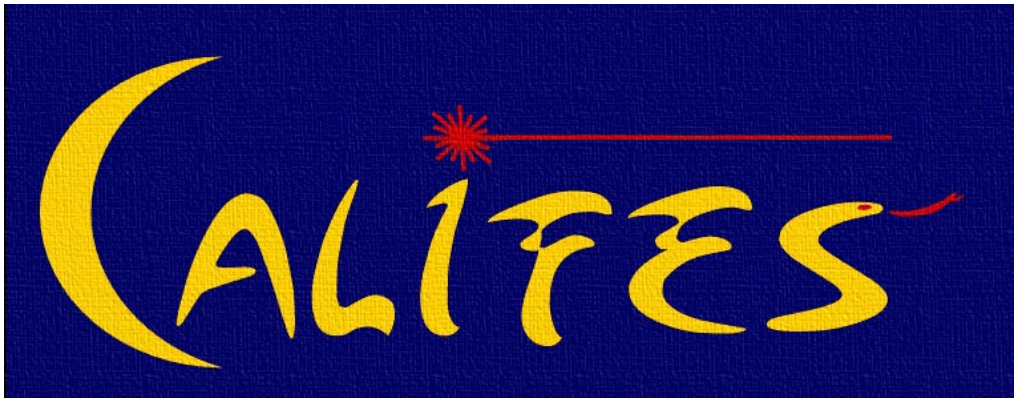
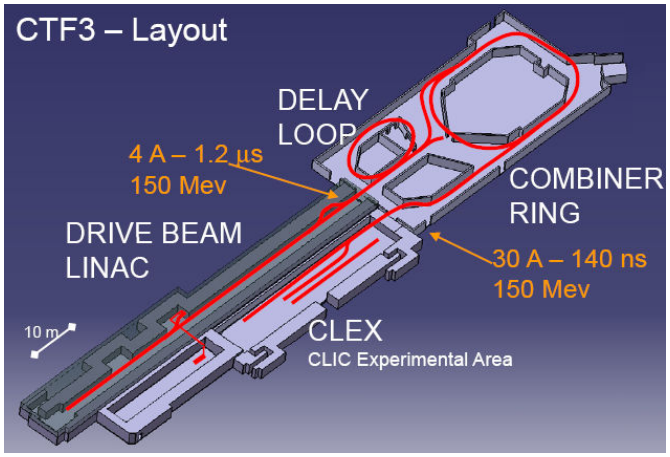
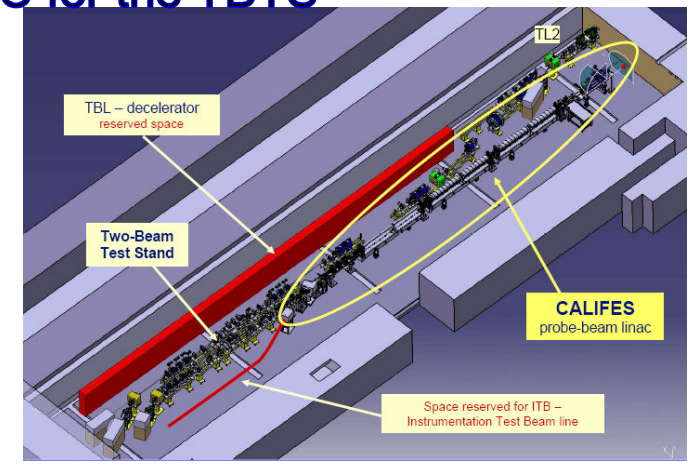
# Status and progress of the CTF3 probe beam



# What is CALIFES ?

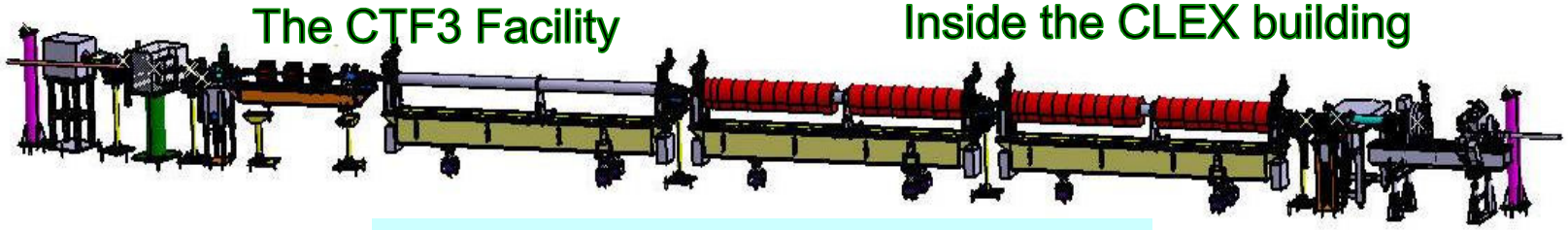
## Probe beam LINAC for the TBTS




## The CTF3 Facility

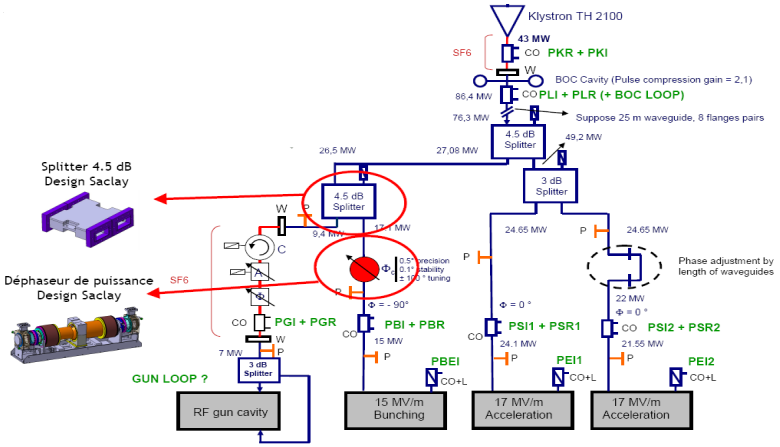
## Inside the CLEX building

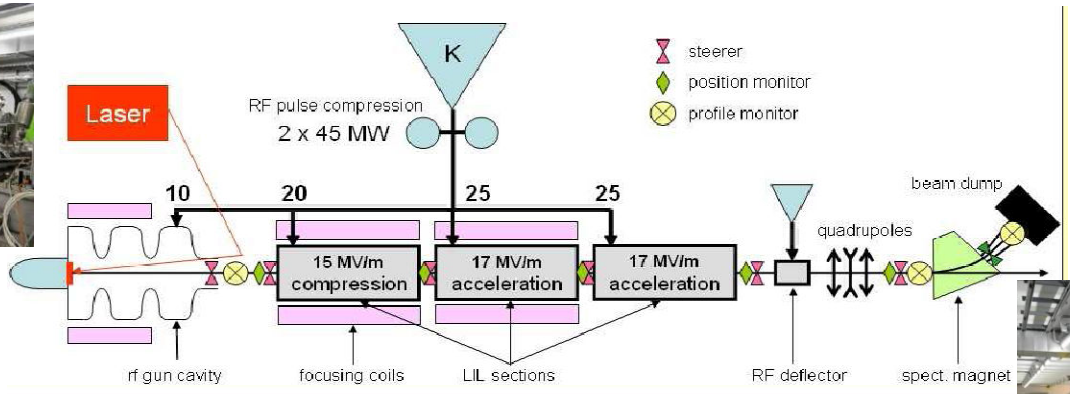


CALIFES specifications:

- Energy : ~ 177 MeV
- Energy dispersion : ± 2%
- Emittance : <20 π mm.mrad
- Bunch charge : 0.6 nC
- Bunch train : 1 – 32 – 226
- Bunch spacing : 0.667 ns
- Bunch length : 0.75 ps
- repetition rate : 5 Hz

# CALIFES layout

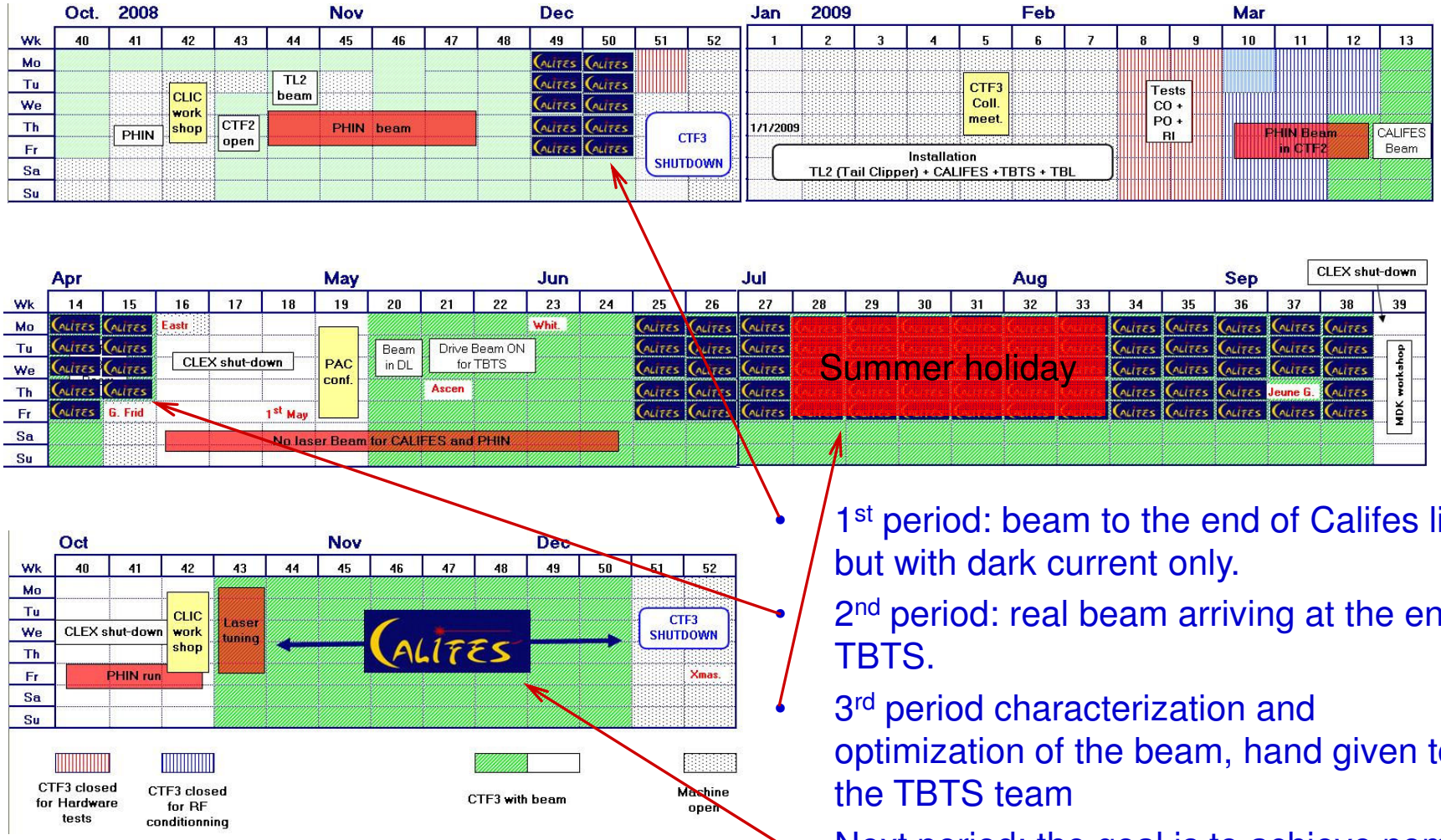



Based on:

- Photo-injector (LAL Orsay)
- Laser line (using the same laser as for PHIN)
- 3 former LIL accelerating structures
- A single klystron 45 MW, RF distributed to the structures and the gun
- A complete set of diagnostics

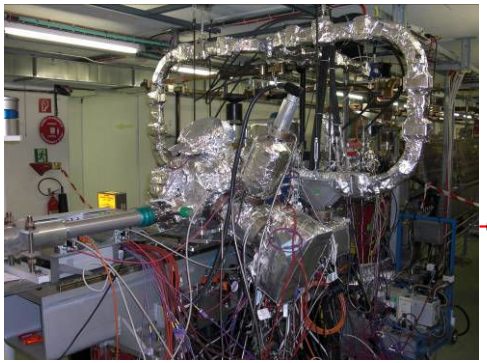
# Operations schedule



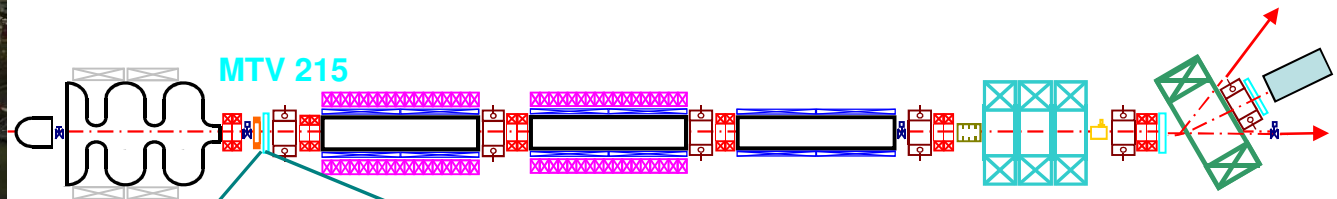

- 1st period: beam to the end of Califes line but with dark current only.
- 2nd period: real beam arriving at the end of TBTS.
- 3rd period characterization and optimization of the beam, hand given to the TBTS team
- Next period: the goal is to achieve nominal performances…

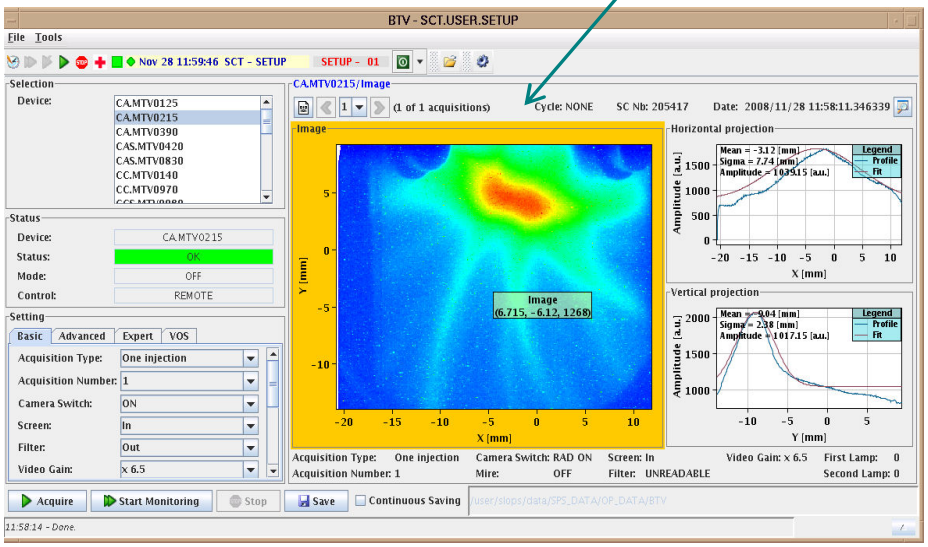
Thanks to Jose Monteiro for planning

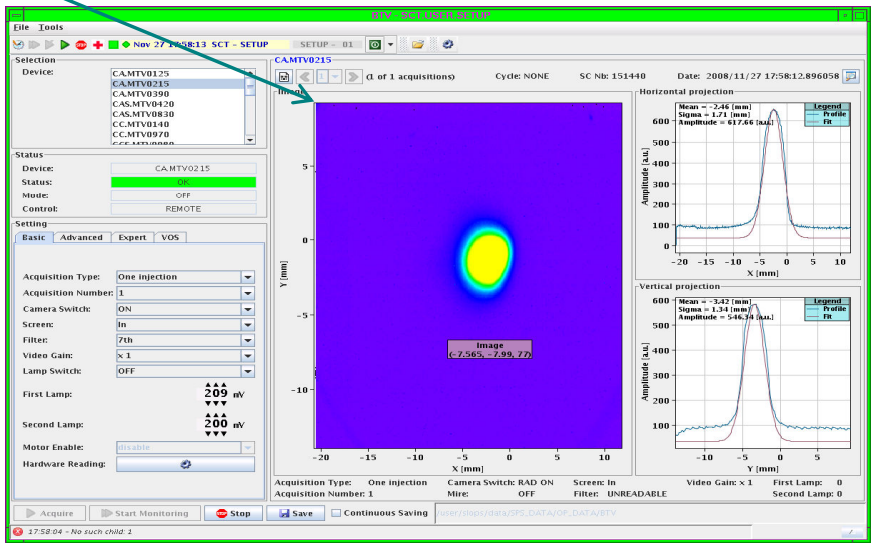
# First period results (overview 1/2)



## Beam was immediately seen at the gun output



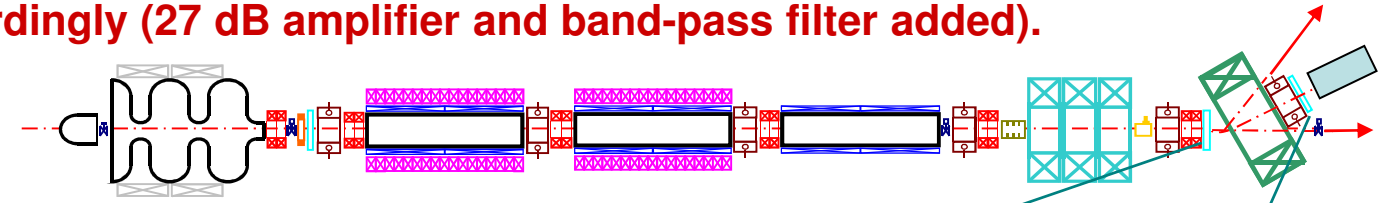




- Dark Current with ~70 MV/m on the photocathode
  (video gain is pushed at x 6.5, no filter)

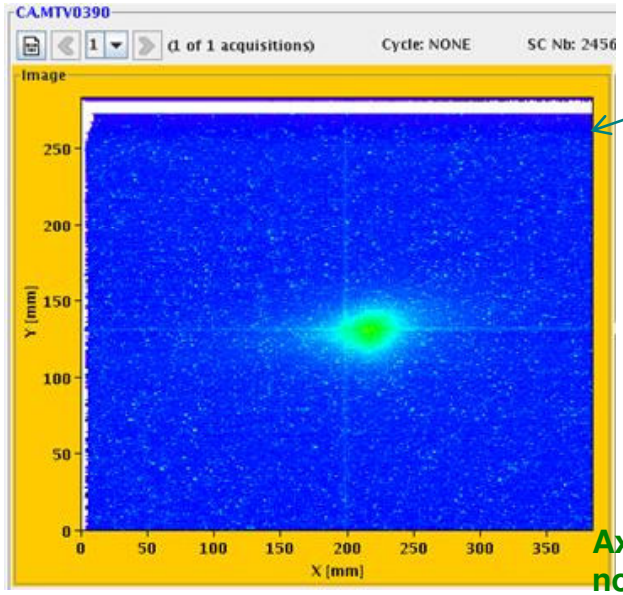
- The beam with laser pulse train of 100 ns: 150 bunches - 0.073 nC per bunch – QE ~1%)
  (video gain x 1 and optical filter inserted)

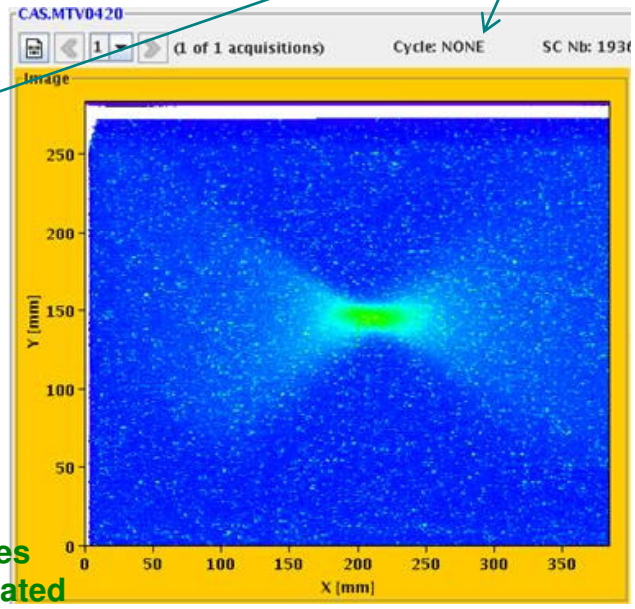
# First period results (overview 2/2)

- **Monday 8 Dec.: the laser driver failed after one month of regular operations.**
- **We decide to carry on with the dark current only, BPM electronics was adapted accordingly (27 dB amplifier and band-pass filter added).**



Thanks to Alexandra Andersson




**Axis scales not calibrated**

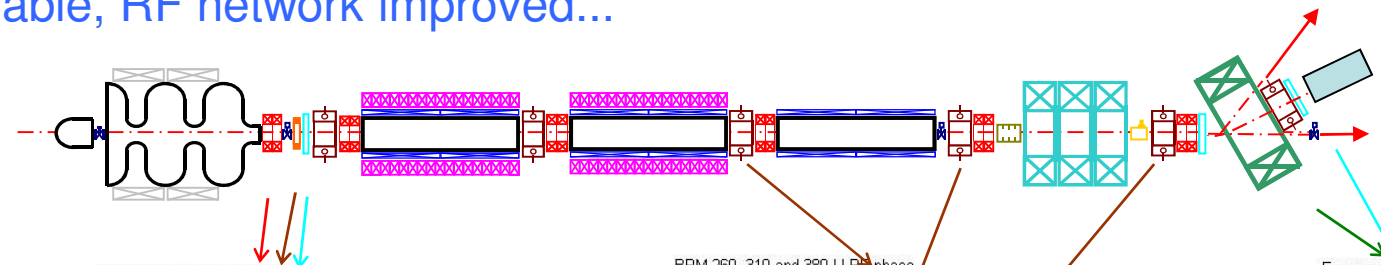
**Video gain x 8,**
**Beam diameter 1mm approx**

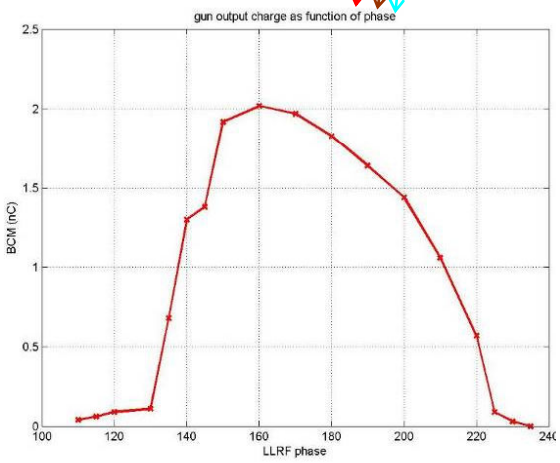
**Dipole current 28.4 A : 114 MeV**
**Energy dispersion : < 1%**

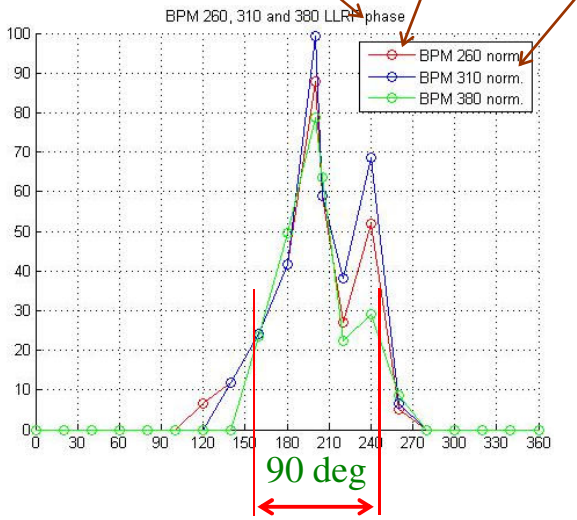
This unusual commissioning gave confidence in the Califes operations and allowed a list of corrective actions to be established and completed before the next run, regarding : RF phase tuning, survey, diagnostics, C/C…

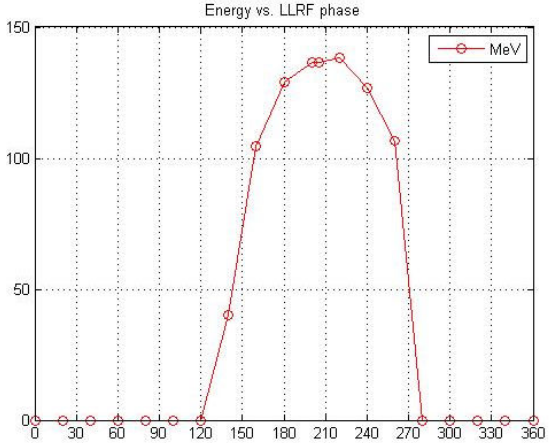
# Second period results (overview 1/3)

A lot of improvements conducted during the shut-down: phases between accelerating structures tuned, deflecting cavity connected, laser made reliable, RF network improved...





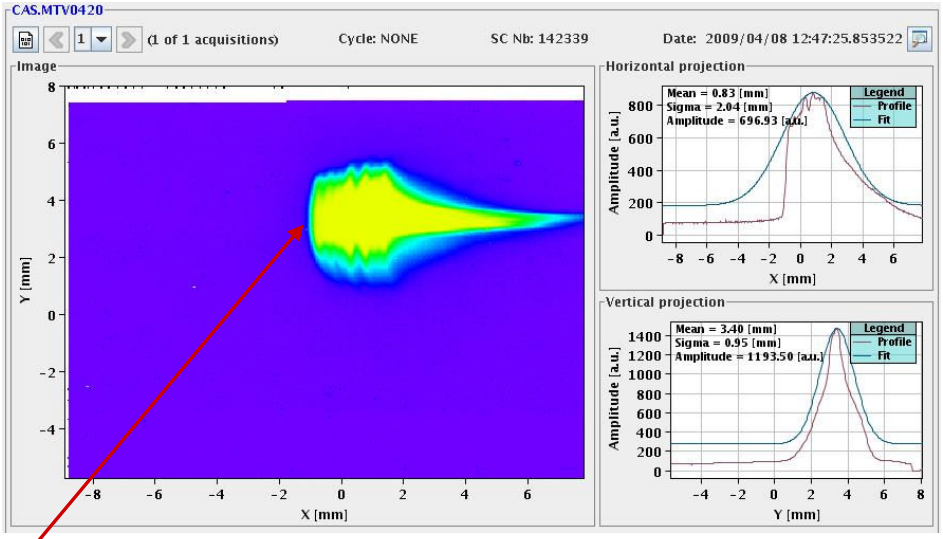




- Gun charge vs. phase scan
- Similar to the PHIN
- 0.2 nC/bunch, QE = 0.5%,
- Energy 5.7 MeV (evaluated with the DH/DV130 corrector)

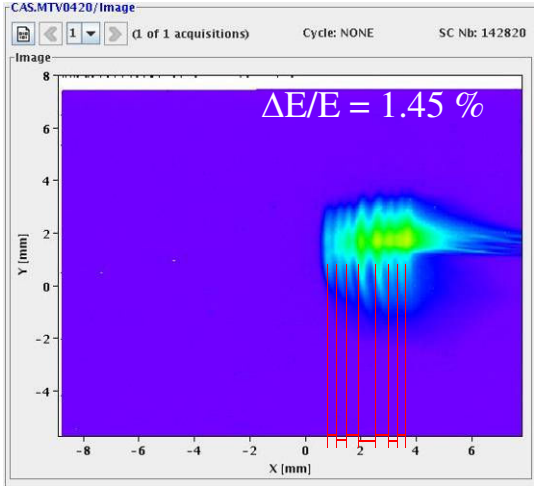
Transmission vs. phase scan

Energy vs. phase scan

# Second period results (overview 2/3)

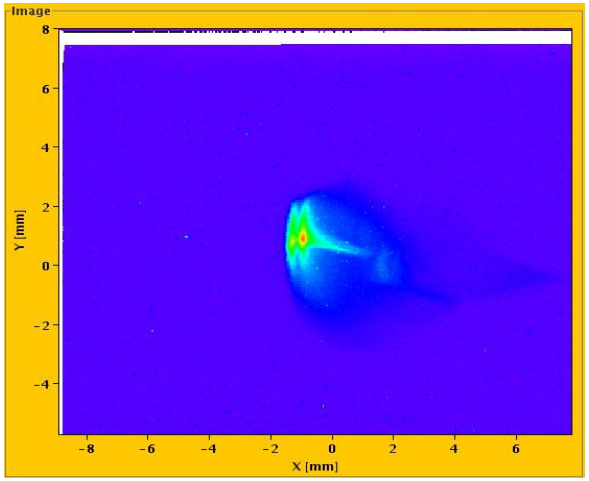



**Bunch train max energy : 140 MeV (nominal 177 MeV)**

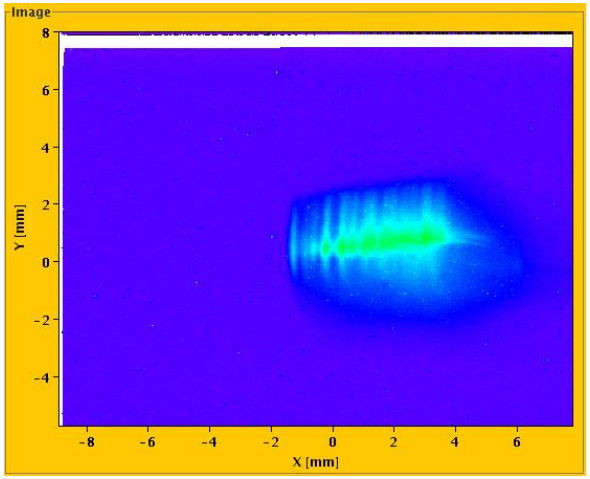



**170 keV < ΔE < 370 keV**

Bunches are energy resolved – 7 ns train

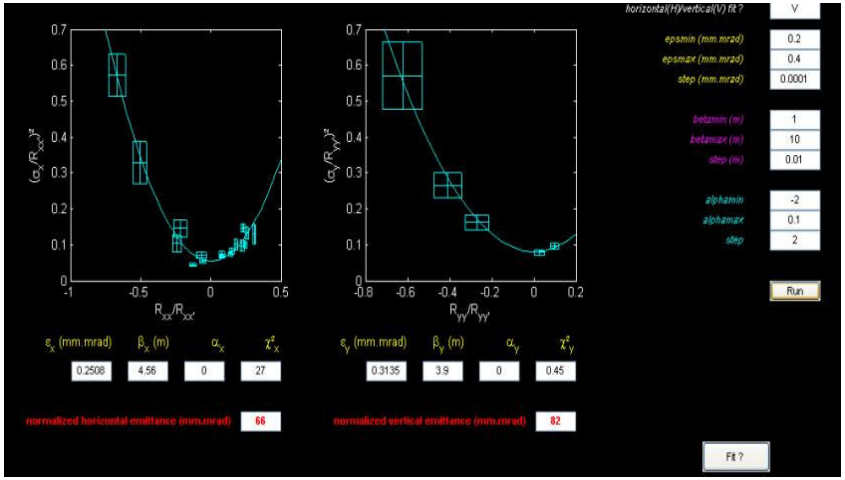



3 ns train



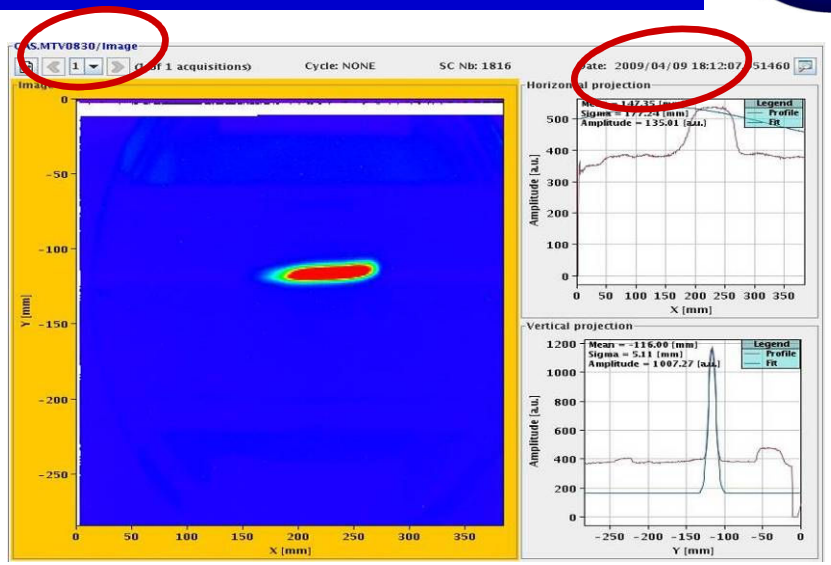

12 ns train

# Second period results (overview 3/3)



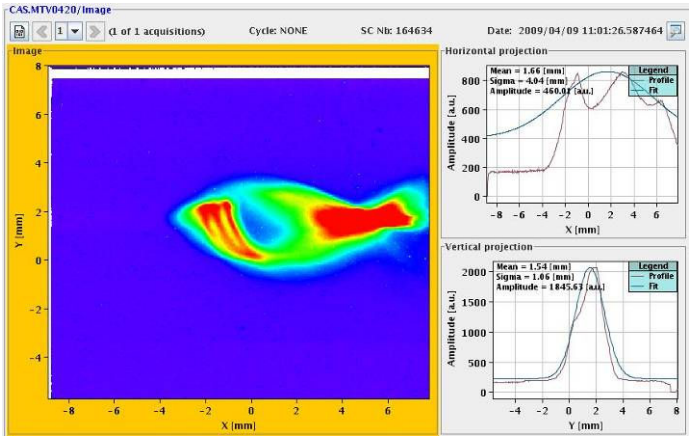

**First measure of emittance with quad scan :**

**$\varepsilon$Nx = 66 μm, $\varepsilon$Ny = 82 μm (specif. < 20 μm)**




**9th April 09: First beam at the end of the TBTS**

**Happiness in the control room**




**Poisson d'Avril for April's fools day**

# Deflecting cavity conditioning

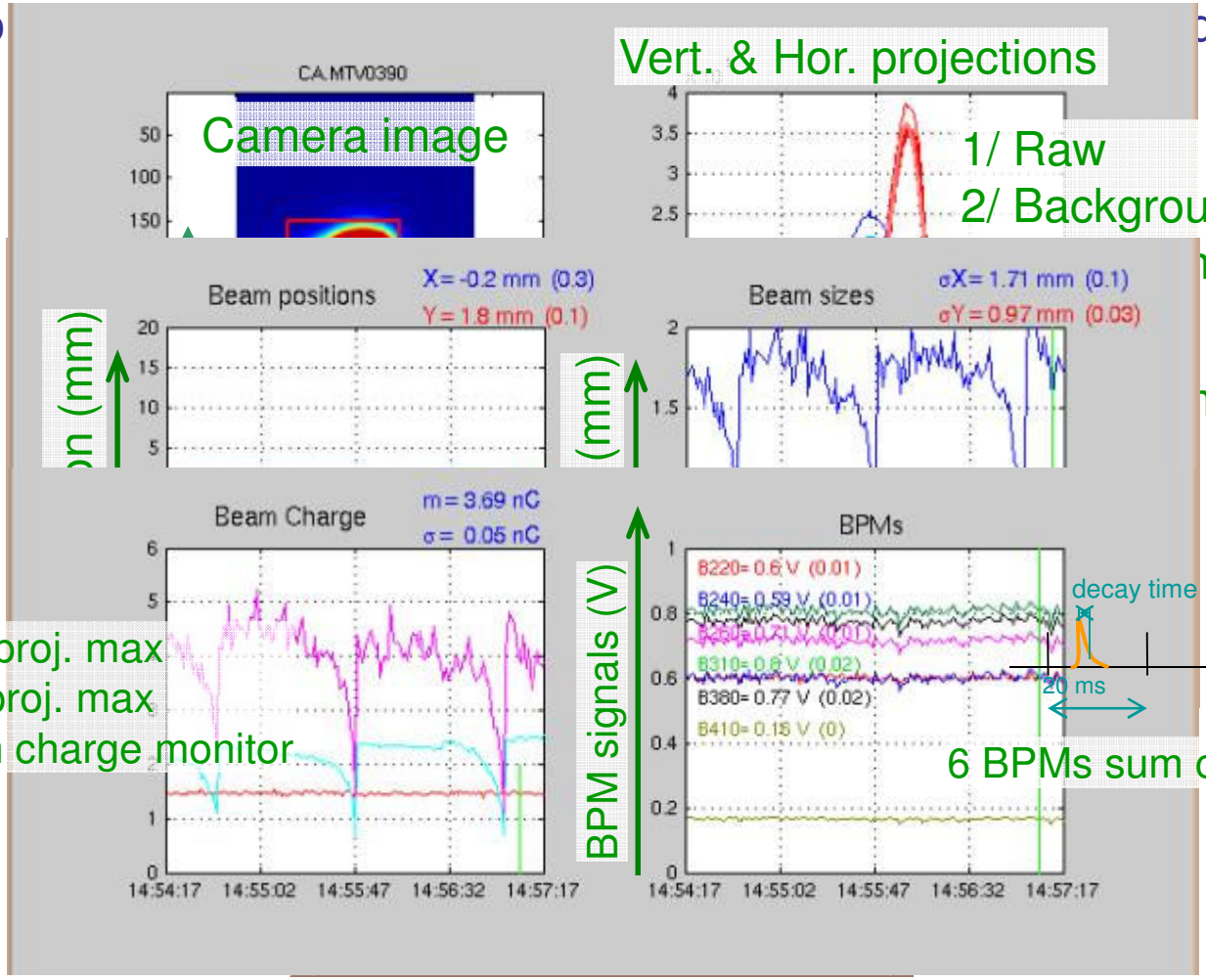
15th May 09: The conditioning of the deflecting cavity experiences too high reflected power (-13 dB).
Eventually, we suspect an obstacle in the long waveguide line (~80 m) from MKS14 to the deflecting cavity.
Reflectometric method allows to spot this waveguide.


Thanks to Gerry Mc Monagle for pictures and investigation

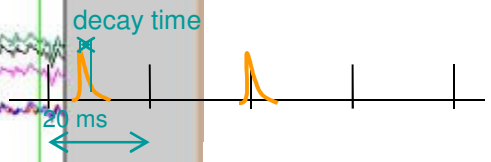
**Object found inside: a device used in the brazing oven**

# Third period results (detailed)

- The laser system has been greatly improved (energy, beam size)
- Command control now allows to operate from the control room.
- Deflecting cavity is ready for bunch length measurement.
- Matlab data analysis.

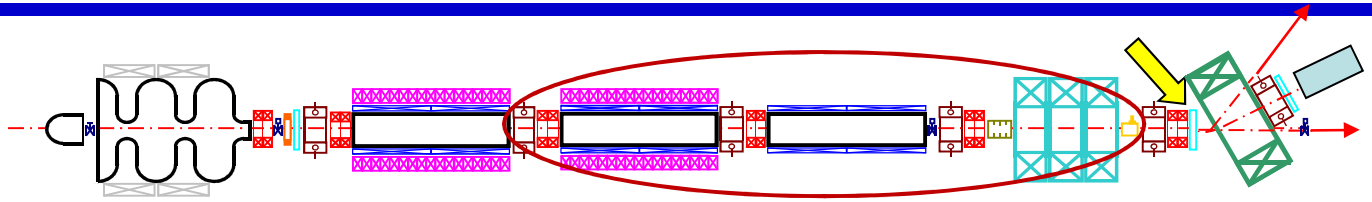


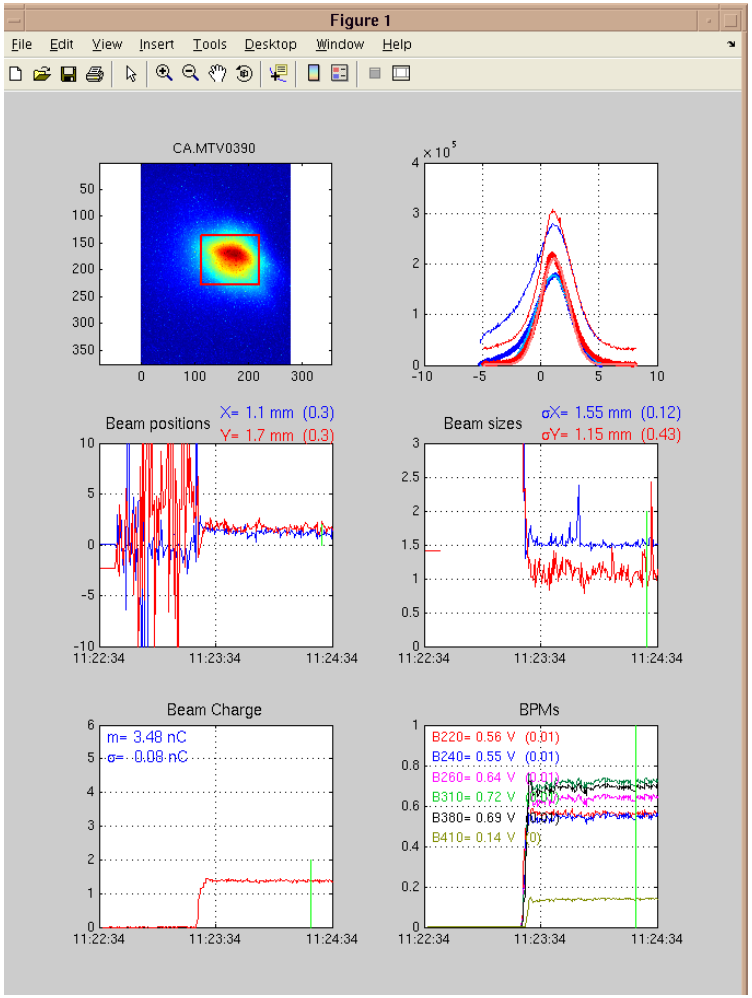

Vert. proj. max
Hor. proj. max
Beam charge monitor




6 BPMs sum channels

# Beam transmission along the line






- Beam size σx = 1.55 mm, σy = 1.15 mm with minimum of magnetic elements used.
- The SNG0250 solenoid was responsible of a significant vertical deviation.
- Nearly 100 % transmission and beam to the end of TBTS with a minimum of tuning every day.

| POW-V | Status | CCV | AQ |
|---|---|---|---|
| CA.SNI0120 | On | 285.00 | |

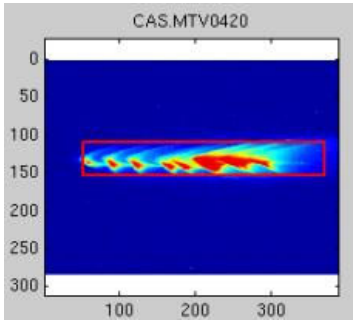
| PowDF7000 | Mode | Control | CCV |
|---|---|---|---|
| CA.SNH0110 | On | Remote | 255.00 |
| CA.SNG0230 | On | Remote | 135.00 |
| CA.SNG0250 | On | Remote | 0.00 |

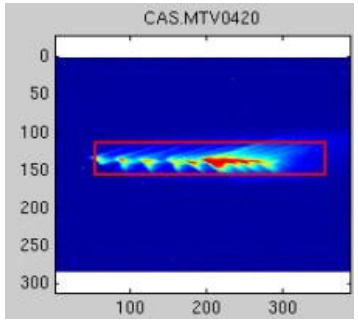
| PowDF7000 | Mode | Control | CCV |
|---|---|---|---|
| CA.QFD0350 | Stand-By | Remote | 80.80 |
| CA.QDD0355 | Stand-By | Remote | 82.00 |
| CA.QFD0360 | Stand-By | Remote | 80.80 |

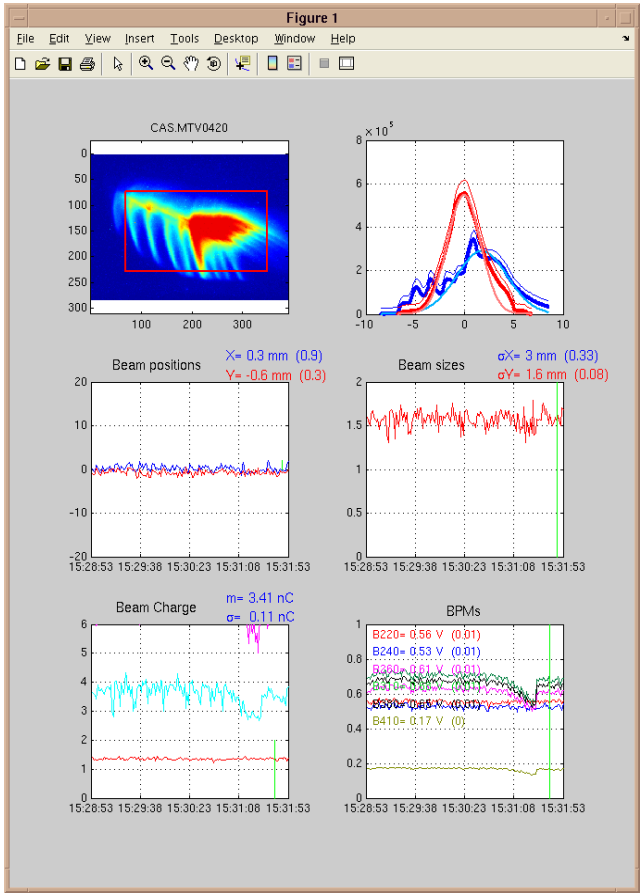
| PowDF7000 | Mode | Control | CCV |
|---|---|---|---|
| CA.BHB0400 | On | Remote | 28.70 |

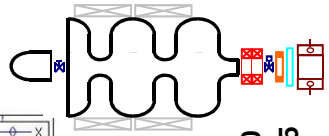
| PowDF7000 | Mode | Control | CCV |
|---|---|---|---|
| CA.DHG0130 | On | Remote | 1.60 |
| CA.DHG0225 | On | Remote | 0.00 |
| CA.DHB0230-S | On | Remote | 0.00 |
| CA.DHG0245 | On | Remote | -0.50 |
| CA.DHB0250 | On | Remote | -1.10 |
| CA.DHG0265 | On | Remote | -2.80 |
| CA.DHB0270 | On | Remote | 0.00 |
| CA.DHG0320 | On | Remote | 0.00 |
| CA.DHG0385 | On | Remote | 2.00 |
| CA.DVG0130 | On | Remote | 0.00 |
| CA.DVG0225 | On | Remote | -1.20 |
| CA.DVB0230-S | On | Remote | 2.60 |
| CA.DVG0245 | On | Remote | 2.00 |
| CA.DVB0250 | On | Remote | 2.00 |
| CA.DVG0265 | On | Remote | 3.10 |
| CA.DVB0270 | On | Remote | 0.00 |
| CA.DVG0320 | On | Remote | 0.00 |
| CA.DVG0385 | On | Remote | -4.00 |

# Energy and energy spread

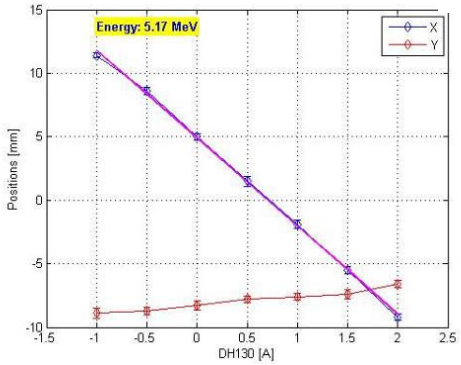


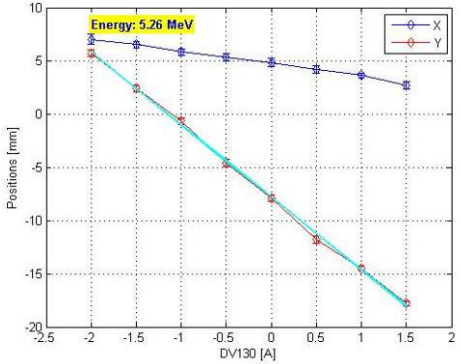



DHG/DVG 0130
MTV 0215

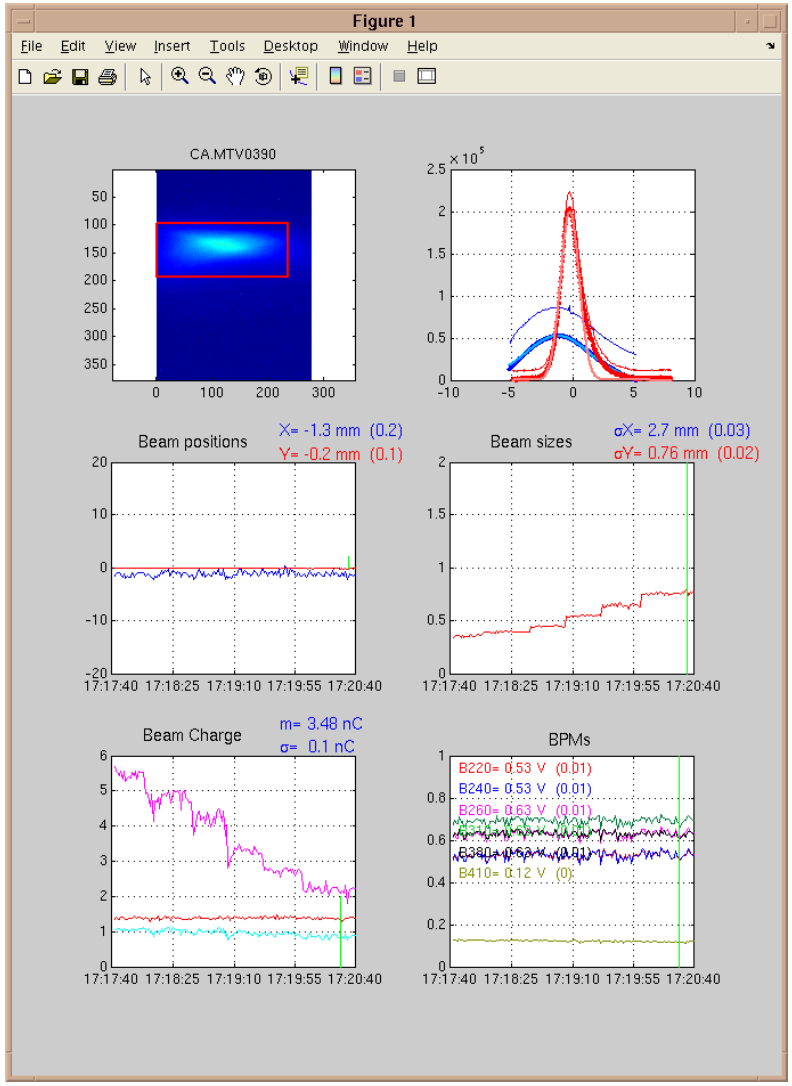


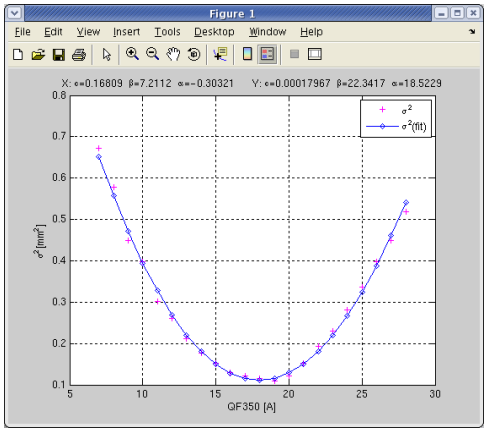



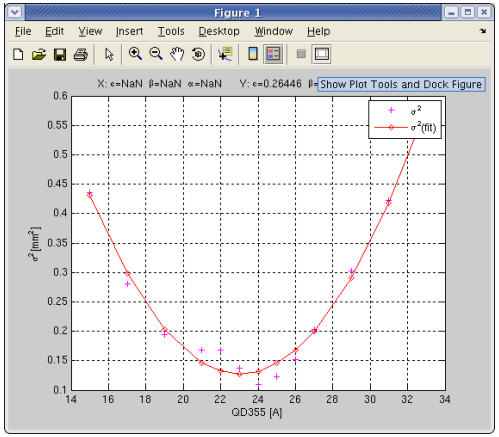

- Max. energy reached 143 MeV at the end of the line.
- Pulse to pulse energy drift (beam loading or amplitude/phase shift during pulse train)

- At gun output, using corrector DV/DH 130 : about 5.2 MeV.
- Hor. and Vert. coupling due to gun solenoids fringe field

# Emittance



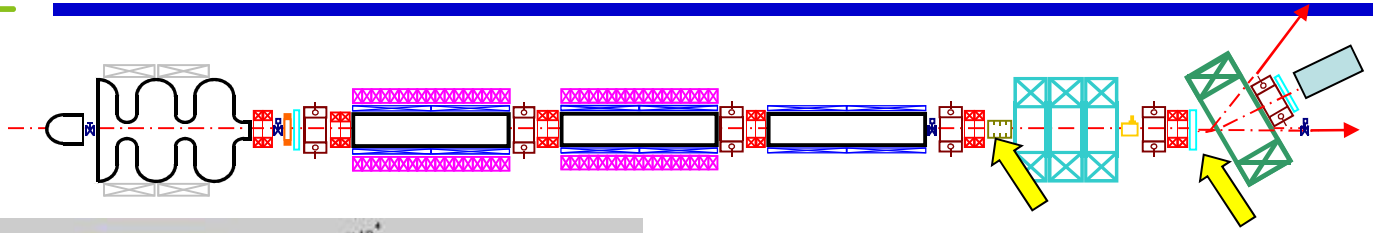



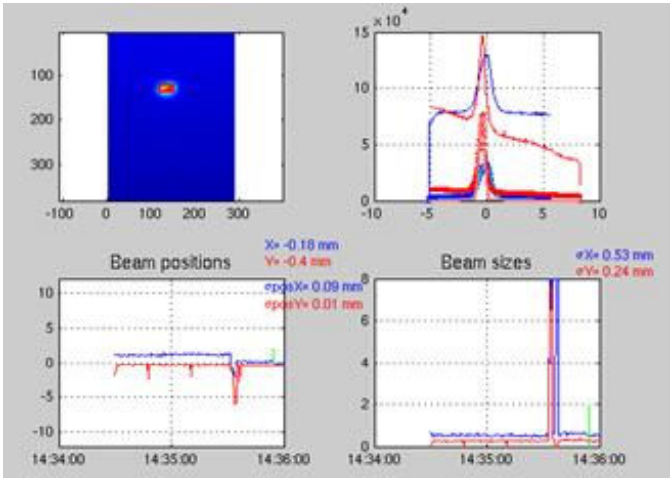




Volker Ziemann program

- Energy = 140 MeV
- $\varepsilon_{norm.}$ Hor : 43.6 mm.mrad
- $\varepsilon_{norm.}$ Vert. : 68.6 mm.mrad (spécif. < 20 mm.mrad).
- The Twiss parameters allowed to compute theoretical settings for the TBTS line and so to drive efficiently the beam up to the TBTS spectrometer.

# Pulses Length

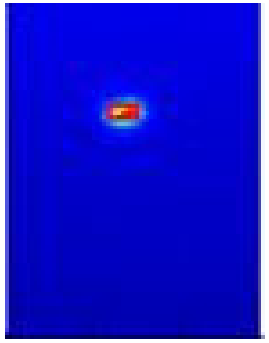




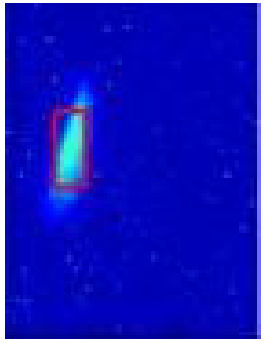

- Calibration 0.94 mm per degree at 3 GHz (333 ps for 360 deg)
- Vert. beam size due to the deflecting cavity: 1.45mm
  ⇨ Bunch length 1.42 ps at 1 σ (spec. 0.75 ps)

Laser pulse duration: 7 ps ⇨ the velocity bunching works

Power phase shifter will allow to tune bunch length



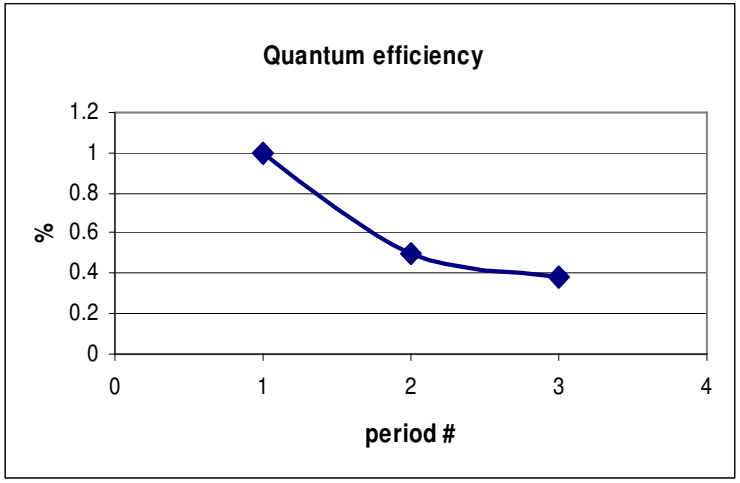
Cavity OFF
σy = 0.24 mm

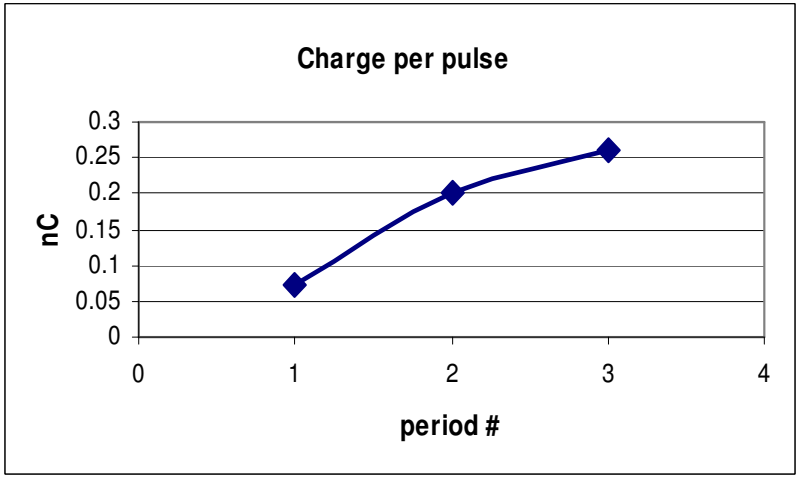


Cavity ON
σy = 1.47 mm

Thanks to Luca Timeo for deflecting cavity operations

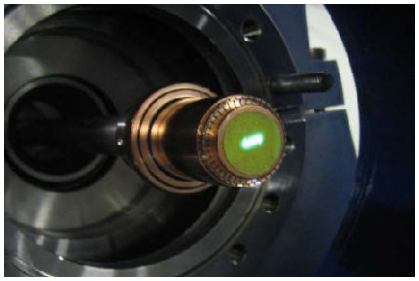
# Charge and QE




- Laser has made huge progress (many thanks to the EN/STI/LP members for their continuous efforts and availability).
  [see Massimo Petrarca talk on Th.15oct. 17.30]

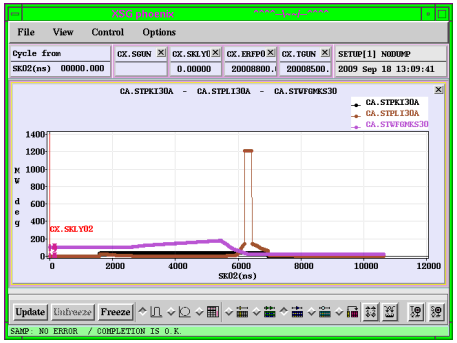
- It's time to regenerate the CsTe photocathode (this week).



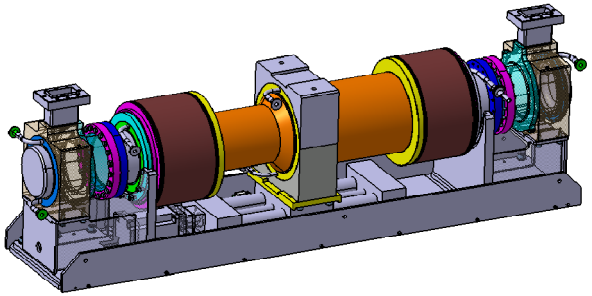
# Route towards nominal performances

- Improve energy (and emittance) using more powerful RF compression laws.
- Improve charge and emittance with even more laser power/ UV conversion/transport efficiency and spot size.
- Improve bunch length or energy, tuning the bunching structure phase with the power phase shifter (to be installed soon).
- Improve reliability, C/C easiness, diagnostics accuracy…


MKS30 @ 37.5 kV, PLI: 130 MW




MKS30 @ 39 kV, detector saturated



RF power phase shifter under construction

# Conclusions

• This year was dedicated to the achievement of CALIFES construction and to deliver its first beams with constant improvements.
• We are reasonably confident in reaching full performances and to provide a beam useful for ACS qualification in the TBTS.

• Beyond CALIFES, CEA IRFU is involved in the CLIC/CTF3 program within the 12 GHz stand alone test station and the development of wakefield monitors for the ACS.

• I am grateful to all teams members from CERN, CEA and the other collaborating institutes for having given to me the opportunity to live such a exciting experience : the starting of a new accelerator.