LINAC HELIOS's Commissionning and Operation

Hundred MeV **E**lectron **L**inac **I**njector **O**f **S**OLEIL

-Presentation

-Commissioning and Operation

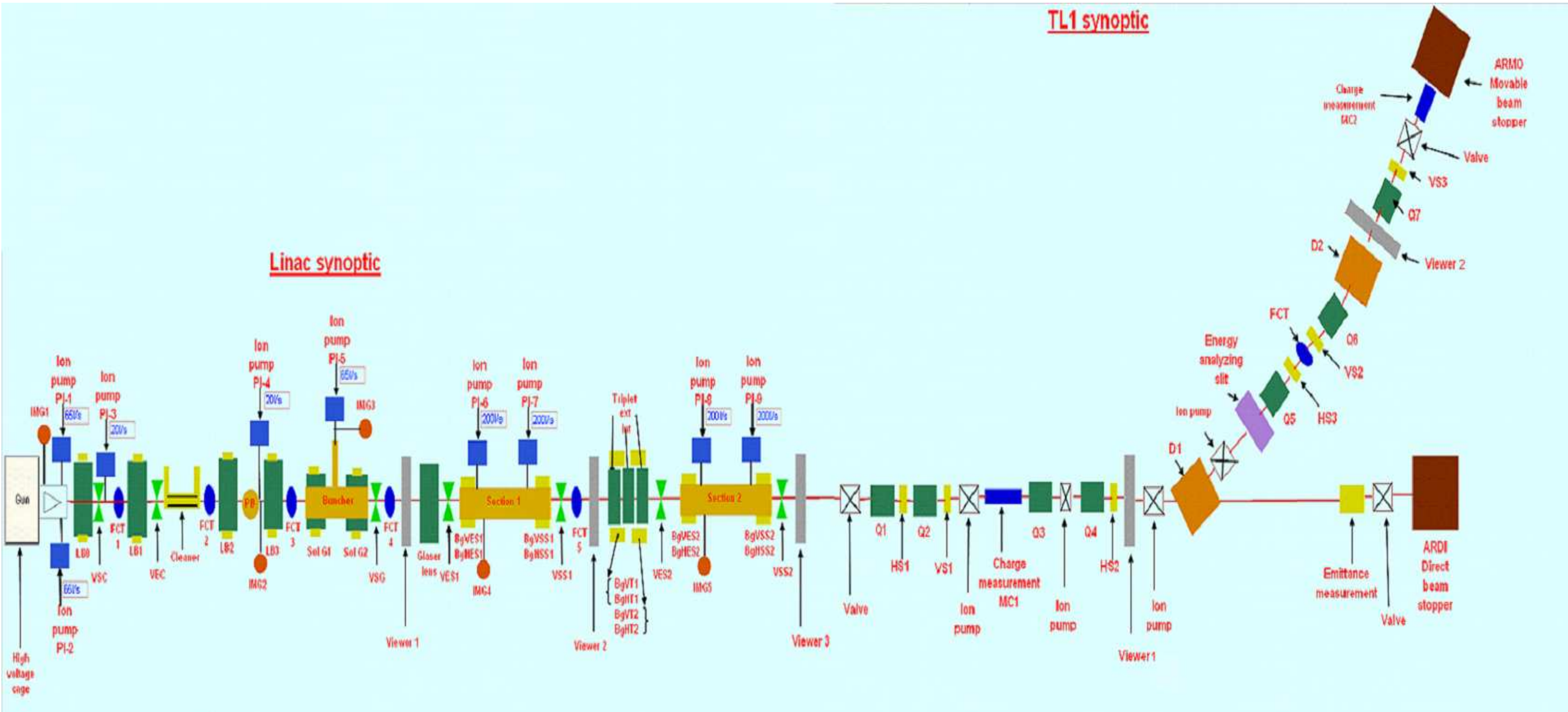
Linac Installation

October 2004 to January 2005

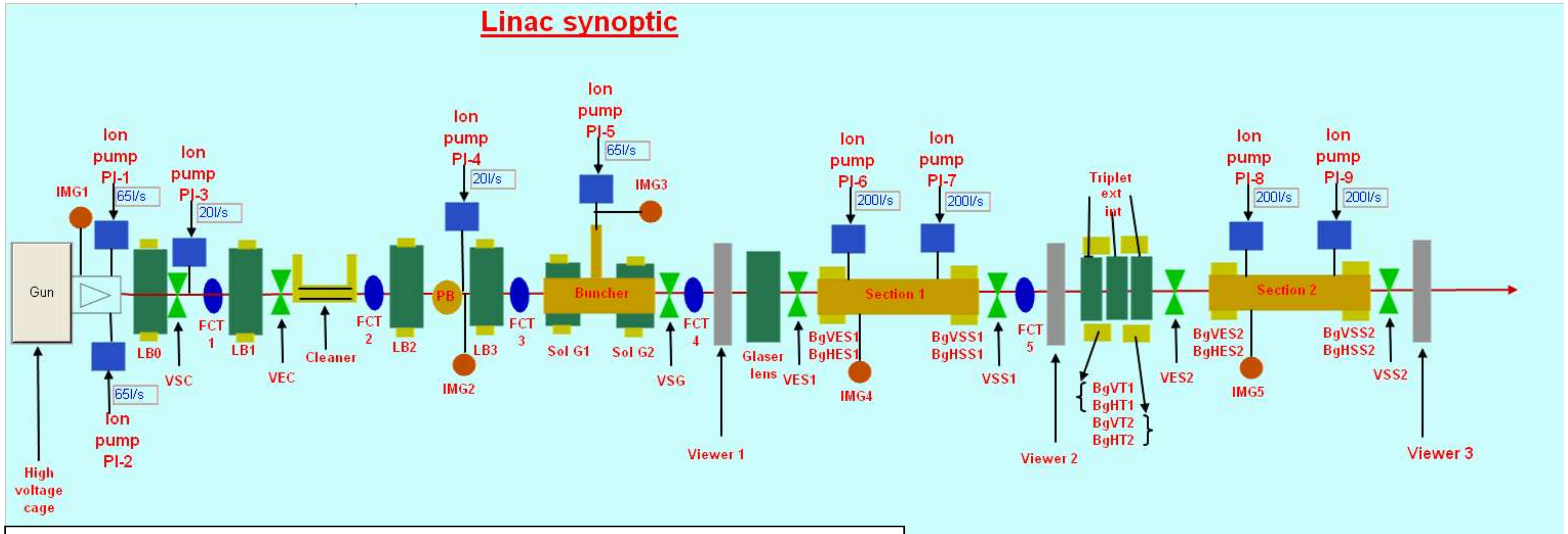
~ 3 months

According to the THALES schedule

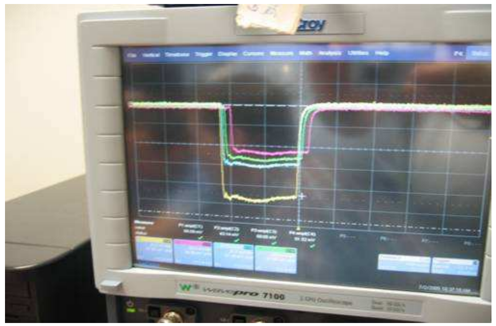
Presentation



Beam Diagnostics: The Linac



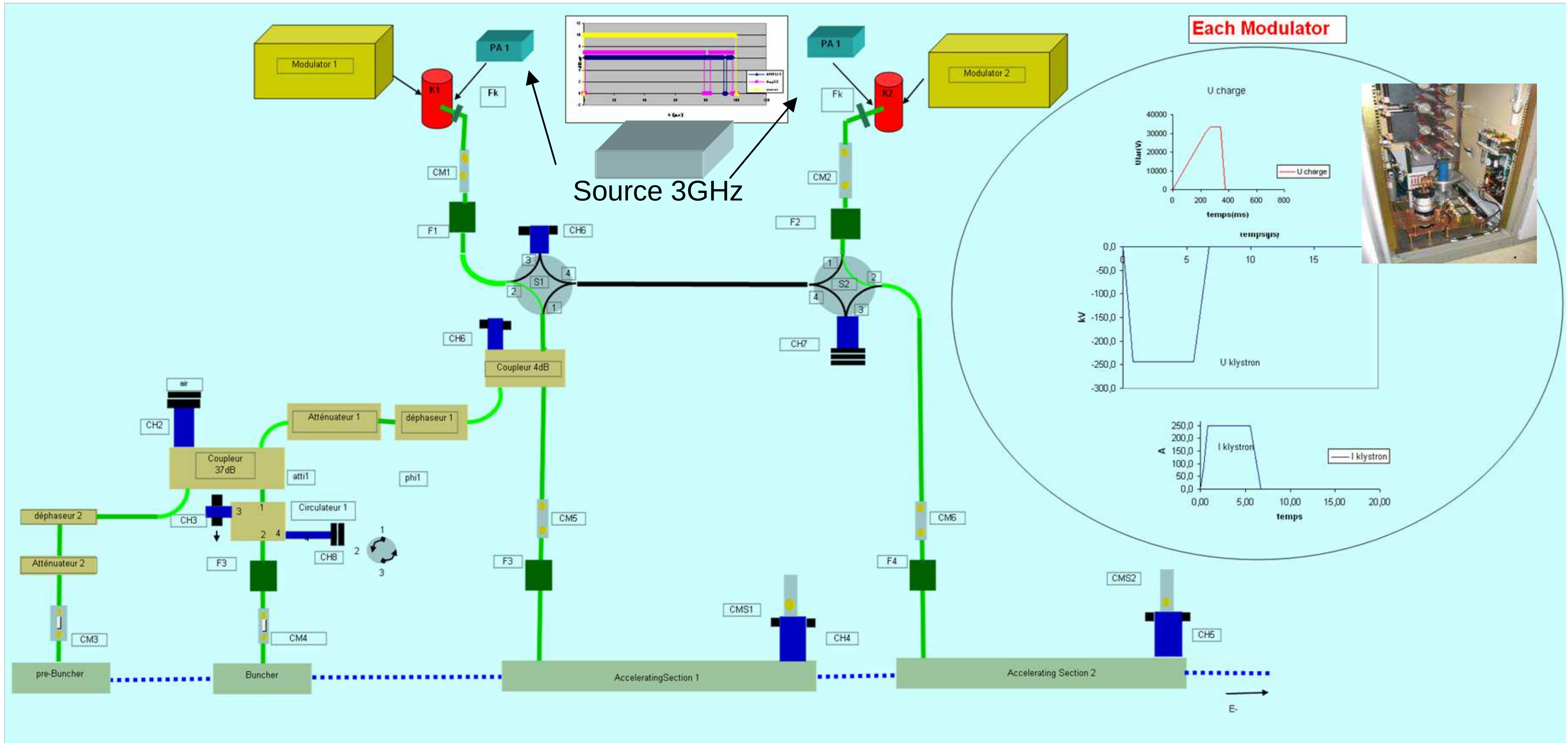
- **Along the Linac (15m):**
  - **5 FCT**: transmission measurement
  - **3 viewers**: - beam position
    - alignment



The different RF Structures

- The linac uses two RF systems:
  - 352.202 MHz for
    - the beam electron gun’s modulation
    - the synchronisation and the events the all PC control (NI’s pci cards)
  - 3GHz for the accelerating structures

3 GHz RF structures



The Klystrons

RF Power: 2 **klystrons** TH 2100 (THALES) **35MW max.**

K1 : **5.5MW** to the buncher
12MW the first accelerating section } → RF klystron output= **28MW**

K2 : **10MW** to the second accelerating section → RF klystron output= **20 MW**

Each klystron is under employ : a fiability aspect

Its radioprotection shielding, more heavy 1.2t

The modulators (2)

Electronic and Local Command Cabinet

PFN
12 cells of
50nF/0.8µH

RF's cooling System

Linac have need SOLEIL's water network 21℃ and 30℃

« the skid » is a own system water cooling of Linac's RF

<u>It has 2 fonctions :</u>

- The cooling and control of different power equipments (*Klystrons, magnet equipments, power supplies and RF loadings*)
- Maintain the temperature with a stability of **< ±0.1℃ between 34 and 39℃**

three RF network

1. Pre-buncher and Buncher 36.5℃
2. The first RF section 35℃
3. The second RF section 34.5℃

RF Structures's Formation

The THALES's high power test began in May 2005

Pre-buncher

Sinus modulation **± 10 kV** avec **90 W**

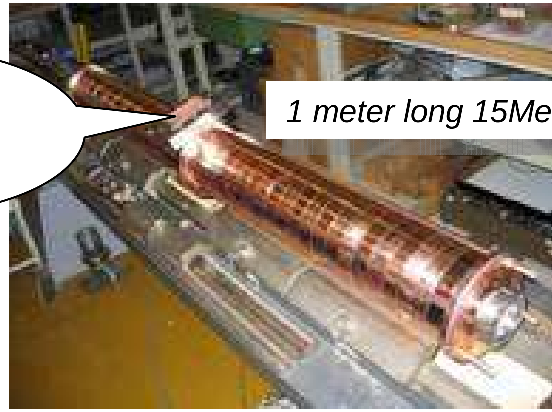
Fréquency : **2998.300MHz @ 36.5°C**

Buncher

Structure stationnary wave

E=**15 MeV** for P= **5.5 MW**

Fréquency: **2998.300MHz @36.5°C**



Accelerating sections

Structure at progressive waves :**4.5m** of long

Energy gain without beam :

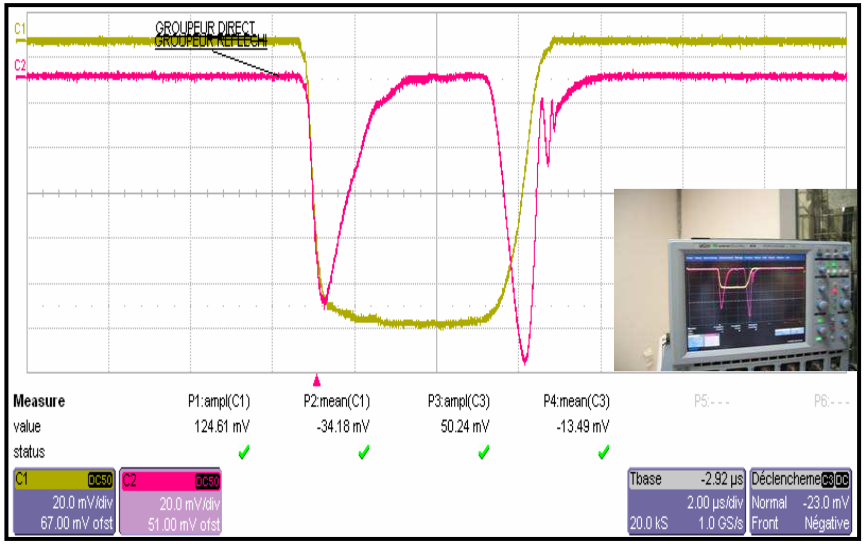
78 MeV pour 25MW in RF input

Frequency : **2998.300MHz @ 35°C**

Buncher conditioning

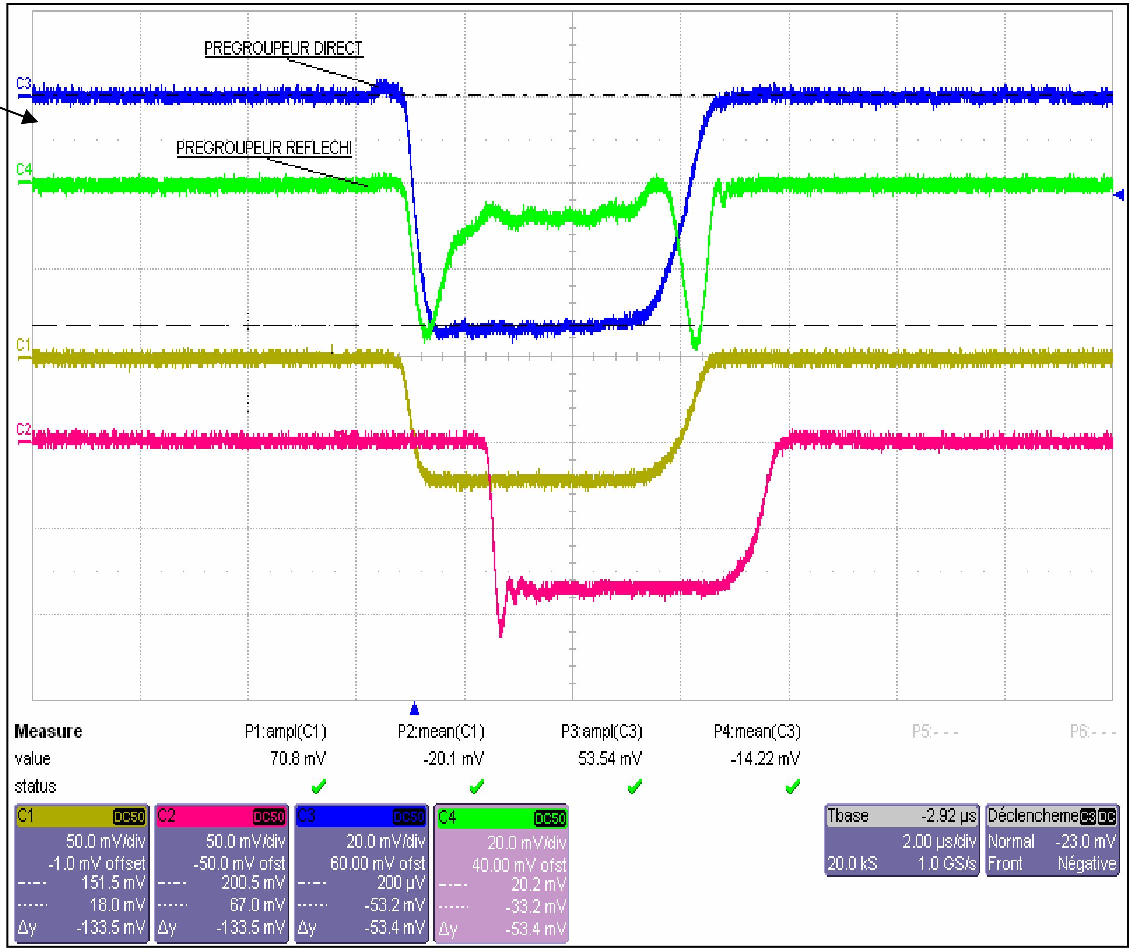
- **Endoscopic** analysis :
  no irregularity present
- **RF conditioning restart** with low power
- According to the MAC committee's advice:
  « An RF conditioning need long runs » :
  During one week : 8h;6h;8h at 1Hz
  5h at 3Hz
  (5µs pulses)

So, the maximal power (6MW) was obtained



The other RF structures

- **<u>Prebuncher:</u>**
  (single cavity)
  New cavity, no problem

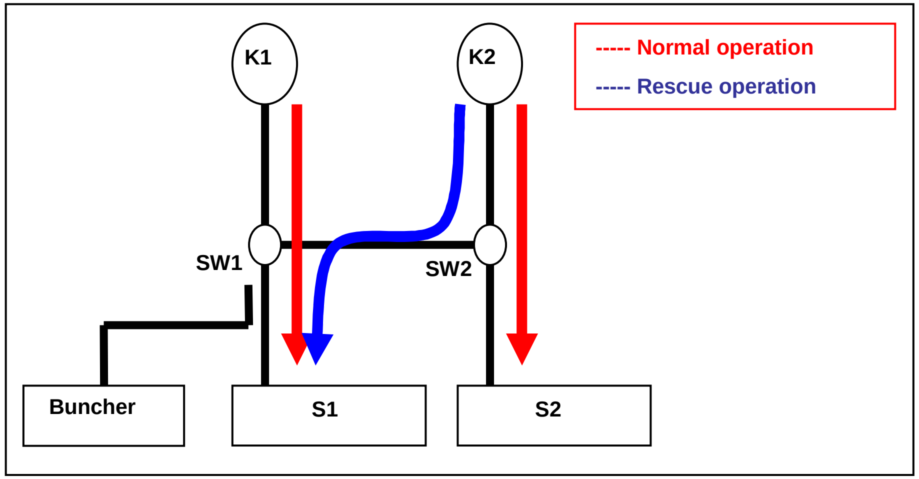


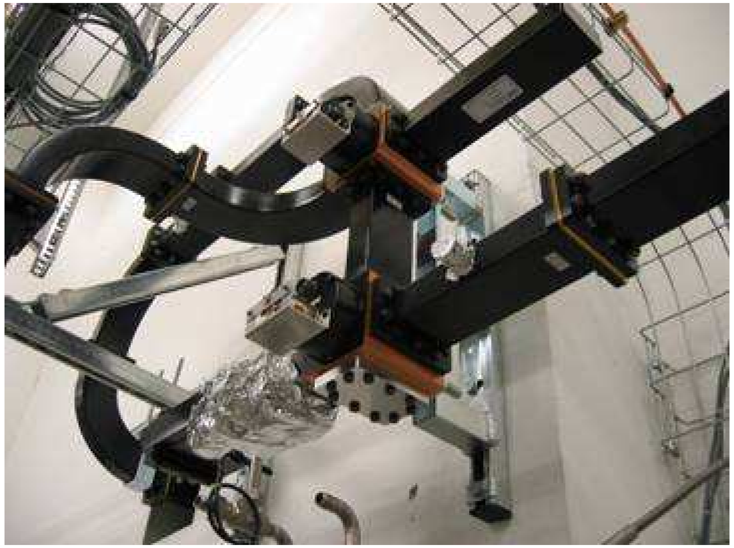
- **<u>Accelerating sections:</u>**
  (progressive wave)
  Structures coming from the CERN, no problem because RF power input is under or near the CERN'using.

Rescue Mode

*When we have **to replace a klystron** (K1 or K2), **a double switch system** (SW1, SW2) on waveguide network **always permits to feed the Linac front end** (buncher and section 1) **with the other klystron***

*In such a case the **Linac will make** a **78MeV beam** capable to be injected into the booster*





Tested with K1 during the first Linac's tests with the 66MeV beam

Tested, with succeed, with K2 (same beam's characteristics)

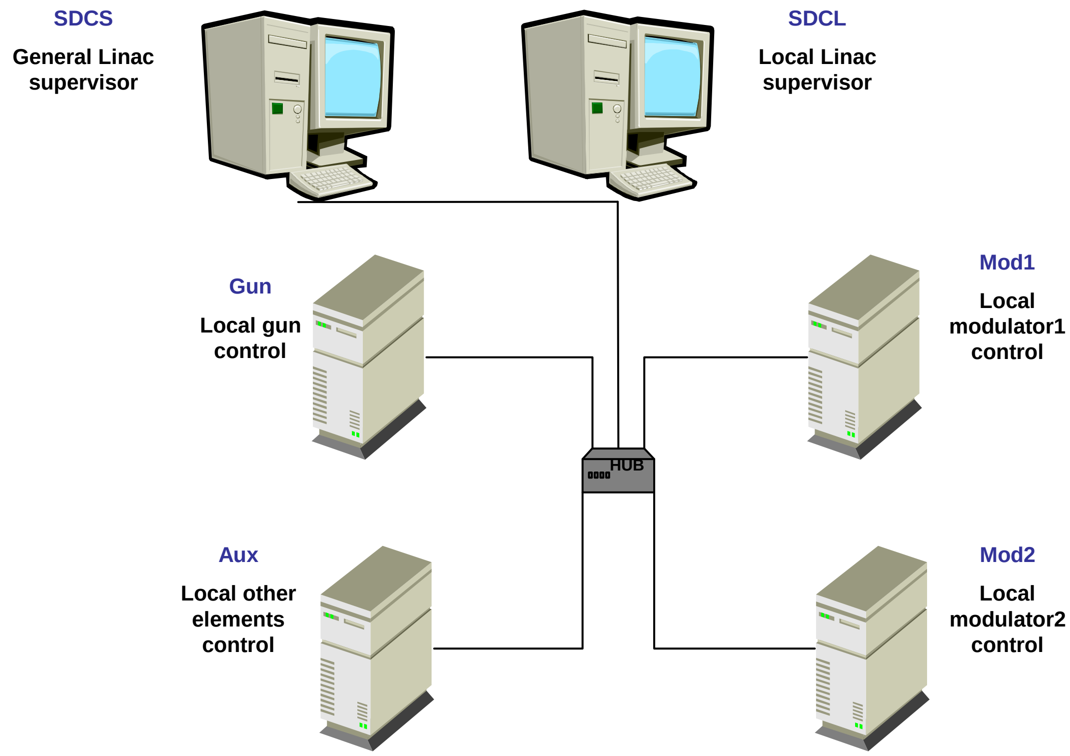
Command control

A local control system with LabVIEW applications using 6 computers:

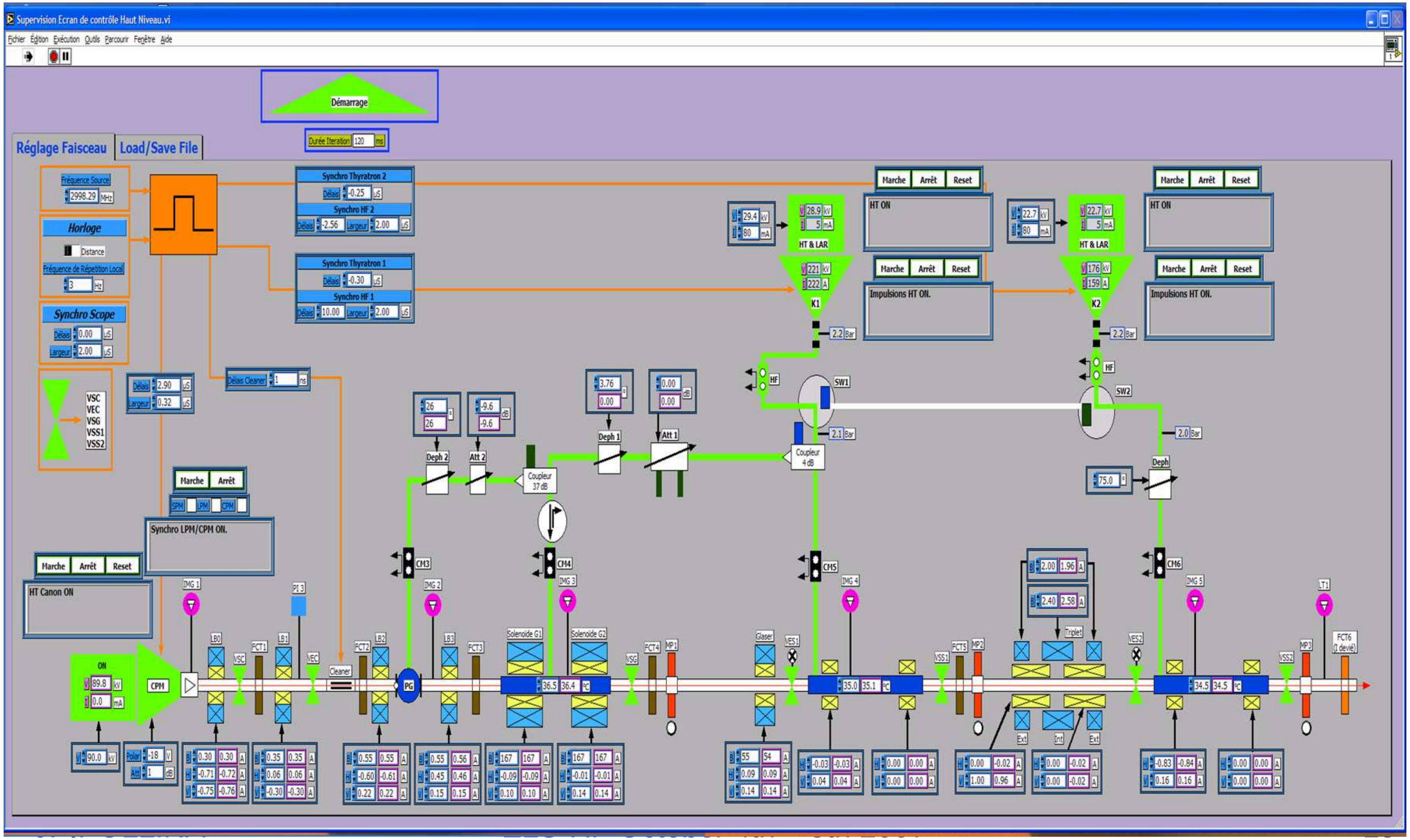
4 in the RF hall, 1 in the Linac local control room (SDCL) and 1 in the general control room (SDCS)

1. **Computer SDCL**: Local Linac supervisor (access to every adjustments)
2. **Computer SDCS**: General Linac supervisor (access to limited adjustments)
3. **Computer Modulator1**:
4. **Computer Modulator2**
5. **Computer Gun's modulator**:
6. **Computer Aux**: (fluids, vacuum…)

In the future this local control system will be linked to the TANGO control system of SOLEIL



Command control panel



Command control

- **Program validation**
  - » Labview program shows now a good efficiency and it's a good conception and stability after a long time
- **Link to Tango**
  - » Now it's use by Ethernet switch
  - » Waiting the definitive tango's software

Commissionning

Technical Reception

Verify the conformity equipments

- ***Water cooling system*** : leaks, stability in temperature, flows, pressure..
- ***Magnets equipments***: steerers, lens, coils, power supplies
- ***Diagnostics*** : FCT, screens and camera
- ***RF System: Sources, amplifiers***
- ***Modulators and klystrons*** (synchronisation., RF power…)
- **Gun's modulator and electron Gun**

Beam reception

Reception for each beam mode (CPM,LPM,SPM)

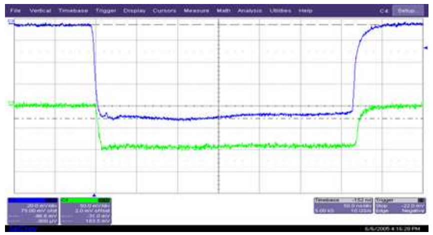
In parallel with the commissioning, the Linac was used to inject inside the Booster a 110MeV beam (LPM mode). This running time consisted in 8 shifts of 8 hours. The Linac showed good equipment reliability and excellent beam stability.

The beam characteristics required

Energy spread < ±1.5 %
Normalized emittance < 200 π mm mrad

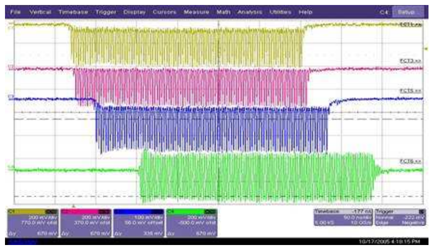
Repetition rate: 3 Hz for booster injection
10 Hz for Linac tests

CPM Mode (Continued Pulse Mode)



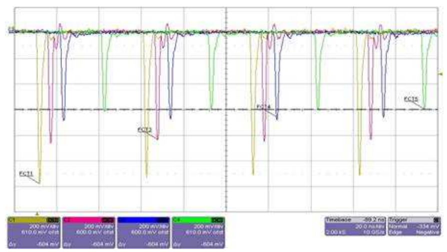
- Continued pulse during 300ns

LPM Mode (Long Pulse Mode)



- Pulses of 1.4ns at 352MHz during 500ns
  (296 ns for booster injection)
- Macro pulse : average current 30mA
- Macro pulse : total charge 8nC (296ns, 27mA)

SPM Mode (Short Pulse Mode)



- 1, 2, 3 or 4 pulses of 2ns FWHM
- peak pulse current 400mA (0.5nC)

Beam optimisation

- **For the know of the LINAC's beam parameters, the LINAC has needed of the LT1's beam diagnostics.**

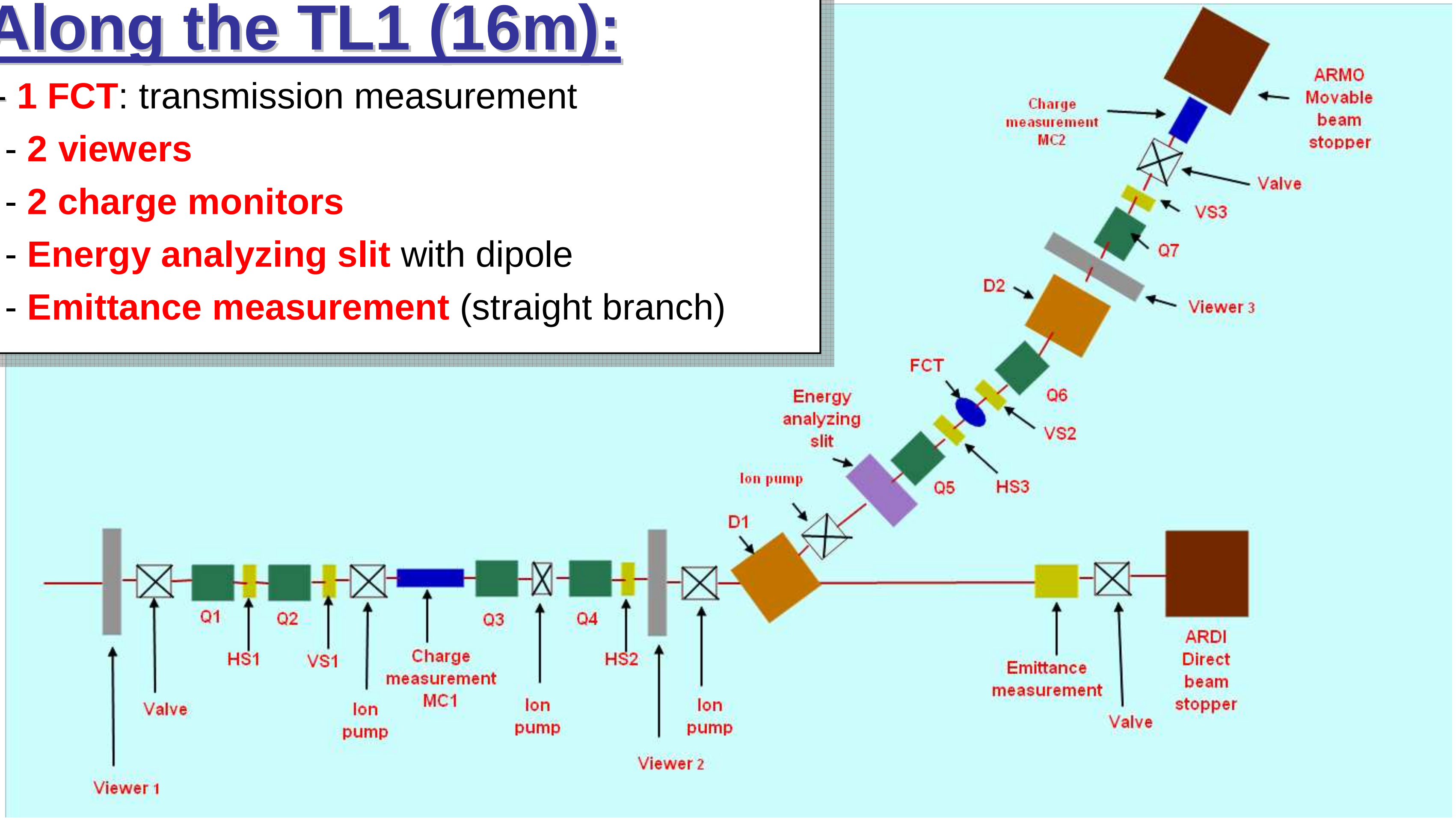
- Energy measurment, determinate energy parameters

***-** Emittance measurment, determinate the beam's dimensions*

Beam Diagnostics: The TL1

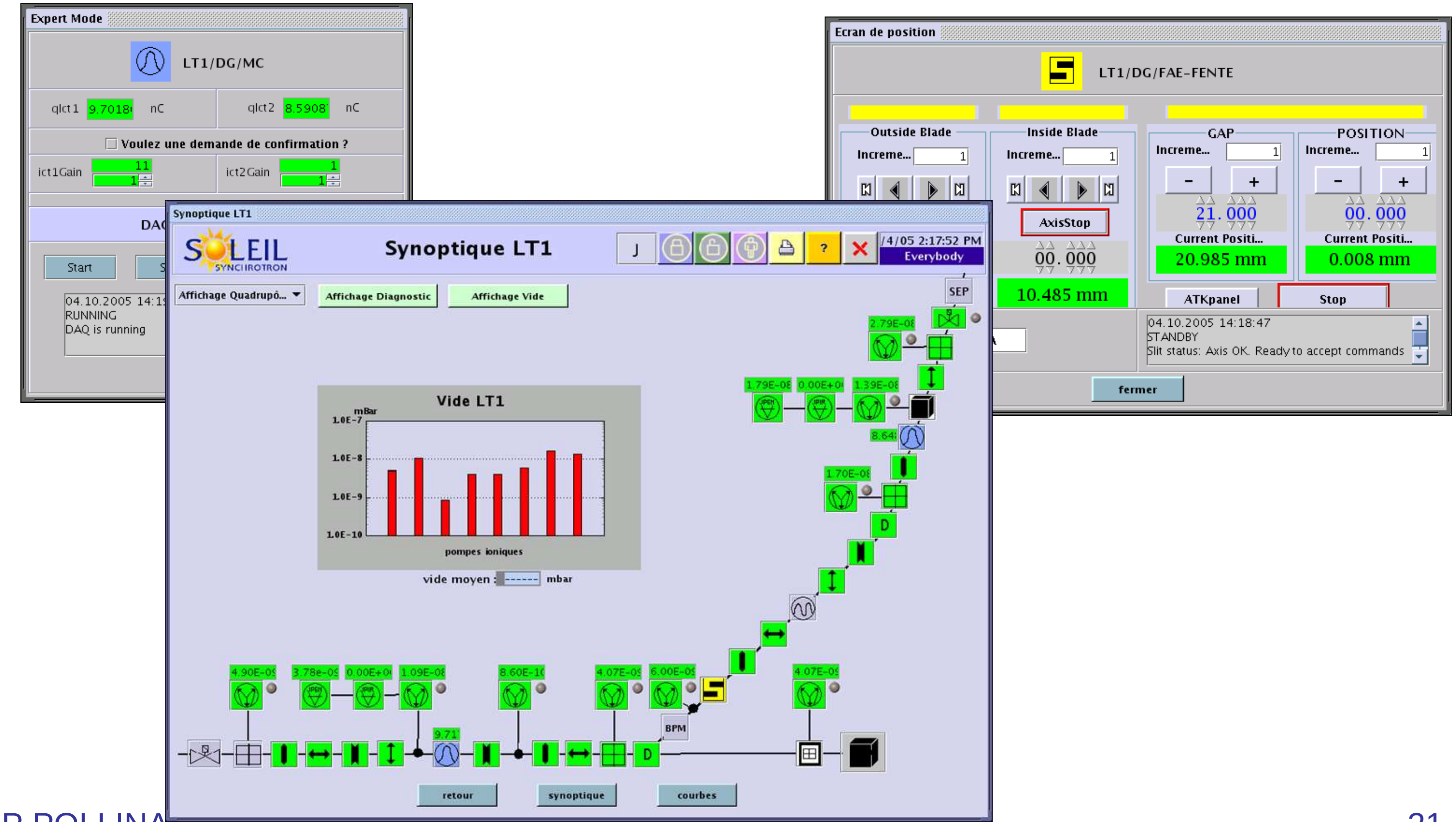
Along the TL1 (16m):

- **1 FCT**: transmission measurement
- **2 viewers**
- **2 charge monitors**
- **Energy analyzing slit** with dipole
- **Emittance measurement** (straight branch)



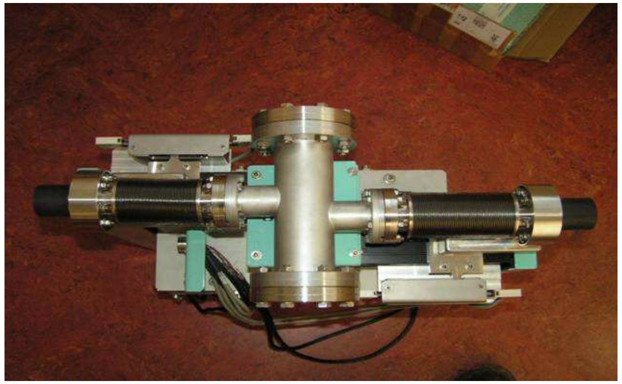
LT1 : control by GlobalScreen

M-A. Tordeux

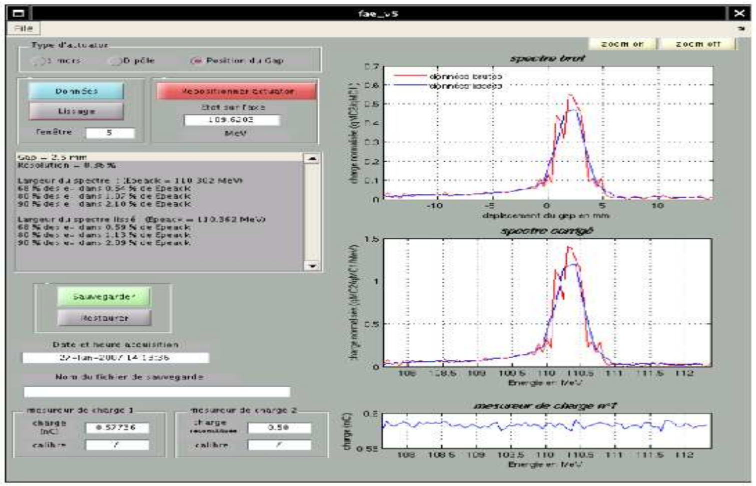


Energy Measurement

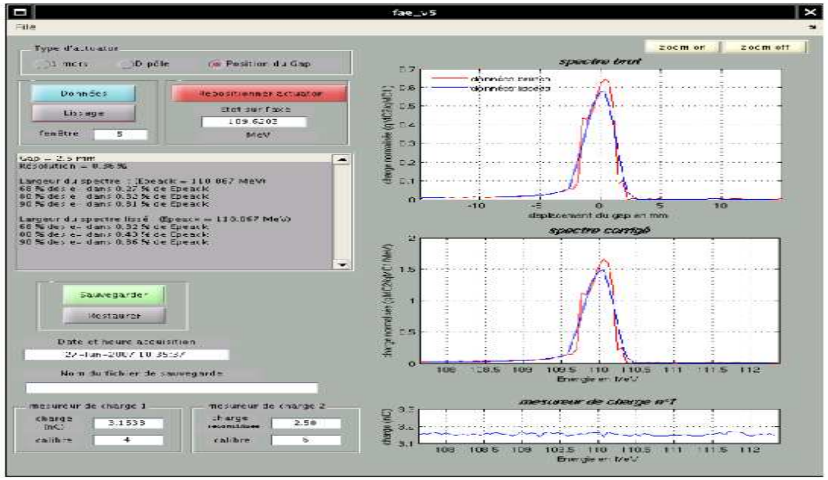
developped by Marie-Agnes TORDEUX



Analysing slits



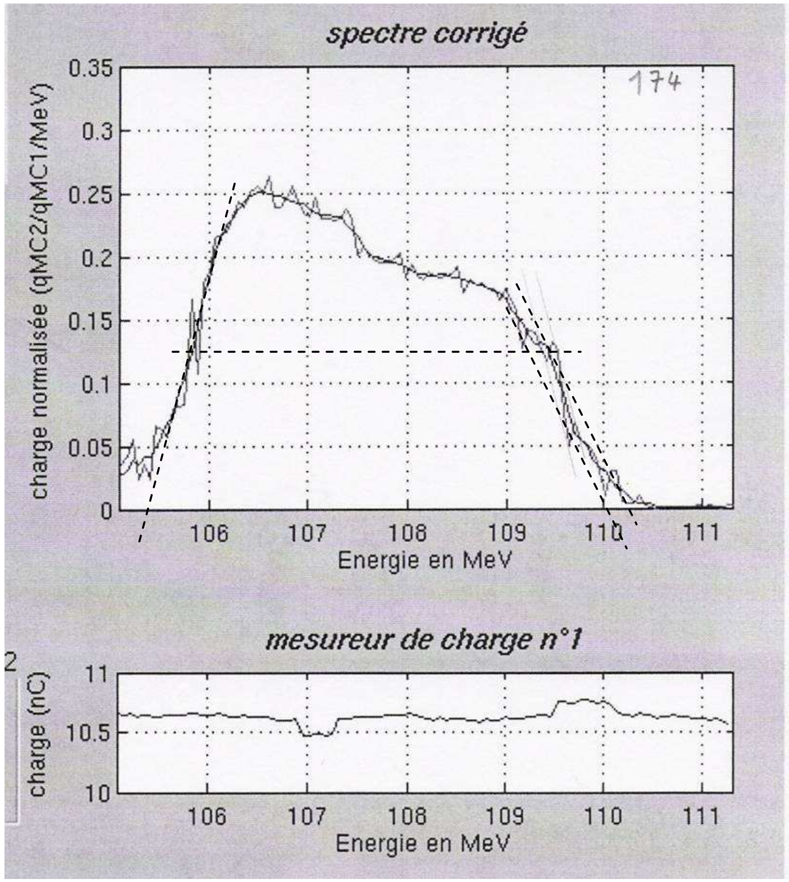
SPM 1 bucket,110 MeV



LPM 3nC,110 MeV

Mode LPM: *Long Pulse Mode*

Classic energy spectrum



This large spectrum is due to the beam-loading

The energy dispersion measured is :

5.2 MeV on the base
3.75 MeV for 50%

±1.5% = 3.2MeV

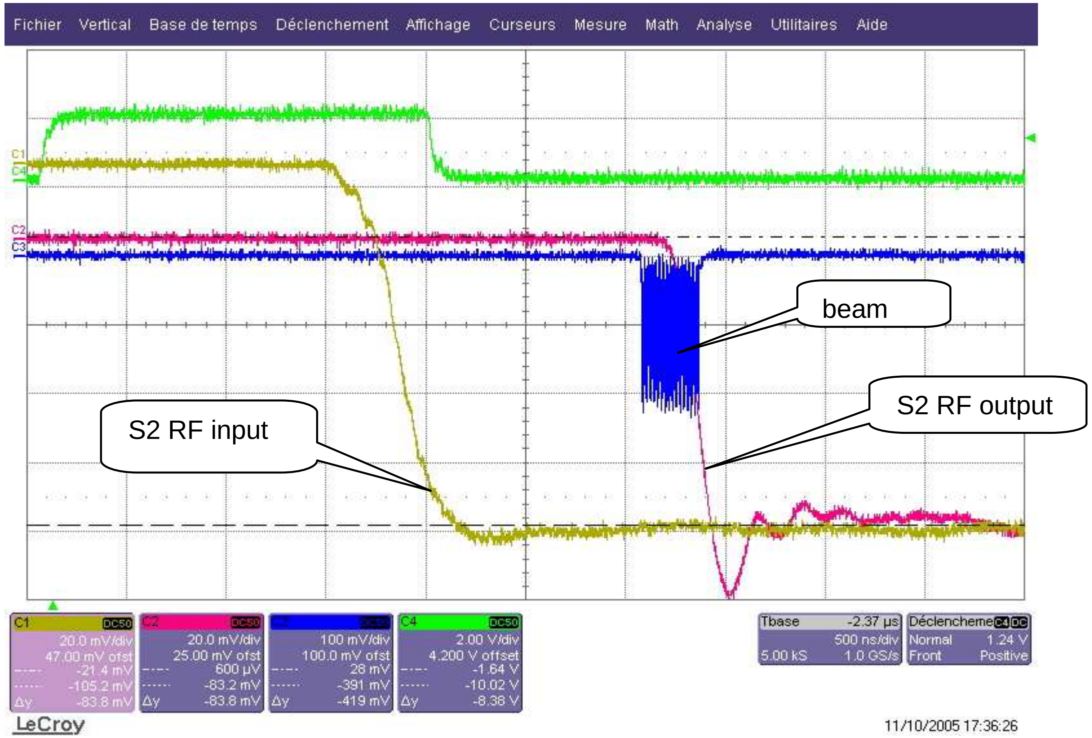
Charge instability with MC1 :

0.25 nCcc

Mode LPM: *Long Pulse Mode*

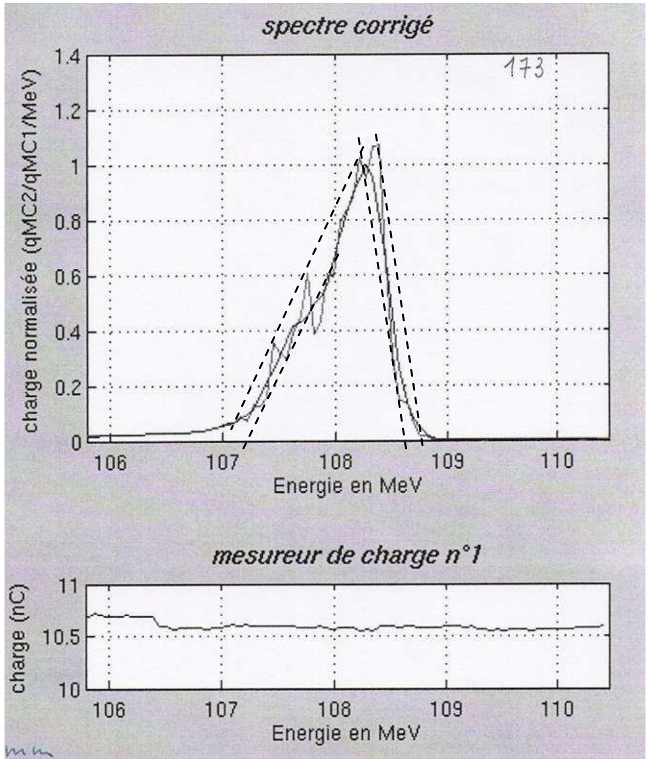
Compensate energy spectrum :

The best energy spectrum is obtained with the beam-loading compensation when the beam is injected during the 2nd section's filling time.



Mode LPM: *Long Pulse Mode*

Compensate energy spectrum



The new energy dispersion measured is :

1.6 MeV, on the base
0.77 MeV for 50%

±1.5% = 3.2MeV

Charge instability:

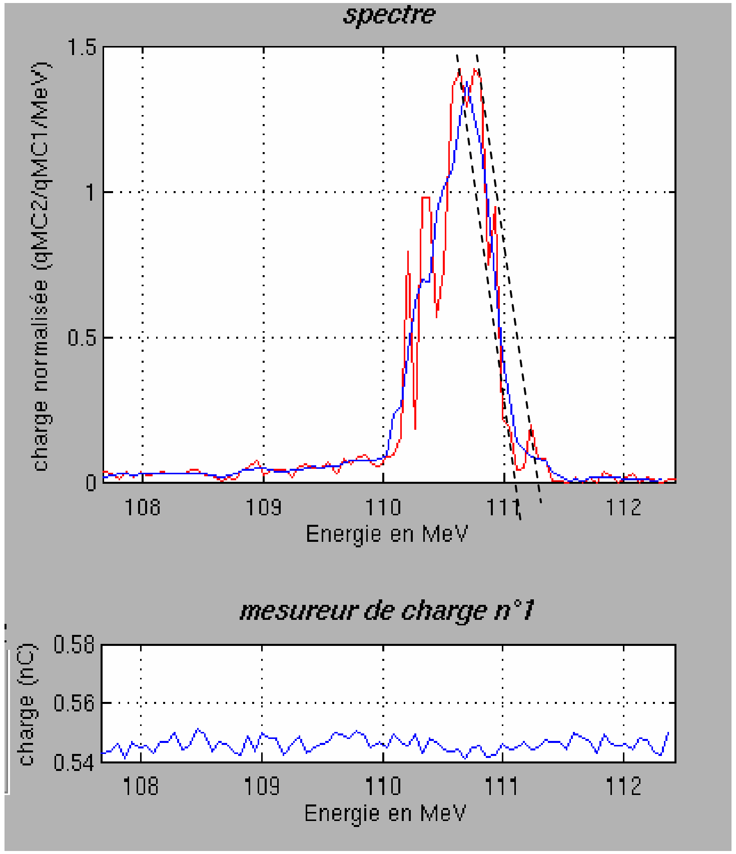
0.1nC (from 107 to 110MeV) = 1%cc

Emittance measurement

Energy (MeV)	Emittance	
108.3	π σ.σ' (π mm. mrad)	Normalized 4 π βγ σ.σ' (π mm. mrad)
Horizontal	0.056	47
Vertical	0.061	52

Mode SPM: *Single Pulse Mode*

Energy spectrum for one pulse



The energy dispersion measured is :

1.3 MeV on the base (1.17%)
0.58 MeV for 50%

Charge instability:

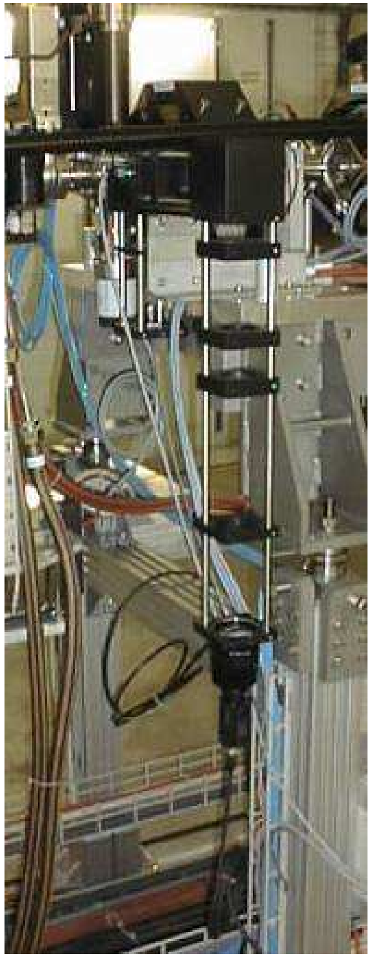
0.07nCcc

Emittance measurement

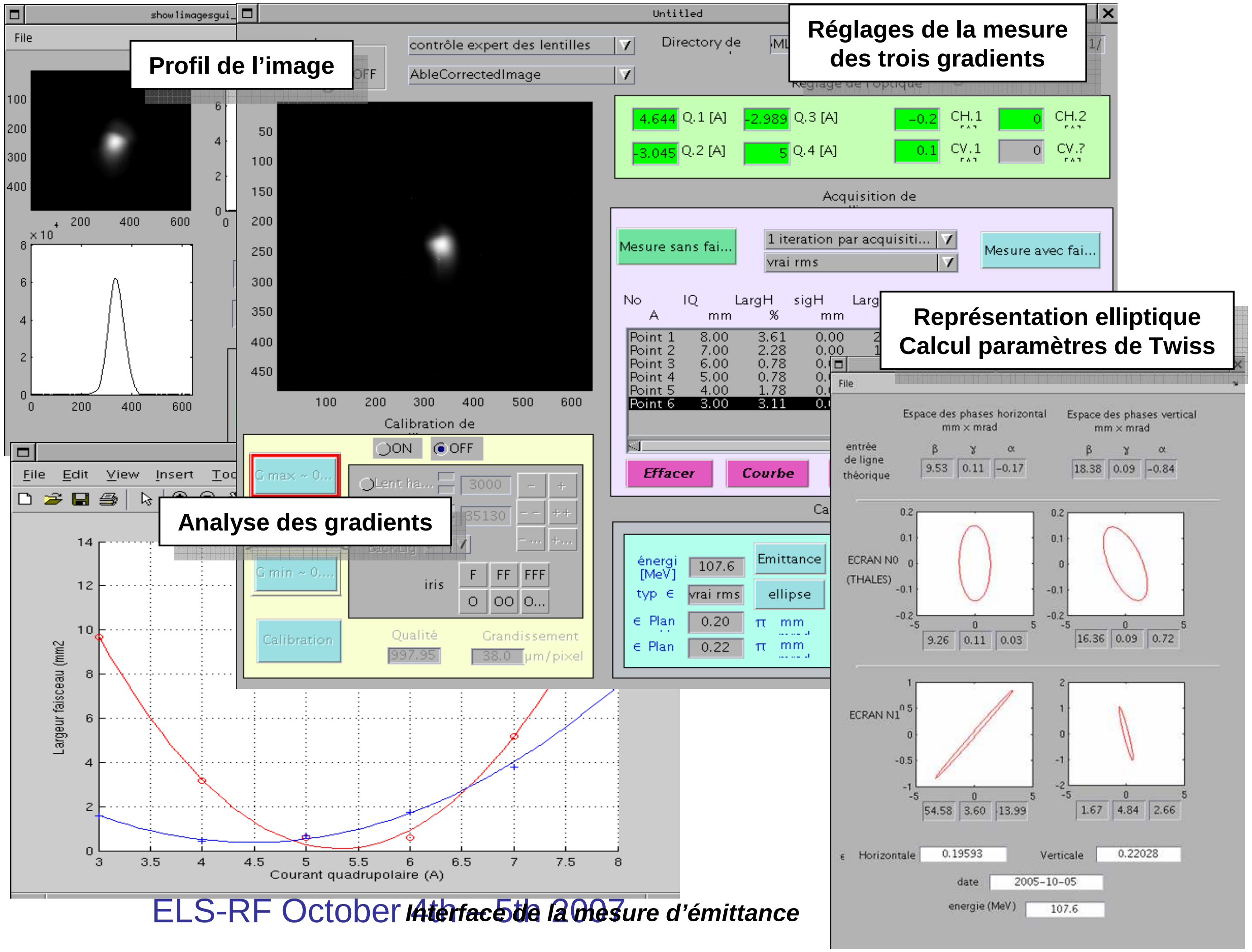
Energy (MeV)	Emittance	
110.7	π σ.σ' (π mm. mrad)	Normalized 4 π βγ σ.σ' (π mm. mrad)
Horizontal	0.073	64
Vertical	0.077	67

Beam measurment :
Emittance

developped by Marie-Agnes TORDEUX

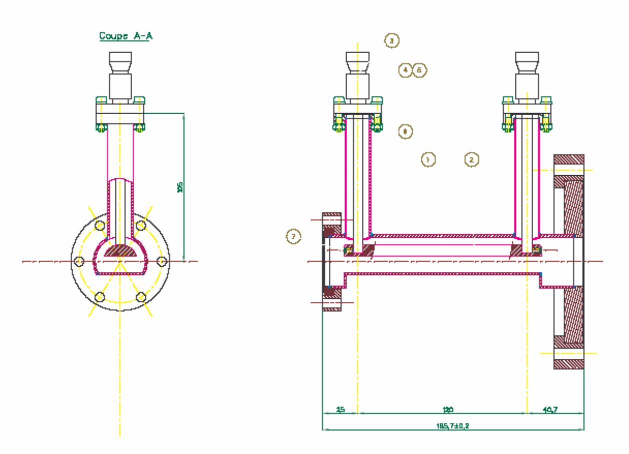


Exemple du système optique de la mesure d'émittance

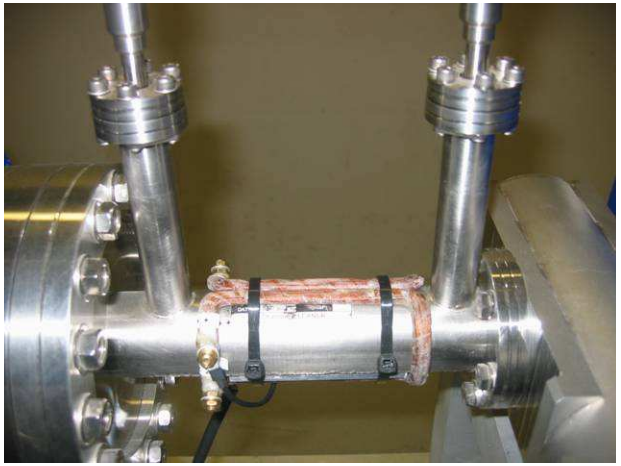


Interface de la mesure d'émittance

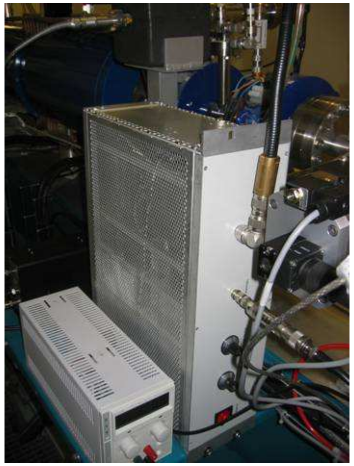
The cleaner



At the beginning, the pulse générator (FID GdmH)did the beam deflection and restore the beam's trajectory inside a window of 2ns



Now, it has got a new design, a magnet coil supply in direct current, and the pulse generator modify at a single function, restore the beam's trajectory



Future measurement

- Verify with ring's purity measurement, the efficiency of the cleaner.
  - In case to buy a spare or developpe a new design for the pulse generator