### Problem
- $\mu^-$ in matter form muonic atoms
- Nuclear capture: $\mu^- N \to \nu_\mu X$
  $X \equiv \gamma, \pi^0, \mu, \text{deuteron, ...}$

What are the yields and spectra?
- Relevance to CLFV: Mu2e, COMET will stop $10^{19}$ $\mu^-$/$s$ in aluminum (Al). Charged emissions near 100 MeV/c can deaden the tracker.
- Inform nuclear theory for momentum transfers 100 MeV/c $\lesssim Q \lesssim 300$ MeV/c.

### Results [arXiv:1908.06902]

#### Data Analysis
- Event selection
  - Muon stops in target
  - Downstream hits after 400 ns ($\tau_{\mu-Al} = 861$ ns)
  - Veto beam accidentals

Normalization: $e^-$ tracks from muon decay
- Known spectrum and branching fraction.
- Well understood acceptance $\times$ efficiency
- Count stopped muons in the selected event sample
- Data/data and MC/MC uncertainty cancellations between electron and signal events.

#### Modified Software
- Short tracks
- Particle $\beta \approx 0.1$
- $dE/dx \gg$ MIP

#### reconstructed data and simulation fit

Particle ID:
About 1/3 of reconstructed positive tracks range out in the detector stack.
Track range observable: $R = (N \text{ crossed planes})/|\cos(\theta)|$

No PID for penetrating tracks, but use their momentum in the global fit.

#### Acknowledgments
This work was supported by the Natural Sciences and Engineering Research Council of Canada, the Russian Ministry of Science, and the U.S.A. Department of Energy.