DE LA RECHERCHE À L'INDUSTRIE

CEA - Saclay

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CRITICAL DESIGN REVIEW #1 FOR MEDIUM BETA CAVITY CRYOMODULES

3-4 APRIL 2017

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PRELIMINARY HIGH LEVEL TESTS PLAN

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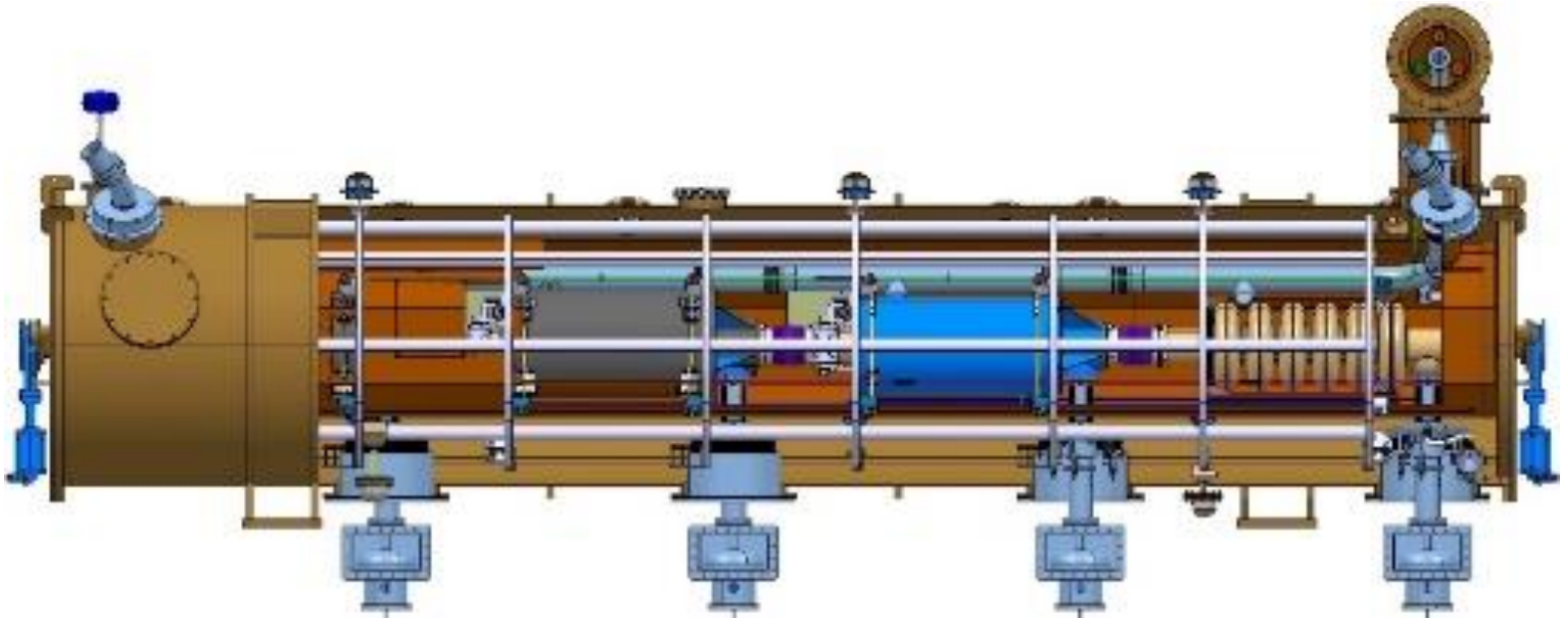
OLIVIER PIQUET

PRELIMINARY HIGH LEVEL TESTS PLAN

- **Test-stand**
- **Instrumentation and Control-command**
- **Preliminary tests plan**



PRELIMINARY HIGH LEVEL TESTS PLAN

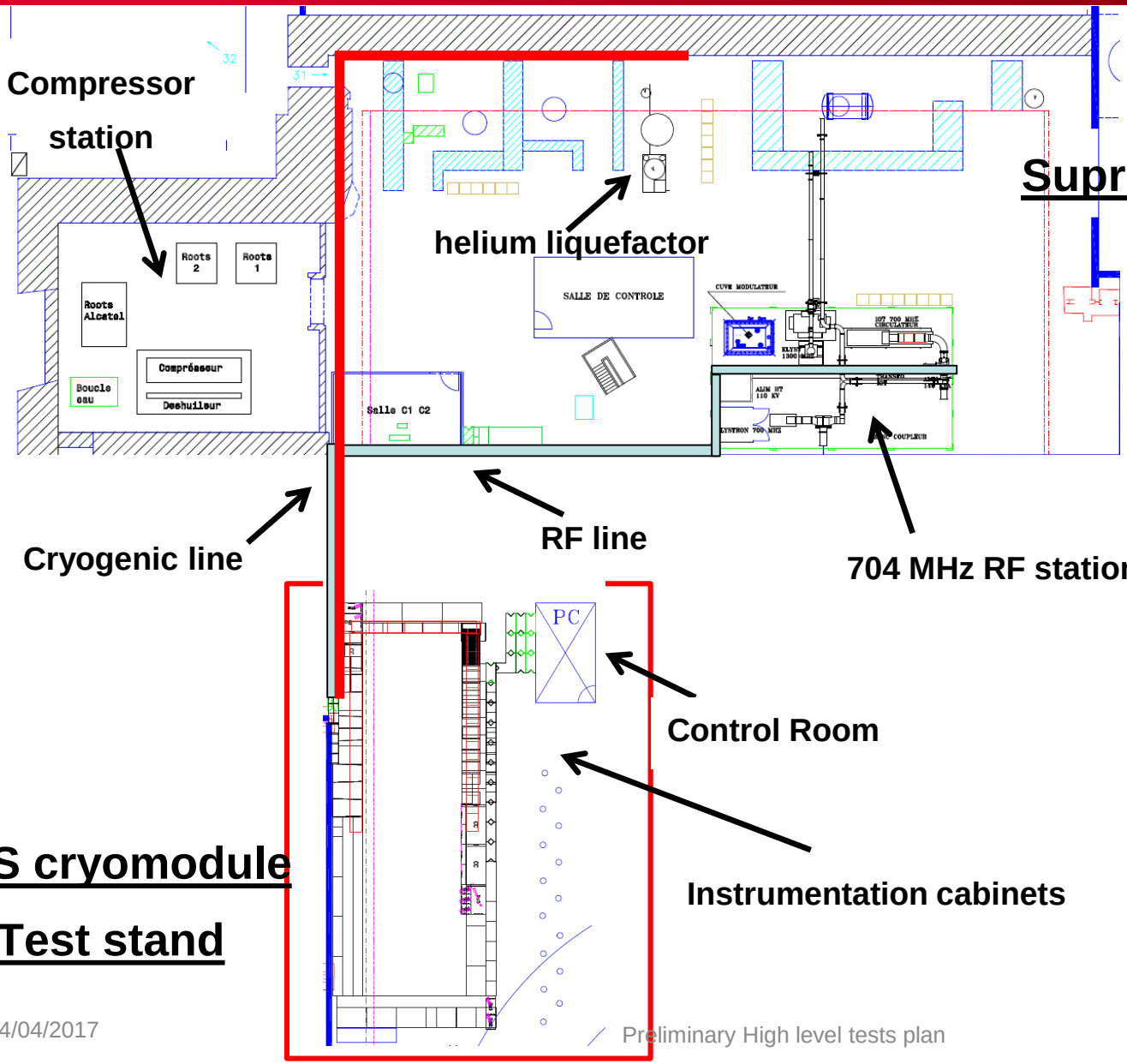
Main goals:

- Cavity performances in a cryomodule configuration
  - Coupler performances (coupling, conditioning….)
  - Cavity performances (Eacc, radiation, fundamental spectra measurement…)
  - Tuner and piezo systems(Range, resolution…)

- Validation of the cryogenic operations
  - Validation of the control and the instrumentation of the cryomodule
  - Cryogenic measurements of cryomodule (static cryogenic losses, temperatures…)
  - Define optimal cooldown procedure

→
- **Verification that the assembly procedure doesn't degrade the performances of cavities and couplers**
- **Definition of test procedures for ESS cryomodules**

M-ECCTD TEST-STAND AT SACLAY



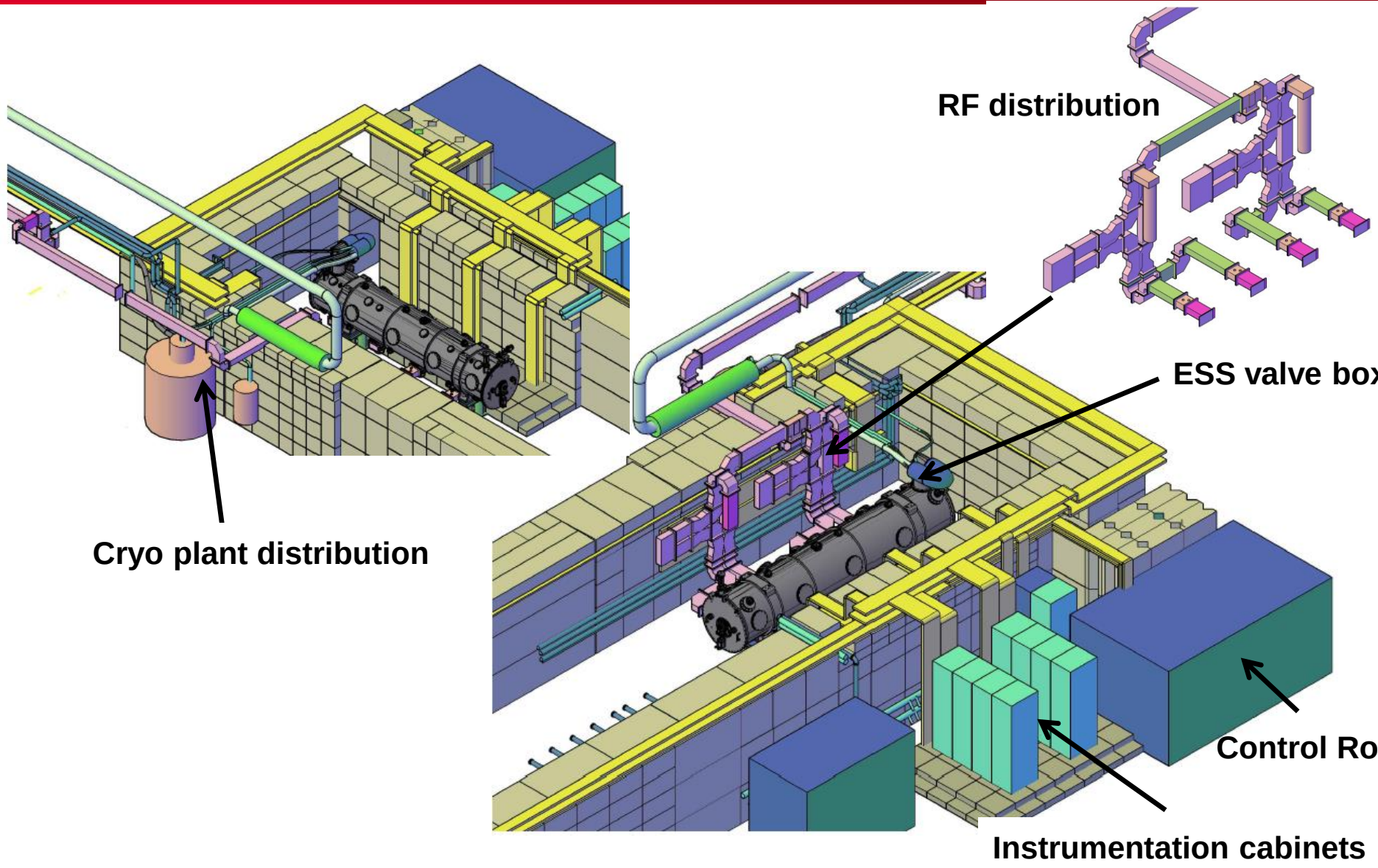
RF POWER SOURCE

- **704 MHz RF station**

(used for the conditioning for the 4 couplers of the M-ECCTD)

1.1 MW peak power at 3.6 ms – 14 Hz

ECCTD TEST-STAND



ECCTD TEST-STAND

Cryo plant distribution

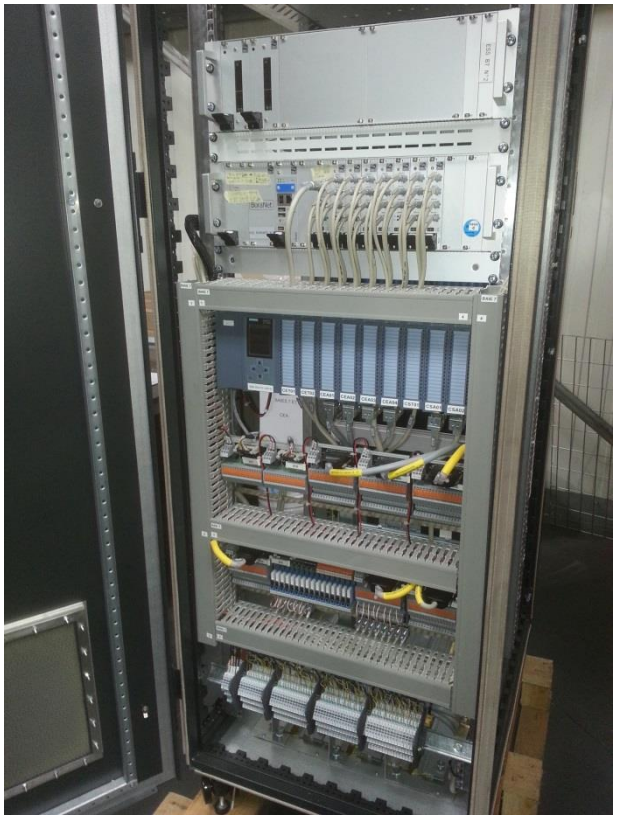
(ready)

RF distribution

(Installation in progress)

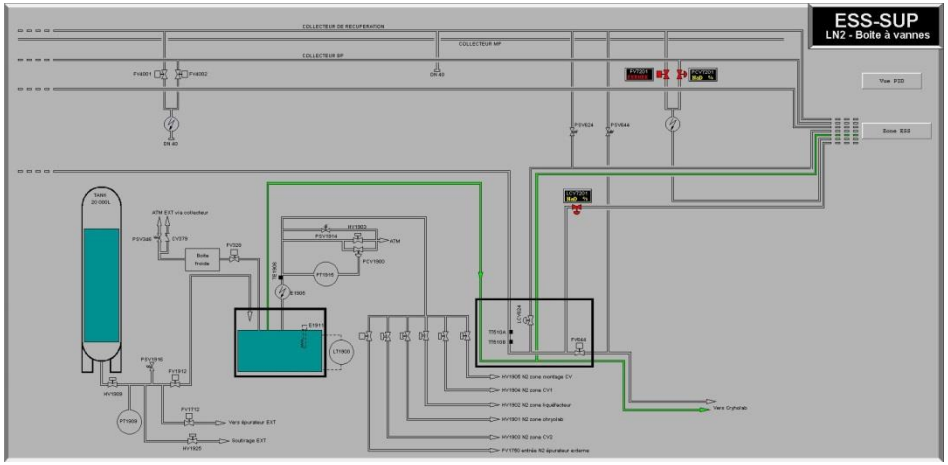
INSTRUMENTATION FOR CRYOGENIC SYSTEMS

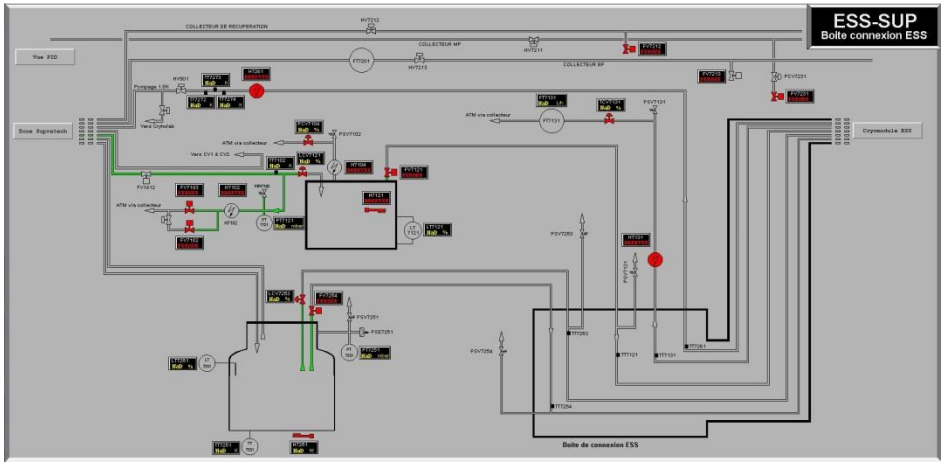
- Instrumentation for temperature, vacuum gauge, valves heater…

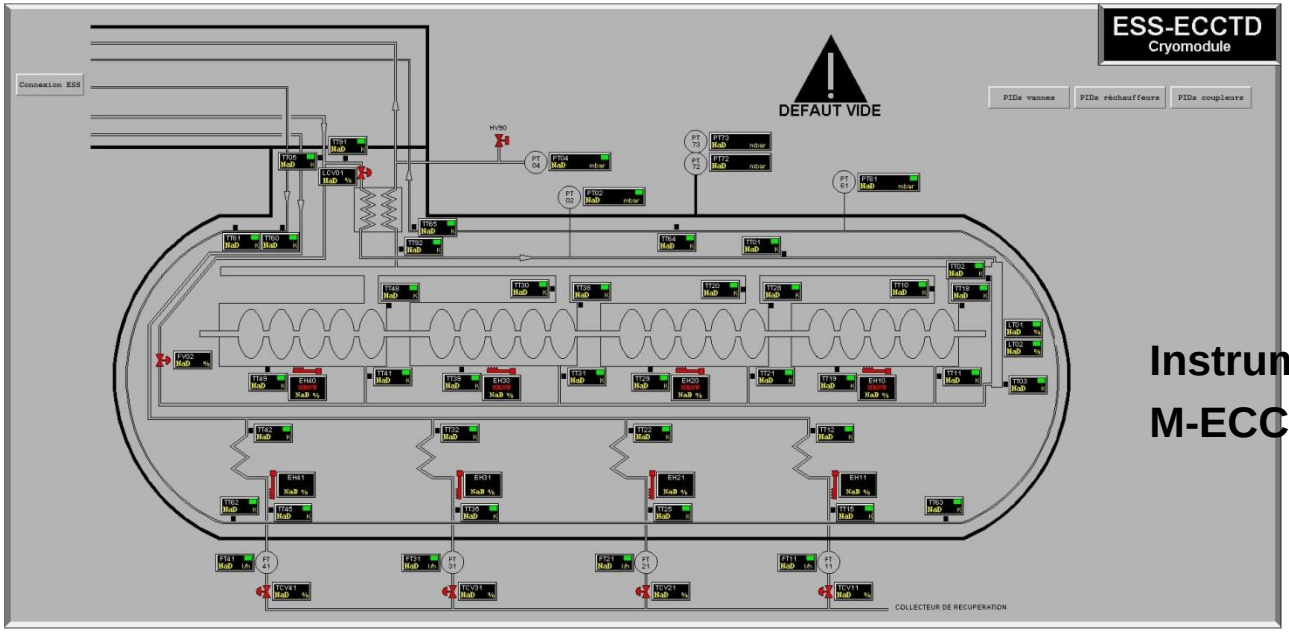

Instrumentation cabinets for M-ECCTD control

CONTROL FOR CRYOGENIC INSTRUMENTATION



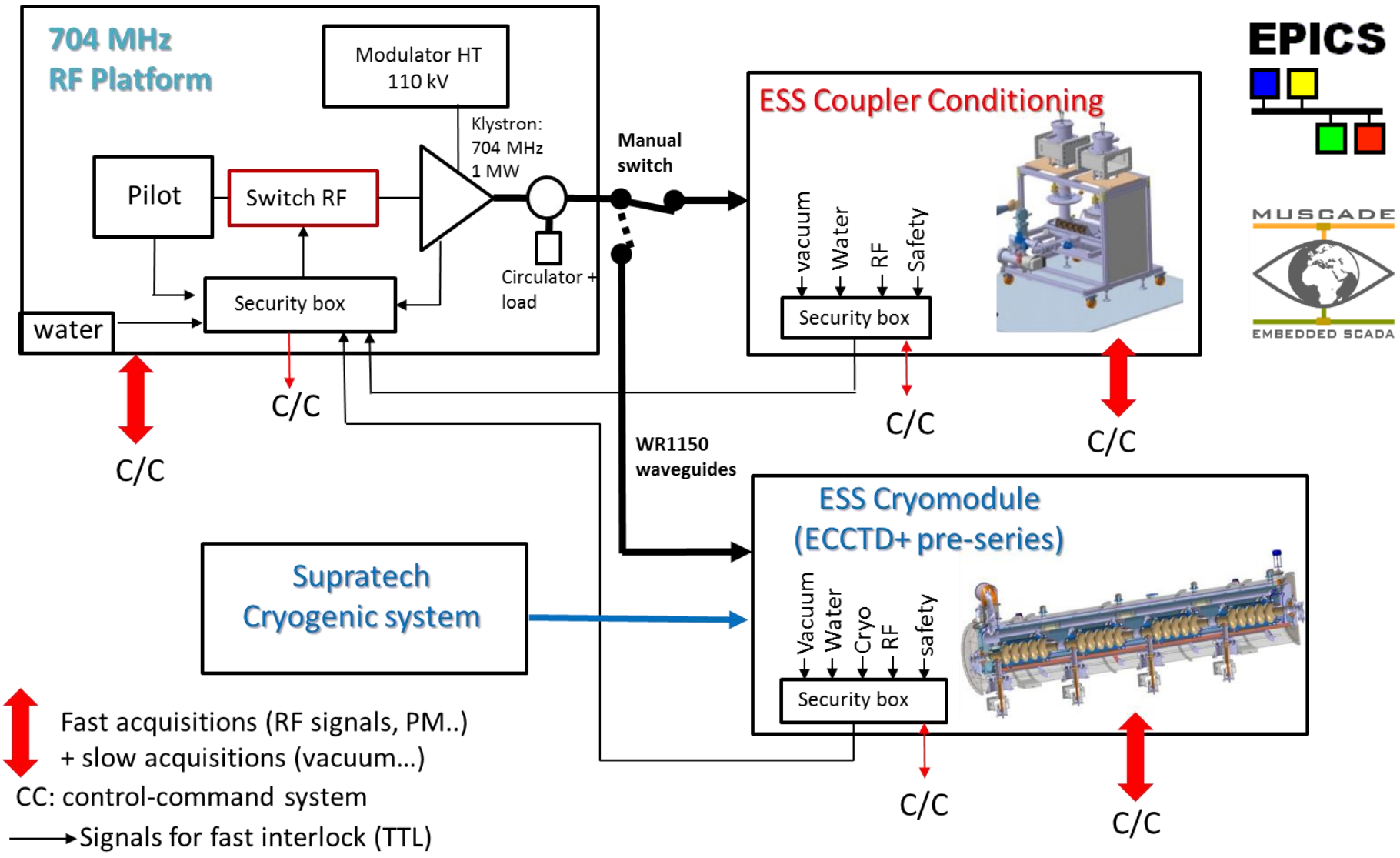


Cryo plant for M-ECCTD



Instrumentation of M-ECCTD

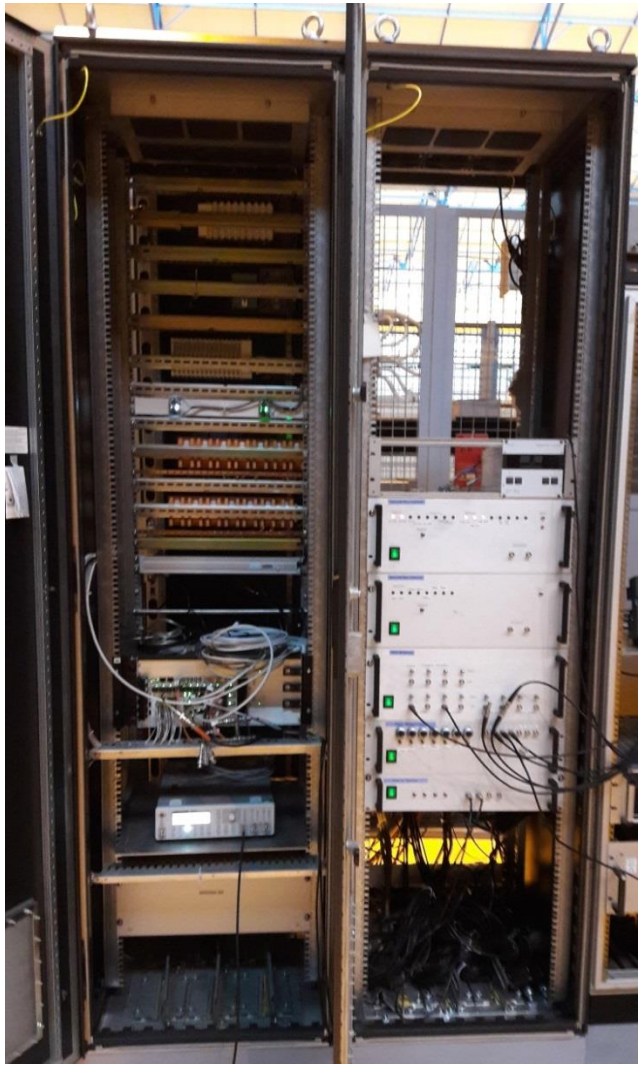
RF TEST-STAND



Same instrumentation for test-stand and RF platform

RF INSTRUMENTATION AND CONTROL

Same for coupler conditioning, RF power station and ECCTD test-stand



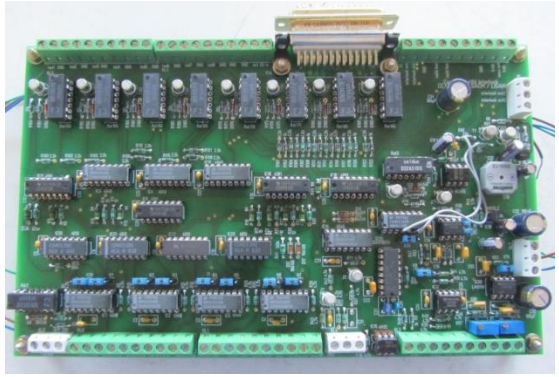
Main roles of RF instrumenation

- Protection of systems (RF source, coupler, cavity…)
  => Stop the RF in less than 20µs in case of interlock
- Acquisition of data (RF, arc-detector, electron current, temperatures, vacuum…)

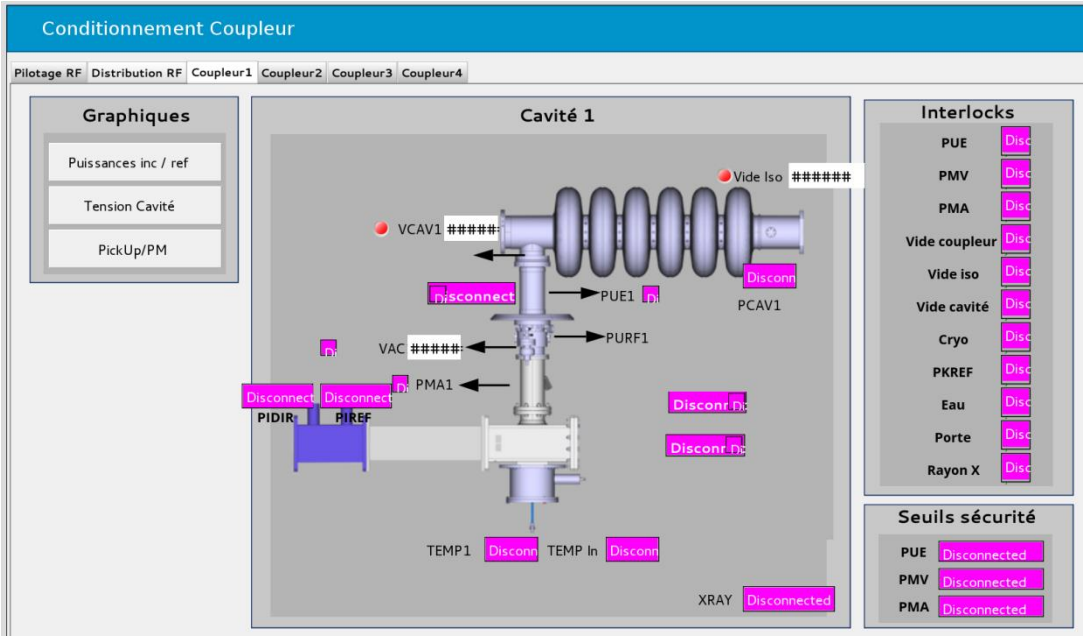
2 cabinets:

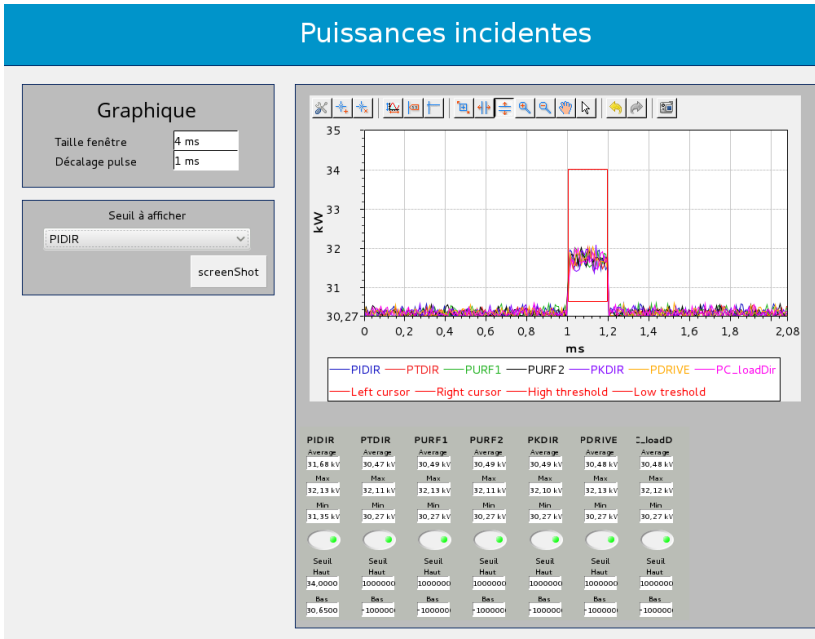
- 1 for RF instrumentation and local protection system (Security Box)
- 1 for fast and slow acquisitions and control-command system

Instrumentation has been designed to be simple and easy to configure with different functions

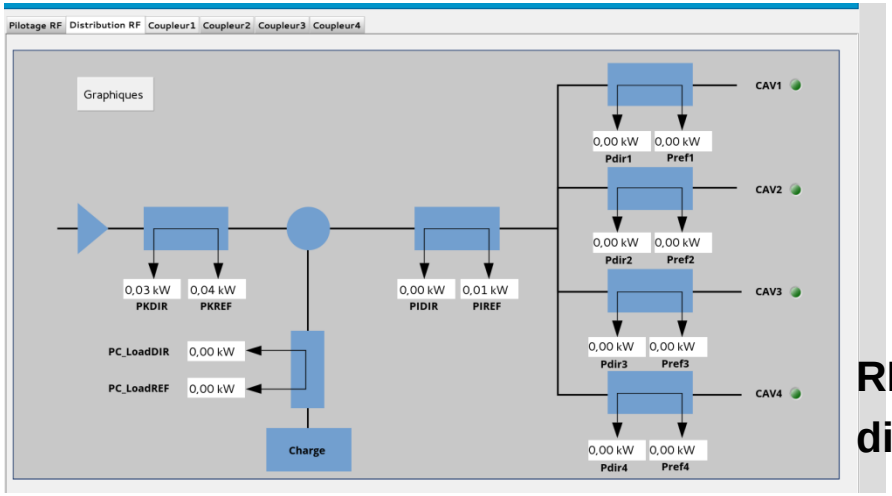


RF CONTROL AND ACQUISITION





Coupler and cavity control

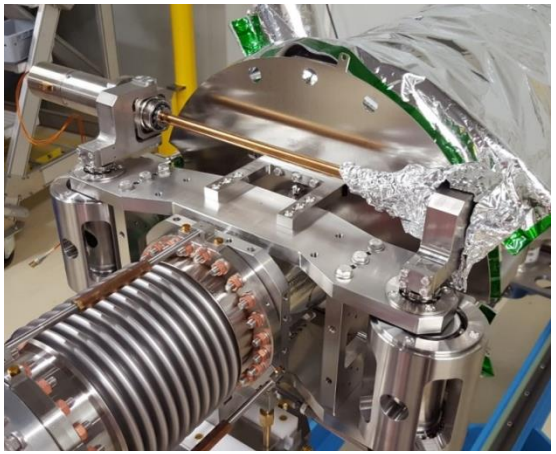


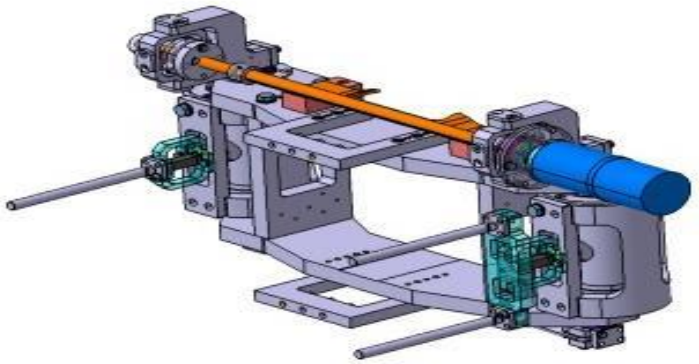
Fast acquisitions

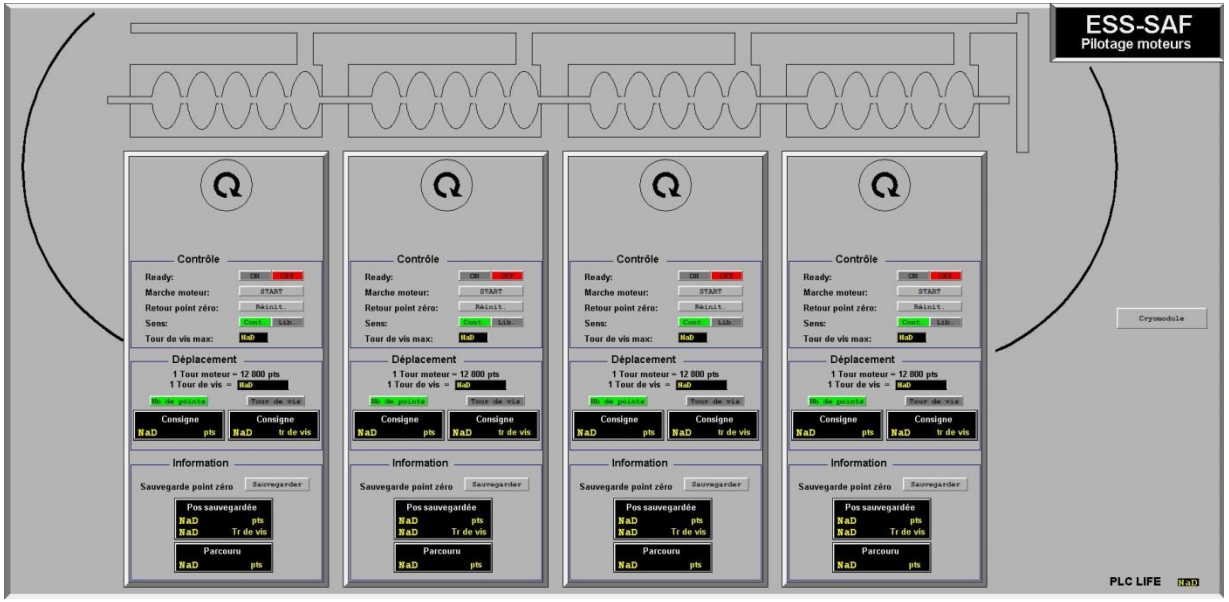
RF power distribution

TUNER SYSTEM CONTROL

- Slow tuning system for compensation of large frequency shifts (at low speed)



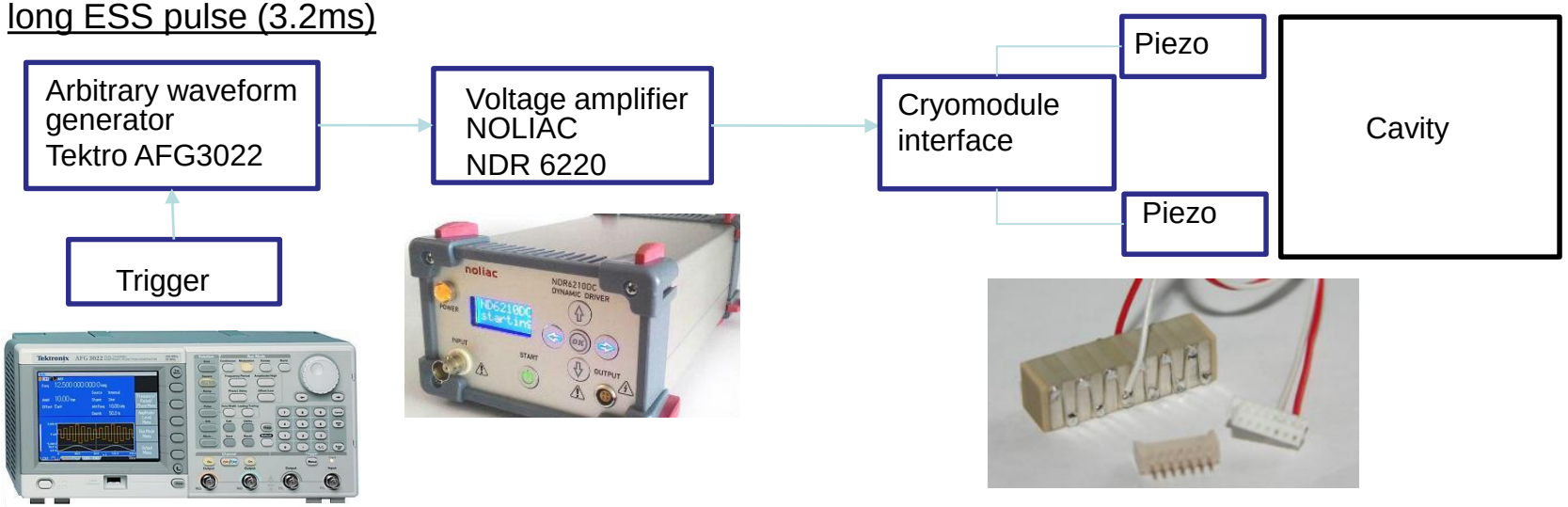




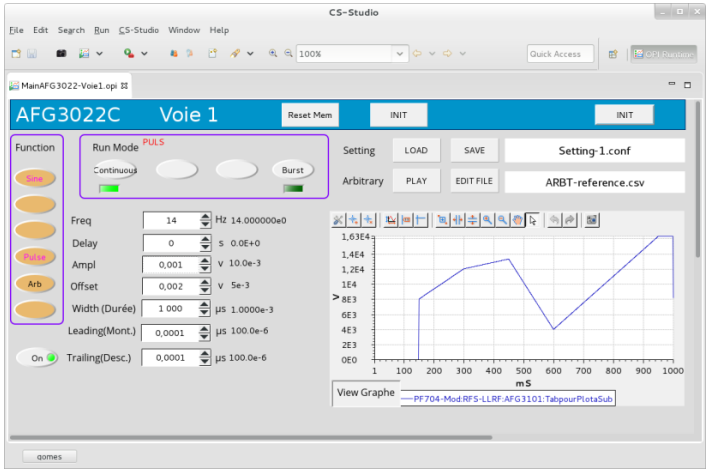
Control for tuner system

PIEZO SYSTEM CONTROL

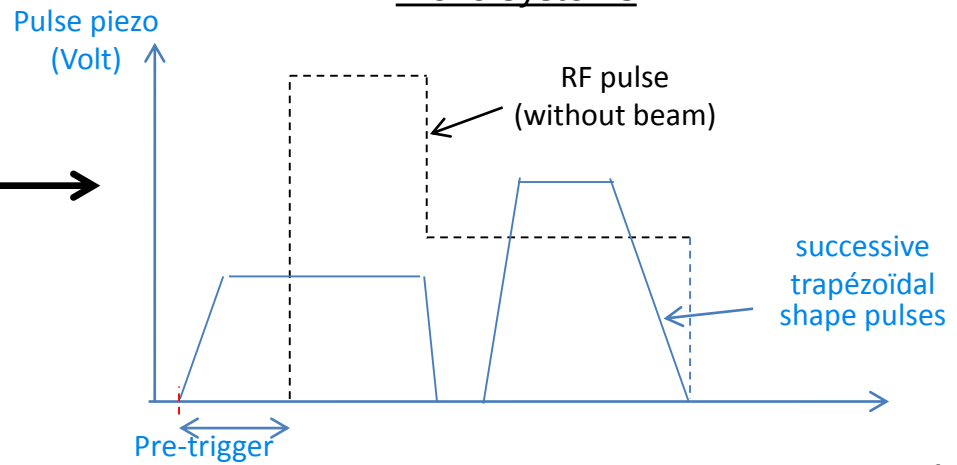
- Lorentz Force Detuning (LFD) compensation (critical system due to the long ESS pulse (3.2ms)



Contrôle of waveform generator in EPICS software



Define optimal (but basic) pulse for Piezo systems



HIGH LEVEL TESTS PLAN

Installation

- Alignment
- Vacuum and cryogenic connections and leak tests
- Instrumentation installation and tests
- Interlocks verified (hardware)
- RF calibration (RF distribution, Directional couplers, cables…)
- Control system tests (software)
- RF source check (waveguides, control, interlock…)

Warm tests

- Cavity frequency sprectra measurement (Low power test)
- Couplers conditioning (off-resonance cavity),

HIGH LEVEL TESTS PLAN

Single RF cavity test at nominal ESS RF pulse

Cooldown to 4K

- Define optimal procedure
- Check of mechanical behavior of cryomodule during cooldown (position of coupler/cavity, vacuum vessel…)
- Low power measurements (frequency sprectra measurement…)
- RF cables calibration
- Cold coupler conditioning
- First tests of tuner and piezo systems (control)

Cooldown to 2K

- Define optimal procedure
- Check of mechanical behavior of cryomodule during cooldown (position of coupler/cavity, vacuum vessel …)
- Alignment at cold temperature
- Low power measurements (Qload, frequency sprectra measurement…)
- RF cables calibrations
- Tests of tuner and piezo systems (range and resolution, control…)
- Coupler Qload measurement

HIGH LEVEL TESTS PLAN

For each cavity

- Cavity ‘’conditioning’’
- Measurement of Eacc max
- Radiation at nominal/maximal Eacc
- Quench limits
- Lorentz forces and microphonics measurements
- Piezo tests: definition of an optimal and basic control for the piezo
- Cryogenic system performances (Cryogenic behaviors, Helium circulation instabilities, static losses, losses from cavity and coupler…)
- Check of cryogenic control (heater, valves, temperature sensors…)
- Cooldown cycles

Test of 2 cavities together (but not at the ESS nominal pulse)

- Check of no crosstalk between adjacent cavities (RF leakage, mechanical vibrations, tuner control…)

SUMMARY

- Define customized instrumentation, tools and software for cryomodule test
- Needs large data storage and powerful tools for analysis
- Define cryomodule test flow
  - installation
  - instrumentation check
  - warm tests
  - Cold tests (4K and 2K)
- Measurement of the performances for each cavity/coupler/tuner assembly
- Validation of the control and the instrumentation of the cryomodule
- Define optimal cooldown procedure

→ Define acceptance criteria according main specification

SUMMARY

- Validate designs and construction capability of cryomodules
- Prepare the industrialization process by validating component life-cycles
- Define CM test procedures for cryomodule production
- Define standardized test reports
- Develop ESS SRF operating procedures
- Validate integration and interfaces with RF, cryogenics, vacuum and control systems
- Validate control command system
- Train people for cryomodule production and tests
- Test-stand for ESS developments: ESS controls architecture (control/command), LLRF, LFD compensation, …

Thank you

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