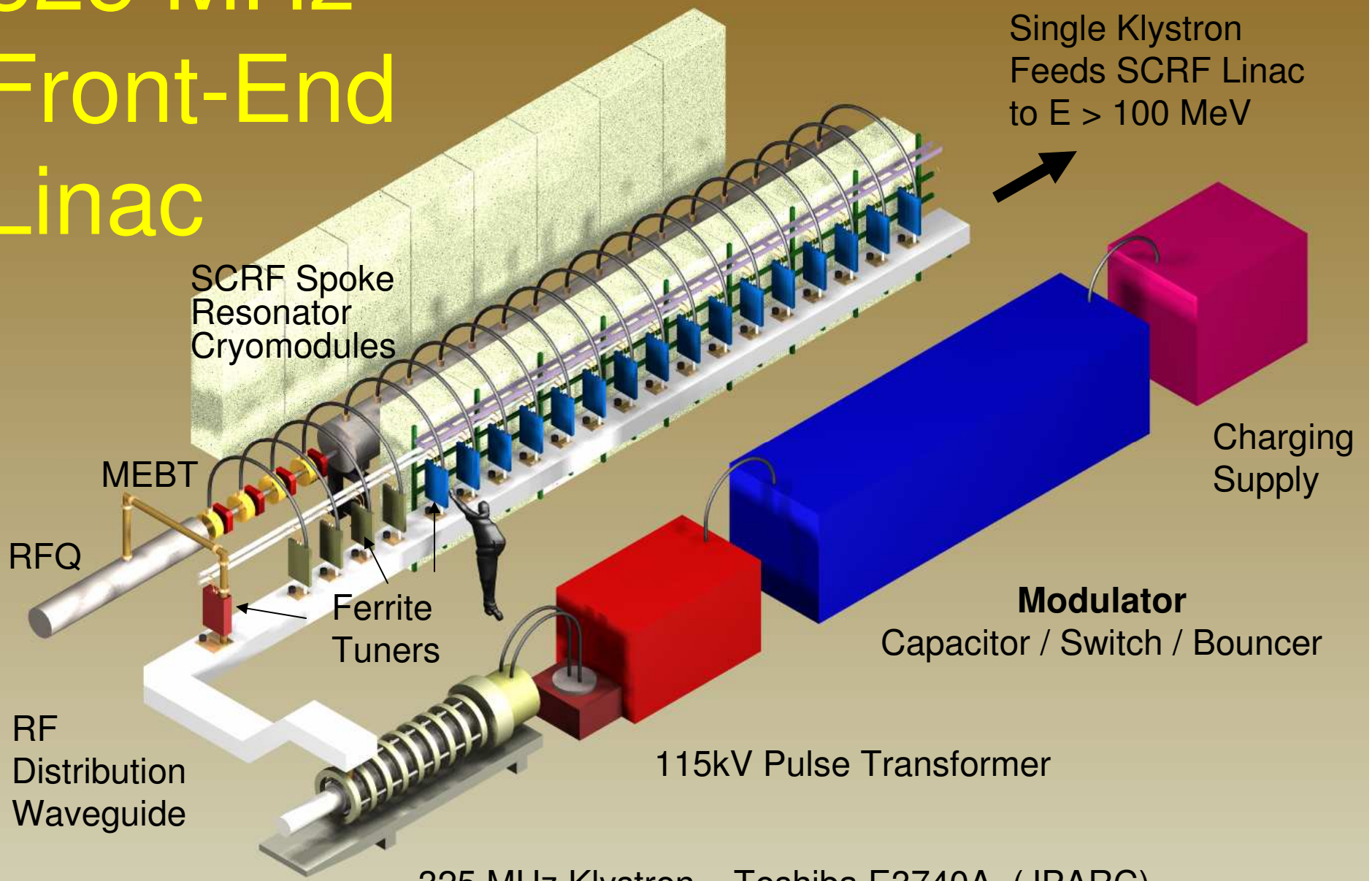
On RF power distribution in room temperature part.

Gennady Romanov

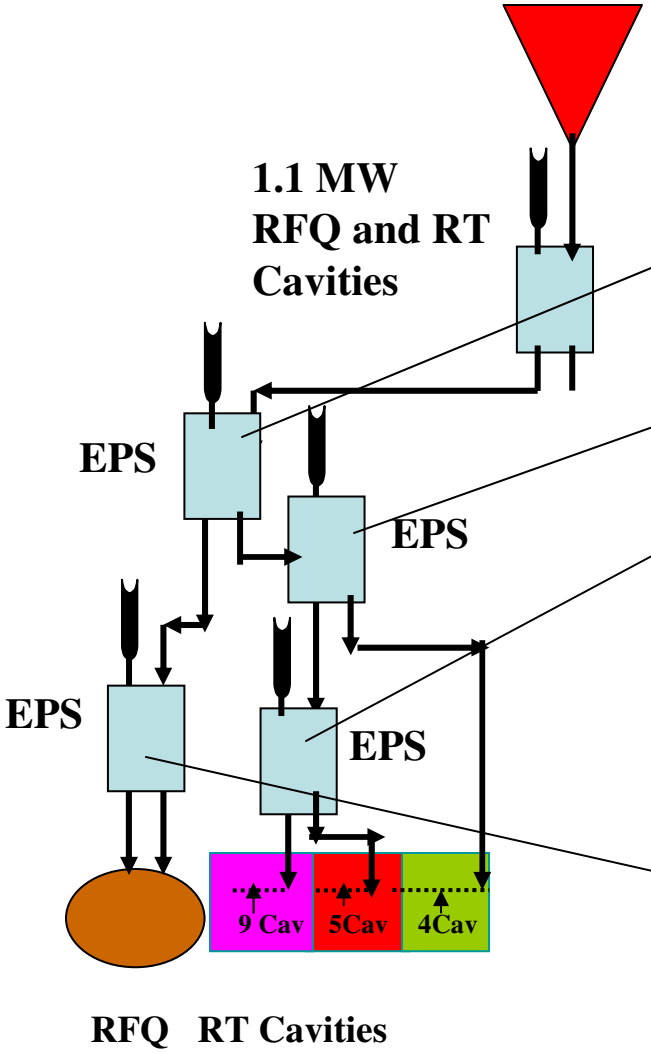
November 29, 2007

325 MHz Front-End Linac

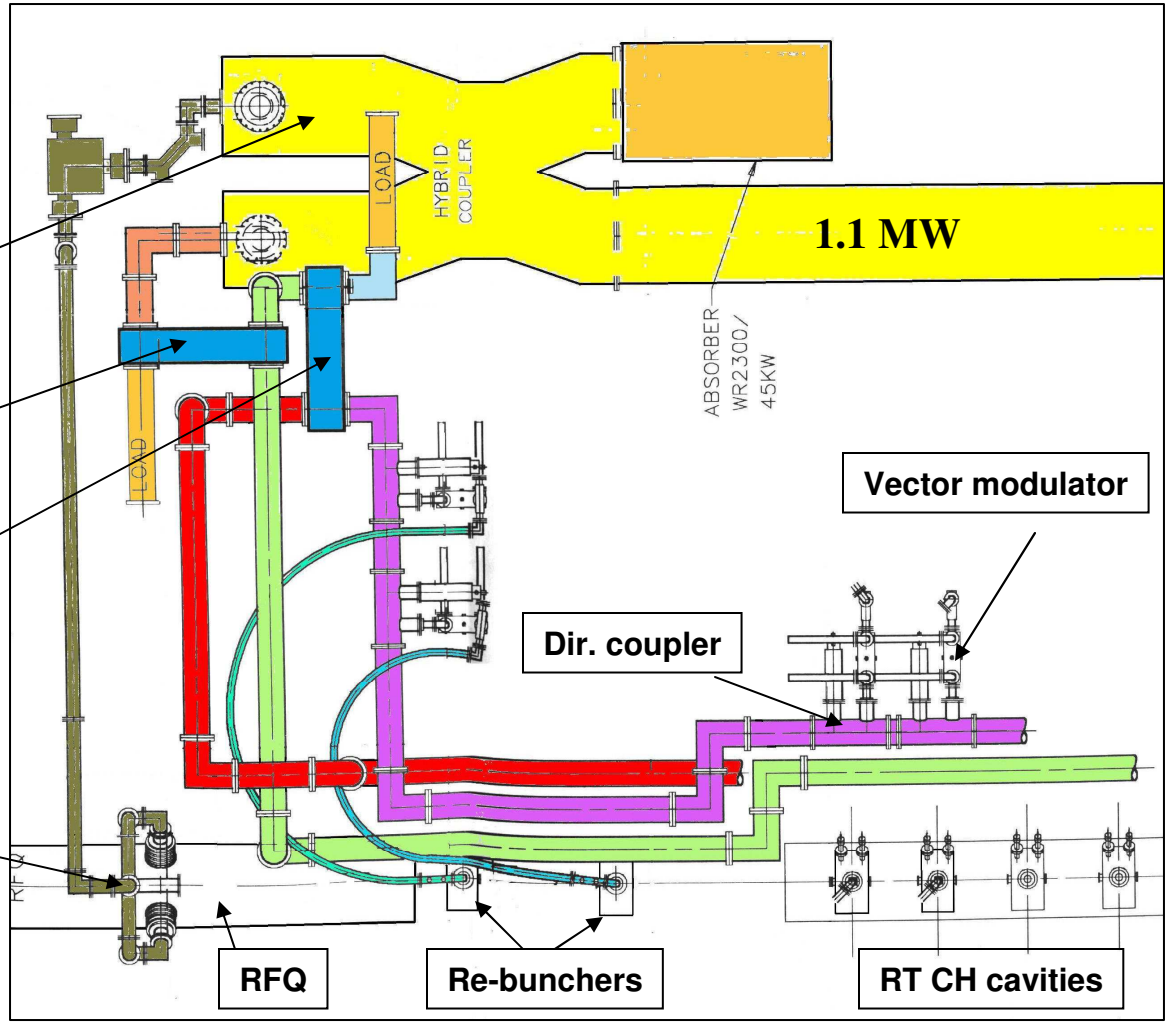


RF power distribution

General scheme (A.Moretti)



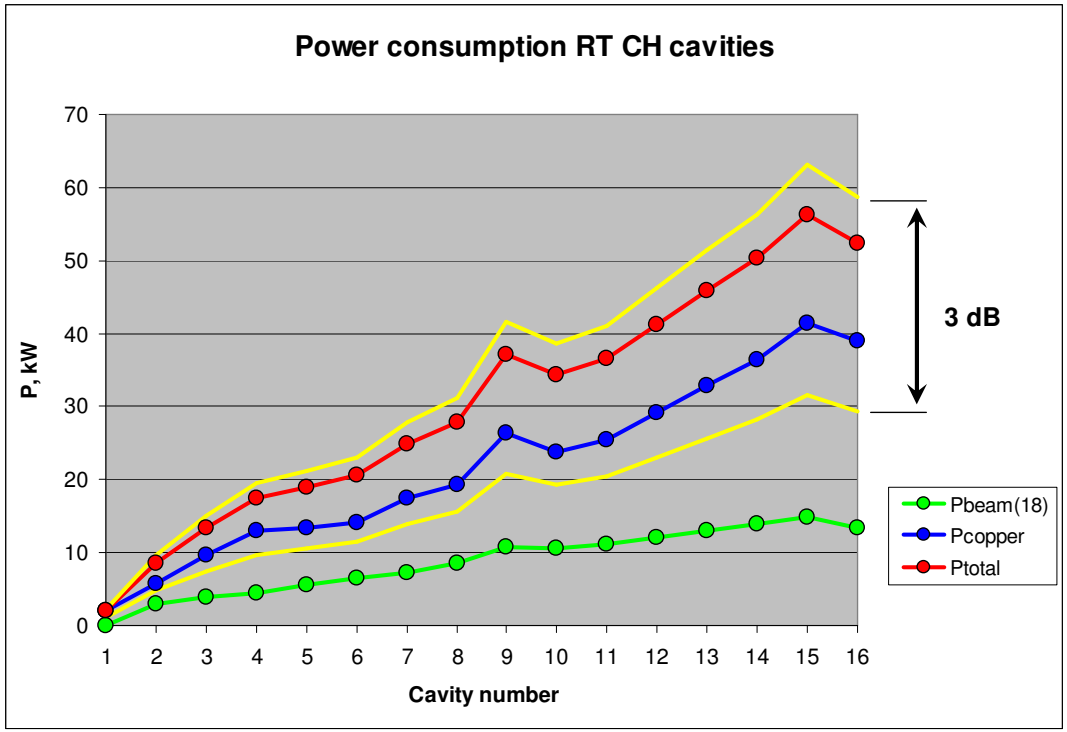
From Bruce Hanna's drawing



RF power to each RT CH cavity

Power table from Nov.2006
Beam pulsed current – 18 mA

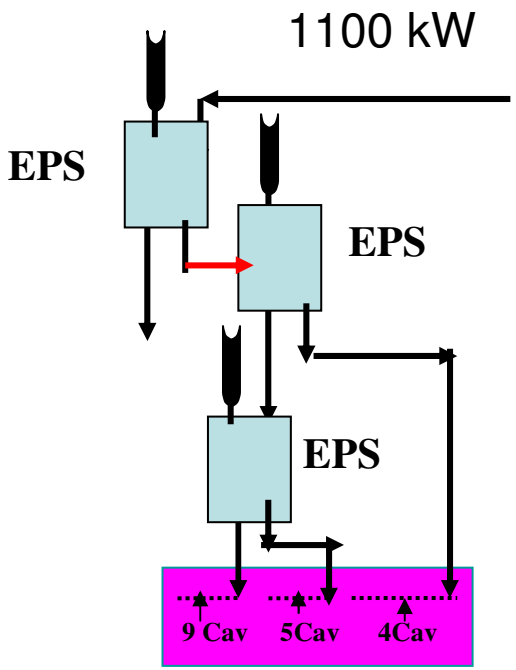
Cav#	Beam beta	Pbeam I=18mA kW	Pcopp kW	Ptotal kW	Pt/Pc dB
1	0.0744	0.00	1.99	1.99	0.00
2	0.0771	2.88	5.68	8.56	1.78
3	0.0804	3.81	9.60	13.41	1.45
4	0.0842	4.47	12.91	17.38	1.29
5	0.0882	5.55	13.34	18.89	1.51
6	0.0923	6.44	14.20	20.64	1.62
7	0.0968	7.31	17.53	24.84	1.51
8	0.1015	8.47	19.32	27.79	1.58
9	0.1063	10.76	26.31	37.06	1.49
10	0.1111	10.64	23.79	34.44	1.61
11	0.1159	11.15	25.41	36.56	1.58
12	0.1210	12.10	29.10	41.20	1.51
13	0.1262	13.01	32.84	45.85	1.45
14	0.1316	13.86	36.39	50.25	1.40
15	0.1371	14.92	41.42	56.33	1.34
16	0.1422	13.34	39.05	52.38	1.28



Total power consumption with beam is 500 kW
Since vector modulators can only reduce input power, so it makes sense to deliver more power to each cavity than simulations require.

More detailed power split for RT CH

There is no simple combination of cavities with equal power consumption by groups



RT Cavities

Ptotal kW	Copper	+beam
11	86	**117**
1.99123		
8.56062		
13.4137		
17.3849		
18.8862		
20.6387		
24.8365		
27.7932	95	**136**
37.0642		
34.4359		
36.5607		
41.1984	179	**246**
45.8547		
50.2507		
56.3337		
52.383		

(2+7)+4+5

20.5 to dump, permanent losses

137.5

31 to dump

275

137.5

550 kW

41 to dump

1.5 to dump, perm. losses

275

67 to dump

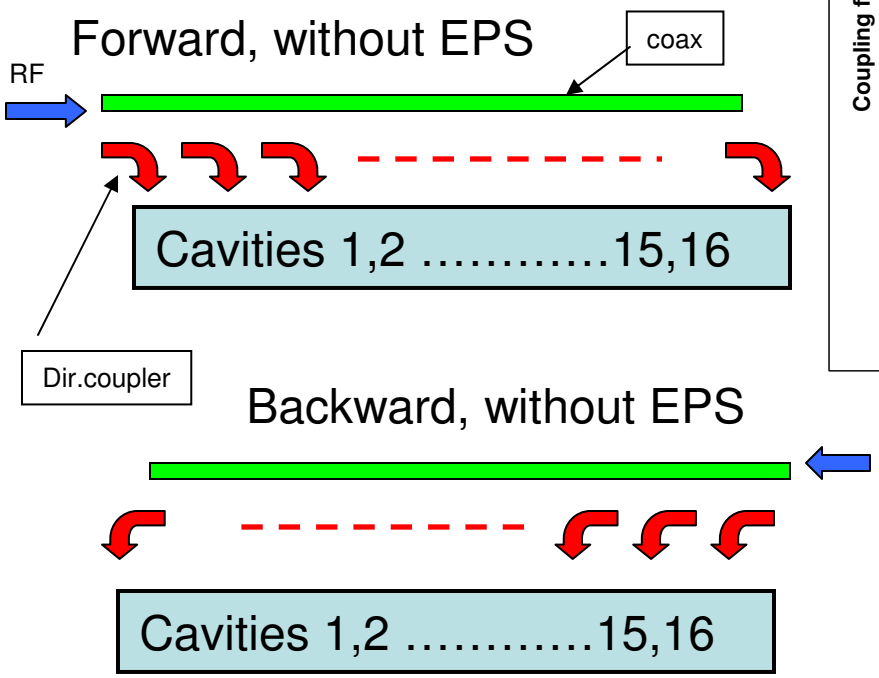
9 to dump, perm. losses

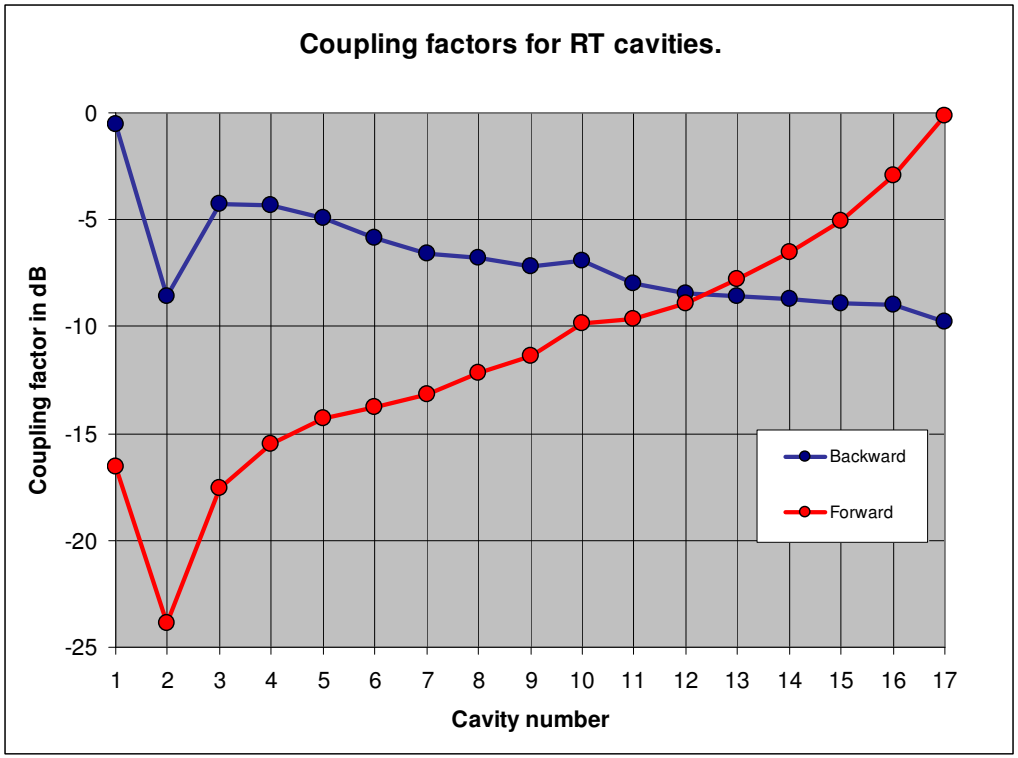
Directional couplers I

Actual coupling factors depend on the chosen scheme of RF distribution.

Coupling coefficient for power

$$K_c=10*\log(A2/A1)$$

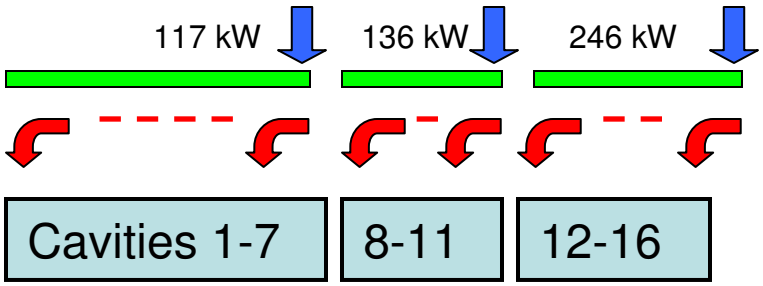


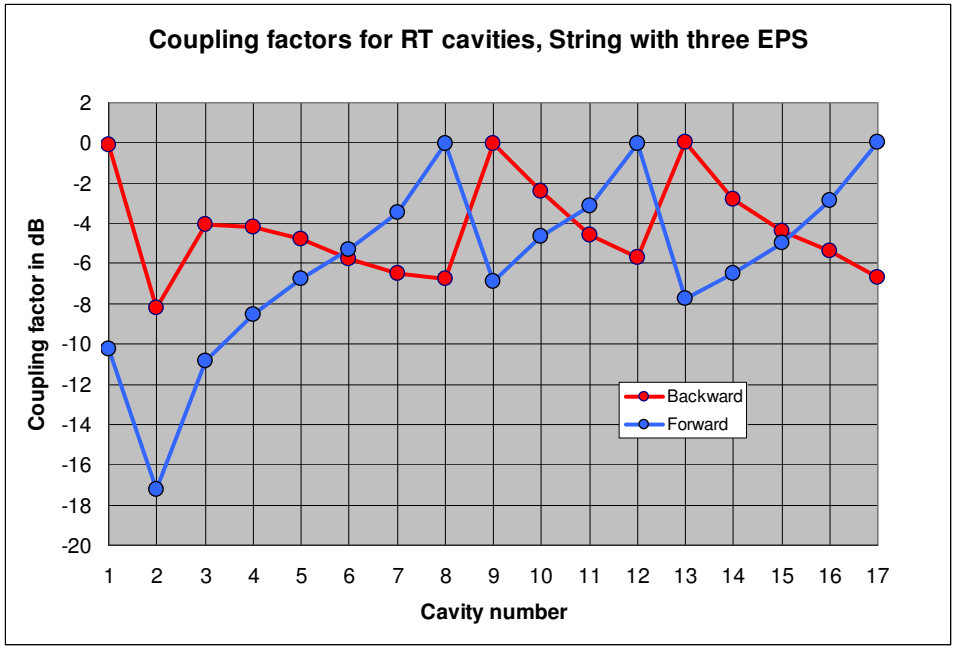


May be using backward feeding we could reduce number of different couplers.

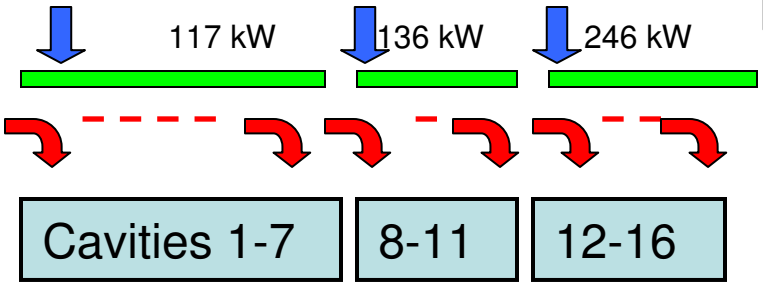
Directional couplers II

Backward, with 2 EPS





Forward, with 2 EPS
(<u>will be used</u>)



May be combining backward-forward feeding we could reduce total length and number of transmission lines.

Power is not a concern – directional couplers and IQMs can do the job.

Additional phase shift is needed?

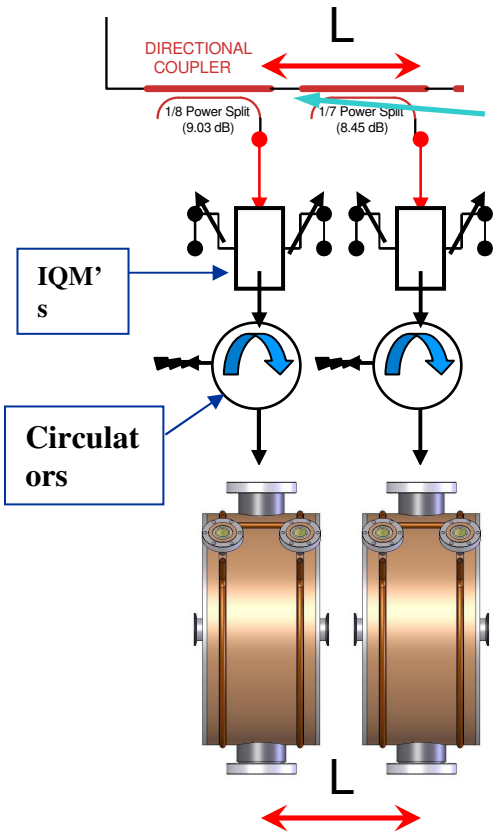
β_{beam} = 0.07÷0.14 – relative velocity of beam.
β_{RF} = 1 - phase velocity of field in air filled coax waveguide

Phase advance for beam:

$$\varphi_{beam} = 2f \cdot \mathrm{L} \cdot 180^{\circ} / \beta_{beam} c - 5 \cdot 360^{\circ}$$

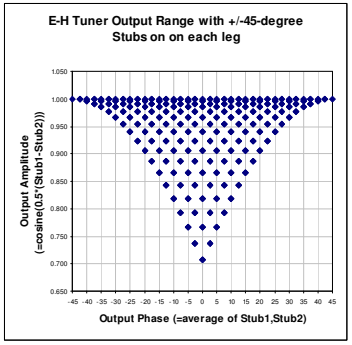
Phase advance for RF field:

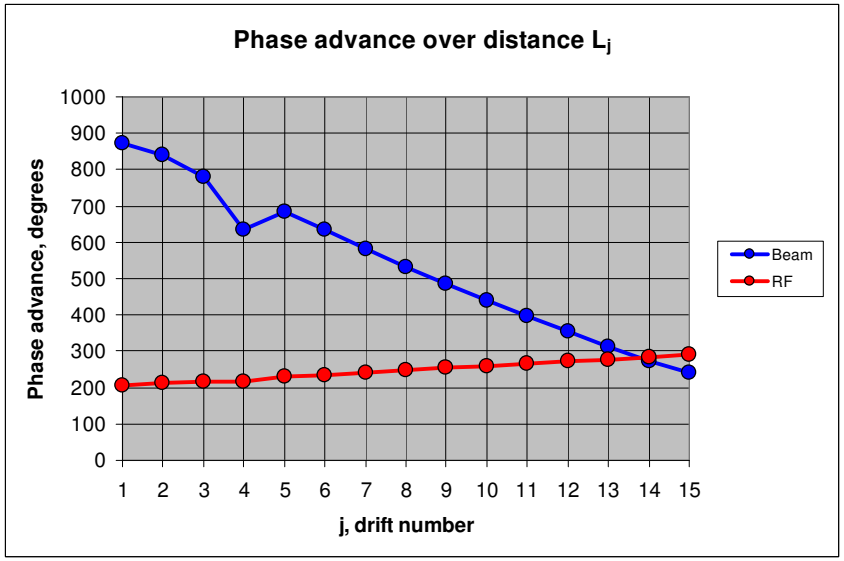
$$\varphi_{RF} = 2f \cdot \mathrm{L} \cdot 180^{\circ} / \beta_{RF} c$$

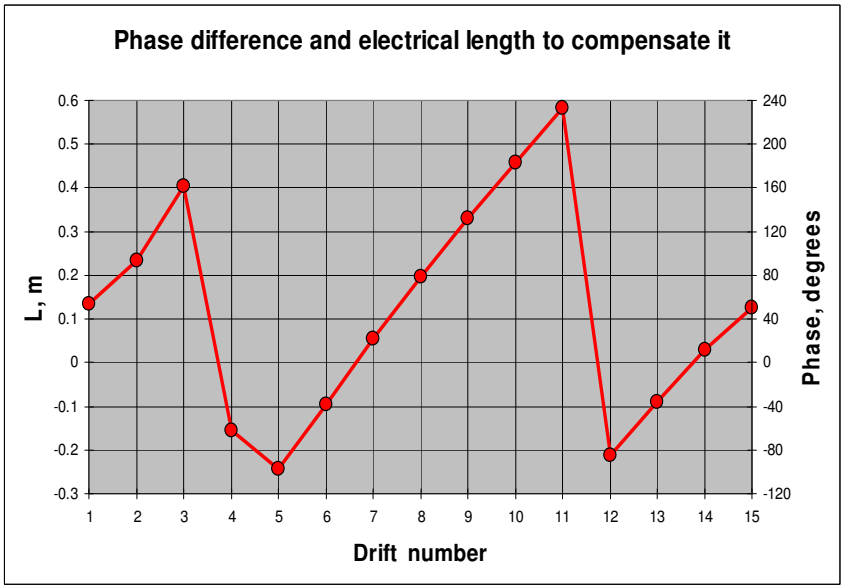


Additional phase shift between couplers is needed here

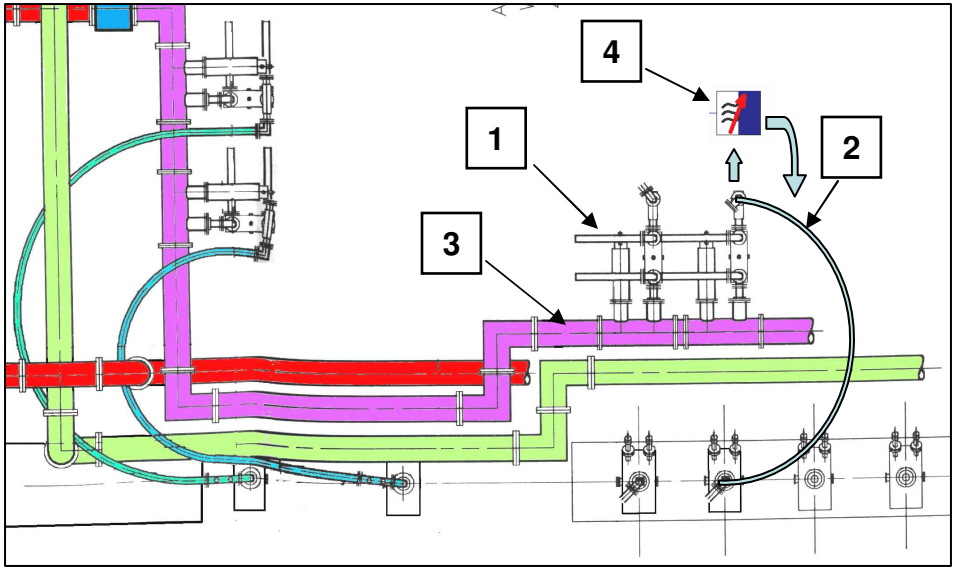
IQM - ±45°, ±17° without beam

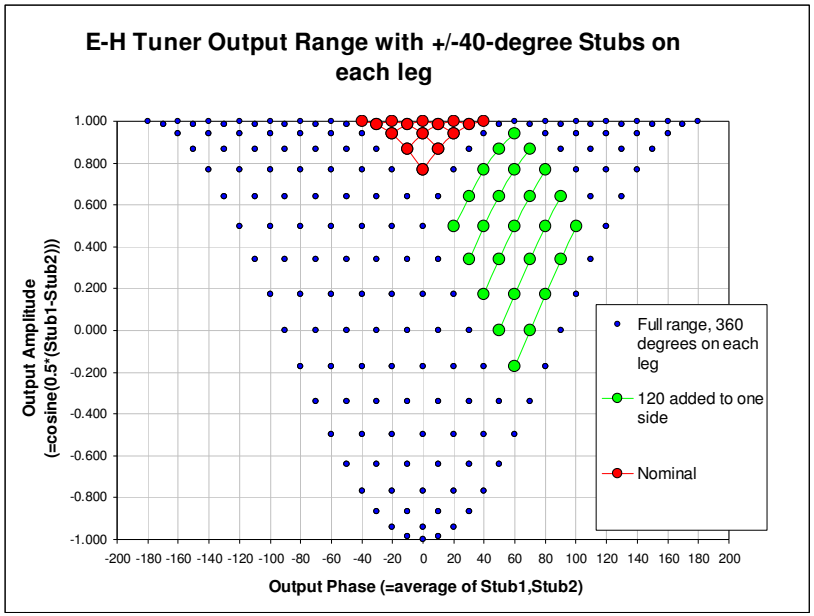


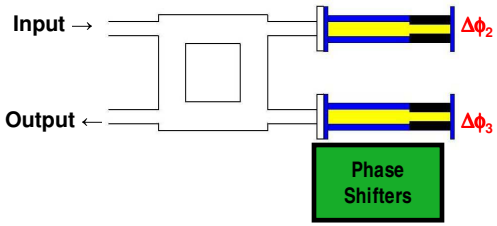




Ways to adjust phases



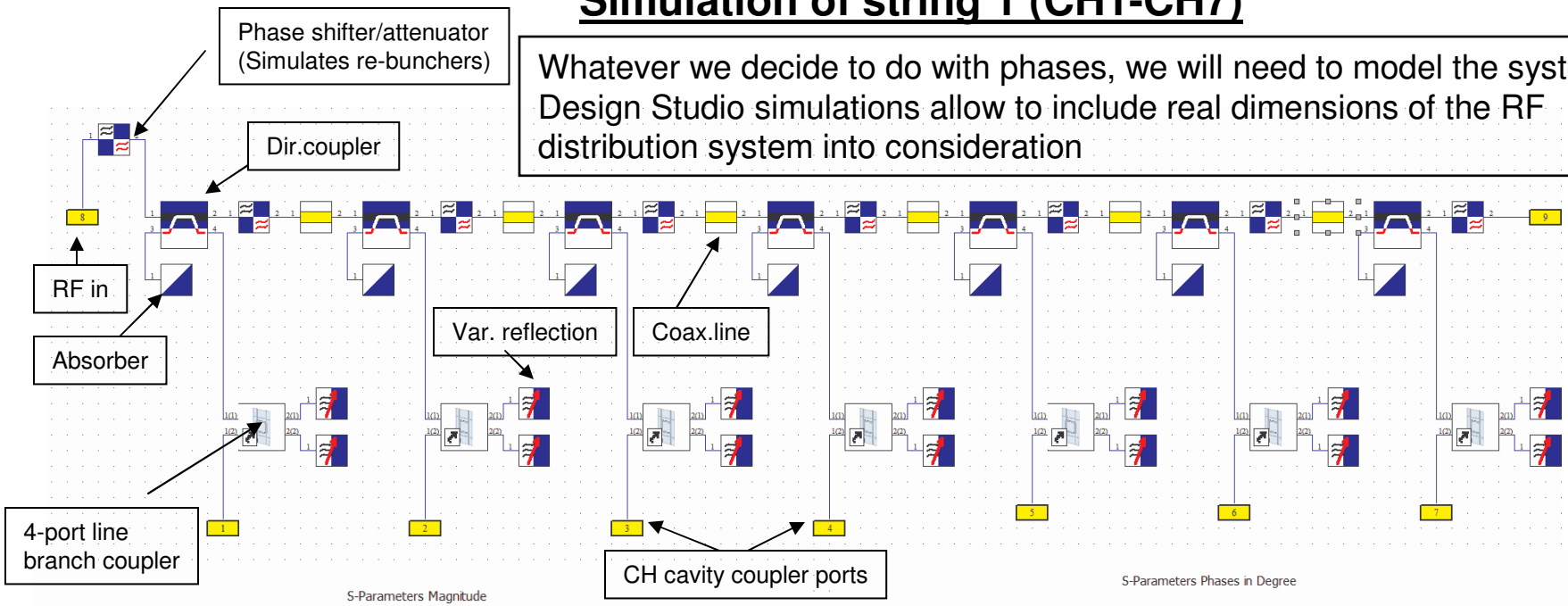


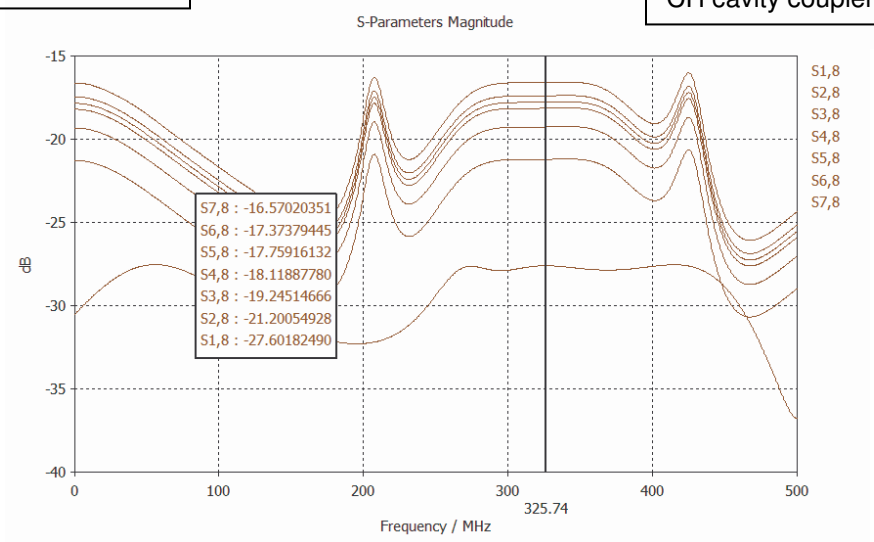


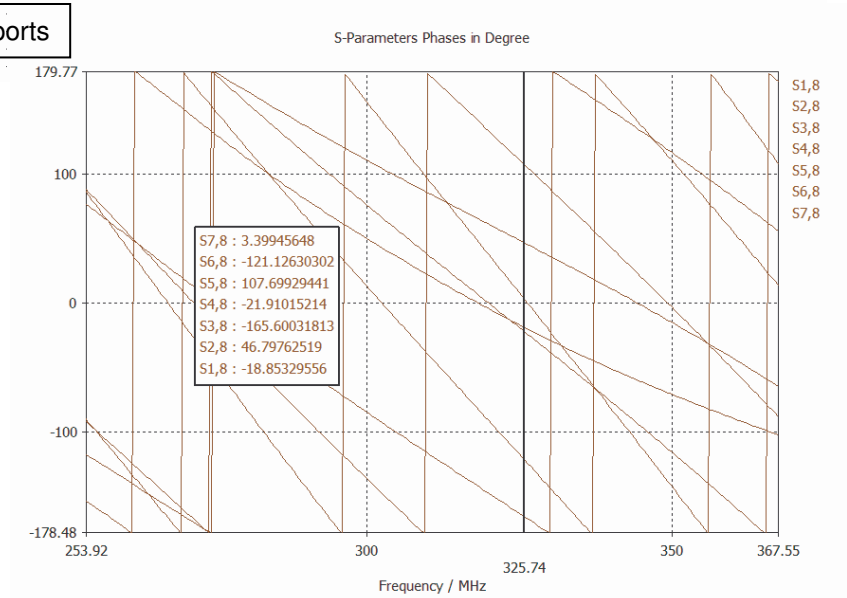
1. Additional phase shift in modulator (arms of different lengths)
2. Cables of different length between modulators and cavities.
3. Move first modulator to the left to get more space. Use insertions to tune phase.
4. Mechanical 360^0 phase shifters between modulators and cavities.
5. Put directional couplers on different lines to get more space for phase adjustment. Requires complete reconsideration of power splitting scheme.

Simulation of string 1 (CH1-CH7)

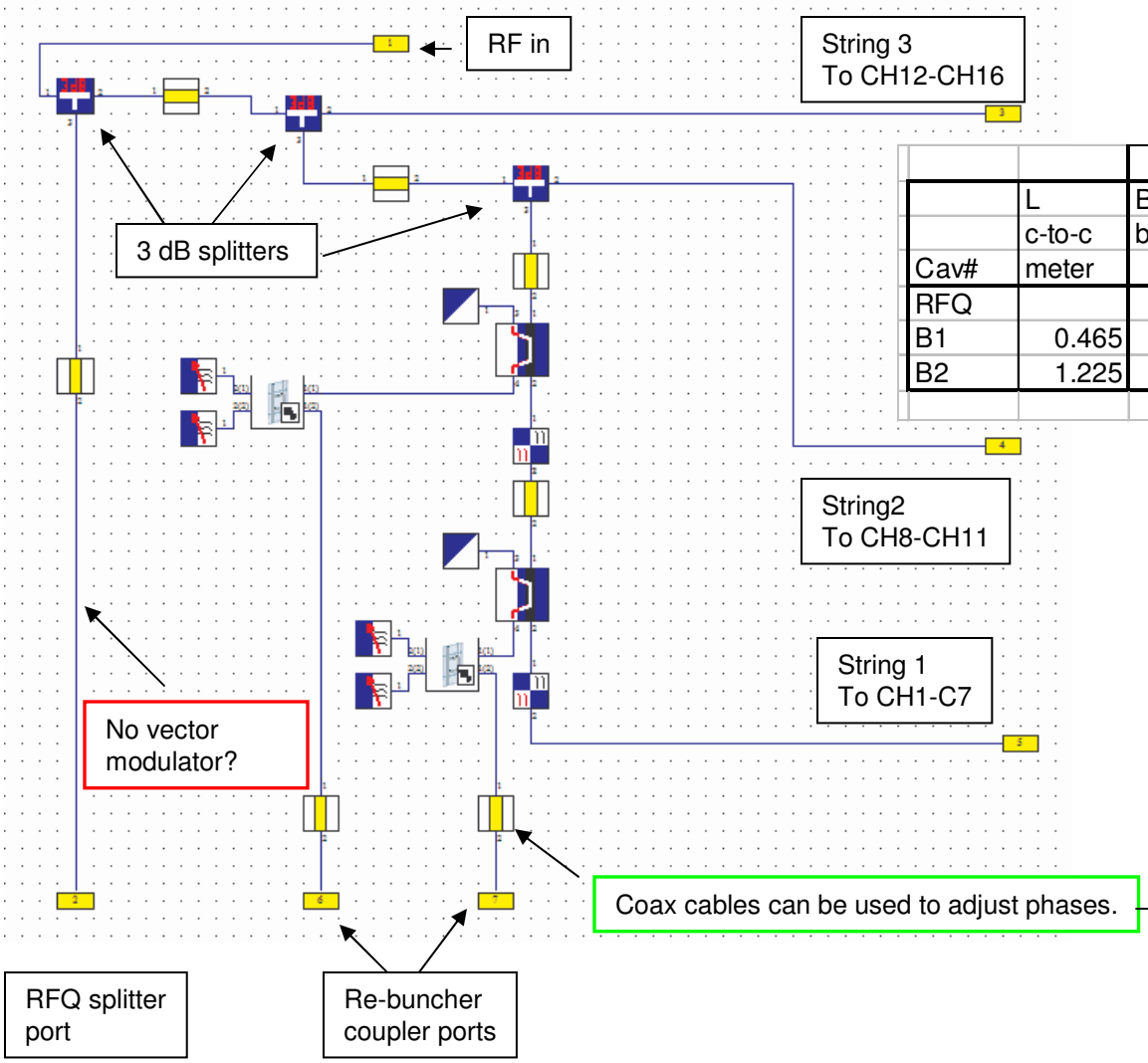
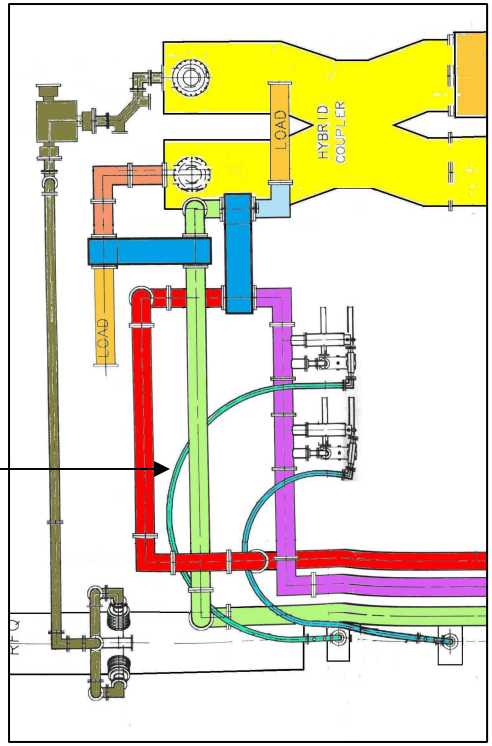
Whatever we decide to do with phases, we will need to model the system
Design Studio simulations allow to include real dimensions of the RF distribution system into consideration







Simulation of RFQ and re-bunchers



		Beam				Cables	lQm
	L	Beam	Phase	Phase	Phase	Phase	Phase
	c-to-c	beta	shift bea	sync	shift RF	shift wg	shift lQm
Cav#	meter		degree	degree	degree	degree	degree
RFQ		0.0744		-60			
B1	0.465	0.0744	2438.5	-90	278.49	119	-189.5
B2	1.225	0.0744	6424	-90	303.99	12.5	68.513