Future Work and Upgrade of CTF3

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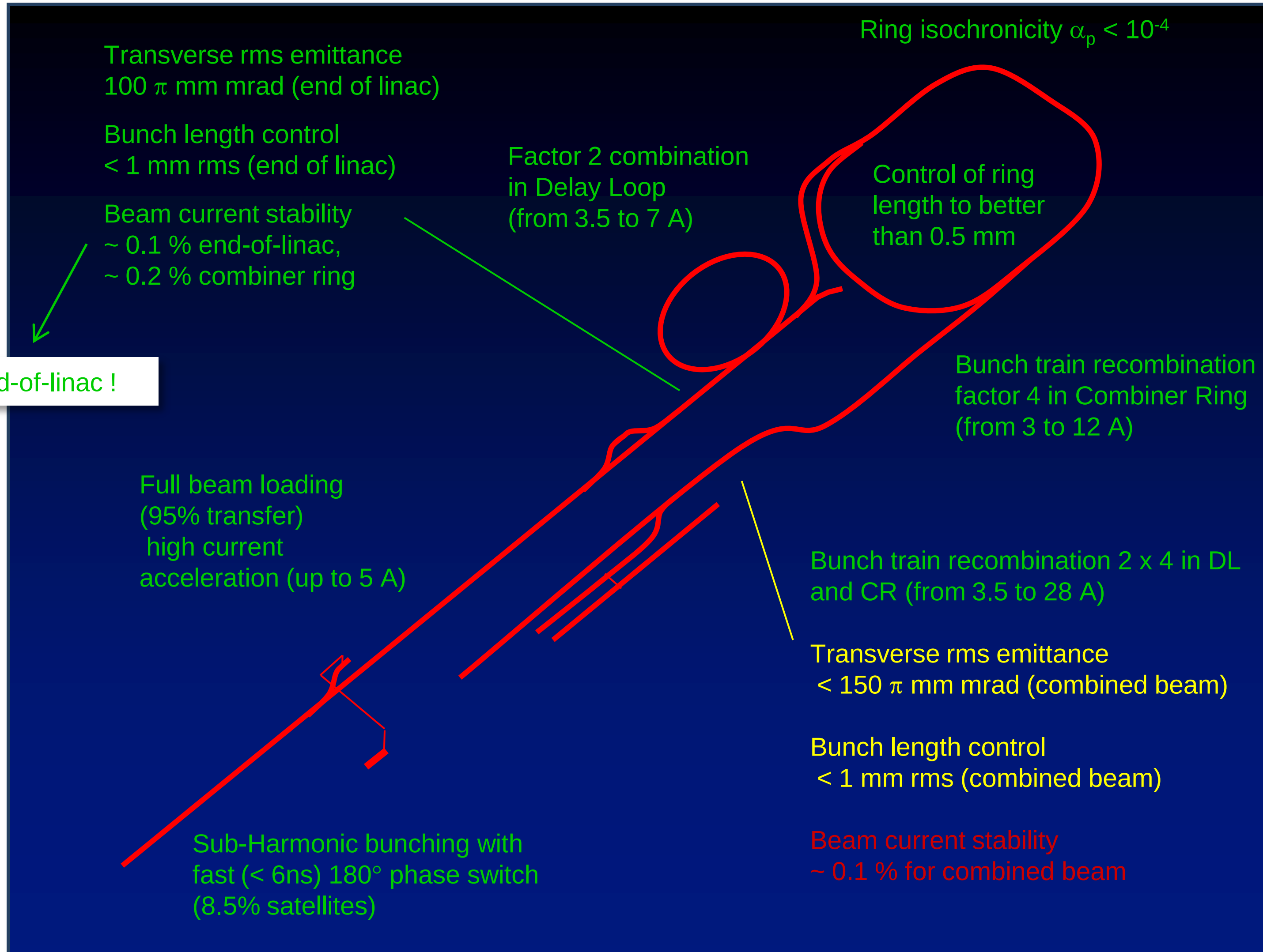
Talk outline

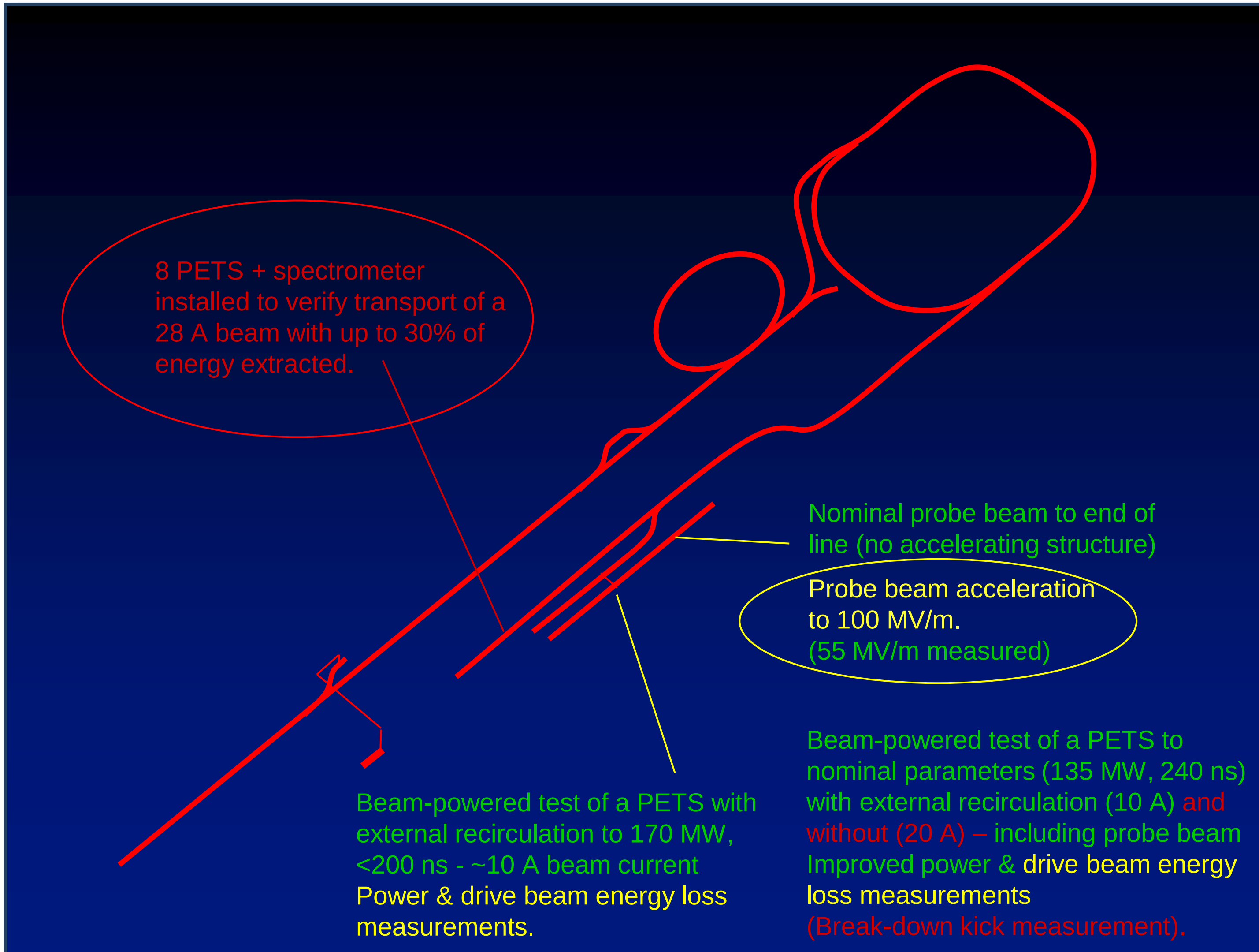
- Short term program – completion of feasibility studies
- Long term program
  - Consolidation
  - Upgrade (energy)
  - Drive beam phase measurements, feedback
  - Power production, TBL+
  - Two-beam modules
- Beyond CTF3

CTF3 Achievements – What is still missing for feasibility – Drive Beam Generation



~ 0.06 % end-of-linac !

CTF3 Achievements – What is still missing for feasibility – TBL / TBTS / CALIFES



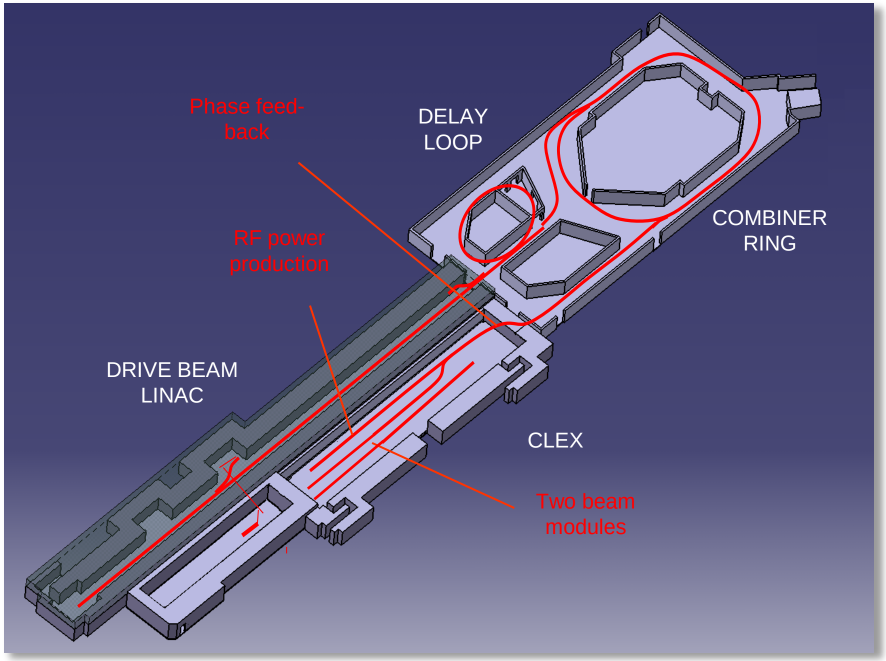
Missing "feasibility" studies

- Decelerator studies. 8 PETS (2011), then 16 PETS (2012)

- TBTS program (until end 2011)
  - Breakdowns (PETS + accelerating structure, cross-talk?)
  - Breakdown kick
  - Basic two-beam studies (higher gradient, phasing, stability, ...)
  - "beam loading" – or, rather, RF pulse shaping & control and acceleration
  - Effect of loading on breakdown rate (???)

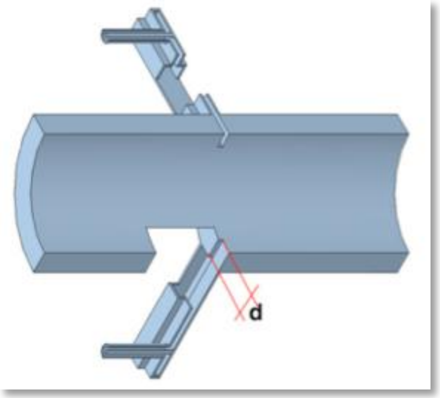
- Drive beam stability – combined beam (2011?)
- Drive beam phase measurements (initial, then INFN phase monitor... 2011+)

- Consolidation/upgrade of CTF3 to fully exploit its potential
  - Verify stability/reliability performance in view of CLIC requirements , improve operational experience, phase feed-back / feed-forward
  - Contribute to high-power RF testing program, demonstrate operation of a drive -beam driven power source
  - Test with beam of ~~nominal~~ as close as nominal as reasonable CLIC two-beam modules

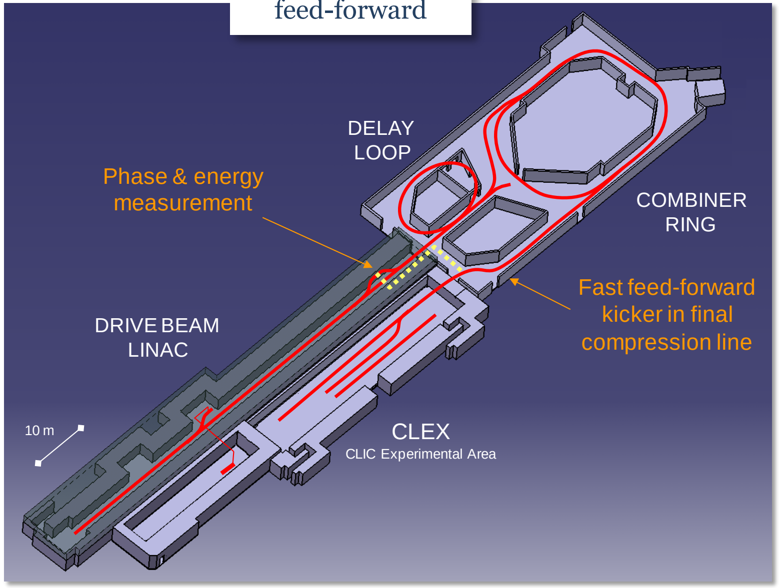


"Drive beam phase"

- Not a single experiment – more a series of related studies
- Measure phase and energy jitter, identify sources, devise & implement cures, extrapolate to CLIC
- Need to identify location and specifications for the CTF3 feed-forward
- Closer link to collaborating partners (INFN, Oxford...)



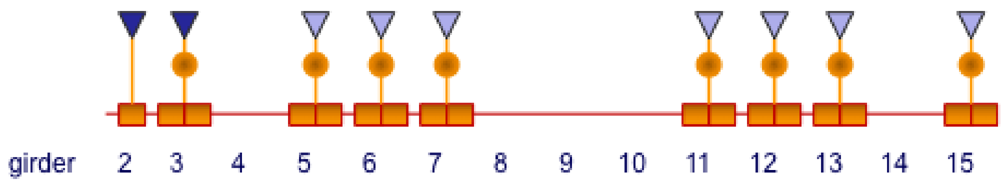
CTF3 - Phase feed-forward



Energy upgrade

30 MW 45 MW

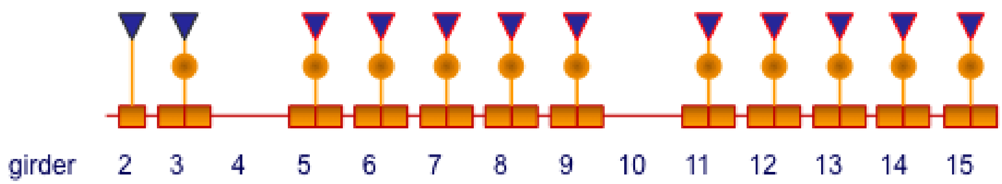
Present



About 120 MeV
for final beam current of
about 28 A

Total beam power 3.3 GW
e.g., enough to feed
24 accel. structures
(final drive beam energy 50 MeV)

Ultimate ?



About 200 MeV
for final beam current of
about 28 A

Total beam power 5.7 GW
e.g., enough to feed
50 accel. structures
(final beam energy 50 MeV)

- Upgrades to 45 MW and MKS14 already planned
- Needs 2 additional MKS, plus 2 new accelerating structures
- Keep spectrometer 10

Needed for long module string

Will help operation and experiments everywhere

Assumptions for CTF3 beam power upgrade

- Need 3 additional power stations
- All modulators/klystrons upgraded to 45 MW nominal power
- RF pulse compression factor ~ 2 (about 38 MW/SICA input, including operational limits and losses)
- 1.4 μs long RF pulse (needed for combination factor 8)
- Keep girder 10 for diagnostics (emittance, momentum, energy spread)

What more could (?) still be done

- Add other power stations & structures (girder 10, CT line ?)
- Further upgrade klystrons
- Combine klystrons by two, double their number (space problem, maybe exceed structure limits…)

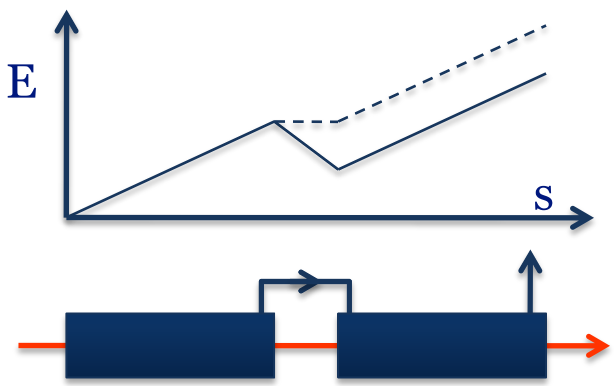
Rep rate upgrade

- Needed for high-power testing (PETS or TBL+) – could help also elsewhere (feed-backs?)

- First tests this year (5 Hz, possibly 10 Hz?), after that:
  - Identify shielding / zone classification needed as a function of rep rate
  - Identify hardware changes needed as function of rep rate
  - Decide ultimate rep rate

TBL as power source (TBL+)

- One TBL PETS is supposed to produce ~ 135 MW for 28 A
- Need factor 8 combination – short RF pulse length



- “chaining” two PETS – almost doubling the length – multiplying by 4 the power
- Conservative assumption for chaining (losses, reduced active length for input coupler) - factor 2 gain, i.e., 135 MW (nominal) power for 14 A
- Can use factor 4 combination, access to up to 260 ns pulses
- Or use substantially lower current to produce needed power (present CLIC TD24 nominal ~ 60 MW), easier and more stable operation, can increase the rep. rate

TBL as power source (TBL+)

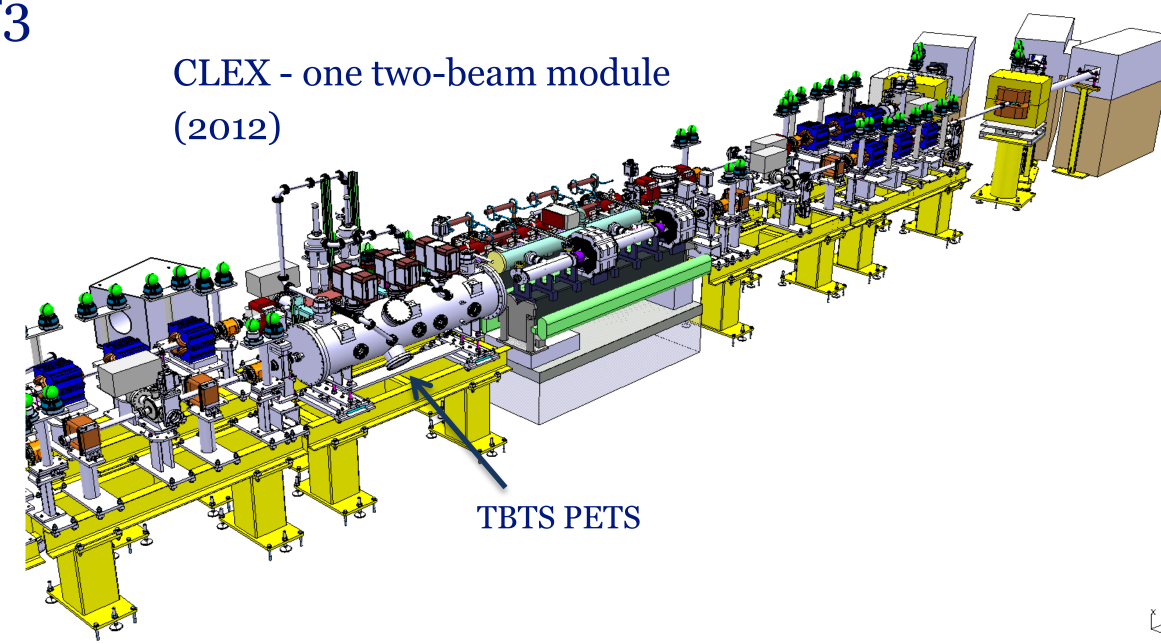
- Contribution to testing program:
  - Klystron based: from 1 to 4 klystrons from 2011 to 2015, 2 slots each, 50 Hz, 80% uptime
  - Npulses = <Nslots>× Nyears ×Reprate × Nseconds_per_year ×uptime

    $= 4 \times 5 \times 50 \times 31{,}556{,}952 \times 0.8 = 25 \times 10^9$
  - TBL based: from 1 to 8 ports, 2 slots each, from 2011 to 2015, 10 Hz, 40% uptime
  - Npulses = <Nslots>× Nyears ×Reprate × Nseconds_per_year ×uptime

    $= 8 \times 5 \times 10 \times 31{,}556{,}952 \times 0.4 = 5 \times 10^9$
- Demonstration of use of two-beam power source. Reliability, stability, uptime…

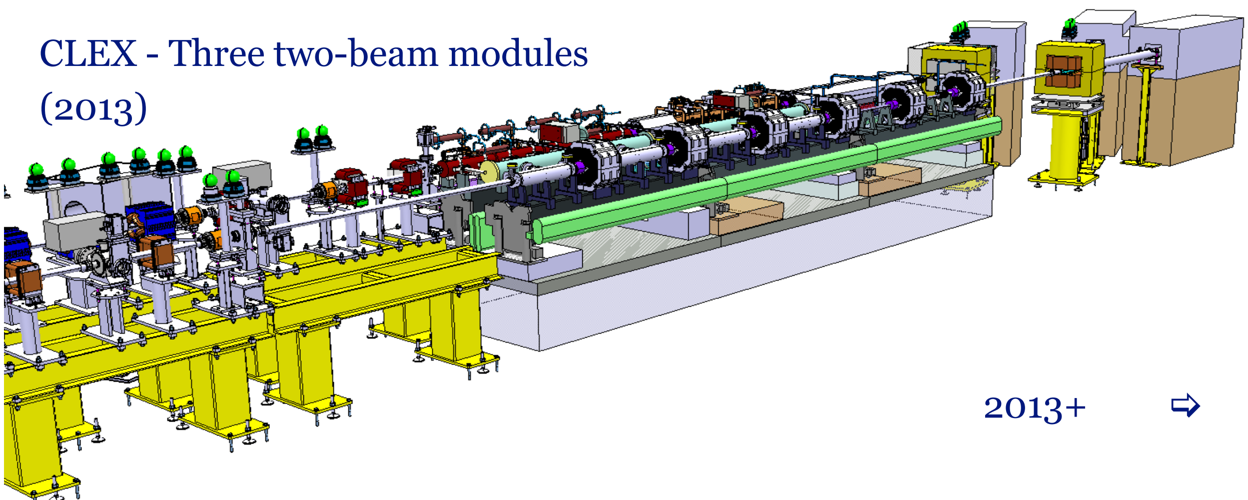
Two-beam modules in CTF3

CLEX - one two-beam module
(2012)



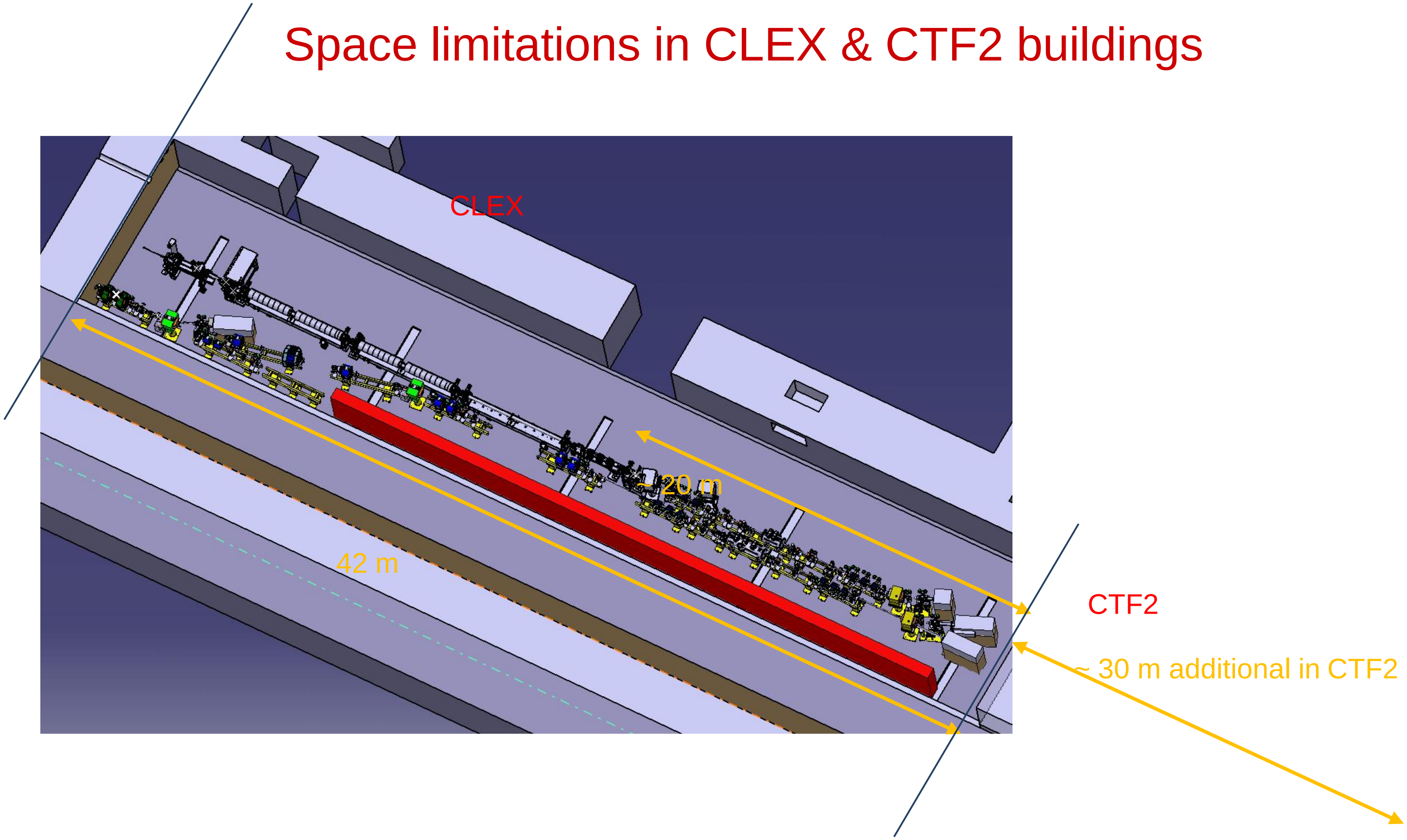
CLEX – TBTS (until 2011)

CLEX - Three two-beam modules
(2013)



2013+ ⇨ N modules (N < 20)

Space limitations in CLEX & CTF2 buildings

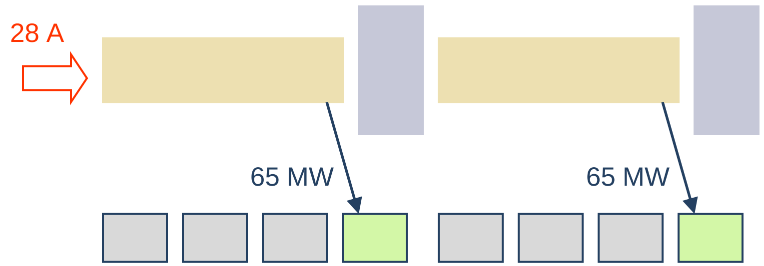


- If CALIFES is kept as it is now, about 50 m available, including CTF2
- About 25 modules maximum (more likely ~ 20)
- Maximum total accelerating structures: 200 (remember, we can fully feed only 50 at most!)

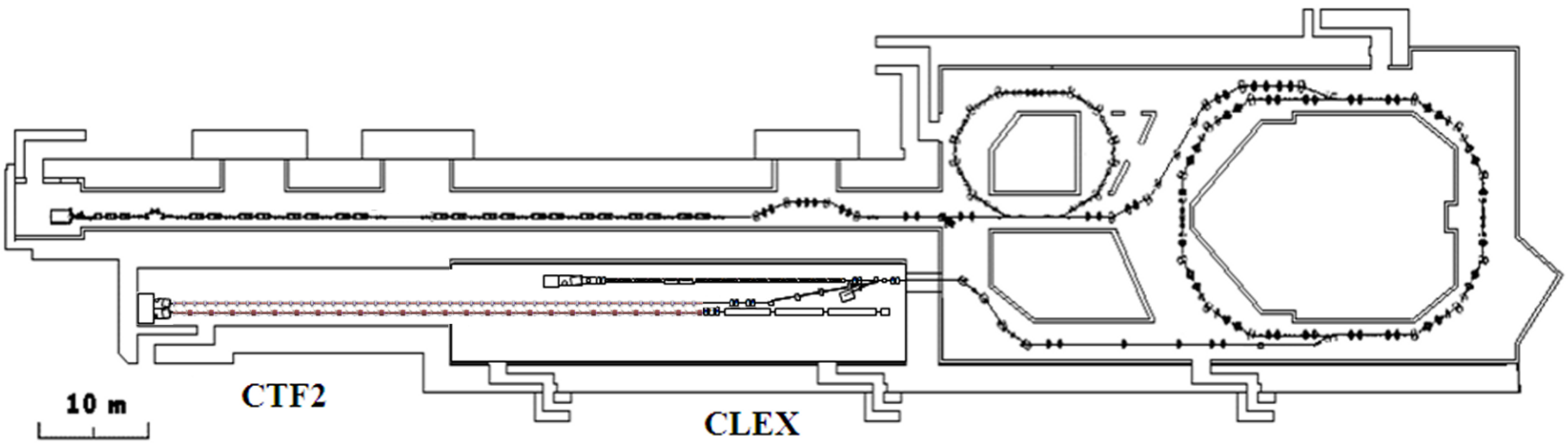
The different scenarios of the CLIC module operation in the CLEX (by Igor).

Boundaries:
The limited DB current will not allow to operate the CLIC PETS as it is. The PETS length must be changed (increased) to compensate lack of current partially. Following the current module layout, the maximal possible length of the PETS could be extended up to ~ 0.5 m (85 cells, c.f. 34 cells in the CLIC PETS).

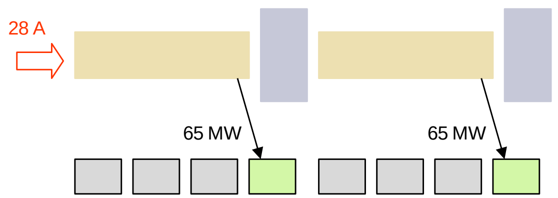
Consequences:
In this configuration, the PETS will barely (28A) produce the required 65 MW RF power and will be able to feed only one accelerating structure out of four. Another important outcome is that PETS itself will generate only half of the declared RF power.



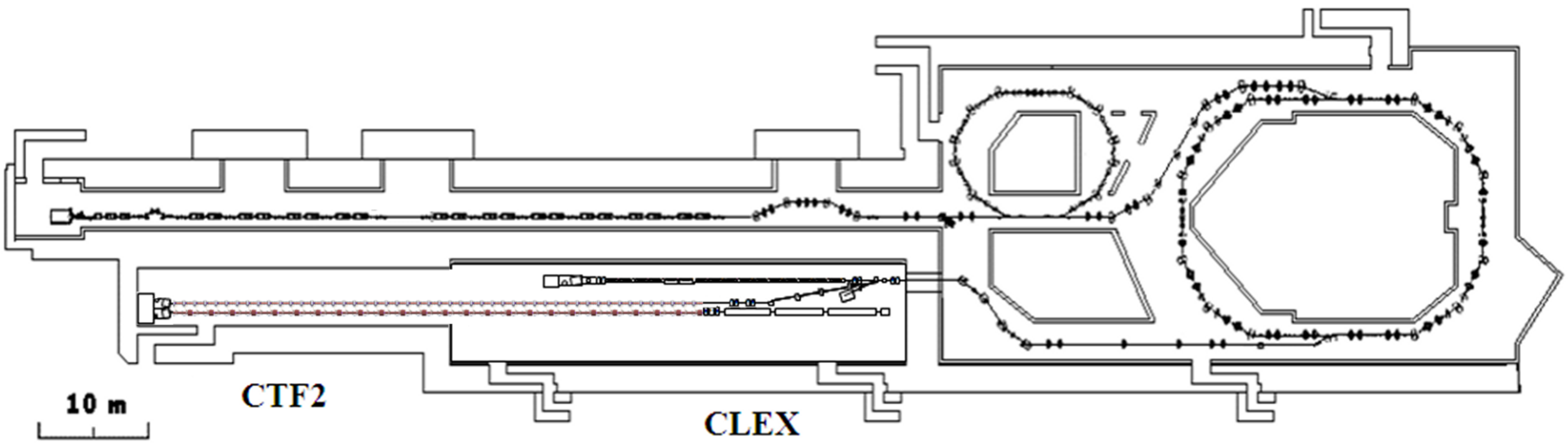
One hypothesis of CTF3 upgrade as a demonstrator



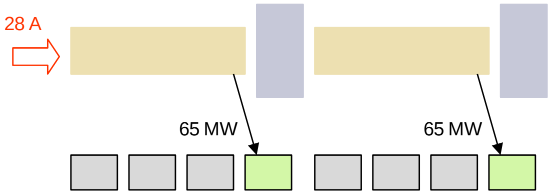
- < 20 modules, about 40 m
- 1 PETS (~ 0.5 m) feeding 1 accelerating structure, nominal power (65 MW)
- 40 structures (2 per module out of 8) can be fed
- Space for one or more quads per main beam module (FODO?)
- Total energy gain in main beam ~ 1 GeV
- Final main beam energy about ~ 1.2 GeV



Drawbacks

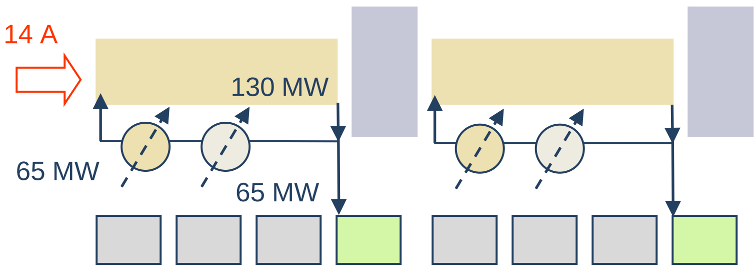


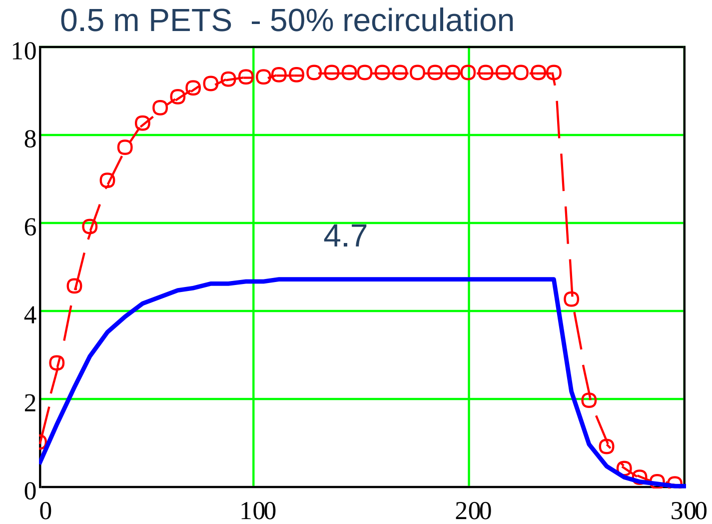
- PETS has twice the nominal length
- PETS have half of the nominal power
- Only one out of four structures fed in the TBA
- RF pulse has 140 ns pulse length instead of 240 ns
- Doubts on drive beam transport, can we decelerate from 200 MeV to 50 MeV ?
- Probe beam does not have nominal CLIC charge/time structure (or need upgrade of CALIFES)



Lower current, long pulse version

Use recirculation (~ 50%) to be able to use 14 A, long pulse beam (CF4)





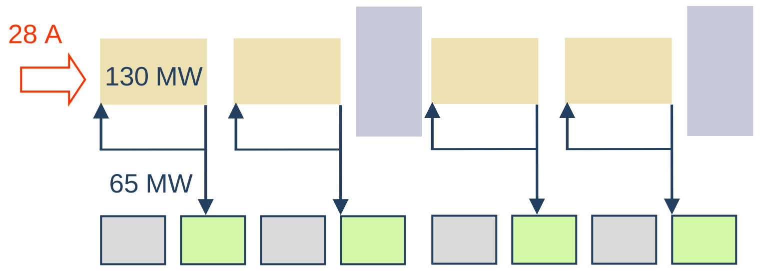
- Gain a factor of 4.7 in delivered power, about 9 in power inside PETS
- 0.5 m long PETS can be run at full power, full pulse length
- 0.5 m long PETS will deliver full power to 1 structure

However: the 14 A beam will have only half of the peak power needed for 50 structures – can feed at most 25

➡ feed half of the modules, or only 1 structure every module

Another option, 28 A + recirculation

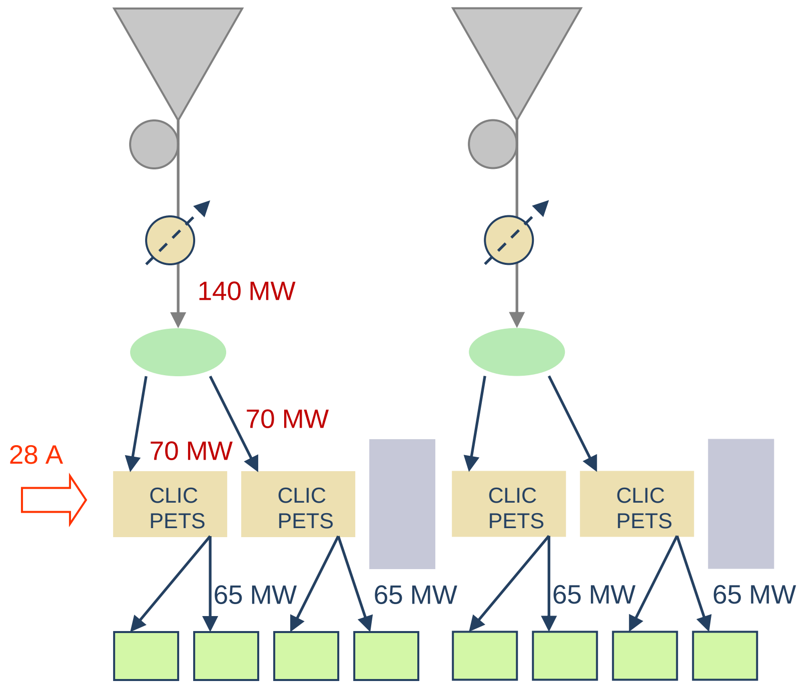
Use recirculation (~ 50%) to feed every second structure (mode #1)



- Could feed a total of ~12 modules this way
- Full power in PETS
- Pulse length only 140 ns

How to feed complete modules

Feed complete modules by using priming

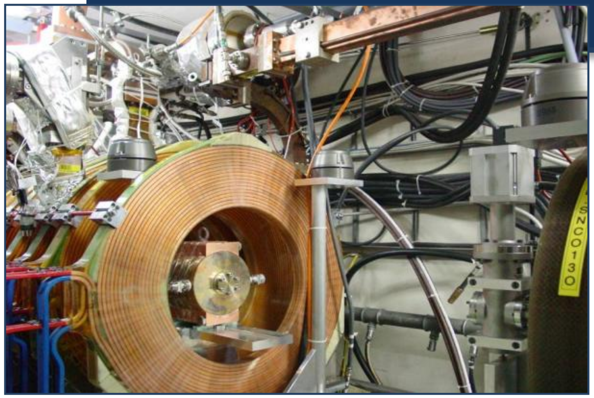


- Use nominal PETS length, nominal PETS power (but not field profile)
- Need 2 klystrons + RF compressors / module
- Part of the power (a bit more than half) provided by klystrons
- Therefore can potentially feed all 25 modules this way, and bring main beam to 2.6 GeV (but would need 50 X-band klystrons!)

Beyond CTF3

Build and commission 30 MeV Drive Beam injector with nominal CLIC parameters

- Build and commission 30 MeV Drive Beam injector with nominal CLIC parameters
- Build and commission a few Drive Beam accelerator nominal modules
- Contribution to Technical Design of full CLIC Zero facility



CTF3 Injector

CLIC Drive Beam injector schematic layout