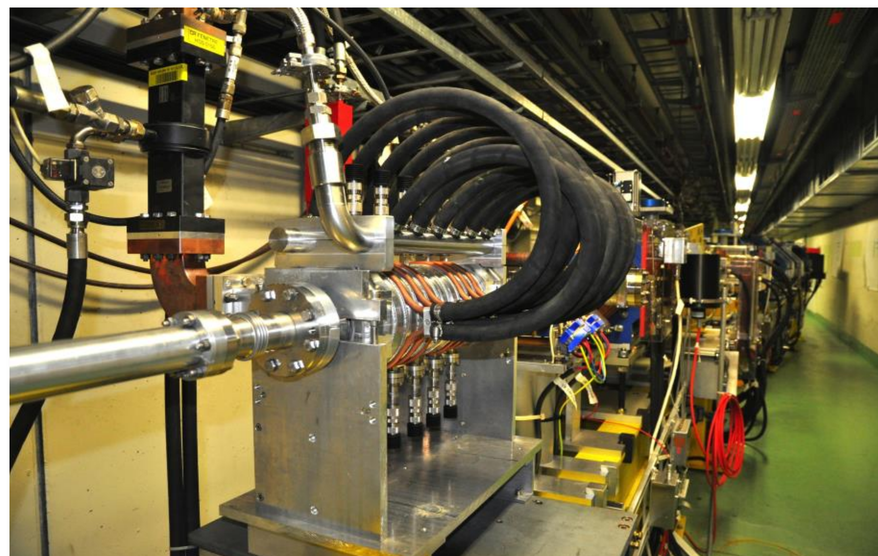
Future system tests at CERN

Possibilities for a post-CTF3 facility, overview

R. Corsini



CLIC Test Facility (CTF3)

Context

- CTF3 went well beyond its initial task of demonstrating CLIC two-beam scheme feasibility
- Has a well established scientific program until end 2016
- Definitely want to stop CTF3 after that (limited resources…)

➔ *What next?*

- Discussions started in beginning 2014. Current proposals:

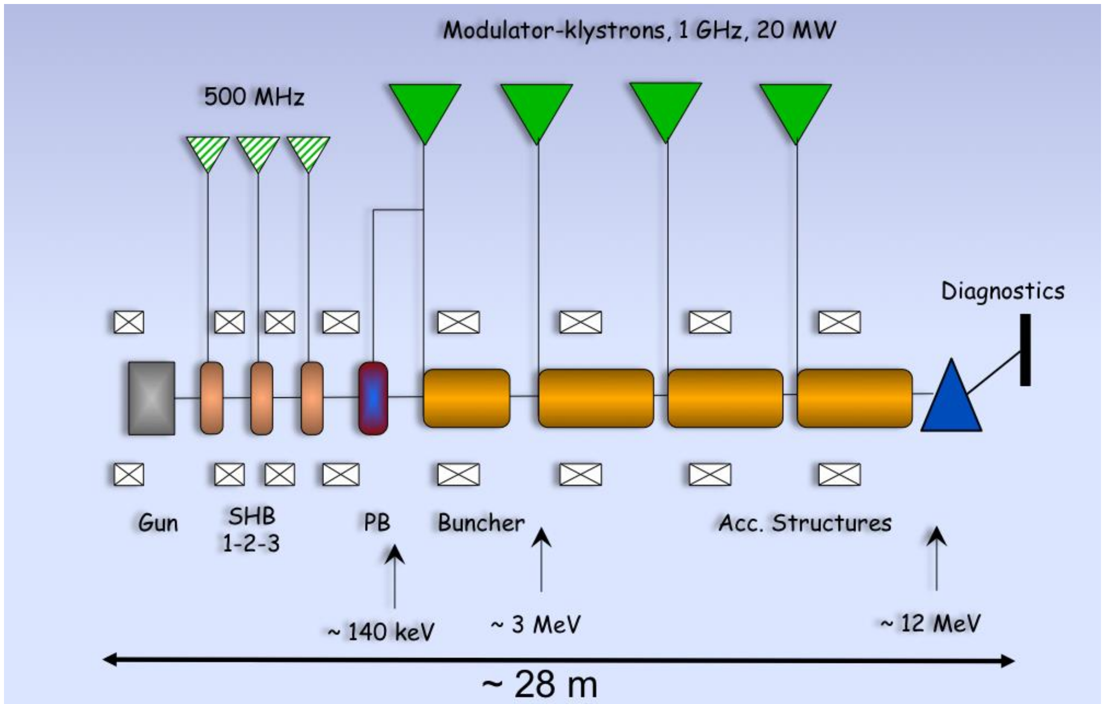
➔ Install new DB front-end in CTF3 linac area (CLIC related).

➔ Keep using *CALIFES* linac in CLEX for as a general test facility after 2016. Possibly interesting beyond CLIC scope (in CERN and outside).

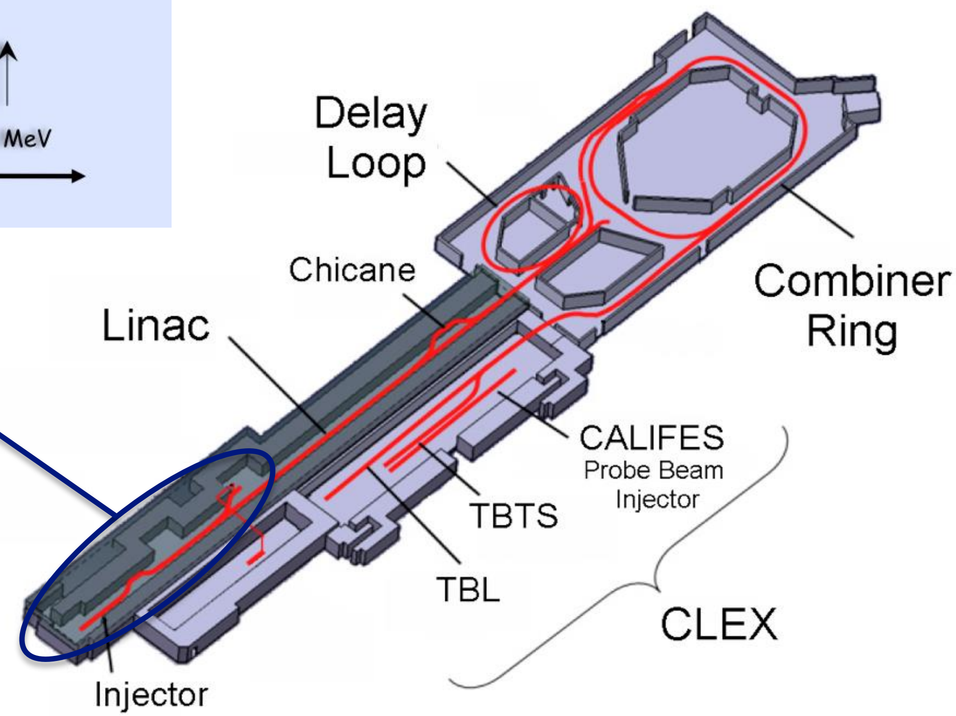
➔ See also discussion at LCWS 2014 – Belgrade: https://agenda.linearcollider.org/event/6389/session/18/#20141009

Drive Beam Front-End

The drive beam front-end in the CTF3 building – F. Tecker, LCWS2014
http://agenda.linearcollider.org/event/6389/session/18/contribution/114/material/slides/0.pptx



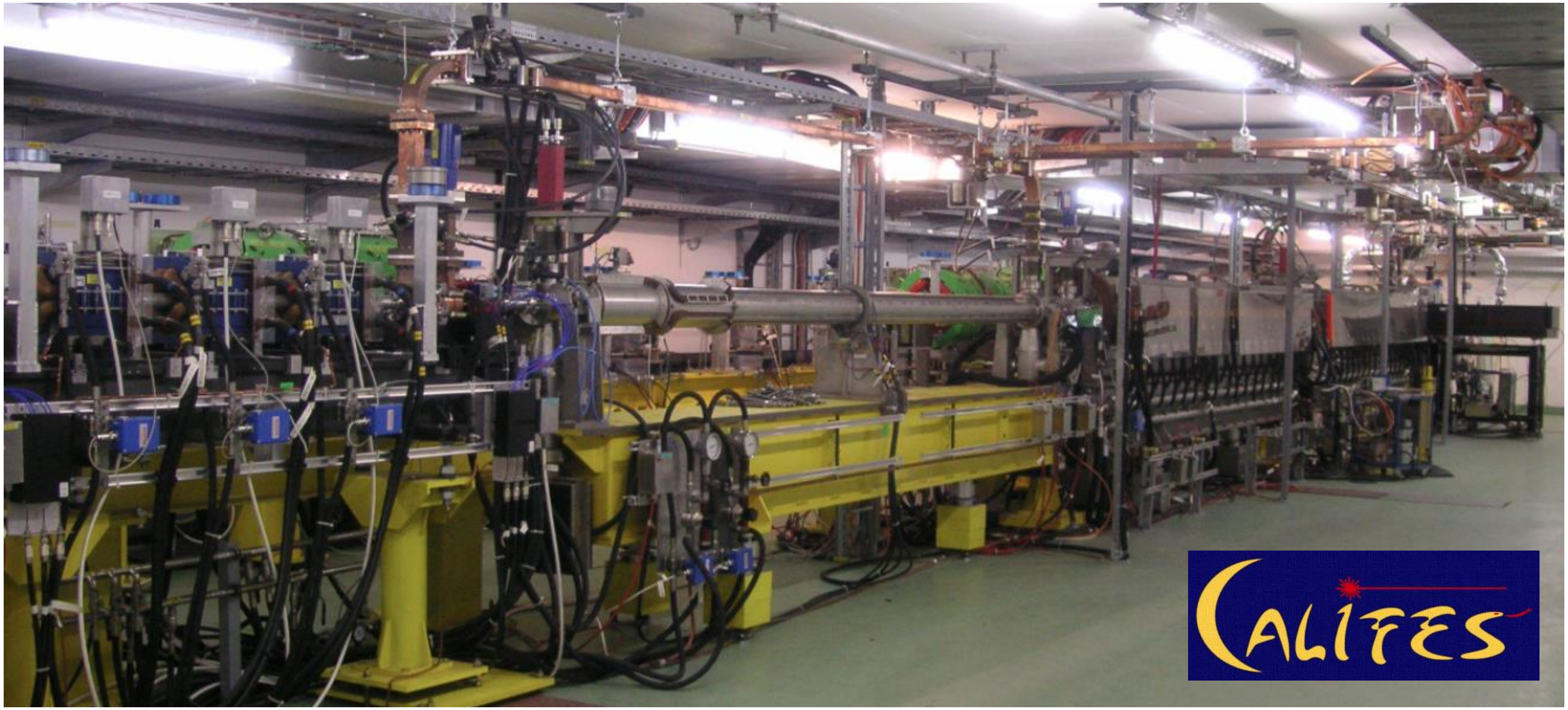
- Same peak current than present CTF3 injector (4 A)
- Longer pulse (140 us instead of 1.4 us)
- Higher rep rate possible (up to 50 Hz)

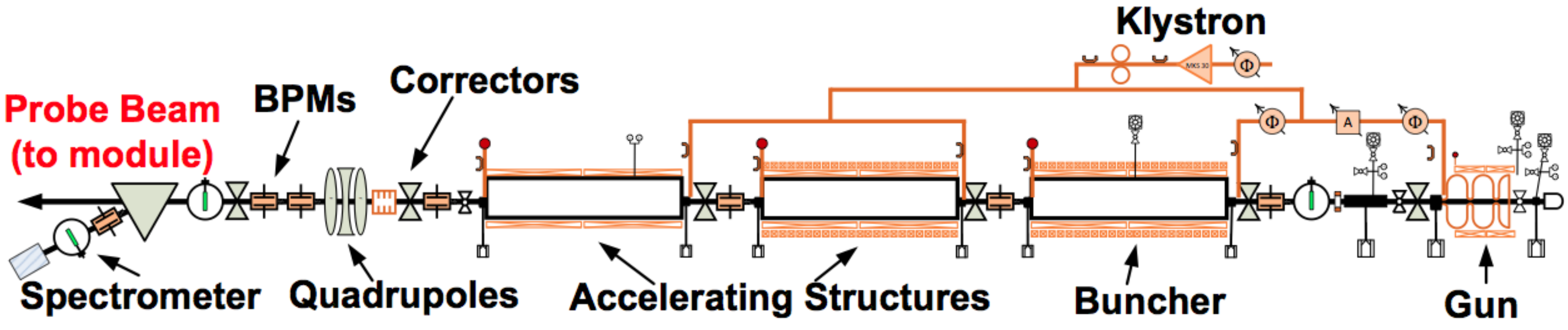


Option: keep operational also (part of) the present 3 GHz linac.

Will enable beam energies up to ~ 100 MeV with limited pulse length(~ 4 us max).

CALIFES

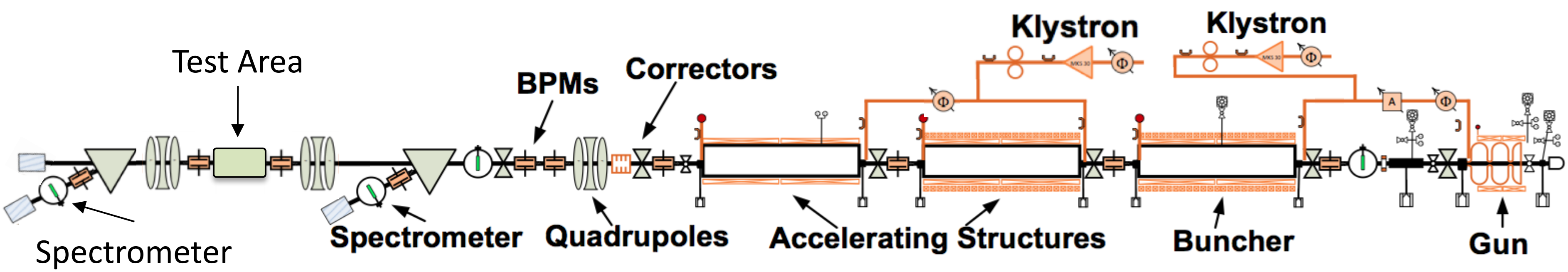

CALIFES


Klystron
Probe Beam
(to module)
BPMs
Correctors
Spectrometer
Quadrupoles
Accelerating Structures
Buncher
Gun

Future CALIFES – minimum configuration

Present

Future: CALIFES for beam instrumentation test



- Add an available S-band klystron + modulator
- More RF power (beam energy), more flexibility (power in 1st structure, phase in structures 2 and 3), possibility of running without RF pulse compression

- Reconfigure present TBM area as test area

- Most (all) hardware already existing

Perspectives for a CALIFES test facility beyond 2016 – R. Corsini, LCWS2014

http://agenda.linearcollider.org/event/6389/session/18/contribution/115/material/slides/0.pptx

Rationale for CALIFES as a test facility beyond 2016

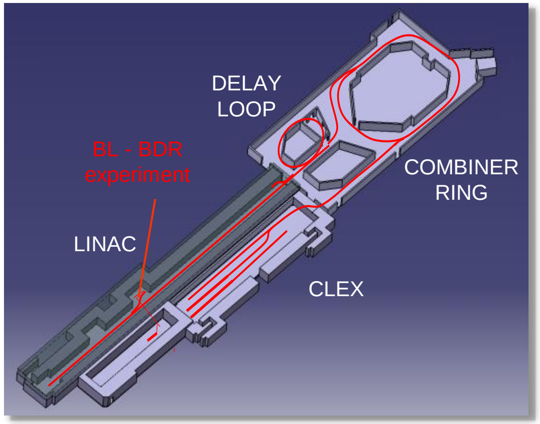
- Need to keep beam test capability for CLIC (diags, components…) locally at CERN after CTF3 stop
- Possibility of beam tests during long shut-downs
- Potential interest of other projects/groups from CERN (AWAKE? LHC? …) and outside – beam diagnostics and others

> *Instrumentation tests in a future CALIFES – S. Mazzoni, LCWS2014*
>
> *http://agenda.linearcollider.org/event/6389/session/18/contribution/116/material/slides/0.pptx*

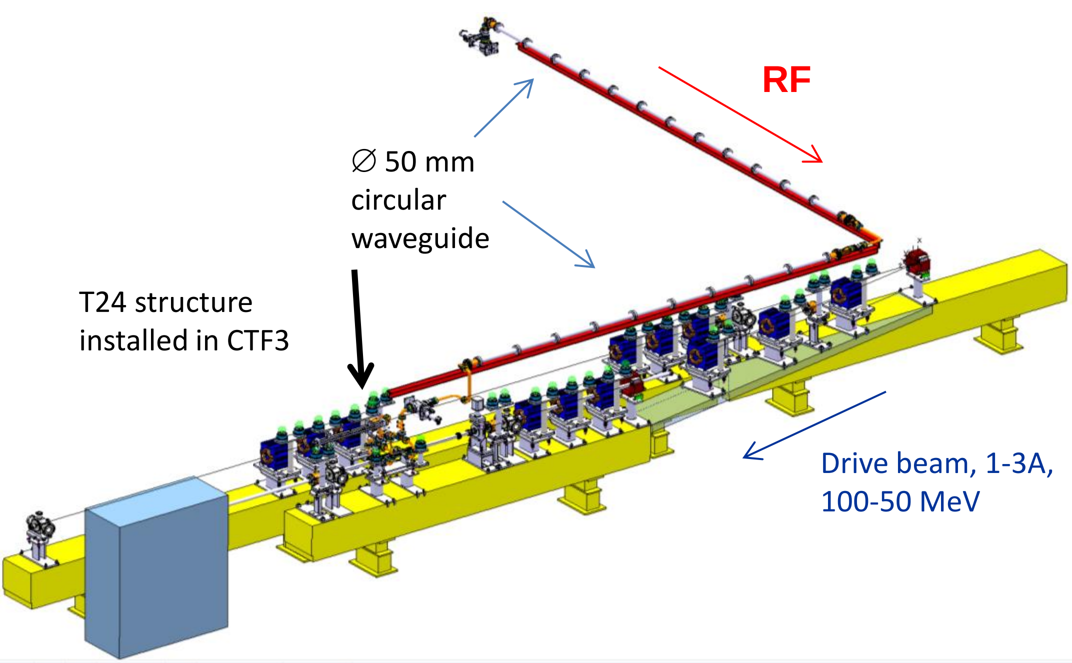
- Keep experimental electron expertise alive at CERN, including laser and photo-cathodes – again link with AWAKE
- Provide training ground for young accelerator physicists at CERN and collaborating institutes
- …

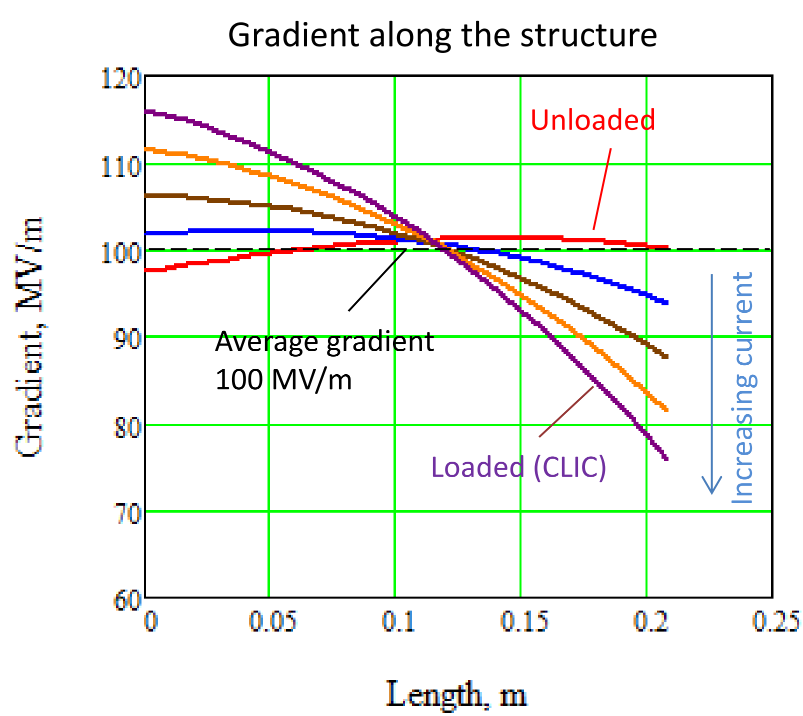
> *The AWAKE project at CERN and its connections to CTF3 –*
>
> *E. Gschwendtner, LCWS2014*
>
> *http://agenda.linearcollider.org/event/6389/session/18/contribution/116/material/slides/0.pptx*

Beam Loading run beyond 2016



- From here to 2016 ~ 3 test slots (one per year) – <u>not a large statistics</u>
- In this time scale could have a new CLIC structure prototype from rebaselining
- May want to test it, especially if the gradient profile turns out to be different from the present one
- Need relative small infrastructure – 5 MKS, first 50 m of linac





Potential interests for post-CTF3 test facility

- Beam diagnostic R&D with beam @ CALIFES (CLIC, LHC, AWAKE…)
- Drive Beam Front-End
- Continuation of beam-loading experiment

- X-band structure testing with beam (X-FEL, medical applications, Wake-Field monitors, deflecting cavities…)
- Irradiation tests (ESA/JUICE Mission, CERN?, others…)

- Impedance and wake-field measurements of components (LHC, CERN Injectors, CLIC… for: Cavities, diagnostic equipment, collimators, kickers…)
- Beam tests of hardware (kickers, SC RF cavities)

- Other medical applications (X-ray imaging, therapy with e-, isotopes production…)
- Test beam for detectors
- Vacuum related tests
- …

JUICE - CALIFES

T. Lefevre – M. Brugger

- JUICE (JUpiter ICy moons Explorer) Mission
  - http://sci.esa.int/juice/55055-juice-mission-gets-green-light-for-next-stage-of-development/
  - Launch a mission in 2022 to explore Jupiter and its potentially habitable icy moons
  - Strong electron cloud environment around Jupiter
    - *Need to test components to electron irradiation*
  - ESA-CERN Collaboration Agreement
    - *Involvement and support of CERN KT group*

- Turning CALIFES in an Electron Irradiation facility
  - Both for Total Integrated Dose and Single Event Effect
  - Beam energy ranging from 10-200MeV
  - Large irradiation area (5x5cm minimum)
  - Required fluence of $10^7/10^8$ electron/cm^2
  - 1st test in 2015

Perspectives for e- beam irradiation tests in CTF3/CALIFES – R. Corsini, ESA visit @CERN
https://indico.cern.ch/event/357271/

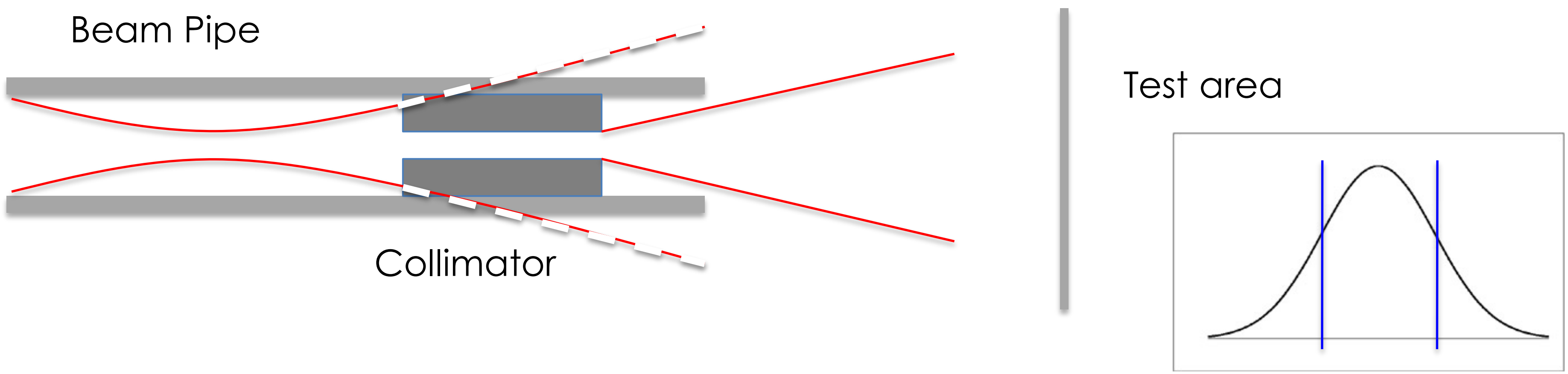
Challenges for CALIFES

- Run at (much) lower beam energy (down to 10MeV)
  - *New RF acceleration scenario (to be tested)*
  - *New test Area in CALIFES after the Gun or after 1st Acc. Structure*
- Need very low flux and large and homogeneous irradiation area
  - *Need to qualify the beam quality (possibly cutting tails with collimators ultimately)*
  - *Characterization and 1st testing possible on CALIFES Dump line*

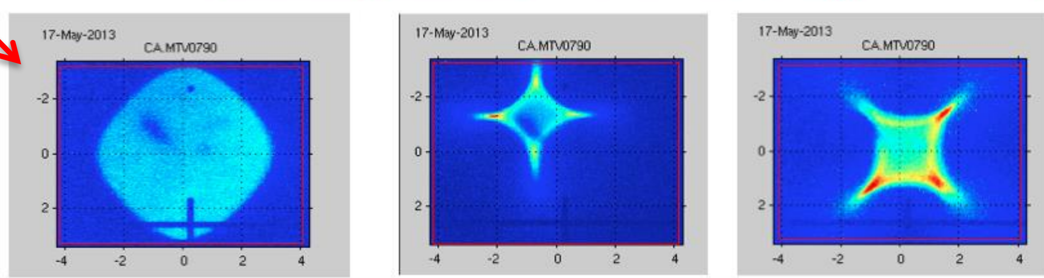
Open issues/questions

- Verify needed fluxes (test pieces, needed area…)
- Energy range – how critical? Verify low energy capabilities in CALIFES.
- How uniform should be the beam?
- What about the time structure (average vs. peak flux)?
- Total dose needed, testing time, running scenario…
- Layout of irradiation region – activation of collimator, air activation, dump…
- Timescale (before and/or after 2016)
- …

Uniform beam - Filling the aperture



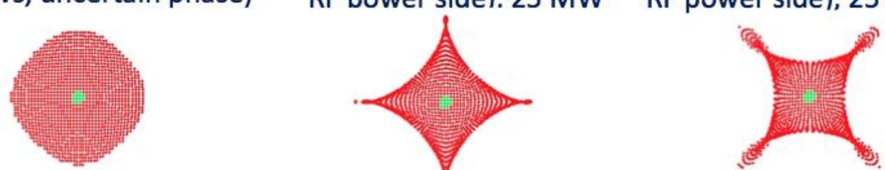
Octupolar field study



For very weak RF power (few MWs, uncertain phase)

At zero-crossing (rising RF power side), 25 MW

At zero-crossing (falling RF power side), 25 MW



Ray-tracing model through octupolar fields

Beam parameters

- CTF3 Drive beam (present)
  - 4 A, 1 us pulses (trains of 1-3 nC bunches, 1.5/3 GHz spacing)
  - rep rate 1-50 Hz
  - 50 – 125 MeV
  - May provide lower energy (>10 MeV), need to study transport
  - Typical beam sizes 1 × 1 mm, may easily fill round chamber, 4 cm diameter.

- CALIFES beam
  - 0.01-1 nC bunches, 1.5 GHz spacing, from single bunch to 100 ns train
  - rep rate 1-50 Hz
  - 150-200 MeV
  - May provide lower energy (>10 MeV), need to study transport
  - Typical beam sizes 0.5 × 0.5 mm, uniform beam sizes obtained up to now 5 mm × 5 mm, up to few cm surely feasible.

Beam parameters

- CTF3 Drive beam (new Front-End)
  - 4 A, up to 140 us pulses (trains of 1-6 nC bunches, 0.5/1 GHz spacing)
  - rep rate 1-50 Hz
  - 10 – 100 MeV
  - Typical beam sizes 1 × 1 mm, may easily fill round chamber, 4 cm diameter.

Fluxes

- 1 nC pulses @ 1 Hz (CALIFES, few bunches)

  ➔ $6.25\ 10^{9}\ e^{-}\ s^{-1}$

- Assume round beam, 40 mm x 40 mm, 90% cut

  ➔ $5\ 10^{7}\ e^{-}\ cm^{-2}\ s^{-1}$

A. Latina - Measurement of Short-Range Longitudinal Wakefields at CALIFES

Longitudinal wake-fields

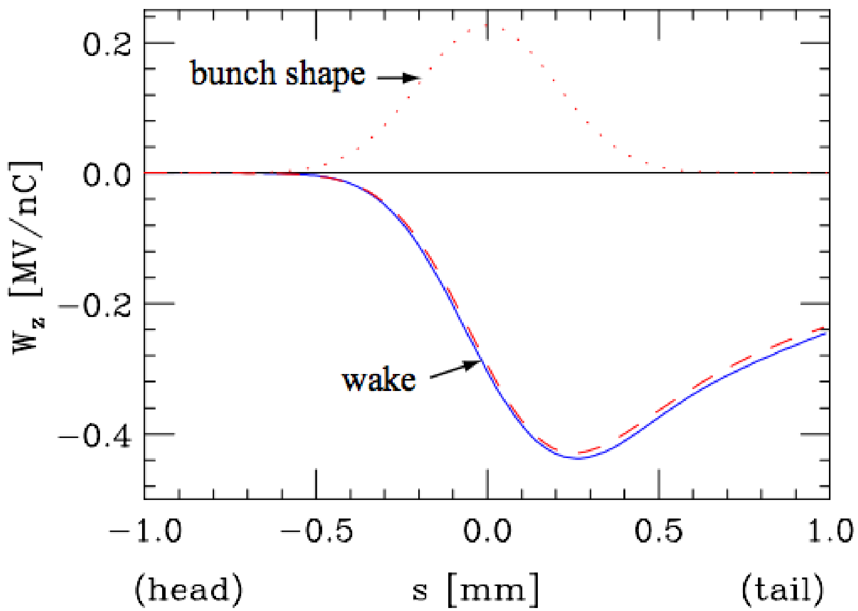
Longitudinal wakes cause energy loss and correlated energy spread (chirp)

Idea:

1. Compensate the correlated energy spread with small off-crest acceleration, and measure the energy spread using a spectrometer

2. Perform a phase / voltage scan to locate the minimum (i.e. compensation)

3. Infer wake-field characteristics from
- energy spread vs phase scan,
- energy spread vs voltage scan



Setup, parameters, and simulation of phase scan

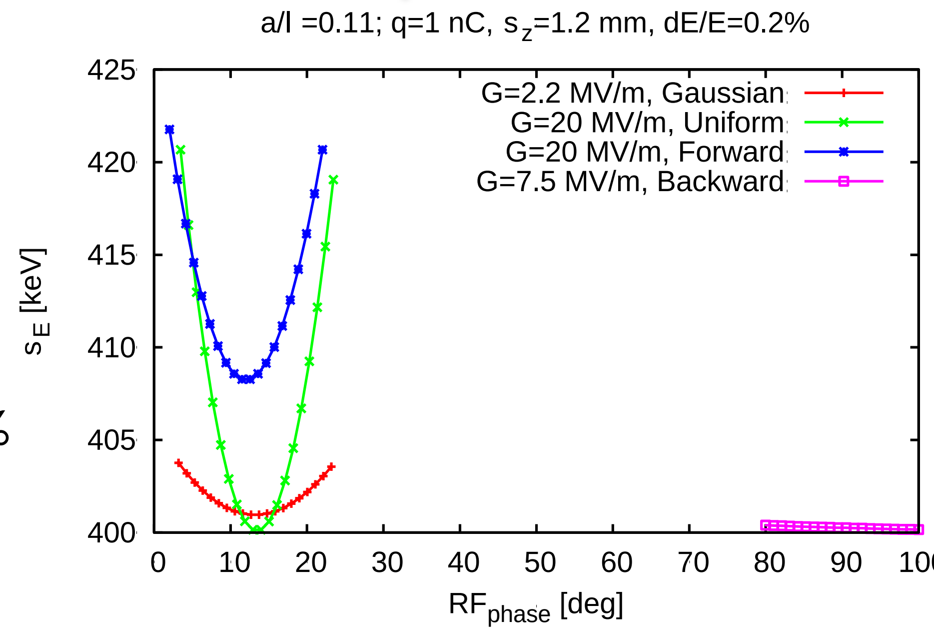
CALIFES-like parameters:
- Two CLIC AS with a/λ = 0.11
- Bunch charge = 1 nC
- Average energy = 200 MeV

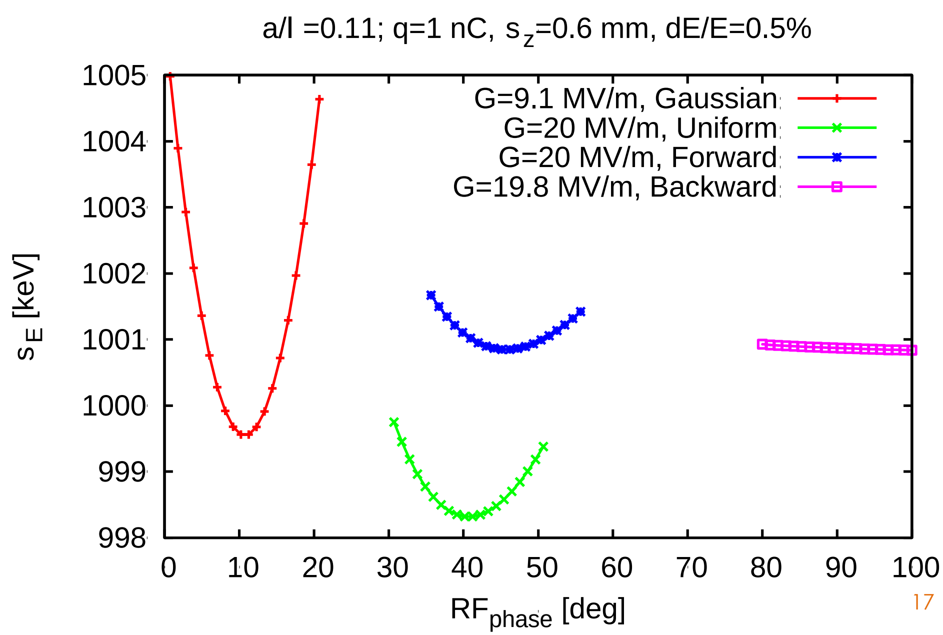
Two bunch configurations considered:
- Bunch uncorrelated espread = 0.25 %
- Bunch length = 1200 um

and:
- Bunch uncorrelated espread = 0.5 %
- Bunch length = 600 um

Four different longitudinal distributions
- Gaussian
- Uniform
- Forward
- Backward

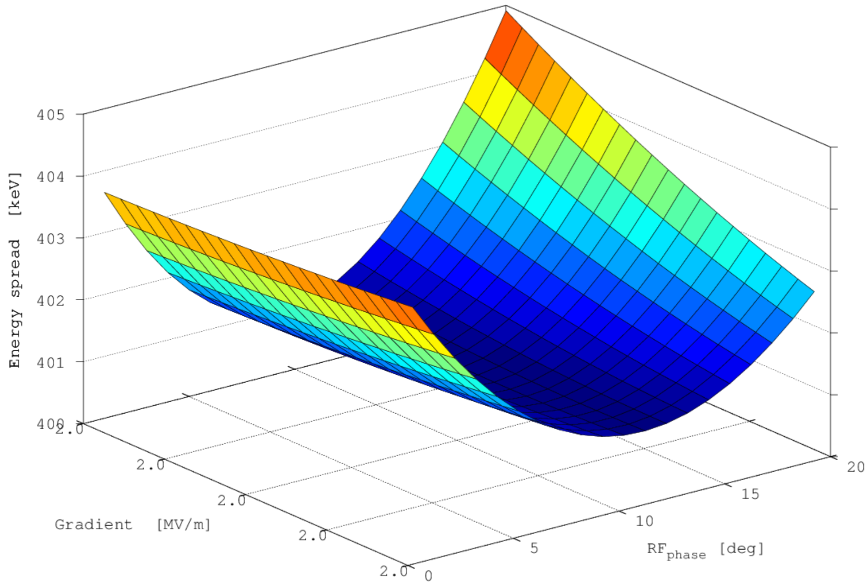
The plots show the result energy spread:





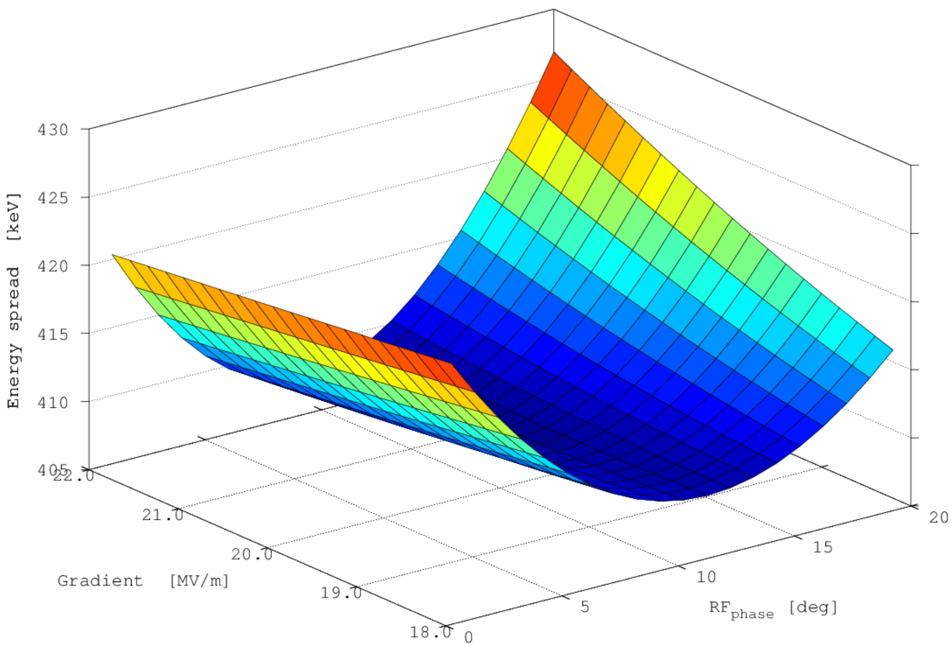
Dependence on voltage is much weaker

Example: 1.2 mm bunch length, 0.2% energy spread, two distributions



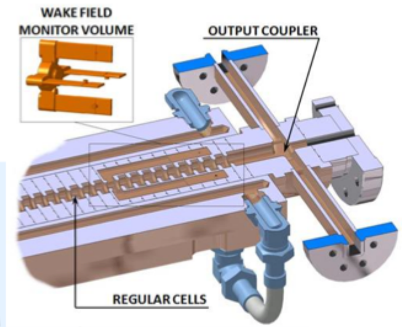
Gaussian:
- Resolution required ~ 1 keV

Uniform
Resolution required ~5 keV

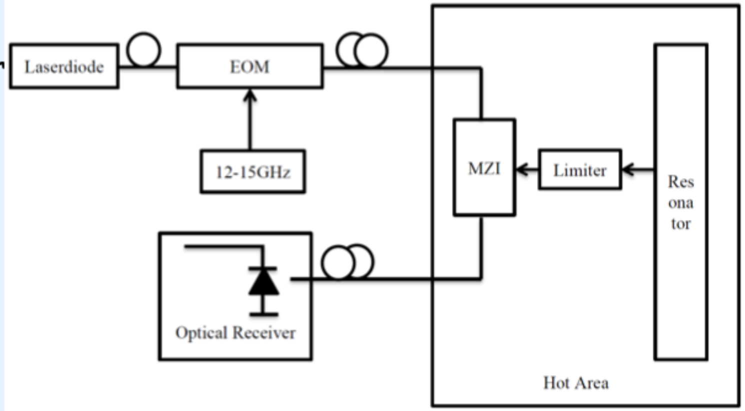


PAUL SCHERRER INSTITUT

Perspectives: WFM characterization at CALIFES



- **Current Situation**
  - Within EuCARD 2, developing electro-optical front end for WFMs integrated in in X band phase space linearizer structure. First tests with in SwissFEL Test Injector Facility (SITF).
  - SITF stopped operation end of october '14, components to be transferred to SwissFEL injector planned to start operation end of 2015/beginning of 2016
  - No beam time for WFM front end characterization and tests in 2015, rather limited time later.

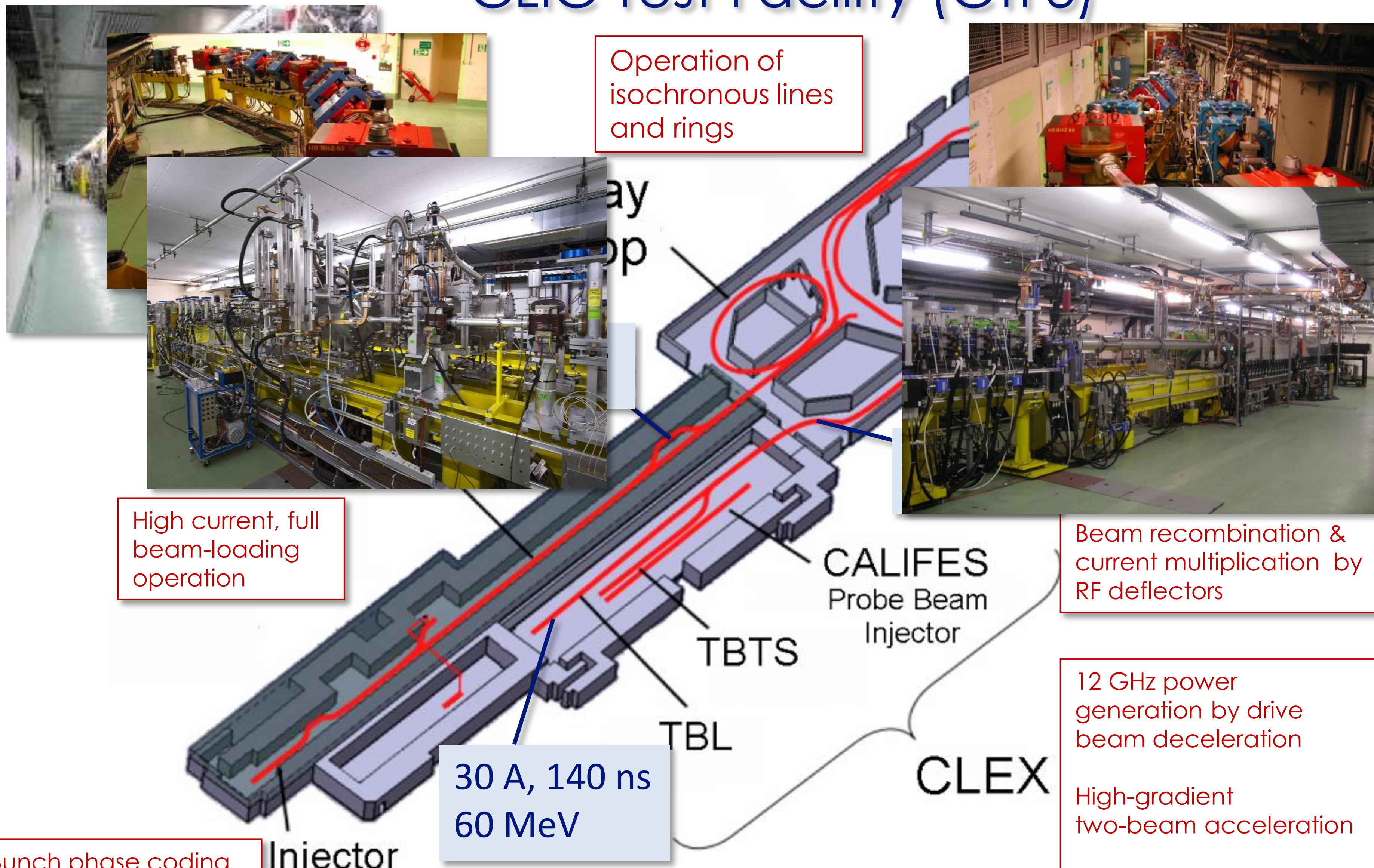


- **Using CALIFES as a test bed for WFM**
  - Using X band linearizer currently at CERN (which developed alignment kinks during brazing), active length 750mm, total 1000 mm
    - Do standard tests moving either structure or beam
    - Kinks in alignment ideal to test advanced measurement modes to determine the internal cell to cell alignment from signal spectra.
    - Open questions: Available space, necessary to condition structure before insertion into CALIFES?
  - Test WFM front end together with WFMs of CLIC accelerating structure: Interesting option due to other signal spectrum.
  - Synergies with CLIC related research (in discussion with Eric Adli and Reidar Lillestol)
  - Modest requirements on beam: orbit control with resolution ~ 5um, beam charge > 100 pC
  - Ideal scenario: having beam available from summer 2015

M. Dehler, M. Leich 12/2014

ADDITIONAL CONSIDERATIONS, MATERIAL FOR DISCUSSION

CLIC Test Facility (CTF3)



Operation of isochronous lines and rings

High current, full beam-loading operation

Beam recombination & current multiplication by RF deflectors

30 A, 140 ns
60 MeV

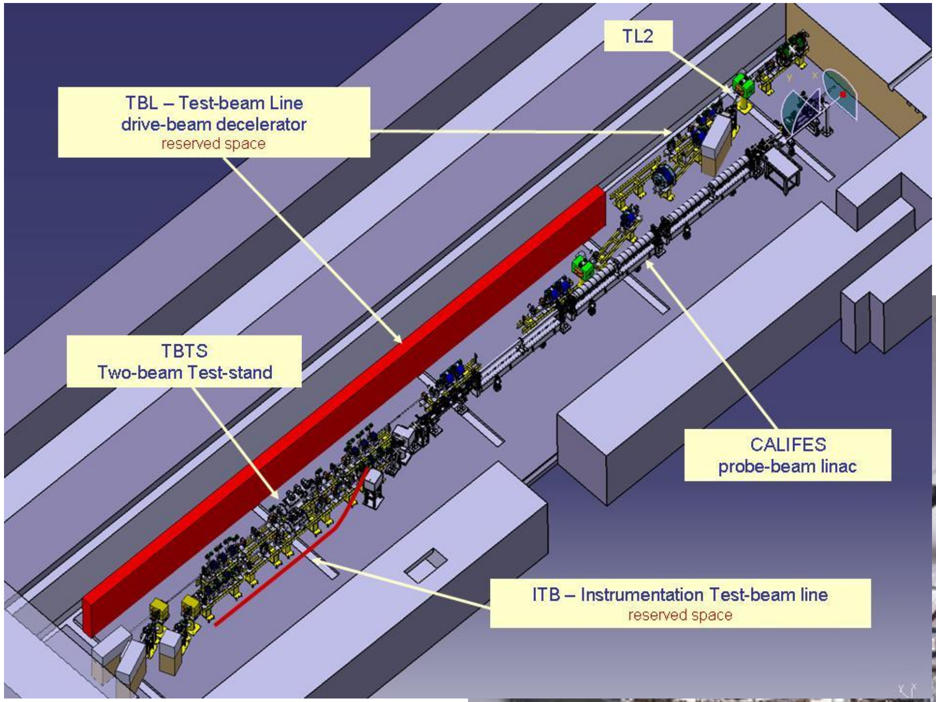
12 GHz power generation by drive beam deceleration

High-gradient two-beam acceleration

PETS ON/OFF

Bunch phase coding

CALIFES hall & infrastructure

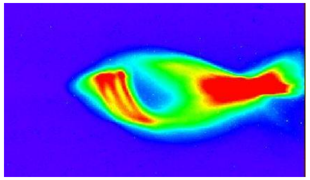


- Convenient hall (42 x 8 x 2.6 m^3) with proper concrete shielding (2.8 m) and large access.
- Instrumentation & klystron gallery just above
- An up-to-date Laser lab, (80 m laser beam line, partly under vacuum)
- Fully equipped (conditioned air, water, access control. No crane.

CLEX

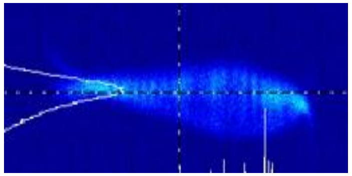
CALIFES

Parameters	Specified	Verified	Comment
Energy	200 MeV	205 MeV	Without bunch compression
Norm. emittance	< 20 π mm.mrad	4 π mm.mrad	With reduced bunch charge
Energy spread	< ± 2 %	± 0.5 %	
Bunch charge	0.6 nC	0.65 nC	With new photocathode
Bunch spacing	0.667 ns	0.667 ns	Laser driven
Nb of bunches	1-32-226	from 1 to 300	Limited by RF pulse length
rms. bunch length	< 0.75 ps	1-2 ps and above	
Repetition rate	0.8 – 5 Hz	0.8 – 5 Hz	Upgrade possibility to 10 Hz

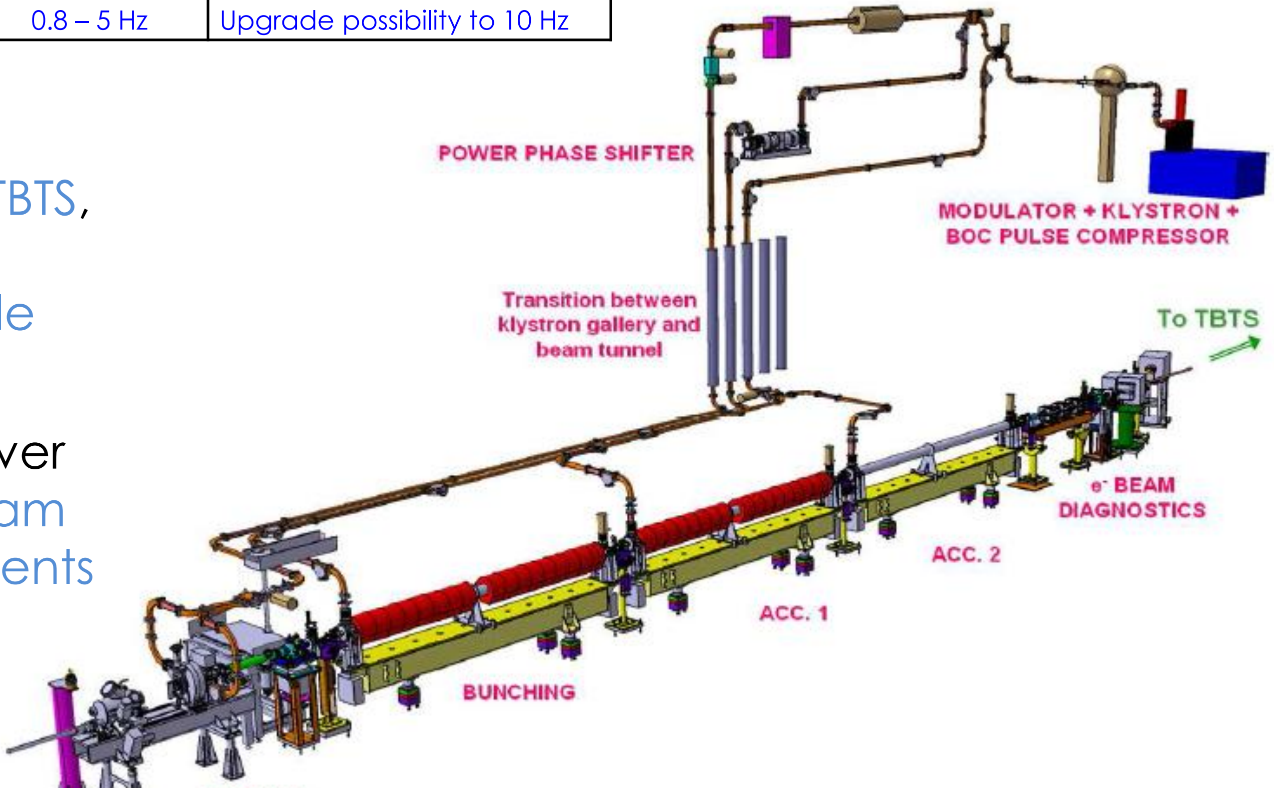


CALIFES

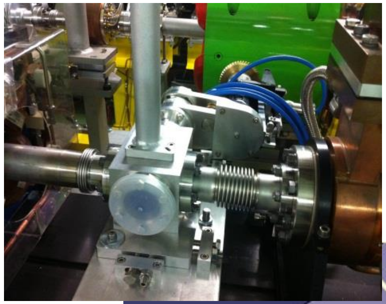
Swiss FEL injector (courtesy Simona Bettoni)



- Up to now used on TBTS, from November:
  ➔ Two-Beam module
- Growing activities over the last years on beam diagnostic/components testing

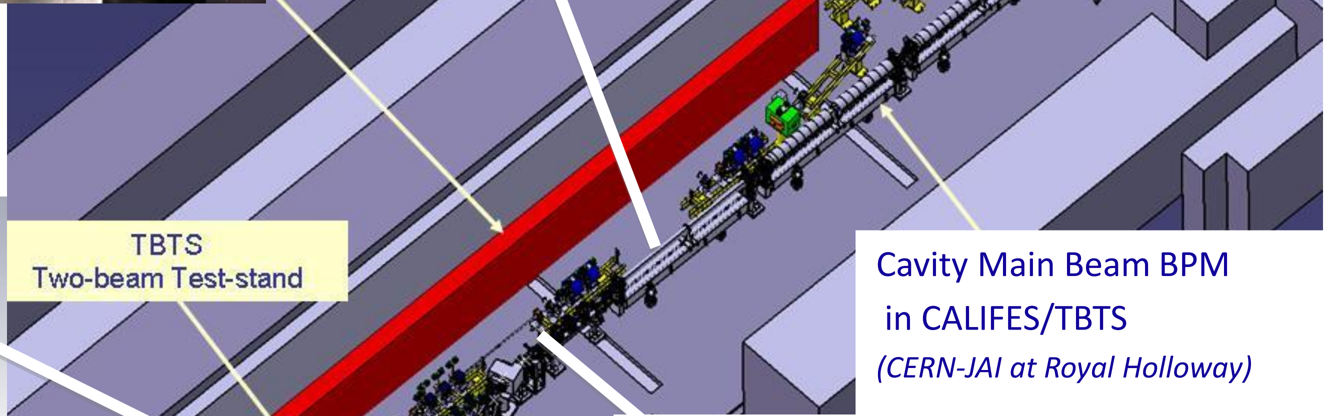


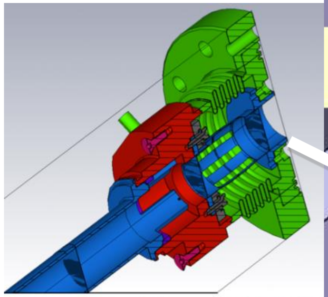
Beam Diagnostic Tests in CLEX



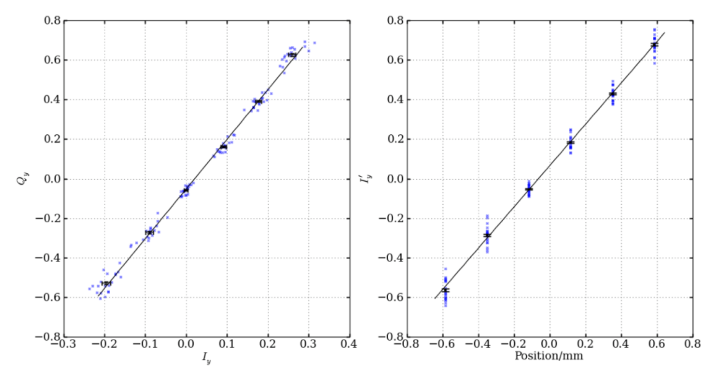
Electro-optic bunch profile monitor
in CALIFES
(CERN-Dundee University)

Stripline Drive Beam BPM in TBL
(CERN-LAPP)





Cavity Main Beam BPM
in CALIFES/TBTS
(CERN-JAI at Royal Holloway)



Irradiation Tests for ESA

- **OBJECTIVES:**
  - Improvement of HAS2 radiation dataset for use in high radiation environment
- **ESA ACTIVITIES**
  - "Evaluation of STR performance in high radiation environments" – 2010-2011
  - "Radiation Characterization of Laplace RH Optocouplers, Sensors and Detectors" – 2011-2012
- **JUICE MISSION**
  - Formerly ESA's contribution to LAPLACE mission with Jupiter Ganymede Orbiter (JGO) reformulated to JUICE ESA standalone mission in March 2011 (includes now two fly-bys of Europa)
  - Exposure to highly energetic trapped-Jovian electrons
  - Exposure to trapped-Jovian protons and solar protons

Hi Markus,
We have a study in support of JUICE project compare Co-60 TID irradiation and electrons TID irradiation test results. This will be a study similar to the one performed by TRAD (see paper attached). The motivation being that JUICE is an electron dominated environment and particularly high energy electrons. Most of the dose contribution on JUICE mission comes from elctrons in the 10-20 MeV electron range.
To answer your questions:

- beam size: We plan to irradiate all components of a same type at once. So a 10X10cm homogenous beam would be great. But we can adapt for smaller beam sizes.
- min/max beam intensity: we would like an intensity corresponding to a flux, and, therefore, dose rate, as low as possible: a dose rate lower than 1 Gray(Si)/minute would be great. We would like to perform irradiation up to 1KGray(Si)
- energy range: We are looking at 2 energies in the 10 to 30 MeV range. For example, 10 and 20 MeV
- required services: to be defined,

Your needs ?

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- required services: to be defined,

If you can provide us with information about your electron beam facility, we could make a first assessment of the possibility of performing the tests for this study in your facility. This would be a great collaboration possibility between ESA and CERN. The contractor for this study is LIP (they are in copy of this email). LIP is a research institute in Portugal.

Electron beam can also be interesting for electrons SET testing in imagers like the tests performed in the attached presentation (see slides 13-14)

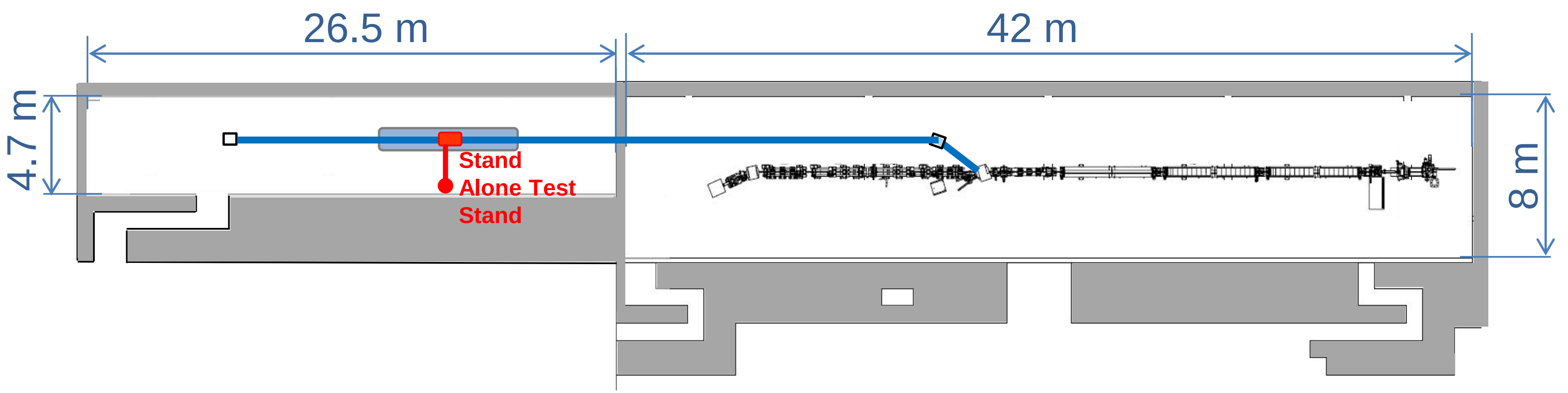
Best Regards,

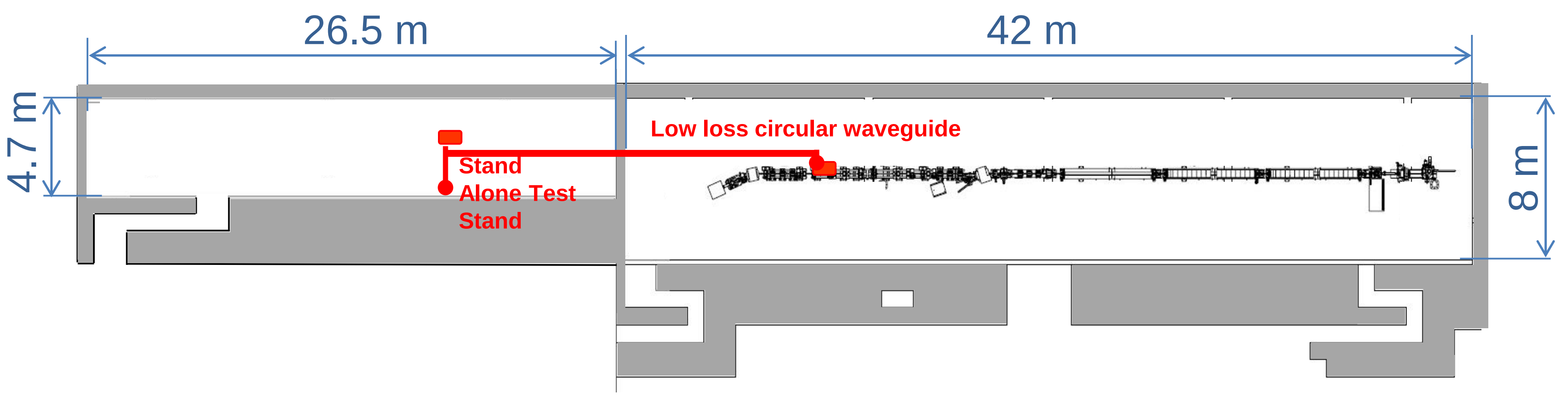
Christian

X-band

- CALIFES may provide an unique opportunity to test X-band structures/modules with beam
- XBOX1 located very close (distance comparable to present low-loss line for dog-leg beam loading experiment)
- Straight-forward solution: connect to XBOX1 for beam testing in CLEX
- An upgraded CALIFES beam may be not too far from what is needed for FELs: "Playing ground" for X-band FEL beam studies and developments
- Future possibility: test a full X-band module (for X-band FEL or klystron-based CLIC) – may need an additional modulator/klystron
- Add more? …

Layouts?


26.5 m
42 m
4.7 m
8 m
Stand
Alone Test
Stand


26.5 m
42 m
4.7 m
8 m
Low loss circular waveguide
Stand
Alone Test
Stand

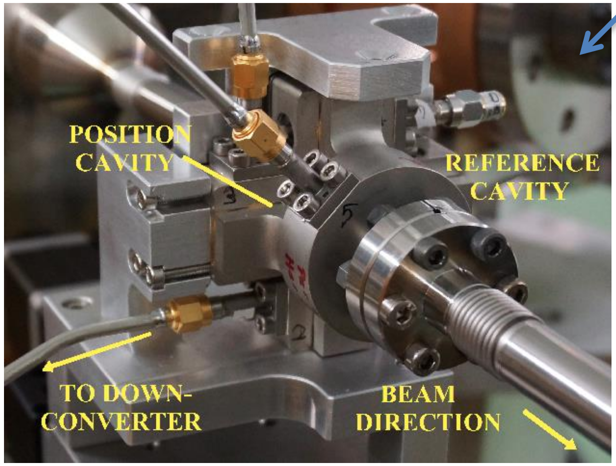
Recent CLIC diagnostics tests

Main linac BPMs

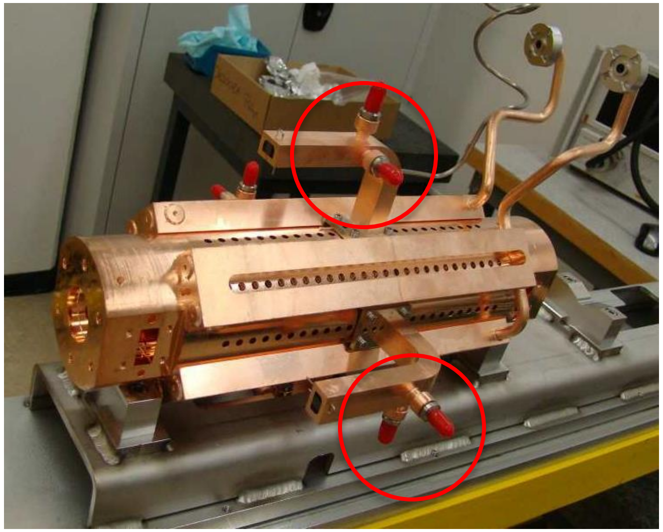
Table 1: CLIC Main Linac BPM specifications

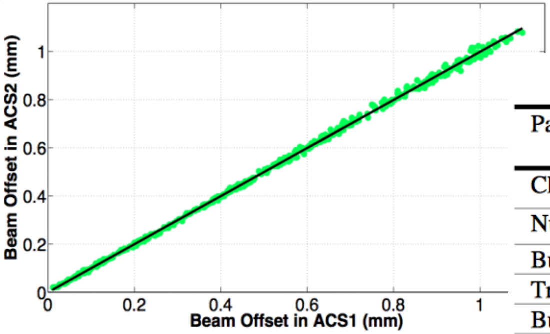
Nominal bunch charge [nC]	0.6
Bunch length (RMS) [μm]	44
Batch length [ns]	156
Bunch spacing [ns]	0.5
Beam pipe radius [mm]	4
BPM time resolution [ns]	<50
BPM spatial resolution [nm]	<50
BPM stability [nm]	<100
BPM accuracy [μm]	<5
BPM dynamic range [μm]	±100
BPM resonator frequency [GHz]	14

Under further development and testing at CTF3



Wake-field monitors





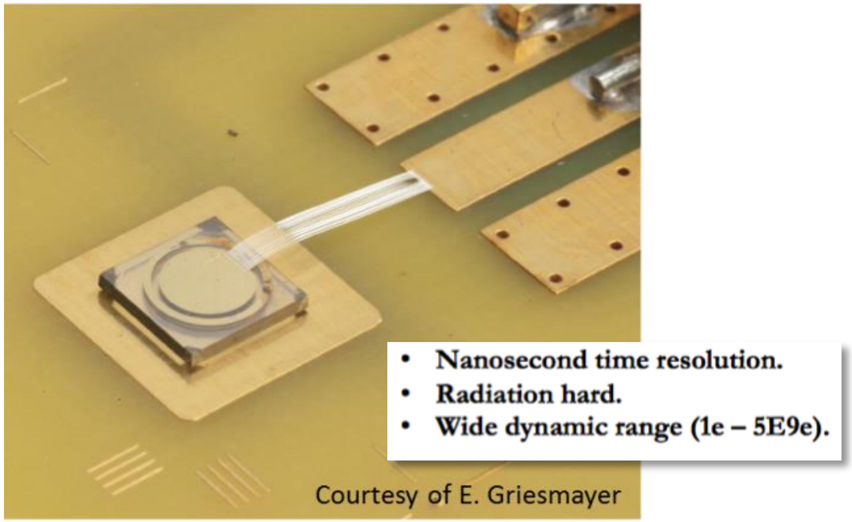
Resolution tested in CTF3

Table 1: Wakefield Monitor Specifications

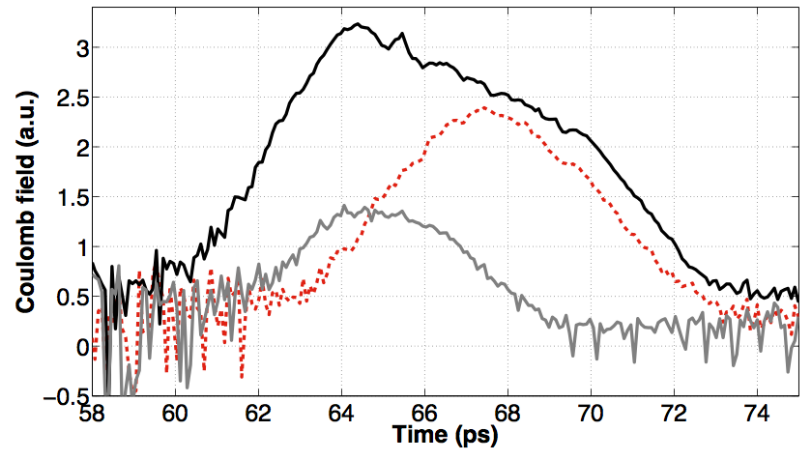
Parameters	CLIC commissioning	CLIC operation
Charge / bunch (nC)	0.06	0.6
Number of bunches	1-312	312
Bunch length (μm)	45-70	45-70
Train length (ns)	156	156
Bunch Spacing (ns)	0.5	0.5
Accuracy (μm)	5	5
Resolution (μm)	5	< 5
Range (mm)	± 2	± 0.1
Beam Aperture (mm)	~5.5	~5.5

Other recent (CLIC) diagnostics tests

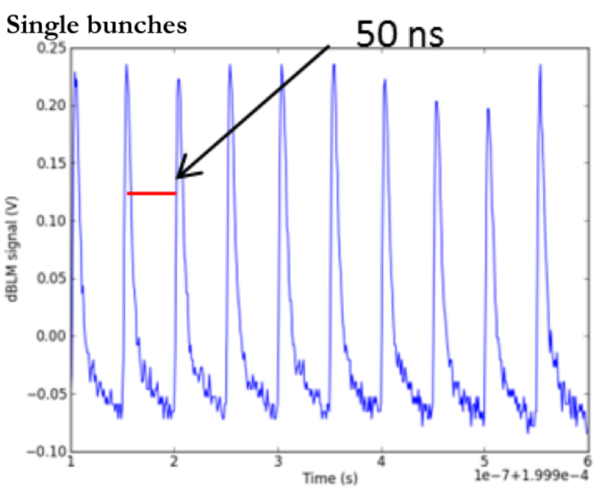
Diamond Beam Loss Monitor

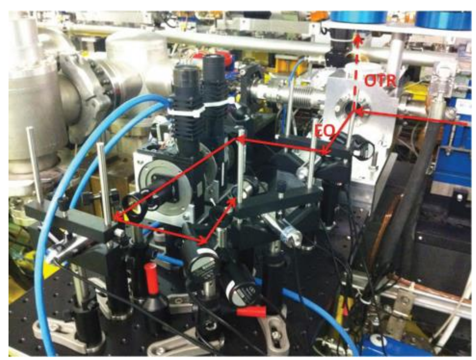


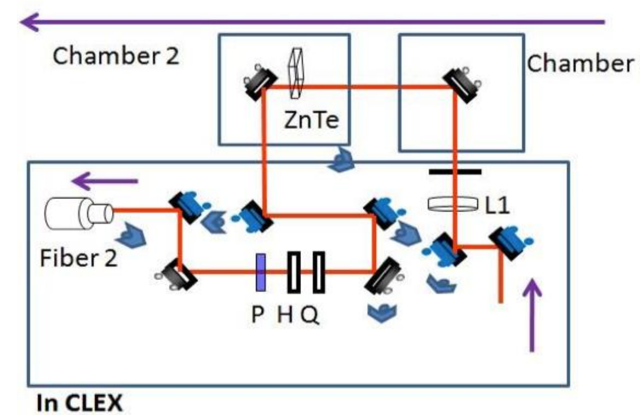
EOS bunch length monitor



Bunch temporal structure measured with a longitudinal profile monitor based on electro-optic spectral decoding for different bunch charges.

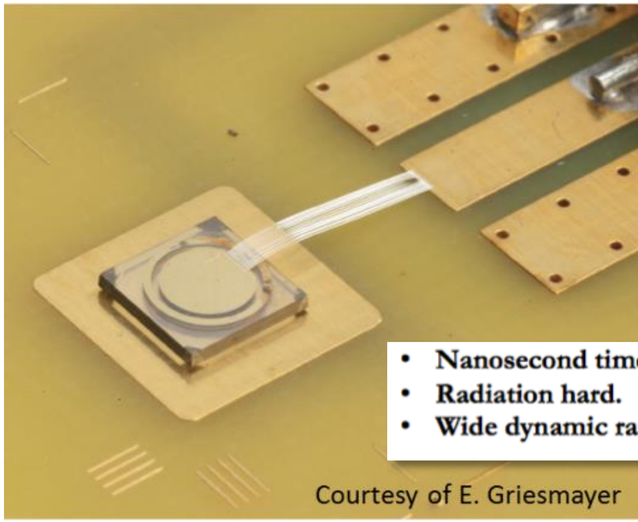






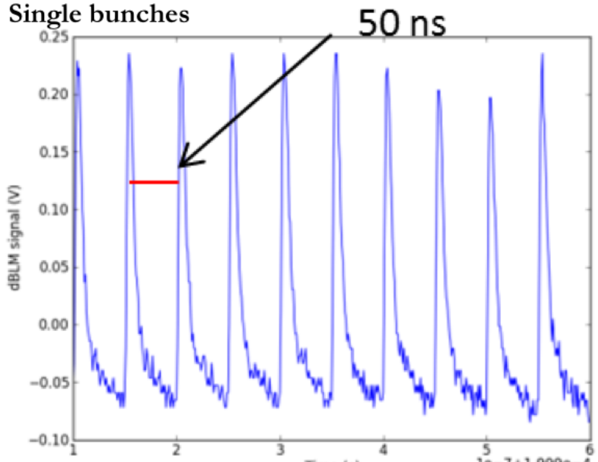
Time resolved beam loss using diamond BLM

Diamond Beam Loss Monitor

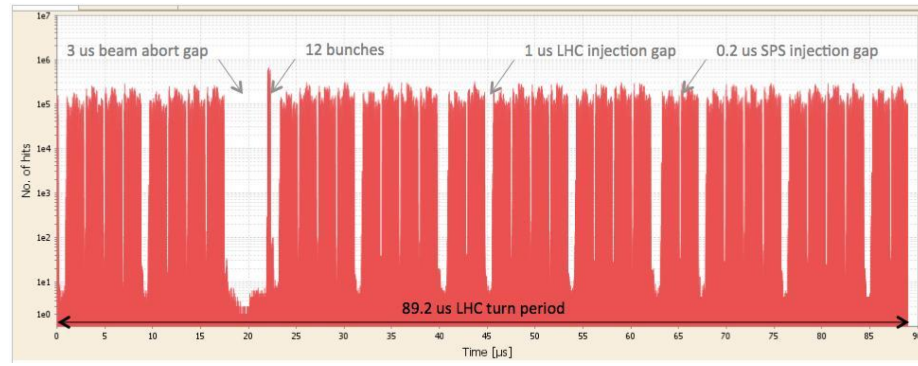

Courtesy of E. Griesmayer

- **Nanosecond time resolution.**
- **Radiation hard.**
- **Wide dynamic range (1e – 5E9e).**

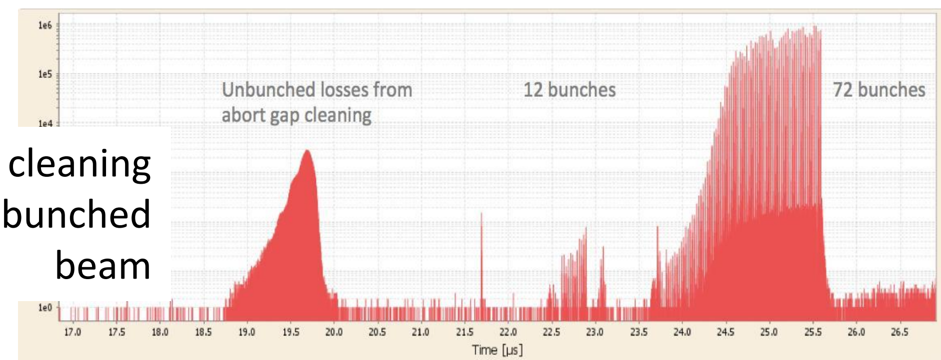
Single bunches

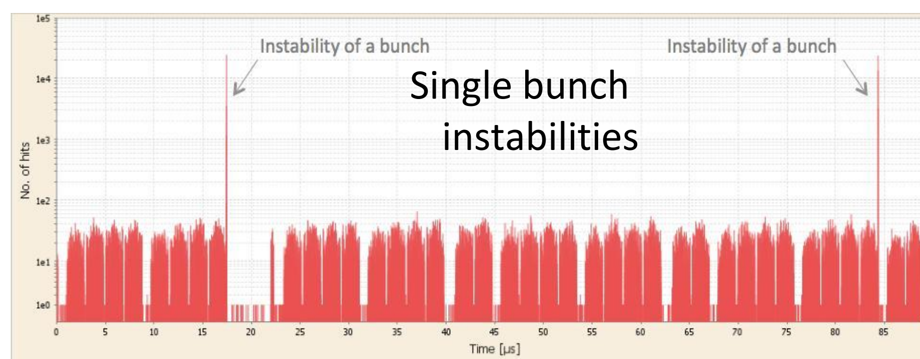


LHC bunch structure near abort gap



Abort cleaning and un-bunched beam



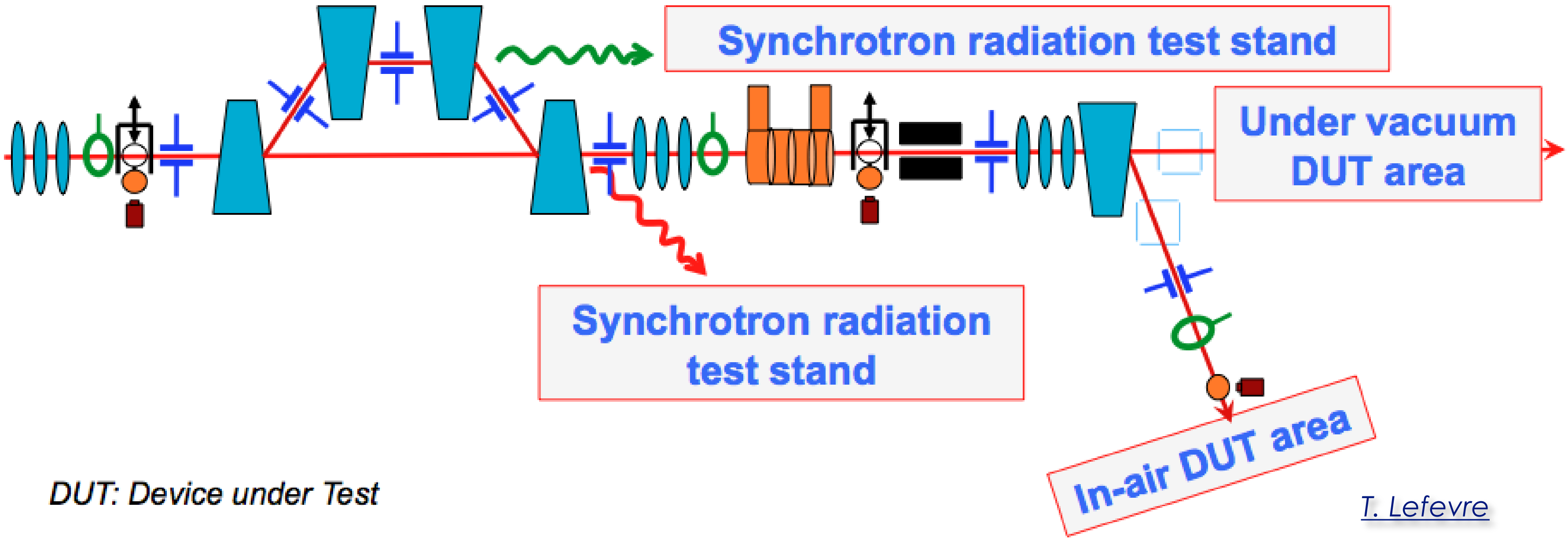


"Ultimate" test area layout to cover BI needs

Magnetic chicane
Shorten or lenghthen
100fs up to 200ps

Collimator
- Reduce the bunch intensity before the DUT zones
- Reduce bunch length further in combination with RF deflector

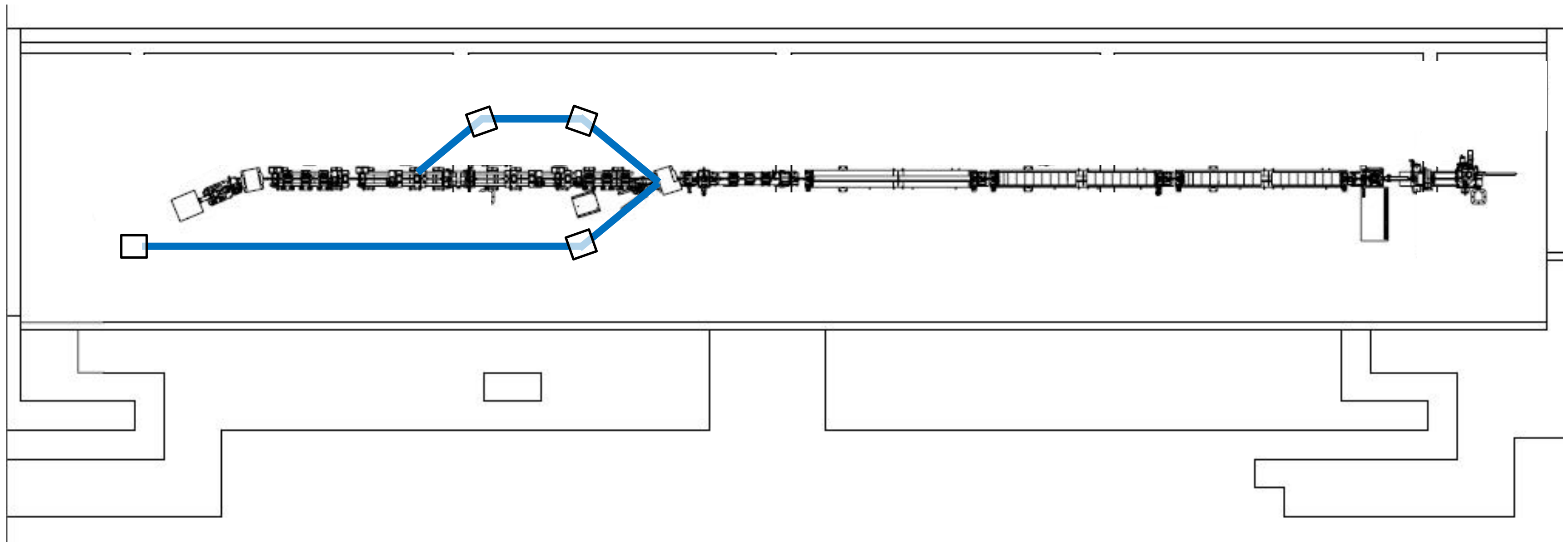
RF deflector
for crabbing



DUT: Device under Test

T. Lefevre

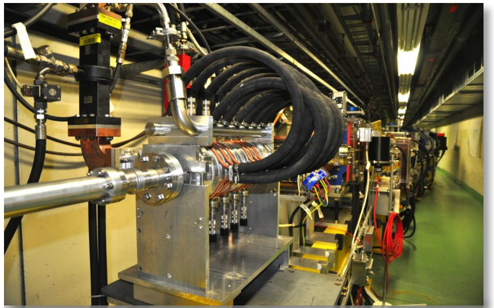
Previous studies – the Instrumentation Beam Line



- A preliminary study has been done: "*Short Pulse Capabilities of the Instrumentation Beam Line – V. Ziemann – 6 May 2010*"
  - Short pulses (200 fs – 35 μm) are necessary to mimic the CLIC main beam for instrumentation tests
  - Pulses of 20 μm are achievable with a chicane R_{56} = 2 cm and energy encoding of 10^{-3} , maximum energy reduced to 78% of the on-crest one
- Other option ➔ four-bend chicane
- All equipment will be available from the DB lines (magnets, powers, chambers…)

Bunch length flexibility

- In many cases a (very) short bunch length is required
- May be accessible using a magnetic chicane or dogleg (need some compression studies, implications on off-crest phase, short range wake-fields)
- Other possibility, RF deflector + collimator (crabbing). May also implement a two-deflector solution (RF bump) to remove crabbing
- Should continue bunch compression studies in CALIFES 2015-2016 with streak camera, EOS and possibly RF deflector



Summary of possible evolutions

- Keep CALIFES for beam instrumentation test
  - Add an available S-band klystron, modify waveguides
  - Add a chicane, another dedicated klystron for deflector
  - Change the deflector to a CR one
  - Closed RF bump + collimator for bunch length control
  - (Switch for the PHIN gun for higher charge)

- (Push the beam line toward the X-Box1 in CTF2)
- Or transport the 12 GHz power to CLEX
  - Add a 12 GHz crab cavity for bunch length diagnostic
  - (Add an undulator, a Compton scattering experiment…)

- Produce special beam for Wakefield study
  - 2 bunches of different energies with adjustable delay
  - Single bunch, short range wakes (A. Latina)

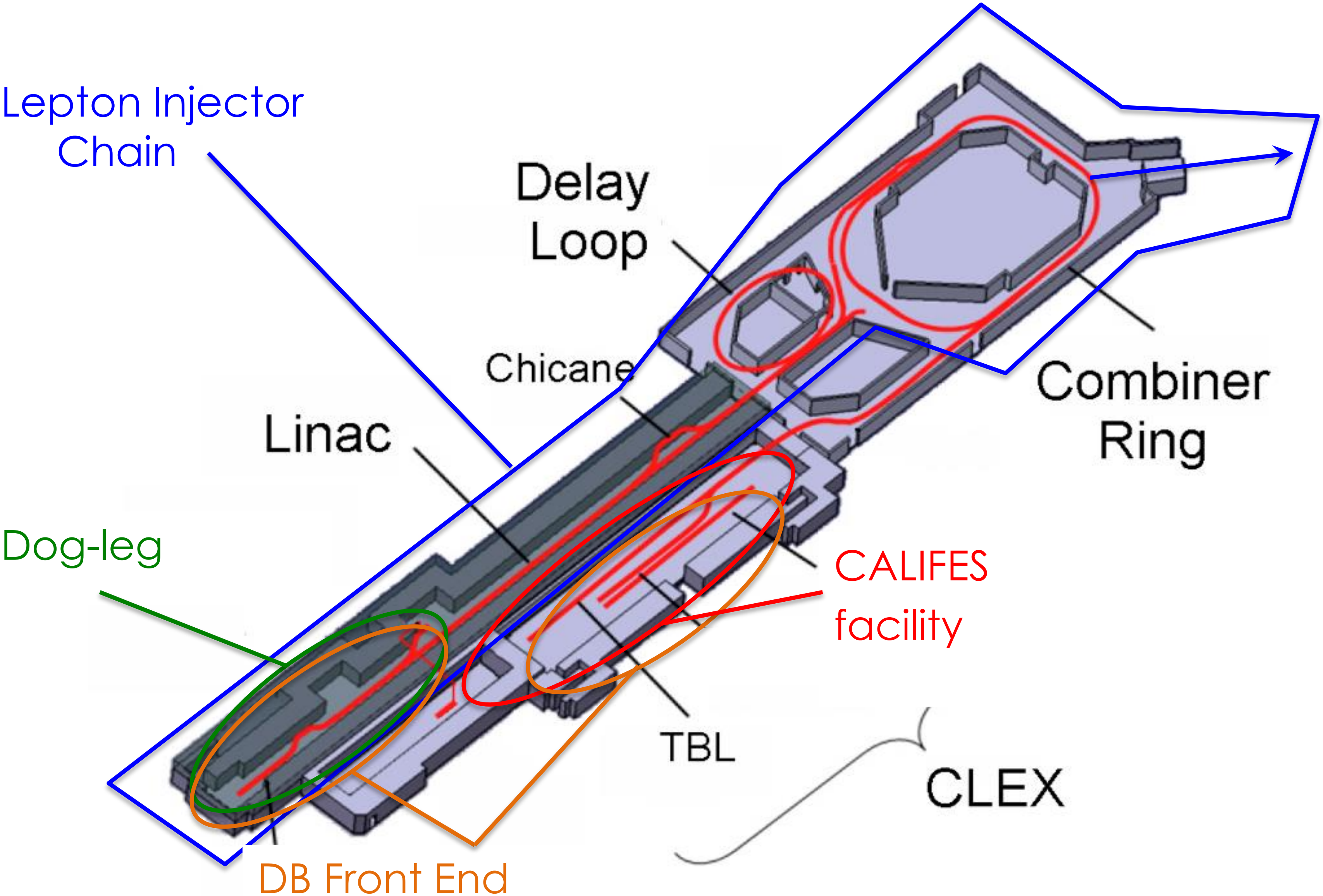
Some consideration on resources

- Given the present CTF3 material budget/manpower, one may roughly evaluate the resources needed to keep CALIFES running after 2016 to about:
  - 200-300 kCHF/year (including M to P – students and PJAS)
  - About 5 FTEs (staff and fellows)
- The above would include a minimum upgrade (1 ½ additional klystron, rearrangement of test area)
- Will do a more precise evaluation, including more ambitious upgrade options

Outlook

- CALIFES may be a reasonably cheap multi-purpose test facility
  - Useful within the CLIC study – potentially much wider interest
  - (Would help if enough support should come from outside the CLIC study or/and outside CERN)
- Minimum to medium upgrades will enhance flexibility/usefulness
- Connection to XBox1 seems logical step
  - Possibilities of further upgrades
- Need more refined cost/resource assessment and evaluation of scientific case
- Develop an integrated proposal, considering other beyond CTF3 options.

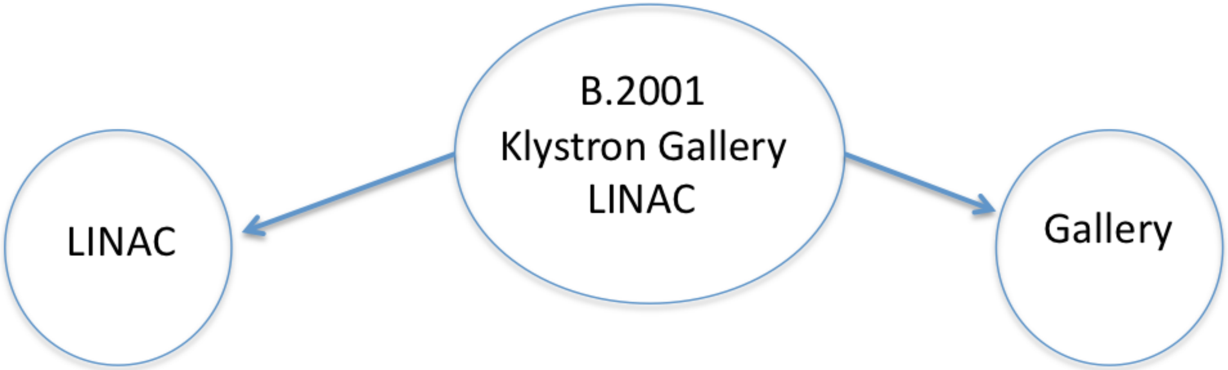
Options


Lepton Injector Chain
Delay Loop
Chicane
Linac
Combiner Ring
Dog-leg
CALIFES facility
TBL
CLEX
DB Front End

CTF3 Decommissioning issues

G. McMonagle

Example of clearing out an area



Controlled area
Not INB .. No INB paperwork needed ☺
Each item that is removed needs RP control
(full time RP technician in situe necessary)
Timescale …… some weeks maybe months
Storage area needed for activated items
Storage area needed for non activated items

No radiation issues as installation is not activated
Mainly klystron modulators
Magnet Power supplies
Control racks
Any requests for reusing components?
Significant manpower needed for removal and reinstallation

CTF3 Decommissioning & re-use issues

G. McMonagle

- Simplest solution close the complex and lock the doors
- Continue running CTF3
  - Costs
    - New access control system needed
    - Upgrade of modulator controls (get rid of non supported CAMAC)
    - manpower
- Reuse the Linac and rings for electron injector to PS
  - Costs
    - New access control system needed
    - Upgrade of modulator controls (get rid of non supported CAMAC)
    - manpower
- CLEX
  - Keep CALIFES operational
    - New access control system needed SOLVED
- New DB injector test area
    - Use LINAC area but probably need civil engineering work in CTF2 area to allow modulators and klystrons to be installed (too large for gallery)
- CTF2
  - Continued PHIN tests, X band test area
    - New access system needed SOLVED

Additional considerations II

- Decommissioning ≠ zero resources !

G. McMonagle

- It may be wise to "mothball" CTF3, also to keep open the possibility to re-start CTF3 after 2016 if needed (new module generation?) and according to CERN priorities
- Hovever, this clashes with requests to re-use CTF3 buildings and equipment…

- The shut-down paradox:

  "Given an accelerator facility, the cost of running it is in general lower or equal than the cost of a shut-down".

Yearly cost of CTF3 running

2012 running, relevant budget codes in blue

CLIC -EV		Budget Code Description	Charged to Budget Code (kCHF)	Annual Open Commitment (kCHF)
ABP	61440	CLIC-EV Drive Beam Phase Feed-forward and feedbacks	56	10
	61441	CLIC-EV Two-Beam module string	23	0
	61442	CLIC-EV Accelerator Beam System Tests	0	0
	61725	CLIC-EV General	480	23
	Total of ABP:		559	33
ABT	65776	CLIC-EV Kickers and Septas	2	0
	Total of ABT:		2	0
BI	64778	CLIC-EV Instrumentation	180	14
	Total of BI:		180	14
EPC	68725	CLIC-EV Power Converters	39	2
	68727	CLIC-EV Drive Beam Front-End (Modulators)	2	0
	Total of EPC:		41	2
OP	67700	CLIC-EV Operation, Consolidation & Upgrades	105	76
	Total of OP:		105	76
RF	69727	CLIC-EV RF	1433	149
	69792	CLIC-EV TBL+	67	3
	69793	CLIC-EV CLIC0 Drive Beam	0	38
	Total of RF:		1500	190
STI	63736	CLIC-EV CLIC0 Photoinjector & Laser	247	16
	Total of STI:		247	16
VSC	86756	CLIC-EV Vacuum	51	17
	Total of VSC:		51	17
Total of CLIC-EV:			2686	350

Include some consolidation and upgrade	2053	273

Yearly cost of CTF3 running

Codes	Equipment	Charged 2012 (kCHF)	Planned 2013 (kCHF)	Spent 2013 (kCHF)
67700+	Operation and Manpower (PhDs, PJAS)	200	380	340
65776	Kickers and Septas	2	4	13
64778	Instrumentation	180	230	170
68725	Power Converters	39	35	26
69727	Modulators	260	1323	890 (1200)
	Klystrons	550		
	Waveguides, networks, various manpower …	350		
	TWTs	100		
86756	Vacuum	51	44	58
63763	CLIC0 Photoinjector & Laser	80	50	50
TOTAL		1812	2066	

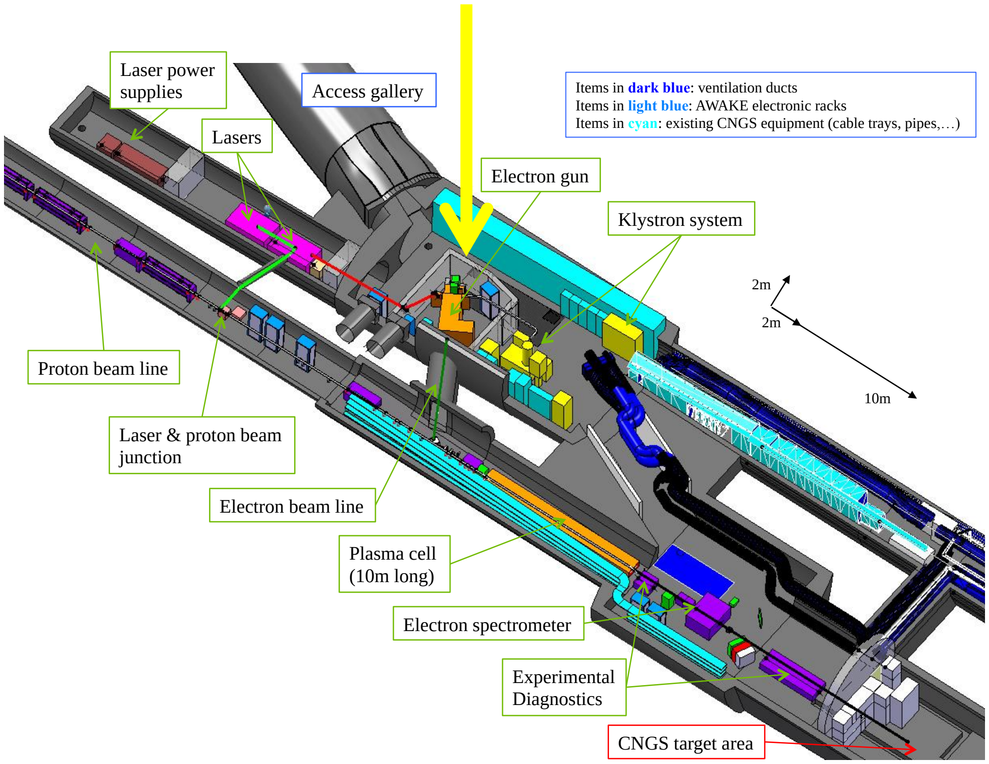
Taking out upgrades, divided by sub-systems

1550 (1860)

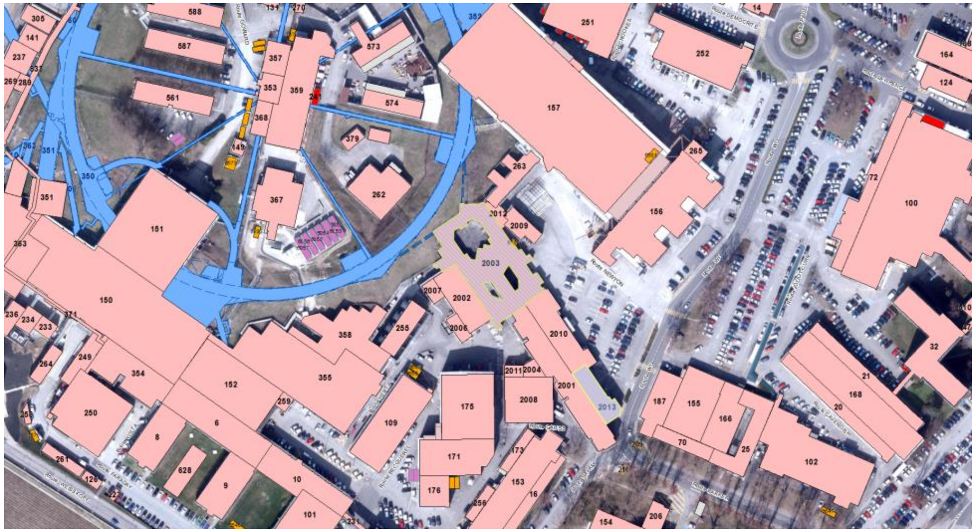
+ Manpower: about 15 FTE, including M to P

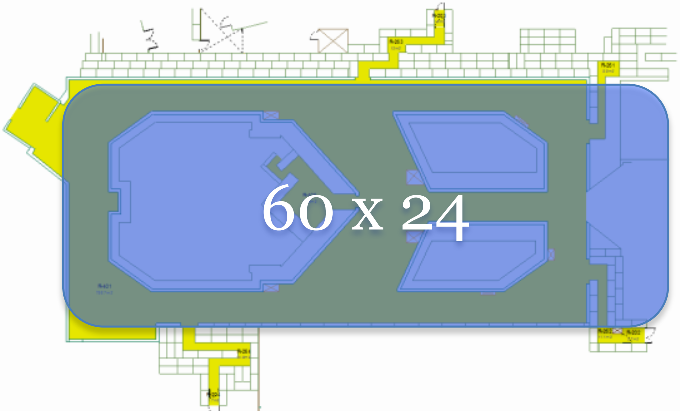
Contribution to AWAKE

- Awake needs 20 MeV electron source with low charge, small emittance and possibly short bunches
- One CTF3-type Klystron-Modulator would be needed to power the injector
- PHIN (Califes) type gun could be used
- Some diagnostics, vacuum equipment and magnets might be useful
- CTF-team experience would be likely helpful as well
- Test facility and pre-commissioning in CTF2 area?



Building re-use, an example: ERL Test Facility





Currently CTF3 to end operation in 2017
Size could be ok when annexing some parts of the current Linac buildings
Complicated topology.
Could be easier to re-assemble

Could accommodate quench tests in CTF2 and CTF3 buildings

Already crowded area

N. Catalan-Lasheras
LHeC Workshop 2014