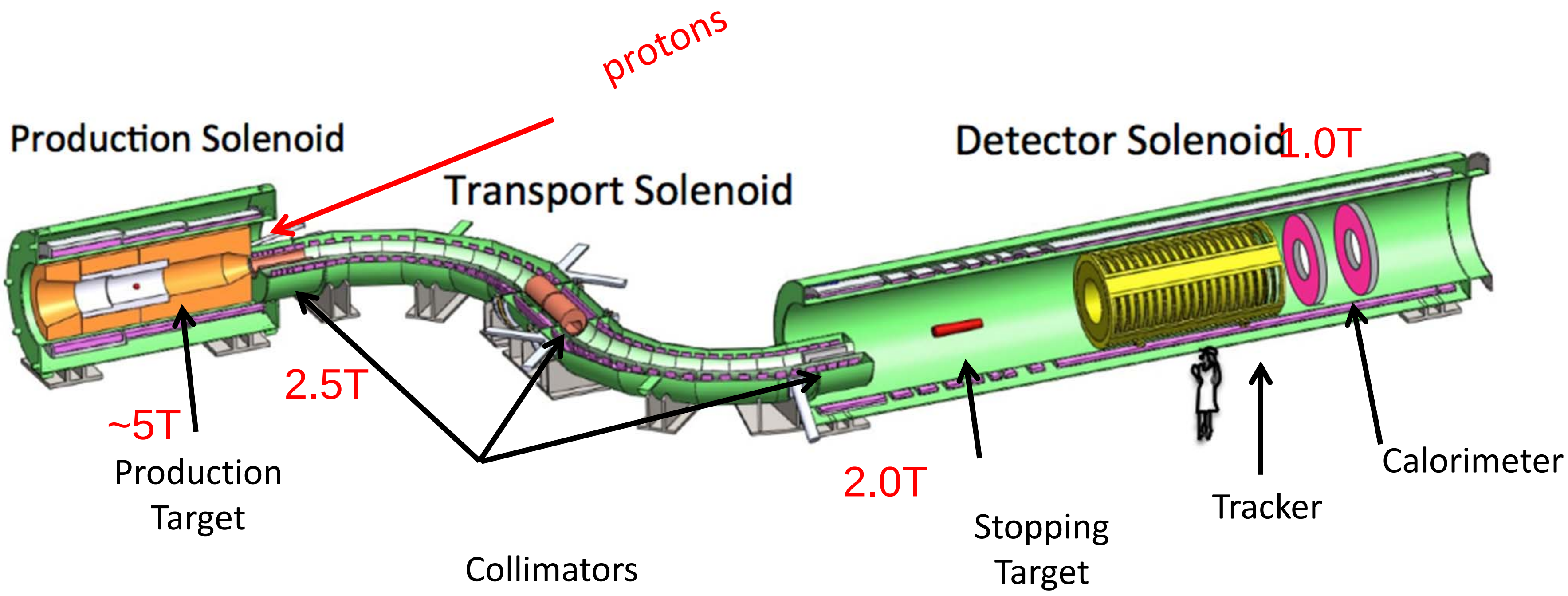
Studies of the PS performance for Mu2e-II beam Scenarios

Mu2e-II

Introduction

- **PS Specification calls for a minimum temperature margin for the superconductor of 1.5 K**
- **Present design for PS and absorber optimized for 8 GeV, 8 kW operating, meeting this temperature margin**
  - HRS material and geometry minimizes cost and still meets requirements
  - HRS is made of bronze
- **Will it be possible to use PS during the Mu2e-II operating conditions?**
  - Without making any modifications to the cryostated magnet
    - Would be very painful (very activated) and expensive to modify
  - Modifications to the Chimney, HRS, cryogenic system ok

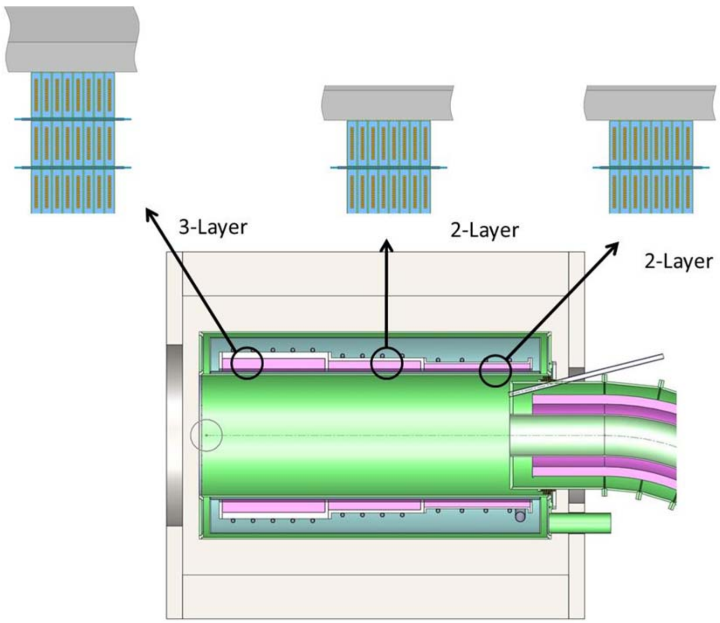
Mu2e Apparatus



(not shown: Cosmic Ray Veto, Proton Dump, Muon Dump, Proton/Neutron absorbers, Extinction Monitor, Stopping Monitor)

PS Baseline Design

4-5T➔ 2.5 T Axial Gradient



Gradient made by 3 axial coils same turn density but increase # of layers (3,2,2 layers)

- Wound on individual bobbins
- I operation ~9kA
- Trim power supply to adjust matching to TS
- Indirect Cooling (Thermal Siphon)

Aluminum stabilized NbTi

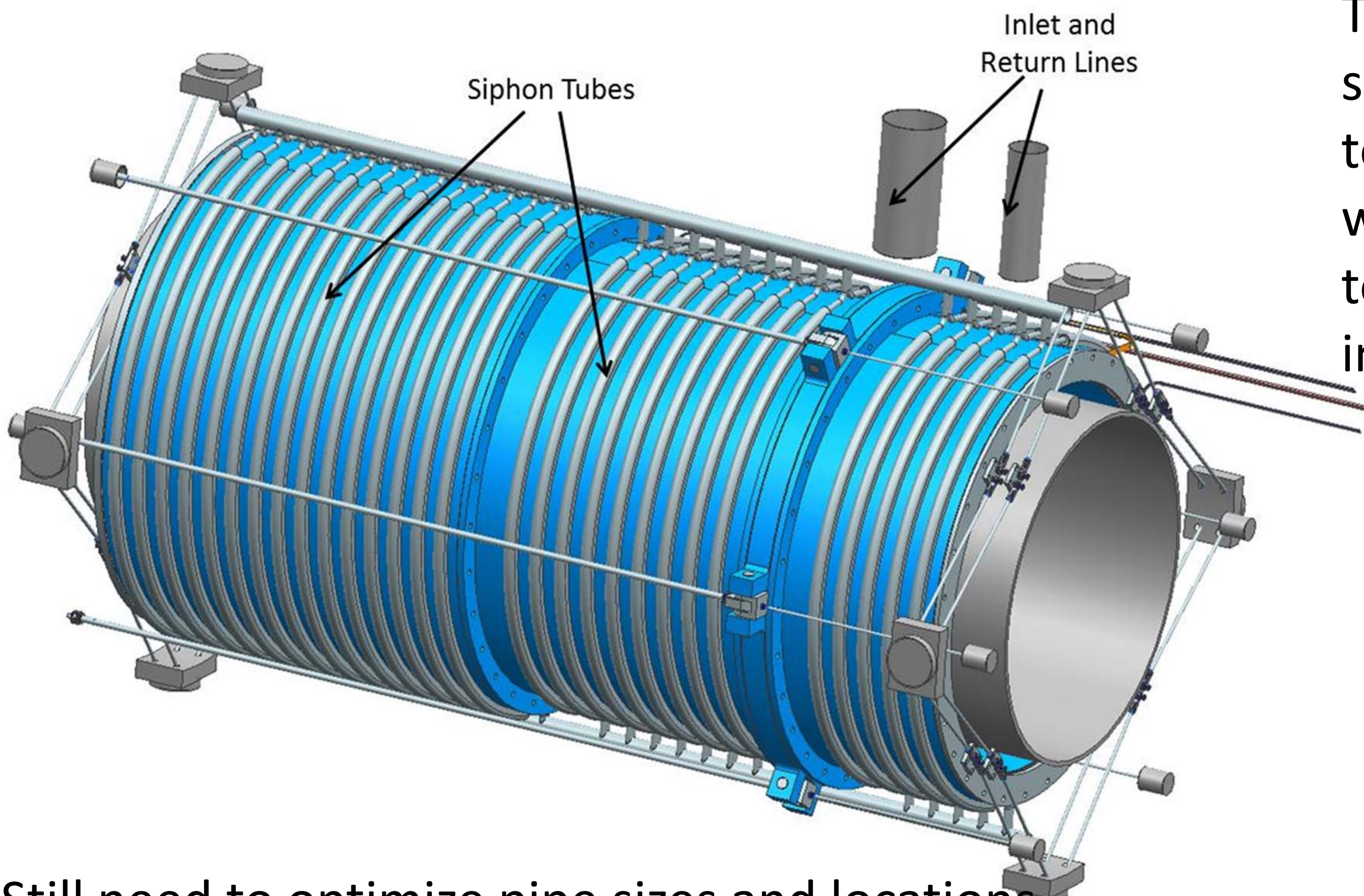
- reduce weight and nuclear heating
- Special high strength/high conductivity aluminum needed (like ATLAS Central Solenoid)

- Peak radiation dose in PS is less than 300 kGy/year
  - No significant damage to superconductor
  - Insulations look s ok
- DPA looks ~ok

Vadim Kashikhin **L3 Manager**

Preliminary Design PS

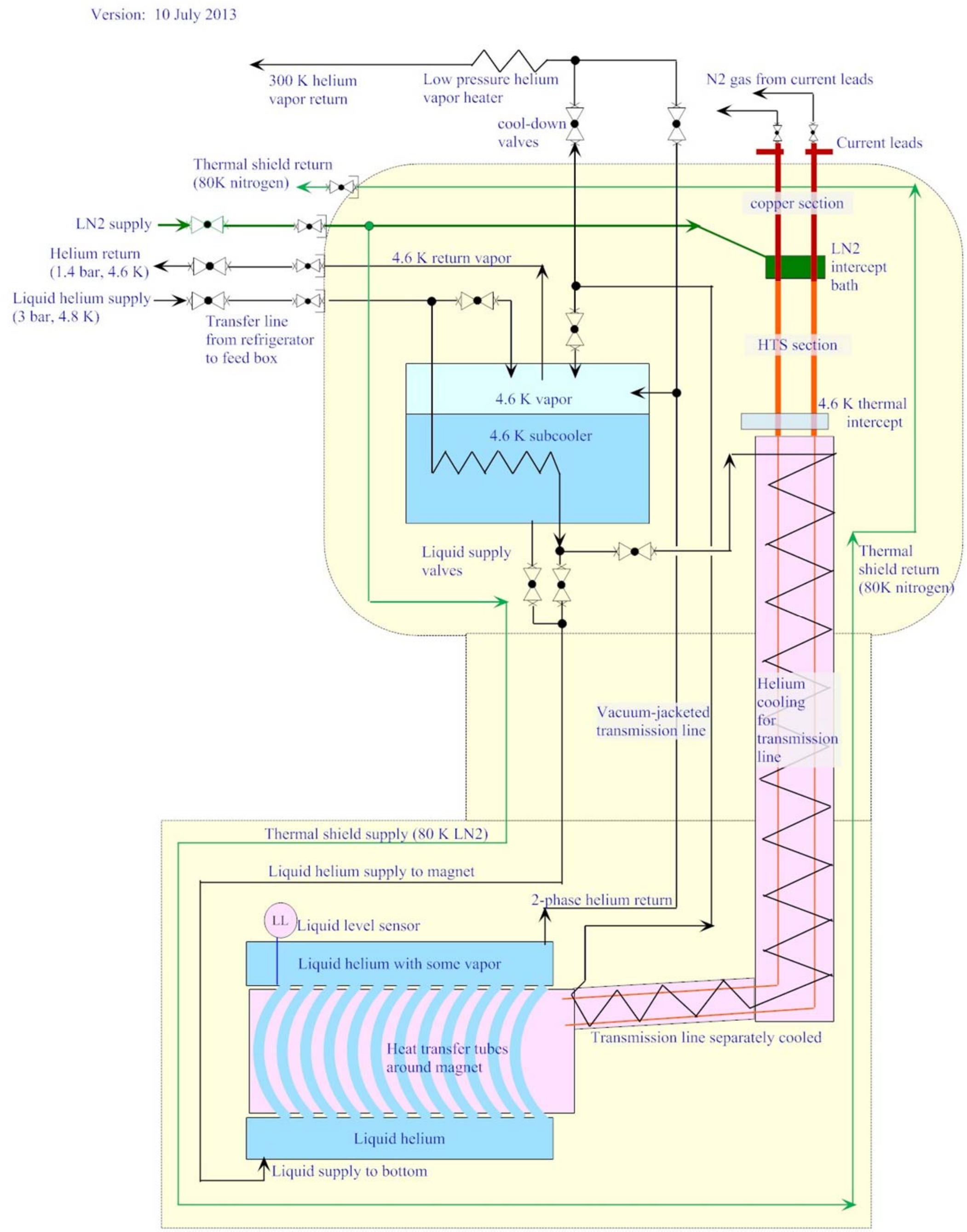
Detailed solid model "in progress"



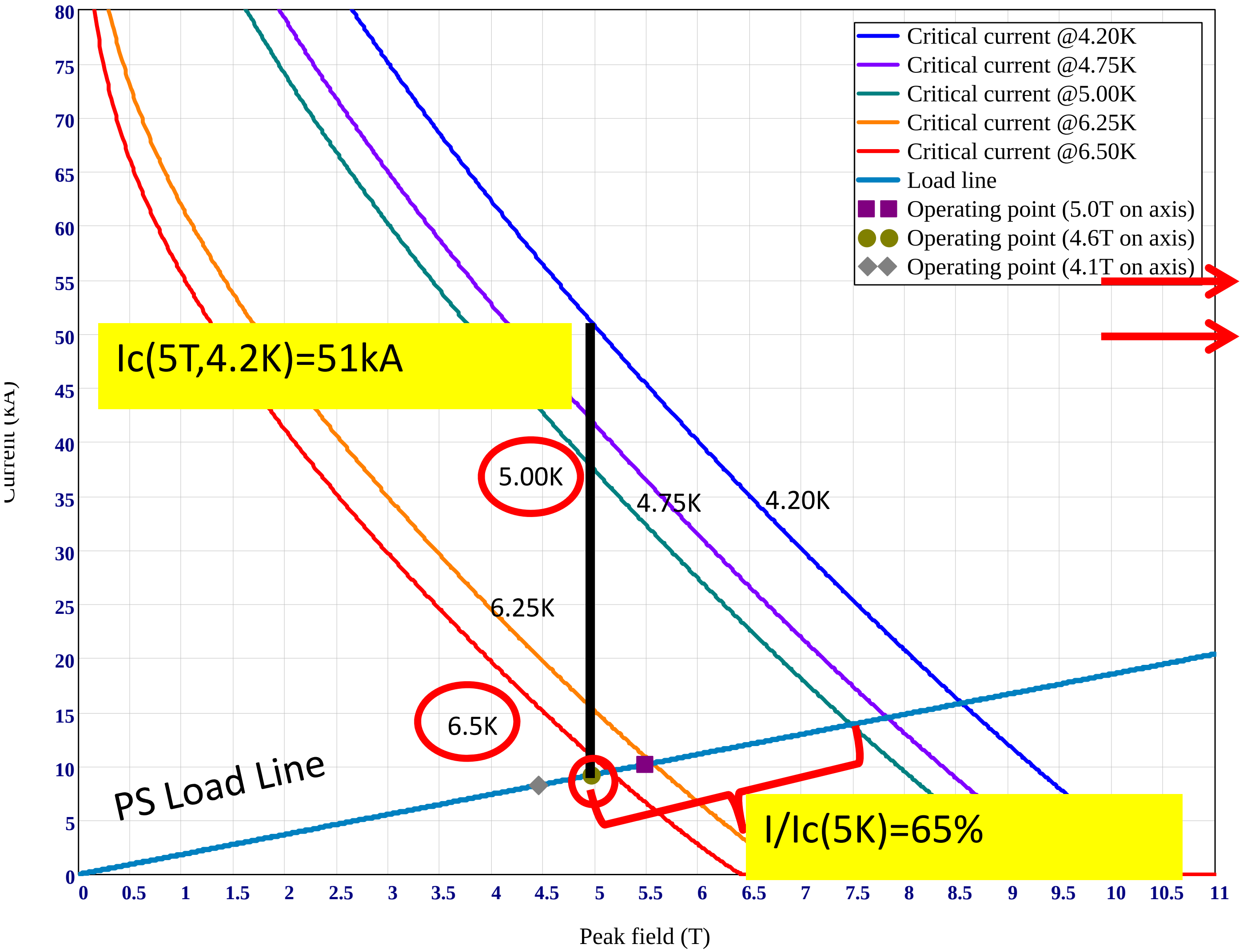
Thermal siphon tubes to be welded prior to coil insertion

Still need to optimize pipe sizes and locations

Thermal siphon schematic



PS Baseline for Mu2e



Requirements

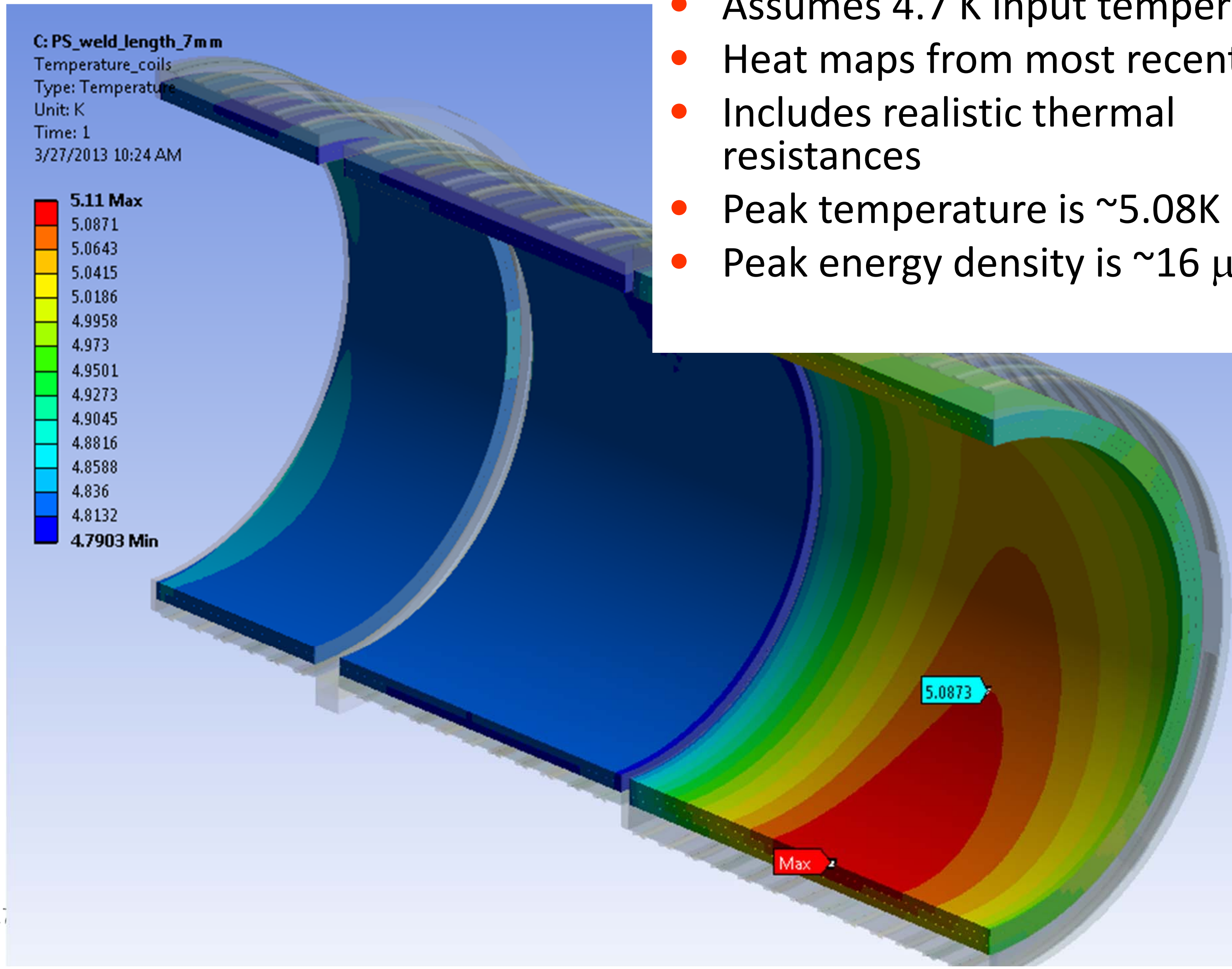
***Beam on(5K) and operating field (4.6 T on axis)**

-1.5 K temp margin

-I/Ic(5K) <70%

Present PS

- Assumes 4.7 K input temperature
- Heat maps from most recent HRS
- Includes realistic thermal resistances
- Peak temperature is ~5.08K
- Peak energy density is ~16 μW/g



Peak Power Density in the coil Vs. Beam Power

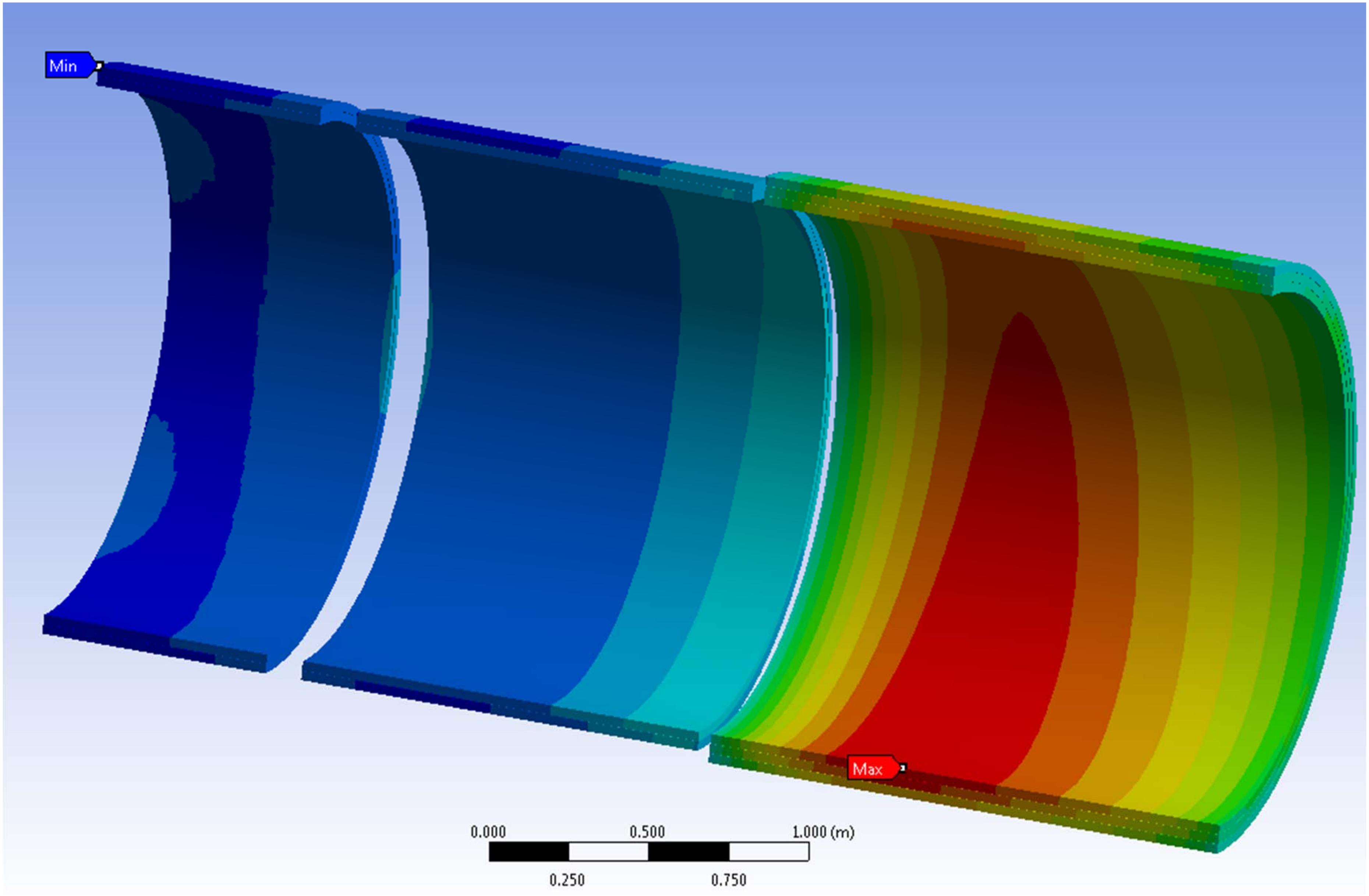
For 1 GeV beam, require power ~150 kW according to White Paper

Beam Power in kW	Peak Power Density in the coil in W/m^3	Peak Power in the coil in W/Kg (µW/g)
50	56.679	0.016 (16)
100	113.36	0.031 (31)
150	170.04	0.047 (47)
200	226.71	0.062 (62)

← Already comparable to present

- **Proposal: Lower Inlet Temperature to 3.7 K**
- This has been achieved in Tevatron
  - 3.5 K is practical limit
- Two possibilities
  - Performed on the entire cryogenic system
    - Inlet to our distribution system
  - Special precooler to PS distribution box
    - Pump on helium reservoir

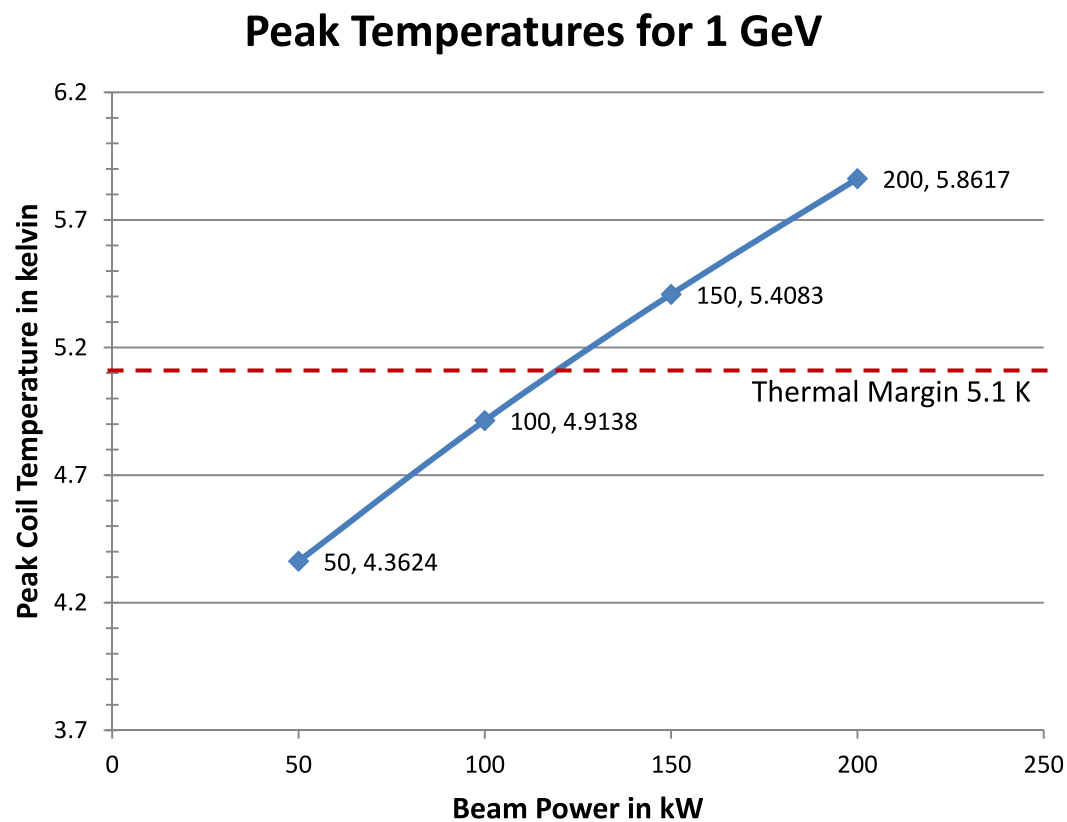
Mu2eII – Generic Temperature Profile for 1 GeV



Coil Peak Temperatures Vs. Beam Power

Beam Power in kW	Coil Peak Temperature in kelvin	Total Magnet Heat Load in watts
50	4.3624	89.61
100	4.9138	155.31
150	5.4083	221.02
200	5.8617	286.72

Helium Temperature assumed 3.7 K



Nominal beam power at 1 GeV ~ 150 kW

Analysis performed by Nandhani Dhanaraj, Tom Peterson, and Vadim Kashikhin

Discussion

- **By lowering inlet temperature to 3.7K, looks like PS may survive in Mu2e-II environment**
- **Doesn't address problem of heat removal**
  - Study in progress
  - We may need to build into present PS design (have to do it now) a larger thermal siphon pipe diameter. This will result in a larger helium volume in the magnet, but not other operational difficulties anticipated.
- **Cryo system will have to be later modified**
  - Additional refrigeration (1 additional refrigerator ?)
  - Redesign or retrofit cryo distribution box
- **Doesn't seem to be much margin for 150 kW however**
  - Margin is most important during up ramp, when Eddy currents and force changes may generate heat from coil movement. Beam will be off, coil temperature will be low
- **Once magnet is in operating we will know how much safety margin we really need.. (full 1.5 K may not be necessary)**
- **Mu2e-III (x100) with the same beam line would require a different magnet strategy, more in line with ITER solenoids or Muon Collider Capture Solenoids**