GDR experiment with an ideal six-box two-layered detector array: an EGS simulation

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One main program with PARIS is study of GDR with SPIRAL beams in hot neutron-rich nuclei

The T and J-dependence of GDR width is a topic with open questions even in experiments with stable beams

We do not fully understand the data under the popular thermal shape fluctuation model (TSFM)

At low T (<2 MeV) the contribution from
Inhomogeneous damping (TSFM) and
Intrinsic damping
should both be there in deciding T-dependence of GDR width

There is no experimental demonstration of simultaneous contribution from both in a certain system

This important issue can be addressed by measurements of GDR width

(a) for a wide range of J for a given T as well as

(b) for a wide range of T for a given J

Our recent program was in the system

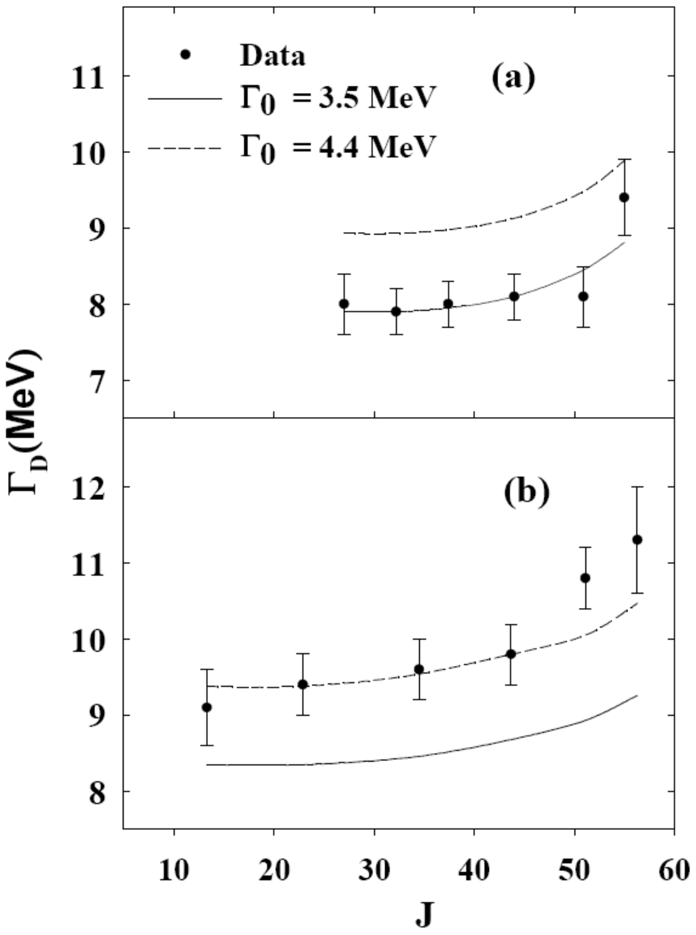
^{28}Si+^{124}Sn at 149 MeV and 185 MeV ^{28}Si-beam energies

at the Pelletron-Linac Facility at Mumbai

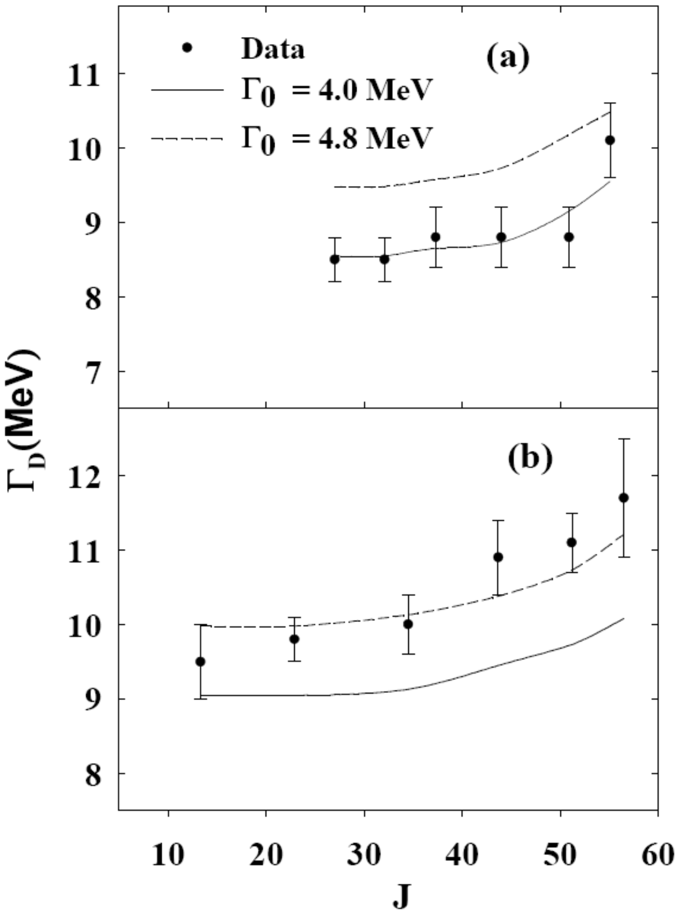
The extracted J-dependence of GDR width was compared with the TSFM based on the calculation Kusnezov et al. [Phys. Rev. Lett. 81 (1998) 542] in the liquid drop regime

Experimental widths and TSFM predictions

NLD A/8.5



NLD A/9.5



E(^{28}Si) 149 MeV

E(^{28}Si) 185 MeV

Different values of Γ_0 are required at different E_X

1. Inhomogeneous contribution cannot fully explain the T dependence of the GDR width
2. Evaporation width contribution is very small

T-dependence of intrinsic width has to be included

However, a T-dependence of intrinsic width to explain low-J data at both energies will give a flatter J-dependence

Is there a bigger shape change at high J ?

Besides these open questions to be addressed in the study of GDR in neutron-rich nuclei, another interesting possibility is to observe the pygmy resonance in hot nuclei for large N-Z values

Pygmy resonance (E1 collective strength at low energy) has been seen in GDR on G.S. of ^{132}Sn (N-Z=32)

One proposal of study is in the system ^{132}Sn+^{12}C producing Compound Nucleus ^{144}Ba (incidentally also with N-Z=32)

We address the experimental issue:

Effect of Doppler shift and broadening

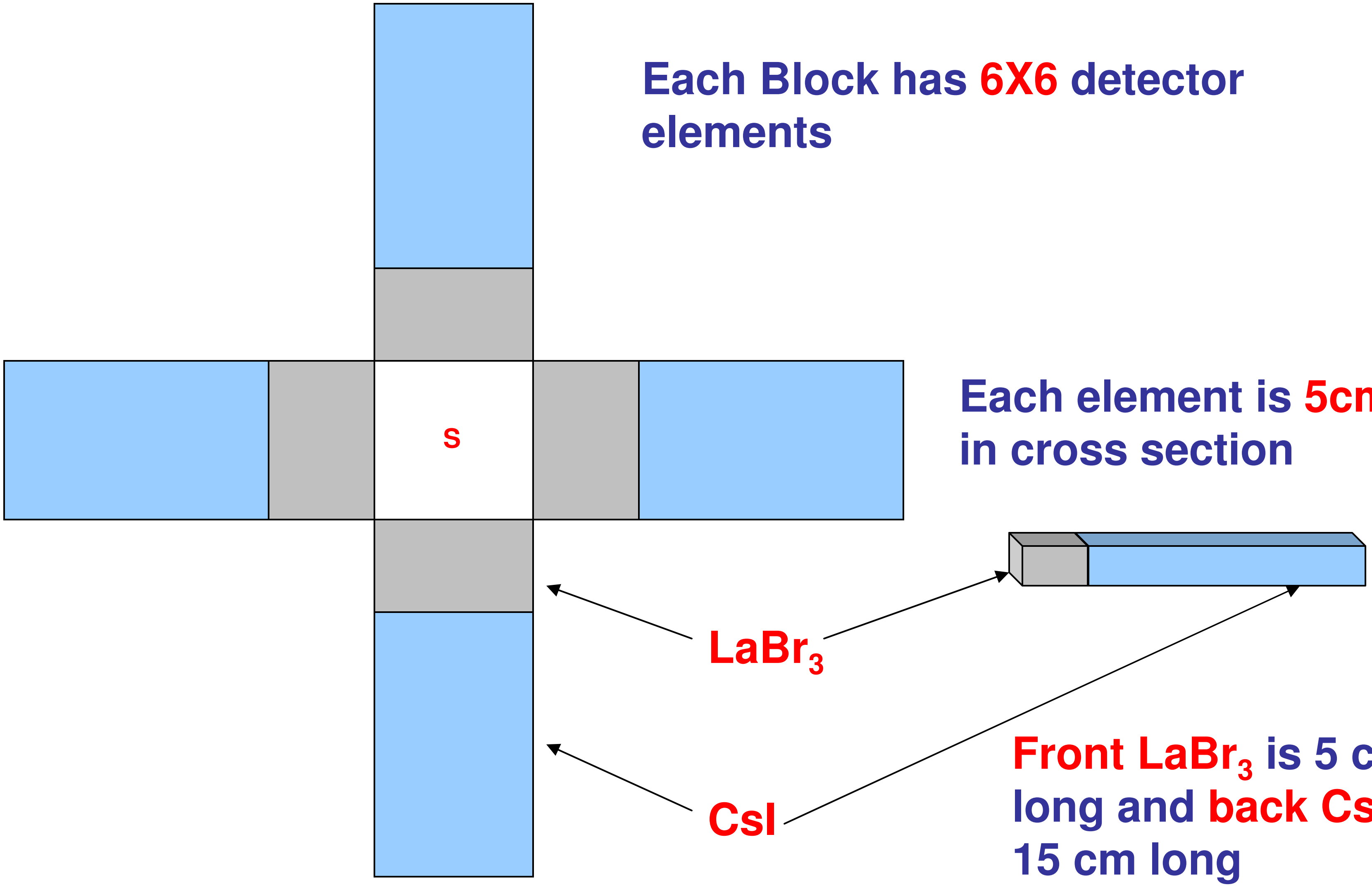
Effect of summing from associated multiplicity gamma rays

One design of PARIS consists of cubic geometry of six sectors consisting of $LaBr_3$ and may be CsI

We take some practical dimensions and address these issues with an EGS simulation

Detector Array:

Six rectangular blocks facing each other. Gamma source (S) at the centre



Each Block has 6X6 detector elements

Each element is 5cmX5cm in cross section

Front $LaBr_3$ is 5 cm long and back CsI is 15 cm long

Event Description

A. Monoenergetic high energy gamma ray

B. High energy gamma ray selection guided by a CASCADE output with the GDR strength function

In both cases, associated multiplicity of low-energy gamma rays has a triangular distribution upto Mmax and energy distributed linearly from 0 to Emax.

Gamma ray source has a velocity β

Flow Chart

- Gamma rays emitted in 4π direction in the rest frame of the source and Doppler shifted in Lab frame depending on the angle of emission

- In each event, multiplicity of associated gamma rays selected at random corresponding to the triangular distribution and energies ascertained with linear interpolation

- Non-zero energy deposited in all the detectors and their ID (out of 6X6X6= 216 $LaBr_3$ and 216 CsI detectors) recorded event by event and a list file created

- In another program analysing each event, detector element (DE) with highest energy deposited is identified and energy of the nearest neighbours added up after taking energy resolution into account

- Energy resolution assumed as

$$R(E) = K/\sqrt{E}$$

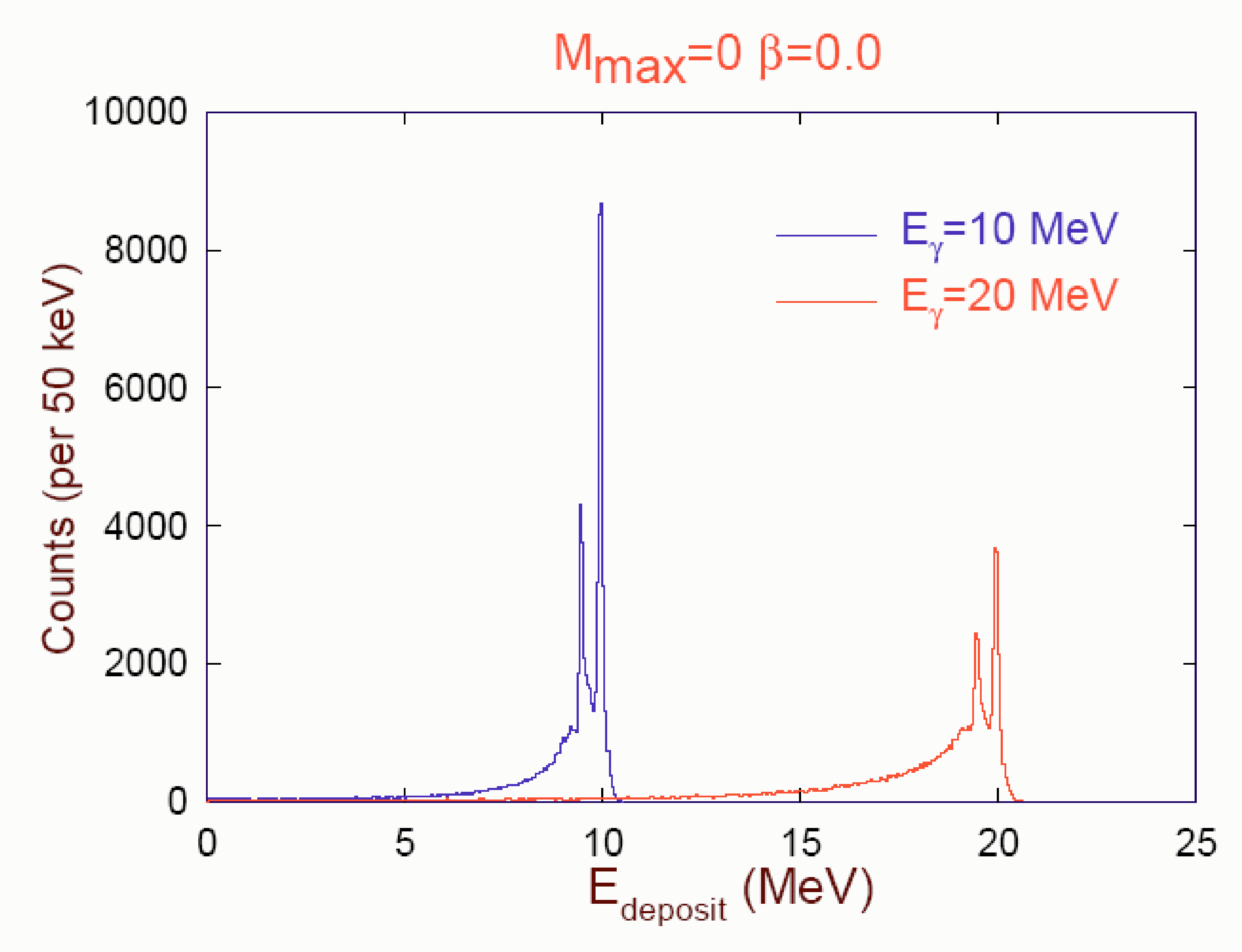
with resolution 3% for LaBr3 and 13% for CsI at 662 keV

- Angle of emission taken as that of the central point on the face of DE and Doppler correction applied

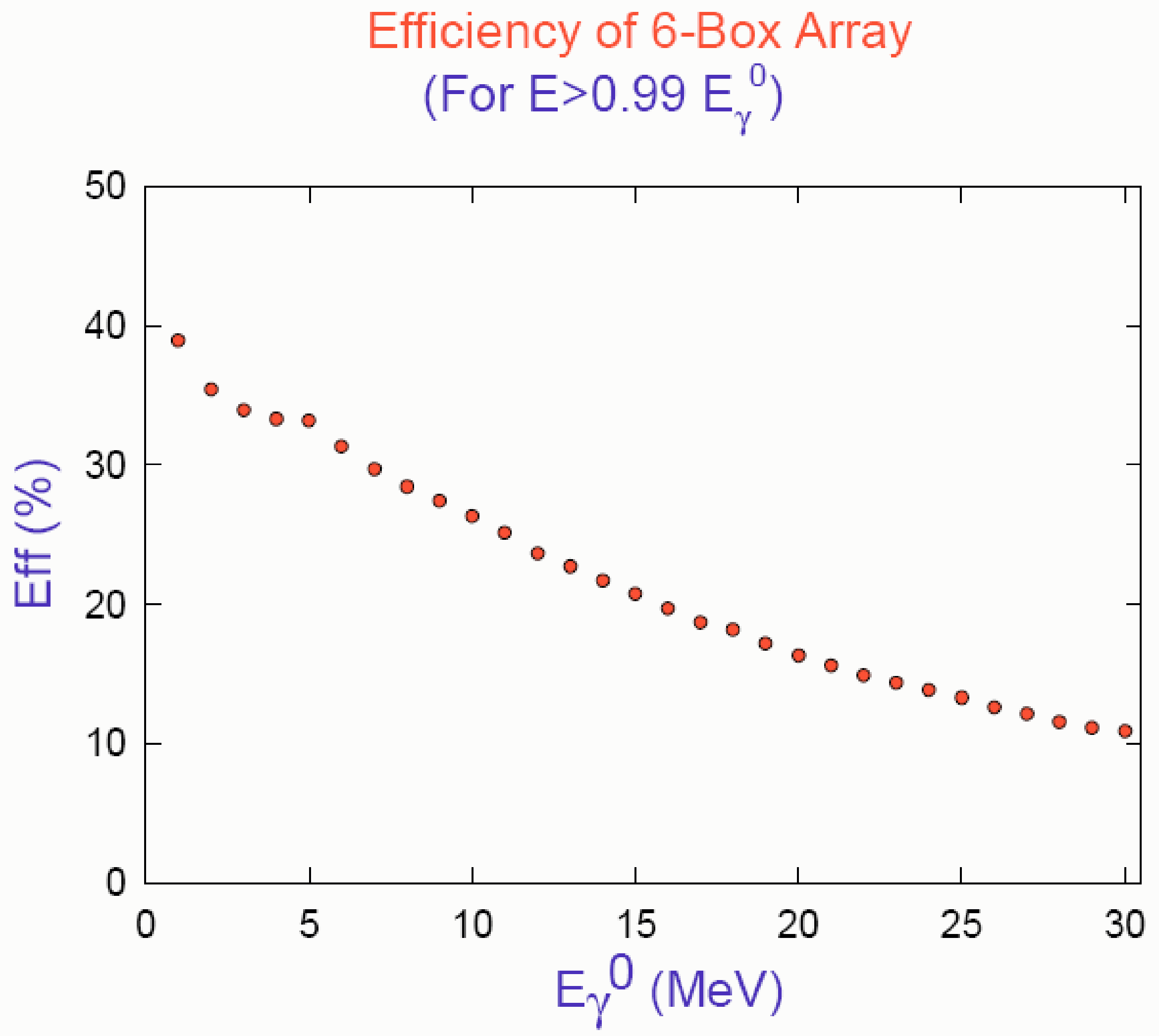
Results :

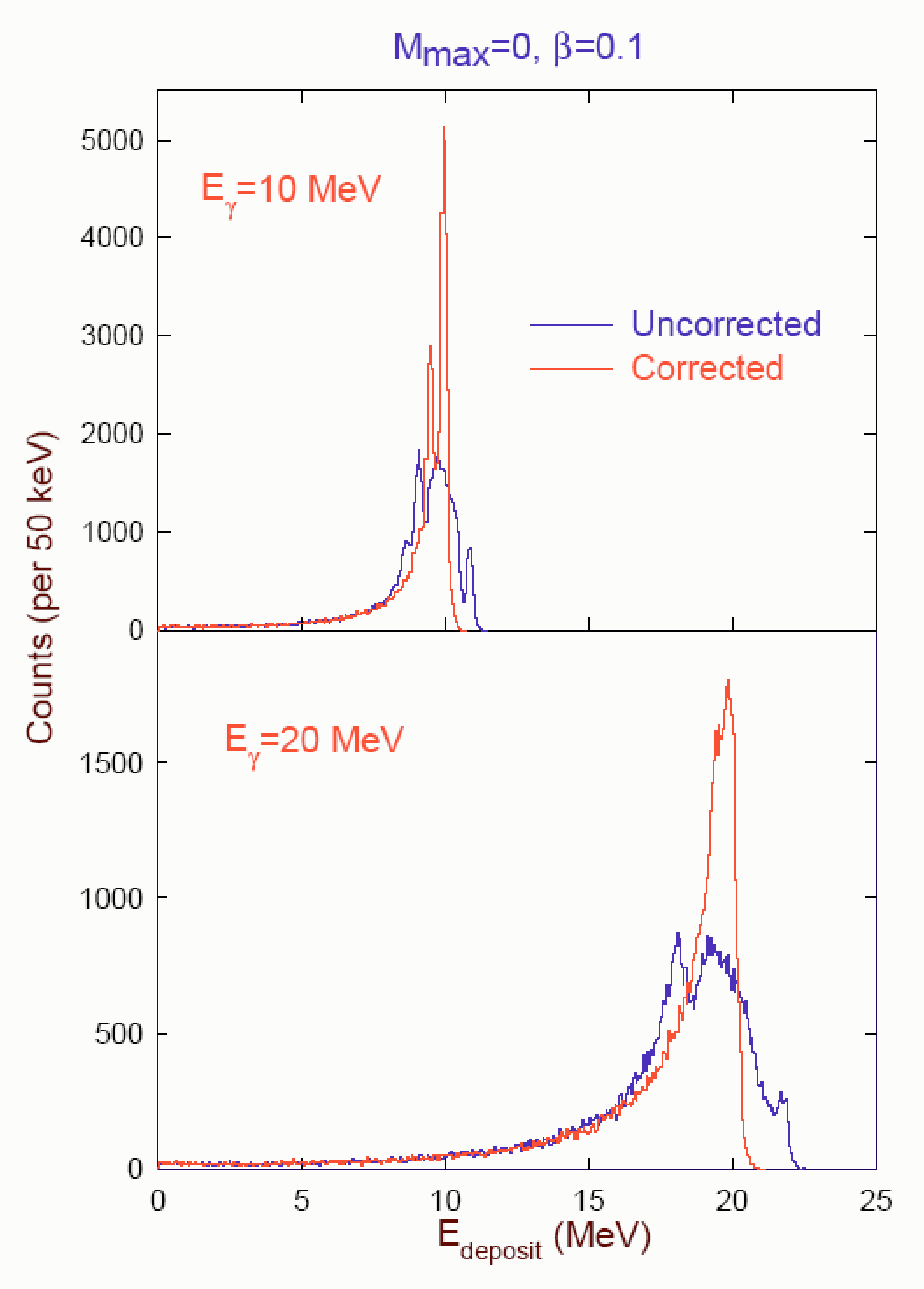
Monoenergetic High energy Gamma ray

Response Function

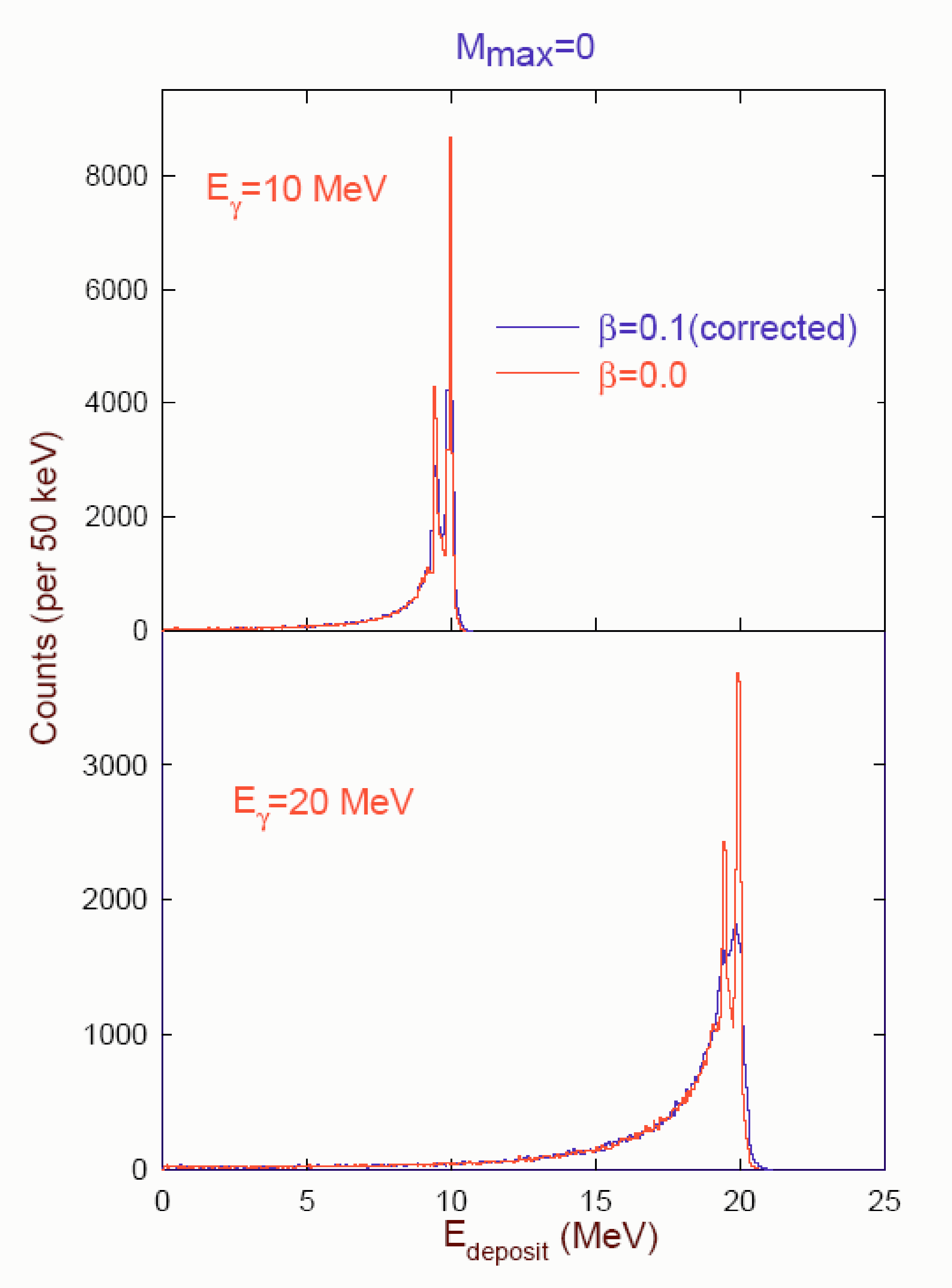


Mmax = 0 β = 0

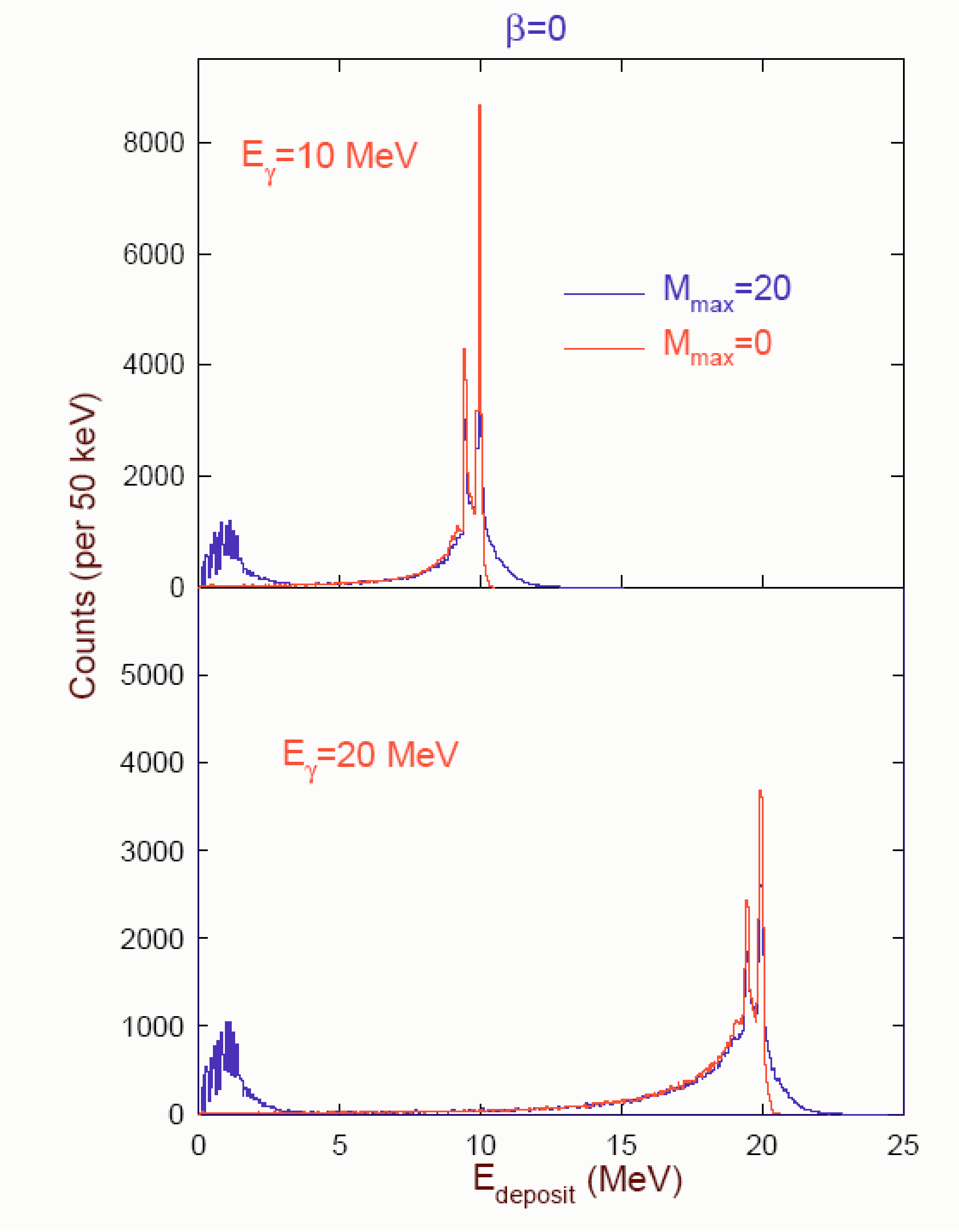

Efficiency of 6-Box Array
(For E>0.99 E_γ^0)
Eff (%)
50
40
30
20
10
0
0
5
10
15
20
25
30
E_γ^0 (MeV)



Effect of Source velocity



Effect of Source velocity



Effect of associated Multiplicity gamma rays : Emax=2.0 MeV

Results:

GDR Spectrum guided continuum gamma energy

CASCADE calculation done for ^{132}Sn bombarding on ^{12}C target with beam energy 800 MeV. This corresponds to the source velocity of $\beta \sim 0.1$

Two sets of GDR parameters taken

Set I: E_D=14.5 MeV and Γ_D=8.0 MeV

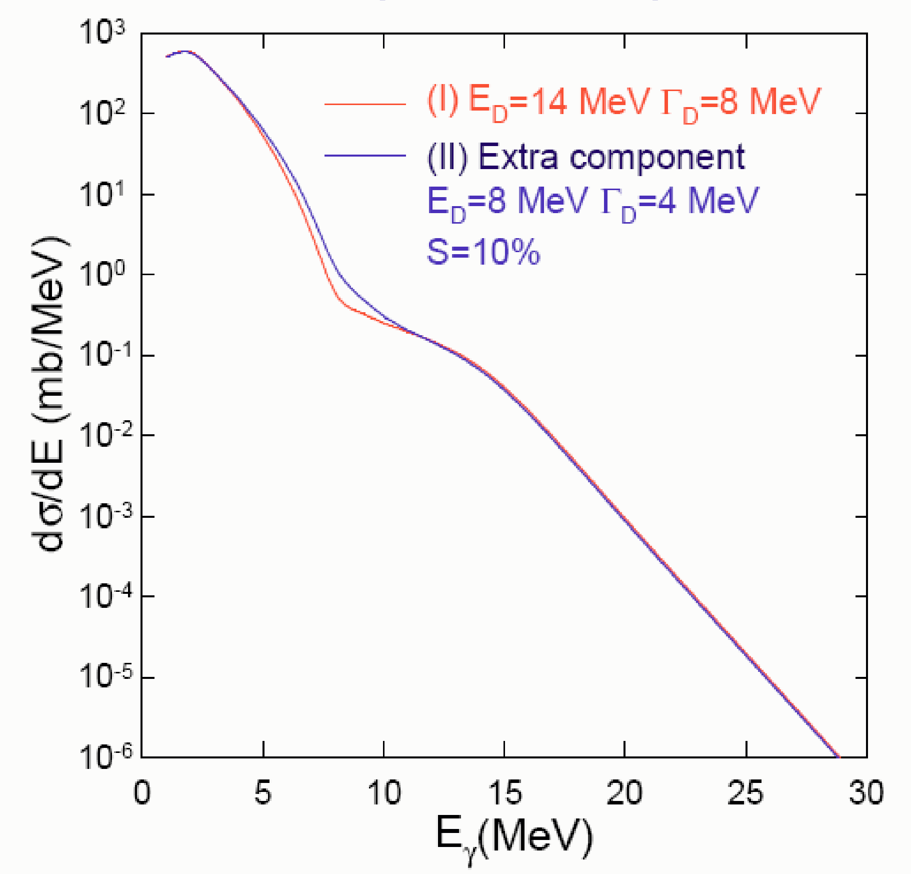
Set II: Main GDR as in set I +

a pygmy resonance with E_D=8 MeV, Γ_D=4 MeV, S=10%

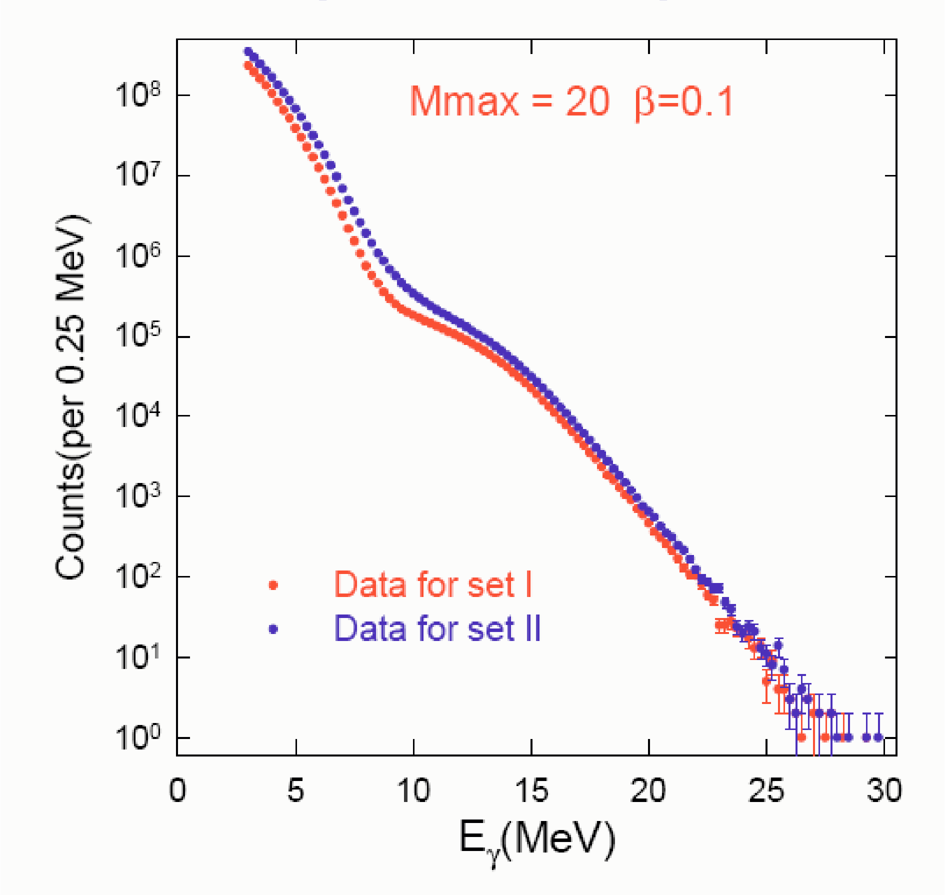
"Experimental" data (list file) created by a random choice of main $E\gamma$ (commensurate with the CASCADE output) and the multiplicity gamma rays, event by event.

The list file analysed with nearest neighbour energy addition and Doppler correction, as mentioned earlier, to create "experimental" gamma spectra

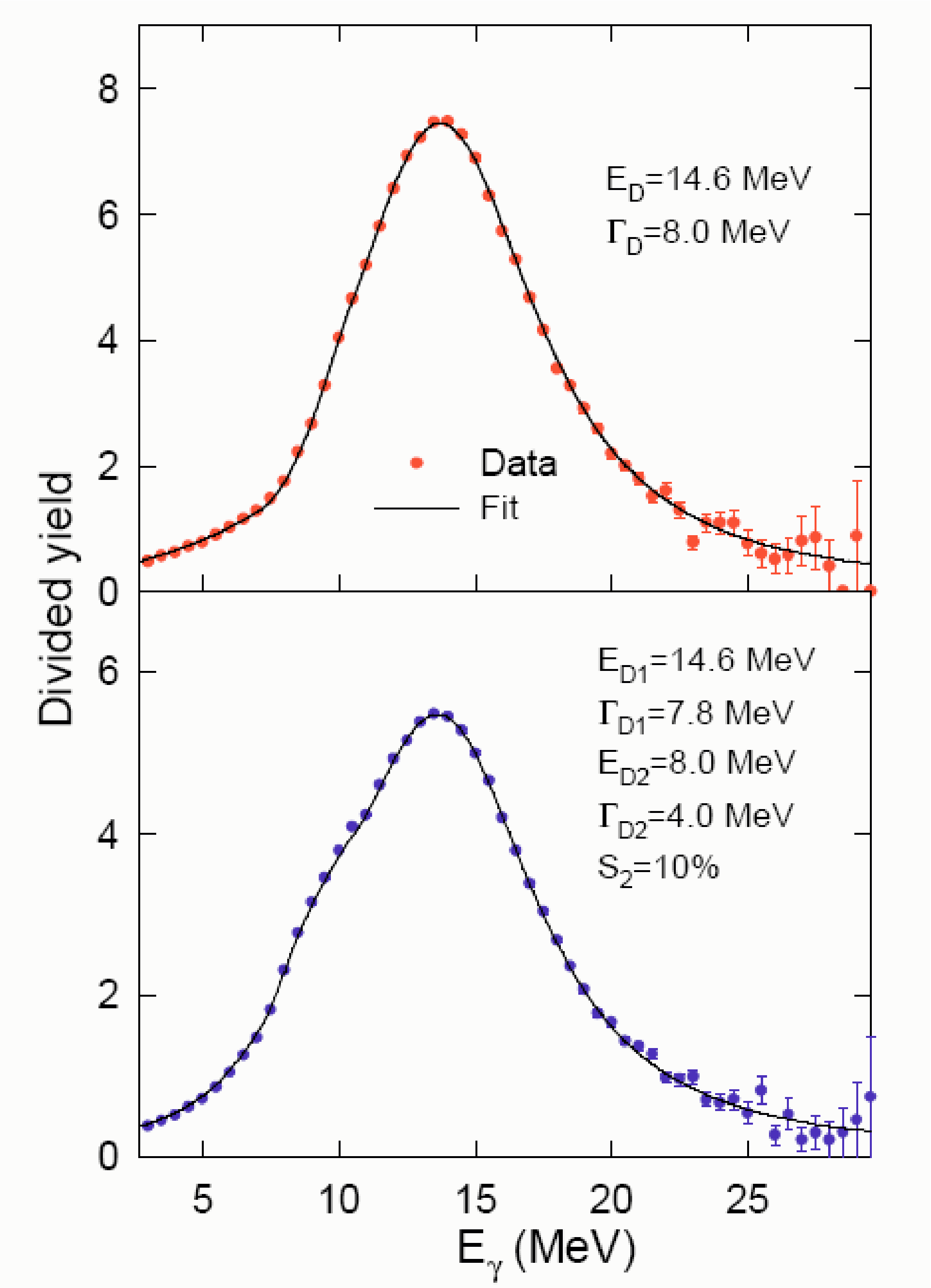
Input Gamma spectra (CASCADE)



Corresponding "Experimental" spectra



The “experimental” spectra then analysed in usual way with EGS response function created with various Mmax



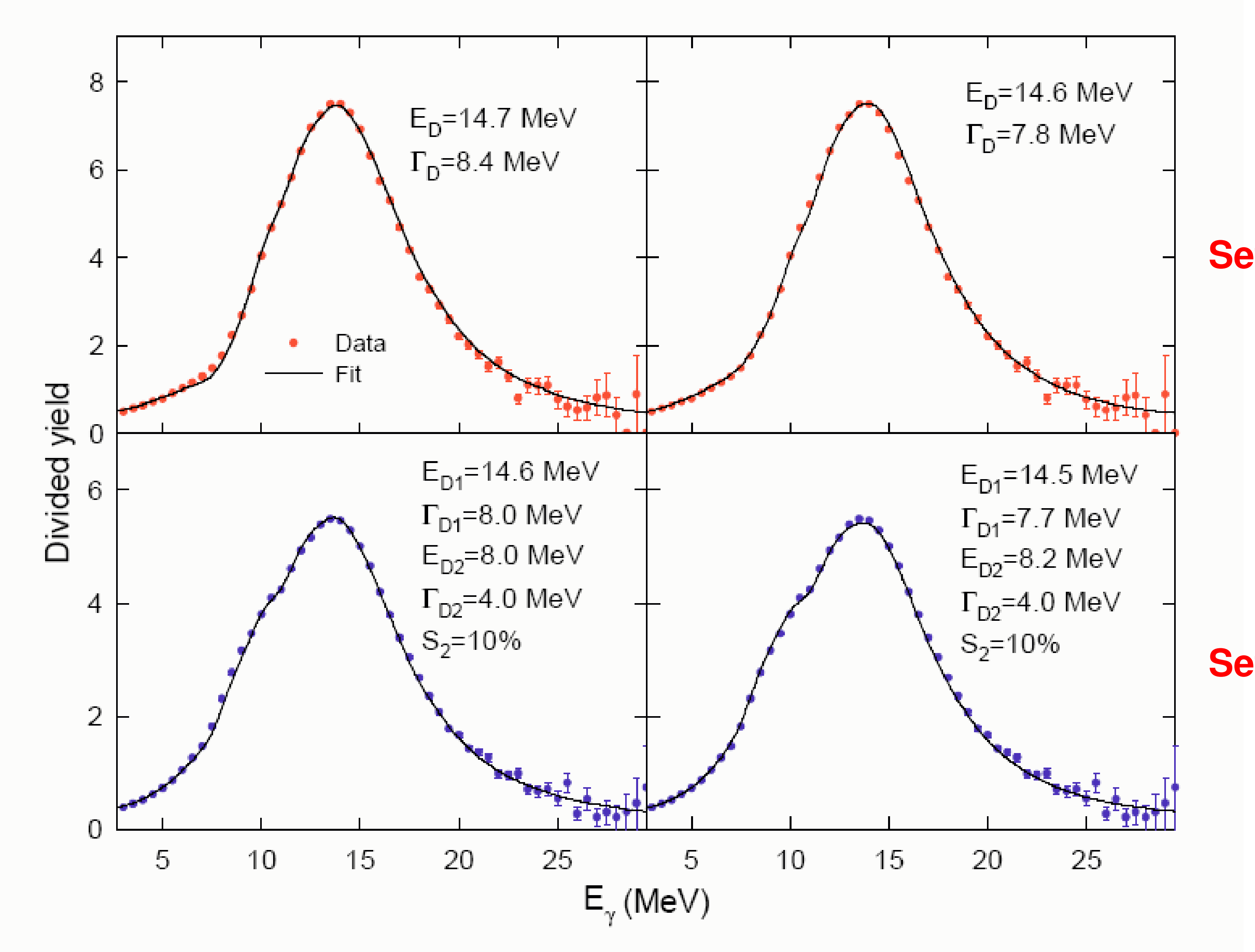
Set I

β=0.1

Data with M_{max}=20

EGS with M_{max}=20

Set II



Set I

Set II

EGS with M_{max}=17

EGS with M_{max}=23

Set I

	E_D (MeV)	Γ_D (MeV)
Input	**14.5**	**8.0**
EGS (Mmax=20)	14.6	8.0
EGS (Mmax=17)	14.7	8.4
EGS (Mmax=23)	14.6	7.8

Set II

	E1	Γ1	E2	Γ2	S2
Input	**14.5**	**8.0**	**8.0**	**4.0**	**10%**
EGS (Mmax=20)	14.6	7.8	8.0	4.0	10%
EGS (Mmax=17)	14.6	8.0	8.0	4.0	10%
EGS (Mmax=23)	14.5	7.7	8.2	4.0	10%

Summary and conclusion

- Presented the EGS simulation of an ideal 6-box detector setup consisting of $LaBr_3$ and CsI
- The algorithm of adding nearest neighbours' energy used
- For the assumed granularity the Doppler correction is reasonably under control
- The presence of associated multiplicity spoils the line shape
- However, with a reasonable uncertainty in the multiplicity distribution around the actual value, one can extract the GDR strength function reasonably well

Thank You