Summary WG 6

Drive Beam and CTF 3

International Workshop on Linear Colliders 2010

October 22, 2010

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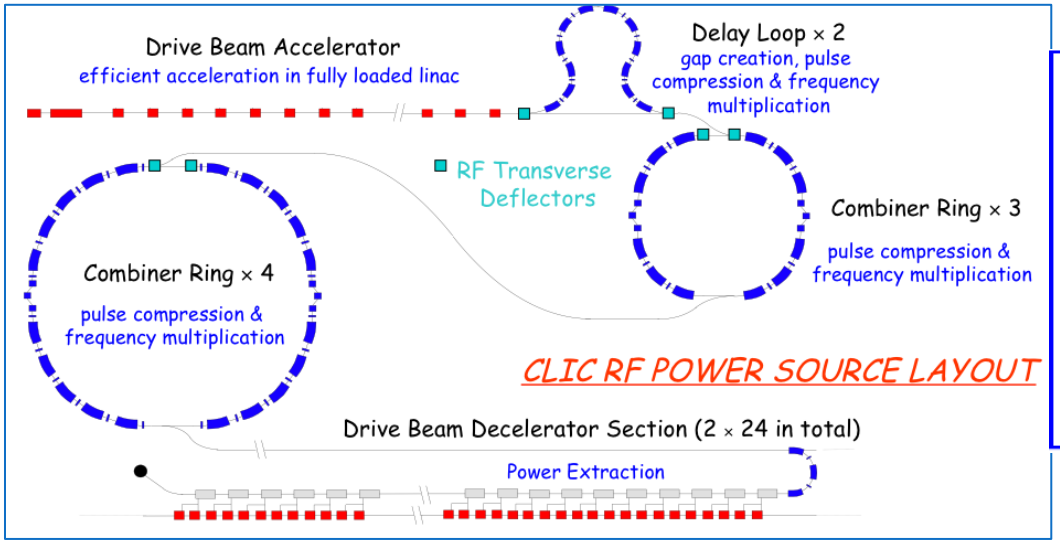
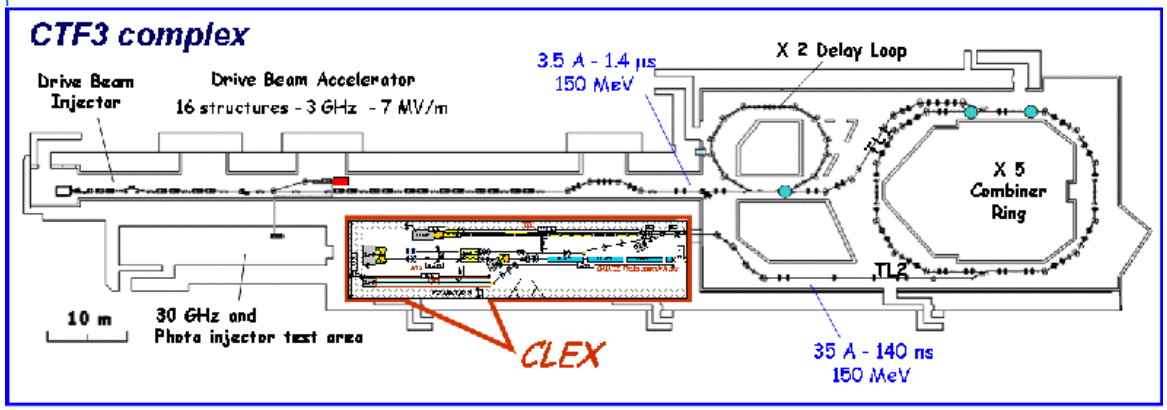
for Working Group 6

Drive Beam and CTF 3

CLIC drive beam: rf source delivering very high power (135 MW x 1500 x 48) in very short rf pulses (240 ns).
CTF3: test facility to demonstrate drive beam generation (acceleration, frequency multiplication), two-beam acceleration and deceleration.



CLIC Drive Beam



CTF 3

To reach a CDR for CLIC:
* conceptual design for all parts of the drive beam
* feasibility demonstration of unproven concepts and technologies

Since last workshop, an impressive amount of work has gone into both design studies and CTF3 experimental studies.

Reminder

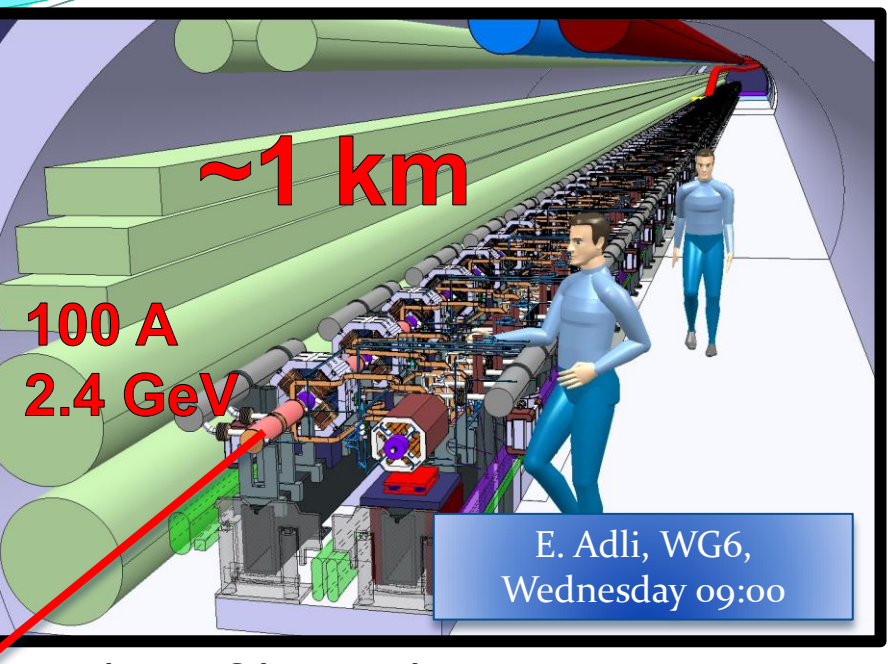
Decelerator: power source for main linacs. Requirements for 1% luminosity loss: $\Delta E/E < 7 \times 10^{-4}$. Converted to drive beam requirements, for the relevant frequencies :

$$\frac{\Delta\mathcal{L}}{\mathcal{L}} \approx 0.01 \left[\left(\frac{\sigma_{\phi,coh}}{0.2^\circ} \right)^2 + \left(\frac{\sigma_{\phi,inc}}{0.8^\circ} \right)^2 + \left(\frac{\sigma_{I,coh}}{0.75 \times 10^{-3} I} \right)^2 + \left(\frac{\sigma_{I,inc}}{2.2 \times 10^{-3} I} \right)^2 + \left(\frac{\sigma_{\sigma_z,coh}}{1.1 \times 10^{-2} \sigma_z} \right)^2 + \left(\frac{\sigma_{\sigma_z,inc}}{3.3 \times 10^{-2} \sigma_z} \right)^2 \right]$$

D. Schulte, WG2,6,7,8, Wednesday 14:00

Important driver for the drive beam studies.

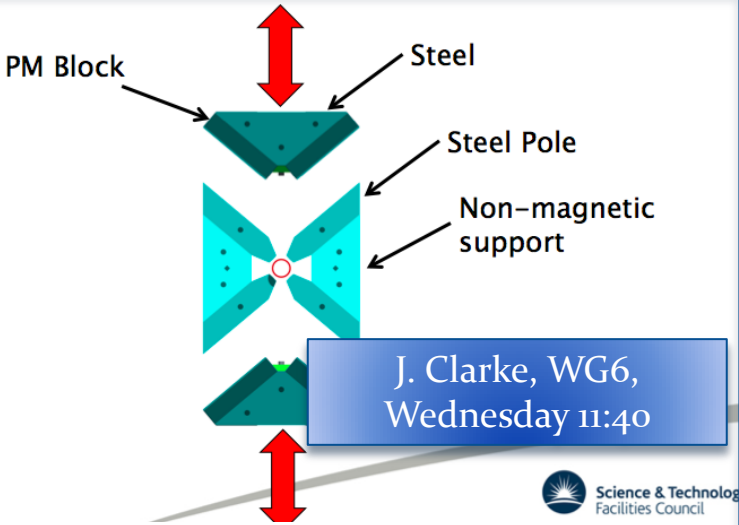
Design: decelerator



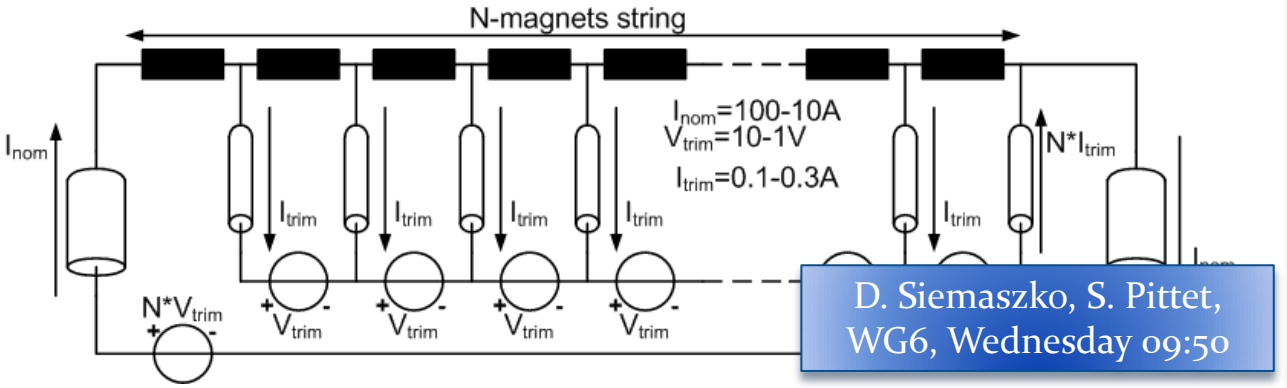
E. Adli, WG6, Wednesday 09:00

42 km of beam line, 28000 BPMs, 40000 quads (tunable), 70000 PETS.

A. Vorozhtsov, WG6, Wednesday 09:30

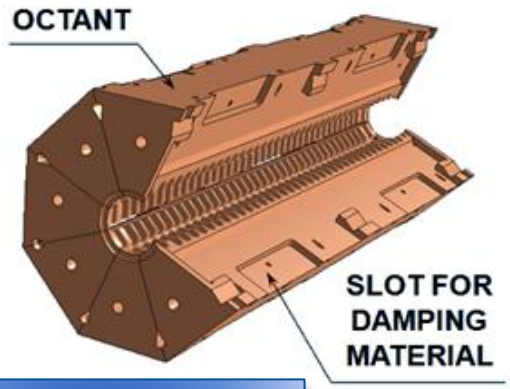


J. Clarke, WG6, Wednesday 11:40



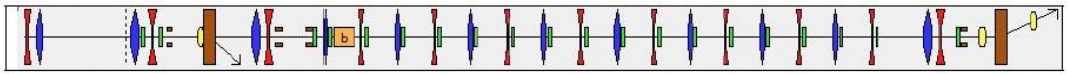
D. Siemaszko, S. Pittet, WG6, Wednesday 09:50

Powered magnets with serial fault tolerant energy efficient powering scheme, and tunable permanent magnets presented, and up to spec.



A. Cappelletti, WG6, Wednesday 10:30

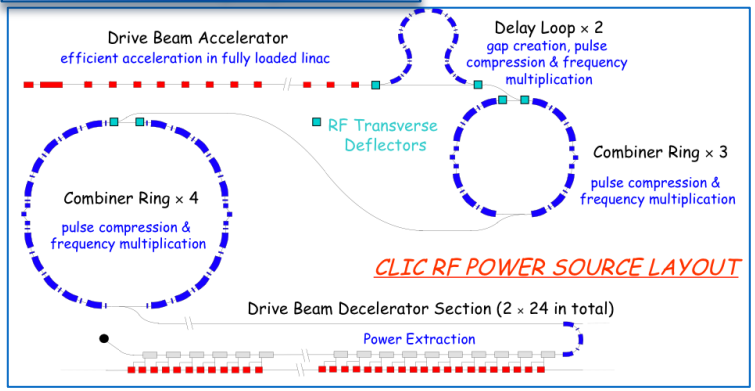
R. Lillestøl, WG6, Wednesday 11:00

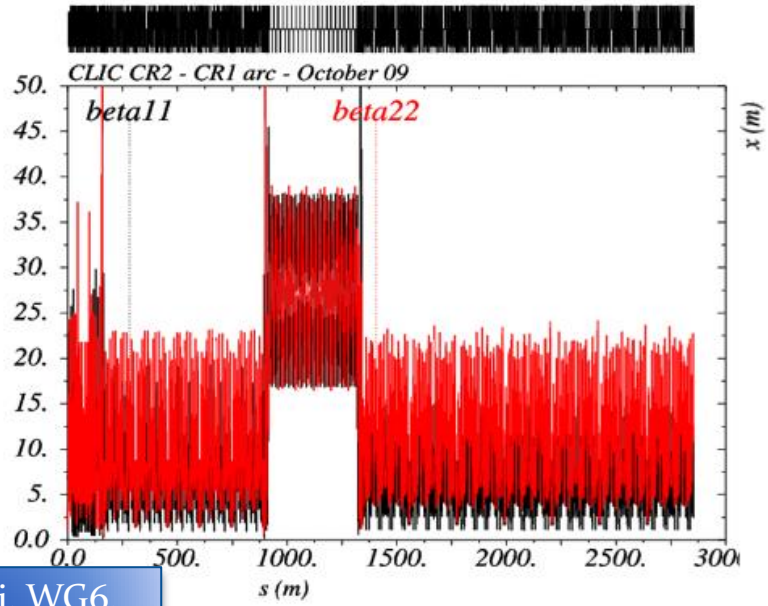


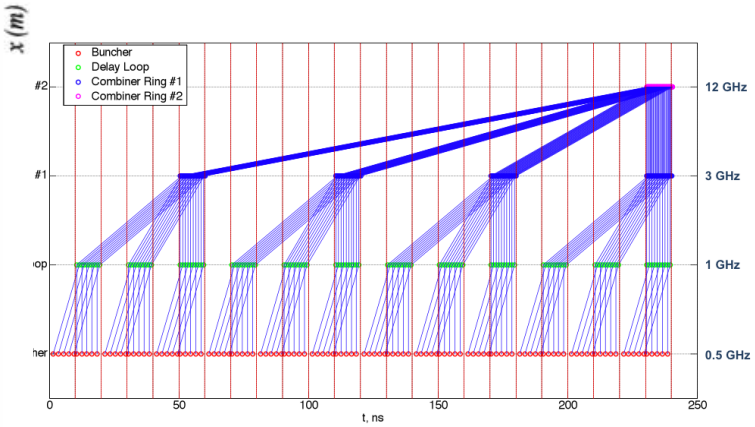
Decelerator prototype: Test Beam Line, commissioning of beam line and instrumentation going well; however, only 1 of 16 PETS installed. 8 PETS, 25-30% deceleration expected mid-2011.

Design: frequency multiplication

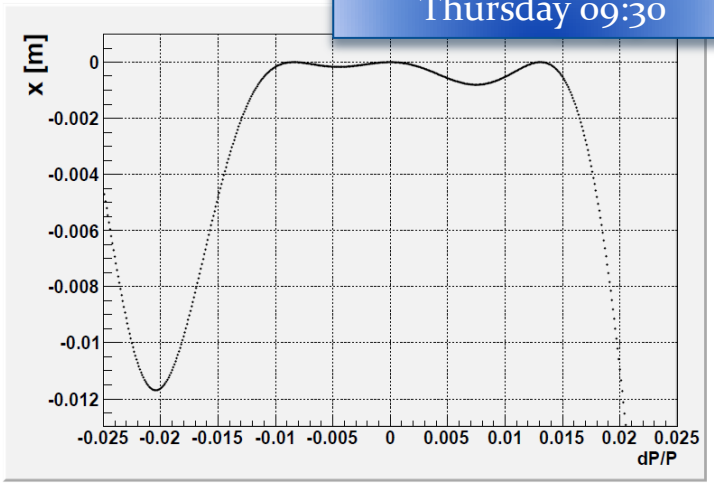
B. Jeanneret, WG6, Thursday 09:00





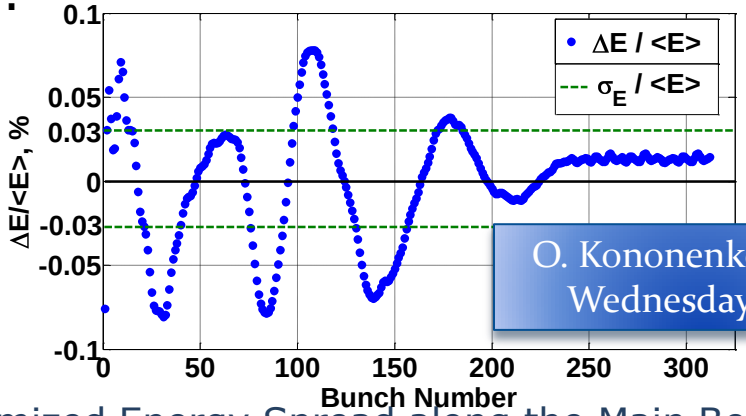


P. Skowronski, WG6, Thursday 09:30



Design for rings in an advanced stage. Still challenges to reach good momentum acceptance due to non-linear dispersion.

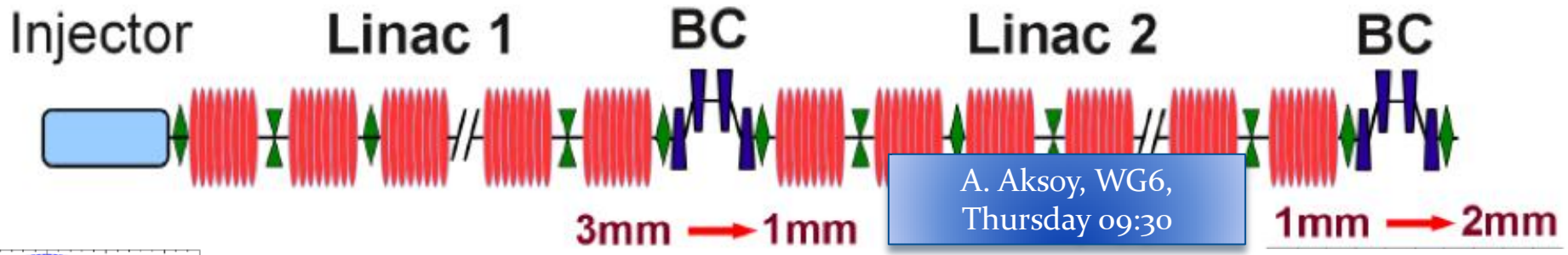
Reminder: frequency multiplication system also used for**: beam loading compensation,** low-energy running operation and drive beam dispersion-free steering :



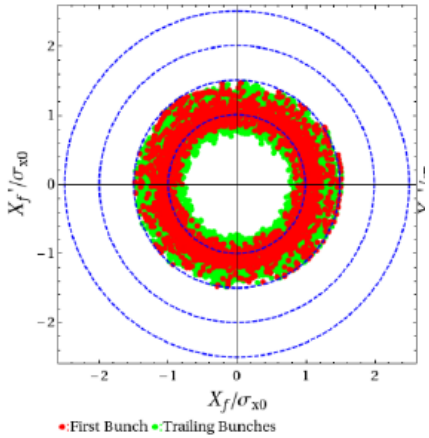
O. Kononenko, WG6, Wednesday, 11:20

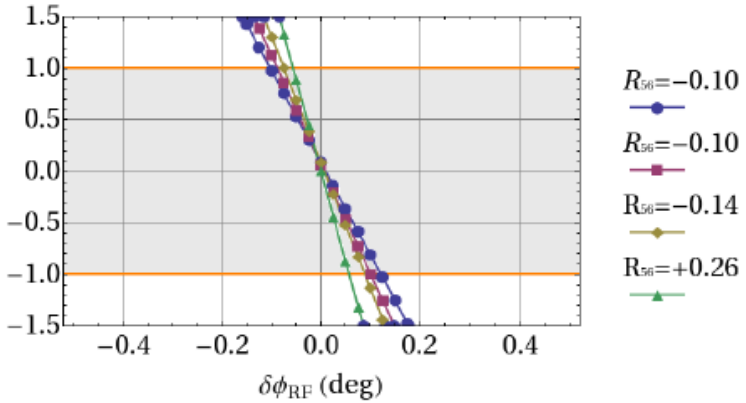
Optimized Energy Spread along the Main Beam: adjusting switching for frequency multiplication

Design: drive beam accelerator



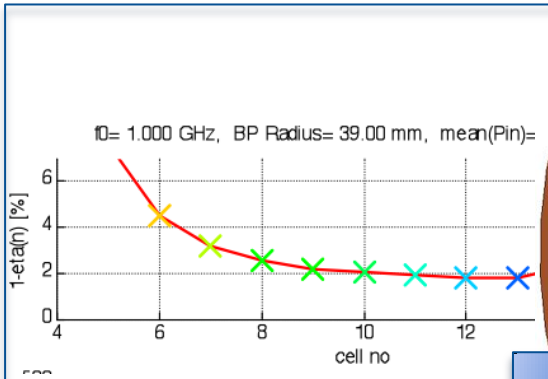
A. Aksoy, WG6, Thursday 09:30





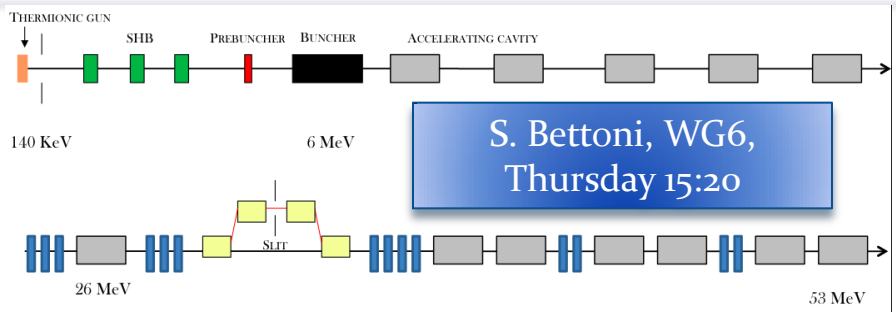
Short-range wake well contained with FODO cells.

Power production requirement gives tough phase-requirements, beam phase of 0.1 deg.



R.Wegner, WG4+6, Thursday 12:00

1 GHz structure design with >97% rf to beam efficiency, based on proven CTF3 structures.

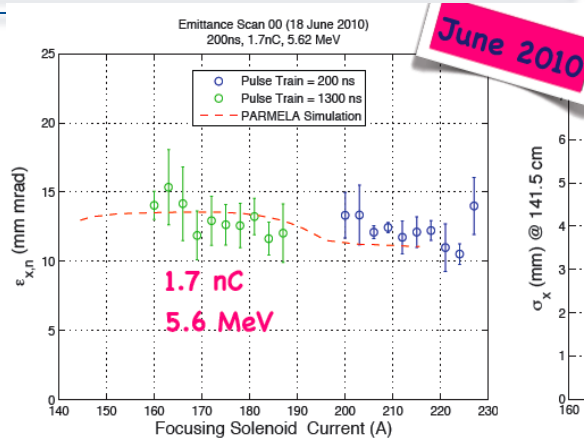


S. Bettoni, WG6, Thursday 15:20

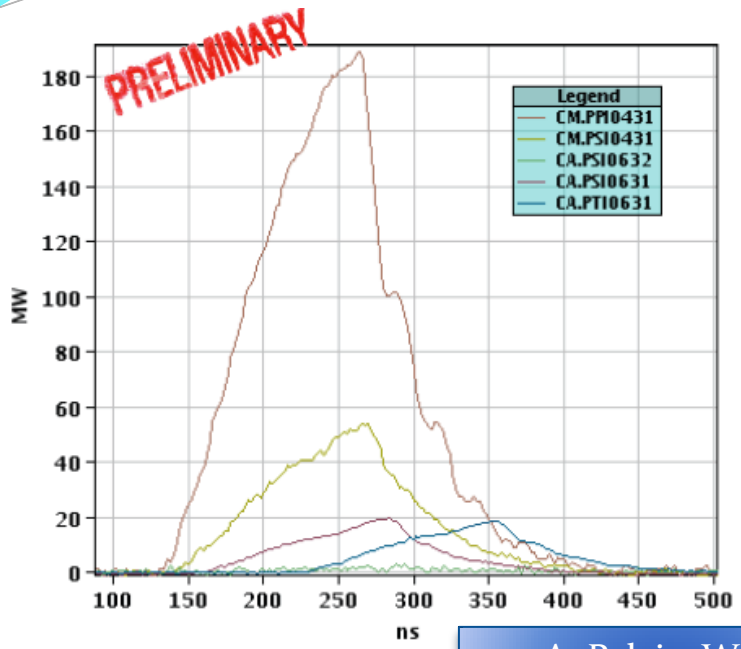
Injector: first design in place. Challenge of satellite population after 0.5 GHz bunching must be addressed further (ideas exist).

Alternative injector: photo-injector, where phase-coding is performed by the laser. Experimental studies (**PHIN**), has shown promising results for such a drive beam injector for CLIC.

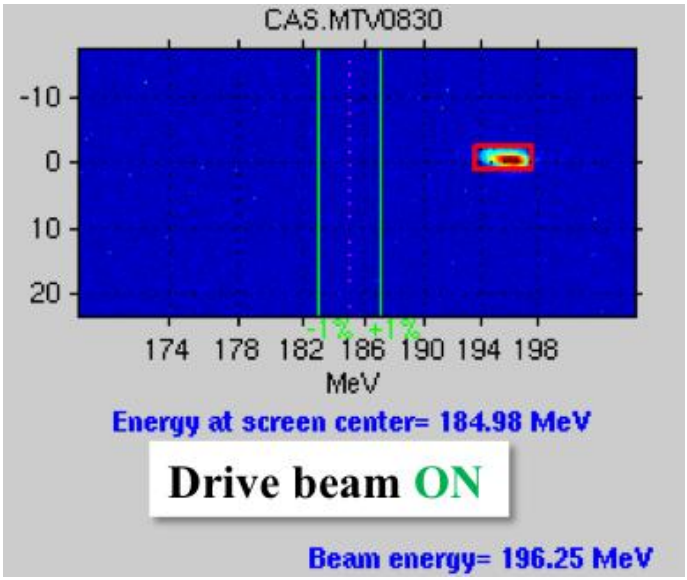
O. Mete, WG6, Thursday 15:00

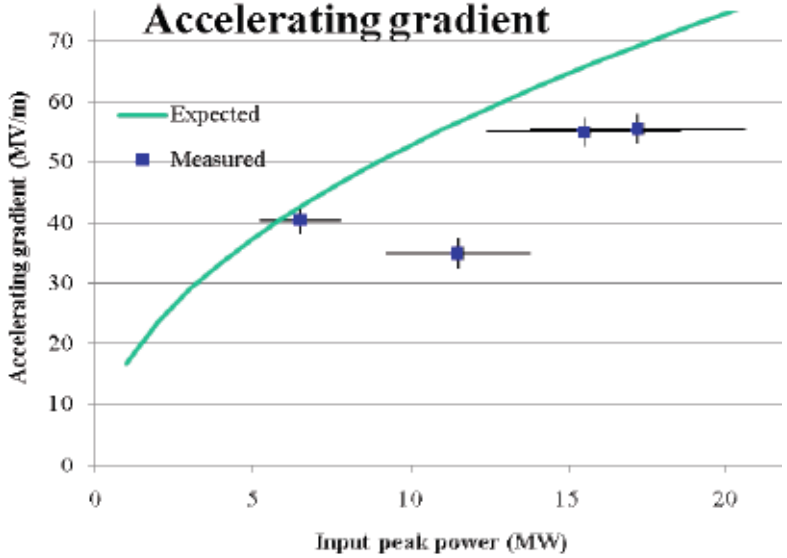


CTF3: two-beam acceleration



A. Palaia, WG6, Thursday 14:00





W. Farabolini, WG6, Thursday 14:20

Probe beam (CALIFES) in very good state; almost all parameters up to spec.

Accelerating gradient of 55 MV/m reached in the Two-beam Test Stand (PETS with feedback). Impressive joint effort drive beam team, TBTS team, laser team.
Still work to be done to fully characterize all the power flow in the system. However, we have every hope to reach CLIC target of 100 MV/m this year.

	PARAMETERS	PHIN	CALIFES
Laser in UV	laser wavelegth (nm)	262	262
	energy/micropulse on cathode (nJ)	>363	947
	energy/micropulse laserroom (nJ)	544	1420
	energy/macrop. laserroom (uJ)	9.8E+02	4.1E+01
	mean power (kW)	0.8	2.1
	average power at cathode wavelength(W)	0.005	2.E-04
	micro/macropulse stability	<0.25%	<3%
Laser in IR	conversion efficiency	0.1	0.15
	energy/macropulse in IR (mJ)	9.8	0.3
	energy/micropulse in IR (uJ)	5.4	9.5
	mean power in IR (kW)	8.2	14.2
	average power on second harmonic (W)	0.49	1.E-03
	average power in final amplifier (W)	9	15

M. Csatiri, WG6, Thursday 14:40

Achieved
Not yet reached

Laser shared between probe beam (short pulse) and PHIN (long pulse).

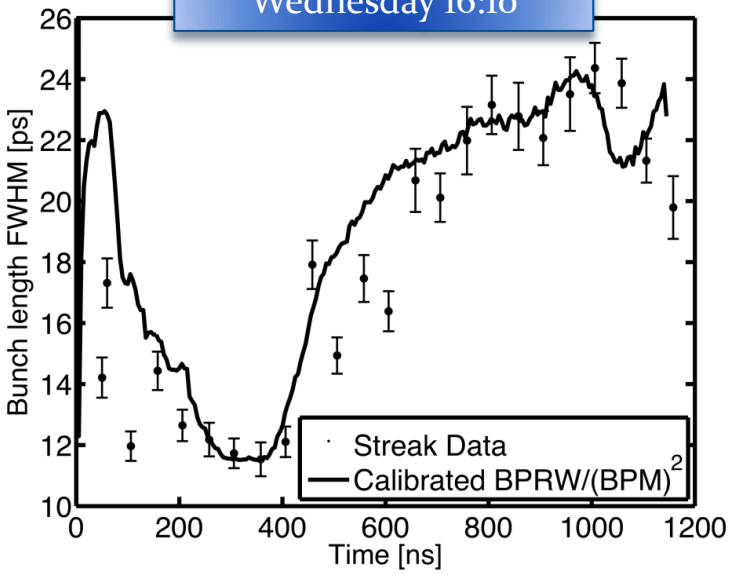
CTF3: Instrumentation

Precise diagnostics are fundamental to benchmark CTF3 beam power production against predicted power (form factor; bunch length and bunch phases) and energy gain and loss (time resolved spectroscopy).
An impressive amount of instrumentation in installed in CTF3 the last few years, allowing also for precise phase measurements. More beam time needed for calibration.

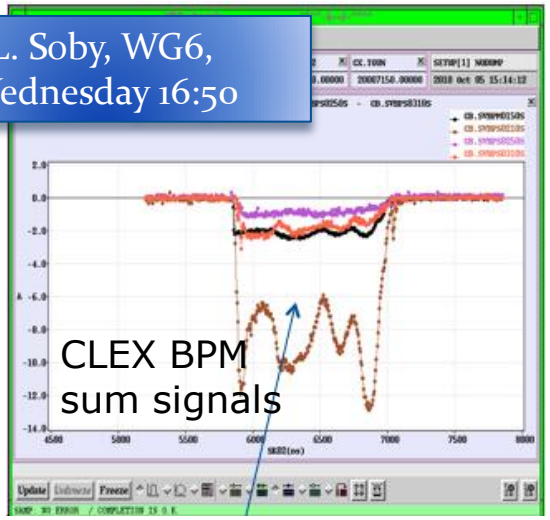
- ✓ Emittance
- ✓ Energy and energy spread
- ✓ Bunch frequency measurements
- ✓ Bunch length
- ✓ Form factor @ 12 GHz

BPMs:
a total of 137 BPMs. Most have performed very well, however, we observe some problems with drive beam in CLEX; under investigation. In general a challenge for machine operation: instrumentation or electronics prototypes is used for machine commissioning.

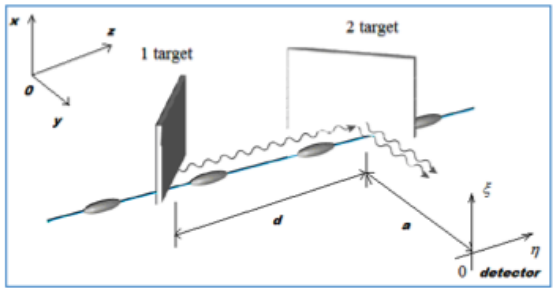
A. Dabrowski, WG6, Wednesday 16:10



L. Soby, WG6, Wednesday 16:50



$impact_{1\,target} = 10\,mm,\ impact_{2\,target} = 10\,mm$



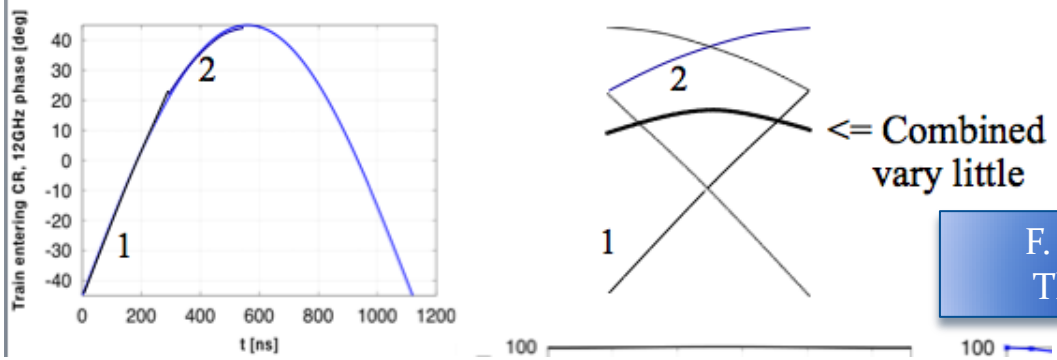
$$S_{coh}(\omega) = N^2 S_e(\omega) F(\omega)$$

K. Lekomtsev, WG6, Wednesday 17:20

Novel Coherent Diffraction Radiation experiment also installed in CTF3. Good progress (but yet for for operational use).

CTF3: critical view

- phase variation leads to power reduction in combined beam

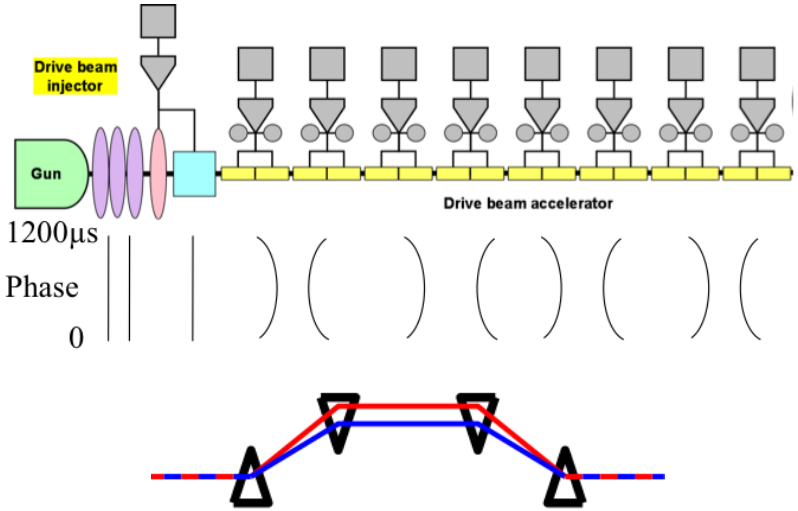


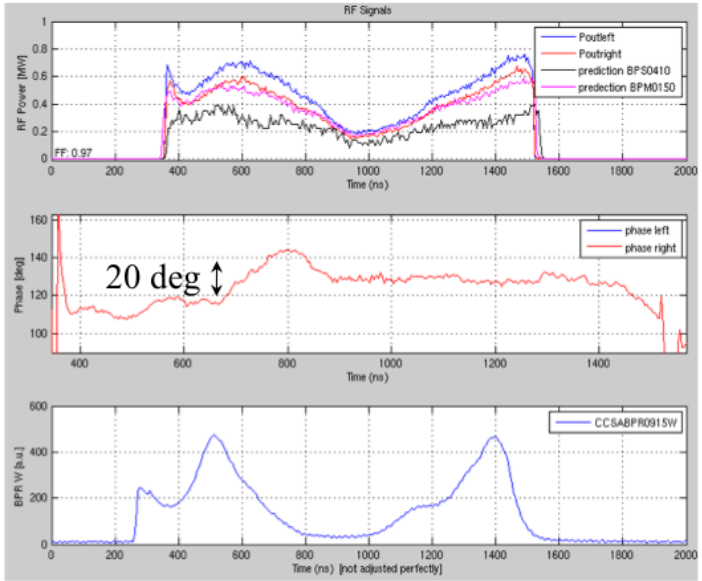
Reaching the desired beam current is not enough; it is the rf power produced that counts.

F. Tecker, WG6, Thursday 16:10

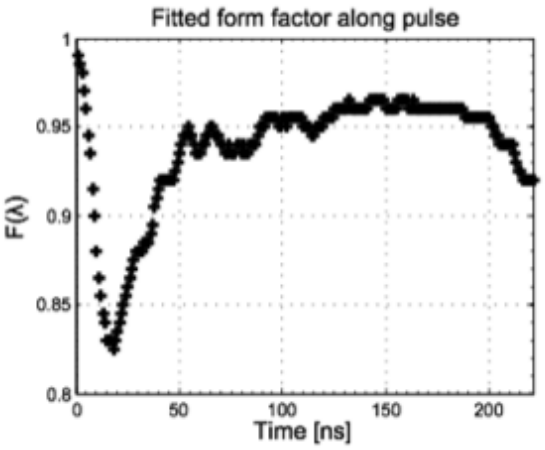
Round-table WG6, Thursday 17:10

Note: CTF3 is not CLIC drive beam complex; CTF3 has rf pulse compression. Much of problems with getting flat pulses in the power structures believed.
CTF3 experience: rf pulse-compression is Very Bad for pulse stability (pulse to pulse, and along the pulse).





Sample TBL measurement (uncombined beam)



Form factor fit from sample TBL measurement (combined beam)

Rf pulse generated in PETS is still quite far from CLIC-type.

CTF3: progress and outlook

CTF3 performance and stability is continuously improving. Some highlights :

Machine tuning for power production:

Large effort from CTF3 operator core team to minimize phase-variations along beam, despite pulse compression.

Beam current :

- We measure and improve the beam stability in the CTF3 linac.

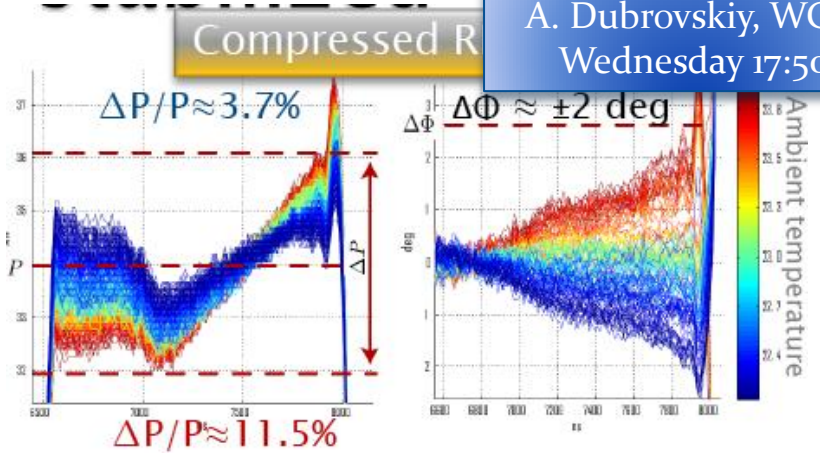
$\frac{\sigma I}{I} = 20\ 10^{-4}$ → HS → $\frac{\sigma I}{I} = 9\ 10^{-4}$ → FB → $\frac{\sigma I}{I} = 6.2\ 10^{-4}$

CTF3 linac current stability is now better than the CLIC requirements.

G. Sterbini, WG6, Wednesday 17:30

Klystrons / PC :

A. Dubrovskiy, WG6, Wednesday 17:50



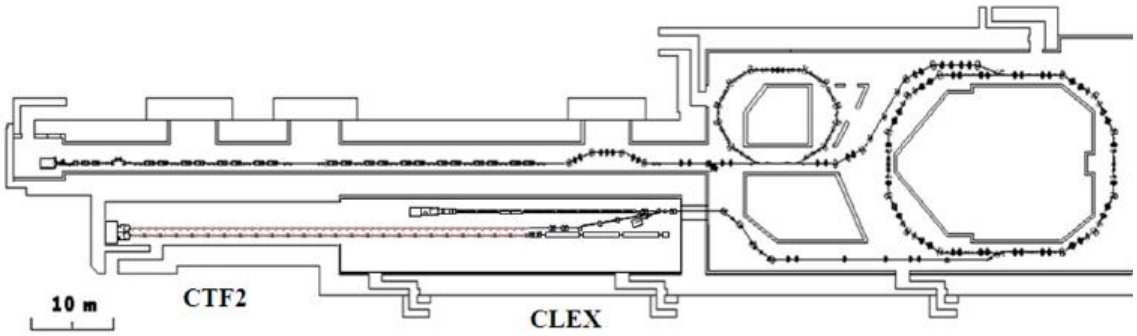
[1] A.Dubrovskiy, F.Tecker, "RF Pulse Compression Stabilization at the CTF3 CLIC Test Facility", IPAC2010

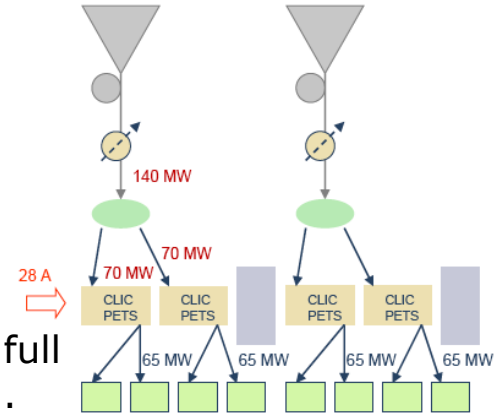
[1] A.Dubrovskiy, "RF phase & amplitude stability of the CTF klystrons", CLIC Beam Physics Meeting (2010)

CTF3 outlooks :

R. Corsini, WG6, Thursday 16:40

CTF3: several interesting upgrade scenarios for the next phase.





One line of though: combining CLEX and CTF2, making room for < 20 full CLIC-like modules; all structures can be powered with PETS + priming.