Beam current stability in CTF3

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Acknowledgments:
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and CTF3 team

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Outline

1. **Motivations for the study.**
2. **Methods.**
3. **Beam current feedback in CTF3.**
4. **Conclusions.**

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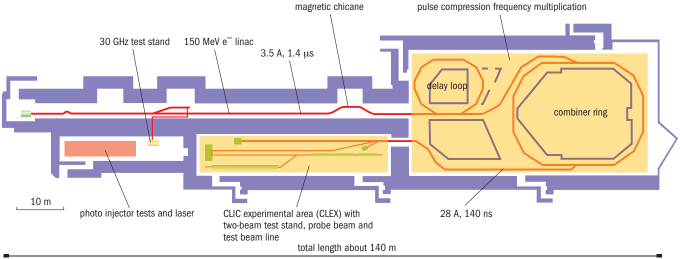
CLIC luminosity and DB current stability

$$\frac{\Delta\mathcal{L}}{\mathcal{L}} = 0.01\left(\frac{\sigma_I}{0.75\ 10^{-3}\ I}\right)^2 + \ldots \text{[D. Schulte et al.]}$$

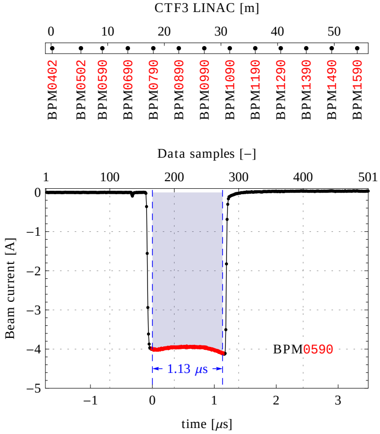
- The luminosity loss is proportional to the square of the DB current jitter $\Rightarrow \frac{\sigma_I}{I} < 0.75\ 10^{-3}$.
- Can we meet this specification in CTF3?



Outline

Our observables

- We studied the beam current jitter before the recombination (13 LINAC BPMs).
- Our observable is the total current of the pulse, I, i.e., for each pulse and BPM we get a scalar number.



Our observables

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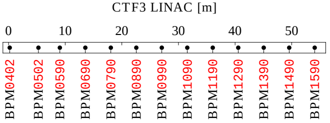
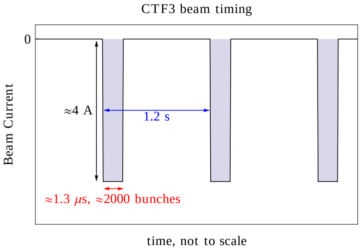
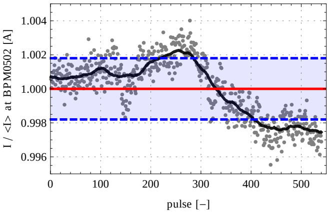
- Our observable is the total current of the pulse, I, i.e., for each pulse and BPM we get a scalar number.
- The pulse period is 1.2 s. Our statistics is on 500-600 pulses ($\approx$ 10 min).

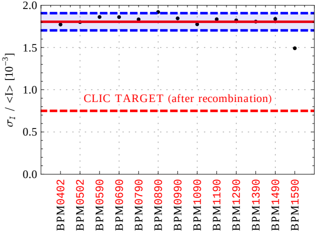




Measurements I

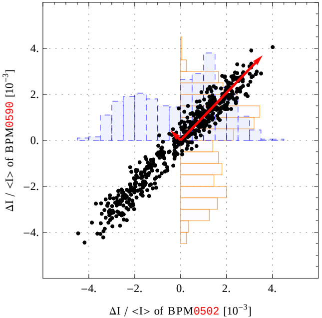
- The observed current jitter has a low frequency component.
- $\Delta I/I \approx 2\ 10^{-3}$ along the linac.





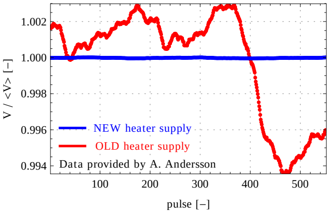
Measurements I

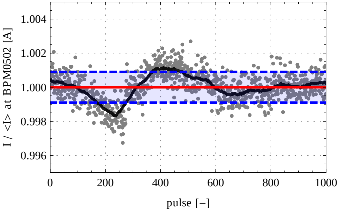
- The observed current jitter has a low frequency component.
- $\Delta I / I \approx 2\ 10^{-3}$ along the linac.
- From correlation studies we conclude that the BPM precision is $\approx 0.3\ 10^{-3}$.
- $\rightarrow$ We observe a physical jitter and not the BPM's noise.



Measurements II

- AFTER the replacement of the power supply of the cathode filament with a more stable one, the beam current jitter of the linac was reduced by about a factor 2 (to a standard deviation of 0.9 10^3)
- Still a low frequency drift. A feedback can cure it!





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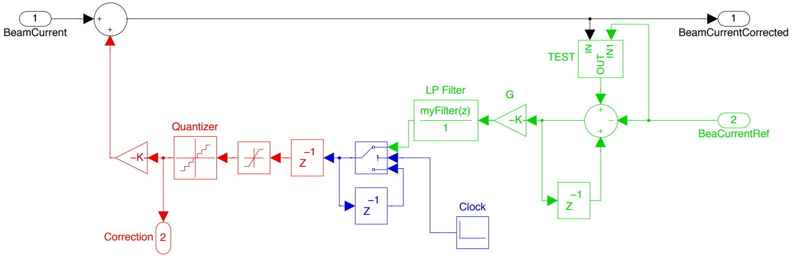
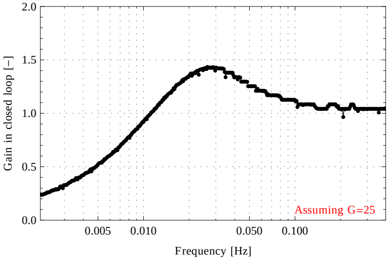
The proposed feedback



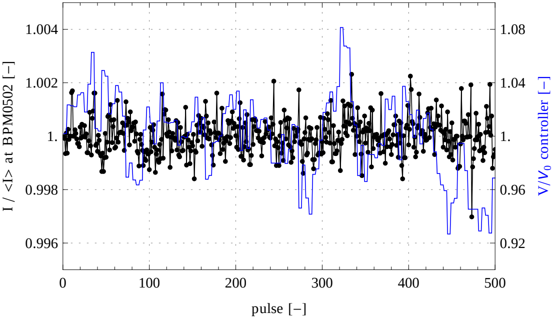
The FB reads the beam current and control it by changing the cathode voltage of the electron gun. This is a slow inter-pulse feedback!

The FB "frequency response" (simulated)

- Keeping in mind the limitations of the present hardware (repetition rate, saturation, discretization) and signal routing (delays), the optimized gain of our controller is 25.
- We can demagnify by ≈ 4 the low frequency jitter (< 4 mHz) whereas we increase up to a factor ≈ 1.5 the jitter at 30 mHz.
- With the optimal gain the simulations show that we can reduce the current jitter to $6\ 10^{-4}$.



Measurements with the FB



After implementing the feedback in CTF3, we measured a beam stability of 6.2 10^{-4}.

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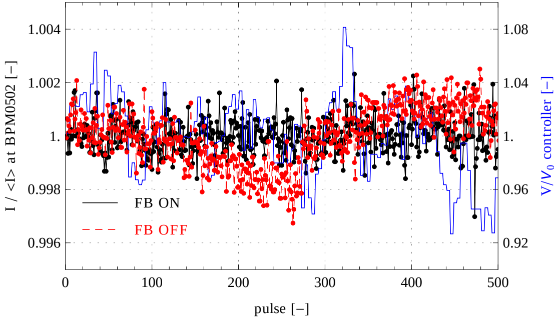
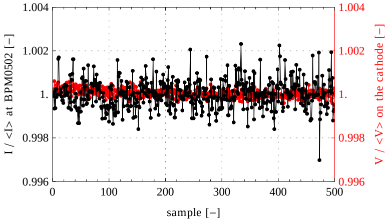
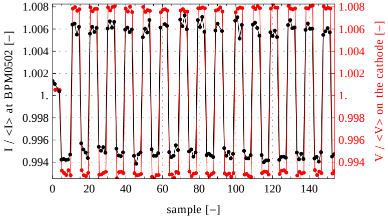


After implementing the feedback in CTF3, we measured a beam stability of 6.2 10^{-4} (instead of 9 10^{-4}). But still a lot of HF noise. . . from where?

The source of the high frequency noise

- Investigation are on going...
- We analyze (1) (parasitically) the noise of the different input and (2) its transfer function with the beam current.
- I.e., from this kind of measurements we can exclude that the EGUN's cathode is responsible for the HF noise.





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- (The DB current stability is directly related to CLIC luminosity: $\Delta\mathcal{L}/\mathcal{L} \propto (\sigma_I/I)^2$)
- We measure and improve the beam stability in the CTF3 linac.

$$\frac{\sigma_I}{I} = 20\ 10^{-4} \longrightarrow \text{HS} \longrightarrow \frac{\sigma_I}{I} = 9\ 10^{-4} \longrightarrow \text{FB} \longrightarrow \frac{\sigma_I}{I} = 6.2\ 10^{-4}$$

- In CTF3 linac the CLIC spec on I_B jitter has been achieved.
- The BPM precision is $\approx 3\ 10^{-4}$.
- Presently, the EGUN's cathode contributes marginally to the I HF jitter.
- Our next step is to analyze the stability of the beam current after the recombination.

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THANK YOU!