H2/D2 White Paper Status

Tom Junk

H2/D2 Meeting

November 18, 2021

Current White Paper Status

- Get editable Overleaf link from Laura's e-mail (I can forward it)
- The Overleaf document contains main.tex (white paper) and loi.tex
- Many thanks to everyone for work on the LOI!
- White Paper Contents: 28 pages so far (including title
- page and references)
- I copied the LOI's author list to the white paper

Title and Author List

Author list taken from the LOI.
We have talks in the group from people not yet on the author list.

Neutrino Scattering Measurements on Hydrogen and Deuterium: A Snowmass White Paper

Luis Alvarez-Ruso[1], Leo Bellantoni[2], Alan Bross[2], Linda Cremonesi[3], Kirsty Duffy[2], Steven Dytman[4], Laura Fields[5], Diego González-Díaz[6], Mikhail Gorshteyn[7], Richard Hill[8,2], Thomas Junk[2], Huey-Wen Lin[9], Xianguo Lu[10], Jorge Morfín[2], Jonathan Paley[2], Vishvas Pandey[2,11], Gil Paz[12], Roberto Petti[13], Ryan Plestid[8,2], Bryan Ramson[2], Federico Sanchez Nieto[14], and Oleksandr Tomalak[8,2]

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[11]University of Florida
[12]Wayne State University
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[14]Université de Genève

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Current Status, cont'd

Contents

Items Still Needed

Theory sections:

Spin polarization physics section 2.1.8 is empty – needs filling in – Sasha Tomalak

Section 2.2.1: Lattice QCD needs some text so the reader knows what's going on without reading the LQCD white paper -- Huey-Wen Lin

Section 2.3: Inelastic processes. Can we be more quantitative? What sorts of measurements/distributions are lacking in the old bubble chamber data? How much more data are needed? Generator tuning needs: Luis Alvarez Ruso, Jorge Morfín, Callum Wilkinson, Clarence Wret

Flux determination: Sec. 2.4.1 needs filling in. How does this compete with or complement with nu-e elastic scattering? Low-nu scattering? How well do we need to measure the energy spectrum? Should this be moved to the experimental section? Callum Wilkinson, Clarence Wret

Sec. 2.5: BSM searches impact – currently section is empty Ryan Plestid

Sec. 2.6.1 – Nuclear Beta Decay and CKM Unitarity – needs filling Mikhail Gorshteyn

Items Still Needed

2.6.1 – Nucleon Axial Radius – needs text. Currently most text is in the figure caption Richard (?)

Experimental Sections

Sec. 3.1 – need text describing TKI and carbon subtraction in SAND
Estimate of achievable precision. Xianguo and Roberto

need text for Hydrogen-rich gas in ND-GAr Xianguo and Roberto

need text mentioning the TMS and ND-GAr-Lite options Tom Junk

Items Still Needed

Need text about hydrogen/deuterium bubble chambers in BNB, NuMI, and LBNF: Jorge Morfín and Bryan Ramson

Would like Experiment requirements: efficiency, resolution, PID, etc. Some of the inelastic physics depends on identifying Kaons and Lambdas.

Need estimates of precision on polarization observables for different detector options. Tom Junk

Progress Since we Met Last

Bryan Ramson has submitted an LDRD (Lab Directed Research and Development) proposal to study hydrogen/deuterium bubble chambers by building a prototype over at the Proton Assembly Building at Fermilab

Sounds like a good idea!
Small bubble chambers have been constructed for DM searches and are running now.
New technologies may make the bubble chamber idea work even better now.
Lots of discussion still needed about how to make a practical neutrino target/detector

- One big one or many small ones?
- Auxiliary detectors (calorimeters, muon ID)
- Surface or underground?

Regarding polarized targets, I've been talking with Wolfgang Korsch and Dustin Keller.

Wolfgang works on polarized ^{3}He targets in electron beams at JLAB. These targets have nice properties:
-- no cryogenics, small B field in the target region (25 g).
-- only problem: the target material is ^{3}He!
Maybe there are still some ideas we can glean from this work.
Papers, theses, presentations Wolfgang pointed me to:
https://drive.google.com/drive/folders/1r6vmasK-5G8ErCsxGnw2Pqh64LrZ1b8w

Progress Since we Met Last

Talking with Dustin about active polarized targets

- NH_3, polymethyl methacrylate, polystyrene are all polarizable with Dynamic Nuclear Polarization (DNP)
- Need a strategy for integrated target and detector
  - Need a detector that works cold and in a high B field.
  - High B field → particles curl up in small loops. Need to be able to resolve short, curly tracks.
  - If the detector itself is not polarizable, it must contribute not so much to the scattering cross section as to overwhelm the parts that are polarizable.

- Some ideas for the detection technology:
  - Silicon strips
  - Silicon pixels (CCDs)
  - Scintillating fibers
  - Sandwich these with the polarized target material.
- Didn't have enough ideas for an LDRD this year, but maybe the next round. Study scintillating fiber performance at low temps and high field for example. Look for old, spare silicon-strip detectors.

Deadlines

Kendall Mahn gave a talk on Neutrino Cross Sections, NF06 on Oct 7 –
I provided a couple of slides to advertise what we are doing.
https://snowmass21.org/neutrino/start#meetings

DUNE Snowmass papers: Draft by Dec. 15 for APB review.
Are we a DUNE White Paper? Not really. It's more of an LBNF white paper.

Neutrino Frontier Topical Group internal report draft due date Feb. 28, 2022.

Snowmass Deadline: March 15, 2022
https://snowmass21.org/submissions/start

A Snowmass Timeline Slide from Elizabeth Worcester with Longer Timescales

Reports Timeline (NF)

- Extended outline due (NF): Dec 18
- Report draft due (NF): Feb 28
- Contributed papers due: March 15
- NF Workshop: March 16-18
- Preliminary Report due (NF): May 10
- Preliminary Report due (Snowmass): May 31
- Final Report due (NF): Sept 9
- Final Report due (Snowmass): Sept 30, 2022

Extras

Kaushik Borah – New Student working at UKY

Working with Richard Hill at UKY, and if he gets a URA fellowship, with Minerba and Tom at FNAL.

Projects:

1) Implement new nucleon vector form factors in GENIE
https://journals.aps.org/prd/abstract/10.1103/PhysRevD.102.074012

2) Electromagnetic radiative corrections
- can induce differences between muon and electron neutrino cross sections and kinematics
- would be good to work with experimentalists when putting things into GENIE

3) Study of polarization observables
- Study of how second-class currents affect predictions of measurable asymmetries
- Significant amount of work needed to compute polarized and unpolarized cross sections
- And estimate the needed uncertainties to make interesting statements. How much data do we need?

  How polarized does the target have to be? What about contamination from unpolarized nucleons, and heavier nuclei? How many events need to be collected? Systematic uncertainties?