Transforming JLEIC Lattice Files into CAD - Status and Path Forward

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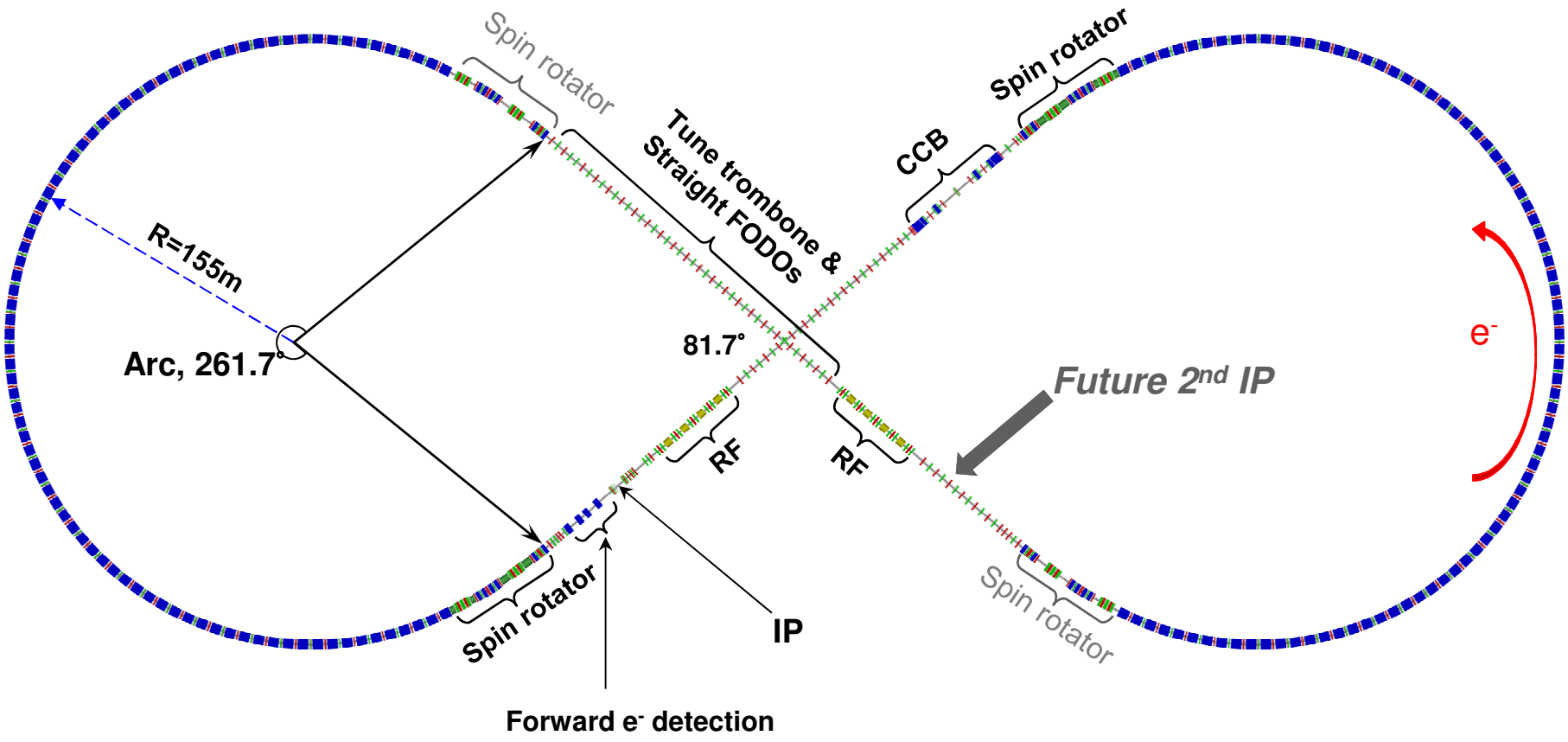
Overview

- The Baseline Designs – looking at the Collider Rings
- The Lattice Files – format
- From Lattice to CAD
- Items for consideration
- Making updates
- The Good, The Bad, and the Ugly
- Looking forward

Baseline Electron Collider Ring Layout

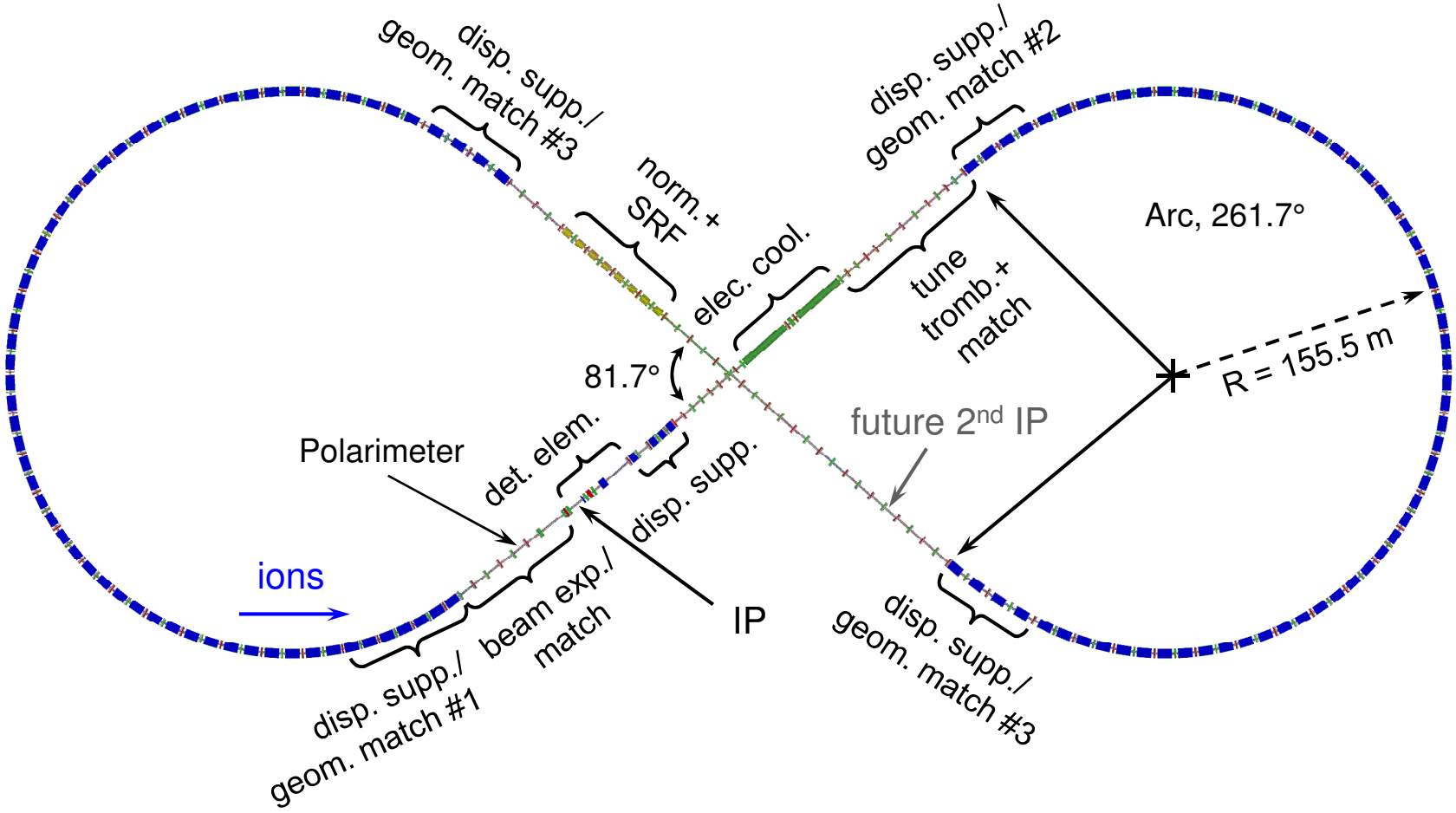
- Circumference of 2154.28 m = 2 x 754.84 m arcs + 2 x 322.3 straights
- Figure-8 crossing angle 81.7˚

Electron collider ring w/ major machine components



Baseline Ion Collider Ring Layout

- Figure-8 ring with a circumference of 2153.9 m
- Two 261.7° arcs connected by two straights crossing at 81.7°
- Vertical doglegs to be added



The Lattice File

- The Nomenclature Field is added for machine elements – matches JEDi
- 774 Elements in the Ion Collider Ring
- 1453 Elements in the Electron Collider Ring
- Does not yet include vacuum elements (valves, pumps, gauges), instrumentation and diagnostics (BPMs, SLMs, etc.)

2153.89 m long MEIC **ion collider ring with one IP**

The origin of the reference frame is common for the electron and ion collider rings and is located at the crossing point of the electron figure-8 ring. Elements are listed in sequential order starting at the IP.
The coordinates are given at the end of each element.
S = positon along the beam.
(X,Y,Z) is a global Cartesian coordinate system. Y = vertical axis. (X,Z) correspond to the symmetry axes of the figure 8.
THETA = horizontal angle.
PHI = vertical angle.

SBEND = sector bend.
RBEND = rectangular bend.
Dipole lengths correspond to the arc lengths along the orbit.
Dipole lengths listed below are magnetic lengths. Physical length of each dipole is (14 + magnetic length + 14) cm.
Solenoid lengths listed below are magnetic lengths. Physical length of each solenoid is (14 + magnetic length + 14) cm.
Quadrupole lengths listed below are magnetic lengths. Physical length of each quadrupole (except those around the IP) is (5 + magnetic length + 5) cm.
Sextupole lengths listed below are magnetic lengths. Physical length of each sextupole is (5 + magnetic length + 5) cm.
Physical lengths of bpms are 15 cm. **Correctors are combined with sextupoles and kickers.**
There are two 31.28 m long gaps in the straight containing the IP. They house two 30.28 m long electron cooling solenoids.
The second straight is filled with FODO lattice and houses 20 m of SRF and 20 m of warm RF.
Field strengths are given at 100 GeV/c.

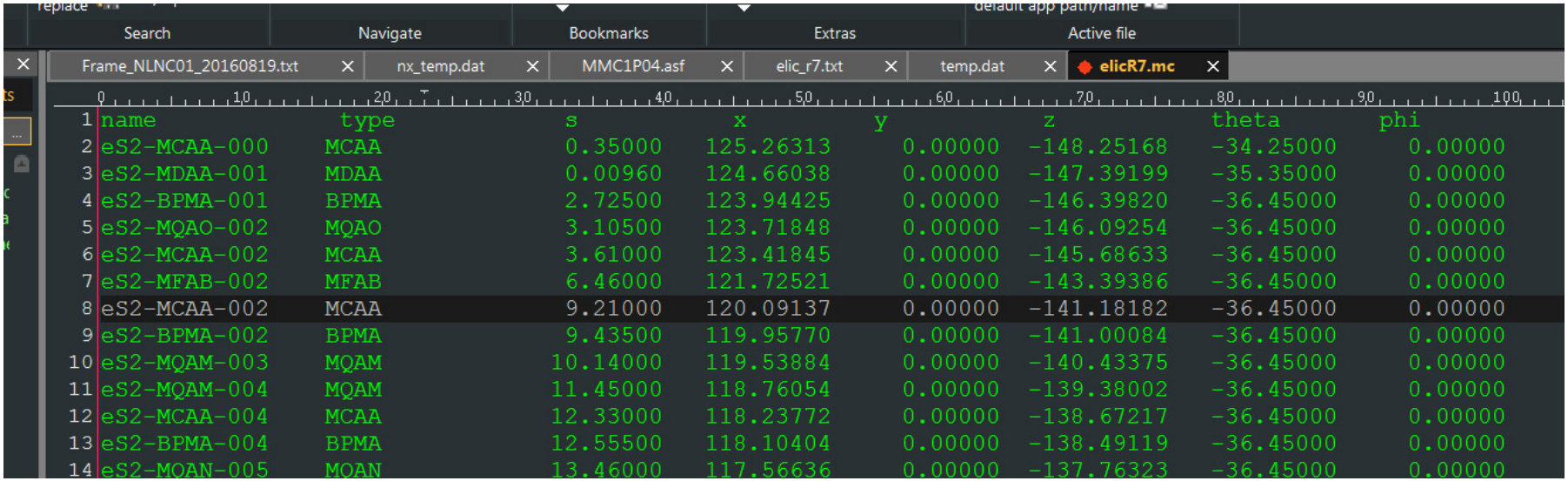
									X	Z		
									-130.4563872	157.428907		
									129.3361743	155.2677489		
									-129.3361743	-155.2677489		
									129.8813467	-157.8684275		
JEDI	NAME	TYPE	LENGTH	FIELD STRENGTH	New Field Strength Limit	S	X	Y	Z	THETA	PHI	REGION DEFINITION
	START					0	73.48696138	0	-84.98541511	-0.662966999	0	
	DFFDS01	DRIFT	5	0		5	70.4096711	0	-81.04456691	-0.662966999	0	
iS1-MDAD-000	BXSP01	RBEND	1.000001498	-2.000050344	2.000	6.000001498	69.79657874	0	-80.25455567	-0.656970991	0	
	DFFDS02	DRIFT	1	0		7.000001498	69.18585759	0	-79.46270993	-0.656970991	0	
iS1-MQAS-001	QFFDS01	QUADRUPOLE	1.2	-87.97323993	140.519	8.200001498	68.45299221	0	-78.51249504	-0.656970991	0	
	DFFDS03	DRIFT	1	0		9.200001498	67.84227106	0	-77.7206493	-0.656970991	0	
iS1-MQAU-002	QFFDS02	QUADRUPOLE	2.4	50.73015062	50.73	11.6000015	66.37654031	0	-75.82021952	-0.656970991	0	
	DFFDS04	DRIFT	1	0		12.6000015	65.76581916	0	-75.02837378	-0.656970991	0	
iS1-MQAS-003	QFFDS03	QUADRUPOLE	1.2	-35.31124242	140.519	13.8000015	65.03295378	0	-74.07815889	-0.656970991	0	
	DFFDS05	DRIFT	4	0		17.8000015	62.59006918	0	-70.91077592	-0.656970991	0	
iS1-MDAF-004	BXSP02	SBEND	4	4.669564585	4.670	21.8000015	60.05980379	0	-67.81342597	-0.712966999	0	
	DFFDS06	DRIFT	16	0		37.8000015	49.59450846	0	-55.71063316	-0.712966999	0	
iS1-MCAB-004	BXYC	KICKER	0.5	0	0	38.3000015	49.26746798	0	-55.33242089	-0.712966999	0	
	DQSPDSE	DRIFT	0.05	0		38.3500015	49.23476393	0	-55.29459966	-0.712966999	0	
iS1-MQAQ-005	QSPDS01	QUADRUPOLE	0.8	59.35287152	79.731	39.1500015	48.71149917	0	-54.68946002	-0.712966999	0	

From Lattice File to CAD

- Lattice file in Excel Format
- Make adjustments, as required – formatting columns, nomenclature, identifying unique components
- "NX_Component_Gen" Program – Each Ring
  - Generates DXF of Points with associated Nomenclature
  - Cross reference CAD models of elements to lattice file
  - Automated assembly via NX Journaling – adds element models to overall assembly
- Combine Machine Segments for Overall Assembly

Translated CASA Lattice

One of the files created has the extension .mc. The .mc file output is shown below in a text editor. This is the major file that is read by the NX Journal program.
The 1st column shows the JEDI Name
Column 2 shows the component name that will be pulled from the team center database.
The remaining columns contain the S, X, Y, Z coordinates plus the theta and phi rotation angles.

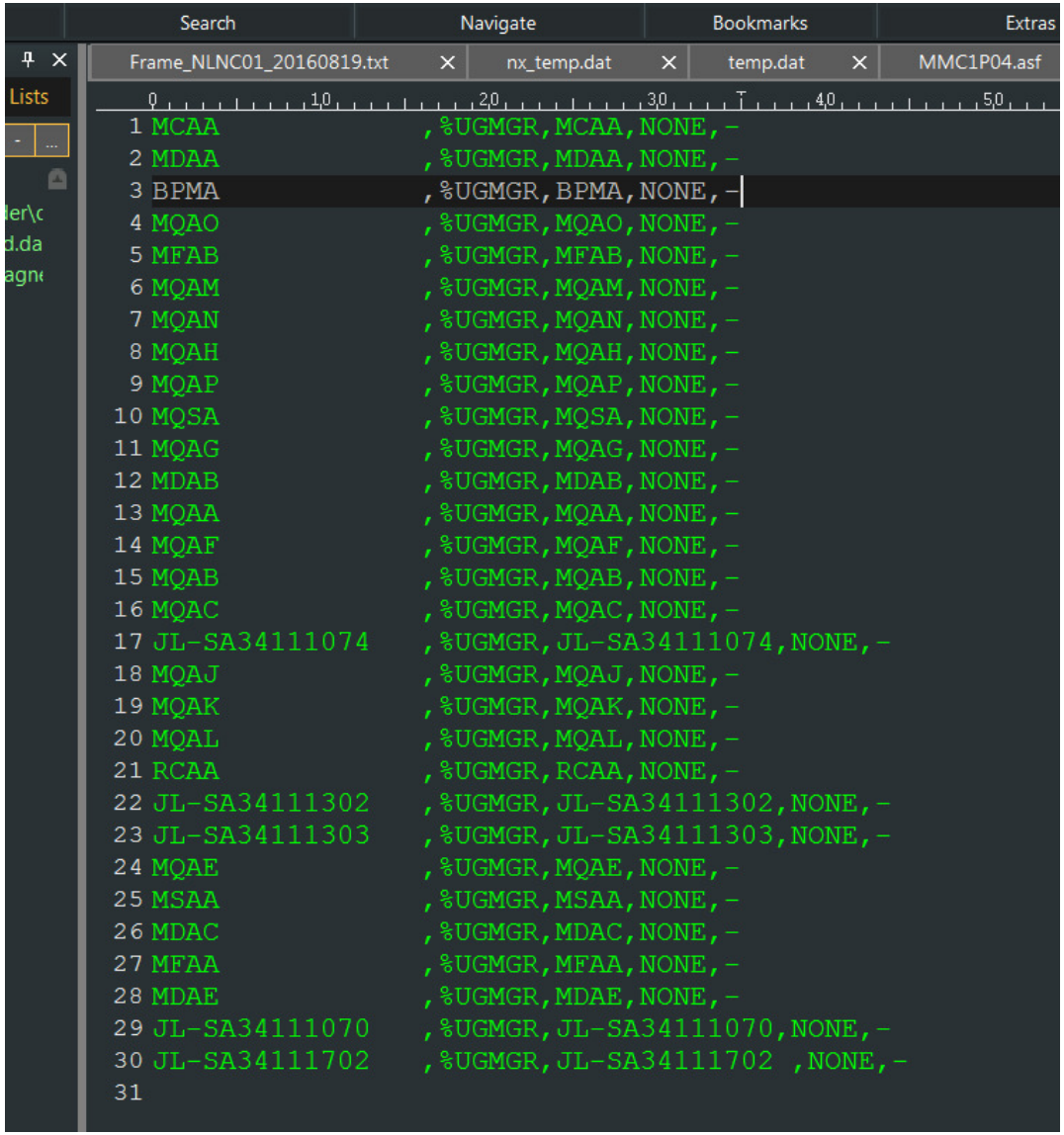


Search | Navigate | Bookmarks | Extras | Active file

Frame_NLNC01_20160819.txt | nx_temp.dat | MMC1P04.asf | elic_r7.txt | temp.dat | elicR7.mc

	name	type	s	x	y	z	theta	phi
2	eS2-MCAA-000	MCAA	0.35000	125.26313	0.00000	-148.25168	-34.25000	0.00000
3	eS2-MDAA-001	MDAA	0.00960	124.66038	0.00000	-147.39199	-35.35000	0.00000
4	eS2-BPMA-001	BPMA	2.72500	123.94425	0.00000	-146.39820	-36.45000	0.00000
5	eS2-MQAO-002	MQAO	3.10500	123.71848	0.00000	-146.09254	-36.45000	0.00000
6	eS2-MCAA-002	MCAA	3.61000	123.41845	0.00000	-145.68633	-36.45000	0.00000
7	eS2-MFAB-002	MFAB	6.46000	121.72521	0.00000	-143.39386	-36.45000	0.00000
8	eS2-MCAA-002	MCAA	9.21000	120.09137	0.00000	-141.18182	-36.45000	0.00000
9	eS2-BPMA-002	BPMA	9.43500	119.95770	0.00000	-141.00084	-36.45000	0.00000
10	eS2-MQAM-003	MQAM	10.14000	119.53884	0.00000	-140.43375	-36.45000	0.00000
11	eS2-MQAM-004	MQAM	11.45000	118.76054	0.00000	-139.38002	-36.45000	0.00000
12	eS2-MCAA-004	MCAA	12.33000	118.23772	0.00000	-138.67217	-36.45000	0.00000
13	eS2-BPMA-004	BPMA	12.55500	118.10404	0.00000	-138.49119	-36.45000	0.00000
14	eS2-MQAN-005	MQAN	13.46000	117.56636	0.00000	-137.76323	-36.45000	0.00000

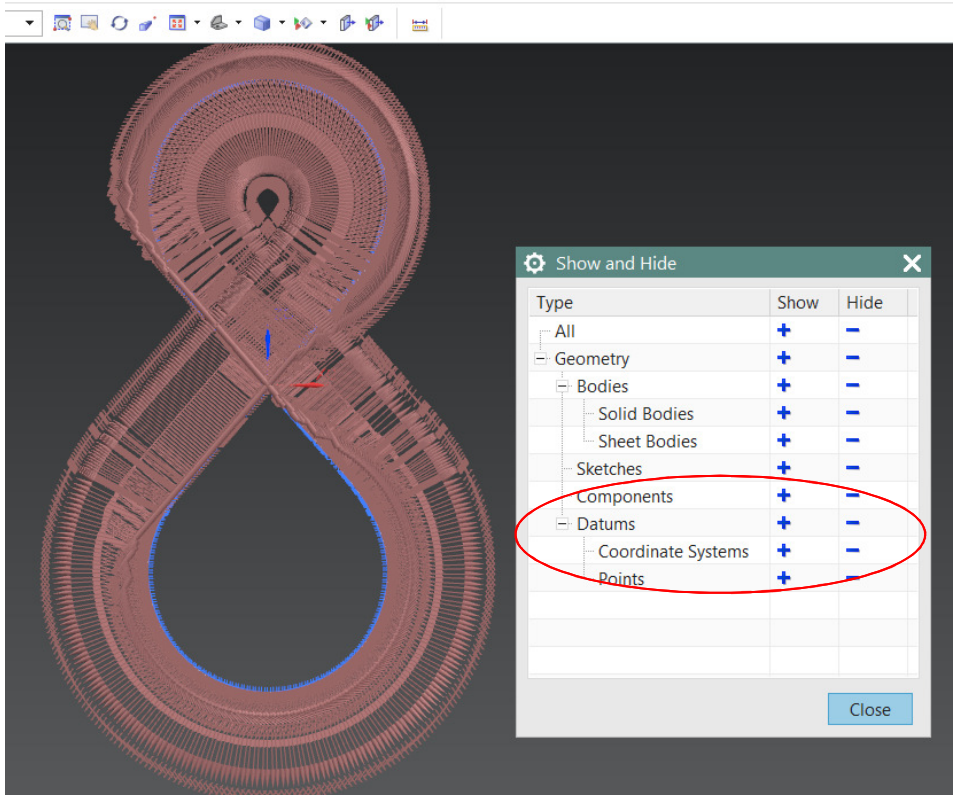
Required component file

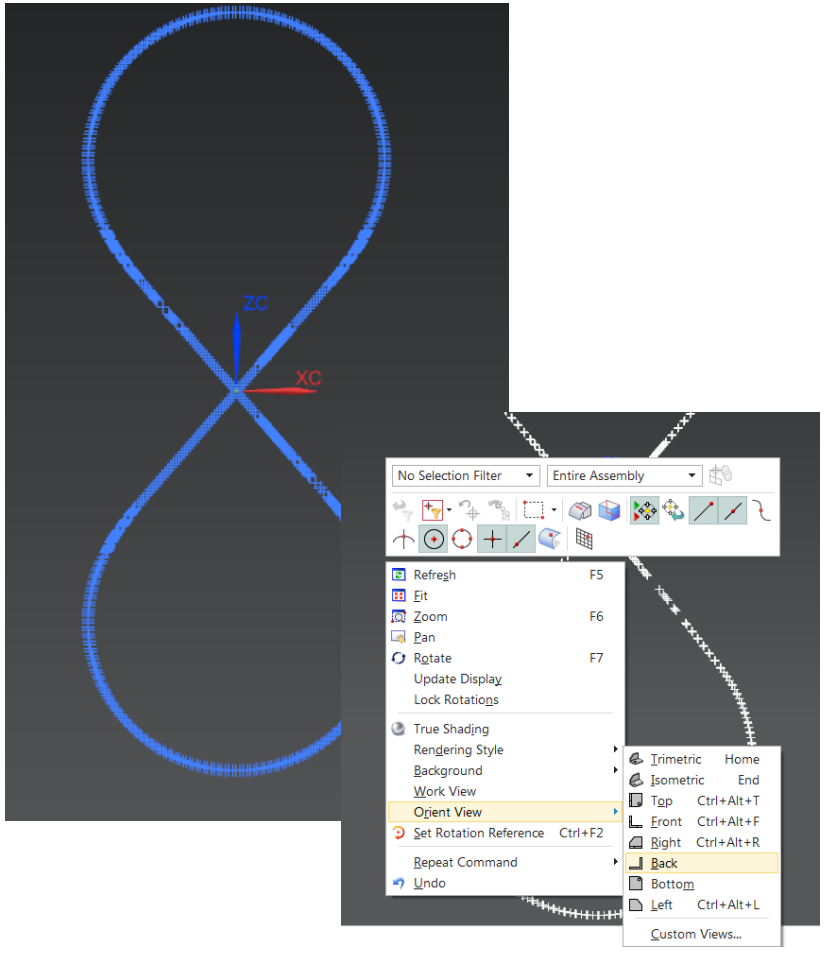


The second file created has a .txt ending and the same prefix as the .mc file. These commands are used to connect to the Team Center database.

Running NX Journal File

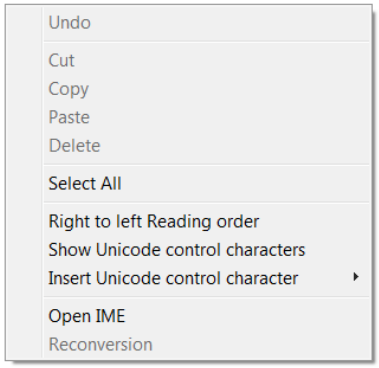
The components should appear in the NX screen. The datum coordinate system arrows may appear. These can be shut off by pressing ‘Ctrl + W’, and turning off the Datum – Coordinate Systems. The final componets are shown in the blue figure 8 image. The figure 8 image was obtained by selecting the Orient View – Back, which shows a plan view of the data in the X/Z plane.





Checking for missing components

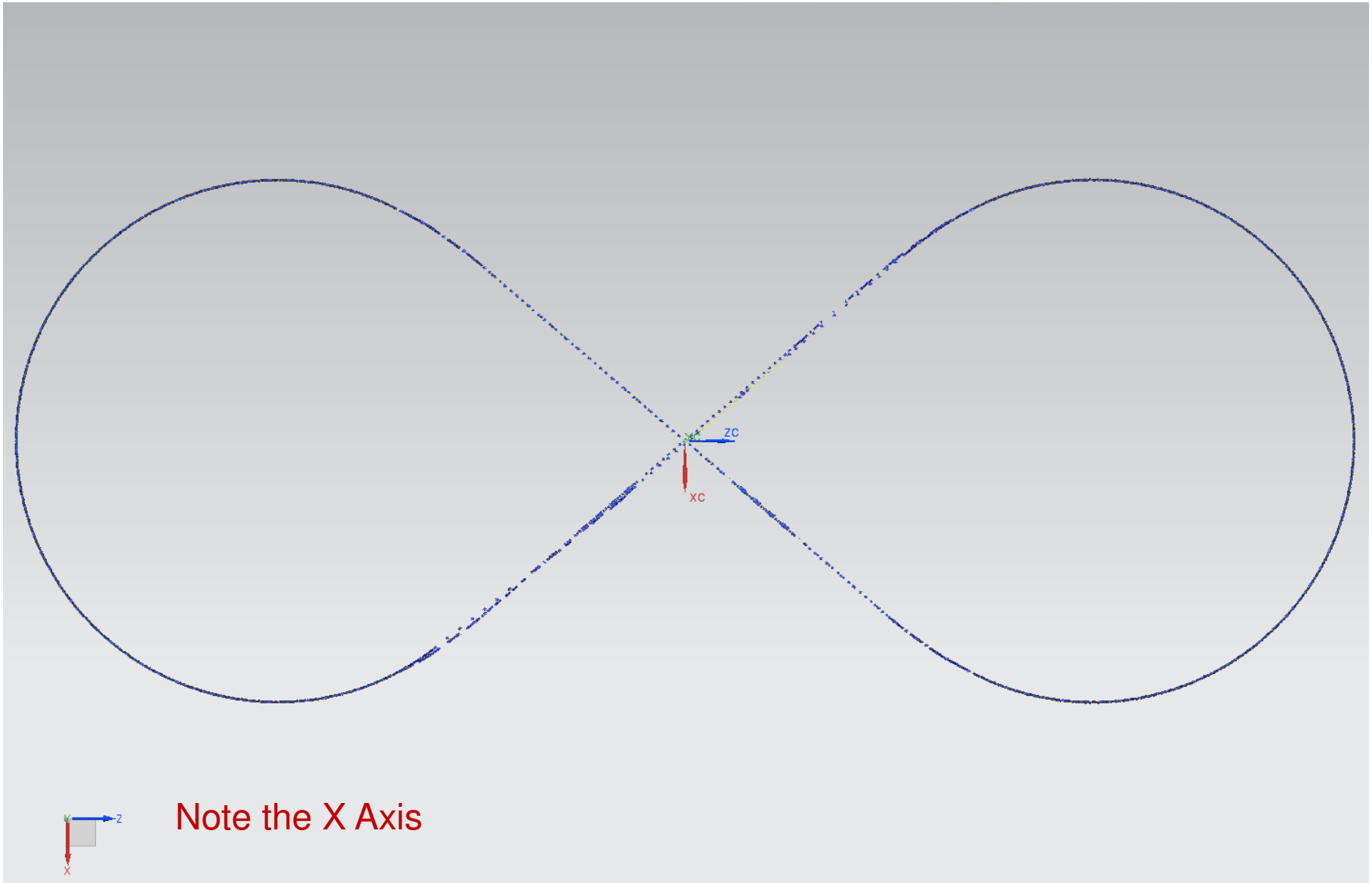
```
Number of components in file                              : 2906
Number of valid components inserted into NX drawing       : 1688
Number of problem components not found in TeamCenter      : 1218

Number of unique components                               : 31
-----------------------------------------------------------
MCAA is a valid component    : count = 660
MDAA is a valid component    : count = 55
MQAO is a valid component    : count = 48
MQAM is a valid component    : count = 64
MQAN is a valid component    : count = 16
MQAH is a valid component    : count = 40
MQAP is a valid component    : count = 8
MQAG is a valid component    : count = 4
MDAB is a valid component    : count = 8
MQAA is a valid component    : count = 8
MQAF is a valid component    : count = 2
MQAB is a valid component    : count = 2
MQAC is a valid component    : count = 30
MQAJ is a valid component    : count = 110
MQAK is a valid component    : count = 40
MQAL is a valid component    : count = 20
RCAA is a valid component    : count = 64
MDAC is a valid component    : count = 3
MQAE is a valid component    : count = 4
MDAE is a valid component    : count = 336
MQAD is a valid component    : count = 166

BPMA is a problem component : count = 662
MFAB is a problem component : count = 8
MQSA is a problem component : count = 12
MSAA is a problem component : count = 263
MFAA is a problem component : count = 8
JL-SA34111074 is a problem component : count = 88
JL-SA34111302 is a problem component : count = 1
JL-SA34111303 is a problem component : count = 1
JL-SA34111070 is a problem component : count = 166
JL-SA34111702  is a problem component : count = 9

tally check 2906
```



After processing the file, a report is generated showing the valid components, the number of components inserted into the assembly and the components not inserted (name problems or else not created in Team Center).

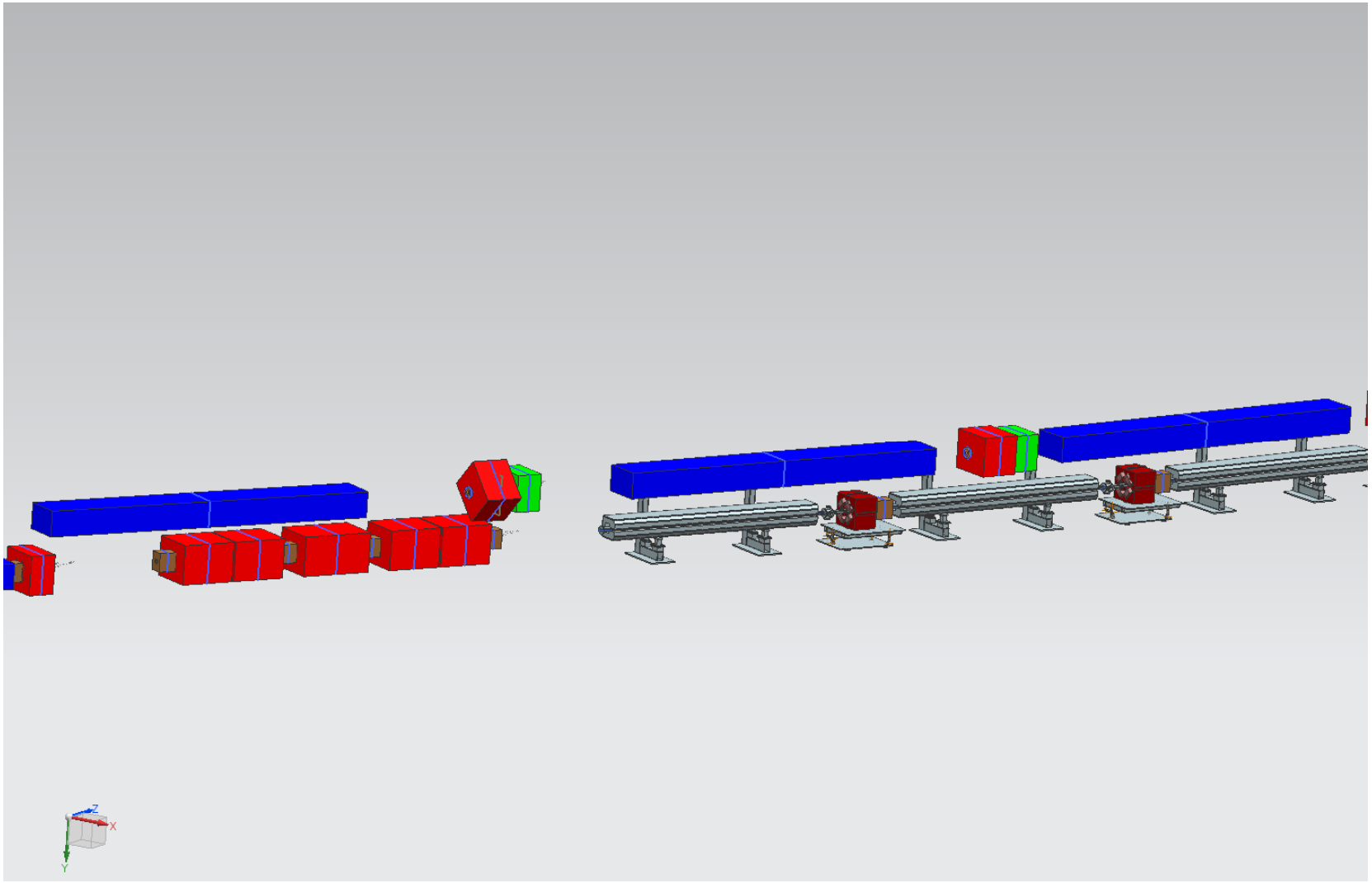
Right click the memo if you wish to select and save the data to a report.

NX CAD Layout of ECR and ICR



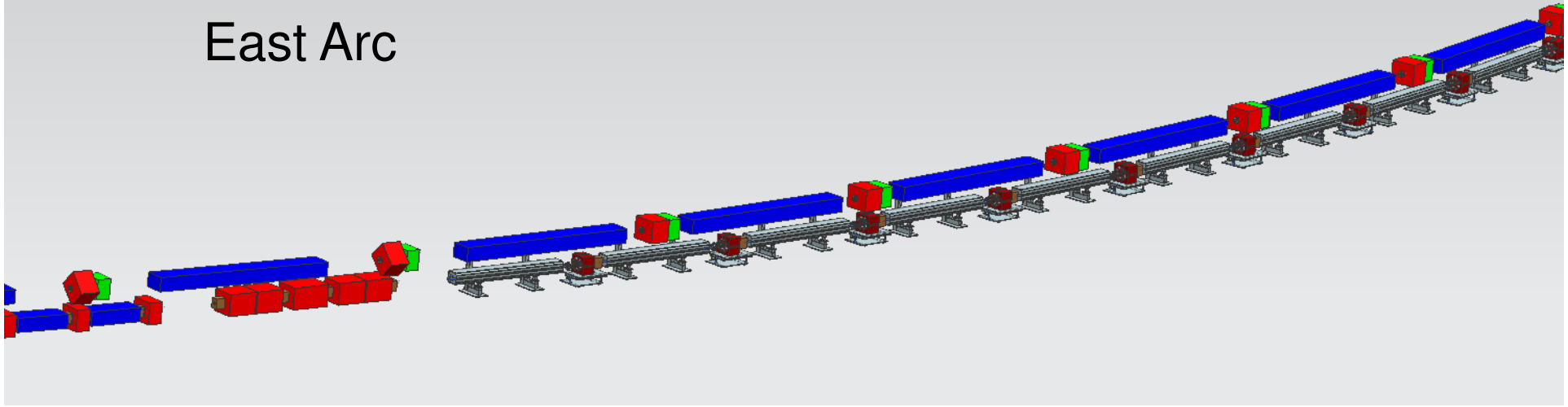
Items for Consideration

Zoom In – ICR on Top, ECR on Bottom

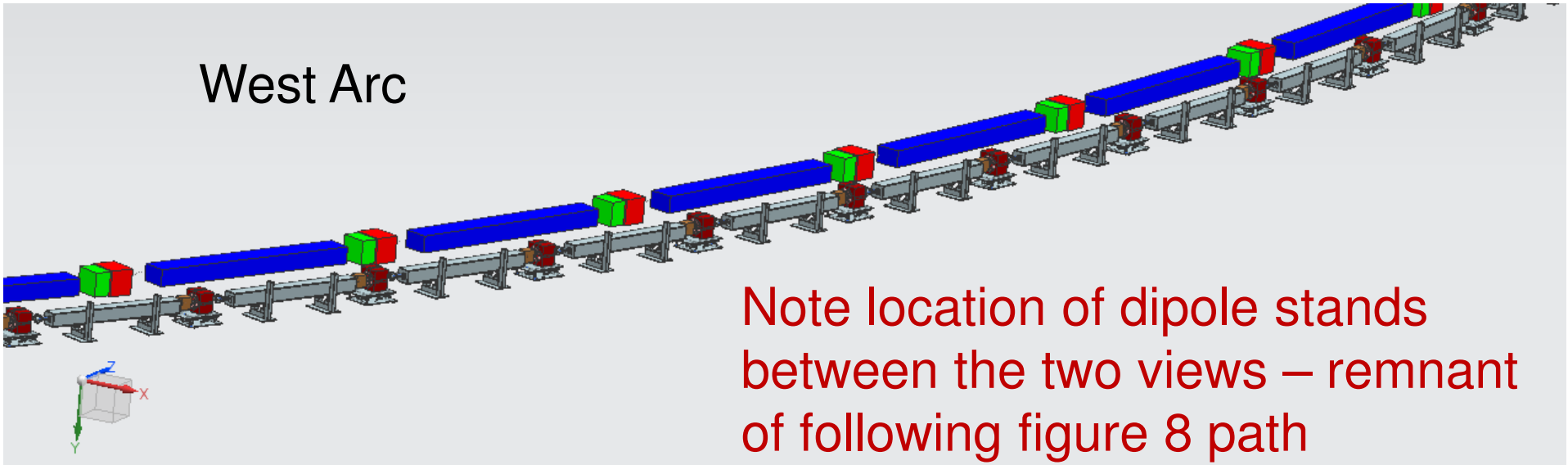


Magnets from Arc to Arc

East Arc

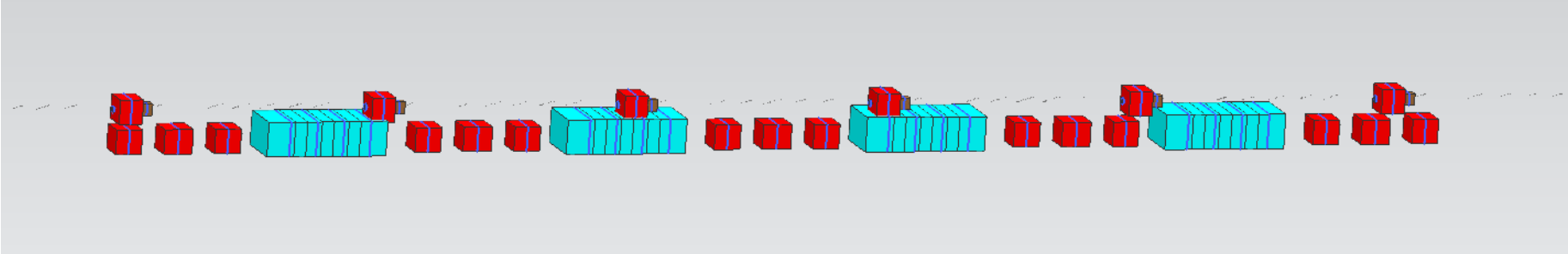


West Arc

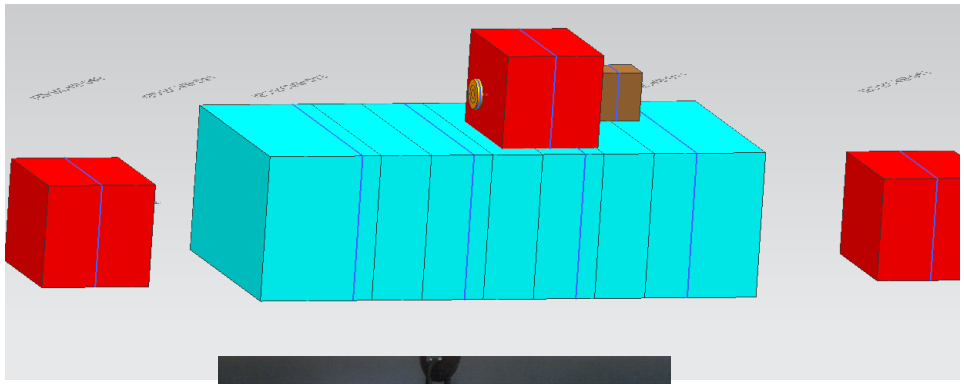


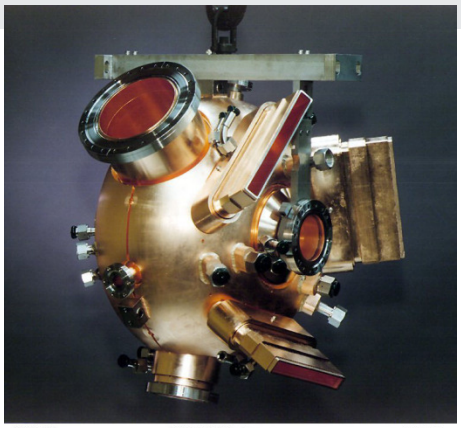
Note location of dipole stands between the two views – remnant of following figure 8 path

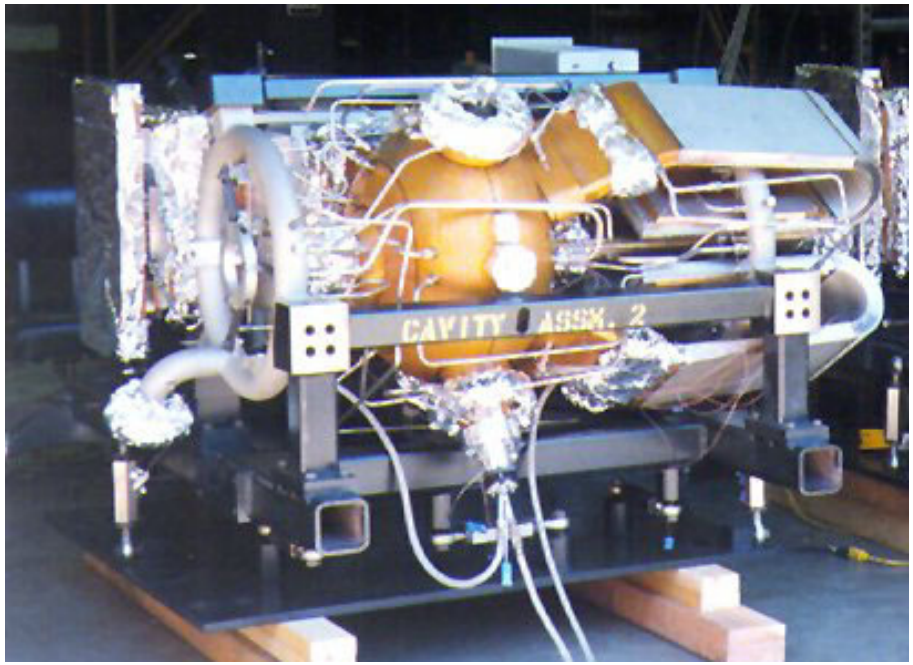
PEP-II RF Cavities



Listed as 1m length in Lattice File – the cavity is, but the assembly is not

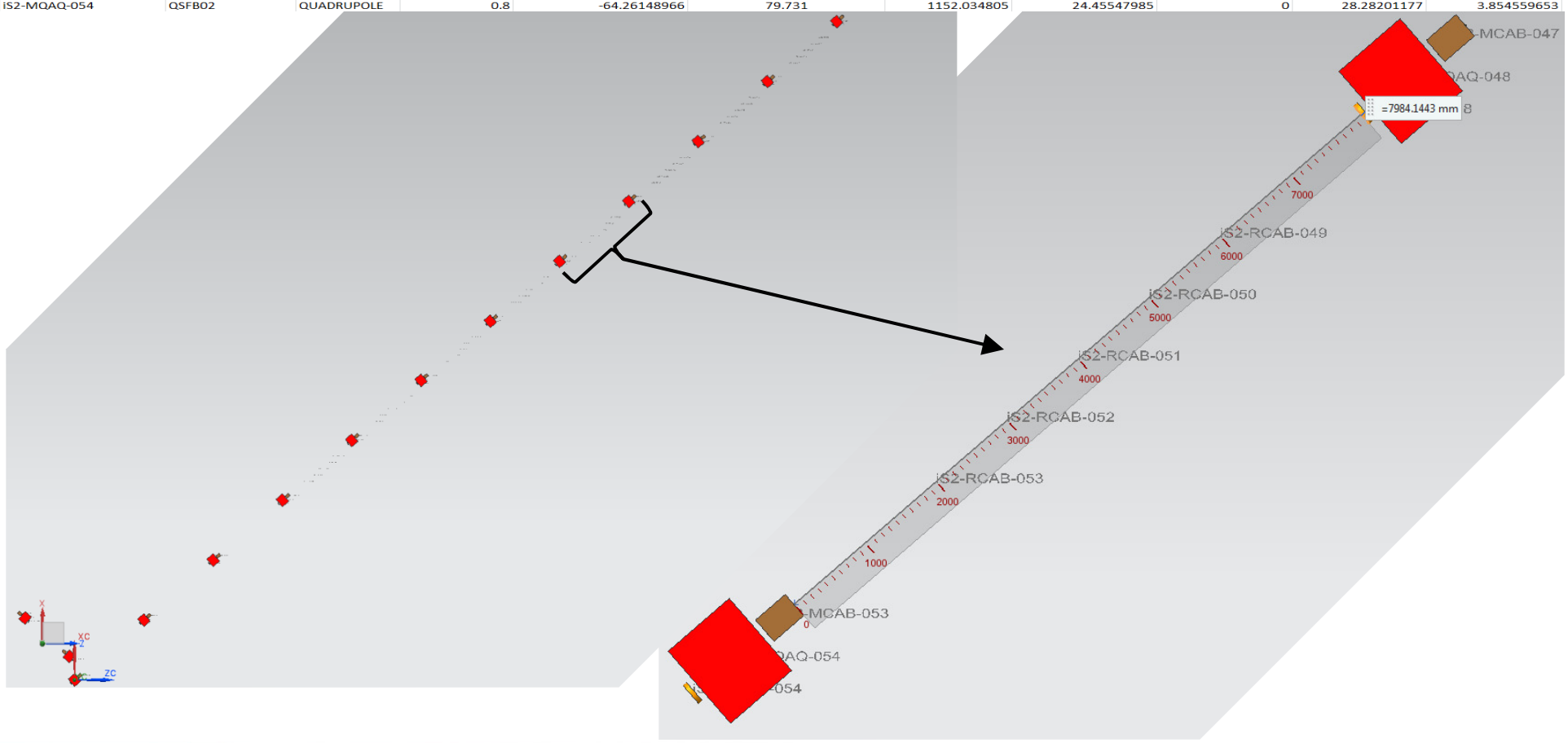






ICR – RF Cavities – as currently defined

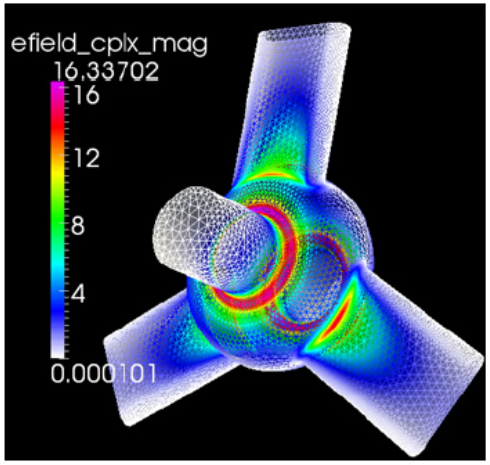
JEDI	NAME	TYPE	LENGTH	FIELD STRENGTH	New Field Strength Limit	S	X	Y	Z	THETA
iS2-MQAQ-048	QSFB01	QUADRUPOLE	0.8	64.26148966	79.731	1142.587537	30.63475791	0	35.42815717	3.854559653
	DQSFBE	DRIFT	0.05	0		1142.637537	30.60205386	0	35.39033594	3.854559653
iS2-BPMB-048	MON	MONITOR	0.15	0	0	1142.787537	30.50394172	0	35.27687226	3.854559653
	DSFB04	DRIFT	1.308633966	0		1144.096171	29.64798916	0	34.2869894	3.854559653
	DRFCE	DRIFT	0.14	0		1144.236171	29.55641782	0	34.18108996	3.854559653
iS2-RCAB-049	RFC	RFCAVITY	1	0	0	1145.236171	28.90233687	0	33.42466541	3.854559653
iS2-RCAB-050	RFC	RFCAVITY	1	0	0	1146.236171	28.24825591	0	32.66824086	3.854559653
iS2-RCAB-051	RFC	RFCAVITY	1	0	0	1147.236171	27.59417495	0	31.91181631	3.854559653
iS2-RCAB-052	RFC	RFCAVITY	1	0	0	1148.236171	26.94009399	0	31.15539176	3.854559653
iS2-RCAB-053	RFC	RFCAVITY	1	0	0	1149.236171	26.28601303	0	30.39896721	3.854559653
	DRFCE	DRIFT	0.14	0		1149.376171	26.1944417	0	30.29306777	3.854559653
	DSFB04	DRIFT	1.308633966	0		1150.684805	25.33848914	0	29.30318492	3.854559653
iS2-MCAB-053	BXYC	KICKER	0.5	0	0	1151.184805	25.01144866	0	28.92497264	3.854559653
	DQSFBE	DRIFT	0.05	0		1151.234805	24.97874462	0	28.88715141	3.854559653
iS2-MQAQ-054	QSFB02	QUADRUPOLE	0.8	-64.26148966	79.731	1152.034805	24.45547985	0	28.28201177	3.854559653



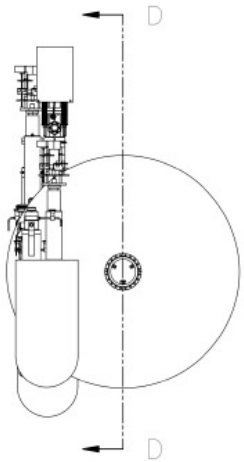
Ion Collider Ring Design Concept

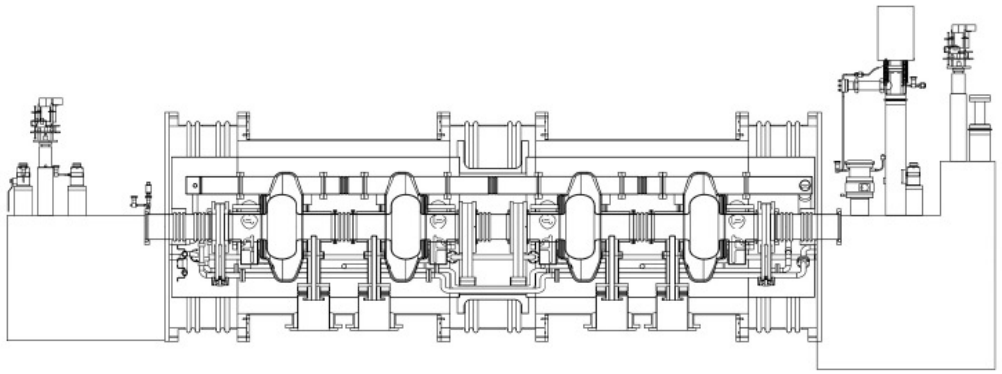
***The following information is from the NSAC Cost Review – January, 2015**

- 952.6 MHz HOM damped 1-cell cavities, modular JLab type cryomodule
- High frequency/high voltage for short bunch (re-bucket at energy)
- Lower power couplers , no synch. rad. Power.
- Tunable within one harmonic (harmonic jumps for path length changes with energy)
- Current limited by space charge (limits charge per bunch)
- Impedance is still a concern so HOM damping is still needed.



New HOM damped cavity concept

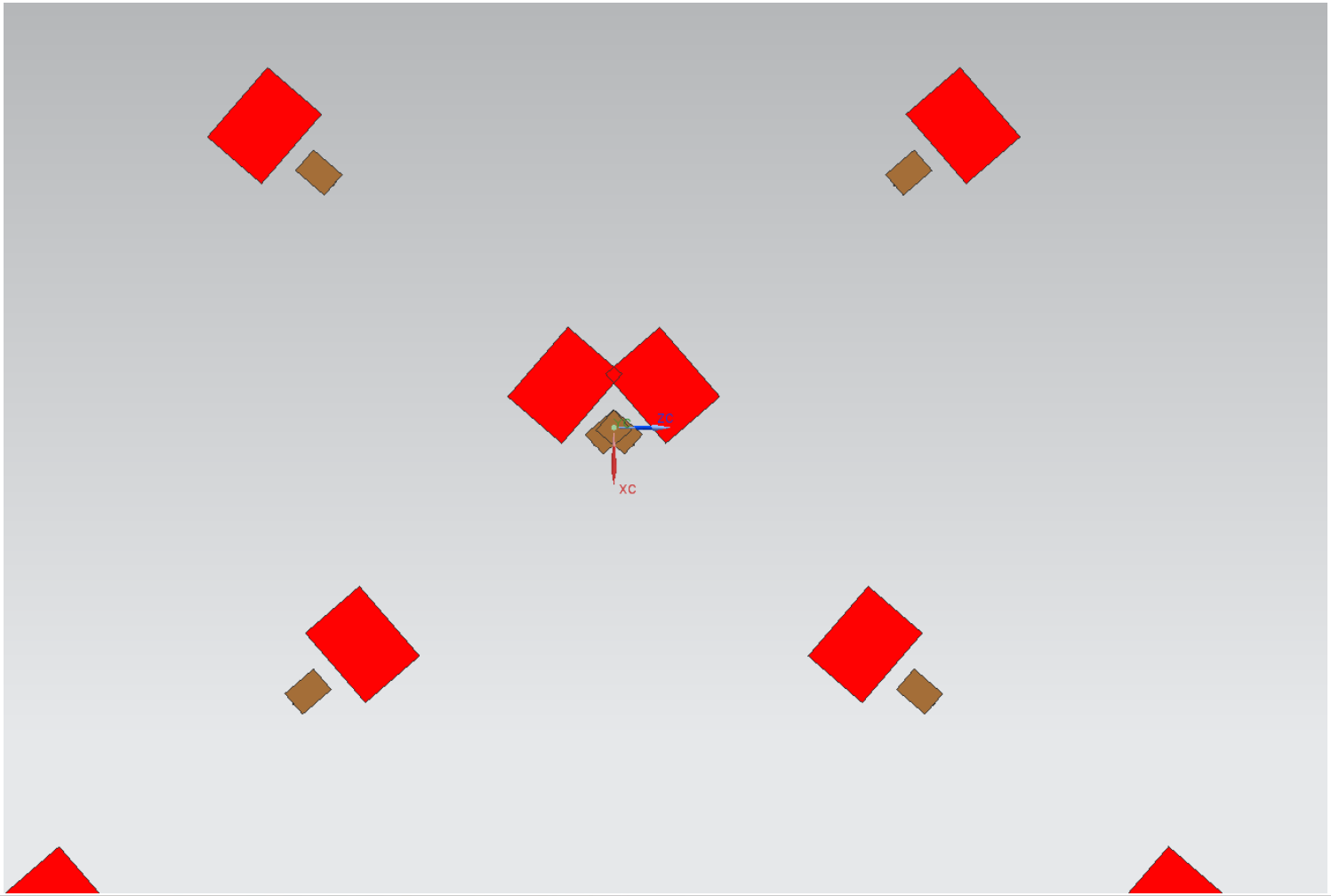




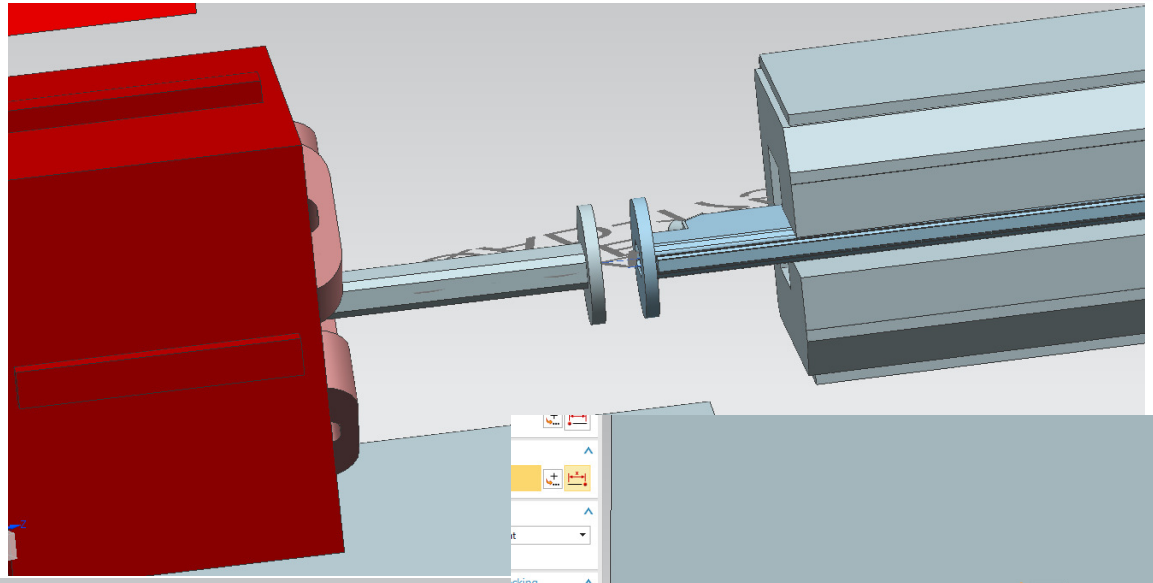
952.6 MHz single cell 4-seater CM
(~4.3m flange to flange)

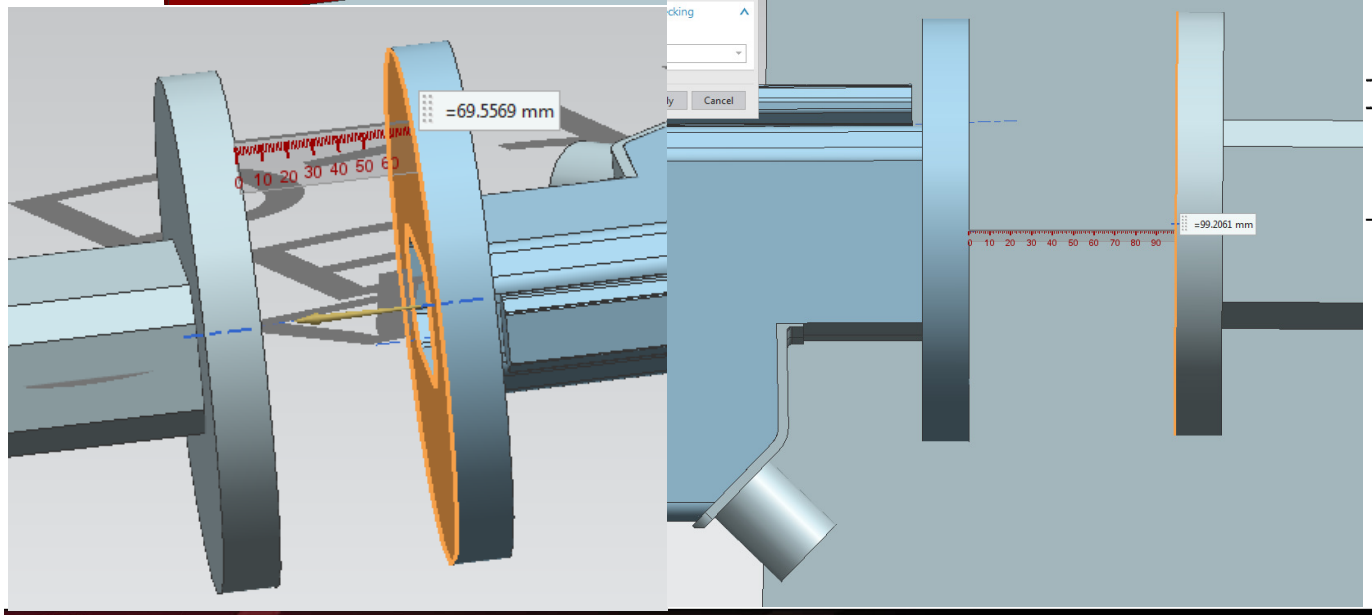
Electron Ring – Cross Over

JEDI	TYPE	LENGTH	FIELD STRENGTH	MAGNET FIELD GROUP	new s	S	X	Y	Z	THETA
eS2-MCAA-084	KICKER	0.3	0		196.1863778	112.4225469	-0.04648579	0	0.053759391	-0.712966999
eS2-BPMA-084	MONITOR	0.05	0		196.3363778	112.5725469	-0.144597933	0	0.167223073	-0.712966999
eS2-MQAJ-085	QUADRUPOLE	0.73	-13.23872118	17.53	197.1963778	113.4325469	-0.707107557	0	0.817748187	-0.712966999
eS1-MCAA-071	KICKER	0.3	0		1273.32793	1189.564099	-0.046485774	0	-0.053759387	3.854559653
eS1-BPMA-071	MONITOR	0.05	0		1273.47793	1189.714099	-0.144597918	0	-0.167223069	3.854559653
eS1-MQAJ-072	QUADRUPOLE	0.73	-13.23872118	17.53	1274.33793	1190.574099	-0.707107542	0	-0.817748183	3.854559653



Space for Bellows - ECR





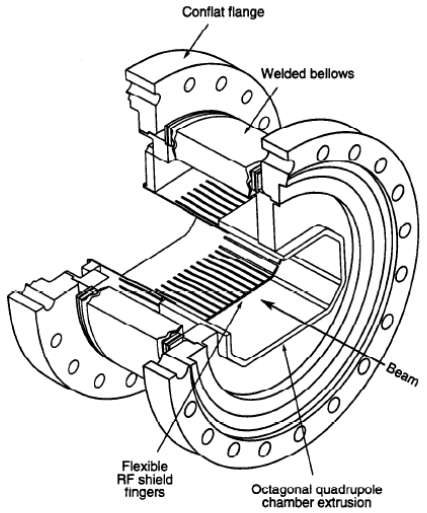


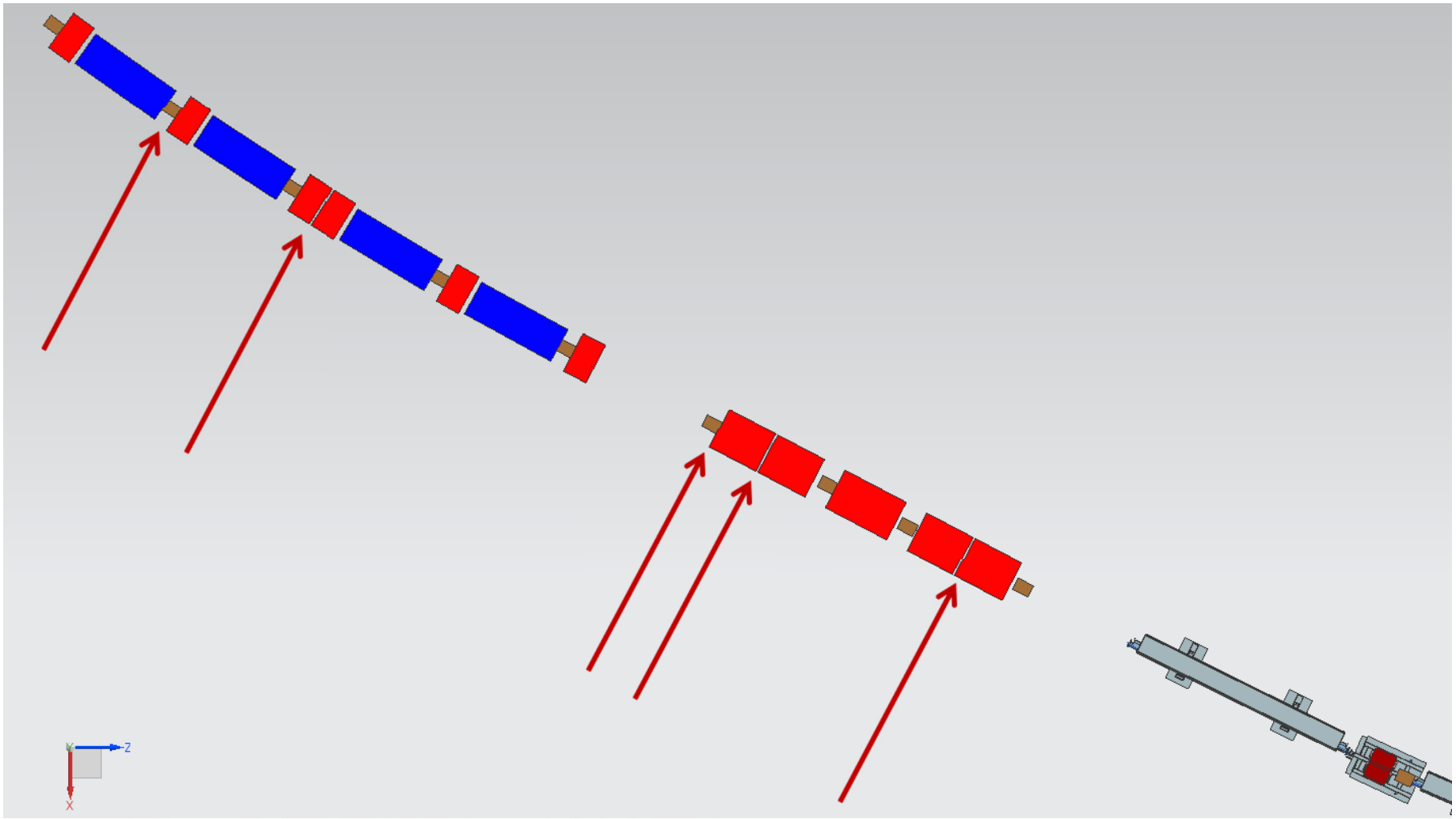
Fig 5-56. CAD illustration of the HER arc bellows, showing inner RF shield.

Table 5-22. Compression requirements for HER arc bellows.

Operational mode	Bellows compression (in.)	Number of cycles
Installation	1.0	100
Nominal (0.99-A beam)	0.09	100,000
Max. design (3.0-A beam)	0.2	100,000
150°C in situ bakeout	0.65	10

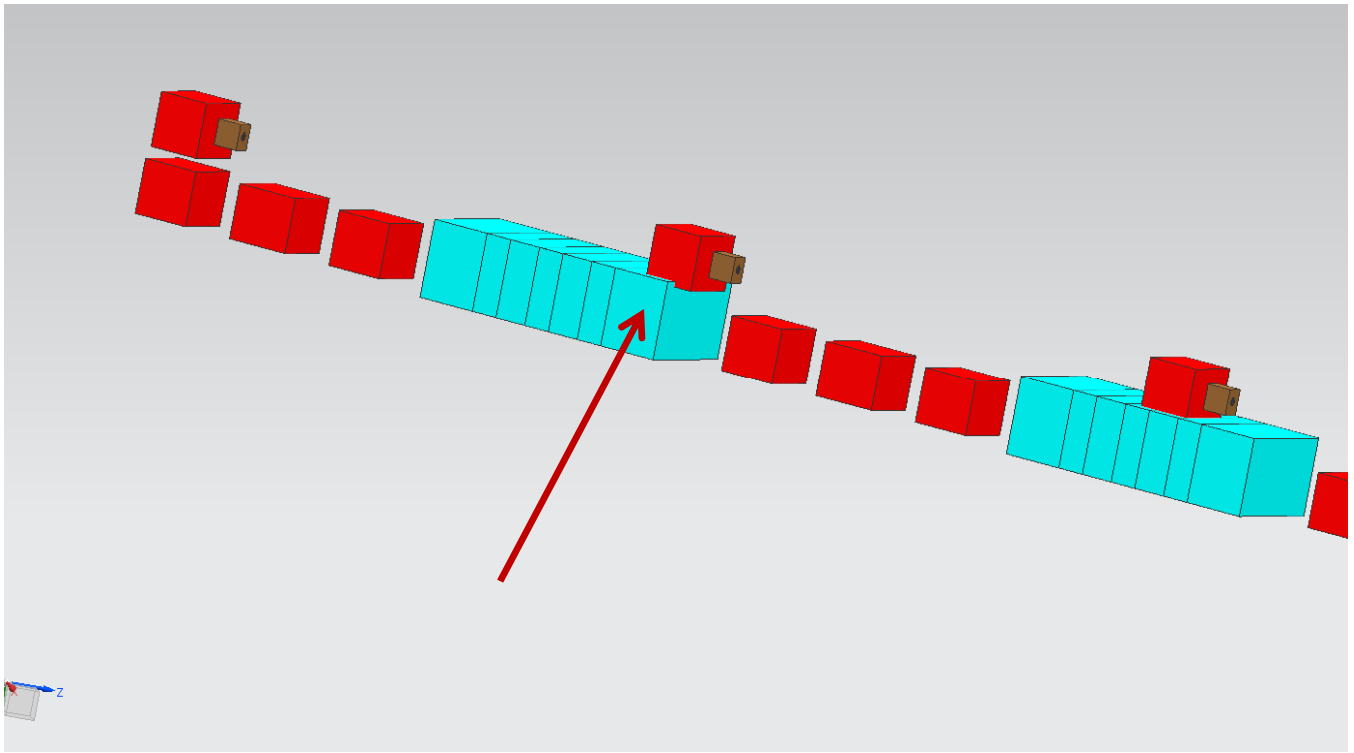
Spacing - Interfaces Between Elements

- Need room to bolt elements together – consideration of multiple elements on “girder” assemblies if spacing is critical



Vertical Spacing

- 1.1m vertical spacing between ECR and ICR may yield element interferences
- Need to refine models for various elements to insure adequate spacing is allotted
- The more added detail, the higher confidence in averting space issues earlier in the process



Space for Upgrades

- Considerations for adding future features or energy increases (more Cryomodules) in the Ion Collider Ring
- Straights in Ion Collider Ring
  - Total DRIFT length in Lattice File = 491m
    - NE Quadrant (location of 2 x 30m Cooling Solenoids) = 136.2m
    - NW Quadrant = 150.4m
    - SE Quadrant (future IP region – current SRF location) = 112.2m
    - SW Quadrant (initial IP region) = 92.3m

Making Updates

- Get updated lattice file(s)
- Assess formatting, nomenclature, changes in elements
- Create new CAD models of new elements, as required
- Re-run the “NX_Component_Gen” Program
- Re-run the NX Journaling process on the affected segment of the machine
- Refresh top level assembly with updated revisions of affected machine segment(s)

The Good, The Bad, The Ugly

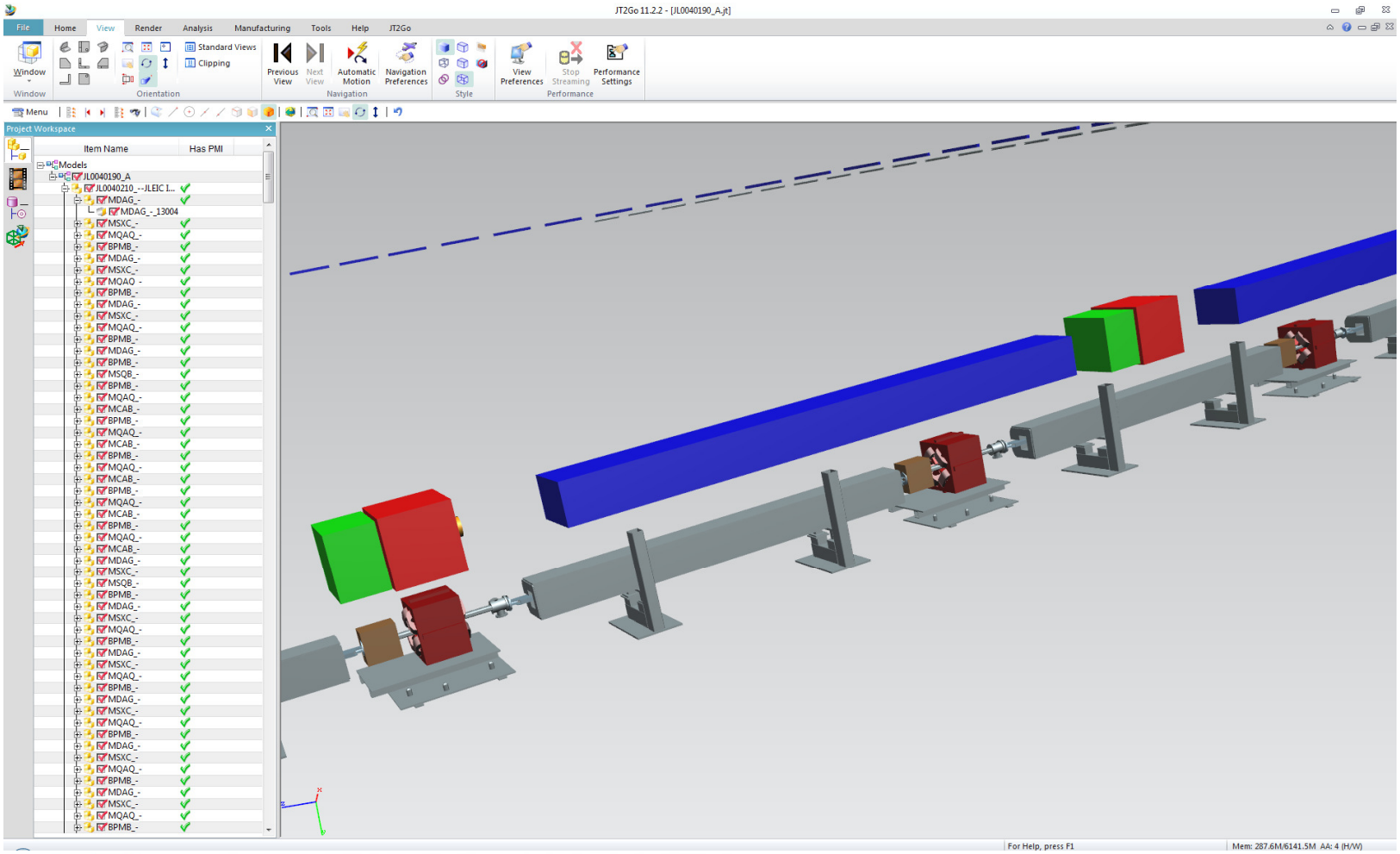
- The Good:
  - Can swap in updated models for individual or groups of elements
  - Can revise layout in hours versus days or weeks
  - Driven directly from the lattice files – no fat fingered data issues
  - Nomenclature is available within the CAD models – not yet tied to the individual elements
- The Bad:
  - Need to get the coordinate systems defined and consistent
  - As we go around the figure 8, the magnet orientation needs to flip from arc to arc - develop automated approach
- The Ugly:
  - Large assembly management will be crucial
  - Revision control of various segments will also be crucial
  - Needs more system components to further validate space utilization (vacuum, instrumentation, beam pipe, etc.)

Looking Forward

- NEXT STEPS
  - Generate the model for the other machine segments (Ion Booster Ring, Transfer Lines, Ion Injector and LINAC)
  - Build confidence in the size and shape of the representative element CAD models
  - Add detail to the PEP-II RF Cavities (with HOM loads)
  - Add in Synchronization Chicanes in ECR Arcs
  - Add the tunnel to the top level layout
- IMPROVEMENTS
  - Resolve magnet orientation from arc to arc
  - Tie nomenclature to metadata for individual elements
  - Tie in the “functional” regions of the machines versus just the “geographical” regions
  - Improve navigation within the CAD model (how to find what you want to look at)
  - Be able to highlight what changes

JT File and Viewer

- JT2Go – Free JT File Viewer from Siemens – https://www.plm.automation.siemens.com/en_us/products/teamcenter/plm-platform-capabilities/visualization/jt2go/



Thank you for your attention.

Questions???

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