Else Okkinga

Detector studies for ALICE and LHCb

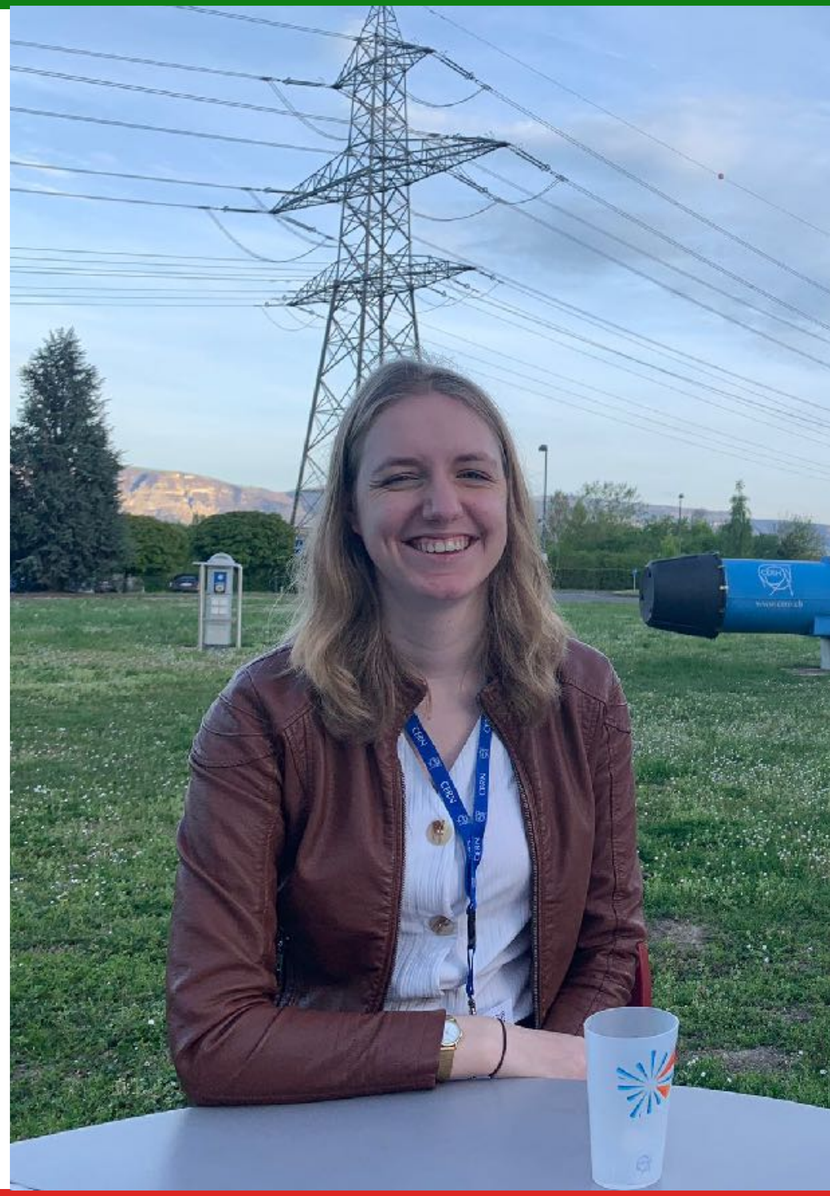
Bachelor and
master's thesis

ATTRACT workshop
22-07-2025

Who am I?

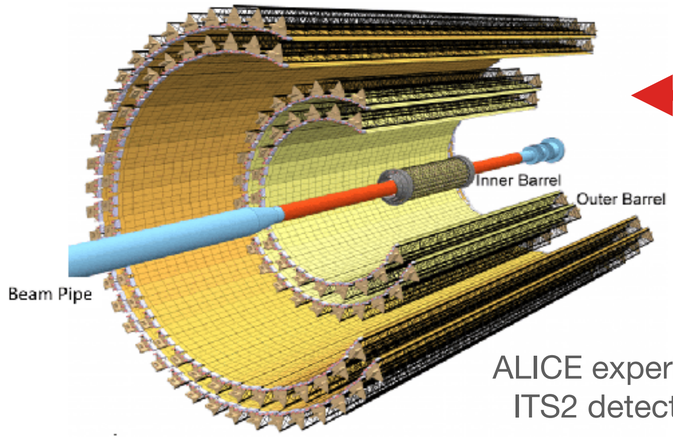
- Name: Else Okkinga
- Age: 27 years old
- Born in: The Netherlands

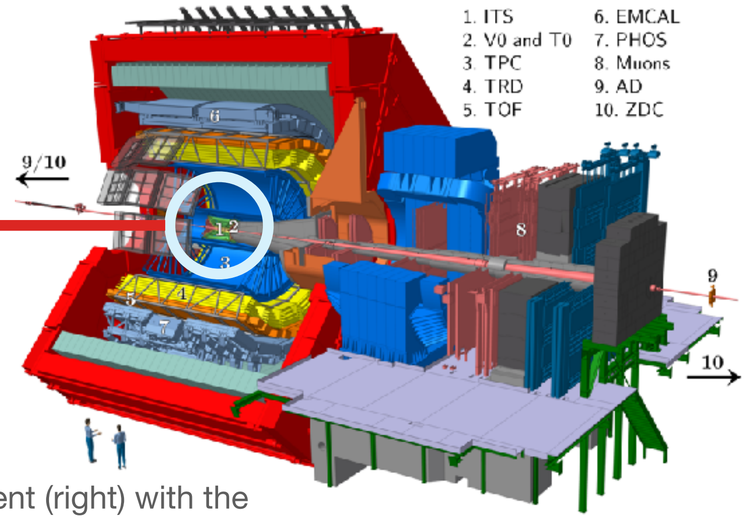
- Bachelor: Fontys University, The Netherlands
  - Thesis: ALICE ITS3 Upgrade
- Master: Utrecht University, The Netherlands
  - Thesis: LHCb Beam profile studies



Bachelor Thesis: ALICE ITS3 silicon bending

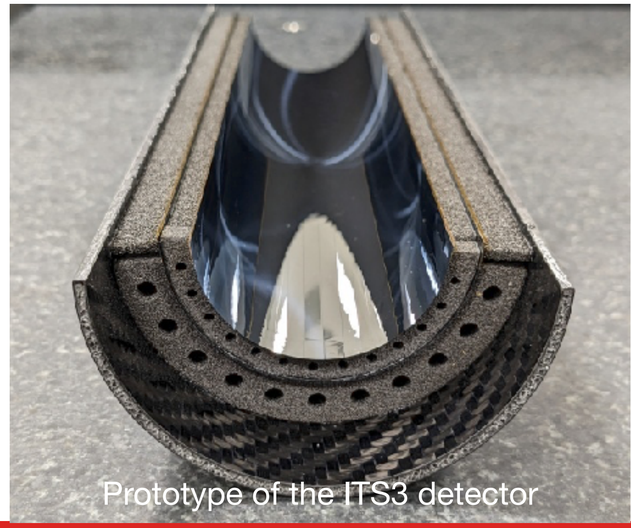
- ALICE experiment: Studying the quark gluon plasma
- Inner Tracking System:
  - Innermost detector
  - 7 layers of silicon pixel sensors for particle tracking





ALICE experiment (right) with the ITS2 detector highlighted (left)

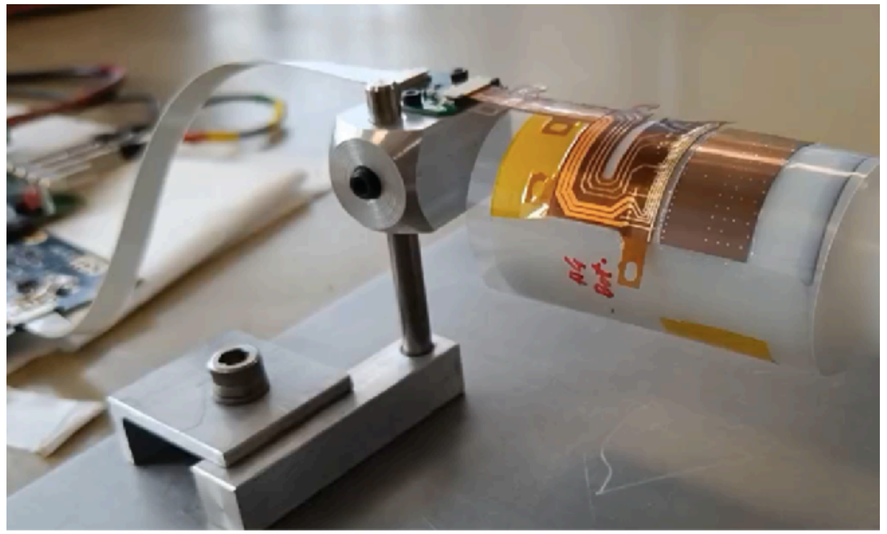
- ITS3 Upgrade: Replacing the three innermost layers with thin silicon pixel sensors that can bend around the beampipe
  - Reducing material budget, decreasing particle scattering
- ALPIDE chips: Monolithic Active Pixel Sensors (MAPS) where the sensormatrix and readout are integrated in a single chip



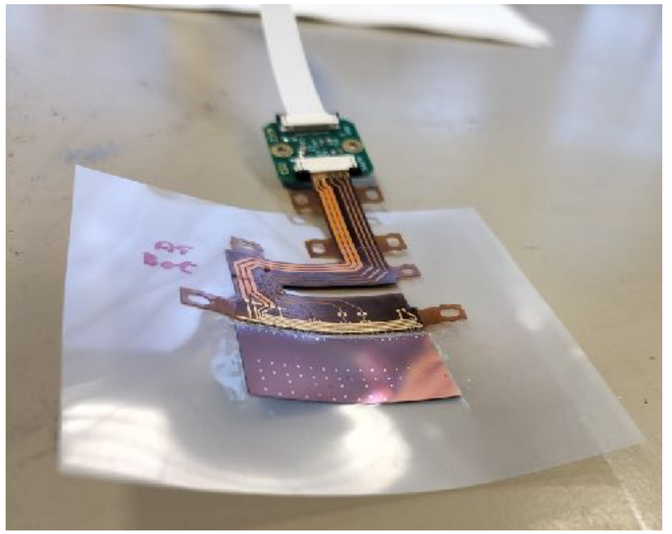
Prototype of the ITS3 detector

ITS3: Bend silicon pixel sensors

- Goal: Studying the effect of stress on the silicon sensors due to bending
  - Using different bending radii, chip orientations and comparing tensile and compressive stress
  - Measuring, among others, the analogue power supply current and DAC output values



Bending setup for tensile stress measurements

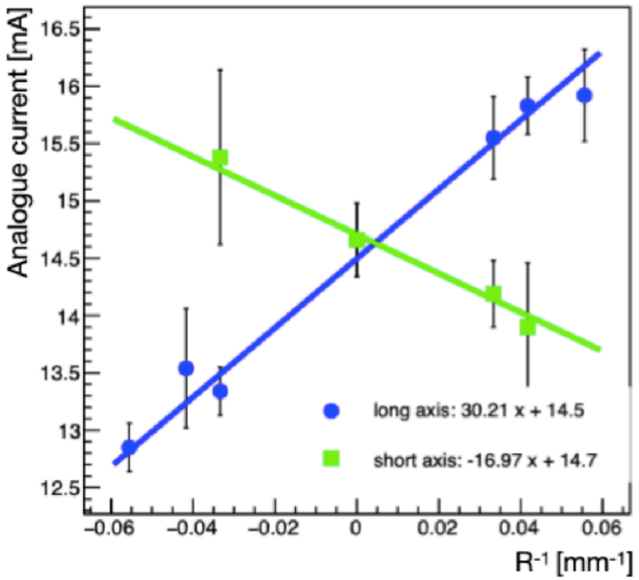


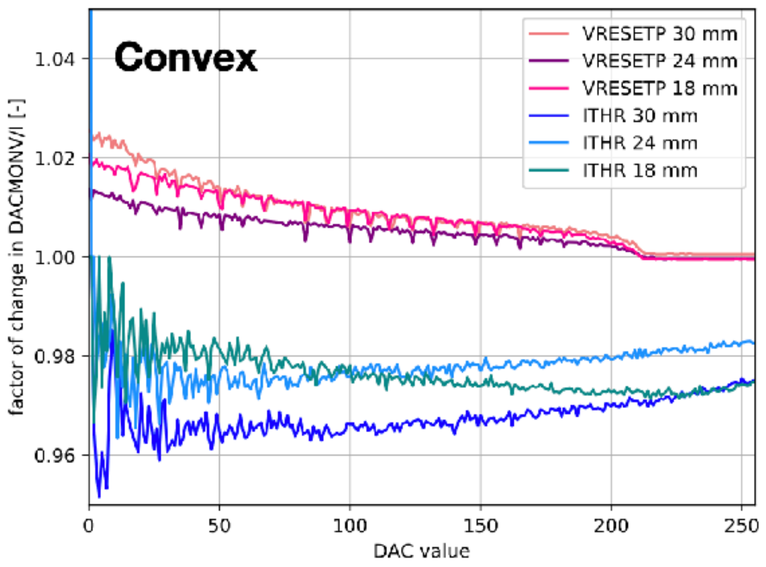
ALPIDE chip after bending, showing slight deformation

- Taking into account hysteresis-like effects because the chip stays slightly bend after the measurements

ITS3: Results

- Stress in the sensor causes changes in the analog power supply current
  - Linear realtion between bending radius and current power supply, depending on orientation of the sensor
- Stress causes some DAC outputs to change as well

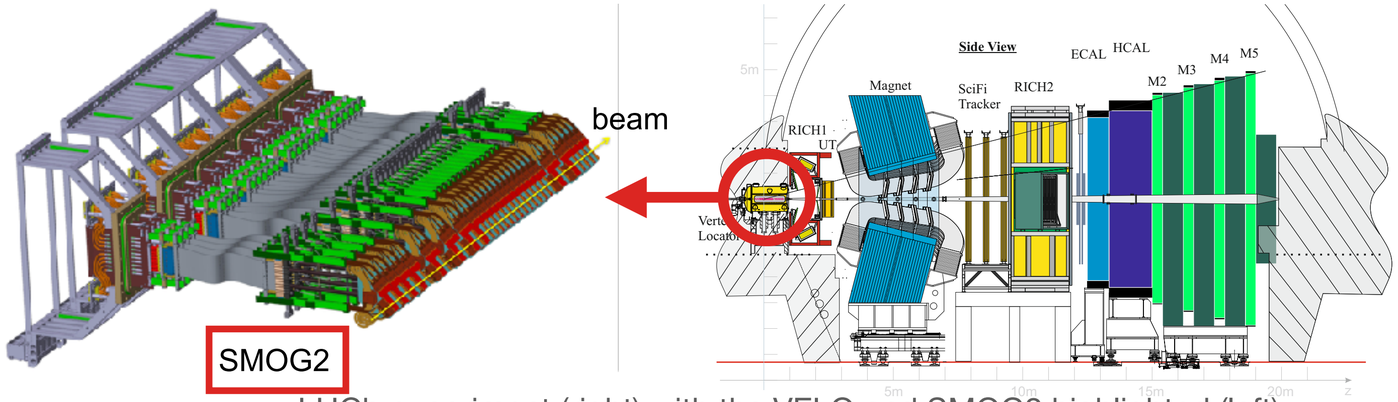




- The observed change in current is likely caused by multiple factors
  - Piezo resistive effect causes change in resistivity
  - DAC output changes
- Threshold and noise level change under stress —> can be used for optimization

Master's thesis: LHCb operations of VELO

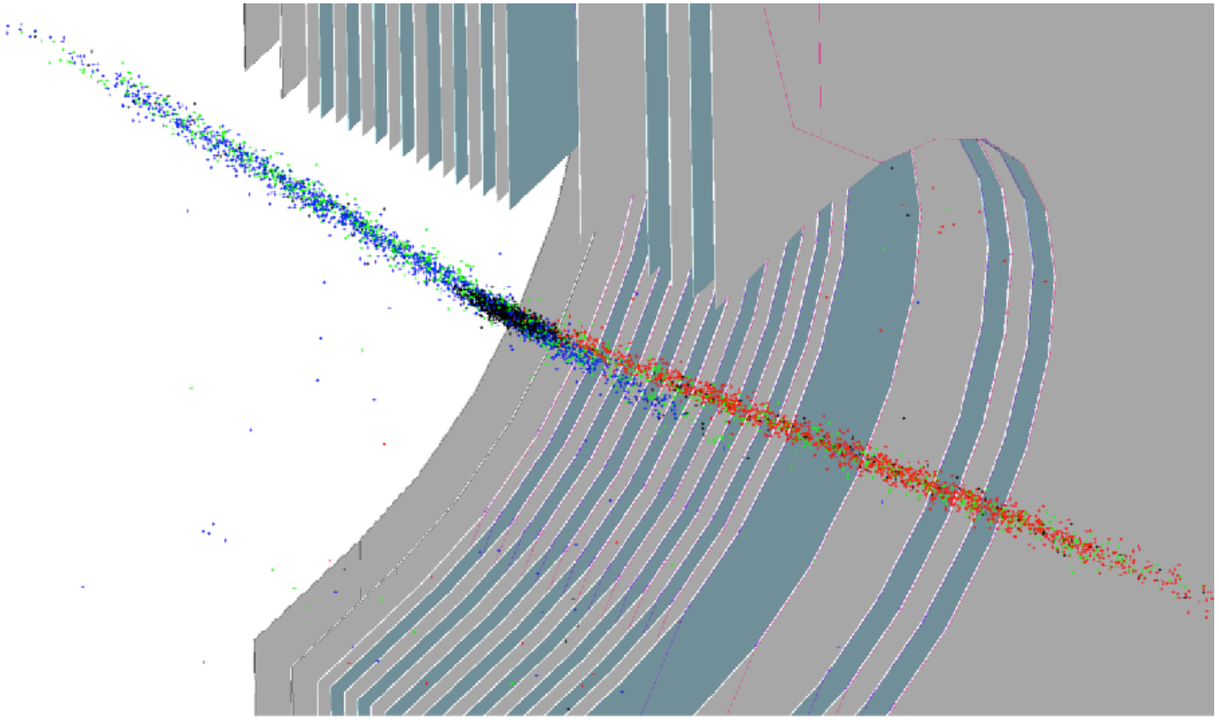
- LHCb: Beauty physics in the forward direction
- Vertex Locator (VELO): Precise reconstruction of vertices and distinguising primary from secondary vertices
- SMOG: Fixed target physics
- Goal: Use vertex information from the VELO to determine the LHC beam positions and distributions
  - Luminosity levelling feedback
  - Dedicated LHC studies



LHCb experiment (right) with the VELO and SMOG2 highlighted (left)

LHCb: Beam-Gas Imaging method

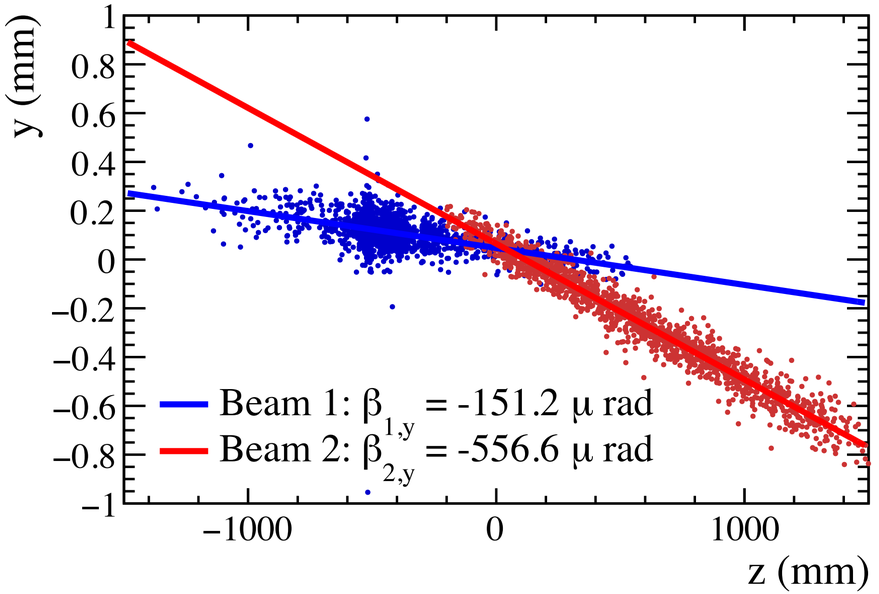
- BGI: Reconstructing beam profiles using beam-gas interactions
- Unique capability of LHCb
  - PV resolution thanks to VELO
  - SMOG system injecting gas in beam volume
- Complementary method of determining the luminosity to the van der Meer scan
- Can also provide (bunch-by-bunch) beam profile information



Beam-gas interaction vertices. Image from C. Barschel, Precision luminosity measurement at LHCb with beam-gas imaging, 2024. https://repository.cern/records/0kgak-yxt70/preview/CERN-THESIS-2013-301.pdf

LHCb: BGI usecases

- The BGI method makes it possible to measure with great accuracy
  - Crossing angle and separation between the two beams for luminosity levelling feedback
  - Beam distributions
  - First steps to measure the overlap integral to determine the integrated luminosity
  - Bunch-by-bunch beam profile information, integrated in dedicated studies by LHC experts:
    - Displaced bunch positions for UFO studies
    - Per-bunch luminous region position for pyTRAIN validation



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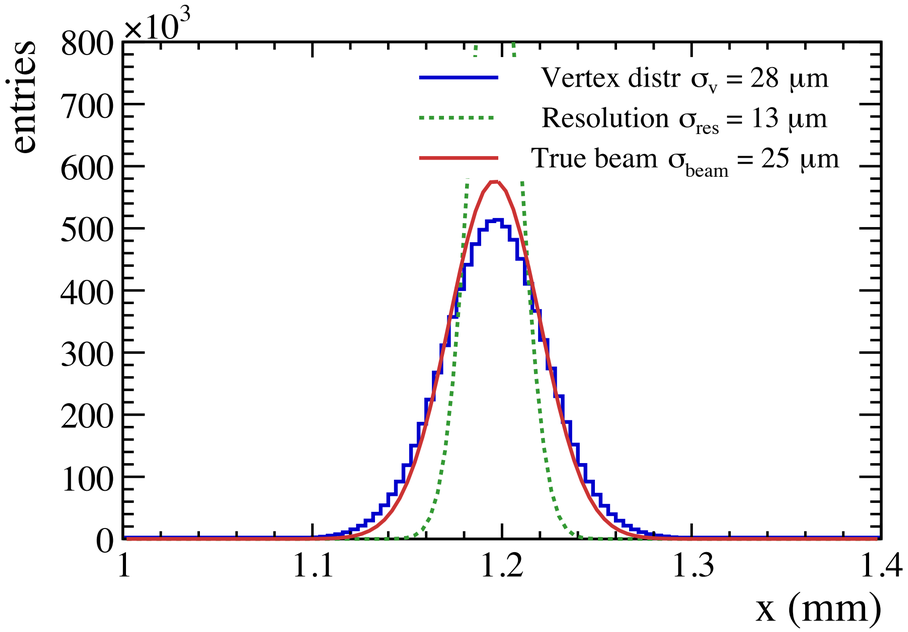

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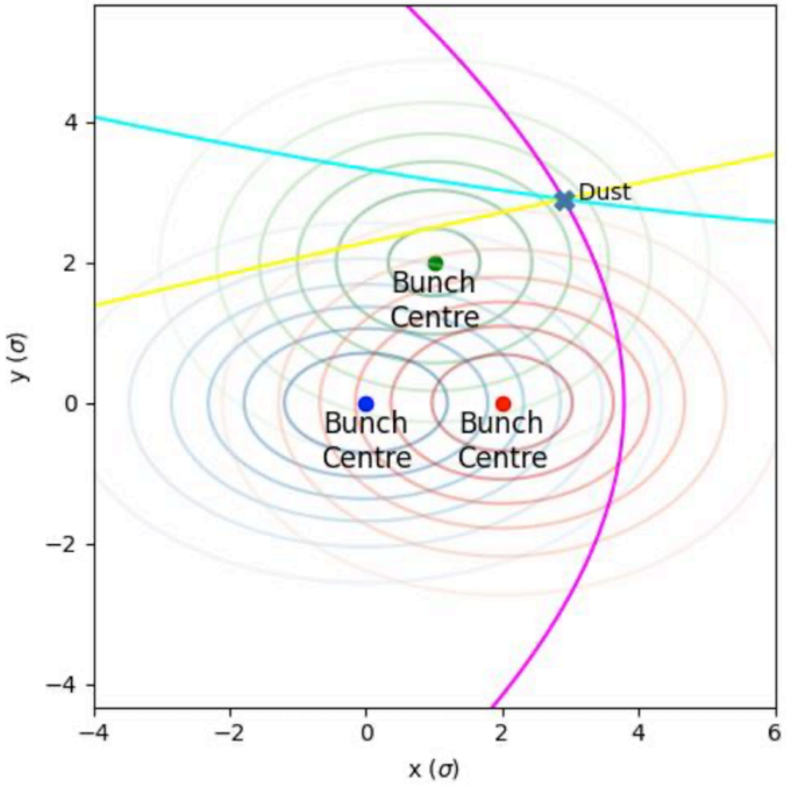

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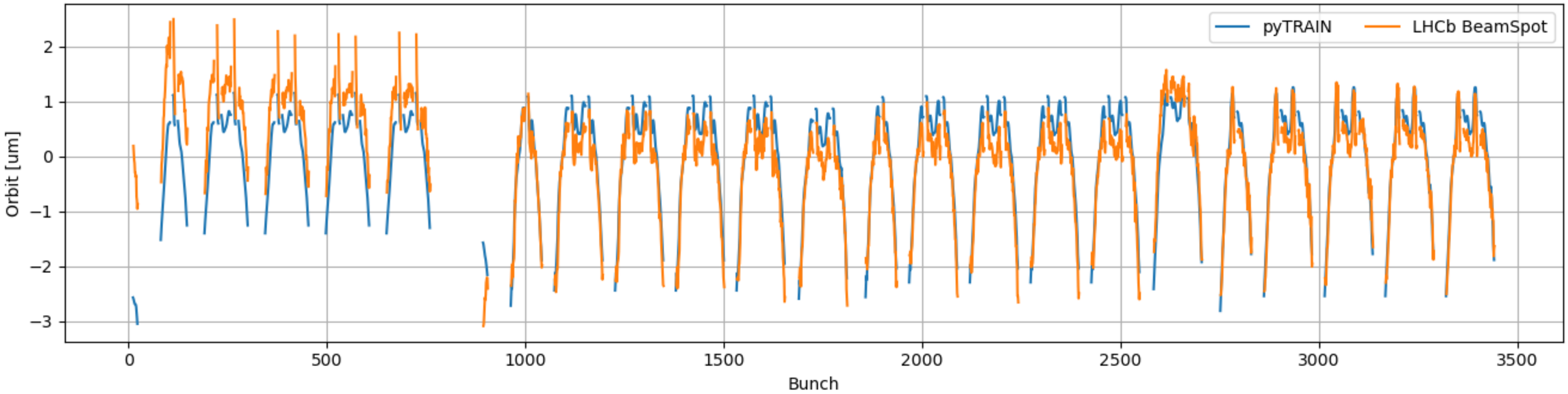

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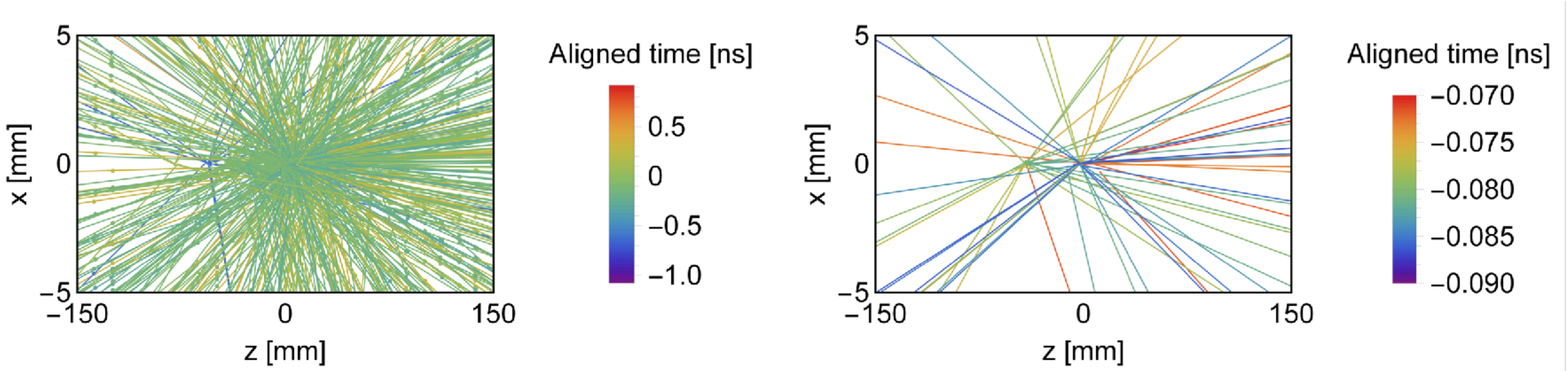
LHCb: Looking at the future

- High luminosity LHC: Requires upgrade of LHCb to adjust for increased luminosity
- VELO Upgrade II will become a 4D tracker to reduce pile-up
  - Different sensor technologies calls for method of testing and characterizing

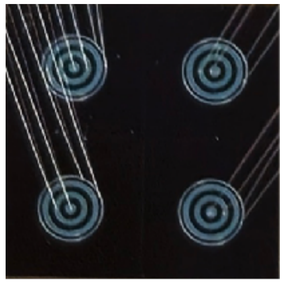


Track density from a single bunch crossing and from a time period of 20 ps. Image from Framework TDR for the LHCb Upgrade II: Opportunities in flavour physics, and beyond, in the HL-LHC era

LHCb: Transient current technique setup

- TCT: localised pulsed laser deposition in DUT and measure response signal

  —> Timing resolution information



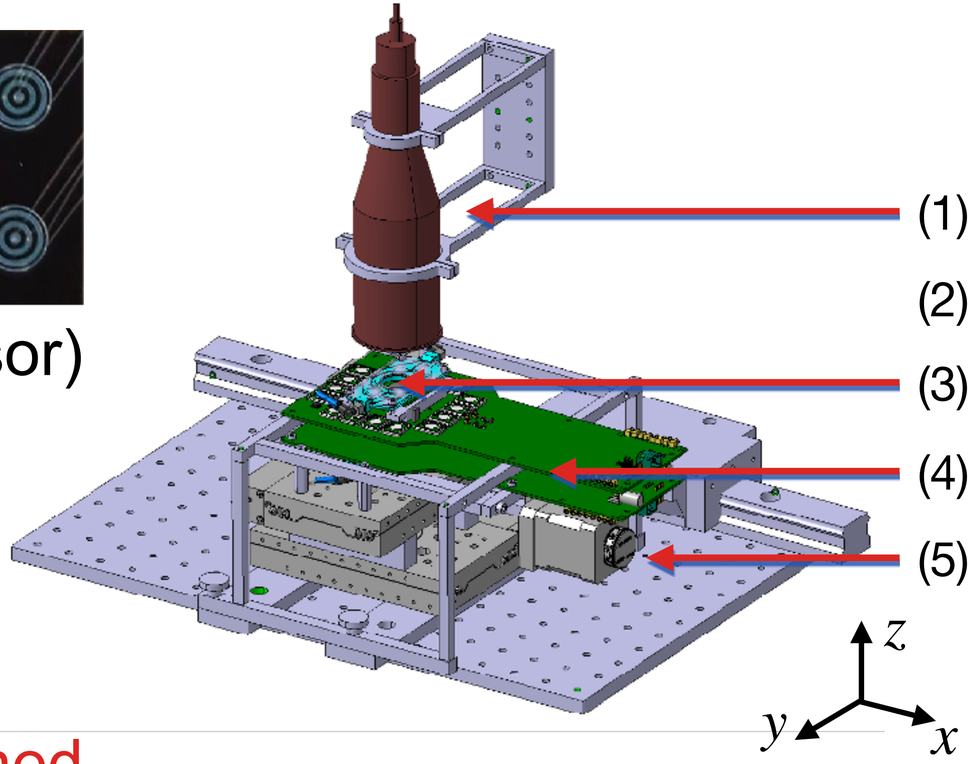
1: Laser and optics

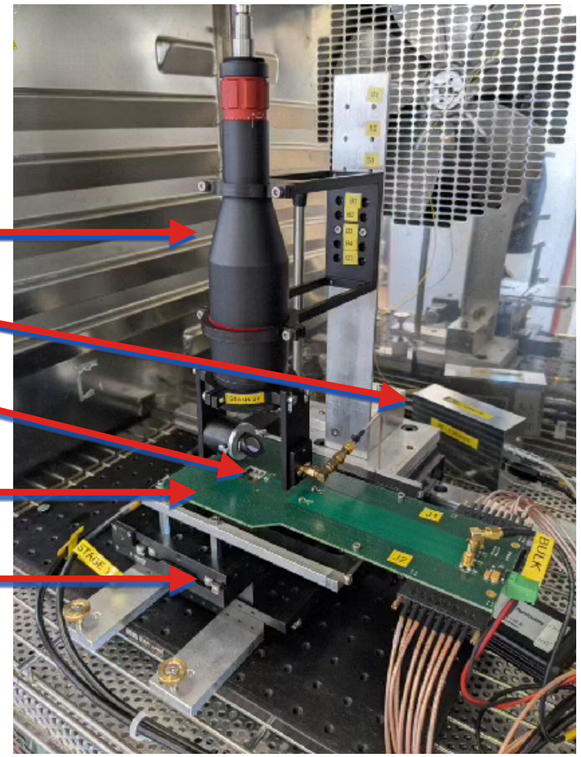
2: Laser driver

3: DUT (200 μm planar sensor)

4: OPTIMA readout board

5: xy translation motor





- Setup is being commissioned

Laser TCT setup overview. Figure produced by Morag Williams

Thank you for your attention