

# Tests of Wakefield Monitors (WFMs) at CLEAR

Kyrre Sjobak

CLIC Workshop 2019

## **Acknowledgements:**

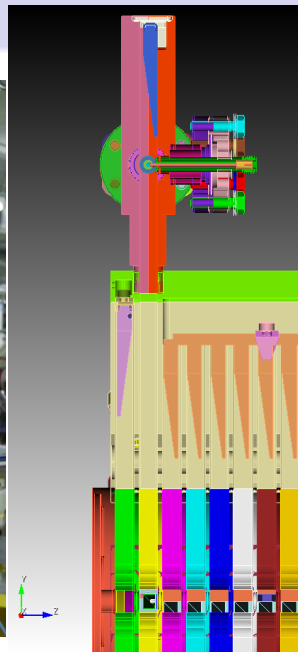
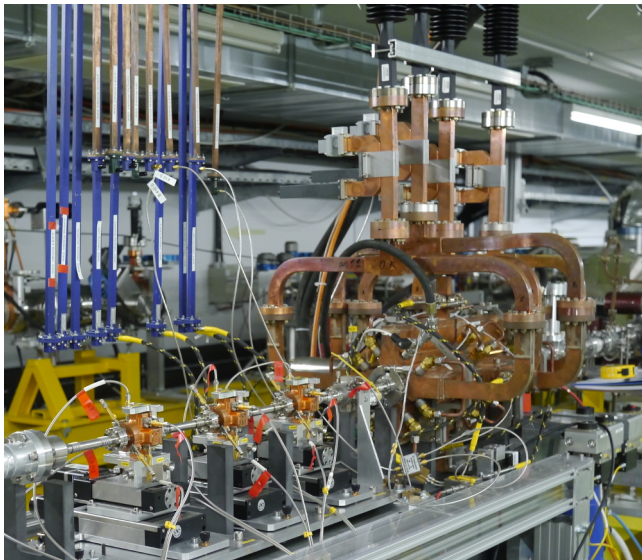
A. Gilardi, W. Farabolini, R. Lillestøl,  
A. Lyapin, J. Nadenau, A. Zemanek, V. Rude,  
E. Adli, R. Corsini



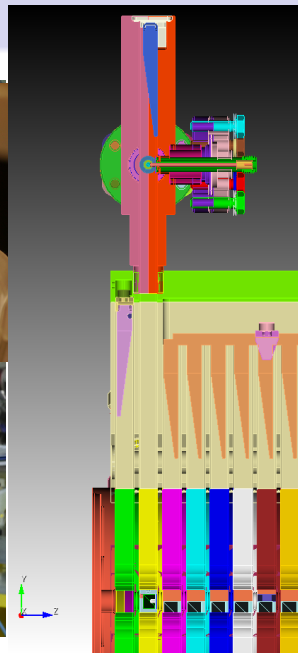
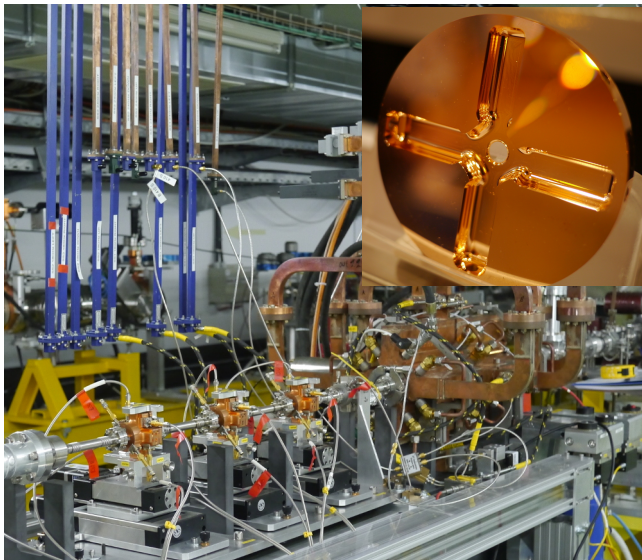
**UiO** : Department of Physics  
University of Oslo



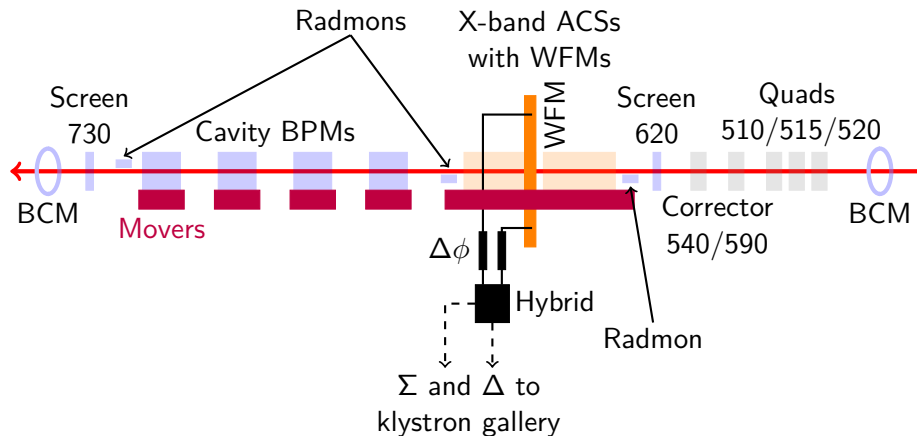
# The CLIC Wake Field Monitors



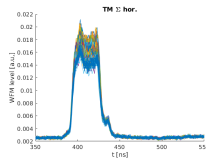
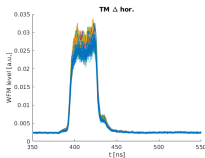
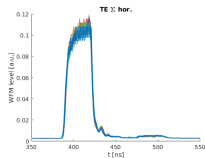
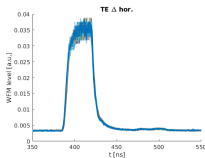
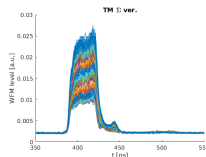
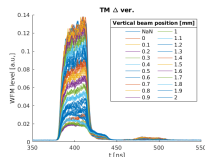
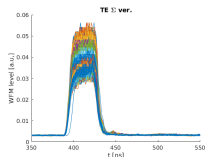
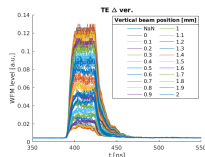
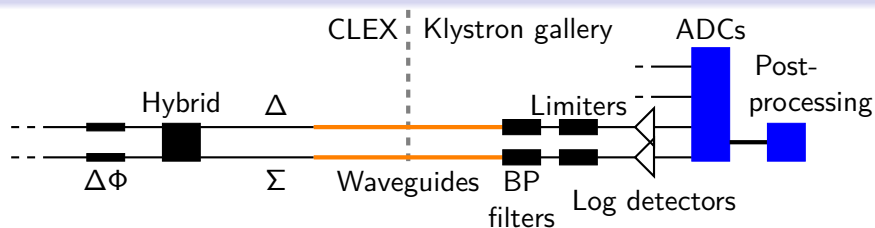
# The CLIC Wake Field Monitors



# WFM experiment overview – main components



# WFM Readout electronics



# Motivation for the CLIC WFMs

- Align the accelerating structures on the beam better than  $3.5 \mu\text{m}$
- Movers on the girder
- Minimization of transverse wakefields  
 ⇒ Minimization of transverse kicks
- Necessary to reach CLIC luminosity goal

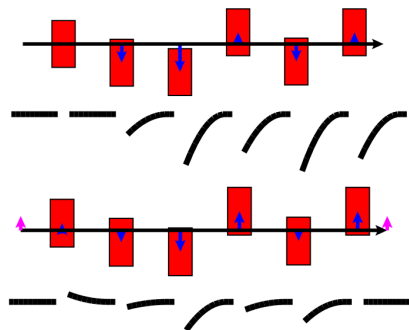


Figure by Reidar Lillestøl

# The CLEAR WFM experiment – general idea

- Demonstration of a CLIC-type WFM setup for beam positioning
  - Test of readout system
  - Which channels are really needed? Can we simplify?
  - Resolution measurement
- CLEAR and CLIC main beam parameters quite different:

Parameter		CLIC	CLEAR
Bunch length	[ $\mu\text{m}$ ]	70	1000
Bunch spacing	[mm]	150	200
Transverse size	[ $\mu\text{m}$ ]	$\approx 1$	$\approx 250$
Energy	[MeV]	3'000 – 1'500'000	200
Beam charge	[nC]	0.8	0.010-0.100
Number of bunches		352	1-100

# Instrumentation improvements

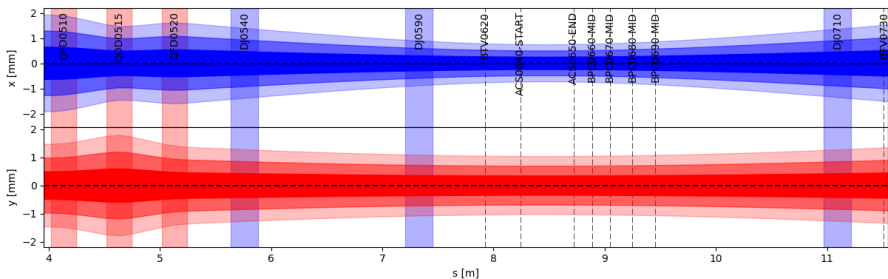
- Three radiation monitors
  - Pinpoint and avoid losses
  - 2 PMTs (without scintillators)
  - 1 diamond detector
- New screen in front of structure
  - Reproducible reference trajectory through the structure (together with old screen after structure)
  - Verification of optics
  - Calibration of corrector magnets
  - Prototype of digital BTV
- Cabling was consolidated
  - Now all pairs are symmetric
- Software improvements





# On-line optics model

- Used for WFM and plasma lens experiments
- Predicts the beam  $\sigma$  given initial Twiss parameters & magnet currents (read directly from the machine)
- General code which could be re-used at experimental lines etc.



Navigation icons: Home, Back, Forward, Add, Search, List, Plot, Save. zoom rect

<b>X parameters:</b> $\beta_x$ [m] = 15.31 $x_0$ [mm] = 0.0		<b>Y parameters:</b> $\beta_y$ [m] = 10.64 $y_0$ [mm] = 0.0		$P_0$ [MeV/c] = 206	<input type="button" value="Update now"/>	H L E P
$\epsilon_x$ [ $\mu\text{m}$ ] = 14.3	$\alpha_x$ = 0.56	$x'_0$ [ $10^{-3}$ ] = 0.0	$\epsilon_y$ [ $\mu\text{m}$ ] = 12.9	$\alpha_y$ = 0.66	$y'_0$ [ $10^{-3}$ ] = 0.0	

<https://gitlab.cern.ch/kyrsjo/CLEARview>

# Moving the beam vs. moving the structure

- Structure mounted on actuated girder
  - Not possible to access via CERN control system
  - Equipped with stretched wire position sensors
- Have pair of upstream correctors
  - Calibrated with low-charge beam and two screens
  - Enables quick and easy scans
- Both methods to be used for cross-check

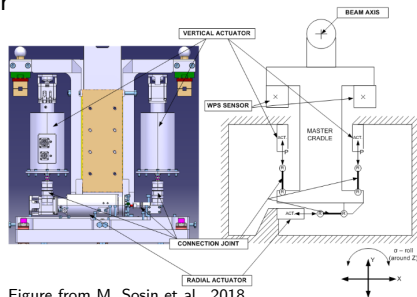
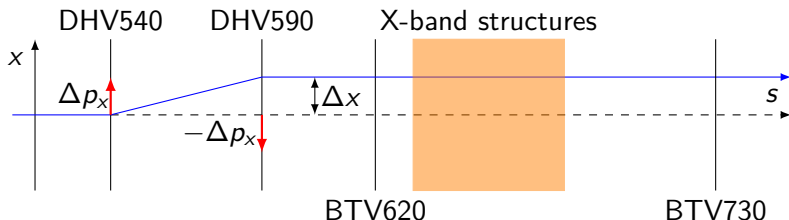
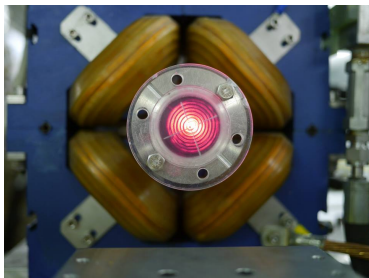


Figure from M. Sosin et al., 2018

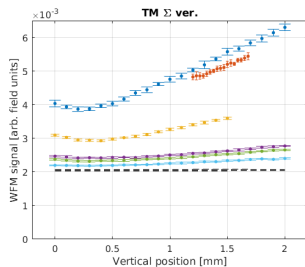
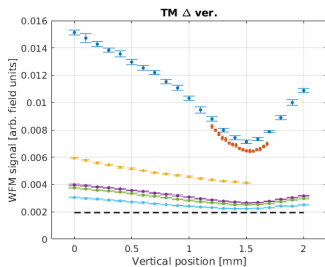
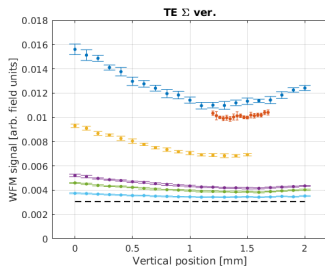
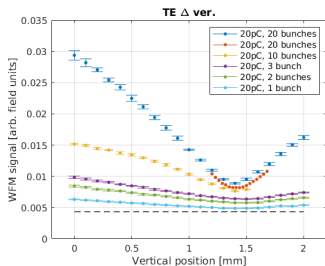


# Aperture alignment

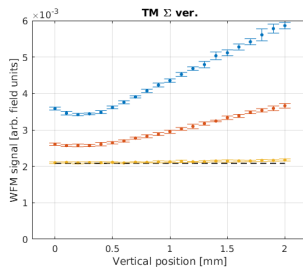
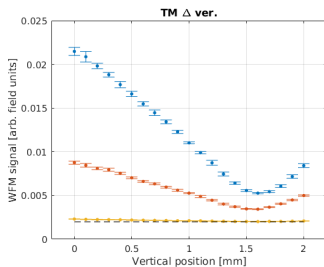
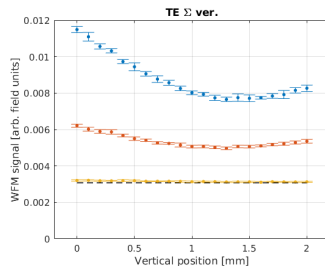
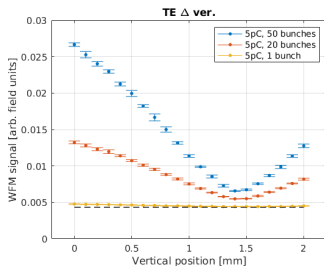
- Aperture diameter of TD26 CLIC structure only **8.0 – 4.7 mm**
- Quadrupoles and some beam instrumentation precisely aligned by survey group
- Beam aperture was not well aligned
- Good alignment crucial for
  - Lossless beam transport
  - Possibility to scan the beam position
- Beamline aperture was straightened out  
⇒ No more losses
- Beamline now offset ⇒
  - Not perfectly centered on quadrupoles
  - Girder mover off to the side



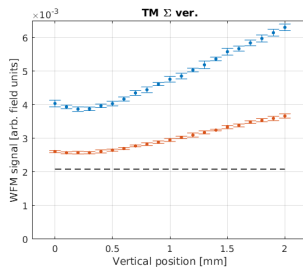
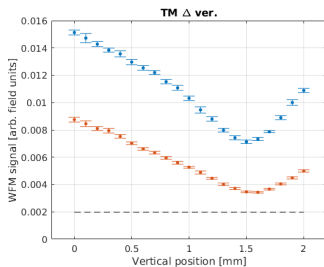
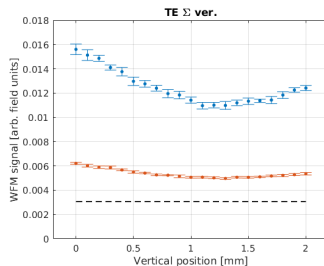
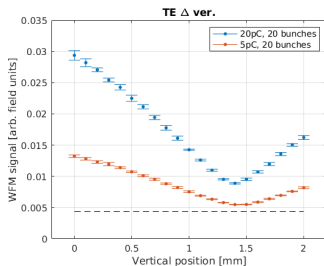
# Effect of number of bunches



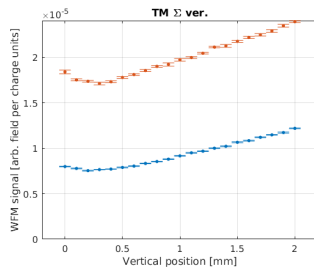
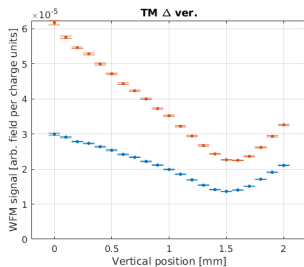
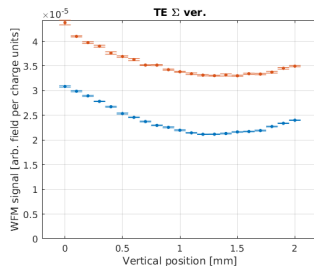
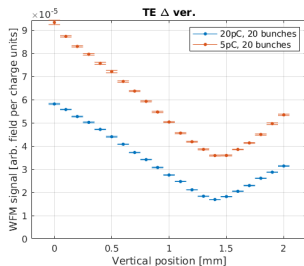
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# Bunch charge normalization



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# Summary and conclusions

- Instrumentation has been greatly improved
  - New screen
  - Radiation monitor
  - Cleaned-up WFM cabling
- Machine performance steadily increasing
  - Trains with good quality
  - Better known optics
  - Setup time reduced
- Calibrated kicker scans have speed things up a lot
- WFM data mostly consistent and reproducible
  - More bunches help
  - Charge normalization is not the full story, even for same number of bunches
  - Discrepancy of minimum between TE- and TM
  - The minimum is “flat”
  - Cancellation of  $\Sigma$  or  $\Delta$  is not perfect.
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# Outlook

Still much to do to fully understand the setup:

- Calibration of the signal paths
- Simulation of the wake field generation and pickup
- Improve machine alignment
- Get the module mover working practically
- Comparison with the CLIC BPM signals  
*See talk by Manuel Cargnelutti and Alexey Lyapin Tuesday!*
- Effect of bunch length, ...
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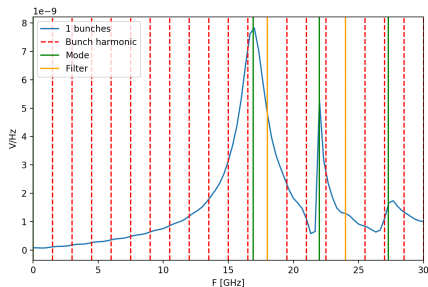
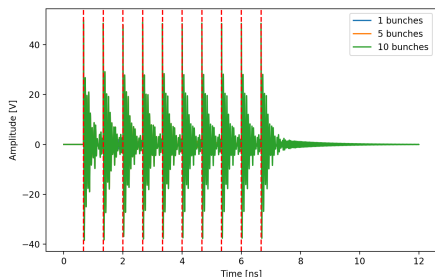
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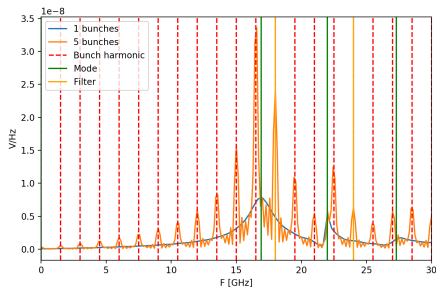
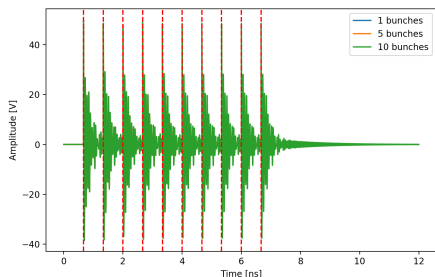
# BACKUP

# Wake spectrum when changing number of bunches



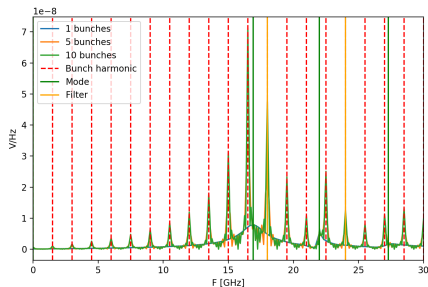
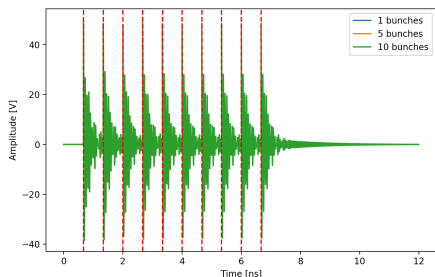
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- Demonstrates how the wake builds up at the beam harmonics
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