Summary of Working Group C

Accelerator System Design
Injection, Extraction, Collimation

Sarah Cousineau

Deepak Raparia

8/29/2008

Talks

• System in Operation	4 Talks + 3 Poster
• System under Design	3 Talks + 1 Poster
• Foil Test	1 Talk
• Discussion	1.5 Hrs
Total	8 Talks + 4 Poster

Systems In Operation

1. Does the system perform as expected? Did the simulations/calculations during design predict actual performance?

2. What are the major performance limitations? Were they known during design?

3. What is the one piece of advice you would give a future designer of this system?

SNS Injection (M. Plum)

Does the system perform as expected?

No. There were a number of surprises:

1. Design bend angles of injection chicanes were not correct.
2. Vertical steering in fourth chicane was unexpected.
3. Beam loss in injection dump was higher than expected.

Many modifications have been made in the injection dump region to date to mediate these issue.

In order to reach 550 kW, more things had to go right than wrong!

SNS Injection Modifications to Date

Radiation monitor on vacuum window water cooling return pipe

New C-magnet

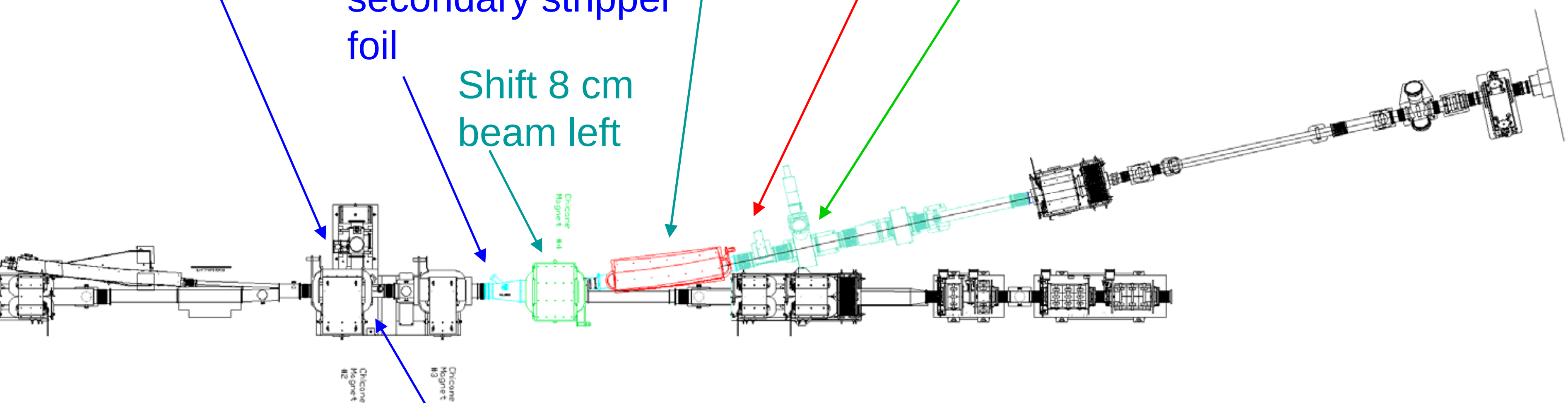
Increase septum magnet gap by 2 cm

New WS, view screen, BPM, NCD (ridicules)

Oversize & thicker primary stripper foil

Thinner, wider secondary stripper foil

Shift 8 cm beam left



Electron catcher IR video

beam line drawing from J. Error

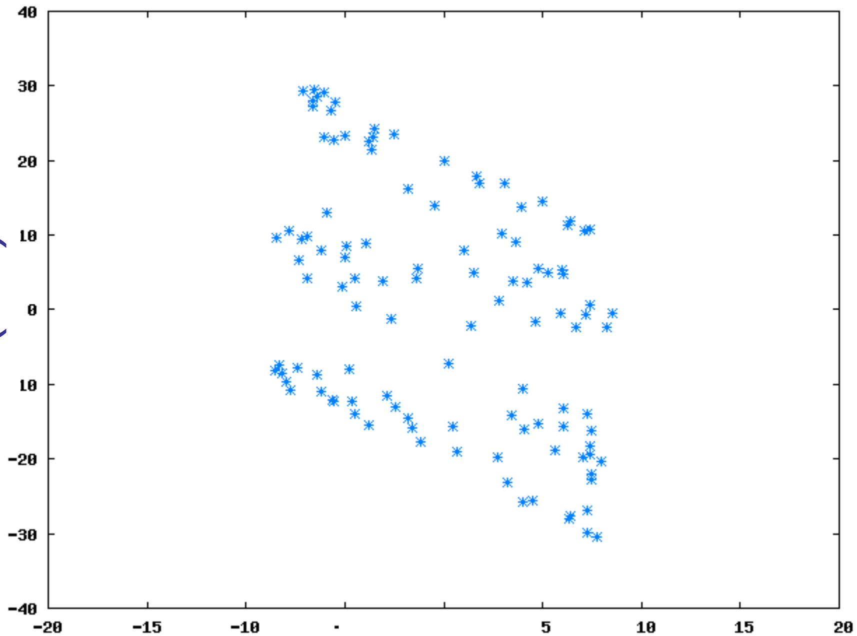
SNS Extraction (M. Plum)

Does the system perform as expected?

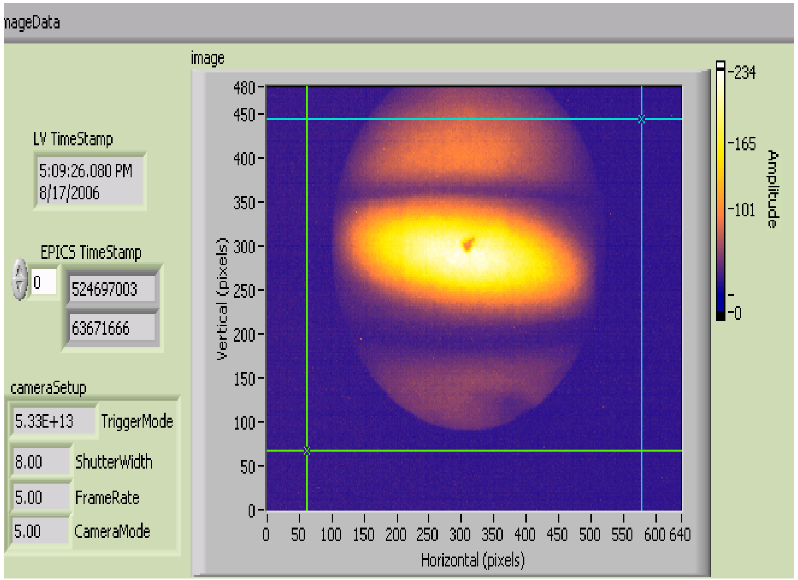
- Yes, mostly. Only surprise was a strong skew quad component in the extraction septum.

- Plans for mediation underway.

Measured Real Space Distribution at BPM



Beam on Target Viewscreen



SNS Injection and Extraction (M. Plum)

What are the major limitation in performance? Where they known during design stages?

Injection:

Biggest issue is beam loss in the injection dump line. This was not known about during design stage

Extraction:

Lack of diagnostics at front of extraction line and at the end of line near the target makes it hard to measure/correct extraction trajectory, and beam position + density on target.
This was known ahead of time.

SNS Injection and Extraction (M. Plum)

What advice would you give to a future designer of the same system?

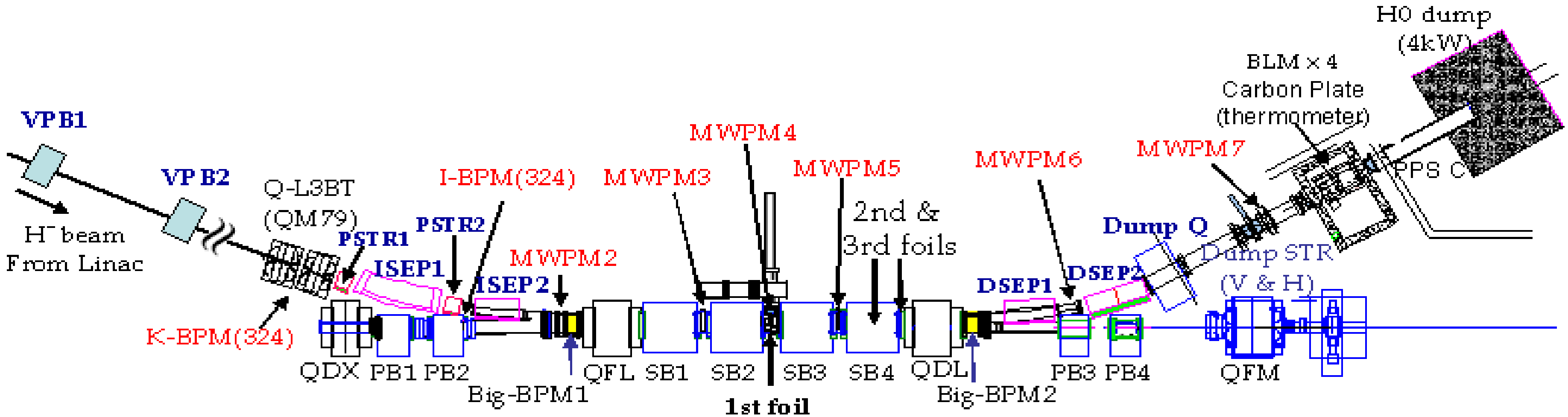
1. Perform 3D field simulations in complex regions such as injection, extraction.
2. Map magnets well enough to measure higher order moments
3. Allow independent control over beam species
4. Have enough diagnostics in critical regions to diagnose beam issues (injection, extraction, etc)

JPARC Injection And Extraction (P. Saha)

Does the system perform as expected?

<u>Injection and Extraction:</u>

- Yes. Injected and extracted beam orbit even with very different parameters goes through expectation.
- The beam profiles are also quite similar.
- The relative parameters of all magnets are exactly similar to the simulation/calculation



HB2008
Loew's Vanderbilt Hotel ★ Nashville, Tennessee, USA ★ August 25-29, 2008

JPARC Injection and Extraction

What are the major limitation in performance? Where they known during design stages?

1. Foil system was one big limitation of the injection commissioning. But it's going to be fine from the next run.

2. No BPM in the extraction section is one small limitation concerning extraction.

JPARC Injection and Extraction (P. Saha)

What advice would you give to a future designer of the same system?

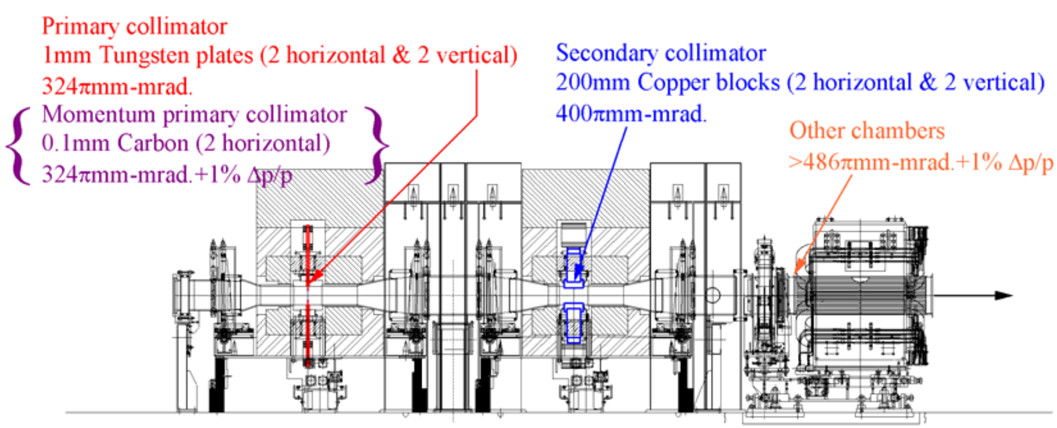
1. Have enough monitors/diagnostics, especially in the complicated areas like injection and extraction.
   (A shared concern with SNS!)

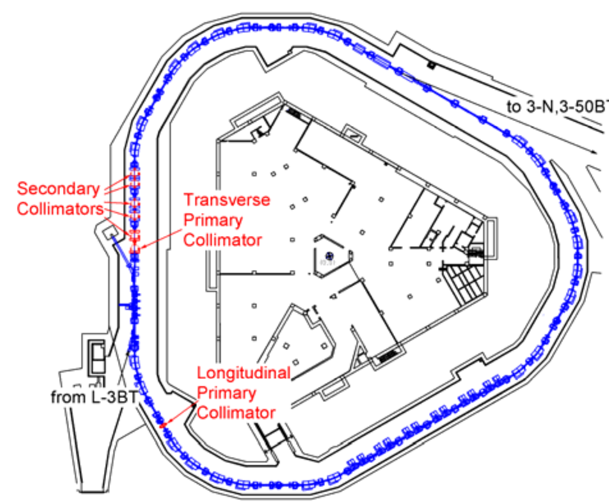
2. Keep (check for) enough space for not to push nearby magnets/elements nor make thinner the shield at the last moment to install later elements/magnets

JPARC Collimation (K. Yamamoto)

Does the system perform as expected?

- Transverse collimation: Yes, so far experiments have shown that it performs as expected.
- Longitudinal collimation: No, the system did not perform as expected – it did not reduce beam loss in the expected area. However no longitudinal halo observed so far, so this is not a problem yet.





JPARC Collimation (K. Yamamoto)

What are the major limitation in performance?
Where they known during design stages?

- The technical limitation is not clear yet because high power has not been run yet due to dump limitations.

JPARC Collimation (K. Yamamoto)

What advice would you give to a future designer of the same system?

1. Focus on high radiation issues, such as creating durable components that are easy to maintain in order to reduce maintenance exposure times.

2. Try to reduce longitudinal halo by other means besides longitudinal collimation (RF, chopping, etc).

FNAL Main Injector Collimation (B. Brown)

Does the system perform as expected?

1. Yes. Reduces un-captured beam loss by factor of 10. Also reduces injection-induced losses by a factor of 2.

2. Greater than 90% loss control with collimators.

FNAL Main Injector Collimation System (B. Brown)

What are the major limitation in performance? Where they known during design stages?

1. Machine irradiation of magnets in collimation regions. Expect a life of only a few years. Yes, knew this during the design stage.

2. Position control but no angle control available for primary collimators. Beam comes in at an angle so it’s not parallel to collimators.

FNAL Main Injector Collimation (B. Brown)

What advice would you give to a future designer of the same system?

1. Do the appropriate simulations in very high details.

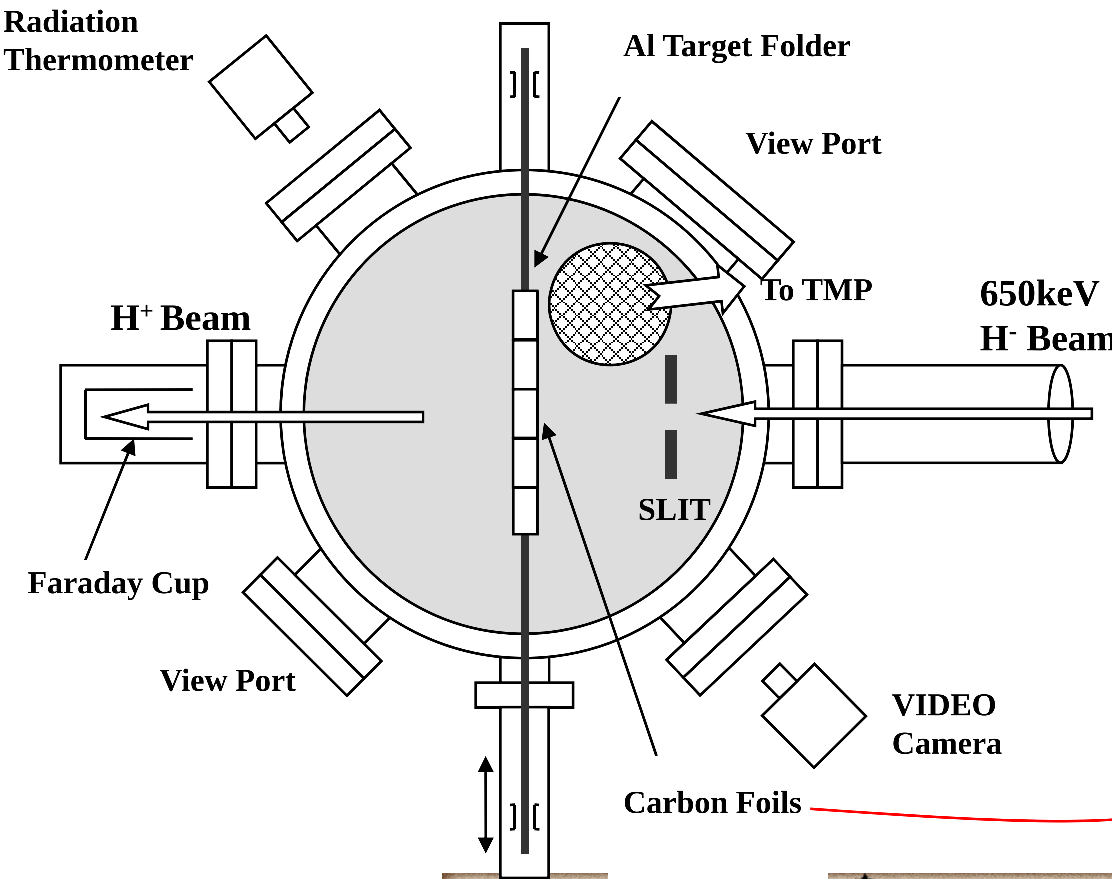
2. For a new facility, incorporate a dedicated cleaning section.

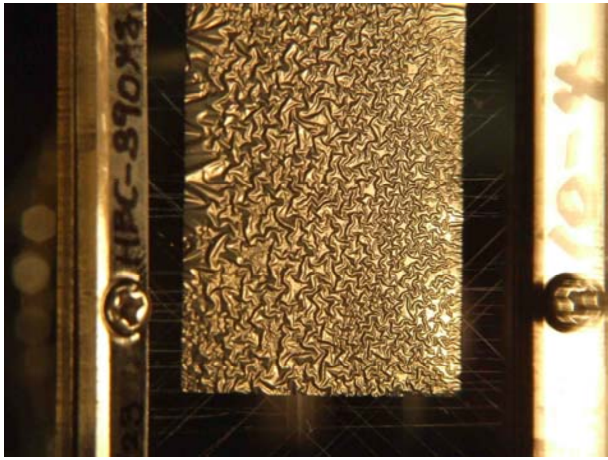
Summary of the Summary… Operational Systems

System	Performed as expected ?	Biggest challenge?	Any Advice?
SNS Injection	No	IDmp loss	3D modeling, Magnet multipole measurement Independent control waste beams
SNS Extraction	Yes	Need more diagnostics	More diagnostics in complex regions
JPARC Injection	Yes	Foil system (fixed soon)	-
JPARC Extraction	Yes	No BPM at extraction	More diagnostics at start of extract More real-estate for magnets
JPARC Collimation	Yes (trans) No (long)	-	Focus on comp. maintenance issues Reduce long. halo other ways
FNAL Collimation	Yes	Lifetime of nearby magnets	Do very detailed design simulations Have a dedicated cleaning section

Lifetime Measurement of HBC Foils using KEK 650 KeV Beams (I. Sugai).

- Described HBC foils – Hybrid Boron-Carbon
- For 9 foils of different variety, measured temperature, lifetime, curl/bend/break properties under irradiation from 650 KeV beam.





HBC Single Layer Foil

Lifetime Measurement of HBC Foils using KEK 650 KeV Beams (I. Sugai).

Type of foil	Lifetime (h)	Initial thickness ($\mu g/cm^2$)	Foil conditions	Foil Temperature (K)
Single HBC sandwiched by SiC fibers (KEK)	256.5 survival	417	No deformation, but pin-holes	1970
Double Layered HBC sandwiched by SiC fibers (KEK)	203.5 survival	210 x 2	Small shrinkage and No pin-holes	1950
Microcrystalline Diamond sandwiched by SiC fibers (SNS)	10.5	349	Back bending and No pin-holes	1930
Nanocrystalline Diamond without SiC fibers (SNS)	21.0	439	Back bending and pin-holes	1950
Nanocrystalline Diamond with Si frame (SNS)	62.0	541	Crack inside frame and No pin-hole	2100
Multi-DLC (TRIUMF)	1.0	480	Broken	2260
Carbon nano-tube (AIST)	9.0	450	Broken	1880
CM (Arizona) with SiC	1.5	425	Broken	1920
Microcrystalline Diamond with Si frame (Kobelco)	61.5	540	Crack inside frame and Big a hole	2080

HBC foils had best overall performance in this study.

Systems Under Design

1. What is the biggest design challenge?

2. Are the tools and knowledge base in the field adequate?

Laser Stripping for Injection for High Intensity Machines (V. Danilov).

What is the most difficult design challenge?

- For the SNS system, laser beam recycling which is necessary to give adequate laser power for the requisite UV laser system.

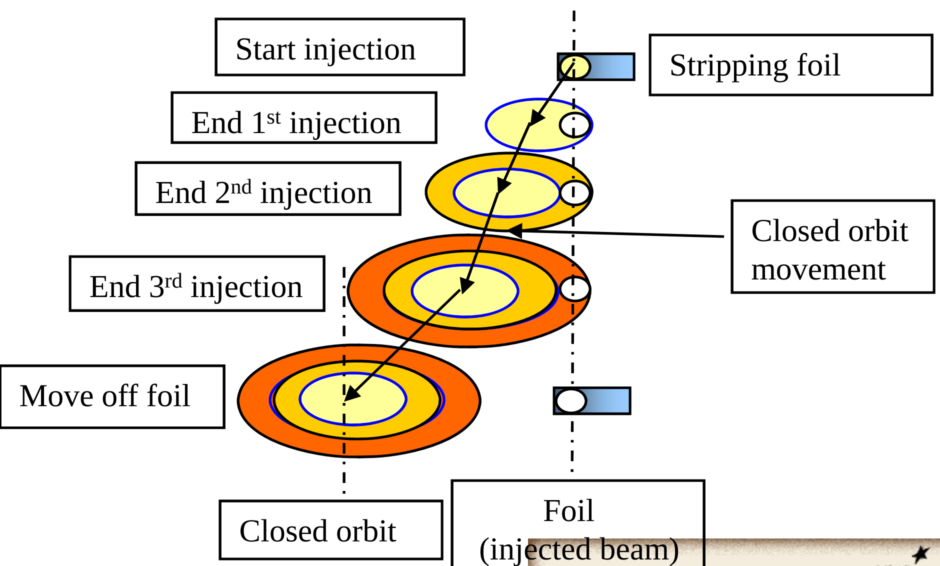
- For machines with energy > 3.5 GeV (LHC 4 GeV upgrade, Project X), infrared laser system can be used, and peak power should not be an issue (calculated factore ~20 less than SNS).

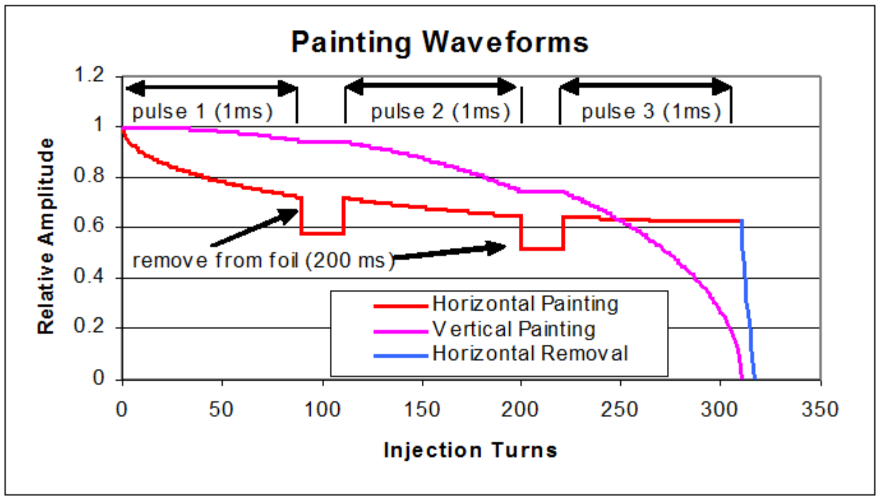
Project-X Injection and Extraction Challenges (D. Johnson).

Project X: 8 GeV linac (5Hz, 9mA, 360 kW) feeding either recycler or Main Injector.

What are the most difficult design challenges?

1. Recycler injection painting system which will span 3 linac beam cycles.

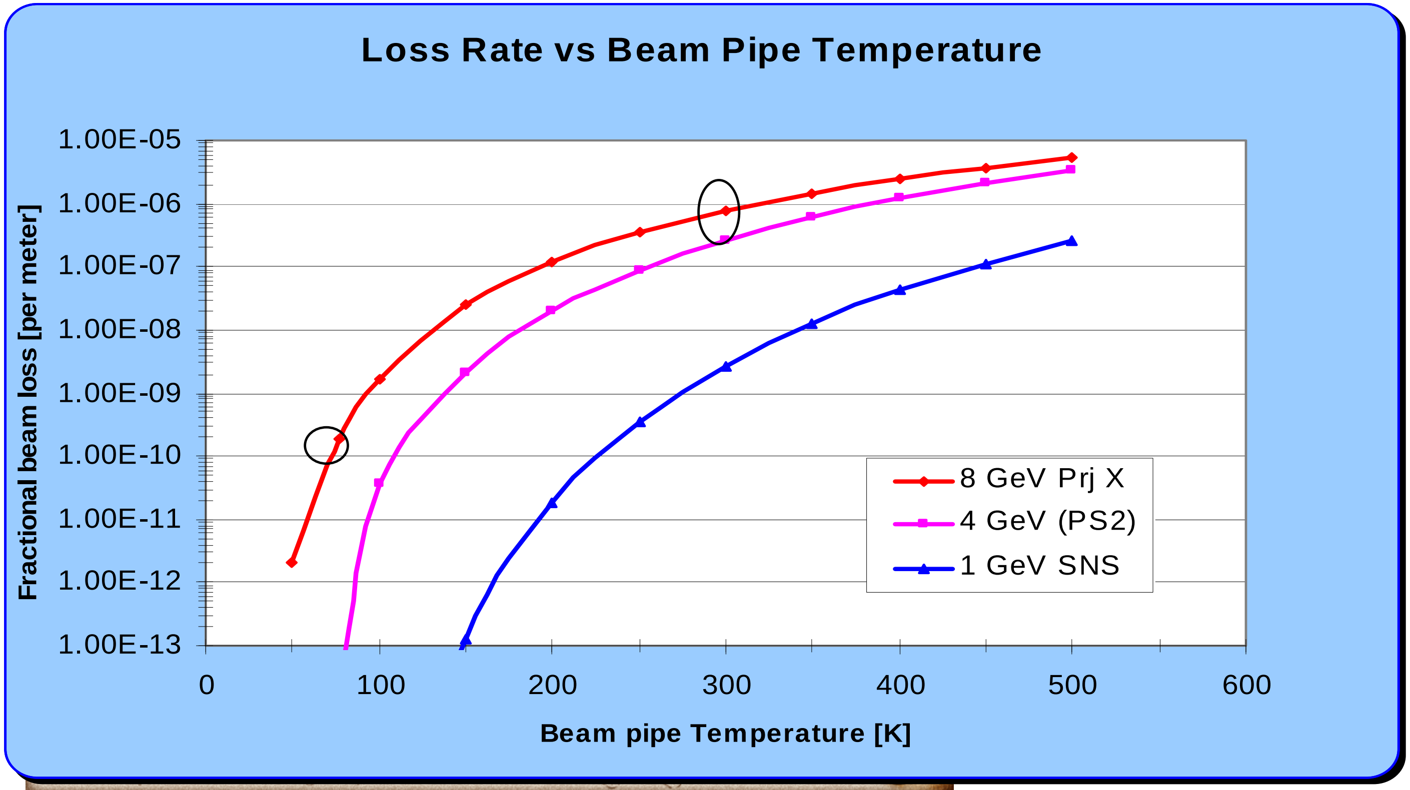




Project-X Injection and Extraction Challenges (D. Johnson).

What are the most difficult design challenges?

2. Achieving 0.05 W/meter loss limit. Black body stripping of H- is major concern. Calculations show it will be necessary to cool beam pipe to ~22K in order to reduce effect and meet beam loss criterion.

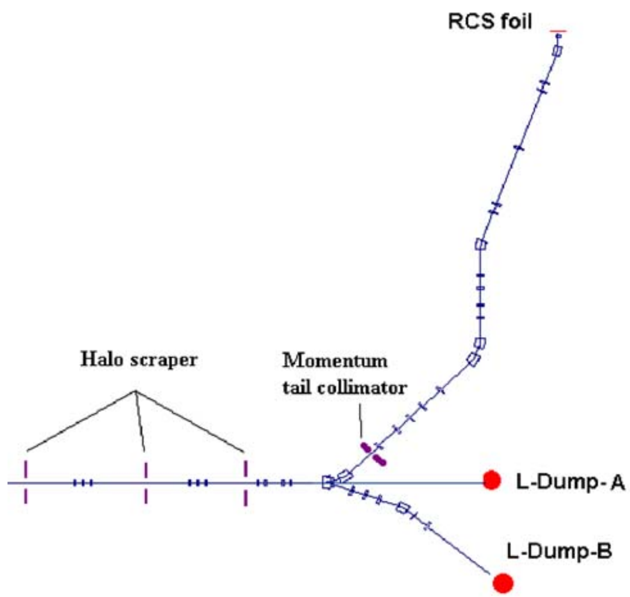


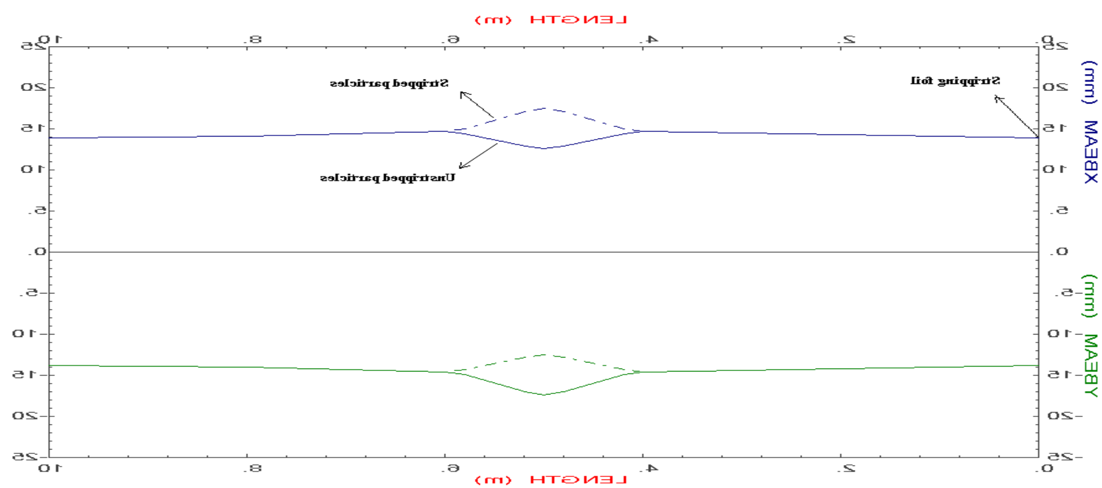
Collimation at CNS by Triplet Foil Scattering (J. Tang).

What is the most difficult design challenge?

Two triplet cells of 60° in the straight section, three double-waists

- **Three pairs of scrapers (stripping foil) at each waist to make hexagonal emittance cut**
- **H+, H0 and H- mixed transport, H+ guided to beam dump after the switch magnet**





- None

Summary of the Summary… Systems in Design

System	Biggest Challenge?	Tools Available?
Project X	Injection Painting 0.05 W/m limit Black-body stripping	Yes.
Laser Stripping	For SNS, laser recycler system for achieving required laser power	Some. Much of theory is under development now.
CSNS Collimation	None	

Other Discussion Items

• FNAL Project X is counting on scraping/collimation in transport line to keep losses low, ensure clean injection.

→ But at SNS, beam halo causes problems at injection foil, but so far scraping in the transport line has had no effect. Why? Uknown.

• SNS is running with wider foils because of halo – Should the design criterion focus more on the 99% emittance than the rms?