Magnet, Support and Infrastructure

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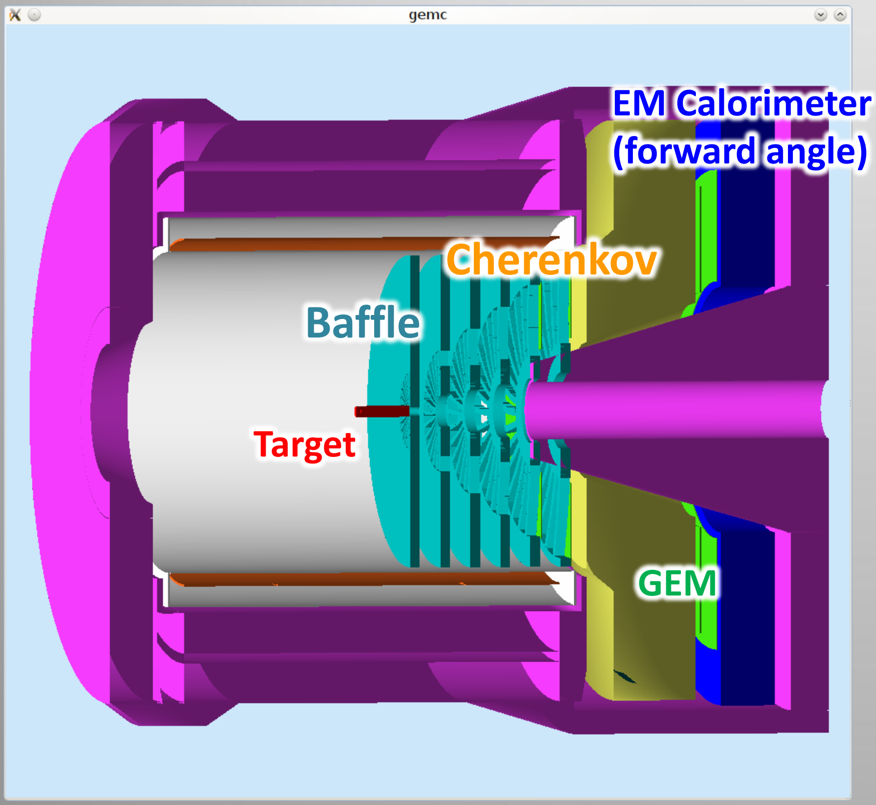
November 7, 2014

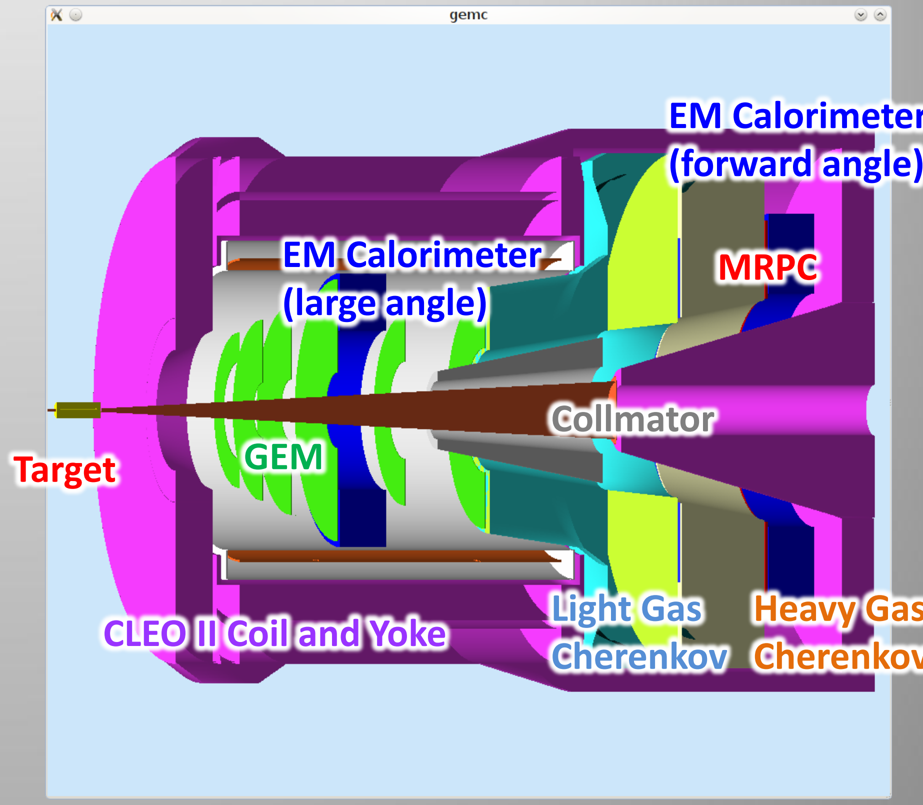
- Engineering Progress
    - Efforts in cost and labor estimate
    - Contributions to pCDR document
    - Visit to Cornell

- Dry Run
    - Magnet
    - Hall A Layout for SoLID
    - Magnet Modifications
    - Magnet Support
    - Detector Supports
    - Power and Utilities
    - Transport and Storage of CLEO II
    - Cost and Labor Estimates
- Preliminary material, needs to be refined, much more than 20 minutes

SoLID



PVDIS

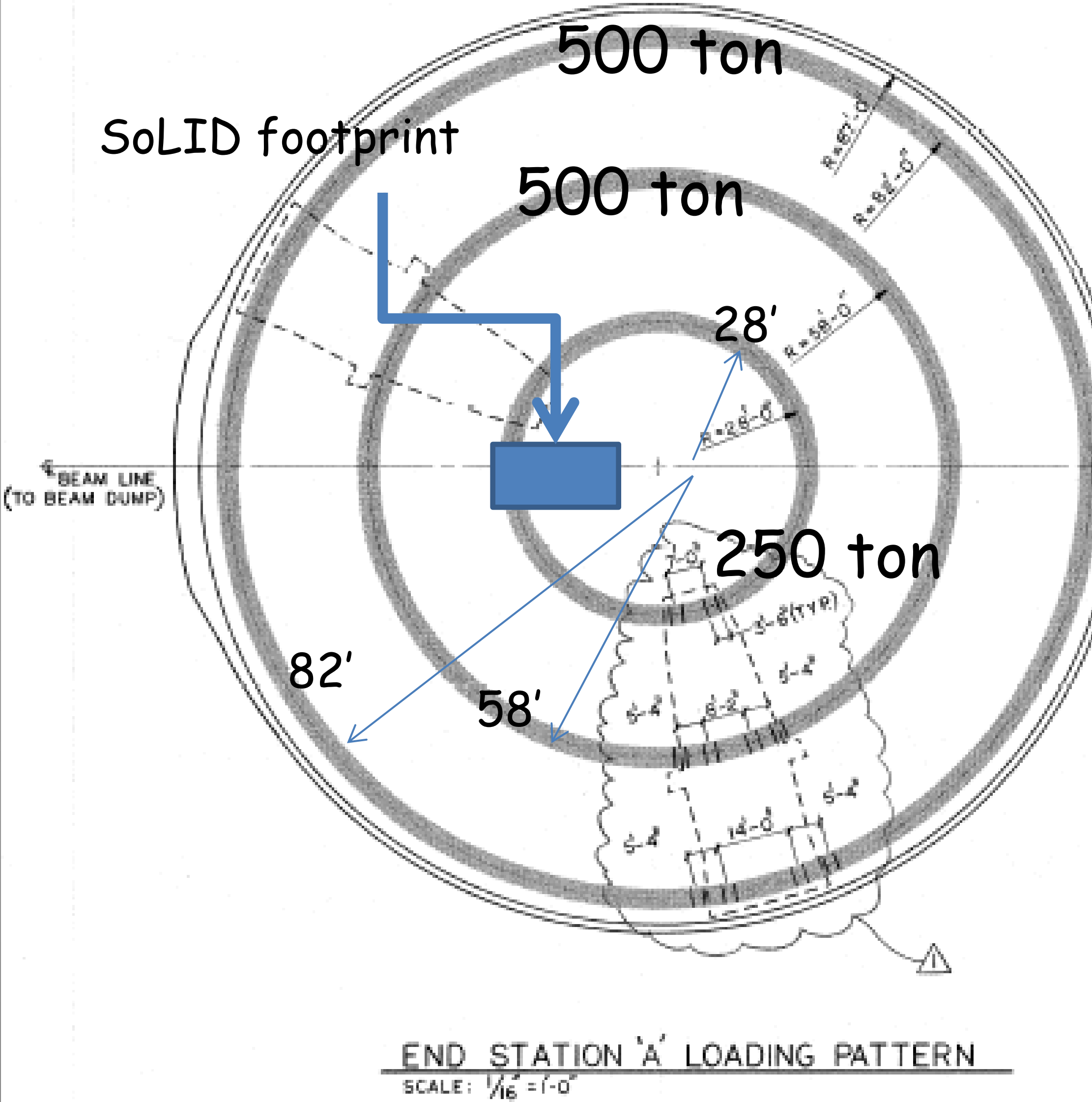


SIDIS

Magnet

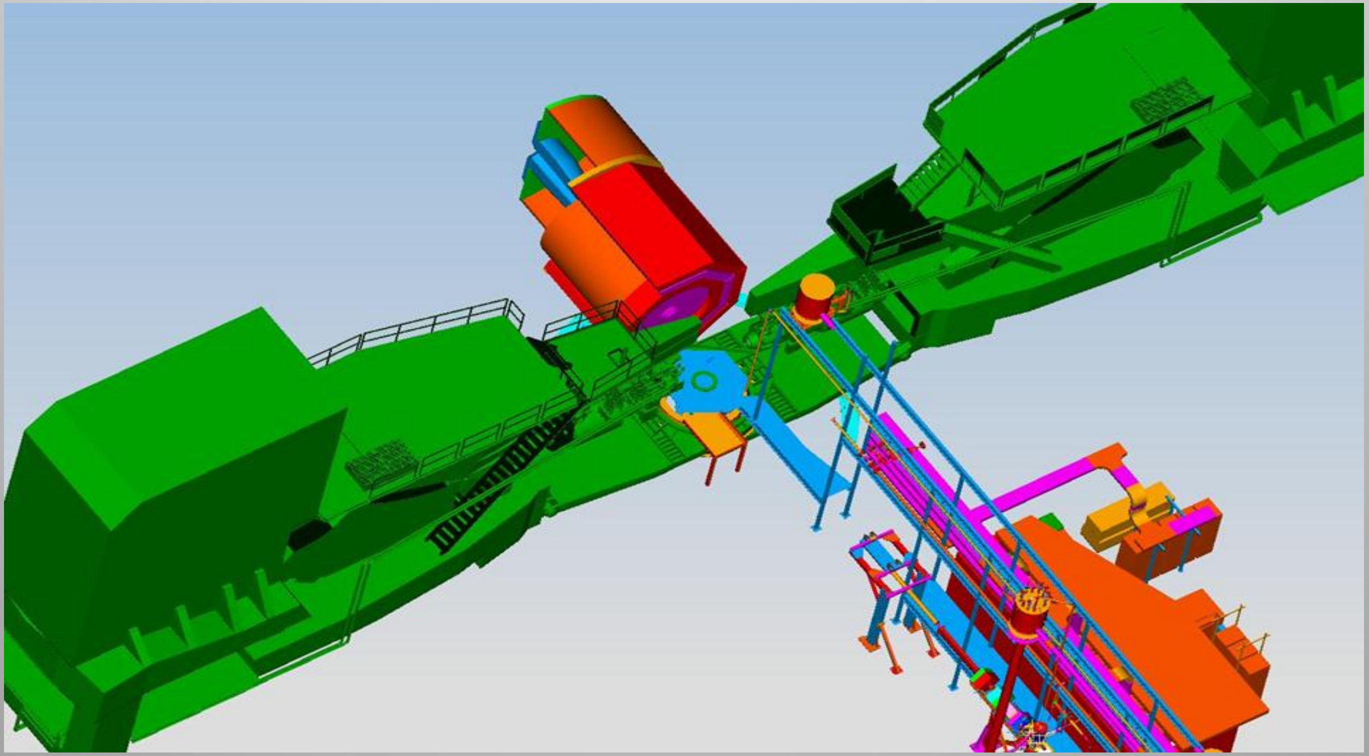
- CLEO II magnet to be used for the SoLID spectrometer
  - Solenoid magnet with a uniform axial central field of 1.5 T
  - Large inner space with a clear bore diameter of 2.9 m
  - Coil diameter of 3.1 m , coil length of 3.5 m
  - Built in 1989, operated until 2008
  - Met with Cornell engineers in June 2014 to discuss design, operation and transport of magnet to Jlab. Details in available trip reports.
- Items available from Cornell: Superconducting magnet, octagonal iron shielding, cryostat transport frame/cradle, Dynapower DC power supply, valve control box, cryogenic bayonets, data acquisition, rotation/turning jigs, steel mounting blocks, third iron layer (on top of the magnet) + yellow plate to support the 700 liter dewar, transfer lines, readout boxes for strain gauge
- Projected disassembly in starting in Summer 2015 and transport from Cornell in Summer 2017.
- New information : Recommendation to replace vapor cooled current leads due to significant heat load – discuss with Cryo Group.

Hall A Floor Loading



- SoLID magnet and detectors encompass an area of 5.8 meters in diameter and 7.3 meters long.
- Clearance to the Hall floor ranges from 10 to 38 cm, sufficient for support.
- Weight of the CLEO-II magnet, detector hut and detectors is 1300 tons. The floor in this installation region is designed for 250 tons for a 12 square foot pad.

CLEO II in Hall A

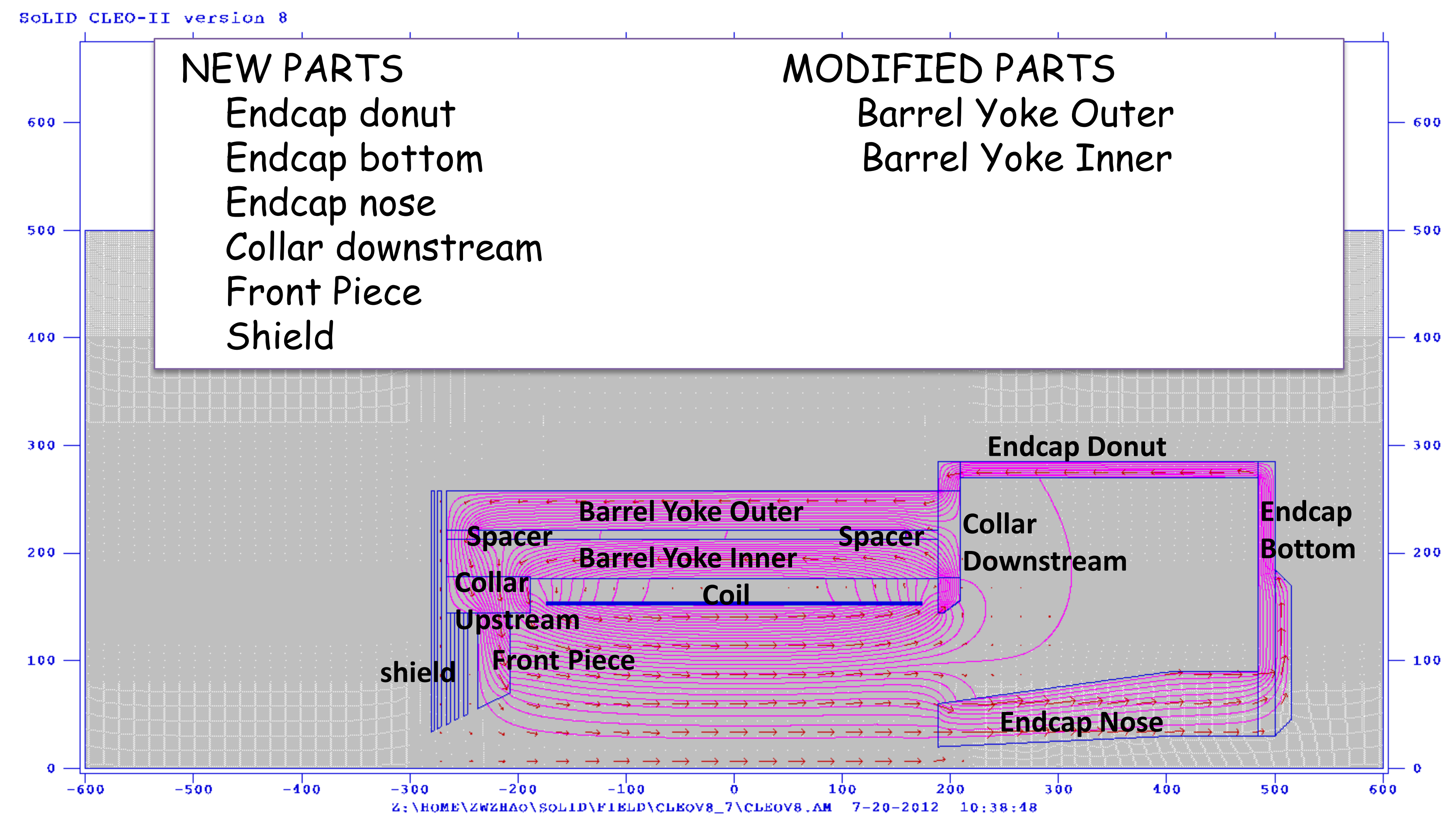


- The experiment layout puts the HRS arms at 90 degrees to the beamline on the left and right. Alternate layout places both HRS arms to the left of beamline.
- Target to be 115cm downstream of pivot for magnet to clear pivot bearing. Center of the CLEO-II magnet would be 350 cm downstream of the target center.
- Hall layout planning is ongoing for SoLID and other experiments.

Magnet Modifications

NEW PARTS
- Endcap donut
- Endcap bottom
- Endcap nose
- Collar downstream
- Front Piece
- Shield

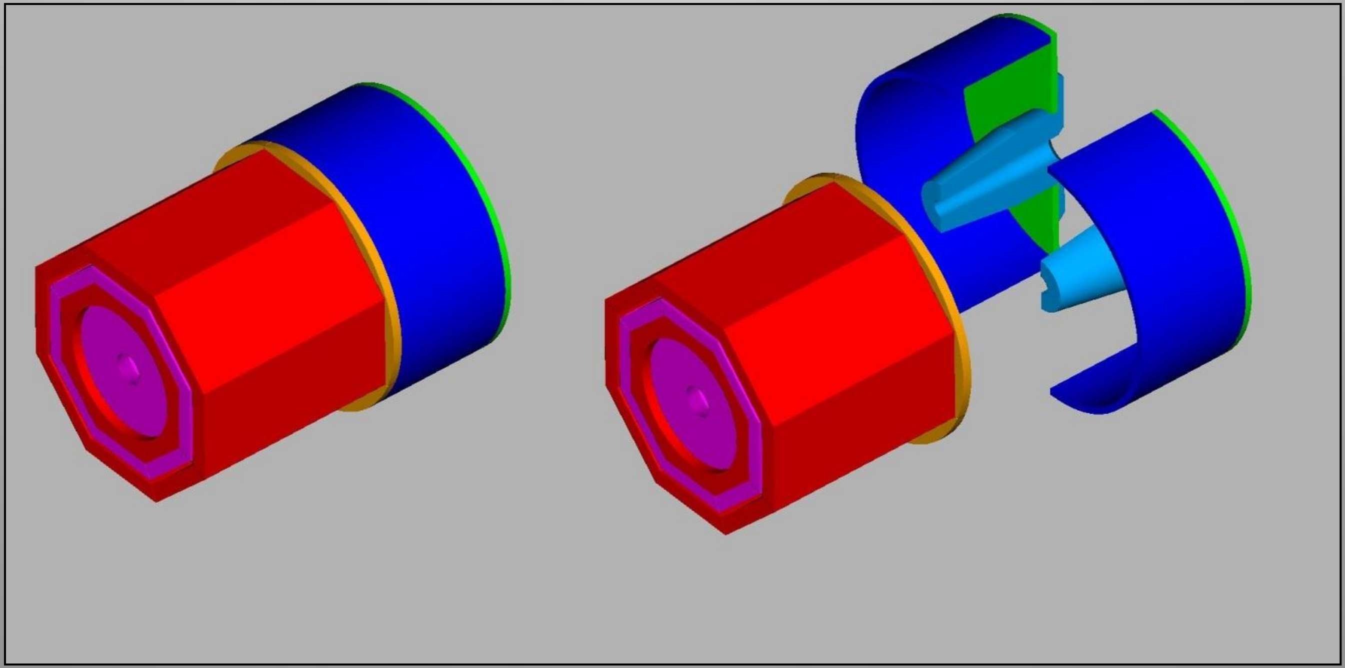
MODIFIED PARTS
- Barrel Yoke Outer
- Barrel Yoke Inner



Magnet Modifications

- The CLEO magnet will require some modifications to its design for use in the SoLID experiments.
- SoLID will not use the outermost muon ring. It will use the inner two rings, each consisting of 8 slabs of iron. Each of these slabs will have to be shortened to allow the proper position of the endcap.
- The original upstream coil collar will be reused.
- The downstream coil collar will be modified if an economical way of reducing its thickness can be found without wasting a majority of its unwanted material. If a solution is not found then a new downstream coil collar will be created.
- Additional pieces of iron will need to be fabricated to allow for the proper mating of the endcap with the barrel yoke.
- All supporting structure for the magnet barrel yoke and detector endcap will be new fabrications.
- The endcap, which consists of the outer cylindrical ring, the backplate, and endcap nose, will all be made from new material.

- The endcap will be split vertically into halves and be capable of separation to allow for access to the detector package.
- The endcap nose with a secondary backing plate will be a cast two piece design to allow for separation.
- Each section of the nose will bolt to the main backplate which consists of a two piece round disk.
- The two halves of the cylindrical outer ring will bolt to the corresponding backplate.



Magnet Support

- The initial plan used for estimating the cost is to build a stationary frame and distribute the approximate 1000 ton load of the modified CLEO-II magnet section using eight 200 ton enerpac jacks.
- Steel plates and large steel blocks and/or large I-beams will be used to distribute the load out over a safe area.
- The 200 ton jacks will be used for vertical alignment and have locking rings which allow for a full mechanical connection and not rely on hydraulic pressure for stationary support.

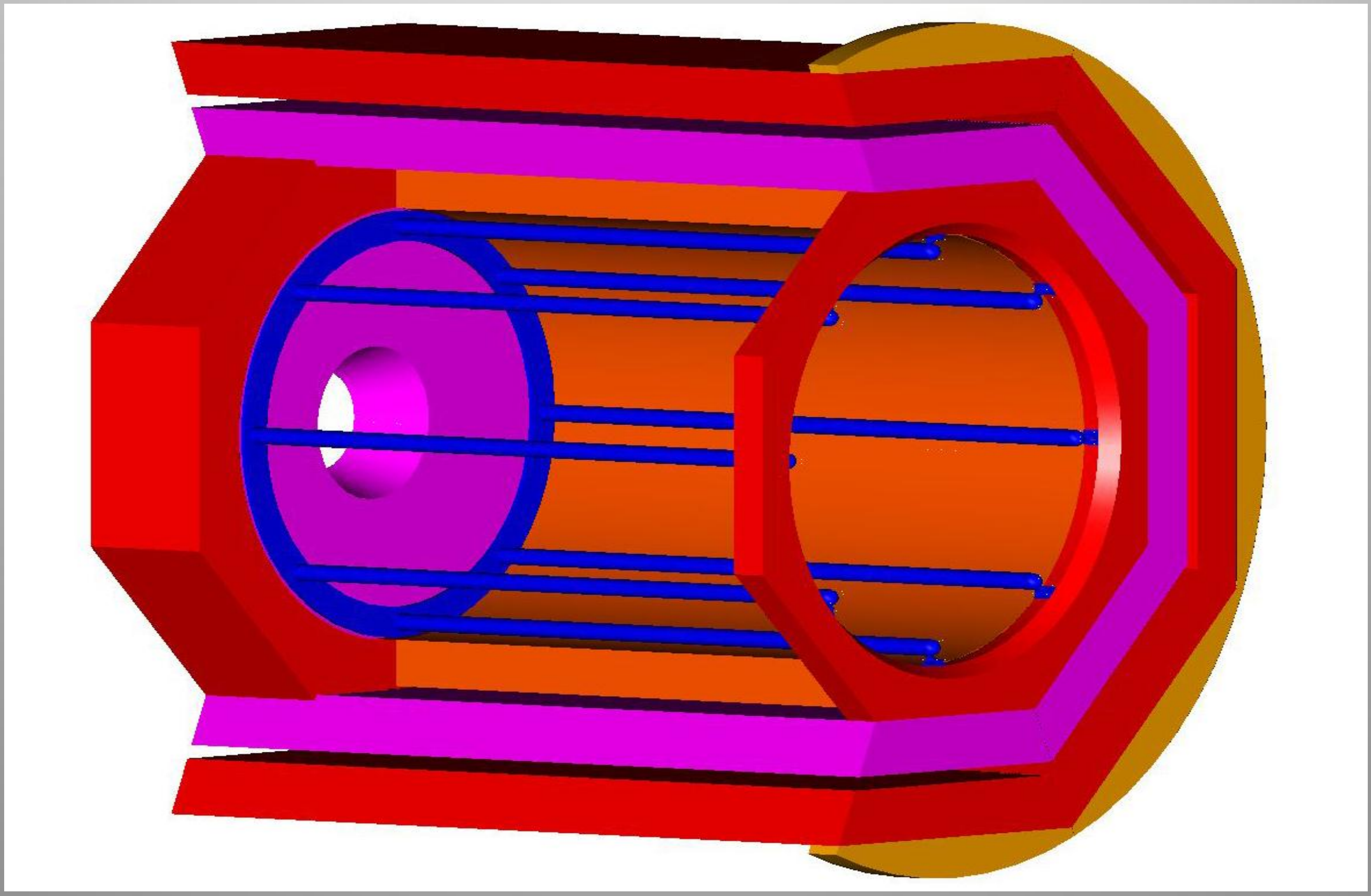
Endcap Support

- The endcap will have a support structure that cradles each half the cylindrical ring.
- The structure will be integrated into a track system that is mounted to steel plates resting upon the concrete floor.
- The initial design concept for the track system requires a set of longitudinal (downstream direction) tracks for moving the endcap away from the magnet. A second set of tracks that would separate the endcap halves in the lateral direction would ride on top of the longitudinal tracks.
- The endcap support structure would then be attached to the top lateral track system.
- Motion can be achieved by using hydraulic or electric cylinders to push and pull the entire system into position

Detector Supports

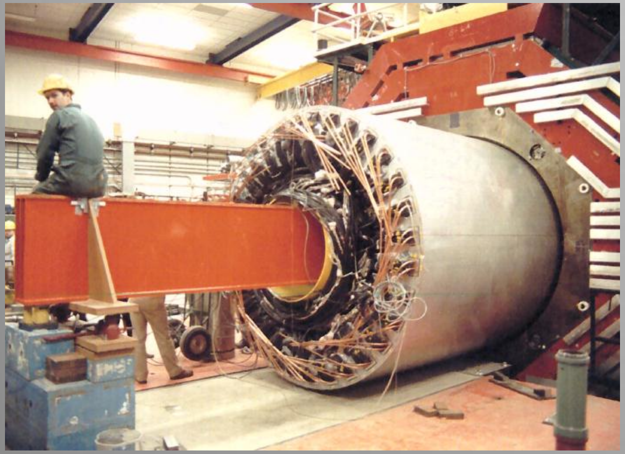
- The magnet will be located adjacent to the existing Hall A center pivot/target mount area and will have limited access to the front of the magnet.
- The insertion of the large angle detector packages that will reside internal to the cryostat will be accomplished from the downstream side of the magnet using a supporting framework to roll the packages in and out. This will require the detector hut to be moved downstream to allow access to the cryostat.
- An internal frame system is needed to mount the lead baffles in the PVDIS experiment. The frame cannot come into contact with the inside bore of the cryostat. This requires the frame to span the entire length of the cryostat and mount to the return yoke iron.
- The rails of the frame will be fabricated from 4 inch diameter schedule 80 welded stainless steel pipe. Either 304 or 316 grade stainless is acceptable.
- The downstream end of the rails will have a hemispherical cap and a stainless steel foot welded on and will be bolted to the downstream collar. The upstream end of the rail will either be bolted or welded to an annular stainless steel plate.
- The upstream end of the frame will be mounted to the frontcup
- Since the frontcup has to be movable to balance the magnetic field on the coils the annular plate will be attached to the frontcup with studs. This will allow the rail framework to remain stationary if the frontcup has to be adjusted. The same rail system can be used for the SIDIS experiment for mounting the large angle calorimeter and GEM’s

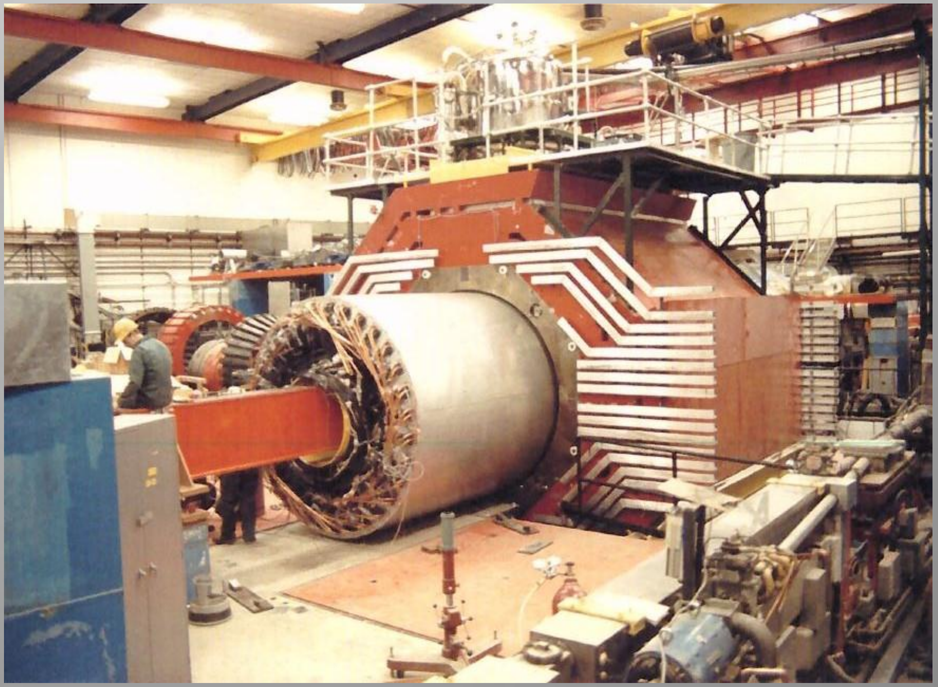
Detector Supports



Large Angle Detector and Baffle Installation

- An installation mechanism is needed to load the large angle detector packages and baffle system into the internal support structure
- This mechanism will likely be mounted to the longitudinal track system used for the endcap movement and can utilize the tracks for rolling the detectors and baffles into the cryostat and transferring the load to the internal frame.





Light Gas Cherenkov Installation

- The light gas Cherenkov will mount to the external downstream end of the magnet and will not traverse with endcap. When the endcap is in the operational position the light gas Cherenkov will be enclosed within the cylindrical ring along with the rest of the forward angle detectors.
- The light gas Cherenkov detector will be made up of six pie shaped sections that will need to be bolted to the downstream side of the magnet.
- A space frame similar to a scaffolding system would hold and position each section while being attached to magnet. The space frame would attach to the rail system and could be movable along the rails if needed. The space frame will be suitable for personnel access to allow workers to perform the installation and maintenance of the detectors

Endcap Forward Angle Detector Installation

- The basic design concept for the detectors mounted inside the endcap will have them supported by individual rails mounted to the inner circumference of the cylindrical ring and on rails attached to the outer horizontal circumferential surface of the nose if needed.
- The heavy gas Cherenkov will be separated into six sections with each section utilizing two rails to attach the section to the outer circumference of the endcap.
- A counterweight balanced installation device that is slung from the crane can be used to orient and position each section onto the rails.
- Personnel access to the endcap will be through man lifts and/or a specialized scaffolding as needed

Power Requirements

- The projected electrical power load is 1.6MVA, maximum current for magnet at 3266A. The present power consumption for Hall A is less than 1 MVA. So upgrade to the Hall substation to have 2 MVA is required

- The CLEO-II magnet is designed to have a low cryogenic heat load with passive cooling. The HRS arms will not be operational during SoLID, so it is expected that the refrigeration heat load will be less than needed for HRS. Two week cool down while maintaining a 25º delta

Magnet Transfer to JLAB

- Cornell is currently determining the detailed steps required for CLEO II disassembly and working hard to develop a plan based on current variables
- Project variables include the outcome of their CESR upgrade proposal, timeline of available JLAB funds, and optimizing their schedule while still meeting the minimum amount of run days for their NSF contract.

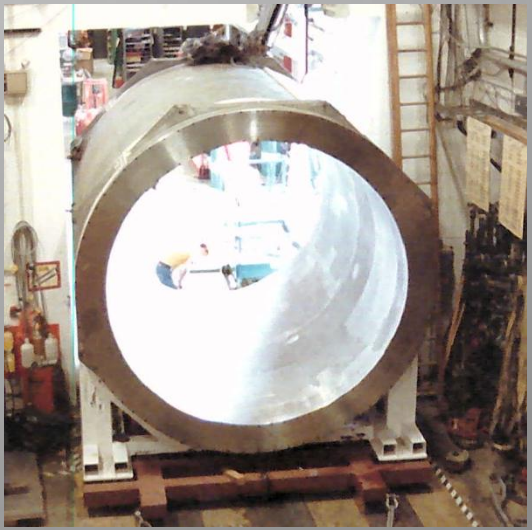
Current planning scenario:

- Spring and Summer 2015 – Preparatory work begins. Removal of scaffolding, adjacent electronics and potentially outer shielding and layer of iron.
- Summer 2016 – Further disassembly of magnet. Cornell will try to maximize amount of work accomplished during this down period to minimize down time in the Summer of 2017.
- Summer 2017 - Final CLEO removal and shipment of parts to JLAB

CESR upgrade will be a concurrent project requiring a good amount of coordination. Experimental equipment and many shielding blocks will be removed during this timeframe.

Transport and Storage of CLEO II

- Disassembled and loaded on trucks for shipping by the Cornell personnel with oversight by Jefferson Lab. It will require 52 trucks to transport the magnet and related equipment.
- We have identified all of the parts of the CLEO magnet, with sizes and weights, anticipating a need for storage of these parts at Jefferson Lab starting Summer 2016, total weight of 1,053k lbs.
- The cryostat (35k lbs) and power supply will need to be stored in an environment-controlled area of approximately 400 square feet. Jefferson Lab projects the use of the CMSA site for storage of all parts.



Cost and Labor for Magnet

	Year-1	Year-2	Year-3	Year-4	Sum		Contrib	Request
Yoke	360				360			360
FTE	0.3	0.3	0.2		0.6			0.6
Upstream Endcap	335	342			677			677
FTE	0.5	0.5	0.2		0.8			0.3
Downstream endcap	450	425			875			875
FTE	0.7	0.5	0.2		1.4			1.4
Nose Extension	330	330			660			660
FTE	0.3	0.3	0.1		0.7			0.7
Downstream coil collar	250	250			500			500
FTE	0.8	0.6	0.1		1.5			1.5
Magnet support, alignment		100	250		350			350
FTE	1	0.4	0.4	0.2	2			2
Control		100	200	100	400			400
FTE	0.5	0.5	1	1	3			3
Cryogenic		300	200		500			500
FTE	0.3	0.3	0.4	0.5	1.5			1.5
Magnet Testing					100			100
FTE		1		1	2			2
Total-magnet	1725	1847	650	100	4322			4322
Total-FTE	4.4	4.4	2.6	2.7	14.1			14.1

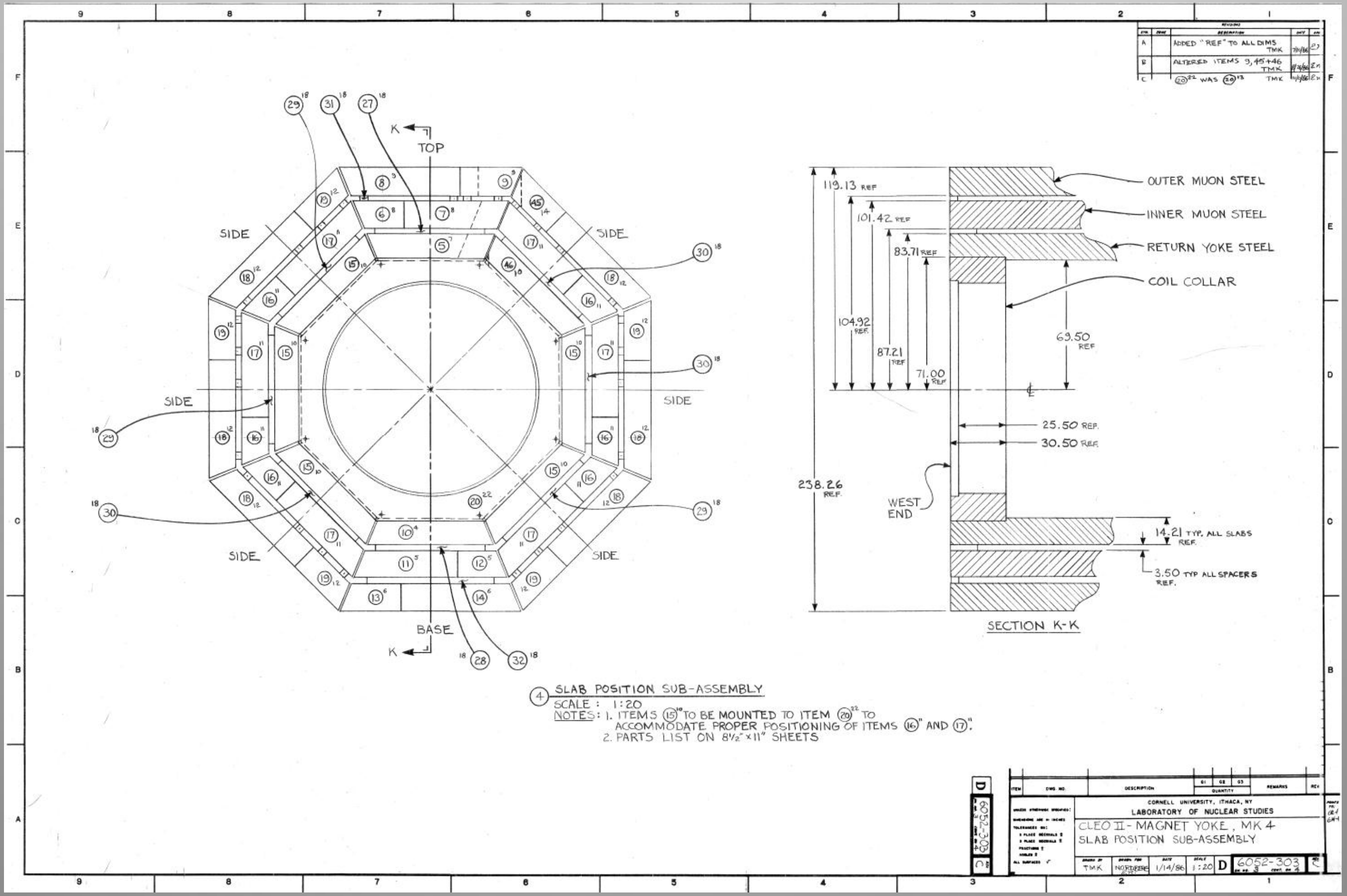
Cost and Labor for Detector Supports and Hall Infrastructure

	Year-1	Year-2	Year-3	Year-4	Sum		Contrib	Request
Detector Engineer FTE	2	2.5	2.5	0.5	7.5			7.5
Detector Support		250	250		500			500
FEC Support		125			125			125
FTE	0.1	0.1			0.2			0.2
LAEC Supp.		80			80			80
FTE	0.1	0.1			0.2			0.2
Baffle		300			300			300
FTE	0.1	0.1			0.2			0.2
Baffle Supp.		220			220			220
FTE	0.1	0.1			0.2			0.2
Access		170			170			170
FTE		0.1	0.1		0.2			0.2
Power		100	100		200			200
FTE	0.1	0.1	0.1		0.3			0.3
Beamline/ Chambers			200	60	260			260
FTE			0.2	0.2	0.4			0.4
Ramp		50			50			50
FTE		0.1			0.1			0.1
Hall	50	50	50		150			150
FTE	0.5	0.5	0.5		1.5			2
Layout FTE	0.1	0.1	0.1	0.1	0.4			0.4
Assembly and Installation			50	100	150			150
FTE	0.5	2	5.5	6.2	14.2			14.2
Total-Structure	50	1225	650	160	2205			2205
FTE	3.6	5.8	7.0	7	23.4			23.4

Analysis

Additional slides

CLEO-II



ADDED "REF" TO ALL DIMS
ALTERED ITEMS 9, 45+46
TOP
BASE
SIDE
OUTER MUON STEEL
INNER MUON STEEL
RETURN YOKE STEEL
COIL COLLAR
119.13 REF
101.42 REF
83.71 REF
104.92 REF.
87.21 REF
71.00 REF
69.50 REF
25.50 REF.
30.50 REF.
238.26 REF.
WEST END
14.21 TYP. ALL SLABS REF.
3.50 TYP ALL SPACERS REF.
SECTION K-K
SLAB POSITION SUB-ASSEMBLY
SCALE : 1:20
NOTES: 1. ITEMS 15 TO BE MOUNTED TO ITEM 20 TO ACCOMMODATE PROPER POSITIONING OF ITEMS 16 AND 17.
2. PARTS LIST ON 8½" x 11" SHEETS
CORNELL UNIVERSITY, ITHACA, NY
LABORATORY OF NUCLEAR STUDIES
CLEO II - MAGNET YOKE, MK 4
SLAB POSITION SUB-ASSEMBLY
TMK
1/14/86
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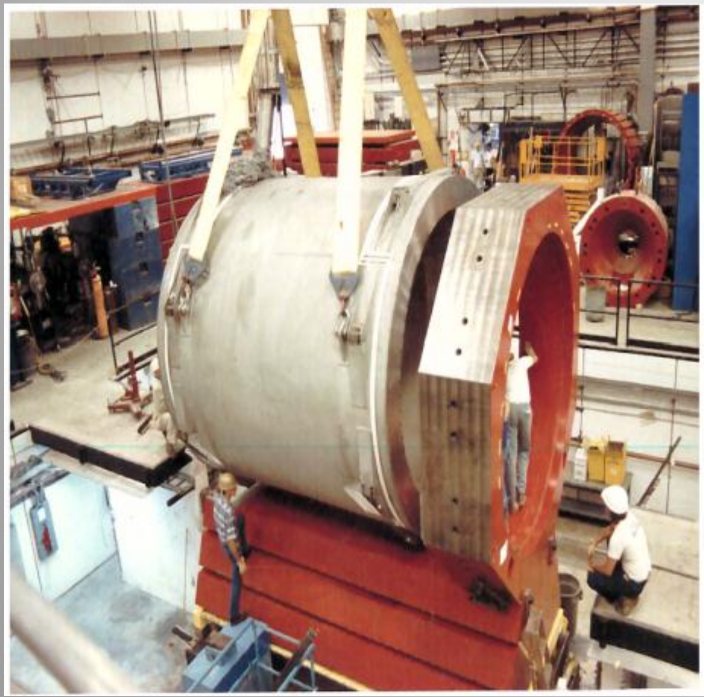
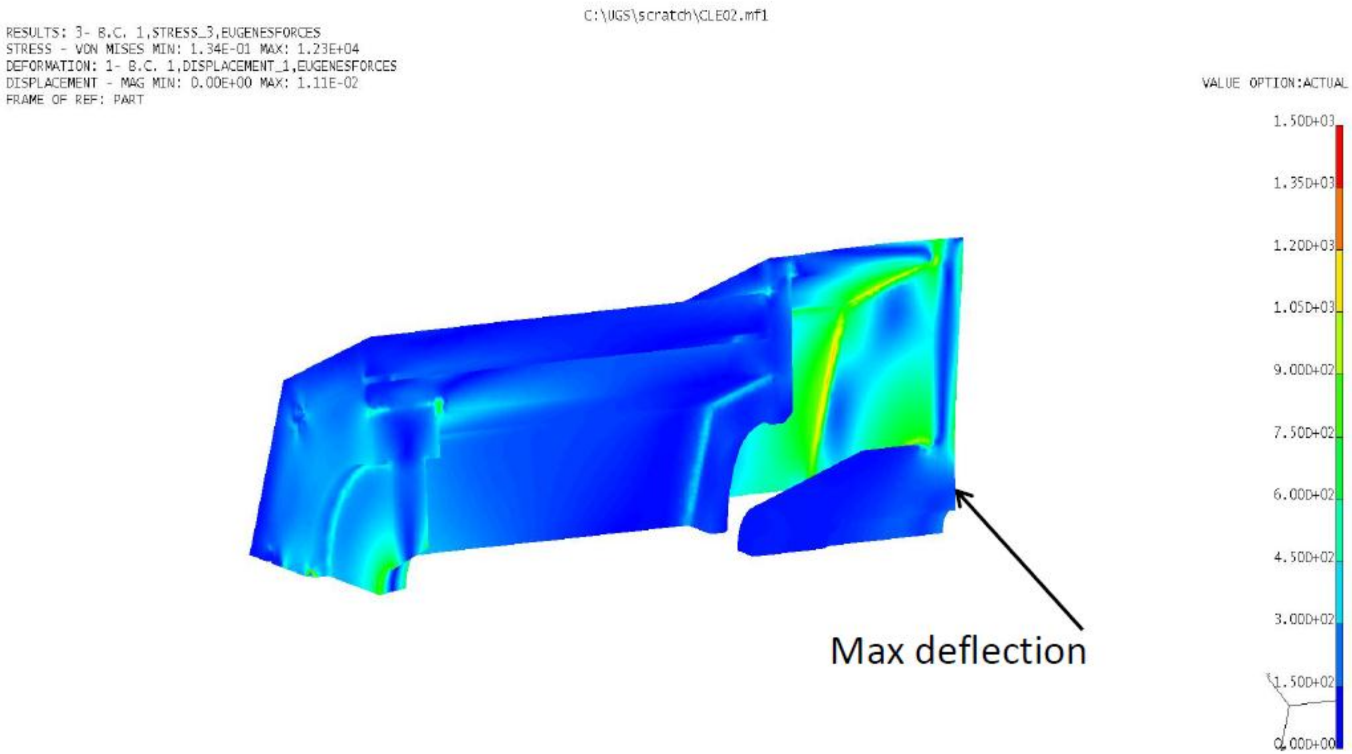


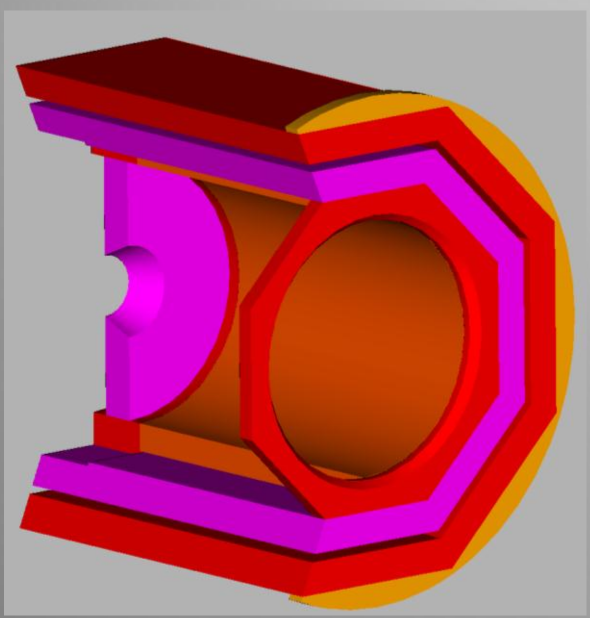
Maximum Von Mises stresses on the model

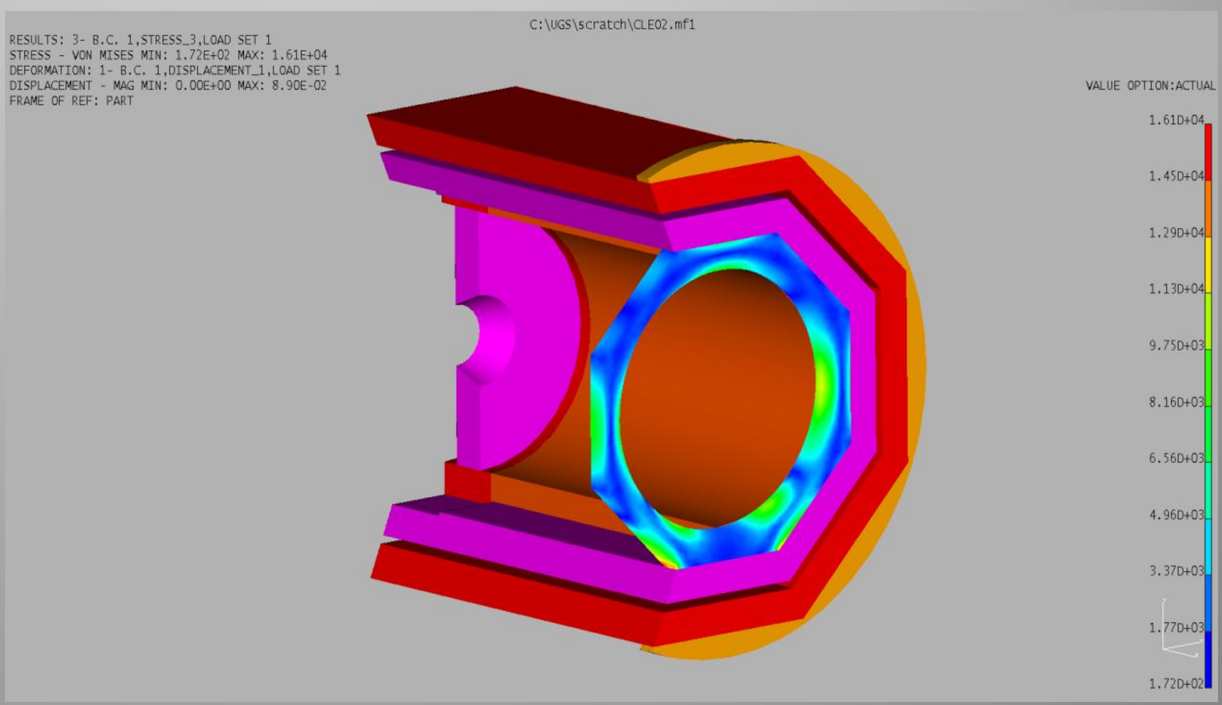
Maximum Von Mises stresses do not exceed <u>1500 psi</u>. (magnetic axial forces only)
Allowable yield stress 1006 steel is 24000 psi.
Maximum deflection is 0.011" = 0.2794mm where region 15 and 16 meet.
Maximum shear was approximately 750 psi and acceptable. (not shown)



New downstream coil collar

- Allowable stress for 1008 hot rolled steel = 14820 psi
- Peak stress due to rigid constraint at the bottom is the only overstress. Conservative simple restraint.
- Buckling not checked – will be retained by the slabs.
- Forces due to gravity only





Detector hut stress analysis

Half of detector weight placed on the outer shell and half on the nose
Forces due to gravity only
Only overstress is from rigid constraint

- Light gas Cherenkov = 6 metric t
- Heavy gas Cherenkov = 8 metric t (assumed)
- Calorimeter = 23 metric t
- W forward angle absorber = 13 metric t