Drive Beam stability issues in CTF3

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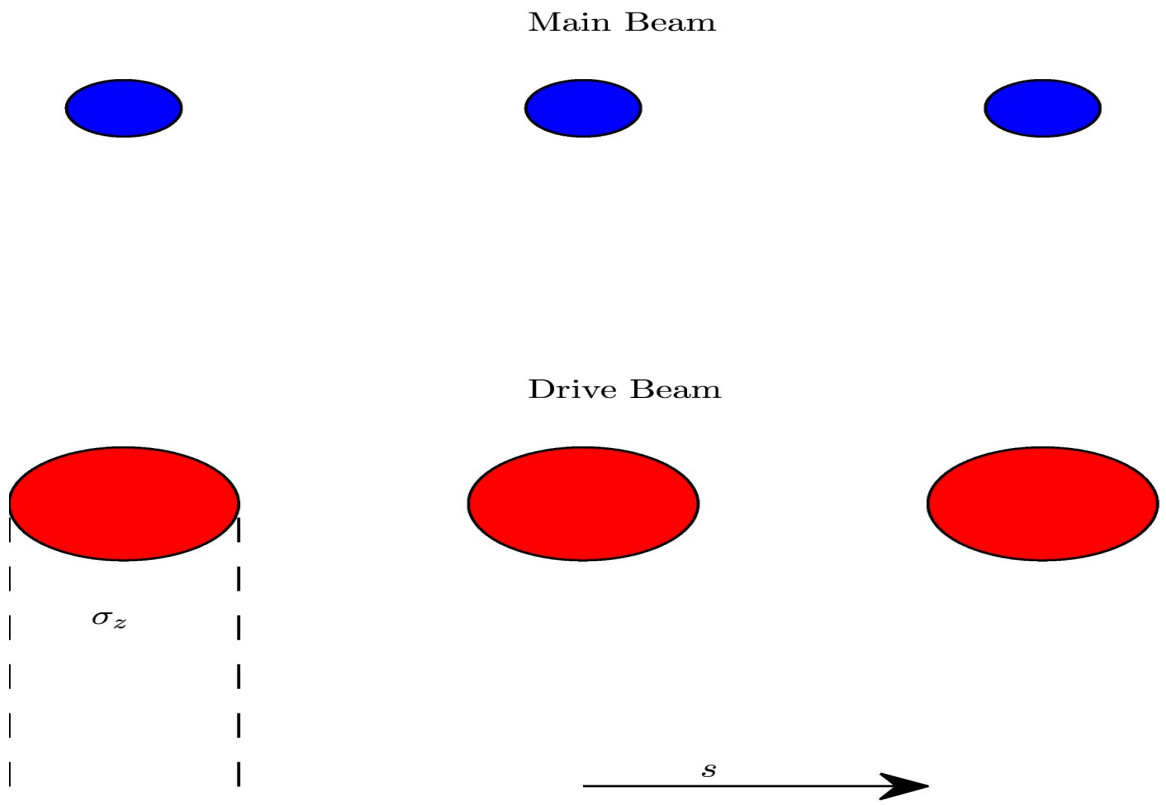
Outline

- Beam stability
- Motivation
- Study of beam current stability
- Feedbacks for energy stabilization
- Feedback for improving the phase stability and bunch length (Injector feedback)
- Conclusion and outlook

Beam Stability

The Drive Beam needs to be stable in terms of:

- Beam Phase
- Beam Current
- Bunch Length



Why is it important?

The integrated luminosity is what counts!

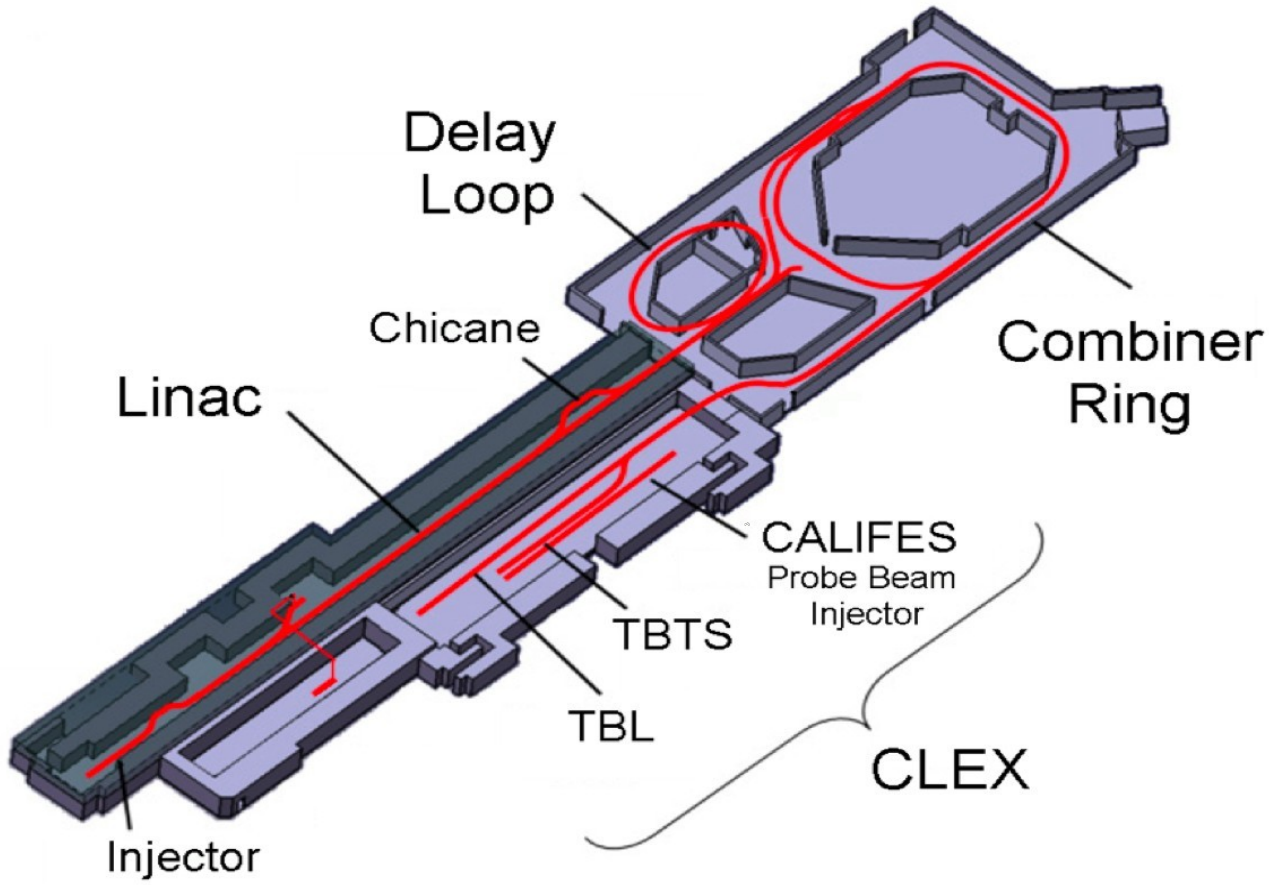
- Puts tight constraints on the main beam reproducibility
  - Puts tight constraints on the Drive Beam
- The luminosity is decreased through mainly two mechanism
- Bandwidth of the beam delivery system
- Emittance increase from energy mismatch

Why is it important in CTF3?

Important to demonstrate beam stability requirements for CLIC

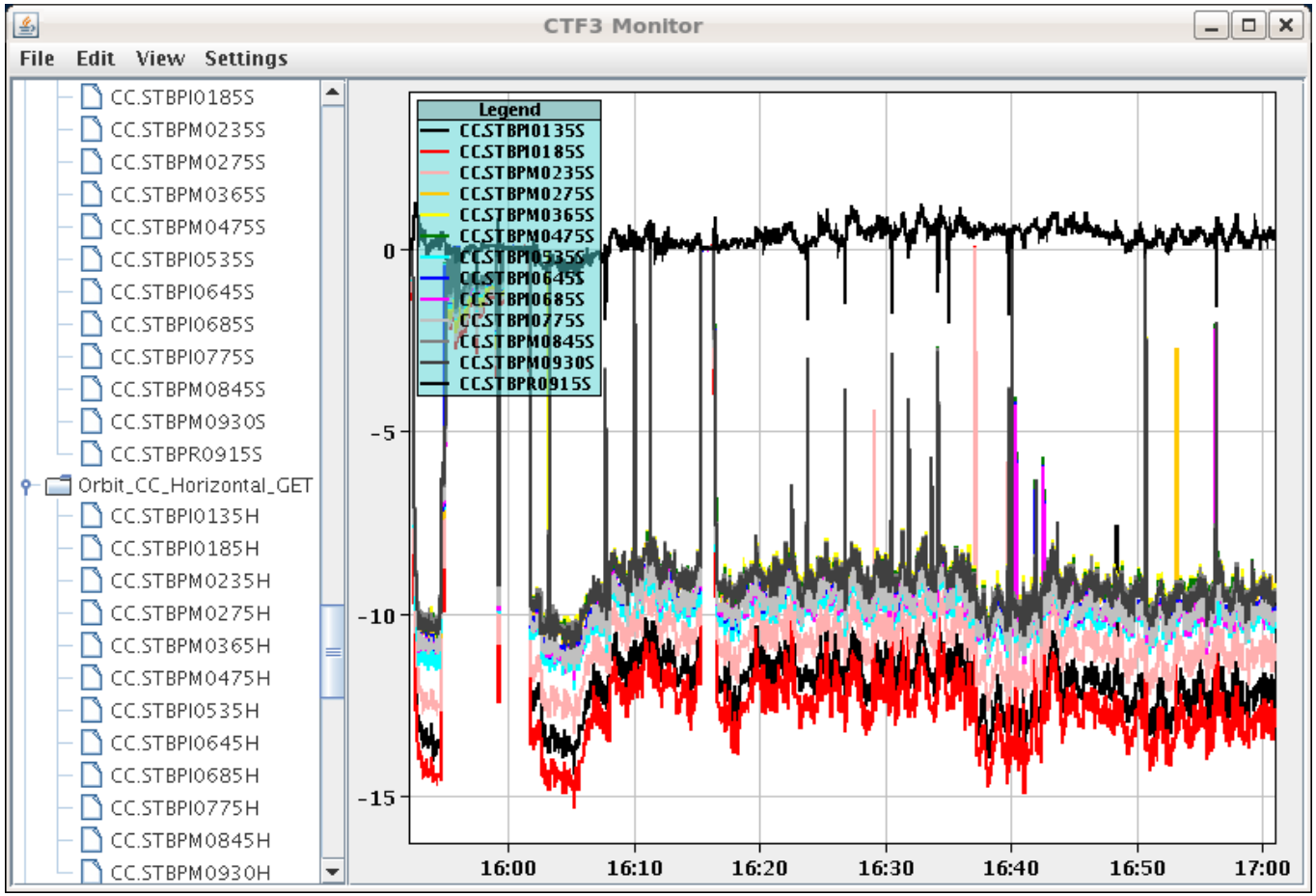
- Difficult because of old equipment with different specifications than for CLIC
- Also important for all the other studies in CTF3
  - Two-beam acceleration
  - Deceleration tests
  - The phase feed-forward system
  - Etc..

CTF3

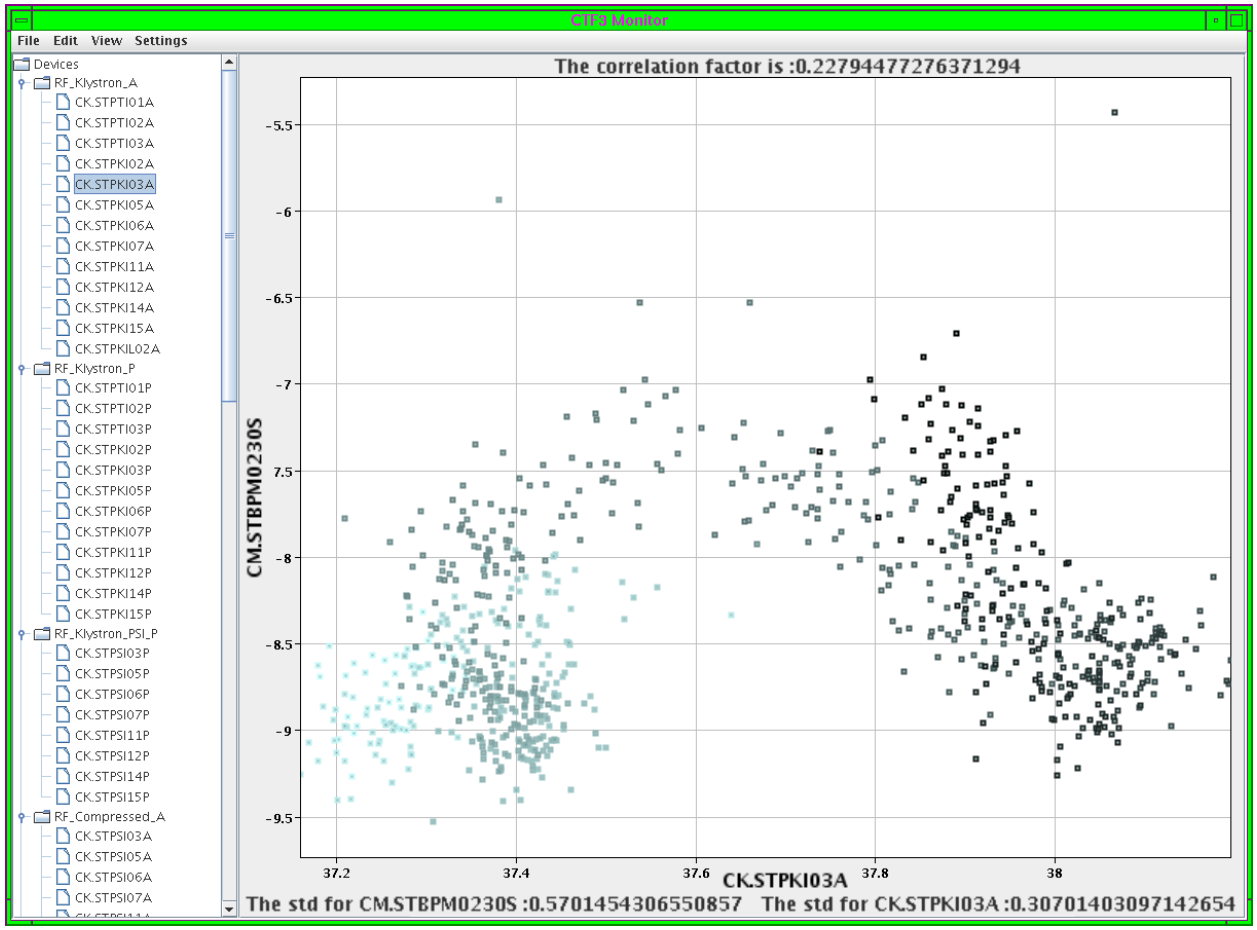

Delay
Loop
Chicane
Linac
Combiner
Ring
CALIFES
Probe Beam
Injector
TBTS
TBL
CLEX
Injector

Study of the time varying beam current variation in CTF3 and implemented feedbacks to mitigate it

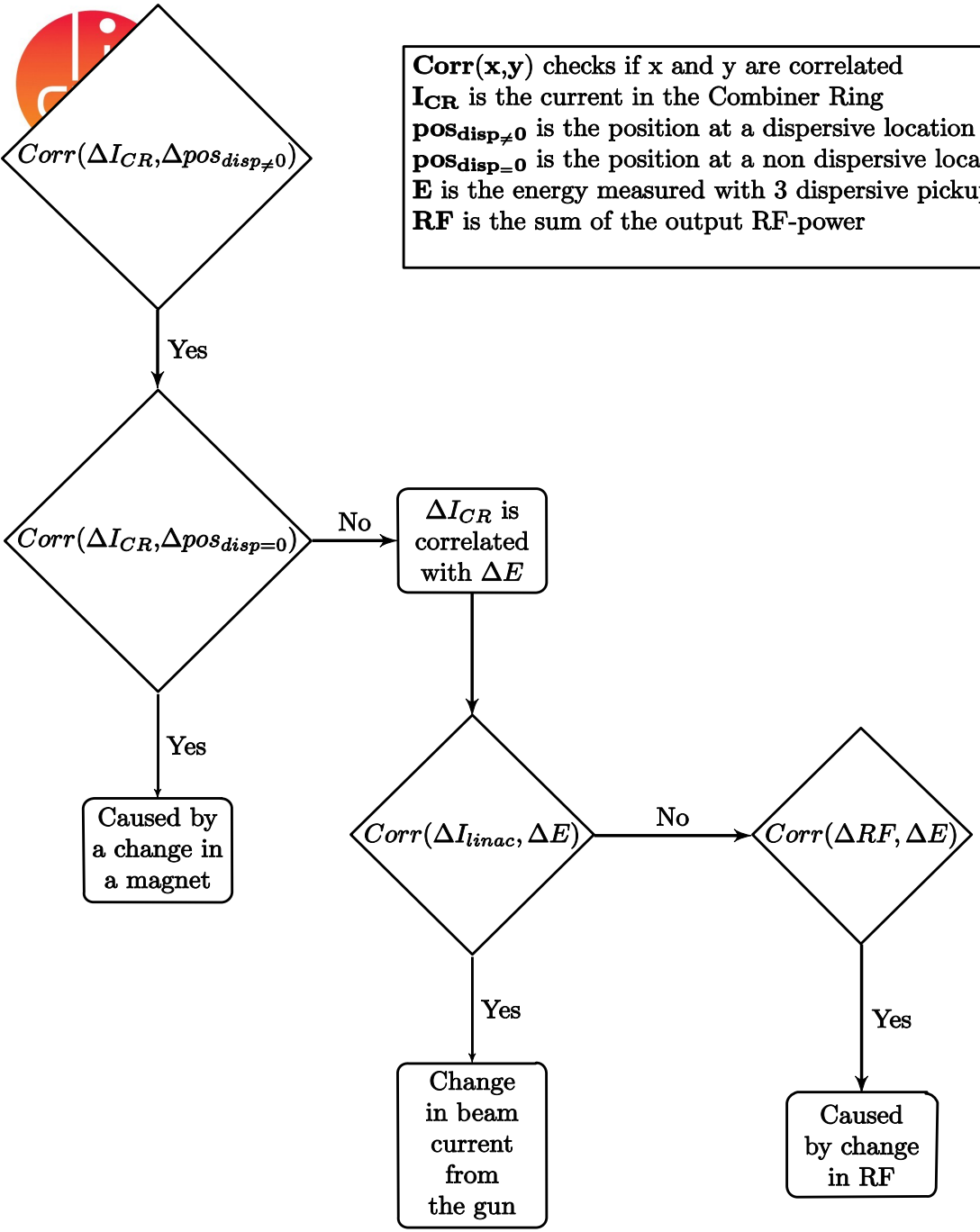
Software to identify drifts online

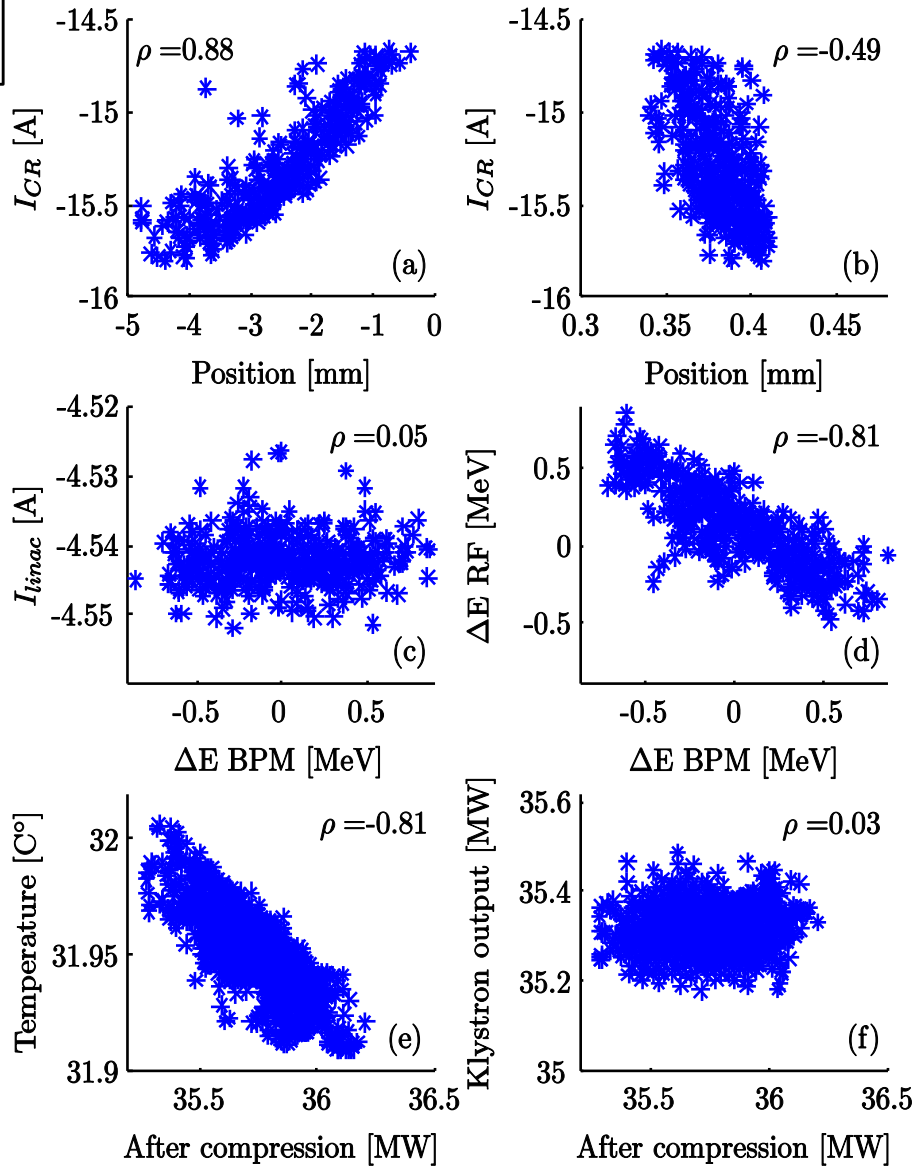


Online correlation studies



Corr(x,y) checks if x and y are correlated
I_{CR} is the current in the Combiner Ring
$pos_{disp\neq 0}$ is the position at a dispersive location
$pos_{disp=0}$ is the position at a non dispersive location
E is the energy measured with 3 dispersive pickups
RF is the sum of the output RF-power





Pulse compression

The klystron sends its power to a resonating cavity

- This increase the peak power

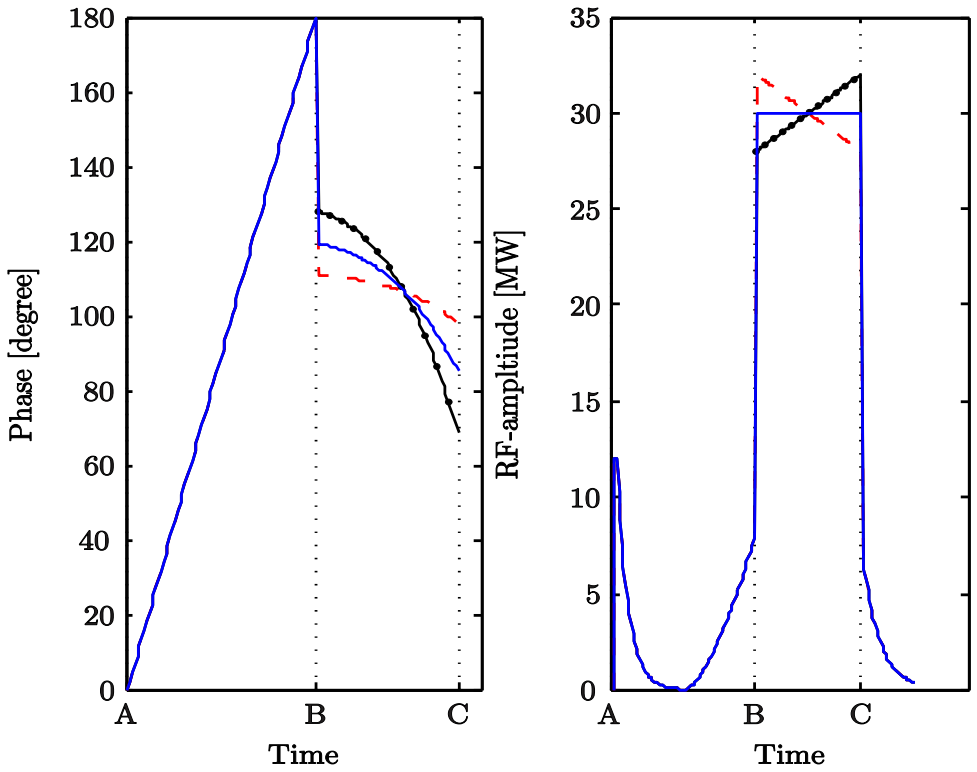
The klystron needs to be precisely tuned in frequency

- Small temperature changes cause detuning
- Water station already stabilizing water to 0.1 degrees

Alexey Dubrovsky and Frank Tecker

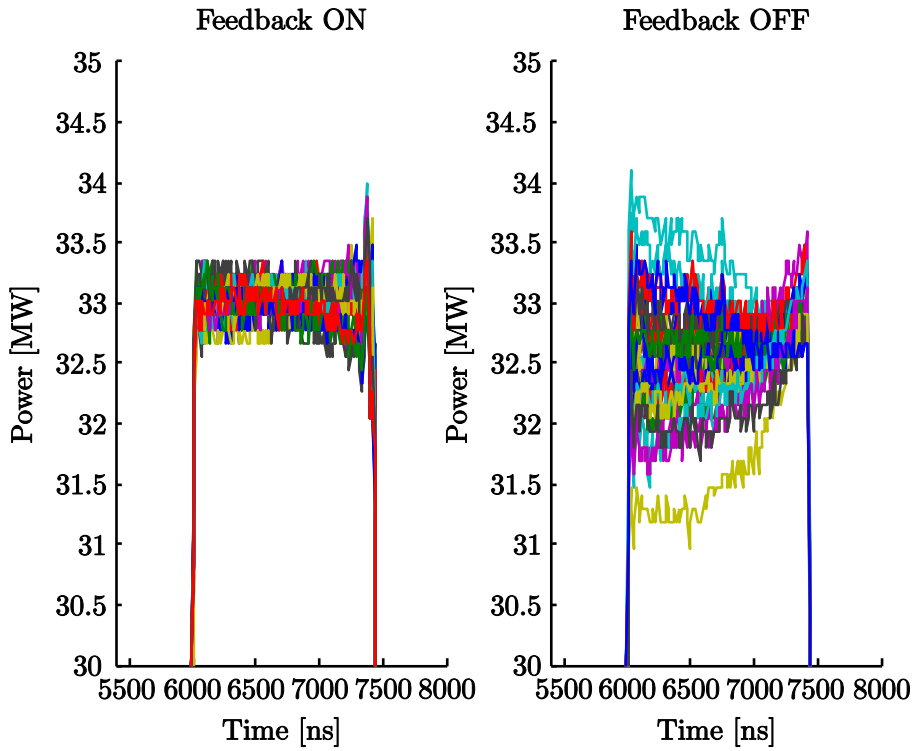
RF-Amplitude Feedback

Instead a feedback changing the phase program, steering the pulse compression.

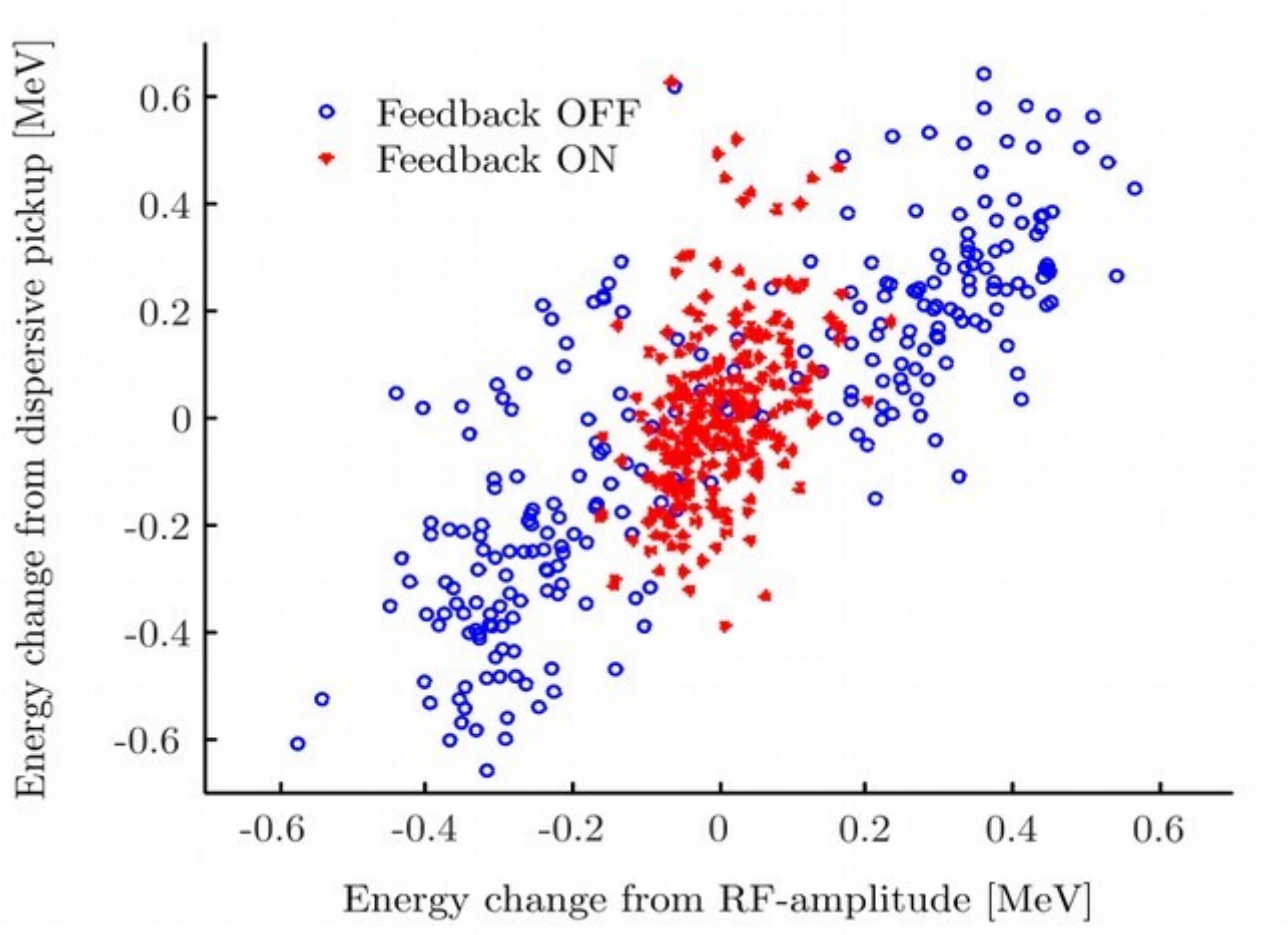


RF-amplitude Stabilization(1)

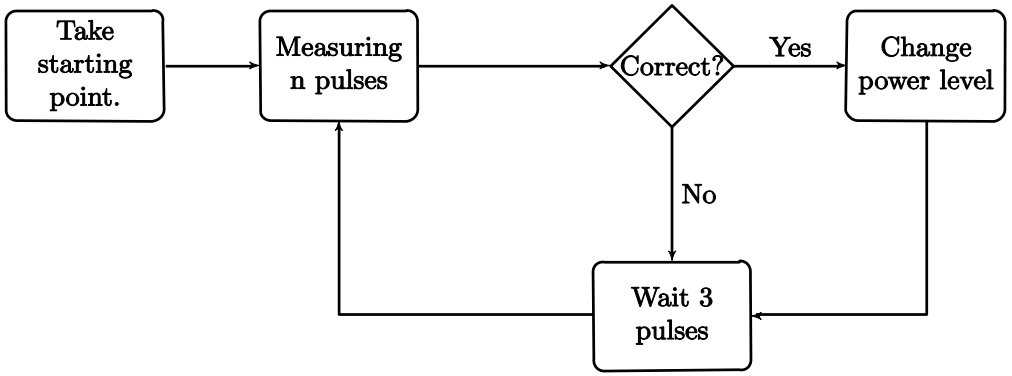
Measurements performed over 4h

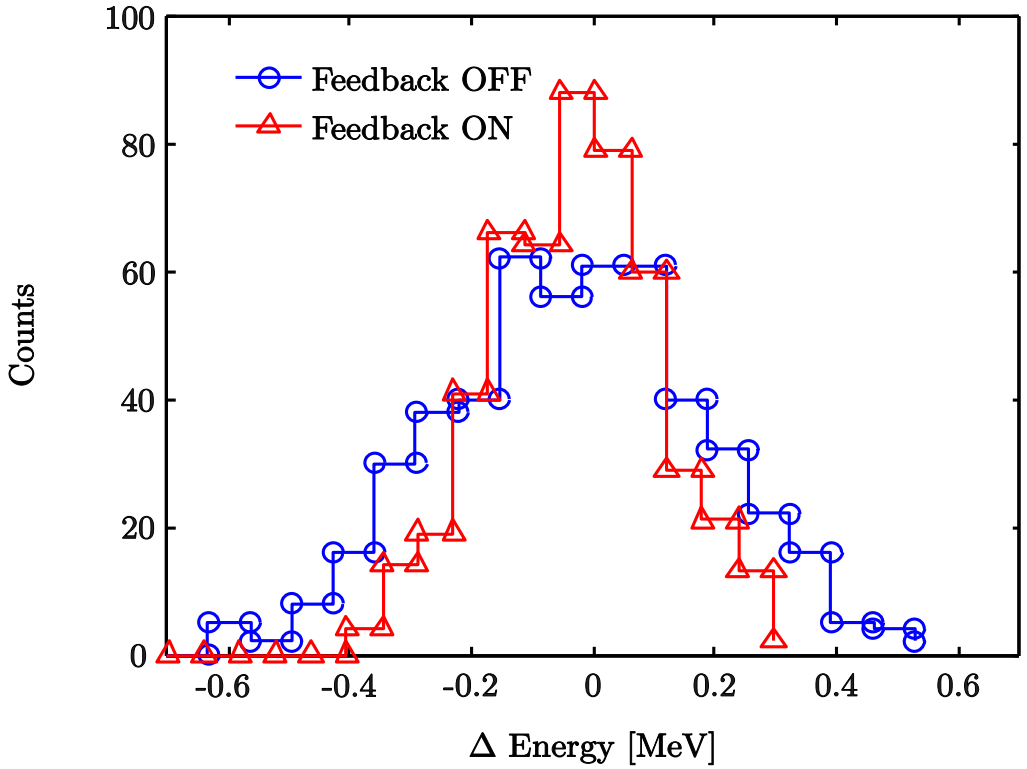


RF amplitude Stabilization(2)



RF Energy Feedback





Beam current stability

The implemented feedbacks have reduced the energy variation with almost a factor 3

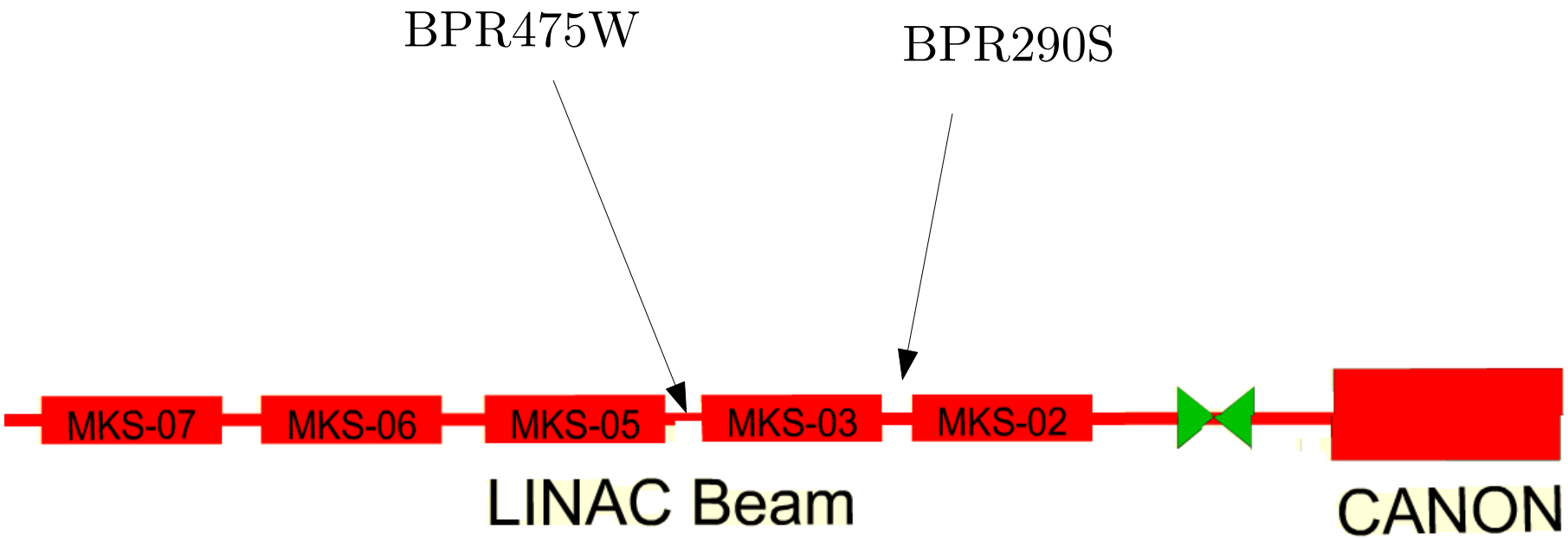
- Without any new equipment being added
- The improved energy stability has together with precise machine tuning, phase-loop and temperature feedbacks resulted in a beam current stability of below for a beam combined 4 times $\frac{\sigma_I}{I} = 10^{-3}$

Very close to the CLIC requirement of $\frac{\sigma_I}{I} = 7.5 \cdot 10^{-4}$

http://www.sciencedirect.com/science/article/pii/S0168900213012722

Stabilizing the beam phase and the bunch length coming from the CTF3 Injector

Injector Feedback



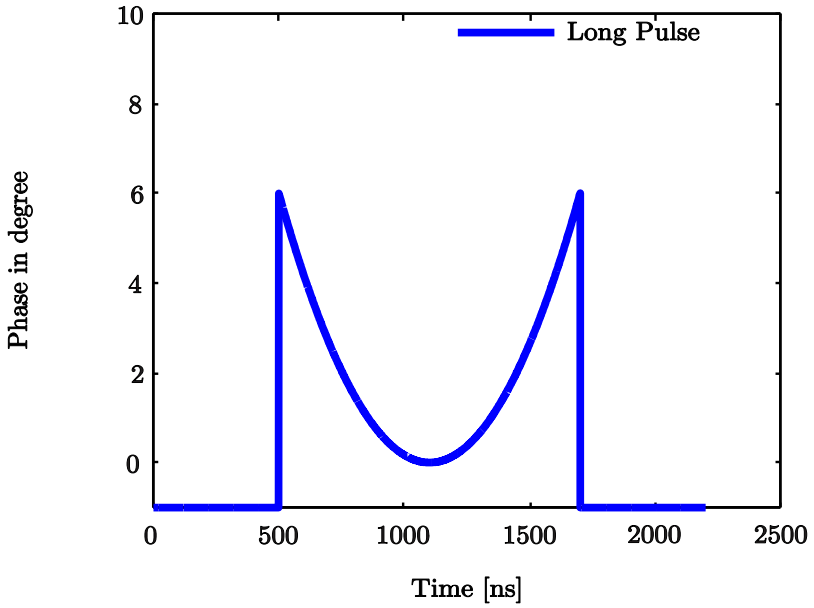
Adjusting the phase of MKS-02 and MKS-03 in order to stabilize the signals.

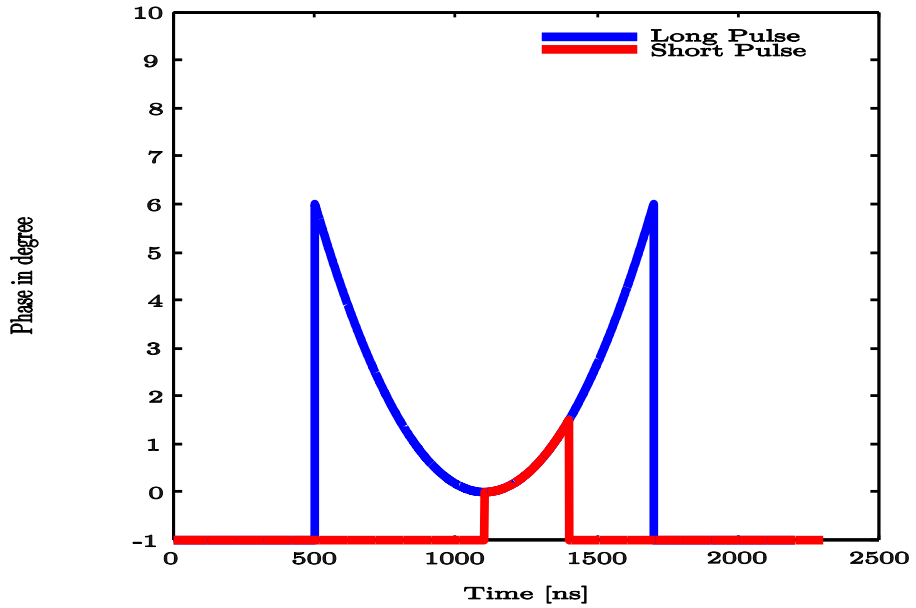
Lukas Malina, CERN

The difficulty is in the details

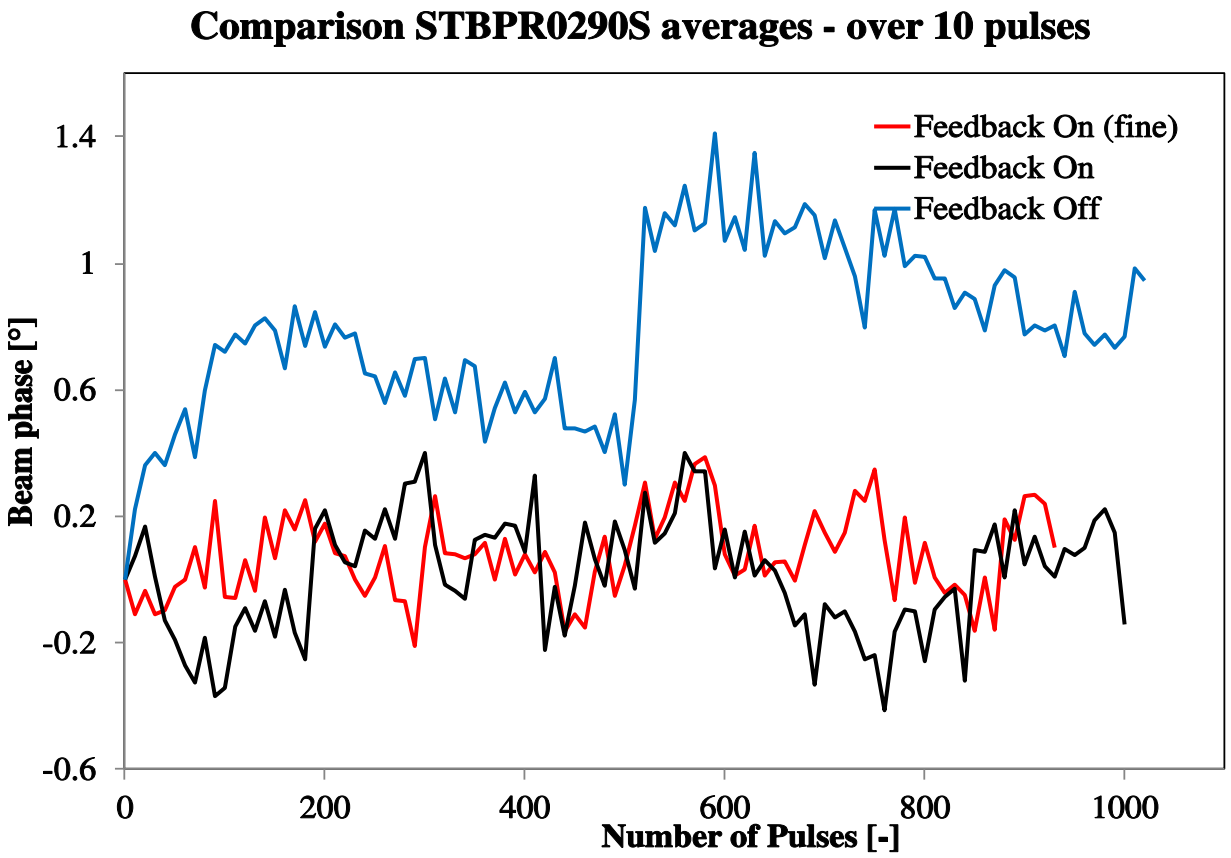
CTF3 is very much a test facility →

- The mode of operation is changed on a hourly basis.
  - The feedbacks need to be able to follow!



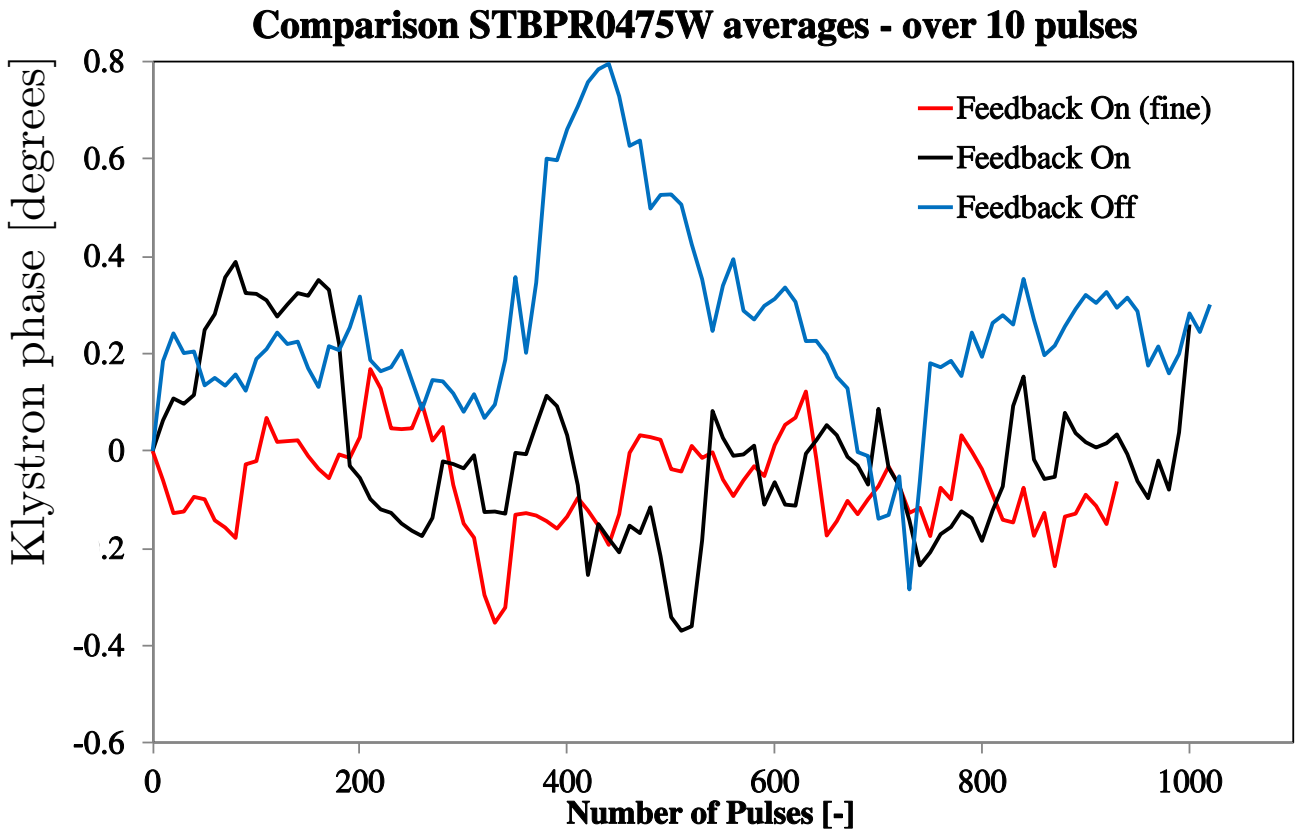


Results from injector feedback



Beam phase in 3GHz

Results from injector feedback(2)



Conclusion and Outlook

- The RF amplitude stabilization together with the dedicated energy feedback reduces the energy variation of almost a factor 3.
    - This together with precise machine tuning has resulted in a beam current stability very close to the CLIC requirement.
- The injector feedback reduces the variation of the phase and bunch length.
- Now the focus is to reach the same stability for the beam combined 8 times.

Thank you for your attention!