

CODEX-b: The COmpact DEtector for eXotics at LHCb

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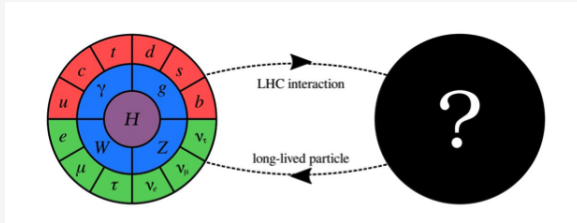
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On behalf the CODEX-b collaboration

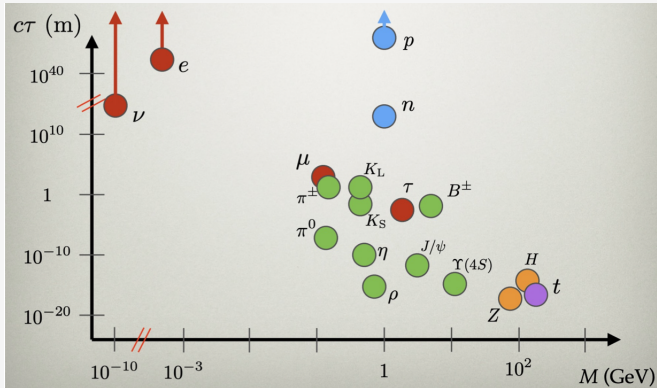
Why no new phenomena so far?

- Several reasons which could explain this issue could be:
 - NP is too heavy to be seen in nowadays' accelerators (HL-LHC).
 - NP is very feebly interacting, need for new degrees of freedom inside the SM.
 - NP is hierarchical or have very small parameters: *hidden sectors* may feature exotic Long-Lived particle decays to usual SM particles.



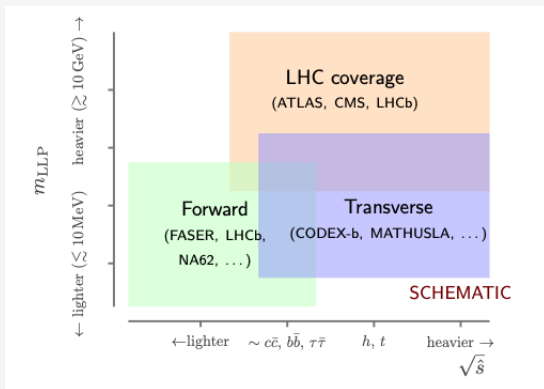
What is a LLP?

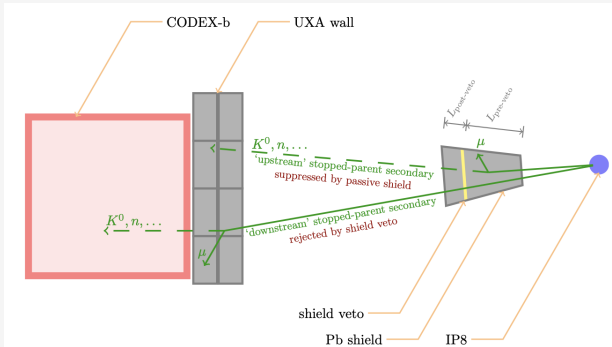
- SM reference: Usual particles can be long-lived if an approximate symmetry makes them stable.
- The same principle can be applied to BSM Physics!
- Several models predict BSM LLPs: Supersymmetry, Hidden Sectors, Higgs Portal...



CODEX-b

- Current detectors specialized in phenomena happening around the interaction vertex.
- Need for specific triggers, reconstruction algorithms and dedicated sim models.

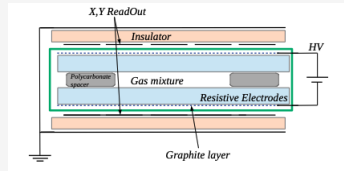
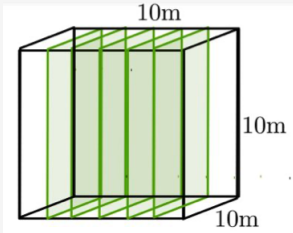


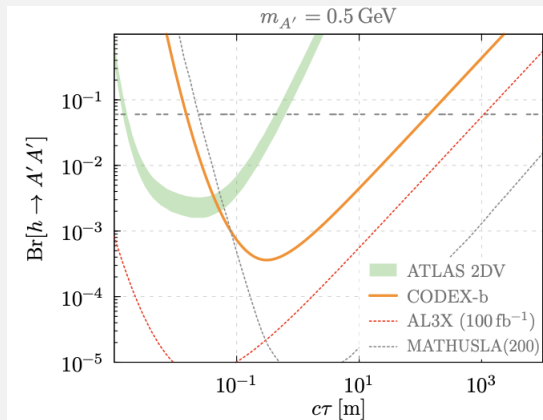


- Expected $\sim 10^{14} n$ and K^0 in $300fb^{-1}$.
- Also muons flying through the shielding.
- Recombinations in the material also dangerous.
- Shielding removes all of these backgrounds.
- Rates and effect of shielding verified in D1 barracks background campaign.

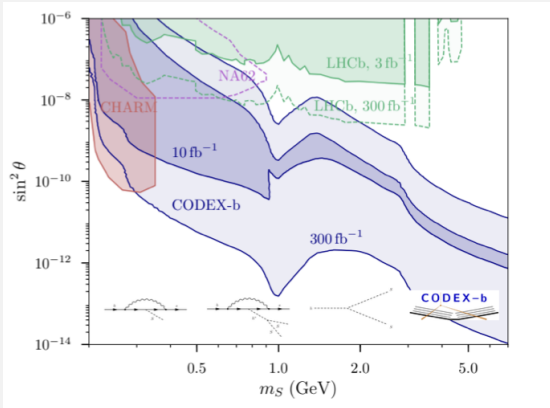
CODEX-b baseline design

- Cubic array of RPCs (inner trackers and instrumentalized faces) mounted on mechanical frames.
- ATLAS BIS-78 technology (3 independent detectors per chamber):
 - 5mm of spatial resolution.
 - 300ps of timing resolution.
- Ensures LLP traceability while vetoing rescattering of soft tracks.
- Specific hermetic coverage.



Abelian hidden sector: $h \rightarrow A' A'$ 

Dark higgs: $SH^\dagger H, {}^2SH^\dagger H$

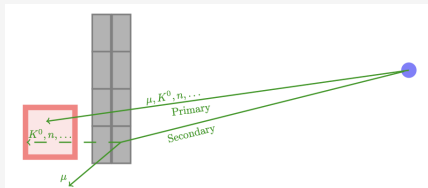
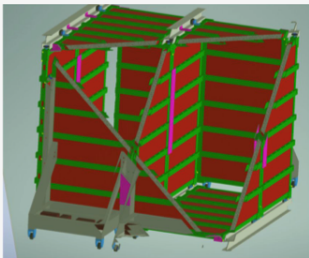


This and more in our expression of interest document:

<https://arxiv.org/pdf/1911.00481>

Design a demonstrator: CODEX- β

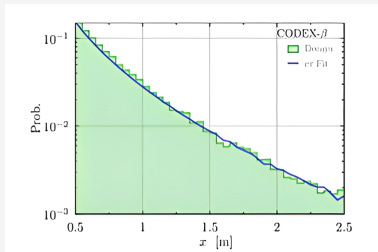
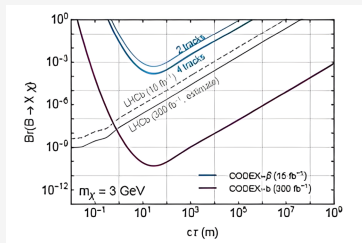
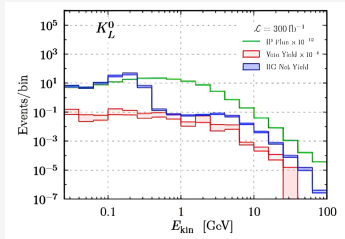
- Small-scale demonstrator in order to:
 - Validate background estimates for CODEX-b.
 - Demonstrate the inclusion within LHCb readout.
 - Demonstrate suitability of RPC tracking technology.
 - Reconstruct known SM backgrounds.
 - Demonstrate suitability of the mechanical frames.



- Reduced fiducial volume: $2 \times 2 \times 2 \text{ m}^3$.
- Reduced number of tracking stations: 42 RPC singlets integrated into 14 modules.
- Inner station for proper tracking.
- TDR is newly accepted by JINST: [https://arxiv.org/abs/2406.12880!](https://arxiv.org/abs/2406.12880)

Physics with CODEX- β

- Distribution of background components in D1 barracks.
- Trial New-Physics analysis.
- K_S^0 lifetime measurement.

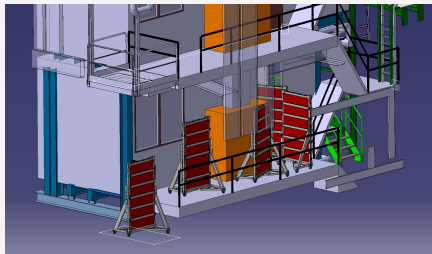


Status of the CODEX- β demonstrator



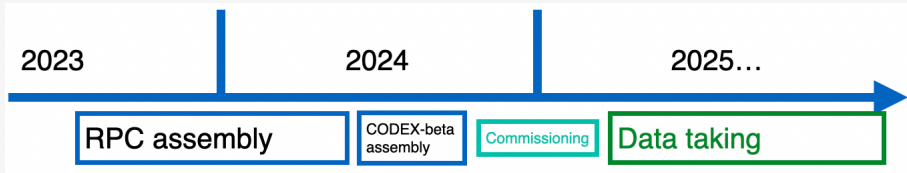
- Assembling and testing of the RPCs started at ATLAS workshop, but now continuing at the CMS! Many Thanks!
- Built and tested 29 of 42 singlets, and triplet characterization also started.
- ANUBIS supplied trigger electronics...thank you!

- Works at D1 barracks starting:
 - Providing a gas line (and system) for RPCs.
 - Transport from workshop to P8 (150 kg/frame).



The road ahead...

- A fast simulation framework has been developed to study geometry optimizations and sensitivity.
- Advances in simulation and reconstruction frameworks.
- Finish RPC frames and testing: 2025 as milestone for data-taking with CODEX- β !
- Integration of detector with the LHCb readout system is work in progress



Conclusions



- CODEX is a young collaboration, but growing!
- Great human team: people from theory, LHCb, CMS, ATLAS...
- Overcome many challenges on the way, on track for data taking in 2025!

Back-Up

Participating institutions



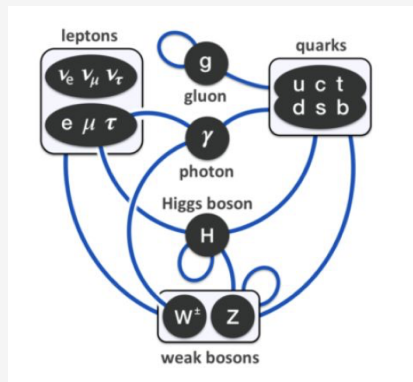
The Standard Model of Particle Physics

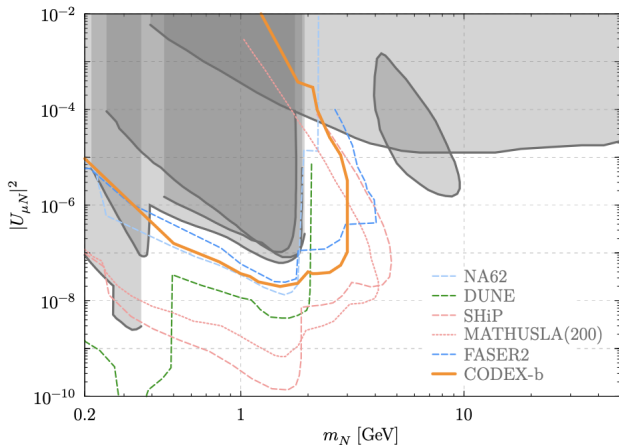
- The SM is the most successful theory describing nature at subatomic scales.

- Accommodates strong, weak and electromagnetic interactions.

$$G_{SM} = SU(3)_c \times SU(2)_L \times U(1)_Y$$

- Very precise and predictive:
 - W and Z bosons
 - Top quark
 - Higgs
- But also an incomplete theory:
 - Dark Matter
 - Baryogenesis
 - Gravity



Heavy neutral leptons: *HLN*

Axion-like particles: $\partial_\mu a \bar{q} \gamma^\mu \gamma^5 q, a \tilde{G}$.

