

*29th Linear Accelerator Conference (LINAC18)
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5' Oral Poster Presentation

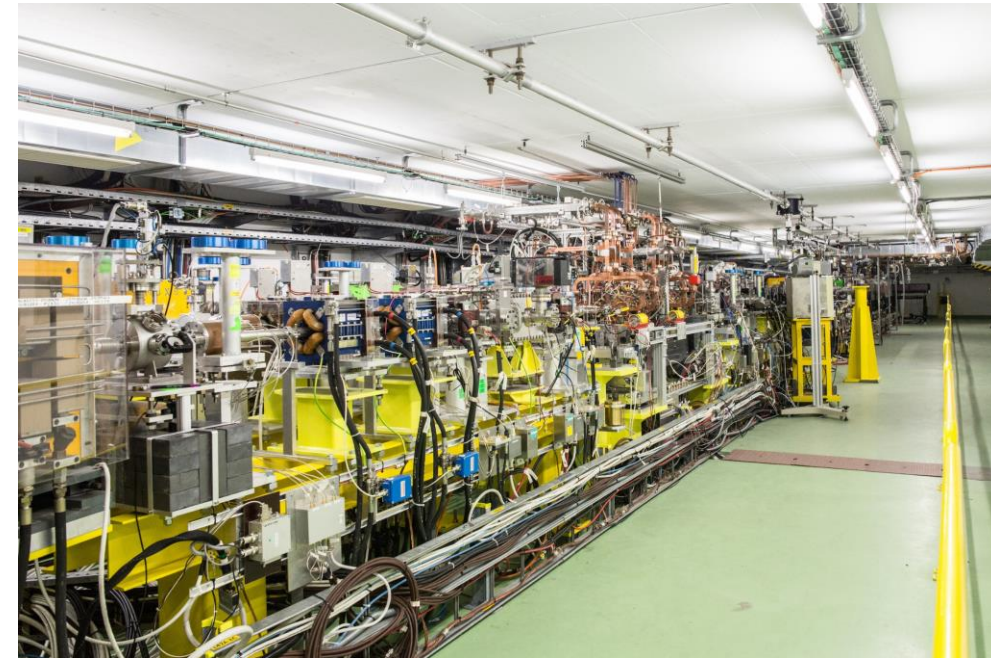
*BEAM DYNAMICS STUDIES AND INSTRUMENTATION TESTS
FOR BUNCH LENGTH MEASUREMENTS AT CLEAR*

*L.Garolfi on behalf of CLEAR team & collaborations
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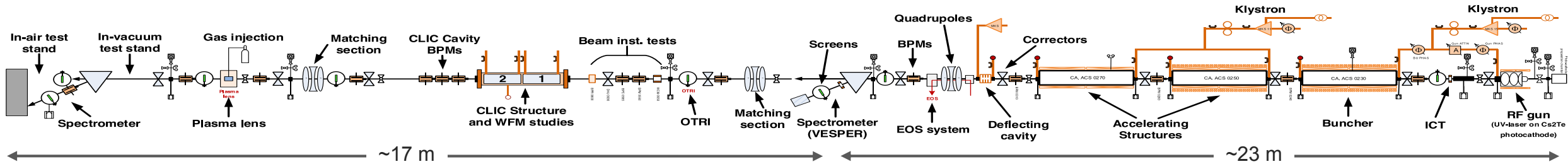
European Organization for Nuclear Research (CERN)

The CERN Linear Electron Accelerator for Research, CLEAR

- CLEAR is a general purpose facility aiming at accelerator R&D and component studies for existing and possible future machines at CERN, based on a broad internal and external user community.
- The program covers two of the top priorities identified by the European Strategy for Particle Physics:
 - prototyping and validation of accelerator components for the upgrade of the Large Hadron Collider and its injector chain,
 - studies of high-gradient acceleration methods.
- The latter cover X-band studies for linear accelerators and also novel concepts as plasma and THz acceleration.
- CLEAR also provides unique training infrastructure for the next generation of accelerator scientists and engineers.



CLEAR: the machine, beam parameters, diagnostics & experiments

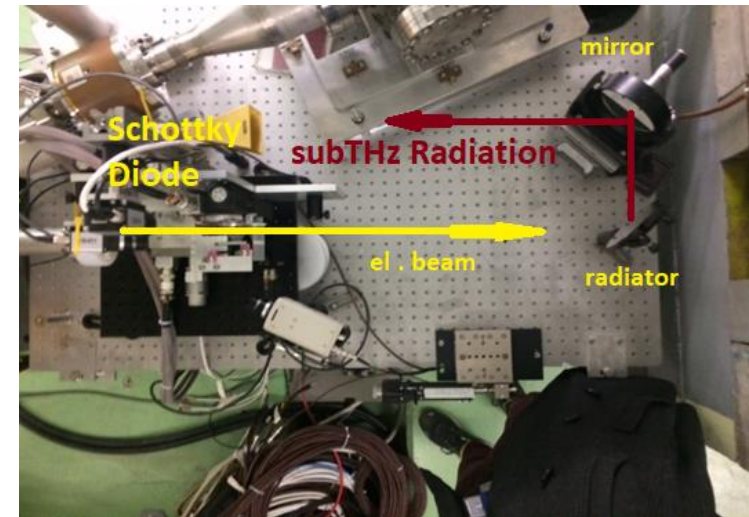


beam parameters	value range
Energy	60 – 220 MeV
Charge per bunch	0.01 – 1.5 nC
Normalised emittance (per bunch, both planes)	3 μm for 0.05 nC 20 μm for 0.4 nC
Relative energy spread	< 0.2% r.m.s
Bunching frequency	1.5 GHz
Number of bunches	between 1 and >100
Repetition rate	1 - 5 Hz (25 Hz with upgrade)

Diagnostics + Experiments
Optical Transition/Diffraction Radiation Interferometry (OTRI/OTDRI)
1 CLIC structure (12 GHz) + 3 CLIC Beam Position Monitors (12 GHz BPMs)
Streak camera
Plasma lens experiments
12 \times 0.9 m ² optical table: Cherenkov & THz radiation

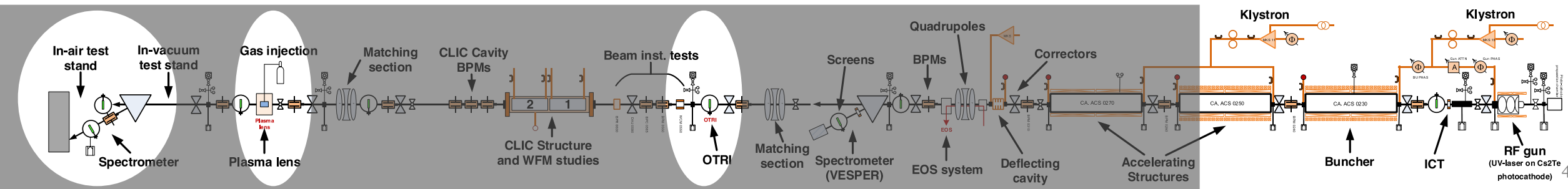
OTR/Cherenkov radiation as GHz/THz source

- GHz/THz production from:
 - **Transition** Radiation
 - (Diffraction) **Cherenkov** radiation
- Requires single high charge (>100 pC), short length (< 1 ps) bunches
- Collaboration **RHUL, Tomsk University, INFN – La Sapienza, Daresbury lab**
- **Investigation ongoing** by [Alessandro Curcio](#)
 - Proposal to use it as beam diagnostic
 - Could be used as plasma diagnostic
- Contact person: [Thibaut Lefevre](#) – CERN



See also:

- Experiment application form #0002 ([link](#))
- Presentation Jan 2018: THz@CLEAR: source and diagnostics for the electron acceleration ([indico](#))
- Workshop Nov 2017: THz@CLEAR Workshop 2017 ([indico](#))



BEAM DYNAMICS STUDIES AND INSTRUMENTATION TESTS FOR BUNCH LENGTH MEASUREMENTS AT CLEAR

- CLEAR is user facility devoted to R&D for accelerators and instrumentation in a broad range of applications.
- **Beam dynamics studies, bunch length measurements** and instrumentation tests have been carried out.
- **ASTRA simulations** have been **compared** with **experimental data** and demonstrated a promising starting point toward a solid tool for predicting the best configuration for very short electron bunches.
- **Bunch length measures** have been performed with: **RF deflecting cavity, streak camera** and **THz Coherent Transition Radiation (CTR)**.
- The **experimental data exhibit good agreement** but for bunches of length of 100 fs further improvements are required.

POSTER ID: MOPO020

Thank you for your attention

BEAM DYNAMICS STUDIES AND INSTRUMENTATION TESTS FOR BUNCH LENGTH MEASUREMENTS AT CLEAR

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CERN Linear Electron Accelerator for Research (CLEAR)
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Accelerator layout
25 m

Instrumentation & diagnostics beam line
16 m

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Diagnostics + Experiments

- Optical Transition Radiation Interferometry (OTRI/OTDR)
- 1 CLIC structure (12 GHz) + 3 CLIC Beam Position Monitors (12 GHz BPMs)
- Streak camera
- Plasma lens experiments
- 12 X0.9 m² optical table: Cherenkov & THz radiation

INJECTOR BEAM DYNAMICS MODEL

SIMULATION WITH ASTRA

- Laser spot size = 0.4 mm,
- Laser pulse duration = 4 ps,
- Gaussian e⁻ distribution (transverse & longitudinal),
- Peak Gun gradient = 90 MV/m,
- Gun energy gain = 8 MeV,

3-D SOLENOIDS MODEL (OPERA)

- Bucking + focusing coil
- for Bz(z = 0) = 0 T (oathode)
- $f_{buck}[A] = \frac{I_{gun}[A]}{1.1846}$
- Solenoids calibration Bz = Bz(t)
- $B_{gun}[A] = 6.344 \times 10^{-4} \cdot I[A] + 0.02$
- MTV screen at z = 1.8 m,

BUNCH LENGTH MEASUREMENTS

Simulations:
Gun-phase reference → simulated & measured charge agreement.

Deflector:
8-band RF deflecting cavity

Streak camera:
Pass-band filter (450 nm, 36 nm bw),
Bunch profile → Gauss fit + slit aperture contribution,
Exp errors → statistics over lens of pictures.

Coherent Transition Radiation (CTR):
Set of 4 zero-biased Bonch-Brukhovits diodes → coupled → waveguide band-pass filter.
Frequencies studied → 58, 80, 72, 84 GHz.
Data fit → model → radiator finiteness (A, disk ϕ = 10 cm) + CTR angular distribution at deflector plane + Gauss longitudinal shape.
CTR spectrum bandwidth is inversely proportional to the bunch length.
Exp errors → shot-to-shot statistical fluctuations (25-bunch train) → charge fluctuations + background noise (other metallic parts located around the deflectors).

CONCLUSIONS

- A&TRA simulations have been performed in order to set up a reliable model for the RF-gun, solenoids and accelerating structures.
- The simulated and measured "phase scan" are in good agreement, validating the RF-gun model.
- The comparison between measured & simulated transverse size looks in agreement even if there is a discrepancy at the minimum.
- Bunch length measurements have been performed with 3 different techniques: deflector, streak camera and THz CTR.
- The bunch length experimental data exhibit good agreement, the simulated model needs further improvements, in order to produce electron bunches of length of 100 fs further improvements are required.