FPF Whitepaper Status: BSM – LLPs

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4th Forward Physics Facility Meeting
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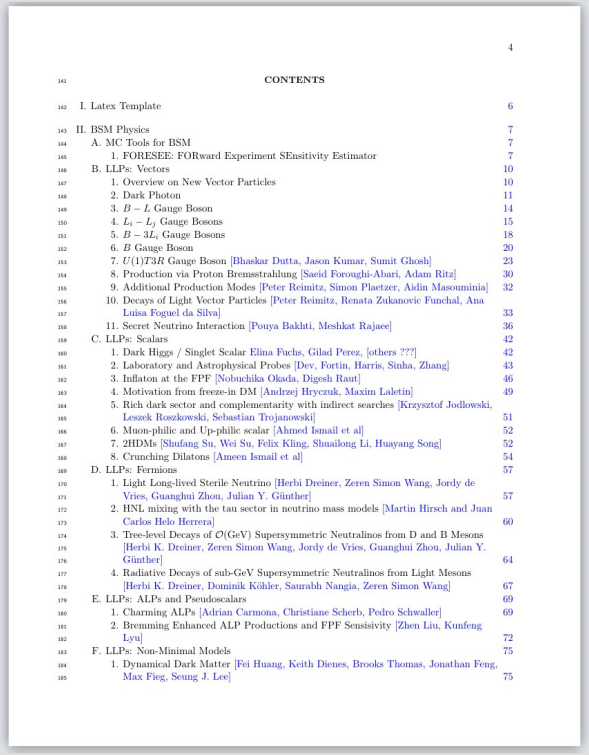
BSM at the FPF: overview

MC tools

Long-lived particles
- vectors
- scalars
- fermions
- axion-like particles
- non-minimal models



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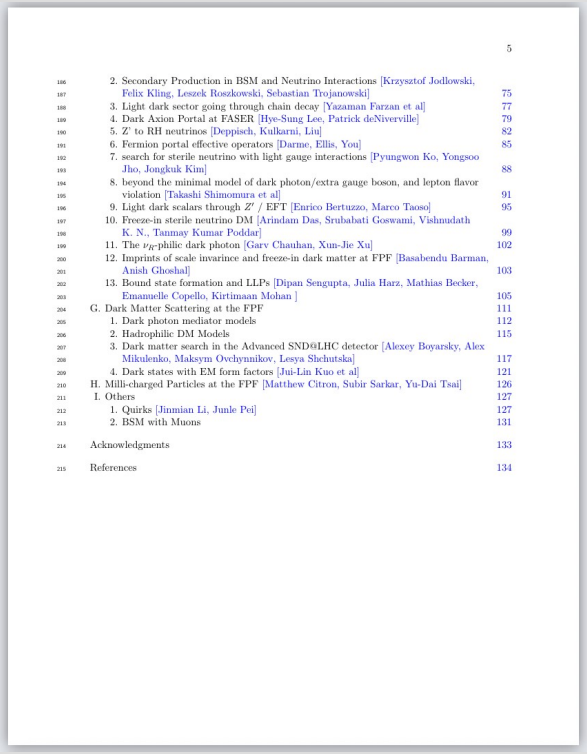


DM scattering → talk by Sebastian Trojanowski

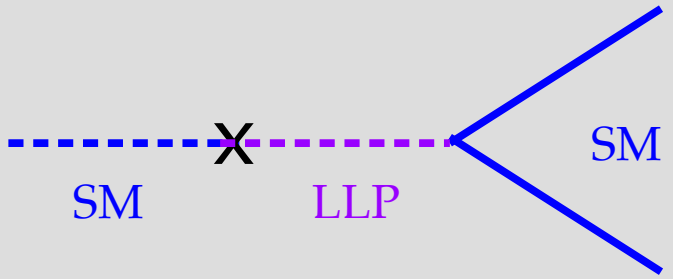
Millicharged particles → talk by Yu-Dai Tsai

Long-lived particles at the FPF

General idea: produce LLP from SM pp collisions

For small momentum transfer, LLP beam is well collimated at high rapidity

LLP decays downstream (FASER2)

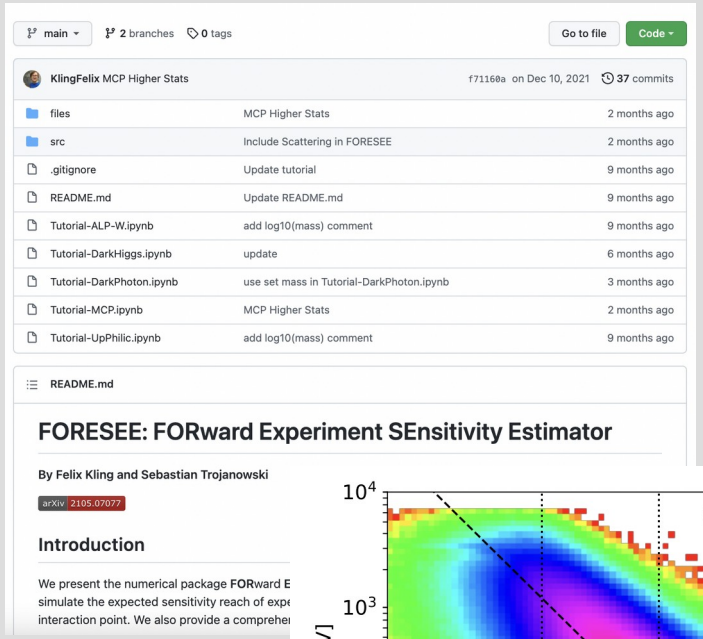


Limited set of renormalizable portals

$$S^2 H^2 \qquad F^{\mu\nu} F'_{\mu\nu} \qquad LHN$$

Different phenomenology in more complicated models

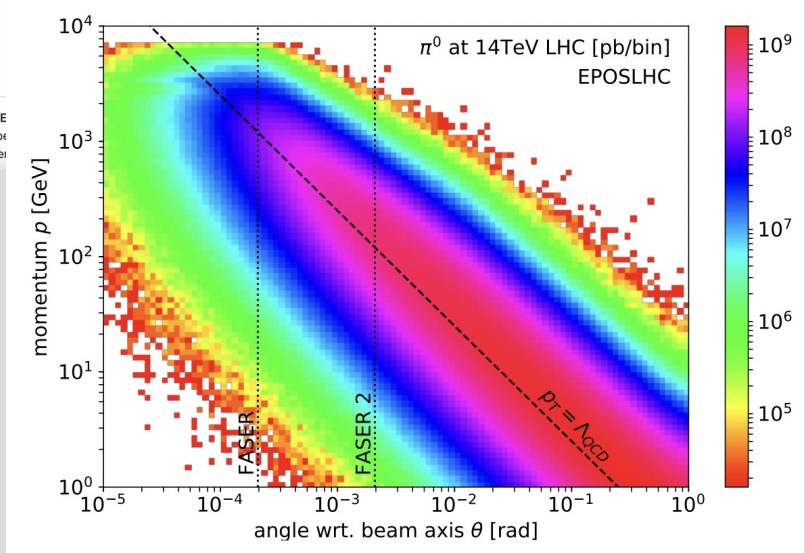
Monte Carlo: FORESEE

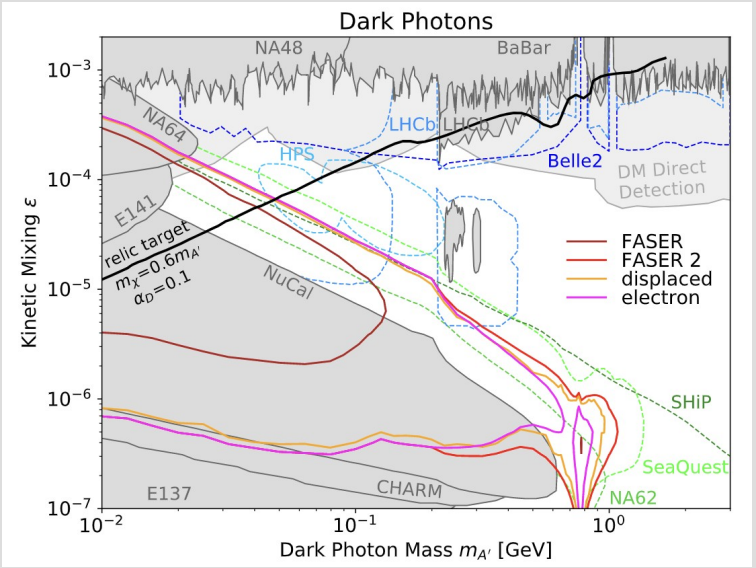


Github

Kling, Trojanowski

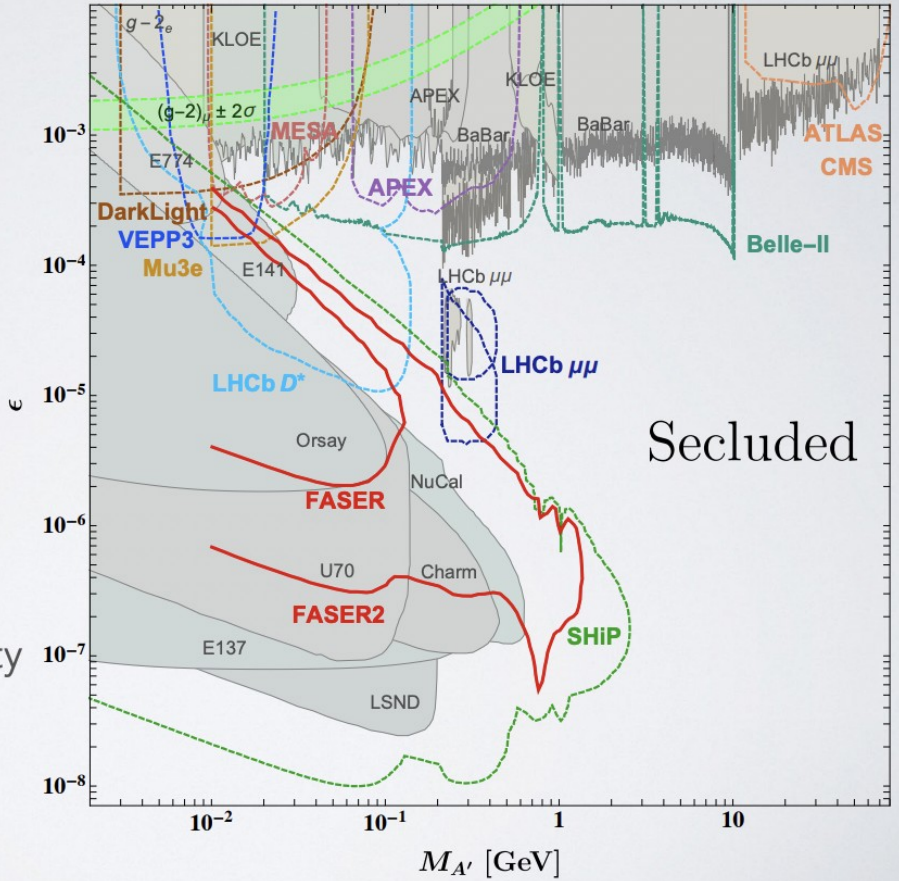
Built-in meson spectra for decays to, mixing with LLPs





SECLUDED $U(1)_X$

- Minimal secluded $U(1)_X$ model for $J^X_\mu = 0$ (only kinetic mixing)
- A' produced in EM processes like bremsstrahlung, radiative return and meson decays
- FASER(2) will be able to search for A′ in visible decays and push sensitivity significantly



[Ilten+ '18, Bauer+ '18, FASER '18, …]

Dark photons

$\epsilon F^{\mu\nu} F'_{\mu\nu}$

talk by Foldenauer

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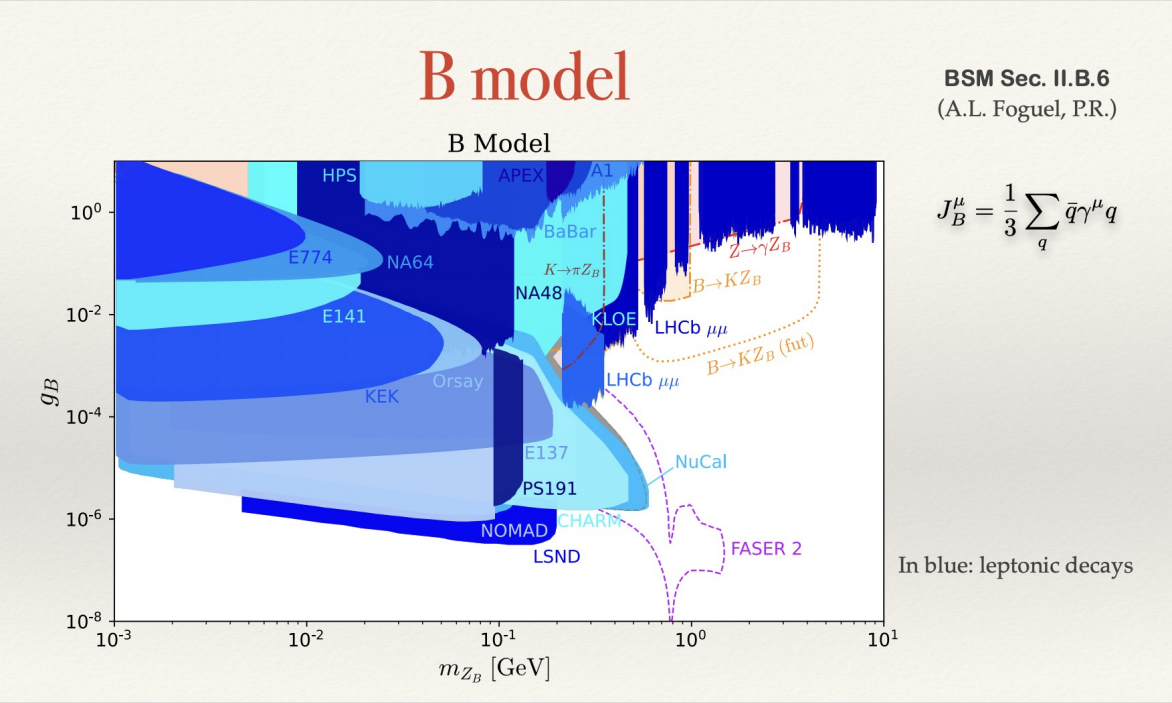
New gauge bosons

$B - L$, $L_i - L_j$, $B - 3\,L_i$ (Foldenauer)
B (Foguel et al.), T3R (Dutta et al.)



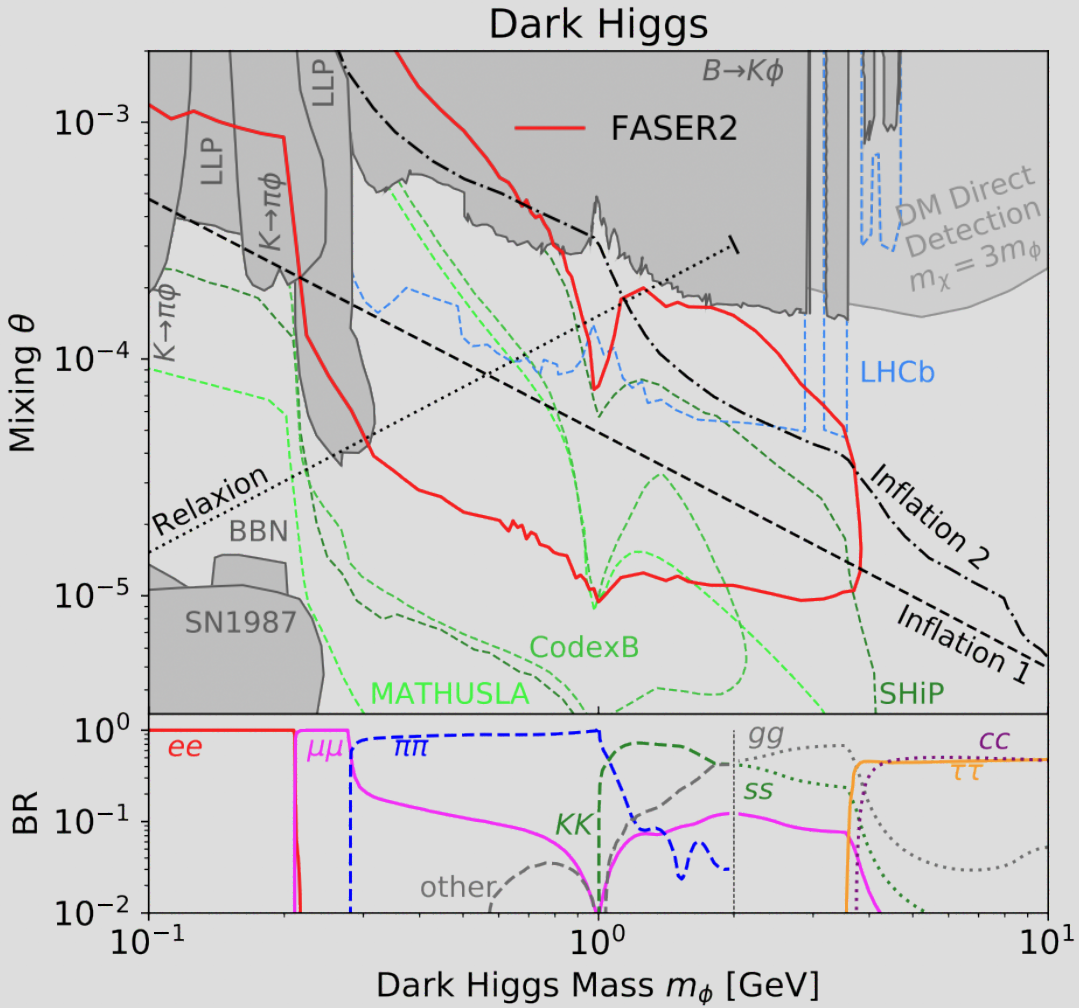
Bremsstrahlung calculations (Foroughi-Abari et al.)

Production (Masouminia et al.)

Decays (Reimitz et al.)

talk by Reimitz

Higgs portal scalar

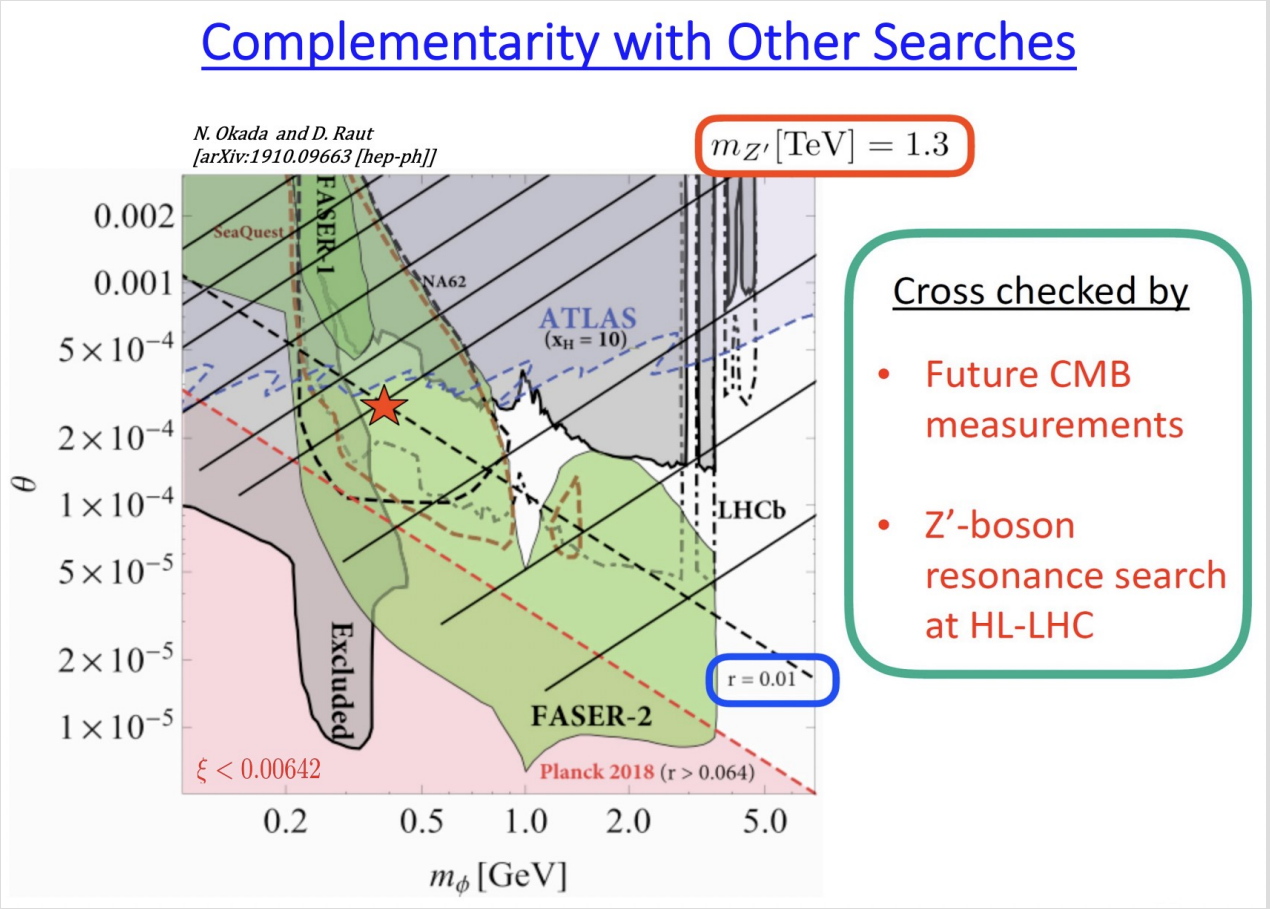


$$\sin\theta \frac{m_f}{v} \phi \bar{f} f$$

Motivations

Dark matter mediator (Hryczuk et al., Jodlowski et al., Barman et al.)
Inflation (Bramante et al., Okada et al.)
Relaxion (Fuchs et al., Winkler et al.)

Higgs portal scalar



Complementarity, e.g. Planck and Z' searches (talk by Raut)

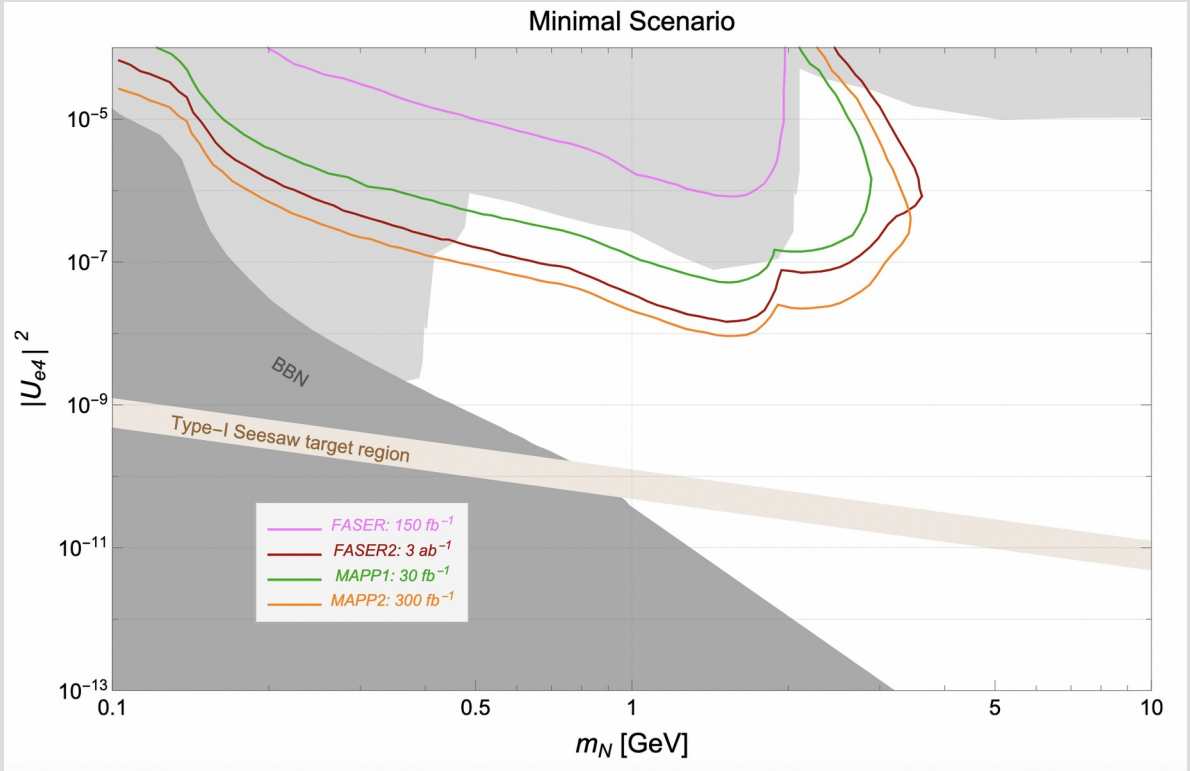
Related searches and models

2HDMs (Su et al.)
Astrophysical probes (Dev et al.)
Dilatons (Ameen Ismail et al.)

Heavy neutral leptons

Simplest *LHN* portal → mixing of *N* with active neutrino flavors

Dreiner et al.



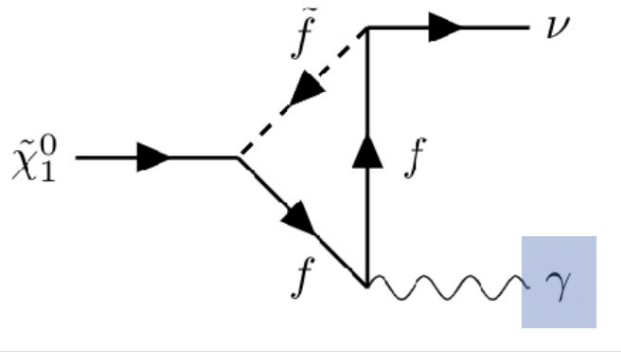
Other flavors (Hirsch et al.)

Effects of extra neutrinos in oscillations: see talk by Timo Karkkainen

Other long-lived fermions

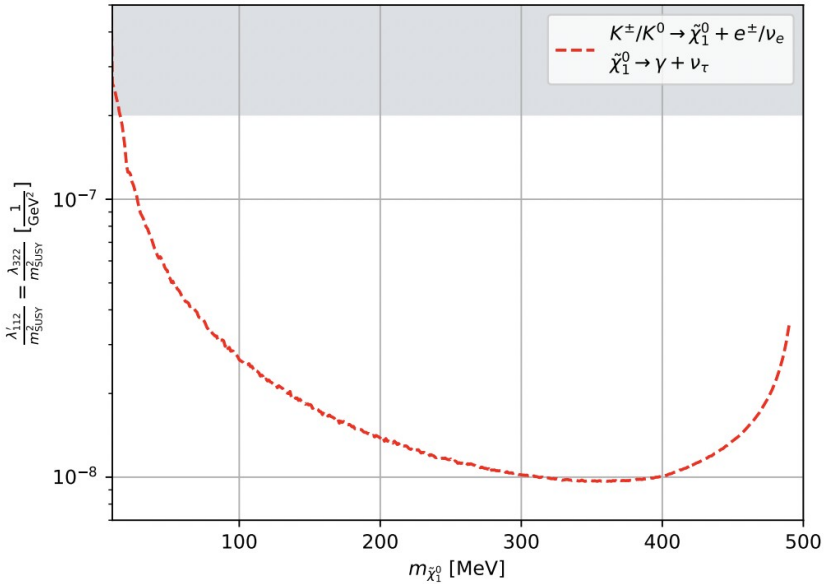
Neutralinos in supersymmetry with R-parity violation

Produce through meson decay, decay to single photon



talk by Kohler

- Probe existing constraints for wide mass range
- Production: λ'_{112} (LQD 112)
- Decay: λ_{322} (LLE 322)



Axion-like particles

Motivated by, though not restricted to, solutions to the strong CP problem

$$\frac{g_s^2}{8} g_{agg} a G^{\mu\nu} \tilde{G}_{\mu\nu}$$

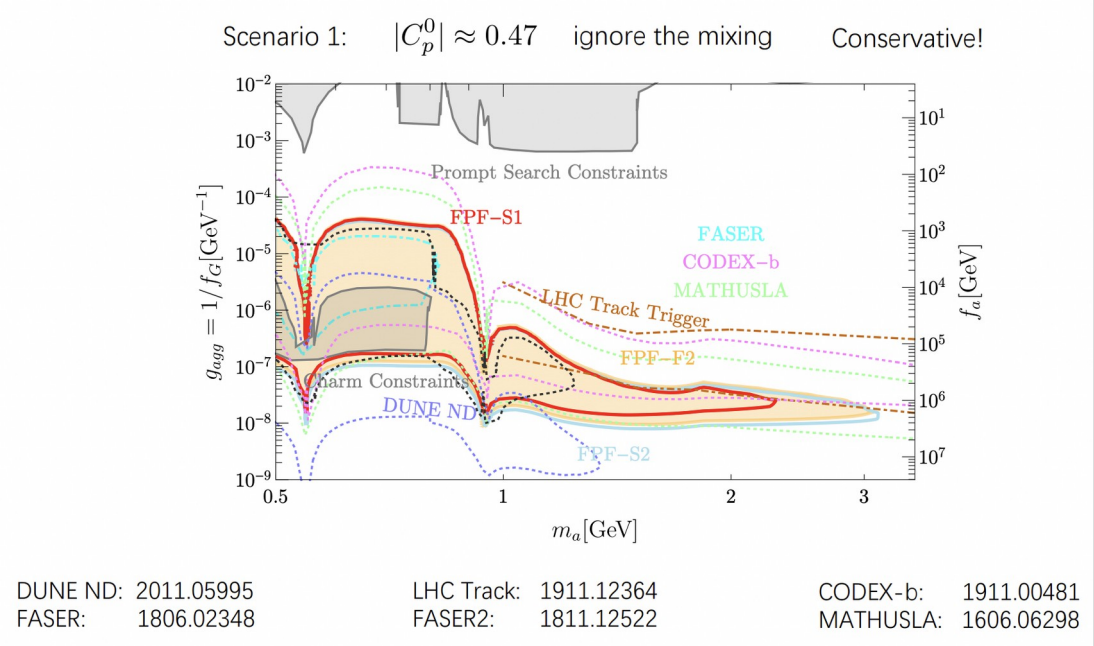
Relative strength of gauge boson, fermion couplings model-dependent

$$\frac{1}{4} g_{a\gamma\gamma} a F^{\mu\nu} \tilde{F}_{\mu\nu}$$

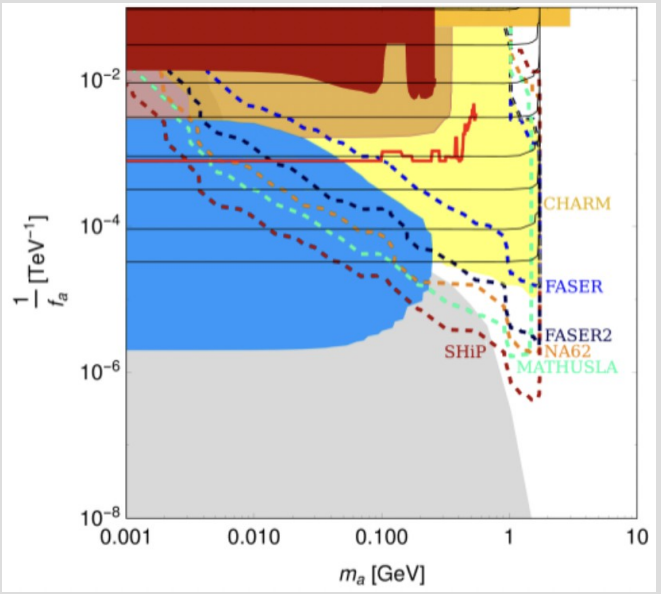
Production: mixing with mesons, flavor-changing decays, Primakoff, brem

$$g_{aff} \frac{m_f}{v} a \bar{f} \gamma^5 f$$

Axion-like particles

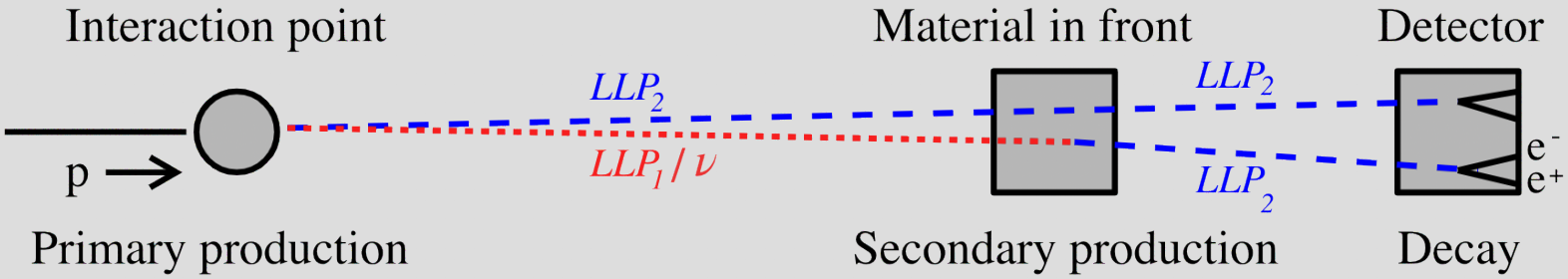


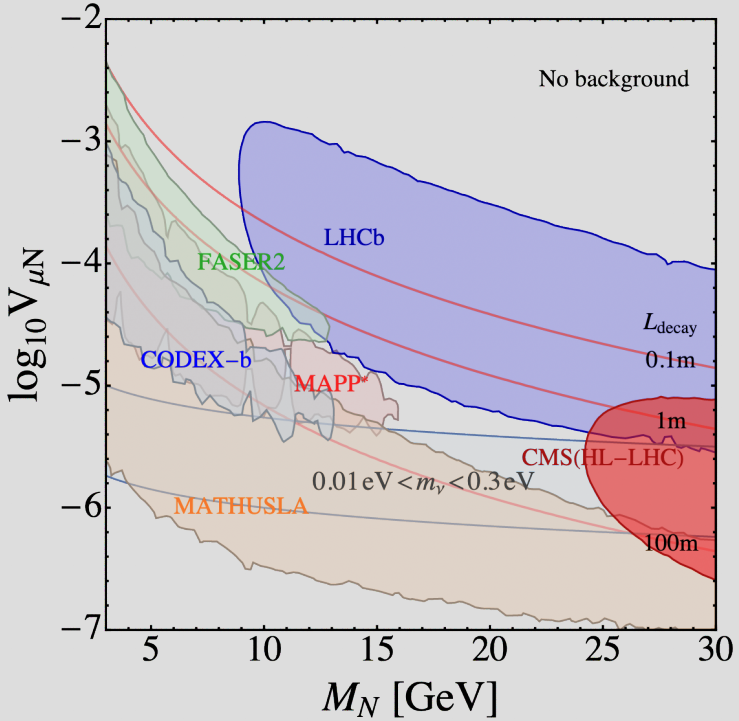
Importance of proton bremsstrahlung when gluon coupling dominates: talk by Lyu



Different coupling structures, e.g. charming ALPs (Carmona et al.)

Non-minimal models, briefly

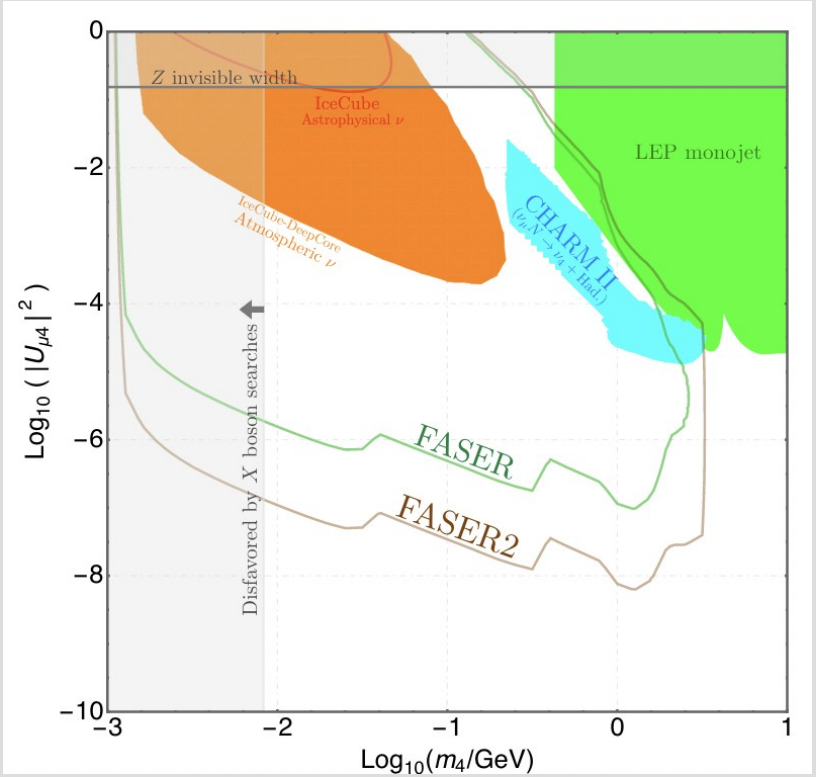




Secondary production with multiple LLPs, Jodlowski et al.

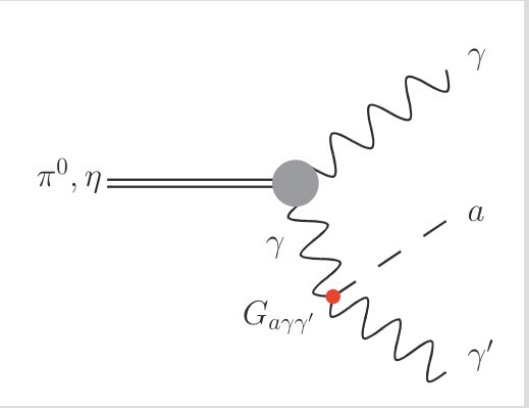
Gauged $B - L$ with RH neutrinos, Deppisch et al.

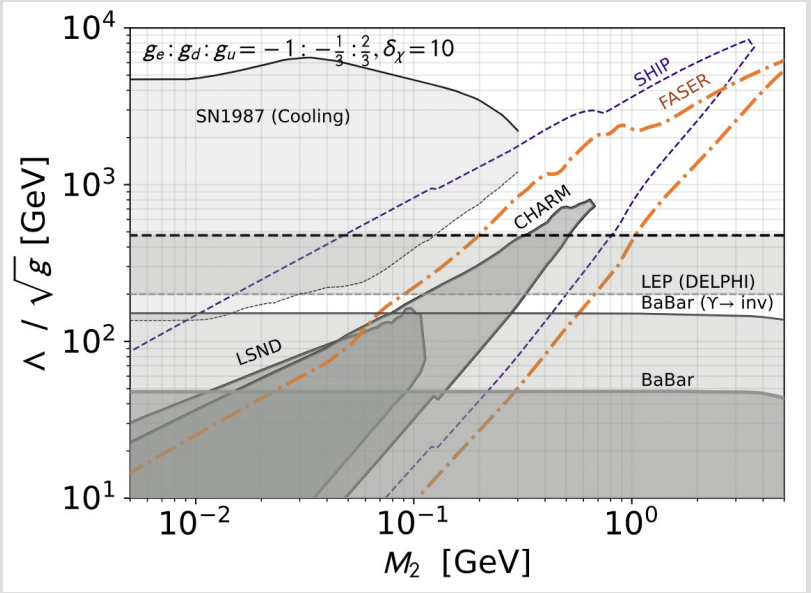
Many more contributions



Sterile neutrino with Z', Jho et al.

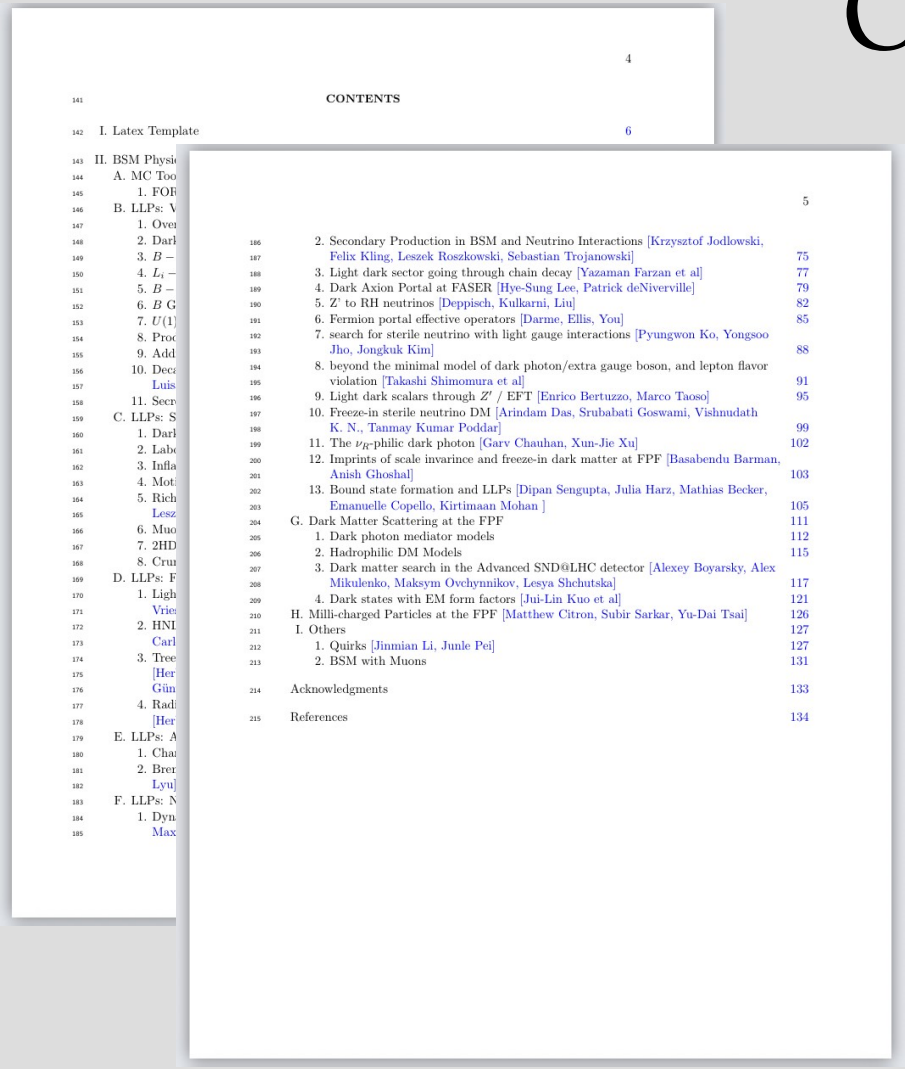
Dark axion portal, deNiverville et al.





Fermion portal effective operators, Darme et al.

Outlook



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Thanks to all the contributors!

Currently at ~100 pages on long-lived particles

Reminder: check name, affiliation, acknowledgments on Overleaf