WBS 1.0, 2.0 Accelerator and NuMI Upgrades (ANU) More Details

June 4, 2007

Nancy L. Grossman

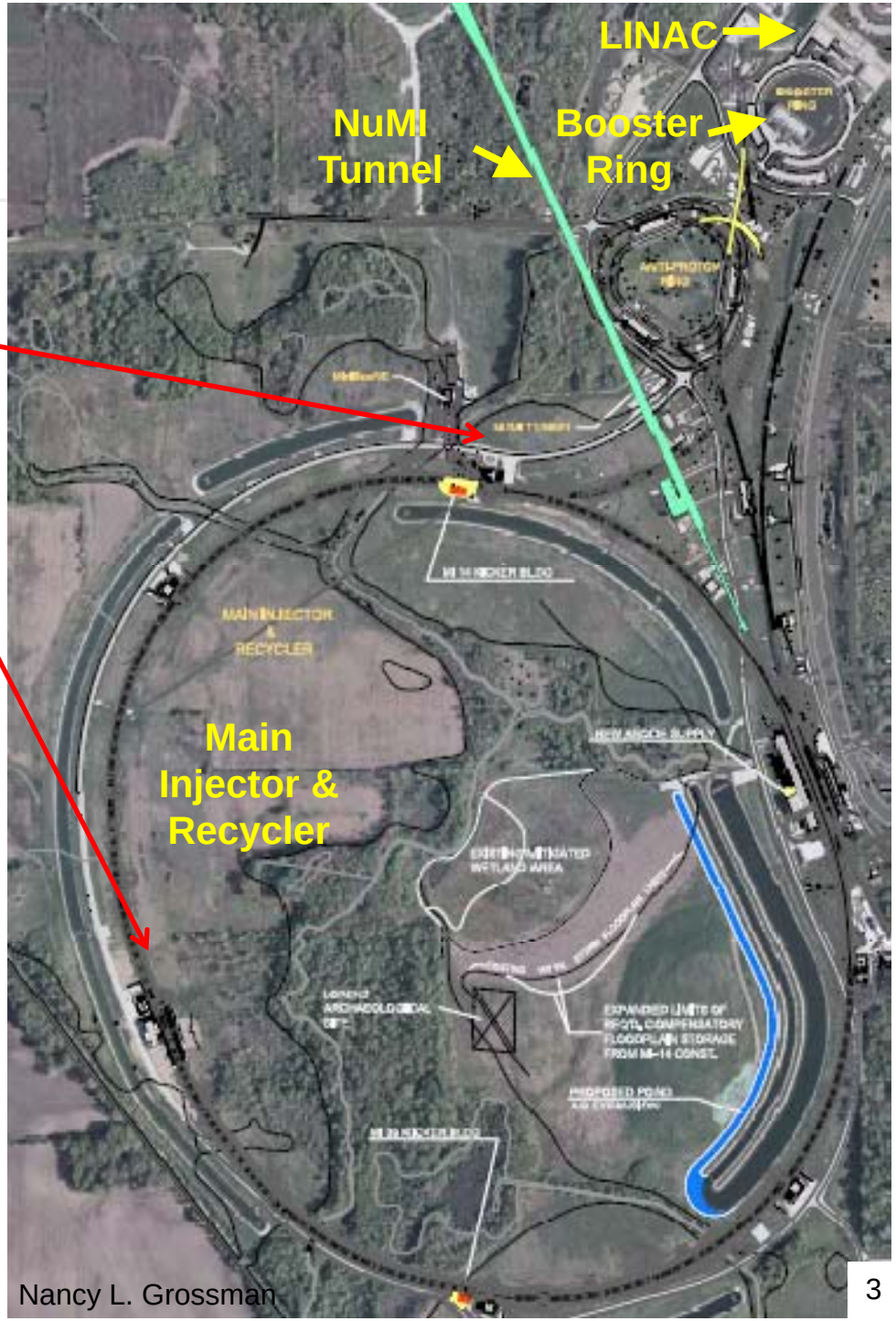
Outline

- Overview/Review (Technical summary/Org Chart/Schedule/Cost)
- Off-Project Items (for those of you at the SNuMI Review)
- Technical: Breakout Talks List
- Costs
- Labor plots
- Critical Path
- Items that still need work for DOE review

- Information in binders

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
  - Cooling & power supply upgrades
- Beam Physics (WBS x.0.4)
  - Beam Simulations & Evaluation of Proton Plan
- Commissioning 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

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 TH Technical Components**
  James Hylen
  Thomas Kobilarcik, Deputy
- **1, 2.0.3.3 NuMI TH Infrastructure**
  Salman Tariq
- **1, 2.0.3.4 NuMI Decay Pipe, Hadron Absorber & Utilities**
  Karlton Williams

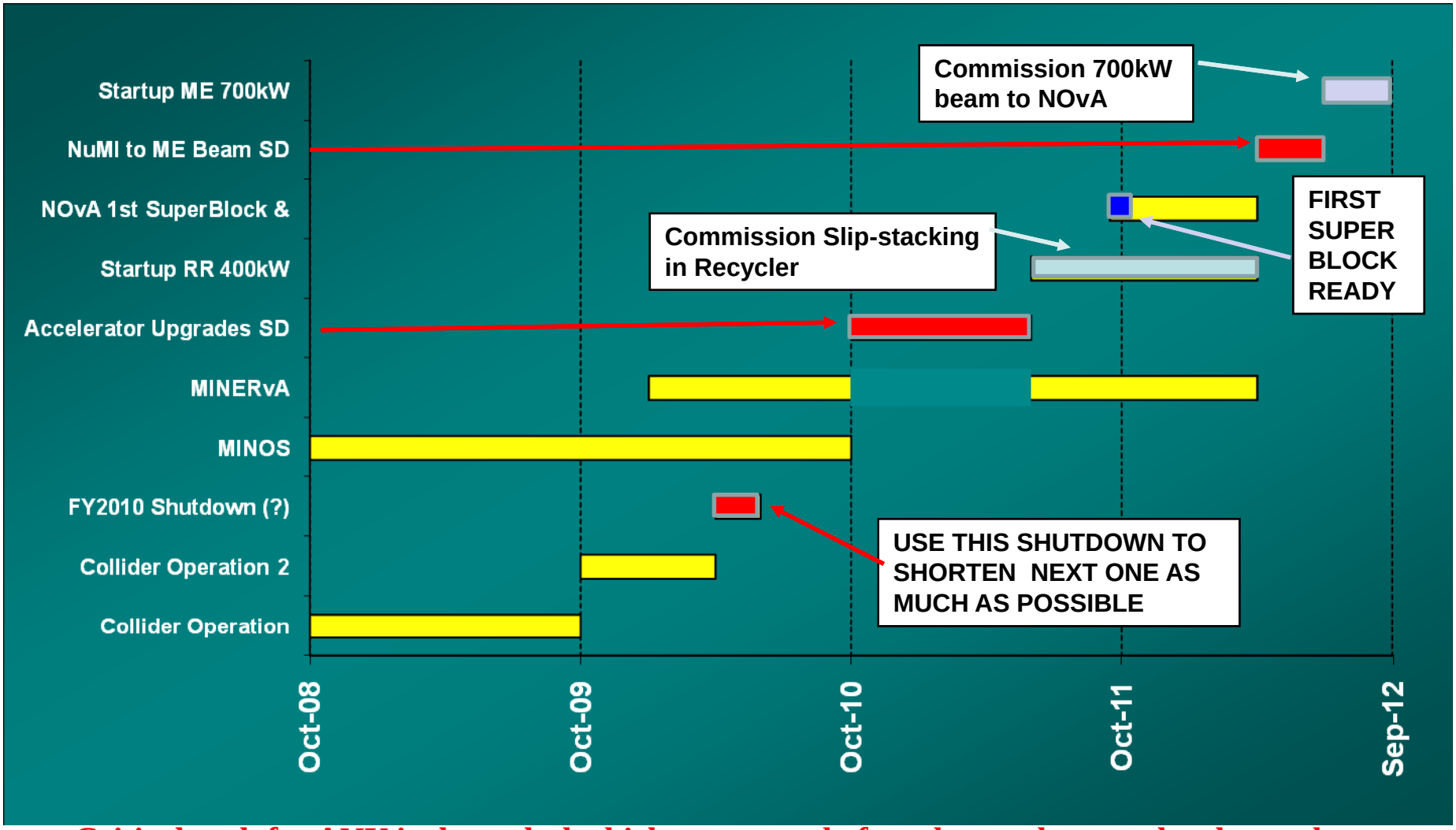
1.0.4 Beam Physics
Robert Zwaska

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

Shutdown Plan

- Accelerator Upgrades Shutdown, 8 months long, 10/1/10 to 6/1/11
  - MI modifications and installation of 2 additional RF cavities
  - RR modifications and installation of new injection & extraction lines
  - NuMI begins preparation for 700 kW
    - Upgrade Target Pile air cooling, RAW systems & Primary beam
    - Extend Stripline to medium energy (ME) location
    - Reconfigure shielding and install dummy horn module in medium energy location (allows quicker change to ME next shutdown)
- Commissioning of Recycler then NOvA first super block ready (fall 2011) with slip-stacking at 400kW (due to low energy target) for 3 months
- Several months of beam to NOvA before the..
- NuMI to ME Beam Shutdown, 3 months, 4/1/12 to 7/1/12
  - NuMI completes preparation for 700 kW
    - Horn 2 relocation
    - Replace low energy target with medium energy target

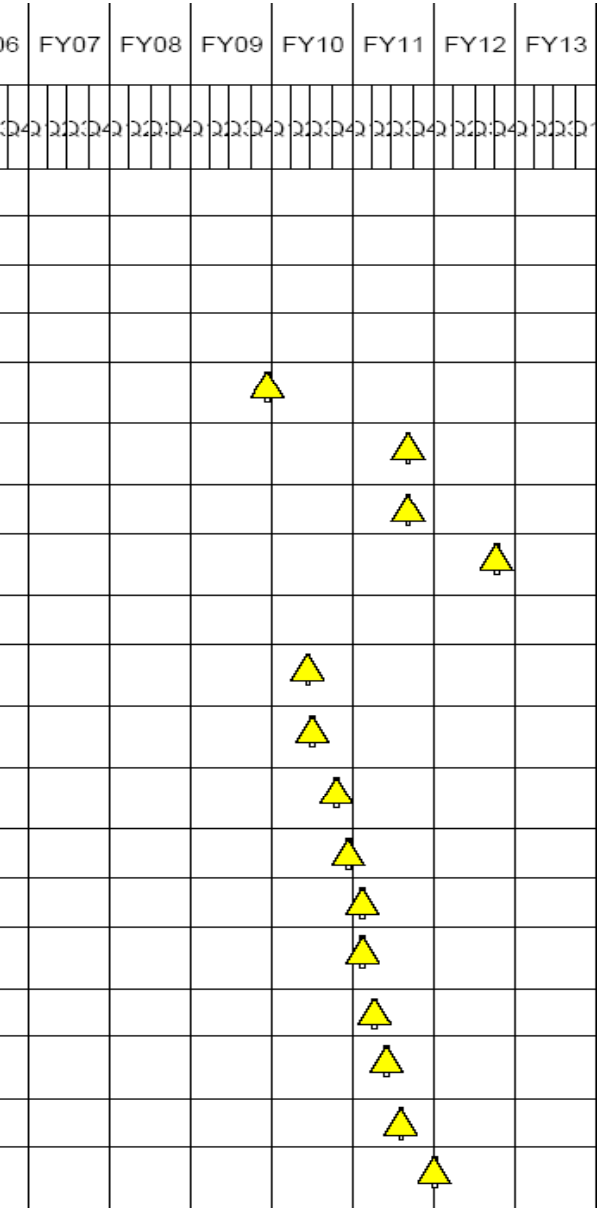
ANU Schedule Overview



Critical path for ANU is through the kicker systems before the accelerator shutdown, then moves to magnets that need to be removed, refurbished and re-installed, then to NuMI

ANU Milestones

Activity ID	Activity Desc.	Date	Milestone Tier
L.2 -- WBS L2 Manager's Milestone			
O -- Other Milestone			
T.2 -- DOE-FSO Milestone			
2.0.1.2.8.1	RR Ready to start Final Procurement for Kicker Magnets	02Sep09	T.2
2.0.4.3.14	MI Ring Modifications Ready for Beam Transport	26May11	T.2
2.0.4.3.15	RR Modifications Ready for Beam Transport	26May11	T.2
2.0.4.3.17	Ready to Commission Upgrades with Medium Energy Neutrino Beam	02Jul12	T.2
T.3 -- Fermilab Director or NOVA Management Milestone			
2.0.4.3.12	ANU Shielding Assessment Updates Complete	05Mar10	T.3
2.0.4.3.13	Ready for Shutdown to Install Accelerator Upgrades	31Mar10	T.3
2.0.3.3.4.1	NuMI Shielding Blocks, Dummy Module & Carriage Complete	09Jul10	T.3
2.0.3.3.4.3	NuMI Stripline Assembly Complete	30Aug10	T.3
2.0.2.1.4.1	MI Vertical Quad Bus Upgrade Complete	02Nov10	T.3
2.0.2.2.5.4	MI RF Cavities (2) Installation & Testing Complete	11Nov10	T.3
2.0.1.1.5.1	RR 53 Mhz RF Ready for Beam	04Jan11	T.3
2.0.3.1.5.2	NuMI Primary Beamline Ready for Faster Cycle Time	21Feb11	T.3
2.0.1.2.8.5	RR All Kicker Systems Ready for Beam	29Apr11	T.3
2.0.3.2.3.3	NuMI ME Target/Carrier/Baffle Assembly Complete	26Sep11	T.3



ANU Costs (Fully Burdened FY07$, breakout talk costs basis)

		ANU Cost Estimate $M (FY07$)									
		Estimated Cost (w/Indirects)			Contingency Estimate			Contingency %			Total
WBS	Name	M&S	Labor	Total	M&S	Labor	Total	M&S Cont %	Labor Cont %	Total	Project Cost
1	**ANU**	**$14.2**	**$26.1**	**$40.2**	**$4.6**	**$8.6**	**$13.1**	**37%**	**36%**	**36%**	**$53.4**
1.0	**ANU Planning, Engineering & Design**	**$1.6**	**$8.5**	**$10.1**	**$0.5**	**$3.2**	**$3.7**	**30%**	**39%**	**37%**	**$13.8**
1.0.1	Recycler Upgrades	$1.4	$4.4	$5.8	$0.4	$1.4	$1.8	27%	33%	31%	$7.6
1.0.2	Main Injector Upgrades	$0.1	$0.8	$0.9	$0.0	$0.2	$0.3	48%	26%	29%	$1.1
1.0.3	NuMI Upgrades	$0.1	$2.3	$2.4	$0.1	$1.3	$1.3	56%	56%	56%	$3.7
1.0.4	Beam Physics	$0.0	$0.0	$0.1	$0.0	$0.0	$0.0	40%	40%	40%	$0.1
1.0.5	Project Management	$0.0	$1.0	$1.0	$0.0	$0.3	$0.3	0%	30%	30%	$1.2
2.0	**ANU Construction**	**$12.5**	**$17.5**	**$30.0**	**$4.2**	**$5.5**	**$9.6**	**38%**	**34%**	**36%**	**$39.5**
2.0.1	Recycler Upgrades	$9.1	$8.6	$17.7	$2.9	$2.8	$5.7	36%	35%	35%	$23.0
2.0.2	Main Injector Upgrades	$1.0	$0.7	$1.6	$0.3	$0.2	$0.4	28%	23%	26%	$2.0
2.0.3	NuMI Upgrades	$2.5	$2.8	$5.3	$1.0	$1.2	$2.2	41%	43%	42%	$7.5
2.0.4	Project Management	-	$5.5	$5.5	-	$1.3	$1.3	-	30%	30%	$6.8

CD-3a Items for ANU

- For CD-3a, need "advanced technical design" at the 90 – 95% level
- Need to procure these items to keep the present labor force working and to minimize labor crunch in FY09 – for kickers it is the critical path.
- Costs include manpower for preparing reqs., receiving items and some assembly
- ANU CD-3a justification table on web page (NOvA-doc-2114)

	Cost Fully Burdened w/Cont. ($K)	Design Status
Magnet Tooling, Lambertson Magnet Parts, Injection Line PDD Magnet parts	$347	Design items relating to the M&S purchase is at least 90% complete
Kickers: Resistors, cables, parts for HV Pulsers, cooling skids, PFL frames and rebuilding some magnets	$2099	NOvA-doc-2114 for details
MI RF Cavity Ferrite Bias Supplies	$140	complete
NuMI PS regulation system parts	$71	complete

- Assume CD-3b by 4/1/08. If not, this list is longer.

Off Project Items from SNuMI

Upgrades to the Facility that one would do regardless of NOvA:

- Construction for MI14, MI39 and anode power supply room (MI-60) – GPP "MIINU"
  - Buildings can be used for other accelerator upgrades necessary to support increases in the number of protons to the NuMI target for a variety of potential users
  - Dixon Bogert is in charge of this GPP (MINU) and attends ANU Managers meetings, provides updates and thus interfacing well with NOvA
  - Milestones in the schedule (Off-Project MS) showing expected dates for Beneficial Occupancy of these Buildings
  - Breakout talk by Dixon Bogert: "MINU"
- NuMI Off- Project Items – "NuMI Upgrades & Operations" – Mike Martens Manager
  - Improve component lifetime
  - Reduce radiation doses to personnel/environment
  - Improve remote repair capabilities
  - Allow for long term operation of the NuMI Beamline:
    - Requiring space for spent components, improving component design
  - Off-project MS in the schedule coordinate with NOvA upgrades
  - Breakout talk by Mike Martens: "NuMI Upgrades & Operations"

Prepared ANU Breakouts

(NOVA-doc-number at end)

Overview talks (L3 Managers):

- 1.0, 2.0: ANU Cost, Schedule, Management Details (Nancy Grossman) 2129
- 1.0.1, 2.0.1: Recycler Upgrades Overview (Paul Derwent) 2043
- 1.0.2, 2.0.2: Main Injector Upgrades Overview (Ioanis Kourbanis) – includes slip stacking successes in MI 2112
- 1.0.3, 2.0.3: NuMI Upgrades Overview (Mike Martens) 2054
- 1.0.4: Beam Physics Overview (Bob Zwaska) 2053

Prepared ANU Breakouts

(NOVA-doc-number at end)

Technical Talks:

- Kicker Systems (Chris Jensen) 2029
- Transfer Lines Design (Daniel Broemmelsiek) 2076
- NuMI Radiation Issues (Kamran Vaziri) 2055
- NuMI Infrastructure (Salman Tariq) 2049
  - ANU Target Hall Infrastructure Overview & Cost
  - Horn 1 Alignment Offsets
  - Horn 2 Relocation to ME – Shielding Reconfiguration
  - Horn 2 Relocation to ME – Stripline Extension
  - Target Chase Air Cooling
- Overall Cooling Needs (Karl Williams) 2000
- Related off-project items:
  - MINU GPP (Dixon Bogert) 2121
  - NuMI Upgrades & Operations (Mike Martens) 2139

Costs: Basis of Estimates (BOEs)

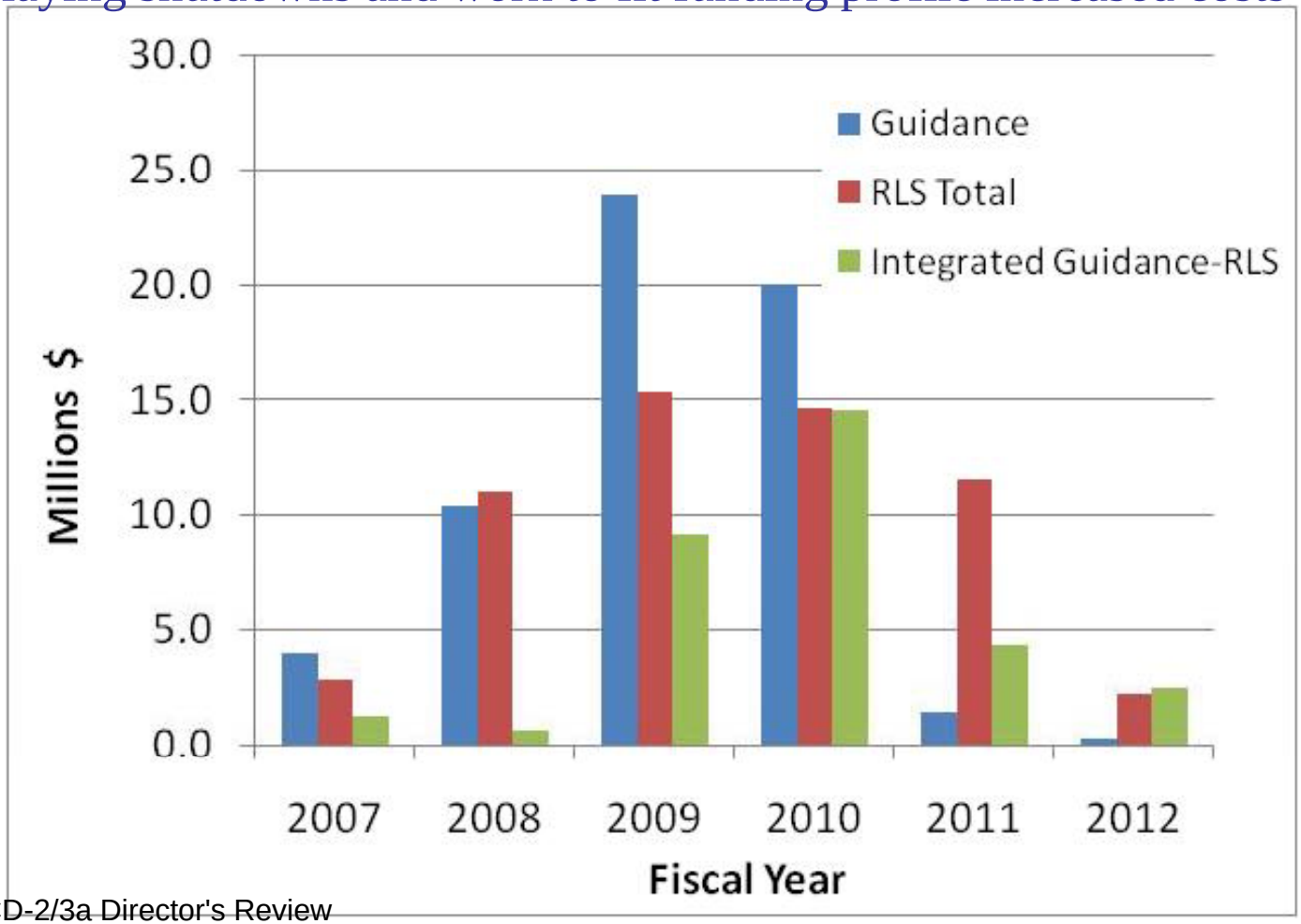
- Fiscal Year 2007 dollars are the baseline – used in BOEs
- BOEs are referenced by docdb # (in the resource loaded schedule) and Unique ID (UID)
  - Needed to write BOEs before the WBS structure was set
- Labor efficiency is assumed to be 85% (folded into the duration) unless otherwise explained.
- Similar tasks or tasks that make up an overall process are covered in one BOE
  - Thus one BOE often covers many tasks and both M&S and Labor if appropriate
- 85% achievable duration: Makes a 3-point estimate of the 85% confidence level duration for tasks unless know from experience 85% confidence duration

- Work is not new concepts, but is based on existing equipment/designs and thus costs are based on extrapolating from previous experiences.

ANU Obligations Profile

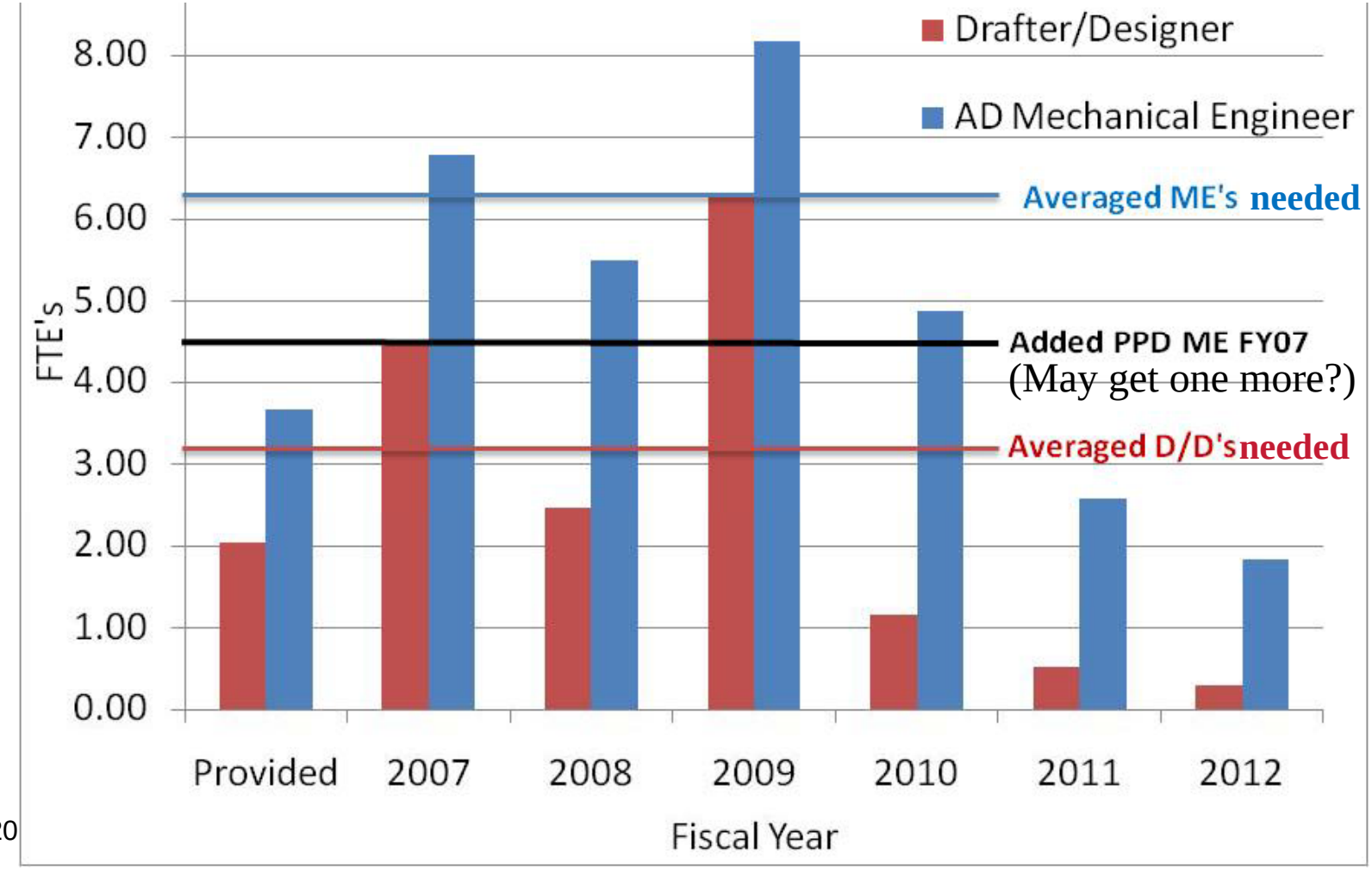
(fully burdened as year dollars with contingency)

- Guidance from John Cooper to optimize detector/beam schedule
- Overall cost $58M
- Delaying shutdowns and work to fit funding profile increased costs



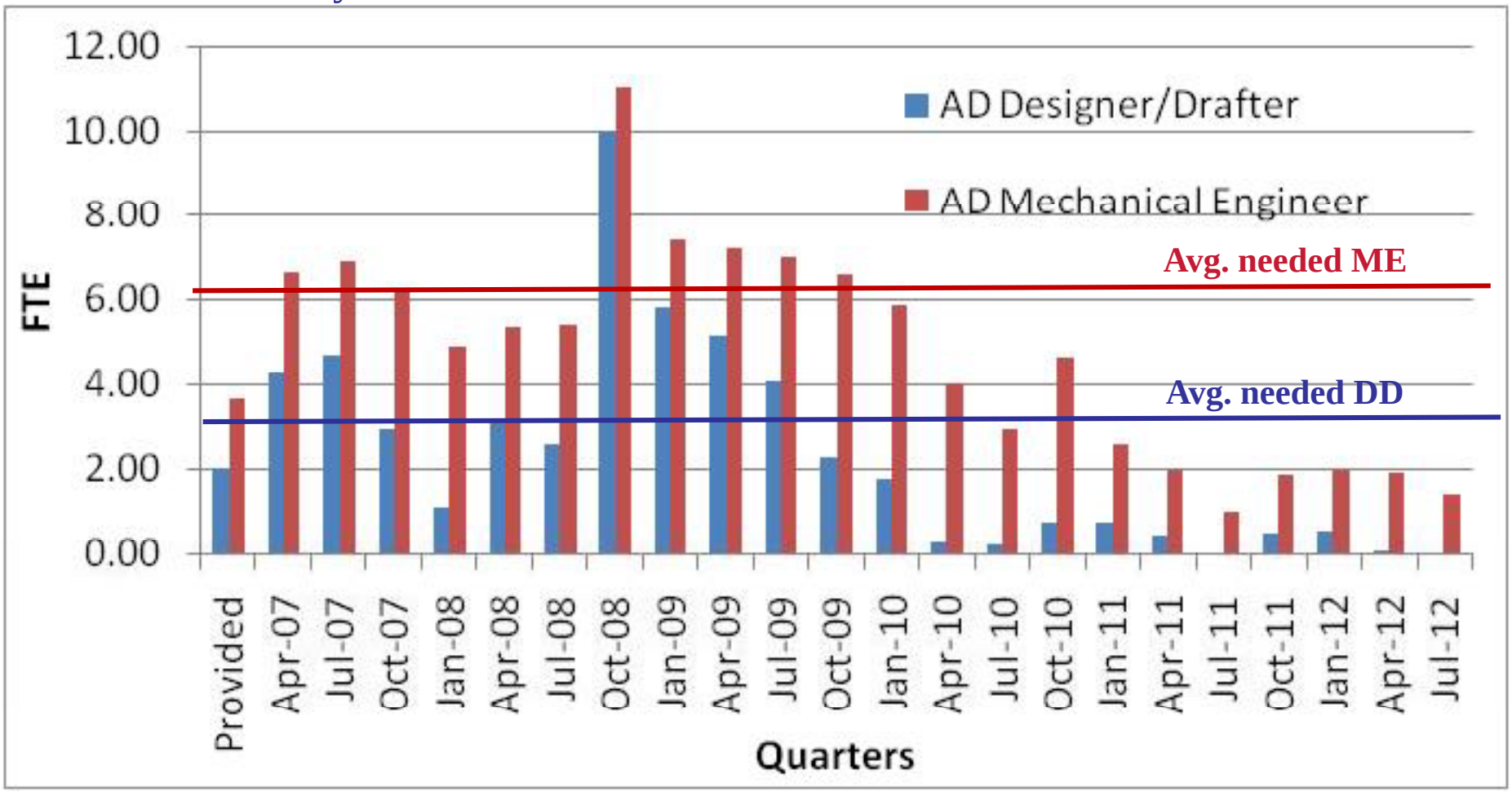
Mechanical Engineers and Drafting

- Mechanical Engineering/Drafting is tight, need to start work on construction in early FY08 in order to keep resources
- Efficiency in FY07 has been higher than expected, so perhaps not as bad as it looks

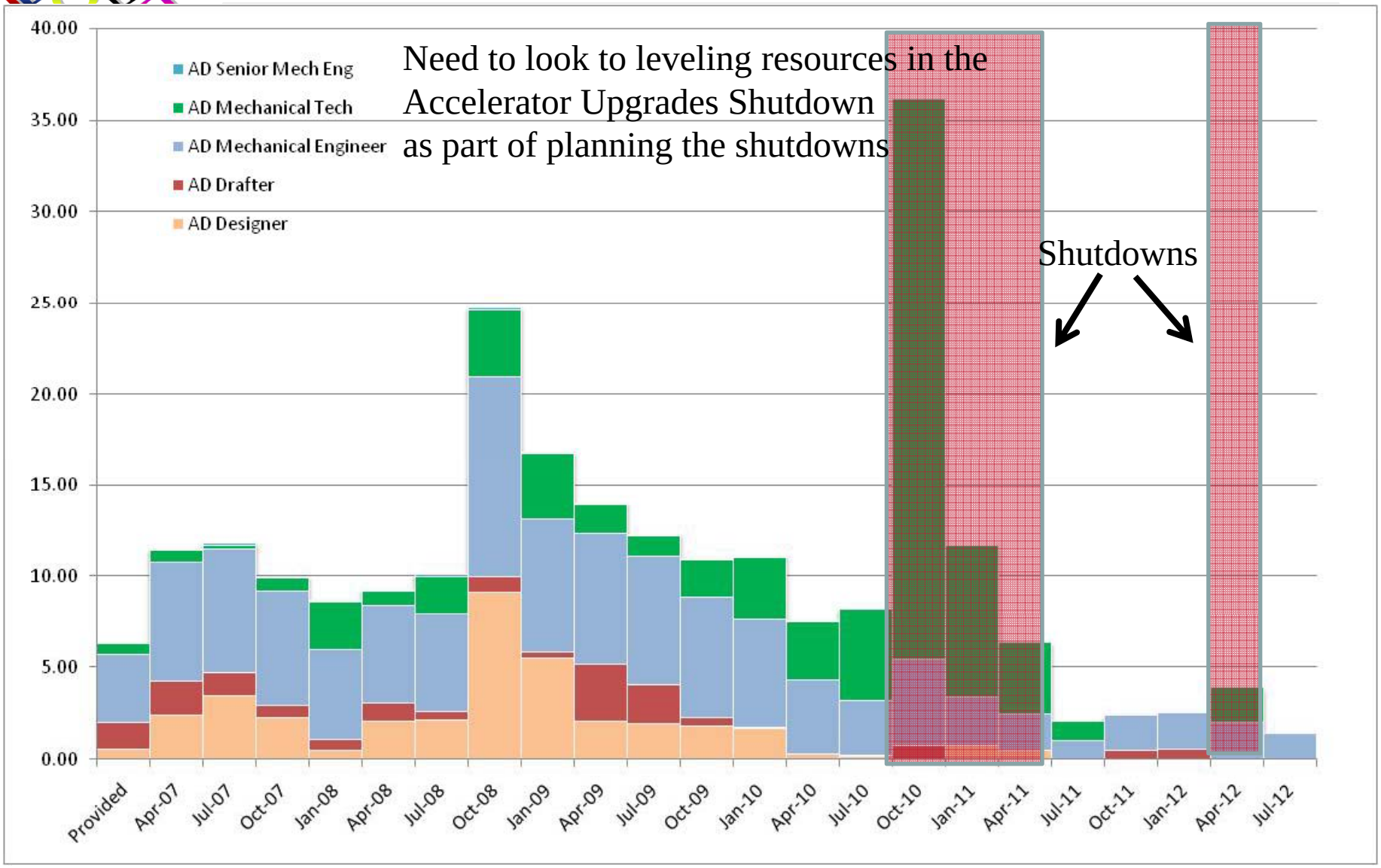


Mechanical Engineers and Drafting

- Low funding in FY08 makes ramp up hard for FY09.
- Need to delay more from Oct. 08 to later in FY08.



Resources – Add Mech. Techs

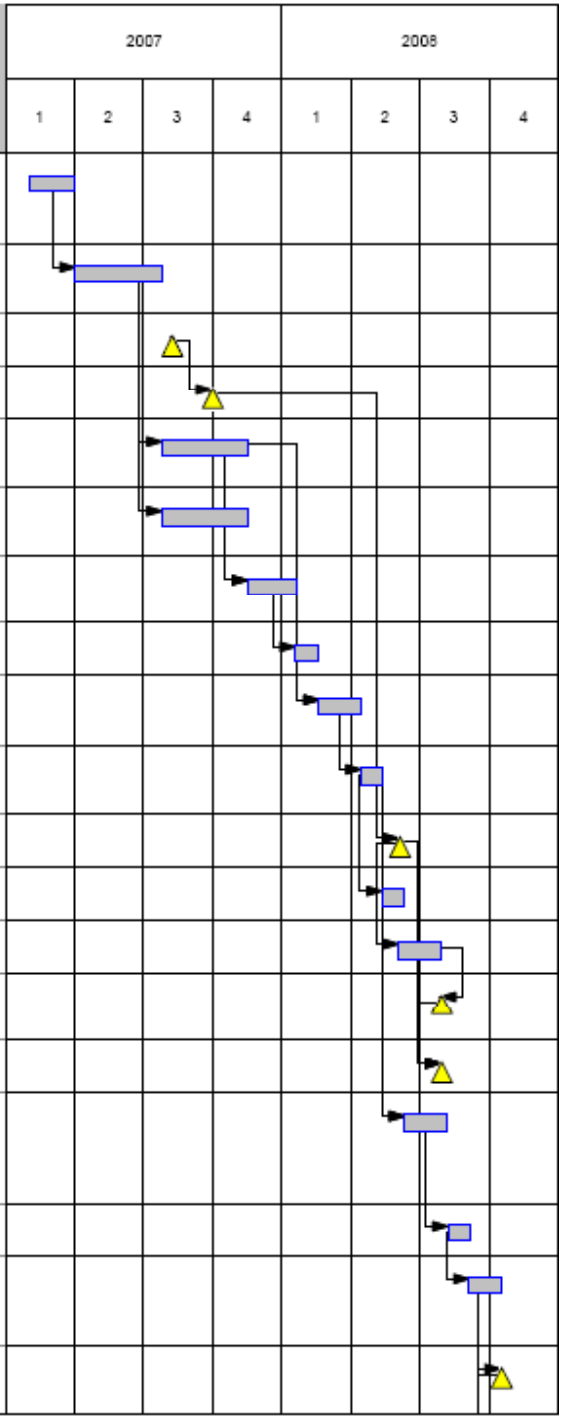


ANU Critical Path

Initially:

- RR Injection Line Prototype Kicker
- For 2008 shutdown, it is the MI RF Cavities Bus Bar work
- Then…..

Activity ID	Uniq	Activity Desc.	Dur	Early Dates	Float
1.0.1.2.1.1.1	862	Design Prototype RR Injection & Cleanup Kicker Magnets - Preliminary	40d	01Feb07 28Mar07	3d
1.0.1.2.1.1.2	3038	Design Prototype RR Injection & Cleanup Kicker Magnets	80d	02Apr07 24Jul07	1d
2.0.4.1.1	2629	2007 Shutdown Begun	0	06Aug07 06Aug07	5d
2.0.4.1.2	2630	2007 Shutdown Complete	0	28Sep07 28Sep07	5d
1.0.1.2.1.2.5	1005	Procure Tooling for Magnet Potting & Measurement	80d	25Jul07 14Nov07	1d
1.0.1.2.1.2.6	1006	Procure parts & Fluorinert for prototype magnets	80d	25Jul07 14Nov07	1d
1.0.1.2.1.3.2	1010	Assemble 1st Design prototype magnet & Existing Ceramic	40d	15Nov07 17Jan08	1d
1.0.1.2.1.3.5	1012	Low voltage testing 1a of Prototype Magnet	20d	18Jan08 15Feb08	1d
1.0.1.2.1.3.7	1014	Assemble 1st Design Prototype Magnet with 2nd ferrite	40d	18Feb08 11Apr08	1d
1.0.1.2.1.3.8	1015	Repeat low voltage & high voltage test of Proto Mag	20d	14Apr08 09May08	1d
2.0.4.1.3	2631	2008 Shutdown Begun	0	02Jun08 02Jun08	-1d
1.0.1.2.1.3.6	1013	High voltage testing of Prototype Magnets	20d	12May08 09Jun08	1d
2.0.2.2.1.2	2459	MI RF Cavities Bus Bar Fab & Install	40d	02Jun08 28Jul08	-1d
2.0.2.2.5.1	2460	MI RF Cavities Bus Bar Fabrication & Installation Complete	0	28Jul08 28Jul08	-1d
2.0.4.1.4	2632	2008 Shutdown Complete	0	28Jul08 28Jul08	-1d
1.0.1.2.1.1.6	877	Revise RR Inject & Gap Clearing Prototype Magnet Design & Fab Revised Parts (After 3rd Test)	40d	10Jun08 05Aug08	1d
1.0.1.2.1.3.11	1018	Pot prototype magnet	20d	06Aug08 03Sep08	1d
1.0.1.2.1.3.12	1019	Repeat low voltage 4a & high voltage 4b testing of Prototype Magnet	30d	04Sep08 15Oct08	1d
1.0.1.2.7.5	1439	RR Injection Line Prototype Kicker Complete	0	15Oct08 15Oct08	1d



Activity ID	Uniq	Activity Desc.	Dur	Early Dates	Float
1.0.1.2.1.1.7	878	Revise RR Inject & Gap Clearing Magnet Design for Production & Choose Ferrite (After 4th Test)	20d	16Oct08 12Nov08	1d
1.0.1.2.6.4	1168	Review Final Design of RR Inject Line Kicker Magnet	1d	13Nov08 13Nov08	1d
1.0.1.2.7.6	1078	RR Ferrite Procurement or Re-design Finalized	0	13Nov08 13Nov08	1d
2.0.1.2.1.1.1	2319	RR Inject & Gap Clearing Prod Kicker Prep Req & Award PO for All Magnet Ferrites (Sole Source)	20d	14Nov08 15Dec08	1d
2.0.1.2.1.1.2	2320	RR Inject & Gap Clearing Prod Kicker Receive Ferrites for All Magnets	20d	12May09 09Jun09	1d
2.0.1.2.1.2.2	2331	Assemble 2 Pre-production Magnets & Loads	40d	10Jun09 05Aug09	1d
2.0.1.2.1.2.3	2332	Low voltage testing of 2 Pre-production Magnets	20d	06Aug09 02Sep09	1d
2.0.1.2.1.2.4	2333	HV Testing of 2 Pre-production Magnets	20d	03Sep09 01Oct09	1d
2.0.1.2.2.1.1	2341	Prep Req & Award PO for Parts for 12 Other Power Supply Controls	40d	02Oct09 30Nov09	1d
2.0.1.2.2.1.2	2342	Receive Parts for 12 Other Power Supply Controls	21d	01Feb10 01Mar10	1d
2.0.4.1.5	2633	Accelerator Shutdown Begun	0	01Oct10 01Oct10	0
1.0.1.1.2.2.2.1	2270	Recycler - Remove all 38 Quads from Q301-Q308 & Ship to TD for Refurbishing	30d	01Oct10 11Nov10	2d
1.0.1.1.1.2	480	Remove Ecool Magnets & Devices	20d	12Nov10 13Dec10	2d
1.0.1.1.2.2.3.7	3066	RR-30 SS Installation Stakeout	12d	14Dec10 03Jan11	2d
2.0.1.2.2.2.2	2353	RR Injection & Gap Clearing PS Assemble Controls Modules & Racks for 8 Pulsers & 4 Bumpers	215d	02Mar10 06Jan11	1d
2.0.1.1.1.14.15	2307	Install RR-30 SS Magnets (incl pre-align)	50d	04Jan11 15Mar11	2d
2.0.1.1.1.14.16	3050	Install RR-30 SS Instrumentation	12d	16Mar11 31Mar11	2d
2.0.1.2.2.3	2357	RR Injection & Gap Clearing Checkout Pulsers into Dummy Load in SB	80d	07Jan11 29Apr11	1d

2007 2008 2009 2010 20

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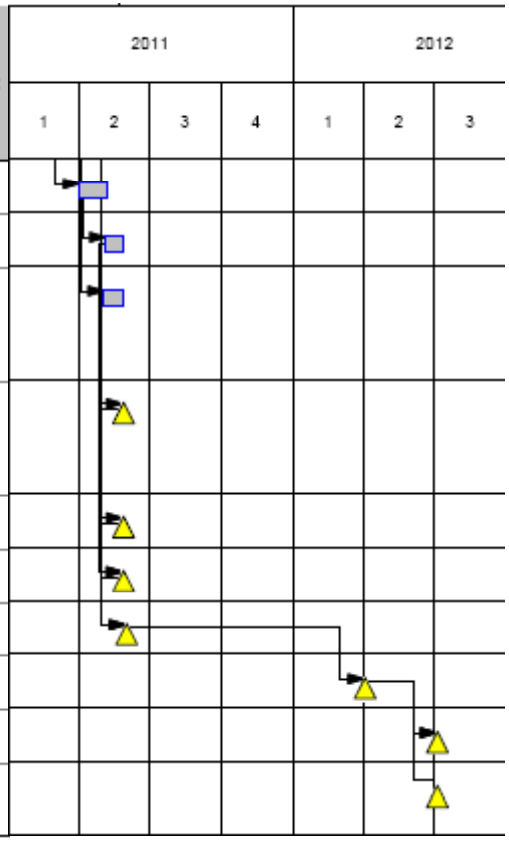
Continues through:

- RR Injection Line Prototype Kicker
- For Accelerator Upgrades shutdown, it is the magnet refurbishing & RR Injection and Gap clearing kickers
- Then…..

ANU Critical Path

ANU Critical Path

Activity ID	Uniq	Activity Desc.	Dur	Early Dates	Float
2.0.1.1.1.14.20	2288	Install RR-30 SS Vacuum	24d	01Apr11 04May11	2d
1.0.1.1.2.2.5.3	2868	RR30 Final Alignment	16d	05May11 26May11	2d
2.0.1.2.2.4	2358	RR Injection & Gap Clearing Install Magnets & Fluorinert Piping In Tunnel & Checkout 2 Systems	20d	02May11 27May11	1d
2.0.1.2.8.4	2359	RR Injection & Gap Clearing Magnets & Fluorinert Piping In Tunnel Checkout Complete	0	27May11 27May11	1d
2.0.1.2.8.5	3165	RR All Kicker Systems Ready for Beam	0	27May11 27May11	1d
2.0.4.3.15	2441	RR Modifications Ready for Beam Transport	0	27May11 27May11	1d
2.0.4.1.6	2634	Accelerator Shutdown Complete	0	31May11 31May11	0
2.0.4.1.7	2635	NuMI Upgrades Shutdown Begun	0	02Apr12 02Apr12	0
2.0.4.1.8	2636	NuMI Upgrades Shutdown Complete	0	02Jul12 02Jul12	0
2.0.4.4.2.11	1533	Off-Project: Work Cell & Equipment Ready for ANU Operation	0	02Jul12 02Jul12	0



Continues through:

- RR Injection Line and Gap clearing kickers
- Then onto NuMI

What is left to do for DOE Review

- Things not done for this review (will change cost/schedule):
  - More resource leveling during shutdowns and FY2009 (minimal effect of costs)
  - Critical path needs to be looked at more closely – especially for NuMI for the second shutdown (Fixed shutdowns do strange things to float)
  - A few value engineering items that should be determined in time to perhaps incorporate them into the resource loaded schedule before the DOE review.
- Things not done (shouldn't change cost/schedule):
  - Check that we have all the necessary design reviews included

Summary

- Accelerator and NuMI Upgrades (ANU) subproject relies on reconfiguration of existing machines
  - Technically achievable, reuses as much as possible existing components, designs and processes
- Overall Cost $40 M (FY07$, fully burdened, no contingency)
- Average contingency 36%
- Schedule
  - Present schedule best matches experimental needs, including schedule contingency for the delay of the shutdown of the Tevatron
  - Allows for commissioning of the recycler with slip-stacking several months before the first NOvA superblock.
- CD-3a items are listed in with cost and risk on the web page, main ones:
  - Various parts for kicker systems $2.1M
  - Parts to start magnet work in Technical Division while labor is available
  - Assumes CD-3b 4/1/08, otherwise there are many more tasks with less complete designs as design work continues on these tasks.