

A very general look at an FFAG RF cavity for ISIS-II

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FFAG for ISIS-II and FETS meeting

17th August 2017



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This is NOT a 'design' for an FFAG cavity.

Presented here is a first look at the general feasibility of an ISIS-II FFAG cavity to potentially highlight any challenges.

Assumptions:

Swept frequency, ferrite loaded cavity

1.0 m x 0.15 m beam pipe

Operating frequency similar to ISIS for the same harmonic number

<2m long (per gap)

Not included:

Biasing

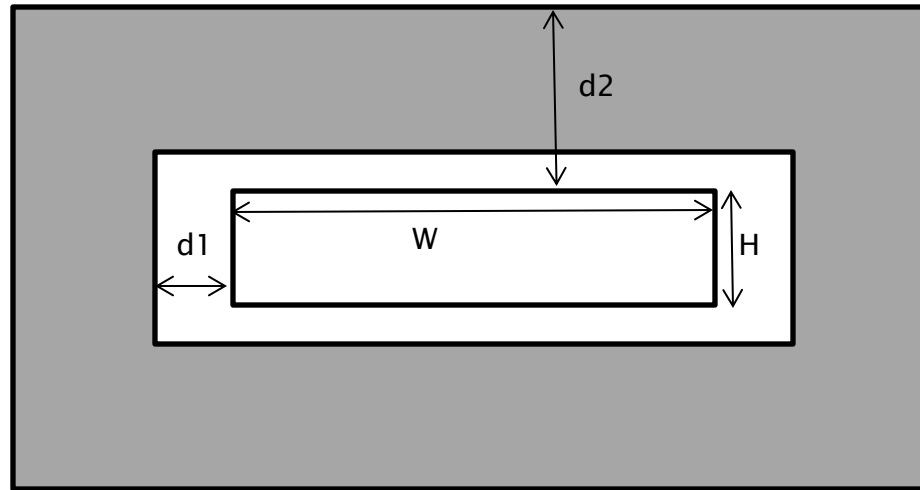
RF drive

Cooling

Etc, etc ...



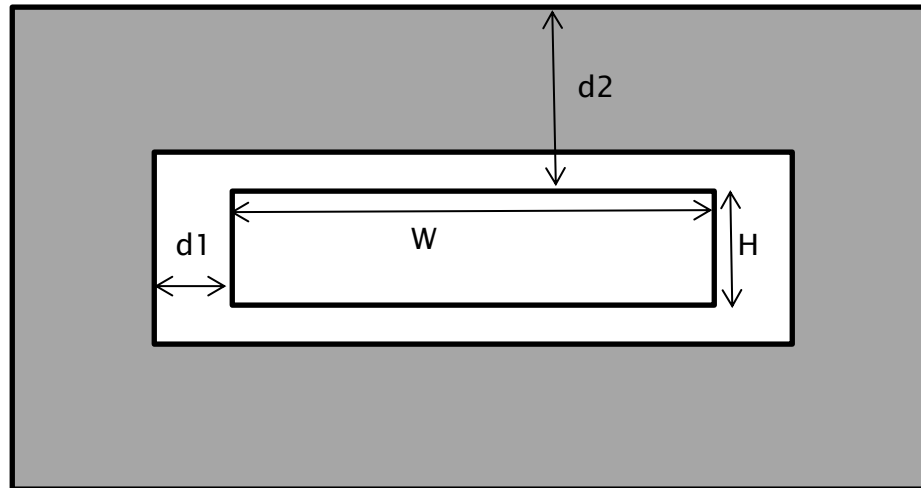
Cross-sectional geometry of the cavity



A capacitive loaded shorted coaxial resonator but with a rectangular rather than circular cross section.

No analytical solutions exist for the inductance and capacitance of a rectangular coax so make some crude (non-physical) simplifying assumptions about the field shapes ...



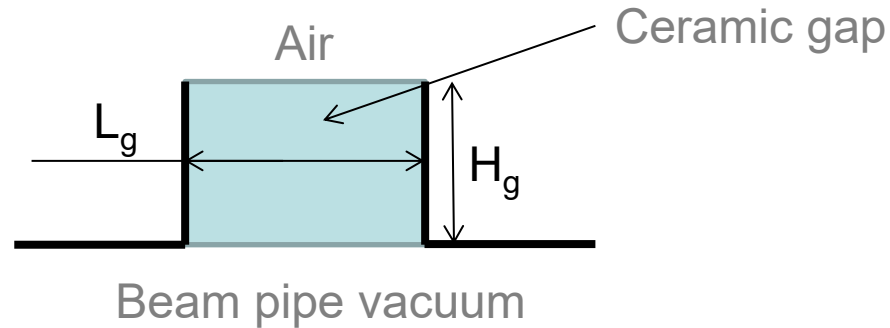


$$\frac{L}{l} = \frac{\mu_0}{8} \left[\ln \left(\frac{W + H + 4d1}{W + H} \right) + \mu_r \ln \left(\frac{W + H + 4d2}{W + H + 4d1} \right) \right] \quad \text{H/m}$$

$$\frac{C}{l} = \frac{8\epsilon_0}{\ln \left(\frac{W + H + 4d1}{W + H} \right) + \frac{1}{\epsilon_r} \ln \left(\frac{W + H + 4d2}{W + H + 4d1} \right)} \quad \text{F/m}$$



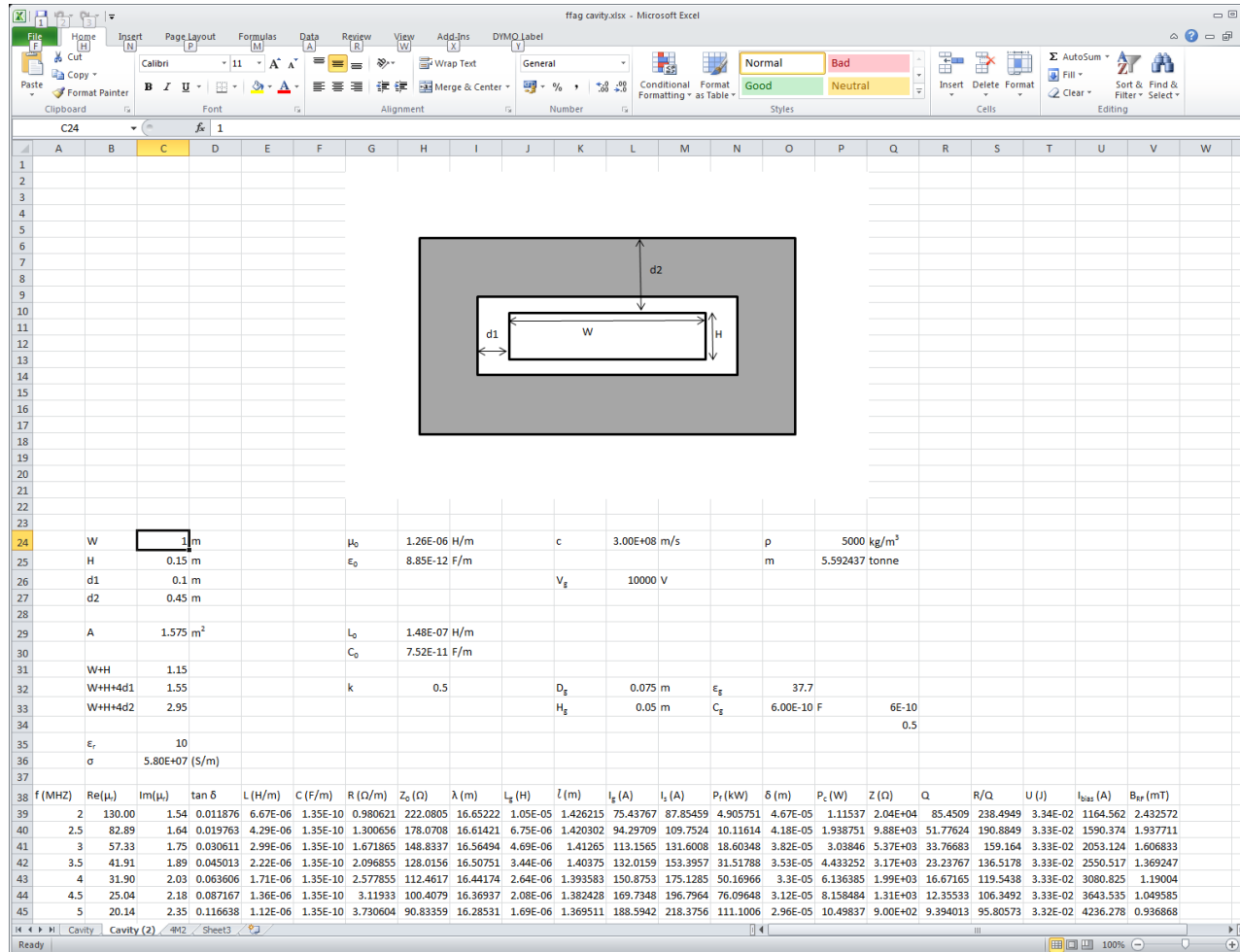
Similar simplifying assumptions allow an approximation of the accelerating gap capacitance



$$C = \frac{\epsilon_0}{2L_g} \left[2\epsilon_g (2H_g(W + H) + 4H_g^2) + WH + 2(W + H) \left(\frac{d^2}{2} - H_g \right) + 4 \left(\left(\frac{d^2}{2} \right)^2 - H_g^2 \right) \right] F$$



Put these expressions into a spreadsheet to quickly explore the parameter space. Having found a possible solution double check the validity using MWS.



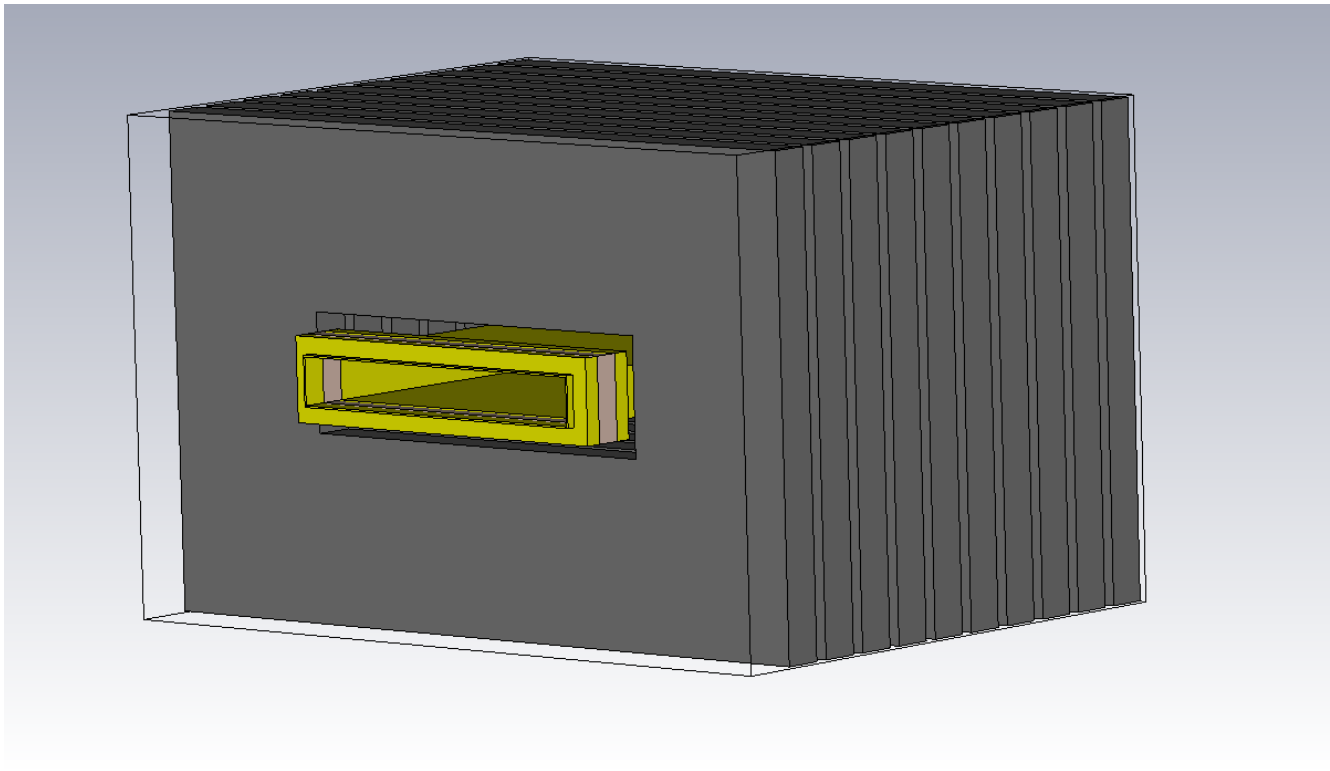
First solution:

Ferroxcube 4M2 ferrite.

Al_2O_3 ceramic gap insulator.

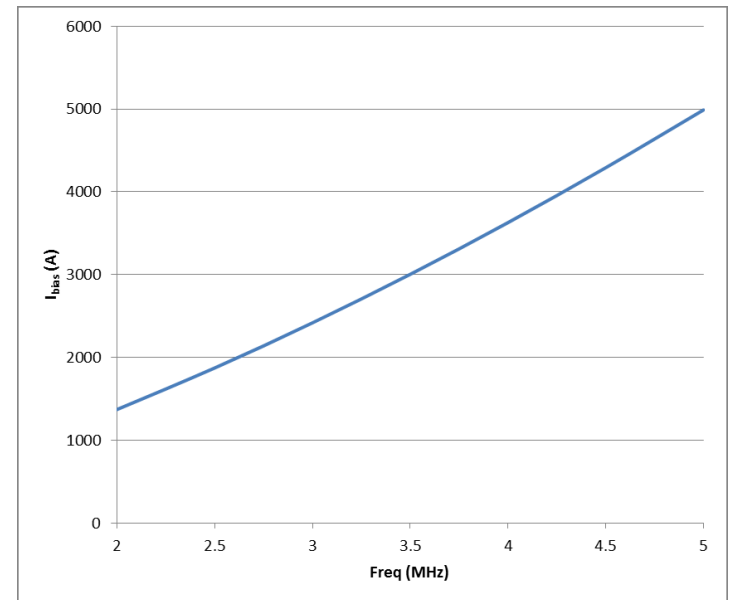
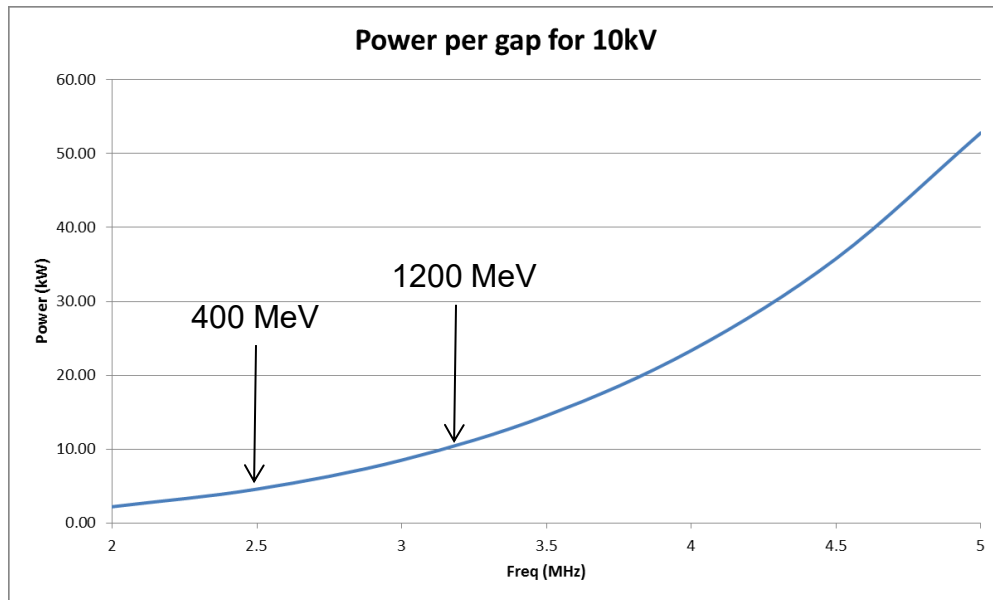
Length = 1.6 m.

2.3m x 1.45m cross section.



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	Analytical	MWS
Freq (MHz)	2.50	2.41
RF Loss (kW)*	4.6	4.59
Q	51.1	50.7
R/Q (Ω)	425	472

*for 10 kV per gap

Looks reasonable but: **17 tonnes of ferrite per cavity!**



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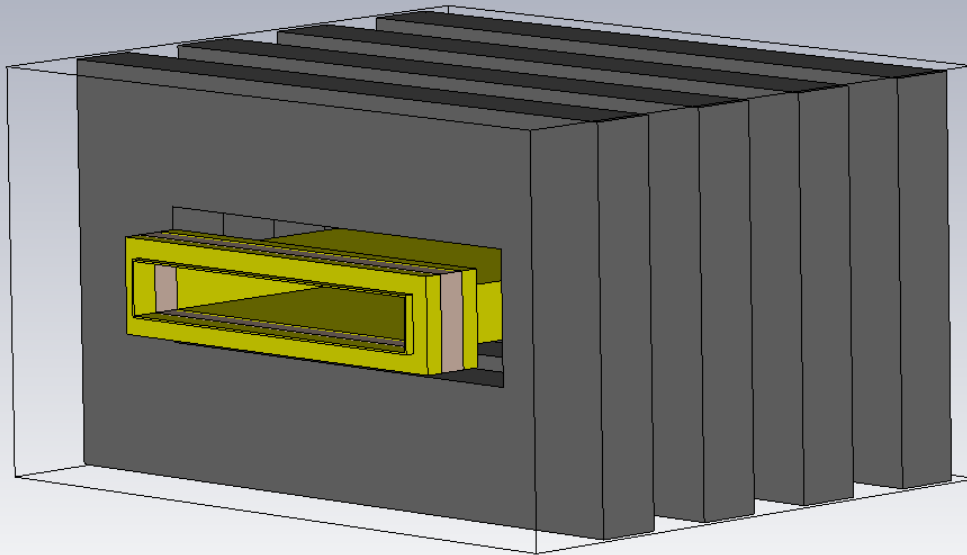
Second solution:

Ferroxcube 4M2 ferrite.

Al_2O_3 ceramic gap insulator with lumped capacitance (600pF).

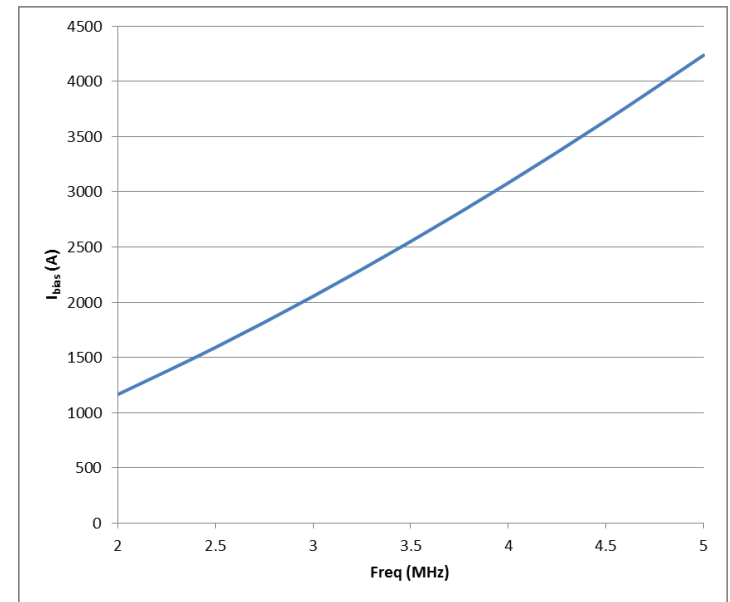
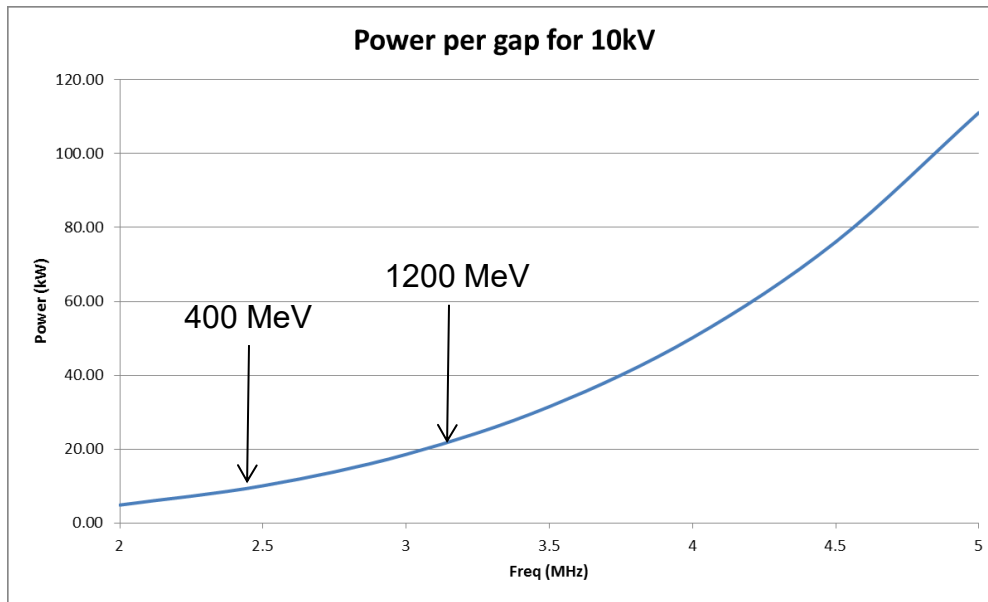
Length = 1.4 m.

1.9m x 1.05m cross section.



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Freq (MHz)	2.50
RF Loss (kW)*	10.1
Q	51.8
R/Q (Ω)	191

Reduction in E_0L across beam aperture is 15%.

*for 10 kV per gap

Now only 6 tonnes of ferrite per cavity but twice the RF losses.

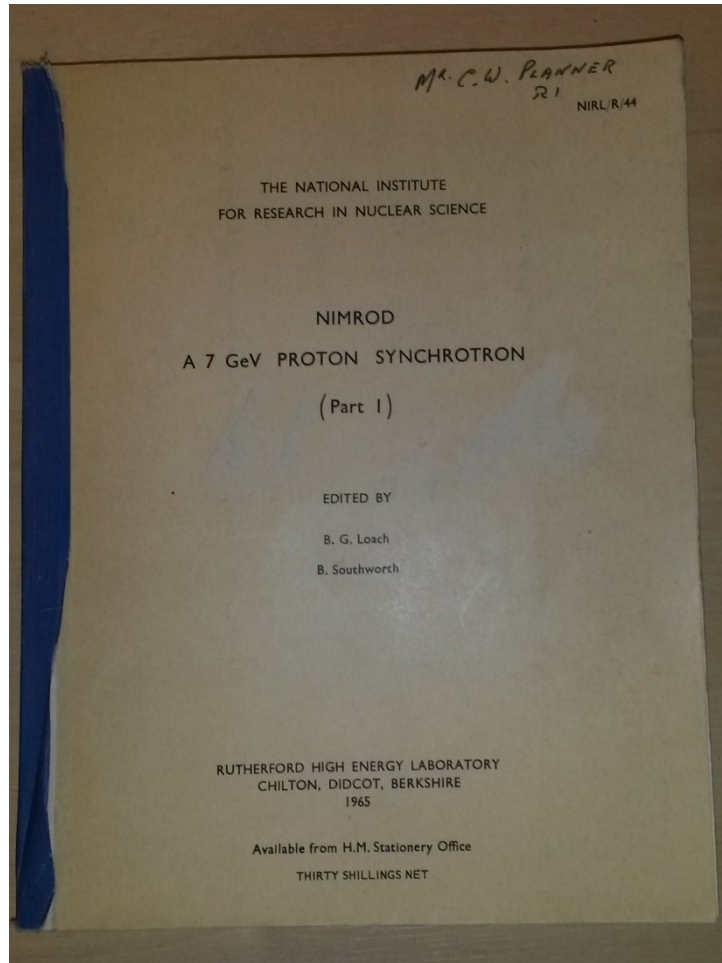


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Addendum:

While searching my bookshelves for something else I found this



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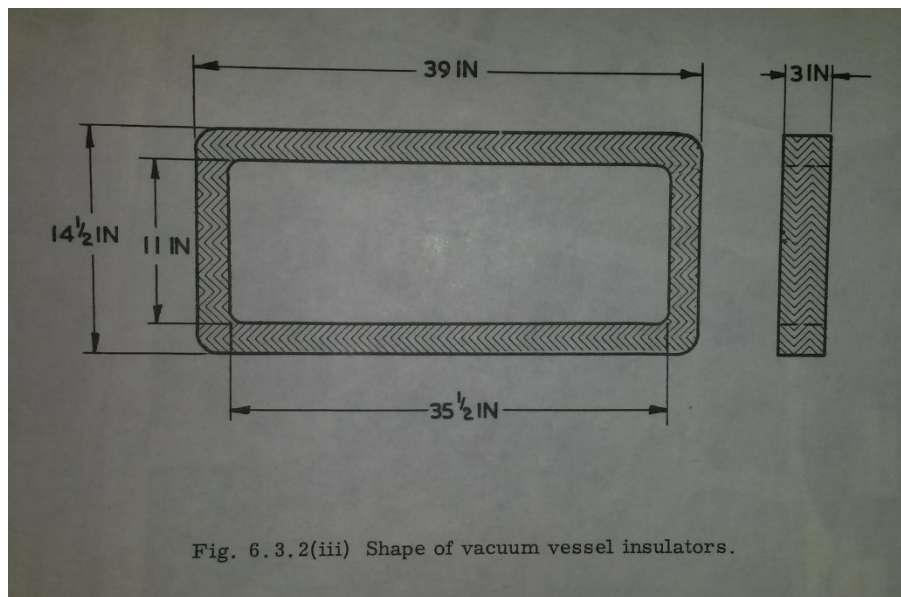


Fig. 6.3.2(iii) Shape of vacuum vessel insulators.

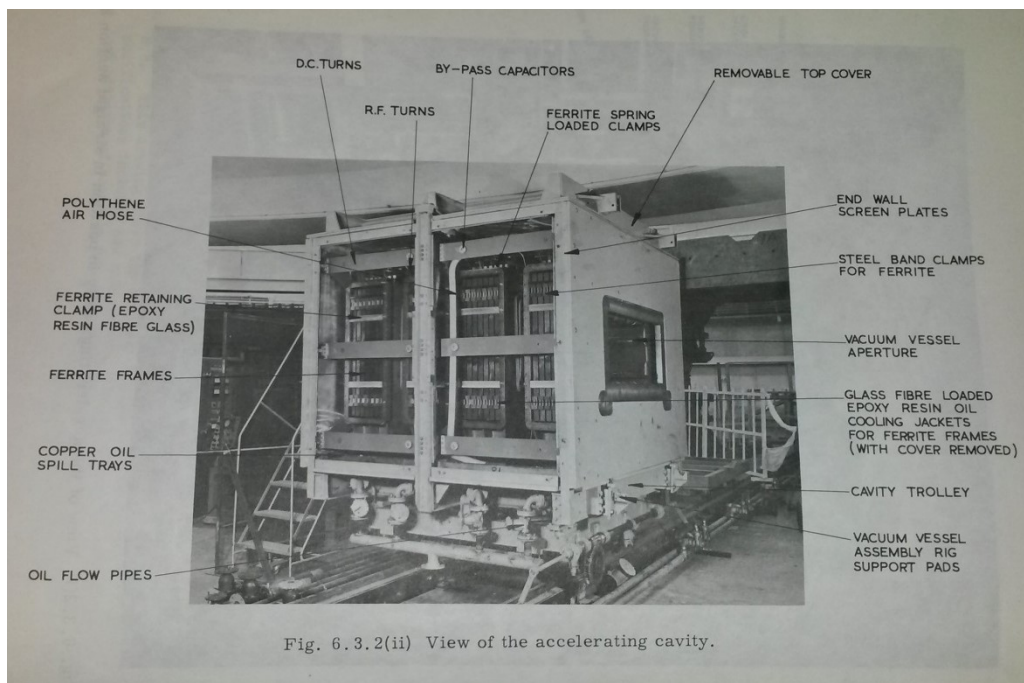


Fig. 6.3.2(ii) View of the accelerating cavity.

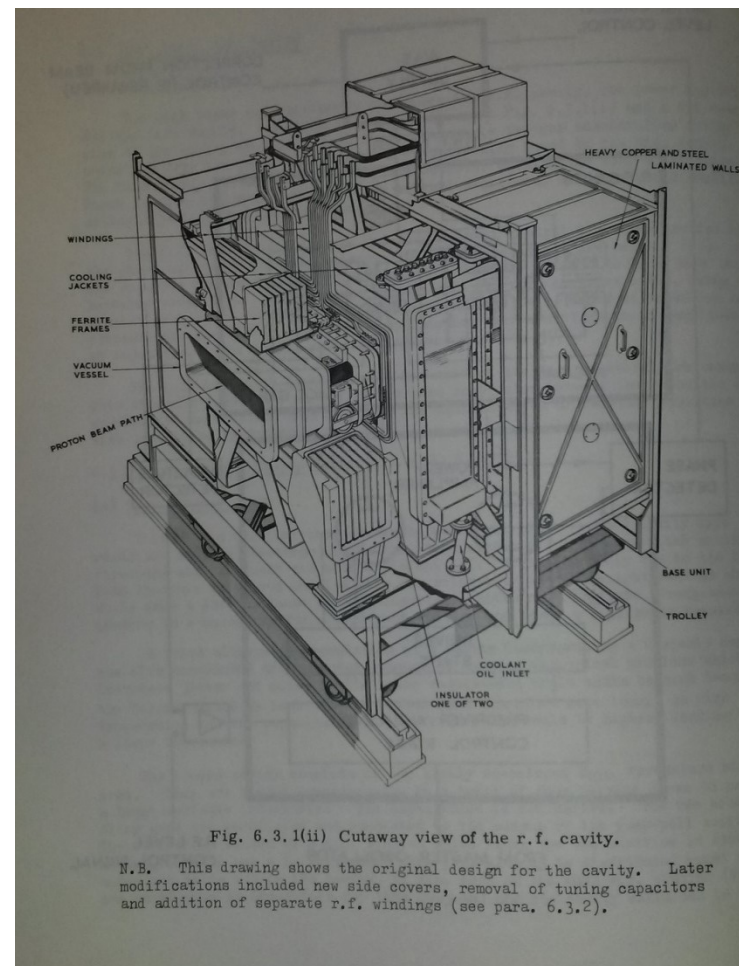


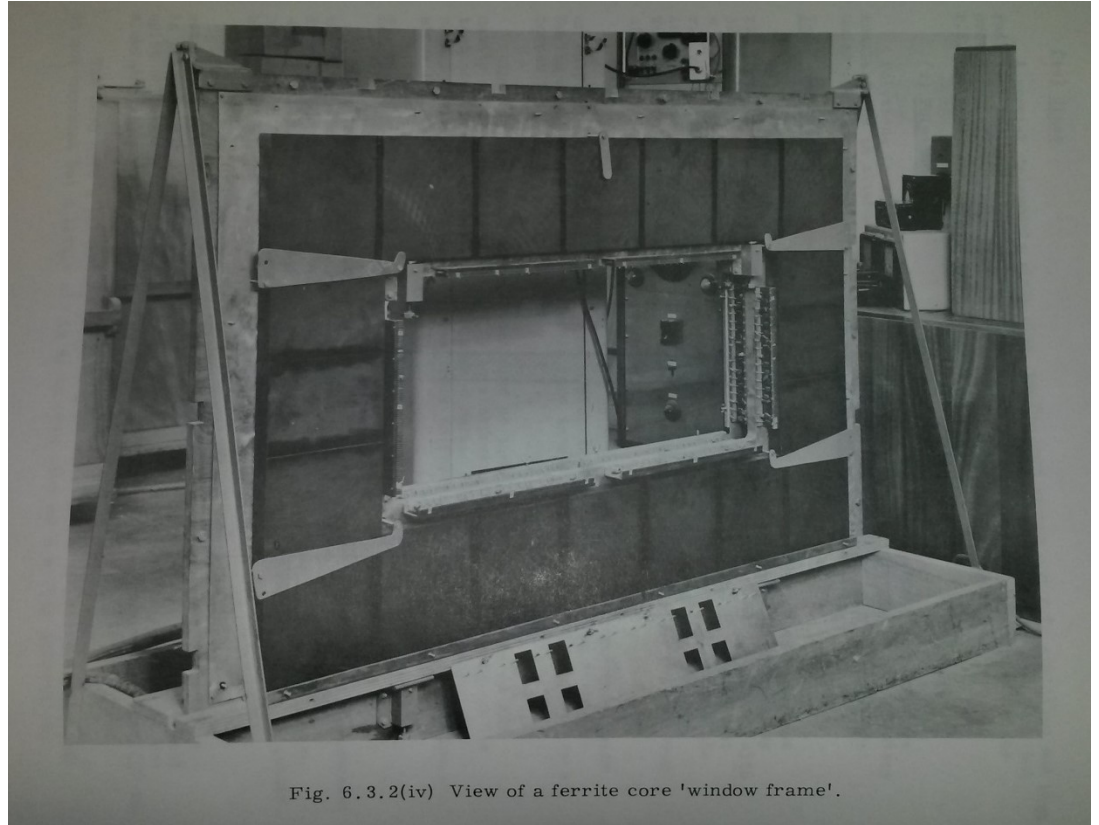
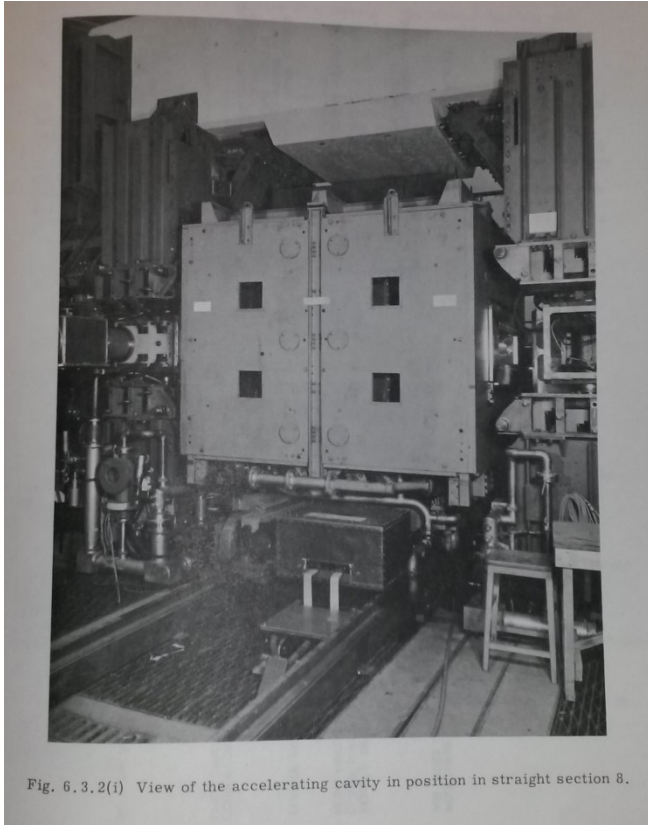
Fig. 6.3.1(ii) Cutaway view of the r.f. cavity.

N.B. This drawing shows the original design for the cavity. Later modifications included new side covers, removal of tuning capacitors and addition of separate r.f. windings (see para. 6.3.2).



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Each Nimrod RF cavity weighed 6 tons.



Conclusions:

If the assumptions made are reasonable then such a cavity looks feasible if large and expensive.

Lots of R&D will be required.

The solution arrived at here looks remarkably like the 50+ year old Nimrod cavity.



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Questions?



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