Studies in scintillator detectors:

Old & New

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Tata Institute of Fundamental Research,

Mumbai

PARIS Workshop

15th Oct.2009

Krakow

Collaborators

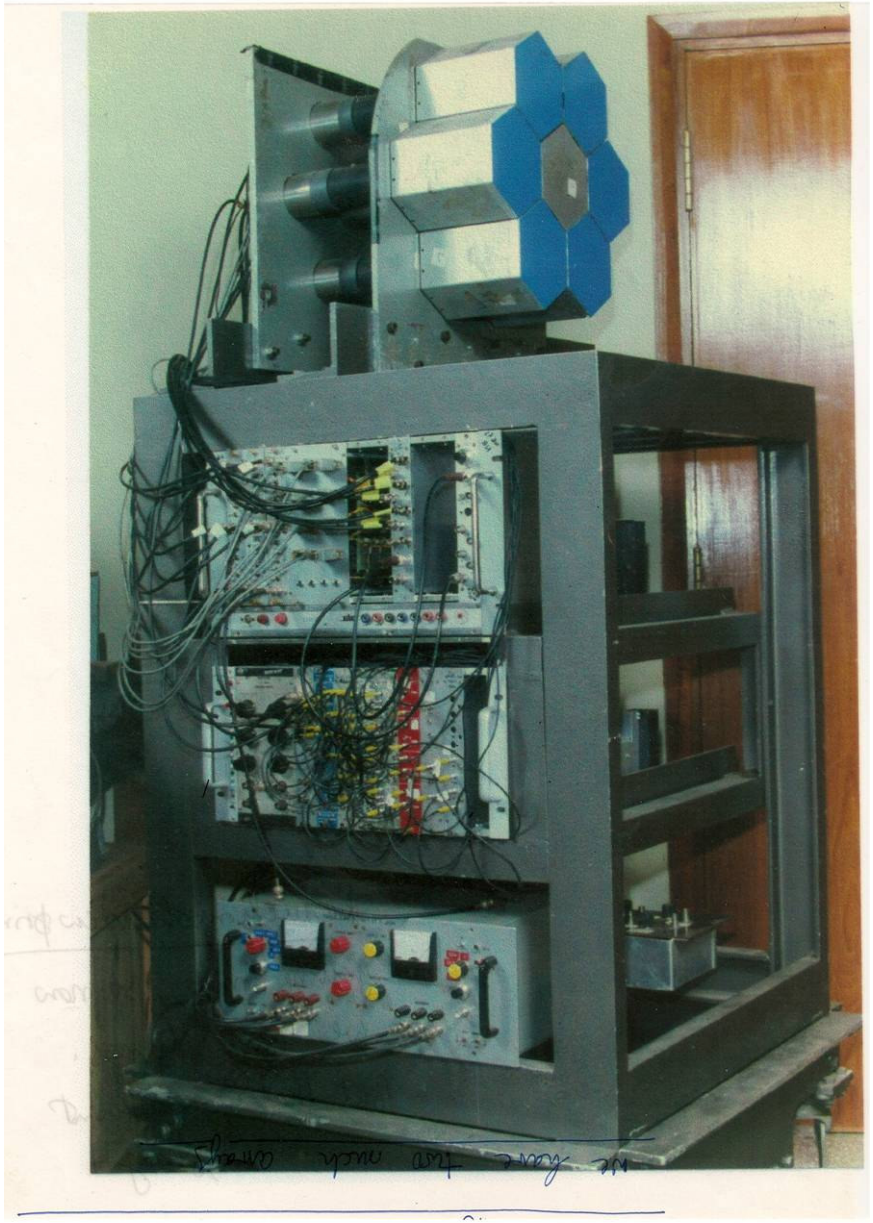
- *G. Anil Kumar*
- *D.A. Gothe*

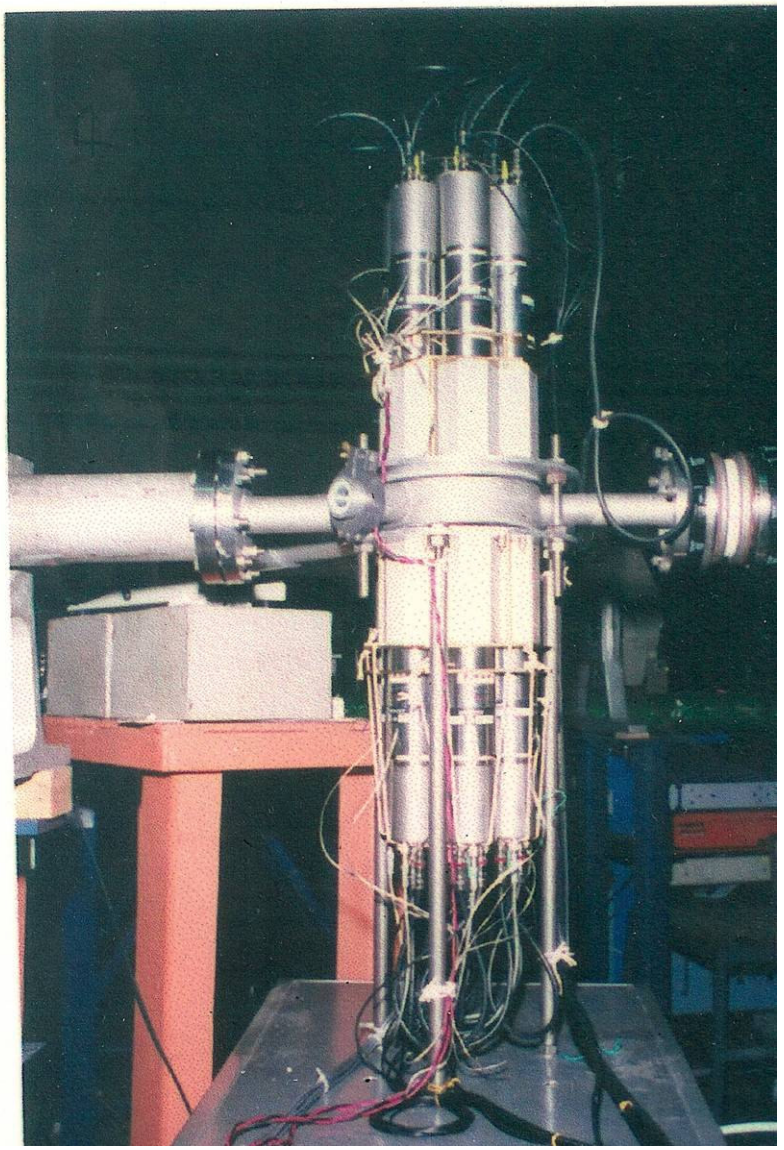
Guergen Gerl, *GSI, Darmstadt*

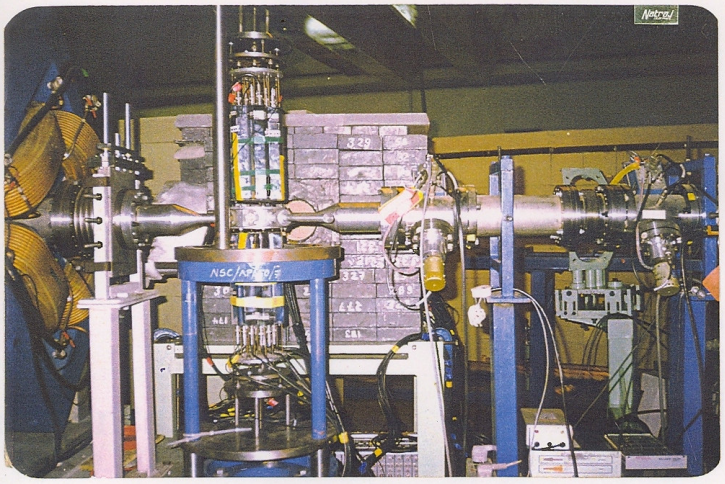
Tata Institute of Fundamental Research, Mumbai

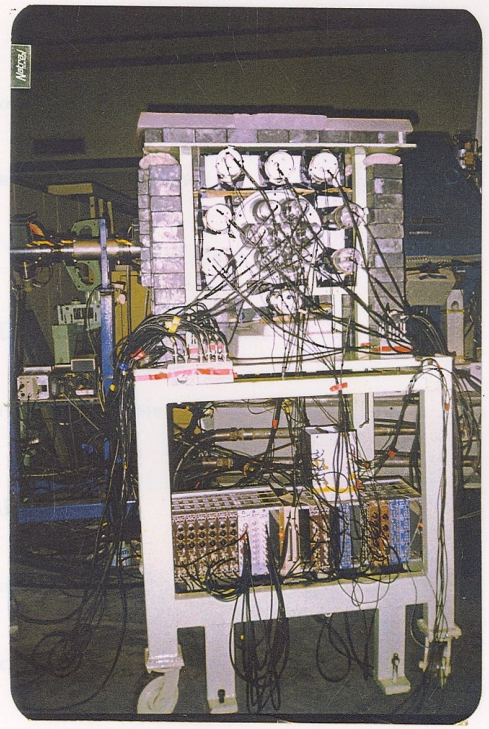
- The TIFR 4π Sum-Spin Spectrometer.
- Studies in $LaBr_3$:Ce crystal.

  Proposition for a combined assembly of scintillators.
- A Phoswich of $LaBr_3$:Ce+NaI(Tl)
- Temperature dependence of pure and doped scintillators:







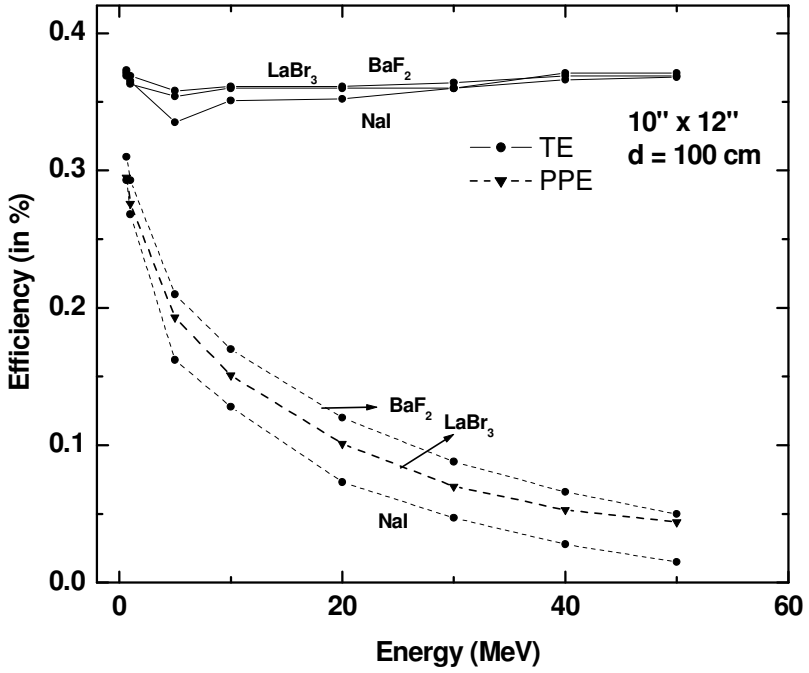


HIGRASP at IUAC, Delhi

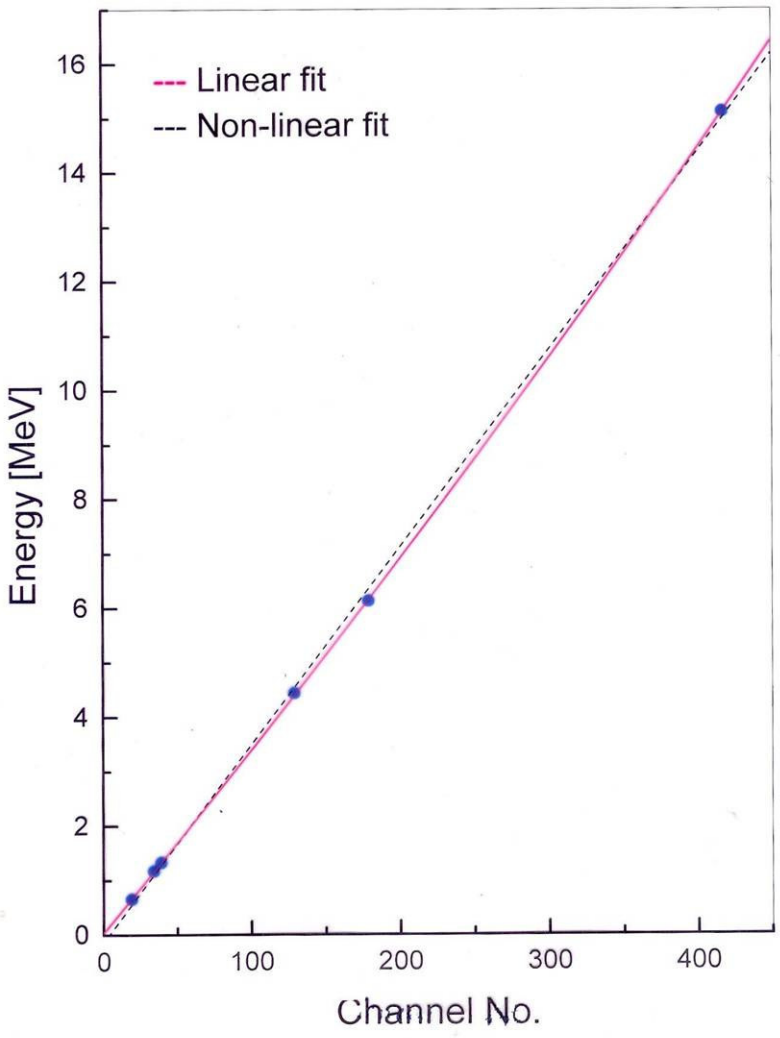
I.Mazumdar et al.
NIM A417

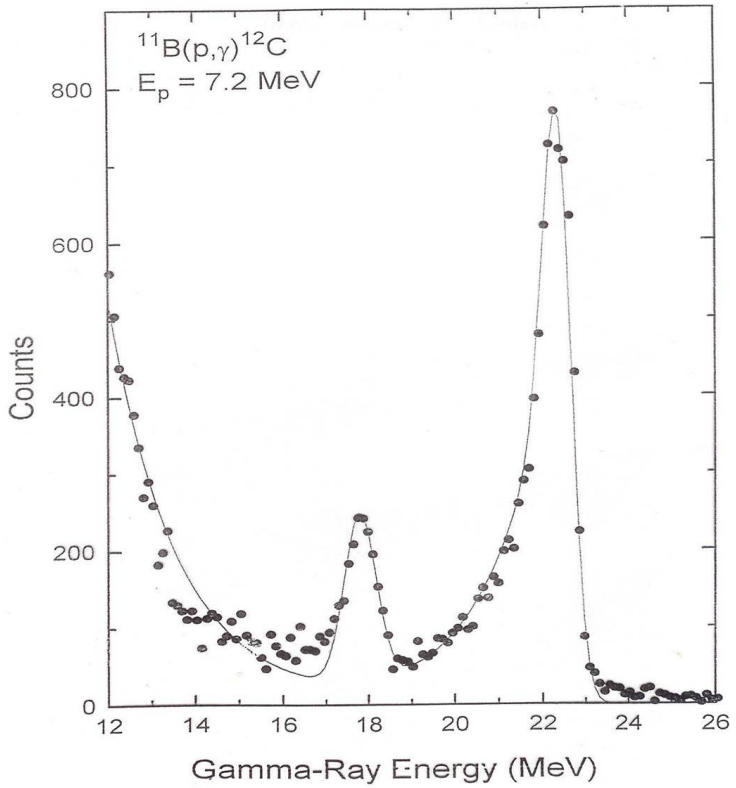
To be kept at ~75 - 100 cm from the target position in the proposed experiment.

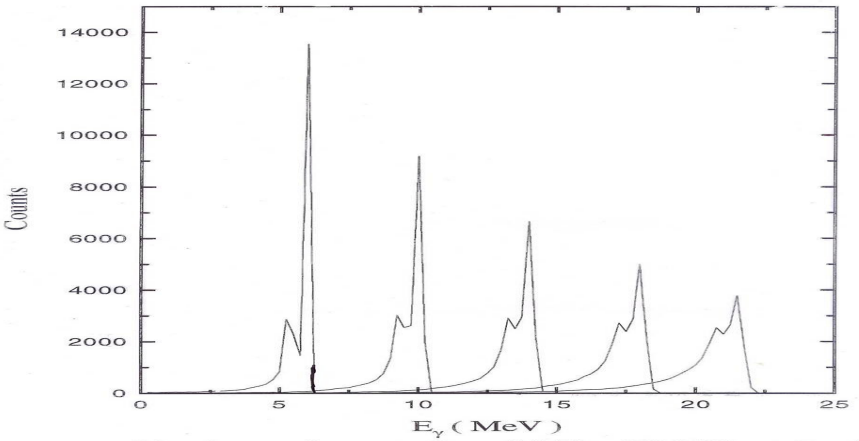
Photo peak efficiency for 15 MeV ~ 50%
(as simulated by EGS or GEANT4)



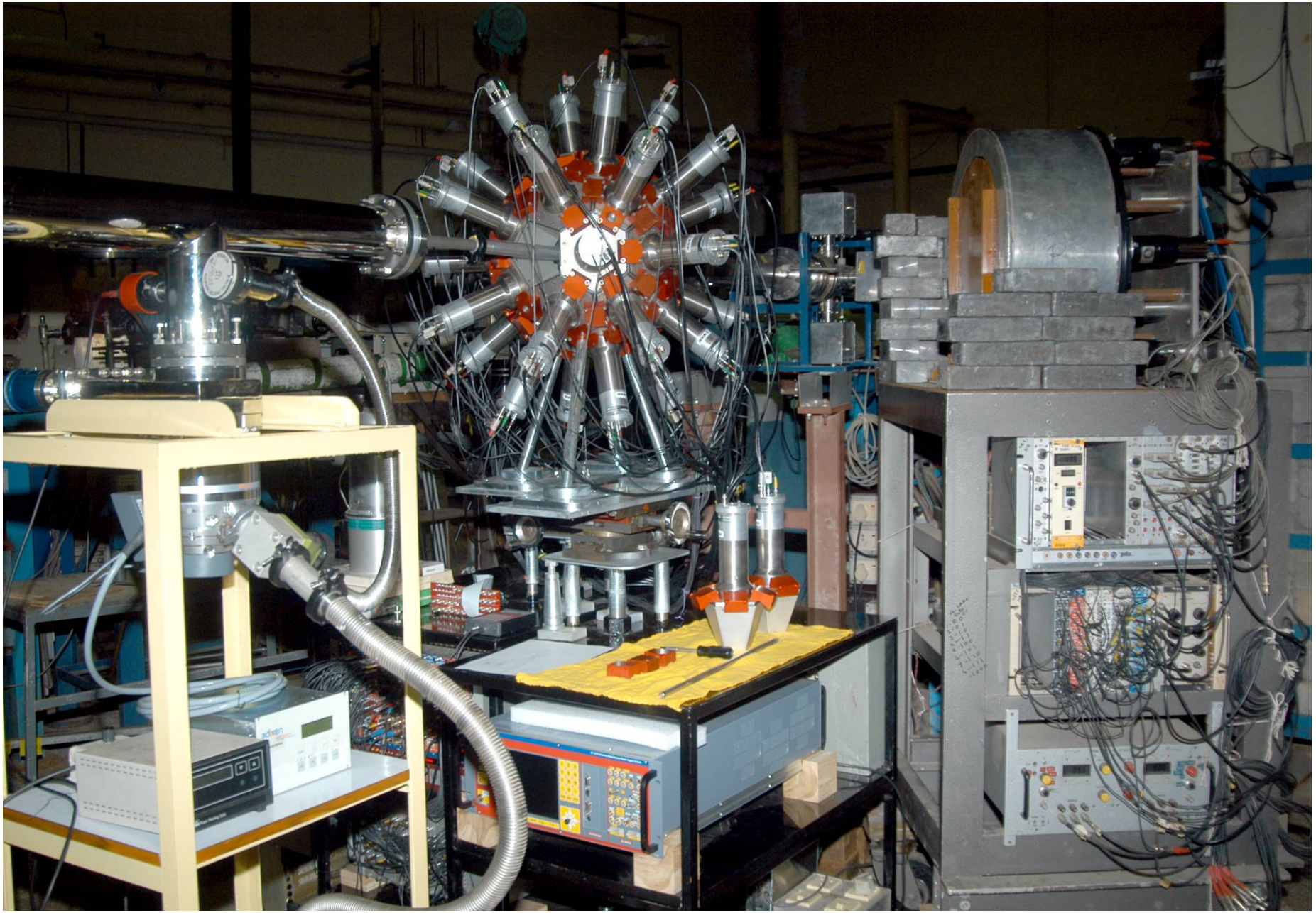
G. Anil Kumar, IM, D.A.Gothe
(Under Review)



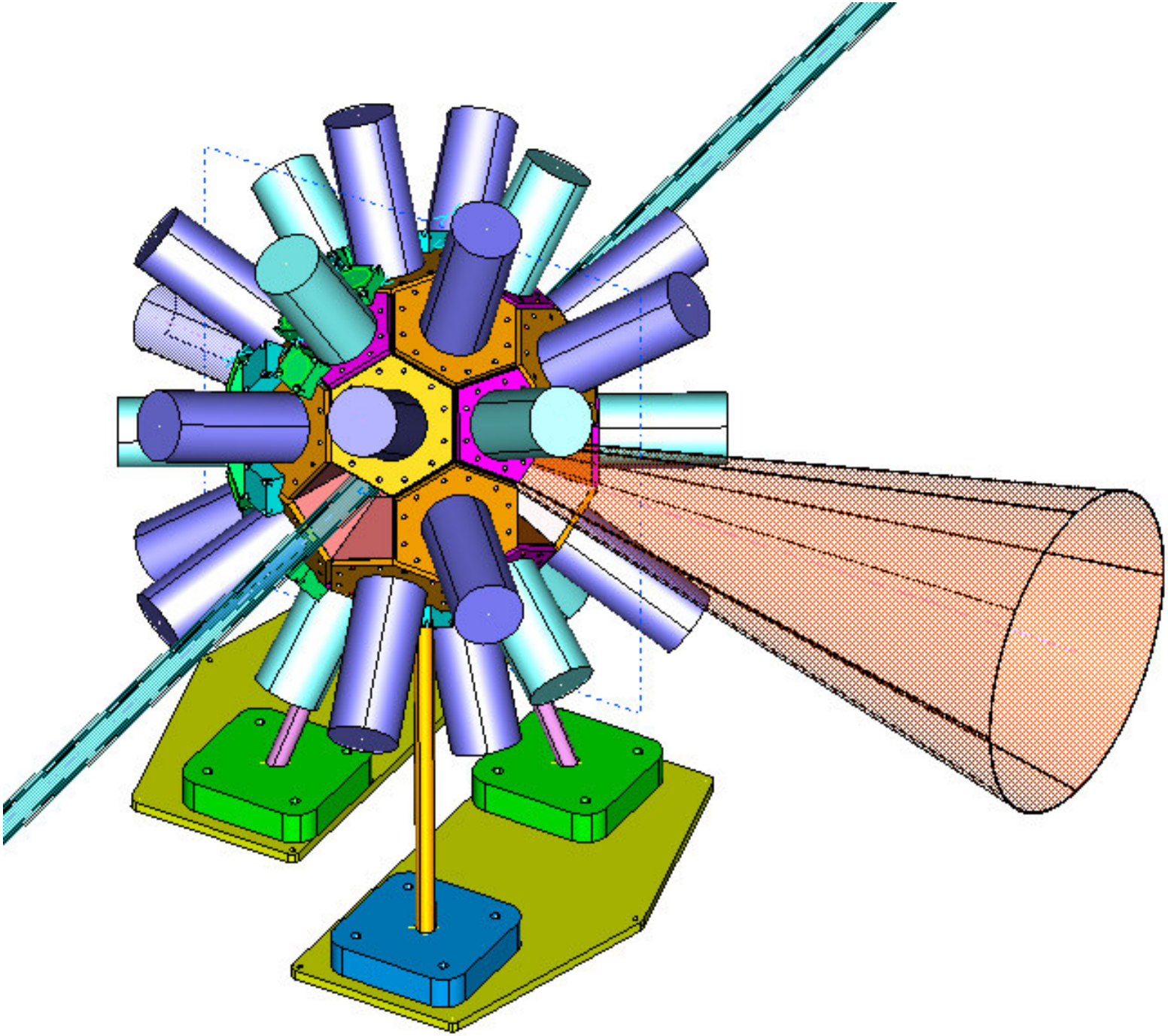




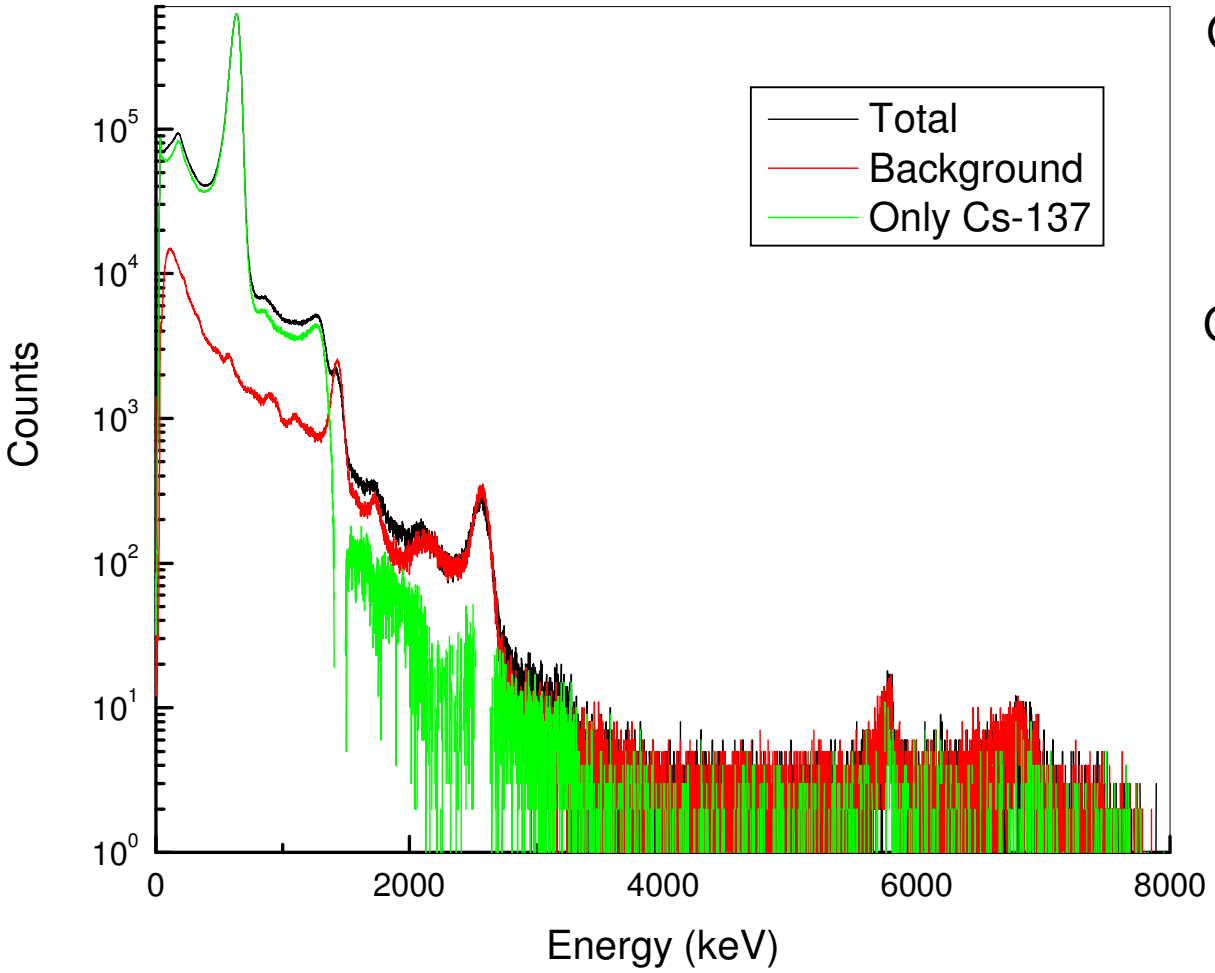
Lineshapes of γ - rays from 6MeV to 22MeV in steps of 4 MeV as calculated by EGS for the large NaI detector.



Mazumdar et al (In preparation), Anil Kumar, Mazumdar, D.A. Gothe, NIM-A (In Press)



Response of the array to single mono-energetic gamma ray



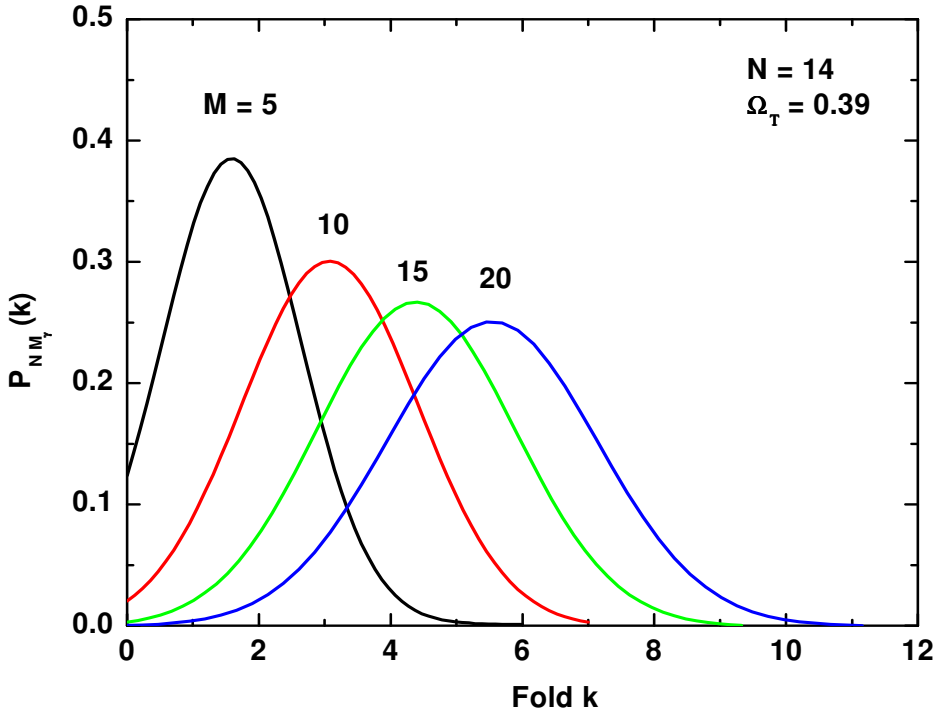
4π Array

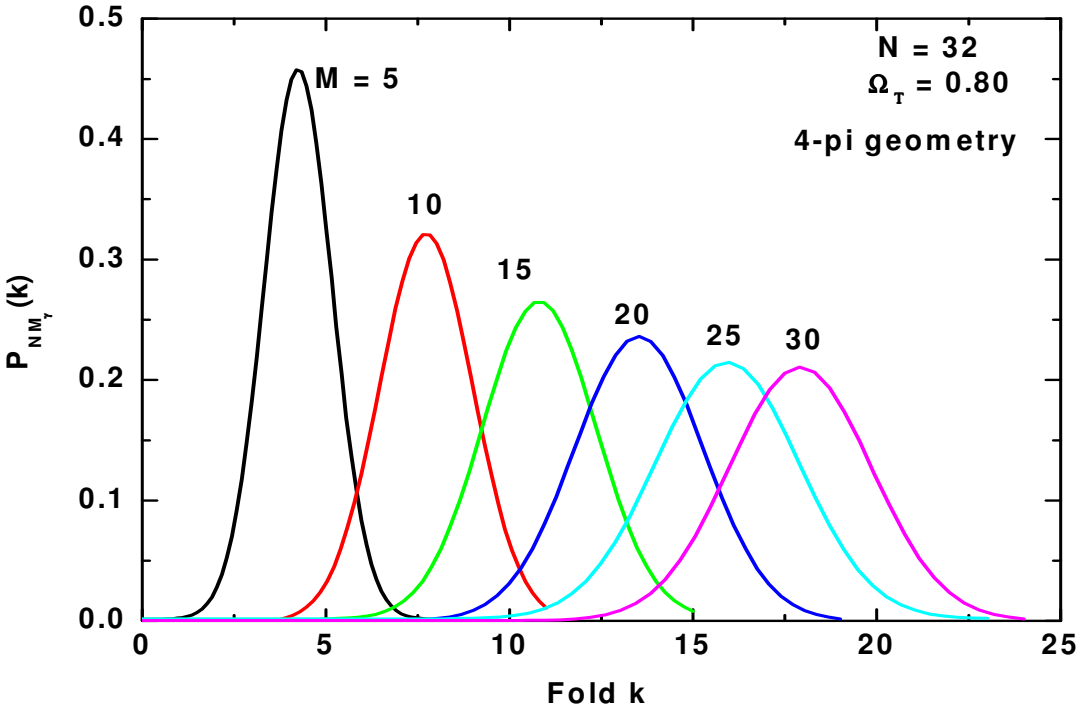
	Total	Photo
Expt.	77.5	54.5
Geant	83.8	59.5

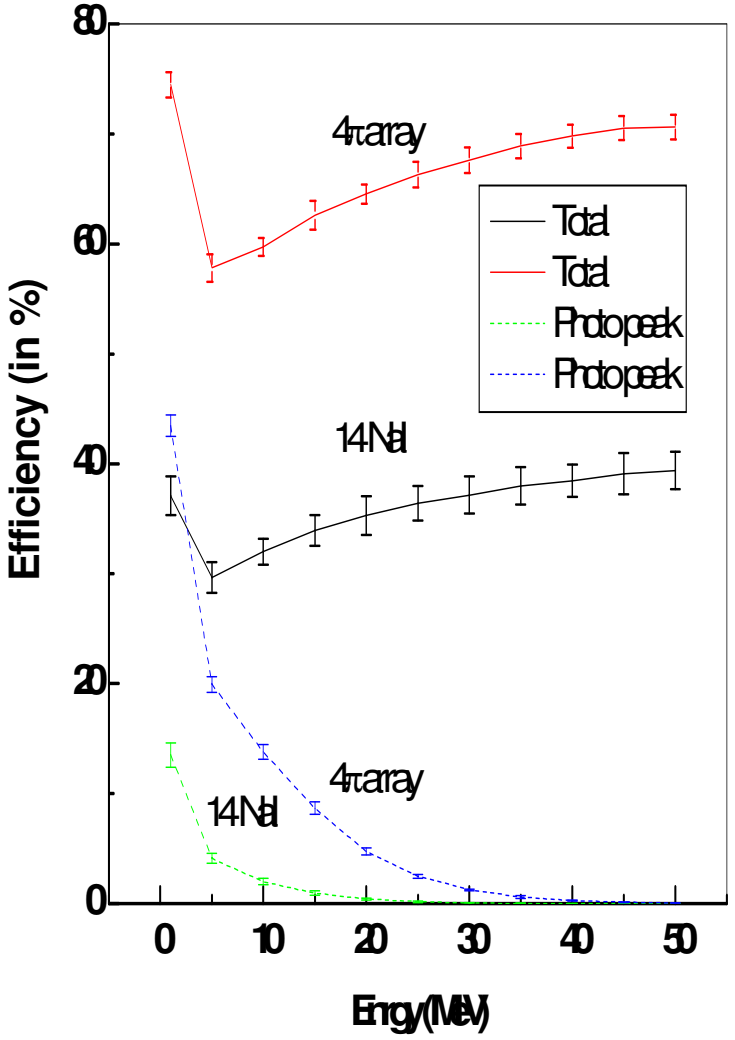
Spherical Shell

GEANT	89.5	70.4

Clibrated ^{137}Cs Source
2.13 μ Ci


N = 14
Ω_T = 0.39
M = 5
10
15
20
P_NM_T(k)
Fold k


N = 32
Ω_T = 0.80
4-pi geometry
M = 5
10
15
20
25
30
P_NM_T(k)
Fold k


4π array
Total
Total
Photopeak
Photopeak
14 NaI
4π array
14 NaI
Efficiency (in %)
Engy (MeV)

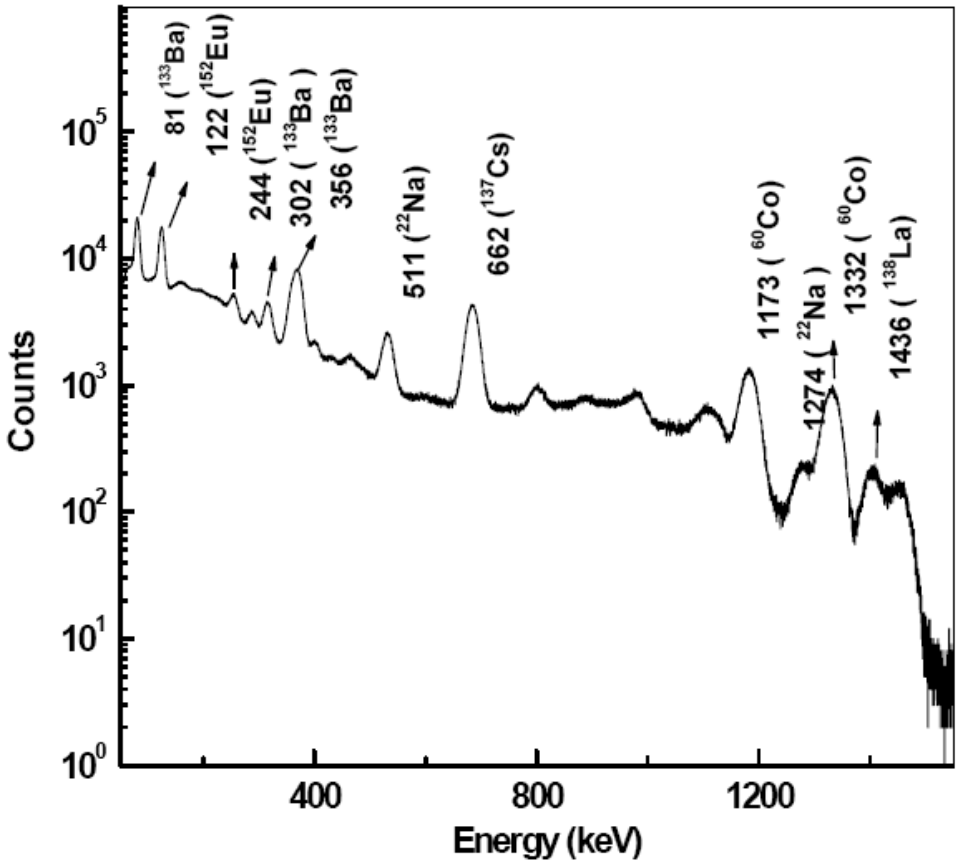
Simulated and measured efficiencies for a single detector for 662 keV at a distance of 10 cm from the centre of the face of the detector.

Configuration	Absolute efficiency (in %)		Photo peak efficiency (in %)	
	GEANT4	Exp	GEANT4	Exp
Conical Hexagon (3")	2.98 ± 0.03	3.03 ± 0.15	1.70 ± 0.04	1.63 ± 0.08
Conical Pentagon (3")	2.00 ± 0.03	2.06 ± 0.10	1.06 ± 0.03	1.03 ± 0.05
Small Hexagon (4")	1.03 ± 0.06	1.08 ± 0.05	0.47 ± 0.03	0.47 ± 3.90

Simulated and measured efficiencies for different configurations of conical pentagons and hexagons at 662 keV.

Configuration	Absolute efficiency (in %)		Photo peak efficiency (in %)	
	GEANT4	Exp	GEANT4	Exp
12 pentagons + 20 hexagons	83.8 ± 1.13	77.5 ± 3.95	59.5 ± 1.31	54.5 ± 2.41
10 pentagons + 20 hexagons	79.4 ± 1.10	76.8 ± 3.84	49.0 ± 1.23	46.5 ± 2.32
10 pentagons + 19 hexagons	76.4 ± 1.09	74.1 ± 3.70	46.5 ± 1.08	43.8 ± 2.19
9 pentagons + 20 hexagons	77.5 ± 1.06	75.0 ± 3.75	47.5 ± 1.38	45.2 ± 2.26
14 NaI system	40.9 ± 1.90	40.0 ± 2.00	17.2 ± 1.32	16.0 ± 0.80

Measurements with a small LaBr3:Ce



Typical spectrum with low energy gamma sources

1" x 1" Cylindrical crystal

0.5 mm Al casing

Glass light guide

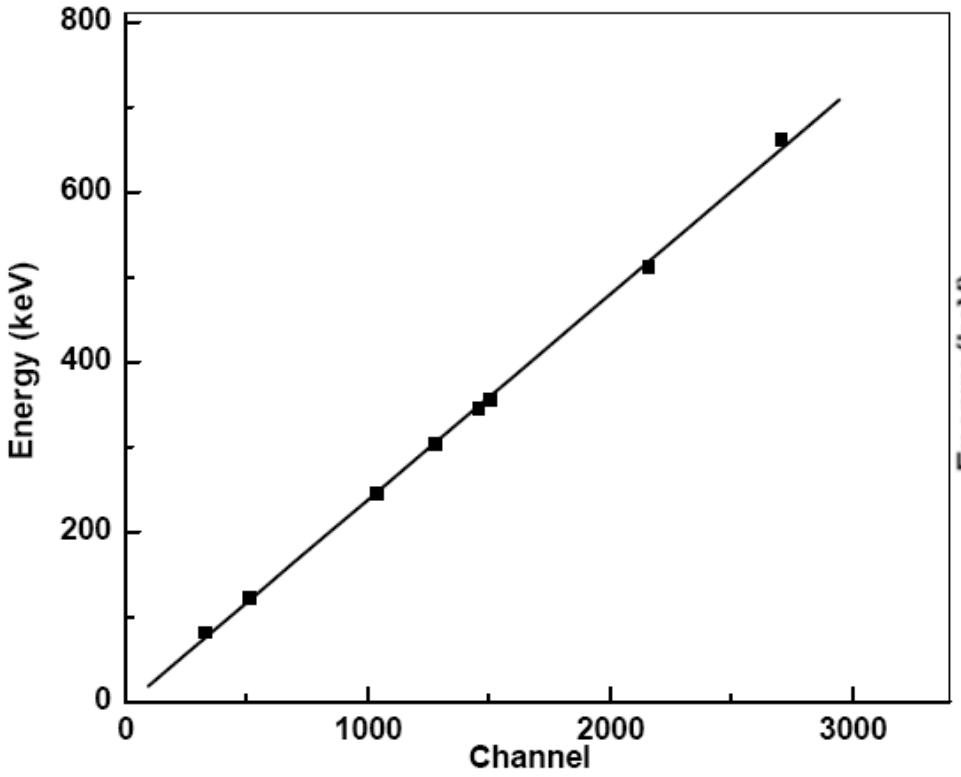
Tested with two PMTs:

2" ET9807B (Equiv. RCA8575)

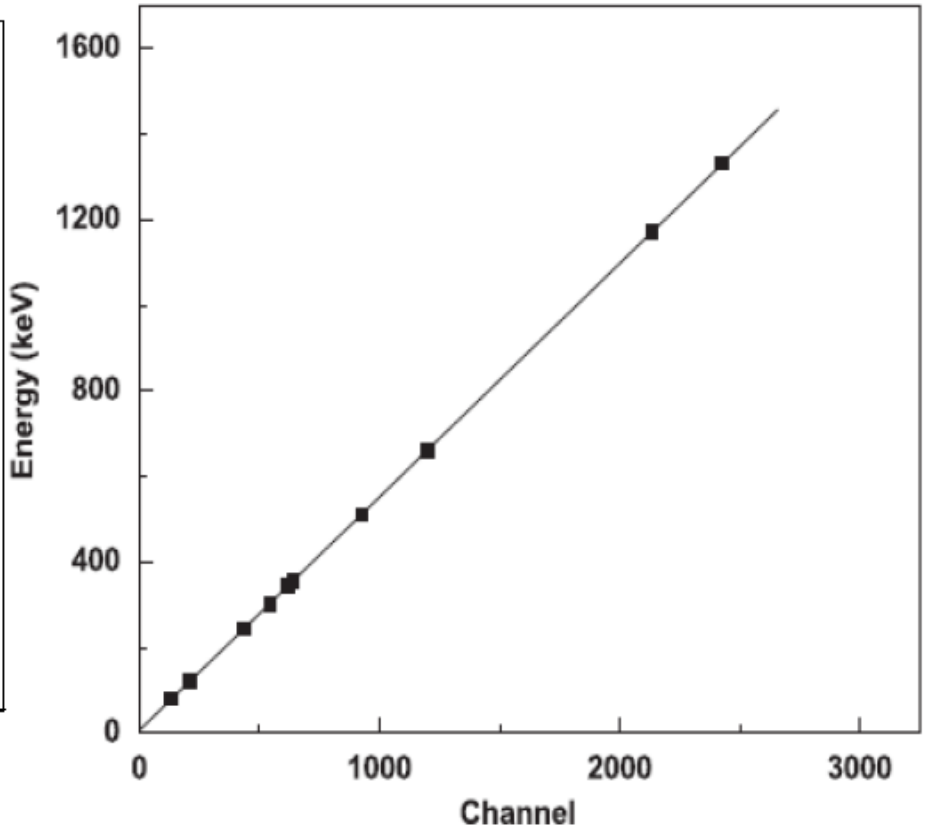
3" BURLE S83021E (Equiv. R1911-01)

(Both have bialkali photocathodes with max. quantum efficiencies in 320 – 420 nm)

DOW CORNING clear white silicone for coupling.

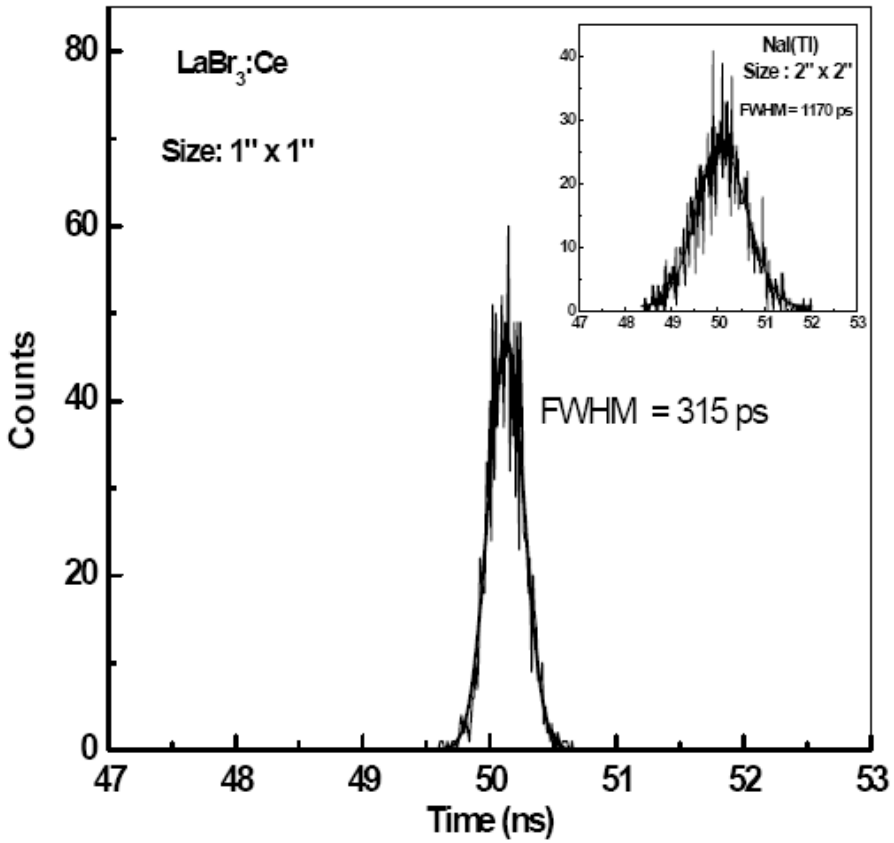


Pulse height vs energy from 81 to 662 keV
(Anode signal)



81 TO 1332 keV (Dynode signal)

3" BURLE S83021E
Resolution ~ 3.2 % (Anode)
~ 3.5% (Dynode)

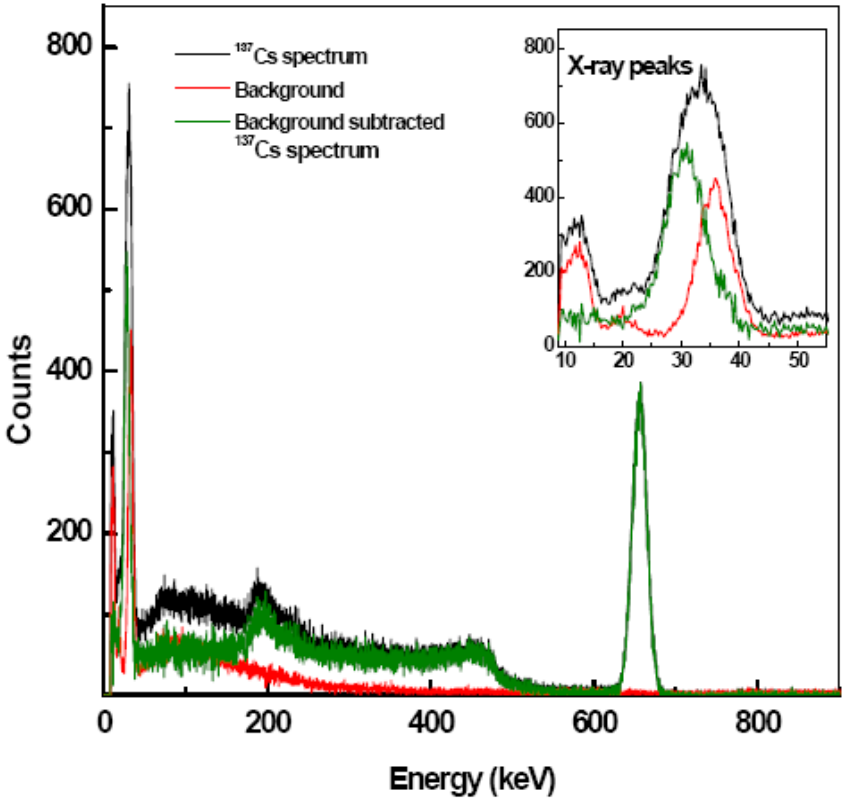


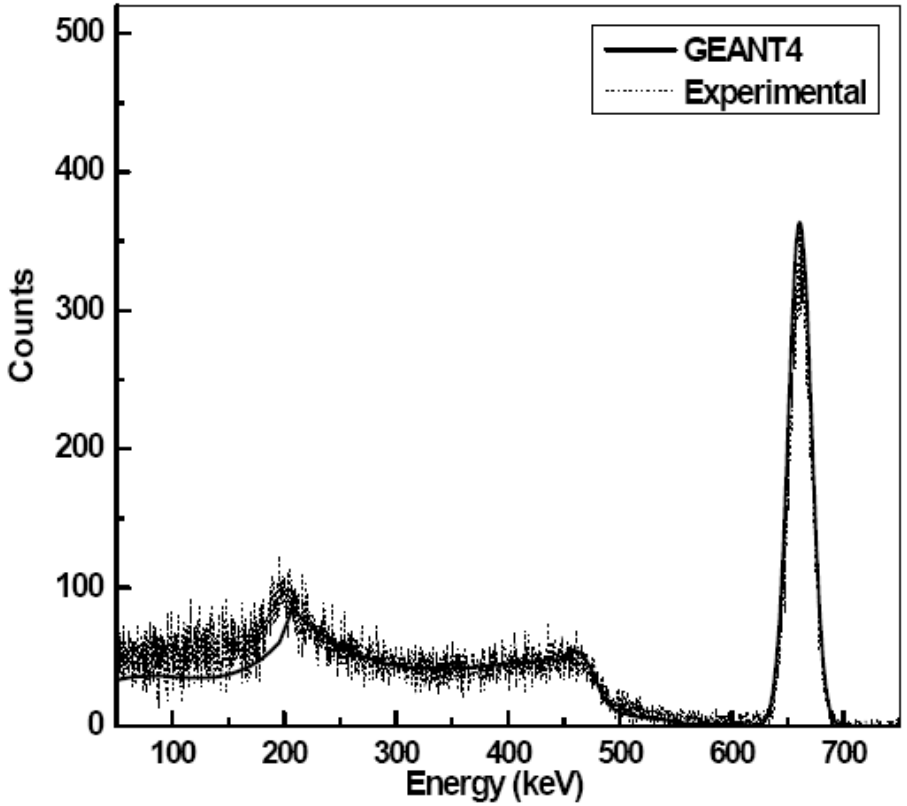
Timing resolution: Standard slow-fast coinc.

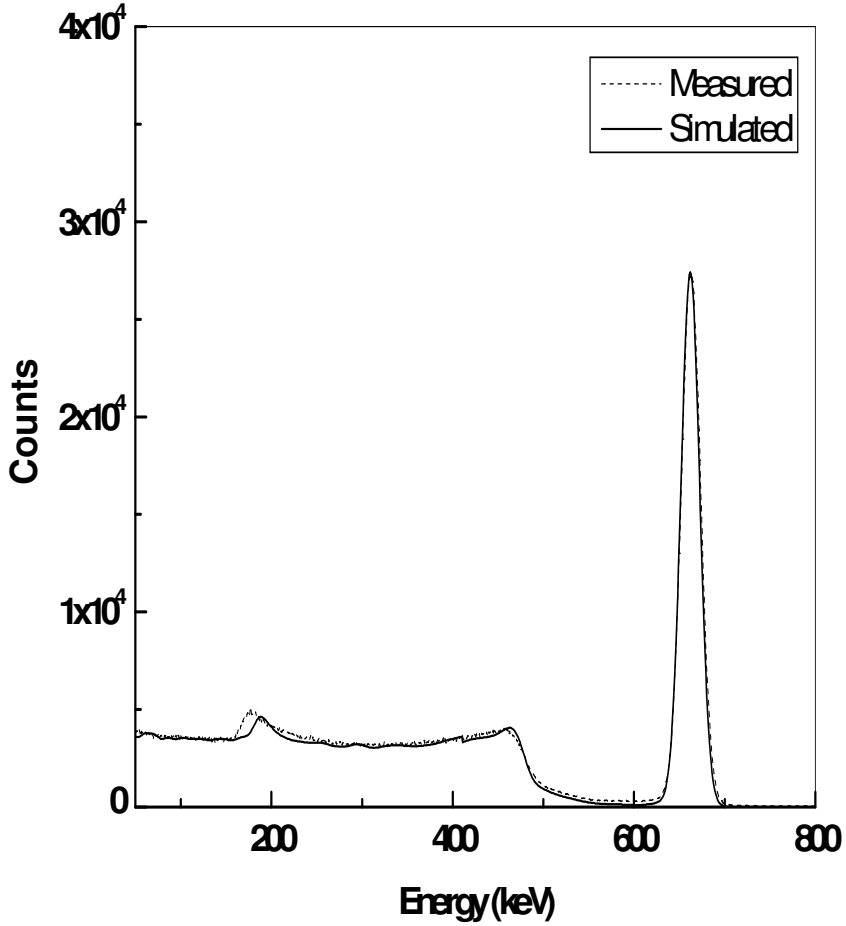
~220 ps at ^{60}Co energy

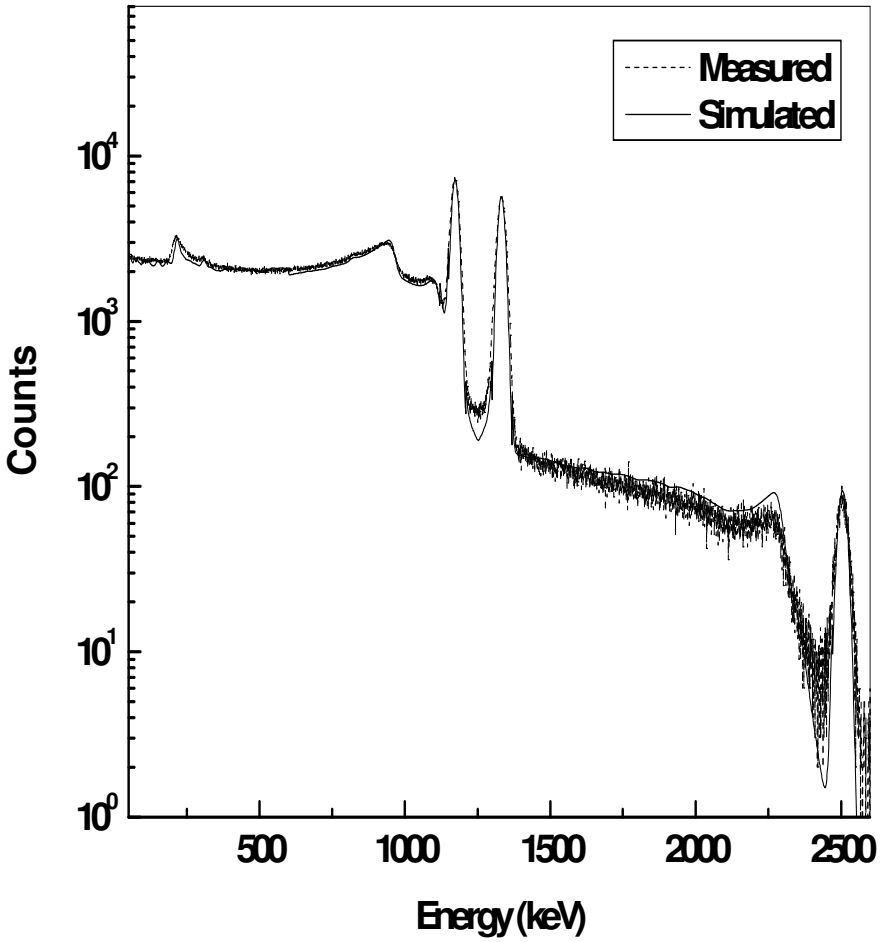
[ET9807B (Equiv. RCA8575)]

Much worse timing resolution with the 3" BURLE S83021E


137Cs spectrum
Background
Background subtracted
137Cs spectrum
X-ray peaks
Counts
Energy (keV)
0
200
400
600
800
10
20
30
40
50


GEANT4
Experimental
Counts
Energy (keV)
0
100
200
300
400
500
600
700





G. Anil Kumar, I Mazumdar, D.A. Gothe.,
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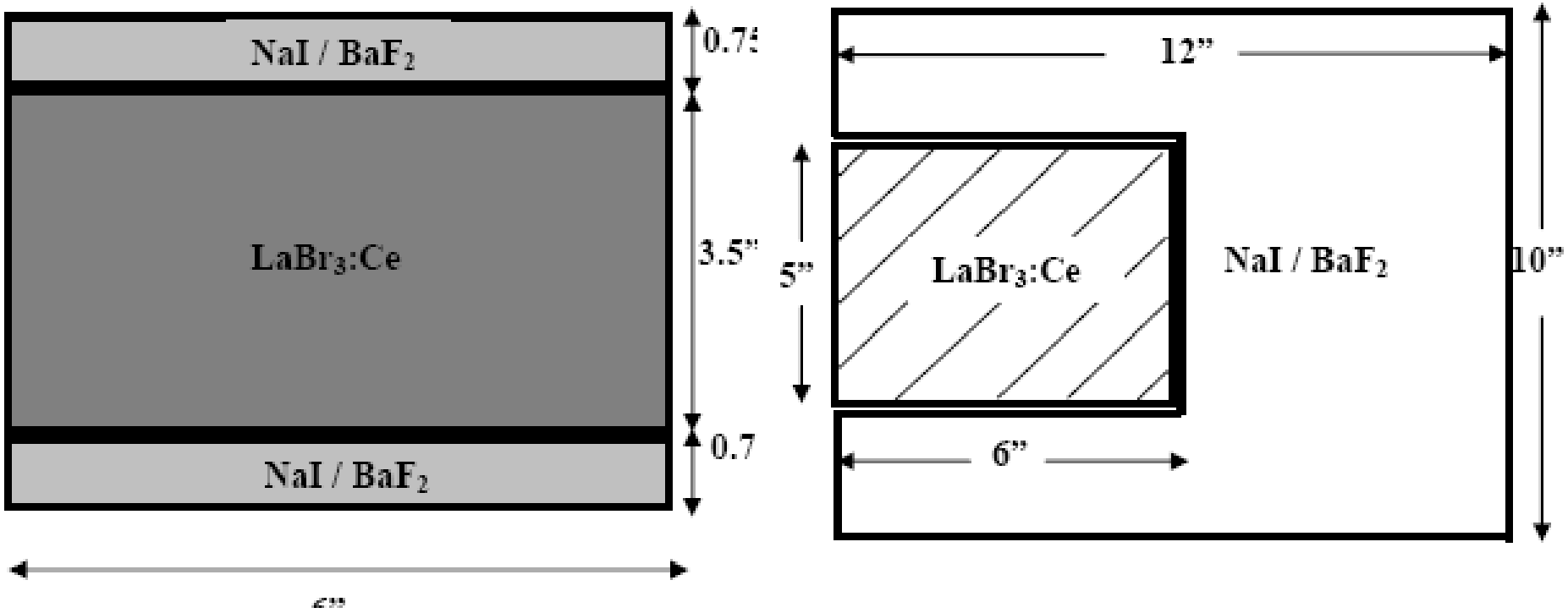
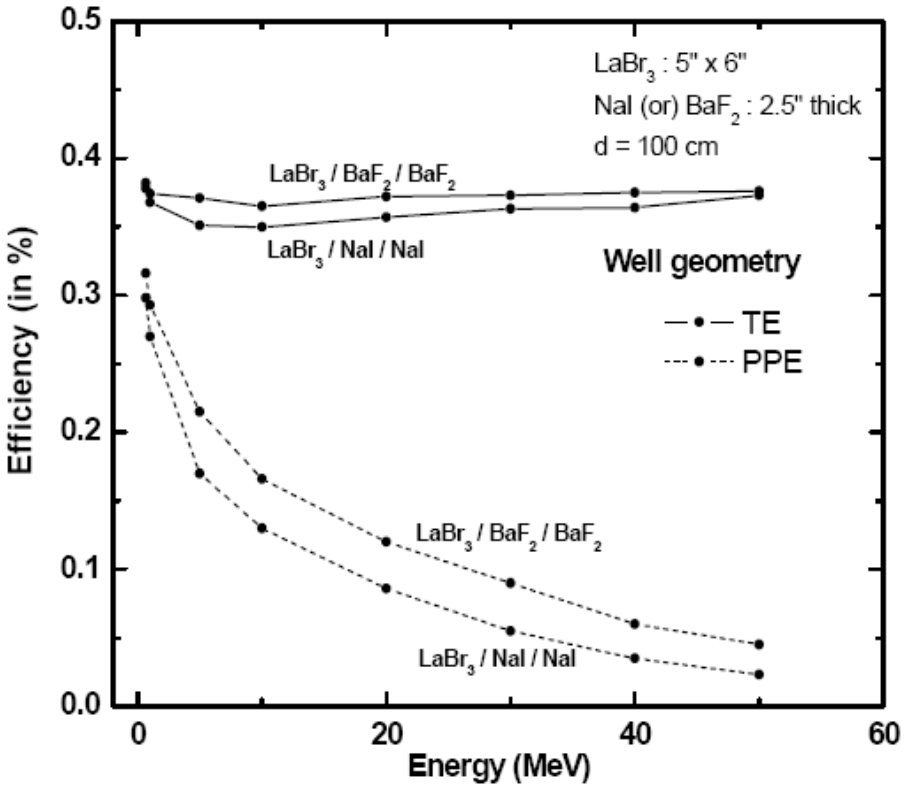
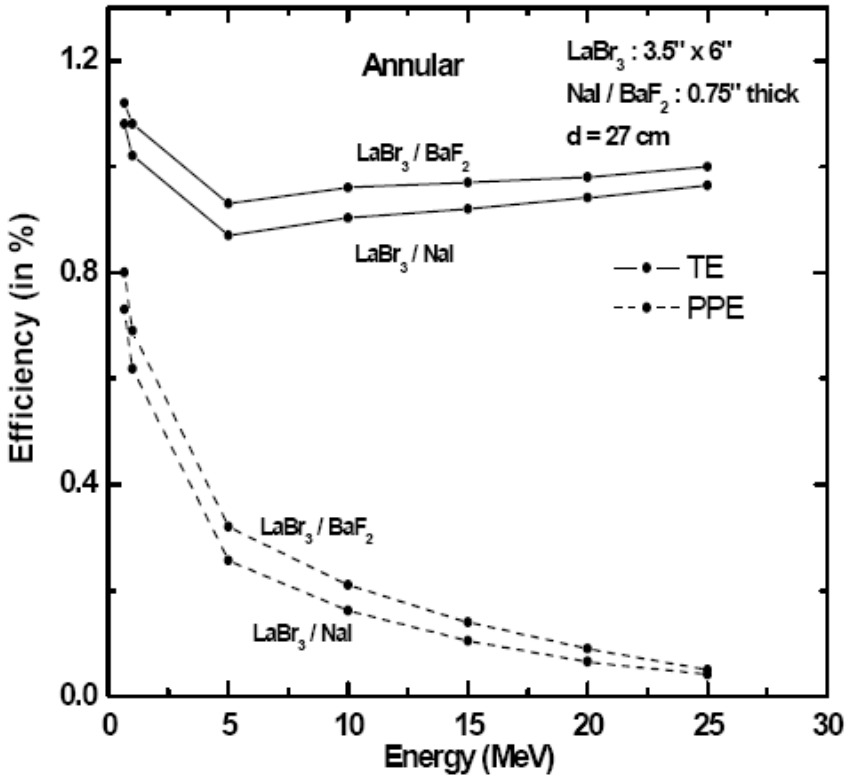
Absolute efficiencies of the 1” X 1” BriLanCe380

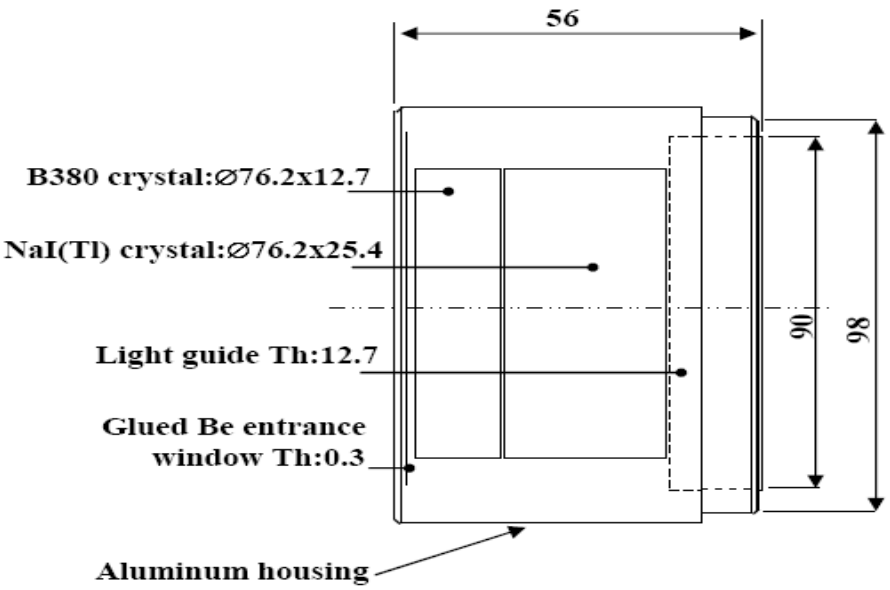
Distance (cm)	ε_{Total}		ε_{peak}	
	GEANT4	Exp	GEANT4	Exp
15	0.105 (0.012)	0.114 (0.005)	0.030 (0.004)	0.027 (0.001)
25	0.041 (0.003)	0.044 (0.002)	0.011 (0.001)	0.010 (0.001)



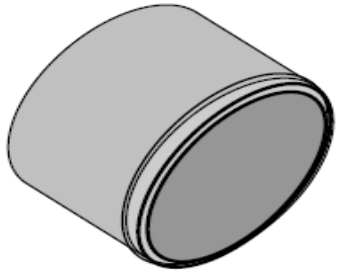
Possible combined arrangement of scintillatiors for high energy gamma ray measurements


LaBr3 : 5" x 6"
NaI (or) BaF2 : 2.5" thick
d = 100 cm
LaBr3 / BaF2 / BaF2
LaBr3 / NaI / NaI
Well geometry
TE
PPE
LaBr3 / BaF2 / BaF2
LaBr3 / NaI / NaI
Efficiency (in %)
Energy (MeV)
0.0
0.1
0.2
0.3
0.4
0.5
0
20
40
60

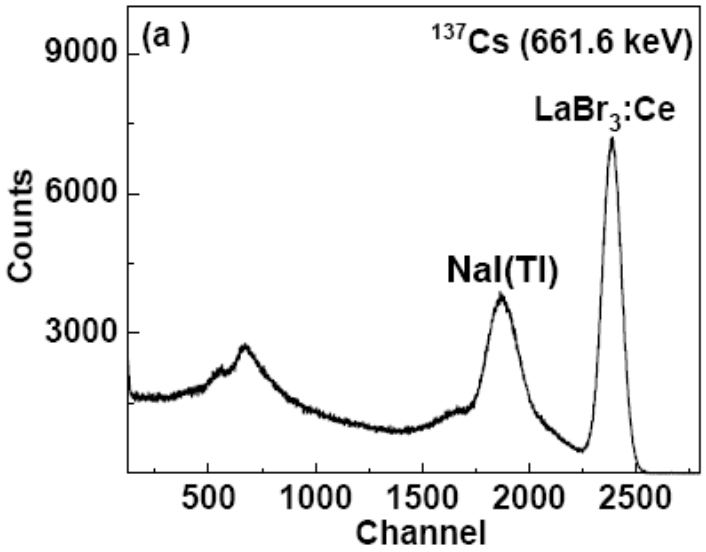

Annular
LaBr3 : 3.5" x 6"
NaI / BaF2 : 0.75" thick
d = 27 cm
LaBr3 / BaF2
LaBr3 / NaI
TE
PPE
LaBr3 / BaF2
LaBr3 / NaI
Efficiency (in %)
Energy (MeV)
0.0
0.4
0.8
1.2
0
5
10
15
20
25
30

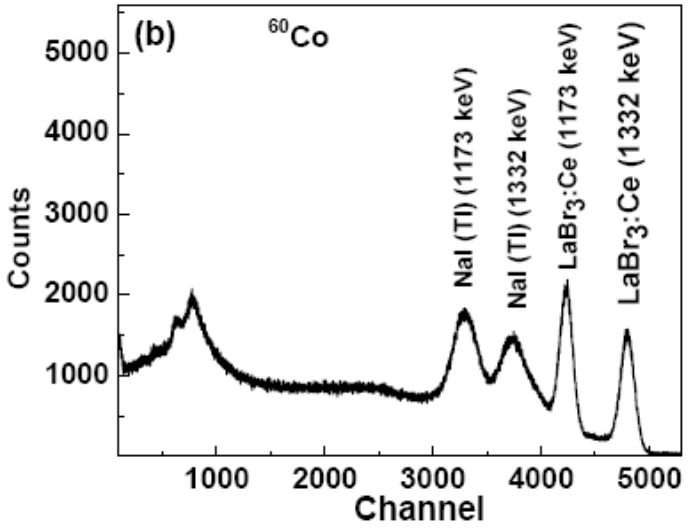

56
B380 crystal:Ø76.2x12.7
NaI(Tl) crystal:Ø76.2x25.4
Light guide Th:12.7
Glued Be entrance window Th:0.3
Aluminum housing
90
98

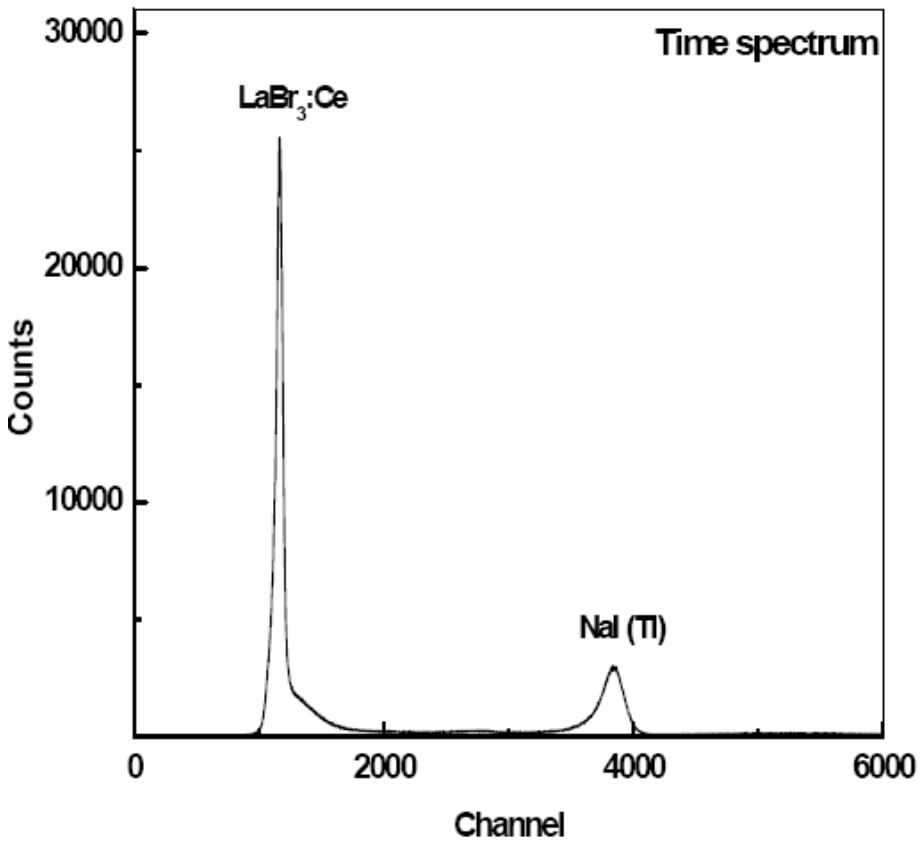
(a)

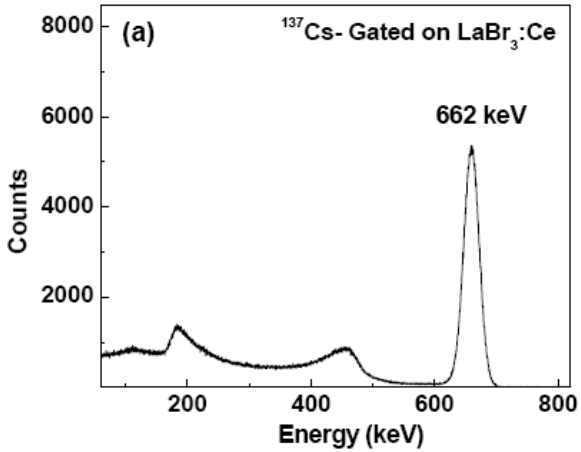


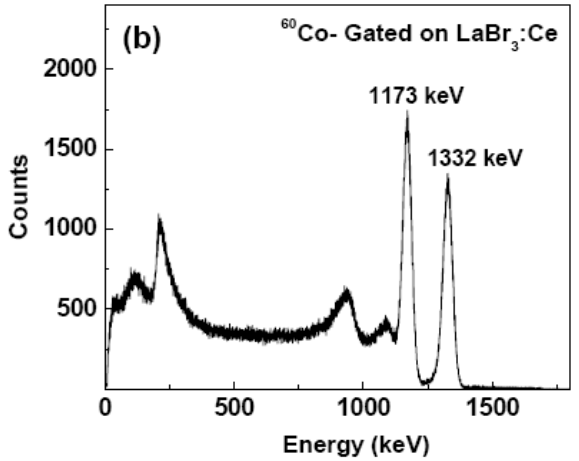
(b)

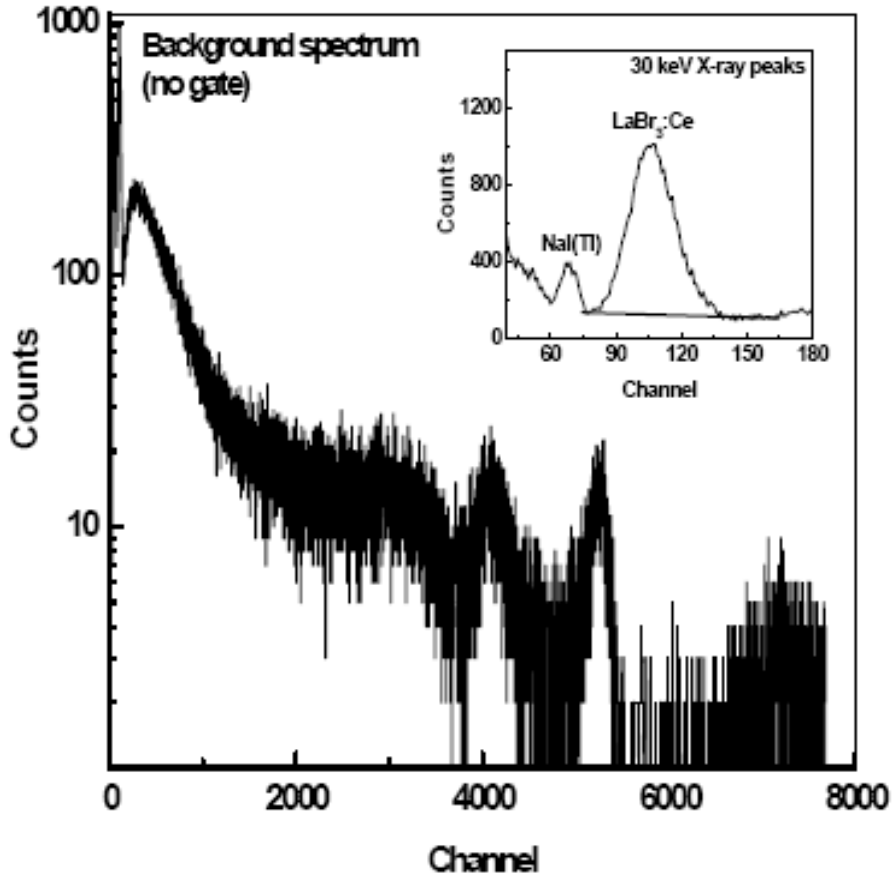

(a)
^{137}Cs (661.6 keV)
LaBr$_3$:Ce
NaI(Tl)
Counts
9000
6000
3000
500
1000
1500
2000
2500
Channel

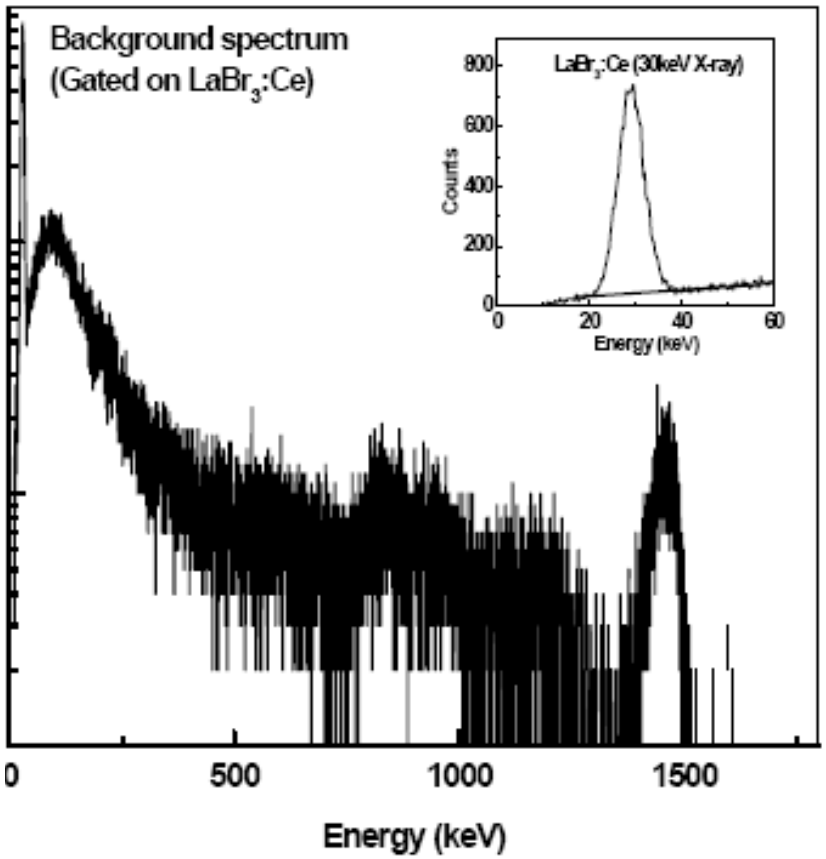

(b)
^{60}Co
NaI (Tl) (1173 keV)
NaI (Tl) (1332 keV)
LaBr$_3$:Ce (1173 keV)
LaBr$_3$:Ce (1332 keV)
Counts
5000
4000
3000
2000
1000
1000
2000
3000
4000
5000
Channel


Time spectrum
LaBr3:Ce
NaI (Tl)
Counts
Channel
30000
20000
10000
0
2000
4000
6000


(a)
137Cs- Gated on LaBr3:Ce
662 keV
Counts
Energy (keV)
8000
6000
4000
2000
200
400
600
800


(b)
60Co- Gated on LaBr3:Ce
1173 keV
1332 keV
Counts
Energy (keV)
2000
1500
1000
500
0
500
1000
1500





Pulse shape discrimination for a $LaBr_3$:Ce+NaI(Tl) Phoswich

Reduction of internal 30 keV radioactivity

- **Temperature dependence of scintillator crystals: (Energy & Timing Resolutions)**

- NaI(Tl), NaI, CsI(Na), CsI, BaF2, BGO (Scionix) (2” X 2” cylinders)

- $LaBr_3$:Ce (SGC)

- Measurements carried out at Room temperature, Ice, Dry Ice and LN_2

- Direct coupling and coupling with Silicone

Work under progress and special arrangements for controlled cooling and testings are being built at TIFR.


Thank You