

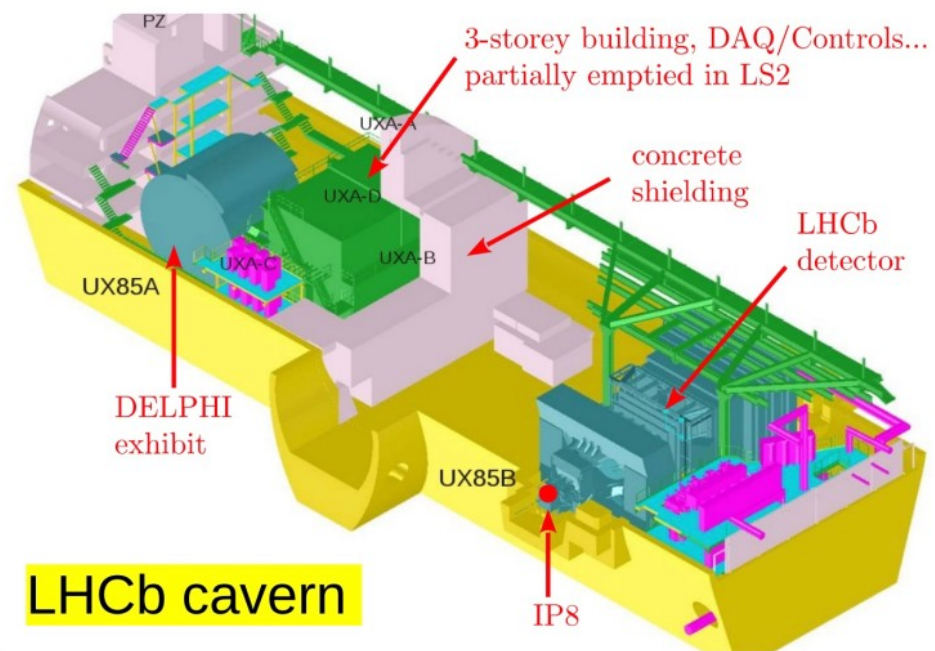
Update on the CODEX-*b* experiment

Louis Henry
CERN, 13/05/2024



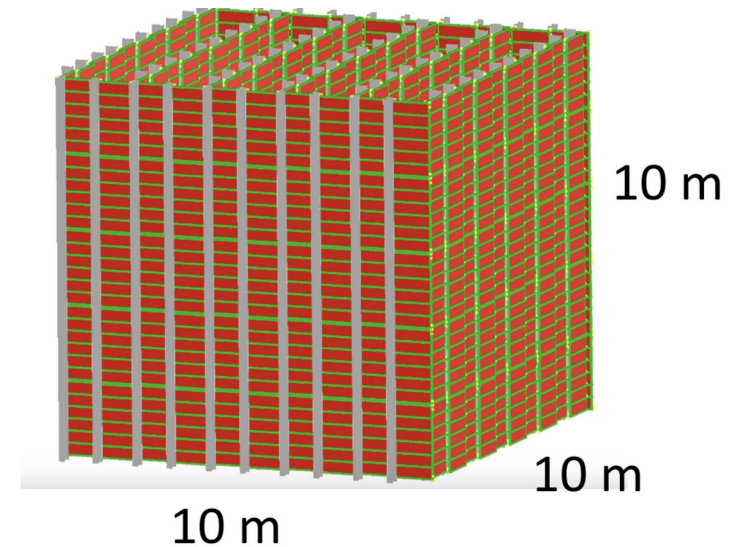
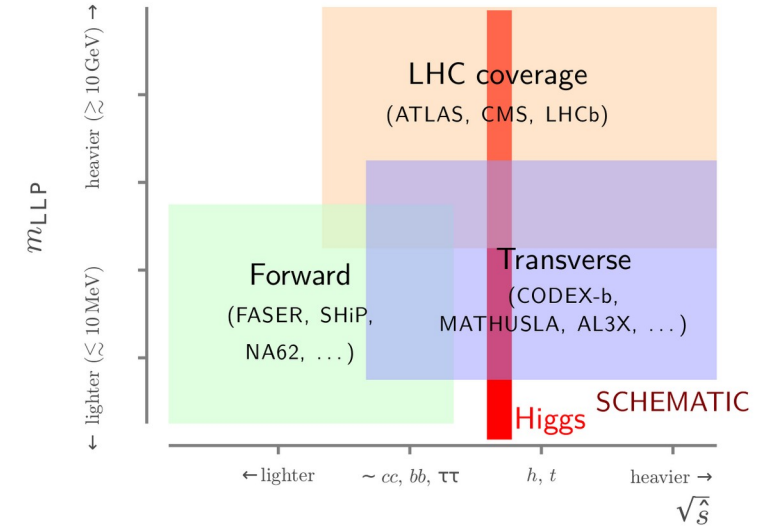
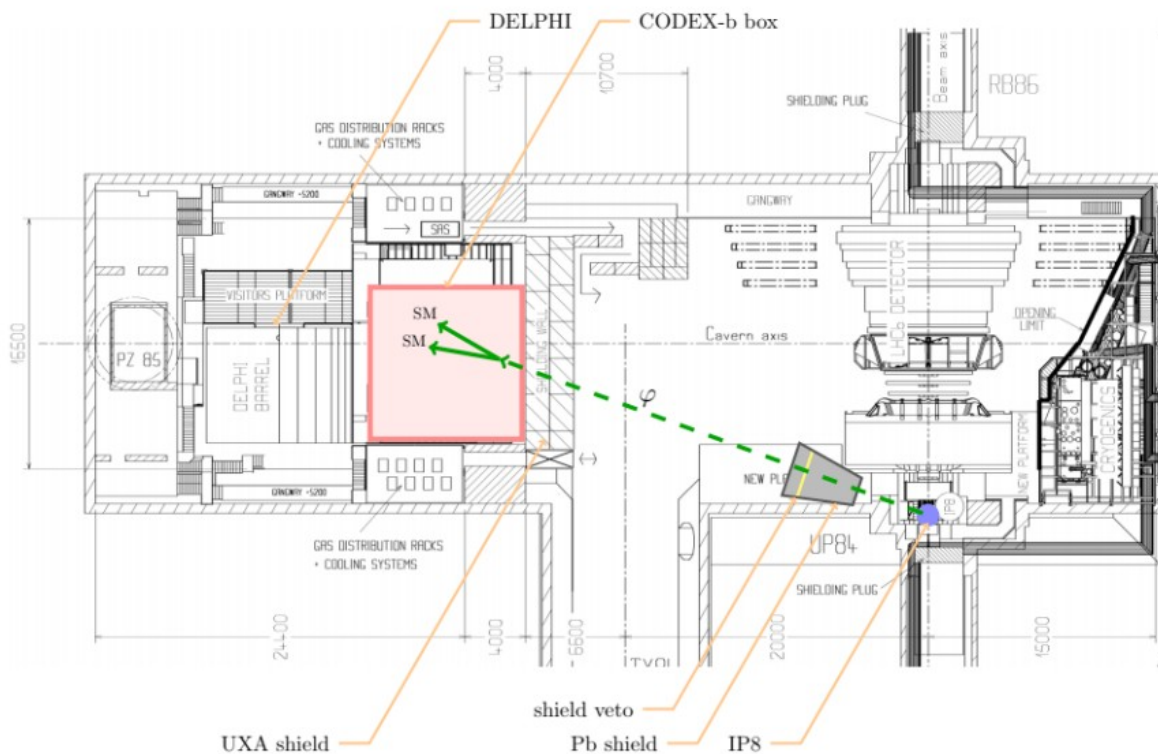
COmpact Detector for EXotics at LHCb

CODEX-*b*



Motivation and experiment design

- LHCb interaction point produces a flurry of particles but instruments **4%** of the solid angle.
- Cheap to add an off-axis (transverse) tracker behind a huge shield and a long distance away from LHCb, in preexisting cavern: **CODEX-b**.



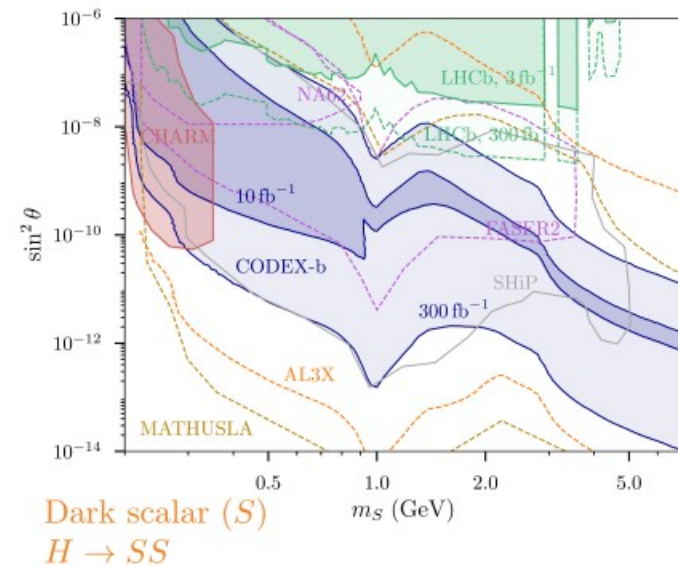
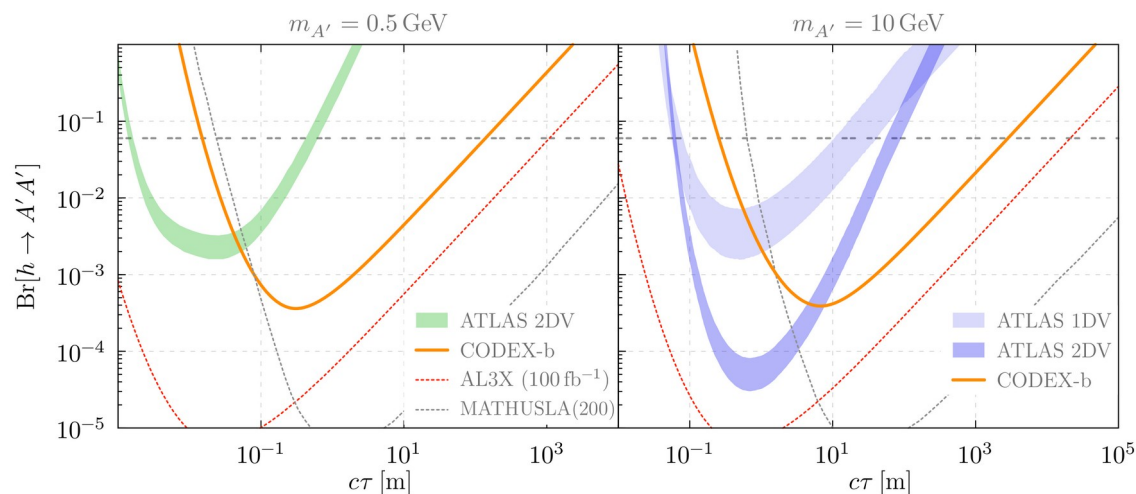
Physic motivation and reach

- More in [1911.00481](#) (HNLs, ALPs, ...).

Vector (A')	$hA'A'$	$F'F$							
$F'F$	Fig. 7	no reach							
	Scalar (S)	$SH^\dagger H$	$S^2 H^\dagger H$						
	$SH^\dagger H$	Fig. 9a	Fig. 9b						
		HNL (N)	$\tilde{H}\bar{L}N$						
		$\tilde{H}\bar{L}N$	Fig. 14						
		ALP (a)	$\partial_\mu a \bar{q} \gamma^\mu \gamma^5 q$	$a\tilde{C}G$	$a\bar{F}F$	$a(W\bar{W} - B\bar{B})$			
			Fig. 11	Fig. 12	pending	pending			

■ Production portal
■ Decay portal
■ UV operator

- LHC is the place to look for dark photons (left), scalar portal (right) interesting too.
 - Complementarity with LHCb.
 - Interesting reach for HNLs, ALPS.



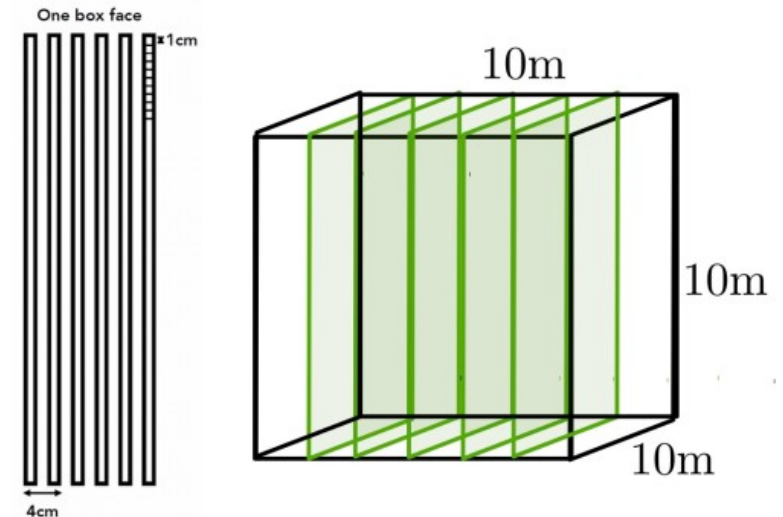
Base layout of the detector

- Far from the primary vertex → large area/volume even with small angular acceptance.
 - Need cheap, efficient and fast detection.
 - Why fast? Interplay with LHCb is easier. For instance, could b -tag an event.

- Answer: Resistive Plate Chambers (RPC's) – fast, precise, cheap for large area. 6 RPC layers at 4 cm intervals on each box face with 1 cm granularity.
 - Additional 5 layers inside (improve vertex resolution and tracking efficiency);
 - 50-100 ps timing from RPC's foreseen for mass reconstruction
 - Mature technology, support from ATLAS.

- No magnetic field, no calorimetry, no Cherenkov
 - Possible to reconstruct mass from geometry, showcased in [Phys. Rev. D 97, 015023 \(2018\)](#).

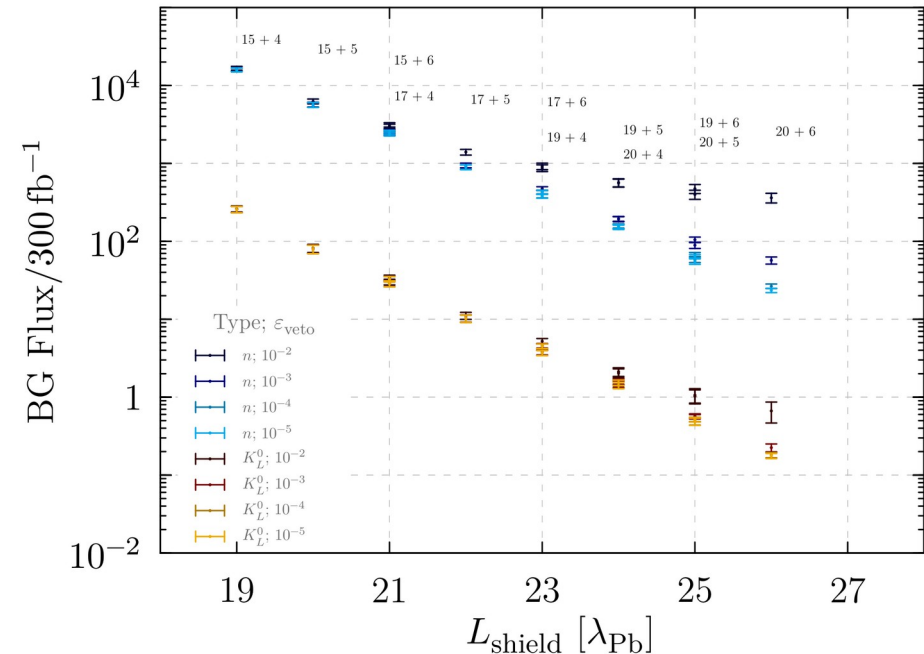
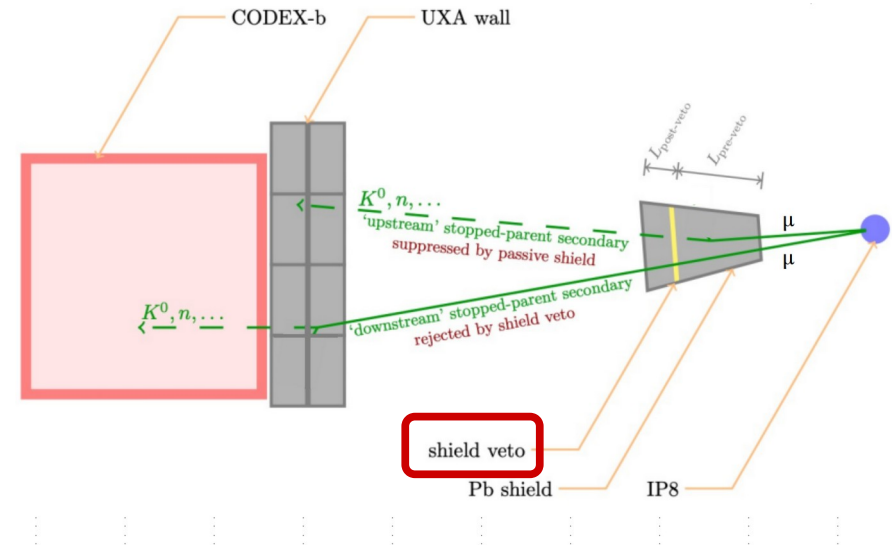
- Coincidence with rest of the event at LHCb being studied



How to achieve 0 background ?

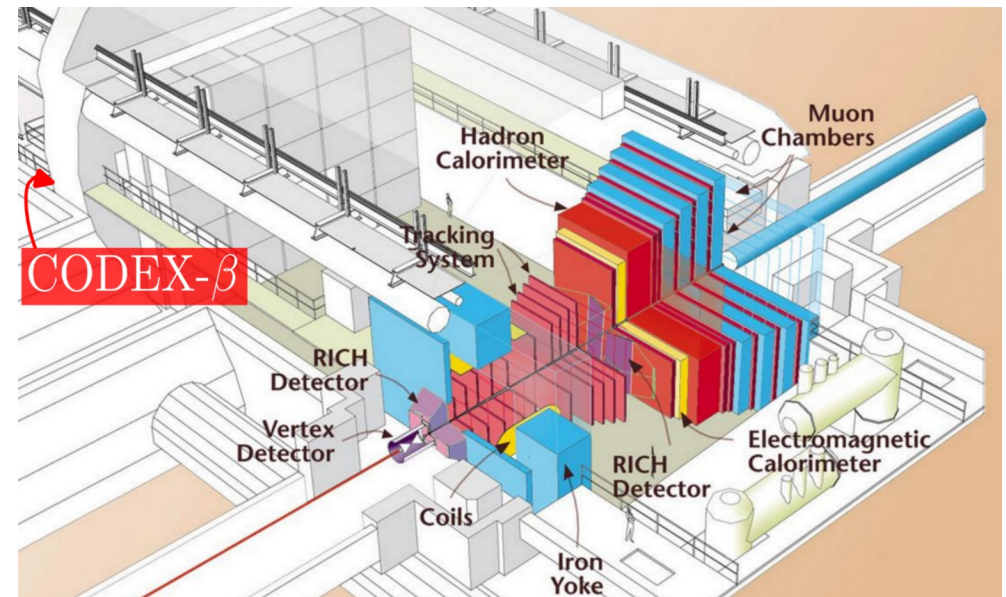
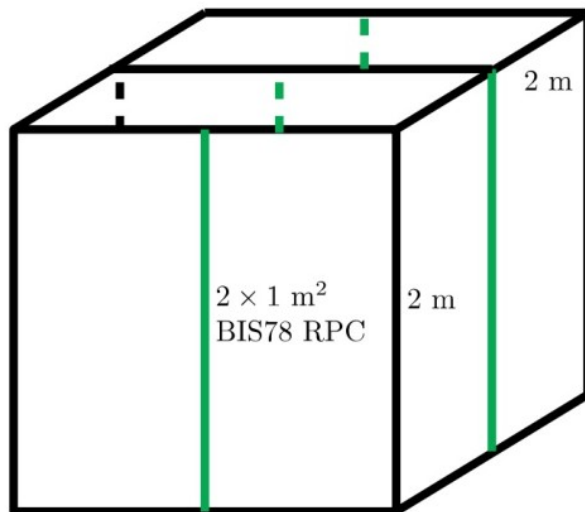
- First answer: let's put a huge shield!
 - 32λ of concrete (7λ)+Pb,W (25λ).
 - Stops the 10^{14} neutrons & $K_L / 300 \text{ fb}^{-1}$.
 - But also gives more chances to muons to interact deep into the shield and shower: **stopped-parent secondaries**.
- Need to use an active shield
 - Deep enough that the rejection rate is much smaller than the event rate
 - Not too close to CODEX-*b*, or else the muon will have been stopped already.
- Nominal shield in so-called '20+5 λ ', in total 12λ from CODEX-*b*.

Less than 1 event expected over entire run of CODEX-*b*



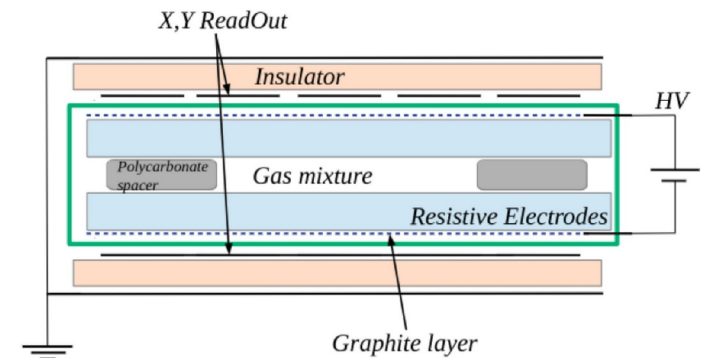
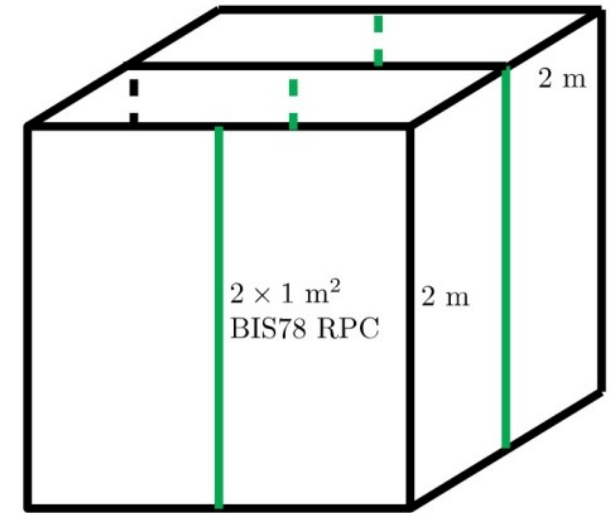
Demonstrator and progress

CODEX- β



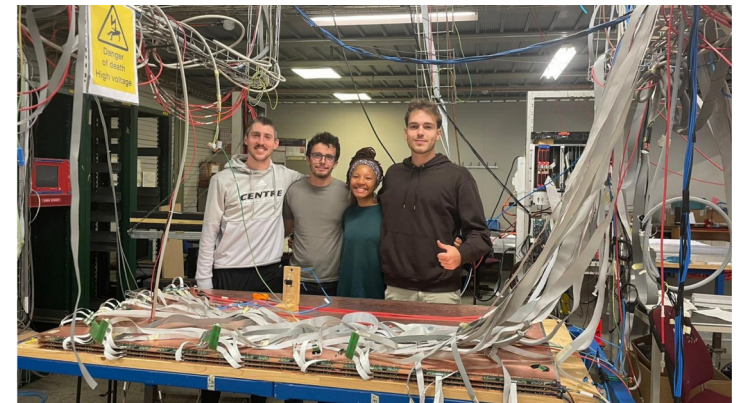
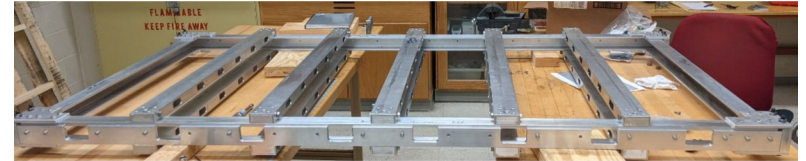
Testing the concept: CODEX- β

- CODEX- b is an HL-LHC detector, but we must do a lot in the meantime.
 - Validate background estimates;
 - Integrate with LHCb data acquisition;
 - Demonstrate suitability of RPC technology;
 - Build expertise in detector production.
- Physics reach limited to 2/4-body.
 - e.g. multibaryonic decays from hidden valley.
- 6 detector faces + 1 inner station: $2 \times 2 \times 2 \text{ m}^3$
 - Use the RPCs developed as part of the ATLAS BIS78 project
- No active veto, so expect $\sim 10^7 K_L$ decays in demonstrator.
- Install during **2024**, take data during **2025**, decommission in **2026**



Progress on the demonstrator

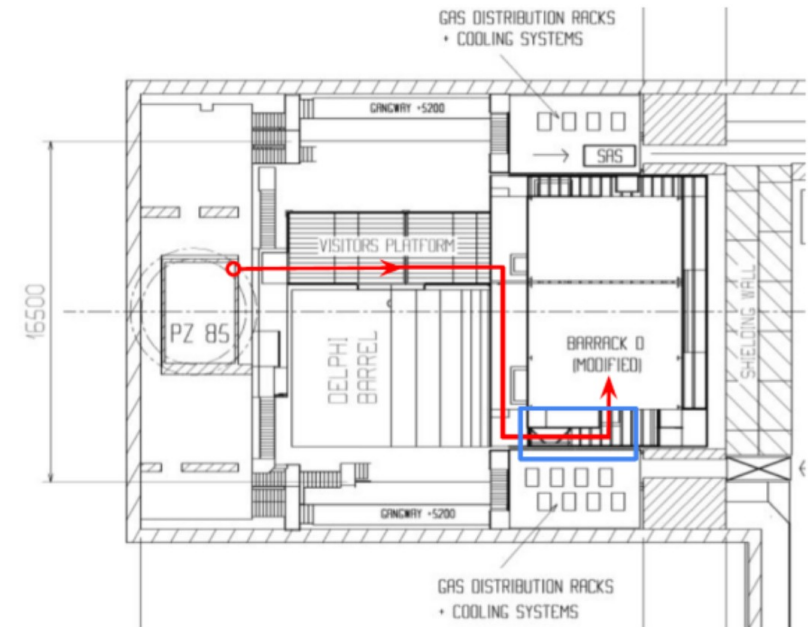
- Mechanical support structure is well developed.
 - Triplet frame redesigned for mechanical needs.
 - 4 of 14 frames built and at CERN.
 - Remaining frames expected at CERN before end of June.
- RPC production on schedule:
 - All 42 panels prepared
 - Readouts attached to 22 of 42 singlets, 22 singlets closed
 - 1 of 14 triplets fully characterized
 - Gas system design and procurement underway
 - Data acquisition is top priority, with self-triggering contingency.
- First frame filled, cabled, and powered!
 - Huge thanks to ATLAS, CMS & ANUBIS.



Installation and to-do

- Gas system to be installed by CERN gas group in June/July
 - Slow controls being developed with LHCb experts
 - DAQ being worked on from both ends (readout from triplet, input to LHCb triggerless system)
 - Urgent need for additional FPGA expertise to make DCT readout LHCb-compatible

- In the next 6 months (incomplete list):
 - Finish singlet and frame production, ship and assemble;
 - Test RPC triplets;
 - Install gas system and build “final mile”;



- Will publish Technical Design Report for CODEX- β this year.

CODEX-*b*: global status

CODEX- β is approved as a 2024-2025 LHCb R&D project

- Perfect time to join:
 - Any contribution will have a large impact!
 - Many different areas: hardware, software, collaboration.
- Next CODEX-*b* week will be at CERN from June 10 – 14
 - No formal commitments required to attend.



