The n3He Experiment

Michael Gericke
University of Manitoba

for the n3He collaboration

March 2014 FnPB Proposal Review & Advisory Committee Meeting

Outline

- *Brief overview of the experiment*
- *Schedule overview / summary (based on current status)*
- *Current status of construction and recent progress*
  i. *Beamline components*
  ii. *Magnetic holding field*
  iii. *Spin rotator*
  iv. *Target/detector chamber*
  v. *Preamplifers and DAQ*
- *Installation and commissioning plans*

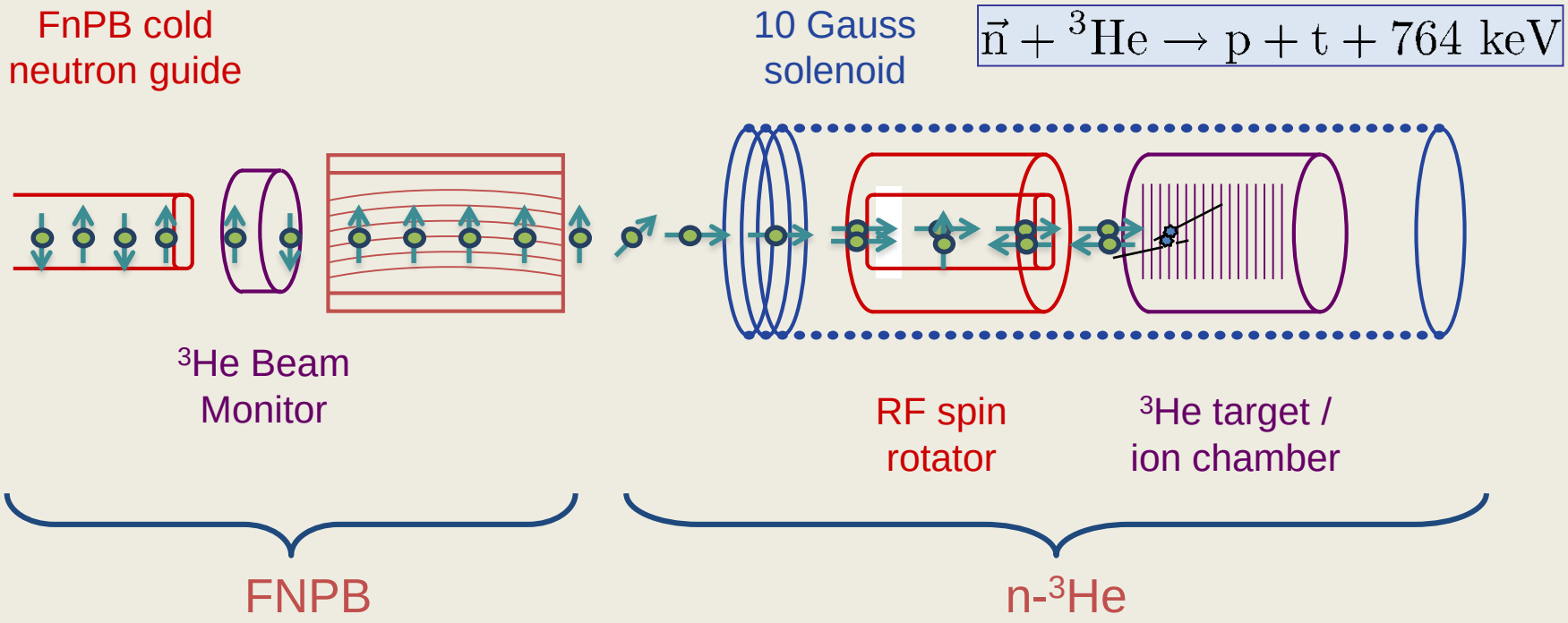
The n3He Collaboration

- Spokespersons
  D. Bowman, M. Gericke, C. Crawford
- Local Project Manager
  S. Penttila
- Project Engineer
  Jack Thomison
- Work Subpackage Leaders

G. Greene	Neutronics
L. Barrón	Solenoid
C. Crawford	Spin rotator
M. Gericke	Target / detector
D. Bowman	Preamplifiers
C. Crawford	Data acquisition
N. Fomin	Online analysis
J. Hamblen	Integration
D. Bowman	Commissioning

Institution	Researcher	Category	2014 Effort
Duke University, Triangle Universities Nuclear Laboratory			
	Pil-Neo Seo	Research Staff	10
Istituto Nazionale di Fisica Nucleare, Sezione di Pisa			
	Michele Viviani	Research Staff	15
Oak Ridge National Laboratory			
	Seppo Pentillä	Research Staff	70
	David Bowman	Research Staff	70
	Paul Mueller	Research Staff	50
	Jack Thomison	Engineer	50
	Vince Cianciolo	Research Staff	10
University of Kentucky			
	Chris Crawford	Faculty	50
	Kabir Latiful	Grad Student	100
Western Kentucky University			
	Ivan Novikov	Faculty	70
University of Manitoba			
	Michael Gericke	Faculty	50
	Mark McCrea	Grad Student	70
	Carlos Olguin	Grad Student	100
Universidad Nacional Autónoma de México			
	Libertad Baron	Faculty	50
	Andrés Ramírez Morales	Grad Student	100
University of New Hampshire			
	John Calarco	Faculty	50
University of South Carolina			
	Vladimir Gudkov	Faculty	5
	Matthias Schindler	Faculty	5
Univeristy of Tennessee			
	Geoff Greene	Faculty	30
	Nadia Fomin	Faculty	30
	Irakli Garishvili	Postdoc	50
	Chris Hayes	Grad Student	100
	Chris Coppola	Grad stduent	100
Univeristy of Tennessee at Chattanooga			
	Josh Hamblen	Faculty	75
	Caleb Wickersham	Undergraduate	100
University of Virginia			
	S. Baessler	Faculty	10

Experimental Setup



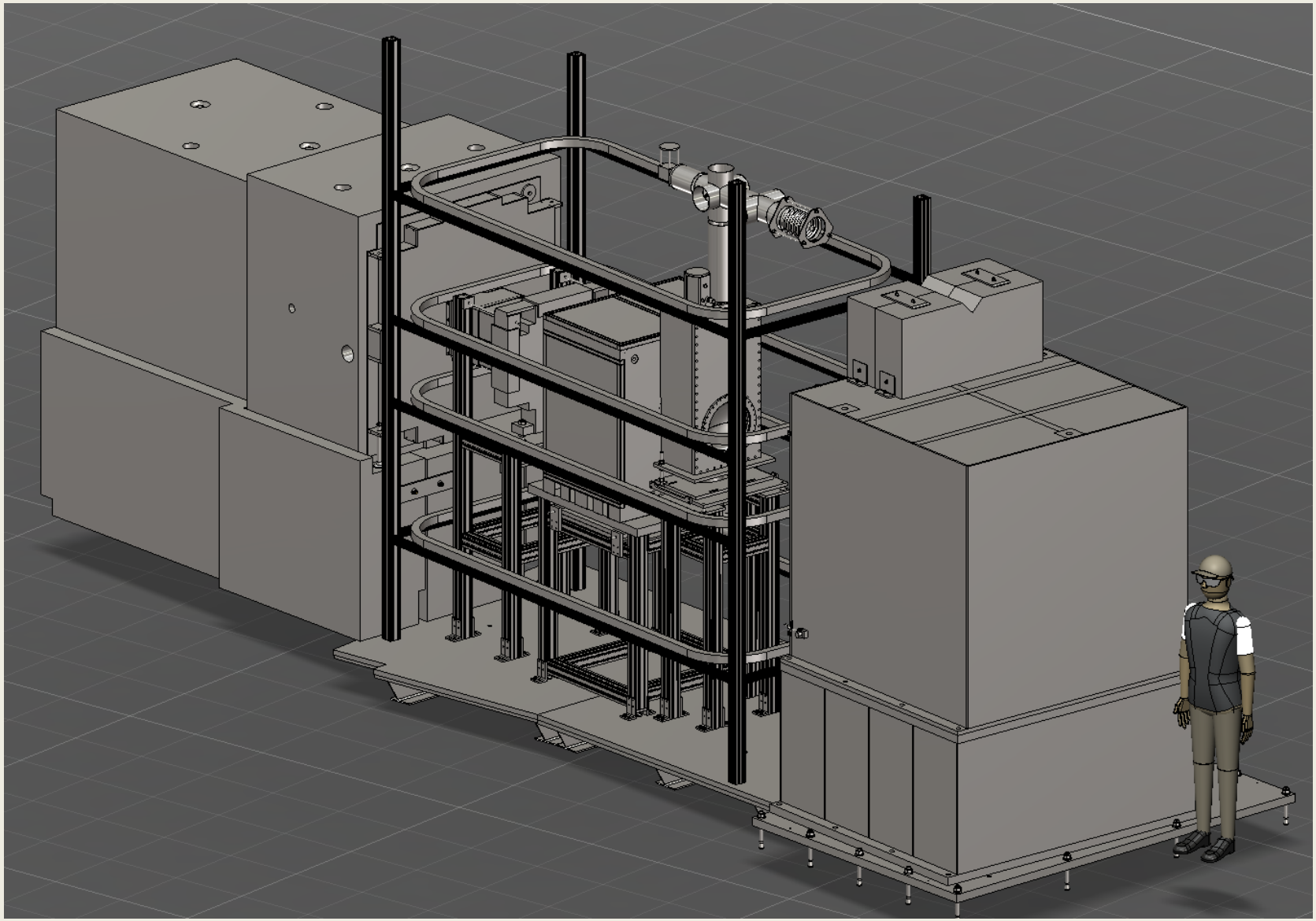
- Measure PV spin asymmetry to 2×10^{-8}
- Longitudinal holding field – suppressing PC nuclear asymmetry:

  $(1.7 \times 10^{-6} \propto s_n \cdot k_n \times k_p$ (Hale) suppressed by two small angles
- RF spin flipper – negligible spin-dependence of neutron velocity
- ^{3}He ion chamber – both target and detector

Schedule Overview

• Complete component construction / bench testing		now - May
• Preassemble in staging are		May - June
• Facility summer maintenance break		June-27 – Aug-15
• Removal of NPDGamma		June-27 – July -7
• Installation of n-3He on beam line		July-7 - Aug-15
• IRR		August
• Alignment of the experiment with beam		Sep – Oct -2014
• Commissioning;	60 days	Oct – Nov - 2014
• Measurement of PC transverse asymmetry;	15 days	Dec - 2014
• Facility winter maintenance break		Dec - 2014 - Feb - 2015
• Measurement of PV longitudinal asymmetry;	200 days	Feb-2015 – Dec- 2015

Experimental Setup



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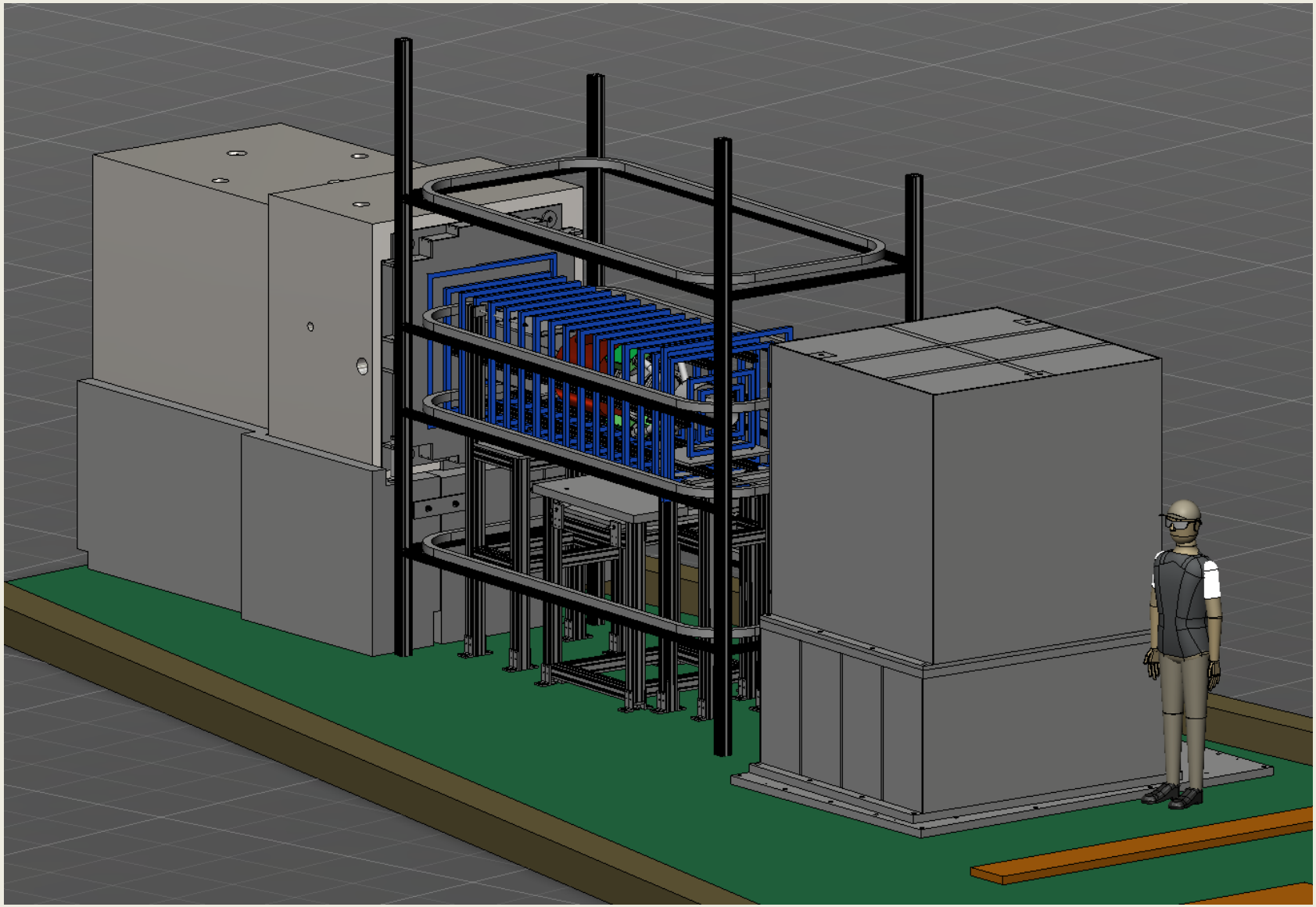
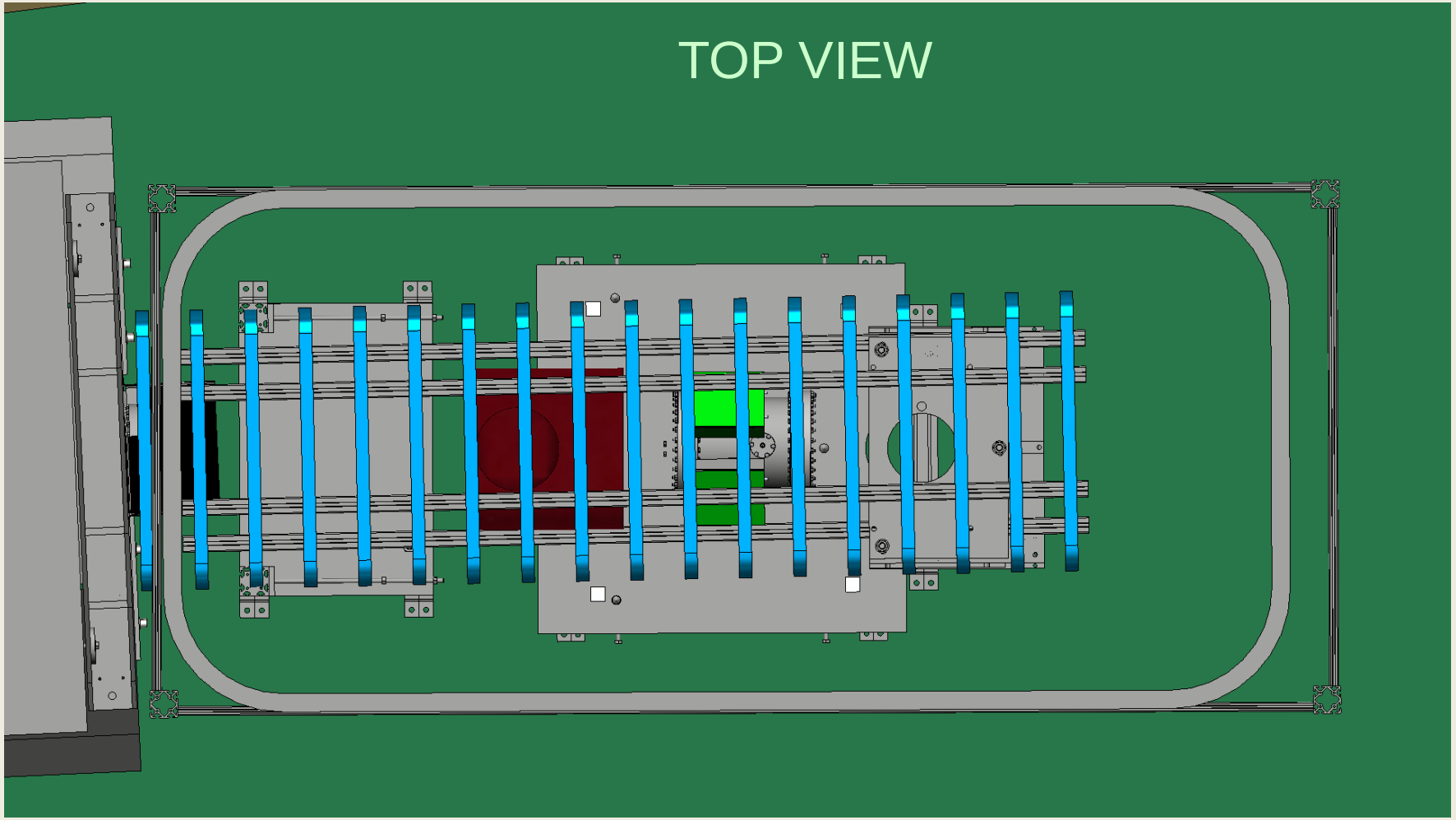


Unistructure support – preliminary CAD model

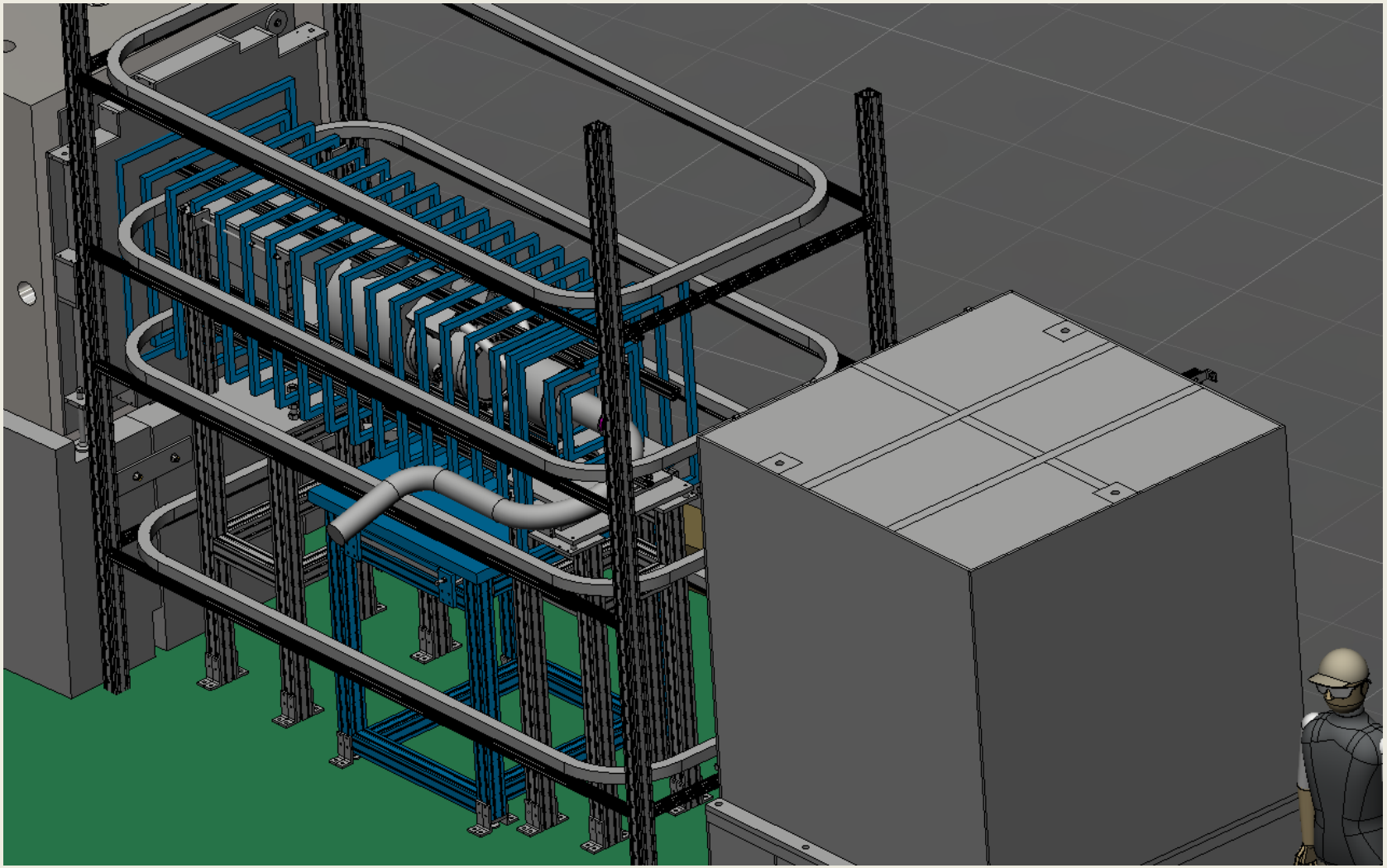


Beamline

- Scope
  - FnPB guide, polarizer, beam monitors – stays UNCHANGED
  - PPS remains UNCHANGED
  - Beam profile scanners, polarimetry
- Status
  - All equipment is being used for NPDG experiment except the beam profile scanners
  - XY-scanners in hand and tested
- Remaining work
  - Design shielding and mounts for xy-scanner – April
  - Design mount for ^{3}He analyzer (polarimetry) – April
  - Modify beamline shielding – April

Chris Hayes,
Kabir Latiful
Josh Hamblen
Geoff Greene

Magnetic Field

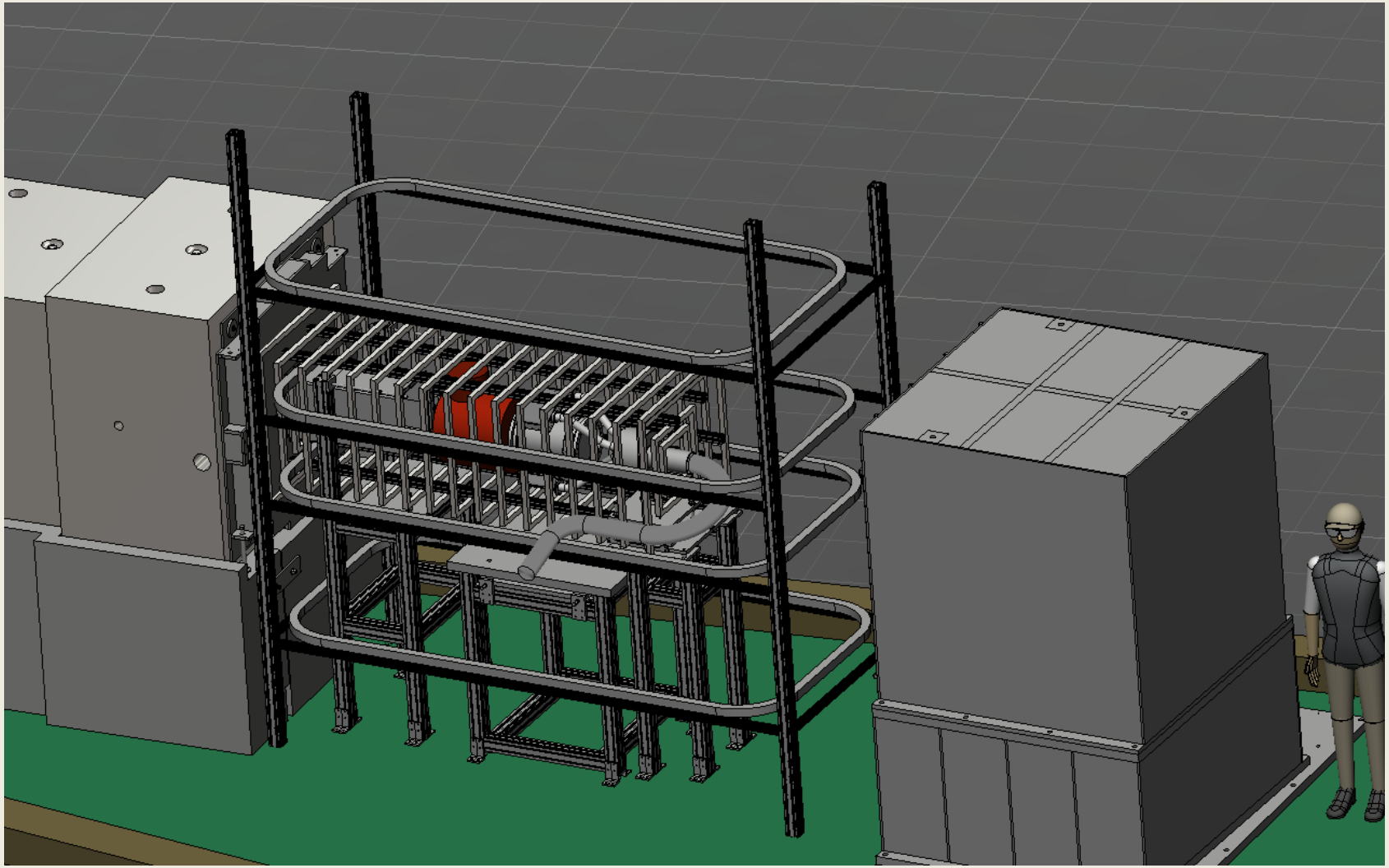


Magnetic Field

- Scope
  - Magnetic field simulations to verify adiabatic spin rotation and uniformity
  - Unistructure frame for Magnetic coils, Spin rotator, and Target/detector mounts directly onto existing NPDG stands on the beamline
  - Design, construction, and testing of longitudinal solenoid
    10 Gauss holding field, just like NDPG
- Status
  - Calculations indicate adiabaticity, coils being machined (winding in parallel)
    18(+1) coils, 15 cm apart, 70(52) cm sides, 150 A turns
  - Materials for frame and coil supports are in hand
- Remaining work
  - Machining of coil supports: April
  - Coil completion: May
  - Coil delivery to ORNL: June

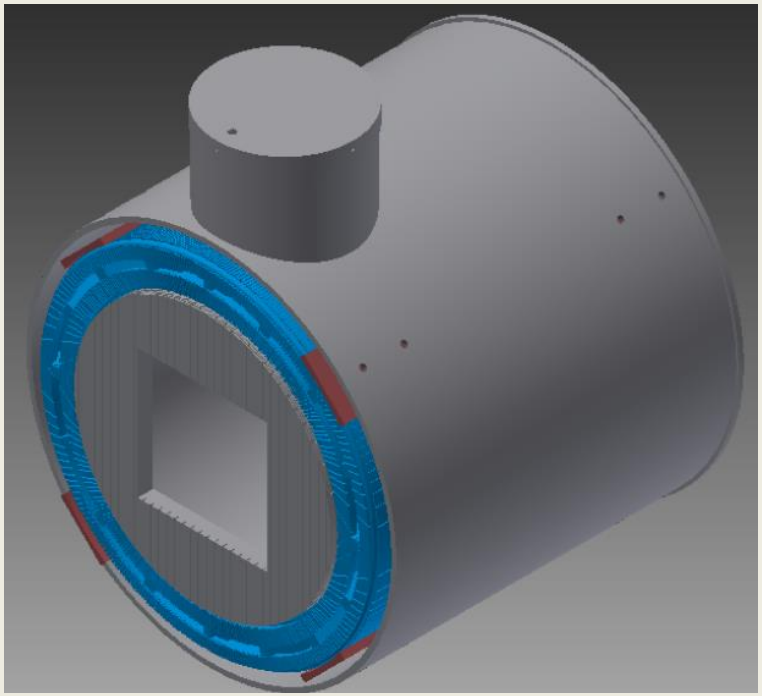
Andrés Ramirez,
Libertad Barrón

Spin Rotator



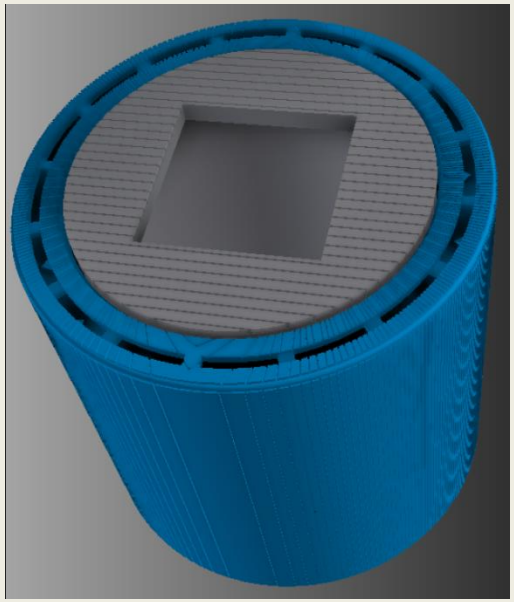
Spin Rotator

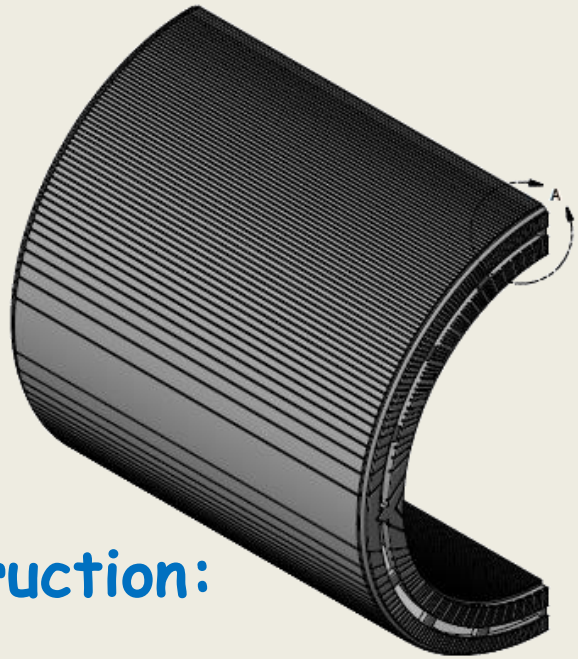
- Scope
  - Design of RF double cos-theta coil
  - Machining forms for inner/outer coils, aluminum enclosure, mounts
  - RF driver electronics
  - Field mapping and testing
- Status
  - Design complete
  - Machining of coils complete
  - Winding of coils Complete
  - RF driver electronics exist and are being used for NPDG
- Remaining work
  - Construction of enclosure: In progress
  - Testing and field mapping: In progress

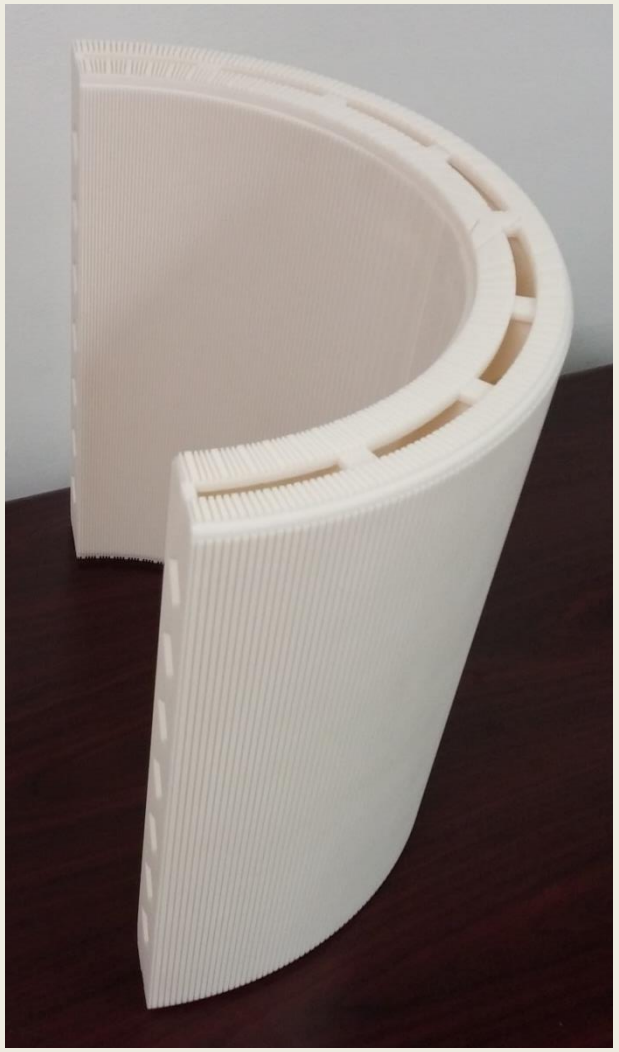


Chris Hayes,
Geoff Greene
Chris Crawford

Spin Rotator (Coils)





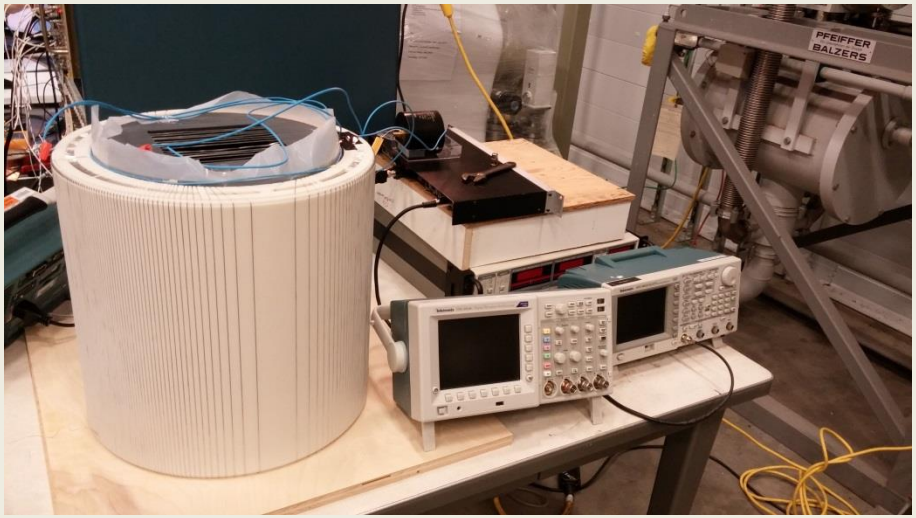


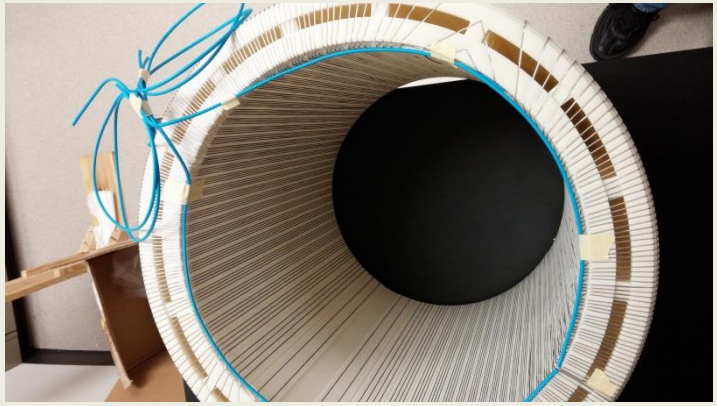
Design and Construction:
Complete

Inner cylinder made from PVC

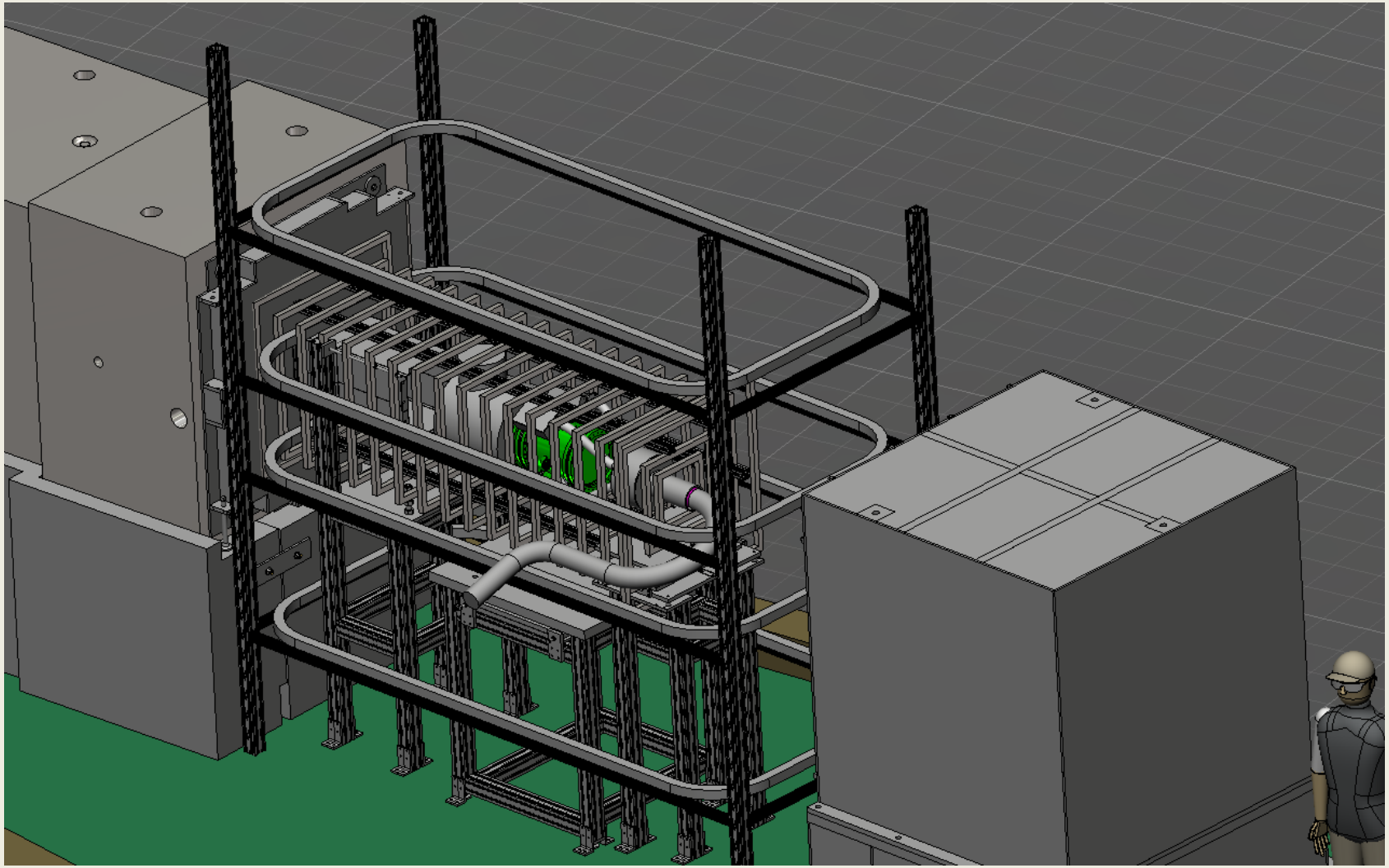
Outer coils fabricated using 3D print Technology.

Spin Rotator (Photographs)





Target / Detector



Target / Detector

- Scope
  - Vacuum enclosure with 1 atm ^{3}He
  - 144 channels of sense wires
  - low leakage / noise
  - good charge collection
- Status
  - Vacuum enclosure in hand
  - Wires soldered to frames
- Remaining work
  - Assemble wire plane stack, readout plane: March
  - HV test and vacuum tests March
  - Fill with ^{3}He: April
  - Electronics noise testing with chamber April

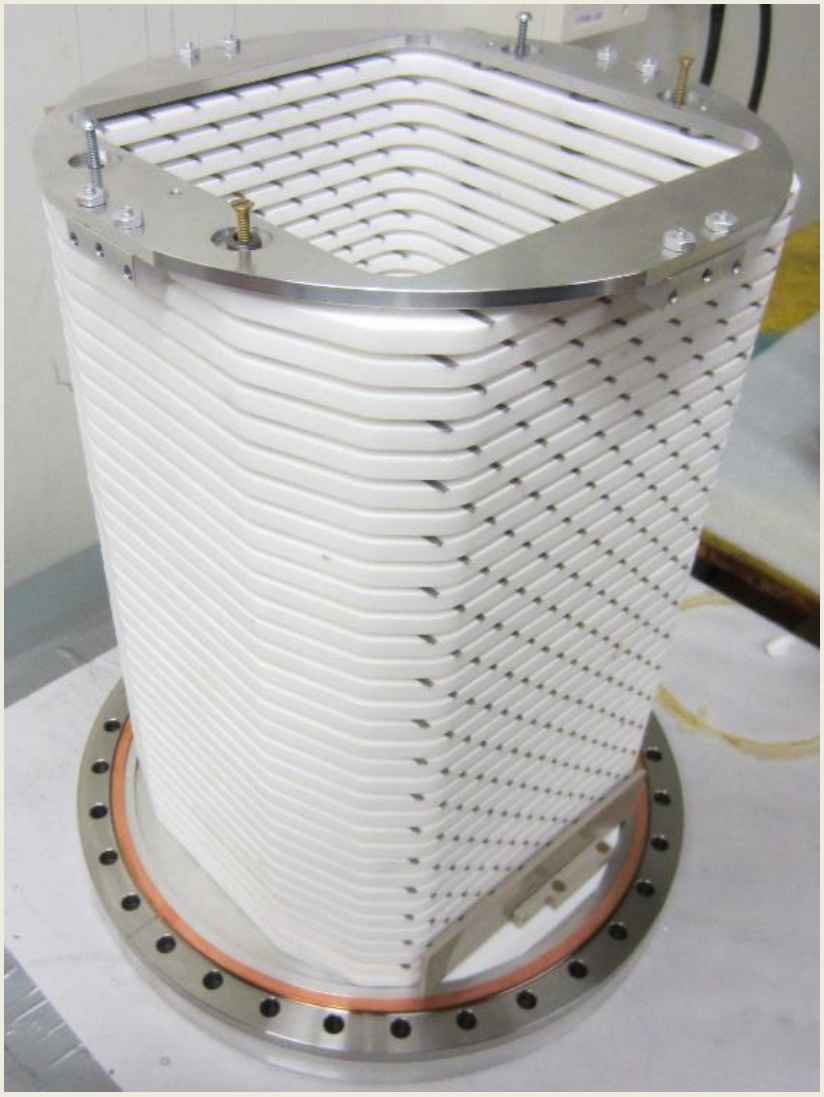
Mark McCrea
Michael Gericke
Seppo Penttila

Target / Detector (Housing)

- 12" Conflat end flanges
- 1 mm Al windows
- Fill gas: 1 atm ^{3}He
- Feedthroughs: 4x signal, 2x high voltage, 2x vacuum

Target / Detector (Wire frame stack)

- 17 HV planes
- 16 signal planes
  - 144 signal wires
- All wires soldered to frames
- Mounting hardware and fittings all constructed
- PCB readout boards will arrive late March
- Assembly March-April
- Testing starting in April



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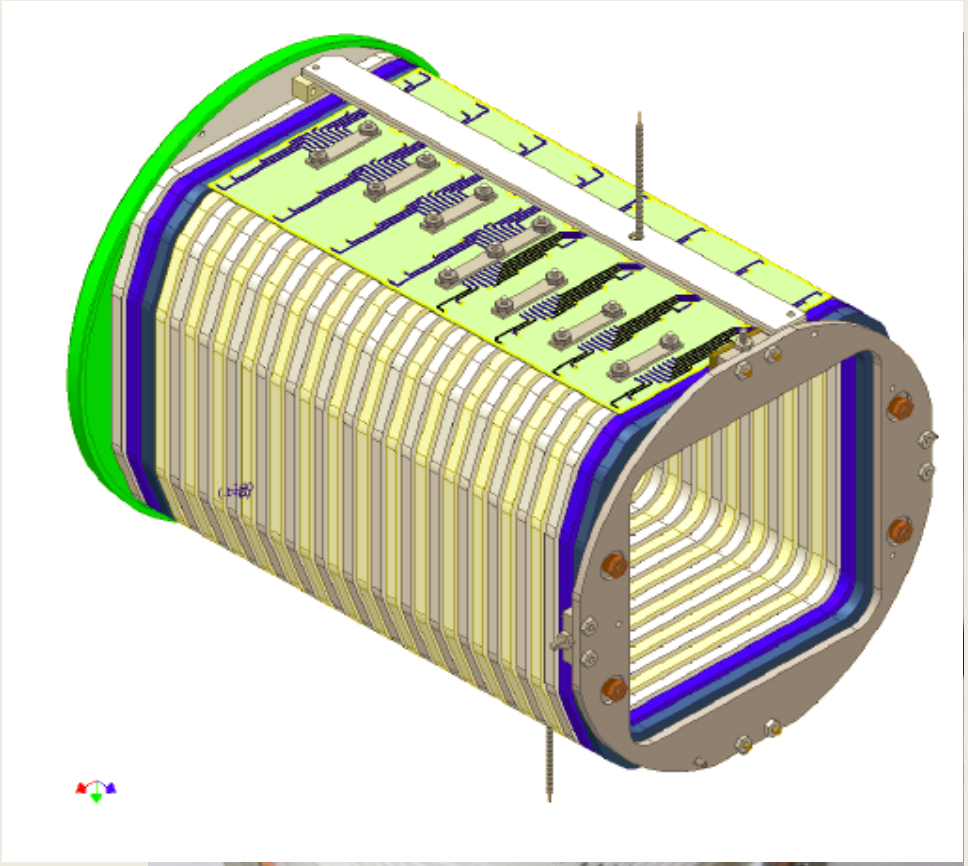

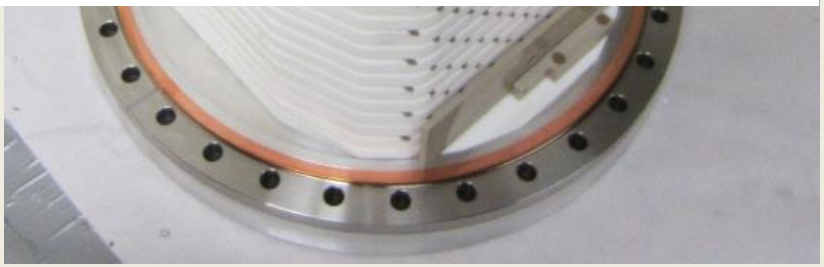

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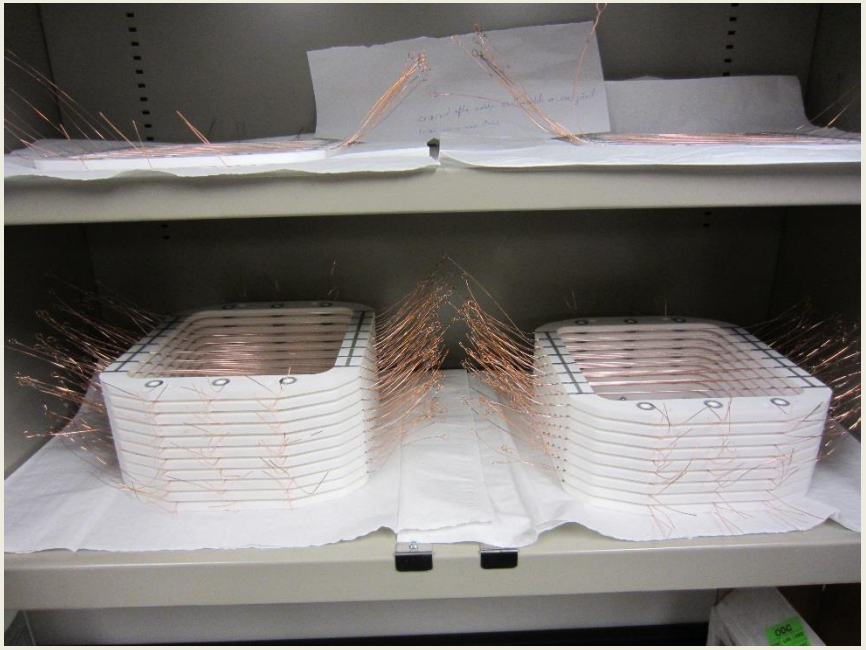
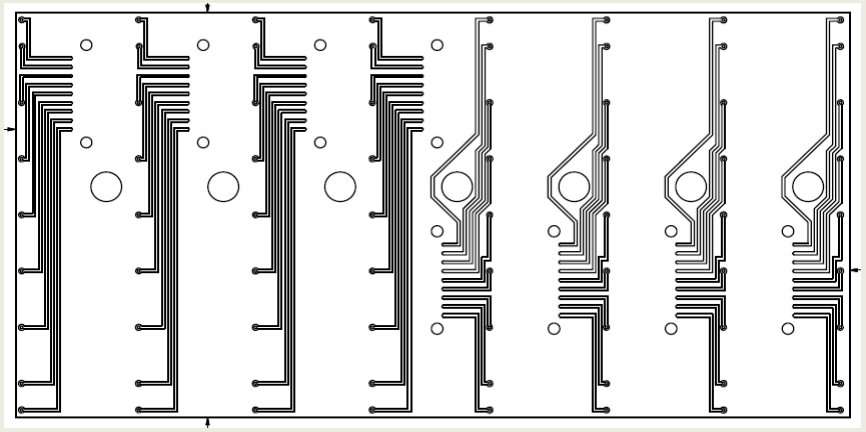
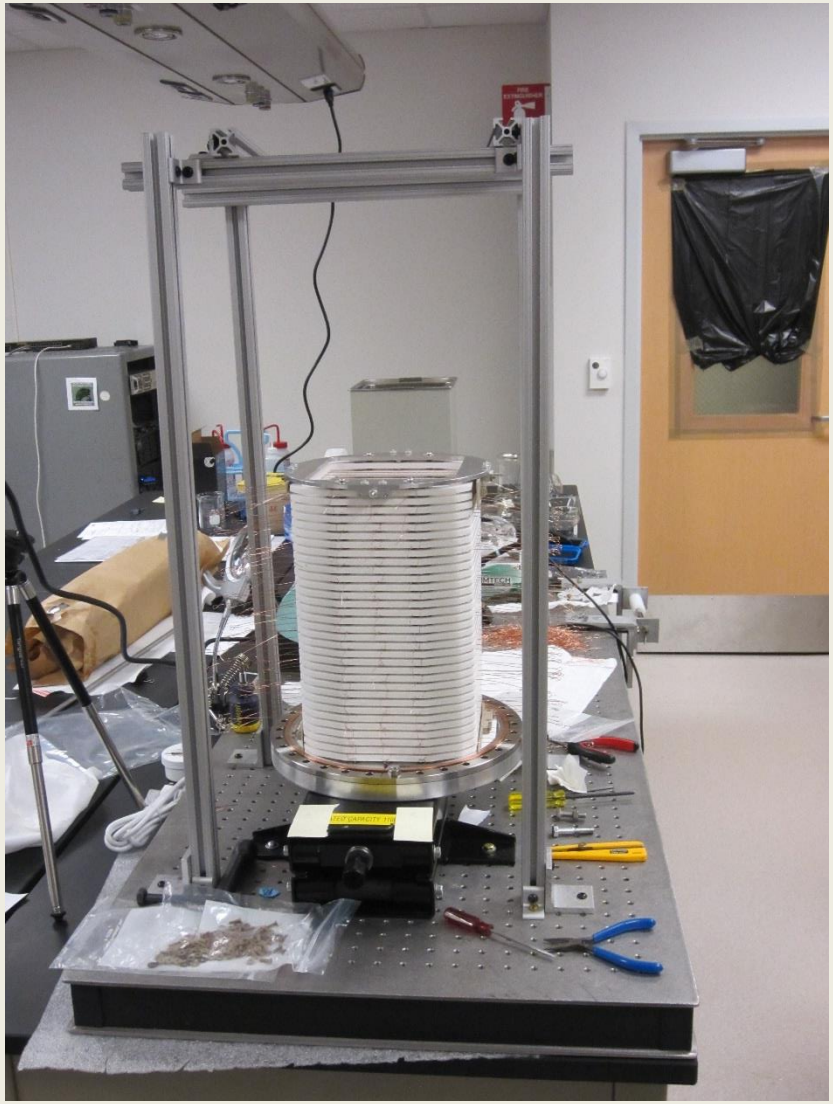


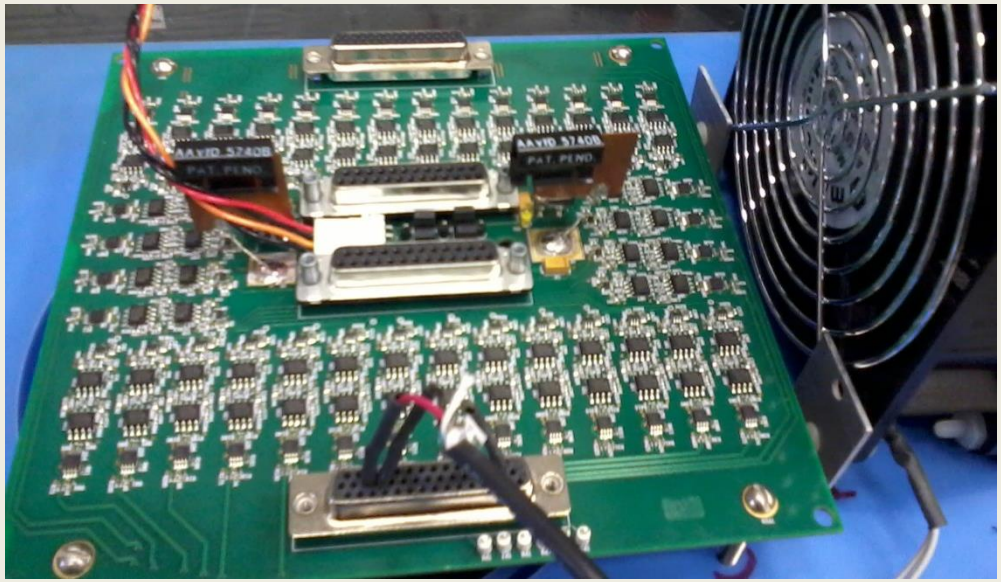




Pre-amplifiers

Kabir Latiful
Irakli Garishvili
David Bowman

- Scope
  - 4 enclosures (one per vacuum feedthrough) with 36 channels each
  - Circuit board designed locally at ORNL
  - Connector to ion chamber vacuum port and cabling to DAQ module
- Status
  - Prototype circuit board tested
  - Achieved theoretical limit on some channels, testing in progress
- Remaining work
  - Test cooled prototype inside enclosures
  - Build final preamps
  - Build cables
  - Test all channels
  - Measure instrumental asymmetries with spin rotator and target



Data acquisition

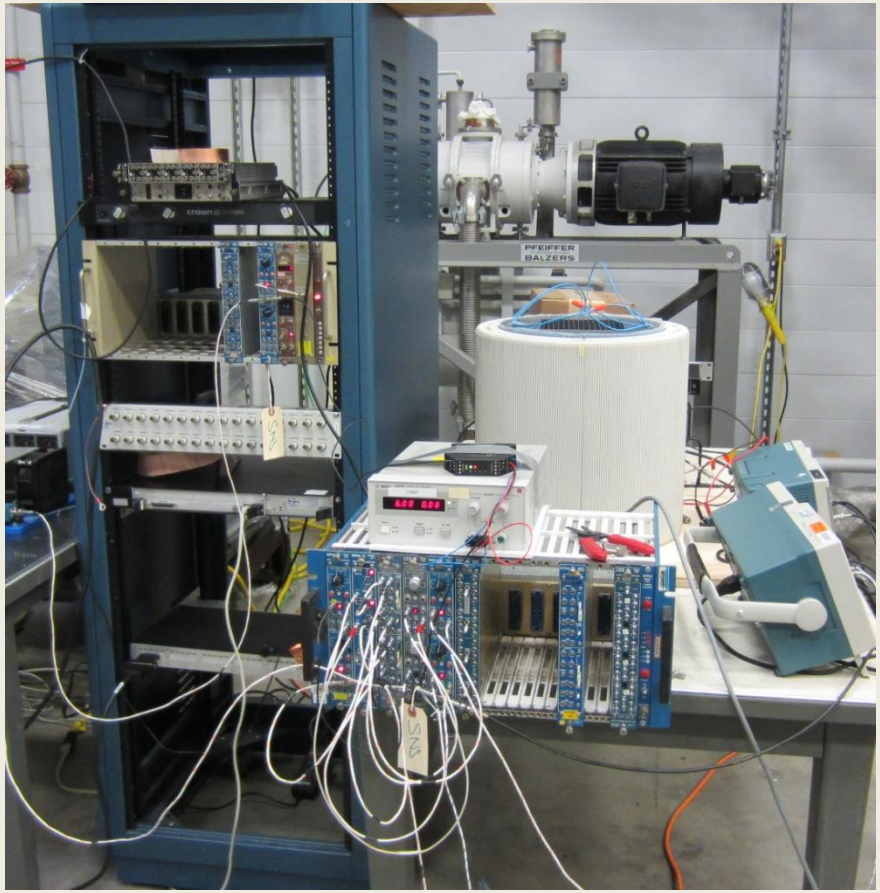
Kabir Latiful
Irakli Garishvili
Nadia Fomin
Chris Crawford

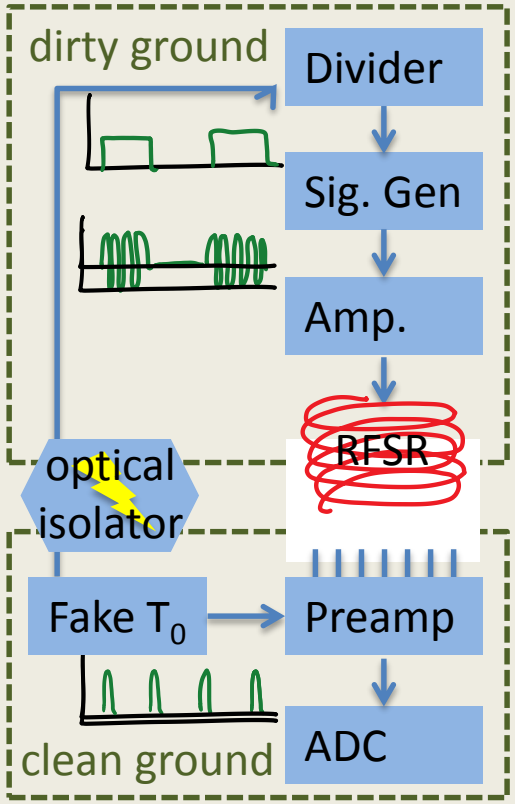
- Scope
  - 144 channels of 24 bit, 128 KS/s ADC
- Progress
  - Basic software used to take and analyze data
  - Extensive testing of two prototype systems
  - **Preliminary measurements of instrumental false asymmetry**
  - ADCs ordered, delivery: April 9th; custom firmware by end of May
  - Two DAQ computers acquired; RAID array ordered
- Remaining work
  - Test complete DAQ hardware: April–May
  - Adjust software for final hardware and custom firmware: May–June

Instrumental false asymmetry measurement

- Measurements with RFSR, preamps, and ADC modules
- Trigger optically isolated

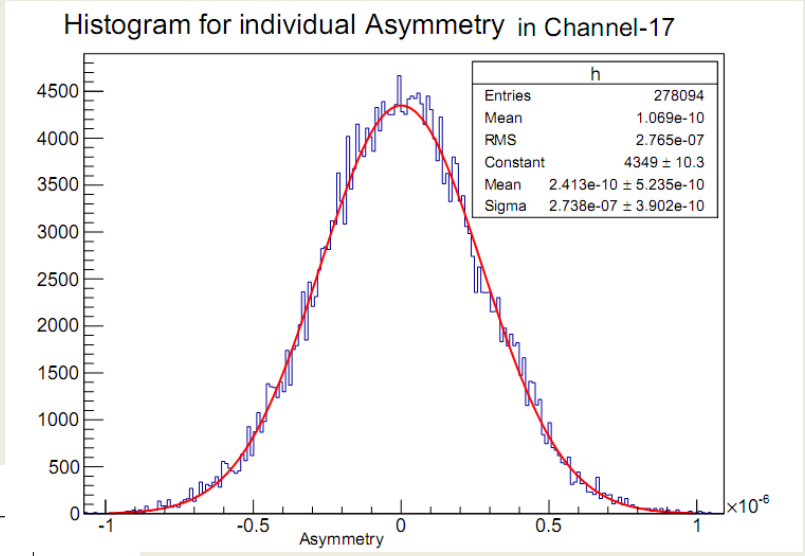
Kabir Latiful
Irakli Garishvili
David Bowman
Chris Crawford

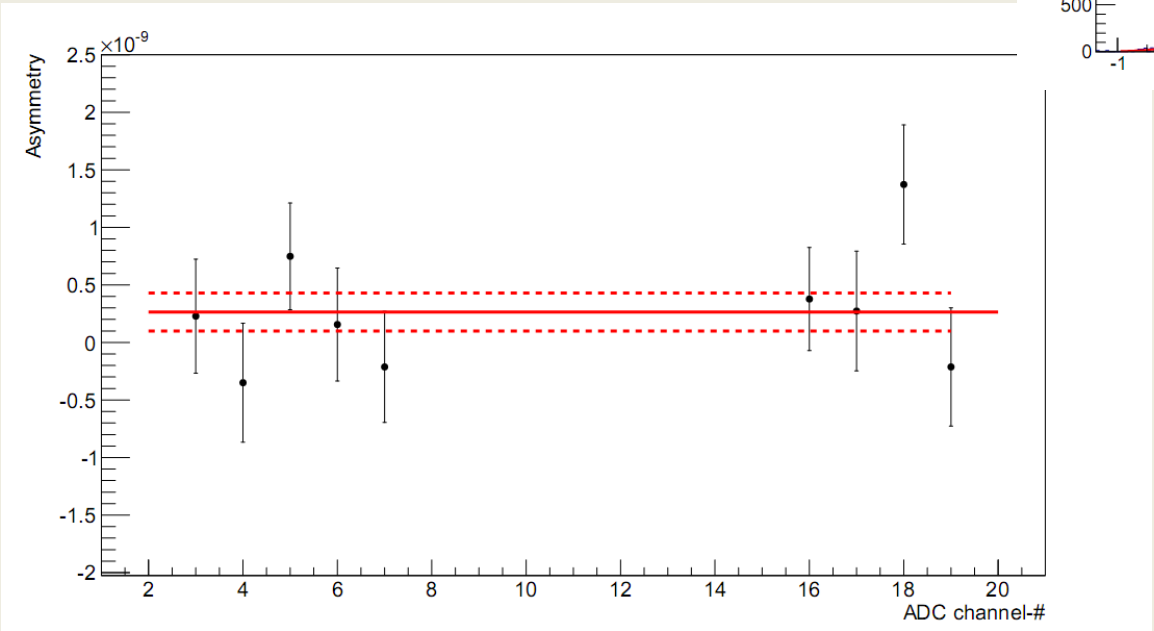




Instrumental false asymmetry measurement

- Data taken for 5 hours
- **$A = (2.64 \pm 1.64) \times 10^{-10}$**
- Will repeat measurements with delivered DAQ and wire chamber





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• IRR		August
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• Commissioning;	60 days	Oct – Nov - 2014
• Measurement of PC transverse asymmetry;	15 days	Dec - 2014
• Facility winter maintenance break		Dec - 2014 - Feb - 2015
• Measurement of PV longitudinal asymmetry;	200 days	Feb-2015 – Dec- 2015

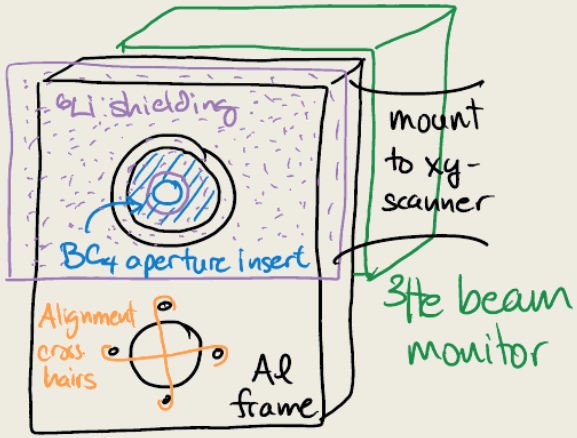
Integration / Pre-assembly

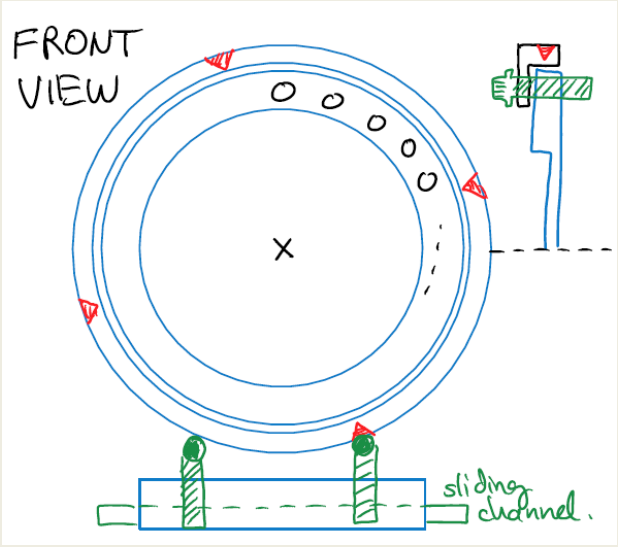
Caleb Wickersham
Mark McCrea
Jack Thomison
Geoff Greene
Josh Hamblen

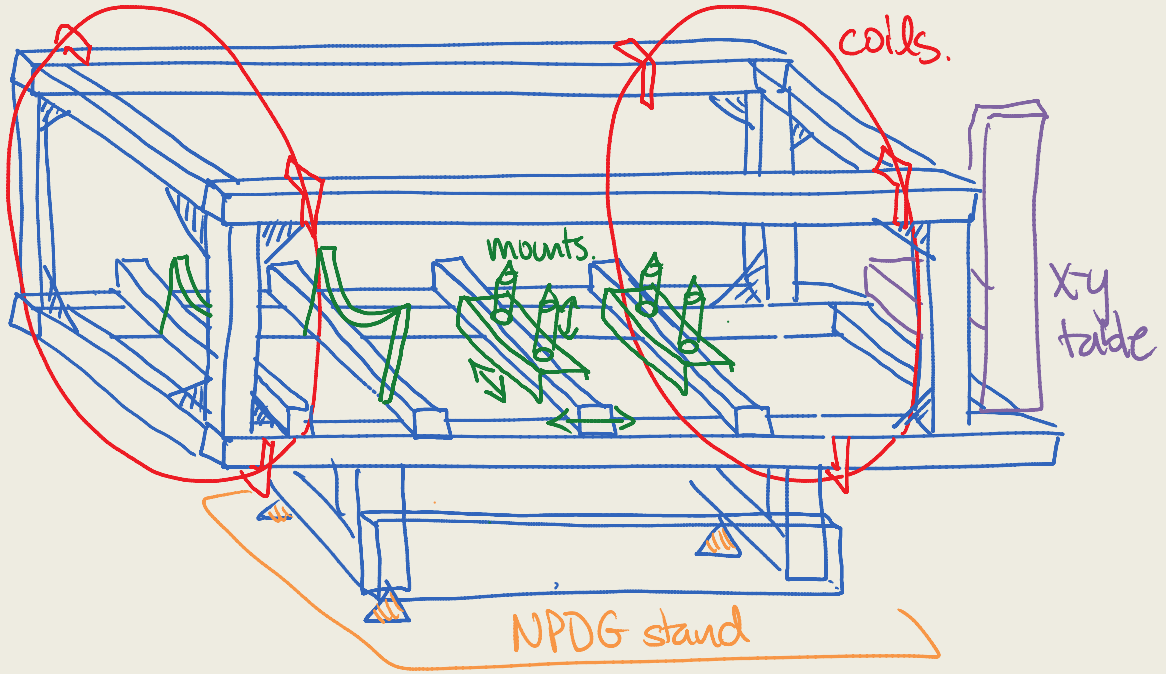
- Scope:
  - Design of unistructure support frame
  - Design, construction of mounting and alignment hardware
  - Maintain 3d solid model of experiment
  - Ensure components fit and that support frame matche the NPDGamma stands
- Status:
  - Preliminary solid model exists
  - Conceptual design for mounts and alignment
  - Model is added to beamline model by SNS designers
- Remaining work:
  - Final design of stand and mounting
  - Construction of mounting, alignment hardware: April
  - Assembly of complete system in staging area: May-June
  - Alignment testing: June

Alignment

- Mounting / alignment components
  - Aperture / crosshairs for beam scan
  - Support stand and xy-adjustment for theodolite
  - Alignment V-block for trimming B-field
  - Optical system and adjustable mount for target
  - 10 mrad tolerance – no need for S/A crew

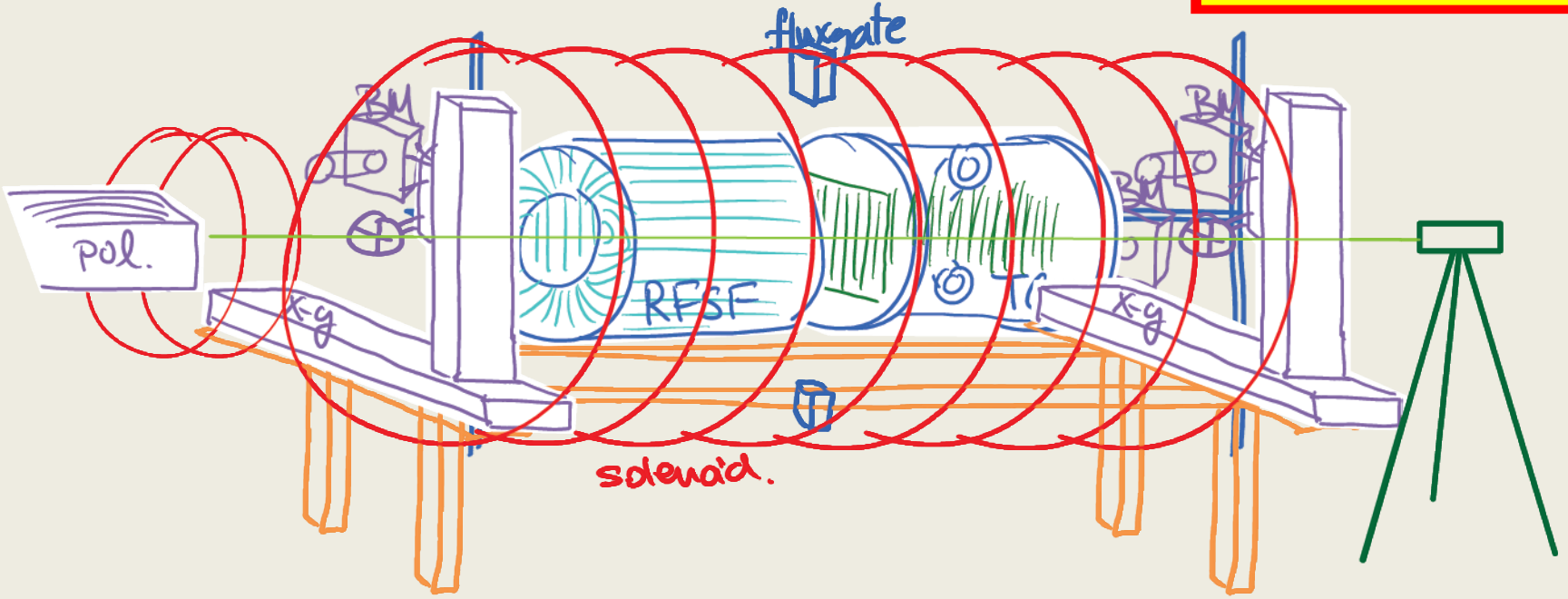






Commissioning / Run plan

IRR #2



1. Scan beam profile upstream and transfer centroid to crosshairs
2. Scan beam profile downstream
3. Align theodolite to crosshairs
4. Align B-field to theodolite
5. Field map in RFSR/Target region
6. Align the position / angle of target with theodolite / autocollimator
7. Tune RSFR / measure polarization
8. Measure physics asymmetry

Backups

n^3He Calculations

- Full four-body calculation of strong scattering wave functions
- Evaluation of the weak matrix elements in terms of the DDH potential (Work in progress on calculation of EFT low energy coefficients)

$$A_p^{\vec{n},^3He}(th.) \approx (-9.4 \rightarrow 2.5) \times 10^{-8}$$

DDH Weak Coupling	(A^p_Z) $n^3He \rightarrow tp$
a_π^1	-0.189
a_ρ^0	-0.036
a_ρ^1	0.019
a_ρ^2	-0.0006
a_ω^0	-0.0334
a_ω^1	0.0413

M. Viviani, R. Schiavilla, Phys. Rev. C. 82 044001 (2010)
L. Girlanda et al. Phys. Rev. Lett. 105 232502 (2010)