Update on Rectilinear Cooling Lattice

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Current status

- Checked if thicker absorber and RF windows have bad effect on the cooling performance.

- Redesigned the magnet lattice from stage 4 to stage 10 in post-merging as the energy density and hoop stress of the coils are over the limit.

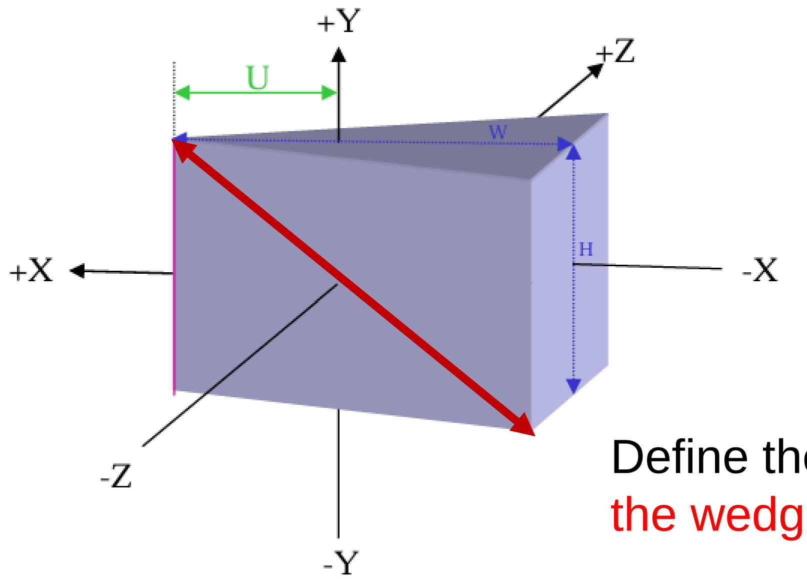
Scale the window thickness

MICE

The liquid absorber system design is dictated by hydrogen safety. The liquid absorber is designed in accordance with pressure vessel code for flammable liquids. The working pressure of the absorber was set to 1.7-bar (25 psig) to meet the minimum design working pressure the safety standard set by Fermilab, where many absorber tests will be done [4]. This means that the absorber thin windows must have a burst pressure of >6.8-bar (100 psi). The Rutherford Appleton Laboratory (RAL) safety standards require that the absorber withstand a double fault. As a result, there is a vacuum vessel around the liquid absorber volume. The absorber vacuum and the absorber are separated by 180-μm thick (center section) thin aluminum windows that have a diameter of 300-mm. There are also 180 μm thick aluminum windows between the absorber vacuum space and the MICE vacuum that can be found at both ends of the AFC module. The parameters of the liquid absorber are found in Table 1.

Cylinder absorber with diameter of 300 mm. 180 μm Al window.

Diameter of wedge absorber



Define the diagonal as the wedge diameter

Scale the window thickness by diameter with the thickness in MICE. Be is window material (low atomic number).

Problems of the coils in post-merging

	Cell length (m)	Stage length (m)	Pipe radius (cm)	Max. on-axis B_z (T)	Integrated B_y (T·m)	Transverse beta (cm)	Dispersion (mm)	On-axis wedge length (cm)	Wedge apex angle (deg)	RF frequency (MHz)	Number of RFs	RF length (cm)	Max. RF gradient (MV/m)	RF phase (deg)
A-Stage 1	1.8	104.4	28	2.5	0.102	70	-60	14.5	45	352	6	19	25.8	18.5
A-Stage 2	1.2	106.8	16	3.7	0.147	45	-57	10.5	60	352	4	19	25.8	23.2
A-Stage 3	0.8	64.8	10	5.7	0.154	30	-40	15	100	704	5	9.5	31.4	23.7
A-Stage 4	0.7	86.8	8	7.2	0.186	23	-30	6.5	70	704	4	9.5	31.7	25.7
B-Stage 1	2.3	55.2	23	3.1	0.106	35	-51.8	37	110	352	6	25	21.01	28.22
B-Stage 2	1.8	61.2	19	3.9	0.138	30	-52.4	32	120	352	5	22	22.68	30.91
B-Stage 3	1.4	77	12.5	5.1	0.144	20	-40.6	24	115	352	4	19	24.27	29.76
B-Stage 4	1.1	70.4	9.5	6.6	0.163	15	-35.1	20	110	352	3	22	25.03	29.48
B-Stage 5	0.8	53.6	6	9.1	0.116	10	-17.7	12	120	704	5	9.5	23.46	23.81
B-Stage 6	0.7	49	4.5	11.5	0.0868	6	-10.6	11	130	704	4	9.5	30.48	19.65
B-Stage 7	0.7	34.3	3.7	13	0.0882	5	-9.8	10	130	704	4	9.5	31.29	17.41
B-Stage 8	0.65	47.45	2.65	15.8	0.0726	3.8	-7.0	7	140	704	4	9.5	26.87	14.37
B-Stage 9	0.65	35.1	2.25	16.6	0.0694	3	-6.1	7.5	140	704	4	9.5	27.67	19.42
B-Stage 10	0.632	43.59	2.1	17.2	0.0691	2.7	-5.7	7	140	704	4	9.5	17.61	16.39

Quick calculation by Siara's codes.

Energy density and hoop stress are above the limit (150 MJ/m^3 and 300 MPa) from stage 4. The difference can be up to a factor of 2 from B-stage 8. Need new lattice from B-Stage 4.

Tracking results – pre-merging

- Thicker windows from stage 1

	$Th_{wedge, old}$ (μm)	$Th_{RF\ old}$ (μm)	$Th_{wedge, new}$ (μm)	$Th_{RF, new}$ (μm)
Stage 1	100	50	300	120
Stage 2	100	50	160	70
Stage 3	100	50	140	45
Stage 4	100	50	90	40

	$\varepsilon_{T,sim}$ (mm)	$\varepsilon_{L,sim}$ (mm)	$\varepsilon_{6D,sim}$ (mm^3)	Transmission
Start	16.96	45.53	13500	
Stage 1	5.220	17.72	485.6	74.8%
Stage 2	2.695	6.870	41.92	84.1%
Stage 3	1.561	3.814	9.489	86.1%
Stage 4	1.257	1.759	2.953	91.4%

	εT (mm)	εL (mm)	ε6D (mm^3)	Transmission
Stage 1	5.165	18.31	492.6	75.2%
Stage 2	2.473	7.113	44.03	84.4%
Stage 3	1.556	3.880	9.594	85.6%
Stage 4	1.239	1.741	2.861	91.3%

Almost the same cooling performance and transmission.

Tracking results – post-merging

- Thicker windows from stage 1 and new solenoid coils from stage 4

	$Th_{wedge, old}$ (μm)	$Th_{RF\ old}$ (μm)	$Th_{wedge, new}$ (μm)	$Th_{RF, new}$ (μm)
Stage 1	100	50	300	100
Stage 2	100	50	240	80
Stage 3	100	50	190	50
Stage 4	100	50	150	45
Stage 5	50	50	90	30
Stage 6	20	20	75	20
Stage 7	20	20	70	20

Small difference. Integrated transmission is lower by ~2%.

Still need to check stage 8 – 10.

	$\varepsilon_{T,sim}$ (mm)	$\varepsilon_{L,sim}$ (mm)	$\varepsilon_{6D,sim}$ (mm^3)	Transmission
Start	5.129	9.991	262.5	
Stage 1	2.841	8.850	72.35	84.9%
Stage 2	2.007	5.590	24.08	90.0%
Stage 3	1.274	4.323	7.213	89.0%
Stage 4	0.9103	3.388	2.928	90.8%
Stage 5	0.6739	2.995	1.383	91.0%
Stage 6	0.4739	2.342	0.5365	87.8%
Stage 7	0.3661	2.076	0.2764	90.0%

	εT (mm)	εL (mm)	ε6D (mm^3)	Transmission
Stage 1	2.848	9.244	75.30	84.2%
Stage 2	2.114	6.006	27.24	88.9%
Stage 3	1.293	4.174	7.092	88.0%
Stage 4	0.9412	3.289	3.002	88.9%
Stage 5	0.6657	3.003	1.351	91.2%
Stage 6	0.4744	2.305	0.5349	86.2%
Stage 7	0.3582	2.176	0.2794	92.1%