CALIFES
Discussions of sessions and programme

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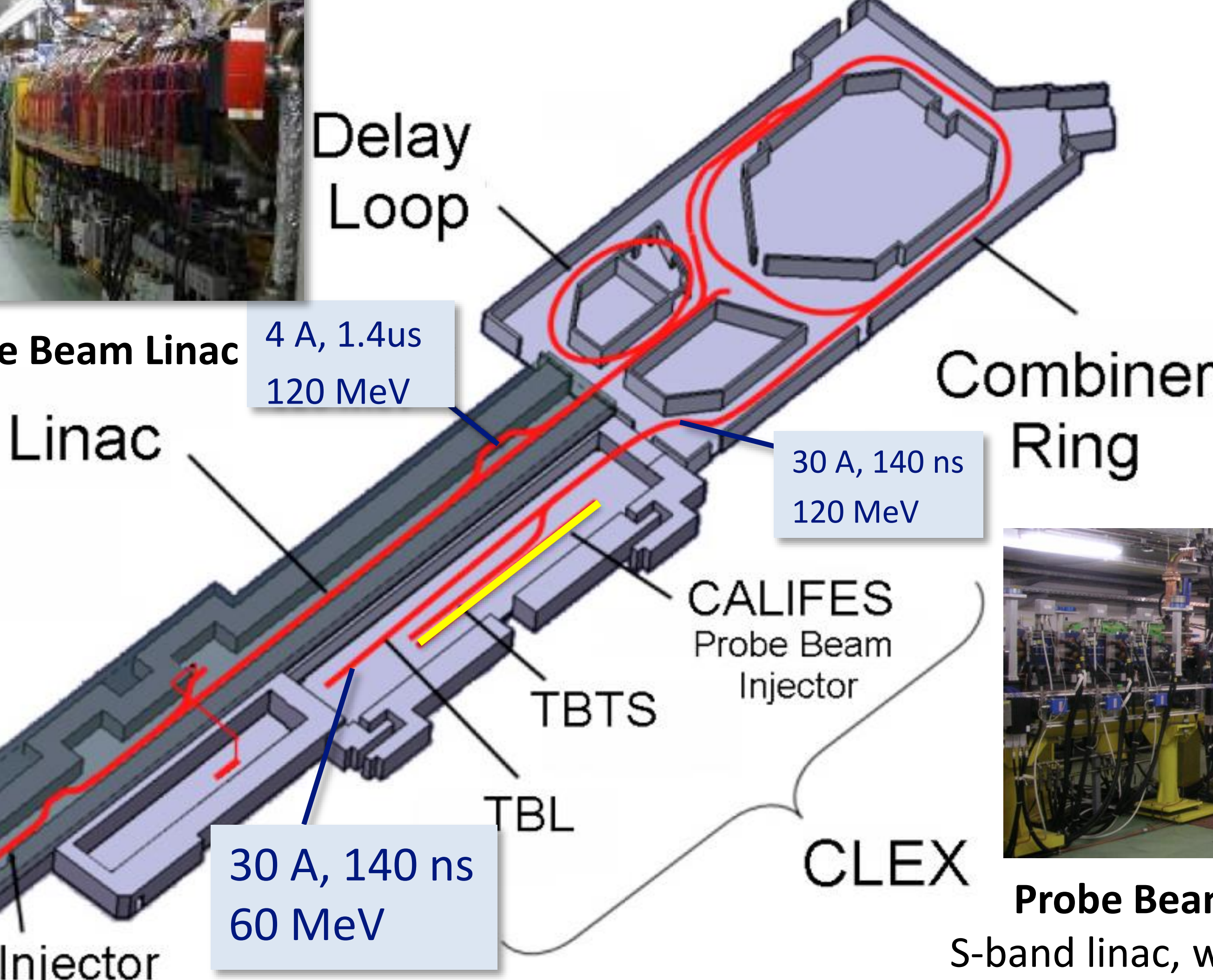
For the CALIFES study group

August 24, 2016

CLIC Test Facility

Drive Beam Linac



CALIFES

Probe Beam Linac : CALIFES

S-band linac, with RF-gun.

Fits entirely inside the CLEX room.

CALIFES parameters

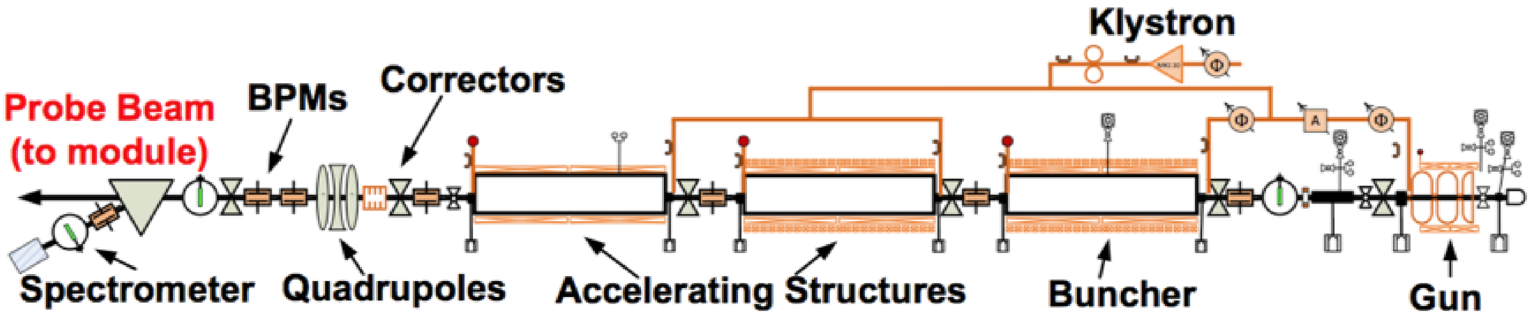


Figure 1: The CALIFES beam line, as installed in the CLIC Test Facility 3

Photo-injector: provides easily adjustable beam parameters, over a large range.

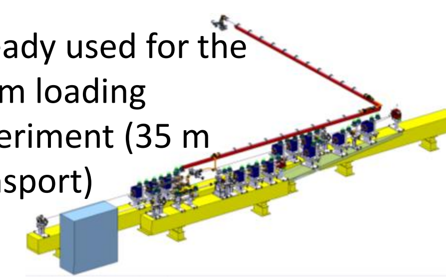
Beam parameter (end of linac)	**Value range**
Energy	80 - 220 MeV
Bunch charge	0.01 - 1.5 nC
Normalized emittances	2 um in both planes
β^*	< 1 m (not tried to push)
Bunch length	300 um -1.2 mm
Peak current	**~few 100 A**
Peak bunch density	**~1e14/cm3**
Relative energy spread	1 %
Repetition rate	1 - 5 Hz
Number of micro-bunches in train	Selectable between 1 and >100
Micro-bunch spacing	1.5 GHz

Table 1: CALIFES parameters.

Additional asset: Xbox 1 as RF-source

Possibility of providing 50 MW, 12 GHz RF power to CALIFES X-band components.

Already used for the beam loading experiment (35 m transport)

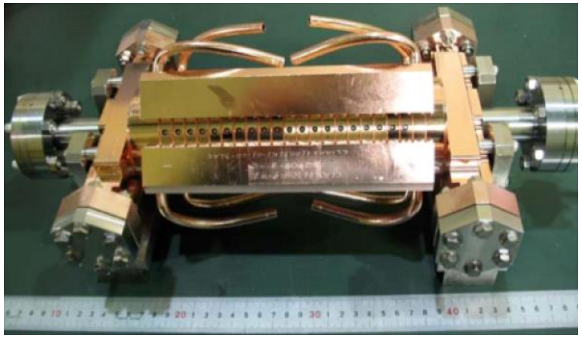


High-gradient energy frontier R&D

(Also see Walter's talk)

CALIFES : brings together high-gradient X-band acceleration and a well instrumented relativistic electron beam in order to address a number of important issues for the CLIC study.

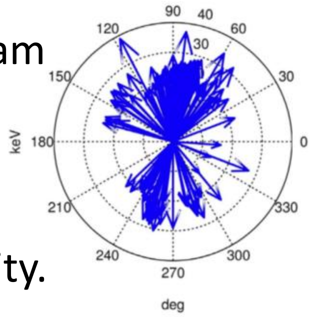
The 11.994 GHz CLIC accelerating structure :



Beam tests of next-generation high gradient accelerating structures : will advance the CLIC project preparation for the next European Strategy update.

Three main categories of interesting studies :

1. **The effect of a beam on the high-gradient behavior of a structure** : Example: beam loading effect on gradient (17% less output field with beam). Currently under study with the CTF3 drive beam. A CALIFES program would allow new studies such as effect of controlled beam loss on gradient, as well as continuation of tests of beam loading.



CTF3 break down kick measurements(A. Palaia)

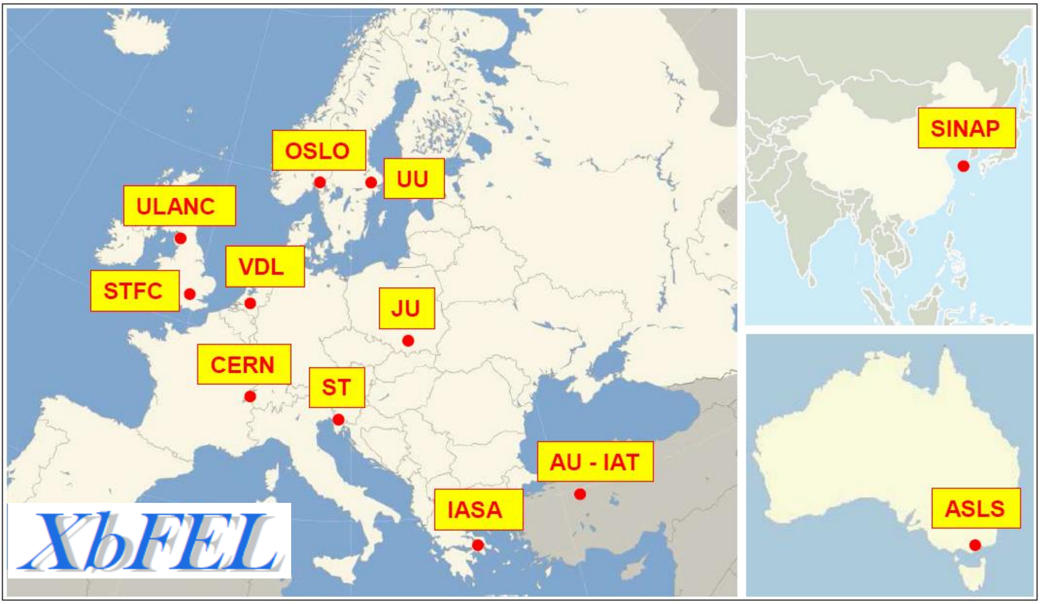
2. **The effect of high-gradient acceleration on the beam.** Example: further understand effect of break down and dark current on beam quality and luminosity.

3. **Wake-fields and structure-based beam measurements.** Example: CALIFES offers ability to further study the X-band wake fields, as well as how to use the wake field as a precise beam position monitor (wake field monitors). See next slides.

"XbFEL" Collaboration: developpement of an X-band FEL

- Institutes access to CERN-developed X-band technology (expertise, test facilities).
- Allows smaller countries with limited resources to work towards a FEL design report. Reduce significantly the risk for each partner.
- Matures X-band technology for a linear collider
- Access to test facilities, including beam tests, will greatly benefit the progress of X-band FEL design

Example of X-band test facility at CERN



ST	*Elettra - Sincrotrone Trieste, Italy.*
CERN	*CERN Geneva, Switzerland.*
JU	*Jagiellonian University, Krakow, Poland.*
STFC	*Daresbury Laboratory Cockcroft Institute, Daresbury, UK.*
SINAP	*Shangai Institute of Applied Physics, Shanghai, China.*
VDL	*VDL ETG T&D B.V., Eindhoven, Netherlands.*
OSLO	*University of Oslo, Norway.*
IASA	*National Technical University of Athens, Greece.*
UU	*Uppsala University, Uppsala, Sweden.*
ASLS	*Australian Synchrotron, Clayton, Australia.*
UA-IAT	*Institute of Accelerator Technologies, Ankara, Turkey.*
ULANC	*Lancaster University, Lancaster, UK.*

Potential tests for an X-band FEL using the CALIFES beam

From presentation A. Latina from CLIC workshop 2015

#	Applications	Tests
1	X-band linearizer	· Check the first CLIAPSI structure CERN-PSI-Elettra (with the 400 μm misalignment)
2	Wake Field monitors	· Activation and calibration · Acquisition systems
3	High frequency bunch spreader/separator	· Bunch separation with RF cavities · Possibility to work out with bunch distances from ns up to μsec · Beam quality degradation (emittance, energy spread)
4	X-band deflectors	· Beam tests · Time resolution (< 10 fs)
5	High frequency Photoinjector	· Beam tests and characterization (i.e. C-band)
6	Bunch compression	· Beam compression studies · Emittance preservation · Longitudinal diagnostics and instrumentation
7	Timing and synchronization	· RF synchronization measurements
8	Low energy test stand for X-band FELs (adding an X-band module downstream the bunch compressor)	· Beam acceleration studies
9	Advanced beam dynamics tests	· Purely-magnetic compression schemes, CSR-free DBA, beam-based measurements

Facility infrastructure existing

Potential collaboration contributions

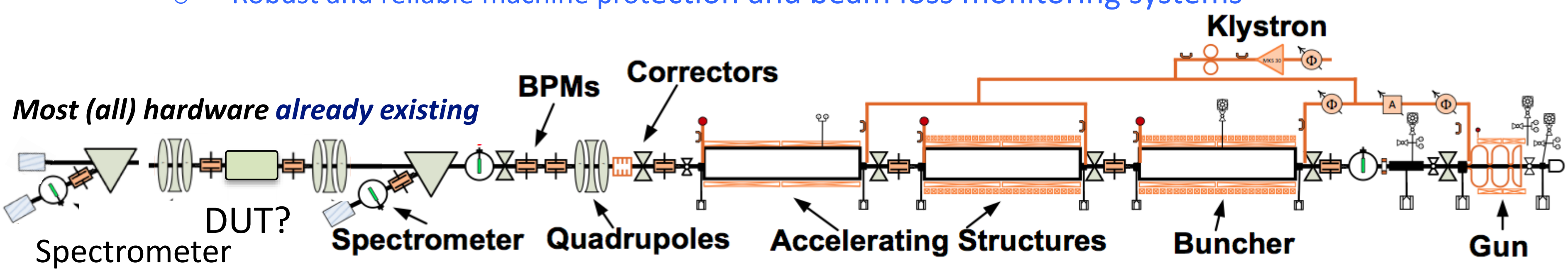
CALIFES for diagnostics R&D

- **R&D required for large number of CERN accelerators**
  - LHC, HL-LHC, LIU (SPS, PS, PSB) projects
  - CLIC/ILC, AWAKE, FCC studies (e-e+)
- **LHC accelerator chain: very limited availability for BI R&D**
- **CALIFES answers many demanding R&D requirements :**
  - Dealing with the (ultra) fast
    - Sub-picosecond bunch lengths in AWAKE and CLIC
    - Fast transverse beam position monitors (HL-LHC Crab cavities and transverse beam Instability diagnostics)
  - Unprecedented request for precision
    - Positioning down to below the micron level
  - Treatment of increasingly more data
    - Bunch by bunch measurements for all parameters: Test of state of the art acquisition system (electric or optical domain)
  - Challenges related to high beam powers
    - Non-invasive measurement techniques (Gas profile monitor, Quadrupolar PU, ..)
    - Robust and reliable machine protection and beam loss monitoring systems

CALIFES: **fully commissioned and well instrumented linac. Flexible optics and steering in CLIC module area.** Ideal place for parametric scans and cross-check measurements for new instrumentation under test.

More details: 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

Most (all) hardware already existing

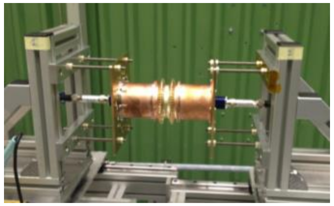


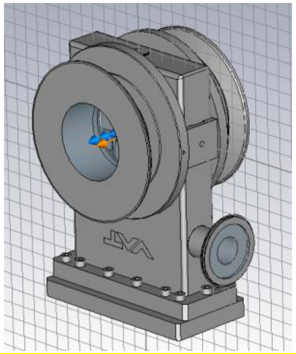
Strong interest from CERN, outside and within CLIC project. Interested groups: CERN, Uppsala University

Impedance measurements - Context

B. Salvant - CERN

- CERN team involved in design and approval of new and modified equipment in all CERN circular machines (in particular PSB, PS, SPS and LHC, but also AD, ELENA and CLIC damping rings).

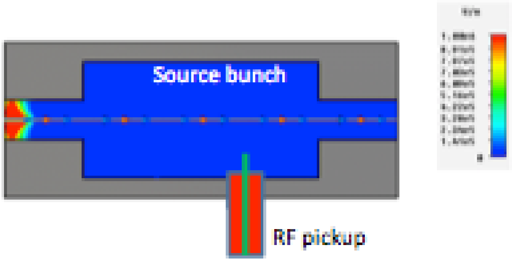


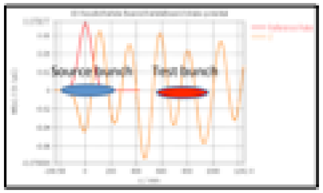


- Tools at our disposal:
  - Bench measurements with wires and probes
  - Numerical simulations

→ Measurement with electron bunches could be an interesting complement to these existing tools

- **Possibility to measure EM fields** from available antennas, buttons, striplines, wires, all mode couplers already in the device (or installed just for that reason).
- Possibility of **direct benchmark of simulations** with fields monitors
  → probe measurements only validate the Qs from simulations
  → wire measurements can perturb significantly the modes.
  → real interest in using an electron source

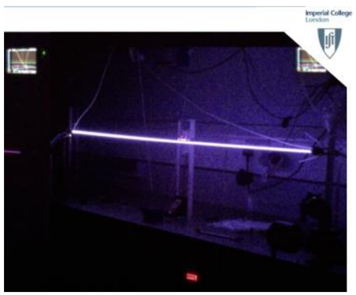


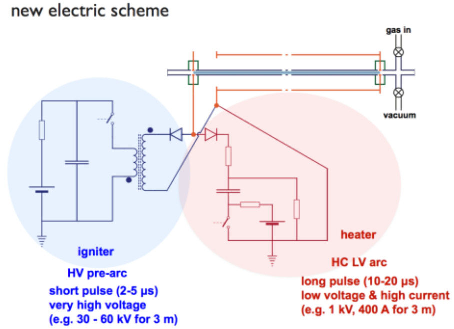


CALIFES: complementary PWFA

- Electron driven plasma, complementary to AWAKE
- Seek complementary program to existing facilities
- One focus: study topics of particular interest for PWFA-collider applications

Plasma source : in dicussion with ICL, about **gas discharge plasma source**. Relatively simple design, easy to fit into CTF3, and does not require a costly laser system for ionization.

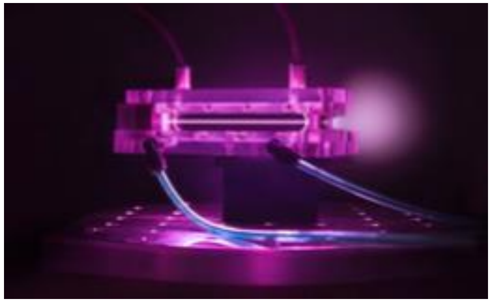


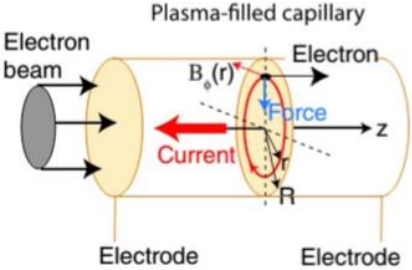


Rough hardware cost estimate : ~100 kEUR

N. C. Lopes[1,2], Z. Najmudin[1]
[1]John Adams Institute for Accelerator Science, Imperial College , London, UK
[2]GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Lisboa, Portugal

Plasma lenses : in discussion with DESY, seek to complement their program.

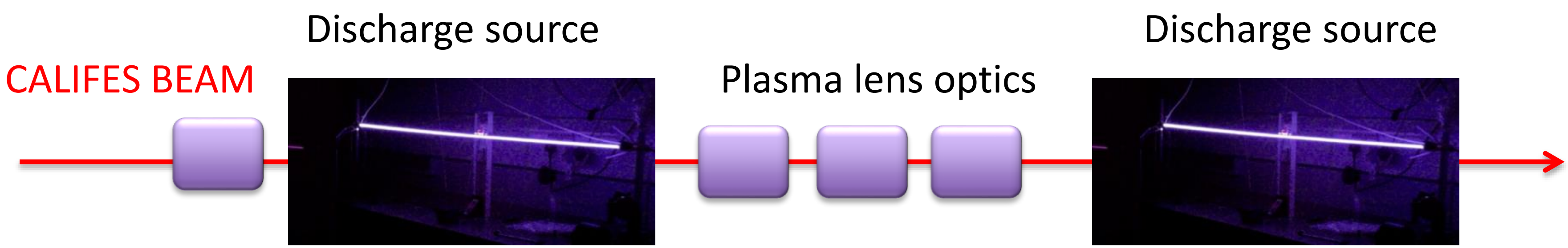




Van Tilborg, J., et al. "Active plasma lensing for relativistic laser-plasma-accelerated electron beams." Physical review letters 115.18 (2015): 184802.

CALIFES dream setup?

Building up step-by-step :



Development of plasma sources

Test and development of plasma lenses

Plasma source staging experiment

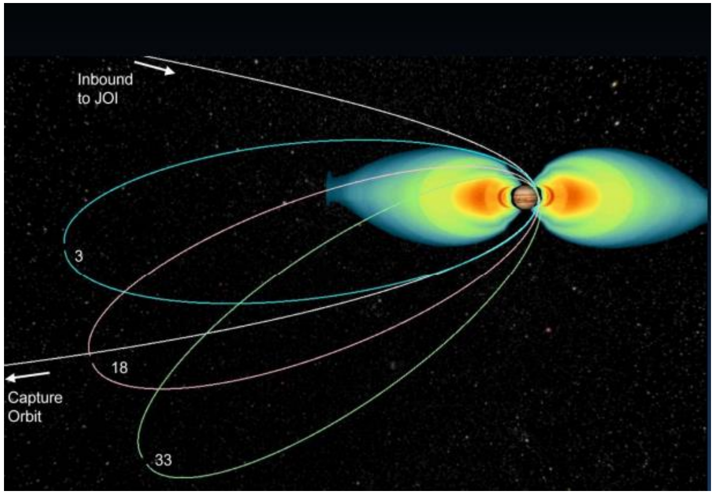
Advanced interstage plasma lens experiments

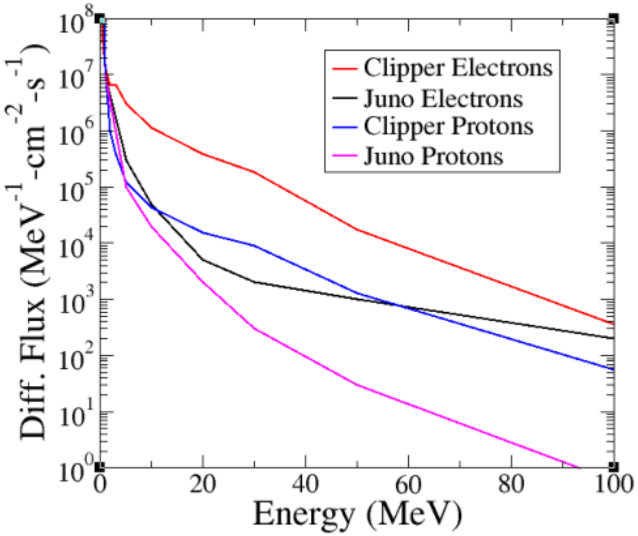
Would require a large amount of beam time, as well as easy access to facility (both available in CALIFES)

ESA-CERN irradiation tests

CERN and ESA have signed a bilateral co-operation agreement (ICA-ESA-0125) in March 2014 in order to facilitate knowledge exchanges and synergies exploitation in key technological fields. One of the most promising areas of potential collaboration is "Rad-hard components and radiation testing and facilities".

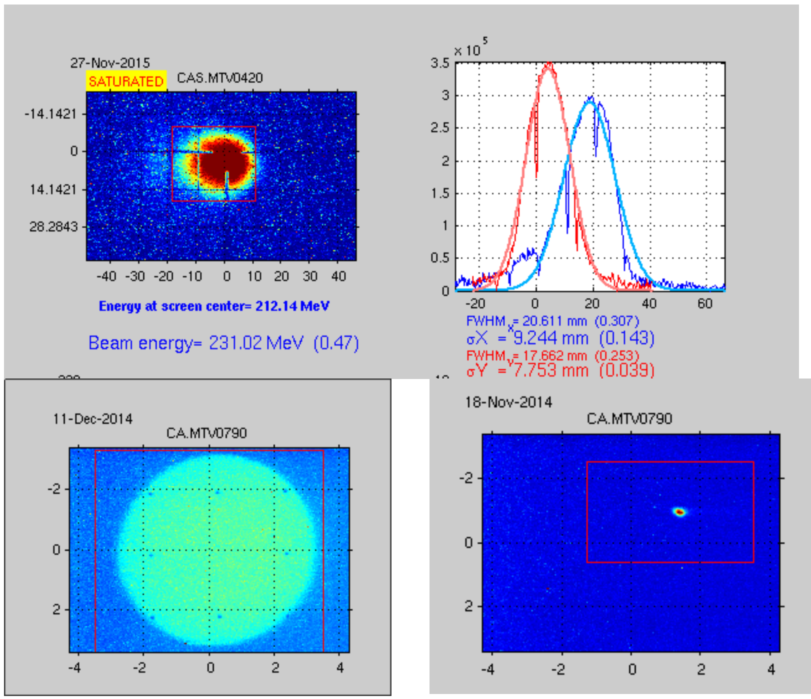
…**JUICE** (Jupiter Icy Moon Explorer) mission; spacecraft and payload design activities executed and the project is moving into the implementation phase. **The spacecraft will be located in an electron dominated environment, including high-energy electrons ranging up to a few hundred MeV.** Such high-energy electron radiation test facilities are not available today.





First CALIFES beam tests successfully concluded (2015)

Using CALIFES dark current beam. Beam successfully enlarged (6 x 6 mm2). Semi-autonomous tests (running at nights).



Flat beam (6 x 6 mm^2) after collimation
And nominal beam (100 μm)

[See talk CLIC workshop 2016 : M. Tali]

Maris Tali (*University of Jyväskylä*)
Rubén García Alía

- Optimized dark current settings
- 0.31nC

ESA is interested, after beam improvements, in conducting SEE/TID tests at the CALIFES facility. Other groups: Laboratório de Instrumentação e Física Experimental de Partículas, University of Montpellier, University of Jyväskylä.

Education and training

- So far in the CTF3/CLIC collaboration **around 80 accelerator students** have performed research and got hands-on experience with electron beam operation at CTF3.
- Similarly, if CALIFES remains operational, new generations of students will have the possibility for hands-on experience.

Institutes from which students have been trained on CALIFES and CTF3 :

Aristotle University of Thessaloniki, Greece
Department of Physics, University of Oslo, Norway
Dep. of Electronics and Telecommunications, NTNU,Norway
Pakistan Atomic Energy Commission (PAEC), Pakistan
Royal Holloway, University of London, UK
University of Gothenburg, Sweden
University of Milan, Italy
University of Oxford, UK
Uppsala University, Sweden
Joint Universities Accelerator School (JUAS)
– **new cooperation 2016**

18 JUAS students getting hands-on training with CALIFES (February 2016)

Session planning

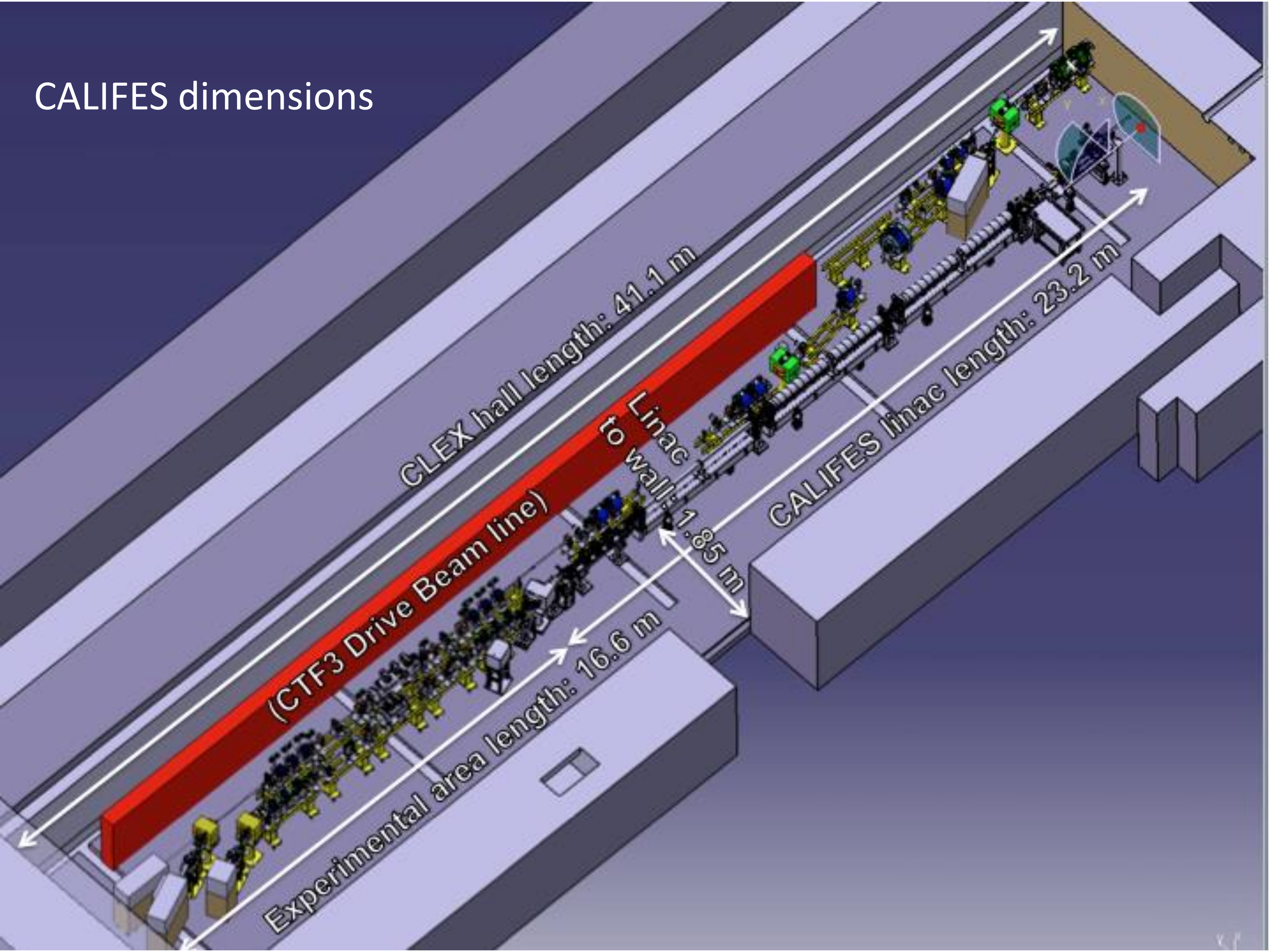
In preliminary time table: 8 x ca. 1.5 hours for presentations.   CALIFES visit in the middle of the workshop.

Plan to adjust length of sessions depending the number of talks we expect

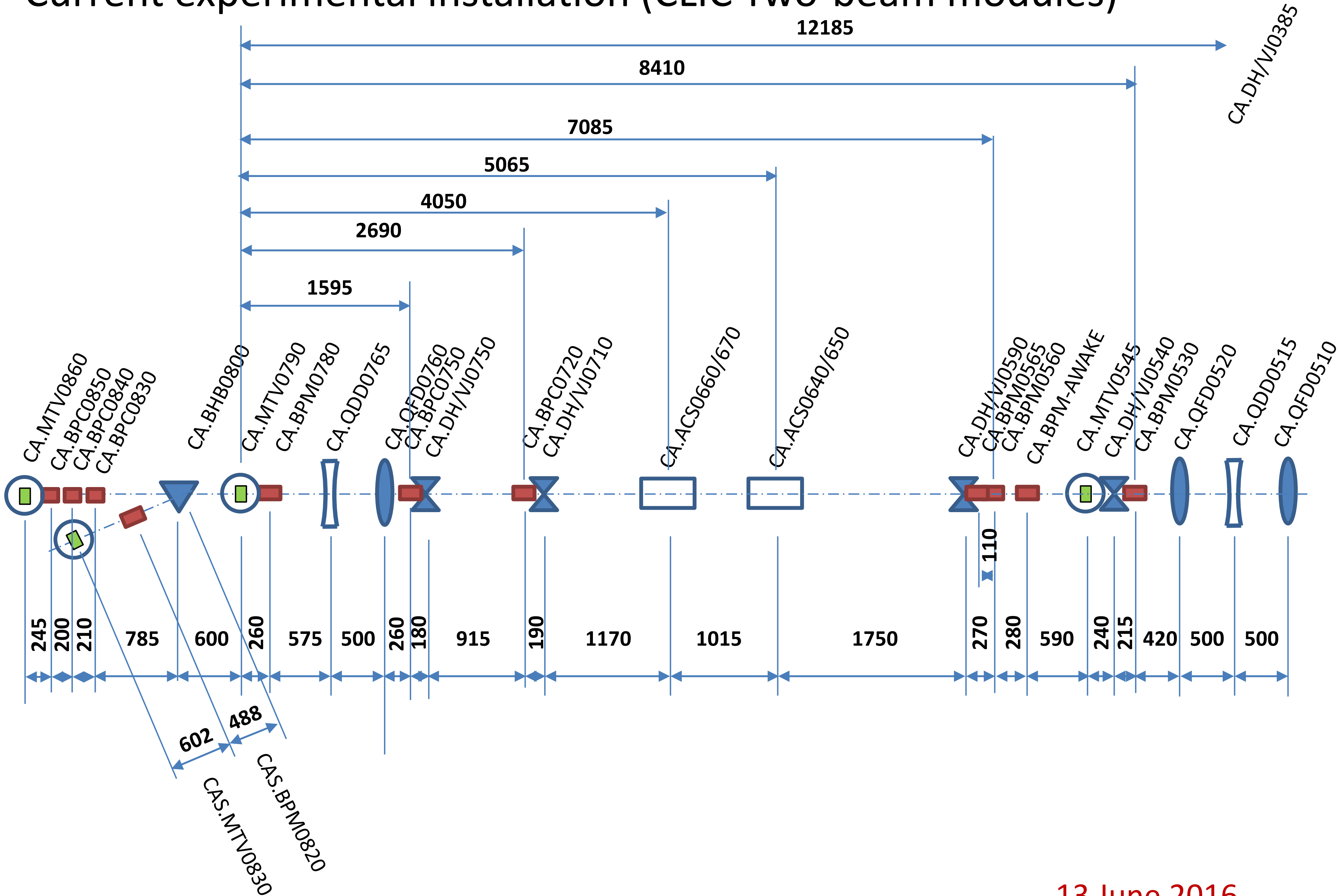
Any comments about our preliminary workshop structure?

Extra

CALIFES dimensions



Current experimental installation (CLIC Two-beam modules)



13 June 2016

Experimental hall