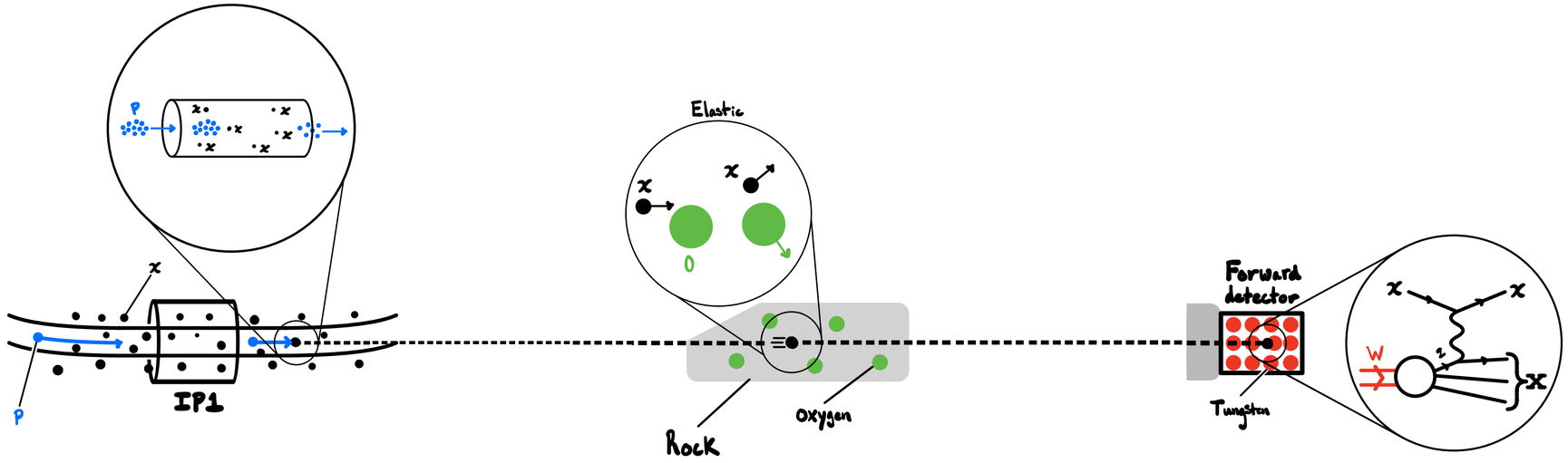


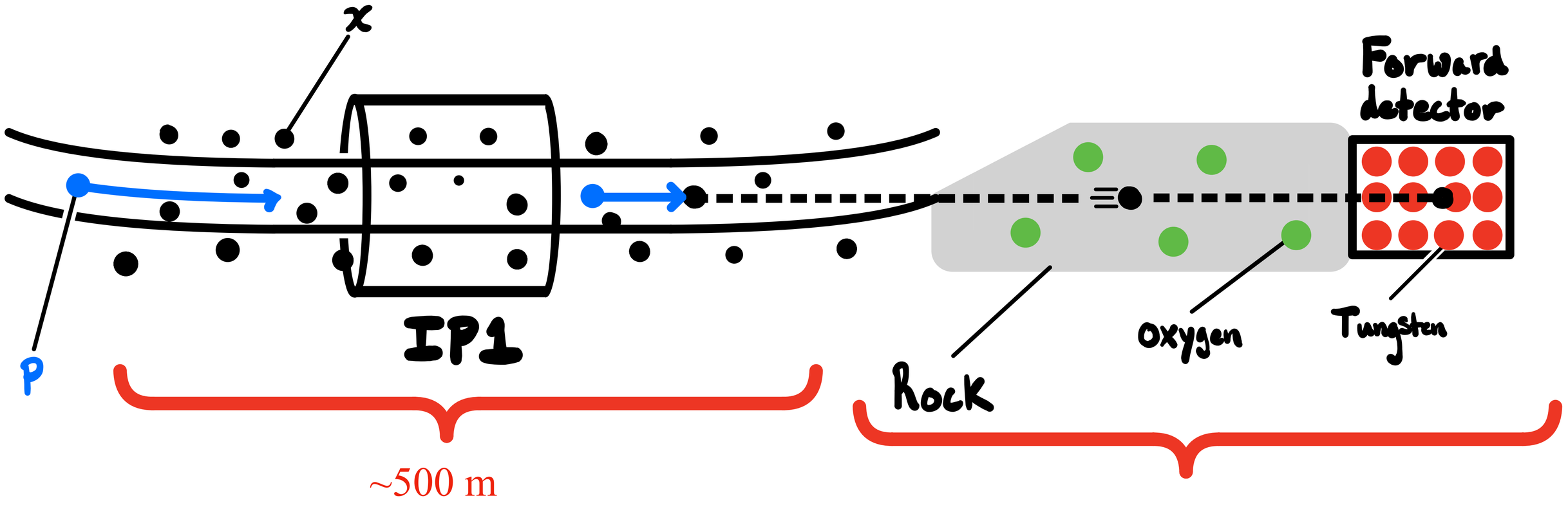
Searching For Signals Of Forward Boosted Dark Matter

Phenomenology Symposium 2026

Andrew M. Evans (UCI)
in collaboration with Jonathan L. Feng & Toni Mäkelä

We could detect boosted DM at the LHC

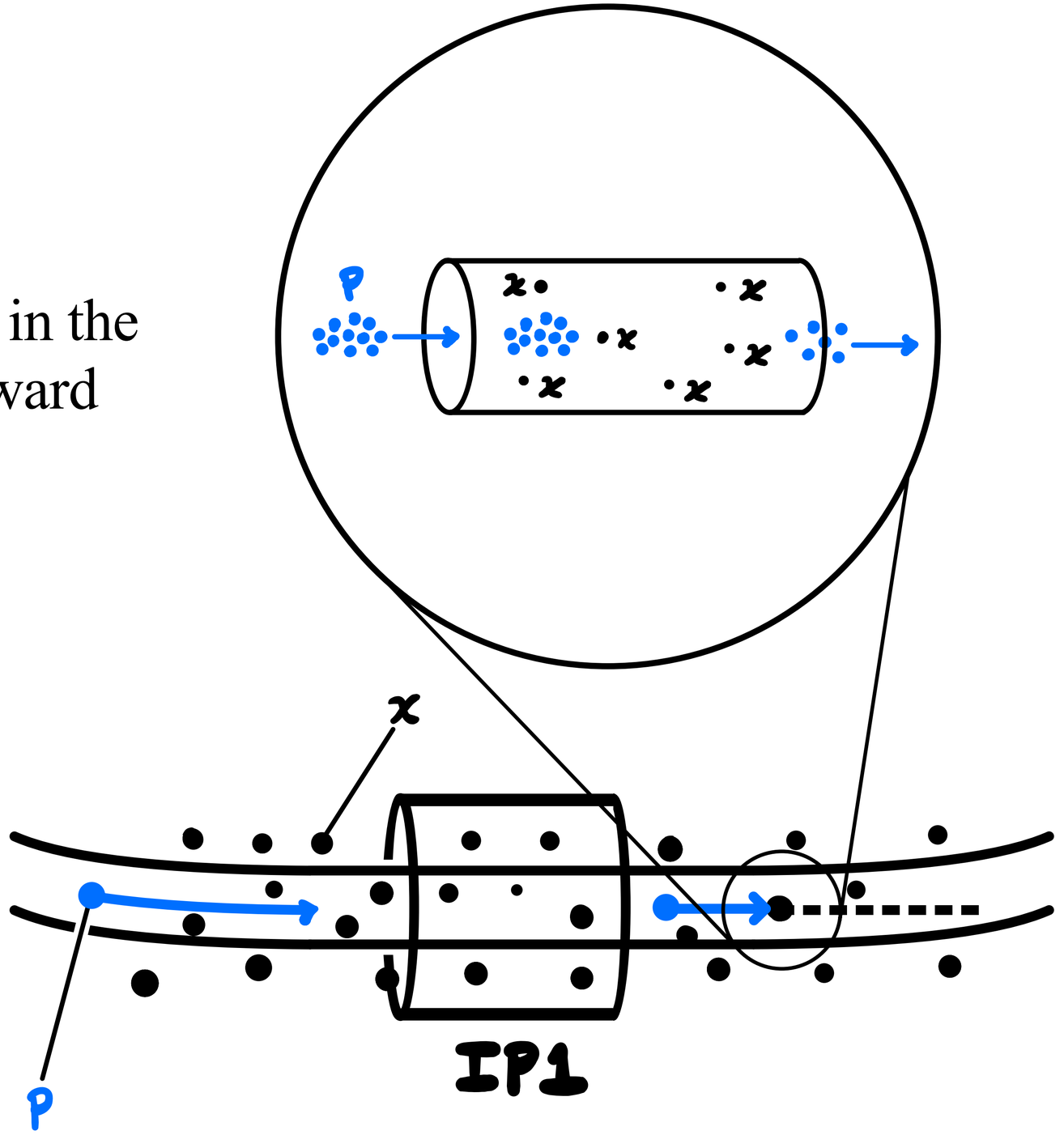
- Ambient DM can be scattered by beam protons into forward detectors.
- Forward physics experiments (like FASER!) can detect these signals.



Step 1: boosting DM

Creating a forward DM flux

- Bunch protons colliding with DM in the LHC beam pipe can boost DM toward forward detectors.



Step 1: boosting DM

Creating a forward DM flux

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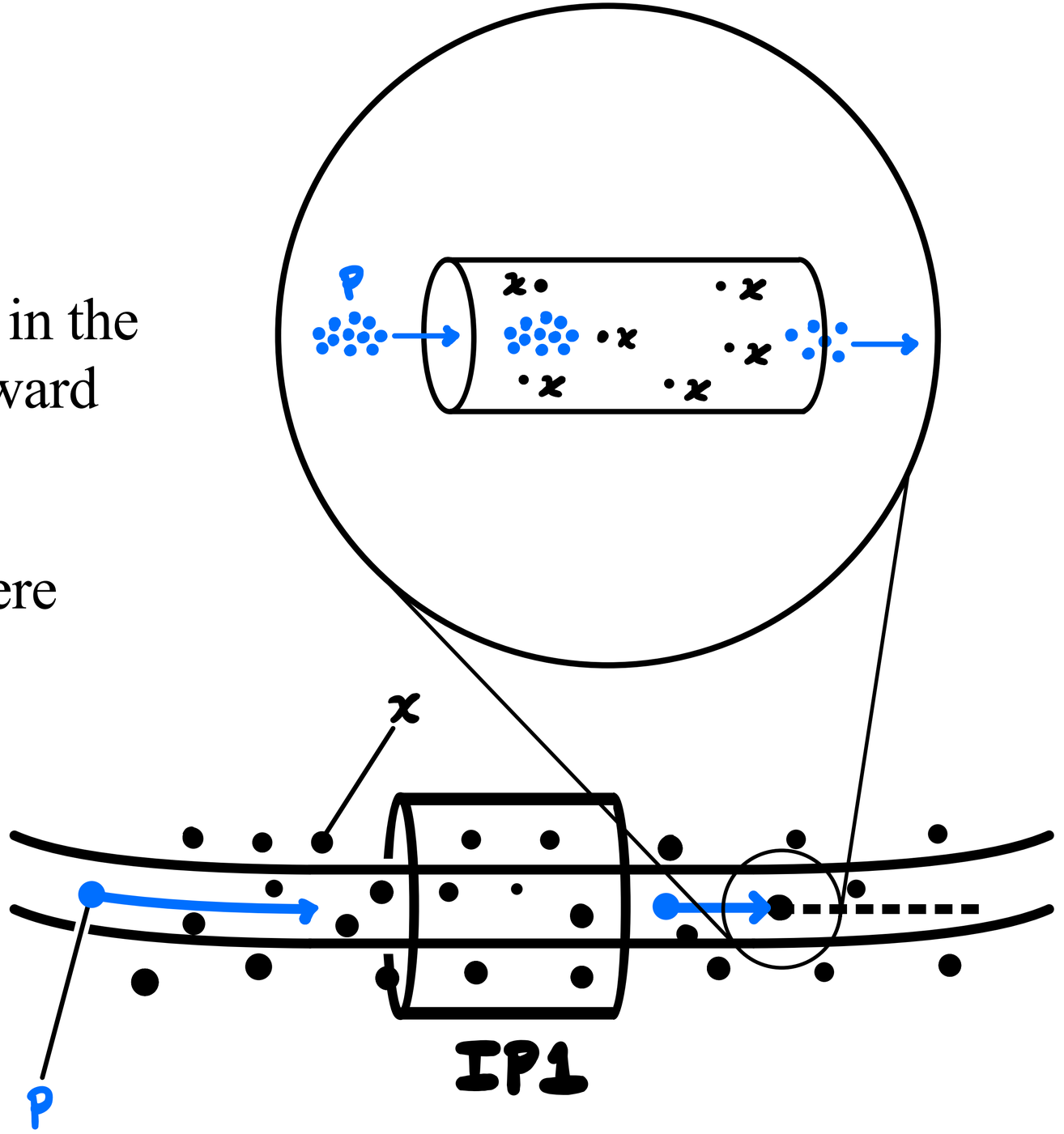
- DM flux can be produced anywhere along straight section (~500m).



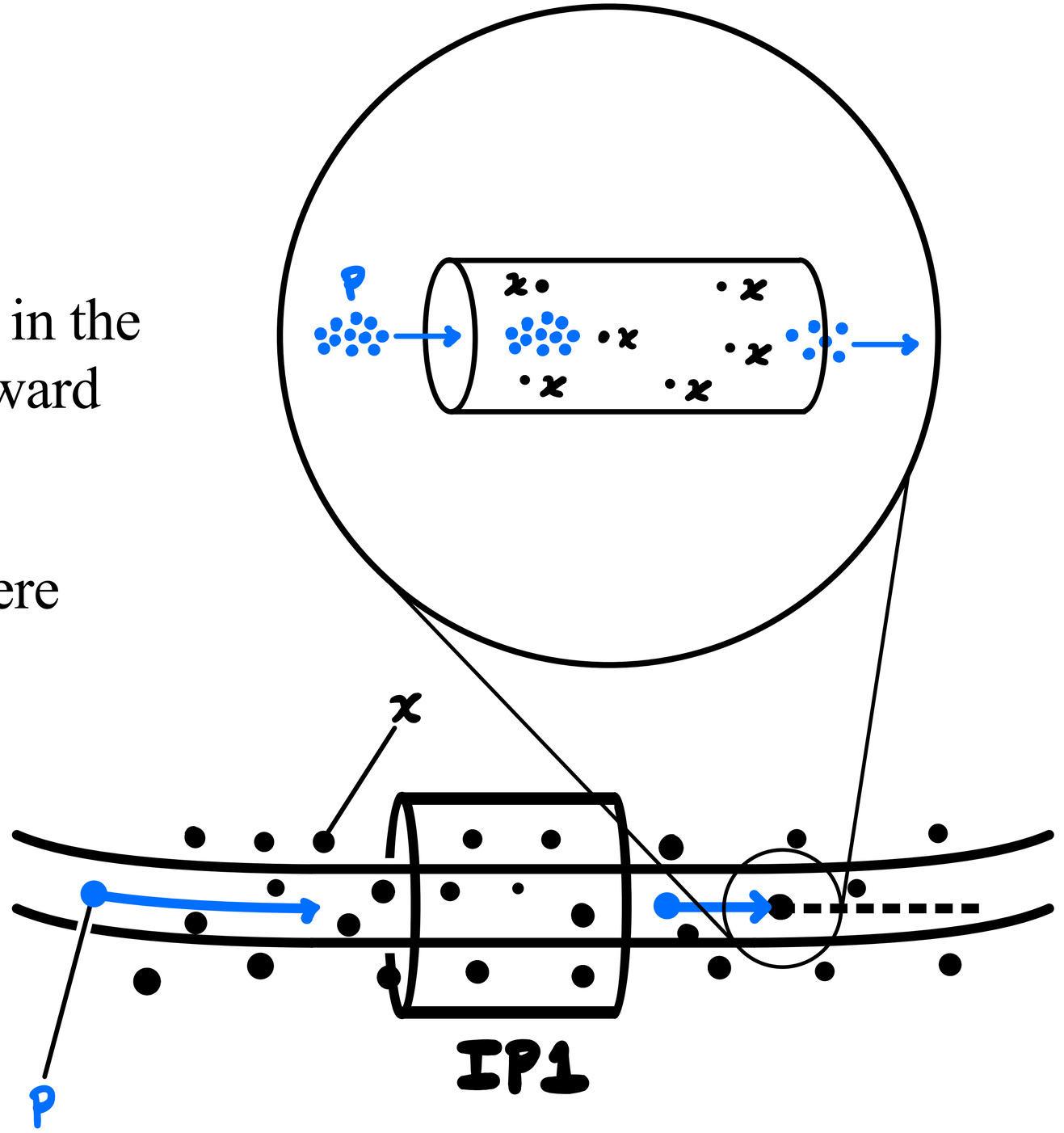
Step 1: boosting DM

Creating a forward DM flux

- Bunch protons colliding with DM in the LHC beam pipe can boost DM toward forward detectors.

- DM flux can be produced anywhere along straight section (~500m).

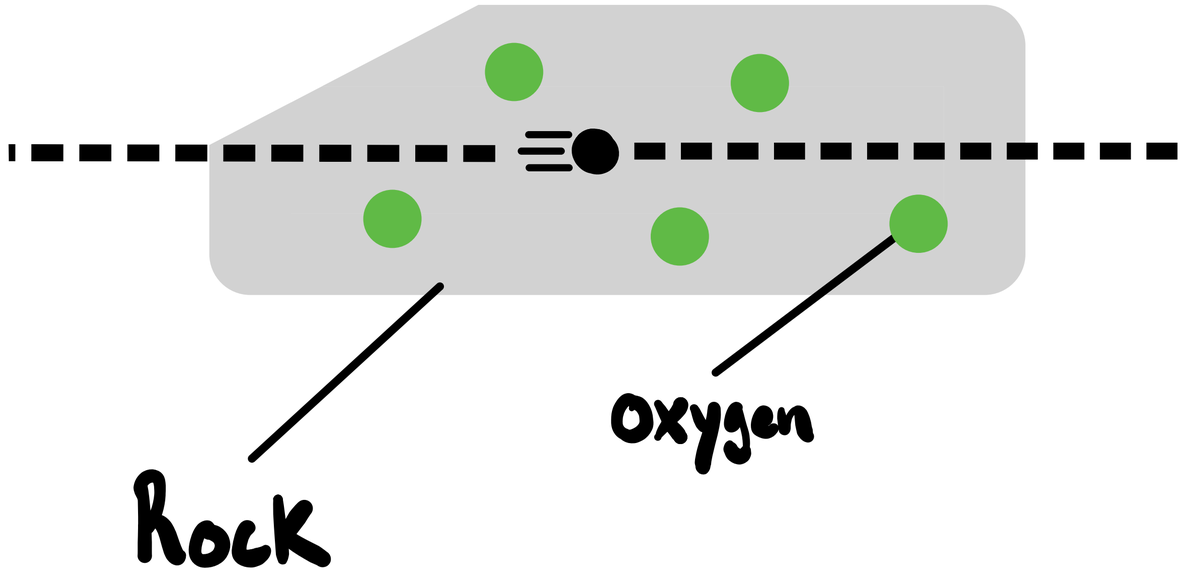
- DM proton interaction must be via deep inelastic scattering (DIS) for visible detector signature.



Step 2: shielding

Attenuation of DM

- We approximate rock to be made of oxygen



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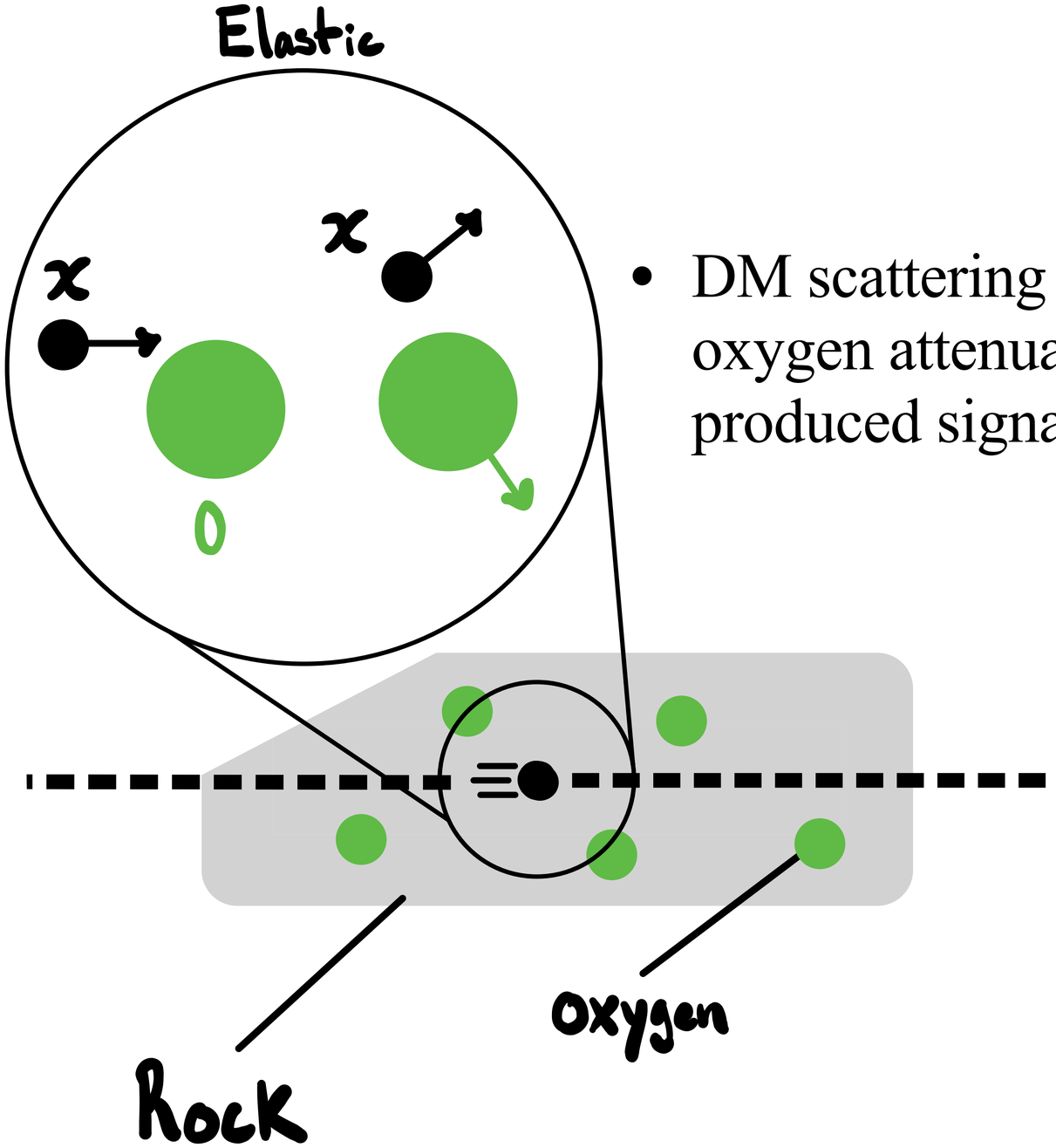
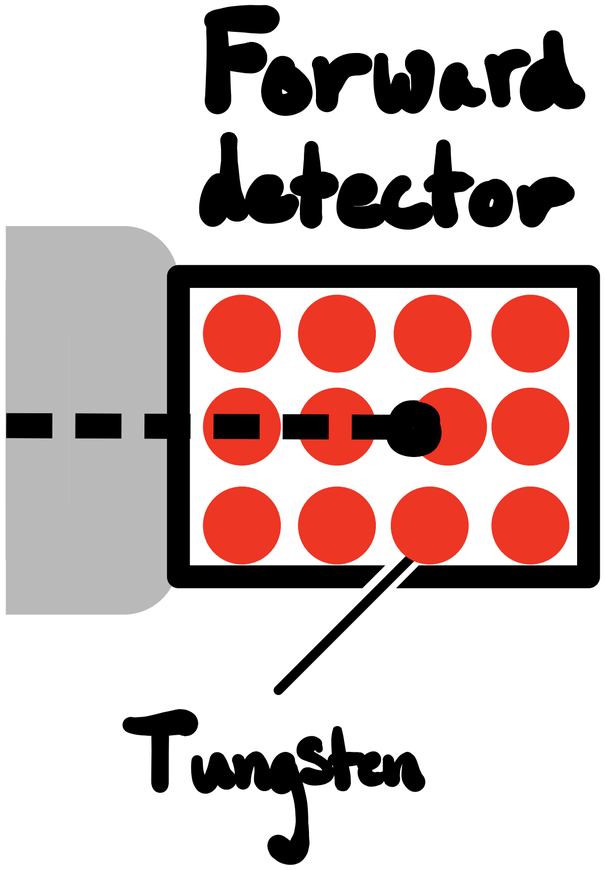
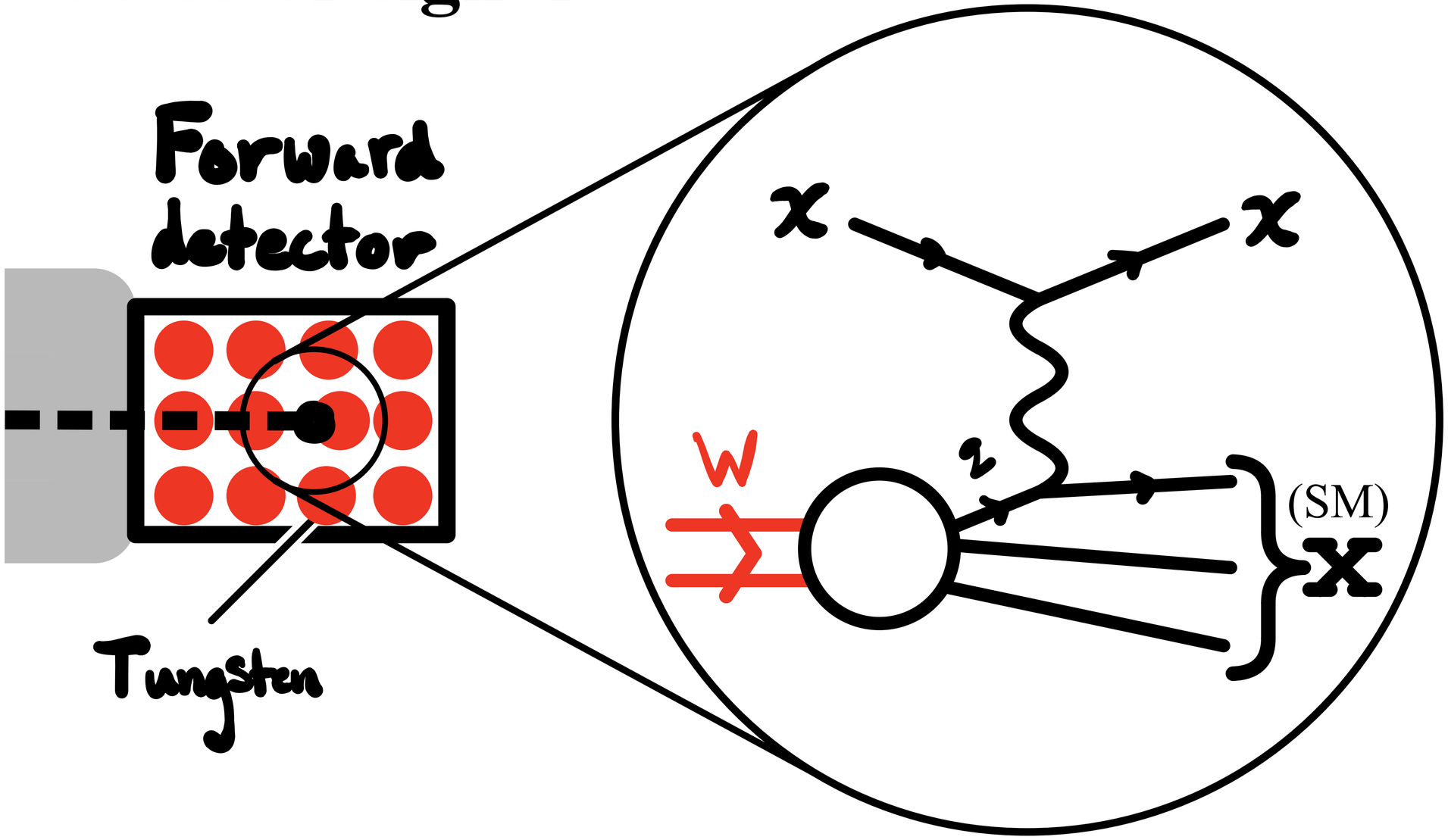


- DM scattering off of oxygen attenuates produced signal.

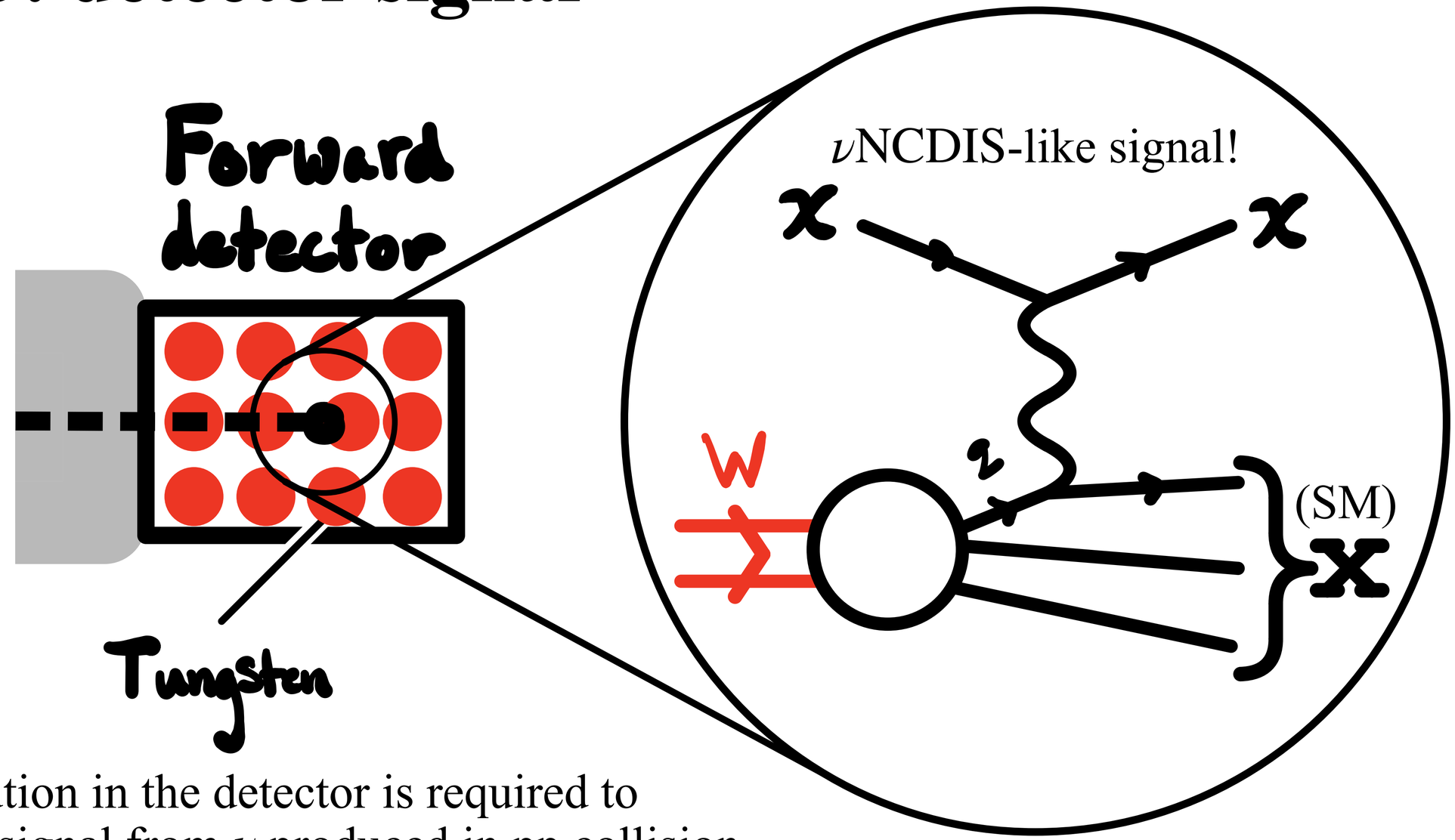
Step 3: detector signal



Step 3: detector signal



Step 3: detector signal



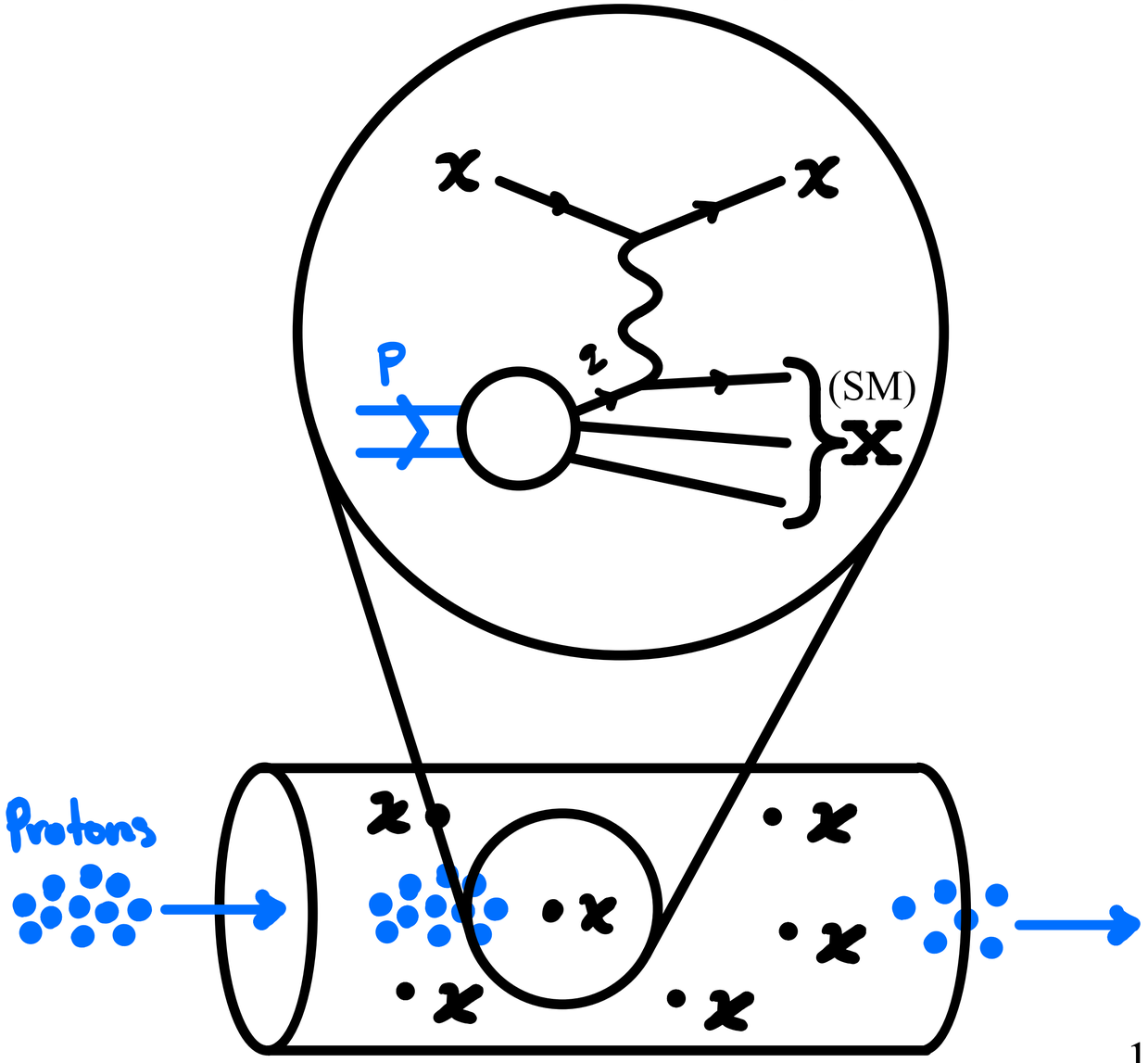
Time resolution in the detector is required to distinguish signal from ν produced in pp collision.

How much DM do we need? (More than ρ_{halo})

- DM in the LHC beam pipe will cause the beam to degrade through DIS.

$$T_{\text{beam}} < \frac{1}{\sigma_{p\chi \to X\chi} \cdot n_\chi}$$

- Maximum DM number density fixed by LHC beam lifetime of 100 hours.



Picking an example model

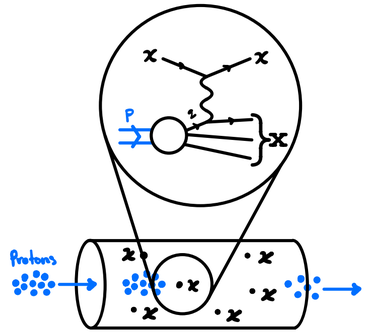
- We choose the $\mathrm{U}(1)_B$ model,

$$\mathscr{L} = \mathscr{L}_\chi - \frac{1}{4}(V_B^{\mu\nu})^2 + \frac{1}{2}m_V^2(V_B^\mu)^2 + g_\chi V_B^\mu J_\mu^\chi + g_{\mathrm{SM}} V_B^\mu J_\mu^{\mathrm{SM}} + \ldots$$

$$\mathscr{L}_\chi = i\bar{\chi}\not{D}\chi - m_\chi\bar{\chi}\chi \text{ (Dirac fermion DM)}$$

- Model parameters: $g_\chi^2/(4\pi) = \alpha_\chi$, $g_{\mathrm{SM}}^2/(4\pi) = \alpha_{\mathrm{SM}}$, m_χ, & m_V
- $m_V = 100$ GeV mediator used as benchmark

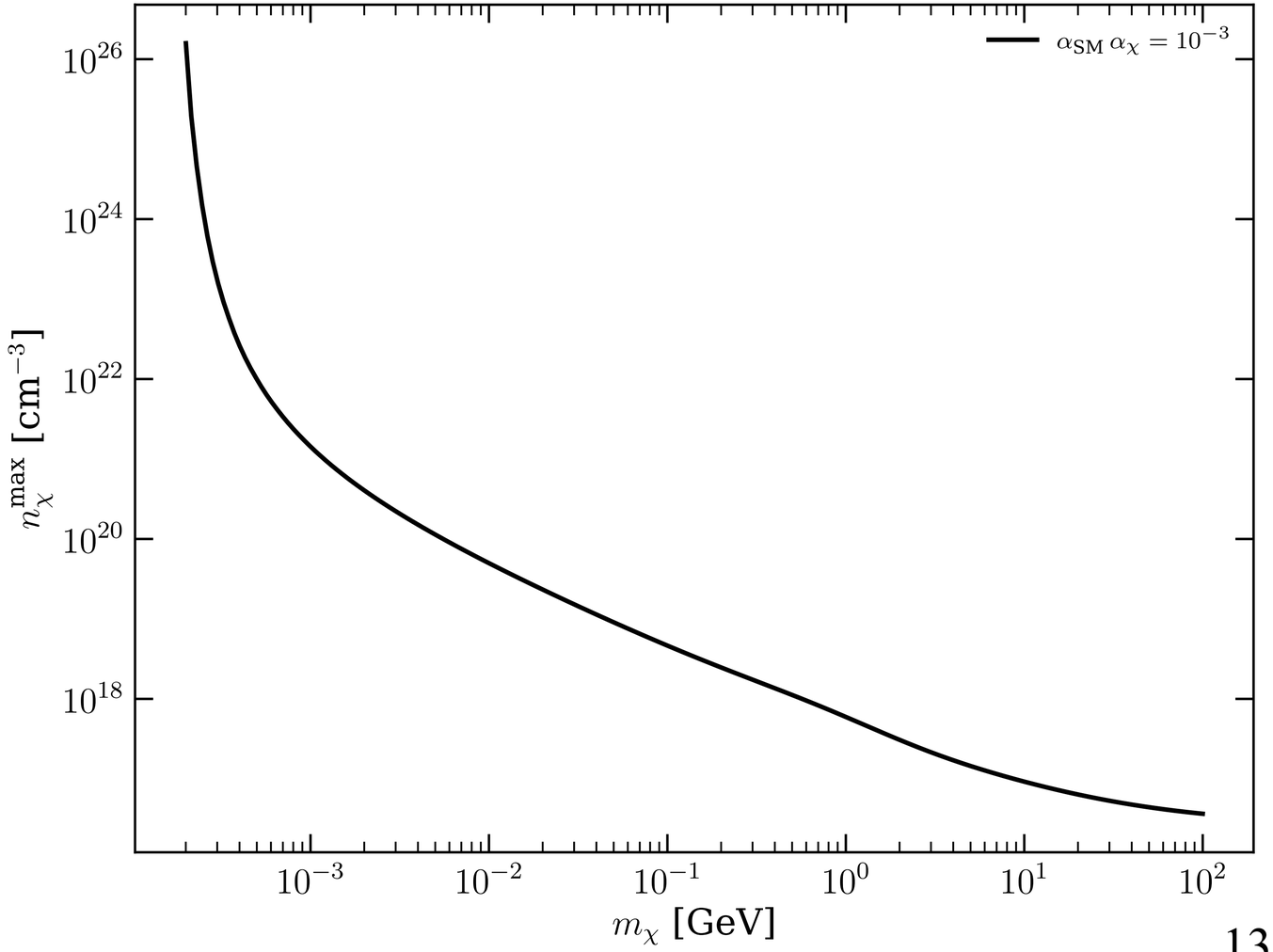
Allowed number density under $\mathrm{U}(1)_B$



- Taking the beam lifetime as a constraint we can plot the maximal allowed number density,

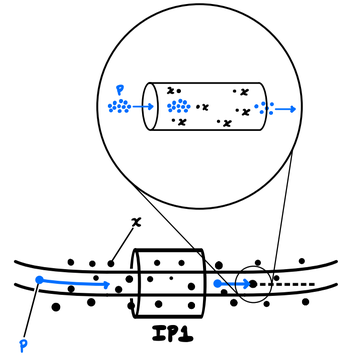
$$n_\chi^{\max} = \frac{1}{T_{\text{beam}} \cdot \sigma_{p\chi \to X\chi}} .$$

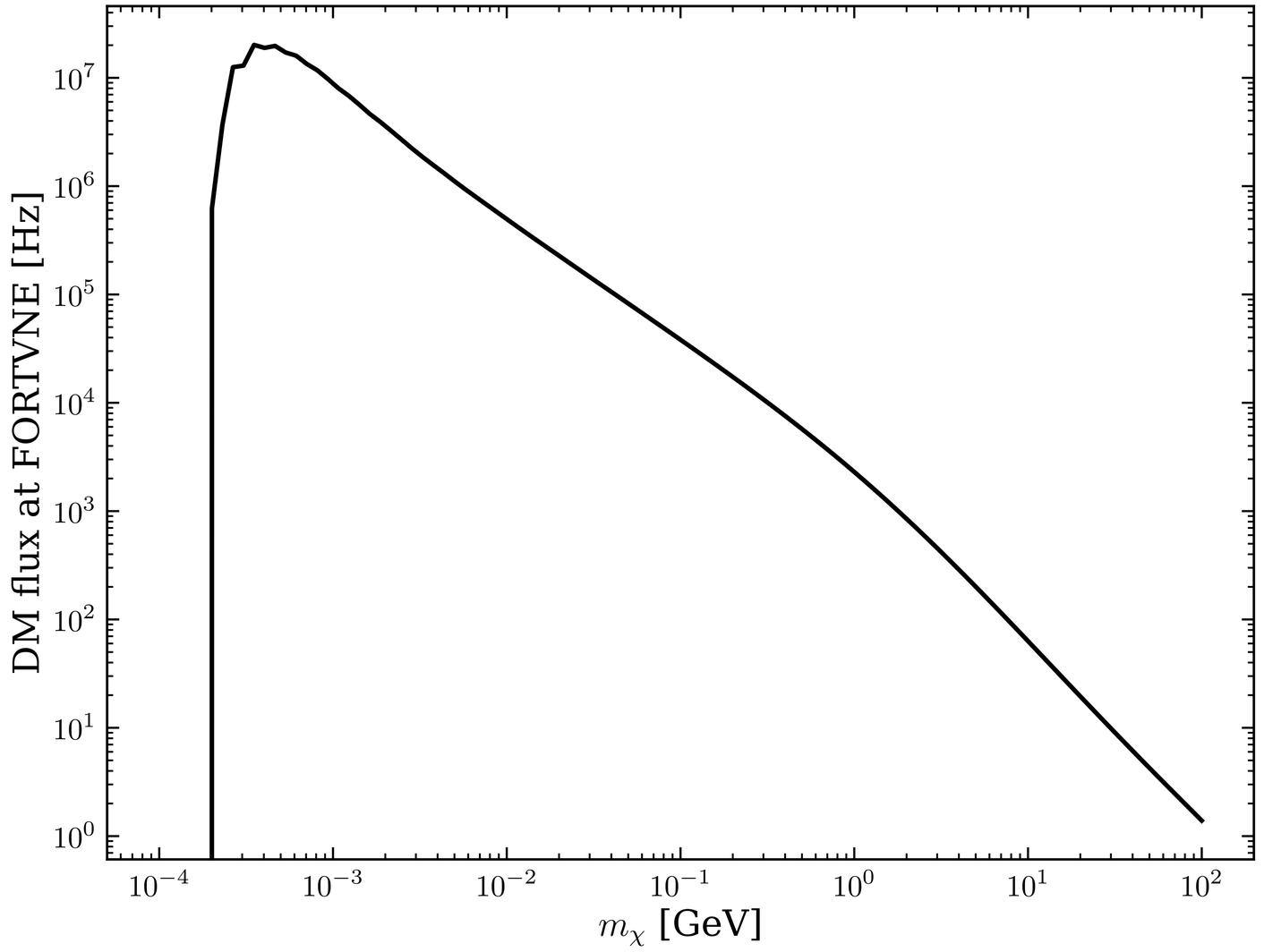
- $\mathrm{U}(1)_B$ model with 100 GeV mediator assumed.



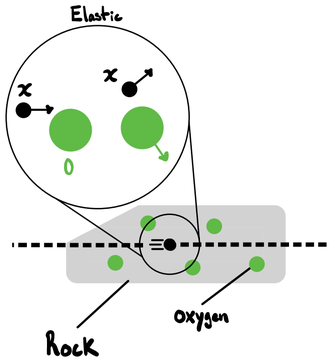
Flux with $\mathrm{U}(1)_B$

- Large flux through detector solid angle during run 4.
- FORTVNE (proposed FASER run 4 upgrade) detector geometry used.
- Mass cutoff is set by DIS kinematics.



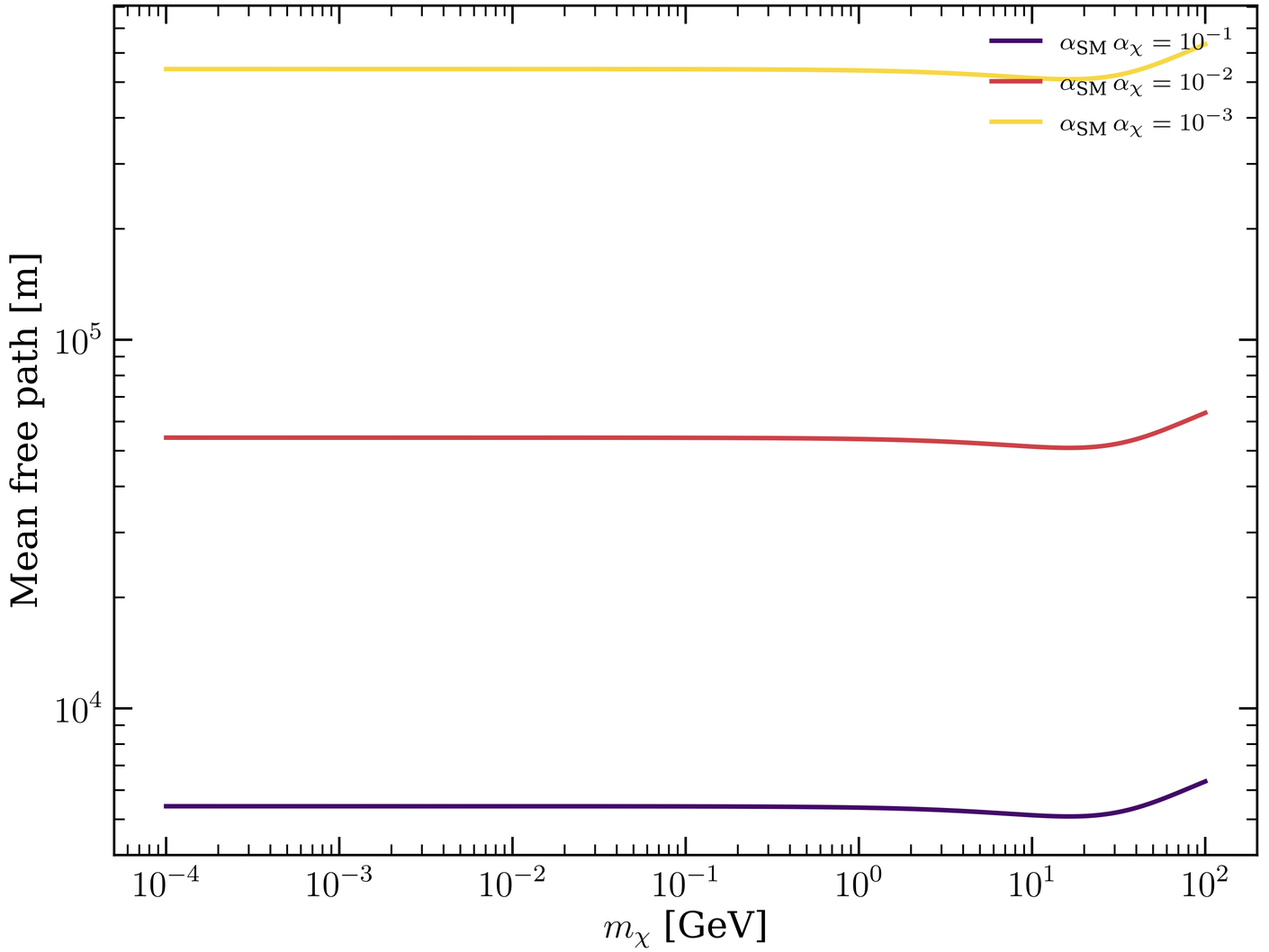


Shielding with $\mathrm{U}(1)_B$

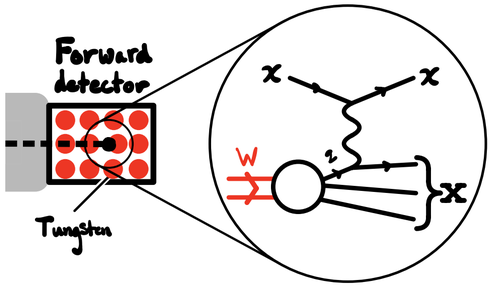


Mean free path O(1000m) with heavy mediator $\Longleftrightarrow$ shielding is negligible since $L_{\mathrm{rock}} \approx 100$ m, i.e.

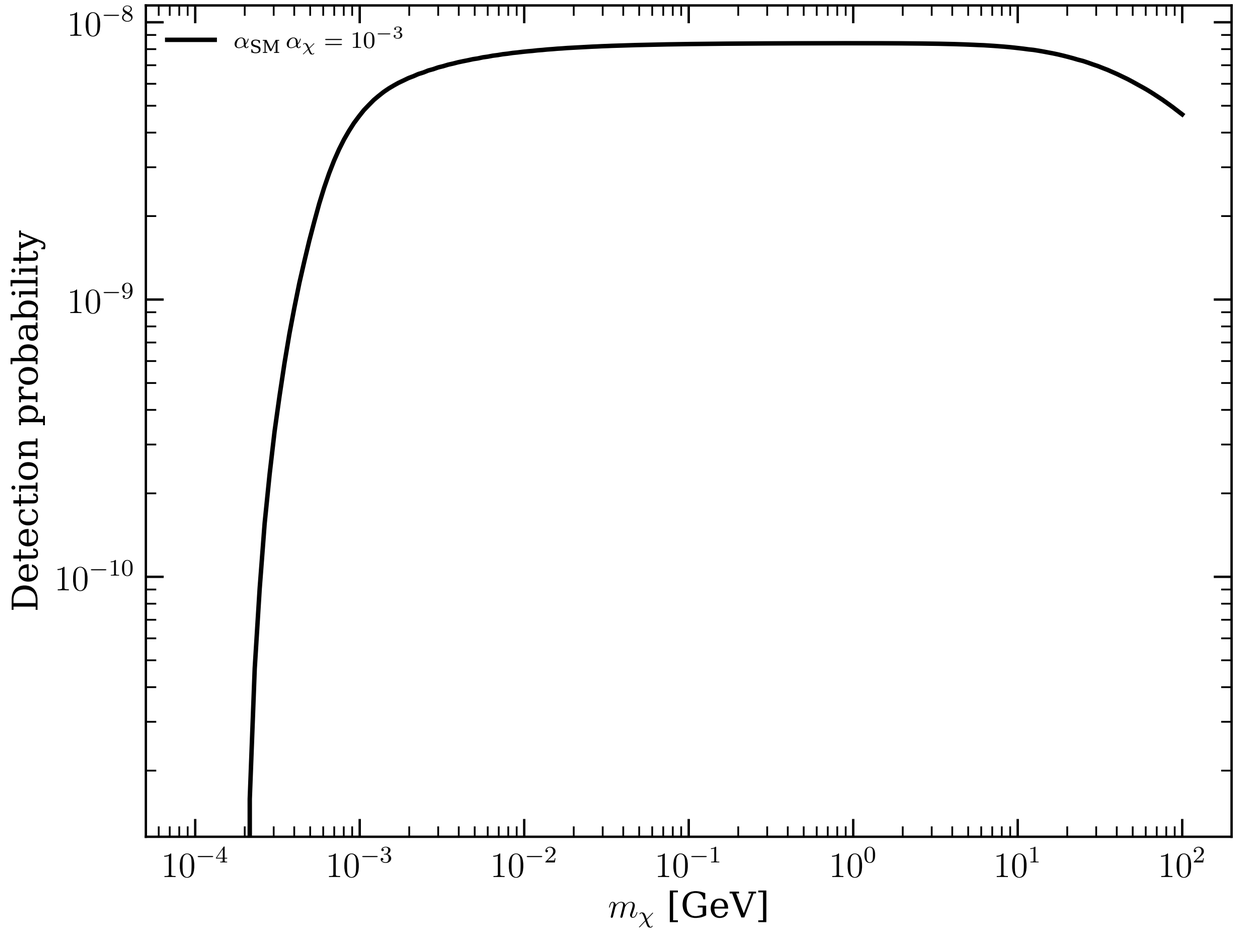
$$P_{\mathrm{surv.}} \simeq 1.$$



Detection with $\mathrm{U}(1)_B$

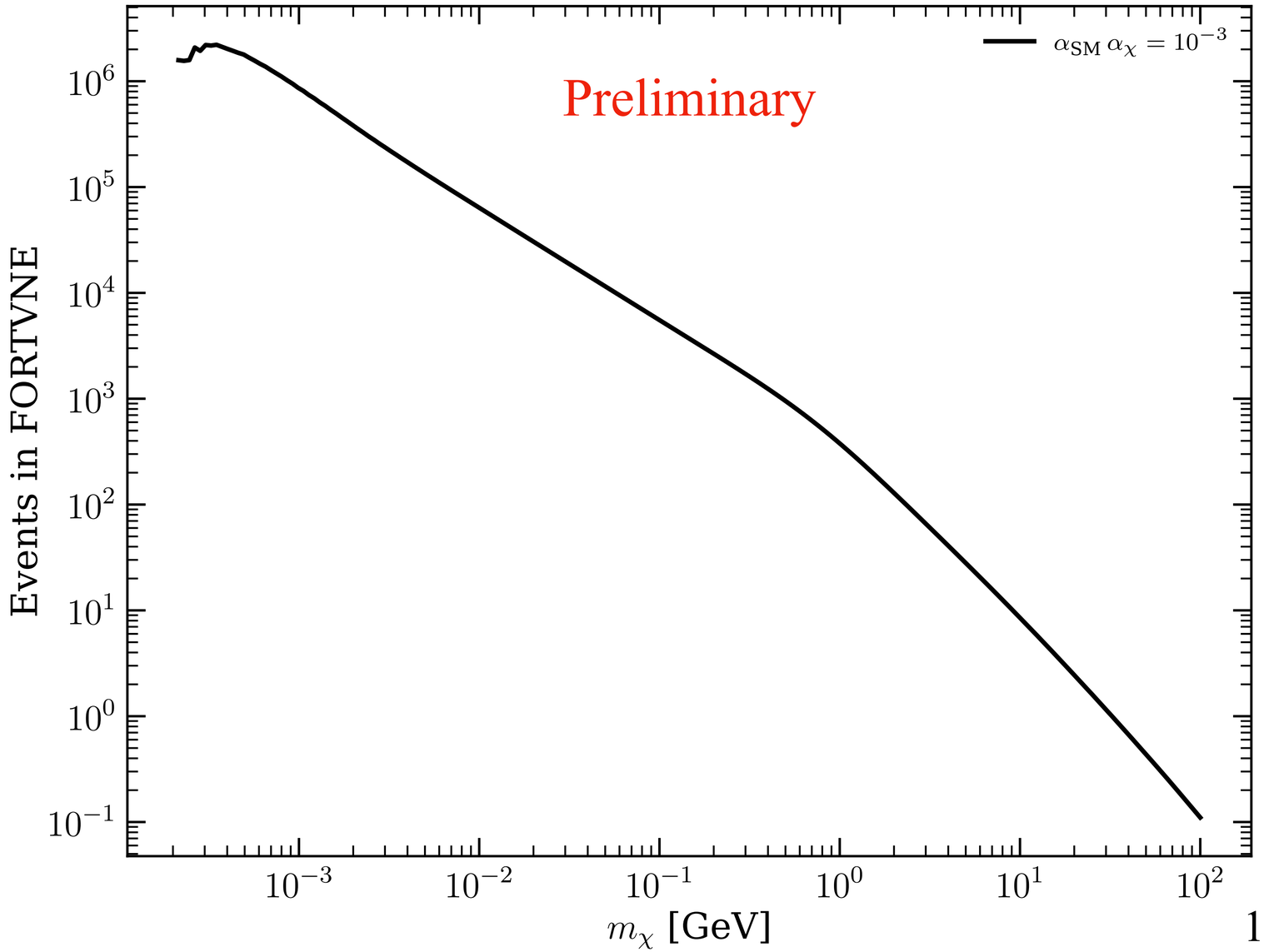


- Detection probability is small, but the number of forward scattered DM particles is large.



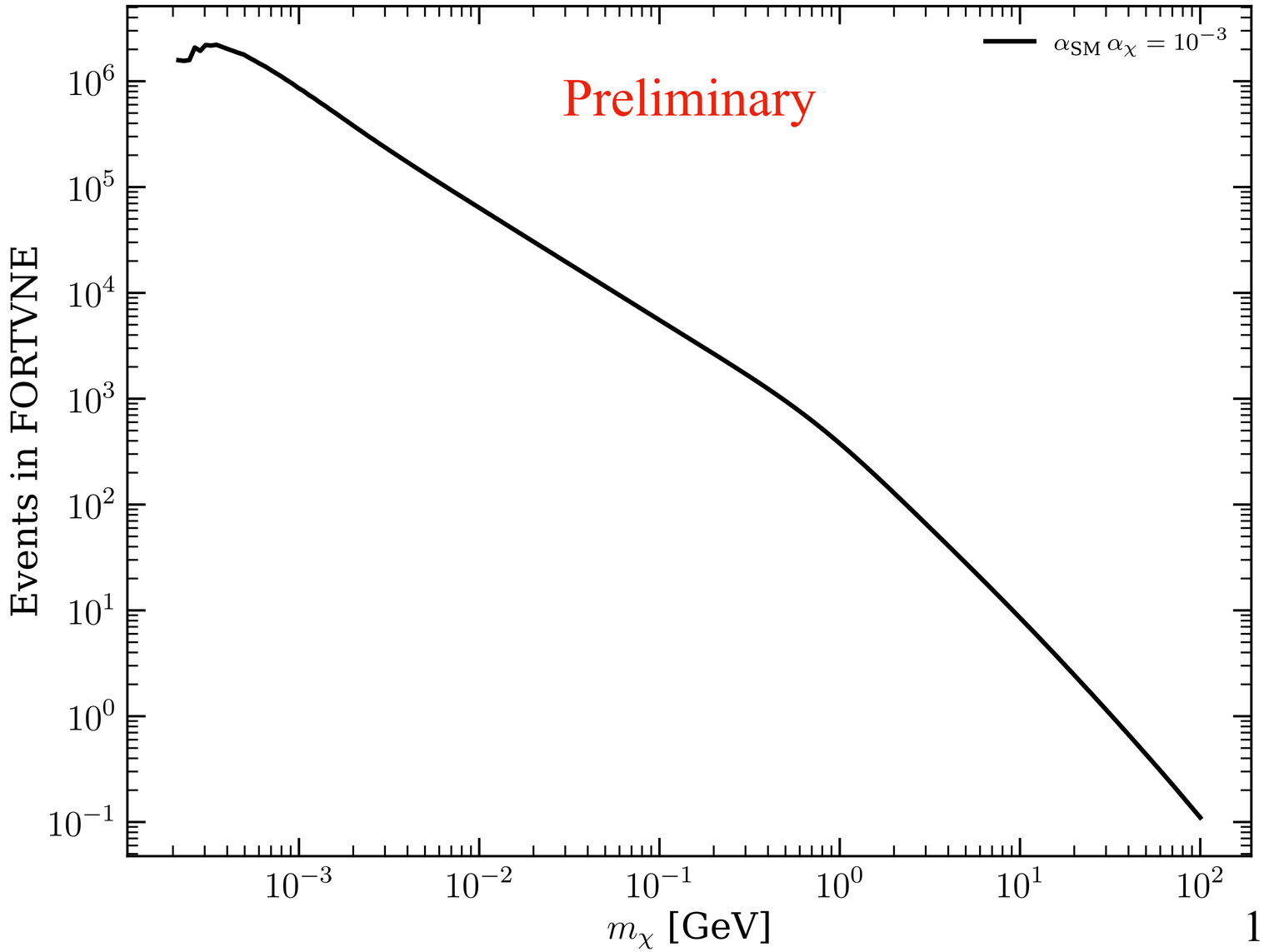
Results: maximal signal

- Maximum allowed number density assumed.



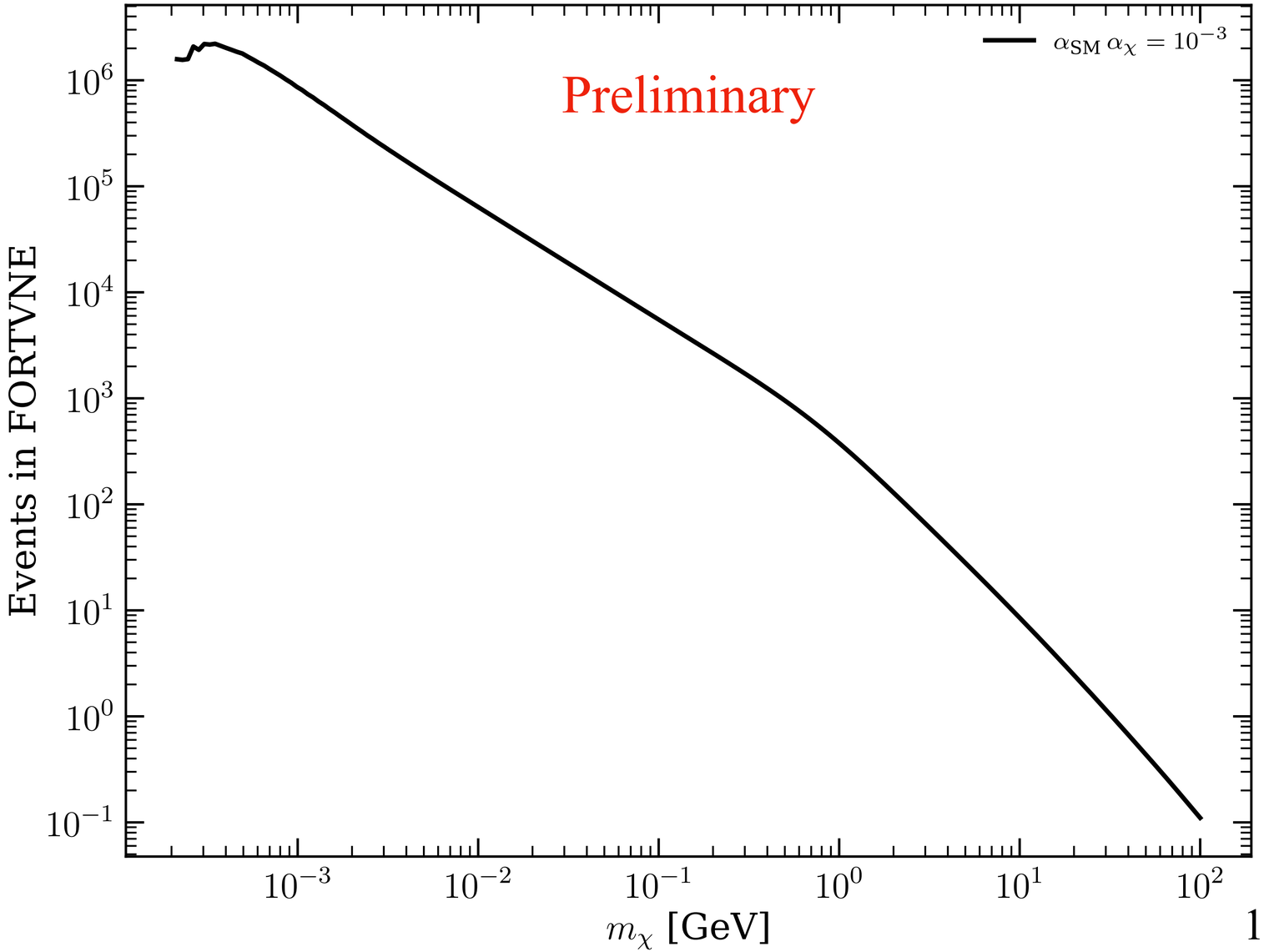
Results: maximal signal

- Maximum allowed number density assumed.
- Over 10^6 events!



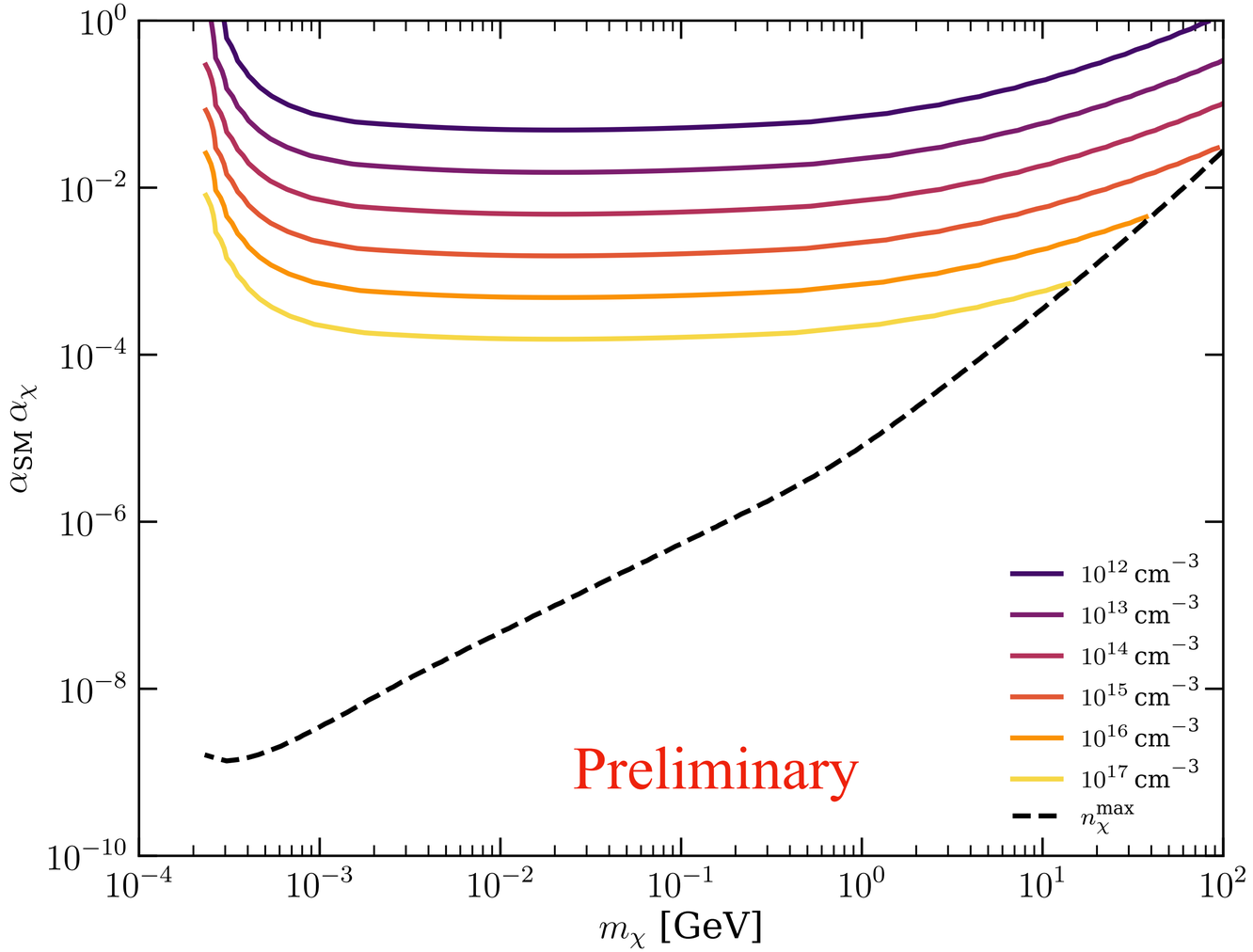
Results: maximal signal

- Maximum allowed number density assumed.
- Over 10^6 events!
- Does the signal exist with more modest number densities?

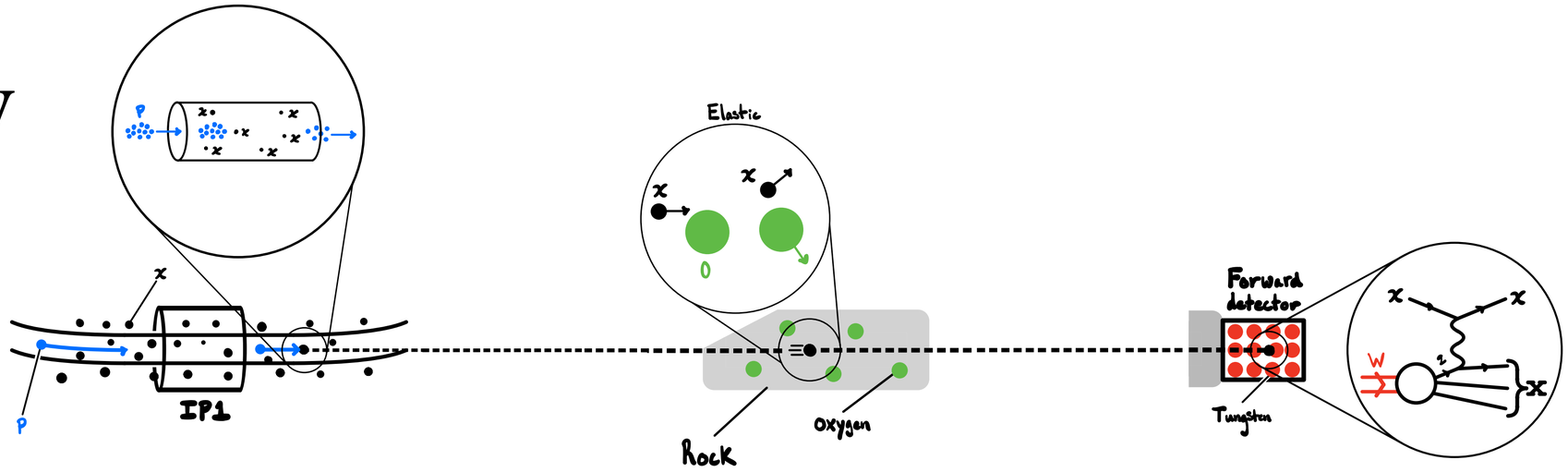


Results: theory motivated number density

- 3 event contours for fixed accumulated DM number densities at LHC beam pipe.



Summary



- LHC can boost accumulated DM into forward detectors allowing for possible DM discovery.
- $U(1)_B$ would provide a signal for number densities much lower than maximum allowed by LHC beam.

Thank you!

Email: evansa3@uci.edu

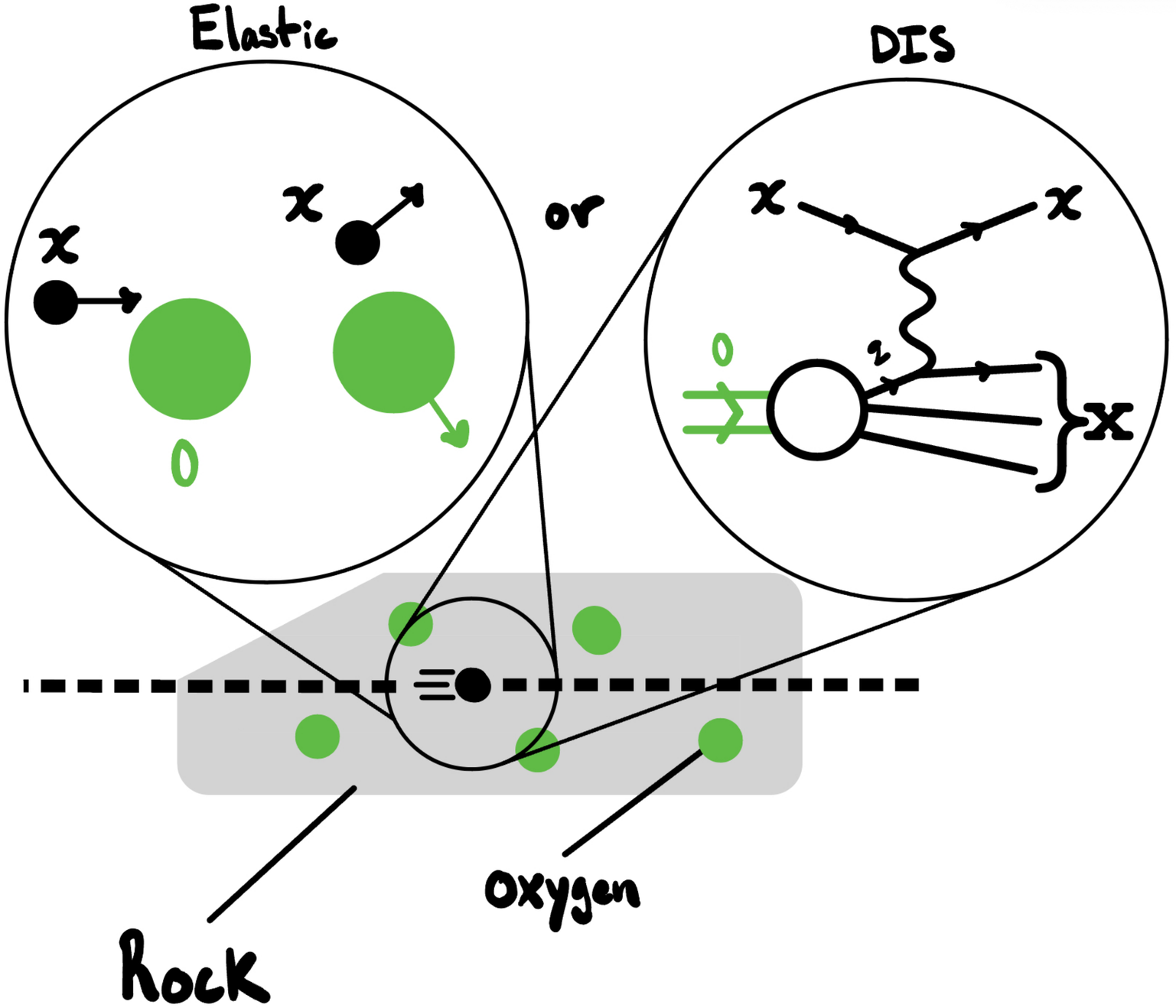
Backup

Step 2: shielding

Attenuation of DM

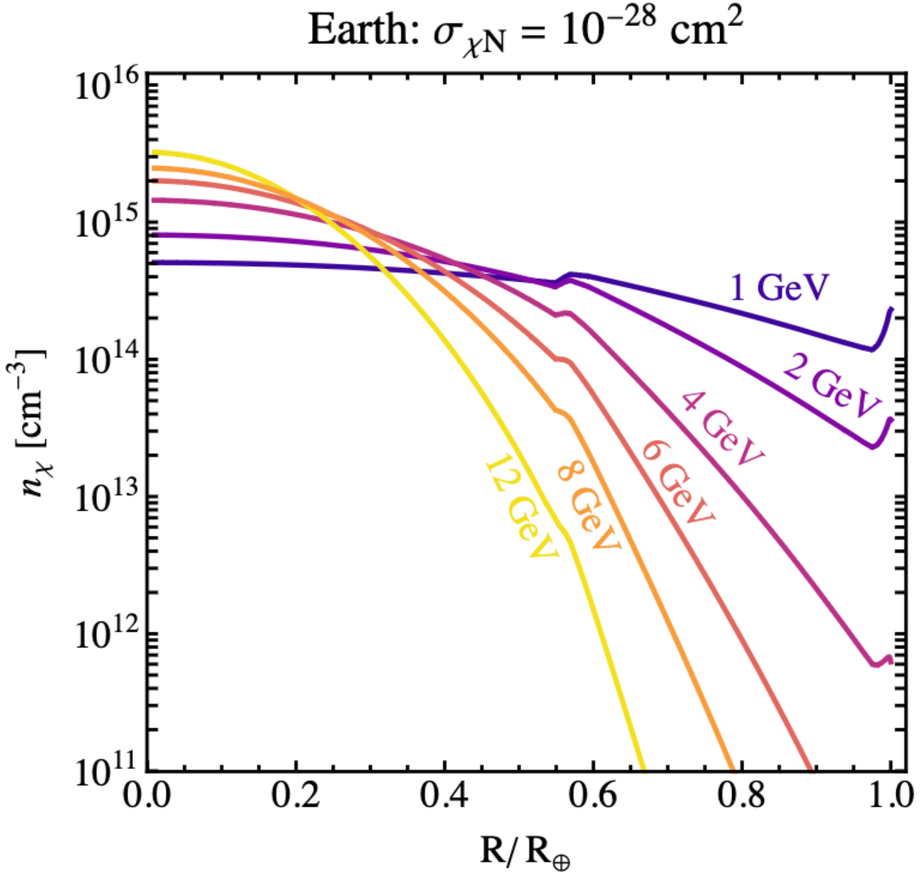
- Elastic scattering attenuates DM signal.

- Inelastic scattering also contributes to DM attenuation.

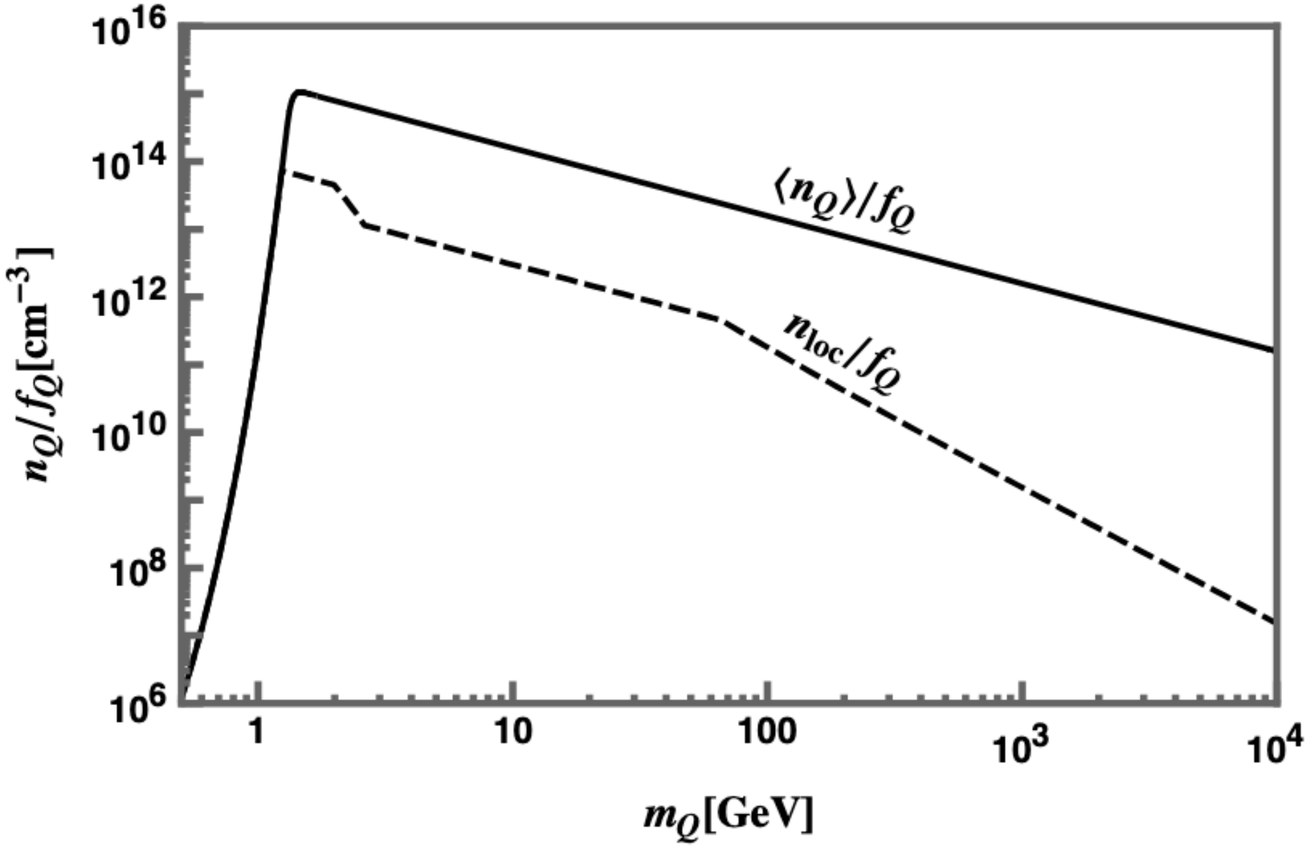


DM in LHC beam?

- Accumulated DM can have much larger local number densities while remaining invisible to terrestrial detectors.

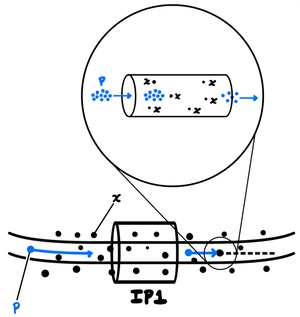


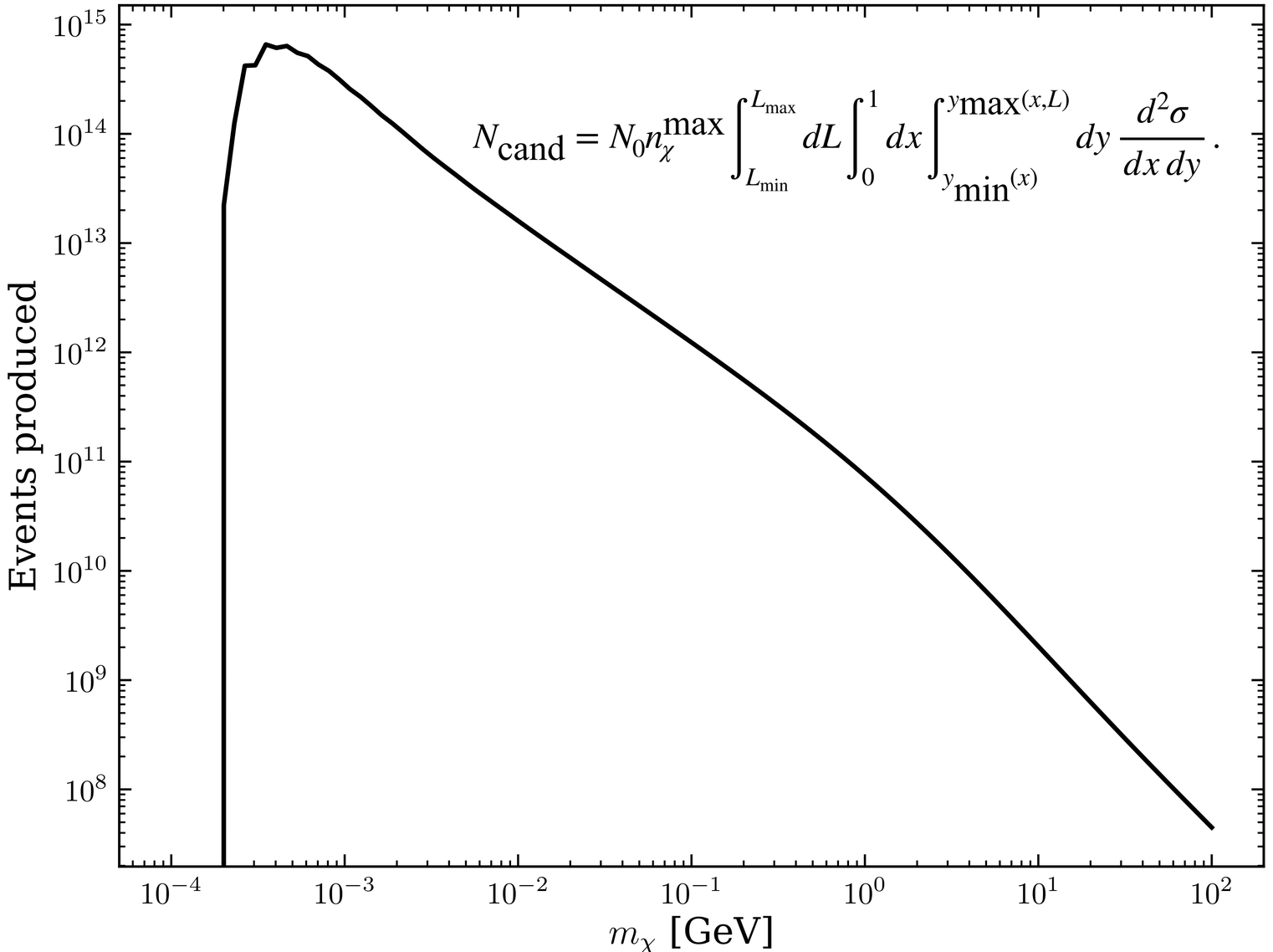
R. Leane, J. Smirnov; 2209.09834



M. Pospelov, H. Ramani; 2012.03957

Event production





Elastic vs DIS