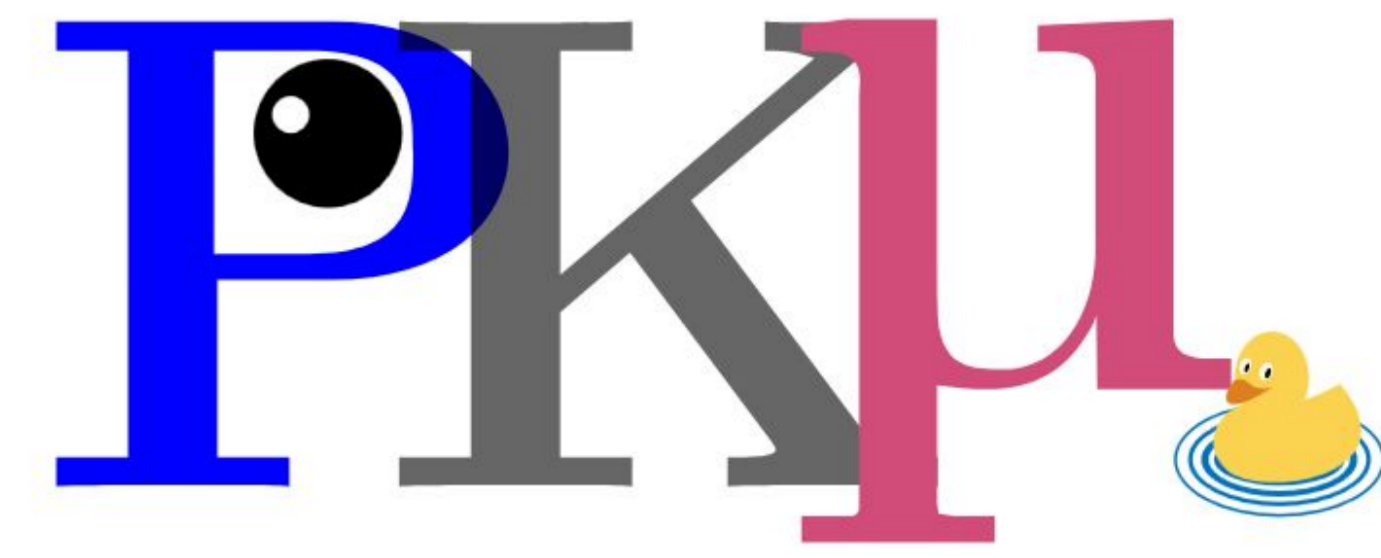


Proposed Peking University muon experiment for muon tomography and dark matter search

Qiang Li (PKU, China) on behalf of the PKMuon Collaboration

2024/07 ICHEP2024, Prague, Czech [arXiv:2402.13483](https://arxiv.org/abs/2402.13483) accepted by [Phys. Rev. D](https://arxiv.org/abs/2402.13483)



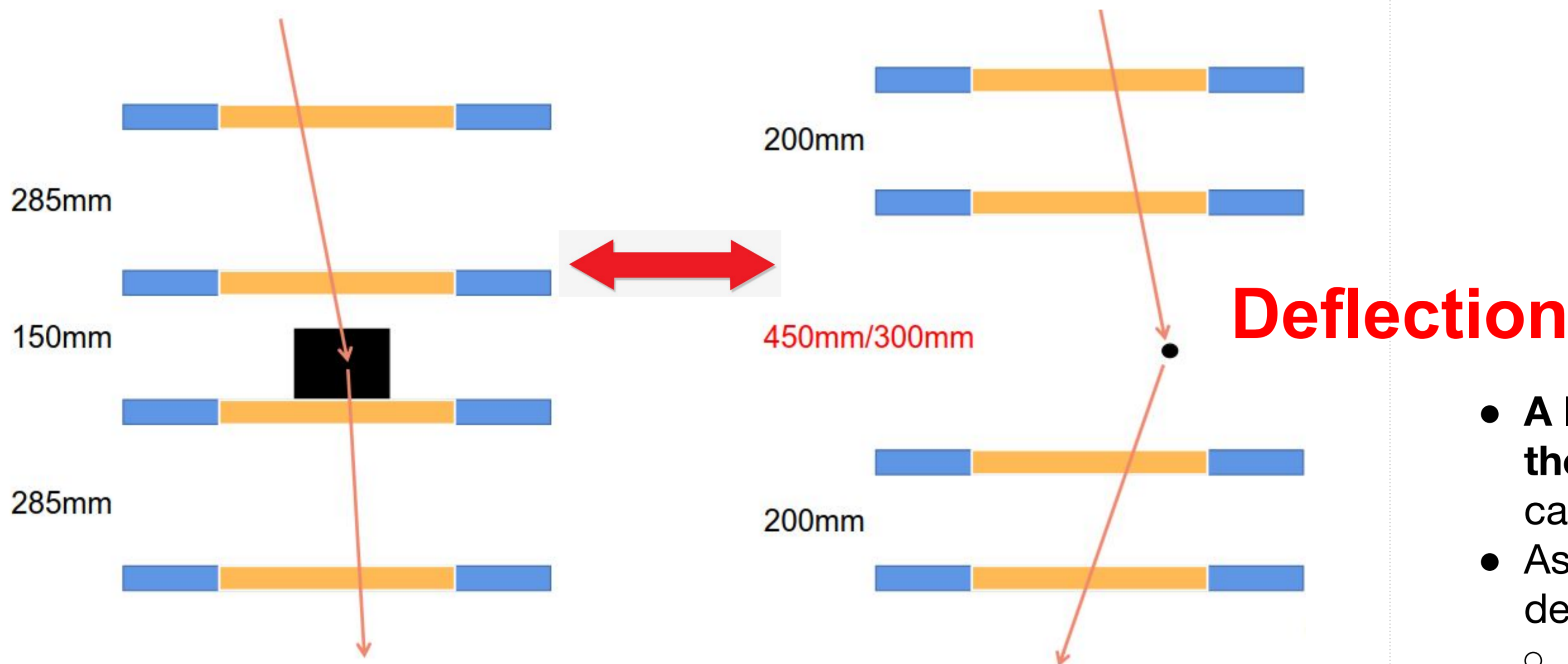
Muon:
a bridge connecting applied study and fundamental research

Cosmic muons

- Free, $1/\text{min}/\text{cm}^2$

or Dedicated Muon beams:

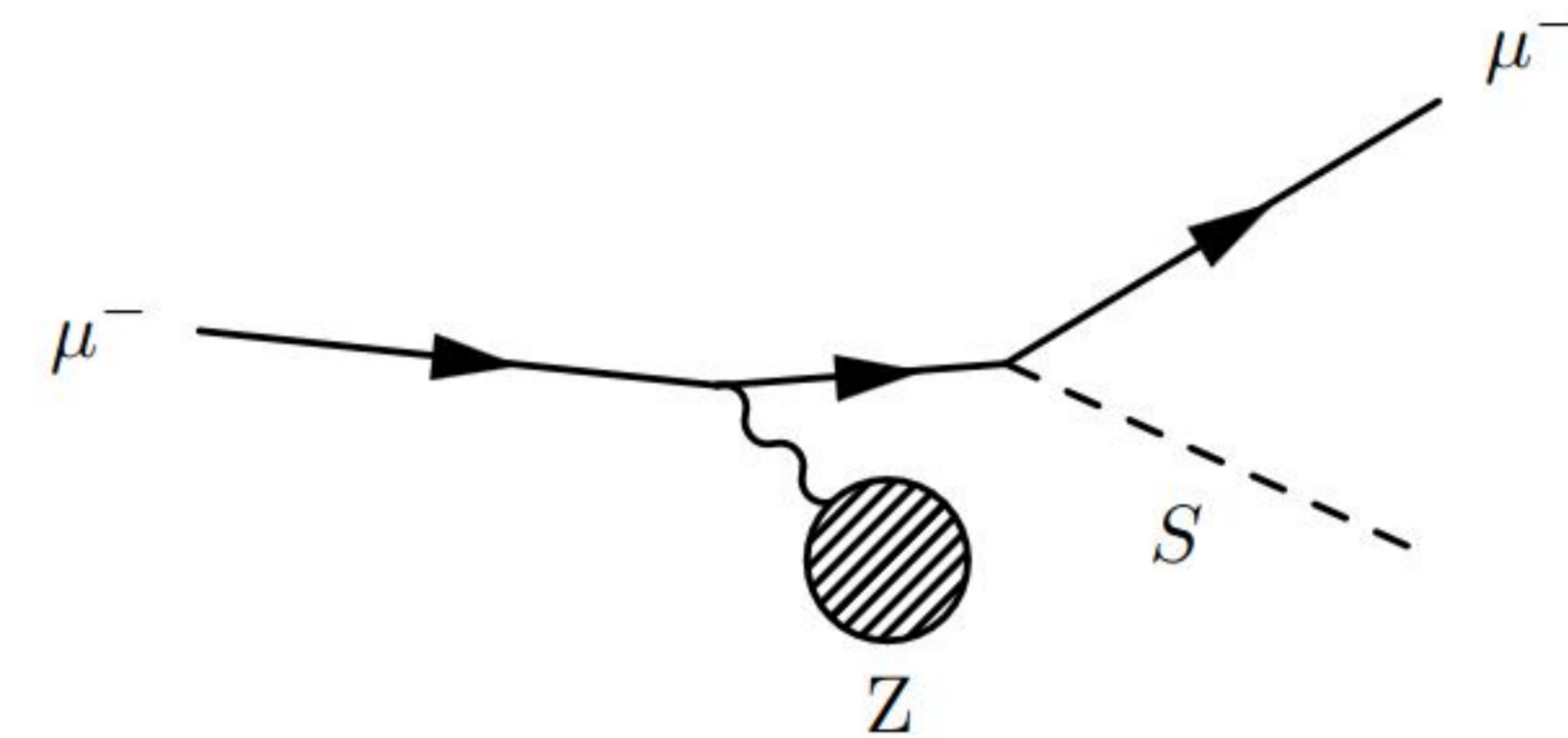
- **Melody**: approved and the first Chinese Muon beam will be built in 5 years.
- HIAF&CIDAS: other possible muon beam in China



Muon Philic Dark Matter:
possible and may explain several current anomalies

Muons on Target Experiments

- **NA64- μ** at the CERN muon beam M2
- **MMM (M3)** is a US proposed muon-LDMX experiment



- **A large amount of dark matter may be concentrated near the Earth, and their speed is very low**, making it difficult to cause recoil signals in experiments. [RPL131 \(2023\) 011005](https://arxiv.org/abs/2301.011005)
- As we will see, muon DM scattering experiment (PKMuon) depends minorly on DM velocity
 - Muon with high velocity
 - DM can be seen as static

Simulation and Feasibility Studies

MC simulation framework

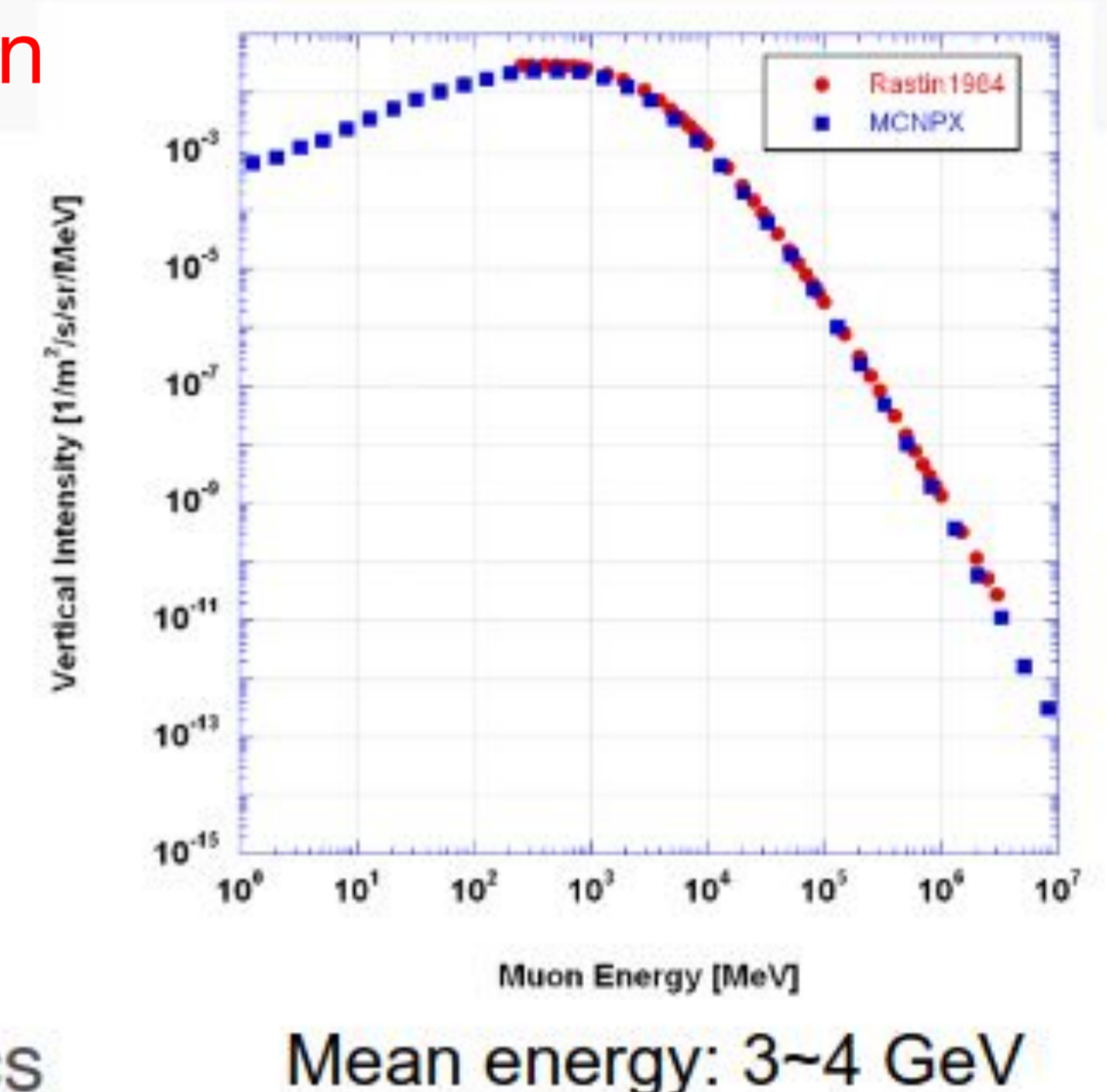
More details in [arXiv:2402.13483](https://arxiv.org/abs/2402.13483), for studies with both cosmic muon and muon beam

→ MC simulation of GEM-based detector based on **Geant4**

- ❖ Triple-GEM detector design refer to [CMS GEM design](https://arxiv.org/abs/1205.3443)
- ❖ Muon material interaction automatically considered by Geant4
- ❖ Reco hit position: Truth hit position smeared by GEM detector resolution ($\sim 200 \mu\text{m}$)

→ DM and muon scattering: **model-independent method**

- ❖ Non-relativistic two-body elastic scattering between muon and DM following Newtonian mechanics
- ❖ Standard halo model: DM velocity distribution follows Maxwell-Boltzmann distribution
- ❖ **CRY** (Cosmic-ray) model: cosmic-ray muon energy and zenith angle distributions at sea-level



→ Muon-DM scattering rate

can reach as low as **microbarn level** in exotic DM scenario as mentioned above

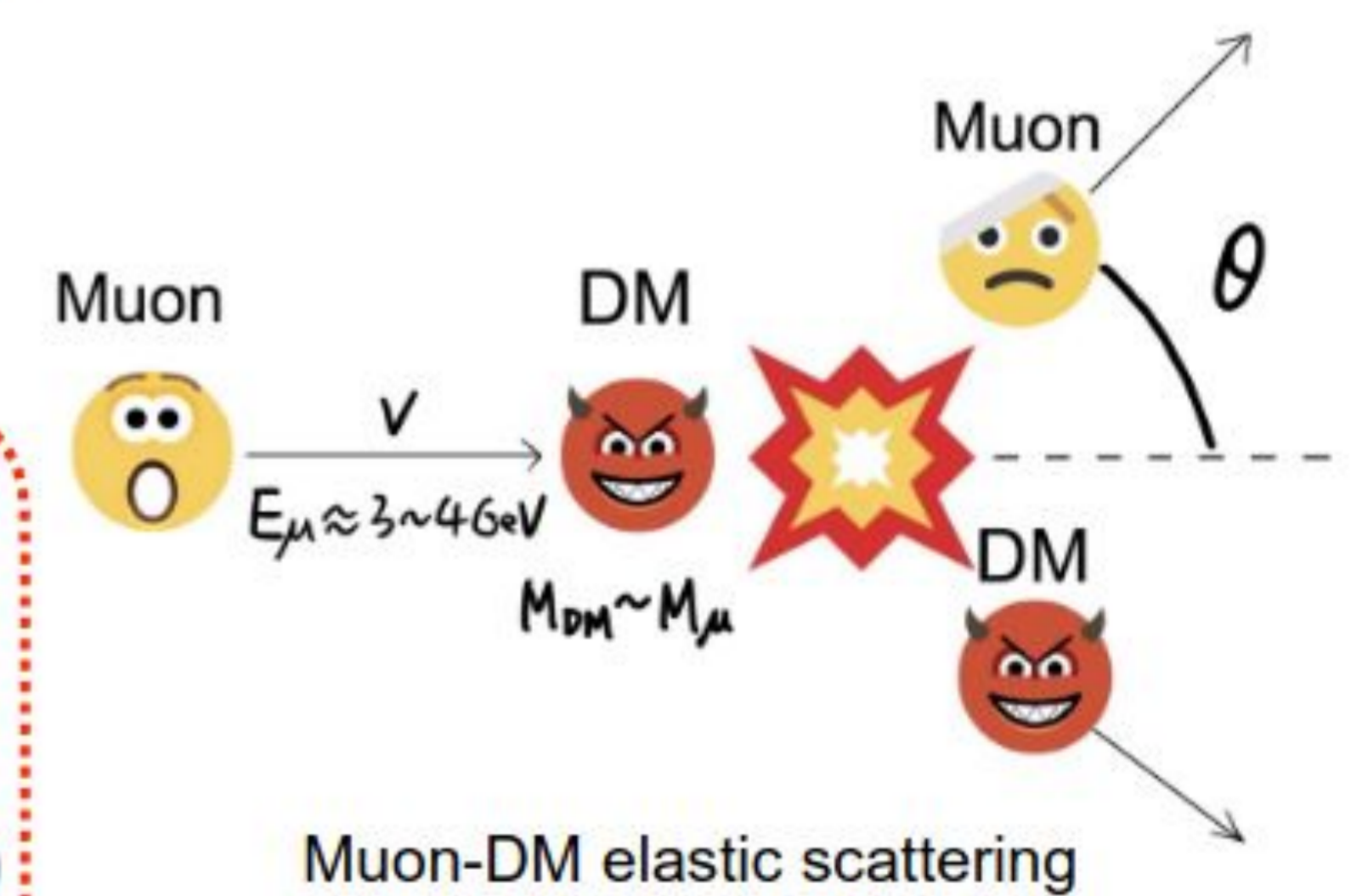
- ❖ Different from XENON1T/PandaX: **Relativistic muon hit quasi-static DM**

❖ DM search in $V = 1 \text{ m}^3$ box:

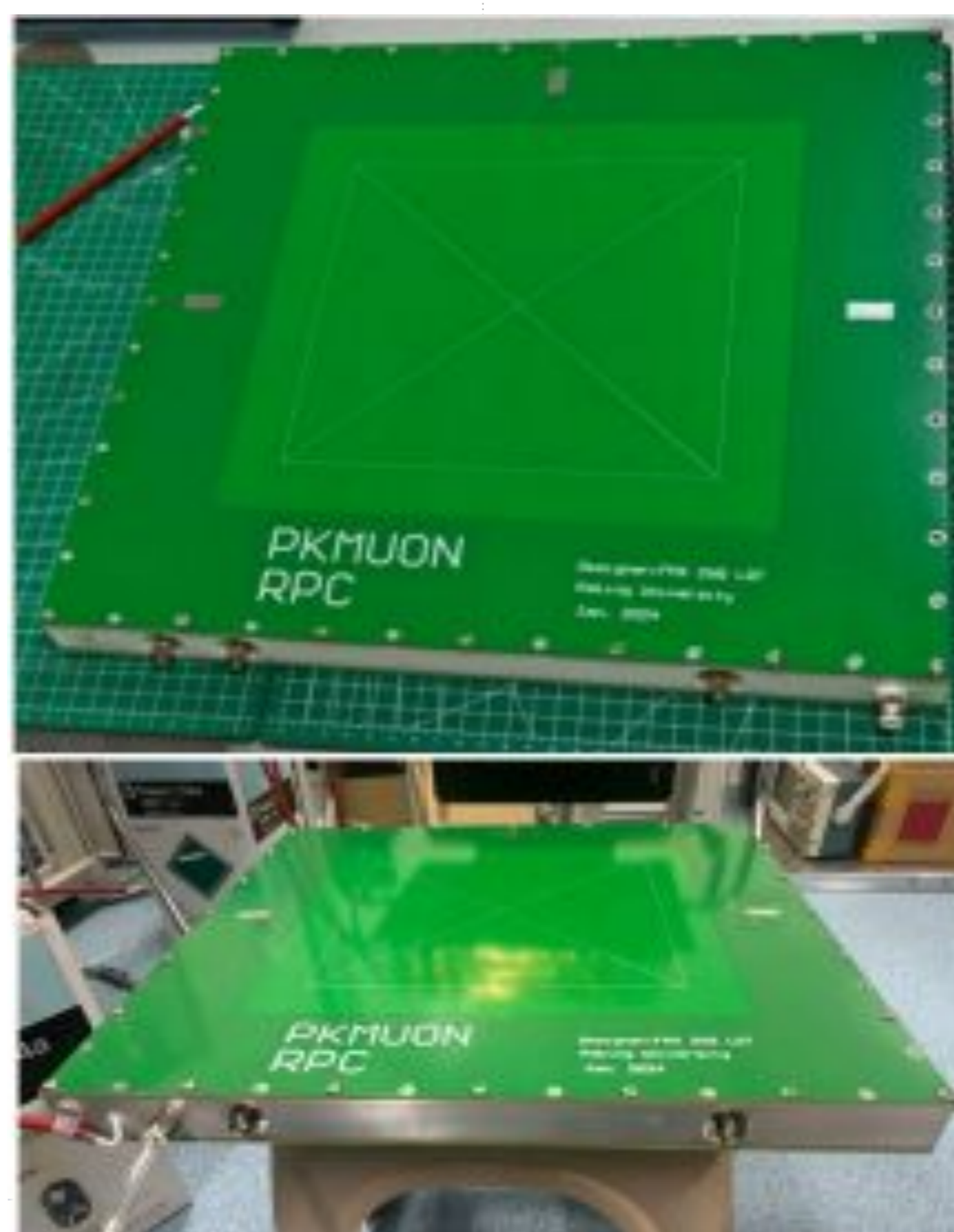
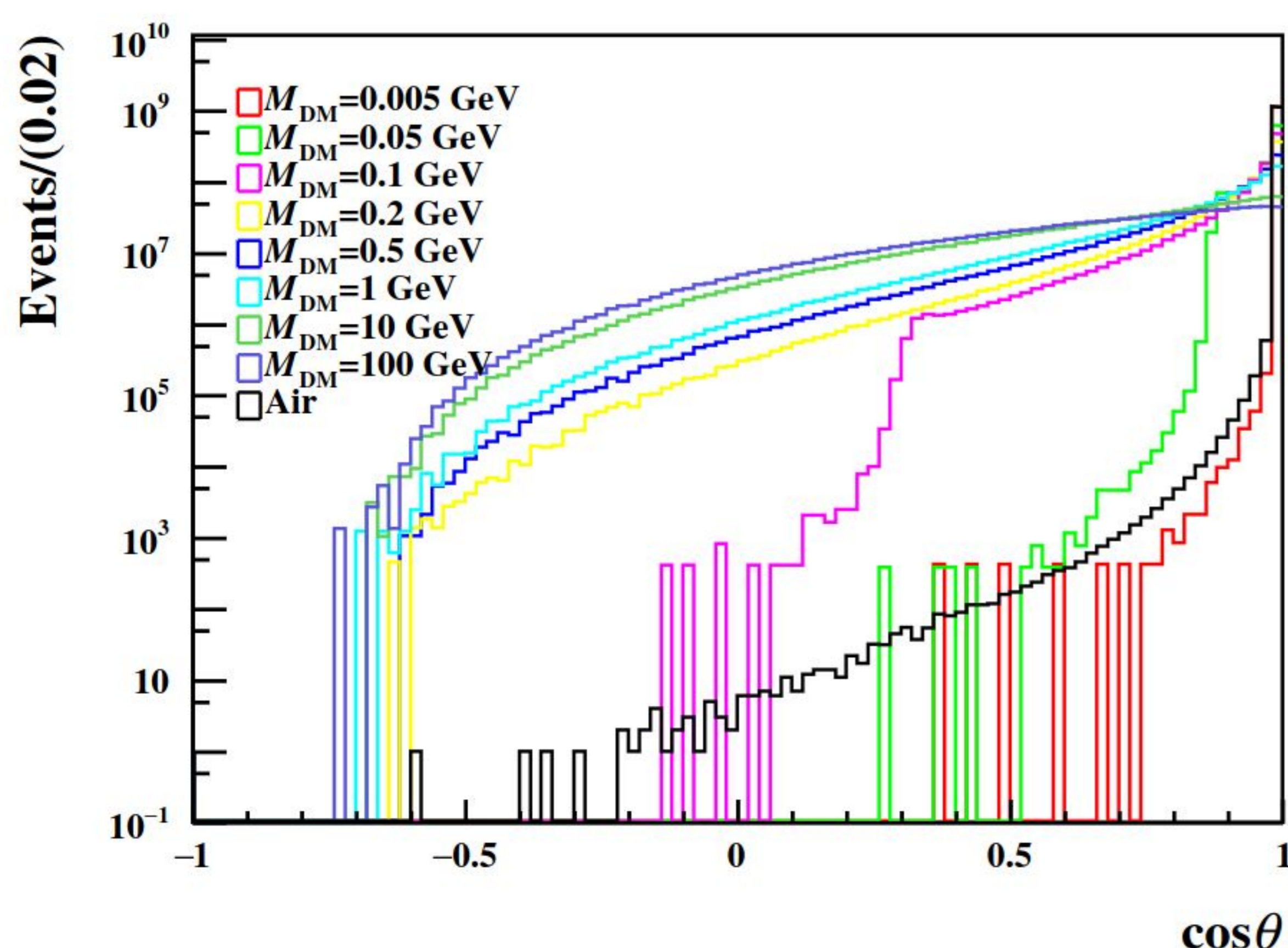
- $dN/dt = \rho_{\text{DM}} V / M_{\text{DM}} \times \sigma_{\mu, \text{DM}} \times F_{\mu}$
- Muon flux $F_{\mu} \sim 1/60 \text{ s}^{-1} \text{ cm}^{-2}$ at sea level
- $\rho_{\text{DM}} \sim 0.3 \text{ GeV}/\text{cm}^3 \Leftrightarrow N_{\text{DM}} \sim 3 \times 10^5$
- ❖ 1 year run: $\sigma_{\mu, \text{DM}} \sim 10^{-11} \text{ cm}^2$

❖ DM search in beam:

- Length $L = 1 \text{ m}$
- $dN/dt = N_{\mu} \times \sigma_{\mu, \text{DM}} \times L \times \rho_{\text{DM}} / M_{\text{DM}}$
- Intensity $N_{\mu} \sim 10^6/\text{s}$ (CSNS Melody design)
- ❖ 1 year run: $\sigma_{\mu, \text{DM}} \sim 10^{-15} \text{ cm}^2$



Muons' Deflection Angle



Summary and Prospect

Rich Physics Programs at the PKMuon Platform

Probing and Knocking with Muons

