

New LHC Experiments for Long-lived particles search



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The Lamppost Landscape



Courtesy Jonathan Feng

The Lamppost Landscape



Courtesy Jonathan Feng

Long-lived particles are generic



LLP Theories

Motivation	Top-down Theory	IR LLP Scenario
Naturalness	RPV SUSY GMSB mini-split SUSY Stealth SUSY Axinos Sgoldstinos Veutral Naturalness Composite Higgs Relaxion	BSM=/→LLLP (direct production of BSM state at LHC that is or decays to LLP) Hidden Valley confining sectors
Dark Matter	Asymmetric DM Freeze-In DM SIMP/ELDER Co-Decay Co-Annihilation Dynamical DM	ALP EFT SM+S SM+V (+S) exotic Z
Baryogenesis	WIMP Baryogenesis Exotic Baryon Oscillations Leptogenesis	decays exotic Higgs
Neutrino Masses	Minimal RH Neutrino with U(1) _{B-L} Z' with SU(2) _R W _R long-lived scalars with Higgs portal from ERS Discrete Symmetries	HNL exotic Hadron decays

Curtin et al, 1806.07396

LLP – Hidden Valley

Hidden sector feeble couplings to SM via various portals, suppressed by the smallness of the couplings



Credit Zhen Liu

Experiment Landscape - current LHC



Experiment Landscape (focus of this talk)



Experiment Landscape





A Compact Detector for Exotics at LHC-b

Some specs:

- 10m x 10m x 10m fiducial volume
- 6 RPC layers on each surface 10 m x 10 m x 10 m Additional decay volume for $\mu\mu$ 5 set of 3 vertical RPC layers in DELPHI CODEX-b box final state the volume RB86 SHELDING PL •1 cm granularity GAS DISTRIBUTION RACKS COOLING SYSTEMS CANEWA SRS Π: EE: ZZA (ZZA SM 6500 SM. PZ 85 E Щ 11 120 87770 <u>/</u>P84 GRS DISTRIBUTION RACKS + COOLING SYSTEMS SHIELDING PL LHCb 9 interaction point shield veto 32-Л Pb shield IP8 UXA shield From 1708.09395

MATHUSLA

Massive Timing Hodoscope for Ultra-Stable neutraL pArticles



ANUBIS

AN Underground Belayed In-Shaft



Some specs:

- 8m radius (shaft)
- Each tracking station is 30 tons and 230 m²
- RPC's for tracking
- Use timing to reject

cosmic rays

A Laboratory for Long-Lived eXotics



Similar strategy as for CODEX-b: use thick shield with active veto to reduce the backgrounds

A Laboratory for Long-Lived eXotics



Similar strategy as for CODEX-b: use thick shield with active veto to reduce the backgrounds

Experiment Landscape











ForwArd Search ExpeRiment at the LHC



ForwArd Search ExpeRiment at the LHC



FASER INTEGRATION



L. Dougherty (CERN)

Current Status

Protection

Before



After



May

April

2020 Prepare ENH1 Install Det. Support Install Calo/Scin & TDAQ (Partial) System Commissioning Installation in TI12

Prototype Tracking Layer

First prototype layer produced and mounted in September



Jan

Feb

Mar

TDAQ test setup

Dec

Nov



Calorimeter Module



FASERv: Neutrino measurements in FASER

- Huge flux of neutrinos (10¹² in Run3) through FASER could allow for interesting neutrino measurements.
- Extend FASER physics program
 * Complementary to existing experiments
 - * Measurement at the highest manmade neutrino energies











Higgs Portal: Minimal Dark Scalar Mixing

$\mathcal{L}_{scalar} = \mathcal{L}_{SM} + \mathcal{L}_{DS} - (\mu S + \lambda S^2) H^+ H$

- Minimal scenario $\lambda = 0$
- More general scenario λ and μ both non-zero





Lifetime Frontier

	Higgs decay	B-decay	π,η-decay (dark photon)	Progress	Cost
FASER				Construction	\$
CODEX-b				Expression of Interest (1911.00481)	\$
ANUBIS		(Proof of Concept	\$
AL3X				Proof of Concept	\$\$
MATHUSLA		G		Letter of Intent (1811.00927)	\$\$
SHiP				Design Report (CERN-SPSC-2019- 049)	\$\$\$

- Clearly and increased interest in Long-lived particle searches at the LHC
 - LLP BSM White paper [1903.04497]
 - Physics Beyond Collider Report [1901.09966]
 - 6th LLP workshop [<u>https://indico.cern.ch/event/849129/</u>]
- New ideas for additional complementary experiments being constructed or proposed
 - FAER aiming for data-taking starting in Run3 (2021)
 - MATHUSLA, CODEX-b expression of interests
 - ANUBIS, AL3X concept approved
 - Future Beam dump experiments (SHiP)