Aperture Model from LHC Functional Database (FDB)

- Reminder: LOC meeting of 19 July 2005:
  - FDB now gives aperture markers for start end end of every vacuum chamber and beam screen in a “MAD” format
    - Aperture class definitions followed by Sequence editing blocks
    - Not immediately useful with MAD
    - Parser written to extract information
    - Various errors, overlapping pipes etc., discovered
- Corrections made since then
  - Covers most parts of Ring 1 and Ring 2
  - Repeated analysis for today ... following slides
    - All done in Mathematica, using Madtomma environment
    - Problematic data exported as CSV files
- Comparison with Collimation Study aperture
  - Complete for Ring 1, not defined for Ring

Undefined Vacuum Chamber Markers

Marker name	s/m	Aperture class
VMAAA.S.4R1.B1	57.972	VMAAA.U
VMAAA.E.4R1.B1	58.172	VMAAA.D
VMAAA.S.A7R1.B1	237.028	VMAAA.U
VMAAA.E.A7R1.B1	237.208	VMAAA.D
VMAAA.S.B7R1.B1	237.588	VMAAA.D
VMAAA.E.B7R1.B1	237.768	VMAAA.U
VMAAA.S.C7R1.B1	241.168	VMAAA.D
VMAAA.E.C7R1.B1	241.348	VMAAA.U
VMAAA.S.D7R1.B1	241.728	VMAAA.D
VMAAA.E.D7R1.B1	241.908	VMAAA.U
VMAAA.S.4L2.B1	3263.139	VMAAA.U
VMAAA.E.4L2.B1	3263.339	VMAAA.D
VMAAA.S.4R2.B1	3401.535	VMAAA.D
VMAAA.E.4R2.B1	3401.735	VMAAA.U
VAMID.S.D6L3.B1	6475.155	VAMID.U
VAMID.E.D6L3.B1	6475.455	VAMID.D
VAMID.S.C6L3.B1	6479.39	VAMID.U
VAMID.E.C6L3.B1	6479.69	VAMID.D
VMJSB.S.B6L3.B1	6483.625	VMJSB.U
VMJSB.E.B6L3.B1	6483.925	VMJSB.D
VMJSB.S.A6L3.B1	6497.548	VMJSB.D
VMJSB.E.A6L3.B1	6497.848	VMJSB.U
VAMID.S.B6L3.B1	6501.783	VAMID.D

70 undefined markers in Ring 1, 10 undefined marker classes

Marker name	s/m	Aperture clas
VMAAA.S.4R1.B2	57.972	VMAAA.U
VMAAA.E.4R1.B2	58.172	VMAAA.D
VMAAA.S.A7R1.B2	237.028	VMAAA.U
VMAAA.E.A7R1.B2	237.208	VMAAA.D
VMAAA.S.B7R1.B2	241.718	VMAAA.D
VMAAA.E.B7R1.B2	241.908	VMAAA.U
VMAAA.S.4L2.B2	3262.986	VMAAA.U
VMAAA.E.4L2.B2	3263.186	VMAAA.D
VMAAA.S.4R2.B2	3401.382	VMAAA.D
VMAAA.E.4R2.B2	3401.582	VMAAA.U
VAMID.S.D6L3.B2	6475.155	VAMID.U
VAMID.E.D6L3.B2	6475.455	VAMID.D
VAMID.S.C6L3.B2	6479.39	VAMID.U
VAMID.E.C6L3.B2	6479.69	VAMID.D
VMJSB.S.B6L3.B2	6483.625	VMJSB.U
VMJSB.E.B6L3.B2	6483.925	VMJSB.D
VMJSB.S.A6L3.B2	6497.548	VMJSB.D
VMJSB.E.A6L3.B2	6497.848	VMJSB.U
VAMID.S.B6L3.B2	6501.783	VAMID.D
VAMID.E.B6L3.B2	6502.083	VAMID.U
VAMID.S.A6L3.B2	6506.018	VAMID.D
VAMID.E.A6L3.B2	6506.318	VAMID.U
VMHCB.S.6L3.B2	6511.578	VMHCB.D

80 undefined markers in Ring 2, same 10 undefined marker classes

Identifying Beam Pipes

- Markers indicating start and end of pipes are not ordered
  - Many zero-length “pipes”
  - Algorithm to match them up according to names (“.S.”->”.E.”)
  - Undefined apertures discarded
  - Incomplete RECTELLIPSE data assumed to indicate elliptical chambers
  - No unmatched markers left
  - Some tapered beam pipes (ends have different apertures)
  - Some of these are “complex” tapers (ends have different shapes)

Presumed elliptical pipes (Ring 2)

Name	s/m	APER_1	APER_2	APER_3	APER_4
VCTNC.E.4R1.B2	59.302	0	0	0.064	0.0265
VCTNB.E.4R1.B2	89.2	0	0	0.064	0.0265
VCTNM.E.B5L3.B2	6519.793	0	0	0.064	0.0265
VCTNM.S.A5L3.B2	6524.193	0	0	0.064	0.0265
VCTNO.E.5L3.B2	6544.613	0	0	0.064	0.0265
VCTNL.E.B4L3.B2	6618.606	0	0	0.064	0.0265
VCTNL.S.A4L3.B2	6623.126	0	0	0.064	0.0265
VCTNE.E.4L3.B2	6647.291	0	0	0.064	0.0265
VCTNE.S.4R3.B2	6682.151	0	0	0.064	0.0265
VCTNM.E.A4R3.B2	6706.376	0	0	0.064	0.0265
VCTNM.S.B4R3.B2	6710.776	0	0	0.064	0.0265
VCTNO.S.5R3.B2	6784.789	0	0	0.064	0.0265
VCTNL.E.A5R3.B2	6805.189	0	0	0.064	0.0265
VCTNL.S.B5R3.B2	6809.709	0	0	0.064	0.0265
VCTNE.S.5L7.B2	19877.85	0	0	0.064	0.0265
VCTNH.S.4L7.B2	19915.7	0	0	0.064	0.0265
VCTNI.E.4L7.B2	19920.88	0	0	0.064	0.0265
VCTNJ.S.4L7.B2	19941.08	0	0	0.064	0.0265
VCTYD.S.6R8.B2	23500.33	0	0	0	0
VCTYD.E.6R8.B2	23506.72	0	0	0	0
VCTNA.E.4L1.B2	26573.86	0	0	0.064	0.0265
VCTND.E.4L1.B2	26599.78	0	0	0.064	0.0265

Missing data?

Complex tapers in Ring 1

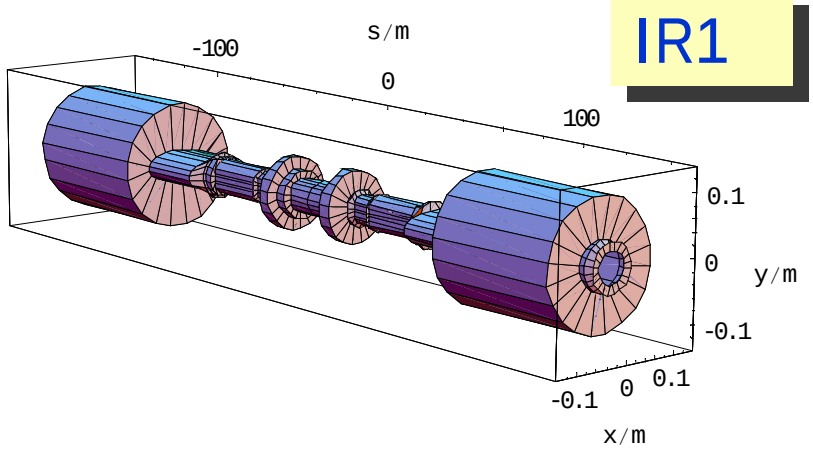
102 tapered pipes in Ring1, 128 in Ring 2,
20 complex tapers in each ring.

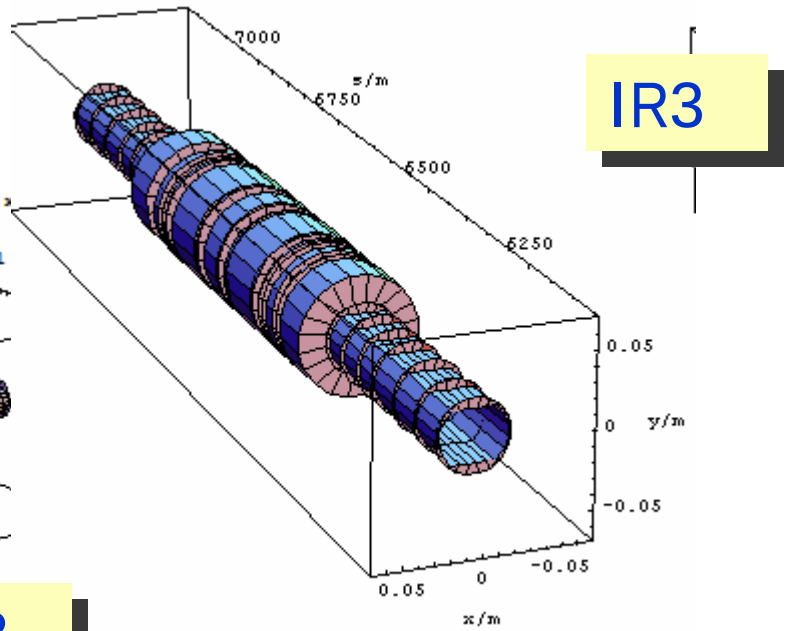
Are they all intended ?

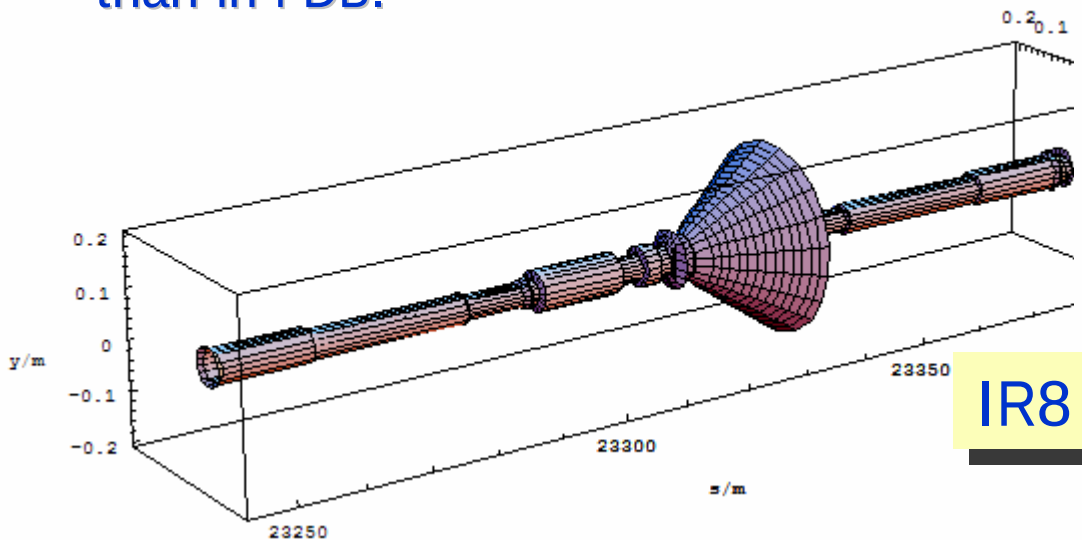
START OF BEAM PIPE						END OF BEAM PIPE					
Name	**s/m**	**APER_1**	**APER_2**	**APER_3**	**APER_4**	**Name**	**s/m**	**APER_1**	**APER_2**	**APER_3**	**APER_4**
VCTNC.S.4R1.B1	59.102	0.10635	0.10635	0.10635	0.10635	VCTNC.E.4R1.B1	59.302	0.064	0.0265	0.064	0.0265
VCTNB.S.4R1.B1	84.898	0.10635	0.10635	0.10635	0.10635	VCTNB.E.4R1.B1	89.2	0.064	0.0265	0.064	0.0265
VCTNL.S.B5L3.B1	6519.683	0.10635	0.10635	0.10635	0.10635	VCTNL.E.B5L3.B1	6519.733	0.064	0.0265	0.064	0.0265
VCTNL.S.A5L3.B1	6524.253	0.064	0.0265	0.064	0.0265	VCTNL.E.A5L3.B1	6524.303	0.10635	0.10635	0.10635	0.10635
VCTNO.S.5L3.B1	6544.508	0.10635	0.10635	0.10635	0.10635	VCTNO.E.5L3.B1	6544.613	0.064	0.0265	0.064	0.0265
VCTNM.S.B4L3.B1	6618.556	0.10635	0.10635	0.10635	0.10635	VCTNM.E.B4L3.B1	6618.666	0.064	0.0265	0.064	0.0265
VCTNM.S.A4L3.B1	6623.066	0.064	0.0265	0.064	0.0265	VCTNM.E.A4L3.B1	6623.176	0.10635	0.10635	0.10635	0.10635
VCTNE.S.4L3.B1	6647.181	0.10635	0.10635	0.10635	0.10635	VCTNE.E.4L3.B1	6647.291	0.064	0.0265	0.064	0.0265
VCTNE.S.4R3.B1	6682.191	0.064	0.0265	0.064	0.0265	VCTNE.E.4R3.B1	6682.301	0.10635	0.10635	0.10635	0.10635
VCTNL.S.A4R3.B1	6706.266	0.10635	0.10635	0.10635	0.10635	VCTNL.E.A4R3.B1	6706.316	0.064	0.0265	0.064	0.0265
VCTNL.S.B4R3.B1	6710.836	0.064	0.0265	0.064	0.0265	VCTNL.E.B4R3.B1	6710.886	0.10635	0.10635	0.10635	0.10635
VCTNO.S.5R3.B1	6784.829	0.064	0.0265	0.064	0.0265	VCTNO.E.5R3.B1	6784.974	0.10635	0.10635	0.10635	0.10635
VCTNM.S.A5R3.B1	6805.139	0.10635	0.10635	0.10635	0.10635	VCTNM.E.A5R3.B1	6805.249	0.064	0.0265	0.064	0.0265
VCTNM.S.B5R3.B1	6809.649	0.064	0.0265	0.064	0.0265	VCTNM.E.B5R3.B1	6809.759	0.10635	0.10635	0.10635	0.10635
VCTNE.S.5L7.B1	19877.85	0.064	0.0265	0.064	0.0265	VCTNE.E.5L7.B1	19877.96	0.10635	0.10635	0.10635	0.10635
VCTNF.S.4L7.B1	19915.7	0.064	0.0265	0.064	0.0265	VCTNF.E.4L7.B1	19915.98	0.10635	0.10635	0.10635	0.10635
VCTNG.S.4L7.B1	19920.5	0.10635	0.10635	0.10635	0.10635	VCTNG.E.4L7.B1	19920.88	0.064	0.0265	0.064	0.0265
VCTNK.S.4L7.B1	19941.08	0.064	0.0265	0.064	0.0265	VCTNK.E.4L7.B1	19941.22	0.10635	0.10635	0.10635	0.10635
VCTNA.S.4L1.B1	26569.68	0.10635	0.10635	0.10635	0.10635	VCTNA.E.4L1.B1	26573.86	0.064	0.0265	0.064	0.0265
VCTND.S.4L1.B1	26599.46	0.10635	0.10635	0.10635	0.10635	VCTND.E.4L1.B1	26599.78	0.064	0.0265	0.064	0.0265

Collimation Study Aperture

- Data files from S. Redaelli
- Madtomma aperture functions compress to 7% of original size.
- Continuous interpolation to any value of s
  - Use outside MAD
  - Define MAD markers à la carte
- Data for Ring 1 only.
- More on experimental chambers than in FDB.





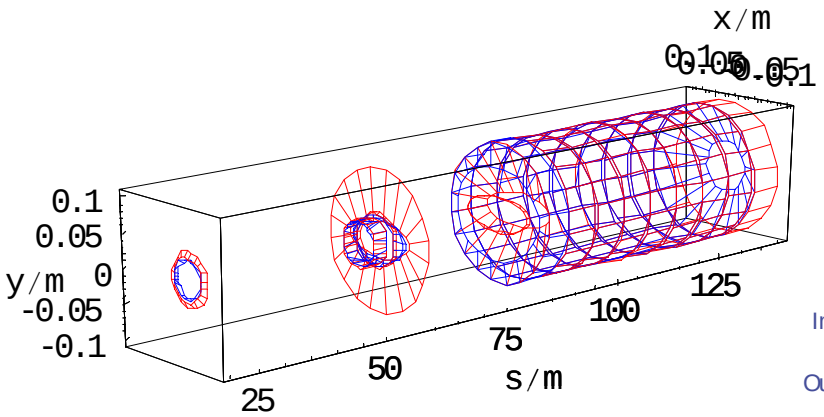


Difference between Collimation Aperture Model (CAM) and FDB

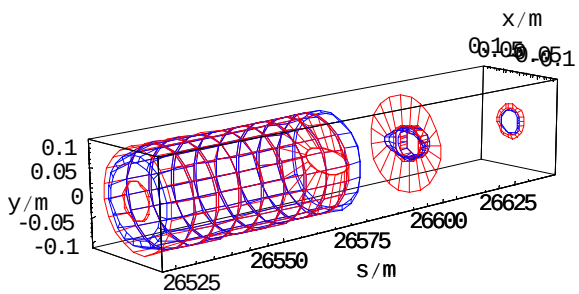
- Many possible ways to compare the information
- To begin with, I choose to compare the values given by the continuous interpolation of the CAM at the aperture markers defined by the FDB.
- Select those markers where values of the 4 RECTELLIPSE components differ by more than a tolerance (usually 0.1 mm)

Differences in IR1 (FDB in red, CAM in blue)

```
In[829]:= LHCmodule["IR11"]

Out[829]= {{IR11$START, 0}, {IR11$END, 144.9}}

In[828]:= LHCrangePipePairPlot[Last /@ LHCmodule["IR11"], 0.0001]
```



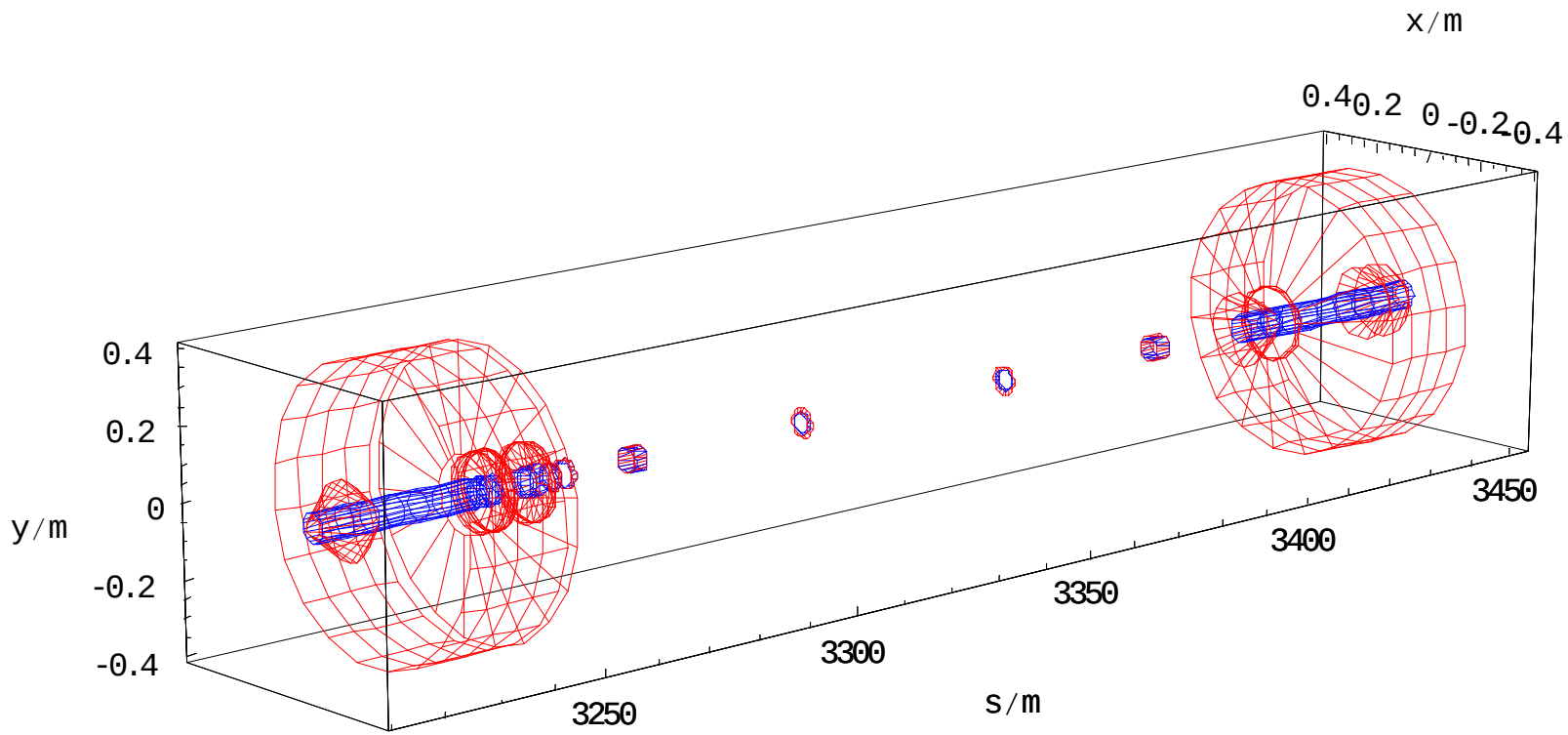

```
Out[828]//Short=

- Graphics3D -

In[831]:= LHCmodule["IR12"]

Out[831]= {{IR12$START, 26514.}, {IR12$END, 26658.9}}

In[830]:= LHCrangePipePairPlot[Last /@ LHCmodule["IR12"], 0.0001]
```




```
Out[830]//Short=

- Graphics3D -
```

Differences in IR2 (FDB in red, CAM in blue)

```
In[798]:= LHCmodule["IR2"]

Out[798]= {{IR2$START, 3215.31}, {IR2$END, 3449.26}}

In[805]:= LHCrangePipePairPlot[Last /@ LHCmodule["IR2"], 0.0001]
```




```
Out[805]//Short=

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```
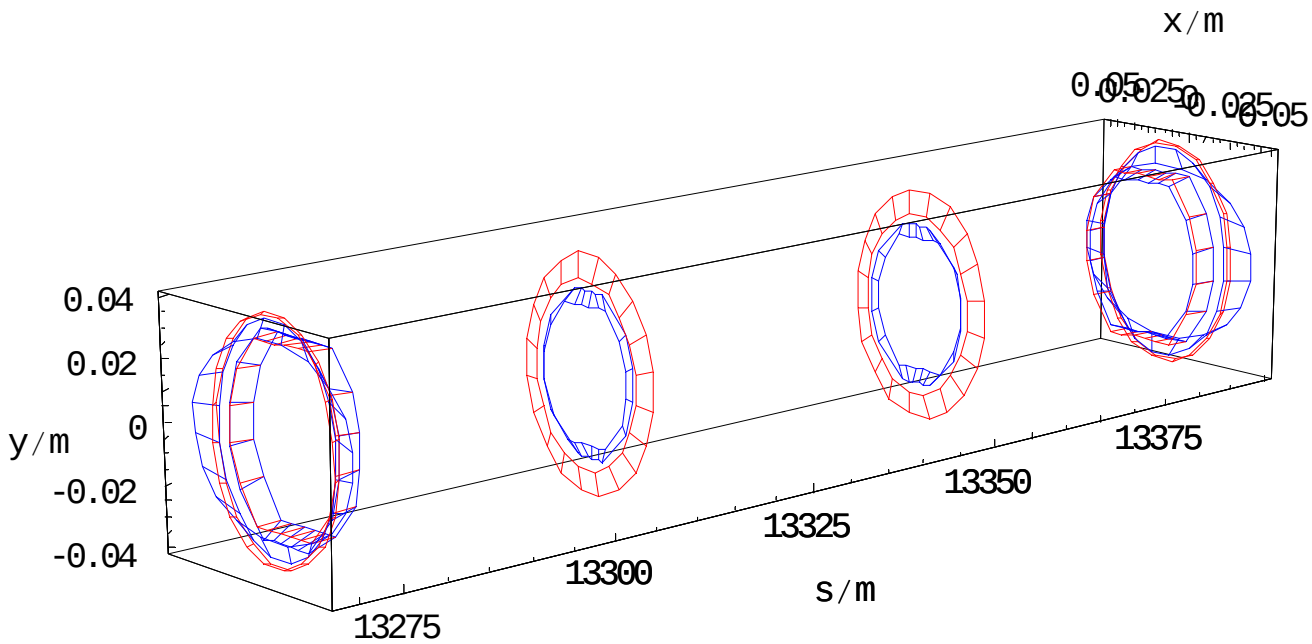

Differences in IR5 (FDB in red, CAM in blue)

In[799]:= **LHCmodule["IR5"]**

Out[799]= {{IR5$START, 13184.7}, {IR5$END, 13474.5}}

In[807]:= **LHCrangePipePairPlot[Last /@ LHCmodule["IR5"], 0.0001]**



Out[807]//Short=

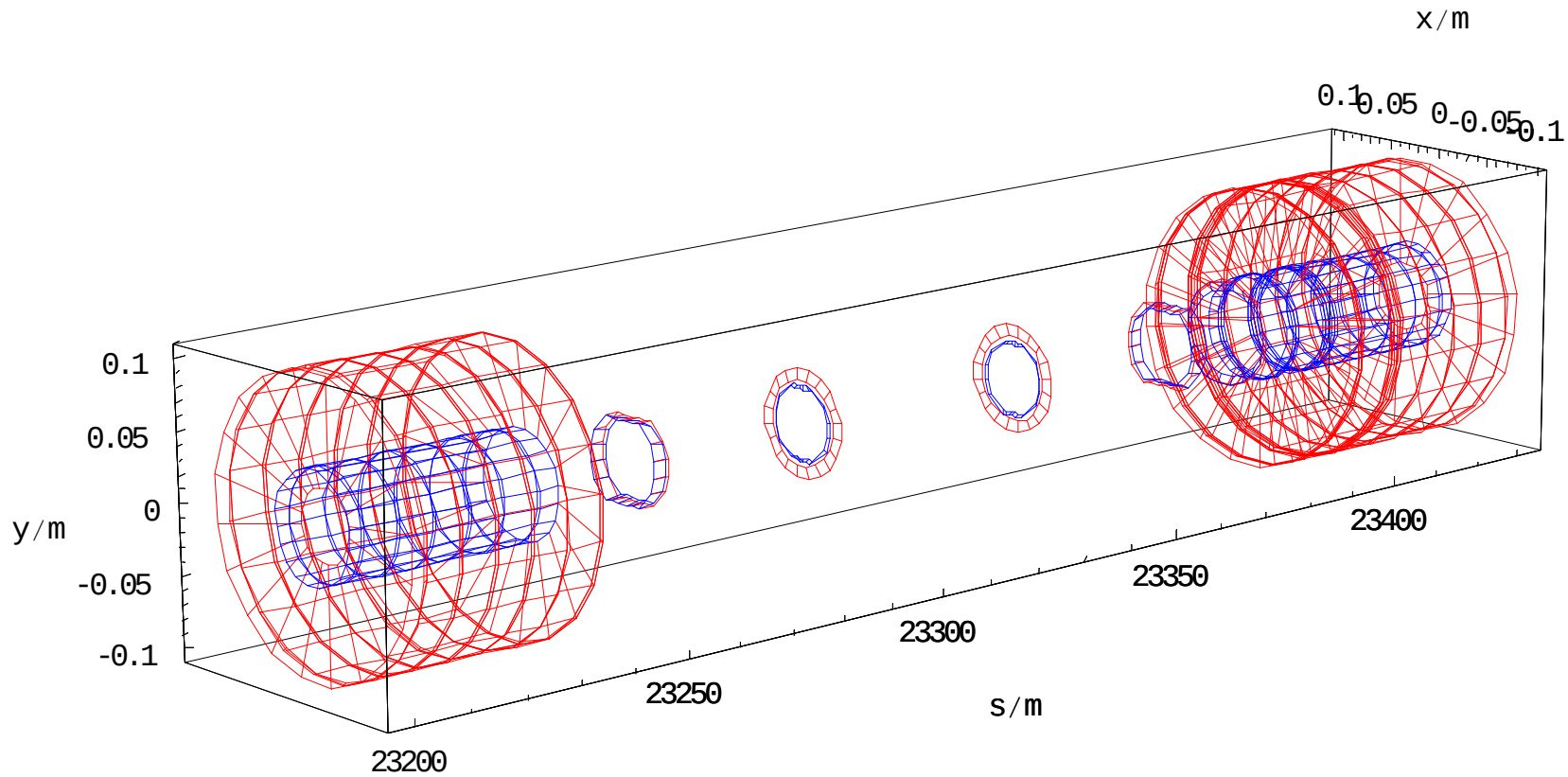
-Graphics3D-

Differences in IR8 (FDB in red, CAM in blue)

In[796]:= **LHCmodule["IR8"]**

Out[796]= {{IR8$START, 23200.9}, {IR8$END, 23429.5}}

In[808]:= **LHCrangePipePairPlot[Last /@ LHCmodule["IR8"], 0.0001]**

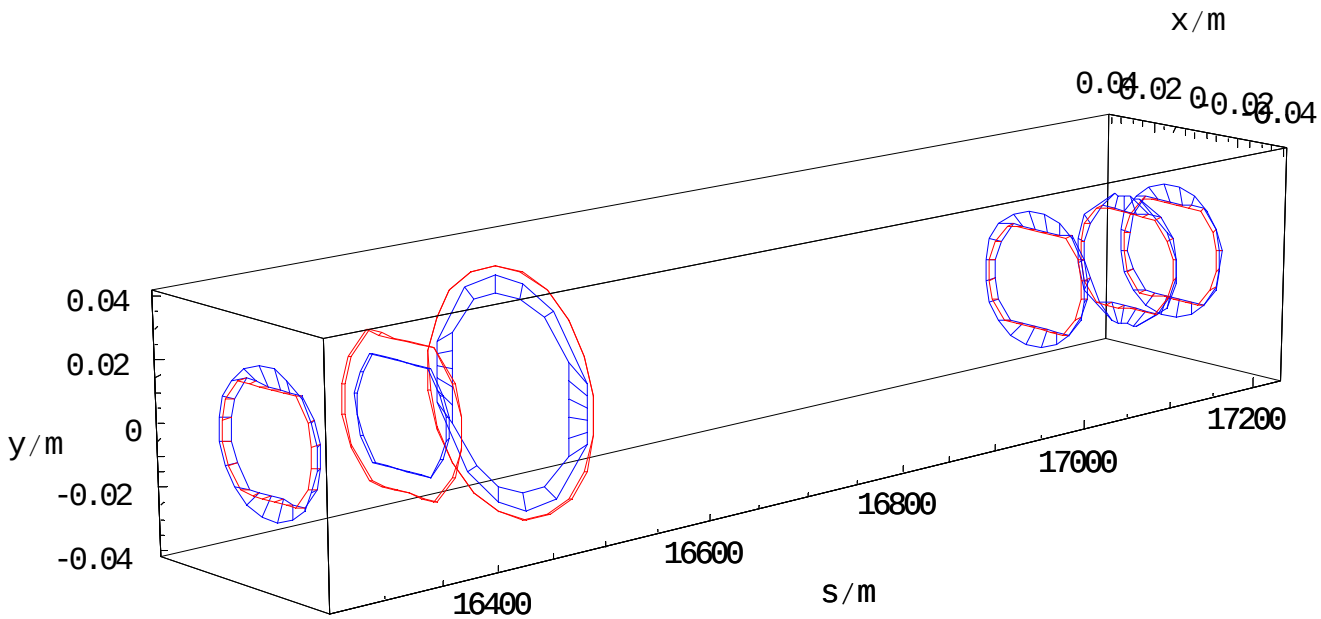


Out[808]//Short=

- Graphics3D -

Differences in Ring 1, IR6 with DSs (FDB in red, CAM in blue)

```
In[817]:= LHCmodule["DS.L6.B1"]

Out[817]= {{S.DS.L6.B1, 16115.}, {E.DS.L6.B1, 16392.3}}

In[818]:= LHCmodule["DS.R6.B1"]

Out[818]= {{S.DS.R6.B1, 16931.1}, {E.DS.R6.B1, 17208.5}}

In[819]:= LHCrangePipePairPlot[{16114.96919`, 17208.48244`}, 0.0001]
```




```
Out[819]//Short=

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```
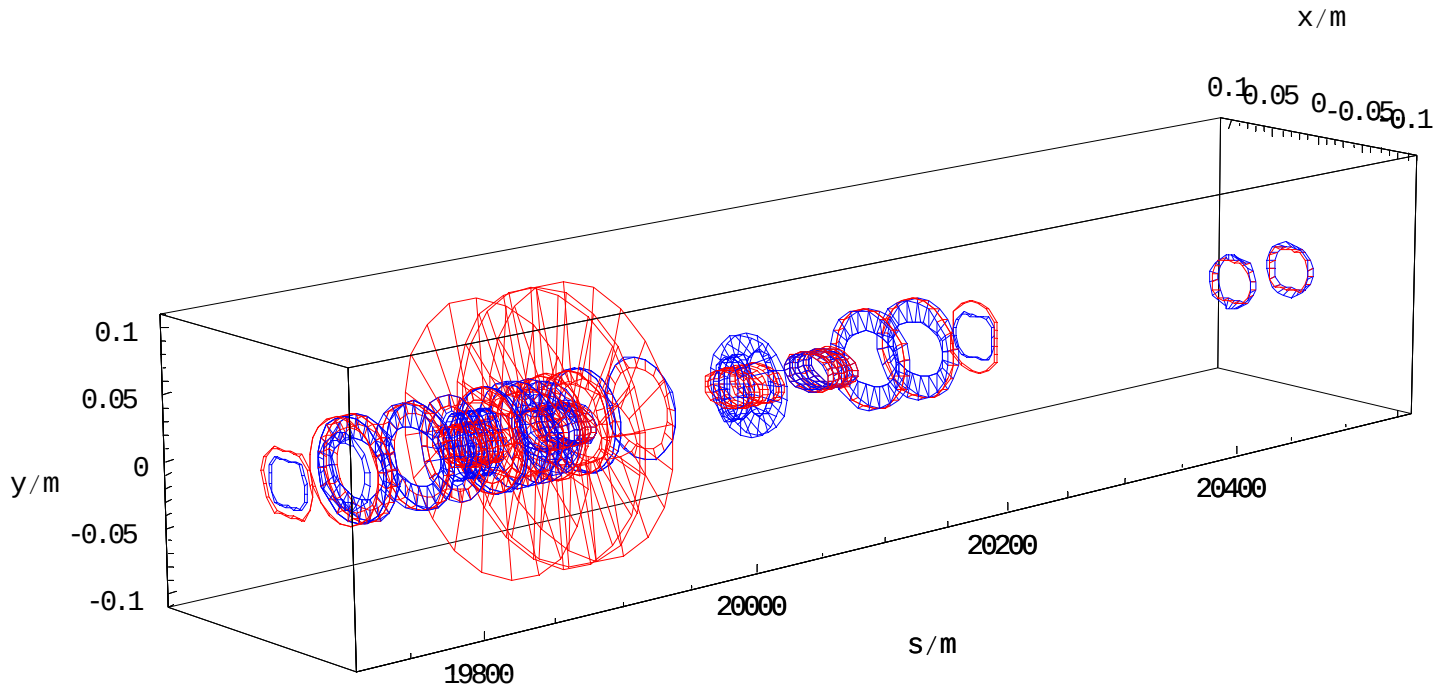

Differences in Ring 1, IR7 with DSs (FDB in red, CAM in blue)

```
In[832]:= LHCmodule["DS.R7.B1"]

Out[832]= {{S.DS.R7.B1, 20263.1}, {E.DS.R7.B1, 20541.4}}

In[833]:= LHCmodule["DS.L7.B1"]

Out[833]= {{S.DS.L7.B1, 19447.}, {E.DS.L7.B1, 19725.3}}

In[834]:= LHCrangePipePairPlot[{19446.97477`, 20541.35003`}, 0.0001]
```



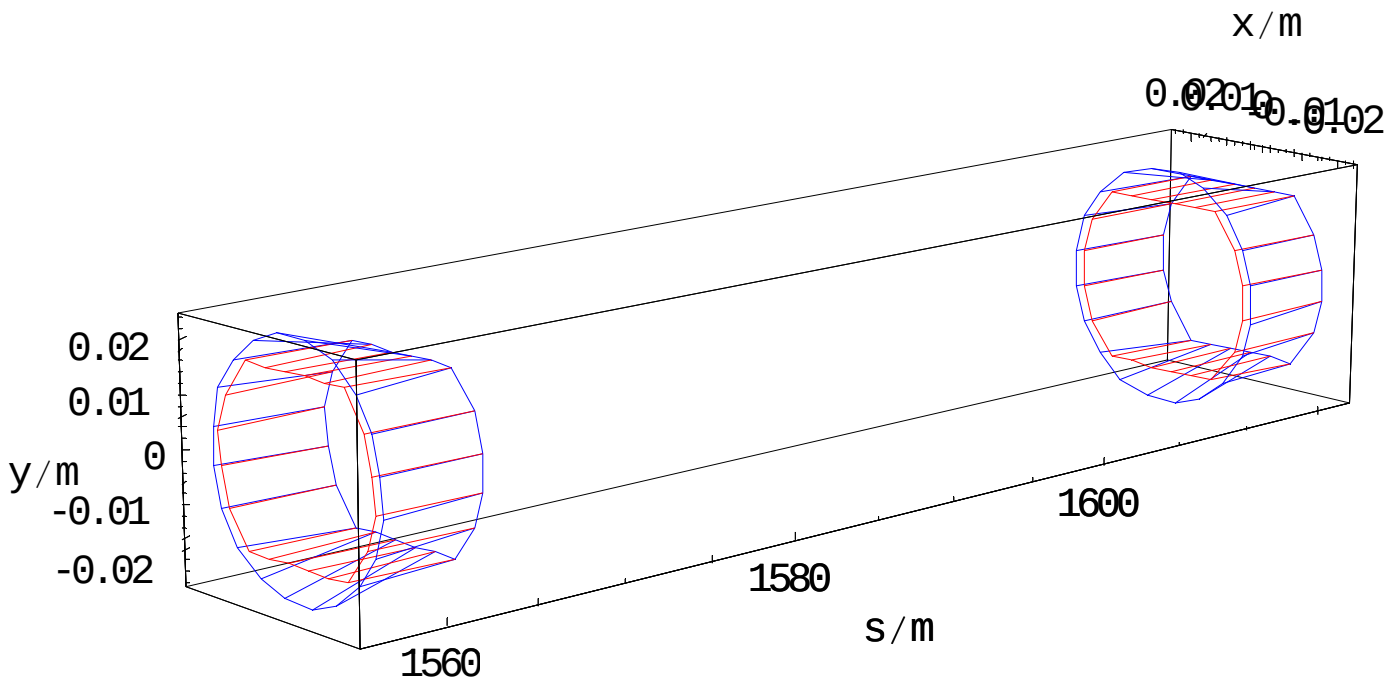

```
Out[834]//Short=

- Graphics3D -
```

Differences in an arc cell (FDB in red, CAM in blue)

In[823]:= **LHCmodule["CELL.12.B1"]**

Out[823]= {{S.CELL.12.B1, 1509.31}, {E.CELL.12.B1, 1616.22}}

In[822]:= **LHCrangePipePairPlot[Last /@ LHCmodule["CELL.12.B1"], 0.0001]**



Out[822]= - Graphics3D -

Summary

- Functional Database aperture has problems:
  - Does not cover all parts of the ring
  - Missing aperture data
  - Possible errors
  - (Problematic data exported in set of CSV files)
- Collimation Aperture Model has problems:
  - Covers whole of Ring 1 but not Ring 2
  - Has various differences from FDB
- I propose to create an aperture model for all of Ring 1 and Ring 2, based on FDB with CAM used only where there are gaps in FDB (experimental chambers, ...)
  - Leave out small BPM variations in arcs ?