

# EMC OPTIONS SIMULATION



**Det+Acc – MDI & Background Session**

3<sup>rd</sup> SuperB Collaboration Meeting

LNF

20/3/2012

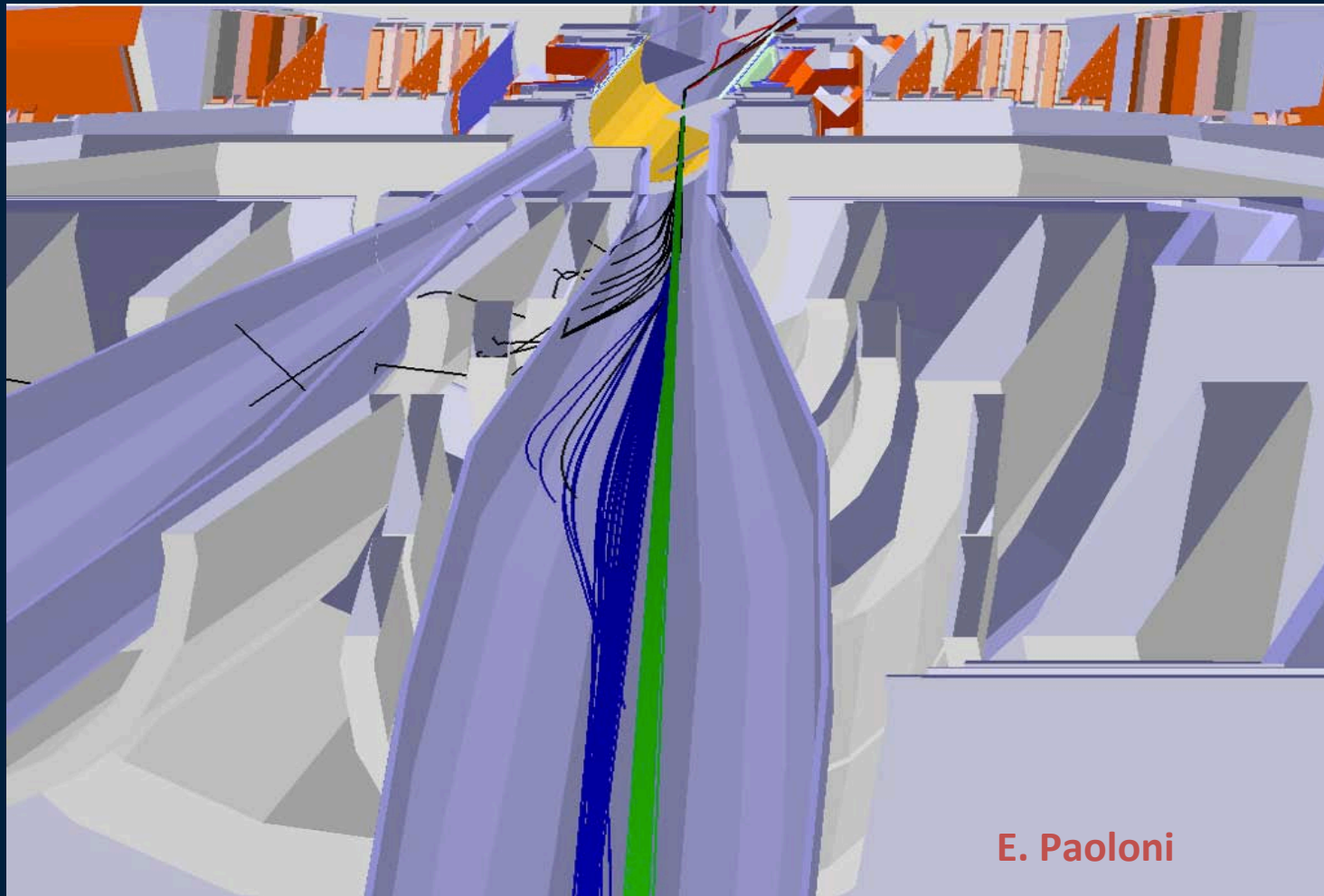
S. Germani

INFN Perugia

# OUTLINE

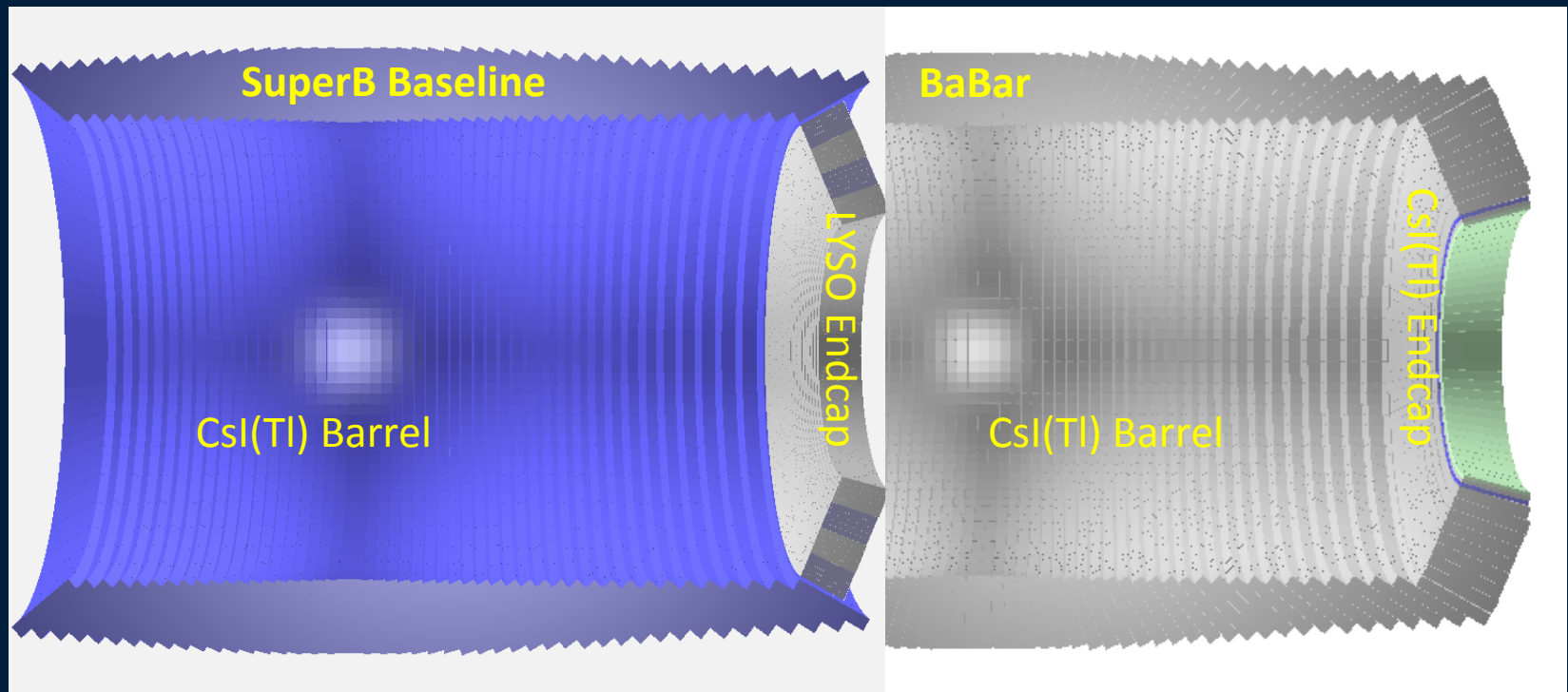
- Simulation Details
  - Geometry with Options
  - Electronic Signal and Noise
  - Work flow
  - Background
- Simulation Results
  - Barrel
  - Fwd Endcap
- Conclusions and Outlook

# BACKGROUND EVENT DISPLAY



# CALORIMETER GEOMETRY

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

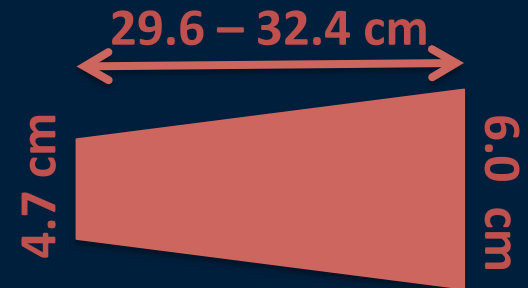




# GEOMETRY OPTIONS

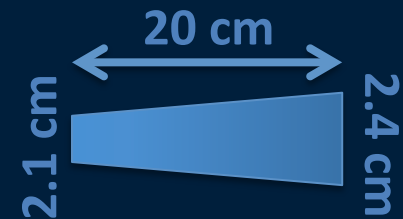
## BaBar Geometry

- Barrel 5768 xtals
- Pure CsI Fwd 820 xtals



## Default SuperB Endcap Geometry

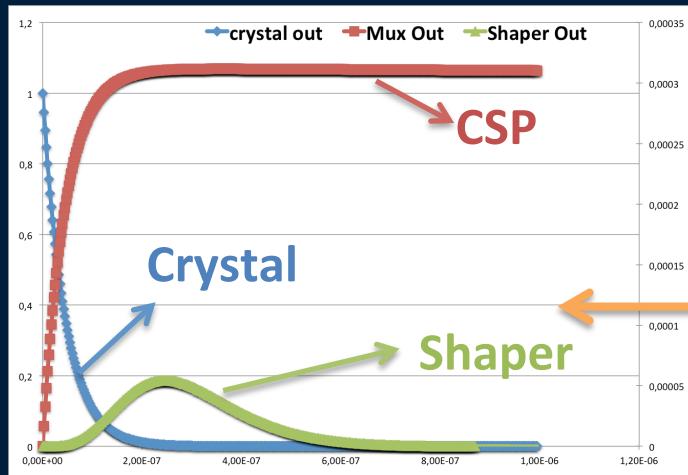
- LYSO
  - BGO
  - PWO
- 4500 xtals



## Hybrid Geometry

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

# ELECTRONICS



Crystal

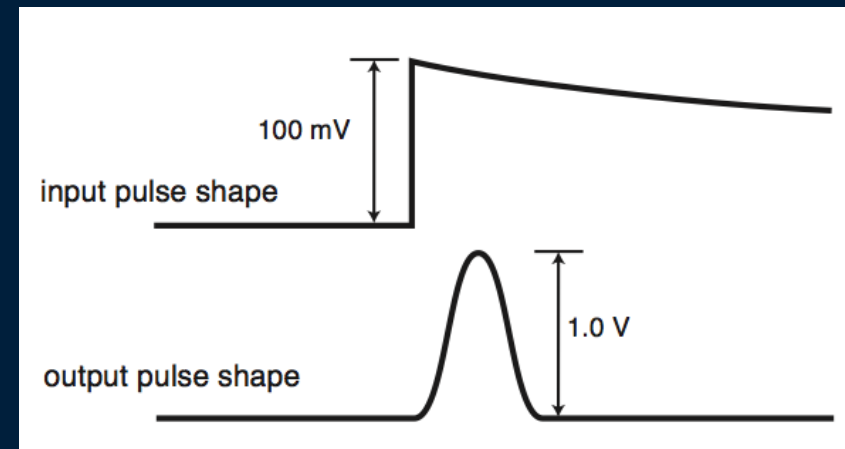
CSP

Shaper

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

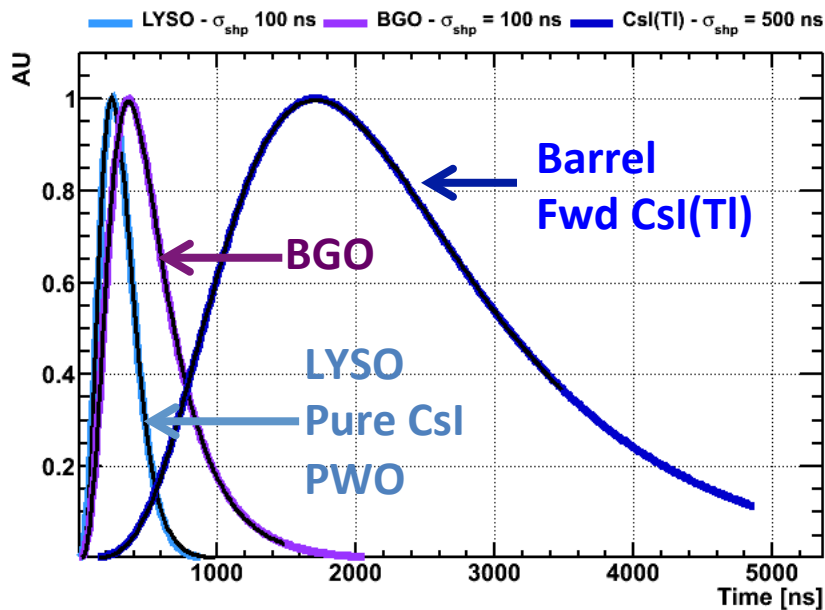
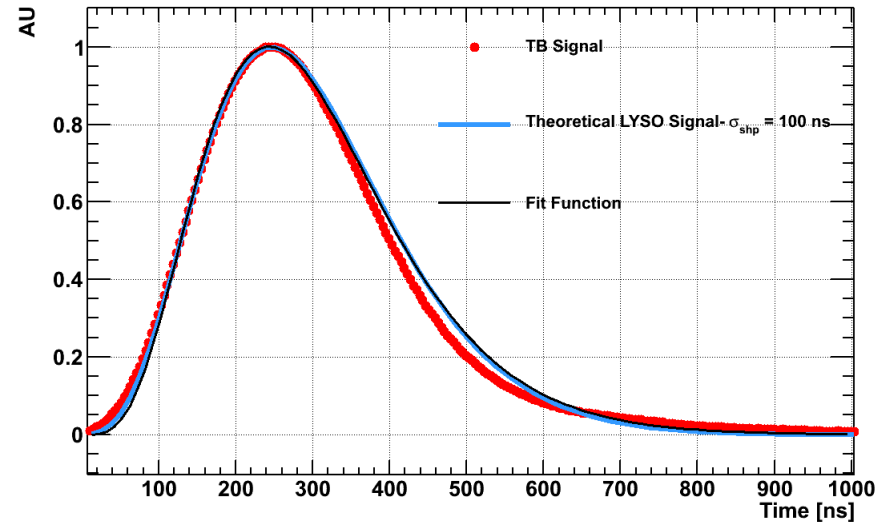
## From Shaper Data Sheet

- 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

- All the S/N evaluations start from TestBeam 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

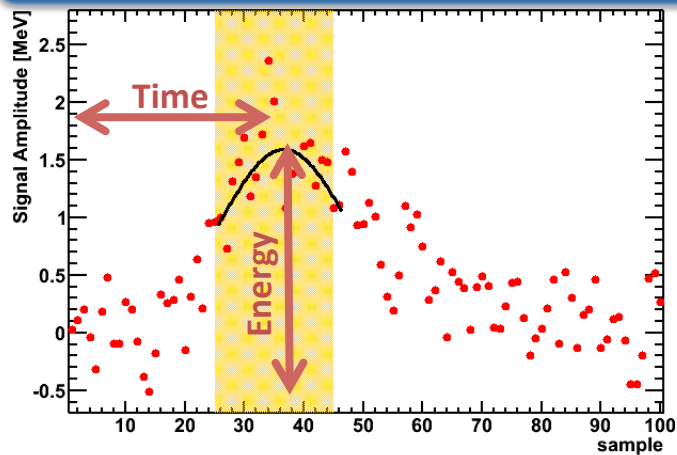
Crystal	Sensor	Sensor Area	Gain	Shaping Time	SN/SN(BTF)
LYSO	APD	0.5 cm <sup>2</sup>	50	100 ns	<b>16</b>
PWO	APD	2 cm <sup>2</sup>	50	100ns	<b>0.86</b>
BGO	APD	0.5 cm <sup>2</sup>	50	100 ns	<b>2.1</b>
CsI	PP	20 cm <sup>2</sup>	180	100 ns	<b>6.4</b>
CsI(Tl)	PIN	4 cm <sup>2</sup>	1	500 ns	<b>0.95</b>
CsI(Tl)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

# SIMULATION WORK FLOW

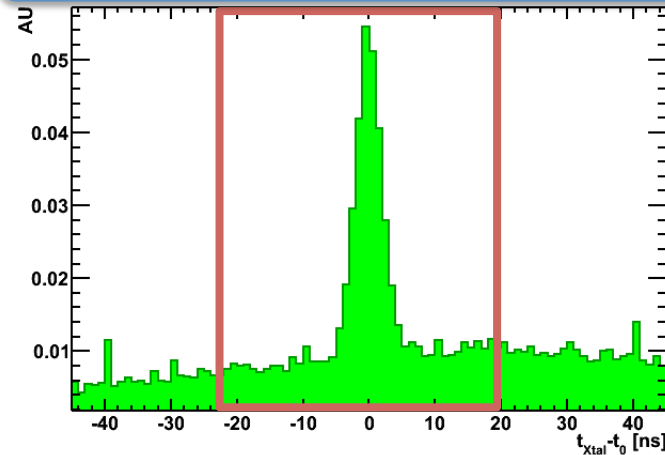
Crystal Energy Deposit (Bruno)

Interleave Single Particles with Background evts.  
(Rad Bhabha)

Get Energy and Time from  
Electronic Signal Peak



Select Crystals within Time  
Window

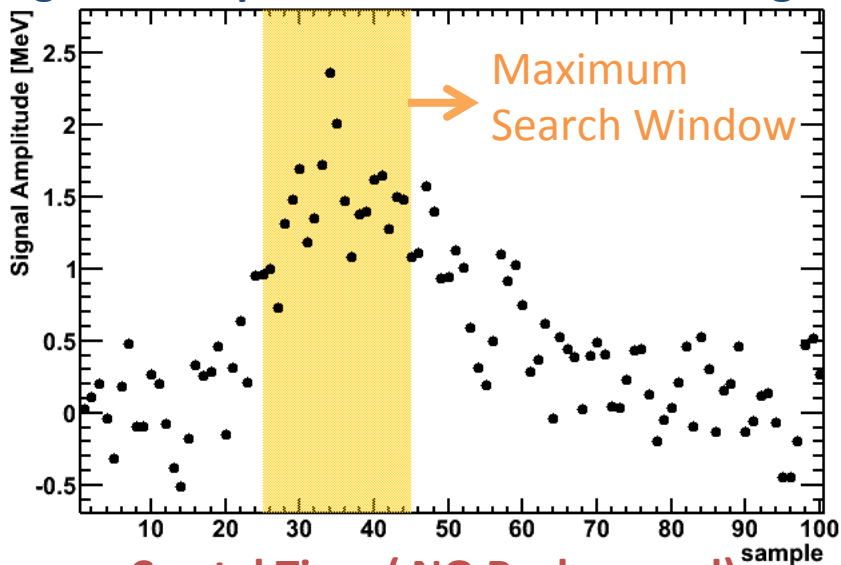


Clustering  
(BaBar algorithm)

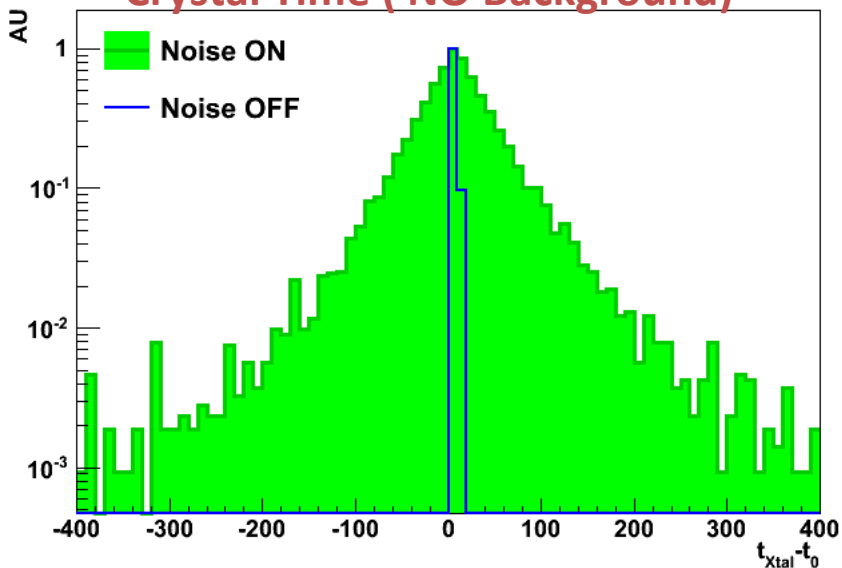
Select Signal Cluster for  
Performance Studies

# ELECTRONIC SIGNAL TIME

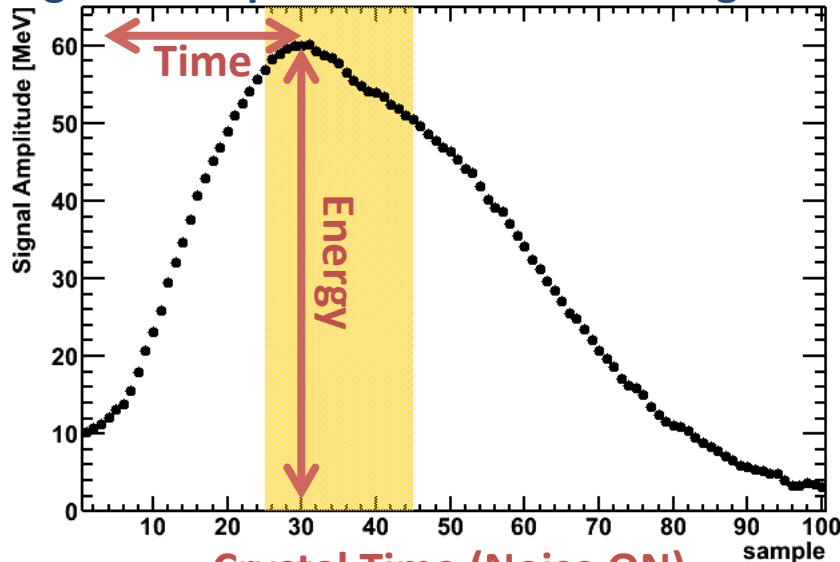
## Signal Example 1 – Noise ON - NO Background



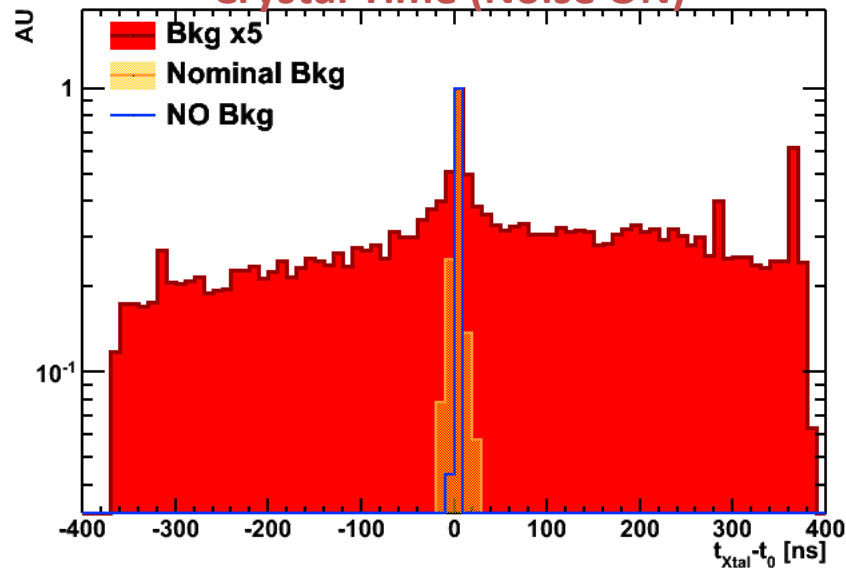
### Crystal Time ( NO Background)



## Signal Example 2 – Noise ON – Background x5



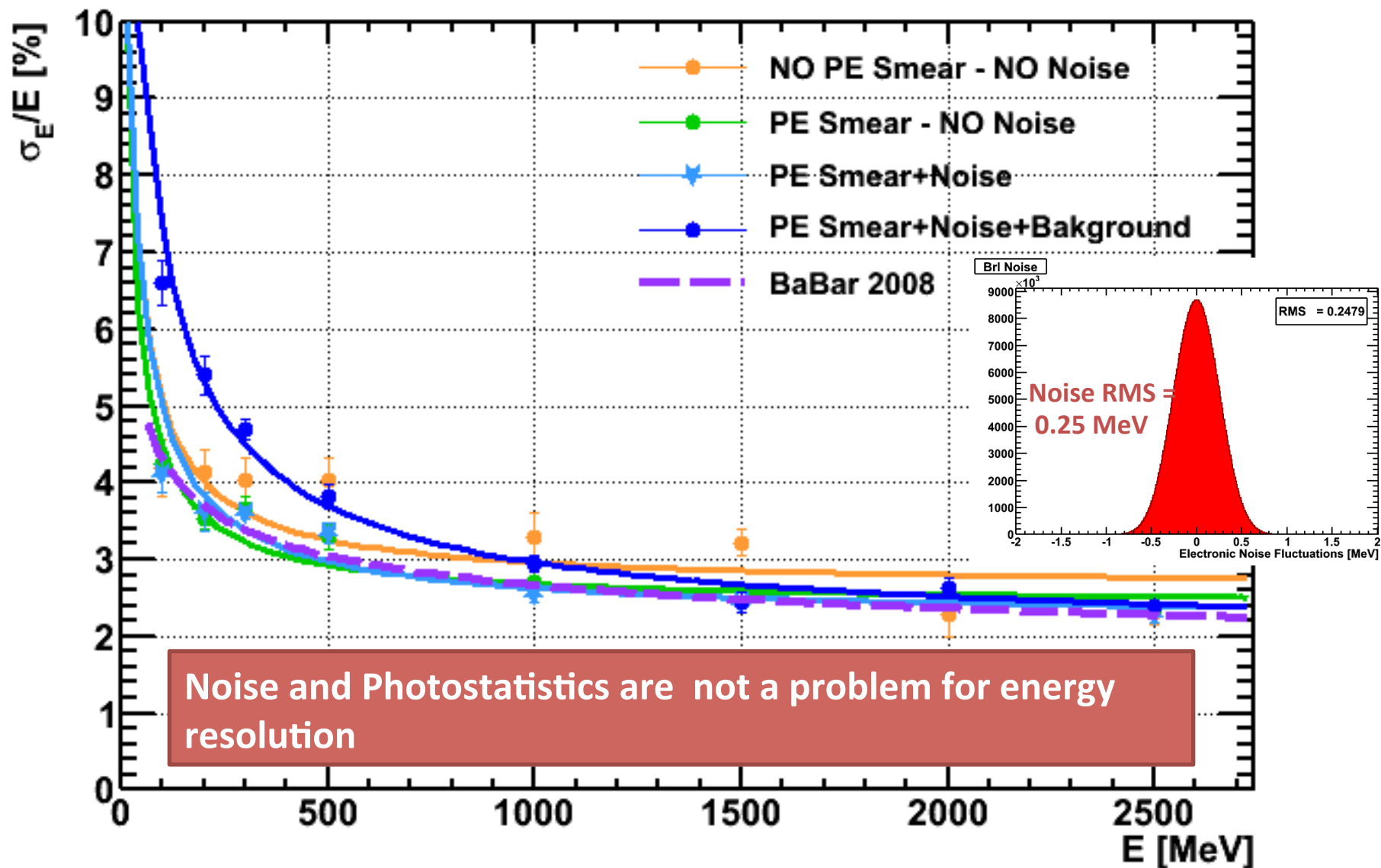
### Crystal Time (Noise ON)



# BARREL RESULTS

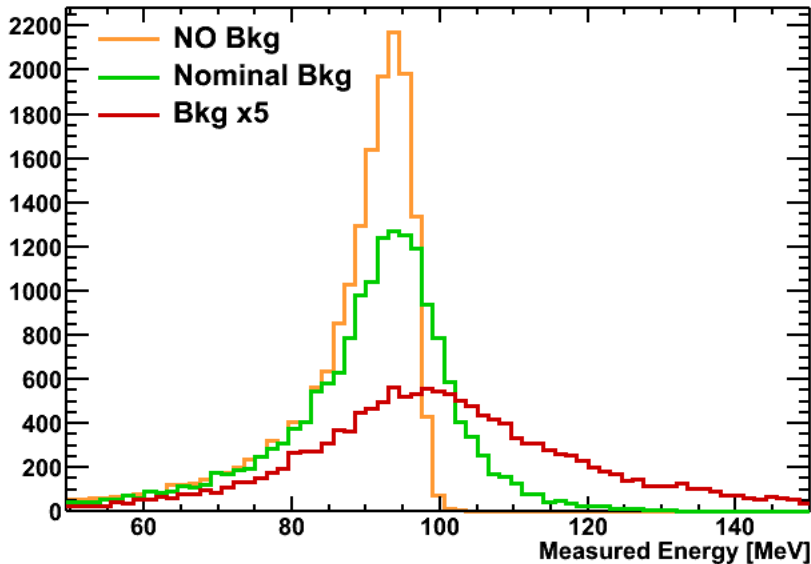


# BARREL

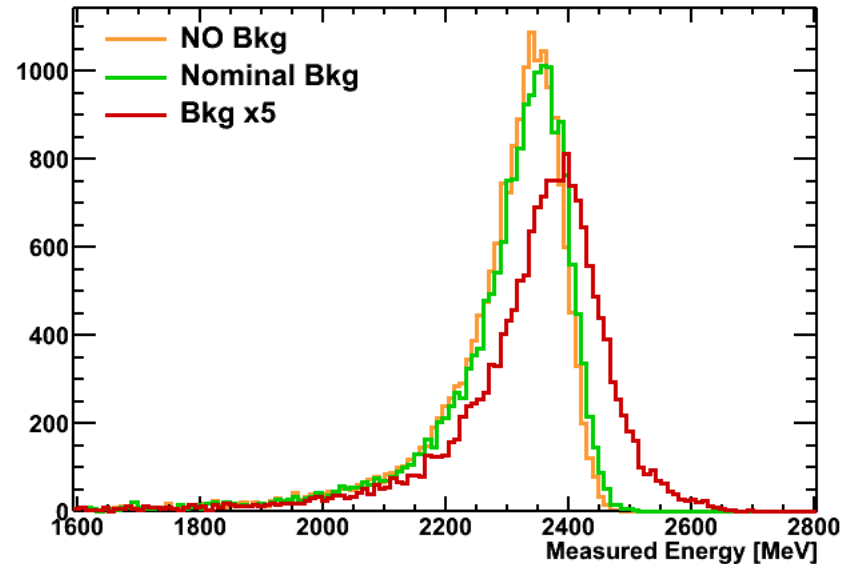


# BARREL ENERGY DISTRIBUTIONS

$E_\gamma = 100$  MeV

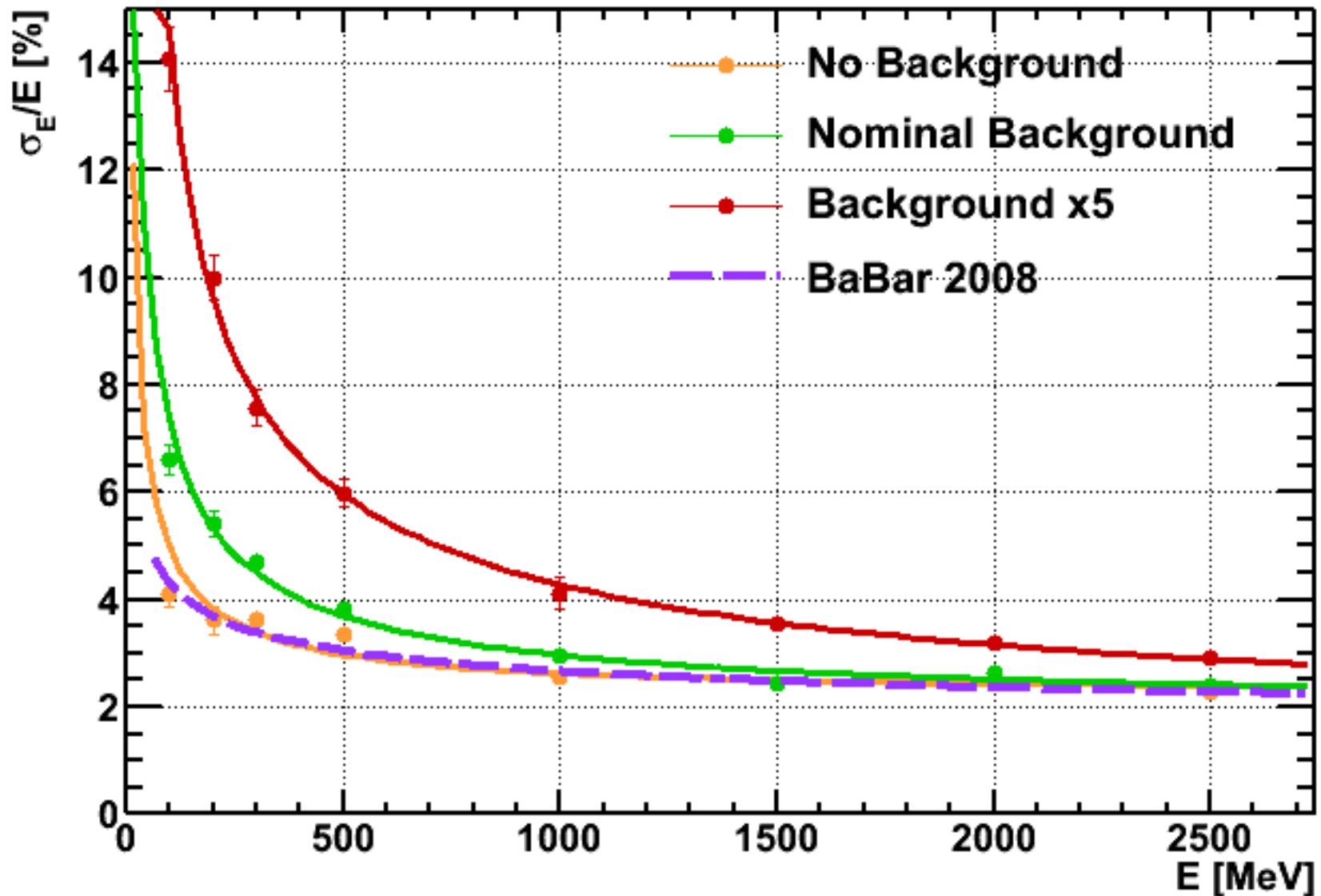


$E_\gamma = 2500$  MeV



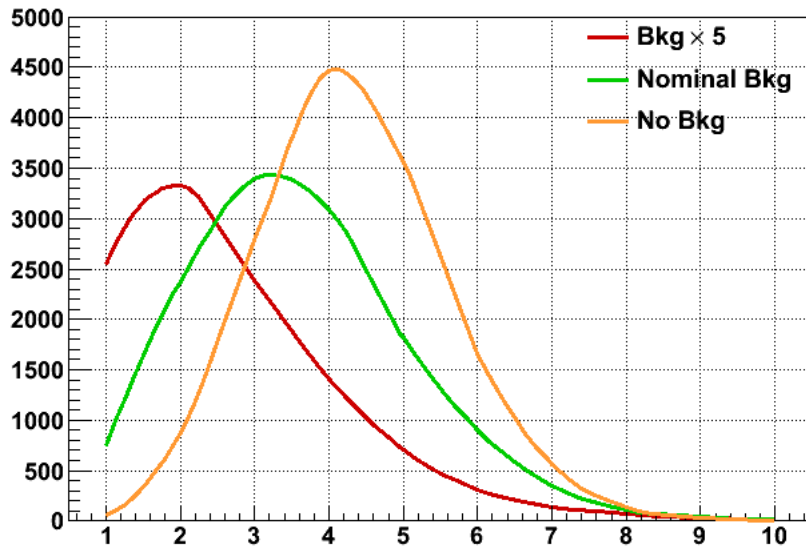
- Background has significant impact on Energy Resolution
- Background shifts peak energy toward higher values
  - ✓ Background adds extra energy to signal crystals

# BARREL – ERES VS BACKGROUND LEVEL

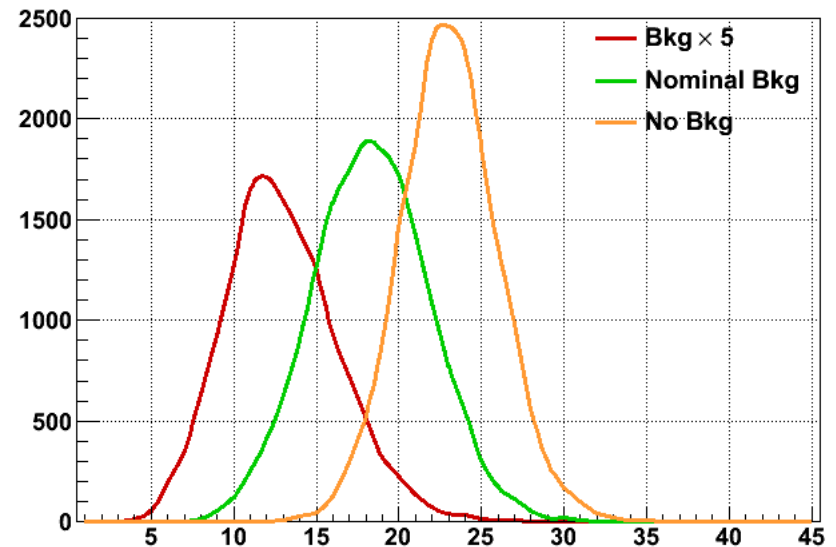


# SIGNAL CLUSTER SIZE

Cluster Size 100 MeV



Cluster Size 2500 MeV



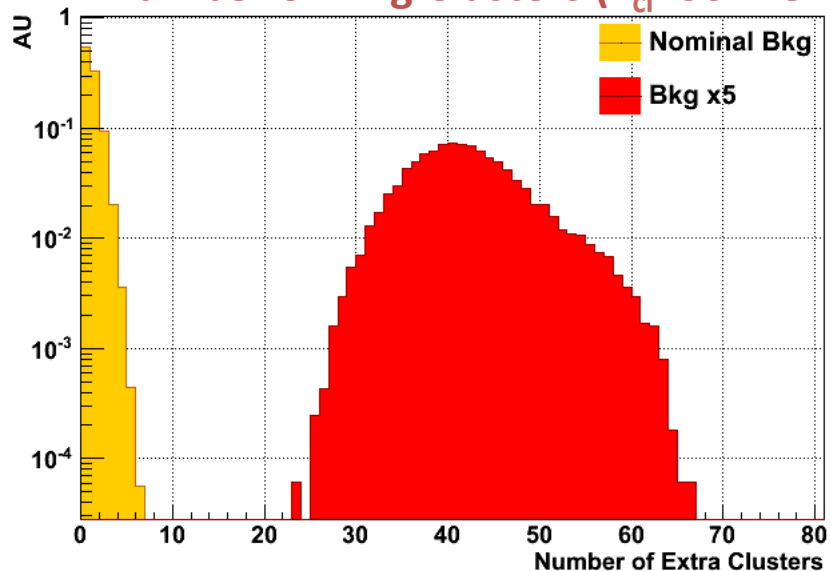
Background reduces signal cluster size

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

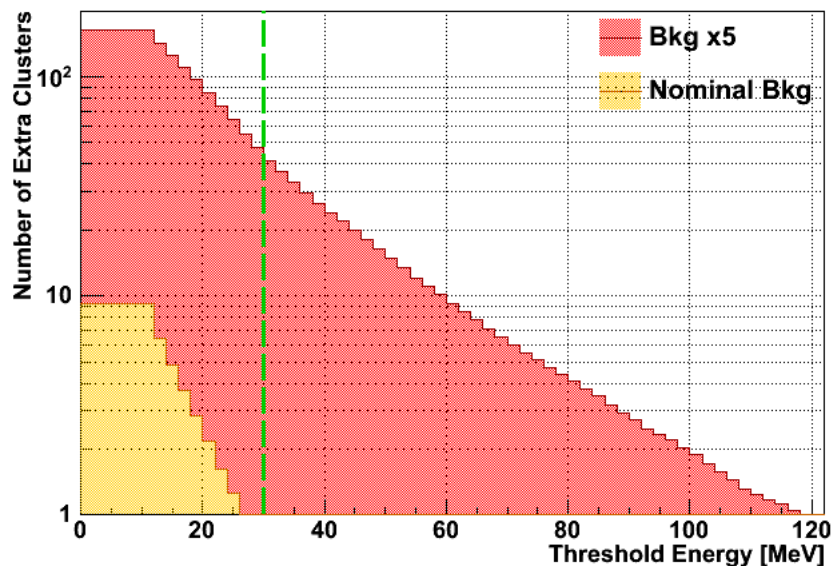
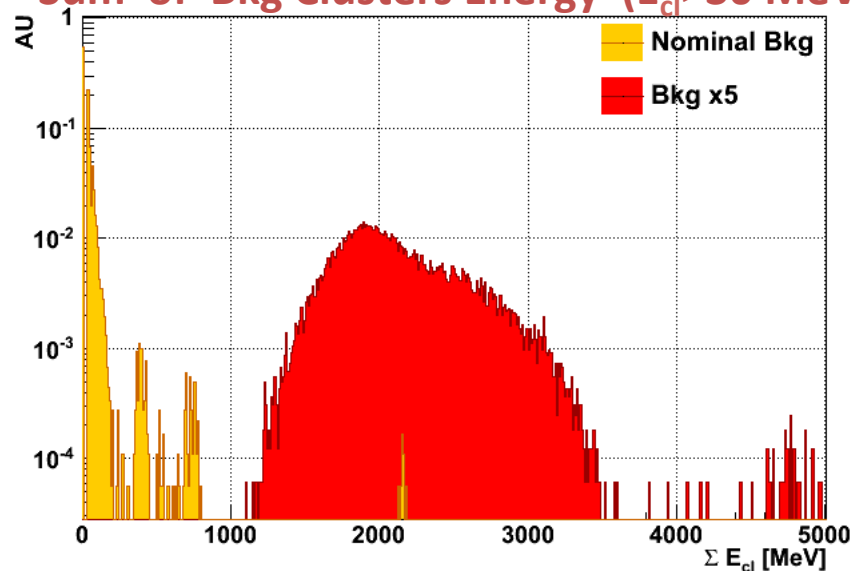
Signal Time Window already optimized to get the best resolution (300 ns)

# NUMBER OF CLUSTERS

## Number of Bkg Clusters ( $E_{cl} > 30$ MeV)



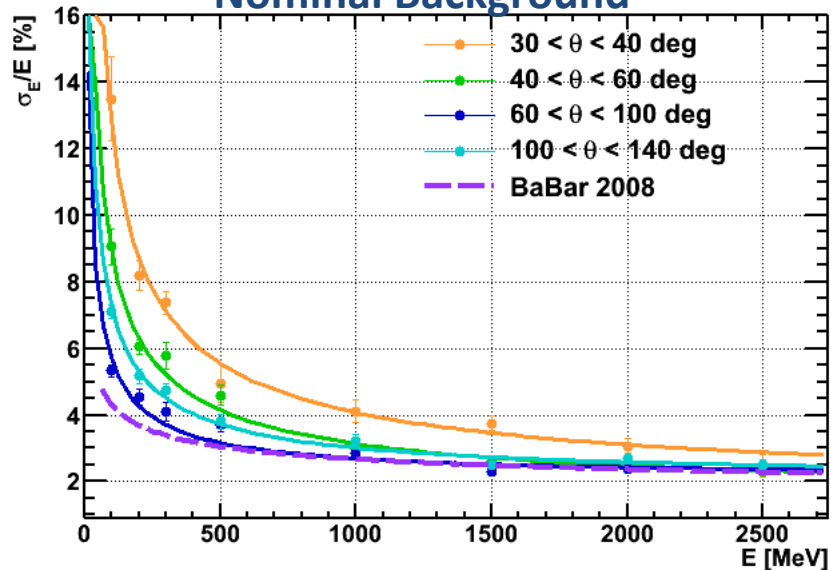
## Sum of Bkg Clusters Energy ( $E_{cl} > 30$ MeV)



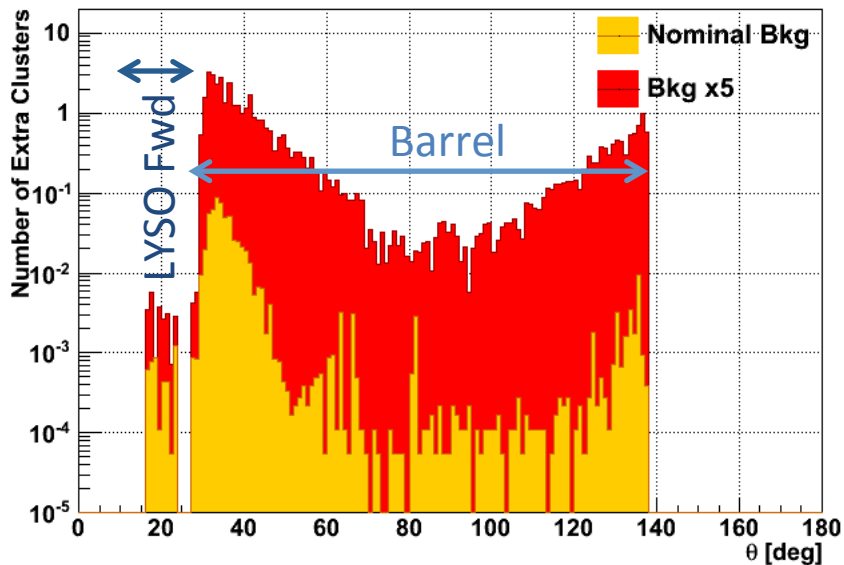
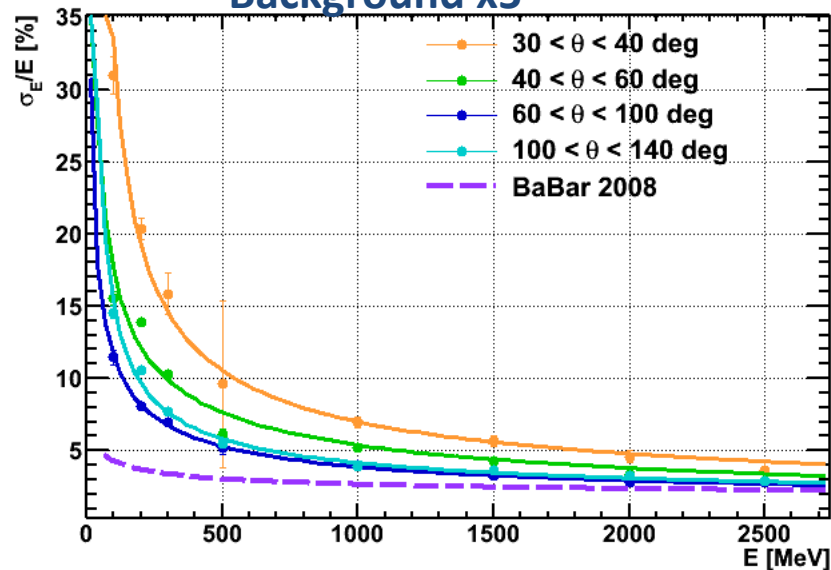
- ✓ Large difference between nominal background and x5 safety factor
- ✓ High multiplicity with x5 background

# BARREL PERFORMANCE VS THETA

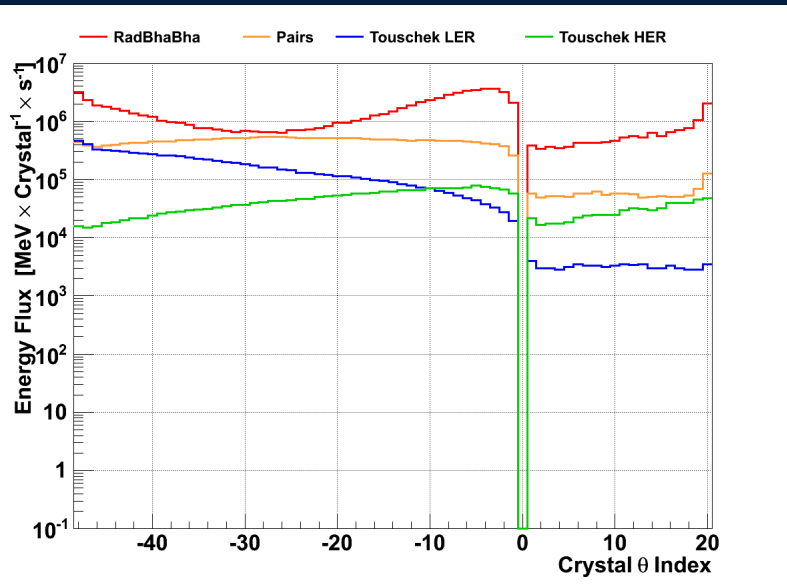
## Nominal Background



## Background x5

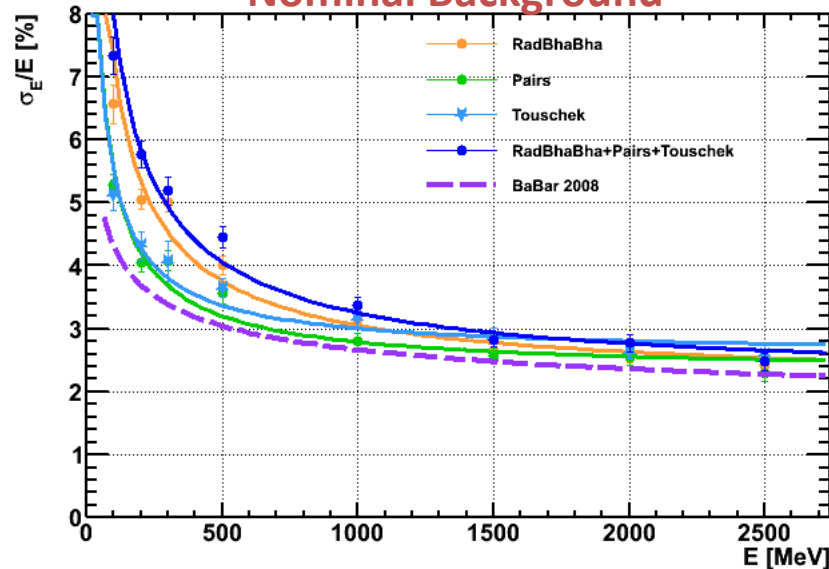


# BARREL – BACKGROUND TYPES

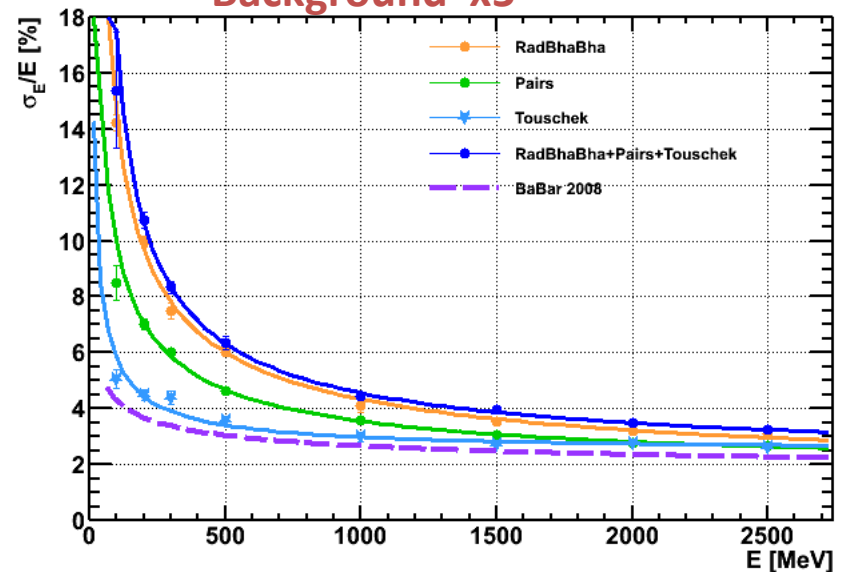


- ✓ Tool from A. Perez allows to study Touschek together with RadBhaBha and Pairs
- ✓ Resolution is mainly affected by Radiative Bhabha background
- ✓ Cumulative effect of Pairs+Touschek +RadBhaBha is close to RadBhaBha alone

## Nominal Background



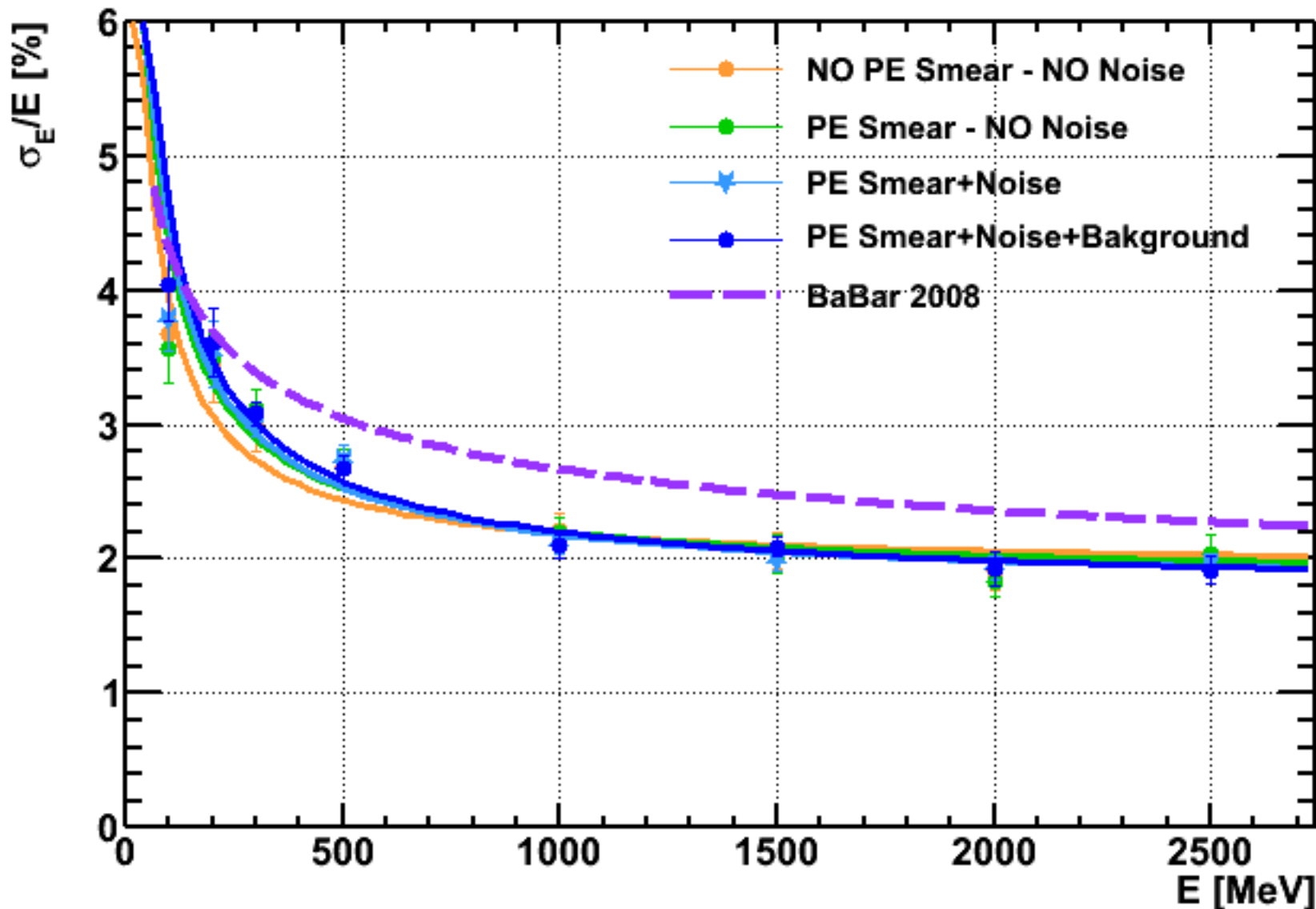
## Background x5





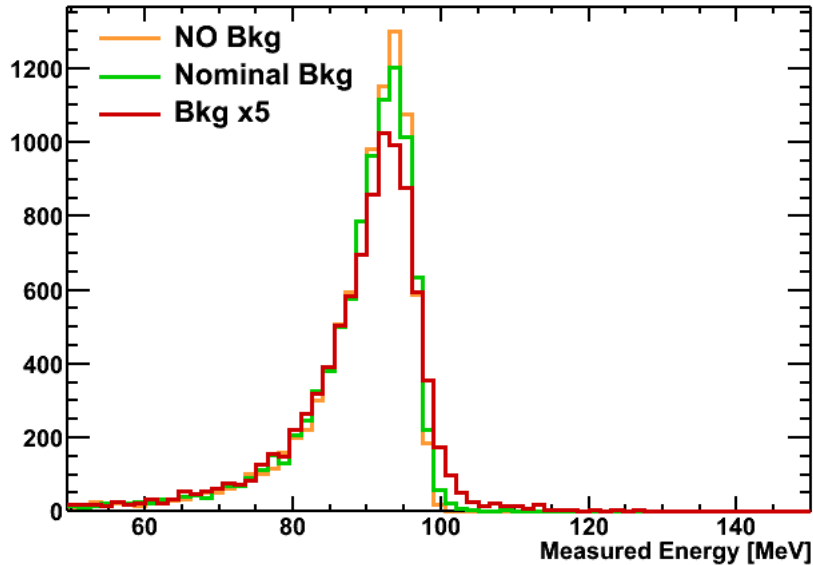
# FWD RESULTS

# LYSO RESOLUTION COMPONENTS

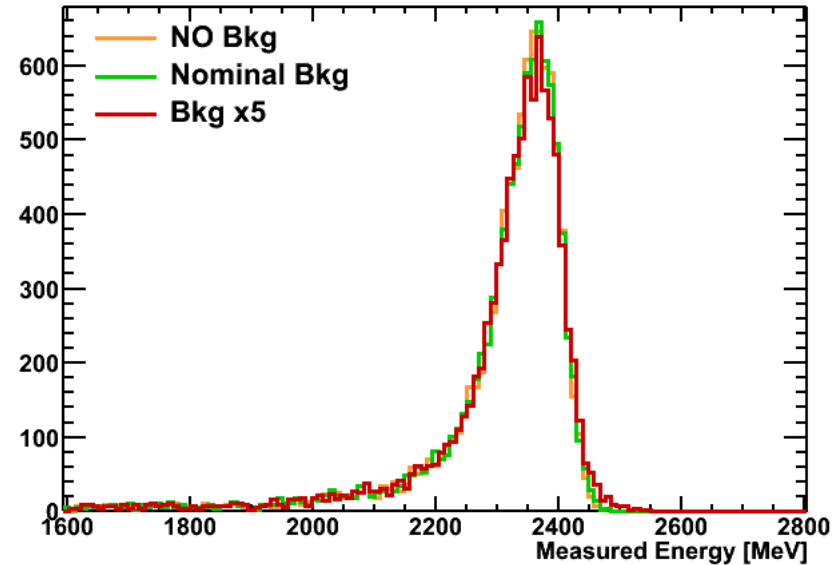


# LYSO ENERGY DISTRIBUTIONS

$E_\gamma = 100 \text{ MeV}$

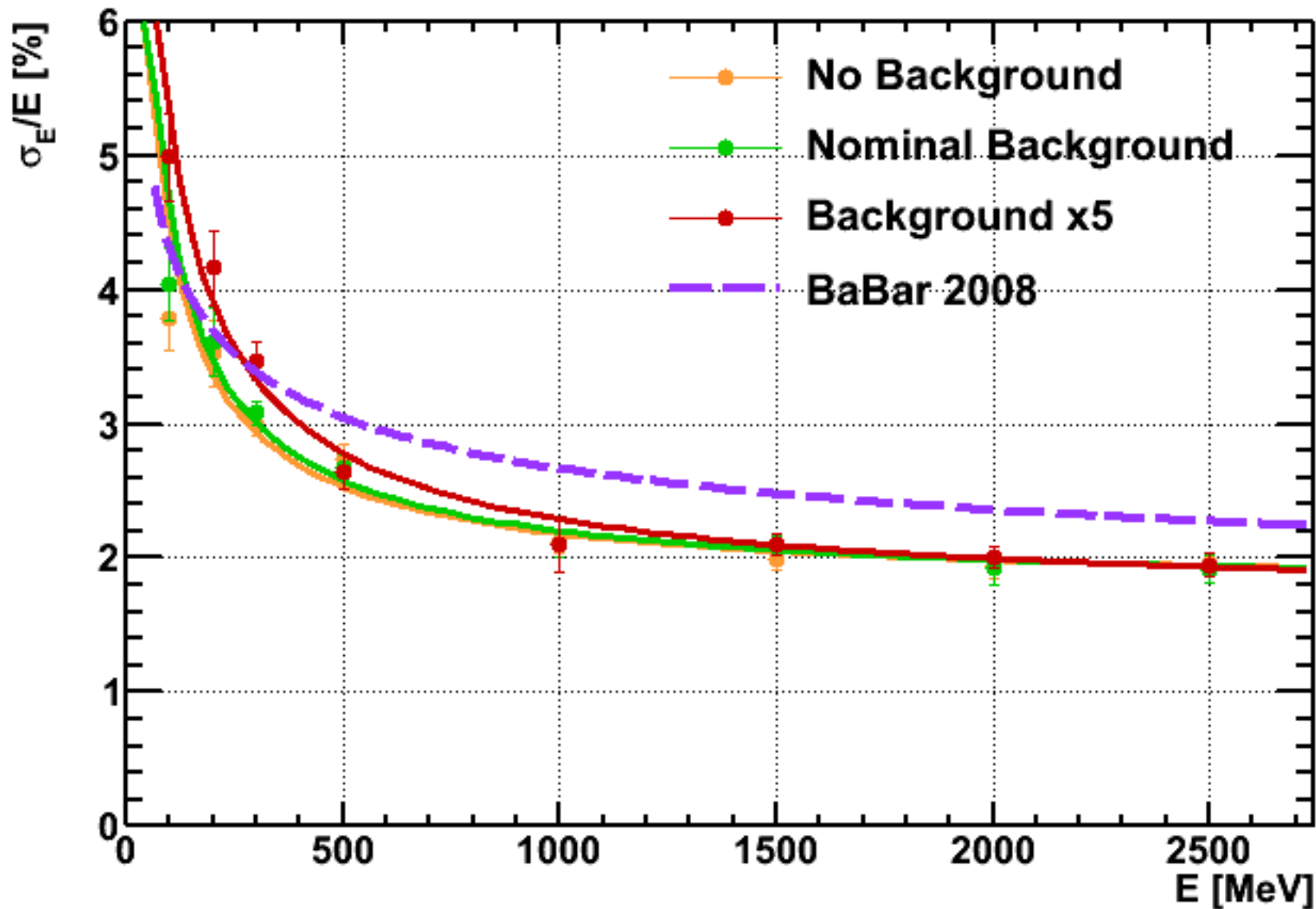


$E_\gamma = 2500 \text{ MeV}$



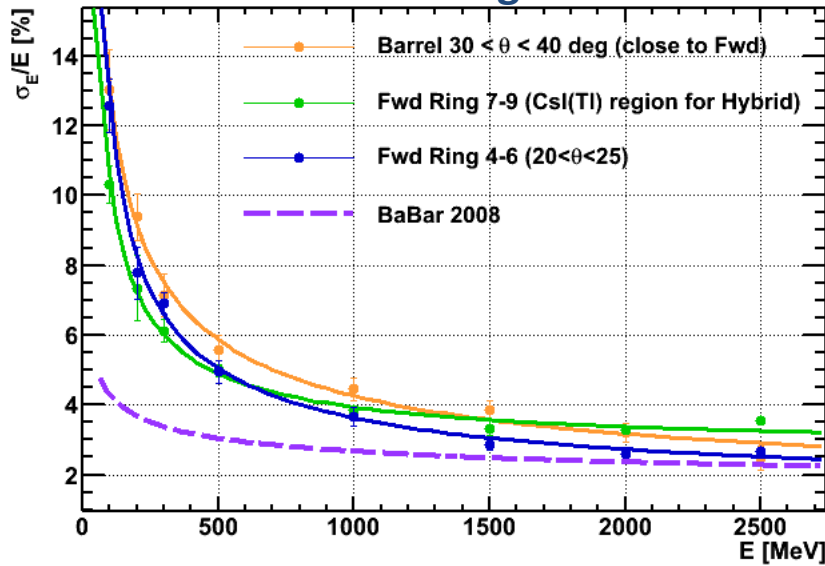
- Background has small impact on Energy Resolution
- Background does not shift peak energy

# LYSO – ERES VS BACKGROUND LEVEL

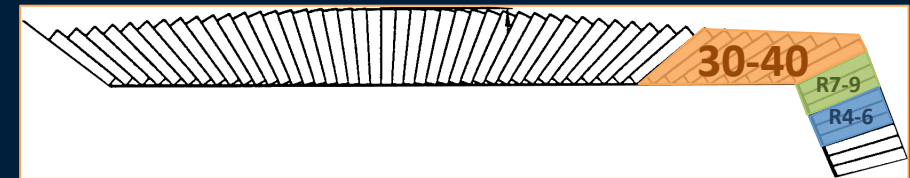
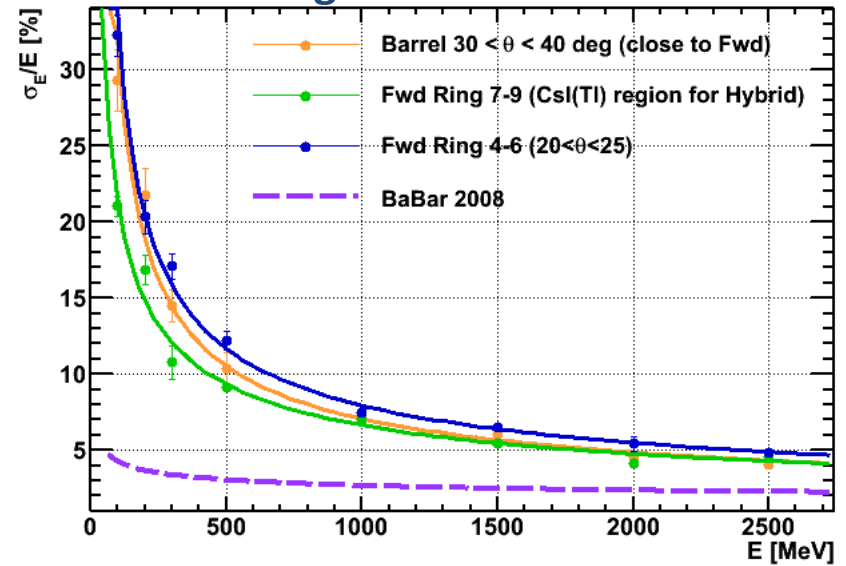


# CsI(TL) FWD – ERES VS BACKGROUND LEVEL

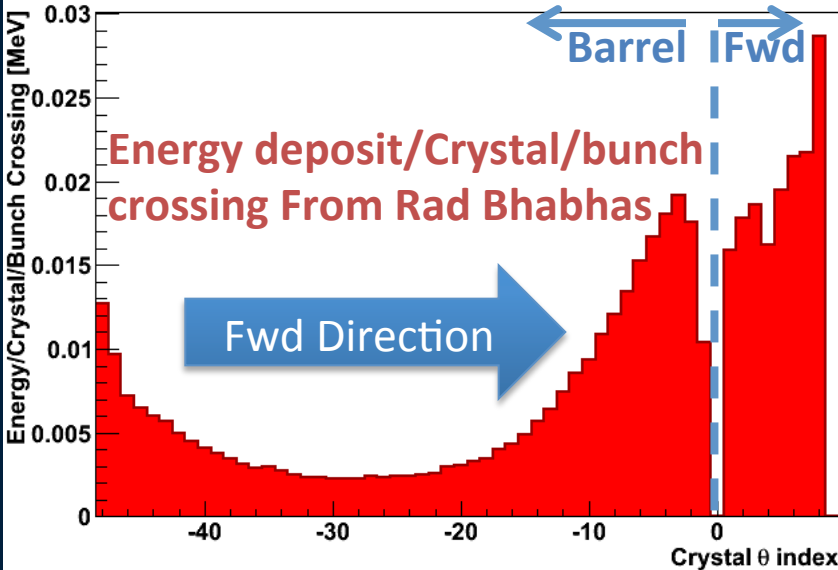
## Nominal Background



## Background x5

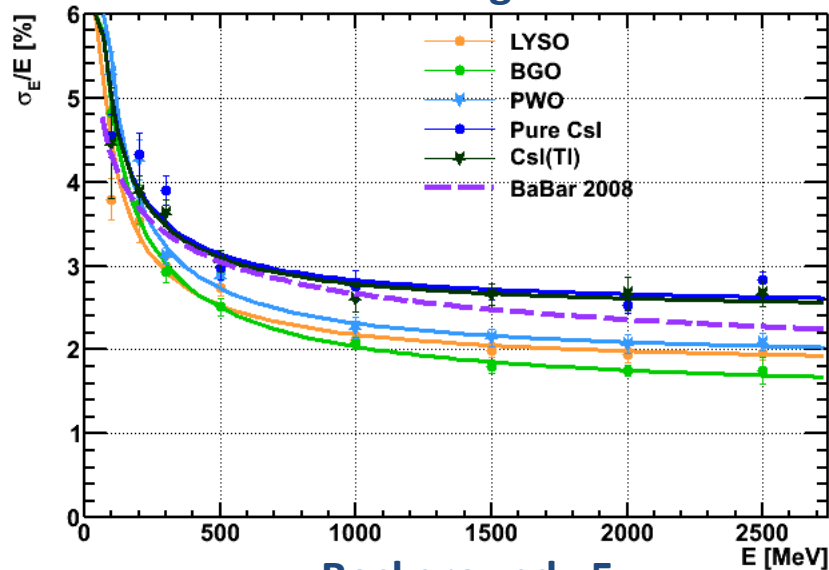


- ✓ The Fwd rings close to the Barrel – Fwd transition (R7-9) seem to have lower background level and better energy resolution than the neighboring section of the Barrel (Theta 30-40)
- ✓ R7-9 is the CsI(Tl) region for the Hybrid Fwd option

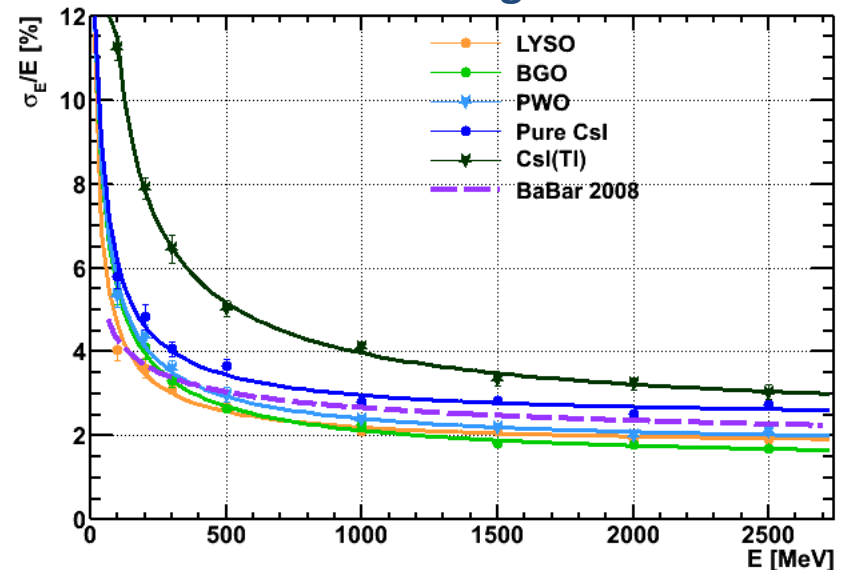


# COMPARE FWD OPTIONS

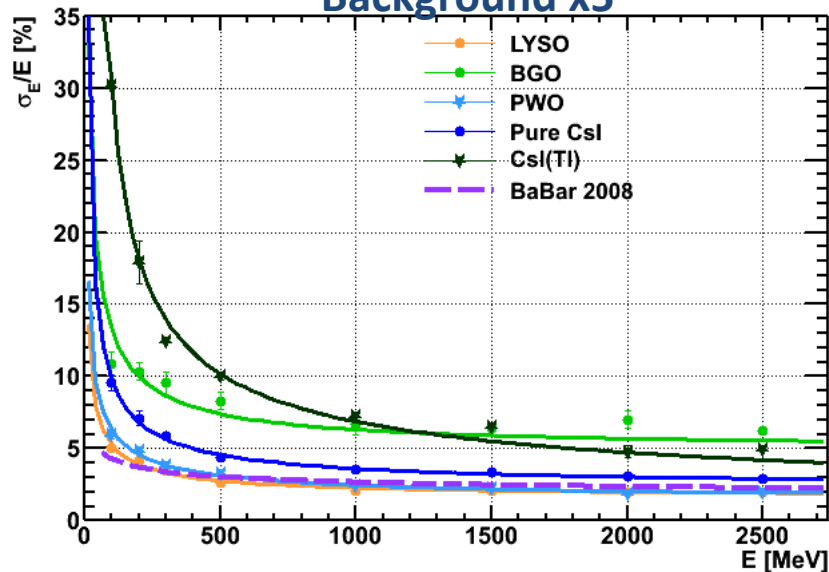
## NO Background



## Nominal Background



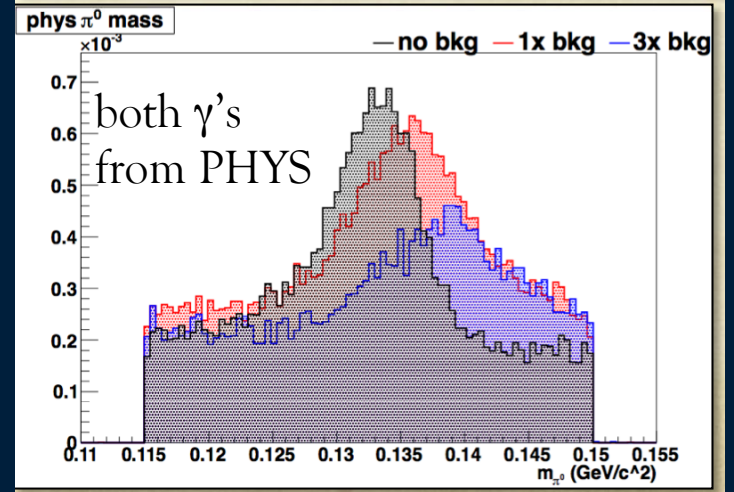
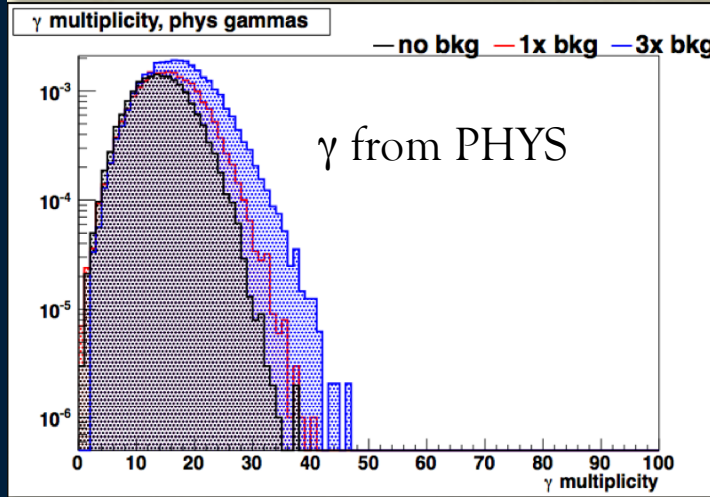
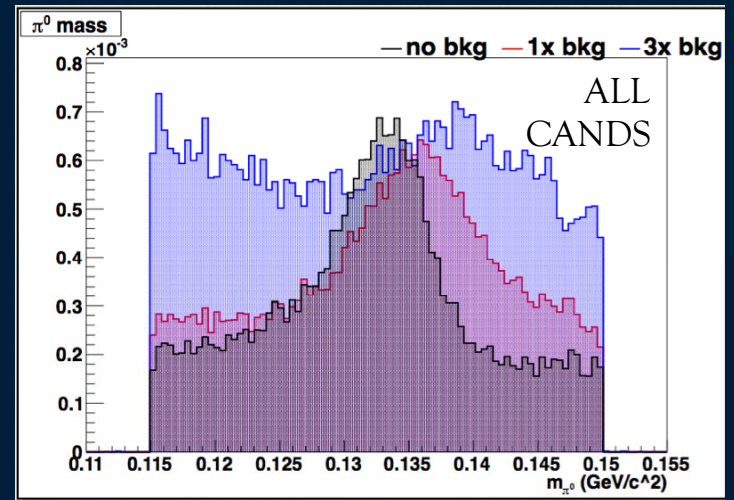
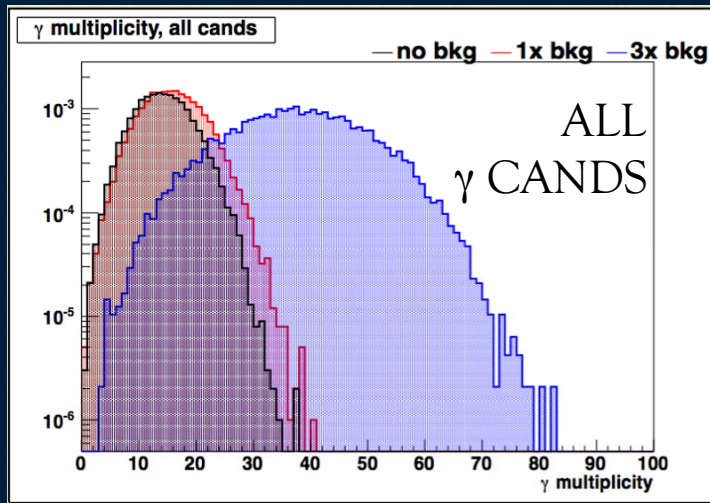
## Background x5



- ✓ Difference between CsI(Tl) and Pure CsI given by signal shape (crystal  $\tau$ )
- ✓ Difference between BGO and LYSO or PWO given by signal shape (crystal  $\tau$ )
- ✓ Difference between Pure CsI and LYSO or PWO given by crystal size ( $\sim x5$ )

# BKG IMPACT WITH FASTSIM – GAMMA, PI0

B B generic sample

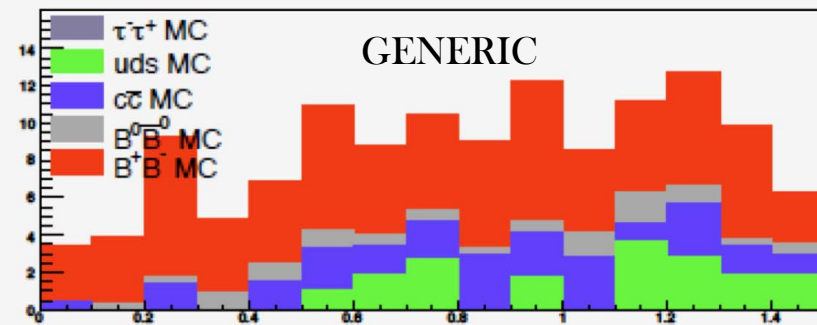
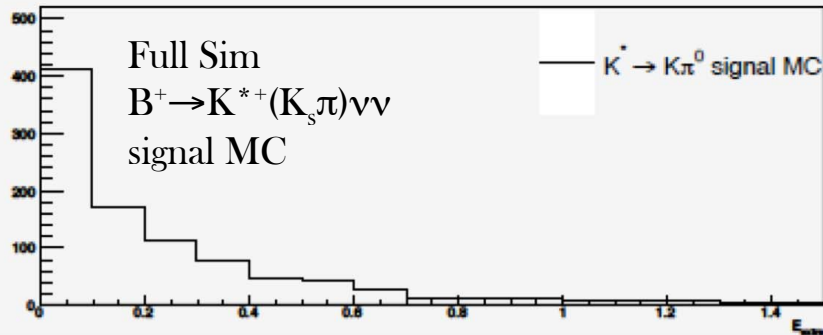


See E. Manoni talk at EMC I parallel session

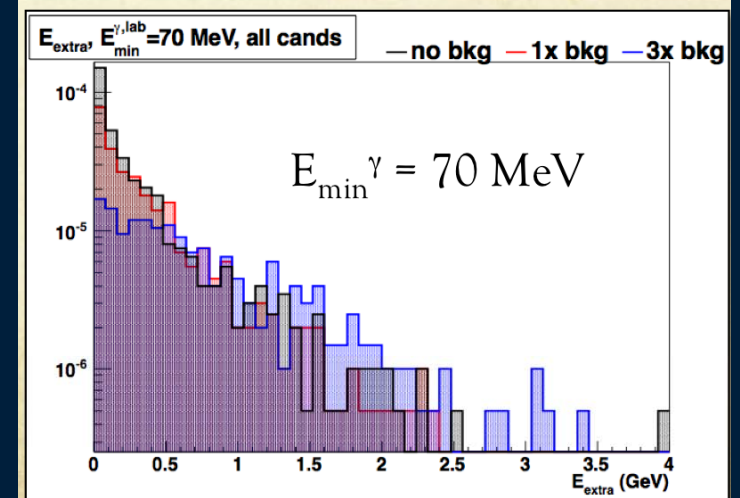
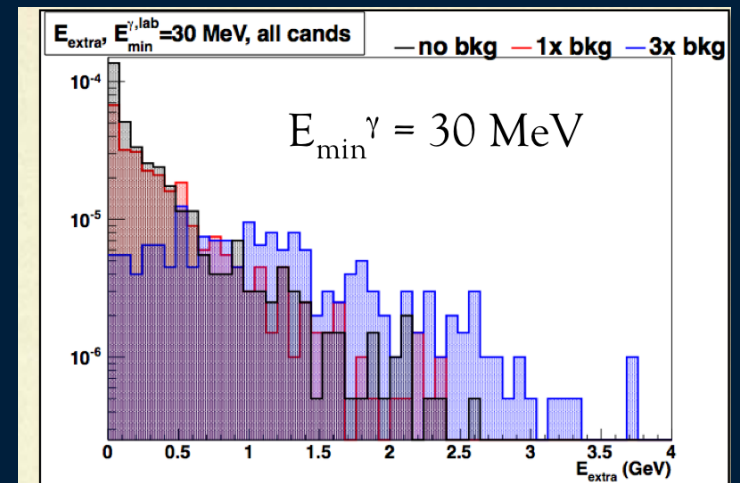
<http://agenda.infn.it/getFile.py/access?contribId=277&sessionId=27&resId=0&materialId=slides&confId=4441>



## BaBar



## SuperB



# CONCLUSIONS

- **Barrel Simulation**
  - Background has large effect on energy resolution
    - Large Theta dependence on resolution
    - Signal shape improvements need measurements to control Noise
- **Fwd Endcap 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
    - Photostatistics and Noise level need to be confirmed with measurements
  - LYSO is not affected by background
    - All input parameters come from measurements and experience
- **Background Types:**
  - Energy resolution is affected mainly by Radiative Bhabha
- **Physics with FastSim**
  - Background has large impact on physics quantities