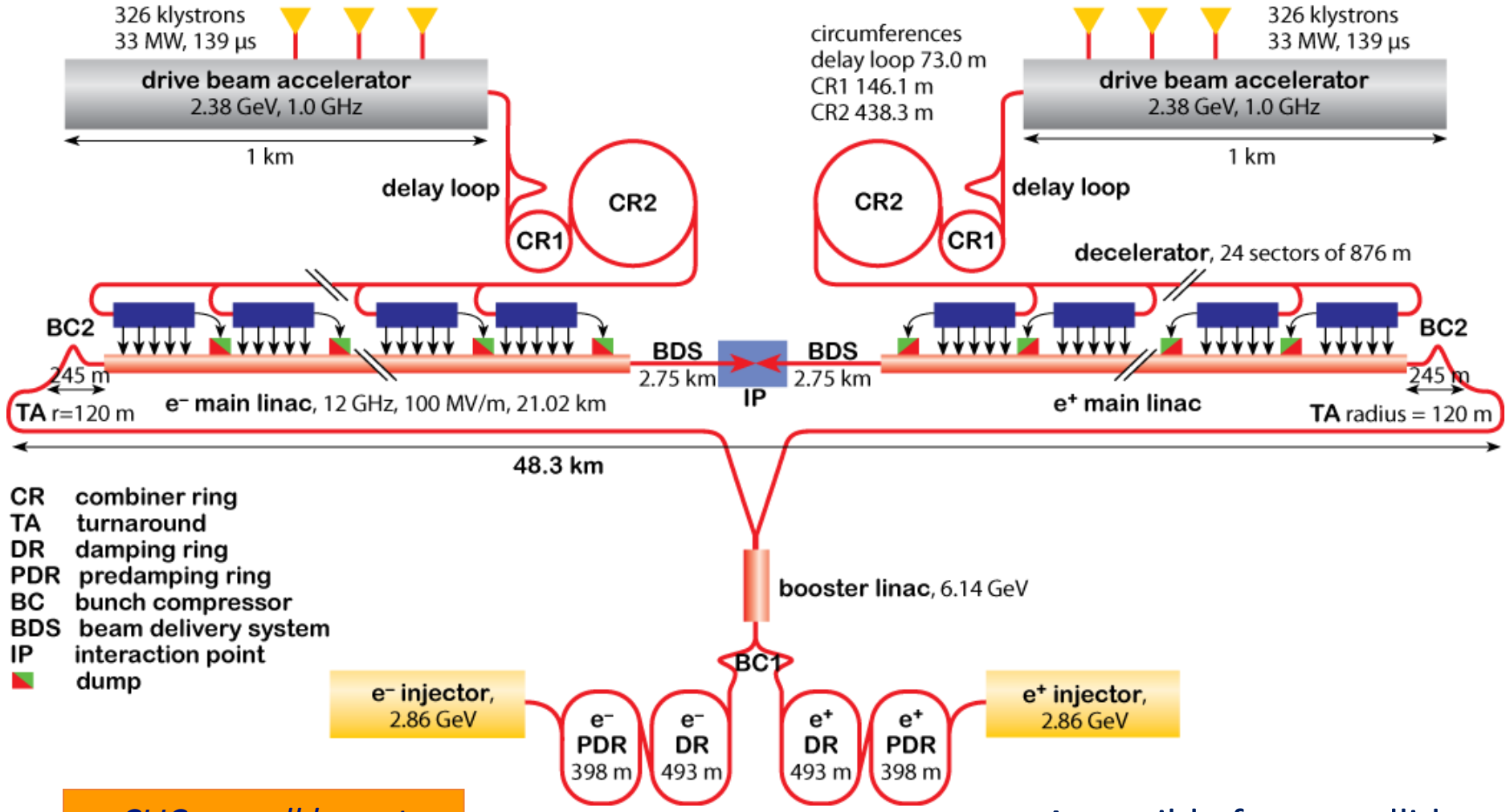
CLEAR Beam Training

Have a chance to operate your own beam at CERN

Contents

- CLIC
- CTF3 overview
- Experiments on CLEAR beam
- Work Proposals

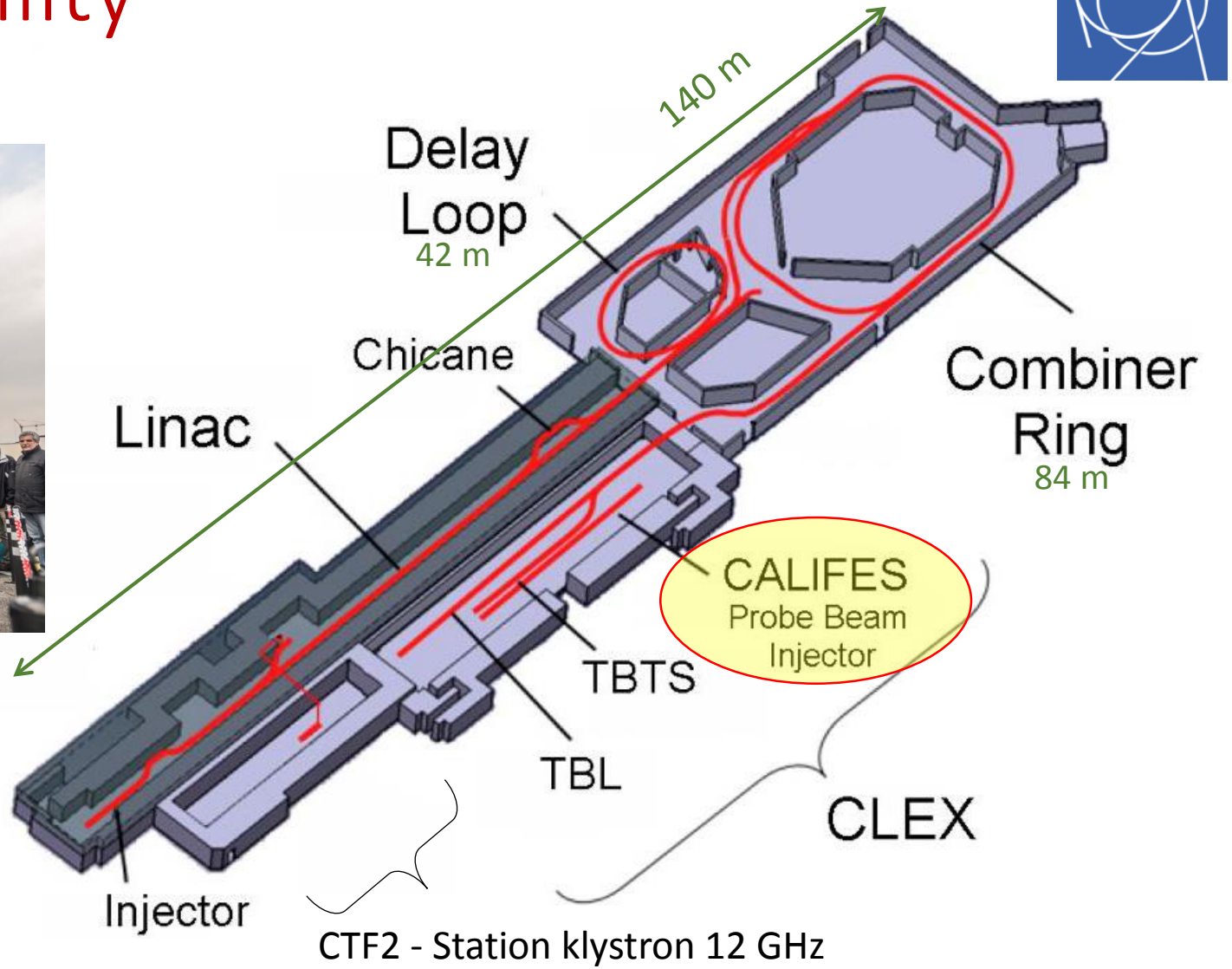
The Compact Linear Collider (CLIC) project



CLIC overall layout for E_{CM} = 3 TeV

A possible future collider after the LHC

CTF3 Facility



A (small) mock-up of the CLIC

CTF2 - Station klystron 12 GHz

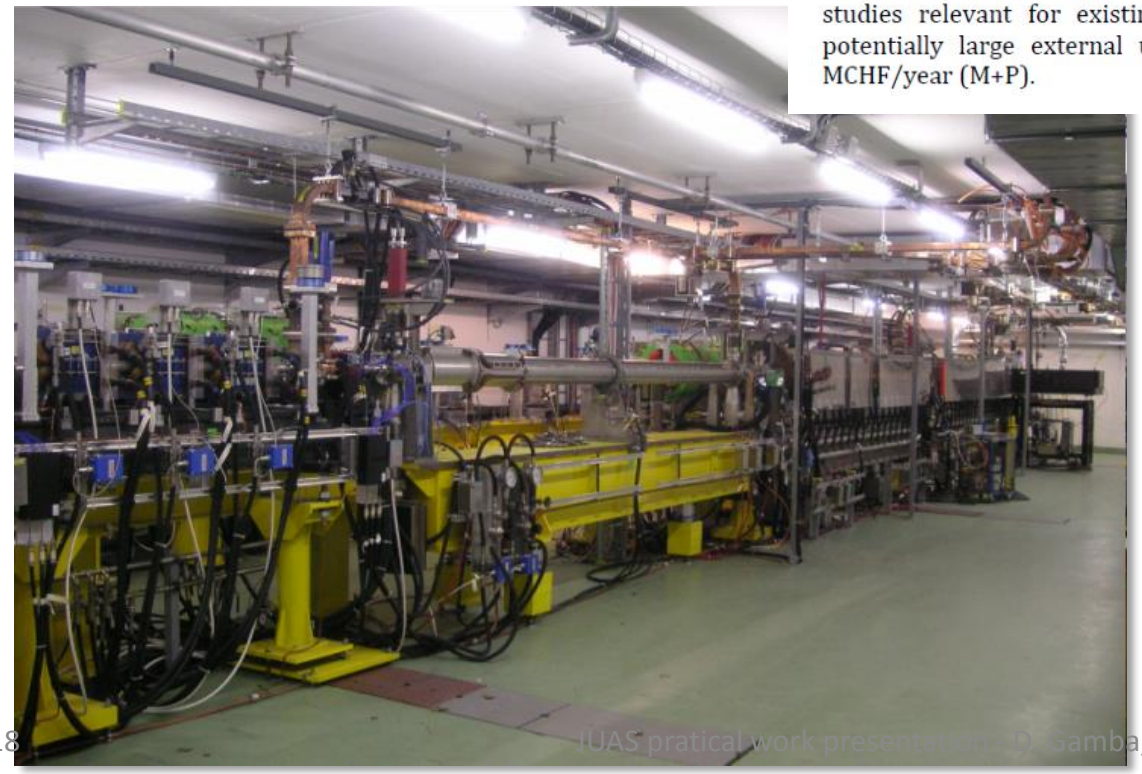
Proposal of a CALIFES-based Accelerator Test Stand

CTF3 scientific program completed as planned in December 2016

What to do with CTF3 hardware & building?

➔

Interest in CALIFES



Expression of Interest for the future operation of the CALIFES linac

Prepared by: E.Adli (Univ. of Oslo), P.Burrows (Univ. of Oxford), R.Corsini (CERN), S. Stapnes (CERN)

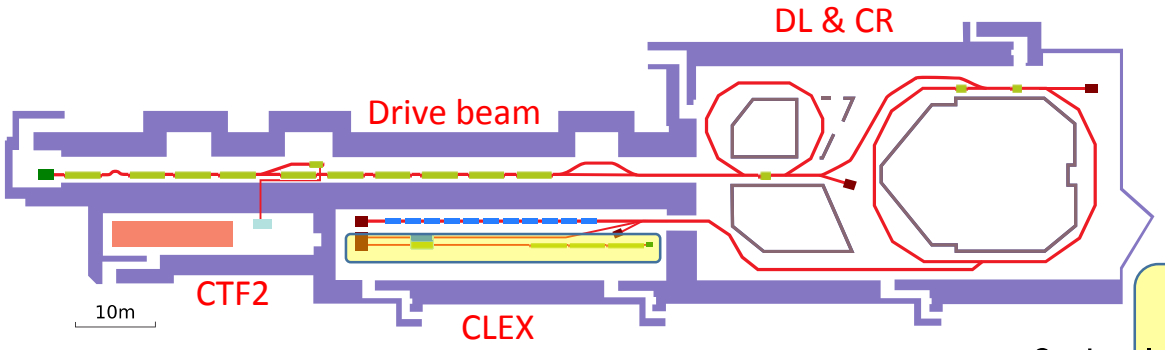
Abstract

In this document we propose to operate the CALIFES electron linac at CERN, presently used as the probe beam line of CTF3, as a stand-alone user facility from 2017 onwards when CTF3 is closed down. The possible uses include general accelerator R&D and studies relevant for existing and possible future machines at CERN, involving a potentially large external user community. The resources required are around 2 MCHF/year (M+P).

- Longer document send in February 2016
  CALIFES_document.pdf
- Positive statement by the CLIC Review Panel in March 2016
- CALIFES Workshop, October 2016

  CLEAR (ED) : Cern Linear Electron Accelerator for Research (and Education)
- Final proposal (CLEAR)
  and
  approval in December 2016

From CTF3 to CLEAR: December 2016 – August 2017



Connected

2 MKS

Improved sensitivity

Created

Moved down-stream

Just insta -lled

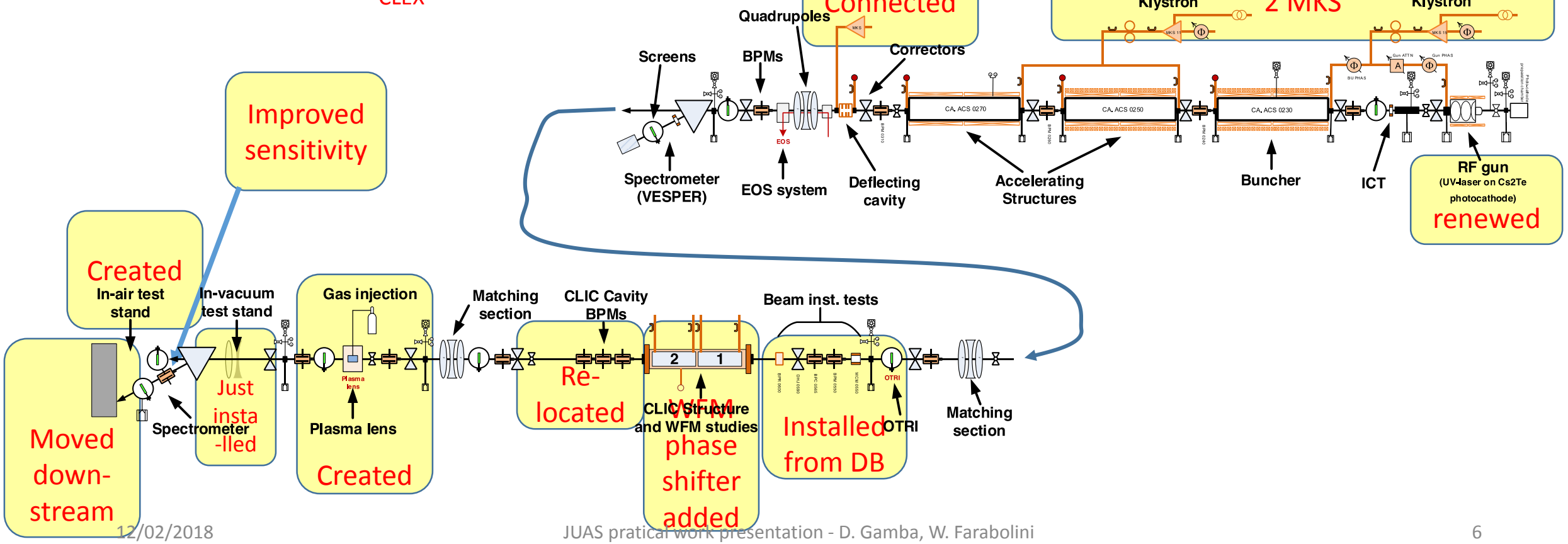
Created

Re-located

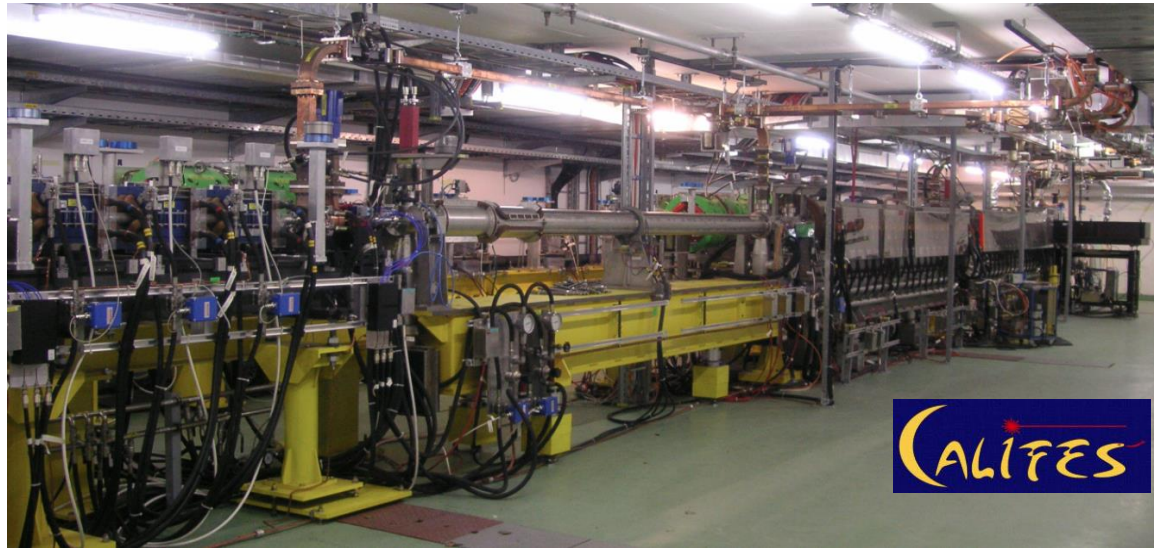
phase shifter added

Installed from DB

renewed



New CALIFES performances

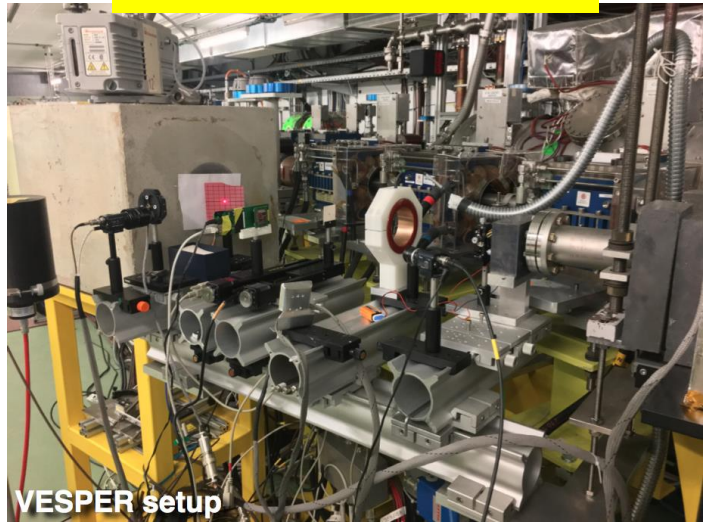


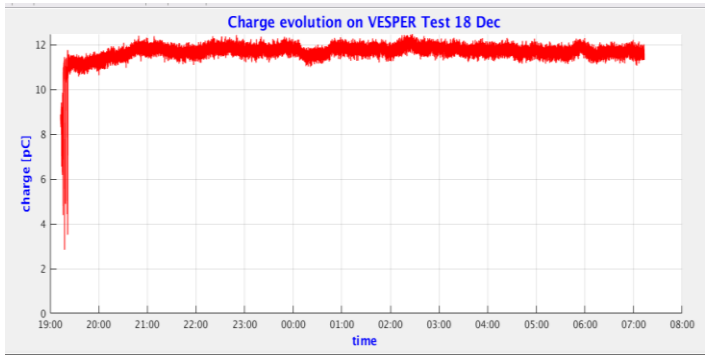
Waveguides from building 2001 to 2010

Beam parameters	Range	Comments
Energy	60 – 180 MeV	More flexible with 2 klystrons. > 220 MeV expected with pulse compression.
Energy Spread	< 1 MeV (FWHM)	
Bunch Charge	1 pC – 200 pC	Photocathode changed but limited laser power. Goal: 0.6 nC.
Bunch Length	2.4 ps – 8 ps	0.1 ps according to simulation. Velocity bunching studies to be resumed
Normalized emittances	3 μm to 30 μm	Bunch charge dependent
Repetition rate	0.8 to 5 Hz	25 Hz with klystrons and laser upgrade
Number of micro-bunches in train	1 to >150	Single bunch capability assessed
Micro-bunch spacing	1.5 GHz (Laser)	3.0 GHz: Dark current

Some experiments in 2017

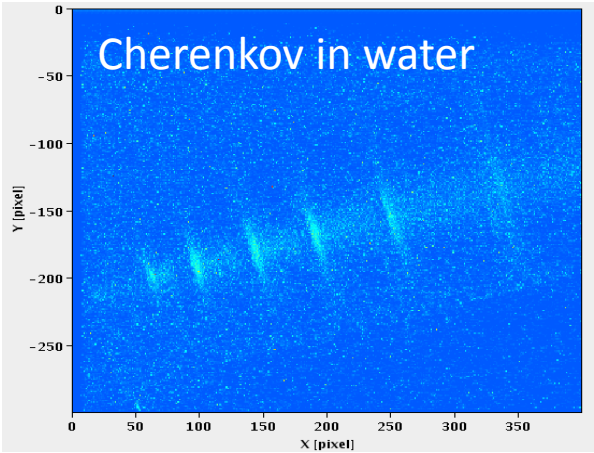
Electronics irradiations





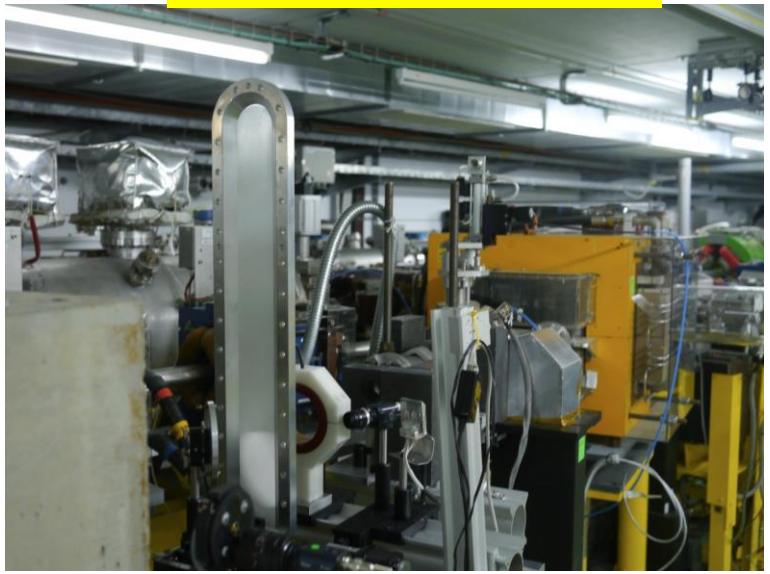
Electronics Irradiation Tests in VESPER.
Maris Tali, Ruben Garcia Alia

VHEE



Results of the VHEE studies in VESPER/CLEAR.
Agnese Lagzda, Roger Jones

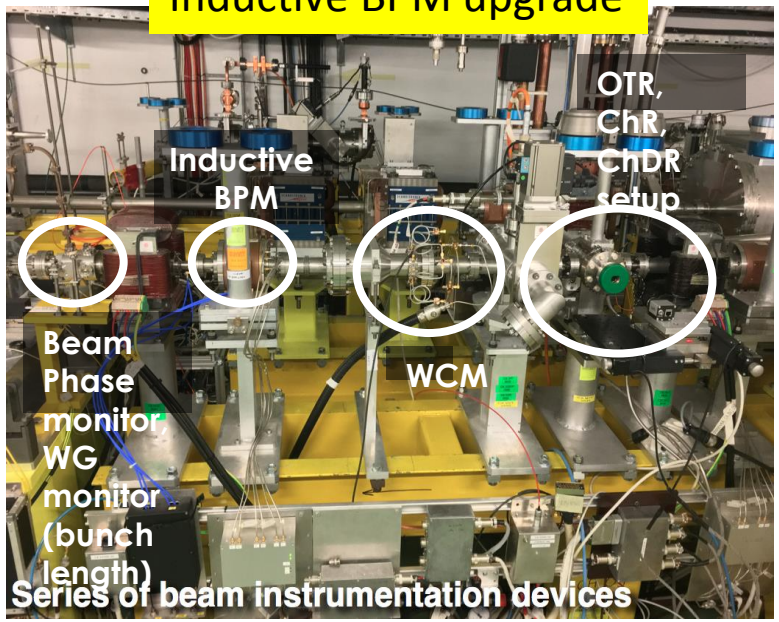
Scintillation screen test

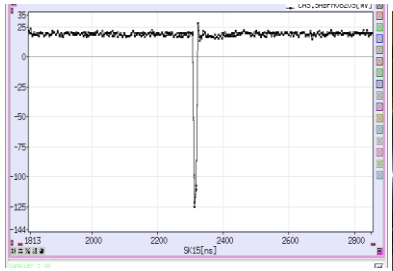


Test and calibration of scintillator for AWAKE electron spectrometer.
Fearghus Keeble

Some experiments (cont'd)

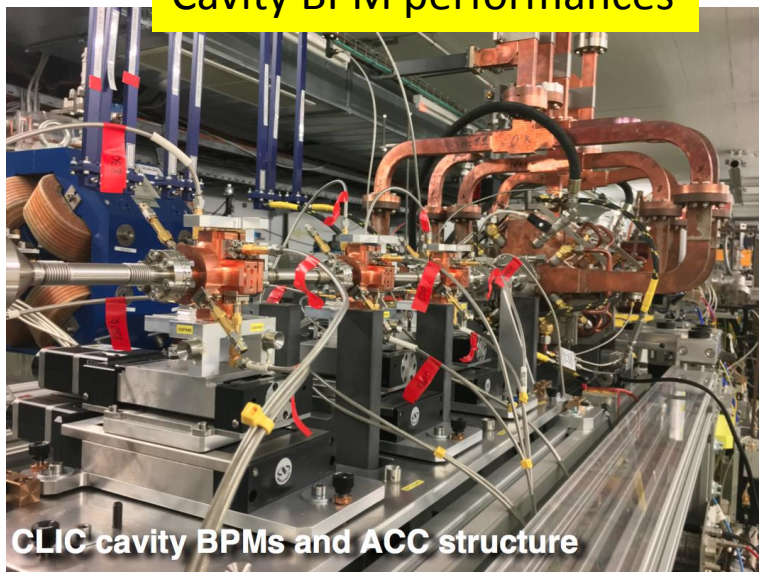
Inductive BPM upgrade





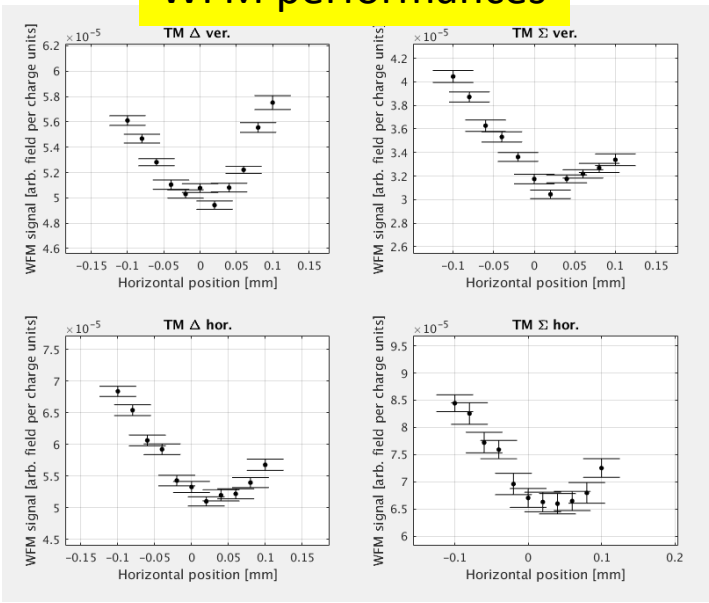
Beam Instrumentation upgrade and development, Michal Grupa

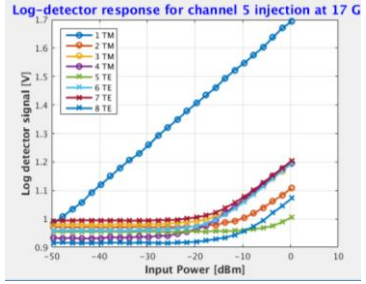
Cavity BPM performances



Status and plans for the Cavity BPMs, Johanes Nadenau

WFM performances

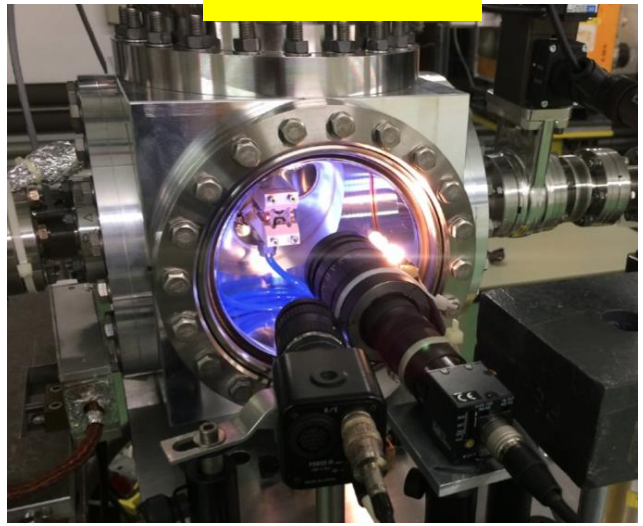


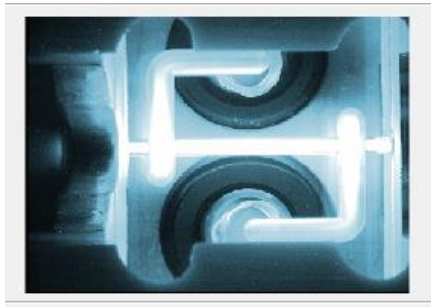


Update on Wake-Field Monitor Studies in CLEAR, Kyrre Sjøbæk

Some experiments (end, so far…)

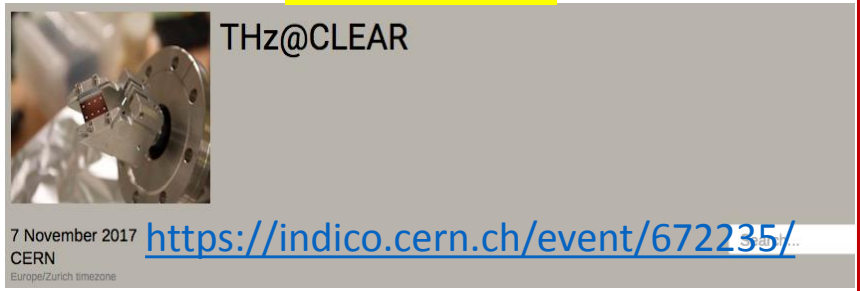
Plasma Lens

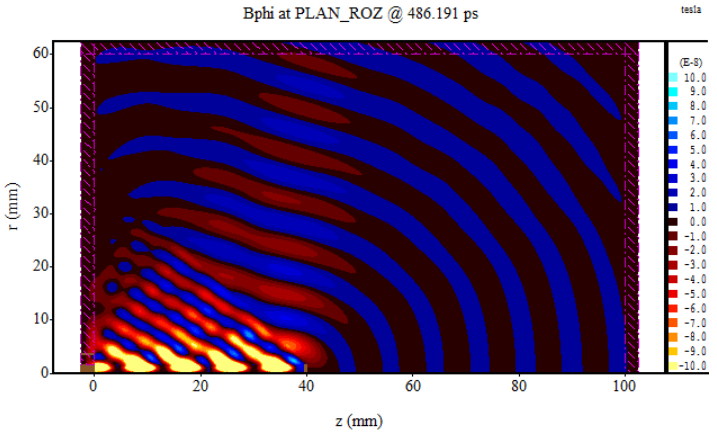




1/ The Plasma Lens Experiment at CLEAR: Experimental Set-Up and Results
2/ Progress on active plasma lens technology in CLEAR, Carl Lindstrøm and all.

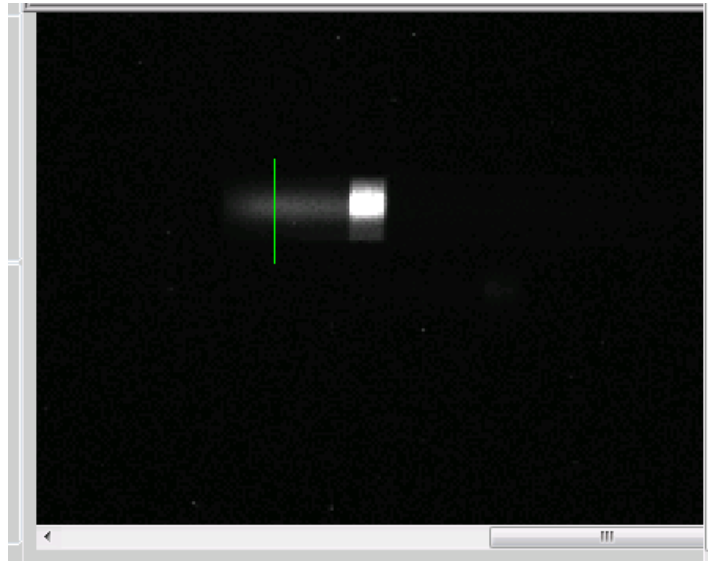
THz studies





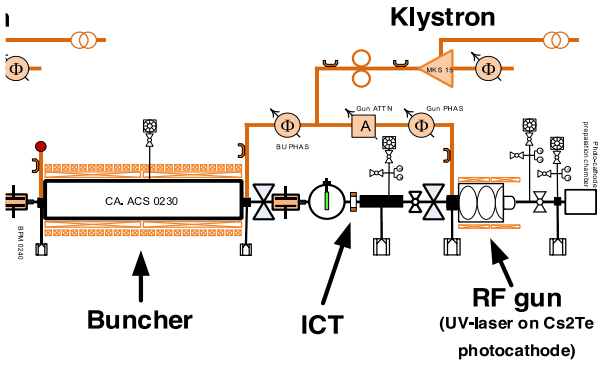
THz@CLEAR: source and diagnostics for the electron acceleration, Alessandro Curcio

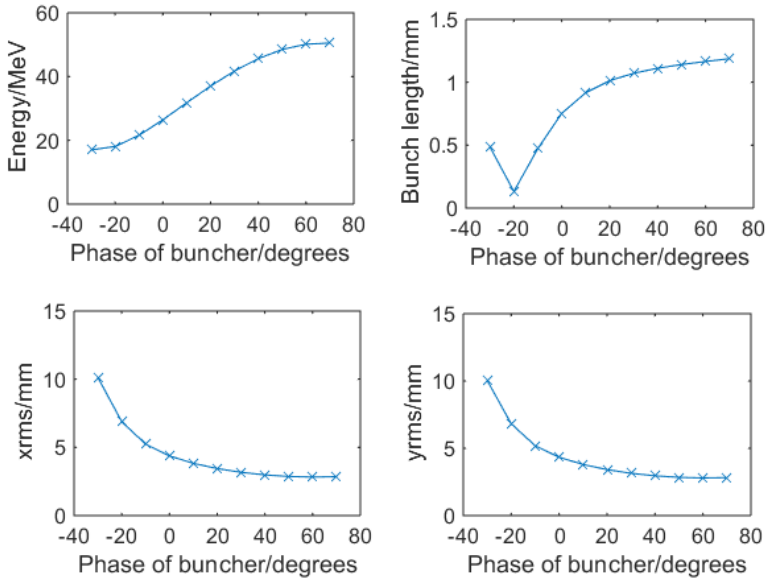
Cherenkov diffraction



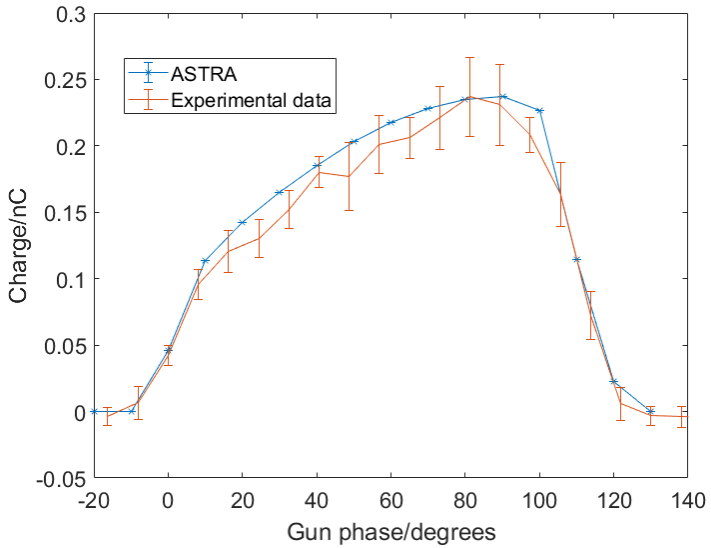
Non-invasive beam diagnostic for advanced accelerators: Cherenkov Diffraction radiation, Robert Kieffer, Thibault Lefevre

Injector optimisation for shorter bunch length





Beam parameters after the buncher as a function of the buncher phase, Aimee Ross, Oxford



Total charge measured at 0.8 m from cathode as a function of gun phase, from ASTRA simulations and experimental data.

- Collaboration with **LAL** colleagues and Oxford technical students.
- Aim to:
  - Verify the theoretical best performance achievable (0.1 ps bunch length, 5 mm-mrad possible?)
  - Crosscheck of **ASTRA** simulations.
  - Guide the optimisation of our injector.

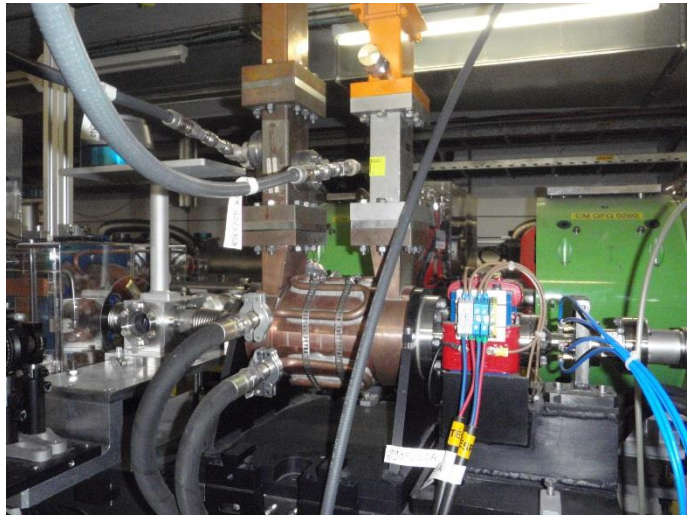
C. Bruni and al., LAL

Experiment proposals

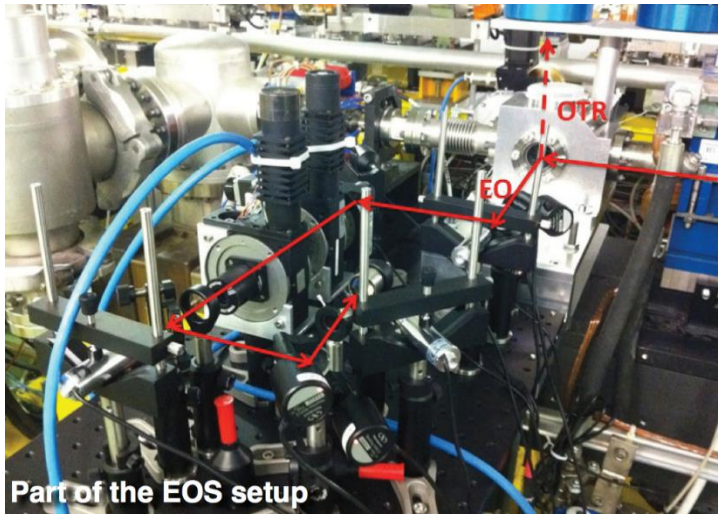
- gun with dark current only (field emission):
  - Optimize dark current extraction using profile monitor.
  - Transport of the dark current through the accelerating structures.
  - Energy, charge and Twiss parameters measurement.
  - Preparation of a large beam for the irradiation test stand.
- Charge measure vs. phase scan of the gun, photo-cathode quantum efficiency measurement
- Energy measure at the gun output using corrector,
- Observation of the gun beam loading on the gun E field antenna.
- Transport of the beam, phase to inject the bunches in the structures, alignment using the BPMs
- Alignment of the beam in the quadrupole observing the kick
- Energy measure in the spectrometer line
- Emittance measurement using the quad scan method
- Experimentation on velocity bunching with bunch length diagnostics

Full set of diagnostics for bunch length measurement

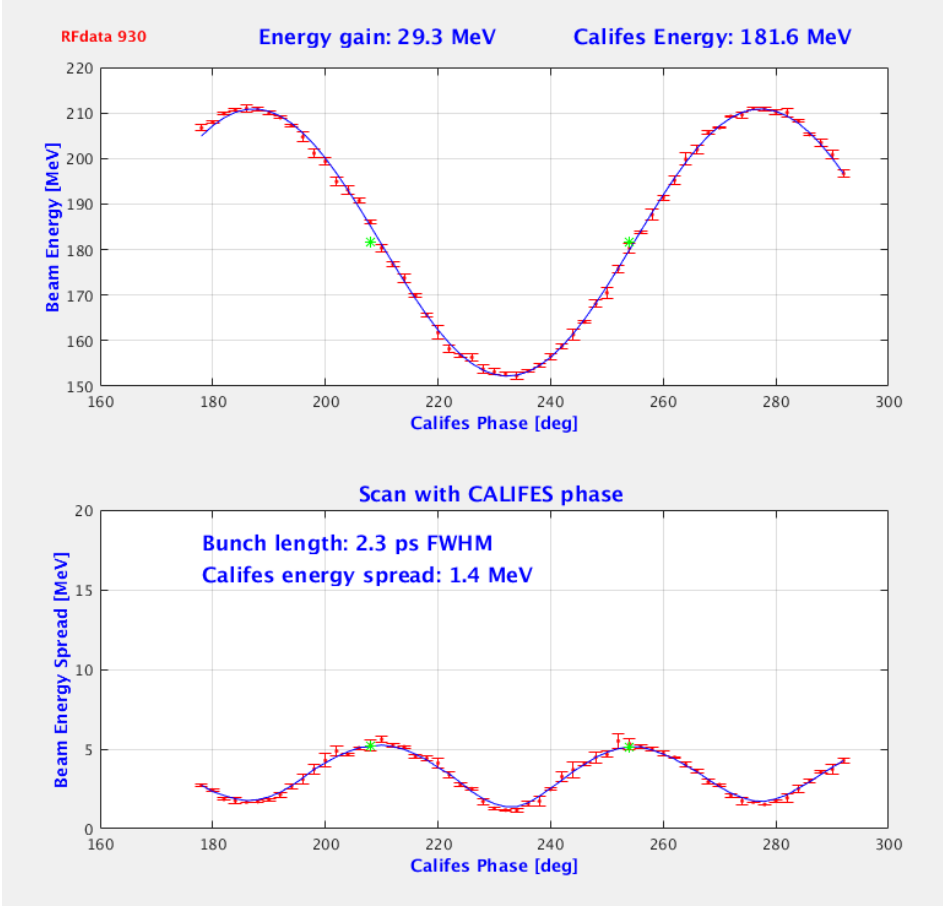
- Streak camera (on laser and on beam)
- S-band deflecting cavity (MKS31 permanently connected)
- Energy spread at zero crossing on LIL structures
- Energy spread at zero crossing on X-band structures (once connected)
- BPR and THz radiation (non interceptive)
- Electro-optical sampling (BI plan for EOS revival, Ishkhan Gorgisyan)



S-band deflecting cavity

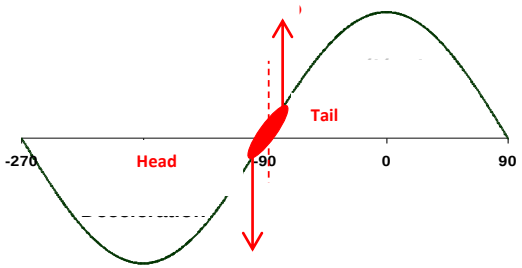


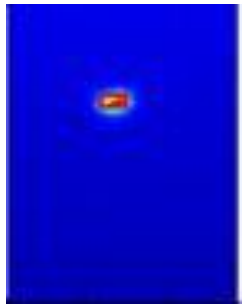
Electro-optical sampling

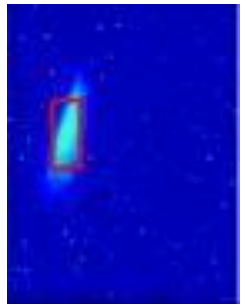


Phase scan with X-band structures (19 oct 2016)

Bunch length measurement with structures







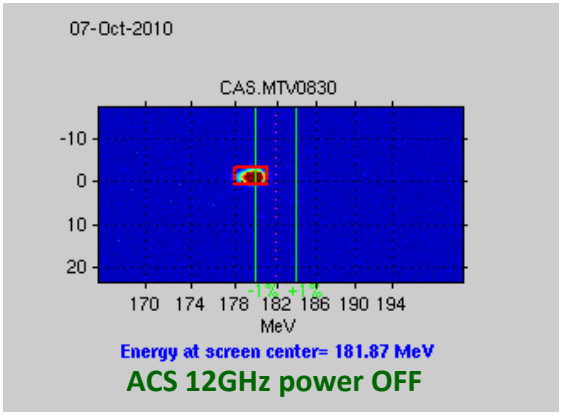
Cavity OFF
σy = 0.24 mm

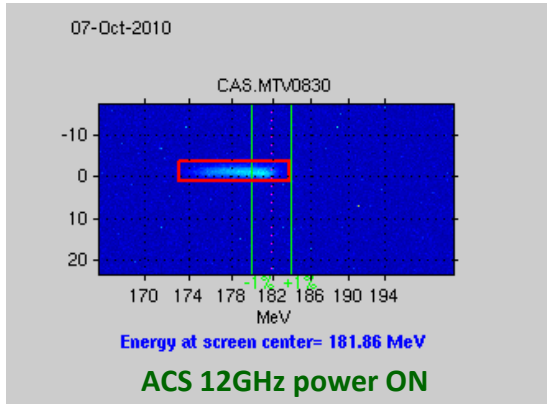
Cavity ON
σy = 1.47 mm

Operating principle:
- bunch pass at zero crossing in a deflecting cavity
- bunch head experiences a transverse kick downward, bunch tail upward
- bunch transverse size is then downstream measured on a beam profile monitor

-Power phase shifter allows to vary the bunch length via the velocity bunching structure

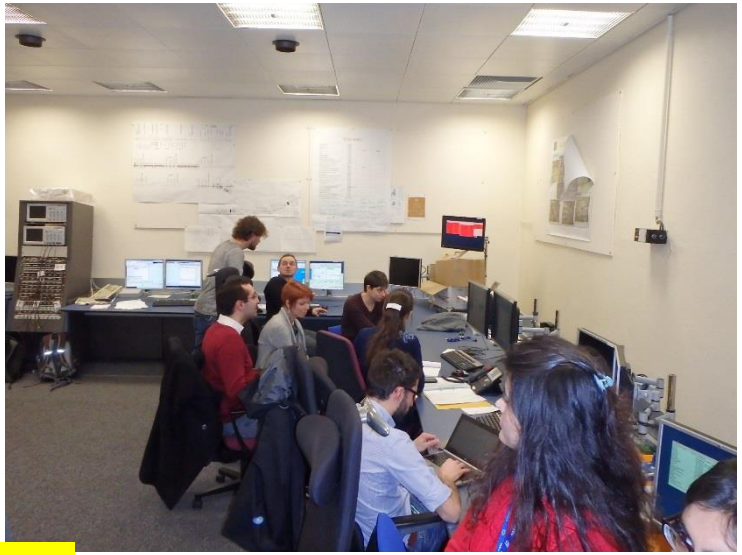
With a deflecting cavity



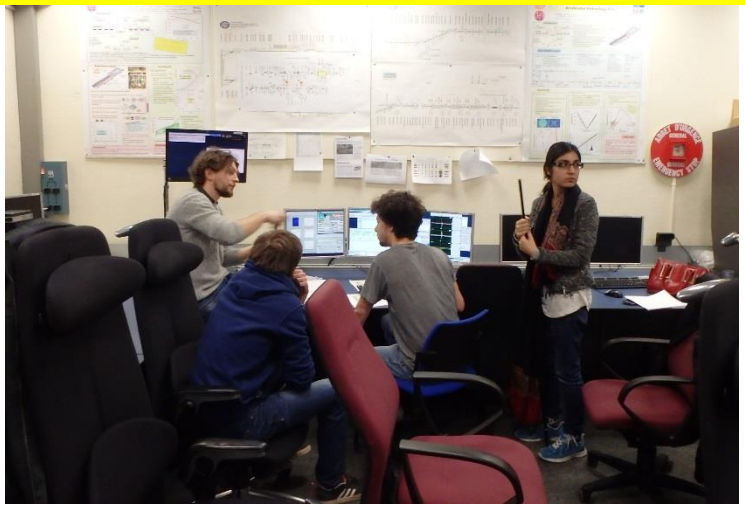


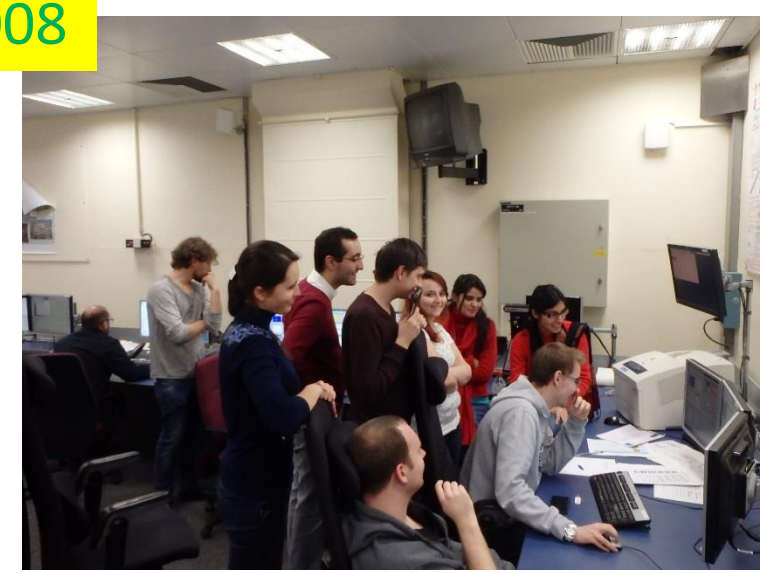
With an accelerating structure

JUAS practical works 2016

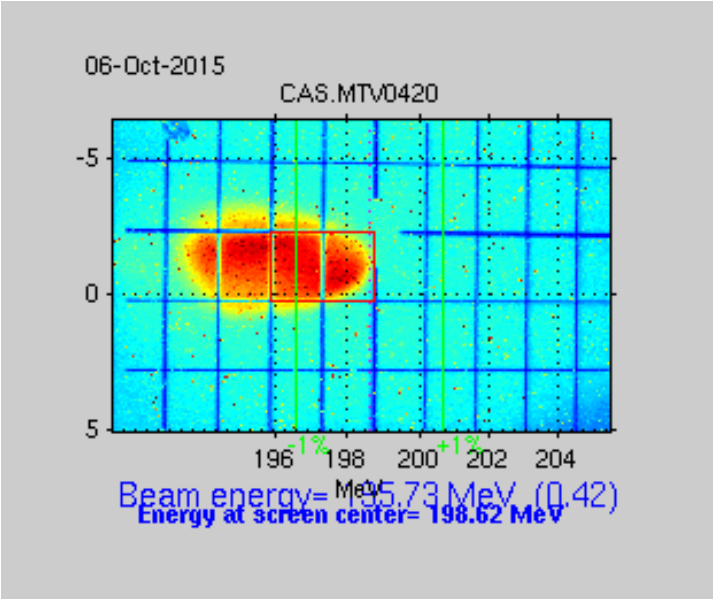


In CLEAR control room: Building 2008

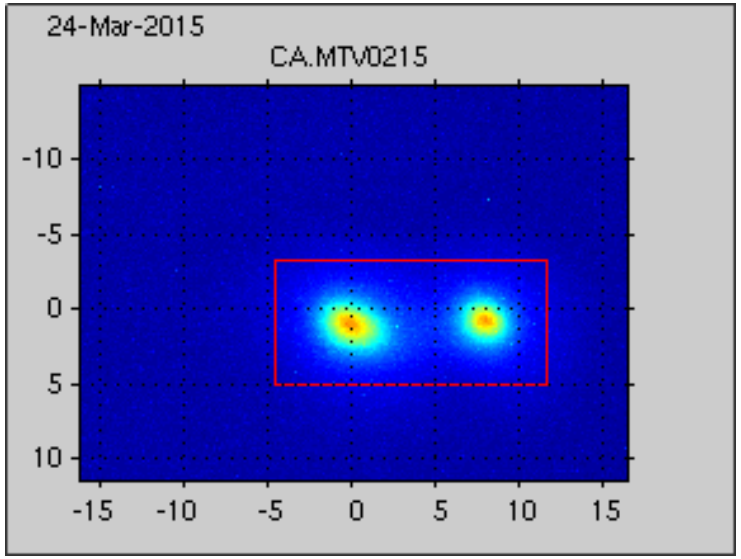




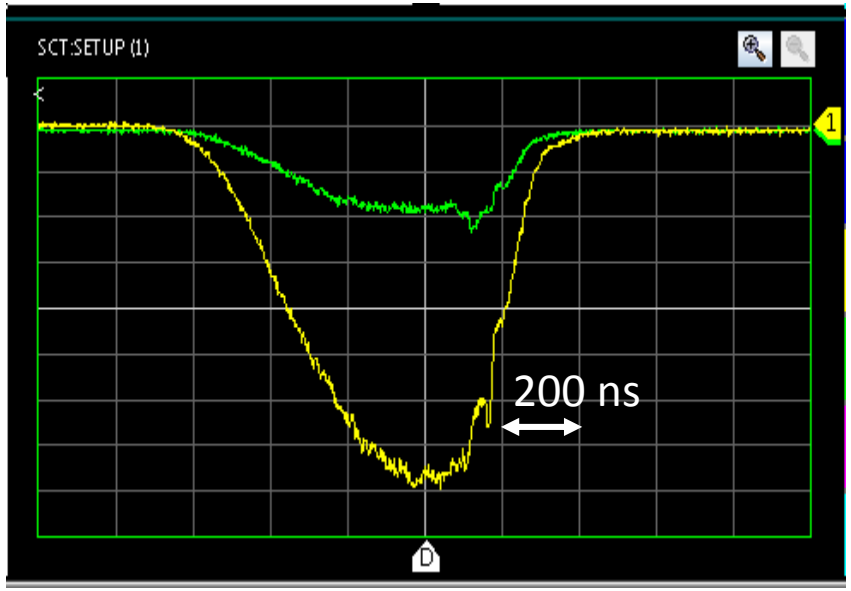
Dark Current



Large dark current beam on irradiation test bench

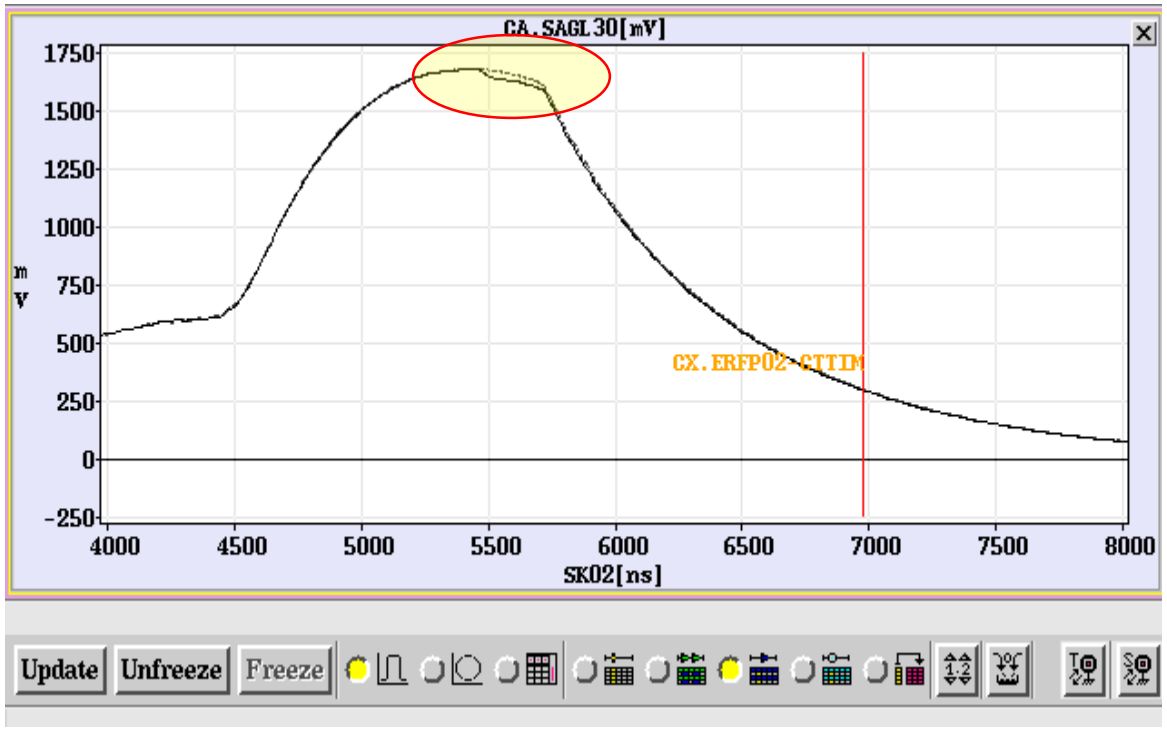


Dark current and laser generated beam separated

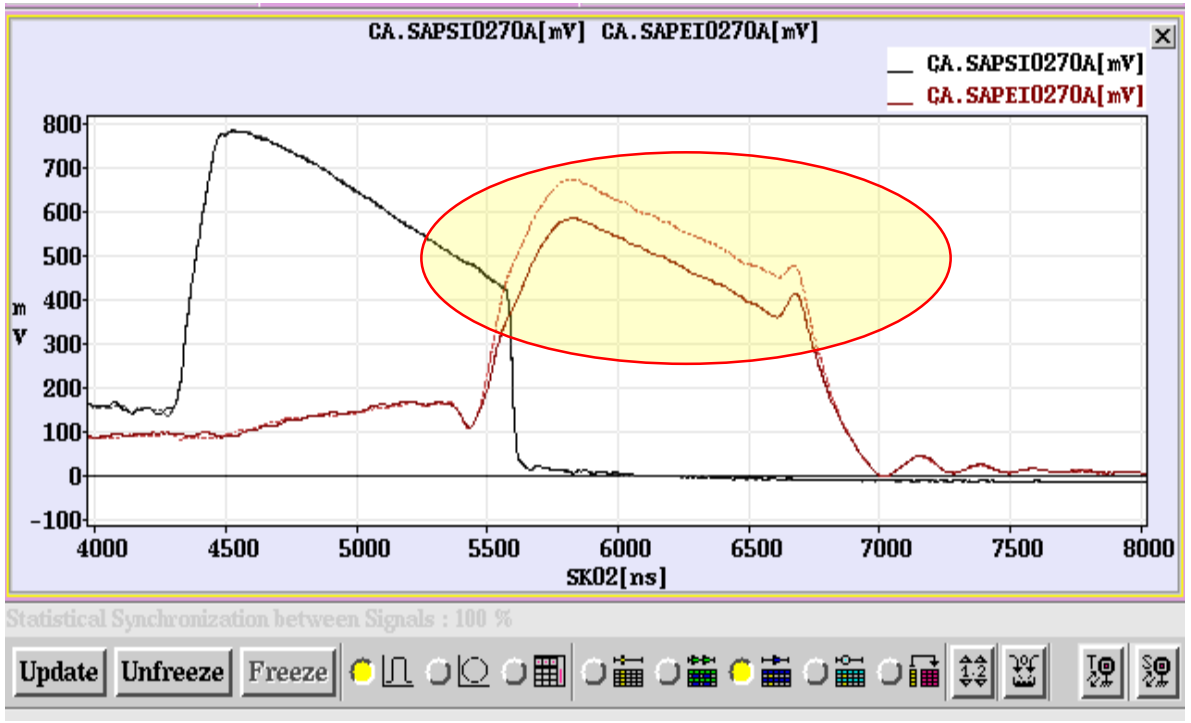


Dark current time profile

Beam loading

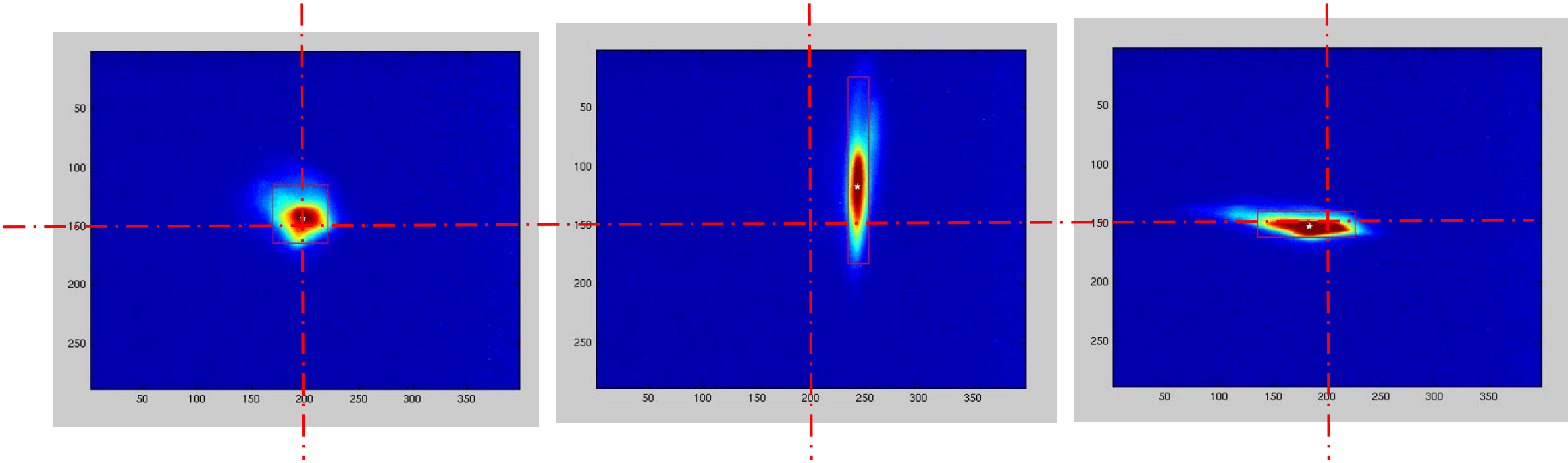


E field in the gun



Accelerating structure input and output power

Alignment of the beam inside quadrupoles



Quads Off

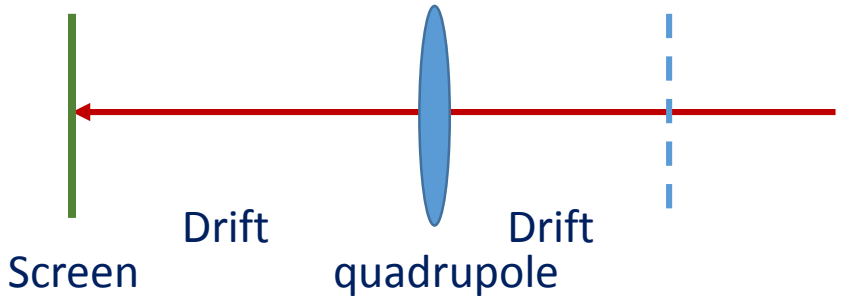
Horizontal focusing quad on
Beam offset in both axis

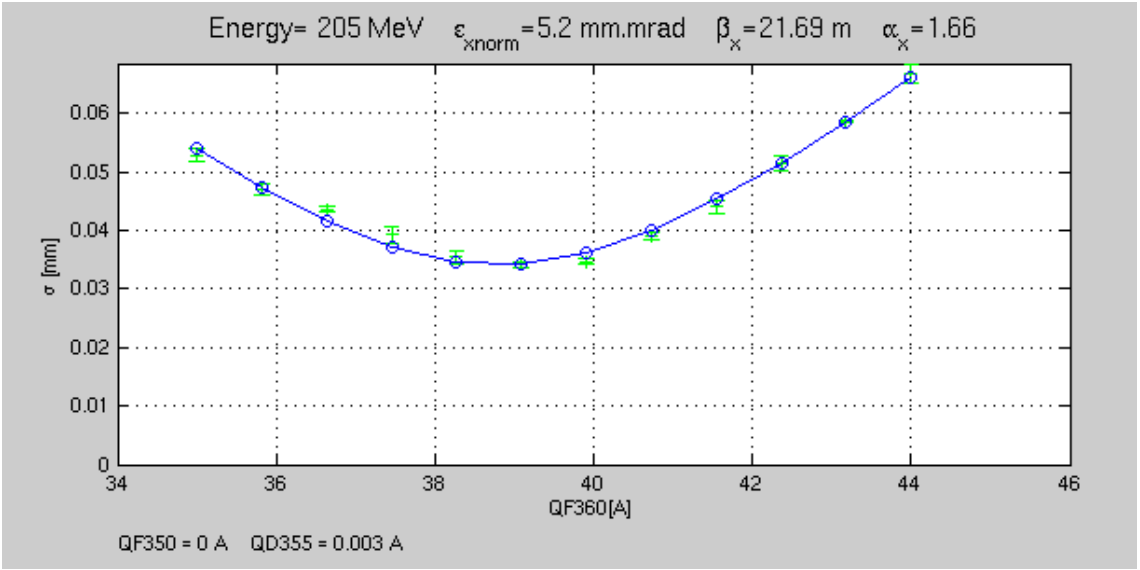
Vertical focusing quad on
Horizontal beam offset

Quadrupole scan

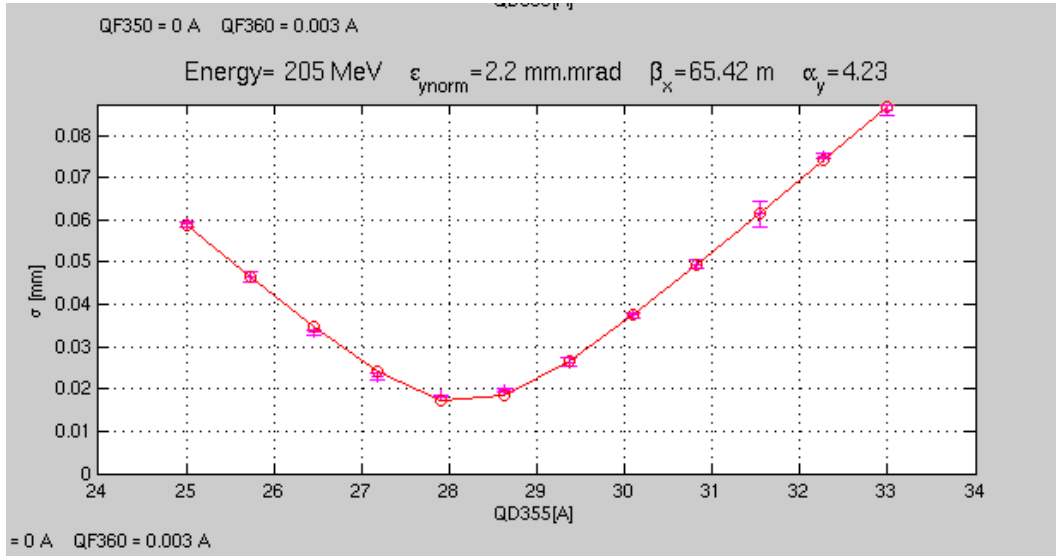
$$\begin{pmatrix} \beta_s & -\alpha_s \\ -\alpha_s & \gamma_s \end{pmatrix} = \begin{pmatrix} A_{0S} & B_{0S} \\ C_{0S} & D_{0S} \end{pmatrix} \begin{pmatrix} \beta_0 & -\alpha_0 \\ -\alpha_0 & \gamma_0 \end{pmatrix} \begin{pmatrix} A_{0S} & C_{0S} \\ B_{0S} & D_{0S} \end{pmatrix}$$

$$\begin{pmatrix} \beta_{s,1} \\ \beta_{s,2} \\ \vdots \\ \beta_{s,n} \end{pmatrix} \epsilon = \begin{pmatrix} A_1^2 & -2A_1B_1 & B_1^2 \\ A_2^2 & -2A_2B_1 & B_2^2 \\ \vdots & \vdots & \vdots \\ A_n^2 & -2A_nB_n & B_n^2 \end{pmatrix} \begin{pmatrix} \beta_0 \\ \alpha_0 \\ \gamma_0 \end{pmatrix} \epsilon$$



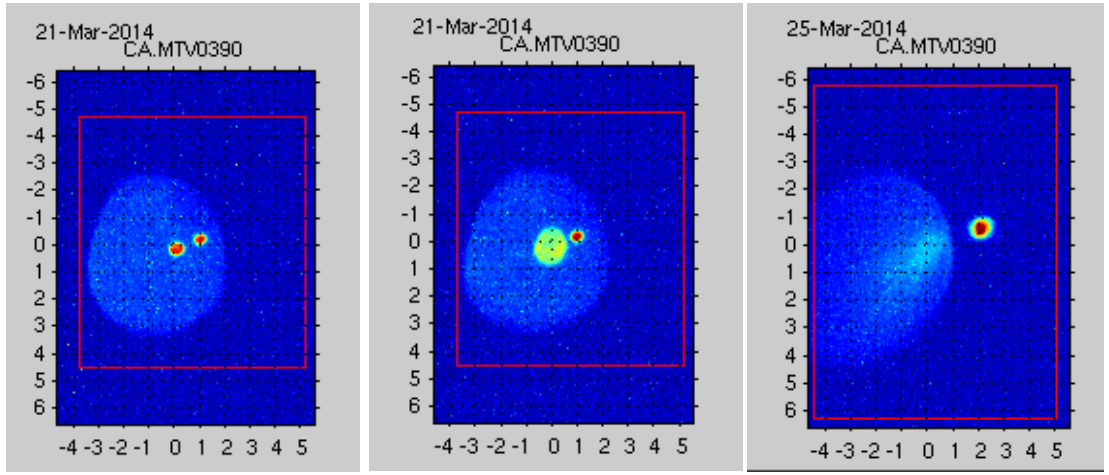


Horizontal beam size as function of quadrupole current

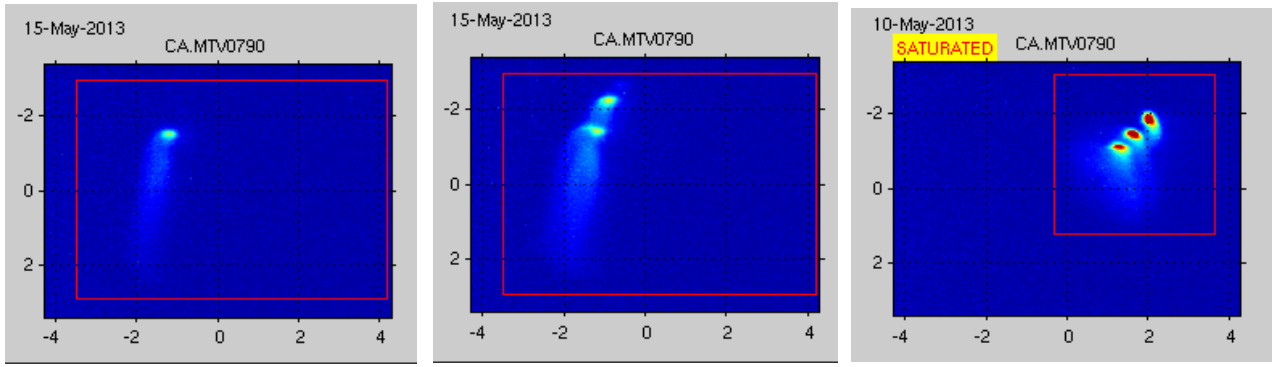


Vertical beam size as function of quadrupole current

Strange beam contest

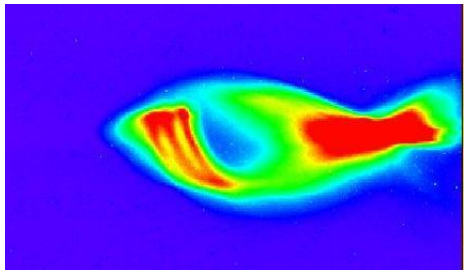


3 bunches of various charge and emittance

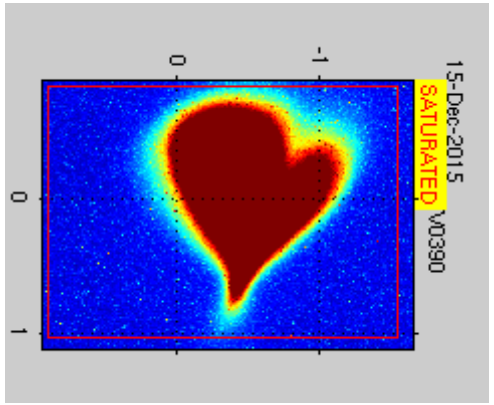


1, 2, 3… bunches with transverse space separation

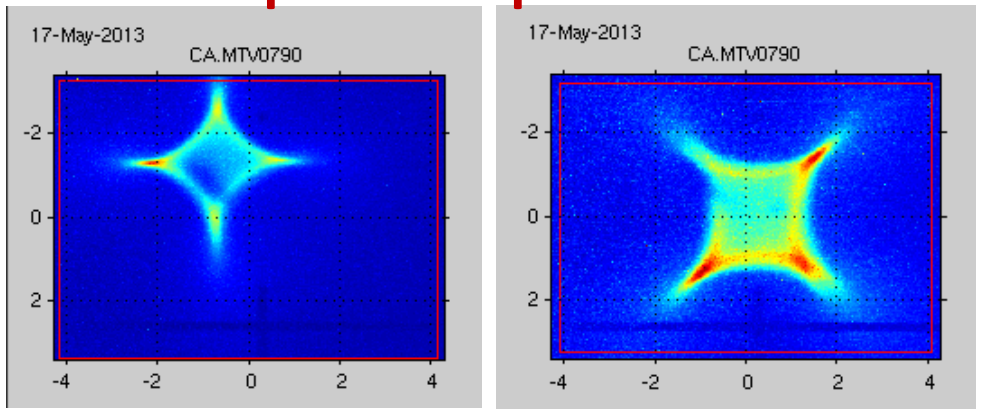
You are very welcome to participate



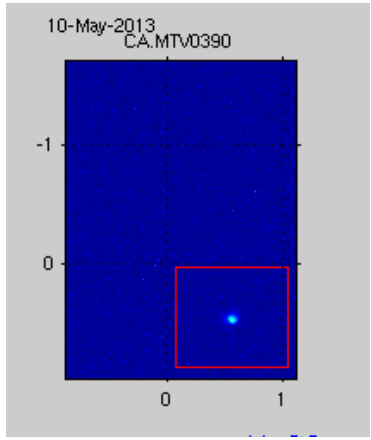
Fishy beam



Valentine's day beam



Octupolar fields beam shape



Beam size 37 x 33 μm