Instrumentation tests in a future Califes

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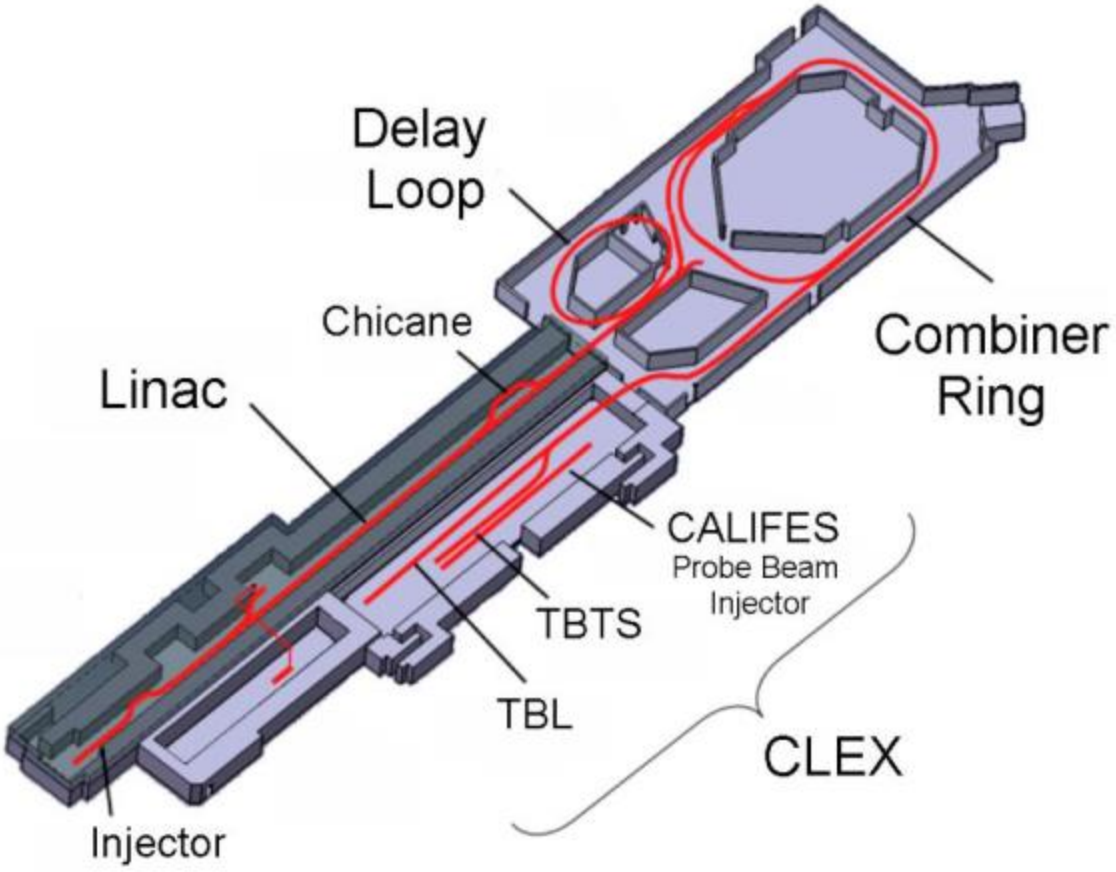
Califes



- From injector to two-beam experiments and CLIC prototypes test line to general instrumentation test line. Already happening?

Instrumentation tests today (I)

- "CLIC prototypes" in califes:
  - Cavity BPMs for CLIC main beam (J. Towler, pres. 43)
  - Fast diamond BLMs (E. del Busto, CERN)
  - Electro-optical bunch length monitor for CLIC probe beam. (R. Pan, T. Lefevre, CERN)
- More recently (2014), instrumentation tests:
  - OTR Interferometer, to test shadowing and formation length in transition radiation
  - Test on silica rods as Cherenkov detector (S. Jakobsen, E. Bravin, CERN)

Why Califes as BI test facility

- BI testing is limited. LHC: long shutdowns with no testing capability. Rely on other machines: ALBA, CESR, Australian synchrotron, ATF2.
- Electron linac (E = 200 MeV) is the cheapest way to provide relativistic beams
- Photo-injector is ideal for providing modular bunch spacing:
  - single bunch possible
  - possibly bunch spacing similar to CERN beams (1ns, 5ns, 25ns, 50ns, ..)
  - pump – probe experiment (wakefield study, impedance measurement, ..)

Challenges for beam instrumentation

R. Jones, 2013

- Unprecedented request for precision
  - Positioning down to well below the micron level
- Treatment of increasingly more data
  - Bunch by bunch measurements for all parameters
- Dealing with high beam powers
  - Non-invasive measurement techniques
  - Robust and reliable machine protection systems
- Dealing with the ultra-fast
  - Measurements on the femto-second timescale
- Dealing with the ultra-low
  - Measurement of very small beam currents

Challenges for beam instrumentation

- Wish list for Beam parameters:
  - Short (100 fs: CLIC, AWAKE) and long (200ps: HLC) bunches
  - Large range of beam/bunch intensity (to be defined…)
  - Possibility to study time to position correlation (Crabbing)
  - …

A possible layout (I)

T. Lefevre, 2014

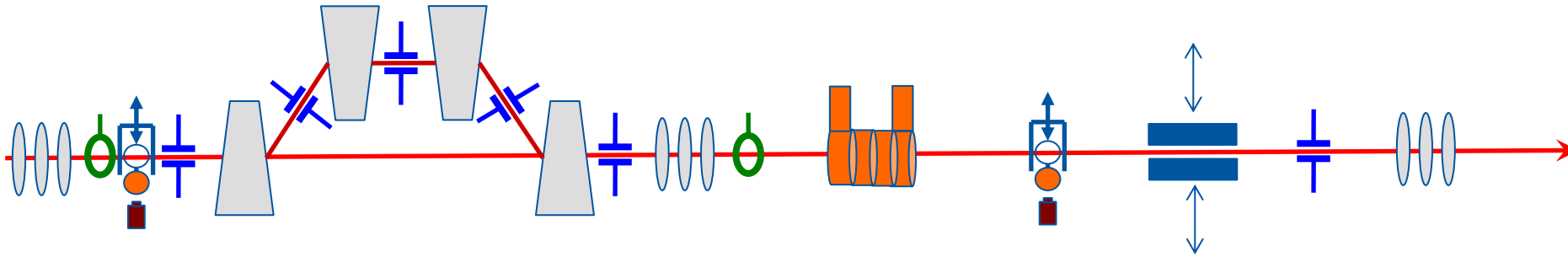
Machine layout to cover BI needs based on CALIFES

Magnetic chicane
Shorten or lenghthen
100fs up to 200ps

RF deflector
for crabbing

Collimator
- Reducing the bunch intensity before the Device Under Test (DUT) zones

- Reducing bunch length further in combination with RF deflector

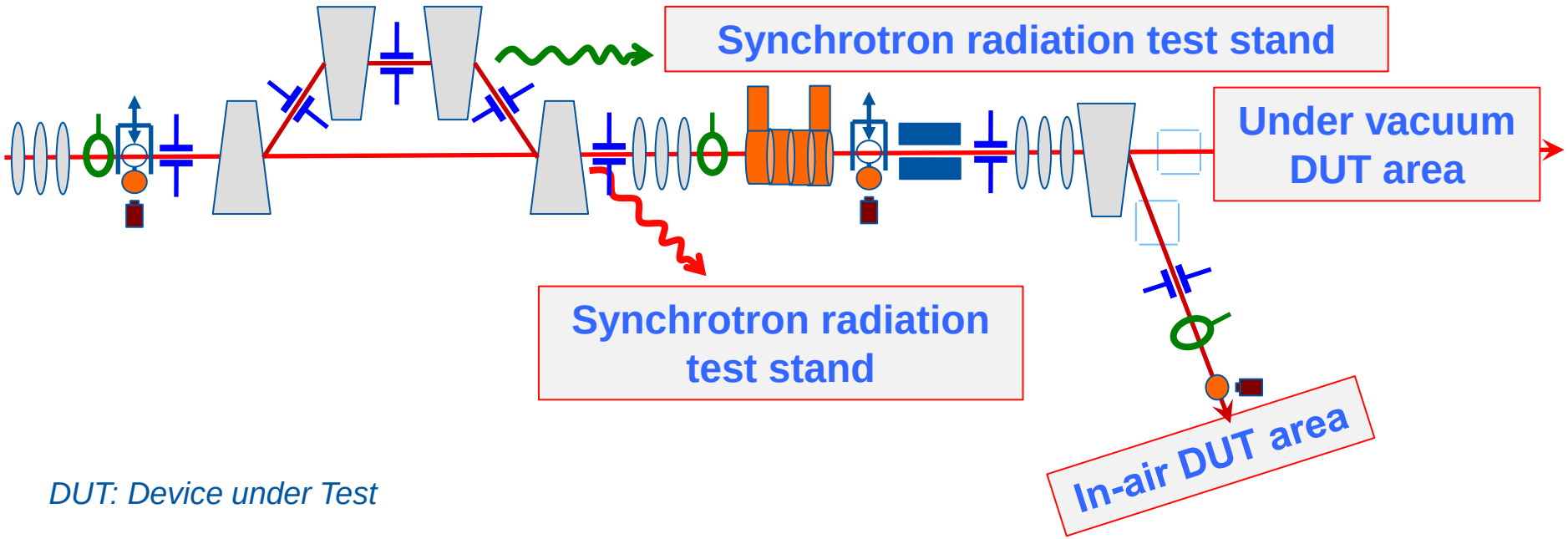


Beam current monitor Beam position monitor Beam profile monitor

A possible layout (II)

T. Lefevre, 2014

Machine layout to cover BI needs based on CALIFES



DUT: Device under Test

- Including SR test stand for infrared, visible and UV light: Several port available
- Including Testing area for beam instruments – Under Vacuum DUT
- Including Testing area for particle detectors – In air DUT – low intensity option

Califes for BI tests

- Synchrotron radiation source
  - Testing optical detectors/techniques with short photon probes over a wide range of wavelength (IR, visible, UV)
  - Potential interest for (HL)-HLC with longer (200 ps sigma) bunch length
  - λ_{cutoff} can reach 200 nm (OK for LHC). SR divergence approx. 4 mrad (300 μrad for LHC @ 7 TeV).
  - Possible use for developing
    - **Beam halo monitor**, longitudinal density monitor, …

Califes for BI tests

- Under vacuum DUT area

- Independent vacuum zone with easy access and pumping capabilities
- Including steering magnets to move the beam around
- Equipped with a Permanent instrumentation test stand
  - Used for beam cross calibration: beam size, position and bunch length
  - But also using ...
    - BTV station for screen and imaging system development
    - Pick-up for providing fast EM signal for testing electronic acquisition system
    - Coherent diffraction slit as a source for GHz-THz
- Possible use for developing
  - Beam position monitor, Wall current monitor, fast beam transformer, Ionization gas monitor, Wire scanner**…**
  - **ideal for short bunch length measurement electro-optical techniques**

Califes for BI tests

- In-air DUT area
  - Possibility to decrease the beam intensity to low or very low values
  - Possible use for developing Beam Loss monitors and Particle detectors
  - Radiation damage test for sensors / electronics

Conclusion

- CALIFES potentially very interesting as BI test facility.
- Bridge the gap for sub- ps bunch length measurements for CLIC and AWAKE
- Tests on SR based beam halo diagnostics for LHC.

Awake electron beam requirements

Parameter	Baseline Phase	Range to check
Beam Energy	16 MeV	10- 20 MeV
Energy spread (σ)	0.5 %	< 0.5 % ?
Bunch Length (σ)	4 ps	0.3-10 ps
Beam Focus Size (σ)	250 μm	0.25 – 1mm
Normalized Emittance (rms)	2 mm mmrad	0.5 - 5 mm mrad
Bunch Charge	0.2 nC	0.1 - 1 nC

Possible utilisation of CTF3 infrastructure

- Test of Beam diagnostic for CERN accelerators (including HL-LHC program)
  - General optimisation detection technique and method
  - Require longer bunches up to 200ps sigma (LHC type beams)
  - *Currently test of fast Beam loss monitor and Luminosity monitor on-going on Califes*
  - Possible future example, HL-LHC crab cavities diagnostic, ..
- Test of Electron beam diagnostic for CERN projects: AWAKE, FCC and CLIC
  - Califes should provide shorter bunches (AWAKE and CLIC – 150-300fs sigma)
  - DB beam injector possibly located in CTF3 DB linac after 2016
    - Continue the development of non-interceptive beam profile monitors
- Irradiation facility for ESA- JUICE (**JUpiter** ICy moons Explorer)
  - Requiring electron beam irradiation due to presence of electron cloud in the vicinity of Jupiter and its moons
  - Beam energy ranging from 10-200MeV
  - Required fluence of $10^7/10^8$ electron/cm^2