Service Work on LumiBelle2

Study on Performance of LGAD and Comparison to Diamond sensor

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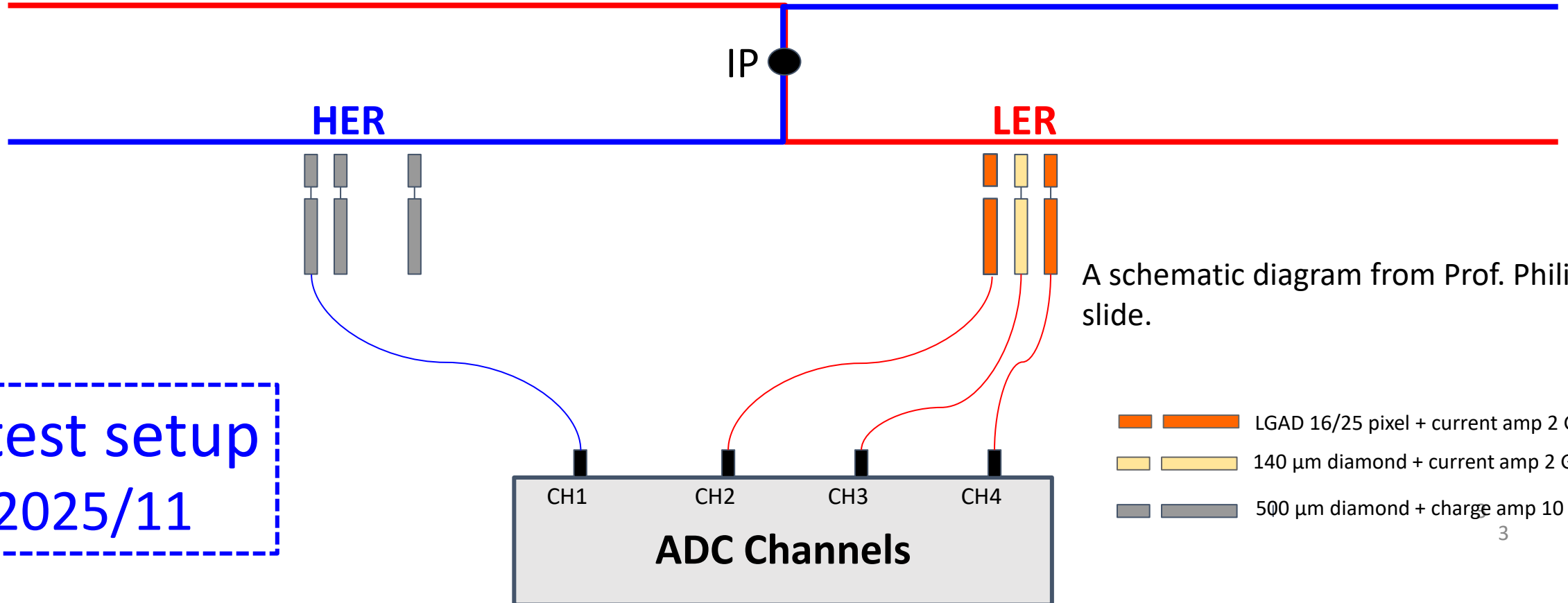
Outline

- Motivation
- Methodology
- Study of relative precision of different channels
- Study of the sensitivity of LGAD
- Summary

Motivation

- The LGAD sensors have been installed in the LumiBelle2 detector, where it will provide real-time luminosity information to the orbit feedback system, thereby contributing to luminosity optimization.
- The performance of LGAD sensors in Belle2 collision environment need further study, such as the relative precision and sensitivity.
- Study the relative precision of LGAD sensors will help us to optimize the setup of LumiBelle2 detector.

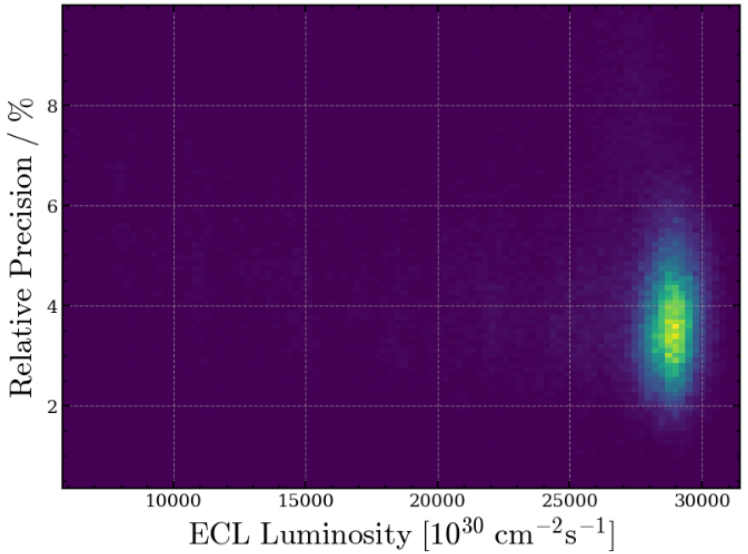


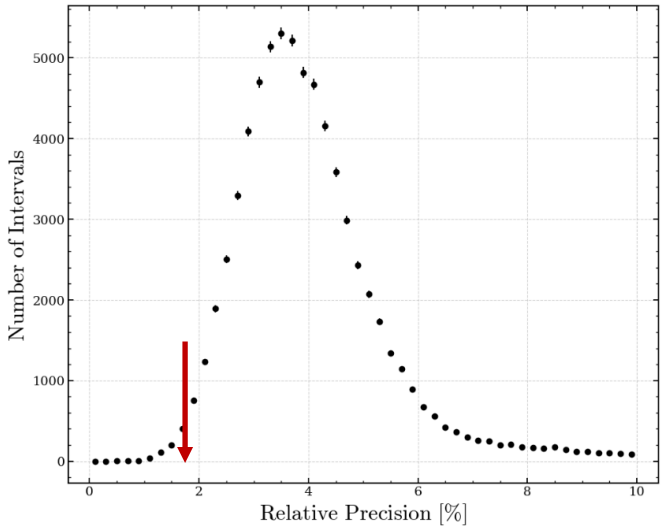
A schematic diagram from Prof. Philip's slide.

latest setup
2025/11

Methodology

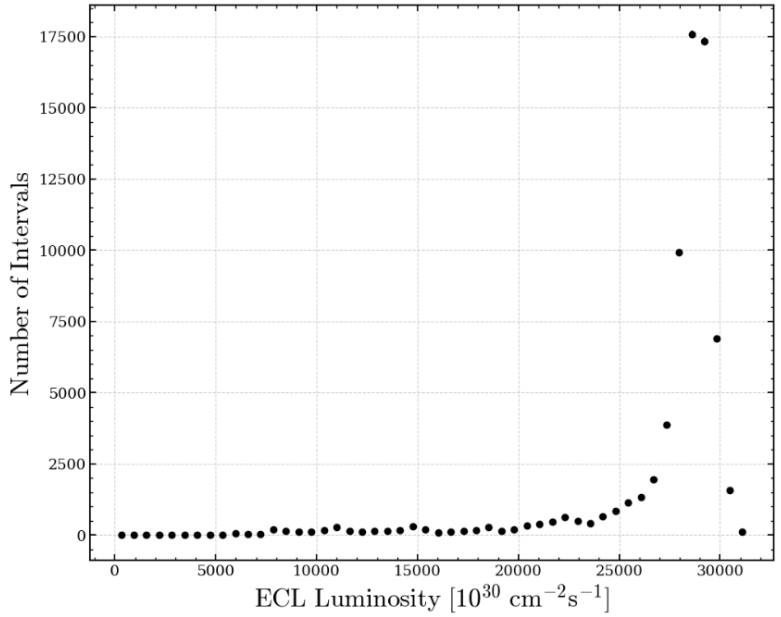
- Select 10-second time intervals, during which the luminosity measured by ECL detector remains relatively stable.





Relative Precision =

$$\frac{RMS(\text{ECL Lumi})}{Mean((\text{ECL Lumi}))}$$

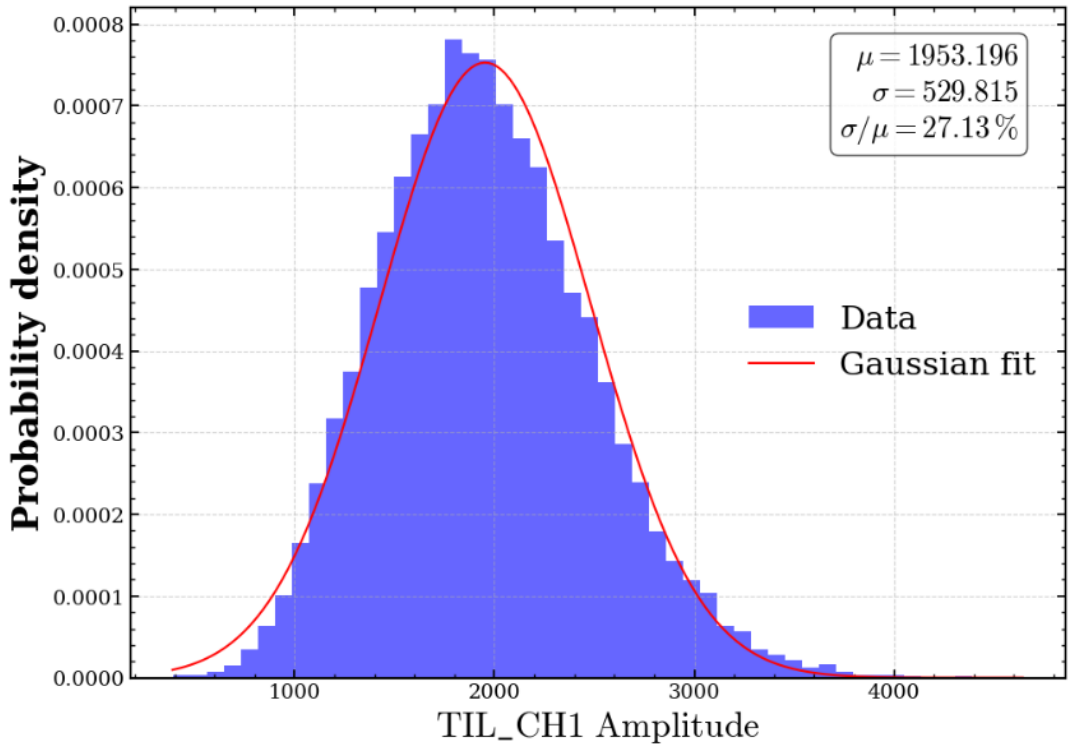


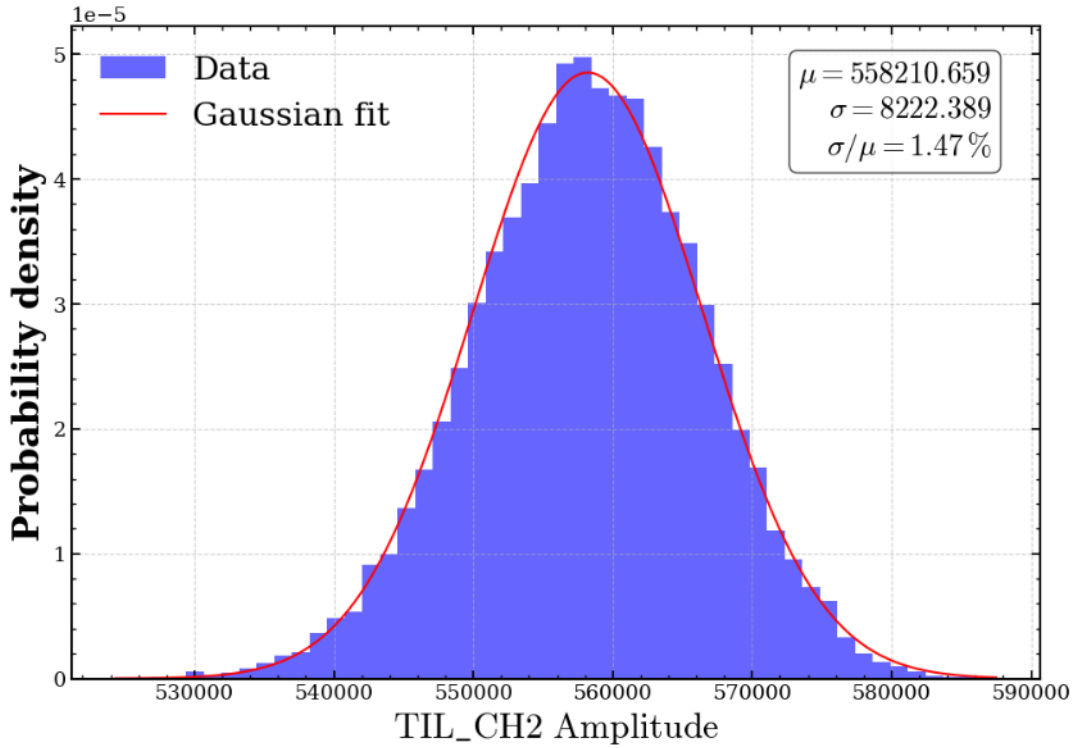
A relatively stable time interval is defined as one in which the relative precision of the ECL luminosity falls within the lowest 5%.

Data taken at 2025-12-15 as an example

Methodology

- For each interval, approximate 10k signals is collected. The distribution of these signals is fitted with free Gaussian assumption.
- The **relative precision** for the i-th interval is obtained, which is defined as $RP_i = \frac{\sigma_i}{\mu_i}$, σ and μ represent the resolution and central value of Gaussian function, respectively.

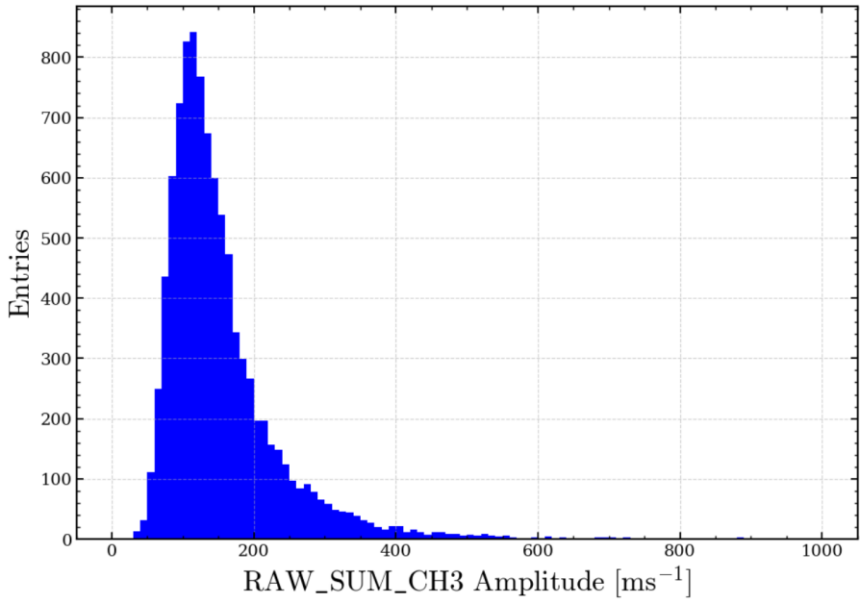


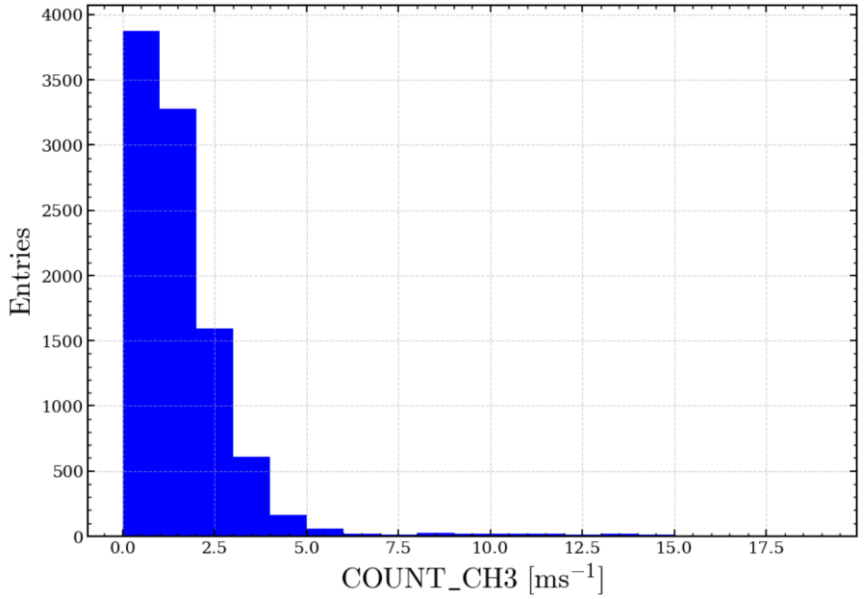


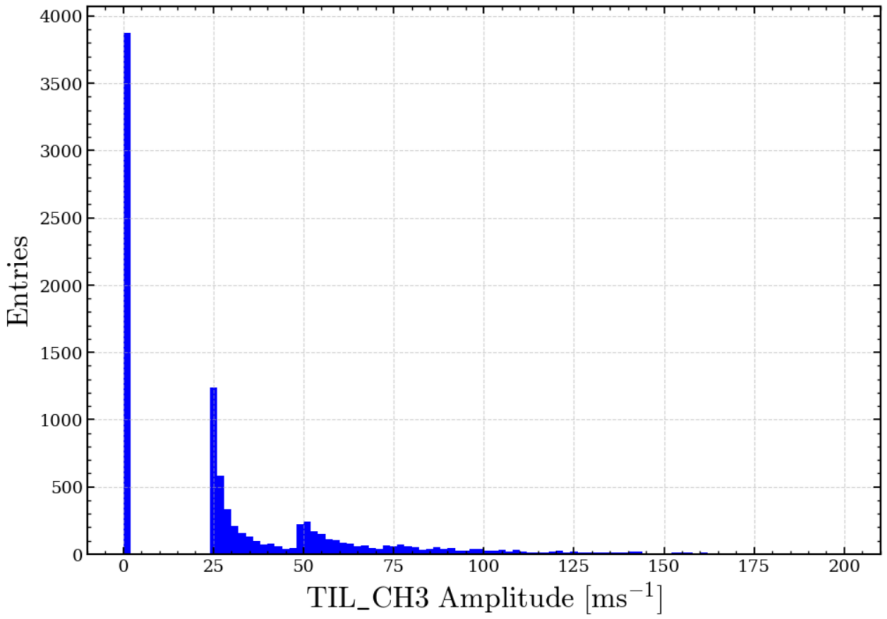
Methodology

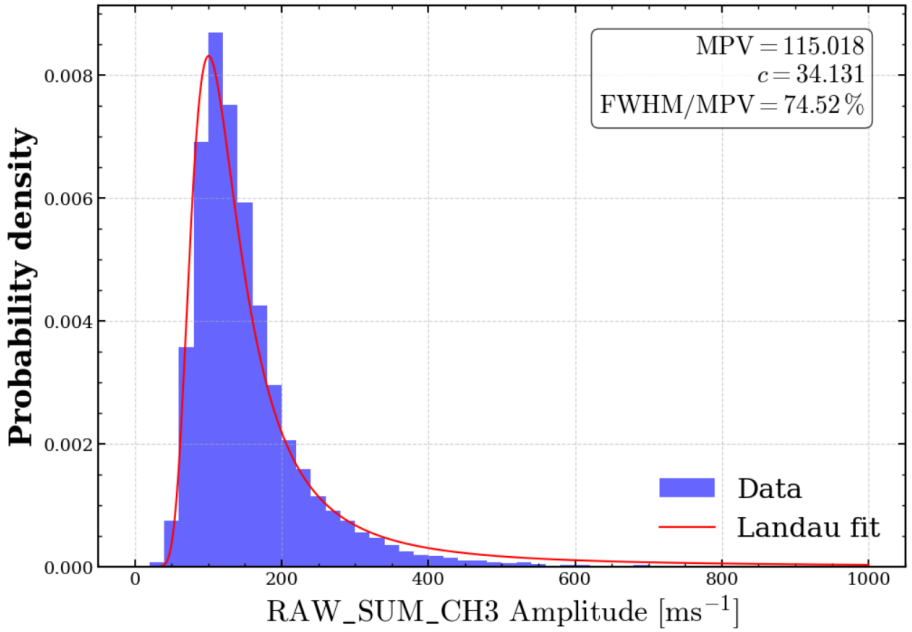
- For channel3(150 um Diamond), only RAW_SUM can be fitted using Landau distribution.
- The relative precision definition is different from others:

  RP = FWHM/MPV.

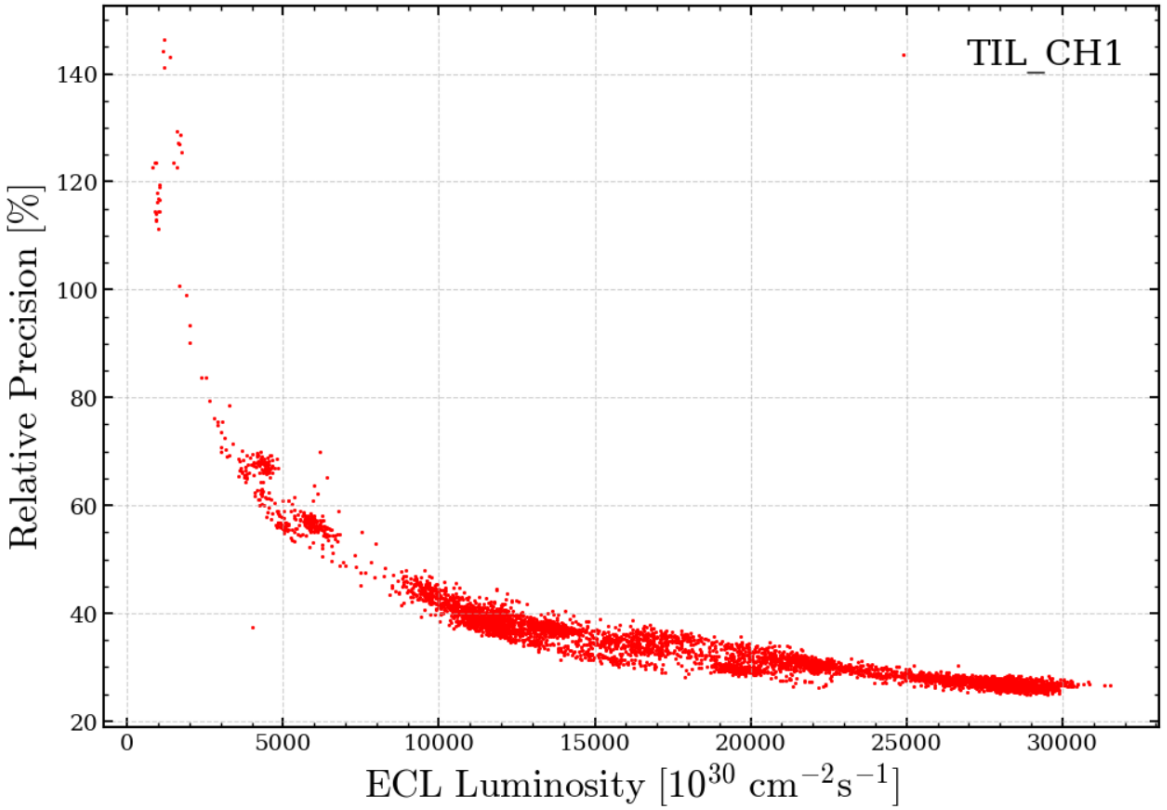


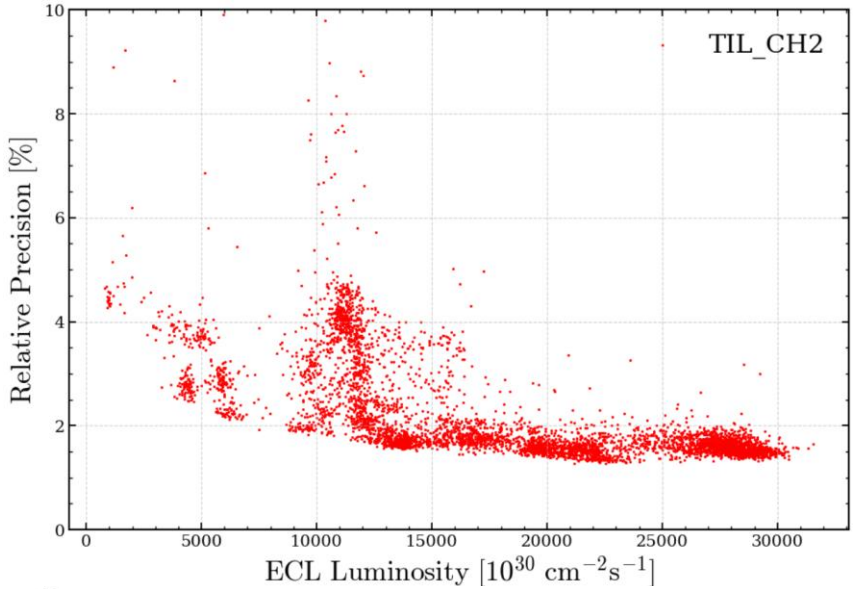


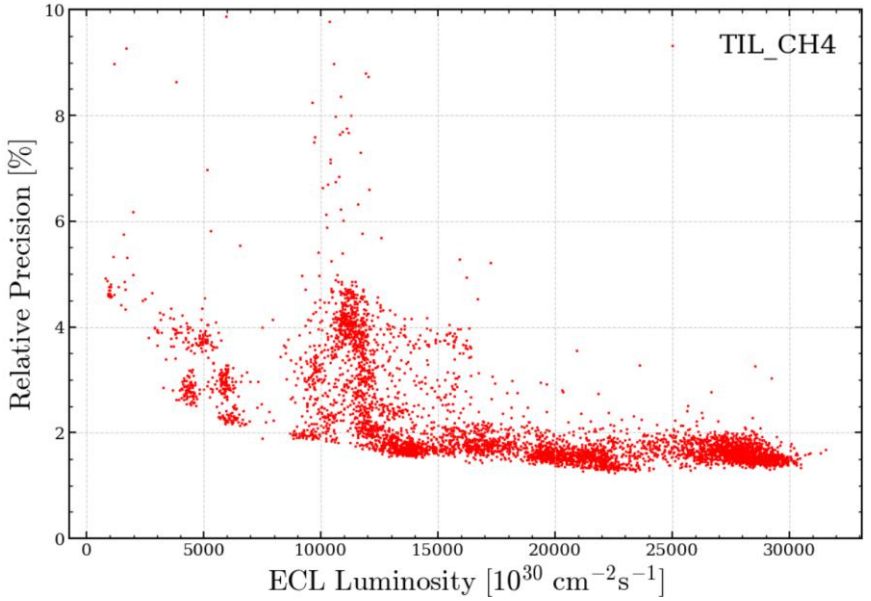




Relative Precision of different channels





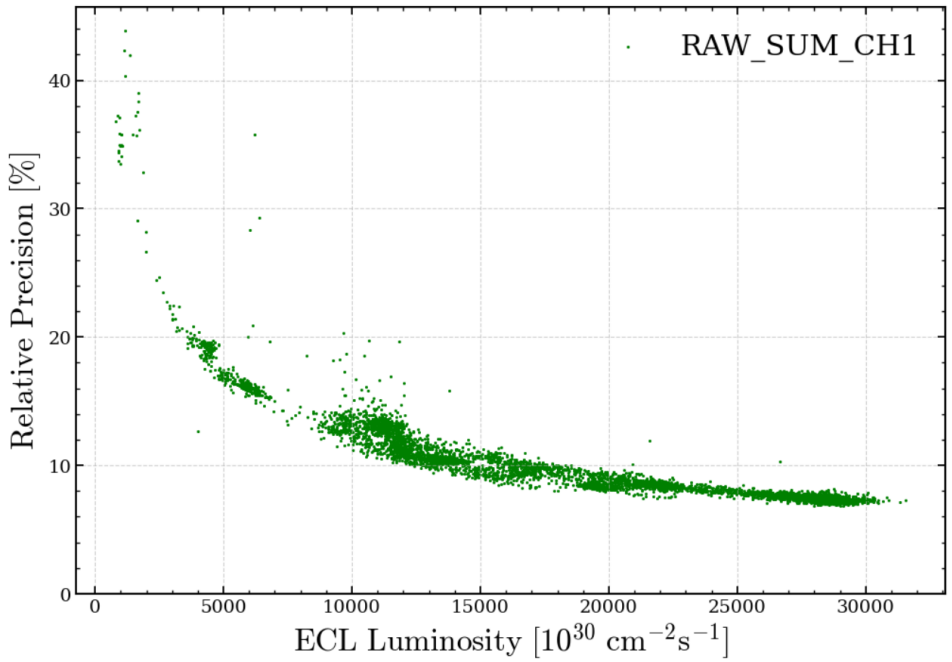


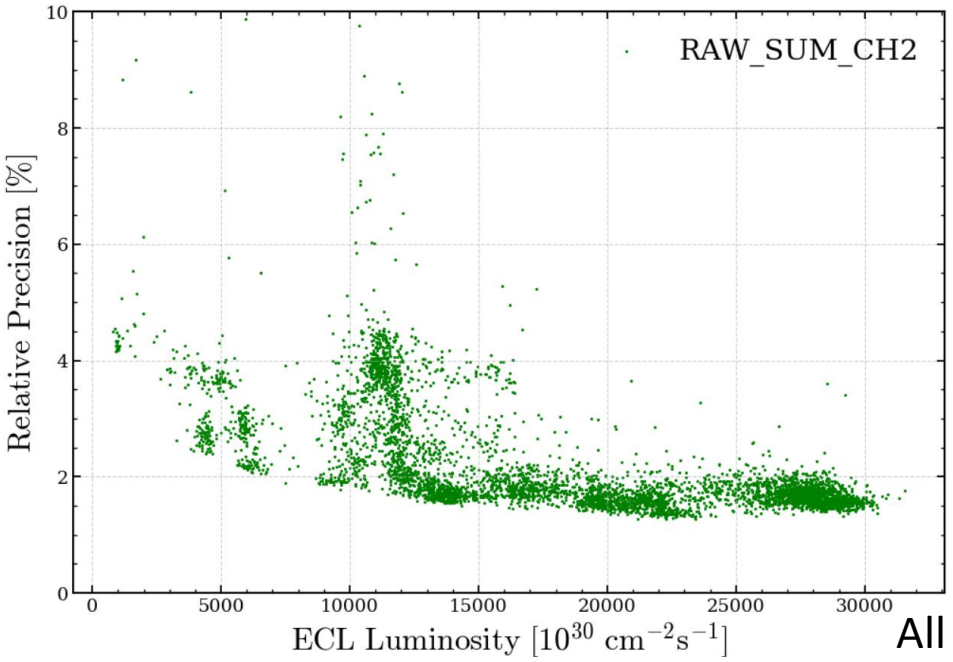
$RP \sim 2\%$

- The diamond sensor's precision has better consistency with this assumption but much worse than LGAD's.

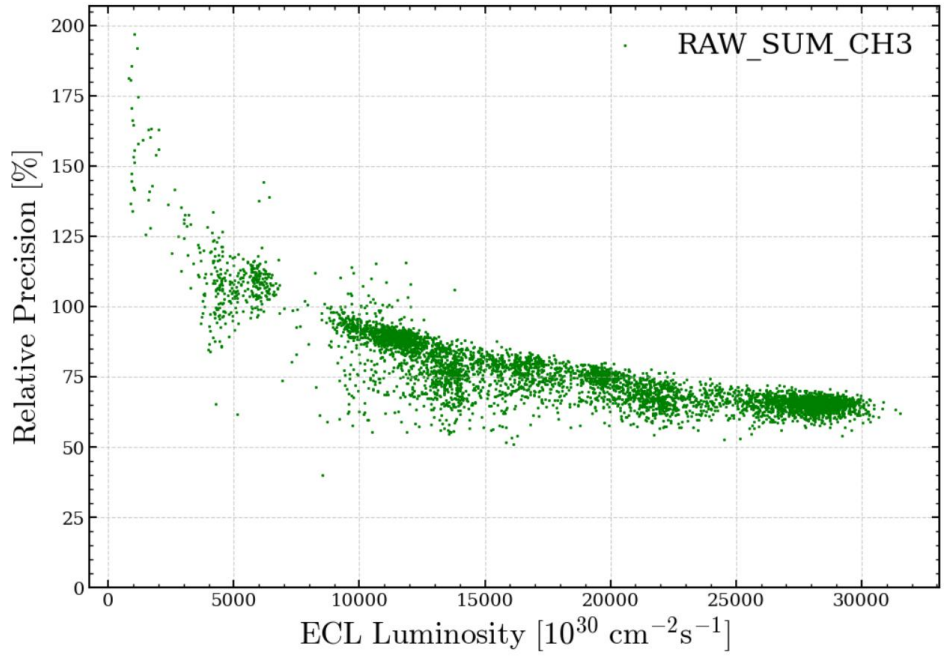
Results for RAWSUM

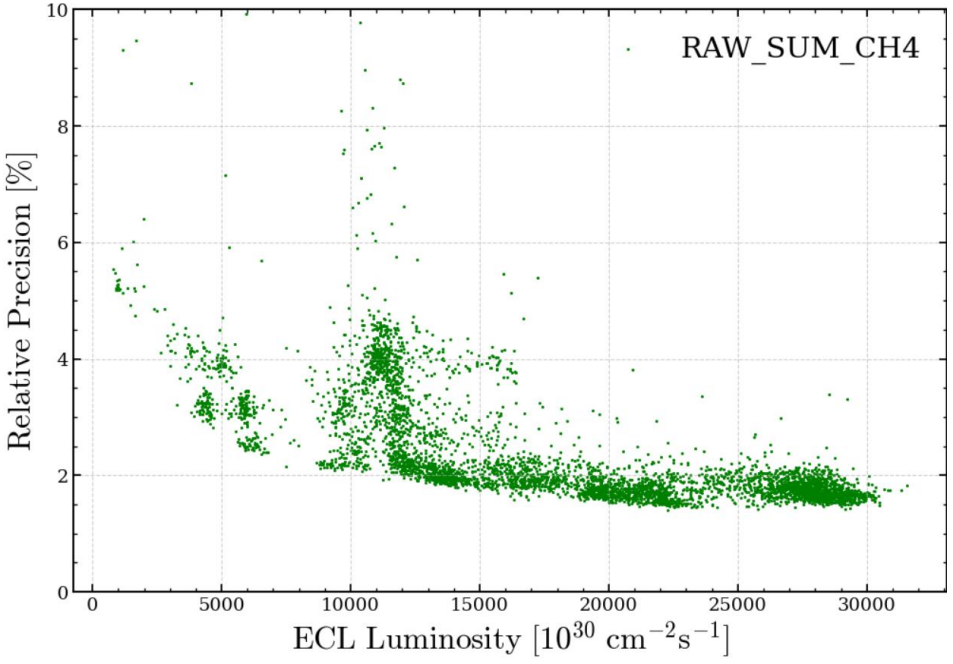
$$RAWSUM = \sum_{0}^{1\,ms} (Sample_i - Threshold_2), \quad if\ Sample_i - Threshold_2 > 0$$



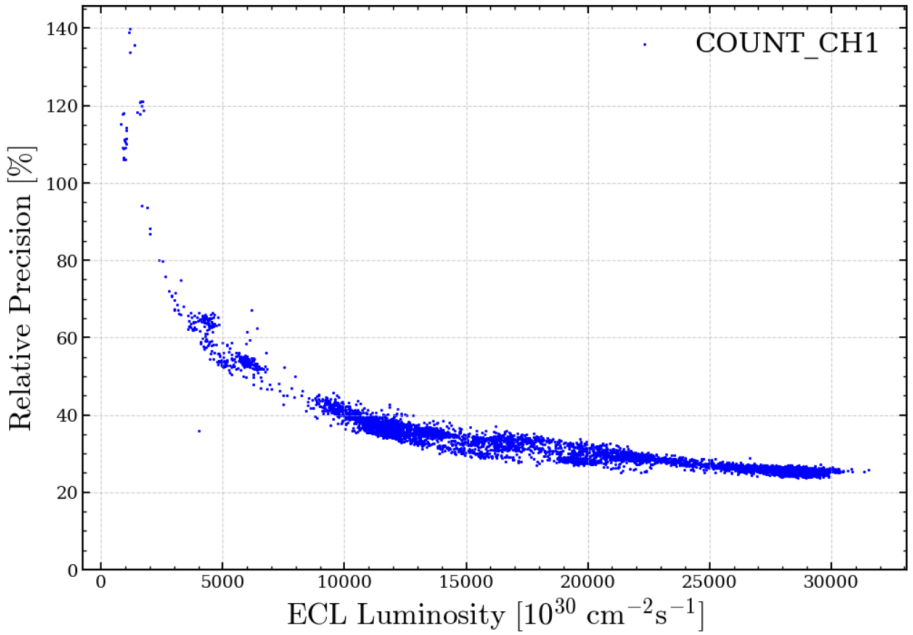


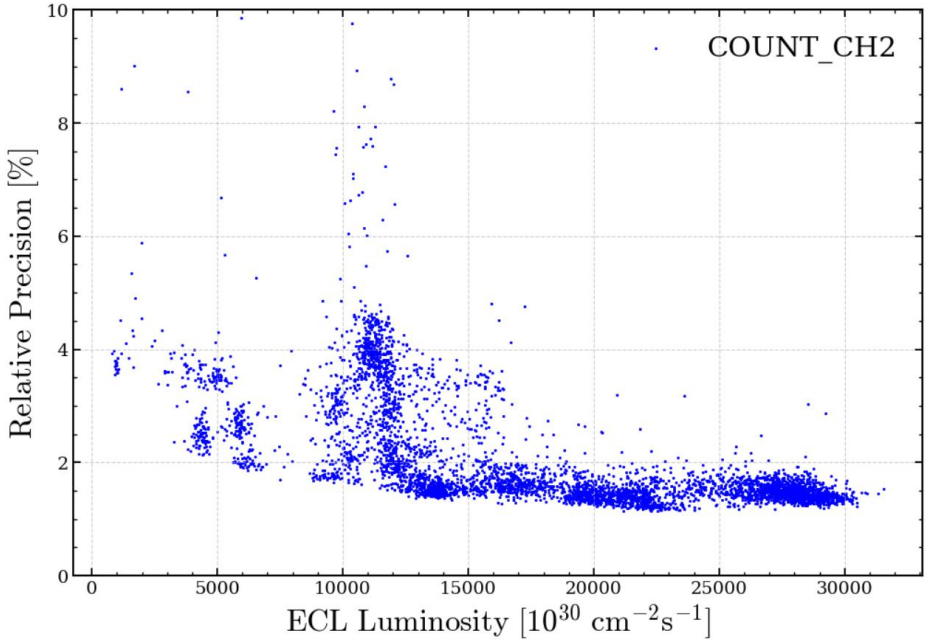
All Data from Nov. 19th to Dec. 19th

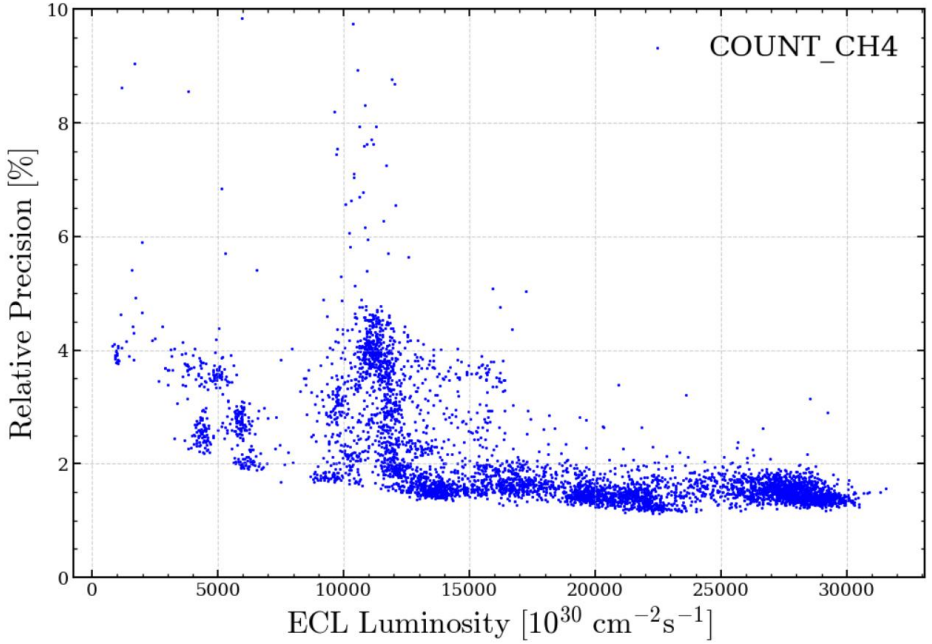




Results for COUNT



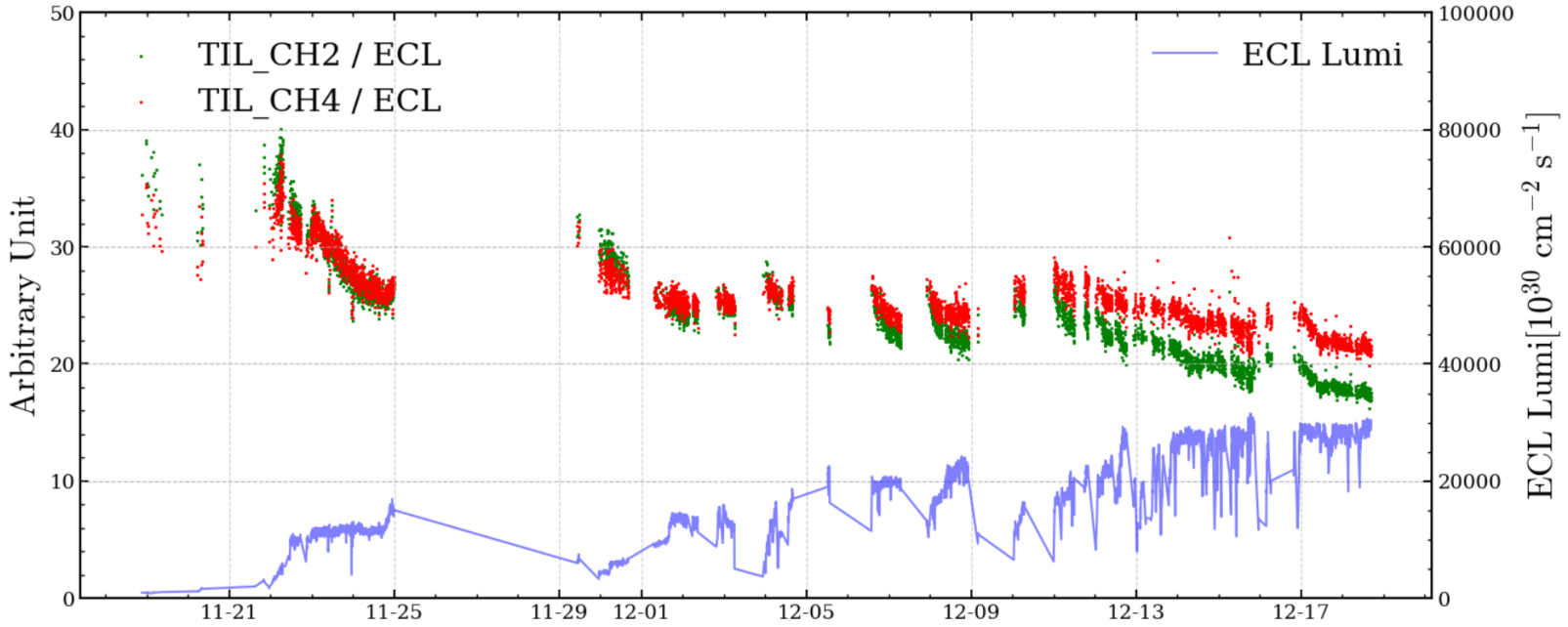


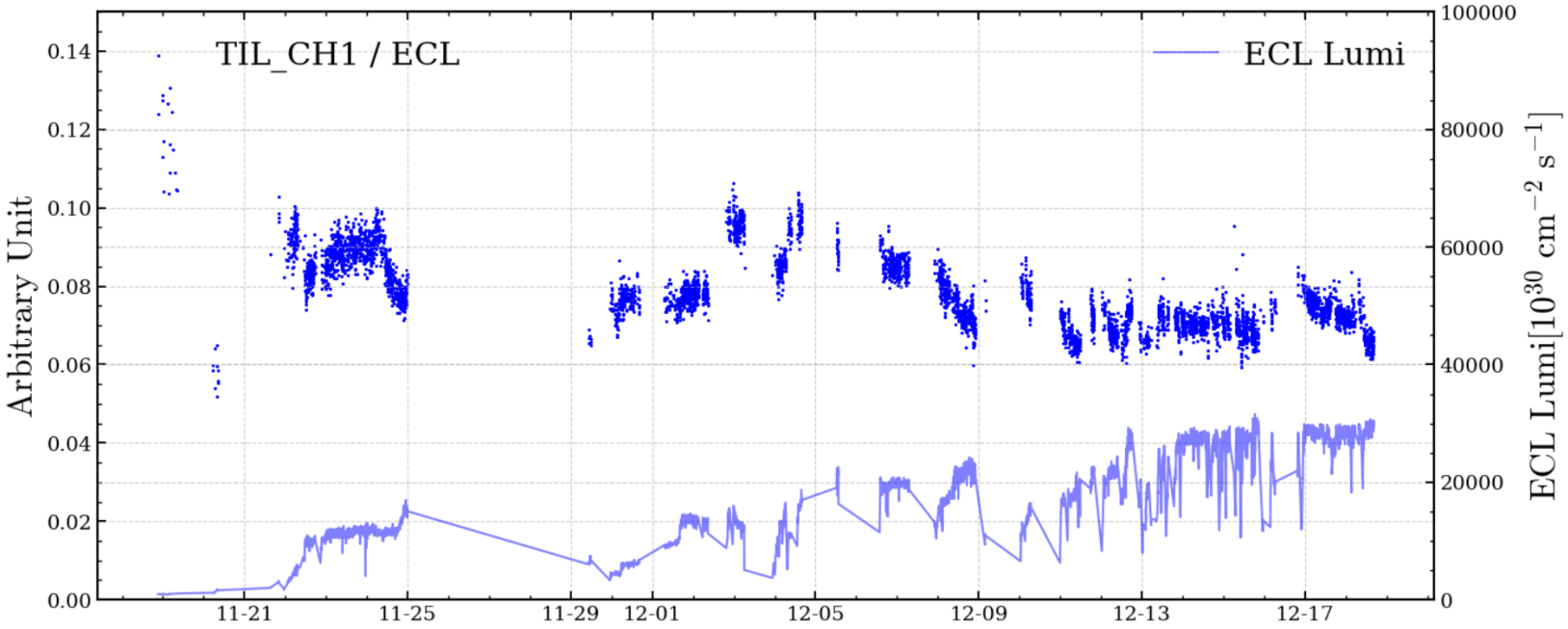


All Data from Nov. 19th to Dec. 19th

$$Count = Count + 1, \quad if\ Diff_i > Threshold_1$$

Study of the Sensitivity of LGAD





$$\text{Sensitivity}_i = \frac{\text{mean of 1kHz data}}{\text{ECL Lumi}}$$

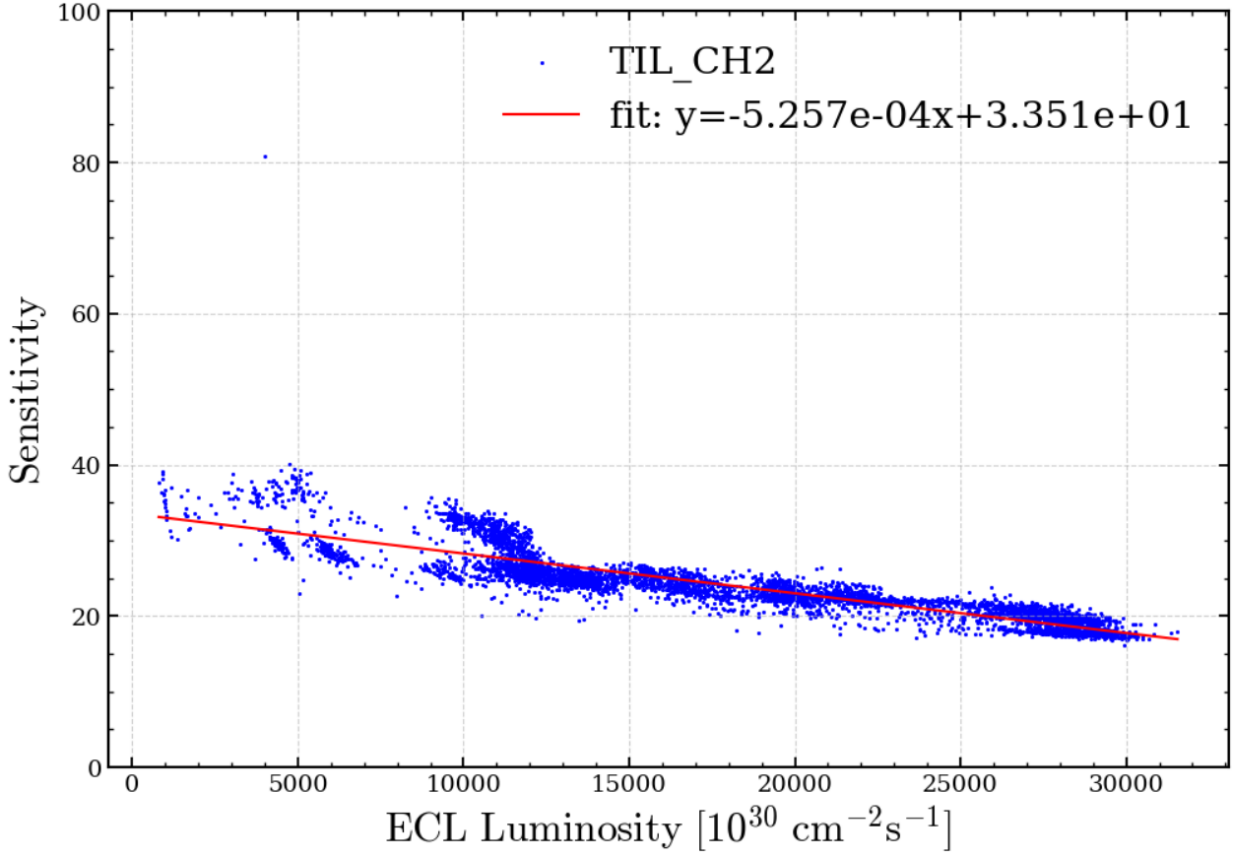
in i^{th} stable time interval,

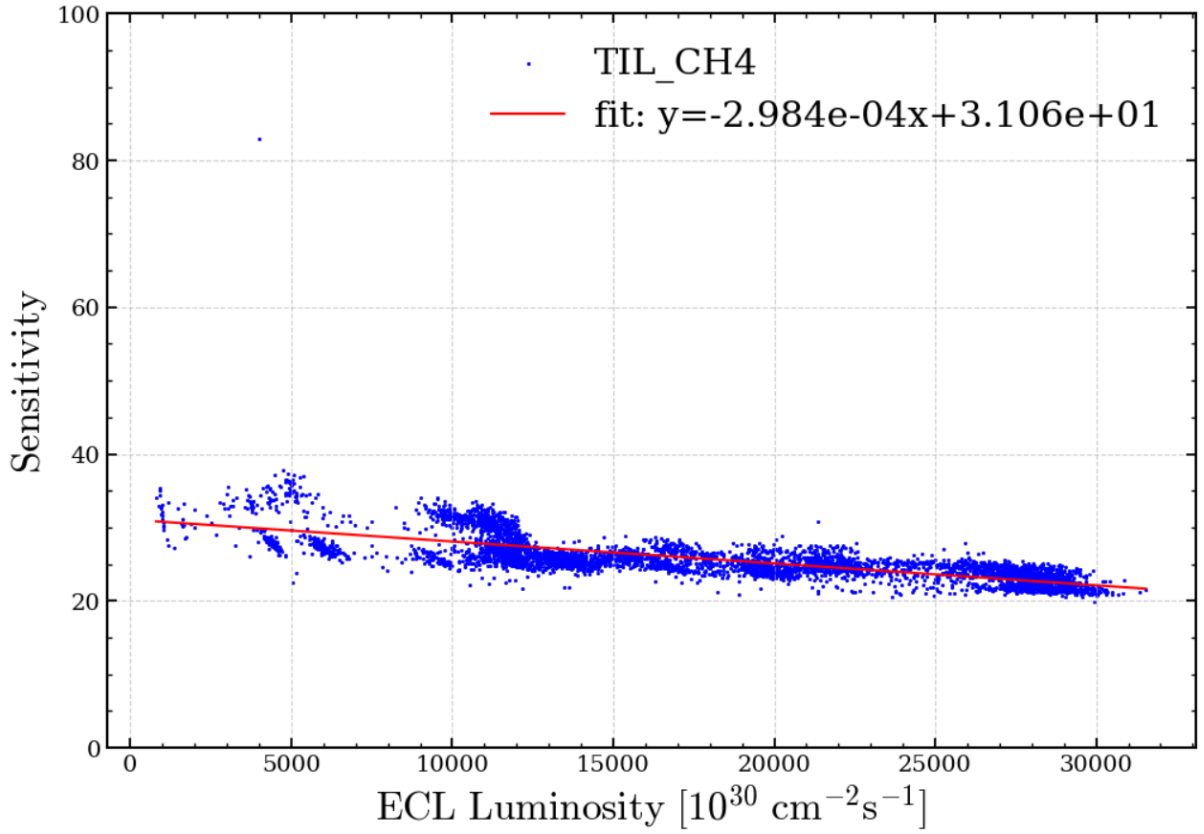
Mean of 1kHz data: μ for CH1,2,4, MPV for CH3

- The difference between two LGADs becomes larger as time goes on.

All Data from Nov. 19th to Dec. 19th

Study of the Sensitivity of LGAD





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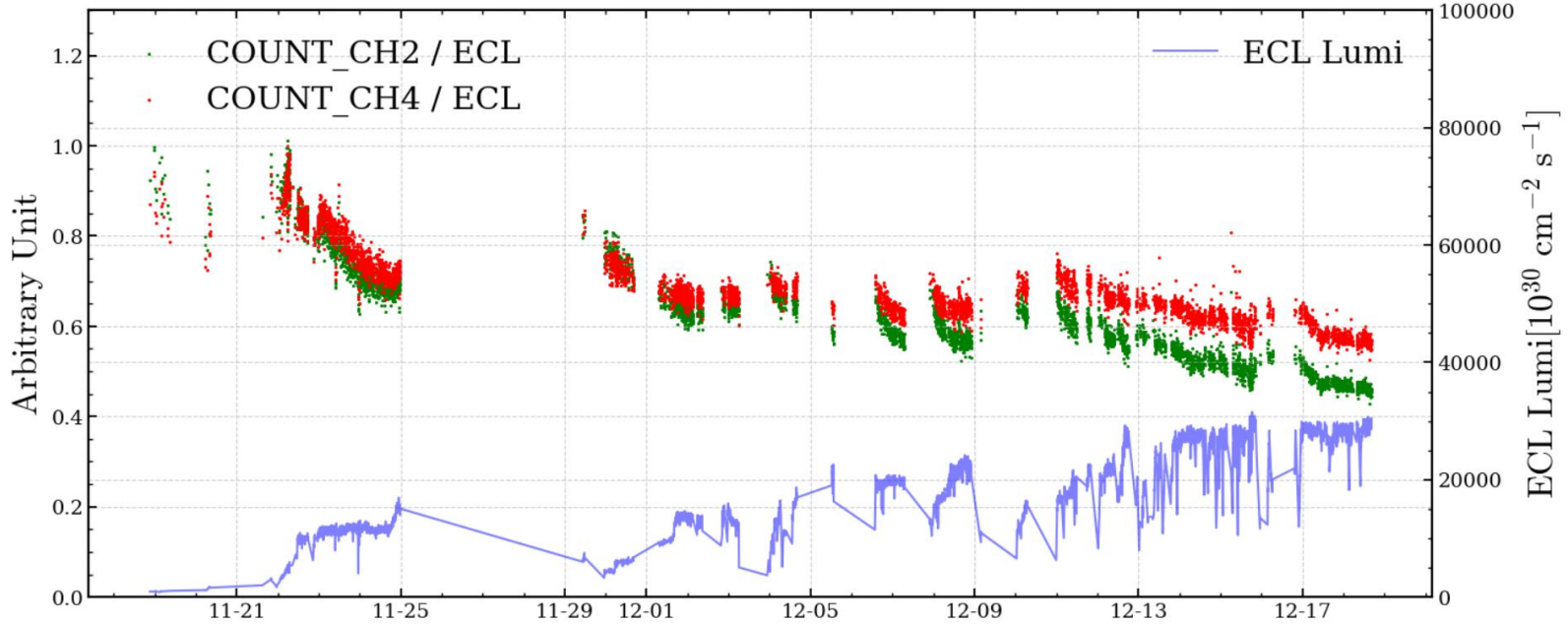

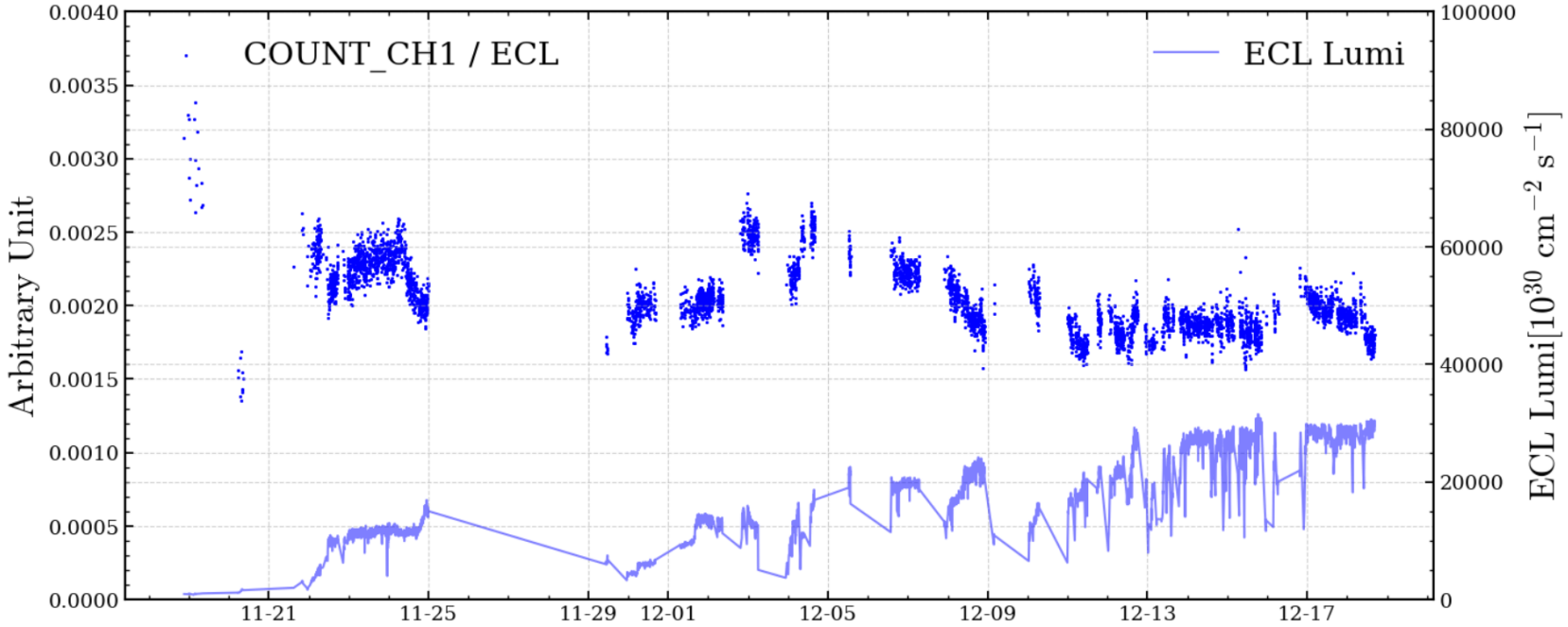

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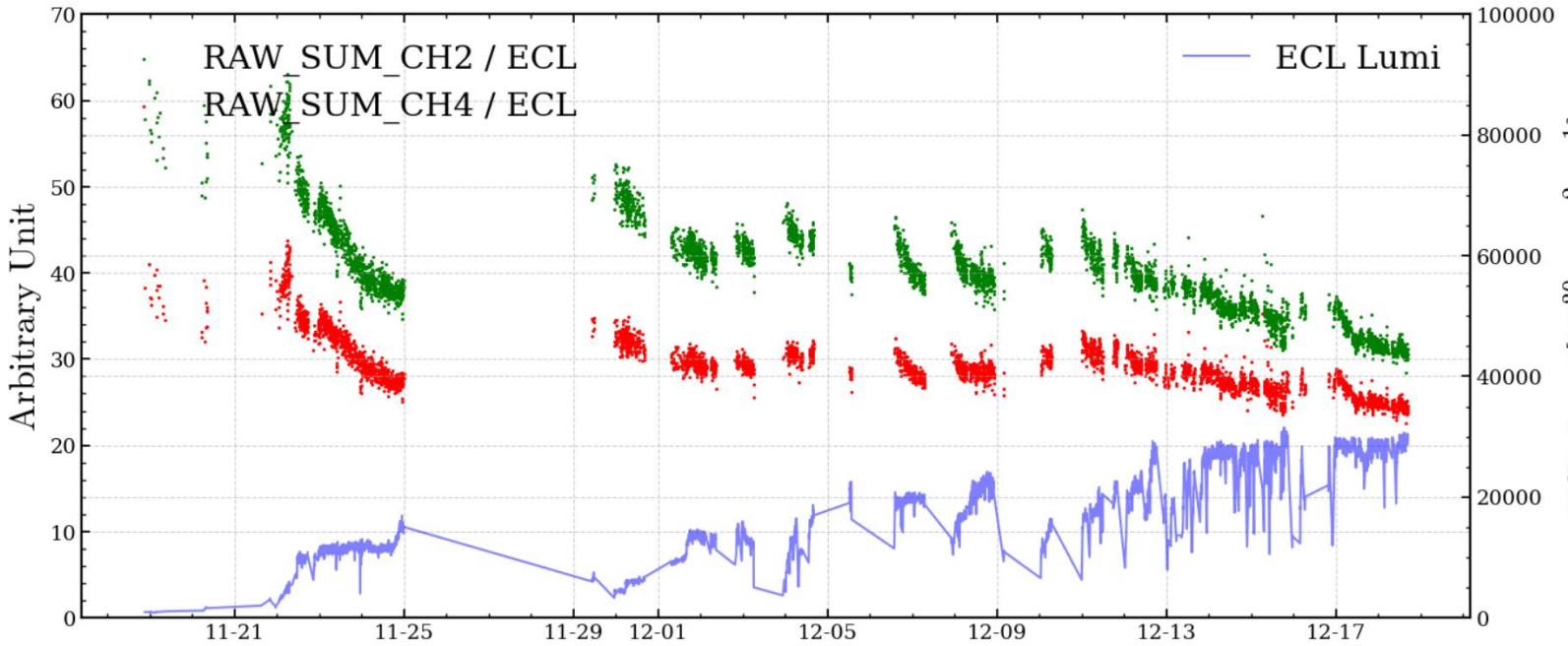
Study of the sensitivity of LGAD



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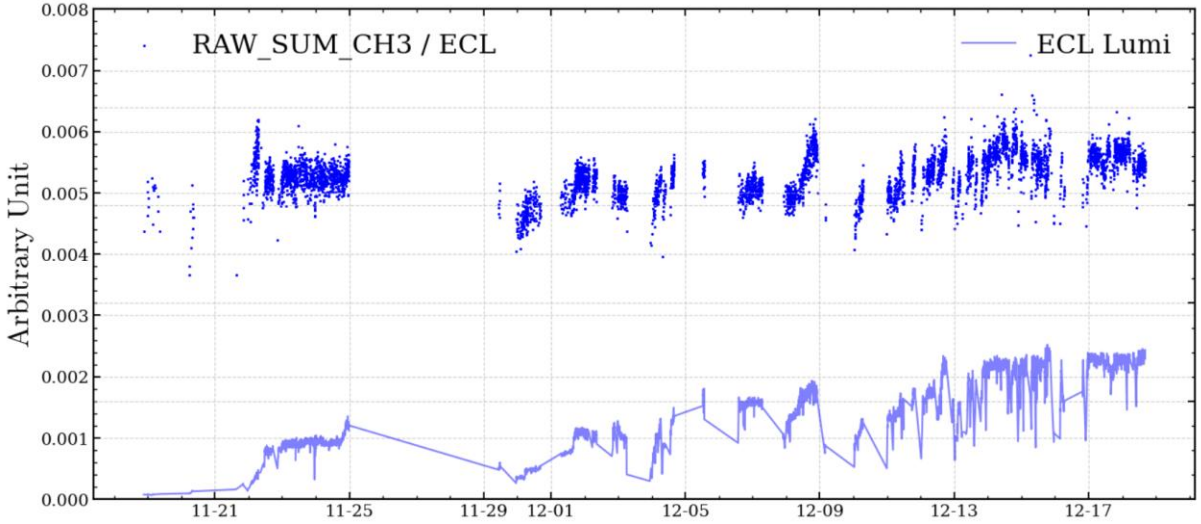

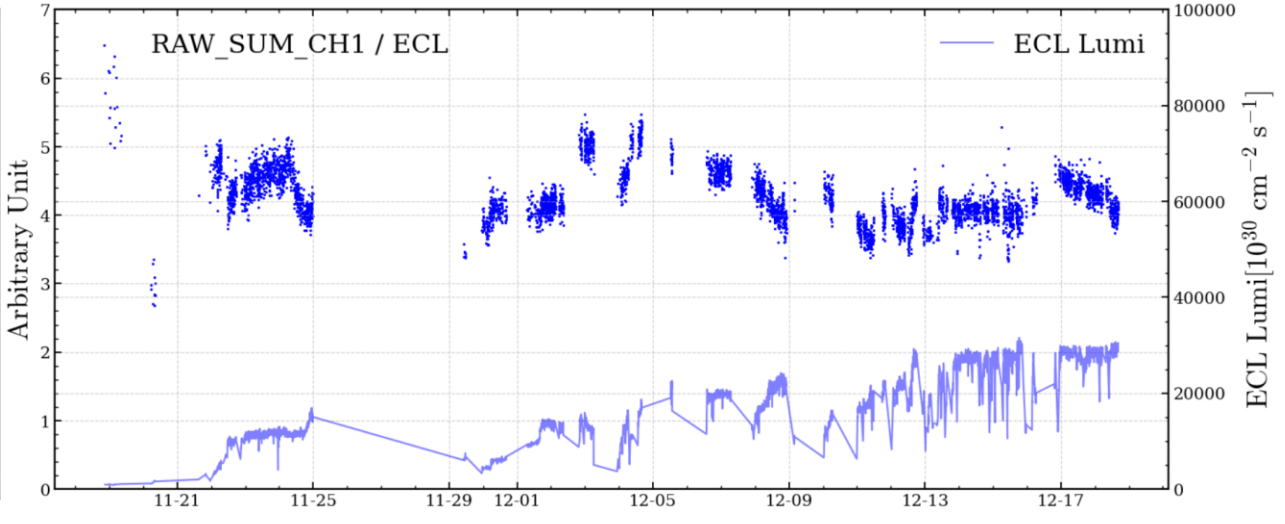

Summary

- A methodology to analysis the relative precision of LumiBelle2 sensors is prompted.
- Using this method, the behavior of relative precision of LumiBelle2 with respect to ECL luminosity is studied.
- LGAD has much better performance than diamond sensors at relative precision aspect.
- The study on the sensitivity of LGAD sensors is ongoing.

To Do List

- Continue the study of sensitivity of LGAD sensors.
- Search for a reliable method to study the 150 um Diamond sensor.