Clustering related issues

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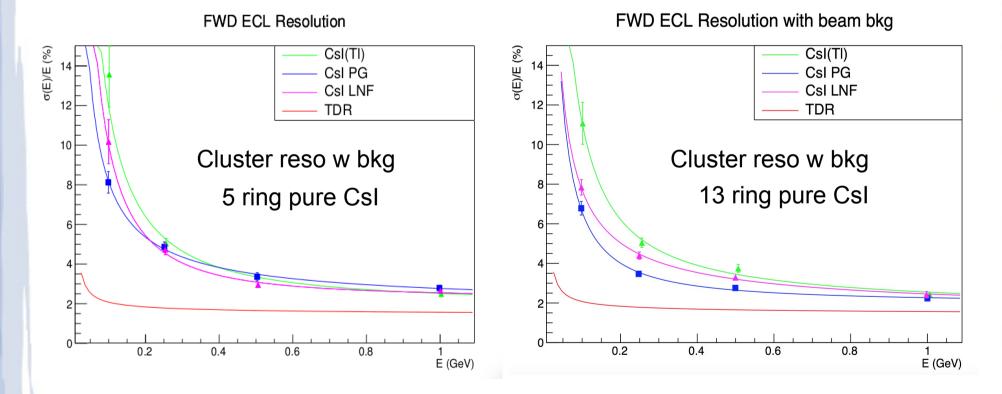
Belle II Meeting Italia, Padova, 31th May 2016





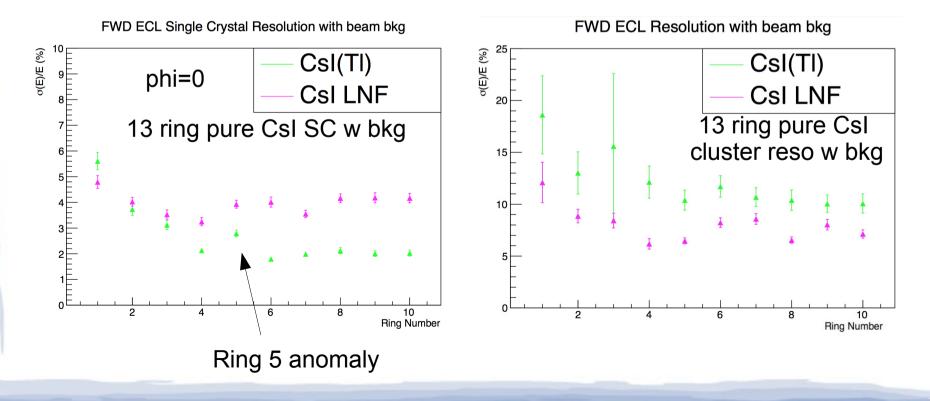
5 vs 13 layer pure CsI FWD with bkg

- Efficiency w bkg is seen to be better for a 13 ring pure CsI FWD rather than a 5 ring-only one: how reasonable is that?
- (Novosibirsk fit, 13 < theta < 30)



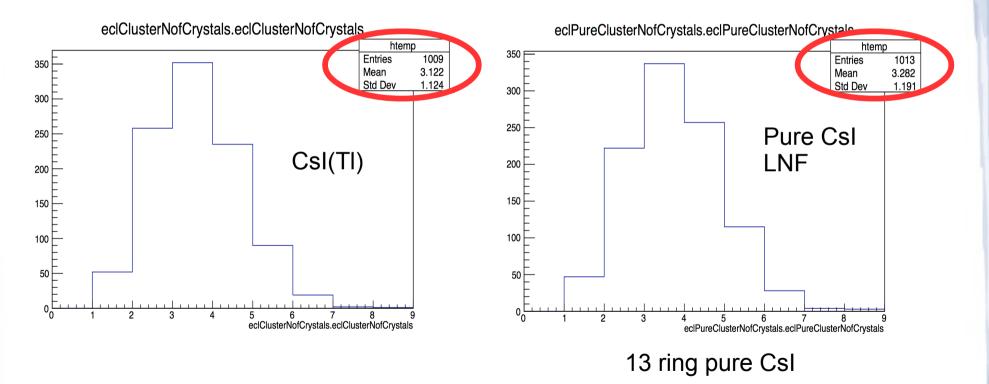
Single crystal studies with photons

- From previous result one could argue that even on the outer rings the bkg rate is high enough that pure CsI performs better than CsI(TI)
- We perform a ring by ring scan to study this dependency comparing resolution on single crystal vs cluster resolution for 100MeV photons
- Left: energy resolution in signle crystal from E_{reco} E_{dep} (gauss sigma, NS mean)
- Right: cluster resolution (only selection is fit range i.e. 0.08<E<0.115)



NofCrystals in clusters w/o bkg

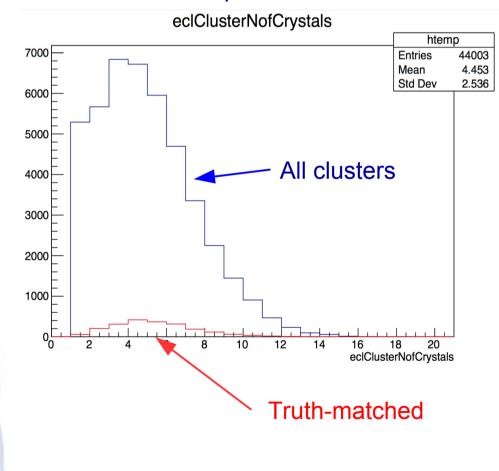
- When shooting single 100 MeV photons, w/o bkg, we observe that the multiplicity of crystals in cluster is low
- CsI(TI) and CsI have very similar multiplicity

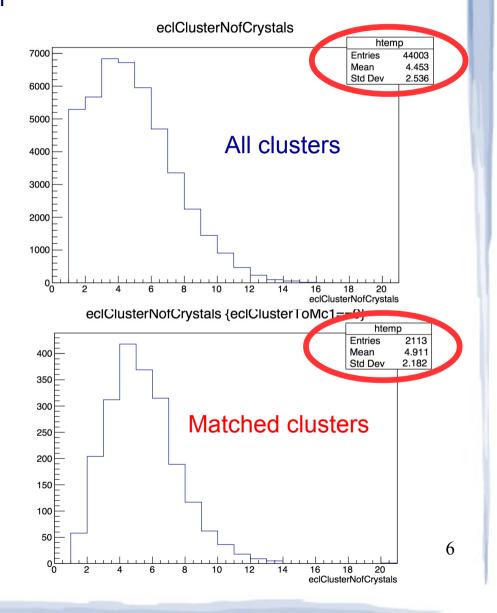


NofCry. in clusters w bkg, FULL sample Much broader distribution, on average 2 more crystals per cluster Minimal difference for the 2 set-ups • NOTE: that's all clusters • eclPureClusterNofCrystals eclClusterNofCrystals htemp htemp 39719 7000 Entries 44003 Entries 000 Mean 4.46 Mean 4.453 Std Dev 2.537 Std Dev 2.536 6000 5000 5000 4000 4000 CsI(TI) **PureCsl** 3000 3000 2000 2000 1000 1000 0 0^L 2 6 10 12 14 16 18 2 ۸ 8 10 12 14 16 18 20 eclPureClusterNofCrystals eclClusterNofCrystals 13 ring pure Csl

NofCry. in clusters w bkg w MC match

- From now on only results for CsI(TI) shown
- On average higher number of crystals if MC truth is required 4.45 -> 4.9

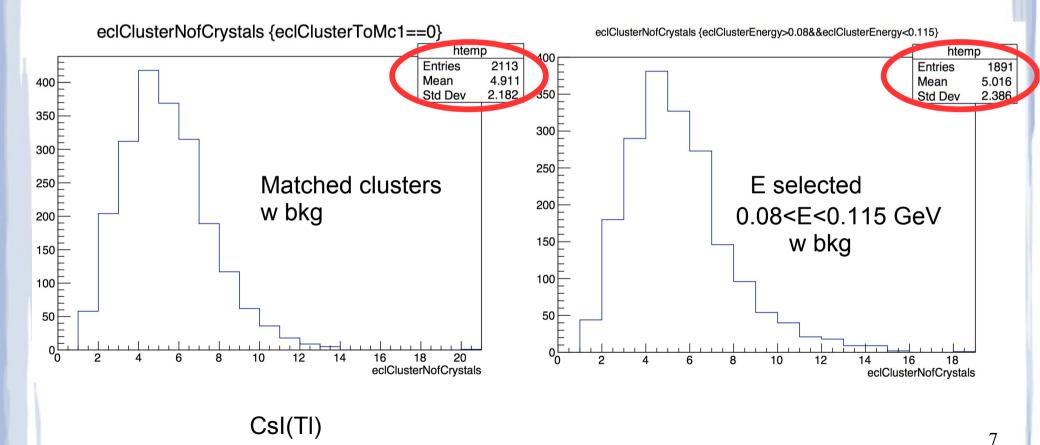




CsI(TI)

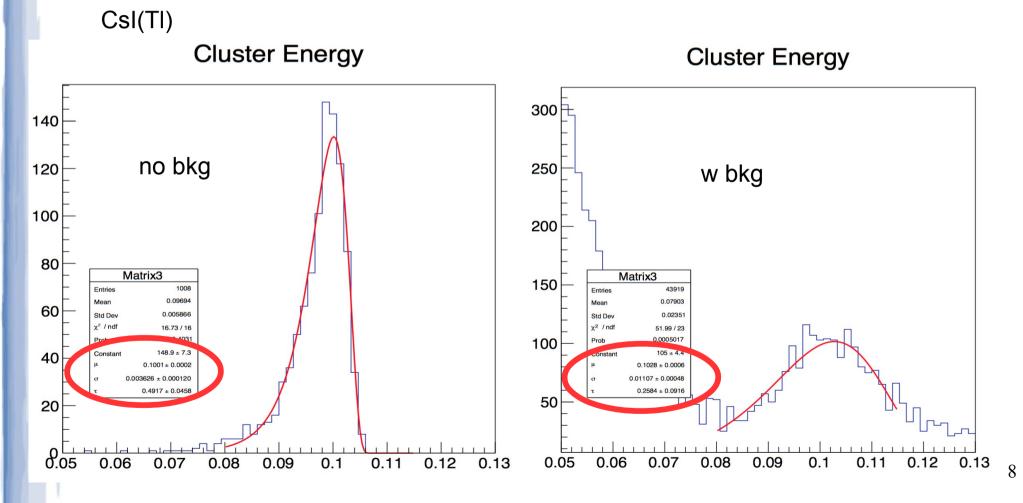
NofCry. in clusters w bkg no MC match

- For fitting cluster energy we use only selection given by fit interval (0.08<E<0.115 GeV)
- Selection based on energy cut reproduces well spectrum from MC truth



Bare cluster resolution

- Here only selection applied is fit interval 0.08 < E < 0.115
- Reference values for full cluster: 3.6% w/o bkg, 11% w bkg

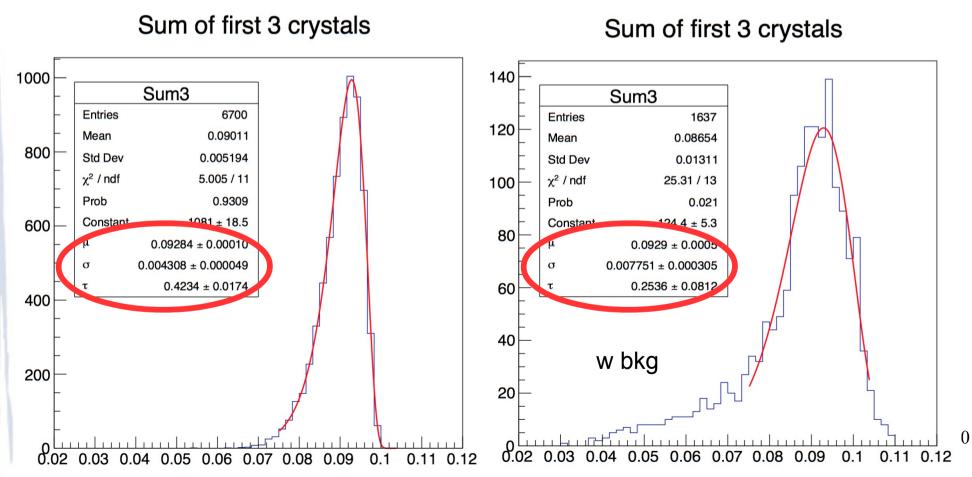


1st, 2nd, 3rd highest E crystals Single crystal energy deposit (eclCalDigit) for three highest deposits in cluster • **Most Energetic** Second Most Energetic **Third Most Energetic** 100 60 First Second 60 Third Entries 995 945 Entries 697 Entries 0.07034 Mean 50 Mean 0.01569 0.006255 Mean 80 Std Dev 0.01529 50 Std Dev 0.01071 0.004172 Std Dev χ^2 / ndf 68.21 / 28 χ^2 / ndf 38.21 / 40 χ^2 / ndf 23.98 / 28 40 Prob 3.299e-05 40 60 Constant 4.249 ± 0.064 Constant 5.194 ± 0.131 0.07855 ± 0.00133 Slope -62.59 ± 3.19 Slope -244.8 ± 15.2 0.0147 ± 0.0014 30 0.3016 ± 0.1224 40 20 20 no bkg 20 10 10 no bkg no bkg 0 00 0^t 0.08 0.02 0.06 0.1 0.12 0.04 0.01 0.02 0.03 0.04 0.05 0.06 0.005 0.01 0.015 0.02 0.025 0.03 0.035 0.04 Second Most Energetic Most Energetic **Third Most Energetic** 100 100 Second First Third 140 Entries 1891 Entries 1838 Entries 1637 Mean 0.065 Mean 0.01588 Mean 0.007605 80 80 120 Std Dev 0.01942 Std Dev 0.009744 0.004427 Std Dev χ^2 / ndf 32.07 / 28 χ^2 / ndf 396.2 / 43 χ^2 / ndf 240.1 / 35 Prob 0.2717 100 2.01e-00 60 60 Constant 4.656 ± 0.036 Constant 5.375 ± 0.041 0.08021 ± 0.00120 Slope -60.55 ± 1.60 Slope -164.1 ± 4.0 80 0.01746 ± 0.00084 0.8828 ± 0.156 40 40 60 · w bkg bkq 40 20 20 w bkg 20 00 0<u>,</u> 0 0.04 0.04 0.06 0.02 0.06 0.08 0.1 0.12 0.01 0.02 0.03 0.05 0,005 0.01 0.015 0.02 0.025 0.03 0.035 0.04 Novosibirsk Exp

1st, 2nd, 3rd highest sum

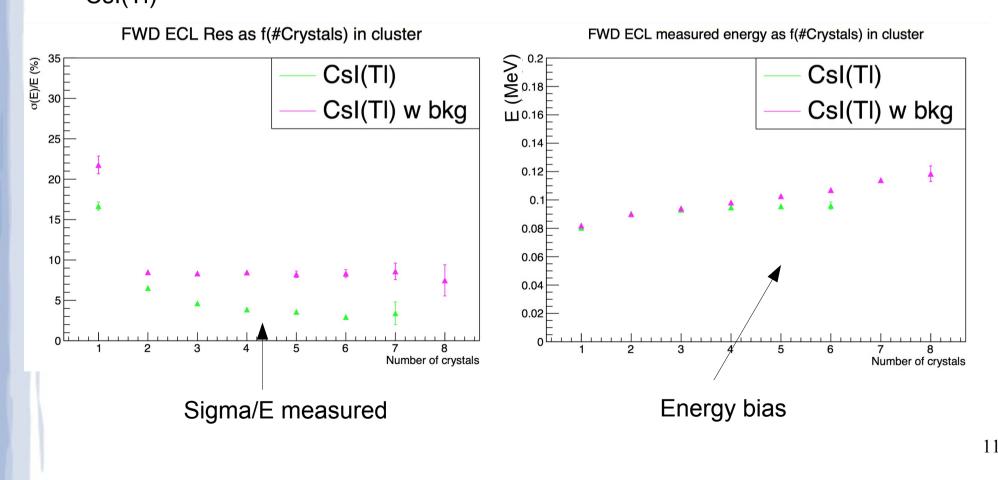
 Resolution of distribution of 3 most energetic cyrstals with beam bkg is better than full cluster

CsI(TI)



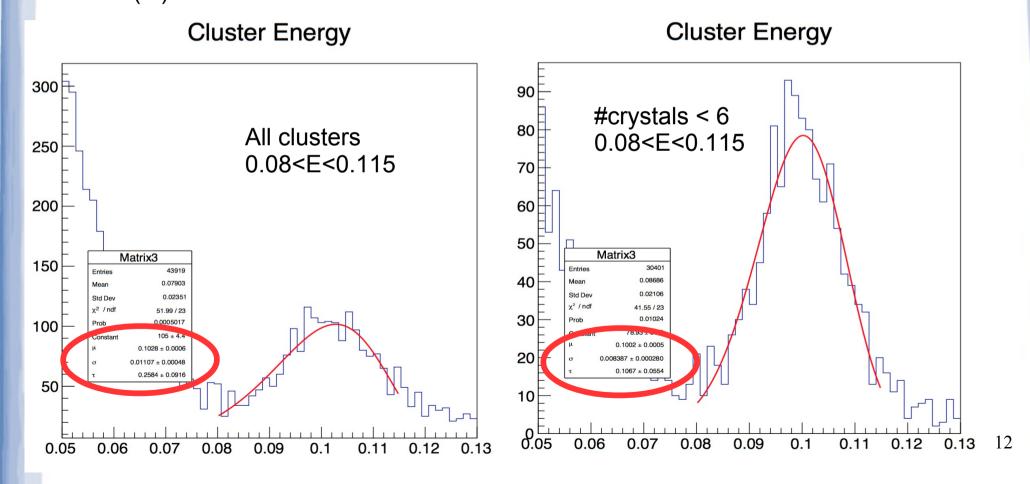
Summing over highest E crystals

- What does happen if we keep just the most energetic digits in cluster?
- (Please note: points are obtained summing highest energy crystals of ALL clusters with NofCrystals > N) CsI(TI)



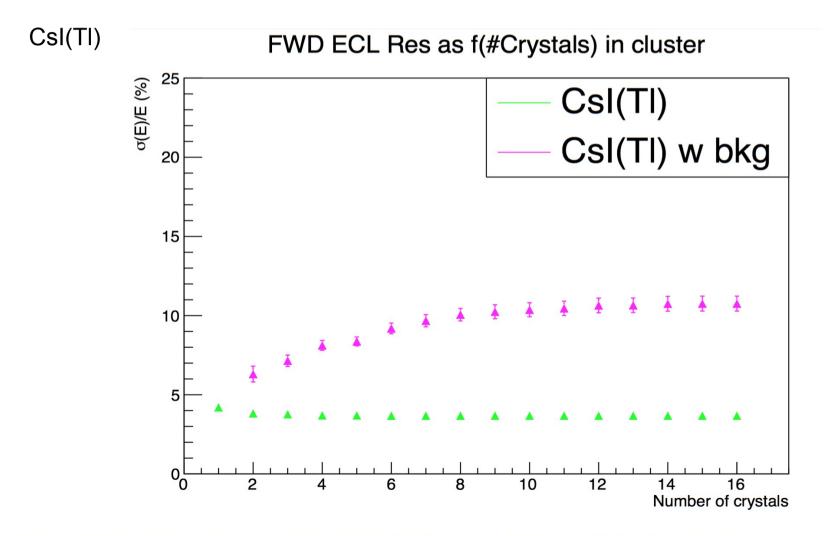
Resolution as function of #crystals

- Previous plot not so easy to read -> we study resolution as f(NofCrystals(Cluster))
- If we keep just clusters with a low number of crystals resolution is seen to better in the presence of bkg CsI(TI)



Resolution as function of #crystals

 If we keep just clusters with a low number of crystals resolution is seen to better in the presence of bkg



(Preliminary) Conclusions

- When bkg is added the comparison of pure CsI and CsI(TI) shows an unexpected behavior
- When beam bkg is added baseline ECL resolution worsens when adding more and more crystals in clustering
- This points clearly out that our algorithm isn't optimized for Belle2 bkg rates
- Current physics performance is expected to improve significantly even for baseline configuration
- Difficult to make a reasonable performance comparison for pure Csl and CsI(TI) without optimized clustering

Additional Slides

Outline

- Our study was initially triggered by the aim to compare results obtained in lab for pure CsI with basf2 simulation:
 - Response to cosmics w and w/o bkg
 - Response to single gammas w and w/o bkg
- 3 crystal configurations compared: baseline and 2 different pure Csl settings (see later)
- Code revision build-2016-04-10 (pre-release 07 build ndr) + r27501 for eclDigitizer and eclDataAnalysis
- bkg from 12th campaign (1ms equivalent, r24370)

Cosmic Test

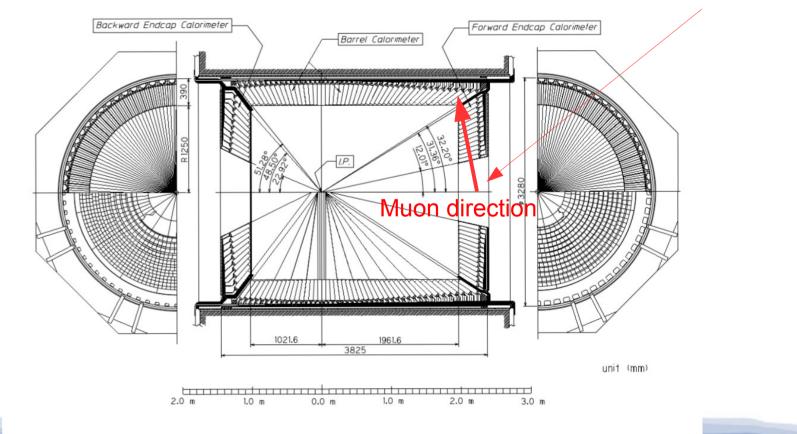
 We shoot 1GeV pGun muons from beam-axis on face of crystal #1 of 1st ring (in the middle) (phi=0 -> max bkg expected)

CSI ELECTROMAGNETIC CALORIMETER

• Geometry: ECL only, 13 ring full pure Csl FWD

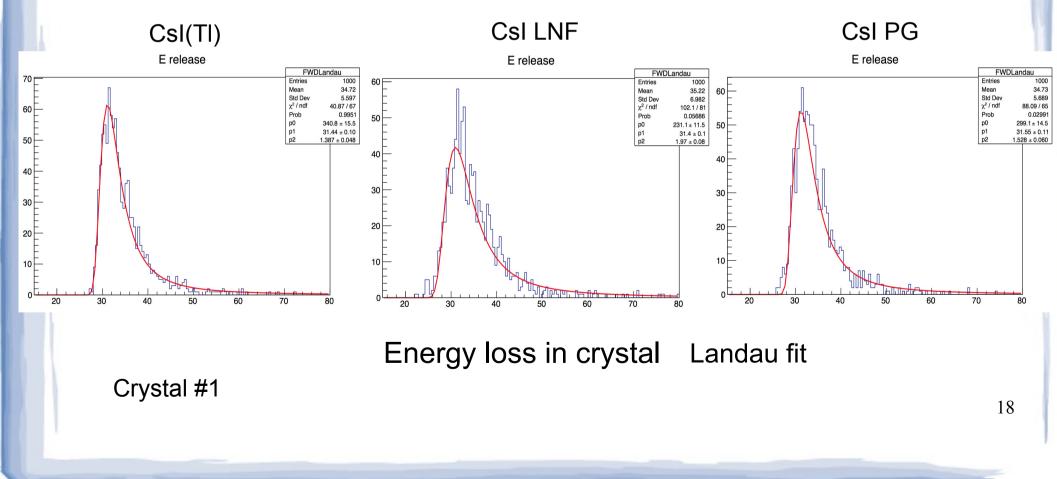
RFIIF

p=1 GeV (was 10 GeV) (theta, phi) -> (102.4,3.5) (x,y,z) -> (0,0,221.55)



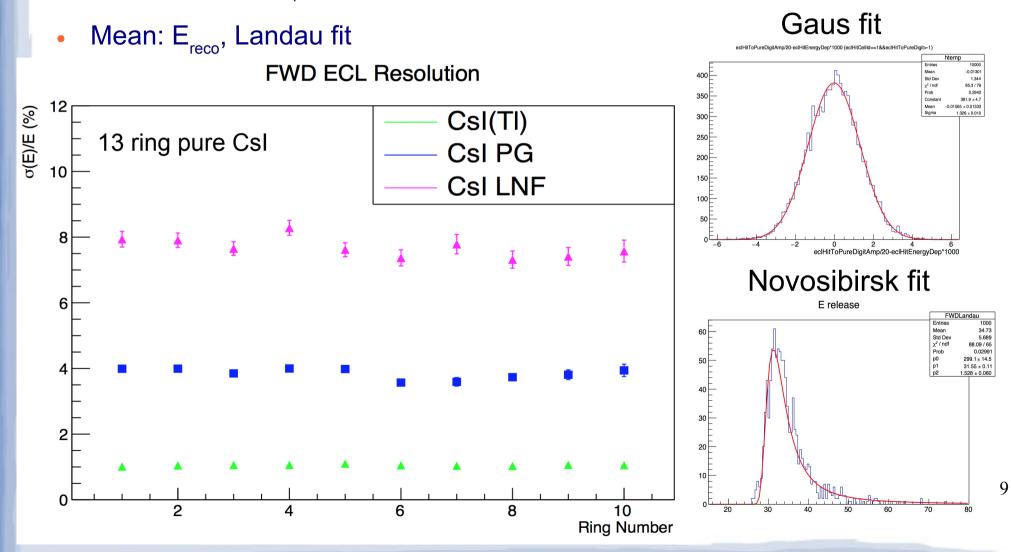
Cosmic Test

- 3 configurations studied:
 - Baseline (CsI(TI))
 - Pure CsI LNF version (ENE=1.3, PS=0.40)
 - Pure CsI PG version (ENE=0.7, PS=0.20)



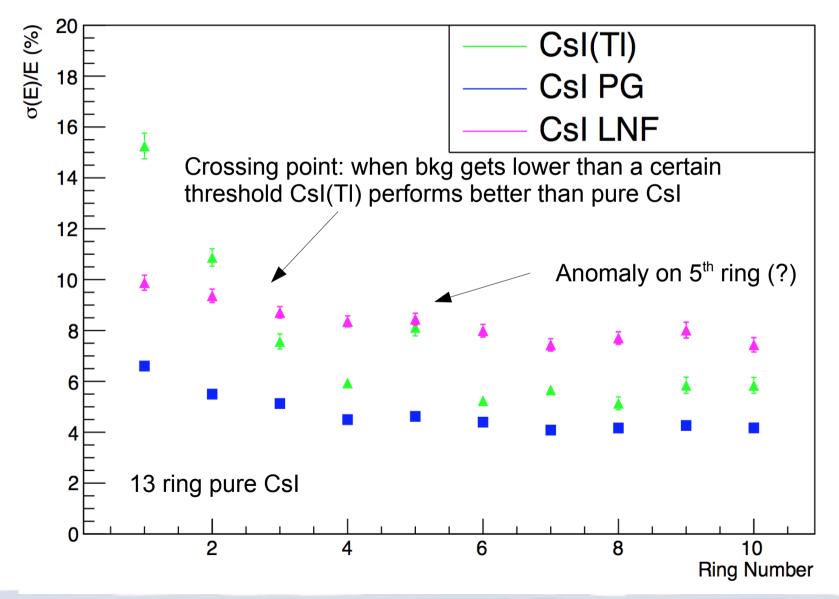
Cosmics: resolution w/o bkg S.C.

- Resolution studied for single crystals
- Sigma: E_{reco} E_{dep} (hit level), sigma from gaussian fit



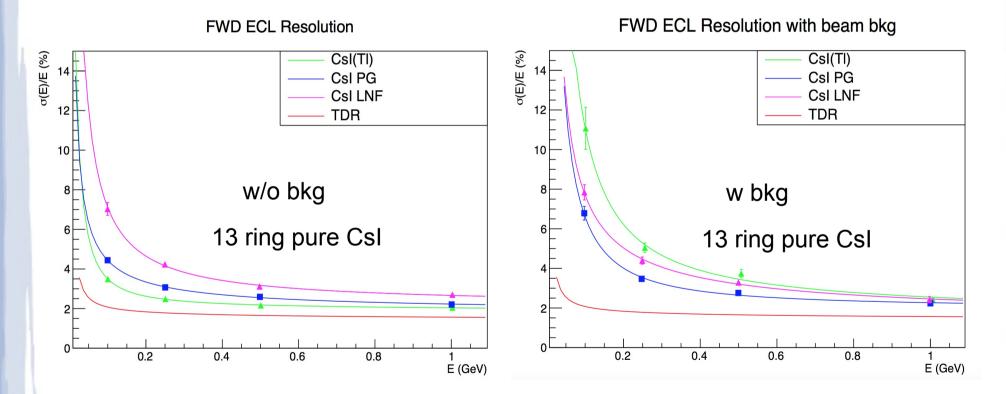
Cosmics: resolution w bkg S.C.

FWD ECL Resolution



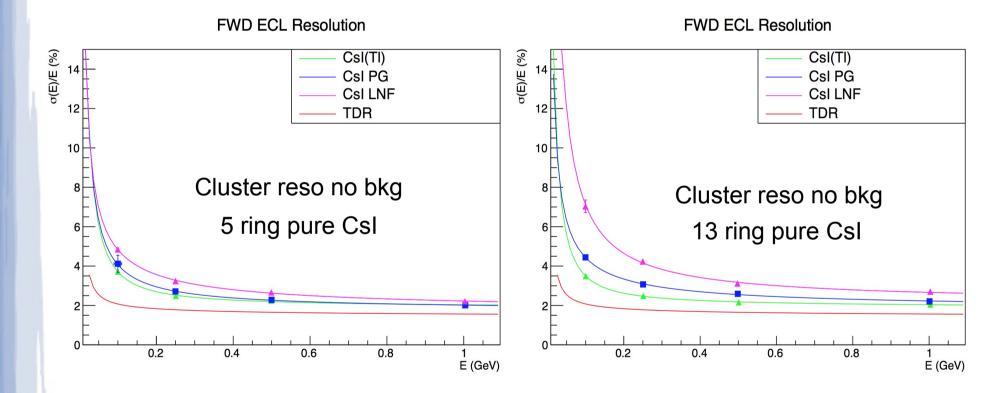
Cluster resolution for photons

- Single photon 13<theta<30, energy scan, no material in front of ECL
- Individual Novosibirsk fit, sigma=FWHM/2.36
- 13 and 5 ring (ring: 1, 2, 3, 4, 5) pure CsI configuration studied



5 vs 13 layer pure CsI FWD w/o bkg

 Without bkg a 5 layer pure CsI FWD performs better than a 13 ring one as expected

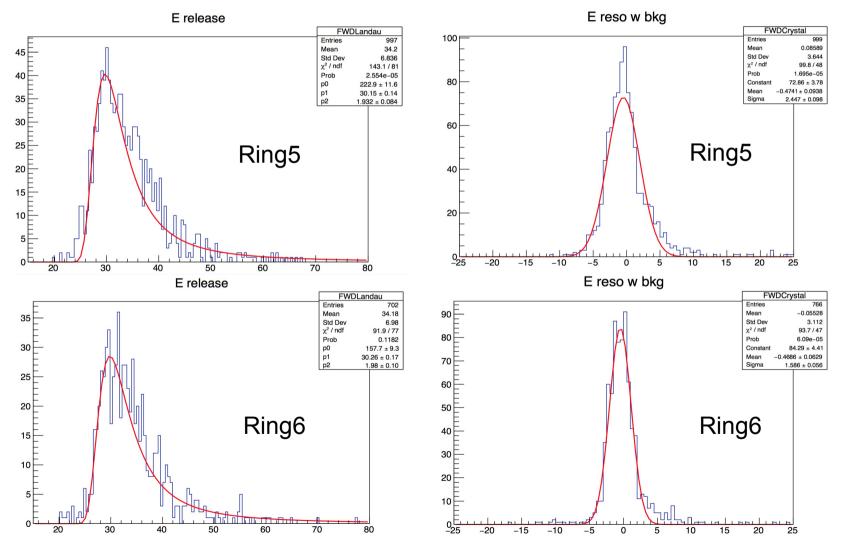


Bkg hits a f(crystal #)

eclHitCellId {eclHitCellId<800} ×10³ htemp 8.03415e+07 Entries 4000 263.7 Mean Std Dev 246.7 3500 3000 2500 2000 1500 1000 500 0 0 Ring48 100 300 400 500 600 700 800 Ring2 Ring1 Ring3 Ring5 **Ring6** Ring8 Ring9 Ring7 eclHitCellId

Ring 5 in cosmics test

• Very bad efficiency on ring 5 (ref. Pag. 6)



Cosmics: E release as f(ring #) S.C.

- Energy release for "cosmic" in crystal as function of the ring number
- Less energy collected for higher ring number, anomaly at ring 8

