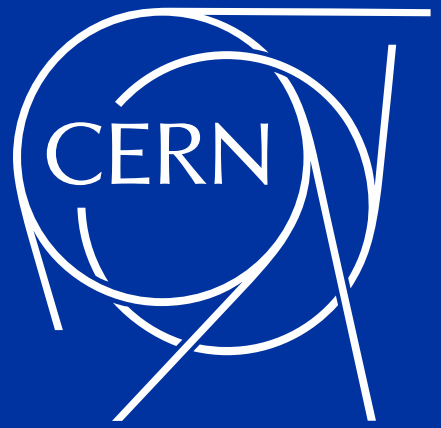


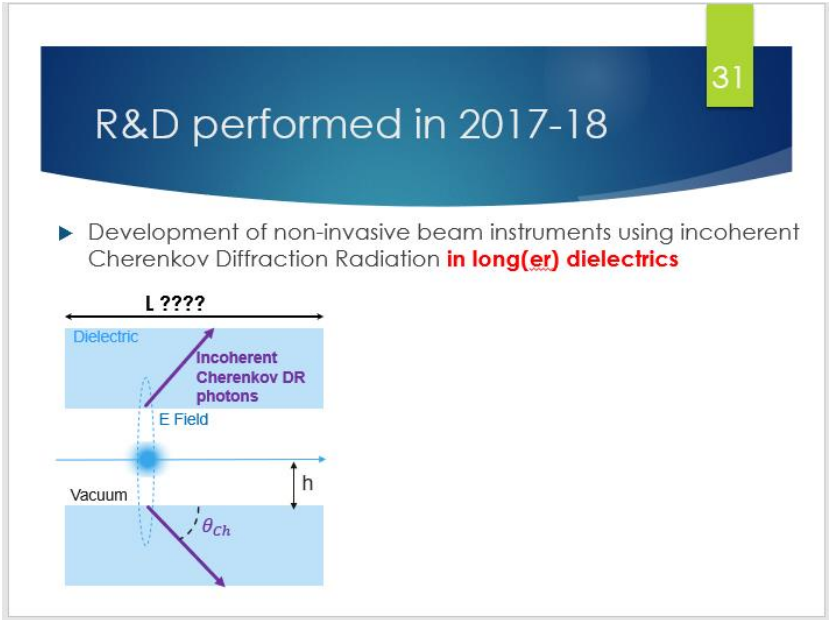
Beam Diagnostics R&D

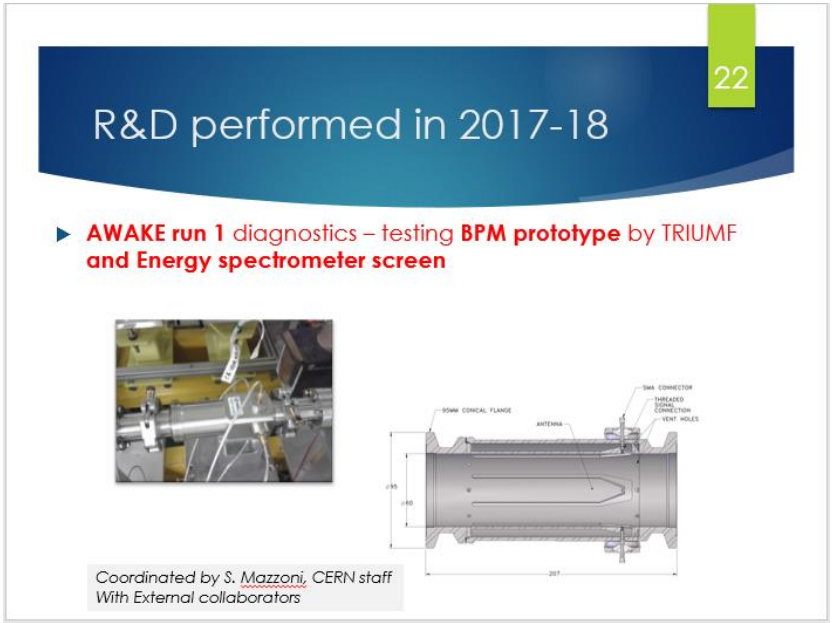
S. Mazzoni on behalf of the beam instrumentation teams

CLEAR review, 16 March 2021

CLEAR as a BI test facility in 2019

- **CLEAR review 2019. Focus on BI R&D:**
  - First tests of coherent and incoherent ChDR for BI applications.
  - Fundamental BI R&D
  - CLEAR as a platform for sub-THz R&D
- **BI tests for future / current facilities**
  - First tests for AWAKE (e- BPMs, EOSD)
  - cavity BPMs for CLIC





A BI R&D programme at CLEAR

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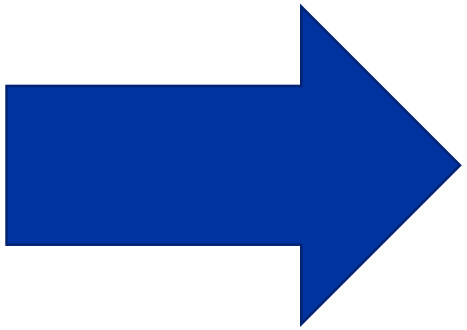

- **Many concepts became protoype instruments / techniques for AWAKE, HL-LHC, FCC:**
  - ChDR BPMs
  - ChDR bunch length
  - ChDR / EO bunch length
  - EO BPMs
- **Continuation of R&D on advanced concepts**

A BI R&D programme at CLEAR

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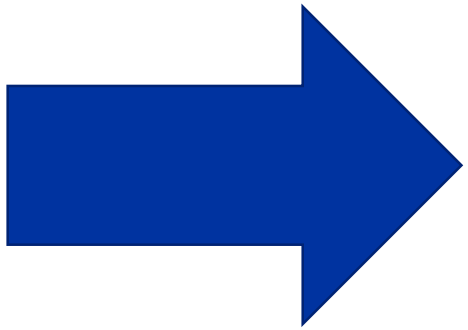


- **At present five BI tests for AWAKE Run 2**
- **BI tests for SPS, HL-LHC, FCC, CLIC**

CLEAR BI test facility in 2021

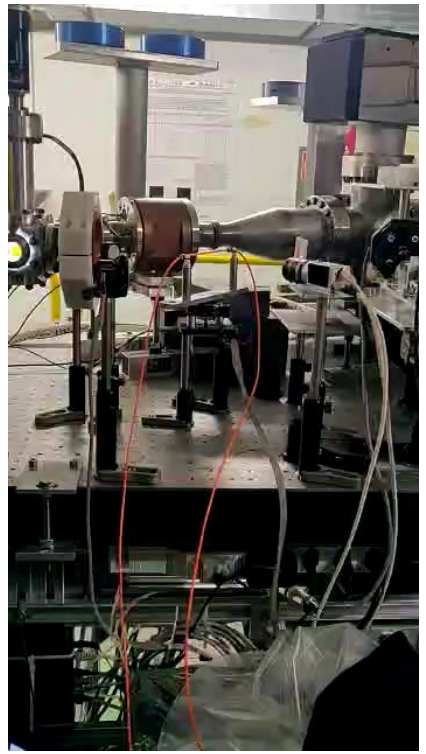
- **Tests on prototype instruments / techniques*:***
  - Screens in Rb (CERN / MPP)
  - Bunch length using EOSD (CERN)
  - Charge calibration (UCL)
  - ChDR Bunch Length tests (U man, RHUL)
  - ChDR BPMs (CERN, Oxford, TRIUMF)
  - **SPS** Optical BLMs tests
  - **CLIC** Cavity BPMs
  - BL tests for **FCC/ HL-LHC**
  - Test of **LHC** EO BPM (CERN/RHUL)

AWAKE (see Edda's pres.)

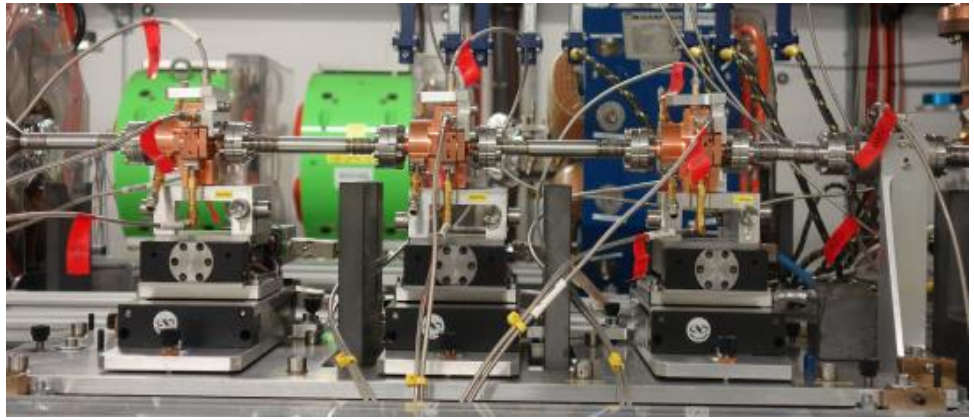
- **Continuation of R&D activity**
  - Validation of ChDR theoretical model
  - X- ray Cherenkov Radiation (Belgorod)

BI tests - status

- **Optical BLM tests (CERN)**
  - Test of new optical BLM. Loss signal: Cherenkov Radiation produced in fibres.
  - 2020: measurement of ChR as a function of angle to benchmark simulations
  - 2021: improved read-out electronics and new sensors (SiPM, PMT, PD) test with low intensity bunches / trains
  - Complement to BL tests in SPS

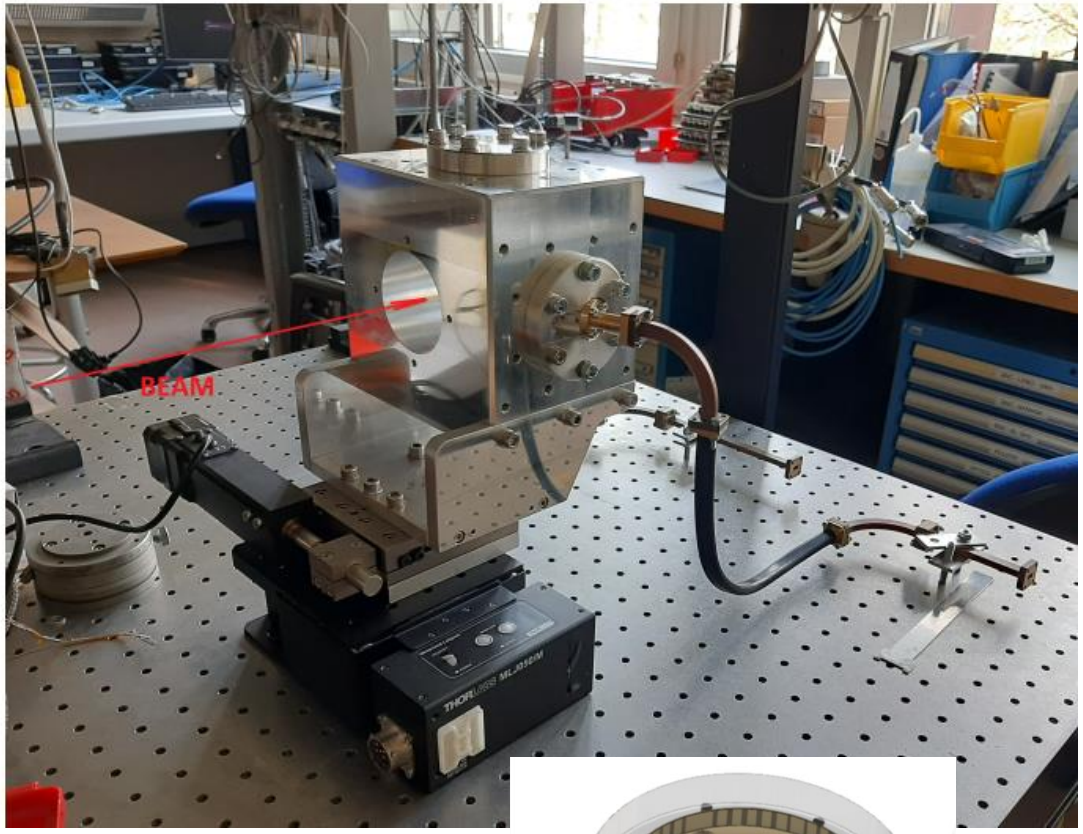


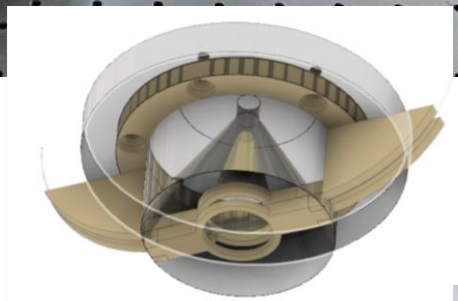
- **CLIC cavity BPM tests (RHUL / CERN)**
  - 15 GHz cavity BPMs for high resolution, sub um position measurement
  - 2021: reinstall three CBPM pickups, and improved front end electronics: integrated analog/digital solution (including analog+digital+FPGA+CPU+EPICS/Tan go) using with an industrial partner (Instrument technologies)

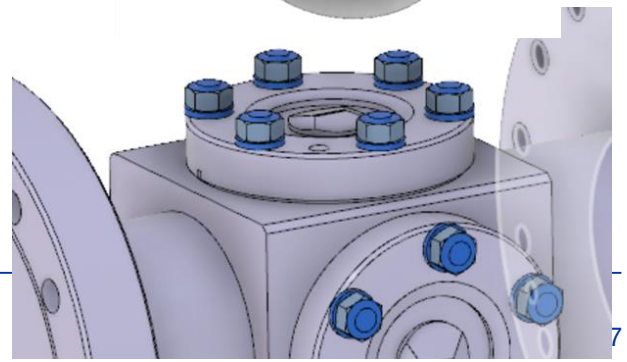


BI tests

- **Longitudinal profile ChDR / EO tests**
  - Test of vacuum ChDR pickups for longitudinal profile measurement with ns / tens of ps resolution
  - Detection scheme using 20 – 40 GHz electro-optical modulators and 780/1550 nm laser at CLEAR. Other EM probes to test
  - Proof of principle at CLEAR, then tests in HRM. Long term study for FCC
- **Test of LHC EO buttons (CERN/RHUL)**
  - Beam validation of a technology being developed in collaboration with RHUL for HL-LHC
  - Using fiber-coupled electro-optical waveguide coupled to a 50 Ohms terminated electrostatic button

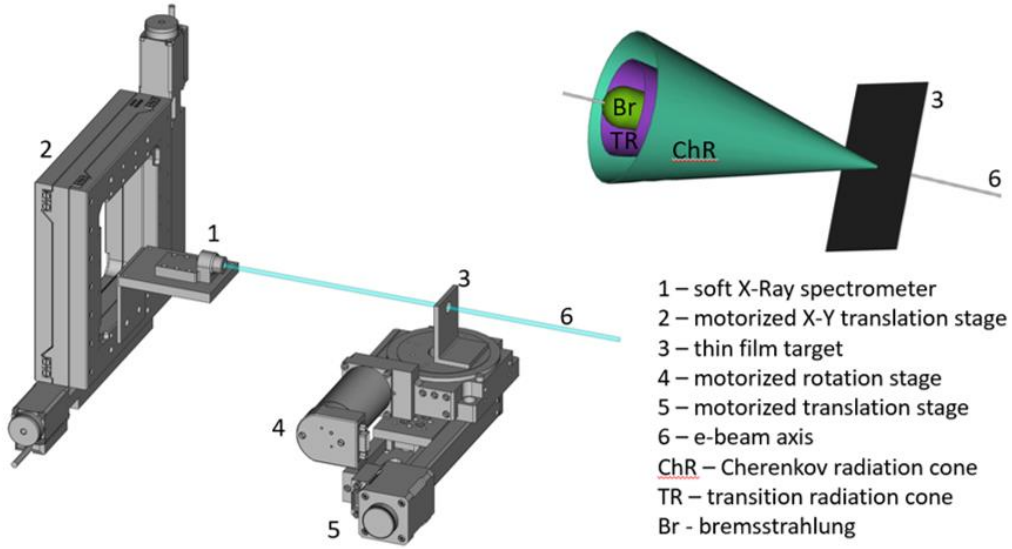




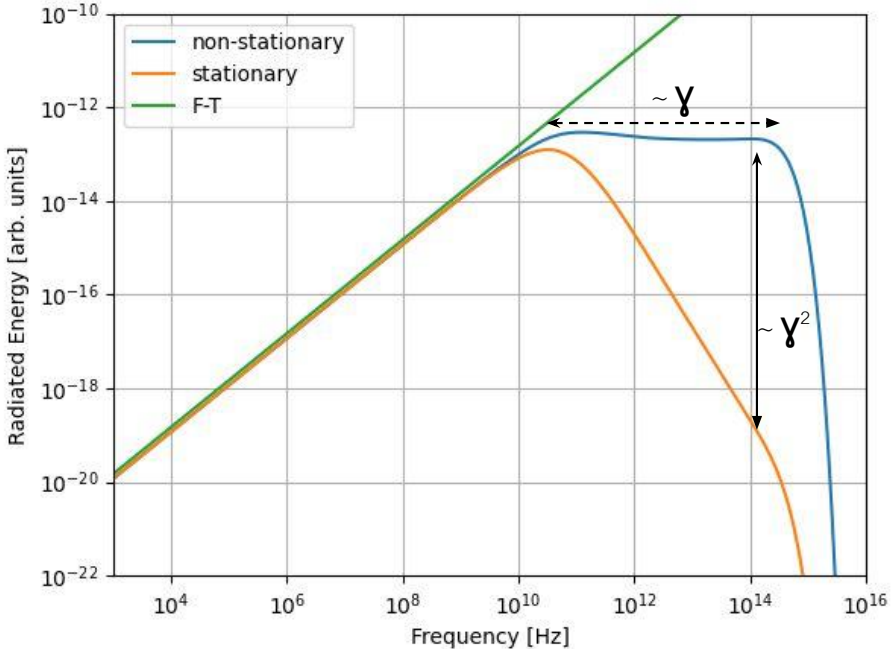


R&D

- **X-ray Cherenkov test (Belgorod)**
  - Study of ChR in soft X-rays regime.
  - Absolute light yield and angular distribution as a function target angle
  - Preparation affected by COVID. Foreseen 2nd half of 2021



- **Validation of ChDR theoretical model (CERN)**
  - Models for ChDR still not fully validated. Basic tests to measure ChDR spectrum in the range 100-300 GHz
  - Verification needed for applications to high energy beams (FCC)
  - Radiation produced by dielectric conical target, tests in Summer 2021

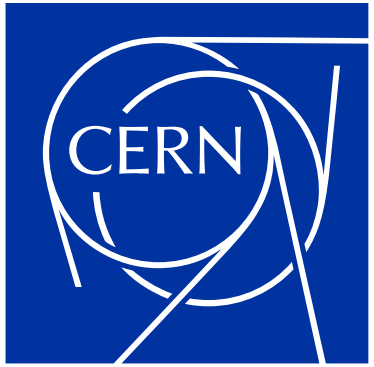


CLEAR as an ideal BI test facility

- **Ease of access:** weekly access (Mondays), low levels of radiations allow frequent access, in-air test section for simple HW design
- **Interesting beam parameters:** low emittance (3-10 um), sub-ps bunch length, can be easily tuned. Close to AWAKE Run 2d electron line (160 MeV, hundreds of pC per bunch, 200 fs BL). Electrons interesting for future e-p colliders (FCCee, CLIC)
- **Multiple test-stands:** two in-vacuum, 1 metre long in- air. VESPER used for charge calibration tests

Community

- **User community is expanding** presently besides CERN BI group (4 staff, 5 fell/PhD) six institutes involved (Max Planck Institut, University College of London, Royal Holloway University of London, University of Manchester, University of Oxford, Belgorod State University)
- **Education (PhDs / postdocs a few numbers)** several fellows and PhD students trained at CLEAR. Hands-on, comprehensive training, no long shutdowns. In line with CERN goal of "Inspiration and Education"
- **Recent Publications**
  - A. Curcio et al, "Diffractive shadowing of coherent polarization radiation", Phys. Lett. A **391,** 127135 (2021)
  - A. Curcio et al, "Noninvasive bunch length measurements exploiting Cherenkov diffraction radiation", PRAB **23** (2020)
  - A. Curcio et al. "Beam-based sub-THz source at the CERN linac electron accelerator for research facility", PRAB **22** (2019)
  - R. Kieffer et al, "Experimental Observation of "Shadowing" in Optical Transition Radiation", Phys. Rev. Lett. **120** (2018)
  - Yearly reporting to conferences (IBIC, IPAC, LCWS, …)



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