MOM Report

Dan Kaplan

(MOM 27 Oct – 23 Nov)

➡ with invaluable input from Alain Blondel

MICE Collaboration Meeting
Harbin Institute of Technology
Jan. 13, 2009
Highlights
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- Hall construction: great progress!
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• Target, beamline and detectors:
  - target worked well … until it died
  - decay solenoid diagnosis effort
  - routine operation of conventional magnets
  - FNAL BPM commissioning
  - TOF1 installation
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• Data taking:
  - pion, electron, proton runs
  - some TOF1 commissioning
  - high-beam-loss investigations
  - ISIS activation studies
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  - ISIS activation studies

• Fixes and failures:
  - CKOV T monitoring (not fixed)
  - Magnet water-flow display (OK)
  - TOF phototubes (changed and fixed)
  - CAEN (KL, TOF) and BPM HV power supplies (bit the dust!)
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Hall Construction
W. Spensley/Merit Proc. Eng., et al.

TOFI in place!

Thanks
Willie Spensley!
False floor installation!
Hall Construction
W. Spensley/Merit Proc. Eng., et al.

- Magnetic-shield-plate installation almost finished:
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North wall, 10 Oct 08
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  Looking west, 19 Dec 08
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- LH$_2$-system mezzanine installed
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- Magnetic-shield-plate installation almost finished:
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- Huge progress in the hall!

- L'H$_2$-system mezzanine installed
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MICE Hall, 6 Jan 09

Huge progress in the hall!

Mezzanine

DSA roof and solenoid platform

This is where MICE step VI will fit

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Beam stop
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  Mezzanine

  Mag. Shielding

  North

  Mag. Shielding

  South

- DSA roof

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- Beam stop

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W. Spensley/Merit Proc. Eng., et al. & Daresbury Lab

- Much interlock hardware installed (to be completed by spring)
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DSA gate
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& TOFI installed!
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  - routine operation of conventional magnets
  - FNAL BPM commissioning
  - TOF1 installation
For months, target trajectory was stable and solid as a rock...until it wasn’t!

Friday 19Dec08... despite trying could not go beyond 27.6 mm dip, and notice target drifting back up!
On 21Dec08 target was not operating.
After access and kicking it it worked for 106 pulses

Last target kick in 2008: (green line)
note that target did not come back fully to hold position.
29 Nov08 to give access to solenoid MOM (AB) stops actuations and puts target in park position *before* having raised the frame.

**===> target was in the beam.**

While this is clearly the wrong order of doing things (the instructions specify the order clearly), this situation should have been protected against.

For a few minutes ISIS was tripping and could not inject. Things went back to normal after Mice operator put target on hold.

Paul Smith and Paul Hodgson came on Friday 5 Dec08 to exchange the control unit in the target with one tested at Sheffield in which the action of the park/hold key is disabled if the frame target is lowered. This was successfully tested by KL on 8 December.

After report to D. Findlay and ISIS we were authorized to operate the target again on 11 December.

Target operated successfully on 11 and 12Dec08 (>10k pulses) for TOF1 commissioning

….. but showed signs of weakness on 19Dec08.
Target

Target comments

2008 target operated 182,572 pulses with great reliability. It allowed us to see first particles in the beam line, demonstrated parasitic operation, raised the issue of rates.

Weaknesses were identified in the mechanics (bearings). A new design is being proposed with aim of providing two target systems for end of March so as to run step I in May and Step II in July.

Priority to reliability

Originally rates observed pointed to factor 500 missing. Gaining a full factor 500 in rate over present system will require
-- increase of beam loss tolerance (we were about to try factor 40)
-- improvement in target design (orientation, dip depth or material) but present idea is to decouple target shaft and target head and concentrate on the former.
Target Optimization (1)

- Target: 1 x 10 mm$^2$ Ti blade oriented along beam, dipping into halo from above, with diamond-like coating on bearing surfaces.
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Target Optimization (1)

• Target: 1 x 10 mm² Ti blade oriented along beam, dipping into halo from above, with diamond-like coating on bearing surfaces

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• But at RAL, bearing wear caused “death by jamming”
  - both on bench in R78 @ 300k, and in ISIS @ ≈180k
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    - may be due to shaft flexure under $\approx 80g$ accel.
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  - both on bench in R78 @ 300k, and in ISIS @ $\approx 180$k
    - may be due to shaft flexure under $\approx 80$g accel.
      $\Rightarrow$ shaft may traverse bearing at an angle
Target Optimization (I)

- Target: 1 x 10 mm² Ti blade oriented along beam, dipping into halo from above, with diamond-like coating on bearing surfaces

- Target prototype ran successfully ~10⁶ cycles on bench at Sheffield

- But at RAL, bearing wear caused “death by jamming”
  - both on bench in R78 @ 300k, and in ISIS @ ≈180k
    - may be due to shaft flexure under ≈80g accel.
    - shaft may traverse bearing at an angle & poor coating due to surface imperfections?
Target Optimization (2)

- ORBIT beam-tracking simulation studies:
  (D. Adams, RAL; A. Dobbs, ICL)
- goal: maximize
  \((\# \pi \text{'s produced} / p \text{ lost})\)
- need MCS & dE/dx per traversal < acceptance limit
- optimal target orientation and material:
  - Ti shaft with Be cylinder or Be blade \(\perp\) beam?
  - also (J. Tarrant, RAL), tighter bearing fit \(\rightarrow\) less wear?
Decay Solenoid

M. Courthold et al./RAL

- Poor cool-down of coil 10 not yet understood
- Many additional temp sensors added in Nov
- Appears to be excessive heat leak to coil 10
- Hope to learn more over coming weeks
- Planning for cold-mass extraction & surgery (& needed beam-hole plug inside ISIS vault)
We now have a great tool: Marco’s beam table excel sheet

- need to enter by hand
- not written out.

MICE operator and DAQ interface with EPICS needed

Problems with cooling-water leaks appear to be behind us

But replacement of rubber hoses with metal may be wise precaution
Beam Diagnostics (1)
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- Suspect non-statistical beam-loss fluctuations
  - yet target trajectory seemed solid as a rock!
  - was beam moving?
  - or fluctuating in size?
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**FAST SAMPLE-AND-HOLD for ISIS BEAM POSITION MONITOR SIGNALS**

D. M. Kaplan, IIT – 13 Nov. 2008

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**Circuit Diagram:**

- NIM Gate
- 2N5770 or similar
- ADG701
- LM317
- 2N5770 or similar
- LM337
- Analog In
- LM337

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**Notes:**

- 50 ohm loads
- +2.5V
- 240 ohm resistors
- 1nF capacitor
Beam Diagnostics (1)

- Suspect non-statistical beam-loss fluctuations
  - yet target trajectory seemed solid as a rock!
- was beam moving?
  - or fluctuating in size?
- BPM signals available from ISIS but needed sample-and-hold ckt for digitization
- Prototype built & working
  - good enough?
  - better diagnostics available from ISIS?
Beam Diagnostics (2)

- FNAL Beam Position Monitors
- Originally installed and tested in summer
- Worked well on bench, excessive noise at RAL
- Now rebuilt with better EM shielding, noise appears to be gone
- Need to optimize thresholds with beam
TOF0 and TOFI are now producing
-- beam profiles
-- time and position info on particle by particle basis.

Ex. run 845 online monitoring plots (300 MeV/c pions)

Left : vertical (7 bins) and horizontal (7 bins) beam profiles in TOF1
Right : vertical (8 bins) and horizontal (8 bins) beam profiles in TOF0

Difference in shape is to be explained by beam optics
==> offline analysis
Beam Diagnostics (4)

Which detectors to keep in the beam line?

With CKOVA, CKOVB, TOF0 and TOF1 working...

GVA2 and GVA3 have become redundant.
⇒ were taken back to GVA

Is GVA1 still useful? (keep it for now) Counts and gives time stamp.

Fermilab Beam Line Monitors will give beam profiles given high enough intensity, ...
... but not position on particle by particle basis ⇒ no emittance.
Emittance is dominated by material in TOF0, CKOV and TOF1 ⇒ granularity is sufficient in TOF0 and TOF1 to perform emittance meas. No need for more?

Open question: will beam loss monitors assure sufficient normalization for optics optimization -- or do we need a luminosity monitor?

Will investigate simple device

-- not as much progress as anticipated
Beam Diagnostics (5)

• Monitor of target-beam interaction, independent of beamline magnets and apertures, seems desirable

• Straightforward in principle:
  - ∃ pair of small counters from µScat & early target tests
  - can easily install next to Q1

  - needed cables already there from former in-vault BPM location
TOF Detectors

- TOF0 has been in for months and worked well except for one PMT
- TOF1 installed Dec. 10
- TOF0 bad PMT replaced Dec. 21
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<thead>
<tr>
<th>Run</th>
<th>Date</th>
<th>Time</th>
<th>eLog #</th>
<th>Description</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>782</td>
<td>8Nov08</td>
<td>16:45</td>
<td>347</td>
<td>300 MeV/c $\pi^+$ ($\pi/2$ optics, TOF0÷3 trigger)</td>
<td>see eLog #346</td>
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<tr>
<td>783</td>
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<td>17:30</td>
<td>348</td>
<td>300 MeV/c $\pi^+$ ($\pi/2$ optics, TOF0÷3 trigger)</td>
<td>&quot;</td>
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<tr>
<td>784</td>
<td></td>
<td>18:50</td>
<td>349</td>
<td>300 MeV/c $\pi^+$ (nom. optics, TOF0÷3 trigger)</td>
<td>$I_Q5$ lowered</td>
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<td>789</td>
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<td>21:00</td>
<td>350</td>
<td>$\approx 100$ MeV/c $e^+$ (MA tune, TOF0 trigger)</td>
<td>$p \approx 15%$ high?</td>
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<td>790</td>
<td></td>
<td>22:30-00:05</td>
<td>350</td>
<td>$\approx 100$ MeV/c $e^+$ (AB1 tune, TOF0 trigger)</td>
<td></td>
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<tr>
<td>805</td>
<td>15Nov08</td>
<td>12:40</td>
<td>358/9</td>
<td>460 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>$I_D2 = 163$ A</td>
</tr>
<tr>
<td>806</td>
<td></td>
<td>13:00</td>
<td>&quot;</td>
<td>460 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>167 A</td>
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<td>807</td>
<td></td>
<td>13:29</td>
<td>&quot;</td>
<td>460 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>171 A</td>
</tr>
<tr>
<td>808-9</td>
<td></td>
<td>13:30</td>
<td>&quot;</td>
<td>460 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>175 A</td>
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<tr>
<td>810</td>
<td></td>
<td>14:00</td>
<td>&quot;</td>
<td>460 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>179 A</td>
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<td>&quot;</td>
<td>430 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>156 A</td>
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<tr>
<td>813</td>
<td></td>
<td>15:05</td>
<td>&quot;</td>
<td>430 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>149 A</td>
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<tr>
<td>814</td>
<td></td>
<td>15:13</td>
<td>&quot;</td>
<td>430 MeV/c $\pi^+$/p (TOF0÷8 trigger)</td>
<td>142 A</td>
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<tr>
<td>816</td>
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<td>15:55</td>
<td>&quot;</td>
<td>400 MeV/c $\pi^+$ (TOF0÷2 trigger)</td>
<td>@161915 dips</td>
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</table>

*raidmice01 system-clock time minus 10 minutes?  †accuracy & completeness not guaranteed!
# More Data Taking†

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<thead>
<tr>
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<tbody>
<tr>
<td>827</td>
<td>29Nov08</td>
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<td>373</td>
<td>475 MeV/c p (TOF0÷9 trigger)</td>
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<tr>
<td>828</td>
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<td>15:42</td>
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<td>175 MeV/c e⁺ (TOF0 trigger)</td>
<td>some pions</td>
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<td>129 MeV/c e⁺ (TOF0 trigger)</td>
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<td>119 MeV/c e⁺</td>
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<td>300 MeV/c π⁺</td>
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<td>846</td>
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<td></td>
<td>390</td>
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<td>849</td>
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<td>312 MeV/c π⁺</td>
<td>Q6 trips</td>
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<td>851</td>
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<td></td>
<td>431 MeV/c π⁺</td>
<td>trig ÷ 9</td>
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<td>18:15</td>
<td></td>
<td>431 MeV/c π⁺ (TOF1 trigger)</td>
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<tr>
<td>855</td>
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<td>20:00</td>
<td></td>
<td>490 MeV/c p (MA tune,TOF0÷9 trigger)</td>
<td>for CKOV</td>
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</table>

*approximate  
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# More Data Taking†

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<td>856</td>
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<td>20:25</td>
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<td>130 MeV/c e⁺ (TOF0 trigger)</td>
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<tr>
<td>865–871</td>
<td>22:50</td>
<td></td>
<td></td>
<td>e⁺</td>
<td>adj. CKOV gate</td>
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<tr>
<td>872</td>
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<td>23:44</td>
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<td>repl. TOF0 splitter</td>
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<td>19Dec08</td>
<td>24:05</td>
<td>401</td>
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<td>300 MeV/c π⁺</td>
<td>@182572 dips</td>
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</table>

*approximate

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Momentum Scans

- Example @ 460 MeV/c (on-line histograms):
Momentum Scans

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$P \ p$

$I_{D2} = 163 \text{ A}$
Momentum Scans

- Example @ 460 MeV/c (on-line histograms):

\[ I_D = 163 \text{ A} \]

\[ I_D = 167 \text{ A} \]
Momentum Scans

- Example @ 460 MeV/c (on-line histograms):

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  \[ 167 \, \text{A} \]

  \[ 171 \, \text{A} \]
Momentum Scans

- Example @ 460 MeV/c (on-line histograms):

  $I_{D2} = 163 \text{ A}$

  $167 \text{ A}$

  $171 \text{ A}$

  $179 \text{ A}$
Momentum Scans

- Example @ 460 MeV/c (on-line histograms):

Protons @ lower momentum than pions due to greater dE/dx in our counters
Some Results
L. Cremaldi/UMiss

Flash ADC Maximum Distribution Histogram

Entries 13409
Mean 140.8
RMS 157.9

Flash ADC Maximum Distribution Histogram

Entries 13409
Mean 170.5
RMS 190.7

Flash ADC Maximum Distribution Histogram

Entries 13409
Mean 181
RMS 189.9

Flash ADC Maximum Distribution Histogram

Entries 13409
Mean 142.6
RMS 164.4
Some Results
L. Cremaldi/UMiss

CKOVA: most likely pulse height $\approx 200$ channels
Some Results
L. Cremaldi/UMiss

CKOVA: most likely pulse height $\approx 200$ channels
Some Results

L. Cremaldi/UMiss

CKOVA: most likely pulse height $\approx 200$ channels

CKOVB: most likely pulse height $\approx 250$ channels
Some Results
L. Cremaldi/UMiss

CKOVA: most likely pulse height $\approx 200$ channels

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Some Results

L. Cremaldi/UMiss

CKOVA: most likely pulse height $\approx 200$ channels

CKOVB: most likely pulse height $\approx 250$ channels

• **BUT**: trend is opposite for upper-right histograms → signals swapped in DAQ??? or in analysis?
Intensity Campaign (I)
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- Dipping our target into the beam sprays particles into ISIS beam loss monitors (BLMs)
Intensity Campaign (I)

• Dipping our target into the beam sprays particles into ISIS beam loss monitors (BLMs)

• Initial ISIS position:
  - require tgt-induced loss < 50 mV on BLMs in “super-periods” 7 and 8
  - limited MICE to about 1 µ/ms (with DS on), ≈500 times below proposed rate!
Accelerator and target developments

Increasing the ISIS proton current

Much preparation has been made over the past year to enable major work on the ISIS accelerator and targets to take place during the 2004 long shutdown. The work is aimed at equipping the facility to run with a 50% higher proton current, providing additional neutrons and muons and enabling operation of the Second Target Station. But how will the proton current increase work?

The Synchrotron

The four new RF accelerating cavities required for the ISIS second harmonic upgrade have now all been installed in the synchrotron ring, along with their high power drives and electrical and mechanical services. Together with the six fundamental RF accelerating cavities the second harmonic system will allow the 50% extra current produced by the linac to be trapped and accelerated whilst keeping the absolute proton loss levels at the same level as before. Commissioning of the systems is now underway. Over the year or so after the end of the long shutdown the proton beam current will slowly be raised to the higher level with beam loss levels and patterns being closely monitored at all times.

Jim Loughrey and Rod Rose of the Operations and Installations Group aligning the beamline next to the second harmonic cavity in super-period 8 of the ISIS synchrotron. 04EC2364

Installations

Much effort has been focused on the preparation of components for installation on ISIS. As well as the RFQ and the two remaining second harmonic RF cavities and associated systems, work is well advanced to install a new stand-alone 1 MW cooling system for the linac and to replace the obsolete high purity water system heat exchanger circuit. Electrical installation and commissioning of a revised beam permit chain to allow operation with the RFQ is also underway.

Stuart Edmonds, Duncan Couchman and Sean Keen of the Operations and Installations Group in front of the new linac water plant. 04EC2365

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• Add’l constraint: R78 test-target cycles > ISIS/3
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- Add’l constraint: R78 test-target cycles > ISIS/82
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• Add’l constraint: R78 test-target cycles > ISIS/3 ≥ 1.5?
Intensity Campaign (2)

• ISIS Accel. Div. Head D. Findlay has given way on MICE tgt-induced beam losses a factor $\approx 2$ at a time

• Procedure: rad survey, “high-intensity 16-hr” MICE run, 8-hour cool-down, rad survey
  - done at 100, 200, 500 mV loss levels
  - each time, no significant activation increase

& 6-hr run @ 1 V to ck extraction losses – OK

BUT: short 2 V & 16-hr run at 1 V Dec. 21 aborted due to tgt jam

➡ Campaign resumes in spring with new target!
2009 operations:

Fix decay solenoid  
make test install new target  
test/measure SSI

Off beam: Install SSI with diffuser 
tracker, TOFI and TOFII  
On beam: run STEP I

Roll SSI on beam  
run STEP II

Install SSII with 
tracker, TOFII, KL  
on beam: run STEPII

run STEP III
To Do List (main items):

- Fix Decay Solenoid
  - forgo future running until this is done!
- Design, build, & commission new targets
- Complete the intensity campaign (spring ’09)
- Integrate DAQ, controls, & monitoring systems
  ➡ goal: seamless and user-friendly!
- Implement standard shift checklist
- Implement standard “run sheet”
- Update contact list:
  - can a single point of contact be designated for each subsystem, available 24/7?
  - is there workable alternative?
- Deliver remaining items (detectors, spectrometer solenoids, AFCs, RFCCs) as needed for Steps II–VI