HCAL Mechanical Design

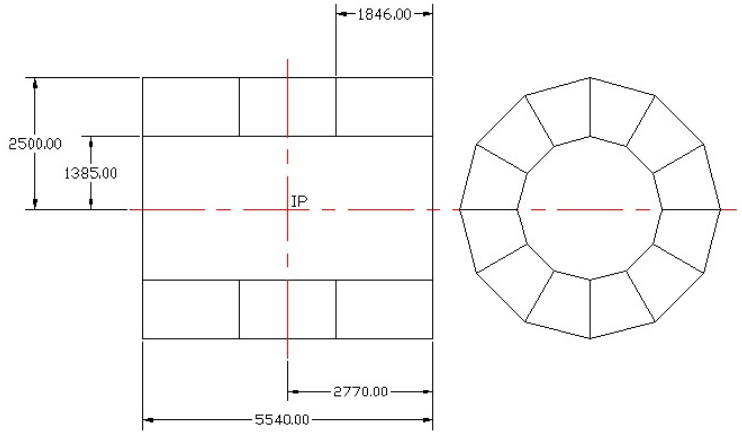
Victor Guarino
HEP-ANL

Work to date..

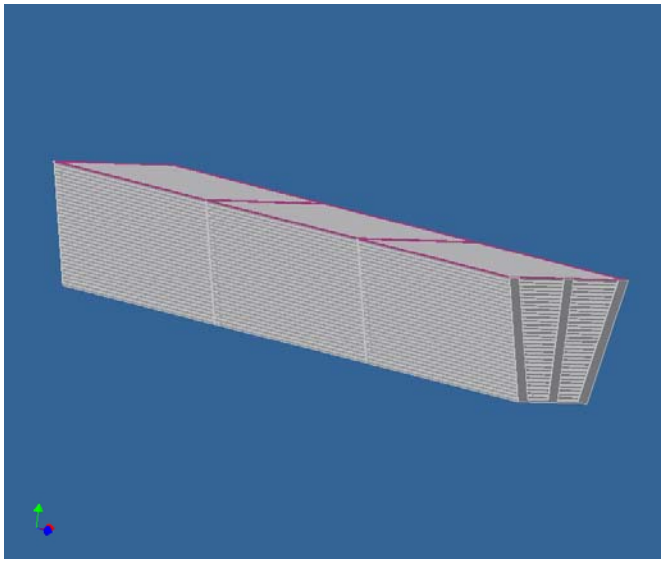
- Have been thinking about how to construct individual modules and assemble them into a barrel.
- Identifying forces on modules/plates/solenoid.
- RPC's have been the considered so far simply because that is the work going on at ANL. No design considered precludes any other technology. There is no problem carrying on parallel mechanical designs that are tailored to specific technologies.
- Challenge is supporting plates over a pretty long distance while minimizing deflections and dead space for structural support and providing space for readout.
- Other Calorimeters:
  - Zeus, CDF, and STAR EMC are stacked compressed plates. Friction between plates provides supports. Zeus modules supported at the ends, CDF forms a barrel on a cradle, STAR is individual modules supported at the outer radius.
  - SDC HCal was welded overlapping plates.
  - SDC EMC was cast lead plates
  - ATLAS is glued and welded plate assembly.
- Typical dead space is 3-6mm in phi and 3mm projected in eta.
- Need physicist input on design to help weigh decisions of dead space/deflections/instrumentation routing/etc.

HCAL Parameters being used

- Length=5540.0mm
- IR=1385.0mm
- OR=2500.0mm
- 32 stainless steel plates that are 20mm thick
- Gap between plates of 11mm
- Back plate of 20mm
- 12 modules
- Module steel weight=28,894 kg



Dimensions of Barrel

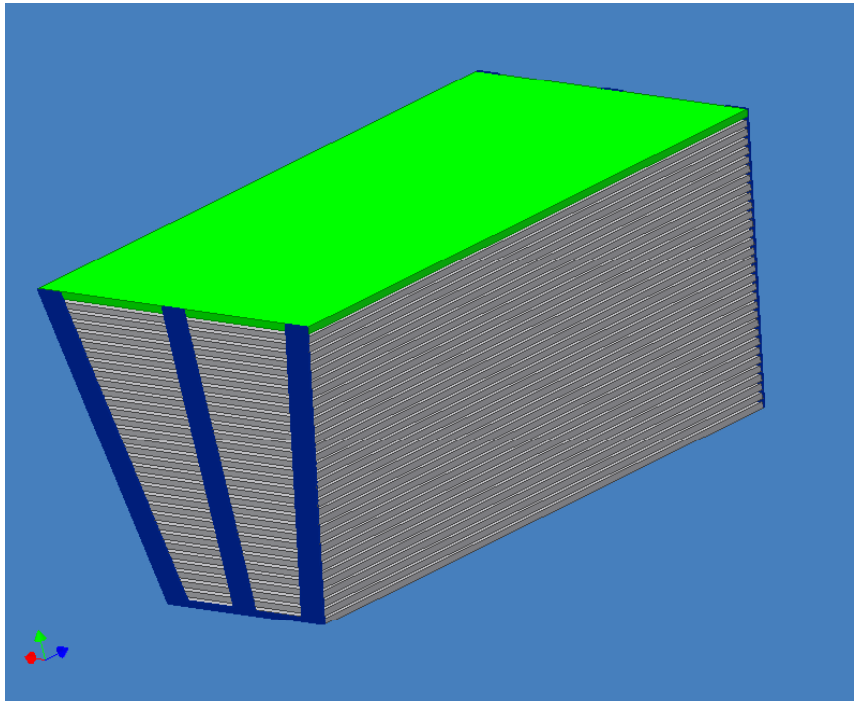


Designs Being Looked At

- Design 1: A compressed stack was considered but rejected for now. Initial calculations show that weight is to high to carry in compression only. A compressed design cannot be stacked into a barrel but requires individual support.
- Design 2: A “submodule” design where a module is divided into 3 submodules, each individually supported from the solenoid.
- Design 3: A complete module design consisting of stacked plates similar in concept to the SDC HCAL and Atlas TileCal. Focus of effort now.

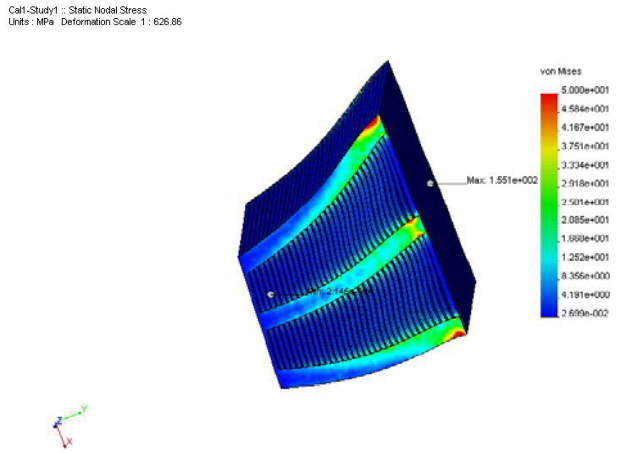
Design 2: Submodule Design

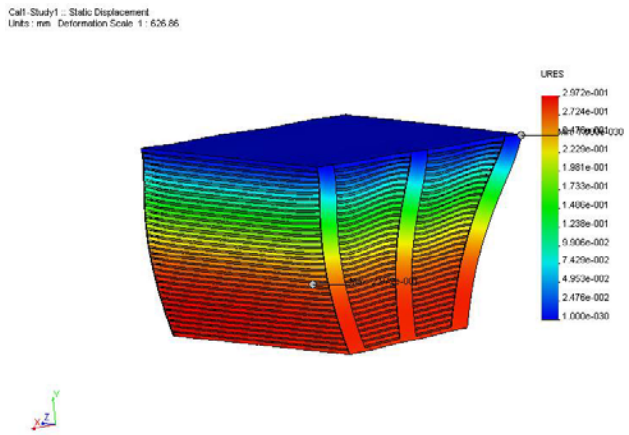
- Module split into 3 submodules along the length.
- Plates are supported by picture frame that is 5mm thick.
- Each submodule is inserted individually on rails mounted to the solenoid.
- Picture frame creates space for routing cables/piping.
- Single RPCs per layer in each submodule.
- Allows for easy maintenance.
- RPC’s preclude a compressed/friction design.



Design 2: Submodule Analysis

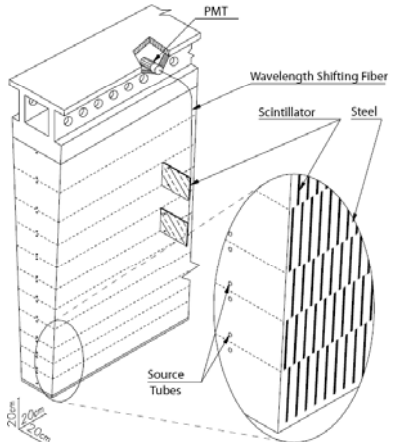
- Examined forces on solenoid.
- Sized rails that could fit in space between modules and solenoid.
- Examined stresses and deflections of individual modules.

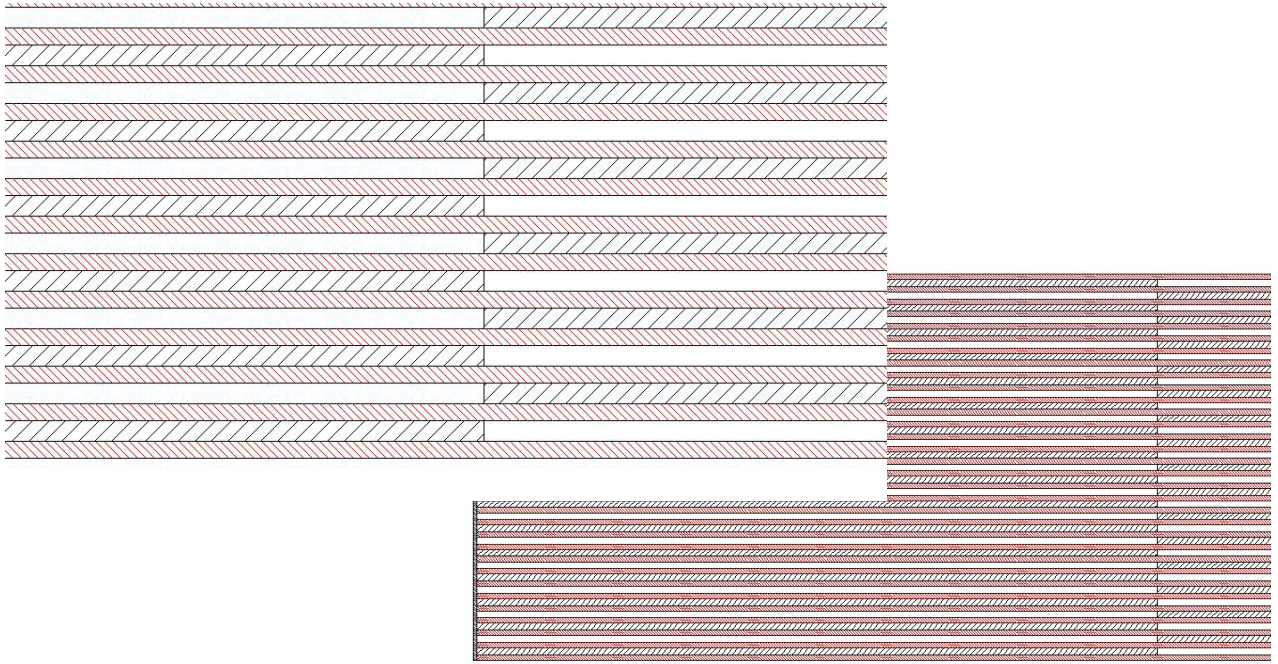




Design 3: Stacked Plate Designs

- Plates will be stacked to transfer loading between modules and back to outer radius supports.
- Alternating cells for scintillator/RPC/GEM which form towers.
- Towers can be projective.
- Need input on requirements for routing out cables.





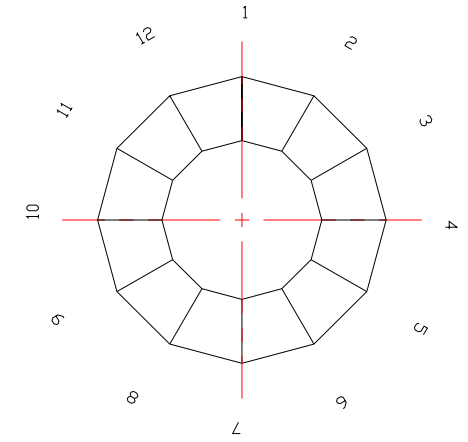
Design 3: Stacked Plate Designs

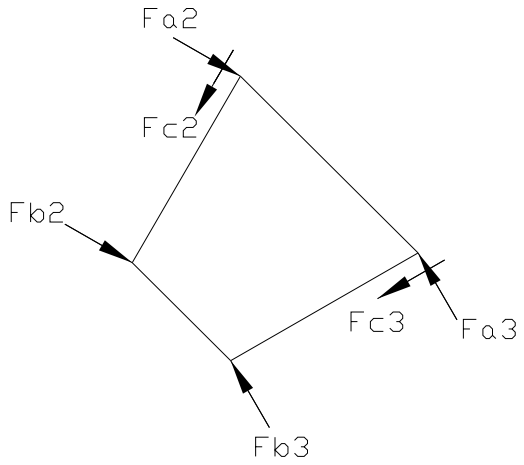
- Calculations on forces between modules and forces within modules. Initial sizing of members to withstand these forces.
- Have been examining completed barrels that are supported by the solenoid.
- Have looked at barrels supported at 45 degrees from the bottom and a design supported at the 3 and 9 o’clock positions.
- Calculated forces between modules and now looking at module construction.

Barrel Concept
45 degree Support

45 Degree Support

Position	FA ton	FB ton	FC ton
1	-121.7	173.6	0.0
2	-117.9	177.9	0.0
3	-102.6	180.6	-15.0
4	-66.3	156.3	-51.9
5	0.0	77.9	-105.0
6	15.3	80.6	90.0
7	-10.9	138.9	0.0
8	15.3	80.6	-90.0
9	0.0	77.9	105.0
10	66.3	156.3	51.9
11	-102.6	180.6	15.0
12	-117.9	177.9	0.0

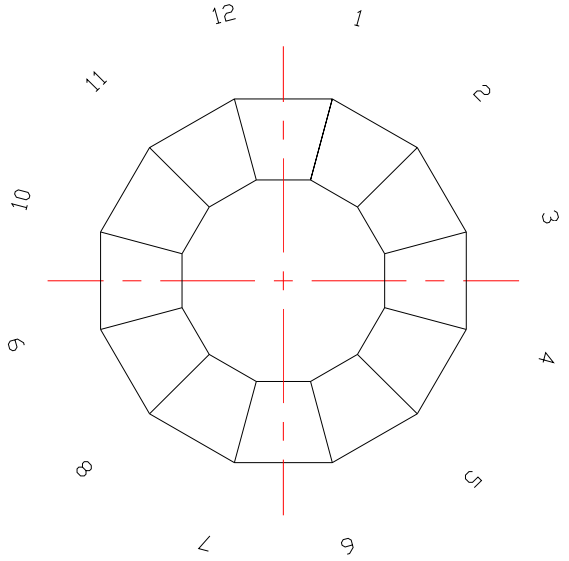


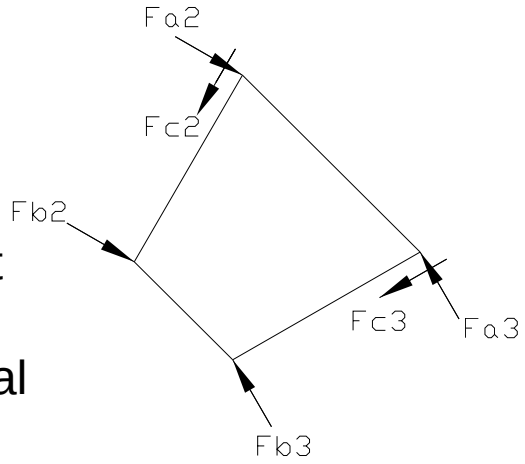


Forces are large – concerned about differential forces that have to be transmitted from the IR to the OR.

Barrel Concept
3 – 9 o’clock supports

	Horizontal Support		
Position	FA ton	FB ton	FC ton
1	93.4	-46.0	2.8
2	99.7	-36.1	0.0
3	120.3	-36.2	-24.1
4	-7.5	-76.6	-24.1
5	13.1	-76.8	0.0
6	19.5	-66.8	2.8
7	19.5	-66.8	-2.8
8	13.1	-76.8	0.0
9	-7.5	-76.6	24.1
10	120.3	-36.2	24.1
11	99.7	-36.1	0.0
12	93.4	-46.0	2.8

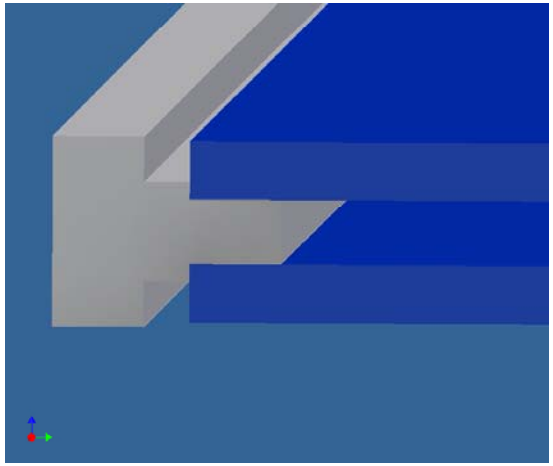


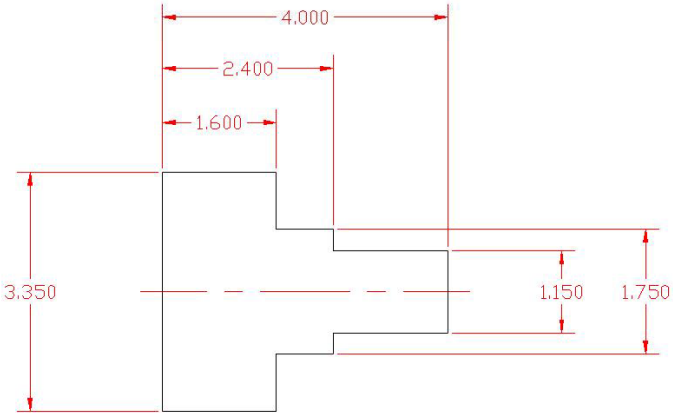


Smaller forces on modules. There is still a large differential force on the module at the support points that has to be transferred from the IR to the OR.
Looking at Module Construction to support this differential force.

HCAL Technology

- Focus has been on RPCs only because that is what is going on at ANL.
- RPCs have inherent dead space due to framework.
- Max size of RPC still up to debate. Want to maximize size to minimize dead space. However, if a large RPC dies then we loose a good percentage of the detector.





Dead Space

- Of course we want to minimize dead space. This will depend on structural supports and requirements for routing out instrumentation.
- Need information on bend radii, size of cables/tubes, number of cables/tubes.
- How do we route out instrumentation? In phi, along eta?

Continuing work

- Focusing now on Design 3 – Stacked Plates.
- Working on a design of the modules that can withstand the applied forces in a completed barrel supported at the 3-9 o’clock positions.
- Need input from other technologies so that any unique requirements can be considered.
- Will begin to look at loading on modules/barrel during assembly on a central mandrel.