Shield Module Design Considerations

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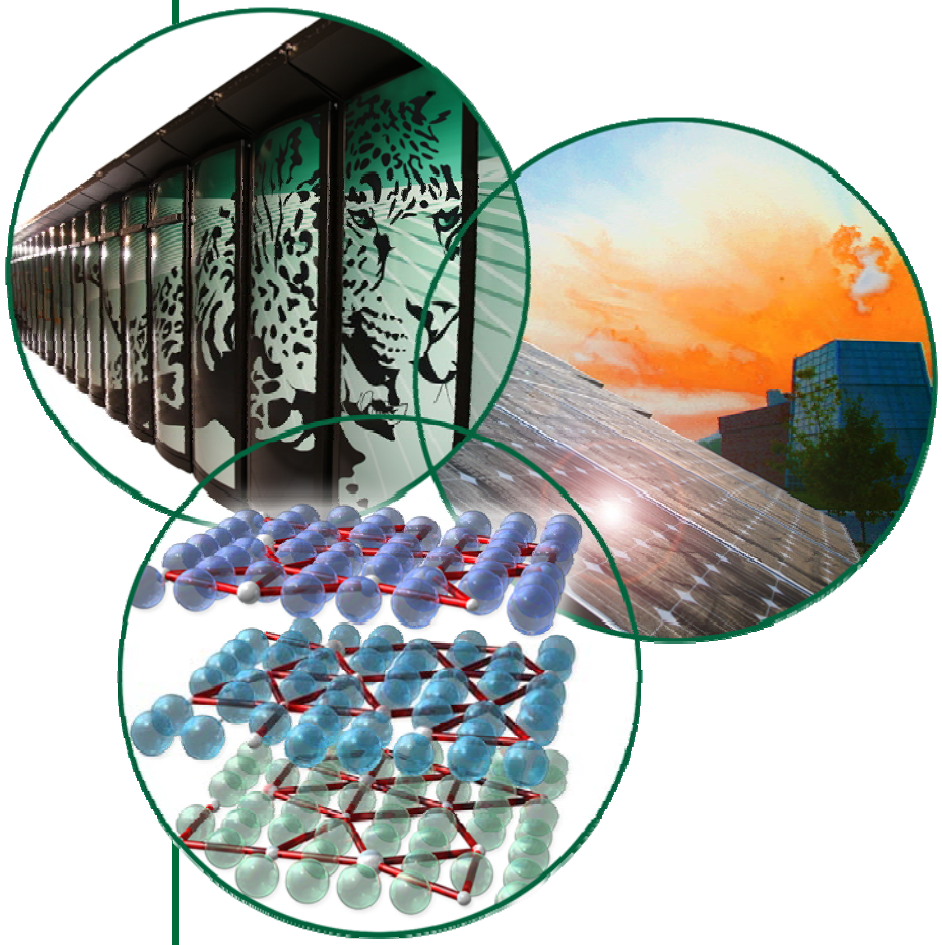

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U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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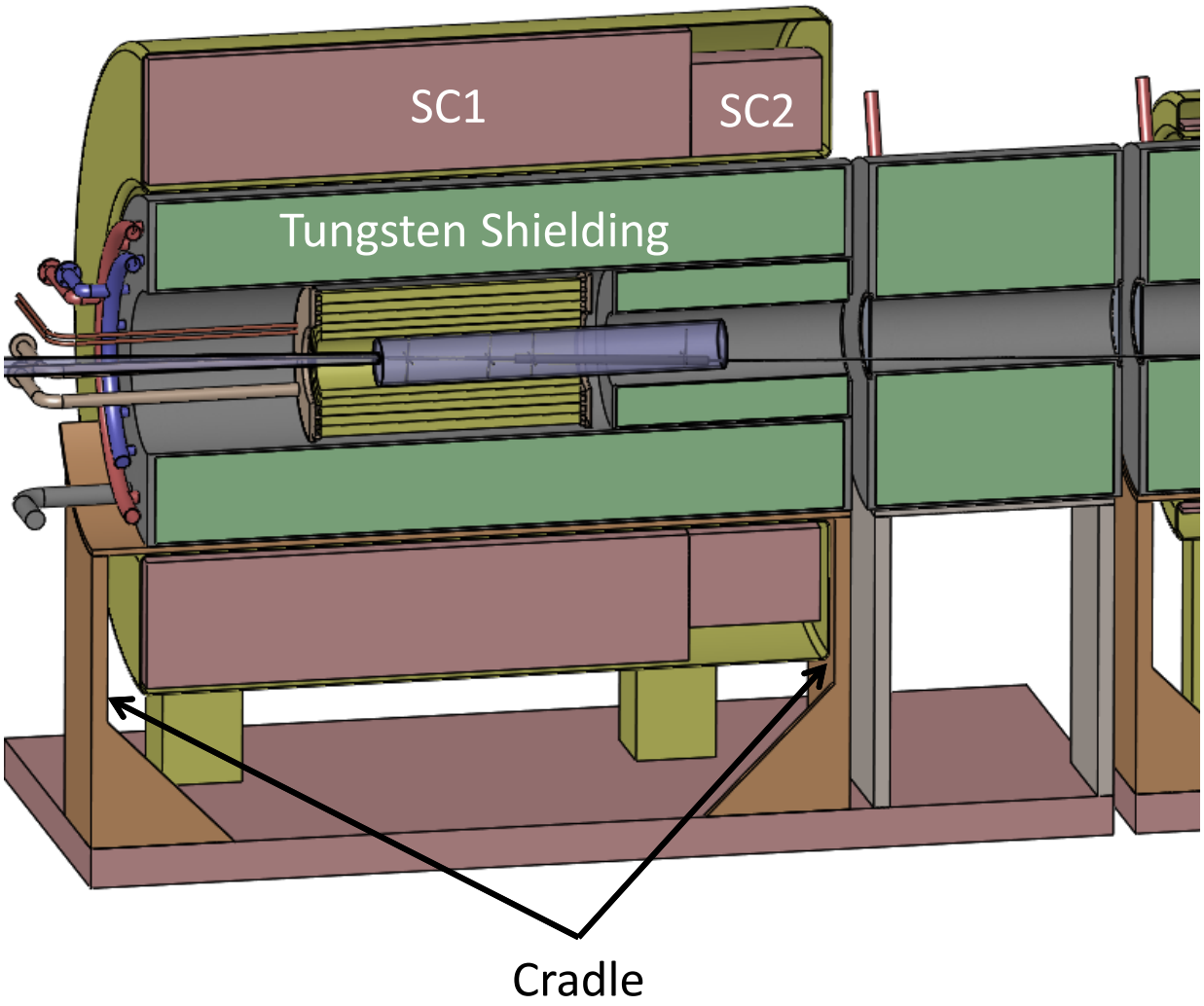
Overview

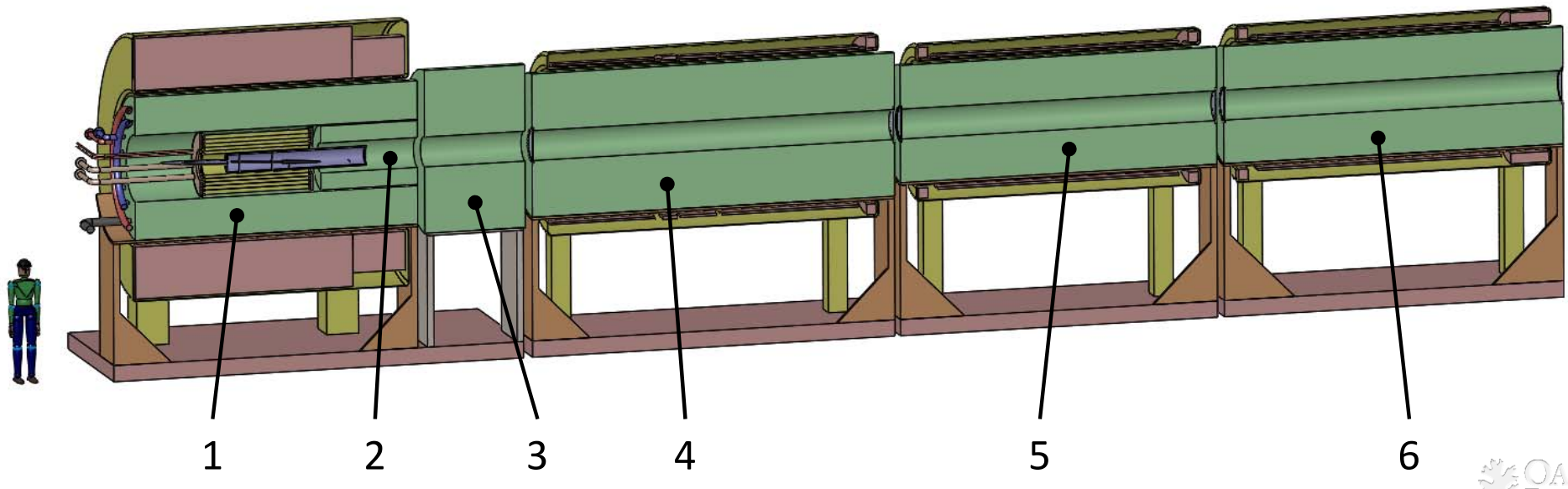
- Capability to remotely remove and reinstall the shield modules is required
- Shield module concept is He-cooled tungsten spheres
- Current shield modules weigh up to 200 tons
- Cradle needs to be sized to support shielding



20to2T5m120cm4pDL Shielding Module Volumes

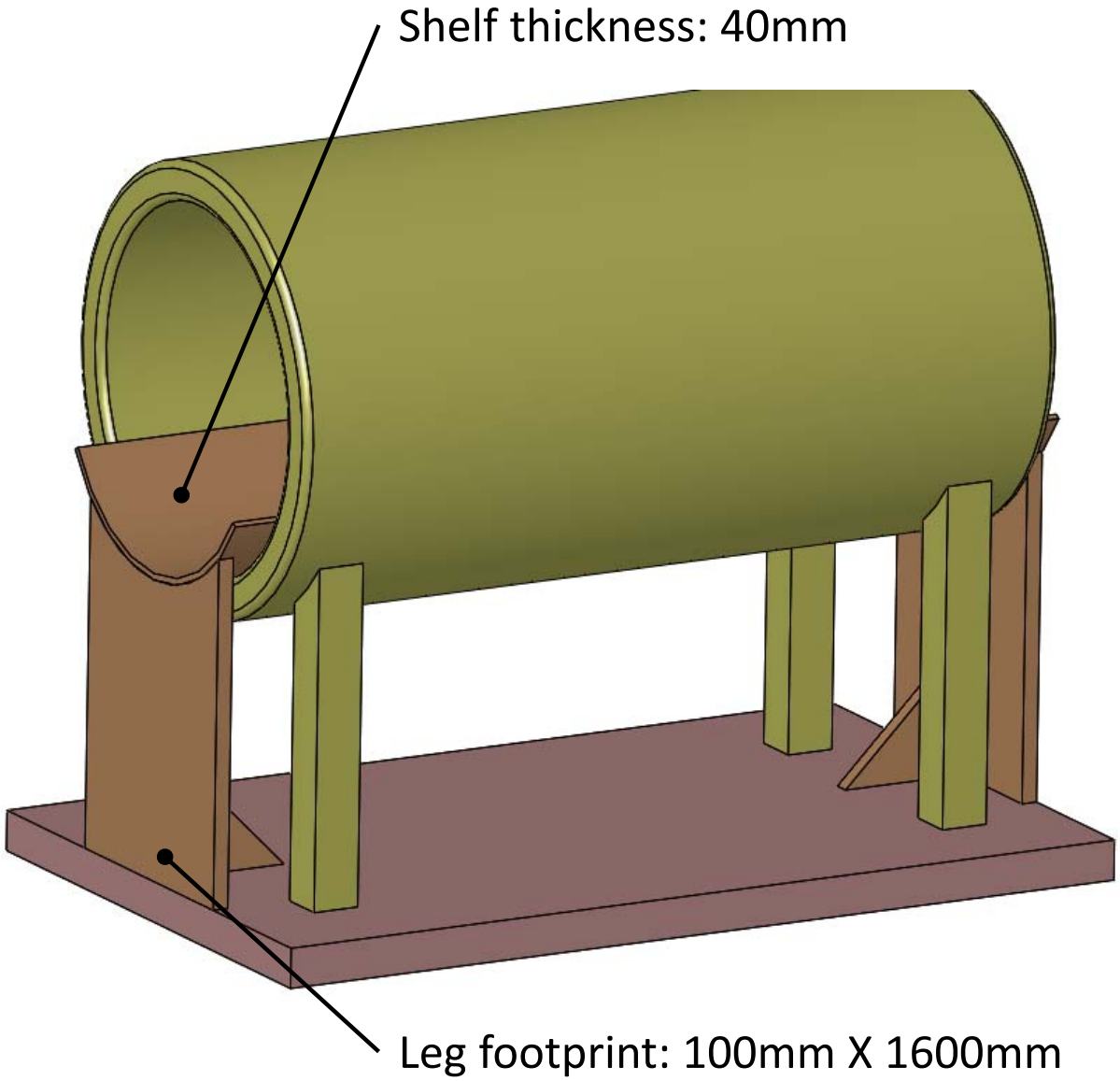
Module	Volume (m^3)	Weight (MT)*	Weight (ton)
1	13.16	152.0	167.6
2	0.89	10.3	11.9
3	7.45	86.0	95.0
4	20.57	237.6	262.0
5	11.75	135.7	150.0
6	12.61	145.6	160.5

*Assuming density of 19,250 kg/m^3, packing factor of 60%



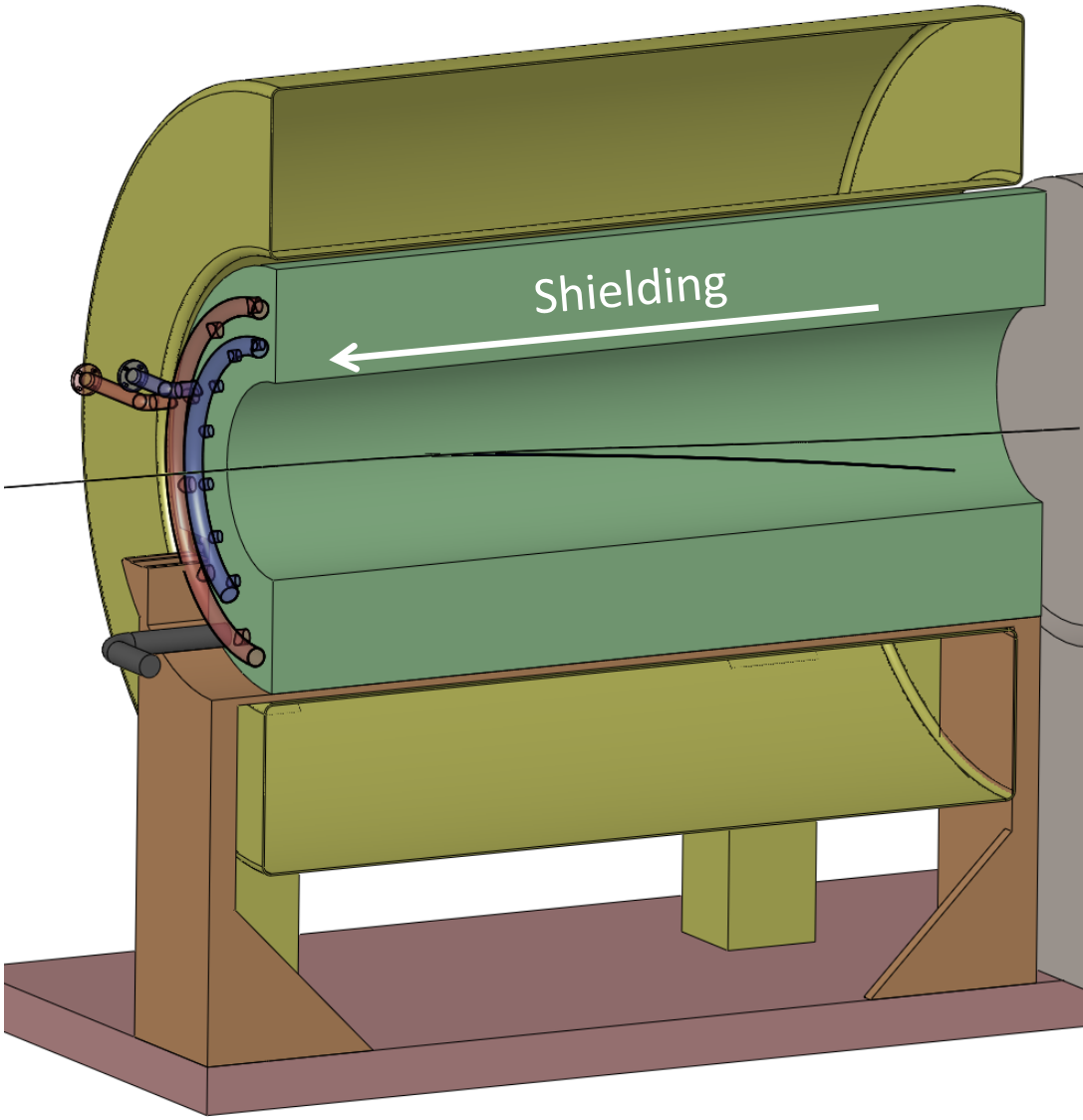
Shield Supports

- Current concept is simple stand integrated with cryostat
- Provides curved shelf to support shield weight without transferring load to cryostat
- Mounted to base platform that can be moved laterally out of beam line
- Some design considerations
  - Inter-coil forces
  - Shielding module support & removal
  - Stability under weight
  - Space requirements
  - Shorter preferred in height and along beam axis



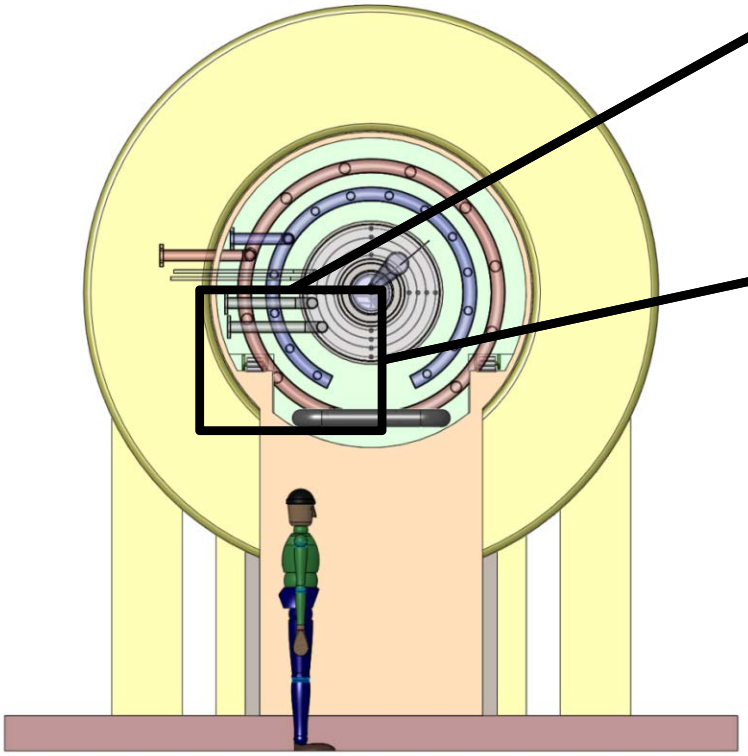
Translating the shielding

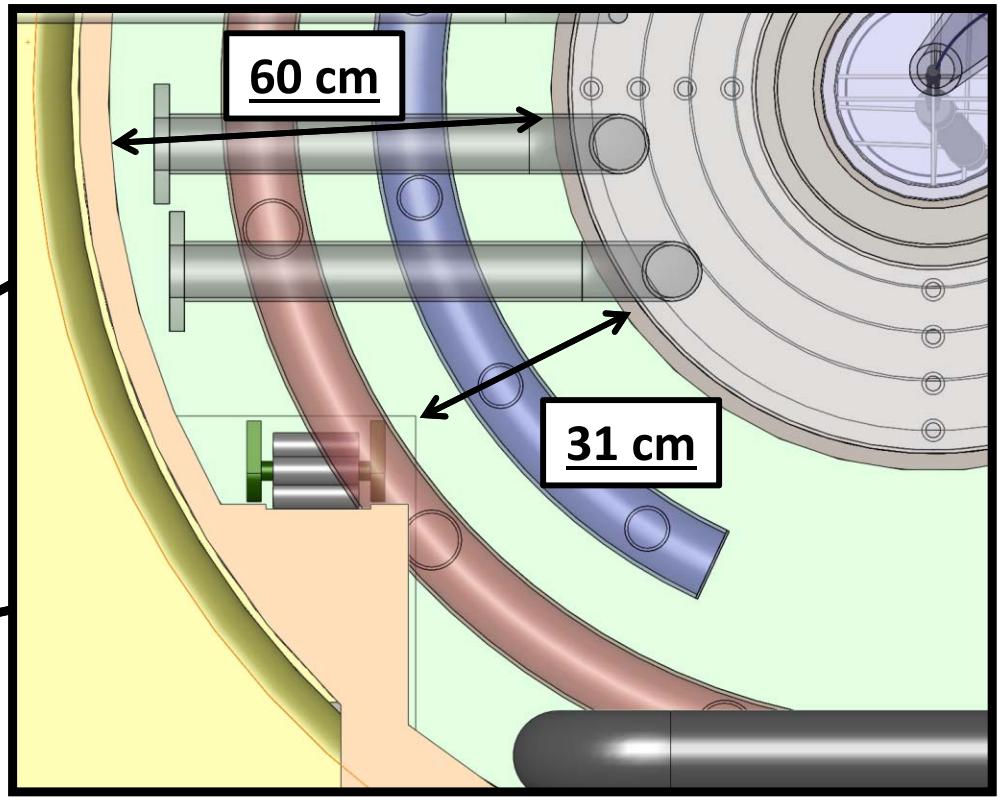
- Options for shield module extraction
  - Sliding material, low friction material to reduce force required to drag shielding
    - Best materials not radiation tolerant
    - Steel on steel: μ_s = 0.5 – 0.8
    - Steel on brass: μ_s = 0.35
  - Tracked wheels, removes significant shielding space, difficult due to high weights, may be possible
  - Rollers, removes significant shielding space, but rad-hard and reliable
  - Lubricants likely not allowed
- Rollers considered for this presentation



Shielding Cut Away for Roller

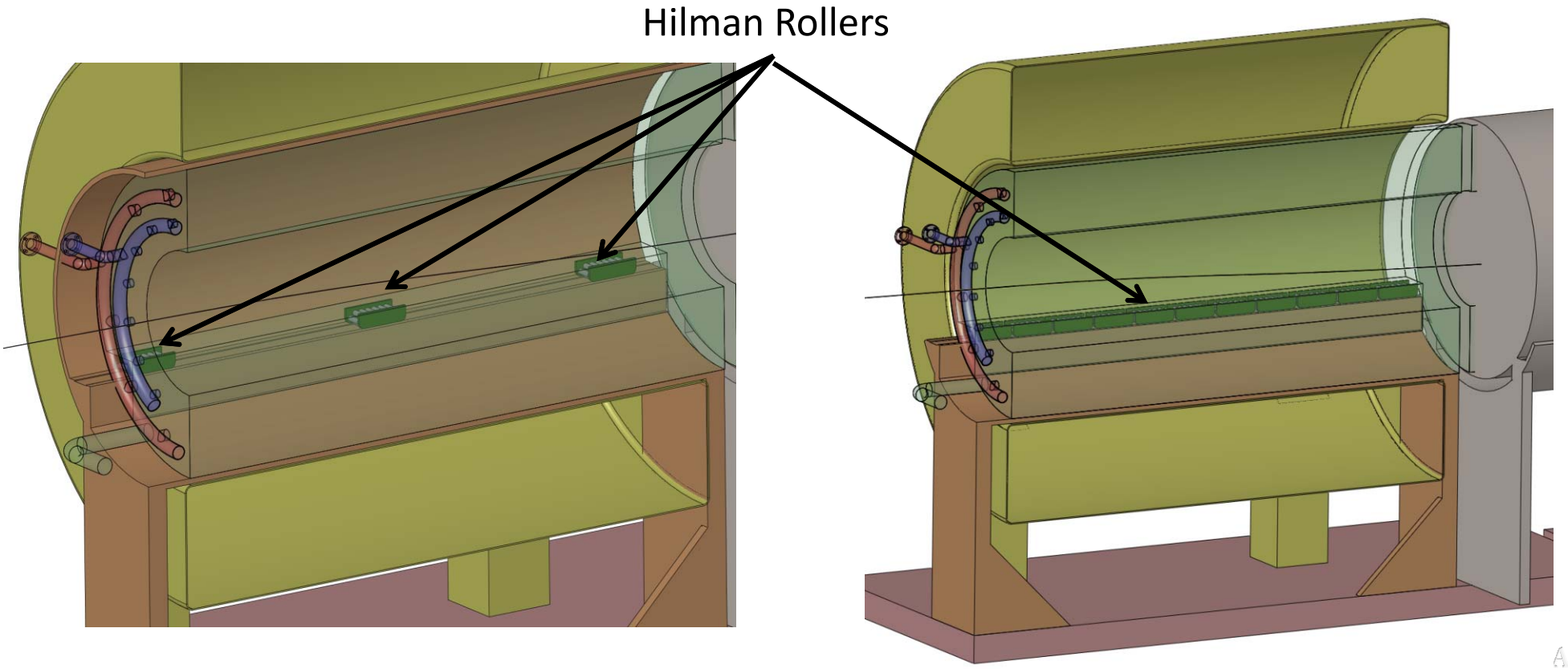
- Shielding cutaway required to allow space for rollers
- Potentially could be optimized to provide more shielding, but a significant localized shielding reduction will always be required





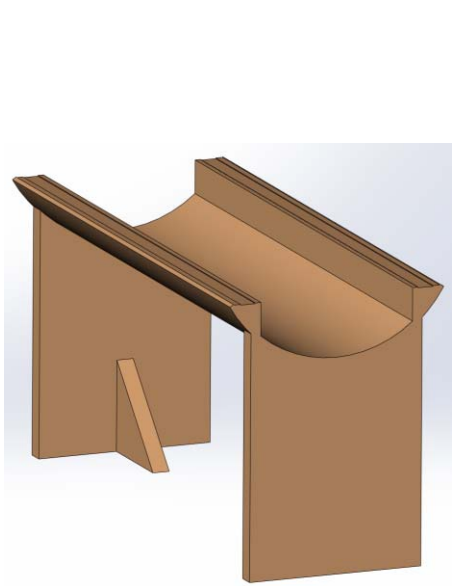
Rollers

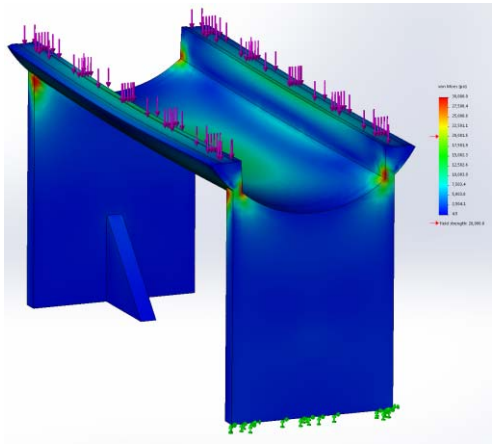
- High weight capacity required
  - First concept is commercially available hardware with adequate capacity
- Minimum of three pairs required
- Continuous line of rollers reduces stress on cradle (see two slides forward for comparison)

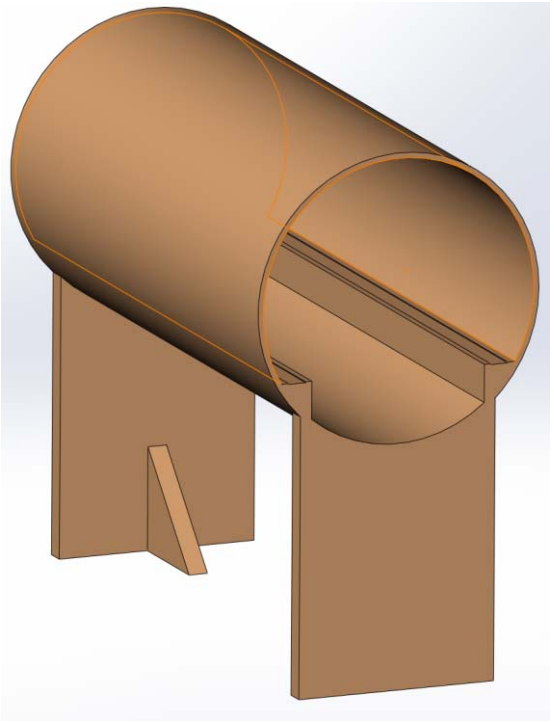


Cradle Stress

- Initial cradle design with the addition of a track is insufficient to support the weight of the shield.
- Transforming the cradle into a tube significantly improves its strength.

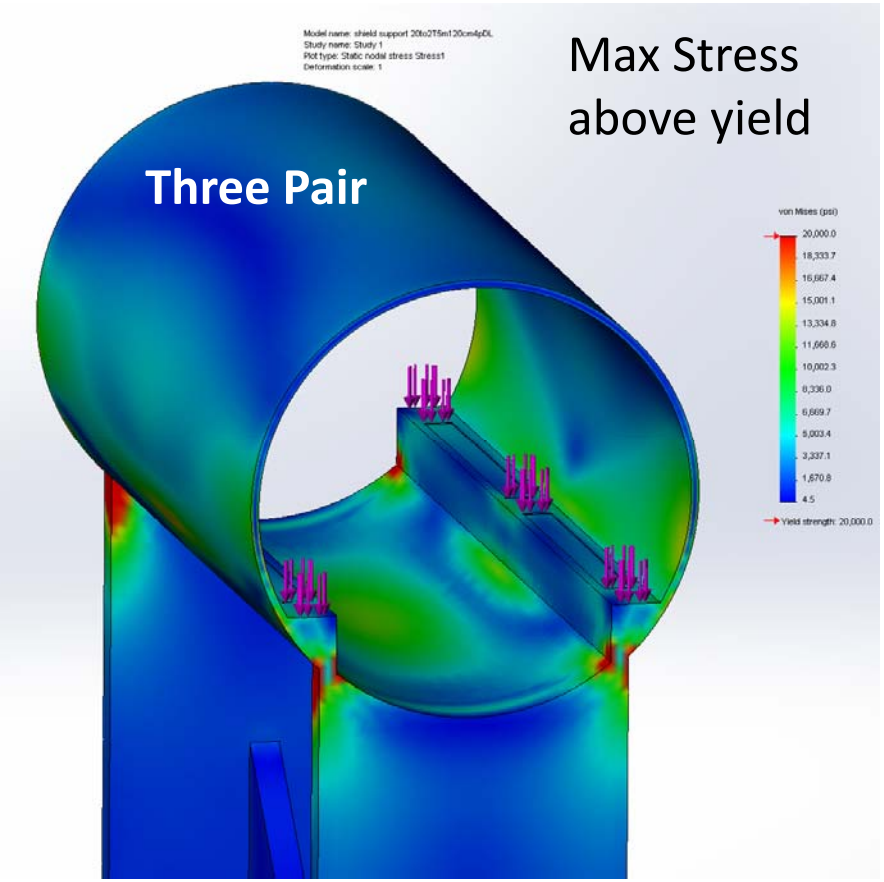


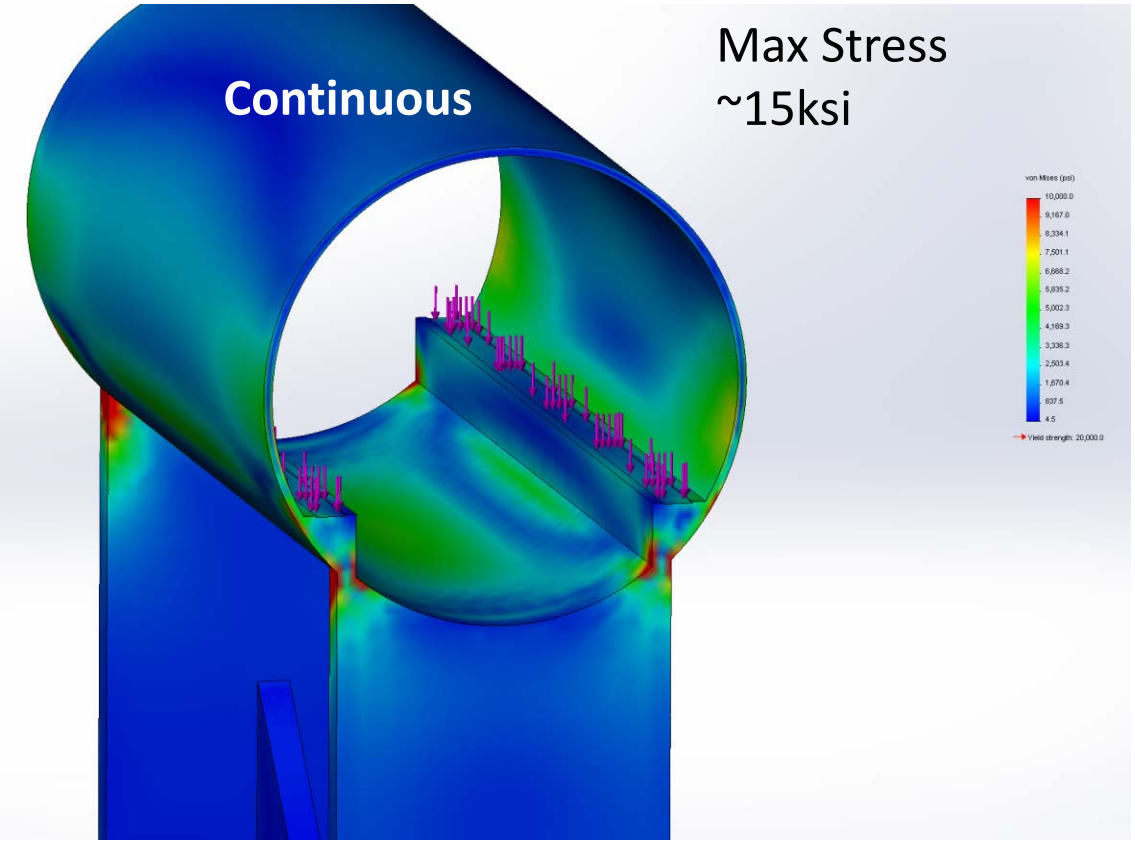




Cradle Stress

- Continuous rollers produce lower stress on cradle
- Other potential worse case loading situation may occur as the shield module is extracted, those situations will need to be considered to continue the conceptual design

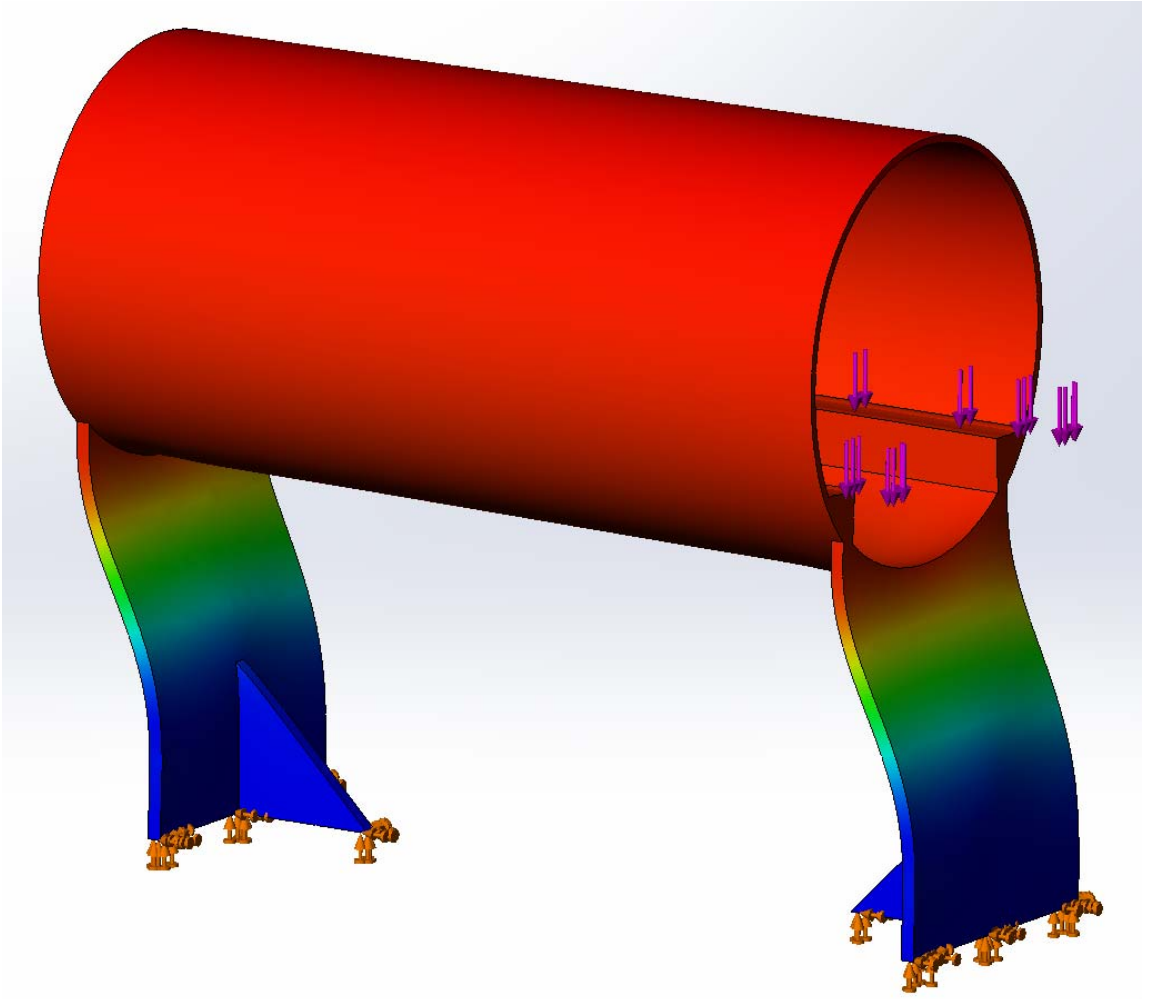




Note: images don't use same scale

Cradle Buckling

- Buckling of the cradle was analyzed
- ~55x load factor calculated
  - Buckling not a concern in current concept
- Horizontal forces from inter-coil attraction/repulsion not considered



Conclusions

- Remotely handling the shielding modules is a significant challenge
- Rollers are an option, optimization to reduce shielding loss required
- Cradle requires some strengthening to handle the shielding load
- Extraction procedure and tooling concepts need to be developed
- Smaller shielding modules beneficial from remote handling perspective
  - One shield per coil, one coil per cryostat
  - Cryostat performance must be considered
  - More utility connections required
  - Increases number of inter-coil forces if each coil is in its own cryostat
  - More and/or larger gaps between cryostats