Model description

December 2011

I have created a more traditional looking CH model based upon the sizes of the model shown in Figure 1.

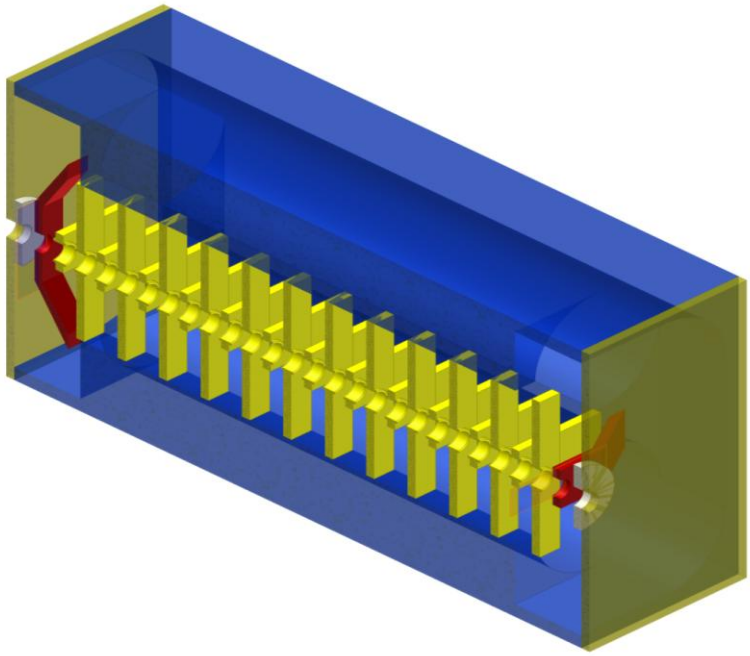

Figure 1: D:\Pete\CAD_2004-now\FETSProject_B\CH\CH_Novel\CH.iam

This new model is shown in Figure 2:

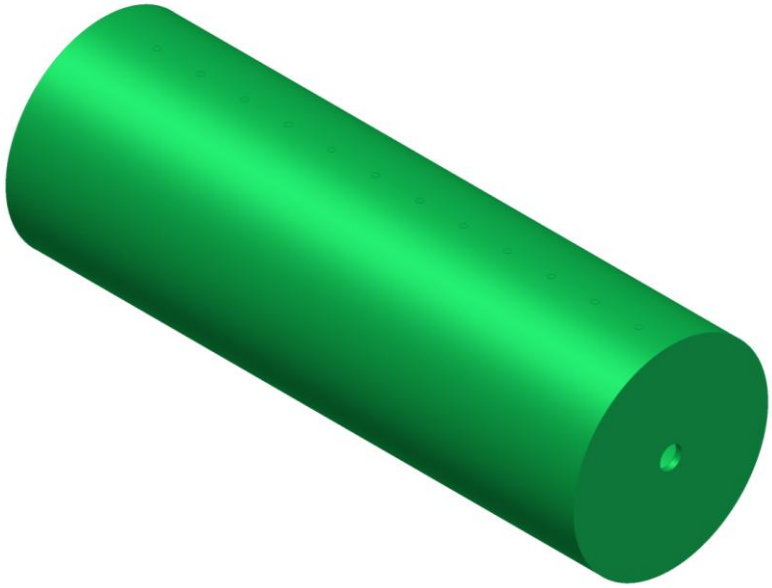

Figure 2. D:\Pete\CAD_2004-now\FETSProject_B\CH\CH_Traditional\CH_Traditional\CH_Traditional.ipt

Figure 3 shows a section view of the new model so that you can see inside:

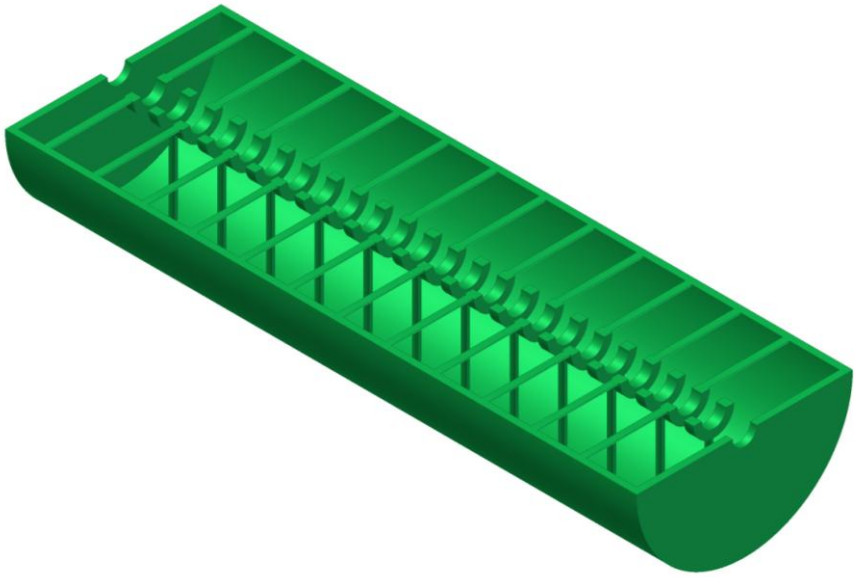

Figure 3. D:\Pete\CAD_2004-now\FETSProject_B\CH\CH_Traditional\CH_Traditional\CH_Traditional.ipt

Figure 4 shows a section view of both the old and new models for comparison. The number of stems, the stem spacing, the stem length and the drift tube inner diameter are approximately equal.

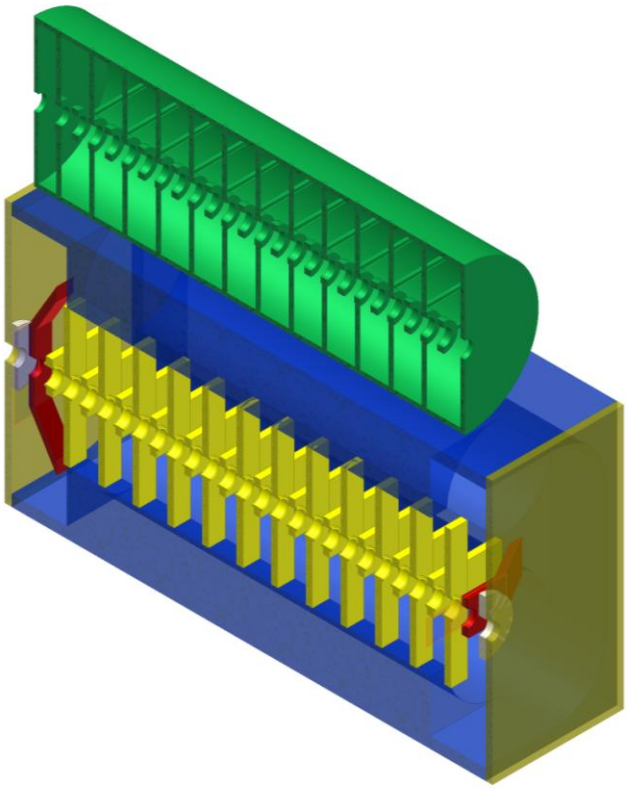

Figure 4. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional\CH_Comparison.iam

Figure 5 shows the inner volume model for the traditional version. This is the volume occupied by the vacuum (if indeed something can be occupied by a vacuum):

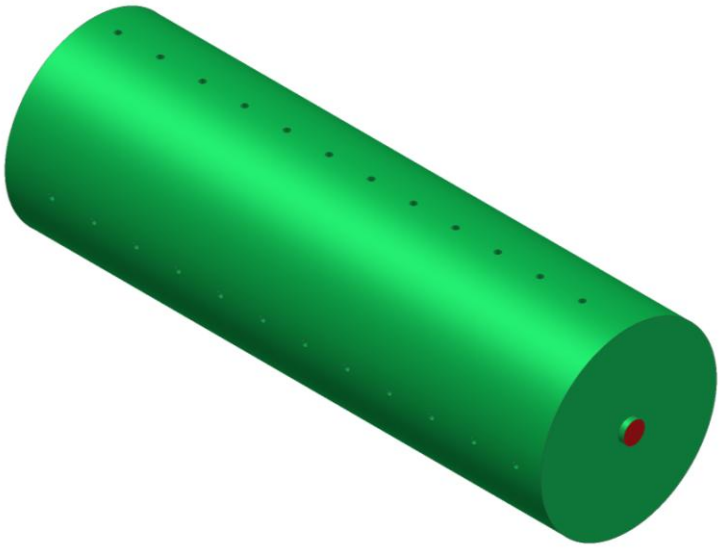

Figure 5. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional\CH_Traditional_InnerVolume.ipt

Figure 6 shows a section view of the inner volume model:

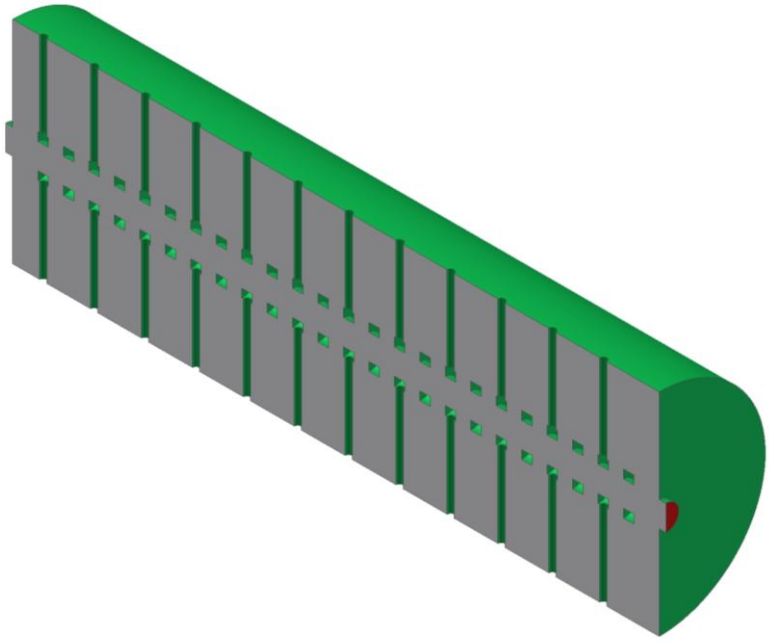

Figure 6. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional\CH_Traditional_InnerVolume.ipt

Problem: CANNOT PRODUCE 1D Ez FIELD PLOT

A model orientation problem showed up in COMSOL. When trying to look at a 1D line plot of the Z component of electric field we could not choose the beam axis for the line plot.

It was noticed that this model was oriented different to previous models – basically, it needs to have the Z axis as the beam axis.

Solution: ROTATE THE CAD MODEL IN INVENTOR

1. Create a new assembly
2. Place in the incorrectly oriented part.
3. Remove its GROUNDED status
4. Constrain the cylinder centre to the Z axis
5. Constrain the stem centres to the appropriate plane.
6. Save
7. Now use the correctly oriented .iam for the overlay and subtraction files as normal.

Note that the rotated version files in:

D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_Rotated

A quick look in COMSOL revealed that it was possible to produce a 2D Z axis plot using the new rotated model.

Scaling the model +30%

Figure 7. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_30\ CH_Traditional_Rotated_30.iam

The original cylindrical CH model **CH_Traditional_InnerVolume.sat** modelled in COMSOL gave a frequency of over 600MHz. Therefore, a model with a 30% increased cylinder diameter was created – see figure 7. **Note for Pete:** it was based upon the 'rotated' original and is hence an assembly file and not a part file.

IH_ModelParameters	0	
General_G	**0**	**mm**
G_Chamfer	0.5	mm
G_MediumChamfer	1	mm
G_LargeFillet	10	mm
Stem_STM	**0**	**mm**
STM_InnerDiameter	0	mm
STM_OuterDiameter	4	mm
Vessel_VSL	**0**	**mm**
VSL_InnerDiameter	125	mm
VSL_OuterDiamater	133	mm
VSL_InnerDiameter_30	162.5	mm
VSL_OuterDiamater_30	170.5	mm
VSL_Length	615	mm
DriftTube_DFT	**0**	**mm**

Figure 8. Excerpt from D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_30\CH_Dec_2011.xls

Scaling the model +50%

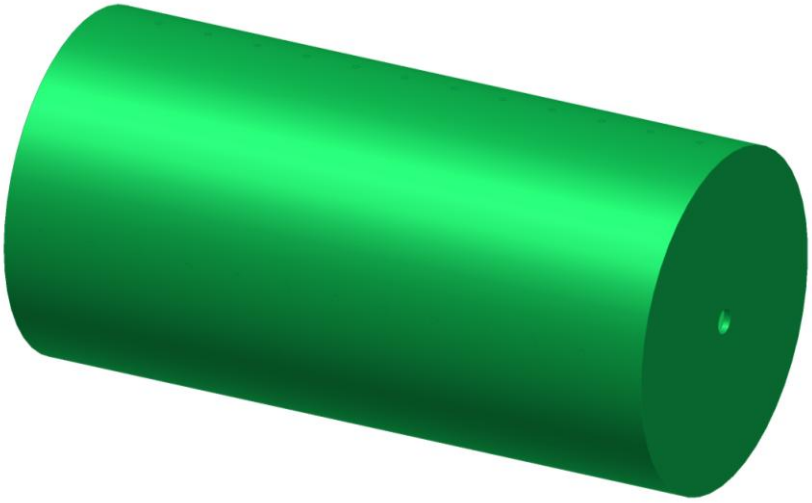

Figure 9. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_50\ CH_Traditional_Rotated_50.iam

The 30% increased diameter model was modelled at around 400Mhz. Therefore a 50% increased diameter model was created, see figure 9.

IH_ModelParameters	0	
General_G	**0**	**mm**
G_Chamfer	0.5	mm
G_MediumChamfer	1	mm
G_LargeFillet	10	mm
Stem_STM	**0**	**mm**
STM_InnerDiameter	0	mm
STM_OuterDiameter	4	mm
Vessel_VSL	**0**	**mm**
VSL_InnerDiameter	125	mm
VSL_OuterDiamater	133	mm
VSL_InnerDiameter_50	187.5	mm
VSL_OuterDiamater_50	195.5	mm
VSL_Length	615	mm
DriftTube_DFT	**0**	**mm**

Figure 10. Excerpt from D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_50\CH_Dec_2011.xls

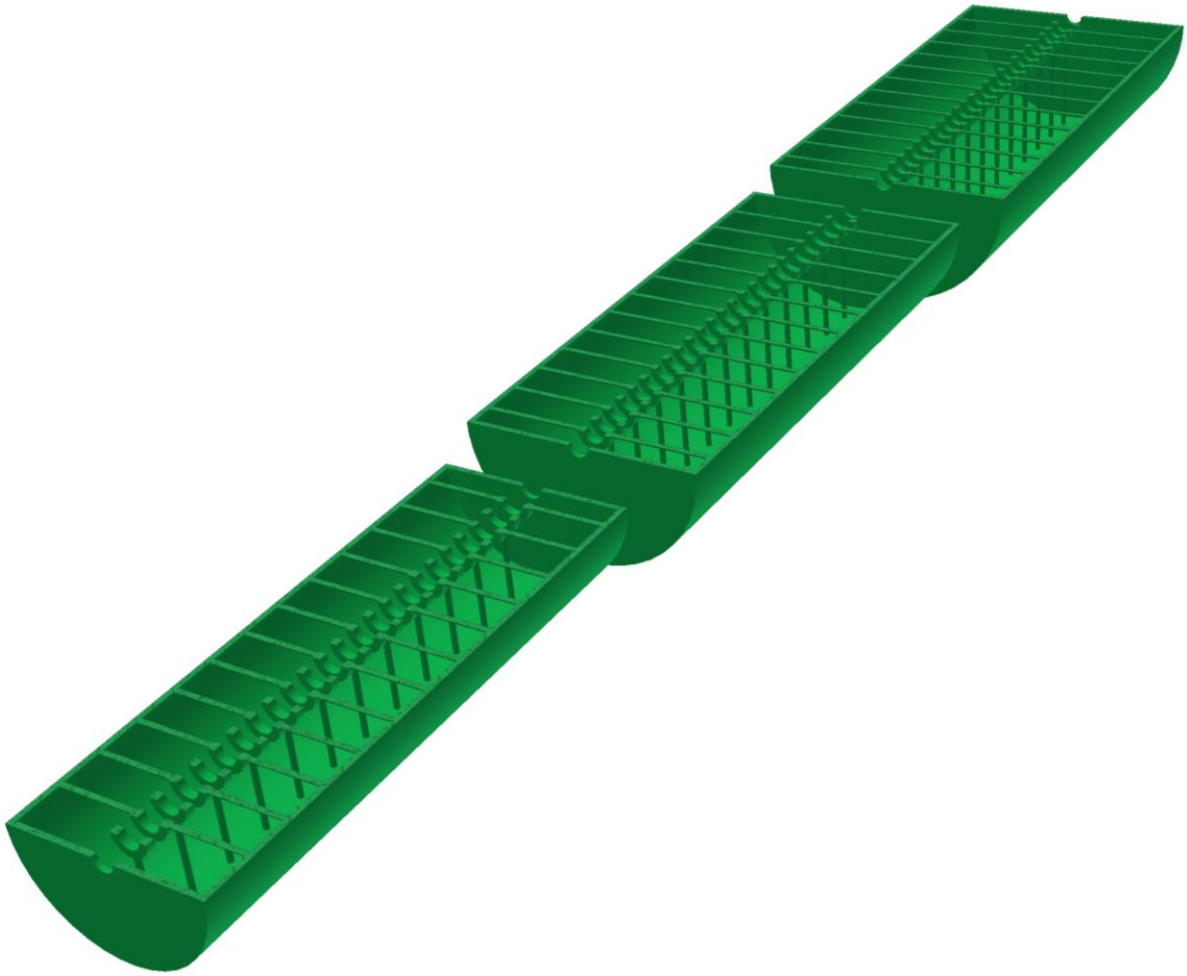

Figure 11. Image showing the original, the +30% and +50% models for comparison.

Scaling the model +60% and increasing the length to match the flat stemmed CH model from JP.

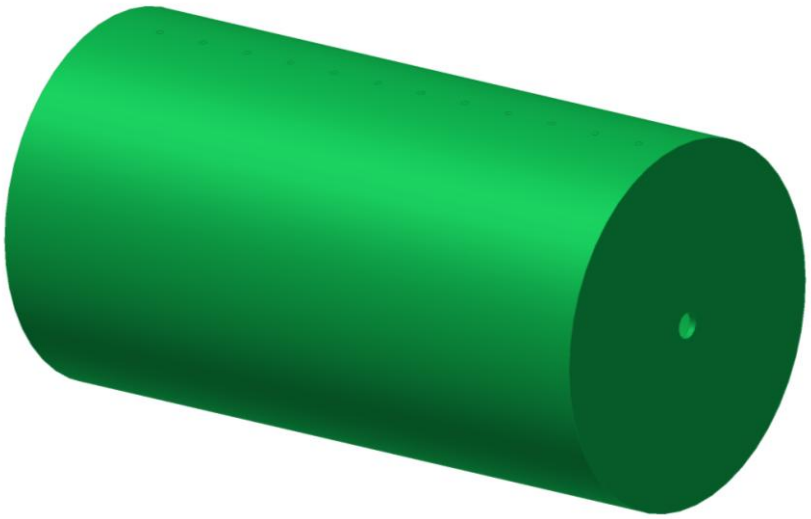

Figure 12. D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_60\ CH_Traditional_Rotated_60.iam

The 50% increased diameter model was modelled at around 370Mhz. Therefore a 60% increased diameter model was created, see figure 12.

IH_ModelParameters	0	
General_G	**0**	**mm**
G_Chamfer	0.5	mm
G_MediumChamfer	1	mm
G_LargeFillet	10	mm
Stem_STM	**0**	**mm**
STM_InnerDiameter	0	mm
STM_OuterDiameter	4	mm
Vessel_VSL	**0**	**mm**
VSL_InnerDiameter	125	mm
VSL_OuterDiamater	133	mm
VSL_InnerDiameter_60	200	mm
VSL_OuterDiamater_60	208	mm
VSL_Length	615	mm
DriftTube_DFT	**0**	**mm**

Figure 13. Excerpt from D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_60\CH_Dec_2011.xls

It was noticed that these cylindrical models were much shorter than the flat stemmed JP model:

Model	Length (mm)
InternalVolume_L2=30_R1=60	681
Cylindrical, 0, 30, 50, 60	389

The decision was made to increase the length and increase the number of drift tubes therefore maintaining the drift tube spacing. This equates to a cylindrical model at 681mm long with 44 drift tubes instead of 24, see figure 14.

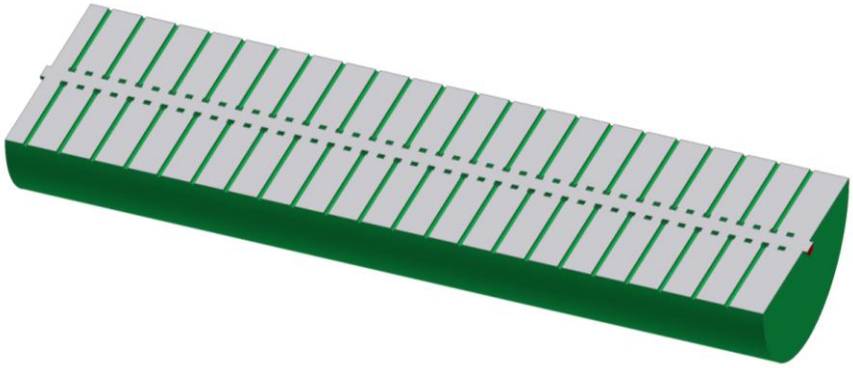

Figure 14. Section view showing 44 drift tubes

D:\Pete\CAD_2004-now\FETSProject_B\CH\ CH_Traditional \CH_Traditional_60_DriftTubes=44\ CH_Traditional_InnerVolume_60_DriftTubes=44.ipt

Figure 15 shows the SAT files for:

CH_Traditional_InnerVolume_60_DriftTubes=44

and

InternalVolume_L2=30_R1=60

They are both now 681mm in length

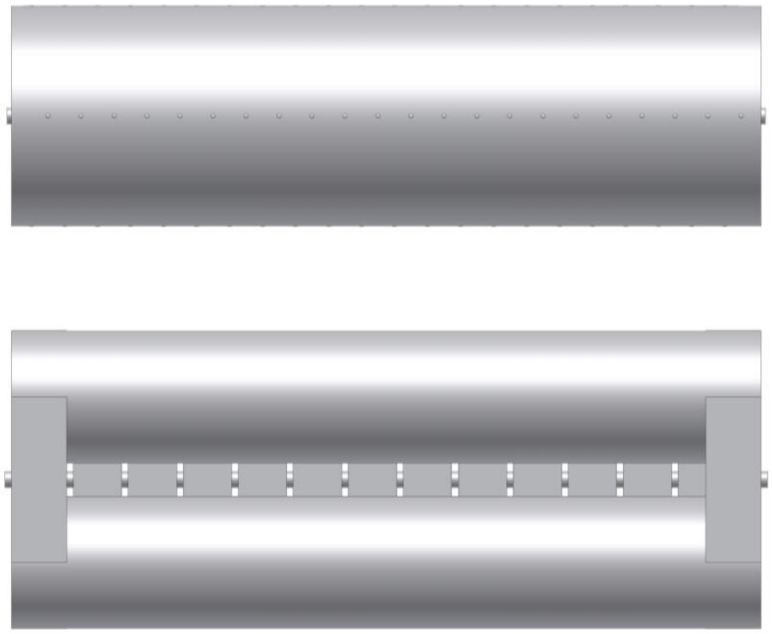

Figure 15. Comparison of SAT files showing equal lengths.

Following the same procedure as used previously four new models were created:

CH_Traditional_InnerVolume_65_DriftTubes=24.sat

CH_Traditional_InnerVolume_70_DriftTubes=24.sat

CH_Traditional_InnerVolume_65_DriftTubes=44.sat

CH_Traditional_InnerVolume_70_DriftTubes=44.sat

The updated parameters are shown in figure 16:

VSL_InnerDiameter_65	206.25	mm
VSL_OuterDiamater_65	219.45	mm
VSL_InnerDiameter_70	212.5	mm
VSL_OuterDiamater_70	226.1	mm

Figure 16. Excerpt from D:\Pete\CAD_2004-now\FETSProject_B\CH\CH_Cylindrical\CH_Traditional.xls

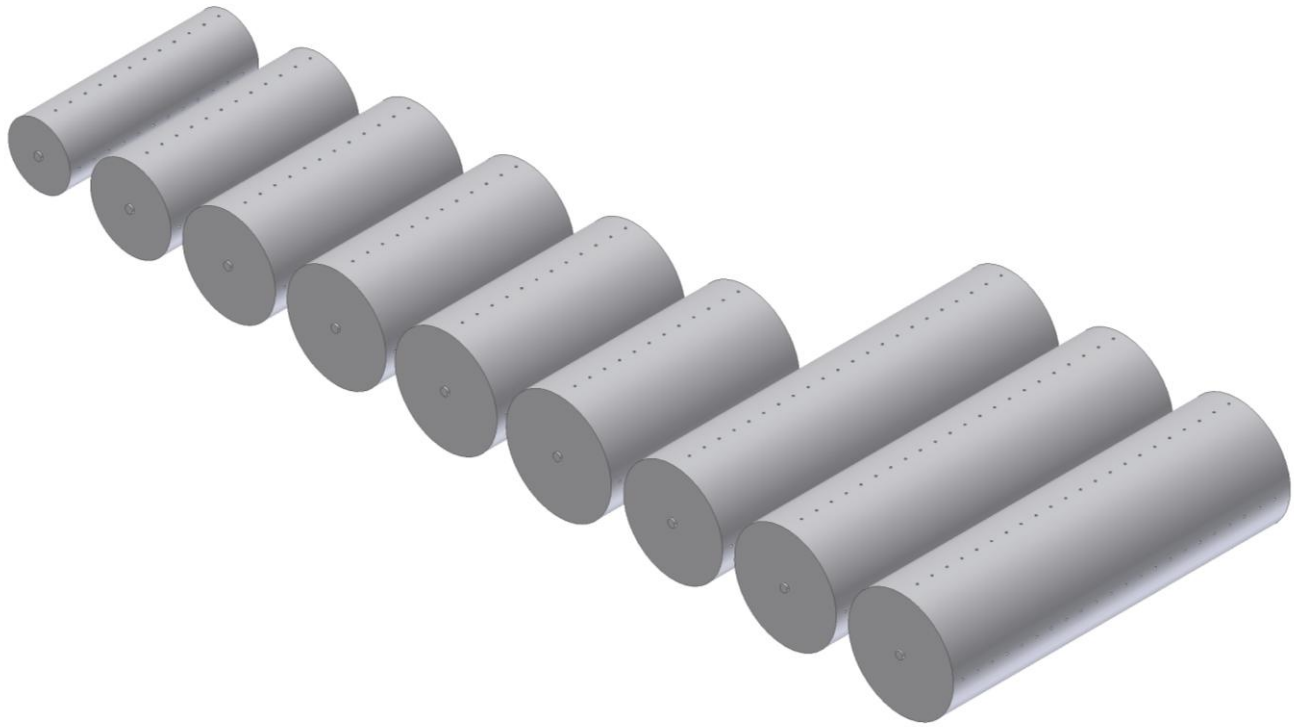

Figure 17, All the SAT models created in this phase of CH modelling.

QUESTION:

Why are the drift tube gaps on these recent traditional models 9mm when JPs novel model uses a 19mm gap?

ANSWER:

Don’t know. Think it’s just a random error.

SOLUTION:

Create a 70% model with 19mm drift tube spacing and approximately equal length.

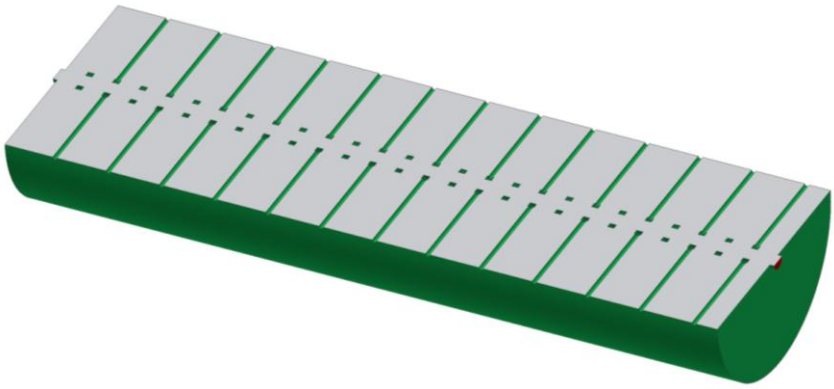

Figure 18, D:\Pete\CAD_2004-now\FETSProject_B\CH\CH_Traditional\CH_Traditional_70_DriftTubes=26\CH_Traditional_InnerVolume_70_DriftTubes=26.ipt

PROBLEM:

The frequency for model CH_Traditional_InnerVolume_70_DriftTubes=26 is 427MHz and we need 324MHz.

SOLUTION:

Increase the outer vessel diameter by a further 50%. This equates to an increase of 150% from the original model.

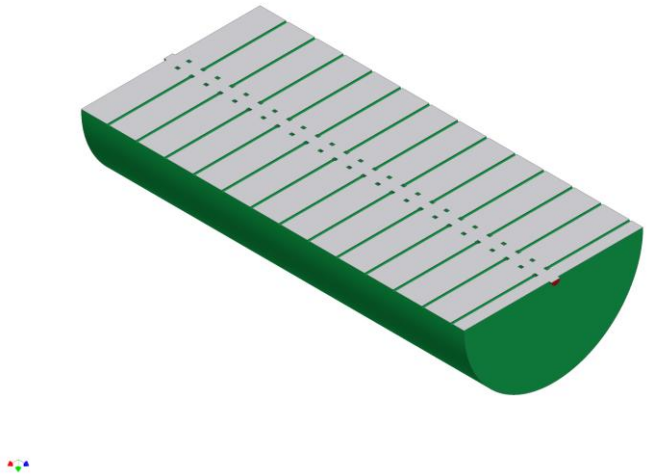

Figure 19. A sliced view of model CH_Traditional_InnerVolume_150_DriftTubes=26

DATE:

19th Jan 2012

PROBLEM:

The frequency for model CH_Traditional_InnerVolume_150_DriftTubes=26 is 285MHz and we need 324MHz.

SOLUTION:

Decrease the outer vessel diameter to 125% (greater than the original model).

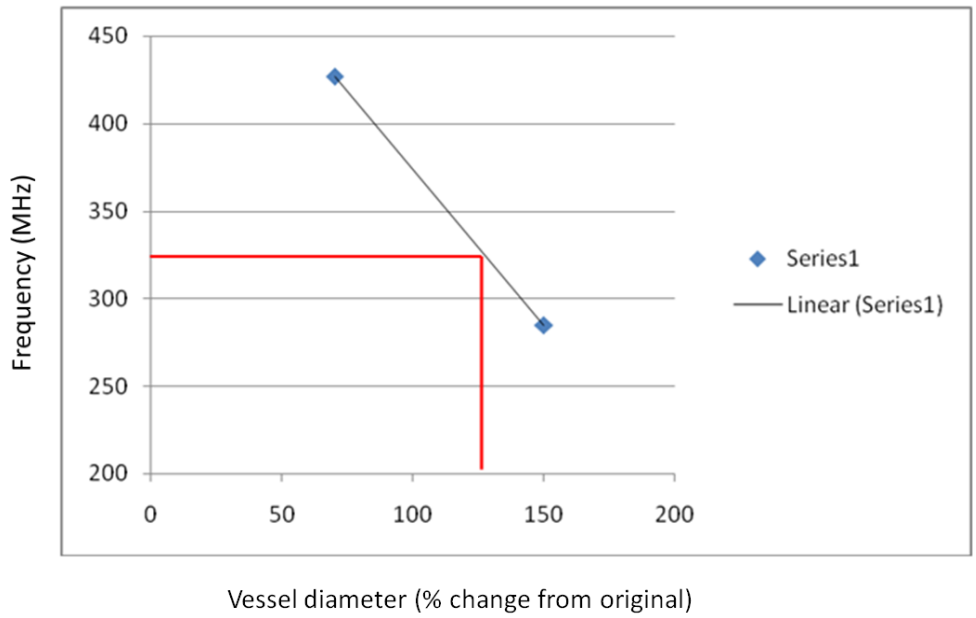

Figure 20. A graph showing the predicted value to get close to 324MHz (assuming a linear relationship between vessel diameter and frequency).

DATE:

19th Jan 2012

26th Jan 2012

For comparison, make an IH version of the model:

CH_Traditional_InnerVolume_125_DriftTubes=26

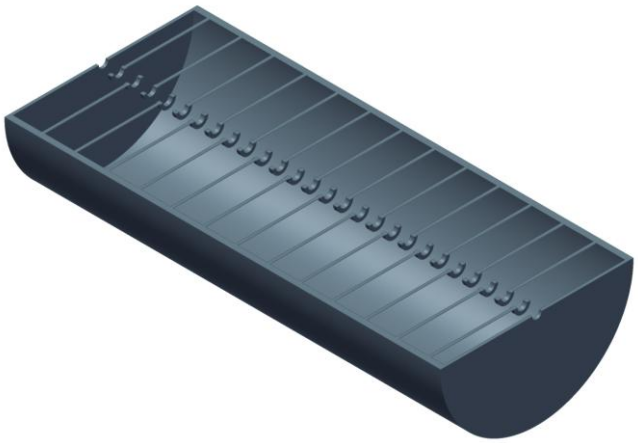

Figure 21. IH_Traditional_InnerVolume_125_DriftTubes=26

26th Jan 2012

For comparison, make a DTL version of the model:

CH_Traditional_InnerVolume_125_DriftTubes=26

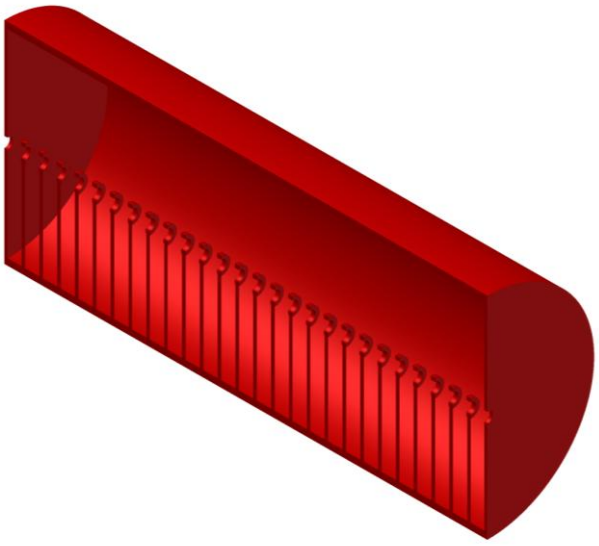

Figure 22. DTL_Traditional_InnerVolume_125_DriftTubes=26

Frequency Results

SAT file	Date Created	Diameter mm	Frequency MHz
CH_Traditional_InnerVolume	9 Dec 2011	125	
CH_Traditional_InnerVolume_30	9 Dec 2011	162,5	
CH_Traditional_InnerVolume_50	9 Dec 2011	187,5	
CH_Traditional_InnerVolume_60_DriftTubes=24	9 Dec 2011	200	
CH_Traditional_InnerVolume_65_DriftTubes=24	9 Dec 2011	206,25	
CH_Traditional_InnerVolume_70_DriftTubes=24	12 Dec 2011	212,5	
CH_Traditional_InnerVolume_60_DriftTubes=44	12 Dec 2011	200	
CH_Traditional_InnerVolume_65_DriftTubes=44	12 Dec 2011	206,25	
CH_Traditional_InnerVolume_70_DriftTubes=44	12 Dec 2011	212,5	
CH_Traditional_InnerVolume_70_DriftTubes=26	18 Dec 2011	212,5	427
CH_Traditional_InnerVolume_150_DriftTubes=26	19 Jan 2012	312,5	285
CH_Traditional_InnerVolume_125_DriftTubes=26	19 Jan 2012	281,25	319
IH_Traditional_InnerVolume_125_DriftTubes=26	26 Jan 2012	281,25	
DTL_Traditional_InnerVolume_125_DriftTubes=26	26 Jan 2012	281,25	

Note that where the gap between drift tubes has been increased the capacitance of the system has decreased resulting in a higher frequency cavity due to:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

7th Feb 2012

We made models for comparison of CH, IH and DTL structures see figure 23.

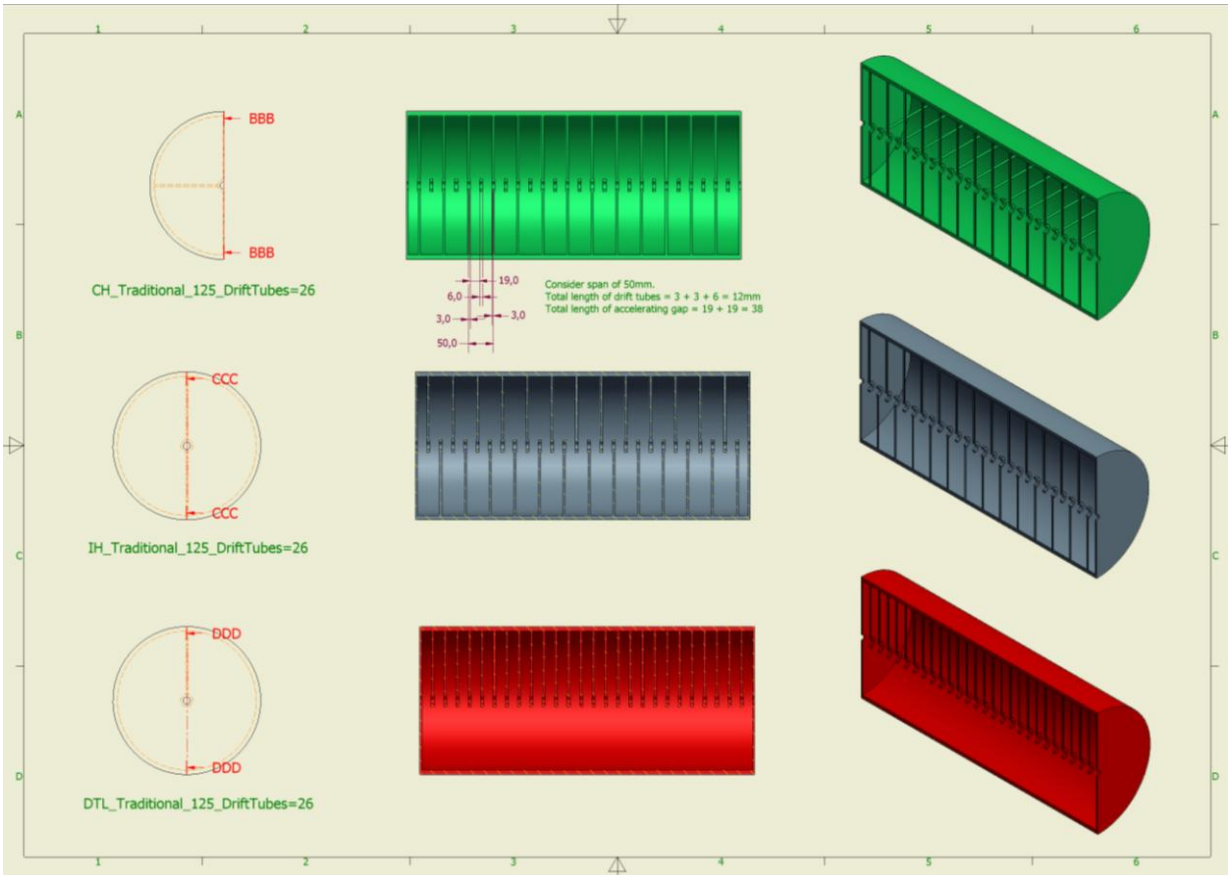

Figure 23. CH, IH and DTL models

The CH model produced a sensible looking electric field of maxima and minima either side of the zero axis with a frequency of ~300MHz.

The IH model also had sensible looking fields with a frequency of ~200MHz. This makes sense because the tube gap is the same and hence the capacitance is the same but the current path is longer and therefore the inductance increases leading to a decreased frequency.

The DTL model did not produce a sensible result. Why?

Structure	Who?		Mode	Beta
CH	Wideroe	Bλ/2	Pi	0.1 to 0.5
IH	Wideroe	Bλ/2	Pi	
DTL	Alvarez	Bλ	2Pi	

So, in order to make a DTL to directly compare to a CH and IH we must remove every other drift tube (because it is a 2Pi mode structure). This is model DTL_Traditional_125_DriftTubes=13.

BUT! Now we have an accelerating gap off 44mm instead of 19mm. Therefore, the length of the drift tubes was increased to bring the gap back to 19mm – see figure 24.

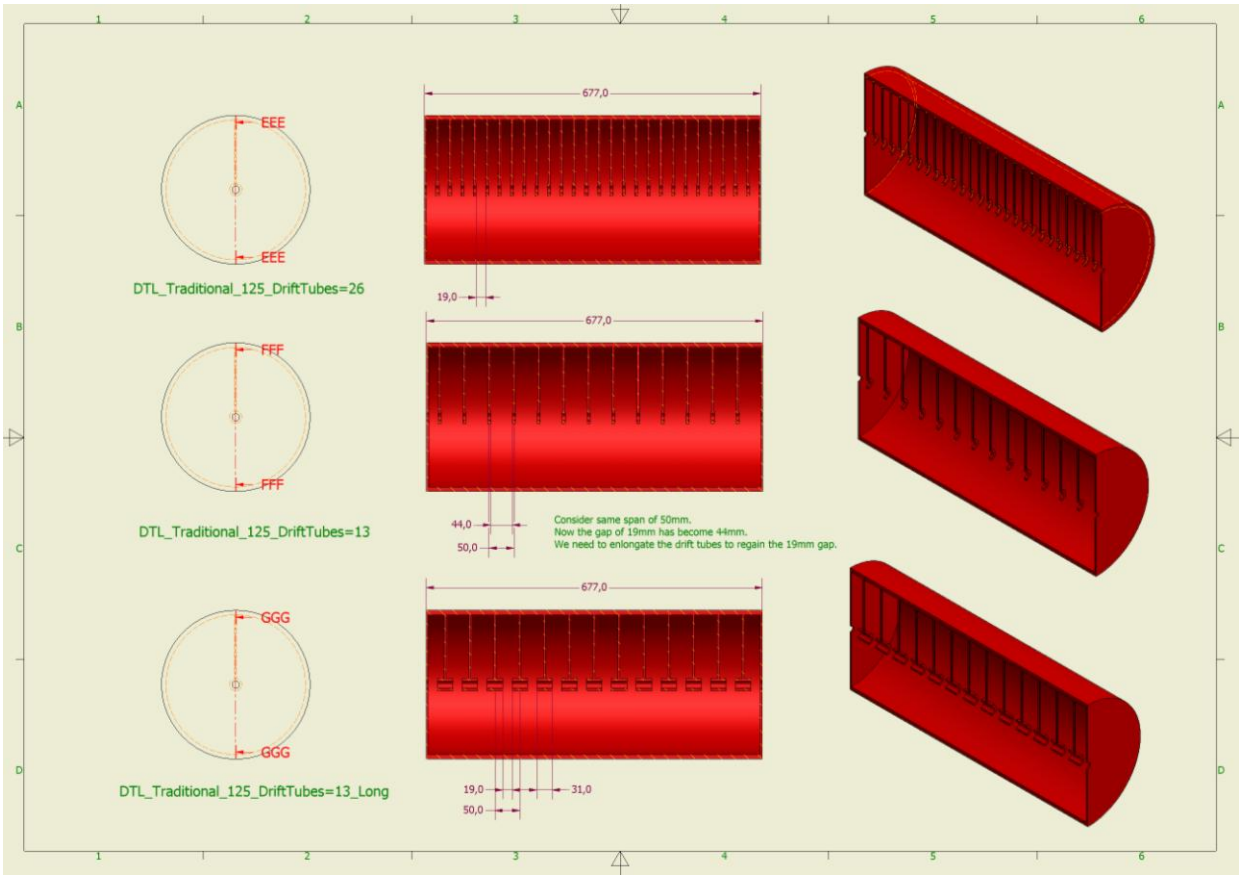

Figure 24. Three DTL models

9th Feb 2012

Morteza sees a positive and negative electric field for the DTL model and this is incorrect. It should be either all positive or all negative. We are therefore trying a smaller accelerating gap between drift tubes. The gaps are 10mm and 5mm for the models:

DTL_Traditional_125_DriftTubes=13_Gap=10

DTL_Traditional_125_DriftTubes=13_Gap=5

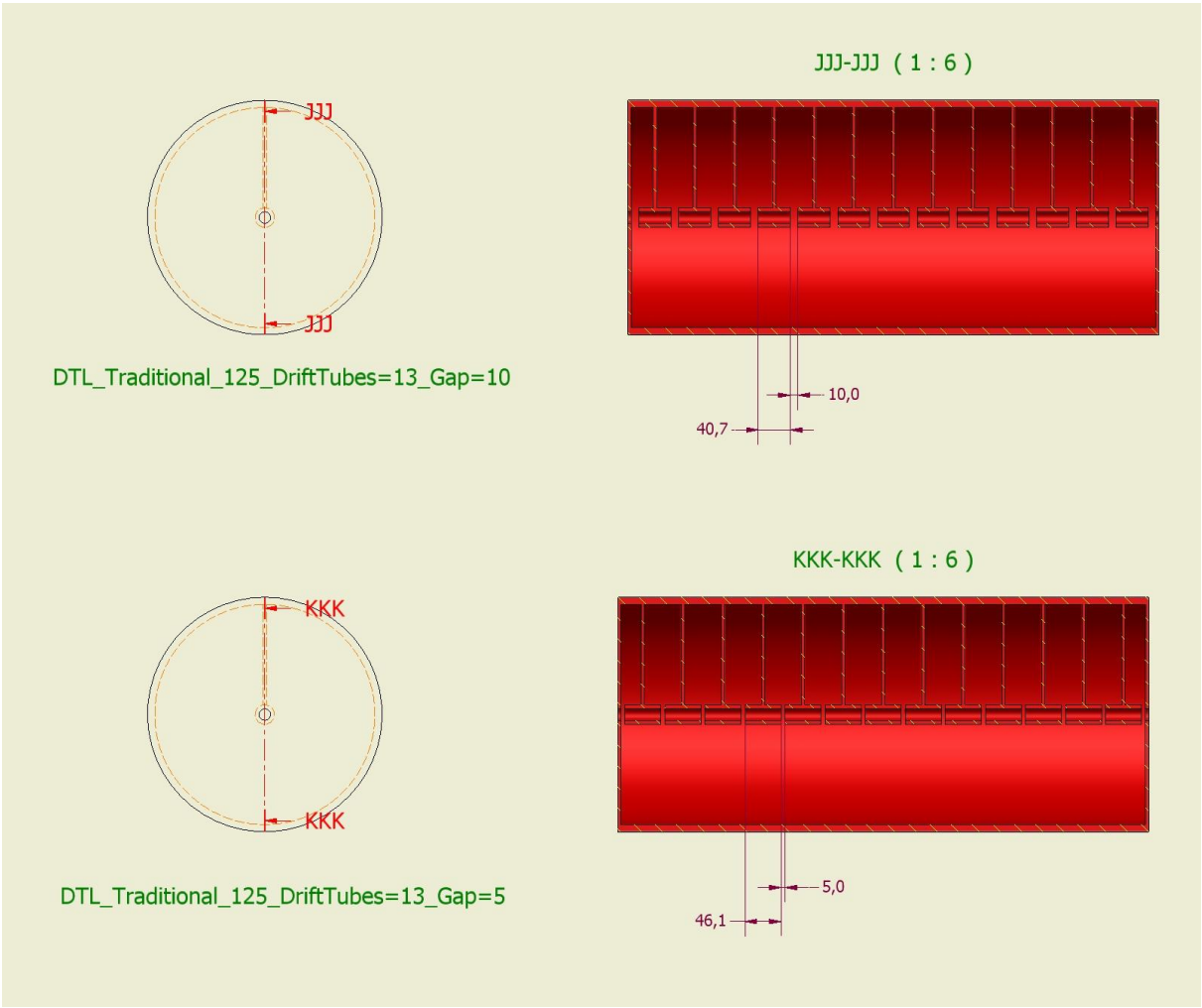

Figure 25. DTL models with 10mm and 5mm accelerating gaps

10th Feb 2012

At 3 MeV an H- particle travels 74mm in one RF period.

$$\frac{\beta\lambda}{2} = \frac{1}{2}\cdot\frac{V}{c}\cdot\frac{c}{f} = \frac{1}{2}\cdot\frac{V}{f}$$

$$= \frac{1}{2}\cdot\frac{24\times10^{6}}{324\times10^{6}}$$

$$= \frac{1}{2}\cdot 0.074 = 37\,mm$$

Therefore a DTL model with equal length drift tubes and gaps of 74/2 = 37mm was created.

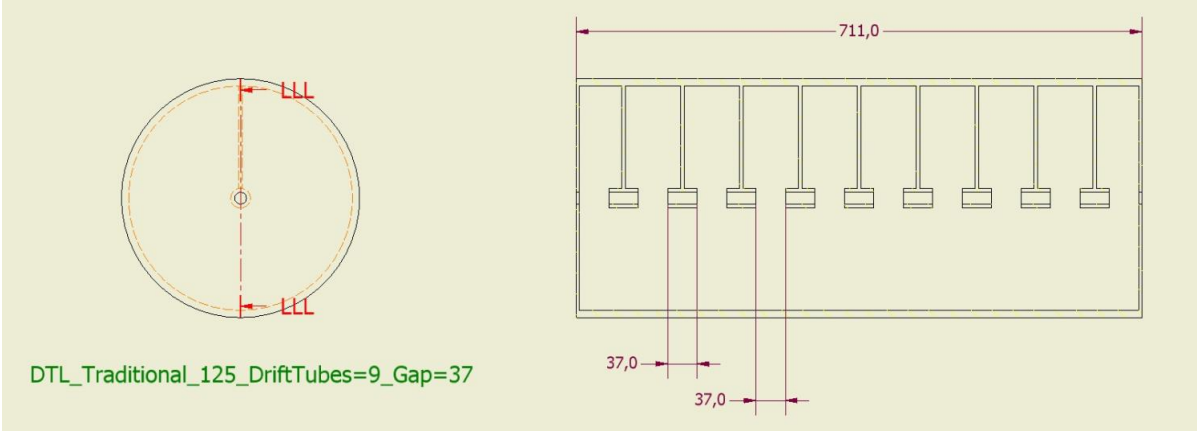

Figure 26. DTL model with 37mm drift tubes and gaps

28th Feb 2012

Adding end flanges to CH model.

We have created end flanges for model:

CH_Traditional_125_DriftTubes=26

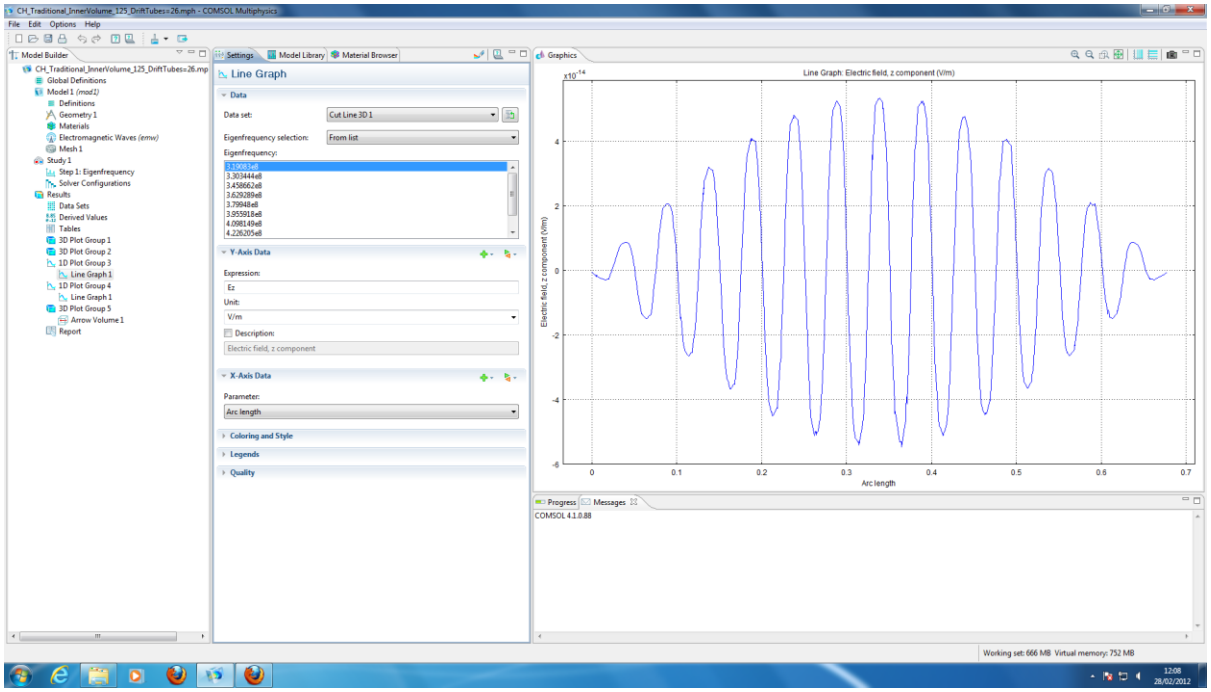

Figure 27. Longitudianl E-field for model **CH_Traditional_125_DriftTubes=26**

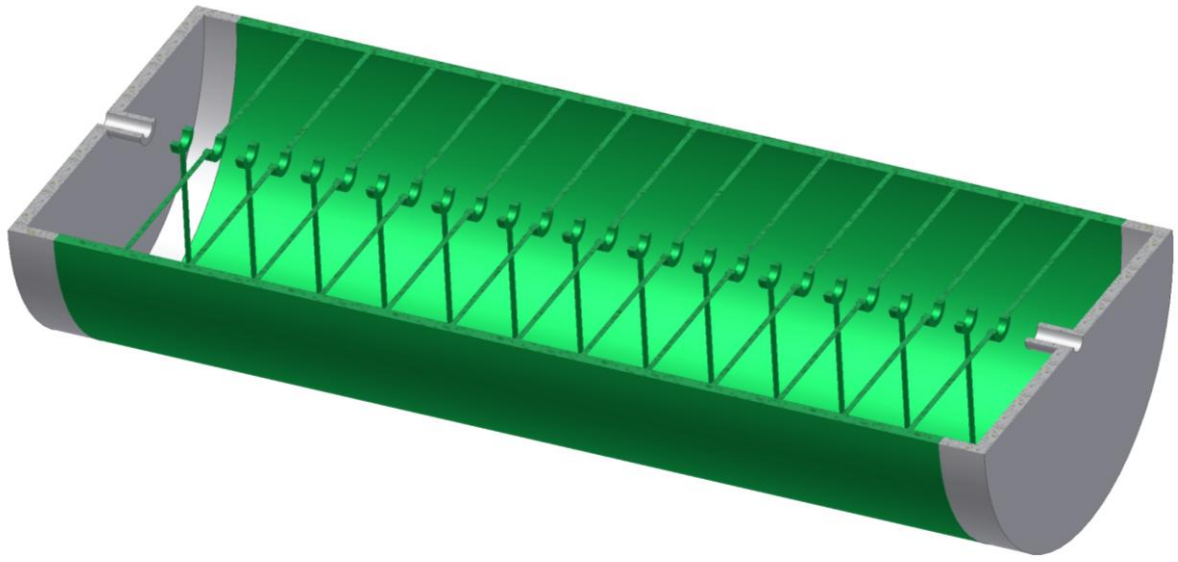

Figure 28. CH_Traditional_125_DriftTubes=26+EndFlange1

The models have been numbered for easy reference:

Index of /cad/Pete/CH_IH_DTL/CH_Traditional

Name	Last modified	Size	Description
Parent Directory		-	
01_CH_Traditional_InnerVolume.sat	07-Dec-2011 17:14	484K	
01a_CH_Traditional_Rotated_InnerVolume.sat	08-Dec-2011 12:59	529K	
02_CH_Traditional_InnerVolume_30.sat	08-Dec-2011 13:49	529K	
03_CH_Traditional_InnerVolume_50.sat	09-Dec-2011 11:22	530K	
04_CH_Traditional_InnerVolume_60_DriftTubes=24.sat	09-Dec-2011 15:41	529K	
05_CH_Traditional_InnerVolume_65_DriftTubes=24.sat	12-Dec-2011 16:53	528K	
06_CH_Traditional_InnerVolume_70_DriftTubes=24.sat	12-Dec-2011 16:58	529K	
07_CH_Traditional_InnerVolume_60_DriftTubes=44.sat	09-Dec-2011 16:44	959K	
08_CH_Traditional_InnerVolume_65_DriftTubes=44.sat	12-Dec-2011 17:13	960K	
09_CH_Traditional_InnerVolume_70_DriftTubes=44.sat	12-Dec-2011 17:18	959K	
10_CH_Traditional_InnerVolume_70_DriftTubes=26.sat	18-Dec-2011 11:18	575K	
11_CH_Traditional_InnerVolume_70_DriftTubes=26.sat	18-Dec-2011 11:18	575K	
12_CH_Traditional_InnerVolume_150_DriftTubes=26.sat	19-Jan-2012 11:45	576K	
13_CH_Traditional_InnerVolume_125_DriftTubes=26.sat	19-Jan-2012 16:31	576K	
14_CH_Traditional_INT_125_DriftTubes=26+EndFlange1.sat	28-Feb-2012 14:33	512K	

Figure 29. New numbering system should clarify communication

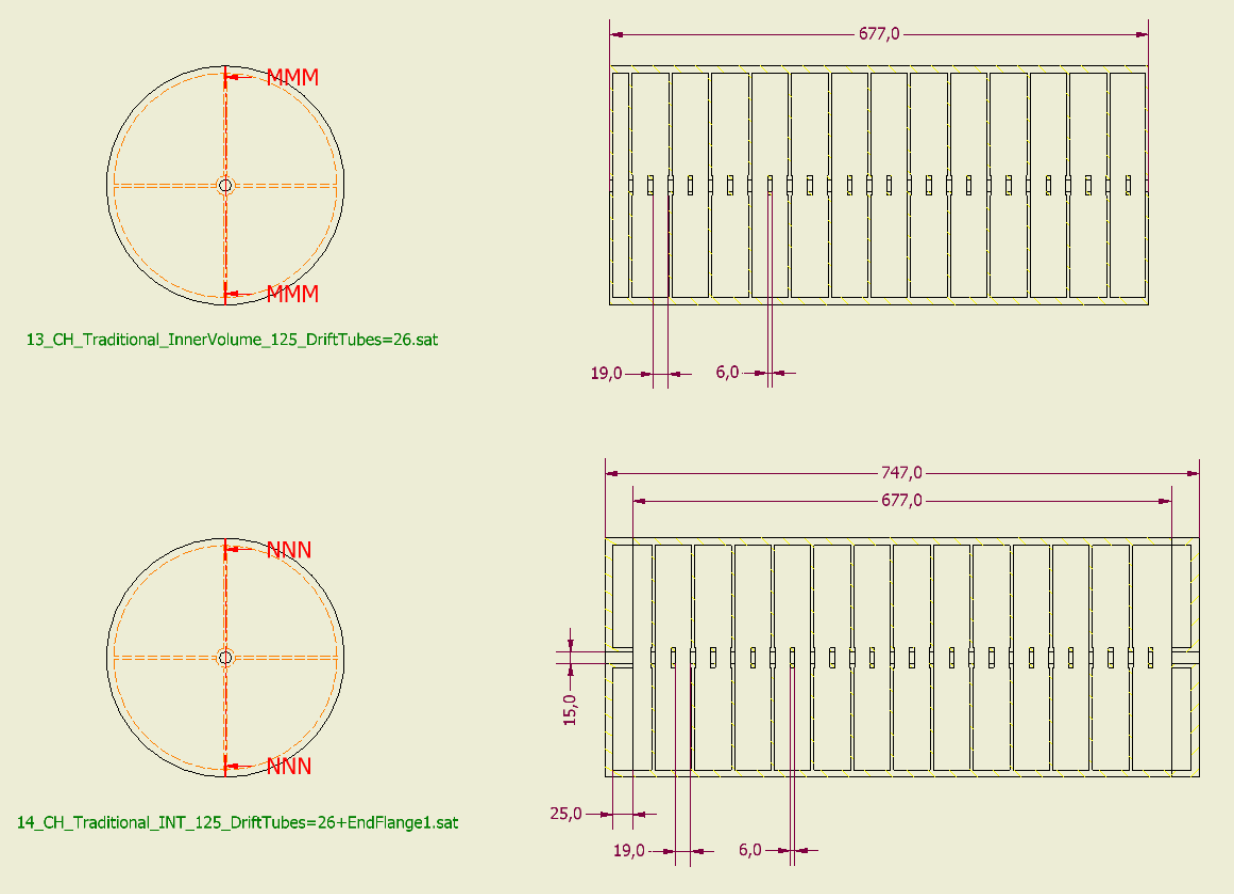

Figure 30. Dimensions for model 14

1st Mar 2012

Models 17, 18, 19, 20 & 21

MODEL 14 DOES NOT MESH
MODEL 15 MESHES BUT DOES NOT SOLVE
MODEL 16 MESHES BUT DOES NOT SOLVE

THEY DIFFER FROM THE PREVIOUS SET OF CH/IH/DTL MODELS BECAUSE THEY ARE ASSEMBLIES AND NOT PARTS.

HOWEVER, WE HAVE SUCCESSFULLY USED ASSEMBLIES FOR THE RFQ RF END FLANGE STUIDES. WE FOUND IN THAT CASE THAT ASSEMBLIES ONLY WORKED WHEN THEY WERE MADE OF PARTS THAT WERE DERIVED COMPONENTS.

MODELS 14, 15 AND 16 ARE ASSEMBLIES OF DERIVED COMPONENTS BUT STILL THEY DO NOT WORK.

MODEL 17 IS A RETURN TO USING A SINGLE PART AND WORKS WELL.

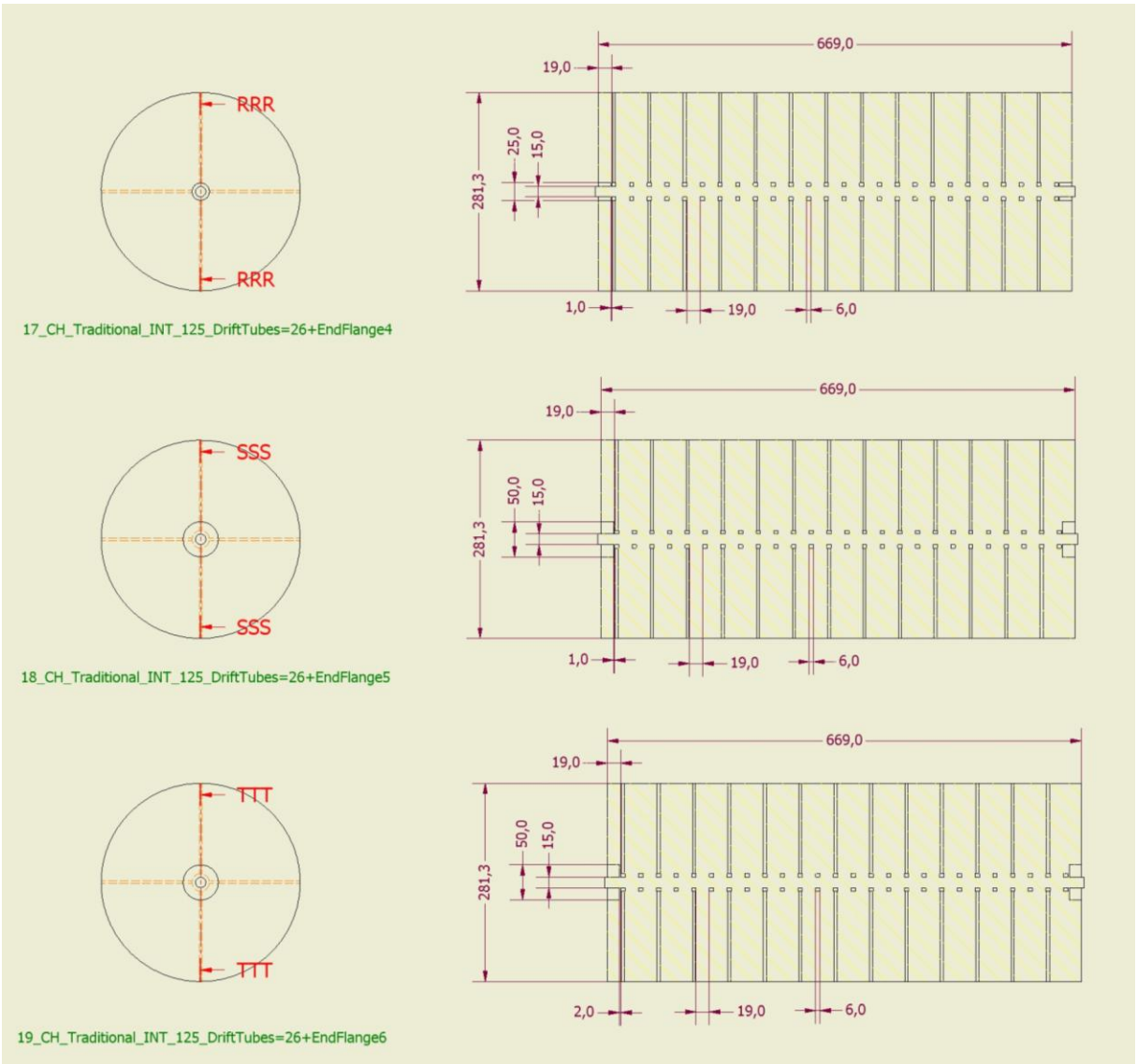

Figure 31. Dimensions for models 17, 18 and 19

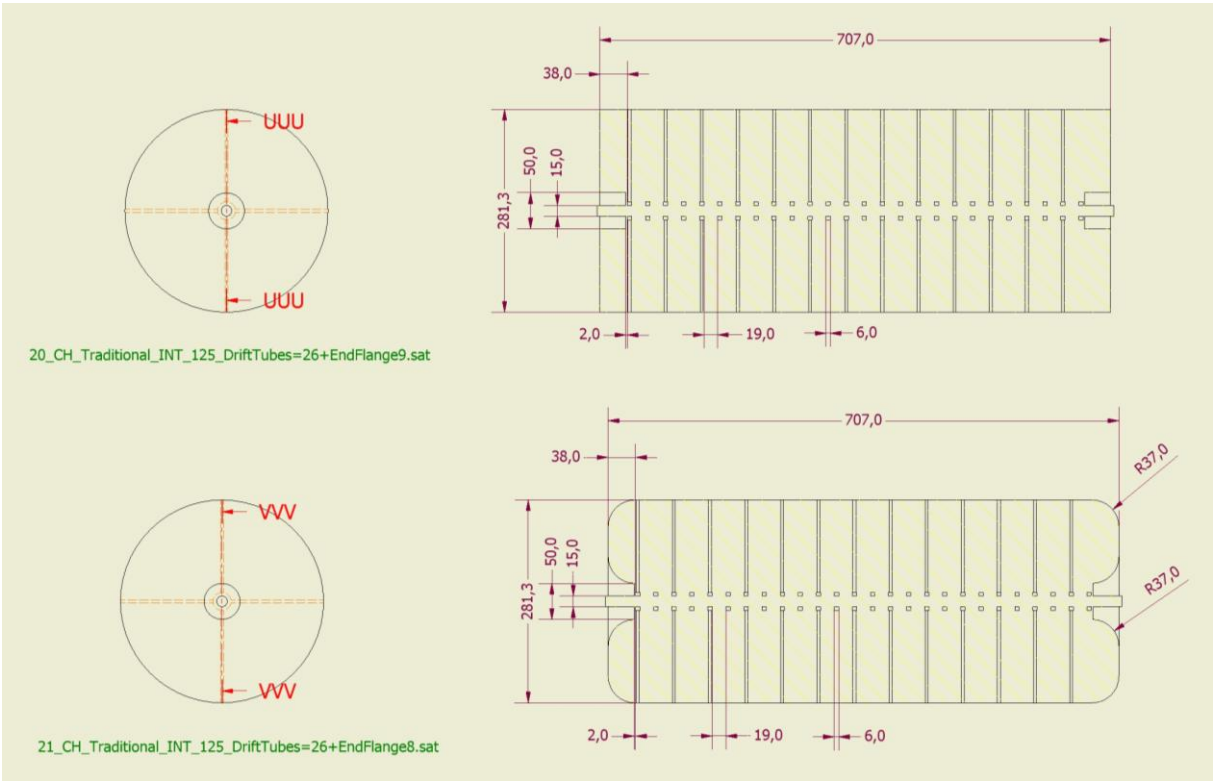

Figure 32. Dimensions for models 20 and 21