CEA activities in the frame of SLHC-PP/WP7

Development of critical components

Task 7.2 : Field stabilization in pulsed sc low beta cavities

S. Chel

SLHC-PP meeting, CERN, 25-26 February 2009

1) From CARE/ HIPPI

- **704 MHz RF power test stand**
- **CryHoLab**
- **Available prototypes**

2) Test and characterisation

- **Cavities**
- **Couplers**
- ***Tuners***

3) Study of RF system in pulse mode

- ***LFD compensation***
- ***LLRF***

704 MHz RF power test stand

HV Pulsed Generator
110 KV ; 25 A ; 50 Hz

HVPS
330 KVA DC

Klystron
704 MHz – 1MW
50 Hz – 2 ms

- In 2007 & 2008, the klystron was operated at 1.2 MW at full d.c.
- As a consequence of the breakdown of some HV diodes, the HV is still limited to 90 kV due to the degradation of oil in the HVPS tank (Prf limited to 800 kW at full d.c.)

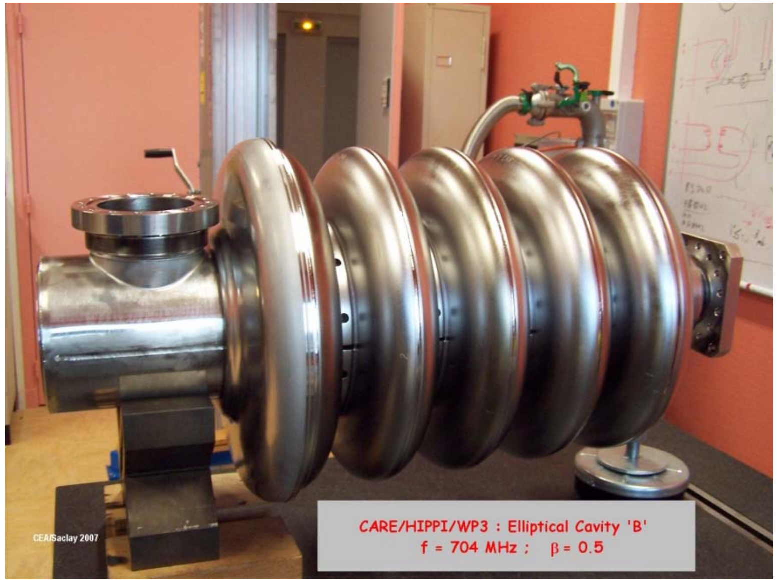
CryHoLab = Horizontal Cryostat

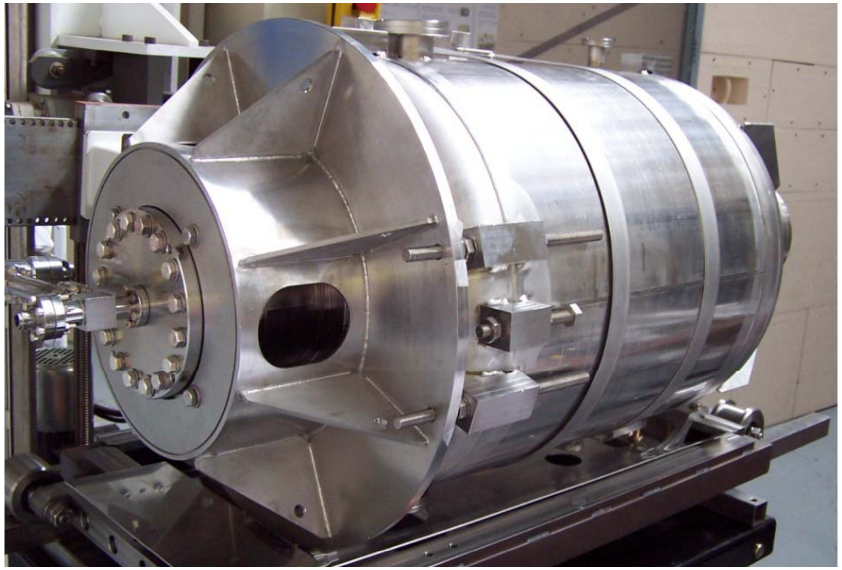
- LN2 shield, cryogenic circuits and controls are ok
- 700 MHz RF tests at few hundreds Watt have been performed
- We need to connect the last pieces of wave guide for the high RF power tests

Available prototype: cavity

From CARE/HIPPI

704 MHz 5cells beta=0.5 cavity





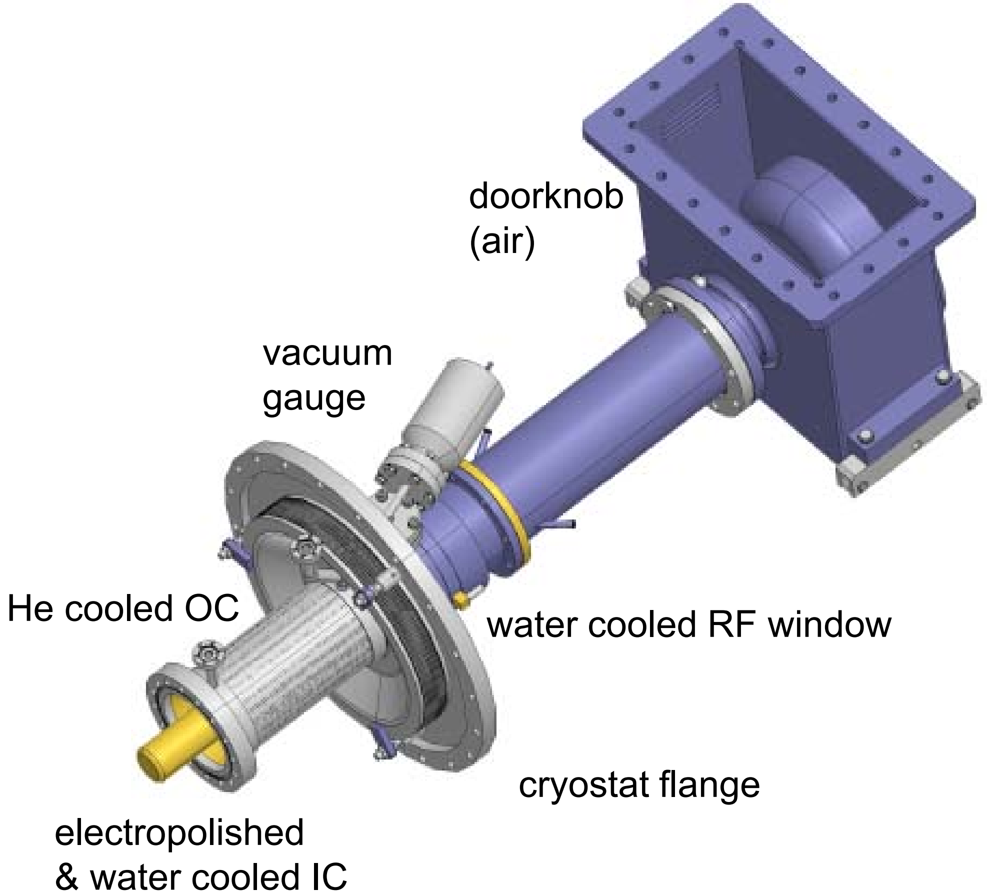
after welding of LHe tank

Available prototype: coupler

From CARE/HIPPI

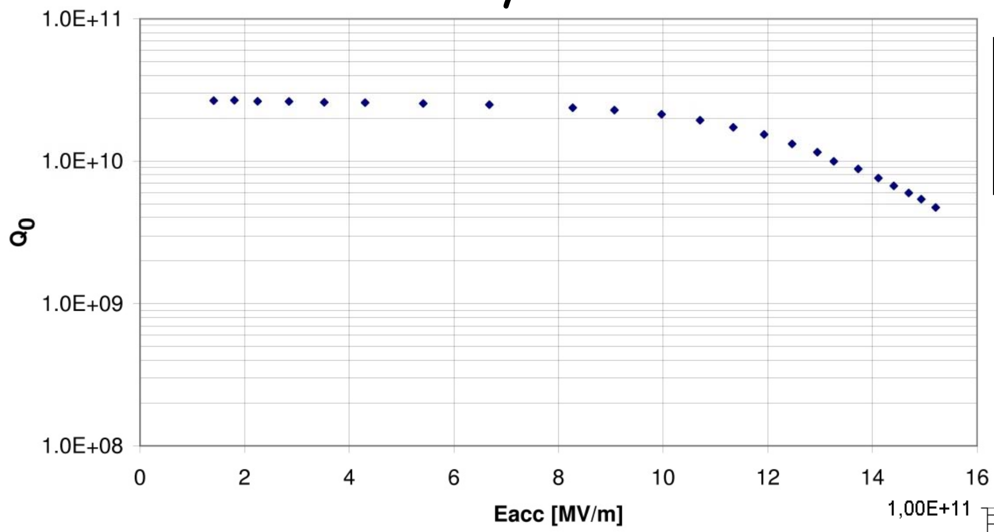
704 MHz high power couplers

100 mm diameter - 50 Ω



Performance of 704 MHz sc cavity

In vertical cryostat: Eacc=13 MV/m at Qo=1e10

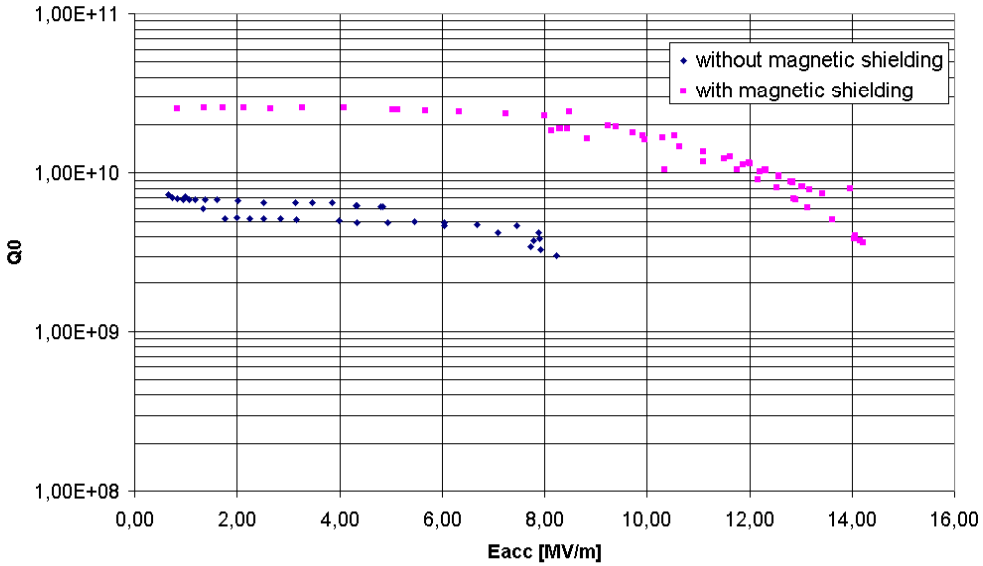


- Rs = 6 nΩ
- Field emission onset 12 MV/m
- Quench at 15 MV/m

In CryHoLab:

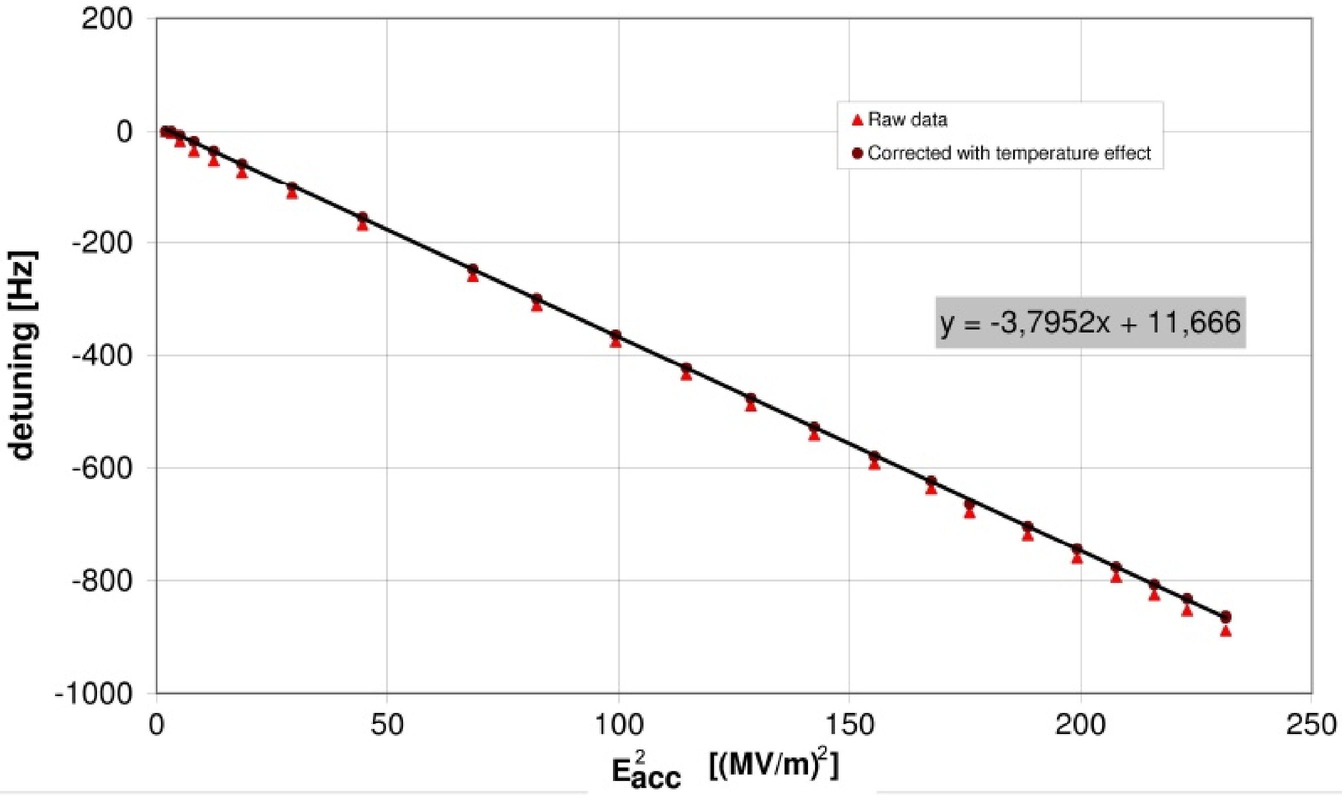
- Eacc>12 MV/m at Qo=1e10
- Qualification of the mag. shielding

  Qo at low field unchanged



Characterization of 704 MHz sc cavity

Lorentz force detuning coefficient of beta=0.47 sc cavity:



Very good result KL = -3.8 Hz/(MV/m)2
External stiffness: 33 – 200 kN/mm

Characterization of 704 MHz sc cavity

SLHC-PP Objective:

- Study and development of a correction algorithm for LFD able to limit the variation of the phase during the beam pulse in order to achieve more easily the required field stability
- Implementation and measurement in pulsed mode on a real sc cavity

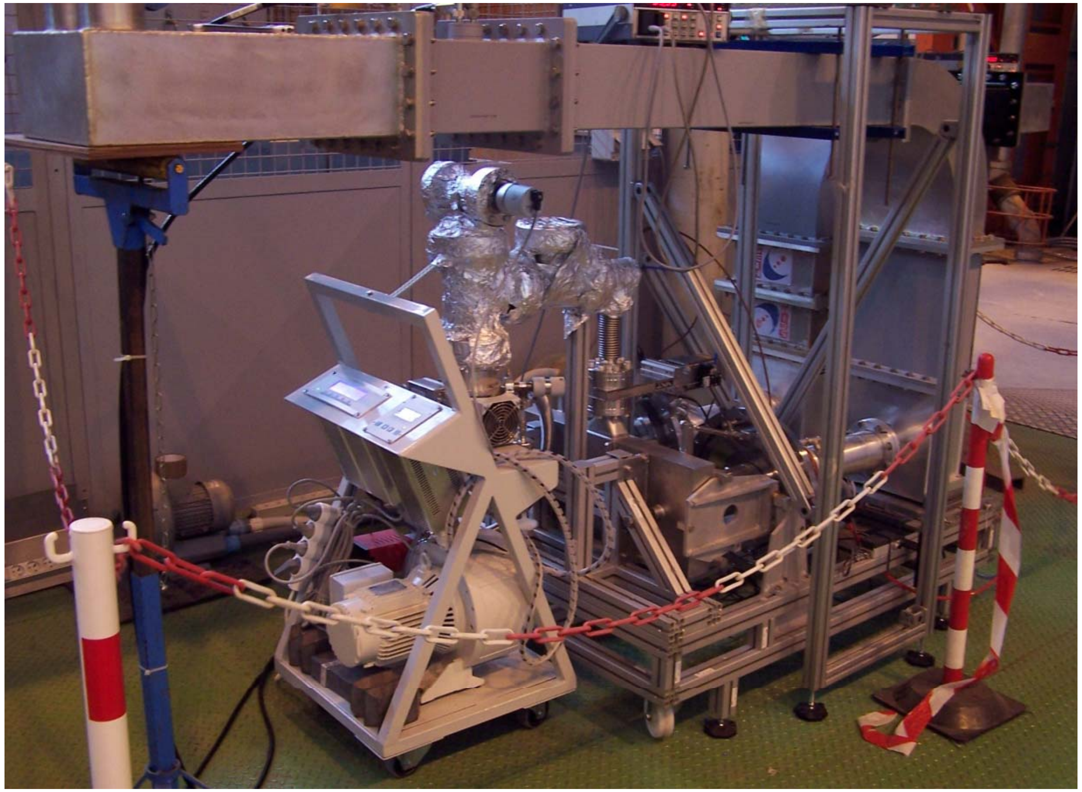
beta	Eacc [MV/m]	K_L [Hz/(MV/m)^2]	static detuning [Hz]	% BW
0.47 (HIPPI)	13	-3.8 (meas.)	642	110
0.65 (SPL - IE)	19	-2 (simul.)	720	113
1 (SPL - HE)	25	-0.6 (simul.)	376	64
1 (FLASH)	23.6	-0.7, -0.9 (meas.)	390, 501	90, 116

- If the KL for SPL-HE cavities can be lowered down to -0.6, LFD compensation should not be an issue
- To be checked for IE cavities (very close to FLASH cavities)
- β=0.47 sc cavity characteristics are similar to those of IE cavities: good candidate for testing the LFD compensation system

Coupler Processing

<u>High power tests in progress:</u>

☑ assembly of couplers on the power test bench
☑ UHV baking (4 days – from 100 to 180° C)
☑ mounting of the doorknobs
☑ connection to cooling system and RF waveguide
☑ test of interlocks
☑ RF power processing in TW
☐ RF power processing in SW

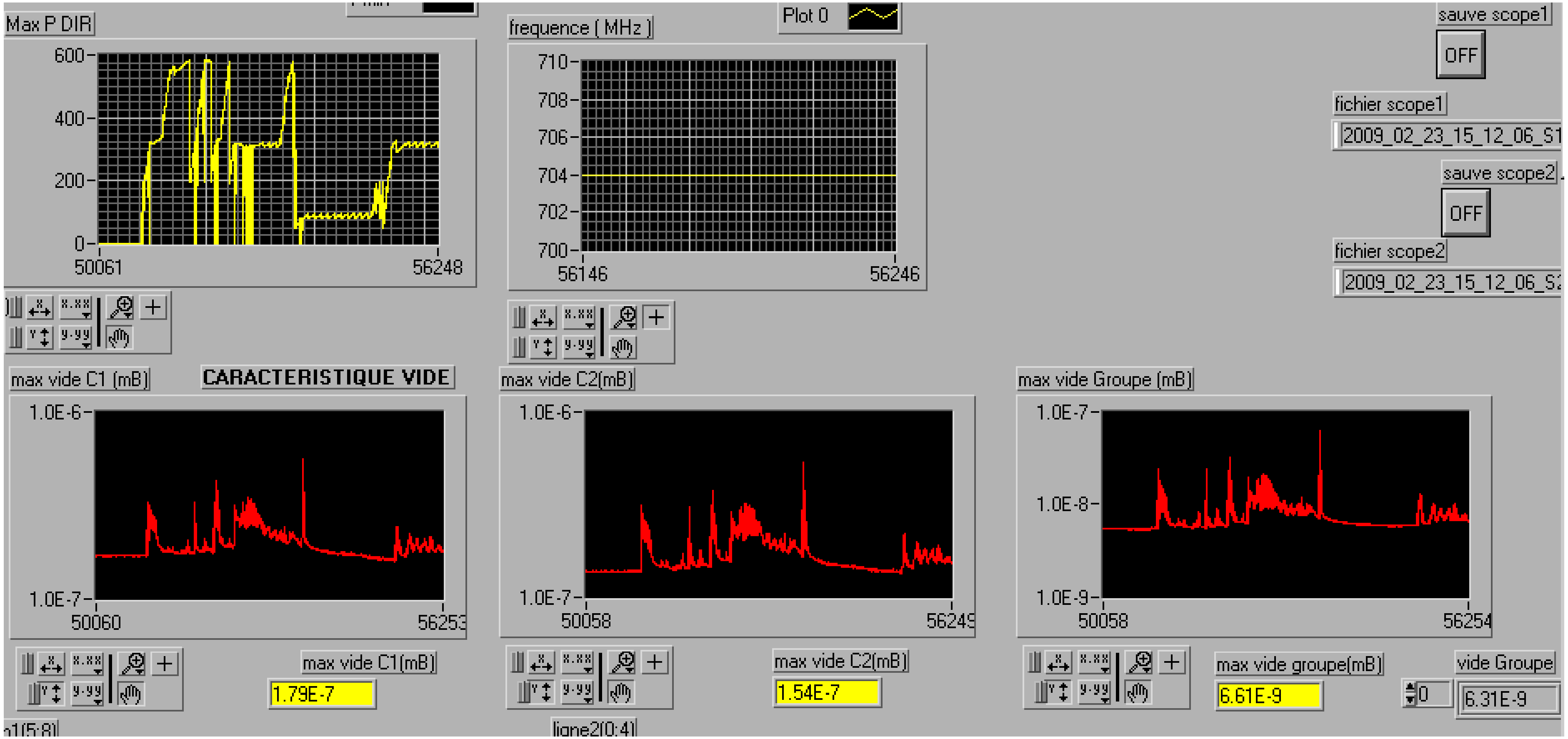


Performance of coupler

In TW mode (full d.c. = 2 ms - 50 Hz):

Pdirmax @ full d.c. = **600 kW**

Pdirmax @ half d.c. = **800 kW**

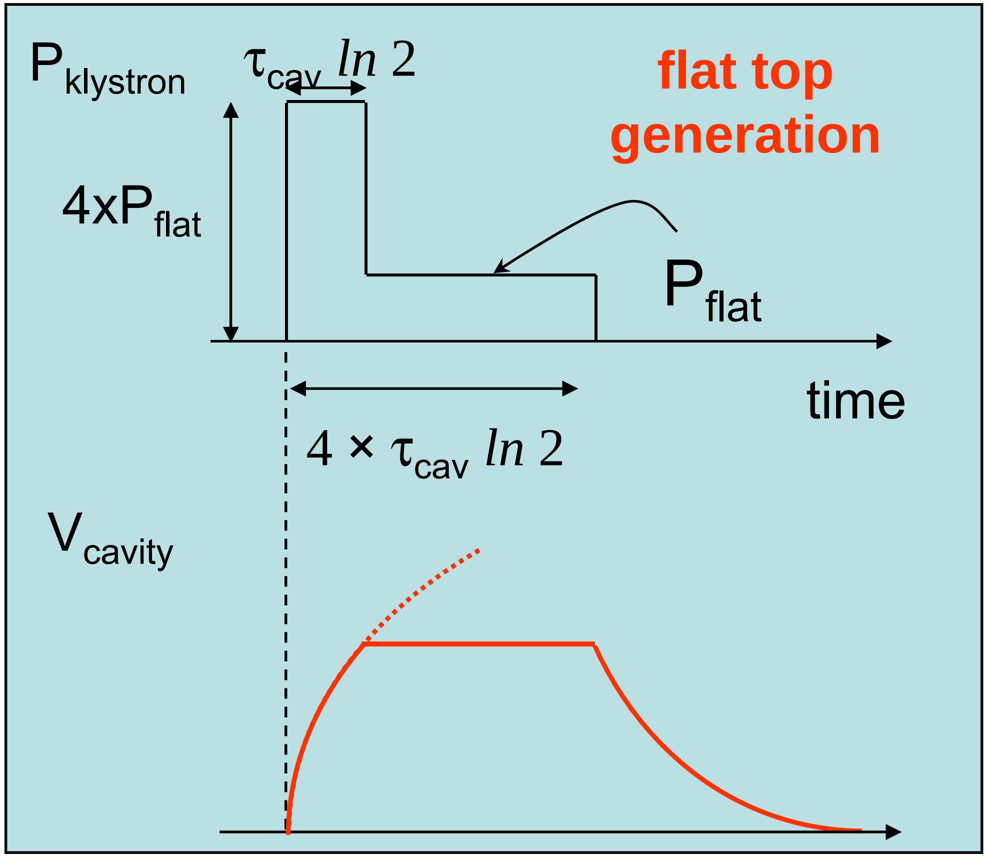


Tests in pulsed mode

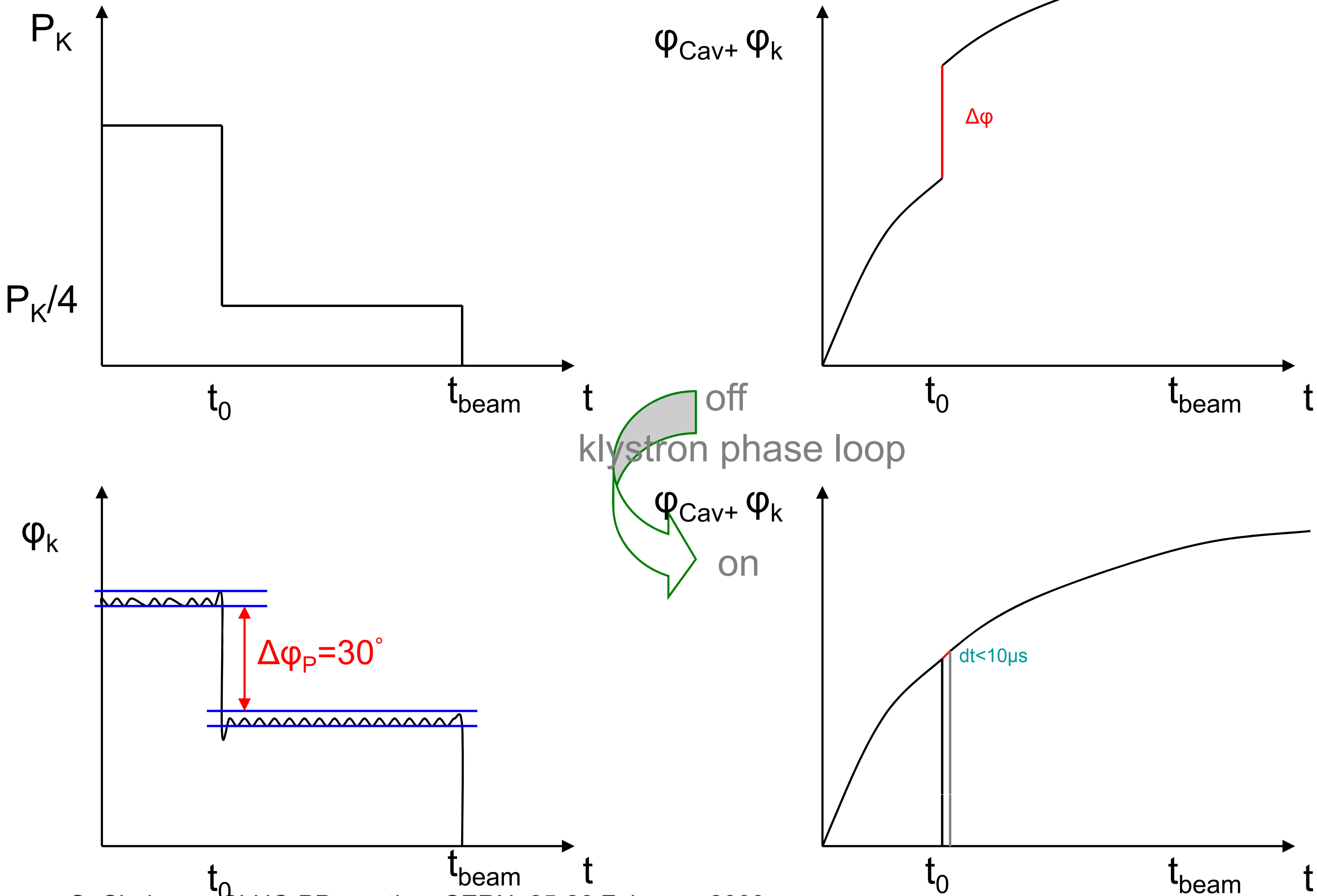
<u>Operation of the cavity β=0.47 in pulsed mode</u>

Filling time=300μs, flat top=1ms, frep=50 Hz

Qex = 1.10^6 , Eacc= 13MV/m ➡ 4xPflat=230 kW

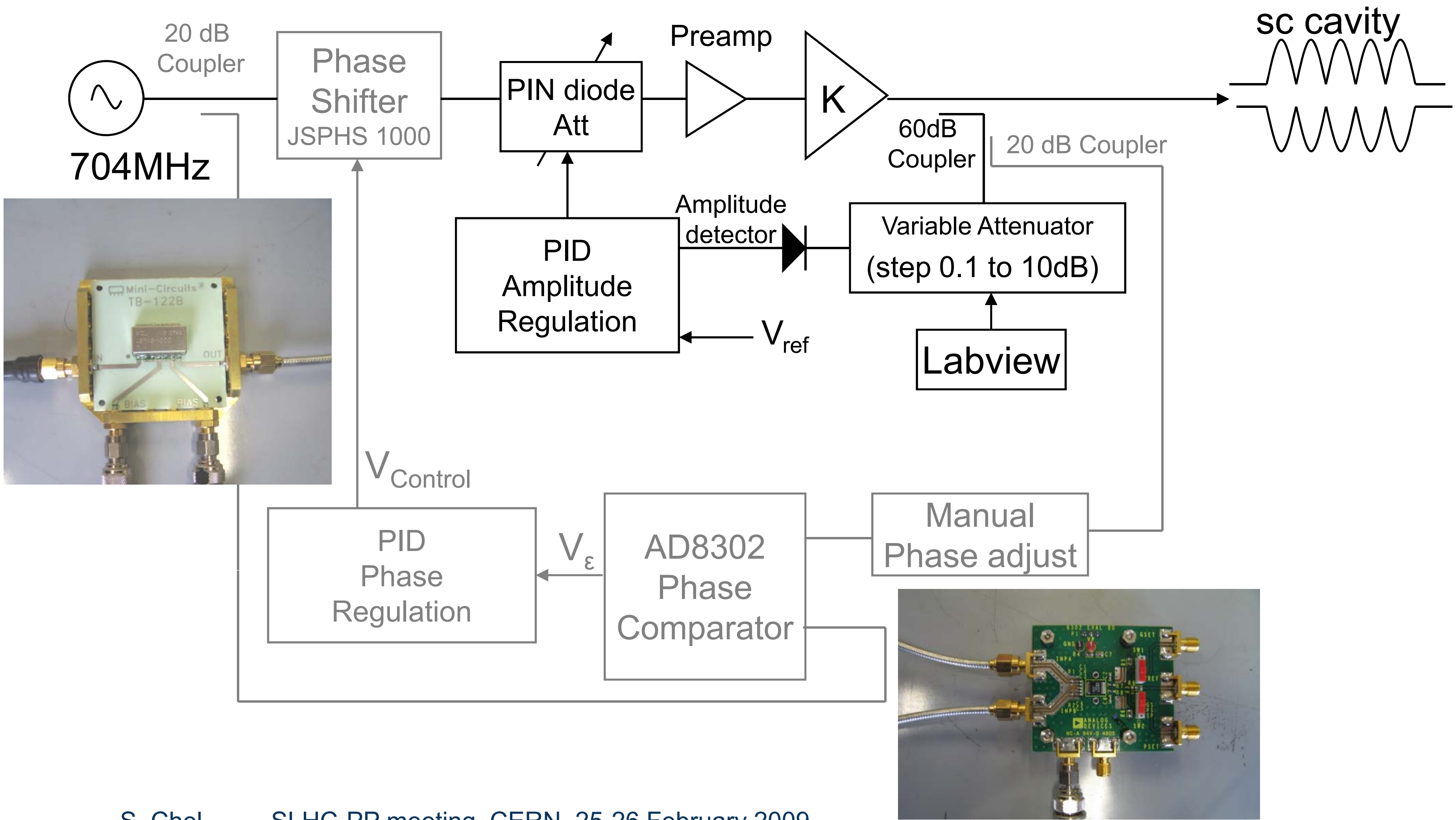


Tests in pulsed mode



Tests in pulsed mode

700MHz Klystron RF regulation



Tests in pulsed mode

What is already available:

☑ β=0.47 sc cavity quenching above 13 MV/m

☑ LFD compensation system (with manual tuning of PZT drive pulse *i.e.* pre-delay, amplitude and rise time)

☑ RF power generator (> 250 kW)

☑ Horizontal cryostat

☑ Helium liquefier, compressor, pumping system

Tests in pulsed mode

What is almost available (will be available in the next 6 months):

☑ coupler processed above 250kW in SW
☑ tuning system with piezo
☑ waveguide connection to CryHoLab
☑ analog A/phi klystron loop

and:
☑ fully-automated LFD compensation system (from CERN)

LLRF simulation

Simulation of the LLRF in pulsed mode: O. Piquet

Preparation of RF tests in pulsed mode

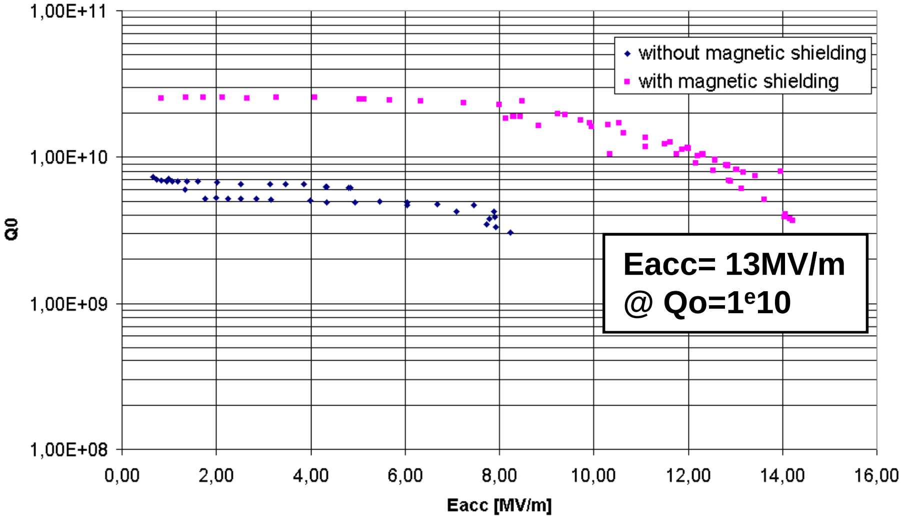
Objective of the tests:

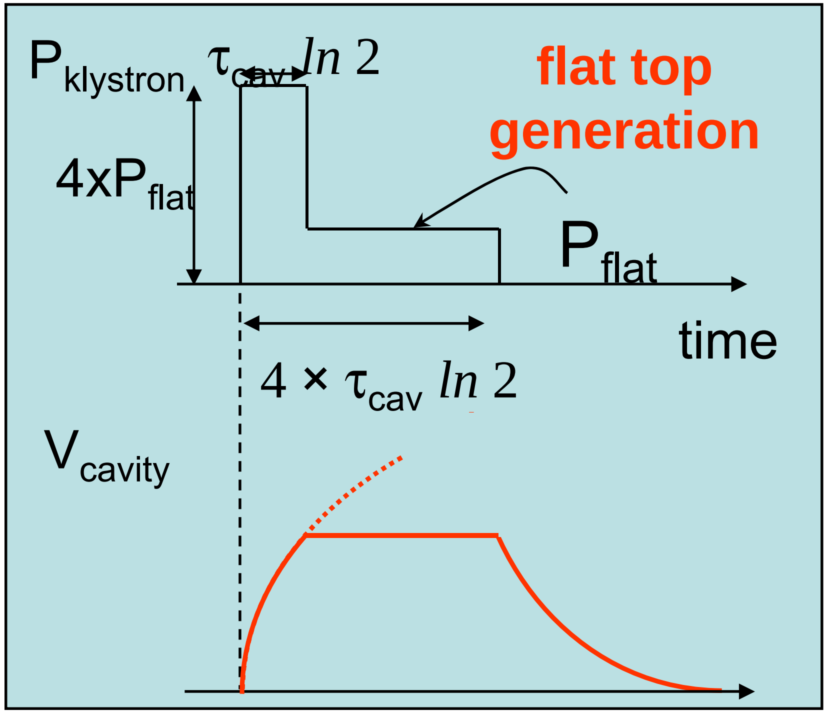
- Study and development of a correction algorithm of the Lorentz Force Detuning able to limit the variation of the phase during the beam pulse in order to achieve more easily the required field stability
- Implementation and measurement in pulsed mode on a real sc cavity

<u>Operation of the cavity β=0.47 in pulsed mode</u>

Filling time=300μs, flat top=1ms, frep=50 Hz

Qex = 1.10^6 , Eacc= 13MV/m ➡ 4xPflat=230 kW



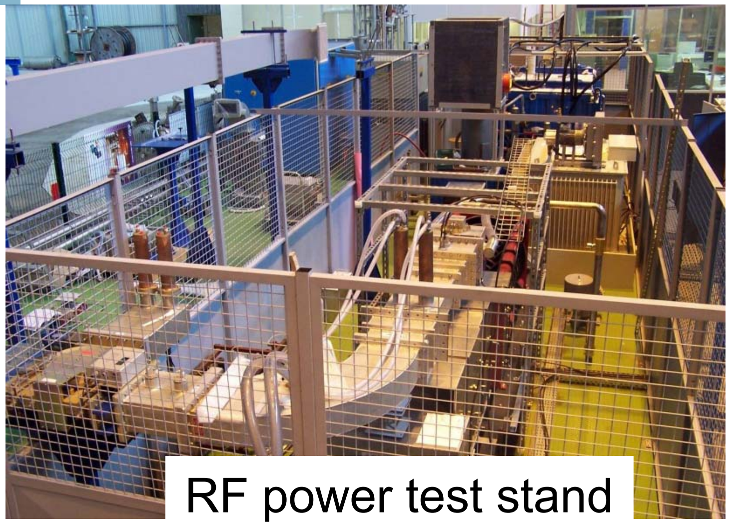


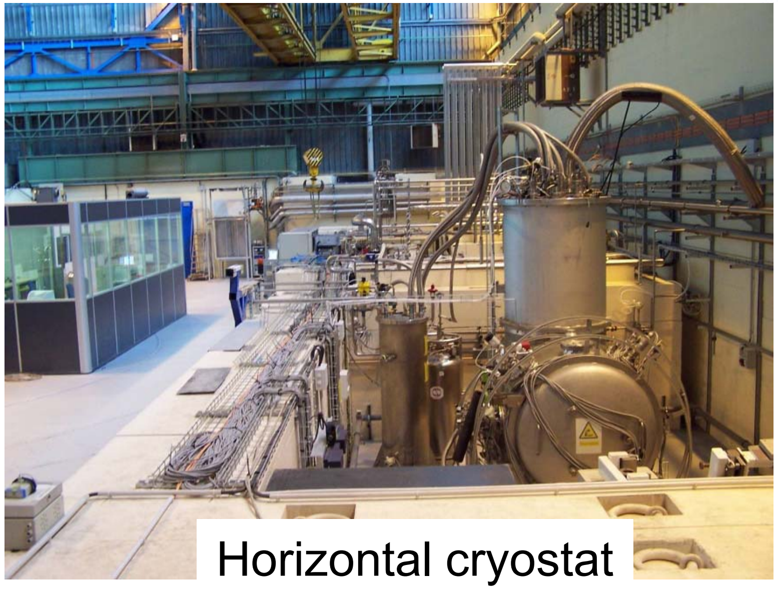
Preparation of RF tests in pulsed mode

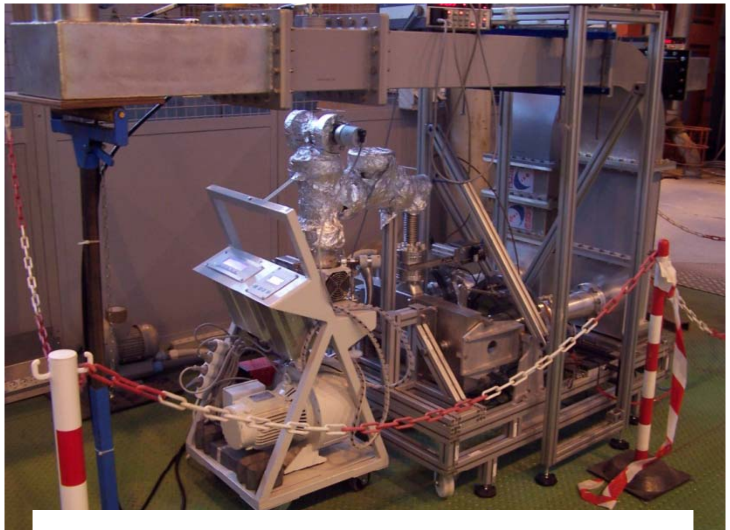
What is needed and (almost) available:

- β=0.47 sc cavity quenching above 13 MV/m
- LFD compensation system (with manual tuning of PZT drive pulse *i.e.* pre-delay, amplitude and rise time)
- RF power generator (> 250 kW)
- Horizontal cryostat
- Helium liquefier, compressor, pumping system
- coupler processed above 250kW in SW
- tuning system with piezo
- analog A/phi klystron loop
- fully-automated LFD compensation system (from CERN)

Preparation of RF tests in pulsed mode


RF power test stand


Horizontal cryostat


Bench for coupler processing


β=0.47 sc cavity