# DQ and Monitoring:

# ECAL 4-Cell Problem Analysis


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LHCb Summer Student Presentations

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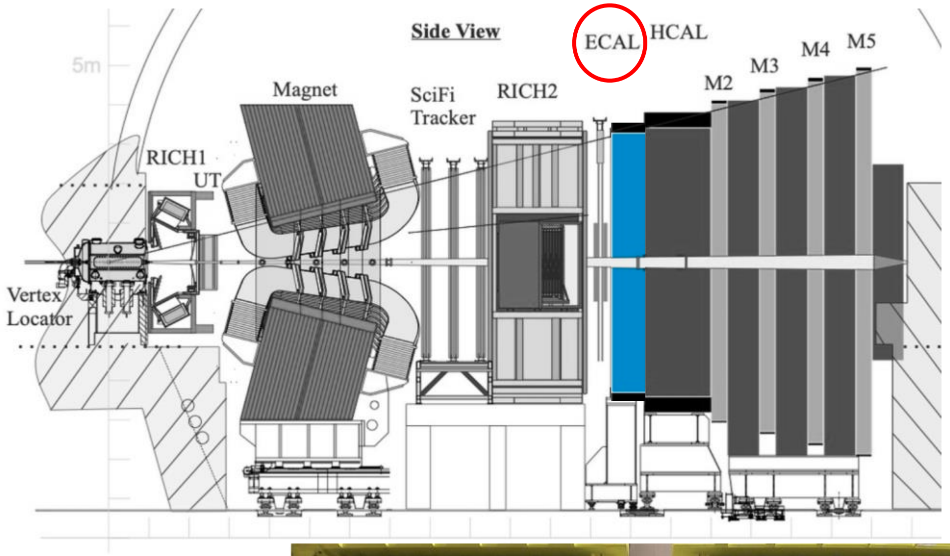
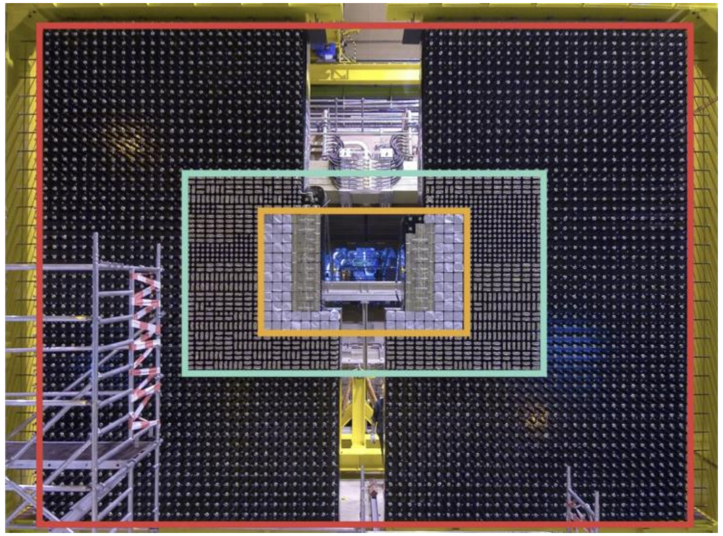
# Electromagnetic Calorimeter at the LHCb

- ❑ Identifies and reconstructs photons & electrons
- ❑ Precise measurement of energy and position
- ❑ Consists of cells in three areas(Inner, Middle, Outer)



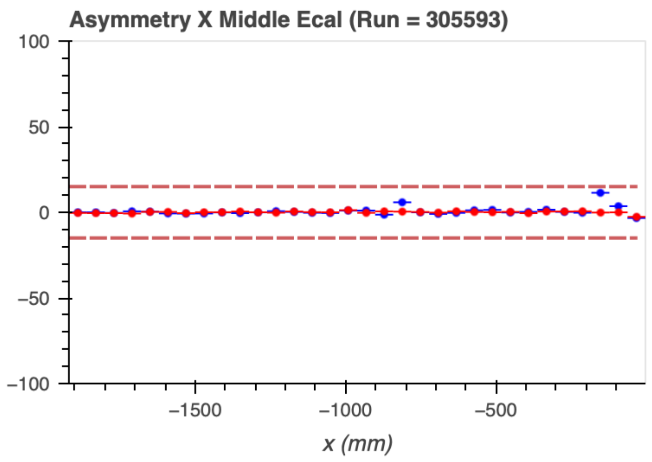

<u>Key variables in my work</u>

- ❑ Photon $p_T$: $\approx E_T$ (transverse energy)
- ❑ IsPhoton: indicates consistency with photon profile
- ❑ Reconstructed Mass: important in decay analysis

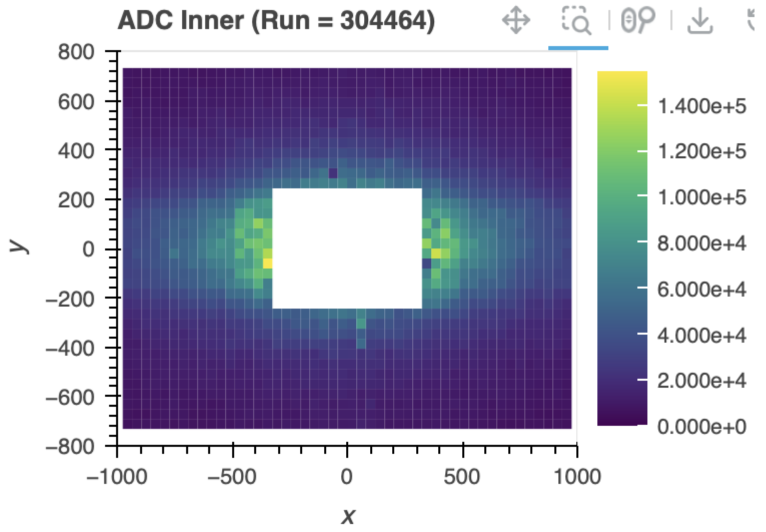


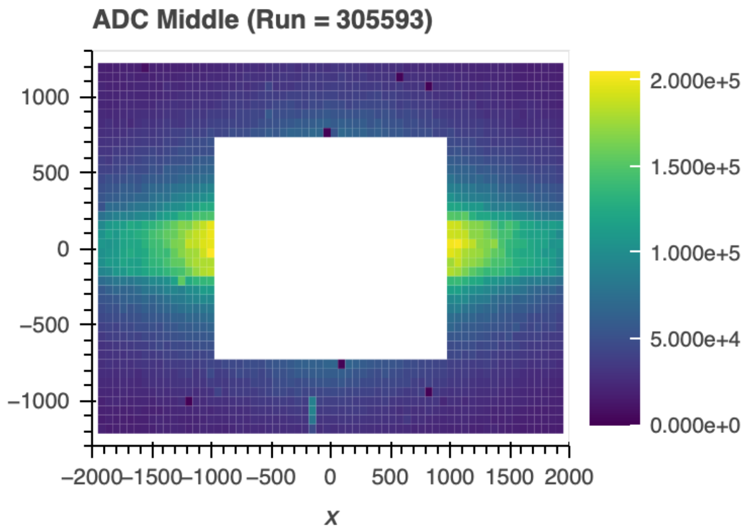
# 4-Cell Problem

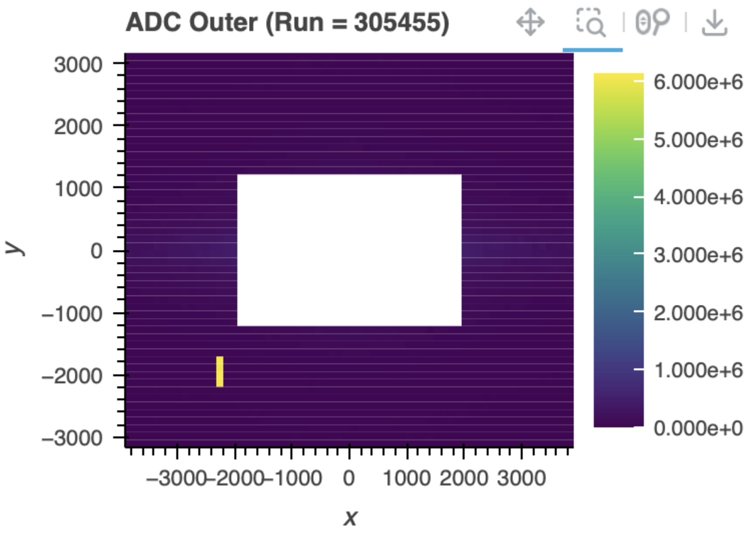
- Problem in the electromagnetic calorimeter recurring from 2024
- Four noisy cells in a column
- Some cases do not trigger the asymmetry alarm
  - → There are data collected with this problem
  - → Identify cases, analyze impact on DQ, and improve monitoring




In Monet (Data Monitoring Interface)

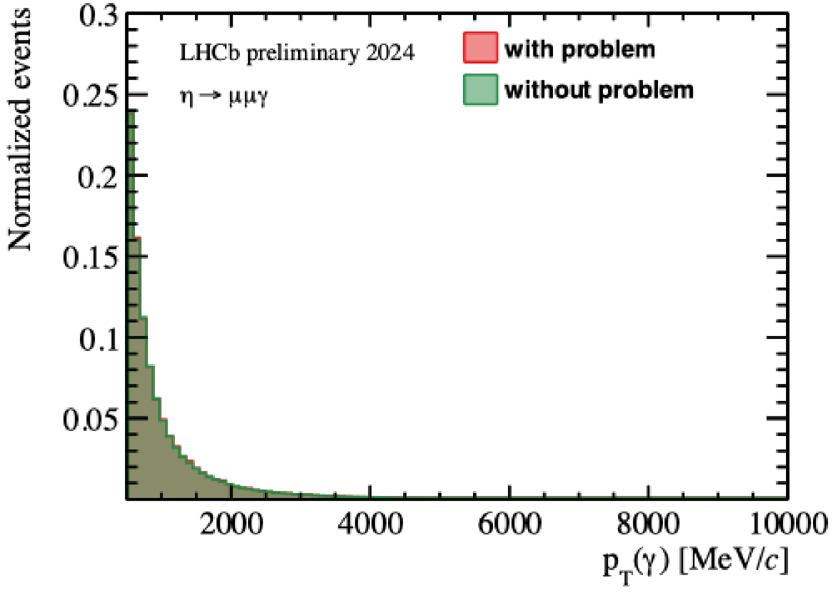


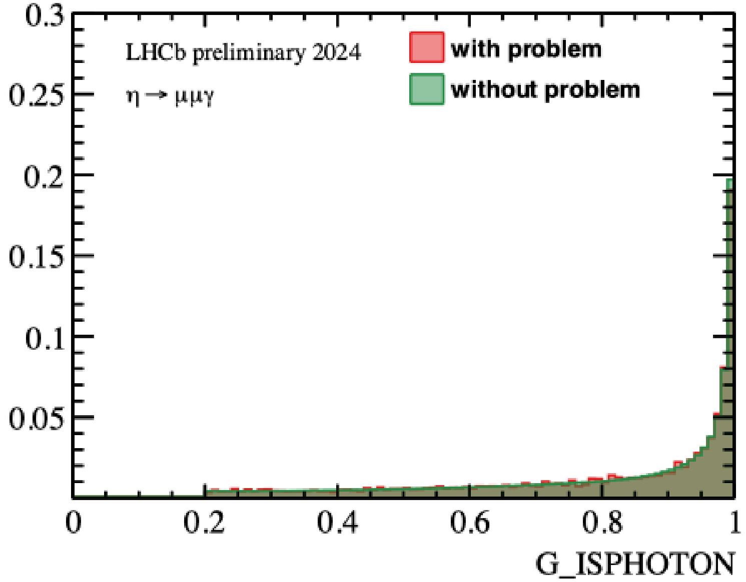



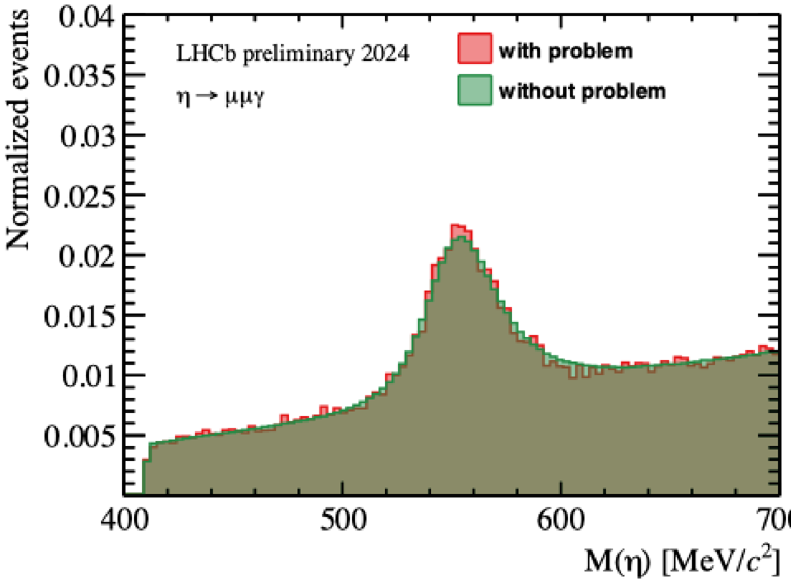



# $\boldsymbol{\eta \to \mu^+\mu^-\gamma}$

- Low-$p_T$ photon, reconstructed system mass $\cong 550\ \mathrm{MeV}/c^2$
- Photon $p_T$, G_ISPHOTON, and $\boldsymbol{\eta}$ mass plots in comparison with all unaffected runs
- Distributions show no anomalies
- Runs with highest noise levels also agree with normal data

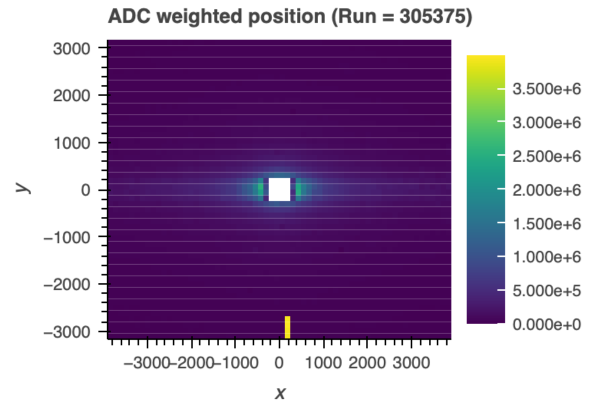


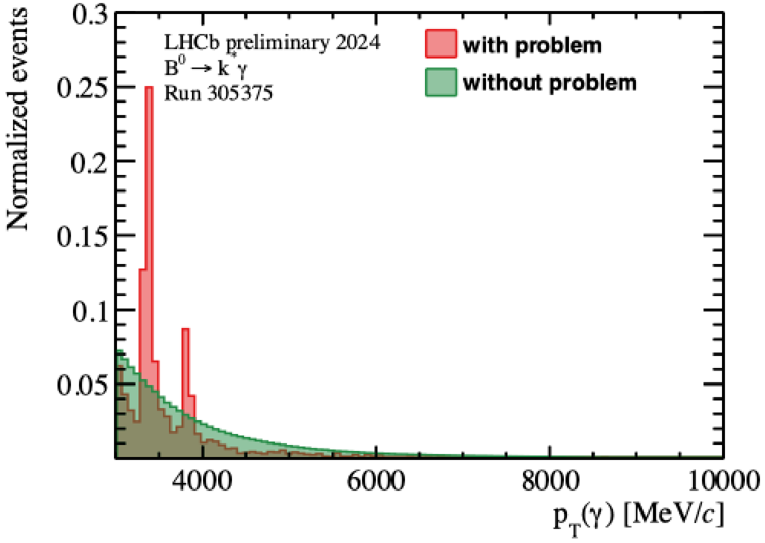



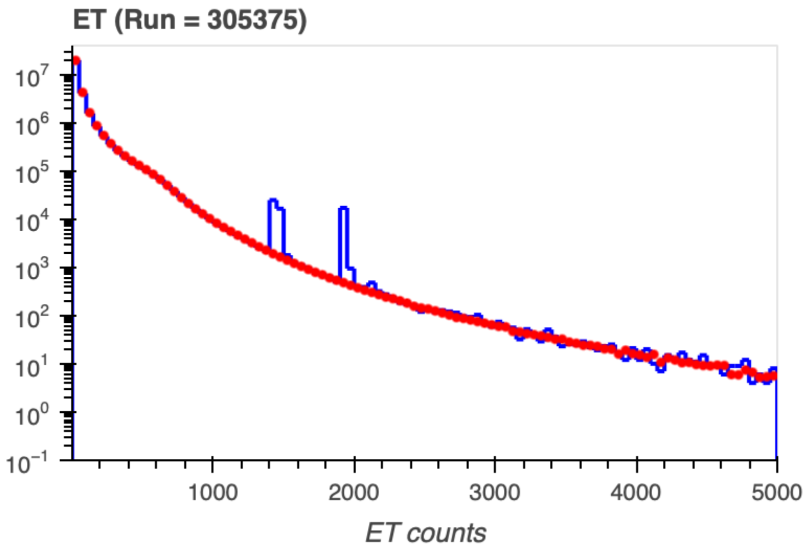
# $B^0 \rightarrow K^{*0}\gamma$

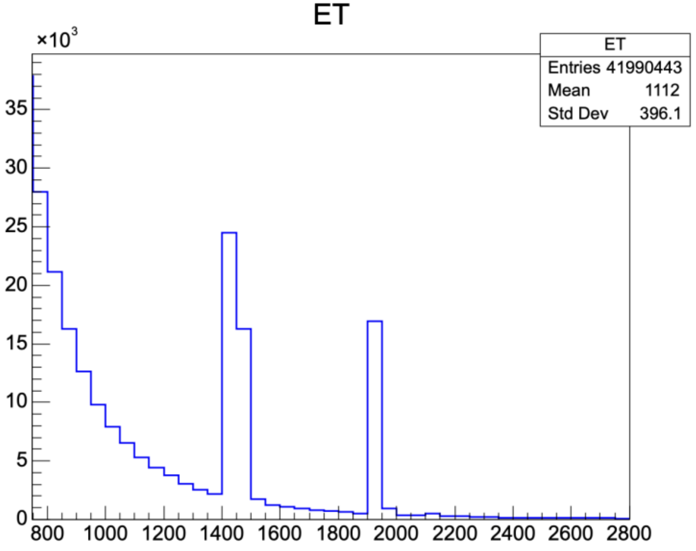
- High-$p_T$ photon, reconstructed system mass $\cong 5.5\ \mathrm{GeV}/c^2$
- Two peaks in photon $p_T$ between $3 \sim 4\ \mathrm{GeV}/c$
- Correspond to ET peaks in Monet




**Run 305375**

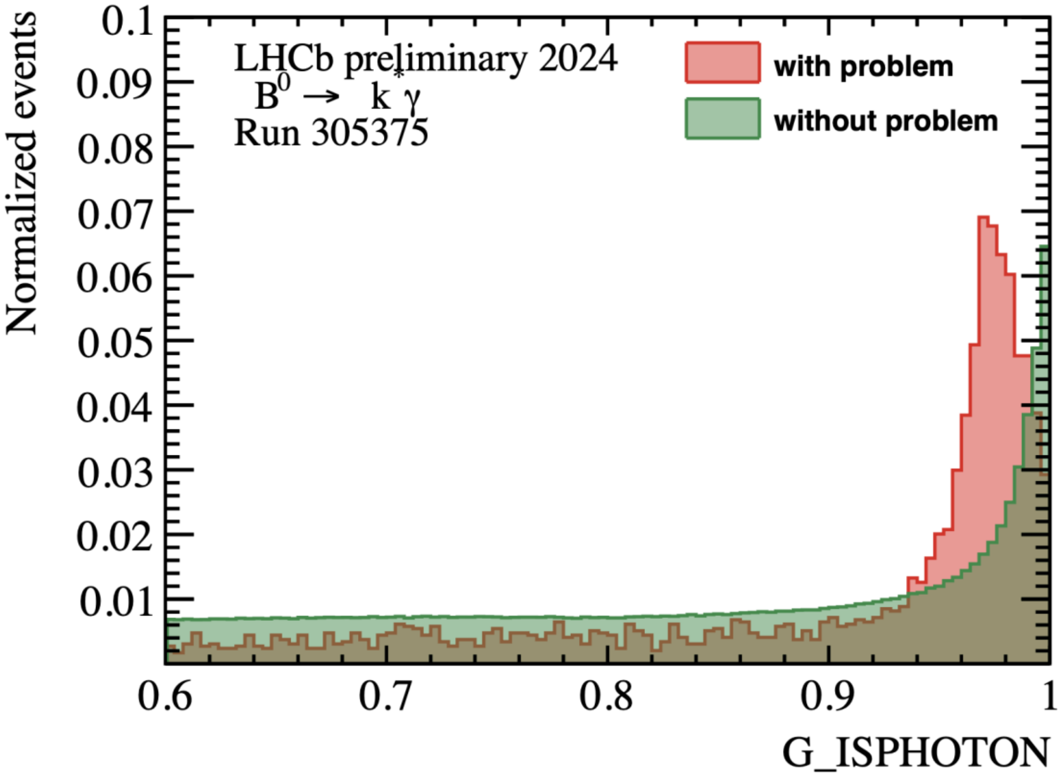


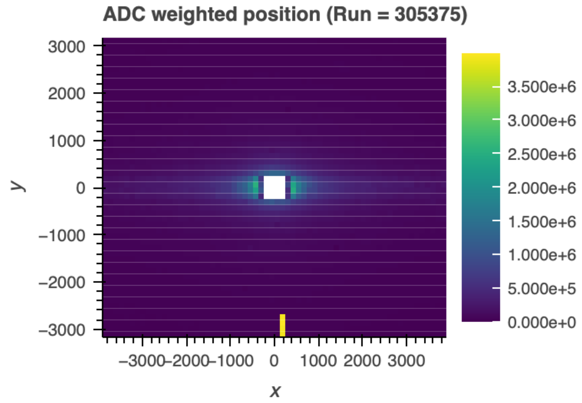



# $B^0 \to K^{*0}\gamma$

- ❑ Shift in G_ISPHOTON peak
- ❑ The 4 cells were often misidentified as photons
- ❑ The photon identification classifier flags them as less photon-like



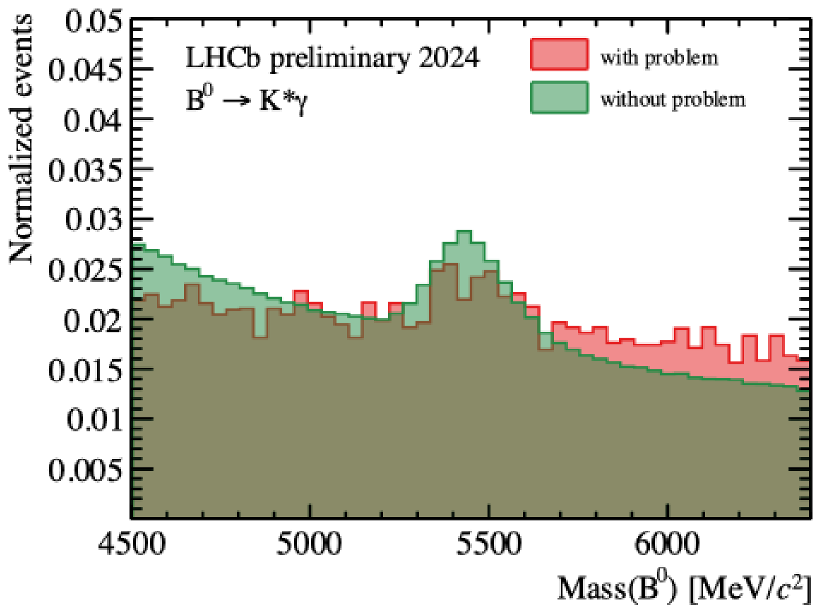

**Related input variables for the classifier**

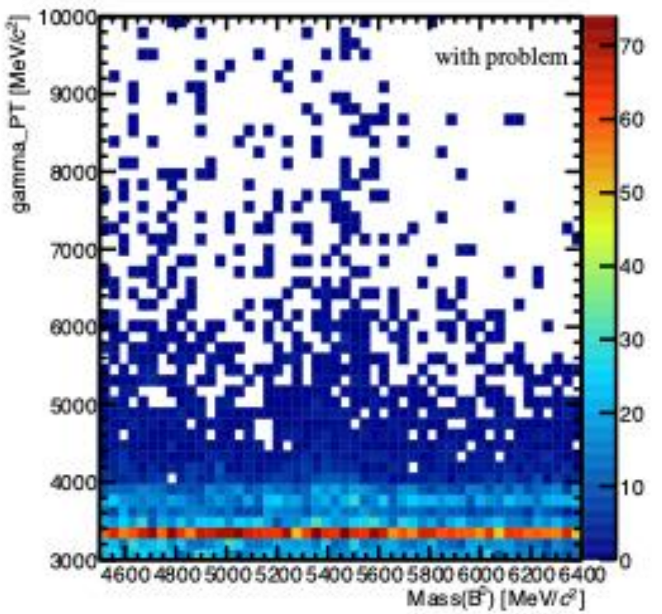
- ❑ Shape of the cluster compared to photon profile
- ❑ Ratio of $E_{seed}$ over $E_{cluster}$

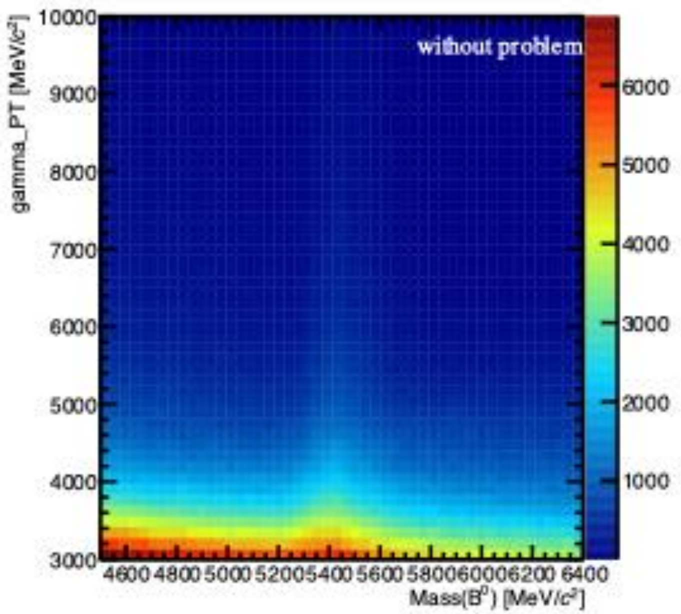
# $B^0 \rightarrow K^{*0}\gamma$

- B mass plot for four runs with highest noise level
  → Reconstructed B mass distribution shows no significant peak
- Photon $p_T$ vs B mass plot
  → The peaks in Photon $p_T$ do not correspond to certain B mass regions

**Run 300255, 302144, 305375, 305455**



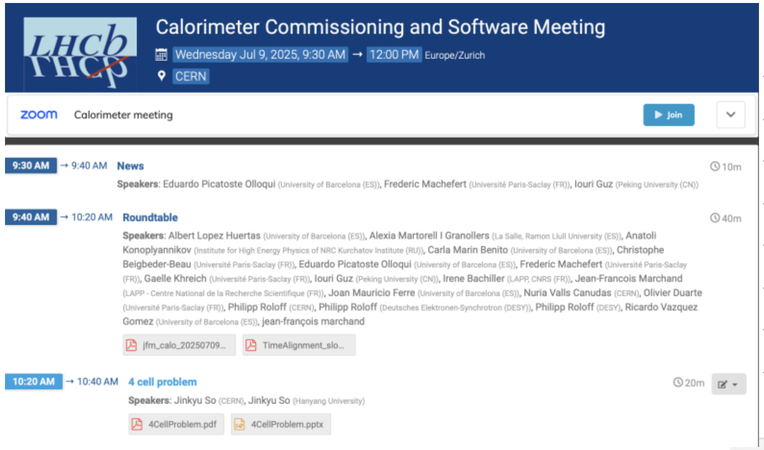



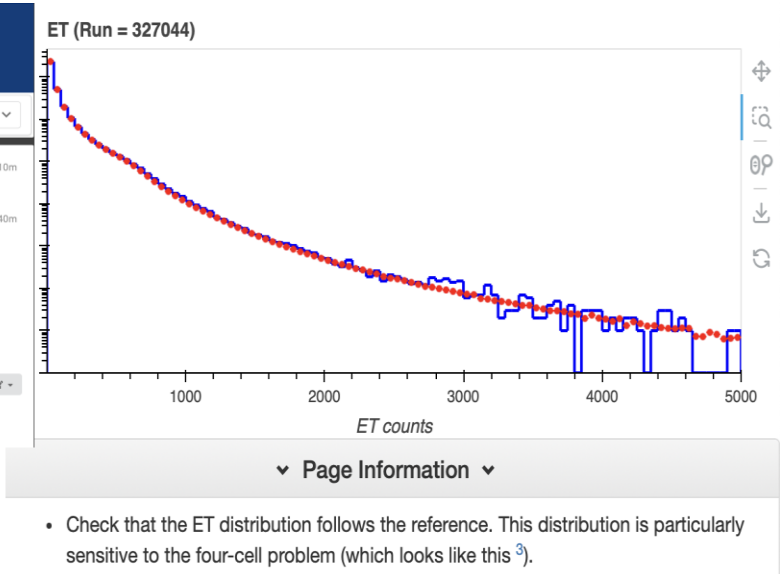
# Conclusion

- The problem is only affecting **high-$p_T$ photons** in radiative decay
- Only the runs with high noise level show clear anomalies
- $B^0 \to K^{*0}\gamma$ decay data with high noise level from the problem had fake clusters **misidentified as photons** and **increased background** in B mass
- For high-energy radiative decays, the events coming from cells with high noise level **should be removed** from analysis

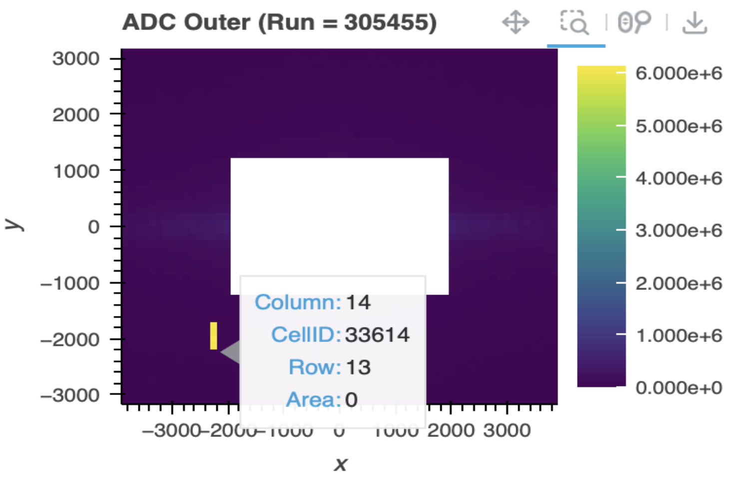
# Key Contributions

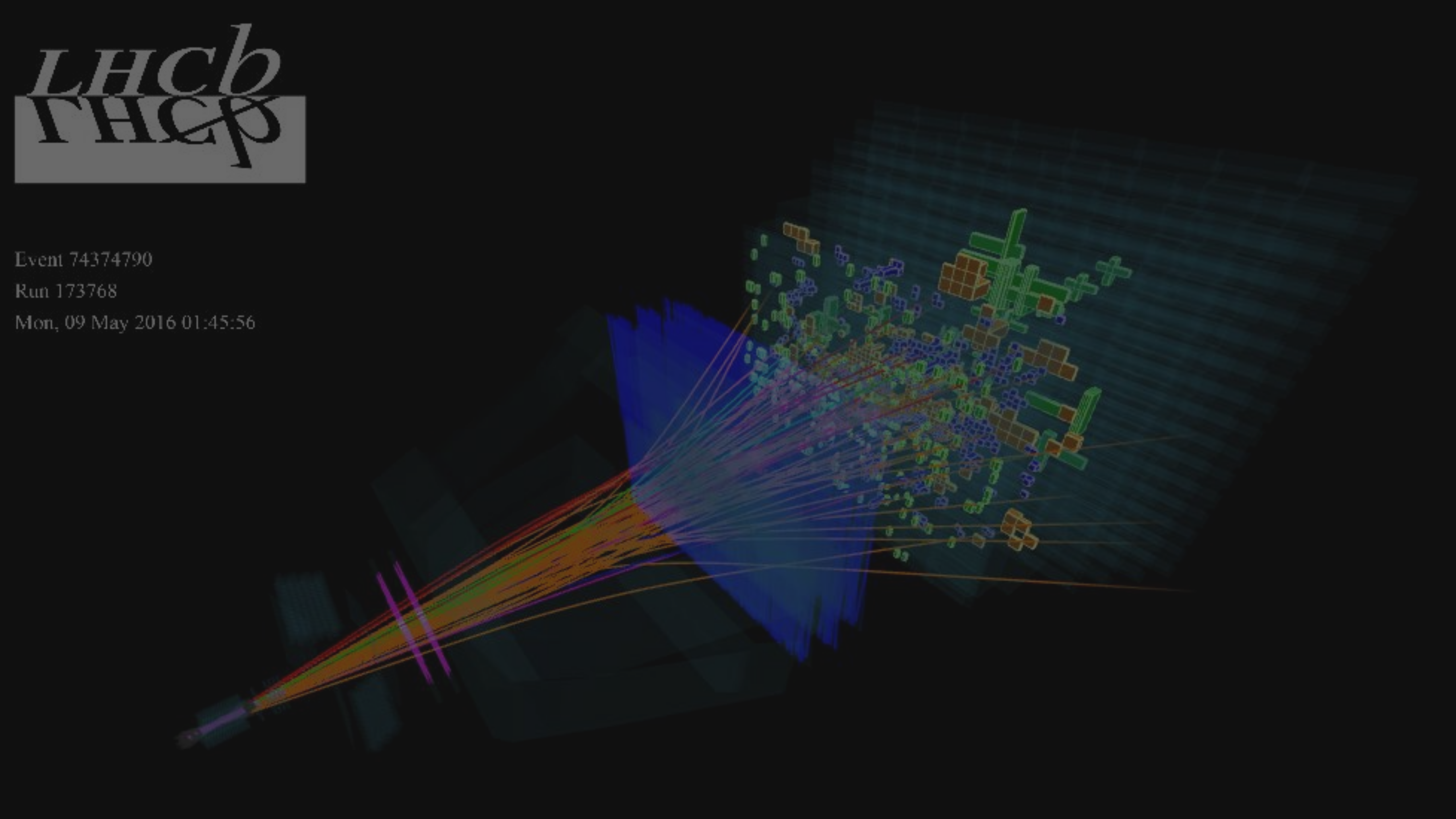
- Found and reported unnoticed cases in the LHCb Problem DB
- Presented at the LHCb Calorimeter group meeting, discussions with CALO, Radiative experts
- Suggested adding ET plot(more sensitive to this problem) for online monitoring by data manager
- Provided the list of all runs & cellIDs to remove from high-energy radiative decay analysis
- Made a new feature in Monet that enables instant cellID checking for future cell-related problems



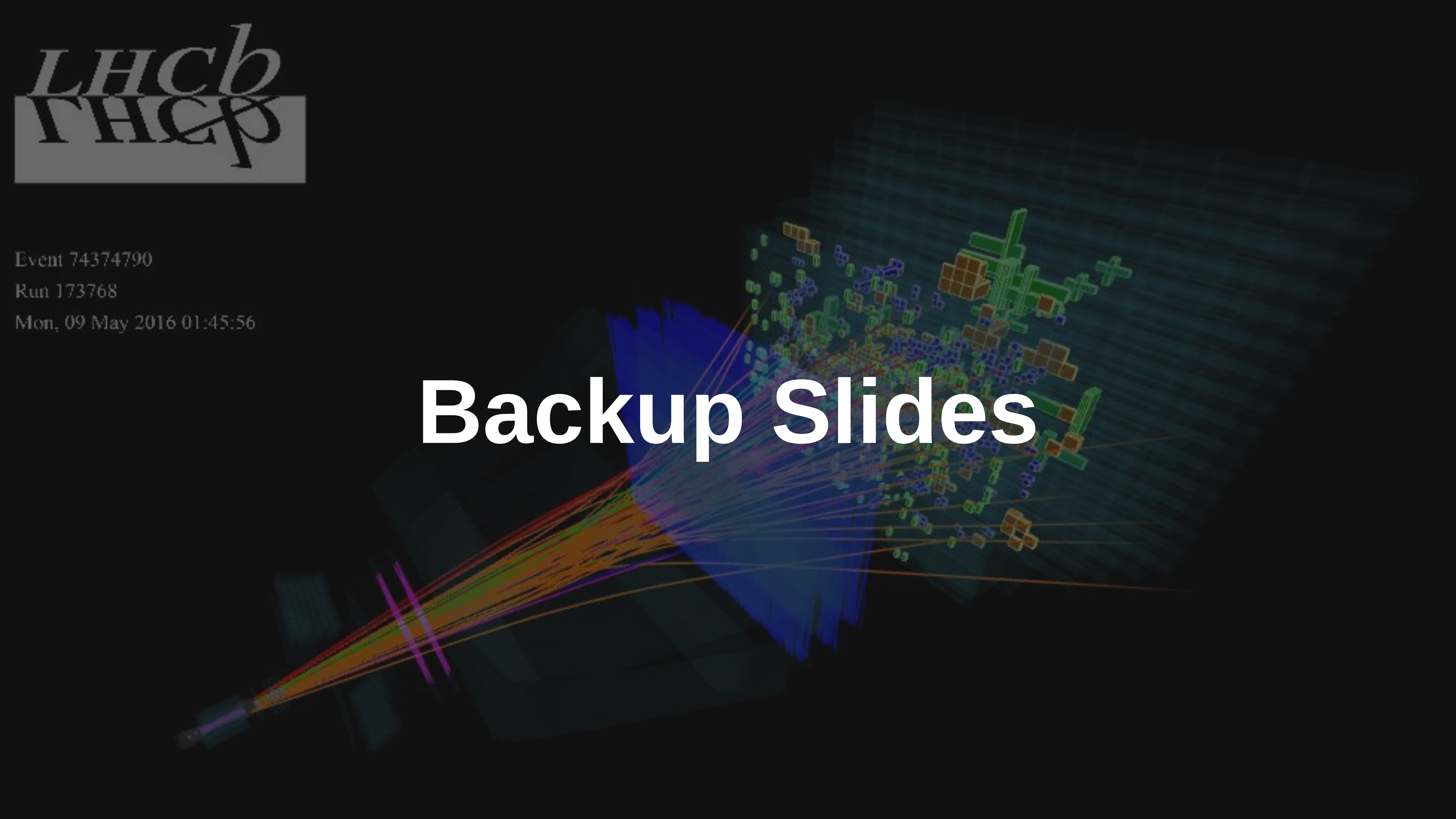




| Run | Duration | Problematic CellIDs [Area.Column.Row] |
|---|---|---|
| 297027 | 30min | [0.36.46] [0.36.47] [0.36.48] [0.36.49] |
| 299082 | 20min | [0.37.14] [0.37.15] [0.37.16] [0.37.17] |
| 300255 | 20min | [0.19.10] [0.19.11] [0.19.12] [0.19.13] |
| 312144 | 10min | [1.4.44] [1.4.45] [1.4.46] [1.4.47] |
| 305375 | 25min | [0.33.6] [0.33.7] [0.33.8] [0.33.9] |
| 305455 | 40min | [0.13.14] [0.13.15] [0.13.16] [0.13.17] |
| 323302 | 60min | [1.16.48] [1.16.49] [1.16.50] [1.16.51] |
| 323331 | 30min | [0.59.18] [0.59.19] [0.59.20] [0.59.21] |
| 323531 | 45min | [1.60.32] [1.60.33] [1.60.34] [1.60.35] |



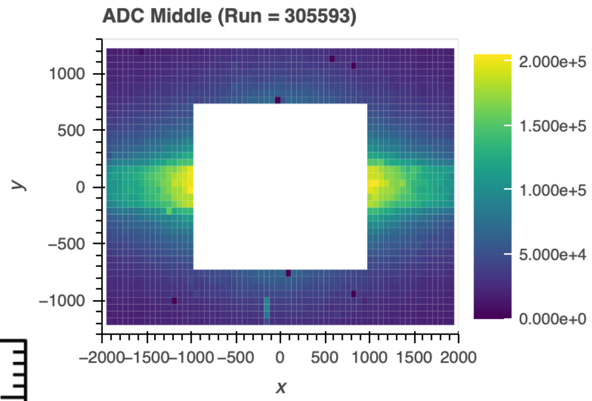

Event 74374790
Run 173768
Mon, 09 May 2016 01:45:56

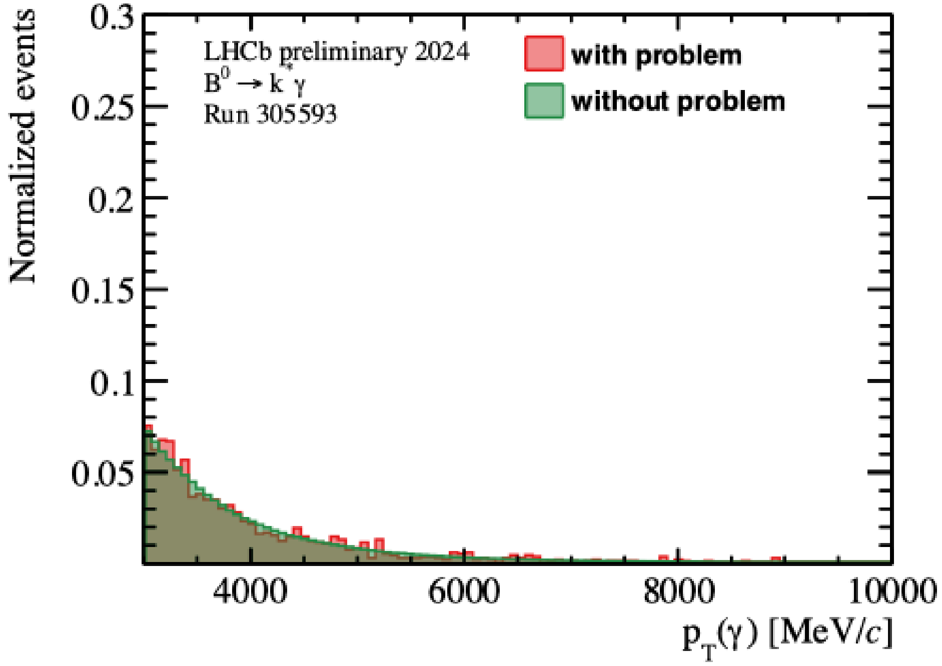
# Backup Slides

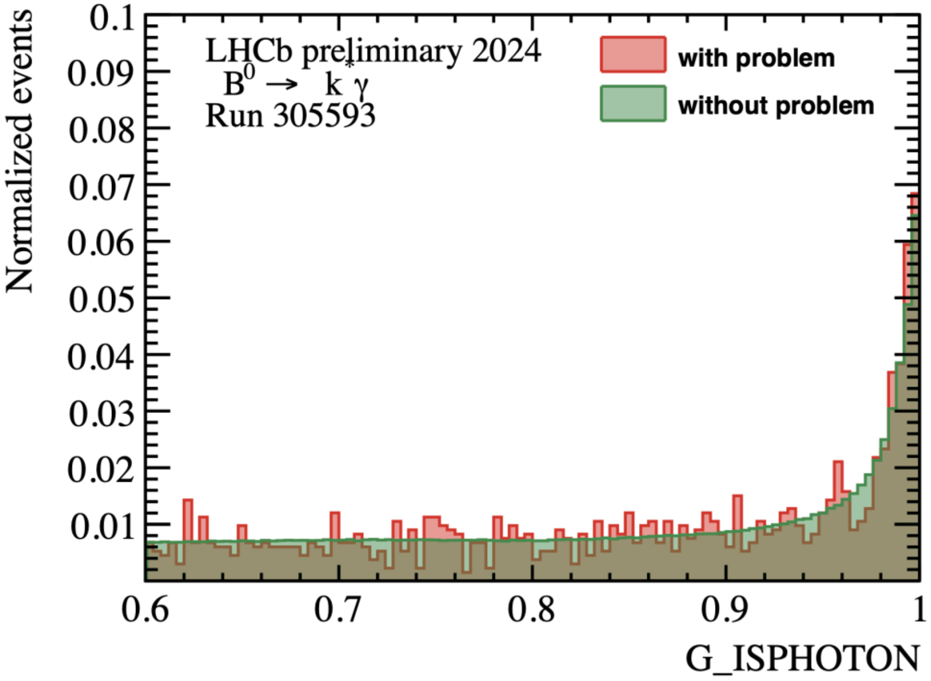


# $B^0 \to K^{*0}\gamma$

- Not all runs with the problem showed clear impact
- Some runs seemed coherent with normal data



# $B^0 \to K^{*0}\gamma$

**Summary chart of all twelve cases**

Evaluated (in comparison)

Noise level(using 2D plots in Monet),

Photon $p_T$, and ISPHOTON

High noise level(Acc. ADC)

→ noticeable affects of problem

Four runs show clear anomalies

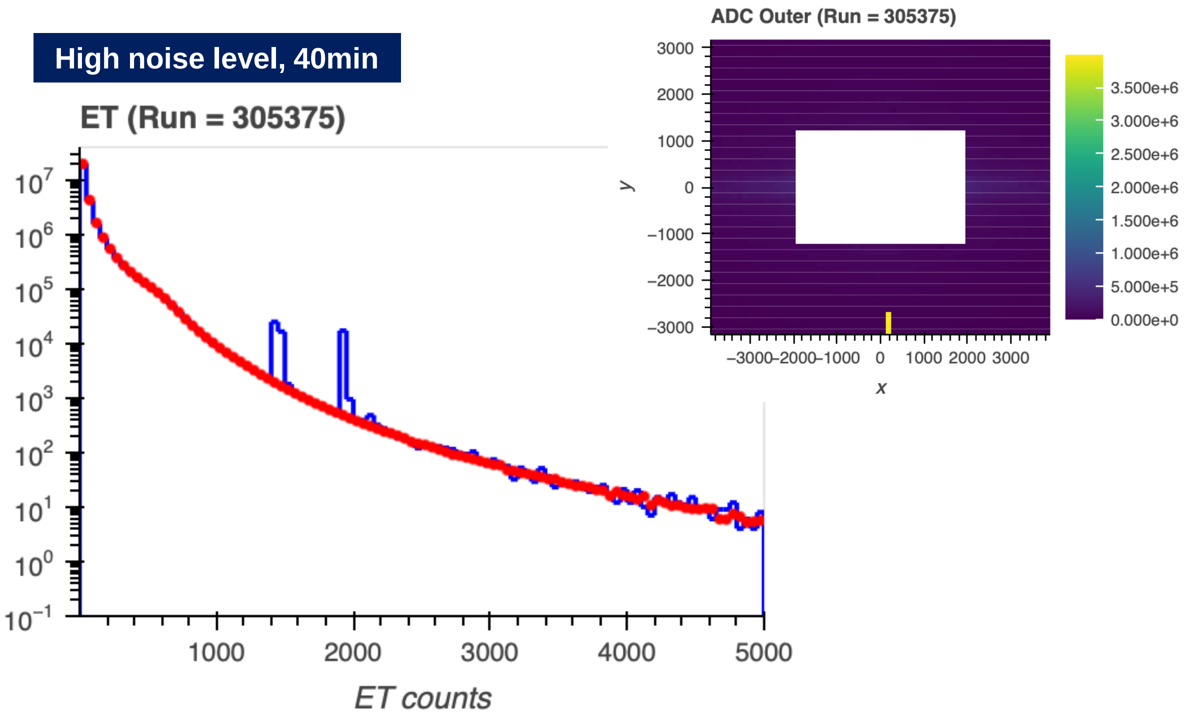
→ Use for further analysis

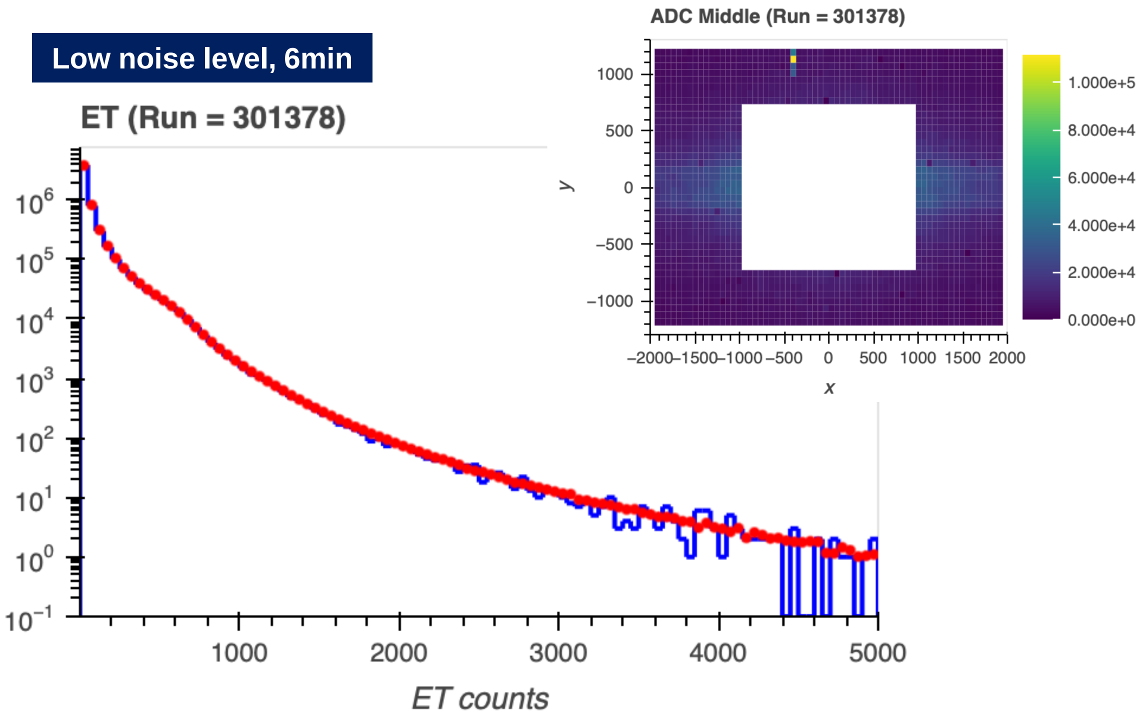
Reported 302144 & 305455 in problem DB

| Runnumber | Runtime | Region | Noise Level | Anomalies in gamma_PT | Anomalies in G_ISPHOTON |
|---|---|---|---|---|---|
| 297027 | 30min | Outer | Mid | Yes | Yes |
| 299082 | 20min | Outer | Mid | Yes | Yes |
| 300255 | 20min | Outer | High | Yes | Yes |
| 301377~301378 | 1h | Middle | Mid | Maybe | No |
| 301796~301844 | 7h | Outer | Mid | Maybe | No |
| 302144 | 10min | Middle | High | Yes | Yes |
| 304464~304494 | 11h | Inner | Low | No | No |
| 305025 | 30min | Outer | Low | Maybe | No |
| 305043~305062 | 12h | Outer | Low | No | No |
| 305375 | 25min | Outer | High | Yes | Yes |
| 305455 | 40min | Outer | High | Yes | Yes |
| 305593 | 25min | Middle | Low | No | No |

# Problems in 2024

- ET plot in Monet (red: reference)
- Runs with high noise levels show two peaks in same region
- Low noise levels show no anomalies; fluctuations in high ET region → normal for short runs



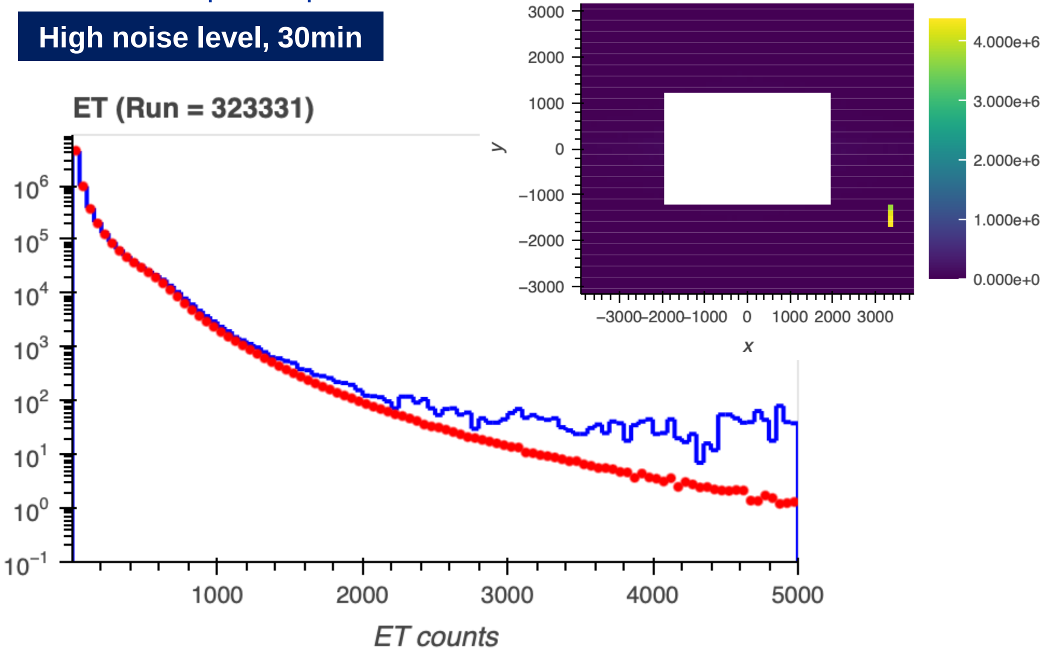
# Problems in 2025

## Fake high-energy photons

- ❑ First to show deviation in high-ET region
- ❑ Does not have peaks in low-ET region
- ❑ In both cases HLT1 rate exploded

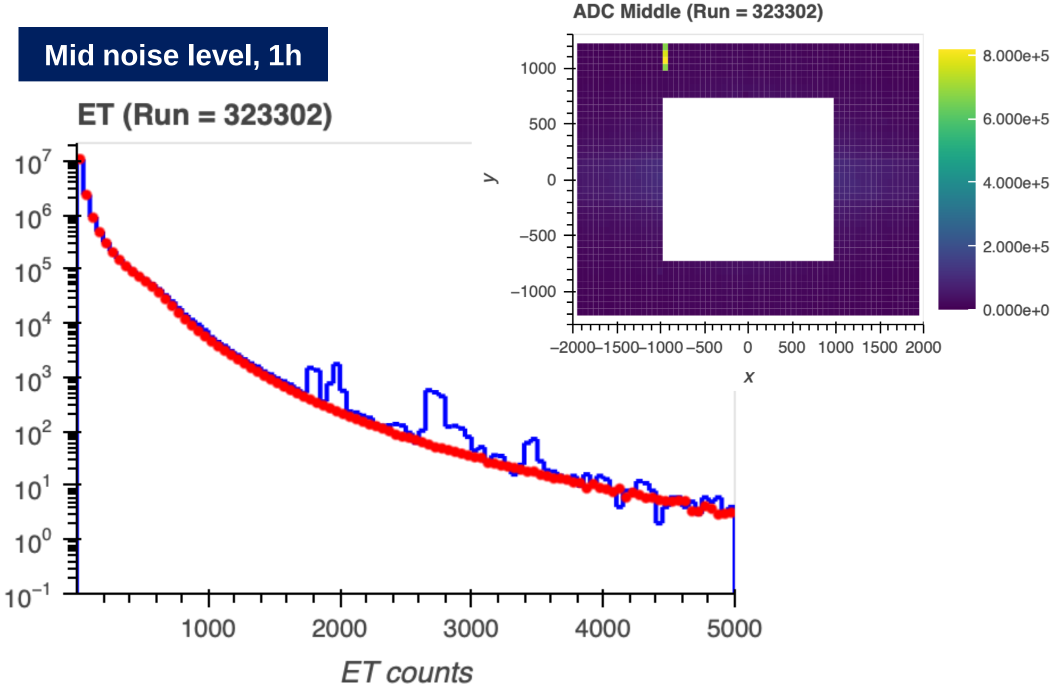
→ ‘Output rate too high’ alarm by DiPhotonHighMass

14-06-2025, Reported problem DB




## Fake mid-energy photons

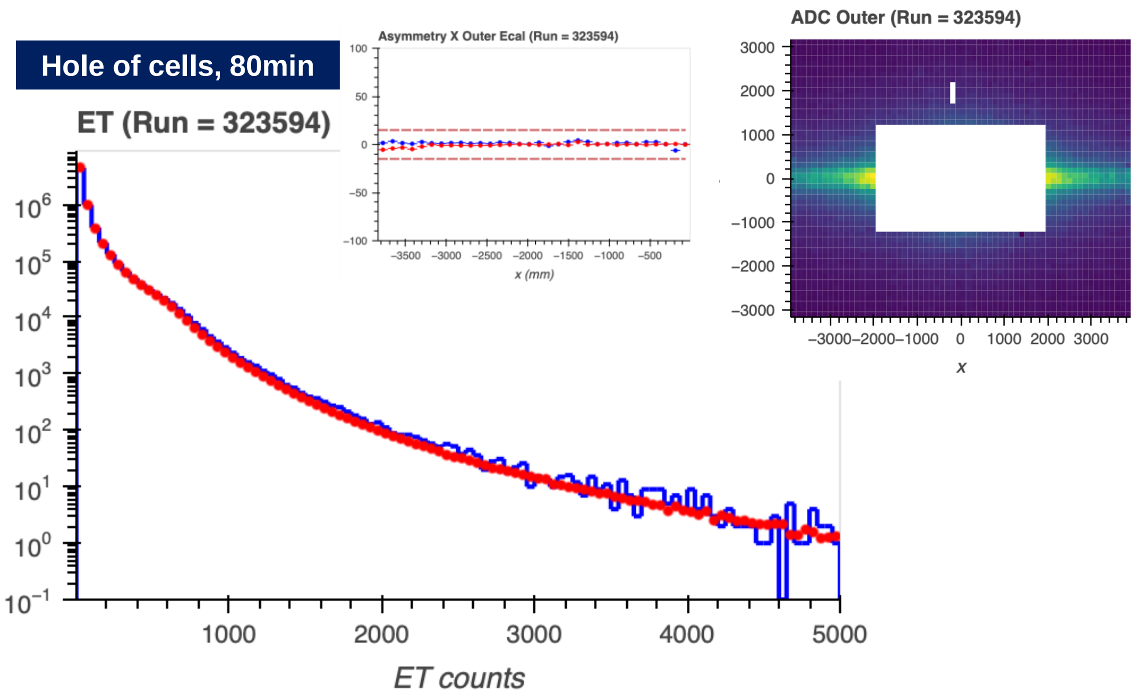
- ❑ Anomalies in higher ET regions than before
- ❑ More peaks?



# Problems in 2025

## 4-cell hole

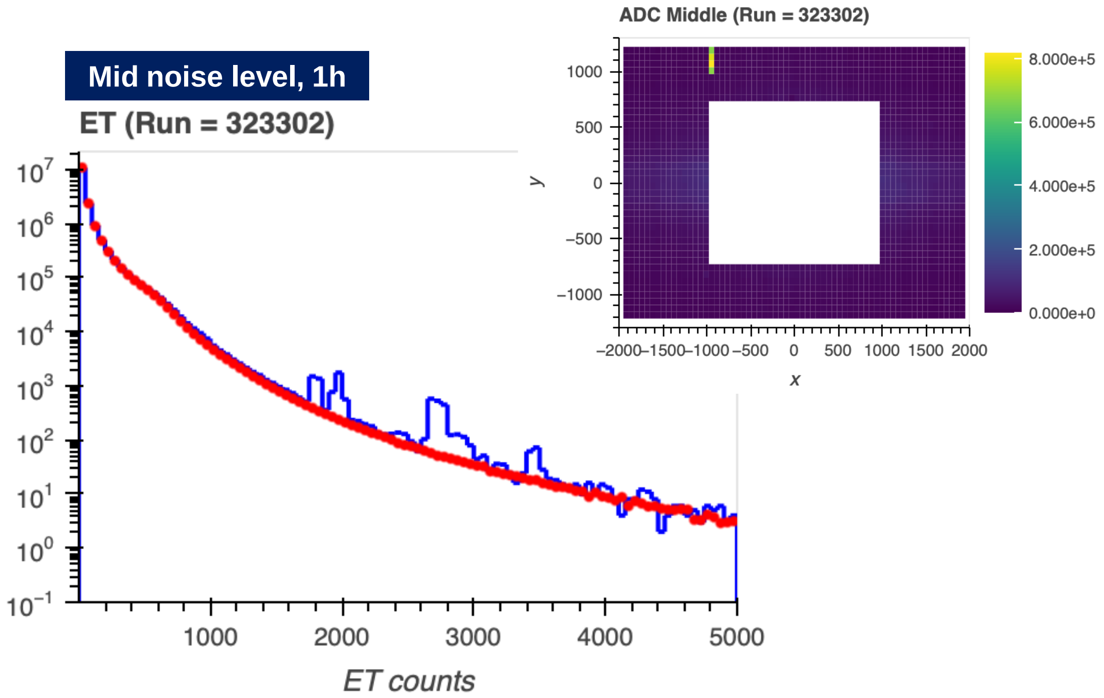
- Runs 323590 ~ 323596
- Did not trigger asymmetry alarm
- Maybe related to the 4-cell problem?




https://lbproblems.cern.ch/problemdb/problems/495/

## Fake mid-energy photons

- Anomalies in higher ET regions than before
- More peaks?




https://lbproblems.cern.ch/problemdb/problems/478/

# ECAL Column_Row Map

Outer