Detector Group Status Report

O. DORVAUX

IPHC/Université de Strasbourg

Outline

- Physics cases requirements and challenges to be solved
- Experimental results obtained for LaBr3:Ce and phoswiches detectors
  - Sources energy and timing measurements
  - In-beam measurements
- Summary and Perspectives

PARIS Specifications from Physics cases (courtesy of Ch. Schmitt - York 2008)

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Experiment type	Energy range	Energy resolution	Timing resolution	ΔM	Counting rate
0< β<10%	[0.05 , 40] MeV	3-5%	< 1ns	4	50 kHz
20< β<60%	[1 , 4] MeV	3-4%	<< 1 ns	4	50 kHz

Challenges to face

- Physics cases requirements and challenges to be solved
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- Very large energy range (~3 orders of magnitude) and high efficiency
  - low gain PM tube
  - good linearity
  - long LaBr3:Ce or phoswiches detectors
- Good energy resolution (at low energy < 2MeV)
  - LaBr3:Ce detectors
- Good timing
  - fast signal => only LaBr3:Ce signals
  - Analog CFD or high frequency (1 GHz)
- Multiplicity => granularity => high number of channels
- High counting rate => digital electronics

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What we had already learnt

- APD are not a solution for LaBr3 and/or phoswiches
- Single $LaBr_3(Ce)$ detectors gives good results and fullfils the PARIS specifications in terms of energy resolution, timing resolution, efficiency, ...
- Large $LaBr_3(Ce)$ detectors are very expensive
- Same results for cubic and cylindrical shape for $LaBr_3(Ce)$ detectors
- Phoswich concept seems to work

Questions we had to answer

- Which second shell for a phoswich : CsI(Na) or NaI(Tl) ?
- Results for these two phoswiches in terms of :
  - energy resolution
  - timing resolution
- Which optimal PM tube ?
- Which electronics ?

Material: the detectors

- Physics cases requirements and challenges to be solved
- Experimental results obtained for LaBr3:Ce and phoswiches detectors
  - In-beam and sources energy measurements
  - With sources timing measurements
  - Efficiency
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Detector type	1st shell	2nd shell
B380_small	1"x1"x2" LaBr3(Ce)	
PW-CsI	1"x1"x2" LaBr3(Ce)	1"x1"x6" CsI(Na)
PW-NaI	1"x1"x2" LaBr3(Ce)	1"x1"x6" NaI(Tl)
B380_big	2"x2"x4" LaBr3(Ce)	

Material we used : the PM tubes

- Physics cases requirements and challenges to be solved
- ☑ Experimental results obtained for LaBr3:Ce and phoswiches detectors
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Reference	Shape	size	Gain	Transit time
R6236-100	square	2''	$2{,}7.10^5$	6 ns
R7723-100	cylindrical	2''	10^4-2.10^6	1,7 ns
R5505-70	cylindrical	1''	$1.8.10^4$ - 5.10^5	1,5 ns
XP2020Q	cylindrical	2''	3.10^7	1,6 ns

Mechanical improvements for a better optical coupling

HV dividers from Hamamatsu and home made (anode and 2/3 last dynode stages)

How we proceed

- Physics cases requirements and challenges to be solved
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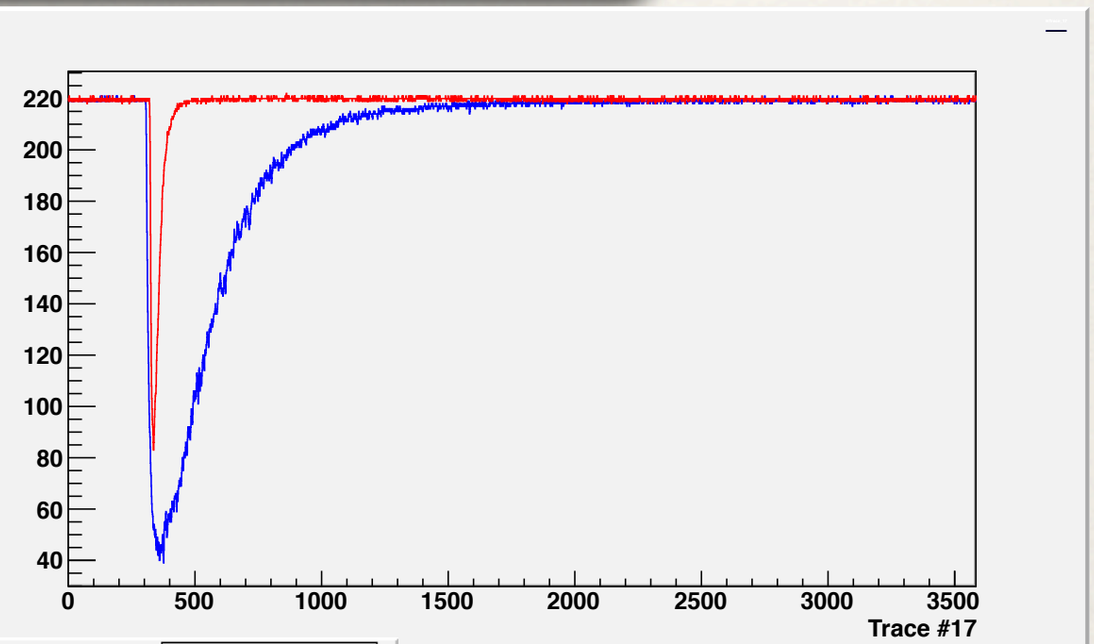
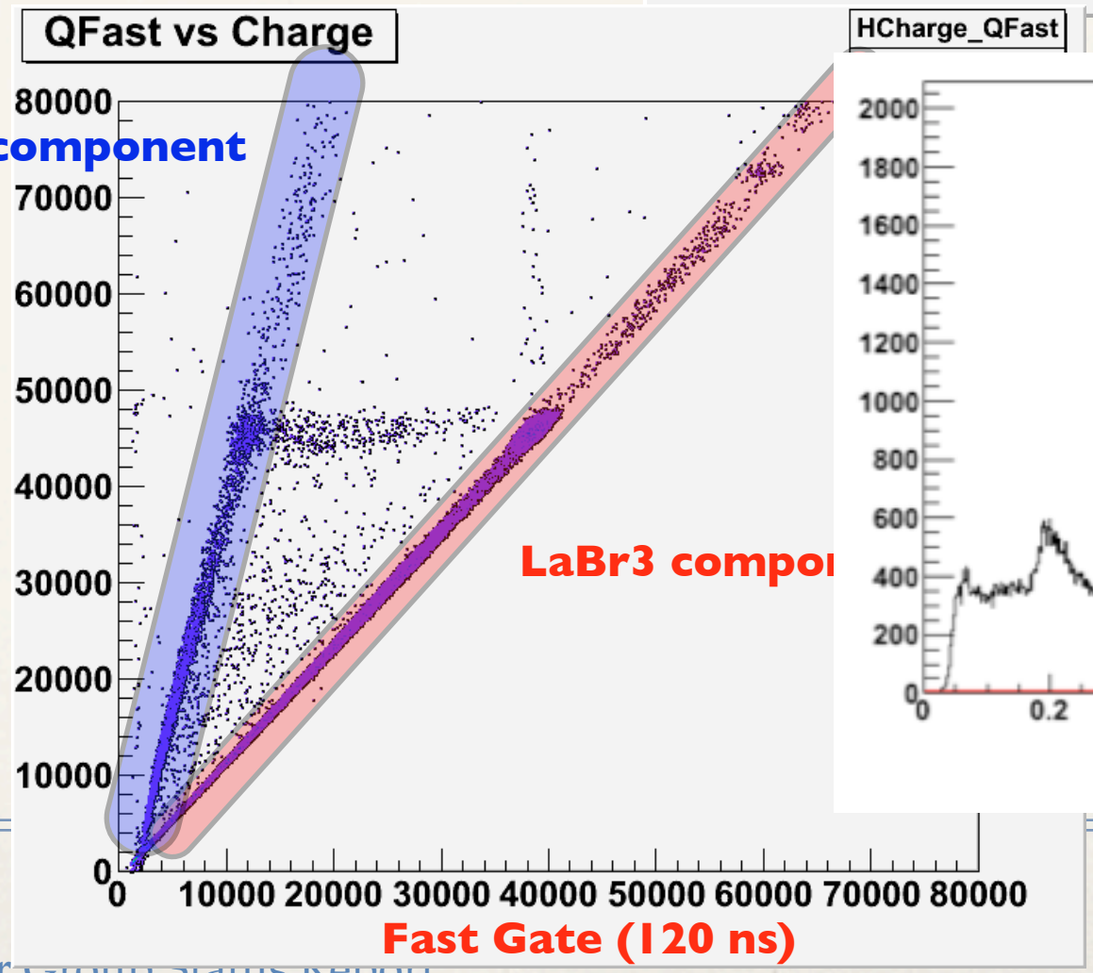
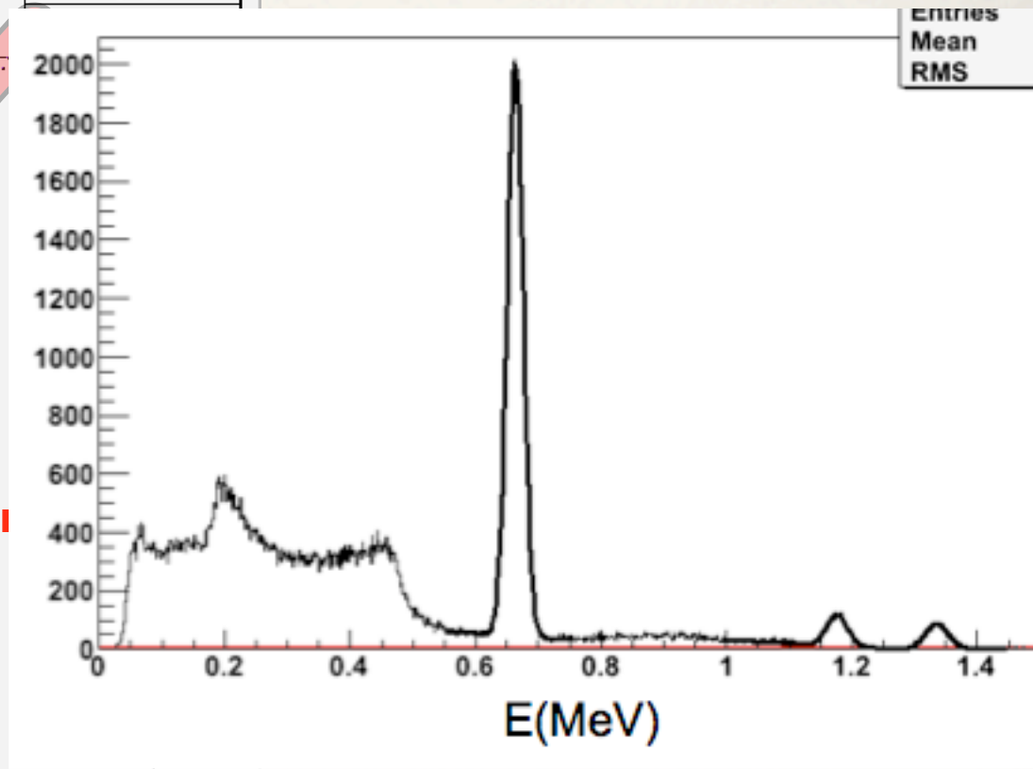
Traces are recorded with a V1751 CAEN digitizer (1 GHz)







Using standard sources : PM tubes comparison (courtesy of D. Lebhertz)

- Physics cases requirements and challenges to be solved
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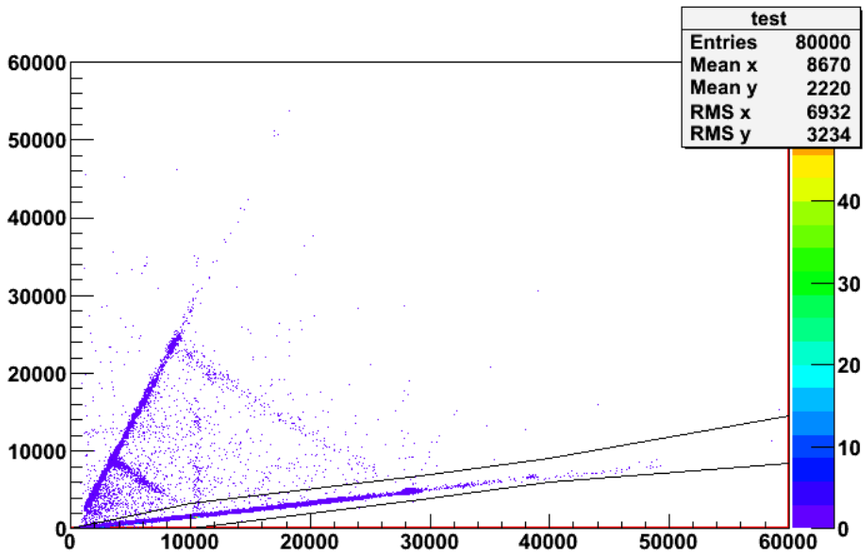
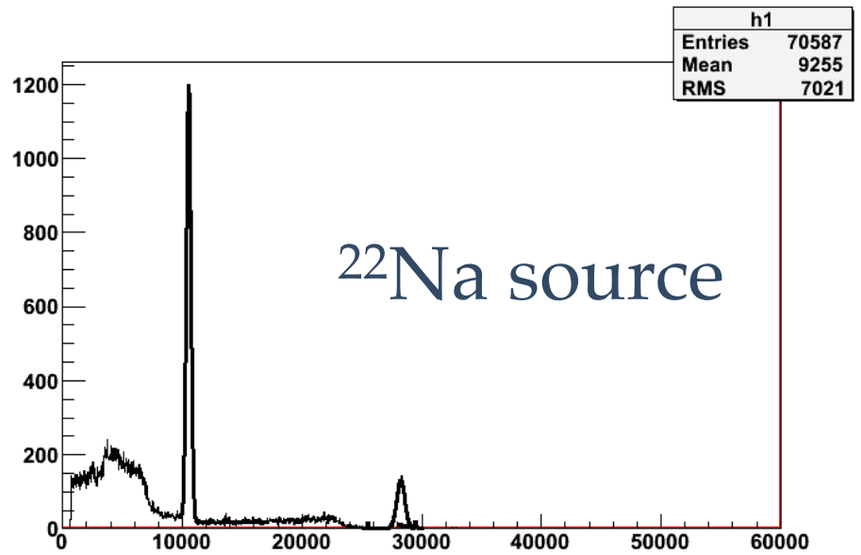
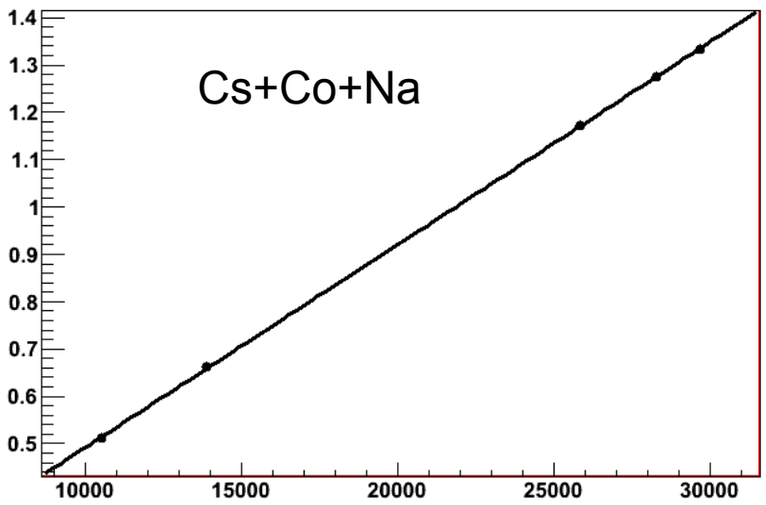
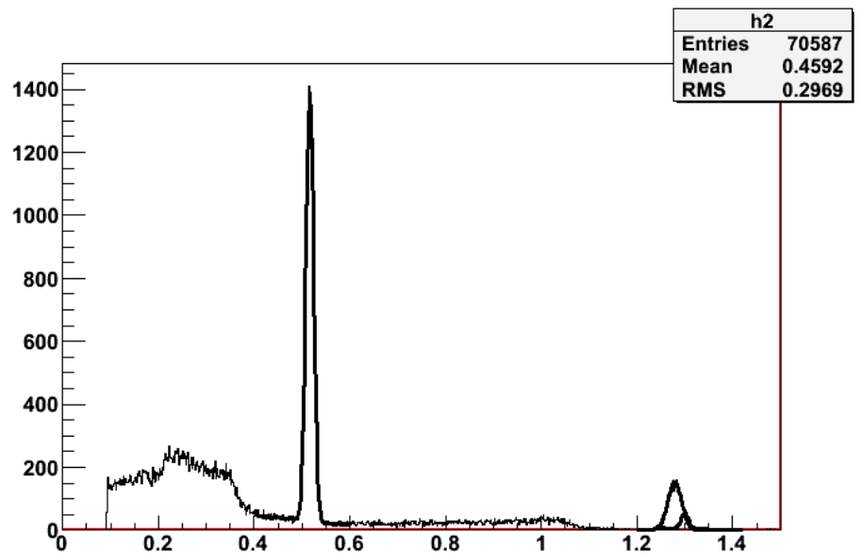
PW-NaI + R6236-100 @ 1000V









PW-NaI + R6236-100 @ 1500V

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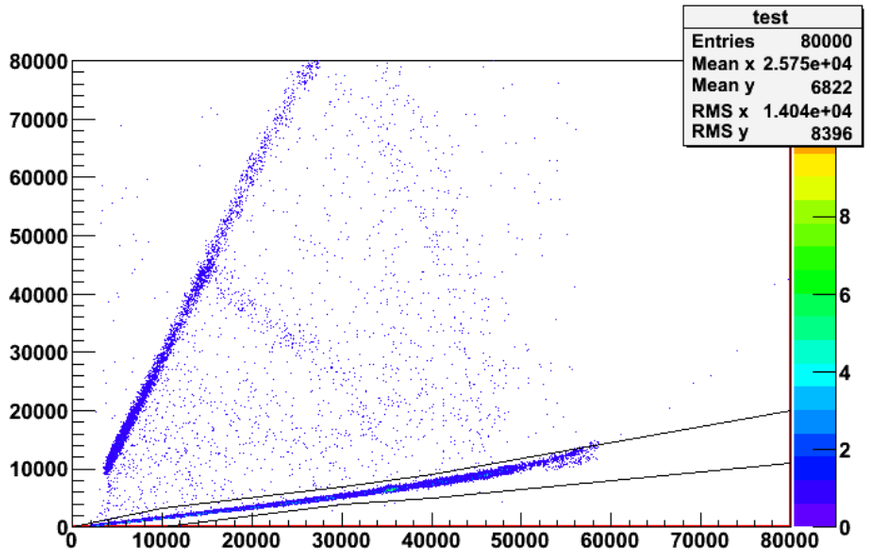

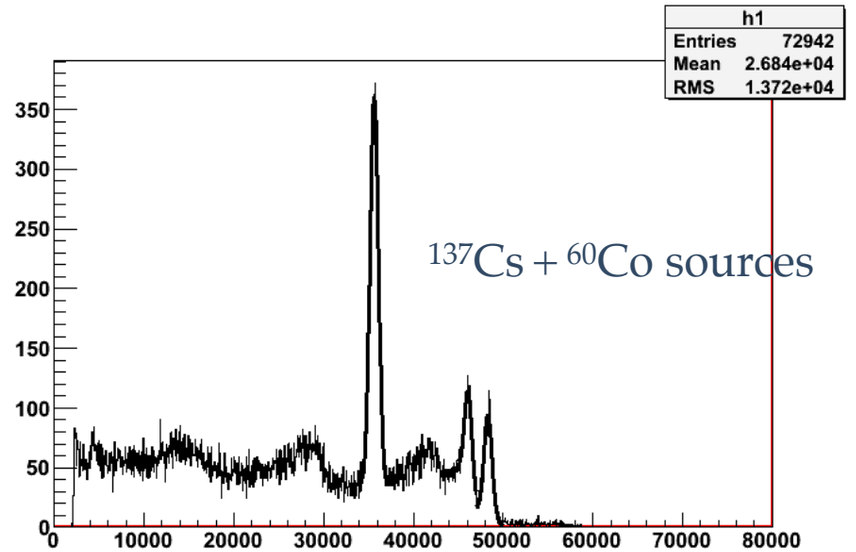

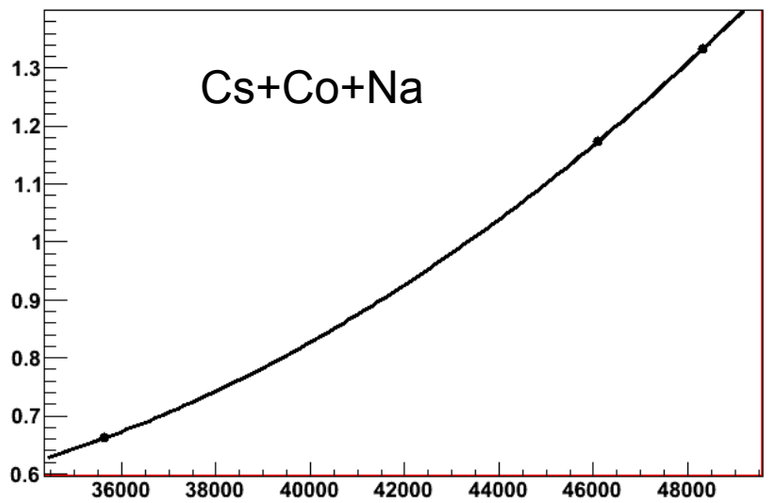

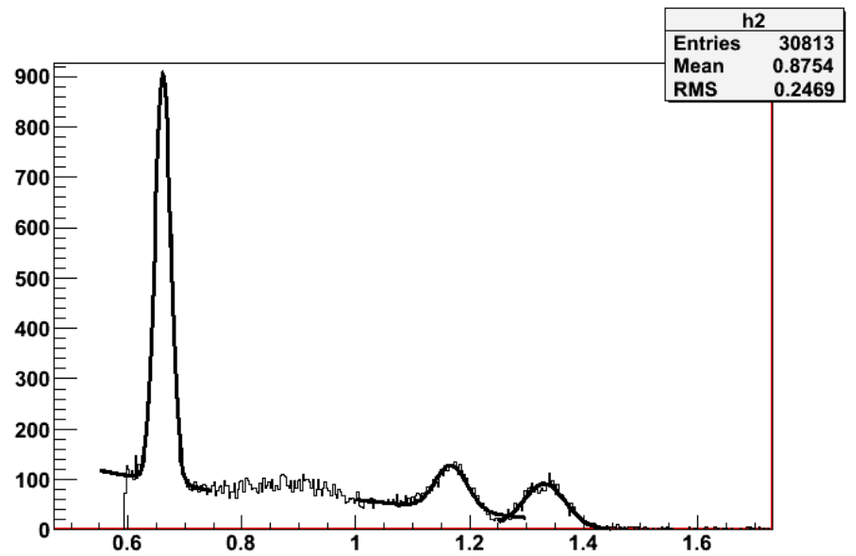

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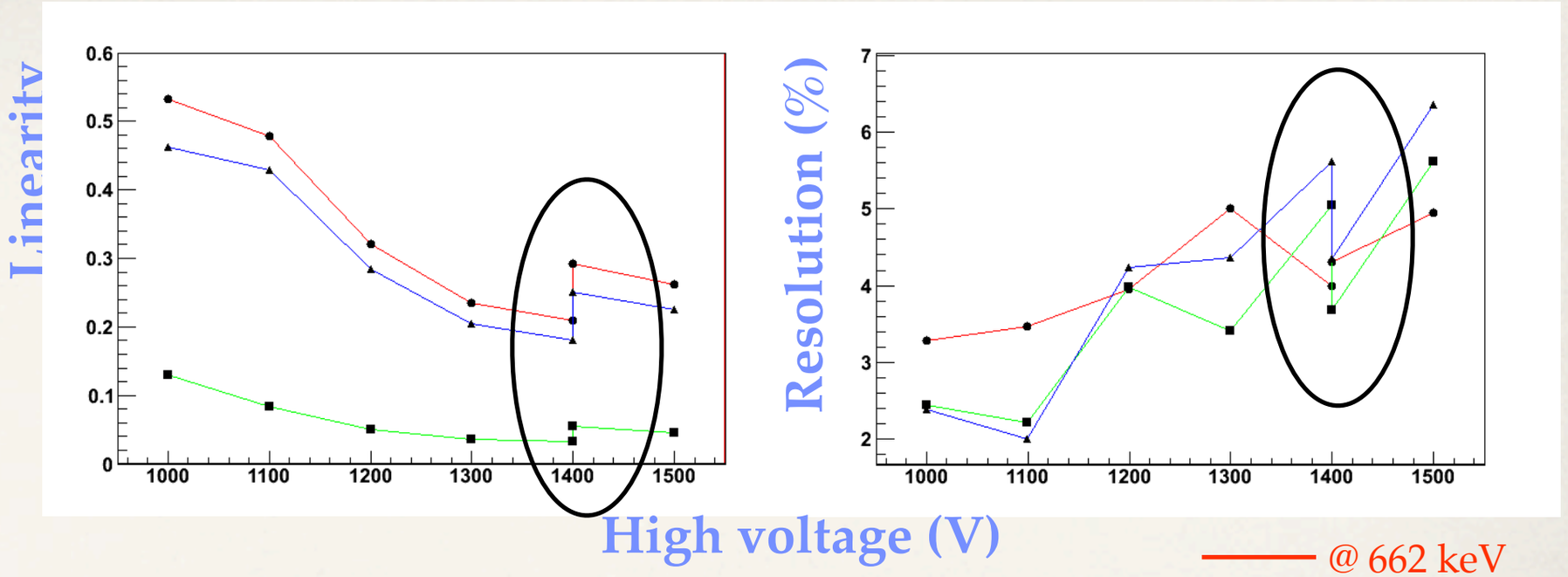
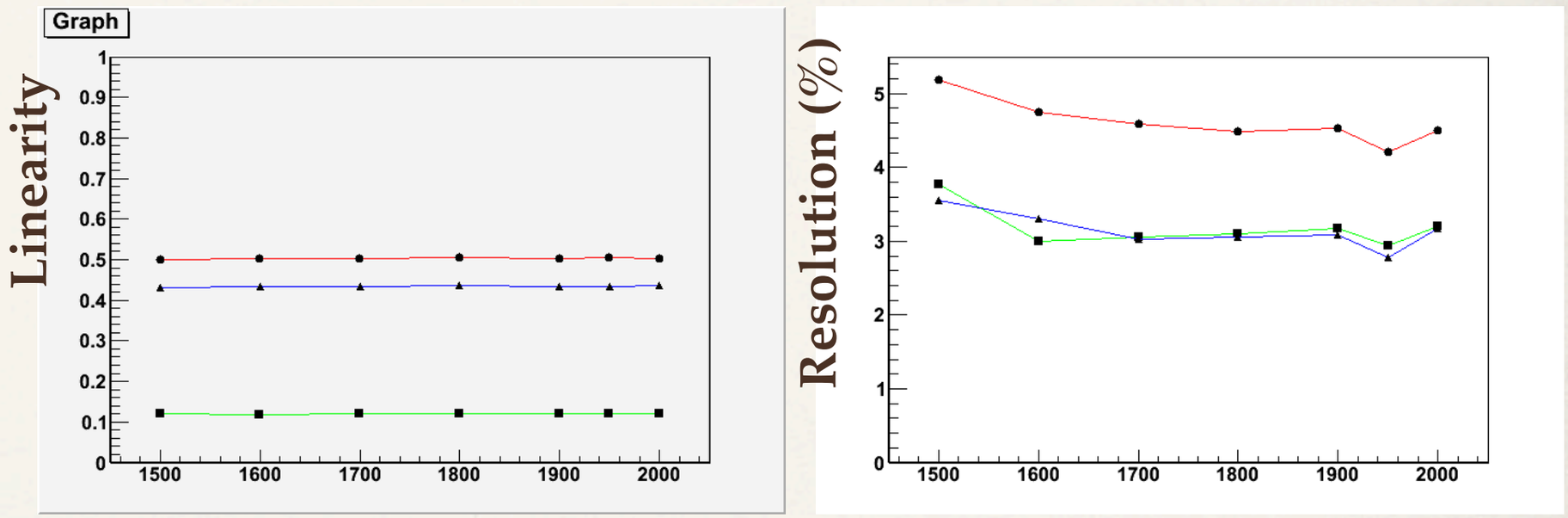


PW-NaI + R7723-100



R7723-100 is linear - R = 4.2% @662 keV

Using standard sources : timing measurements (courtesy of M. Torres)

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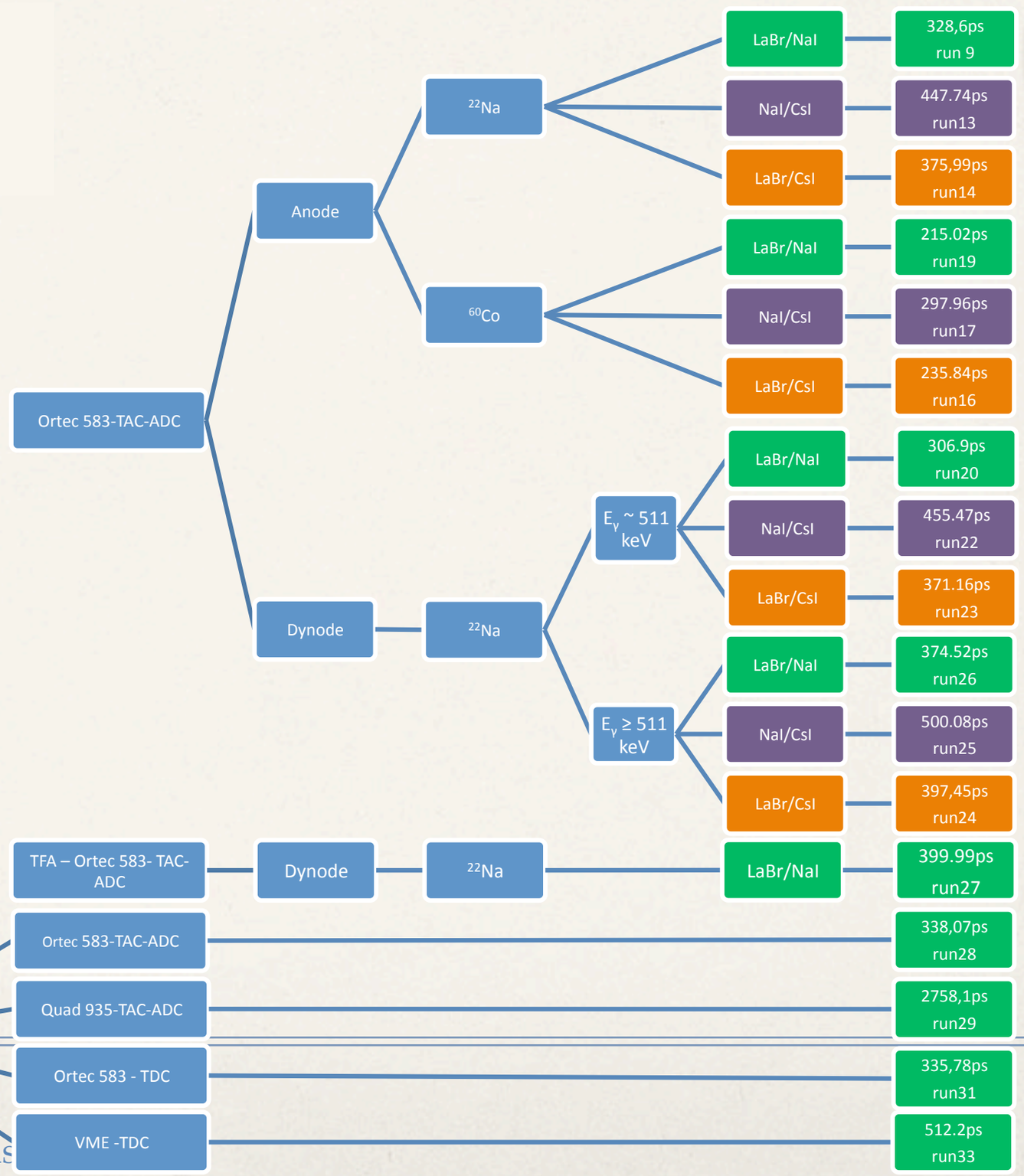

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Intrinsic timing resolution using ORTEC 583 + TAC + ADC

Output	Source	B380_1	PW_NaI	PW_CsI
Anode	^{22}Na	377 ps	679 ps	801 ps
	^{60}Co	188 ps	468 ps	519 ps
Dynode	^{22}Na	259 ps	672 ps	831 ps

Experiment @ the 4 MV tandem IneSS

Reaction : $^{27}Al(p@1MeV,\gamma)^{28}Si$

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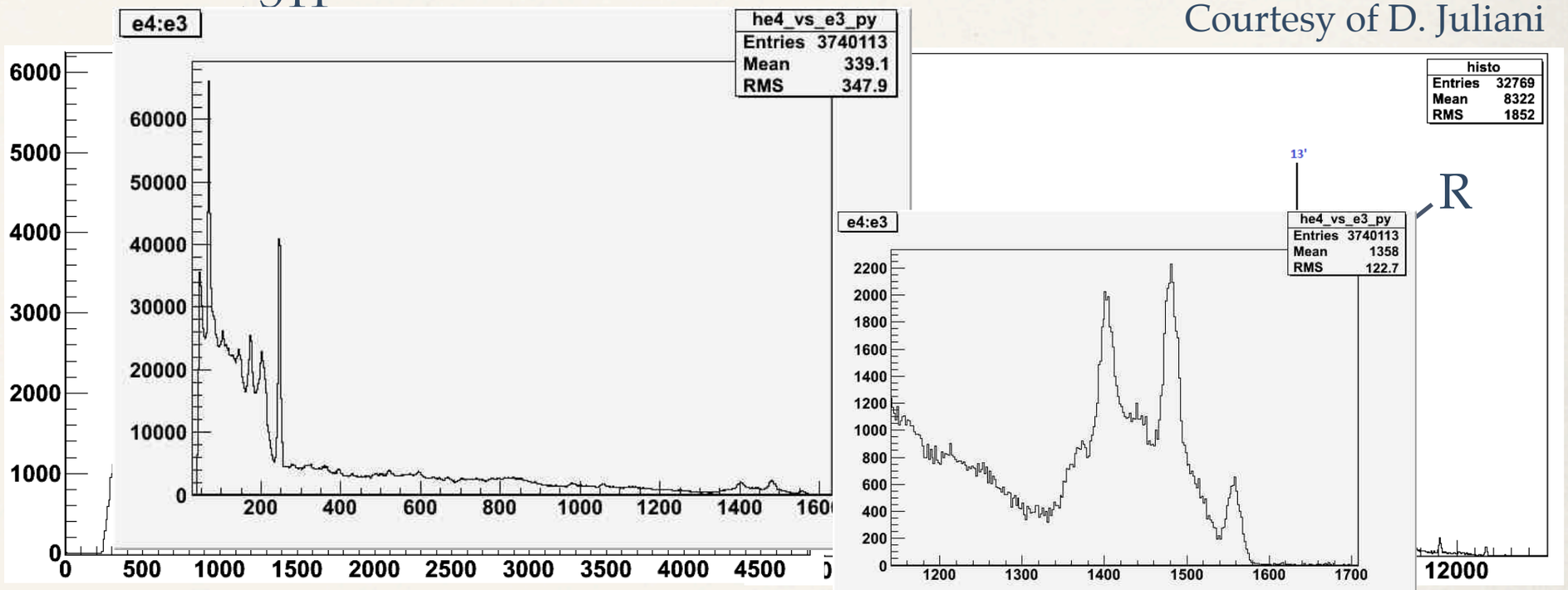
Courtesy of D. Juliani



PW-NaI couple with XP2282 @ 1600 V

Experiment @ the 4 MV tandem IneSS

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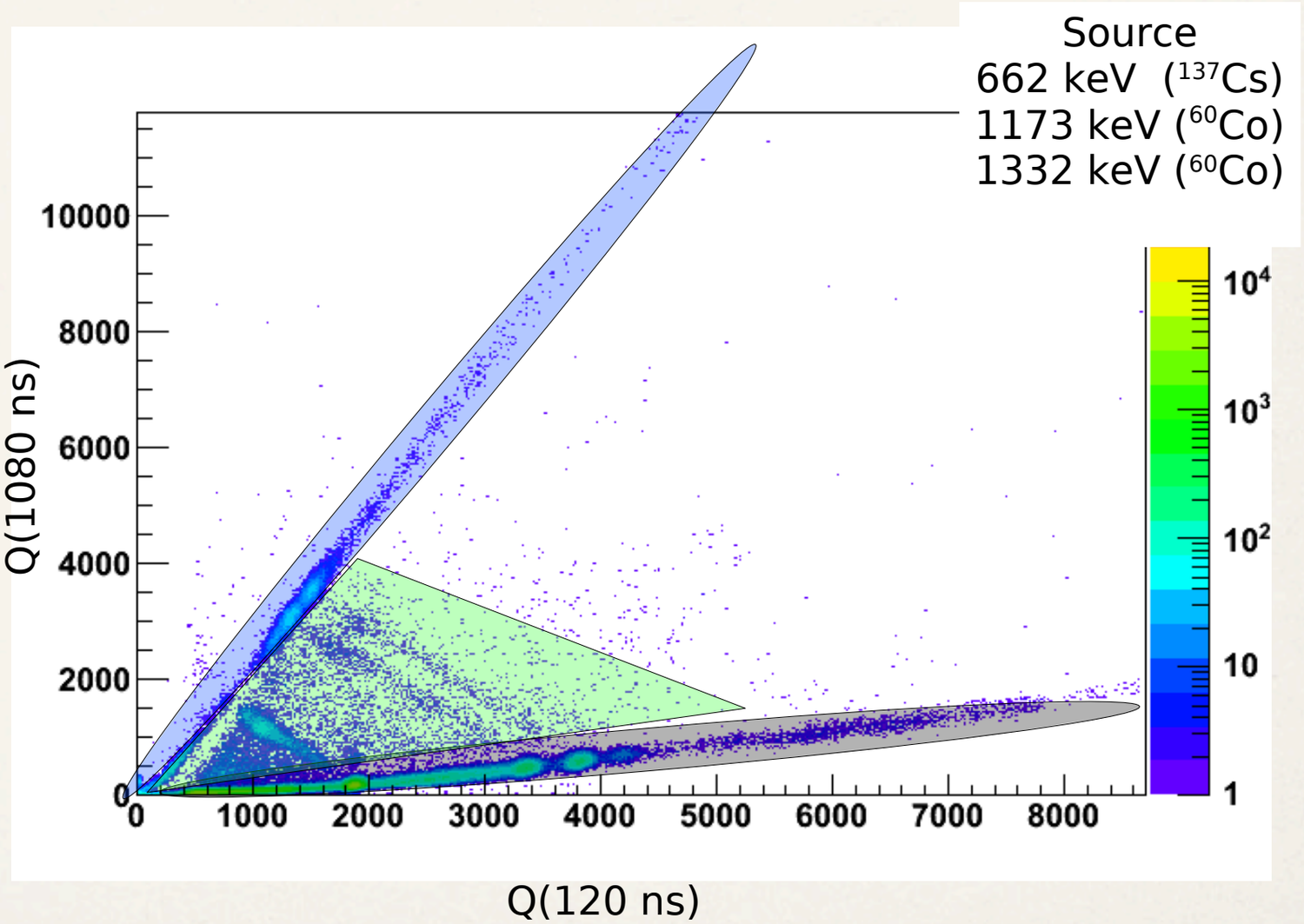
Tentative of add-back (D. Lebhertz)

Qslow/ Qfast PWNaI



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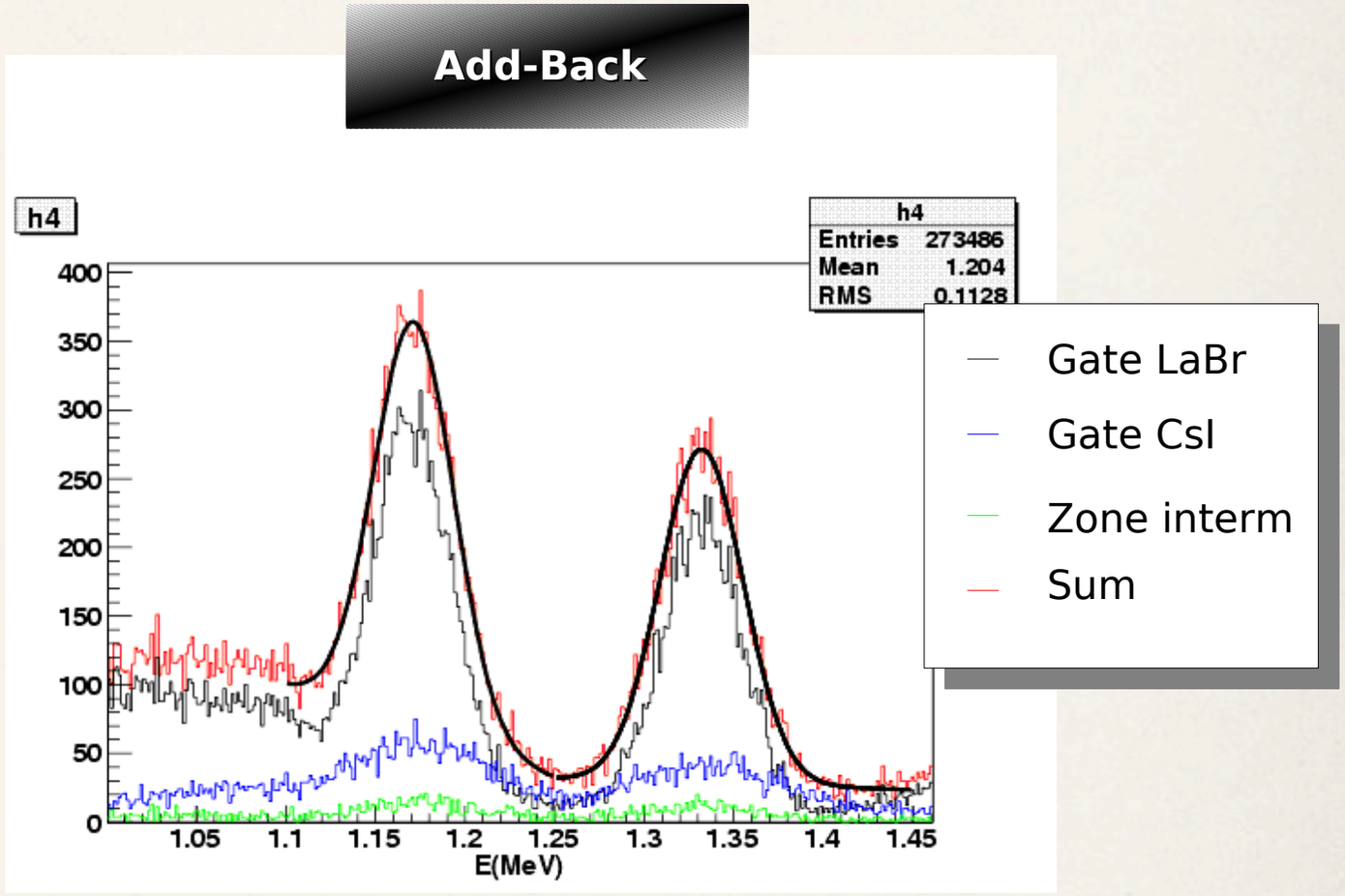

E(keV)	662 exp	662 tab	1173 Exp	1173 tab	1332 Exp	1332 Tab
LaBr	5.28%	3.00%	4.09%	2.25%	3.75%	2.12%
NaI			7.51%	5.20%	7.75%	4.94%
AB			6.34%	Simu	4.32%	Simu
Sum			4.48%	Simu	4.10%	Simu

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Reaction : $^{27}Al(p@1MeV,\gamma)^{28}Si$

B380_1	R5505-70	not linear
PW_NaI	R7723-100	linear
Pw_CsI	R6236-100	not linear

Summary

- Physics cases requirements and challenges to be solved
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Best Results obtained

	B380_2	PW_CsI		PW_NaI	
		LaBr3	CsI	LaBr3	NaI
Energy FWHM (@662 keV)	3.2 %	4.2 %	12.7 %	3.8 %	8.2%
Timing FWHM (ns)	270	800		680	
Linearity	Yes (sources)	Yes (<1.3 MeV)		Yes (< 12 MeV)	

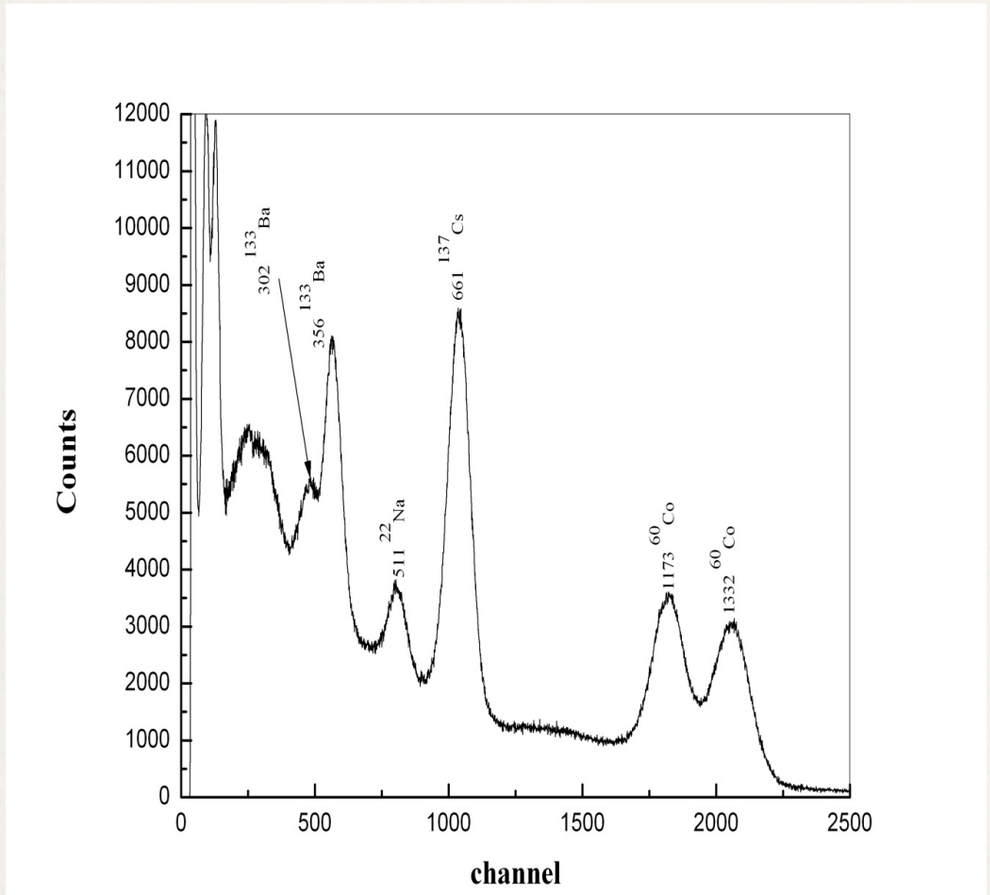
The adopted strategy to fullfil the PARIS specifications is based on
Cubic PW-NaI : 2"x2"x2" $LaBr_3$(Ce) + 2"x2"x6" NaI(Tl)
coupled with R7723-100 Hamamatsu PM tube

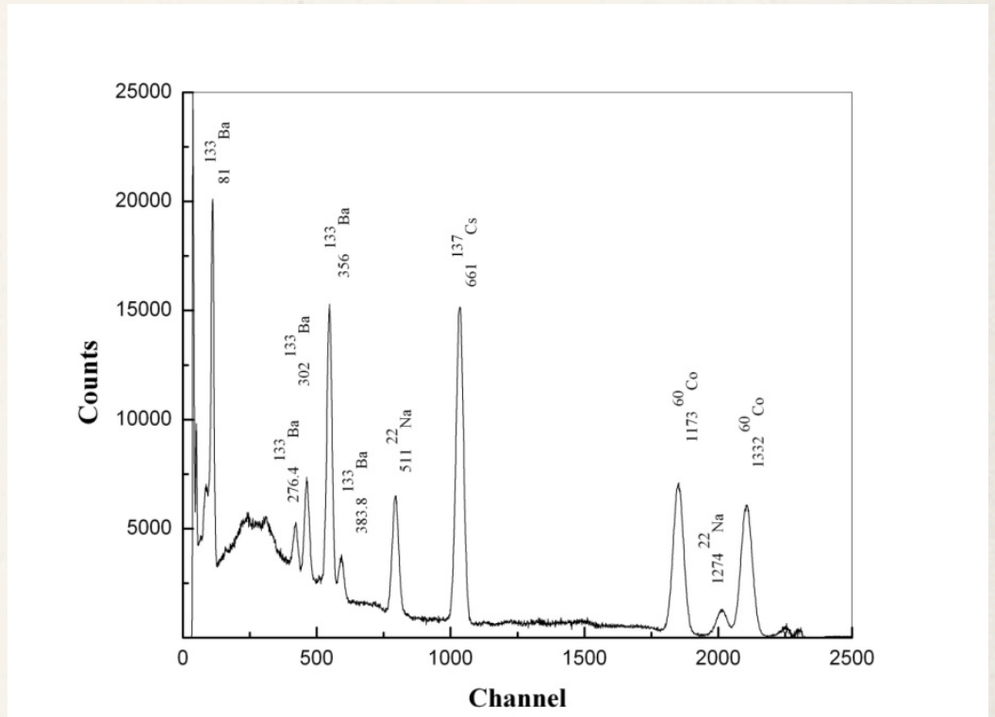
Summary

Results obtained @ Mumbai (courtesy of I. Mazumdar)

Energy resolution for single crystals

NaI(Tl) : R=7-7.5 % @ 662 keV



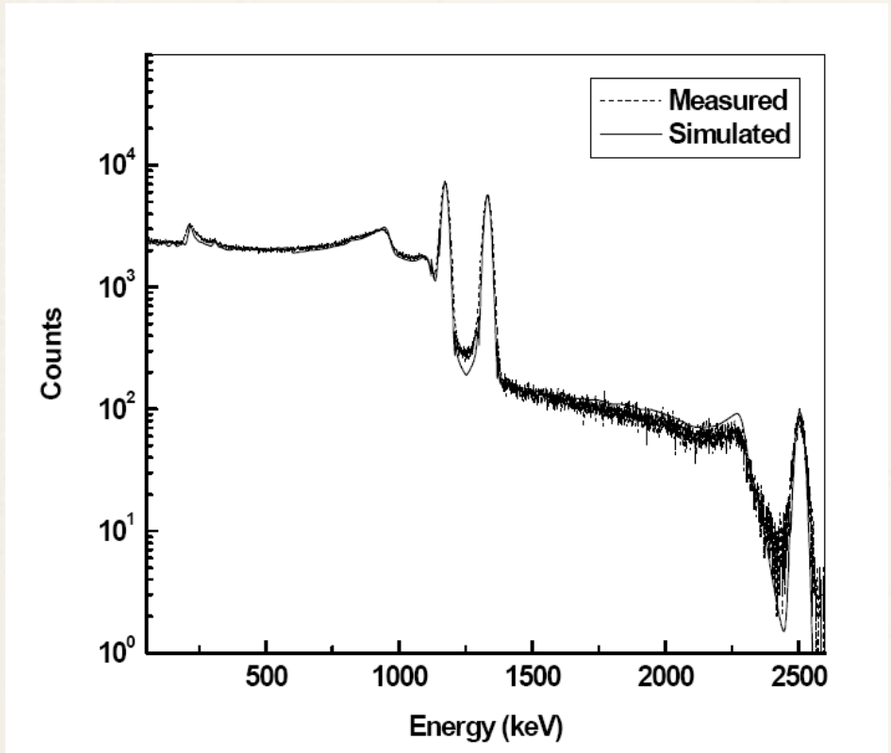


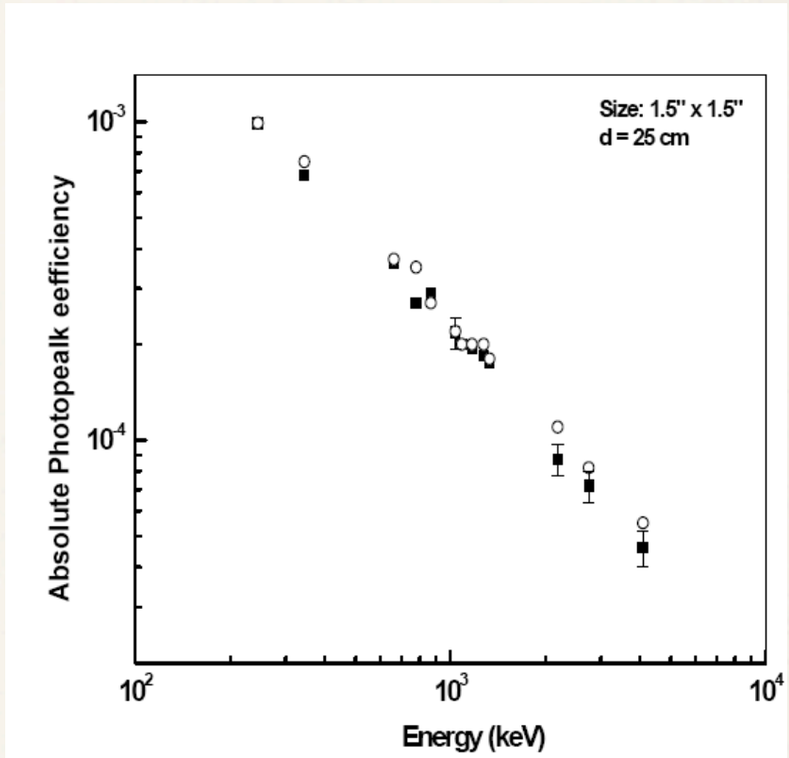
$LaBr_3(Ce)$: R=3% @ 662 keV

Summary

Results obtained @ Mumbai (courtesy of I. Mazumdar)

Comparison simulated and measured ^{137}Cs and ^{60}Co calibrated source data





Distance (cm)	ε_{Total}		ε_{peak}	
	GEANT4	Exp	GEANT4	Exp
15	0.105 (0.012)	0.114 (0.005)	0.030 (0.004)	0.027 (0.001)
25	0.041 (0.003)	0.044 (0.002)	0.011 (0.001)	0.010 (0.001)

Summary

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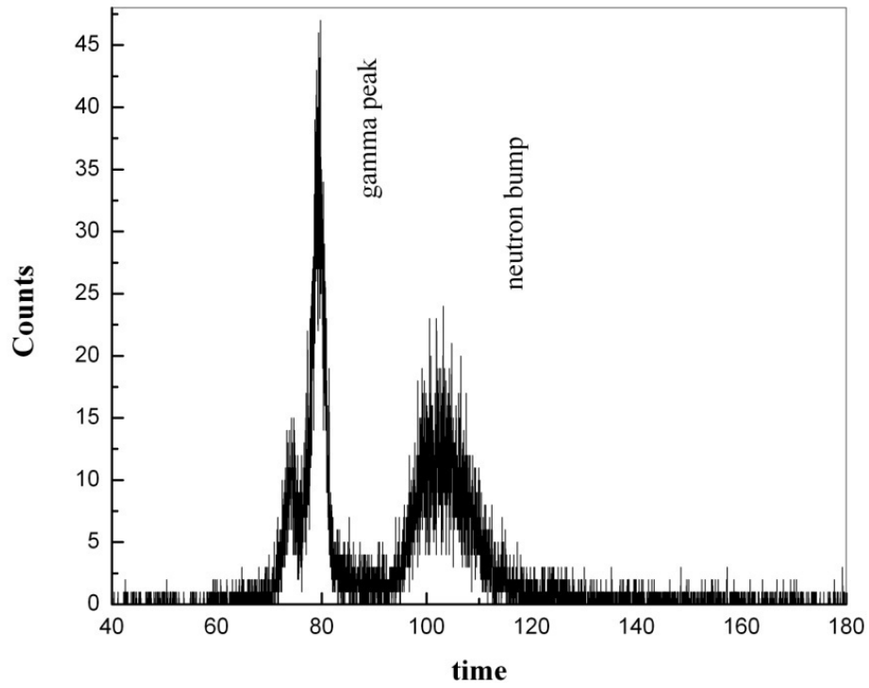
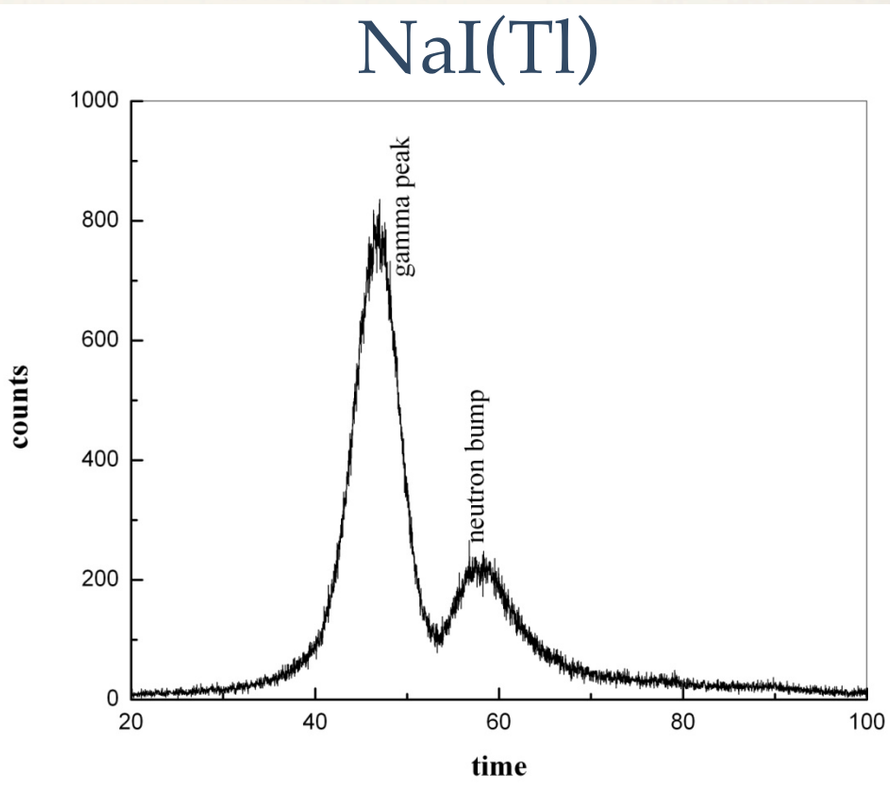
Time of flight n-γ discrimination

$LaBr_3(Ce)$



NaI(Tl)



Summary

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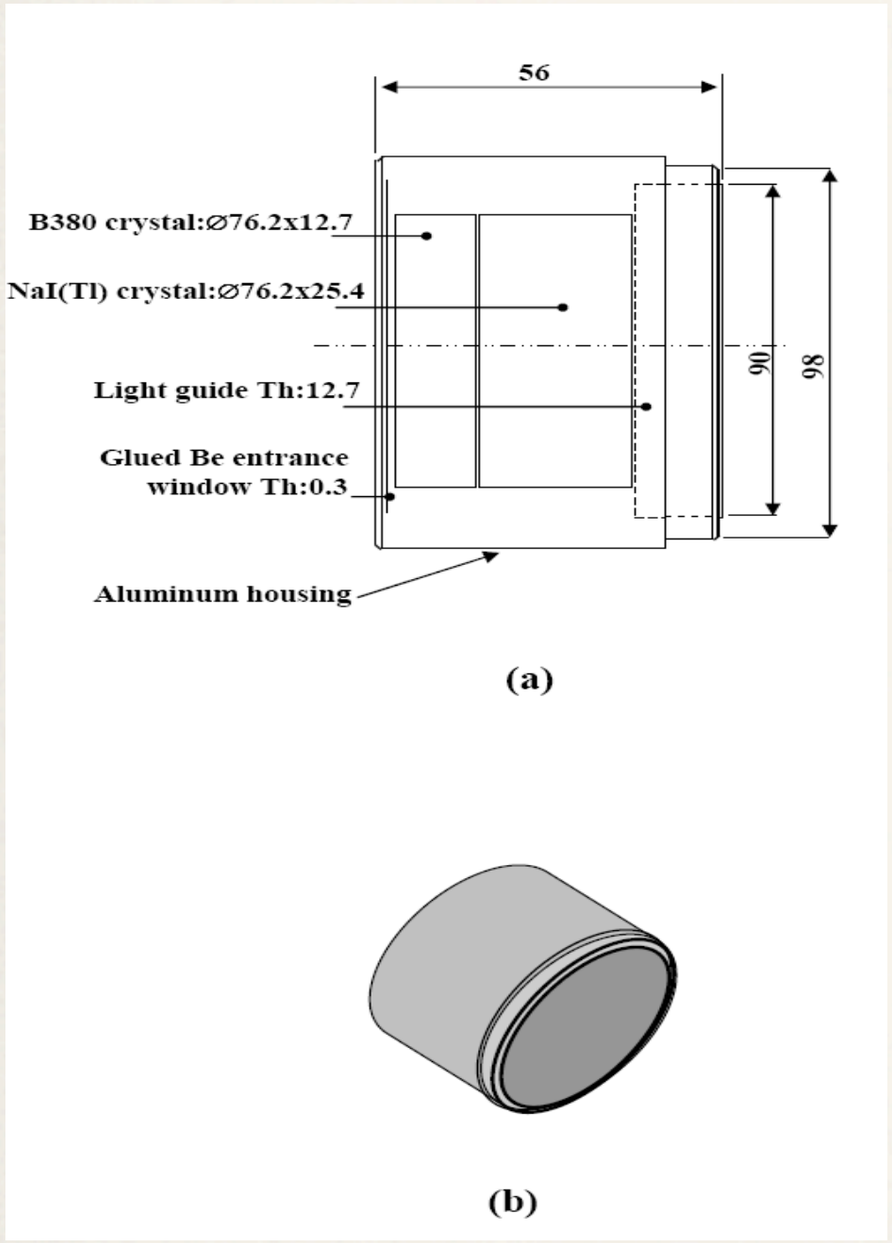
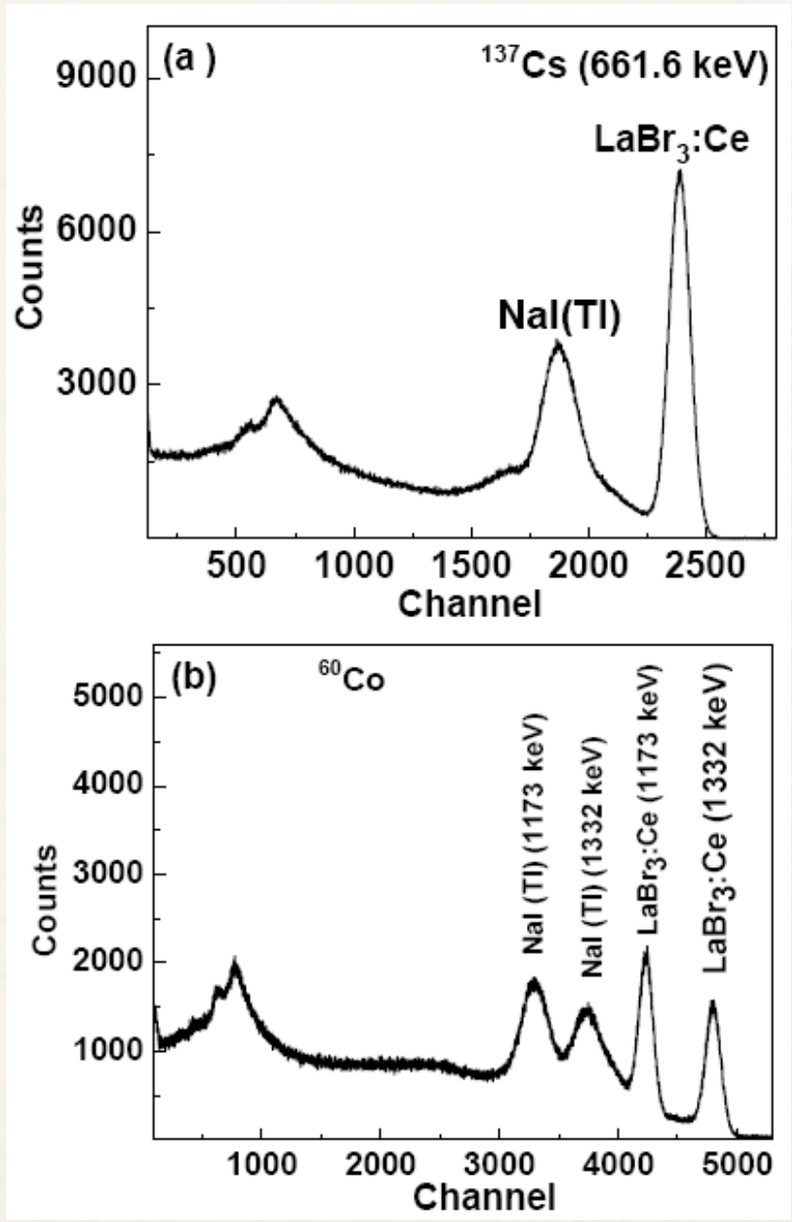
Results with a PW-NaI





Mazumdar, Anil Kumar, Gothe, Manchanda, 2010

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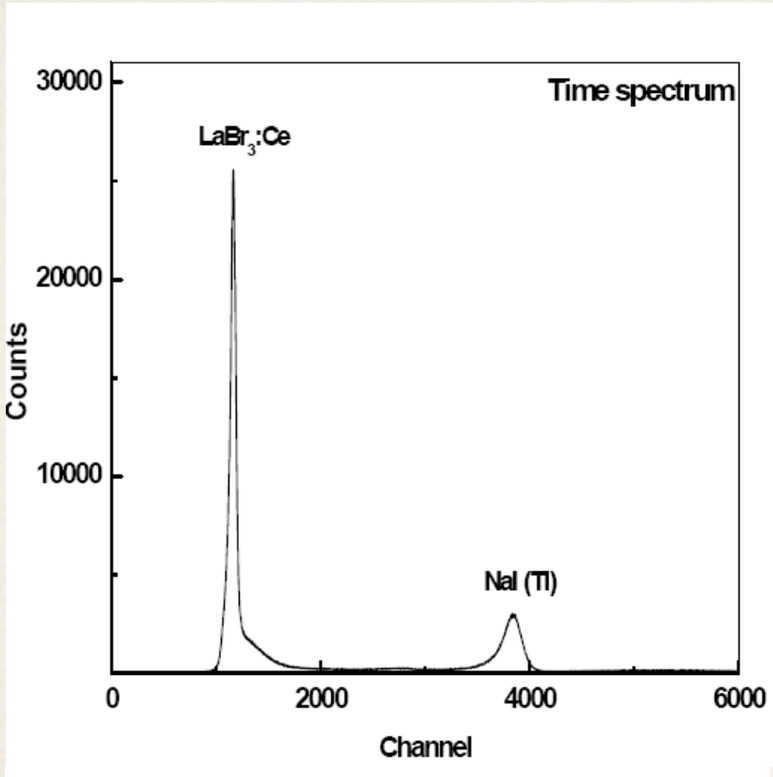

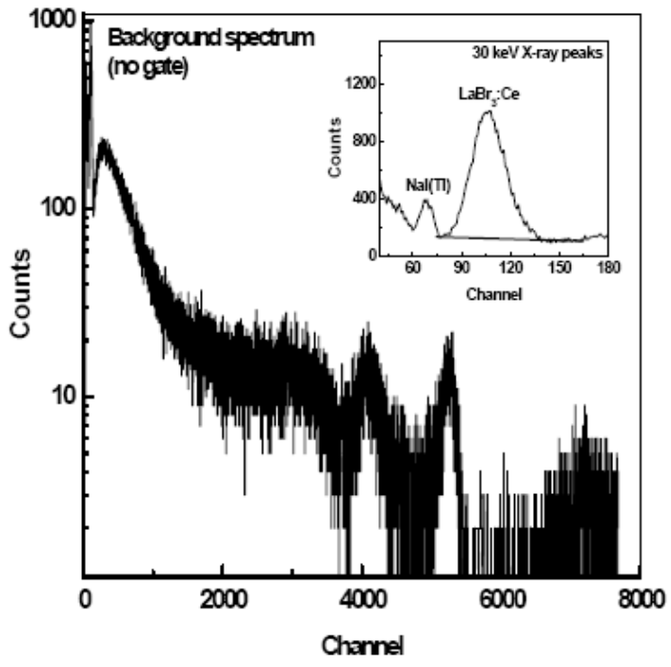

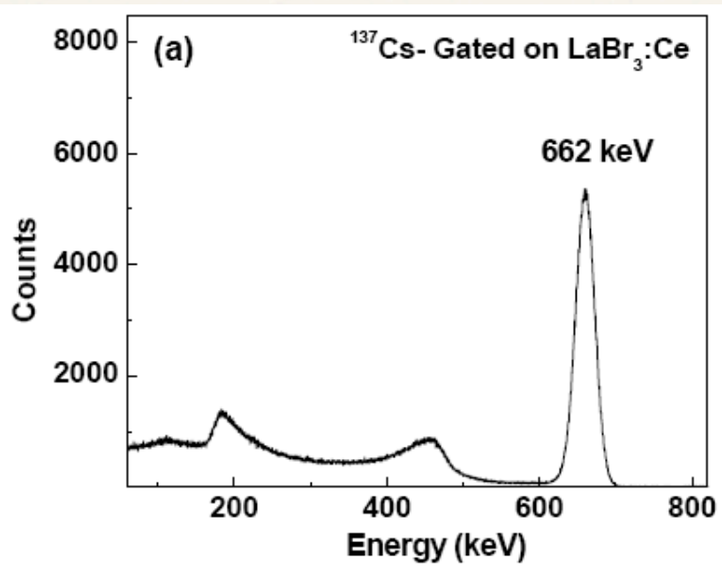

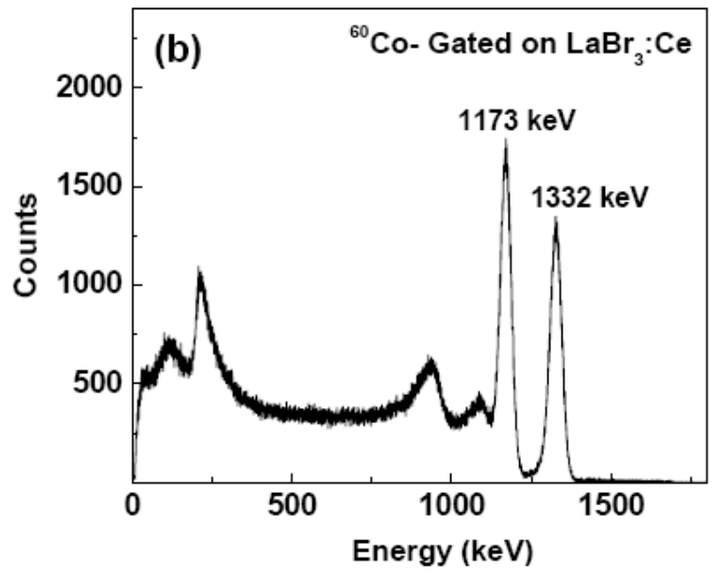

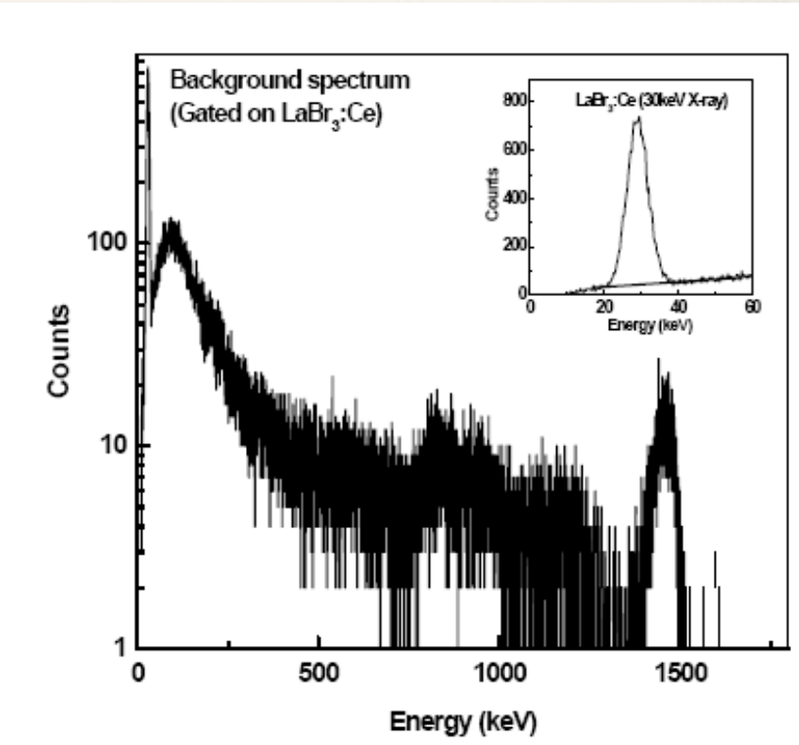

Mazumdar, Anil Kumar, Gothe, Manchanda, 2010

Perspectives

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Foreseen schedule

Main goal : Prototype = cluster of 9 PW-NaI detectors at the end of the year 2011

- **2 PW-NaI already ordered @ Saint-Gobain by IPHC and IPNO**
- **3 PW-NaI will be ordered very soon by Krakow (FP7)**
- **4 PW-NaI will be ordered this year by Mumbai**

But

- **Orders are under conditions of the success of the first one (answer ~May 2011)**

equipped with Hamamatsu R7723-100 PM tubes (bought by York and/or GSI)
coupled with electronics (and DAQ) system : CAEN V1751 digitizer/ TNT2-like / NUMEXO ? / ...

Perspectives

and then, what has to be done

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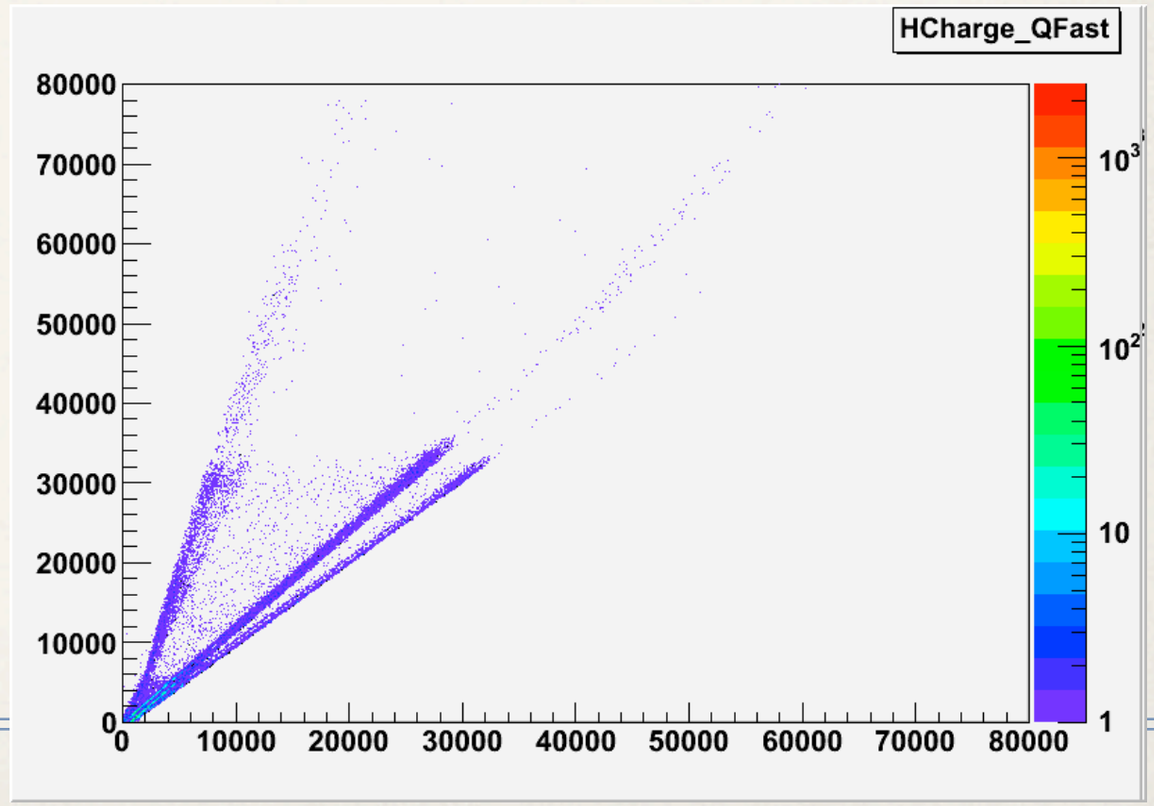
- handle them and transport them carefully ...
- assembly all these 9 single PW detectors together (see talk of J. Pouthas/S. Courtin)
- find a reliable optical coupling
- Take care at the shift from PM+Voltage Divider

While highly precised ISEG HV + modified VD



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- perform measurements with standard sources and high energy γ-rays to test the add-back algorithm and to compare with simulations (which efficiency ?)
- test the cluster under neutron emission
- test the cluster under high counting rate and see the pileup effect
- tests other PM tubes : D. Jenkins is in contact with Electron tube company
- High voltage divider development
- New material : http://spie.org/documents/Newsroom/Imported/003196/003196_10.pdf ?!

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Thanks to all Detector WG members

and Special thanks to :

Th. Adam, A. Chietera, J. Devin, Ch. Finck, J. Hosselet, D. Juliani, D. Lebhertz, R. Lozeva, Ch. Maazouzi, I. Matea, C. Mathieu, Ph. Peaupardin, O. Roberts, M. Rousseau, M. Torres