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# TRIGGER DEVELOPMENT FOR LUMINOSITY MEASUREMENT AT LHCb

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This quantity relates the cross-section for a given physical process to the number of times it is observed by detectors

Luminosity can be written in terms of the beam parameters and geometries



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$$\mathcal{L} = \frac{N_1 N_2 f N_b}{2\pi \sqrt{\sigma_{1x}^2 + \sigma_{2x}^2} \sqrt{\sigma_{1y}^2 + \sigma_{2y}^2}}$$



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Key in the measurement of absolute cross-section

## VDM (VAN DER MEER SCAN)

- It relies on move the beams in transverse coordinates to scan the overlap integral
- Cross section depends on the average number of interactions  $\mu$

$$\sigma = \int \frac{\mu(\Delta x, \Delta y)}{N_1 N_2} d\Delta x d\Delta y$$

## BGI (BEAM GAS IMAGING)

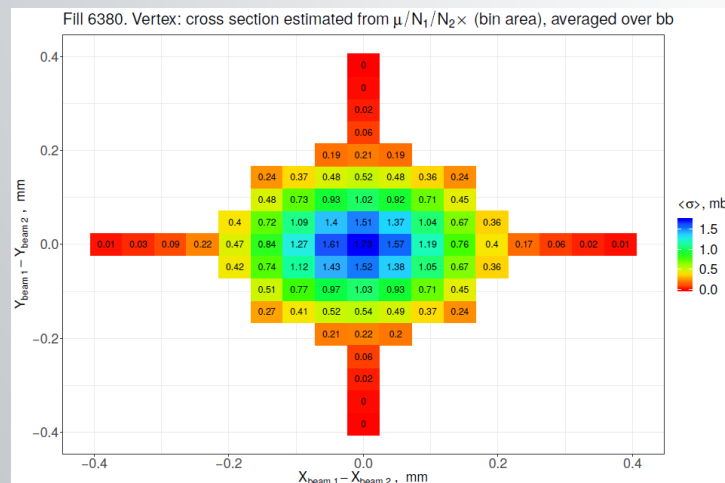
- Determination of overlap integral after direct measurement of beam profiles
- It relies on the precise vertexing (primary vertex) capability of the LHCb experiment

$$\sigma = \int \int \int \int_{-\infty}^{\infty} \rho_1(x, y) \rho_{1z}(z - z_0) \rho_2(x, y) \rho_{2z}(z + z_0) dx dy dz dz_0$$

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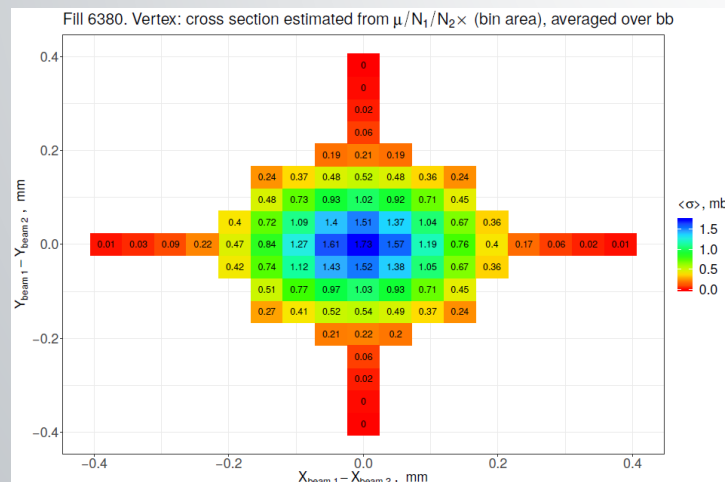
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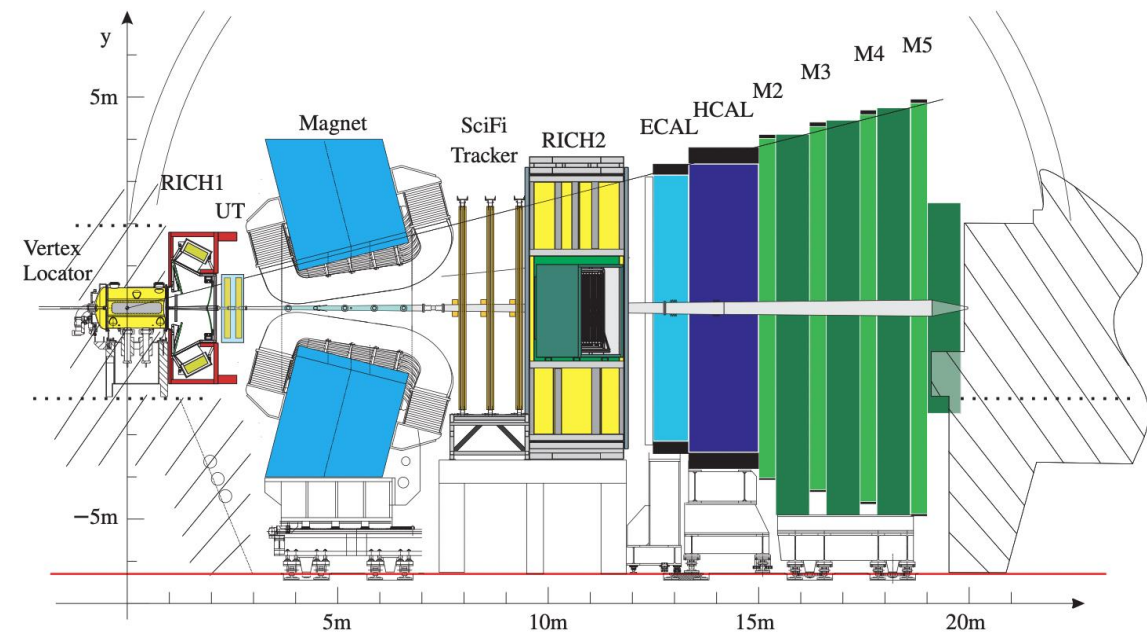
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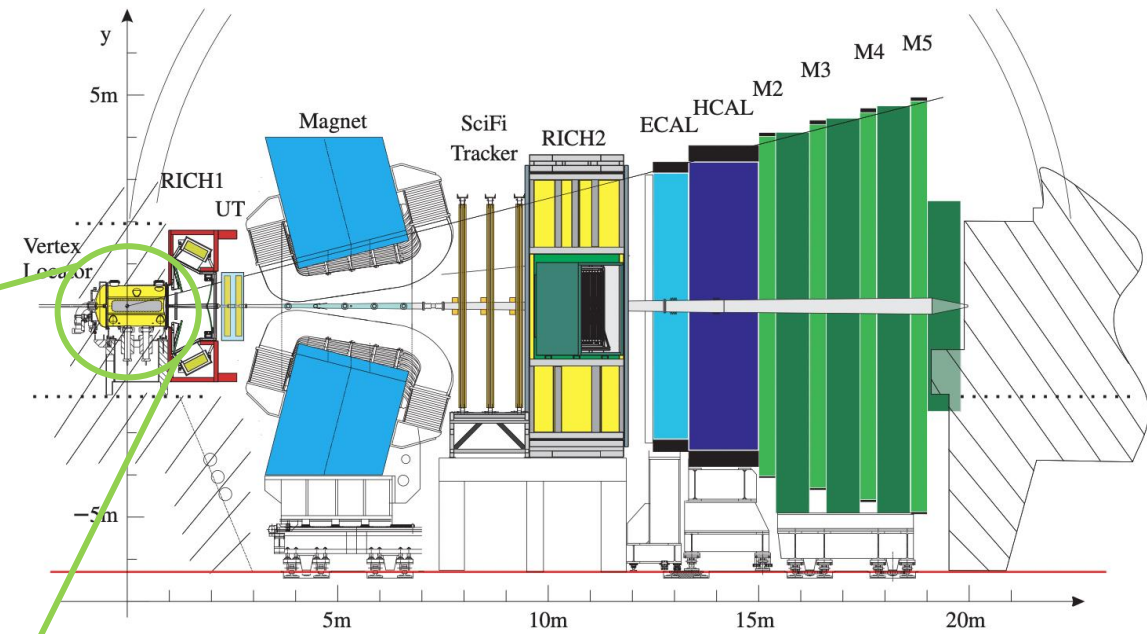


# VELO



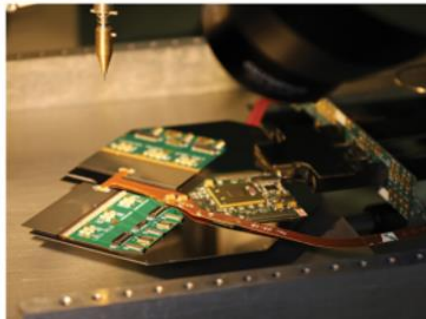
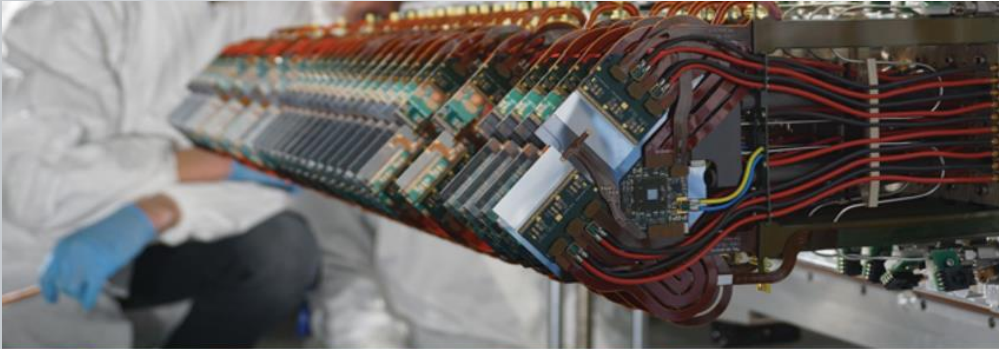
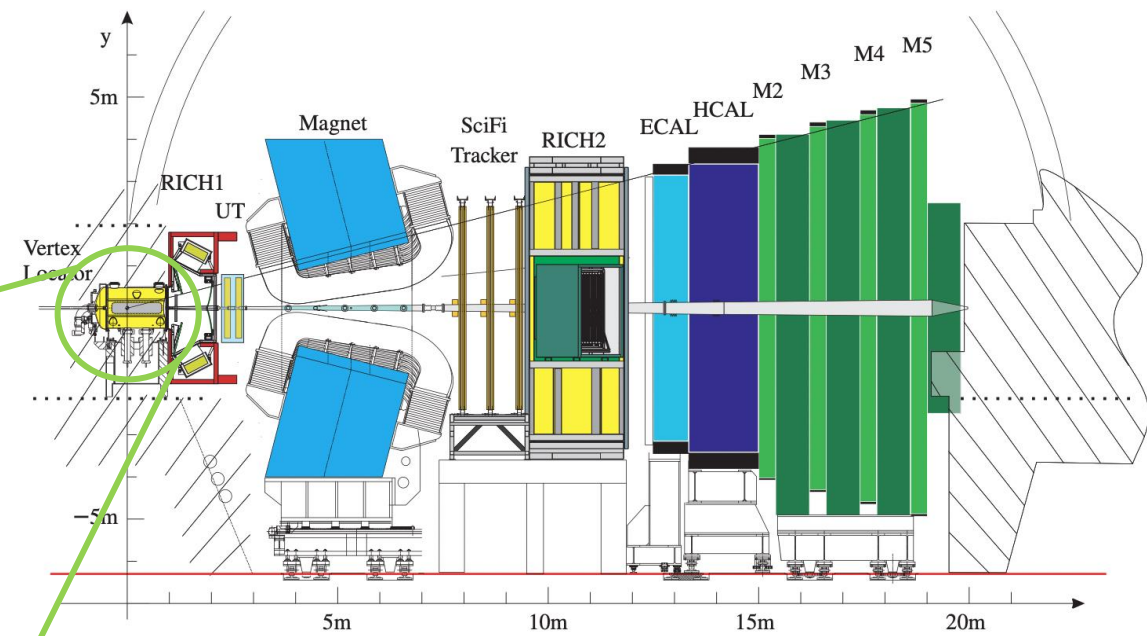
- VErteX LOcator detector
- Surrounds the collision region to reconstruct primary vertices
- The whole detector contains 41 million 55 by 55  $\mu\text{m}$  silicon pixels
- Vacuum of  $\sim 10^{-6}$  mbar, beam pipe vacuum of  $\sim 10^{-9}$  mbar

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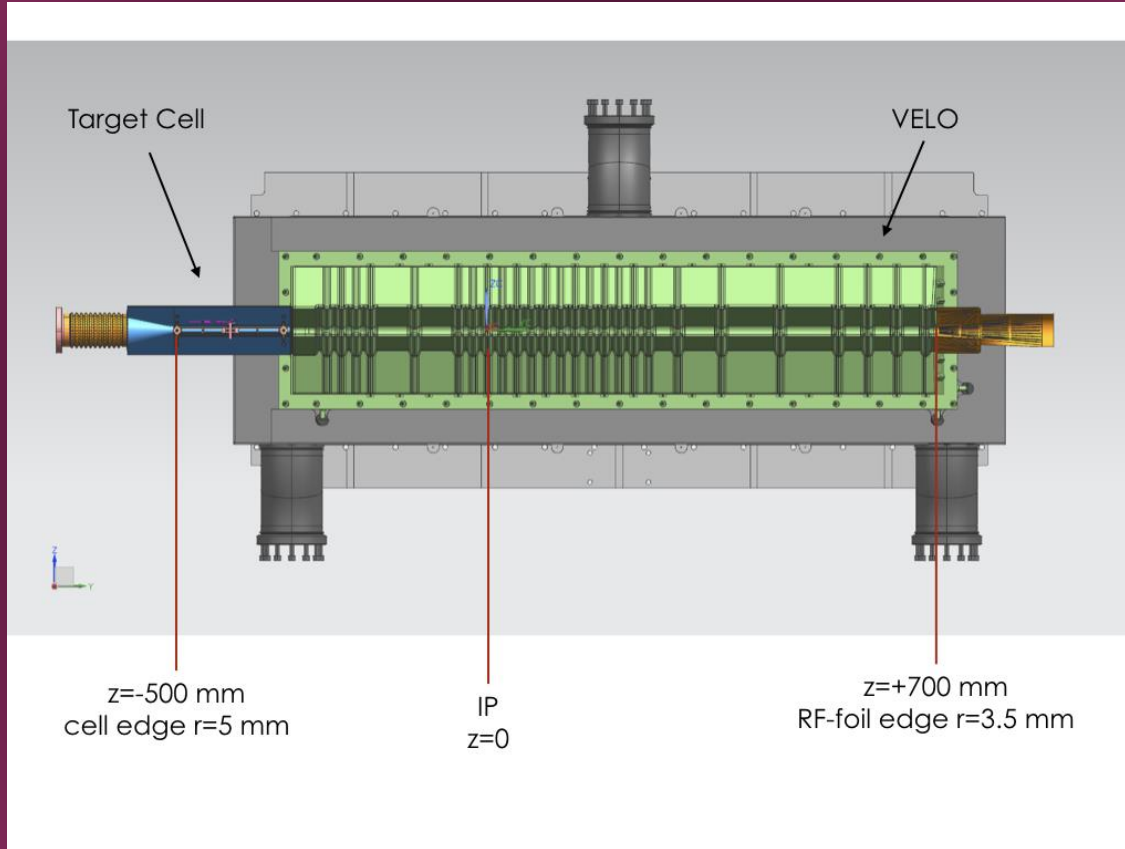
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# SMOG<sub>2</sub>



- System for Measurement the Overlap with Gas
- It inject a noble gas with a low rate into the target cell
- Increase the pressure by two orders of magnitude (from  $\sim 10^{-9}$  to  $\sim 10^{-7}$  mbar)





# BGI CONSTRAINTS

- Gas injection through SMOG2 system, to produce beam-gas events with a veto in the interaction region
- Radius < 3 mm

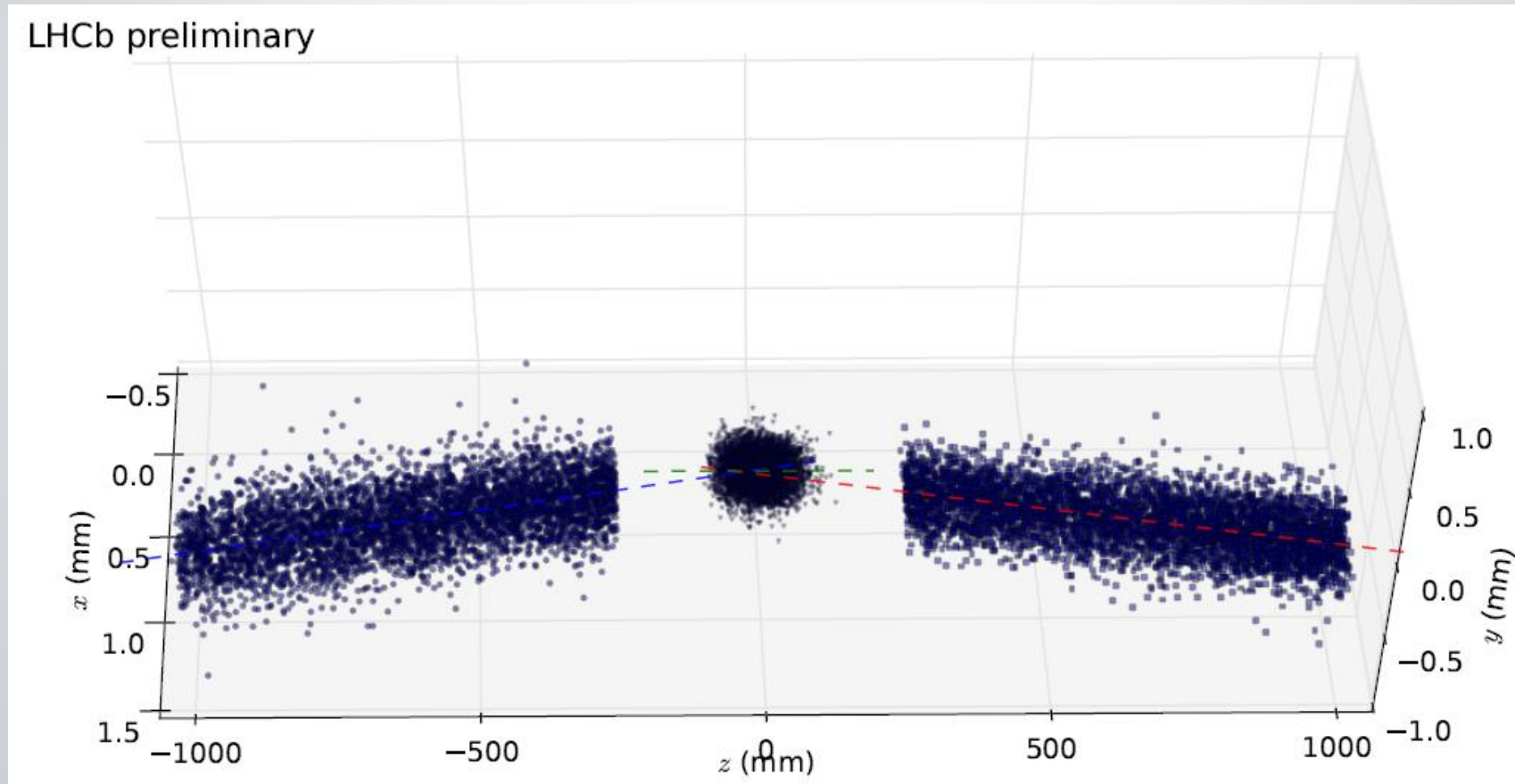
Selection over three regions:

- "Up" for  $z < -250$  mm
- "IR" for  $-250 \text{ mm} < z < 250$  mm
- "Down" for  $z > 250$  mm

Minimum track selection

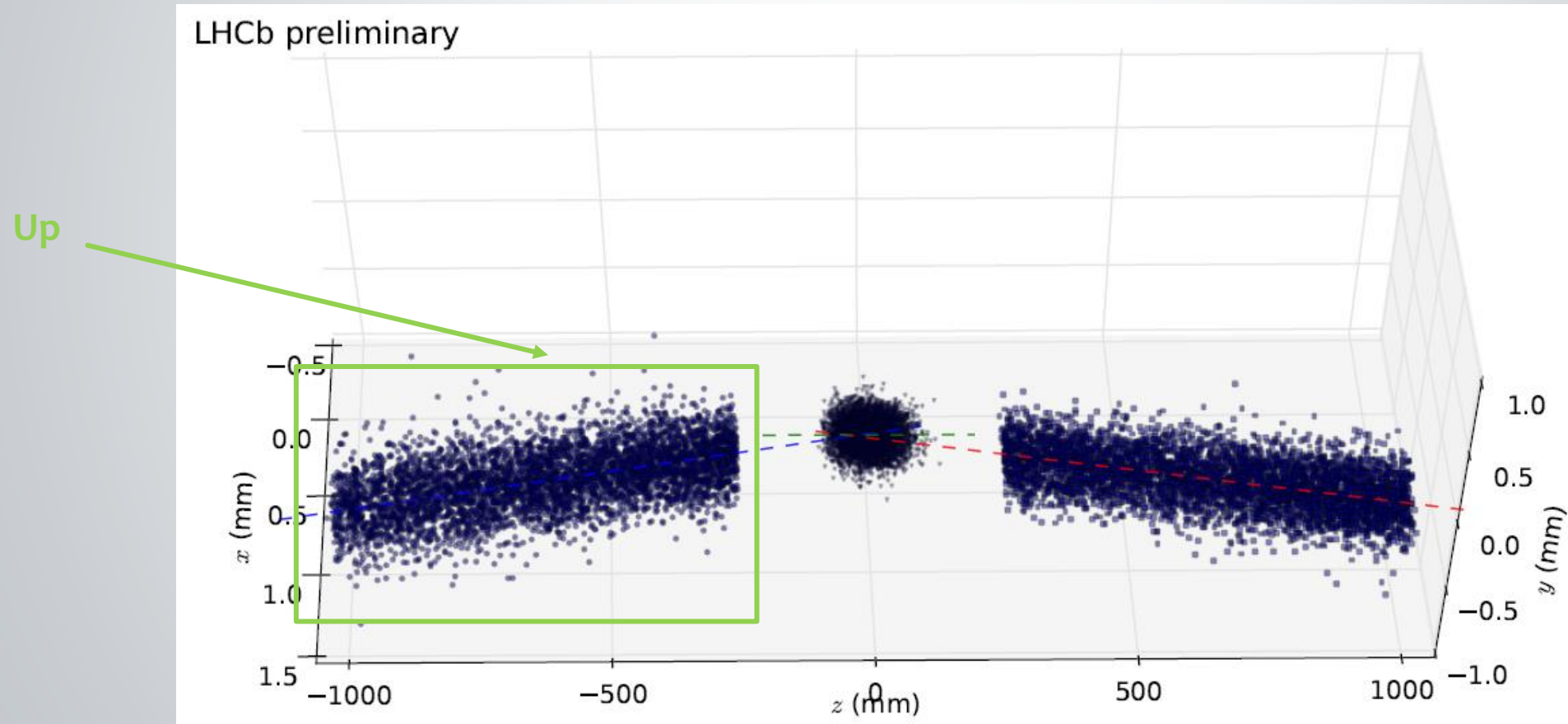
- 10 tracks for "Up" and "Down"
- 28 tracks for "IR"

# THREE-DIMENSIONAL PRIMARY VERTEX DISTRIBUTION



Georges Coombs, CERN Thesis 2021

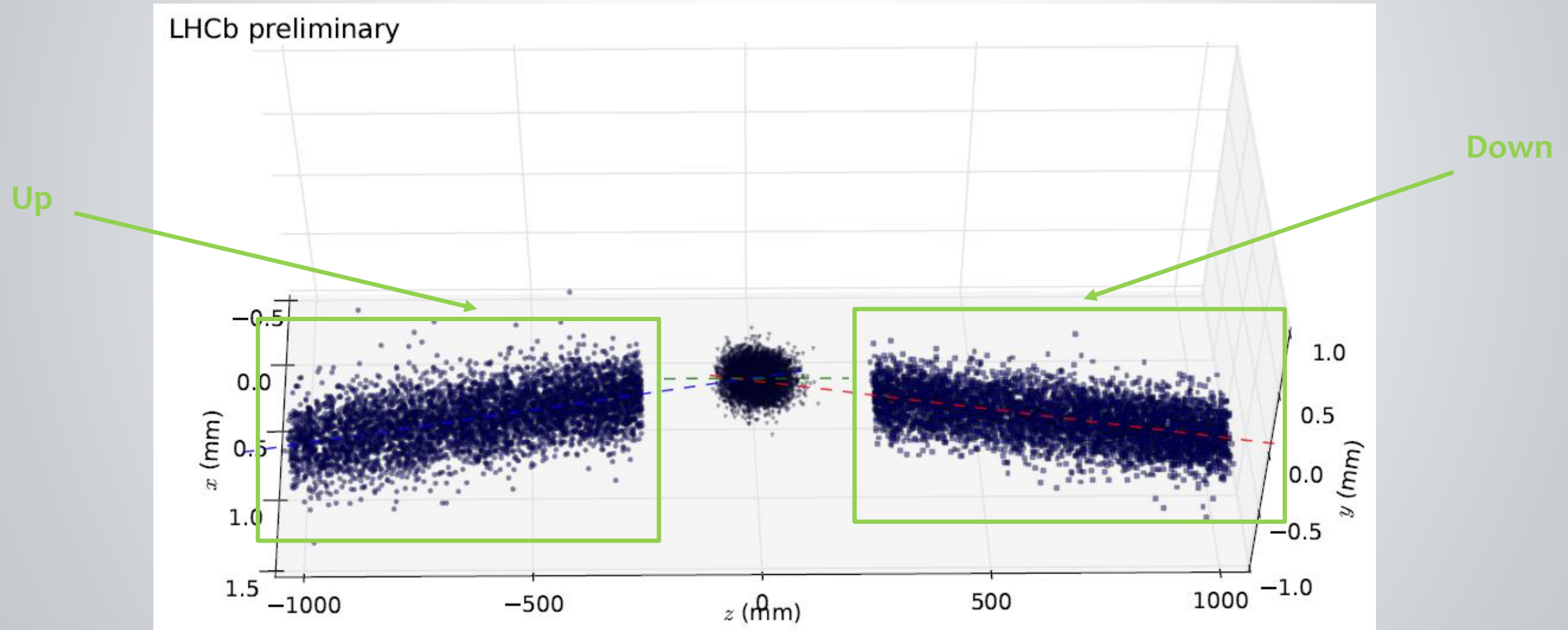
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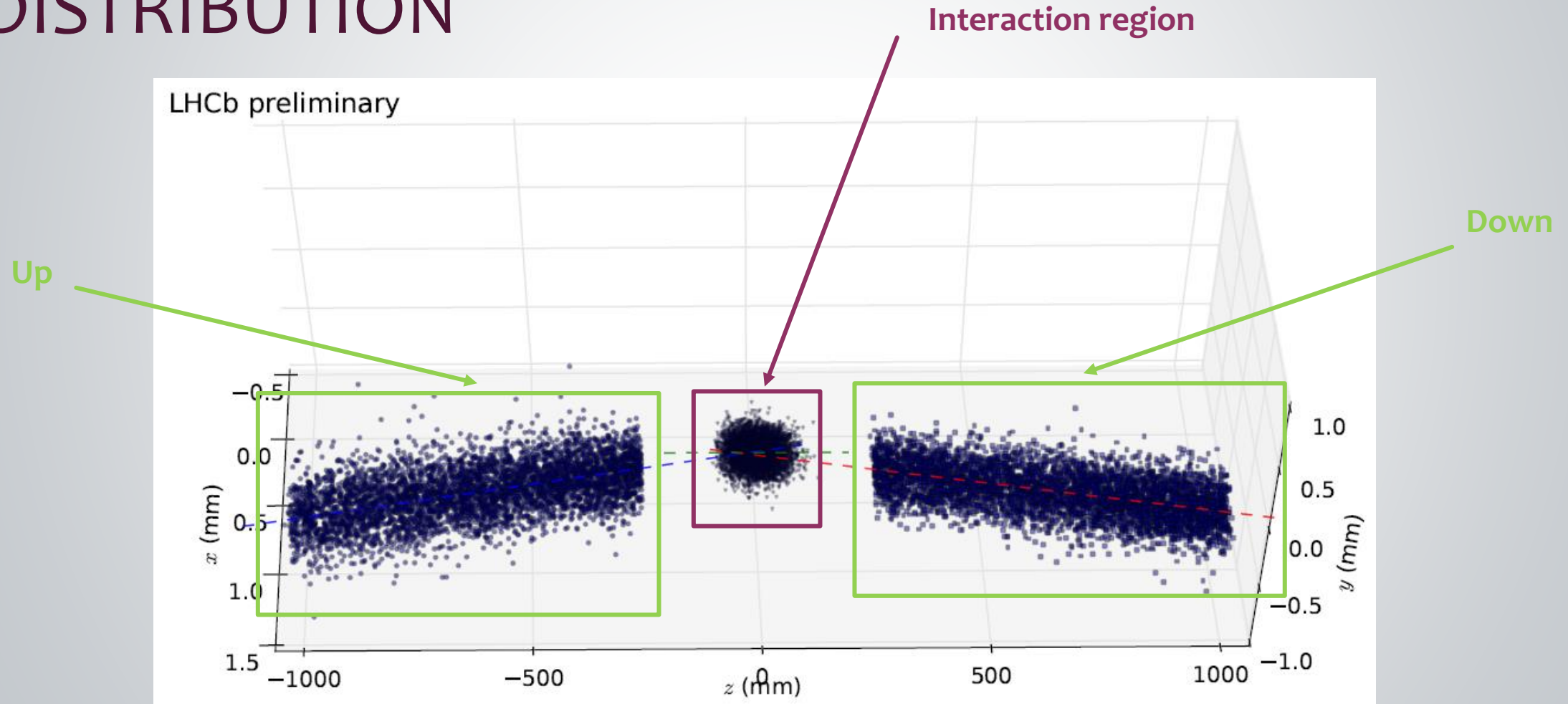


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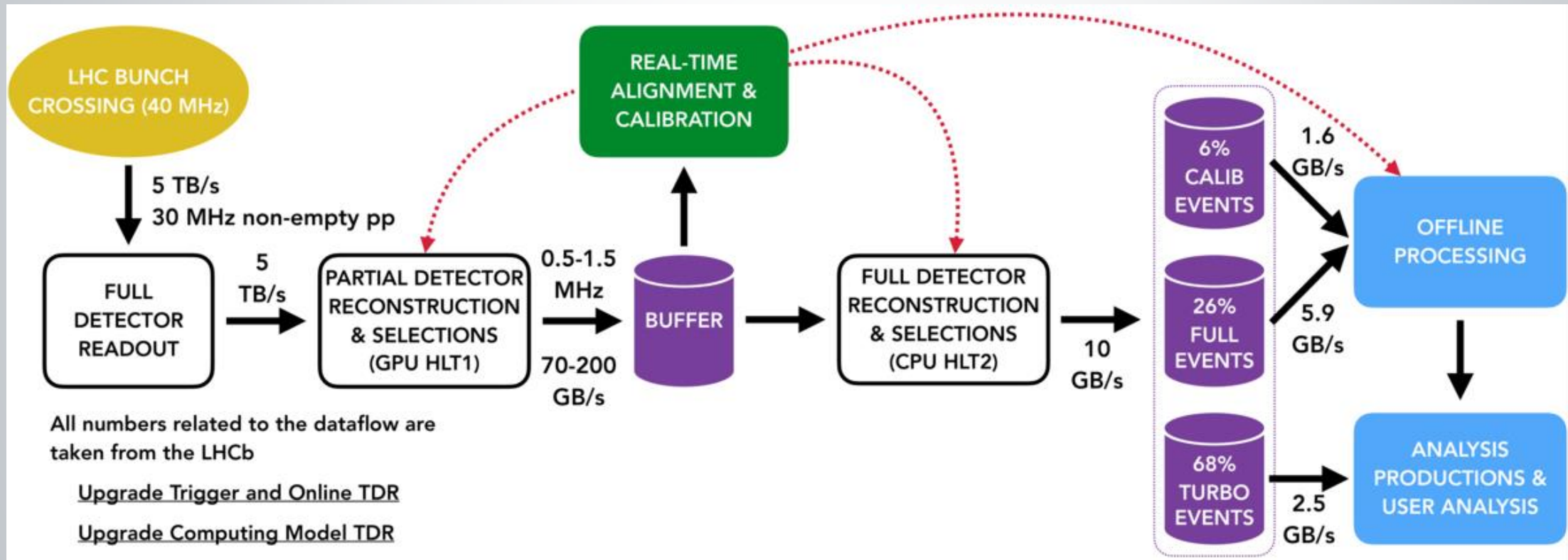
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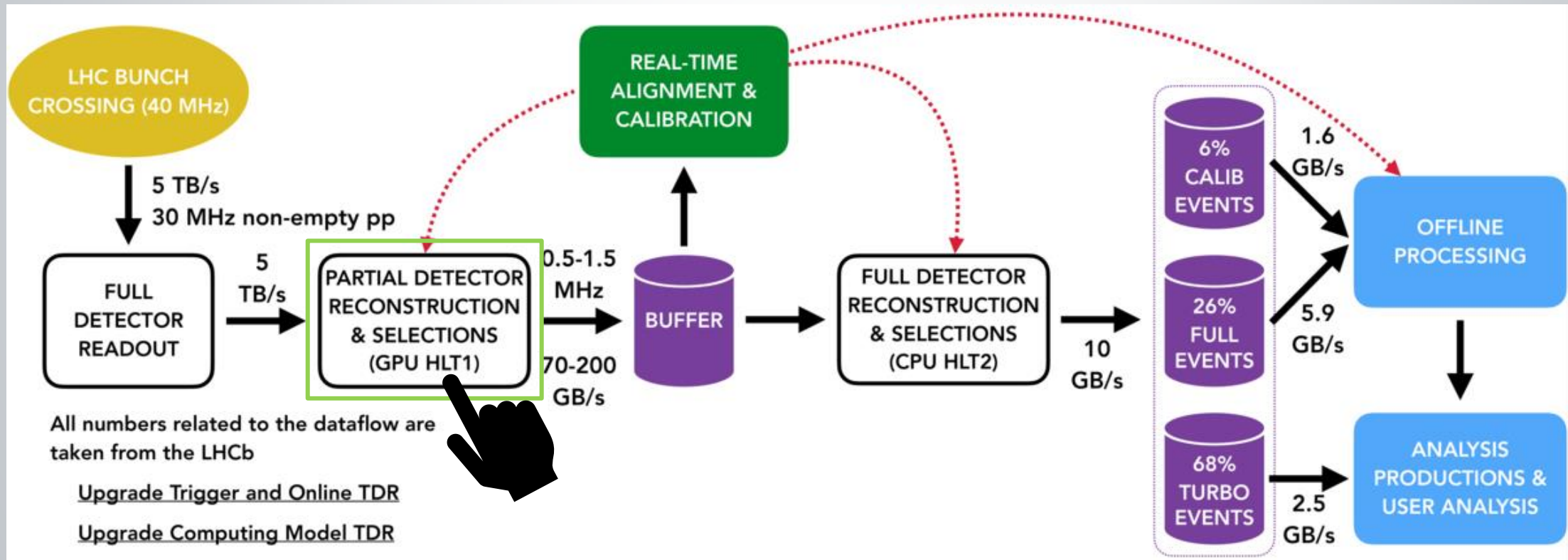


# DATA FLOW IN LHCb





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# ALLEN PROJECT

- LHCb High Level Trigger 1 (HLT1) application
- Filtering 30 million collisions per second to around 1-2 MHz
- Runs on Graphical Processing Units (GPUs)
- Goal: **Development of trigger lines**





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# TEST OVER SIMULATED SAMPLE WITH HELIUM

Beam one – Gas collisions

Trigger line 	Event selection 
Up region	1035/5000 (20%)
Interaction region	0/5000
Down region	0/5000

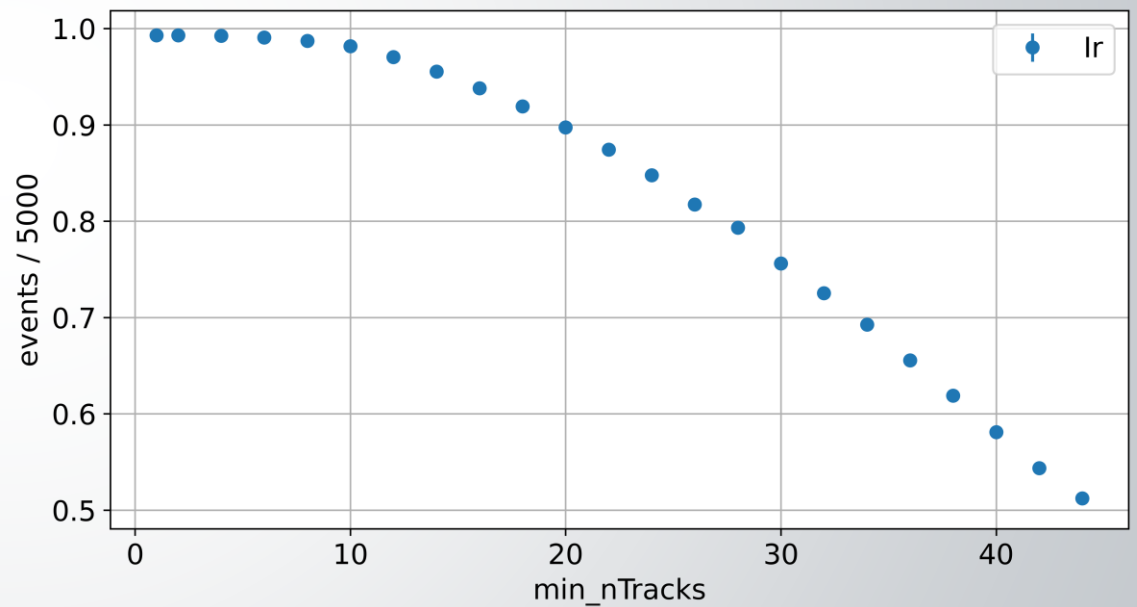
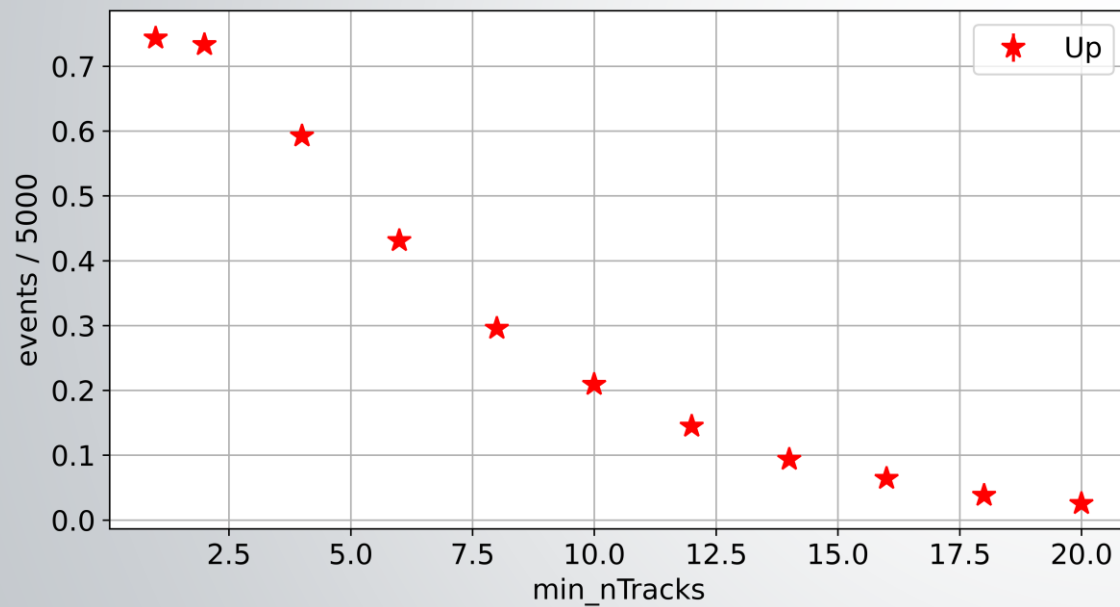
Beam – Beam and Beam one – Gas collisions

Trigger line 	Event selection 
Up region	2055/10000 (20%)
Interaction region	7931/10000 (79%)
Down region	3/10000 (0.03%)

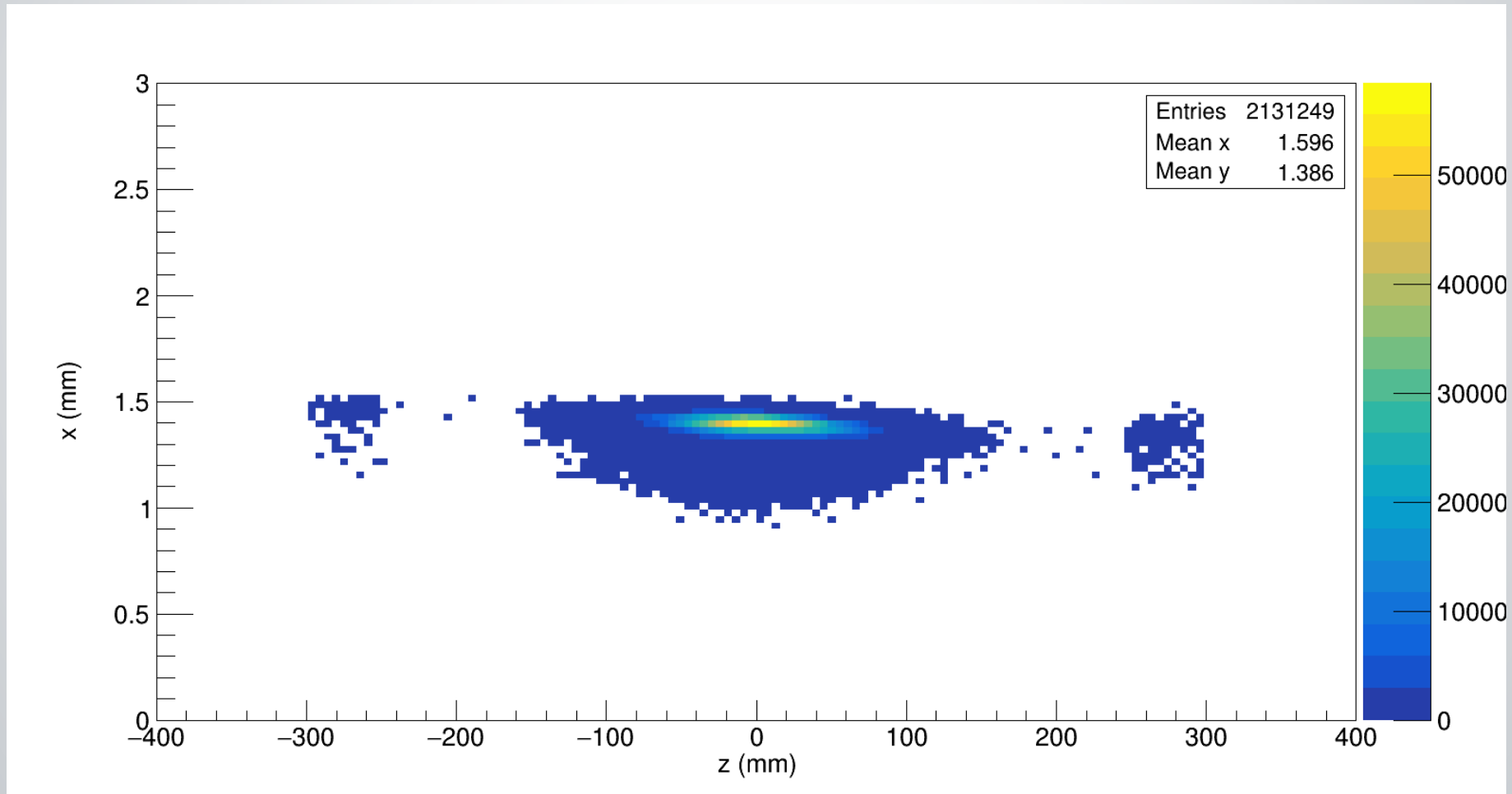


# TRACK MULTIPLICITY

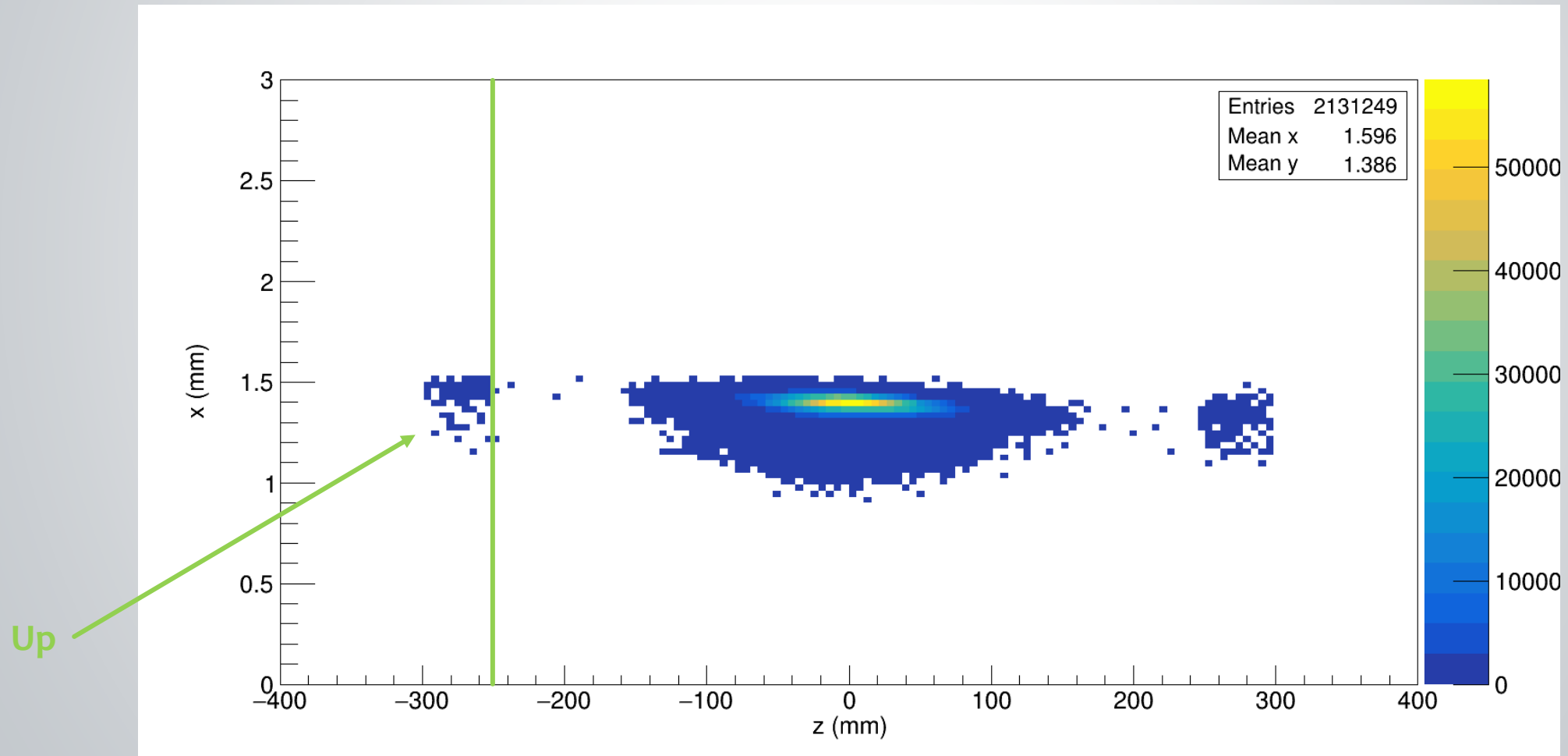
Event selection vs min\_nTracks



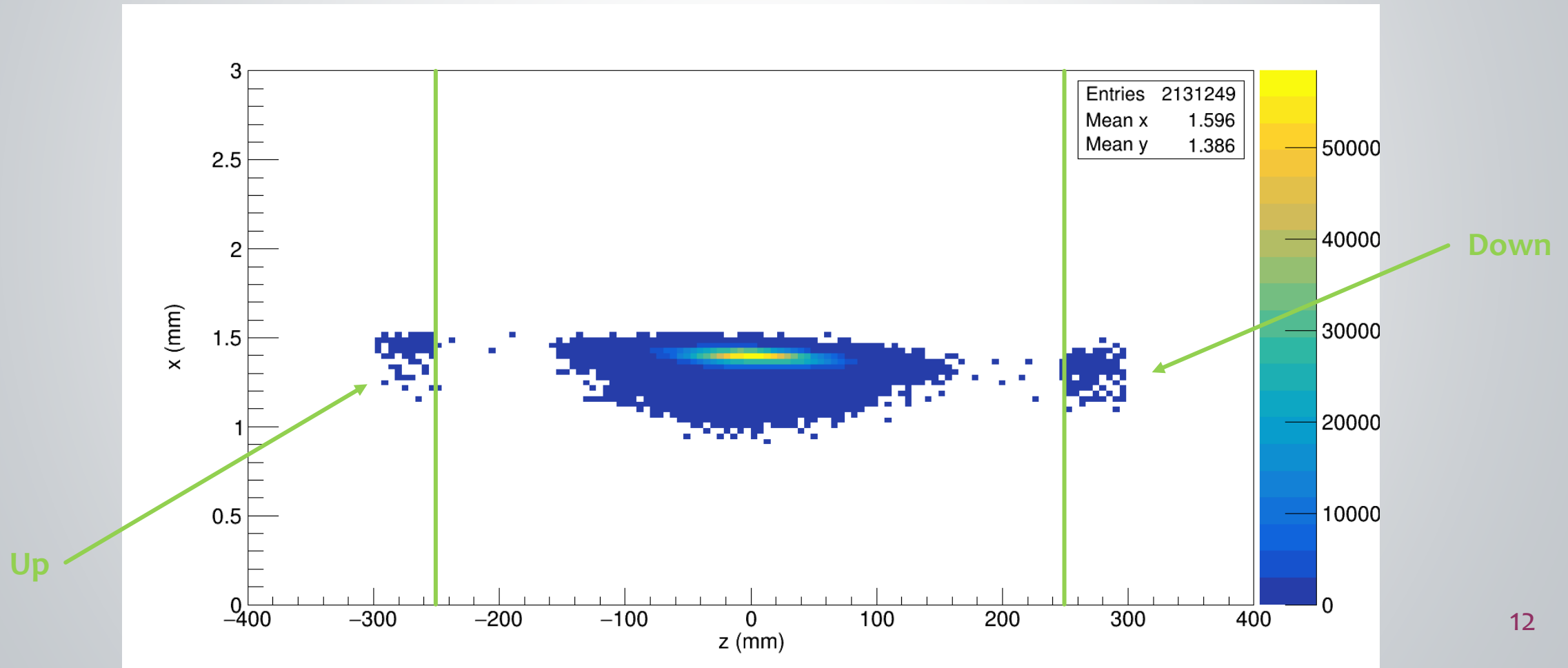
# TEST OVER CURRENT DATA



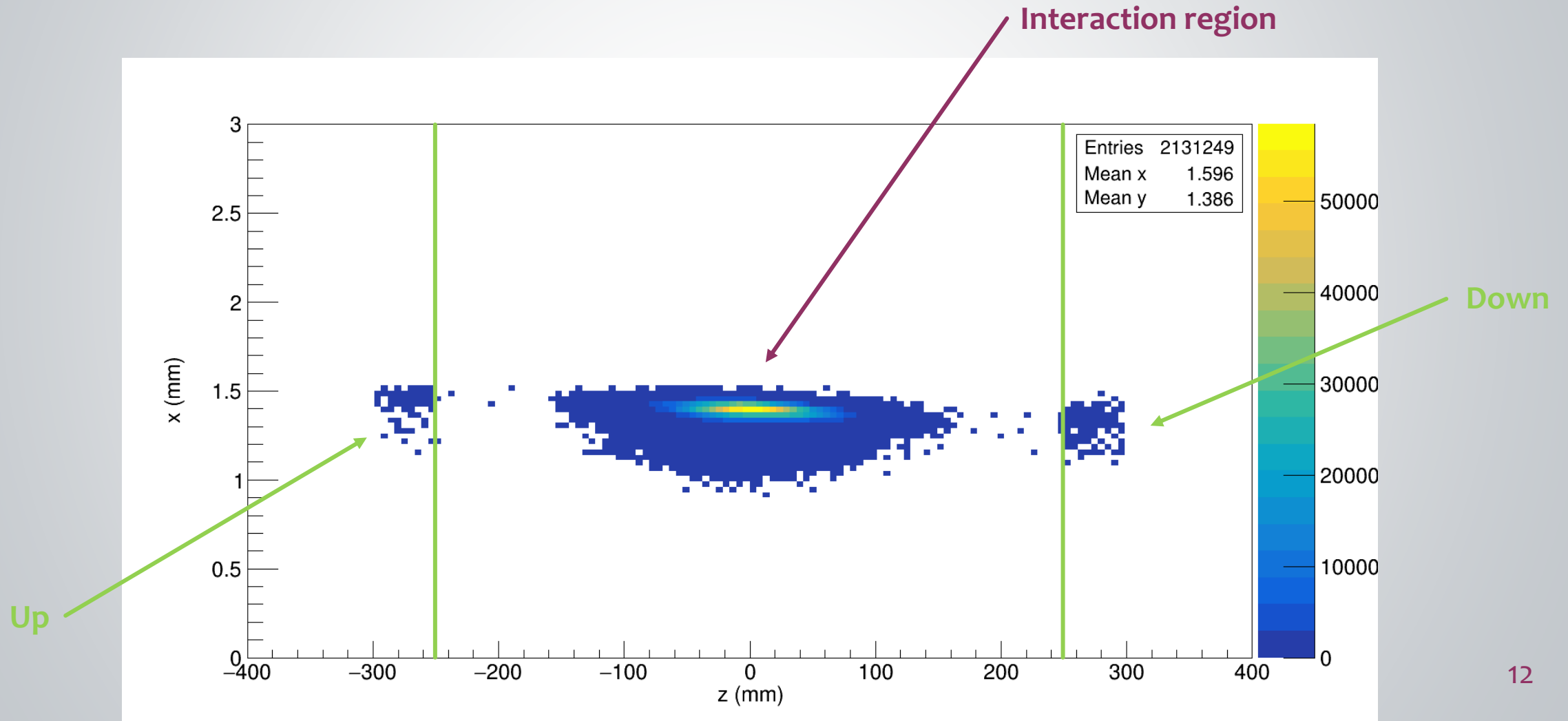
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# SUMMARY

- Cross-section can be measure with VDM or BGI methods
- VELO is key for luminosity measurement
- SMOG2 is a useful tool for beam profile reconstruction in BGI
- Exploit increased beam-gas events with SMOG2 injection
- Check the efficiency of data selection on the trigger

THANK YOU !!

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