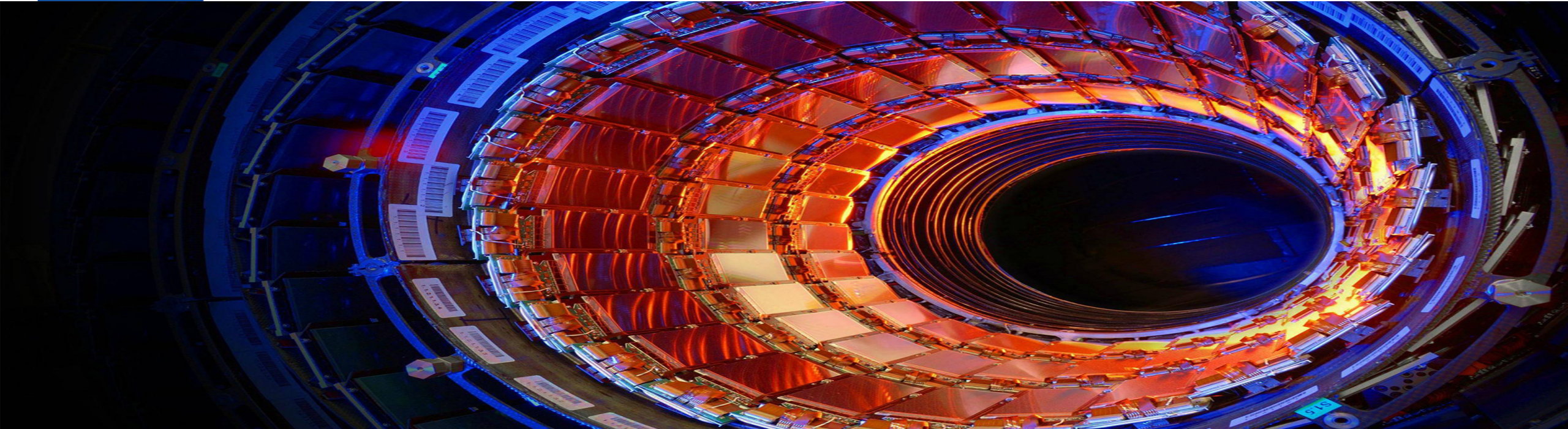




JRA2- Fixed Target Experiments at the LHC

Pasquale Di Nezza (INFN-LNF) Cynthia Hadjidakis (IJCLab Orsay)

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WP objectives:

- ◆ Investigation and implementation of fixed-target experiments with ALICE and LHCb detectors at high-luminosity
- ◆ Develop new theoretical ideas (rare events, large rapidities, ...)
- ◆ Quantify phenomenological opportunities with ALICE and LHCb in fixed-target modes
- ◆ Benchmark selected observables using realistic simulations

Fixed target collisions at the LHC represent a unique possibility for a laboratory for QCD and astroparticle in unexplored kinematic regions

Three tasks defined:

- ◆ Task 1: Feasibility studies in ALICE
- ◆ Task 2: Gas-target development in LHCb
- ◆ Task 3: Phenomenological and theoretical studies

ALICE-FT progress

Possible fixed-target systems [CERN-PBC-Note-2019](#)

- beam splitting with bent crystal and solid target in the beam pipe

Solid target setup

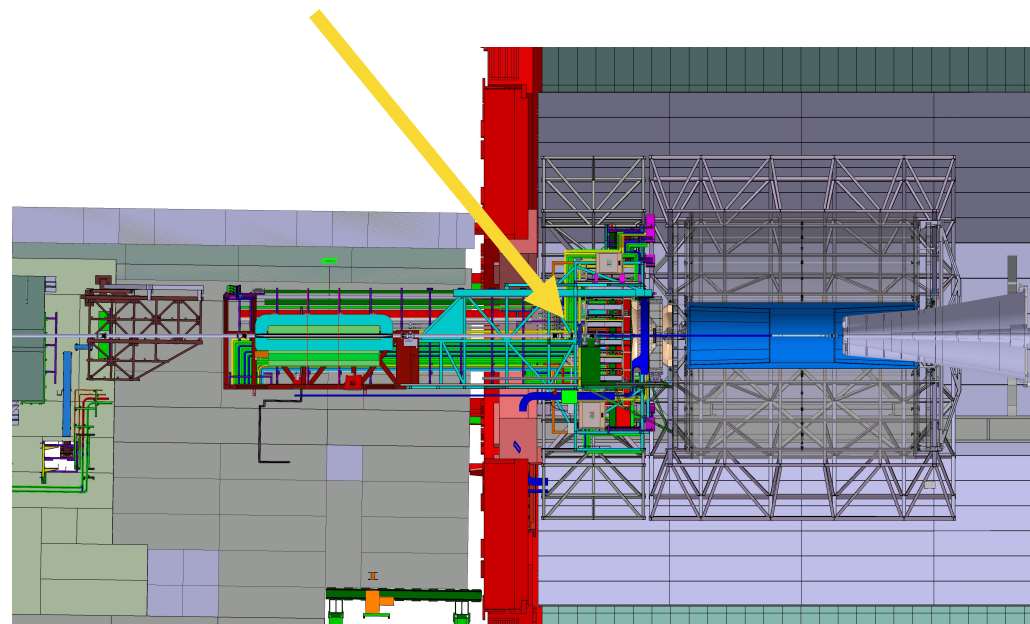
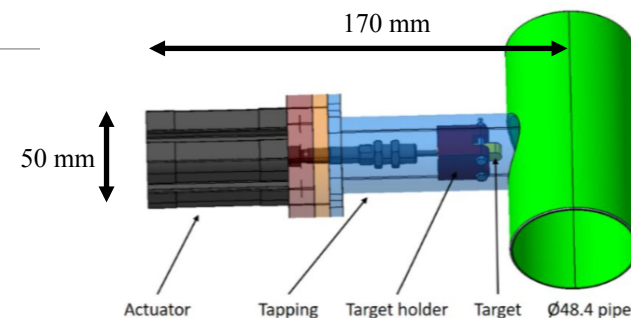
- Pneumatic motion system with several target positions (IN and OUT of the beam pipe)
- Various target types possible: from Be to W
- Target length from ~100 μm to 1 cm (depending on beam flux on target)

SPS test beam preparation (2021/2022)

- Test and validate the crystal + target configuration
- Design a prototype of the ALICE target setup and test it at SPS

Target integration

- Possible space defined: ~5 m upstream of IP2
- Impact on ALICE detectors: ongoing
- FoCal detector LoI (June 2020) aims at LS3 as for the solid target: impact of valve and target setup on FoCal ongoing



ALICE-FT progress

Study of performance of ALICE detector with a shifted vertex

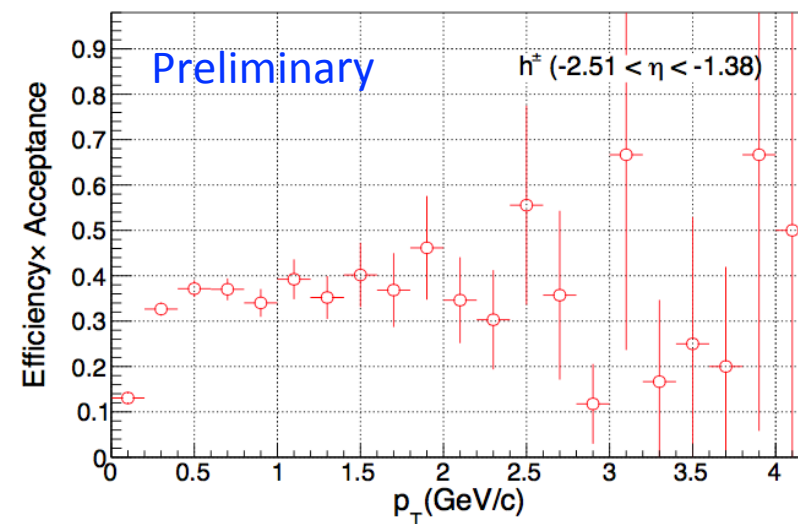
- First simulations started to study the Time Projection Chamber performance located in the ALICE central barrel with a shifted vertex

Towards full simulation

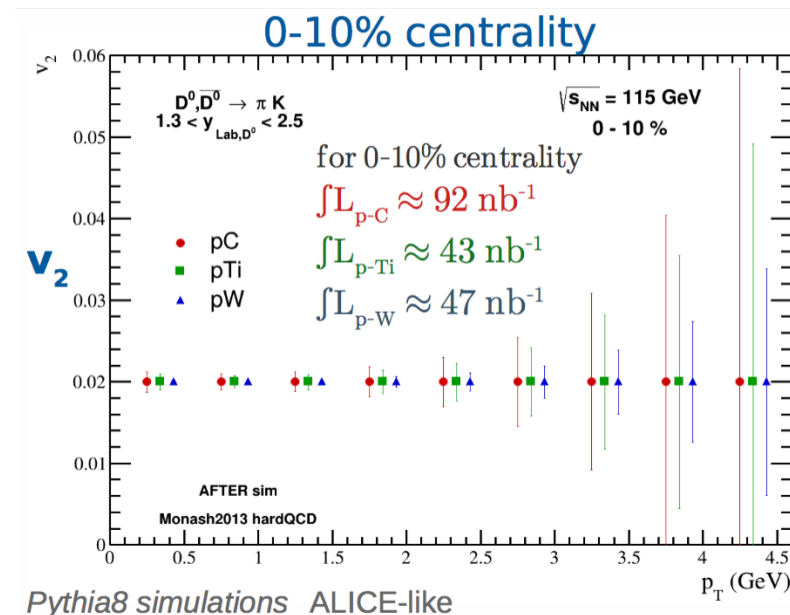
- Feasibility studies with fast simulation for charmed meson production: simultaneous measurements of R_{CP} and v_2 in pC, pTi and pW to study collectivity and cold nuclear matter effects in pA collisions

Polarised gas-jet target (delivery D20.2)

- Additional constraints with FoCal
- Polarised gas-jet target not investigated further due to its size (compact system preferred)

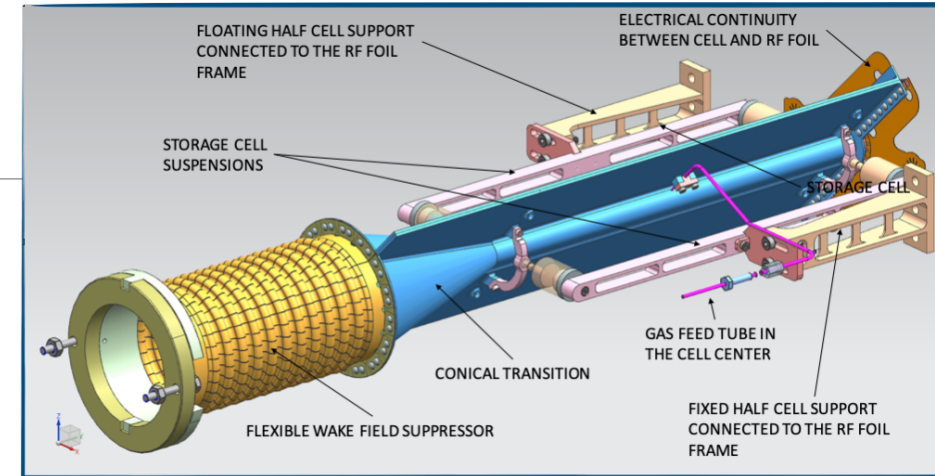
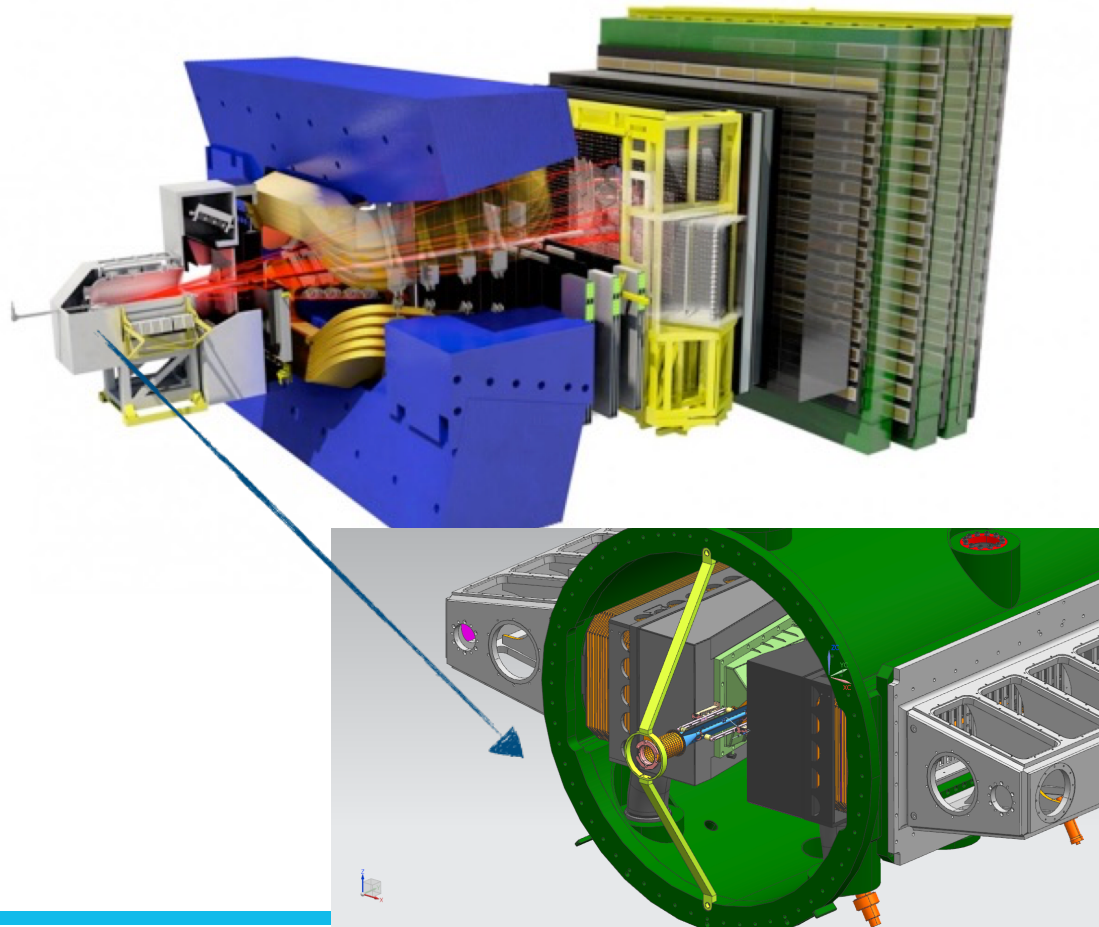


Md Rihan Haque

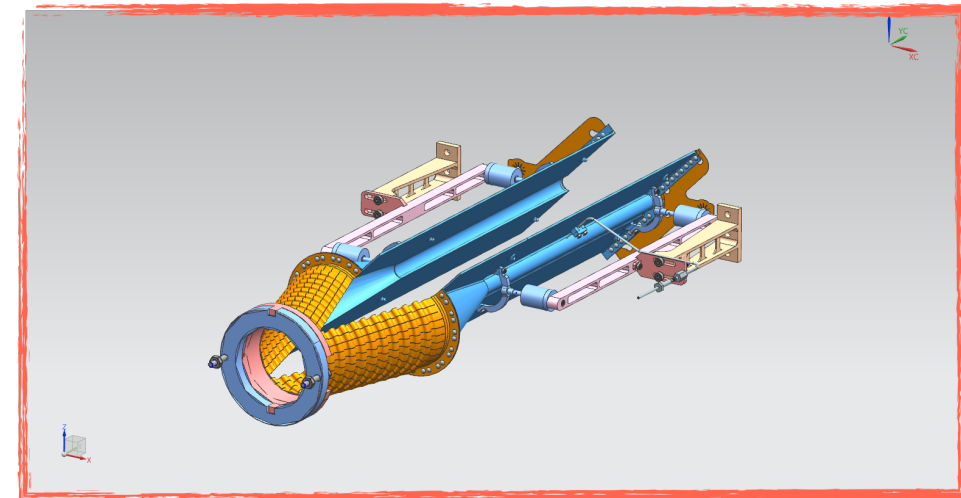


B. Trzeciak HP2019

LHCb – The storage cell

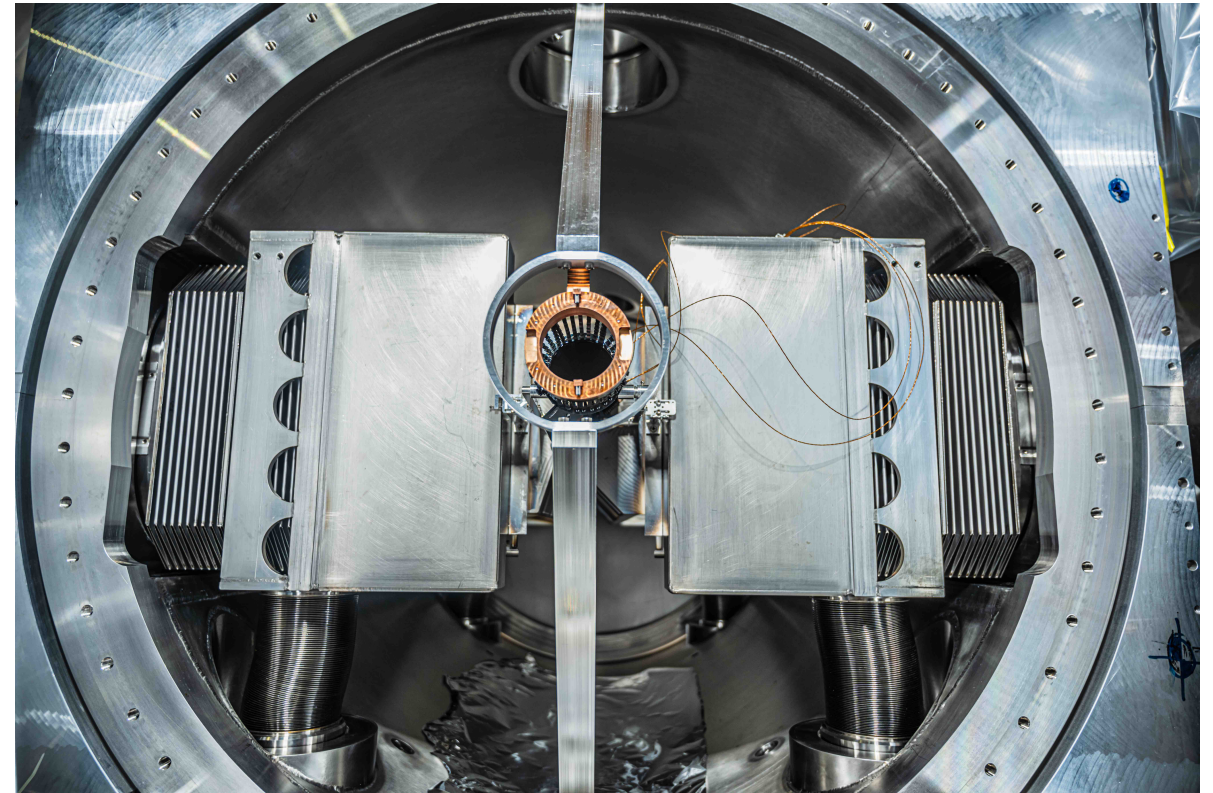
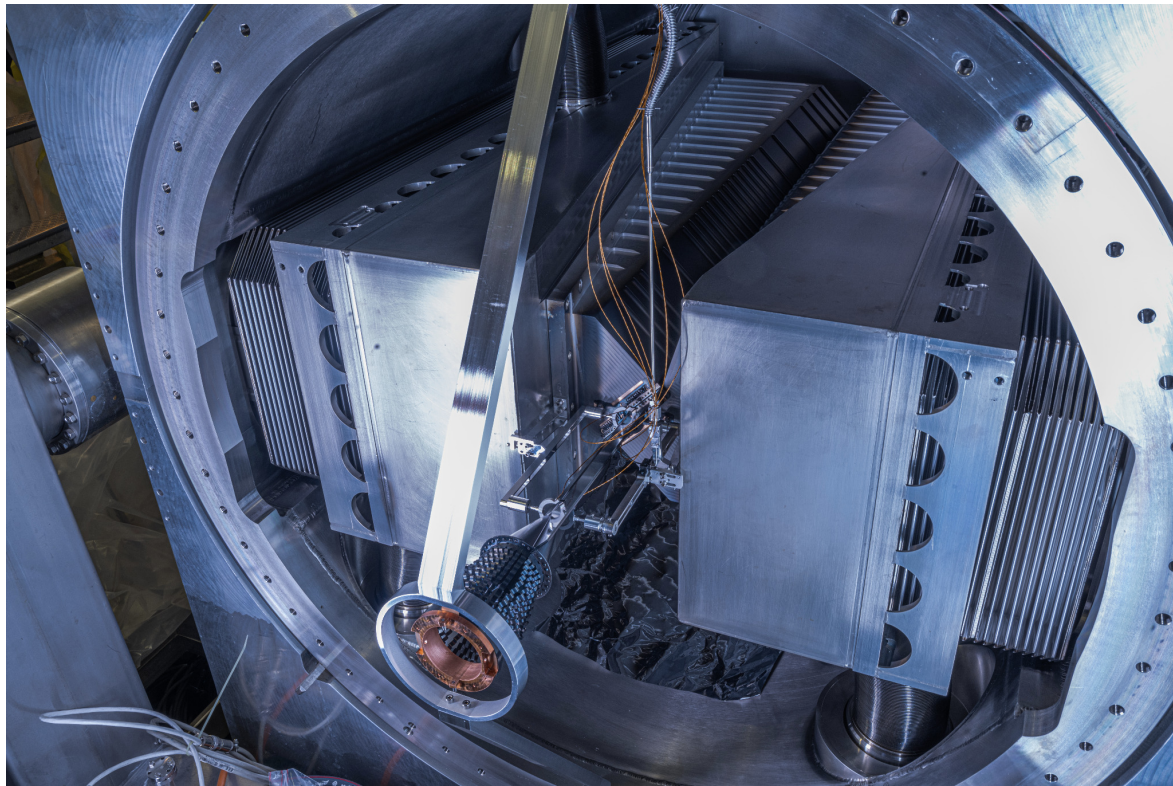


Openable cell



The storage cell has been installed

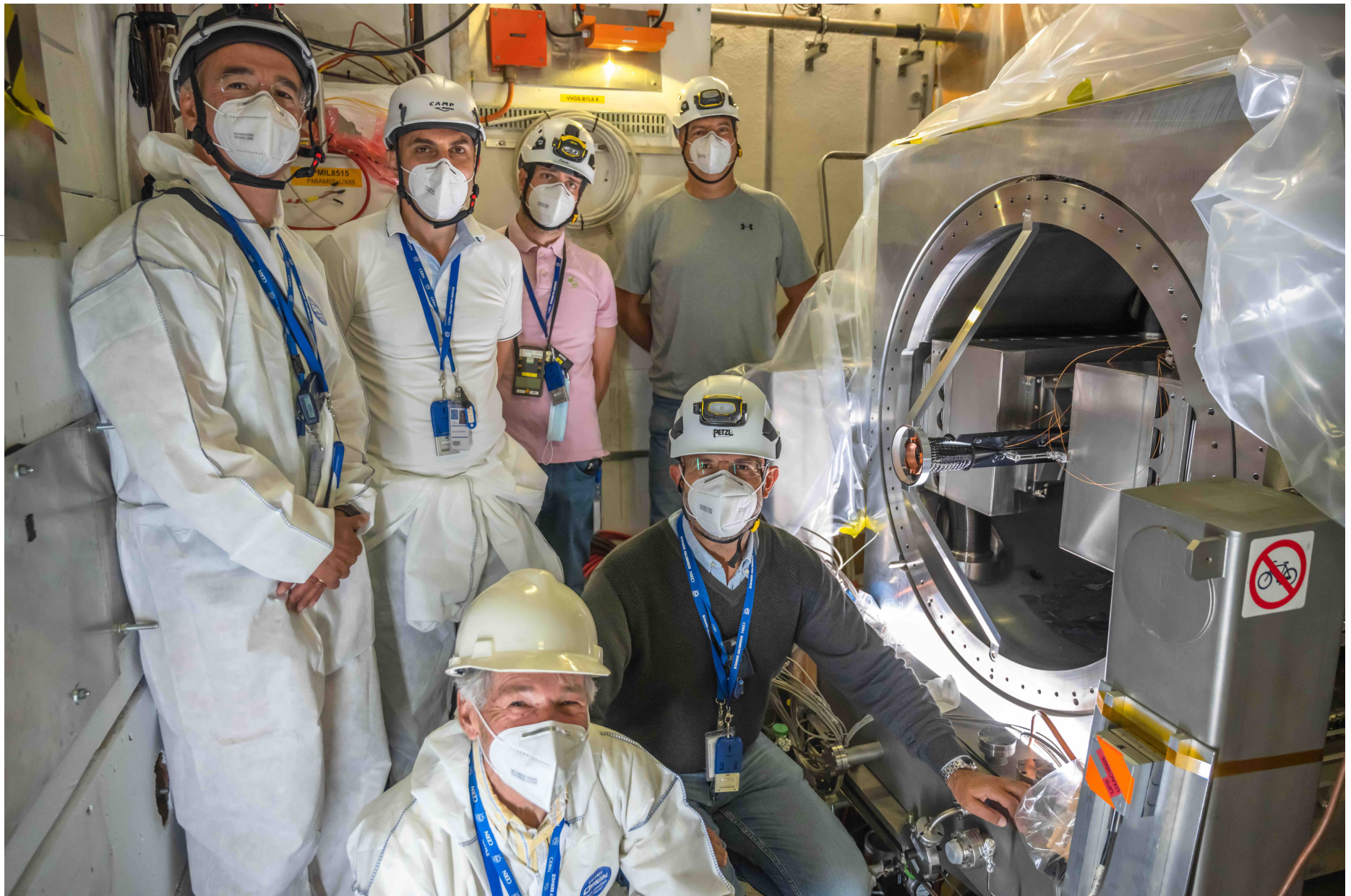
It is the only object present in the LHC primary vacuum



August 2020

SMOG2 team
during the
installation

August 2020



The Gas Feed System

Luminosity studies

3 (noble gases) + 1 (H/D) lines
It is still in its construction phase
It will be installed at the end of 2021

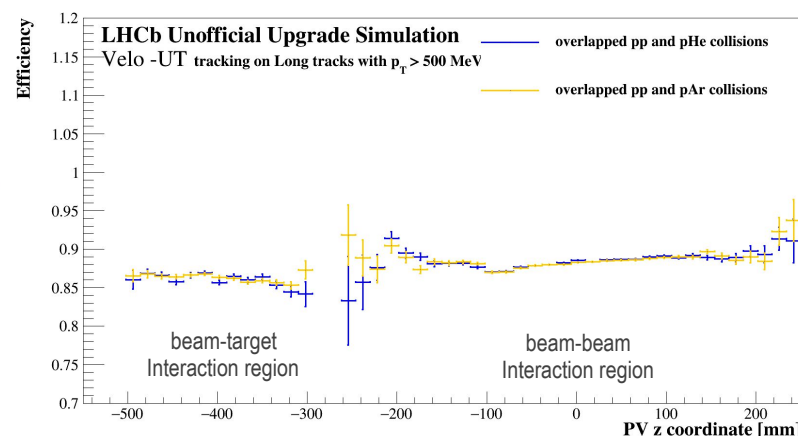
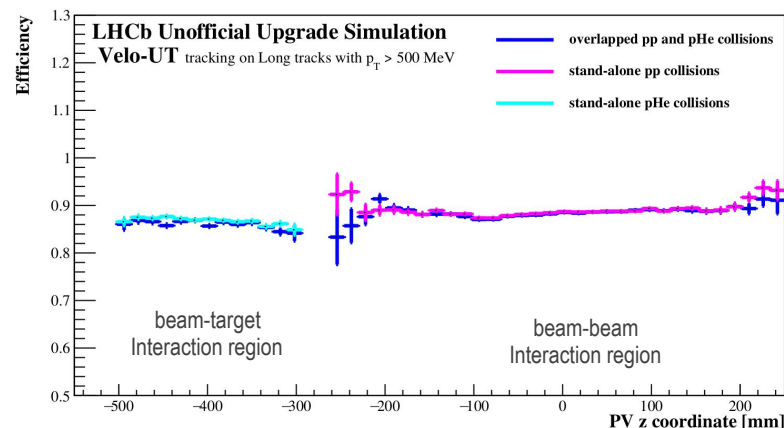
Contributions to the luminosity systematic uncertainty:

Molecular Dynamics (Molflow): 0.5 %
Temperature: $T < 0.1 \text{ K} \rightarrow$ negligible
Leakage: wings ensure a negligible conductance along the cell edges $\rightarrow$ negligible
Sticking Factor: 1.4% (pessimistic estimation)
Geometry: real geometry measured by CMM $\rightarrow$ negligible
GFS: $< 1\%$ (to be confirmed after the calibration of the whole system)

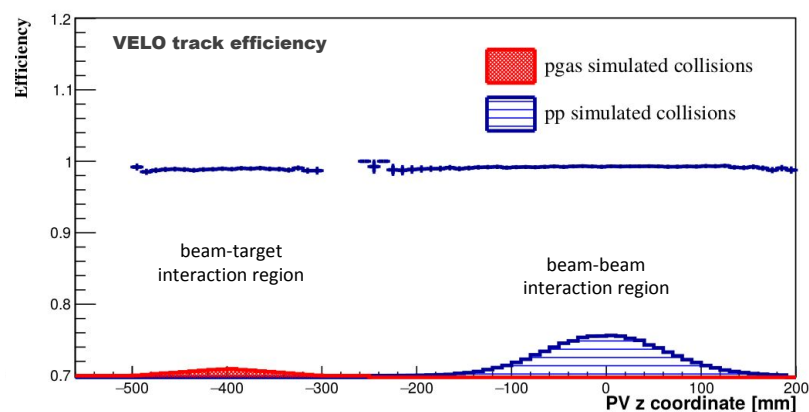
Total expected uncertainty on luminosity $\sim 2\%$ 
(slightly dependent on the gas: worse for H_2 than for Xe)



Event Reconstruction within the LHCb framework



In parallel data acquisition pp and p-gas the data flow increases of 1.5 - 3.1% (from H to Ar)



- ◆ For long tracks the p-gas efficiency is 1-2% smaller, it does not affect pp and it is independent on the gas injected
- ◆ For short tracks (vertex reconstruction) the efficiency is basically identical (~100%) for pp and p-gas

R&D for Polarized Target at LHCb

- Storage cell drawing: ADVANCED

- Aperture studies: FINALIZED

At HL-LHC-25ns, LHCspin can reach $L=8.3 \cdot 10^{32} \text{ cm}^{-2}\text{s}^{-1}$

- Electron clouds: FINALIZED

- Coating: IN PROGRESS

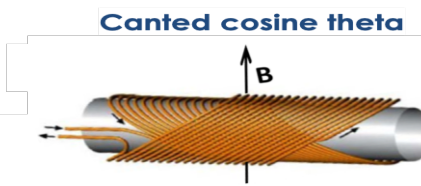
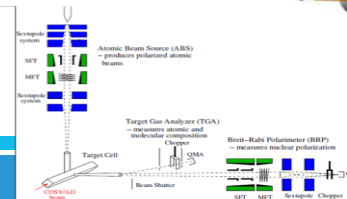
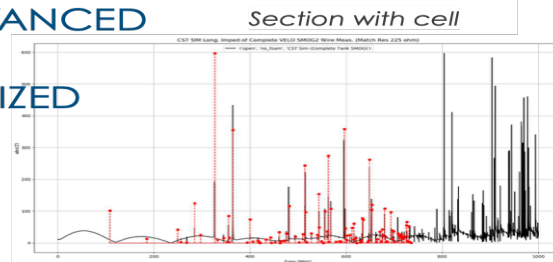
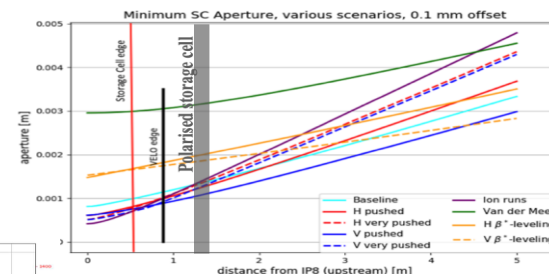
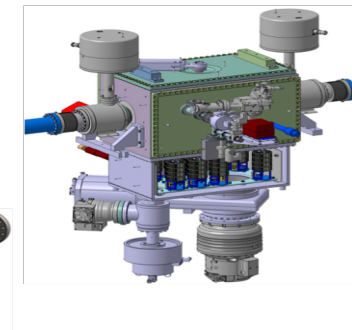
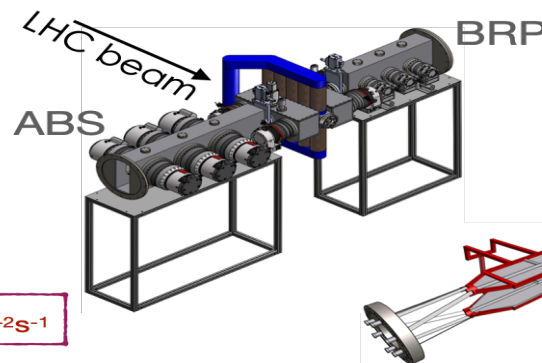
- Impedance and beam stability: ADVANCED

- Beam Induced Depolarization: FINALIZED

- Transverse Magnet: IN PROGRESS

- Compact ABS+BRP: IN PROGRESS

- Additional tracker: TO BE STARTED



Pheno progress

Identified particles in pA in a fixed-target mode with the LHCb setup

- PhD started at USC on measurement of the nuclear modification factor of identified particles both in collider and fixed-target mode in LHCb and phenomenological related calculations

Workshop

- [CERN workshop](#) 7-8 November 2019: FTE@LHC and NLO Access joint kick-off meeting
- Next meeting at CERN: spring 2021

Physics Beyond Colliders

LHC fixed target experiments

CERN Yellow Reports: Monographs CERN-2020-004

Manpower

Generally, delay in hiring postdocs due to Covid

1. Feasibility studies in ALICE

- Md Rihan Haque in WUT since April 2020 (2 year postdoc)
- Charlotte Van Hulse in IJCLab since September 2020 (1 year postdoc)

2. Gas-target development in LHCb

- Barbara Passalacqua at Ferrara (PhD co-funding)
- Marco Santimaria at LNF from November 2020 (2 year INFN postdoc)

3. Phenomenological and theoretical studies

- Sara Sellam in USC since September 2020 (PhD co-funding)

Plan: schematic achievements

1 Work performed

ALICE: **i)** a first version of the solid target design was achieved and its integration within ALICE is under discussion; estimation of the material budget of the target system design and its impact on the ALICE detectors has started as well; **ii)** first simulations have started for studying the tracking performance with the Time Projection Chamber located in the ALICE central barrel;

LHCb: **i)** All the studies connected both to LHC and LHCb have been completed, the approval of the Technical Design Report (CERN-LHCC-2019-005) brought to the construction and then to the installation of the unpolarised target; **ii)** Codes for implementing the storage cell into the LHCb simulation and DAQ have been written and included into the experiment's software chain.

Phenomenology: Starting PhD at USC - the proposal includes the measurement of the nuclear modification factor of identified particles both in collider and fixed-target mode and phenomenological related calculations. These measurements will be used to characterize the initial states of the collision and determine the different physical phenomena involved.

2 List of the Deliverables and Milestones achieved

Code for full simulation in LHCb (<https://cds.cern.ch/record/2673690/>)

3 Progress beyond the state of the art, expected results until the end of the project and potential impact

Develop, for the first time, a full program for fixed-targets physics at the LHC