CLEAR Plans and Experimental Program in 2024

W. Farabolini on behalf of the CLEAR team:

R. Corsini – A. Aksoy – A. Malyzhenkov – P. Korysko – V. Rieker – L. Wroe – M. Marcandella – A. Gilardi

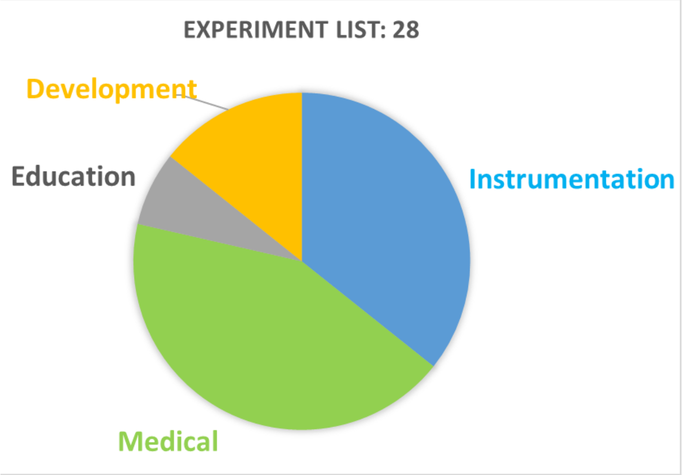
E. Granados – M. Calderon – R. Rossel (Laser and photocathode experts)

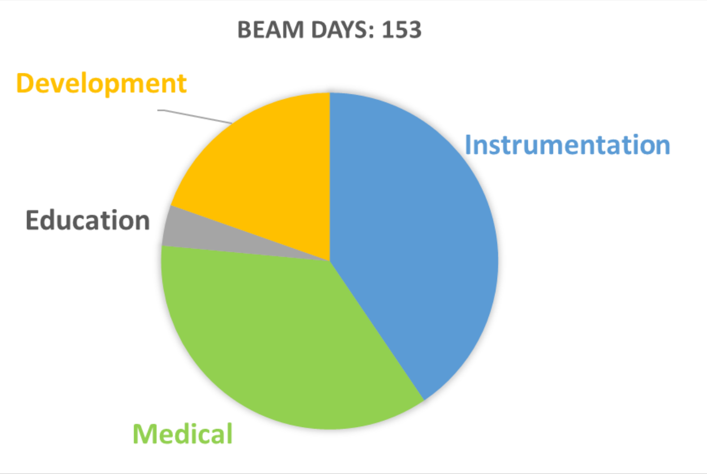
S. Doebert - S. Curt – A. Chauchet (RF experts)

K. Sjobaek (remotely from Oslo)

Beam time requests (so far)

- 28 experiments in the list: 23 beam requests officially received, 5 in preliminary discussions
- 14 of them are continuation of last year experiments
- Already a total of 153 days of beam time requested by the users (before optimization). Last year: 185 days of beam delivered, including MD.
- 12 exp. related to Medical Applications (55 beam days)
- 10 exp. for Beam Instrumentation (62 beam days)
- 4 exp. for Accelerator Development and Physics (30 days)
- 2 cessions for Education (6 days): JUAS and Eurolabs
- Growing interest in FCC-ee (instrumentation and physics)





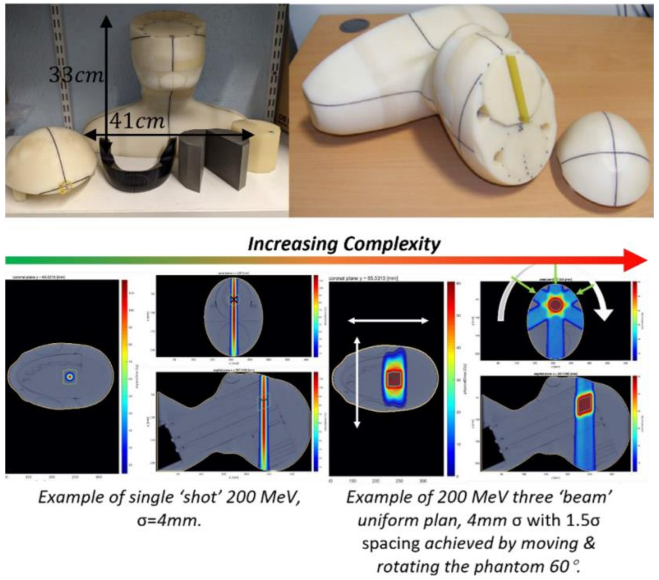
Medical related experiments

- **UNIGE / HUG**
- CHUV / IRA
- Manchester Univ. / Cockcroft Inst. / Christie NHS
- Victoria Univ. / EPFL / Laval Univ. / Lawrence Berkley Lab.
- **Gustave Roussy Inst. / ISMO**
- **DESY**
- CERN

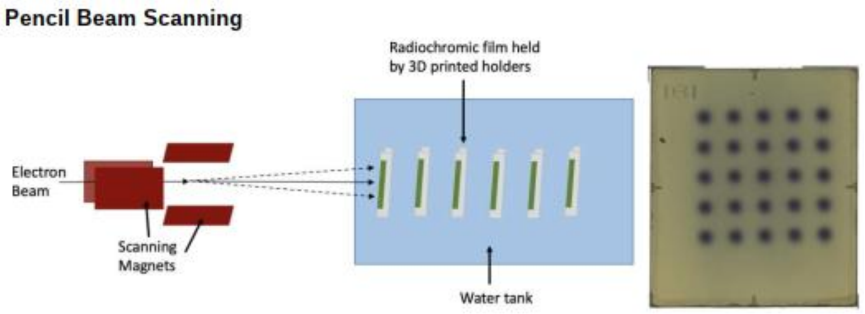
(Newcomers are in bold)

- Flash therapy on various types of sample
- **Beam delivery on an anatomical phantom**
- Spatially Fractionated Radio-Therapy (SFRT)
- Film and screen dosimetry
- **Radiosensitivity enhancement by nanoparticles**
- **Metal implants beam interaction**
- **Computed Tomography with e^-**

Many more details will be given by P. Korysko, next talk



Anatomical phantom (Manchester U.)

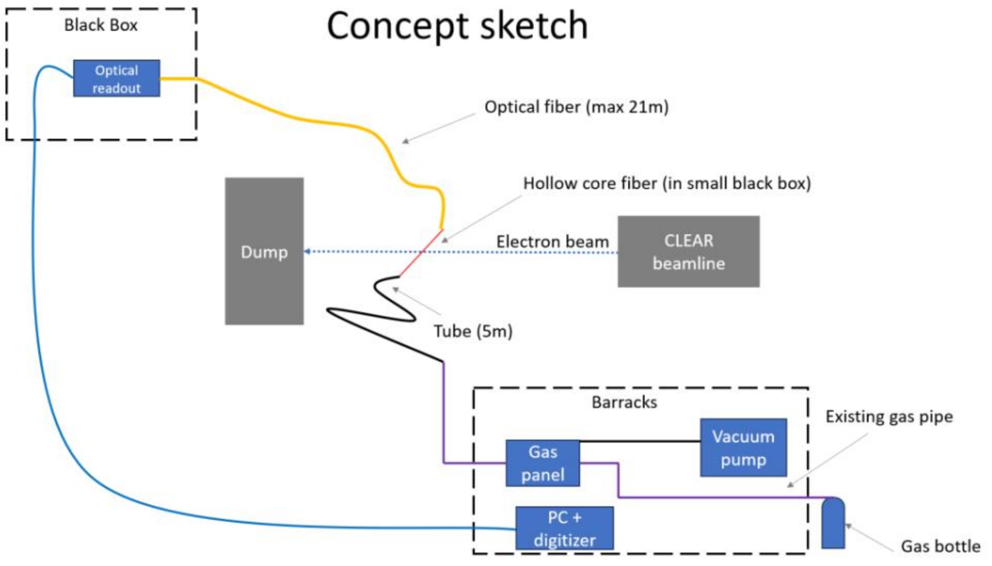


Spatially Fractionated Radio-Therapy (Victoria U.)

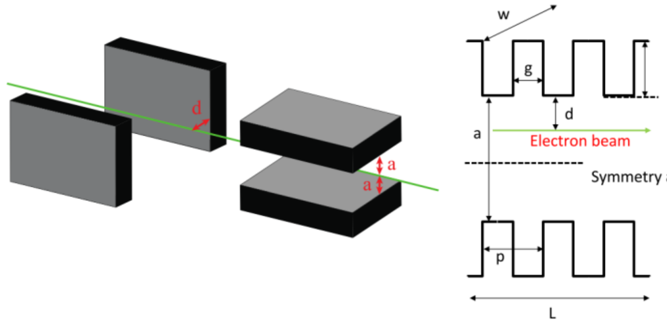
Beam diagnostics experiments

- **Rijksuniversiteit Gronigen / Southampton Univ. / CERN**
- BERGOZ
- KIT / CERN BI
- INFN Bologna
- INFN Padova
- University College of London / CERN BI
- Liverpool Univ. /ASTeC / CERN BI
- Manchester Univ. / RHUL / CERN BI
- CERN ABP

- **Hollow core fibre filled with gas**
- High frequency Wall Current Monitor
- EOS bunch length monitor for FCC-ee
- Beam Profile Monitor for LUXE experiment
- Screen resolution study of AWAKE spectrometer
- Fibre beam loss monitor
- Emittance measurement with Digital Micro-mirror Device and Micro-Lens Array
- ChDR bunch length monitor using a Martin-Puplett Interferometer (for AWAKE)
- **Corrugated streaker for time resolved diagnostic**

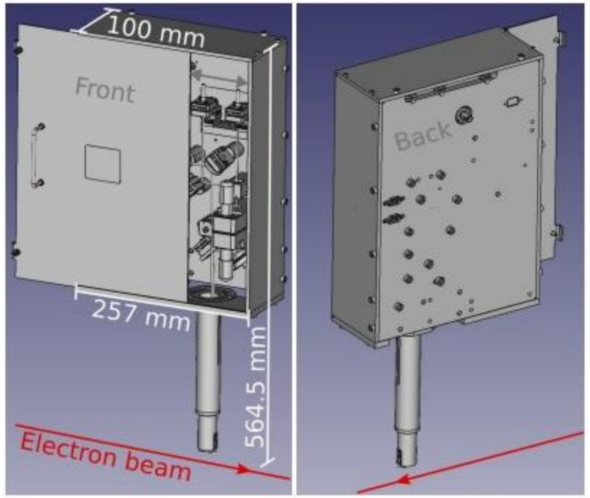


Hollow core fibre (RUG / CERN)

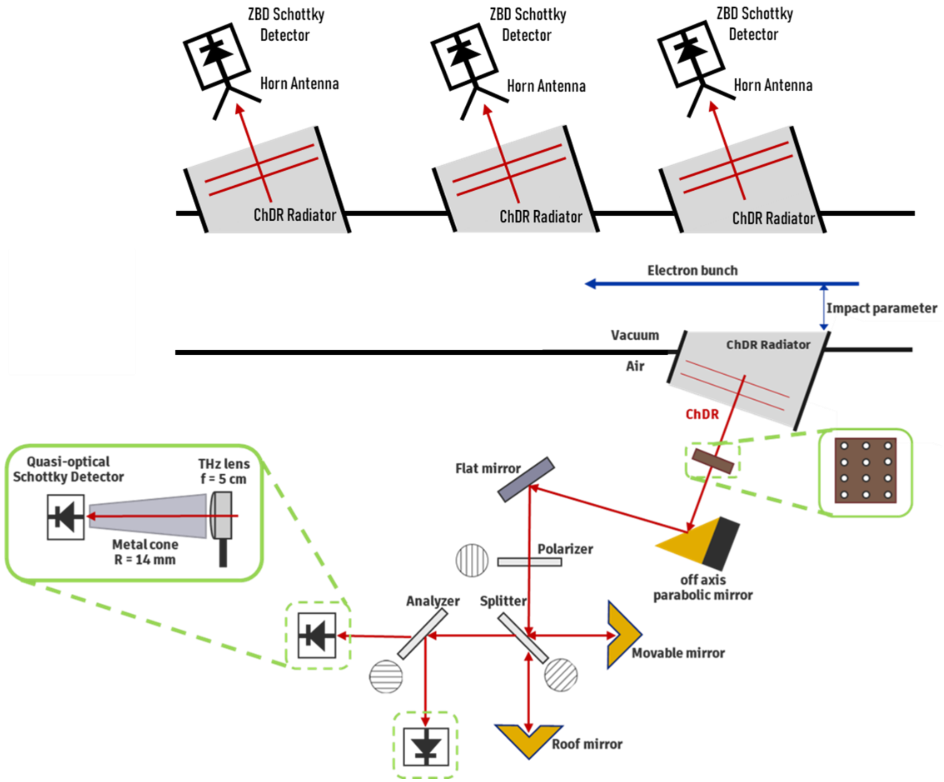


Passive beam streaking with corrugated jaws (CERN ABP)

Bunch length measurement

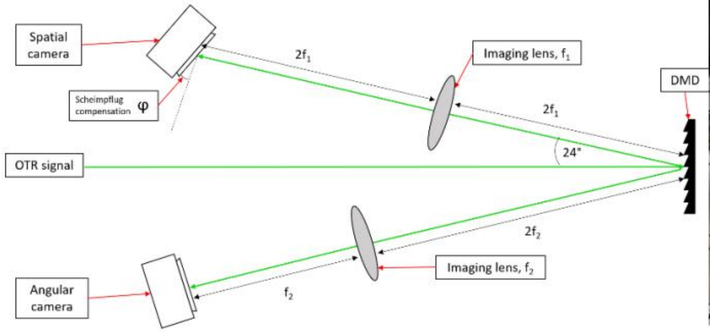


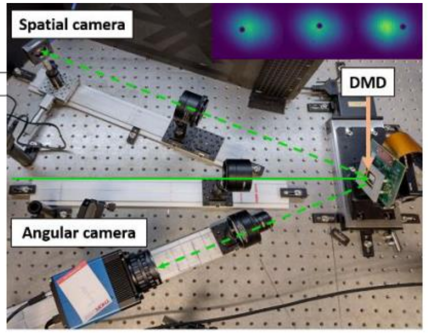
In-air test of EOS for FCC-ee (KIT)



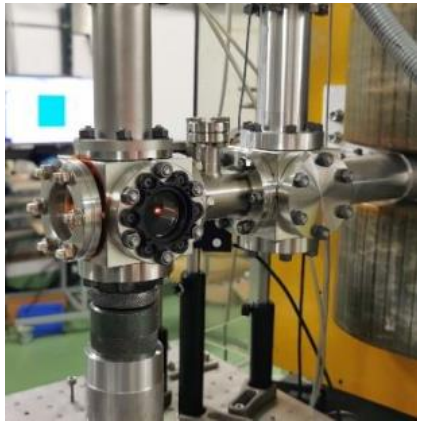
3 bandwidth channels (top) and Martin-Puplett Interferometer (bottom) for AWAKE (Manchester U.)

Emittance measurement with OTR light

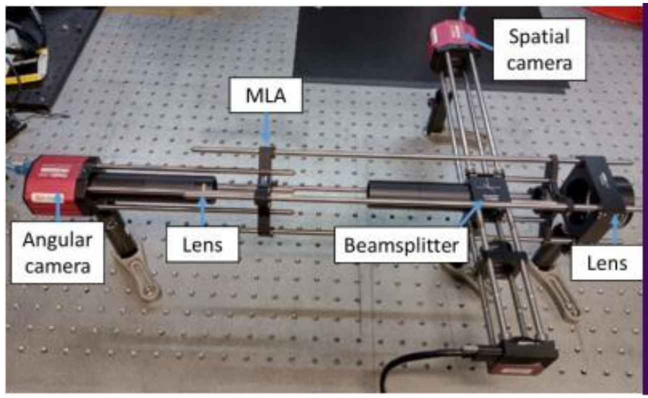


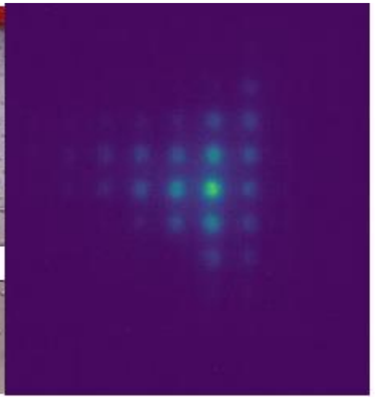


Two images generated from OTR light by the Digital Micro-mirror Device (DMD): spatial and angular, acting like a pepper-pot or a slit on the beam (Liverpool U.)

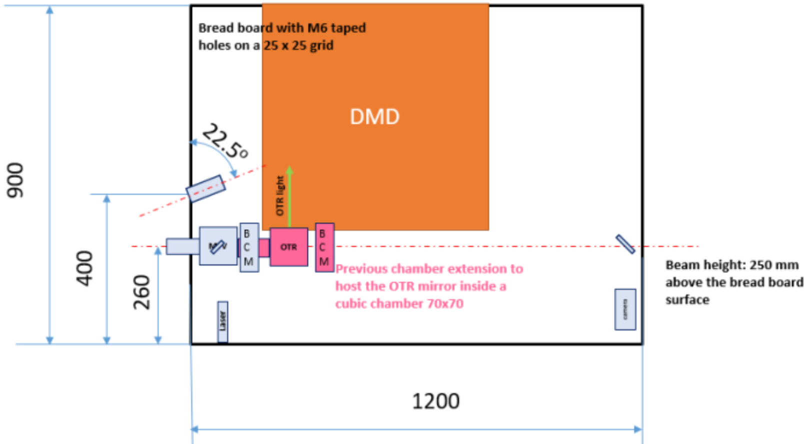


Cube hosting the OTR screen. Later will be SR light.





Same as above but using a Micro-Lens Array (MLA) instead of a DMD

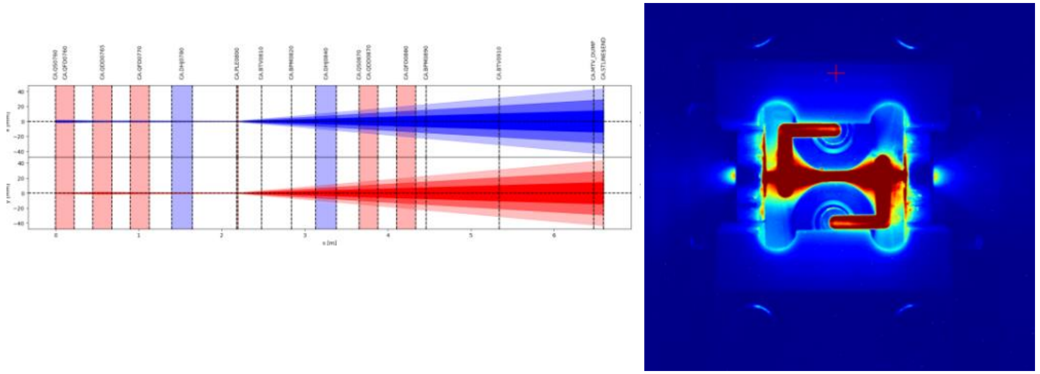


Set-up footprint on the in-air test stand

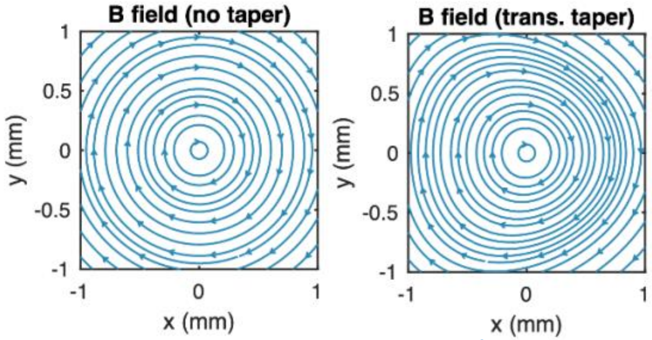
Accelerator development and Physics experiments

- **DAES SA**
- **LAL / IN2P3**
- CERN / PSI
- Oslo Univ. / Oxford Univ. / DESY / Berkley

- **Neutron target / cryogenic moderator**
- **Resonance of the electron internal clock**
- **Target for positron source (FCC-ee)**
- Active plasma lens defocusing device
- **Non-linear plasma lens generated by Hall effect**



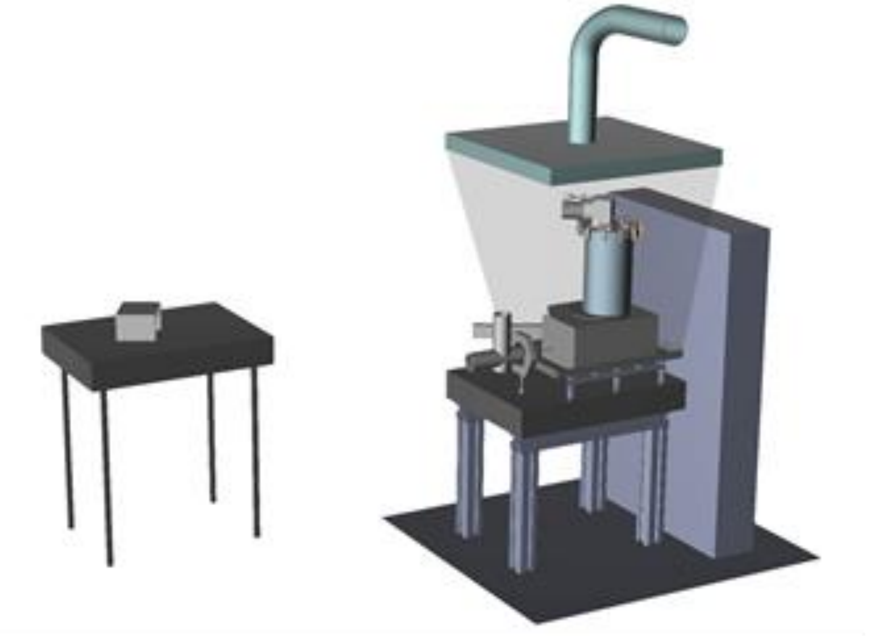
Active Plasma Lens used for beam defocusing (Oslo U.)



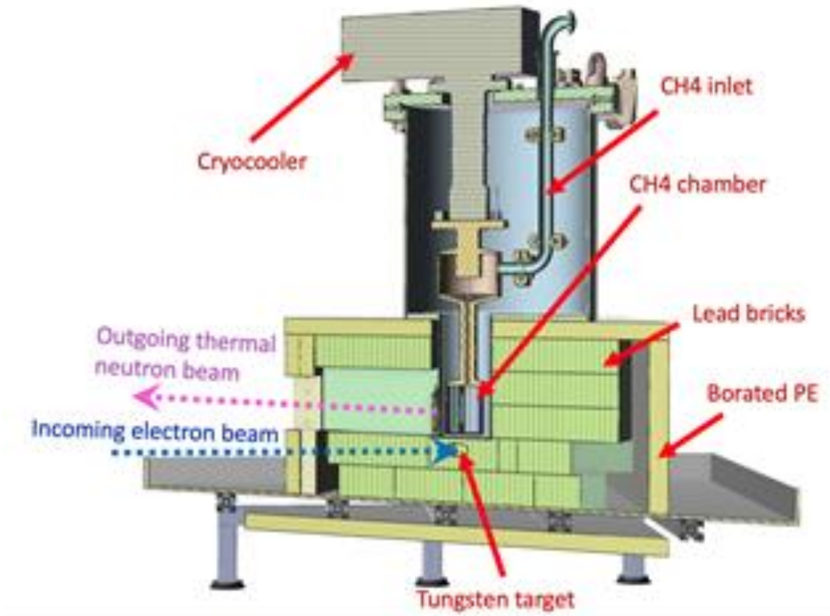
B field in plasma lens with and w/o external magnetic field for shaping by Hall effect (Oslo U.).

Usually, these experiments require larger effort for their set-up development and installation, as well as longer beam time campaign.

Neutron target and cryogenic moderator



Target/Moderator installation on the in-air test stand and movable neutron detector for TOF (DAES SA)

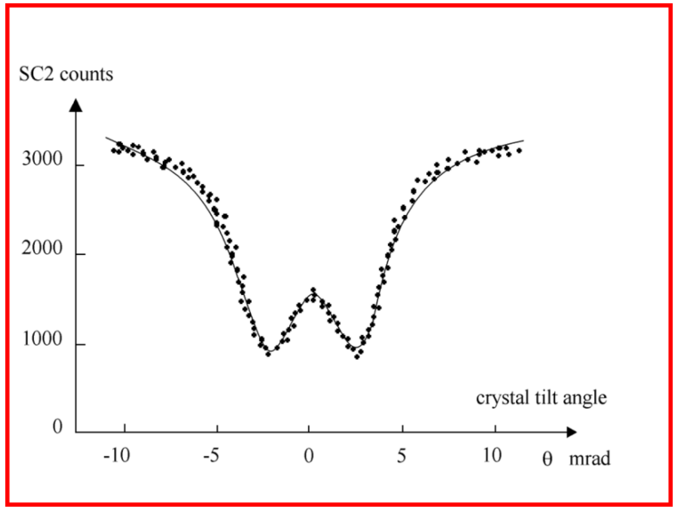


Target/Moderator elements (DAES SA)

Ultimate scope: to produce a neurography instrument (based on a X-band LINAC) aimed to be used in labs developing fuel cells. Private company supported by KT as green initiative.

Basic research on the electron internal clock

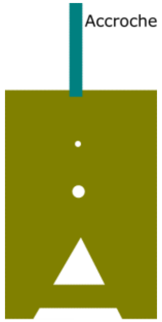
Hypothesis from L. de Broglie 1925 : $\nu_0 = m_e c^2/h = 1.2 \times 10^{20}$ Hz,
Alternative hypothesis from Schrodinger 1930 : Zitterbewegung frequency $\nu_{ZB} = 2mc^2/h = 2\nu_0.$



	Silicium <110>		Diamant <110>	
	ZB	Internal clock	ZB	Internal clock
	Pe (MeV/c)	Pe (MeV/c)	Pe (MeV/c)	Pe (MeV/c)
n=1	161,79	80,89	106,21	53,11
n=2	80,89	40,45	53,11	26,55
n=3	53,93	26,96	35,40	17,70

Effect is reachable with the energy range available at CLEAR.

Expected anomaly in the scattering by a crystal superposed to the channelling effect (LAL)



Preliminary test with collimator to assess the ability of delivering single electron beam with very accurate energy resolution (50 keV)

Enhancement of Beam Time Capability

Increasing effort

- Group compatible experiments (last year: 1.9 exp/week), but difficult exercise.
- Develop standard beam procedures: laser position and RF phase control, beam-based alignment, beam dynamic models, predictive dosimetry tools, flat beam generation
- Optimize set-up efficiency: larger robot samples storage, larger Eppendorf, double-holder
- Manage more carefully the high dose irradiations: shielding, longer decay time
- Limit the number of visits: Usually authorised only on Monday during set-up installation
- Allow RP access after 5pm and during week-end: training of some team members to become RP competent (2 weeks formation)
- Increase manning: a new fellow: **Antonio**, a new part-time operator: **Mathieu**, a technical student: **Alfred**, possibly a new technician for set-up preparation (shared with the RF team), participation to a doctoral network. Conversely, there is a risk to lose some present team members due to contract ending.
- Construct of a second beam line: on-going, but with no extra-shutdown period.
- So far, no experiment has been refused due to lack of beam time. But MD was largely performed during WE and nights.

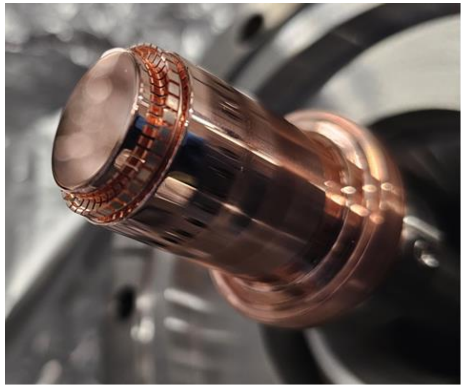
Facility consolidation

- All cameras are being replaced by a digital standard (1000 x 1200 px). Software adapted accordingly and unified.
- Cavity BPMs electronics could be extended for simultaneous reading.
- Vacuum synoptic (SCADA) has been actualised.
- Laser parts received for a new system.
- A modulator is being dedicated for klystron hot spare.
- Beam Base Alignment program being deployed
- Improved Quad scan methods
- Extensive study on the best laser position on the photocathode

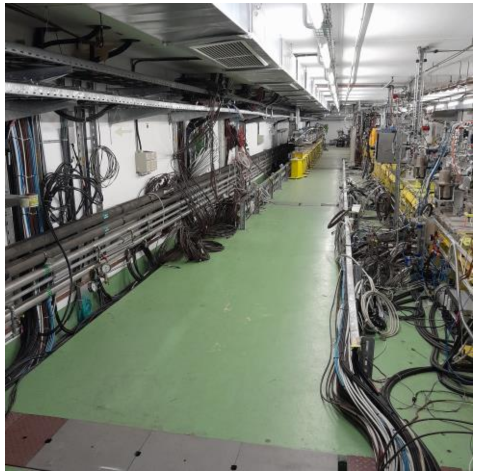
Improvements of the facility

- The photocathode has been fully renewed, for an expected bunch charge >1nC.
- Turbo-pump controller moved in the gallery (less exposed to radiation damage).
- Construction of the second beam line (parallel experiments, adapted for large beam, in-air and in-vacuum test stands)
  - Beam dynamic optimized (9 quads – 2 sextupoles)
  - Drawings achieved, 2 vacuum chambers in project
  - Location cleaned from the disused TBL (girder, dump, cables),
  - All magnets available and renewed,
  - Footprint traced, DC power cables available,
  - Some equipment purchased (screens, breadboard…),
  - But limited time and resources (internal + Eurolabs grant).

Old cathode

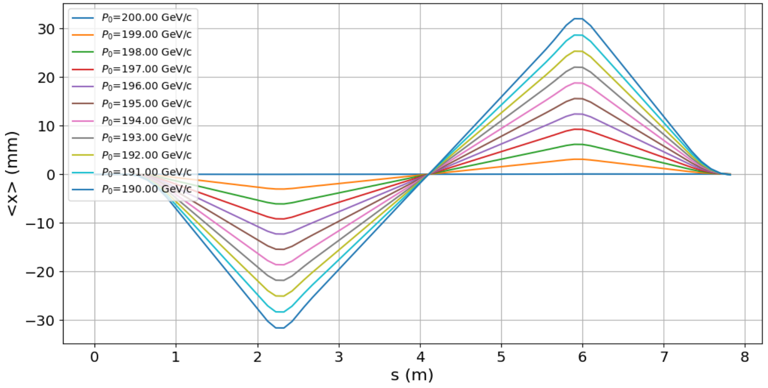


New cathode

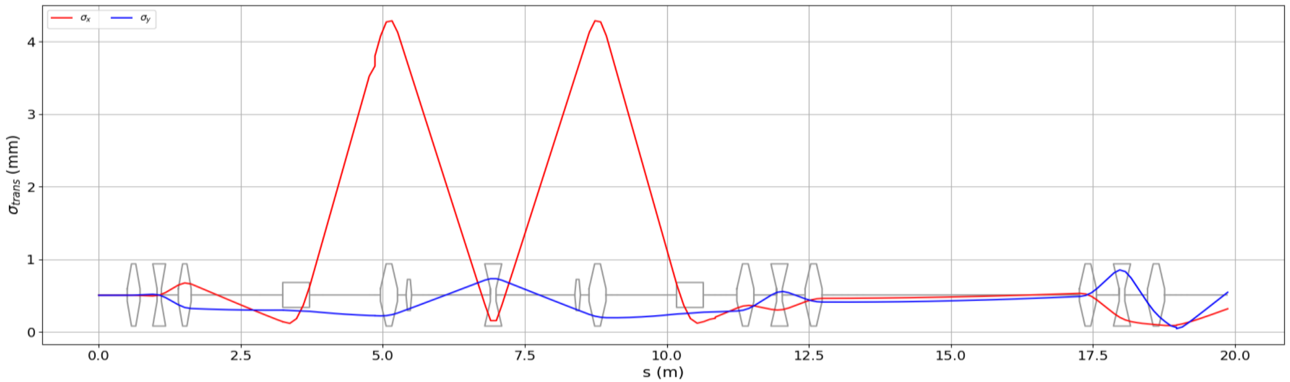


Second beam line location cleared

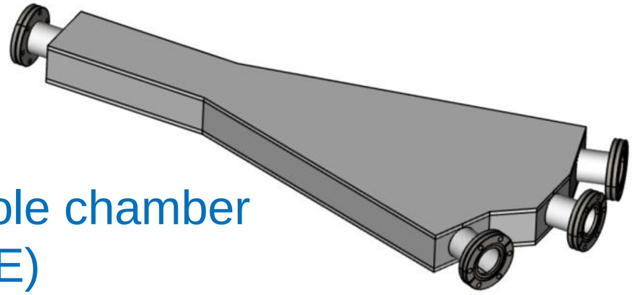
Second beam line study and plans



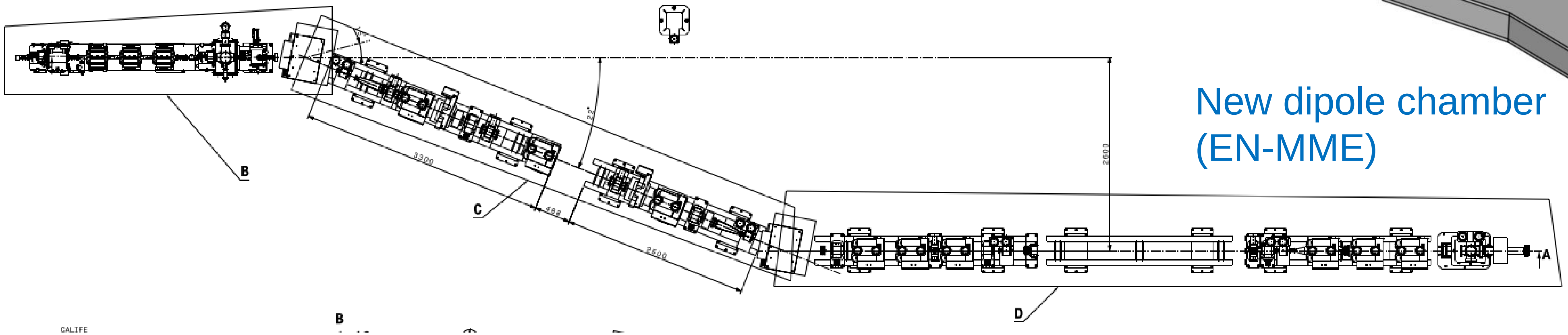
Bunch center for different bunch energies along beamline With sextupoles (Avni)



Beam sizes along the line (Avni)



New dipole chamber (EN-MME)



Implementation drawing (EN-MME)

Conclusions

- The interest of the scientific community for CLEAR is ever growing.
- CLEAR is instrumental in the field of medical research based on VHEE and UHDR (Flash therapy).
- Being the only electron machine at CERN, it could also play a significant role in the FCC-ee development, as a test stand for diagnostics and equipment as well as an education tool for the future accelerator physicists.
- Presently, the facility needs additional resources, especially human, for continuing to fulfil all the received beam requests.