RF DEFLECTOR DESIGN

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SUMMARY

1) <u>Number of cells choice</u>:
   - 1a) Shunt Impedance ⇒ Power;
   - 1b) Mode separation ⇒ Tuning;
   - 1c) Cavity length ⇒Available space;
   - 1d) Surface peak electric field⇒Discharges;

2) <u>5 Cells RF deflector Design</u>:
   - 2a) 2D study ⇒field flatenss & sensitivities;
   - 2b) 3D study ⇒coupler design, mode separation & tuning

3) <u>Power feeding system</u>

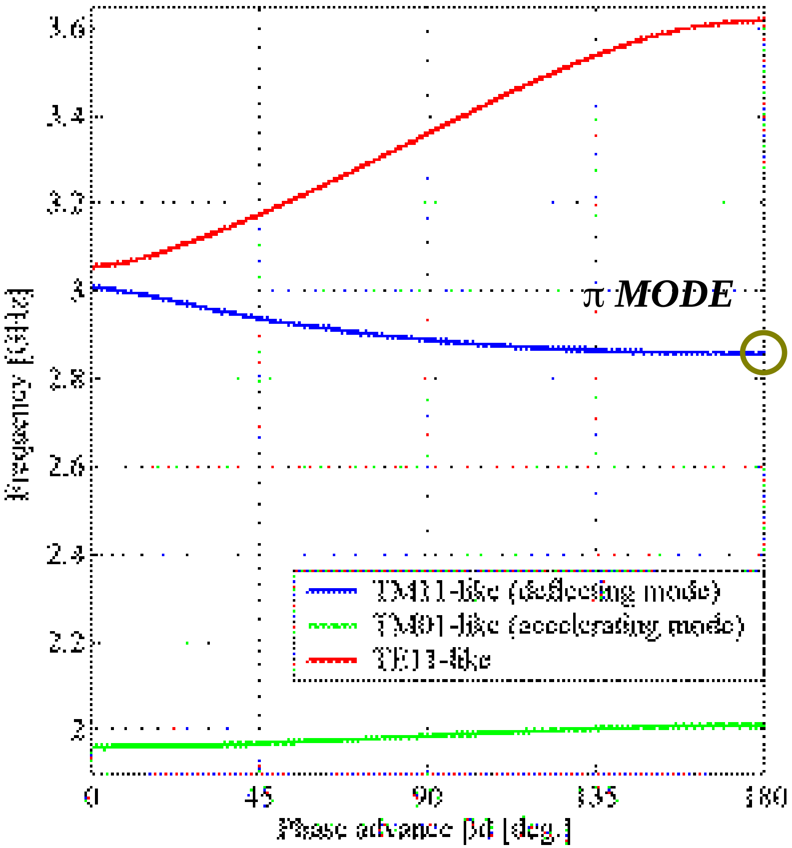
4) <u>Next steps</u>:
   - 4a) Prototype measur.: Field map ⇒ tuning;
   - 4b) Brazing tests @ LNF;
   - 4c) Final device on Cu_{OFHC};

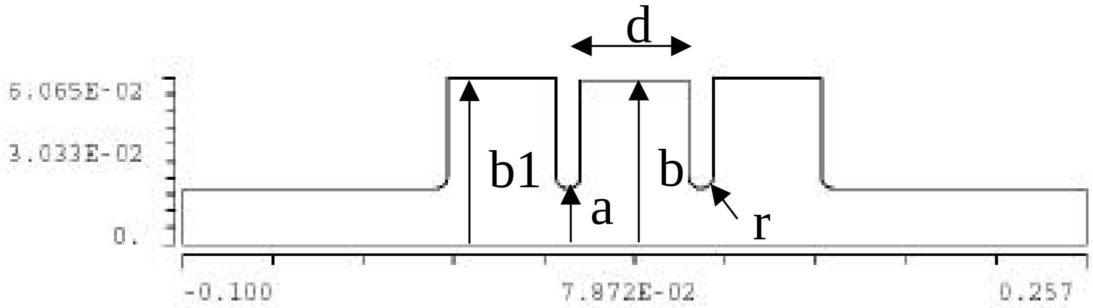
1) Number of cells choice

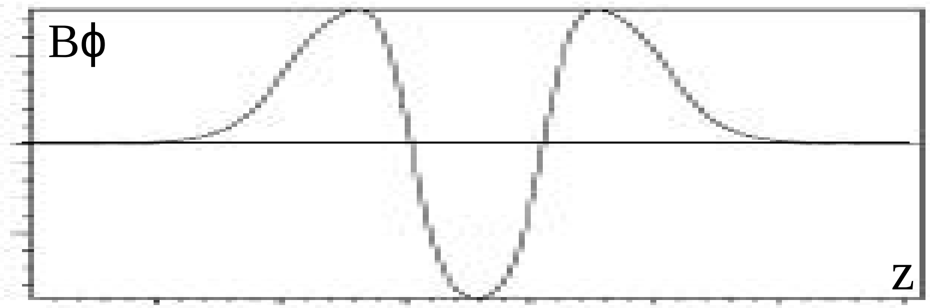
Simplest and more efficient structure

-SW multicell structure
-π MODE
-f_{RF}=2.856 GHz

Dispersion curve (2D profile)







Simbol	Value	Description
a	20 mm	Beam pipe transfer line radius
b	≈60 mm	Tuned to resonate @ 2.856 GHz
b1	≈60 mm	Tuned for field flatness
d	52.48 mm	Synchronism condition π MODE $d=c/2f_{RF}$
r	4.75 mm	Free dimension (1st order)

Deflecting voltage

$$V = \sqrt{2 \overbrace{P_{RF}} \underbrace{R}}$$

Dissipated power in the cavity

Number of cells (n)	RF defl. Length [m]	Transv. Impedance ($R_\perp$ [MΩ])	Quality factor (Q)	Bandwidth [kHz]	Δf nearest mode [MHz]
3	0.16	1.5	17100	167	25
5	0.26	2.5	16700	171	6
9	0.47	4.5	16900	169	1.5

$L = 2\ m$ **(Distance defl.-screen)**

$f_{RF} = 2856\ MHz$

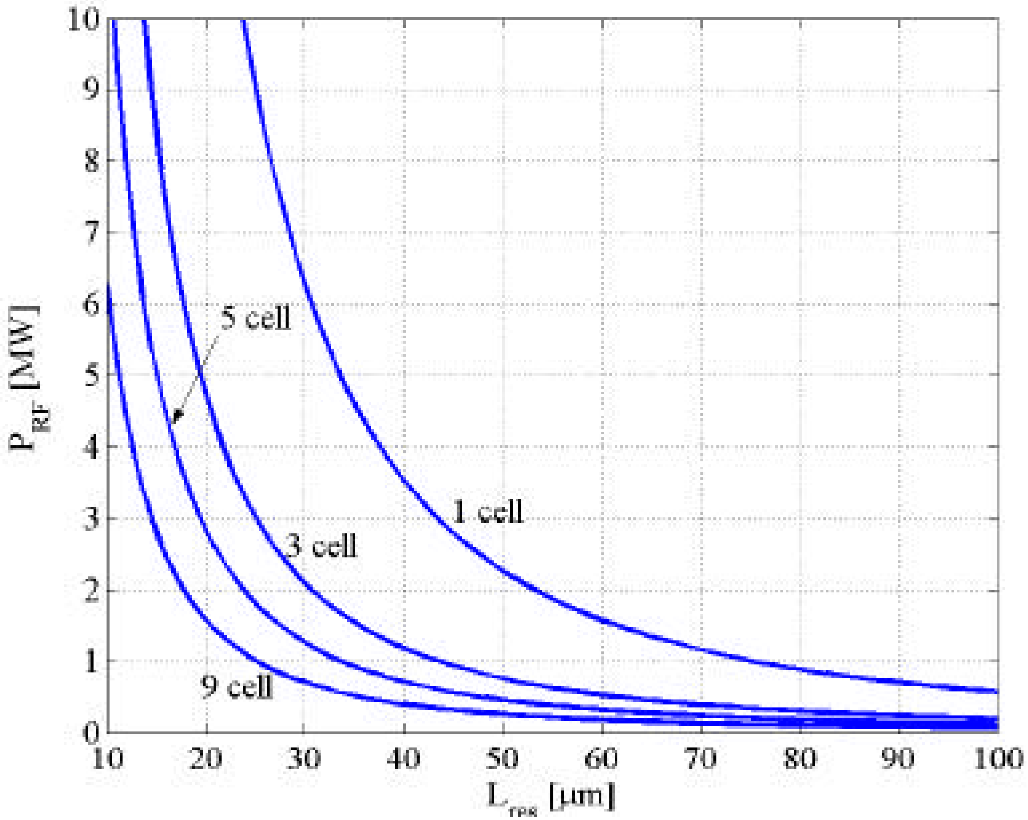
$R \qquad n\ \ 0.5\ M\Omega$

$E = 150\ MeV$

$\sigma_x = 30\ \mu m$

Number of cells

Transverse beam size on the screen



Surface peak E field

$$E_P\left[\frac{MV}{m}\right] \quad 90\sqrt{\frac{P_{RF}[MW]}{n}}$$

Number of cells choice criteria:

a) ***available transverse deflecting voltage*** for a given input power;

b) available ***space*** in the SPARC transfer line;

c) ***mode separation*** to avoid problems of mode overlapping;

d) maximum acceptable ***surface peak electric field*** to avoid problems related to high field intensities, discharges and so on.

5-cell deflecting structure

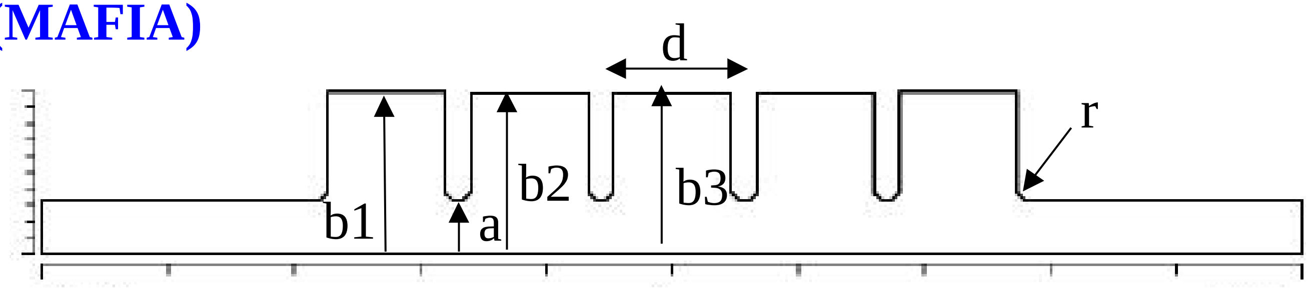
a) it allows to operate with a ***very low input power P_{RF}≤2MW*** obtaining contemporary ***low peak surface*** electric field and ***resolution length of the order of ~25 μm*** at P_{RF}=2MW.

b) These parameters permit measurement of the longitudinal beam profile with good accuracy, even considering the possibility of ***longitudinal compression factors of up to 20***.

c) Moreover the operation at low input power (≤2MW) allows to ***simplify the power line design*** as discussed below.

2) 5 cells RF Deflector Design

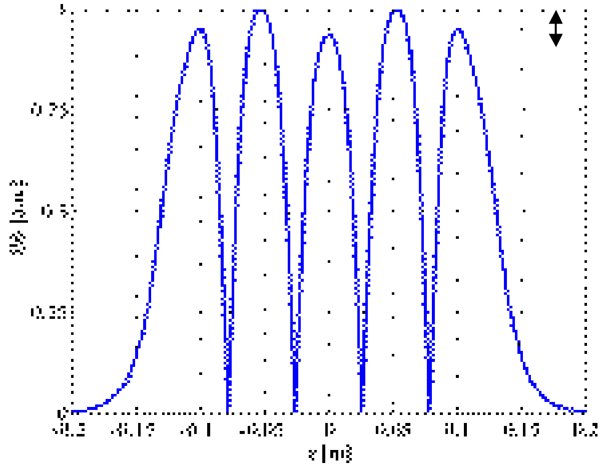
2a) 2D Profile study (MAFIA)



-Field Flatness

DIMENSION	VALUE [mm]
a	20.00
b2=b3	59.97
b1	60.67
r	4.75
d	52.48

F [GHz]	2.85699
$R_\perp$ [MΩ]	2.47
Q	16800



-Sensitivities

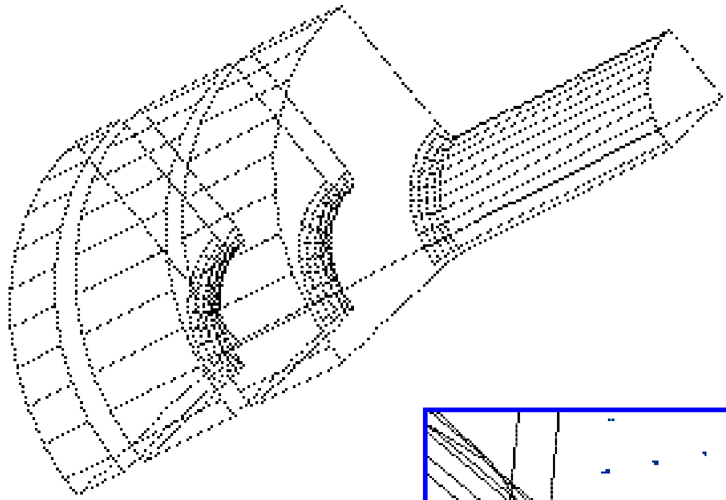
∂f/∂b1=8.6 [kHz/μm]	∂f/∂b2=10.8 [kHz/μm]	∂f/∂b3=9.7 [kHz/μm]

Errors in the cells machining of the order of 10^{-2} mm give frequency errors of the order of 100 kHz and field errors of few percent.

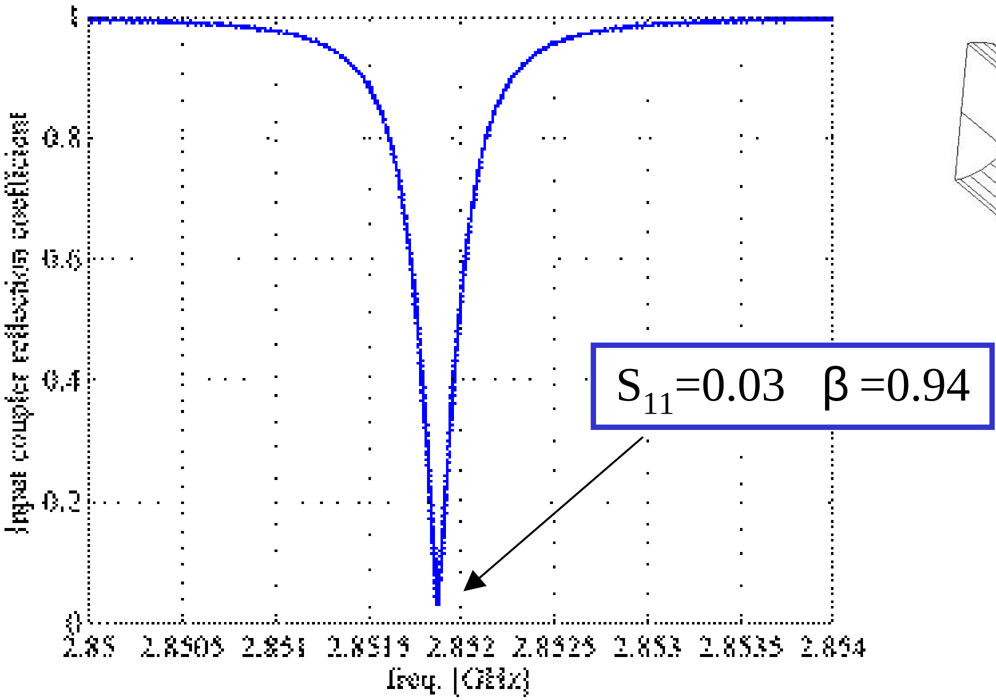
2b) 3D Profile studies (HFSS)

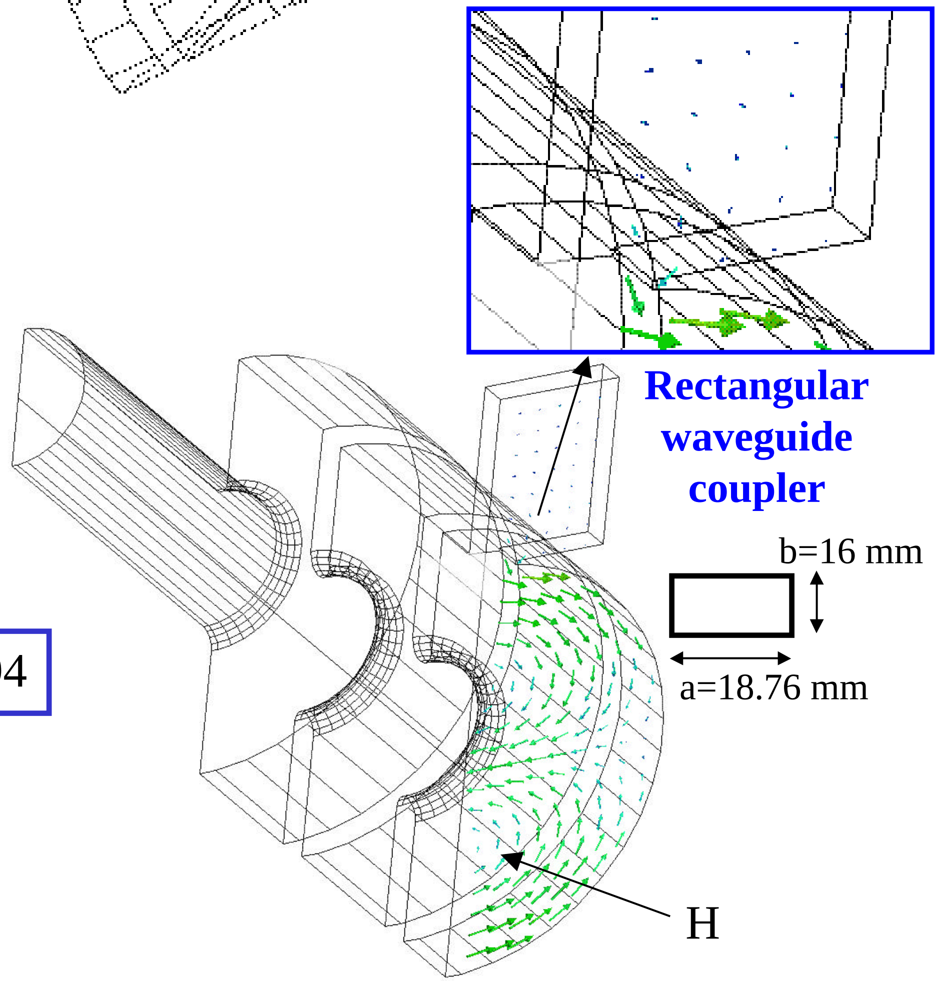
• compare 2D-3D simulations

	2D MAFIA (eigenmode)	3D HFSS (eigenmode)
Frequency [GHz]	**2.85699**	**2.85467**
Q	**16800**	**16400**
$R_\perp$ [MΩ]	**2.47**	**2.43**



• coupler design





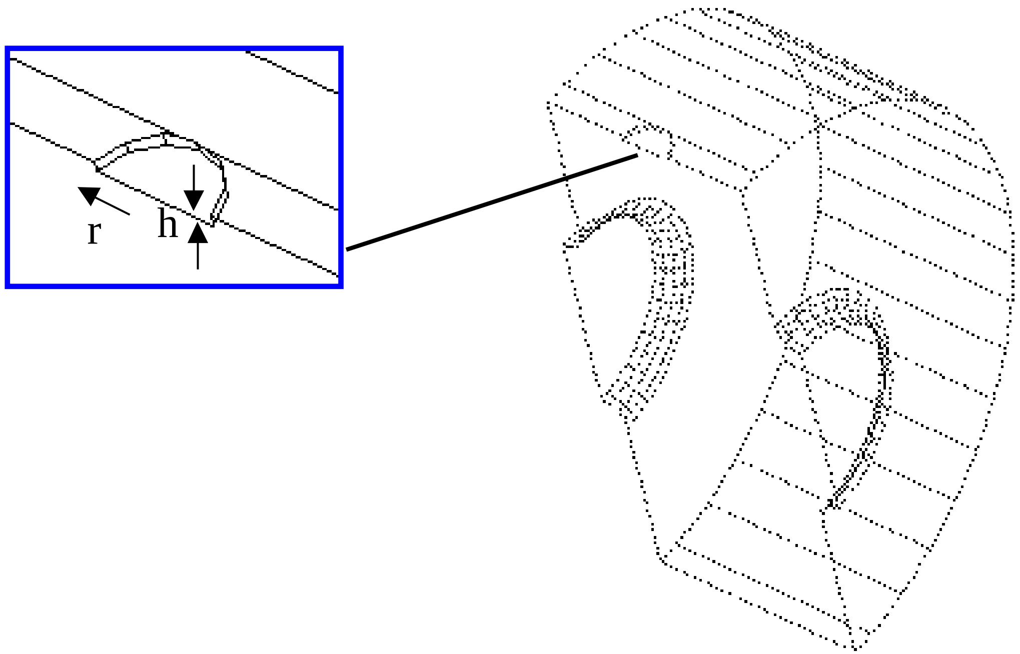
- **mode separation**

MODE	Excited by the coupler	Δf [MHz]
π Deflecting mode tilted polarity (90^o)	NO	6.5
_π mode polarities 0^o	NO	5.4
_π mode polarities 90^o	NO	5
π/2 mode polarity 0^o	YES	20

- **tuning**

r=5mm
h=1 mm

Δf=550 kHz



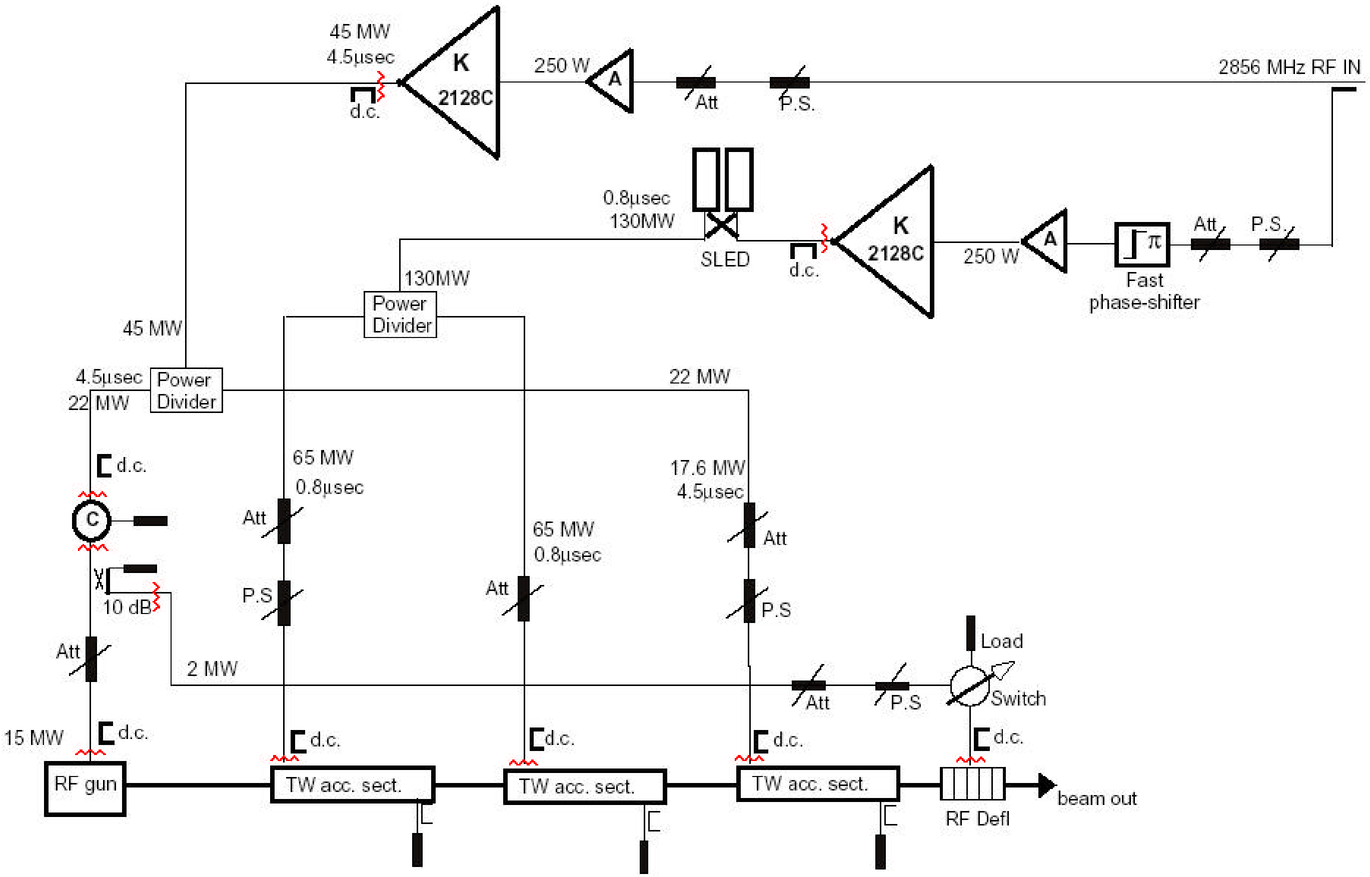
3) Power feeding system

a) The 2 MW input power needed to feed the structure can be ***split out from the first klystron*** waveguide feed with a ***10 dB directional coupler***

b) The ***circulator and the directional coupler*** shown assure that every reflected power from the deflector ***does not interact with the power feeding the RF gun***.

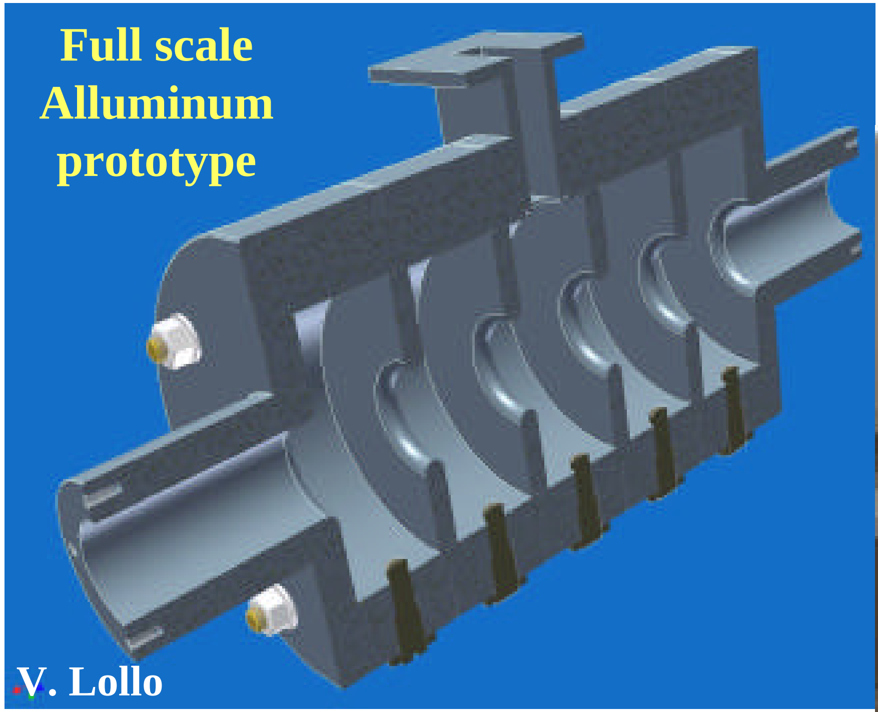
c) Moreover the ***high power switch*** is included to allow the deflecting field to be completely ***turned off***.

d) Because of the reduced power needed for the structure it is possible to simply employ a ***waveguide system with air-fill***, thuis reducing the costs of the entire power feed system.



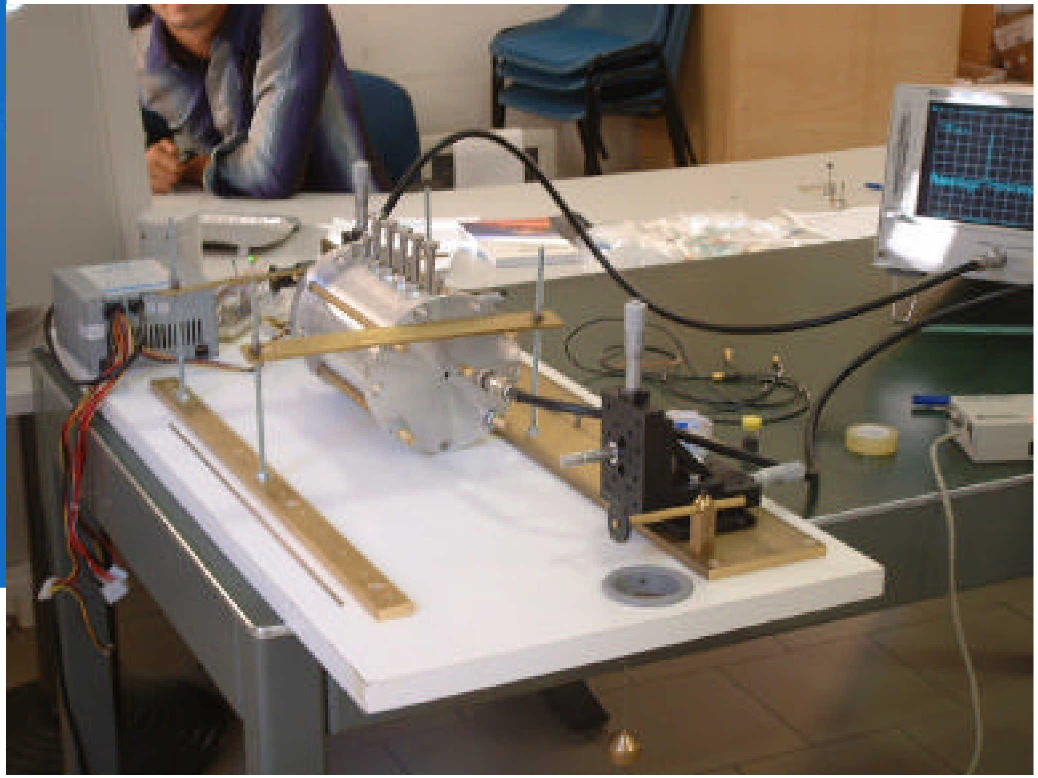
4) Next steps

4a) Prototype measurements (Oct. 2003)



Bead-pull measurement set up

(Univ. of Rome “La Sapienza” Dip. Energetica)



4b) Brazing tests @ LNF (Oct. 2003): to invetsigate the effect of the brazing procedure on the resonant frequency of the cells

4c) Final device on Cu_{OFHC} (Jan. 2004) machined outside and brazed @ LNF

CONCLUSIONS

a) **The investigation of the RF deflector properties as a function of the number of cells has been done showing that the 5 cells choice fits the whole requirements;**

b) **A complete 2D and 3D study of the RF deflector has been done in term of:**

-field flattness optimization

-sensitivity calculations

-coupler design

-mode separation

-peak surface E field calculation

c) **The next steps are:**

-bead-pull measurements on an alluminum prototype

-brazing tests @ LNF

-final device realization (machined outside and brazed @ LNF)