EMC Options Simulation

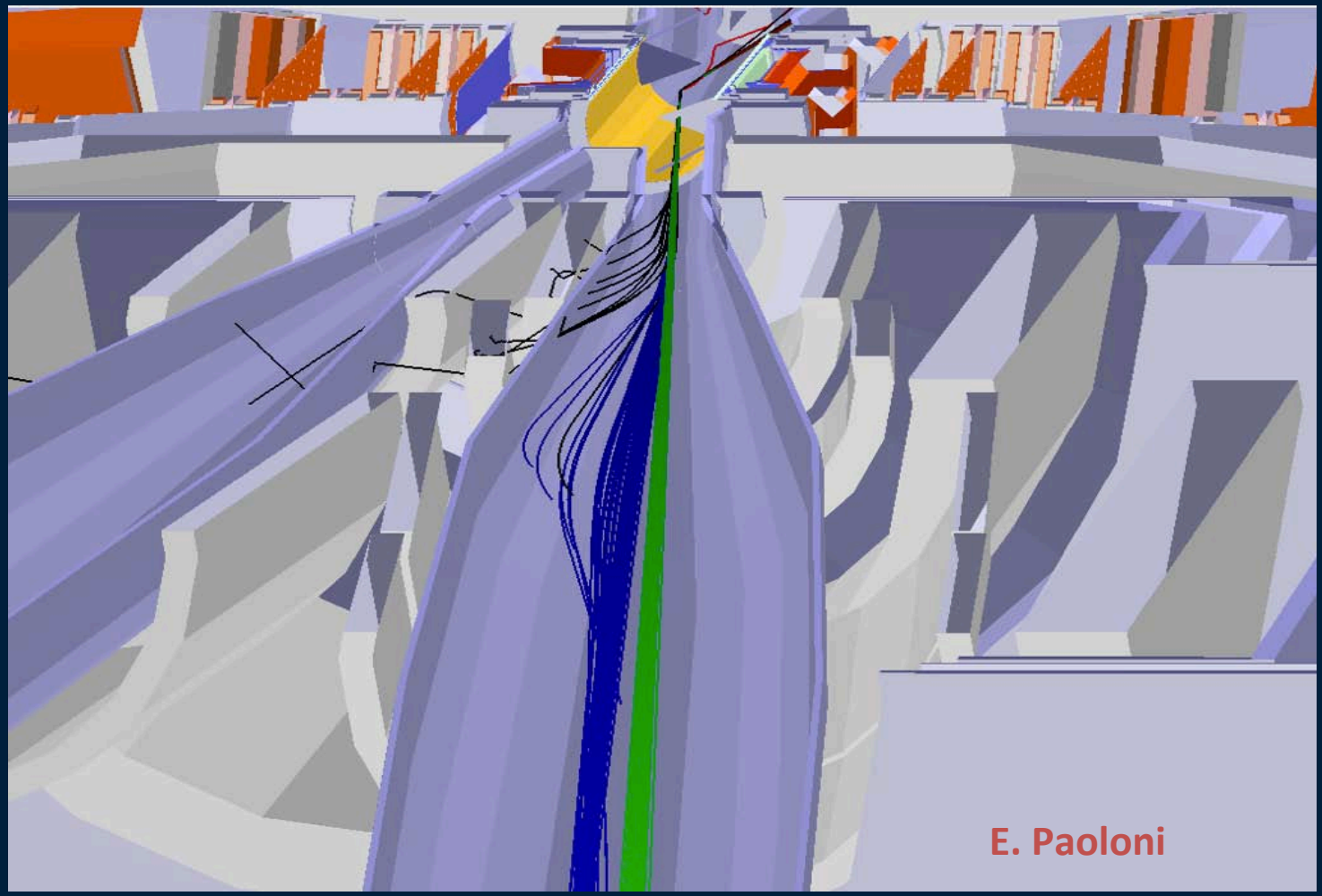
EMC Session
3rd SuperB Collaboration Meeting
LNF
21/3/2012

S. Germani
INFN Perugia

Outline

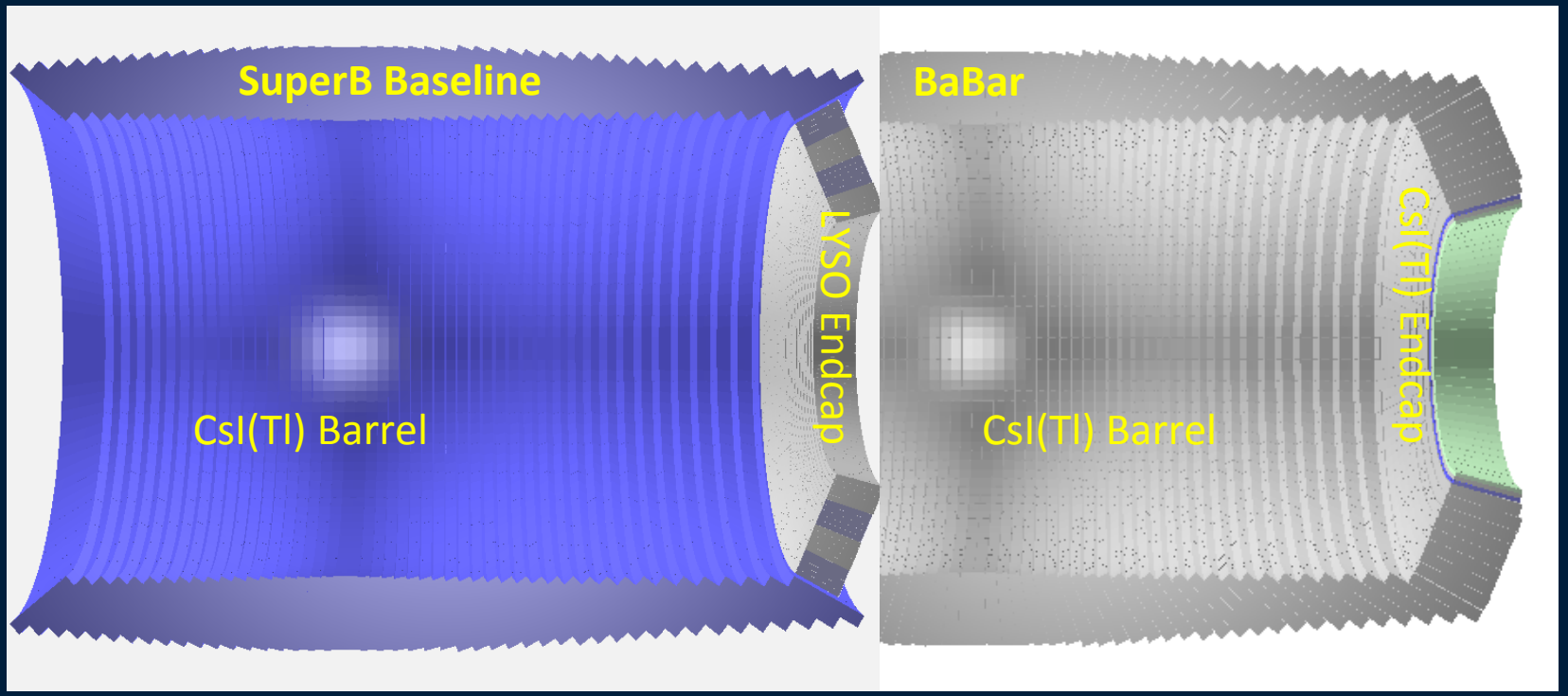
- Simulation Details
  - Geometry Options
  - Electronic Signal and Noise
  - Work flow
  - Background
- Simulation Results
  - Barrel
  - Fwd Endcap Options
- Conclusions and Outlook

Background Event Display



Calorimeter Geometry

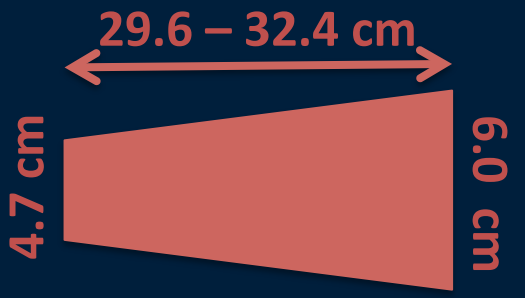
SuperB baseline option for the calorimeter is to reuse the BaBar Barrel and to build a LYSO Forward Endcap



Geometry Options

BaBar Geometry

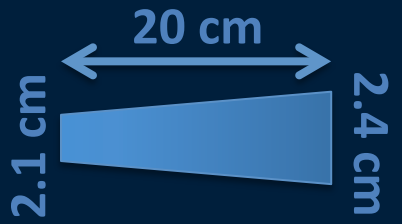
- Barrel — 5768 xtals
- Pure CsI Fwd — 820 xtals



Default SuperB Endcap Geoemtry

- LYSO
- BGO
- PWO

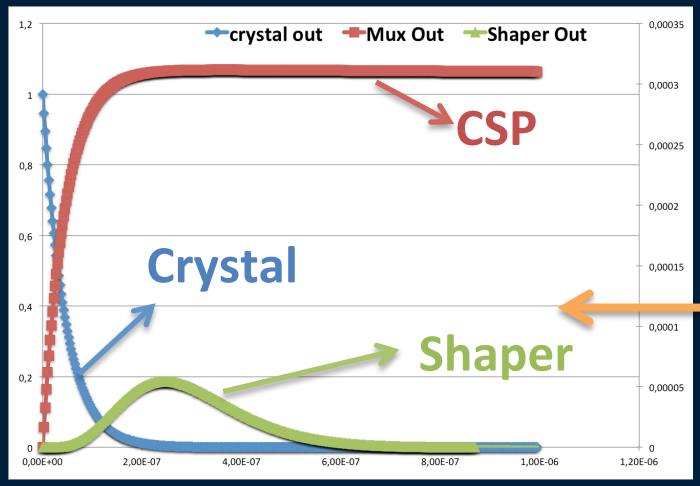
4500 xtals

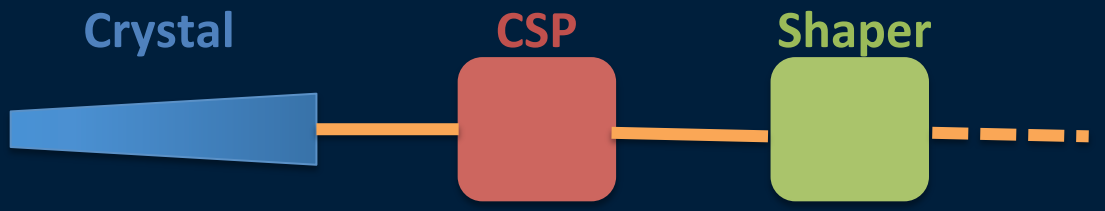


Hybrid Geoemtry

- 3 Babar CsI(Tl) rings close to Barrel + LYSO
  - CsI(Tl) and LYSO simulated separately

ELECTRONICS

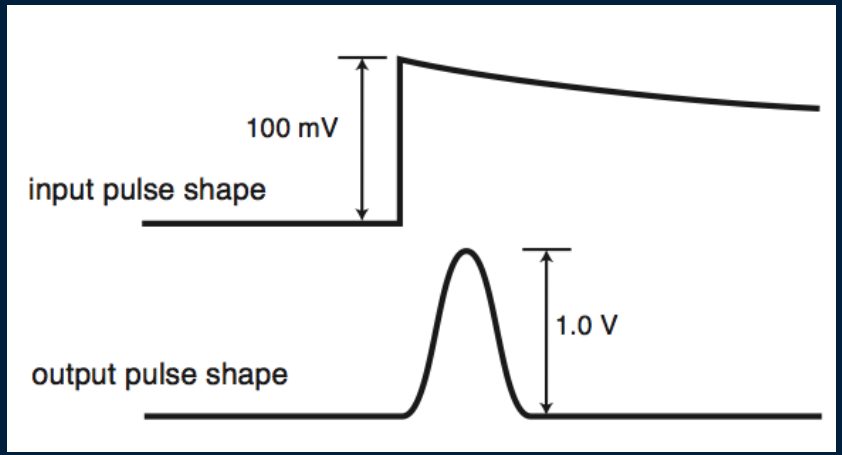




Use Tool provided by V. Bocci to evaluate the response of the Crystal-CSP-Shaper chain

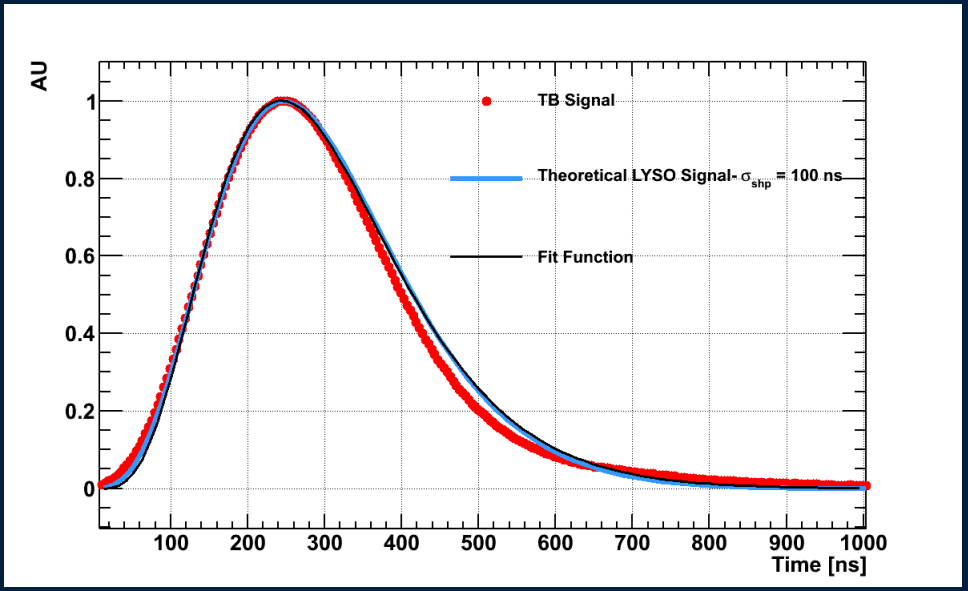
From Shaper Data Sheet

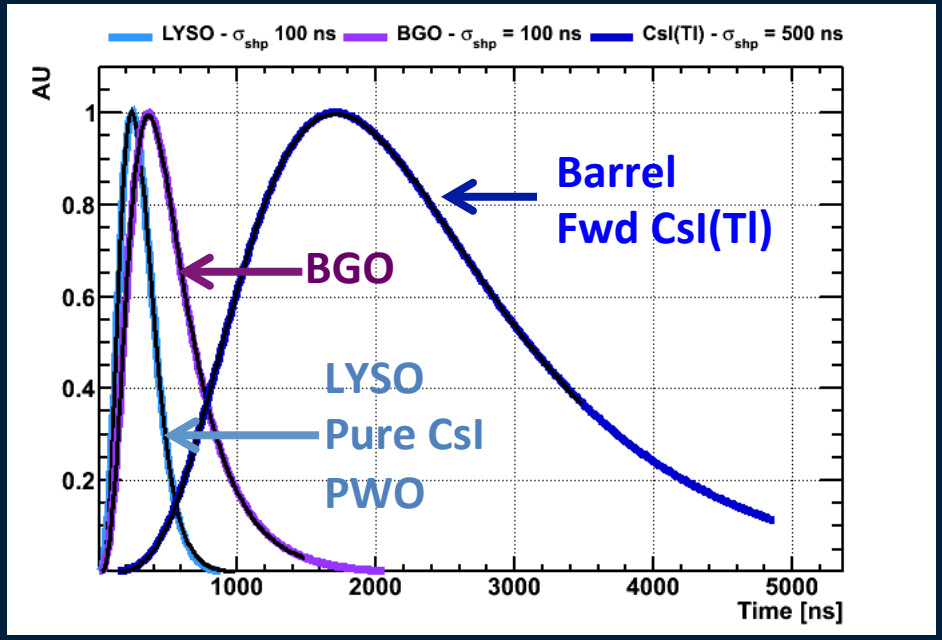
- → Gaussian shaping amplifiers accept a step-like input pulse and produce an output pulse shaped like a Gaussian function…
- → The **shaping time** is defined as the time-equivalent of the "standard deviation" of the Gaussian output pulse
- → The shaping time must be long enough to collect the charge from the detector



Shaper Signal

Theoretical Tool Signal for LYSO gives good agreement with Testbeam data





Output signal shape depends on
- ✓ Shaping Time
- ✓ Input signal

Crystal Type affects Shaper output

Signal/Noise evaluation

In agreement with RY Zhu measuremnts presented today

- All the S/N evaluations start from TB experience
- Electronic Noise RMS is the same for CERN and BTF TB (~2 ADC counts)
  - Noise is mainly generated at the Shaper Level
  - S/N depends on the Signal Amplitude at Shaper input

Crystal	LO [pe/MeV]	Reference
PWO	35	Panda and CMS
BGO	225	RY Zhu paper
CsI	36	A. Rossi meas. with PMT
LYSO	900	RY Zhu measurement
CsI(Tl)	7000	BaBar

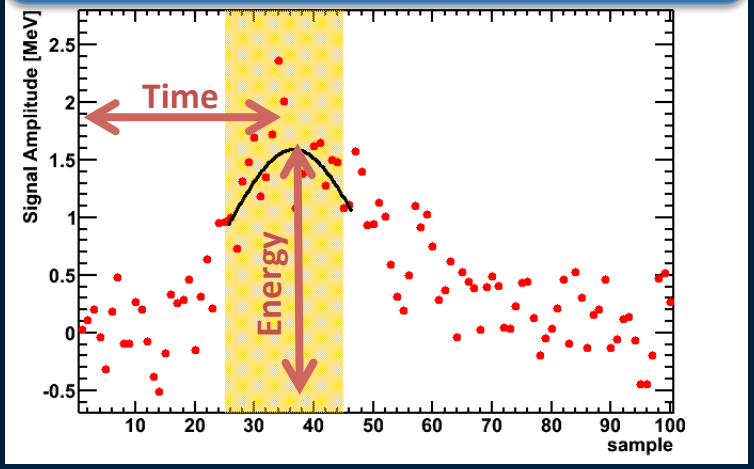
Crystal	Sensor	Sensor Area	Gain	Shaping Time	SN/SN(BTF)
LYSO	APD	0.5 cm2	50	100 ns	**16**
PWO	APD	2 cm2	50	100ns	**0.86**
BGO	APD	0.5 cm2	50	100 ns	**2.1**
CsI	PP	20 cm2	180	100 ns	**6.4**
CsI(Tl)	PIN	4 cm2	1	500 ns	**0.95**
CsI(Tl)	APD	4 cm2	50	500 ns	**48**

Simulation Work Flow

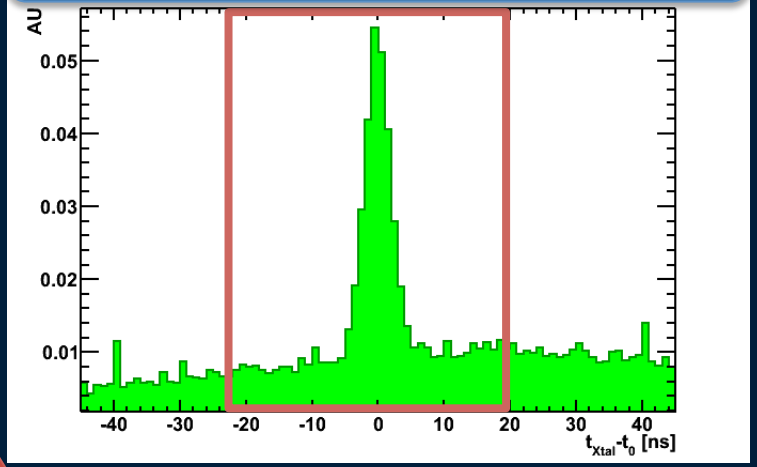
Crystal Energy Deposit (Bruno)

Interleave Single Particles with Background evts. (Rad Bhabha)

Get Energy and Time from Electronic Signal Peak



Select Crystals within Time Window

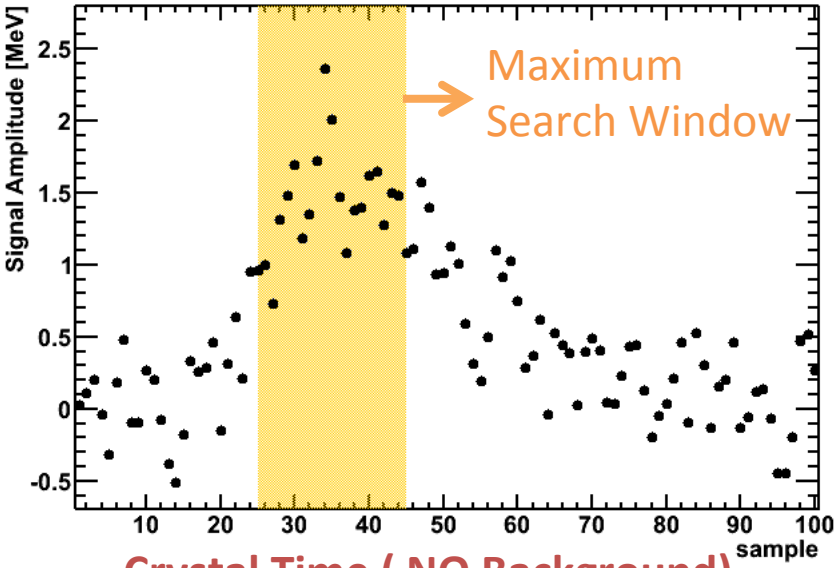


Clustering (BaBar algorithm)

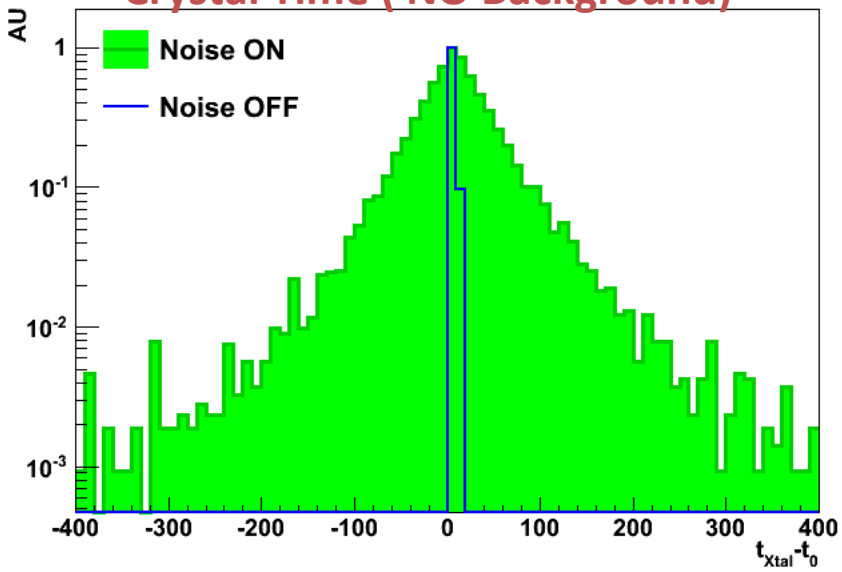
Select Signal Cluster for Performance Studies

Electronic Signal Time

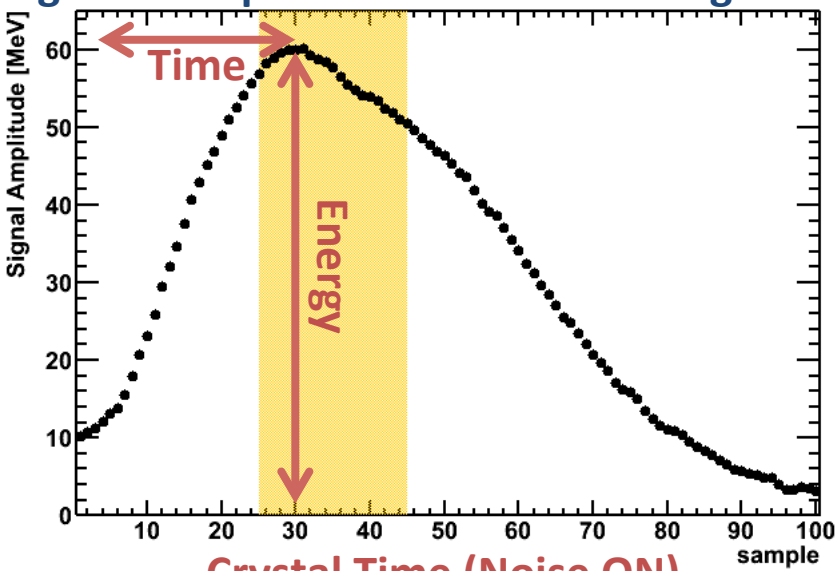
Signal Example 1 – Noise ON - NO Background



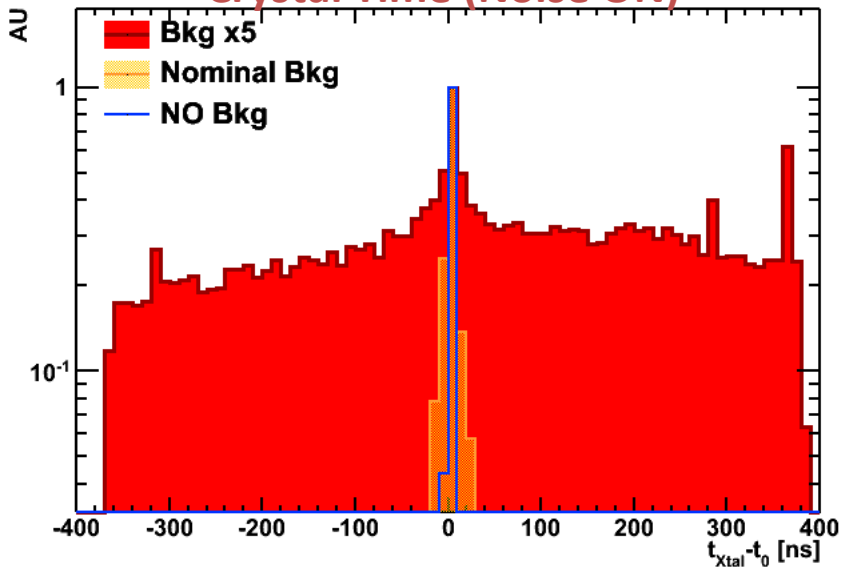
Crystal Time (NO Background)



Signal Example 2 – Noise ON – Background x5

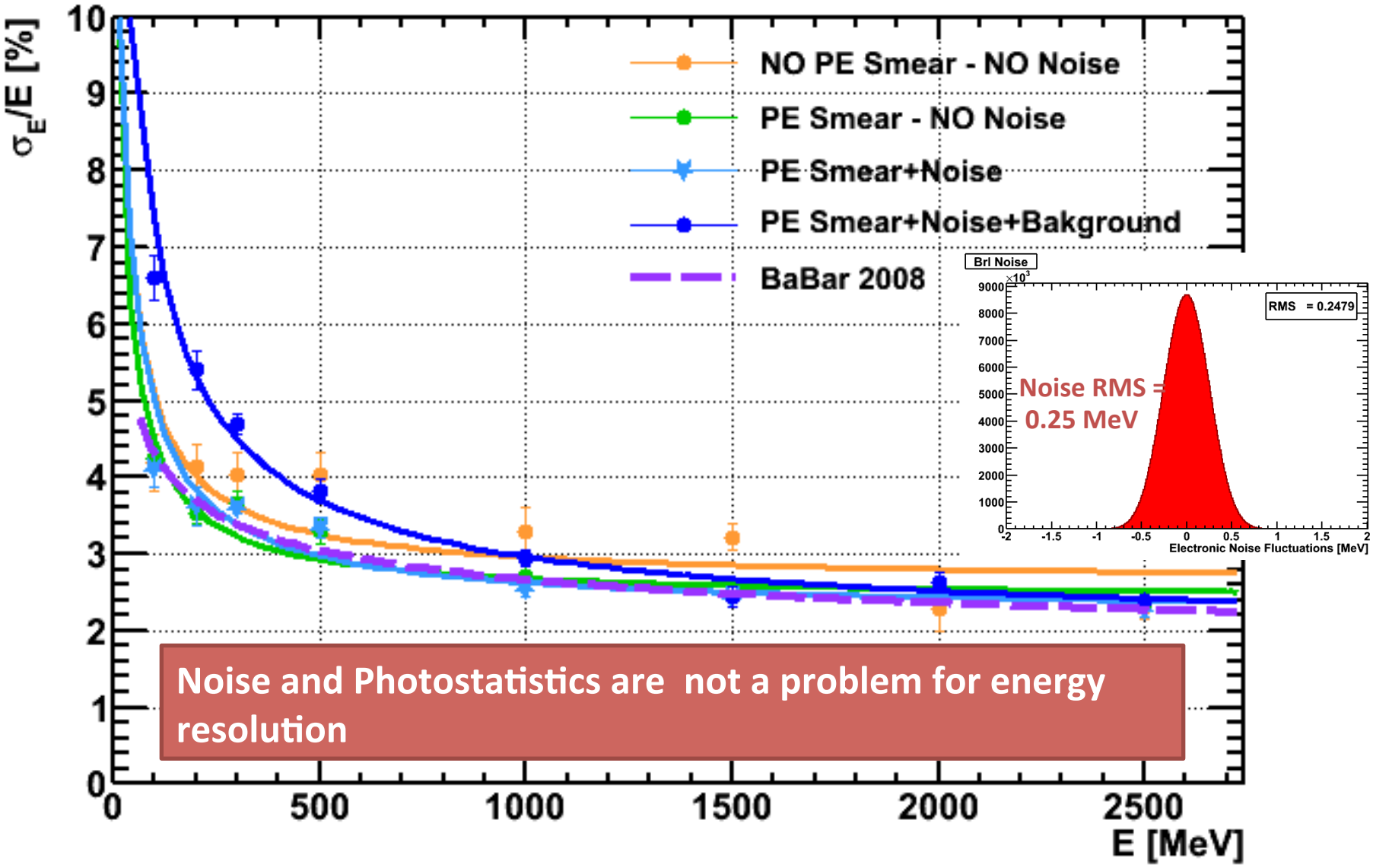


Crystal Time (Noise ON)

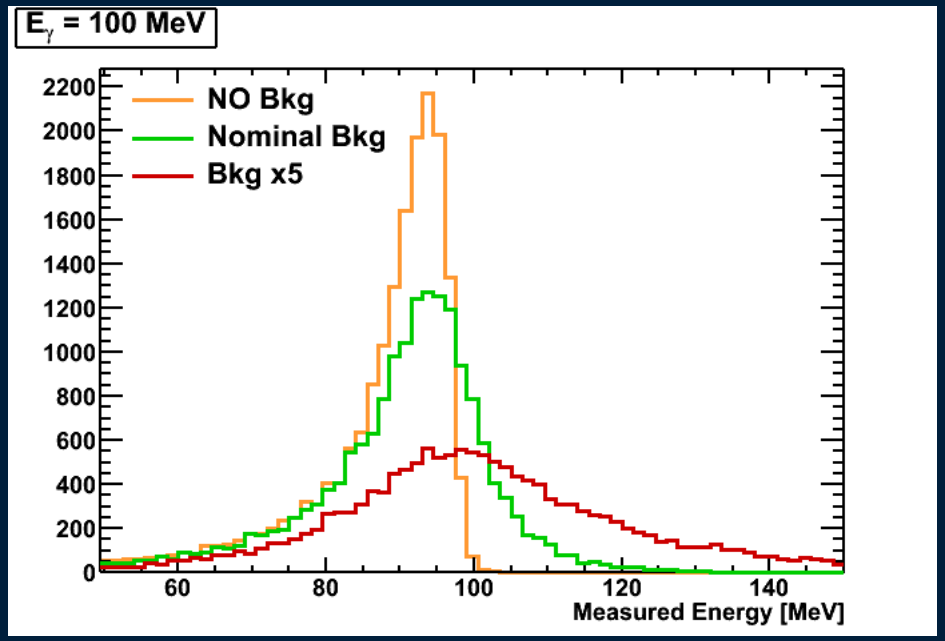


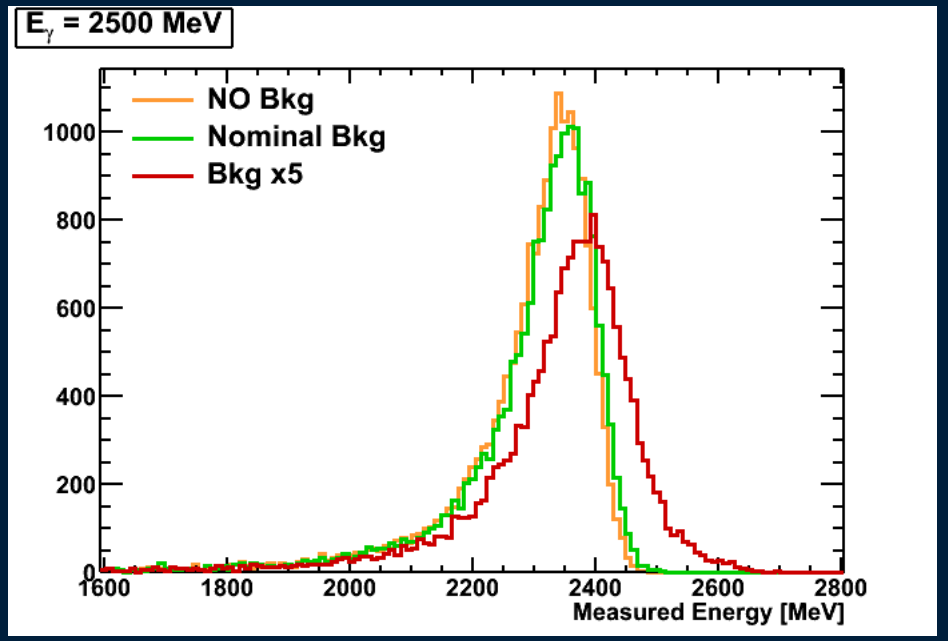
Barrel Results

BARREL


σ_E/E [%]
E [MeV]
NO PE Smear - NO Noise
PE Smear - NO Noise
PE Smear+Noise
PE Smear+Noise+Bakground
BaBar 2008
Brl Noise
RMS = 0.2479
Noise RMS = 0.25 MeV
Electronic Noise Fluctuations [MeV]
Noise and Photostatistics are not a problem for energy resolution

Barrel Energy distributions



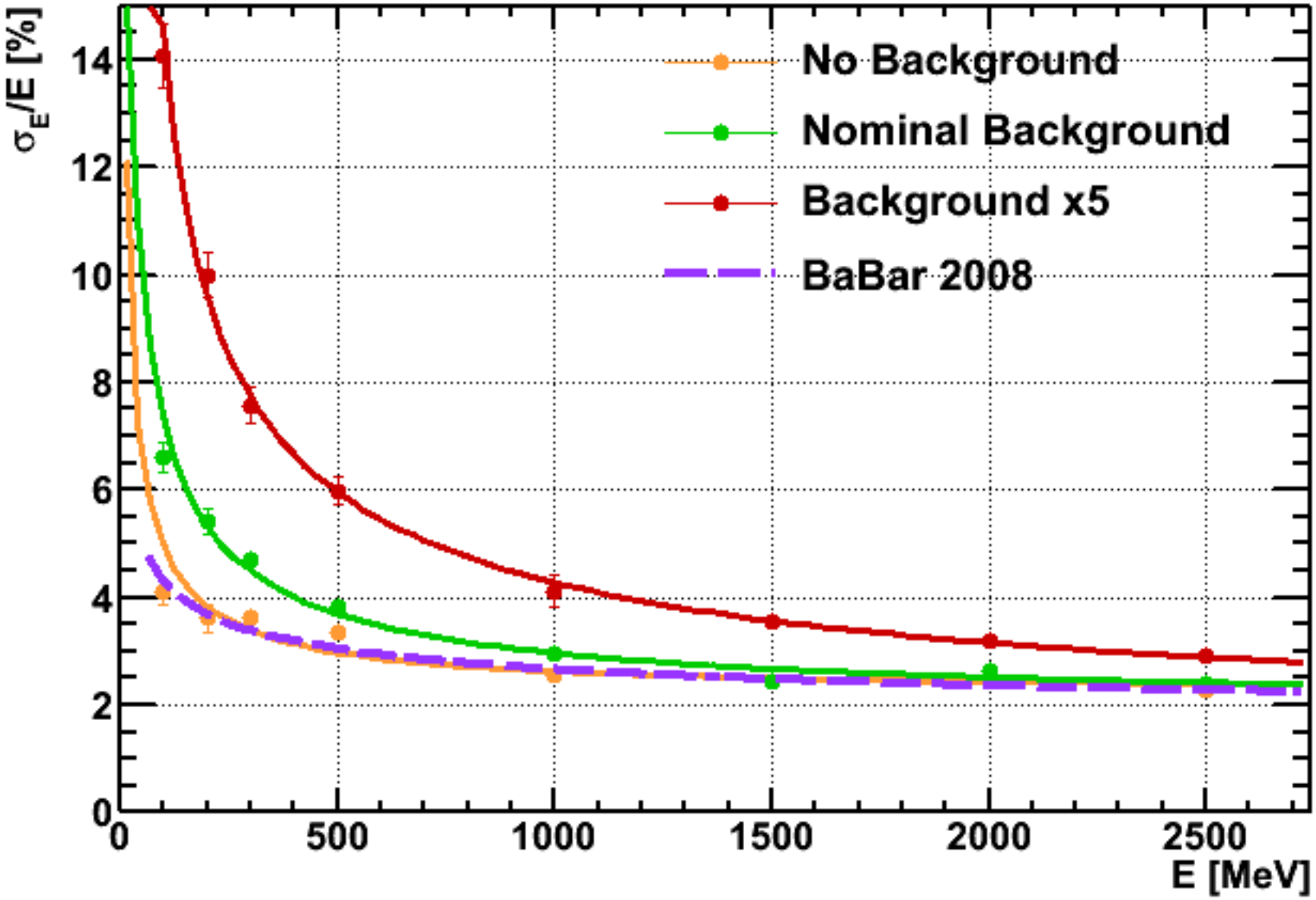


→Background has significant impact on Energy Resolution

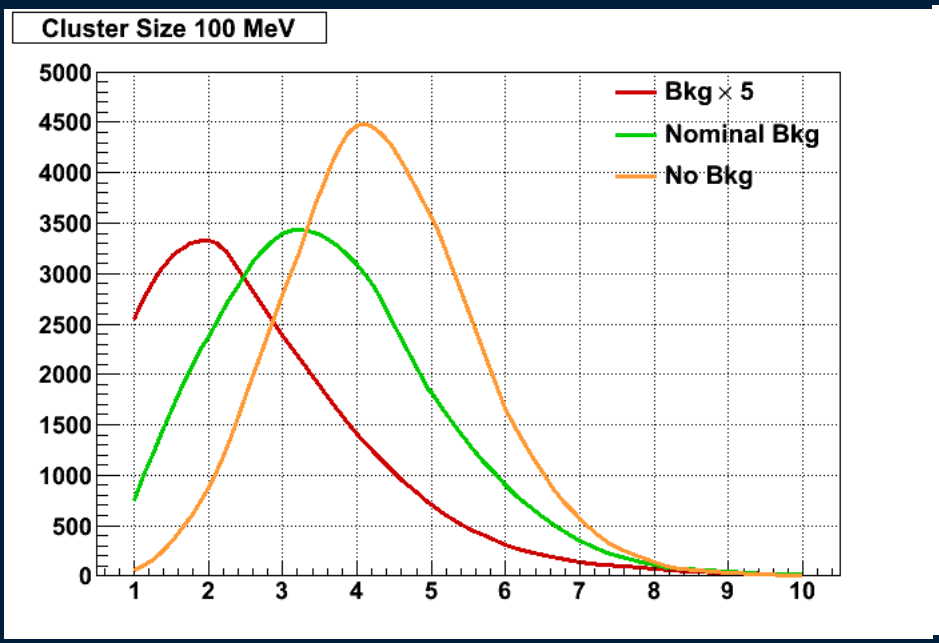
→Background shifts peak energy toward higher values

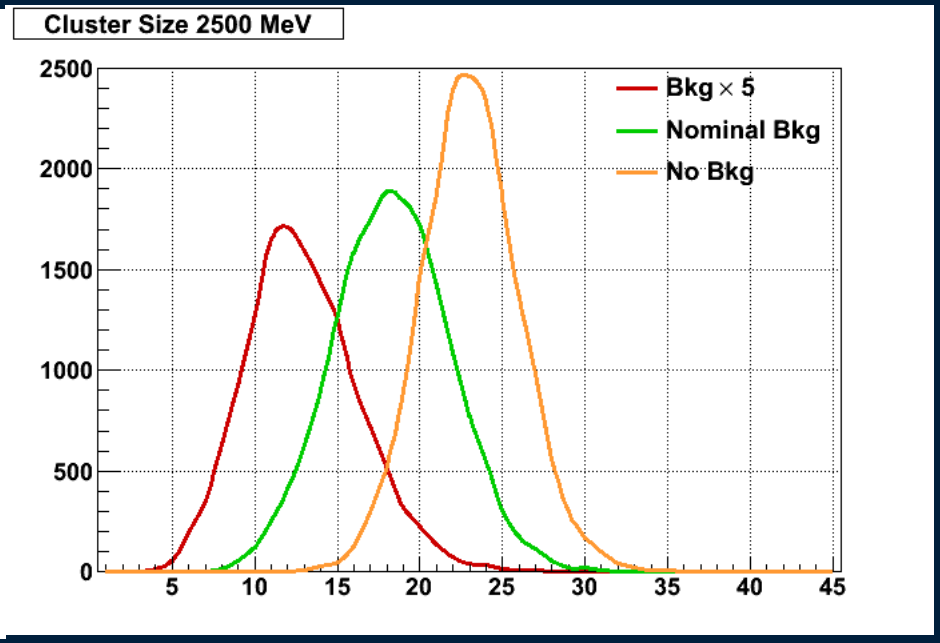
- ✓ Background adds extra energy to signal crystals

Barrel – Eres vs Background Level



Signal Cluster Size



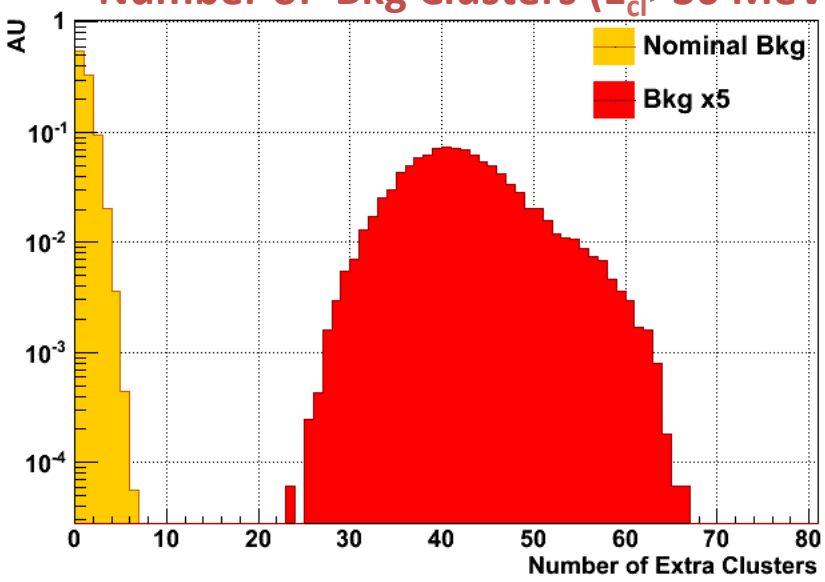


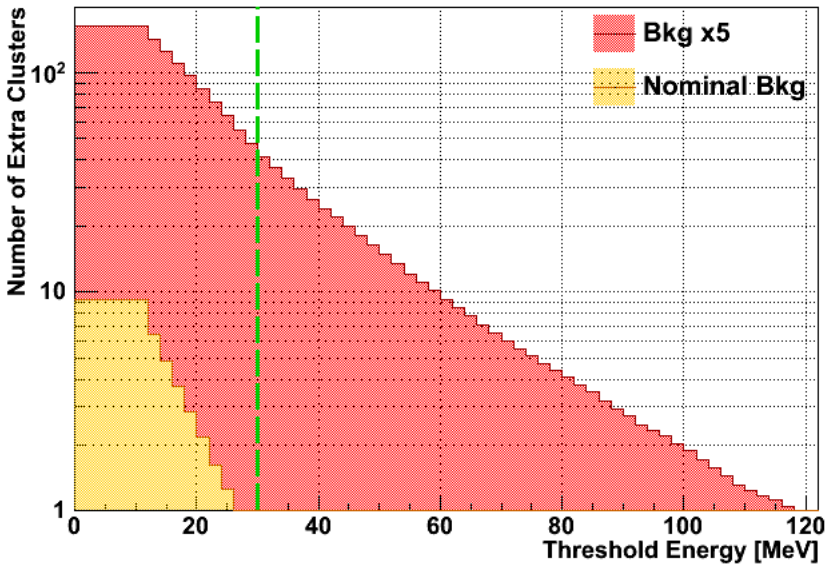
Background reduces signal cluster size

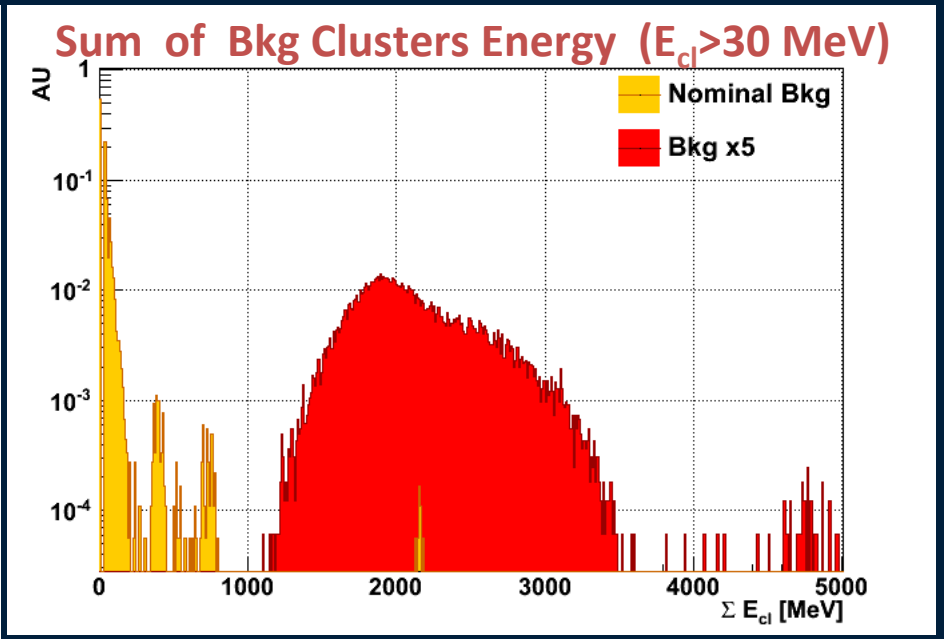
- ✓ The effect is related to signal shape distortion for low energy crystals
- ✓ Signal peak moves out of the time window

Signal Time Window already optimized to get the best resolution (300 ns)

Number of Clusters



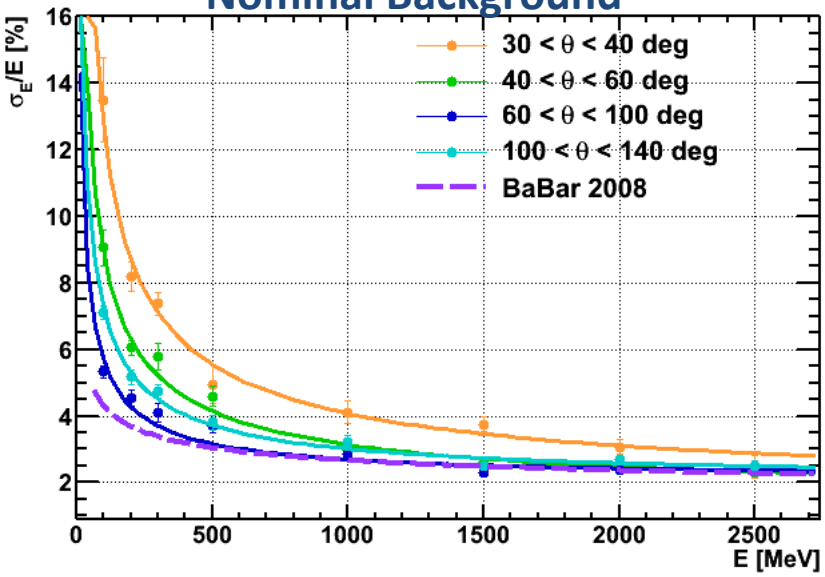




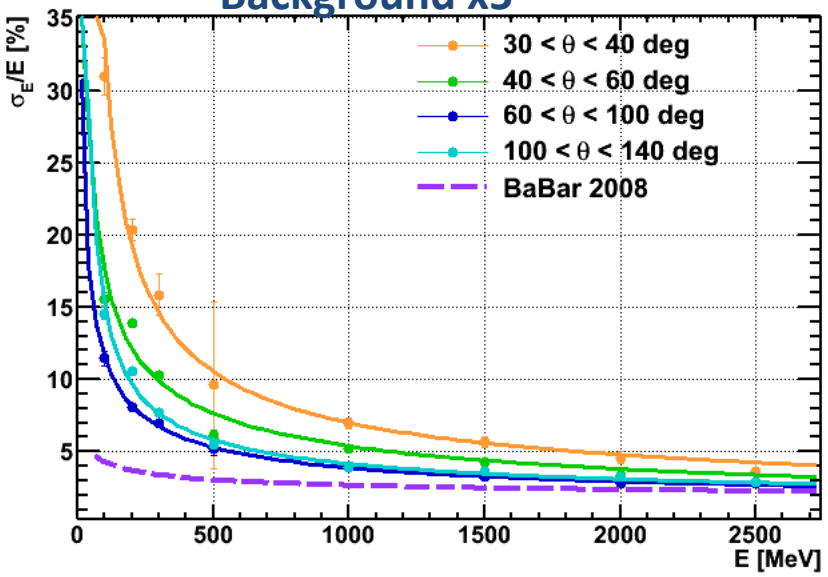
- ✓ Large difference between nominal background and x5 safety factor
- ✓ High multiplicity with x5 background

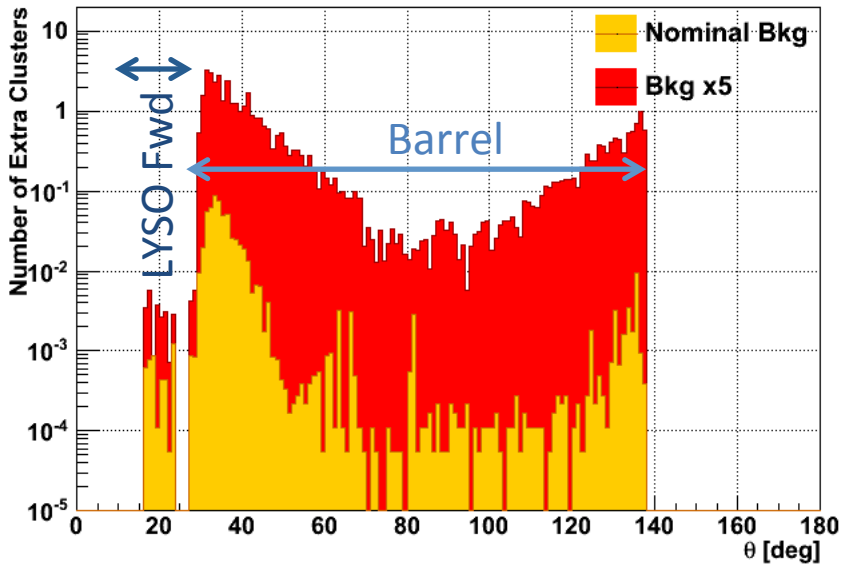
Barrel Performance vs Theta

Nominal Background



Background x5

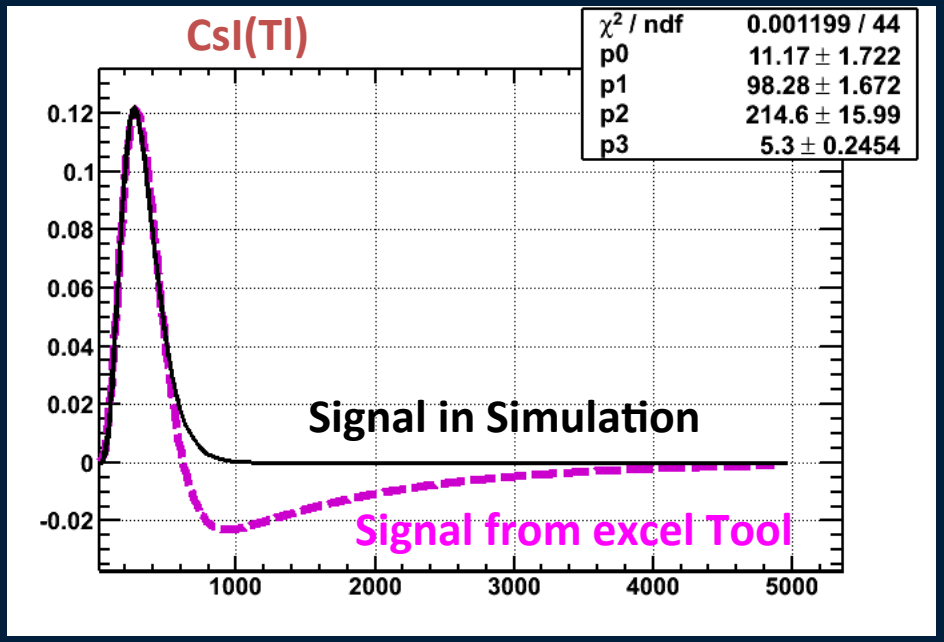


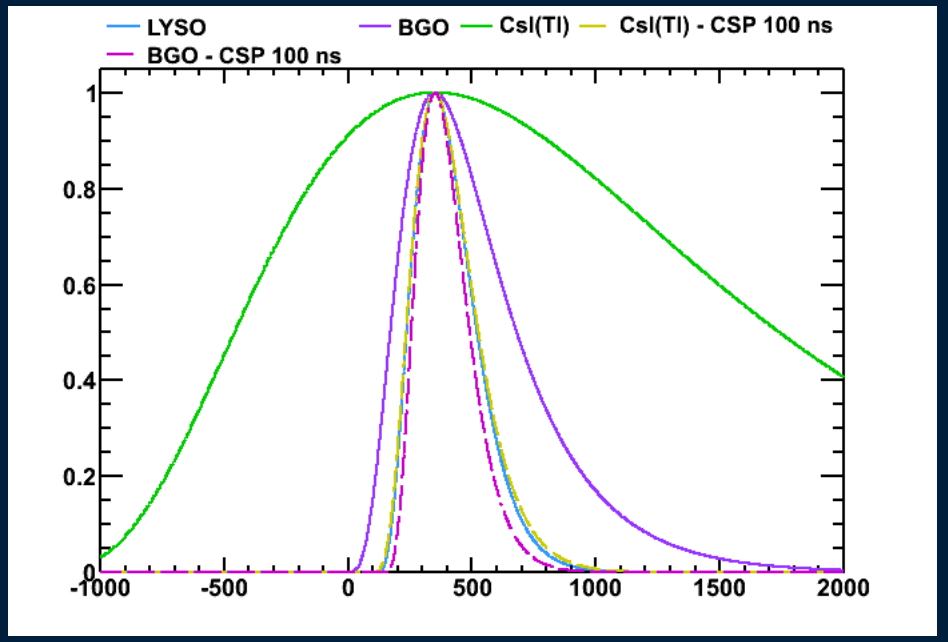


CSP WITH 100 NS RC - SIMULATION

Try to shorten signal from long CsI(Tl) time constant using a CSP wit 100 ns RC constant instead of 140 µs used at TB

- ✓ Overshoot correction is beyond the simple excel tool purpose
- ✓ According to Valerio my "hand-made" correction is reasonable
- ✓ Signal amplitude is the same as for 140 µs CSP (need measurements to feed simulation with realistic numbers)



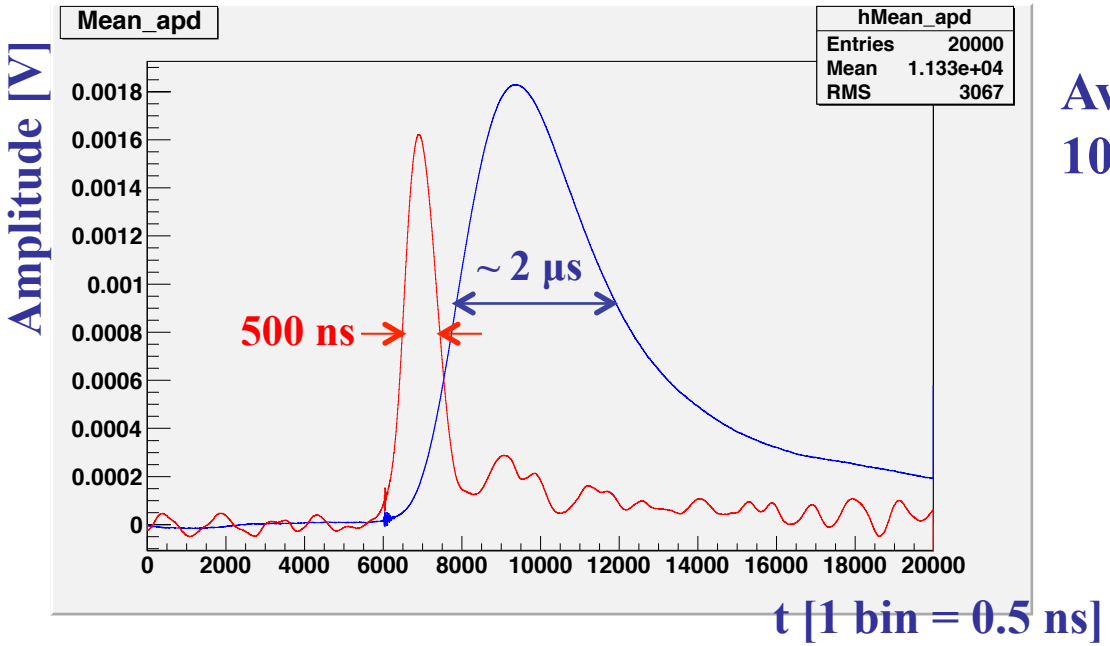


CSP WITH 100 NS RC - MEASUREMNTS

Measurments performed at Rome show that reading out CsI(Tl) with 100 ns CSP and 100 ns Shaper may be possible (see P. Gauzzi talk at EMC II session).

1) CSP Cremat integr. time = 140 µs + shaping time = 500 ns

2) CSP Hamamatsu integr.time = 100 ns + shaping time = 100 ns

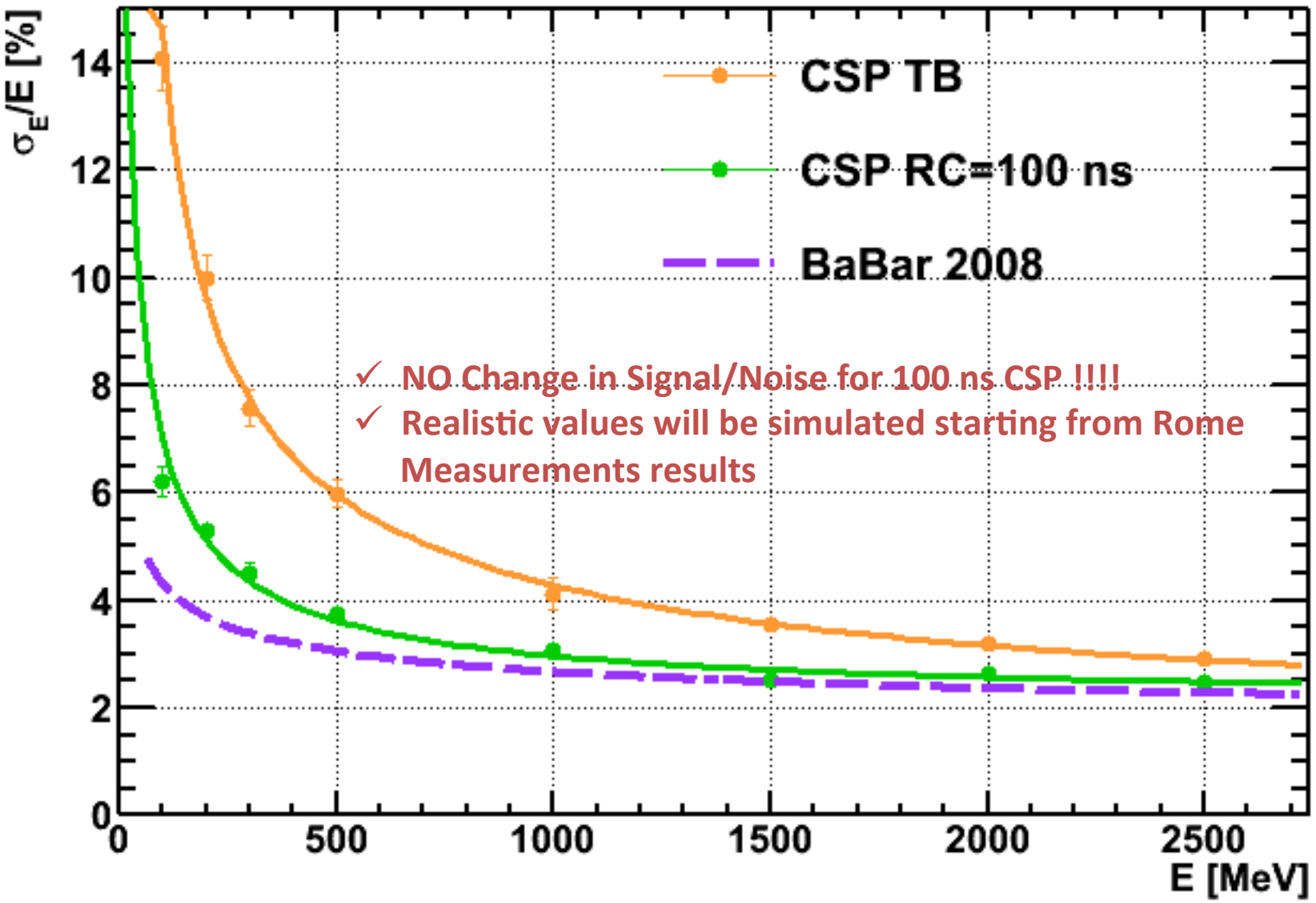


Average over 100000 waveforms

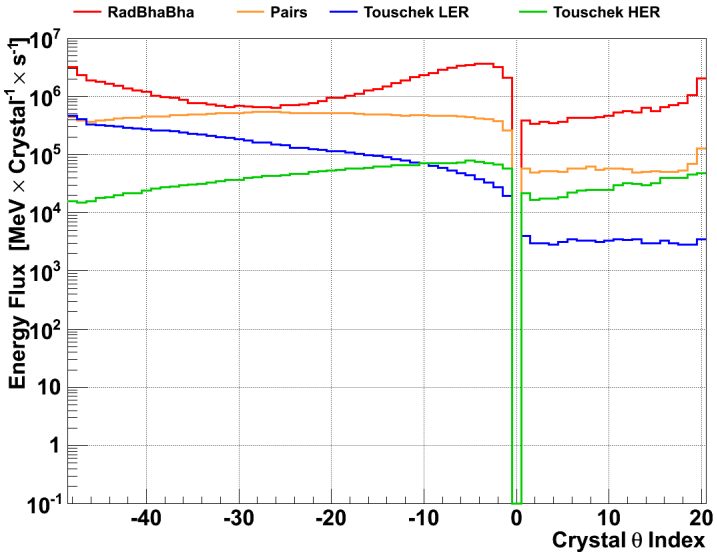
P. Gauzzi

Need a precise signal and noise amplitude assessment to feed simulations

Barrel x5 Background – Compare CSP

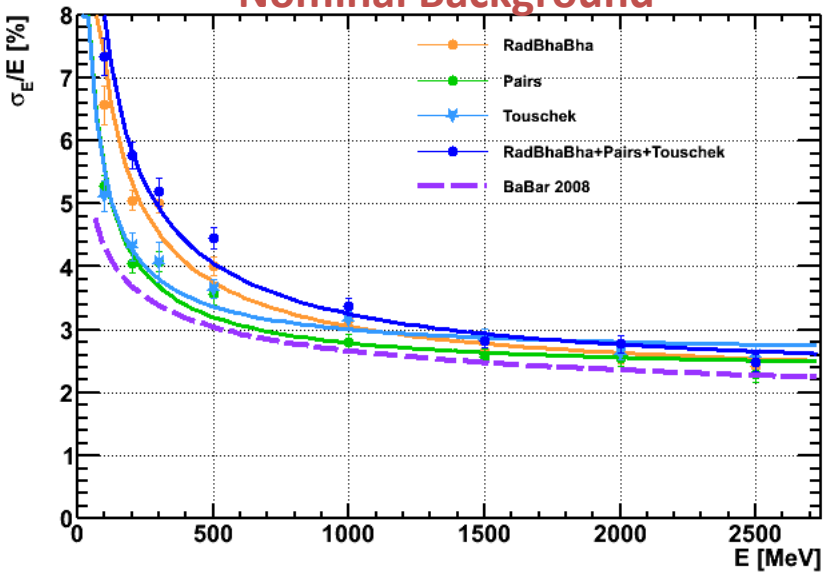


Barrel – Background Types

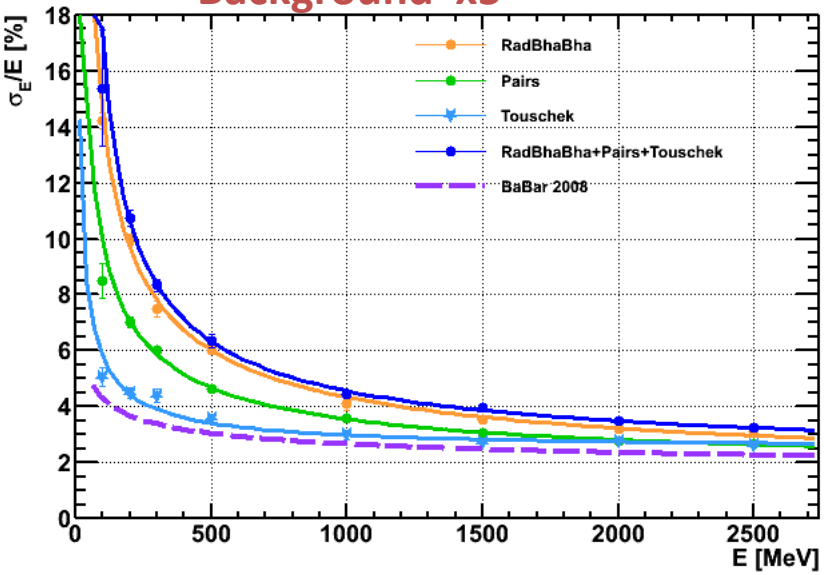


- ✓ Tool from A. Perez allows to study Touschek together with RadBhaBha and Pairs
- ✓ Resolution is mainly affected by Radiative Bhabha background
- ✓ Cumulative effect of Pairs+Touschek +RadBhaBha is close to RadBhaBha alone

Nominal Background

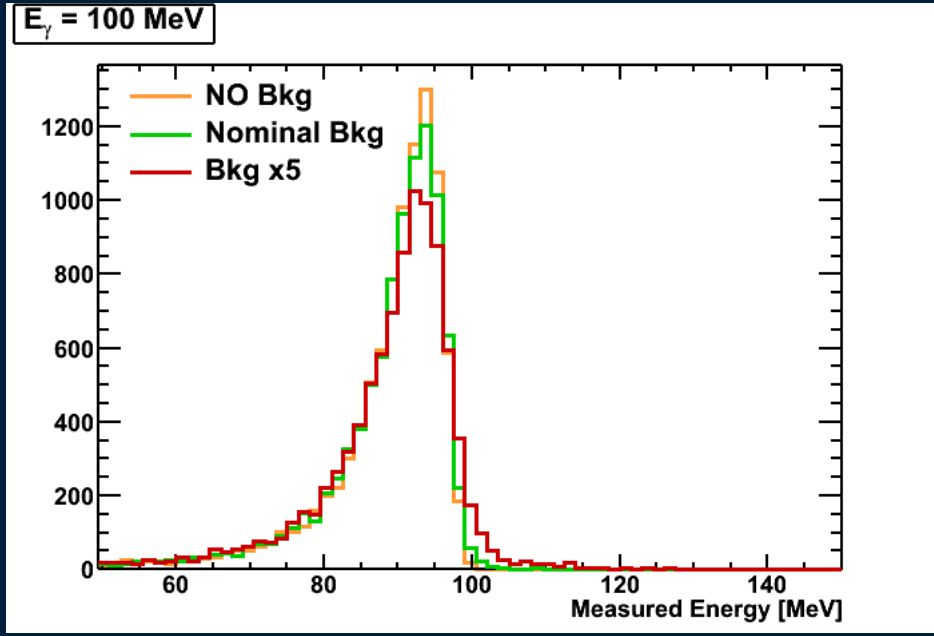


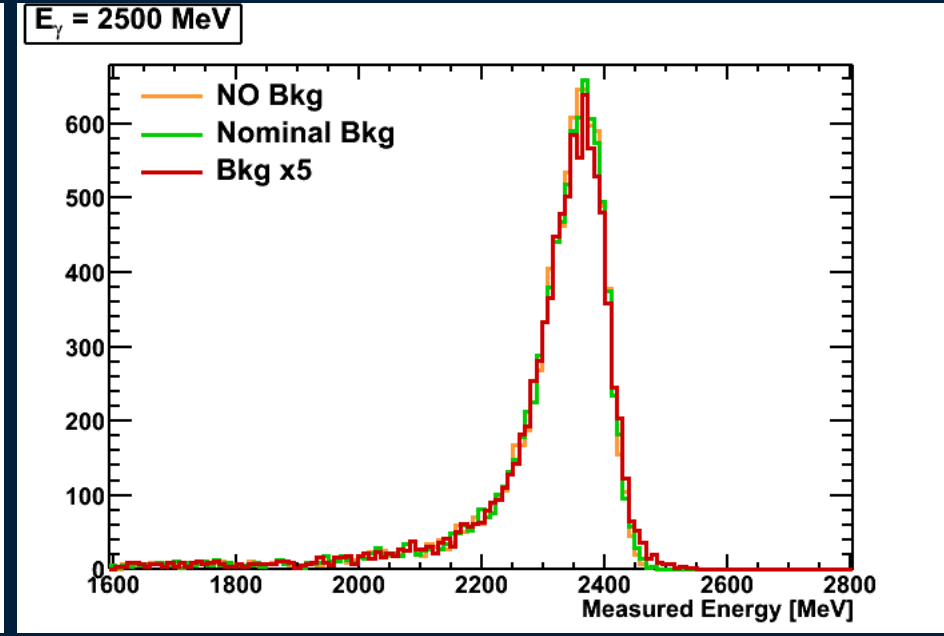
Background x5



Fwd Options Results

LYSO Energy distributions

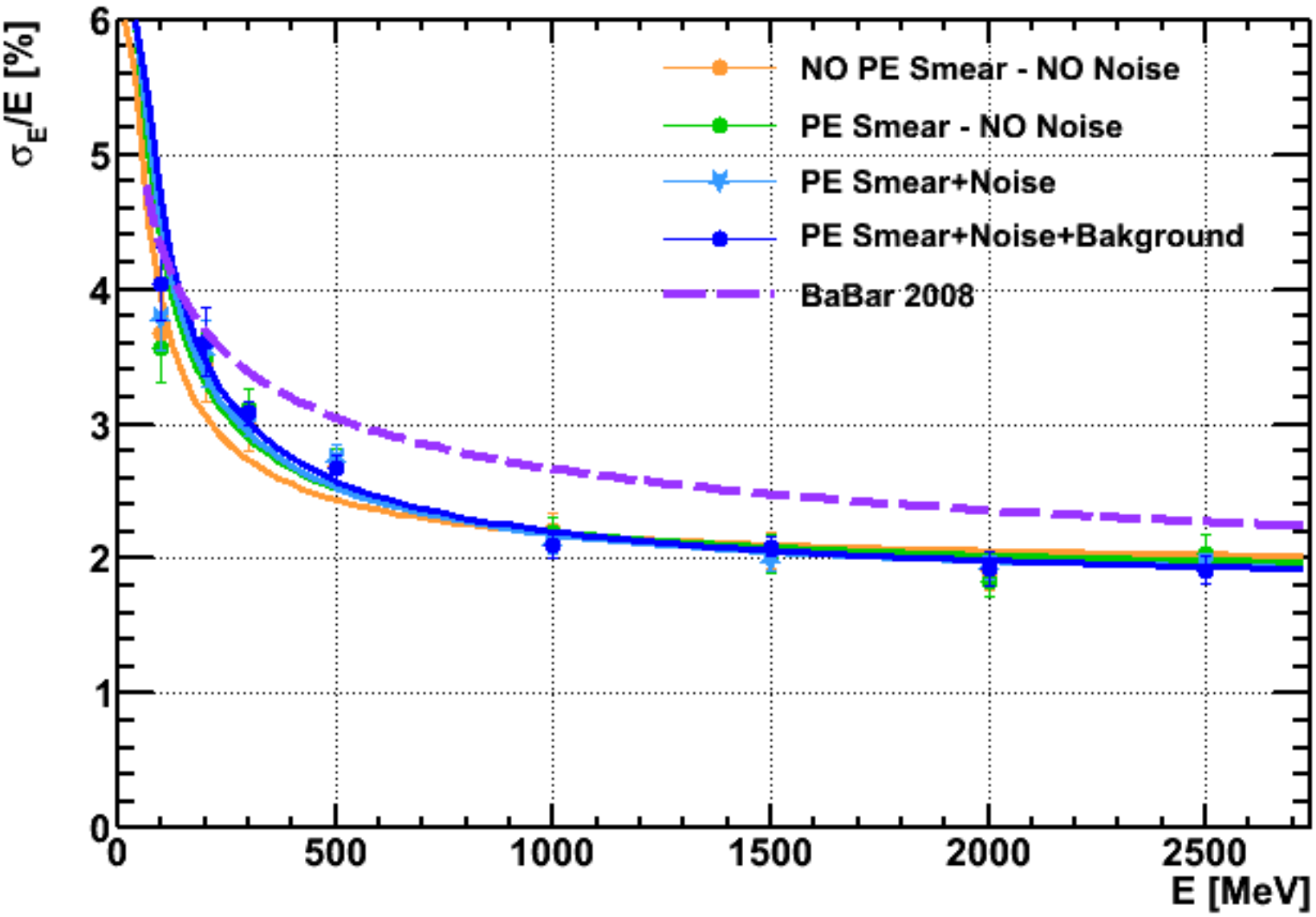




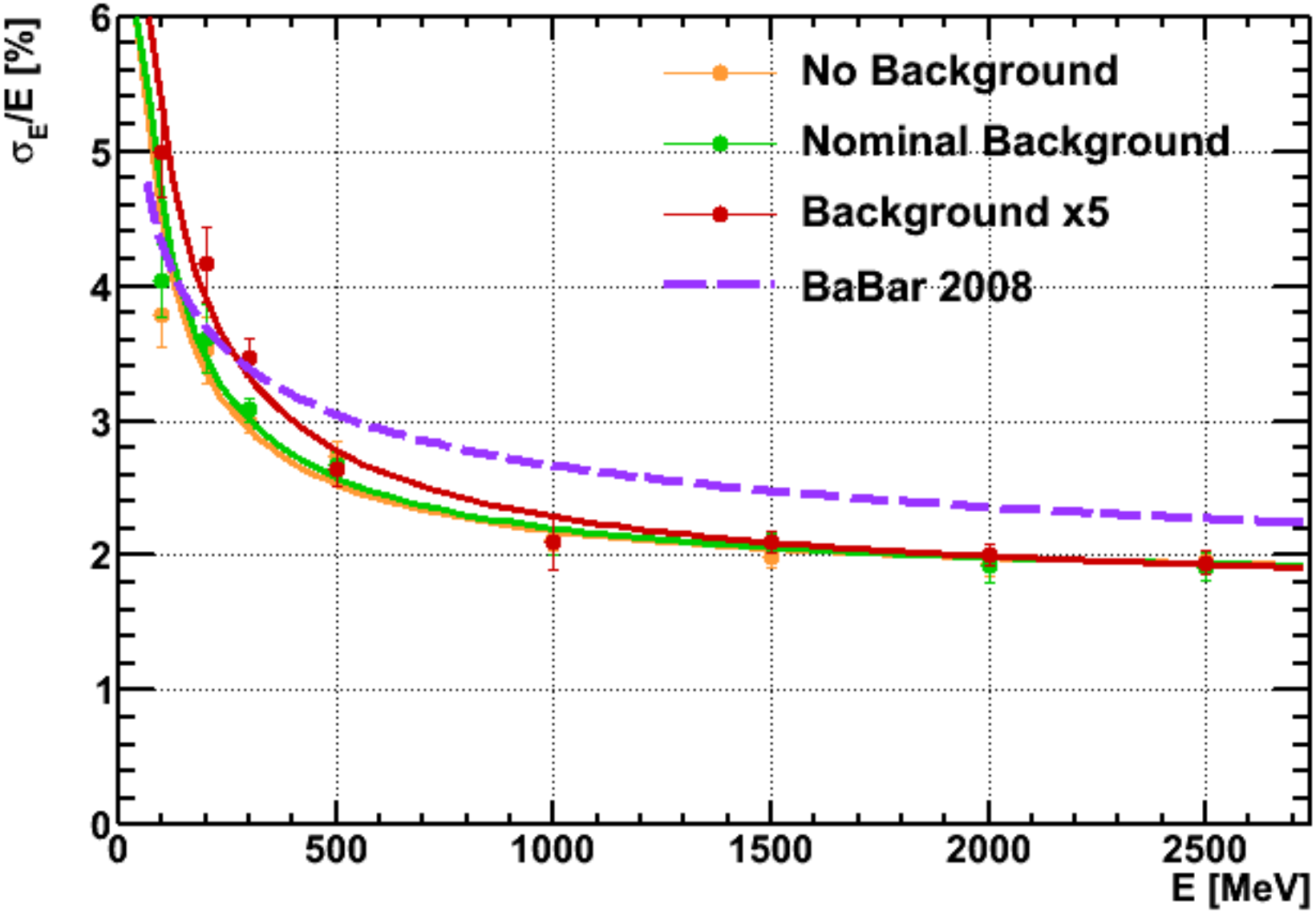
→Background has small impact on Energy Resolution

→Background does not shift peak energy

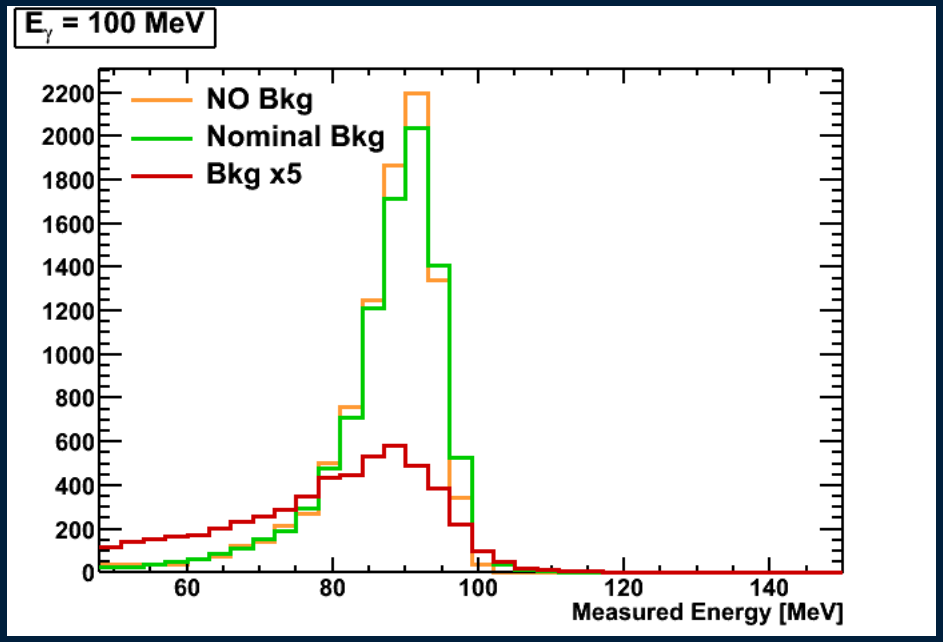
LYSO Resolution Components

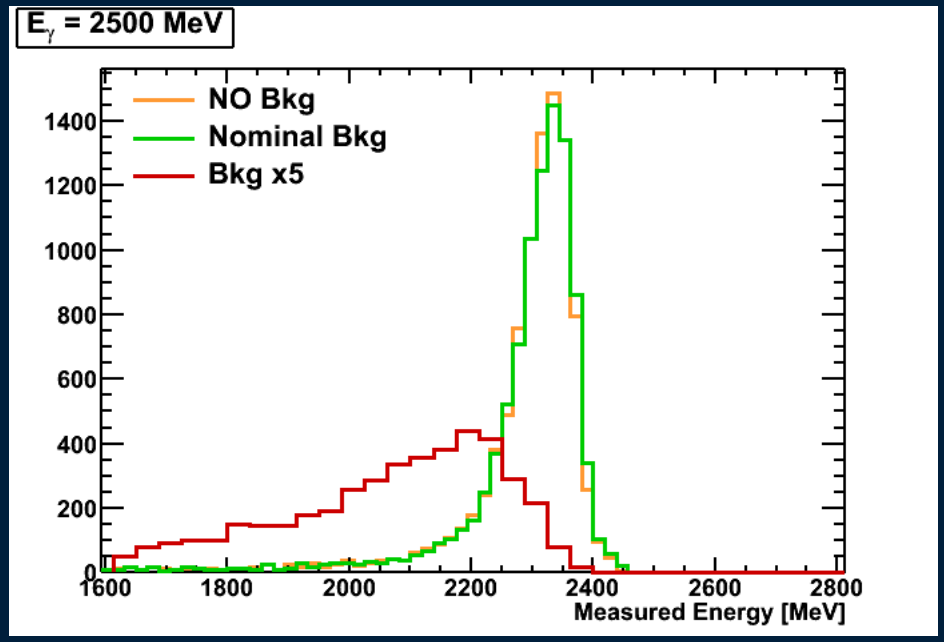


LYSO – ERES VS BACKGROUND LEVEL



BGO Energy distributions



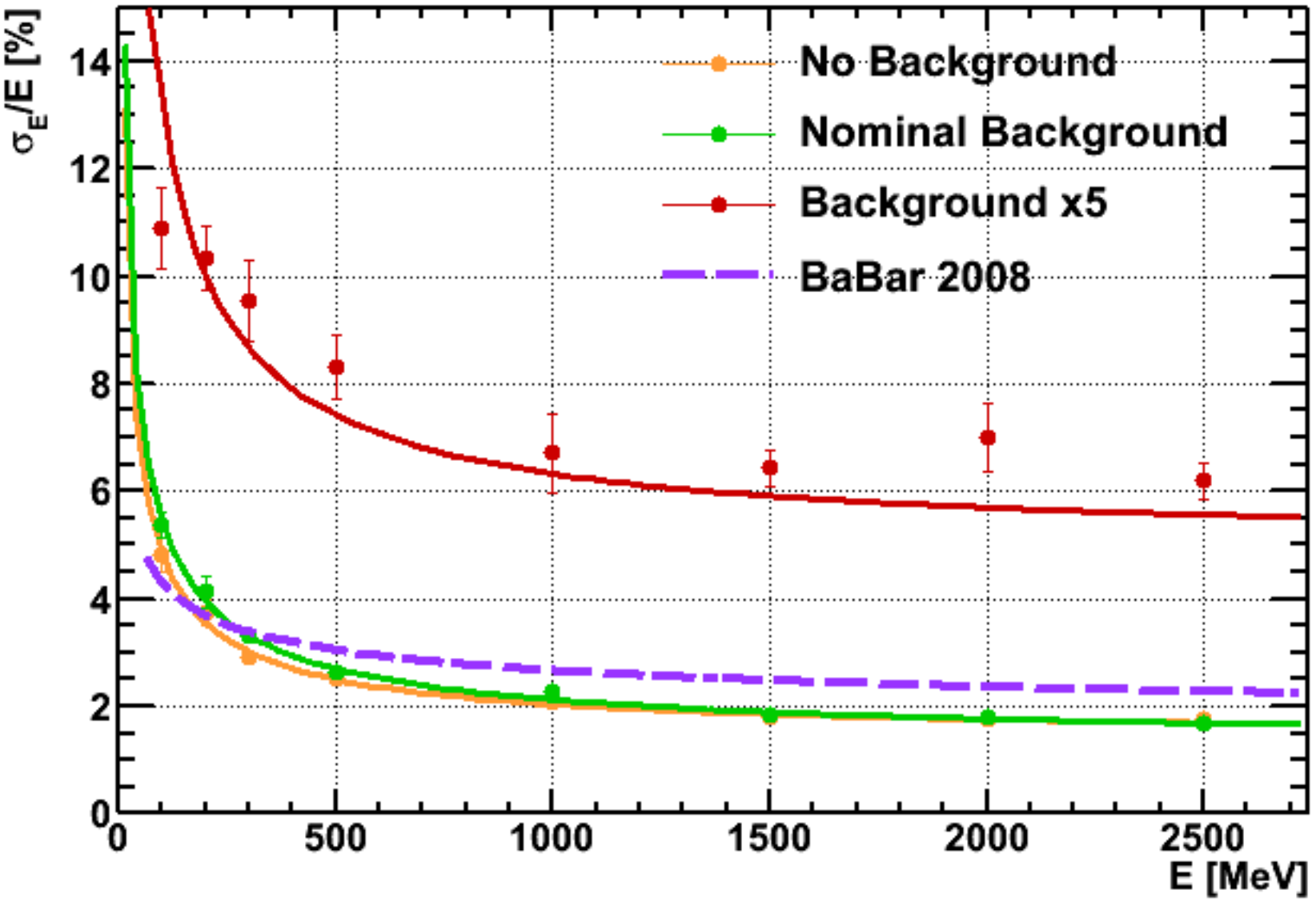


→Background has significant impact on Energy Resolution

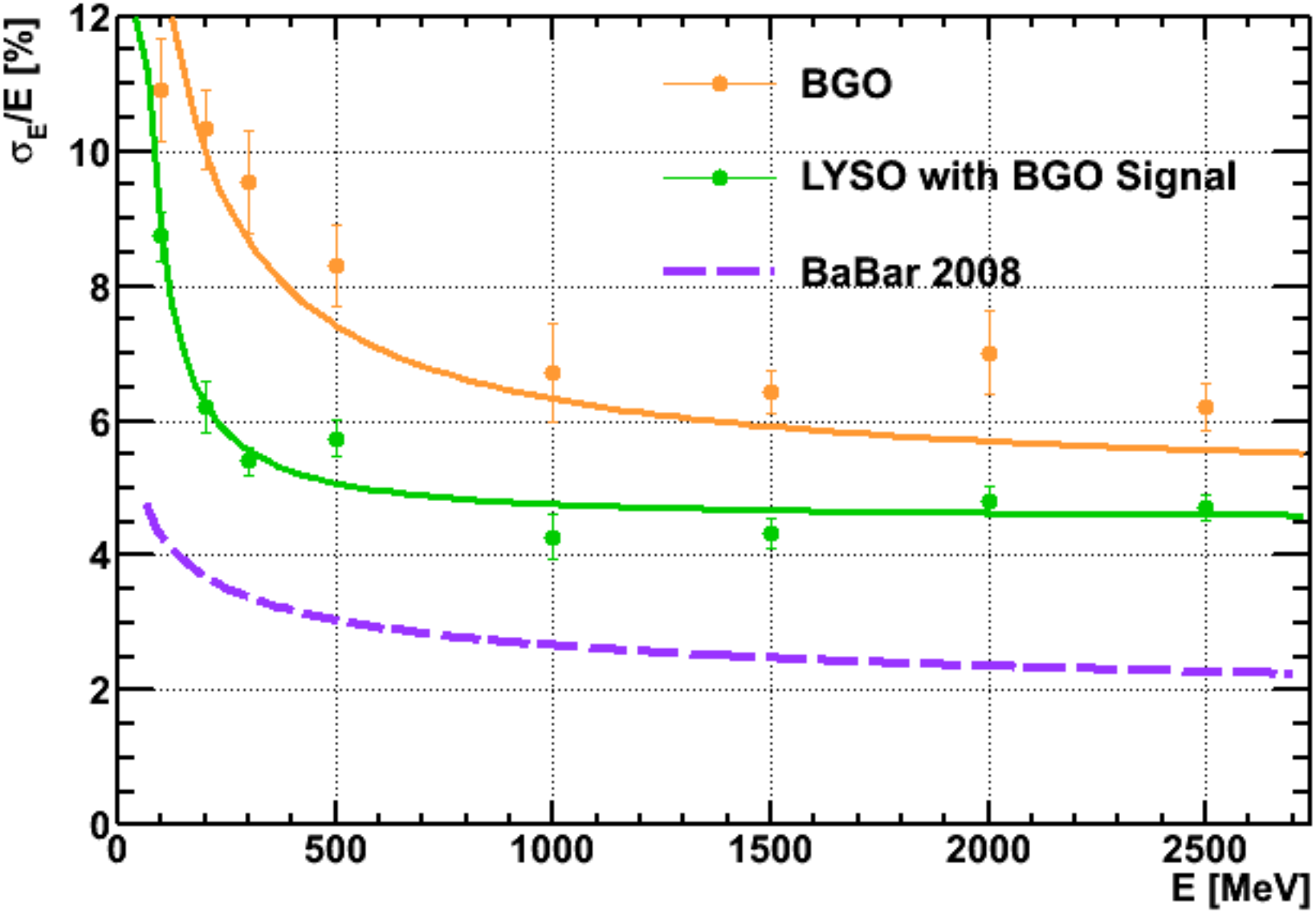
→Background shifts peak energy toward lower values

- ✓ Opposite effect with respect to Barrel
- ✓ Background moves low energy crystals out of time

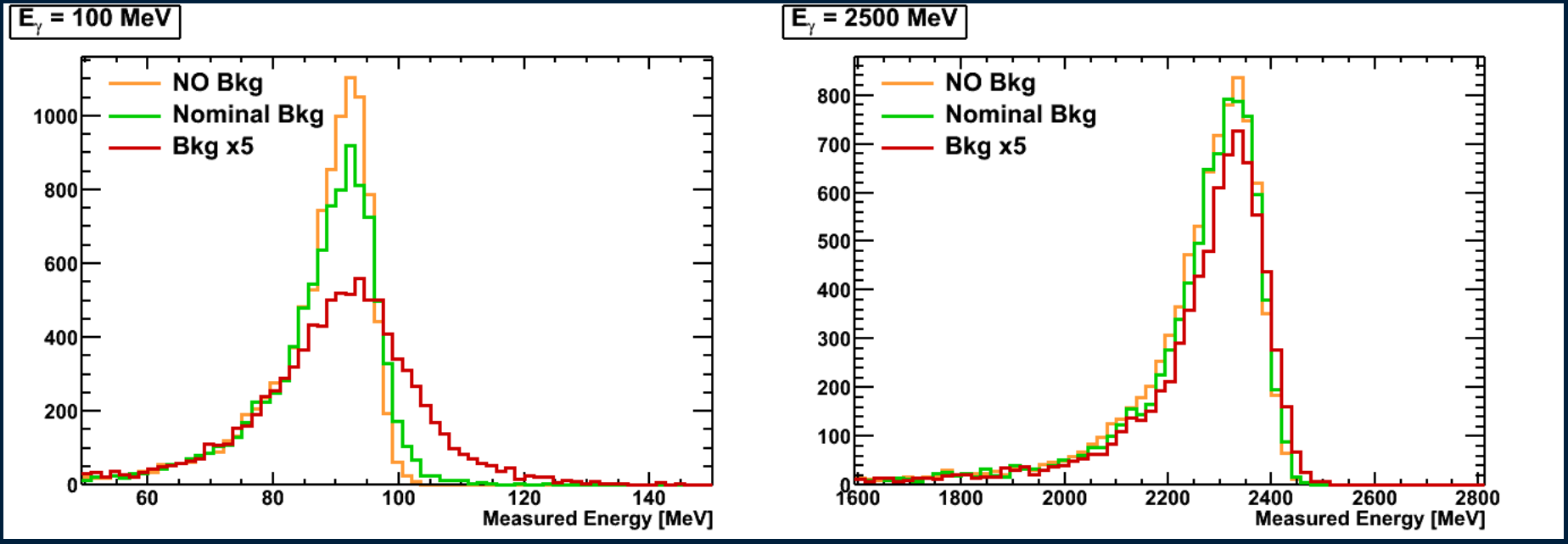
BGO – Eres vs Background Level



BGO Backgrouns x5 Studies



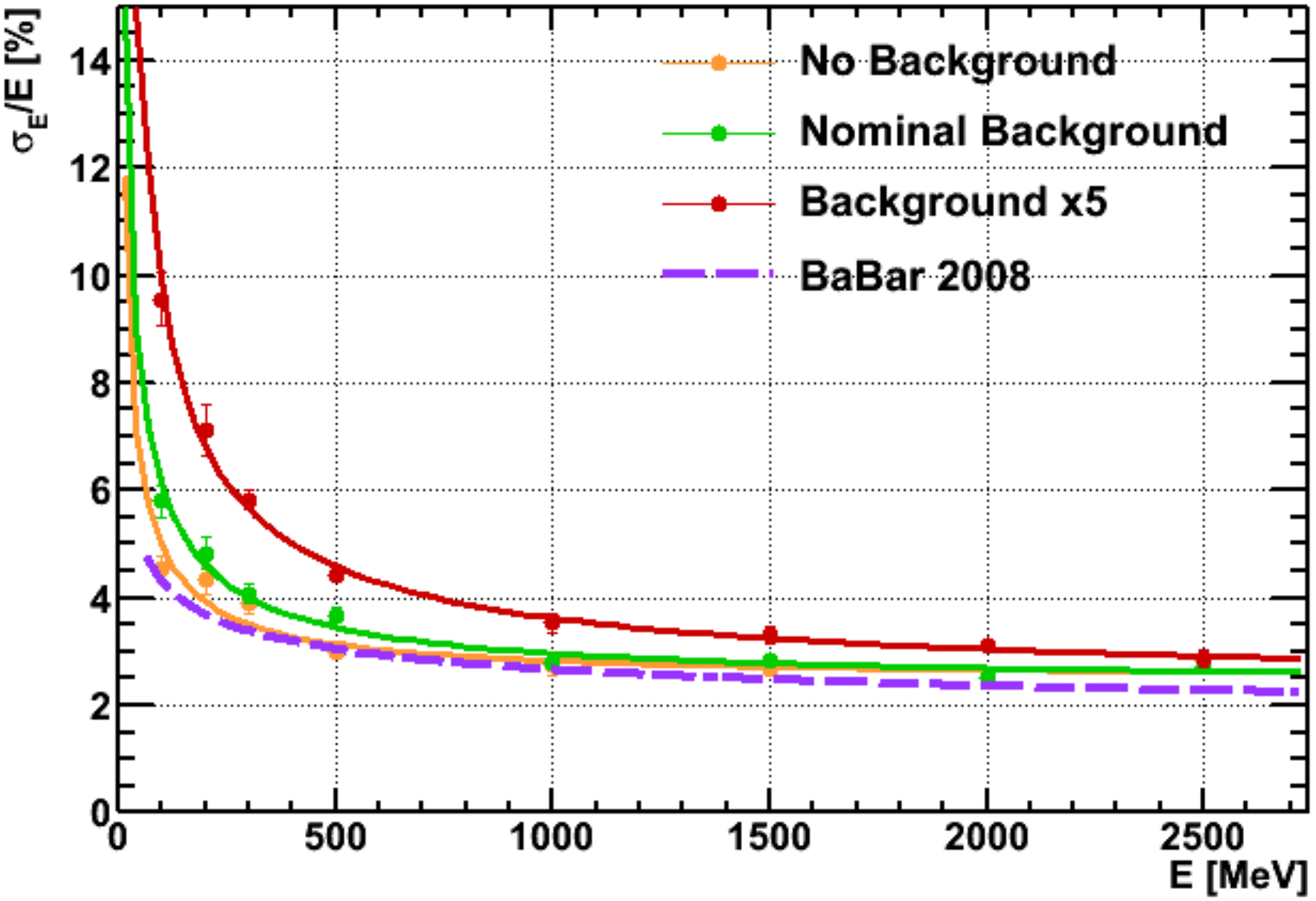
Pure CsI Energy distributions



→Background impact on Energy Resolution is not negligible

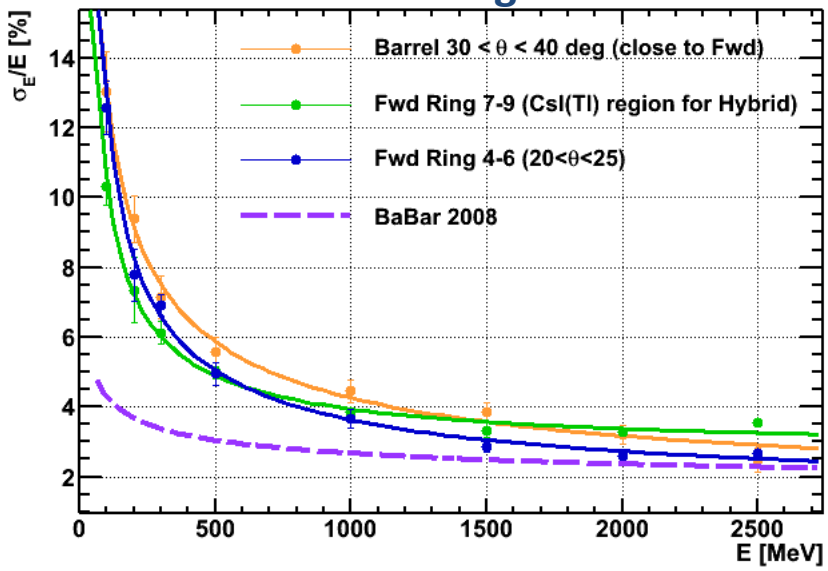
→Background does not shift peak energy

Pure CsI – Eres vs Background Level

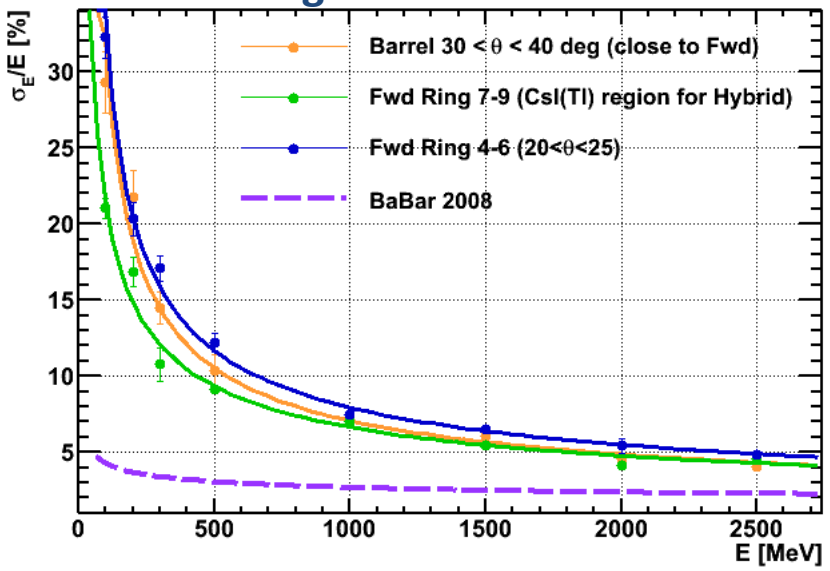


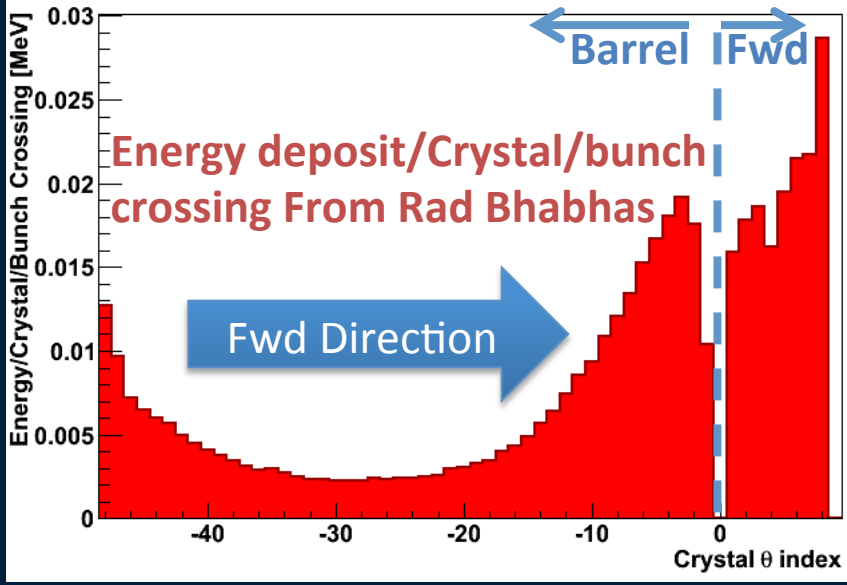
CsI(Tl) – Eres vs Background Level

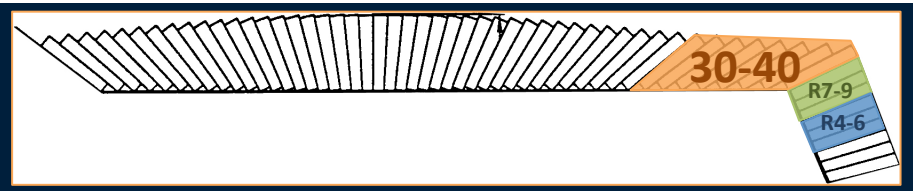
Nominal Background



Background x5

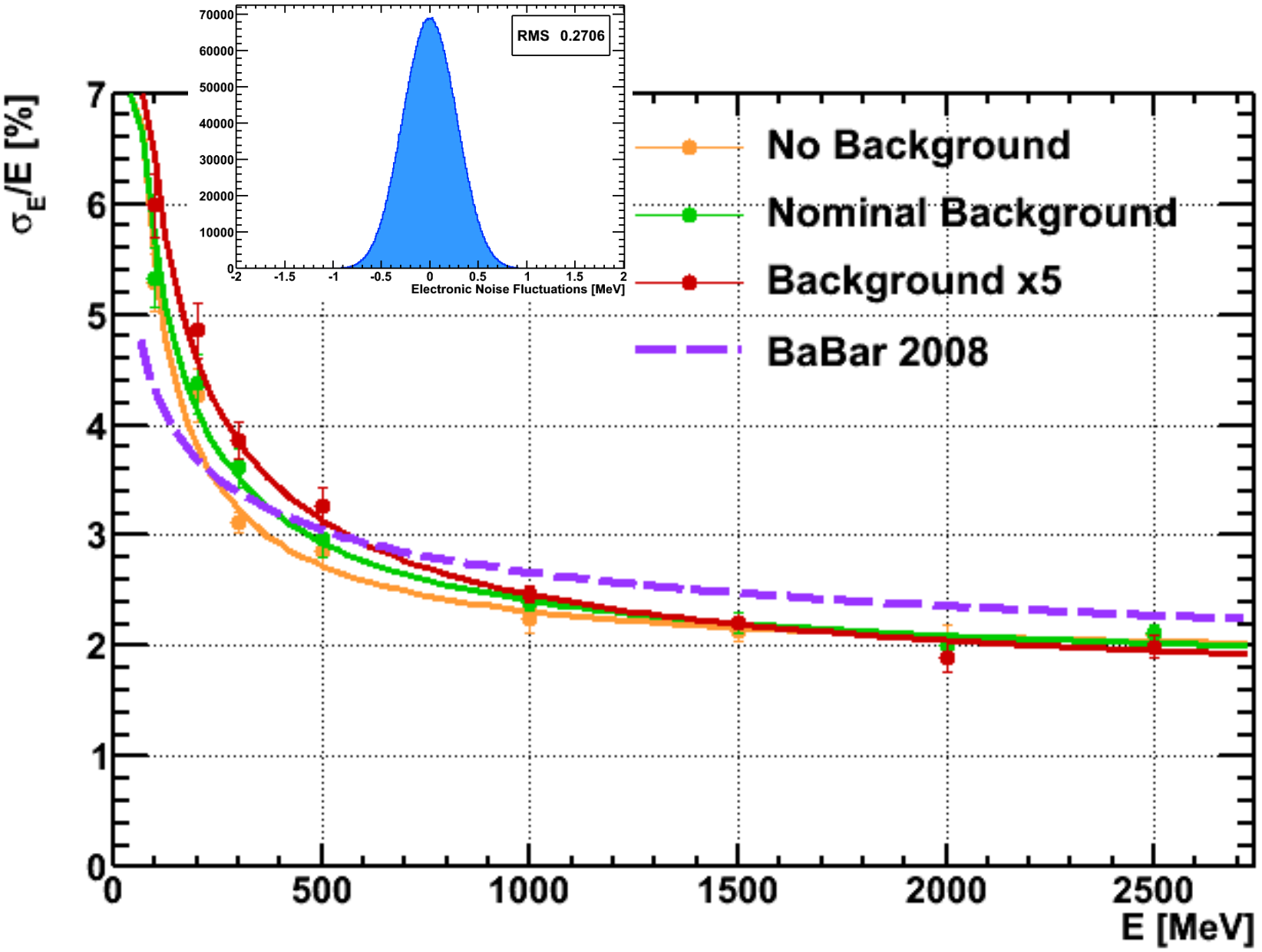






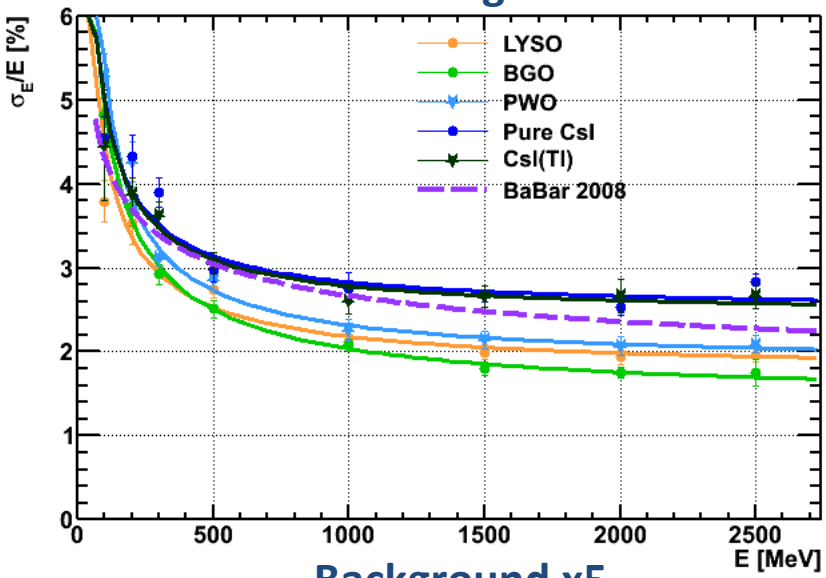
- ✓ The Fwd rings close to the Barrel –Fwd transition (R7-9) seem to have lower background level and better energy resolution than the neighboring section of the Barrel (Theta 30-40)
- ✓ R7-9 is the CsI(Tl) region for the Hybrid Fwd option

PWO – Eres vs Background Level

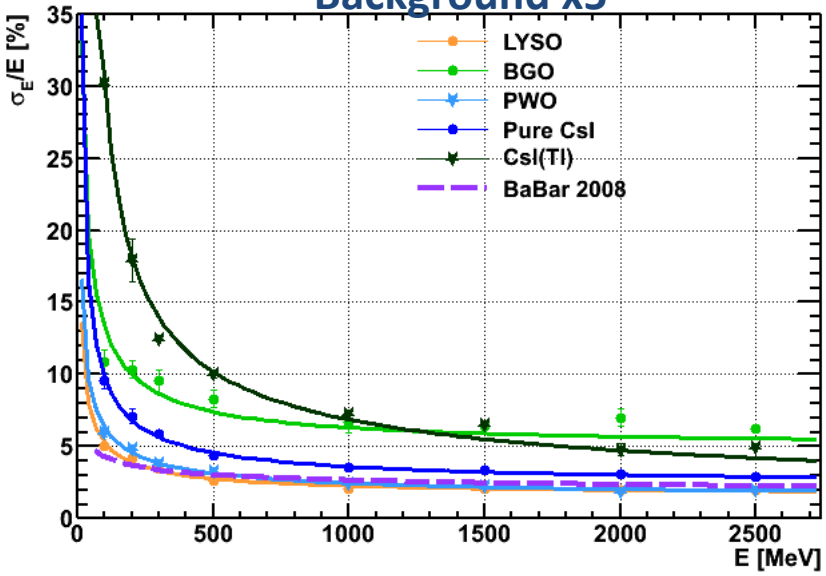


Compare Fwd Options

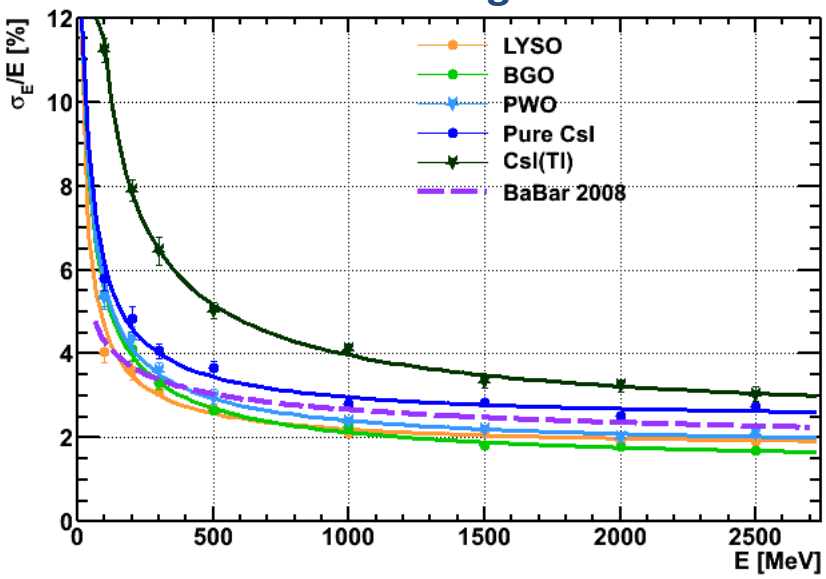
NO Background



Background x5



Nominal Background



- ✓ Difference between CsI(Tl) and Pure CsI given by signal shape (crystal τ)
- ✓ Difference between BGO and LYSO or PWO given by signal shape (crystal τ)
- ✓ Difference between Pure CsI and LYSO or PWO given by crystal size (~x5)

Conclusions and Outlook

- Barrel Simulation
  - Background has large effect on energy resolution
    - Large Theta dependence on resolution
    - Significant signal shape improvements may be possible

- Fwd Options Simulations
  - CsI(Tl) performances are similar to Barrel
  - BGO needs signal shape improvements but also crystal size match with Moliere Radius
  - Pure CsI: background has non negligible effect
    - Performance with background limited by crystal size
  - PWO is not affected by background
    - Noise level need to be confirmed with measurements
  - LYSO is not affected by background
    - All input parameters come form measurements and experience

- Background Types:
  - Energy resolution is affected mainly by Radiative Bhabha