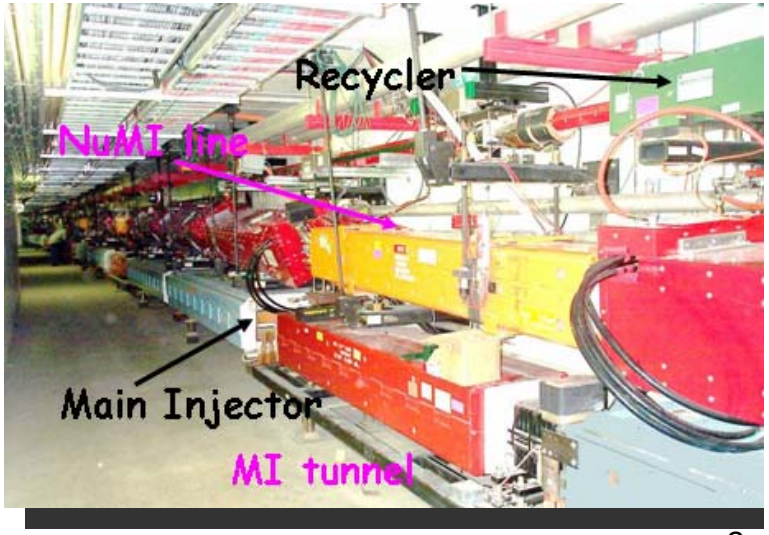
ANU & Related Work Status

- Overview (brief)
- Schedule
- Costs/Budget
- Change Requests
- Progress /Plans
- Off Project Related Work
  - MINU/Gap Clearing Kicker in MI
  - NuMI – Horns & Remote Radioactive Component Handling/Removal

NOνA: 700 kW
Recycler: 8 GeV Proton Pre-injector

- When Collider program concludes, use the Recycler as a proton pre-injector
  - Use the Recycler to accumulate protons from the Booster while MI is accelerating
  - Can save 0.4 s for each 6 Booster batches injected
- Recycler momentum aperture is large enough to allow slip-stacking operation in Recycler, for up to 12 Booster batches injected
  - 6 batches are slipped with respect to the other 6 and, at the time they line up, they are extracted to MI in a single turn and there re-captured and accelerated
  - Main Injector will run at its design acceler-ation rate of 240 GeV/s (1.3s cycle time) (operates at 204 GeV/s presently)
  - 4.3×10^{12} p/batch, 95% slip-stacking efficiency
  - 4.9×10^{13} ppp at 120 GeV every 1.333 s

  ⇒ **700 kW**



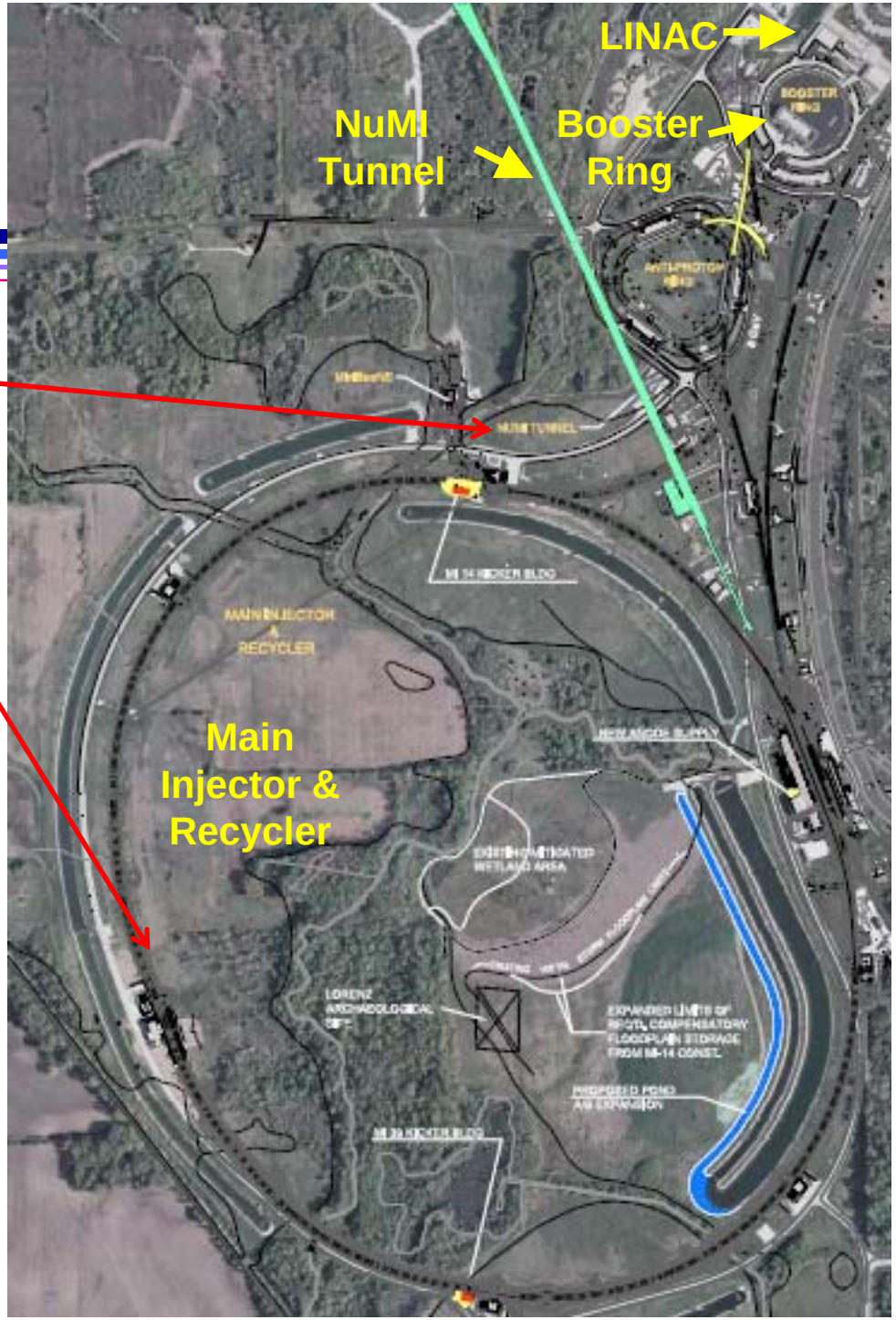
Present & Future Operating Scenarios

	Present Conditions Multi-batch slip-stacking in MI	Proton Plan Multi-batch slip-stacking in MI	NOνA Multi-batch slip-stacking in Recycler
Booster intensity (protons/batch)	$4.3\text{-}4.5\times10^{12}$ →	4.3×10^{12} →	4.3×10^{12}
No. Booster batches	7 →	11 →	12
MI cycle time (s)	2.4	2.2	1.333
MI intensity (ppp)	3.3×10^{13}	4.5×10^{13}	4.9×10^{13}
To anti-proton source (ppp)	8.8×10^{12}	8.2×10^{12}	0
To NuMI (ppp)	2.45×10^{13} →	3.7×10^{13} →	4.9×10^{13}
NuMI beam power (kW)	192 →	320 →	700
PoT/yr to NuMI	2×10^{20}	3×10^{20}	6×10^{20}

NOνA design parameters in TDR and ANU Parameters Document (NOvA-Doc-1556)

Main Items: ANU

- Recycler Ring, RR (WBS x.0.1)
  - New injection line into RR
  - New extraction line from RR
  - New 53 MHz RF system
- Main Injector (WBS x.0.2)
  - Two 53 MHz cavities
  - Quad Power Supply Upgrade
  - RR Low Level RF System
- NuMI (WBS x.0.3)
  - Change to medium energy ν beam configuration (new target)
  - Cooling & power supply upgrades
- Beam Physics (WBS x.0.4)
  - Beam Simulations & Evaluation of Proton Plan
- Commissioning with beam not included on NOvA



ANU Org Chart

1. 0, 2.0 ANU
Nancy Grossman
Elaine McCluskey, Deputy
Robert Reilly, ANU ME; Robert Ducar, ANU EE
Michael Andrews, ANU ES&H/QA Coordinator
Karlton Williams, Cooling Systems Engineer
Linda Valerio, MI/RR Installation Engineer

1.0.1, 2.0.1 Recycler Upgrades
Paul Derwent

- **1, 2.0.1.1 Recycler Ring Modifications**
  Daniel Broemmelsiek
  David Johnson, Deputy
- **1, 2.0.1.2 Recycler Kicker Systems**
  Christine Ader
  Chris Jensen, Deputy
- **1, 2.0.1.3 Recycler Instrumentation**
  Martin Hu
- **1, 2.0.1.4 Recycler Radiation Safety**
  Peter Kasper

1.0.2, 2.0.2 Main Injector Upgrades
Ioanis Kourbanis

- **1, 2.0.2.1 Main Injector Modifications**
  David Capista
- **1, 2.0.2.2 Main Injector RF Cavities**
  Joseph Dey
- **1, 2.0.2.3 Main Injector Radiation Safety**
  Peter Kasper

1.0.3, 2.0.3 NuMI Upgrades
Michael Martens
Kamran Vaziri (RSC)

- **1, 2.0.3.1 NuMI Primary Proton Beam**
  Samuel Childress
- **1, 2.0.3.2 NuMI Technical Components**
  James Hylen
  Thomas Kobilarcik, Deputy
- **1, 2.0.3.3 NuMI Infrastructure**
  Salman Tariq
- **1, 2.0.3.4 NuMI Decay Pipe, Hadron Absorber & Utilities**
  Karlton Williams

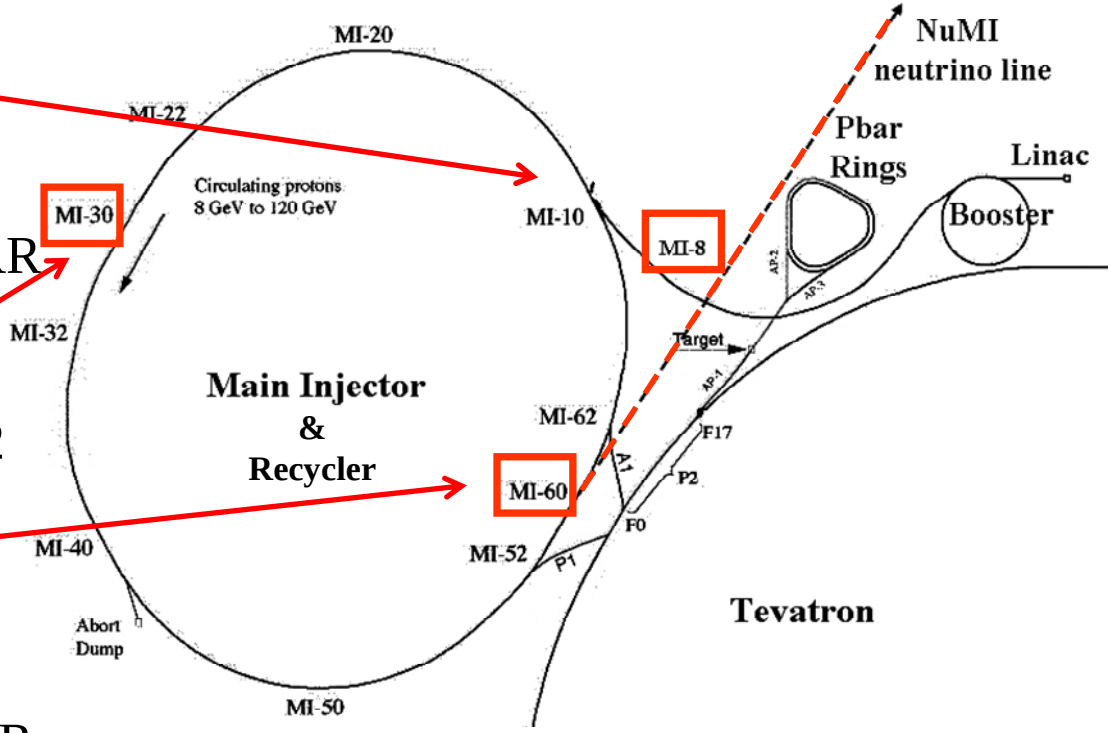
1.0.4 Beam Physics
Robert Zwaska

Notes:

1. The individuals shown with responsibility on subprojects are matrixed to the NOvA Project.
2. Line management for safety is through the subproject departments within AD and TD.
3. RSC: Radiation Safety Coordinator

Main Items: Recycler Ring Upgrades

- Decommissioning of anti-proton specific devices
- Design, build & install:
  - New injection line connecting MI-8 (from the Booster) into the Recycler
  - New extraction line from RR to MI at RR-30 straight section (near MI-30)
  - 53 MHz RF system using 2 new RF cavities w/controls & power in MI-60
  - Five new kicker systems (RR Injection, RR Extraction, MI Injection, RR Abort and Gap Clearing)



Linac, Booster, MI, RR and NuMI Line

- Upgrade Recycler instrumentation (new beam position monitors, new intensity measuring devices, and new dampers)

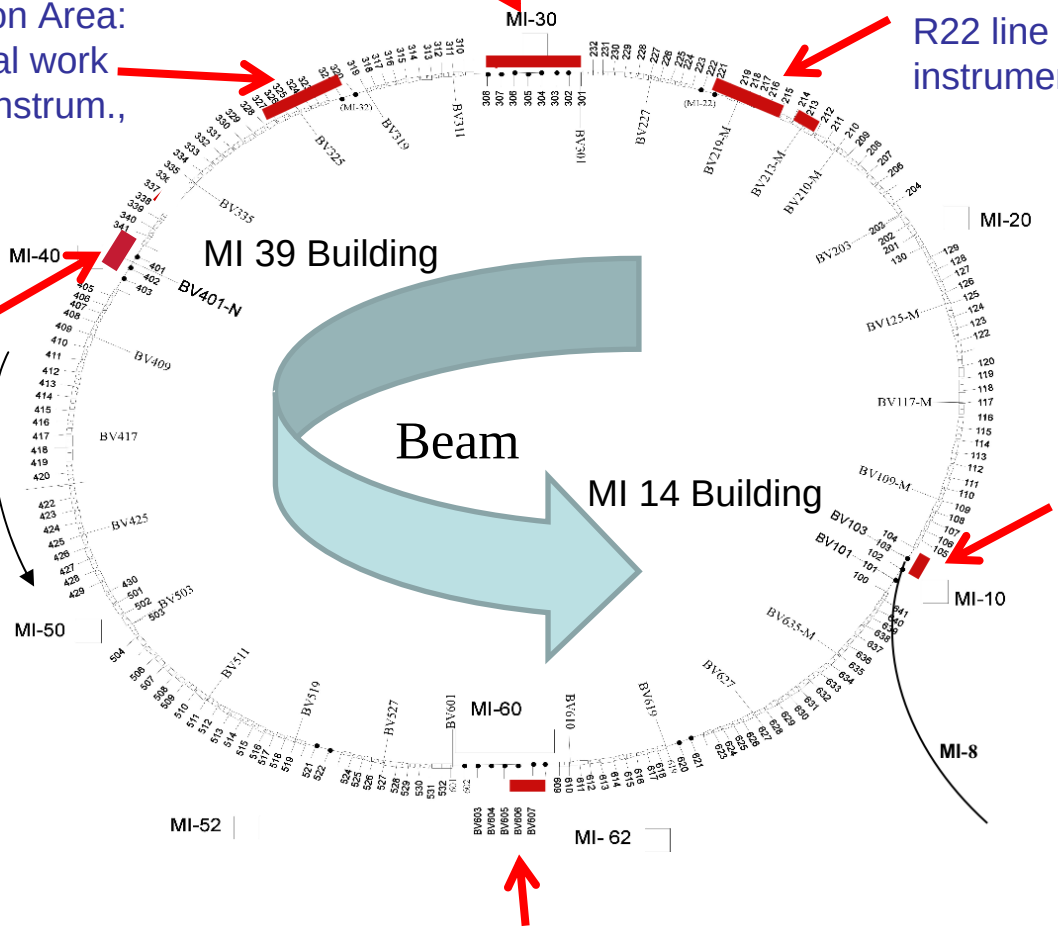
Main Items:
Recycler Ring Upgrades

Electron Cooling Insert
New RR Extraction Line
New RR30 Straight

Stochastic Cooling Pickups
Current Injection Area:
R22 line removal (Lambertson's, instrumentation, trims)

Current Extraction Area:
R32 Line removal work (Lambertson's, instrum., trims, mirror)

New Abort Kicker, Gap Clearing Kicker moved here from MI (nearby)



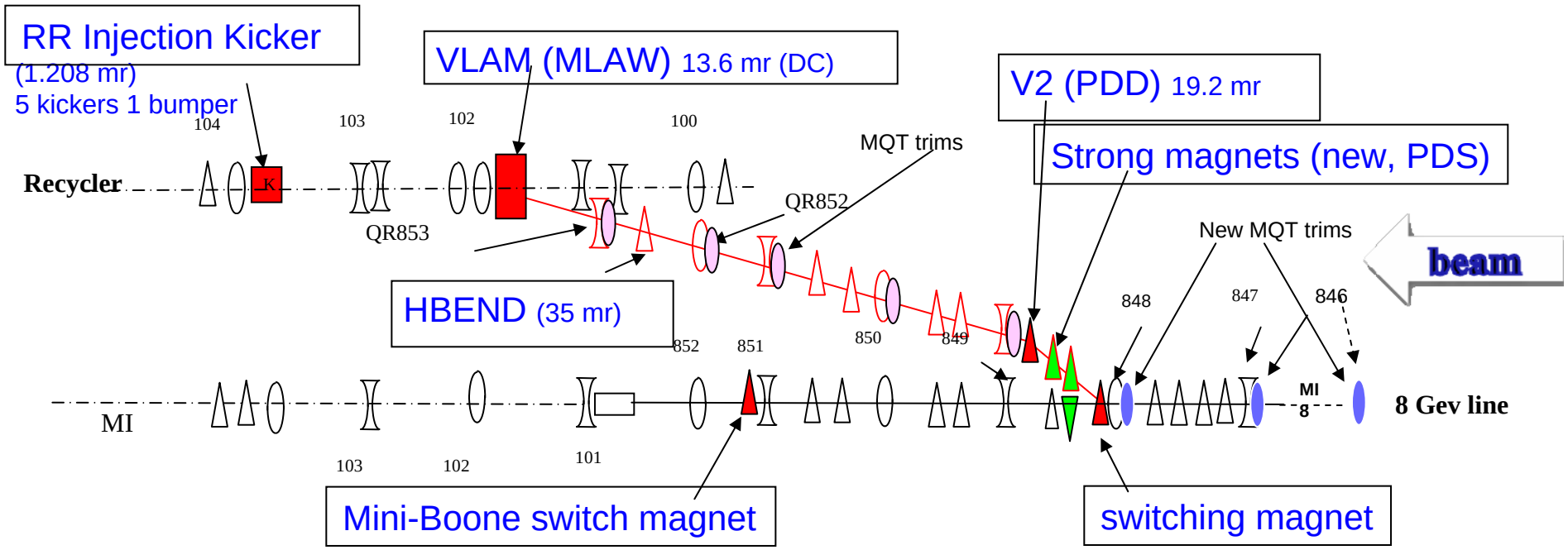
Proton Direction

Stochastic Cooling Kickers
New RR Injection Area

Key: WBS
Elements Removed
New Elements
Areas Affected

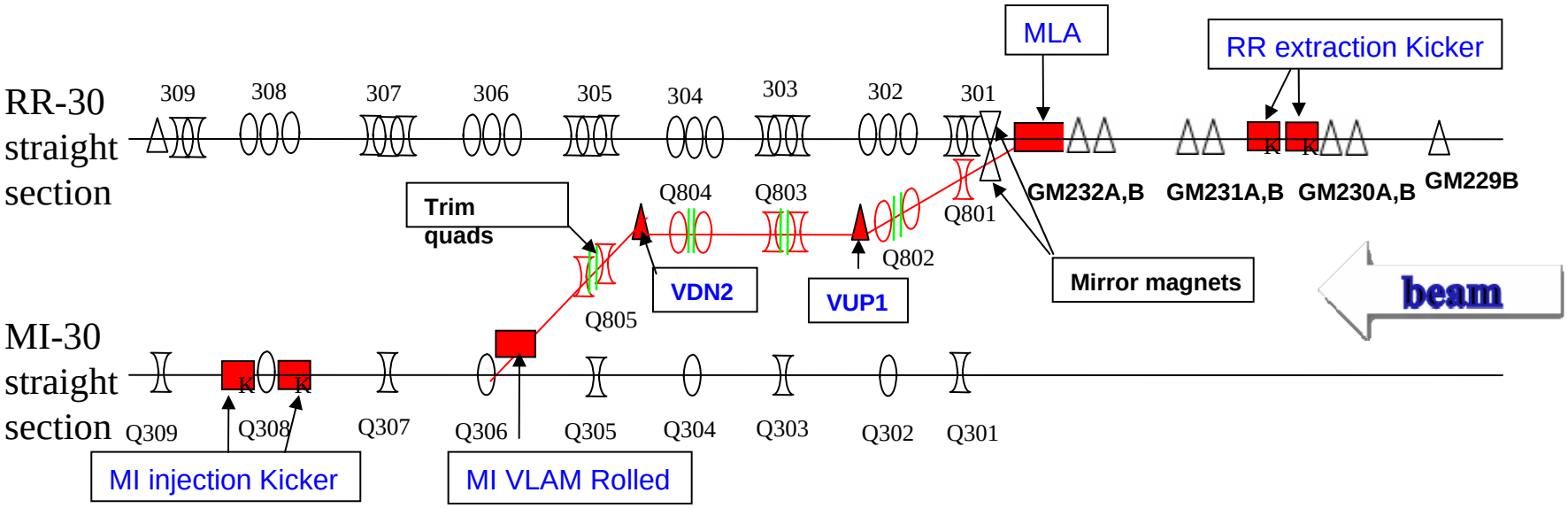
New 53 MHz RF

Recycler Ring Injection Line



- Keep ability to transfer from MI-8 into MI and MiniBoone with a vertical switching magnet
- Strong/small magnets (PDS) – value engineering these magnets to determine best option
- Keep AC magnetic fields away from RR
- MLA vertical injection Lambertson – cancels vertical dispersion from switching magnet
- RR Injection kicker: Required kick implies 5 kicker magnets and 1 bumper magnet

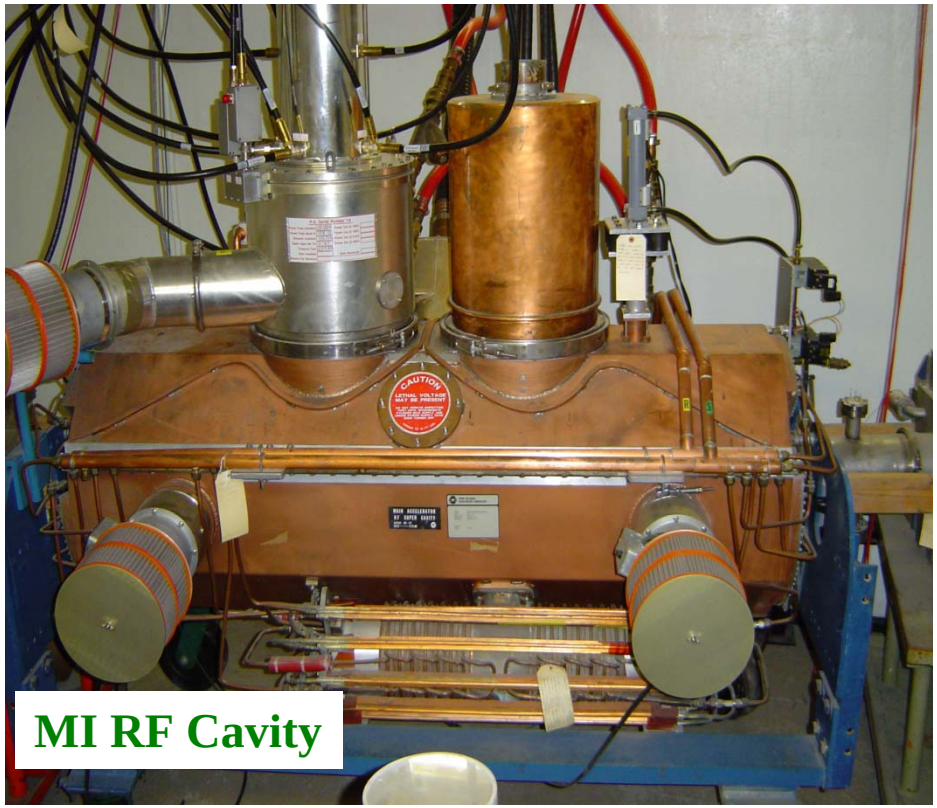
Recycler Ring Extraction Line



- Extraction line redesigned to reduce required kicker strength by extending the whole line by a cell.
- 8GeV Lamberston used for initial vertical bend.
- Apertures at Lambertsons and Kickers fit 20pi-10sigma beam envelope.
- RR Extraction Kicker: 2 kicker magnets
- MI Injection Kicker: 1 kicker magnets, 1 bumper magnet

Main Items: Main Injector Upgrades

- Accelerating only 10% more proton intensity
- Beam power out of the MI much larger since the cycle time will be reduced from 2.2 seconds to 1.33 seconds.
  - Using the Recycler Ring for stacking, MI cycle time reduced to 1.5 sec
  - Reduce to 1.33 seconds by increasing the maximum acceleration rate from 204 GeV/sec to 240 GeV/sec.
- Requires an upgrade to one of the quad power supplies.
- 2 additional RF cavities need to be installed (18 stations now)
- Also included in this WBS is the Recycler Ring Low Level RF (RR LLRF) since it is a minor upgrade to the existing MI LLRF – used for slip-stacking in the RR for NOνA

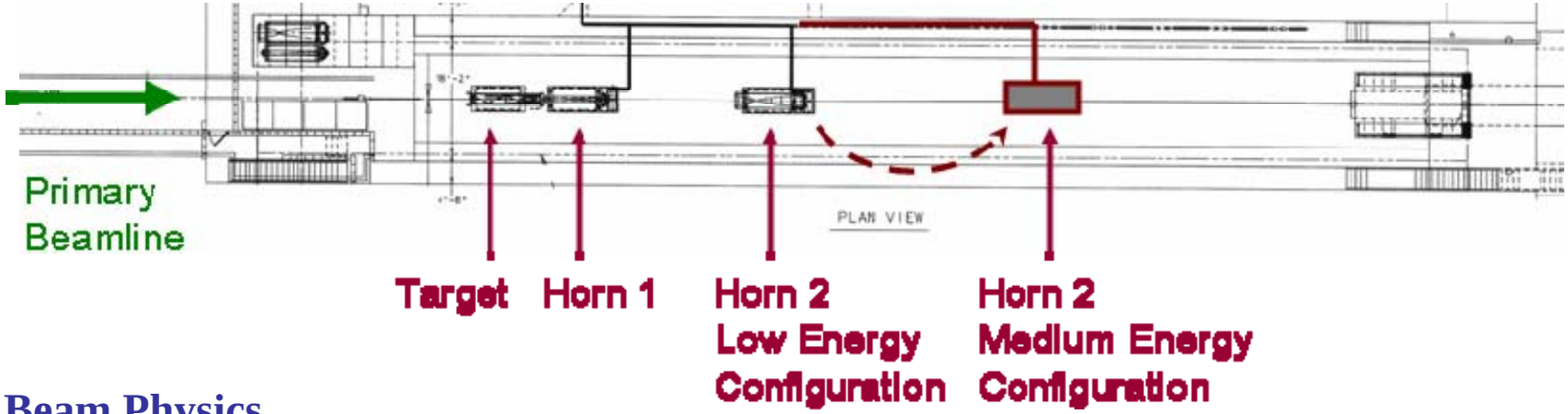


MI RF Cavity

Main Items:
NuMI Upgrades & Beam Physics

NuMI - designed for 4E13 ppp every 1.87 s (400 kW beam power)

- Design, build, install a new medium energy target/carrier/baffle
- Reconfigure shielding & move horn 2 to the medium energy location & extend the stripline
- Upgrade cooling & power supplies for increased power and rep. rate

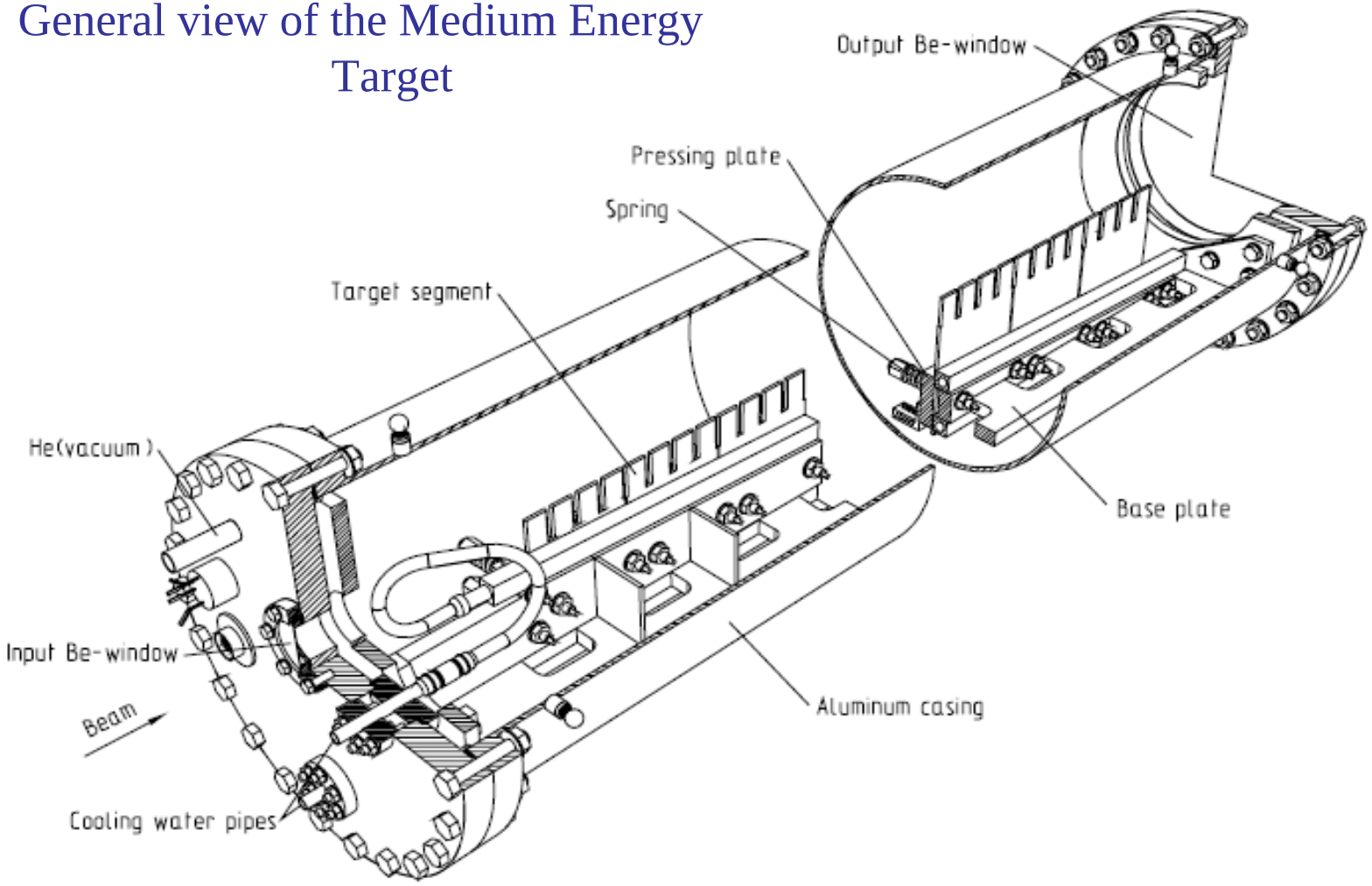


Beam Physics

- Analyze improvements implemented by the Proton Plan
- Machine and process analysis: collection of theoretical, experimental and simulation studies on the existing machines
- Provide a method for predicting realistic proton projections to NOvA

Main Items: NuMI Upgrades

General view of the Medium Energy Target



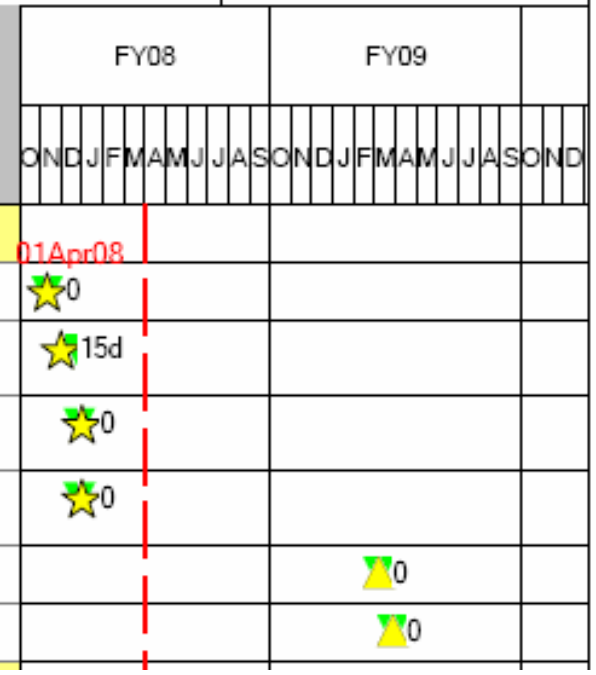
ANU Schedule Summary: Milestones

- Will make the upcoming Milestone dates, probably will be early on both.

NoVA Project
Milestone Gantt Chart
Progress Reporting - thru Mar08
Time Now: 01Apr08
Baseline: Nova_PMB

Baseline Milestone
Milestone
Completed Milestone

Activity ID	Milestone Description	Early/Actual Date	Baseline Date	Milestone Level
1.0 -- ANU Planning, Engineering & Design				
1.0.3.3.5.11	NuMI FEM 3-D Thermal Analysis Complete	07Nov07	07Nov07	L5
1.0.3.3.5.1	NuMI Analyze Predicted Block Temperatures Effect on Chase Components Complete	30Nov07	21Dec07	L5
1.0.1.2.7.5	RR Injection Line Prototype Kicker Complete (Moved Off Project)	28Dec07	28Dec07	L5
1.0.1.2.7.6	RR Ferrite Procurement Finalized (Moved Off Project)	28Dec07	28Dec07	L5
1.0.3.2.5.9	NuMI Hadron Monitor Initial Re-design Complete	06Mar09	06Mar09	L5
1.0.2.2.4.1	MI Cavity Pre-install Testing Complete	27Mar09	27Mar09	L5

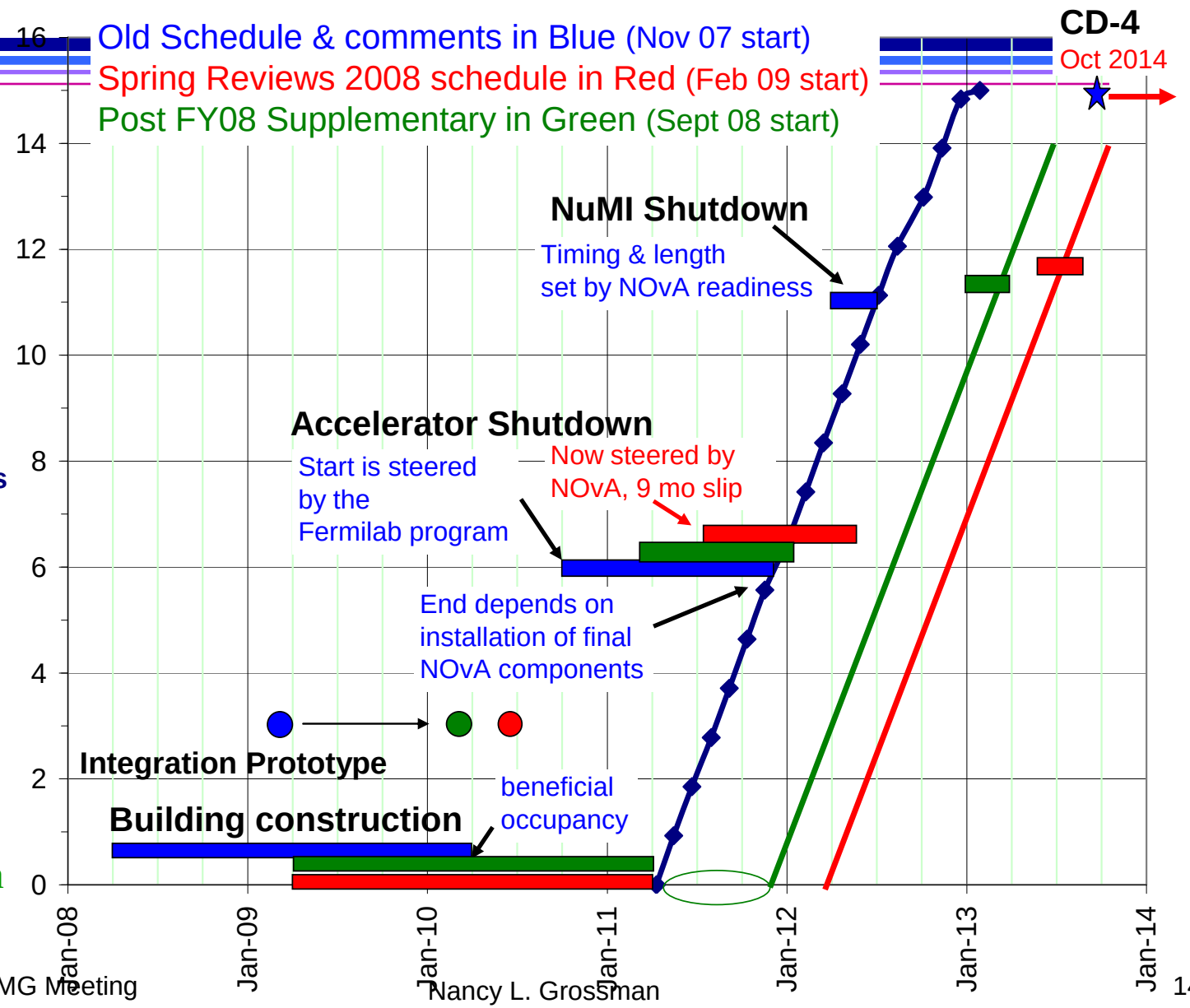


Graphic Schedule Summary

- **Accelerator shutdown schedule can only advance by number of months before 2/1/09 we get CD-3a**

Detector Progress (in kilotons outfitted)

- Building does not advance
- Accelerator and Detector advance 5 mo.
- Generates a squeeze in outfitting for assembly at Ash River



ANU Shutdown Schedule

- Shutdown Schedule (based on NOvA CD-2 schedule):
  - Accelerator Upgrades: July 2011 to May 2012
  - NuMI Upgrades: June 2013 to Sept. 2013
- John is looking to speed these up by 3 mos. (due to supplemental funding)
- If we get CD-3a by Nov. 1, 2008 (best case scenario) – Then:
  - Accelerator Upgrades: April 2011 to Feb. 2012
  - NuMI Upgrades: March 2013 to June 2013
  - NOvA RCRP (Radioactive Component Repair and Removal Plan), 700 KW Horn 1 done by then (and modules for horns, Target/baffle) – off project
- Be prepared for a shutdown before our scheduled longer one, but after TeV off so can take out magnets to refurbish.
  - Accelerator upgrades shutdown length driven by the permanent magnets that must come out of RR, get refurbished/rebuilt and then installed.
  - If we could get these out ahead of time, could shorten the shutdown a couple months perhaps.

ANU Costs/Budget

- Need to do a variance analysis from work done before January 1, 2008 - over ran on labor
  - More time spent on preparing /doing reviews in FY07 & FY08 then anticipated
  - Under-estimating labor seems to occur no matter how hard I try

CONTRACT PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME Fermi National Accelerator Laboratory	a. NAME	a. NAME NOvA project	a.FROM 01-Mar-2008 b.TO 31-Mar-2008

8. PERFORMANCE DATA

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION
	BUDGETED COST		ACTUAL COST	VARIANCE		BUDGETED COST		ACTUAL COST	VARIANCE		
	WORK SCHEDULED	WORK PERFORMED	WORK PERFORMED	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED	WORK PERFORMED	SCHEDULE	COST	BUDGETED
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(14)
DA DOE-ACEL MIE											
2.0 ANU Construction Fully burdened AY$K	0	0	0	0	0	207	207	132	0	75	30,084
DD DOE-ACEL R&D											
1.0 ANU Planning, Engineering & Design Fully burdened AY$K	6	0	0	(6)	0	1,348	1,353	1,570	5	(217)	7,401
CostAcctFndSrcTotals:	6	0	0	(6)	0	1,348	1,353	1,570	5	(217)	7,401
DO DOE-ACEL OPS											
1.0 ANU Planning, Engineering & Design Fully burdened AY$K	0	0	0	0	0	80	80	7	0	73	1,206
CostAcctFndSrcTotals:	0	0	0	0	0	80	80	7	0	73	1,206

Change Request Status

CR#	CR Title	Status	Comments
37	ANU Horn 3 ME Position Change	In pr	: controls
38	ANU Change PDS Magnet Design, PDS & PPD Magnet Count	In process	In project controls
46	53 MHz RF – Move Tuner PS to Prototyping Phase	Submittted	Awaiting preliminary approval
	Salvage steel instead of purchased for NuMI shielding	Not yet submitted	Salman preparing
	ADC/Perm quad magnet changes	Not yet submitted	Ollie preparing

Now done ($34K)

- CR 46 is needed since we need the tuner power supply for the prototype testing – should have costed it in 1.0 to begin with. No design work needed for the tuner PS.
- ADC/Perm quad magnet changes is value engineering to make the most of the prototype/tooling work .

Recycler Ring Task Ramp Up

1.0.1.1 RR Modifications

- Preliminary RR-30 SS, IL and EL Installation planning
- Tech Division: Perm. Quads, PDS (permanent dipole), PDDW (permanent dipole), MLAW (lambertson)
- Intermediate design 53 MHz RF system

1.0.1.2 RR Kicker Systems

- RR Injection pre-production pulser procure PFL frames, cable and pulser
- RR ext line kicker PS update current HV pulser design
- MI Inj/RR Extract/Abort prepare req. for cable for prototype
- Buy pulser for bumper kicker so can start prototype tail bumper kicker work (MI Injection).

1.0.1.3 RR Instrumentation

- Finalize design BPM cables and transition boards

1.0.1.4 RR Radiation Safety

- Review/revise RR (MI) Shielding Assessment

MI & NuMI Task Ramp Up

1.0.2.1 MI Modifications

- Analyze MI (& RR) LCW & Pond cooling system capacities
- RR LLRF system design -> RR LLRF system develop hardware/software

1.0.2.2 MI RF Cavities

- Analyze MI cavity & RF cooling system capacities
- MI Cavity pre-install testing (existing)

1.0.3.2 NuMI TH Technical Comp.

- Review IHEP ME Target Design Study 1
- Analyze baffle for higher heat loads

1.0.3.3 NuMI TH Infrastructure

- Overall TH layout for operations (part 2)
- Develop stripline layout scheme in Target Hall and blue block & T-block removal/re-location plan
- Analyze all components & chase items for temperature limits & Design additional chase temp. monitoring equipment

Beam Physics Task Ramp Up

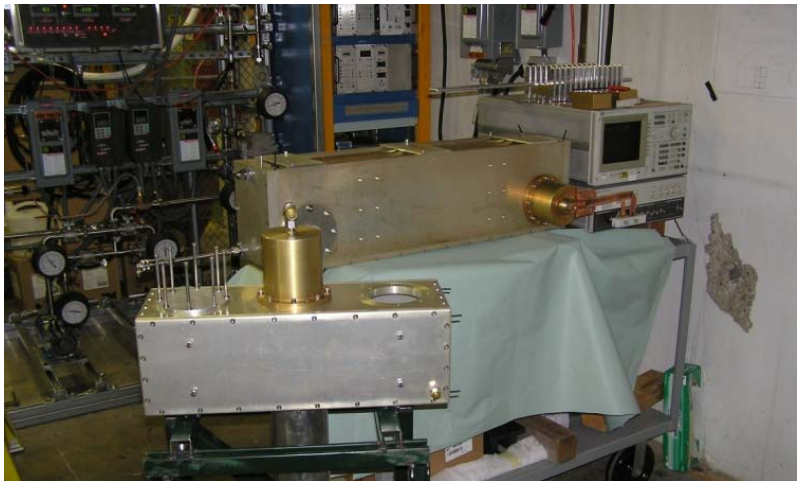
1.0.4 Beam Physics

- Evaluate MI-8 Collimator Performance, Slip-Stacking Performance and MI Collimator Performance for ANU
- Transfer Line Simulation
- Beam Cleaning Analysis
- Slip-Stacking Simulation & Optimization for the Recycler-2
- Recycler & MI Beam Dynamics Simulation-2
- MI Machine Measurements-2
- MI Loss Pattern Measurement-2
- Recycler Machine Measurements-2
- Electron Cloud Measurement in MI & RR-2
- Electron Cloud Simulation & Analysis for ANU-2
- Proton Plan Projections: Maintain Measurements & Predictions of Performance-2

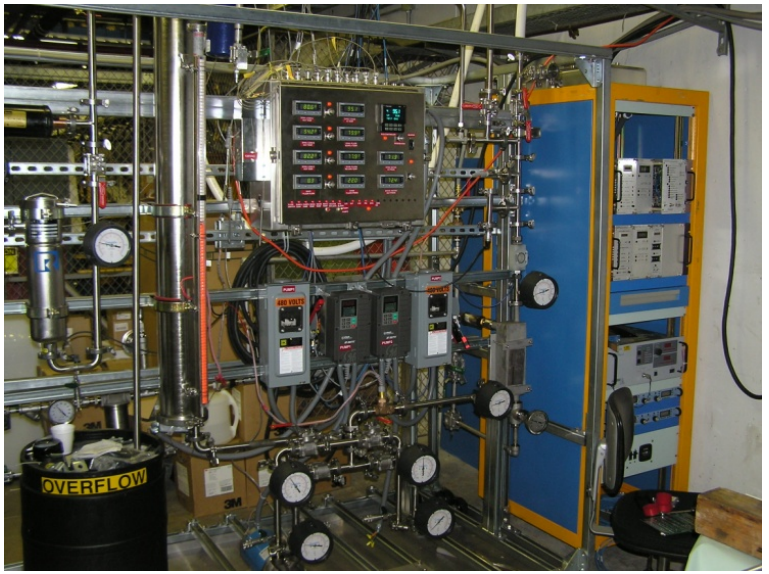
Many of these continued in FY08 with scientist effort. The remainder are ramping up.

Off-Project: Gap Clearing Kicker (GCK)

- Monthly “PMG’s” with “Project” group
- Goes in MI to reduce losses in MI-10 region (where NOvA Injection Line will go)
- On schedule for completion for April 6, 2009 shutdown (not a lot of float)
- Prototype testing complete, design nearly complete (only minor parts left)
- Getting all the parts/tooling to start building the first magnet
- Start building first magnet that will go in the tunnel in November



Load Magnet & Prototype Kicker #1 on Test Bench



Flourinert Skid

Off-Project: MINU GPP, NuMI

MINU GPP:

- 10 week shutdown of 2009: penetrations, below grade utilities, and footings at MI-14 and MI-39.
- Remaining work can be accomplished independently of the accelerator operating schedule:
  - Buildings at MI-14 & MI39, flood plain mitigation, anode PS room at MI-60
- Directorate is committed to doing this work in FY 2009 – budget planned
- When we get to Oct. shutdown
  - Check rad. levels at that point and determine how we will proceed
  - Concern that levels are high and will impact work and/or HEP program
- In order to start work April 6, 2009, need to go out for bid mid. Nov. at the latest, would be good to go out for bid earlier in case we get surprised with the bids.

NuMI:

- NOvA Horns and modules etc. a constant effort – hard to keep on schedule

Shutdown Issues for Spring 2009

At Proton PMG, CDF and DZero suggested running through the end of 2010 without a major shutdown.

- Revisit the question at the Proton PMG following the October shutdown, and make a decision shortly thereafter.

As input to the discussion and decision, Steve said we need input on the following topics:

1. AD's strategy for cooling down the MI10 area in advance of an April 2009 shutdown.
   - Measure in October and show options for running NuMI vs. estimated radiation levels
   - Lead blankets (as we planned) and very well planned work
   - If we have to, remove 2 dipoles (and maybe a quad), replace dipoles with new ones/spares
2. Projections of activation levels in the MI10 region if we were to delay the shutdown to October 2010.
   - Very rough estimates at this point, 6-7 times hotter (600-700 mr/hr in hottest areas?) – need data for long-lived component from the shutdown in October.
   - Level of uncertainly in this is high until we get October 2008 data

Shutdown Issues for Spring 2009

3. What is the latest date at which the MINU GPP could commence without delaying the NOvA schedule?
   - Building ready in Sept. 2009 in schedule, have float though
   - If assume NOvA schedule advanced 3 mos. due to supplemental funding, then April 1, 2010 need buildings (removing all float minus 3 months)
   - Working backward this means a 10 week shutdown 6 months earlier or Oct. 1, 2009. (starting in fall makes it more likely that the work will be delayed and the shutdown will be longer)
   - The longer this work is delayed, the higher the radiation levels will be, the longer it will take to do the job & more money & risk & dose
   - Leaves no schedule contingency in getting the kicker infrastructure set up in the buildings.
4. What would the AD strategy be if directed to continue operations through September of 2010 without a major shutdown?
   - Roger will address this for the Proton PMG (clearly running that long is really tough)

Conclusions

- ANU Budget/Costs:
  - BUDGET: R&D: $7.4M Operating: $1.2M Construction: $30.1M
  - Need to do a Variance Analysis for Recycler R&D work

- Schedule: If we get CD-3a by Nov. 1, 2008 (best case scenario) – Then:
  Accelerator Upgrades: April 2011 to Feb. 2012
  NuMI Upgrades: March 2013 to June 2013

- Progress: Ramp up looks to be better than I had hoped, but won't know for sure until we have a couple months of statusing under our belts (and EVMS)
  - Very concerned about getting everything together for EVMS this fall…

- Off Project work is always a concern as there are so many outside influences that make it hard to keep on schedule