Probing the dark sector and "new" muon-philic forces at KLF facility

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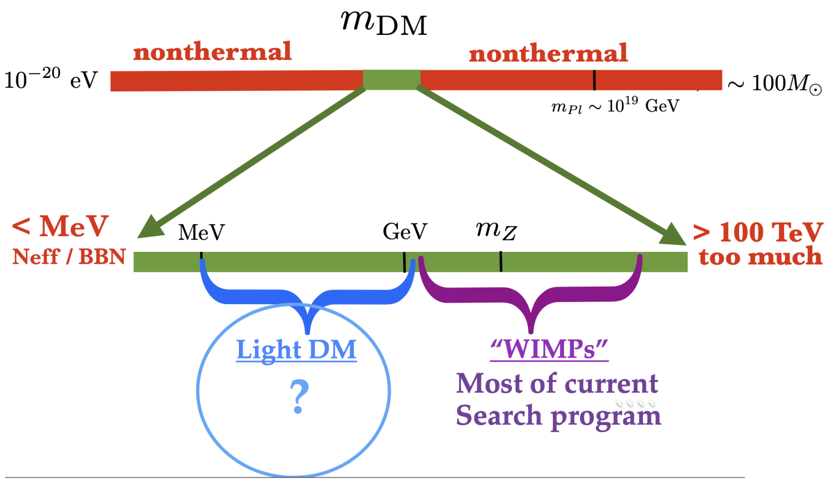
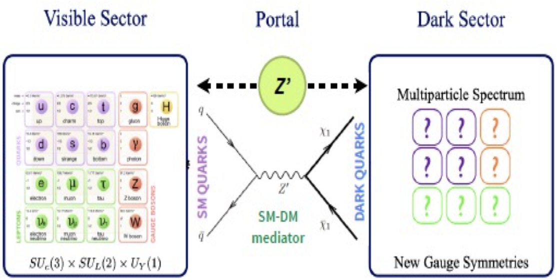
Dark Matter

- Dark Matter is there but **we know nothing about the particle content of DM**
  - Plenty of cosmological/ astrophysical observations: CMB anisotropies, galaxy rotation curves, gravitational lensing,cluster collisions...
- No hints on DM particle properties (mass, cross section)
- Common assumption: **thermal origin of DM**:
  - DM in thermal equilibrium with SM in early Universe. Current relic abundance set by the strength of the SM-LDM interaction ("freeze-out mechanism")
  - constrain on available mass range
- Light Dark Matter: mass range 1 MeV÷1 GeV



Muon-philic forces

- Sub-GeV DM $\hookrightarrow$ Hidden Sector[a]
  - Matter neutral under SM[b]
  - LDM needs light new forces to explain thermal origin;
    - Would be overproduced without light "mediators";
- In a well-motivated class of such models, DM interacts predominantly with muons through a new force carrier;
  - New scalar/vector particle couples to muons decays invisibly to DM[c]
- Muon-specific forces are also well-motivated independently of any possible connection to dark matter. **They can account g-2 anomaly**.
- How do we look for light new mediators?



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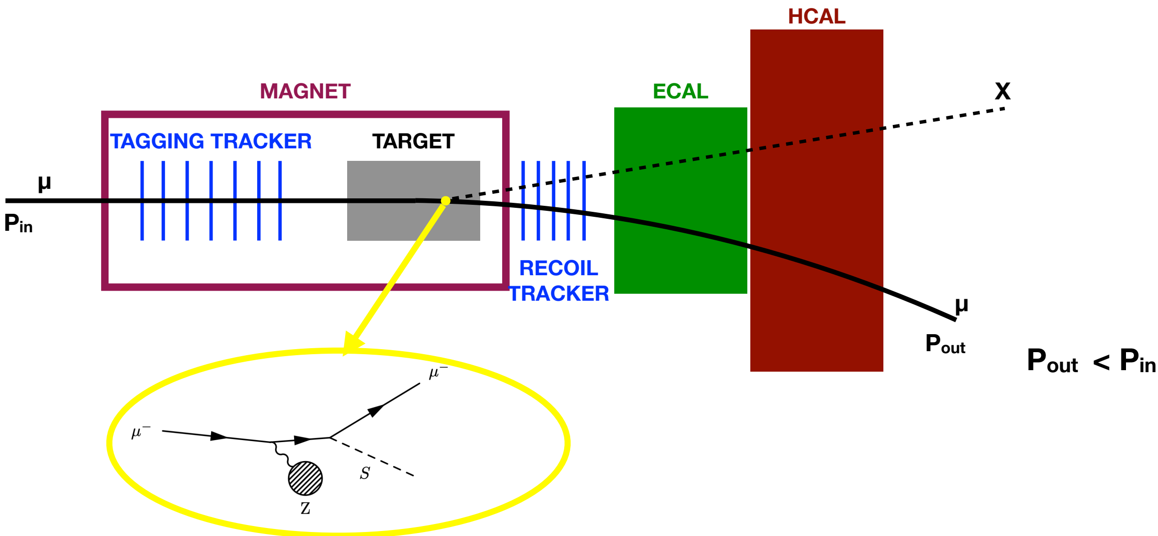
a For a comprehensive review: 1707.04591, 2005.01515, 2011.02157

b Very small electric charges

c 2305.01715, 1804.03144, Phys. Rev. D 95, 115005 (2017)

Missing Momentum Muon-beam Experiment *a la* M^3

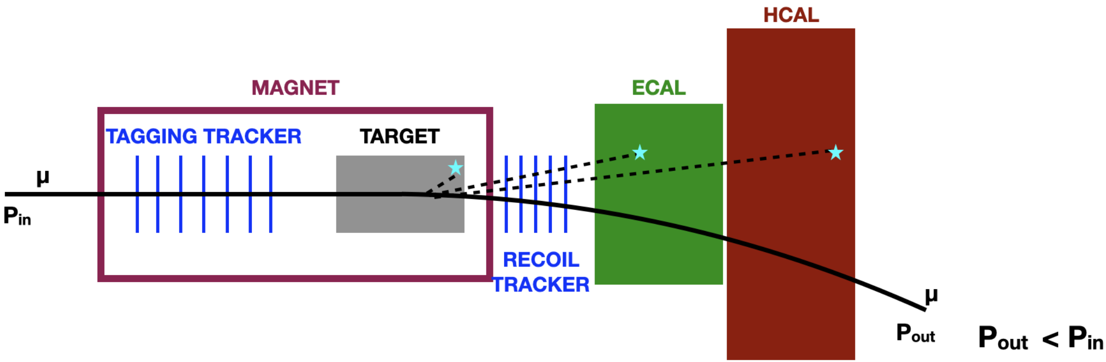


Requirements[a]

- high-intensity O(GeV)-muon beam
- thick active-target (O(20X0))
- compact detector
- momentum resolution $< 1\%$

[a] Similar effort proposed @ FermiLab - 1804.03144

Missing Momentum Muon-beam Experiment - Background



Reducible background

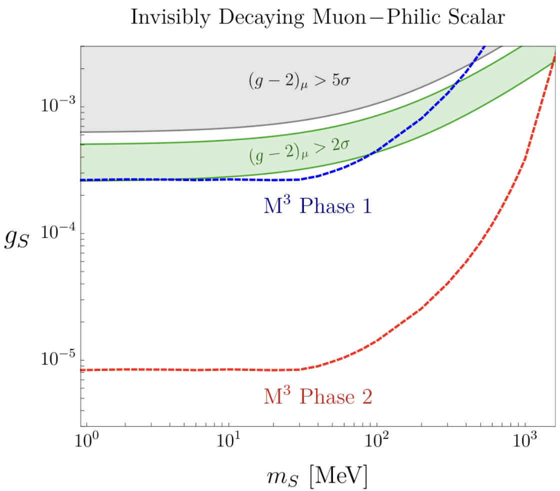
- Single bremsstrahlung: $\mu N \to \mu N \gamma$
- Bremsstrahlung-initiated hadronic events: $\mu N \to \mu N \gamma$; $\gamma \to$ hadrons
- Muon pair production: $\mu N \to \mu\mu$

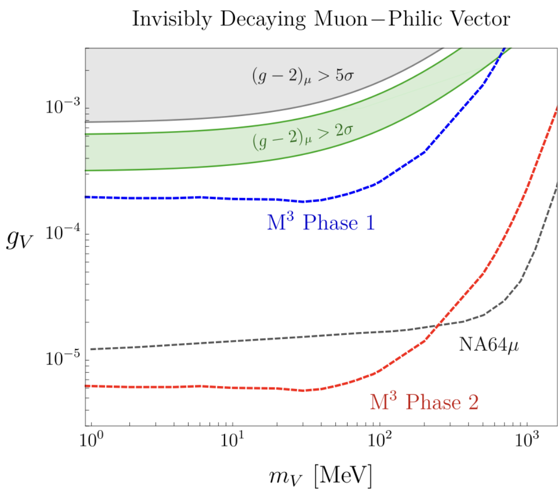
Irreducible background

- Neutrino pair production
- Moller + CCQE: $\mu e \to \mu e$; $ep \to n\nu_e$

Missing Momentum Muon-beam Experiment - M^3 Reach

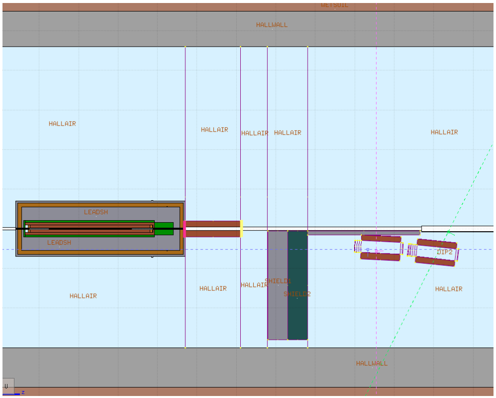
The experiment promises to cover an incredible range of parameter space. M^3 example:

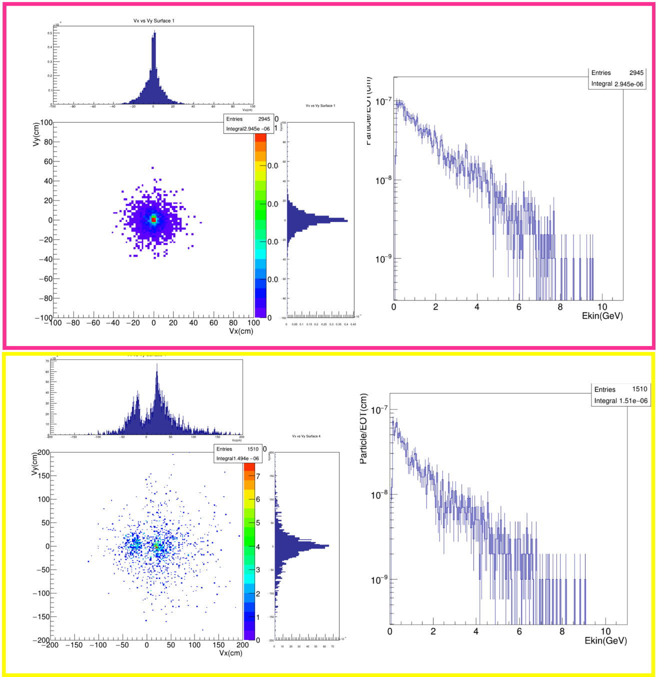




- muon beam $\sim$ 15 GeV
- Phase 1: 10^{10} MOT
- Phase 2: 10^{13} MOT

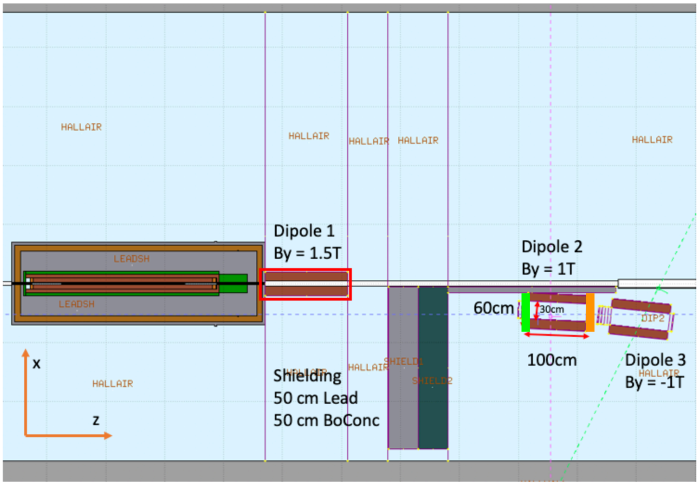
Muon Flux @ KLF - old geometry

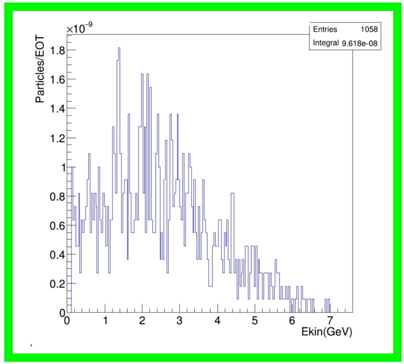


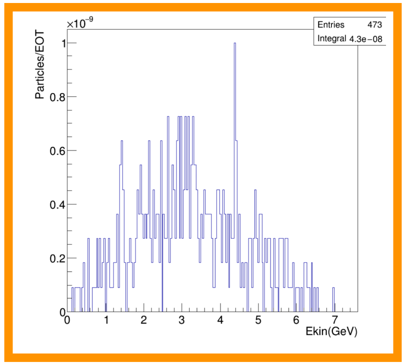


- Estimated muon flux at CPS exit ~3E-6 muon/EOT
- Bending magnet ~1.5T

Missing Momentum @ KLF - old geometry

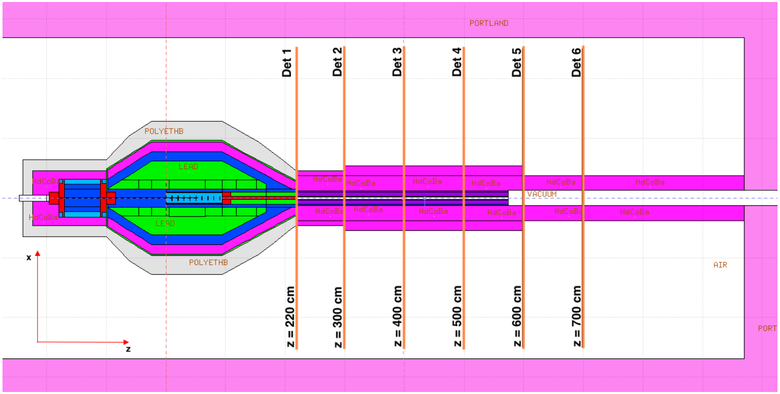


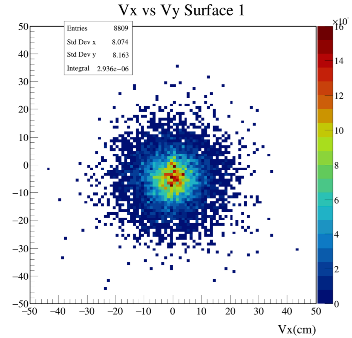


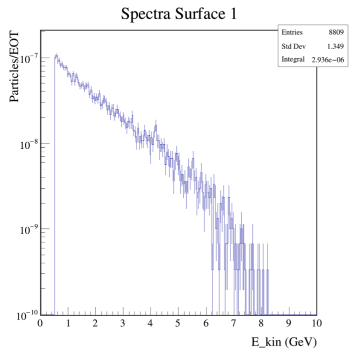


- Implemented a passive shielding for photons and neutrons
- no-optimized tracker system: 2 magnet ~1.5T

Muon Flux @ KLF - new geometry







- In coordination with KLF collaboration (Pavelm, Hovanes, Tim...) we started to investigate the possibility of making use of the muon beam (in a parassitic experiment) in this new configuration
- Estimated muon flux 3E-6 muon/EOT
- We are exploring if the M3 experimental setup is compatible in terms of weight, size with the CPS final design