MECO Plans and Needs

Michael Hebert
UC Irvine

May 14, 2004
LFV Workshop

The Punch Line, Up Front

You've seen that the physics case for MECO is very compelling.

The bottom line of *this* talk is that MECO is gaining momentum but there is still time to get in on the "ground floor" and have a major impact upon the experiment.

To demonstrate that I will briefly review:

- The status of MECO's approval/peer review
- The status of the funding, specifically the (positive) slope with time
- What we have achieved thus far on each major MECO subsystem and what needs to be done
- Some of the places where new people could contribute right now

Peer Review

The peer review and approval process is best summed up in a January 2003 letter from Bob Eisenstein (then NSF Assistant Director for MPS) to John Sculli:

"First, the initial proposal was peer reviewed and found to have outstanding prospects for major advances in our understanding of some of the most important questions in fundamental particle physics. Second, RSVP was critically reviewed internally at NSF by senior management from all of the NSF Directorates, resulting in broad, strong support for going forward. Third, RSVP was selected by the NSF Director as a project whose scientific goals and readiness warranted consideration by the National Science Board. Fourth, the National Science Board reviewed the case for RSVP and approved it for 'inclusion in the FY2002 or later budget.' This is the current status of RSVP in the funding process. It represents a strong showing by RSVP in an extremely competitive process between different fields of science, and the rate of advancement is faster than any other major construction project that I can remember."

"I can say that RSVP is now the highest priority construction project from the Directorate of Mathematical and Physical Sciences…"

Enthusiasm within the HEP Community

- MECO endorsed by the HEPAP P5 subpanel on long-range planning
- MECO endorsed by the recent Drell subpanel identifying 21st century physics challenges as addressing two of the nine questions they identified

Primary US Physics Program of Selected Smaller Facilities

This table summarizes the physics goals of selected smaller facilities of the US program whose primary physics goals align most directly with the report's nine questions.

	Unification				Particle World			Birth of the Universe	
Question	1	2	3	4	5	6	7	8	9
Mini-BooNE							X		
MECO	X				X				
Reactor ν Experiments							X		
CLEO-c					X				
K0PI0									X
Neutrinoless Double Beta Decay				X			X		
SDSS						X			
LSST		X				X			
Underground Dark Matter Detectors						X			
WMAP		X				X		X	
CMB Polarization								X	
Lattice Computational Facilities					X			X	
Precision Gravity			X						

LEGEND

The Questions

1 Are there undiscovered principles of nature: new symmetries, new physical laws?
2 How can we solve the mystery of dark energy?
3 Are there extra dimensions of space?
4 Do all the forces become one?
5 Why are there so many kinds of particles?
6 What is dark matter? How can we make it in the laboratory?
7 What are neutrinos telling us?
8 How did the universe come to be?
9 Where did the antimatter go?

Funding Status

- We are currently operating on R&D funding, with a total of $2.6M committed to MECO over the past three years
- Congress has mandated another $6M be committed to RSVP pre-project development this year
- A construction start for RSVP is in the President's FY05 Budget Request to Congress

The Budget initiates construction of the National Ecological Observatory Network (NEON), the Scientific Ocean Drilling Vessel, and the Rare Symmetry Violating Processes (RSVP) installation.

Imagine 64 of these in your back yard. The Atacama Large Millimeter Array will consist of an array of 64 mobile antennas based on one of these two prototypes.

RSVP would combine two groundbreaking experiments to address important scientific questions in physics that have the potential to transform our basic understanding of the universe.

NSF Schedule for RSVP

The NSF FY05 budget request establishes RSVP's planned construction and operations schedule

If we maintain progress on the magnets we will start running in FY09

FY 2004 Milestones:
- Complete MECO magnet acquisition plan.
- Begin KOPIO beam studies at AGS.
- Begin MECO detector studies

FY 2005 Milestones (Requested Construction Start):
- Complete KOPIO and MECO AGS and beam design modifications.
- Begin KOPIO detector construction.
- Begin MECO detector design and construction.
- Complete MECO magnet engineering design and start construction

FY 2006 Milestones:
- Begin KOPIO delivery of modules
- Begin MECO trigger and data acquisition design
- Begin MECO magnet coil production.

FY 2007 Milestones:
- Complete construction of AGS beams for KOPIO and MECO
- Begin KOPIO and MECO detector installation
- Complete design of the KOPIO and MECO data acquisition and trigger sys

FY 2008 Milestones:
- Complete data acquisition system and trigger construction and installation.
- Complete delivery and installation of MECO magnet coils.
- MECO Magnet acceptance tests
- KOPIO Trigger and data acquisition tests

FY 2009 Milestones:
- Complete construction and installation
- Perform engineering runs

FY 2010 Milestones:
- First data runs

Requested MREFC Funding for RSVP
(Dollars in Millions)

FY 2005 Request	FY 2006	FY 2007	FY 2008	FY 2009	Total
$30.00	$42.66	$44.00	$20.25	$8.00	$144.91

RSVP Funding Profile
(Dollars in Millions)

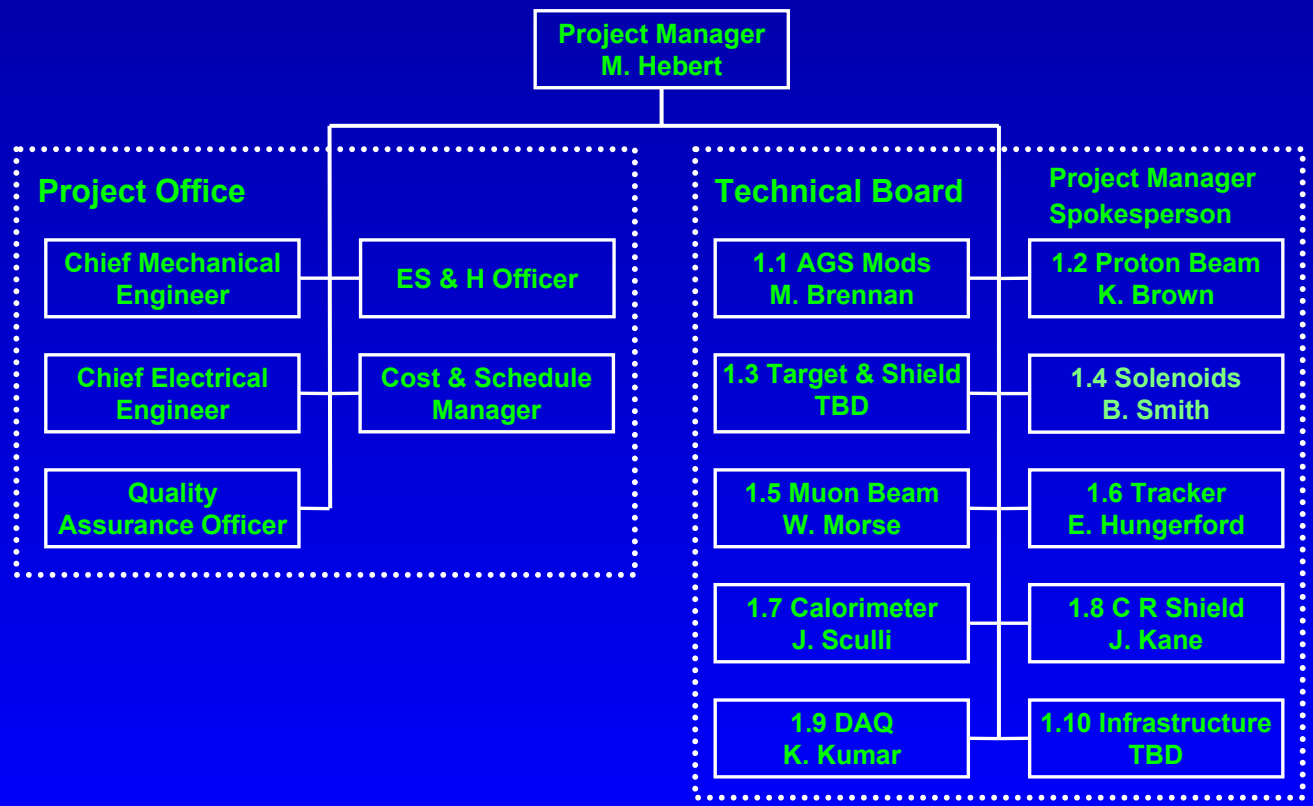
	Concept/ Development		Implementation[1]		Operations & Maintenance		Totals		Grand Total
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	
FY 2001	0.90						$0.90		**$0.90**
FY 2002	1.20						$1.20		**$1.20**
FY 2003	1.90						$1.90		**$1.90**
FY 2004 Estimate	6.00						$6.00		**$6.00**
FY 2005 Request				30.00				$30.00	**$30.00**
FY 2006 Estimate				42.66				$42.66	**$42.66**
FY 2007 Estimate				44.00				$44.00	**$44.00**
FY 2008 Estimate				20.25	5.30		$5.30	$20.25	**$25.55**
FY 2009 Estimate				8.00	8.50		$8.50	$8.00	**$16.50**
FY 2010 Estimate					8.50		$8.50		**$8.50**
FY 2011 Estimate					13.50		$13.50		**$13.50**
FY 2012 Estimate					15.00		$15.00		**$15.00**
Subtotal, R&RA	$10.00				$50.80		$60.80		
Subtotal, MREFC				$144.91				$144.91	
Total, each phase		**$10.00**		**$144.91**		**$50.80**			**$205.71**

NOTE:. The estimated operational lifetime of the experiments will be least 10 years after the end of construction. A steady state of about $15.0 million in operations support is expected to occur on or about FY 2012. Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

[1]The total project cost for RSVP has had several reviews. However, the total shown is still an estimate, and the funding stream has not yet been baselined. A baseline review is scheduled for June 2004.

MECO Project Organization

- The MECO collaboration and project management structures are in place, although *RSVP* management is still in a state of flux
- Preliminary Work Breakdown Structure for the construction project is developed
- Cost and schedule have been developed
- The preceding have been reviewed favorably by the NSF
- We will begin staffing up the project office with this year's R&D money



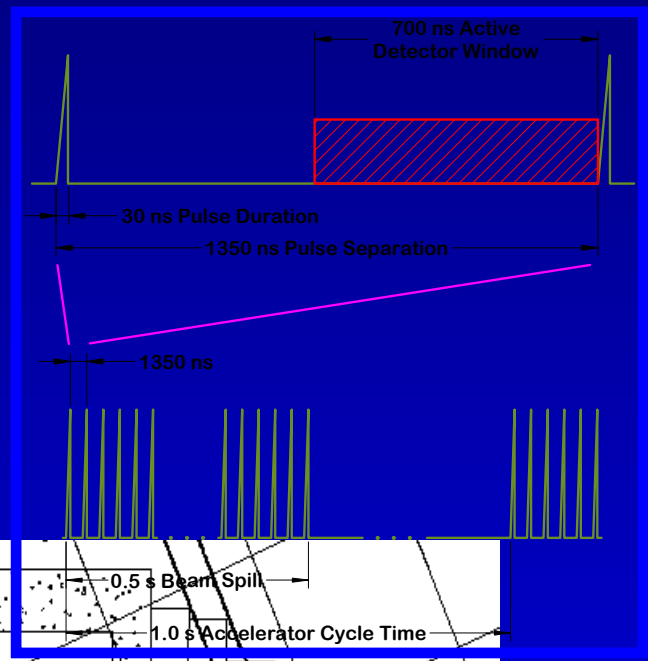
MECO WBS at Level 2

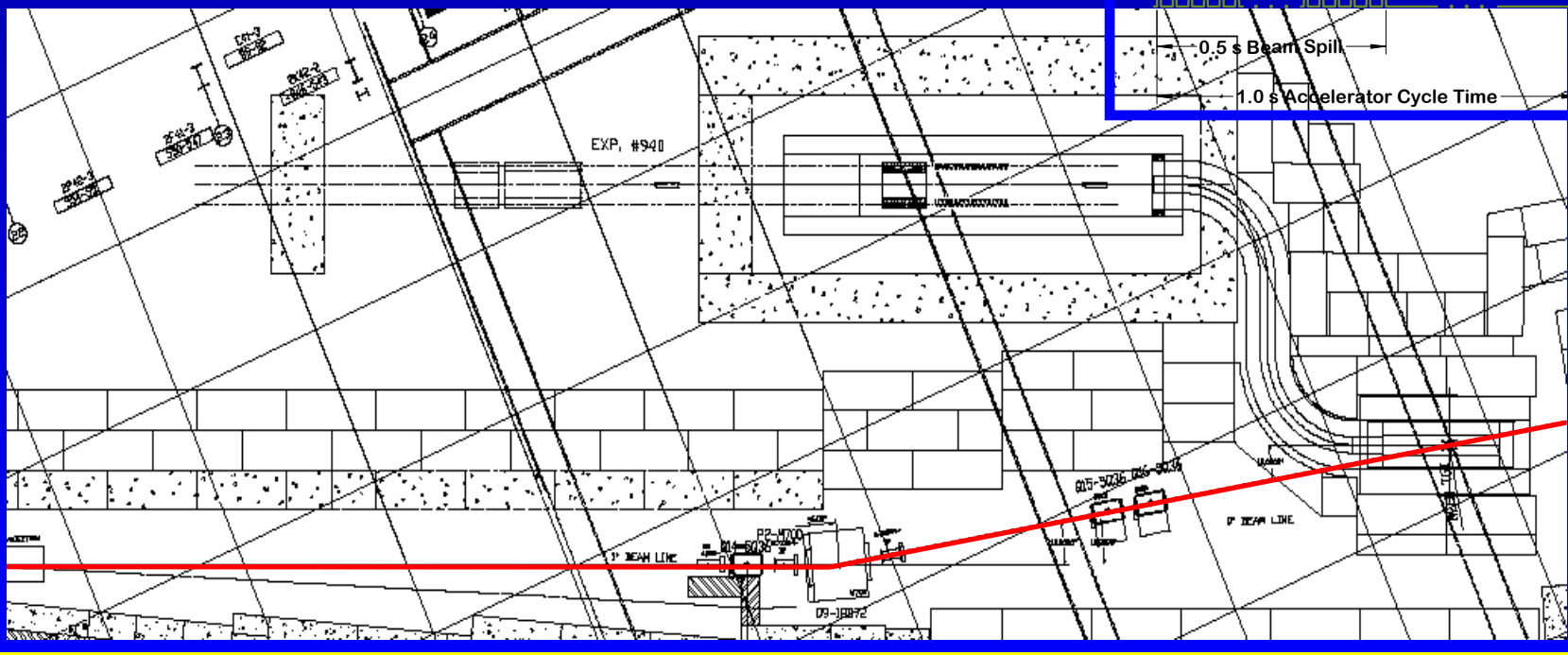
1.01 AGS Modifications and Studies

Hardware additions and studies needed to provide 40 Tp of stable, slow-extracted 8 GeV pulsed beam

1.02 Proton Beamline

Three new magnets and refurbishment or replacement of existing beamline elements required to transport the proton beam

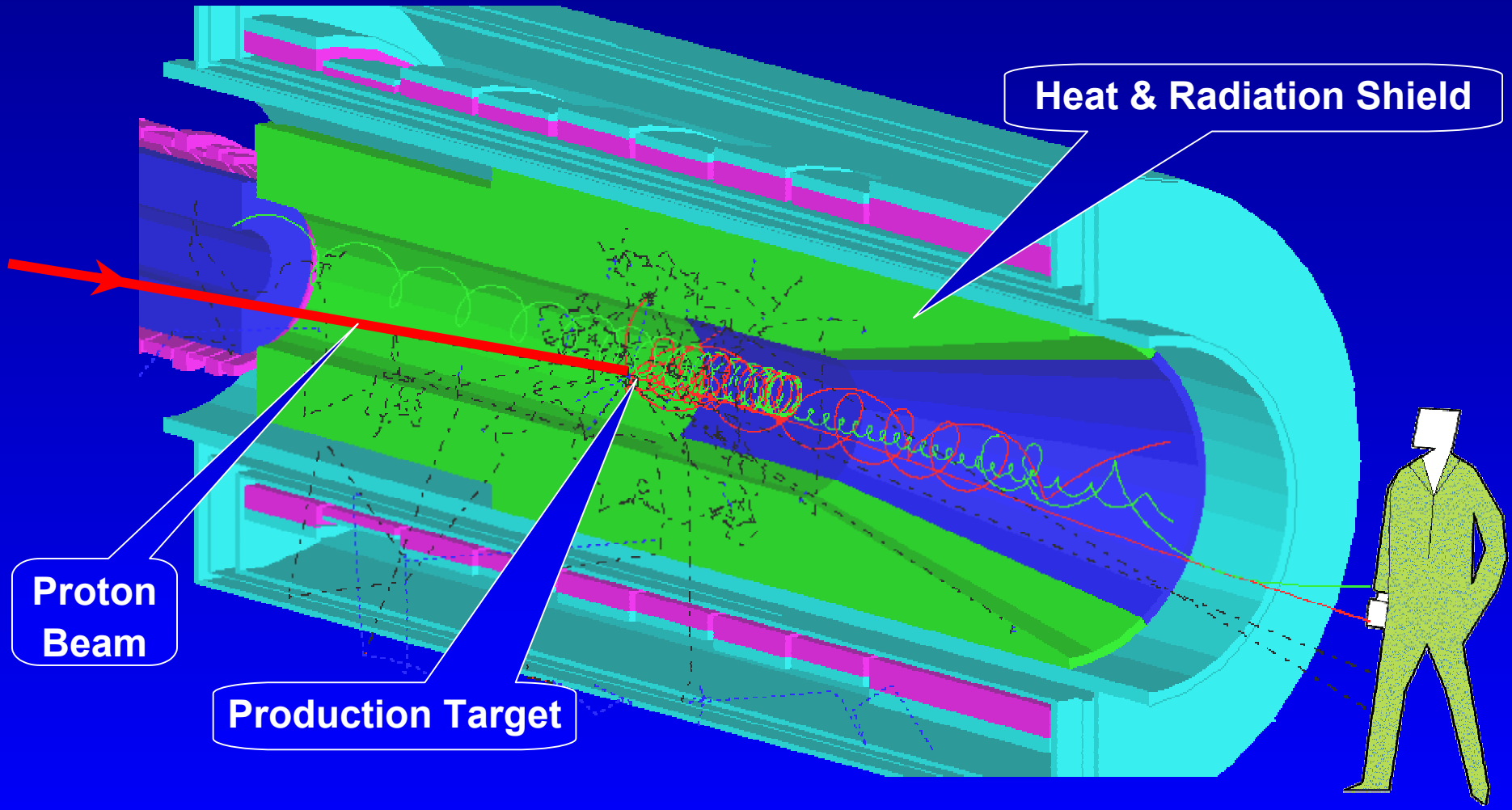




MECO WBS at Level 2

1.03 Production Target and Shield

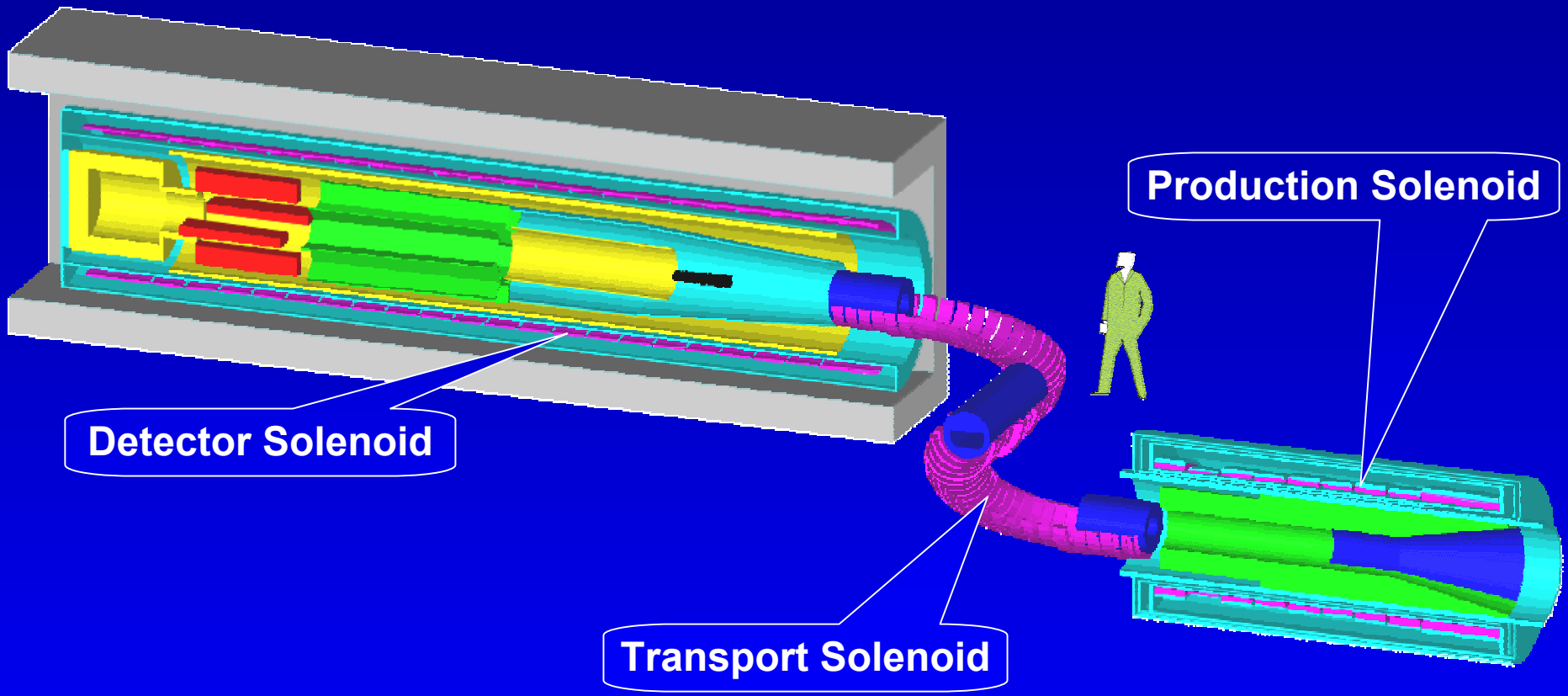
The muon production target, the surrounding heat and radiation shield, and the shield's support structure



MECO WBS at Level 2

1.04 Superconducting Solenoids

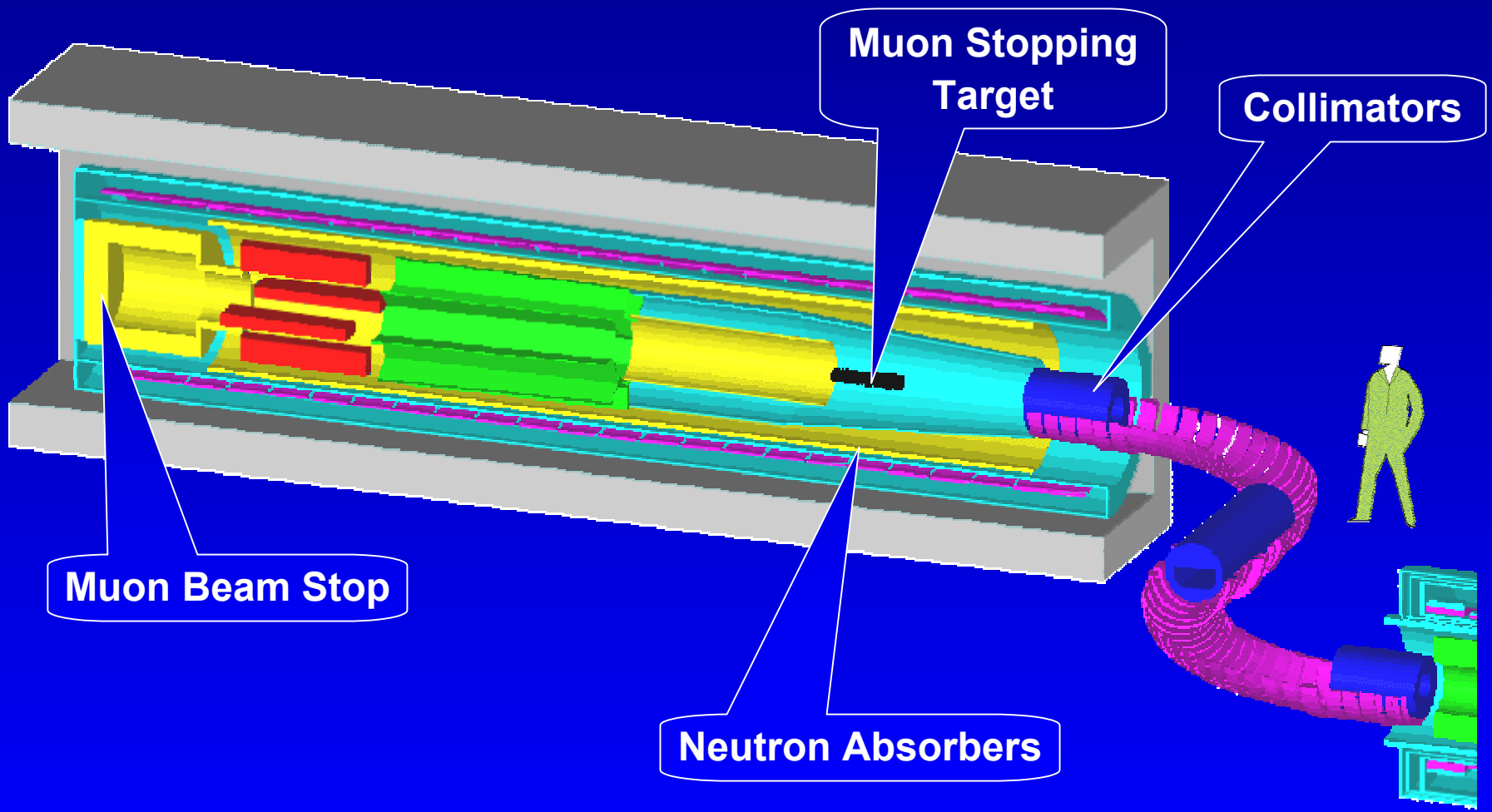
The cost and schedule drivers of the project, providing the strong, axially graded fields required to collect muons, filter the muon beam, and analyze conversion electron candidates



MECO WBS at Level 2

1.05 Muon Beamline

The elements that define the muon beam including the μ stopping target and monitor, neutron absorbers, detector supports, μ beam stop, and vacuum systems



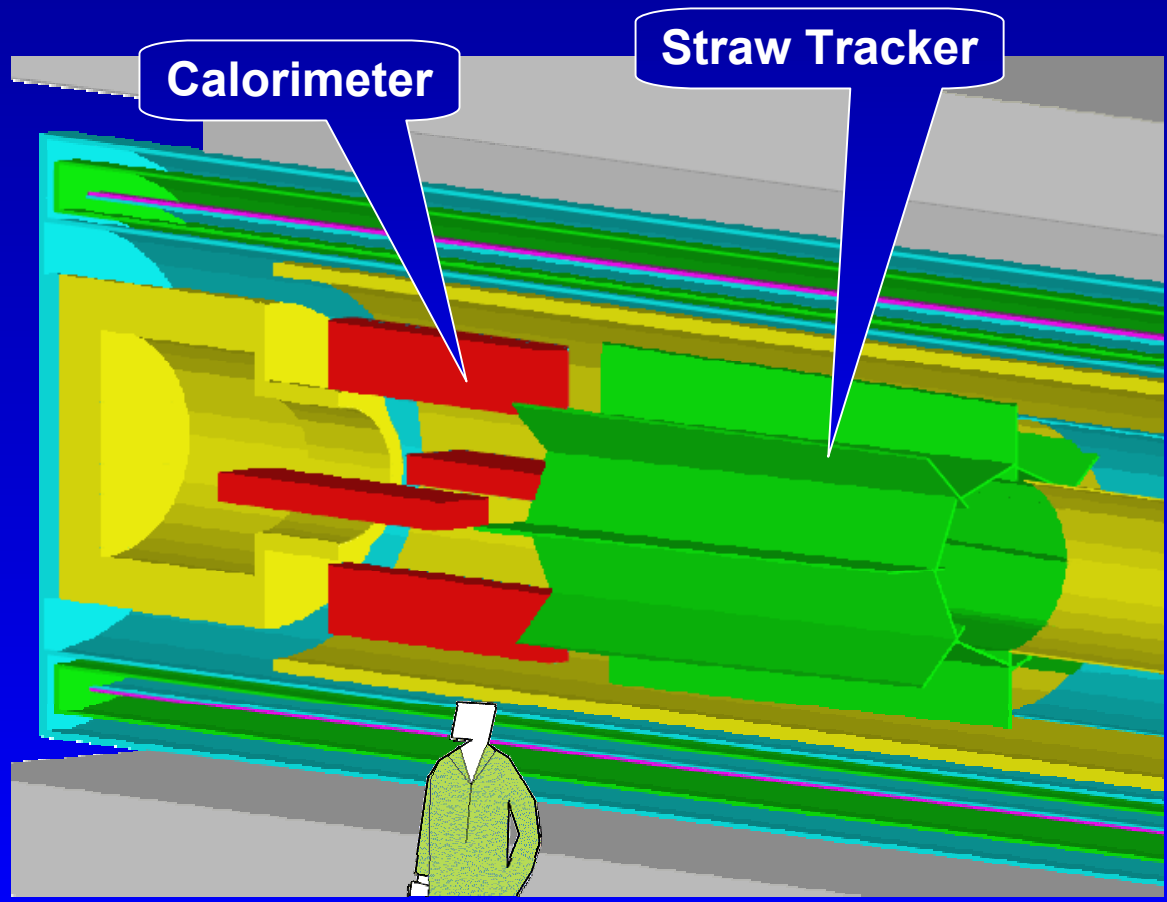
MECO WBS at Level 2

1.06 Tracker

Detects conversion electrons, intercepting their helical path in the 1 T detector solenoid field at several points allowing for the reconstruction of momentum and point of origin in stopping target

1.07 Calorimeter

Provides the hardware trigger for the experiment and constraints on electron energy and reconstructed shower centroid position



MECO WBS at Level 2

1.08 Cosmic Ray Shield

A combination of active and passive shielding designed to limit the contribution of cosmic ray induced backgrounds to acceptable levels

1.09 Data Acquisition and Online Computing

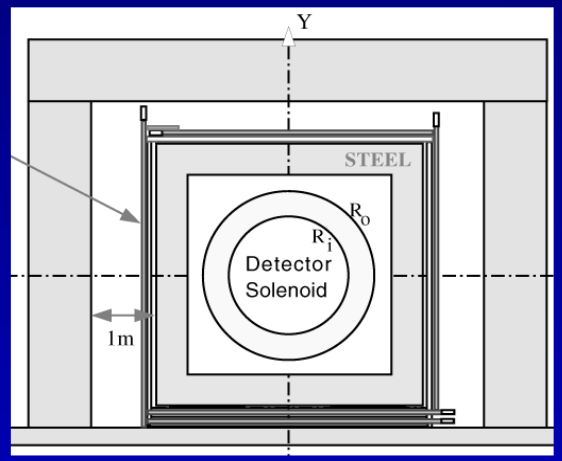
Digitization and Level 1 Trigger hardware, higher level trigger hardware and software including offline analysis and data quality monitoring

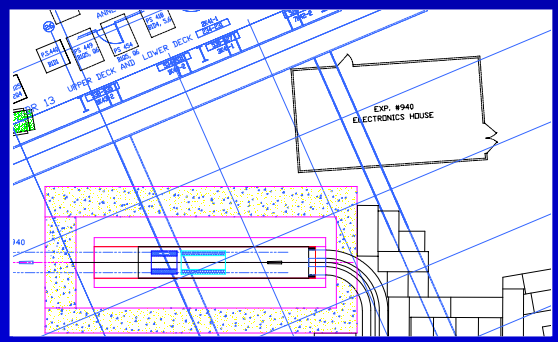
1.10 Infrastructure

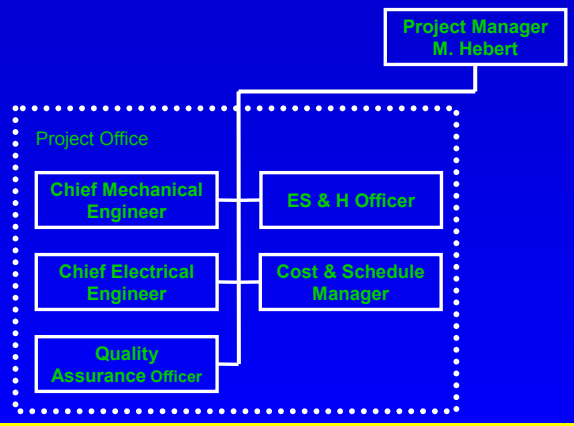
New construction or modification of existing structures required for housing the front-end electronics, shift personnel, online computing, and portions of the solenoid refrigeration system

1.11 Project Management and Administration

The Project Office and Project supported AGS Liaison Engineer and Liaison Physicist



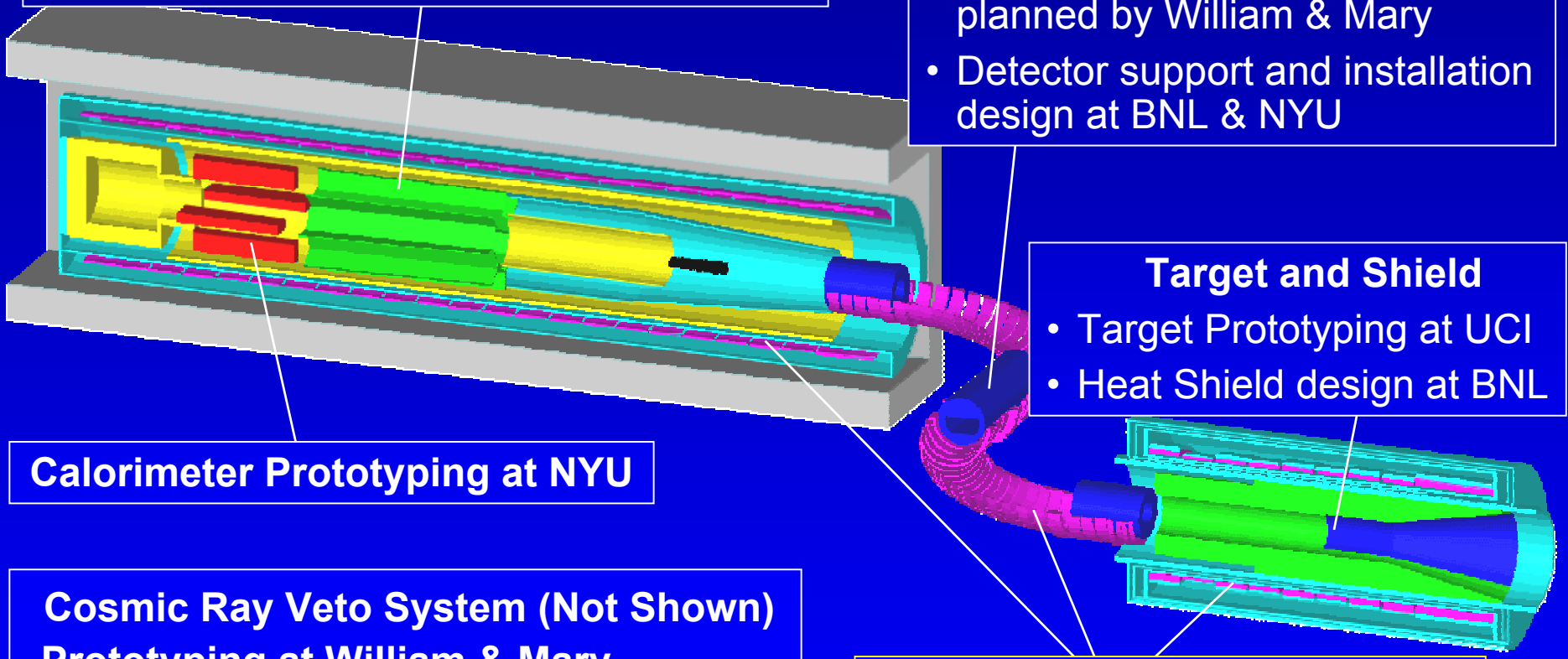




Current R&D Efforts

Tracker Studies
- Chamber prototypes at Houston & Osaka
- Electronics design at Houston
- Detector simulation at NYU and UCI
- Straw testing at UCI

Muon Beamline Development
- Vacuum and window conceptual design at BNL
- Optimization studies at UCI
- Muon stop monitor tests planned by William & Mary
- Detector support and installation design at BNL & NYU



Target and Shield
- Target Prototyping at UCI
- Heat Shield design at BNL

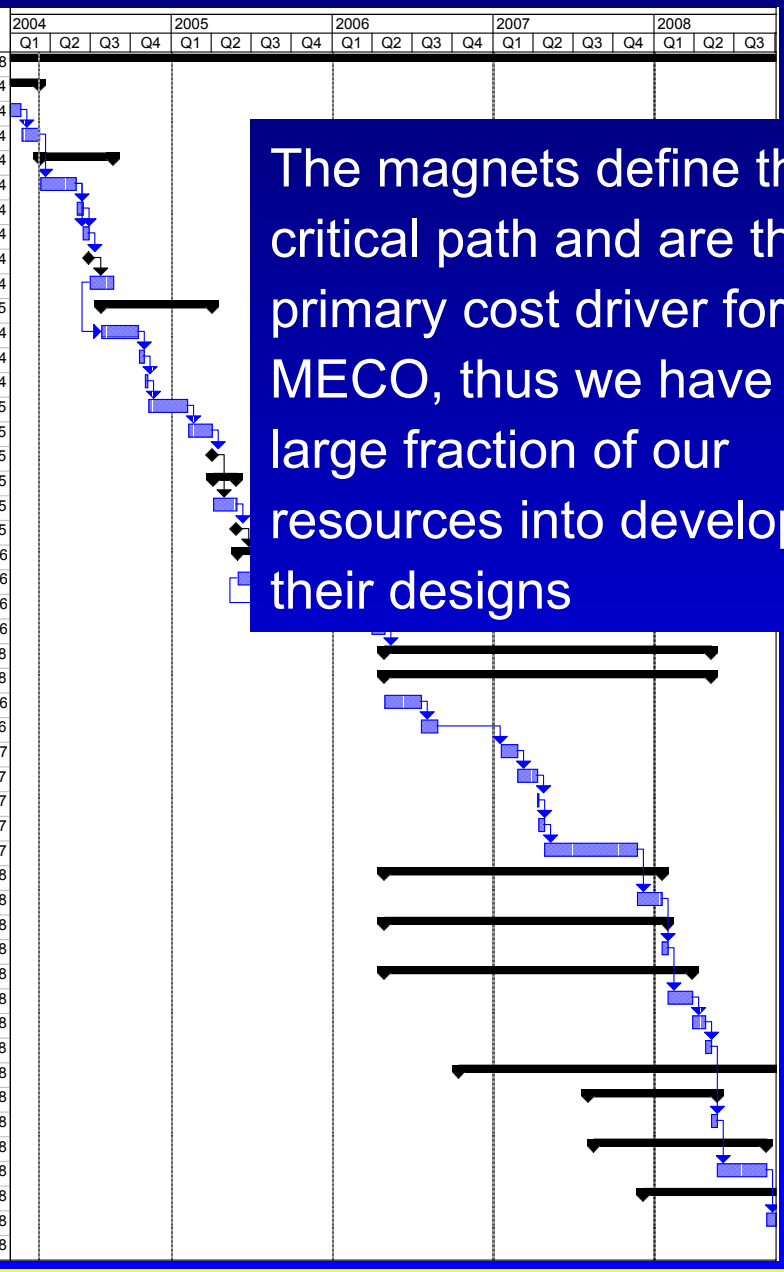
Calorimeter Prototyping at NYU

Cosmic Ray Veto System (Not Shown)
Prototyping at William & Mary

Magnet Design at MIT & UCI

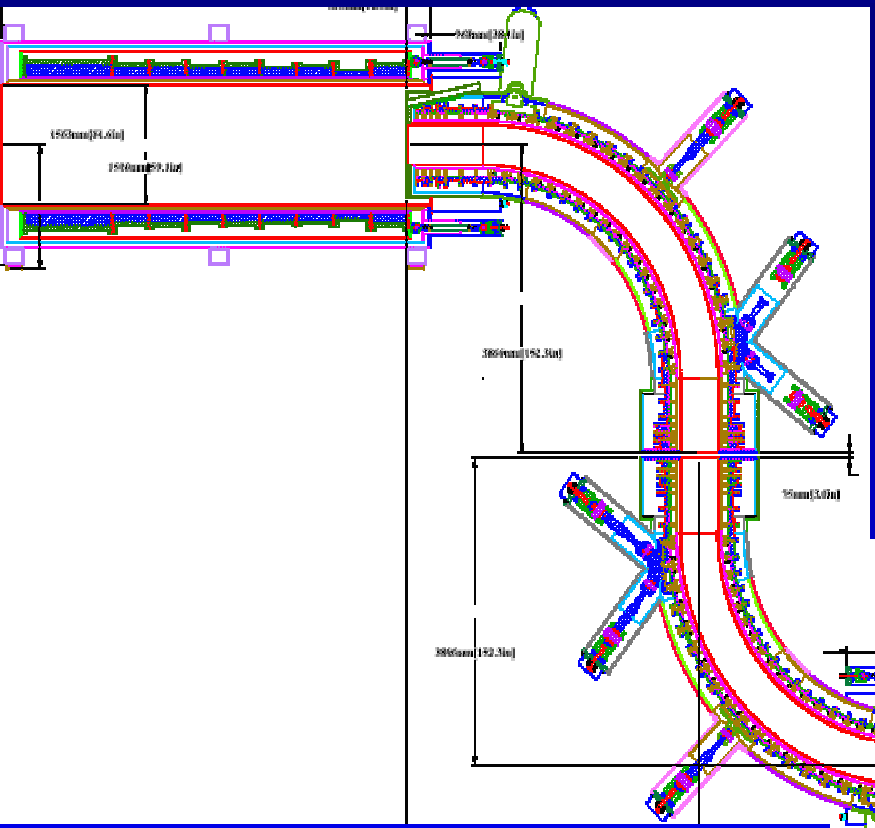
The MECO Critical Path

Name	Constraint Type	Constraint Date	Duration	Start	Finish
1.4 Solenoids	**Possible**	**NA**	**1310 days**	Mon 12/1/03	Wed 12/3/08
Acquisition Plan	**Possible**	**NA**	**70 days**	Mon 12/1/03	Fri 3/5/04
Draft Plan from contracting agency	er Than	###	8 wks	Mon 12/1/03	Fri 1/23/04
Develop Written Acquisition Plan	ossible	NA	6 wks	Mon 1/26/04	Fri 3/5/04
Draft RFP	**ossible**	**NA**	**120 days**	Mon 3/8/04	Fri 8/20/04
Prepare Contractual Portion	ossible	NA	12 wks	Mon 3/8/04	Fri 5/28/04
Incorporate magnet Tech Spec/SOW into I	ossible	NA	2 wks	Mon 5/31/04	Fri 6/11/04
MAP Review	ossible	NA	2 wks	Mon 6/14/04	Fri 6/25/04
Release draft RFP	ossible	NA	0 wks	Fri 6/25/04	Fri 6/25/04
Obtain Industry Feedback	ossible	NA	8 wks	Mon 6/28/04	Fri 8/20/04
Final RFP	**ossible**	**NA**	**180 days**	Mon 7/26/04	Fri 4/1/05
Revise Contracting Terms	ossible	NA	12 wks	Mon 7/26/04	Fri 10/15/04
Obtain NSF Approval for Release	ossible	NA	2 wks	Mon 10/18/04	Fri 10/29/04
Release RFP	ossible	NA	1 wk	Mon 11/1/04	Fri 11/5/04
Vendor Bid Development	ossible	NA	13 wks	Mon 11/8/04	Fri 2/4/05
MECO Evaluation of Bids	ossible	NA	8 wks	Mon 2/7/05	Fri 4/1/05
Vendor Selected	ossible	NA	0 wks	Fri 4/1/05	Fri 4/1/05
Procurement	**ossible**	**NA**	**40 days**	Mon 4/4/05	Fri 5/27/05
Negotiate Detailed Contracting Terms	ossible	NA	8 wks	Mon 4/4/05	Fri 5/27/05
Initiate Engineering Design	ossible	NA	0 wks	Fri 5/27/05	Fri 5/27/05
Final Design	**ossible**	**NA**	**240 days**	Mon 5/30/05	Thu 4/27/06
Final design drawings	ossible	NA	9 mons	Mon 5/30/05	Thu 2/2/06
SOW prep and awards	ossible	NA	3 mons	Fri 1/6/06	Thu 3/30/06
Design review	ossible	NA	1 mon	Fri 3/31/06	Thu 4/27/06
Fabrication	**ossible**	**NA**	**530 days**	Fri 4/28/06	Wed 5/7/08
PS	**ossible**	**NA**	**530 days**	Fri 4/28/06	Wed 5/7/08
Winding tooling (2 winding lines)	ossible	NA	3 mons	Fri 4/28/06	Thu 7/20/06
Wind 1st coil	ossible	NA	1.3 mons	Fri 7/21/06	Fri 8/25/06
Wind 9th coil	ossible	NA	1.3 mons	Thu 1/18/07	Thu 2/22/07
VPI prep, VPI, cleanup--9th coil	ossible	NA	1.6 mons	Fri 2/23/07	Mon 4/9/07
Electrical test 9th coil	ossible	NA	0.1 mons	Tue 4/10/07	Wed 4/11/07
Machine OD 9th coil	ossible	NA	0.5 mons	Thu 4/12/07	Wed 4/25/07
Coil assembly	ossible	NA	7.5 mons	Thu 4/26/07	Wed 11/21/07
He can	**ossible**	**NA**	**450 days**	Fri 4/28/06	Wed 1/16/08
Assemble coils in He cans, close +	ossible	NA	2 mons	Thu 11/22/07	Wed 1/16/08
Assemble LN shields	**ossible**	**NA**	**460 days**	Fri 4/28/06	Wed 1/30/08
Close-out and tubing welds	ossible	NA	0.5 mons	Thu 1/17/08	Wed 1/30/08
Vacuum can	**ossible**	**NA**	**500 days**	Fri 4/28/06	Wed 3/26/08
Close-out and leak test	ossible	NA	2 mons	Thu 1/31/08	Wed 3/26/08
Prepare to ship	ossible	NA	1 mon	Thu 3/27/08	Wed 4/23/08
Ship	ossible	NA	0.5 mons	Thu 4/24/08	Wed 5/7/08
Site work at BNL	**ossible**	**NA**	**560 days**	Thu 10/12/06	Wed 12/3/08
Coil Receipt Inspections	**ossible**	**NA**	**210 days**	Thu 8/2/07	Wed 5/21/08
PS	ossible	NA	0.5 mons	Thu 5/8/08	Wed 5/21/08
Coil Installations	**ossible**	**NA**	**280 days**	Thu 8/16/07	Wed 9/10/08
Install PS	ossible	NA	4 mons	Thu 5/22/08	Wed 9/10/08
Coil Testing	**ossible**	**NA**	**220 days**	Thu 12/6/07	Wed 10/8/08
Test PS	ossible	NA	1 mon	Thu 9/11/08	Wed 10/8/08
Final coil alignments and field test	ossible	NA	2 mons	Thu 10/9/08	Wed 12/3/08

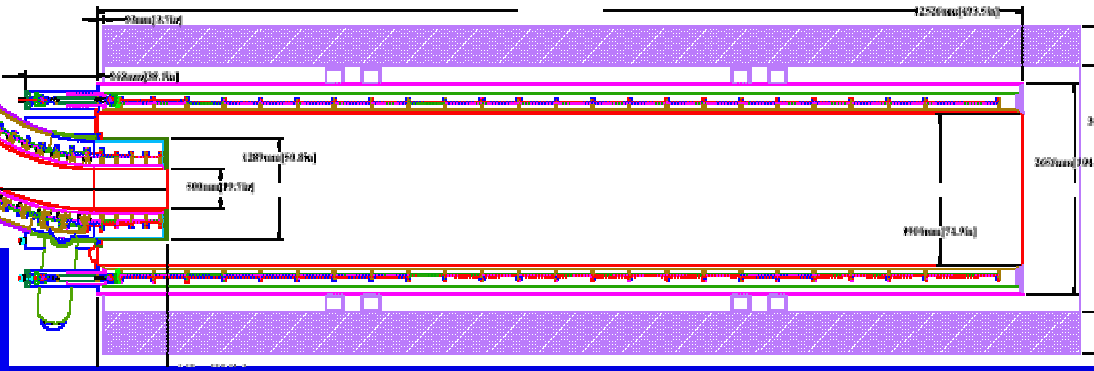


The magnets define the critical path and are the primary cost driver for MECO, thus we have put a large fraction of our resources into developing their designs

The MECO Magnets



- Very detailed CDR completed (300+ pages)
- Complete 3D drawing package
- Draft Technical Specification and SOW for commercial procurement completed
- Industrial “manufacturability” studies completed
- Interface engineering ongoing as funds allow



- 5 T maximum field
- 150 MJ stored energy
- Uses surplus SSC cable
- Within industry capabilities
- Draft Acquisition Plan completed

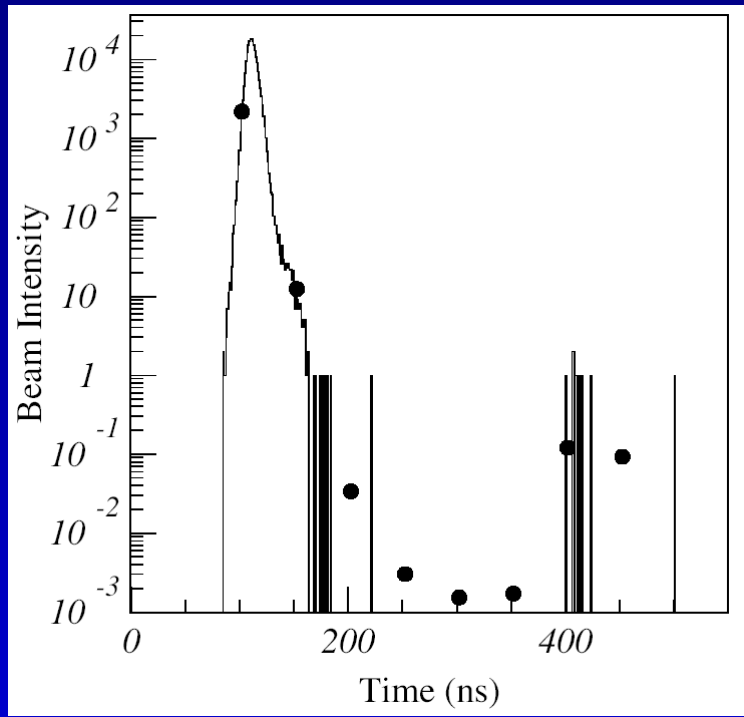
- Draft RFP to be released soon
- Field tolerance studies continue
- Design continues to evolve (PS Return Yoke)

Magnet Schedule

Milestone	Target Month
Issue draft magnet (RFP/RFI)	June `04
Issue final magnet RFP	Nov `04
Award magnet design, fabrication, installation and acceptance testing contract	June `05
Complete final design	June `06
Ship first magnet cryostat to BNL	Dec. `07
All acceptance testing complete	Dec. `08

AGS Modifications and Studies

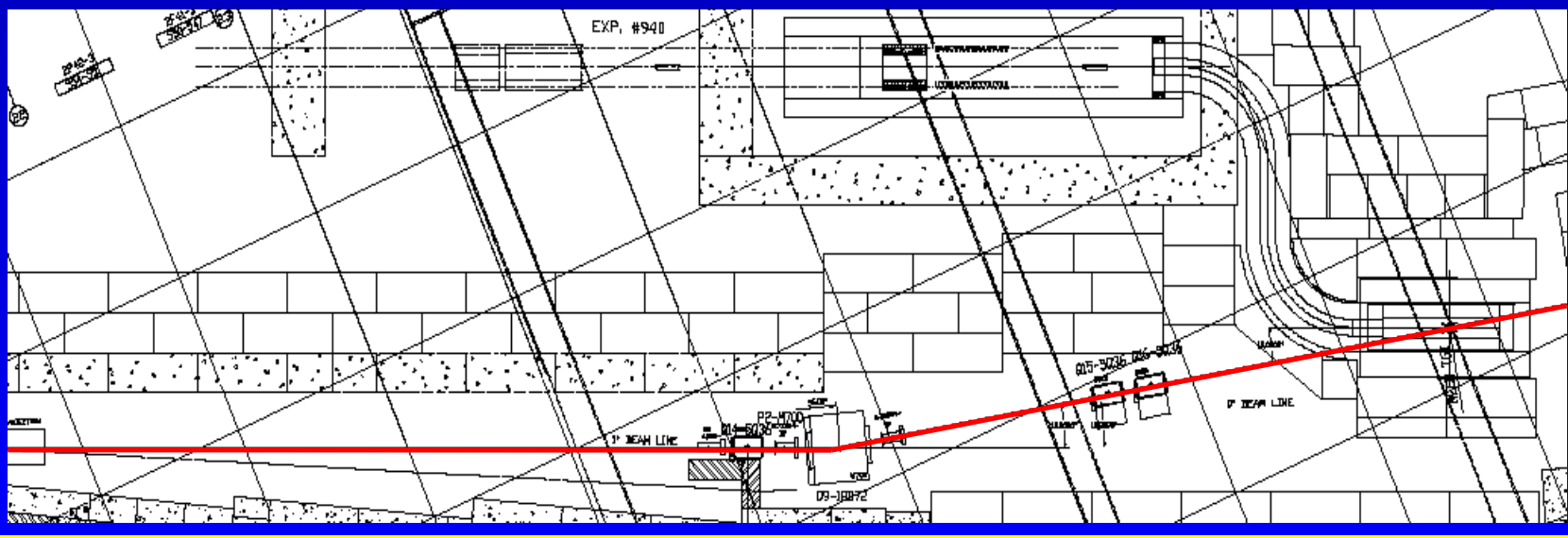
- **Current Status**
  - Two brief tests of extinction using the existing AGS hardware demonstrated extinction at the 10^{-7} level dominated by protons captured in unfilled buckets
  - Additional studies of extinction, extraction at 8 GeV (below transition), and high single bunch intensity remain to be done and await MREFC funds



- **Needs for Collaboration Contribution**
  - Understand how to reach design intensity
  - We aim to test the extinction achievable with the existing AGS hardware, requiring setting up an apparatus to measure beam arriving outside the filled bunches at the 10^{-9} level
  - Those measurements will need to be repeated as each component of the beam cleaning hardware is commissioned

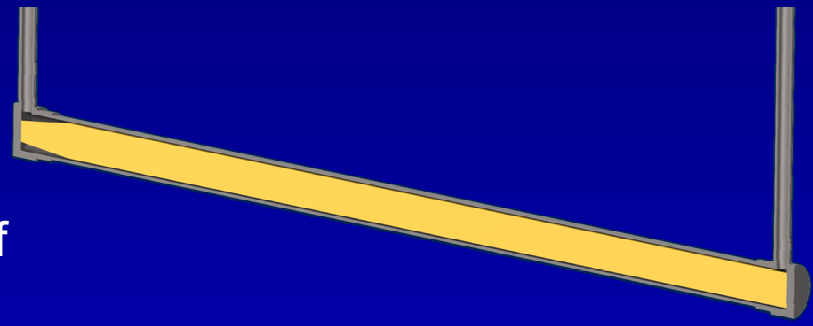
Proton Beamline

- **Current Status**
  - C-AD physicists developing beamline optics
  - Preliminary shielding design and AGS floor layout in A line by C-AD engineers
  - RF Modulated Magnet (RFMM) studies at UCI, conceptual design work to begin this fall
- **Needs for Collaboration Contribution**
  - External extinction monitoring system design and testing

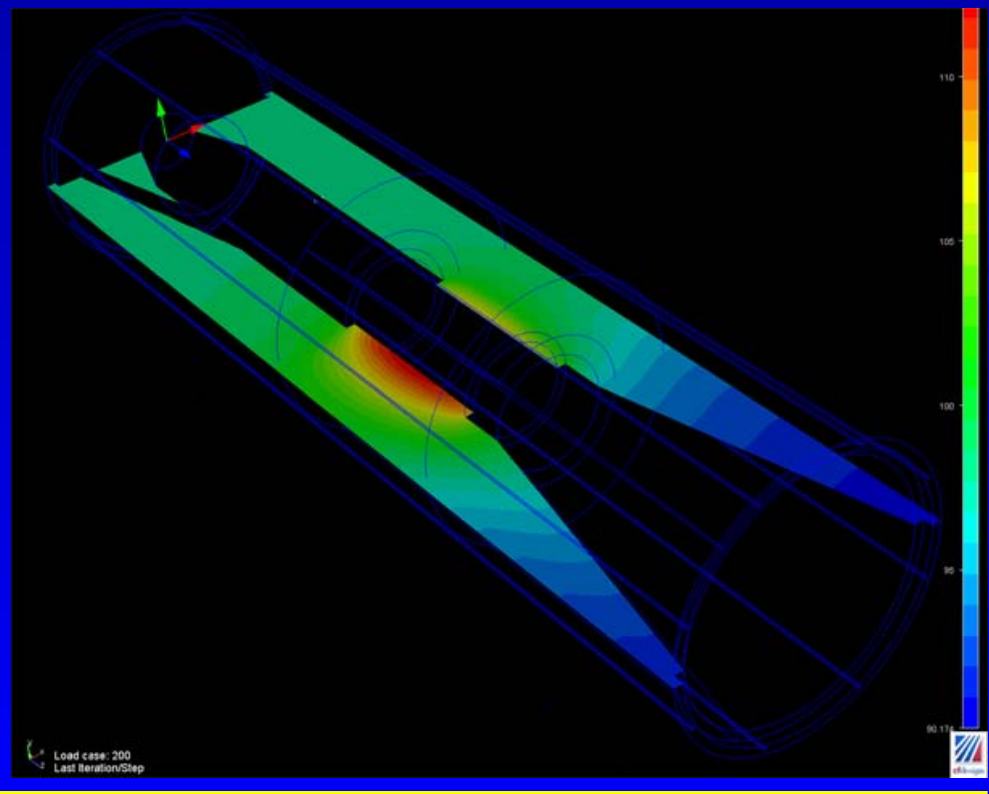


Production Target & Heat Shield

- **Current Status**
  - Initial version of Target Reference Design exists
  - Extensive simulation, design, and testing of water-cooled prototypes at UCI
  - Heat Shield conceptual design effort underway at BNL

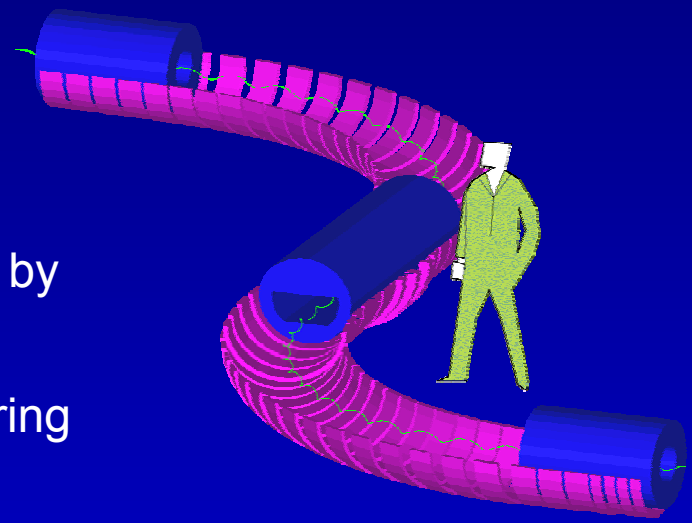


- **Needs for Collaboration Contribution**
  - Subsystem Manager
  - Beam testing of target prototypes

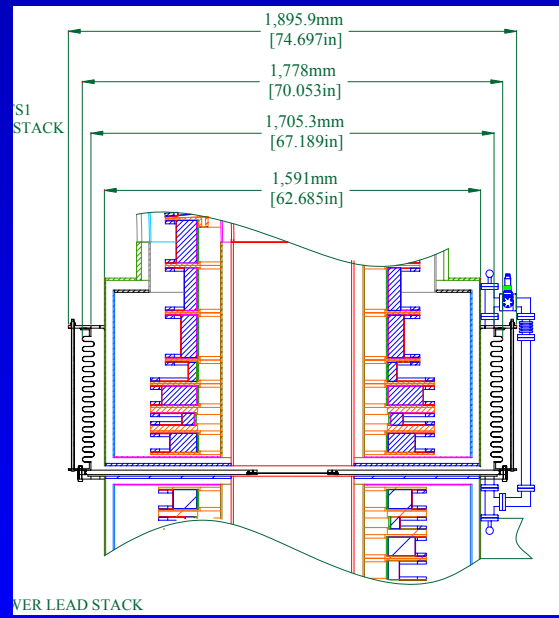


Muon Beamline

- **Current Status**
  - Vacuum, Collimator, μ Beam Stop, n Absorber Reference Designs exist
  - Vacuum window conceptual design completed by BNL
  - Vacuum, μ Beam Stop, and Absorber engineering efforts ongoing at BNL
  - Vacuum studies, Beam Stop and Absorber optimization at UCI

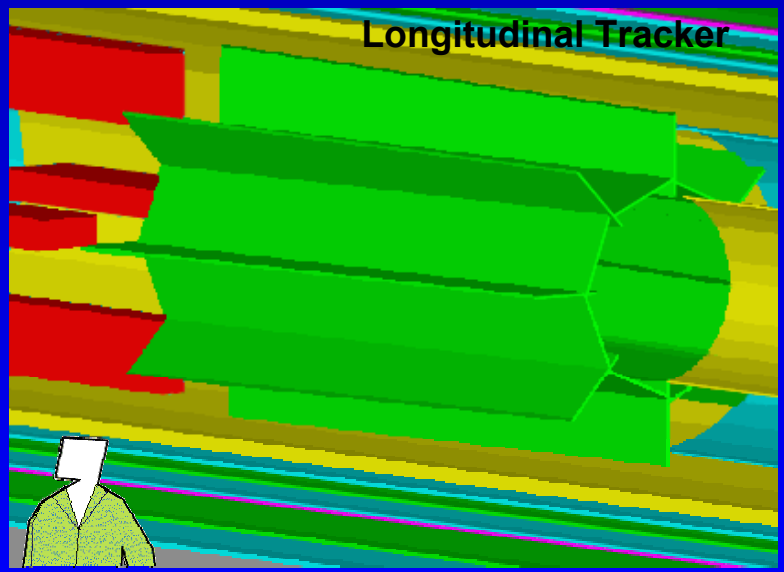


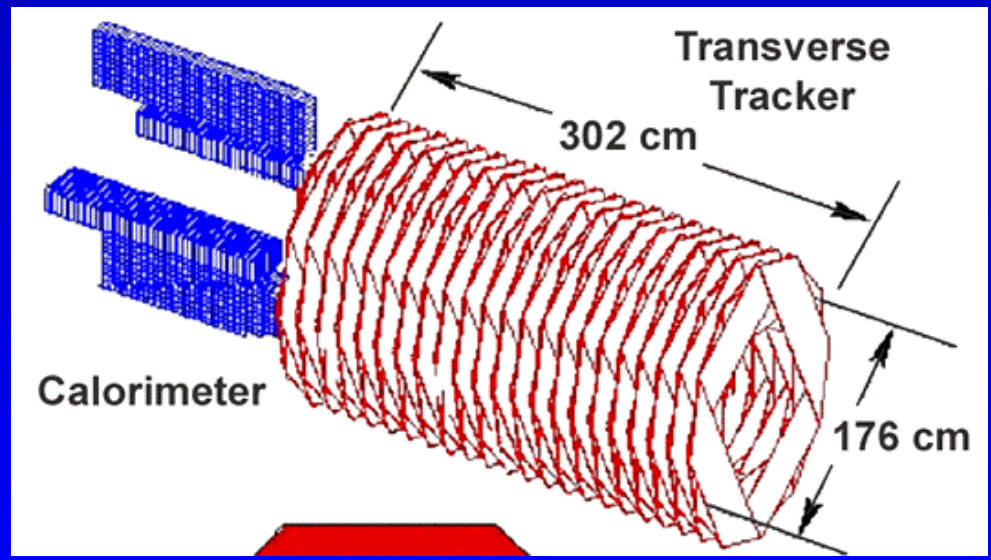
- **Needs for Collaboration Contribution**
  - Additional physics simulation effort to evaluate the impact of engineering changes on the experiment (more on this later)



Tracker

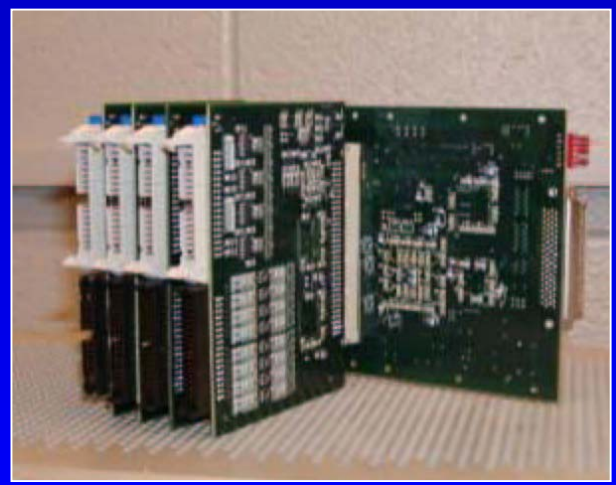
- **Two Geometries Under Consideration**
  - "Longitudinal" geometry with ~3000 3m long straws oriented nearly coaxial with the DS and ~20000 capacitively coupled cathode strips for axial coordinate measurement
  - "Transverse" geometry with ~13000 1m straws, oriented transverse to the axis of the DS, readout at both ends
- **Two readout options as well**
  - Digitizing inside the DS cryostat or passing analog signals out and digitizing remotely

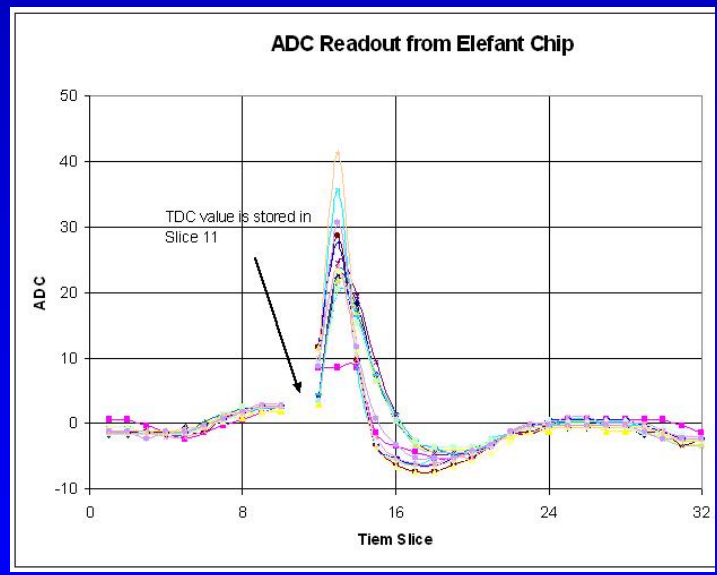




Tracker R&D

- **Studies Underway**
  - Full-length longitudinal vane prototype construction at Houston
  - Houston is testing prototype preamplifier, digitizer, and controller boards using a version of BaBar's Elefant readout chip with very promising results
  - Seamless straw chamber tests in beam have been conducted by Osaka
  - Simulations of both the longitudinal and transverse geometries at UCI and NYU, indications are that either geometry might work
- **Plenty of Opportunity for Additional Involvement, particularly on Transverse Option**

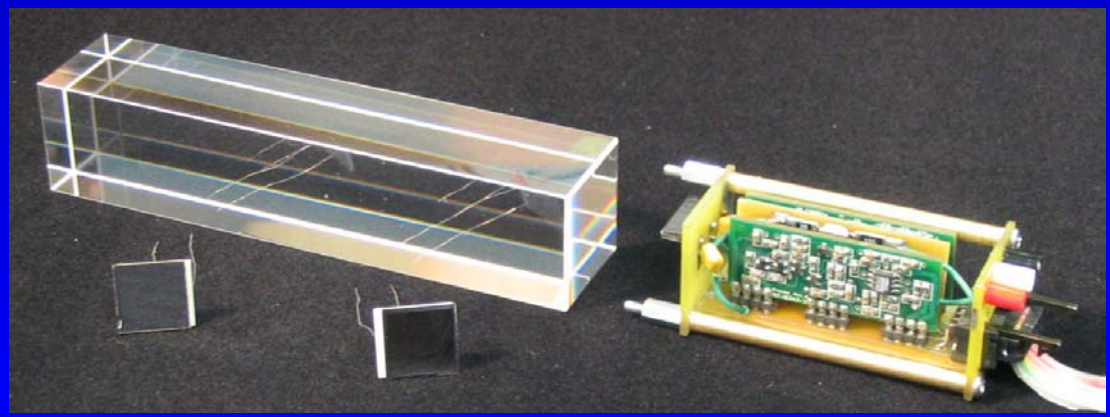


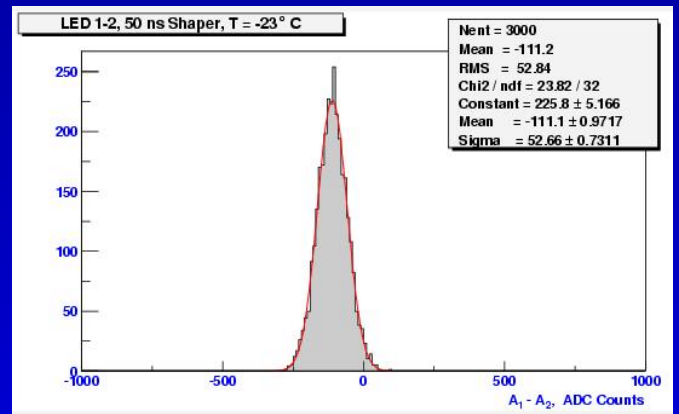


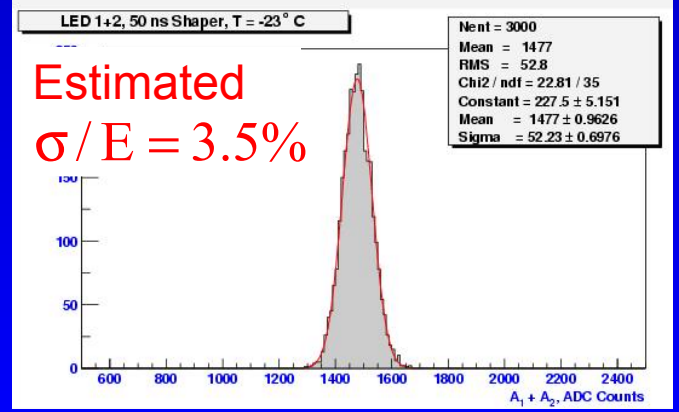
Calorimeter

- **Current Status**
  - $PbWO_4$ crystals cooled to –23 °C coupled with large area avalanche photodiodes will meet MECO requirements, demonstrating 20-30 photo e^-/MeV (as compared with CMS' 5 pe/MeV)

- **Needs for Collaboration Contribution**
  - We need to verify the system performance via beam tests of an 8×8 crystal array



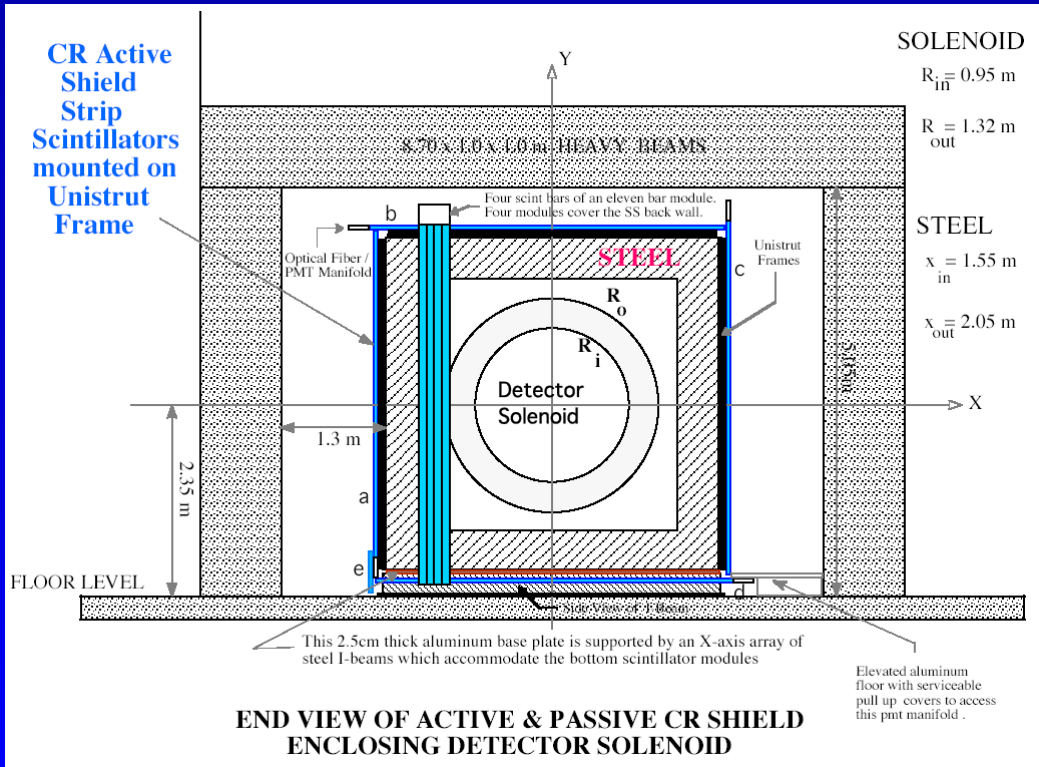




Cosmic Ray Shield

- **Current Status**
  - Extensive testing at William & Mary have established a combination of scintillator, wavelength shifter, and multi-anode PMT that will meet MECO's cosmic ray veto requirements
  - Extrusion of ~100 4m slats this summer at Itasca following MINOS' lead
  - Test slats will be assembled into a prototype module this Fall

- **Needs for Collaboration Contribution**
  - Neutron rates
  - System veto efficiency simulations
  - Engineering modules and the means of installing them beneath the Detector Solenoid



END VIEW OF ACTIVE & PASSIVE CR SHIELD ENCLOSING DETECTOR SOLENOID

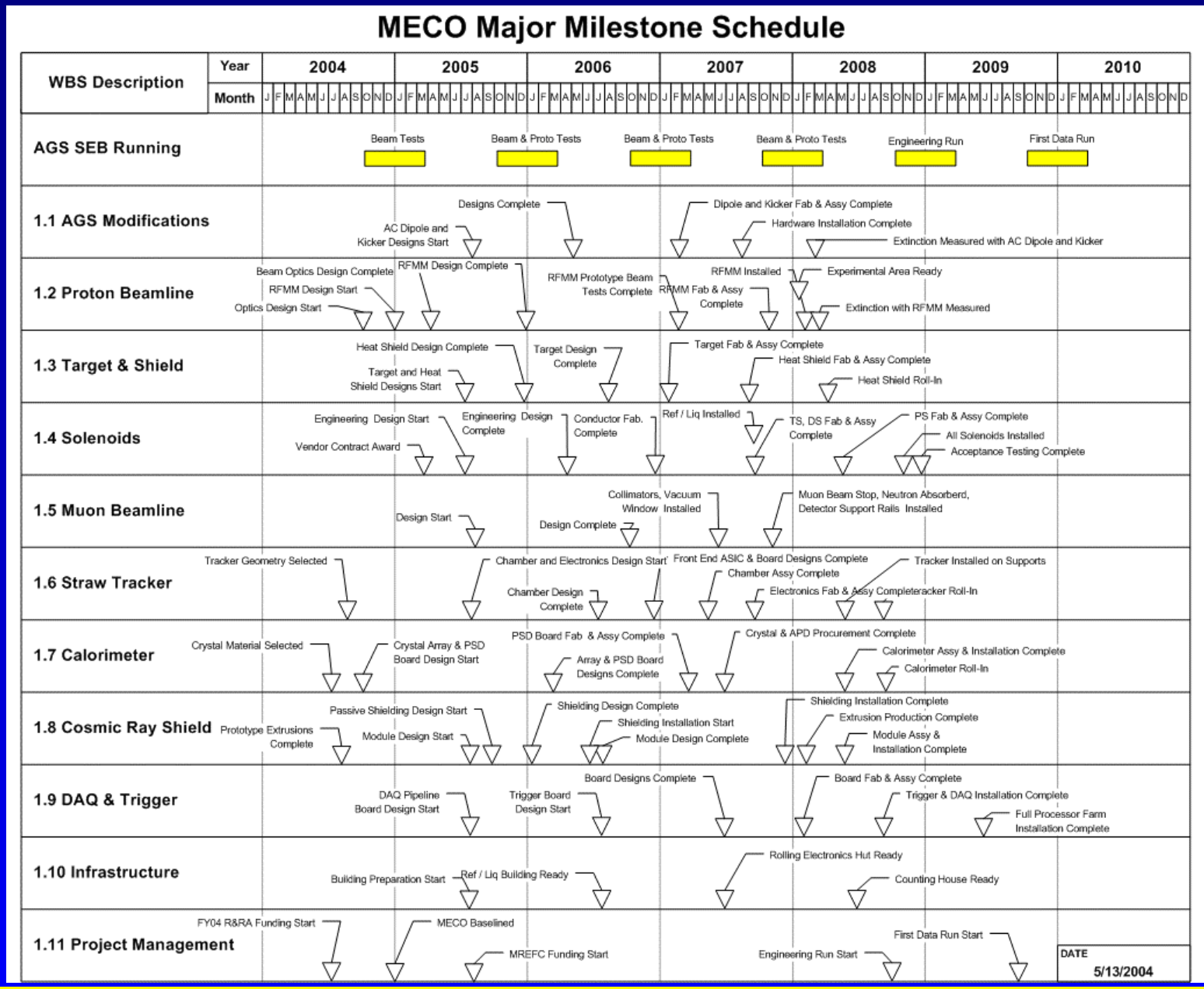
Trigger & Data Acquisition

- **Current Status**
  - Although several ideas for the designs of these systems have been floated, no engineering money has yet gone into this yet.
  - We will be starting a modest design effort at BU this summer
  - Rates are expected to be well within current technology
- **Needs**
  - This effort is just starting out. Plenty of opportunity to adopt new ideas

Software

- **Current Status**
  - Full GEANT simulations exist in varying degrees of sophistication for the detectors and the muon beamline. None of these has yet reached the level of simulating hardware signals in detail
  - We do not yet have a single, collaboration wide simulation
- **Needs**
  - Simulations at signal level (a.k.a. GEANT DIGI info)
  - Event Reconstruction
  - Online Monitoring and Slow Control
  - Organization / Support

Schedule


MECO Major Milestone Schedule
WBS Description
Year
2004
2005
2006
2007
2008
2009
2010
Month
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
AGS SEB Running
Beam Tests
Beam & Proto Tests
Beam & Proto Tests
Beam & Proto Tests
Engineering Run
First Data Run
1.1 AGS Modifications
Designs Complete
AC Dipole and Kicker Designs Start
Dipole and Kicker Fab & Assy Complete
Hardware Installation Complete
Extinction Measured with AC Dipole and Kicker
1.2 Proton Beamline
Beam Optics Design Complete
RFMM Design Start
Optics Design Start
RFMM Design Complete
RFMM Prototype Beam Tests Complete
RFMM Fab & Assy Complete
RFMM Installed
Experimental Area Ready
Extinction with RFMM Measured
1.3 Target & Shield
Heat Shield Design Complete
Target and Heat Shield Designs Start
Target Design Complete
Target Fab & Assy Complete
Heat Shield Fab & Assy Complete
Heat Shield Roll-In
1.4 Solenoids
Engineering Design Start
Vendor Contract Award
Engineering Design Complete
Conductor Fab. Complete
Ref / Liq Installed
TS, DS Fab & Assy Complete
PS Fab & Assy Complete
All Solenoids Installed
Acceptance Testing Complete
1.5 Muon Beamline
Design Start
Design Complete
Collimators, Vacuum Window Installed
Muon Beam Stop, Neutron Absorberd, Detector Support Rails Installed
1.6 Straw Tracker
Tracker Geometry Selected
Chamber and Electronics Design Start
Chamber Design Complete
Front End ASIC & Board Designs Complete
Chamber Assy Complete
Electronics Fab & Assy Completeracker Roll-In
Tracker Installed on Supports
1.7 Calorimeter
Crystal Material Selected
Crystal Array & PSD Board Design Start
PSD Board Fab & Assy Complete
Array & PSD Board Designs Complete
Crystal & APD Procurement Complete
Calorimeter Assy & Installation Complete
Calorimeter Roll-In
1.8 Cosmic Ray Shield
Prototype Extrusions Complete
Passive Shielding Design Start
Module Design Start
Shielding Design Complete
Shielding Installation Start
Module Design Complete
Shielding Installation Complete
Extrusion Production Complete
Module Assy & Installation Complete
1.9 DAQ & Trigger
DAQ Pipeline Board Design Start
Trigger Board Design Start
Board Designs Complete
Board Fab & Assy Complete
Trigger & DAQ Installation Complete
Full Processor Farm Installation Complete
1.10 Infrastructure
Building Preparation Start
Ref / Liq Building Ready
Rolling Electronics Hut Ready
Counting House Ready
1.11 Project Management
FY04 R&RA Funding Start
MECO Baselined
MREFC Funding Start
First Data Run Start
Engineering Run Start
DATE
5/13/2004

Conclusion

Once again, the bottom line of this talk is that MECO is gaining momentum but there is still time to get in on the "ground floor" and have a major impact upon the experiment.

Every subsystem would benefit from additional physicist input and guidance

Of course, that guidance will have the greatest impact sooner rather than later