HyCal Digitization Radiative effect

- Using simulation to study whether the small radiative tail from the data and HyCal digitization make sense

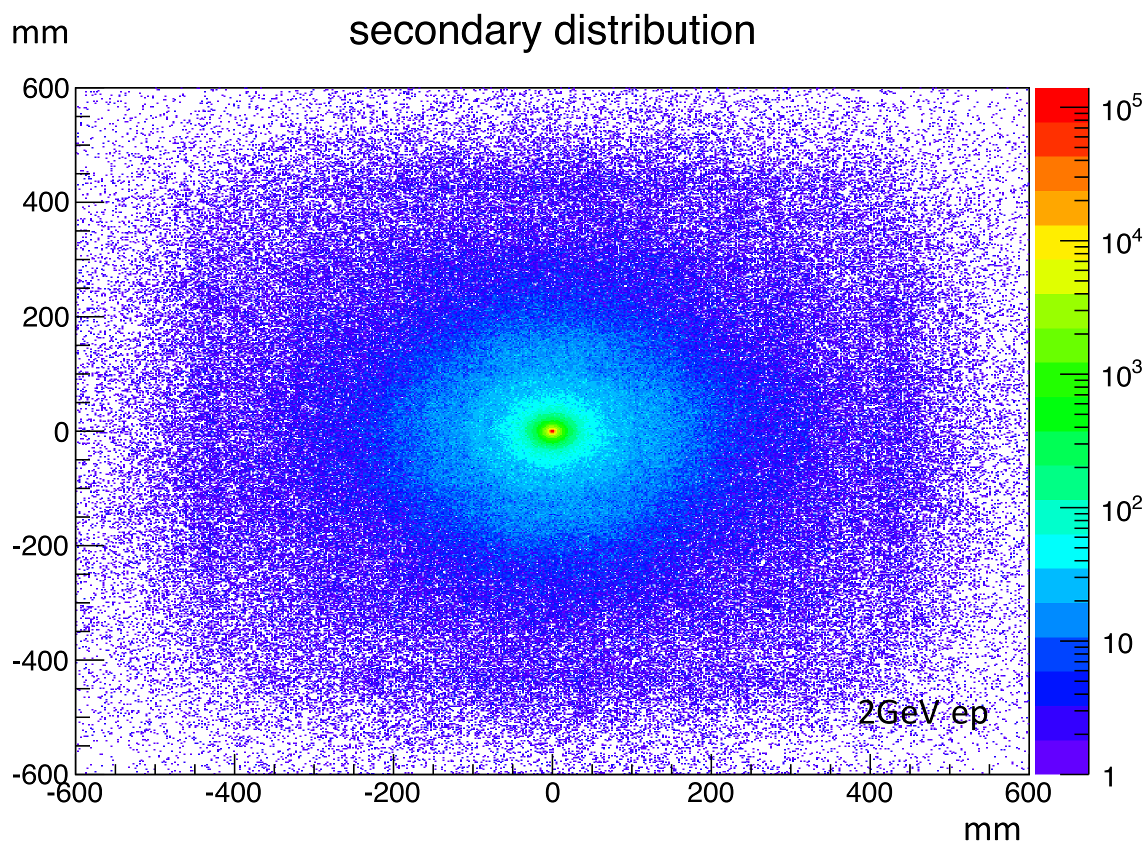
- Due to granularity of HyCal, there is no way to separate two particle if they are within 1.5 times the module size (we need at least a valley to define two local maximum)

- Even if two particle are separated by more than 1.5 times the module size, it is not guaranteed that there are two local maximum (low energy particle landing on a large and fast descending tail)

- From this study, I want to get a rough estimation on how much the radiative tail will change with and without using HyCal digitization, so that we can trust our digitization

Radiative effect for ep

- Using ep to start as it is much easier
- Select ep with with 0.7 deg < theta < 5.5 deg
- Plot shows all secondary particles (e+, e- and photons) hit position relative to the scattered electron position on HyCal
- Includes external and internal radiation and their secondaries
- We still see the LG boundary because most of the ep are near the center of HyCal
- Most of the secondary are within +/- 50mm from the scattered electron



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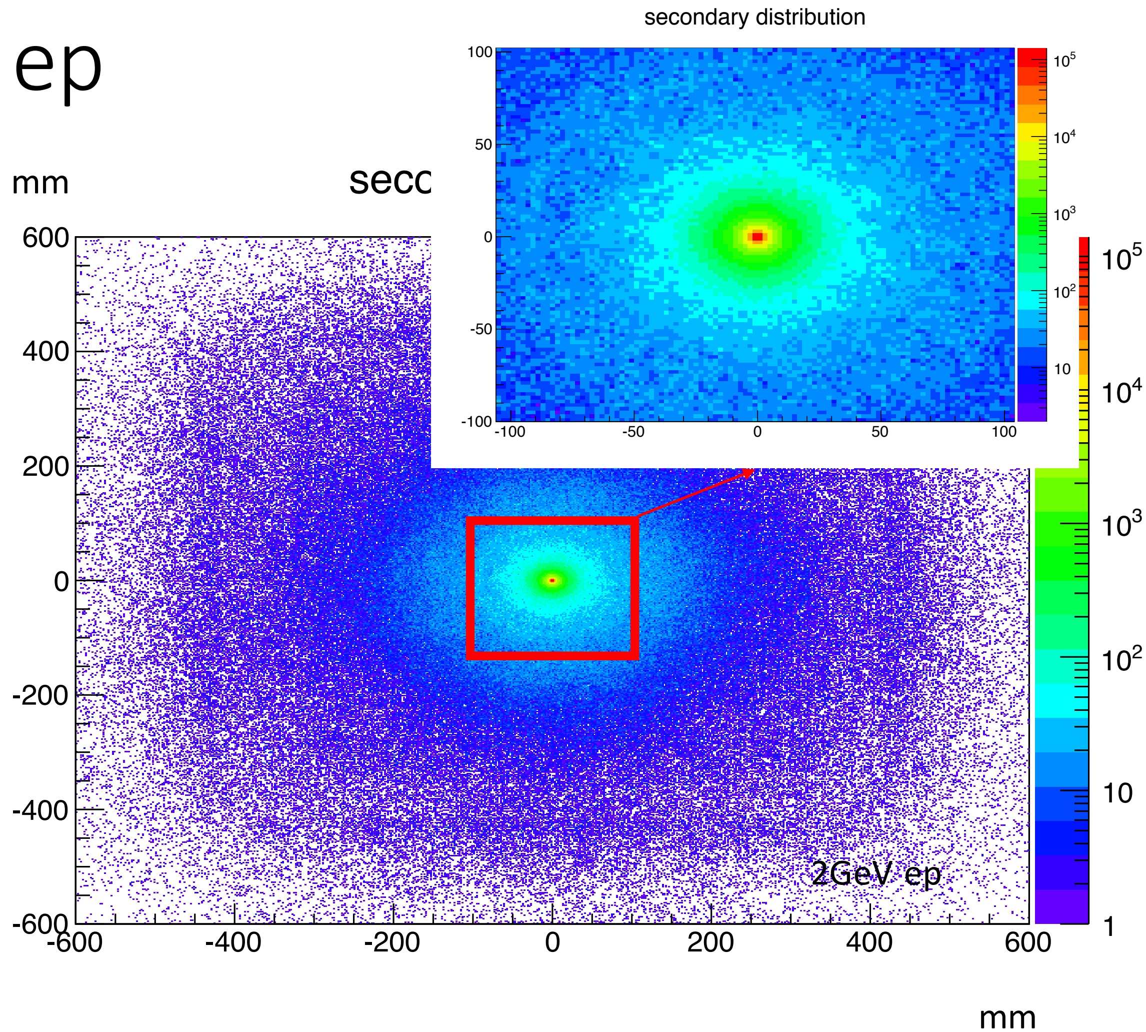
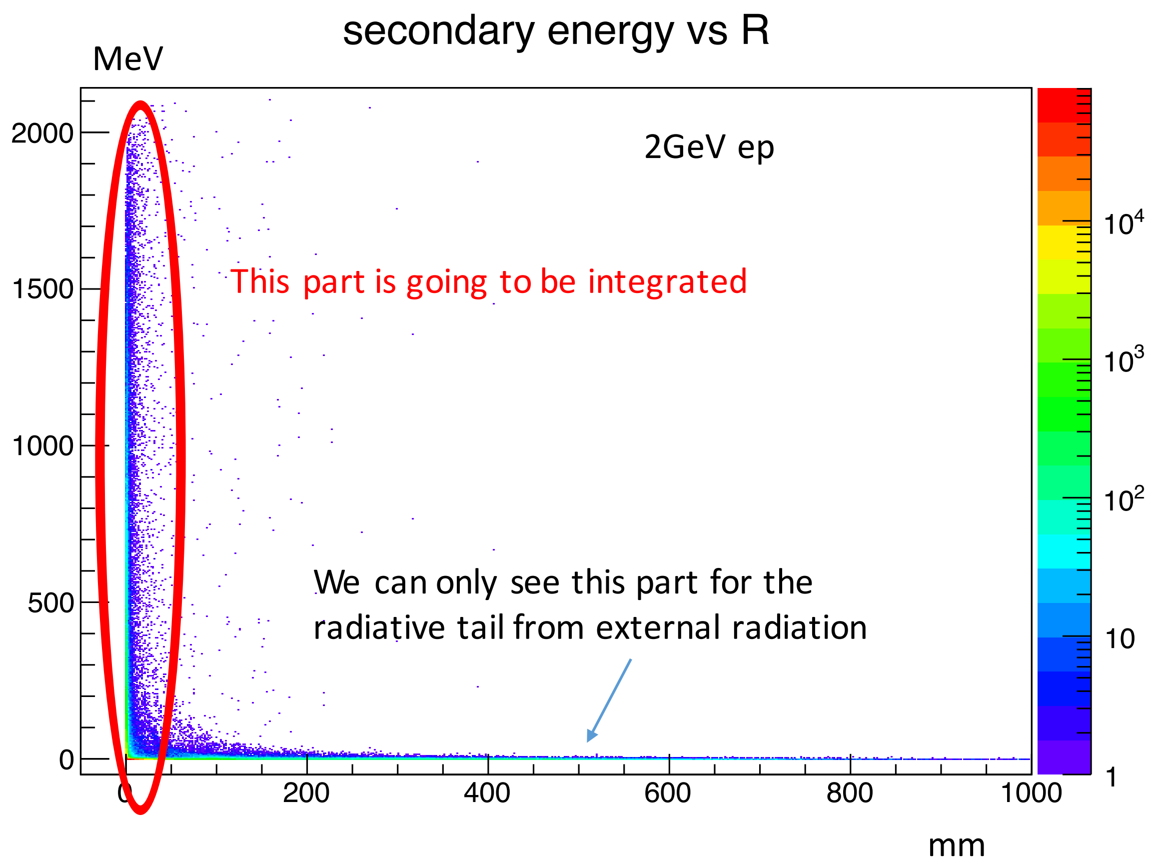


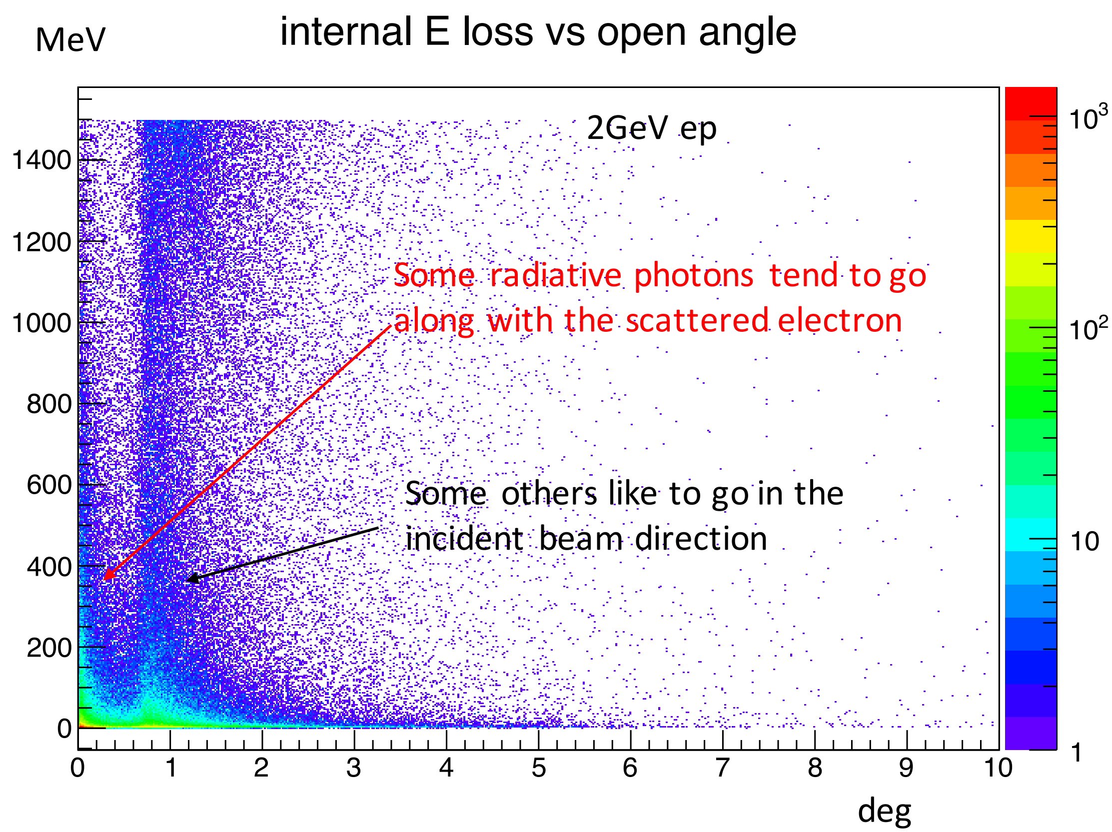
External Radiative effect for ep

- Plot shows the energy of all particles from external radiation as a function of the distance to the hit position of the scattered electron on HyCal
- Select event that has no internal radiative photon to exclude internal radiation effects
- High energy secondary from the external radiation tend to go very closely with the scattered electron
- High energy ones are going to be integrated into the same cluster as the scattered electron
- Low energy ones can go very far away



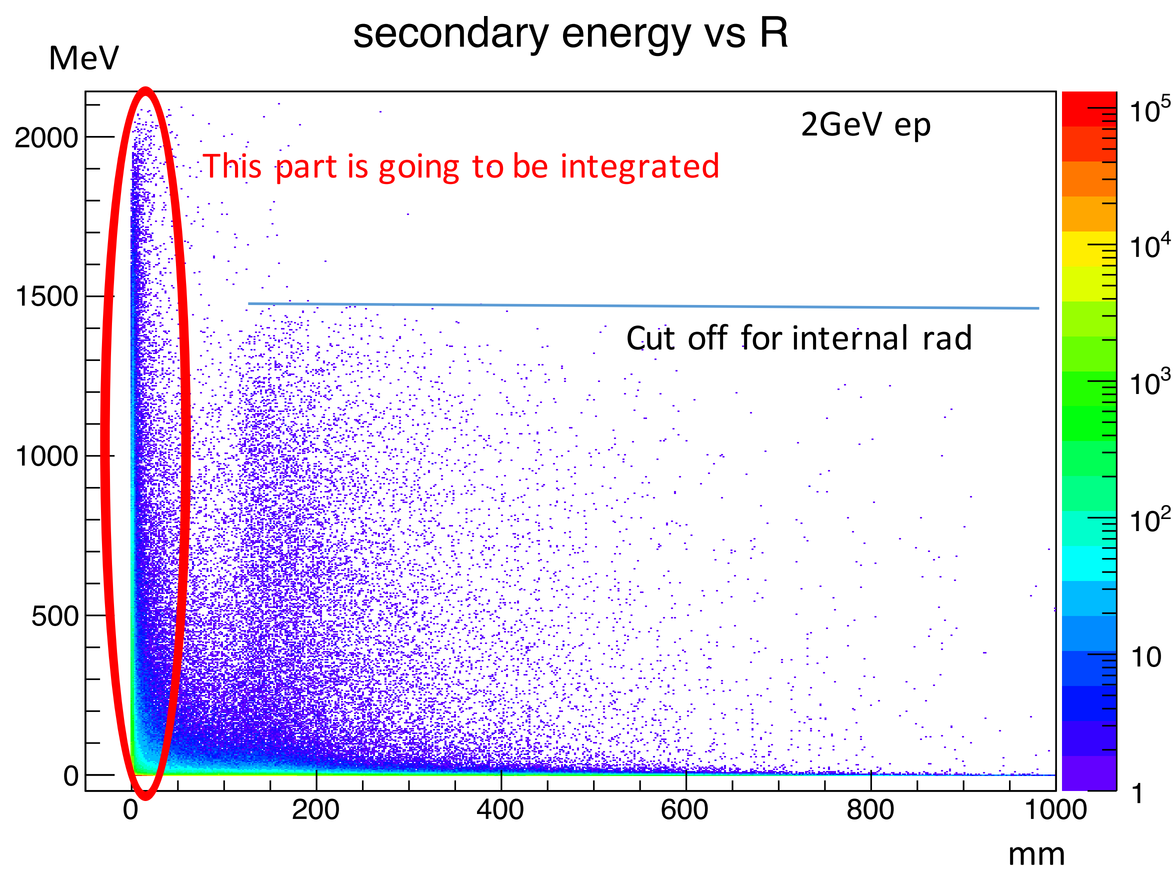
Internal Radiative effect for ep

- Using Gramolin's ep event generator
- Plot shows the energy of the radiative photon as a function of the opening angle between the photon and the scattered electron
- Gap between 0 and 0.7 deg due to the minimum theta angle cut (0.7 deg) for the scattered electron
- Maximum internal radiative photon energy set at 1499MeV (default value in the program)



Total radiative effect for ep

- Plot shows the secondary particle energy as a function of their distance to the scattered electron on HyCal
- Maximum internal radiative photon energy set at 1499 MeV (default value)
- All secondary within 30mm from the scattered electron are going to be integrated into the cluster energy for sure
- Most of the high energy secondary (mainly from external radiation) are going to be integrated into the same cluster as the scattered electron
- Gap between R = 0 mm and R = 150mm comes from the gap in internal radiation



Radiative effect for ep

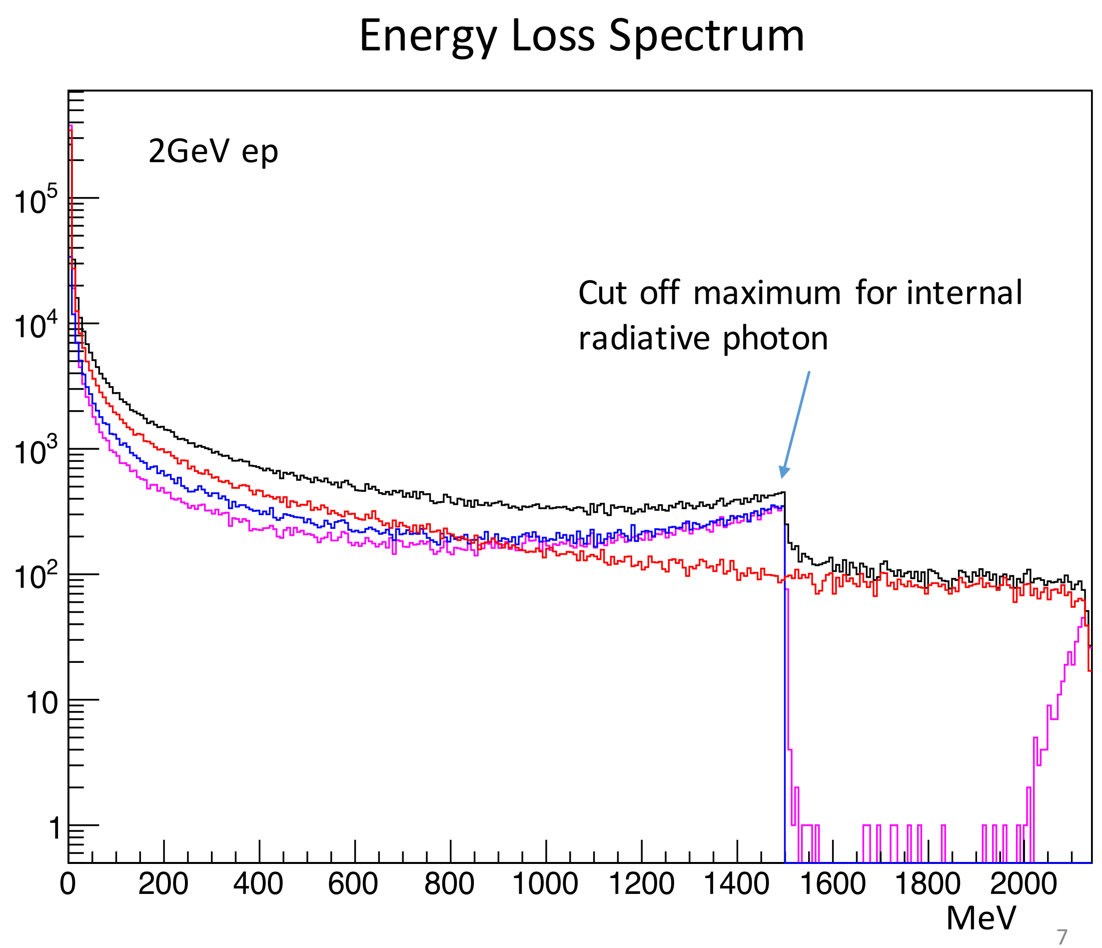
Blue: energy loss of internal radiation, as given by the energy of the internal radiative photon

Rad: energy loss of external radiation, as given by the difference between the scattered electron energy at the vertex and at HyCal

Black: total energy loss, sum of internal and external energy loss

Magenta: sum energy of all secondary within a 30mm radius from the scattered electron on HyCal. And subtract this from the total energy loss

We do expect to see a few times smaller radiative tail if using HyCal digitization



Radiative effect for ee

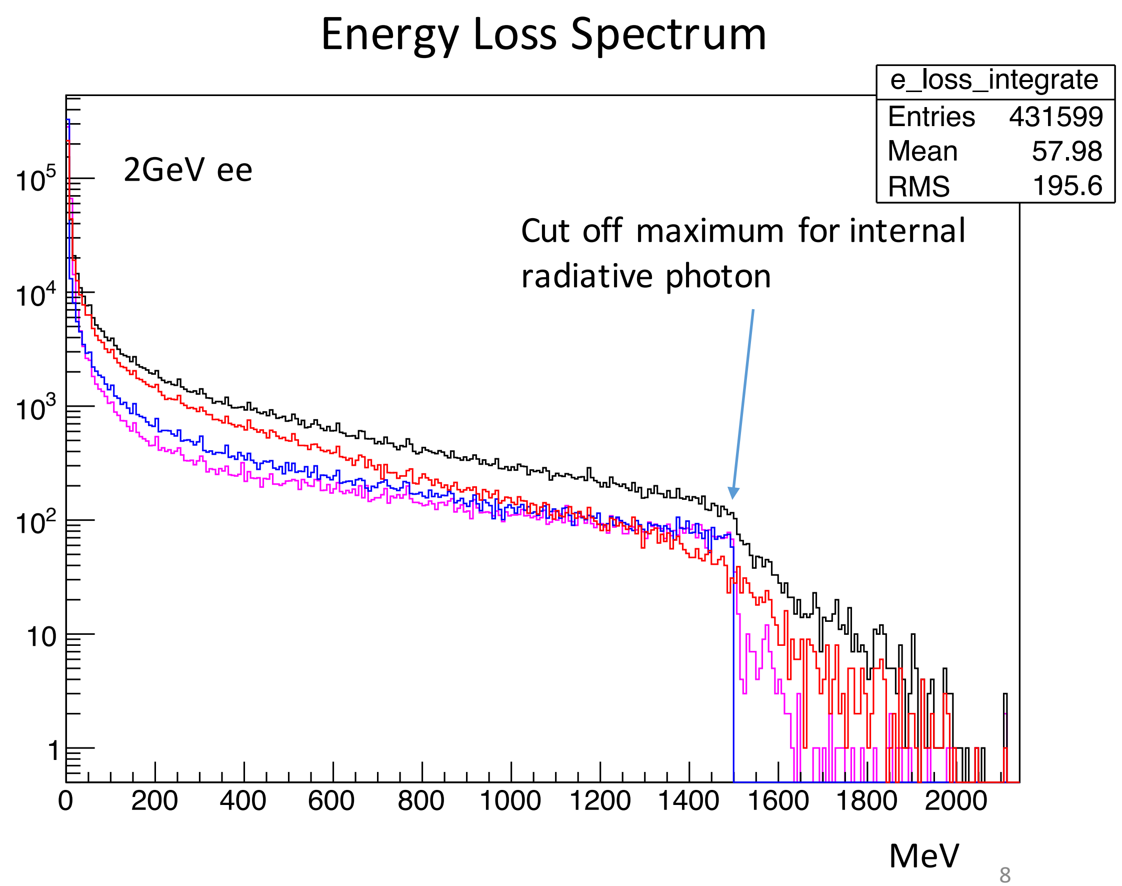
Blue: energy loss of internal radiation, as given by the energy of the internal radiative photon

Rad: energy loss of external radiation, as given by the difference between the sum of the two electrons energy at the vertex, and at HyCal

Black: total energy loss, sum of internal and external energy loss

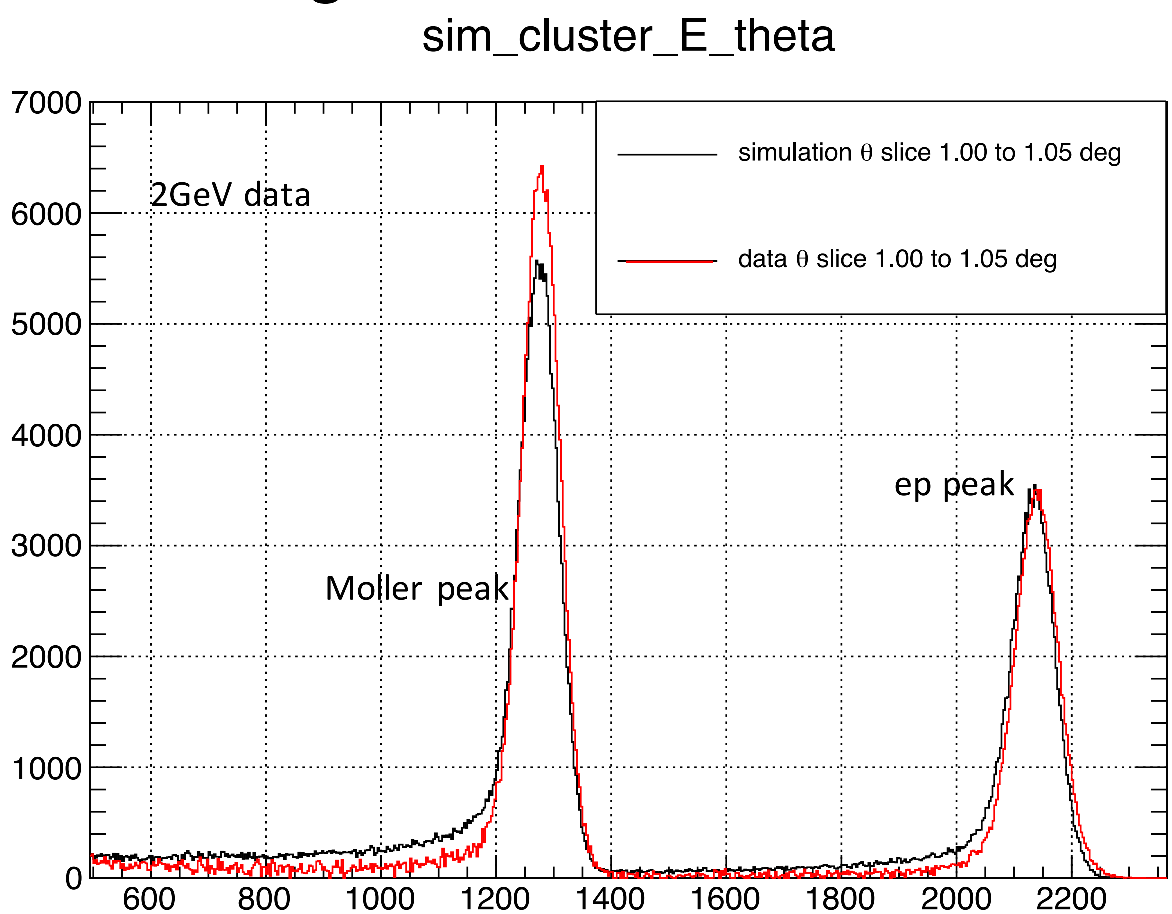
Magenta: sum energy of all secondary within a 30mm radii from each scattered electron on HyCal. And subtract this from the total energy loss

We do expect to see a few times smaller radiative tail if using HyCal digitization



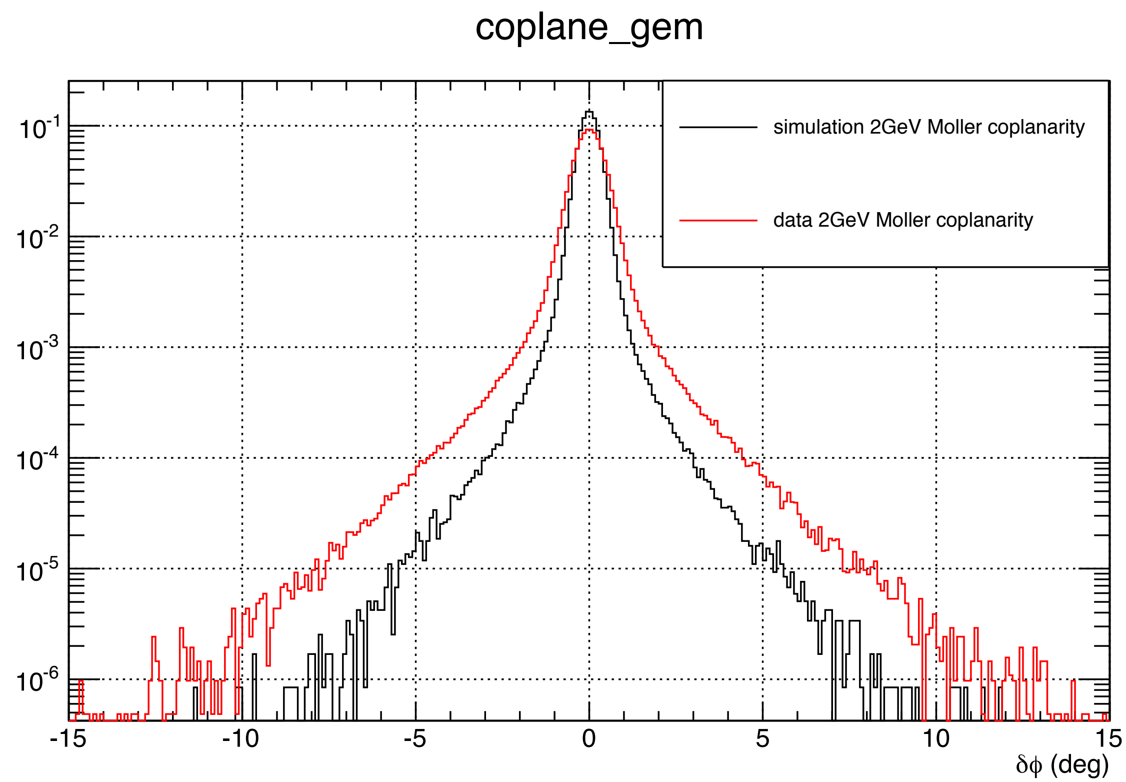
Comparison between non-digitized simulation and data

- Cutting a small theta slice from the cluster E vs scattering angle theta distribution
- If without using HyCal digitization, the radiative tail is about 2times larger than the data
- We should achieve good agreement if using the HyCal digitization



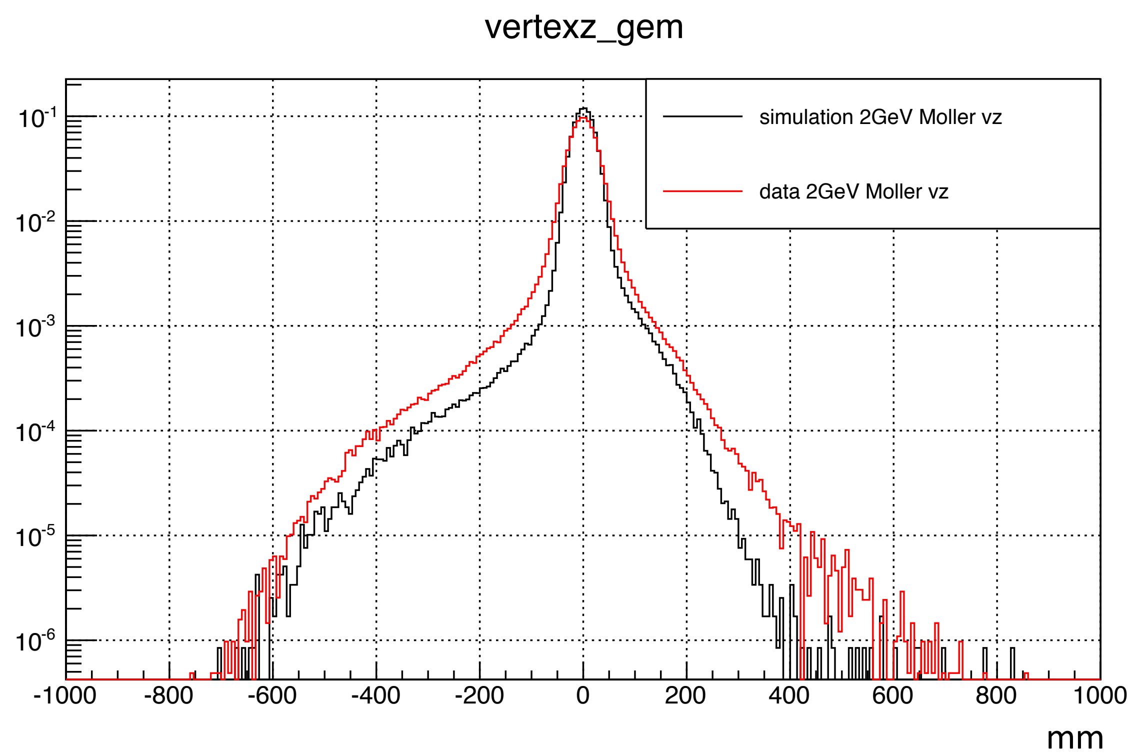
Comparison between non-digitized simulation and data

- Coplanarity between double arm Moller
- Distribution after following cuts:
  - Expected E cut (4 sigma)
  - N cluster cut (2)
  - Elasticity cut (4 sigma)
- Data is wider than the simulation
- Possible reasons:
  - Some materials are missing or underestimated
  - Position of the materials are more downstream in the simulation (effect of multiple scattering increase with distance)
  - Not using digitization makes the cuts more sensitive to various radiative effects



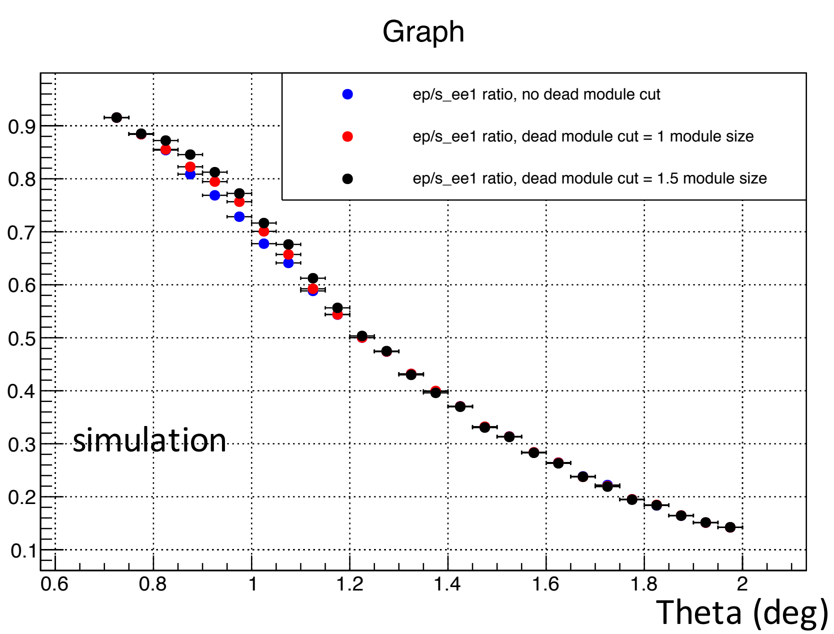
Comparison between non-digitized simulation and data

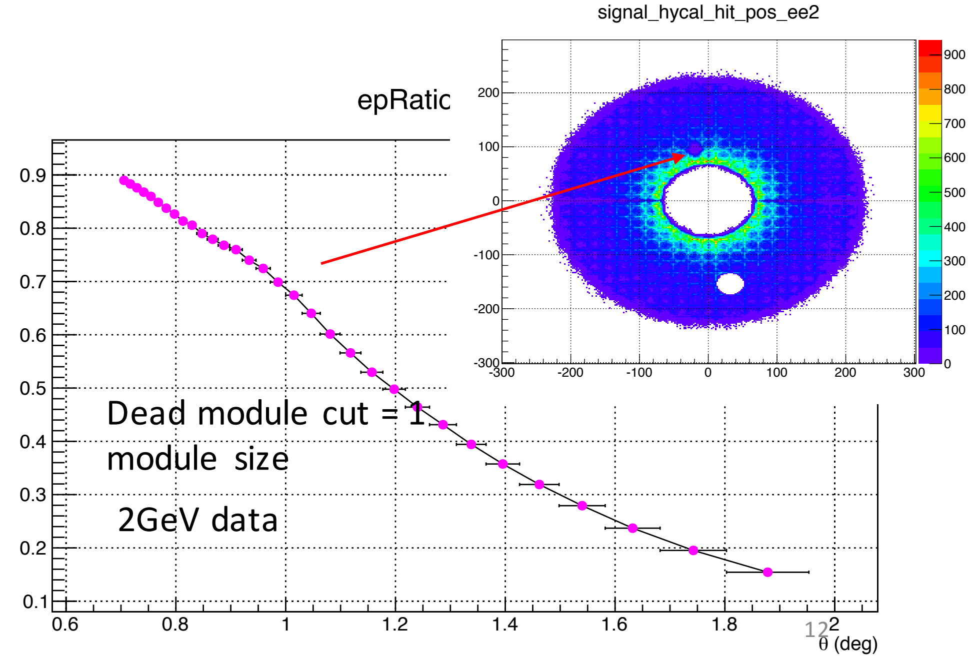
- Vertex z of double arm Moller
- Distribution after following cuts:
  - Expected E cut (4 sigma)
  - N cluster cut (2)
  - Elasticity cut (4 sigma)
  - Coplanerity (5 deg)
- Data is wider than the simulation
- Possible reasons:
  - Some materials are missing or underestimated
  - Position of the materials are more downstream in the simulation (effect of multiple scattering increase with distance)
  - Not using digitization makes the cuts more sensitive to various radiative effects



Comparison between non-digitized simulation and data

- ep / s_ee1 ratio: using HyCal to select double arm Moller but do not require both of them have matching hit found on the GEM. Only the one has matching hit will be used
- GEM efficiency and acceptance are canceled in this way but HyCal related efficiency and acceptance will not
- A bump is observed from the data, likely due to dead module cuts
- From simulation, a bump is also observed as the size of the dead module cuts increases





Conclusion

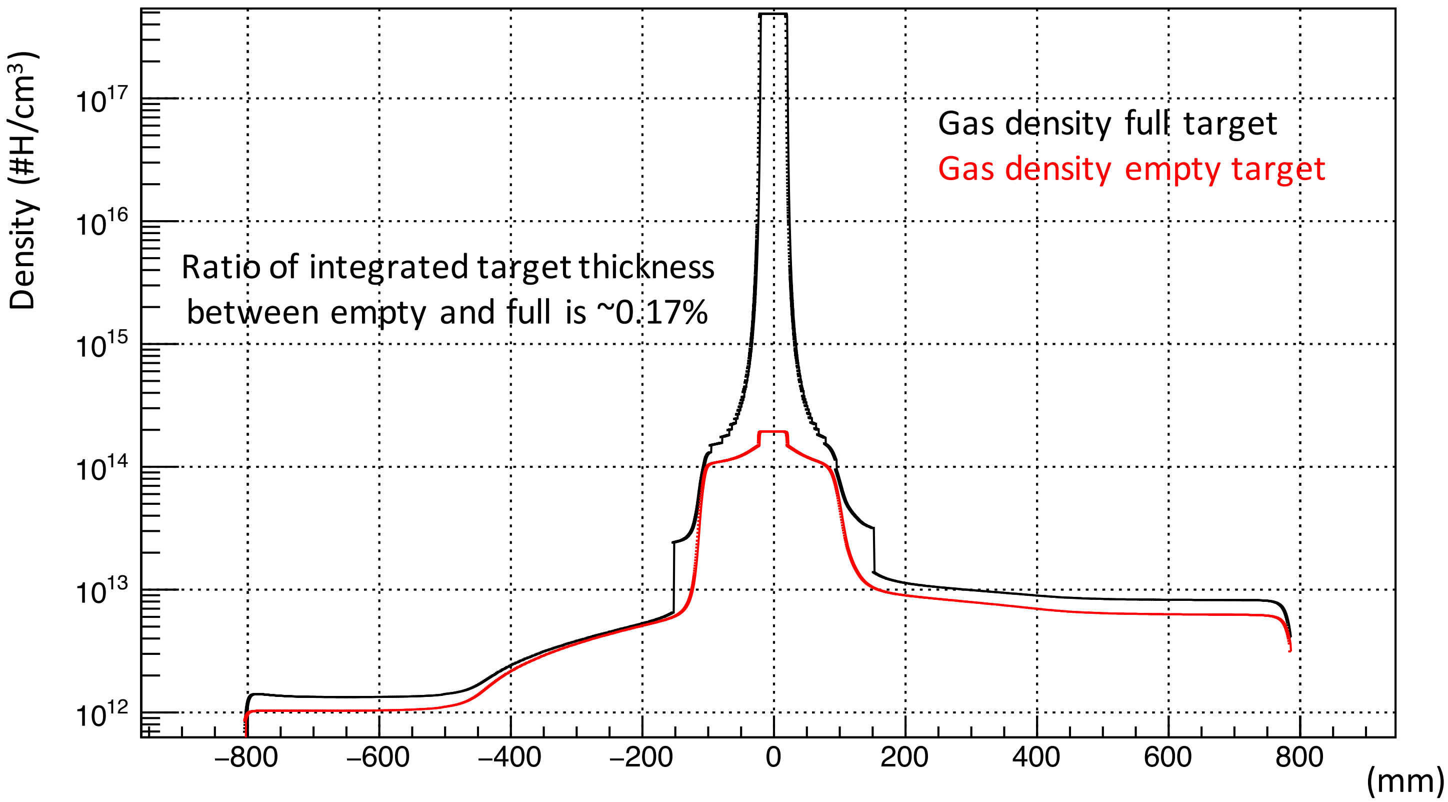
- We expect a much smaller radiative tail from data and HyCal digitization

- We need the HyCal digitization part to be ready in order to compare the simulation with the data

- The top priority right now is to compare simulation with the data and make sure the simulation agree with the data for all distributions. After this we can start move on to the radiative correction

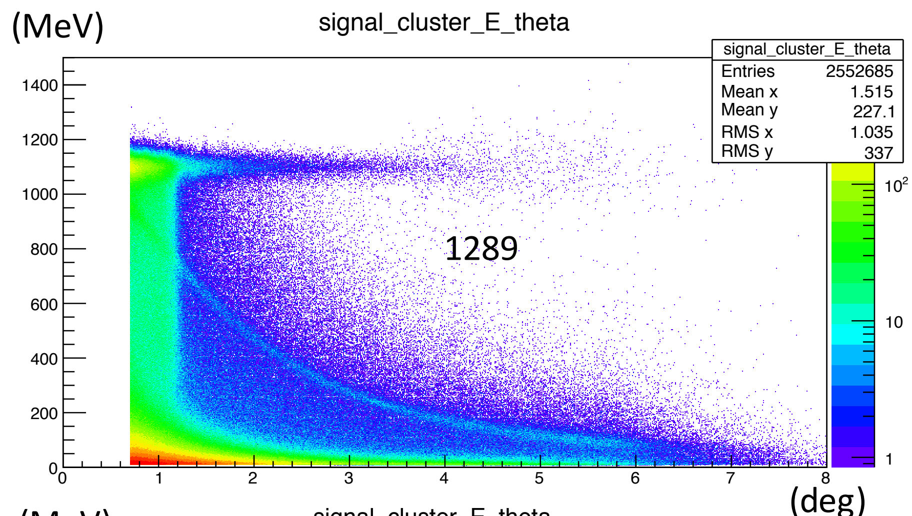
Comsol simulation for the gas distribution

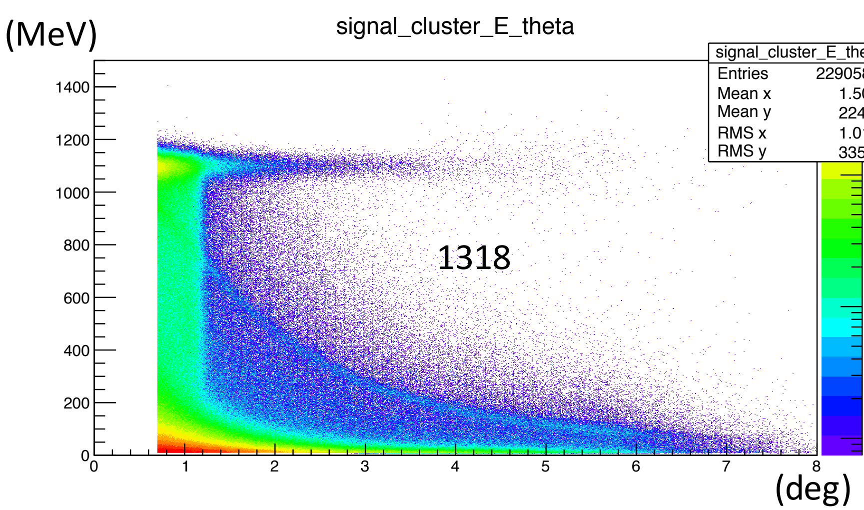
Simulation result from Yang Zhang

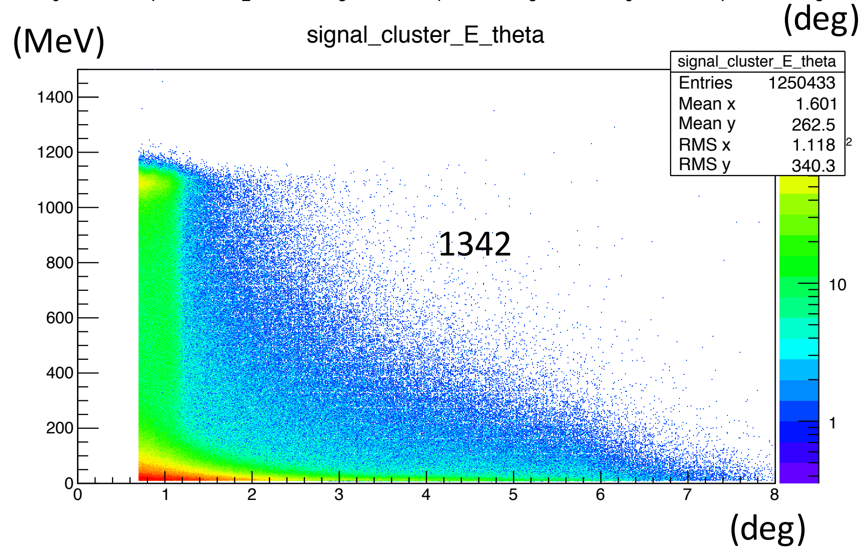


1GeV empty target run revisit

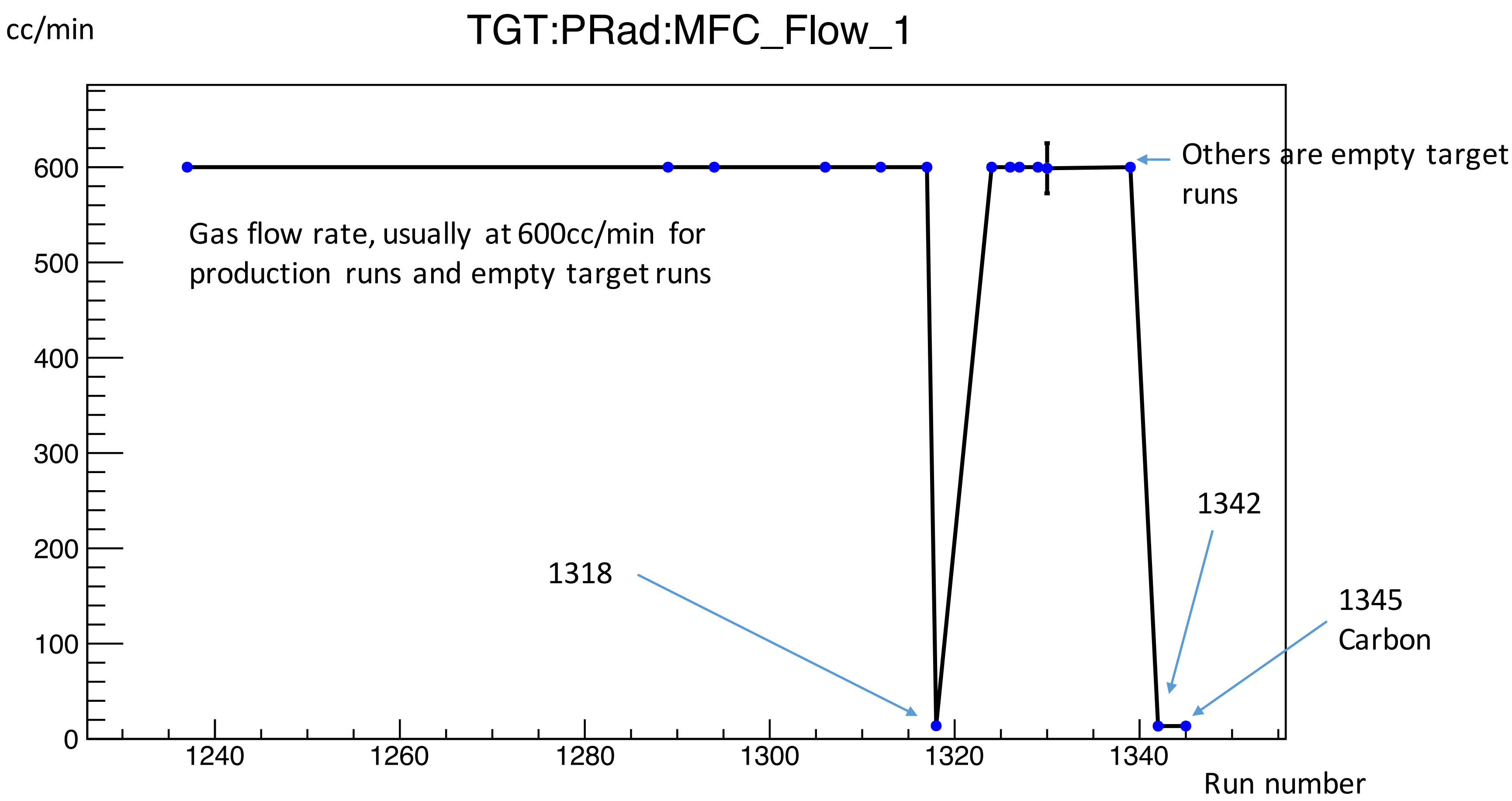
- Run 1289 is a normal empty target run (no gas in cell, gas in chamber)
- Run 1342 is a normal empty chamber run (no gas everywhere)
- Run 1318 looks like a empty target run, but as very odd EPICS values, in particular, gas flow rate is nearly 0







1GeV empty target run revisit



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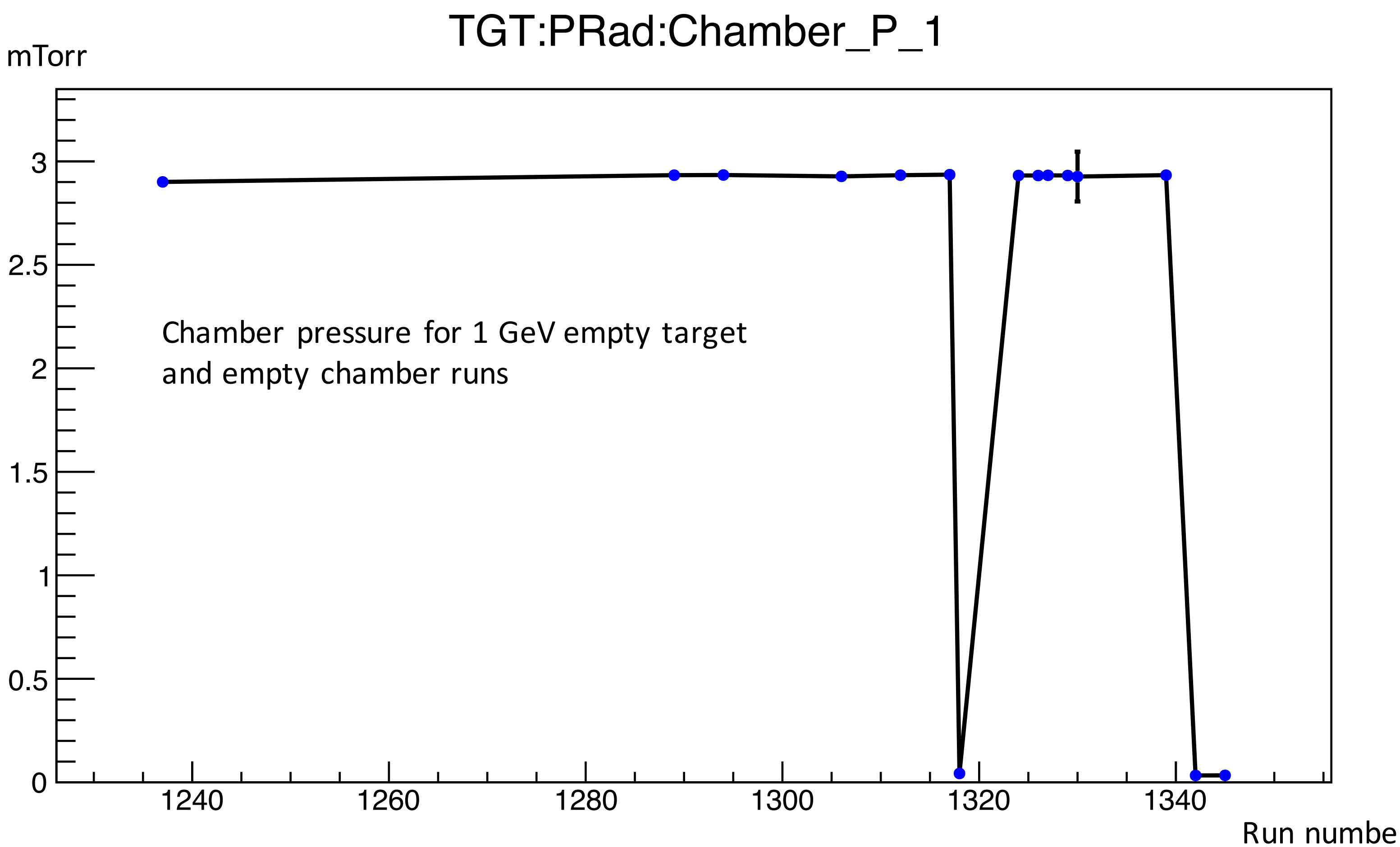

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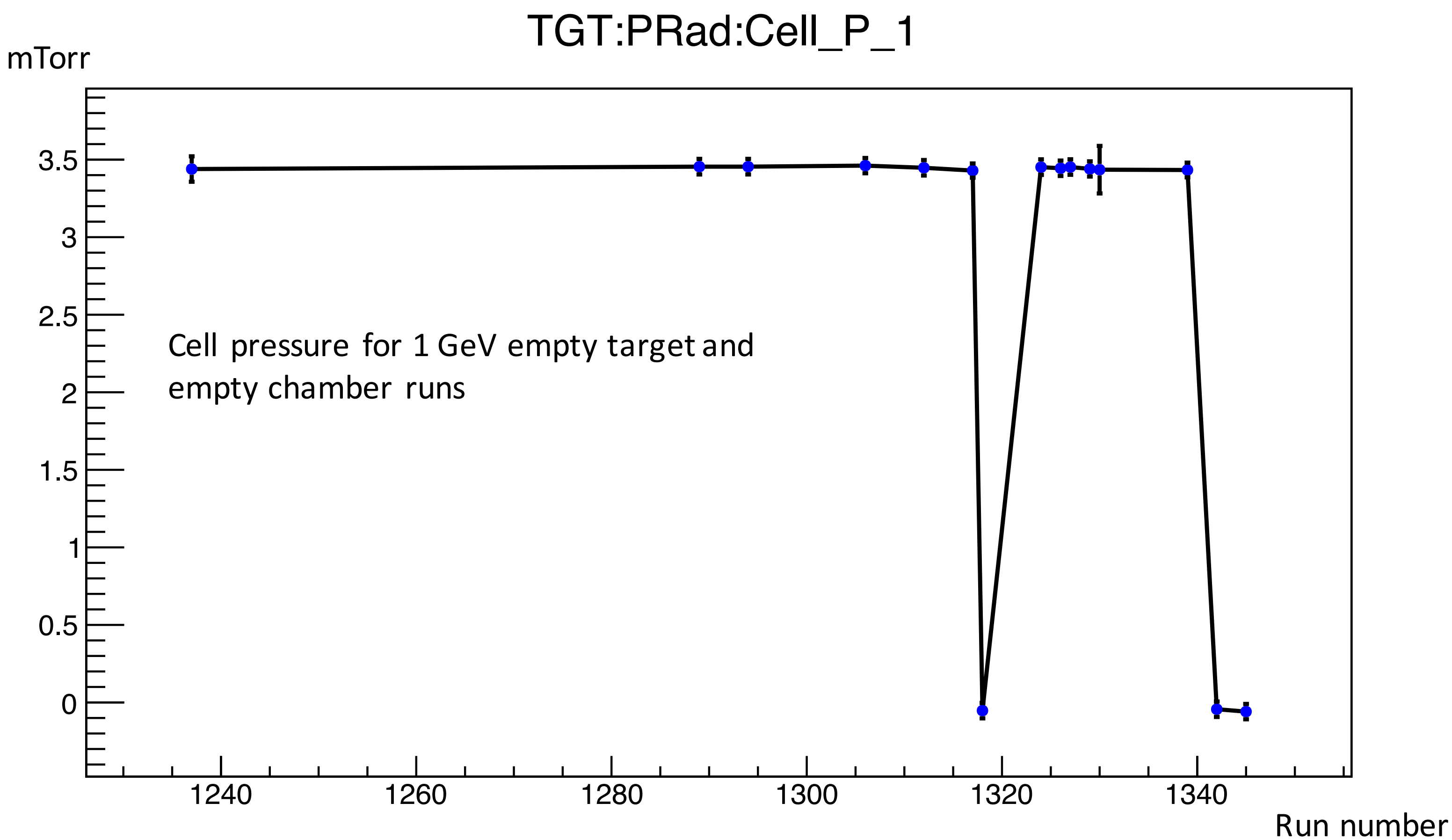

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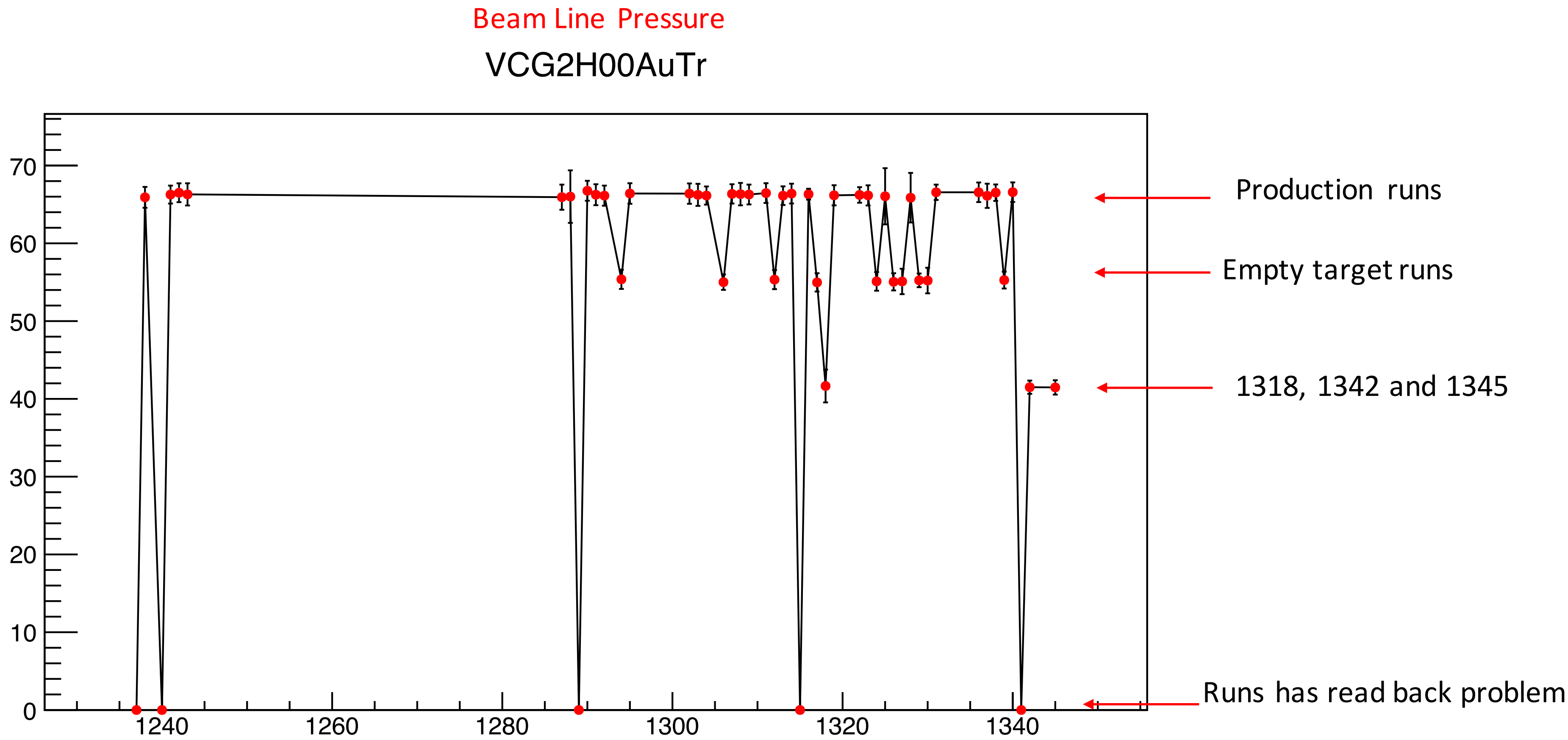

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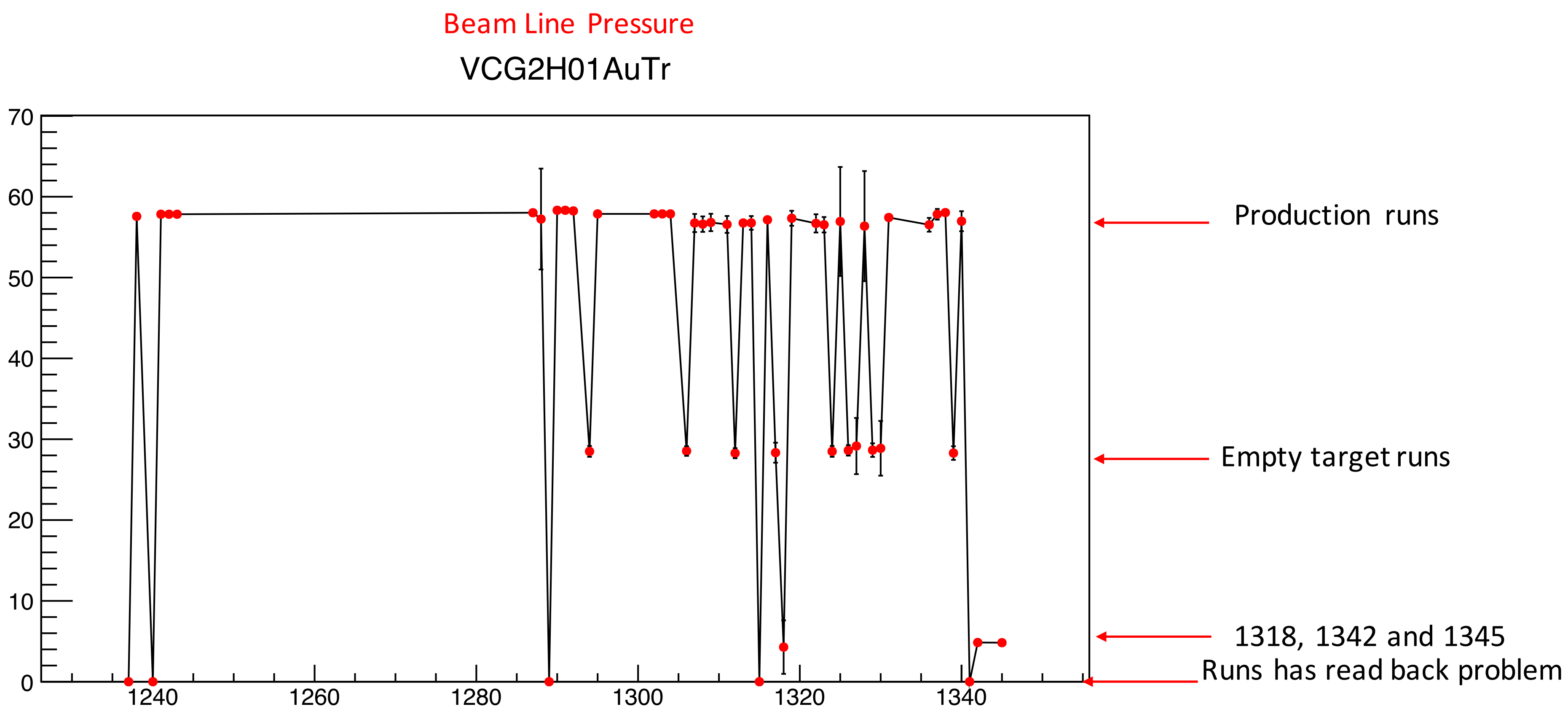

1GeV empty target run revisit

- It seems like 1318 always have the same EPICS values as the empty chamber run 1342 and carbon run 1345
- What if there is really no gas everywhere for run 1318, but then where are its ep and ee signals come from?
- Is the target cell lifted up for run 1318?
  - No idea, target cell position missing since 1306 and come back at 1342
  - Possible to regain that info somewhere?
- If the target is in position, could the background generated by beam halo hitting the kapton window?
  - If this is the case, the major background source may actually be the window, not residual gas
  - This will also make ep has relatively more background than Moller

Simple simulation to study the signal to background ratio

- Want to check whether we get ~10% ep background, ~2% ee background at 1GeV and ~2% ep background at 2GeV
- My simulation not fully developed for background study yet (lack of beam pipe structure upstream)
- Generate 2 data samples, each with 2M events, based on the full target and empty target gas distribution separately
- Theta range for full target 0.5 ~ 5.5 deg, for empty target 0.3 ~ 8 deg
- Study signal to background ratio in range 0.7 ~ 5.5 deg
- After analysis (in the same way as analyze experimental data), scale the two samples based on the 0.17% ratio, and make sure they have the same integrated luminosity

Simple simulation to study the signal to background ratio