

BSM Physics Overview

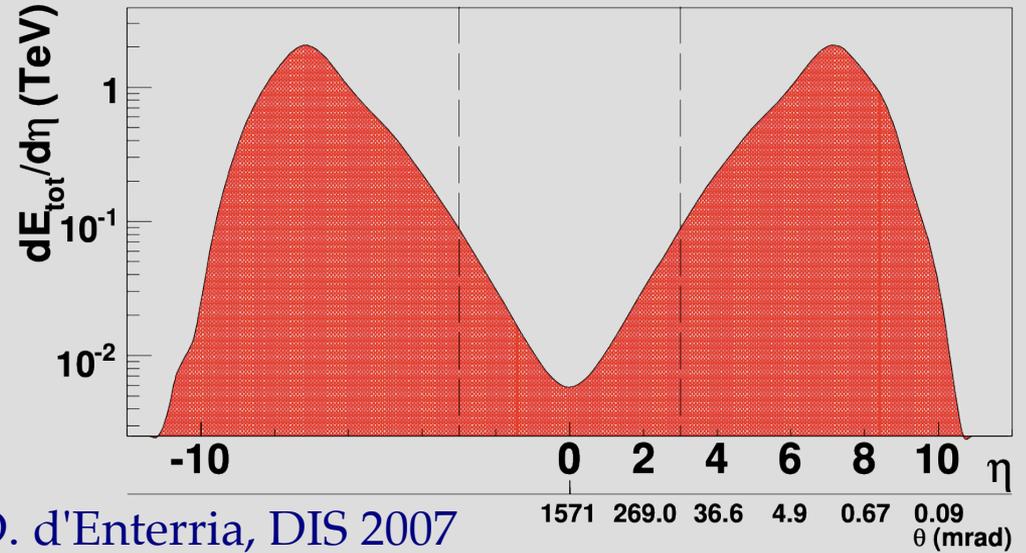
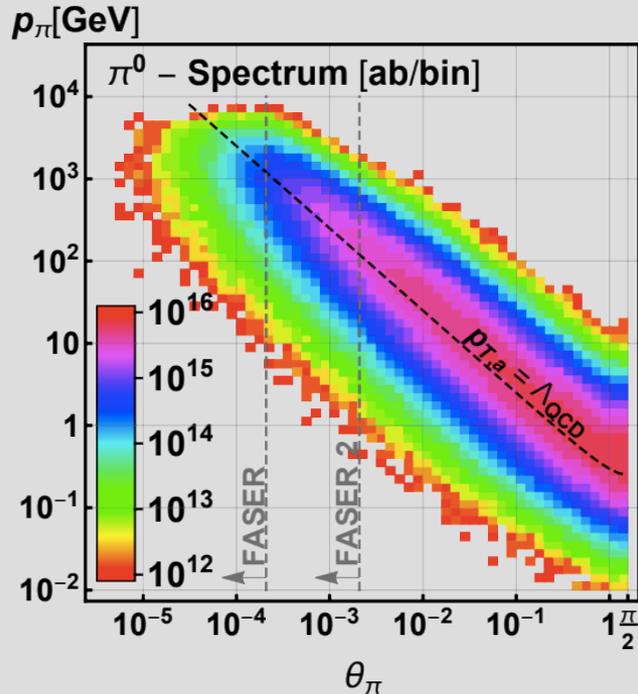
Ahmed Ismail
Oklahoma State University

Forward Physics Facility Kickoff Meeting
November 9, 2020



Forward LHC physics and light states

LHC produces a beam of light particles that is *intense*, *collimated*, and *energetic*



D. d'Enterria, DIS 2007

Typical angle of light particle
 \sim mass scale / energy

$$\text{GeV} / \text{TeV} \leftrightarrow \text{m} / \text{km}$$

FASER LLP paper

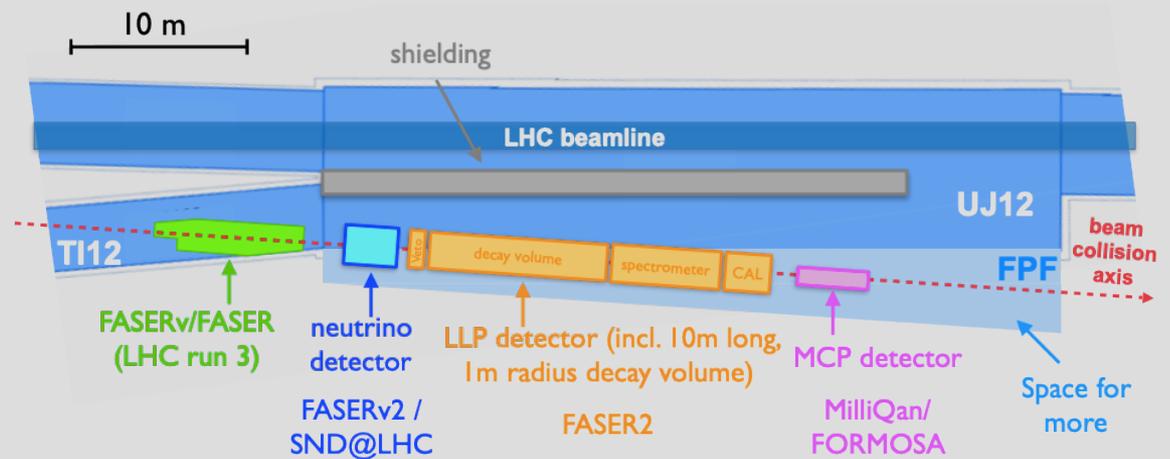
Myriad probes of BSM physics

Long-lived particles

Neutrinos

Dark matter

Millicharged particles



credit: Felix Kling

Dedicated parallel sessions: LLP, dark sectors and cosmology, QCD and neutrinos

PDF, cosmic rays, cosmic neutrino applications tomorrow; only briefly mentioned here

Long-lived particles

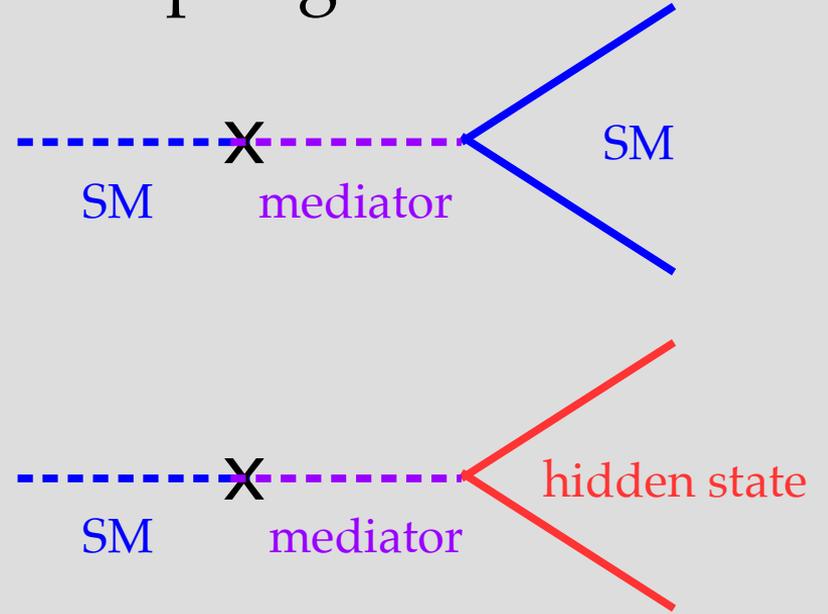
Portals to **hidden sectors** with small couplings

– dark scalars $S^2 H^2$

– dark photons $F^{\mu\nu} F'_{\mu\nu}$

– heavy neutral leptons LHN

– axion-like particles $a F_{\mu\nu} \tilde{F}^{\mu\nu}$



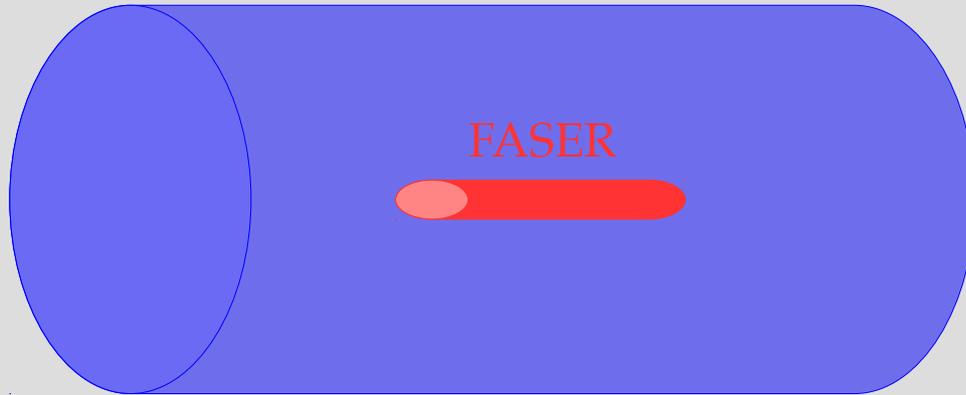
Also: new gauge interactions, SUSY

Larger LLP detectors

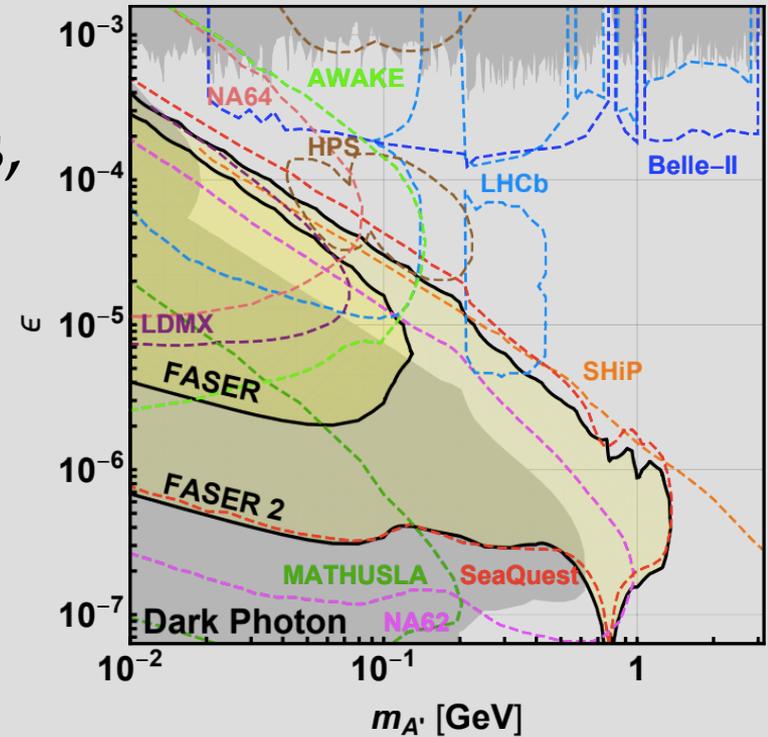
Many mesons at HL-LHC

e.g. $\sim 10^{19}$ π^0 , 10^{17} η , 10^{16} D mesons,
 $\sim 10^{15}$ B mesons

FASER2



$\sim 500\times$ detector volume at FPF



FASER LLP paper

See FASER2 talk by
Brian Petersen

Next steps for LLP

New pheno in slightly less minimal models

e.g. secondary production

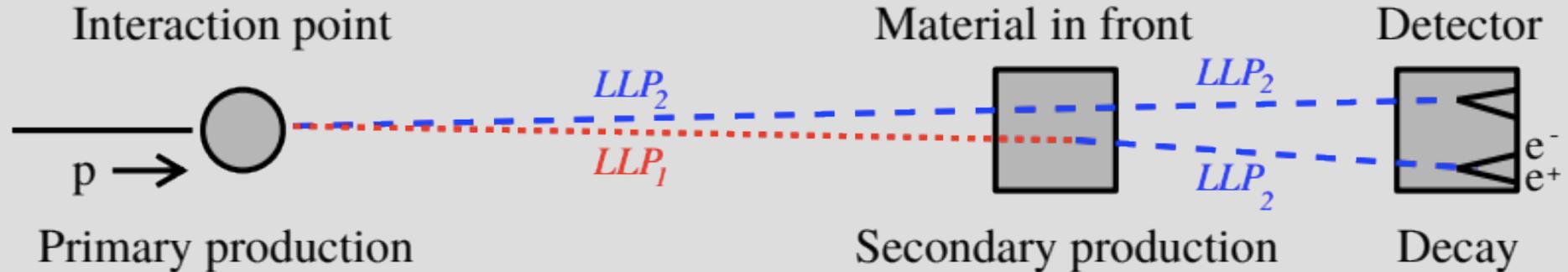
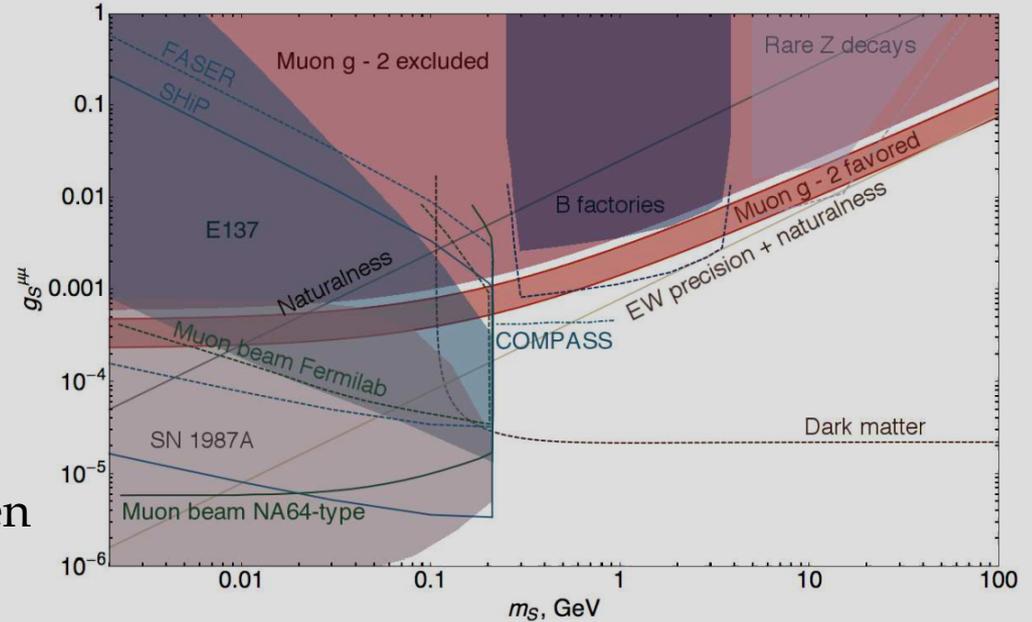
e.g. non-standard portals

Flavor-specific scalars

Batell, Freitas, AI, McKeen

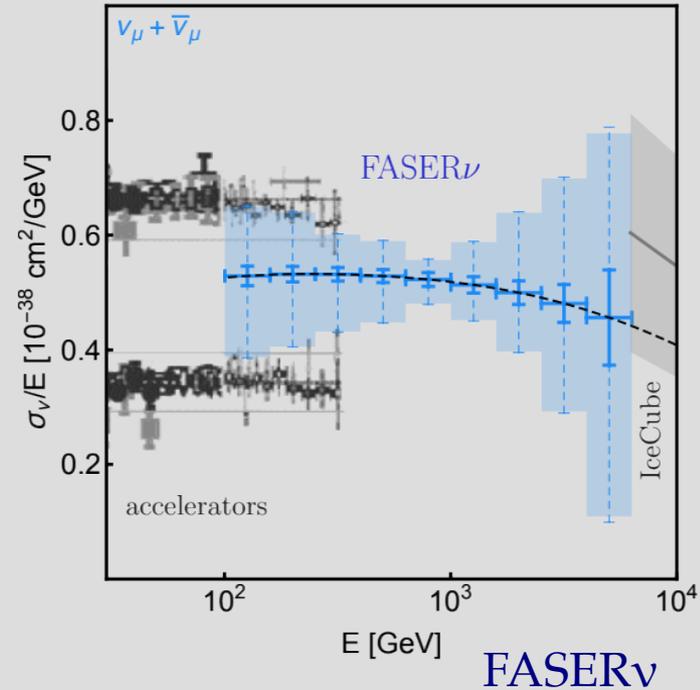
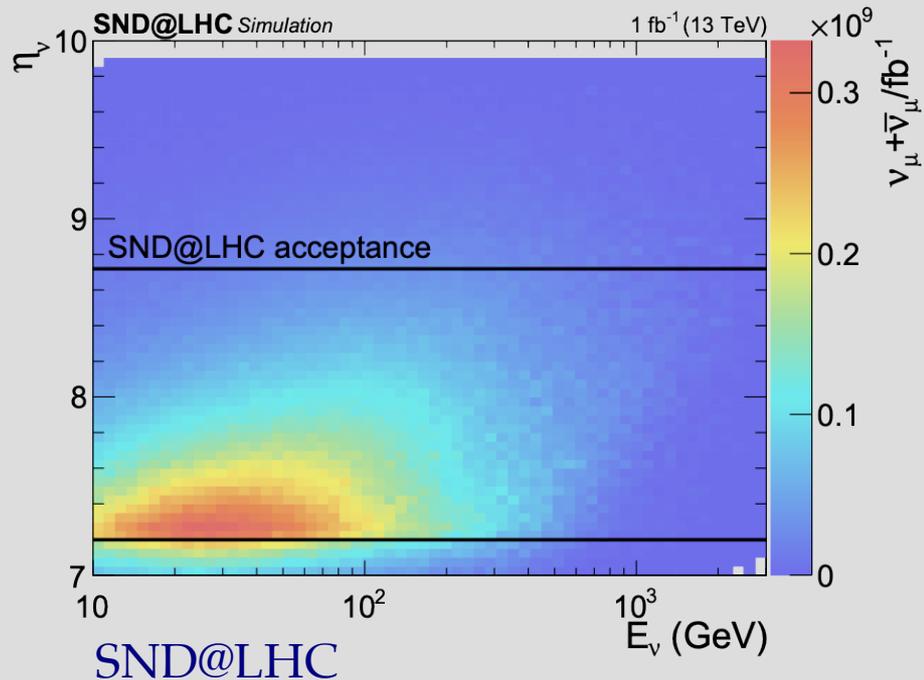
Secondary production for smaller lifetimes

Jodlowski, Kling, Roszkowski, Trojanowski



Neutrino interactions at the LHC

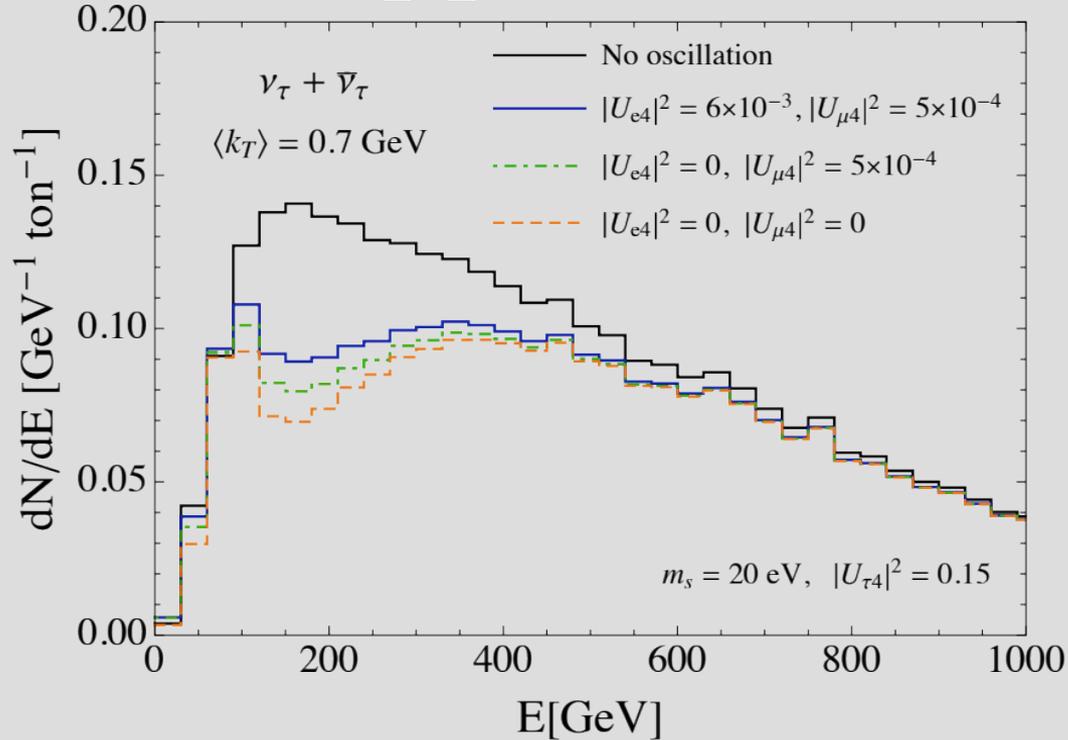
Missing energy in general purpose detectors, but potentially visible in forward region with dedicated experiments



FASER ν 2 talk, Aki Ariga

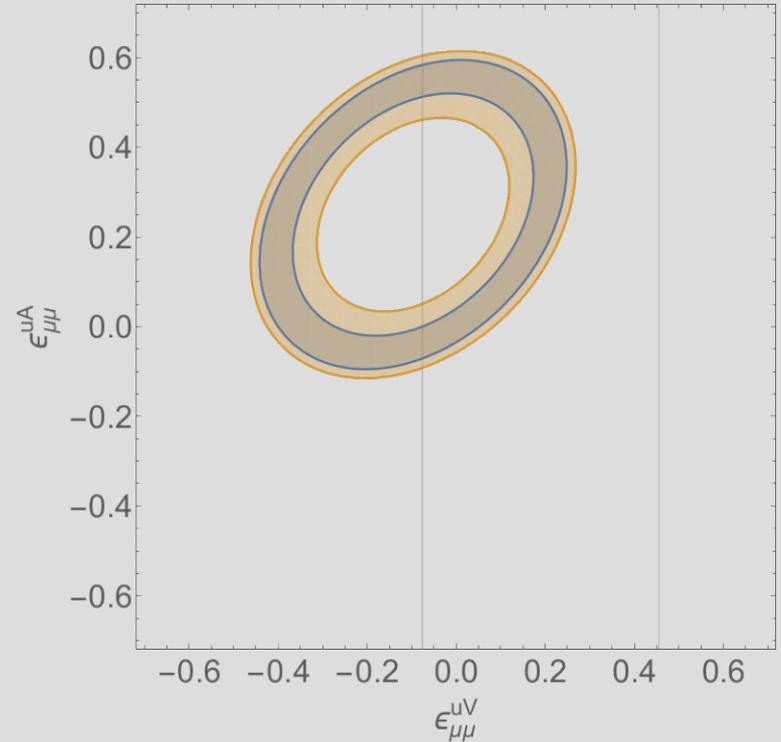
SND@LHC talk, G. de Lellis

Opportunities with neutrinos



Sterile neutrinos

Bai, Diwan, Garzelli, Jeong, Reno



Non-standard interactions

AI, Kling, Mammen Abraham

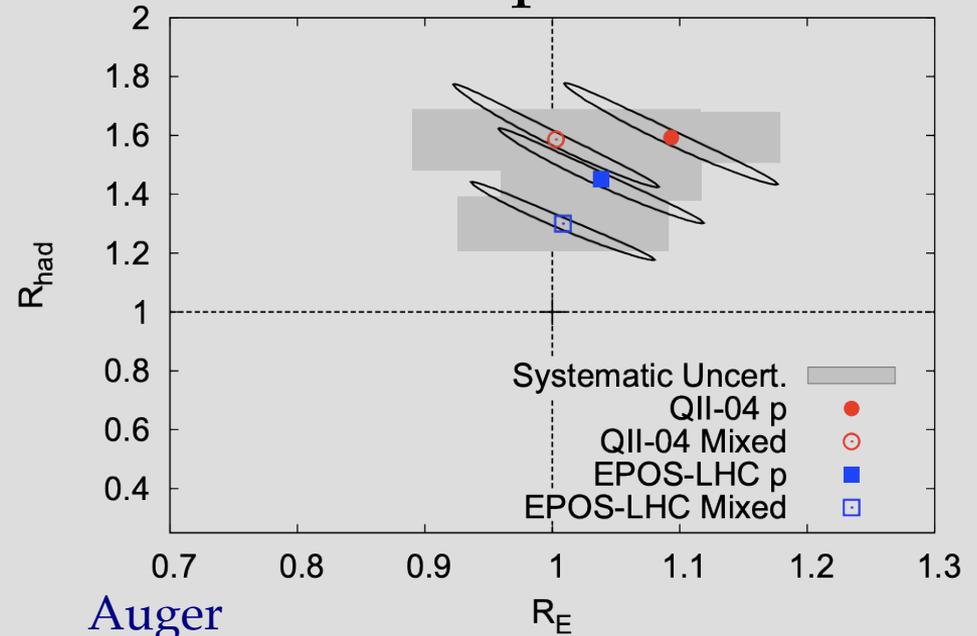
Importance of charm production, tau neutrinos

More tomorrow on SM-related physics

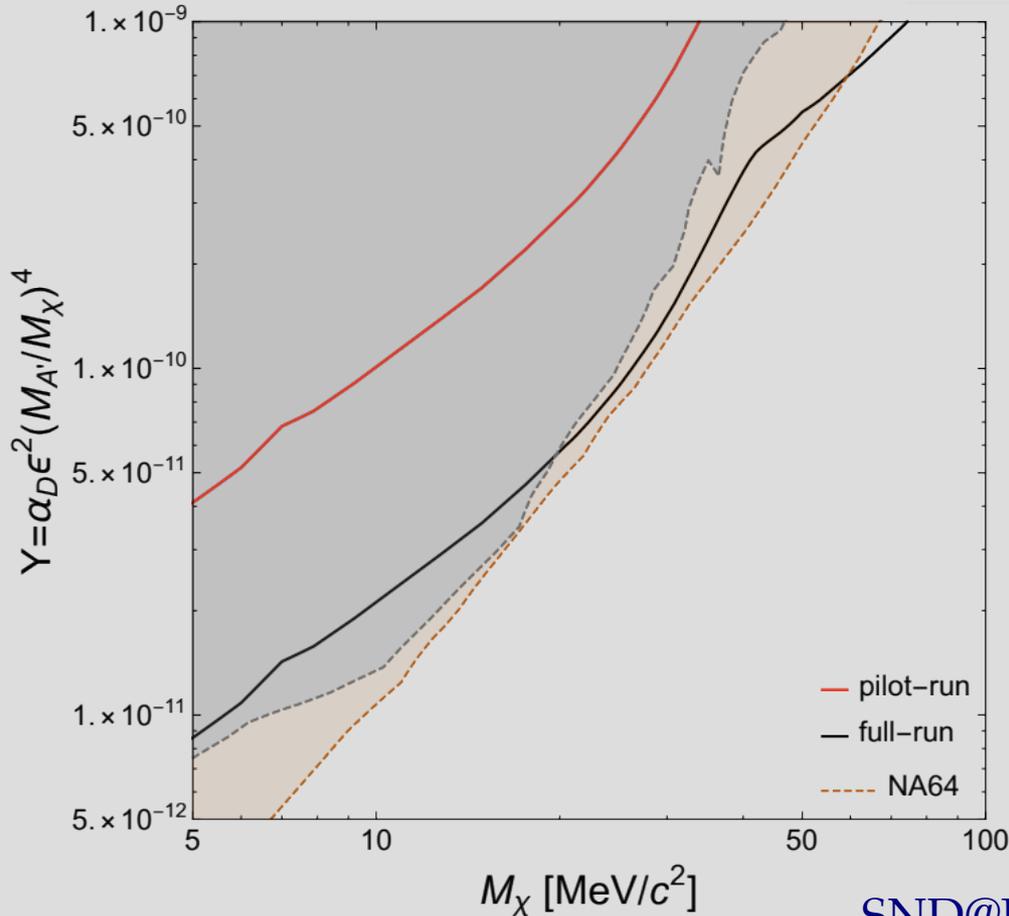
16:00	First talk on Implications for PDF	Pavel Nadolsky	16:00 - 16:15
	(n)PDF issues and opportunities at the Forward Physics Facility	Maria Vittoria Garzelli	16:20 - 16:35
	Further thoughts..... & Discussion	Dr Grigorios Chachamis	16:40 - 17:00
17:00	Forward Physics in PYTHIA 8	Torbjorn Sjostrand	17:00 - 17:15
	Other talk on Implications for general-purpose MC event generators & non-pert. uncertainties	Frank Martin Krauss	17:20 - 17:35
	Further thoughts..... & Discussion	Holger Schulz	17:40 - 18:00
18:00	Forward production in MC generators: constraints from other observables and relevance for high energy cosmic ray st...	Sergey Ostapchenko	
	Forward hadronization: the key of muon production in air showers	Dr Tanguy Pierog	18:20 - 18:35
	Further thoughts..... & Discussion	Ralph Richard Engel	18:40 - 19:00
19:00	IceCube and Forward Charm Production	Francis Halzen	19:00 - 19:15
	Muon and Neutrino Fluxes in IceCube	Dennis Soldin	19:20 - 19:35
	Further thoughts..... & Discussion	Mary Hall Reno	19:40 - 20:00
20:00	Summary and conclusions	Felix Kling	20:00 - 20:20

Probe PDFs with neutrino
deep inelastic scattering

Implications for forward
hadronic production



Light dark matter



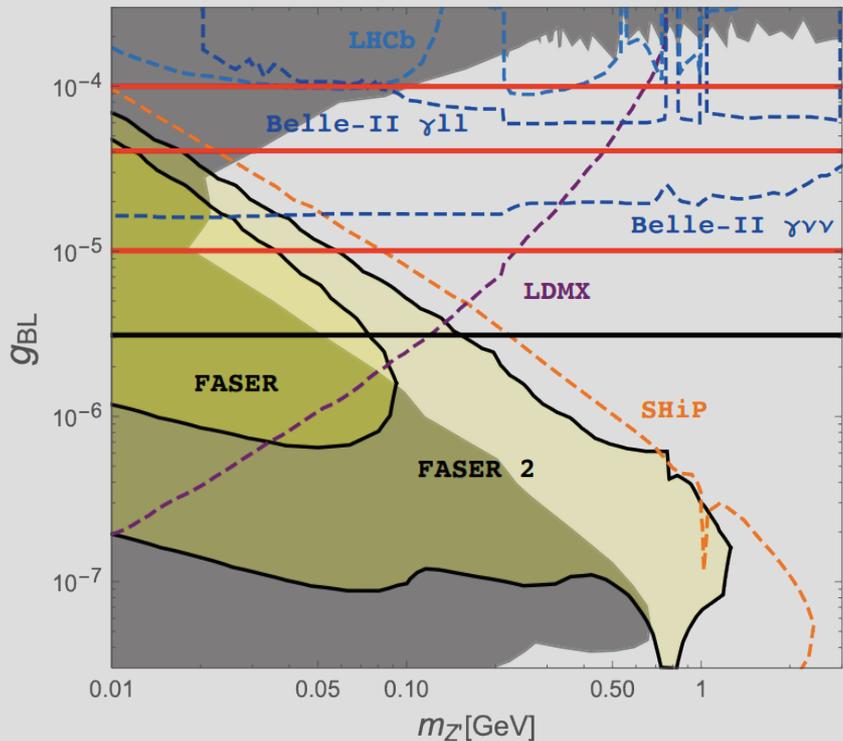
SND@LHC

Portals to sub-GeV DM
Mediators decay to DM
which subsequently scatters
in detector

e.g. dark photons decaying
to DM scattering off electrons

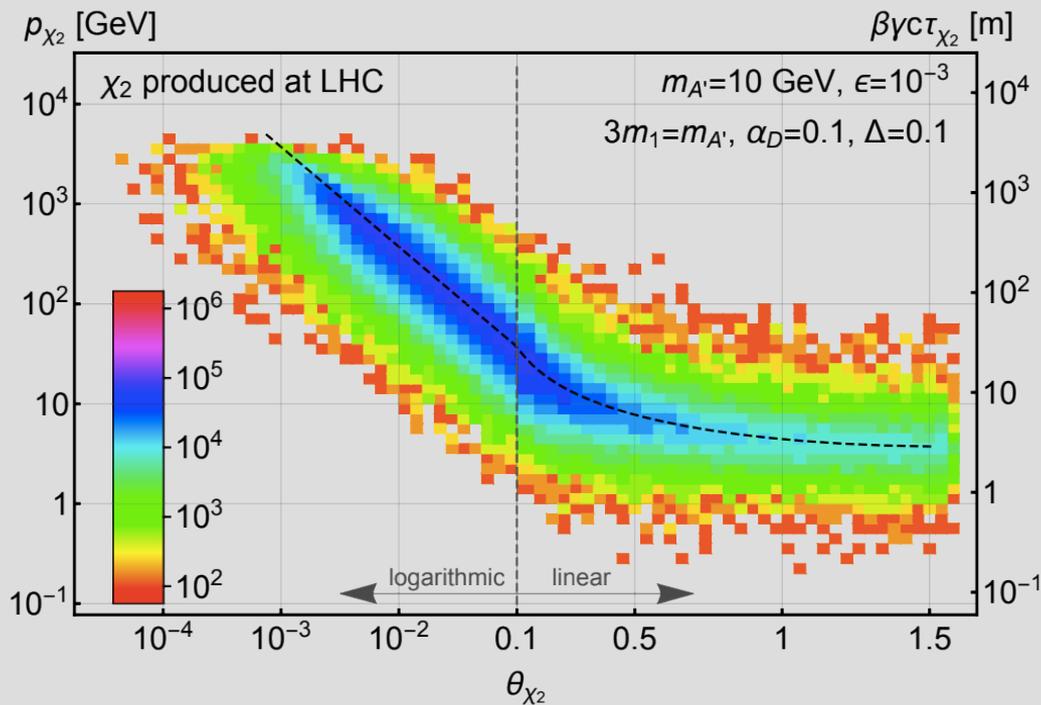
See also talk by Brian Batell

Dark matter models \leftrightarrow FPF signatures



Gauged B – L

N. Okada, S. Okada, Shafi



Inelastic DM

Berlin, Kling

Freeze-in (talk by Dipan Sengupta), inelastic models

Millicharged particles

Massless dark photon with kinetic mixing induces small EM coupling to hidden sector states

$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}F'^{\mu\nu}F'_{\mu\nu} - \frac{\epsilon}{2}F^{\mu\nu}F'_{\mu\nu} + \bar{\chi}(i\gamma^\mu D_\mu - m_\chi)\chi$$

New fermion coupled only to $U(1)'$ acquires effective charge ϵe after gauge field redefinition

Light MCP produced at LHC through meson decay
Drell-Yan also important above several GeV

Results from milliQan demonstrator: see talk by Chris Hill

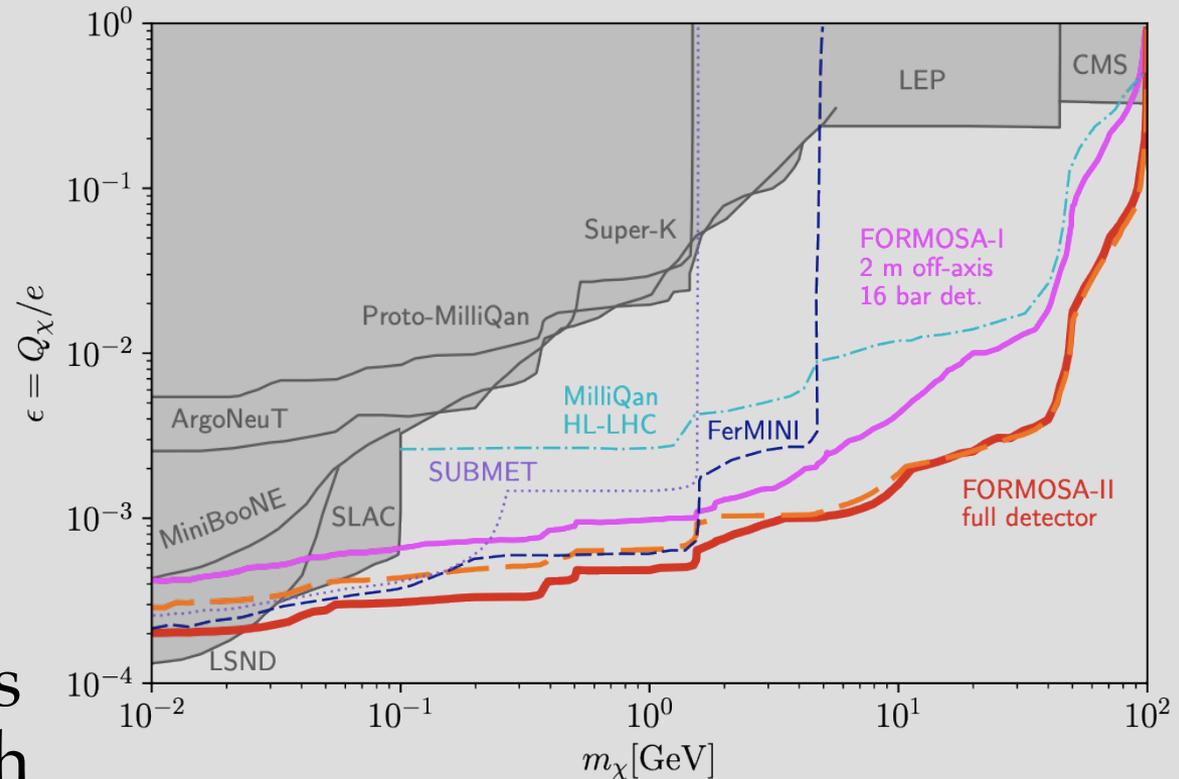
MCP detection in the far forward region

Tiny energy deposition
because of small effective
electric charge

Forward production
enhanced

Put milliQan or
demonstrator at FPF?

Other potential applications
including new particles with
electric dipole moments



FORMOSA

Foroughi-Abari, Kling, Tsai

Outlook



Even more: muon physics (Sebastian Trojanowski), timing to reduce backgrounds, [your idea here]

Enjoy!