Technology Development

- Outline
  - Organization
  - Goals
  - Program Overview
    - Where we are & where we are headed
  - Milestones
  - Planning and Resources

Technology Development
L2 Organization

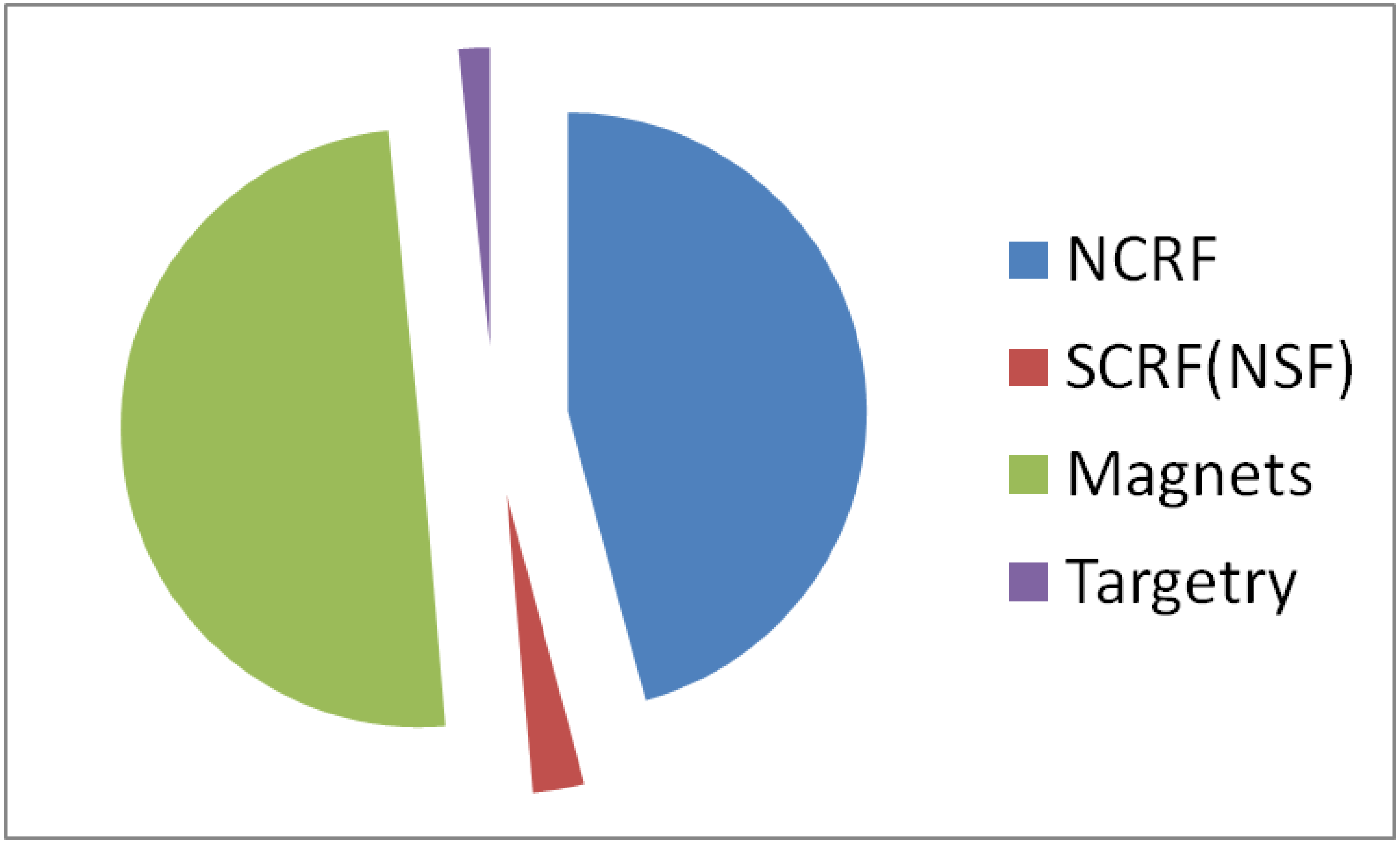
- Normal Conducting RF
  – Derun Li, LBNL, RF scientist for the MuCool program
- Superconducting RF
  – Don Hartill, Professor Cornell University
- Magnets
  – Mike Lamm, Department Head Fermilab (TD) Magnet Systems
- Targets and Absorbers
  – Kirk McDonald, Princeton University & co-spokesperson of the MERIT experiment
- MuCool Test Area Coordinator
  – Yagmur Torun, Professor Illinois Institute of Technology & deputy MuCool spokesperson

Primary Goals

- Establish the viability of the concepts and components that will be used in the design reports
  - Neutrino Factory Reference Design Report (NF-RDR)
  - Muon Collider Design Feasibility Study Report (MC-DFSR)
- Establish the engineering performance parameters to be assumed in the design studies
- Provide a good basis for cost estimates.

TechDev – Total Effort *Snapshot*

M&S + Manpower



TOTAL = $35M + $1M

Normal Conducting RF

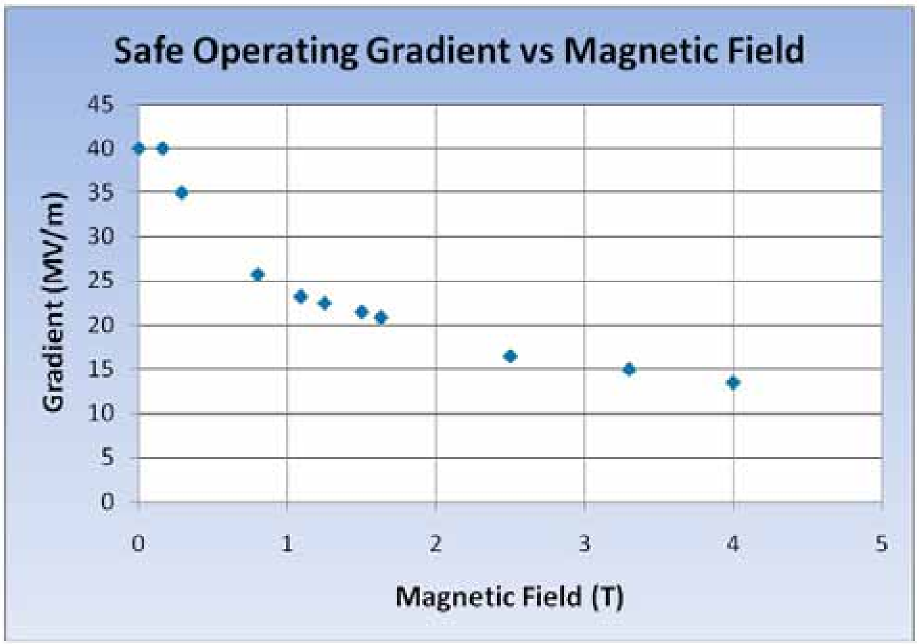
R&D Issues and Present Status

- Muon bunching, phase rotation and cooling requires Normal Conducting RF (NCRF) that can operate at high gradient within an approximately 3 to 6T magnetic field
  - Required gradient easily obtainable in absence of magnetic field

But

The RF *Challenge*

- Significant degradation in maximum stable operating gradient with applied B field



- 805 MHz RF Pillbox data
  - Curved Be windows
  - E parallel B
  - Electron current/arcs focused by B
- Degradation also observed with 201 MHz cavity
  - Qualitatively, quite different

Details will be presented in RF parallel

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201 MHz Cavity Test

Treating NCRF cavities with SCRF processes

- The 201 MHz Cavity –*Achieved 21MV/m*
  - Design – 16MV/m
  - At 0.75T reached 10-12 MV/m

However, No observed damage!

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NCRF R&D Program

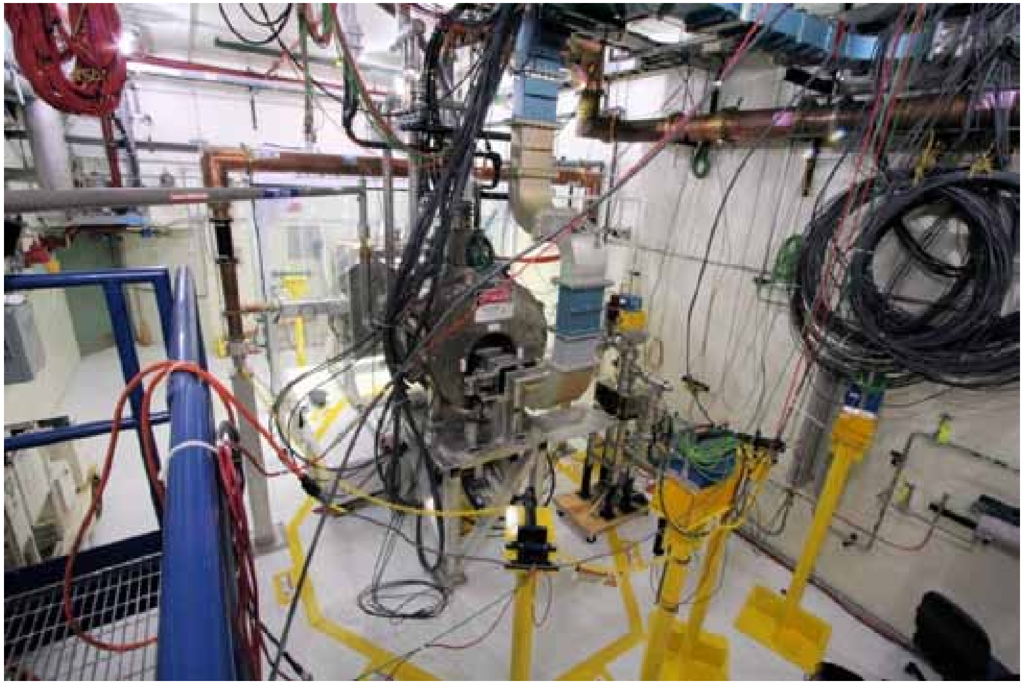
Ø Potential paths towards a solution: *Phase I: Technology Assessment (continuation of existing multi-pronged approach)*

- Materials studies: Use base materials that are more robust to the focusing effects of the magnetic field
  - Cavity bodies made from Be or possibly Mo
- Surface Processing
  - Reduce (eliminate?) surface field enhancements, field emission
    - SCRF processing techniques
      - » Electro-polishing (smooth by removing) + HP H_2O rinse
    - More advanced techniques (Atomic-Layer-Deposition (ALD))
      - » Smooth by adding to surface (conformal coating @ molecular level)
- High-Pressure Gas-filled (H_2) cavities show promise
  - Paschen's Law (V_{bd} µ p) ® p inhibits breakdown
  - Operation with beam critical next test
- Magnetic Insulation
  - Eliminate focusing of electrons

Details in RF Strategy Talk Tomorrow

RF Test Facility

- MuCool Test Area
  - RF Power
    - 201 MHz (5MW)
    - 805 MHz (12 MW)
  - Class 100 clean room
  - Instrumentation
    - Ion counters, scintillation counters, optical signal, spectrophotometer
  - 4T SC Solenoid
    - 250W LHe cryo-plant
  - 400 MeV p beam line



You all will have an opportunity to tour the MTA tomorrow

Phase I RF Program (2 year)

- Complete first round of tests on Magnetic Insulation
  - Second round with identical cavity, but with orientation E || B
- Materials tests: Be
  - Button cavity test
  - Be wall cavity
- ALD coated button test
  - In addition with recently awarded DOE supplemental funds, we believe we may be able to do an ALD test on a full cavity in Phase I
- Beam tests of high pressure H_2 filled cavity
- 201 MHz tests in higher B field
  - Need new SC magnet - FY2012

RF Down Selecting

- Down selection of RF cavities will be based on the outcome of these experimental studies. The cavity must work at an acceptable RF gradient (requirements are, of course, dependent on the position along the channel, ie, phase rotation, bunching, initial cooling, final cooling, etc.) in a multi-tesla magnetic field. Engineering, fabrication, integration and cost of the cavity and RF power must also be considered

Phase II RF Program

- Design, build and bench test a short cooling channel section to demonstrate cavity performance in a realistic magnetic channel, and ensure that all of the engineering and safety details that affect cavity operation are well understood.
- There is, of course, uncertainty regarding what will be done in this phase
  - Guggenheim
  - Helical Cooling Channel
  - Helical FOFO Snake
- *And impacts magnet program*

Magnet R&D - Overview

- Neutrino Factory and Muon Collider accelerator complexes require magnets with quite challenging parameters
  - Target Capture Solenoid
    - What is the most effective scheme to protect the target solenoid from the radiation environment near to the target?
  - HTS solenoid R&D to assess the parameters that are likely to be achieved
    - What is the highest practical achievable solenoid field & what is the R&D required before these solenoids can be built?
  - HCC magnet R&D to assess the feasibility of this type of cooling channel and
    - Eventually build a demonstration magnet for a HCC test section (dependent on success of HP RF tests)
  - Magnet design R&D for collider ring and IR magnets that have to deal with the expected high level of energy deposition from mdecay electrons
    - What is the optimal design for the collider ring magnets that will enable them to operate in the presence of the decay electrons? Paper studies only (with D&S group)
  - Fast Ramping Magnets utilized in rapid-cycling synchrotron for final acceleration for the MC

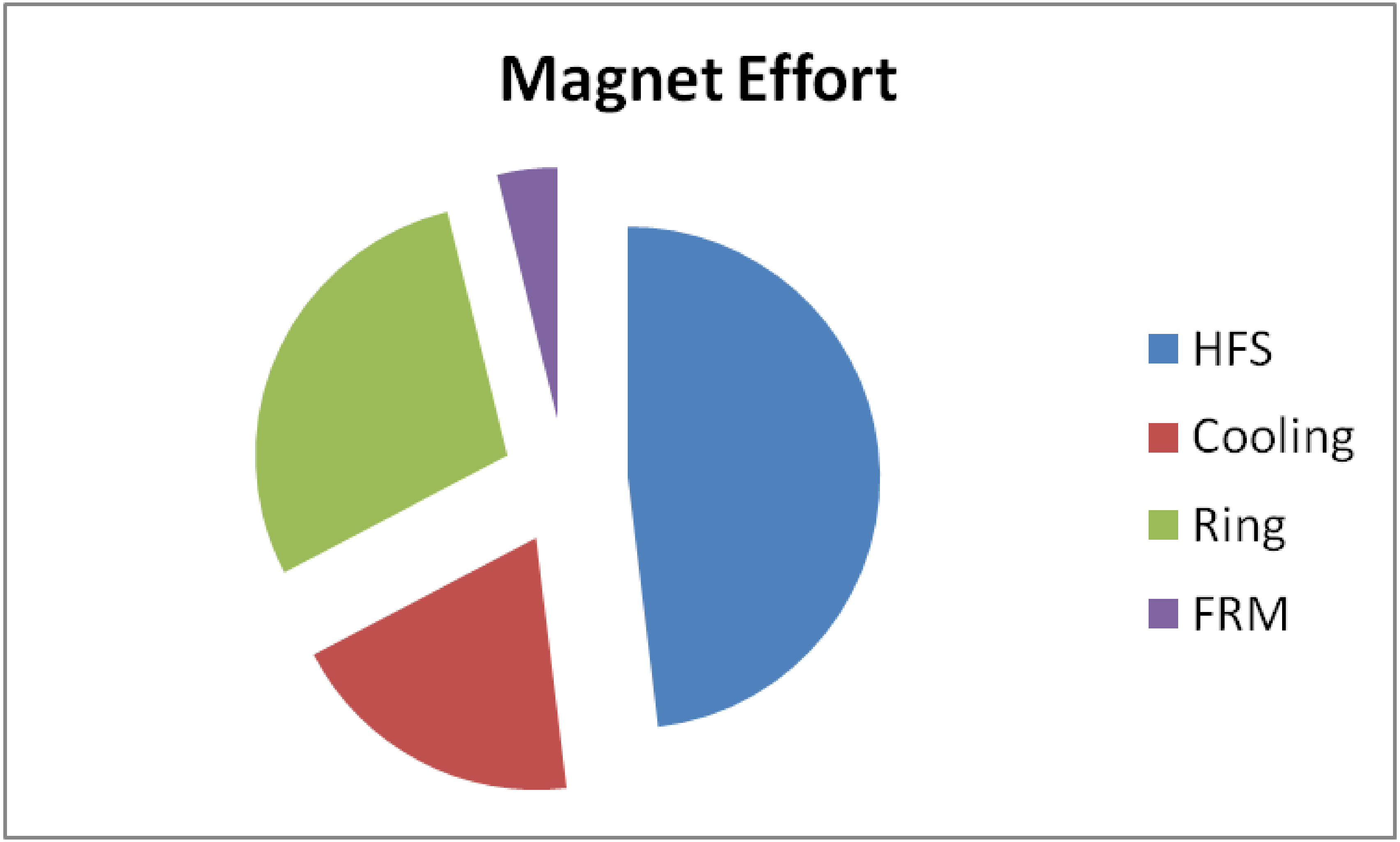
Magnet R&D – Overview II

- HTS Solenoid
  - Develop functional specifications for the high field solenoid
  - Evaluate/compile a data base on state-of-the-art of conductors
    - Propose R&D to fill in gaps from existing data from Industry, DOE lab core programs and the VHFSMC through additional conductor tests
      - Note: The VHFSMC is working with industry to develop conductor
  - Build HTS and hybrid inserts to prove technology.
  - Perform conceptual designs for highest field practical magnet
  - Present plan for building magnets in years 1-3 post plan
- HCC
  - Continue work on HCC magnet development (first 2 years)

Magnet R&D – Overview III

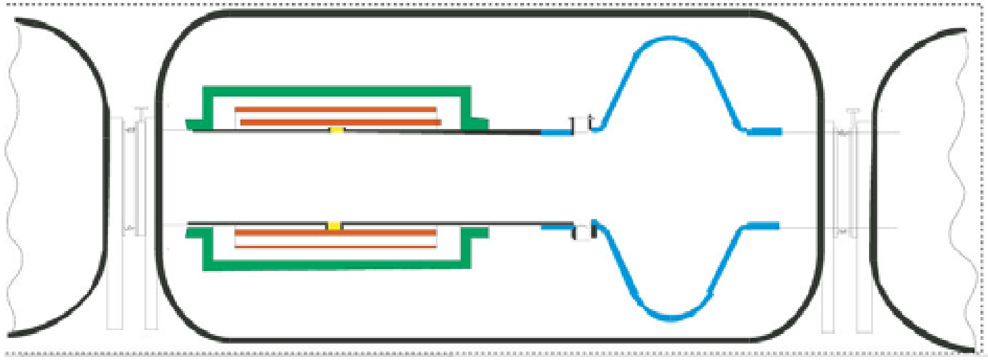
- Collider Ring Magnets
  - Produce effective conceptual designs for
    - IR quads & dipoles
    - Collider ring dipoles and quads
- Fast Ramping Magnets (400 Hz)
  - Build two 6mm gap prototype dipoles
    - First - 30 cm long
    - Second – 6.3 m long

$17M


Magnet Effort
HFS
Cooling
Ring
FRM

Superconducting RF R&D

- Develop high accelerating gradient superconducting RF cavities to provide rapid acceleration of low energy muons
- Develop a single cell superconducting cavity operating at 200 MHz with an accelerating gradient of at least 15 MV/m
- SCRF R&D is supported through NSF



Targetry

- Within Technology Development, targetry R&D is limited to
  - Support for completion of analysis of MERIT data
  - Some M&S for target hardware development

TechDev Milestones

FY10	Complete engineering design for Be-wall rf cavity	TD10.1	DR, MR
	Complete initial HPRF cavity beam test	TD10.2	DR, MR
	Test magnetically insulated “box” cavity	TD10.3	DR, MR
FY11	Fabricate Be-wall rf cavity	TD11.1	DR
FY12	Test new HPRF cavity	TD12.1	DR
	Complete Be-wall rf cavity tests	TD12.2	FR
	Test 201-MHz cavity with coupling coil in MTA	TD12.3	DR
FY13	Fabricate small HTS test magnet	TD13.1	DR
	Begin conceptual design of collider magnet	TD13.2	DR
FY14	Prepare rf test cavity with ALD coating	TD14.1	DR
	Begin conceptual design of >30-T solenoid	TD14.2	DR
	Complete component designs for 6D cooling bench test	TD14.3	FR
FY15	Fabricate components for 6D cooling bench test	TD15.1	MR
FY16	Complete components for 6D cooling bench test	TD16.1	DR
	Assemble components for 6D cooling bench test	TD16.2	MR
	Complete conceptual design of >30-T solenoid	TD16.3	DR,ER
	Finish technology section of Final MC DFS report	TD16.4	FR

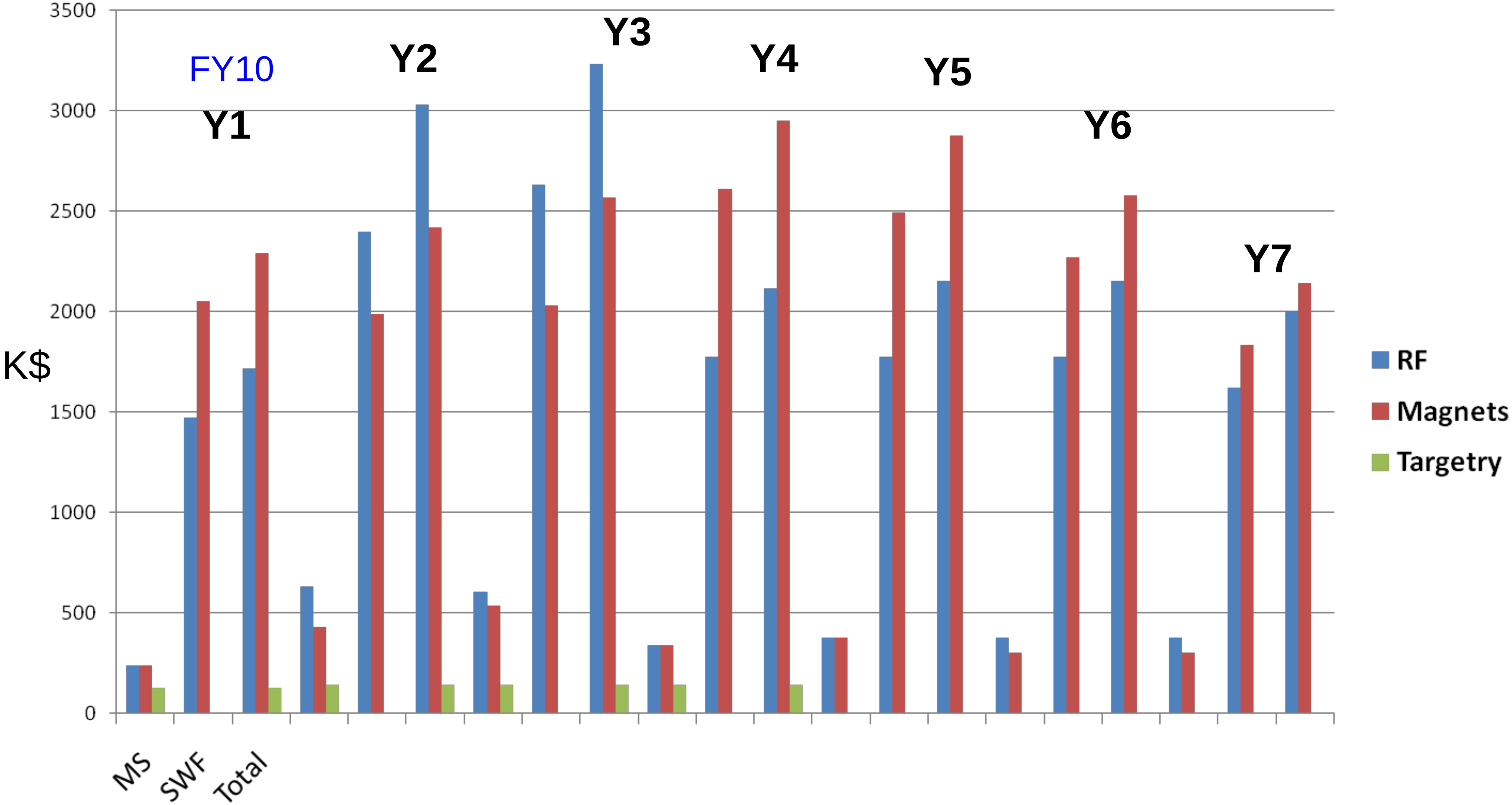
RF Down Select

Goals at End of 7th Year

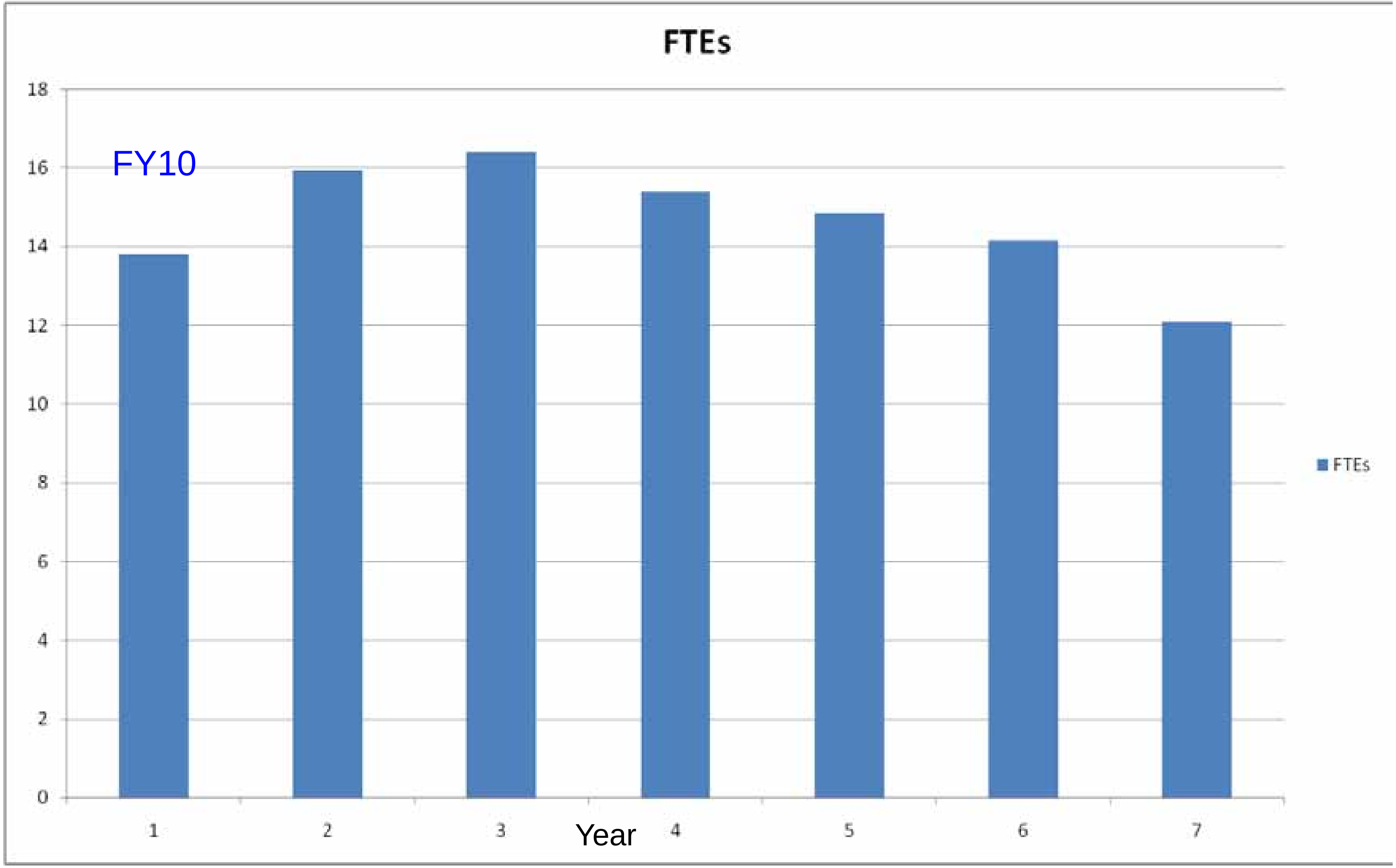
	Spec	Concept D	Engin. D	Proto
• High field HTS solenoid	X	X	X	
• HCC magnets	X	X	{X	X}[1]
• Fast-ramping magnets	X	X	X	X
• Collider ring magnets	X	X		
• Target design	X	X	X	

[1] If the HCC option is chosen

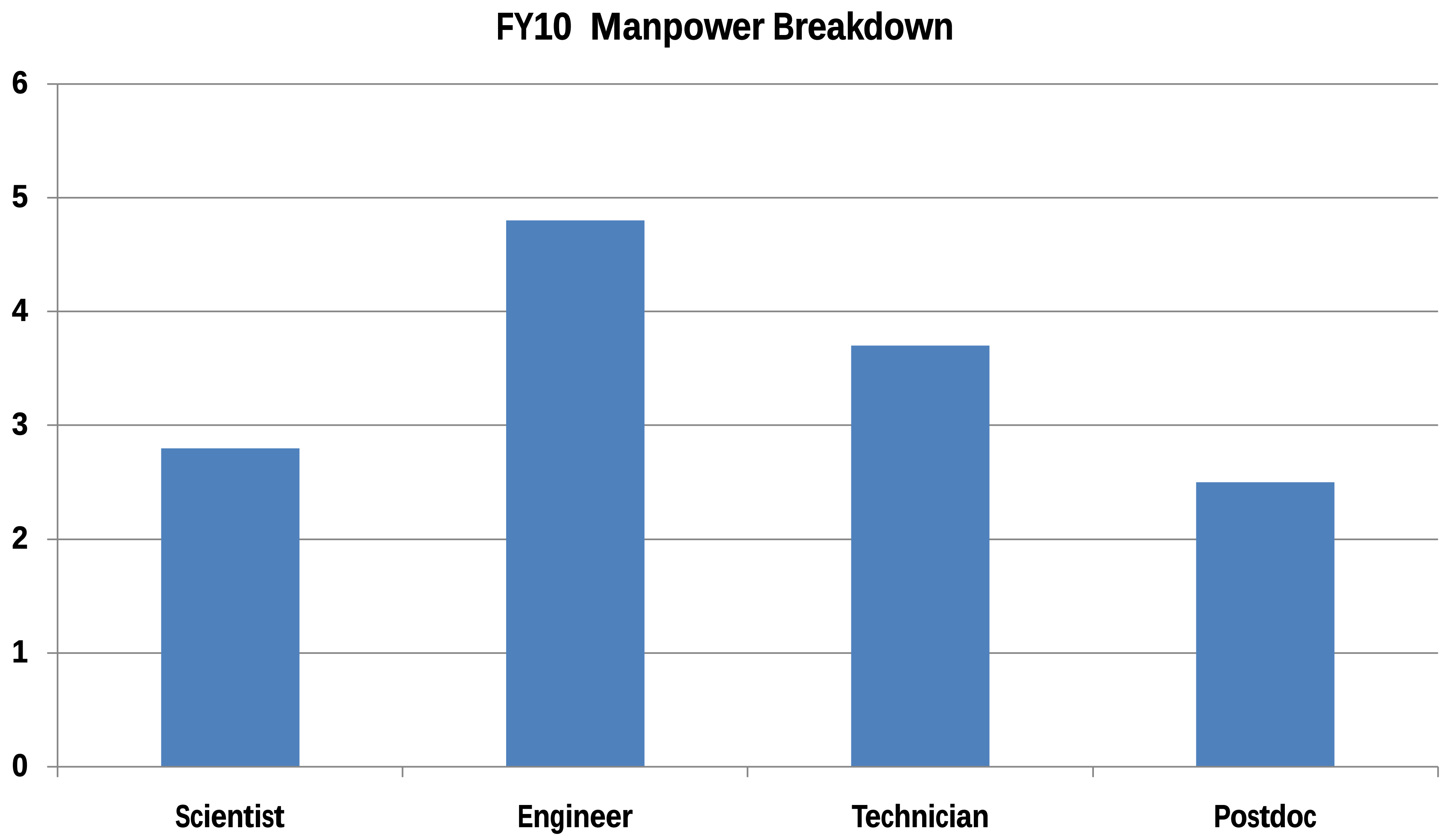
TechDev - Resources



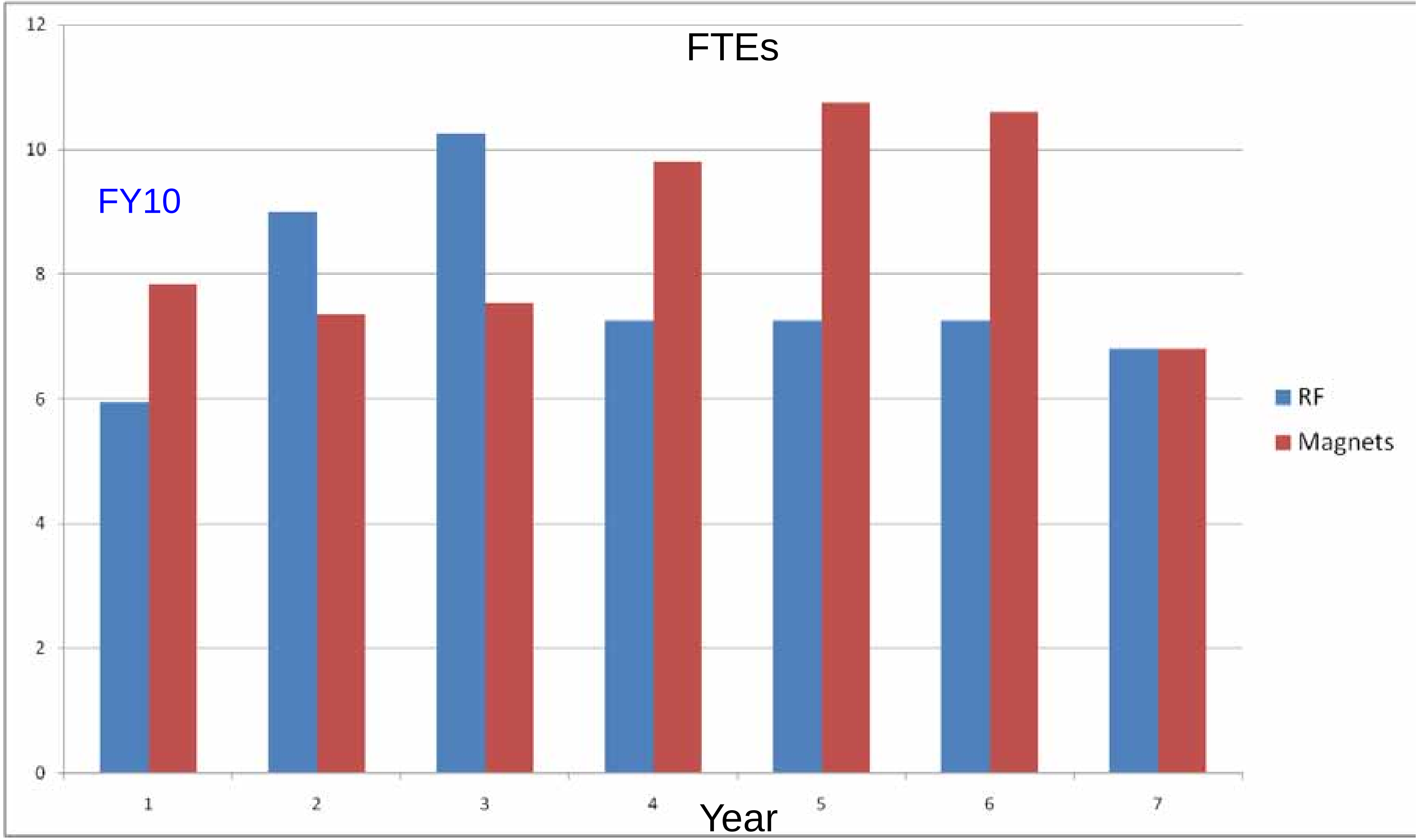
TechDev - Manpower



TechDev - Manpower



TechDev – Manpower II



Summary

- The MAP effort in Technology Development (& Assessment) focuses on cooling (as it should)
  - Important for the Neutrino Factory performance optimization
  - Crucial for a multi-TeV, high-**L** MC
- The RF program is taking a multi-pronged attack on the technology
  - The MTA is now a smoothly running facility that is unique in the world
    - Multi-frequency RF
    - SC magnet(s) & cryogenics infrastructure
    - Extensive RF diagnostic instrumentation
    - Clean room for RF cavity work
    - H_2 handling infrastructure
    - p beam line

Summary II

Ongoing RF Program

- Technology Assessment
  - Magnetic Insulation
  - Materials studies
    - SCRF processing
    - ALD
    - Cavity materials (Be)
  - High-pressure H_2 filled RF exposed to p beam
  - Continuing 201 MHz program
    - Future studies @ higher B field

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Summary III

- Magnet program primarily addresses cooling issues
  - Final cooling via very-high-field HTS solenoids
  - HCC solenoids as potential option
- But also addresses the other critical magnet issues for the MC complex
  - Ring magnets
    - Open-plane dipoles, quads, etc
  - Acceleration
    - Fast-ramping magnets

Summary IV

- Much of this program pushes the state-of-the-art and might better be characterized as technology invention rather than development
- With this there is, of course, risk. However, at this early stage of this endeavor, our approach is needed in order to minimize the technical risk of a future Muon Collider

END