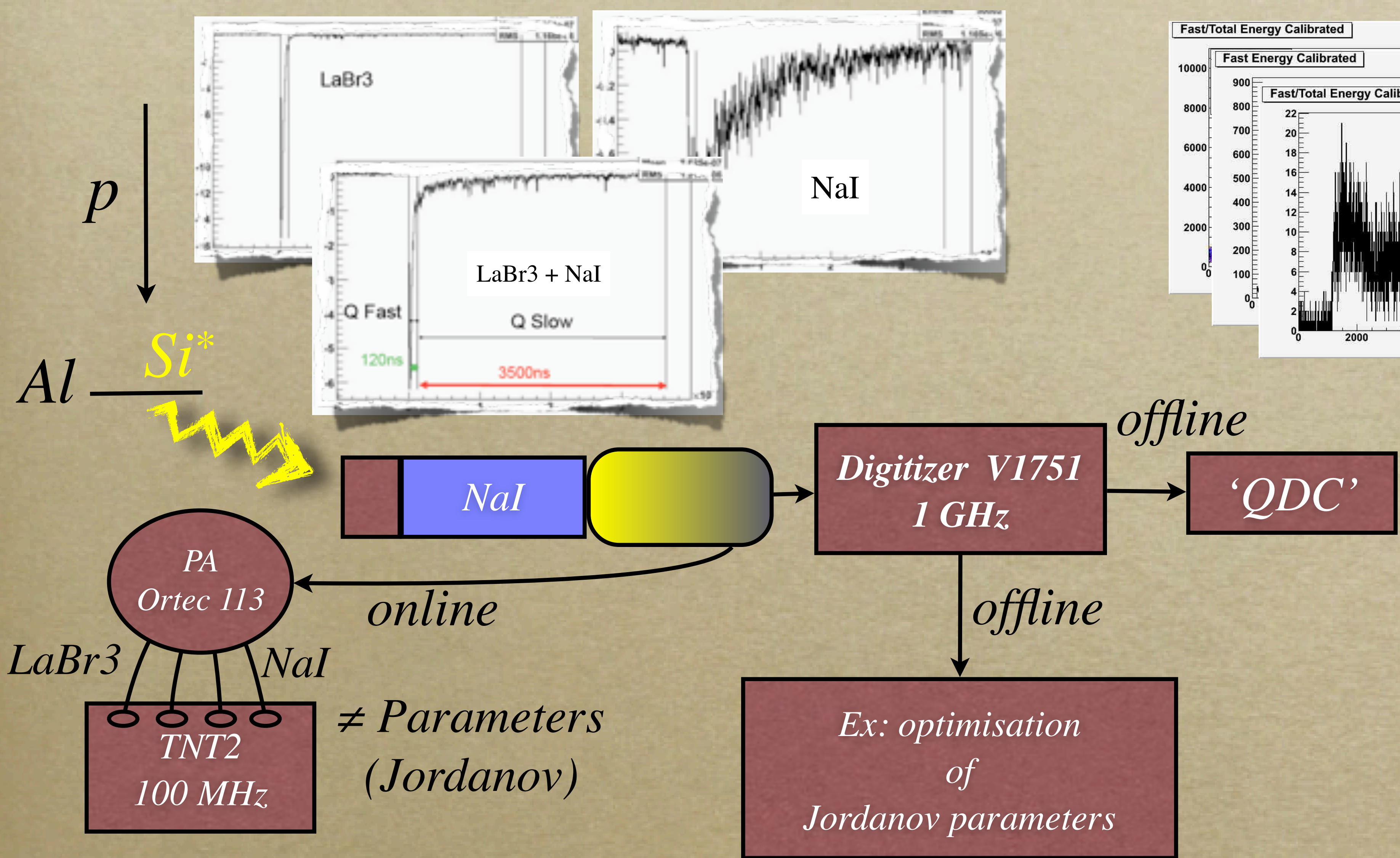
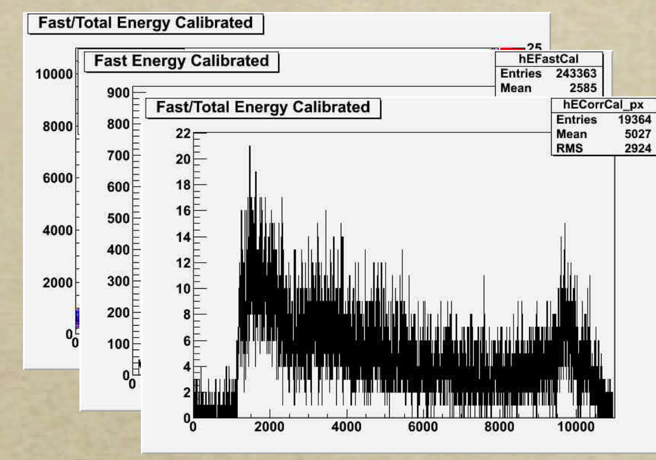
Signal processing





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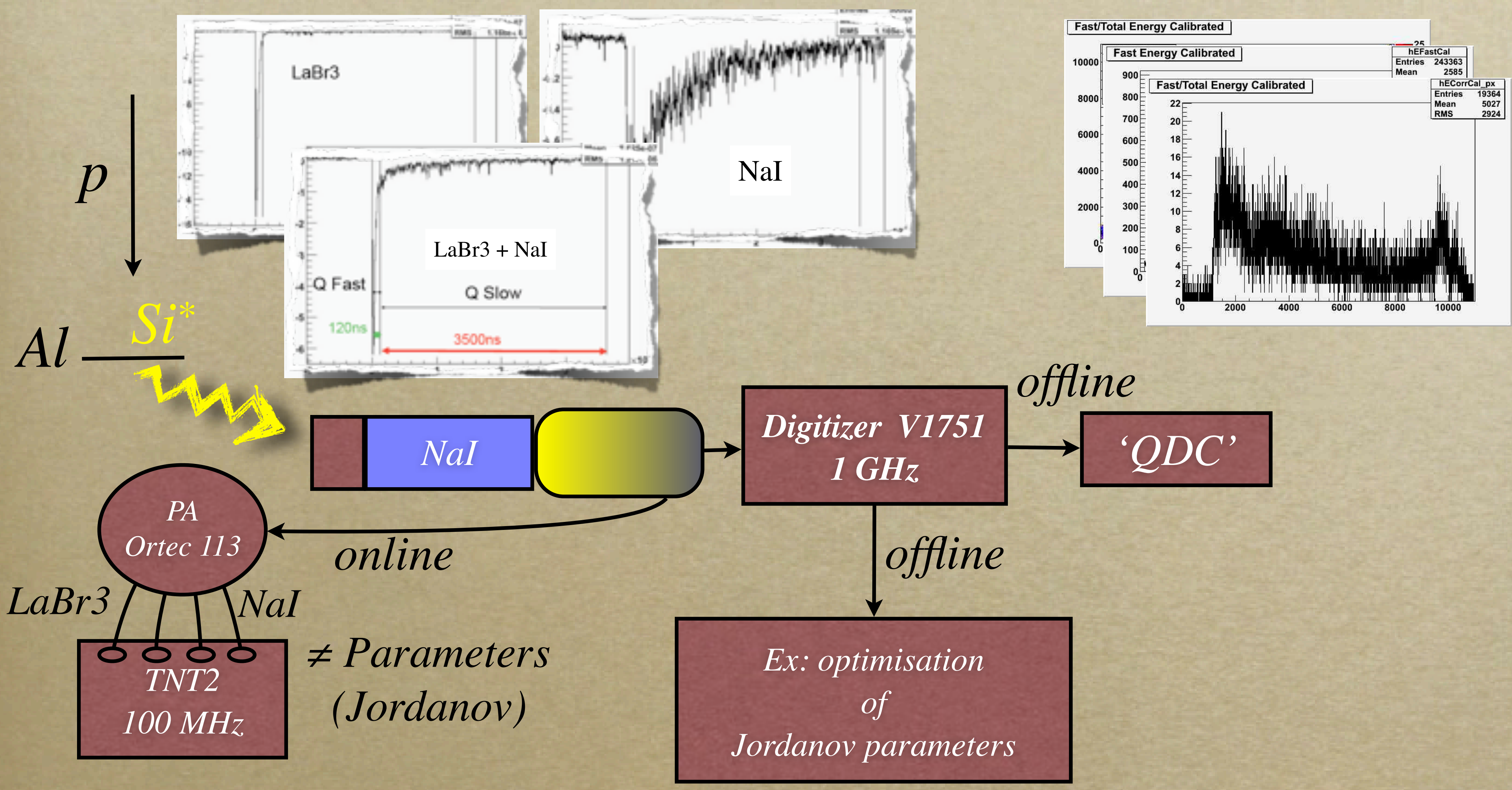
$R_{10762\ keV} = 1\%$

Signal processing



LaBr3

$R_{511\ keV} = 4.5\%$

$R_{1778\ keV} = 2.4\%$

$R_{10762\ keV} = 1\%$

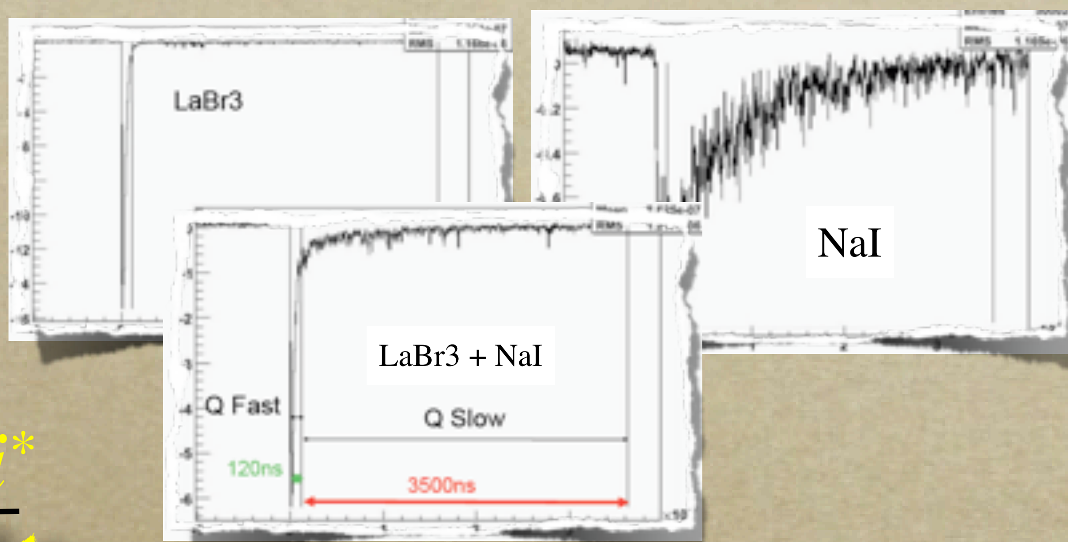
LaBr3

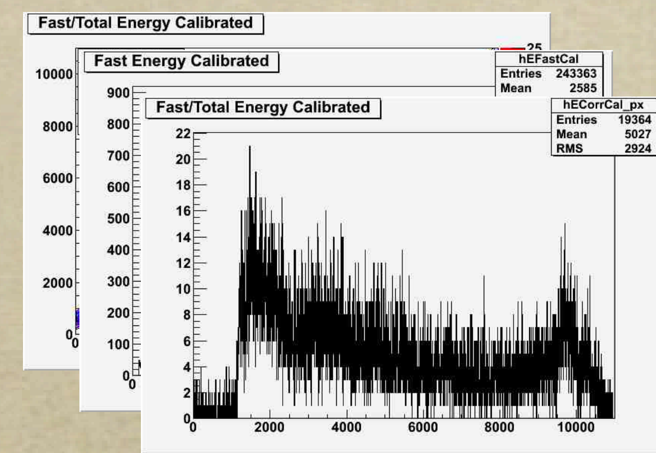
$R_{511\ keV} = 5.3\%$

$R_{1778\ keV} = 2.7\%$

$R_{10762\ keV} = 1\%$

Signal processing





LaBr3

$R_{511\ keV} = 4.5\%$

$R_{1778\ keV} = 2.4\%$

$R_{10762\ keV} = 1\%$

p

Al — Si^*

NaI

Digitizer V1751
1 GHz

offline

'QDC'

offline

Ex: optimisation of Jordanov parameters

online

PA
Ortec 113

LaBr3 NaI

TNT2
100 MHz

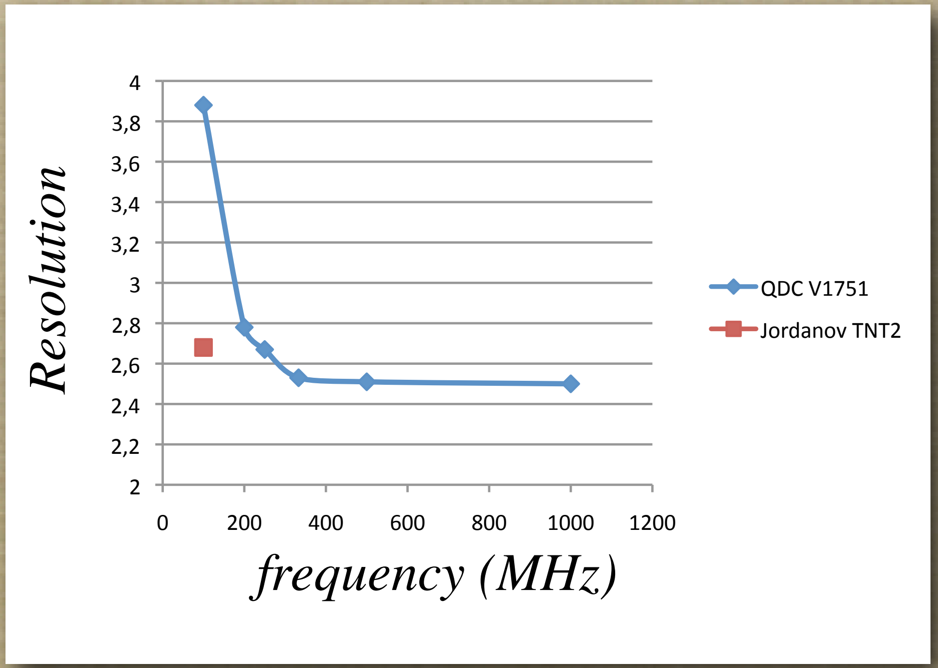
≠ Parameters (Jordanov)

LaBr3

$R_{511\ keV} = 5.3\%$

$R_{1778\ keV} = 2.7\%$

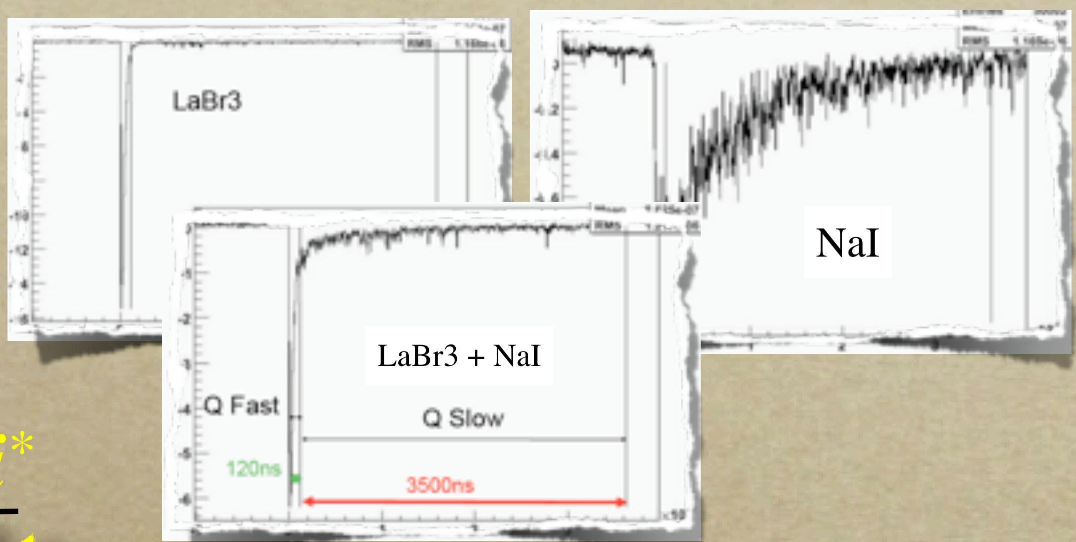
$R_{10762\ keV} = 1\%$

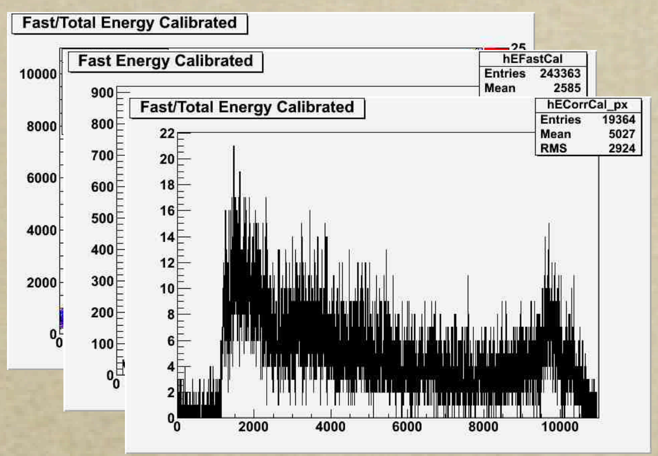


Signal processing

p

$Al \xrightarrow{} Si^{*}$





NaI

Digitizer V1751
1 GHz

offline

'QDC'

PA
Ortec 113

online

LaBr3 NaI

TNT2
100 MHz

≠ Parameters
(Jordanov)

offline

Ex: optimisation
of
Jordanov parameters

LaBr3

$R_{511\ keV} = 5.3\%$

$R_{1778\ keV} = 2.7\%$

$R_{10762\ keV} = 1\%$

LaBr3

$R_{662\ keV} = 3.9\%$

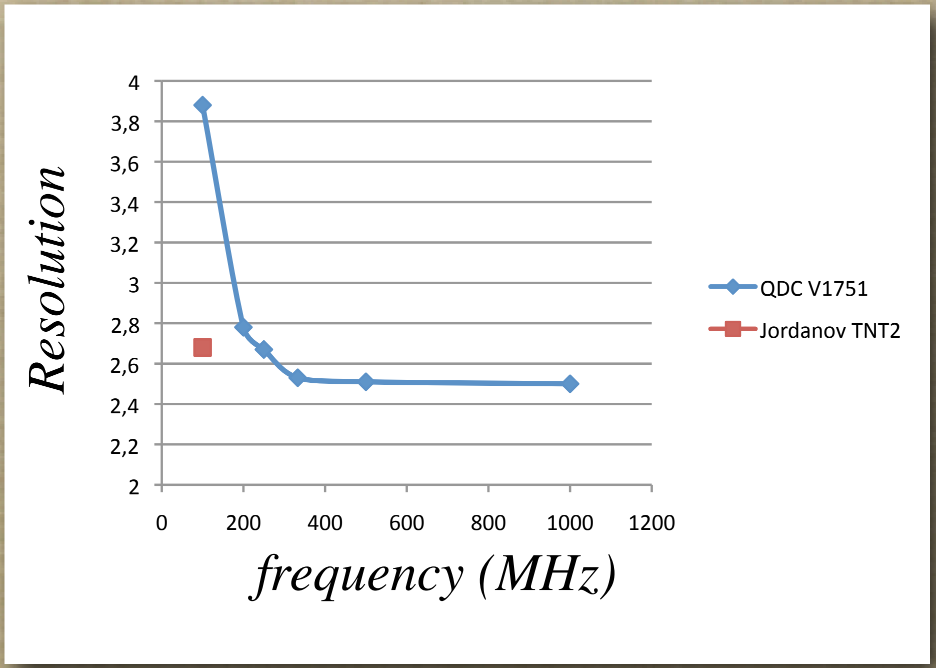
PA cremat 113
TNT2

LaBr3

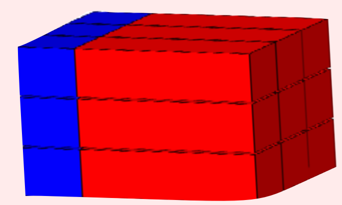
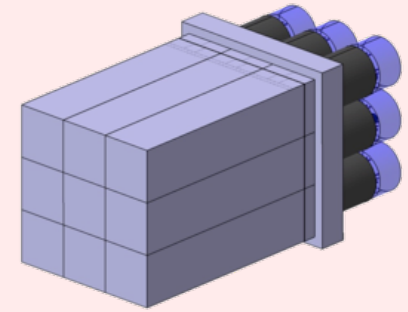
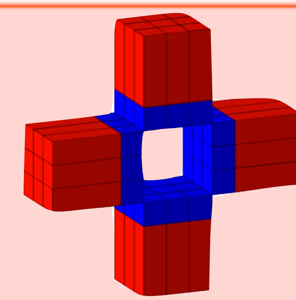
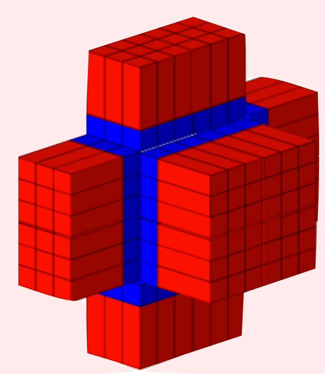
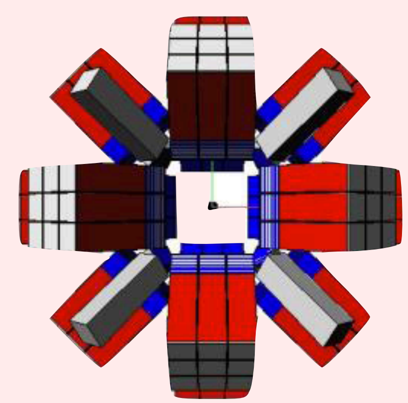
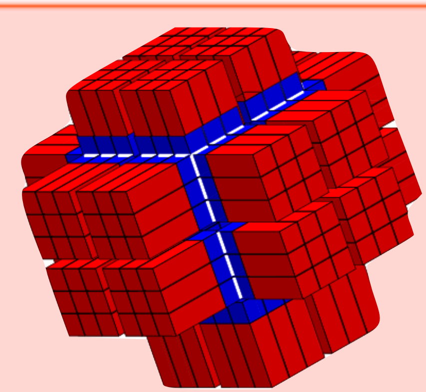
$R_{511\ keV} = 4.5\%$

$R_{1778\ keV} = 2.4\%$

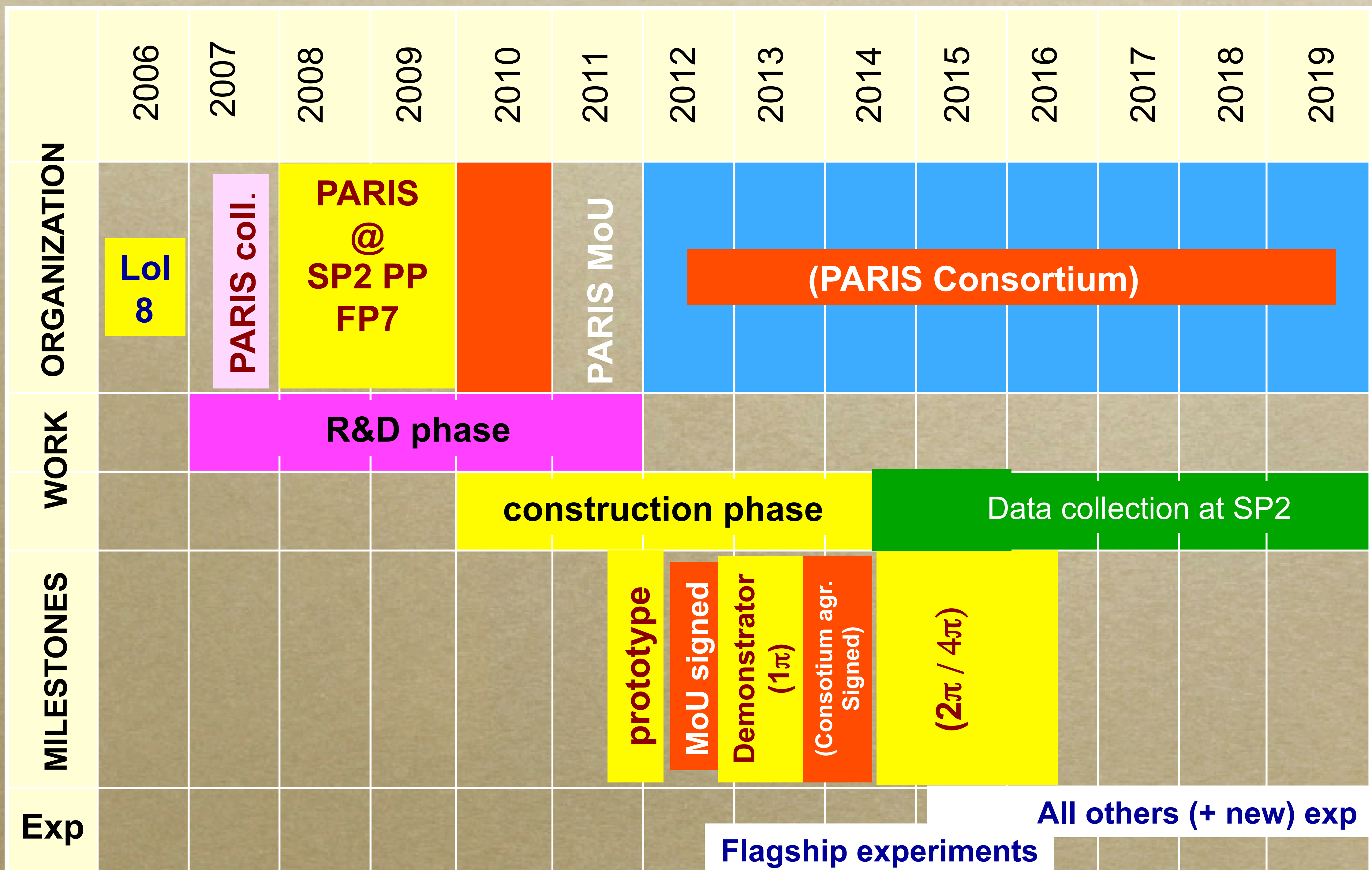
$R_{10762\ keV} = 1\%$



PARIS phases & costs

Phase 1 **2011** **PARIS Prototype**	1 cluster: 9 phoswiches	 		**Decided** Funds: SP2PP, ANR, Orsay, Strasbourg, Kraków, Mumbai Tests in-beam and with sources
Phase 2 **2013** **PARIS Demonstrator**	4 clusters: 36 phoswiches			**Only if Phase1 validated** Funds: MoU Ph1Day1 exp@S3
Phase 3 **2015** **PARIS 2π**	12 clusters: 108 phoswiches	 		**Only if Phase2 validated** Funds: MoU, PARIS consortium Ph2Day1 exp. with AGATA and GASPARD Other exp.
Phase 4 **≈2017** **PARIS 4π**	≥24 clusters: ≥216 phoswiches	 		**Only if Phase3 validated** Funds: PARIS consortium Regular experiments in various labs

Preliminary time schedule



Conclusions

found best

Studies for a new calorimeter for SPIRAL 2 *(2006 ➟2011) :*

based on LaBr3

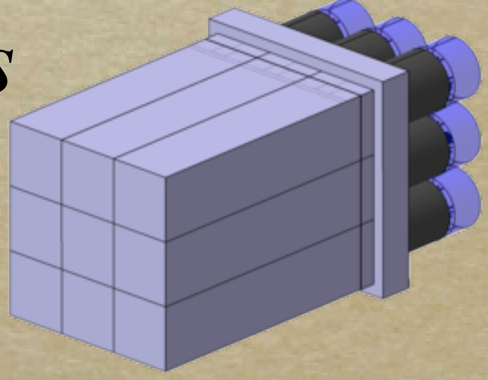
single LaBr3 or phoswich LaBr3::NaI in clusters

Cluster 3x3 LaBr3::NaI ordered, to be fully tested *:*

Δe,Δt, homogeneity, efficiency, linearity, neutrons

[source, beam, high counting rates]

➥ *choices : detector, PM, electronics, etc ...*



towards physics at Spiral2

Conclusions

best

Studie ... *11) :*

ba

sin

Cluste

Δe

➥ *c*

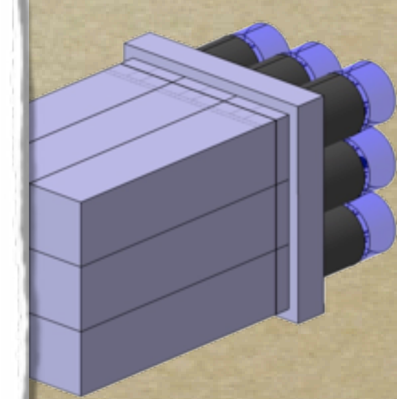
Study of collective modes of excitations in the neutron-rich Ba region via fusion-evaporation reactions

Spiral2 Day1-Phase2 LoI

Adam Maj (Kraków), Silvia Leoni (Milano) - spokespersons
Christell Schmitt - GANIL Liaison

A. Maj[a], K. Mazurek[ac], M. Kmiecik[a], P. Bednarczyk[a], M. Ciemala[a], B. Fornal[a], W. Meczynski[a], J. Grebosz[a], J. Styczeń[a], M. Zieblinski[a] et al.,
S. Leoni[b], A.Bracco[b], G.Benzoni[b], F. Camera[b], F.C.L. Crespi[b], N. Blasi[b], B. Million[b], O. Wieland[b], P.F. Bortignon[b], G. Colò[b], E. Vigezzi[b] et al.,
Ch. Schmitt[c], J.P. Wieleczko[c], M. Lewitowicz[c], G. de France[c], M. Rejmund[c], N. Alahari[c], E. Clement[c] al.,
F. Azaiez[d], I. Matea[d], I. Stefan[d], M. Niikura[d], D. Beaumel[d], A. Korichi[d], A. Lopez-Martens[d] et al.,
O. Stezowski[e], N. Redon[e], D. Guinet[e], G. Lehaut[e] et al.,
J. Dudek[f], O. Dorvaux[f], S. Courtin[f], M. Rousseau[f], G. Duchene[f], D. Curien[f], Ch, Beck[f] et al.,
D.R. Chakrabarty[g], V. Nanal[g], I. Mazumdar[g] et al.,
T. Dossing[h], B. Herskind[h] et al.,
G. De Angelis[i], D.R. Napoli[i], J.J. Valiente-Dobon[i] et al.,
D. Bazzacco[l], E. Farnea[l], S.M. Lenzi[l], S. Lunardi[l], D. Mengoni[l], C. Ur[l], F. Recchia[l] et al.
A. Gadea[m], T.Hüyük[m] et al.,
J. Simpson[n] et al.,
W. Korten[o] et al., A. Goergen[p] et al.,
D. Jenkins[q], R. Wadsworth[q] et al.,
M. Palacz[r], G. Jaworski[r], K. Hadynska-Klek[r], P. Napiorkowski[r], K. Wrzosek-Lipska[r] et al.,
A. Atac[s] et al.,

and the PARIS-EXOGAM-AGATA collaborations



PARIS — PHOTON ARRAY FOR STUDIES WITH RADIOACTIVE ION AND STABLE BEAMS

Many thanks to :

A. Maj, M. Kmiecik, M. Ciemała, K. Mazurek - *Kraków*
J.P. Wieleczko, D. Lebhertz, Ch. Schmitt - *GANIL*
D. Jenkins, O. Roberts - *York,*
F. Azaiez, G. Hull, M.Josselin, I. Matea, M. Niikura, J.Peyré, J. Pouthas, A. Scarpaci, T.Zerguerras *Orsay*
A. Chietera, S. Courtin, O. Dorvaux, J. Dudek, Ch. Finck, M. Rousseau – *Strasbourg*
M. Csatlos, Z. Dombradi – *Debrecen*
I.Mazumdar, D.R. Chakrabarty, V. Nanal, A.K. Gourishetty – BARC&TIFR *Mumbai*
J.Strachan – *Daresbury*
A.Smith – *Manchester*
K. Hadyńska, P. Napiórkowski - *Warsaw*

+ ...