



DESY Summer Student Program 2023

Afterglow calibration for BCM1F

SUMMER STUDENT

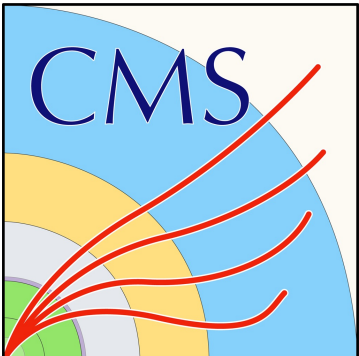
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BRIL Group

Beam Radiation, Instrumentation and Luminosity



Main focus:

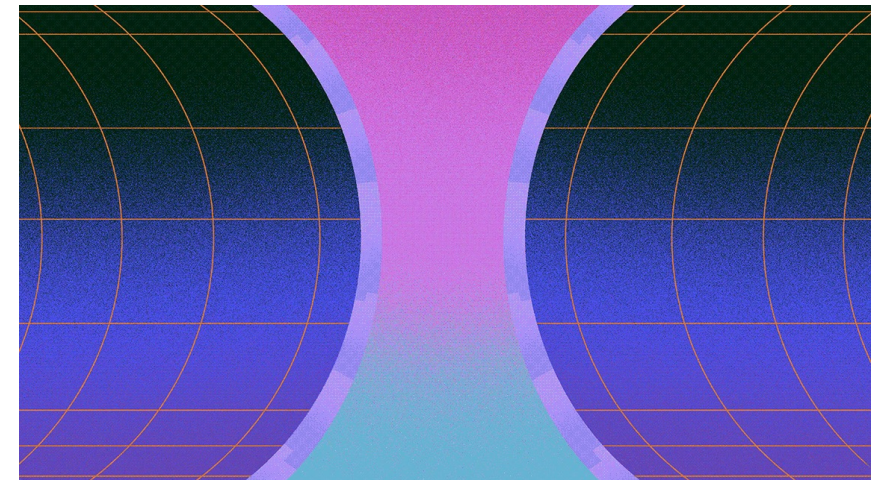
To perform **high precision** measurements of the **luminosity** delivered by the LHC at CMS

- Gives information about the **collision rate**
- Proportionality constant between the collision rate and the **cross section** of a specific process

$$\rightarrow R = \mathcal{L} \cdot \sigma$$

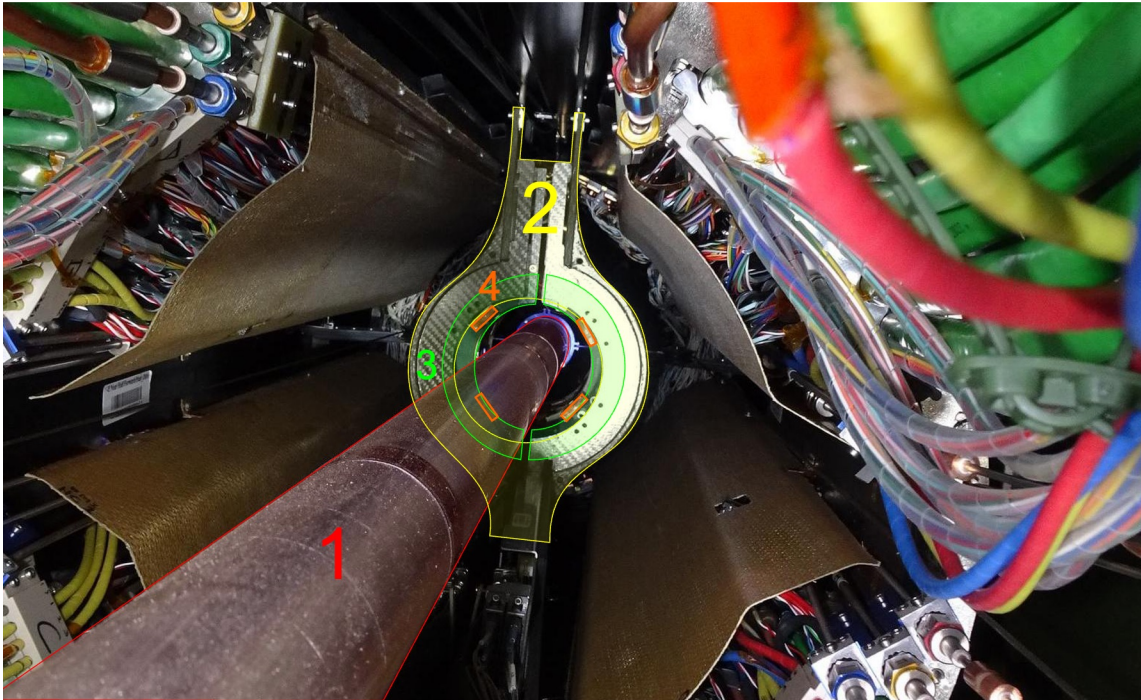
INSTANTANEOUS LUMINOSITY

$$\mathcal{L} = \frac{N_1 N_2 n_b f}{4\pi\sigma_x\sigma_y} [cm^{-2}s^{-1}]$$



What is BCM1F?

The Fast Beam Condition Monitor



- **Luminometer:** detector performing luminosity measurements and monitors
- **Counts hits** from pp collisions and from backgrounds
- Instantaneous luminosity is determined bunch-by-bunch from the **measured rate**

What is BCM1F?

The Fast Beam Condition Monitor

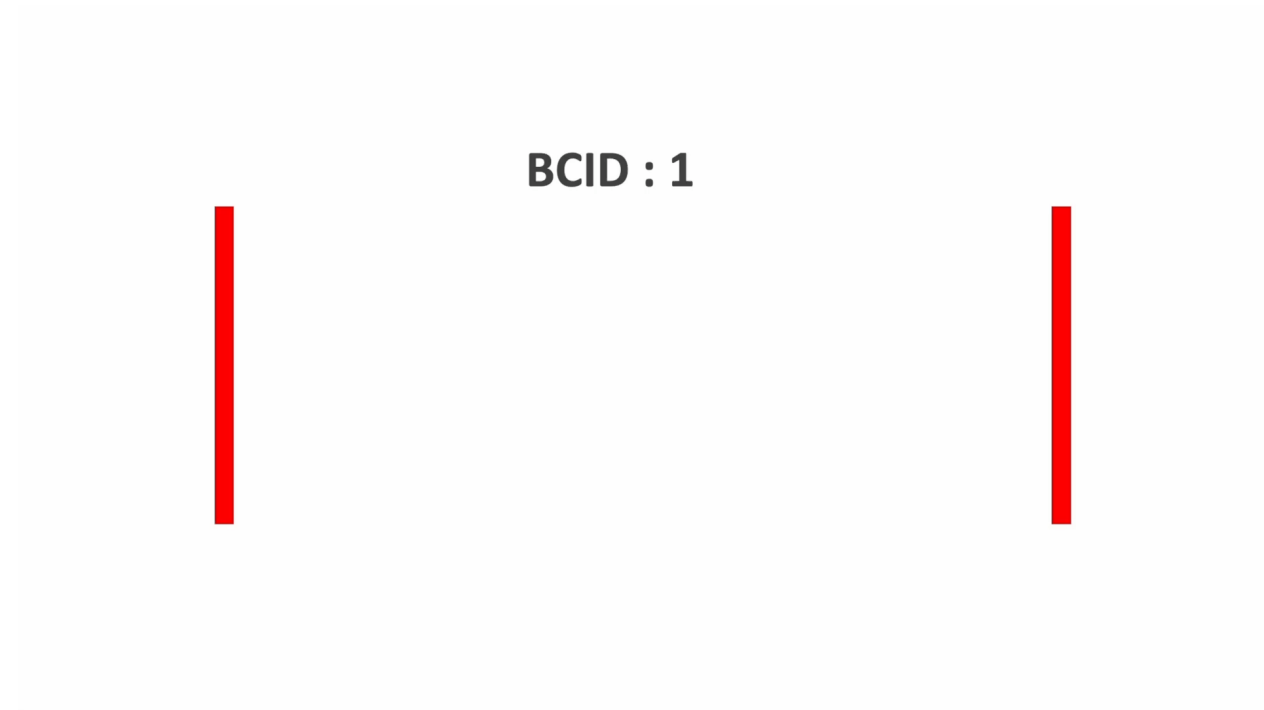
- Consists of **four C-shapes**, two on each side.
- Each C-shape has **six double silicon diodes** as sensors
 - **48 readout channels**
- Arranged in **two rings** around the beam pipe



What is Afterglow aka Albedo ?

One of the most relevant sources of background and noise at the LHC

- **Late signals** formed at a given BCID measured in the subsequent collisions
- Due to **back-scattering** or activation of the **detector material**



What is Afterglow aka Albedo ?

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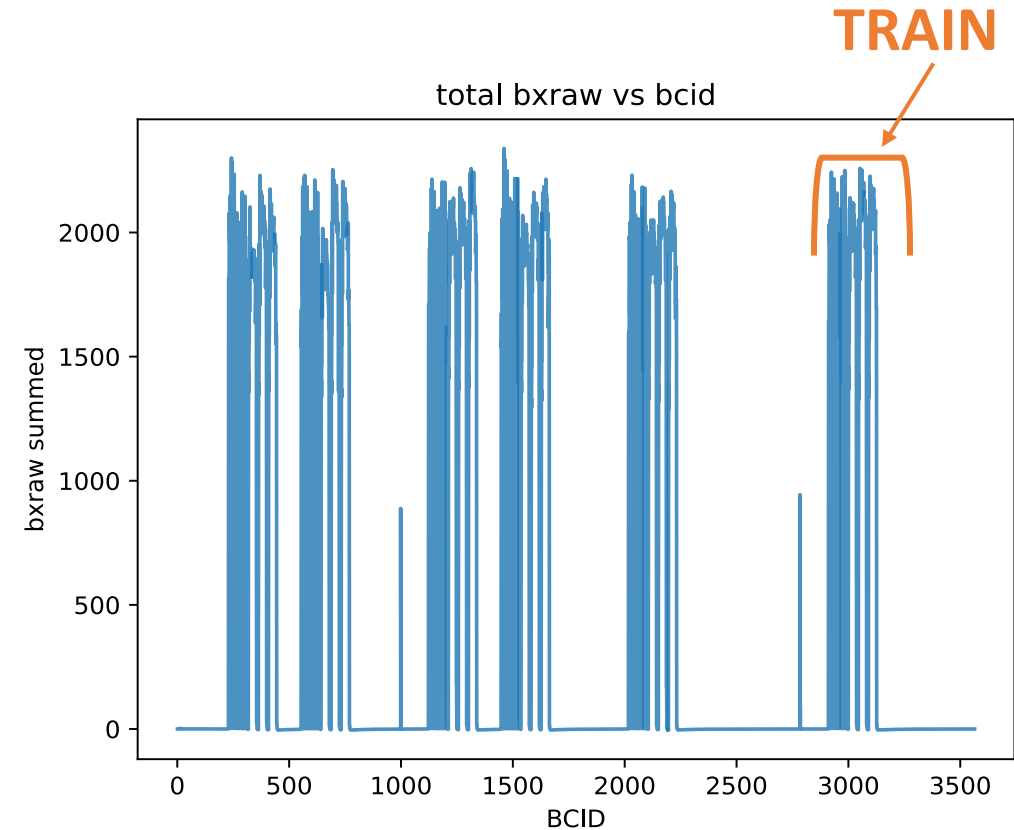
- Additional hits in **subsequent** colliding **bunches**

→ Clearly visible at the end of each train in the rate of the **first empty bunch**

- **Overestimate** of **luminosity** and background for each bunch crossing

- Necessity to **correct** the afterglow background

→ **higher precision** measurements of luminosity



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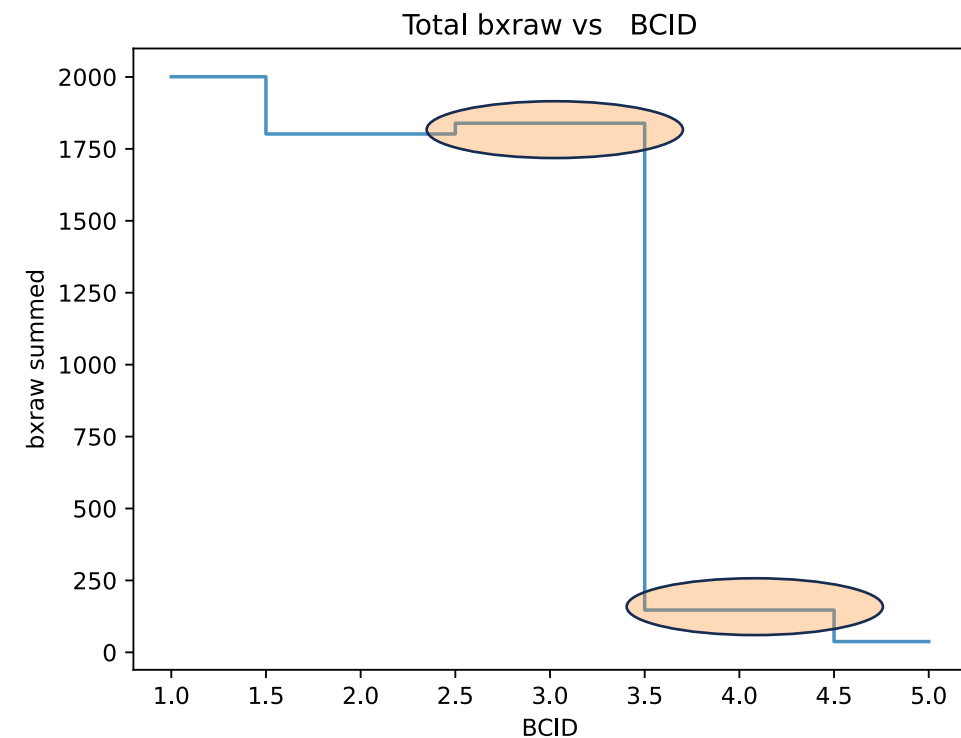
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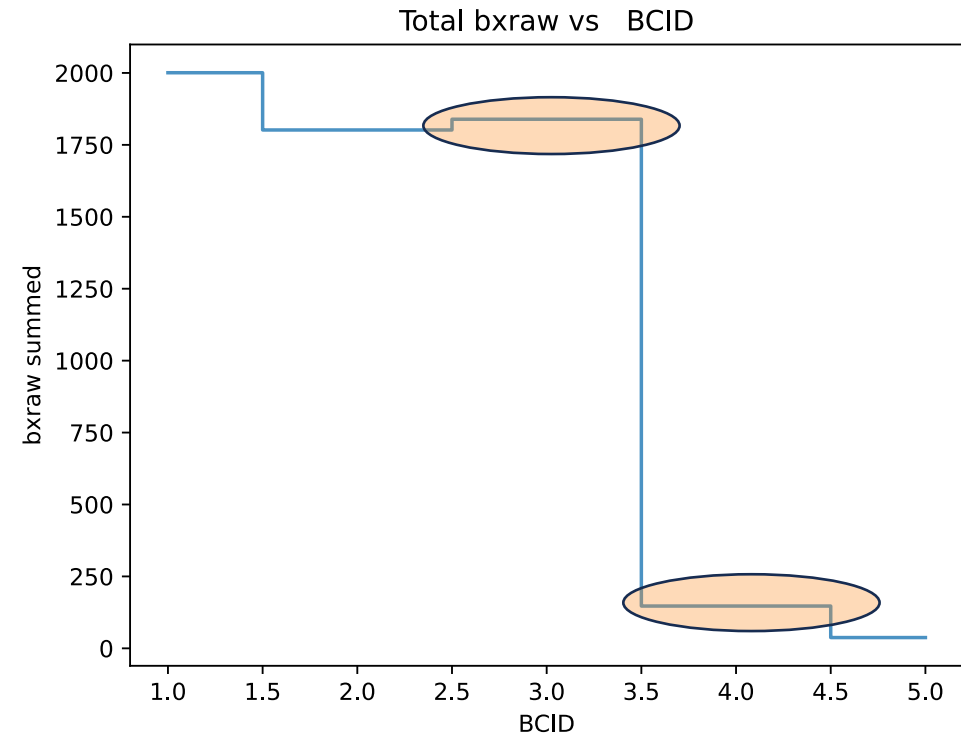


Albedo model

NORMALIZED BUNCH **NEXT BUNCH** **CORRECTION** **FURTHER BUNCHES CORRECTIONS**

albedo_model = [1.0, 0.0224, 0.0023, 0.0007, 0.0003 ...]

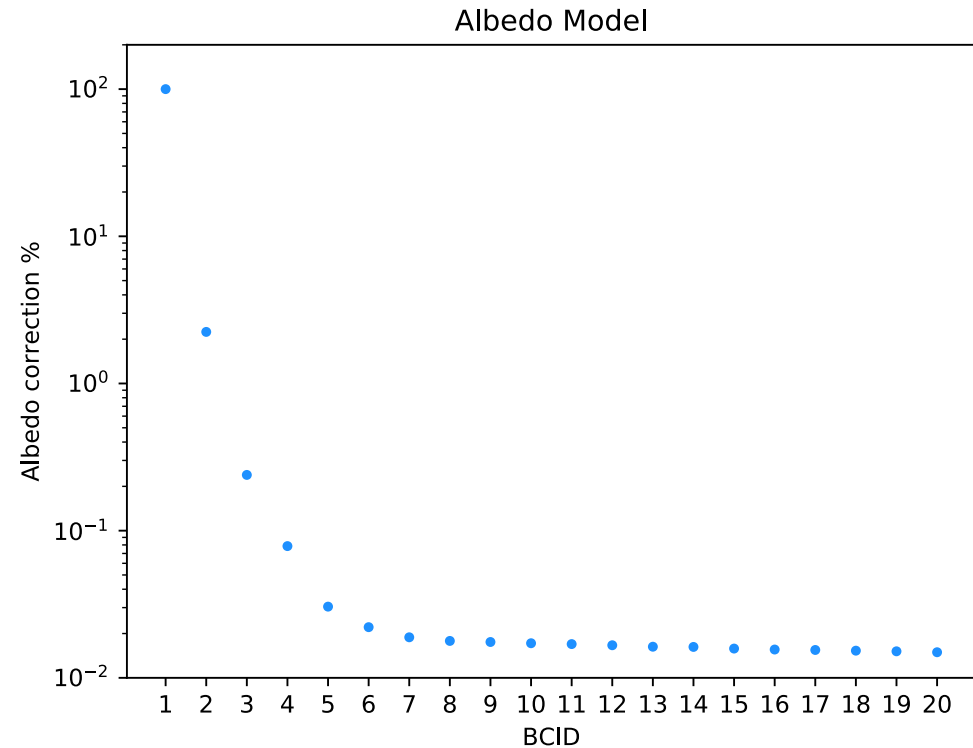
- **One** array, average over all channels
- Obtained from the analysis of a **single bunch fill** in 2022
- **Exponential decrease**
- **Correction terms** : subtract relative rate from previous bunches



Albedo model

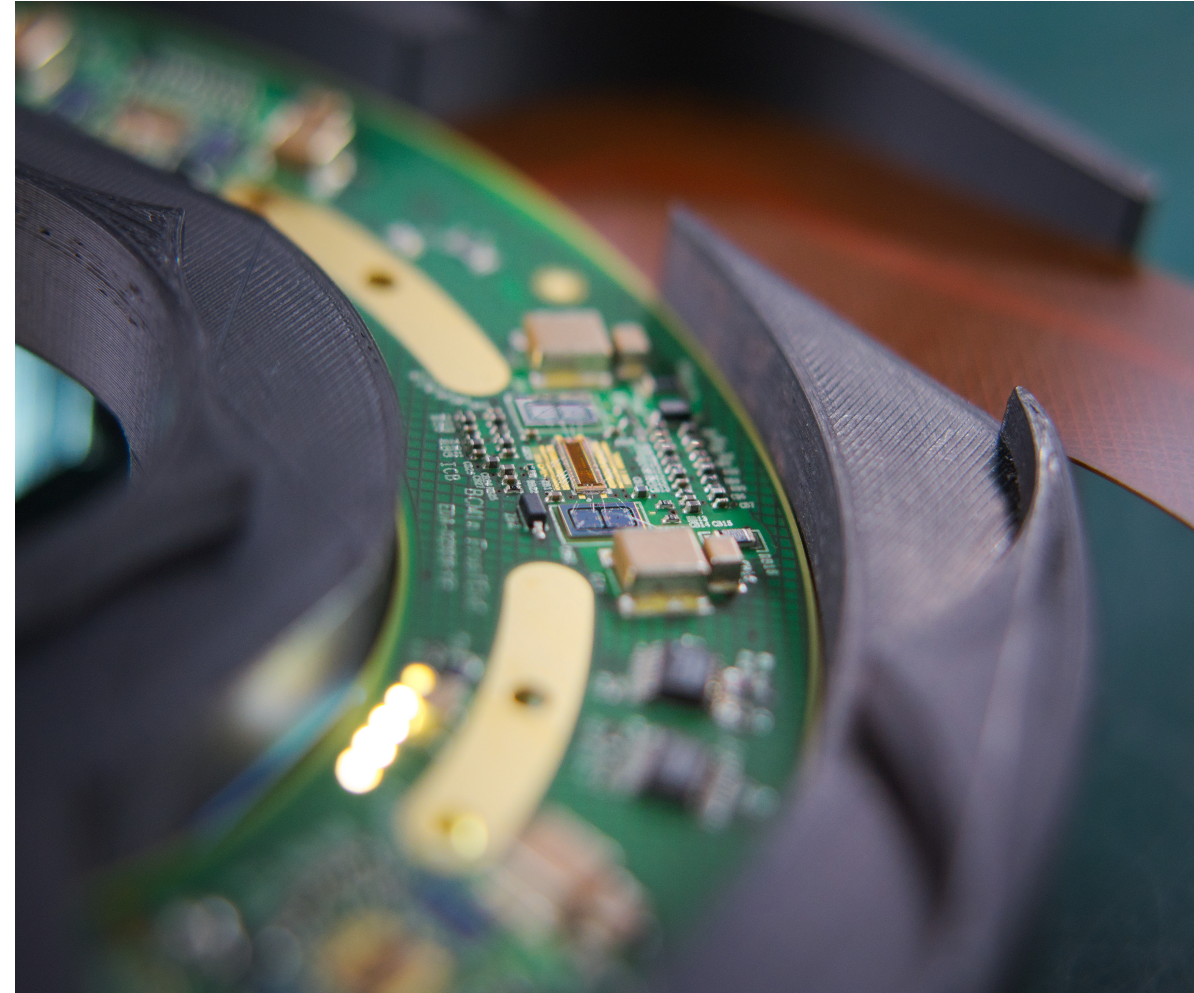
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What has been done for calibration ?

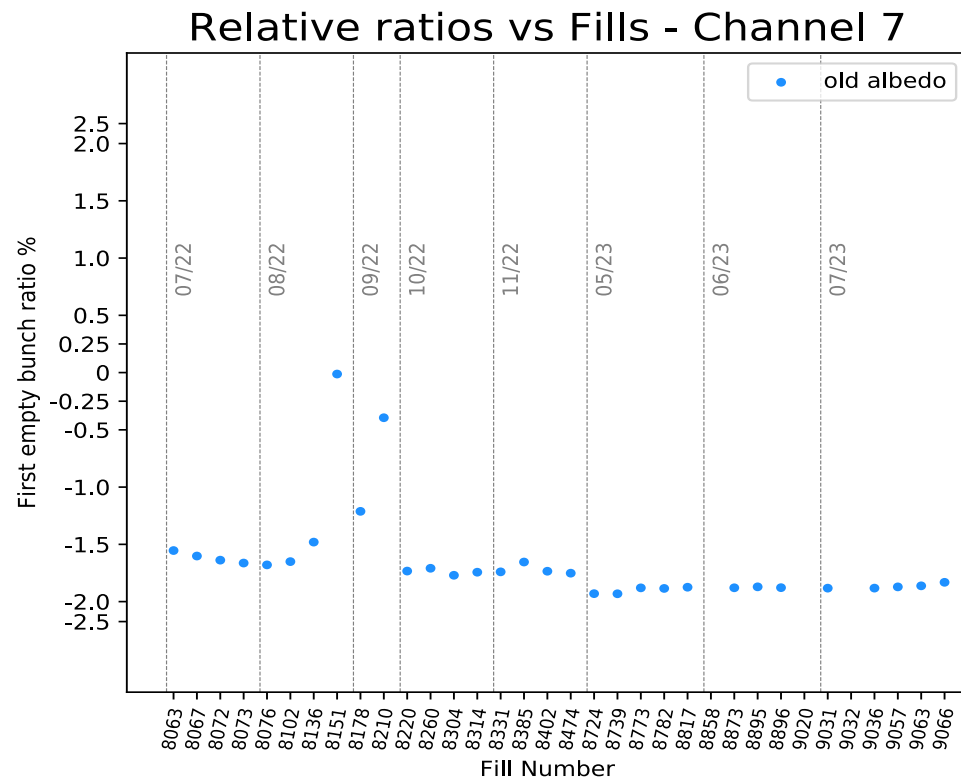
- Apply the current Albedo model
- **Channel-by-channel analysis** :
 - Check **train independence** of the rate in each fill
 - Test **channel dependence**
 - Exclusion of **faulty channels**
 - Measure rates as a function of **time (fills)**
- Albedo model **update**



Channel by channel analysis

Time evolution of rates as a function of fills on a set of *good channels*

- Anomalous albedo **overcorrection** for *good channels*



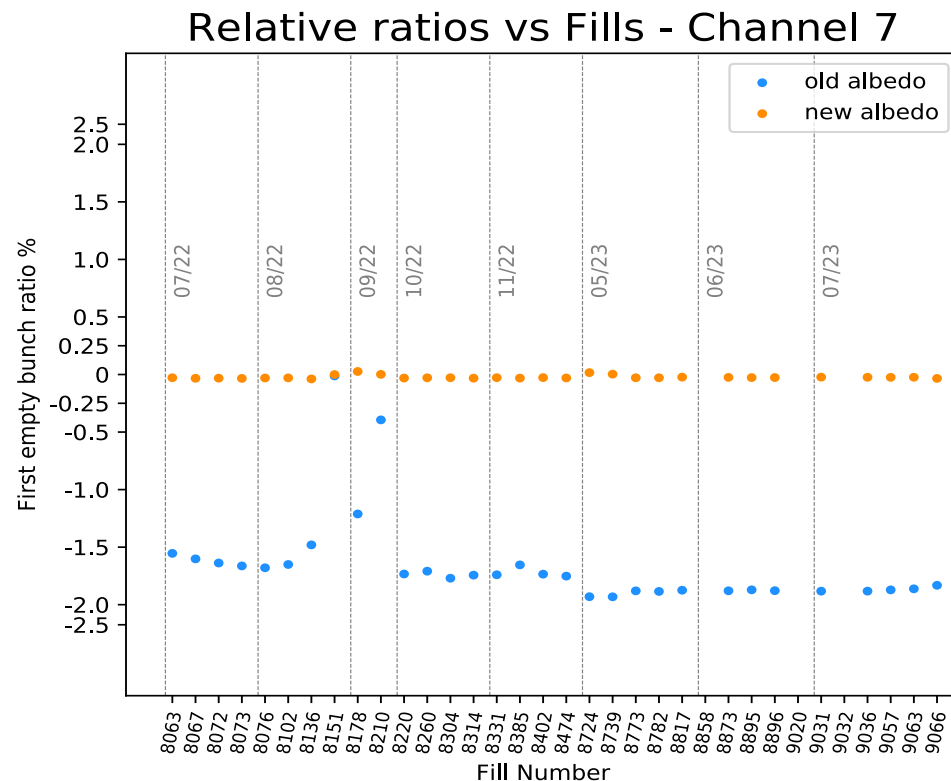
Why?

- The Albedo model obtained on rates from **all 48 channels**
 - **overestimate** for good channels
 - **underestimate** for faulty channels

Channel by channel analysis

Channel customized Albedo correction for offline analysis

- Anomalous albedo **overcorrection** for *good channels*



- **Recalculate** first term individually for each channel :

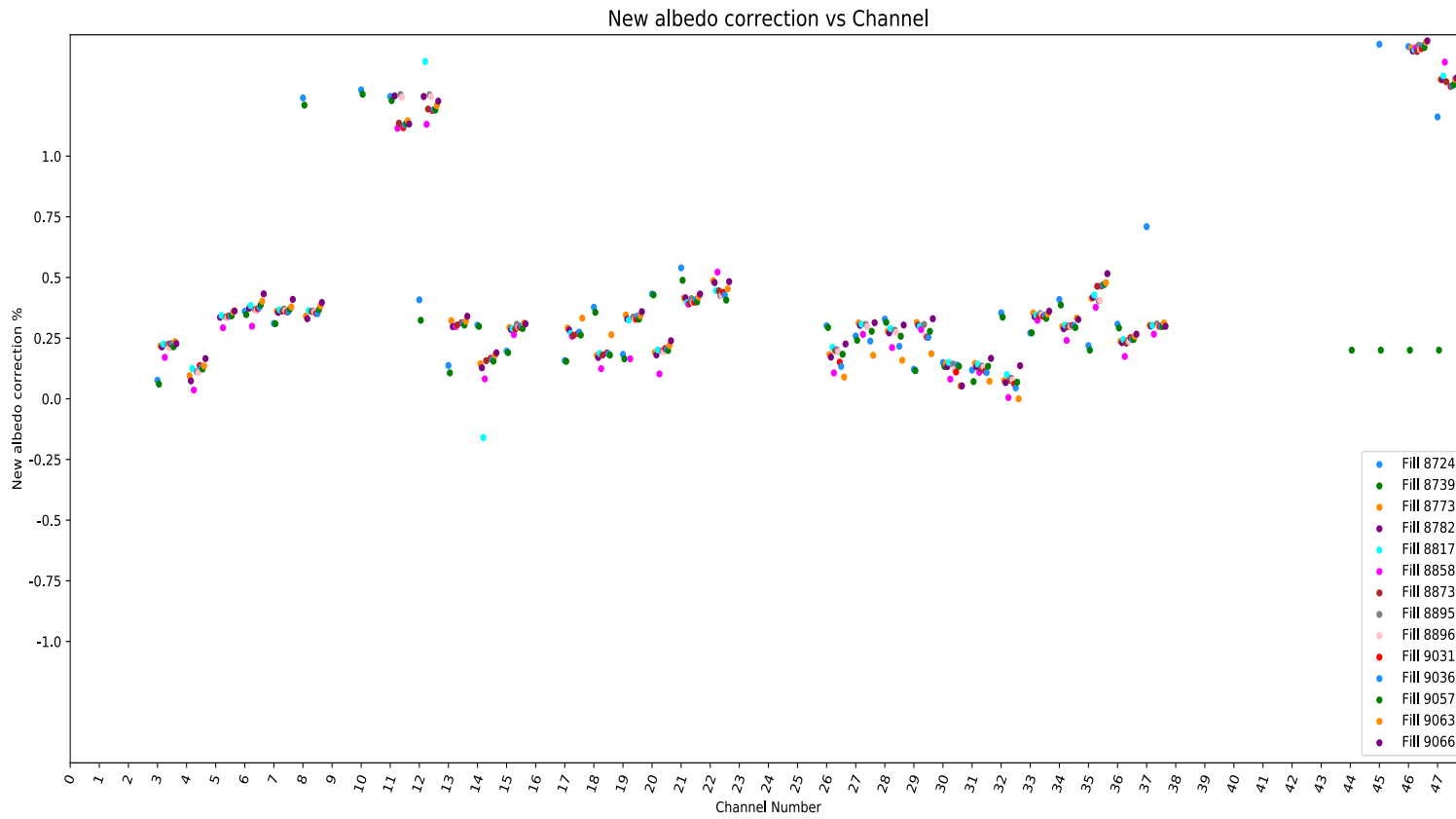
$$\text{old_albedo} = 0.022$$

$$\text{new_albedo} = \text{relative rate} + \text{old_albedo}$$

- Shifts the relative rates towards zero

Albedo model update

New Albedo correction for the online analysis

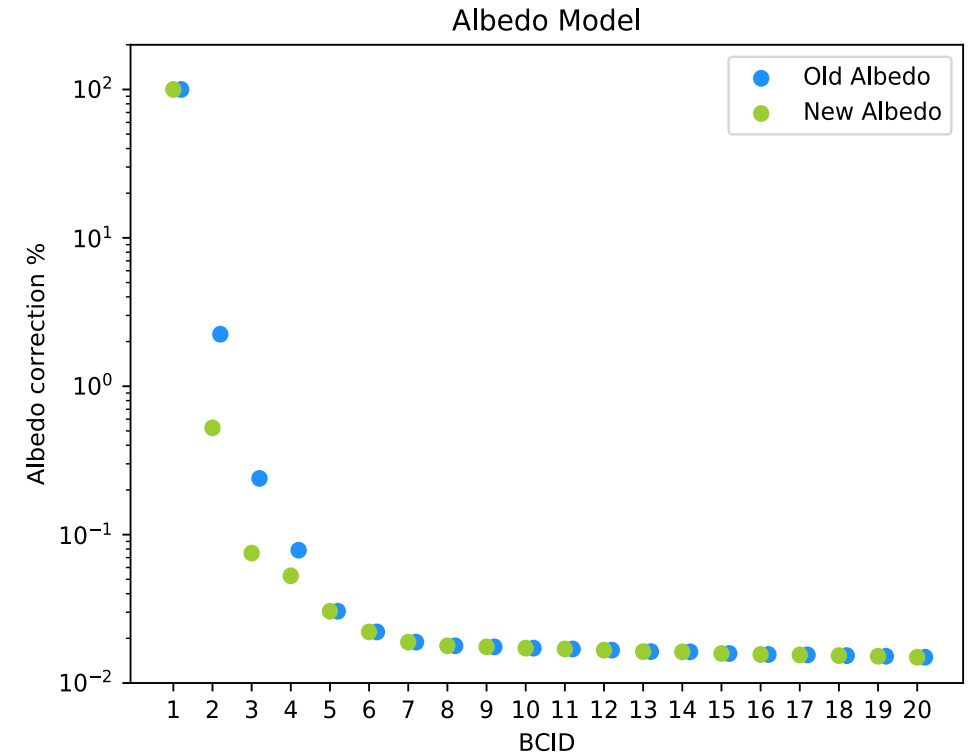


- New Albedo corrections observed to be **channel dependent**, but **fill independent**
- Select channels with **similar Albedo corrections**
- Mask out dissimilar channels and average over the remaining 26

Albedo model update

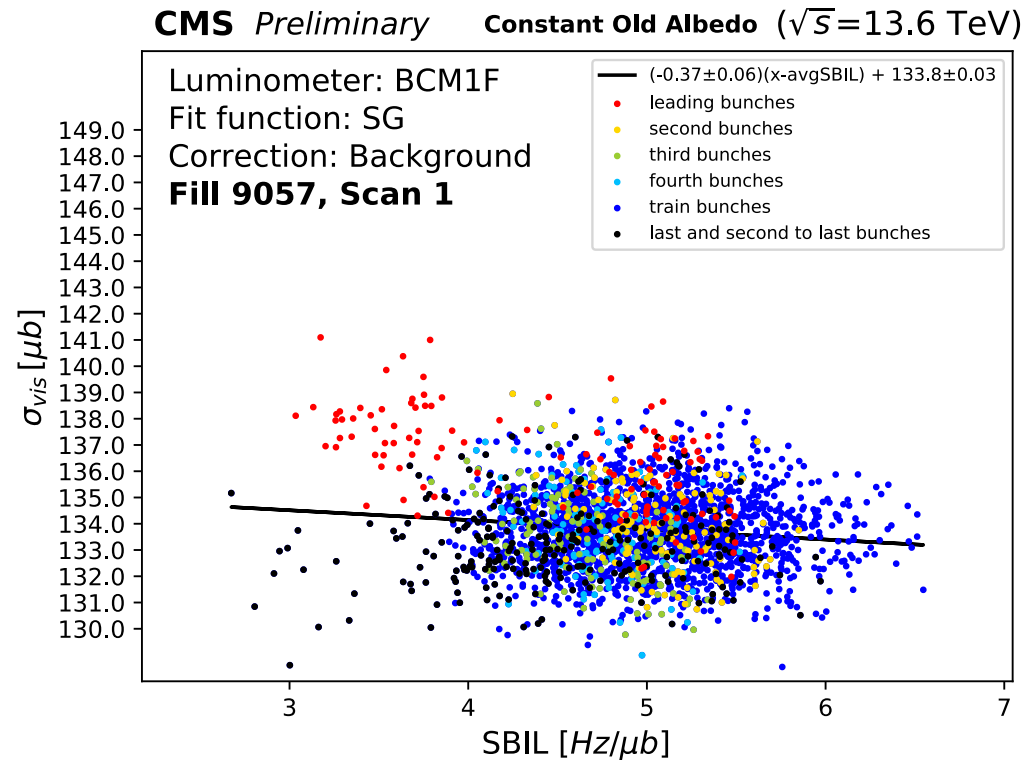
New updated constant array for the online analysis

- Refine the procedure for the model update:
 - Consider **further correction terms**
 - Reproduce a **physical (exponential) behaviour**



Emittance scan analysis

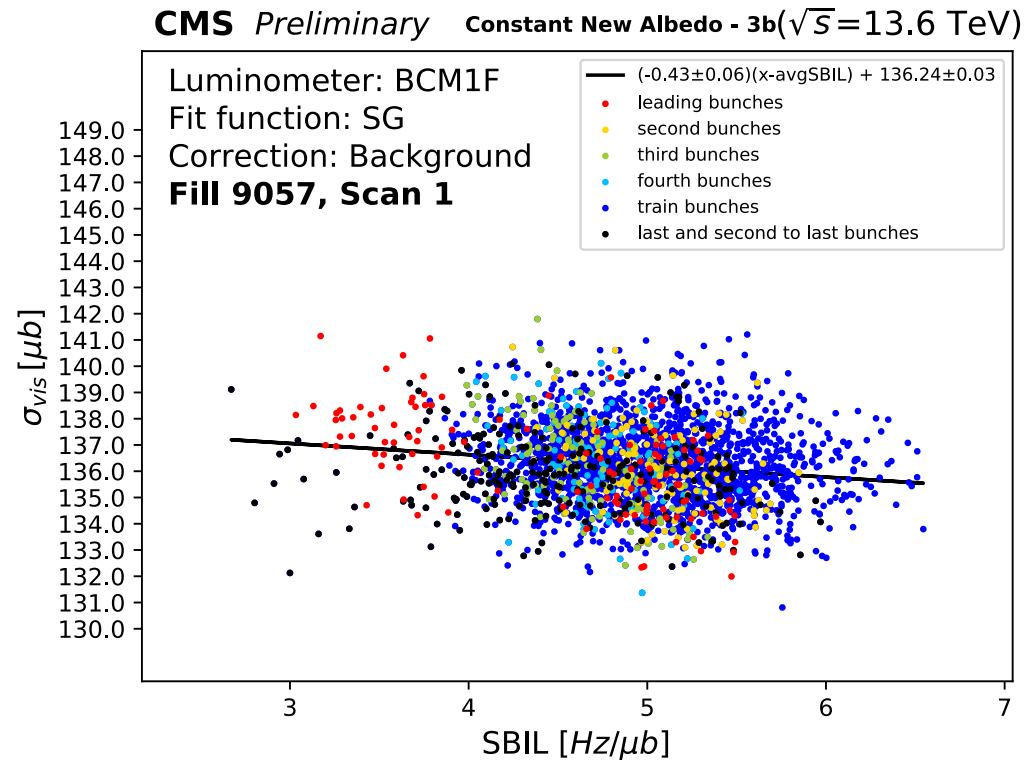
Comparison among the two Albedo models



- **Leading bunch** is almost **not affected** by Albedo
 - **Subsequent bunches** differ significantly when the **new model** is applied
- **improved background correction**

Emittance scan analysis

Comparison among the two Albedo models



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THANK YOU
FOR YOUR LUMINOUS
ATTENTION.

