# Accelerator & NuMI Upgrades Update

Paul Derwent

20 Nov 2012

# The Plan: Installation Shutdown May 2012

- ~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
- Pulled more than 650,000 feet of cable, should be complete by end of November
    - Beam Position Monitors
    - Multiwires
    - Magnets
    - Vacuum components
- Completed magnet replacement for the NuMI transfer line

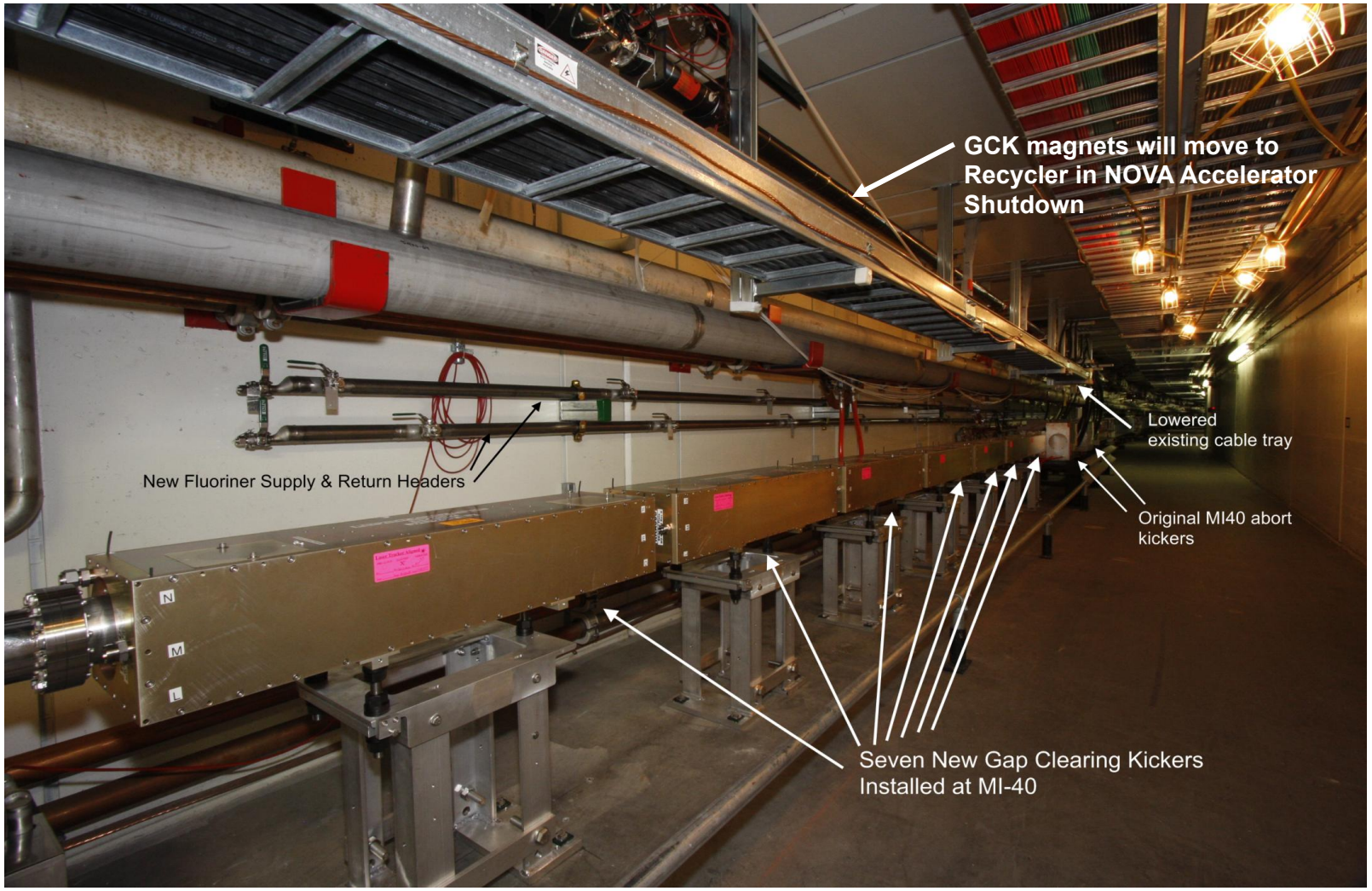
# Recycler and MI Tunnel Work

- Repair and maintenance work on MI RF, P1 line, MI 52 extraction area (support SeaQuest)
- Installed 50% of the gradient magnet end shims, designed to change the base tune and chromaticity of the Recycler to better handle 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!

- MI Shielding Assessment approved -- areas where need additional shielding identified and mitigations underway (dominated by additional shielding around penetrations for power and water)

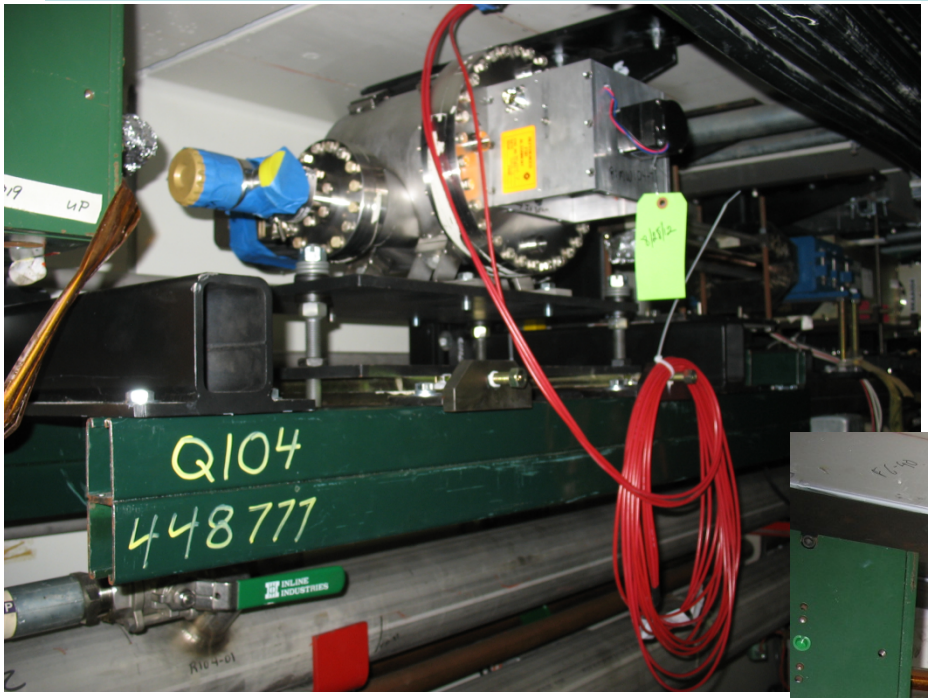
# AIP work – Gap Clearing Kickers

- 7 magnets installed during 2009 shutdown



# MI 40 Vacuum Reconstruction

# Multiwire Installations




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

- 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:
  - 1st cavity has outer loops, finishing final water manifolds, testing in August
  - 2nd cavity had major vacuum welds in June, need to complete vacuum ports, then start on cooling hoops
  - 3rd cavity at the e-beam welder in August

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Complete

Complete

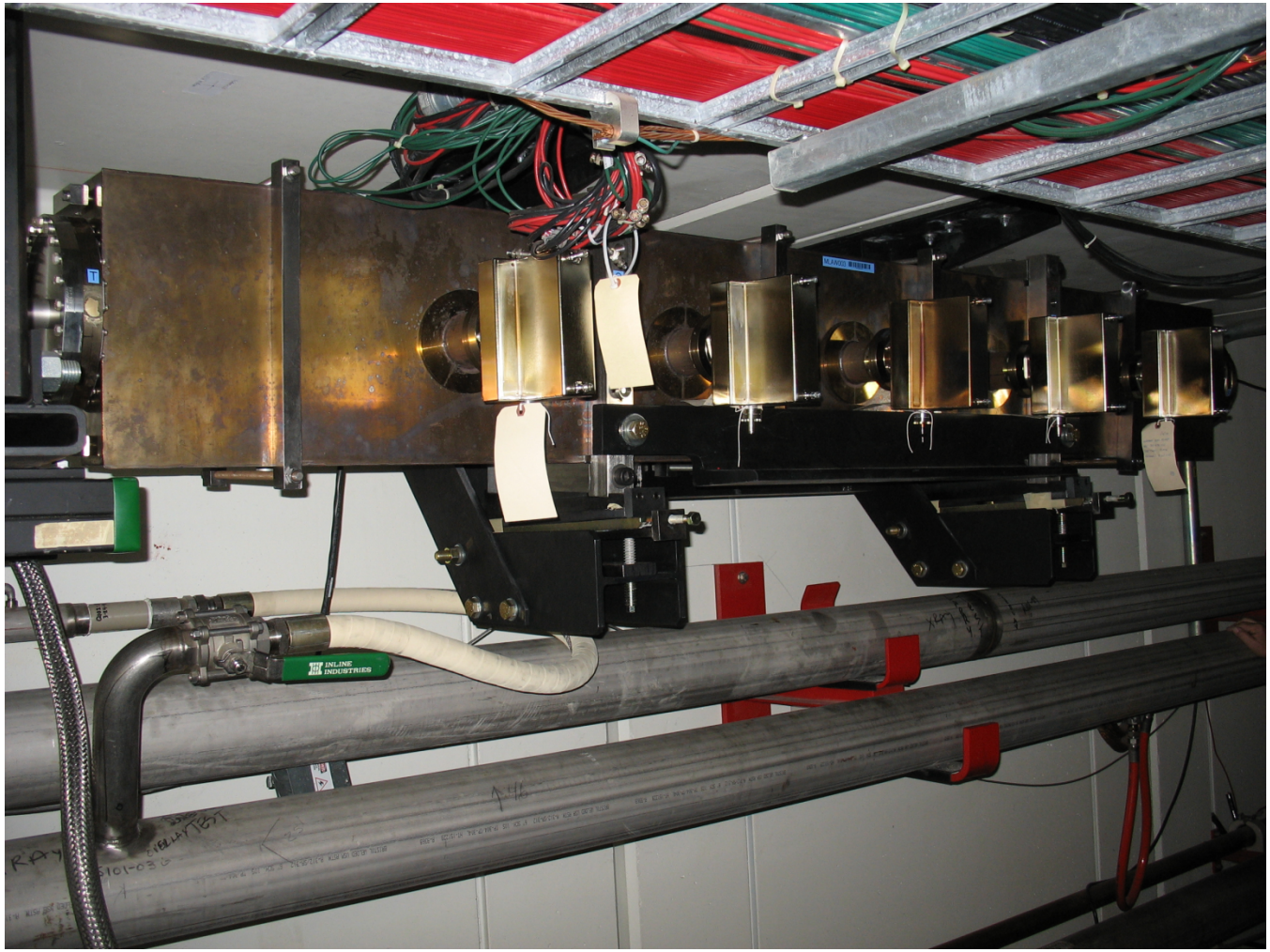
2 complete, 2 more by end of November

In progress, impact start of R30 work

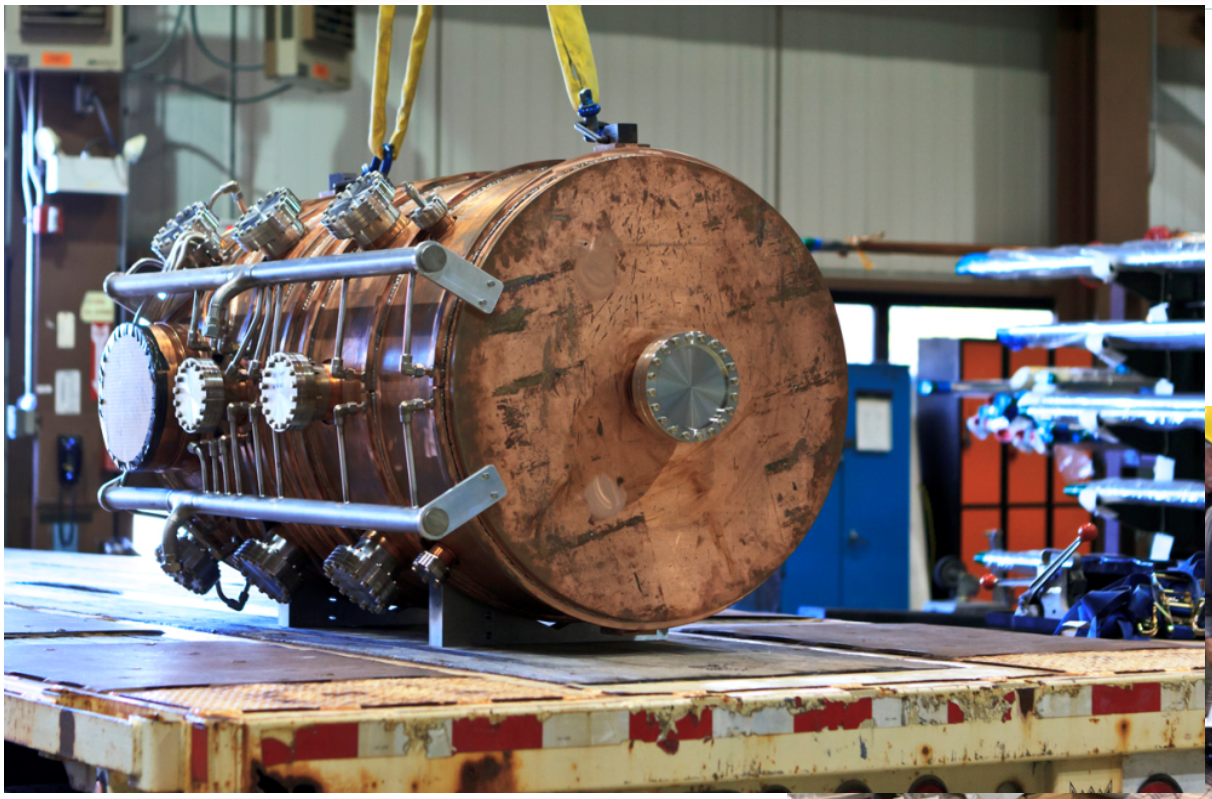
Complete in testing

Complete: inner hoops done, outer hoops by end of November

# Injection Lambertson

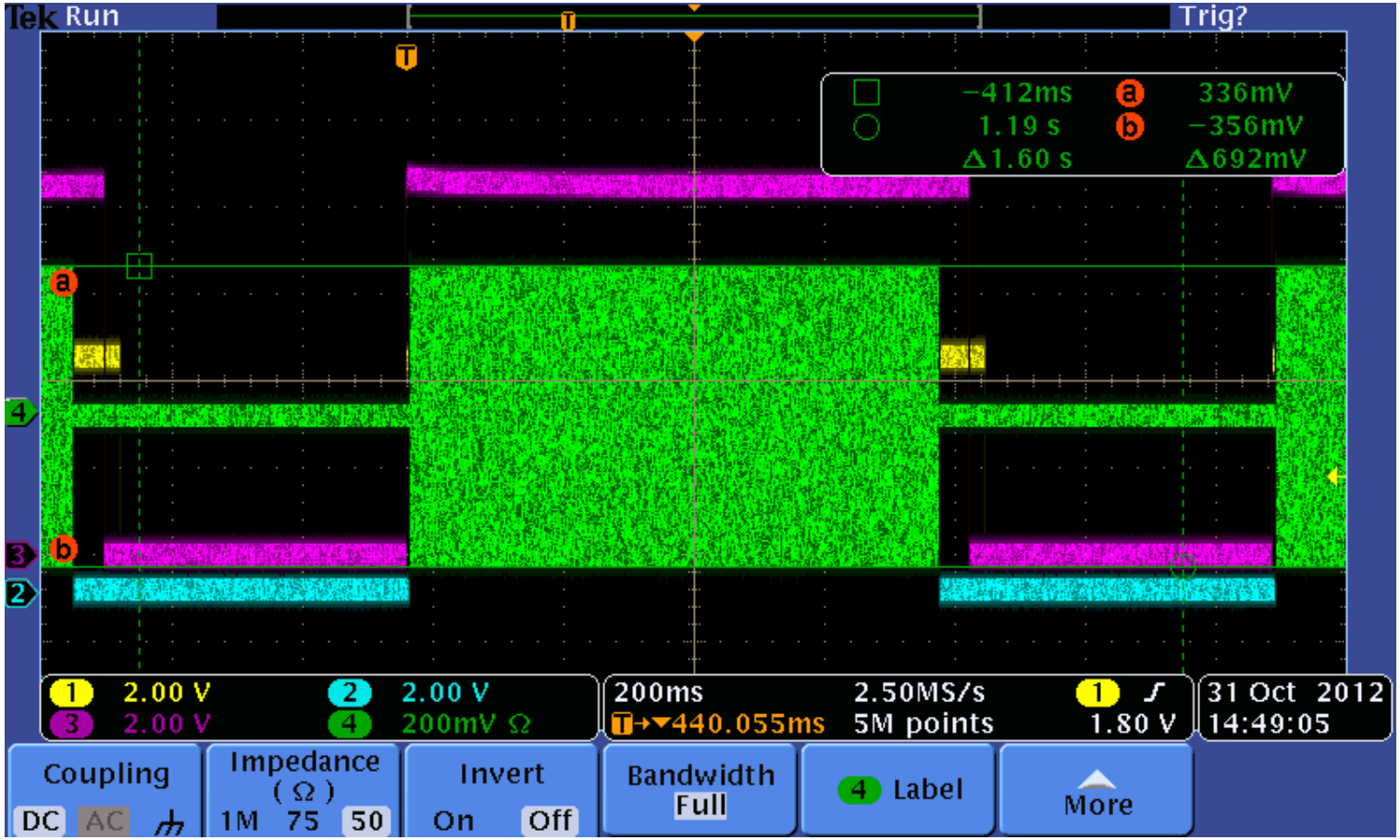


# 1st Cavity Complete



# RF Testing

- Specifications: 150 kV, 60% duty factor, ±10 kHz frequency sweep




- 122 kV, 60% duty factor (800 msec, 1.33 sec cycle)

# NuMI Target Hall Work

- 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
- Air handling upgrades for dehumidification and target chase cooling on schedule
- Target and baffle mounted on carrier/module, ready for installation

# Installation of DI Casks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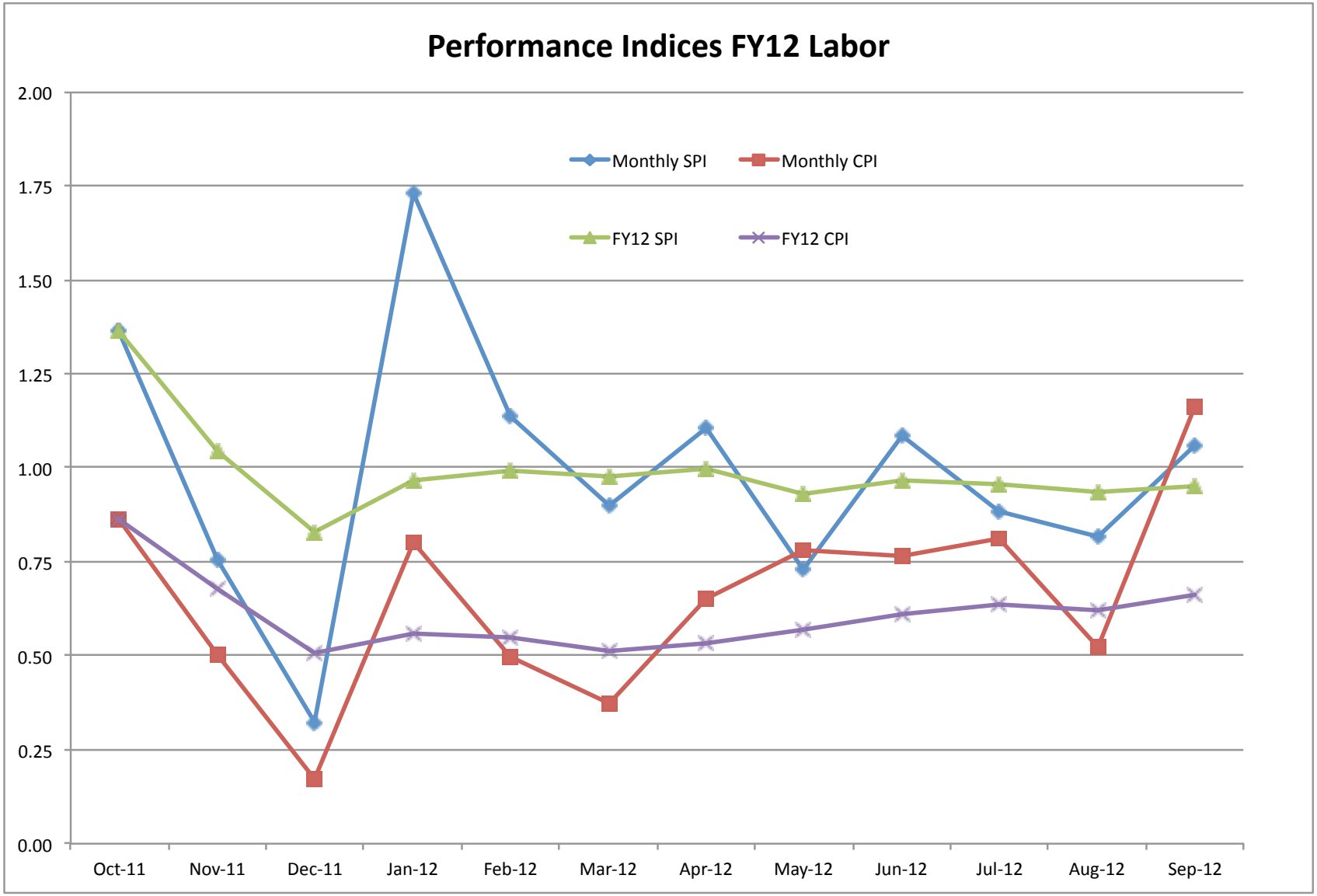
# ANU Costs

- 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

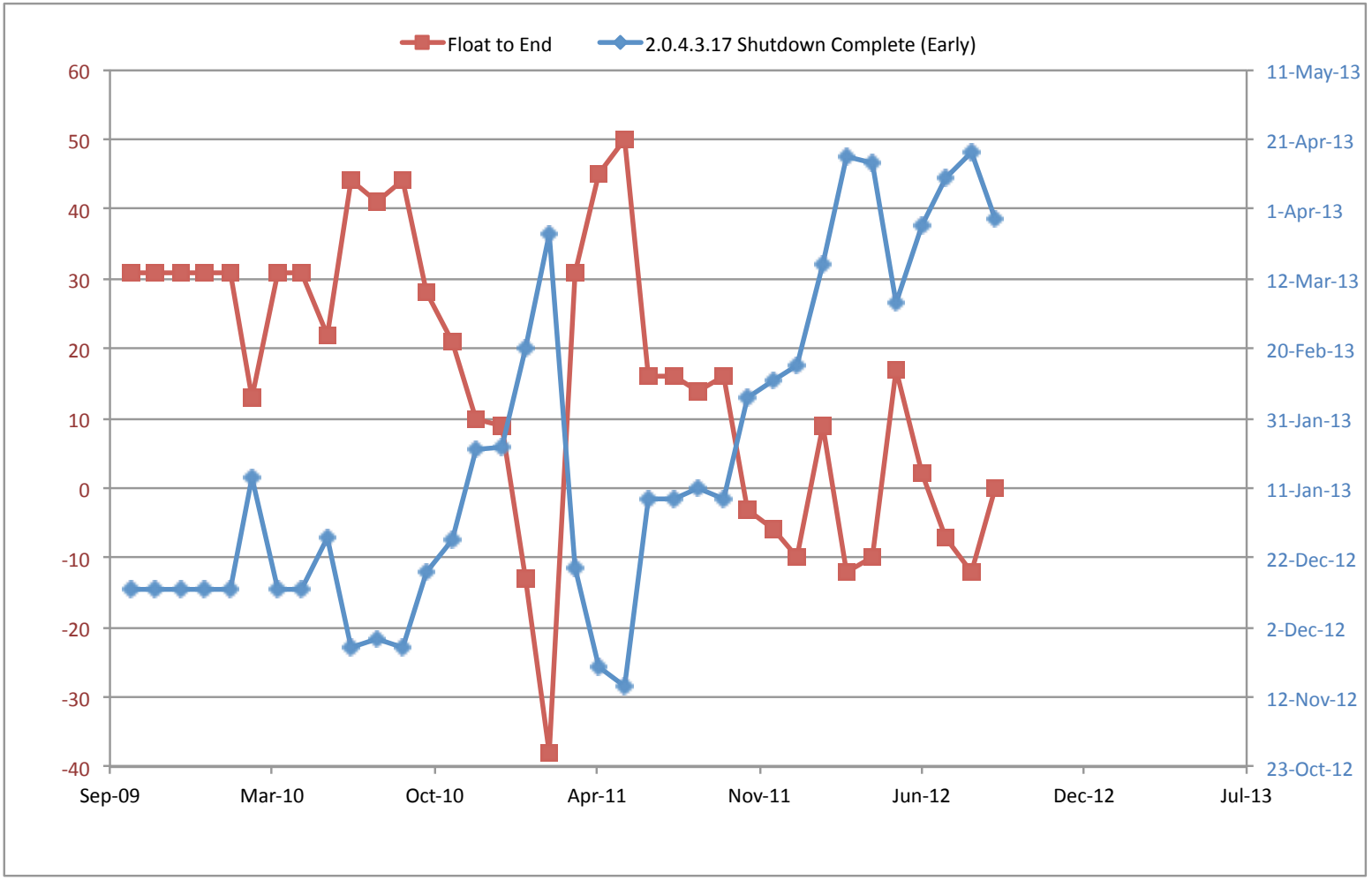
- At direction of project manager, in April increased labor budget for May-July time period by 15% (CR487 $748K) and reduced labor contingency by 15% (CR487 $748K) , based on cumulative labor CPI ~0.85 at the time
  - Visible change but not enough

- 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 1st
    - Addressing recommendations, anticipate work starting in December
  - Did not include RF installation: reviewed and well defined installation task

# Summary

- Shutdown proceeding:
  - Major items:
    - R30 and Extraction line installation:  December 2012
    - RF Installation: January 2013
    - Target and Horn 1 Installation:  January 2013
  - Anticipate completion on schedule
- Laboratory providing necessary resources to stay on schedule
- ANU Critical path items still kickers / RF cavities / beam pipe

# Shutdown float




- 0 days of float to end of shutdown: Friday March 29

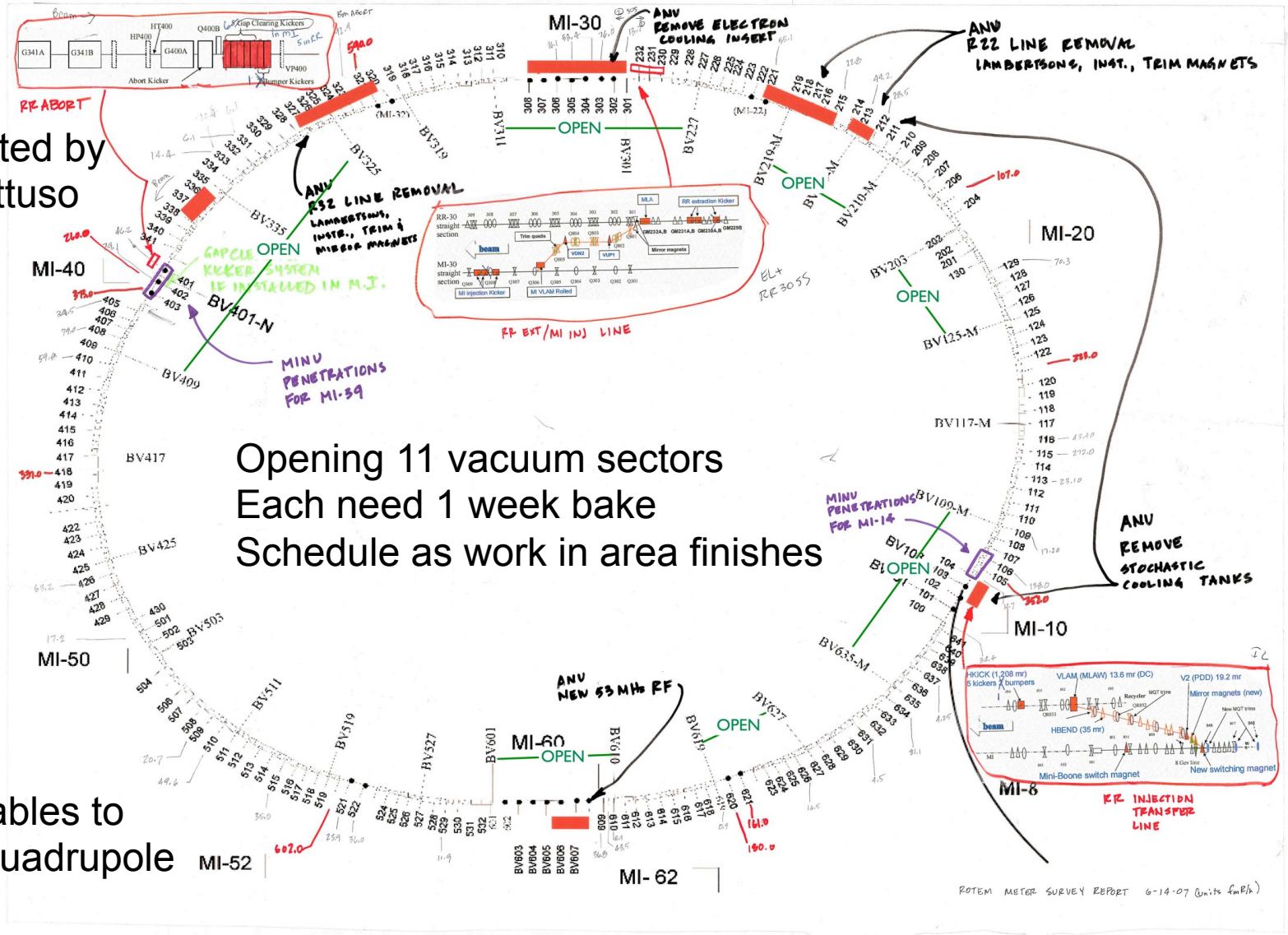
# Backups

# 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 ν flux
  - Installation and Hardware commissioning

# Installation: Scope of Work

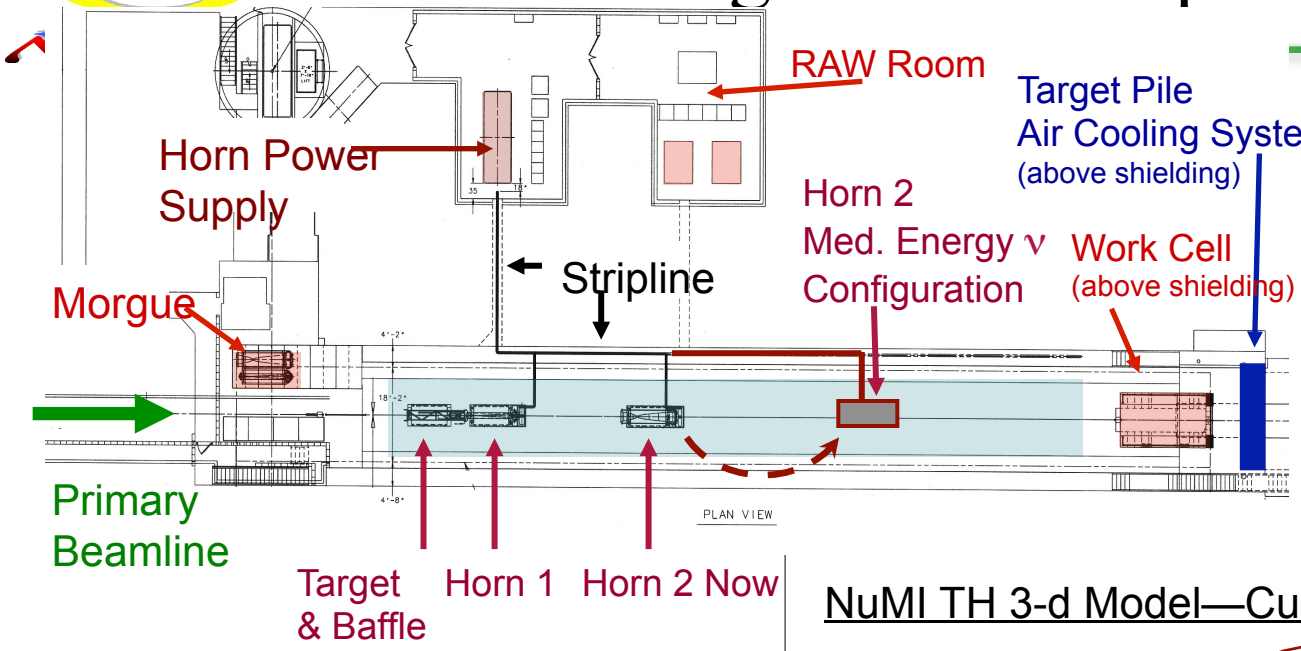
Coordinated by
Cons Gattuso




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

BPM cables to
every quadrupole

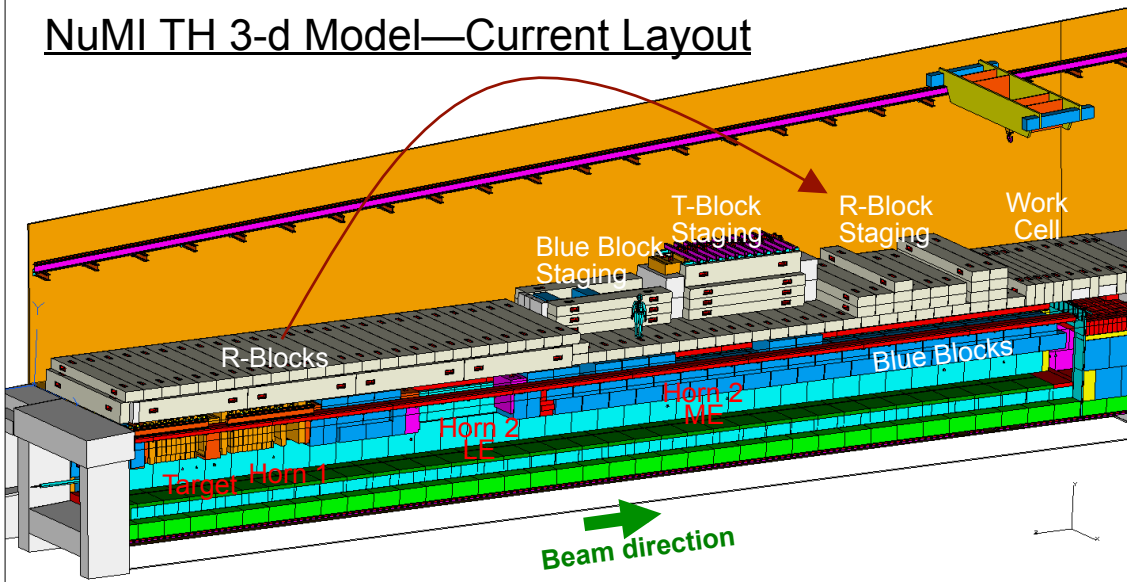
# Target Hall: Scope of work




Utility work associated with upgrades: RAW most significant

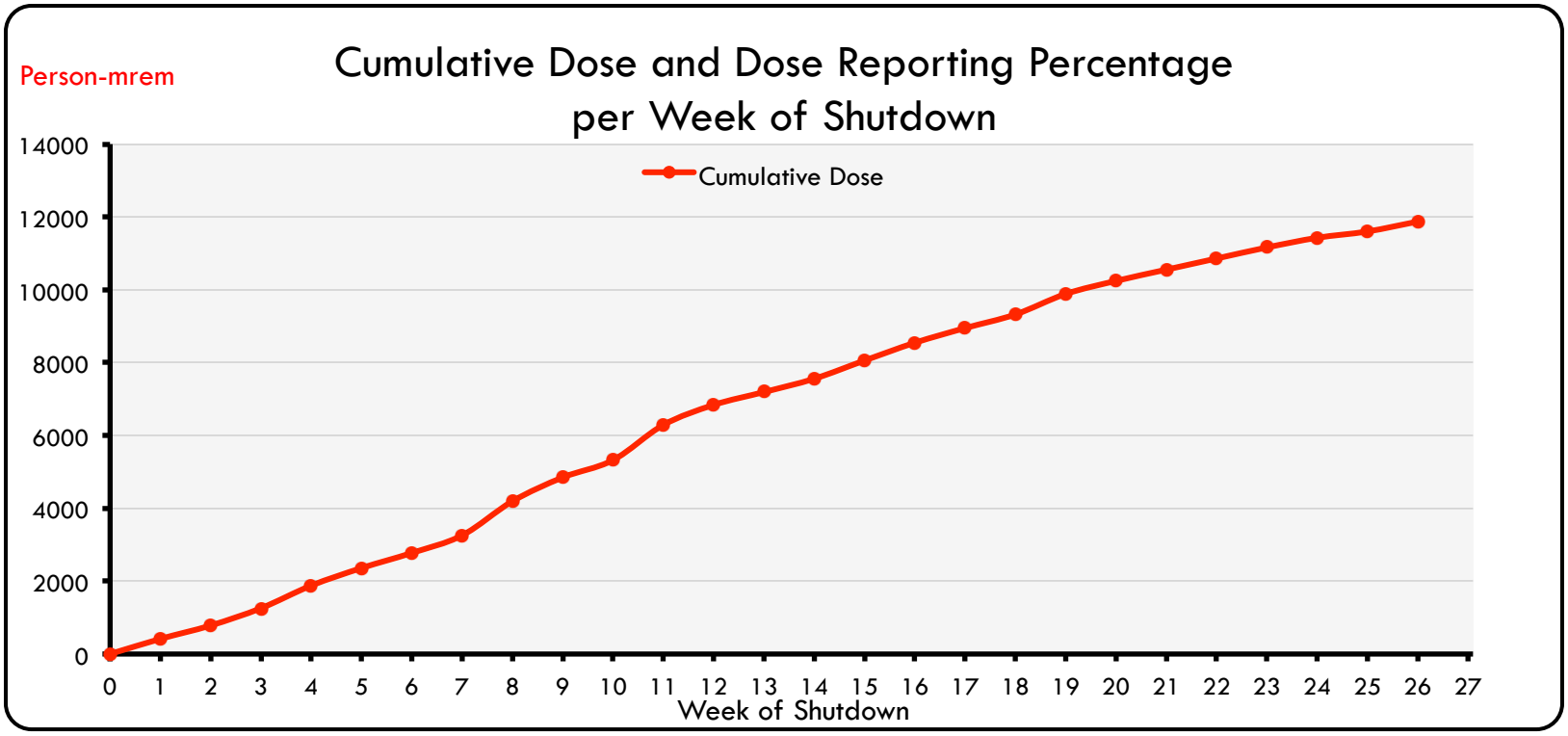
Coordinated by Mike Andrews

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



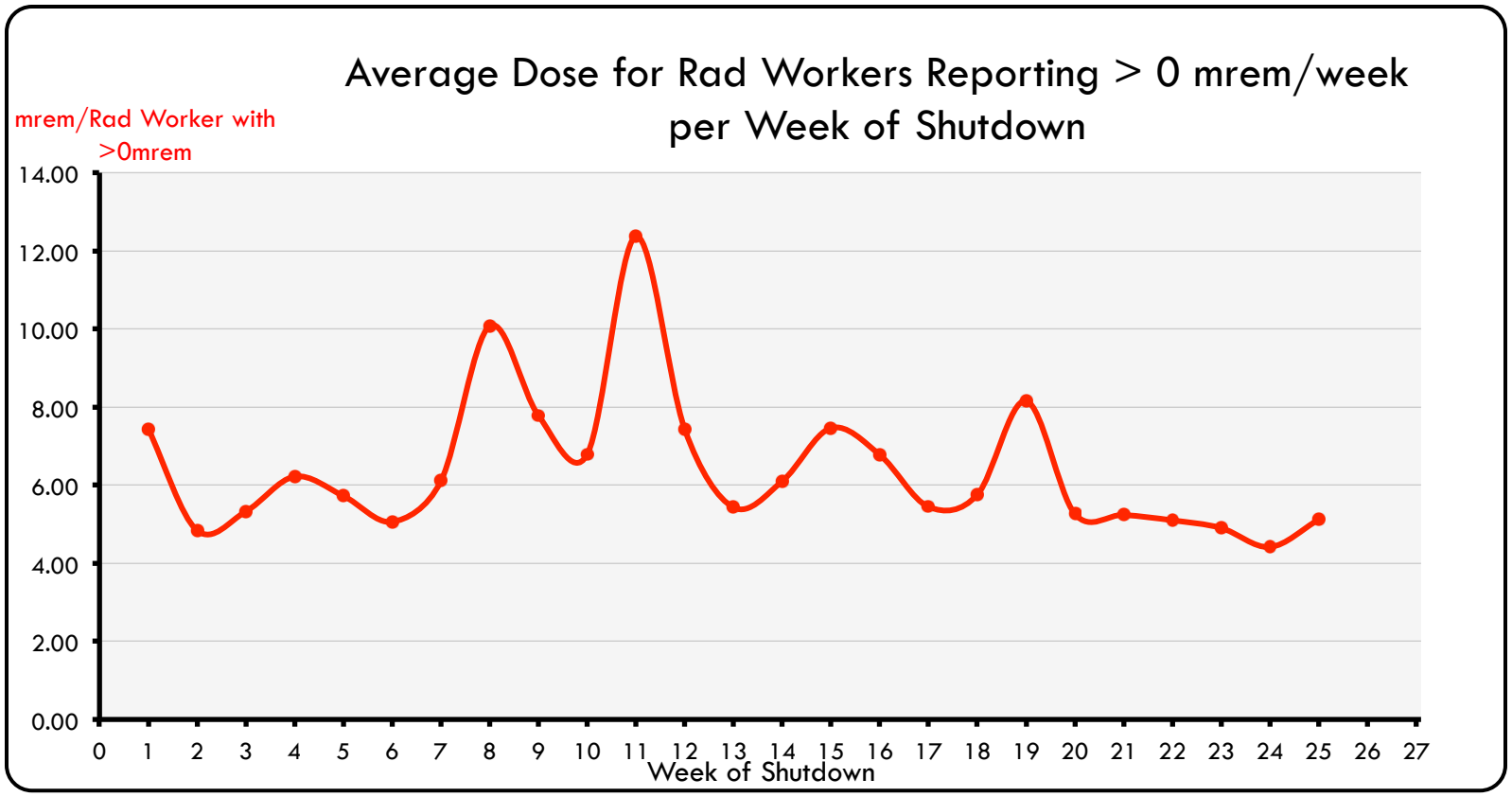
# Shutdown 2012 ES&H

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



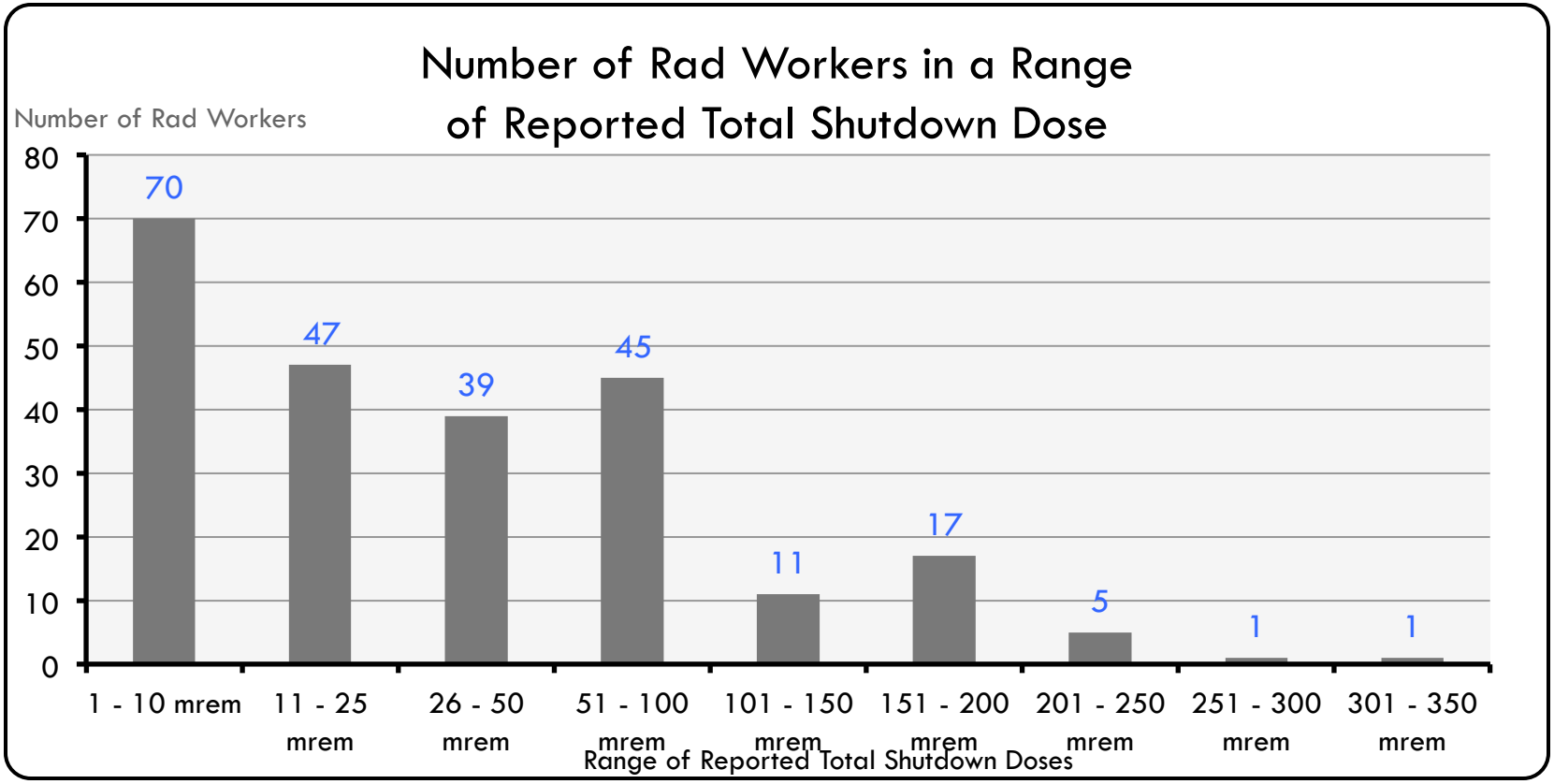
# Shutdown 2012 ES&H

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

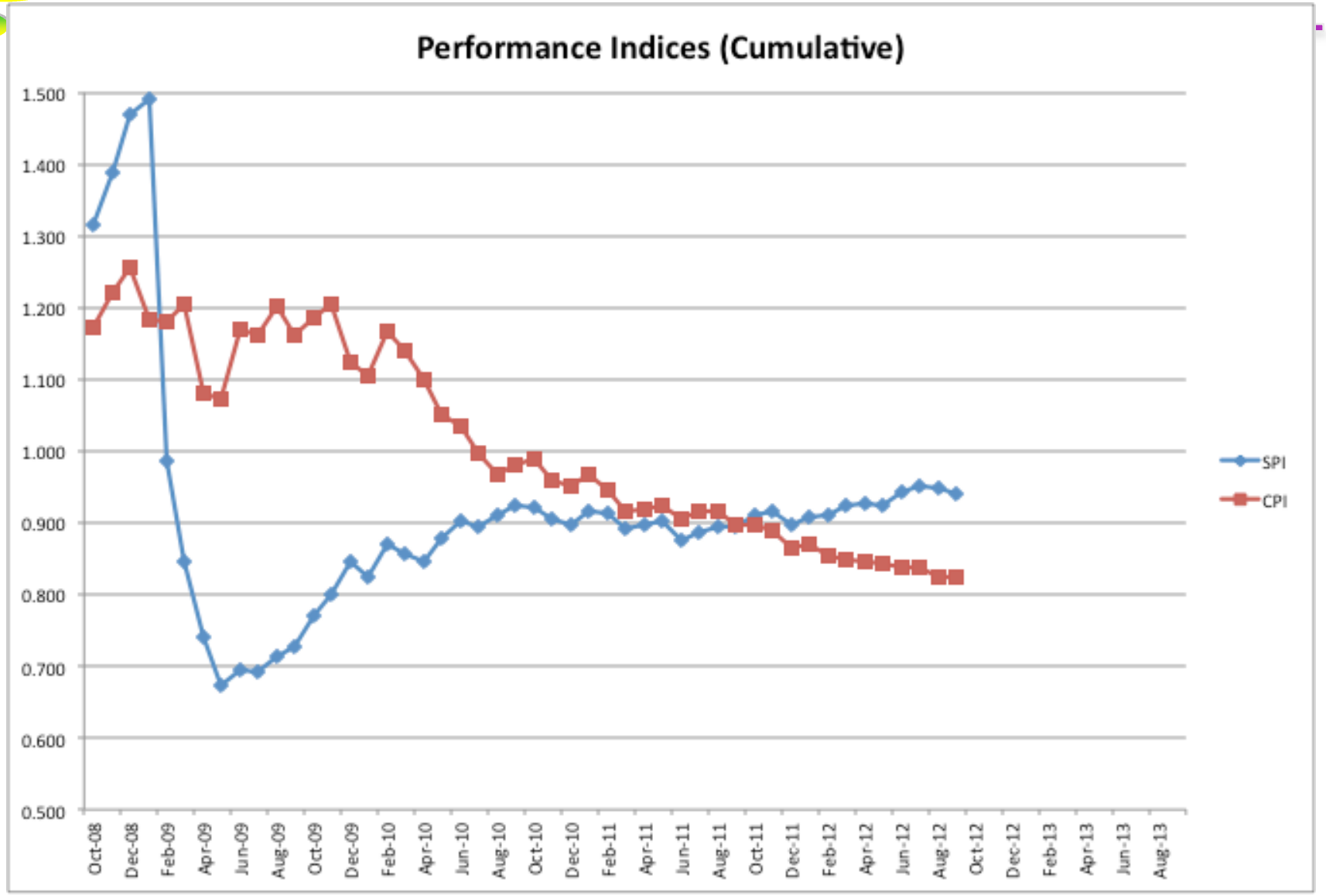


# Shutdown 2012 ES&H

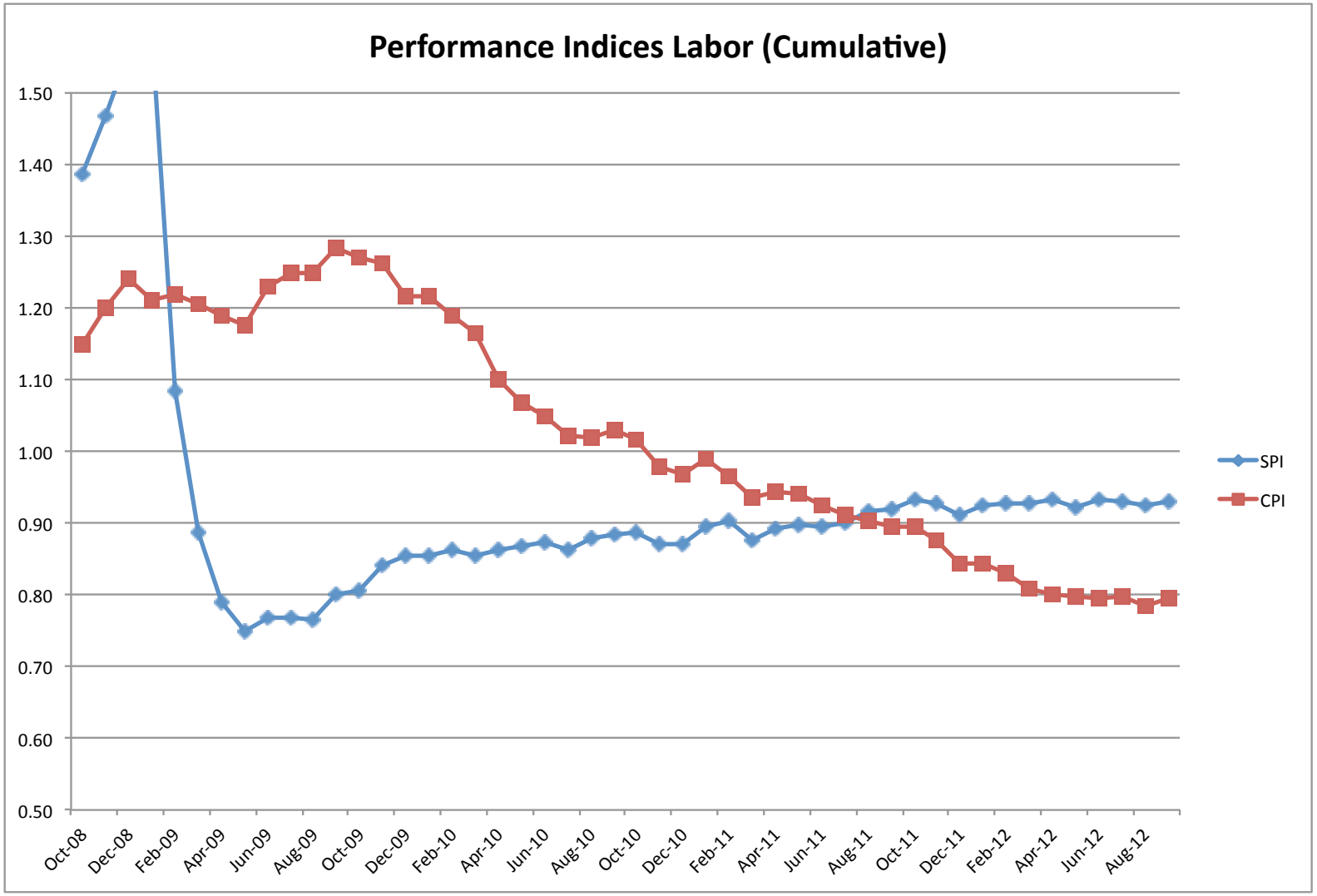
- Shutdown Radiological Exposure
  - Currently tracking 236 shutdown workers



# EVMS Metrics



# Labor CPI


Performance Indices Labor (Cumulative)
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
Oct-08
Dec-08
Feb-09
Apr-09
Jun-09
Aug-09
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Dec-10
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Apr-11
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
SPI
CPI

# Shorter term trending?