SoLID Heavy Gas Cherenkov Update

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for HGC group

SoLID Collaboration Meeting. June 08, 2018

Duke UNIVERSITY

University of Regina

STONY BROOK UNIVERSITY

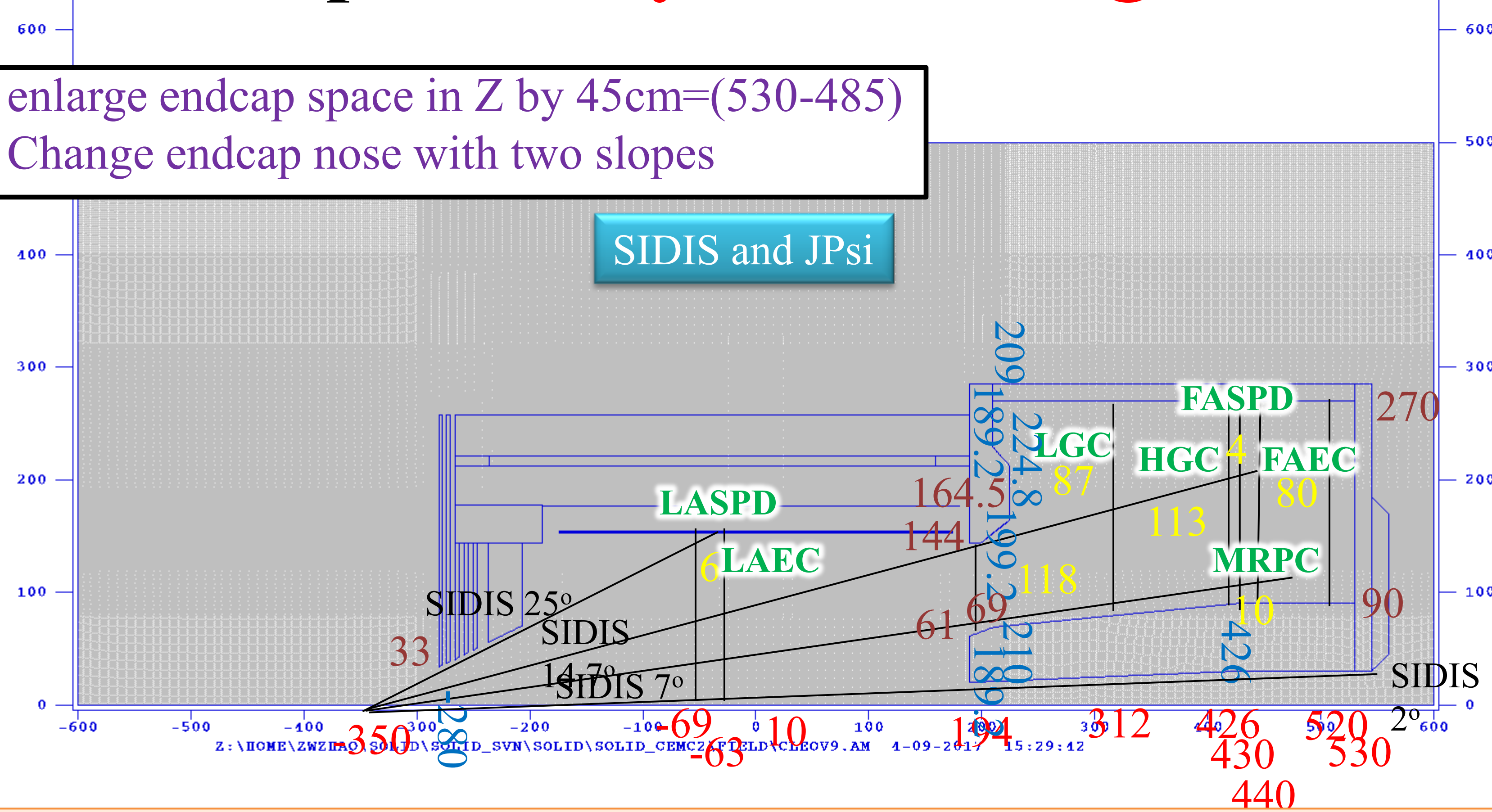
Overview

- New optical design with new magnet
- New engineering design with new magnet
- Window design and test
- Gas system
- Magnetic Shielding
- Readout and DAQ
- Mirror coating update

Proposed Layout and Magnet

enlarge endcap space in Z by 45cm=(530-485)
Change endcap nose with two slopes

SIDIS and JPsi



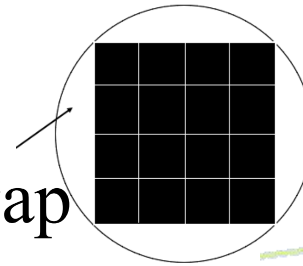
HGC change and condition:

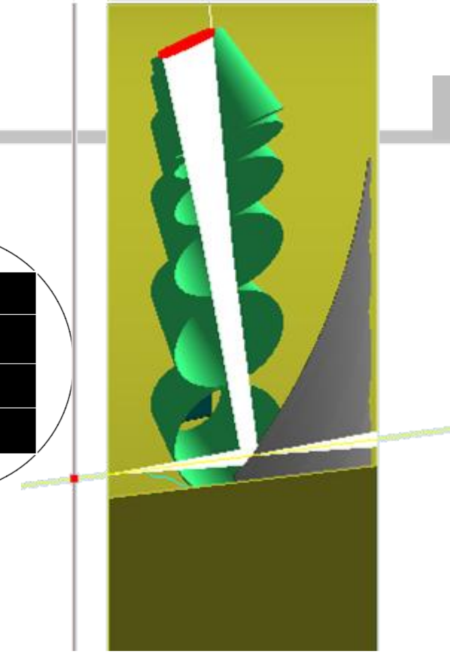
- move 20cm downstream, boundary Z=312-426cm
- assume front window at z=326cm and leave 14cm for window bulging and clearance
- cover more forward particle, 7 deg instead 8 deg from He3 target center at Z=-350cm
- cover large angle 14.7 deg at Z=-350cm, and optimize for full 40cm target
- Take field effect into account for both He3 and NH3 setup

Optical Design

Old design

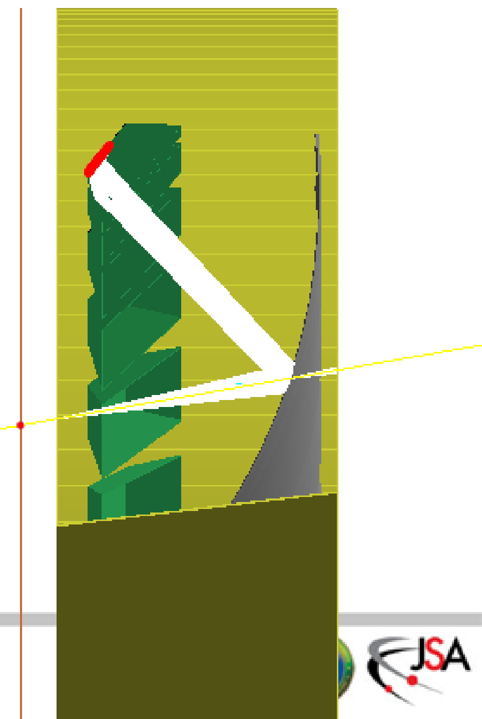
- No shielding behind PMT
- large light loss (20-30%) at the gap between PMT and cone





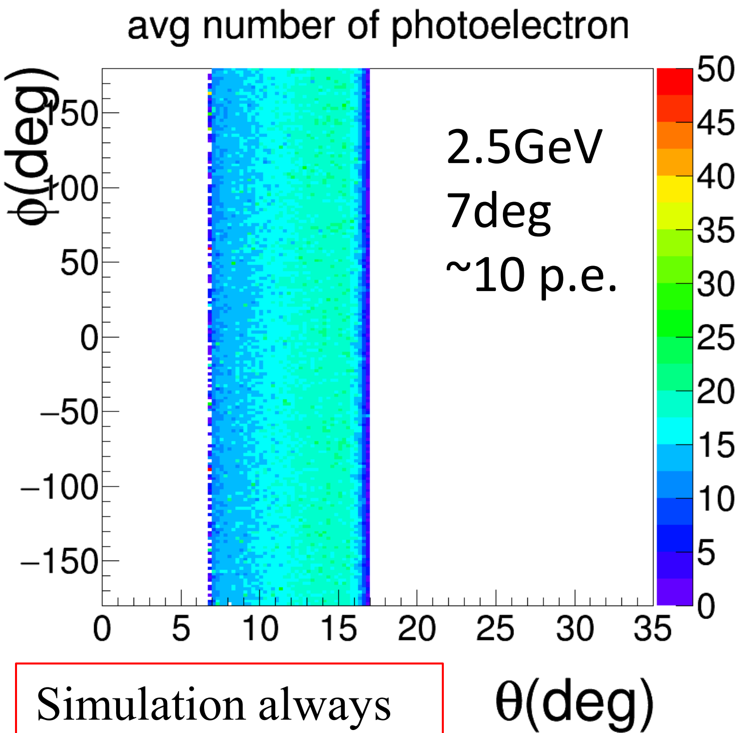
New design

- Room for shielding behind PMT
- Pyramid shape collects all lights
- Optimize for 7deg to have one bounce photons only
- Use as much as possible gas length with mirror inner edge at Z=390cm with 210cm radius
- Less gas volume, more room for tank mechanic structure

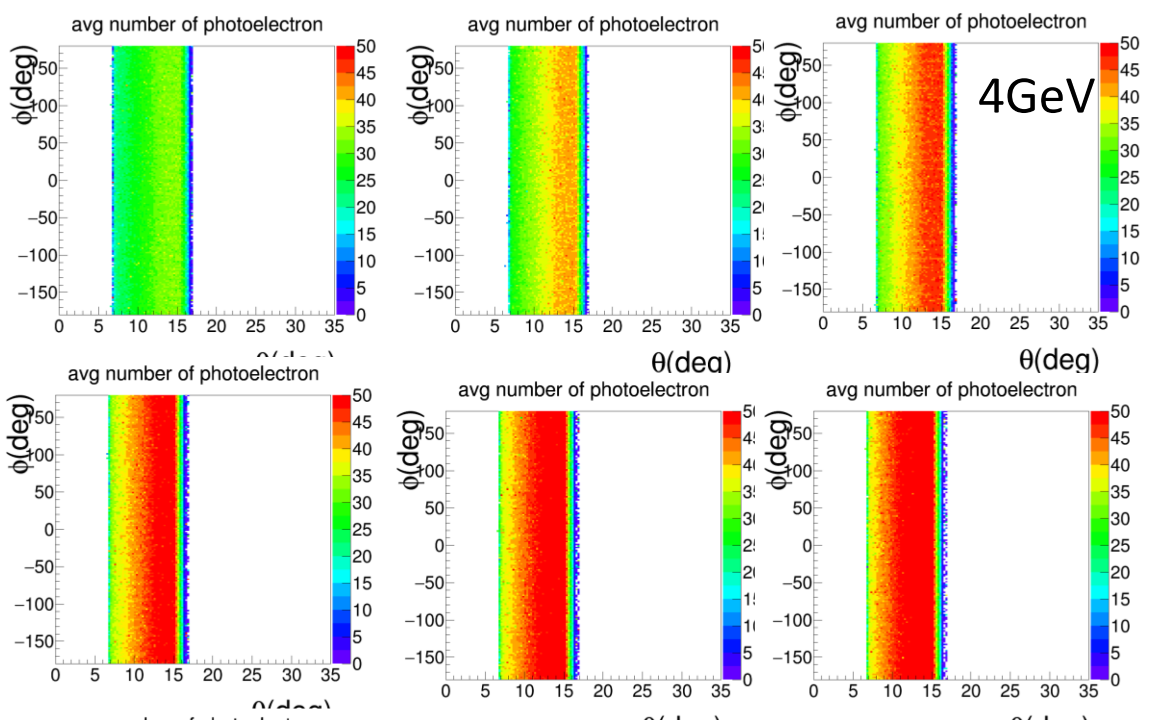


Bo Yu, visiting undergrad from Shandong U. China

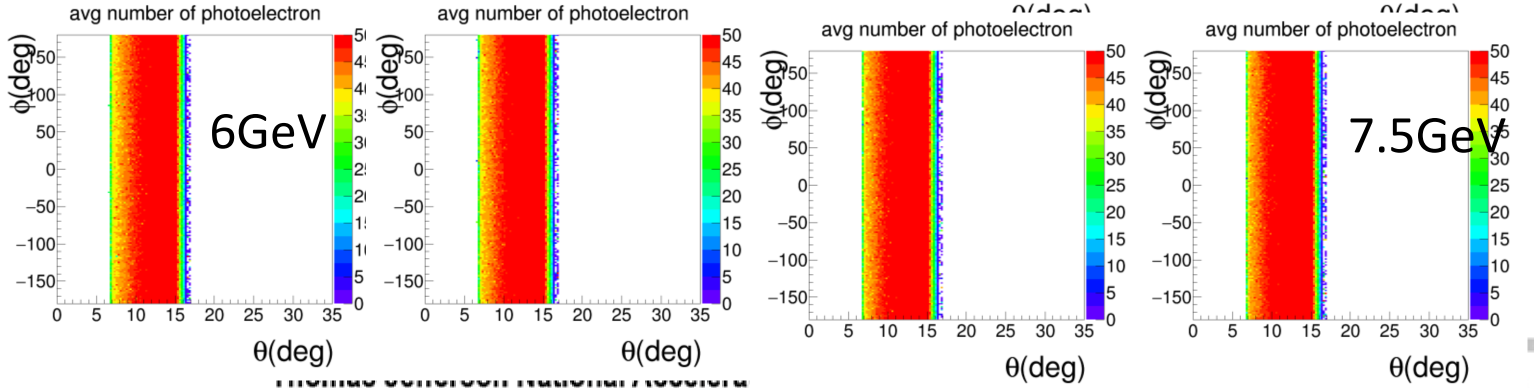
SIDIS He3, 2.5-7.5GeV, pi-,Vz=-350cm, no field



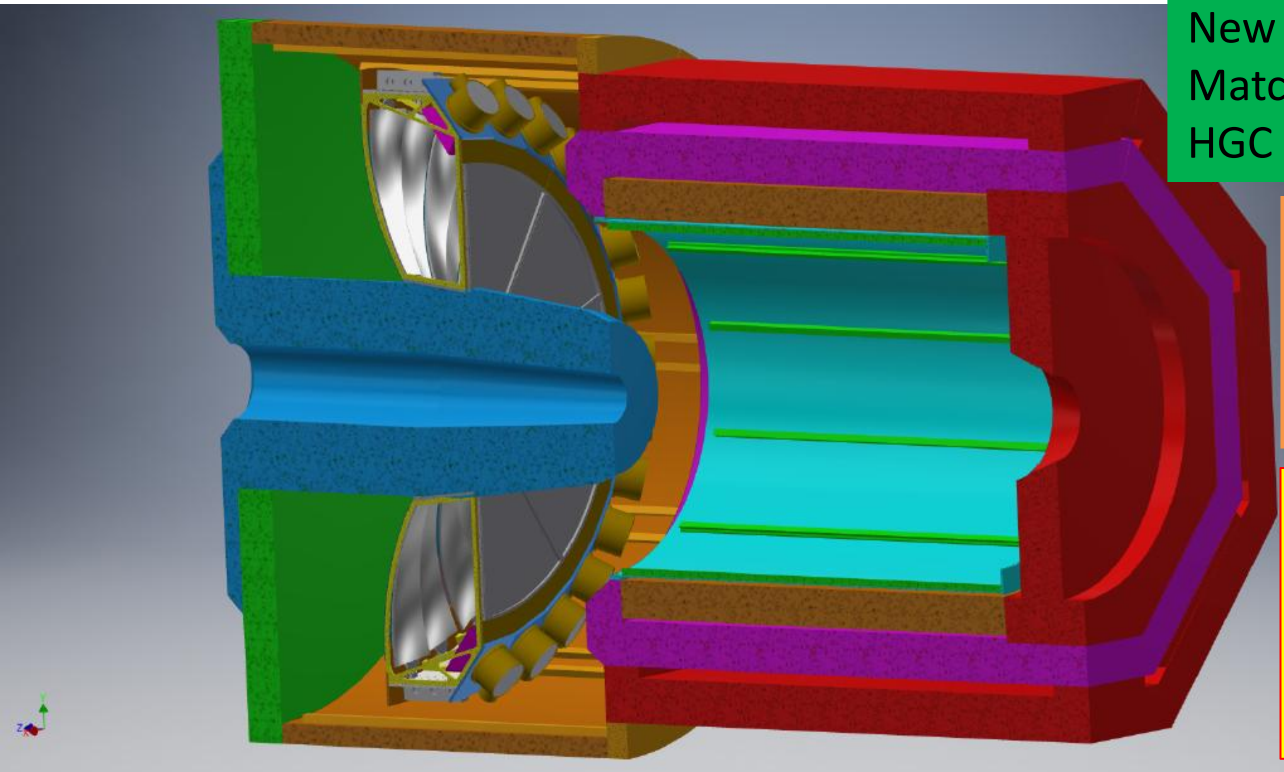
Simulation always has a safety factor 2



Work ongoing to study field effect



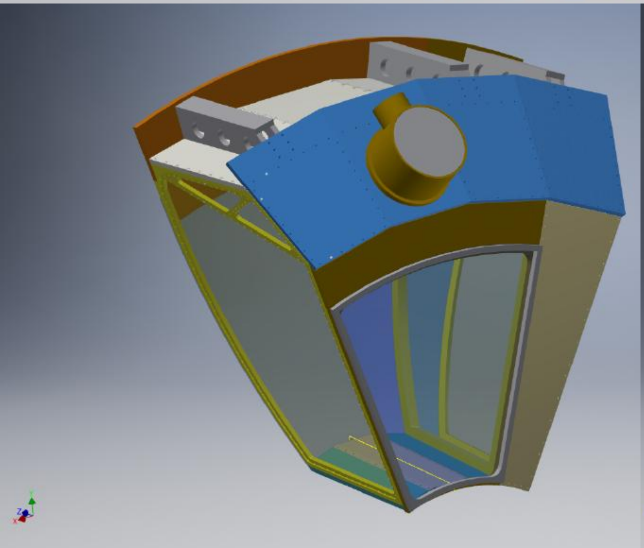
Design of whole HGC detector and one sector prototype

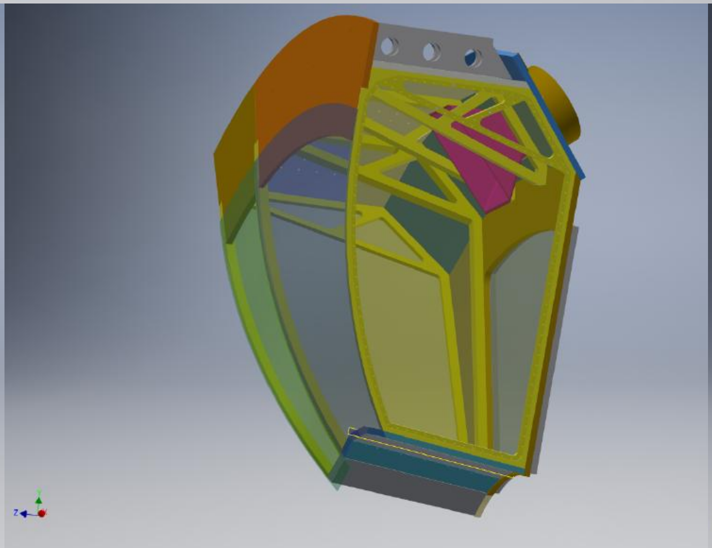


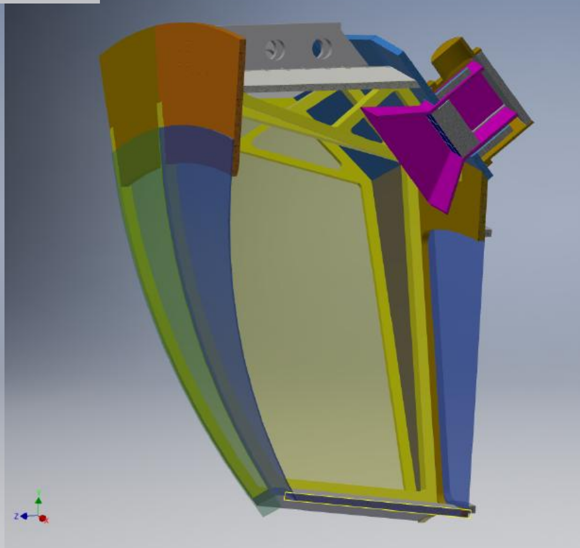
New Magnet CAD from Whit Seay
Matching Jay Benesch's field design
HGC CAD from Gary Swift @ Duke

To reach physics at 7deg, may need trim endcap nose from 7 to 6.8 deg, wait for other detector like LGC to confirm

Need Jlab support to review design to reach the goal of building prototype by end of 2018 at Regina

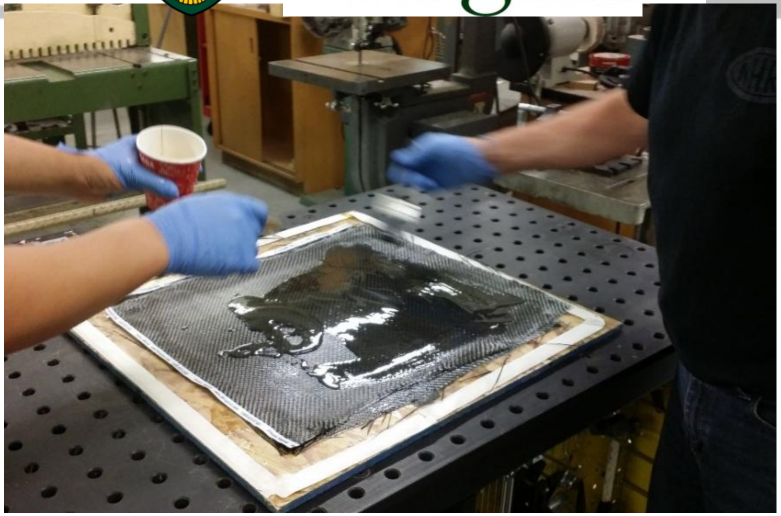






Carbon-Fiber Shell

- Hard shell constructed with Fiber-Glast carbon- fiber and epoxy.
- Mylar inner window beneath shell is used to seal against O-ring.
- Kevlar from previous test placed on top as a safety measure, as protection against a catastrophic shell failure.



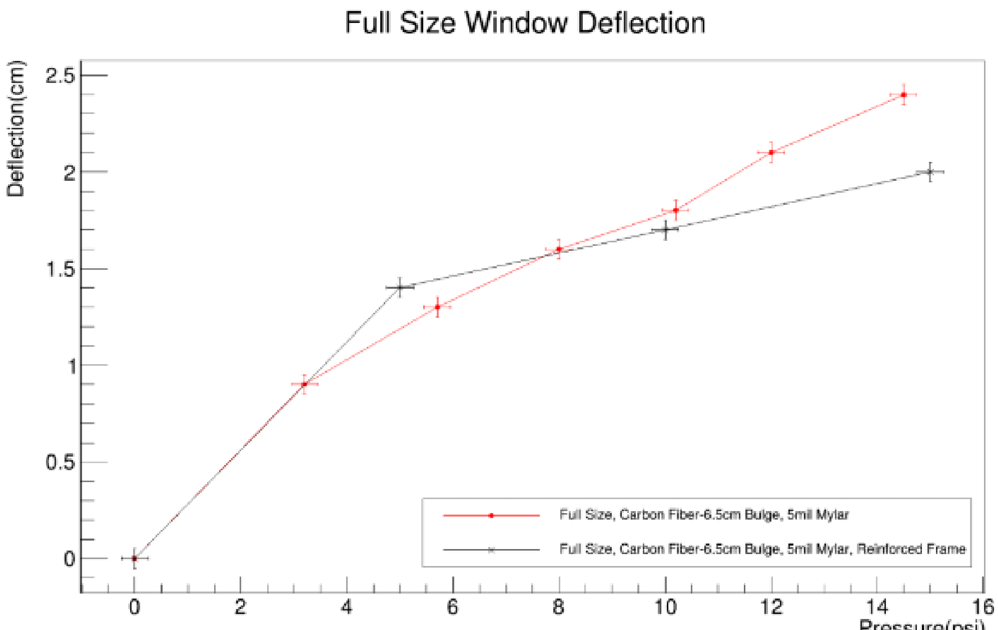
Above: Fabrication of carbon fiber shell with epoxy

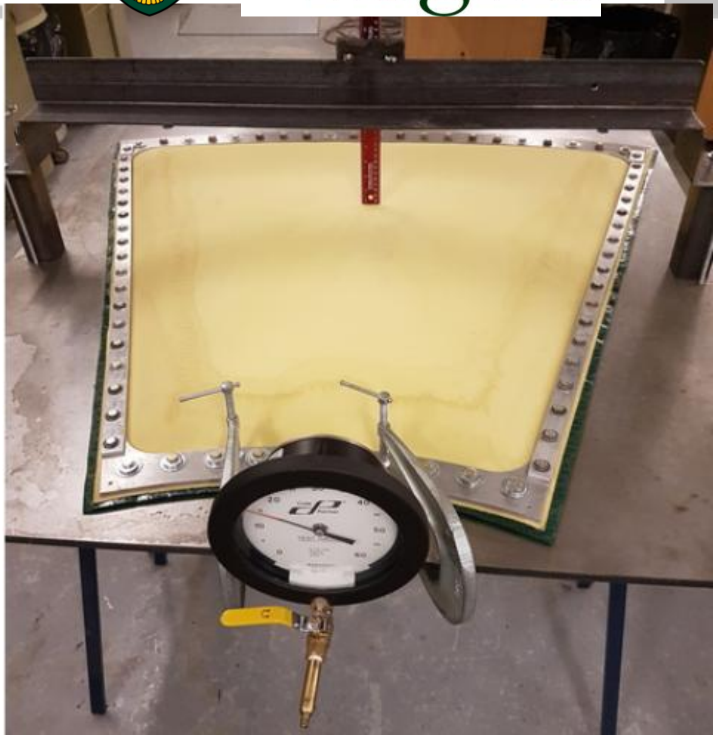
Left: Foam mold for full size window shell

Full Size Carbon-Fiber Window

University of Regina

- Moderate success with full size CF shell:
  - Structurally stable at +1 atm
  - Failure in pressure seal due to previously identified frame issues
  - Alarming creaking noises from shell under stress while inflating; potential safety concern
  - Deflection only 2cm beyond constructed bulge at maximum pressure



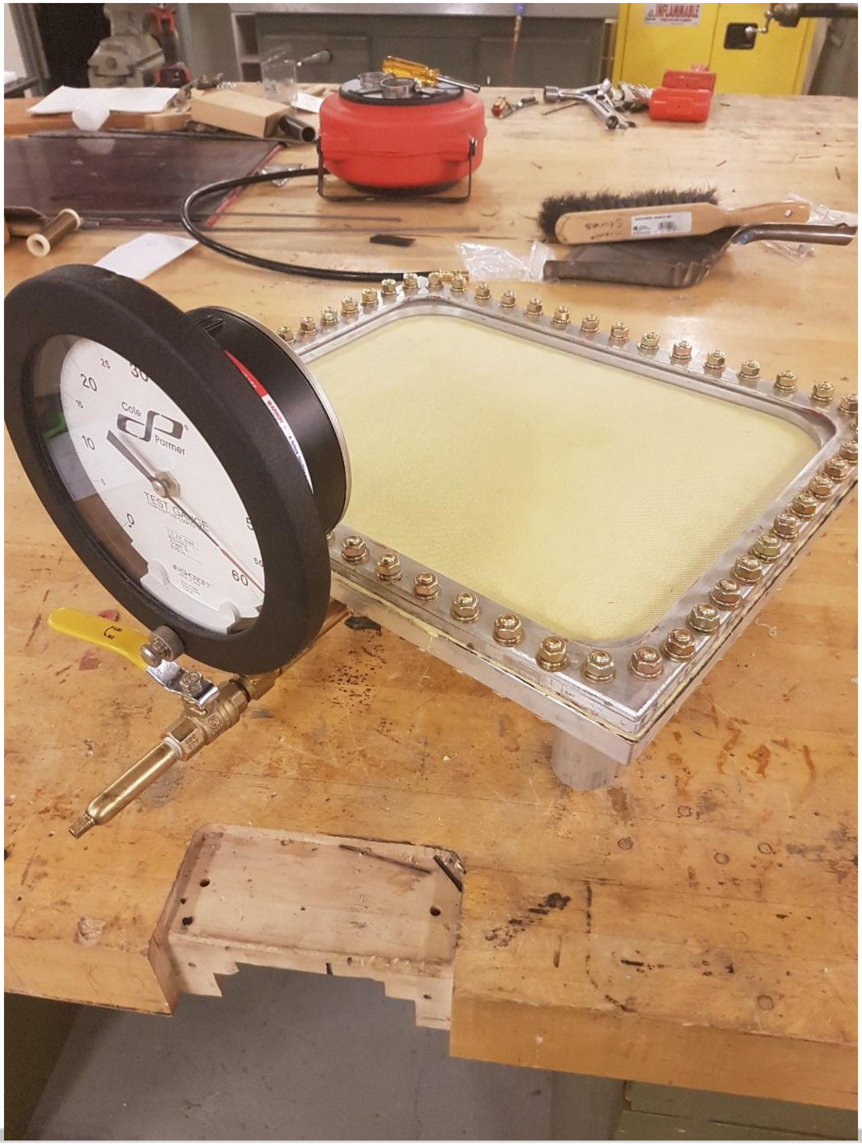


- New test frame following recent modifications forthcoming
- Replacement of O-ring with gasket being considered

Heavier Stock Carbon Fiber

- Heavier stock carbon fiber fabric obtained from Fiber Glast
- Want to try flat window to improve clearance and simplify fabrication
- Flat window structurally stable at +4 atm where previous flat window (with lighter CF) failed
- Significantly reduced creaking noises over previous tests
- Maintaining pressure for 40 days and counting!

- Very promising results from the thicker Carbon Fiber
- Next test will be a full size version, possibly on whole new frame



Gas System

Chao Gu

- HGC gas system: The volume of the detector is 20 m^3 filled with 300kg heavy gas (C_4F_{10}) at 1.5 atm (0.5 atm pressure difference)
- Hall B LTCC gas system designed by George Jacob
  - Large volume (7.2 m^3 x 6), thin window at 1 atm
  - Major components: gas supply, pressure control and protection, C_4F_{10} recovery and distillation unit

- Since the heavy gas is expensive, we prefer a similar system with recovery and distillation unit after consulting with Jack Segal and George Jacob
- Detector tank can not be vacuumed, so a "flushing" procedure with N_2 pre-flush will be used during filling
  - Single fill requires 3 flushes (700 kg heavy gas) to reach ~95% purity, and most of 400kg of them could be recovered by the distillation unit
- Sealed after the gas filling

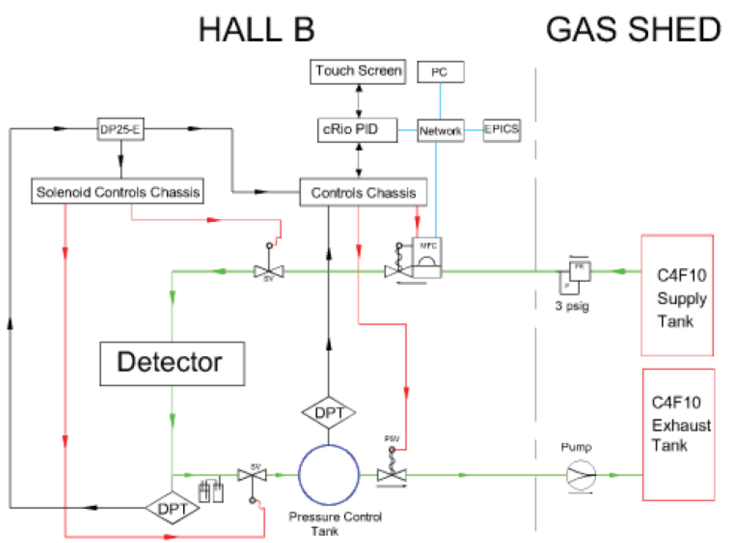
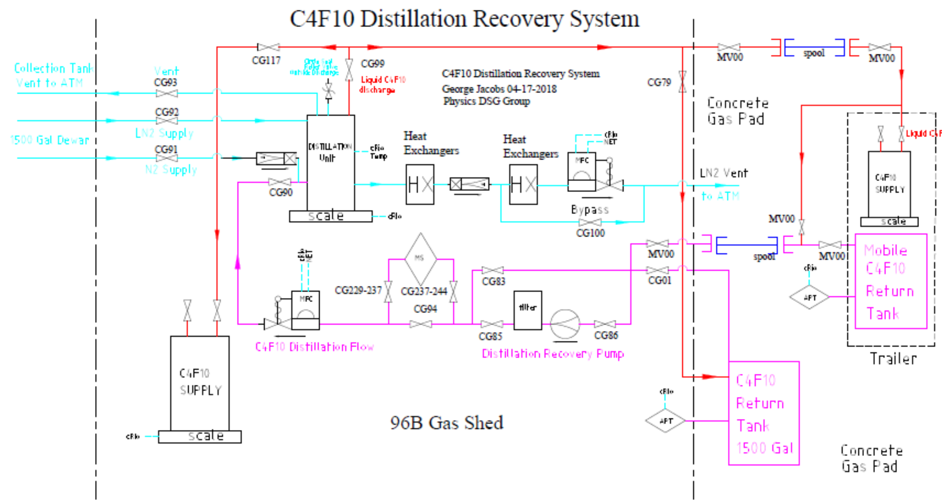


FIG. 1. LTCC gas controls diagram. Red lines are power, blue are network, black are signal, and green are gas flow.

Gas System

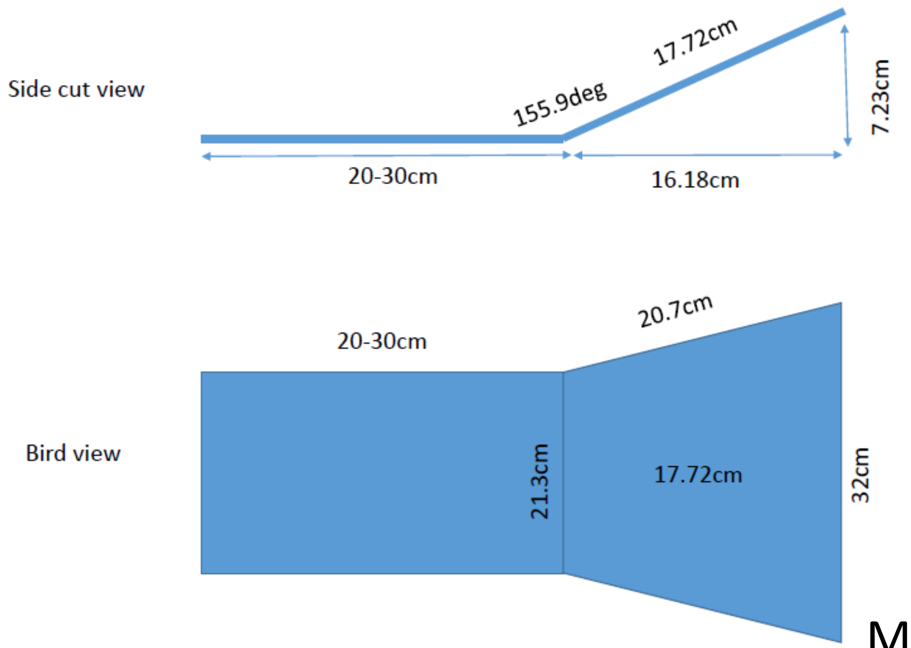
Chao Gu

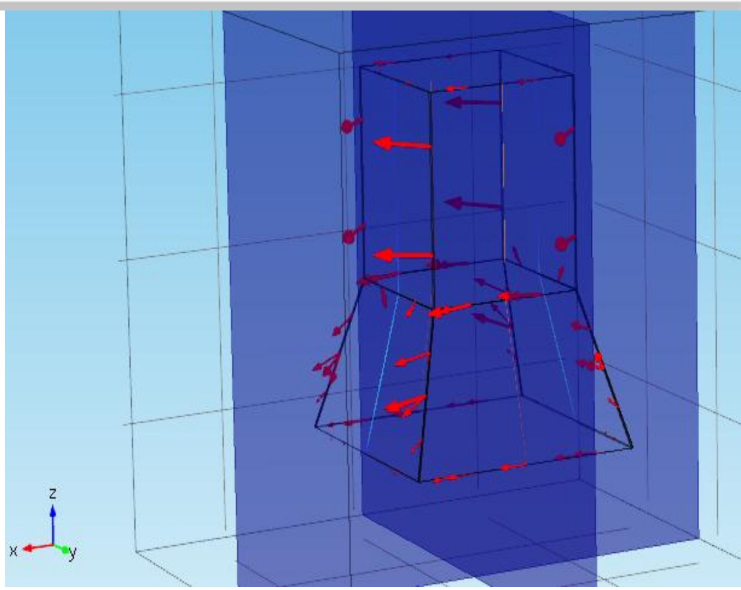
- C_4F_{10} gas recovery and distillation
  - Gas will be flushed out by nitrogen and collected by a large return tank
  - The return tank could be located on a mobile trailer so we could share the distillation unit with Hall B LTCC and other project



- Cost estimation for a fill-and-seal system:
  - ❑ The material cost of the system is \$600k ~ \$650k in total
    - o \$200k for the C4F10 supply tank and the filling system
    - o \$200k for the return gas tank and the gas recovery system
    - o \$200k ~ \$250k for the gas distillation unit (could be less if we could share it with LTCC)
  - ❑ About 2 FTE manpower cost for design and build this system

Magnetic shielding





Simulation with COSMOL

Join 4 sides by welding and annealing

Use layers of low carbon steel and mumetal

Prototyping starts this summer

Drew Smith and Chao Gu

Material: Pure Iron

Permeability: 4000 - 10000

Thickness: 1mm - 2 mm

B outside : 100 G in trans or long

Shielding factor at PMT center: 10 -50

Gap at 4 sides affects trans more

endcap affect long

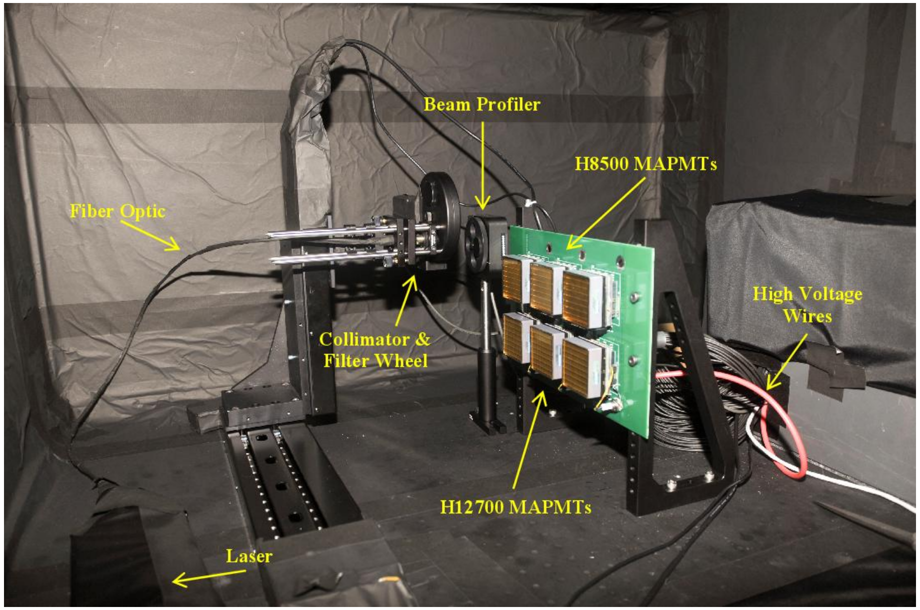
Wei Ji, grad

Tsinghua U China

Readout and DAQ

- MAROC readout system

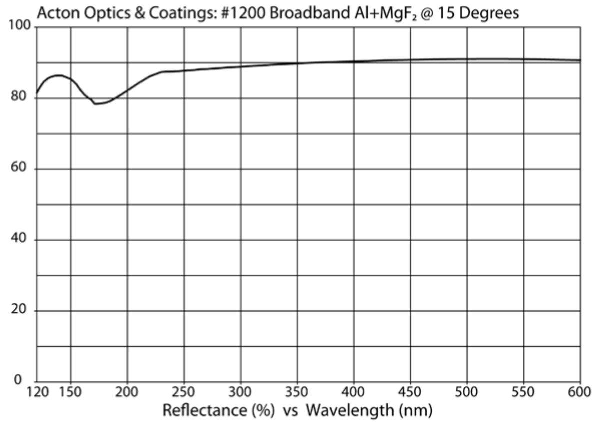
  - Planning a high rate readout test with existing MAROC boards using the Hall B test platform with laser, starting this summer
  - Will purchase new readout board with MAROC chips and a total sum for H12700 PMT readout
  - The system will be used for the prototype telescopic Cherenkov and a high rate beam test will be performed in the future



Drew Smith and Chao Gu

Mirror coating update

- In April 2018, last piece of equipment, the rotating shaft + motor for rotating the mirror blank (frame) inside the evaporator was received
- installation of the equipment at least until August because of current work with sPHENIX
- will coat and test the small CFRP coupons first
- Plan to pursue the highest reflectivity down to 120 nm, and hope to match WLS-coated MAPMT at 160nm at least. will see how it goes once start coating



Klaus Dehmelt and Tom Hammick @ SBU

backup

HGC optical system optimization

Elements

- Spherical mirror: determined by z1, z2 and radius r
- PMT: determined by tilt angle and distance d from PMT center to z2
- Reflective/shielding cone: shape, length, opening

Approach

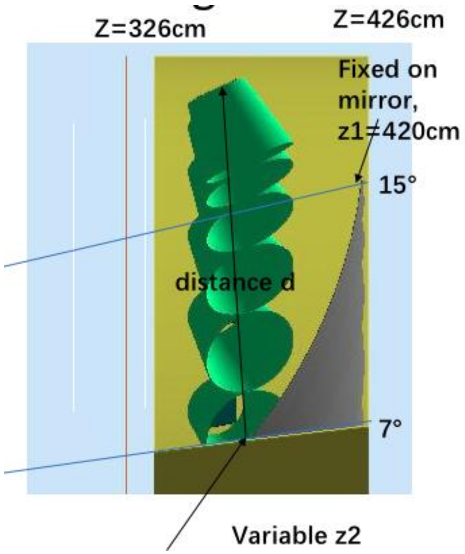
- z1=420cm is determined by boundary
- Try the radius r and variable z2 to set the mirror
- Then adjust the position of PMT and parameters of cones to collect photons effectively
- Very small region found when given r and z2 because we hope to collect all the photons
- Approximate feasible region of r and z2:

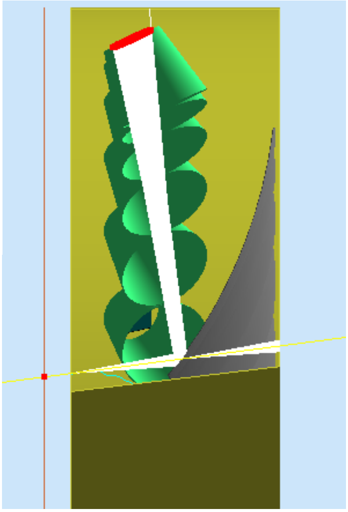
  z2=390cm r=210 to 250cm

  z2=380cm r=240 to 280cm

  z2=370cm r=280 to 300cm

  outside which we can't find a position for PMT to collect all the light





- Make light emitted by 7 degrees pions directly reflected to the center of PMT
- Large z2 and smaller r will give more gas length and more photons

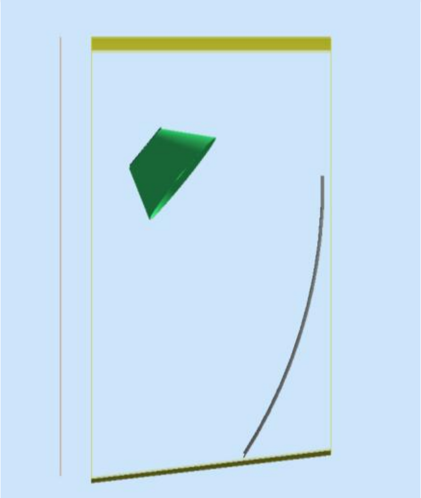
Mirror

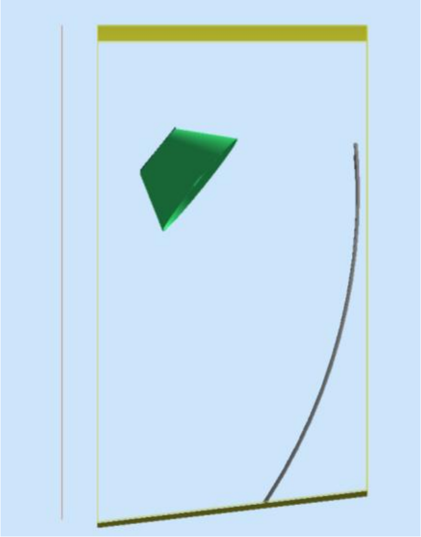
- 1. Cover more on small and large angles

Change: cut by 7 and 15 degrees --> cut by 6.8 and 16 degrees

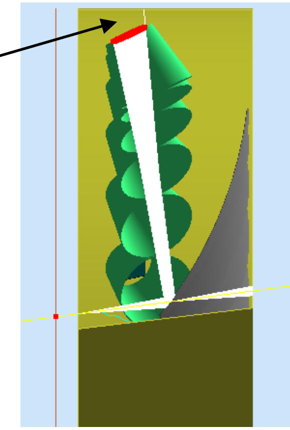
- 2. Adjust the position and radius to lengthen path distance for small angles

Change: Make r smaller and z2 greater, currently r=210cm, z2=390cm

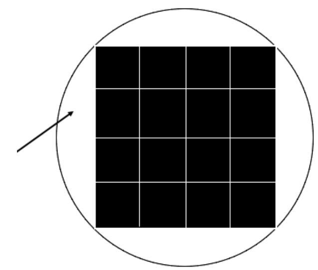


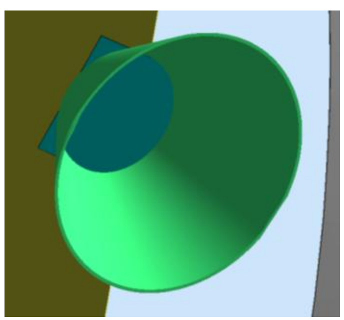


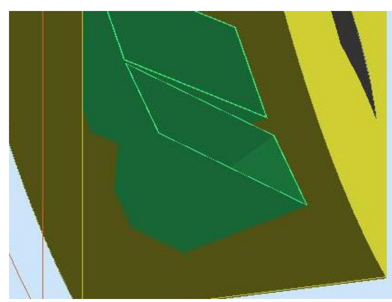
Reflective cone and shielding



- 1. No shielding behind PMT
  Change: leave enough room behind
- 2. Light loss at the gap between PMT and cone
  Change: Use smaller-end cone or pyramid-like cone
  We used the latter one when testing
  TBD by the test on the shielding effect

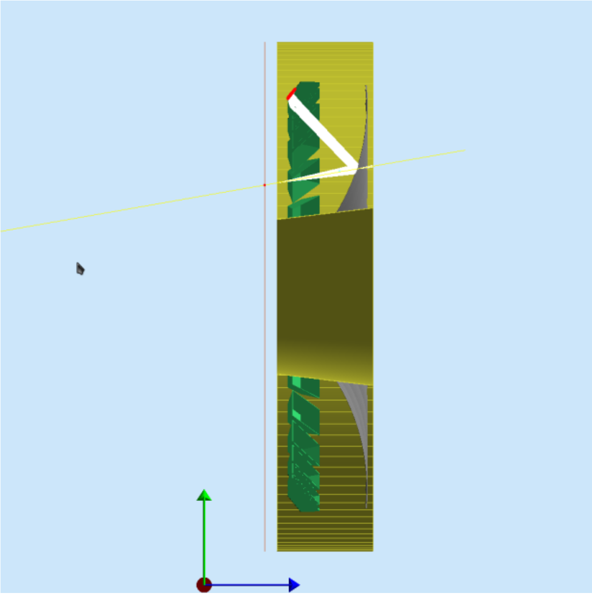




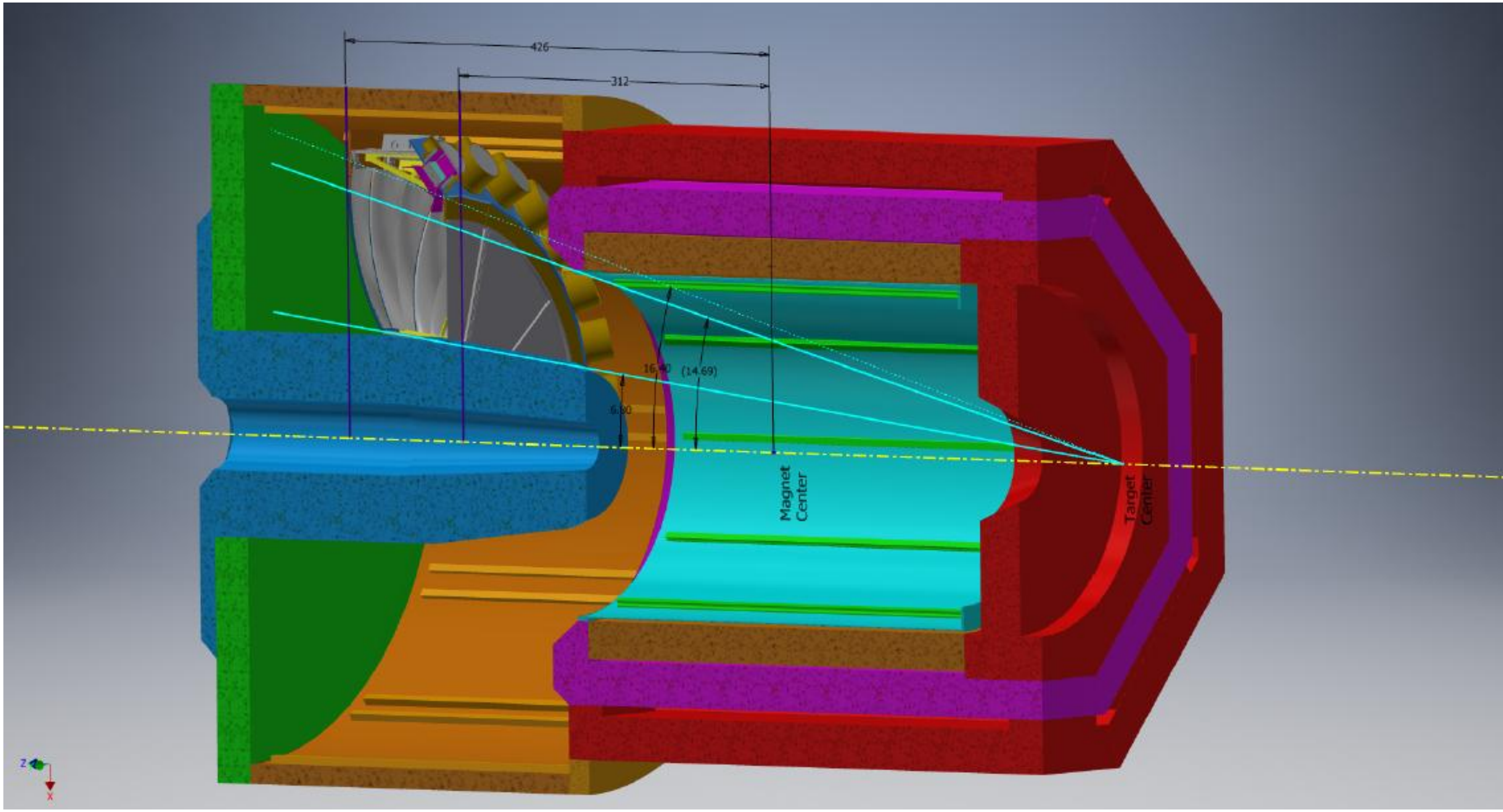


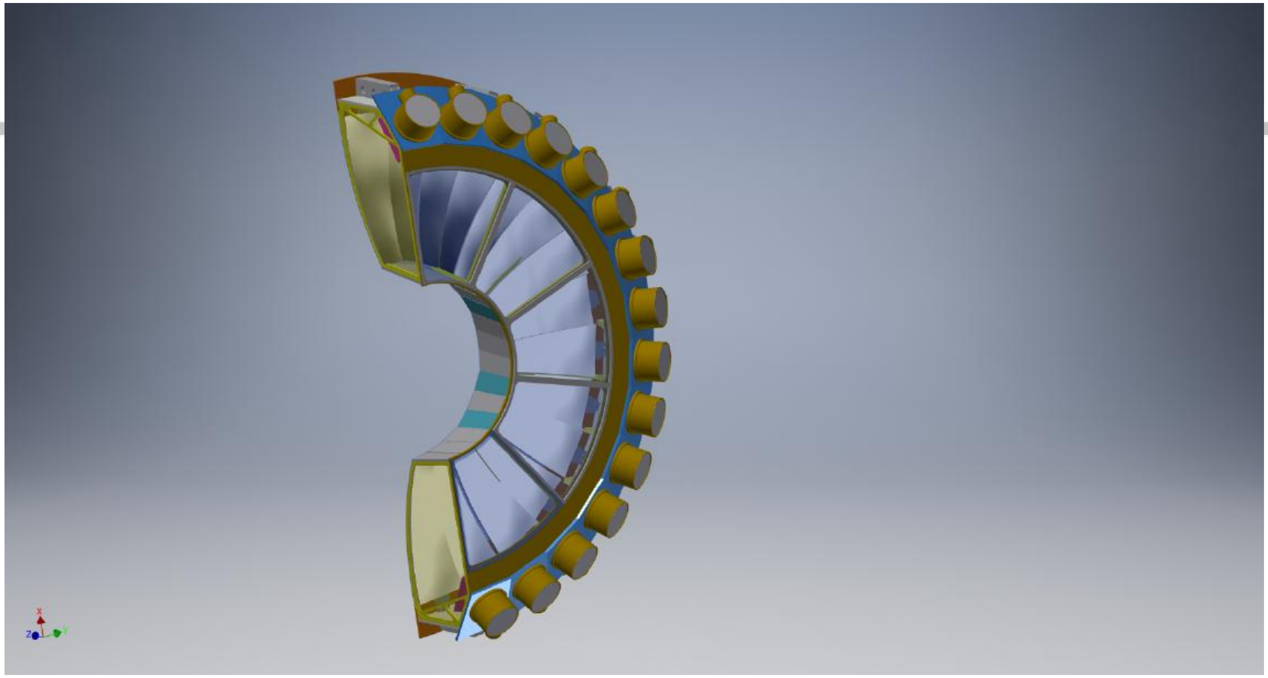
Configuration 2018_02_19_SVNr1361

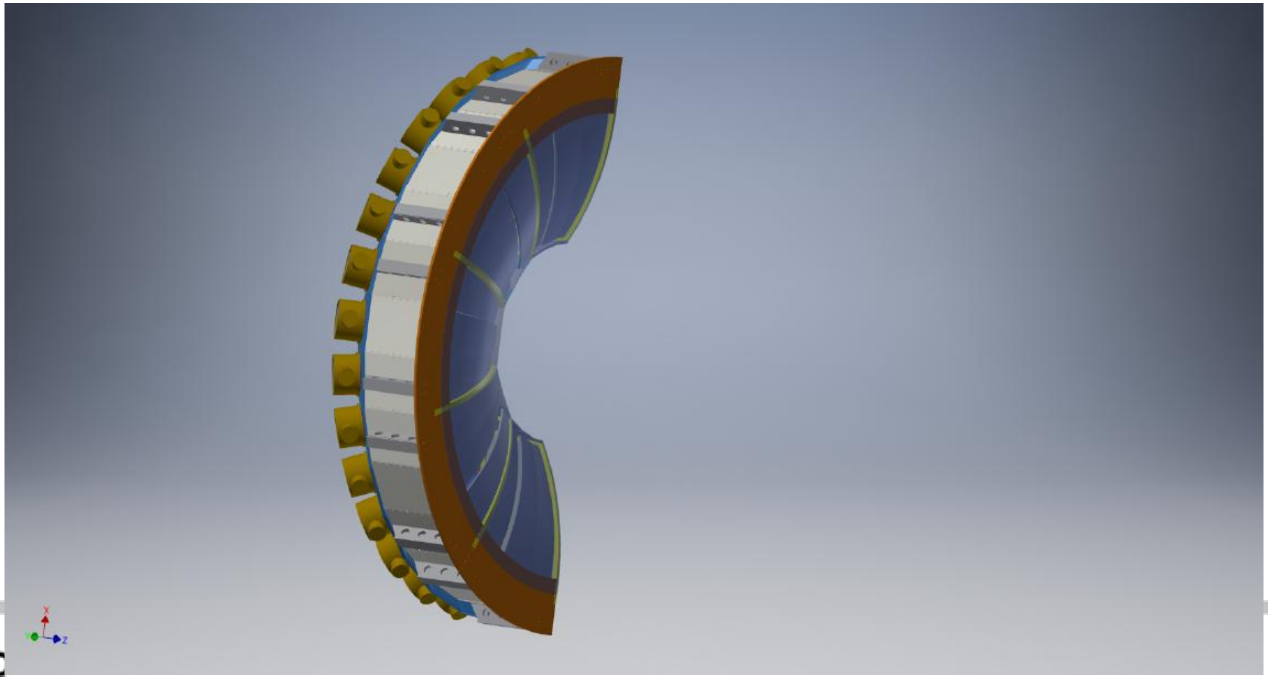
the sector at phi=0 deg

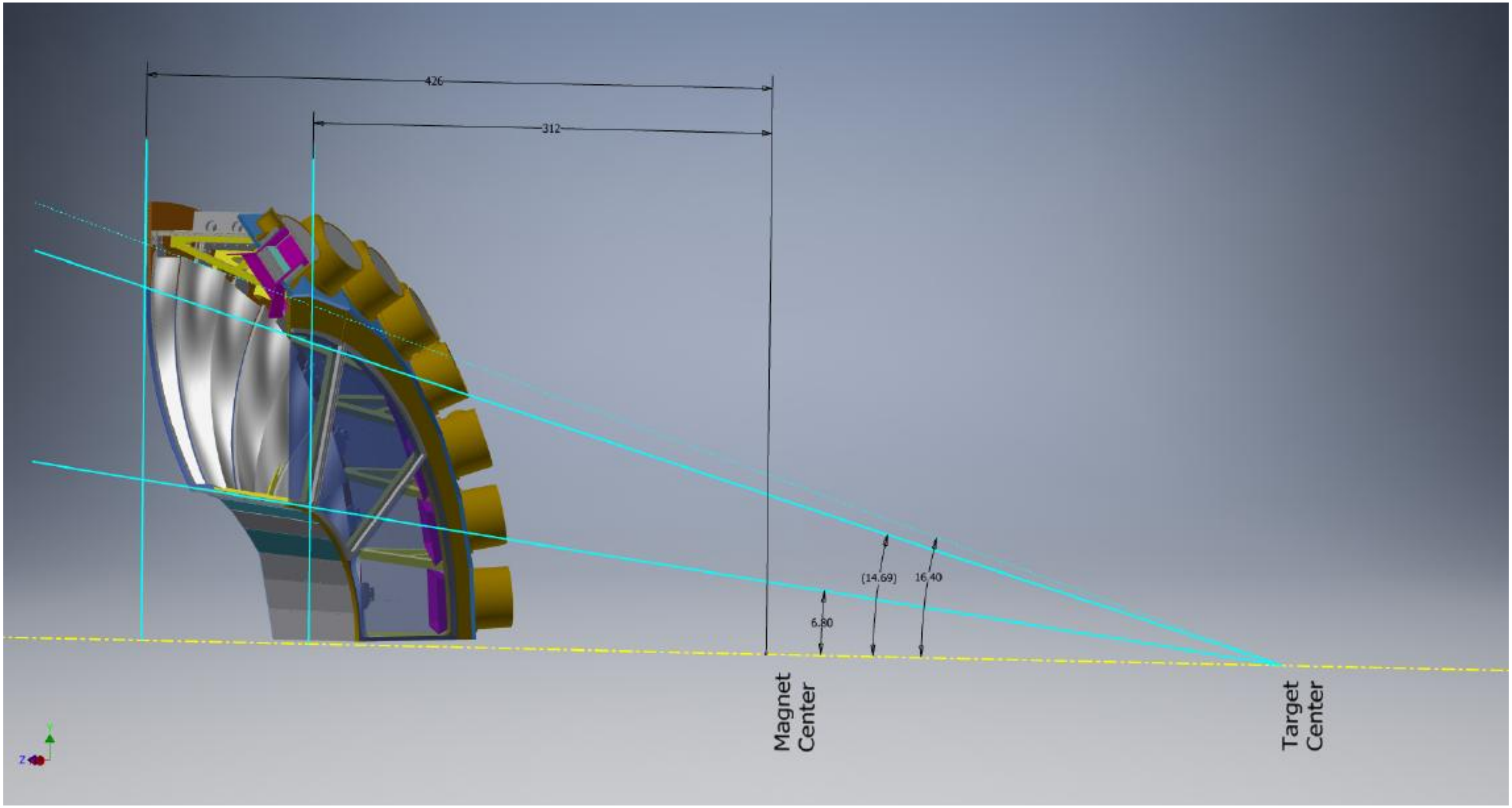


- Mirror: radius r=210cm, z2=390cm
  center: x=199.23cm, y=0cm, z=210.12cm
- PMT: distance d=135cm, tilt angle=39 degrees
  center: x=215.48cm, y=0cm, z=343.74cm
  width: 21.3cm
  four corners: x=223.76cm y=±10.65cm z=350.44cm
  x=207.20cm y=±10.65cm z=337.04cm
- Refelection: length=16.18cm, end 32cm*44.82cm
  x=222.71cm y=±16.00cm z=370.41cm
  x=187.88cm y=±16.00cm z=342.22cm


426
312
16.40
(14.69)
Magnet Center
Target Center







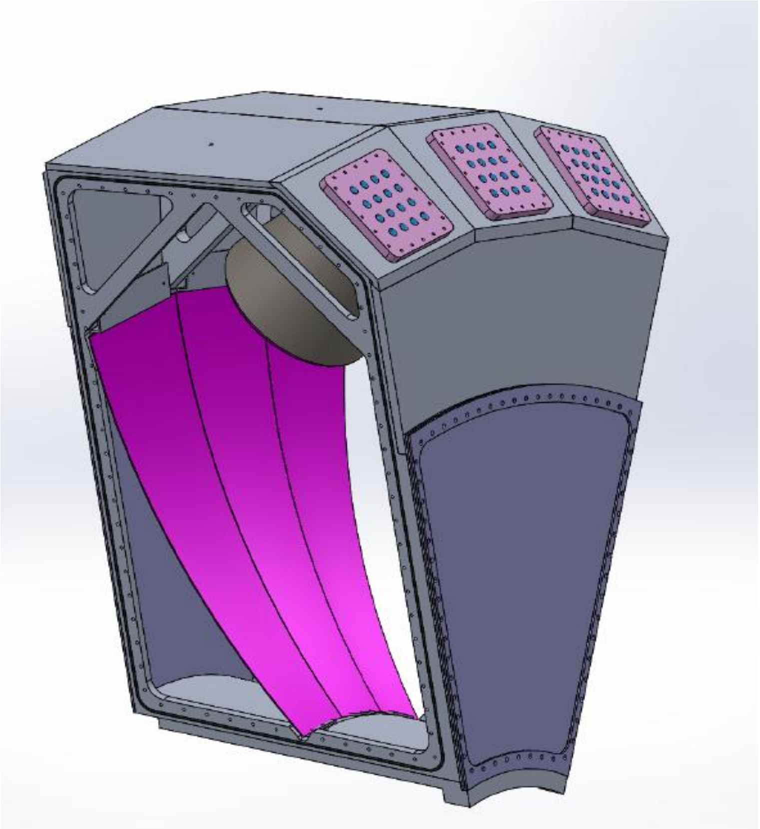
426
312
(14.69)
16.40
6.80
Magnet Center
Target Center

HGC Prototyping Update

C$100k grants allow the U.Regina group to construct one SoLID HGC module for testing.

Questions to be addressed:

- Enclosure deformation at 1.5 atm operating pressure (investigate design and metal alloy options).
- Performance of the O-ring seals against adjacent units.
- Performance of thin entrance window in terms of light and gas tightness (test several options).



Conceptual design by Gary Swift, Duke U.

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NSERC CRSNG

FRN: SAPIN-2016-00031

Window Prototypes

- Testing Requirements:
  1. Safely hold 2x operating pressure for extended time periods
  2. Minimize bulge for clearance in SoLID
  3. Reproducible fabrication
- Two prototype window frames:
  - Full size window testing at +1 atm
  - Quarter-scale version testing at +4 atm

Above: Full size test window
Left: Quarter-scale test window frame