



LHCb VERtEX LOcator

Particle detection

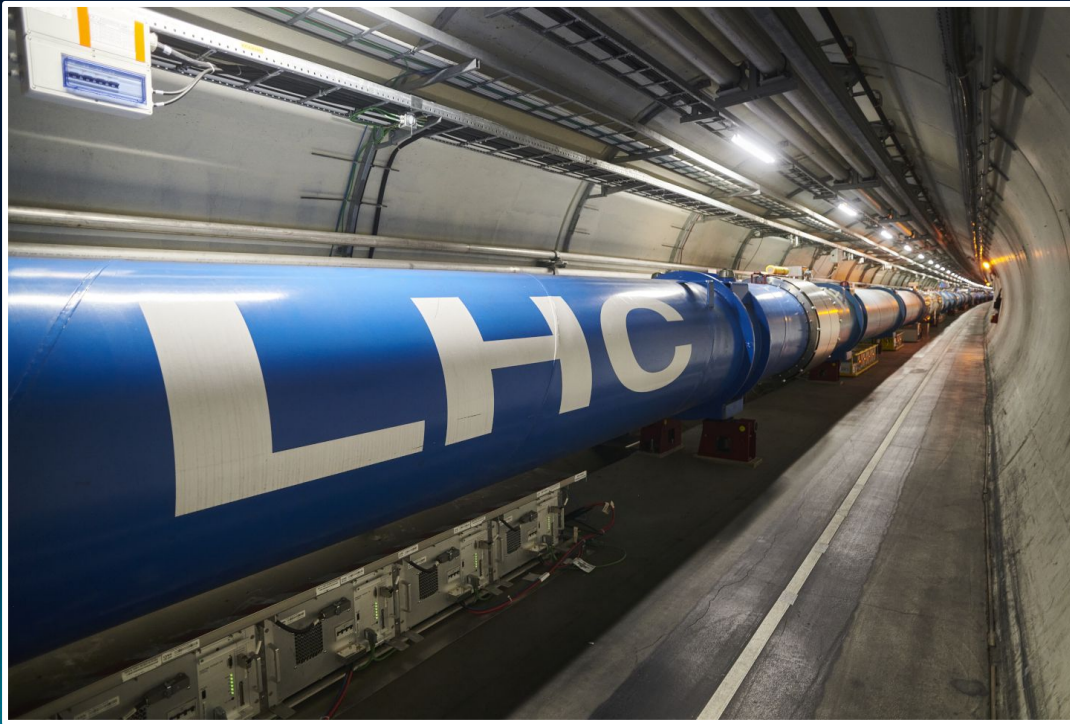
Presented by

Esther-Lauren M'Bilo

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1. Large Hadron Collider



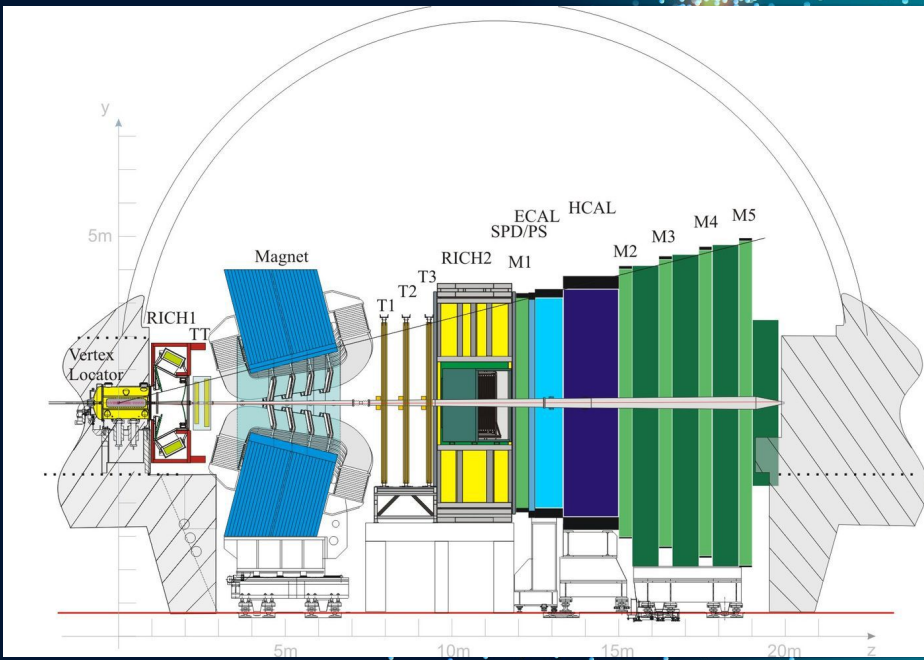
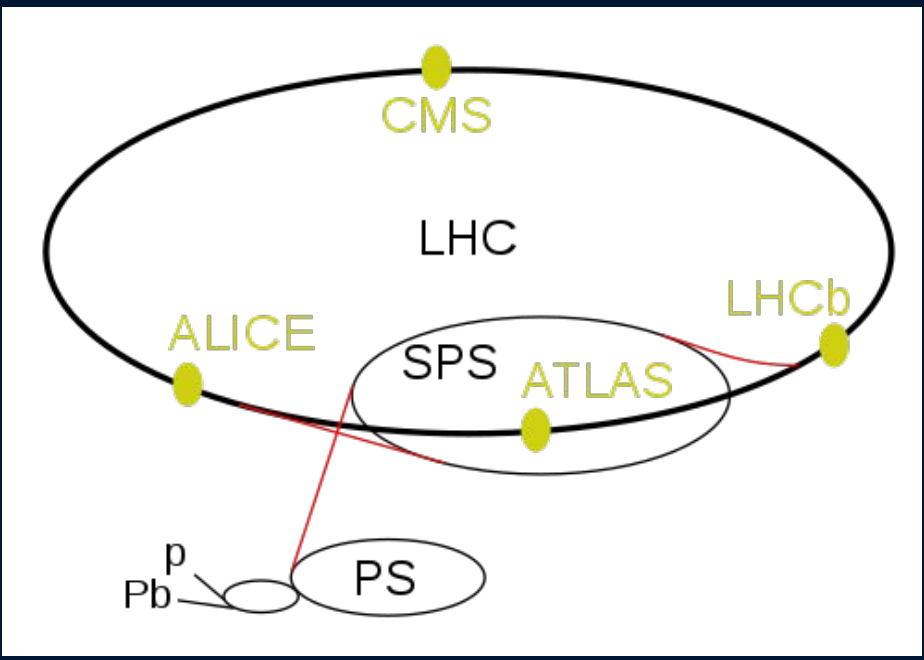
CERN. 22 April 2022. The Large Hadron Collider

Key numbers:

- 27 km long
- Collision energy up to 13.6 TeV
- Luminosity = $10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- Third run

CERN, 2018

2. LHCbeauty



Horvath, A. 3 April 2006. Layout off the LHC complex

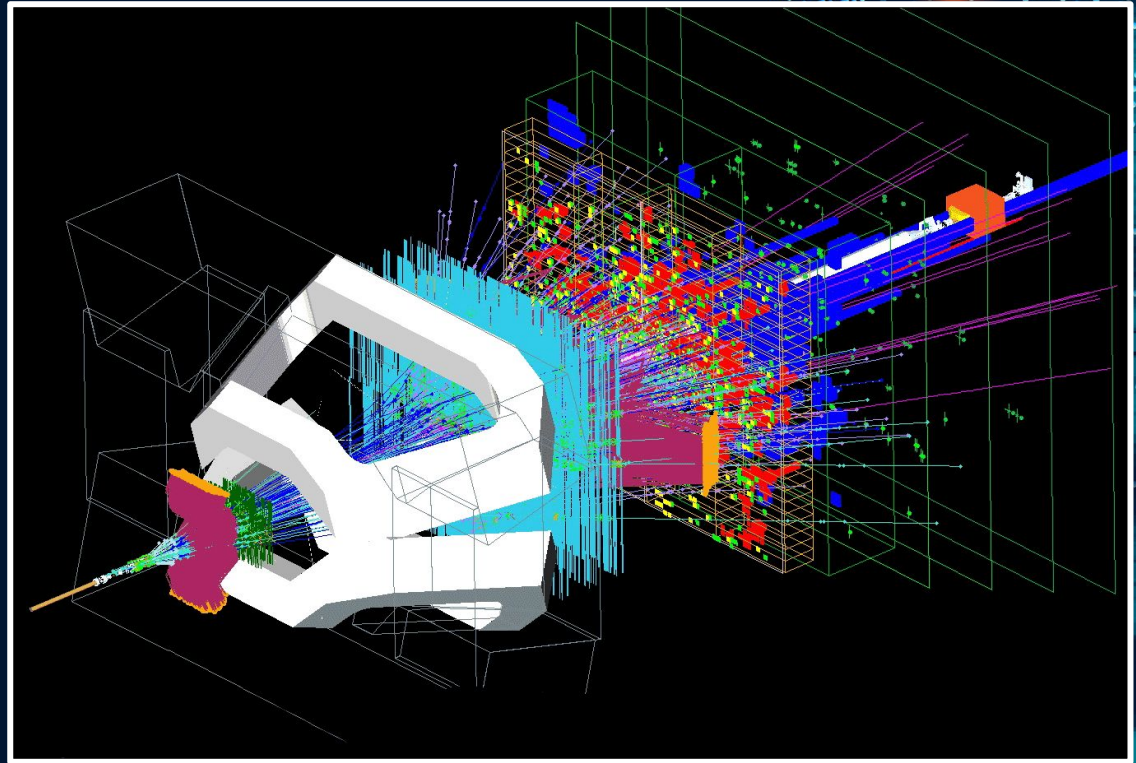
CERN. 8 February 2008. LHCb detector view among the bending plane

2. LHCbeauty

Main purpose :

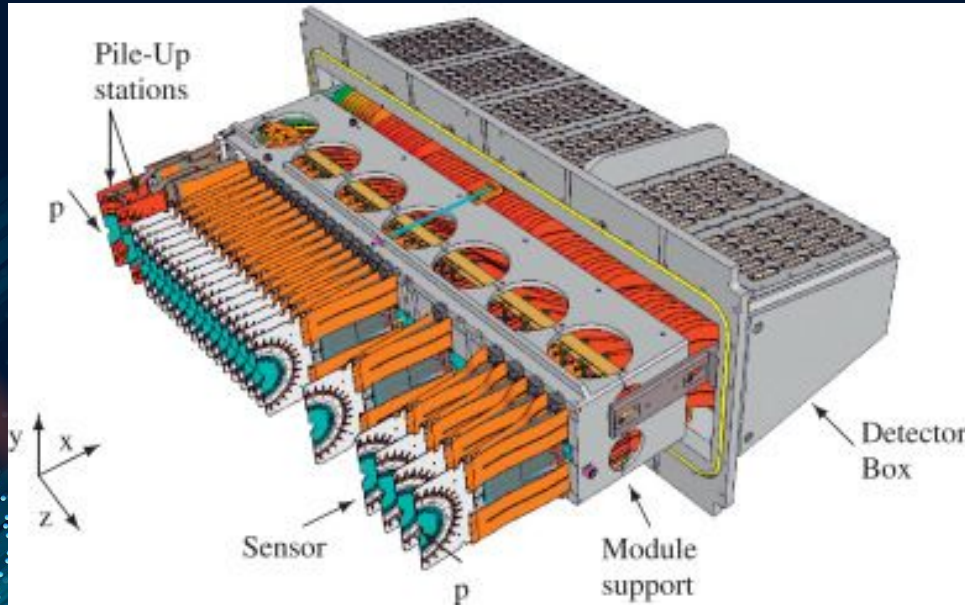
Investigation of
rare decays of
beauty and
charm particles

LHCb group, 2008

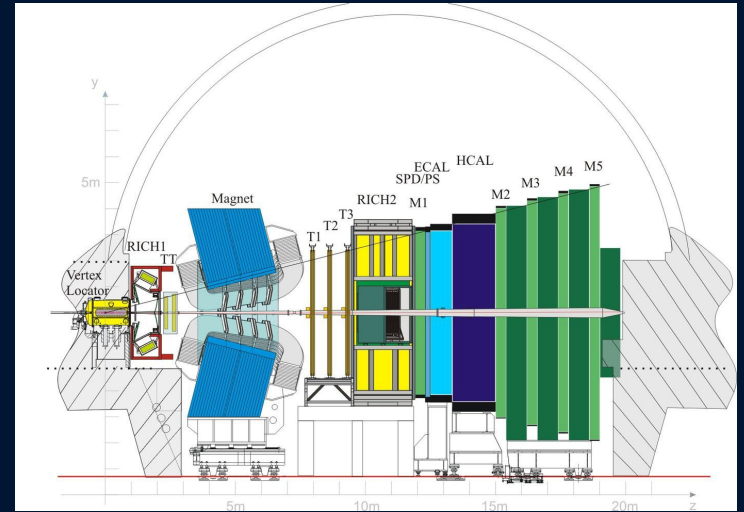


Del Rosso, A. 19 February 2013. Proton-lead ion
collision observed by the LHCb

3. The vertex locator



LHCb group. 1 November 2010. The Vertex Locator



CERN. 8 February 2008. LHCb detector view along the bending plane

Main purpose :

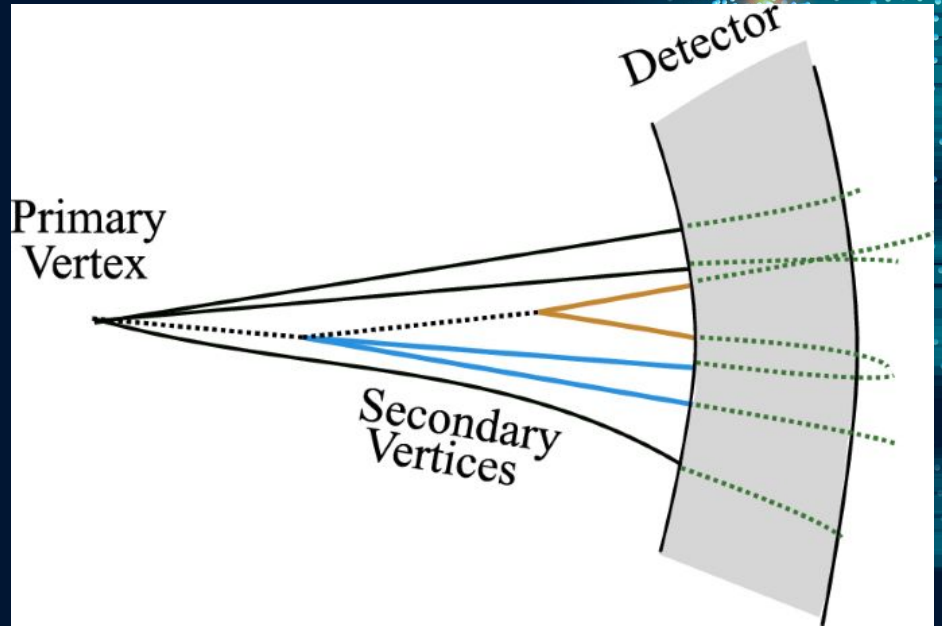
Identify primary and secondary vertices

LHCb group, 2014

3.1. General purpose

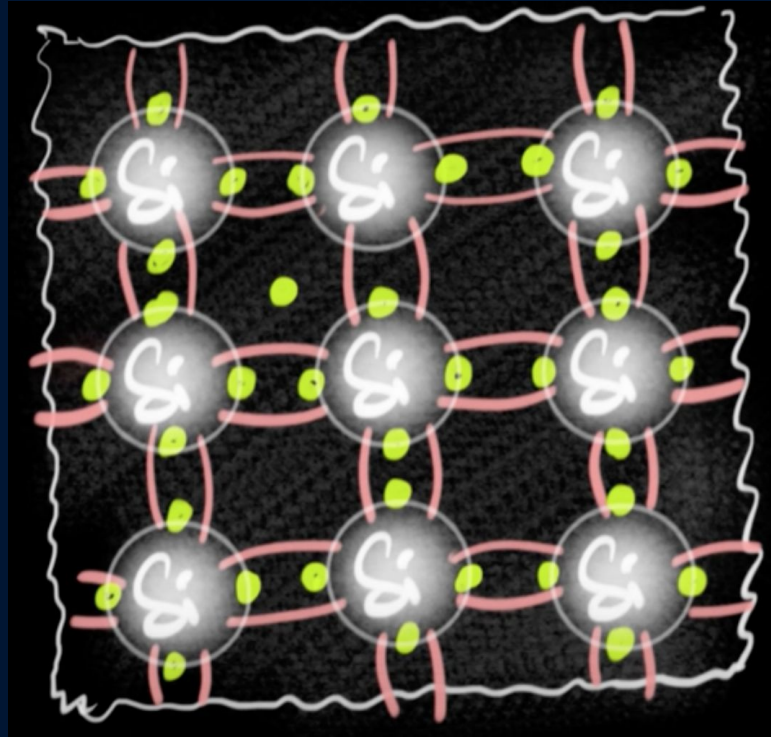
- Primary vertex = pp collision
- Secondary vertices = decay point of pp collision products

Wikipedia contributors, (2009)



Shlomi, J. et Al. 13 June 2021. Illustration of a jet with secondary decay vertices.

3.2. Silicon detectors



Khan Academy India. 29 March 2018. Introduction to semiconductors

3.3. Technical aspect of the VELO

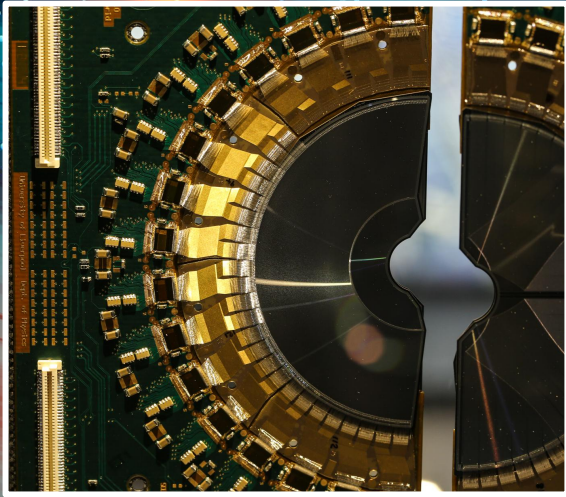


- 1 meter long
- 42 sensors
- 7 mm away from the beam
- Sensors thickness = 0.3 mm

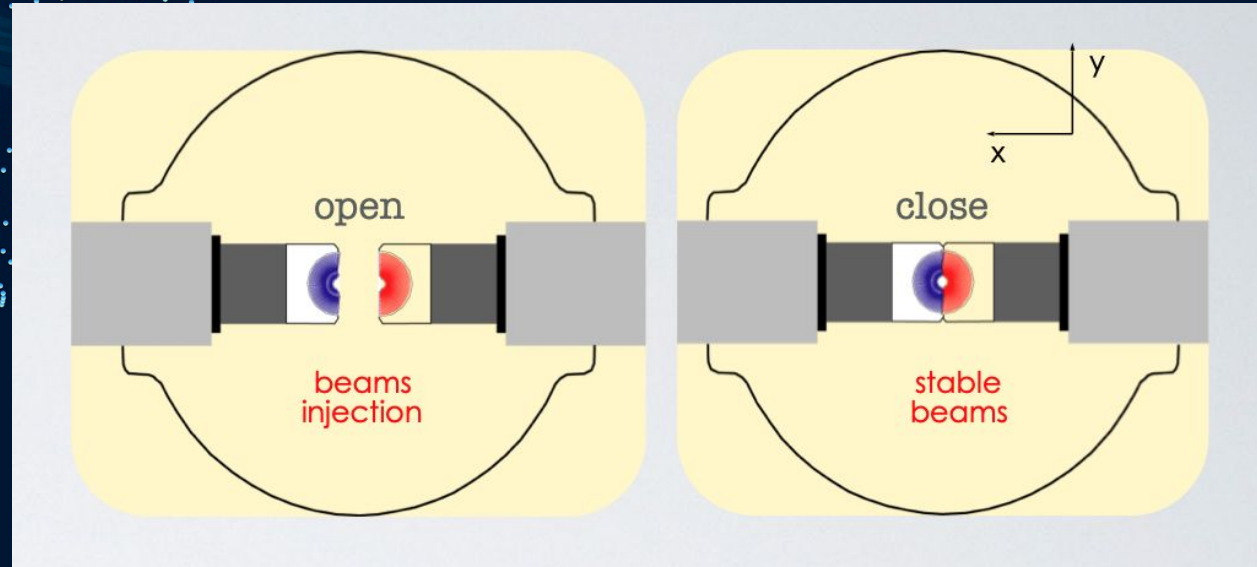
Saavedra, F et al, (N.D).

LHCb group. 1 November 2010. The Vertex Locator

3.3. Technical aspect of the VELO

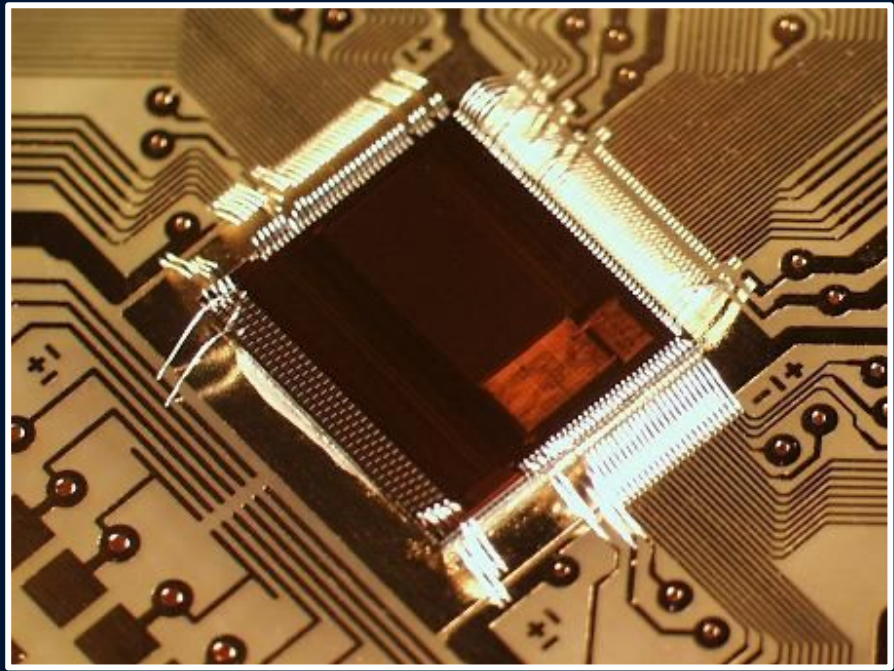
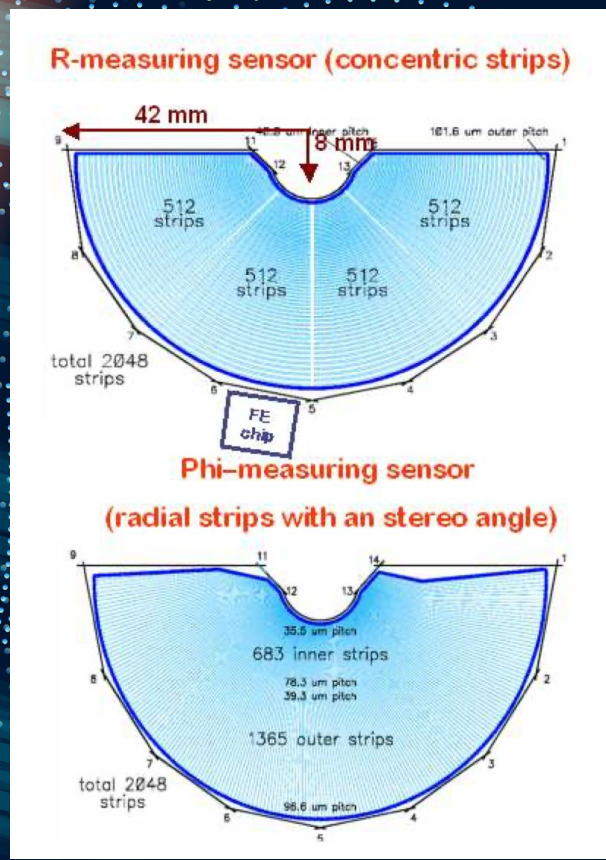


Foster C. 22 May 2014. Close up of the VELO module



De Capua, S. 7 July 2018. VELO modules motion

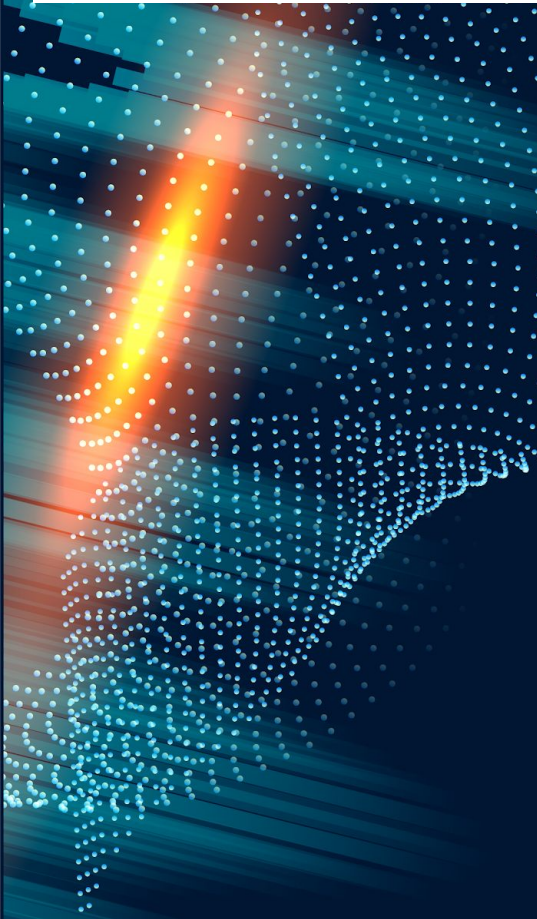
3.3. Technical aspect of the VELO



Anonymous author. 3 April 2007. Beetle Chip

The VELO group. NA. The R and phi sensors

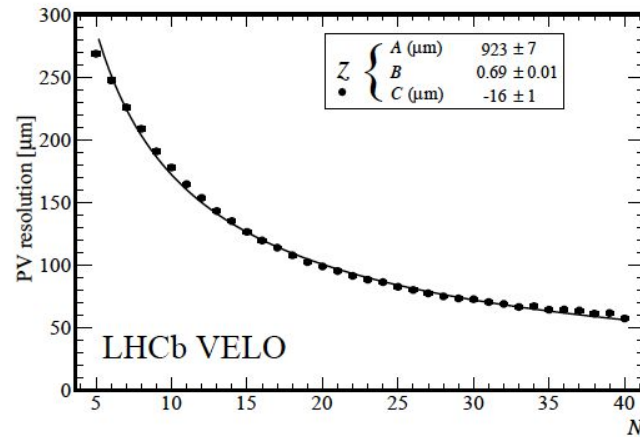
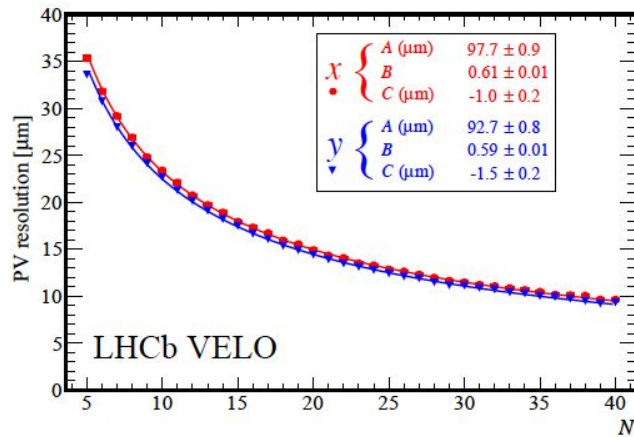
3.4. Performance



Feature	VELO	Upgrade
Sensors	R & ϕ strips 0.22 m ² 172,032 strips electron collecting 300 μ m thick 40-100 μ m pitch	Pixels 0.12 m ² 41 M pixels electron collecting 300 μm thick 55 μm pitch
# of modules	42	52
Max fluence	4.3×10^{14} MeV n _{eq} cm ⁻²	8×10^{15} 1 MeV n _{eq} cm ⁻²
HV tolerance	500 V	1000 V
ASIC readout rate	1 MHz	40 MHz
Total data rate	analog (eq. to 150 Gb/s)	2.8 Tb/s
Total Power consumption	1 kW	1.6 kW (30 W/module)

De Capua, S. 7 July 2018. VELO performance

3.4. Performance



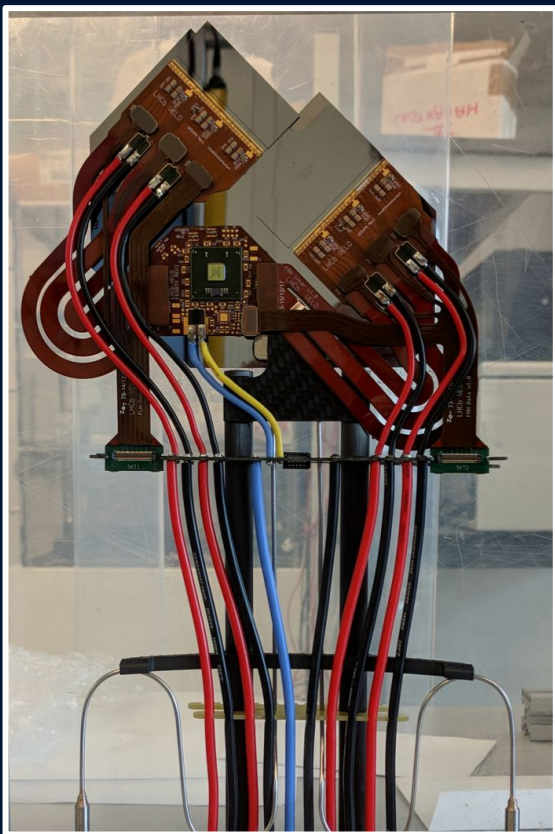
The VELO group. NA. PV resolution of events

$$\sigma_{PV} = \frac{A}{NB} + C$$

The VELO group. NA. PV resolution fit

- A, B and C are constants
- N is the number of tracks
- σ_{PV} is the PV resolution

VELO upgrade



De Capua, S. 7 July 2018. Upgraded VELO module



Ordan, J.M. 19 March 2019. Famous scientist working on the new VELO modules

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- CERN. (2022, November 1). *Alignment of the VELO subdetector of the LHCb experiment* [Video]. YouTube. <https://www.youtube.com/watch?v=MeZeic2FACQ>
- CERN. (2014, September 11). *Performance of the LHCb Vertex locator*
- Wikipedia contributors. (2023, December 12). *Semiconductor detector*. Wikipedia. https://en.wikipedia.org/wiki/Semiconductor_detector
- rammer, M. (2015). Silicon detectors in High Energy Physics experiments. *Scholarpedia*, 10(10), 32486. <https://doi.org/10.4249/scholarpedia.32486>
- Saavedra, A. F. & VeLo group. (n.d.). The Vertex detector of the LHCb Experiment: The VeLo. *Glasgow University*. <https://cds.cern.ch/record/1027437/files/p201.pdf>
- *VErtex LOcator (VELO)*. (n.d.). <https://lhcb-outreach.web.cern.ch/detector/vertex-locator-velo/>