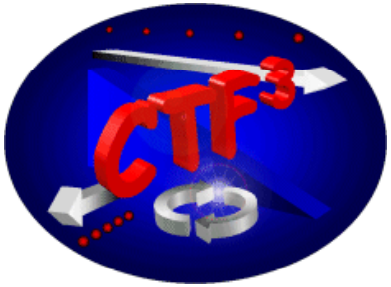


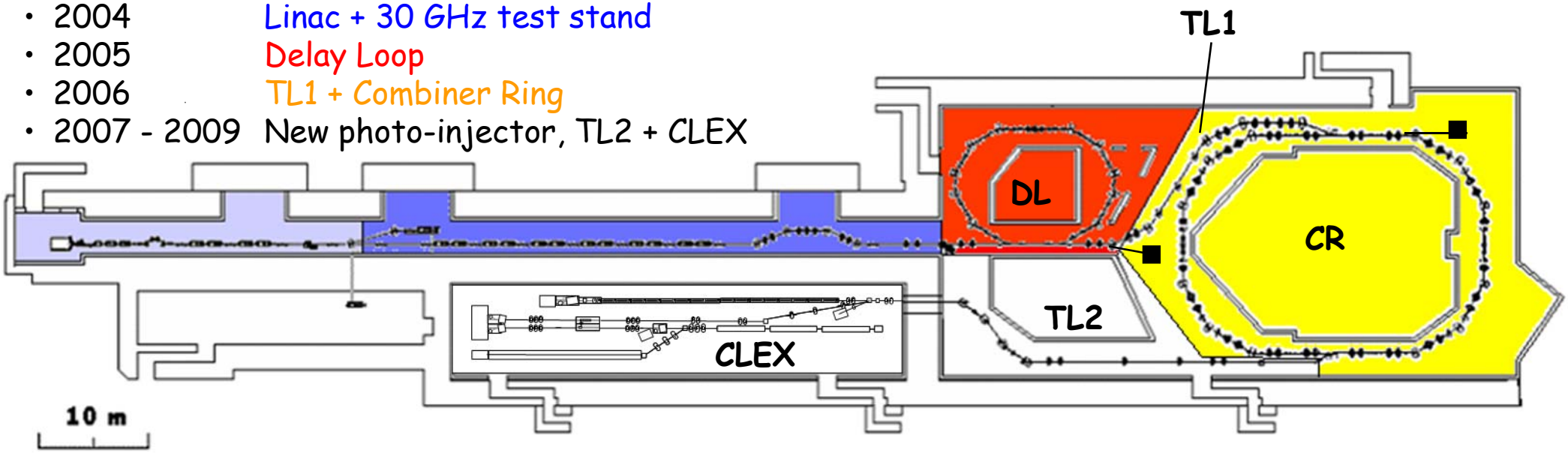
Existing Hardware Machine components

Frank Tecker - AB/OP
for the CTF3 Team

- Review of various hardware
  - gun, RF, …
- Software / Controls
- Conclusion

Preface

- 2003 Injector + part of linac
- 2004 Linac + 30 GHz test stand
- 2005 Delay Loop
- 2006 TL1 + Combiner Ring
- 2007 - 2009 New photo-injector, TL2 + CLEX



- CTF3 in steady evolution since 2003
  - Machine extending every year
  - Work concentrated on commissioning of new components
  - Increased complexity
  - Higher demand for availability of components
- Full recombination (DL + CR) to be demonstrated
  - Operation becomes more demanding in terms of stability
  - Review the performance and identify bottlenecks

Gun

- the source of a lot of down-time and problems this year
  - Heater power supply
  - Bias power supply
  - Bad contacts
  - Gun pulser
  - Cathode
  - Dark current
  - 2 vacuum leaks after solenoids on Oct 9 and Nov 20, caused by gun dark current, 6 and 5 days downtime
  - Stability and jitter

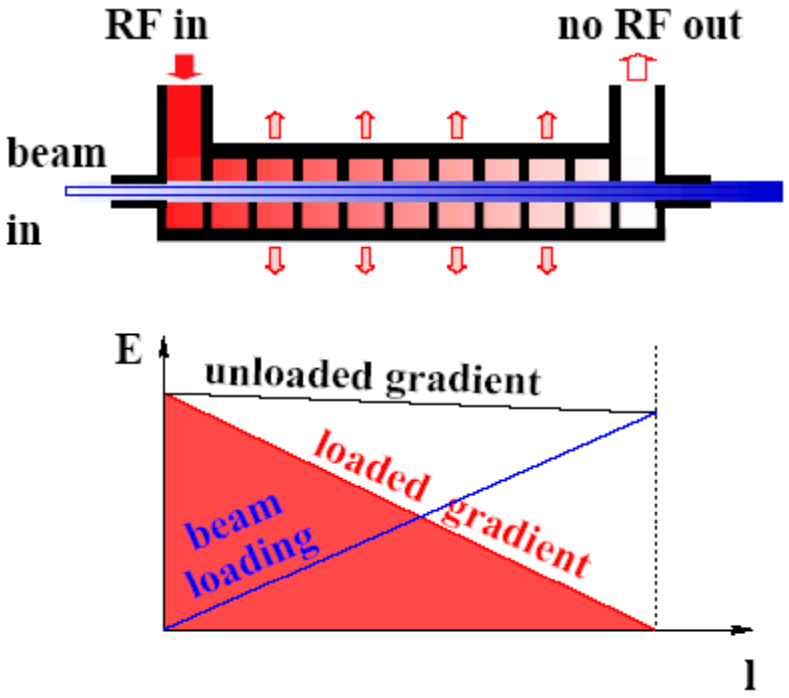
Gun – Current stability

- Current stability crucial because of full beam-loading in the linac

$$\frac{dV/V}{dI_{beam}/I_{beam}} = -\frac{I_{beam}}{I_{opt}}$$

1% current variation = 1% energy variation

- Also for other effects changing current (SHB phase switch, bunching variations)



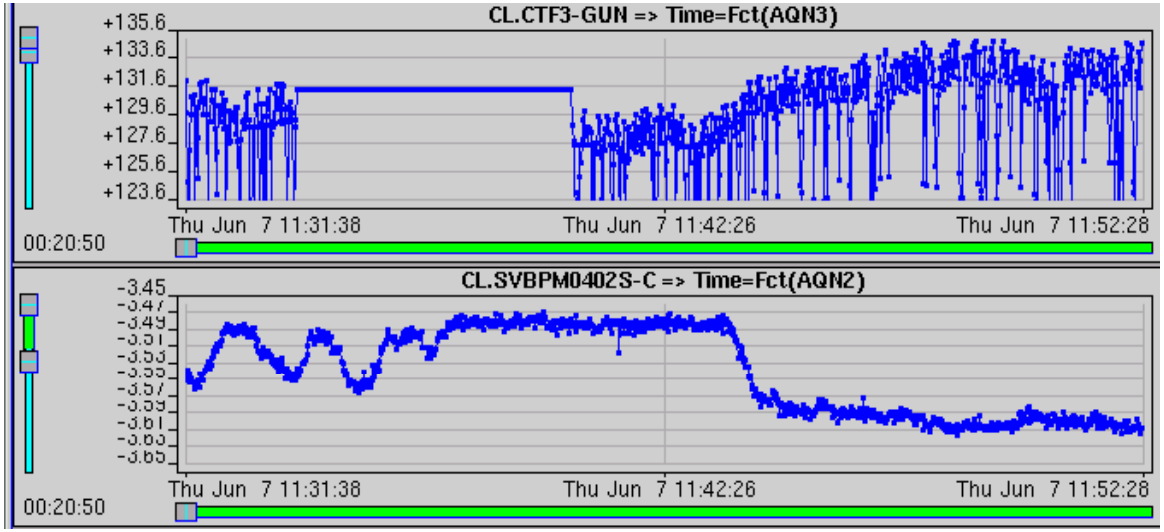
- Specification:
  For the nominal working point (6 A), the possibility of a ± 5% current modulation signal with bandwidth of up to 20 MHz is required.

Table 1: Parameters for the CTF3 gun for the nominal working point

Parameters	Unit	Initial and Nominal
Voltage (Running)	kV	140
Voltage (Conditioning)	kV	160
Pulse flat-top	ns	200 - 1600
Gun current	A	6
Max mean current	mA	0.5
Rise/ Fall time	ns	≤ 20
Charge flatness on flat top	%	≤ 0.1
Voltage stability ΔV/V for 200 to 1600 ns (flat-top)	%	≤ 0.1
Repetition rate	Hz	5

Gun current variation

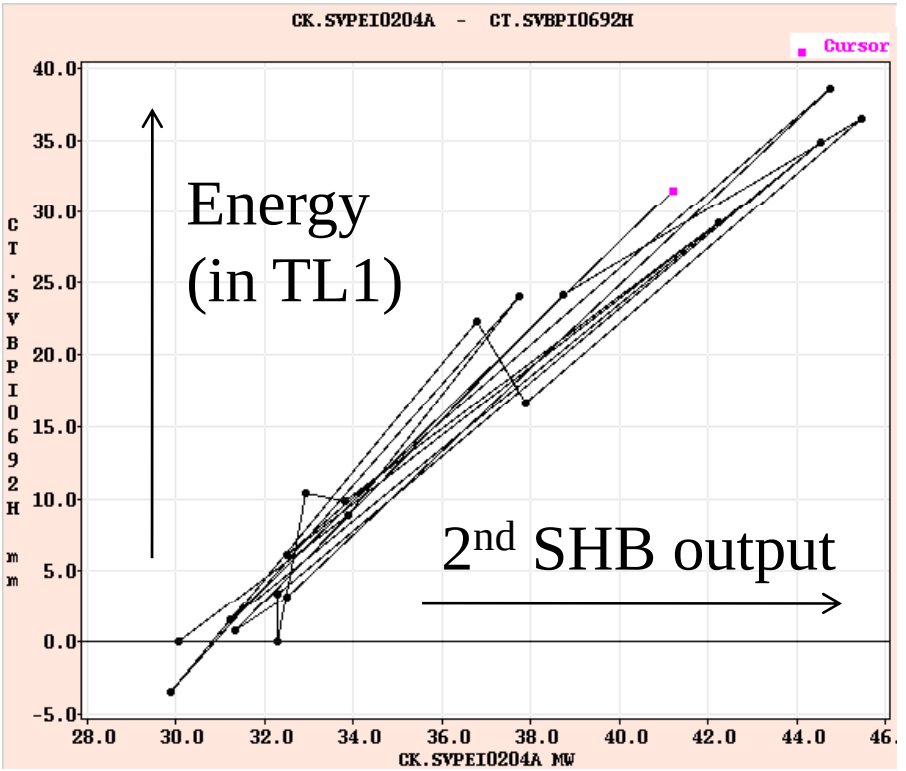
- We observed current variations caused by HV change
  - Small HV variations not obvious since acquisition is noisy



- Could trace them to the gun regulation:
  for a high dark current
  the gun changes from current to voltage regulation and lowers the HV to limit the current
- Could be fixed by increasing the threshold for switching
- But the problem reappeared …

Energy variations and jitter

- Correlation between energy (hor position in dispersive region) and SHB02 loaded signal
- Stable SHB phases measured
- Gun current stable
- => other variation from gun, HV? but we miss proper diagnostics

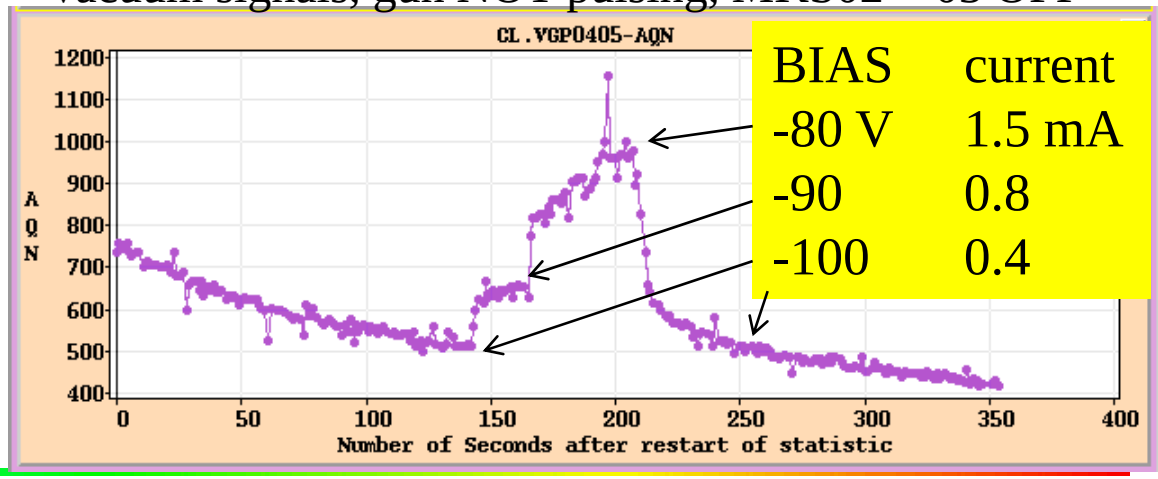


- Periods of better or worse jitter, not understood why
- Jitter variations bigger than tuning variations
- Beam very difficult to set up
- Lower variations without 1.5 GHz SHBs => used 3 GHz beam

Dark current

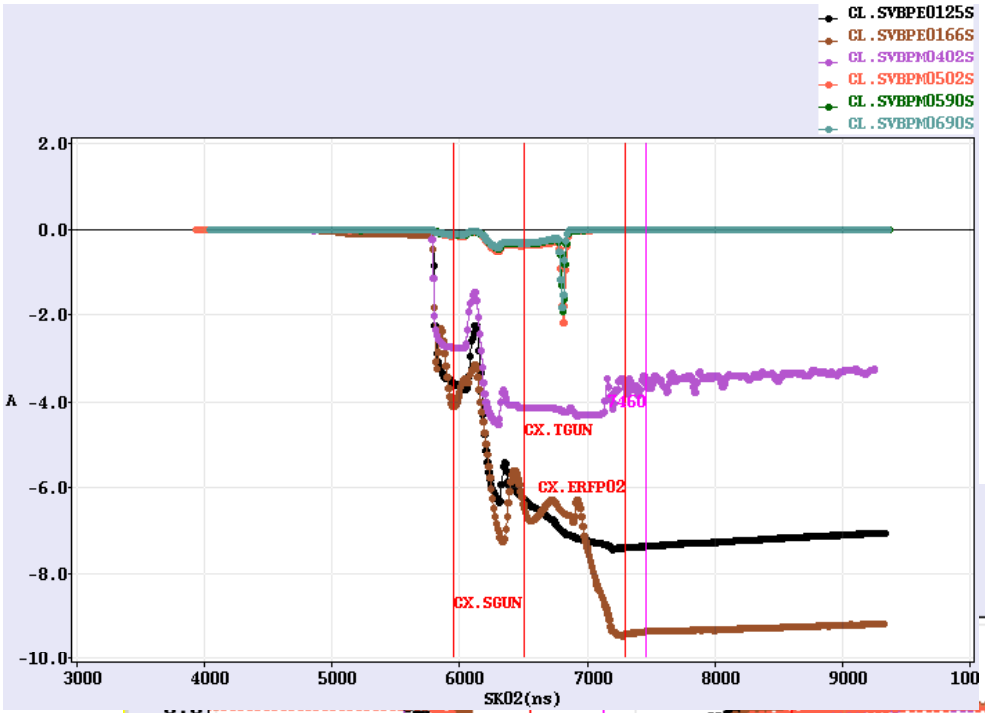
- 2 Oct: high dark current after cathode change
- 9 Oct: vacuum leak after solenoid exit (CL.0405)
- 15 Oct: restarting, almost 10 mA dark current, try to fix
- 23 Oct: restarting commissioning
- 20 Nov: new leak at same location
- 25 Nov: restart, temperature probe installed
- Conclusions: Vacuum activity and local temperature at the leak
  - NOT correlated to
    - beam pulsing or not
    - RF on or off
  - BUT are correlated to
    - gun average current readings
- Dark current (cw) from gun responsible for leaks

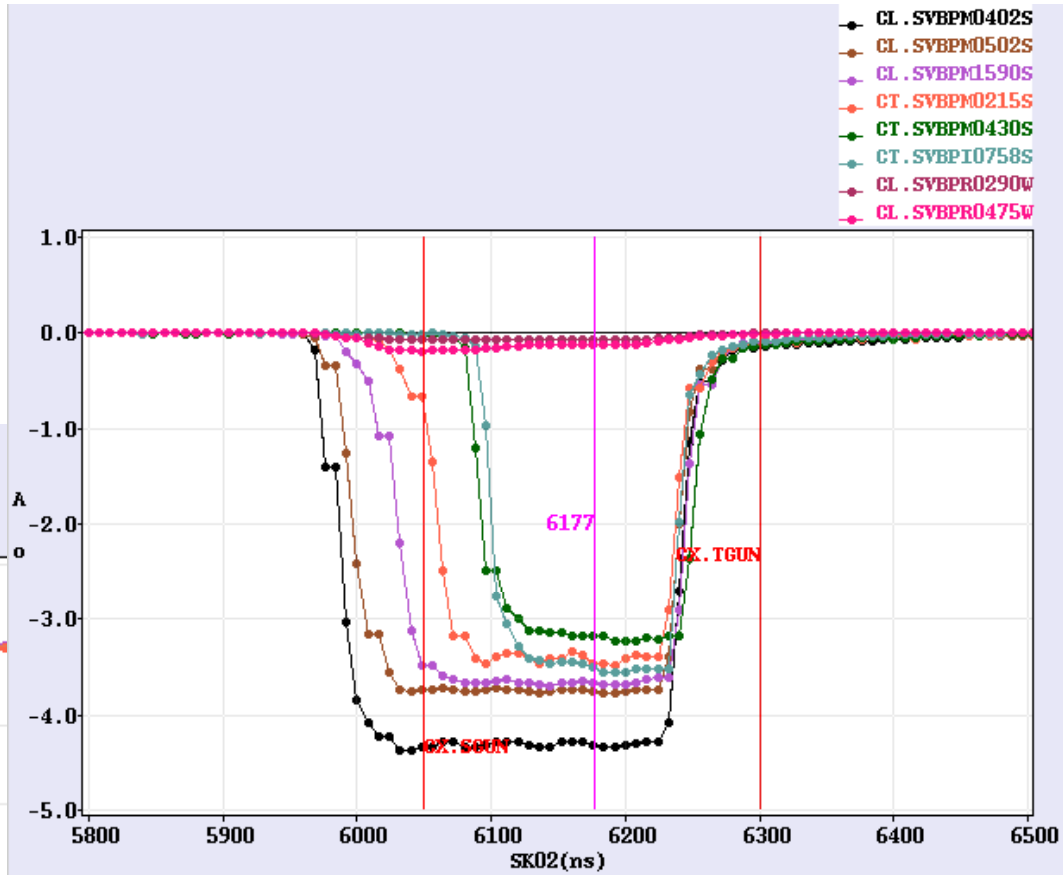
Vacuum signals, gun NOT pulsing, MKS02 + 03 OFF

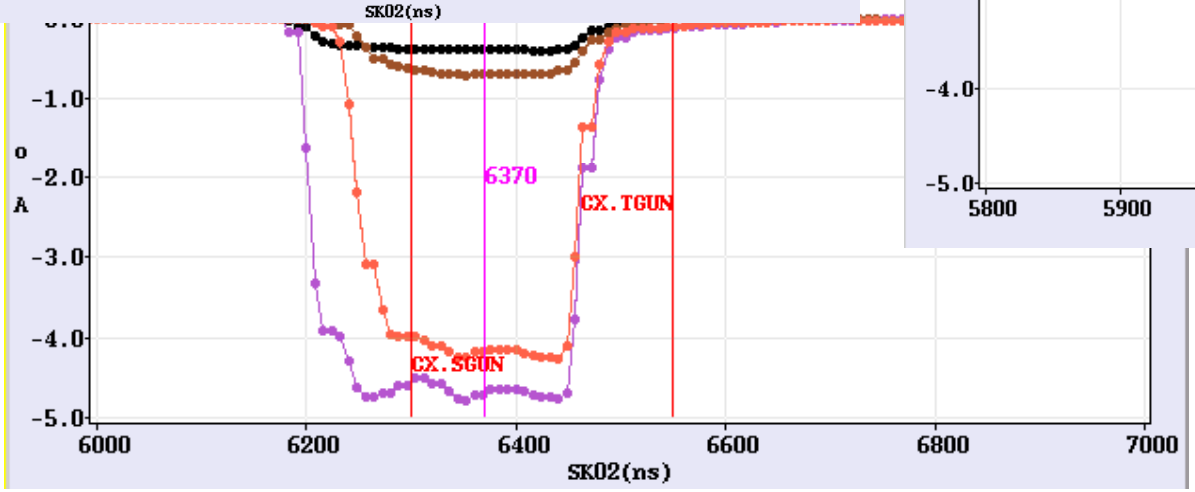


Gun pulse shape

- Current pulse shape shows variations, ringing needs to be optimized







Gun - improvements

- With the present gun performance
  - It is extremely difficult to set up combination
  - It will be even more difficult with DL+CR and beam for CLEX!

- We certainly need a consolidation of the gun !
  - Review different power supplies
  - Add proper measurement signals to allow better diagnostic
  - Review the voltage regulation
  - Implement feedbacks as an upgrade?
  - Activate current modulation feature (in design) to compensate current modulation during SHB phase switch

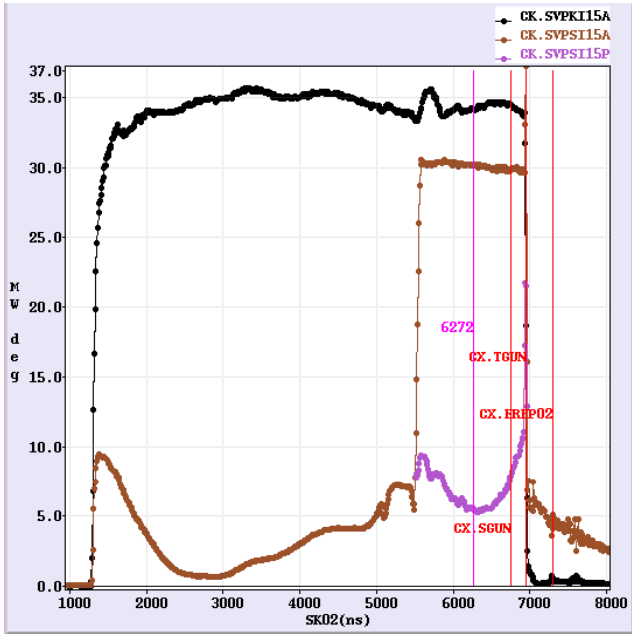
Sub-harmonic bunchers (SHB)

- three 1.5 GHz SHBs fed by Traveling Wave Tubes (TWT)
- Required for DL operation

- 1 tube broke in May
- We have 1 spare tube but no spare amplifier
- => amplifier has to be send to repair
  2-3 month delay
- We were left with 2 SHBs for a large fraction of the run
  larger satellite bunches
- Other point: no remote indication of status
  we had periods of faults, not immediately obvious to operation

Klystrons + RF

- Need all 11 klystrons available reliably for proper operation
- Klystron trip consequence:
  - Direct down time
  - Recuperation time (for RF pulse compression)
    - temperature change in LIPS/BOC cavities
    - phase adjustment
- Set-up of power level with margin to avoid trips



- Important: proper conditioning at the beginning
- Plan in sufficient time in the schedule

- Remark: small team of specialists, very efficient but limited

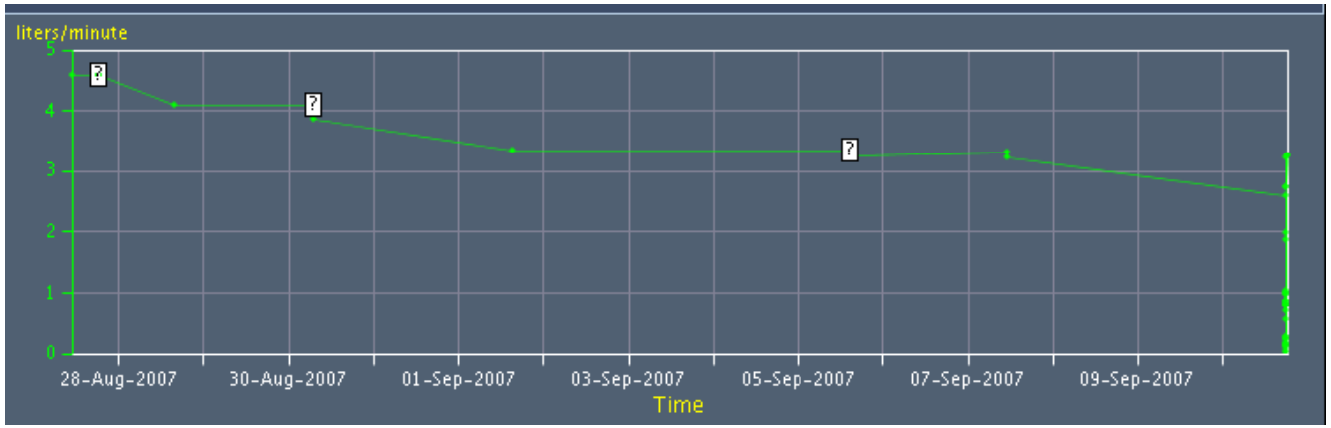
Klystron - Spares

- Two klystrons failed due to charging power supply failures
  - MKS15 End Oct
  - MKS11 27 Nov
- No spares available
- Could continue operation but needed a completely new setup of the machine
  => several days time lost each time
- We need spares for these power supplies
- We also need spares for klystron tubes
- => Gerry's talk

- Option: install structures on girder 14 to increase linac energy
  we need another modulator for this

Water station for LIPS/BOC

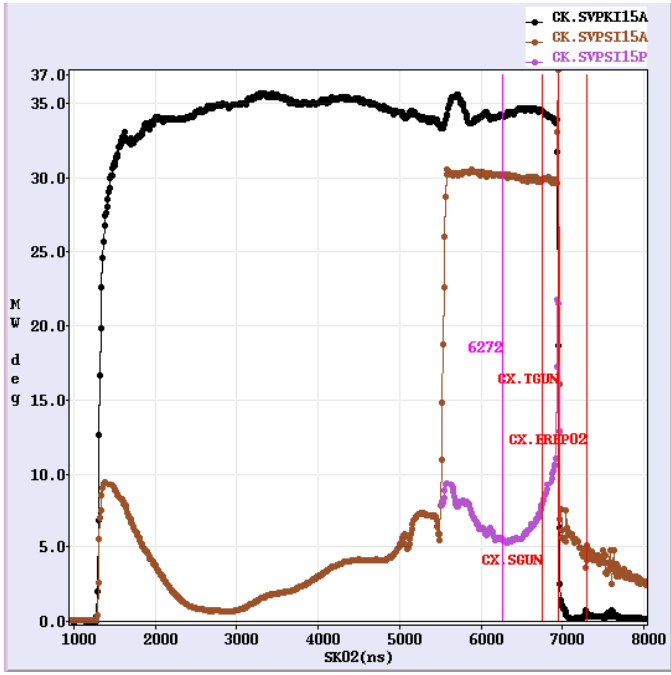
- Temperature control for RF pulse compression cavities
- Tuning very crucial
- Filter for one device got blocked twice
  => flow rate reduced, cavity detuned



- Regular maintenance + cleaning needed
- Regulation for some devices slower than others
  => needs regulation, evtl. change of feedback to include power dependance

RF pulse compression

- We had frequent problems with the waveform generators on one front-end computer
- Finally fixed by CPU card exchange



- Setting up improved by Hamed's software
- Slow drifts in compressed pulse shape
- Should invest time into automatic feedback to keep power constant
- A basic version for this exists but needs testing

- Combination for long beam pulse difficult due to energy variation over the pulse
- Need to review phase sag, eventually lower compression ration

1.5 GHz RF deflector (DL)

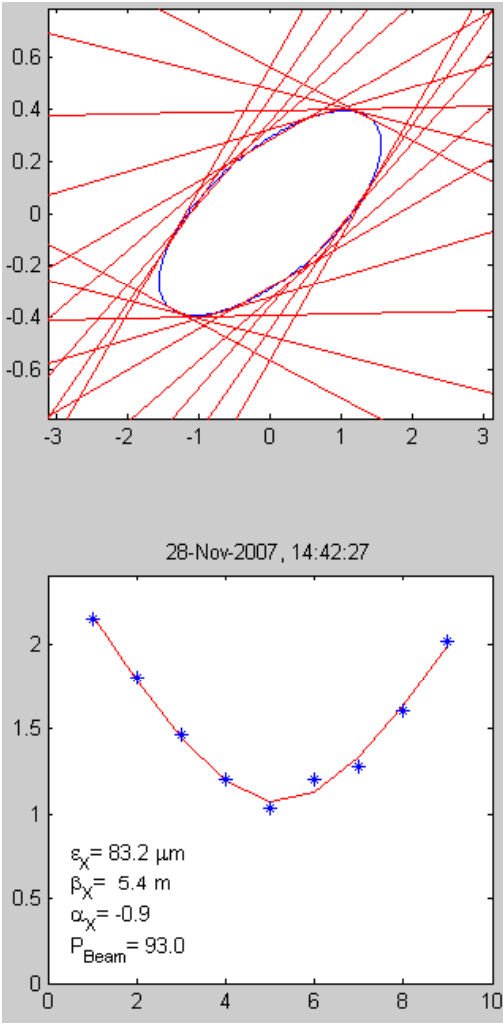
- Problem with reflected RF limiting power
- Difficult to diagnose
- Leak in the water load, no spare, had to wait for 1 month

- Driver amplifier for MKL02 was unstable at some time
- Could be regulated but there was no spare

- Pulse shape of pulse forming network of klystron MKL02 needs to be regulated

Quad scans + spectrometers

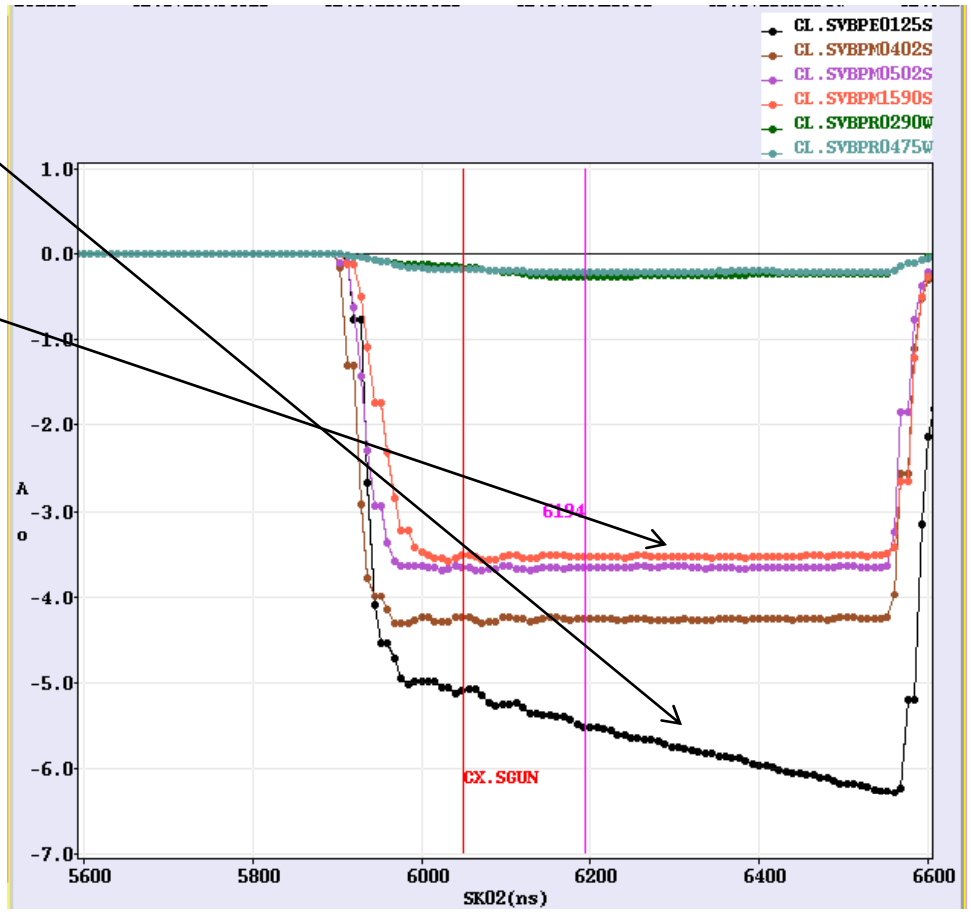
- Quad scans essential for optics studies and machine setup
- on girder 10 (for linac matching) during 2nd run
  - Al screen was damaged
  - Carbon screen did not give sufficient light
- Got repaired => widely used for linac matching
- Screen control + analysis software not optimum



- Spectrometer 10 screen has radiation hard camera => not enough light for energy measurement
- New segmented dump foreseen (=> Thibaut)
- We would profit from measurement software for energy

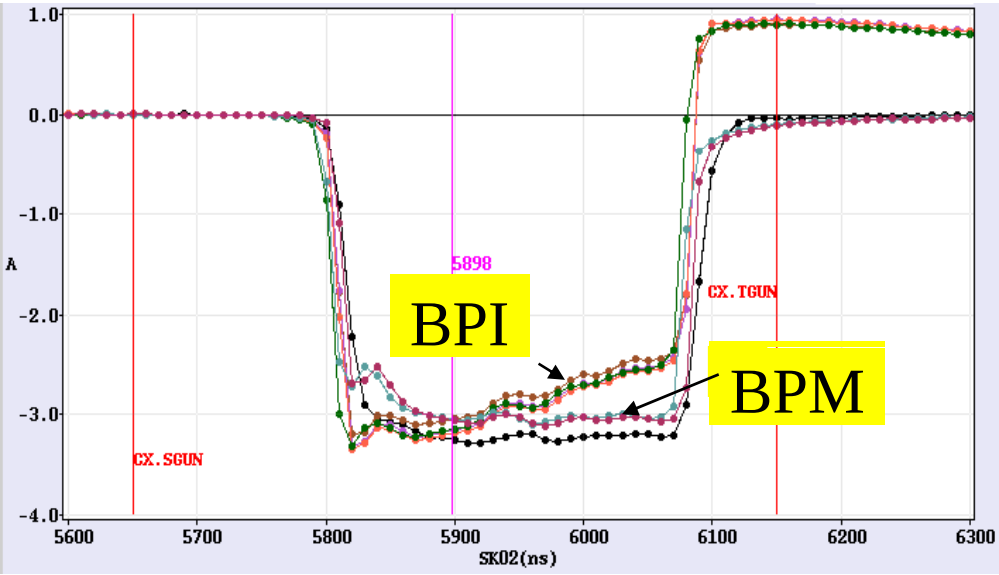
BPMs and WCMs

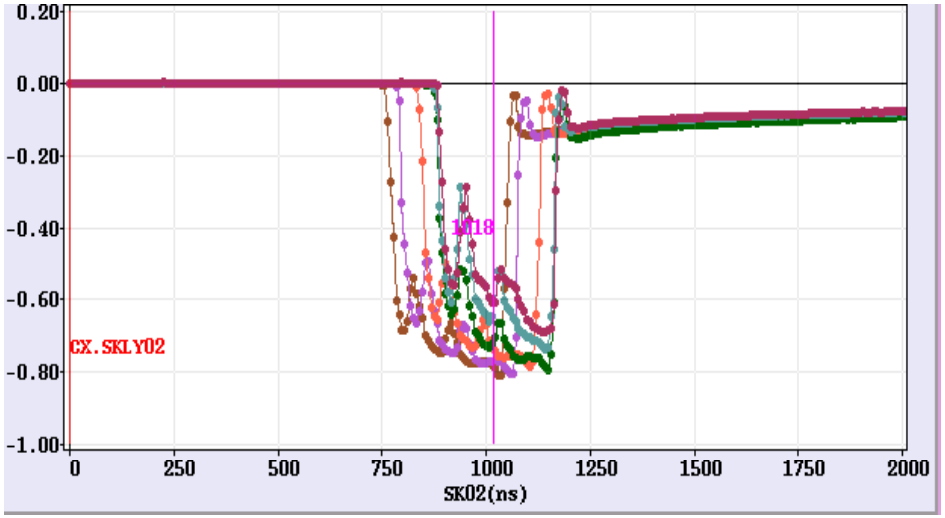
- We have different types of current / Beam Position Monitors (different chamber geometry) with different electronics
- BPE: electrostatic, in solenoids
  charge up during pulse,
  bias test not successful
- BPM: circular,
  working very well
  since the beginning
- BPR: RF BPM
  working well,
  one phase-shifter needs
  proper remote control
- WCM (Wall Current Monitor):
  working well, basically unused
  foreseen beam loss system



BPIs

- BPI: racetrack, similar to BPM, different electronics
- First version had a signal droop due to different low frequency cut-off
- CR BPMs overcompensated for droop during 1st run 2007

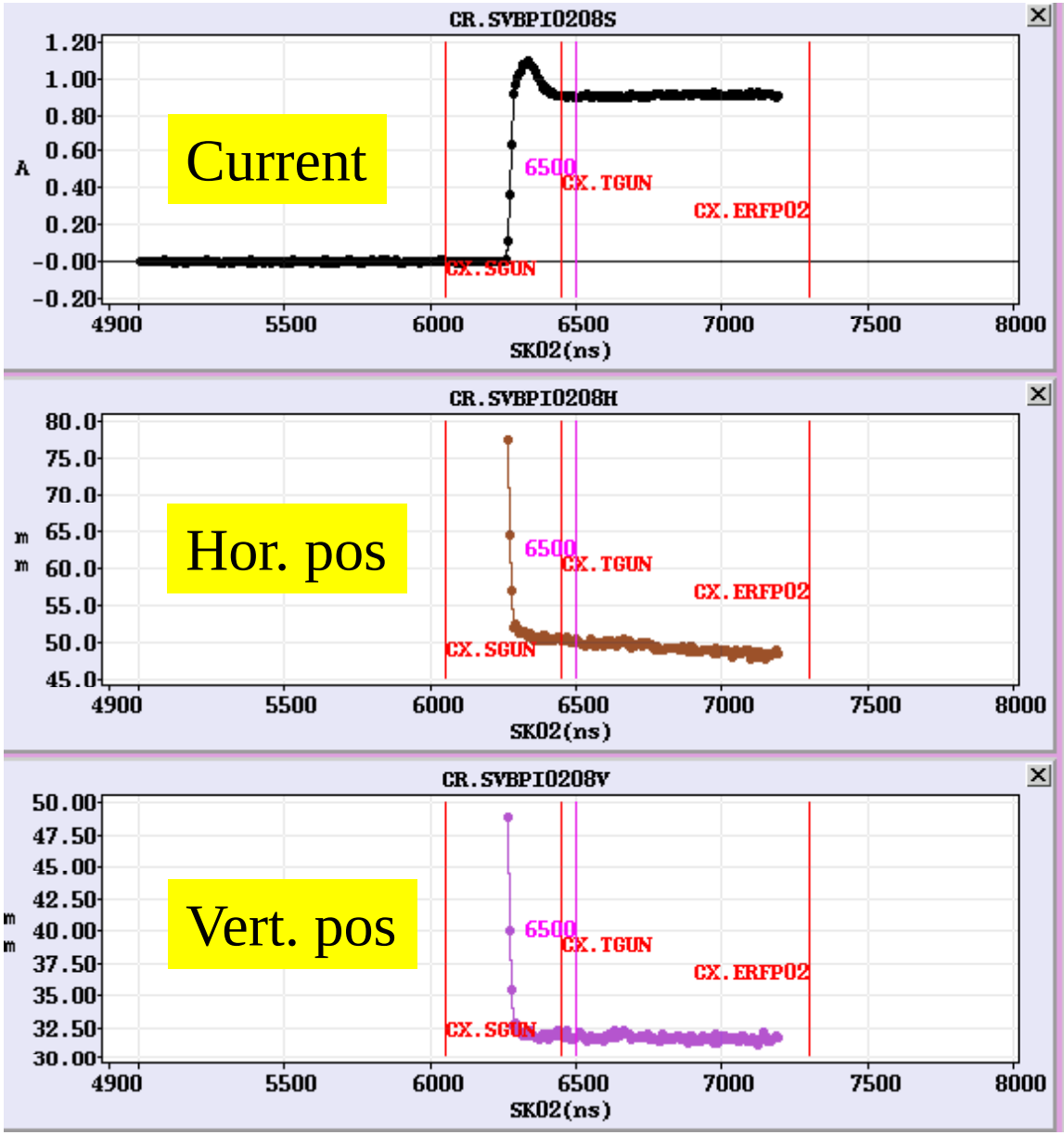




- Finally, also working very well (see next slide)
- But we had only ~2/3 of all BPIs in the CR until last period

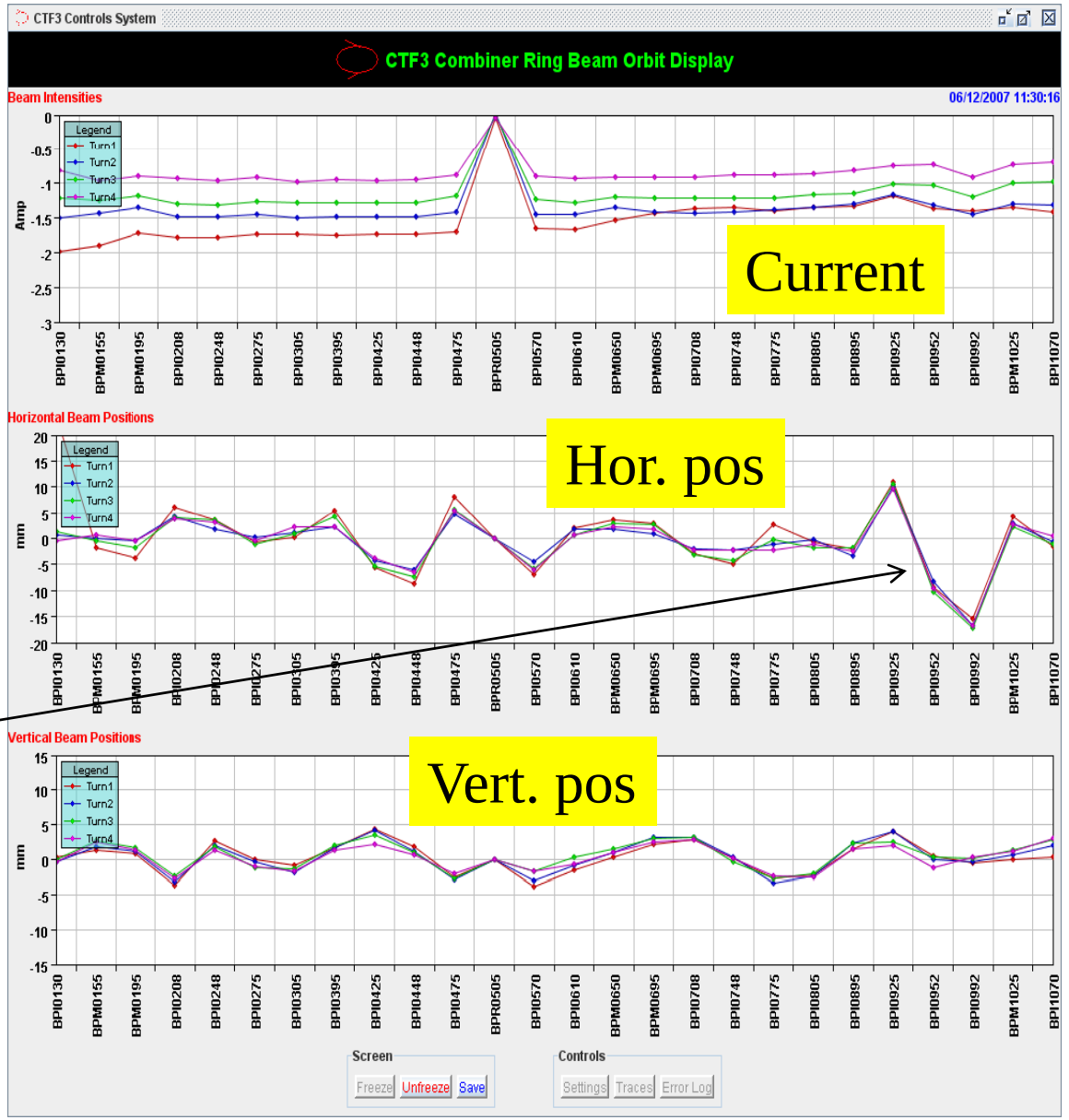
BPI signal droop corrected

- Adjustment of electronics solved droop for current signal
- Still small droop for position signals left



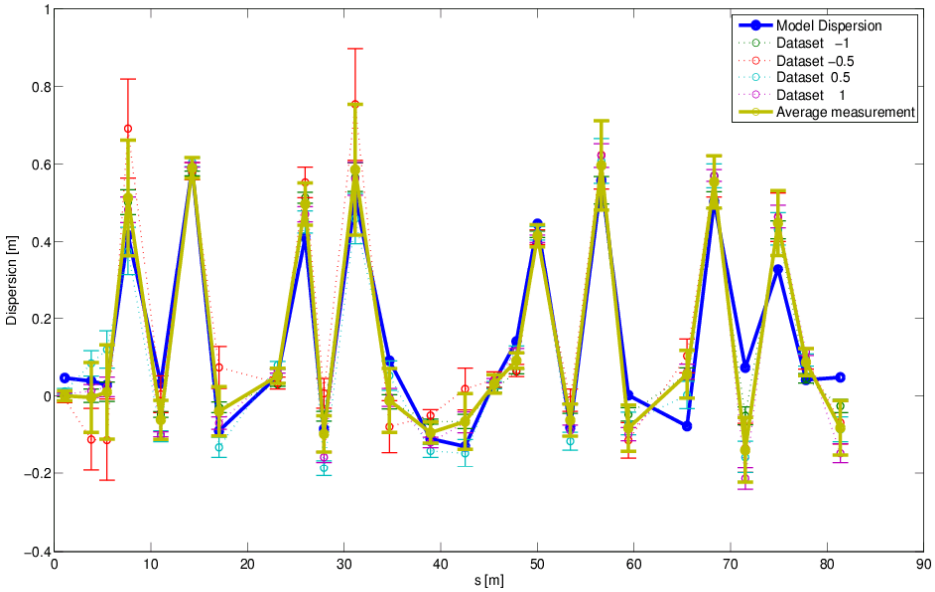
BPM alignment

- DL and CR vacuum chamber has sparse bellows
- Difficult to align
- BPM offsets up to 15mm measured
- Taken into account in software but still questionable
- Will be realigned during shut-down



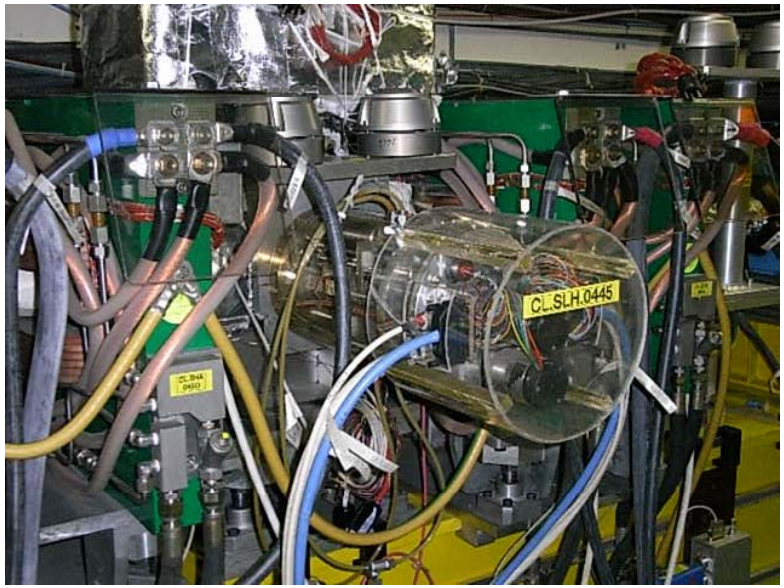
BPM calibration

- We had quite some problems/confusion with the different type of BPIs concerning calibration
  - Different calibration windings
  - Different gain
  - Different signal treatment
- Doubts about position calibration
  - BPMs in CR show smaller position variation than BPI
  - Measurement data to be analyzed …
- BPMs and BPIs used for many important optics studies
  - Dispersion
  - Corrector kick measurements



Slits + Stepping motors

- We use stepping motors for collimating slits and RF equipment
- Most have been upgraded to PLC control
- CK.MKS14-PHAS / -ATTN are not working remotely (still on old system, extremely slow – locally OK
  new system does not yet support this motor)
- Will be upgraded
- Slit calibration needs to be added



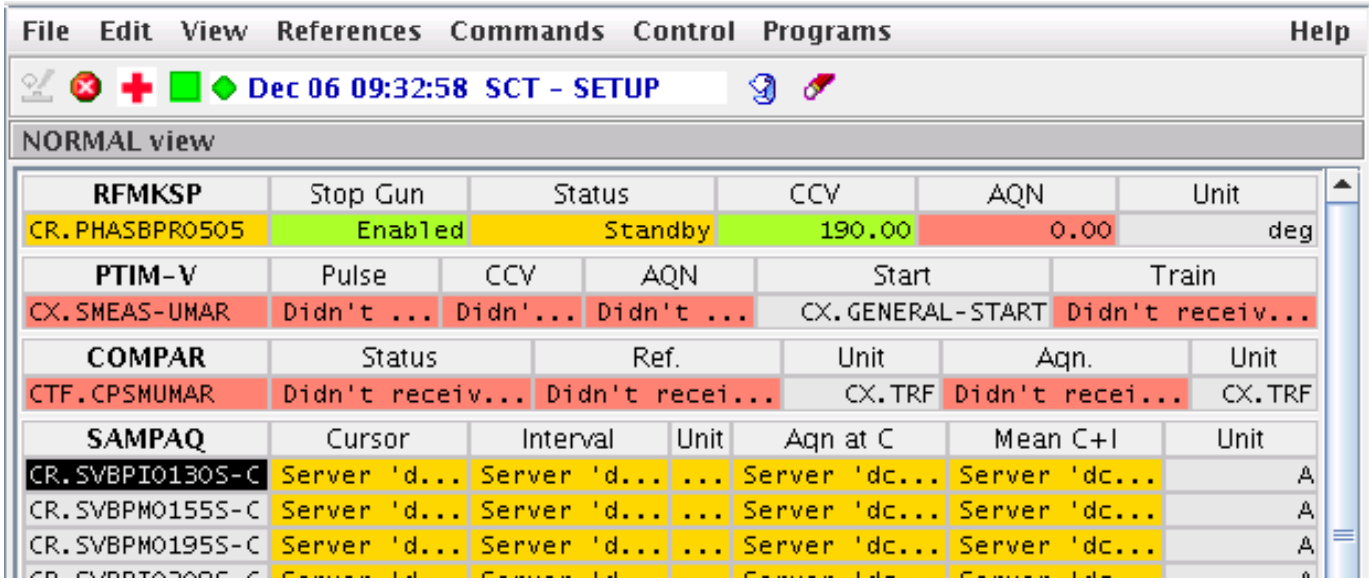
Magnets / Power supplies

- In general OK
- Startup after power cut / lock-out lengthy (1/2 – 1 day)
- Several power supplies without remote reading
  (after CPU card change – new EPROM version?)
  need to be verified
- Stability usually not verified (instability from gun dominant)

- We had some problems with polarities / calibration / control
- A complete field verification might be useful

Controls issues

- Operation console
  - extremely slow, significantly slower than the old one
  - often unreliable, the values are not updated, inconsistencies
  - => we use the old one whenever possible
  - Major upgrade improvement foreseen for 2008



  - CPU cards will be upgraded
- Some other (little) things to be fixed (too detailed for here)
- Recent meeting with controls group to address this

Conclusion

- Operation becoming more and more complex
- We suffered from a lot of down-time and problems
- For smooth commissioning, we need
  - Higher availability of the components, SPARES are vital !!!
  - Higher reliability of the equipments
- Gun
  - Jitter problem not completely understood
  - Review / consolidation required
- RF
  - Assure availability => sufficient spare parts
  - Proper conditioning
- Then we should manage the combination DL + CR
- We are only now starting to address performance
- Automatic measurement + analysis programs very helpful