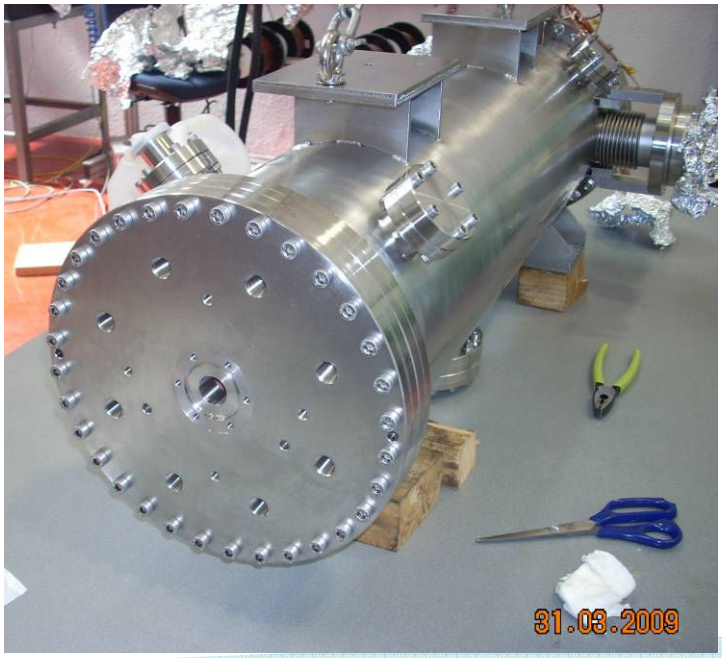
Review of TBL PETS prototype production



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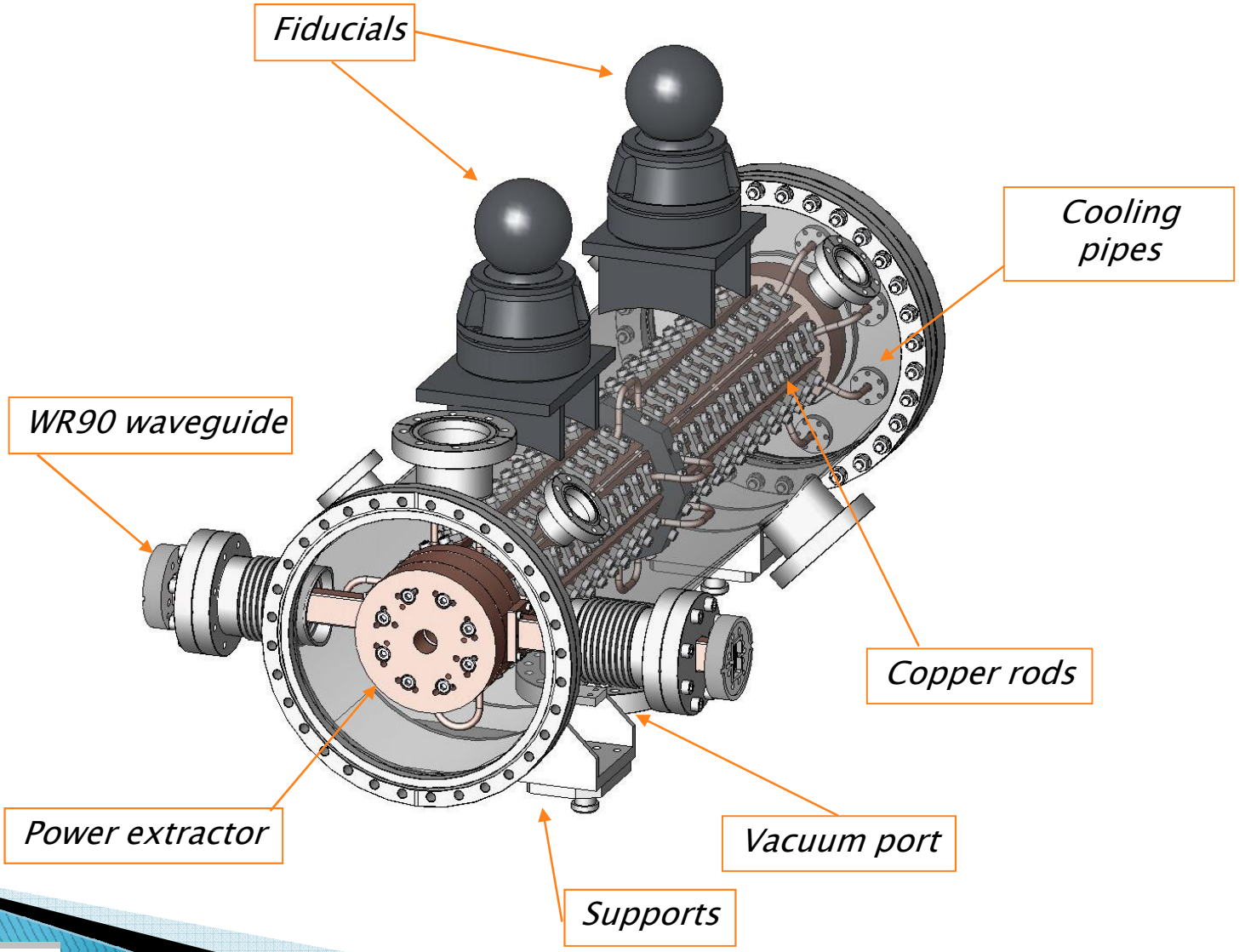
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

David Carrillo on behalf of Accelerators Group, CIEMAT

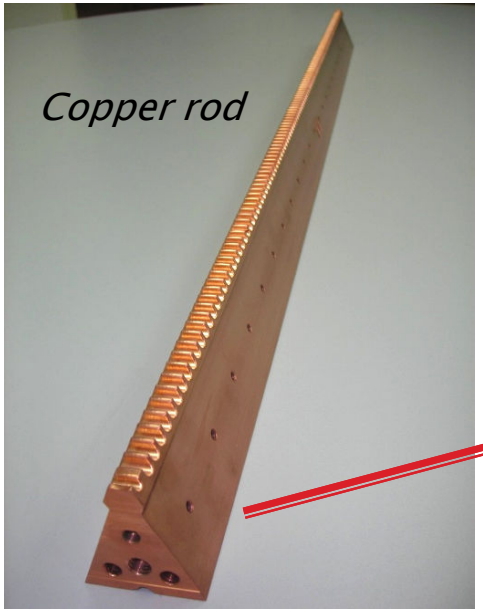
CLIC09 WORKSHOP 14/10/2009

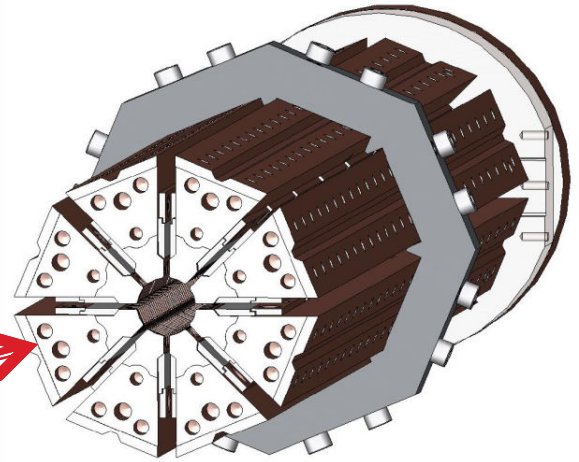
General layout

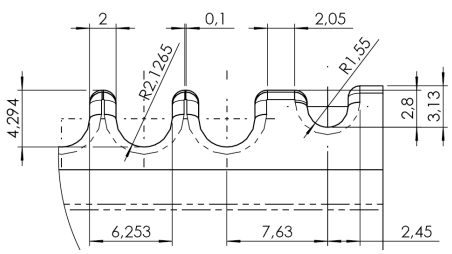


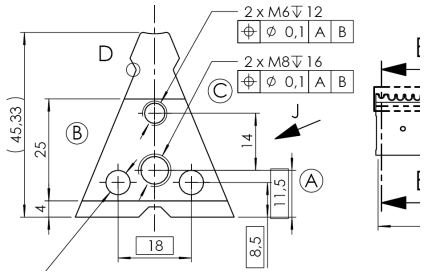
Copper rods

- Each PETS was made of eight OFE copper rods (800 mm)
- These were the most difficult parts to fabricate: overall tolerance is +/- 0.02 mm and roughness should be better than 0.4 micron
- The coupling cell is smaller: two different tools were necessary
- Two intermediate thermal treatments for stress relaxation



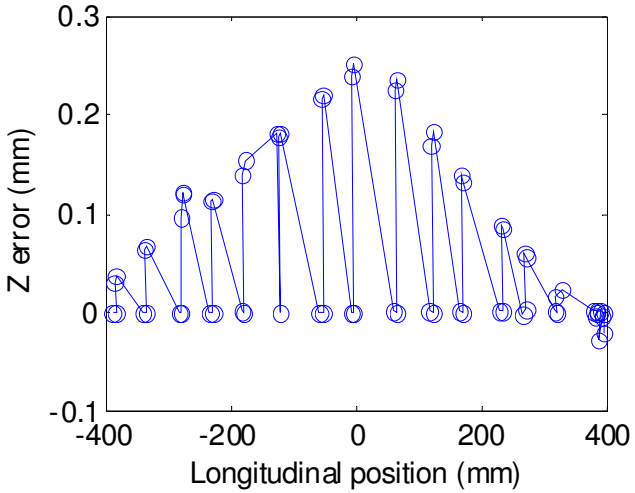


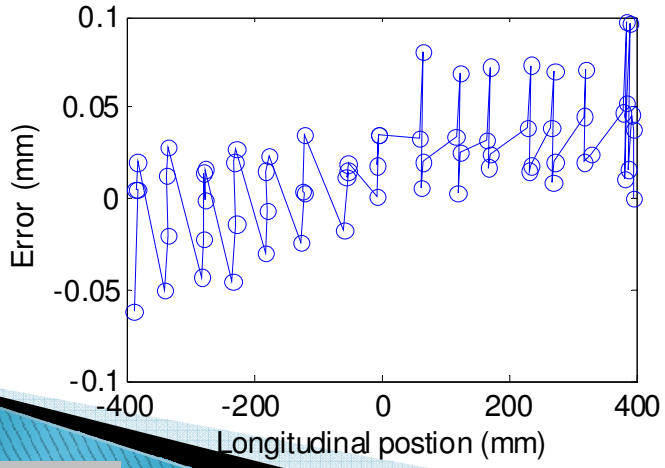


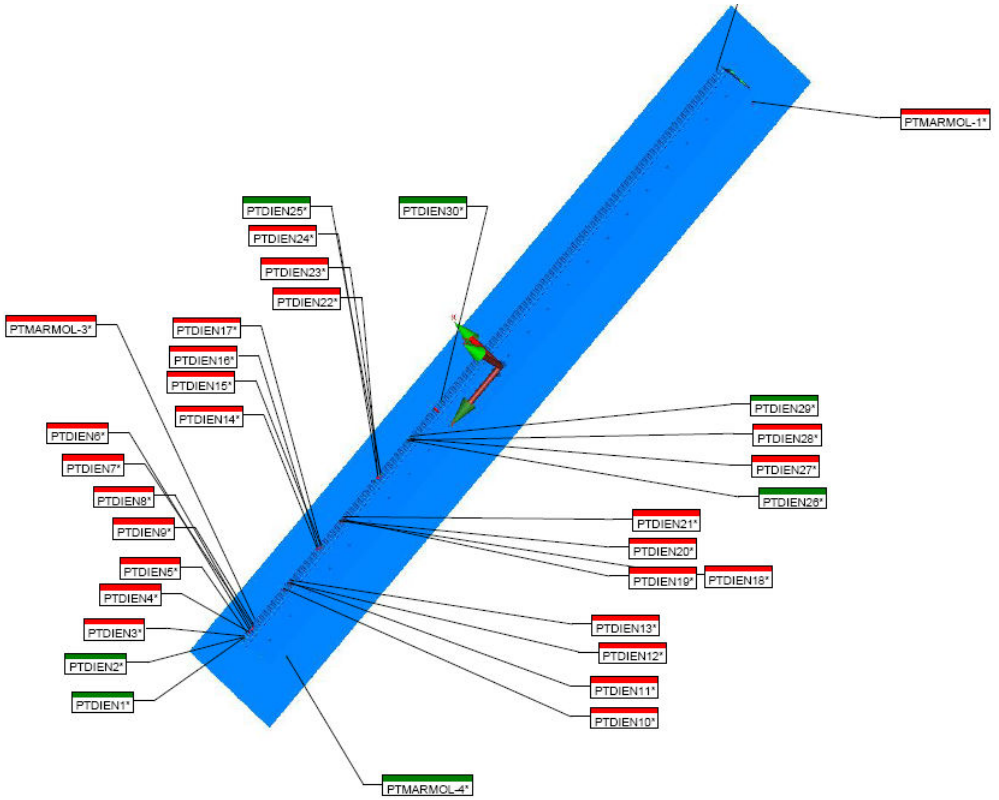


Copper rods problems

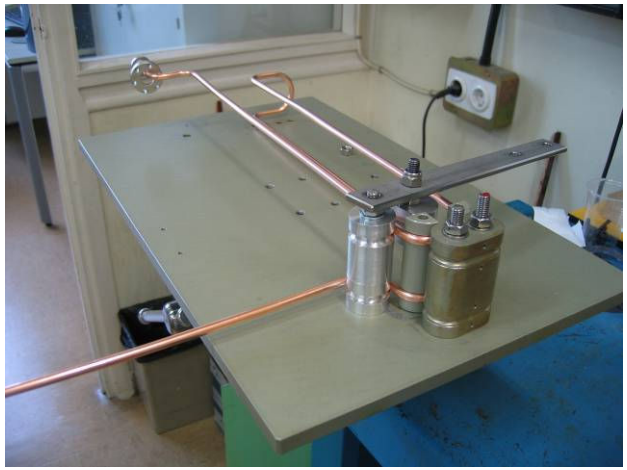
- Problems with temperature control during machining
- Internal stresses are higher than those in OF copper (previous prototype)
- The copper rods were not measured while screwed to a flat plate

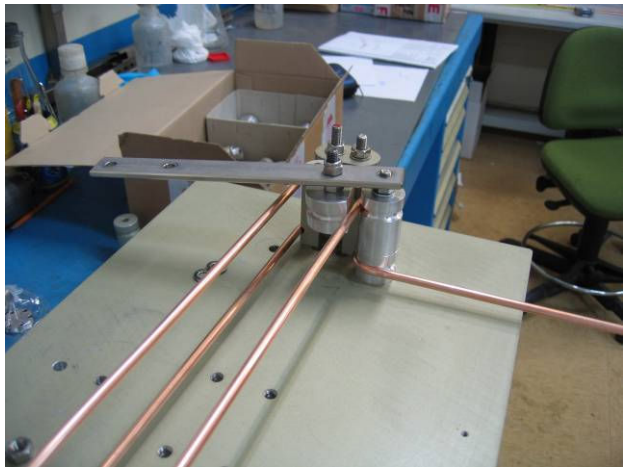


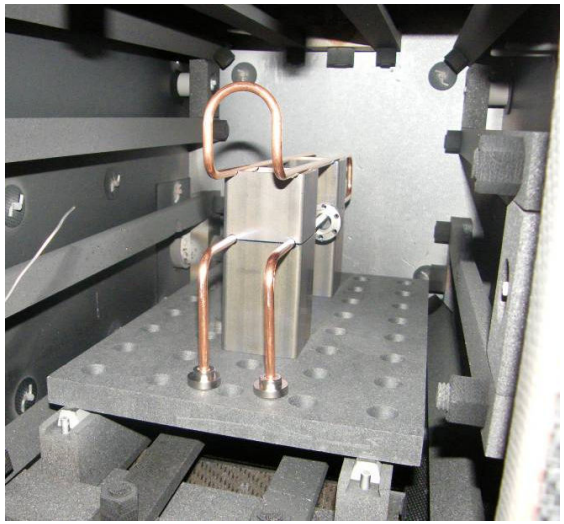




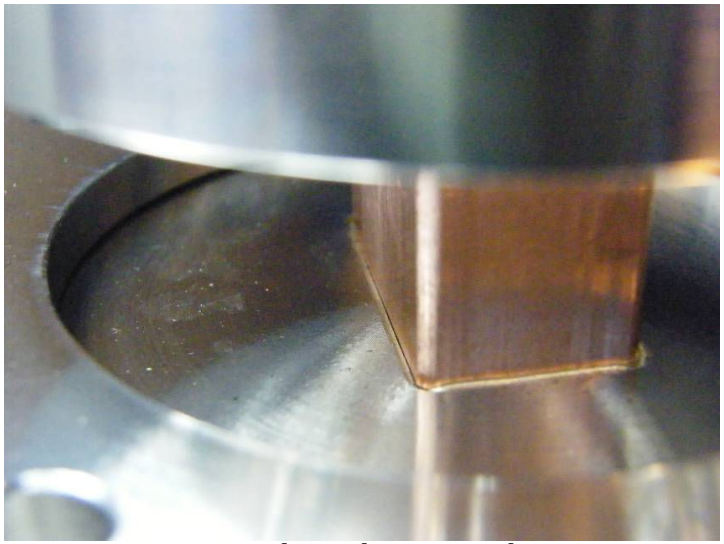
Cooling pipes production

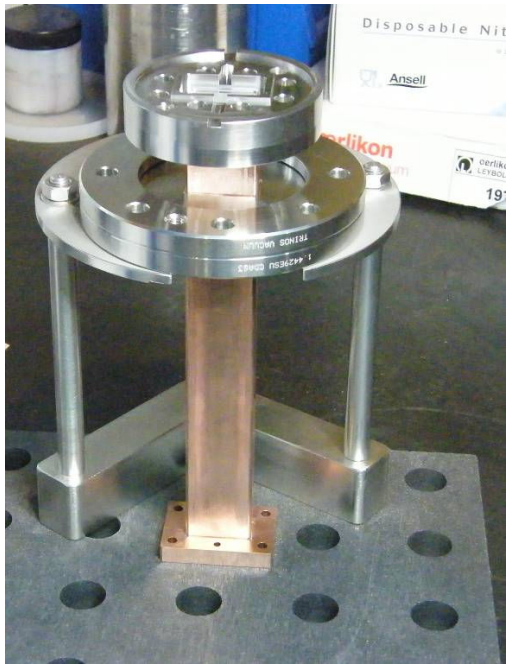




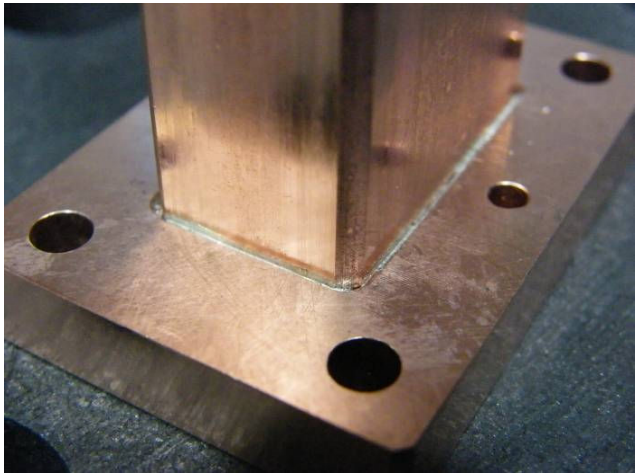


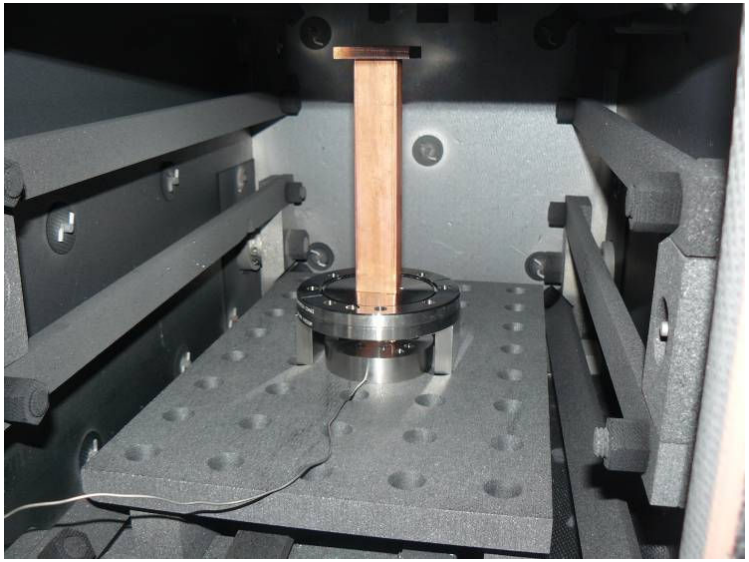
Waveguides





Waveguides brazed in Spanish company AIMEN





Waveguide. Brazing problems in Spain

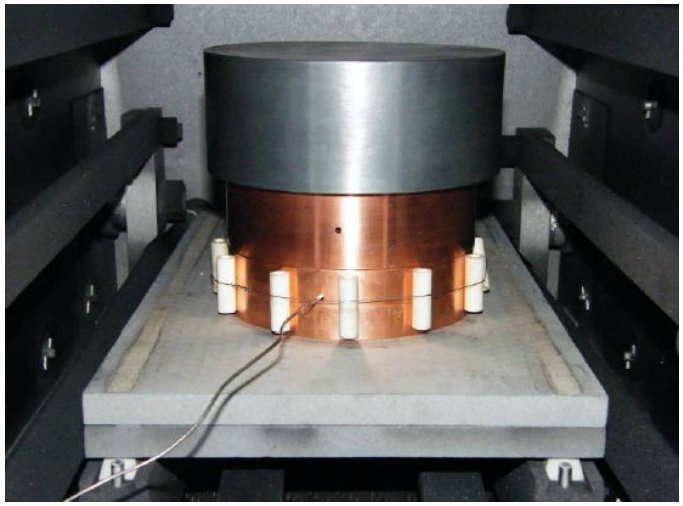
- In the first test, the company used AgCu alloy. Afterwards the company chose the NiAu alloy because in case of leaks, reparation is easier and to avoid nickel coating of steel flanges. Risk of leaks due to copper transformation

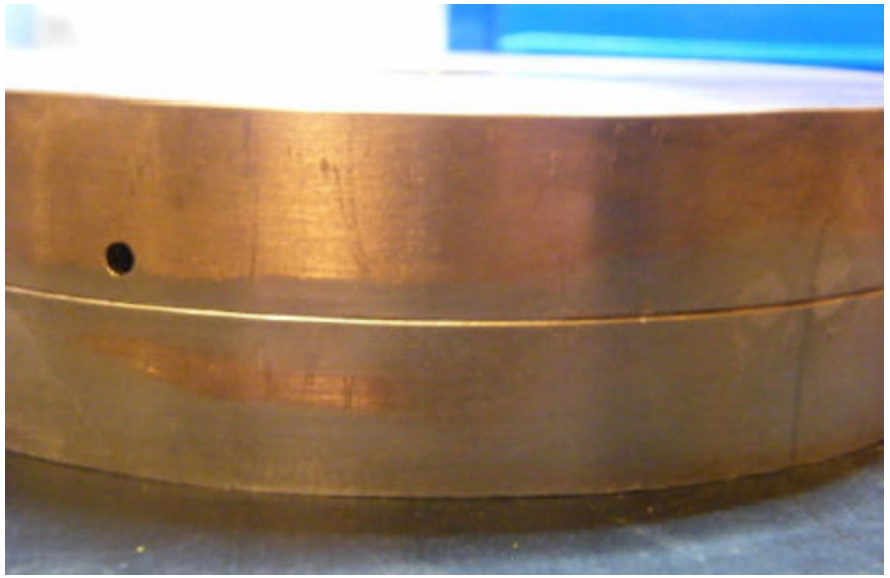
- One waveguide was bent due to deficient packing Solution: to unbend the waveguide as it is soft enough and polish the contact surface to get a good thermal contact and parallelism

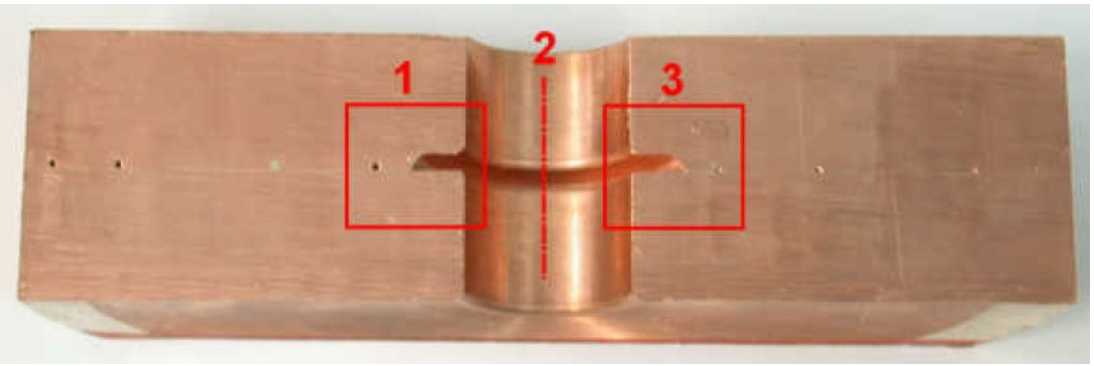
- Copper parts were cleaned by ultrasonic bath only

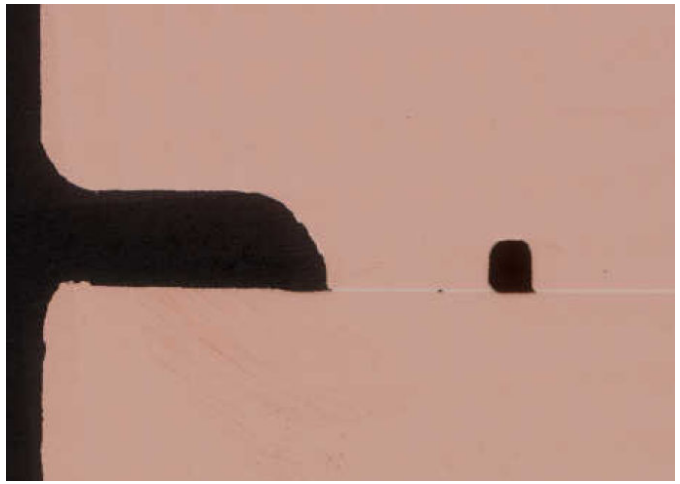
- The oven at the Spanish company:
  - has not view port
  - It has graphite heating elements
  - The temperature measurement error is unknown

Power extractor.
Problems with brazing in Spain

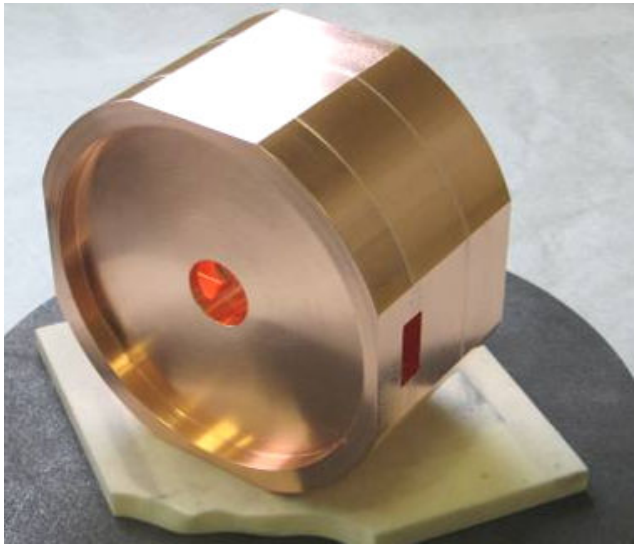


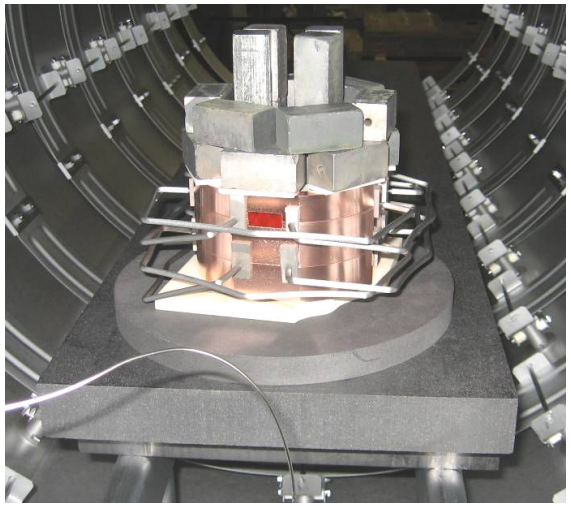






Power extractor. Brazing at CERN





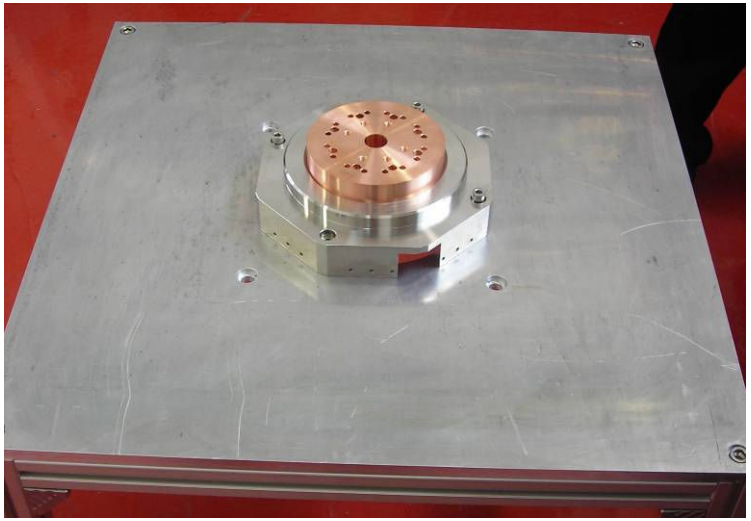
Courtesy Serge Mathot, CERN

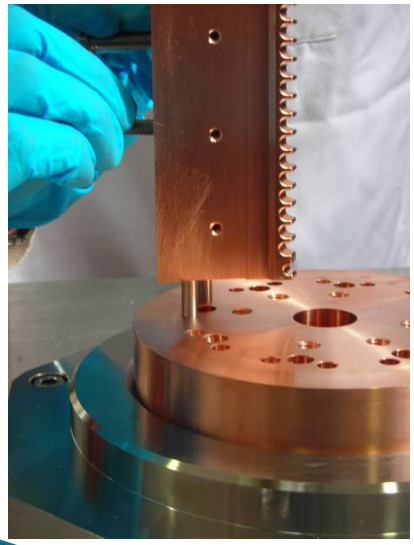
- Copper parts were polished at CERN, because they were not flat enough (machining error in Spain)

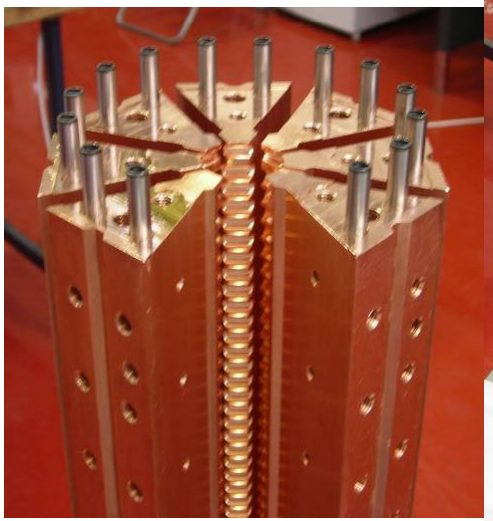
- Copper parts were cleaned by ultrasonic bath, and at CERN, they were also etched and passivated

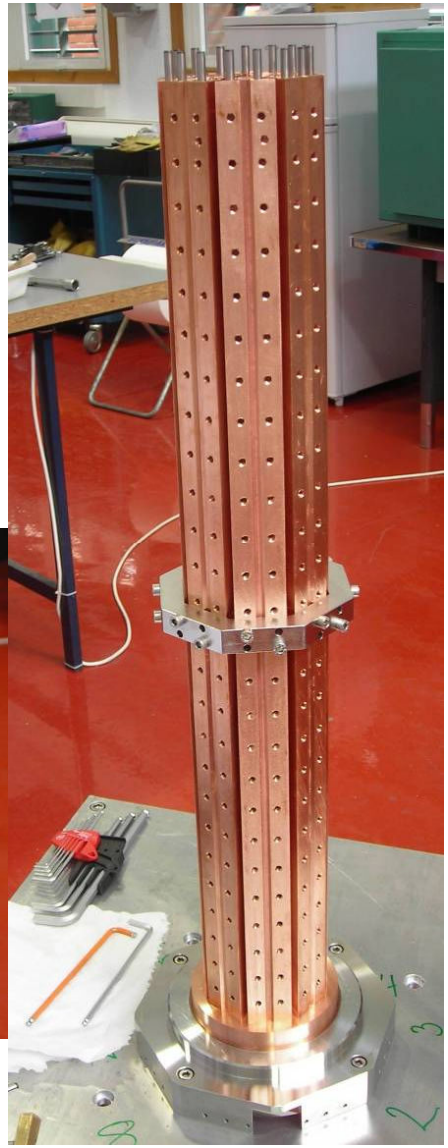
- Power extractor was successfully brazed at CERN

RF structure assembly



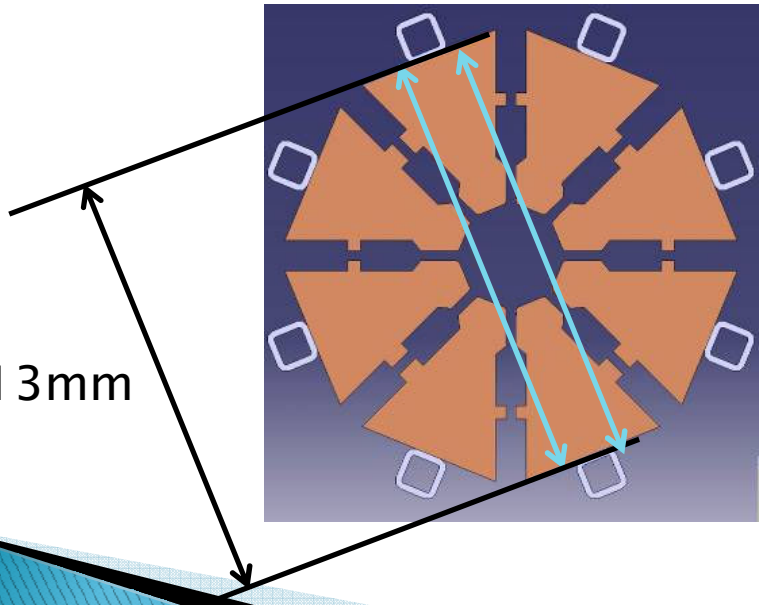


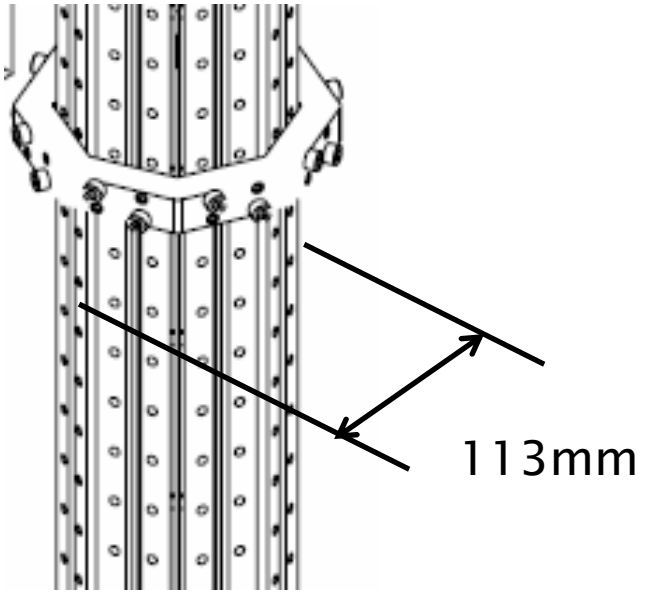




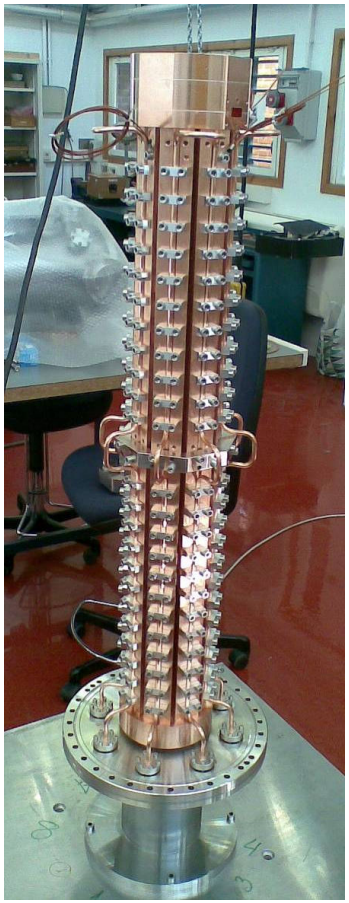
Mechanical measurements on the assembly

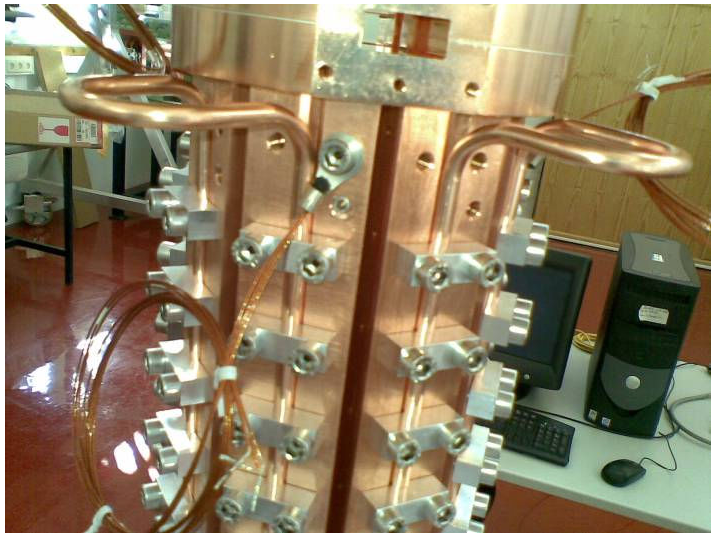
	ROD 1-5		ROD 4-8		ROD 7-3		ROD 6-2		
	R	L	R	L	R	L	R	L	AVERAGE
DOWN	113.045	113.035	112.950	112.990	113.045	113.010	112.950	112.950	112.997
MID-DOWN	113.040	113.040	112.960	112.980	112.930	112.925	112.955	112.960	112.974
BELOW RING	**113.055**	**113.040**	**113.045**	**113.055**	**113.035**	**113.010**	**113.045**	**113.035**	113.040
ABOVE RING	**113.040**	**113.020**	**113.045**	**113.060**	**113.070**	**113.050**	**113.065**	**113.055**	113.051
MID-UP	112.965	112.980	112.990	112.995	112.980	112.985	113.035	113.020	112.994
UP	112.990	113.010	113.040	113.050	112.970	112.940	113.080	113.060	113.018
AVERAGE	113.023	113.021	113.005	113.022	113.005	112.987	113.022	113.013	113.012

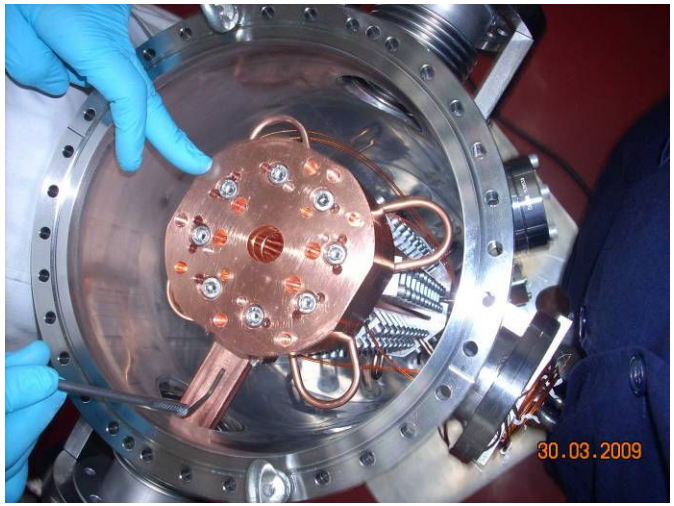


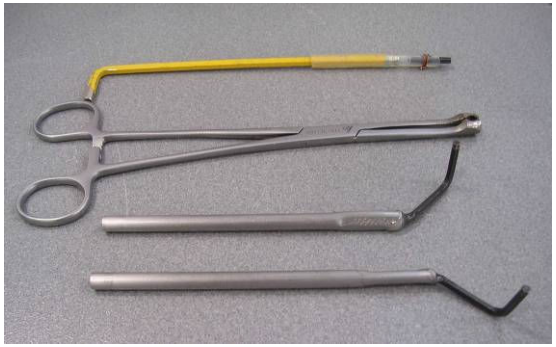


PETS tank assembly (I)

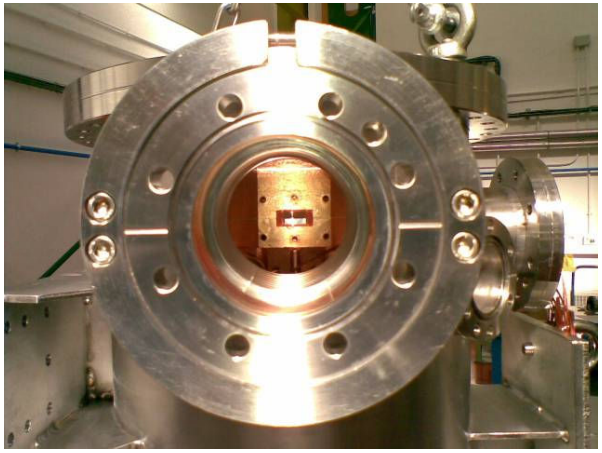








PETS tank assembly (II)



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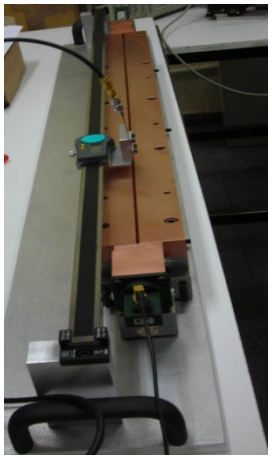
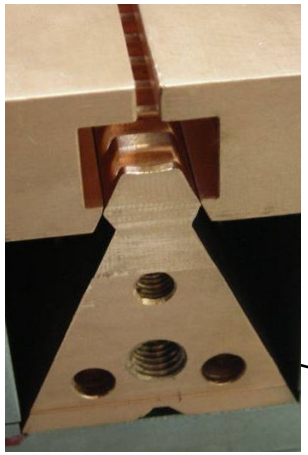
TBL PETS MEASUREMENTS

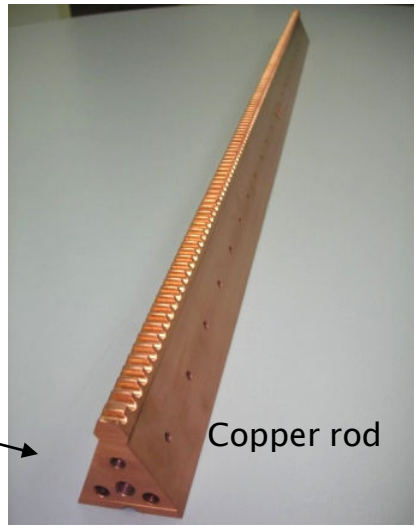
David Carrillo on behalf of Accelerators Group
CIEMAT
CLIC09 WORKSHOP 14/10/2009

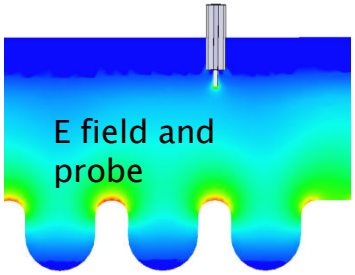
Single PETS bar measurements: Test device

- A device was designed* to do RF tests of the single PETS bar
- It consisted of two side blocks put together with a single PETS bar in order to create inside a mode (TE_{10}) with same phase advance, v_g, etc as the decelerating mode









Phase/period=90°

Frequency =11.994 GHz

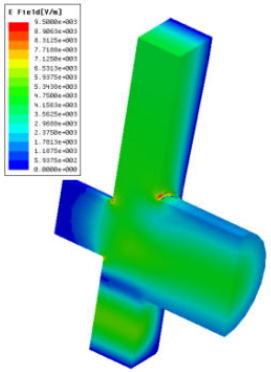
Vg/c=0.466

- The first 800 mm long bar has been successfully measured with the RF test bench

- Measurements strongly depend on electrical contact between device and copper rod and we could observe some deformations in the copper. As 3D measuring machine were quite repetitive no more copper rod have been tested using this device

**Under Igor Syratchev's supervision*

Mode launcher

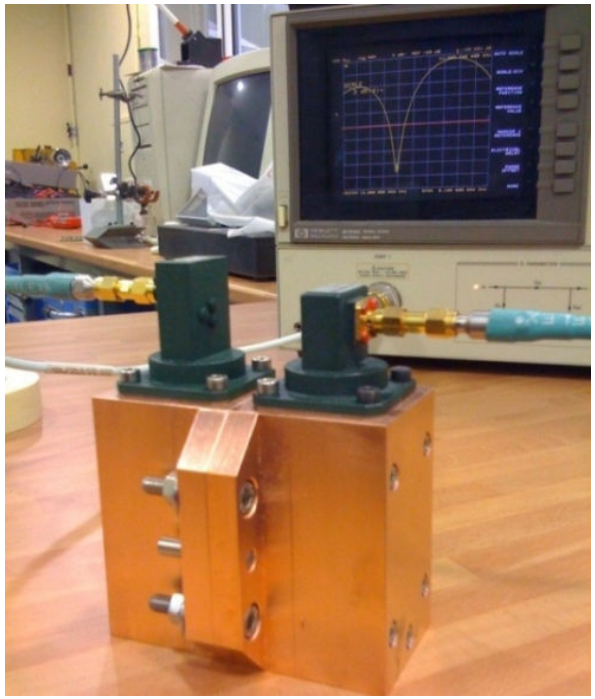


HFSS input coupler model

- Mode launcher was needed to produce working mode in order to do RF measurements on PETS before final assembly

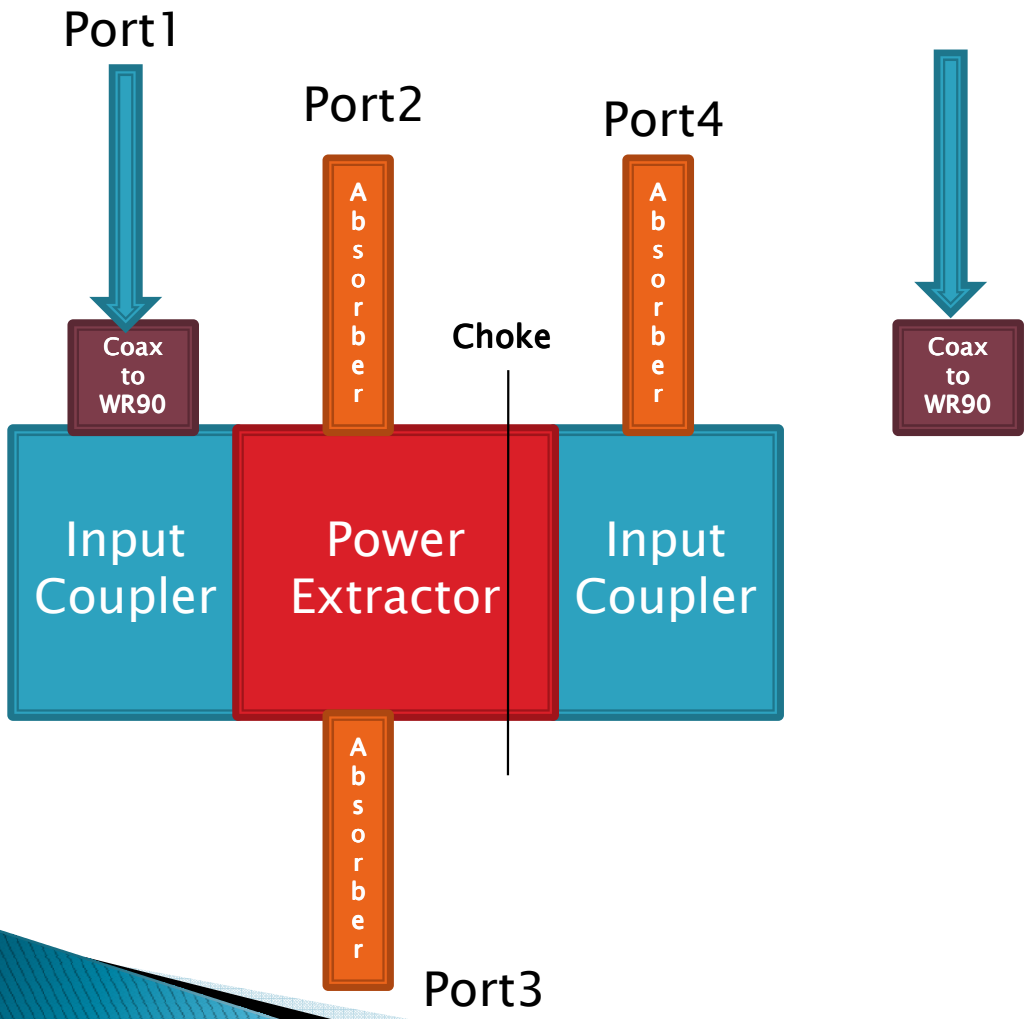
- Two mode launchers were manufactured and measured and they were ok for measuring PETS final assembly

- The two mode launchers were tested together. S11=-30dB S22=-41 dB (Min At 11,989GHz)

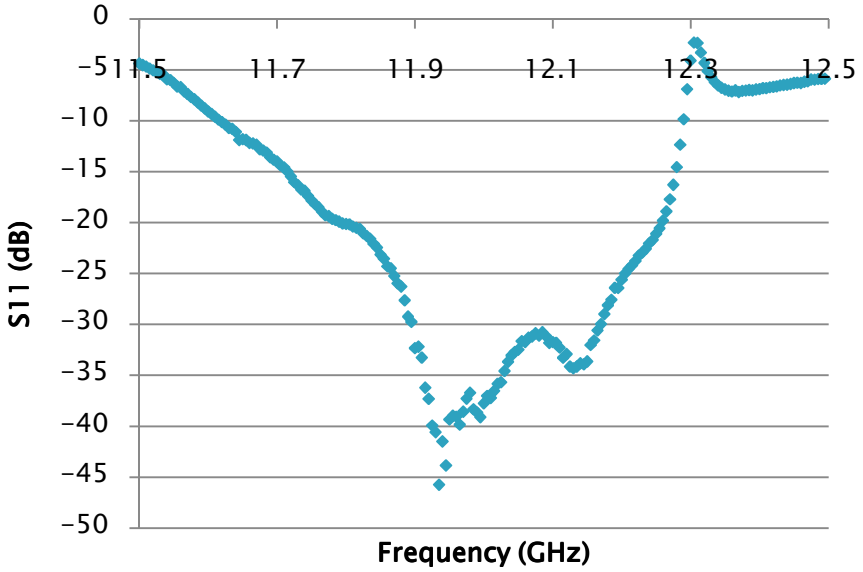


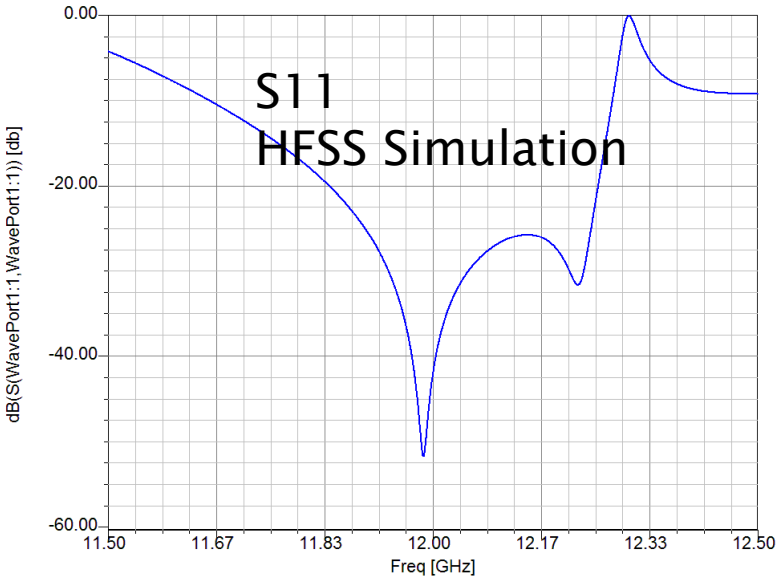
Input couplers manufactured

Power extractor test bench



Power extractor measurements

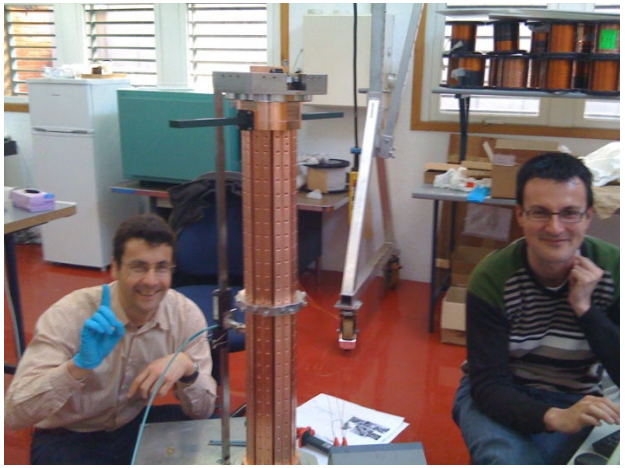


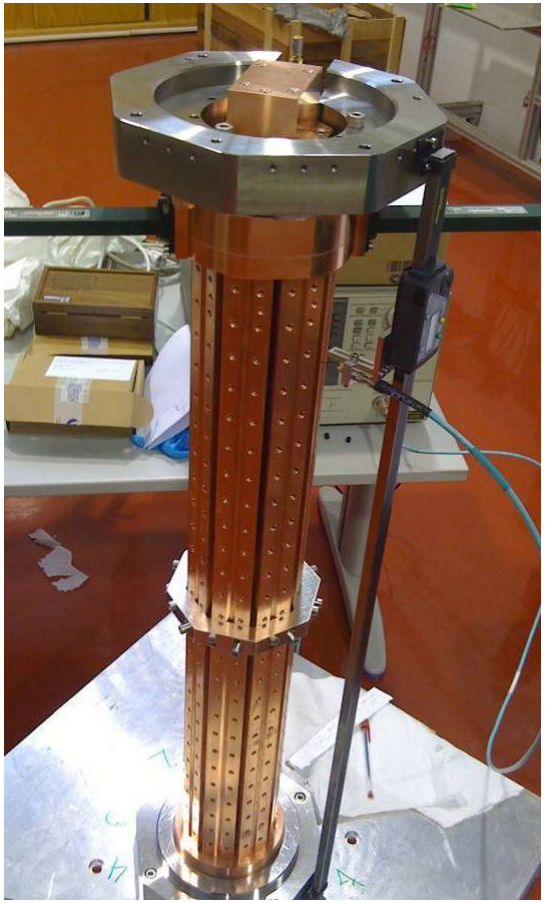


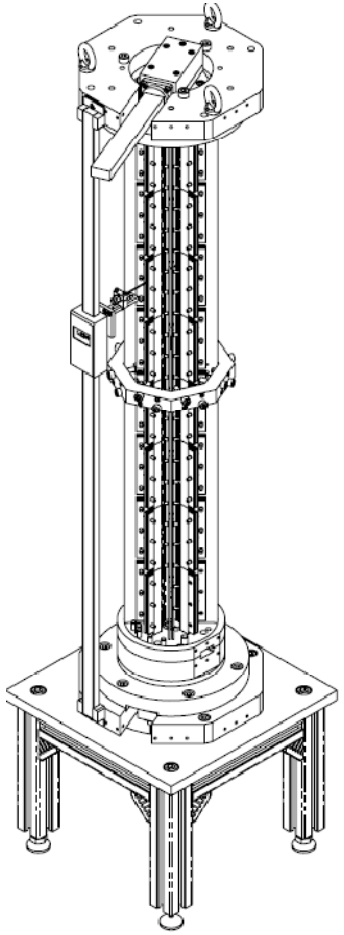
No visible change in S11 when removing wire, or absorber from port 4

Both S21 and S31 are aprox. -3dB at 12 GHz

PETS RF measurement bench

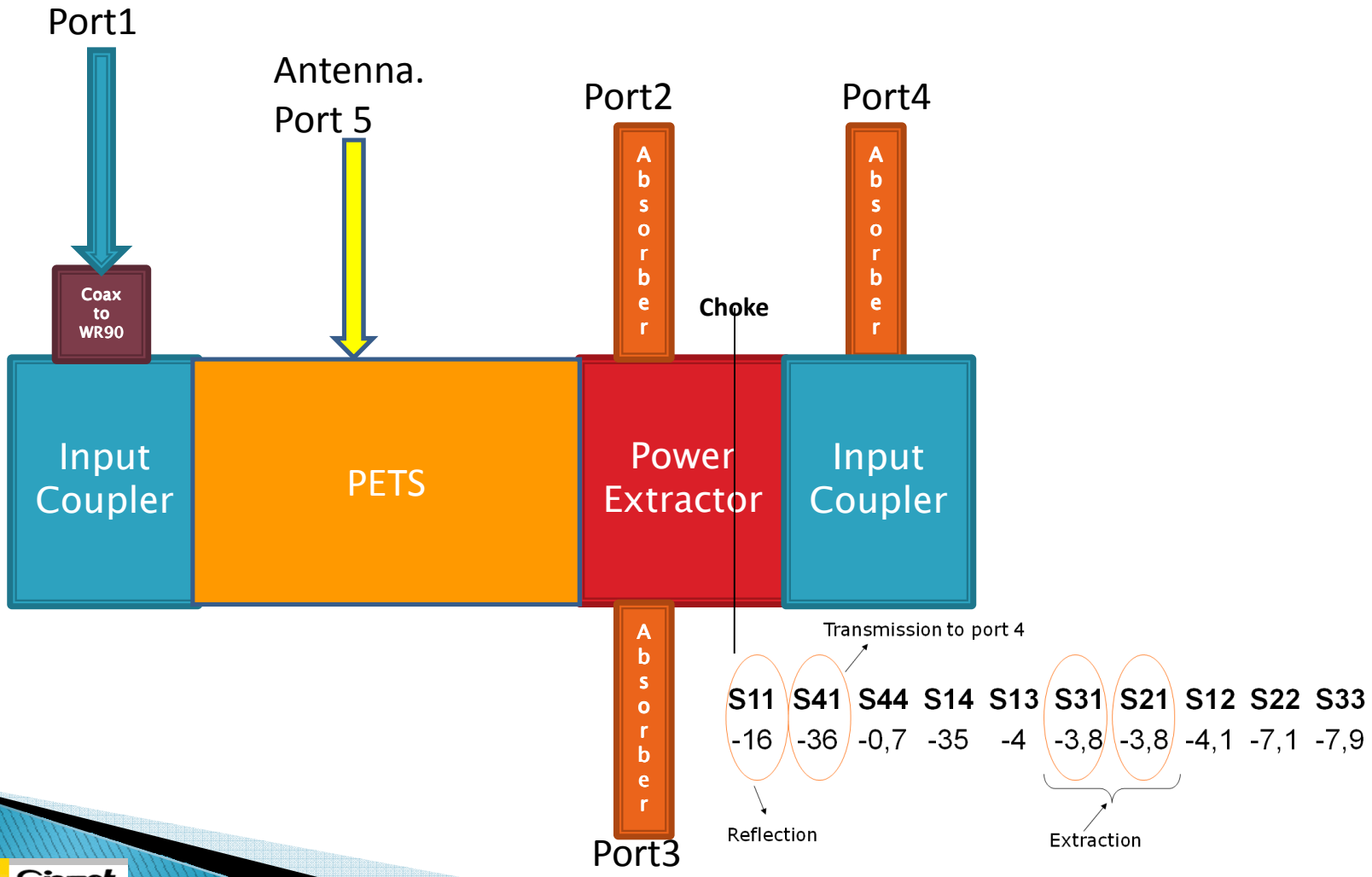




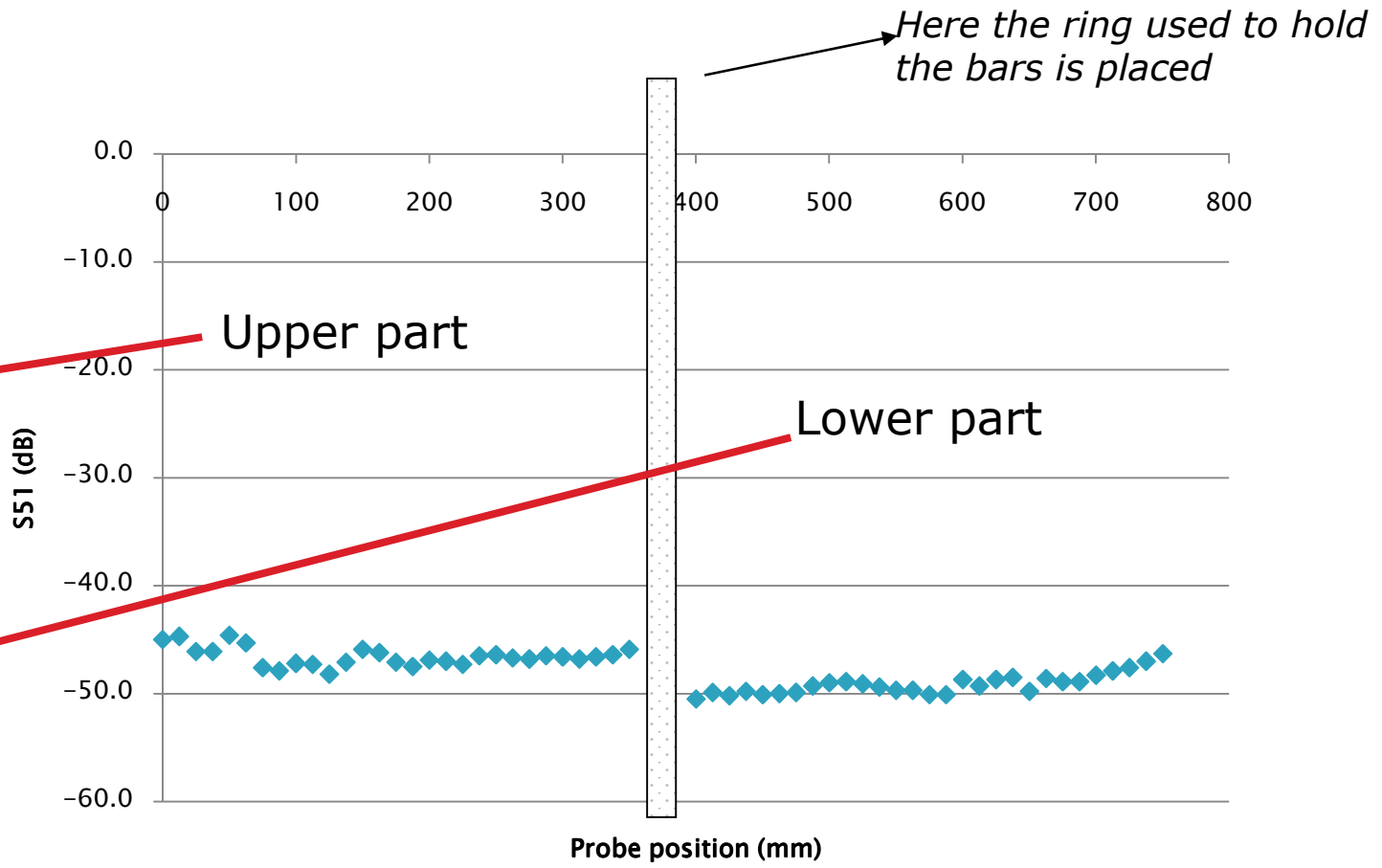


- A special test bench was designed to measure the assembly of rods
- A coaxial antenna was used to measure the field through the slots between the rods

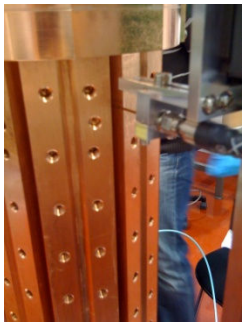
PETS Test bench

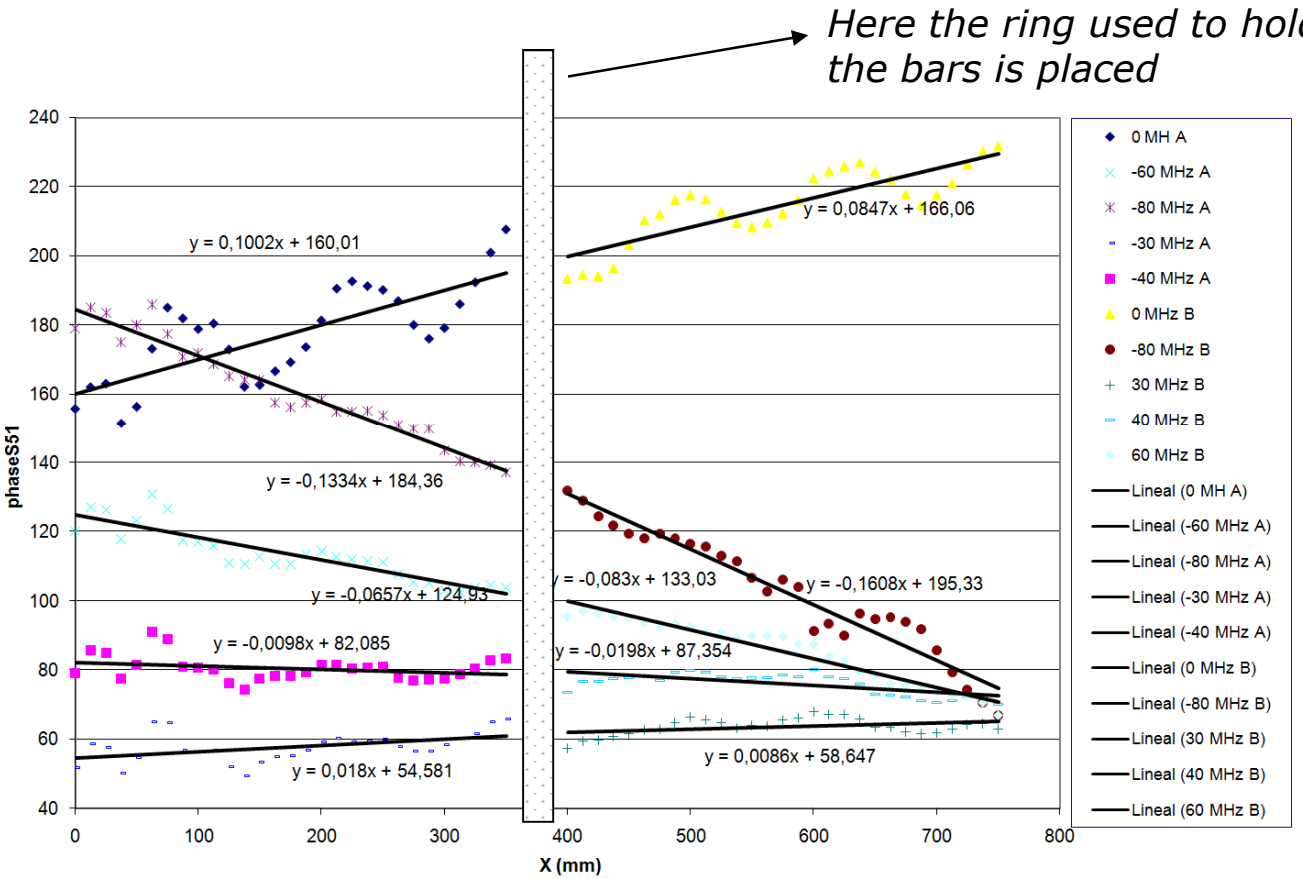


S51 Amplitude (Port1 -> Antenna)



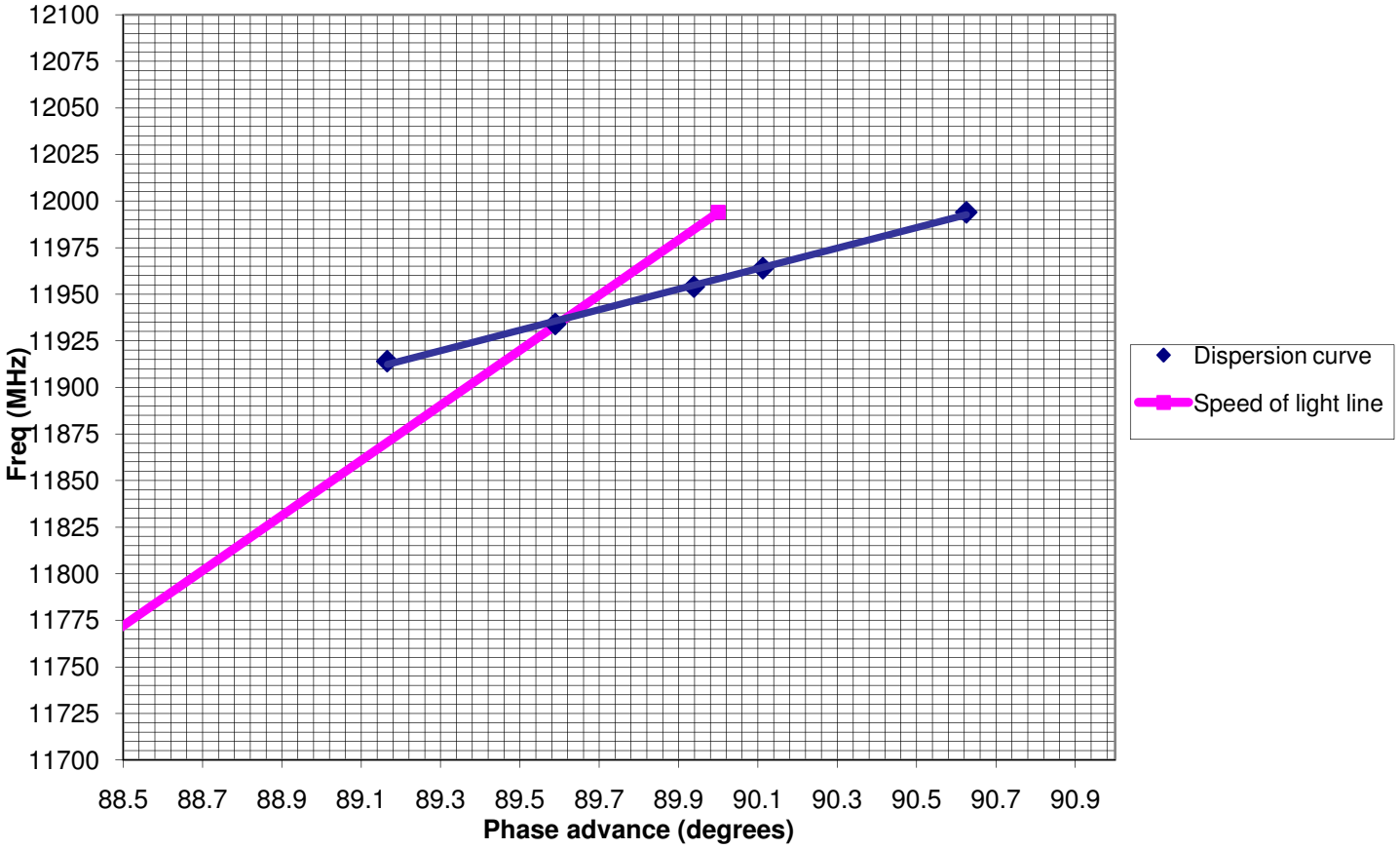
PETS phase shift measurements





Origin is placed in one of the peaks near power extractor

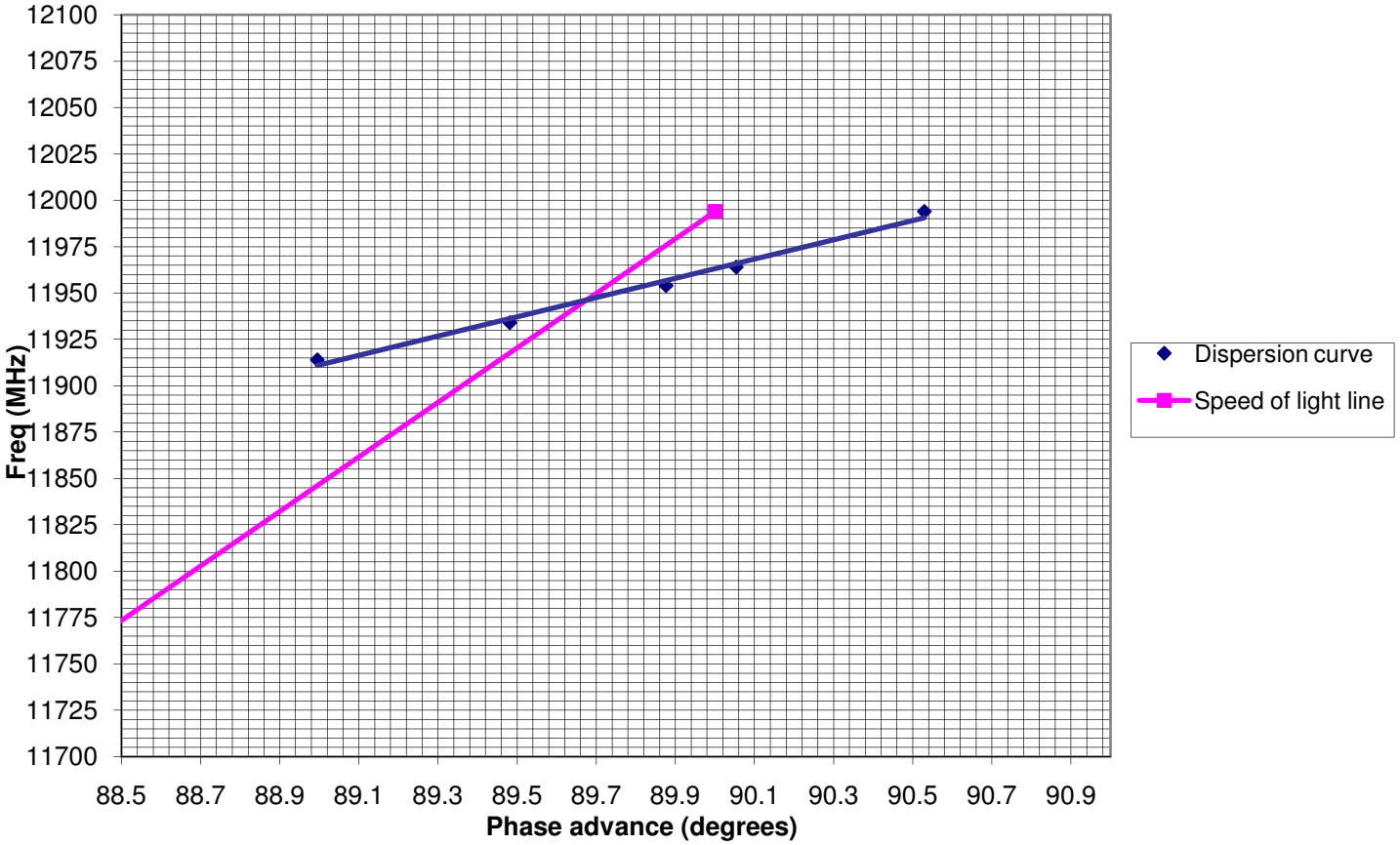
Dispersion Curve
Upper part



11933 MHz ⇒ 61 MHz detuning

Dispersion Curve Lower part

In the worst case a 10% power loss extraction is expected



11944 MHz ⇒ 50 MHz detuning

Mechanical measurements

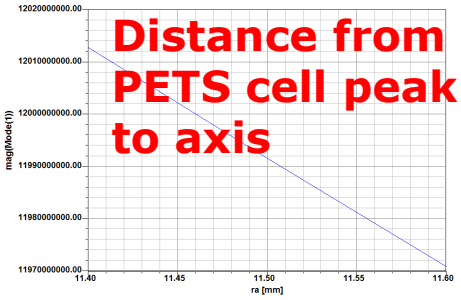
Before shims

	ROD 1-5		ROD 4-8		ROD 7-3		ROD 6-2		AVERAGE
	R	L	R	L	R	L	R	L	
DOWN	113.045	113.035	112.950	112.990	113.045	113.010	112.950	112.950	112.997
MID-DOWN	113.040	113.040	112.960	112.980	112.930	112.925	112.955	112.960	112.974
BELOW RING	**113.055**	**113.040**	**113.045**	**113.055**	**113.035**	**113.010**	**113.045**	**113.035**	113.040
ABOVE RING	**113.040**	**113.020**	**113.045**	**113.060**	**113.070**	**113.050**	**113.065**	**113.055**	113.051
MID-UP	112.965	112.980	112.990	112.995	112.980	112.985	113.035	113.020	112.994
UP	112.990	113.010	113.040	113.050	112.970	112.940	113.080	113.060	113.018
AVERAGE	113.023	113.021	113.005	113.022	113.005	112.987	113.022	113.013	113.012

After shims

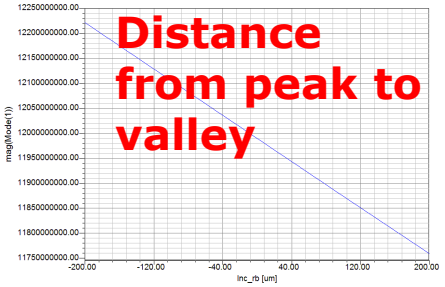
	ROD 1-5		ROD 4-8		ROD 7-3		ROD 6-2		AVERAGE
	R	L	R	L	R	L	R	L	
DOWN	113.040	113.035	113.000	112.945	113.015	113.040	112.950	112.950	112.997
MID-DOWN	113.015	113.015	112.960	112.925	**112.885**	**112.890**	112.940	112.945	112.947
BELOW RING	**113.025**	**113.010**	**113.015**	**112.980**	**112.970**	**112.985**	**113.000**	**113.005**	112.999
ABOVE RING	**113.010**	**112.995**	**113.010**	**112.980**	**113.005**	**113.025**	**112.995**	**113.010**	113.004
MID-UP	112.955	112.940	112.950	112.930	112.930	112.955	112.975	112.990	112.953
UP	112.990	113.000	113.045	113.045	112.955	112.975	113.050	113.065	113.016
AVERAGE	113.006	112.999	112.997	112.968	112.960	112.978	112.985	112.994	**112.986**

Sensitivity Analysis

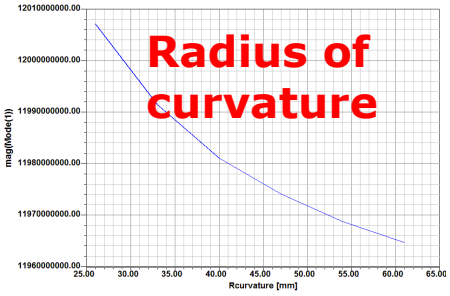


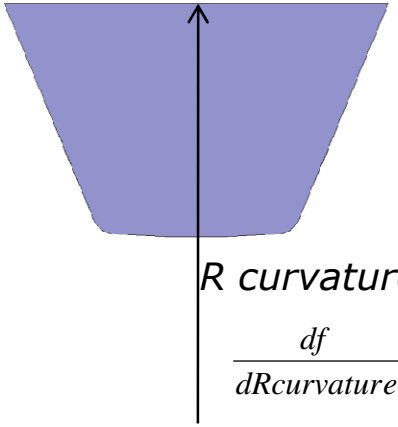
$$\frac{df}{dRa} = -0.2\frac{MHz}{\mu m}$$

$$\frac{df}{dIncRb} = -1.1\frac{MHz}{\mu m}$$

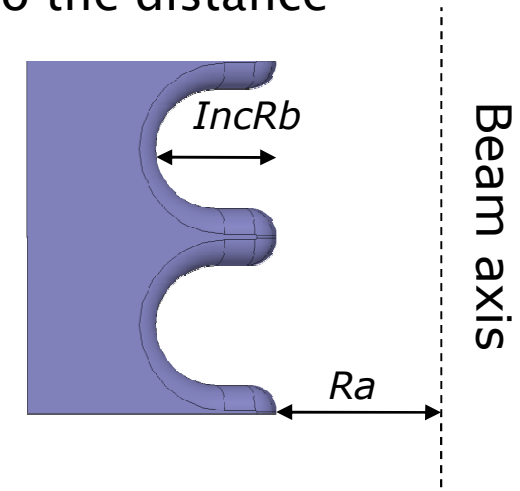


In principle frequency looks quite sensitive to the profile flatness and to the distance from peak to valley





$$\frac{df}{dRcurvature} = -2\frac{MHz}{\deg}$$

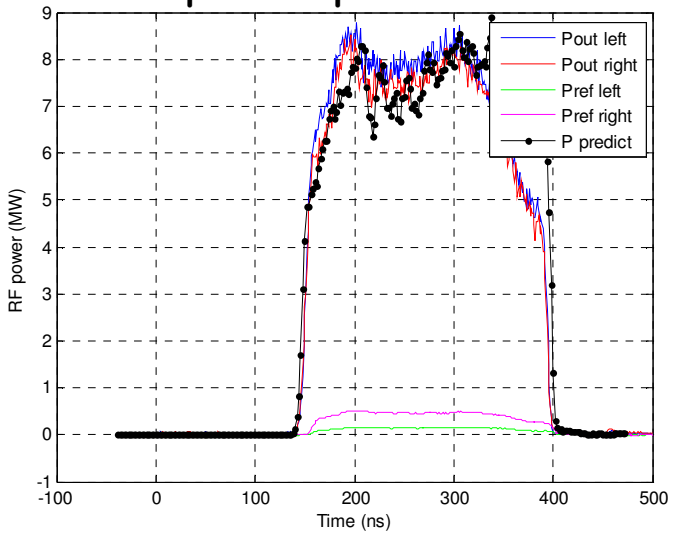


A sensitivity analysis is ongoing to understand the cause of this detuning

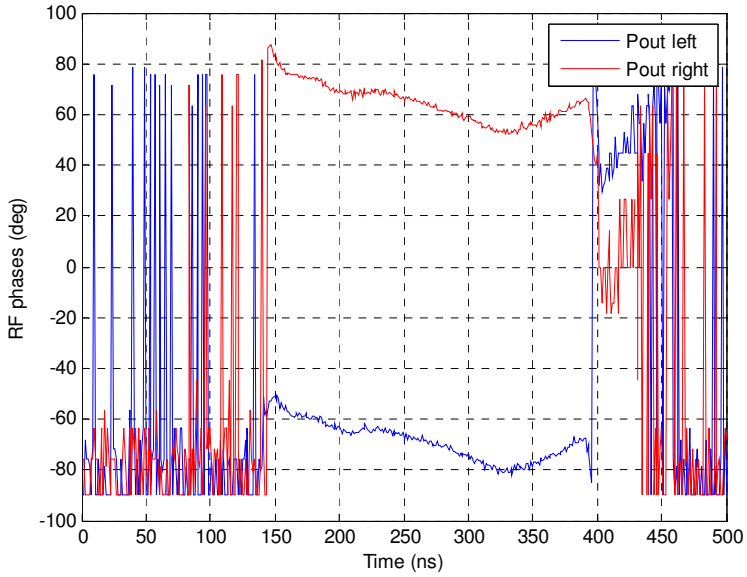
TBL Commissioning Status

Courtesy Steffen Doebert, CERN

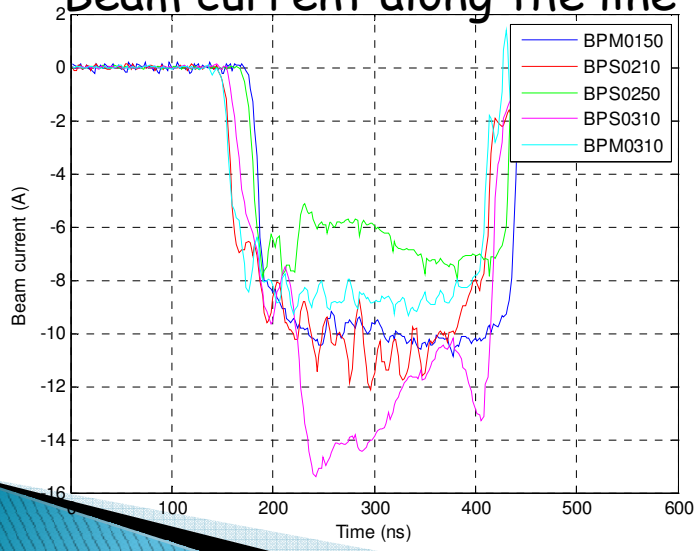
RF power produced



RF pulse phase



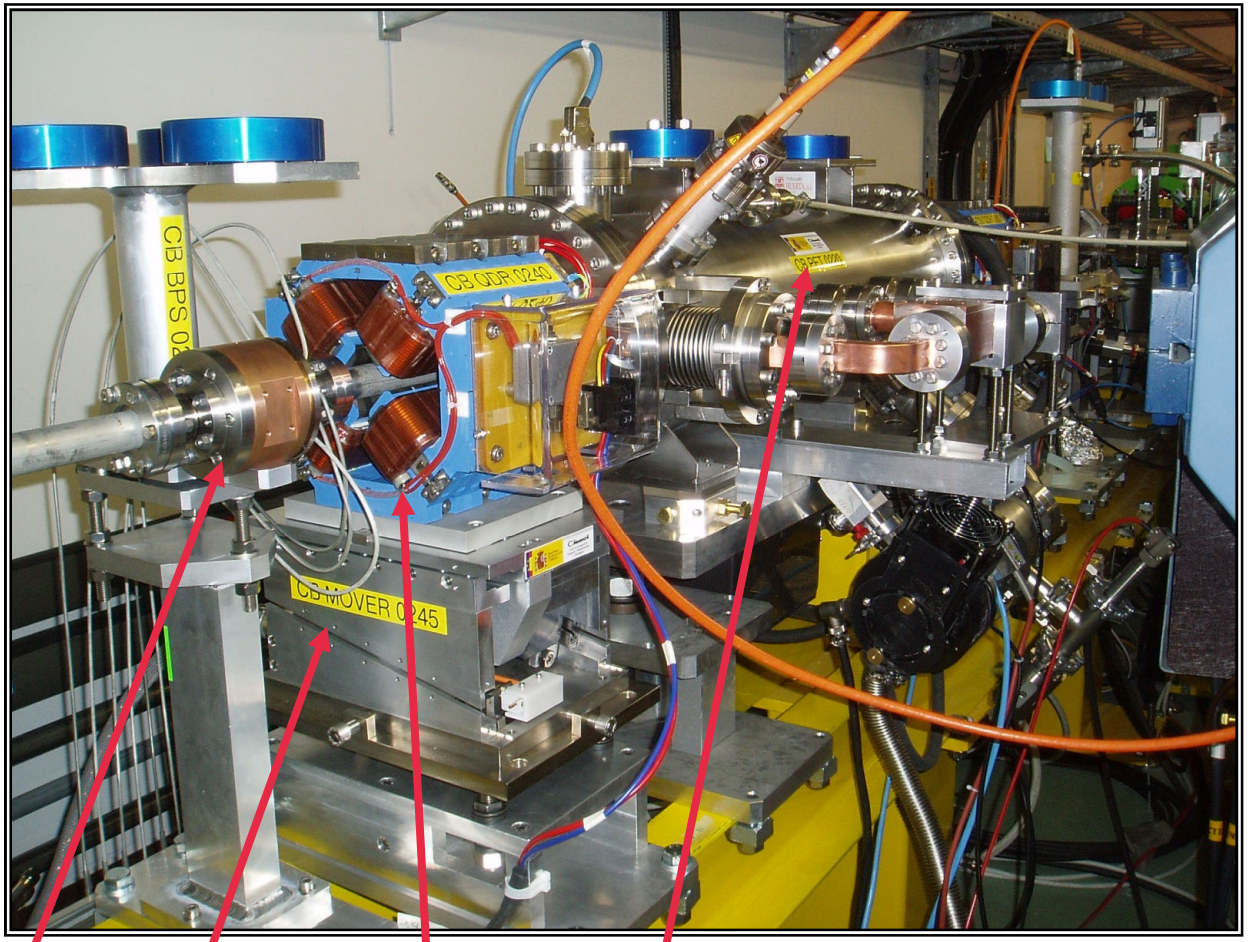
Beam current along the line



- up to 10 A through PETS
- 20 MW max produced at a pulse length of 280 ns
- Power production consistent assuming a form factor of 0.9
- PETS series production launched together wit CIEMAT(series of 8)

TBL prototype beam line spring 2009

Courtesy Steffen Doebert, CERN



BPM, Quad Mover, Quad, PETS-tank

Conclusions & near future work

- TBL PETS prototype manufactured, assembled and its RF properties measured
- It has been installed in the beam line and is doing ok
- We are taking care of the assembly of three more TBL PETS units. Parts production is shared between CERN and CIEMAT
- We are going to contribute in the Test Module with the production of 1 double length PETS unit and a hammer choke mode flange