SNS Ring Operational Experience and Power Ramp Up Status

by M. Plum

for the SNS Ring team

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SNS Accelerator Complex

Front-End:
Produce a 1-msec long, chopped, H- beam

1 GeV LINAC

1000 MeV

Accumulator Ring:
Compress 1 msec long pulse to 700 nsec

2.5 MeV

1 ms macropulse

Chopper system makes gaps

Liquid Hg Target

HEBT

RTBT

Collimators

Injection

Extraction

RF

Liquid Hg

Front-End:

Current

945 ns

minipulse

1 ms macropulse

1 ms macropulse

Current

1 ms

Managed by UT-Battelle
for the Department of Energy
Overall status

- The Ring has kept up with all the beam power that the linac can deliver
- Reliability and availability of ring systems is very good (>95%)
- Activation per Coulomb continues to improve. Total beam loss in ring is a few parts in $10^4$ (design goal is $2 \times 10^{-4}$).
- Record high beam charge in ring: $1.3 \times 10^{14}$ ppp on Feb. 3, 2008, at 845 MeV
- Stripper foils are working well
- Beam instability measurements, extrapolated to full power operations, predict that instabilities will not interfere with normal operations
SNS power ramp up to date

Energy and Power on Target

Full design power is 1.4 MW
Ring area equipment issues

- **Momentum dump**
  - Failed due to a concurrent pressure and temperature excursion caused by a combination of excessive beam power and the inability to effectively vent the gases created by radiolysis in the water-cooled dump
  - A new momentum dump is now being designed (*M. Plum WE4PBC02*)
  - The new dump will be cooled by forced recirculated air

- **Ring injection chicane / injection dump beam line**
  - Design change in early stage of project had unintended consequences. Two chicane magnets do not have correct bend angles. Causes problems in ring injection and beam transport to injection dump.

- **Cross plane coupling in extraction beam line**
  - Traced to large skew quadrupole component in extraction septum magnet
High intensity issues

• Stripper foil lifetime
  – Now beginning to see some high-intensity effects in our diamond foils (e.g. one corner curls up)
  – Active foil development program (R. Shaw, TU6RFP042)

• Activation
  – Ring losses are mostly in line with expectations. Surprising hot spot due to combination of foil scattering and circulating beam loss. (J. Galambos, WE1GRI01)

• Instabilities
  – See small e-p instability during production conditions, installing active damping system (Z. Liu, TH5PFP027)

• Space charge effects
  – Tune shift, profile broadening
Space charge effects

\[ \Delta Q_{sc} \propto \frac{N}{\beta^2 \gamma^3} \]

<table>
<thead>
<tr>
<th>Description</th>
<th>( \Delta Q_{sc} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full power design intensity of 1.4 MW (1.5x10^{14} ppp, 1 GeV, 60 Hz)</td>
<td>0.15</td>
</tr>
<tr>
<td>For highest production (low loss) beam power to date (850 kW, 928 MeV)</td>
<td>0.11</td>
</tr>
<tr>
<td>For highest stored charge to date (845 MeV, 1.3x10^{14} ppp). Losses were high, but could be due to non-optimized tune.</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Tilted beam caused by skew quad component in extraction septum magnet

Tilted beam on the target view screen

RTBT20 wire scanner for 3 different horizontal injection kicker amplitudes

Beam distribution at BPM25 in the extraction line, reconstructed using single minipulse injection and varying extraction time
Harmonics calculation (J.G. Wang)

- ~5% due to proximity of quad
- ~75% due end effects

Integrated skew quad component 0.26 – 0.28 T at 1 GeV beam energy, reduced by ~60x at 1 GeV
Extraction septum shim replacement

OLD

NEW
Cross plane coupling

- After replacing shims in February 2009, the single minipulse reconstruction measurements were repeated.
- Cross plane coupling is now below measureable limit!
Ring area upgrades

• Now in progress:
  – Redesign primary and secondary stripper foil mechanisms
  – Neutron production target view screen
  – Injection dump beam line aperture increase

• Future upgrades
  – View screen for injection dump vacuum window, to determine beam size and position at window / dump
  – Ring extraction region to improve ability to correctly launch beam into extraction line
Summary

- The SNS power ramp up is going very well
- The ring and associated beam transport lines have kept up with all the power the linac can deliver
- We’ve solved some interesting problems
  - Cross plane coupling
  - Ring optics correction (Z. Liu, TH6PFP058)
  - Ring injection with chicane errors
  - Injection dump beam line modifications
- Upgrades are in progress to improve operability and reliability
  - Momentum dump
  - Primary and secondary stripper foil mechanisms
Beam aperture in the injection dump beam line

<table>
<thead>
<tr>
<th>Aperture [mm]</th>
<th>H0 req. aperture</th>
<th>Aperture</th>
<th>H− req. aperture</th>
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<tbody>
<tr>
<td>100.00</td>
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<td></td>
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<td>120.00</td>
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<td>200.00</td>
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Plan to increase aperture to ~100 mm radius

High BLM readings, high activation

ORBIT simulations by J. Holmes