4DLumiTracker: introduction and goals

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Introduction

- 4DLumiTracker, a tracker for:
  - luminosity and beam monitoring
  - DIPOLE-b project
- Possible layout
  - 4 Velopix + 2 Timespot sensors
- Challenges:
  - operation in the beam pipe
  - cooling

Luminosity and beam monitoring

Beam, background and online luminosity monitoring in LHCb for the LHCb Upgrade I, LHCb-INT-2019-021

See Federico's talk

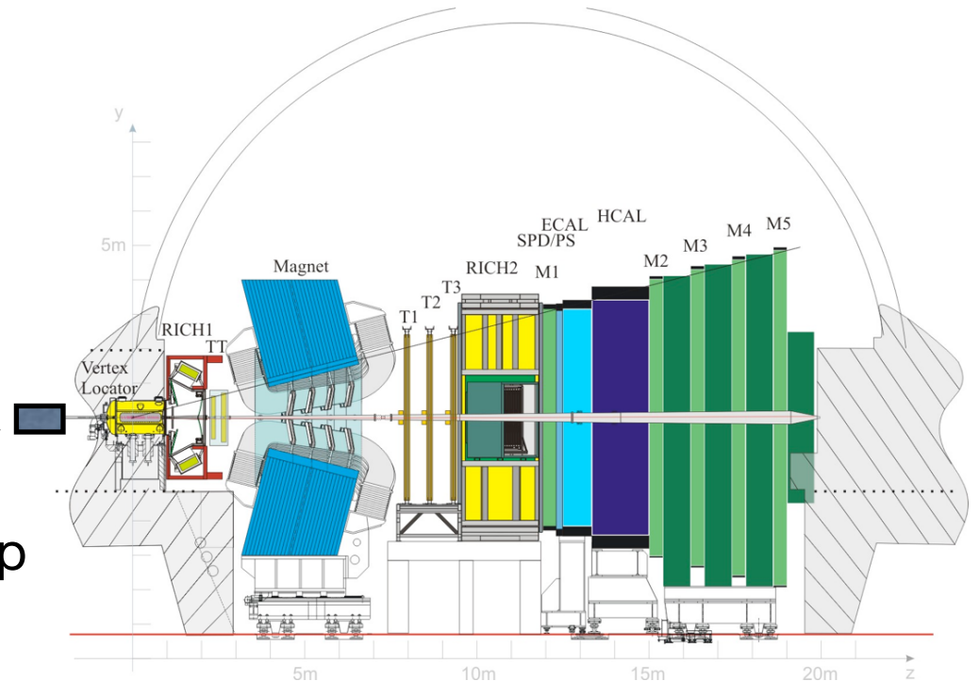
- Online **beam** and **luminosity** monitoring provides crucial information for physics, detector, and LHC operations
- The system, independent from DAQ, should measure
  - bunch-by-bunch luminosity
  - bunch-by-bunch beam shape parameters
  - machine induced background
- A pixel **tracker with fast timing** would provide time (clock phase) information for such measurements

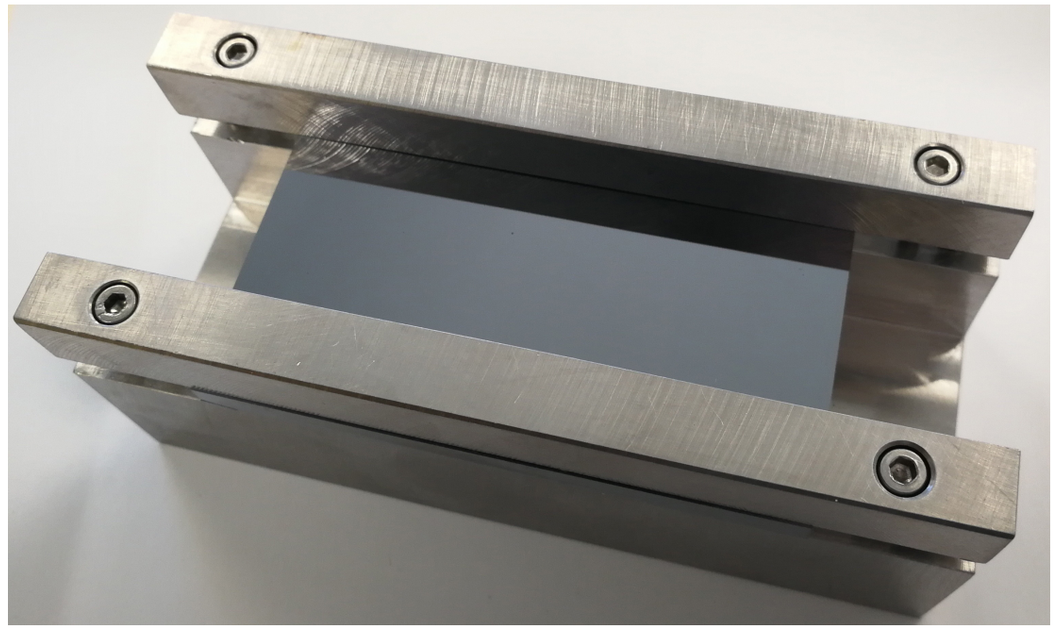
DIPOLE-b project

- Measurement of dipole moments of charm baryons at LHCb
  - Eur. Phys. J. C **77** (2017) 828.
  - Eur. Phys. J. C **77** (2017) 181
- A novel fixed-target experiment at LHC for charm baryons

Proposal to search for baryon EDMs with bent crystals at LHCb, LHCb-INT-2017-011

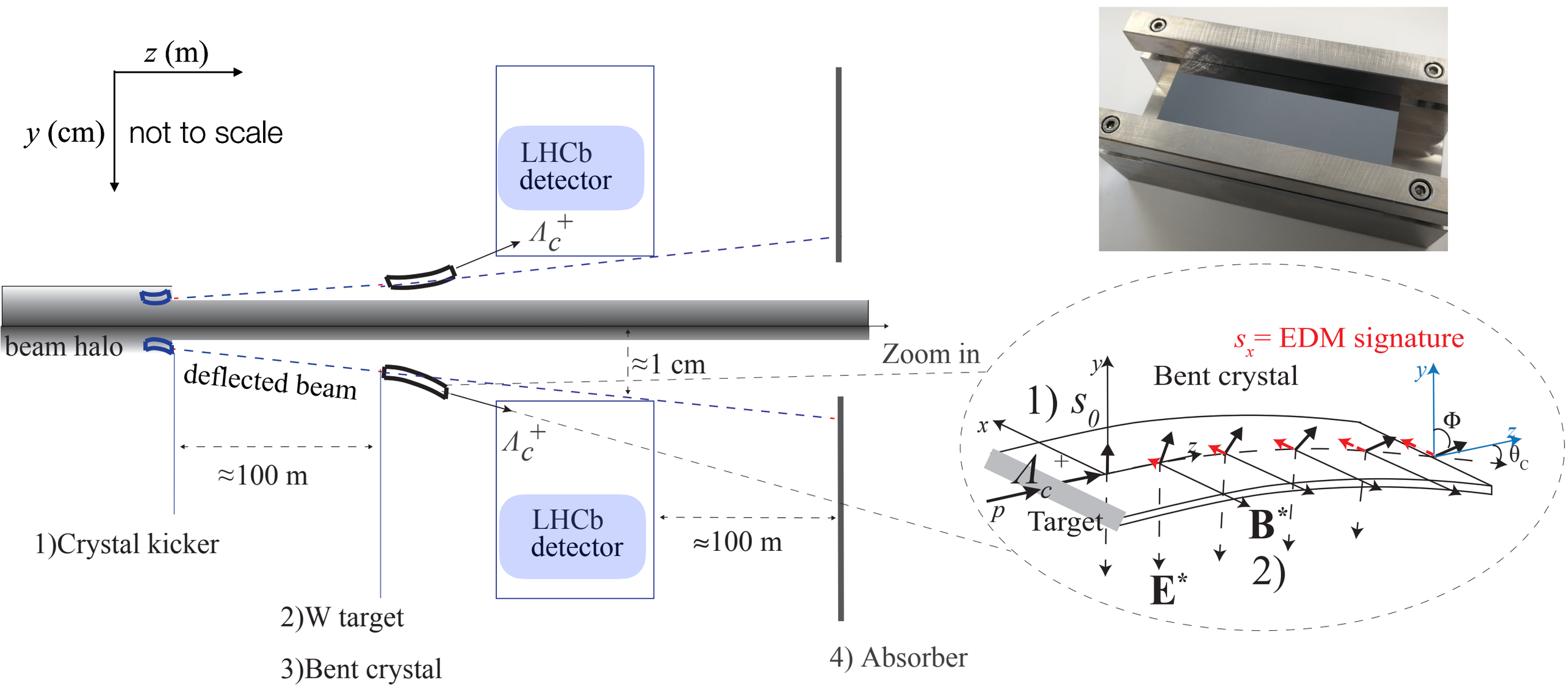
Fixed-target setup





Novel fixed-target experiment at LHC for charm baryons

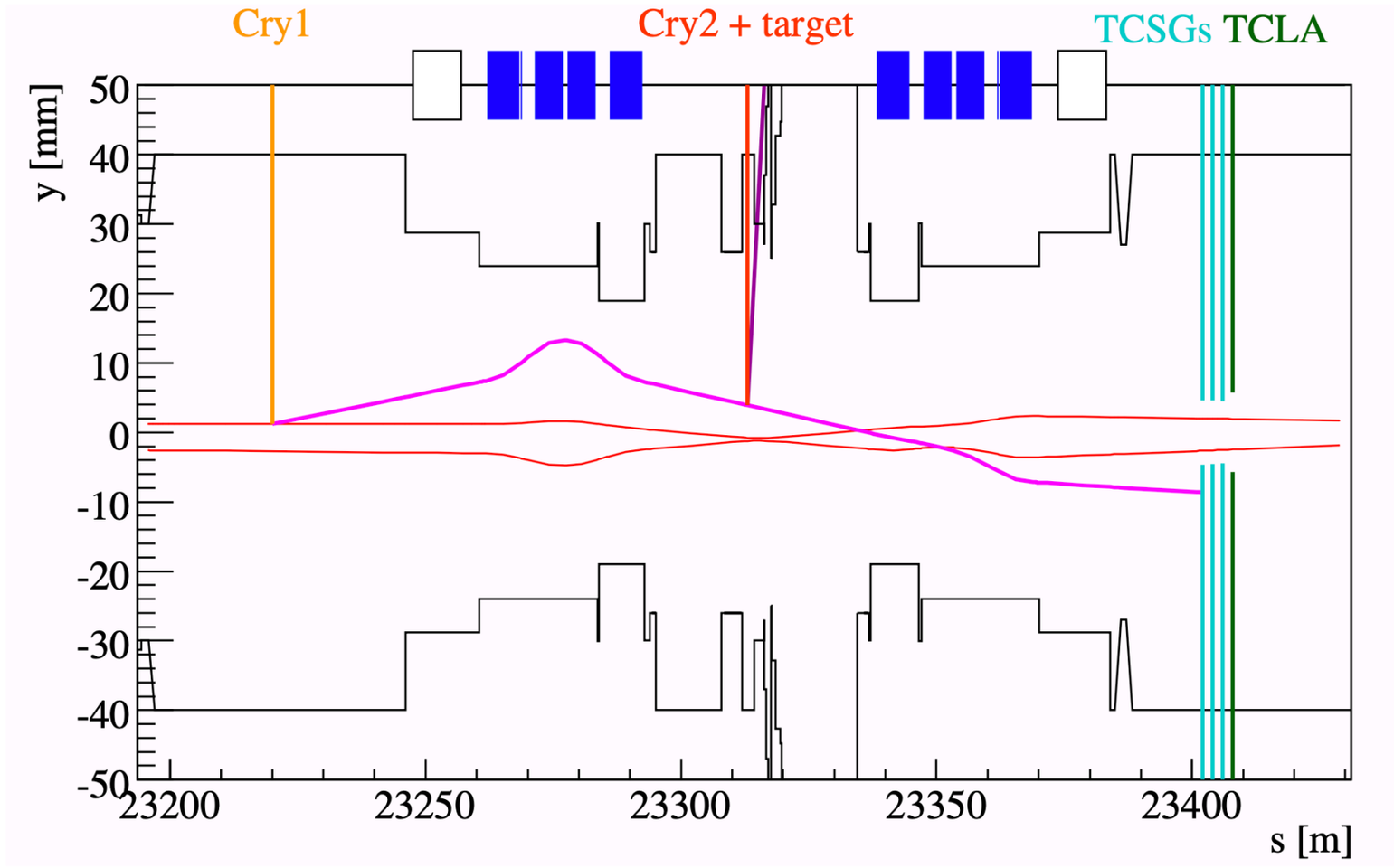
EDM/MDM from spin precession of channeled baryons in bent crystals



p extraction | Λ_c^+ polarised production | channeling | spin precession | event reconstruction

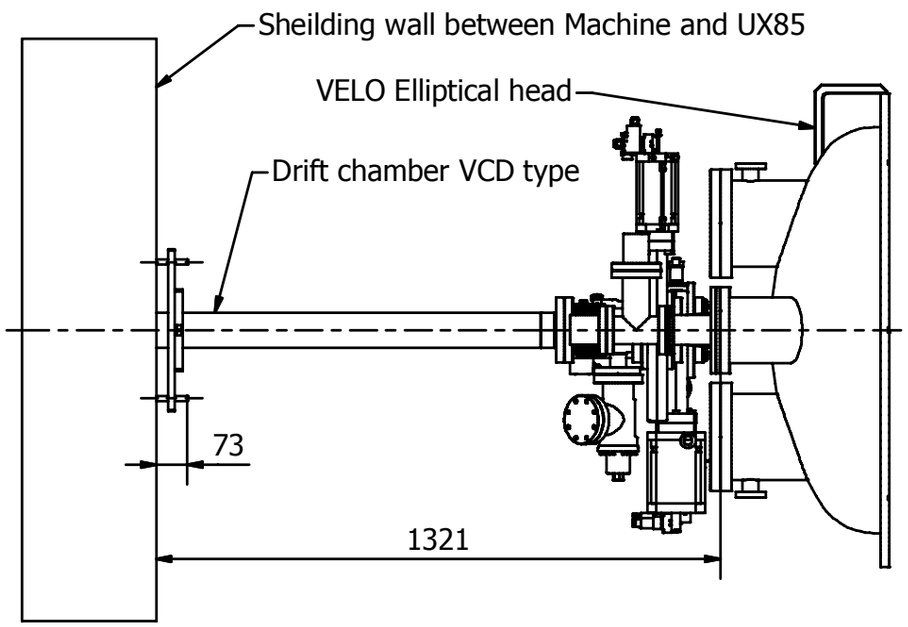
Implementation at IP8

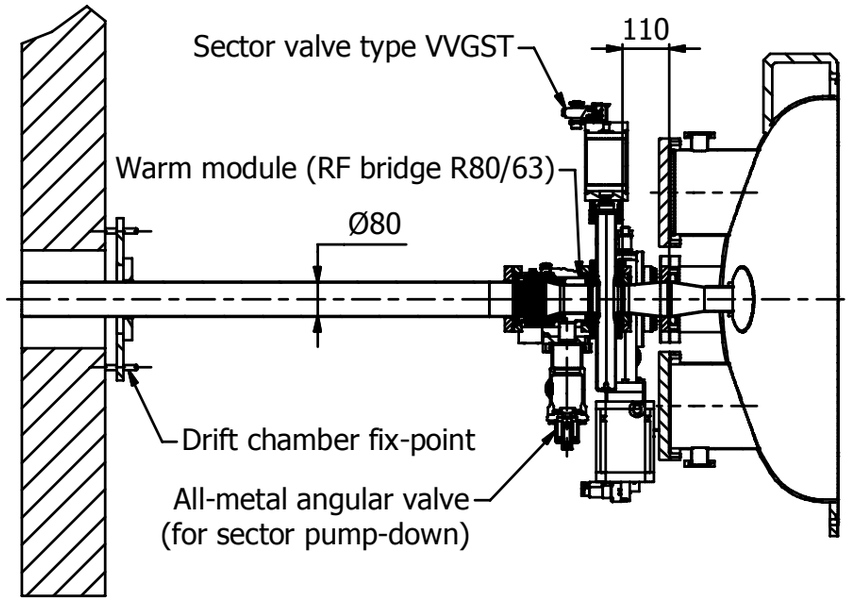
D. Mirarchi et al., (2019), 1906.08551

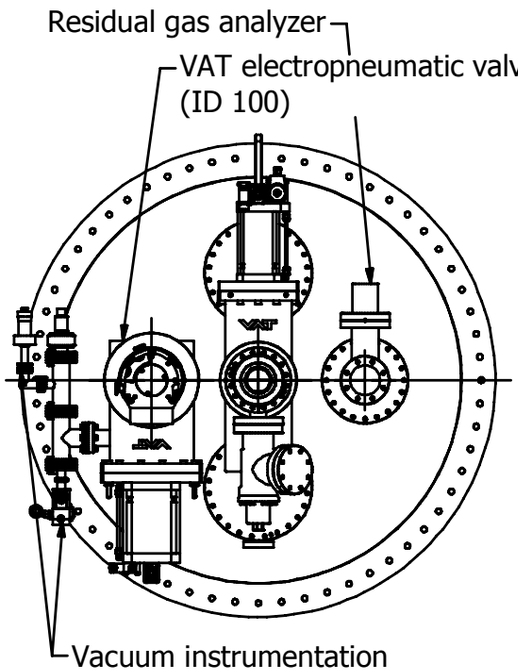


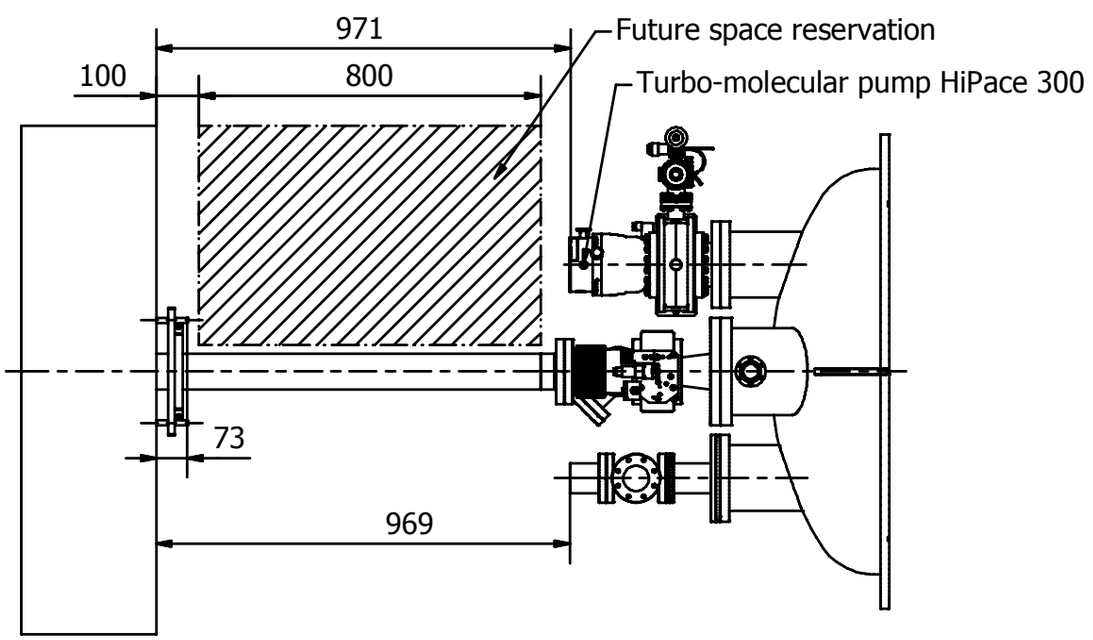
- **Channeling** of 6.5 TeV protons **at LHC** already **demonstrated** by UA9 collaboration W. Scandale et al., PLB 758 (2016) 129–133
- Detailed machine **simulations** for **optimal layout** by the LHC collimation group by S. Redaelli arXiv:1906.08551

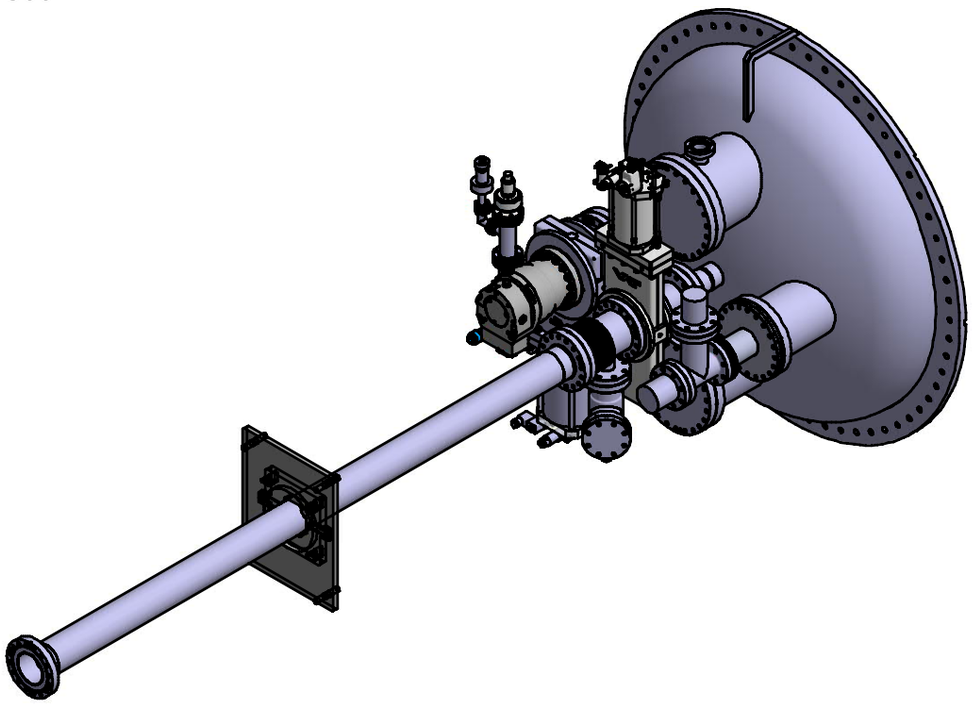
VELO upstream sector after LS2



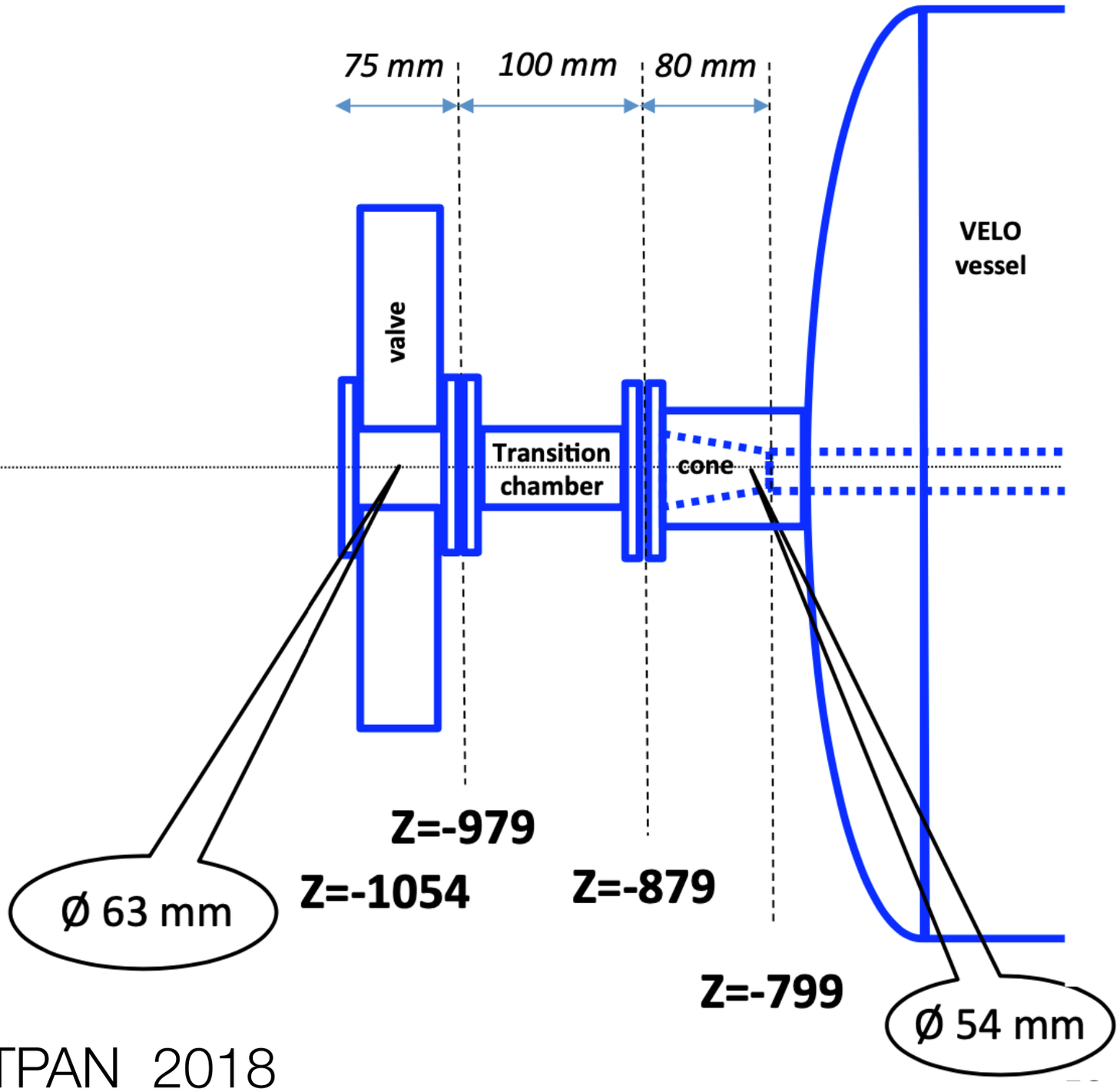






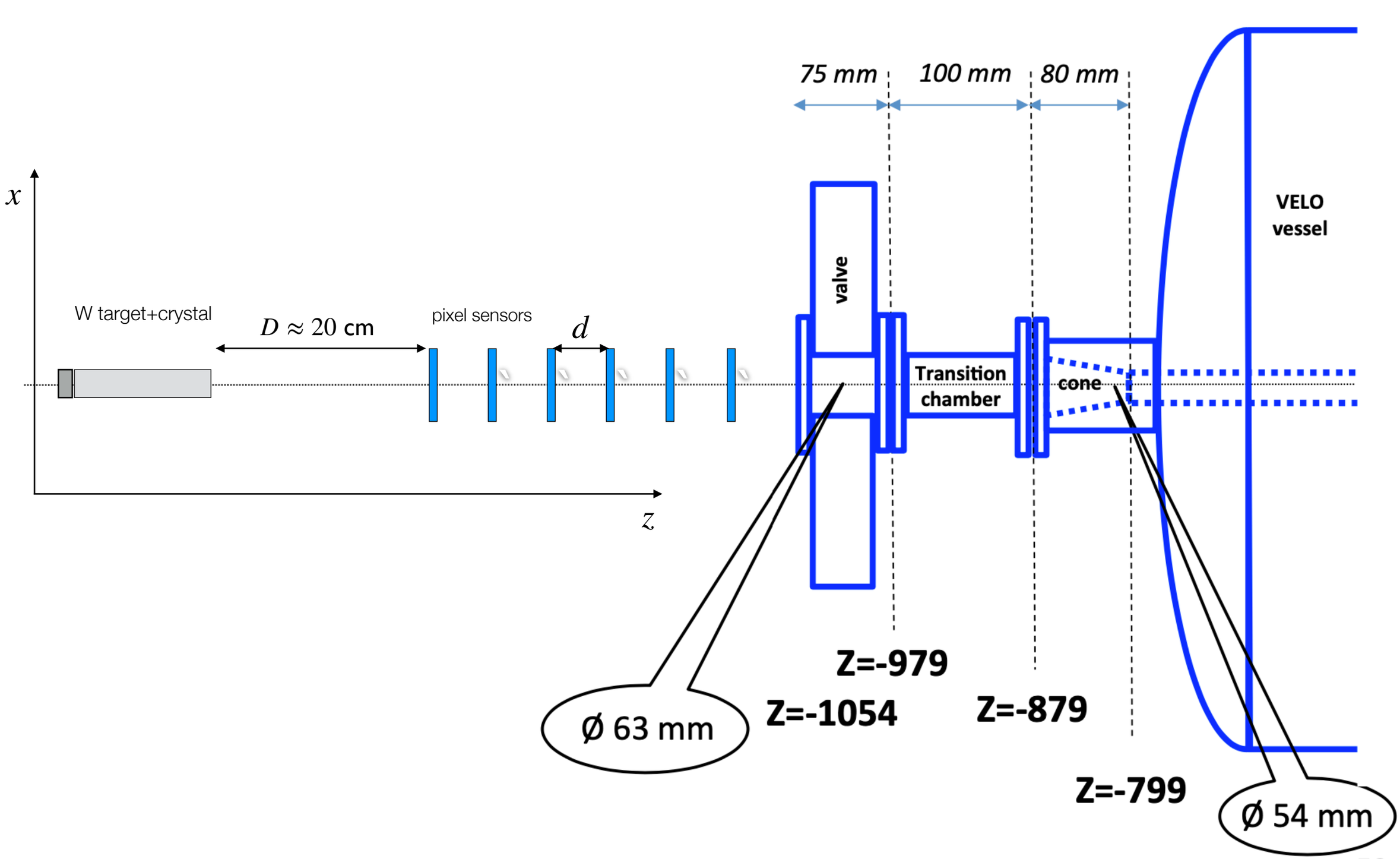


The setup after the LS2 (not in scale)



From P. Di Nezza slides at FITPAN 2018

Proposed layout for 4DLumiTracker and DIPOLE-b fixed target



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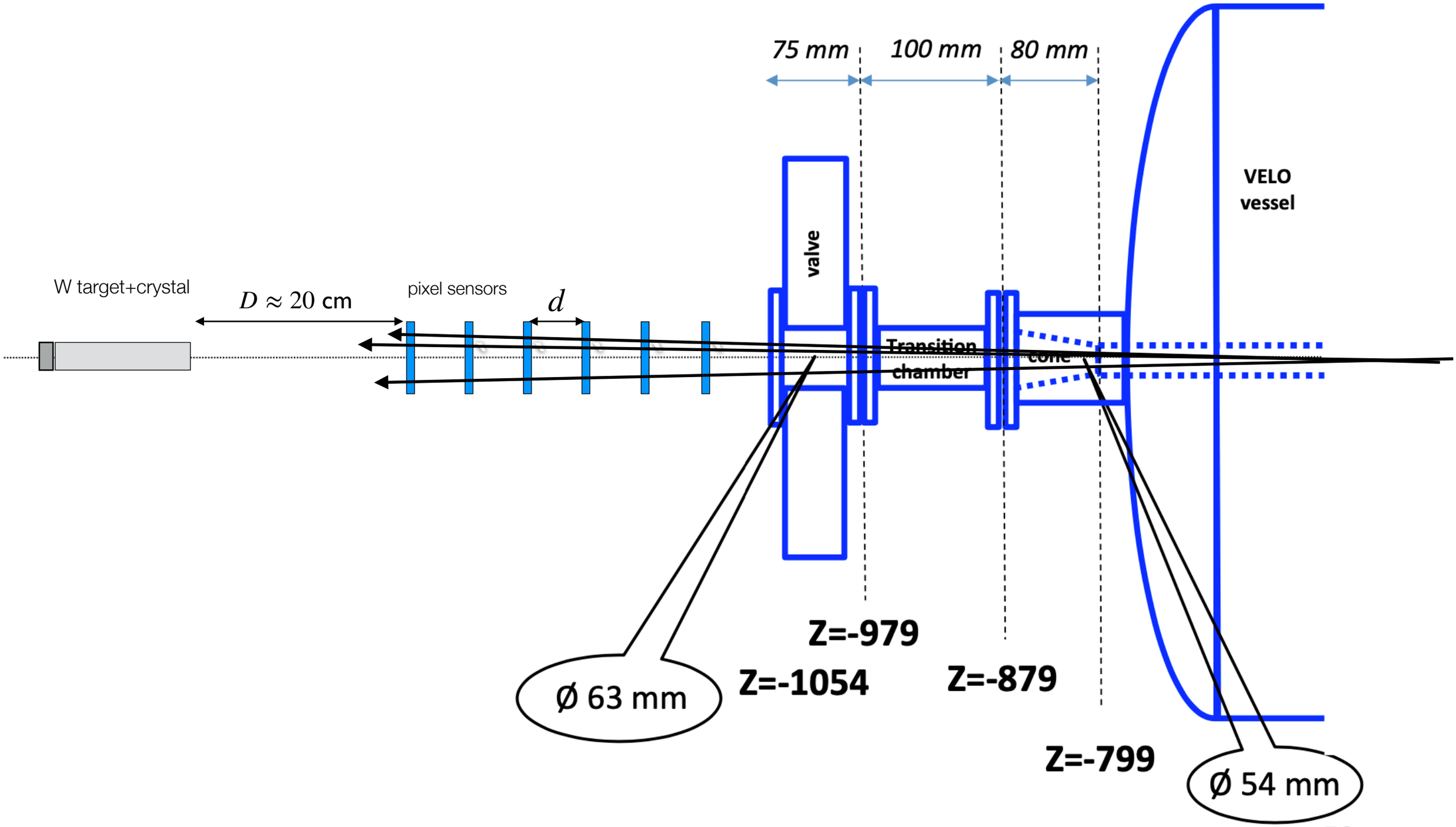

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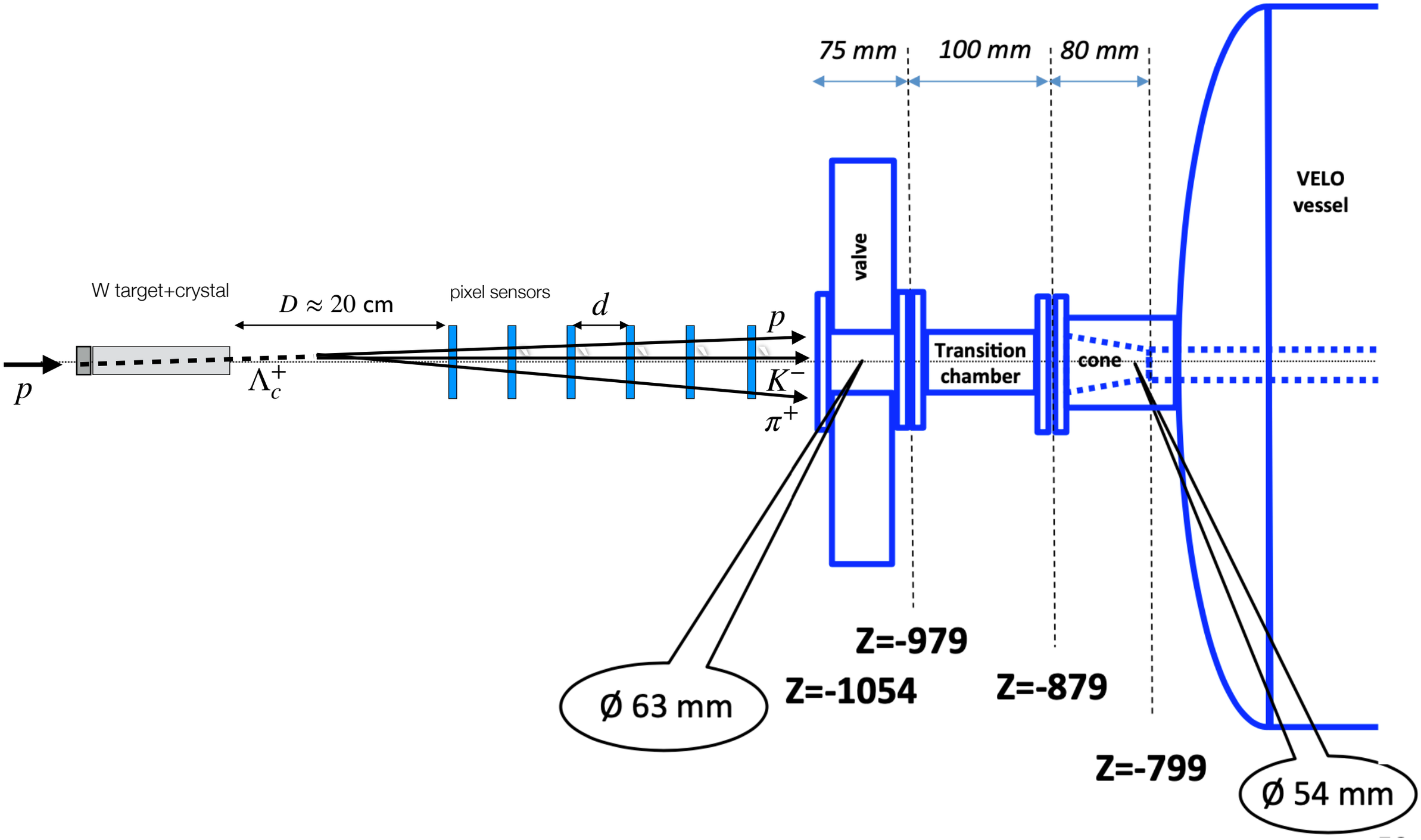
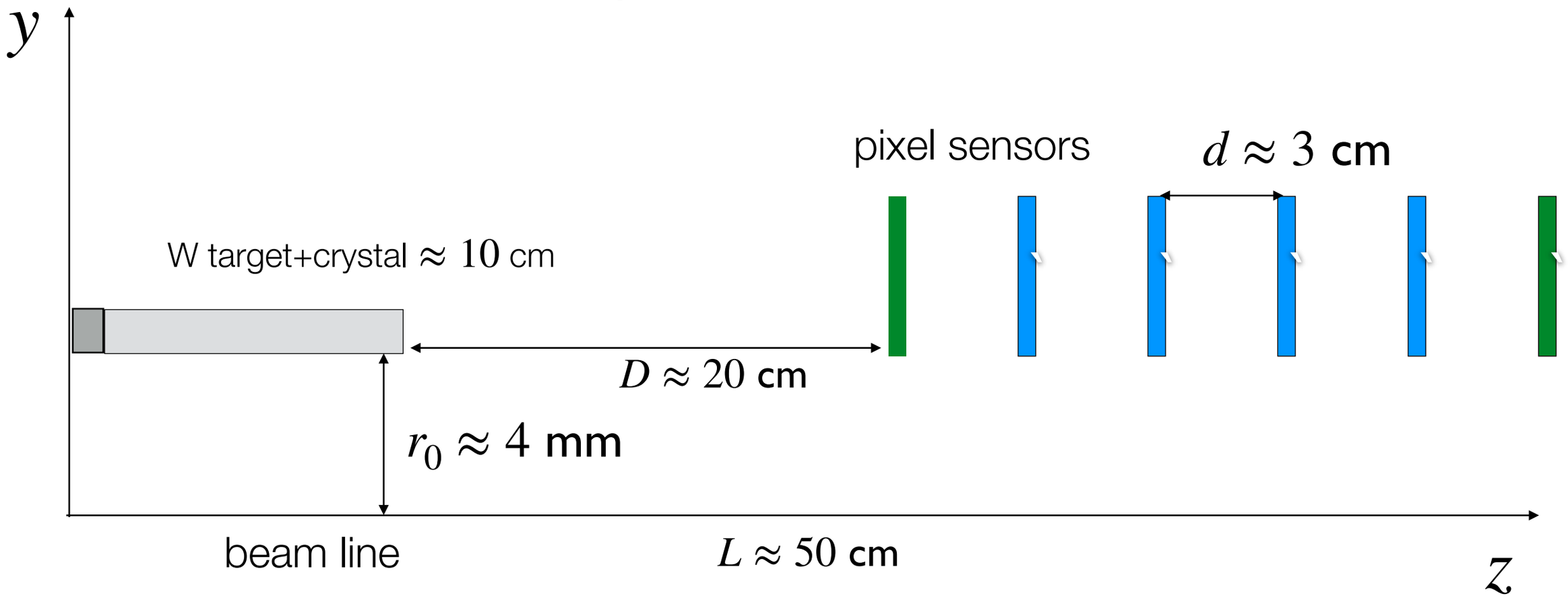


Baseline layout

- 4 VeloPix layers + 2 Timespot layers (aim at 30 ps resolution). Pixel pitch $55\mu m$
- Operations inside the beam pipe and cooling for sensors and Ge crystal



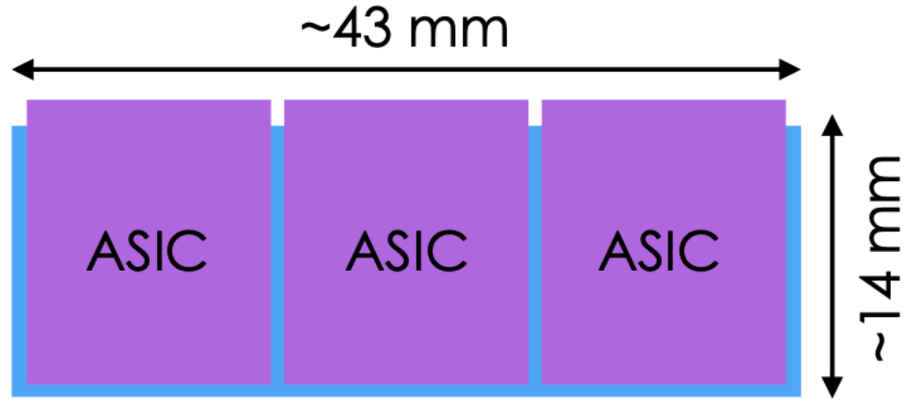
VeloPix sensors and ASIC

- Collaboration and support from VELO group is crucial
- For Timespot sensors and electronics see Adriano's talk

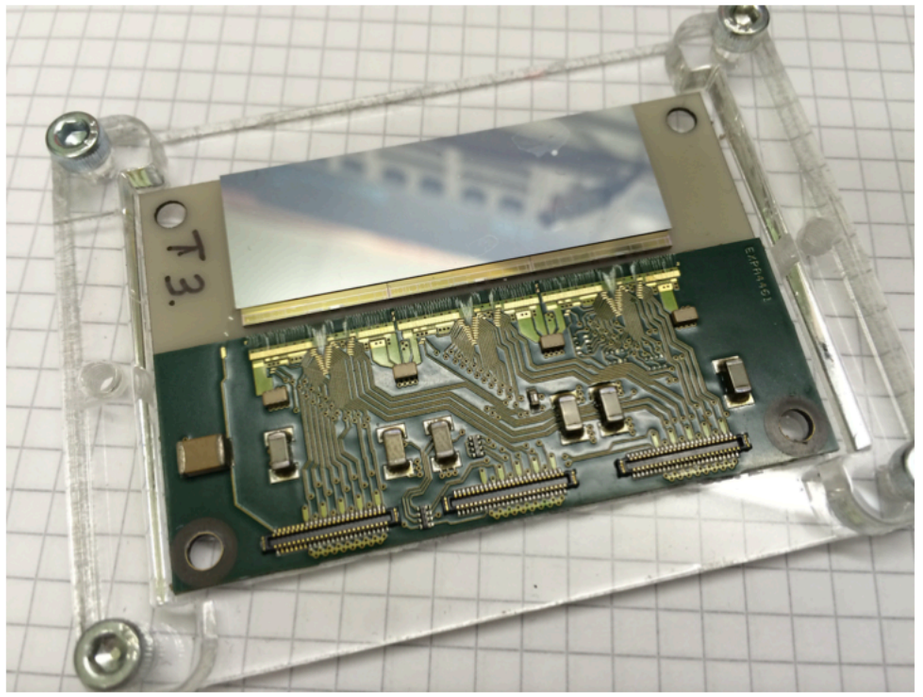
from E. Dall'Occo slides

The technology is hybrid pixel detectors

- **sensor**: triple used for the VELO upgrade
- **ASIC**:
  - Timepix3: charge and time info
  - VeloPix: higher pixel hit rate and readout chain ready (from VELO)



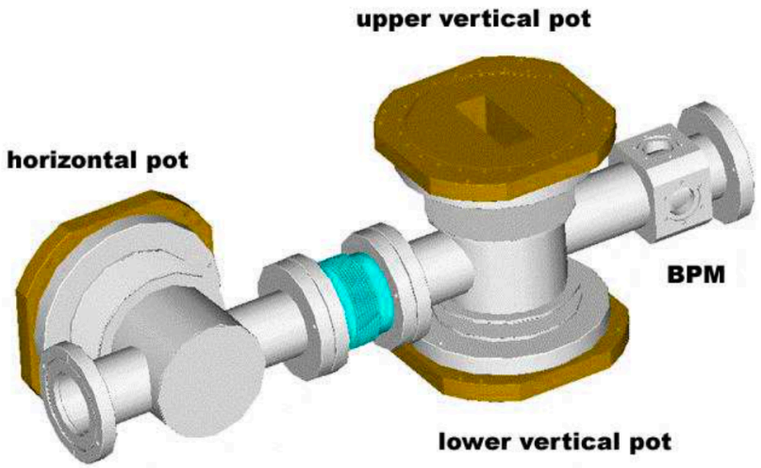
Specification	Timepix3	VeloPix
pixel size	$55 \times 55\,\mu m^2$	$55 \times 55\,\mu m^2$
matrix size	256×256	256×256
timestamp resolution	1.56 ns	25 ns
Time over Threshold	yes	low rate only
peak pixel hit rate	80 MHit/s	900 MHit/s
power consumption	< 2 W/ASIC	< 3 W/ASIC
radiation hardness	no spec.	> 400 MRad
single event upset robust	no	yes



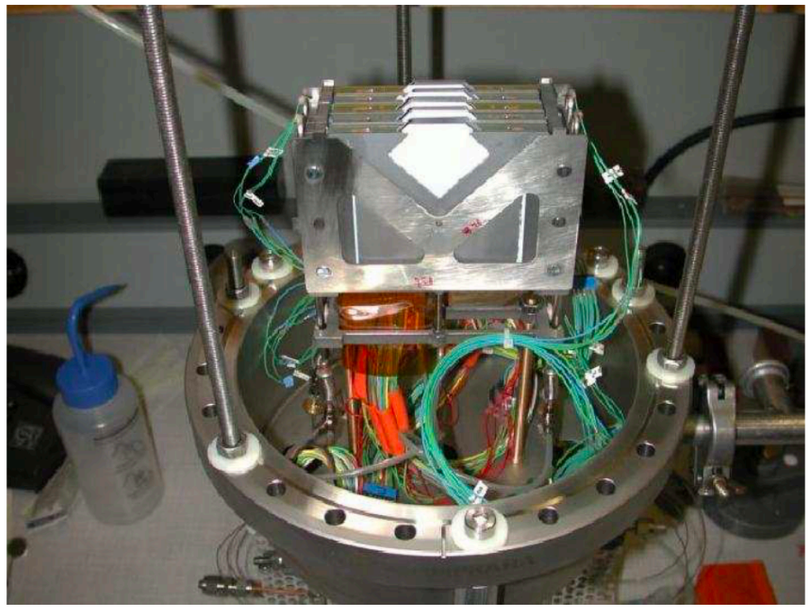
Operations in the beam pipe

- Detector and crystal to be placed inside a Roman Pot. Several examples at LHC, e.g. AFP, ALFA, TOTEM

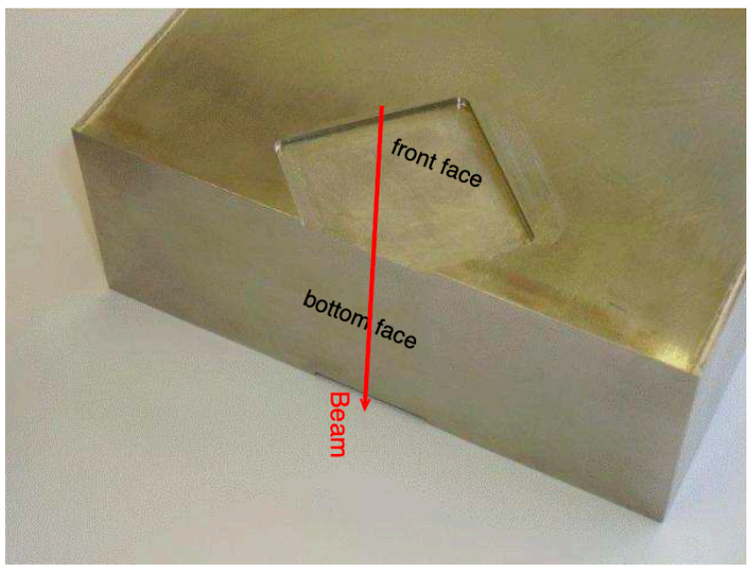
Totem experiment *JINST* 3 (2008) S08007



Detector package



Ferrite collar to reduce beam coupling impedance

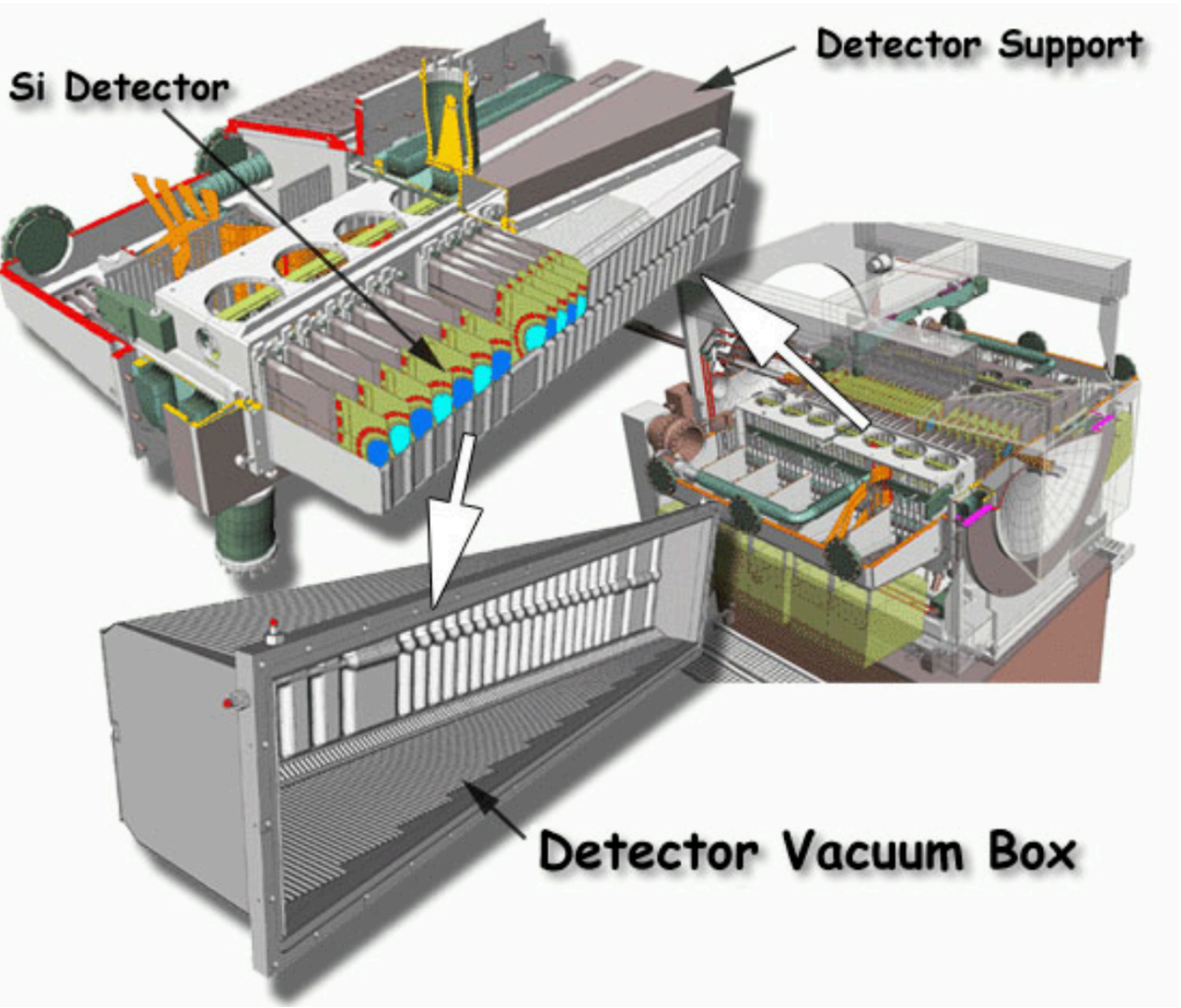


Front face
0.5 mm thick

Bottom face
0.15 mm thick

Operations in the beampipe

- VELO detector: modules are separated from primary vacuum by a thin aluminum foil (RF foil)



Thinned by etching
Thin region 150 μm

Cooling

- Pixel sensors and electronics need to be cooled down below 0 °C (VELO sensors –20 °C)
  - is CO_2 microchannel cooling the only solution for pixel sensors? Can we find a simpler solution?
- Ideally we would like to cool the germanium crystal at 77 K (liquid nitrogen)
  - in principle no problem to cool Ge at 77 K. Is it feasible inside a Roman Pot?

Ongoing studies

- Simulations of tracker performance and determination of optimal configuration for
  - beam and luminosity monitoring
  - Λ_c^+ decay vertex resolution
- Mechanical design and remote control
  - compliant with operation in (secondary) vacuum
  - accuracy on crystal position, angle: 10 μm, 10μrad
  - radiation hardness

Work breakdown structure

- Roman pot stations
  - Roman Pot (RP) , motor, goniometer, flanges, interlock system
- Silicon Tracker
  - sensors, ASIC, bump-bonding, flex, assembly
- Bent crystal
- Trigger&DAQ
- Infrastructure
  - cooling, HV and LV, secondary vacuum, cables
- Installation
  - beampipe, RPs, cables

Next steps

- Identify group interests and available manpower
- Start an official LHCb activity and invite other interested groups to contribute
- Organise a more detailed work breakdown structure
- Organise bi-weekly meetings for the moment