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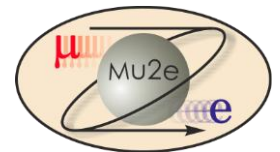
# Mu2e Tracker Infrastructure

A. Mukherjee

Tracker L2 Manger

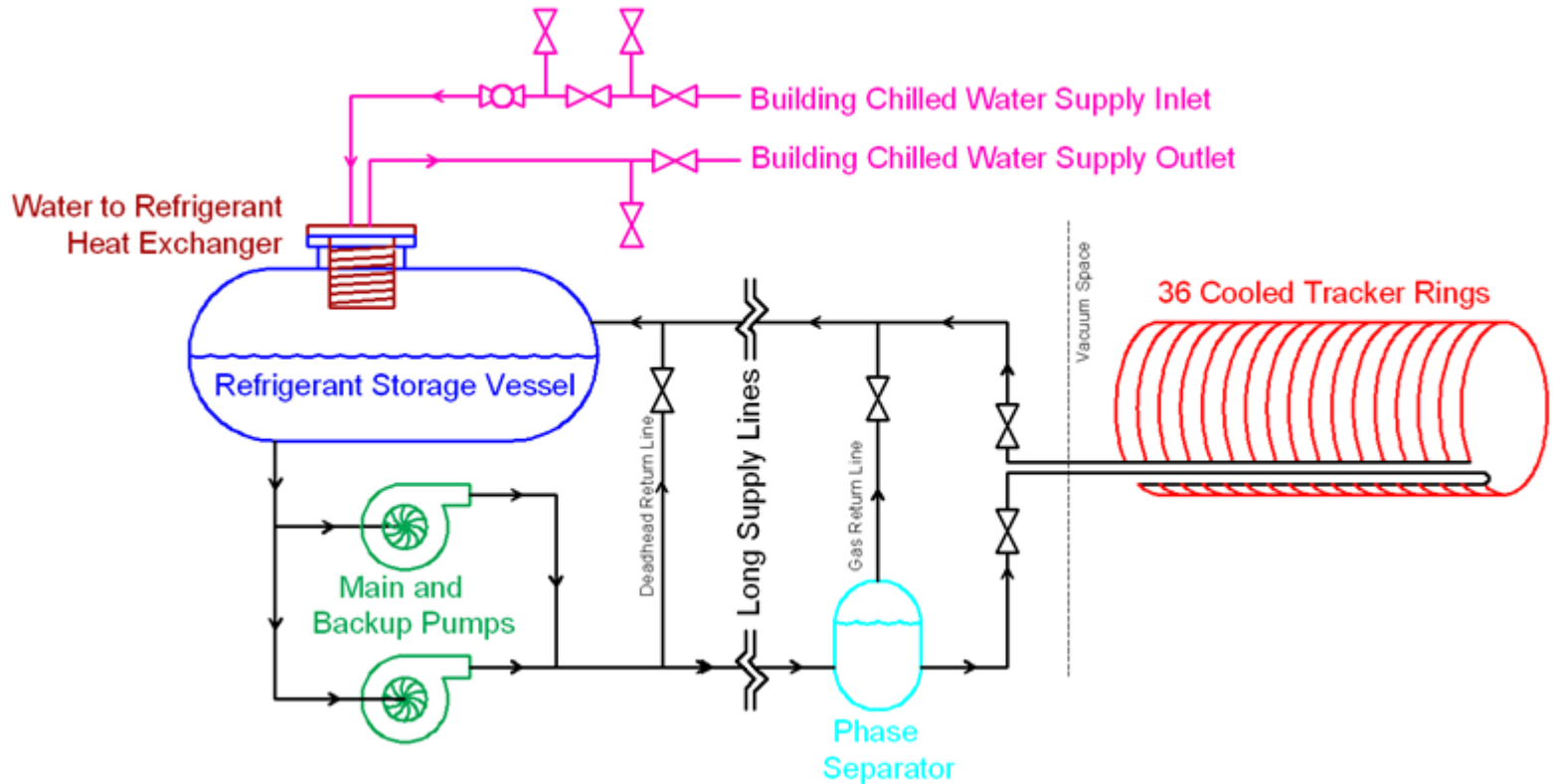
Acting Infrastructure L3 manager

22 Oct 14



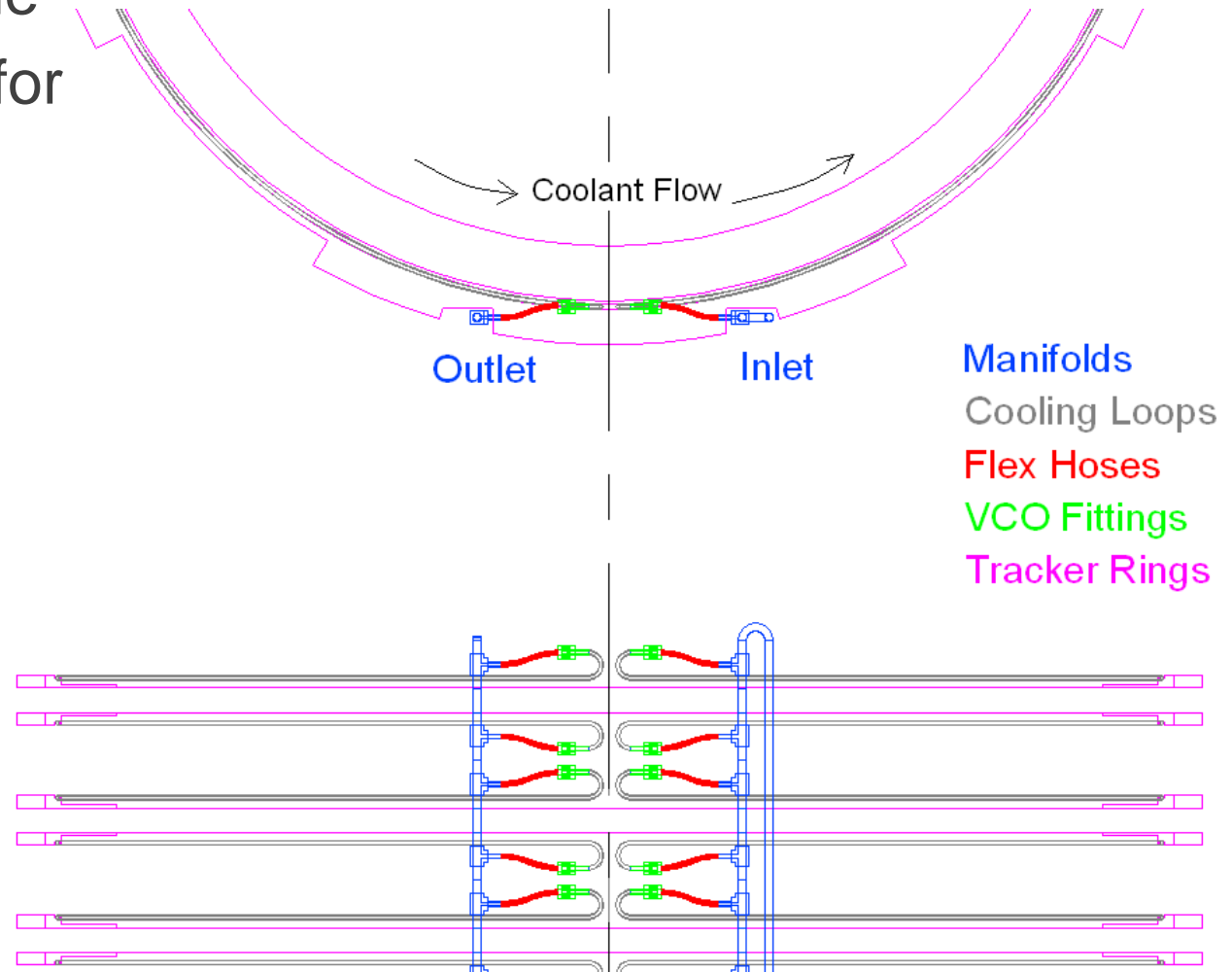
# Cooling

- 10kW tracker + 5kW calorimeter → 15kW SUVA system
  - Passive distribution by equalizing line lengths
  - Tap points for calorimeter cooling not shown



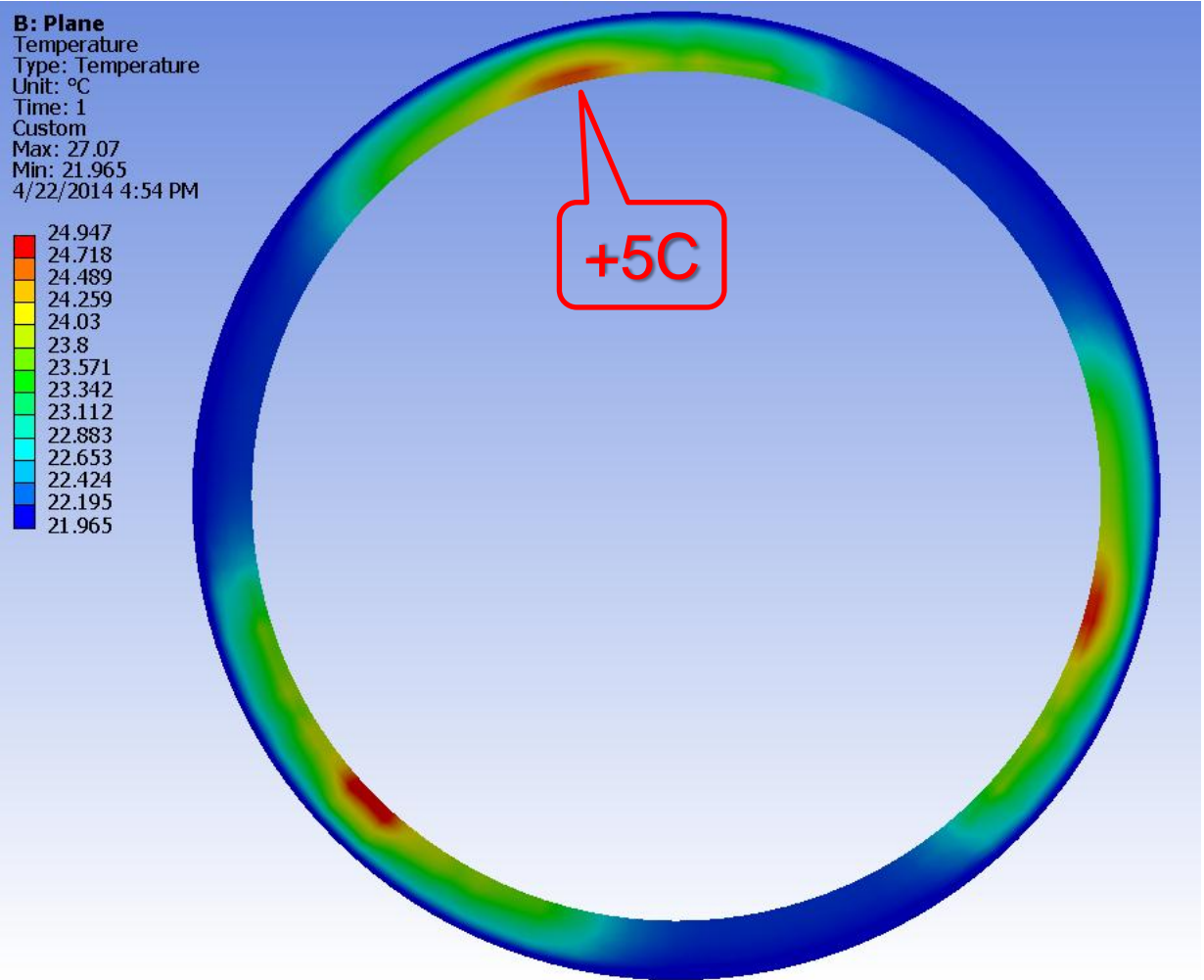
# Cooling

- One ring per plane
- VCO disconnect for removing planes
- $\pm 2^\circ\text{C}$  at OD



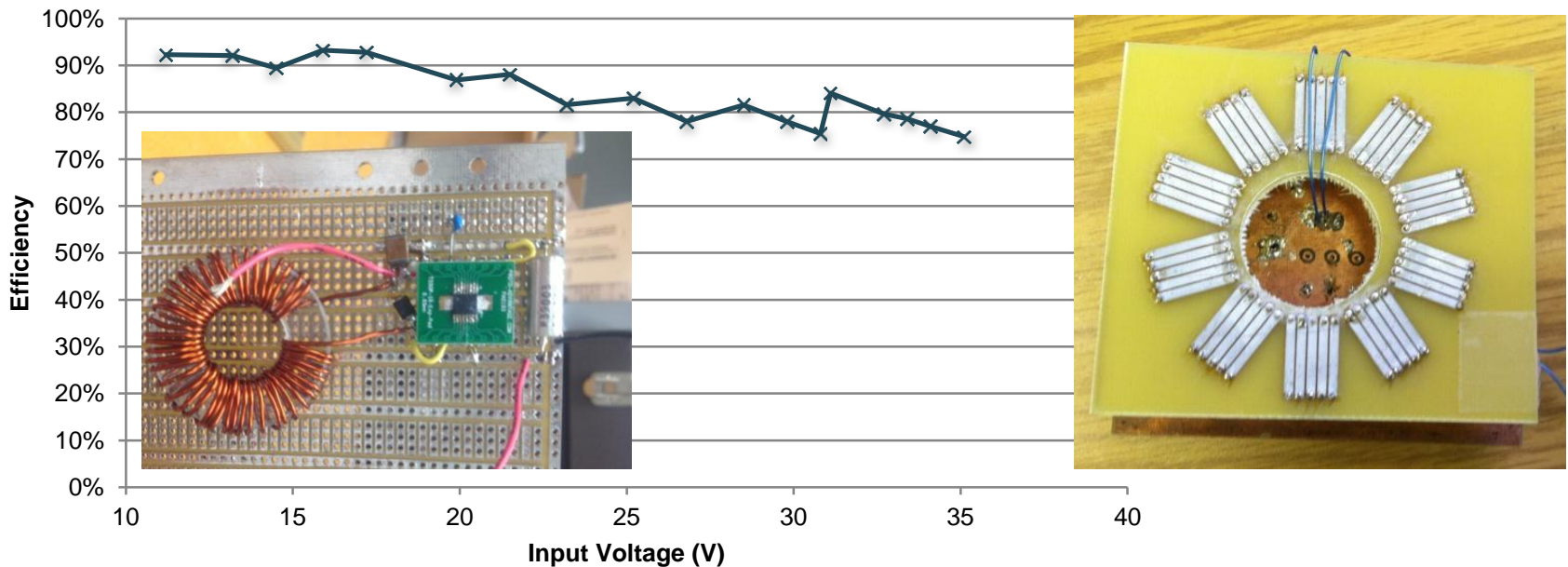
# Cooling

- Temperature gradient with full electronics load



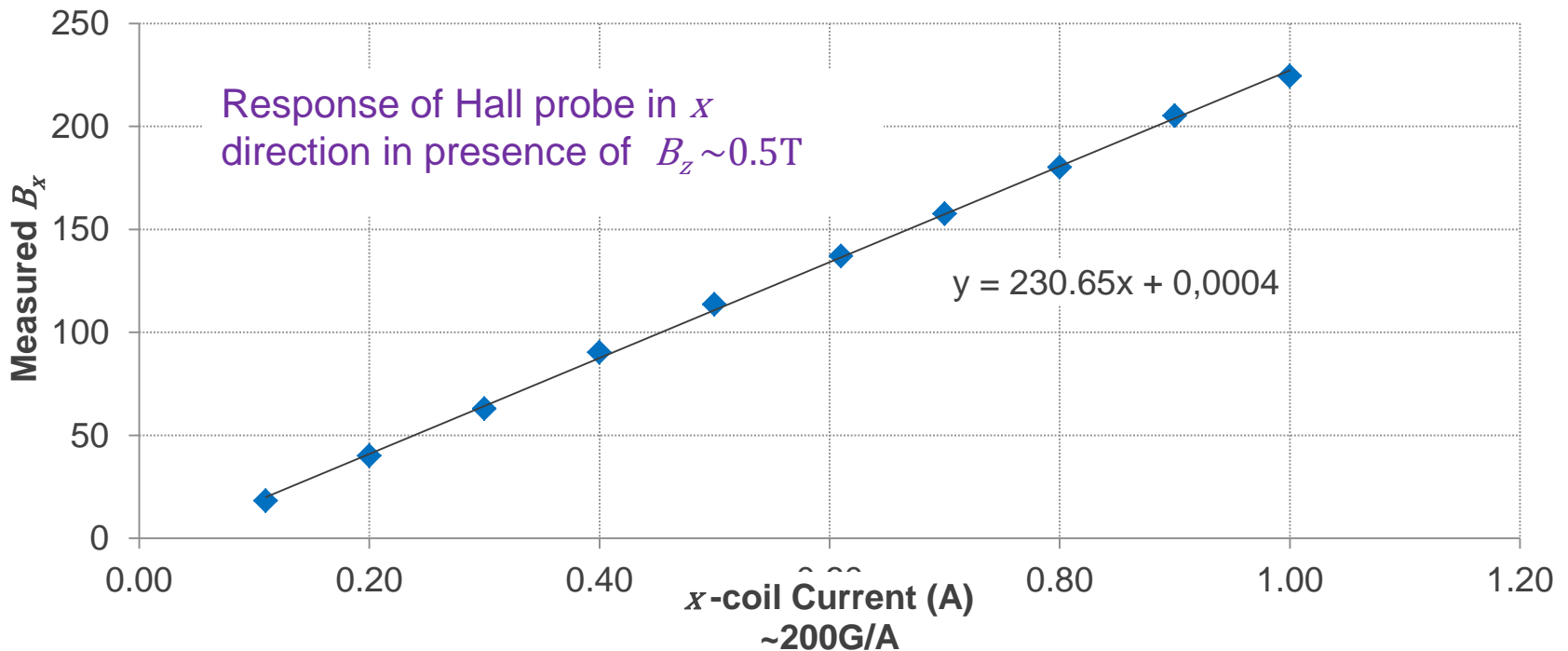
# Power

- Reduce magnetic field perturbations and power loss in lines by sending power at 48V
- Buck DC-DC convertor with air-core toroid
  - Tested to 36V with hand-wound toroid
  - Developing 48V version with toroid manufactured on PCB



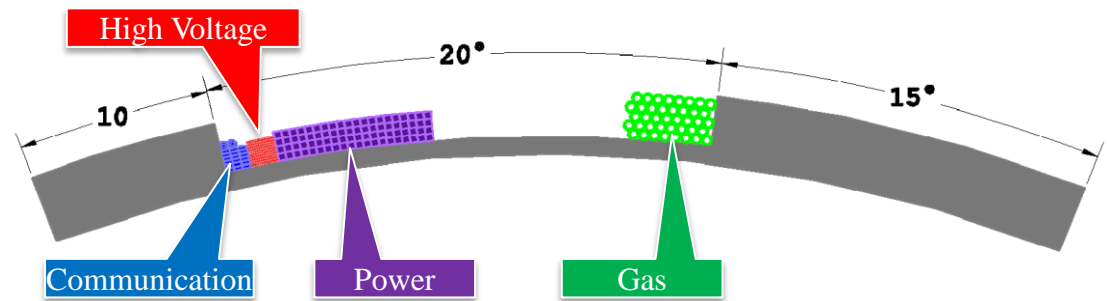
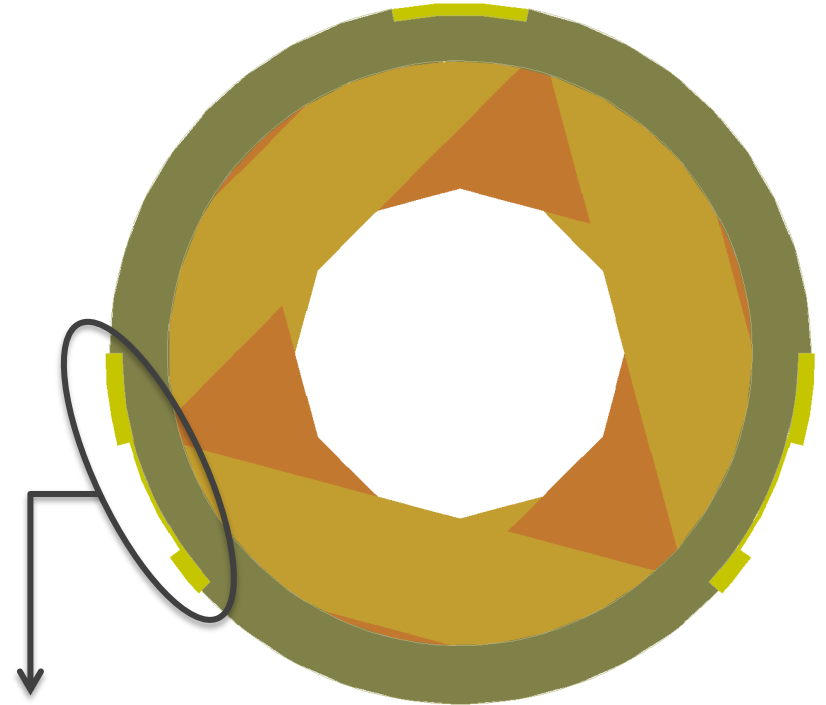
# Alignment Monitoring: Hall Probe

- Not for absolute alignment: monitor variation over time
- 2-axis Hall probe aligned perpendicular to magnetic field
- 20  $\mu$ radian resolution with  $B_z=1$  Tesla field



# Cabling

- Horizontal beams support cabling, gas lines on tracker
- Cables run past calorimeter and beam stop to IFB
- Azimuthal position set to minimize interference with calorimeter electronics
- Leave room to sight panel survey monuments



# Cabling

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- Gas
  - One pair per plane
  - IFB penetration: Standard welded feedthroughs
  - Panel penetration: stainless steel compression fitting with epoxy
- Low voltage
  - One pair per plane
  - In vacuum: Nomex<sup>®</sup> covered ~2.5mm square magnet wire  
Similar to that used by CDF
  - Outside vacuum: THHN (flexible) wire
  - IFB penetrations: standard electric vacuum feedthroughs
  - Panel penetrations: Copper with Kapton<sup>®</sup> sleeve



# Cabling

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- High Voltage
  - One line per panel
  - Silicone insulated, 0.05” pitch ribbon cable
  - IFB penetration: Vacuum rated DB25
    - Note all lines are at the same voltage
    - Panel penetrations: Copper with ceramic sleeve
- Copper communication
  - Two coax per panel
  - IFB and Panel Penetration: Standard vacuum rated SMA

# Cabling

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- Optical Communication
  - One pair per panel
  - Jacket but no fiber reinforcement
    - Reinforcement traps air and forms a virtual leak
  - IFB penetration: standard vacuum rated fiber feedthrough
  - Panel penetration: individual fibers with epoxy seal

# Outgassing from Cables

- Optical fibers tested for outgassing
  - Reinforcing fibers normally used trap too much air
  - CERN's unreinforced optical cable gives acceptable results
    - $\sim 8 \cdot 10^{-4}$  ccm/370mm for 12-fiber ribbon after pumping for 48 hours
    - $< 4 \cdot 10^{-4}$  ccm/370mm after pumping  $\sim 1$  week
    - Worst case extrapolation (linear in length)
      - $< 1.0$  ccm in 2 days
      - $< 0.5$  ccm in a week



# Electrical Breakdown (Townsend Effect)

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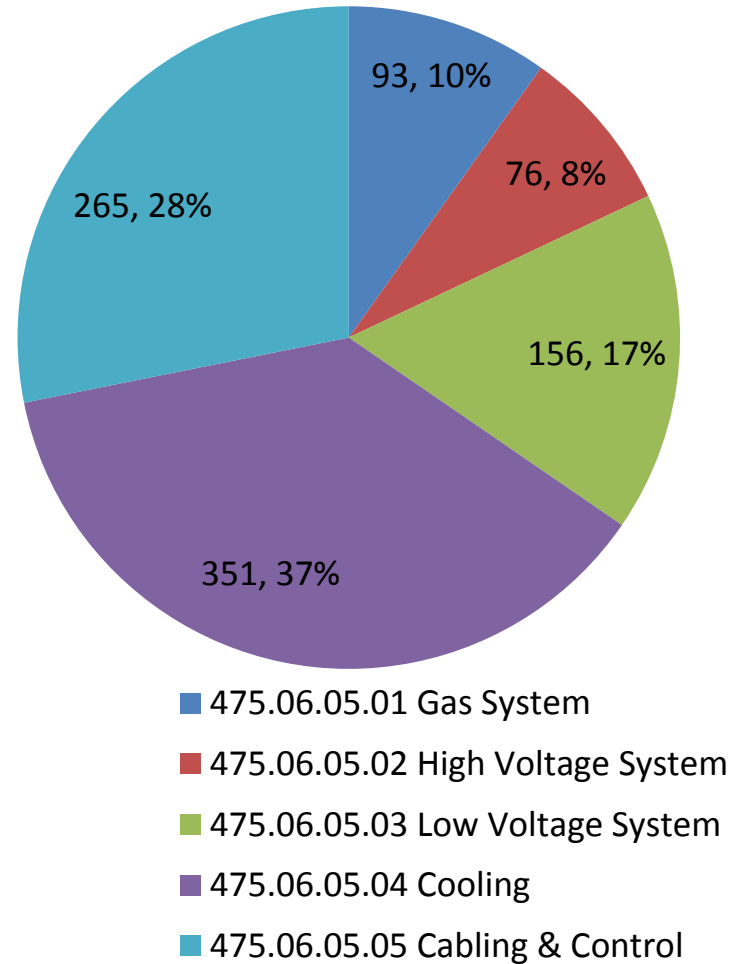
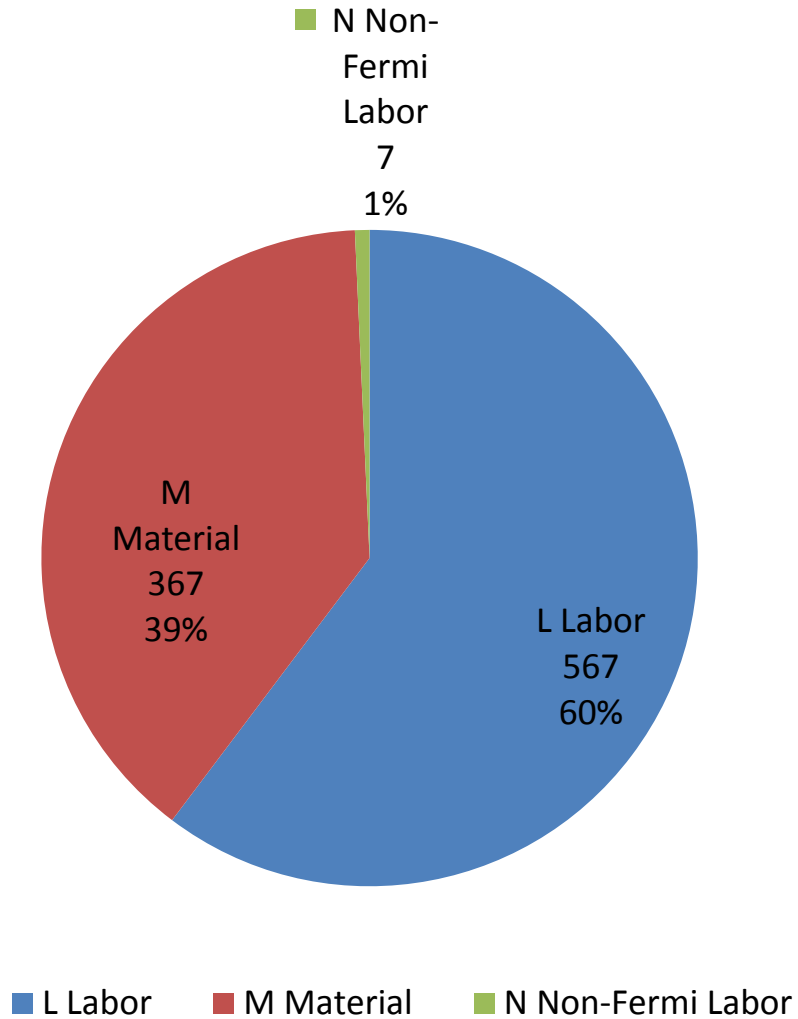
- Our residual gas is (probably) mostly water absorbed into plastics... not air
- Tested for breakdown with just water
  - Standard solder tail DB25 (female) connector, being considered for HV penetration at IFB
  - Coat solder connections with acrylic (nailpolish)
  - Connector side left open
  - Withstands 1.8kV up to ~0.1 Torr
- No problem operating at nominal DS pressure of  $10^{-4}$  Torr

# Cost Table

	Base Cost (AY K\$)			Estimate Uncertainty (on remaining costs)	% Contingency on ETC	Total Cost
	M&S	Labor	Total			
475.06 Tracker						
475.06.05 Tracker Infrastructure						
475.06.05.01 Gas System	8	85	93	44	51%	137
475.06.05.02 High Voltage System	12	64	76	33	43%	109
475.06.05.03 Low Voltage System	65	91	156	70	45%	226
475.06.05.04 Cooling	129	222	351	142	41%	493
475.06.05.05 Cabling & Control	160	104	265	63	25%	327
Grand Total	374	567	941	352	38%	1,293

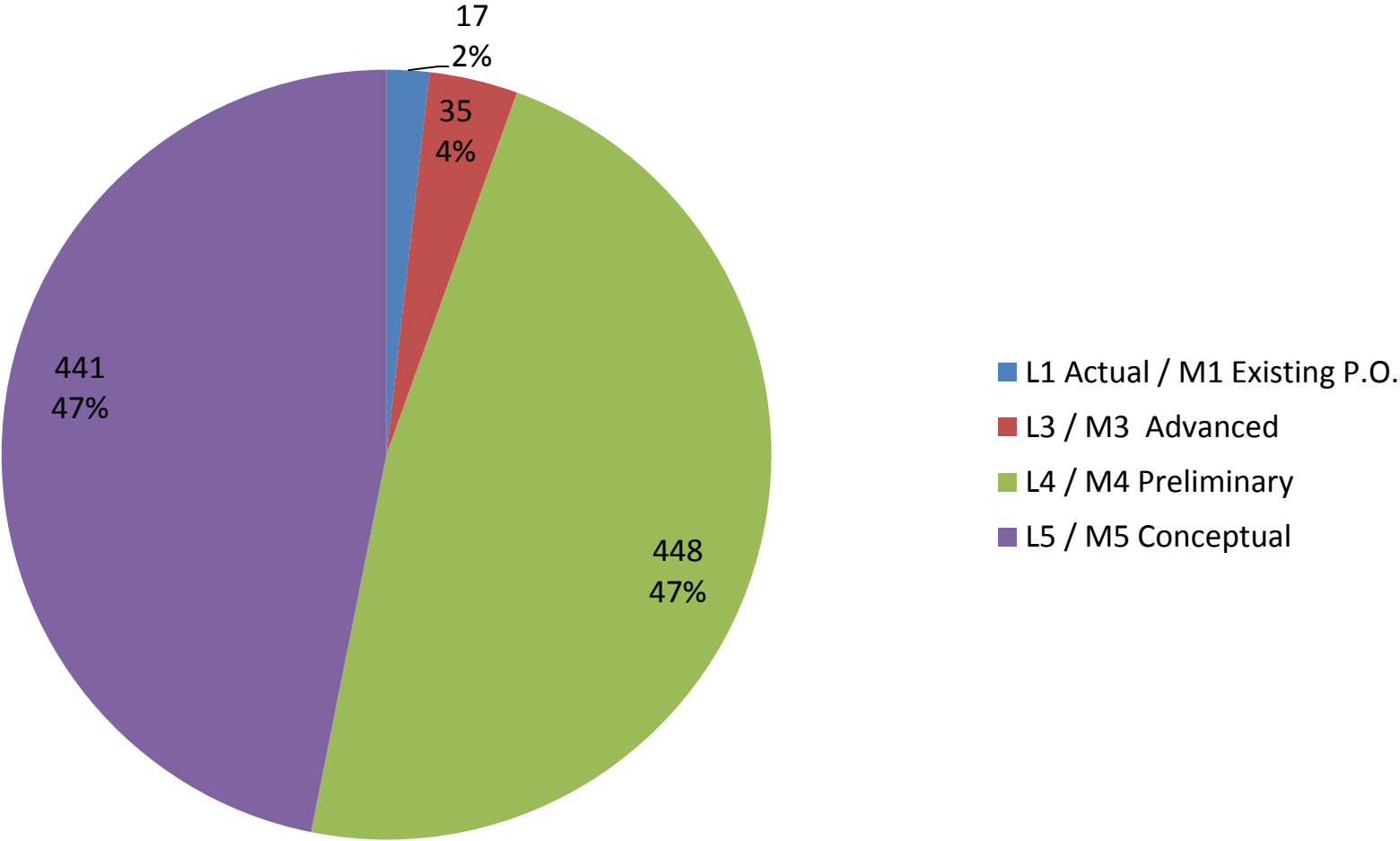
# Cost Breakdown

Base Cost (AY K\$)



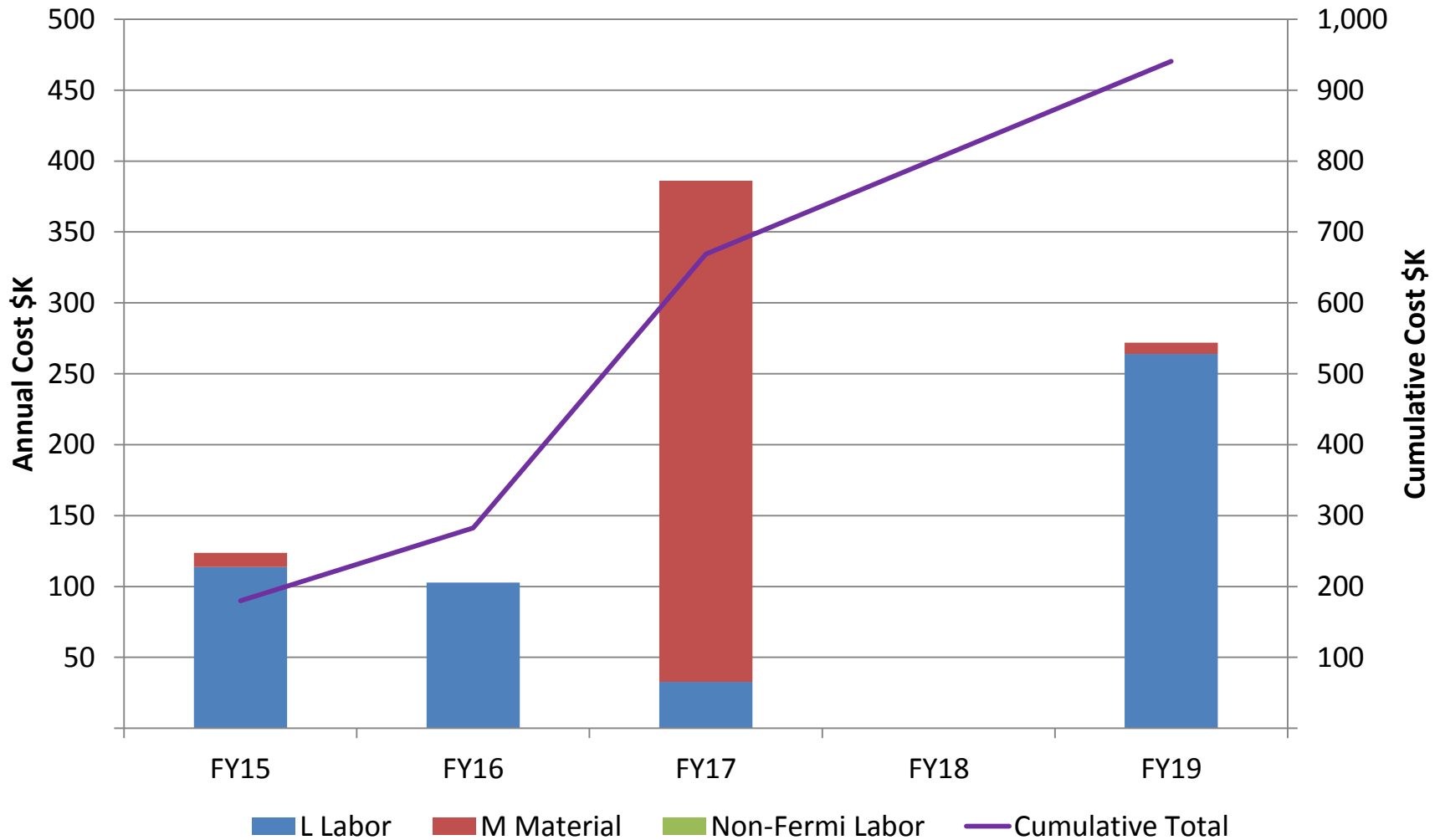
# Quality of Estimate

Base Cost (AY K\$)



# Labor & Material by FY

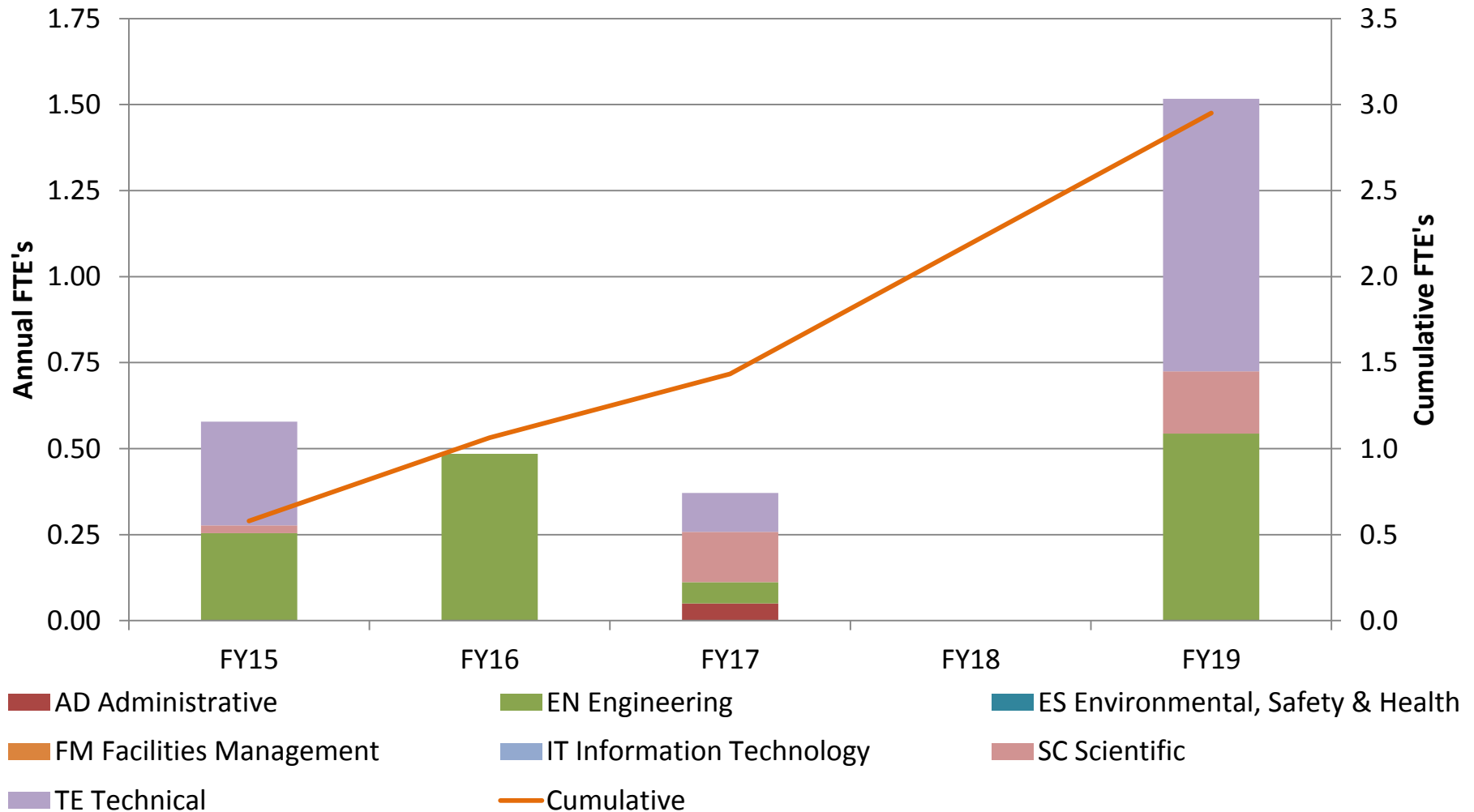
Base Cost (AY K\$)





# Labor Resources by FY

FTEs by Discipline



# Summary

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- Preliminary design exists for key subsystems: cooling, power
- Conceptual design exists for all other subsystems
- Outgassing studies in progress
- Vacuum penetration design will be done at York
  - Vacuum equipment and expertise available
- Fermilab engineering becomes available as other L3s move into production