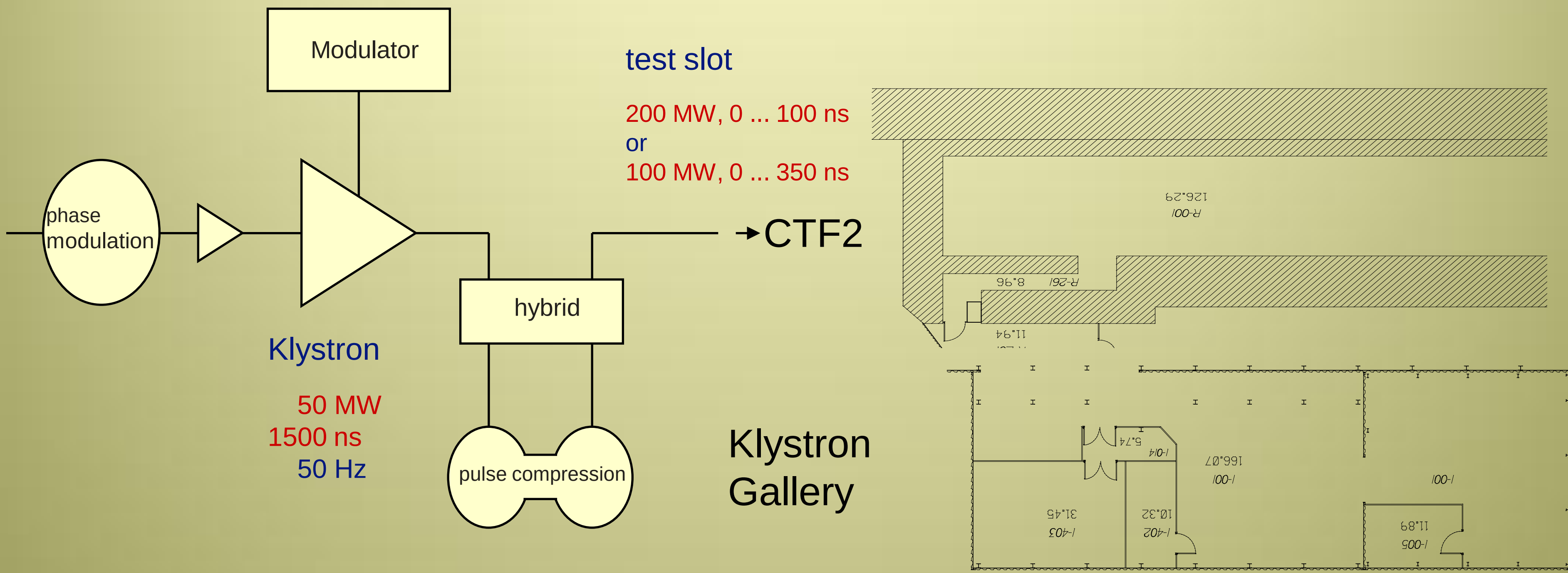
# CERN X-band Test-Stand

**Status and Perspective**

- **Reminder:** Mandate and Location
- **Strategie:** Different Phases of Commissioning
- **Critical Items**
- **Status of Installation**
- **Planning**
- **Conclusion**

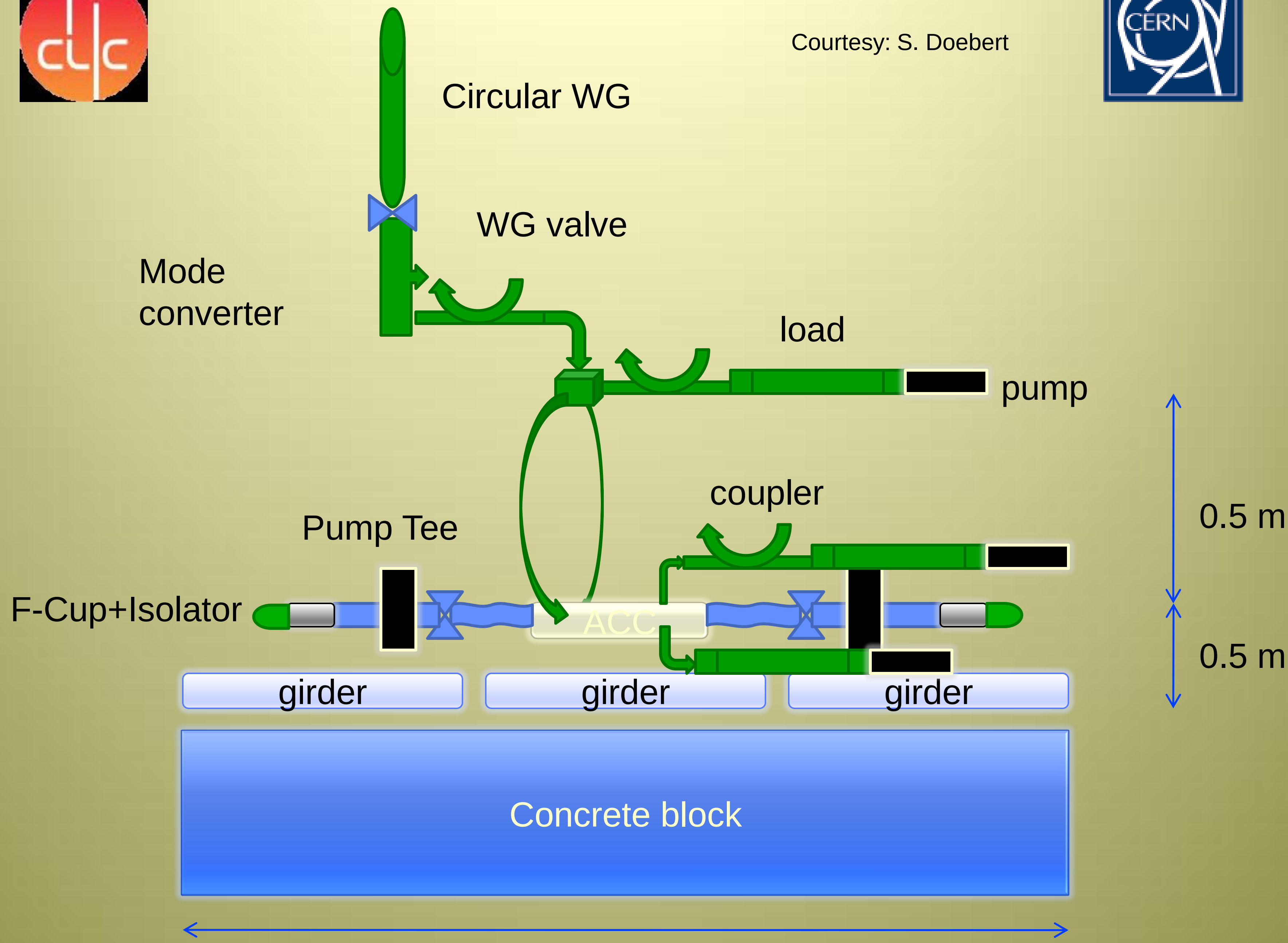
# Reminder



Modulator
test slot
200 MW, 0 ... 100 ns
or
100 MW, 0 ... 350 ns
phase modulation
CTF2
hybrid
Klystron
50 MW
1500 ns
50 Hz
pulse compression
Klystron Gallery

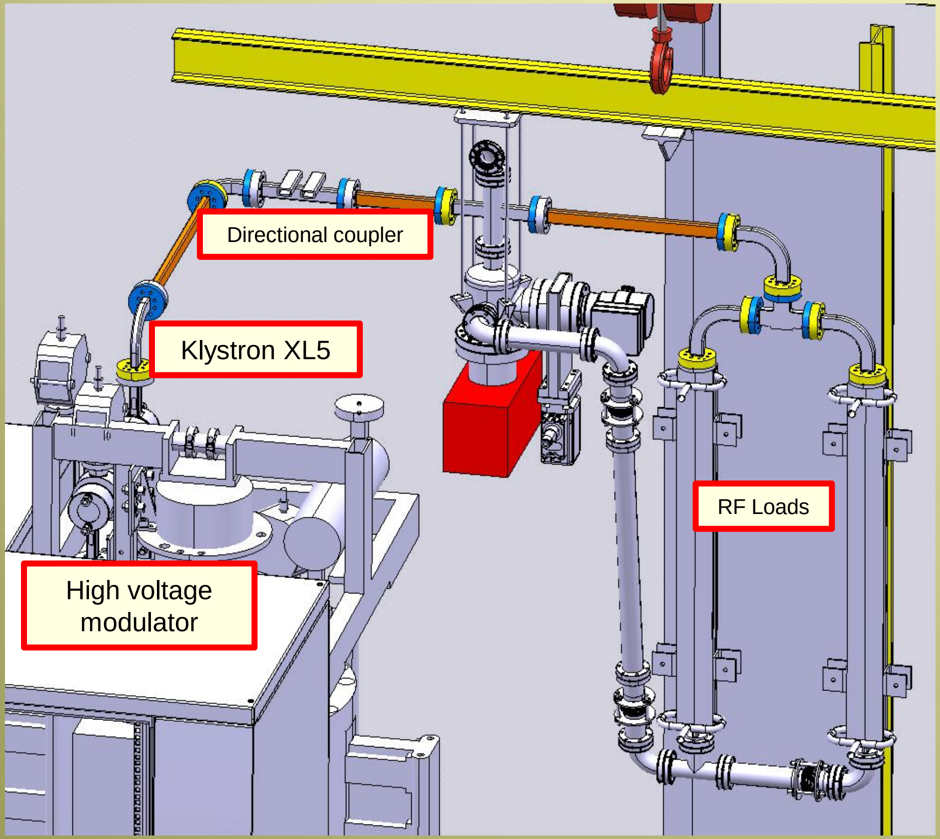
# Stand alone Test Stand in CTFII

Courtesy: S. Doebert

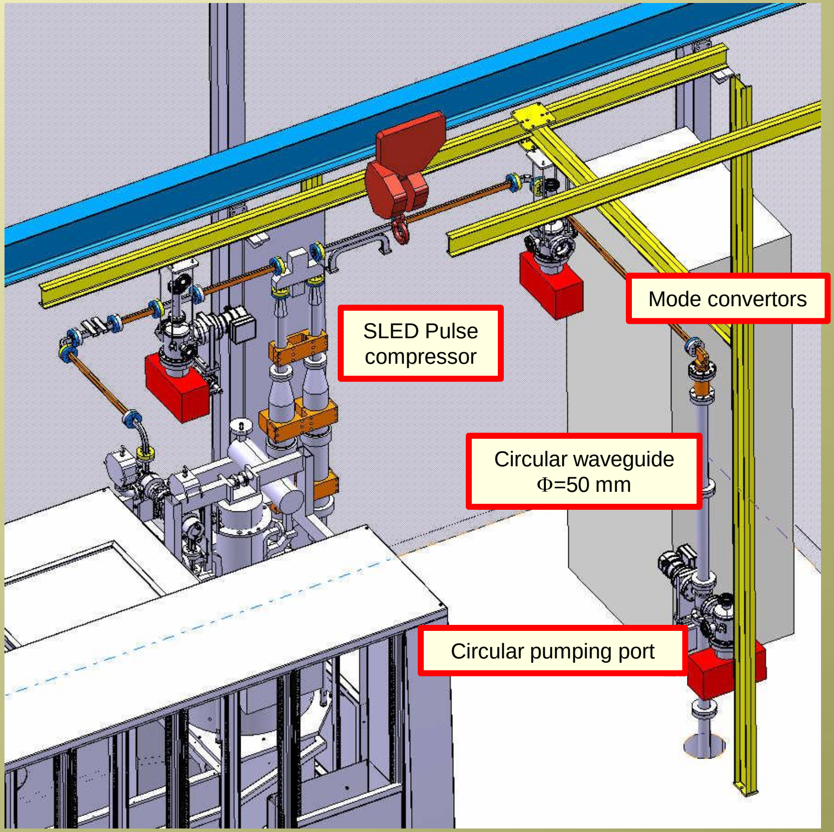


# RF network layout

**Layout phase 1 (→11.2010)**




**Layout phase 2 (→01.2011)**



# Installation Progress

⇐CTF2 test bunker

XL5 @ CERN ⇒

Modulator in gallery

# Pulse Compressor (Gycom)

# Puls Compressor:

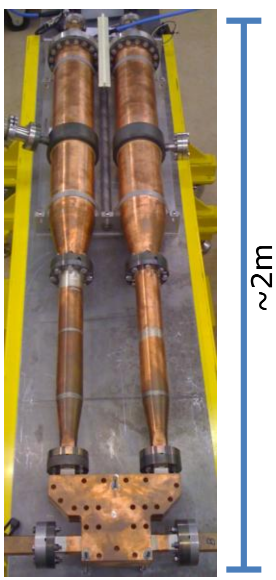
see Poster J. Kovermann

**Status of the SLED type pulse compressor for the CERN X-band test stand**

-Pulse compressor was assembled and rf measured after realignment

- First pulse compression with synthesized low power input pulse and phase program

- Very sensitive to detuning, requires temp. stabilization to 0.1K, failsafe tuning mechanism and fast interlocks on reflection




Measured parameters:

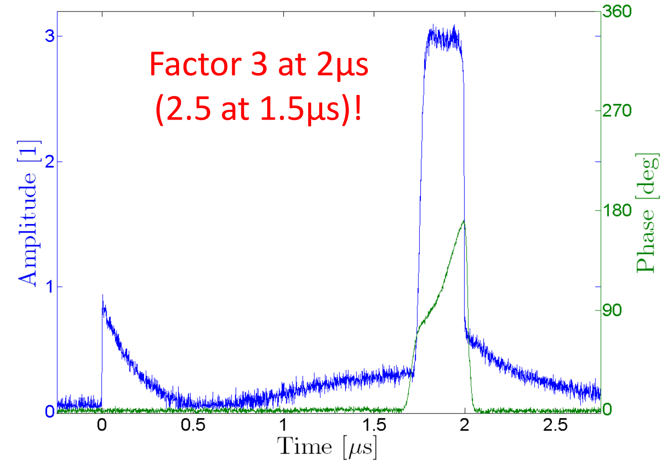
$Q_{loaded}$ = 26300
(design: 25000)

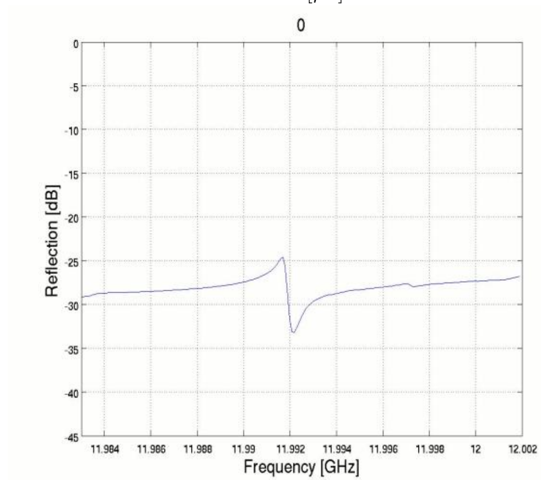
$Q_0$ = 90000 – 100000
(design: 150000)

β = 2.4

Max. compression 2.5
(design: 2.7)

Reflection to klystron:
-20dB




Reflection (detuning full step.motor steps)

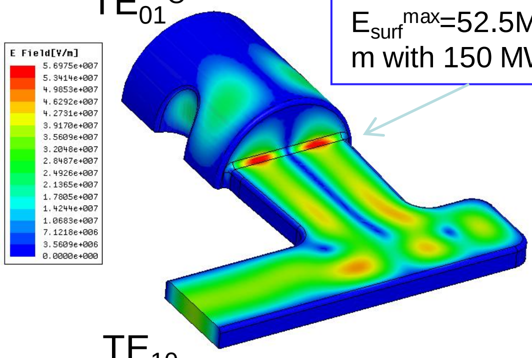
# 12 GHz RF components (1/3)

## Development strategy:

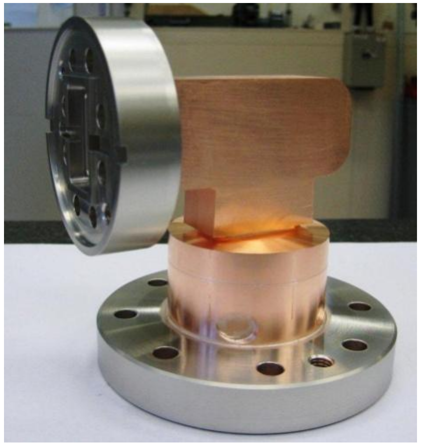
- RF design by CEA
  - HFSS
  - Scaling of existing SLAC components or new design based on SLAC experience and publications
- Mechanical design and drawings by CERN or CEA
  - Tolerance of 20 µm
  - Internal surface roughness of Ra=0.1 to 0.2
- Precise machining of Cu-OFE elementary pieces by CEA
  - Done in firms
- Precise machining of Stainless steel elementary pieces by CERN
- Cleaning, Ni and Cu (thickness>2µm) coating, brazing and re-machining by CERN
  - Vacuum brazing at high temp (>780°C)
- Hydrogen baking 800 °C ?...
- Storage under N2

# 12 GHz RF components (2/3)

## Bent Mode Converter

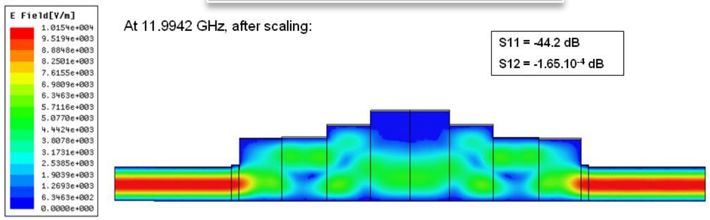



$E_{surf}^{max}$=52.5MV/m with 150 MW



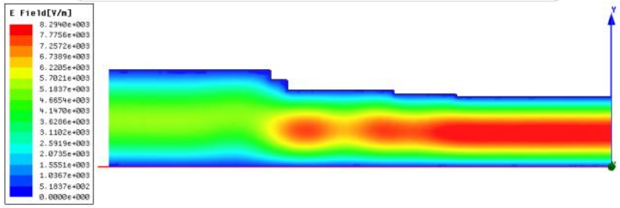
☞ **2 ready for rf tests and 2 in order**

## RF Valve




☞ **2 ready for rf tests**

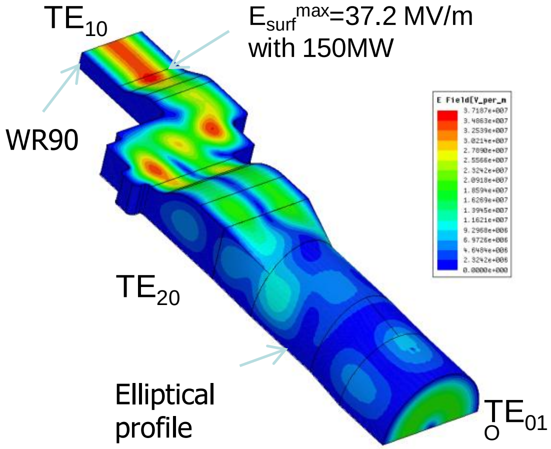
## Circular taper 36–50 mm




☞ **4 ready for rf tests**

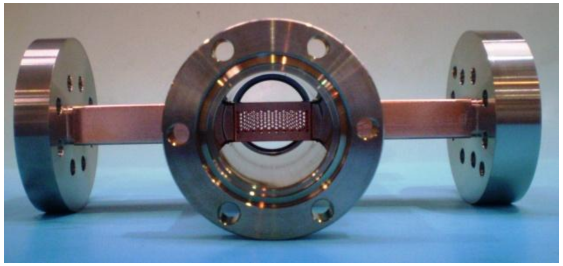
# 12 GHz RF components (3/3)

## Straight Mode Converter



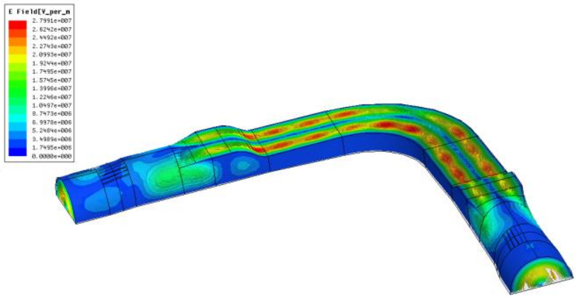

☞ **Tender done, order in progress**

## Rectangular Pumping ports



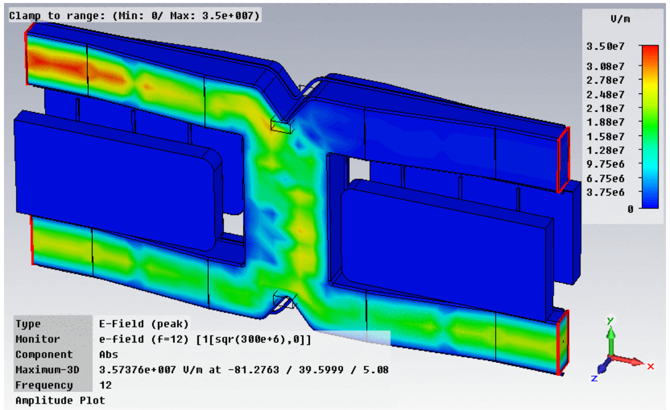
☞ **4 ready for rf tests**

## 90° circular bend



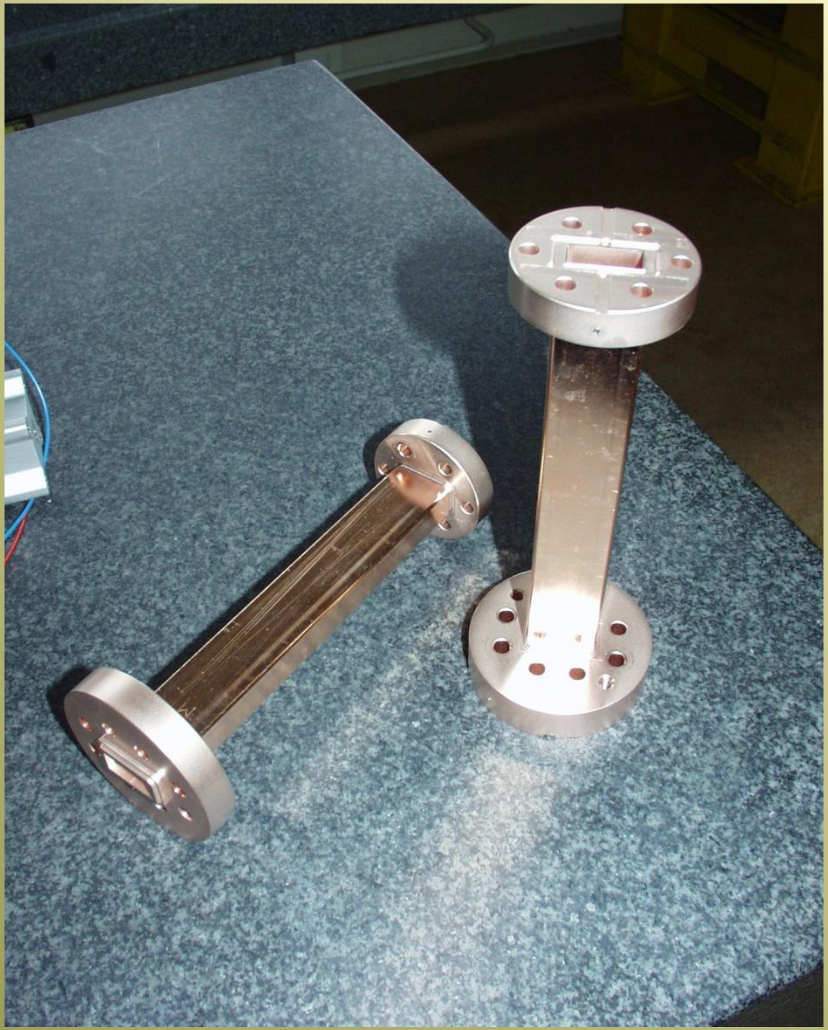
☞ **Finalization of mechanical drawings**

## 3 dB Hybrid coupler

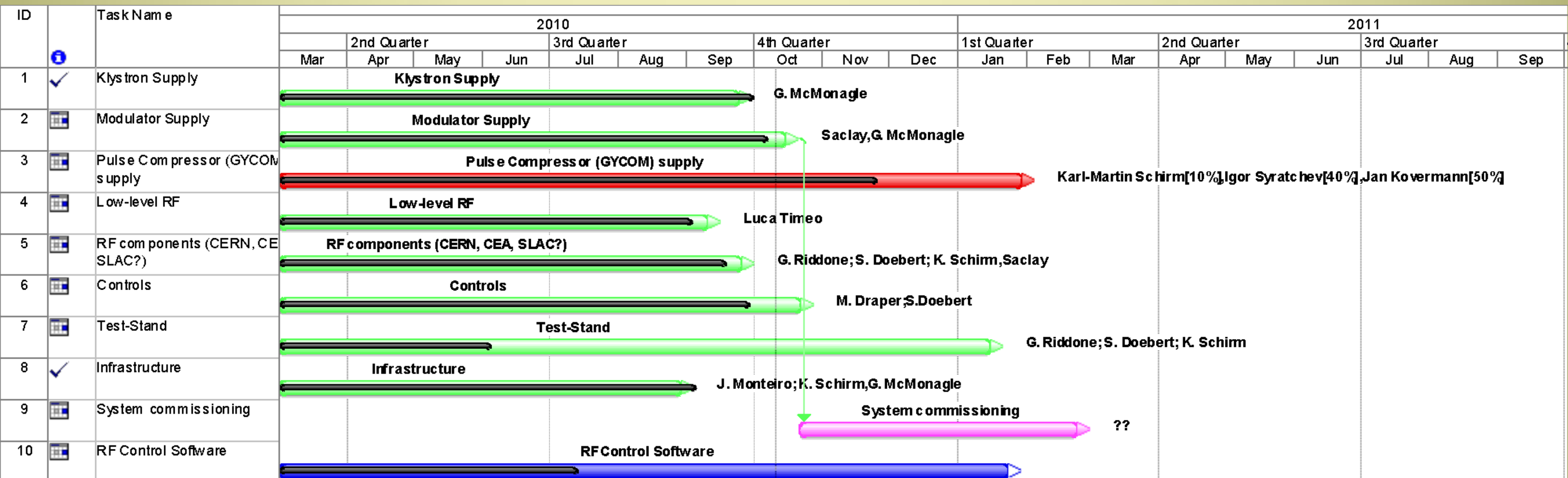



☞ **under call for tender**

# Flanges



# Schedule (10/2010)




! Klystron and Modulator commissioning now driving the schedule (►G. McMonagle)

! Cavity Pulse Compressor requires refurbishing (► J. Kovermann – Poster)

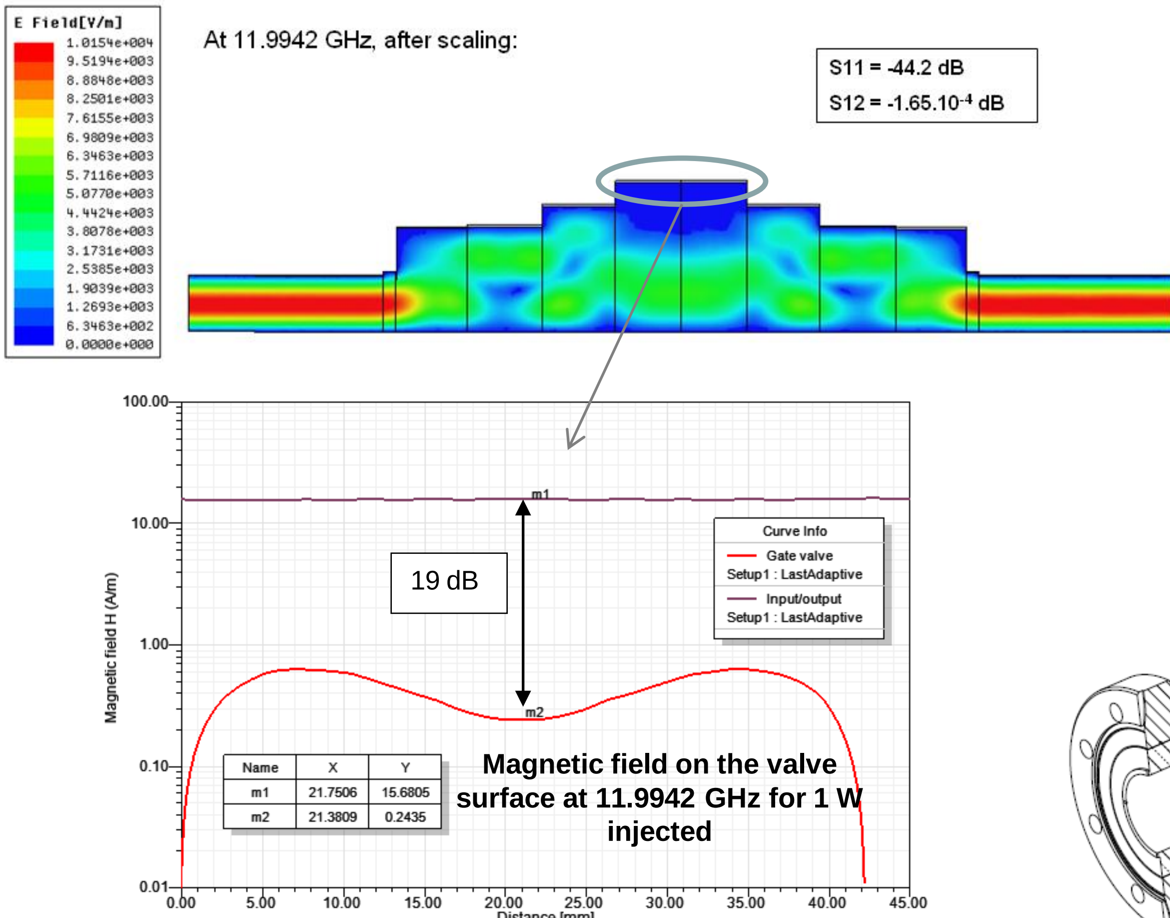
! 12 GHz power (without compression) should be available in CTF2 in Dec. 2010

# Conclusion:

- Hardware is finally coming together – the "real" work is started. Klystron installation and commissioning with SLAC assistance in November.
- All RF network components are prototypes – layout allowing for interchanging between different types.
- Structure test program can be established when phase 1 commissioning is under control.
- Pulse Compressor prototype needs improvement.
- Procurement for 2nd test stand incl. 2 klystrons is launched – Klystron producer?

## Design and fabrication by CEA/CERN

The RF valve has been introduced by A. Grudiev (CERN) in the CTF3 30 GHz test stand. It works on the circular mode $TE_{01}^{o}$ mainly to avoid surface electric field and have steps in diameter to "focus" the wave in the center of the guide. Based on the same principle, RF valves working at 11.4 GHz have also been developed at SLAC for accelerating structure testing. The 12 GHz RF valve is a scaled version of the SLAC one.



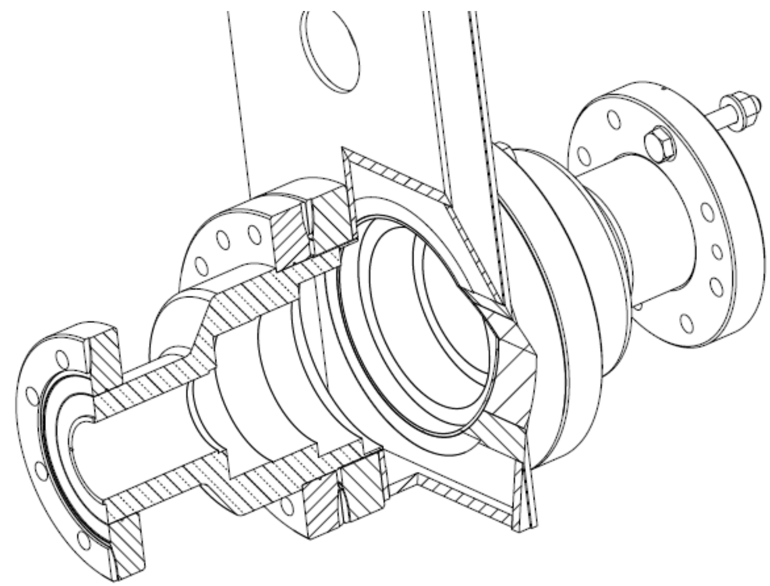

Magnetic field on the valve surface at 11.9942 GHz for 1 W injected

**Frequency:** 11.994 GHz

**Peak power:** 120 MW

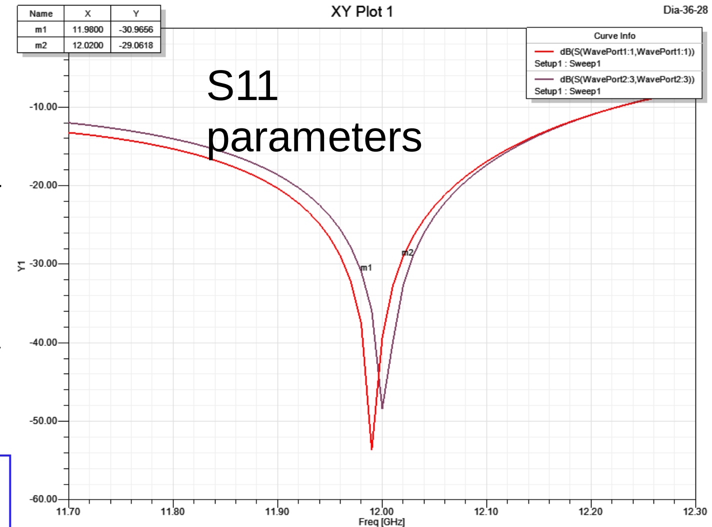
**Pulse length:** 300 ns

**Repetition rate :** 50 Hz

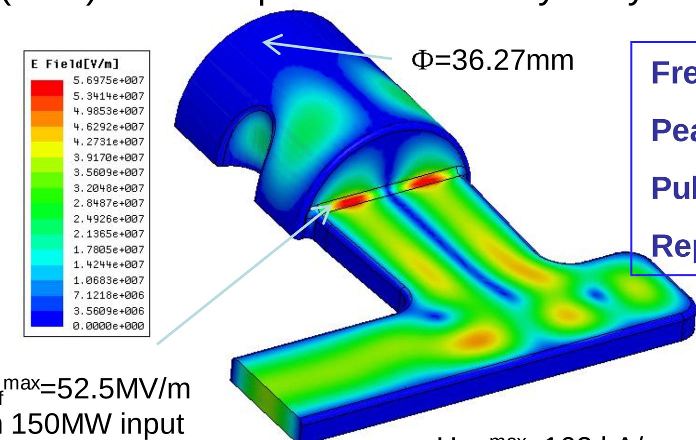


## Design and fabrication by CEA/CERN

The mode converter is made in two parts. The first part is a rectangular waveguide bend on H plane. It converts the $TE_{10}^{\square}$ mode into a $TE_{20}^{\square}$ mode. The second part is a circular waveguide with two posts positioned at 180 ° at a certain distance of the rectangular section. This design is based on an original idea of S. Kazakov (KEK). It is compact and relatively easy to fabricate




Bandwidth of 150 MHz @ -20dB reflection and -0.0618 dB transmission at 11.994 GHz giving 98.6% conversion efficiency in power




| | |
|---|---|
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| **Peak power:** | **120 MW** |
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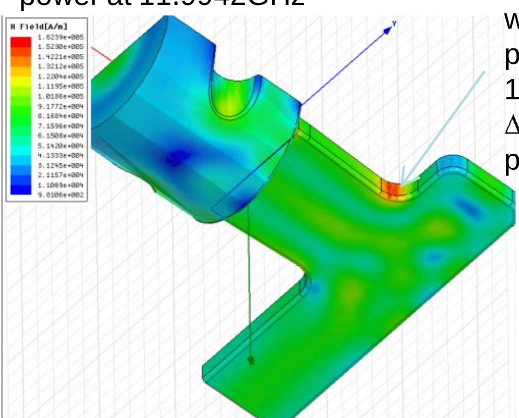
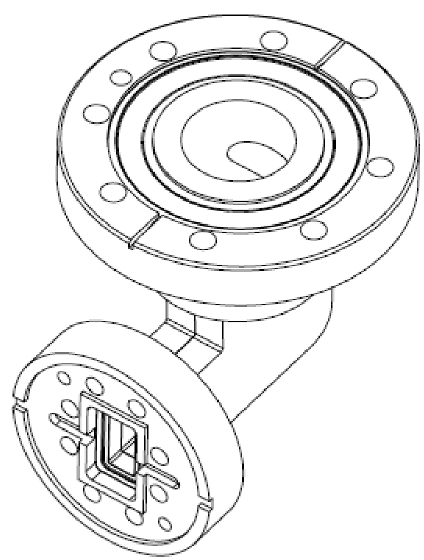
$E_{surf}^{max}$=52.5MV/m with 150MW input power at 11.9942GHz



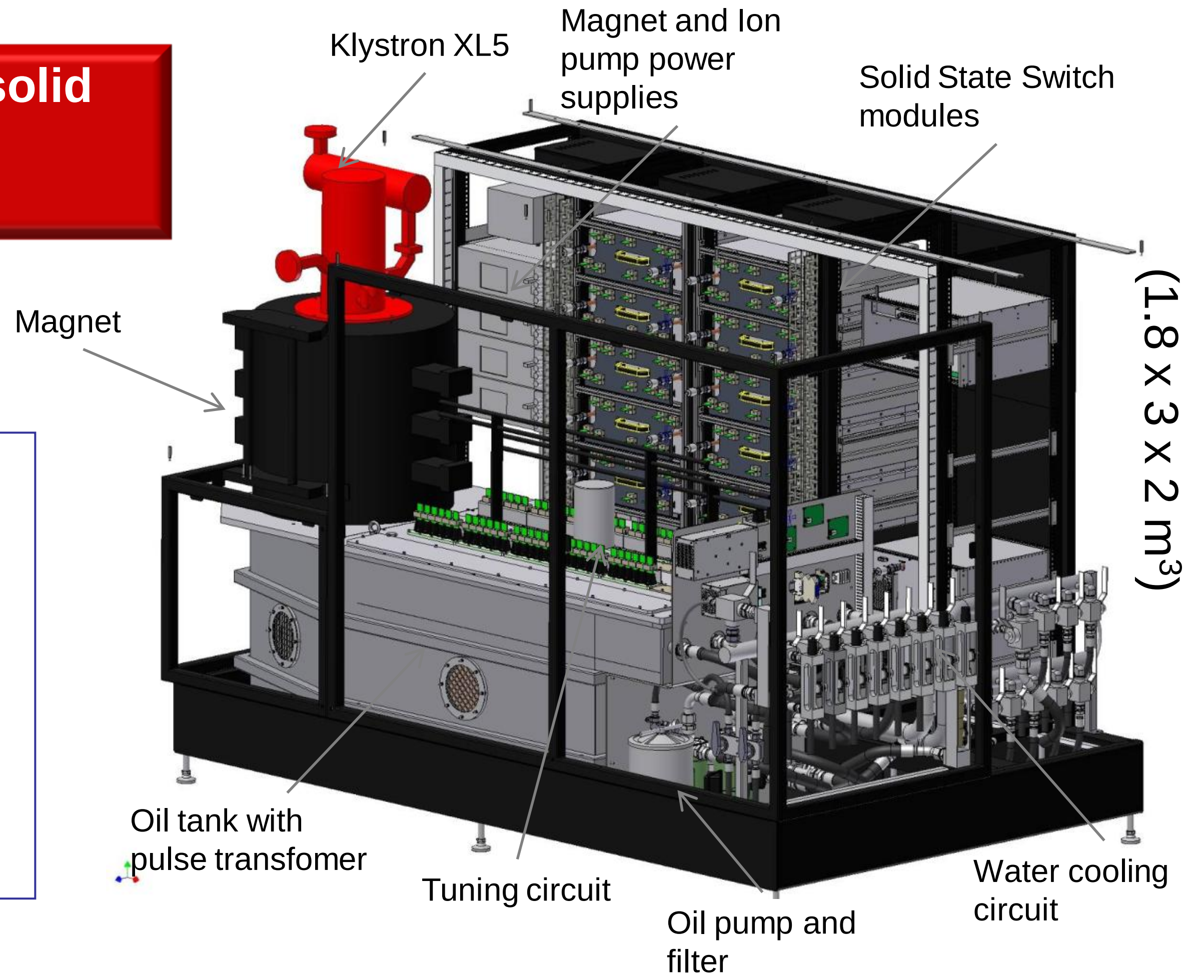

$H_{surf}^{max}$=162 kA/m with 150MW input power at 11.9942GHz giving ΔT=5.8° with 250 ns pulse length



The fabrication technology is based on classical high temperature vacuum brazing of machined CuC2 and 316LN pieces. First the two half parts of the bend and the circ. waveguide with the two posts are brazed separetly. The stainless steel flanges are brased in a second step after re-machining. The third brazing concerns the two sub-assemblies and an intermediate round base used for the transition between the rect. and the circ. Parts.

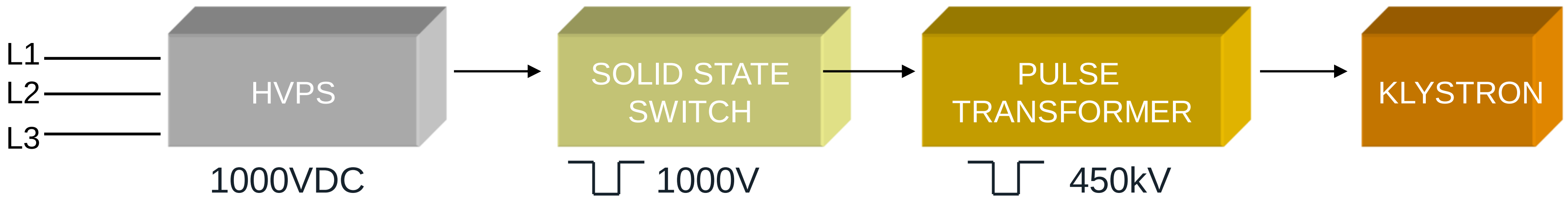
# High Voltage Modulator

**Development of a new solid state modulator by SCANDINOVA**

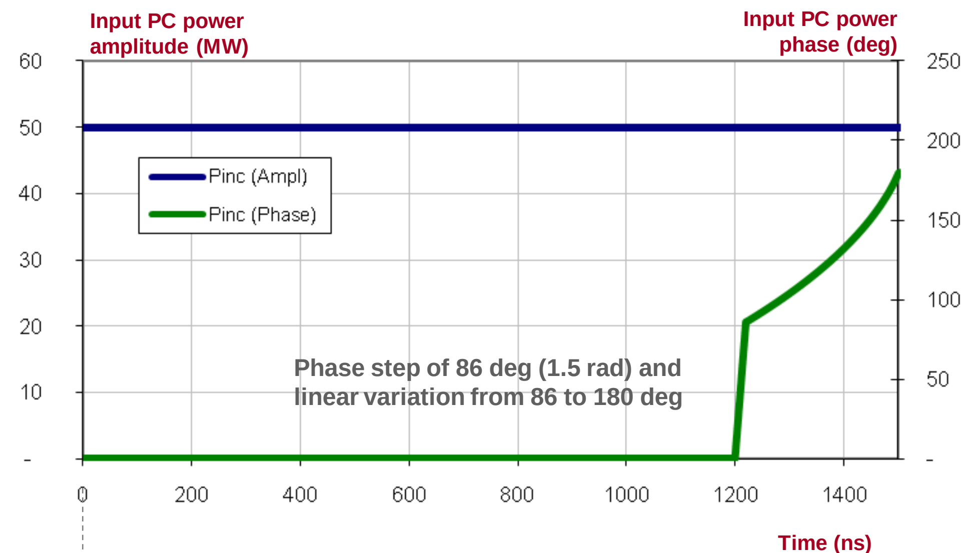


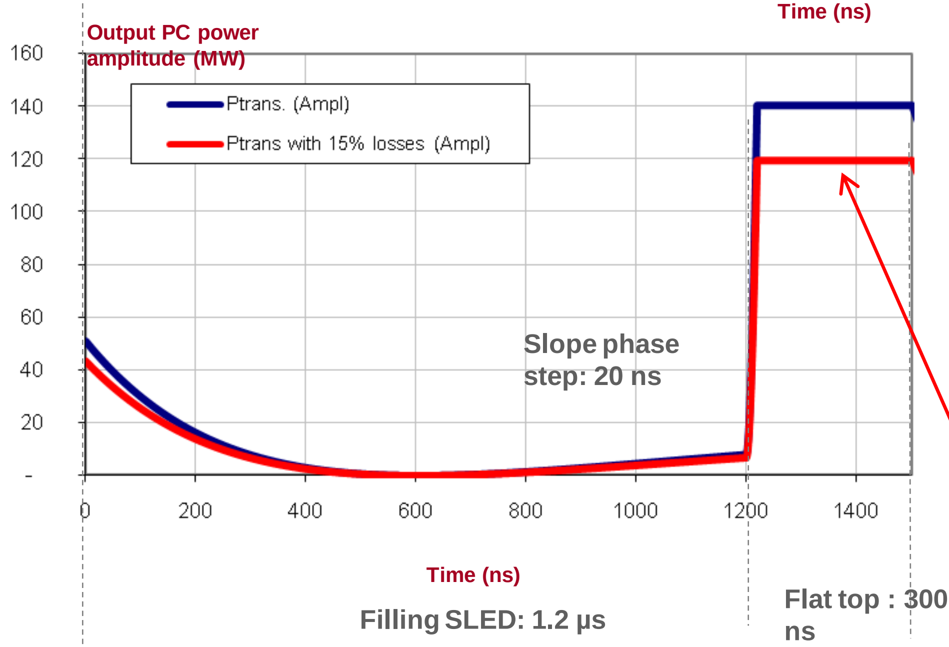

<u>**Specification :**</u>

| | |
|---|---|
| **High Voltage :** | **450 kV** |
| **Current :** | **335 A** |
| **Flat pulse length:** | **1.5 µs** |
| **Pulse length at 50%:** | **2.3 µs** |
| **Repetition rate:** | **50 Hz** |
| **HV ripple:** | **0.25 %** |
| **Pulse to pulse stability:** | **0.1 %** |



# Pulse waveform after SLED compression




Q0 = 150000

QL = 25000

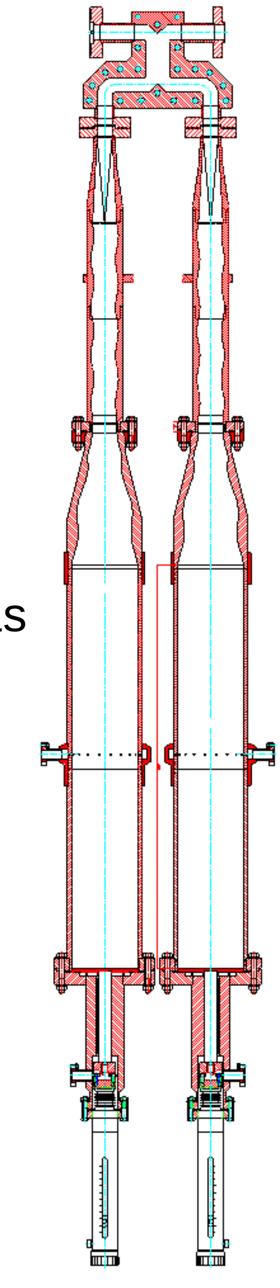
β=Q0/Qx = 5

Reflexion coef = 0.67

SLED Filling time = 0.663 µs

Power multiplication factor = 2.75

120 MW, 300 ns assuming 15% of losses in the RF network



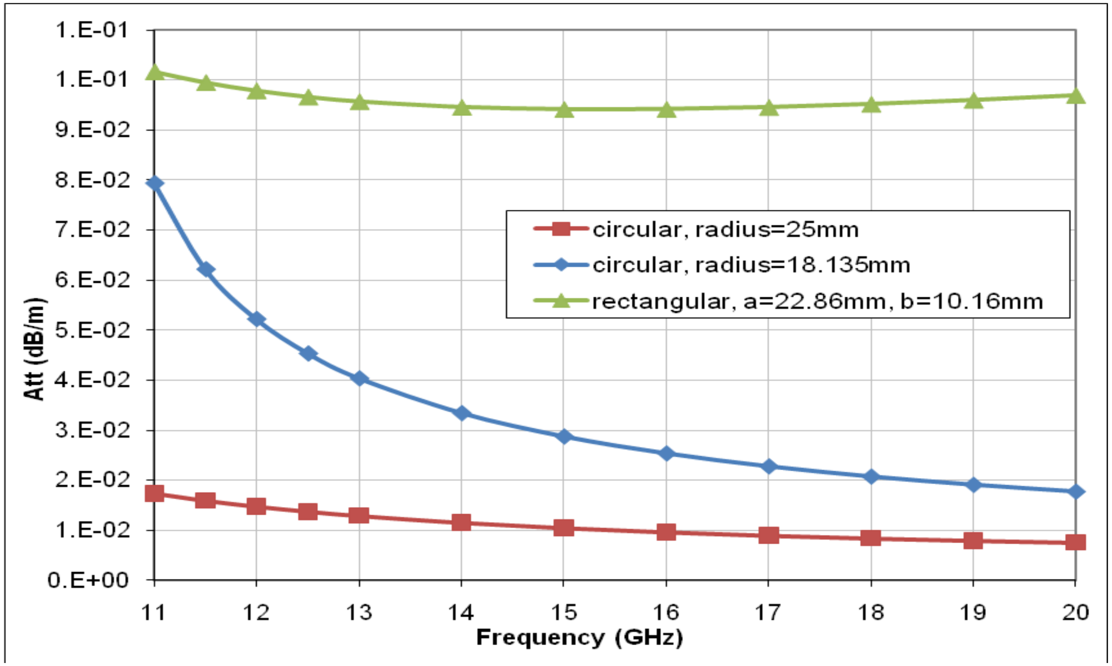
# Propagation in the circular higher order mode $TE_{01}^{O}$

## Attenuation:

$$\alpha_c(dB/m) = 8.686\,\frac{Rs}{a\beta\eta k}\left(k_c^2 + \frac{k^2}{p'^2_{01}-1}\right)$$ for $TE_{01}^{o}$ in circ. waveguide with radius a (m)

$$\alpha_c(dB/m) = 8.686\,\frac{Rs}{a^3 b\beta\eta k}\left(2b\pi^2 + a^3k^2\right)$$ for $TE_{10}^{\square}$ in rect. waveguides with dimensions a x b (m²)

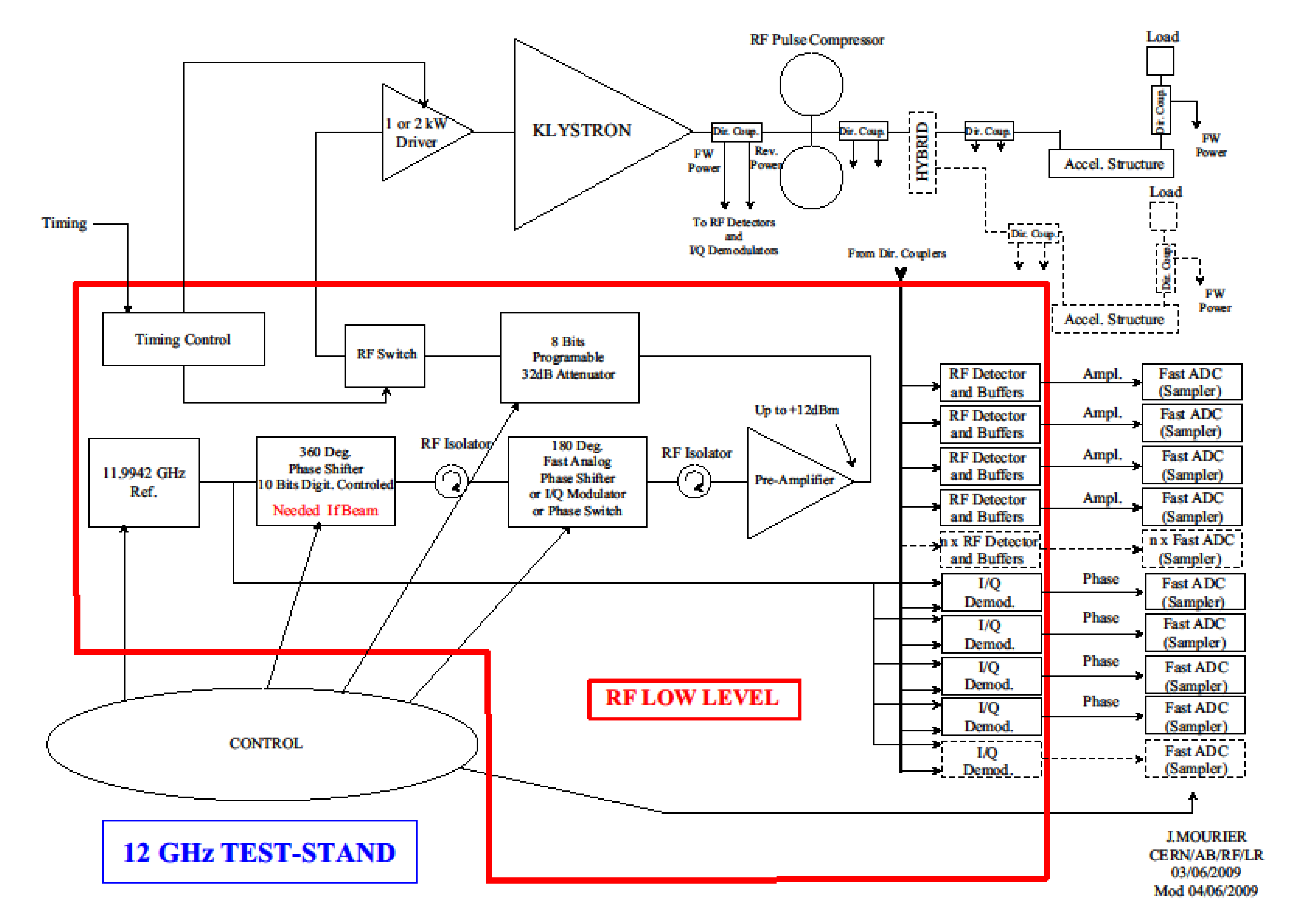
With Rs the surface resistance, $p'_{01}$=3.832 the first root of $J'_0$ which is the derivative of the Bessel function of first kind $J_0$, $\beta$ the propagation constant, k the wavenumber, kc the cut-off wavenumber and $\eta$ = 376.7 ohm the impedance of free-space.




**At 12 GHz, losses are almost ten times lower in 50 mm diameter circular wg than in rectangular wg**

(“Microwave Engineering”, D.M. Pozar, p.125 and 136):

# LL-RF


RF Pulse Compressor
Load
KLYSTRON
1 or 2 kW
Driver
Dir. Coup.
FW
Power
Rev.
Power
To RF Detectors
and
I/Q Demodulators
HYBRID
Accel. Structure
From Dir. Couplers
Timing
Timing Control
RF Switch
8 Bits
Programable
32dB Attenuator
RF Detector
and Buffers
Ampl.
Fast ADC
(Sampler)
n x RF Detector
and Buffers
n x Fast ADC
(Sampler)
Up to +12dBm
11.9942 GHz
Ref.
360 Deg.
Phase Shifter
10 Bits Digit. Controled
Needed If Beam
RF Isolator
180 Deg.
Fast Analog
Phase Shifter
or I/Q Modulator
or Phase Switch
Pre-Amplifier
I/Q
Demod.
Phase
RF LOW LEVEL
CONTROL
12 GHz TEST-STAND
J.MOURIER
CERN/AB/RF/LR
03/06/2009
Mod 04/06/2009