sPHENIX Director's Review

OUTER HCAL DETECTOR

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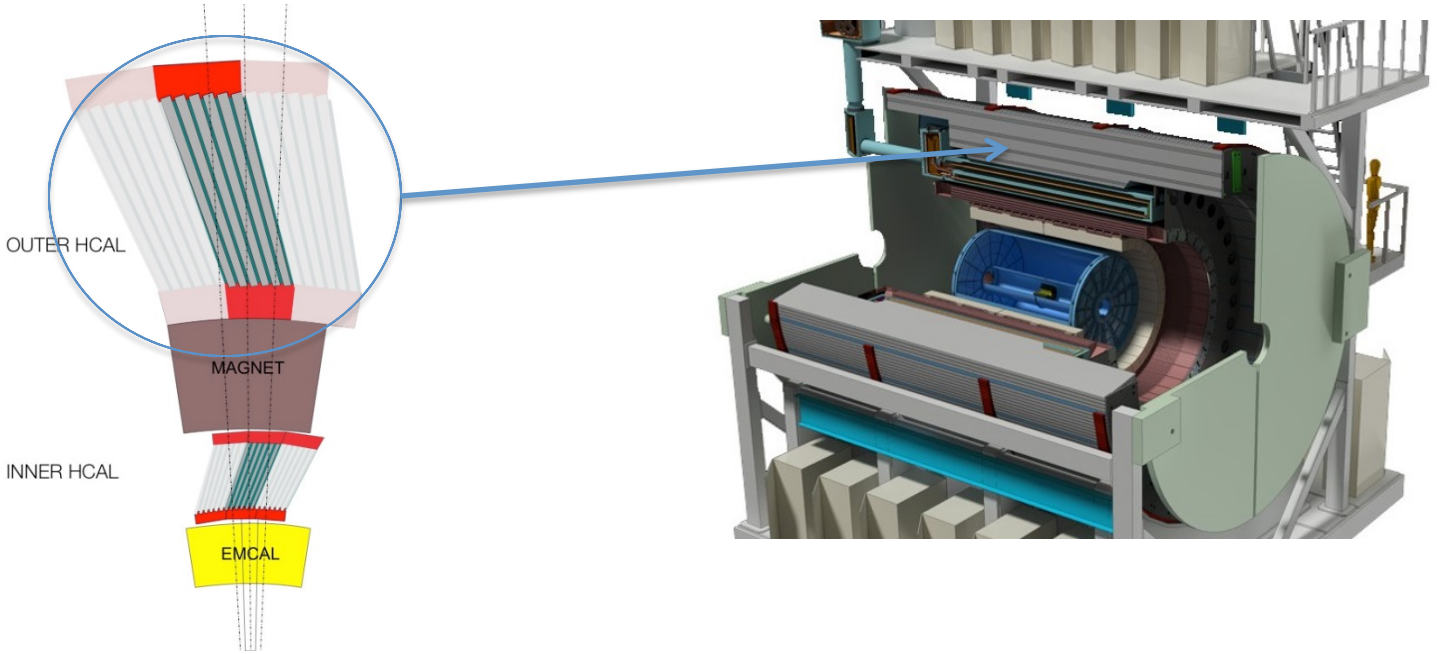
August 2-4, 2017

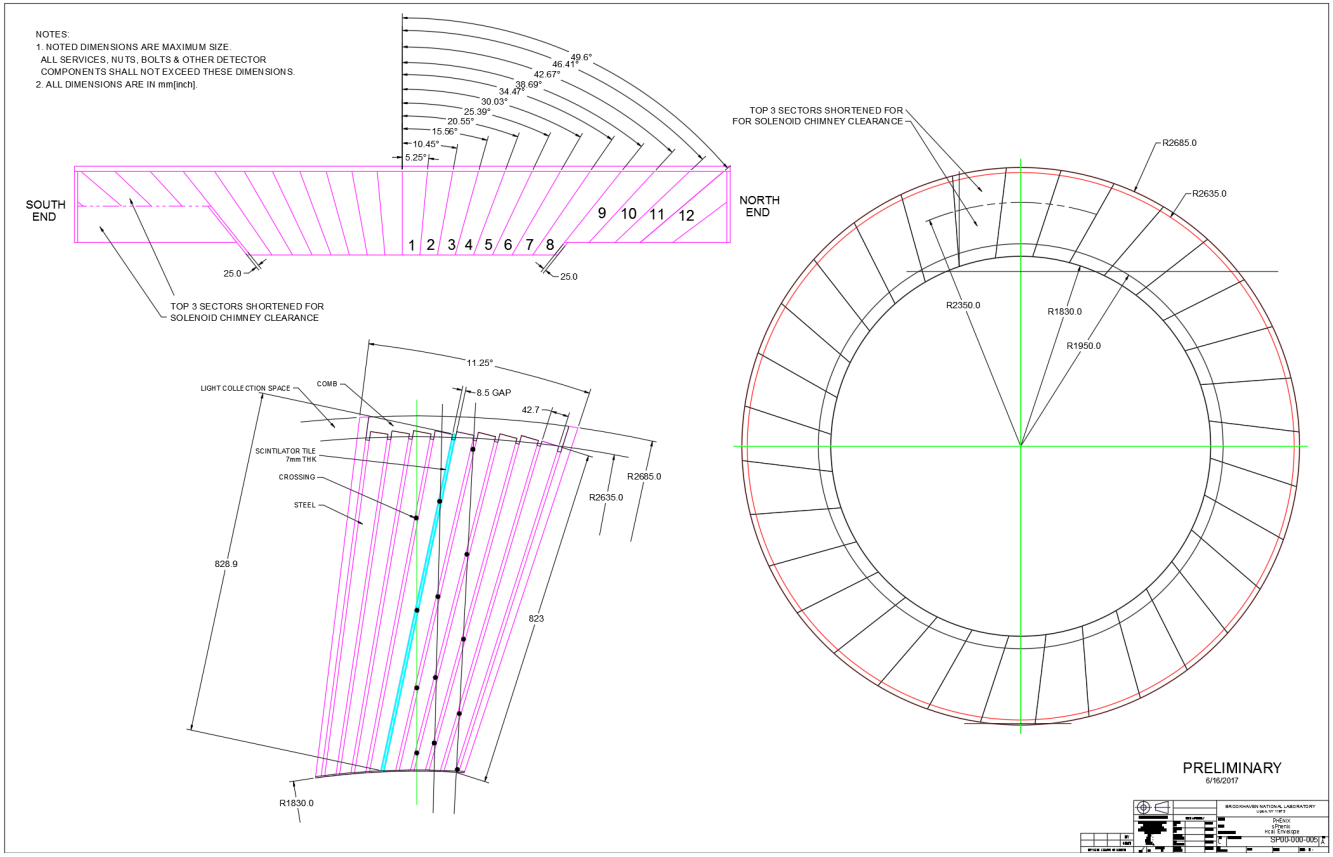
BNL

sPHENIX OUTER HCAL Description



- HCAL steel-
  - **HCAL ABSORBER STEEL**
  - **MAGNET FLUX RETURN**
  - **STRUCTURAL SUPPPORT FOR INNER DETECTORS AND MAGNET**
- Scintillating tiles with wavelength shifting fiber
- SiPM Readout

The Subsystem Technical Overview

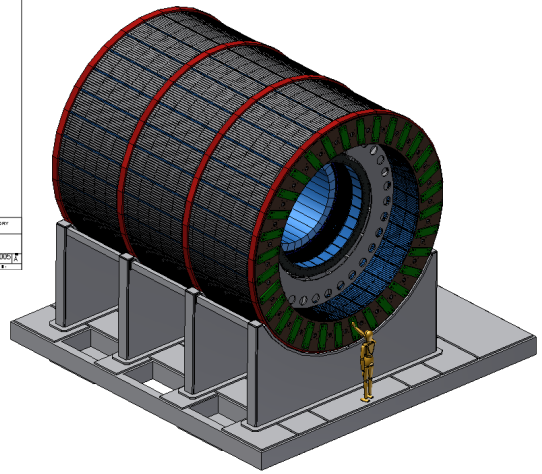


32 SECTORS, 13.5 tons each

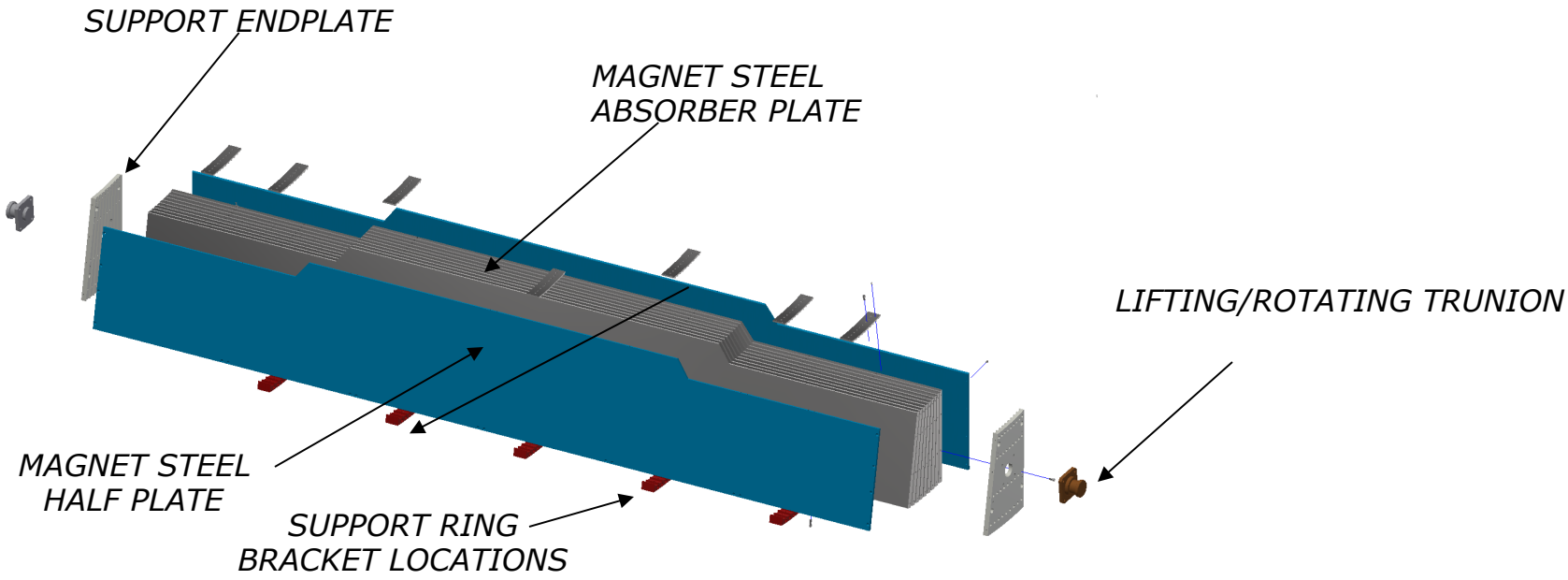
INNER RADIUS 1.9m
OUTER RADIUS 2.6m

10 GAPS of 7mm Scint Tiles
24 Tiles in each row.

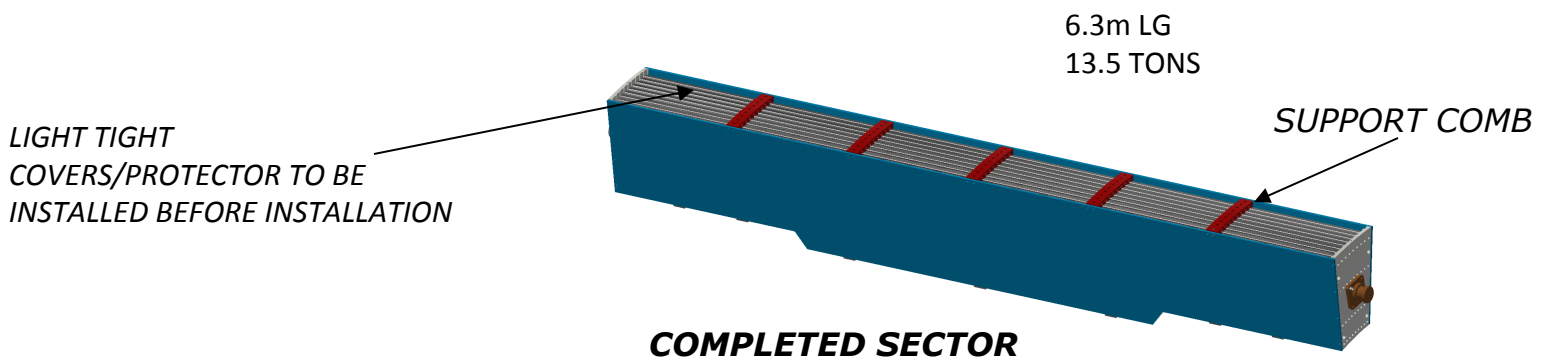
~26.1mm - ~42.4mm
Tapered 1020 Steel Plates



OUTER HCAL SECTOR



6.3m LG
13.5 TONS

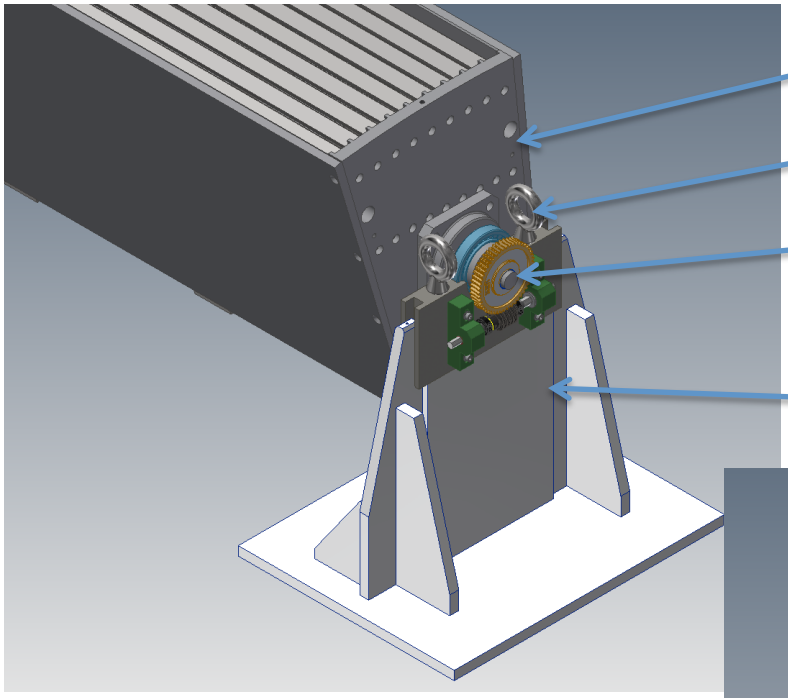


COMPLETED SECTOR

Design Drivers

- Outer HCal structure
  - Absorbers designed for HCal performance
  - Also serve as structural support for all internal detectors and SC Magnet (load transfer to Cradle carriage)
  - Also serve as magnet flux return
- Scintillating tiles with embedded waveshifting fiber
  - HCal performance
- Why a tilted plate design?
  - A tilted plate design can provide a uniform acceptance, adequate energy resolution and simplified construction
- How are the tilt angles chosen?
  - **Chosen to avoid channeling (tails in resolution function)**
- Lifting, Handling

OUTER HCAL HANDLING FIXTURES



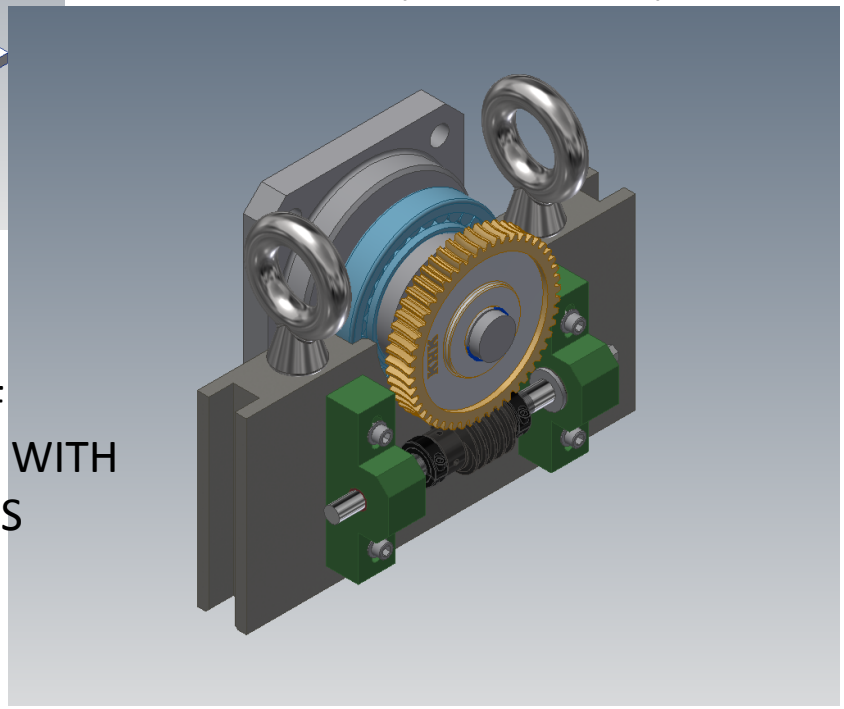
OUTER HCAL SECTOR

LIFTING FIXTURE

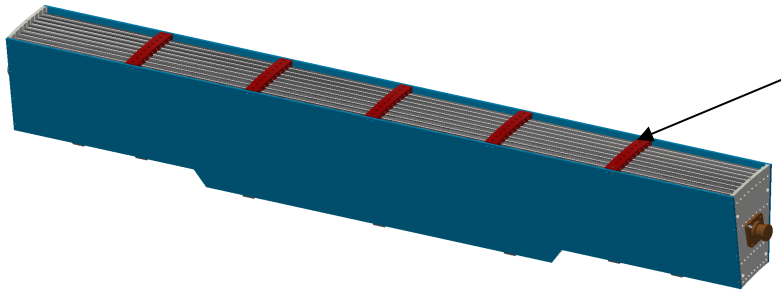
SECTOR ROTATION ATTACHMENT (WORM GEAR)

HOLDING FIXTURE (BASE STAND)

CLOSER VIEW OF LIFTING FIXTURE WITH ROTATION GEARS



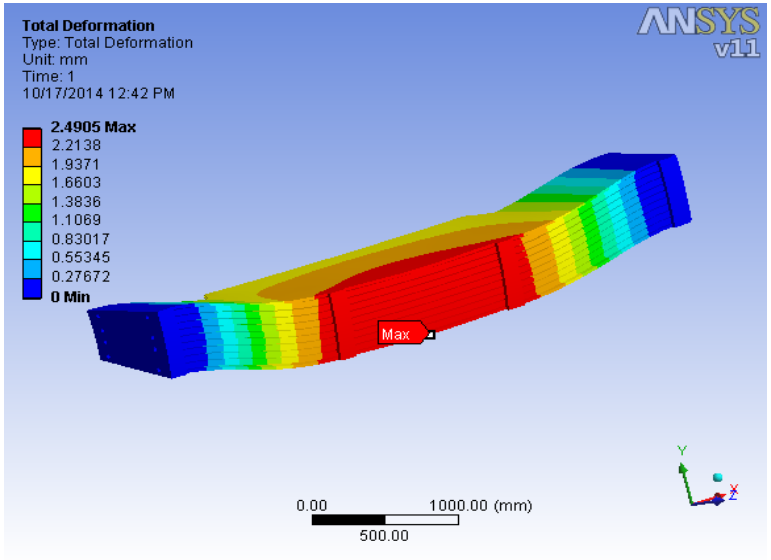
OUTER HCAL SECTOR ANALASYS



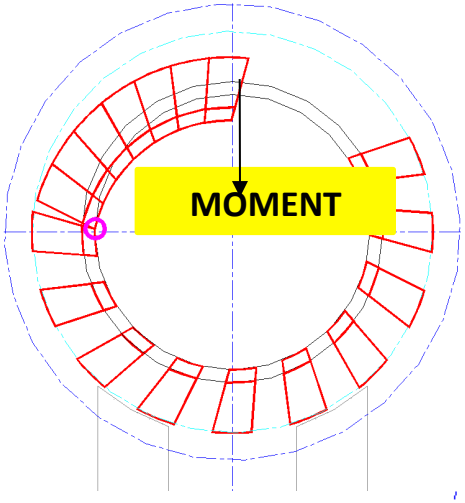
TOTAL DEFORMATION
WITHOUT SUPPORT COMBS 4.6mm

TOTAL DEFORMATION
WITH 5 SUPPORT COMBS ON TOP
7 COMBS ON BOTTOM 2.5mm

WORST CASE SCENARIO – HORIZONTAL LIFT

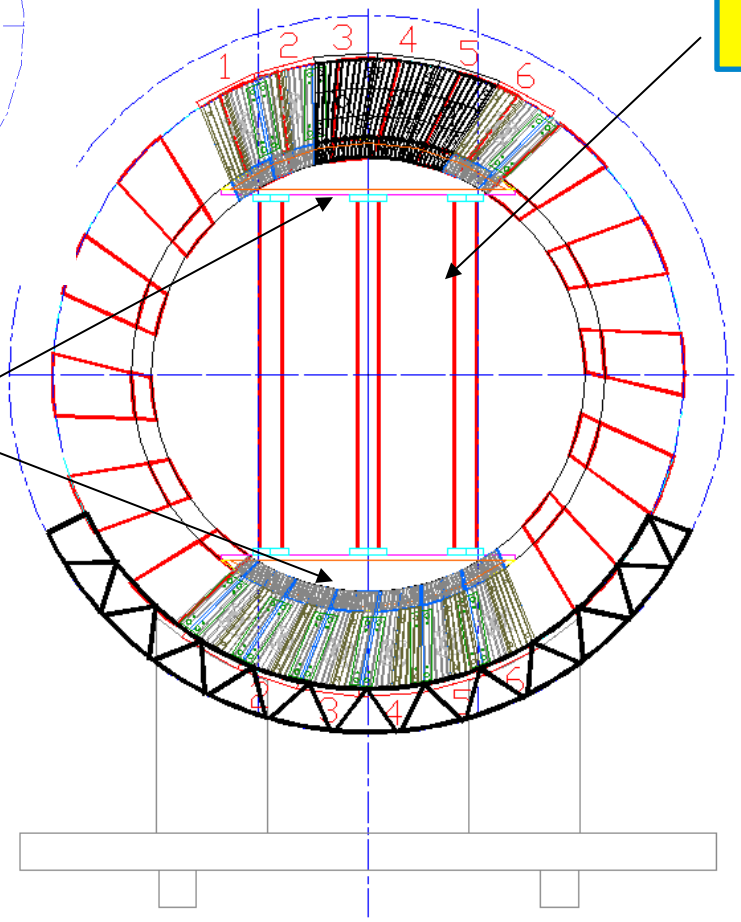


TEMPORARY SUPPORT FOR TOP SECTOR INSTALLATION

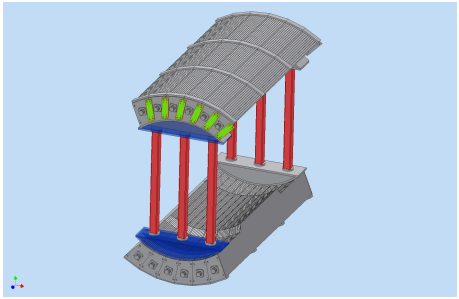


FRONT AND BACK SUPPORT COLUMNS

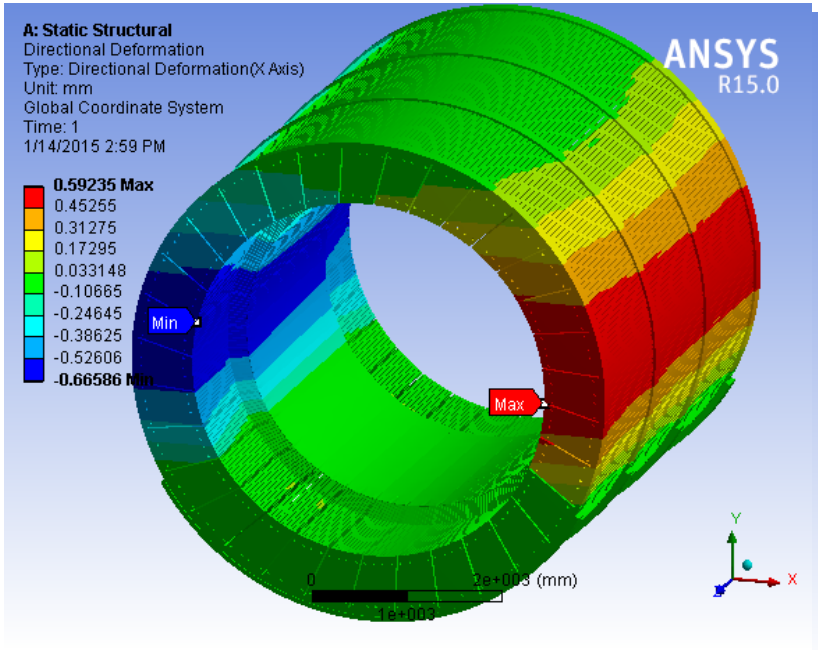
TOP AND BOTTOM FRAME SUPPORTS

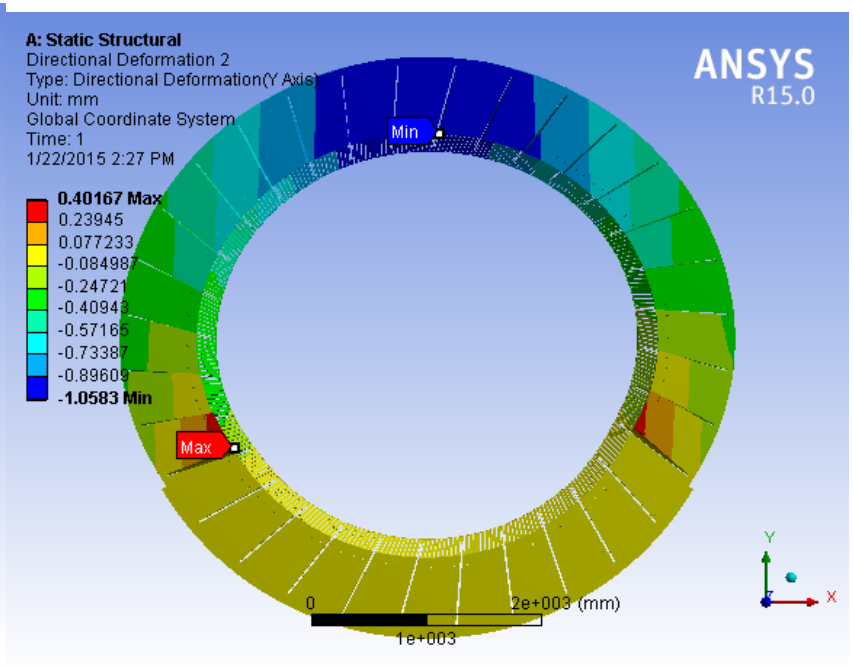


ONE POSSIBLE SOLUTION SHOWN. OTHER OPTIONS INCLUDE USING HYDRAULIC PISTONS BETWEEN SECTOR TRUNIONS TO ACHIEVE ADEQUATE SEPARATION FOR INSTALLATION



COMPLETED ASSEMBLY ANALYSYS





X DEFORMATION +/- 0.6mm

Y DEFORMATION 1mm MAX

FINAL ASSEMBLY DEFORMATION IS WITHIN TOLERANCE AFTER REMOVAL OF TEMPORARY SUPPORTS

Additional Analyses in Backup

Resources/Cost Drivers

- Cost is dominated by Sector steel and machining costs
  - **1020 A36 steel 6.3 meters long**
  - **Mechanical assembly at vendor**
  - **Fixed price contract option in place with vendor for full scale prototype**
- Scintillator tile production
  - **Surface flatness over long distances a key specification**
    - **Wrapped tile thickness < 7.5mm, Uniplast can meet this spec.**
  - **Uniplast (T2K, PHENIX)**
    - **FNAL/Elgen also investigated, Uniplast most economical for complete tile assemblies**
- Final Tile and Electronics Assembly at BNL
  - **University labor (installing tiles, testing)**
  - **BNL Labor (sector handling electronics connections, general technical support)**
  - **Lifting and handling fixtures**

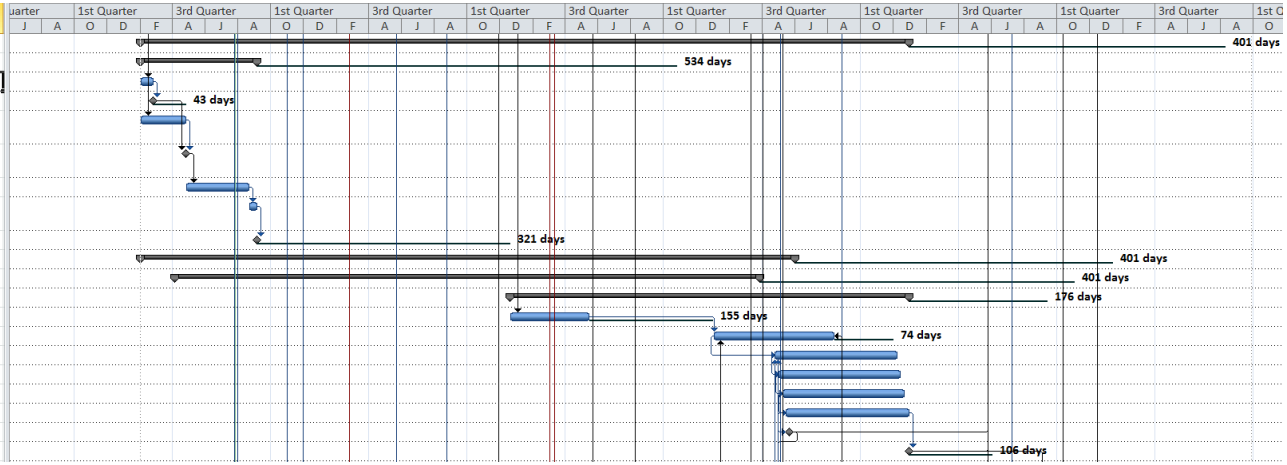
Schedule Drivers

- Sector Mechanical Prototypes: Contract for full scale prototype with option for production
- Scintillating Tiles
- Sector assembly and testing
  - **Location at BNL currently being negotiated (912 floor)**
  - **Plan to have parallel lines for**
    - **Inspection Tile assembly**
    - **Electronics assembly**
    - **QA testing**
    - **Prep for delivery to 1008**
  - **4 sets of stands**
  - **2 sets of handling/lifting fixtures**
- Planned mechanical sector delivery- 4/month

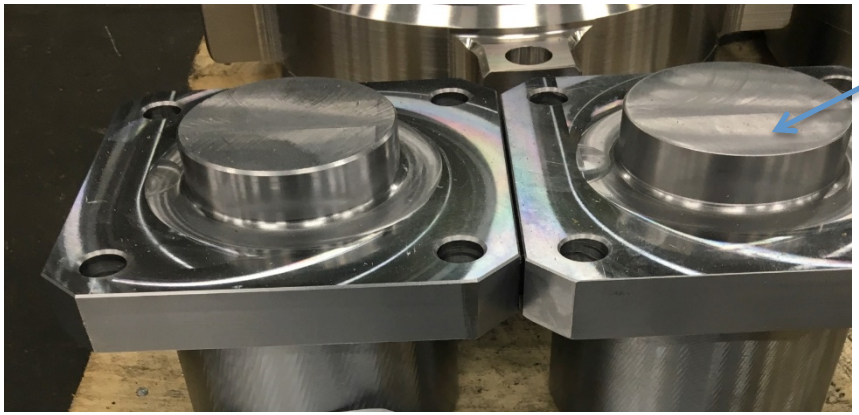
Production schedule integrates availability of electronics/SiPMs (WBS 1.5).

BNL labor planned. Schedule slip in assembly can be addressed by adding additional University labor.

Task Mode	WBS	Name
	1.4.3	**Outer HCAL**
	1.4.3.1	**Outer HCAL Sector Prototyping**
	1.4.3.1.1	Outer HCAL Prototype v2.0 Test Beam Operation
	1.4.3.1.2	Complete Outer HCAL Prototype v2.0
	1.4.3.1.3	Procurement for Outer HCAL Prototype v2.1 Mechanical Structure
	1.4.3.1.4	Award Procurement for Outer HCAL Prototype v2.1 Mechanical Structure
	1.4.3.1.5	Outer HCAL Prototype v2.1 Mechanical Structure Production
	1.4.3.1.6	Incorporate Feedback from Prototype v2.1 into Outer HCAL Design
	1.4.3.1.7	Complete Outer HCAL Prototype v2.1
	1.4.3.2	**Outer HCAL Sector Mechanical Structure**
	1.4.3.3	**Procure Outer HCAL Scintillating Tiles**
	1.4.3.4	**Outer HCAL Sector Assembly, Testing and Integration**
	1.4.3.4.1	Prepare Outer HCAL sector assembly and testing area
	1.4.3.4.2	Populate Outer HCAL sectors with scintillating tiles
	1.4.3.4.3	Populate Outer HCAL sectors with electronics
	1.4.3.4.4	Outer HCAL Sector LED testing and Light Tighting
	1.4.3.4.5	Outer HCAL Cosmics testing and initial calibration
	1.4.3.4.6	Outer HCAL Sector Transportation to 1008/Staging Area
	1.4.3.4.7	First Outer HCAL Sector Available for Installation
	1.4.3.4.8	Last Outer HCAL Sector Available For Installation

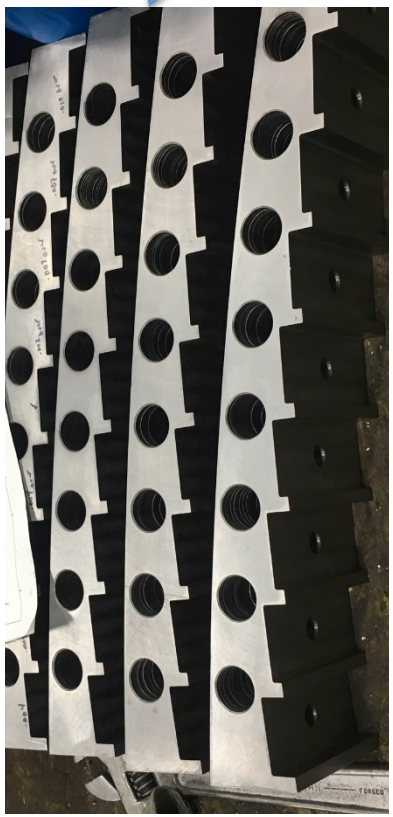


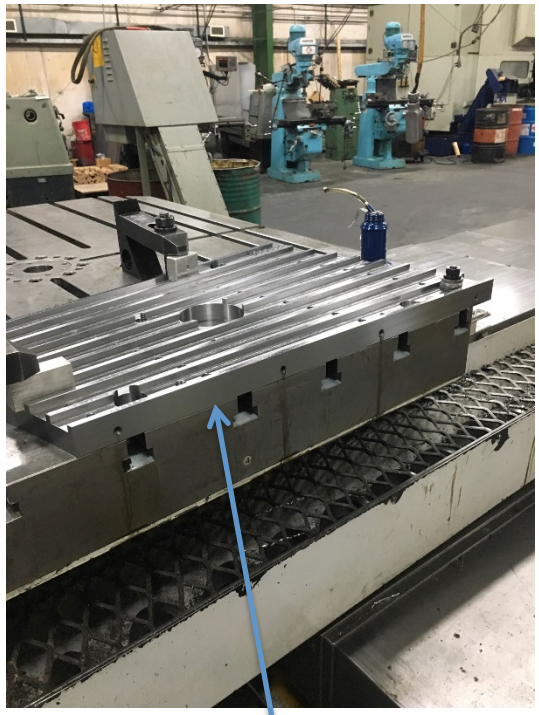
Full Scale Prototype Sector in Progress



Trunions

Combs





End Plates

Absorber Plates

Full assembly to be delivered to BNL August 2017

Outer HCAL Assembly Area

Building 912

- Area behind Door 16 and behind former RPC tent
- 40 Ton crane, 5 Ton aux.
- 1 Ton mobile gantry
- 30’ x 16’ Tent

Status and Highlights

- Analyses are continuing (near completion)
  - Outer HCal to Cradle carriage
  - Adding SC Magnet, Inner HCal and EMCAl support loads to model
  - Splice Plate and Pin stresses
  - Modified sectors (with cut out for SC Magnet Chimney extension)
- Lifting fixture design (including rotation attachment) nearly complete
  - Design to be submitted to BNL lifting safety committee this month
  - Tile/electronics assembly stands detailed awaiting final approval for fabrication
- Full scale prototype sector in production at vendor. (Delivery late summer 2017)
  - Validate and qualify lifting and handling fixtures/tools
  - Evaluate tile holding features and alignment
  - Evaluate cable management
  - Partial instrumentation to validate operational characteristics with cosmic rays
  - Evaluate light tightness design
  - Test structural integrity in all installed orientations

Summary

- Design is maturing rapidly
- Analyses indicate acceptable structural integrity
- Full scale prototype sector (near final design) in production
- Design drawing package nearly complete
- Interfaces with Cradle Carriage and other detectors under development
- Assembly area at BNL to be finalized shortly (candidates identified, negotiating availability)
- Cost and production schedules being validated with full scale prototype sector

Back Up

1ST HCAL MODULE INSTALLATION

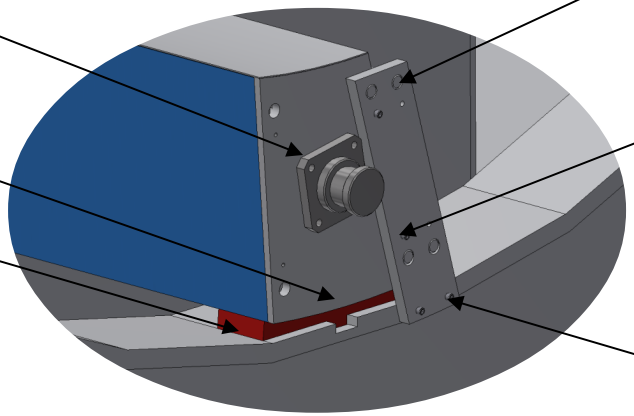
LIFTING/ROTATING TRUNION

1ST MODULE SHIMMED/SURVEYED AND KEYED IN PLACE

SHIM HERE

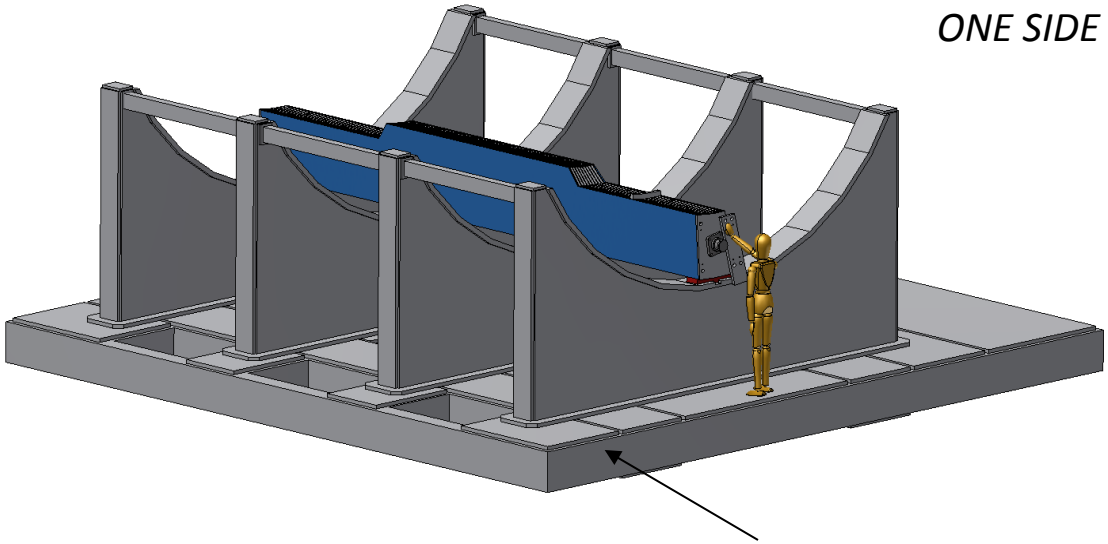
PINNED TO NEXT MODULE

BOLTED TO ENDPLATES



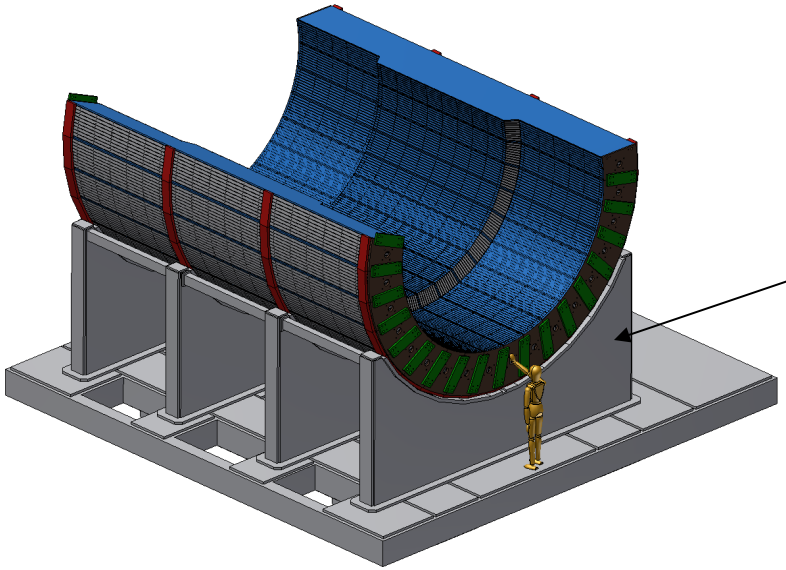
OUTER HCAL SERVES AS THE SUPPORT STRUCTURE FOR THE DETECTOR AND MAGNET FLUX RETURN

BOLTED TO CRADLE ONE SIDE



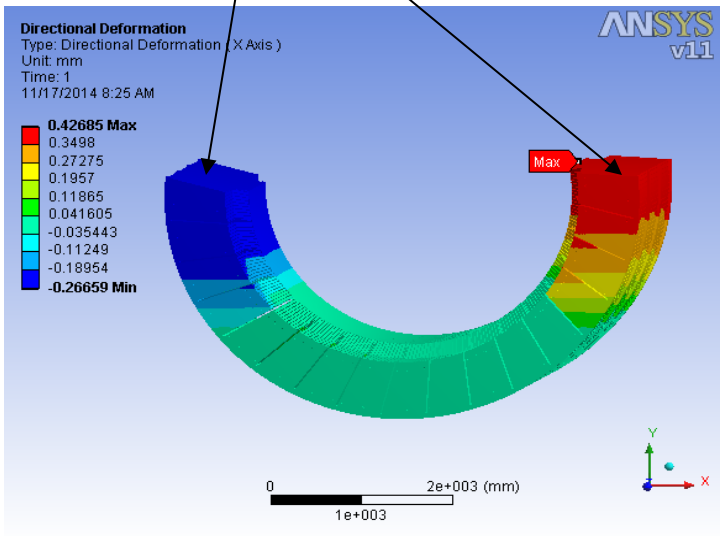
CRADLE CARRIAGE WELDMENT

~180 deg OUTER HCAL ASSEMBLED



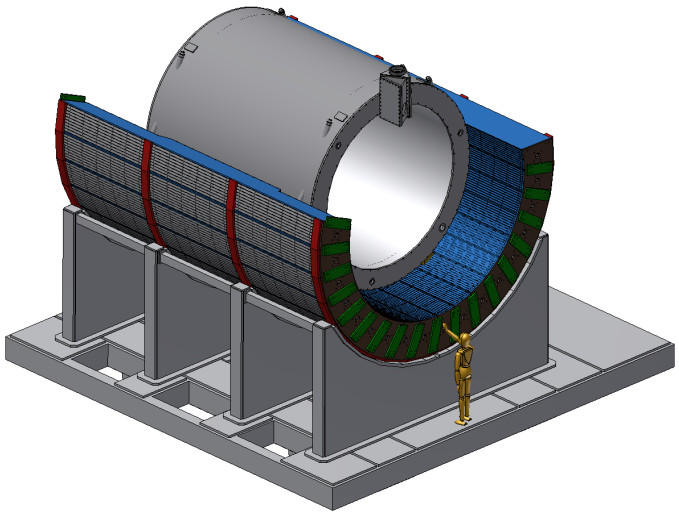
120 DEGREE OR MORE BOTTOM SUPPORT WILL BE SUFFICIENT

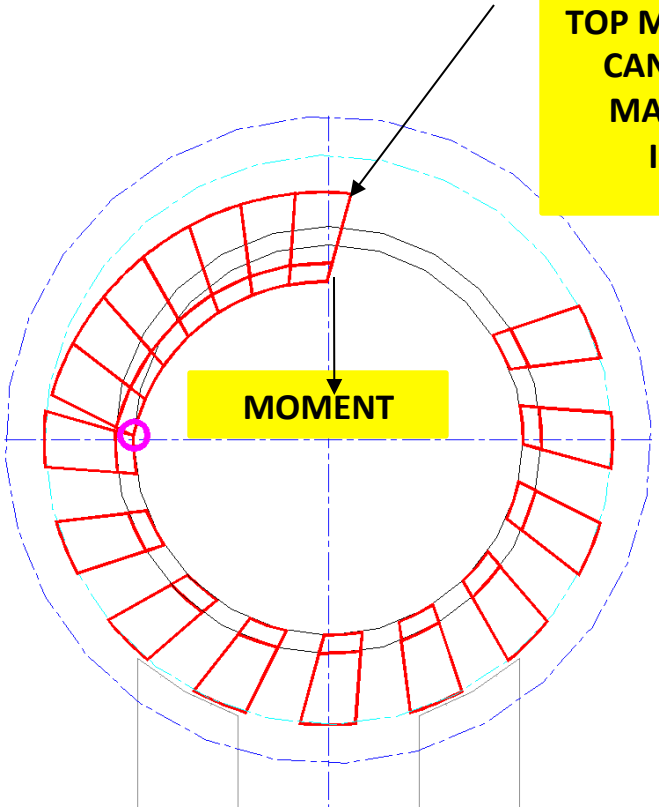
TOTAL DEFORMATION IS 0.4mm MAX



ASSEMBLE UPPER QUADRANT

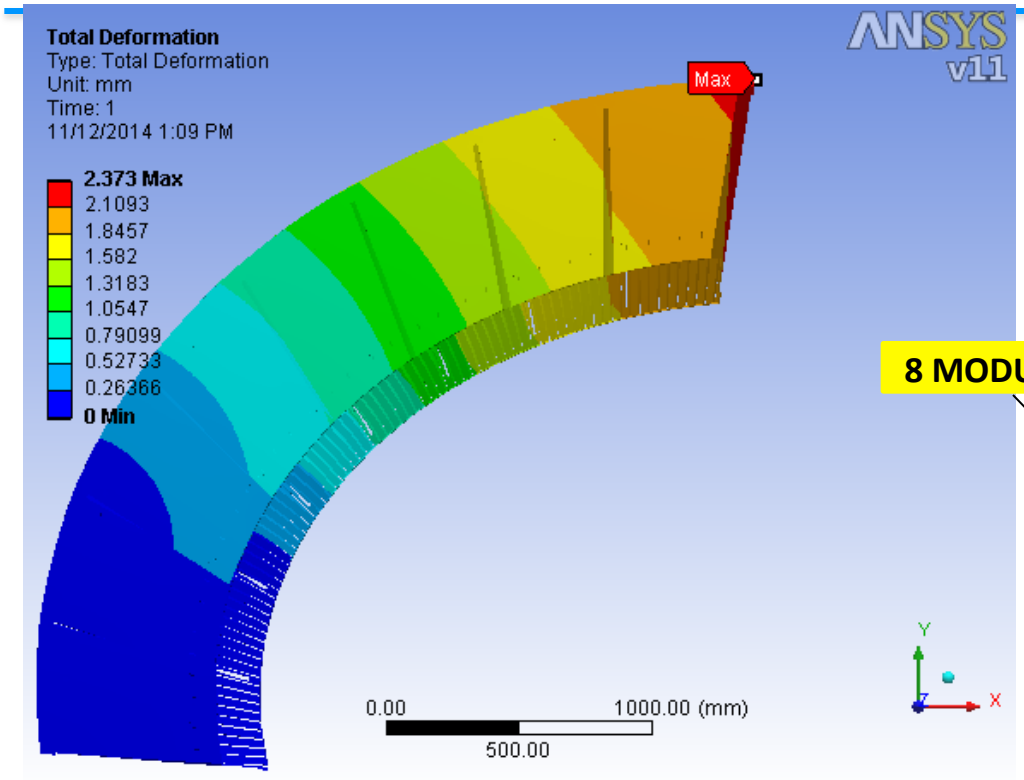
AFTER MAGNET IS INSTALLED
REMAINING SECTORS ARE INSTALLED





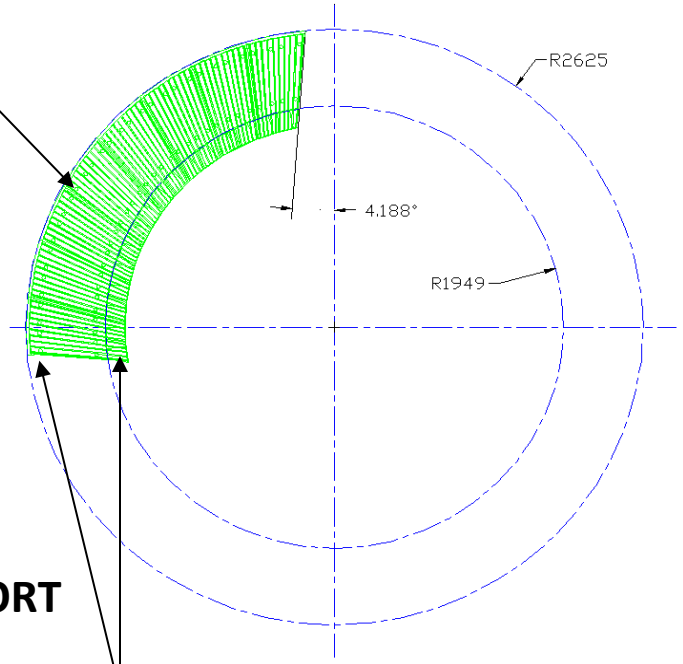
BOLTED SECTOR CONNECTION – FRICTION CONNECTION. TOP MODULE SECTION CAN ROTATE AND MAKE ASSEMBLY IMPOSSIBLE

ASSEMBLY DEFORMATION



2.3mm DEFORMATION

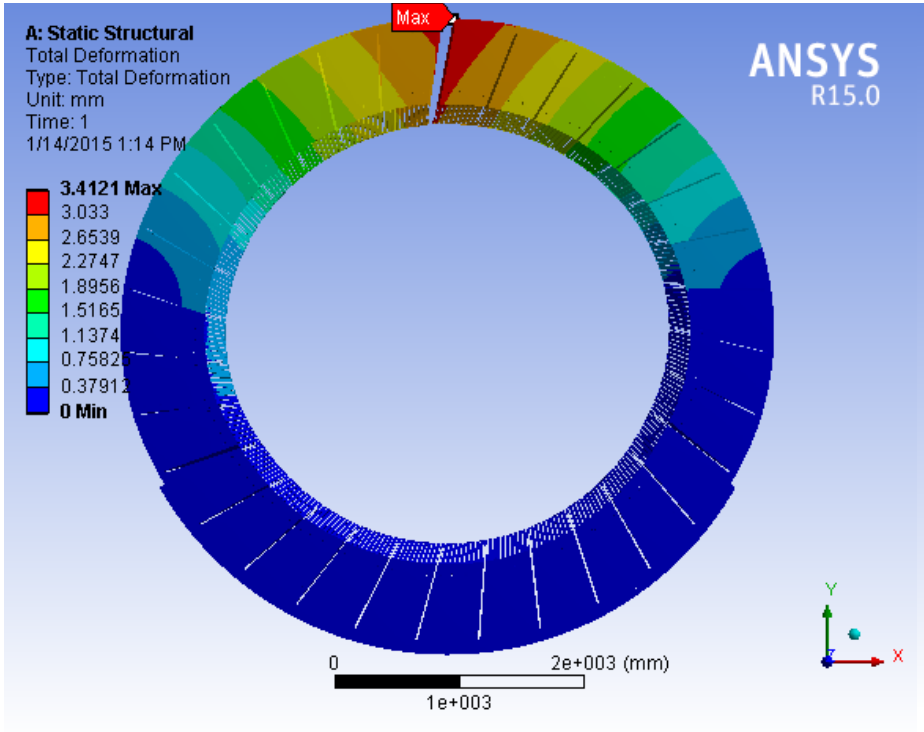
8 MODULES

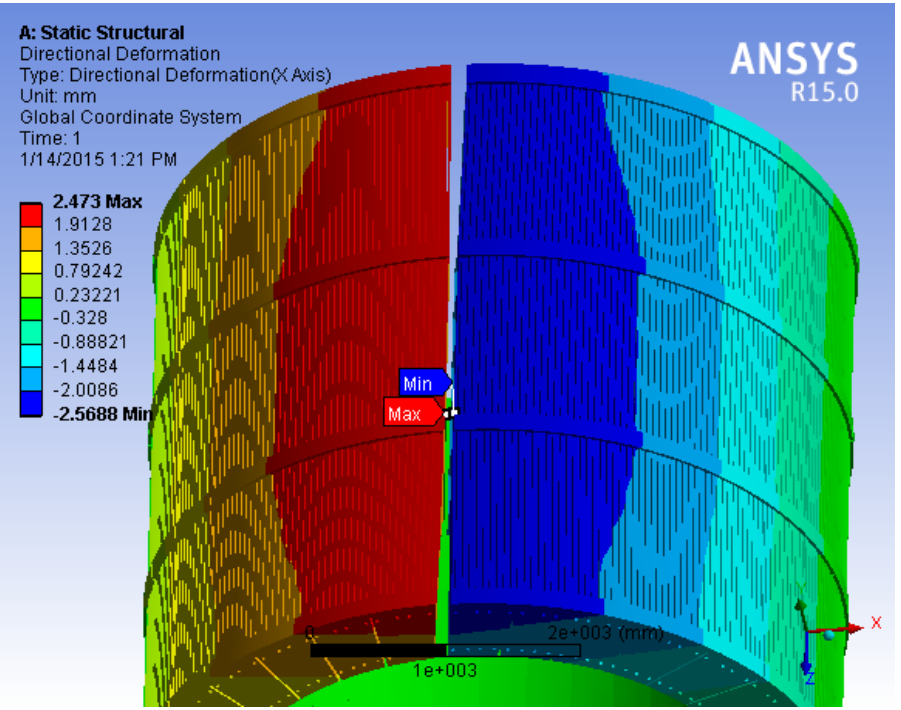


FIXED SUPPORTS

DEFORMATION IS TOO GREAT FOR INSTALLATION OF REMAINING SECTORS WITHOUT ADDITIONAL TEMPORARY SUPPORT

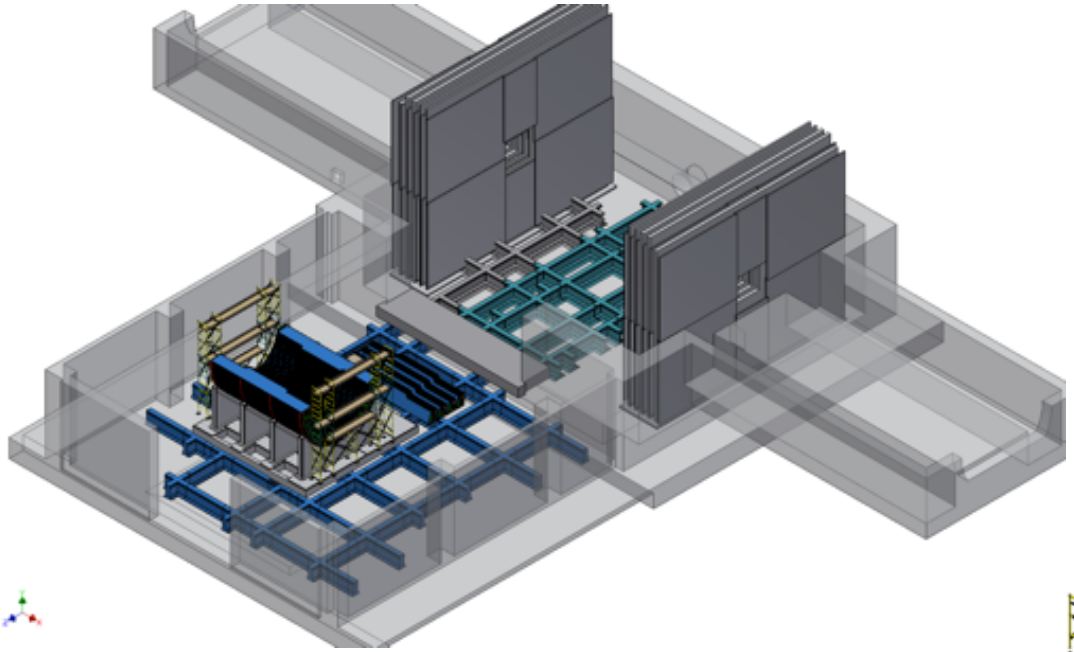
ASSEMBLY DEFORMATION

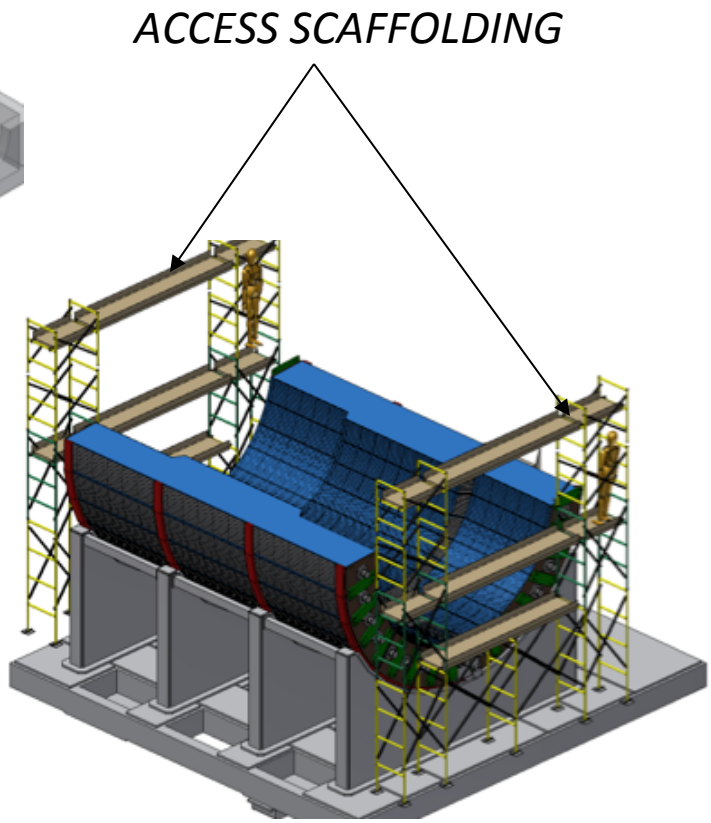




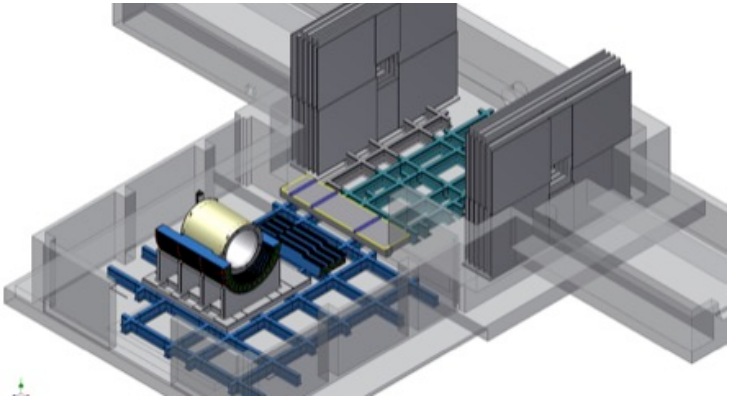
AN EXTERNAL SUPPORT IS REQUIRED
FOR REMAINING MODULES TO BE INSTALLED

OUTER HCAL LOWER HALF INSTALLATION

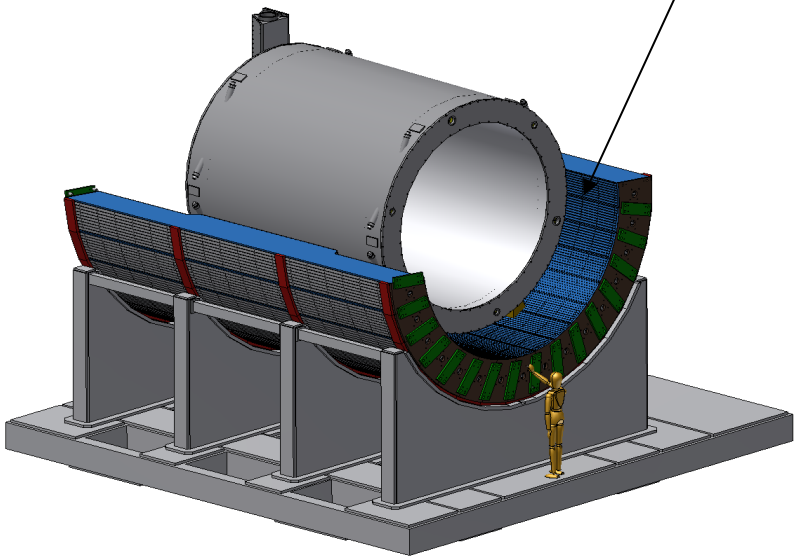




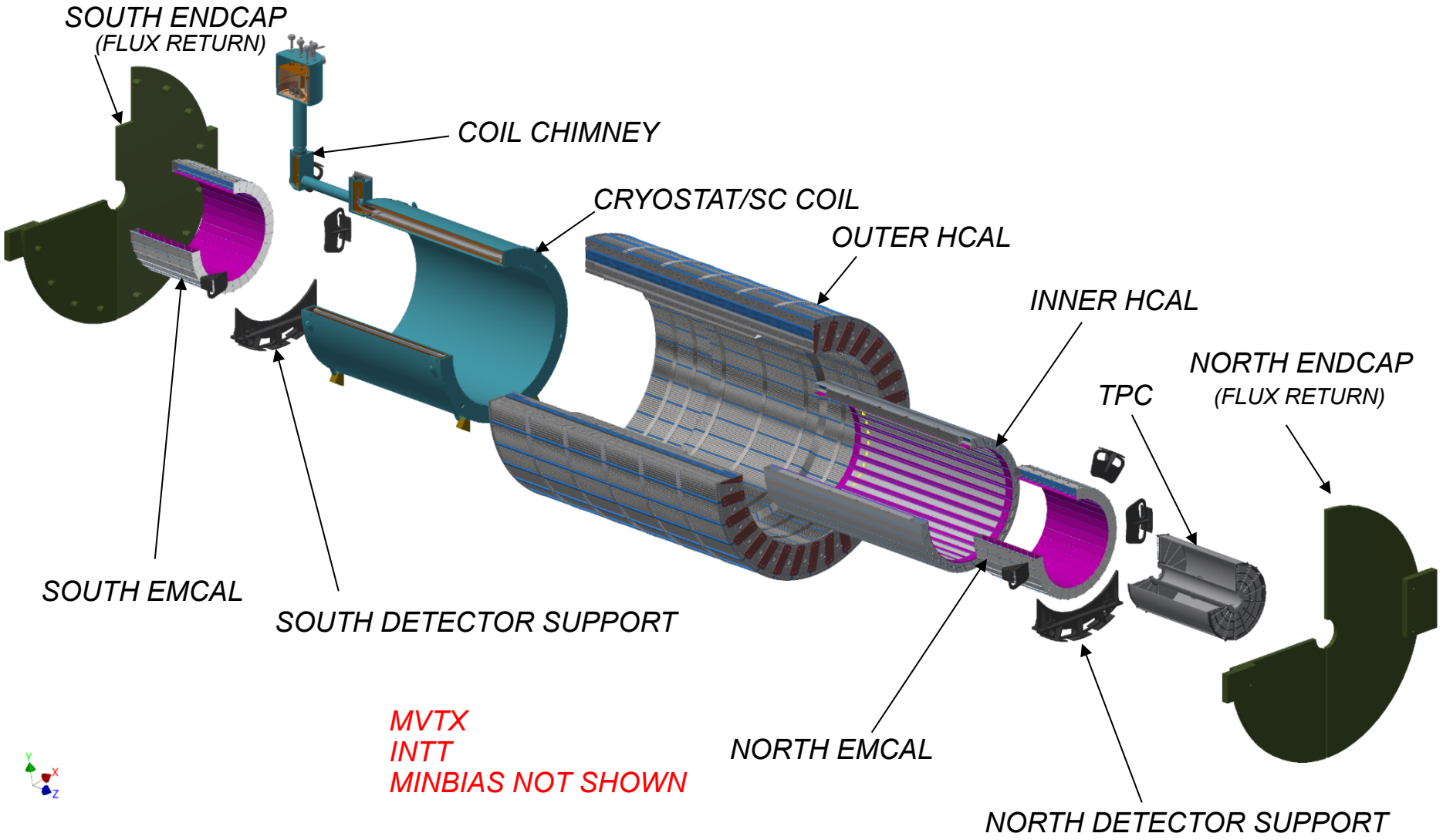
SC MAGNET INSTALLATION



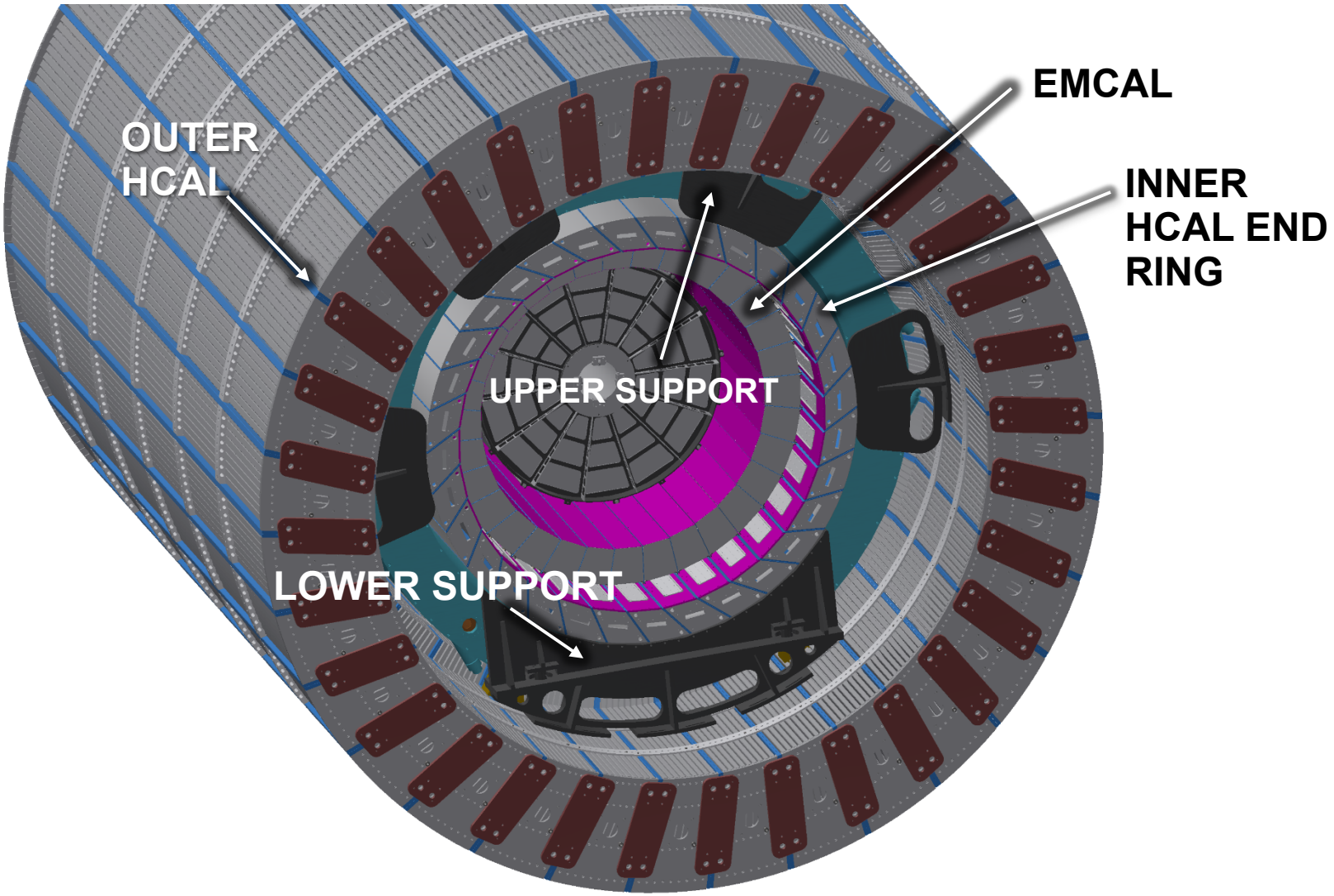
MAGNET IS SUPPORTED BY THE OUTER HCAL



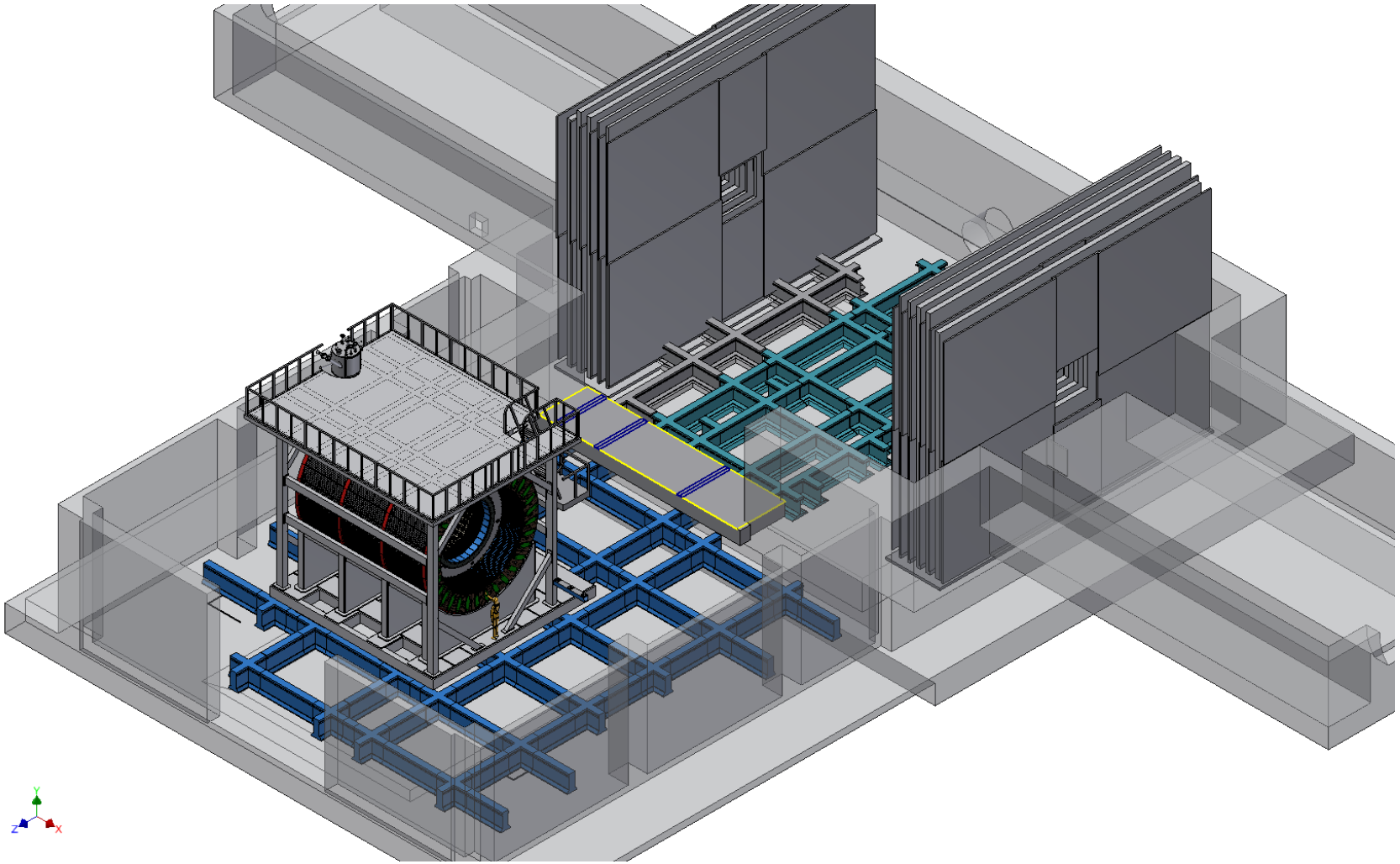
SPHENIX EXPLODED VIEW



INNER DETECTORS SUPPORT POINTS

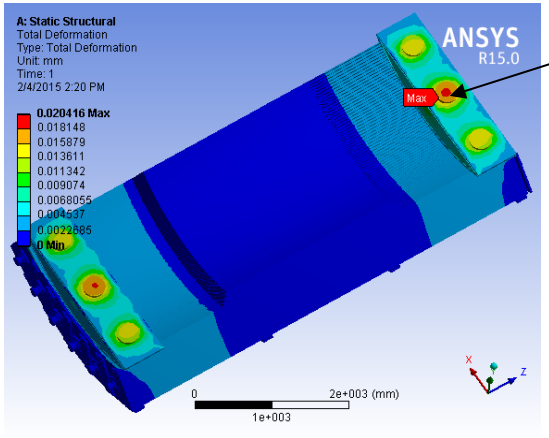


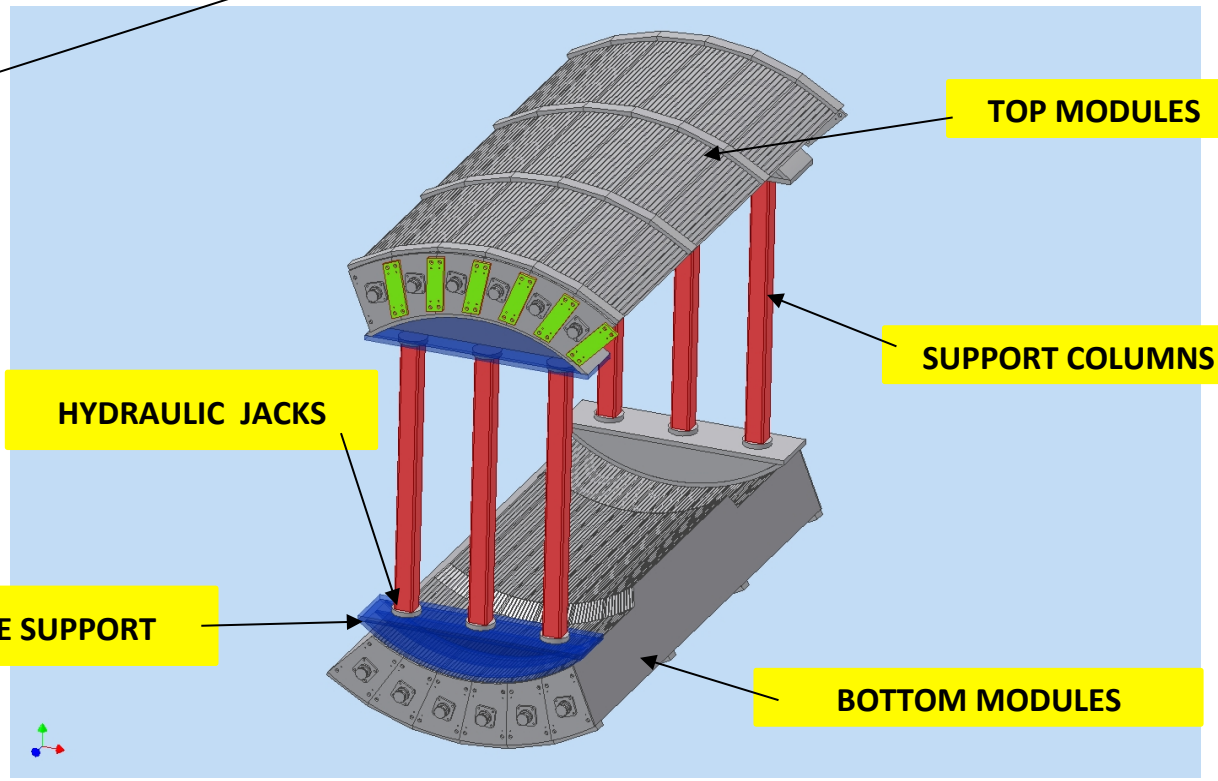
COMPLETED HCAL INSTALLATION



TEMPORARY SUPPORT FOR TOP MODULE INSTALLATION

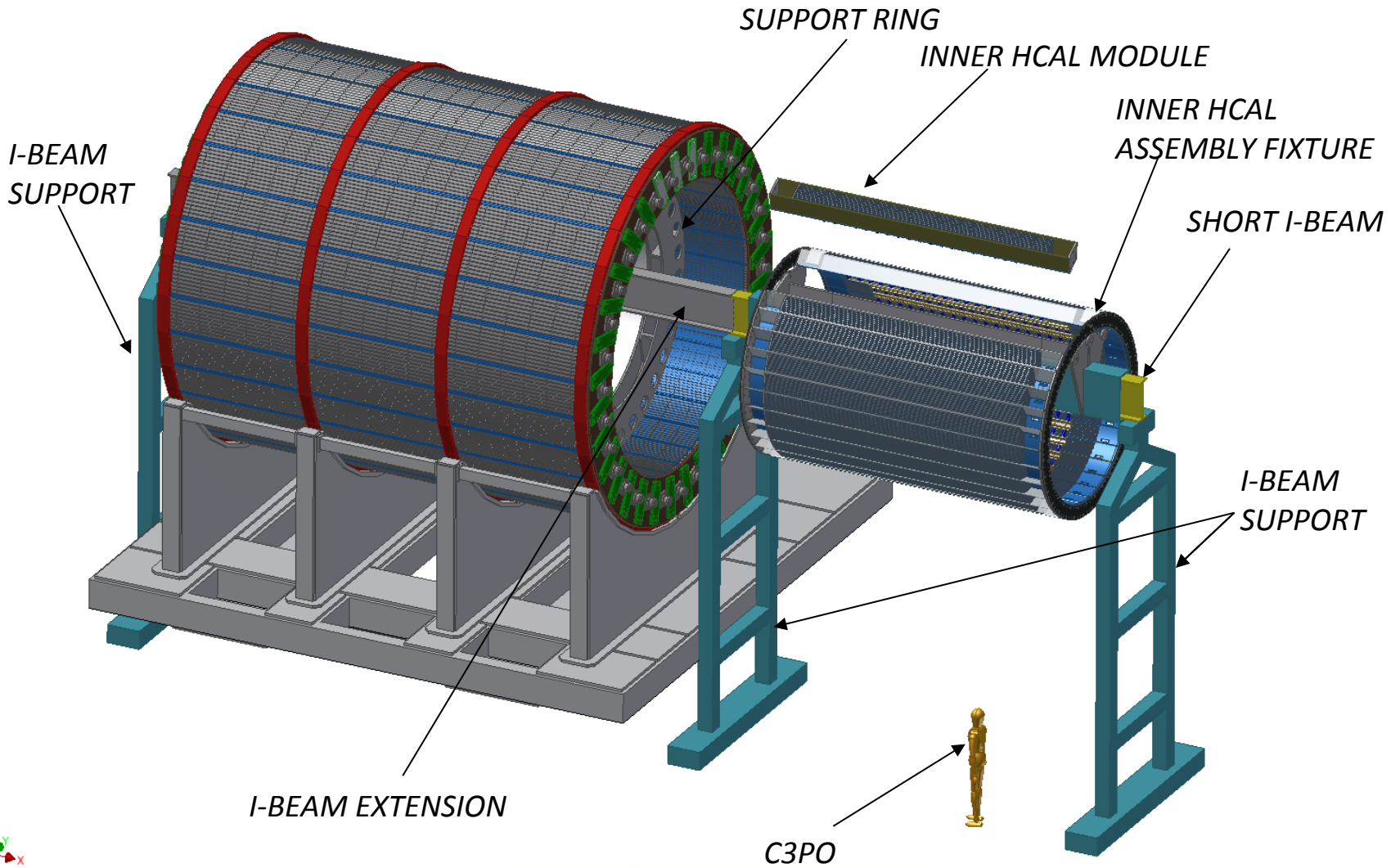
FRAME SUPPORT DEFORMATION IS ONLY 0.02mm



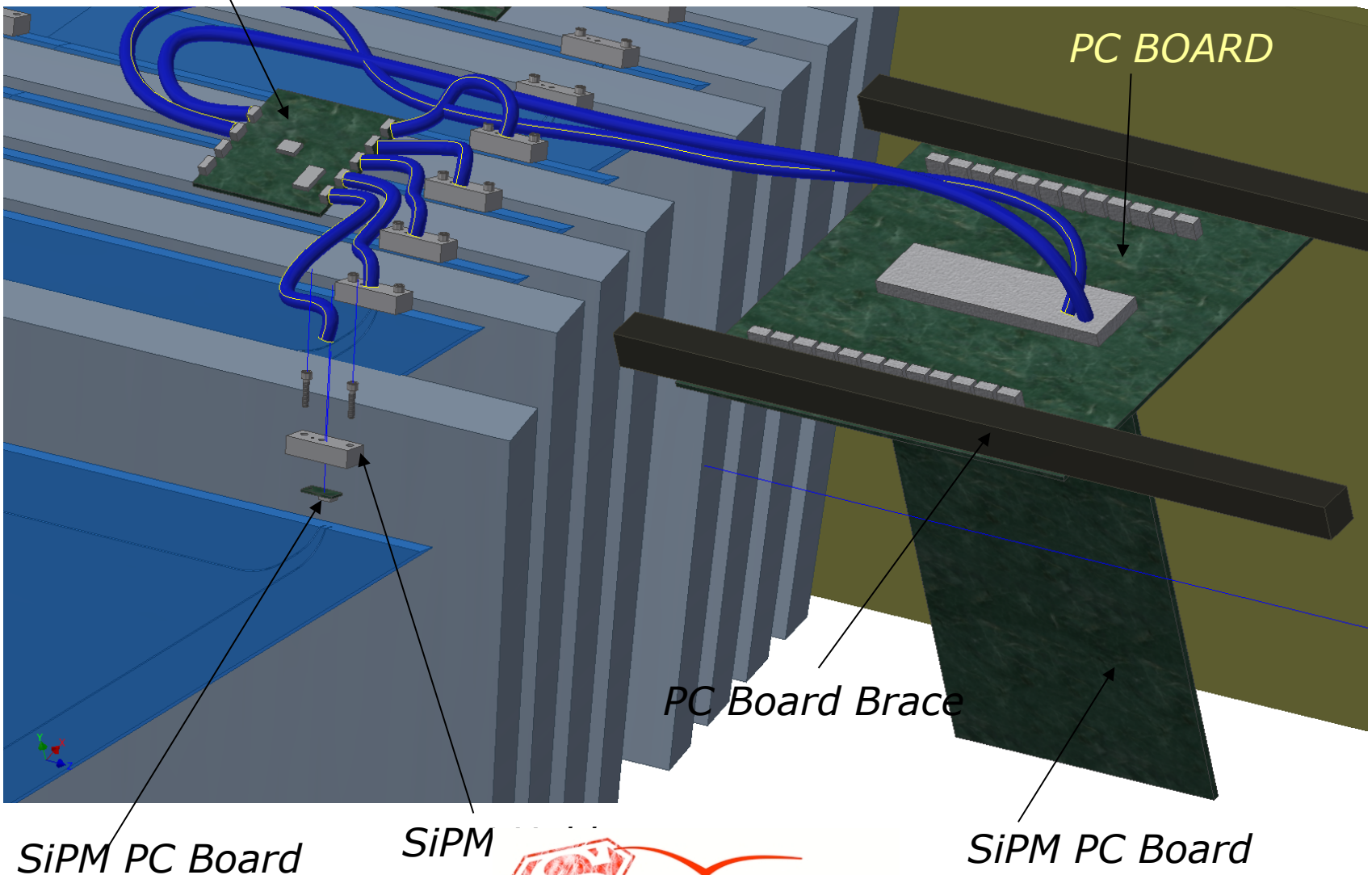


DEFORMATION DOES NOT EFFECT LOWER HCAL MODULES INTERNAL STRUCTURE

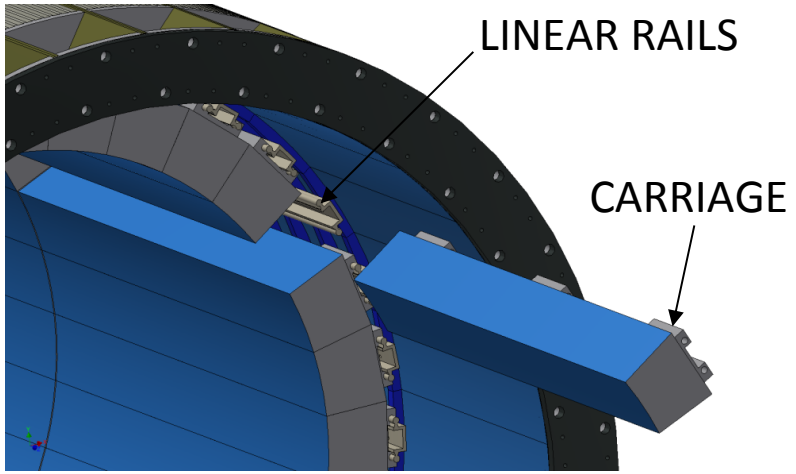
INNER HCAL INSTALLATION

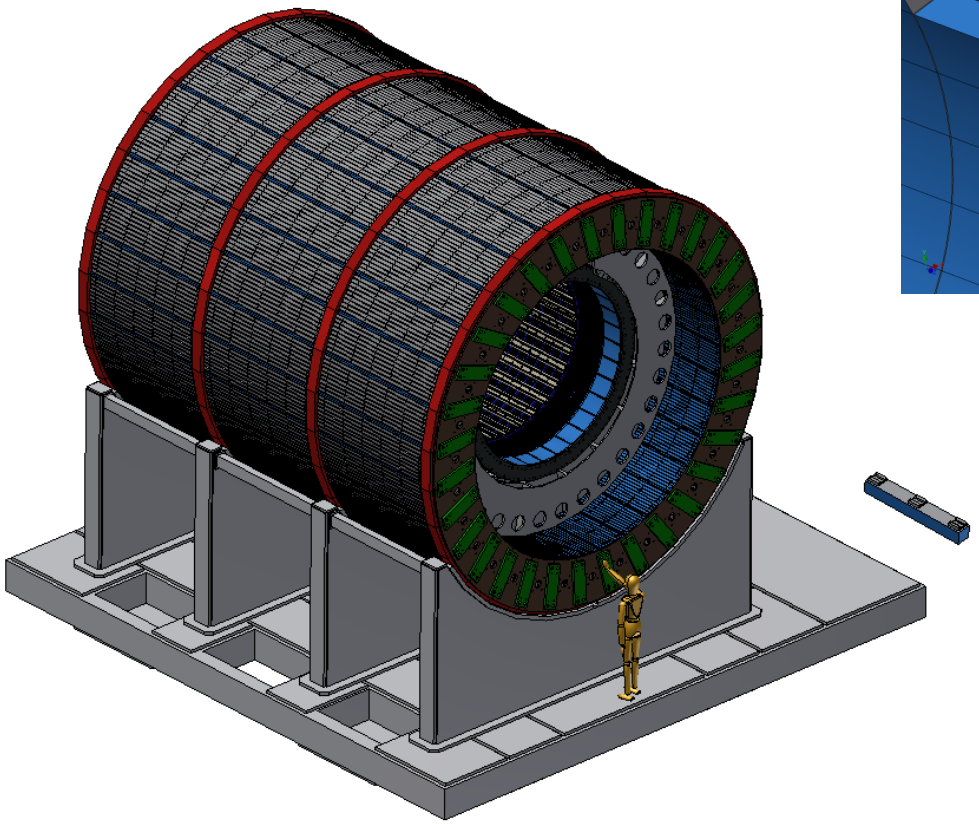


HCAL ELECTRONICS & CABLE ROUTING



EMCAL MODULES ATTACHED TO INNER HCAL





Risk Registry/Issues and Concerns

1.4 HCal	Loss of scintillating tile provider (Uniplast)	Uniplast is unable to engage in or complere the production contract	Schedule delay in the procurement of rthe scintillating tiles, along with corresponding delays in inner and outer HCAL assembly.	Moderate	Explore alternate scintillator vendors (FNAL, Elgin, IHEP).
1.4 HCal	Unable to produce inner HCAL in SS310 in a cost effective manner	Evaluation of inner HCAL prototype yields higher than anticipated production costs	Schedule delay in finalizing the design of the inner HCAL; re-engineering required.	Moderate	Investigate value-engineering designs and alternate materials (brass); will require re-engineering.
1.4 HCal	Unable to identify suitable site(s) for inner HCAL assembly (scint. and electronics)	No participating University site can idetify the space resources for assembly.	Schedule delay to set up assembly site at BNL	Low	Investigate possibility of assembly (scintillator and electronics) at BNL.

Risk registry currently includes three major items, two of which are rated at moderate risk (all three relevant to inner HCAL).

Personnel

- **BNL**
  - Edward Kistenev (scientist)
  - Don Lynch (engineer)
  - Rich Ruggiero (designer)
  - Anatoli Gordeev (engineer, OHCAL L3)
- **ISU**
  - J. Lajoie (L2 Manager/IHCAL L3)
- **Colorado** (tile testing)
  - J. Nagle (faculty)
- **GSU** (tile testing, outer HCAL)
  - Megan Connors (faculty)
  - Xiaochun He (faculty)
- **WSU**
  - Bill Llope (faculty)
  - Joern Putschke (faculty)
- **ACU**
  - Rusty Towell (faculty)
- **Rutgers**
  - Sevil Salur (faculty)
- In discussions with Russian institutions (MEPHI/IHEP/Kurchatov)

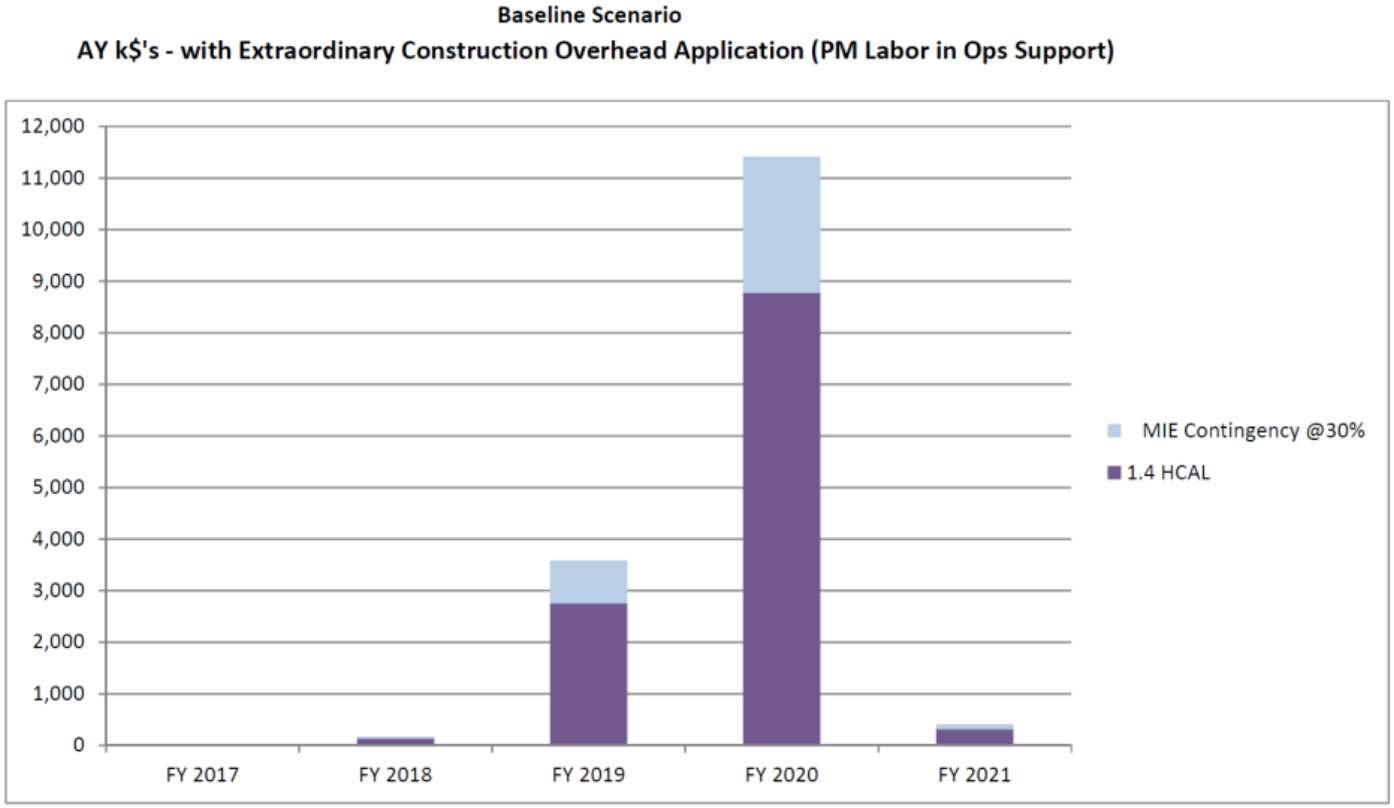
BNL engineering has decades of experience with PHENIX.

ISU was responsible for the PHENIX LL1 trigger and MPC-EX.

WSU has a wide range of experience in building detectors.

ACU worked on the PHENIX MuTR chambers.

HCAL Budget Profile



Baseline Scenario

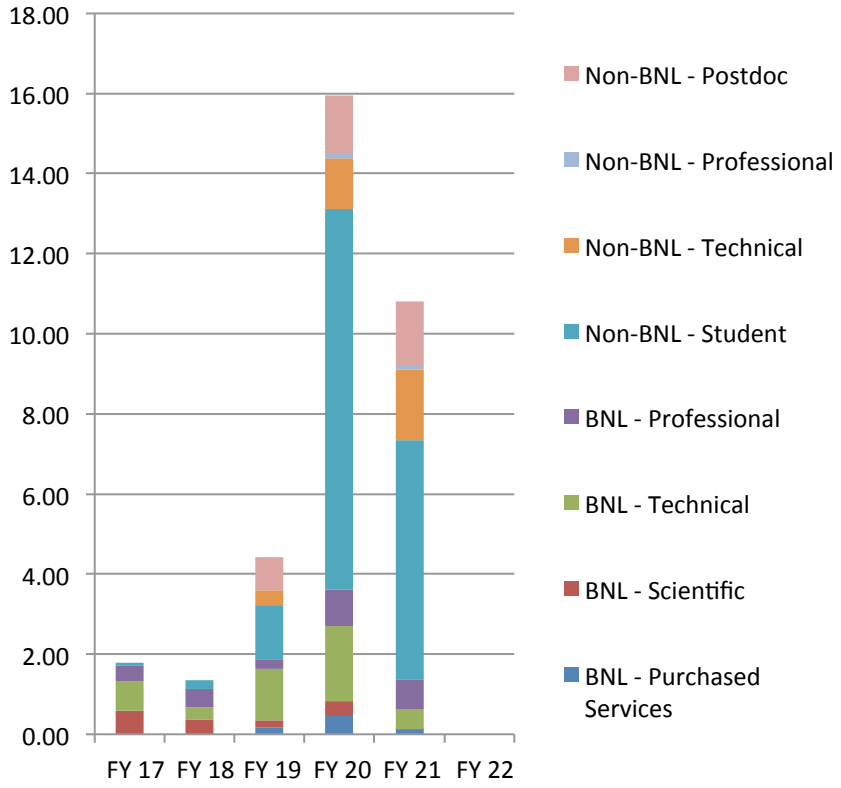
AY k$'s - with Extraordinary Construction Overhead Application (PM Labor in Ops Support)

WBS	SYSTEM	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	Total
1.4	**HCAL**	15	129	2,752	8,777	313	11,986
	MIE Contingency @30%	5	39	826	2,633	94	3,596
	MIE Total	20	168	3578	11410	407	15582

WBS	**SYSTEM**	**Baseline**	Contingency(30%)	**Total**

HCAL Staffing

FTE Profile by Category



FTE Profile by Fiscal Year

WBS Level	Org Sort	Group	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22
1.4	BNL	Purchased Services	0.00	0.00	0.18	0.46	0.12	0.00
		Scientific	0.60	0.36	0.16	0.37	0.00	0.00
		Technical	0.74	0.31	1.29	1.87	0.51	0.00
		Professional	0.38	0.47	0.23	0.91	0.75	0.00
	BNL Sum		**1.71**	**1.13**	**1.87**	**3.61**	**1.38**	**0.00**
	Non-BNL	Student	0.08	0.23	1.35	9.50	5.97	0.00
		Technical	0.00	0.00	0.38	1.27	1.76	0.00
		Professional	0.00	0.00	0.00	0.12	0.10	0.00
		Postdoc	0.00	0.00	0.82	1.46	1.61	0.00
	Non-BNL Sum		**0.08**	**0.23**	**2.55**	**12.34**	**9.43**	**0.00**
Grand Total			**1.79**	**1.36**	**4.42**	**15.95**	**10.81**	**0.00**

Quality of Estimate

HCal

SUBSYSTEM	PERCENT OF ESTIMATES	CONTINGENCY
Engineering estimate	43	0.40
Quotes	57	0.20
Average contingency		0.29