

INSTITUTE OF  
PARTICLE  
PHYSICS

# TRIUMF PMT Test Facility

H. A. Tanaka (UBC/IPP)

3rd Open Meeting for the Hyper-Kamiokande Project

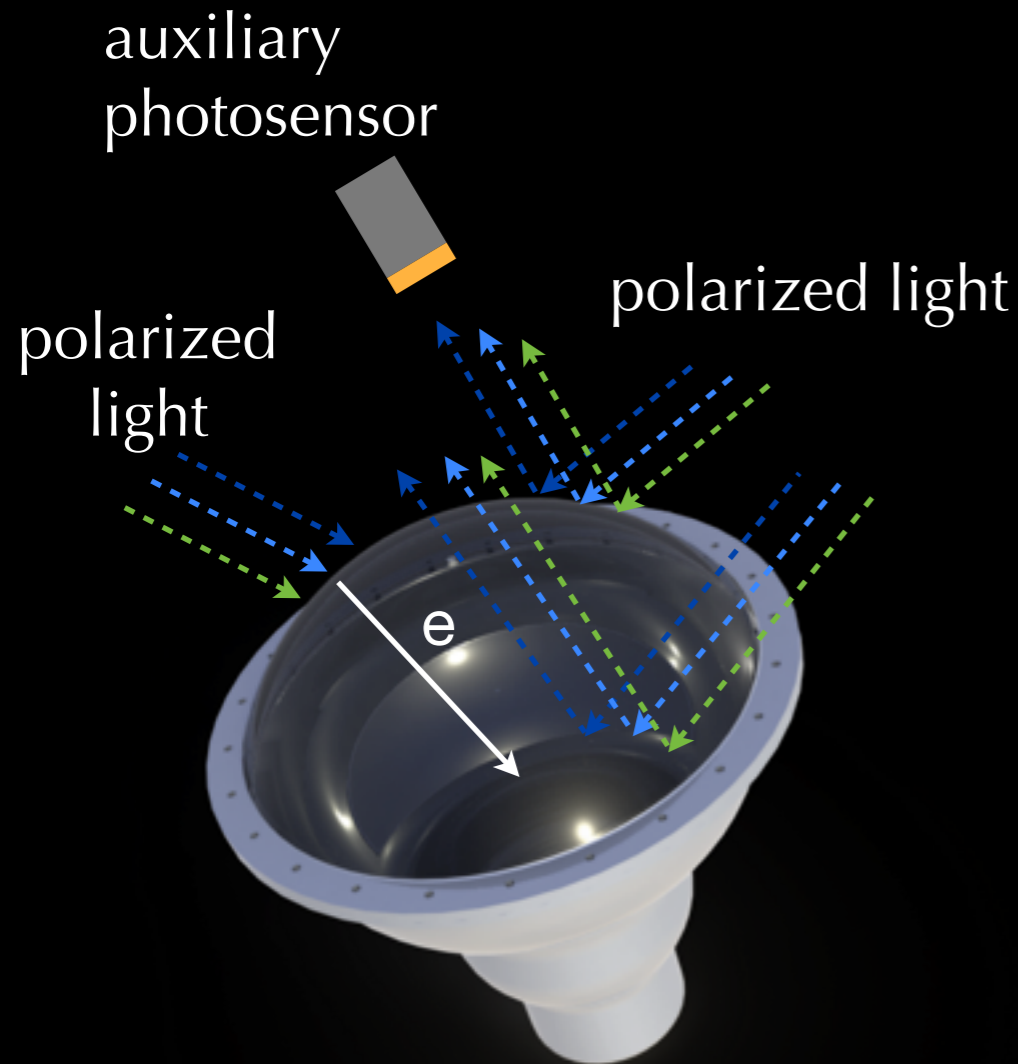
# Motivation

Error source	$\sin^2 2\theta_{13} =$	
	0	0.1
Beam flux & $\nu$ int. (ND280 meas.)	8.5	5.0
$\nu$ int. (from other exp.)		
$x_{CCother}$	0.2	0.1
$x_{SF}$	3.3	5.7
$p_F$	0.3	0.0
$x^{CCcoh}$	0.2	0.2
$x^{NCcoh}$	2.0	0.6
$x^{NCother}$	2.6	0.8
$x_{\nu_e/\nu_\mu}$	1.8	2.6
$W_{eff}$	1.9	0.8
$x_{\pi-less}$	0.5	3.2
$x_{1\pi E_\nu}$	2.4	2.0
Final state interactions	2.9	2.3
Far detector	6.8	3.0
Total	13.0	9.9

- Relative uncertainty in the number of  $\nu_e$  candidates (S+B)
- Flux (5%) +  $\nu$  interaction
  - additional NA61 data
  - better  $\nu$  interaction modeling
  - refined near detector analysis
- Far detector (3%):
  - data/MC differences in control samples (ATM, “hybrid  $\pi^0$ ”, etc.)
  - combination of detector modeling and  $\nu$  interaction uncertainties

In my opinion, aggressive effort is needed on all fronts to achieve “2%” uncertainty in HK LBL analysis

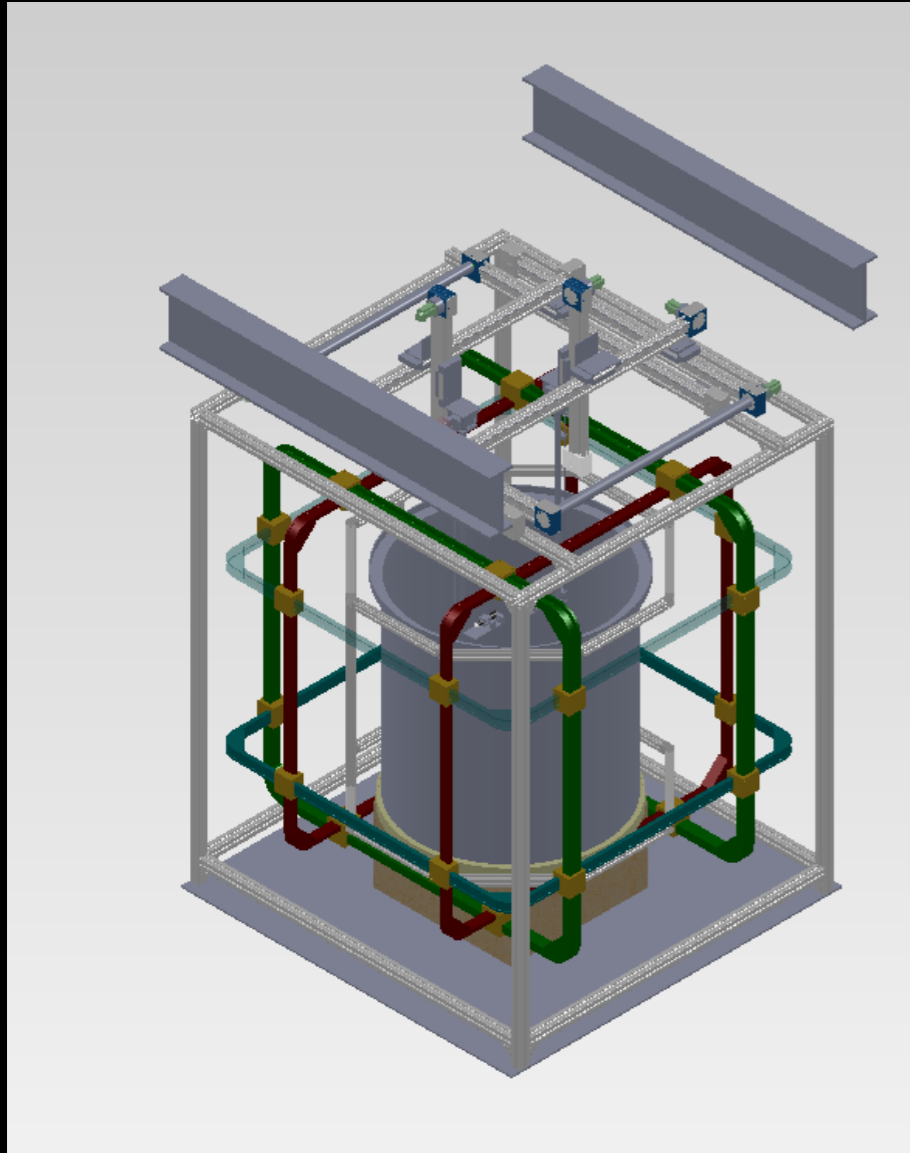
# PMT test facility (PTF)



- Study response of large area photosensors to light (in water) across:
  - wavelengths (330-550 nm)
  - incident angles to surface
  - locations on the PMT
  - polarization
- Light reflected from the PMT affects response of other PMTs (in water)
- Study reflectivity of photosensor across same parameter space,

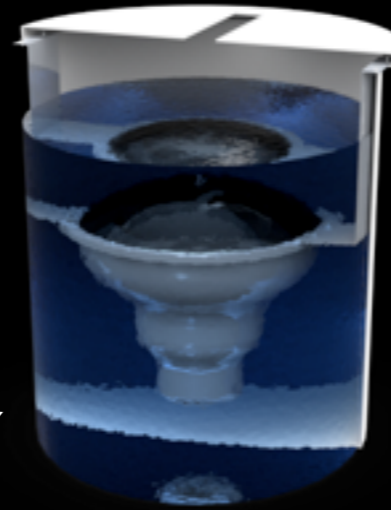
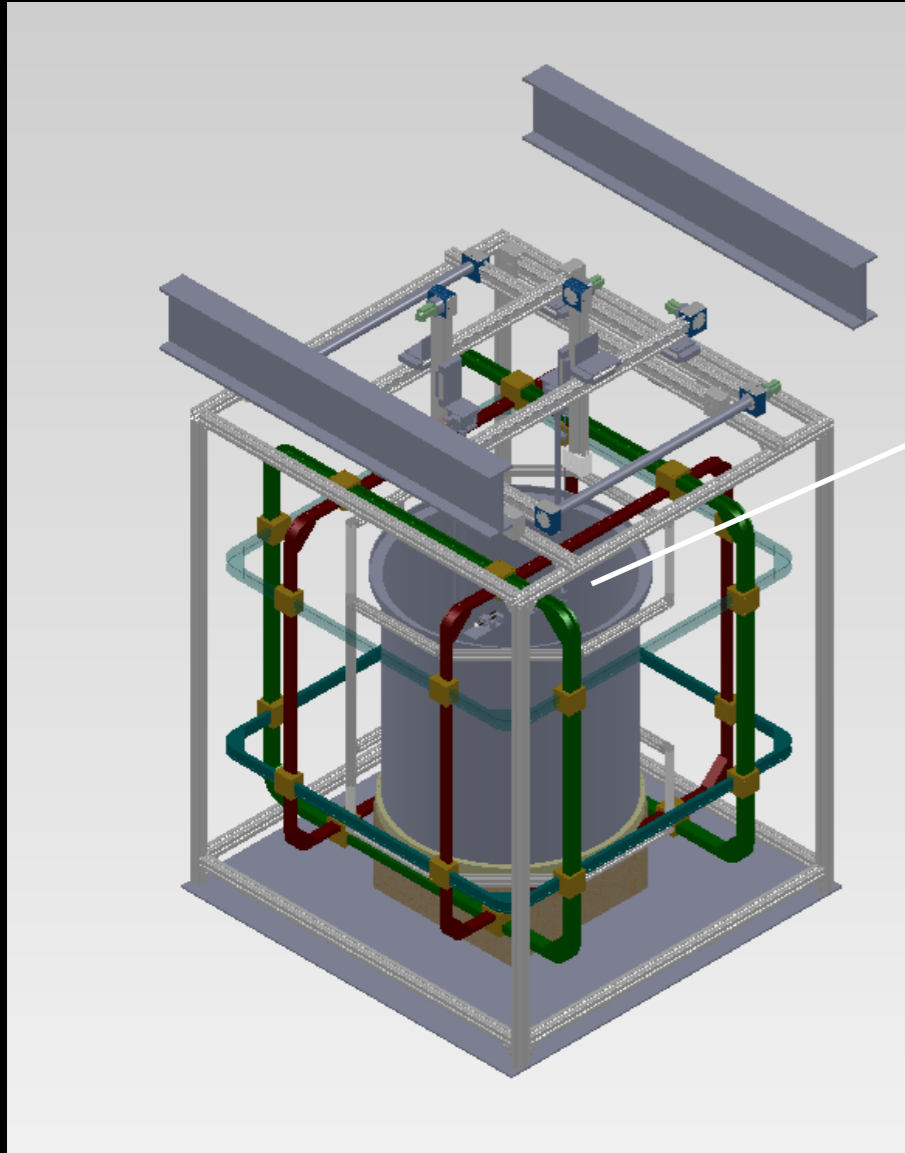
Goal: provide parameterized model of PMT response and reflection that can be “fit” with *in situ* data (somewhere in between calibration/photosensor development)

# Conceptual Design



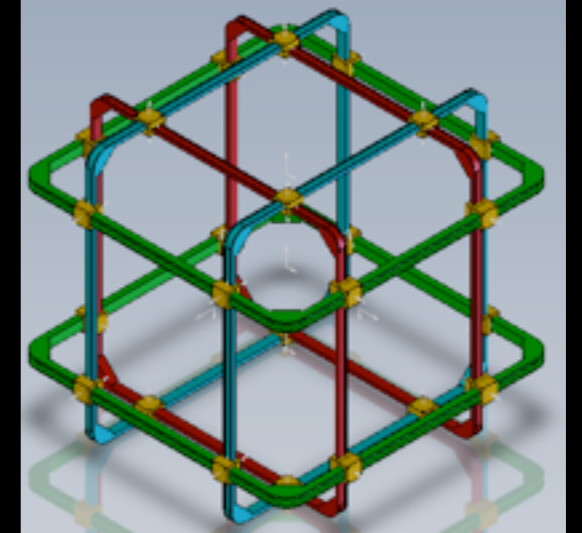
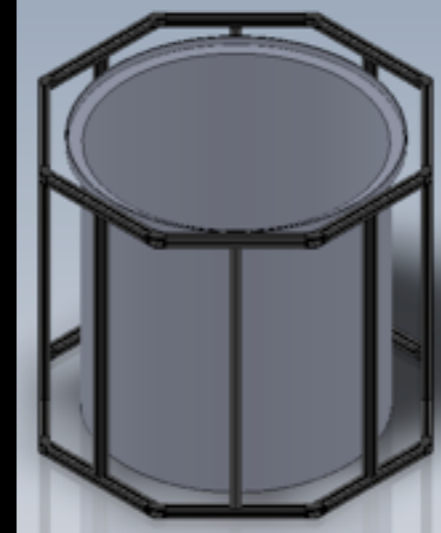
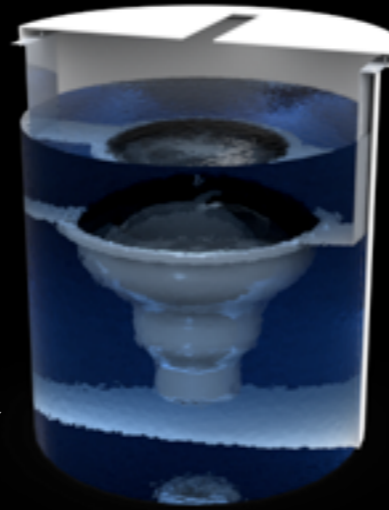
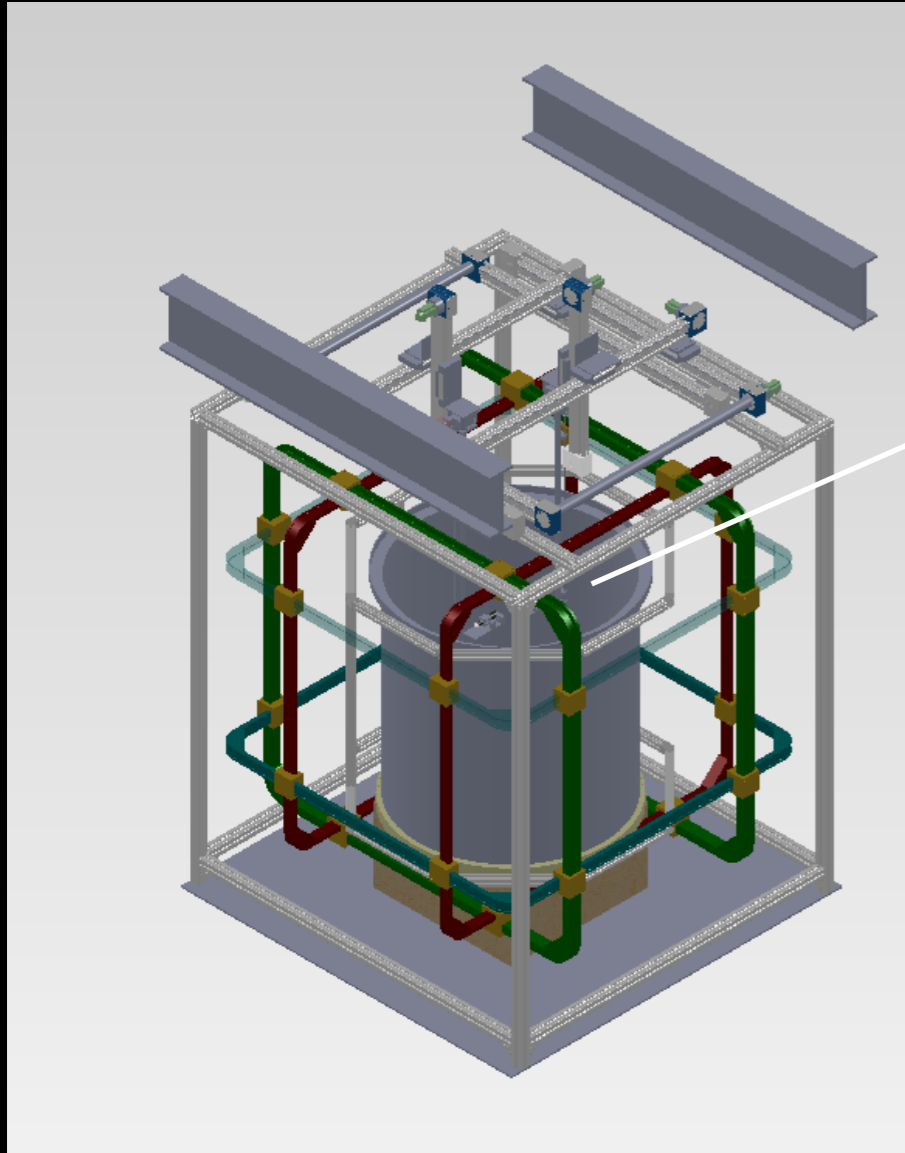
W. Faszler/P. Lu

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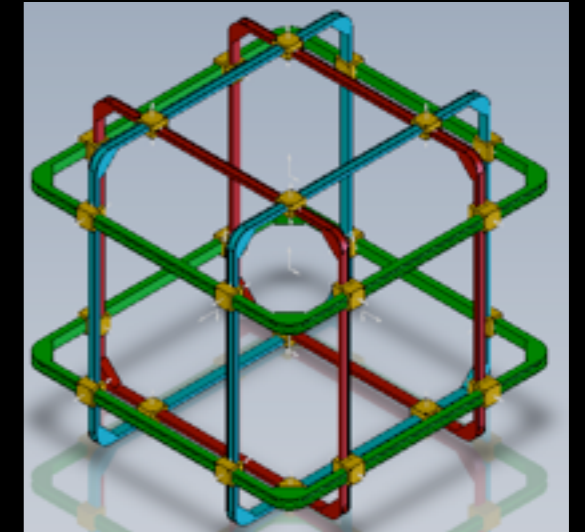
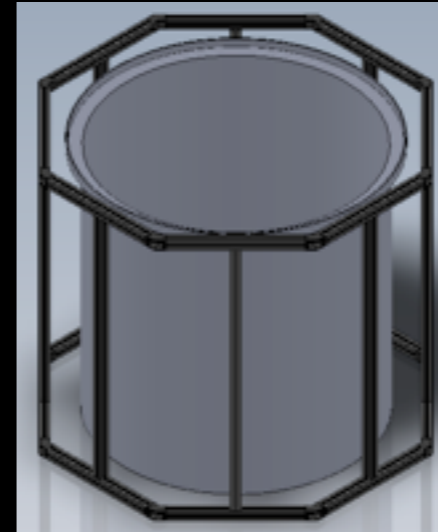
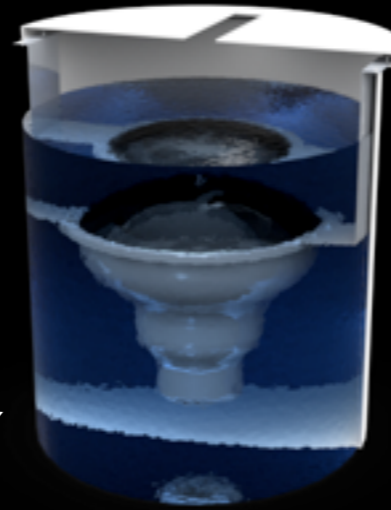
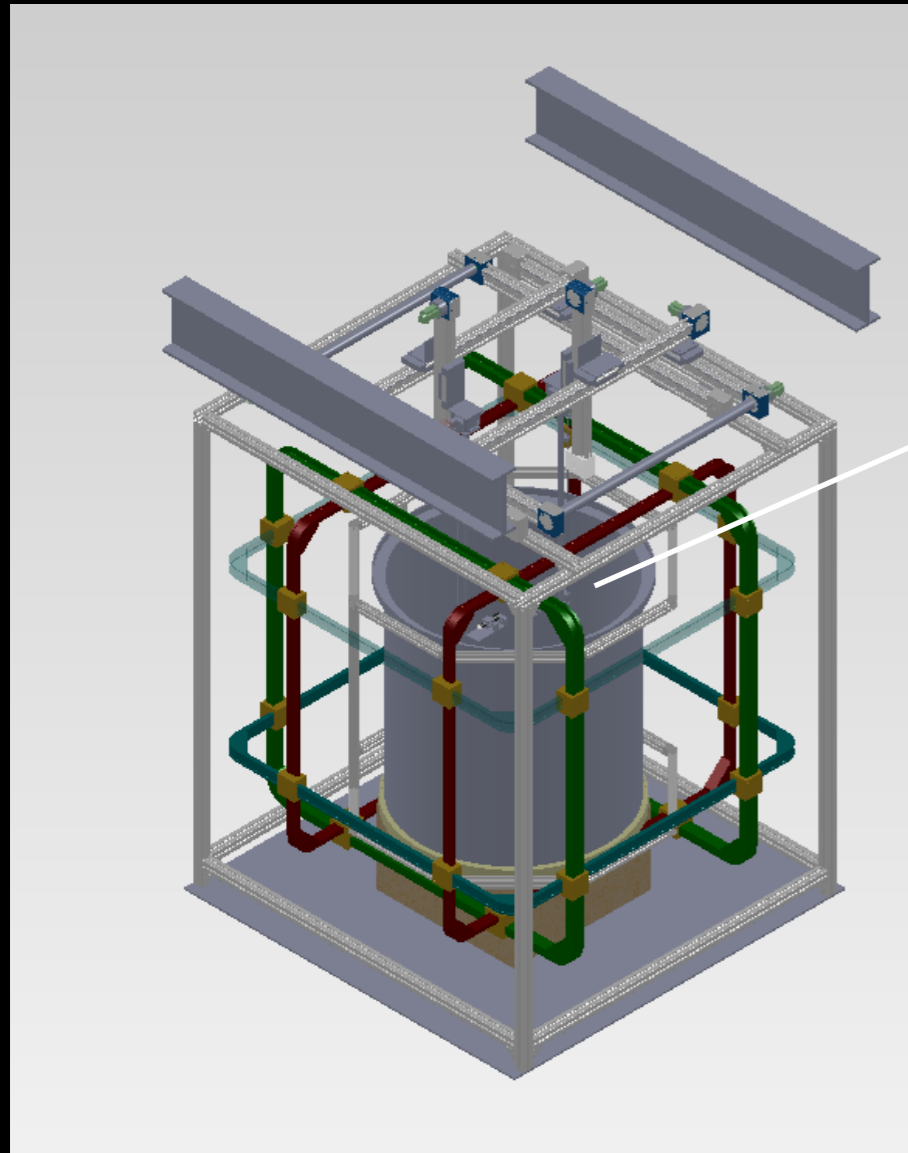
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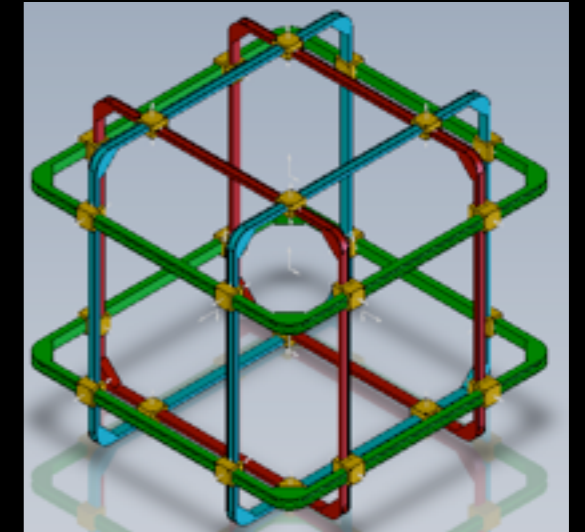
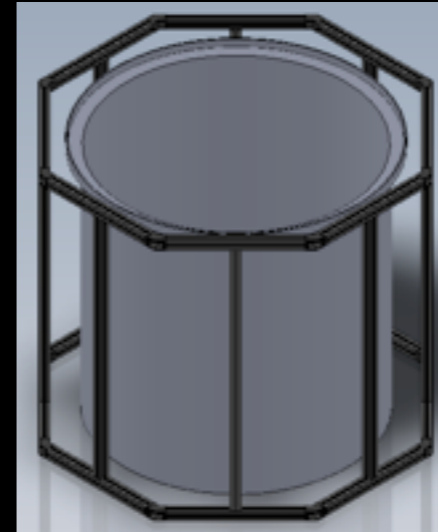
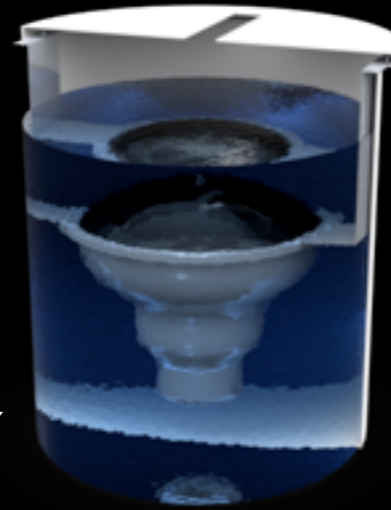
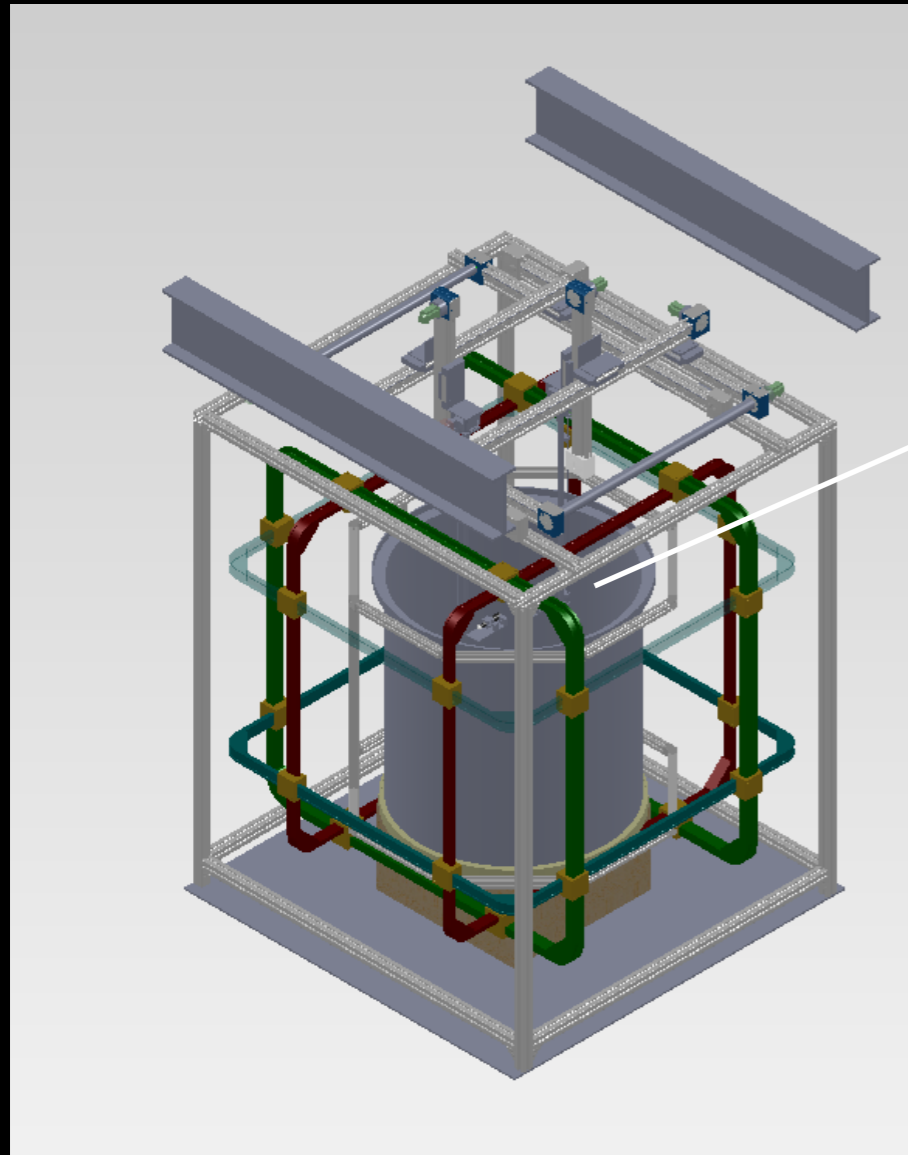
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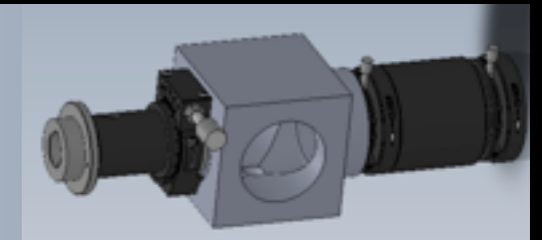
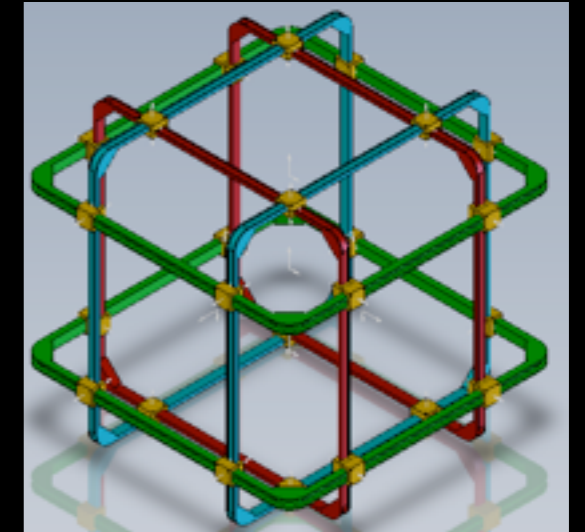
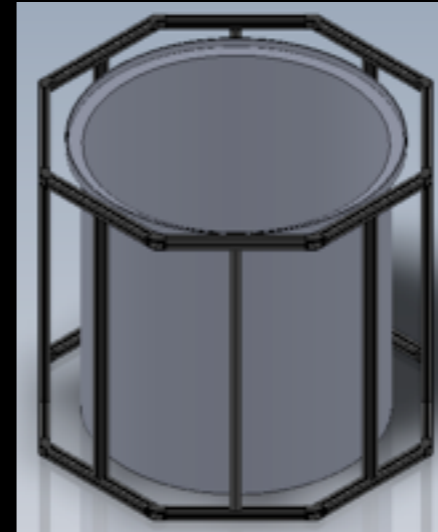
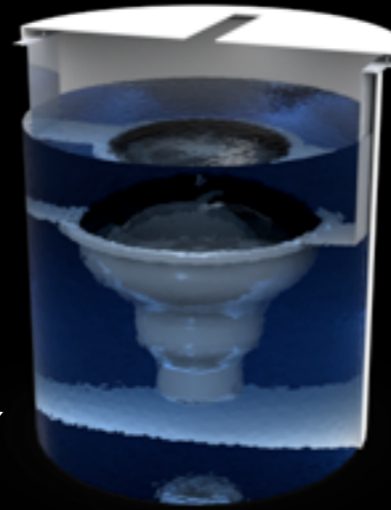
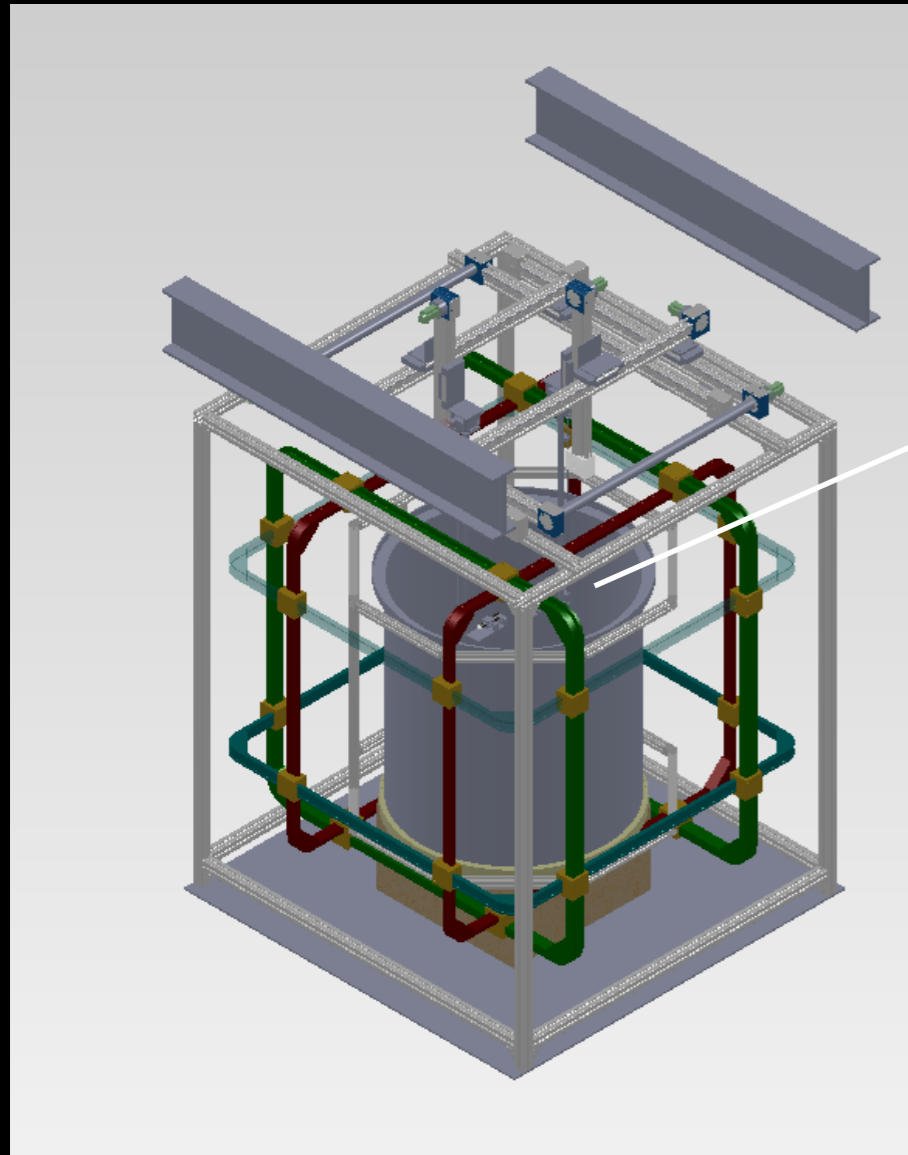
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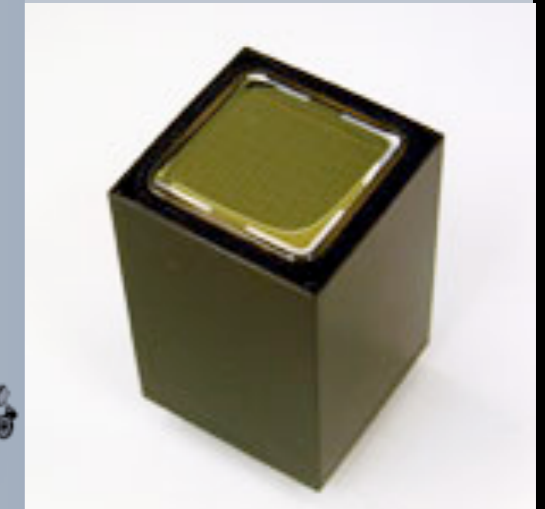
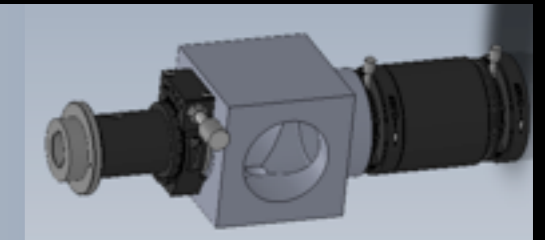
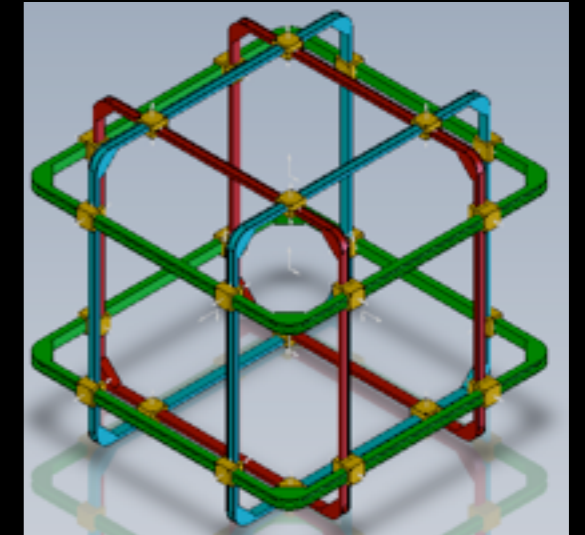
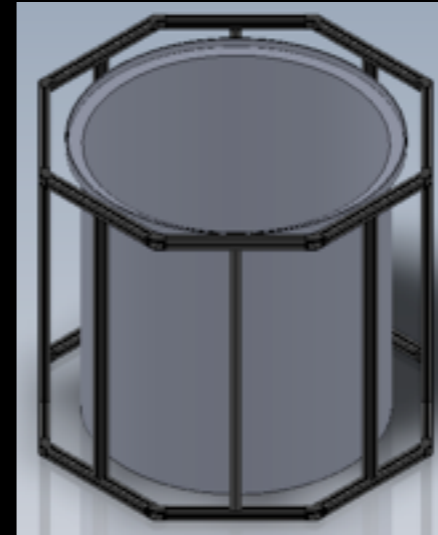
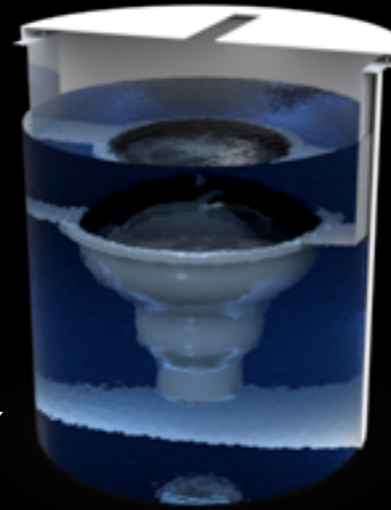
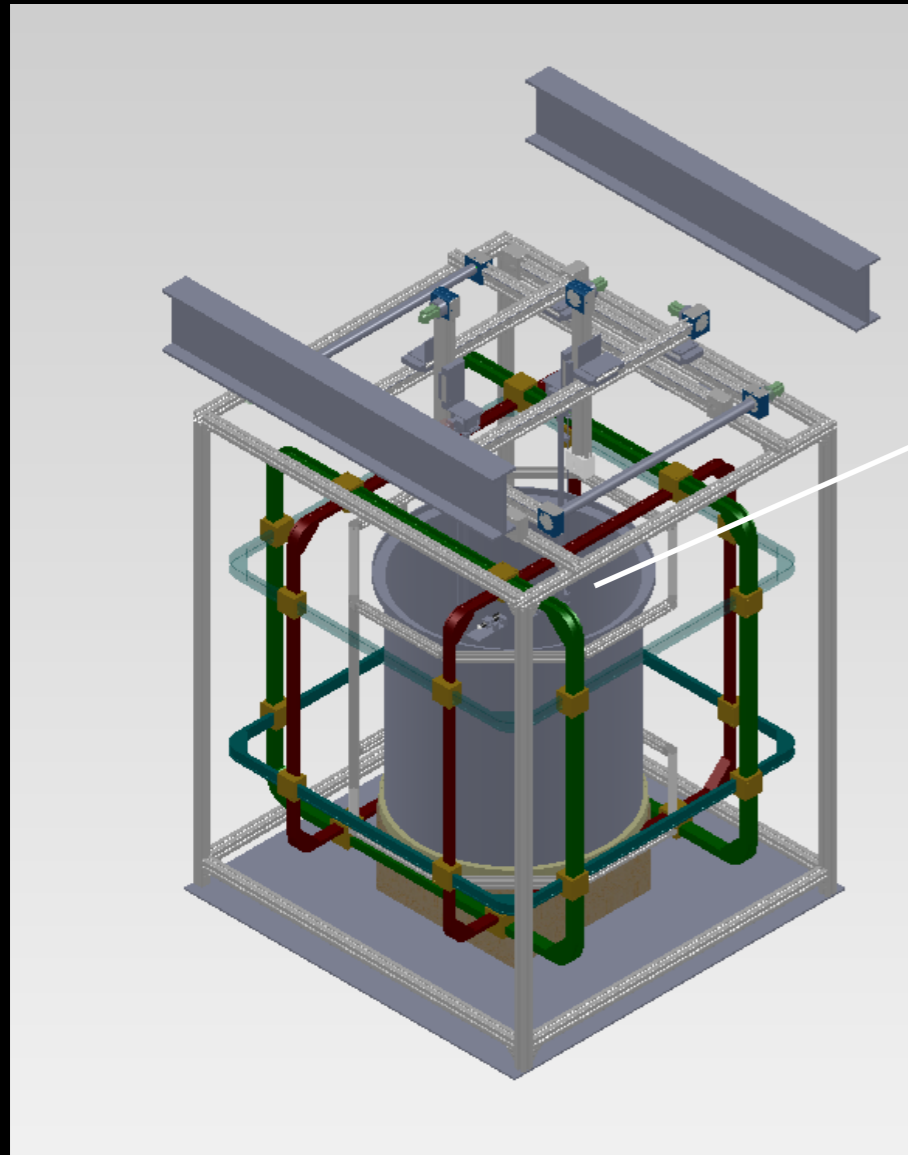


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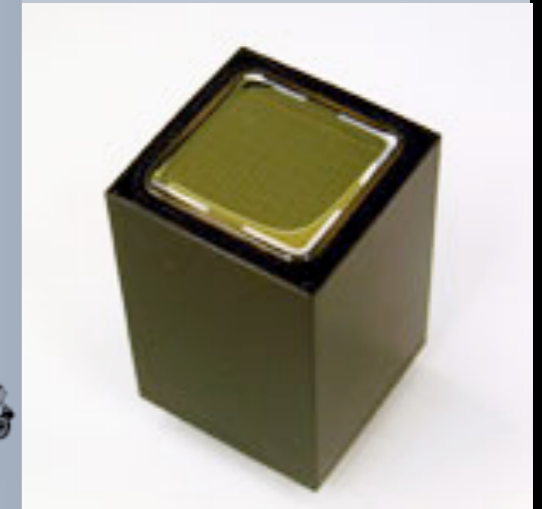
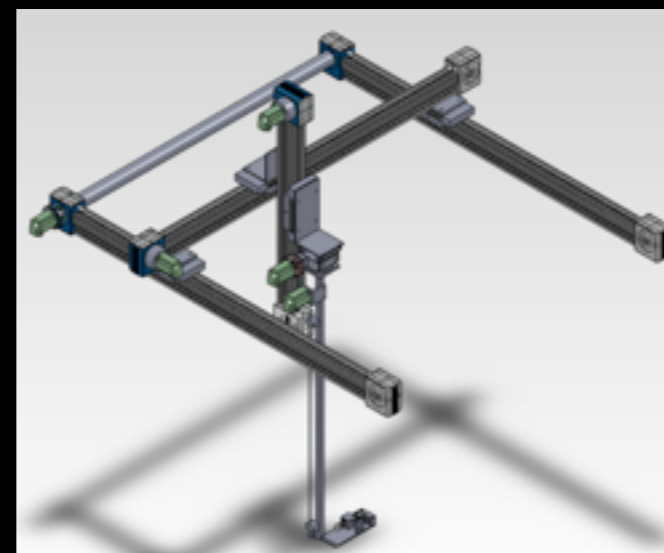
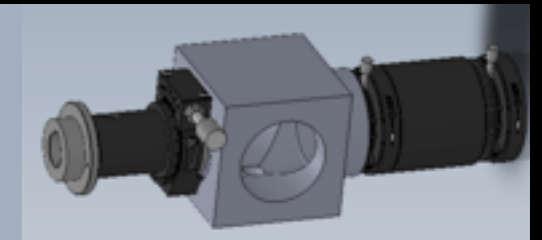
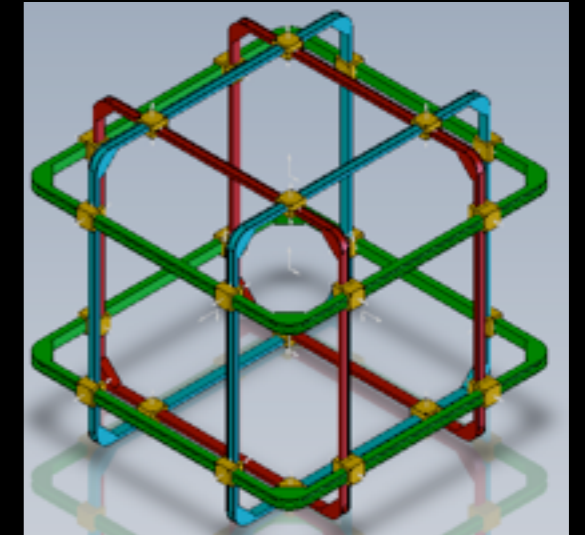
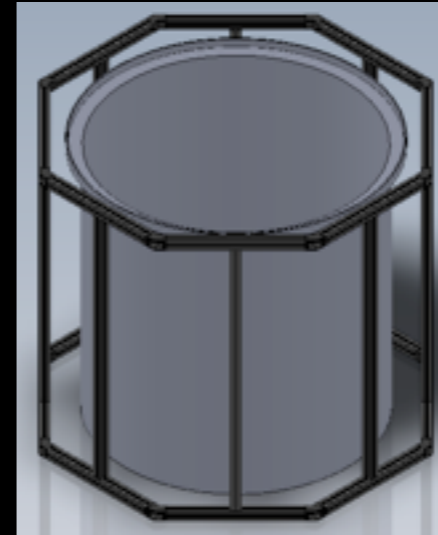
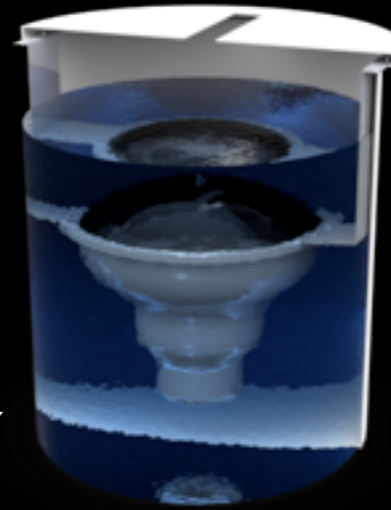
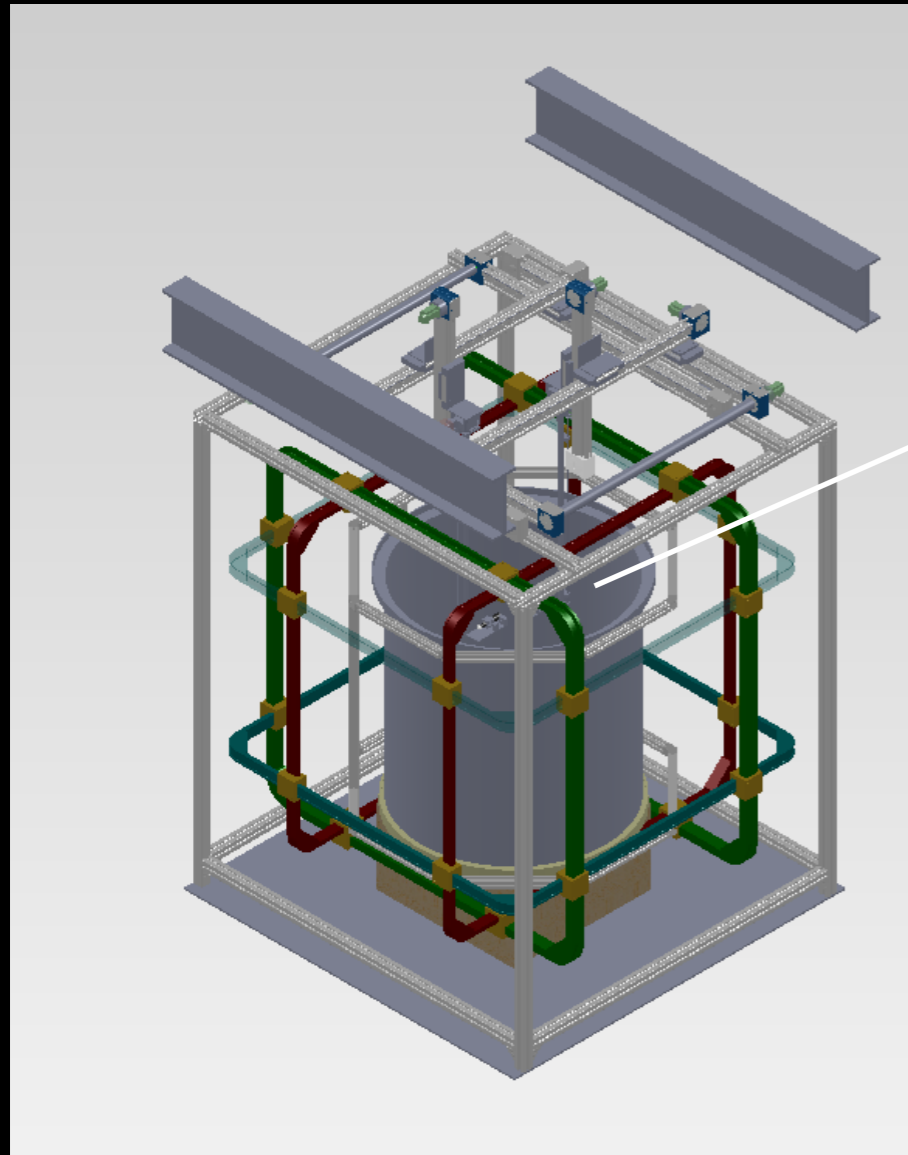
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# Conceptual Design



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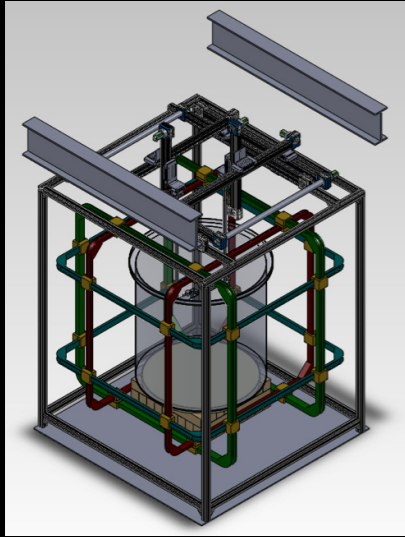


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# Recent Developments

- Mechanical system fully designed and assembled
- Moved into new (permanent) laboratory space
  - renovation courtesy of TRIUMF Science Division
- MIDAS-based controls system developed
  - position either arm into desired position/angle
  - collision avoidance logic
  - motion sequencing to perform multiple runs
  - reproducibility to  $< 1$  mm and  $< 1^\circ$  demonstrated
- Magnetic field survey without coil/shielding performed
  - 3D magnetic probe readout into MIDAS
  - use sequencing to automatically position the arm in various locations to map out magnetic field
- Auxiliary photosensor linearity measurements
  - small PMTs used as reference and to detect reflected light.

# Mechanical Assembly



- Left: Solidworks rendition
- Above/Right: test assembly
- Bottom right: assmebly in new lab room
- Far Right: motor control system
  - each board controls up to 8 axes of motion (tran./rot.)

# Examples of MIDAS control

MIDAS experiment "midptf" Tue Jun 4 14:17:57 2013 Refr:60

Start ODB Messages ELog Alarms Programs History MSCB Sequencer Config Help

Gantry Move GantrySlow

Run #109 Stopped Alarms: On Restart: Sequencer Data dir: /home1/midptf/online/data

Start: Wed Apr 24 17:00:53 2013 Stop: Wed Apr 24 17:00:58 2013

Equipment	Status	Events	Events[/s]	Data[MB/s]
Motors00	Ok	0	0.0	0.000
Motors01	(frontend stopped)	0	0.0	0.000
Move	feMove@midptf01.triumf.ca	0	0.0	0.000
Trigger	(frontend stopped)	55305	2.0	0.000
Scaler	(frontend stopped)	0	0.0	0.000
Scan	(frontend stopped)	91	0.0	0.000
PTFDVM	(frontend stopped)	0	0.0	0.000
Phidget	fePhidget@midptf01.triumf.ca	157134	2.0	0.000

Channel	Events	MB written	Compression	Disk level
#0: run00109sub000.mid.gz	2	0.019	89.0%	5.1 %

14:16:05[feMove,INFO] Program feMove on host midptf01 started

ODBEEdit [midptf01.triumf.ca] Logger [midptf01.triumf.ca] mhttpd [midptf01.triumf.ca]

fePhidget [midptf01.triumf.ca] feMotor00 [midptf01.triumf.ca] feMove [midptf01.triumf.ca]

- Top:
  - overall run control for single position run
- Bottom left:
  - gantry motion control interface with status messages
- Example of live B-field monitoring and recording

## PTF Gantry Movement Control

Gantry Status

- Gantry is stopped.
- Gantry is not initialized.
- Last move was completed.
- Current Gantry Position:
  - o X = 0 m
  - o Y = 0 m
  - o Z = 0 m
  - o Rotate = 0 deg
  - o Tilt = 0 deg
- Current Gantry Destination:
  - o X = 0.05 m
  - o Y = 0.03 m
  - o Z = 0.05 m
  - o Rotate = -45 deg
  - o Tilt = 10 deg
- Phidget Measurements:
  - o Tilt = 1.13 deg
  - o MagField = 0.161 -0.542 0.978

Gantry Control

feMove is active

Reinitialize Gantry Move Gantry

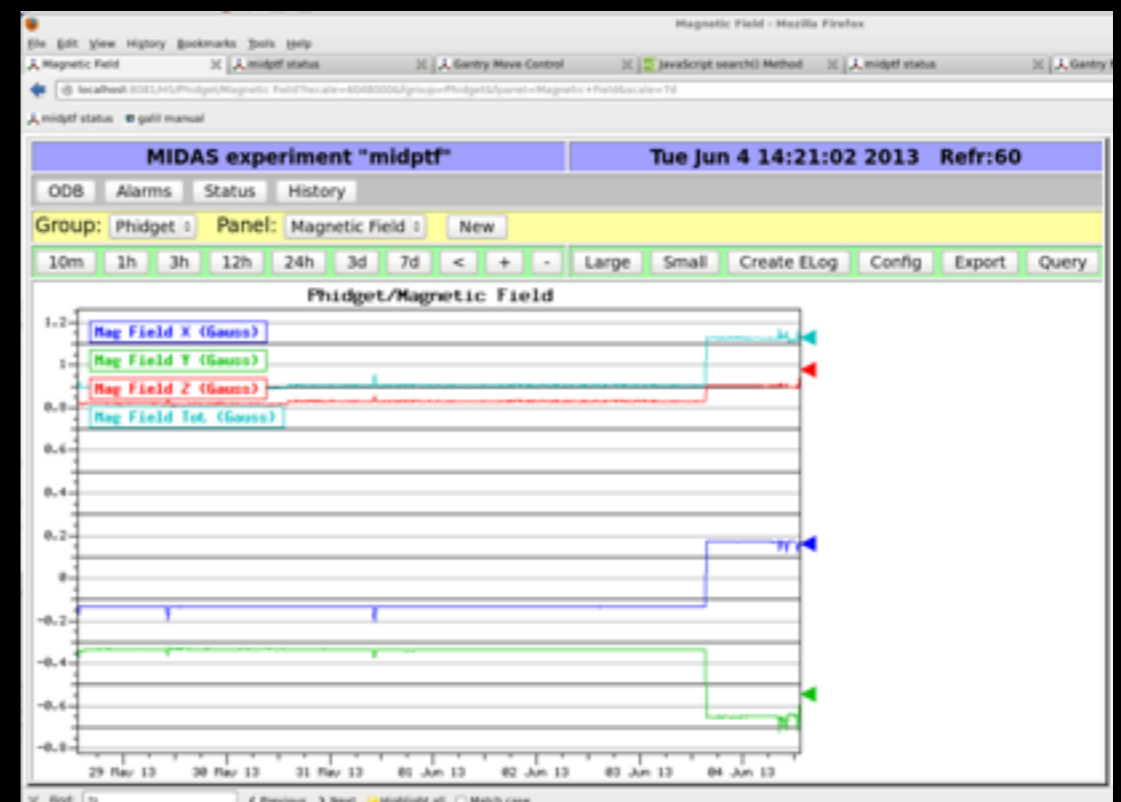
Destination:

X Y Z Rotate Tilt

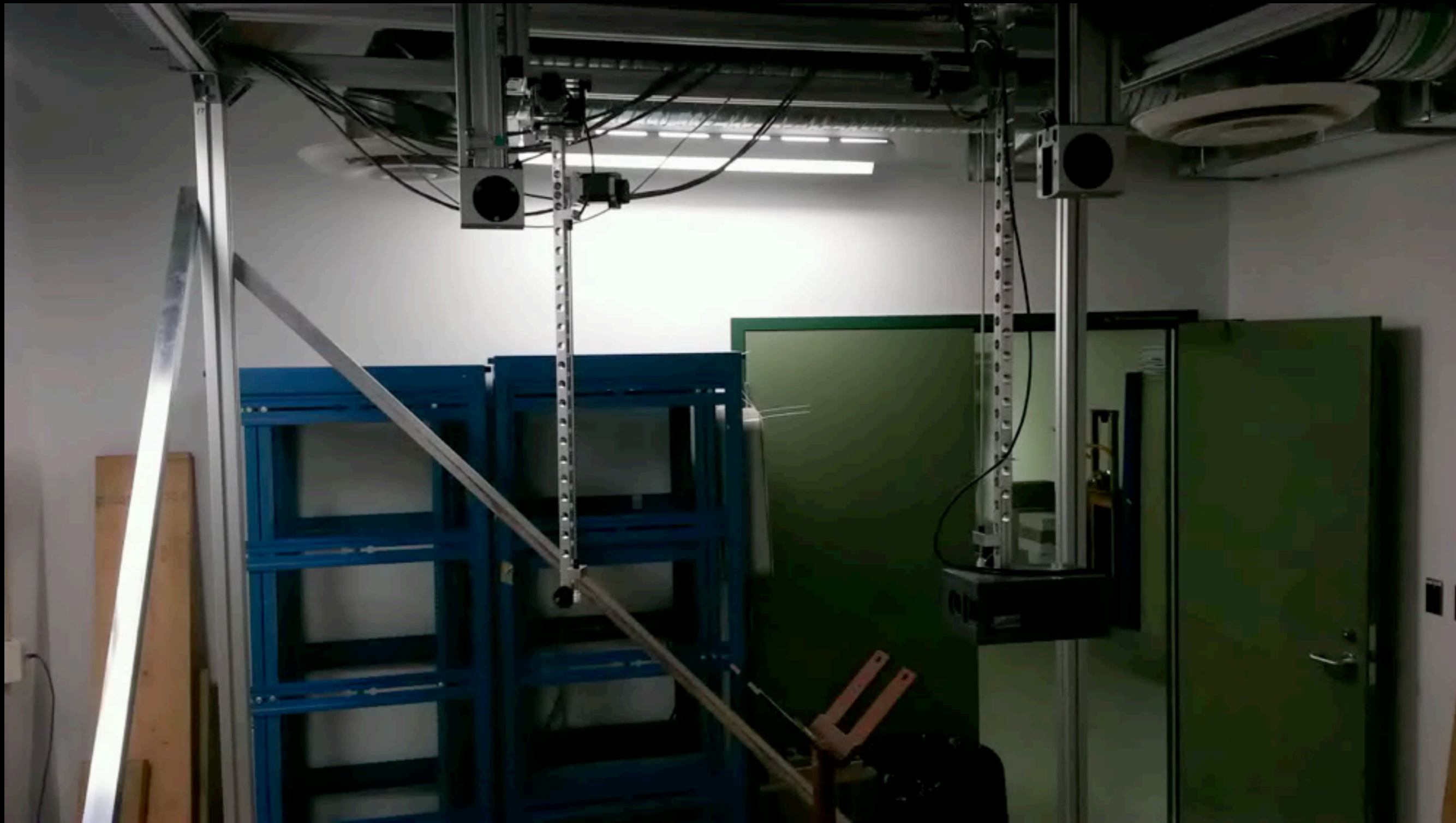
MIDAS Messages

- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 3
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 4
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 5
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 6
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 7
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut1 request CB 8
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 5
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 6
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 7
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 8
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 9
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 10
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 11
- Tue Jun 4 14:15:07 2013 [feMotor00,INFO] DigitalOut2 request CB 12
- Tue Jun 4 14:16:05 2013 [feMove,INFO] Program feMove on host midptf01 started

Last updated: Tue Jun 04 2013 14:26:19 GMT-0700 (PDT)

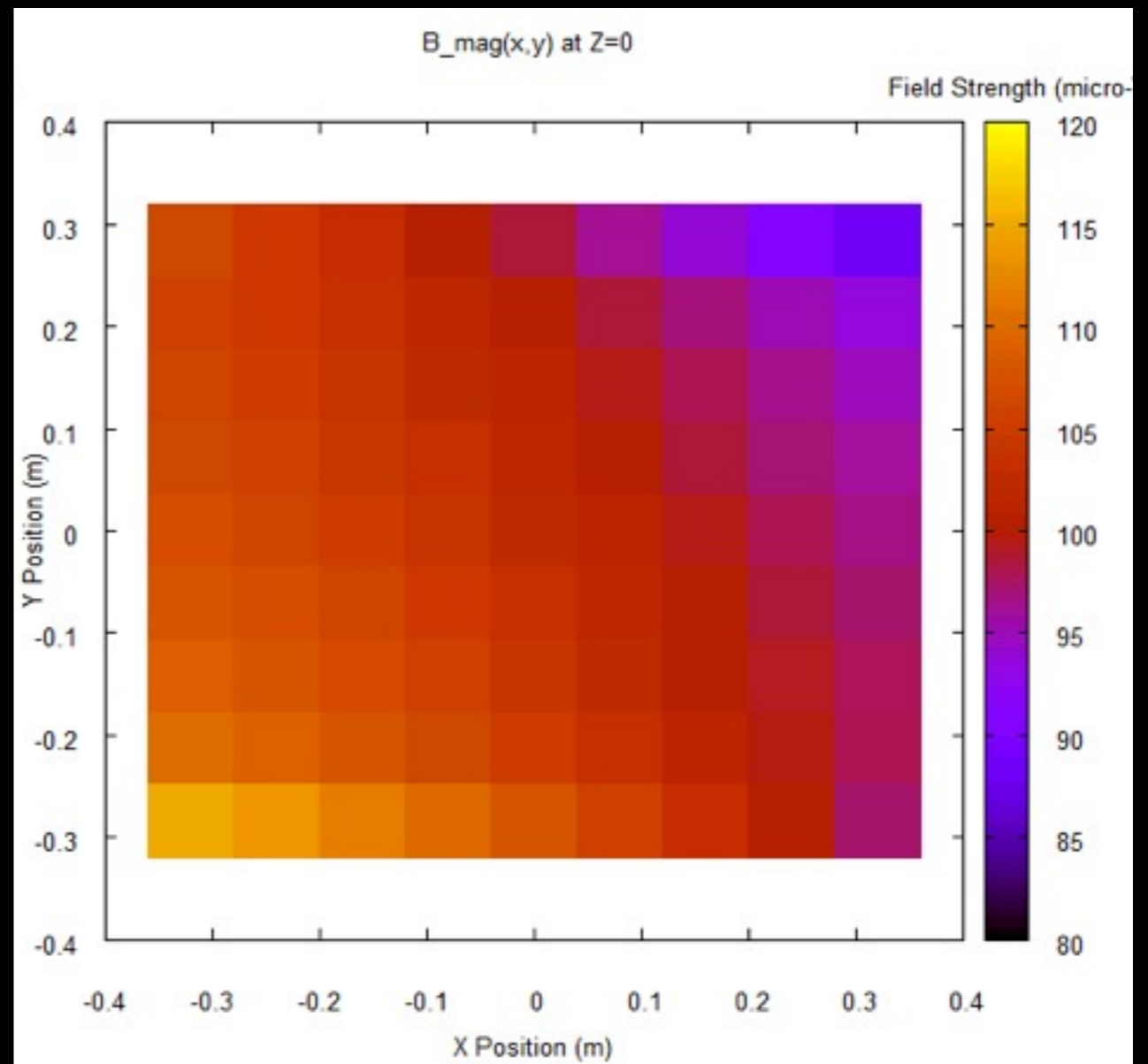
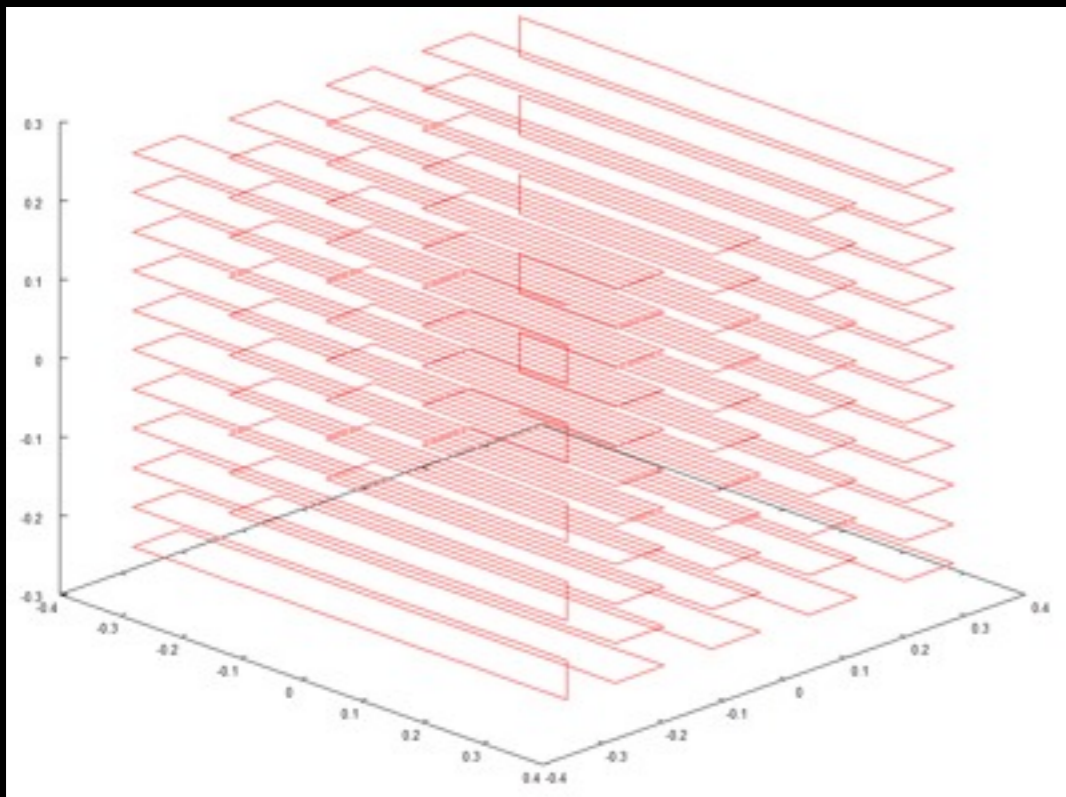
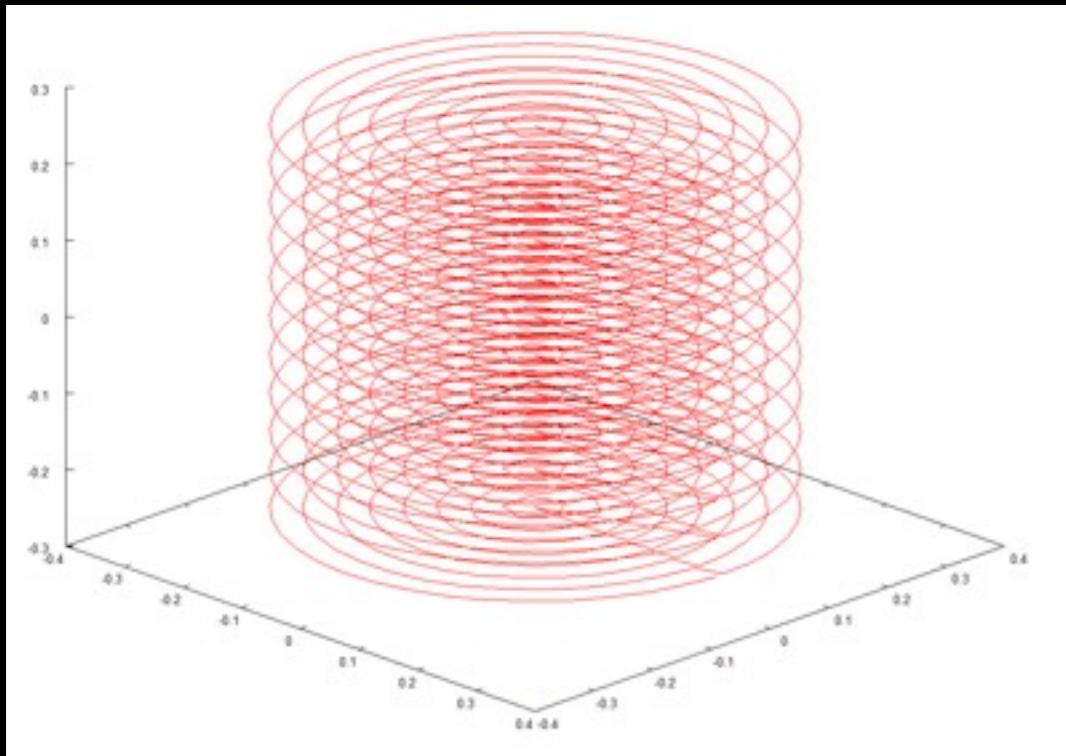


# Example Motion



# Motion sequencing

- Left: examples of sequenced motion/measurements for field map
- Bottom: example slice of B-field measurements at  $z=0$





# Next Steps

- Test Helmholtz coils and GIRON shielding (~summer)
  - see if target shielding is achieved ( $<10$  mG in PMT region)
- Conclude tests of reference PMT (~summer)
  - signal/HV cable feedthrough in arm to optical head
  - test housing and operate in water.
- Other items (dark curtain, cabling, etc.)
- Develop optical system (summer + fall)
  - laser fiber feedthrough in arm to optical head
  - polarization/collimation optics
  - test in water
- Assemble/test water filtration system
  - need to finalize degassification system
- We welcome collaboration and applications!