

# Injection and extraction - lessons learned

USPAS

by

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# Lessons learned

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- It can be very educational to learn about problems that have occurred at other accelerators
- Each generation of accelerators builds on the accomplishments and lessons learned from the previous generation

# SNS injection

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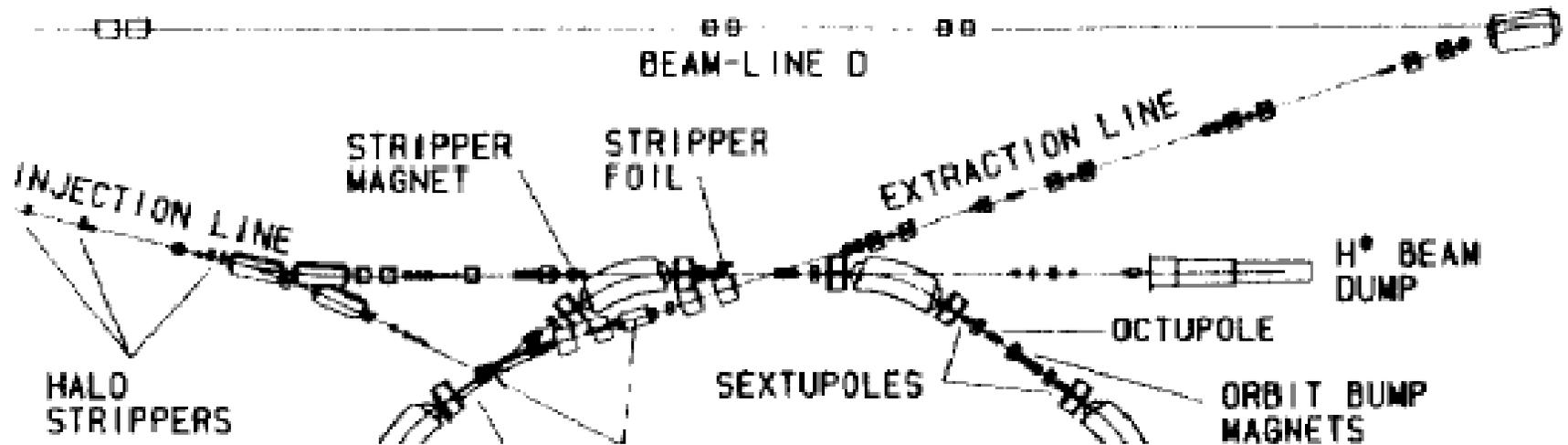
- SNS was the first ring to put the stripper foil in a magnetic field
- So far it is working well, except for a design change made in the location of the stripper foil within the magnet. The consequences of this change was not appreciated at the time, and this caused problems in the ring injection and injection dump line trajectories.
- The usual design codes did not pick up the problem with the injection trajectories because everything is relative to the closed orbit
- **Lesson learned:** Particle tracking simulations through 3-D magnet models provide a more thorough test of the design. Use this technique in complex beam transport areas.

- The SNS has issues with cross plane coupling in the extraction beam line, caused by a large skew-quad component in the extraction Lambertson septum magnet
  - Magnet was not thoroughly modeled or measured due to lack of resources
- **Lesson learned:** Carefully model the un-ordinary magnets
- **Lesson learned:** Map every magnet, especially the un-ordinary ones

# PSR $H^0$ injection

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- It was a clever idea at the time
- Effect of stochastic magnetic stripping of  $H^-$  to  $H^0$  was not appreciated ( $\sim 3x$  increase in emittance)
- Effect of injection mismatch was not appreciated (another  $\sim 3x$  increase in emittance)
- **Lesson learned:** Think hard about new injection schemes!



# Rolled (skewed) beam lines

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- These beam lines are often proposed as a way to save space and money
  - PSR injection line is rolled
  - PSR extraction line is rolled
  - SNS extraction septum magnet is rolled
- They always seem to cause problems
  - Difficult to tune
  - 2-D emittance can increase
  - Difficult to model with sufficient accuracy
  - After man-years of effort, the PSR extraction line profile measurements still do not agree with model calculations
- **Lesson learned:** Avoid rolling those beam lines!
- Also avoid offset quads for steering (we have some of these at SNS)

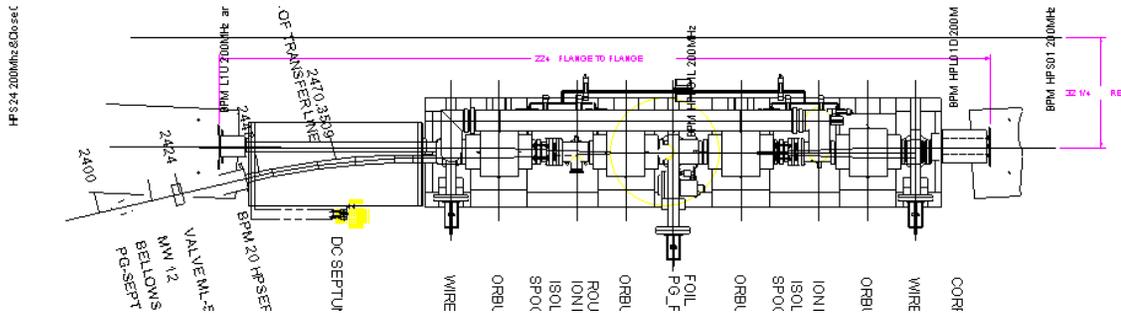
# Lack of diagnostics

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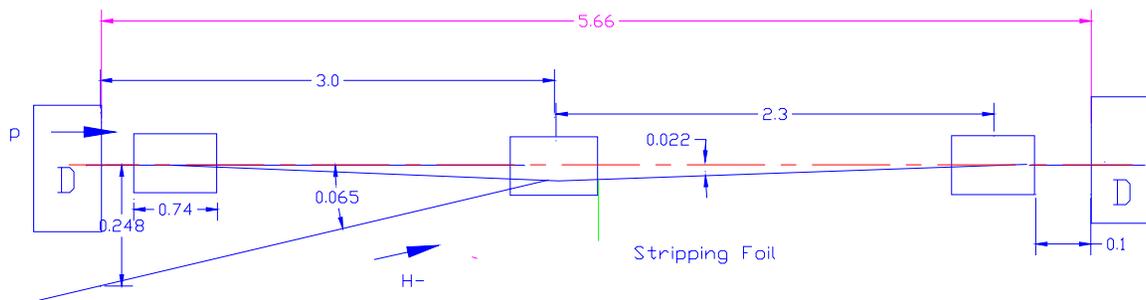
- At SNS we have difficulty tuning the extraction line because there are no position monitors just upstream and downstream of the septum - have to set 14 kicker amplitudes and understand offset quad
- We also have difficulty steering the  $H^0$  and  $H^-$  beams to the injection dump, and steering the high-power beam to the spallation target
- **Lesson learned:** Don't skimp on beam diagnostics, especially where it is important to get the beam positions to their final destinations and around complex beam lines

# FNAL Booster injection

- DC Septum had small hole for circulating beam and some amount of field was leaking into the circulating beam
- More complex than necessary - plan is to simplify
  - Eliminate septum
  - Reduce chicane magnet count from 4 to 3
  - **Lessons learned:** Beware of stray fields (map those magnets!); simple is good!



Old



New

(Courtesy M. Popovic)