FSR and line-shape energy tail studies

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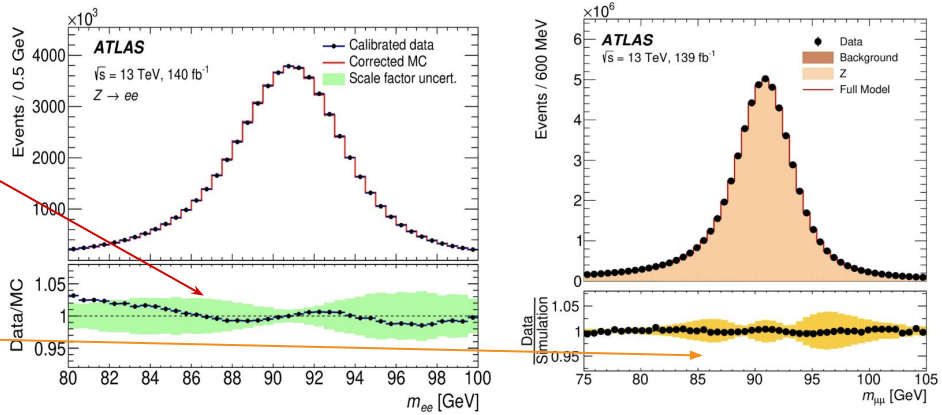
See Maarten slides : here

Original idea and motivation

Motivation:

- **Z → ee** data show an excess of energy tails, since ever (Run1, Run2, sliding windows and supercluster reco) this generates energy scale systematics (from fit window variations) that limit the overall calibration precision.
- **Muons** behave better

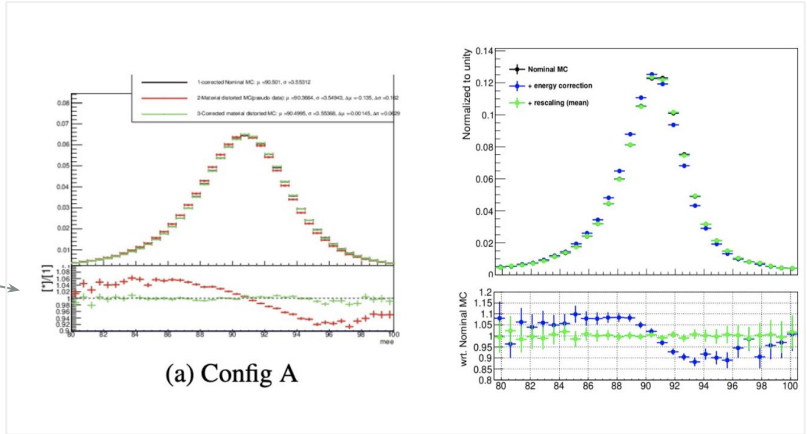


Mainly affecting W&Z analysis

Possible causes studied over the years:

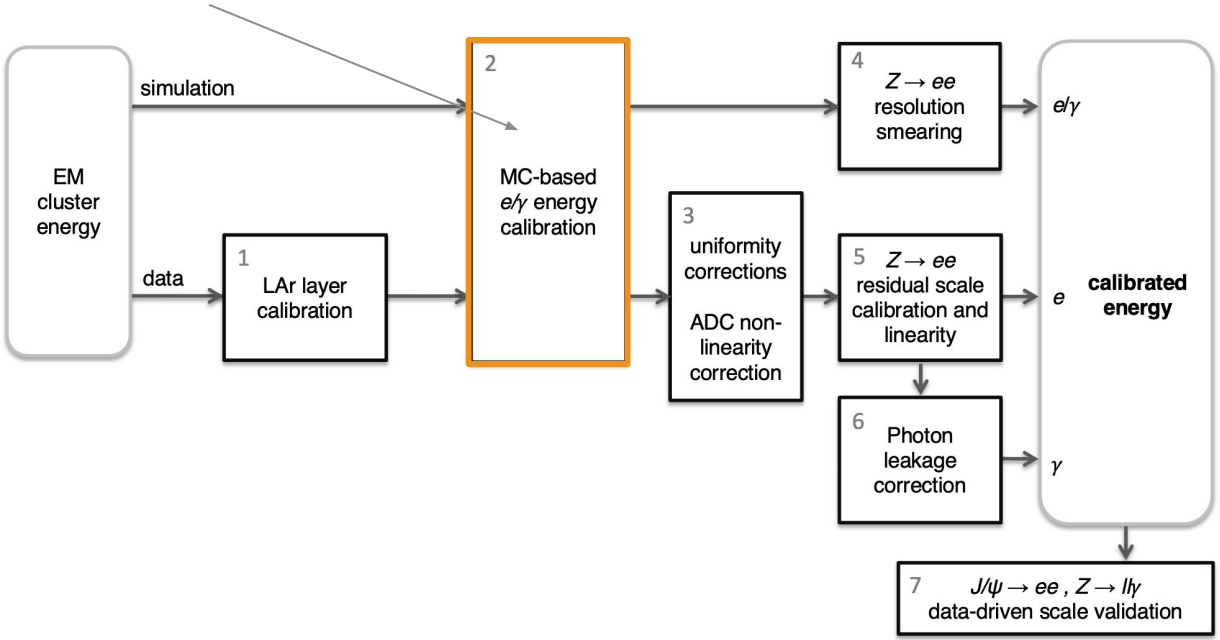
- Intercalibration of the Presampler and the accordion layers, even S3
- Readout non-linearity
- Lateral shower shapes
- Passive Material variation

Nothing conclusive until now !



Egamma MVA calibration

MVA calibration (regression) based on cluster kinematics and longitudinal shower



But the training is done with special single particle gun sample, **where events have only single e/y particle and nothing else**

-> MVA is trained with electron w/o FSR

Effect of close by FRS on MVA ?

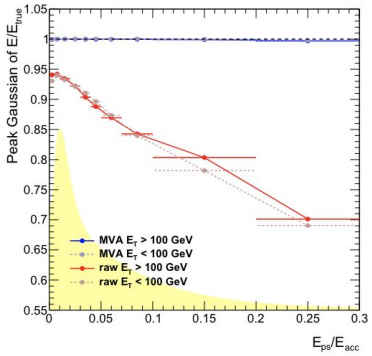
- **MVA is trained without FSR**

If E1/E2 energy distribution are affected by FSR energy, MVA could over/under correct the mass :

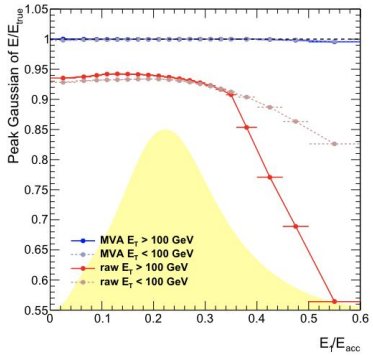
- Situation 1: A bit harder FSR (usually larger dR) can modify E0,E1,E2, E1/E2
- Situation 2: FSR is too hard to be within the cluster
  - This is lateral leakage, we lost completely FSR information in this case
  - MVA would not correct the energy, and consider this is a lower energy electron

Ideally, the effect of FSR on MVA is the same between data and MC, so cancelled. But FSR is not perfectly modelled.

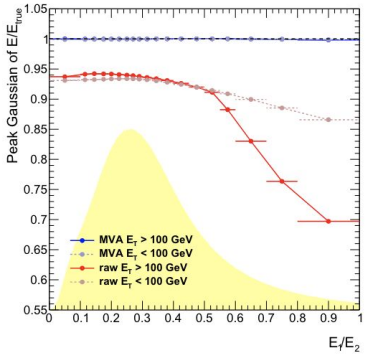
Aim to study Mee w/ different FSR to see if we can reproduce the data/MC lineshape



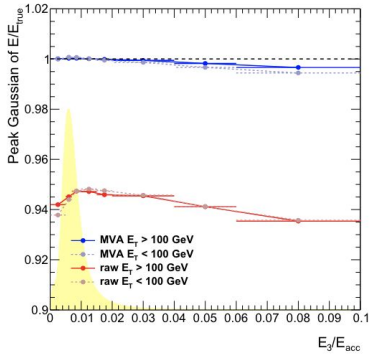
(a) Presampler fraction



(b) E_1 fraction



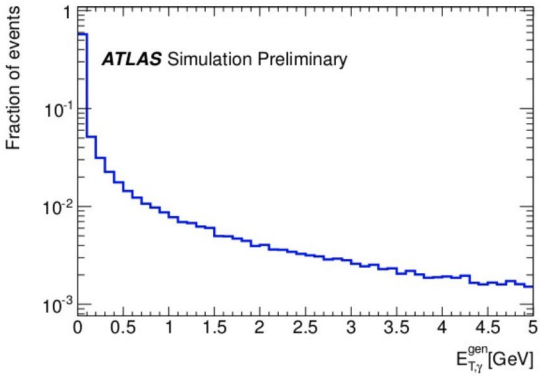
(c) E_1/E_2 fraction

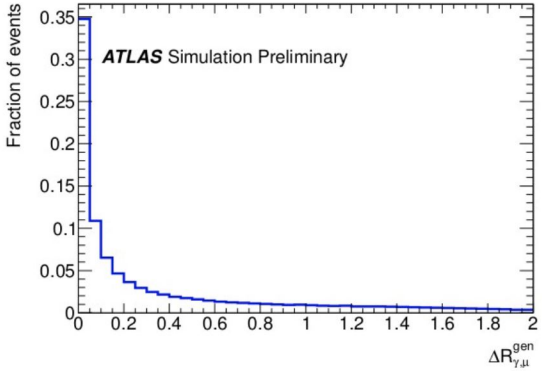


(d) E_3 fraction

FSR modelling

Plots from Maarten



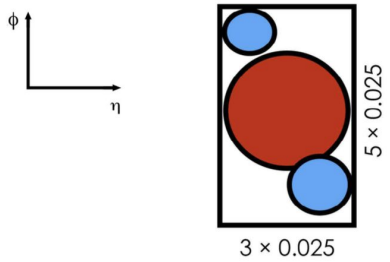


Study FSR close enough with the reconstructed electron cluster, and the impact on the mee distribution.

dR: 0, 0.025, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.5, 1.0, 1.5, 2, 10

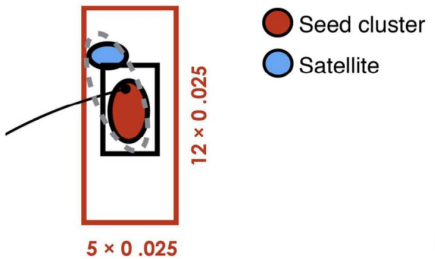
All $e^{\pm}$, γ:

Add all clusters within 3 × 5 window around seed cluster.



Electrons only:

Seed, secondary cluster **match the same track**.



Setup with mc16 samples

MC16e Zee: mc16_13TeV.361106.PowhegPythia8EvtGen_AZNLOCTEQ6L1_Zee.deriv.DAOD_EGAM1.e3601_s3126_r10724_p4615

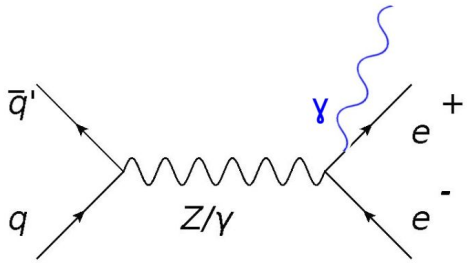
Reco level: e+e- pair with medium ID, loose isolated, with standard d0, z0 cuts

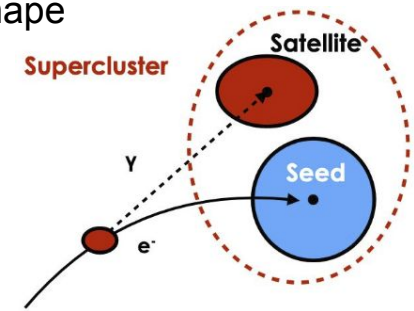
Truth level:

- Born (Powheg status=3) and Bare (Powheg status=1) truth electrons dR-matched to leading or subleading reco electron
- All stable **FSR truth photons (status=1), excluding G4 photons (barcode < 200000)** and those from hadron/tau decay; so far replying on minimum dR(e, y) to match between FSR photon and electron, plan to improve in coming ntuple.

Choice between Born and Bare:

- As Bare is geometrically close to reco cluster, it is taken as the core to define dR rings with which we classify FSR photons and study the mass lineshape





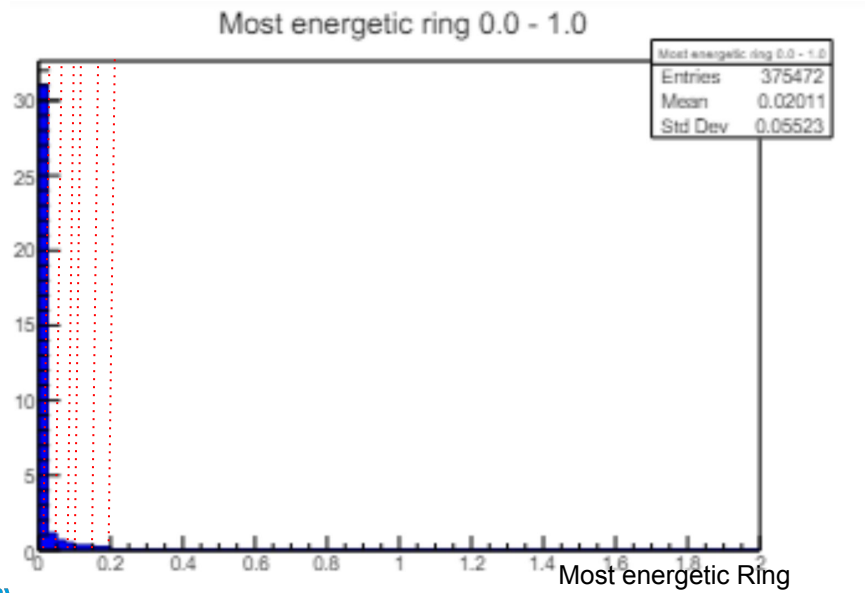
Categorize the FSR

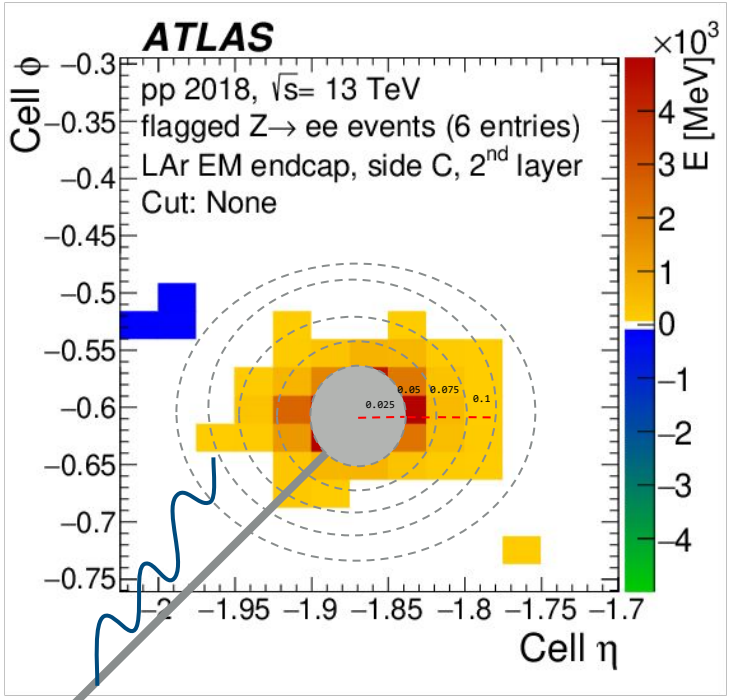
Categorizing events by the ***most energetic FSR*** concentric rings around the “bare” electron axis :

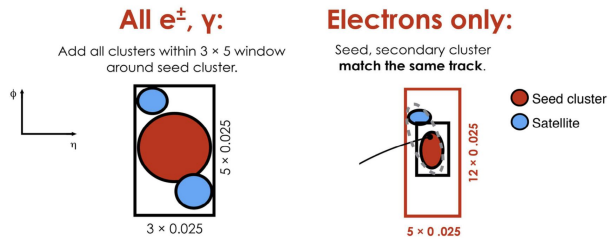
Rings: 0, 0.025, 0.05, 0.075, 0.1, 0.15, 0.2, 0.25, 0.3, 0.5, 1.0, 1.5, 2, 10

Near seed cluster

Possible within supercluster

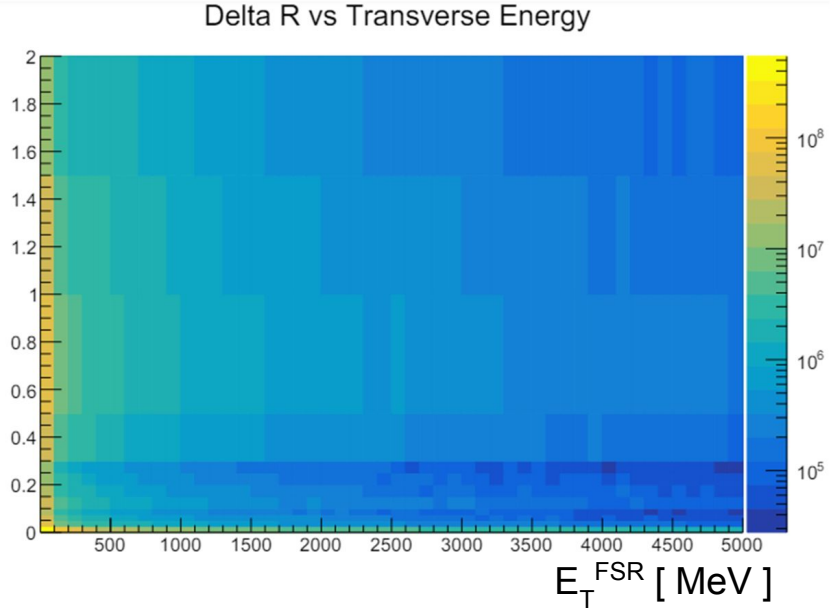




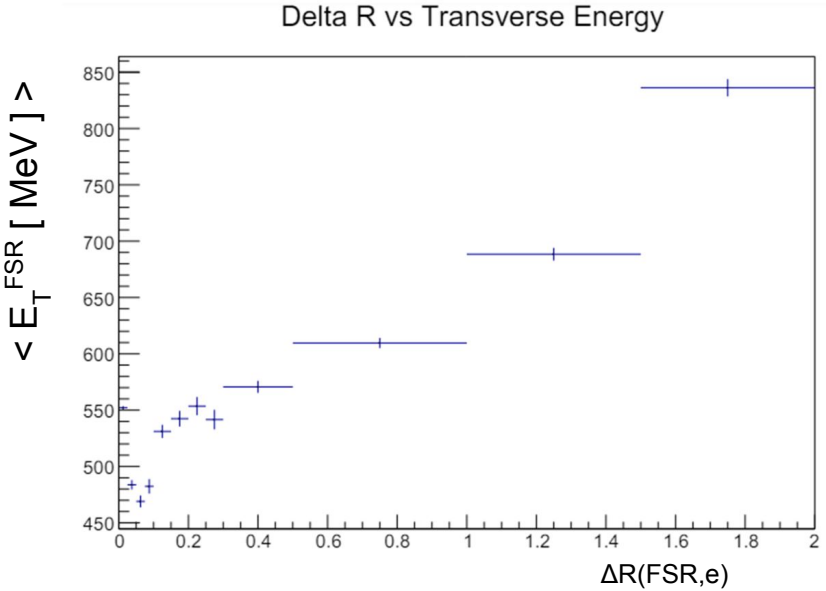


FSR Some basic distributions

dR(e,y) vs E_Ty (transverse energy) – all FSR γ matched to truth bare electron



dR(e,y) vs avg. E_Ty (transverse energy)

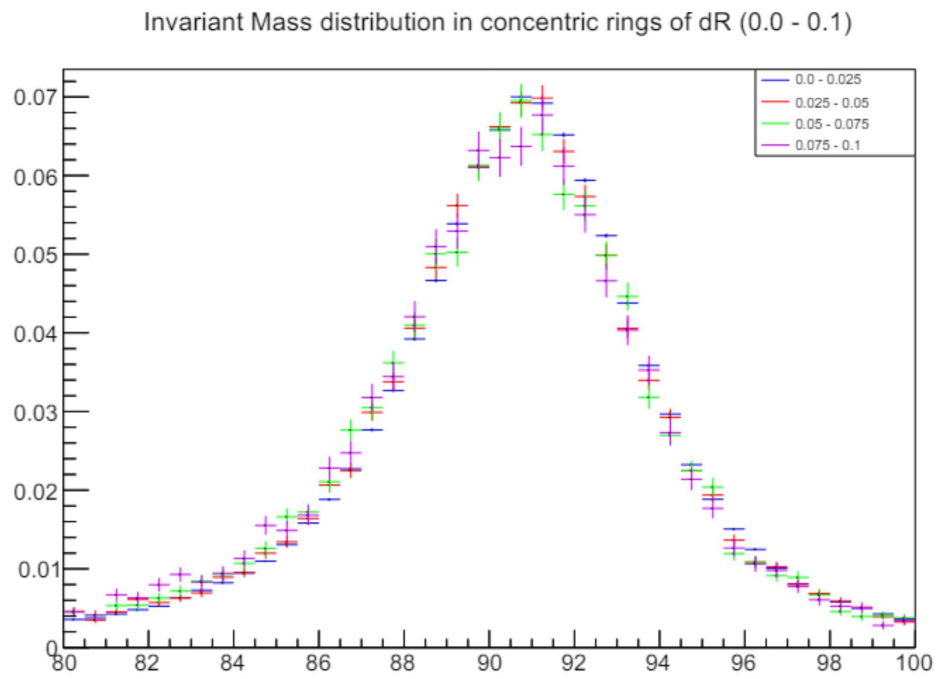


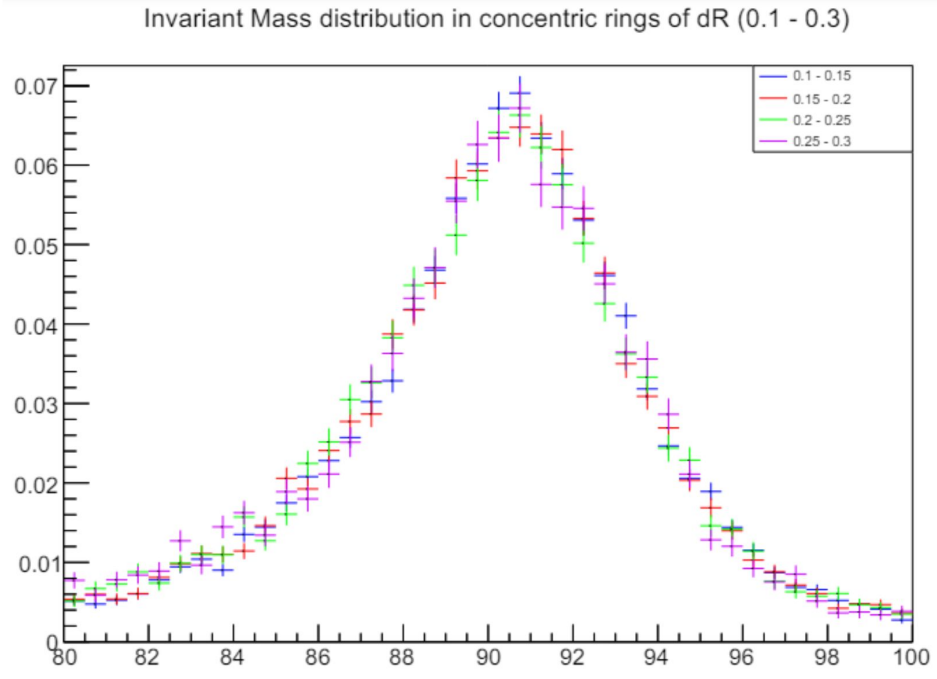
Energy profile of the FSR γ vs ΔR(FSR,e)

NB. for ΔR < 0.2 γ energy will be included in the electron cluster reconstruction.

At least 1 electron in eta [0.0-1.0]

Invariant Mass (M_ee)

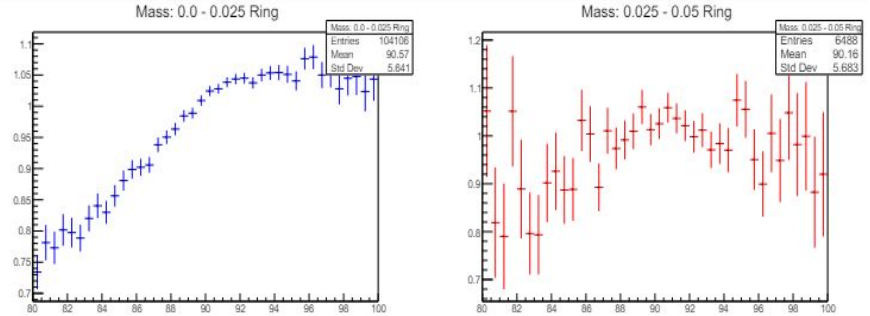


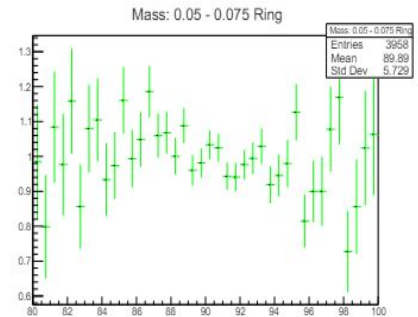


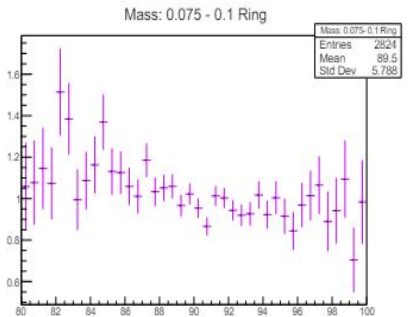
- Categorizing events with most energetic FSR in concentric rings around the “bare” electron axis.
- Response clearly not uniform while FSR are collinear or leaking outside the cluster. Why ? How MVA correct the electron Energy ?

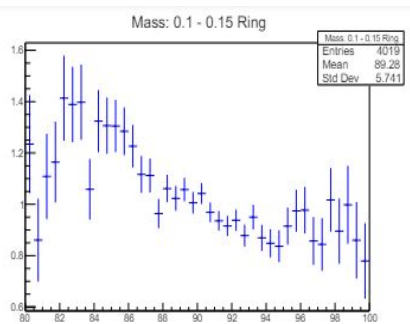
At least 1 electron in eta [0.0-1.0]

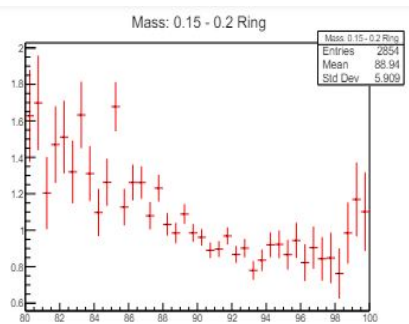
M_ee ratio

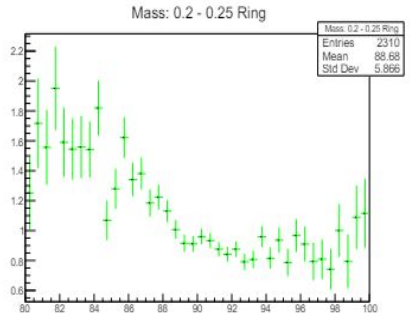


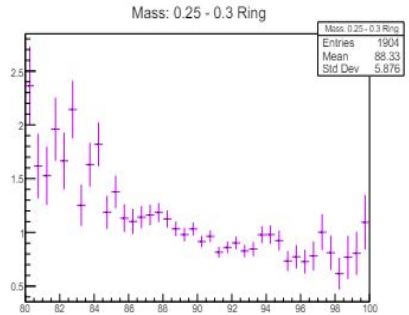








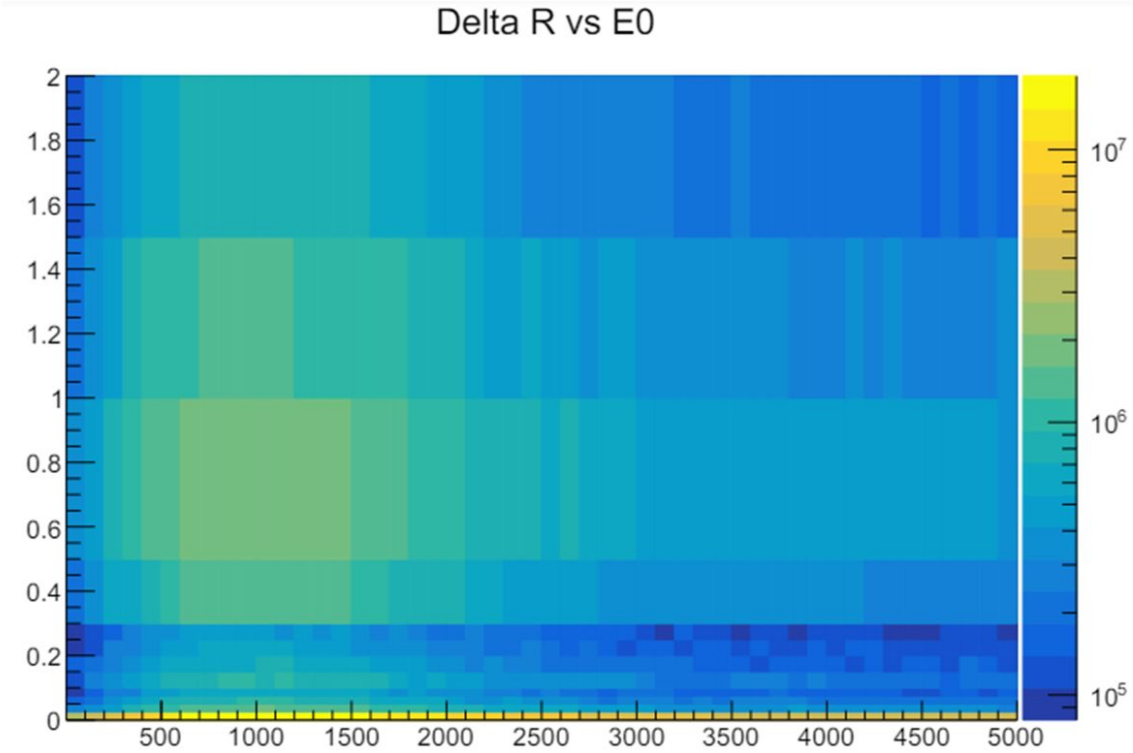




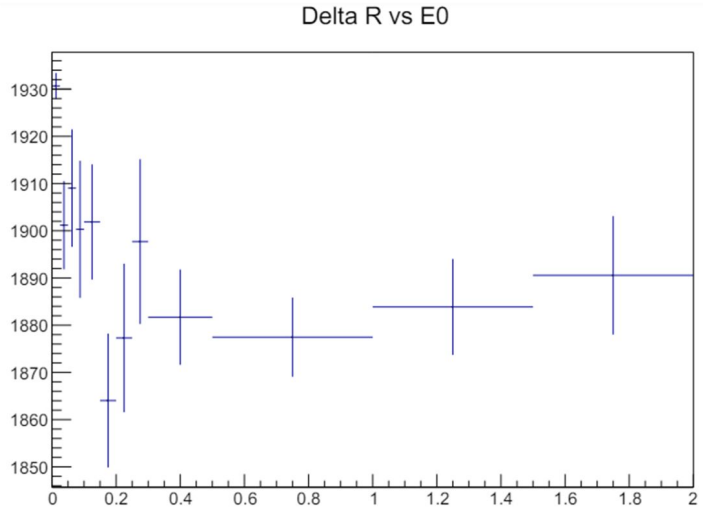
Response clearly not uniform while FSR are collinear or leaking outside the cluster
Why ? How MVA correct the electron Energy ?

dR[FSR,el] vs E0 of electron

dR(e,y) vs E_0y – most energetic FSR y matched to truth bare electron

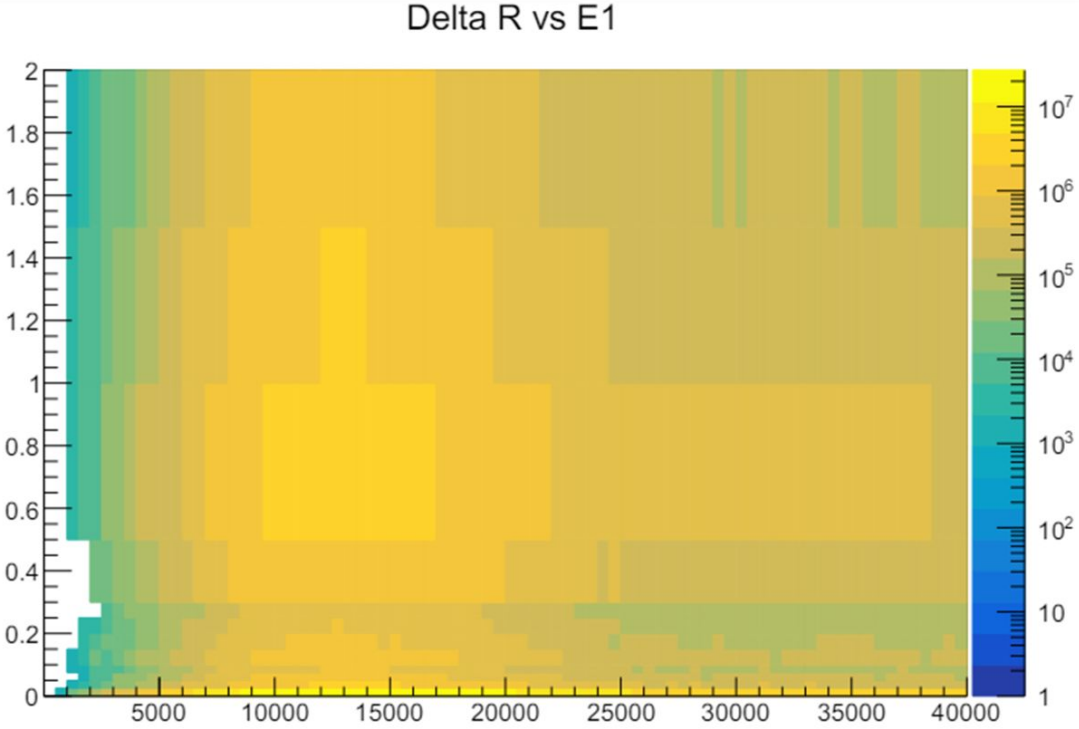


dR(e,y) vs avg. E_0y

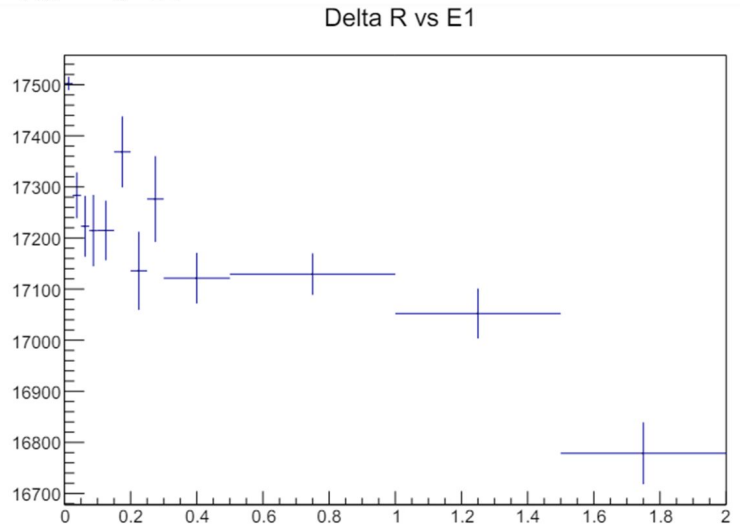


dR[FSR,el] vs E1 of electron

dR(e,y) vs E_1y – most energetic FSR y matched to truth bare electron

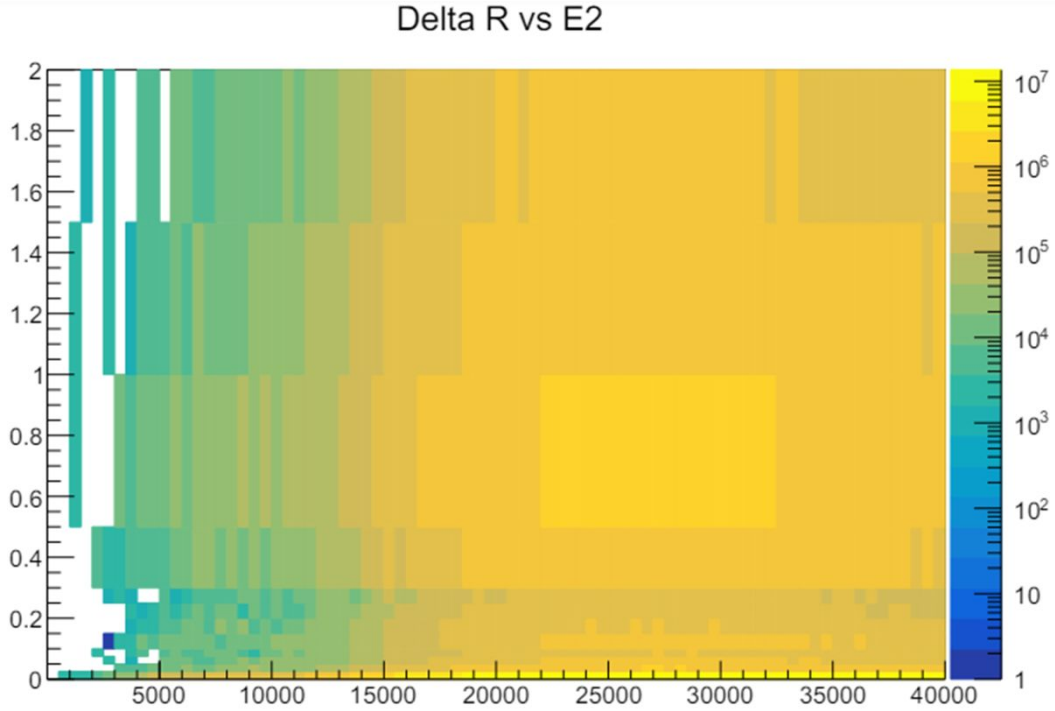


dR(e,y) vs avg. E_1y

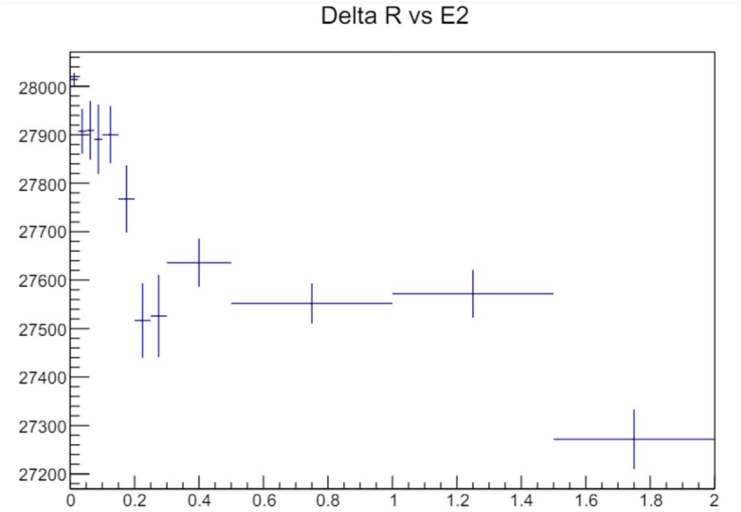


dR[FSR,el] vs E2 of electron

dR(e,y) vs E_2y – most energetic FSR y matched to truth bare electron

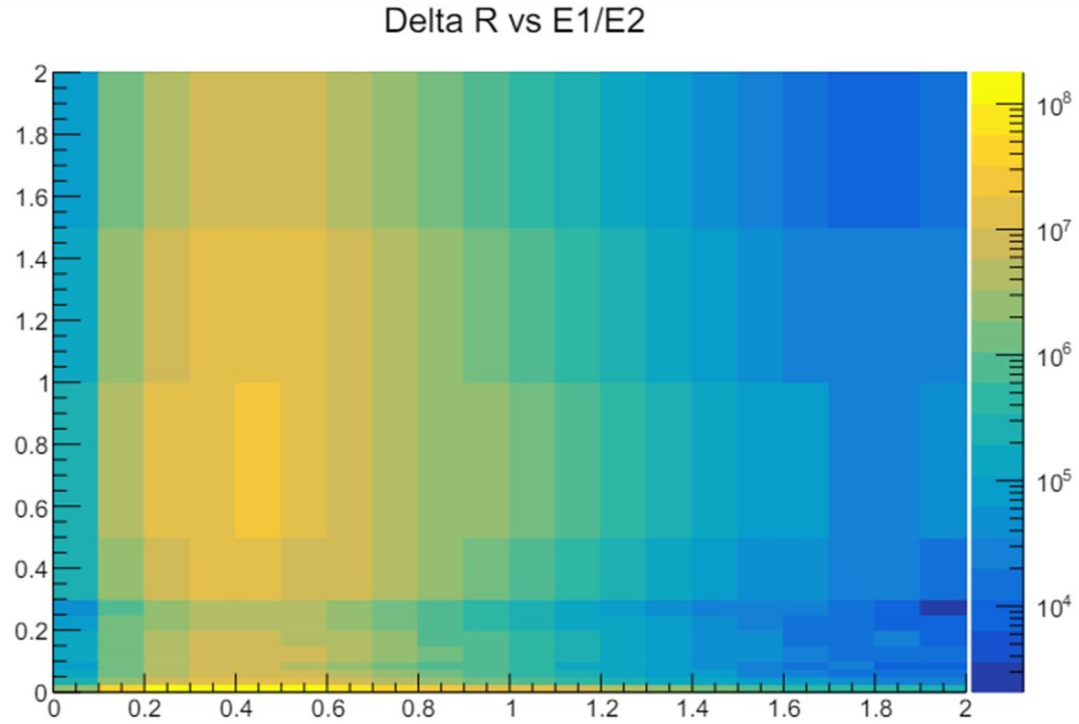


dR(e,y) vs avg. E_2y

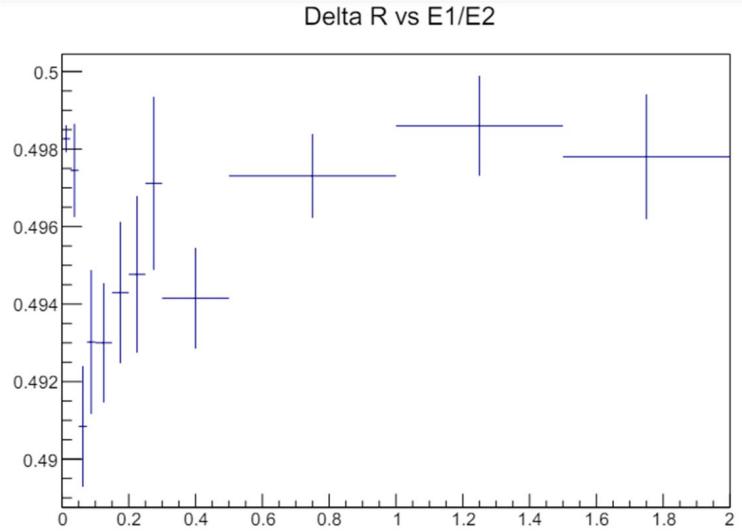


dR[FSR,el] vs E1/E2 of electron

dR(e,y) vs E_1/E_2y – most energetic FSR y matched to truth bare electron



dR(e,y) vs avg. E_1/E_2y



backup

Idea behind this study

- *A general possibility is that **a fraction of low-energy photons are somehow "lost" from the electron cluster**. This would generate energy tails, without disturbing the muons which are measured "bare" (and look good)*
- *Nearby photons (FSR, Brems)*
  - *Assume mis-modelled ΔR distributions → some energy lost around the cluster. Can the observed disagreement be reproduced with reasonable FSR variations?*
  - *In the case of FSR, the study can be done with existing samples + reweighting **[focus of these studies]***
- *Low-energy response : our main question to this group*
  - *Idea : randomly "kill" FSR or Brem photons entering the calorimeter volume below some threshold, to be varied. Can we reproduce the observed disagreement?*
  - *Idea to modify GEANT shower photons …*