Mock-ups to Predict Beam Axis Displacements of Cavities and Solenoids in PIP-II SSR2 Cryomodule

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Introduction

PIP-II is Fermilab's planned high-intensity proton beam facility. Cryomodules house the 5 different types of superconducting accelerating cavities needed for the PIP-II linear accelerator. SSR2 (Single Spoke Resonator Type-2) cavities are housed in their respective cryomodules, along with focusing lens solenoids. These cryomodule string components' alignment is studied as acceptable beam deflection, offset, and defocusing, which may otherwise cause beam loss.

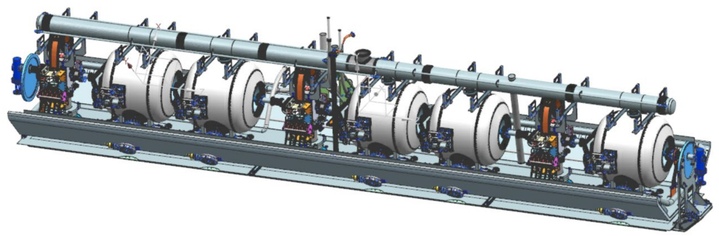

Figure 1. SSR2 Cryomodule String on Strongback Assembly

H-BCAMs (Brandeis CCD Angle Monitors) are used to monitor the alignment of cavities and solenoids in PIP-II cryomodules. BCAMs survey reflective targets rigidly attached to reference surfaces.

Alignment adjustment kits are used to move cavities and solenoids into alignment during the string assembly process. The positions of the cavities and solenoids can be changed using a system of set screws and rod ends. They allow for 5 degrees of freedom.

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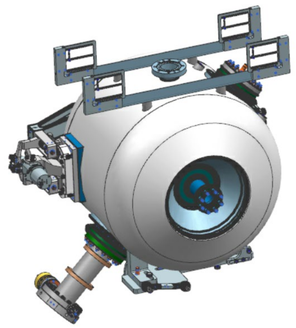

Figure 2. SSR2 Cryomodule Cavity

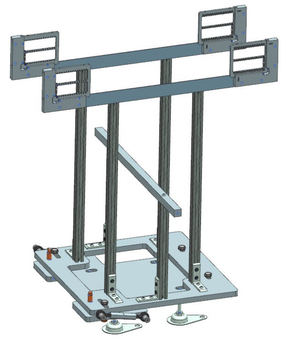

Figure 3. SSR2 Cavity Mockup

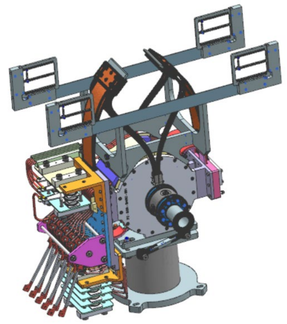

Figure 4. SSR2 Cryomodule Solenoid

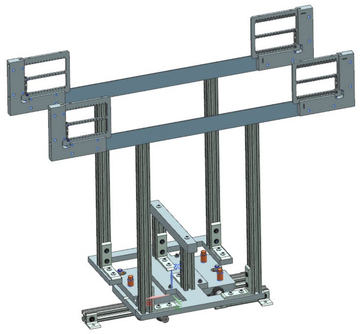

Figure 5. SSR2 Solenoid Mockup

Mock-ups

To study the alignment of the cavities and solenoids mock-ups were designed using the actual adjustment kits for each component along with aluminum extrusions to hold BCAM targets and an aluminum target bar to represent the beam axis.

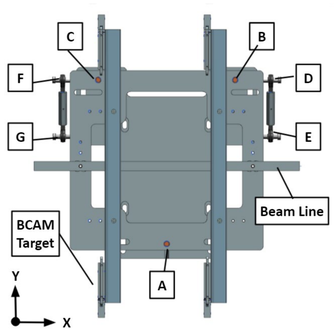

Figure 6. Cavity Mock-up Diagram

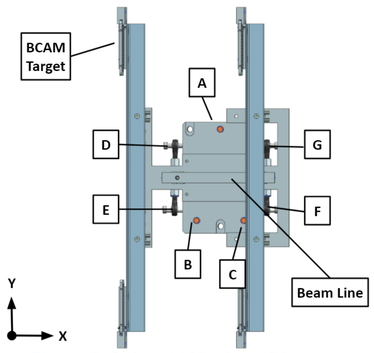

Figure 7. Solenoid Mock-up Diagram

	DOF	Max	Set Screws A/B/C (Turns)			Rod Ends ED/GF (Tums)	
Rotations (Degrees)	x+	3.3	-4.1	10.6	10.6	0.0	0.0
	x-	3.2	8.7	-6.1	-6.1	0.0	0.0
	y+	4.2	3.3	-3.9	10.6	0.0	-3.4
	y-	4.2	3.3	10.6	-3.9	-3.4	0.0
	z+	2.8	0.0	0.0	0.0	-1.2	8.0
	z-	2.8	0.0	0.0	0.0	8.0	-1.2
Translations (mm)	x+						
	x-						
	y+	18.3	0.0	0.0	0.0	-7.2	-7.2
	y-	20.7	0.0	0.0	0.0	8.8	8.8
	z+	13.2	8.6	9.0	9.0	-1.6	-1.6
	z-	7.1	-4.7	-4.7	-4.7	0.6	0.6

Figure 8. SSR2 Cavity Maximums

	DOF	Max	Set Screws A/B/C (Turns)			Rod Ends ED/GF (Tums)	
Rotations (Degrees)	x+	5.6	9.3	-3.4	-3.4	0.0	0.0
	x-	6.2	-5.3	11.3	11.3	0.0	0.0
	y+	12.4	4.0	11.3	-3.4	-3.2	0.8
	y-	12.4	4.0	-3.4	11.3	0.8	-3.2
	z+	7.8	0.0	0.0	0.0	-10.4	0.0
	z-	7.8	0.0	0.0	0.0	0.0	-10.4
Translations (mm)	x+						
	x-						
	y+	22.4	0.0	0.0	0.0	-8.8	-8.8
	y-	12.4	0.0	0.0	0.0	4.8	4.8
	z+	14.0	9.3	9.3	9.3	-1.4	-1.4
	z-	5.1	-8.4	-8.4	-8.4	0.8	0.8

Figure 9. SSR2 Solenoid Maximums

Conclusions and Future Work

The next step in the process is to use the mock-ups to develop a mathematical model that will give the approximate adjustment parameters to achieve a desired beam axis position, as well as relate the position of the beam axis to the positions of the BCAM targets. This can be used to align the components during the assembly of the cryomodule.

References

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3) Valeri Lebedev, ***The PIP II reference design report.*** Tech. rep, Fermi National Accelerator Lab. (FNAL), Batavia, IL (United States), 2015;