THE APS UPGRADE ACCELERATOR

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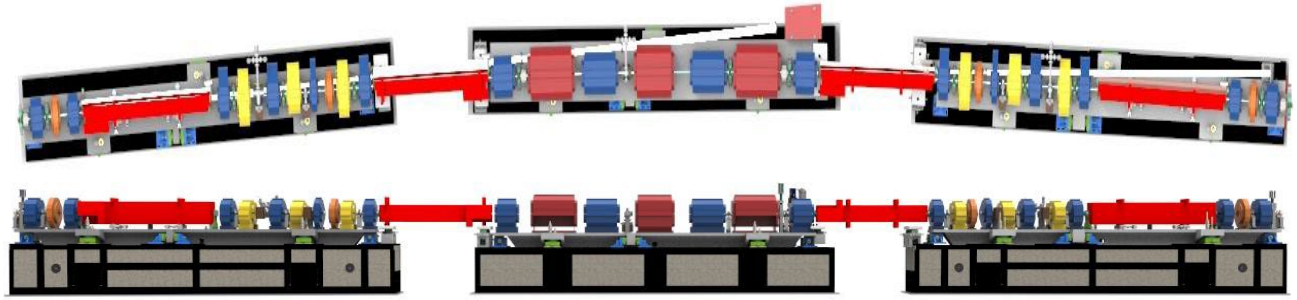
THE APS-U ACCELERATOR LATTICE

Number of sectors: 40

40-fold symmetric multi-bend achromat based on ESRF design, including 6 reverse bends per sector in addition to 7 forward bends.

The design is the brainchild of Michael Borland.



- Beam Energy: 6 GeV
- Beam Current: > 200 mA
- Maximum single bunch current: > 4.2 mA
- Circumference: 1103.608 meters
- Minimum bunch spacing: 11.36 ns
- Available fill patterns: 48 to 324

- Available fill patterns: 48 to 324 uniformly-spaced bunches, with ion clearing gaps
- Tunnel temperature stable within +/- 0.1 degrees C
- Horizontal on-axis swap-out injection

HIGH-LEVEL LATTICE PARAMETERS*

Quantity	APS Before	APS MBA Timing Mode	Units
Beam Energy	7	6	GeV
Beam Current	100	200	mA
Number of Bunches	24	48	
Bunch Duration (rms)	34	104	ps
Energy Spread (rms)	0.095	0.156	%
Bunch Spacing	153	77	ns
Emittance Ratio	0.013	1	
Horizontal Emittance	3100	31.9	pm-rad
Horizontal Beam Size (rms)	275	12.6	μm
Horizontal Divergence (rms)	11	2.5	μrad
Vertical Emittance	40	31.7	pm-rad
Vertical Beam Size (rms)	10	7.7	μm
Vertical Divergence (rms)	3.5	4.1	μrad

*Parameters c. 2017

Previous APS APS MBA

Emittance is related to the product of beam size and angular divergence (phase space area)

KEY PERFORMANCE PARAMETERS

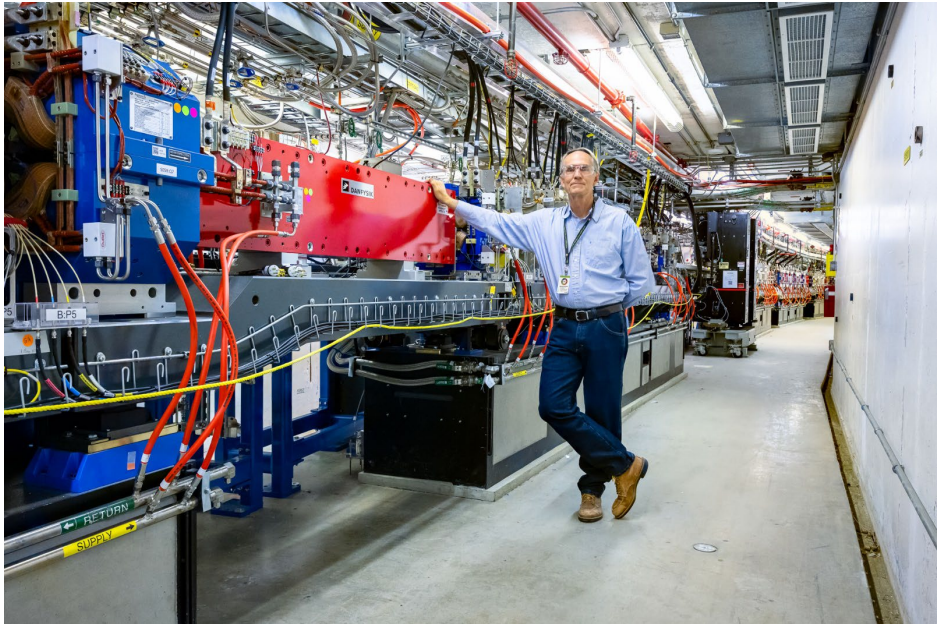
Key Performance Parameters	Thresholds (Performance Deliverable)	Objectives
Storage Ring Energy ✓	> 5.7 GeV, with systems installed for 6 GeV operation	6 GeV
Beam Current ✓	≥ 25 mA in swap-out injection mode with systems installed for 200 mA operation	200 mA in swap-out injection mode
Horizontal Emittance	< 130 pm-rad at 25 mA	≤ 42 pm-rad at 200 mA
Brightness @ 20 keV[1]	> 1 x 10^{20}	> 1 x 10^{22}
Brightness @ 60 keV[1]	> 1 x 10^{19}	> 1 x 10^{21}

[1]photons/sec/mm^2/mrad^2/0.1%BW

✓ **Complete**

ACTUAL HARDWARE

September 2004



May 2024

HISTORICAL FOOTNOTE

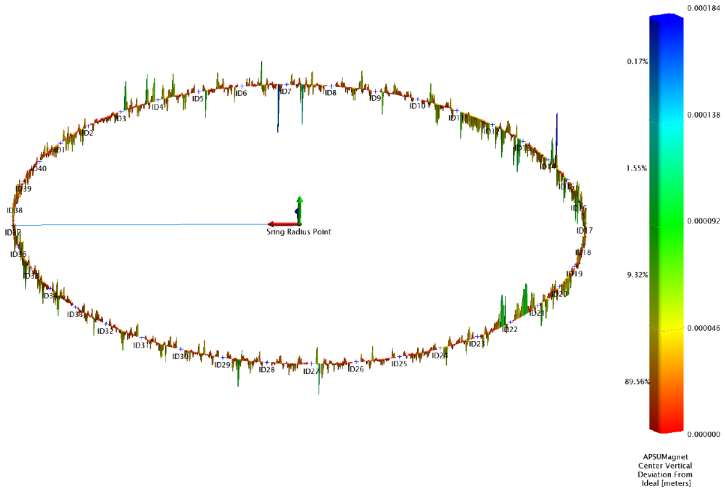
CESR

- **5 GeV**
  (APS-U is 6 GeV)
- **768-meter circumference**
  (APS is 1104 meters)
- **Used for B meson research**
  (Now used for synchrotron radiation studies – CHESS and accelerator training)
- **Correct color scheme**

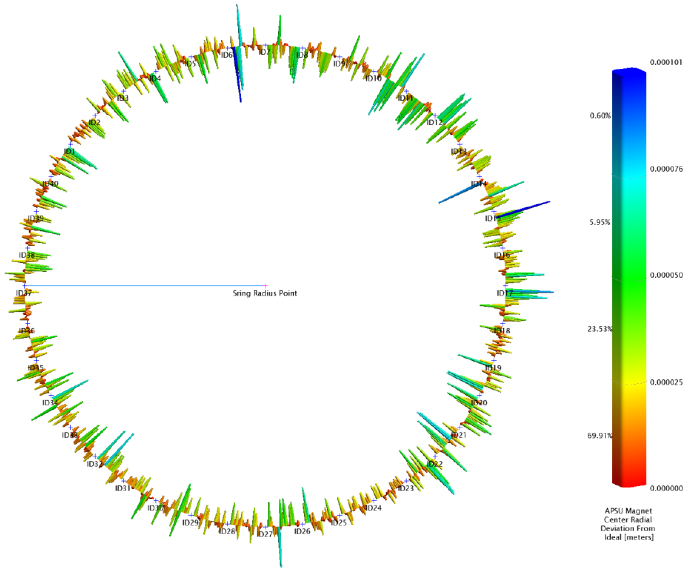
Cornell Electron Storage Ring c. 1980

PERFORMANCE – SURVEY

Vertical Deviation from Plane



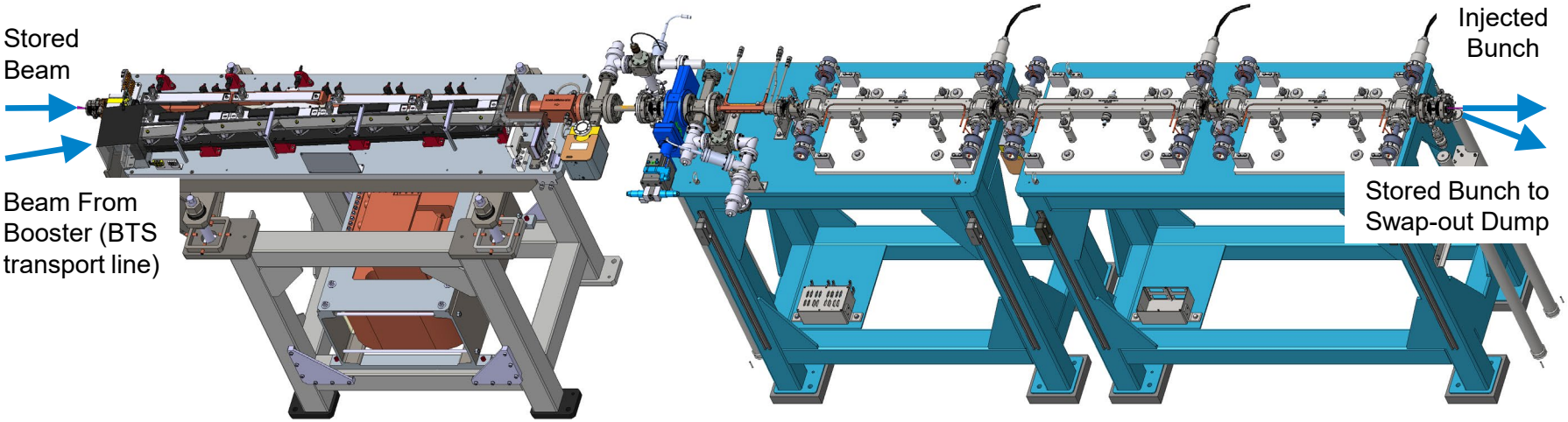
Radial Deviation from Design



- **Achieved < 30 microns rms globally;**
- **Circumference within 600 microns vs. 30 mm required**

INJECTION STRAIGHT SECTION, SECTOR 39

Very fast, very strong magnets, very small apertures

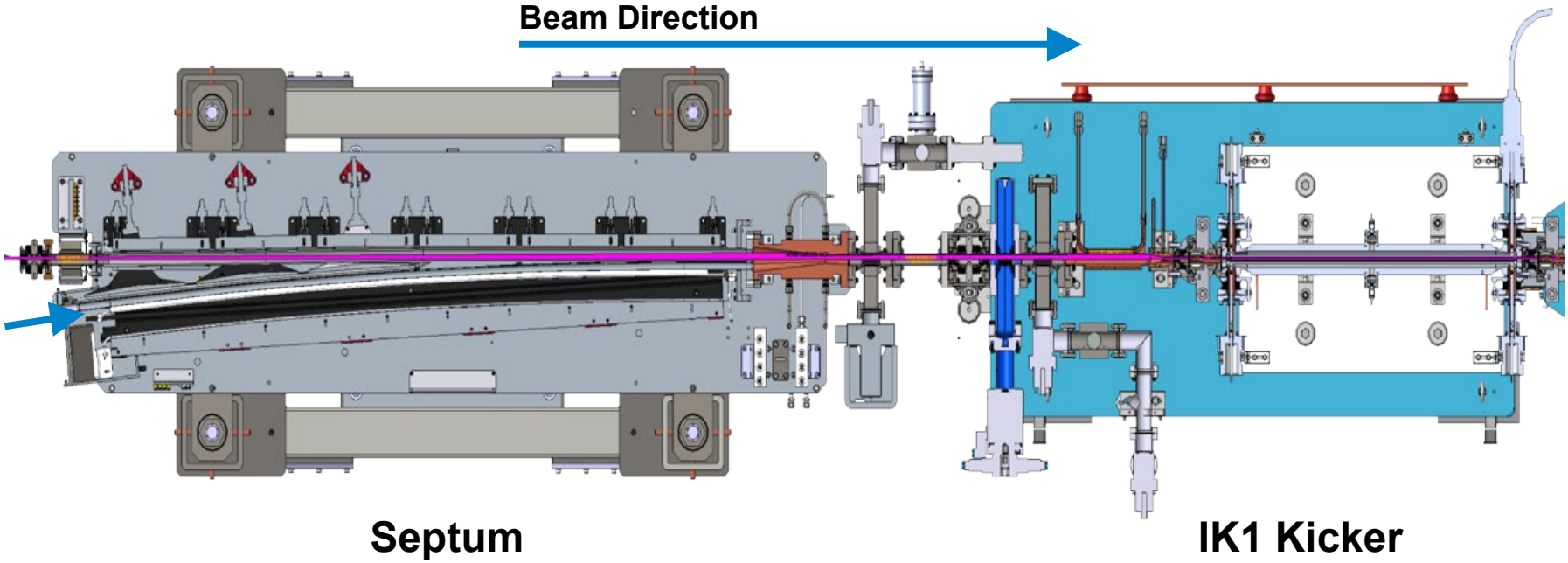


Injection Septum Magnet
18 kA, 0.5 millisecond pulse width

Injection Stripline Kickers
27 kV, 20 nanosecond pulse width

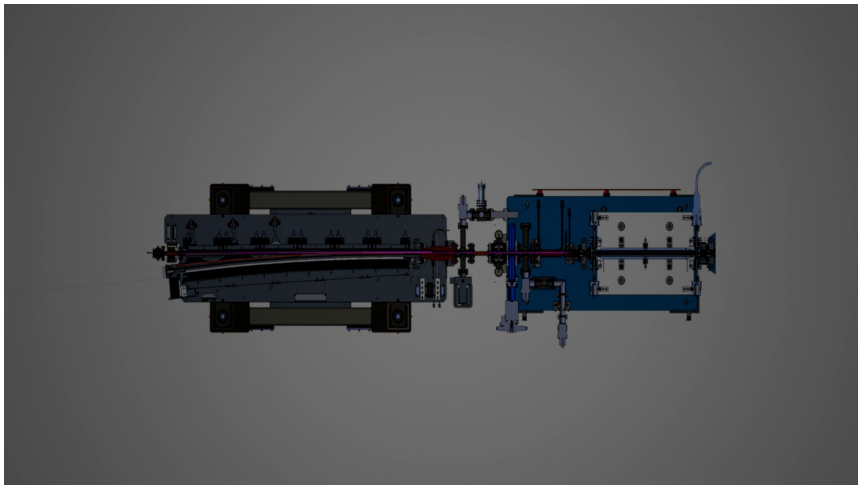
INJECTION SEPTUM AND FIRST KICKER

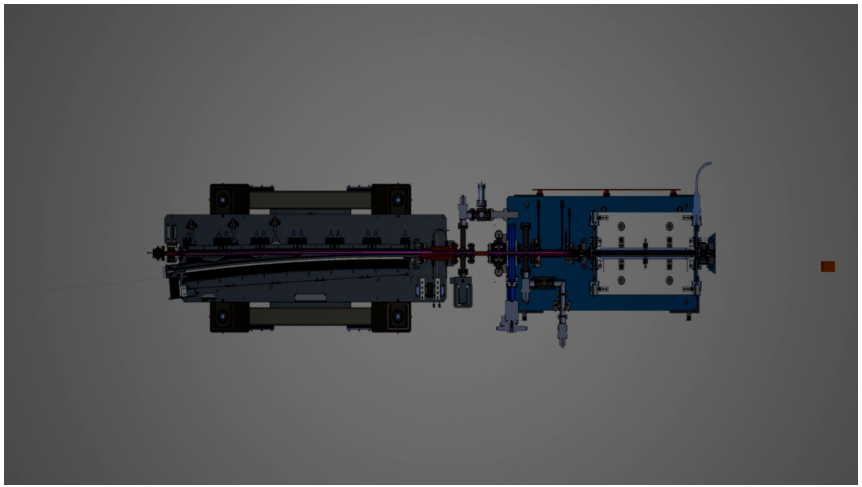
Cross Section, Top View



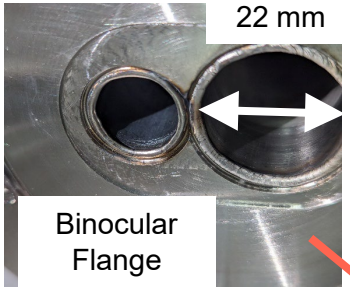
INJECTION SEPTUM AND FIRST KICKER

Cross Section, Top View



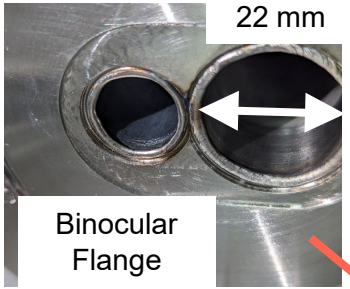


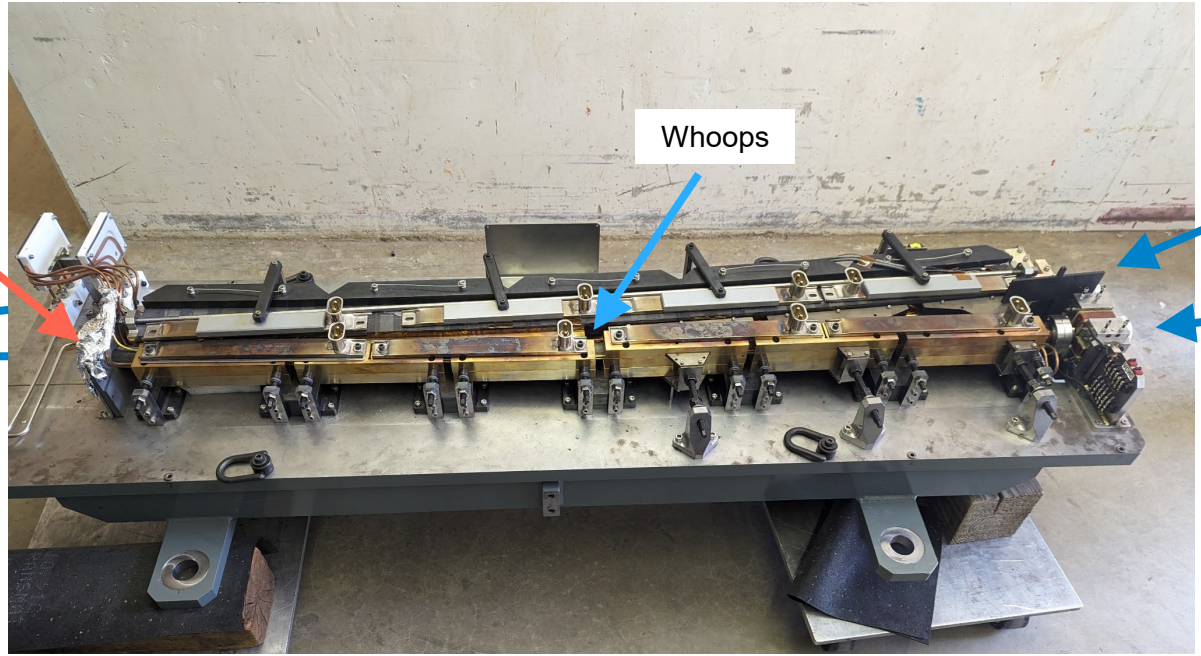
INJECTION SEPTUM



Septum #1

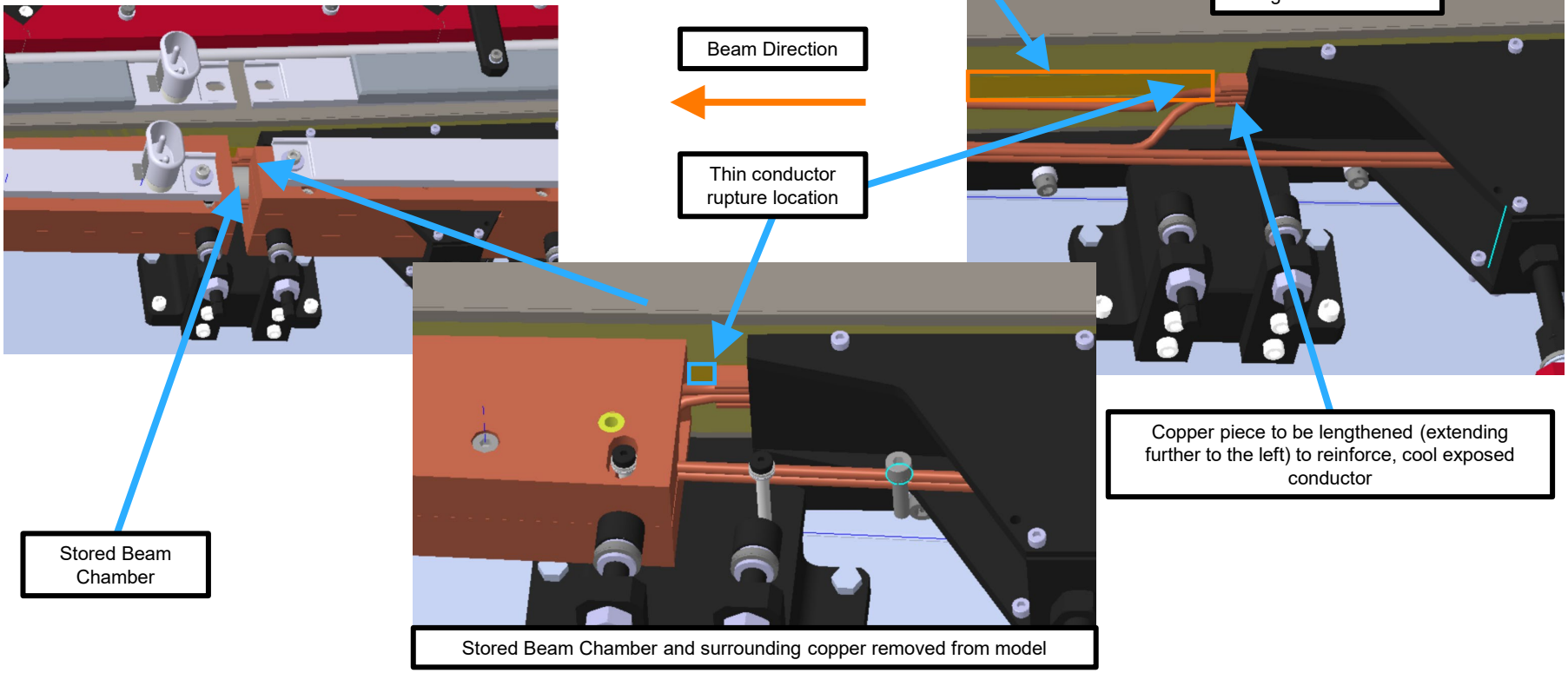
INJECTION SEPTUM



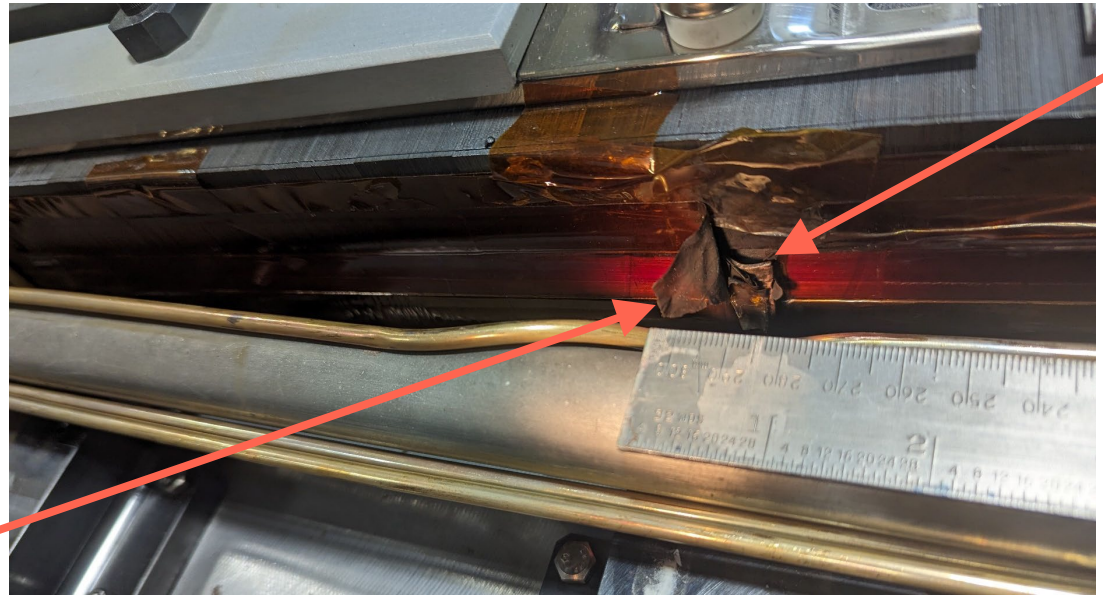


Septum #1

FAILURE LOCATION



INJECTION SEPTUM FAILURE



Septum #1 Rupture Site

INJECTION SEPTUM TEAM

MILESTONES

MILESTONE	SCHEDULE DATE	FORECAST/ ACTUAL DATE	COMPLETE
Install Septum Magnet	01-Dec-23	19-Dec-2023 (A)	✓
Start RF Conditioning	03-Jan-24	26-Feb-2024 (A)	✓
200th Magnet Module/Bridge Assembly Installed	22-Dec-23	14-Dec-2023 (A)	✓
Storage Ring Testing w/o beam completed	24-Jan-24	10-Apr-2024 (A)	✓
ID assembly and acceptance testing complete	30-Apr-24	30-Jun-24	
Achieve 25mA in the Storage Ring	15-Apr-24	19-May-2024 (A)	✓
Storage Ring Threshold KPPs Achieved	01-May-24	01-Jun-24	✓