SNS Ring Operational Experience and Power Ramp Up Status

by M. Plum

for the SNS Ring team

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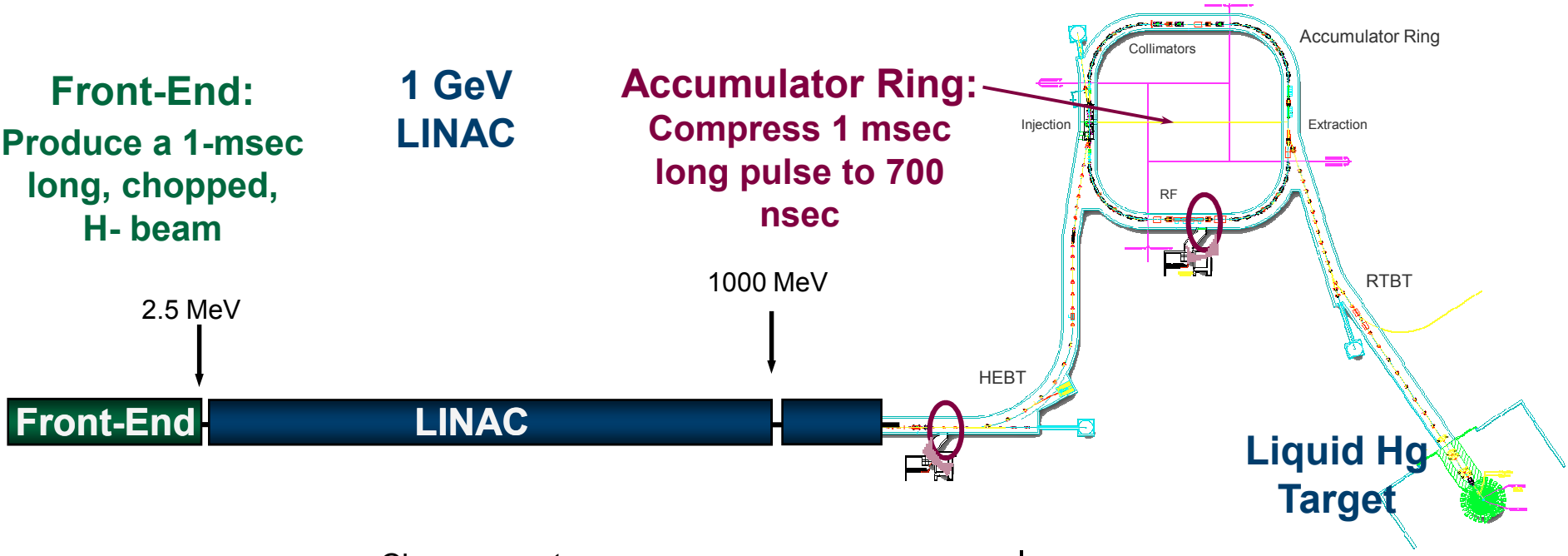
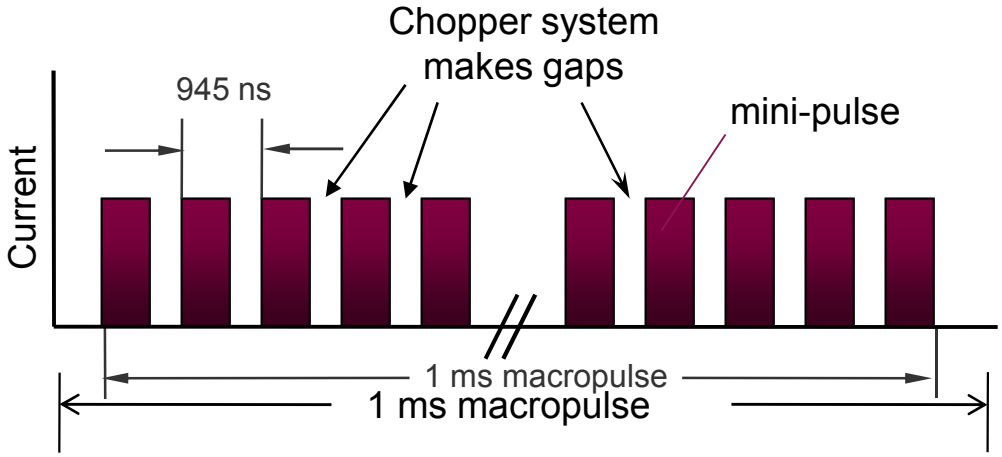
SNS Accelerator Complex

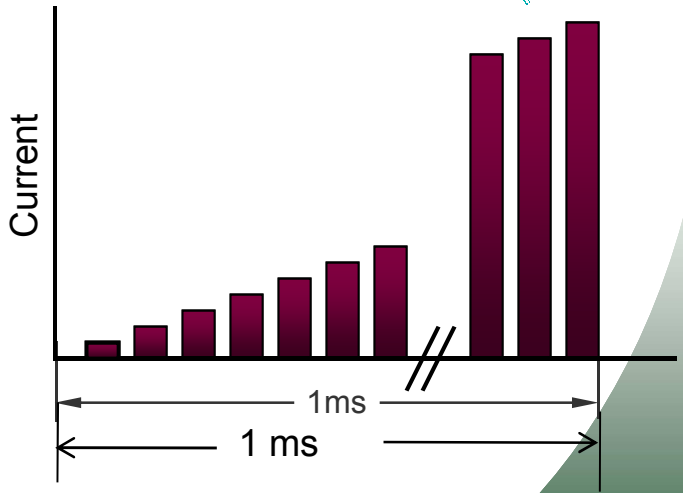
Front-End:
Produce a 1-msec long, chopped, H- beam

1 GeV LINAC

Accumulator Ring:
Compress 1 msec long pulse to 700 nsec



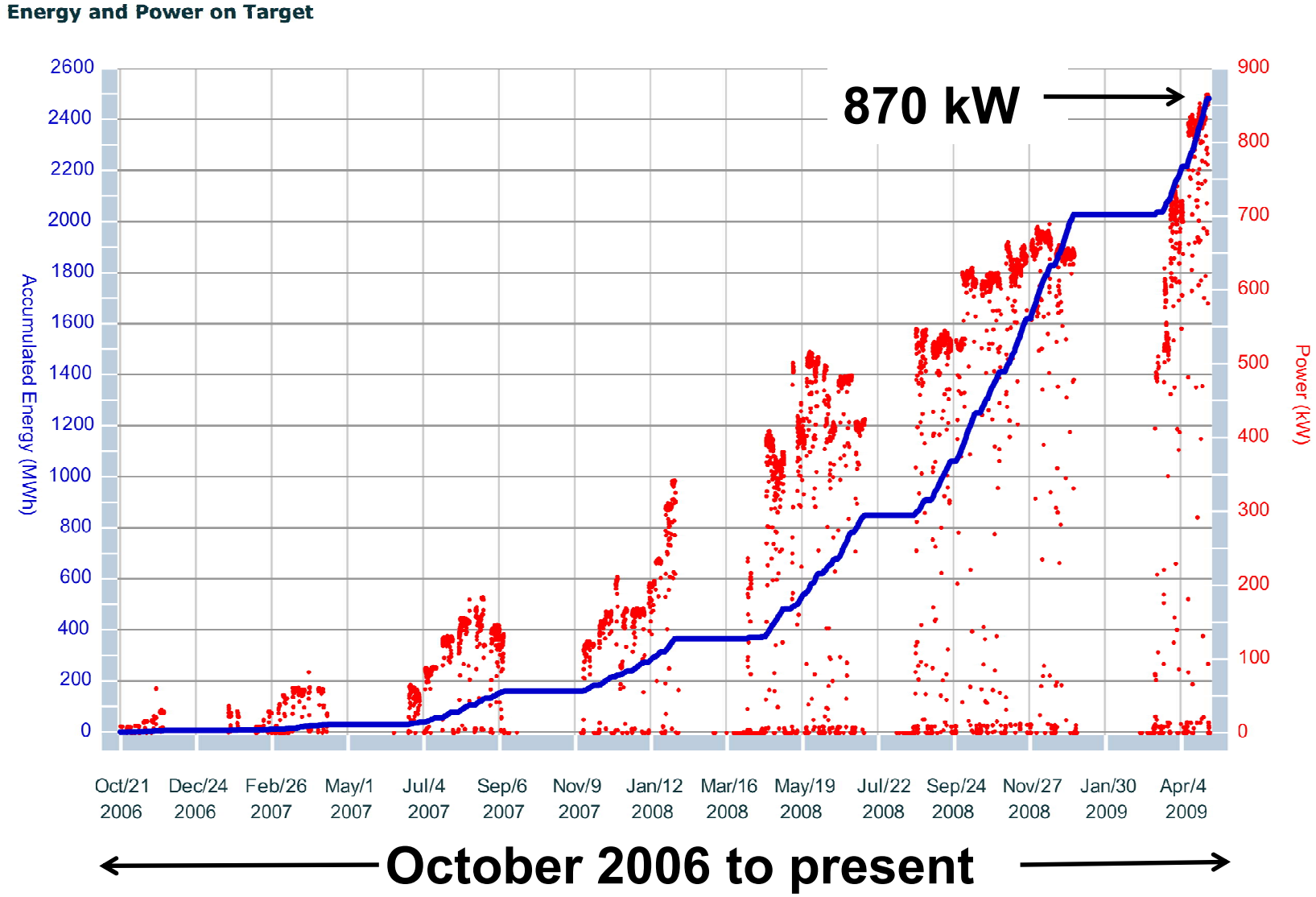




Overall status

- 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 2×10^{-4}).
- Record high beam charge in ring:
  1.3×10^{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



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

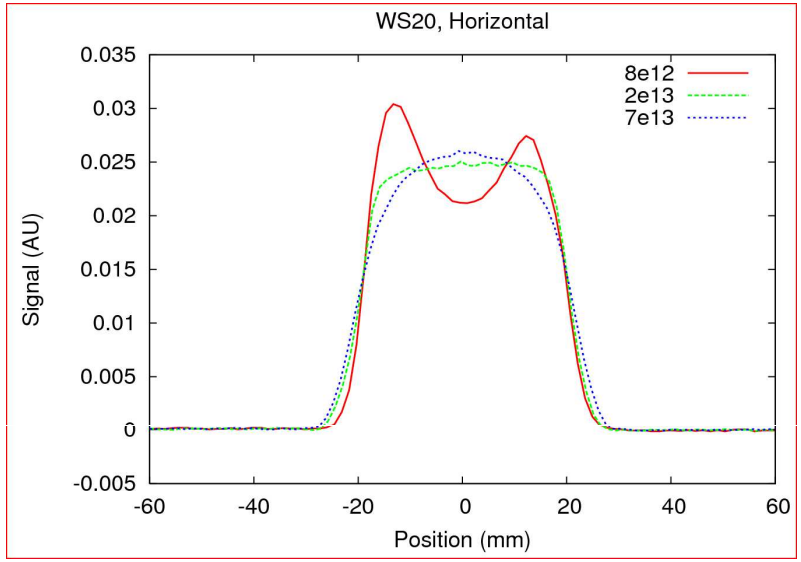
- **Stripper foil lifetime**
  - Now beginning to see some high-intensity effects in our diamond foils (e.g. one corner curls up)
  - Active foil development program *(R. Shaw, TU6RFP042)*
- **Activation**
  - Ring losses are mostly in line with expectations. Surprising hot spot due to combination of 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

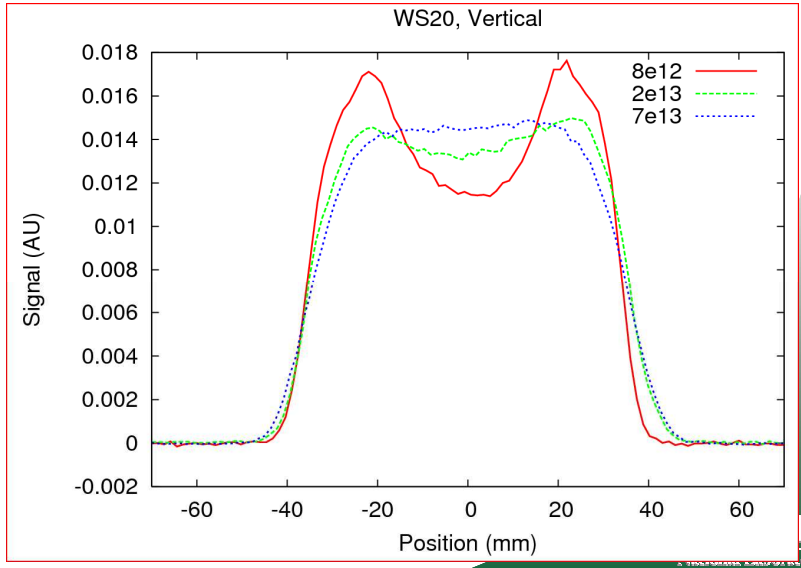
Space charge effects

$$\Delta Q_{sc} \propto N/\beta^2\gamma^3$$

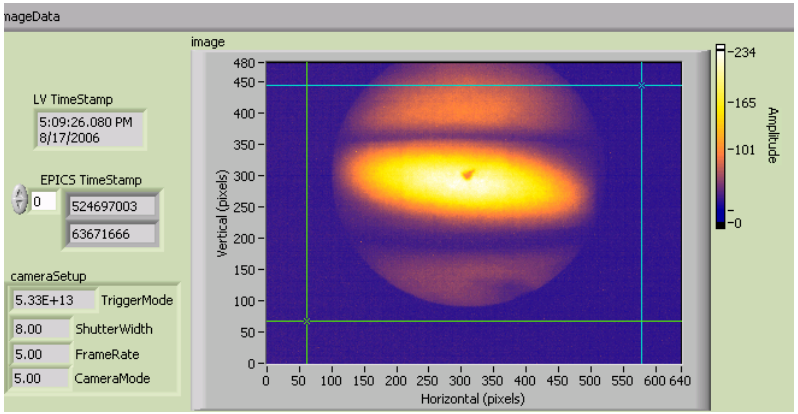
	ΔQ_{sc}
Full power design intensity of 1.4 MW (1.5×10^{14} ppp, 1 GeV, 60 Hz)	0.15
For highest production (low loss) beam power to date (850 kW, 928 MeV)	0.11
For highest stored charge to date (845 MeV, 1.3×10^{14} ppp). Losses were high, but could be due to non-optimized tune.	0.18

Low, medium, and high intensity wire scanner profiles

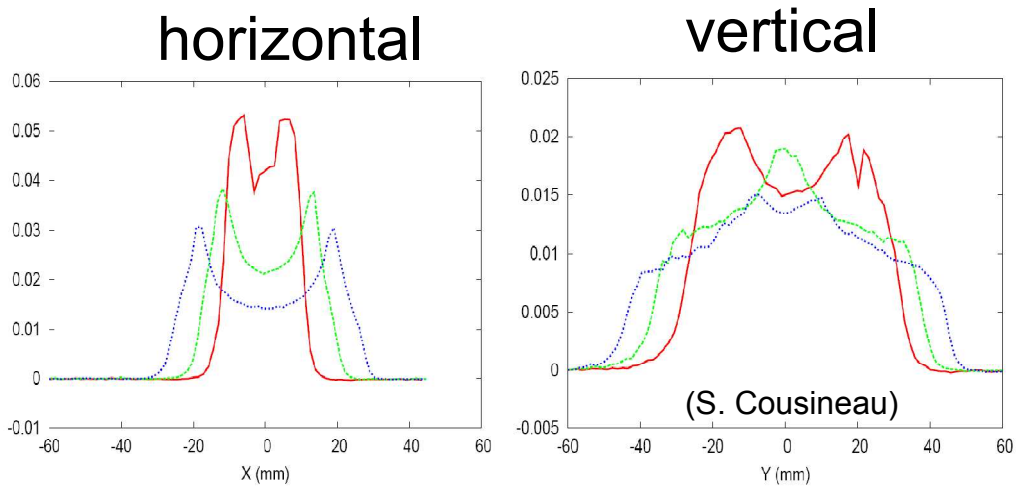




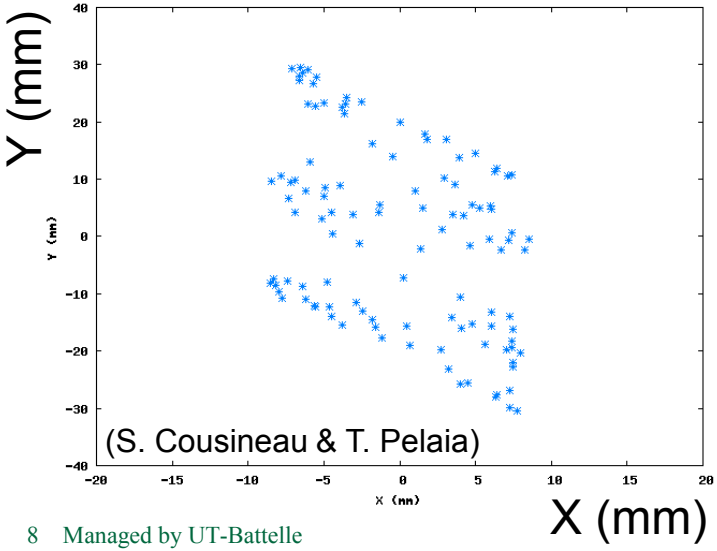
Tilted beam caused by skew quad component in extraction septum magnet



Tilted beam on the target view screen

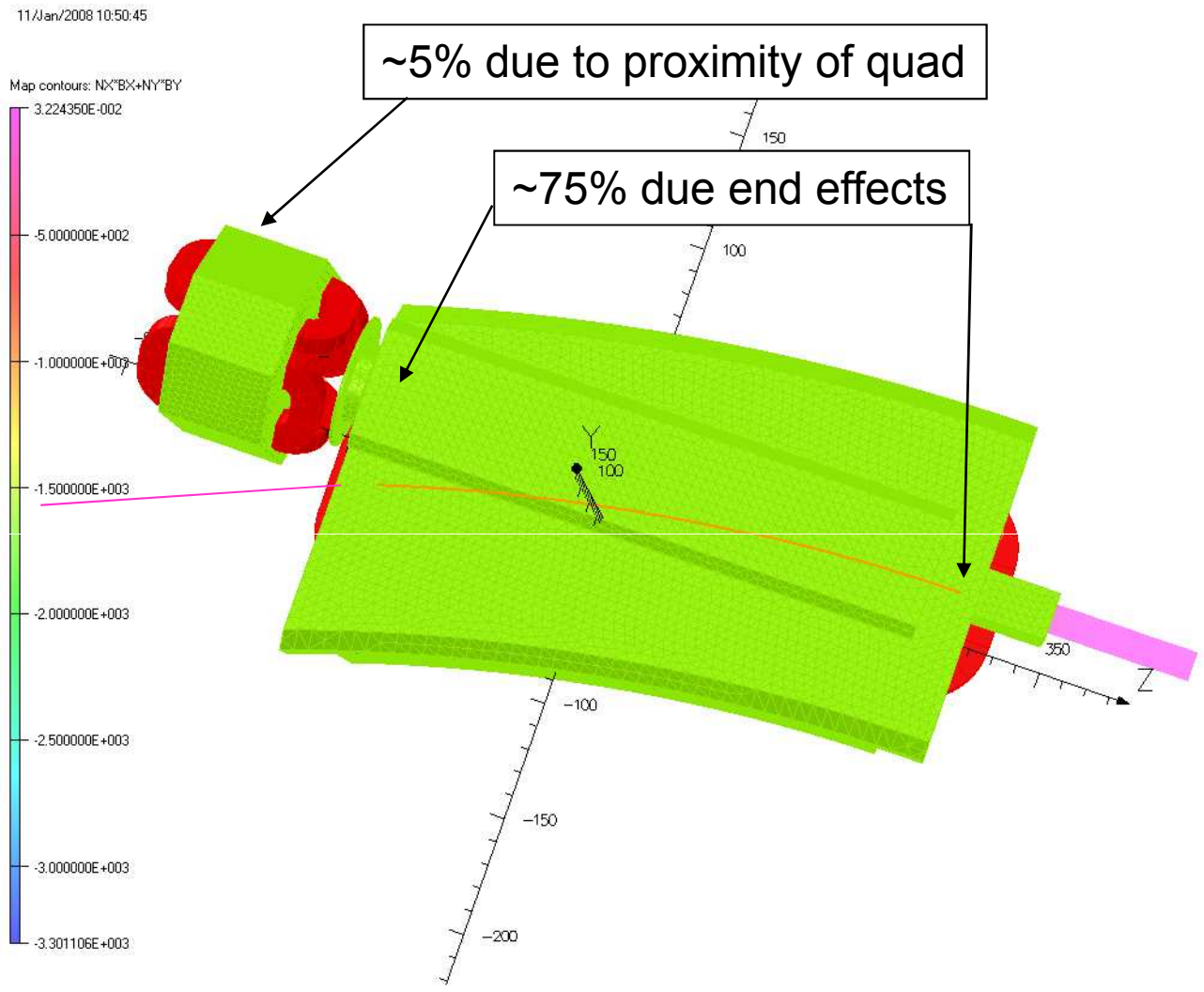


RTBT20 wire scanner for 3 different horizontal injection kicker amplitudes



Beam distribution at BPM25 in the extraction line, reconstructed using single minipulse injection and varying extraction time

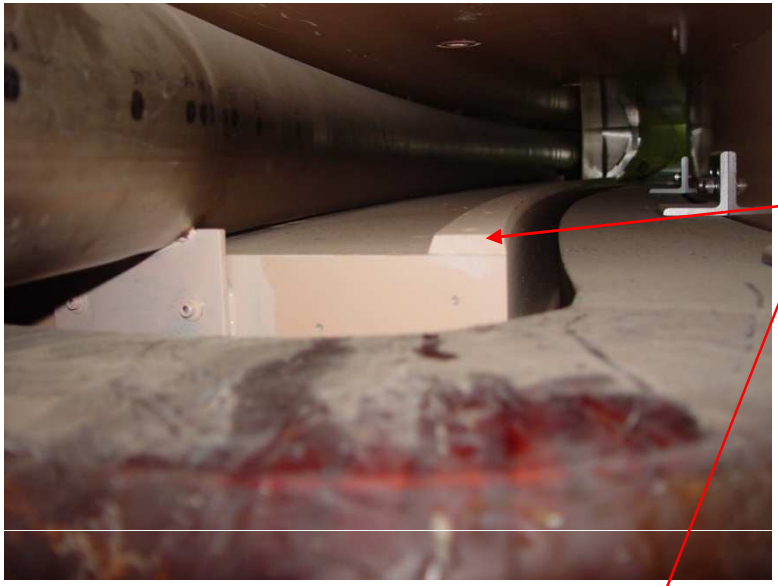
Harmonics calculation (J.G. Wang)



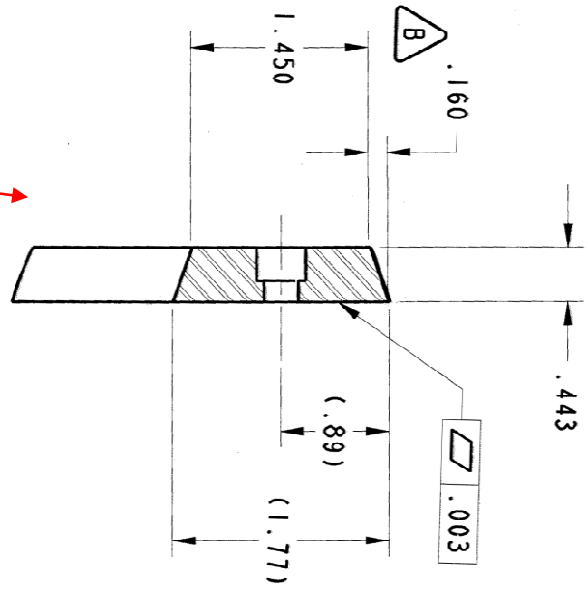
	x=-4.191 to 8.36168, y=8.88178 to -1.7764E-15, z=0.0 to 100.0
Cartesian88	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-8.8818 z=0.0 to 100.0
Cartesian89	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-8.8818 to 1.77636E-15, z=0.0 to 100.0
Cartesian90	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-6.6613 to -4.4409E-16, z=0.0 to 100.0
Cartesian91	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=1.55431 to 0.0, z=0.0 to 100.0
Cartesian92	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-1.1102 to 1.33227E-15, z=0.0 to 100.0
Cartesian93	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-1.7764 to 8.88178E-16, z=0.0 to 100.0
Cartesian94	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=1.11022 to -8.8818E-16, z=0.0 to 100.0
Cartesian95	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-8.8818 z=0.0 to 100.0
Cartesian96	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=4.4408 to 1.33227E-15, z=0.0 to 100.0
Cartesian97	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-1.3323 to 1.11022E-15, z=0.0 to 100.0
Cartesian98	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=3.33067 to -8.8818E-16, z=0.0 to 100.0
Cartesian99	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-5.5511 to -9.992E-16, z=0.0 to 100.0
Cartesian100	CARTESIAN 401x51 Carte (nodal) x=-4.191 to 8.36168, y=-1.0265 to -1.5047E-15, z=0.0 to 100.0
Arc	ARC (nodal) 1001 Carte x=0.0 to -36.06153, y=0.0 to -1.7271E-15, z=0.0 to -244.2

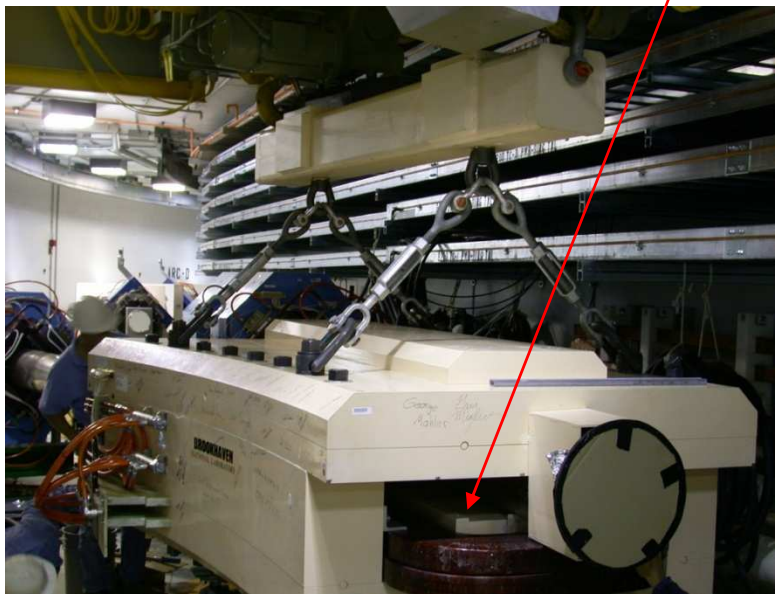
Integrated skew quad component 0.26 – 0.28 T at 1 GeV beam energy, reduced by ~60x at 1 GeV

Extraction septum shim replacement

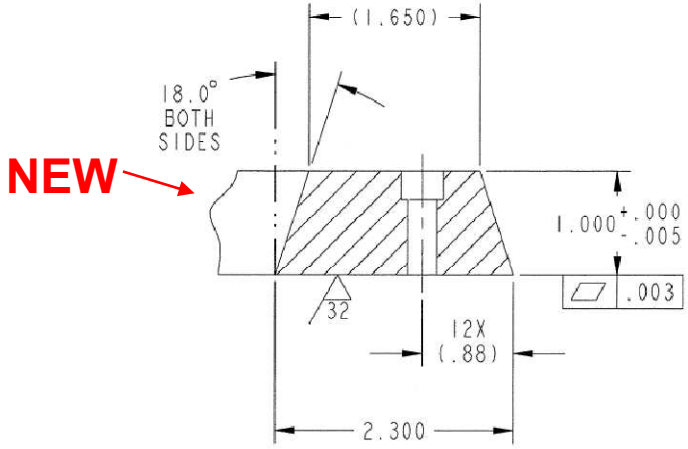


OLD →



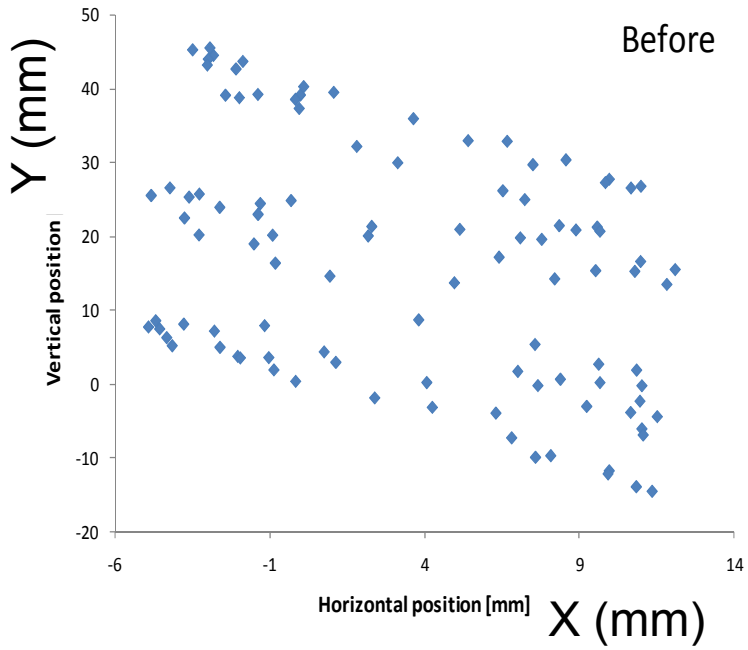


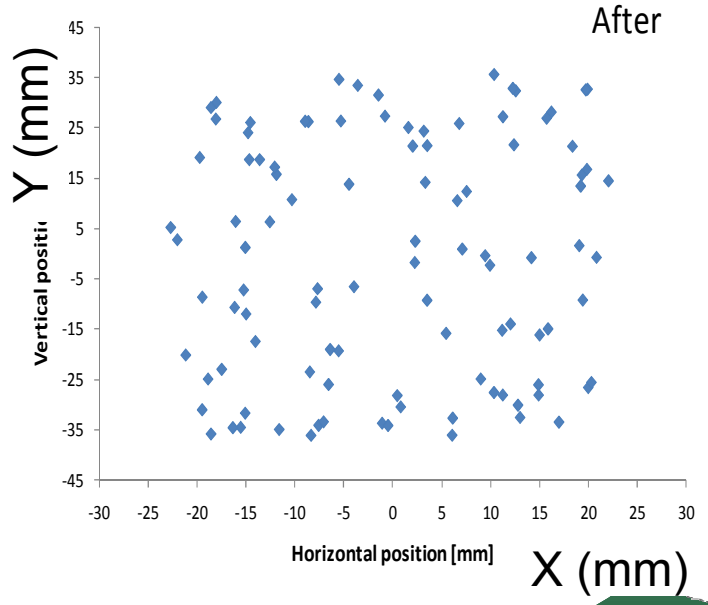
NEW →



Cross plane coupling

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





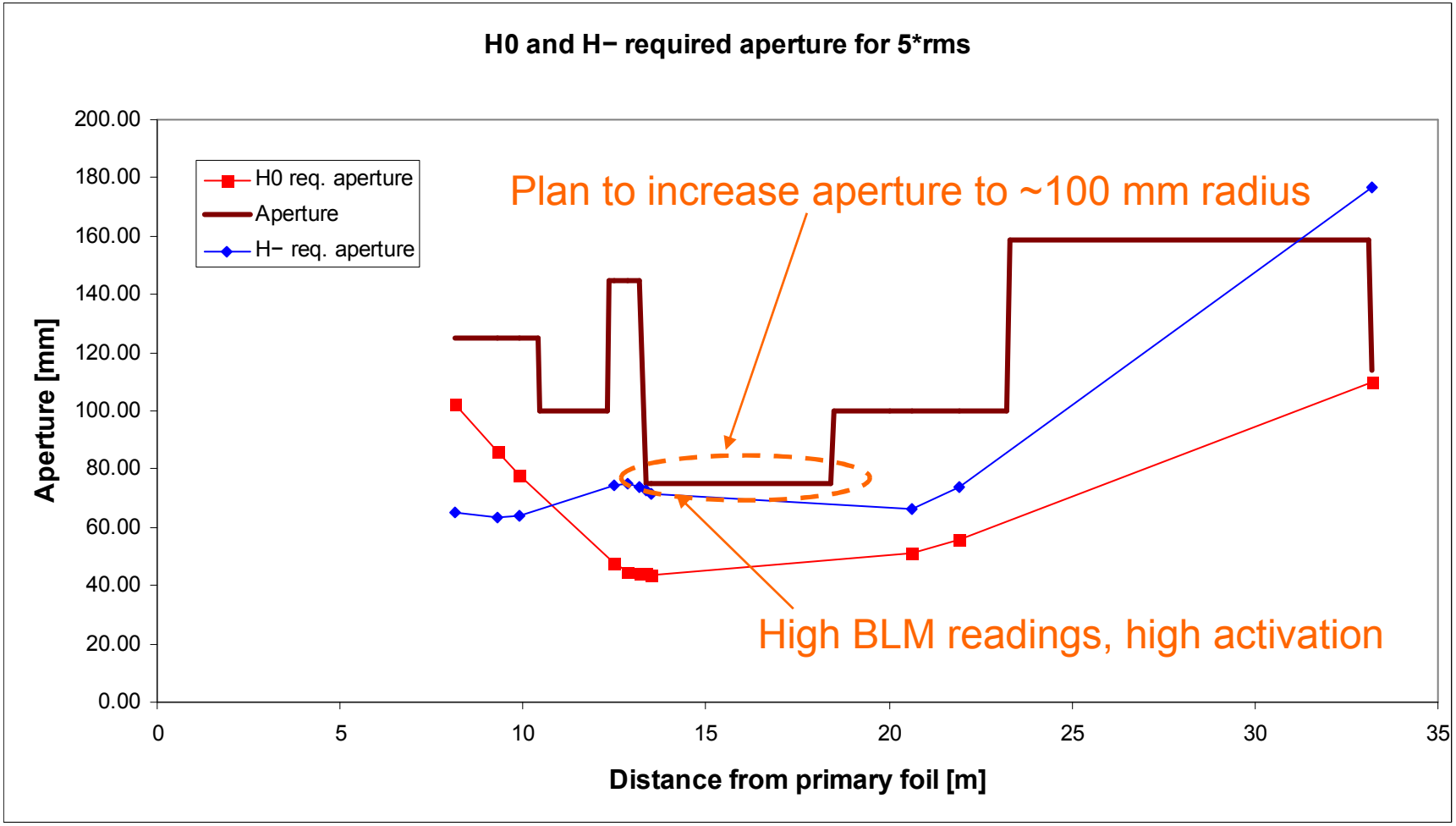
Ring area upgrades

- **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



ORBIT simulations by J. Holmes