Magnet, Support and Infrastructure

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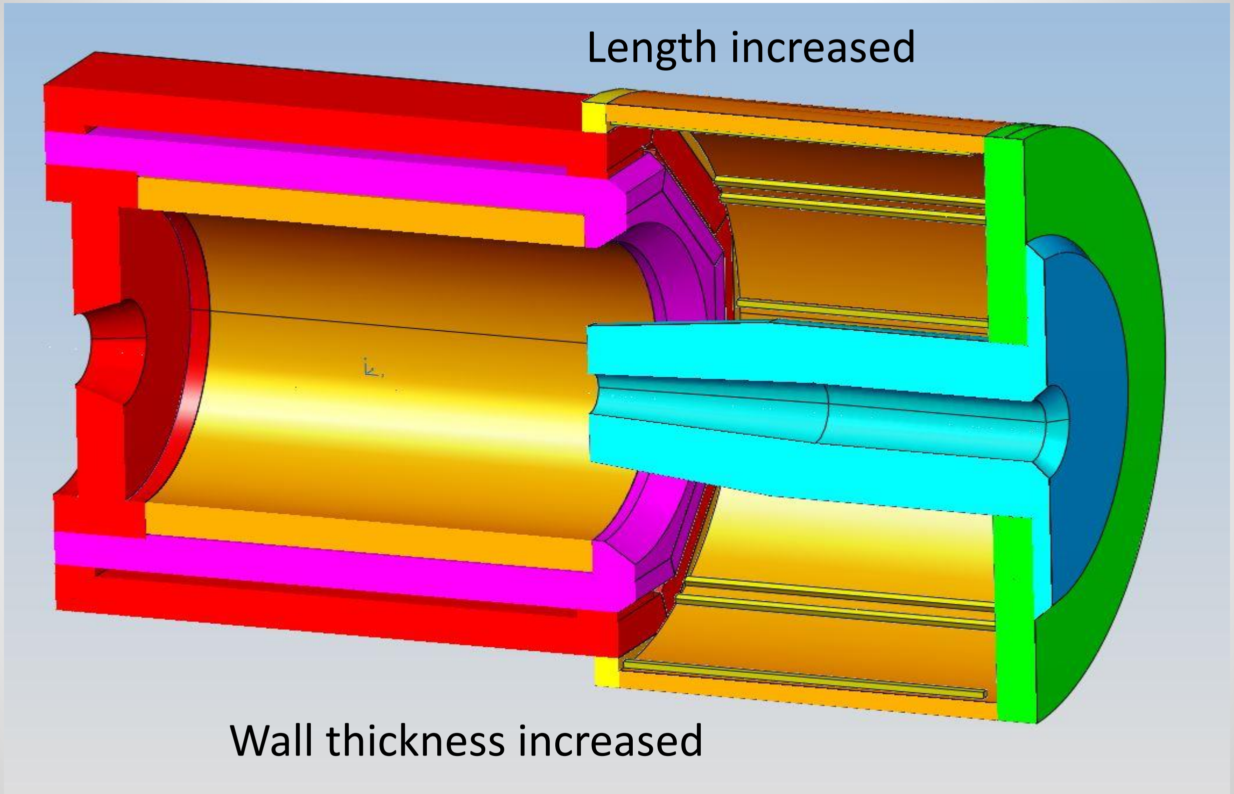
October 13, 2017

Update on Engineering and Design efforts from the Summer of 2017

- Updated CAD model with the latest detector files provided and adjusted spacing as discussed during the last collaboration meeting.
- Estimated opening area for cable routing.
- Identified locations for cable exit.
- Started development of guidelines for pressurized detectors to meet JLAB's safety requirements for pressure systems.
- Example stored energy calculation for Cherenkov detector.

A Few Notable Dimensions of the Endcap

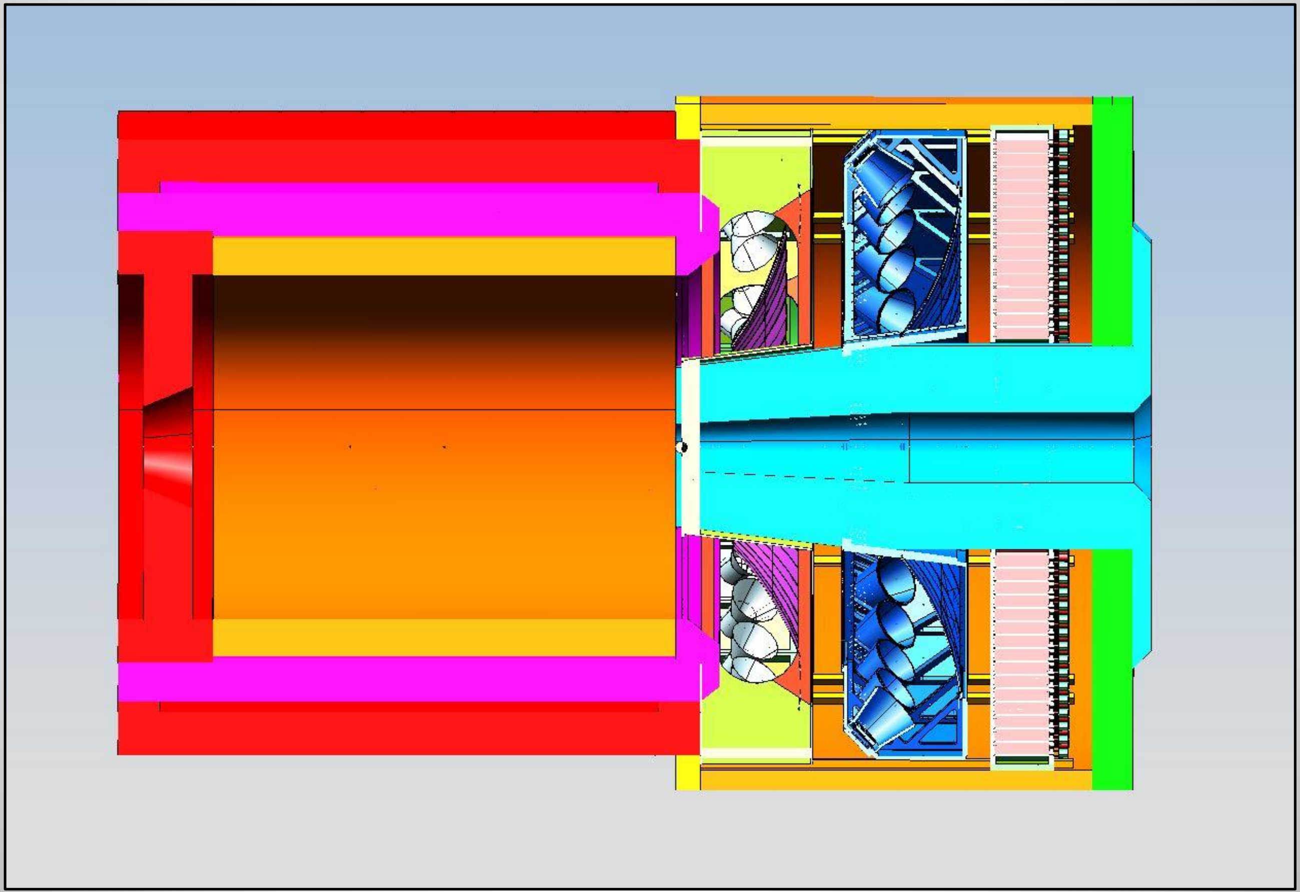
Jay's extended version



- Length of endcap increased by 59.2 cm for additional detector and cabling space
- Wall thickness increased to 6.5" – I.D. remained the same

Updated positions of detectors in the CAD file

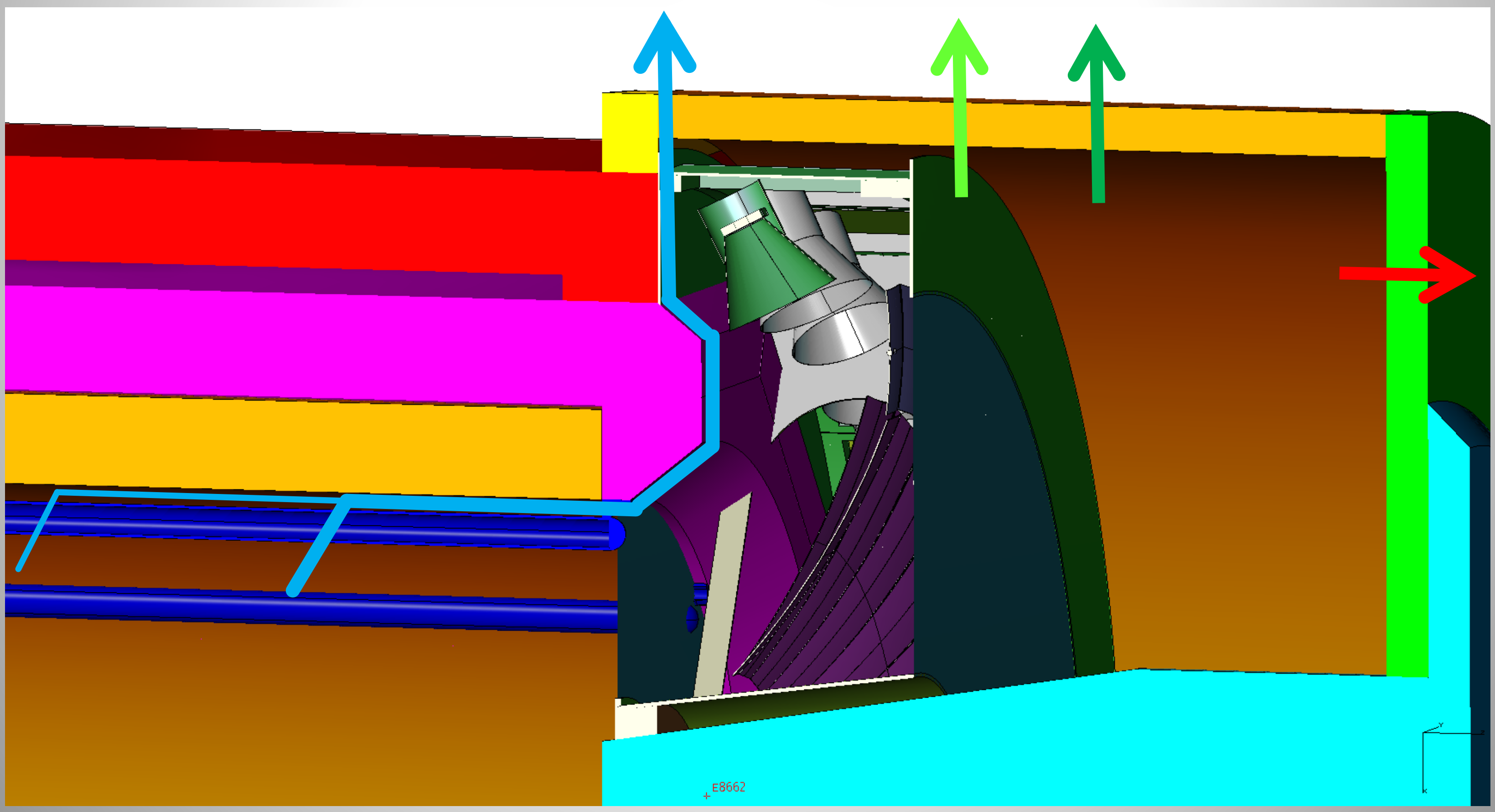
Noticeable gaps between detectors



Please provide updated CAD models if you have them. We do not have a model for FASPD, LASPD, MRPC, and GEM's

Cable Routing

Below demonstrates the possibility of running cables from inside the bore downstream and out radially along the perimeter of the coil collar, layers of return iron and out through openings in the front of the endcap. This could create channels for bundles to weaves their way out. This also impacts the LGC space.

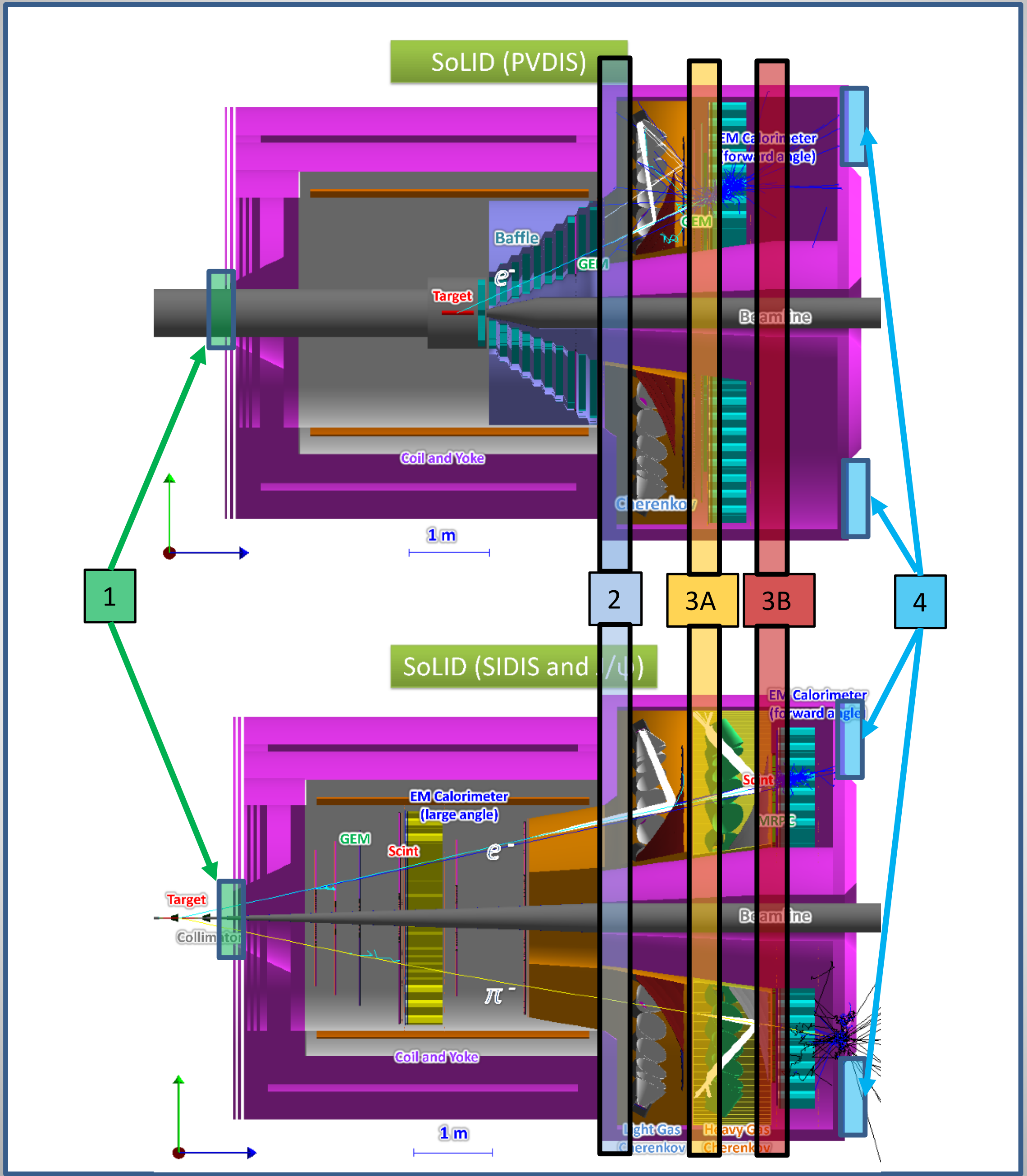


Detector Cables

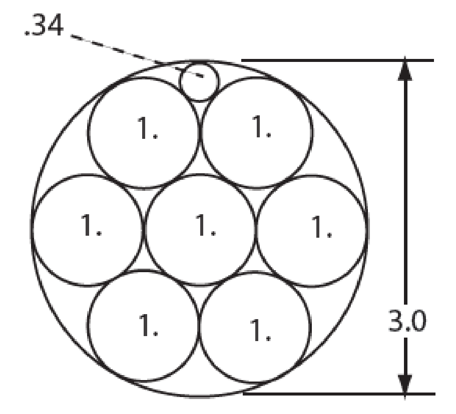
Info provided by Zhiwen

	Total area(cm2)	Location to go out	comment
FAEC (PVDIS)	1800	Endcap Back plate	1800 1.1cmD fiber bundle, 1800 0.3cmD fiber bundle
LAEC (SIDIS)	500	near downstream collar?	500 1.1cmD fiber bundle, 500 0.3cmD fiber bundle
FASPD	tiny	endcap side	240 1mmD fiber
LASPD	40	near downstream collar or solenoid front?	60 HV, 60 BNC
LGC	170	Near downstream collar or endcap side?	270 5mmD HV, 270 3mmD BNC
HGC	300	Endcap side	480 HV, 480 BNC 2 gas line at top, 2 gas line at bottom
GEM (PVDIS)	650	Near downstream collar or endcap side?	1,2,3 GEM planes, total cable 540 HDMI, 90 SHV, 180 Gas, 6mmD each, use 10mmD for safety, 3.1416*(10/2)^2/100*(540+90+180)=636cm2
	730	endcap side	4,5 GEM planes, total cable 720 HDMI, 60 SHV 120 Gas, 6mmD each, use 10mmD for safety, 3.1416*(10/2)^2/100*(720+60+120)=707cm2
GEM (SIDIS)	1380	Near downstream collar or solenoid front?	Assume same like PVDIS
MRPC	1650	endcap side	3300 channels, assume 0.5cm2 each

Cable Exit Locations



Calculating the required openings for the cables



The voids between the cables need to the be accounted for when determining the required opening size in the iron for power and data cables to exit.

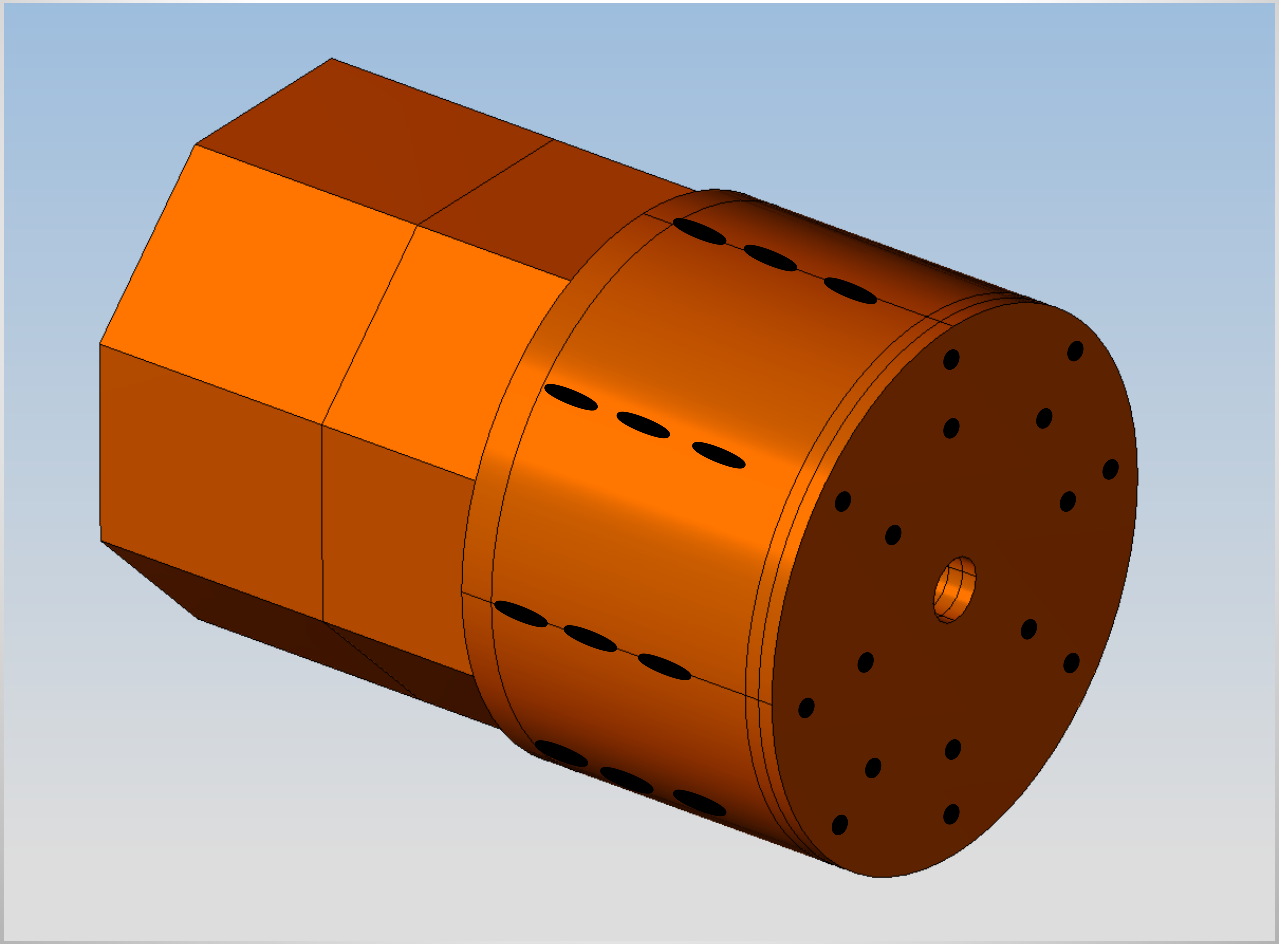
The above example is used as a general guide for area estimation. The empty space above accounts for approx. 23% of the total area. This was rounded up to 25% for the table to the right.

SIDIS detectors						
name	cable area (in^2)					
	1	2	3a	3b	4	exit location
GEM (6 planes)		214				
LASPD		6				
LAEC		78				
LGC		26				
HGC			47			
FASPD				6		
MRPC				256		
FAEC					279	
Cable area only	0	324	47	262	279	
Empty space included 125%	0	**405**	**58.75**	**327.5**	**348.75**	
Area per opening (10)	0	**41**	**6**	**33**	**35**	

PVDIS detectors						
name	cable area (in^2)					
	1	2	3a	3b	4	exit location
GEM (planes 1, 2, 3)		101				
LGC		26				
GEM (planes 4, 5)			113			
FAEC				279		
Cable area only	0	127	113	279	0	
Empty space included 125%	0	**159**	**141**	**349**	**0**	
Area per opening (10)	0	**16**	**14**	**35**	**0**	

To start, 10 openings per half on 15° increments. No openings along the bottom due to access issues.

Access Holes for Cabling



JLAB's Pressure and Vacuum Systems Safety Program

for SoLID detectors with pressurized gaseous volumes

Link to JLAB's program:

https://www.jlab.org/ehs/ehsmanual/manual/6151.html

Link to pressure and vacuum system supplement:

https://www.jlab.org/ehs/ehsmanual/Pressure and Vacuum Systems Supplement/index.html

Excerpt from Chapter 6151 of JLAB ESH&Q Manual:

The following systems are excepted from the requirements of this program:

- Any system where **all** of the following criteria are met:
  - The maximum system pressure cannot exceed 15 psid (pounds per square inch differential) at any time including all credible failure modes,
  - The system fluids are nonflammable, nontoxic, and not damaging to human tissue,
  - The system design temperature is greater than -20F and less than 366F,
  - The total stored energy of the system is less than **10000 ft-lbs**.

LGC (SIDIS) Stored Energy Calculation

Volume below is for half of the detector and taken from a mock-up volume. Will need to be re-checked with up to date SIDIS LGC CAD model. Gas volume displaced by internal components ignored.

LGC (SIDIS) Stored Energy Calculation

Gas: 100% CO_2 @ 1 atm

Baker Equation

Volume =	6.26E+05	in^3 =	362.1	cubic feet
Patm =	14.7	psia		
Ptest =	14.9	psia		
k=	1.29	ratio of specifc heats		
E=	97515	in-lbs =	8126	ft-lbs

Equivalent mass in TNT

TNT =	0.005459	lbs

Baker Equation for stored mechanical energy of a gas

$$E = \frac{Ptest\,V}{k-1}\left[1-\left(\frac{Patm}{Ptest}\right)^{(k-1)/k}\right]$$

Where

E =stored energy of test

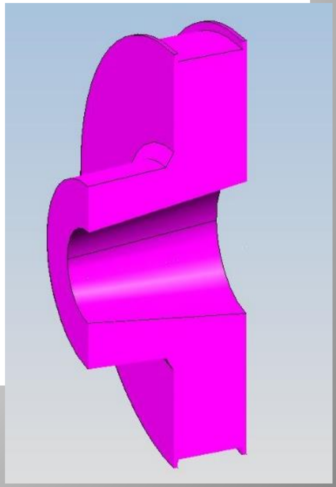
V =test volume

P_{atm} =absolute atmospheric pressure of test

P_{test} =absolute pressure of test

k =ratio of specific heats

$$TNT = \frac{E}{k-11488617}$$



HGC Stored Energy Calculation

Volume below is for half of the detector and taken from latest CAD model. Gas volume displaced by internal components ignored. The higher operating pressure (vs LGC) is the main contributor to the higher stored energy value. K value assumed.

HGC Stored Energy Calculation

Gas: 100% C4F8O @ 1.5 atm

Baker Equation

Volume =	5.75E+05	in^3 =	333.0	cubic feet
Patm =	14.7	psia		
Ptest =	22.1	psia		
k=	1.29	ratio of specifc heats (assumed)		
E=	3841091	in-lbs =	320091	ft-lbs

Equivalent mass in TNT

TNT =	0.215026	lbs

Baker Equation for stored mechanical energy of a gas

$$E = \frac{Ptest\,V}{k-1}\left[1-\left(\frac{Patm}{Ptest}\right)^{(k-1)/k}\right]$$

Where

E =stored energy of test

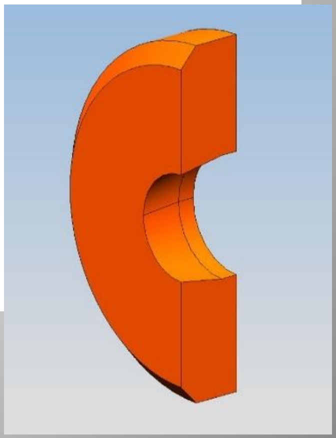
V =test volume

P_{atm} =absolute atmospheric pressure of test

P_{test} =absolute pressure of test

k =ratio of specific heats

$$TNT = \frac{E}{k-11488617}$$

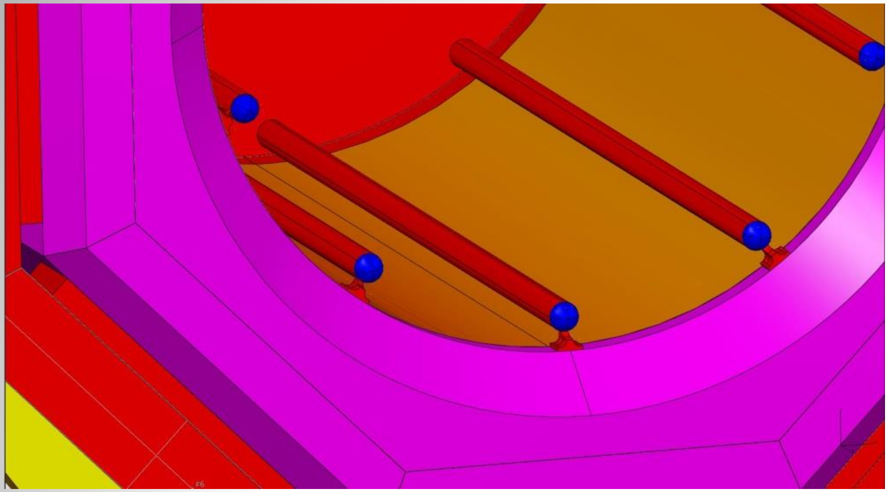


Future Work

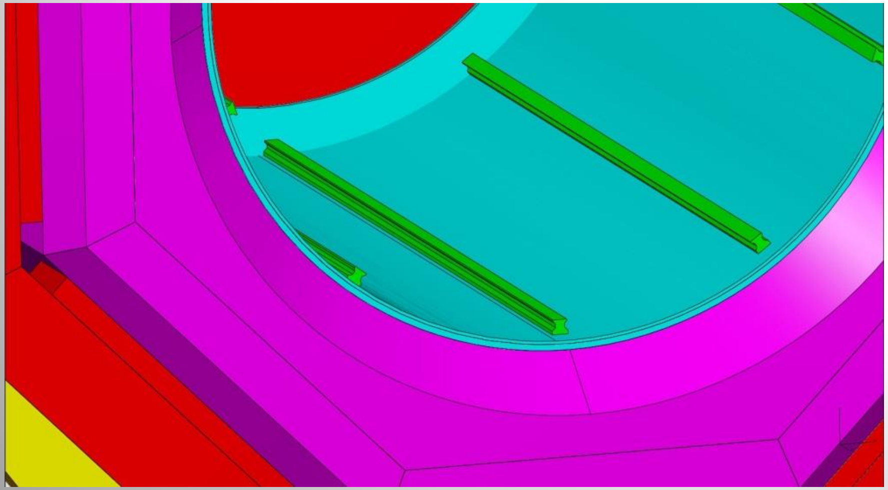
- Gather additional information on large gas filled detectors at JLAB
- Further pursue new internal rail concept
- Explore options for endcap movement
- Migrate mock-up model to new CAD system (NX) and start adding details
- Continue to update model with latest detector CAD files and continue to resolve space issues and cabling routes

Additional slides

Exploring new concept for supporting the items inside the bore of the magnet

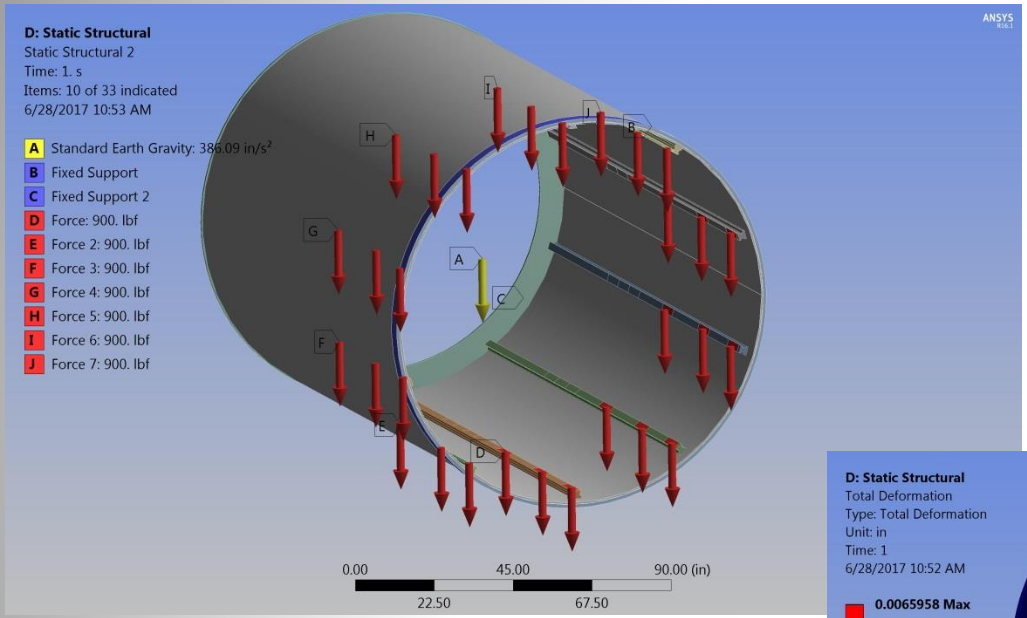


The old design used large SS pipes to bridge across the cryostat. Deflections were a concern. Custom, yet to be designed, rollers required.

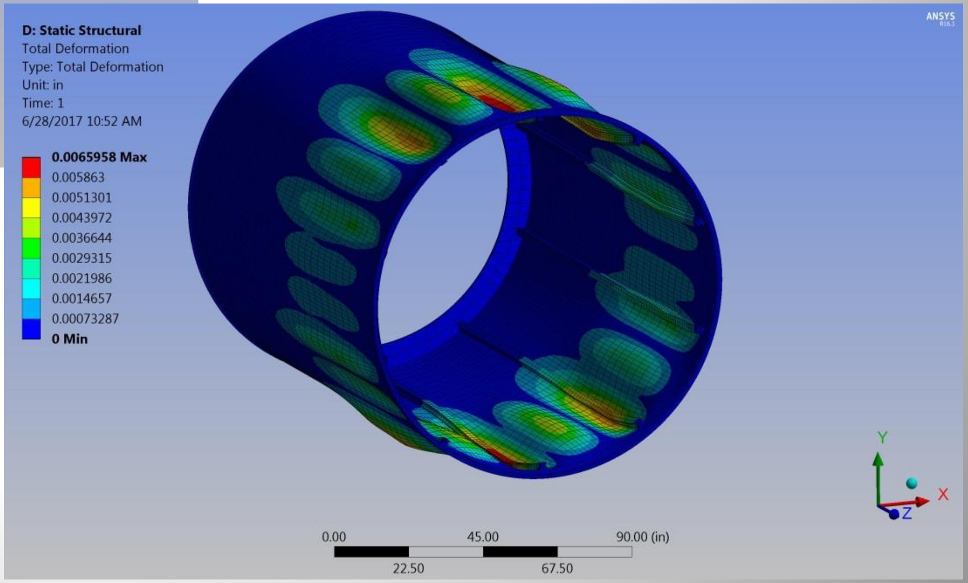


The new concept employs a rolled SS cylinder inserted in the bore. Attached to the same locations as previous design. Allows the use of "Off The Shelf" rails and rollers. More compact and smaller deflections.

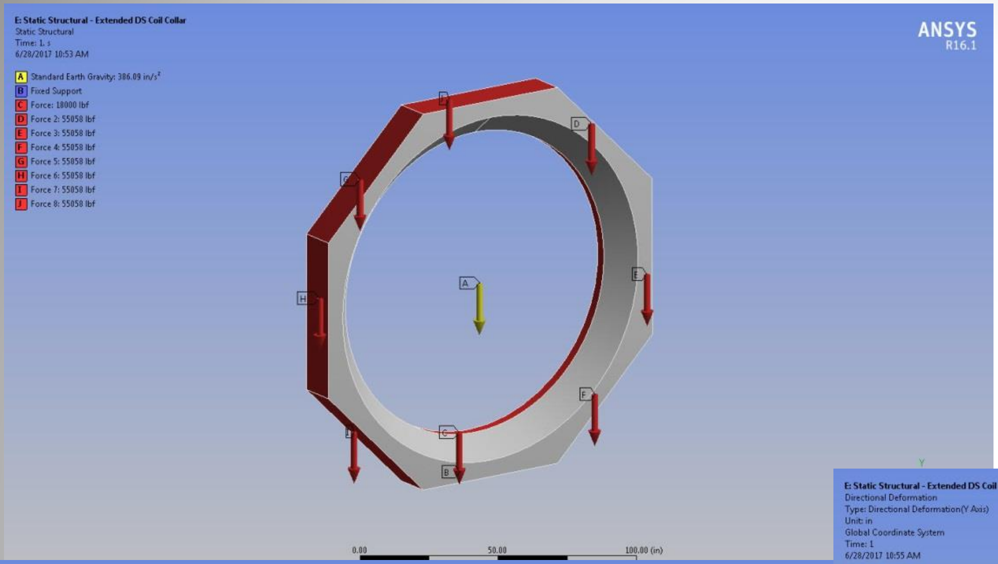
FEA analysis of new support concept



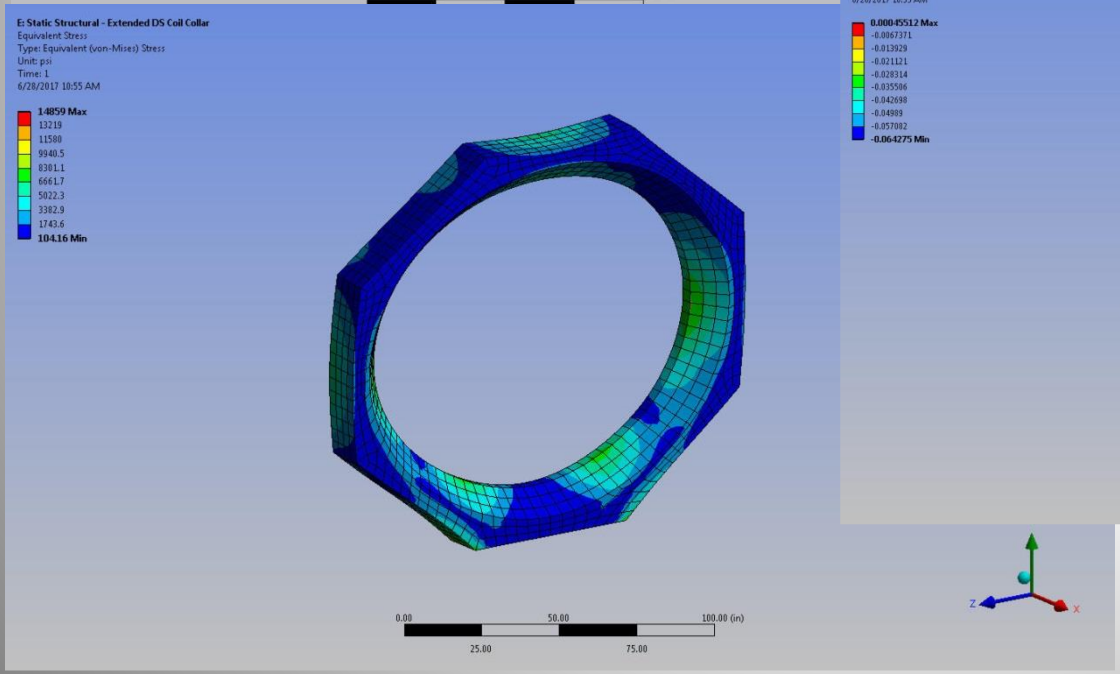
Max stress = 3100 psi
Max deflection = 0.007"
Results from 35 kip Baffle load case
LAEC case showed similar results

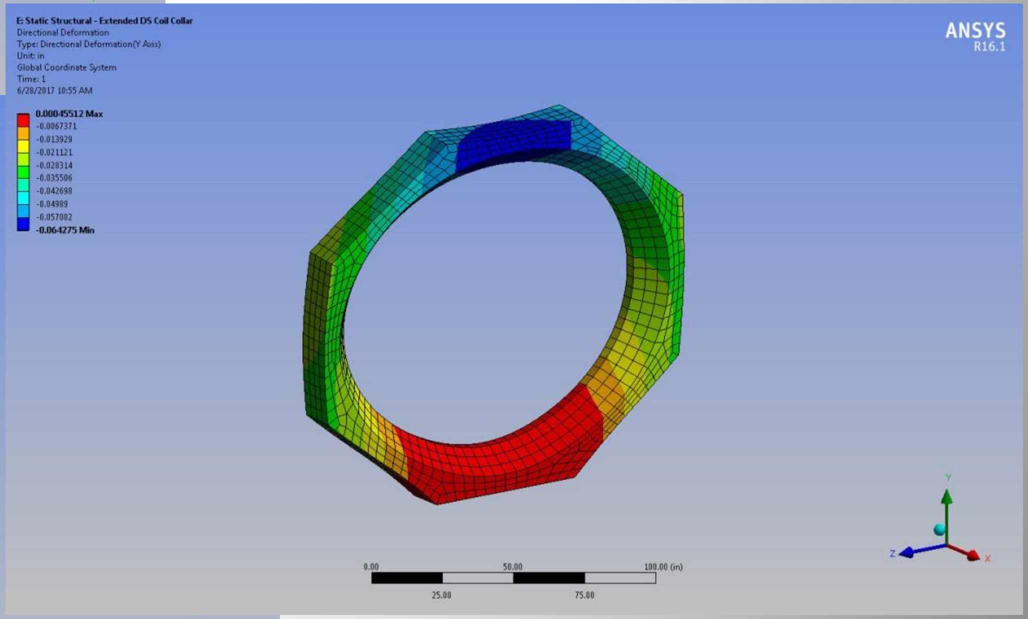


Structural analysis of thicker downstream coil collar



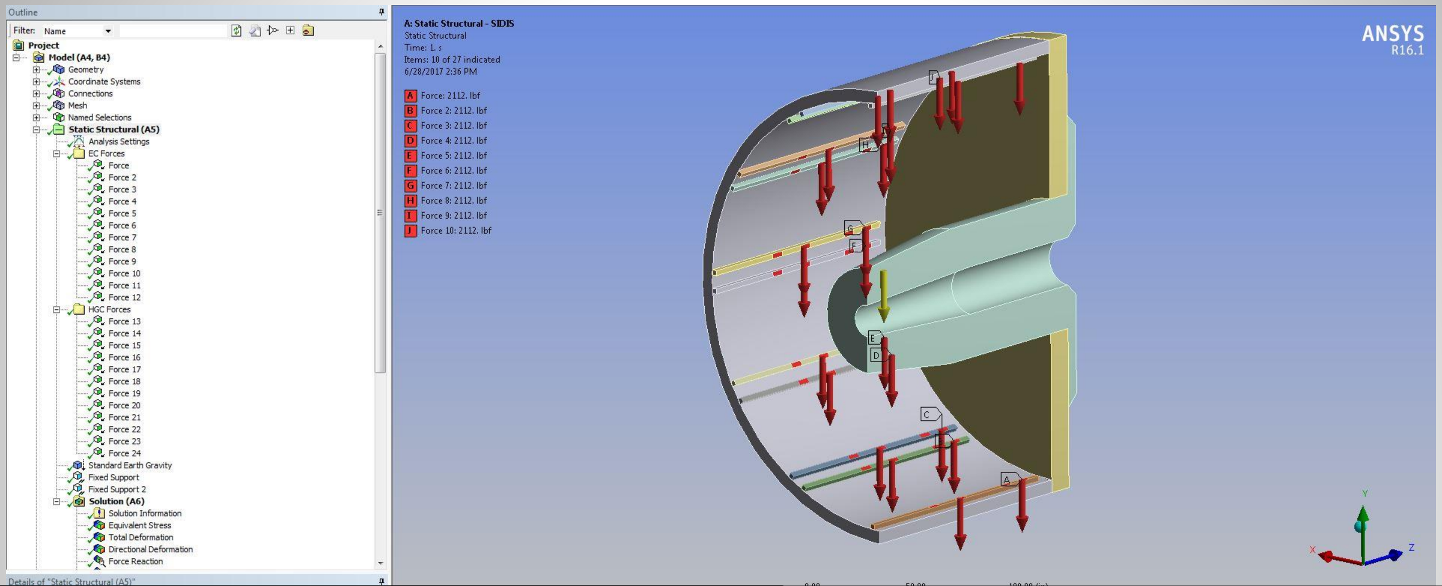
- Loads from iron and detectors applied
- Max stress (non peak stress) 8550 psi
- Max vertical deflection = 0.064”
- Thickness is sufficient to handle loads
- Peak stress of 14.9 ksi occurs at corner node of the rigid constraint

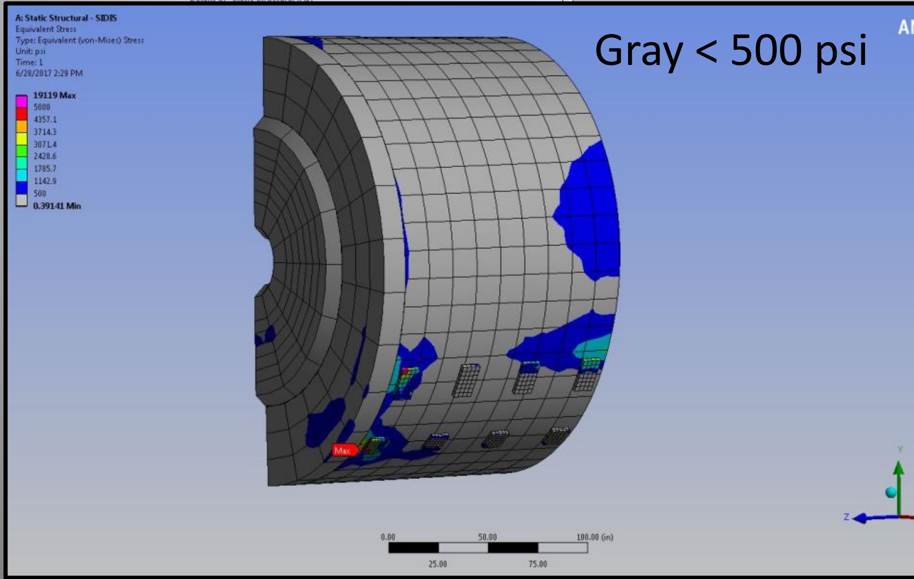


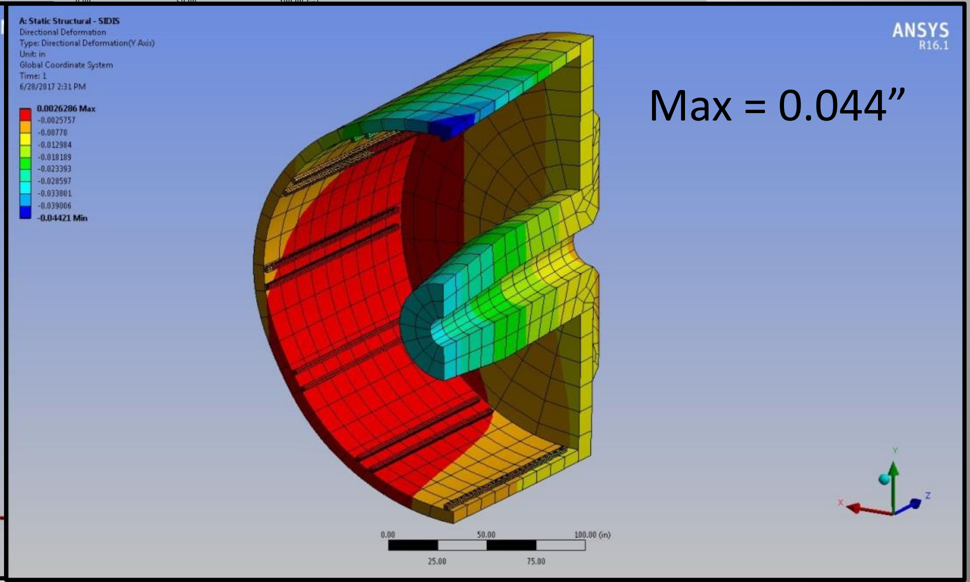


Stress analysis of freestanding endcap half - SIDIS

Explores strength of deflection of endcap design under detector loads

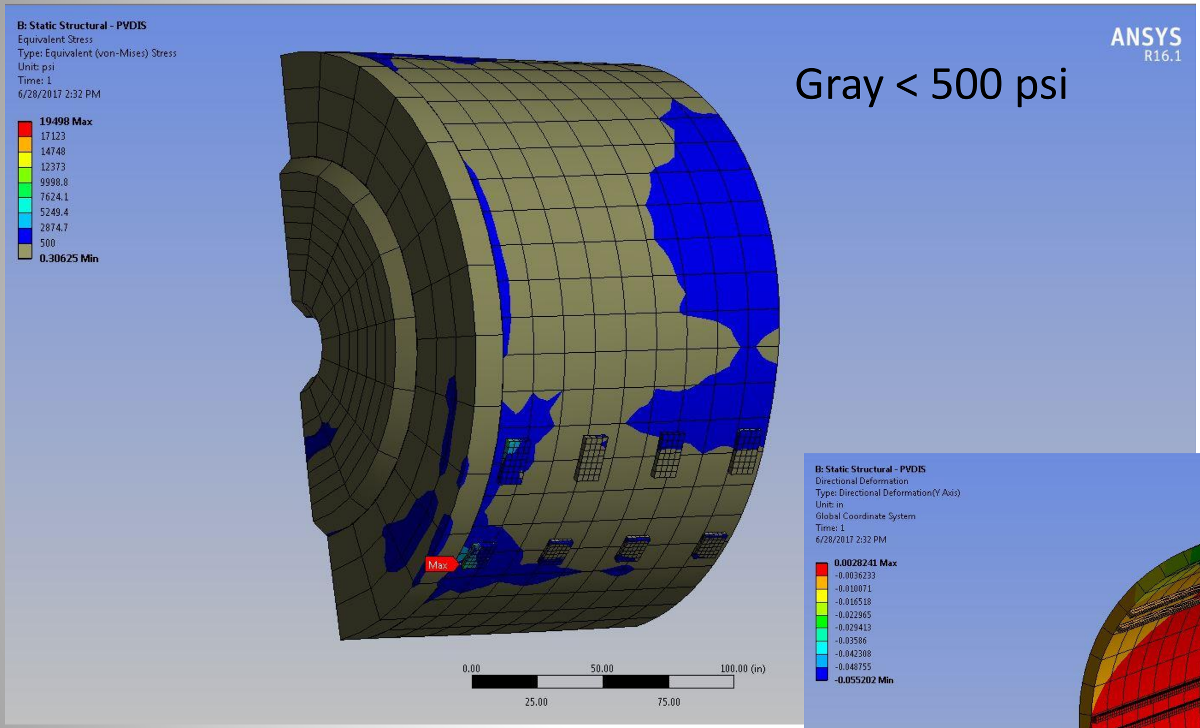


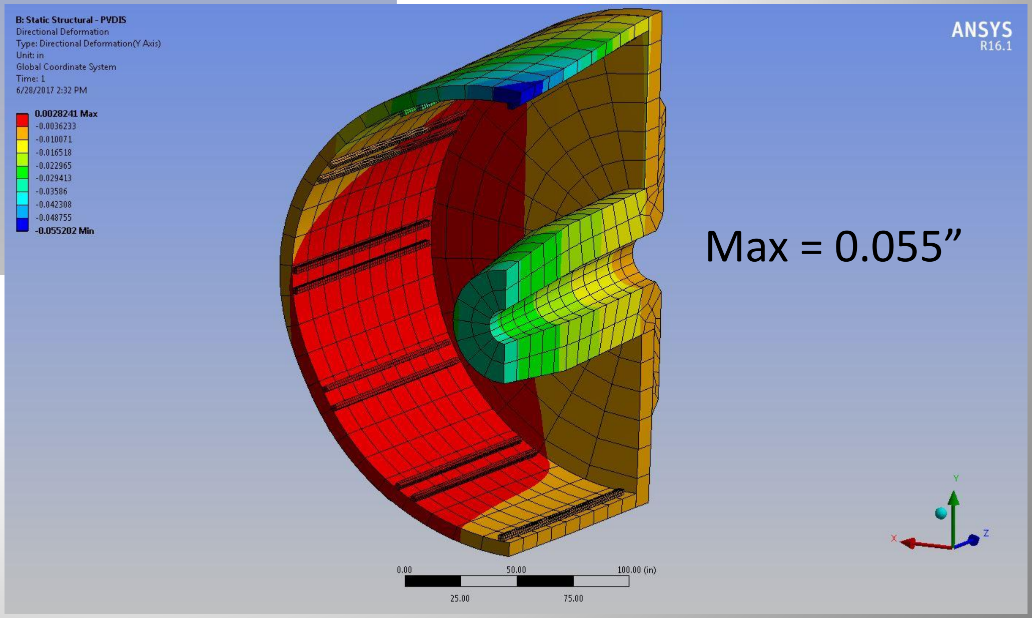




Stress analysis of freestanding endcap half - PVDIS

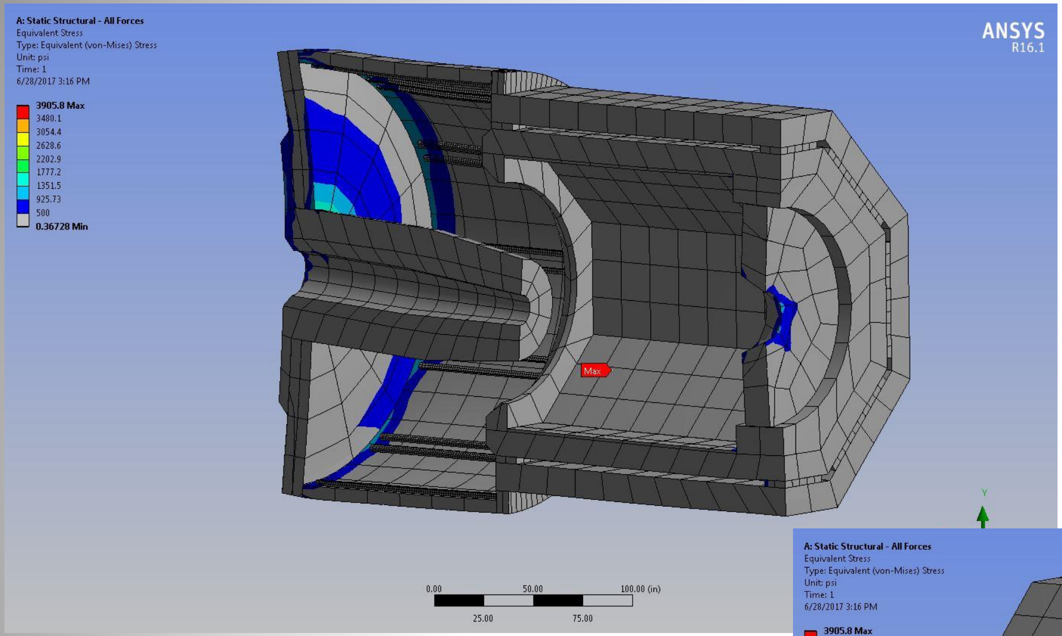
Explores strength of deflection of endcap design under detector loads





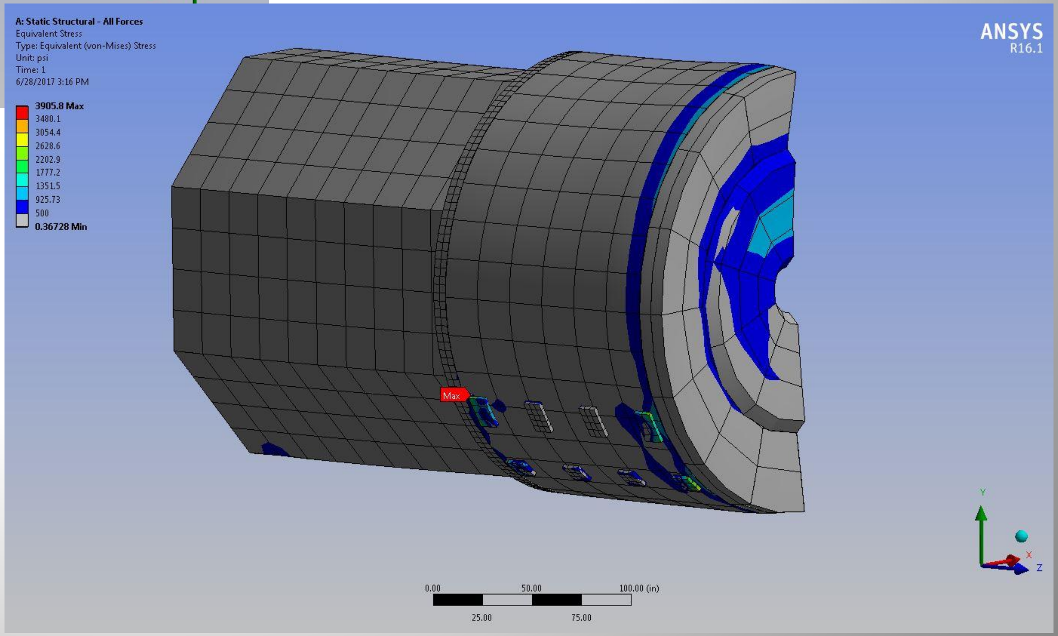
FEA analysis of SoLID iron

Magnetic, detector and gravitational forces - STRESS



Stresses are low!

Max = 3900 psi



FEA analysis of SoLID iron

Magnetic, detector and gravitational forces - DEFLECTION