



# **EO bunch length monitor for Run 2c: plans and preparations**

**Collette Pakuza, Stefano Mazzoni**

**21<sup>st</sup> AWAKE Instrumentation Meeting, Tuesday 21 January 2025**

# Contents

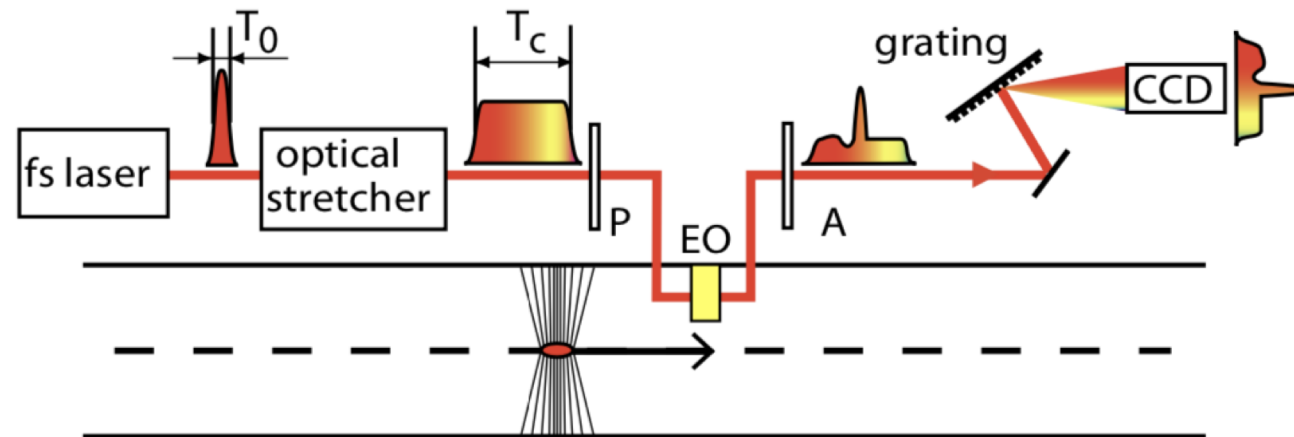
- Overview
- EO sampling techniques
- Plans and preparations

# Overview

- Run 2c involves new 150 MeV line where the nominal bunch length (BL) is 200 fs (sigma)
- At the limit of bunch length measurements with streak camera
- Few options are being studied:
  - Coherent Cherenkov diffraction radiation BL monitor – Jack Mcgunigal (UoM) – please see next presentation
  - CSR imaging without and CTR imaging with machine learning – Joe Wolfenden (UoL), Catherine Swain (UoL), Ana Maria Guisao Betancur (UoL)
- Another option which is being studied is BL monitor based on **electro-optic techniques** in collaboration with Morgan Hibberd (UoM)

# EO sampling techniques

- Longitudinal bunch profile probed with a chirped laser pulse
- Temporal overlap of the chirped laser pulse with the E-field of the particle bunch in the EO crystal imprints the longitudinal bunch profile on the laser pulse as a polarization modulation (as beam field changes the birefringence of the EO crystal)
- Optical analyzer transforms this into spectral intensity modulation
- Spectrum measured with grating + CCD
- **Electro-optic spectral decoding**
- A BL monitor based on this could be **single shot, non-invasive, high-resolution**



# Plans and preparations

## Tests timeline:

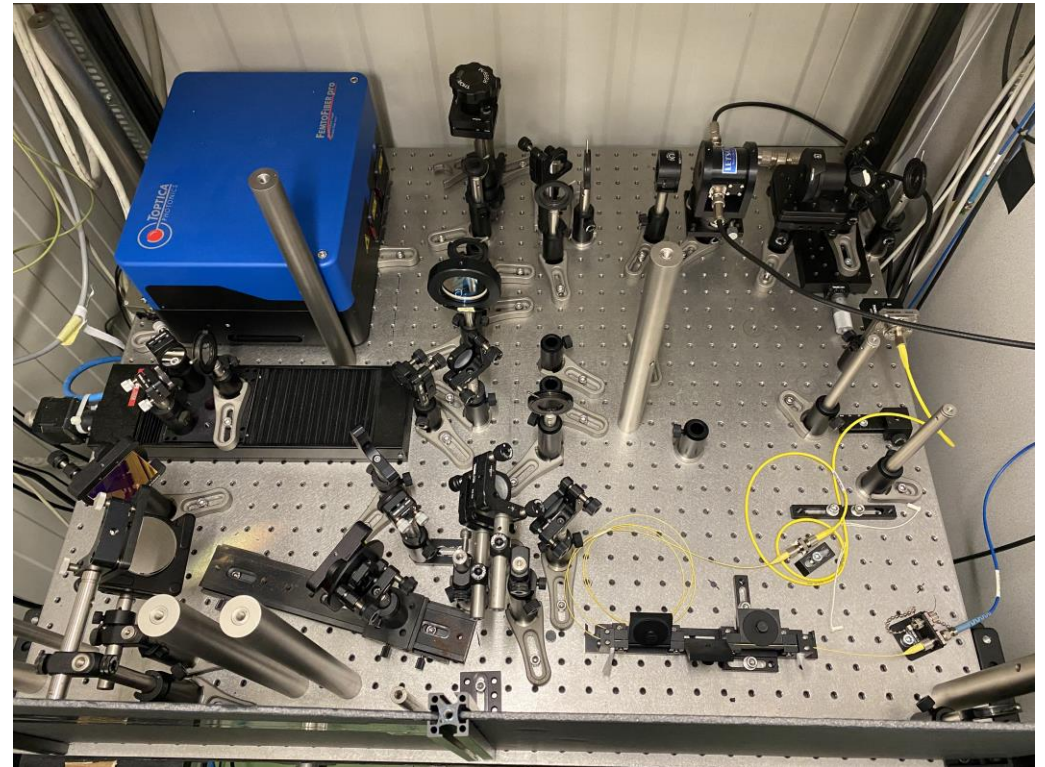
- In-air tests at CLEAR 2025/26 – simplified set-up for proof of concept and gain knowledge/experience
- In-vacuum tests at CTF2 – possibly starting 2026
- With UoM where a potential PhD student (COAS) would work on this

## System improvements and preparations:

### Laser pulse length at in-air test stand:

- At present 780 nm laser in laser lab in KG at CLEAR delivered to in-air test stand via approx. 66 m of fiber
- Two fixed gratings stretches pulse to 13 ps negative dispersion
- The fiber then stretches to 61 ps FWHM normal dispersion – too much for the bunch lengths at CLEAR (order of ps)
- In the process of reducing to the order of ps with installation of new gratings (already received)
- Pulse lengths will be measured using an autocorrelator and compared to calculations – Eva Roikova, PhD student with Edu
- Installation of new gratings should also improve the optical transmission

Laser Parameter	Specification	Unit
Laser type	Erbium-doped fibre	
Center wavelength	780	nm
Average output power	140 to 200	mW
Peak power	< 50	kW
Pulse duration	< 120	fs
Customised repetition rate	75	MHz
Pulse spacing	13.3	ns
Beam diameter	1.2	mm
Linear polarisation	> 95%	



# Plans and preparations

## Laser jitter:

- Improved laser jitter (end of 2023) few ps to few hundred fs – help from Edu and Miguel (PM section)
- Should improve the stability and visibility of the EO signal – want to profit from this in our tests this year

## Crystal characterization:

- Crystals from our repository need to be characterized (missing markings), done with a THz source
- Set-up was worked on by Valentina and Morgan last year, most equipment already in place
- Missing THz generation crystal

## Time-synchronization:

- Review and improve the time-synchronization measurement of laser pulse and beam using OTR screen (improving laser transmission, better control of angle/position of collimators in the set-up to maximize coupling to/from in-air test stand)
- Already started these preparations and beam time request will be submitted to CLEAR end of this month

# Thank you for your attention!