COMET Mu2e Collaboration

Memorandum of Understanding On Joint Efforts Between the COMET and Mu2e Collaborations

Date: 3/6/09

James P. Miller
Boston University
Co-Spokesperson for
Mu2e Collaboration

Date: 3/11/09

Yoshitaka Kuno
Osaka University
Contact Person for
COMET Collaboration

Date: 3/6/09

Robert H. Bernstein
Fermi National Laboratory
Co-Spokesperson for Mu2e Collaboration

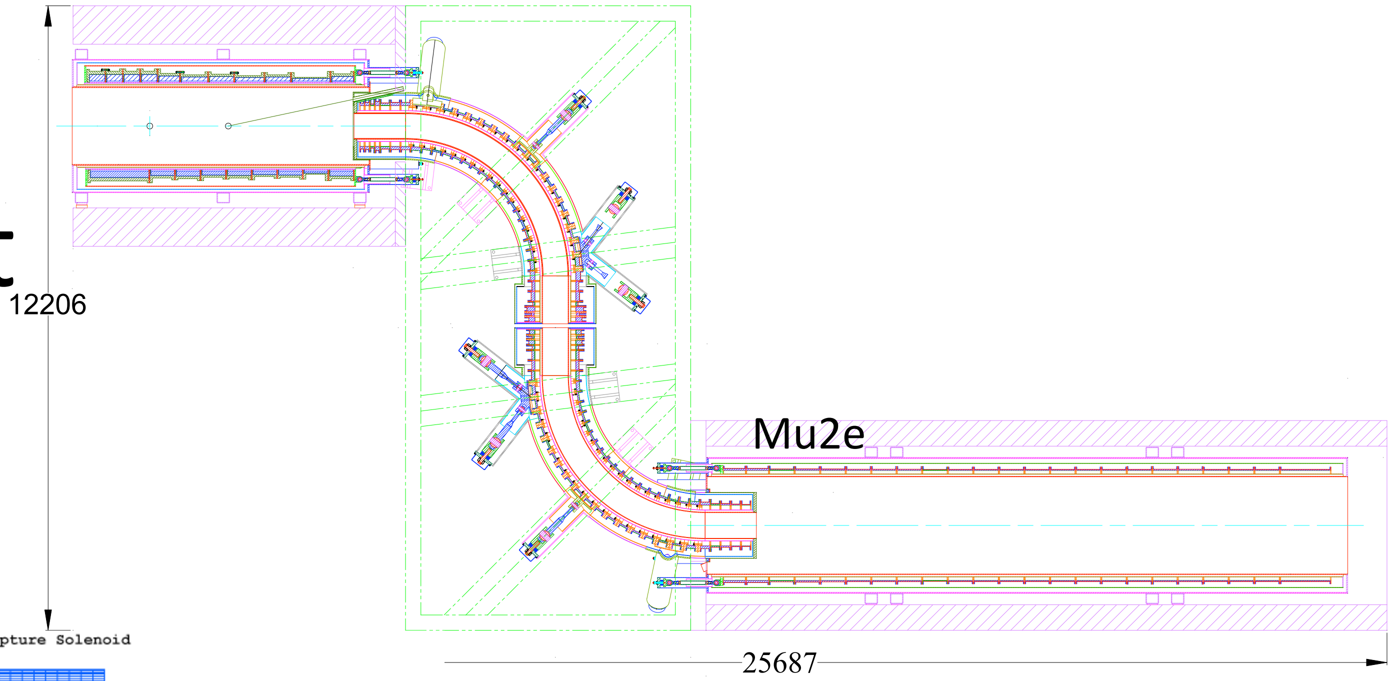
- reason

1. Both experiments have limited financial and human resources.
2. A joint effort between the Mu2e and COMET collaborations could result in improvements to both designs.
3. A joint effort on common problems will speed the design process and allow the world-wide effort to optimize the use of scarce resources.

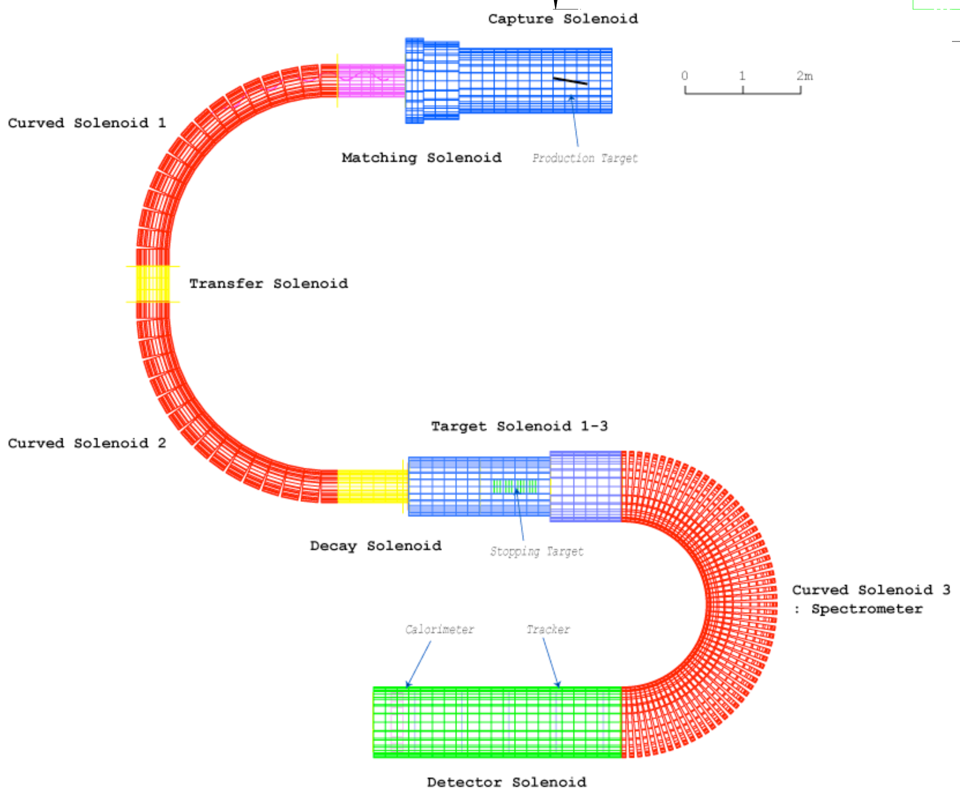
- action

1. The Spokespersons or their designees from the Mu2e and COMET collaborations will coordinate these efforts and the exchange of information.
2. The Spokespersons or their designees from the Mu2e and COMET collaborations will establish technical sub-groups to explore mutually agreed-upon issues through meetings on a regular basis.
3. The Spokespersons or their designees from the Mu2e and COMET collaborations will establish and carry out joint R&D efforts on technical issues of common interest, subject to availability of funding.

R&D for SC Magnet



COMET

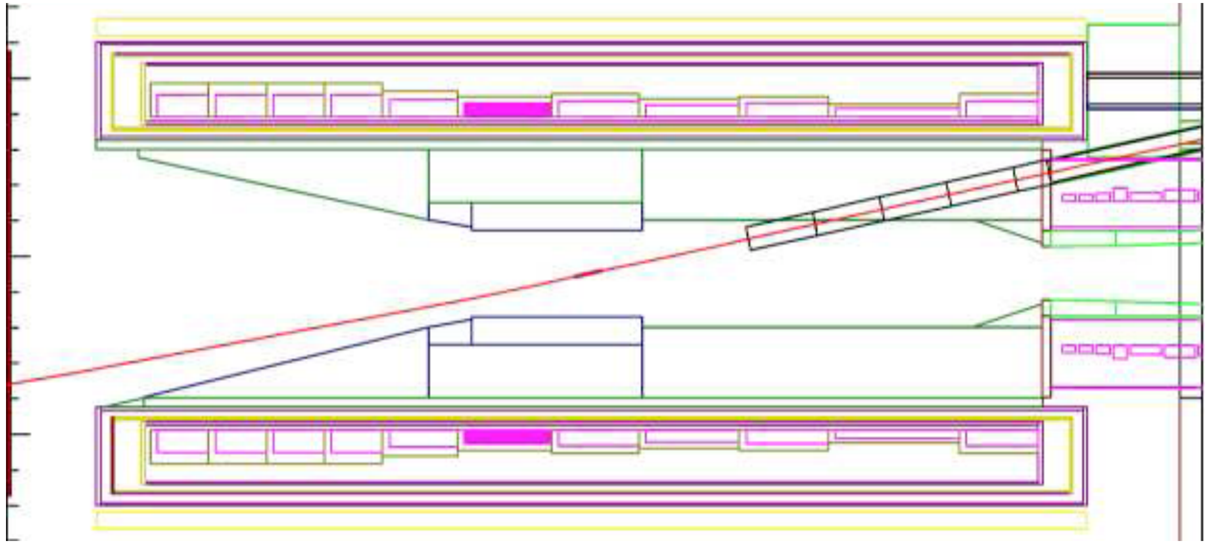


Similarity in SC Magnet Specs

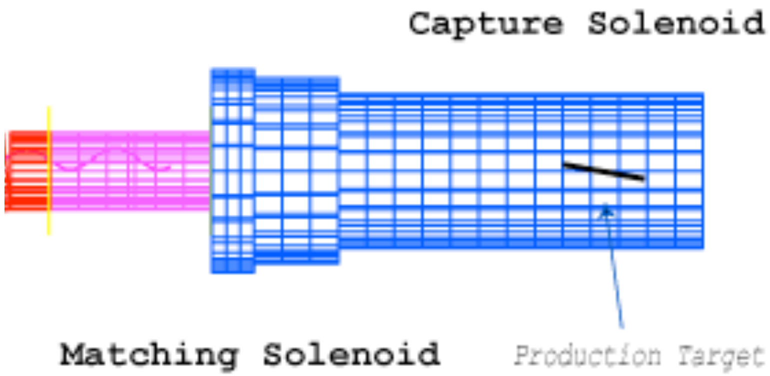
- Production Magnet
  - Large Aperture Solenoid (1~1.8 m)
  - Field 5~6 T
  - High Radiation
- Transport Magnet
  - Curved Solenoid (Aperture 0.4~0.8 m)
  - Field 2~2.5 T
- Detector Magnet
  - Large Aperture (1~2 m)
  - Field 1~2 T

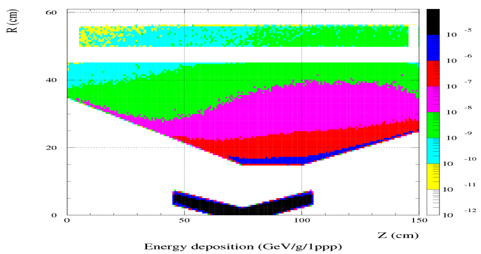
Production Solenoid

Mu2e



COMET

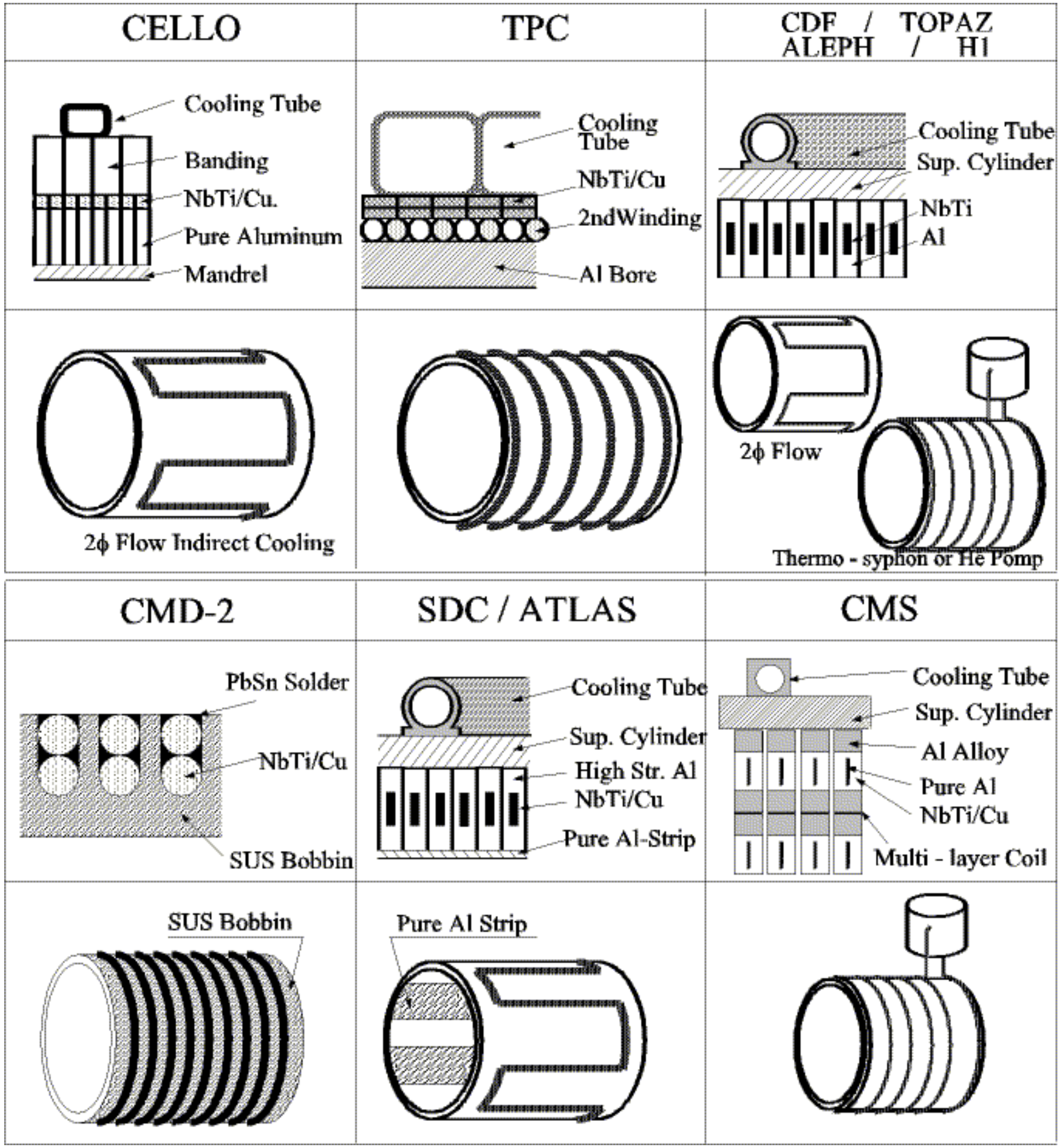




Requirement

- High Field (~5T)
  - More pion to capture
  - More (better) conductor
  - Larger stored energy
- High Radiation
  - High Power Beam
  - Heat Load
  - Radiation Damage

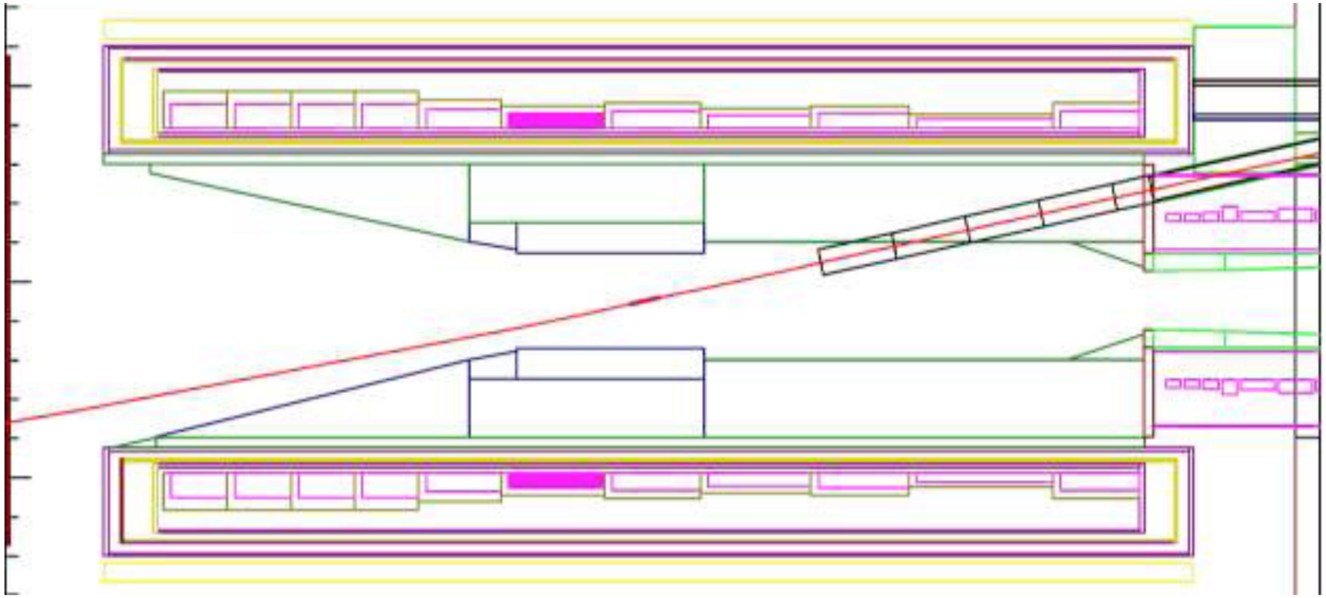
Detector Solenoids



Mostly Common Feature

- Aluminum stabilized cable
  - quench stability
  - quench protection
  - Transparency
    - Less heat deposition
- Indirect cooling with cooling pipe
  - 2 phase forced flow
  - Thermo siphon
    - Less helium irradiated
- Technology well established
  - Many solenoids are in use
  - Familiar to people in high energy physics
- Good for field up to ~5T
  - 4T already achieved
- Good Solution for near future plan
  - With modest budget

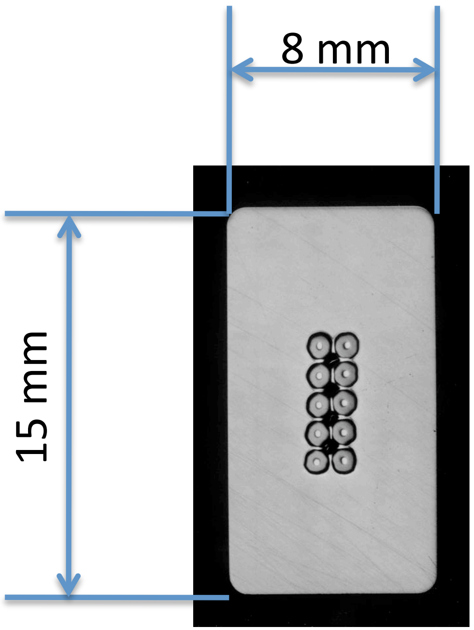
Mu2e production magnet

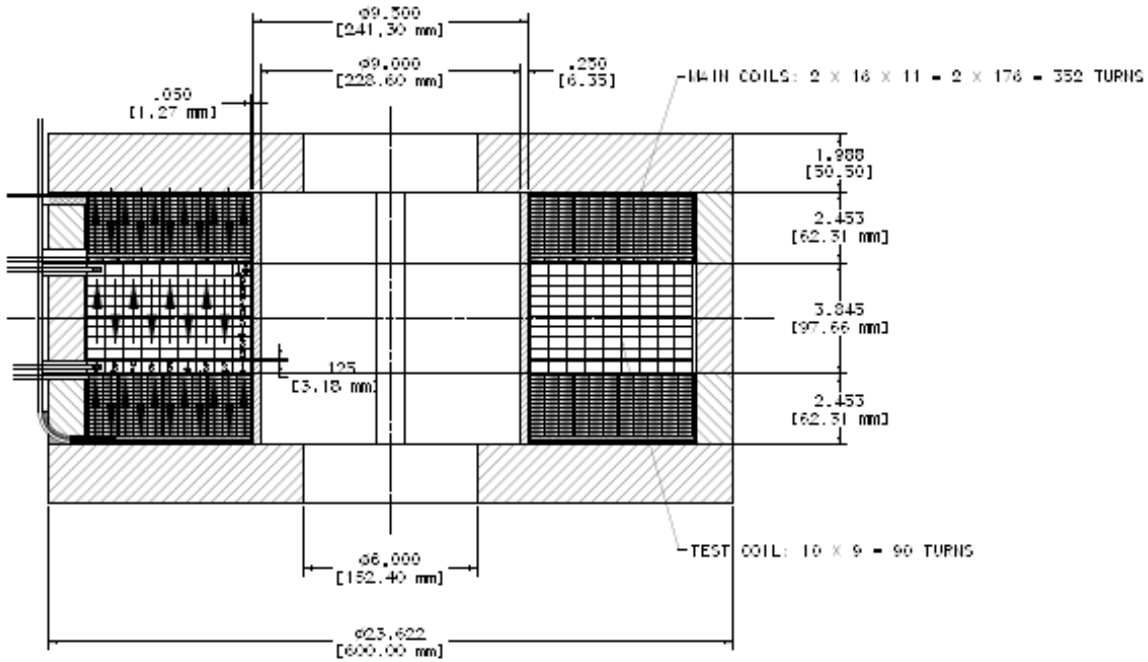


- Current Design
  - Copper stabilizer Helium bath cooling
- Try to adapt detector solenoid technology as an case study
  - Aluminum stabilized conductor
  - Indirect cooling with Helium piping

R&D with USJ Funding

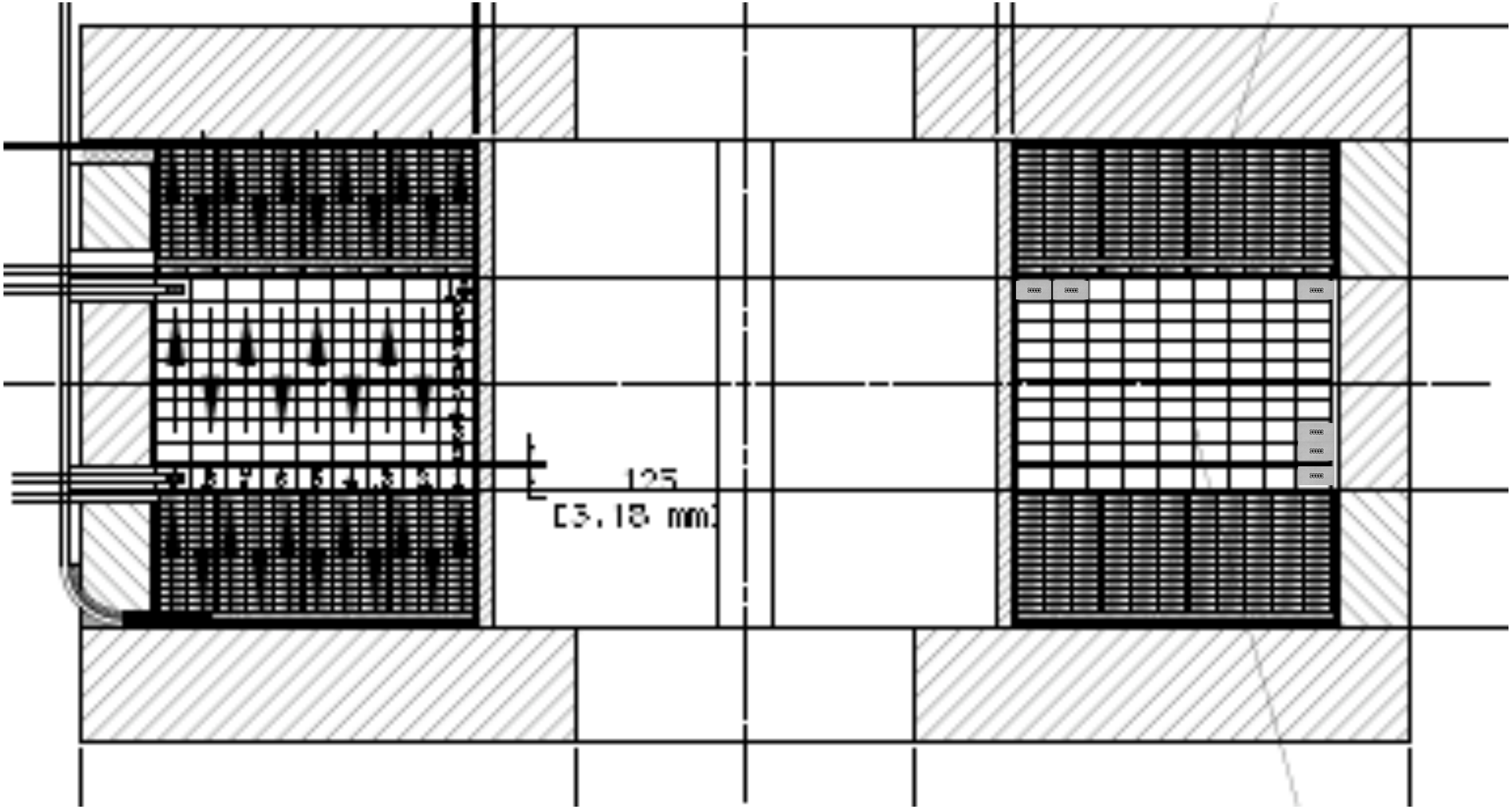
- Approved for JFY 2009
  - Make small R&D coil to establish coil winding technology with Al stabilized conductor at FNAL
  - Use existing conductor = RIKEN SRC conductor





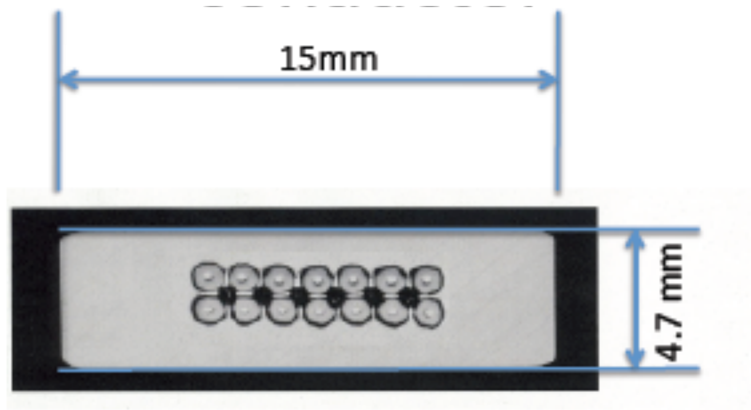
Test Coil

- Aluminum Stabilized Conductor Coil with Rutherford Cable Coils for back up field



R&D with KEK internal Funding

- Develop New Aluminum stabilized conductor
  - Modified RIKEN SRC Conductor
  - Aim for higher yield strength
    - Aluminum Stabilizer
      - Ni or Cu+Mg

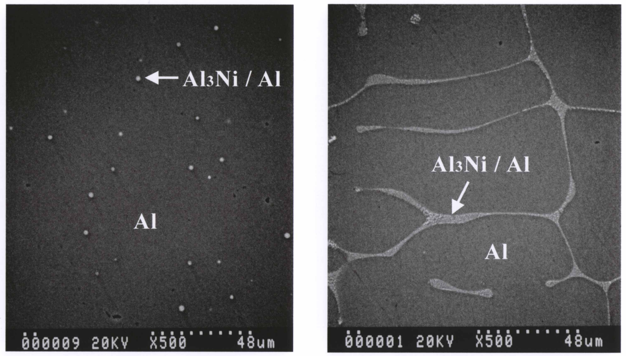


- Dimension 15mm*5mm
  - Including Insulation
  - 15*4.7 w/o ins.
- 14 strands (1.15mm dia)
- Al/Cu/SC ~ 7.3/0.9/1

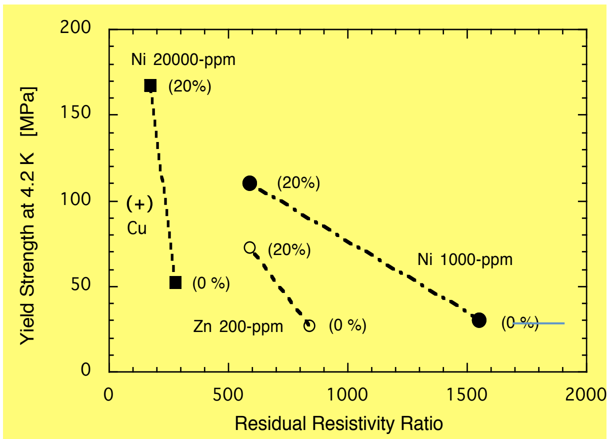
Yield Strength VS RRR

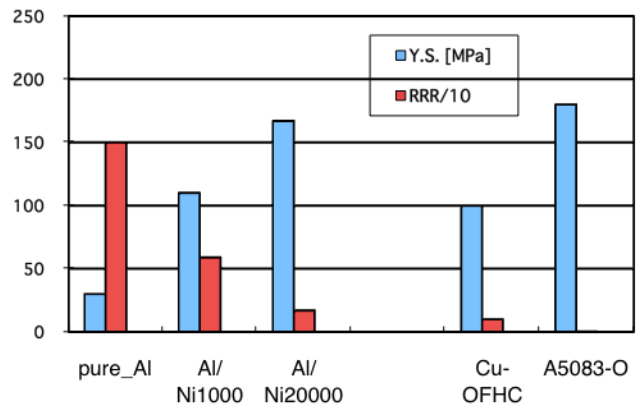
Good RRR: for quench stability and protection

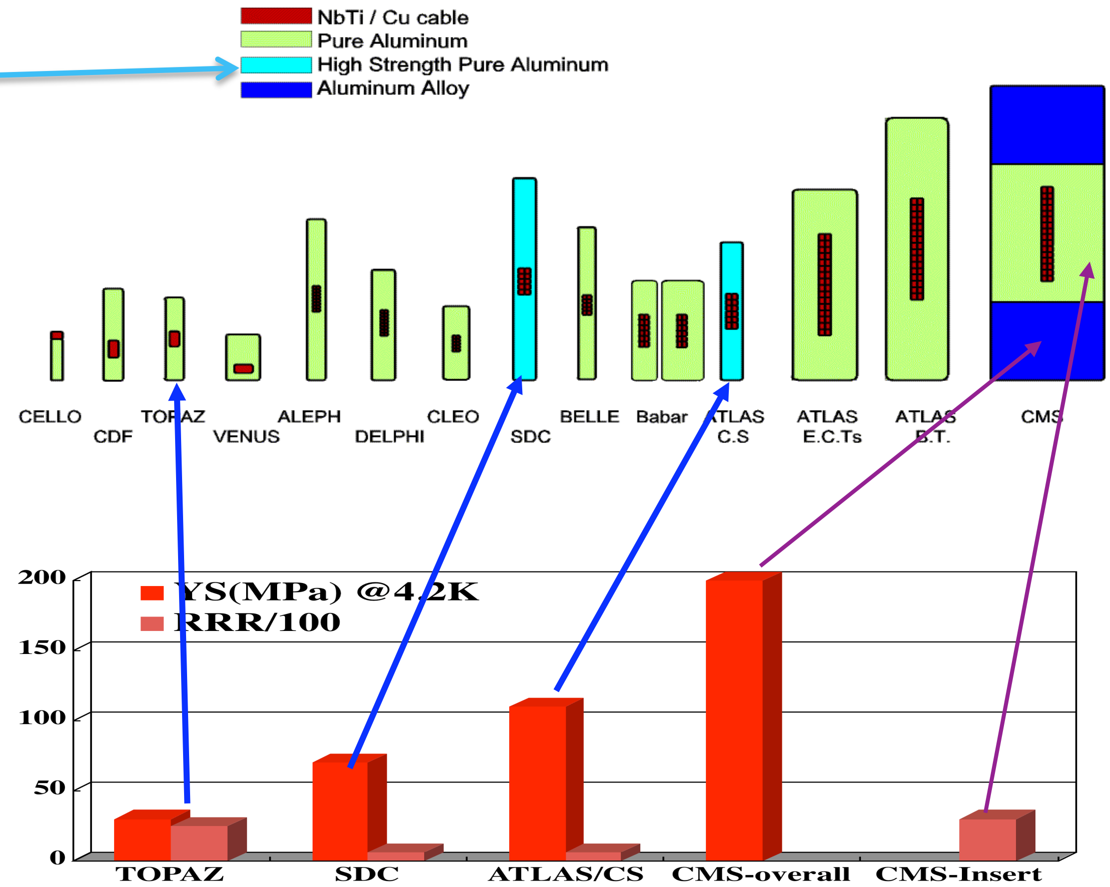
High Yield Strength: for high EM force



a) Al-0.1wt%Ni Alloy b) Al-0.5wt%Ni Alloy







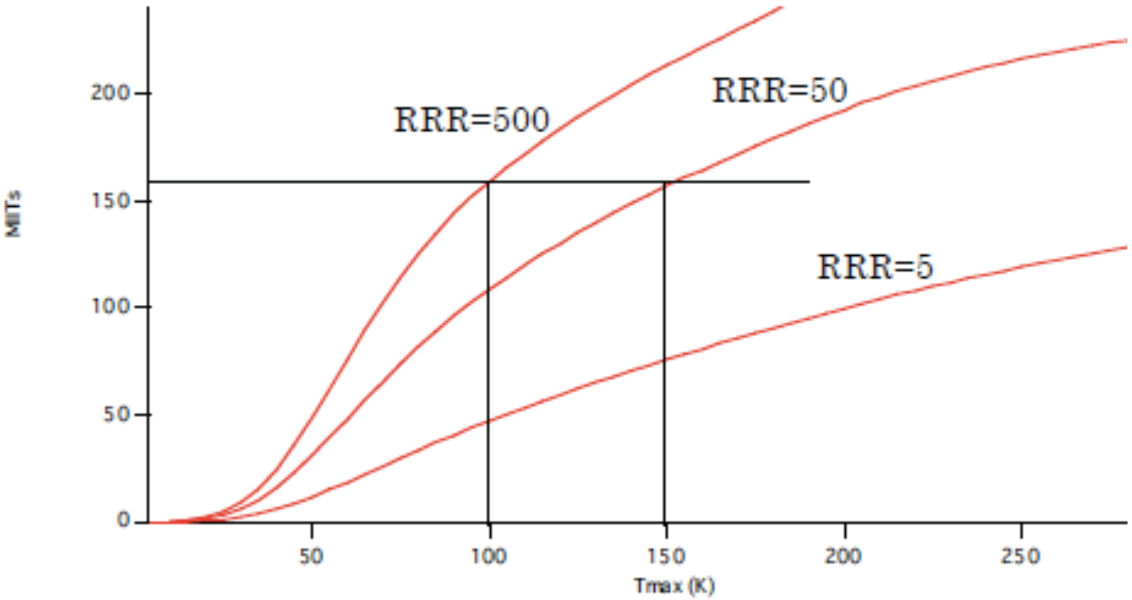
Issues & Discussions Radiation Damage

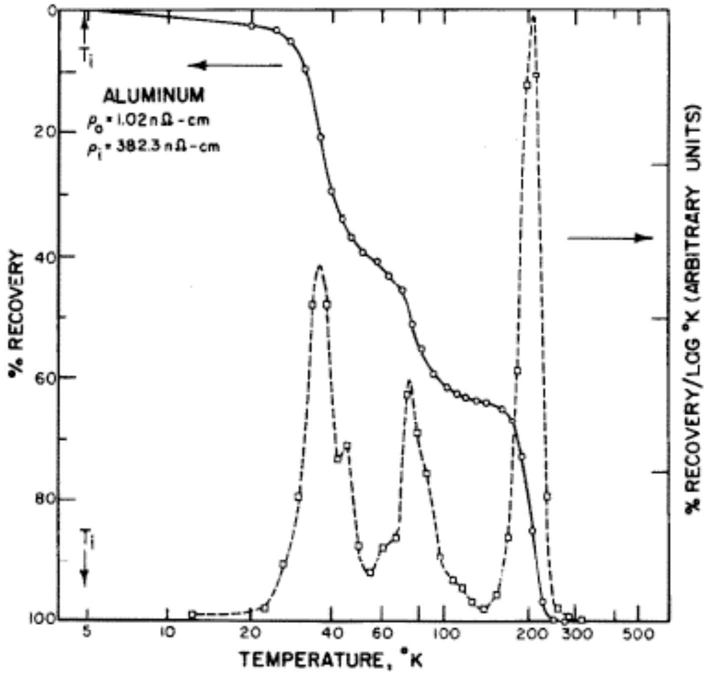
- Aluminum Stabilizer
  - Conductance degradation
  - Starts with 10^{20} n/m^2
  - Recoverable by thermal cycle to room temp.
- Insulator
  - 10MGy or 10^{22} n/m^2
- Superconductor
  - Tc or Jc degradation starts 10^{22} n/m^2

Normal Conductor Degradation

- MIITs: $\int_{t_{quench}}^{t_{end}} I^2 dt = \int_{T_0}^{T_{\max}} \frac{C_p A}{\rho / A} dT$

- ρ increase ➔ temperature increase



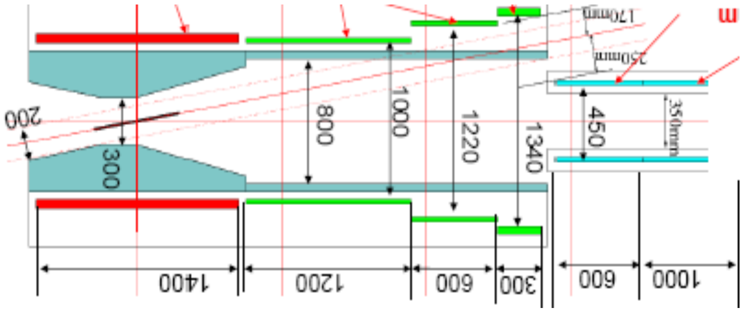


For COMET

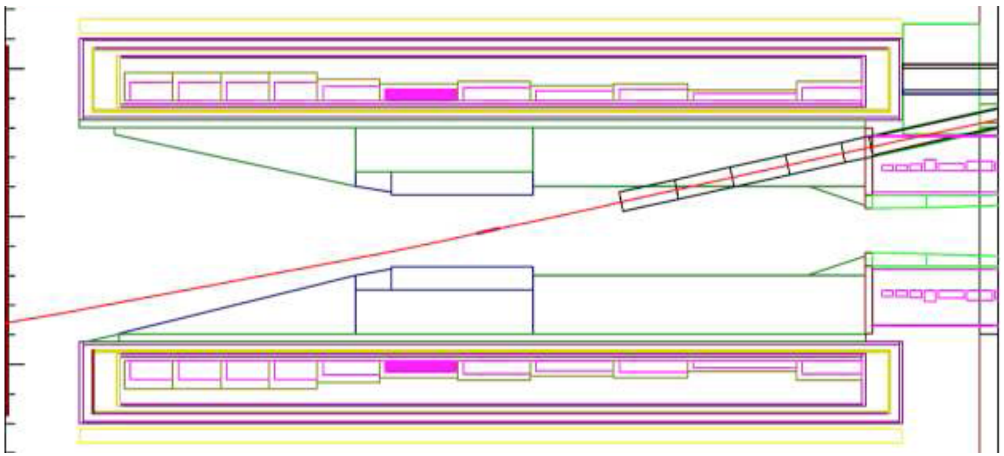
- Current Neutron Flux is marginal
  - 10^{22} n/m^2 for ~300 days operation (Machine Life)
    - Experiment requires ~200 days
  - 10^{21} n/m^2 for 30 days operation (Thermal Cycle Limit)
    - Degradation starts 10^{20} n/m^2 : 3 days !
- Need to increase coil aperture
  - Increase shield thickness
  - Stored energy increase : quench protection
  - Hoop stress increase: conductor yield strength

Design Comparison

COMET



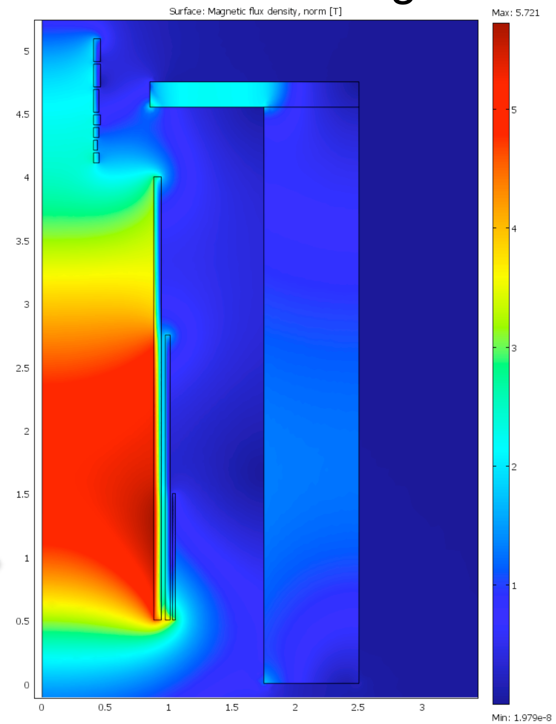
Mu2e



Increase aperture

Simple Design

COMMON Design?

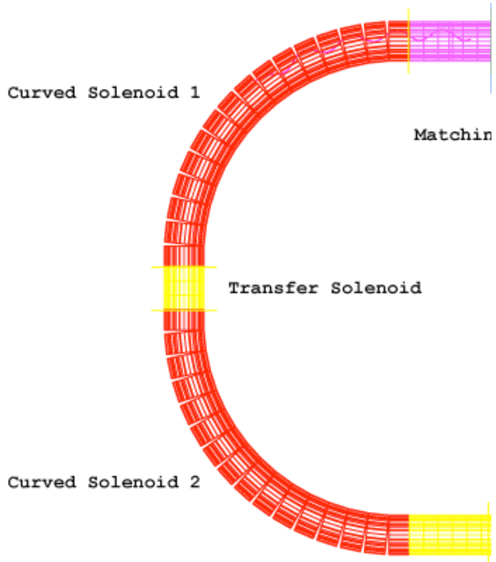


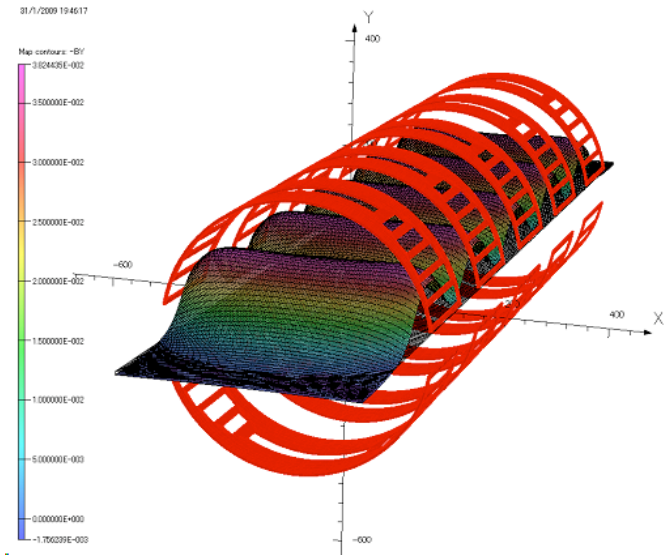
Production Magnet

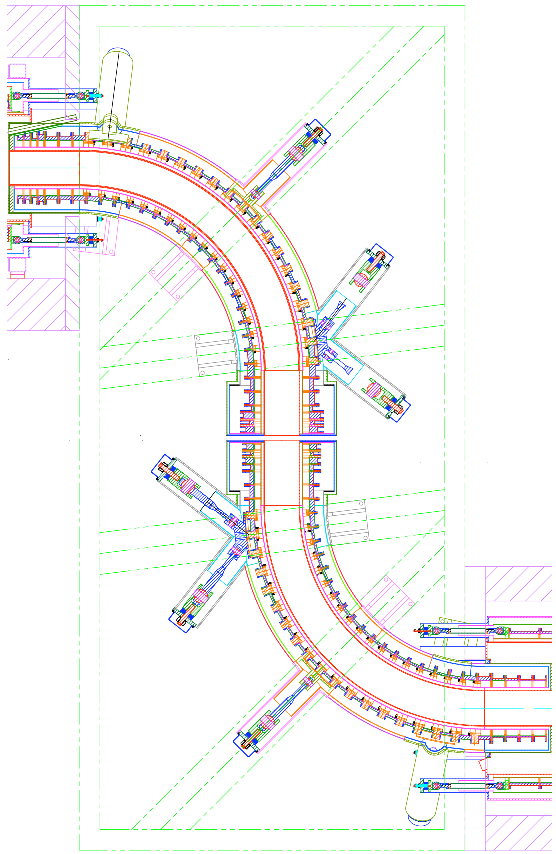
- Detector Solenoid Technology
  - Aluminum Stabilized Conductor
  - Indirect Cooling
- Radiation Damage
  - Conductor degradation by neutron flux
  - Insulator degradation by radiation

Transport Magnet

- Mu2e
  - Large aperture S shape
- COMET
  - Small aperture C shape with dipole field corrector

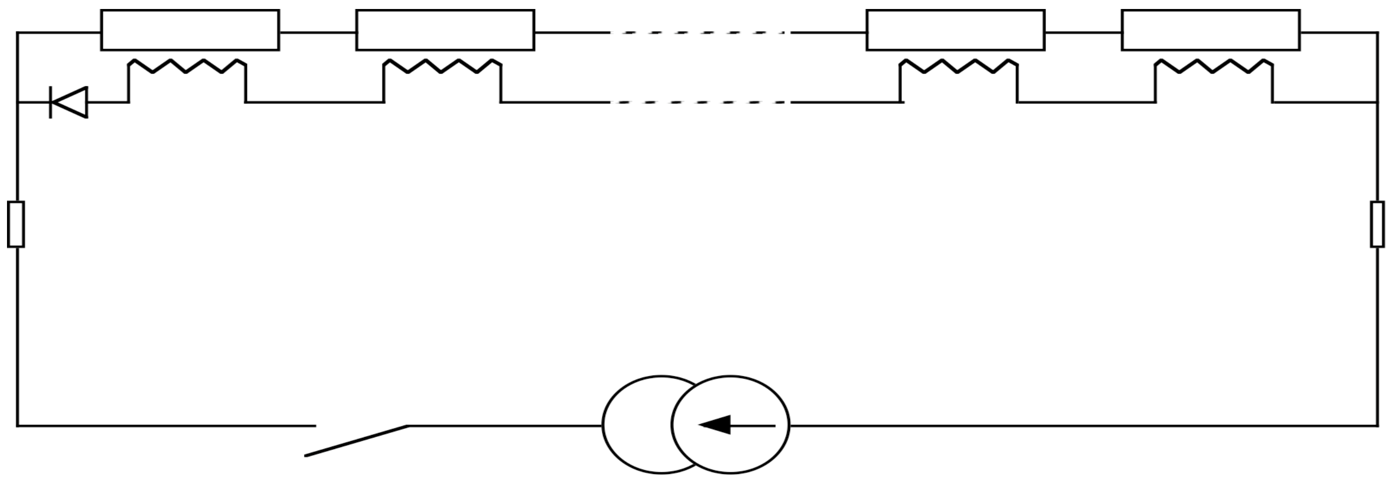






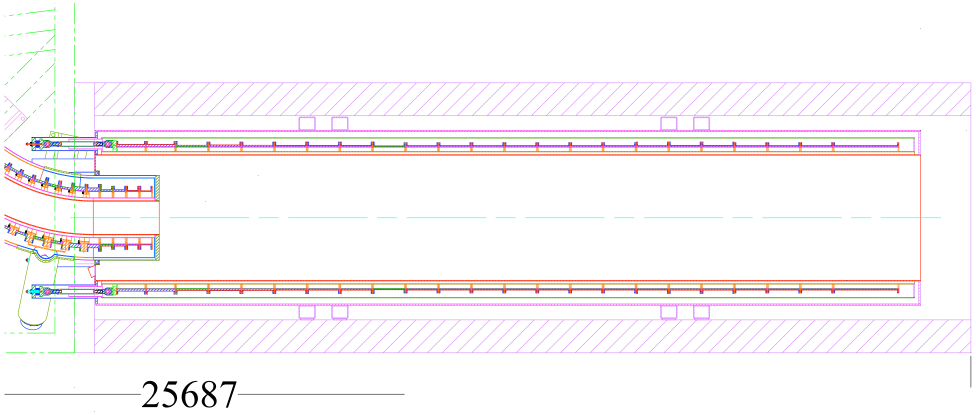
Issues and Discussion

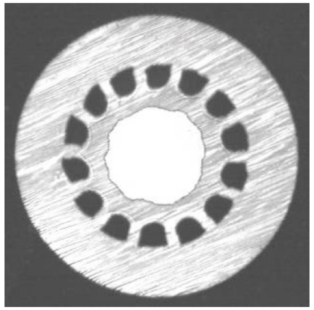
- Dipole Correctors
  - Optics needed to be optimized
- Quench Protection
  - Solenoids are segmented
  - Quench Propagation maybe impeded
  - Quench back system needed

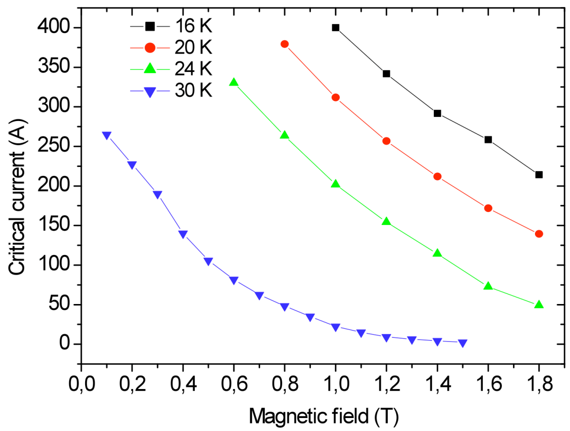


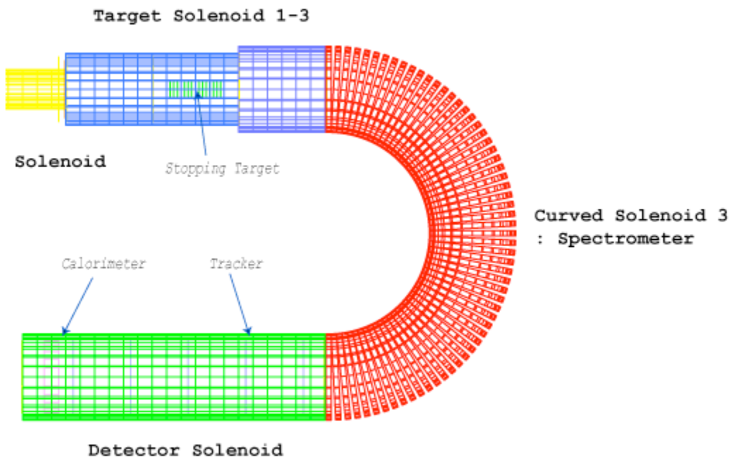
Detector Solenoid

- Field 1~2 T (except COMET target solenoid)
- Possibility to use MgB_2 for better stability?









Future R&D

- Built indirect cooling coil with new conductor
  - Check cooling parameters
- Starts R&D for radiation damage
  - Insulator R&D is on going at KEK (cyanate ester)
  - Need to starts conductor R&D such as
    - Stabilizer conductance degradation
    - Tc or Jc degradation on SC material
  - Bench mark of simulation codes
    - Mars, Phits, etc
- Possibility of New Superconductor
  - Nb_3Sn, Nb_3Al, MgB_2, etc