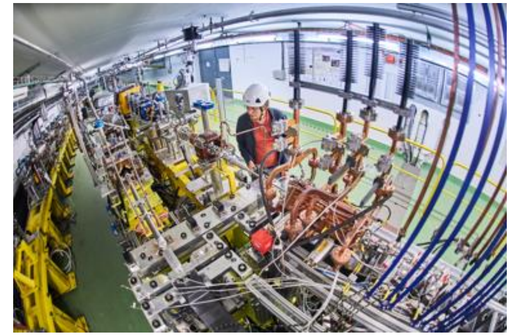
LC studies 2021-25

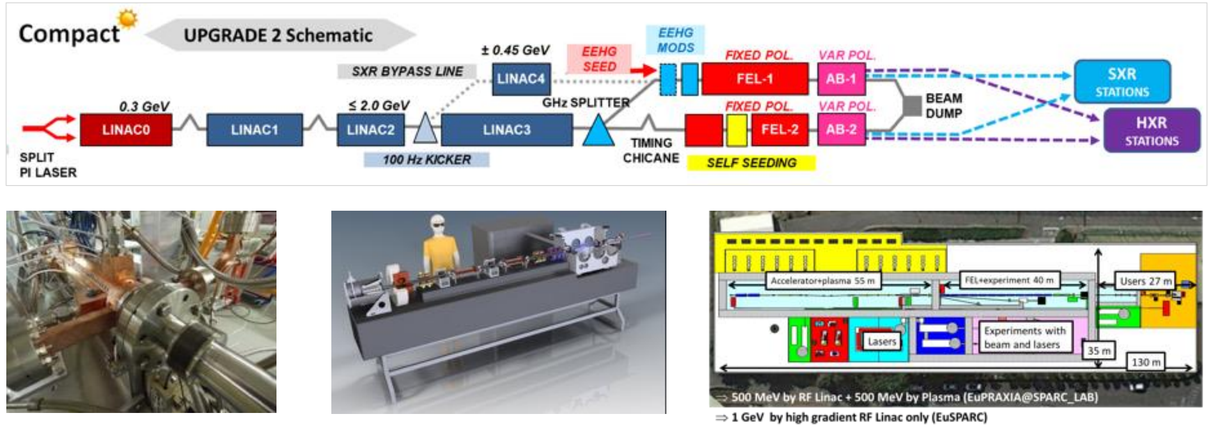
X-band technology:

- Design and manufacturing of X-band structures and components
- Study structures breakdown limits and optimization, operation and conditioning
- Baseline verification and explore new ideas
- Assembly and industry qualification
- Structures for applications, FELs, medical, etc

Technical and experimental studies, design and parameters:

- Module studies (beyond CLIC, see some targets for developments below)
- Beamdynamics and parameters: Nanobeams (focus on beam-delivery), pushing multi TeV region (parameters and beam structure vs energy efficiency)
- Tests in CLEAR (wakefields, instrumentation) and other facilities (e.g. ATF2)
- High efficiency klystrons
- Injector studies suitable for X-band linacs (coll. with Frascati)





Application of X-band technology (examples):

- A compact FEL (CompactLight: EU Design Study 2018-21)
- Compact Medical linacs (proton and electrons)
- Inverse Compton Scattering Source (SmartLight)
- Linearizers and deflectors in FELs (PSI, DESY, more)
- 1 GeV X-band linac at LNF
- eSPS for light dark matter searches (within the PBC-project)

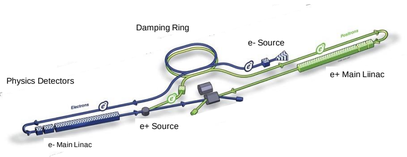
LC studies 2021-25

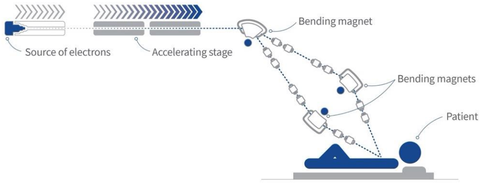
ILC related R&D:

- Positron flux concentrator, ATF2/3, Hi-klystrons, various SRF topics, cryo, dumps, beam-dynamics (these are ILC and/or KEK collaborative R&D)

Not considered yet:

- A so-called ILC Pre-lab effort, or Flash RT construction – both could require/benefit from CLEAR measurements (for hardware in addition to the work described by M

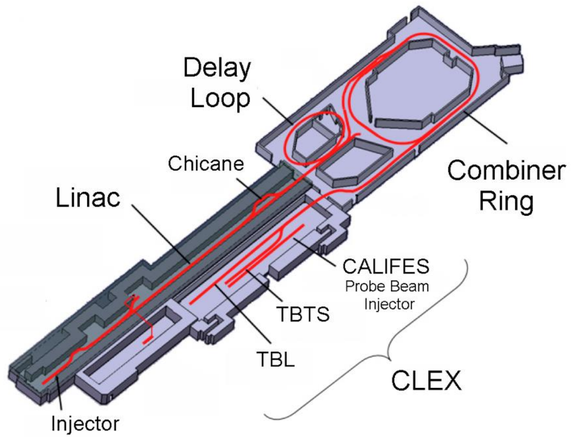


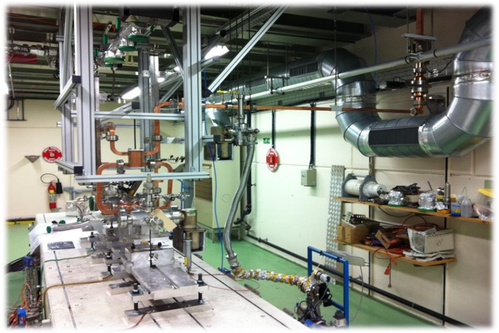


LC and CLEAR

We consider CLEAR together with the XBOX1 RF system, which is essential for several of the studies mentioned in the following

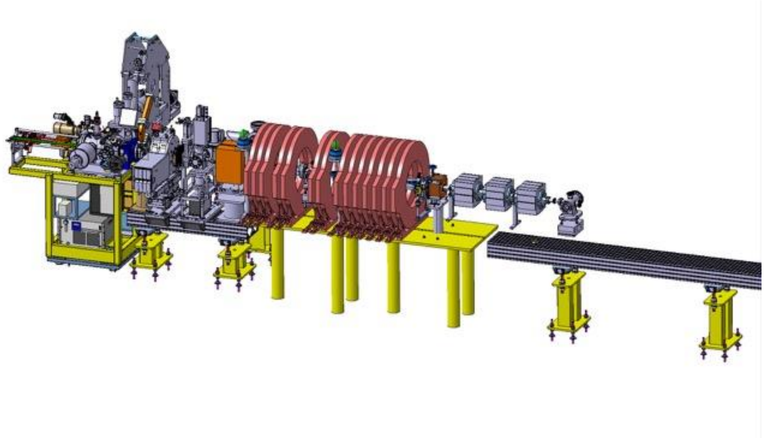
In many cases these activities involve collaborators in leading roles





LC and CLEAR - I

1) Photo-gun/injector part of 2016-2020 INFN collaboration agreement.
   For any X-band application from FEL to Flash, for CLEAR and AWAKE.
   Assembled, tested, conditioned in CTF2. Much more in talk of Edda.



We consider further injector work with INFN (Flash RT) ?

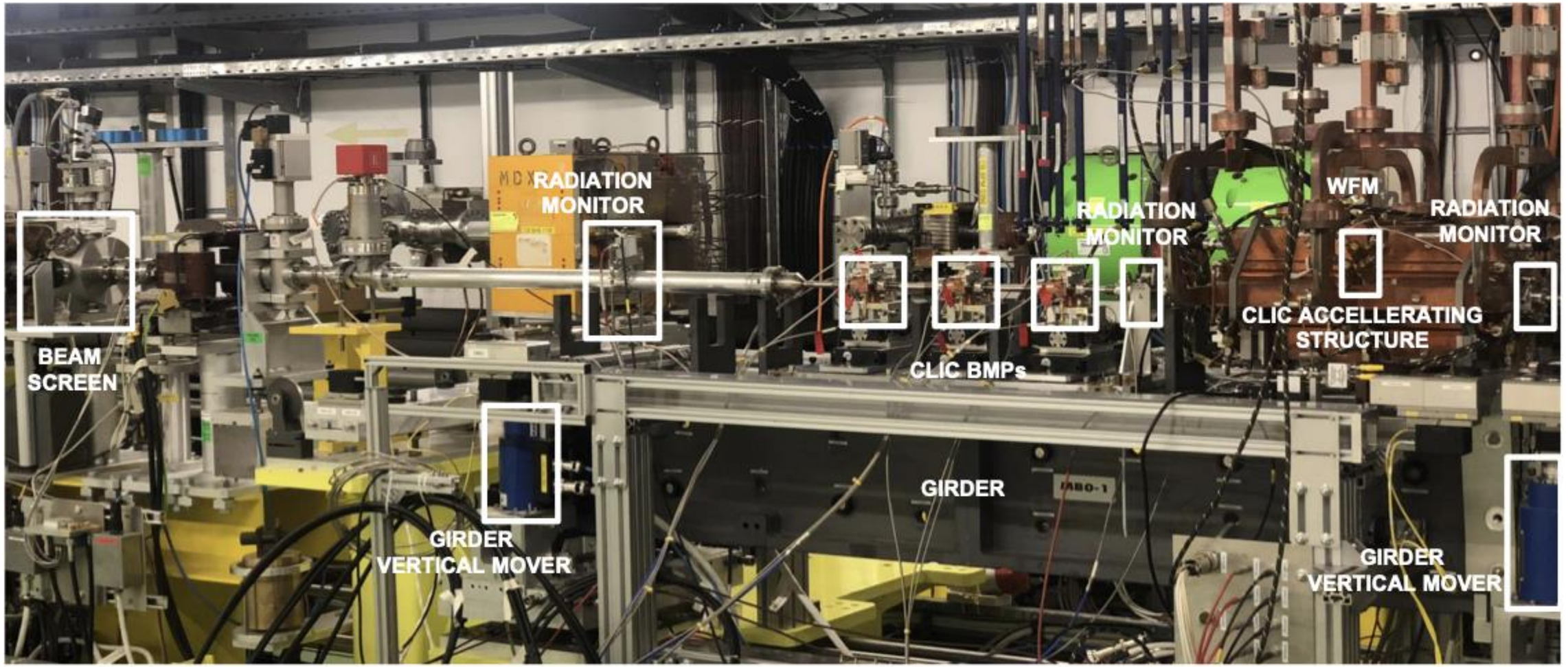
LC and CLEAR-II

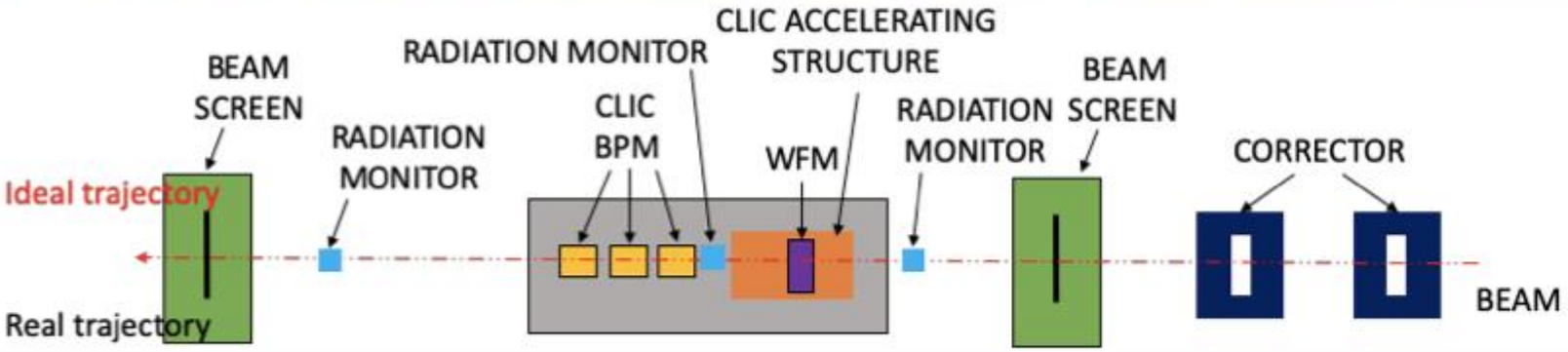
2) - 4) Structure performance studies (with RF power)

- Wakefields studies (important part of the CLIC luminosity performance strategy)
- Kicks, due to discharges (goes to heart of the breakdown rate limit) or imperfect alignments (wakefields)
- Long term operation, stability over time – demonstration

5) Instrumentation/diagnostics – relevant for CLIC and some cases ILC.
Primarily work on high resolution cavity BPMs, but also interests in other technologies, e.g. coherent Cherenkov diffraction radiation (short bunches)

See earlier talk of Stefano


RADIATION MONITOR
BEAM SCREEN
CLIC BMPs
RADIATION MONITOR
WFM
RADIATION MONITOR
CLIC ACCELLERATING STRUCTURE
GIRDER
GIRDER VERTICAL MOVER
GIRDER VERTICAL MOVER


BEAM SCREEN
RADIATION MONITOR
CLIC ACCELERATING STRUCTURE
RADIATION MONITOR
CLIC BPM
WFM
RADIATION MONITOR
BEAM SCREEN
CORRECTOR
Ideal trajectory
Real trajectory
BEAM

Key CLIC related activities

A. Gilardi, K. Sjobaek, M. Wendt, A. Lyapin

Experiments:

- Wake-Field monitors
- Wake-field kicks
- CLIC cavity BPMs

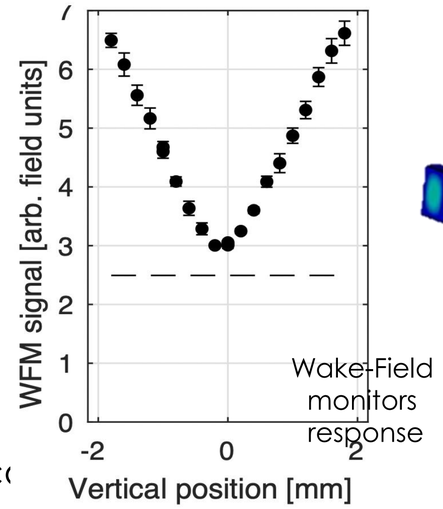
Main collaborators

- University of Oslo
- CEA - Saclay
- Università di Napoli Federic
- RHUL

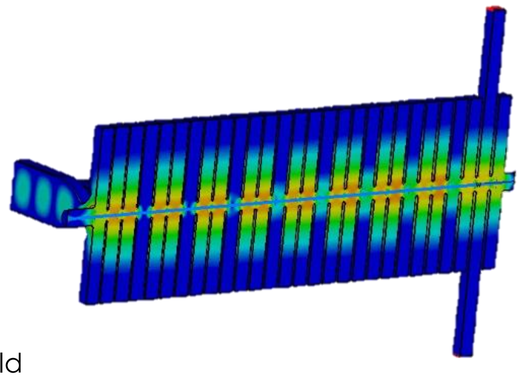
Future step, connecting the cavity to X-Box1

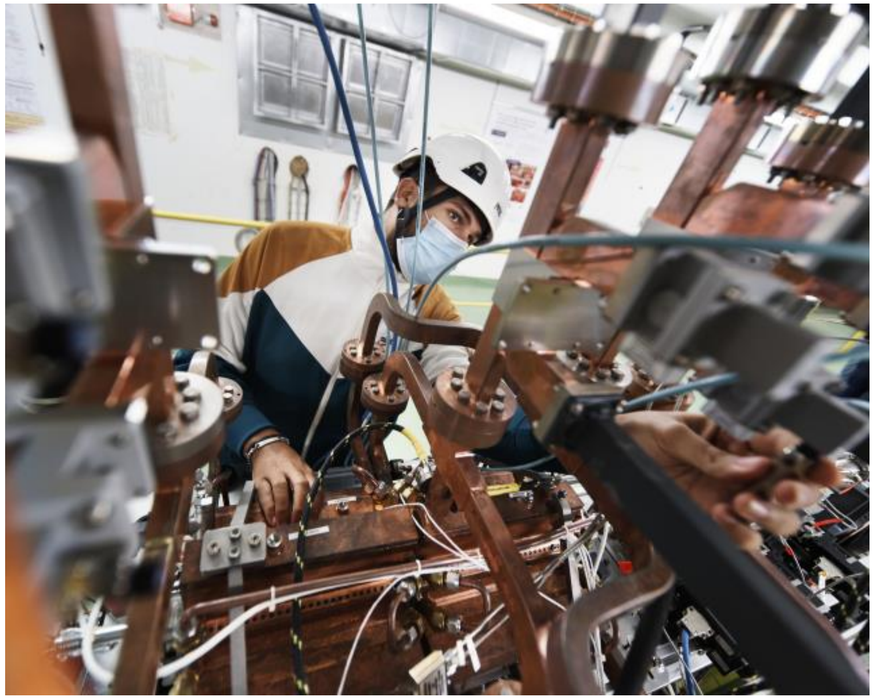
possible tests:

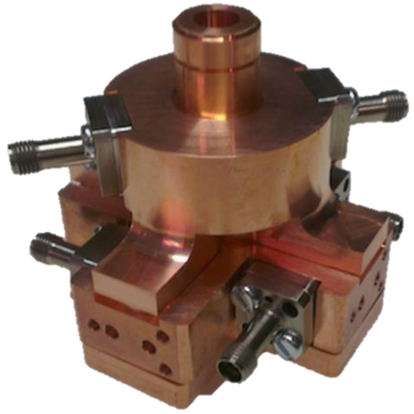
- RF kicks
- Breakdown kicks
- RF effect on WFMs
- Stability & reliability runs

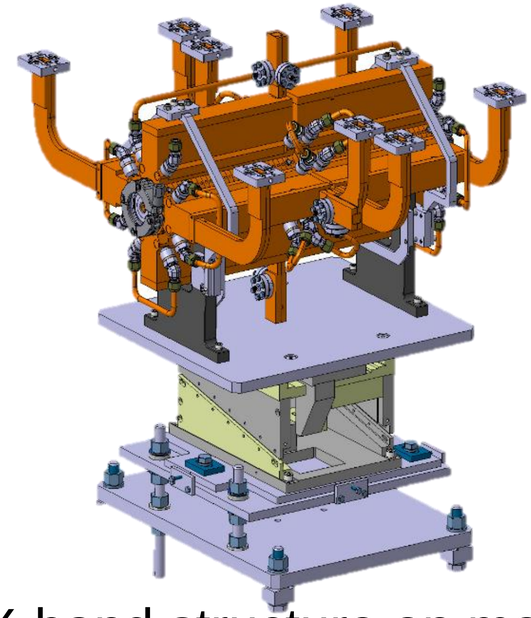


Wake-Field monitors response





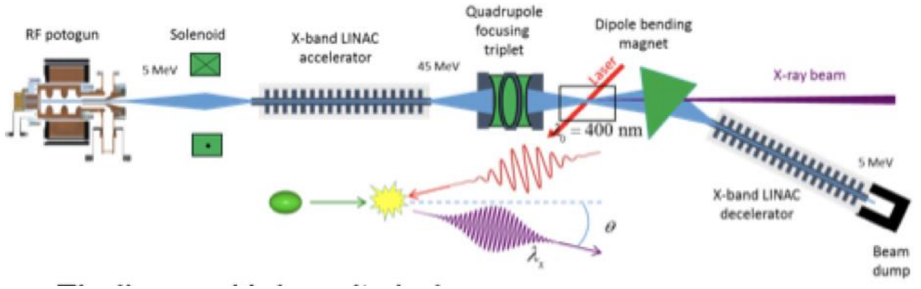




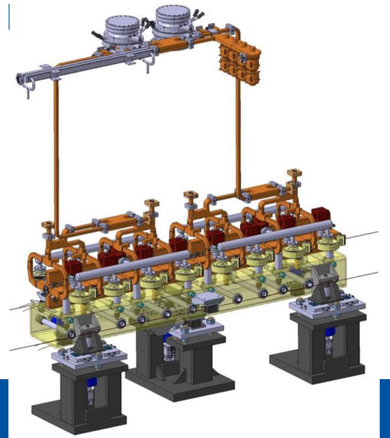
Cavity BPM and X-band structure on movers

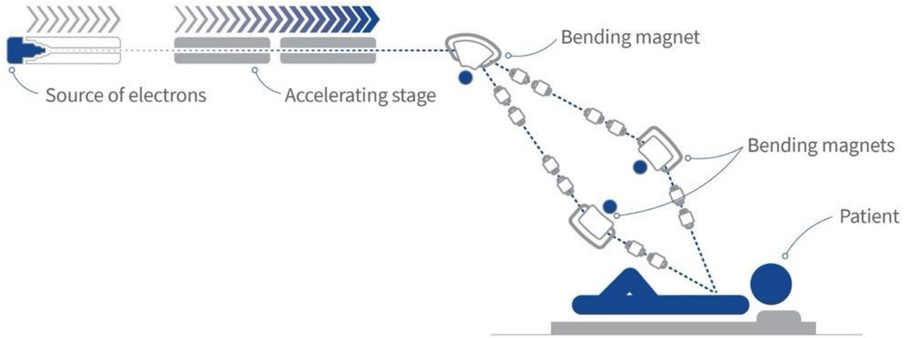
LC and CLEAR - III

6) X-band technology applications: VHEE studies, Flash RT including appropriate dosimetry, possibly inverse Compact Scattering studies
More general for Flash see talk of Marie-Catherine Vozenin



7) Possibly complete modules in CLEAR: Long term goal to construct a CLIC or Flash RT module, beam-test considered



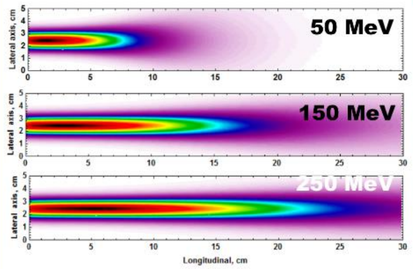


Medical irradiation tests - VHEE

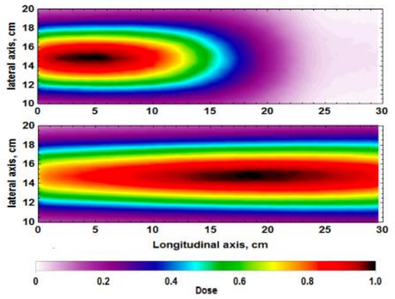
VHEE

- Rapid advances in compact high-gradient (~ 100 MV/m) accelerator technology in recent years
  - CLIC
  - NLC
  - W-band*
- **Superior dose deposition properties compared to MV photons**
- **High dose-reach in tissue**
- **High dose rate (compared to photons)**
- **More reliable beam delivery around inhomogeneous media**
- **Better sparing of surrounding healthy tissue**
- **Particle steering**

*V. Dolgashev, HG2016

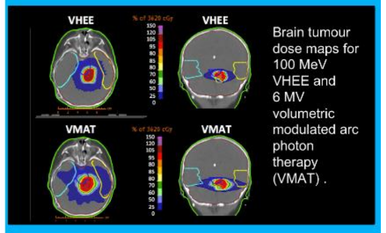


Dose maps of narrow ()
VHEE beams in water

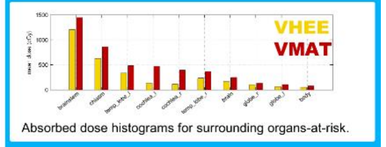


Dose maps of wide ()
VHEE beams in water

- **Clinical studies by M. Bazalova-Carter *et al.* (2015) have compared 100 MeV VHEE** with conventional **(and MV) VMAT** (Volumetric Modulated Arc Therapy) photon radiotherapy plans
- ***Pediatric brain tumour, lung*** and ***prostate cases***
- VHEE therapy plan showed a **decrease of dose** up to **70%** in surrounding organs-at-risk (**OARs**)
- ***VHEE plan was found to be more conformal than VMAT plan***



Brain tumour dose maps for 100 MeV VHEE and 6 MV volumetric modulated arc photon therapy (VMAT) .



Absorbed dose histograms for surrounding organs-at-risk.

M. Bazalova-Carter *et al*, «Treatment planning for radiotherapy with very high-energy electron beams and comparison of VHEE and VMAT plans», Medical Physics, vol. 42(5), **2015**.

Manchester University: A. Lagzda, R. Jones and other
- Project to characterize VHEE irradiation on radiosensitive films

11

Activities:

- Experimental verification of dose deposition profiles in water phantoms
- Calibration of operational medical dosimeters – nonlinear effects with short pulses
- Demonstration of "Bragg-like peak" deposition with focused beams

Initial interest: Manchester Univ. *(A. Langzda, R. Jones)*

- Three measurements campaigns (2017-2018)

Further requests from:

Nat. Phys. Lab. UK *(A. Subiel et al.)*

- Two measurement campaigns (end 2018, spring 2019)

Strathclyde University *(K. Kokurewicz et al.)*

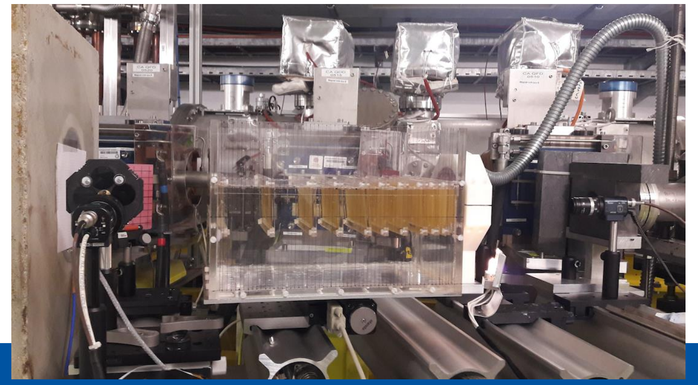
- One campaign completed (end 2018)

Oldenburg University and PTW *(B. Poppe, D. Poppinga et al.)*

- Two campaigns completed (end 2018, September 2019)

CHUV Lausanne *(M.C. Vozenin, C. Bailat, R. Moeckli et al.)*

- Preliminary tests (end 2018, spring 2019)



Relative Insensitivity to Inhomogeneities on Very High Energy Electron Dose Distributions

IPAC 2017 Proceedings • May 19, 2017

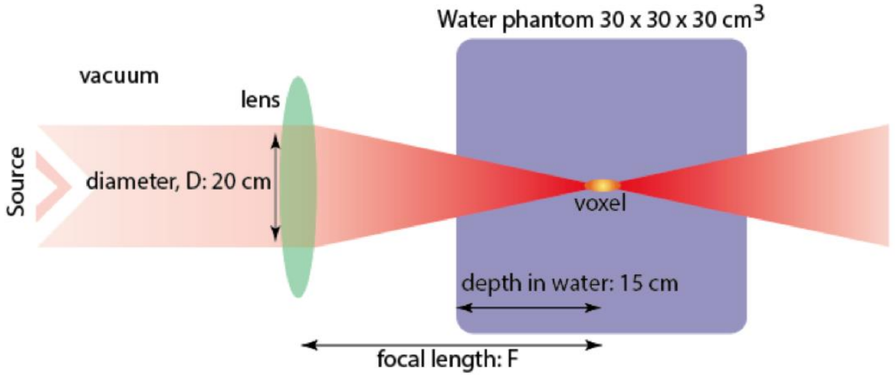
Agnese Lagzda, R.M. Jones, D. Angal-Kalinin, J. Jones, A. Aitkenhead, K. Kirkby, R. MacKay, M. van Herk, W. Farabolini, S. Zeeshan

Very-High Energy Electron (VHEE) Studies at CERN's CLEAR User Facility

IPAC 2018 Proceedings • 2018

Agnese Lagzda, R.M. Jones, A. Aitkenhead, K. Kirkby, R. MacKay, M. van Herk, R. Corsini, W. Farabolini

VHEE strong focusing

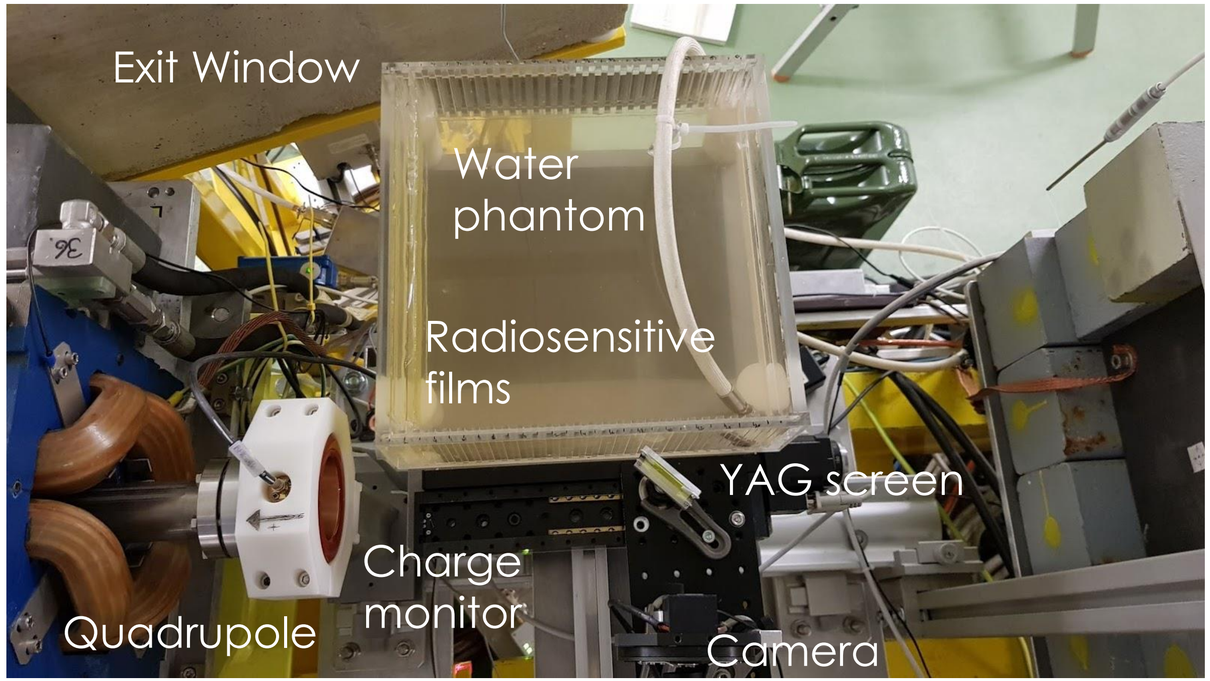


Aim:

Focus the beam on the tumour to minimize the dose on the nearby healthy tissues

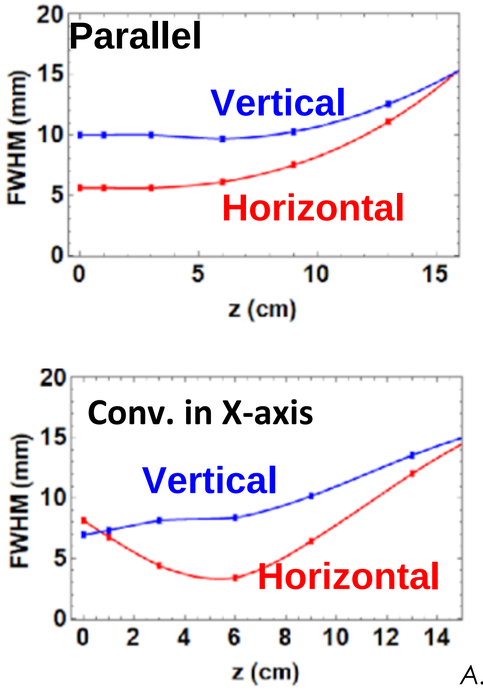
- Main activity in 2019

- Two groups (Strathclyde and Manchester) Two full week of testing (plus installation and dismounting)
- Required rearrangement of beamline, with a temporary dump.

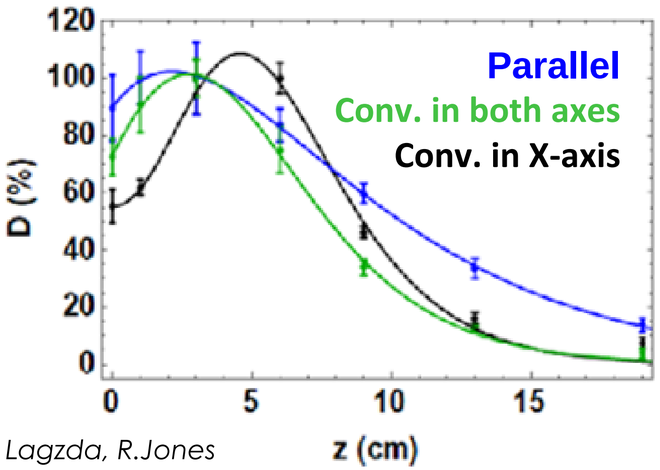


W. Farabolini, E. Senes, K. Kokurevicz

Beam size



Dose deposition



A. Lagzda, R.Jones

Other comments

Reminder:

A significant amount of relevant work for CLIC is happening at outside labs, linked to FEL systems and components using X-band, medical linacs as for Flash -> work in CLEAR related to these fields directly benefit the LC studies and visa versa

Finally:

The combination of CLEAR and XBOX1-3 in a transnational access scheme also opens up for supporting existing and new collaborators and ideas in the area of X-band technology. Being planned.

- All slides from the CLIC/CLEAR team, in the expert audience -

- MANY THANKS -