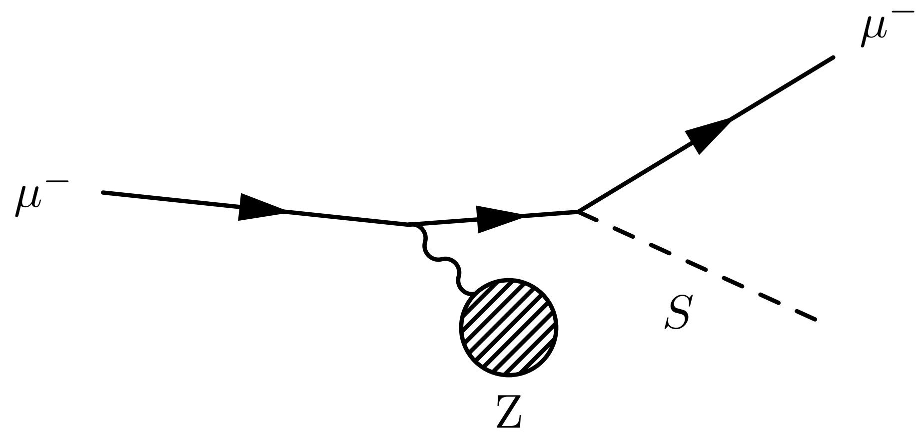
M^3:
Muon Missing Momentum

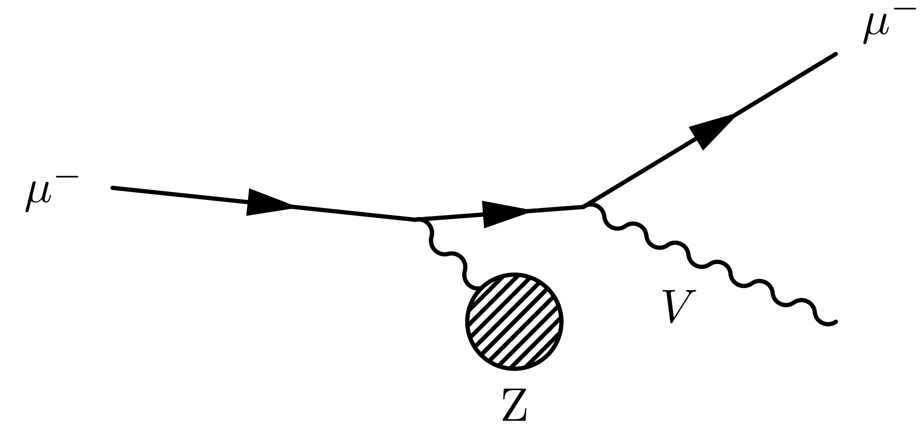
Yoni Kahn, UIUC

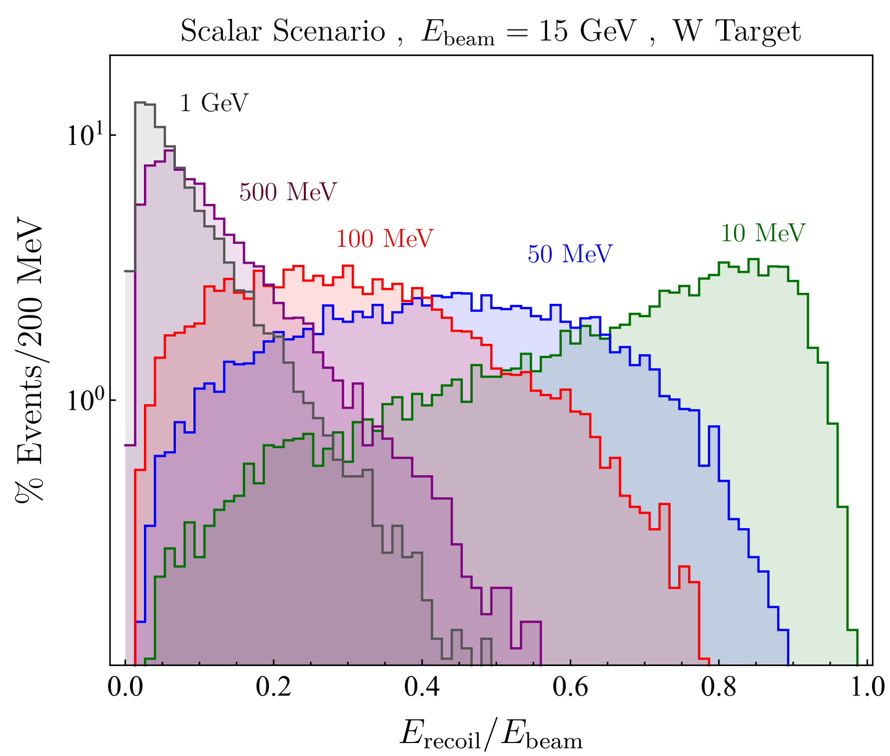
w/Gordan Krnjaic, Nhan Tran, Andrew Whitbeck

FNAL ACE Workshop, 6/15/23

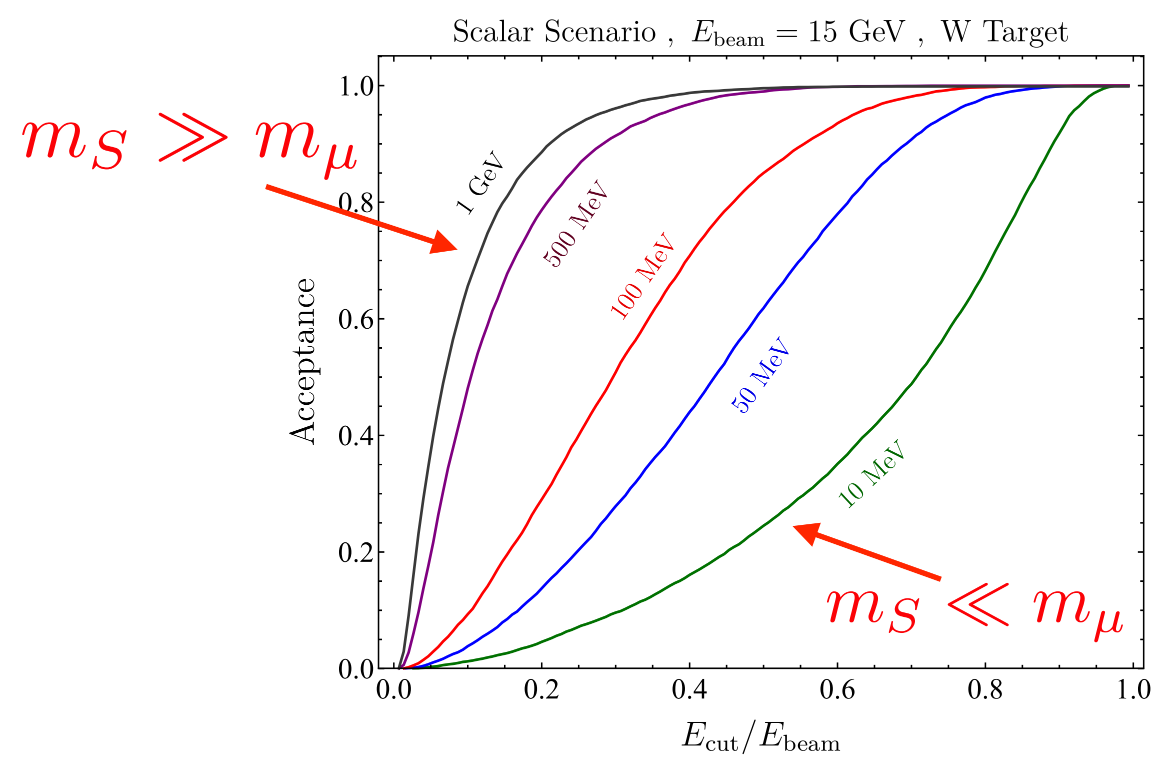
Setup







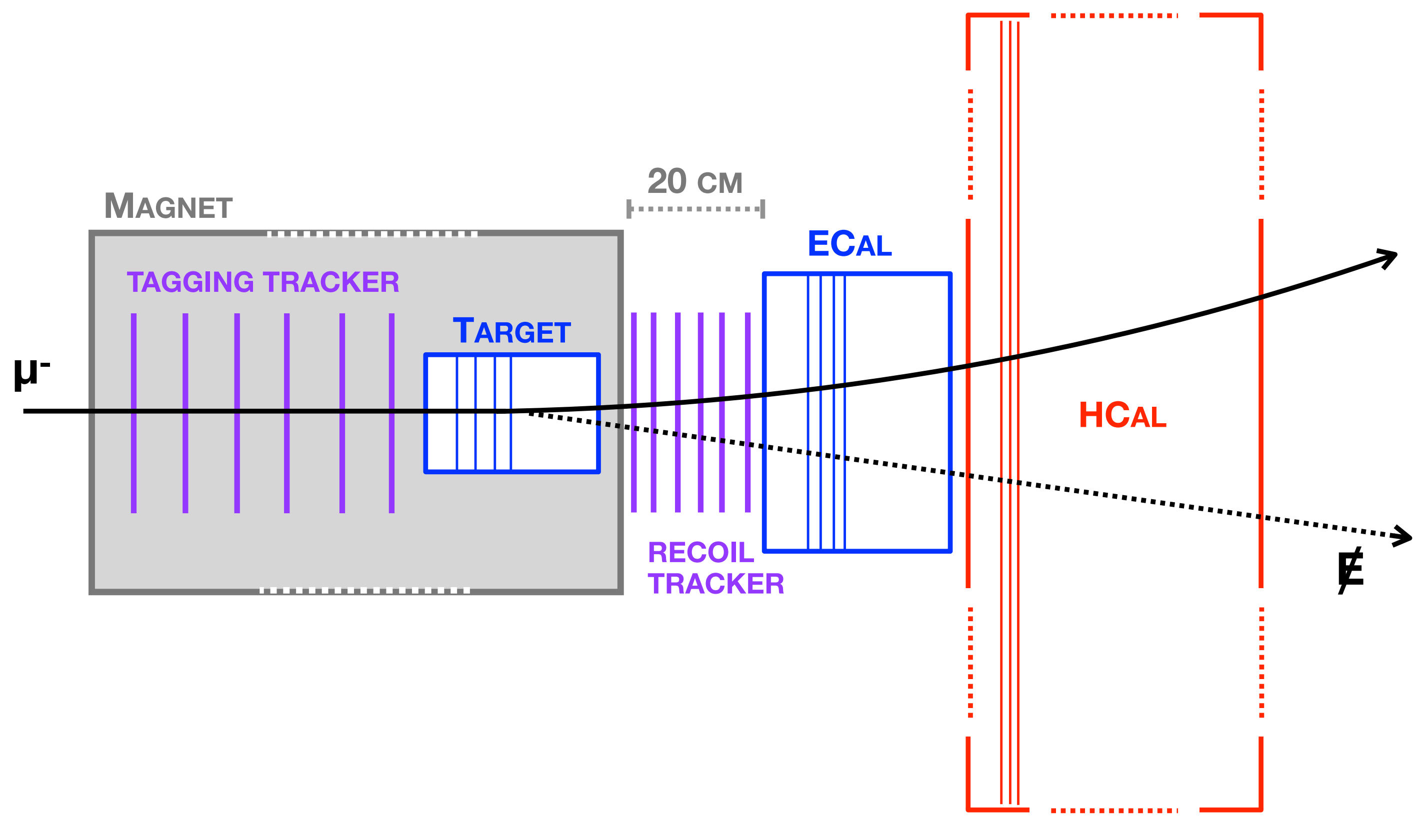
outgoing energy distribution



acceptance

Unlike electron beam, invisible particle doesn't take all the beam energy:
low-mass invisibles are QED-like (and hard to distinguish from background)

M³ schematic



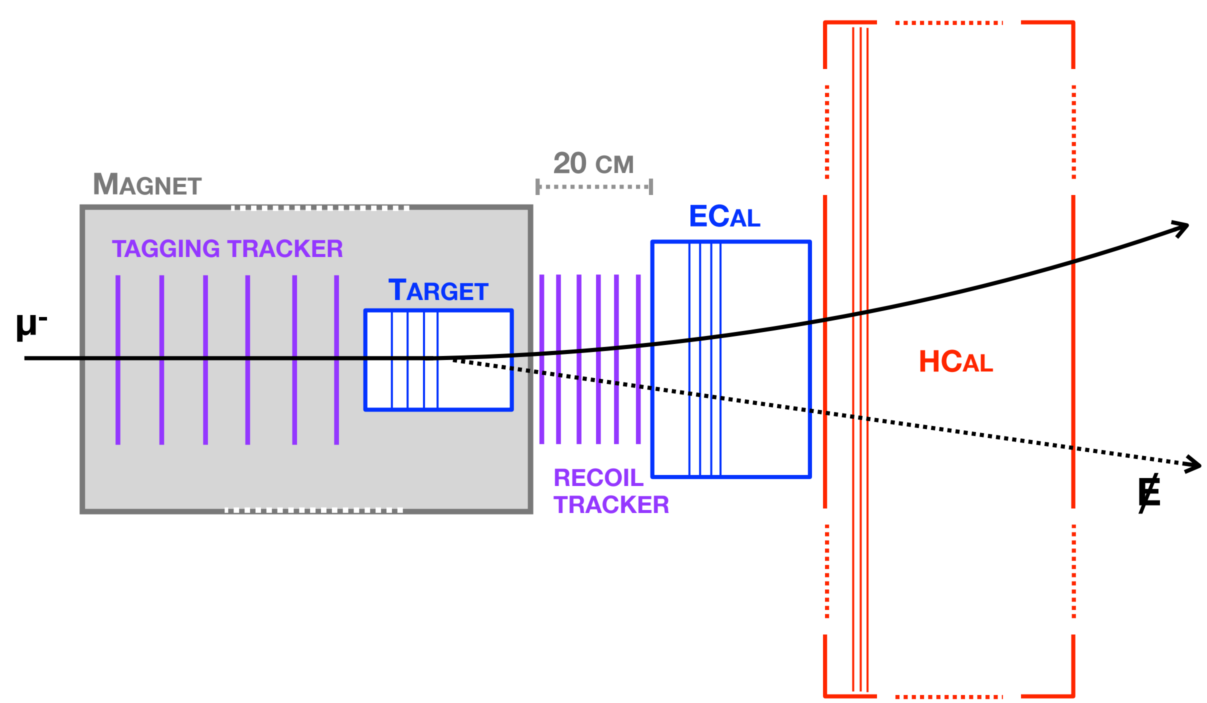
Similar in spirit to LDMX (electron beam missing momentum)

Main differences from LDMX:

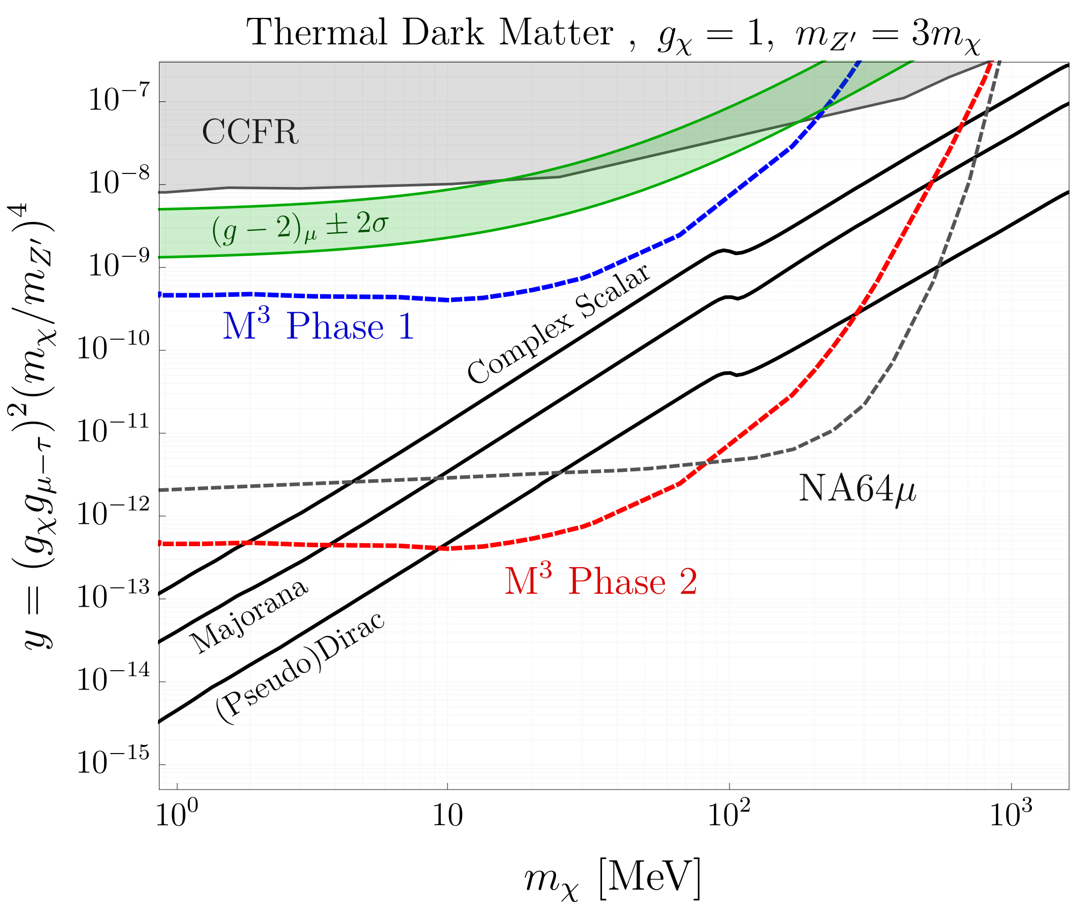
- **thicker (50 X0) active target** (muon is a MIP)
- outgoing muon momentum measured **exclusively by recoil tracker** (ECal and HCal for veto only)

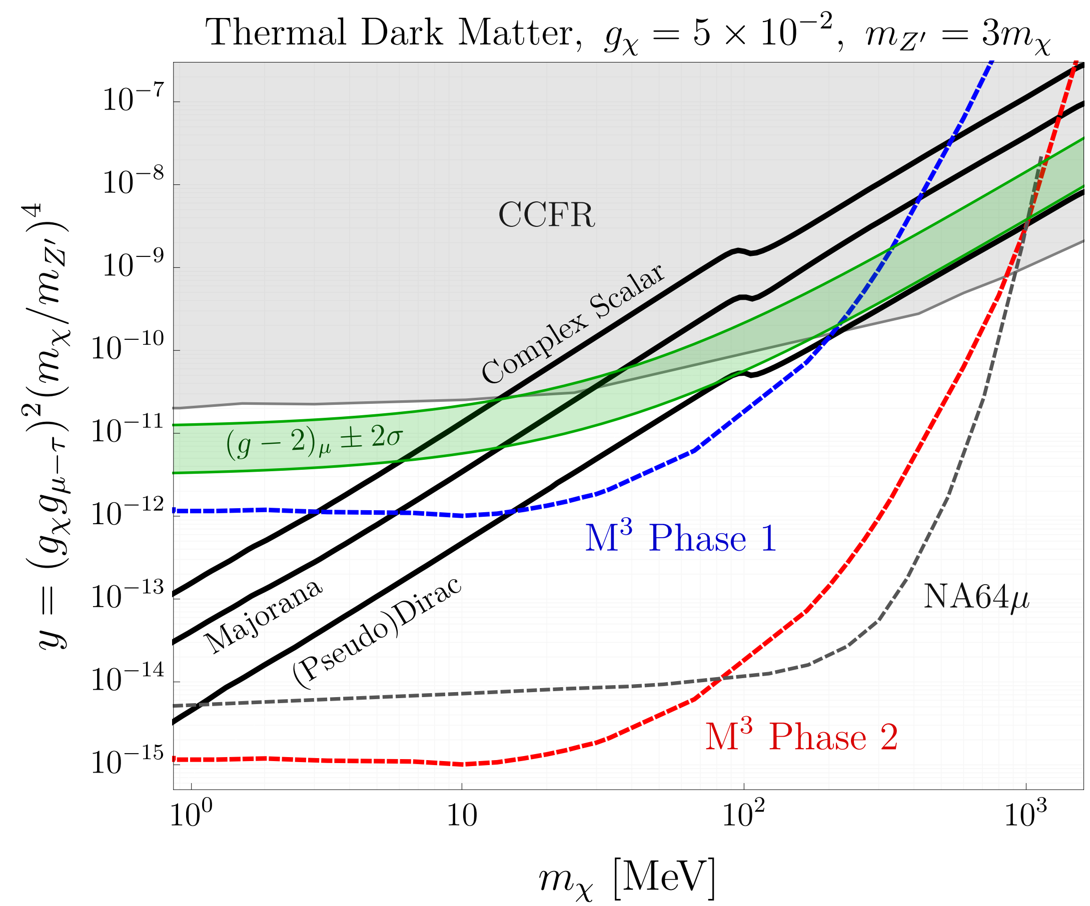
Beam requirements

- Lots of muons on target (MoT), i.e. high rep rate
- Identify and track each one so that we know they lost a significant amount of momentum $(p_{\rm out} \lesssim 0.5\, p_{\rm in})$
- Pion contamination = bad (esp. pions decaying in target). Estimate 10^{-6} will suffice for g-2 search
- p_{in} > ~several GeV - 10s of GeV:
  - **lower boundary:** need significant amount of lost momentum above detector thresholds to detect bkg processes
  - **upper boundary:** high momentum beam requires more B field lever arm, makes for a big and expensive detector with poor coverage



Reach





Phase 1 (10^{10} MOT): **complete coverage of g-2 region** for any invisibly-decaying particle lighter than the muon

Phase 2 (10^{13} MOT): can probe large parts of **well-motivated DM parameter space**