Dark Sectors + CLFV Parallel Discussion

Matt Solt[1] & Jure Zupan[2]

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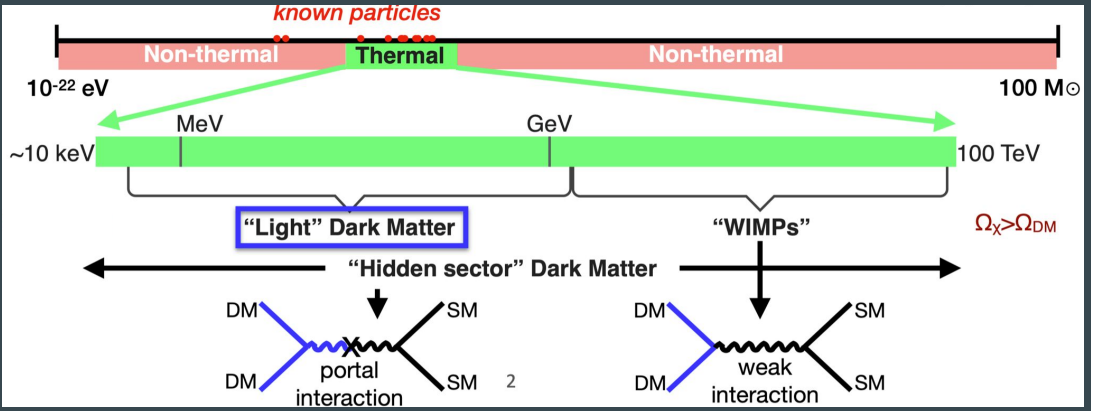
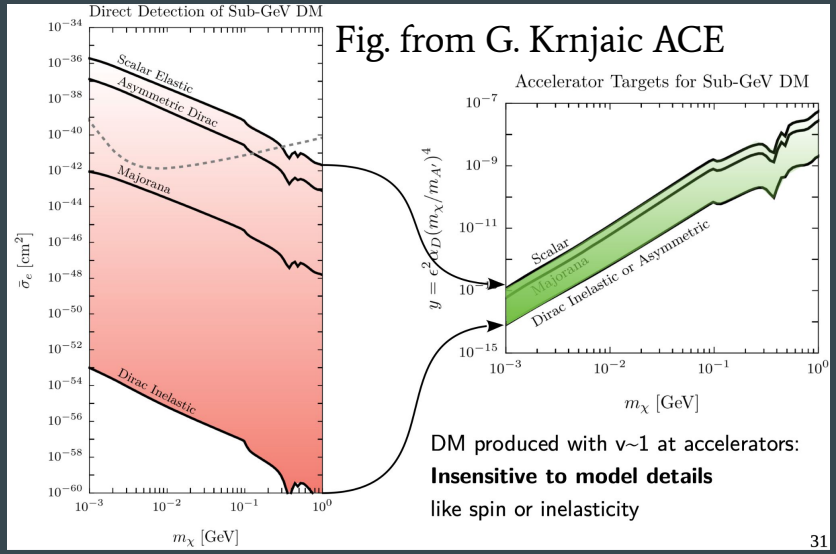
[1]University of Virginia & [2]University of Cincinnati

Theoretical Motivation - Dark Sectors

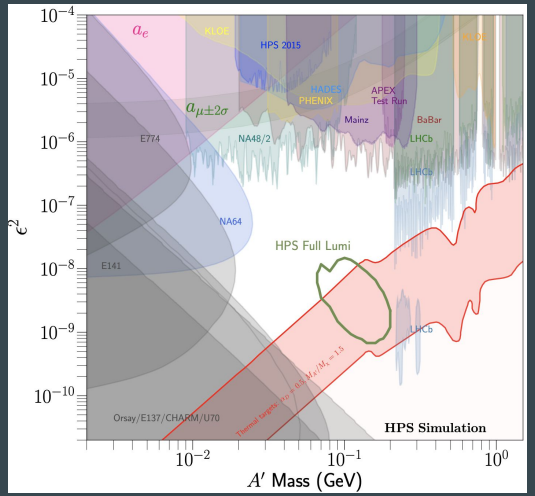
- Goal: Probe the parameter space of thermal dark matter
- Accelerator-based dark sector experiments advantage as the sensitivity is fairly independent of the specific dark matter model type

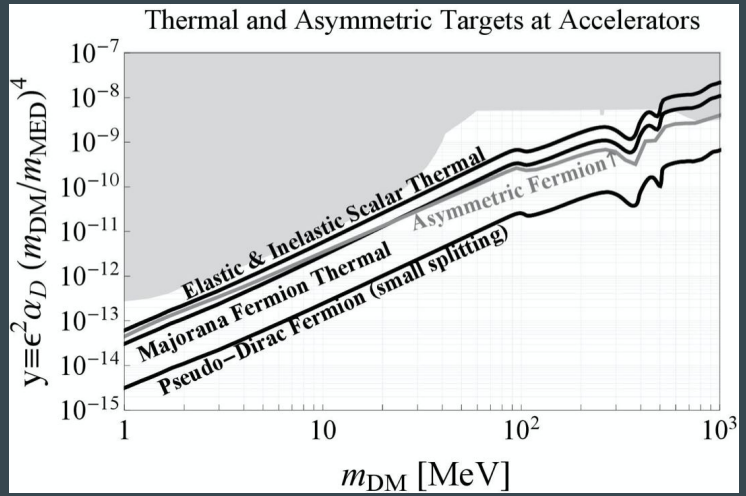




Current Experimental Landscape - Dark Sectors

- Many experiments probing a variety of dark sector models
  - PP collider, e+e- collider, P fixed target and beam dump, e- fixed target and beam dump
  - Visible final states: Resonance searches, displaced vertex searches (left)
  - Invisible final states: Missing mass, missing momentum, and missing energy (right)
- Session discussion: Unique opportunities for future dark sectors at PIP-II and ACE

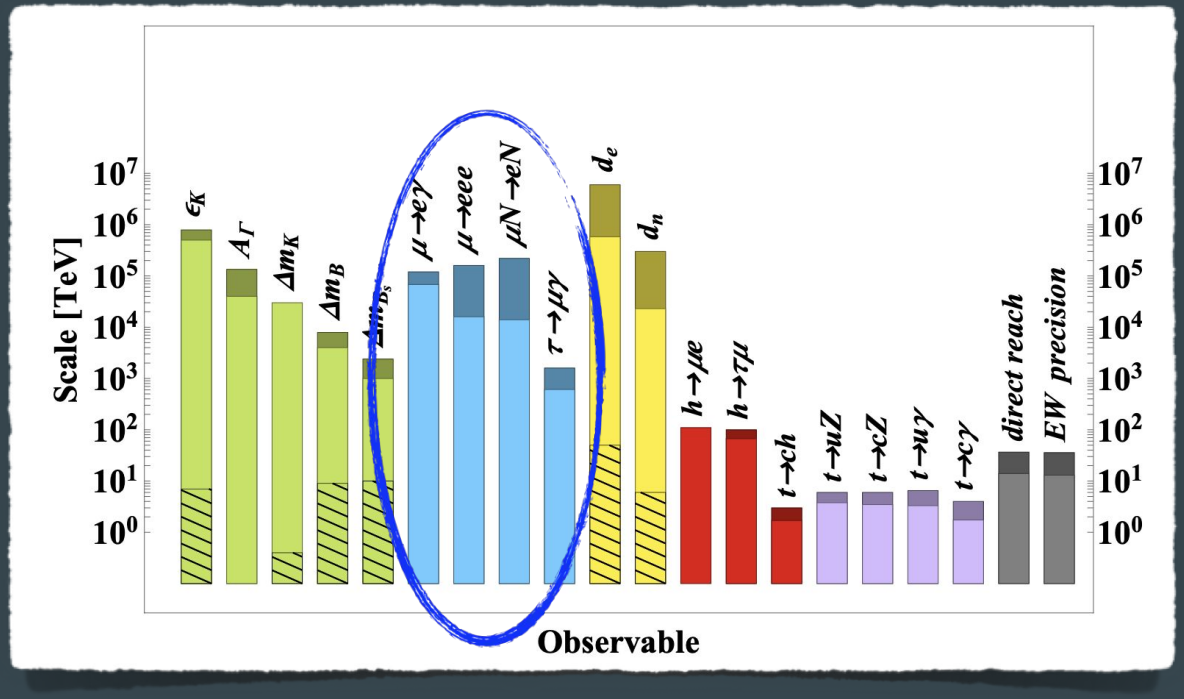




*Dark photon models shown here as benchmark models

Theoretical Motivations -CLFV

- High reach in effective scale of high new physics
- An even higher scale, if decays to light new physics: $\mu^+ \to e^+ a$



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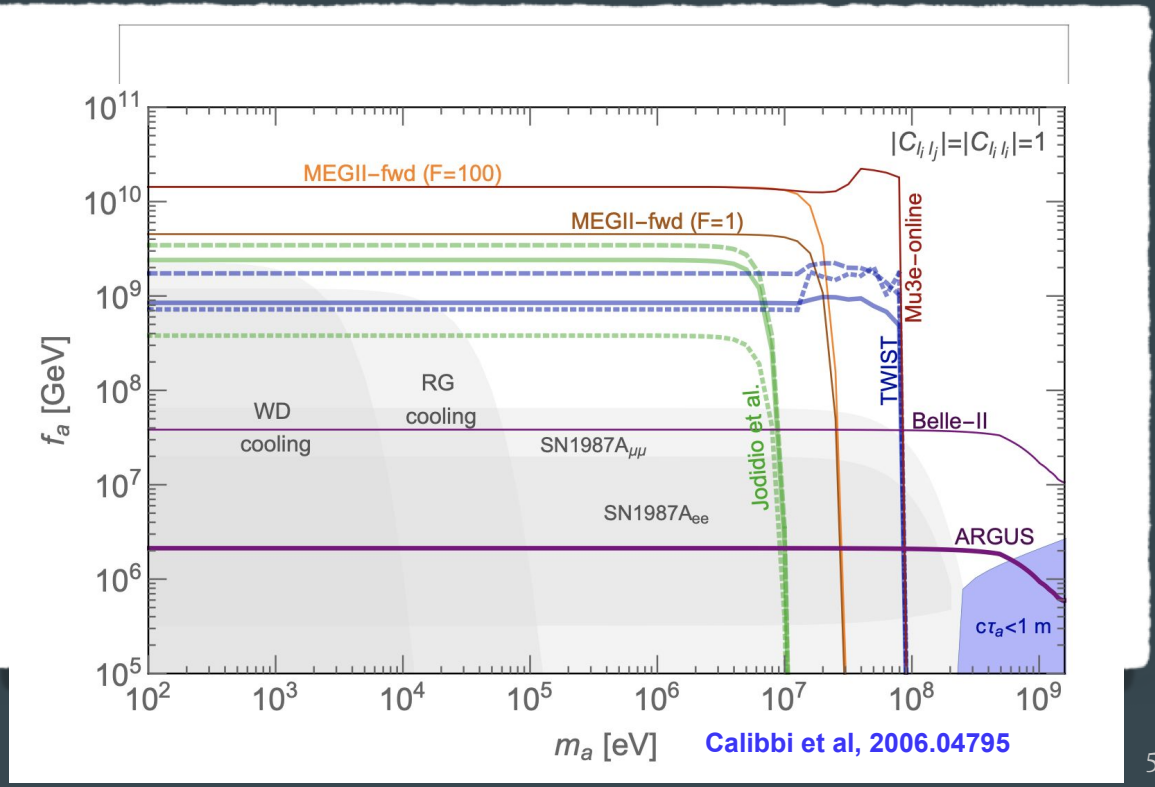
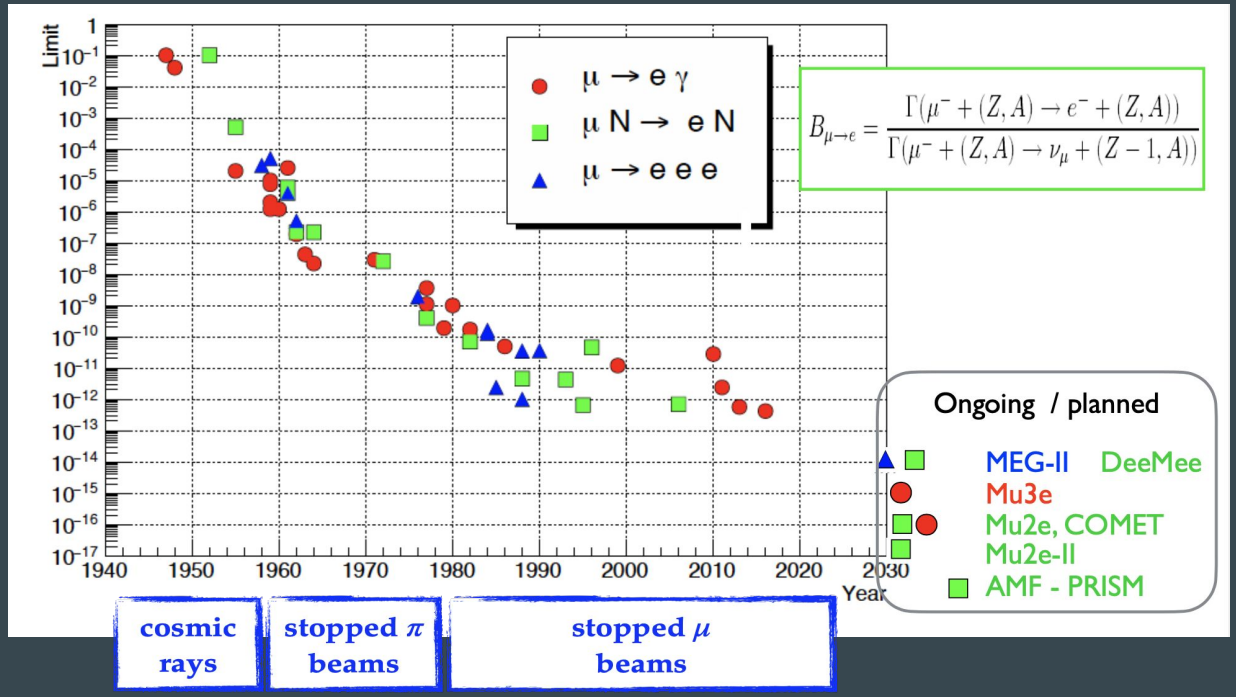


Current Experimental Landscape - CLFV

Steady experimental progress since 1940s



See talk by Cirigliano

Experiment	Experiment type	Proton Beam			Uses existing or new beamline?
		Energy [GeV]	Power [kW]	Time Structure	
Proton Storage Ring: EDM and Axion Searches	Precision tests Dark Matter	0.232	1e11 polarized protons per fill	Fill the ring every 1000s	new
Physics with Muonium	Precision tests	0.8	1e(13+/-1) POT per second	CW	new
REDTOP Run I	Precision tests	1.8 - 2.2	0.03-0.05	slow extraction	Muon Campus
REDTOP Run II	Precision tests	0.8 - 0.92	200	CW,	new
REDTOP Run III	Precision tests	1.7	>1,000	CW,	new
Ultra-cold Neutron Source for Fundamental Physics Experiments, Including Neutron-Anti-Neutron Oscillations	Precision tests	0.8-2	1,000	quasi-continuous	new
CLFV with Muon Decays	CLFV	Not critical 0.8 to a few GeV	100 or more	continous beam on the timescale of the muon lifetime i.e. proton pulses separated by a microsecond or less. The more continuous the better	new
Mu2e II	CLFV	1 to 3	100	pulse width 10s of ns or better separated by 200 to 2000 ns. Flexible time structure and minimal pulse-to-pulse variation	new
Fixed Target Searches for new physics with O(1 GeV) Proton Beam Dump	Dark Sector, Neutrino	0.8 to 1.5 GeV	100 or more	<O(1 micro s) pulse width for neutrino measurements, <O(30 ns) pulse width for dark matter searches, 10^{-5} or better duty factor	new
PRISM-like Charged Lepton Flavor Violation	CLFV	1 -3 GeV	up to 2 MW	15ns pulses at a rep rate of about 1 kHz	new
Proton Irradiation Facility	R&D	Energy is not very important	1e18 protons in a few hours	Pulsed beam (duty factor not specified)	new
SBN	Neutrino	8	32	20Hz	BNB
Mu2e	CLFV	8	8	<10^{-10} extinction	Muon Campus
Fixed Target Searches for new physics with O(10 GeV) Proton Beam Dump	Dark Sector, Neutrino	8	up to 115	Beam spills less than a few microsec with separation between spills greater than 50 microsec	BNB
Muon beam dump	Dark Sector	8 (producing 3 GeV muons)	3e14 muons in total on target for the whole run	CW	Muon Campus
Muon Collider R&D	R&D	8 - 16GeV	4e13 to 1.2e14 protons per bunch	5 - 20 Hz rep rate and bunch length 1-3 ns	new
Muon Missing Momentum	Dark Sector	few 10s of GeV	10^{10} muons per experimental runtime	Pulsed beam (duty factor not specified)	new
High Energy Proton Fixed Target	Dark Sector, Neutrino	O(100 GeV)	1e12 POT/s therefore ~20 kW	CW via resonant extraction. "IF we could up the duty factor that woul dbe even better"(?)	Switchyard or new
Test-Beam Facility	R&D	120, lower energies would also be beneficial	10 to 100 kHz on the testing apparatus	Pulsed beam (duty factor not specified)	Switchyard or new
Tau Neutrinos	Neutrino	120	1200 or higher	MI time structure	LBNF

Dark Sector/CLFV Experiments at PIP-II/ACE

Spigot	Energy (GeV)	Accelerator Features	Experiment/Type
S0A	0.8	CW	Mu2e-II
S0B	0.8	Pulsed	Surface Muon Experiments
S0C	0.8	Accumulator Ring	PIP-II BD Dark Sectors
S0D	8	Booster	SBND Dark Matter
S0E	8	Recycle/Delivery Ring	Mu2e
S0F	120	Slow Extraction	Spin(Dark)Quest/M³
S2	O(1)	Accumulator Ring	PIP-II BD Dark Sectors
S3	O(10)	Booster	Muon Beam Dump

Proposed Questions for Discussion

WH13NW Oscillatorium

- Dark sector experiments at PIP-II and ACE
  - How do we maximize probing the thermal dark matter parameter space? - beam dumps, fixed target, muon beams, etc.
  - Dark photons, ALPs, SIMPs, milli-charged particles, other exotic models of interest
- CLFV experiments at PIP-II and ACE
  - How do we maximize probing CLFV with PIP-II and ACE capabilities?
  - Exotic muon decay signatures, theory/experiment for $\mu \rightarrow e$, etc.
- Maximize synergies between CLFV experiments and dark sector experiments with PIP-II and ACE
  - Parasitically run with proton beam dump, dark sector experiments utilizing muon beams, theory synergies, etc.
- Are we missing anything? Any other big ideas?
- Feel free to participate in the Living Document for active discussion

All are welcome in the Dark Sectors + CLFV parallel discussion section!