

# Hope Springs Eternal A Future 50 MeV Facility at TRIUMF

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# Mentality

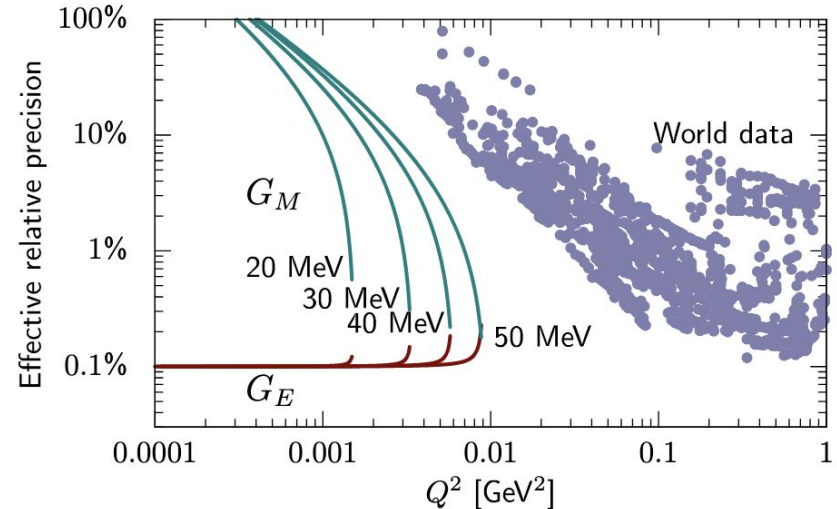
- This is a longer-term facility
- We should design with the future in mind
- Broaden our horizons, not just medium energy nuclear or dark matter searches

# Key Requirements

- The spectrometer arms must be moveable!
  - This means we need smaller tracking detectors on the arms, or to move the experiment away from the wall
- The target chamber should be large enough to accommodate different technologies
  - Ta foil,  $\text{LH}_2$ , Jet or waterfall
- Will need more detectors

# Nuclear Physics Opportunities

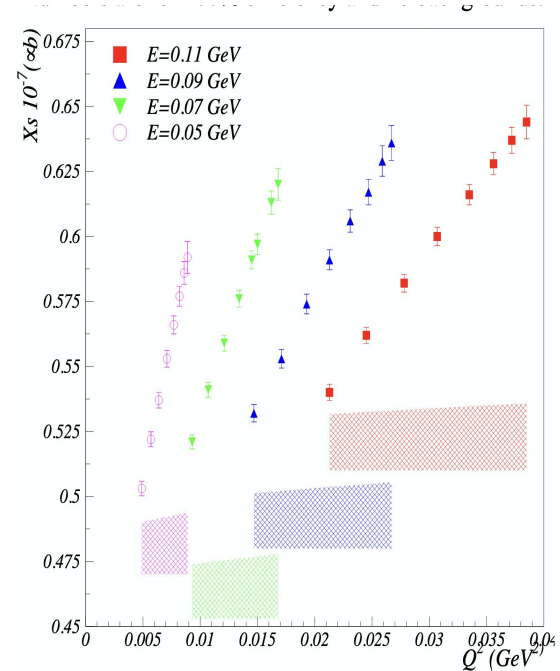
- Proton target - LH<sub>2</sub>
  - Low  $Q^2$  measurement of  $G_M$ , magnetic radius
  - Axial form factor with polarized e-beam, inverse beta-decay
- Deuterium target - LD<sub>2</sub>
  - Form factor measurement, electric radius, impactful for deuterium radius puzzle
  - Measure recoil neutron



Jan Bernauer, et al [2022](#)  
[J. Phys.: Conf. Ser. 2391 012001](#)

# Nuclear Physics Opportunities

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A.Deur, [HP2030](#)

# Nuclear Physics Opportunities

- Polarized Helium target
  - Measurement of neutron form factor ratios
  - Target normal single spin asymmetry
    - First ever measurement in 2015 at JLab
  - Can be used to inform TPE

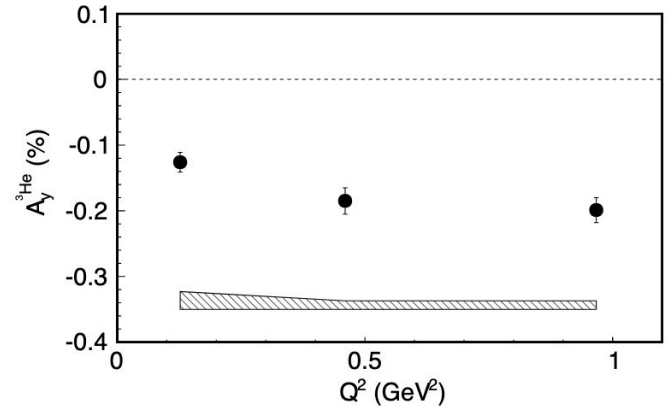


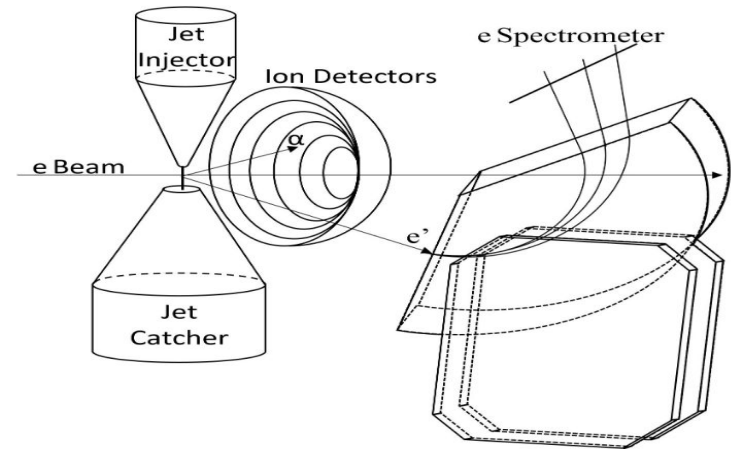
FIG. 3. Measured  $^3\text{He}$  asymmetries,  $A_y^{3\text{He}}$ , as a function of  $Q^2$ . Uncertainties shown on the data points are statistical. Systematic uncertainties are shown by the band at the bottom.

Y.-W. Zhang, et al.

<https://doi.org/10.1103/PhysRevLett.115.172502>

# Nuclear Physics Opportunities

- Oxygen jet target
  - $^{16}\text{O}(e, e'\alpha)^{12}\text{C}$
  - Using inverse electron induced-disintegration to determine astrophysical radiative capture processes



I. Frišćić, T. W. Donnelly, R. G. Milner, [Phys. Rev. C 100, 025804 \(2019\)](#)

# Particle Physics Opportunities

- Dark boson search can be extended to other interpretations (we should also do this for 30 MeV!)
  - Explicit searches for scalar, pseudoscalar, etc. mediators have different kinematics and exclusion curves
- Axion like particles:
  - Axion-electron coupling can be probed with the current apparatus
  - Axion-photon coupling could be probed with additional calorimeters
- Moveable arms would expand our acceptance
- More DM searches would be possible with a way to reconstruct missing energy, would mean some serious consideration about detector location and construction

# Particle Physics Opportunities

- QED mesons
  - Somewhat interesting interpretation of the 17 MeV and 38 MeV anomaly seen by JINR (<https://arxiv.org/pdf/2401.04142>, <https://arxiv.org/pdf/2601.01879>)
- Could possibly produce, but would benefit from increased acceptance in the spectrometers

# Particle Physics Opportunities

- Potential for LLP searches
  - Would require additional detector infrastructure
  - Behind the current beam dump? Something down the dogleg to ARIEL?



# Particle Physics Opportunities

- Seems to be of interest to measure  $e$  on  $N$  for neutrinos
- SNOWMASS proceedings
  - <https://indico.fnal.gov/event/51519/>
  - <https://indico.fnal.gov/event/46620/>
  - <https://indico.fnal.gov/event/51519/contributions/226566/attachments/149225/192013/Hayes-Snomass-2021.pdf>
  - <https://arxiv.org/pdf/2203.06853> (NF06 SNOWMASS whitepaper based on above workshops)

“Because inelastic neutrino interactions have big uncertainties, in the future it will be crucial to measure inelastic electron scattering cross sections at energies below the 50 MeV mark and use those data to calibrate theoretical models for the neutrino scattering process.”

# Particle Physics Opportunities

- Seems to be of interest to measure  $e$  on  $N$  for neutrinos
- In particular  $e^{40}\text{Ar} \rightarrow \nu^{40}\text{Kr}^*$ 
  - MESA is doing this!
    - They built a gas jet target to do it
  - Possibly interesting as test for MARLEY
    - <https://www.marleygen.org>
- Generally not well-documented in neutrino community. Talk to your local neutrino person for more info!

# Summary

- Variety of physics possible with 50 MeV e-linac
- Requires movable spectrometer arms and new target chamber
- This is a longer term project, design with the future in mind
- Can facilitate discussion between both the theory group and the nuclear astrophysics team at TRIUMF to see if they have any fun ideas
- Workshop on  $^{16}\text{O}$  in the coming year
- Have created a living page on the wiki for everyone to populate if they come across something interesting that we could possibly do:

<https://github.com/DarkLight-EXP/wiki/wiki/Living-page-of-ideas-for-50-MeV>

Thanks



T-Shirts?



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