RF6
Experiments and Facilities

editors: Phil Ilten and Nhan Tran
July 20, 2022

Resources

- arXiv v1: https://arxiv.org/abs/2206.04220
  - Thanks for your comments!
  - arXiv version will be updated based on feedback
- Overleaf - https://www.overleaf.com/4135382448wfbfbfqbcjzz

Document Overview

Thank you to all the folks who have contributed to the white paper!

If you have contributed but did not put your name on the author list, please do.

If you would still like to add input, let us know.

If you have any comments on our edits, please reach out

Contents

Experiment classification

To characterize the dark sector experiments and their strategies to search for the physics drivers presented above, we classify the experiments into the following categories:

- **LLP**: Here LLP stands for long-lived particles where the primary detector signature is a portal particle with a significant lifetime that it decays visibly to SM particles on macroscopic scales relative to detector capabilities.
- **DM rescattering**: This denotes experiments where the primary signature is a dark matter particle that is rescattered off of a dense detector of SM particles after being produced at an accelerator.
- **millicharged**: this denotes experiments which have specialized detection capabilities targeting particles that have fractional charge at the $10^{-3}e$ to $10^{-6}e$ level.
- **missing X**: This denotes experiments where the primary signature is an invisible particle and detection is based on missing momentum, energy, or mass.
- **rare prompt**: This denotes experiments where the primary detector signature is a portal particle that decays visibly to SM particles promptly (near the interaction point) on macroscopic scales relative to detector capabilities.

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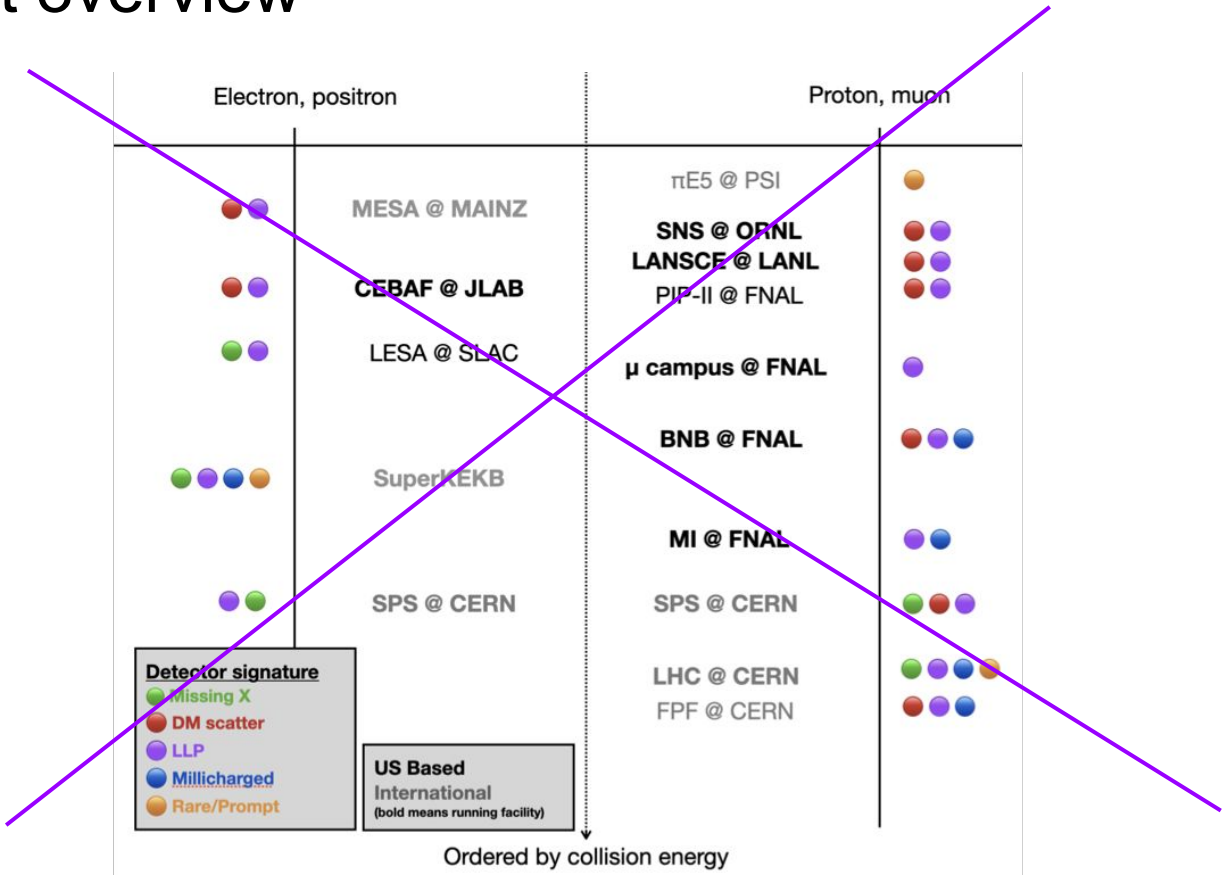
Document overview

Table 1. Summary of experimental initiatives, facilities, and key features. To discuss: how to include connection to physics drivers.

Experiment	Facility	Beam Config	Beam Energy	Det Signature	Physics Driver Priorities			Timeline	Refs.
					DM	Visible	Flavor		
US-based									
HPS	CEBAF @ JLab	electron FT	1-6 GeV	LLP	-	-	-	running	section 3.15, [13]
COHERENT	SNS @ ORNL	proton FT	1 GeV	DM Scatter	-	-	-	running	section 4.5, [14]
CCM	LANSE @ LANL	proton FT	0.8 GeV	DM Scatter	-	-	-	running	[15]
SpinQuest/DarkQuest	MI @ FNAL	proton FT	120 GeV	LLP	-	-	-	construction, proposed upgrade	section 3.5, [16]
LDMX	LESA @ SLAC	electron FT	4-8 GeV	Missing X	-	-	-	R&D funding, 2024	section 3.17, [17]
BDX	CEBAF @ JLab	electron BD	11 GeV	DM Scatter, Millicharged	-	-	-	proposed	section 3.1, [18]
JPOS	CEBAF @ JLab	positron FT	11 GeV	Missing X	-	-	-	proposed	section 3.16, [19]
PIP-II BD	PIP-II @ FNAL	proton FT	1 GeV	DM Scatter, LLP	-	-	-	proposed (2029)	section 3.23, [20]
SBN-BD	Booster @ FNAL	proton BD	8 GeV	DM Scatter	-	-	-	proposed (2029)	[21]
REDTOP	TBD	proton FT	1-5 GeV	Missing X, LLP, Prompt	-	-	-	proposed	section 3.25, [22]
M^3	MI @ FNAL	muon FT	15 GeV muons	Missing X	-	-	-	proposed	[23]
FNAL-μ	muon campus @ FNAL	muon FT	3 GeV	LLP	-	-	-	proposed	section 3.13, [24]
International									
Belle-II	SuperKEKB @ KEK	e+e- collider	150 MeV	Missing X, LLP, Prompt	-	-	-	running	section 3.2, [25]
CODEX-β	LHC @ CERN	pp collider	6.5-7 TeV	LLP	-	-	-	construction (2023)	section 3.4, [26]
CODEX-b	LHC @ CERN	pp collider	6.5-7 TeV	LLP	-	-	-	proposed (2026)	section 3.3, [27]
LHCb	LHC @ CERN	pp collider	6.5-7 TeV	LLP, Prompt	-	-	-	running, future upgrade planned	section 3.18, [28]
NA62	SPS-H4 @ CERN	proton BD	400 GeV	LLP	-	-	-	dedicated running planned	[29]
FASERnu	LHC @ CERN	pp collider	6.5-7 TeV	DM Scatter	-	-	-	running	section 3.9, [30]
milliQAN	LHC @ CERN	pp collider	6.5-7 TeV	Millicharged	-	-	-	running	section 3.19, [31]
DarkMESA	MESA @ Mainz	Electron FT	150 MeV	DM Scatter, LLP	-	-	-	construction (2023)	section 3.6
NA64-e	SPS-M2 @ CERN	electron FT	100-150 GeV	Missing X, Prompt	-	-	-	running	section 3.20, [32]
NA64-mu	SPS-H4 @ CERN	muon FT	100-160 GeV	Missing X	-	-	-	commissioning	section 3.21
NA64/POKER	SPS-M2 @ CERN	positron FT	100 GeV	Missing X	-	-	-	planned (2024)	section 3.24, [32]
PIONEER	πE5 @ PSI	proton FT	10-20 MeV pions	Prompt	-	-	-	planned (2028)	section 3.22, [33]
FASER2	FPF @ CERN	pp collider	6.5-7 TeV	LLP	-	-	-	proposed (2029)	section 3.8 [34]
FORMOSA	FPF @ CERN	pp collider	6.5-7 TeV	Millicharged	-	-	-	proposed (2029)	section 3.14, [35]
FASERnu2	FPF @ CERN	pp collider	6.5-7 TeV	DM Scatter	-	-	-	proposed (2029)	section 3.10, [30]
FLArE	FPF @ CERN	pp collider	6.5-7 TeV	DM Scatter	-	-	-	proposed (2029)	section 3.12, [36]
SND@LHC	LHC @ CERN	pp collider	6.5-7 TeV	DM Scatter	-	-	-	running	section 3.27, [37]
Advanced SND@LHC	FPF	pp collider	6.5-7 TeV	DM Scatter	-	-	-	proposed (2029)	section 3.27, [37]

Document overview



Today

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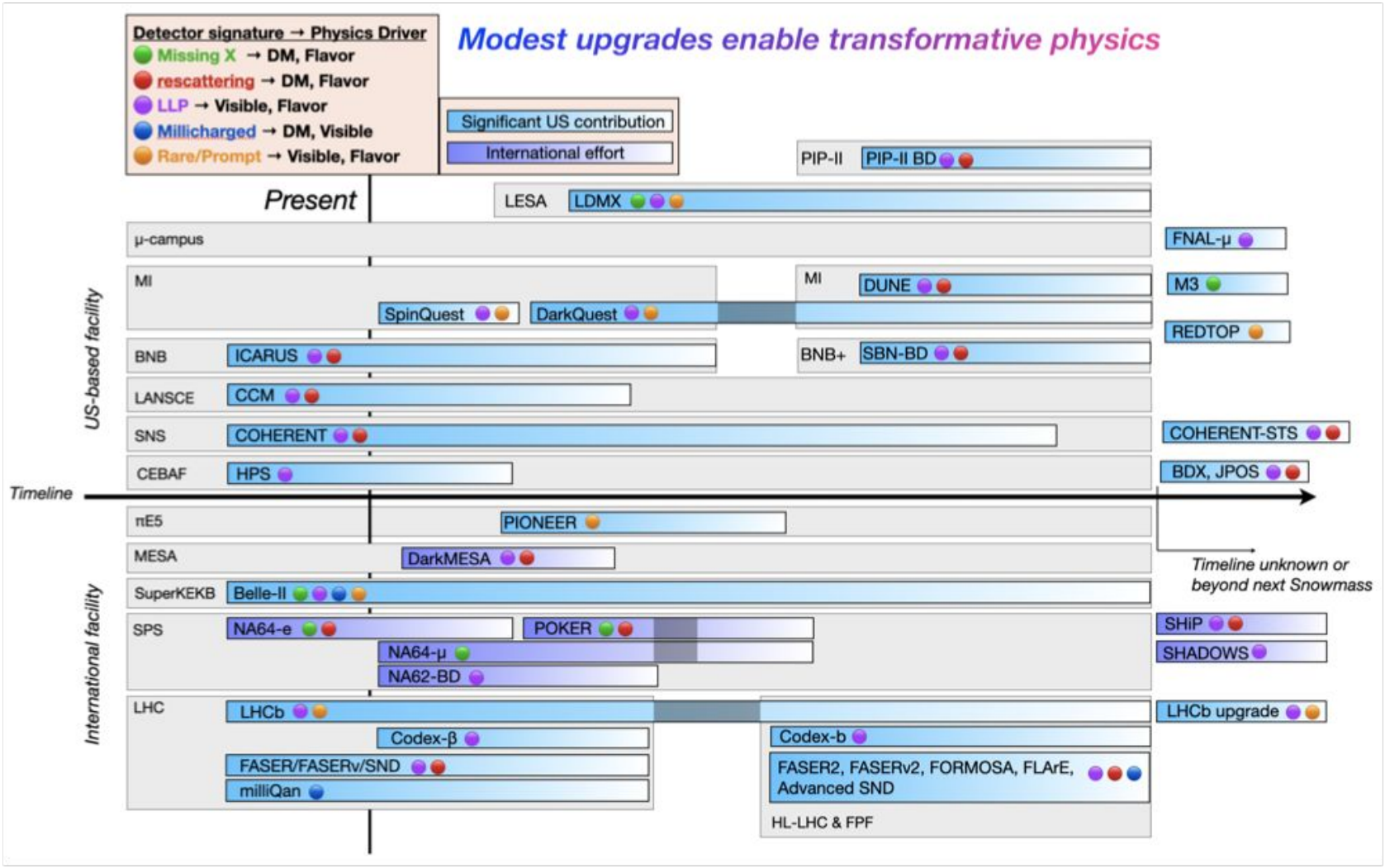
Modest upgrades enable transformative physics
Detector signature → Physics Driver
Missing X → DM, Flavor
rescattering → DM, Flavor
LLP → Visible, Flavor
Millicharged → DM, Visible
Rare/Prompt → Visible, Flavor
Significant US contribution
International effort
Present
Timeline
US-based facility
International facility
PIP-II
PIP-II BD
LESA
LDMX
μ-campus
FNAL-μ
MI
SpinQuest
DarkQuest
MI
DUNE
M3
REDTOP
BNB
ICARUS
BNB+
SBN-BD
LANSCE
CCM
SNS
COHERENT
COHERENT-STS
CEBAF
HPS
BDX, JPOS
πE5
PIONEER
MESA
DarkMESA
SuperKEKB
Belle-II
SPS
NA64-e
POKER
NA64-μ
NA62-BD
SHiP
SHADOWS
LHC
LHCb
LHCb upgrade
Codex-β
Codex-b
FASER/FASERv/SND
milliQan
FASER2, FASERv2, FORMOSA, FLArE, Advanced SND
HL-LHC & FPF
Timeline unknown or beyond next Snowmass

Points for Discussion

Much of the challenge with our white paper content was how to succinctly summarize all of the information you have sent to us.

We can basically stare at the last two slides and talk about:

- What’s missing? wrong?
- Known issue, there are some lines in the final plots that do not show up in the summary graphic or table
    - would need some input from proponents