



# Accelerator & NuMI Upgrades Update

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(updates in **red**)

20 Nov 2012



# The Plan: Installation Shutdown

## May 2012

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- ~1 year to change over to new mode of operations: from pbar ring to proton accumulator
  - Removing all pbar hardware
    - About 100 magnets, 8 cooling tanks, 2 beamlines, diagnostics for storage rings
  - Installing more than 150 magnets (dipoles, quads, trims, kickers, lambertsons)
  - Pulling a lot of cable (including 300,000 ft of 3/8" heliax for the Beam Position Monitors)
  - 5 RF cavities (2 to MI, 3 to RR)
  - Opening 11 RR vacuum sectors – all of which require baking to recover  $10^{-10}$  vacuum level
  - Alignment of new components and areas where components are removed
  - 1 target carrier, 1 new horn
  - Moving Horn 2 and rearranging the shielding
- Lots of people and equipment traffic!
  - 40+ technicians and engineering staff
  - 40+ trades (pipefitters, riggers, electricians)
  - 1 equipment access point to the Main Injector Tunnel, 1 access point to NuMI Target Hall



# Recycler and MI Tunnel Work

- Decommissioned and removed all pbar equipment: stochastic cooling, electron cooling, A1 line extraction system.
- Installed and aligned injection line magnets and instrumentation, including kicker magnets and lambertson
- Installed and aligned gap clearing and abort kicker magnets
- Installed and aligned specialty instrumentation
- **Installed 2 additional Main Injector RF cavities**
- Pulled more than 700,000 feet of cable, nearing completion
  - Beam Position Monitors
  - Multiwires
  - Magnets
  - Vacuum components
  - Kickers**
  - RF**
- Completed magnet replacement for the NuMI transfer line
  - **Removal / installation on the sloped transfer line**



# Recycler and MI Tunnel Work

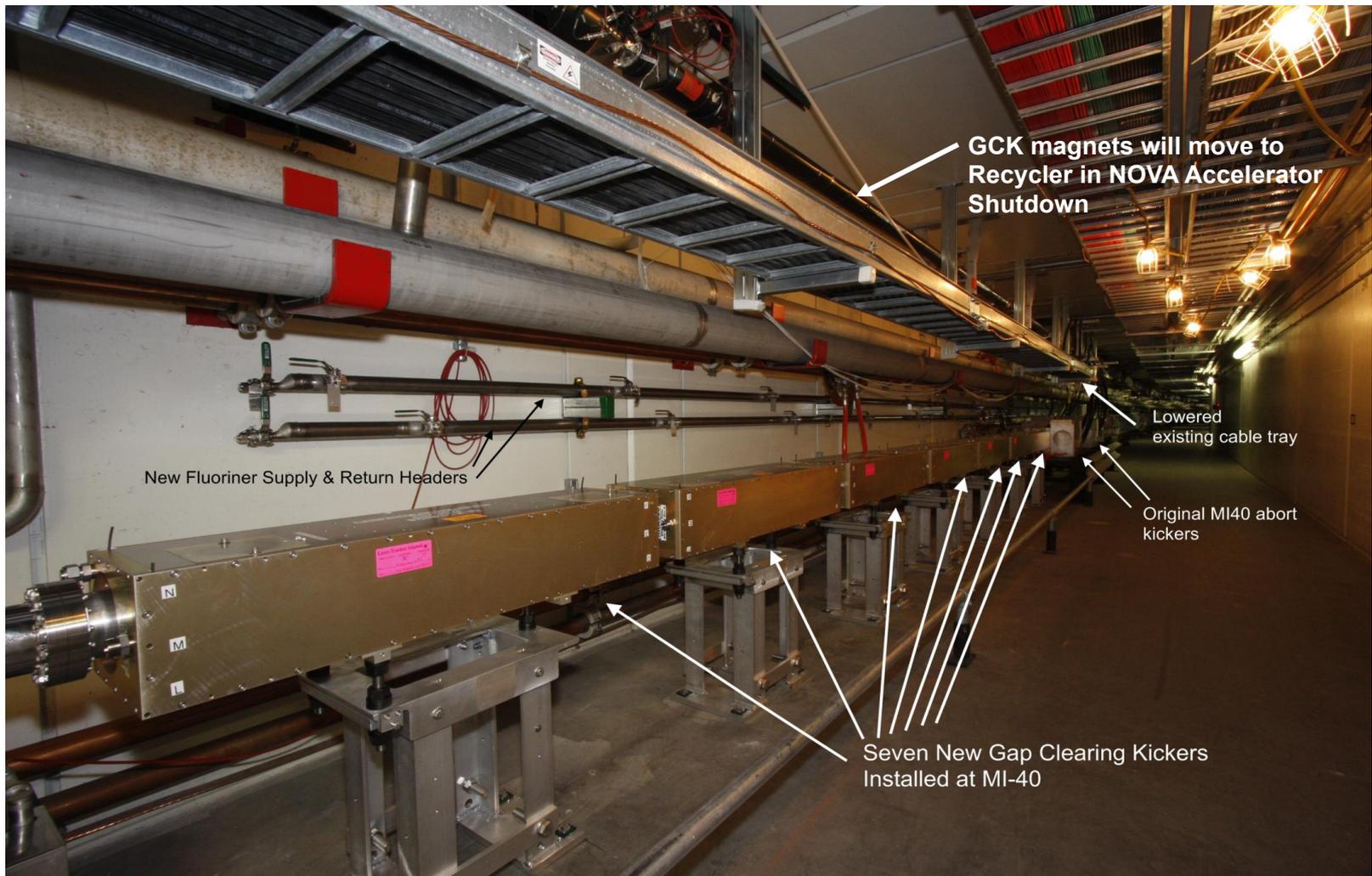
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- Installed 50% of the gradient magnet end shims, designed to change the base tune and chromaticity of the Recycler to address longitudinal stability during slip stacking
- Recovered 7 (of 11 vacuum sectors to be opened) in the Recycler to  $10^{-10}$  level
- Preparing for R30 and Extraction line work
  - High Radiation areas, taking all the lessons learned on installation from the injection line to this area
  - Relocated radiation sensitive devices to cooler areas in the ring
  - Had an Internal Readiness Review Oct 1, addressing recommendations
  - Added ~20 tons of lead shielding around this area, dropping radiation levels by factors of 2-10, goal of <20 mR/hr so that we can work in the area!
- Repair and maintenance work on MI RF, P1 line, MI 52 extraction area (support slow spill – SeaQuest)
- MI Shielding Assessment approved -- areas where need additional shielding identified and mitigations underway (dominated by additional shielding around penetrations for power and water)



# AIP work – Gap Clearing Kickers

- 7 magnets installed during 2009 shutdown





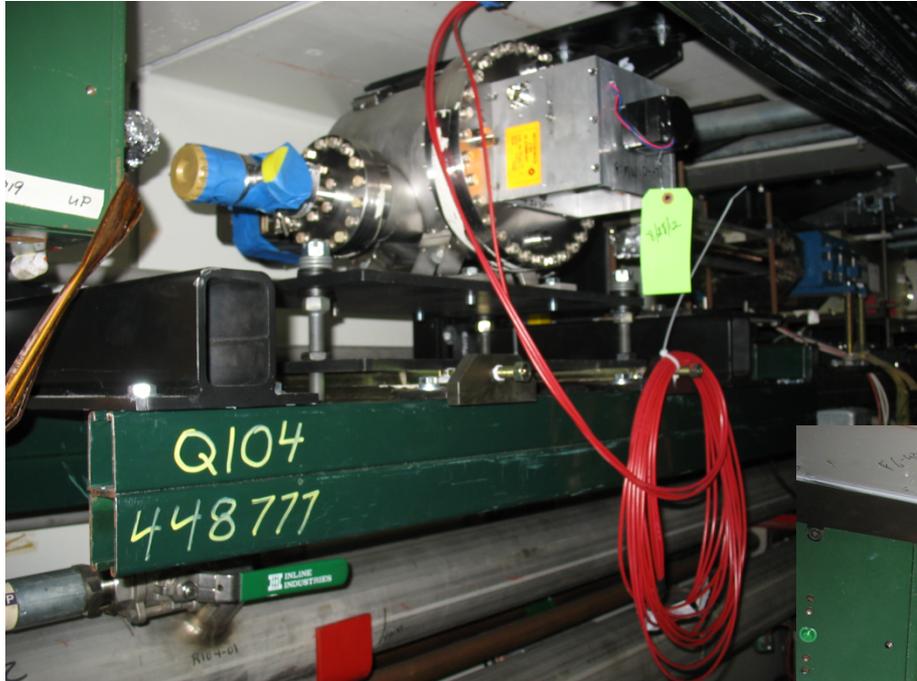
# MI 40 Vacuum Reconstruction

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# Multiwire Installations





# ANU Critical Path items: **In August**

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- Lambertson magnets: 1 delivered, 1 completed magnet measurements
  - Installation scheduled in August (Injection line) and December (Extraction line)
- Remaining kickers are in fabrication
  - 5 of 6 (4 + 2 spares) short full turn magnets complete (with beam tubes!) and in power testing, installation scheduled in September
  - Long full turn magnets to follow (all parts in hand), installation scheduled in December
- Beam pipe (316L stainless, seamless 4" OD)
  - Had a difficult time finding it in quantity (in April had vendor cancel order)
  - US vendors but Chinese mills
  - Beam pipe now at polishing vendors (for vacuum specifications)
  - Impacts “complete injection line installation” (impacts progress reports as tasks defined with PMT type E 50-50: 50% when start, 50% when complete)
- RF cavities:
  - 1<sup>st</sup> cavity has outer loops, finishing final water manifolds, testing in August
  - 2<sup>nd</sup> cavity had major vacuum welds in June, need to complete vacuum ports, then start on cooling hoops
  - 3<sup>rd</sup> cavity at the e-beam welder in August

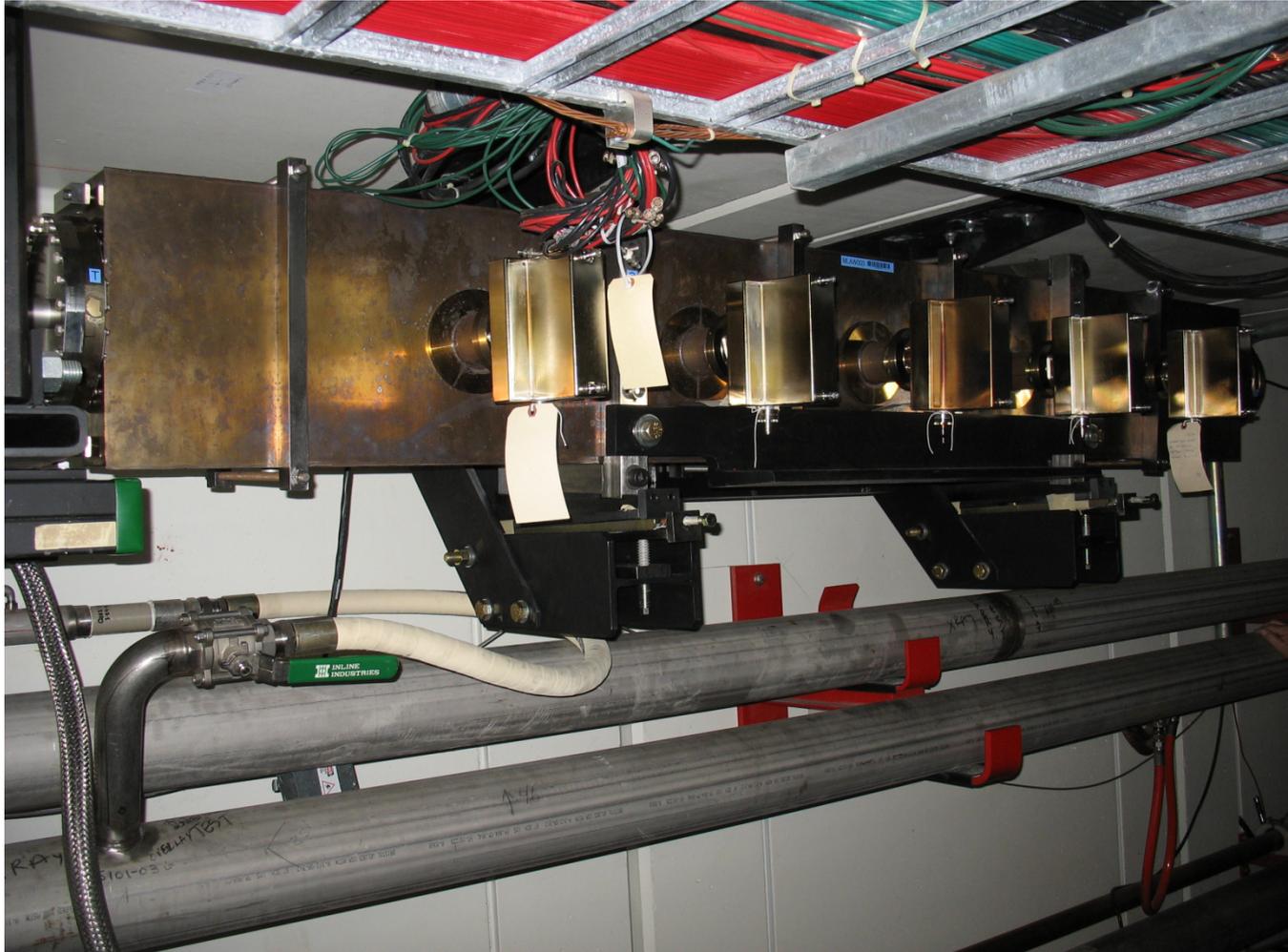


# ANU Critical Path items: **In November**

- Lambertson magnets: 1 delivered, 1 completed magnet measurements
  - Installation scheduled in **Complete** August (Injection line) and December (Extraction line)
- Remaining kickers are in fabrication
  - 5 of 6 (4 + 2 spares) short full turn magnets **Complete: installed (see** in power testing, installation scheduled in September **slide 6)**
  - Long full turn magnets to follow (all parts in hand) installation scheduled in December **2 complete, 2 anticipated by end of November**
- Beam pipe (316L stainless, seamless 4" OD)
  - Had a difficult time finding it in quantity (in April had vendor cancel order)
  - US vendors but Chinese mills **In progress, impact start of R30 work,**
  - Beam pipe now at polishing vendor: **completion of Injection line work**
  - Impacts “complete injection line installation” (impacts progress reports as tasks defined with PMT type E 50-50: 50% when start, 50% when complete)
- RF cavities:
  - 1<sup>st</sup> cavity has outer loops, finishing final water manifold **Complete in testing**
  - 2<sup>nd</sup> cavity had major vacuum welds in June, need to complete vacuum ports, then start on cooling hoops **Complete: inner hoops and manifolds,**
  - 3<sup>rd</sup> cavity at the e-beam welder in Australia **outer hoops**  
**Manifolds by end of November**



# Injection Lambertson





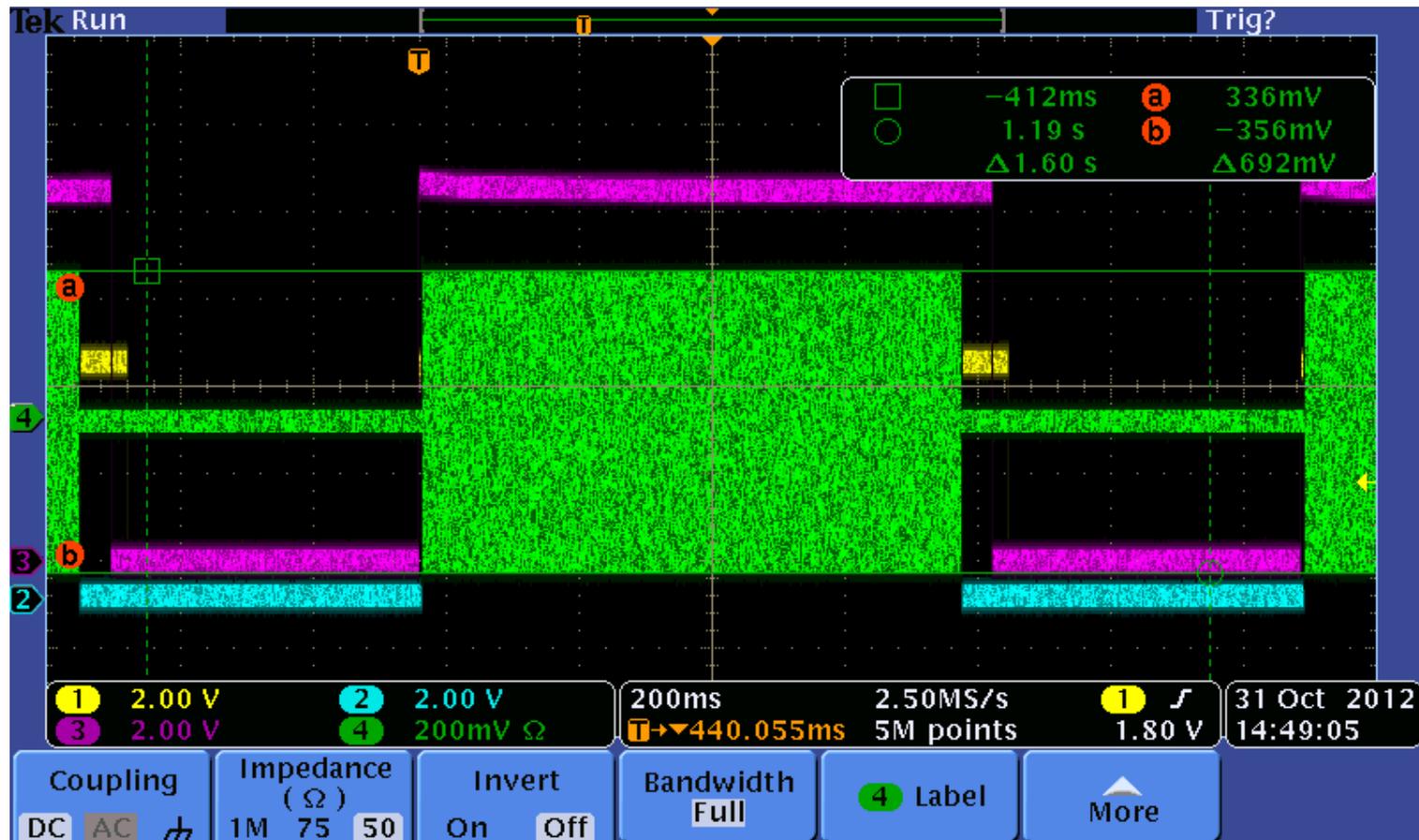
# 1<sup>st</sup> Cavity Complete





# Cavity 1 RF Testing

- Specifications: 150 kV(peak), 125 kV (operating), 60% duty factor,  $\pm 10$  kHz range



- 150 kV, 1% duty factor
- 122 kV, 60% duty factor (800 msec, 1.33 sec cycle): operational cycle



# NuMI Target Hall Work

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- Horn 2 move complete: complicated rearrangement of equipment in a confined, radioactive space
  - Shielding
  - Water
  - Power
- Water upgrades to support higher power complete by end of November
  - Completed Target, Horn 1, and Horn 2 radioactive water systems
- Target and baffle mounted on carrier/module, ready for installation
- Horn 1 (supported off project but necessary for experimental success):
  - completed 100,000 pulses at NOvA repetition rate (0.75 Hz)
  - Undergoing vibrational measurements this week
  - Attach water collection lines and ready for installation in January
- Air handling upgrades for dehumidification and target chase cooling on schedule



# Installation of DI Casks



20 ton steel cask  
4 DI bottles/cask  
5 casks: Target, Horn 1,  
Horn 2, Absorber, Spare  
Target cask ~ 2 years

Reduced pictures to 1 slide



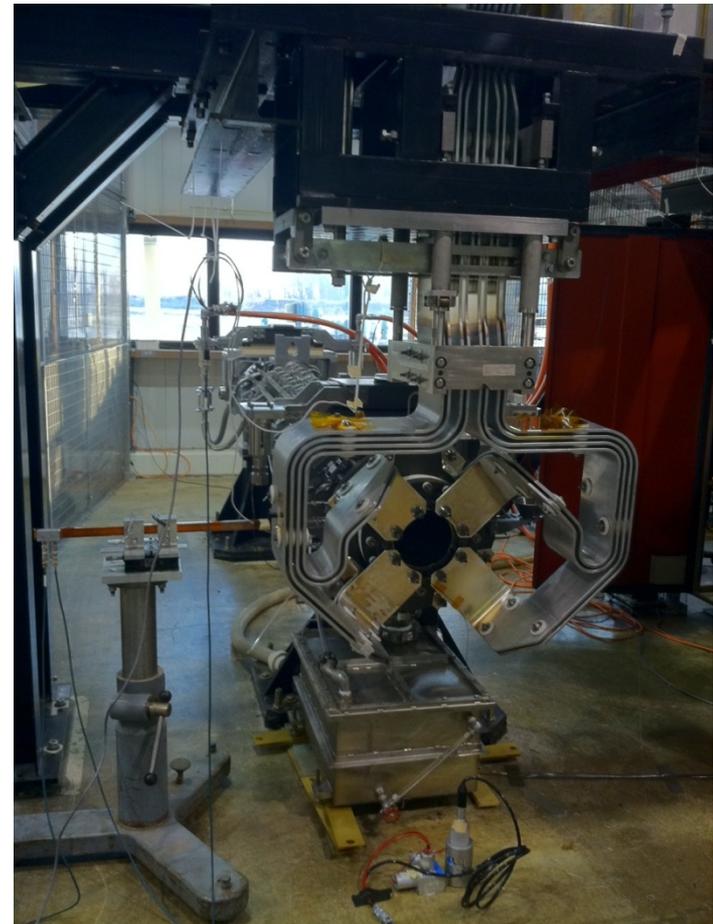


# NoVA Target & Horn 1

Target and baffle mounted on carrier



Horn 1 in the test stand



New slide



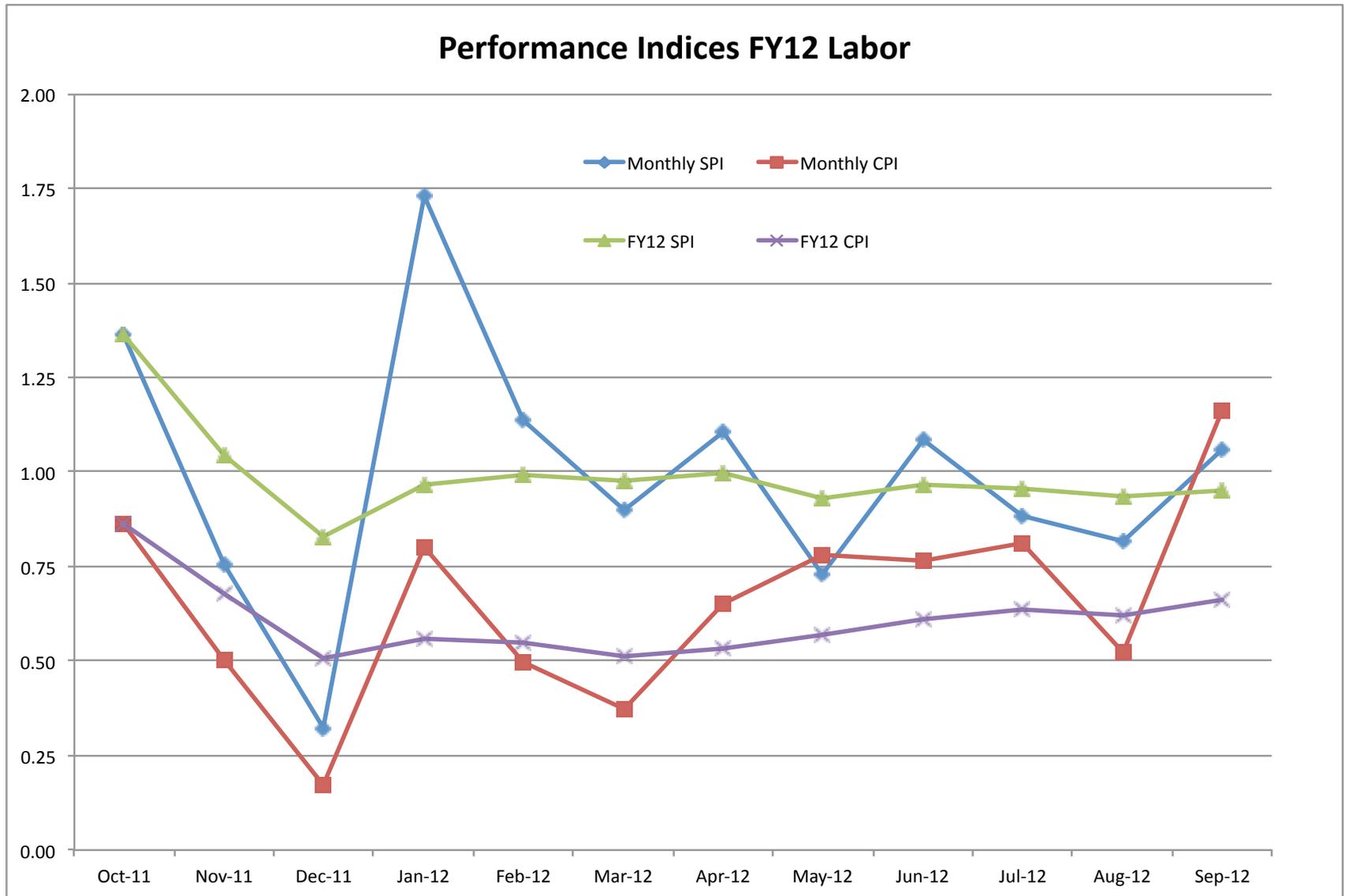
# ANU Costs

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- ANU continues to have a negative cost variance
  - In many places we underestimated the necessary labor to complete the tasks
  - Additional labor was approximately covered by the estimated assigned labor contingency
  - RF cavities are an exception where major technical problems contributed to a significant cost variance
  - Changes in staffing over the past year have affected our ability to get work done efficiently
    - Rearrange the tunnel and upstairs work force to make best use of skill set
    - Impacts cost and schedule: train workers for different jobs
    - Down ~10 FTE mechanical technicians from the August staffing levels
- Keeping up with the schedule, but it is taking more labor than anticipated



# Labor performance metrics





# ANU Costs

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- At direction of project manager, in April increased labor budget for May-July time period by 15% and reduced labor contingency by 15% (CR487 \$748K) , based on cumulative labor CPI ~0.85 at the time
  - Visible change but not enough
- At direction of project manager, doubled labor for most future tasks starting as of September 2012 (CR573 \$1.33M). Based on 60% CPI for FY12 as of August.
  - Did not include R30 and Extraction line work:
    - Readiness review: October 1<sup>st</sup>
    - Addressing recommendations, anticipate work starting in January
  - Did not include RF installation: reviewed and well defined installation task



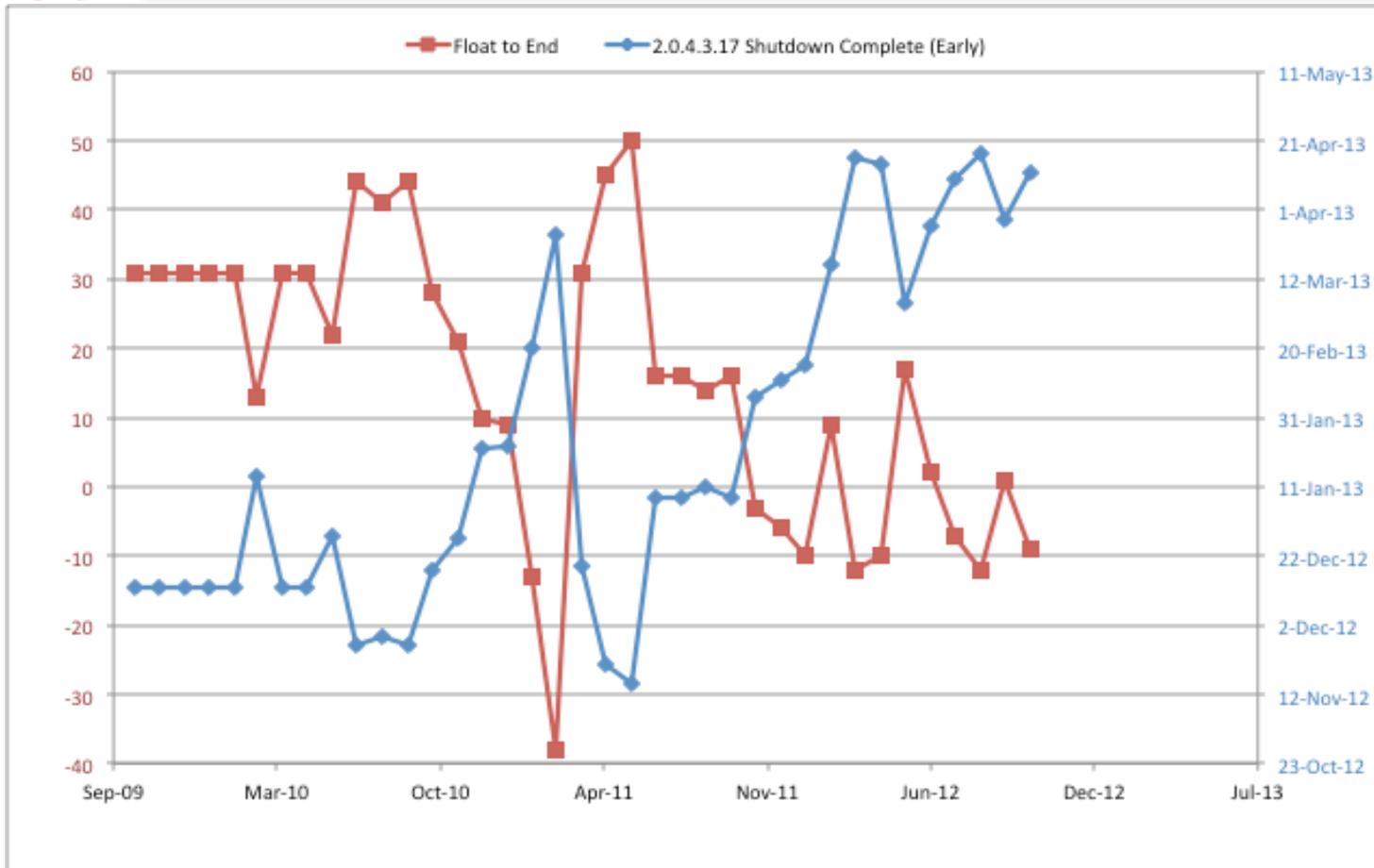
# Summary

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- Shutdown proceeding:
  - Major items:
    - R30 and Extraction line installation: **January 2013**
    - RF Installation: **February 2013**
    - Target and Horn 1 Installation: January 2013
  - Anticipate completion **nearly on schedule: but no margin for error**
- Laboratory providing necessary resources to stay on schedule
- ANU Critical path items still kickers / RF cavities / beam pipe



# Shutdown float



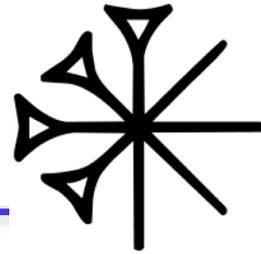
- September Status: 1 day of float to end of shutdown: Friday March 29
- Estimate for October Status: -9 days of float: Friday April 12



# Backups



# Context of ANU

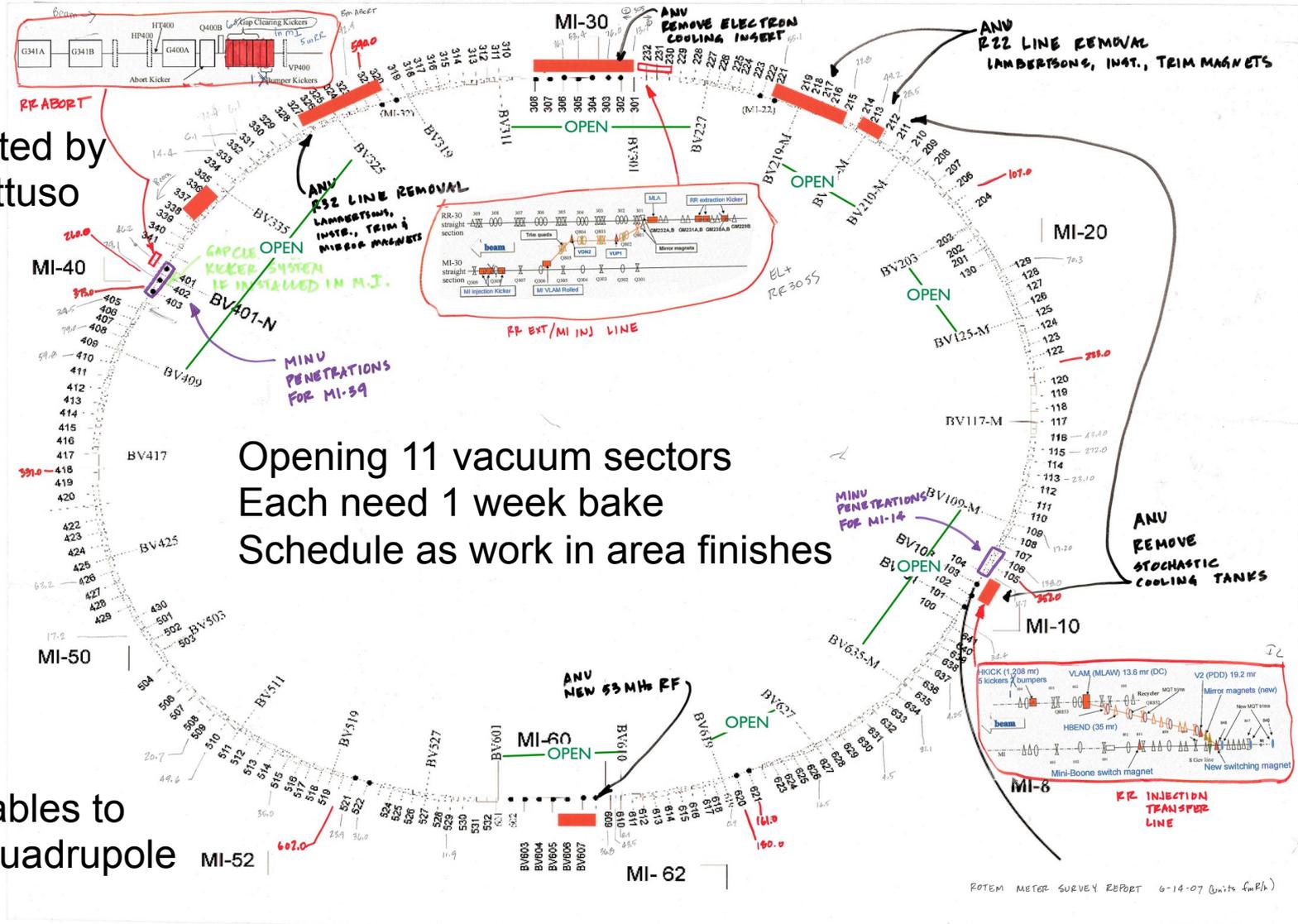


- Changes to the FNAL Accelerator complex to
  - Turn Recycler from pbar to proton ring
    - Injection and extraction lines
    - Associated kickers and instrumentation
    - 53 MHz RF
    - Decommission/remove pbar devices
  - Shorten MI cycle to 1.33 seconds
    - RF upgrades
    - Power Supply upgrades
    - Decommission/remove pbar devices
  - Upgrade NuMI target station to 700 kW
    - Target & Horns to handle power
    - Configuration to maximize  $\nu$  flux
  - Installation and Hardware commissioning



# Installation: Scope of Work

Coordinated by  
Cons Gattuso

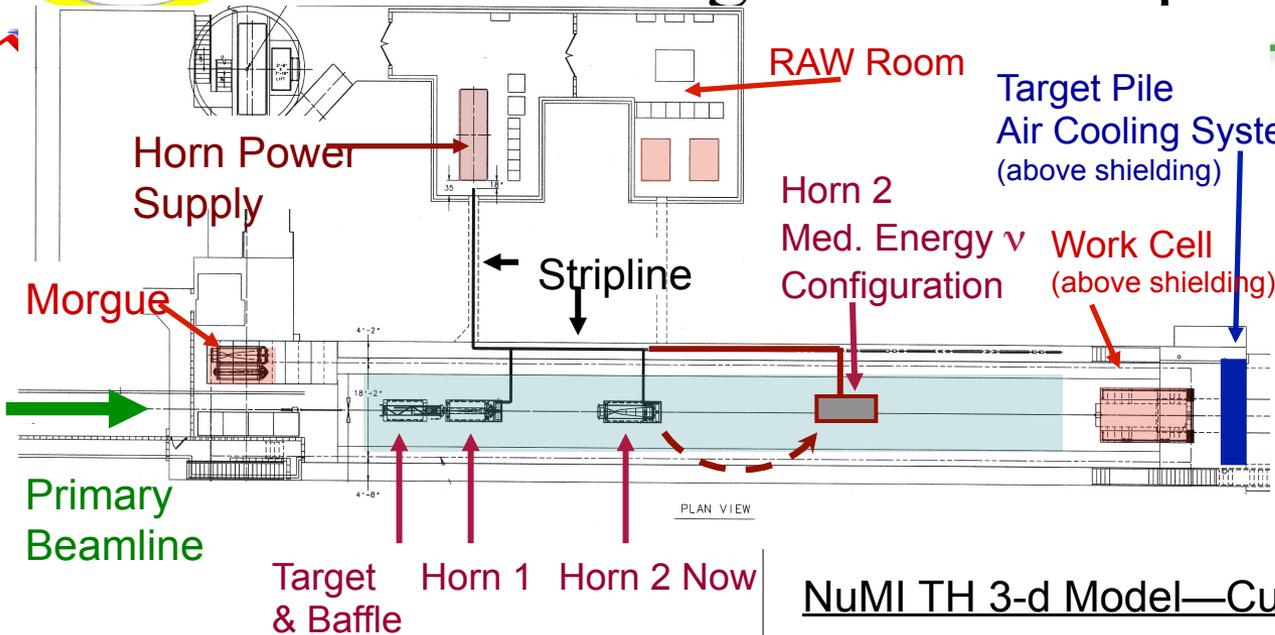


Opening 11 vacuum sectors  
Each need 1 week bake  
Schedule as work in area finishes

BPM cables to  
every quadrupole



# Target Hall: Scope of work

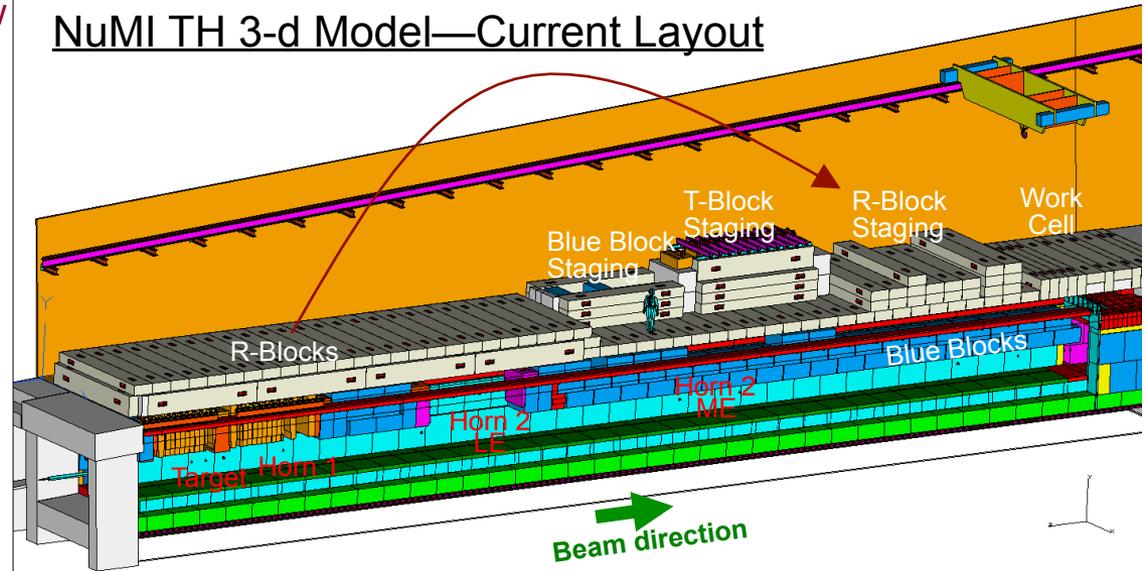


Utility work associated with upgrades: RAW most significant

Coordinated by Mike Andrews

Limited space available for Target Hall activities (Horn 2 move, Target & Horn change outs & repairs, Radioactive Component Repair/Removal)

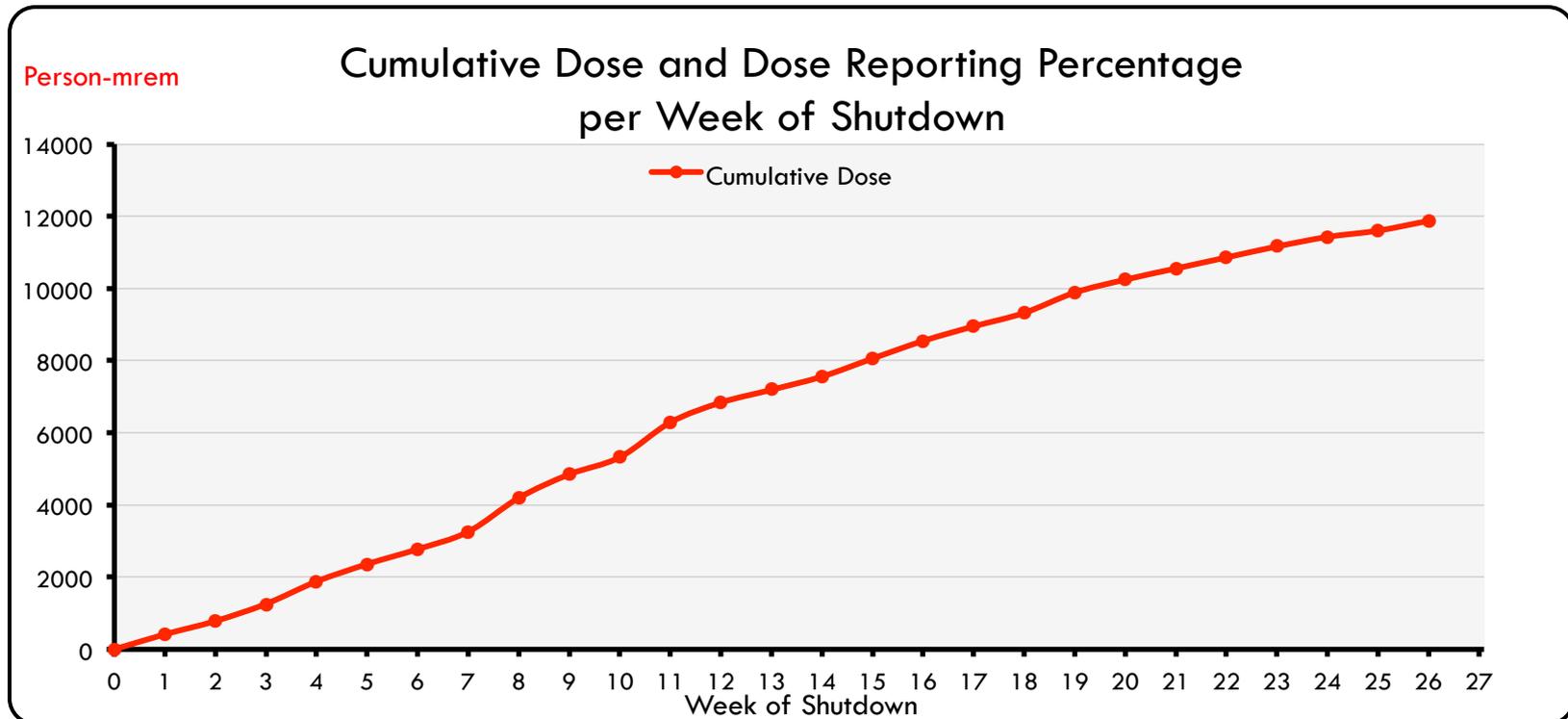
NuMI TH 3-d Model—Current Layout





# Shutdown 2012 ES&H

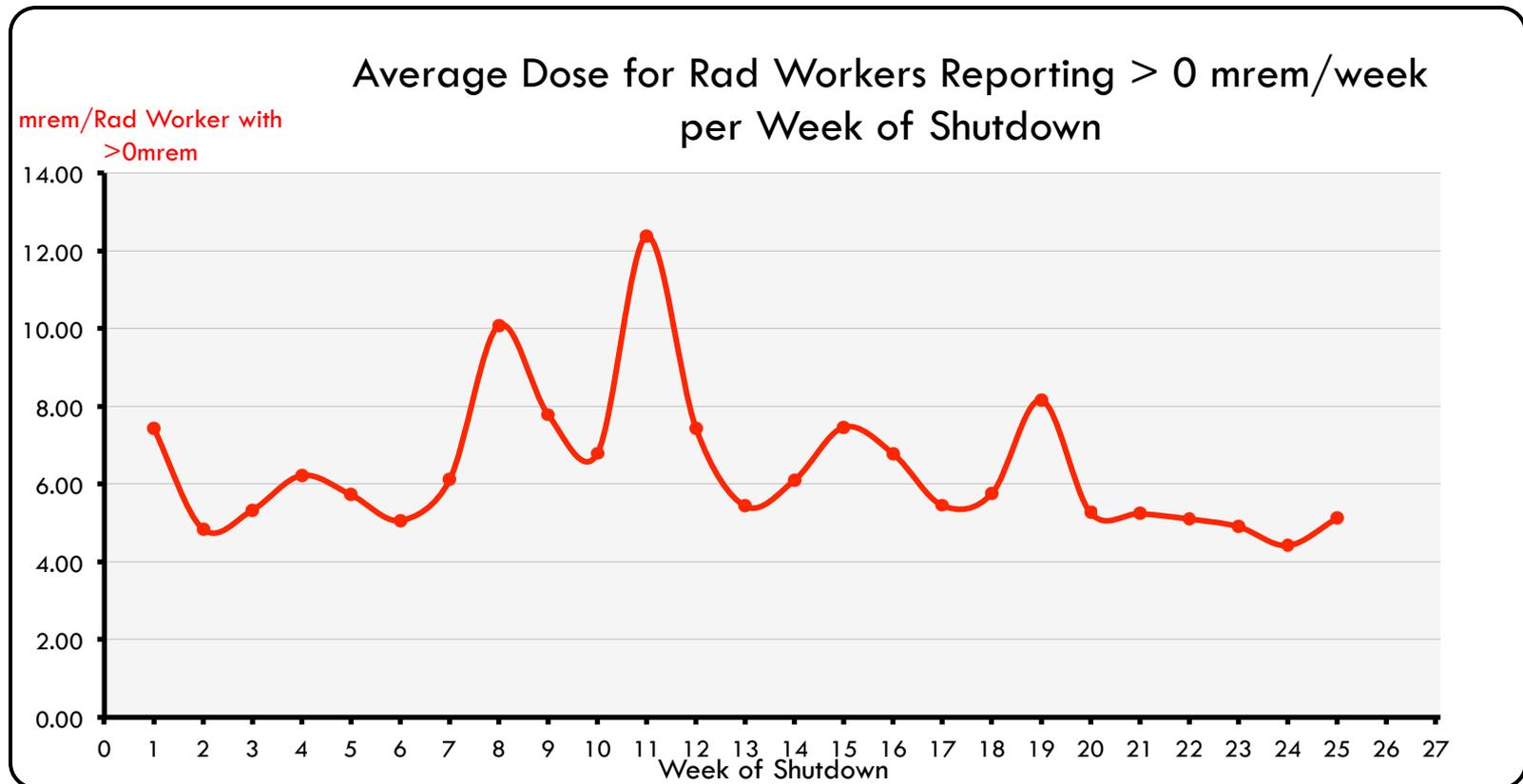
- Shutdown Radiological Exposure
  - 18,000 Person mrem anticipated through shutdown
  - 11,873 Person mrem through 26 weeks





# Shutdown 2012 ES&H

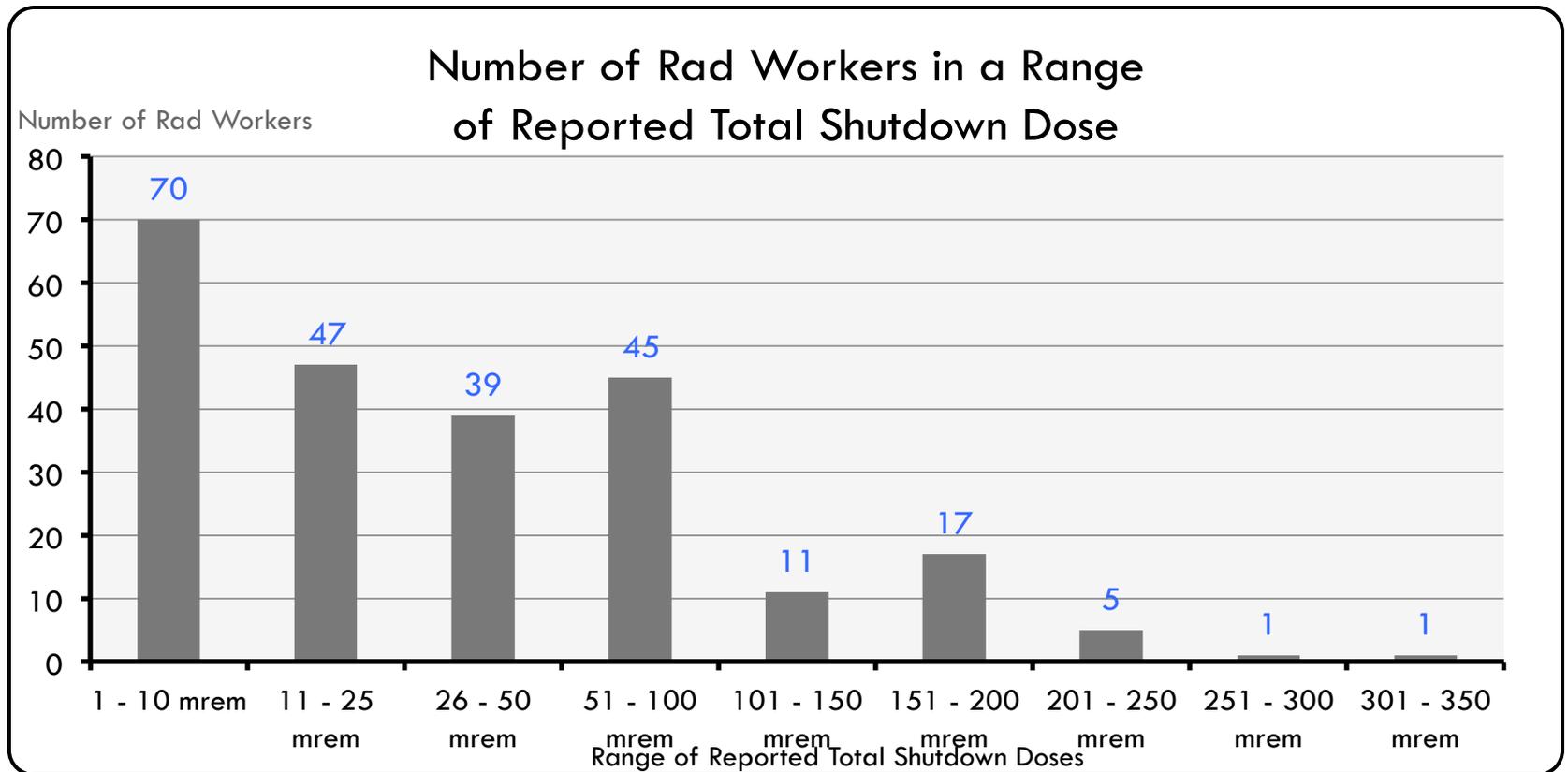
- Shutdown Radiological Exposure
  - Cumulative average dose to a shutdown workers is 6.4 mrem





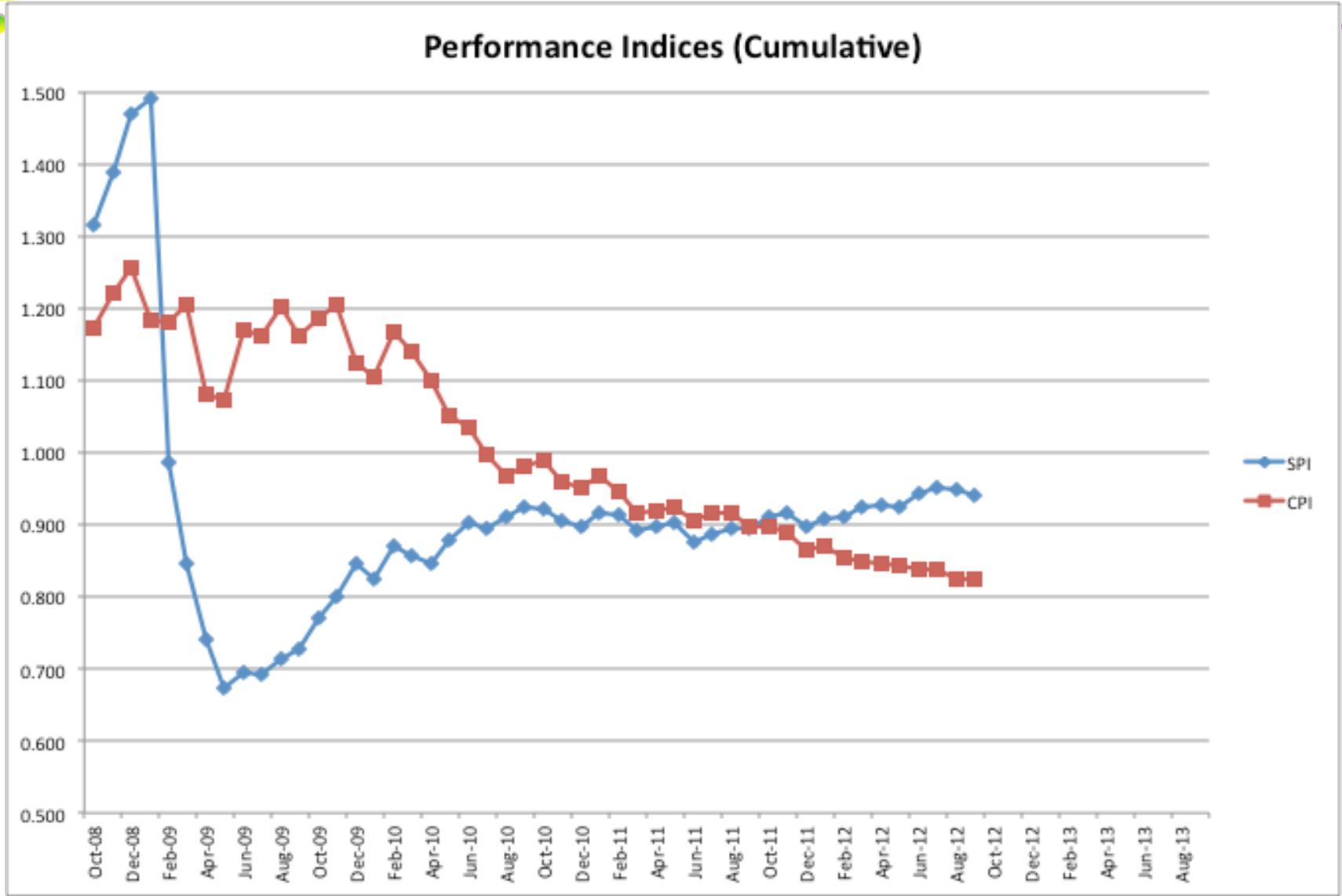
# Shutdown 2012 ES&H

- Shutdown Radiological Exposure
  - Currently tracking 236 shutdown workers



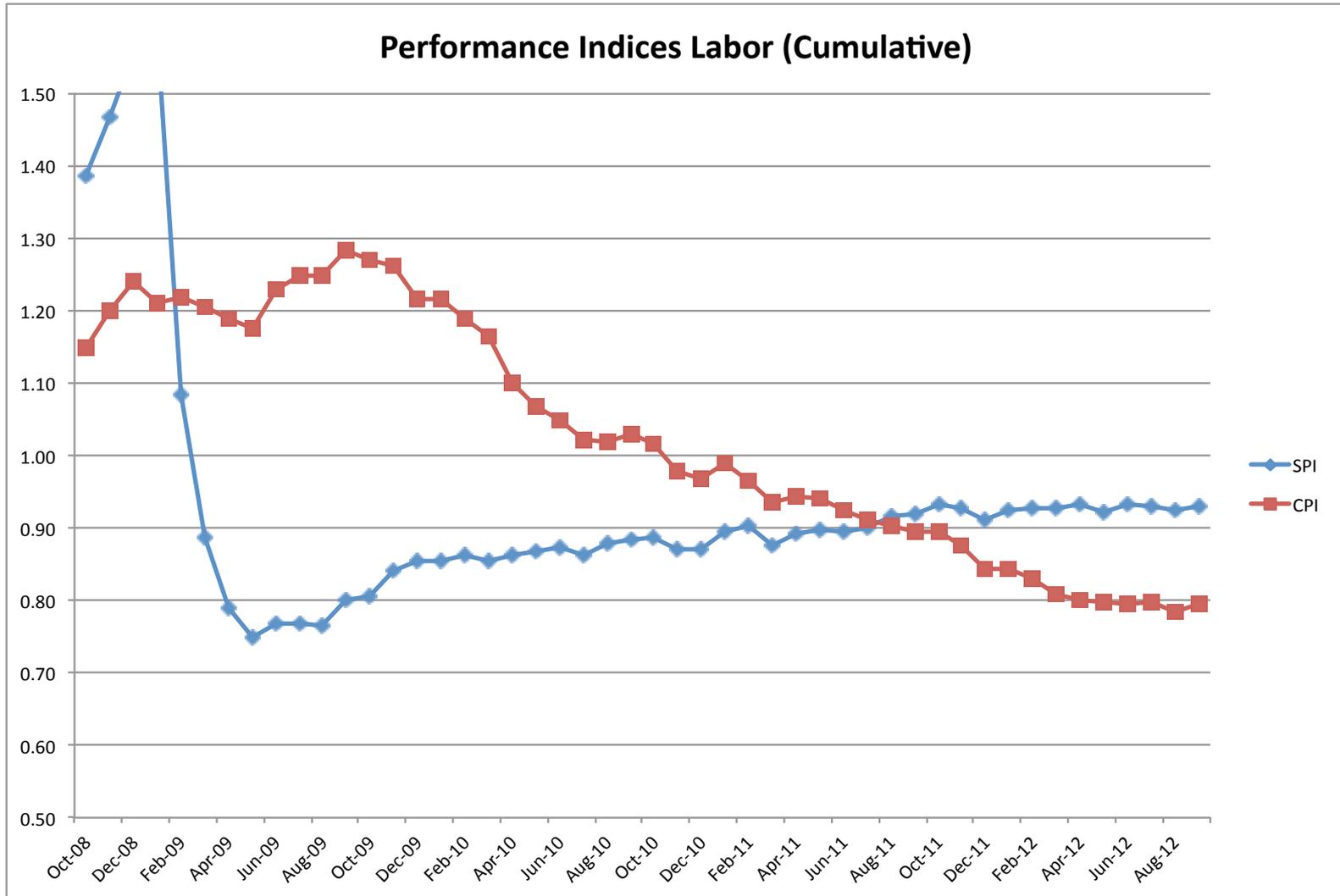


# EVMS Metrics





# Labor CPI





# Shorter term trending?

