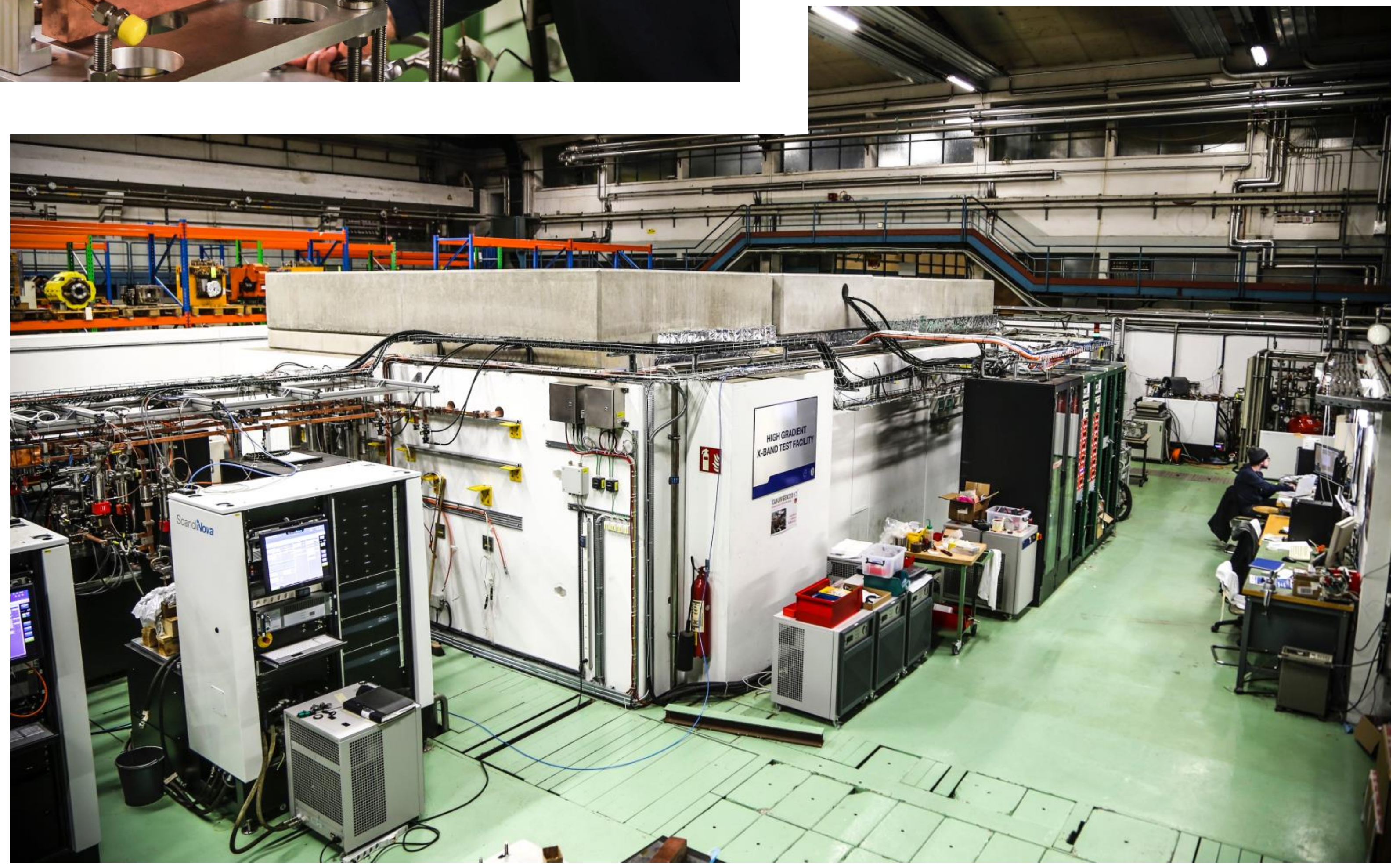
CLIC - Compact Linear Collider

CLIC is ready to be built

A damped accelerating structure prototype for CLIC being installed at the XBOX3 facility at CERN

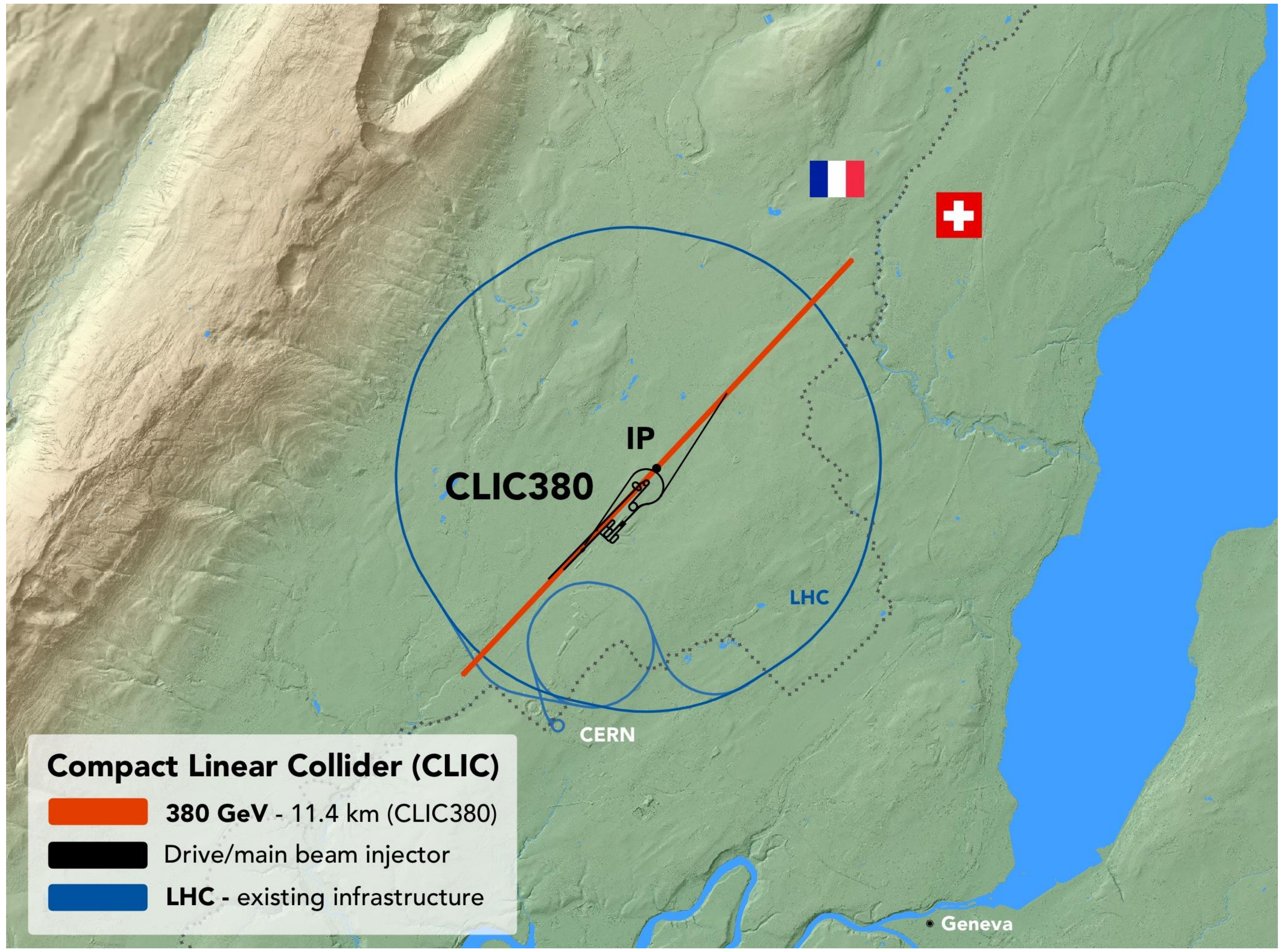


The high-gradient X-band test facility at CERN

- CLIC baseline – a drive-beam based machine with an initial stage at 380 GeV
- The CTF3 (CLIC Test Facility at CERN) programme addressed all drive-beam production issues
- Accelerating gradient at ~100 MV/m demonstrated in numerous prototypes
- Other critical technical systems (alignment, damping rings, beam delivery, etc.) addressed via design and/or test-facility demonstrations
- A klystron-based CLIC machine is also an option for 380 GeV – hardware demonstrated in accelerating-structure test stands
- Two C-band XFELS (SACLA and SwissFEL) now operational: large-scale demonstrations of normal-conducting, high-frequency, low-emittance linacs

CLIC at 380 GeV

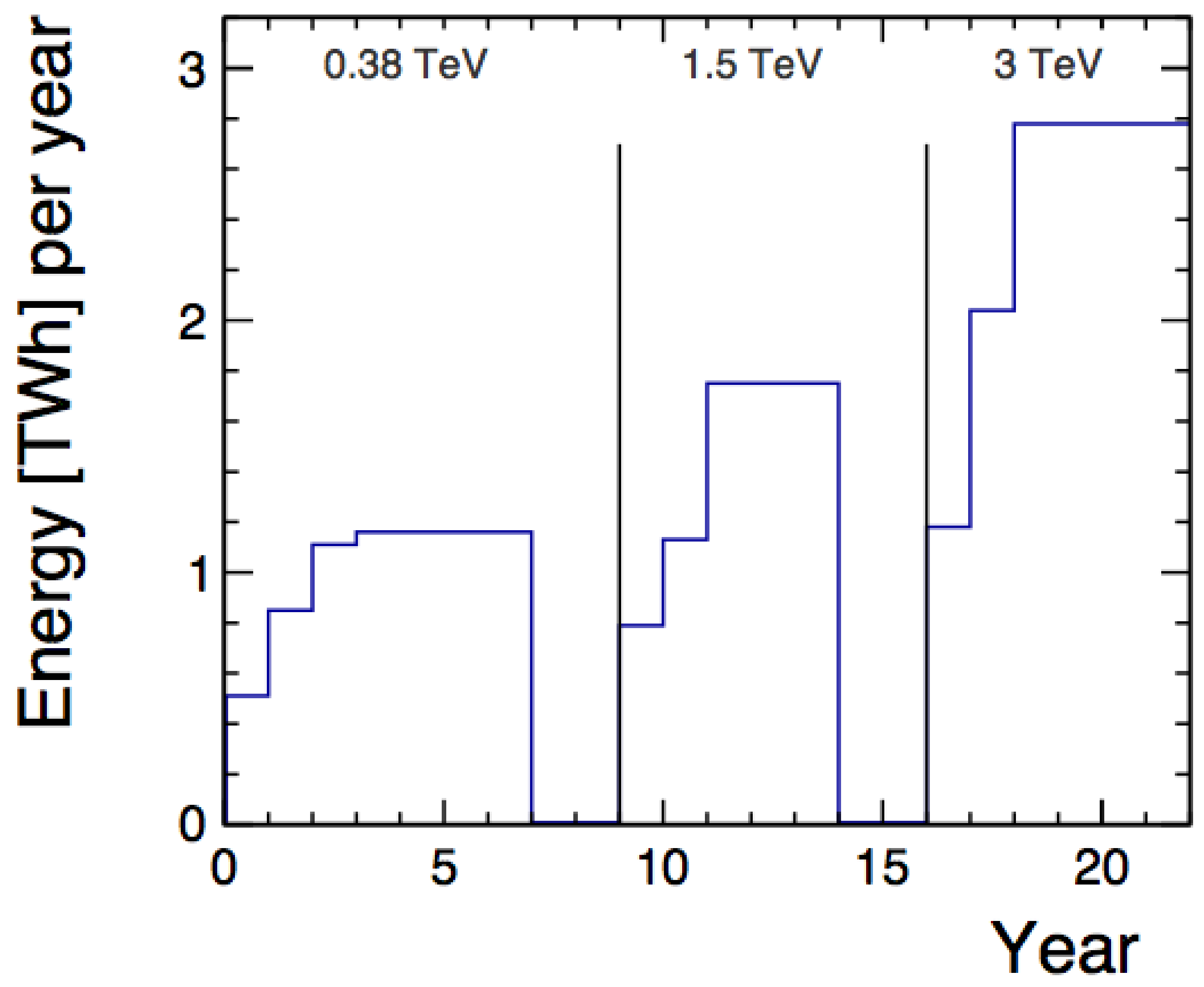
A compact accelerator optimised for luminosity, power, and cost



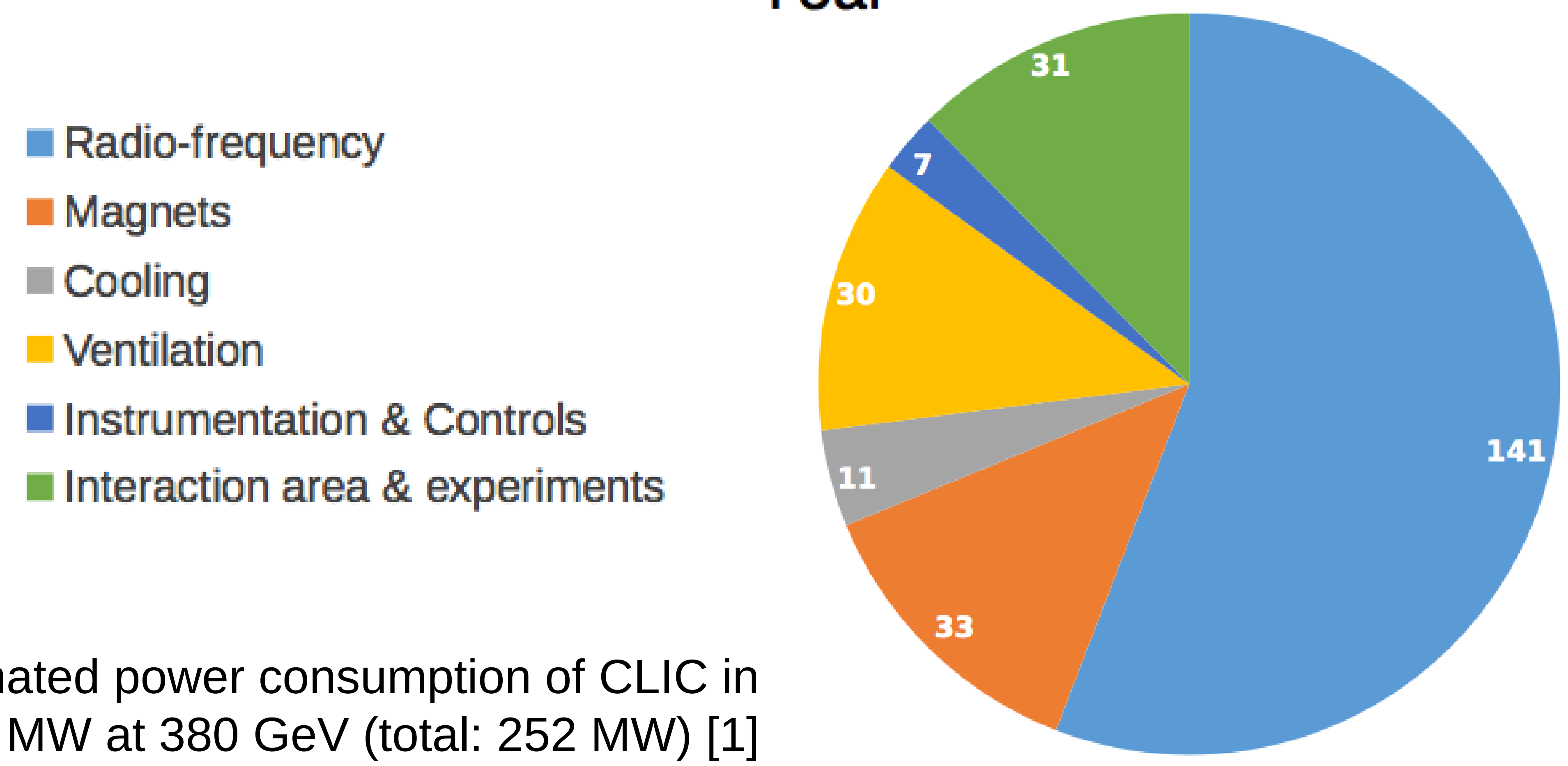
The footprint of CLIC at 380 GeV incl. drive and main beam complex

- CLIC high gradient technology allows for a compact accelerator
- 11 km total length ~LHC diameter, interaction region on CERN premises
- Proposed site geology well understood and extremely stable
- High luminosity: 1.5×10^{34} cm^{-2} s^{-1}
- The CLIC design attempts to minimise use of power and cost
- Ongoing technical studies (accelerating structures, RF system, magnets, …) will allow further reduction of power and cost while maintaining overall performance

CLIC power consumption



[1] P. Burrows et al. (eds.), 2016, DOI 10.5170/CERN-2016-004



Estimated power consumption of CLIC in MW at 380 GeV (total: 252 MW) [1]

- Power and energy consumption at 380 GeV is well within the existing parameters and installations at CERN
- Substantial development work is focused on:
  - improving efficiency of the RF systems (high efficiency klystrons and modulators)
  - reducing magnet power (e.g. by using permanent magnets)
  - minimising overheads for auxiliary systems
- At 1.5 TeV the energy consumption will surpass the current CERN usage (2017) by ~30% [1]
- Normal conducting – significant potential for reduced energy costs by operation in off peak periods
- At 3 TeV the energy consumption will be a factor two of the current CERN usage (2017) [1].
- Beyond the on-going studies mentioned above, further reduction might be needed (e.g. by reducing yearly operation from 8 to 6 months)

CLIC could be expanded to above 3 TeV with novel technologies

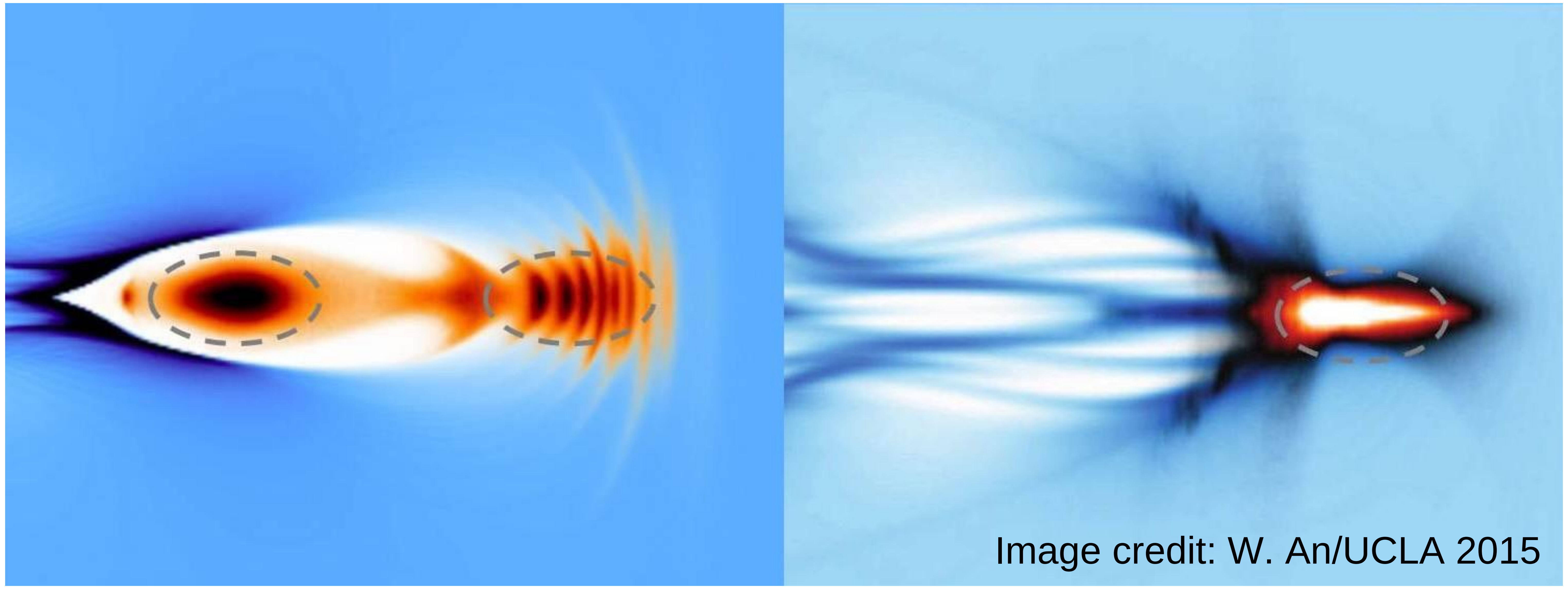
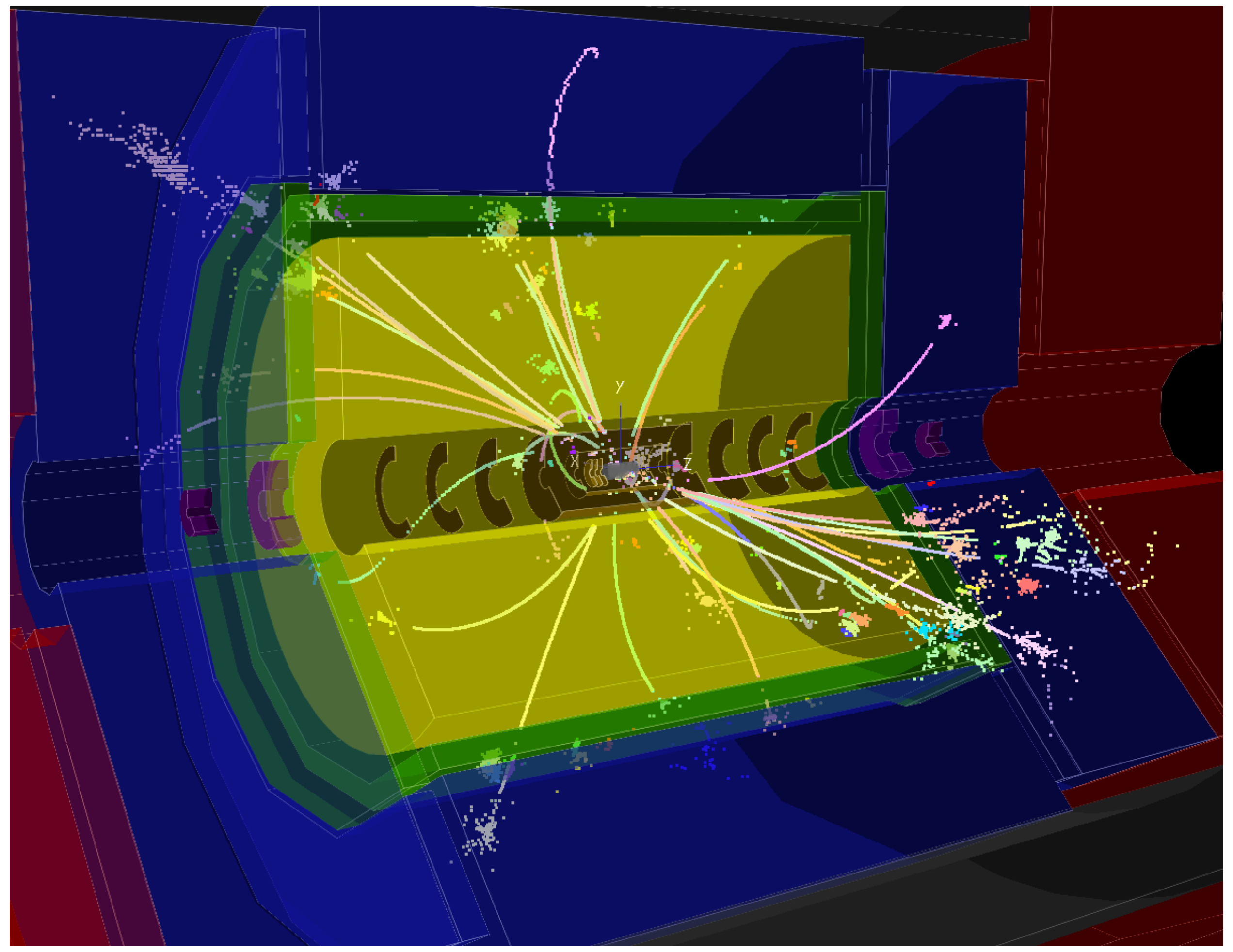


Image credit: W. An/UCLA 2015

- 100 MV/m can be achieved with CLIC X-band technology – with this technology 3 TeV can be reached
- Novel accelerating technology, including plasma wakefield and dielectric accelerators, have recently demonstrated accelerating gradients largely exceeding 100 MV/m
- The CLIC project studies whether novel technologies could be used to expand the energy range of a CLIC machine to reach collisions at 10 TeV or higher

Excellent coverage of the Standard Model

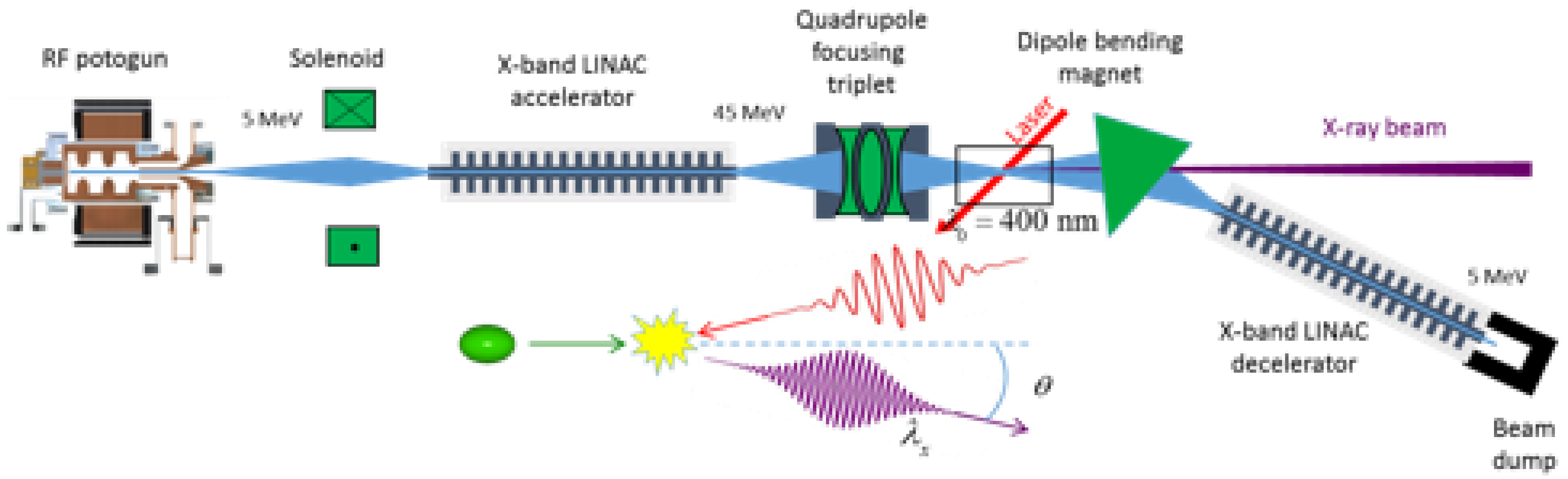
- Physics programme of CLIC at 380 GeV provides excellent coverage of the Standard Model
- The centre-of-mass energy of the first CLIC stage was recently changed to 380 GeV to maximise the potential for precision measurements of both the Higgs boson and the top quark
  - Two different Higgs boson production modes: Higgsstrahlung and WW-boson fusion (enhances the overall knowledge of the Higgs boson)
  - Large number of top quark pairs are produced at the same time (never studied in electron-positron collisions before)
- The Higgs and top coupling strengths to the other SM particles can be determined with very high precision – sensitive to a wide range of beyond the Standard Model (BSM) phenomena
- Beyond Higgs and top physics, CLIC allows to perform many other precision measurements at 380 GeV, with expected precisions far exceeding the LEP results



A simulated top-quark pair at 380 GeV

CLIC high-gradient applications

- Inspired by the progress made in CLIC high-gradient technology, a growing number of projects are planning to use high-gradient and/or X-band technology:
  - Compact linacs and advanced diagnostics for photon sources (XFEL and Compton)
  - Medical applications (proton acceleration and very high energy electron therapy)
  - Linacs to test advanced acceleration techniques



Eindhoven University led SMART*LIGHT Compton Source

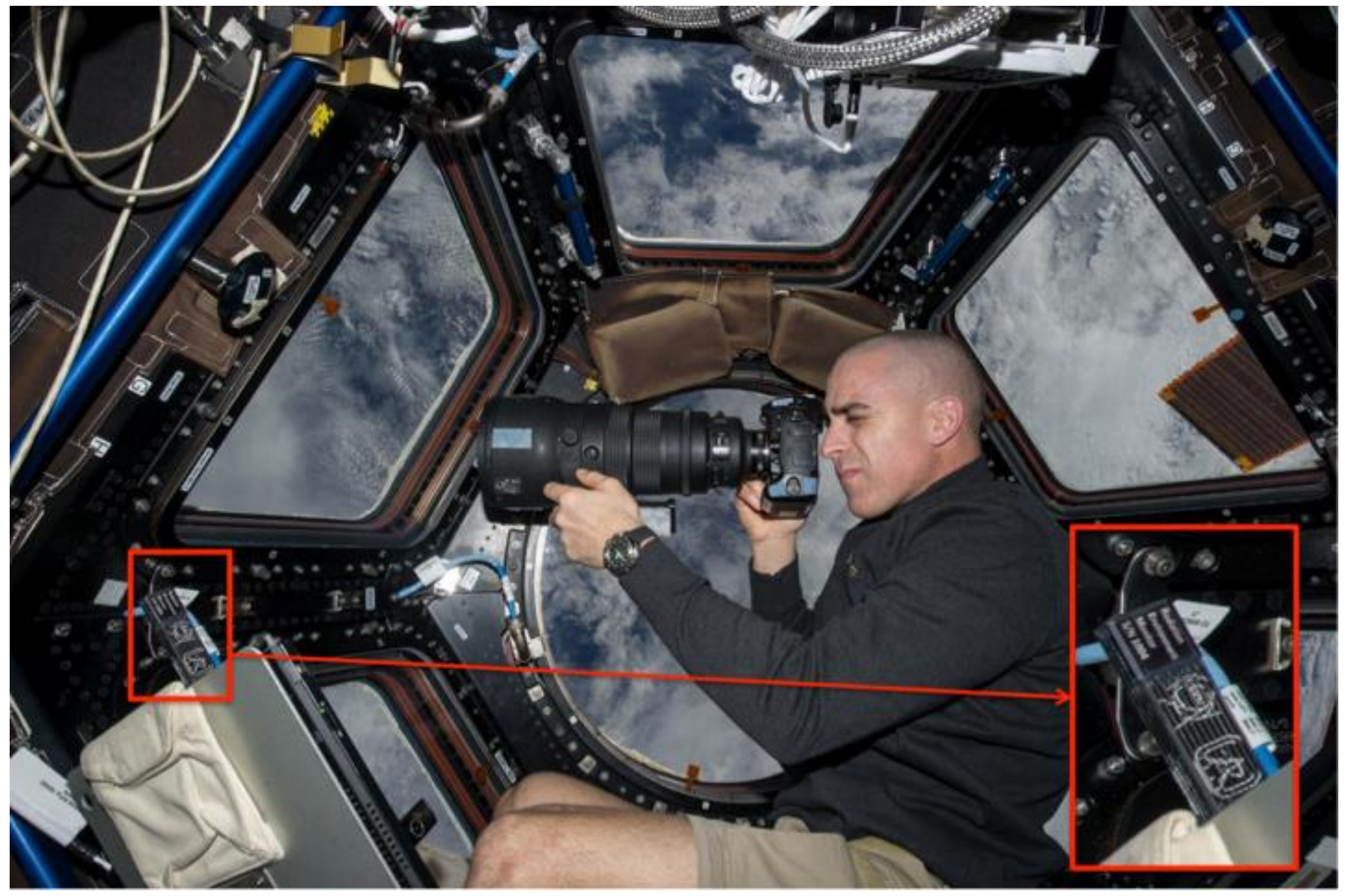
- Motivations include:
  - higher performance (energy, repetition rate)
  - lower cost (length, stored energy, efficiency)
  - integration (energy upgrades to existing linacs)

INFN Frascati advanced acceleration facility EuPARXIA@SPARC_LAB

Use of CLIC detector technologies for other applications

- Compared with LHC, CLIC detectors need to have smaller individual detector cells, better position resolution and more accurate time stamping
- Such general features are of interest for other applications as well
- Technologies developed for CLIC are now being used within particle physics and for society applications

- Silicon pixels detectors co-developed by CLICdp within the Medipix/Timepix collaborations are used in e.g. material analysis with X-rays, medical imaging, dosimetry in space missions, dosimetry for hadron therapy, school projects, electron cryo-microscopy (2017 chemistry Nobel prize), LHCb detector upgrade, CAST experiment
- Fine-grained calorimetry, initially developed for linear collider experiments, is now adopted by other experiments (e.g., CMS and ATLAS detector upgrades).
- The silicon photomultipliers developed for linear collider hadron calorimeters are now used in time-of-flight assisted Positron Emission Tomography (PET)

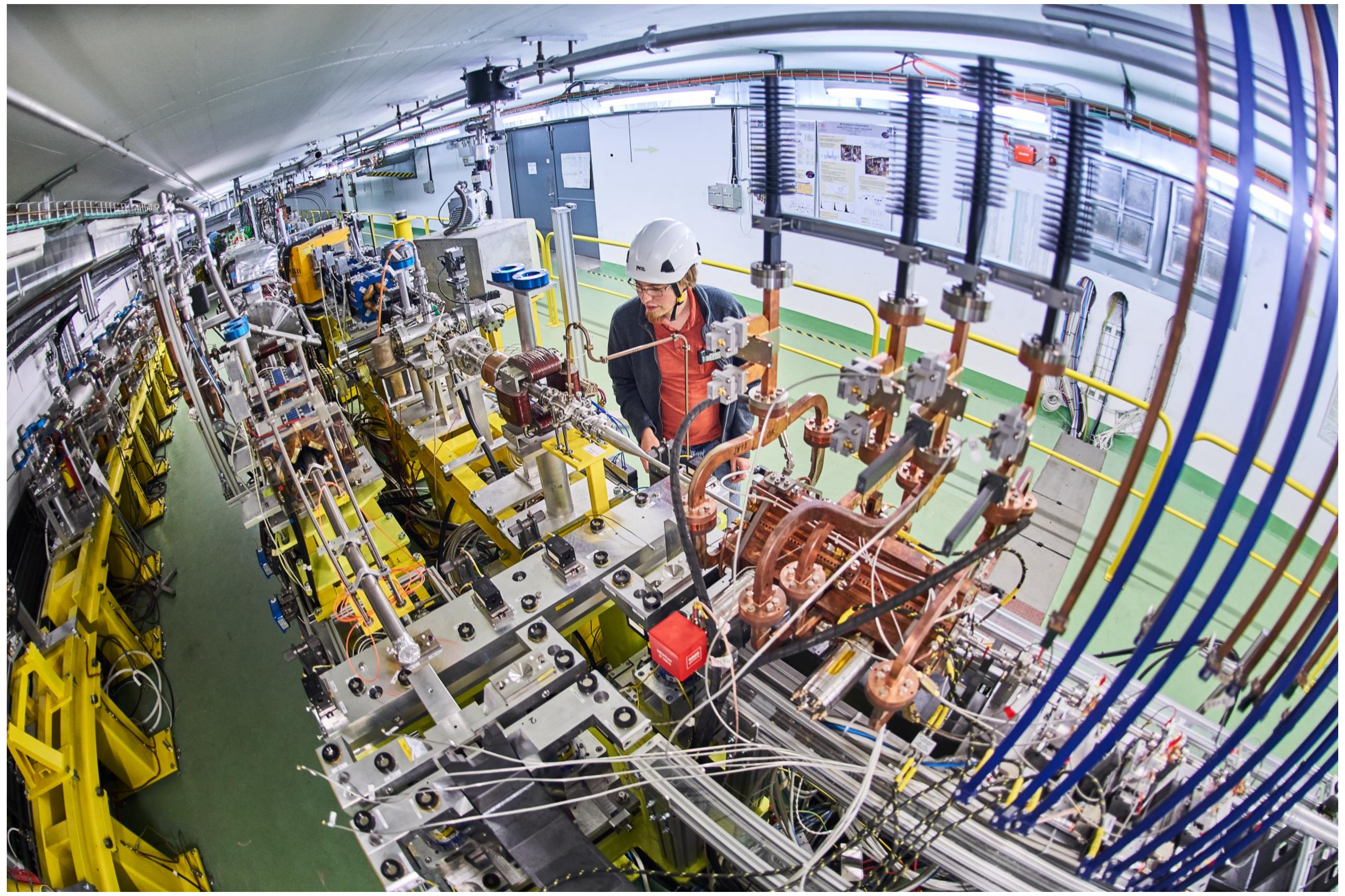


Timepix detector at ISS, Astronaut Chris Cassidy, 2013, NASA

CLIC technology R&D continues at clear

- The CLIC Test Facility at CERN (CTF3) has successfully demonstrated the main CLIC key concepts – now converted into a general purpose accelerator R&D facility:
  - The CERN Linear Electron Accelerator for Research (CLEAR)

  - At CLEAR, CLIC foresees the continuation of Wake Field Monitor (WFM) studies and cavity BPMs (Beam Position Monitor) prototyping to allow un-precedent beam-based alignment (micrometre level) and beam orbit control
  - With the experience gained from X-band technology and with the combined complementary effort at the XBOX test facilities at CERN, CLEAR aims to carry on X-band accelerating and deflecting structure tests and characterisation specific for CLIC and other projects



The CERN Linear Electron Accelerator for Research (CLEAR) clic.cern