

Recent and upcoming work on CLARA

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on behalf of the CLARA project team

CLIC Workshop 2019
CERN, 21-25 January 2019



CLARA

Compact Linear Accelerator for Research and Applications

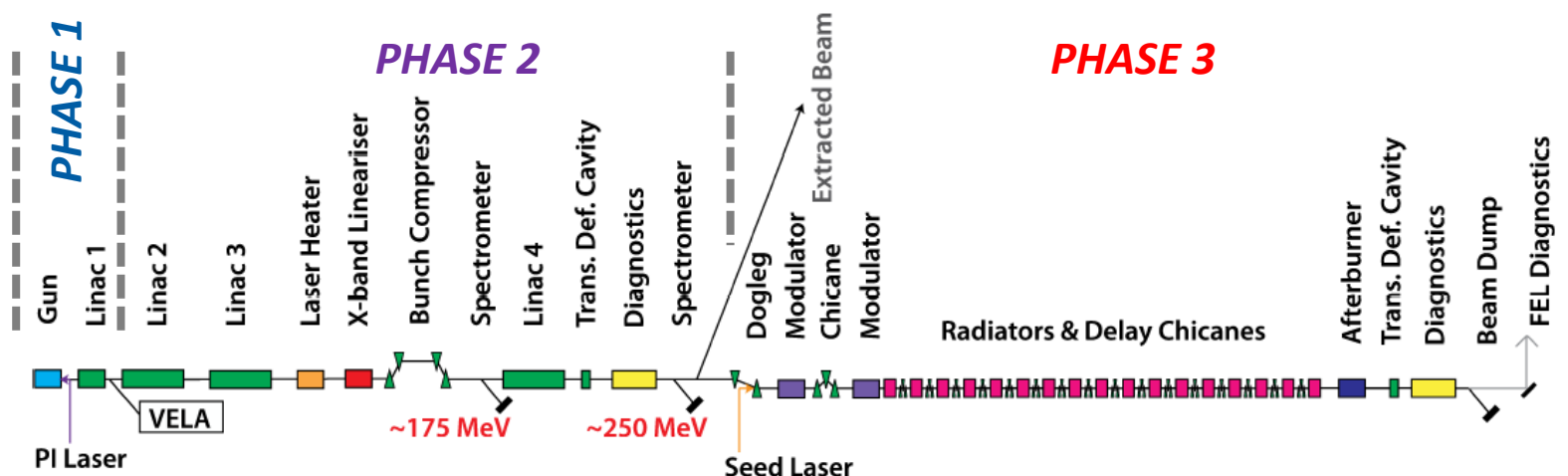
A flexible FEL Test Facility

Proof-of-principle demonstrations of novel FEL concepts and development of future accelerator technologies

*Emphasis on **Stability, Synchronisation and new FEL capabilities***



CLARA: FEL Layout and Status



PHASE 1: **50 MeV, INSTALLED AND NOW COMMISSIONING**

- 2018: Beam characterisation, machine development and exploitation with 10Hz gun
- 2018-19: Conditioning and characterisation of 400Hz gun

PHASE 2: **250 MeV, BEING PROCURED AND ASSEMBLED**

- 2018: Module assembly offline
- 2019: Shielding changes
- 2020: Installation

PHASE 3: **100 nm FEL, NOT YET FUNDED**

- ~~2018: Full release of funds...?~~
- 2021: Installation
- 2022: Lasing!!

CLARA: Refurbished, insulated building



CLARA: Phase 1 Installed



CLARA Phase 1: 50MeV Beam December 2017 250pC March 2018



CLARA - First Beam Celebration

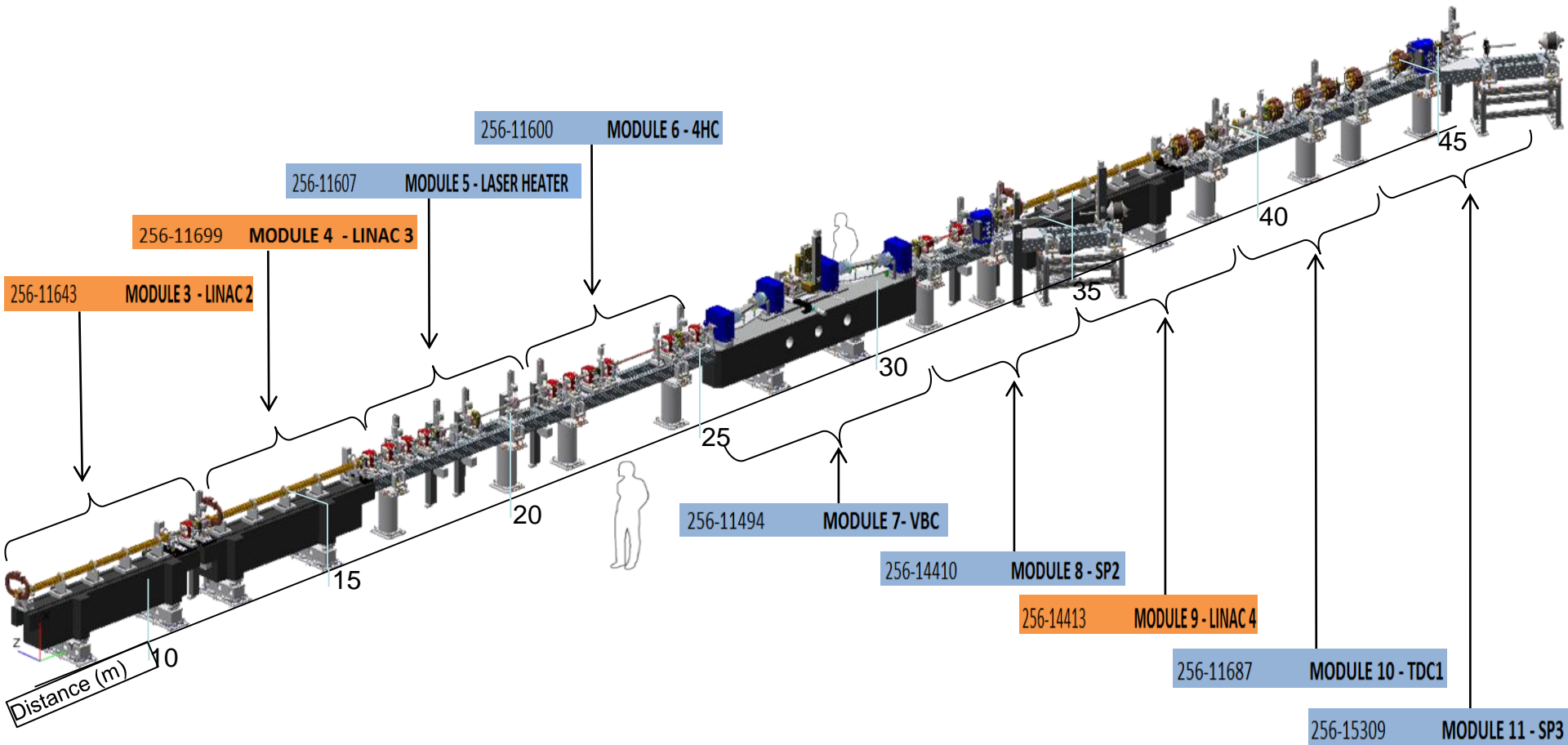
Congratulation to the whole CLARA team and to those throughout STFC who have supported and helped in the delivery this major CLARA project milestone.
December 2017

First Accelerated Beam (48MeV/c)

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CLARA Phase 2

- CLARA Phase 2 will complete the accelerator (up to 250MeV)
- **The modules are now being built offline at Daresbury**
- **Assembly of remaining shielding enclosure for full facility this year**



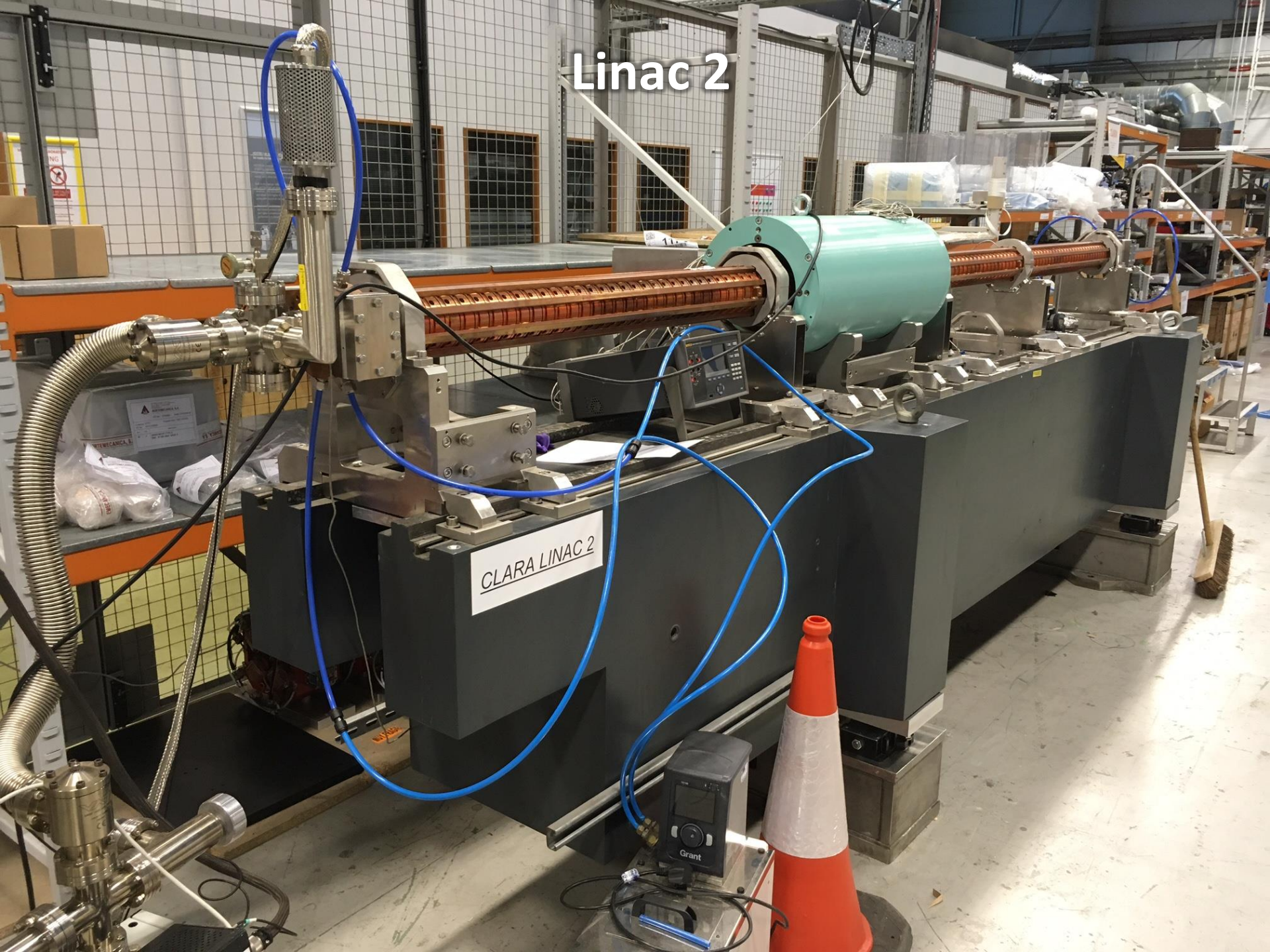
Variable Bunch Compressor: Under Vacuum



Modules 5, 6 & 10 Assembly



Linac 2



CLARA LINAC 2

Grant

Linac 2 RF Modulator



CLARA Funding Status

- So far we have received funding year by year, from STFC internal funds, which makes it difficult to manage the project
- A £30m application in 2018 to UKRI Strategic Priorities Fund to complete the project was **rejected**
- We are studying options for CLARA to continue
- Likely to go ahead: **FEBE** (Full Energy Beam Exploitation)

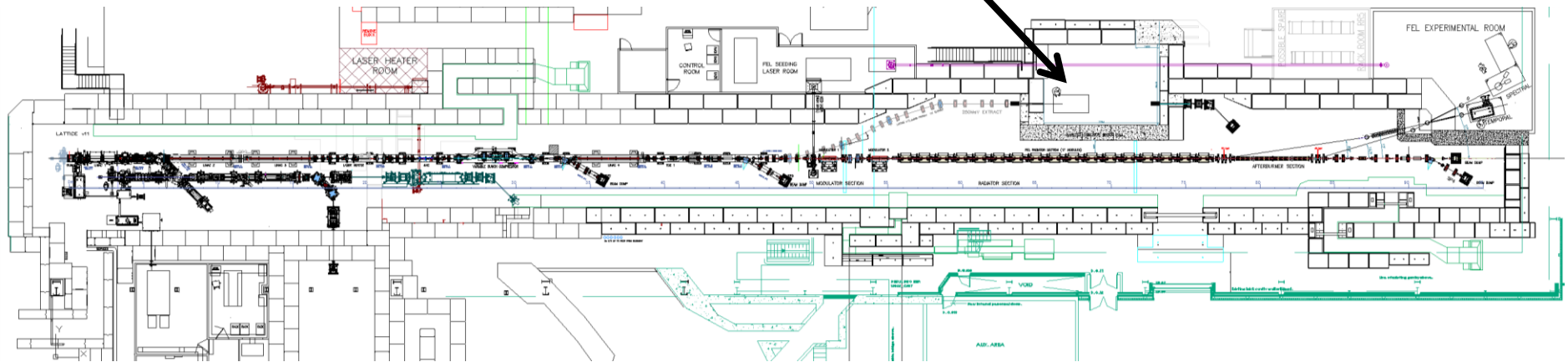
CLARA Exploitation: Phase 1

- Phase 1 exploitation started in September 2018
 - For UK researchers from our partner institutes
 - For European researchers via Trans-National Access, funded by ARIES (H2020)
 - For industry
- 3 months of beamtime was allocated between Sept and Dec 2018
 - Due to laser problems, this was **extended** to the end of February 2019
- So far: six experiments
 - Novel acceleration
 - Diagnostics development
 - Radiotherapy studies
- Next: major shutdown (~4 months) to reconfigure the shielding at the downstream end of the existing facility
- Following this shutdown, and the subsequent recommissioning, we are planning additional exploitation time in 2019

CLARA Exploitation: Longer Term

- We are actively developing plans for access to the 250 MeV electron beam in the final facility for novel acceleration, VHEE, etc
- Access will be via an extracted beamline:

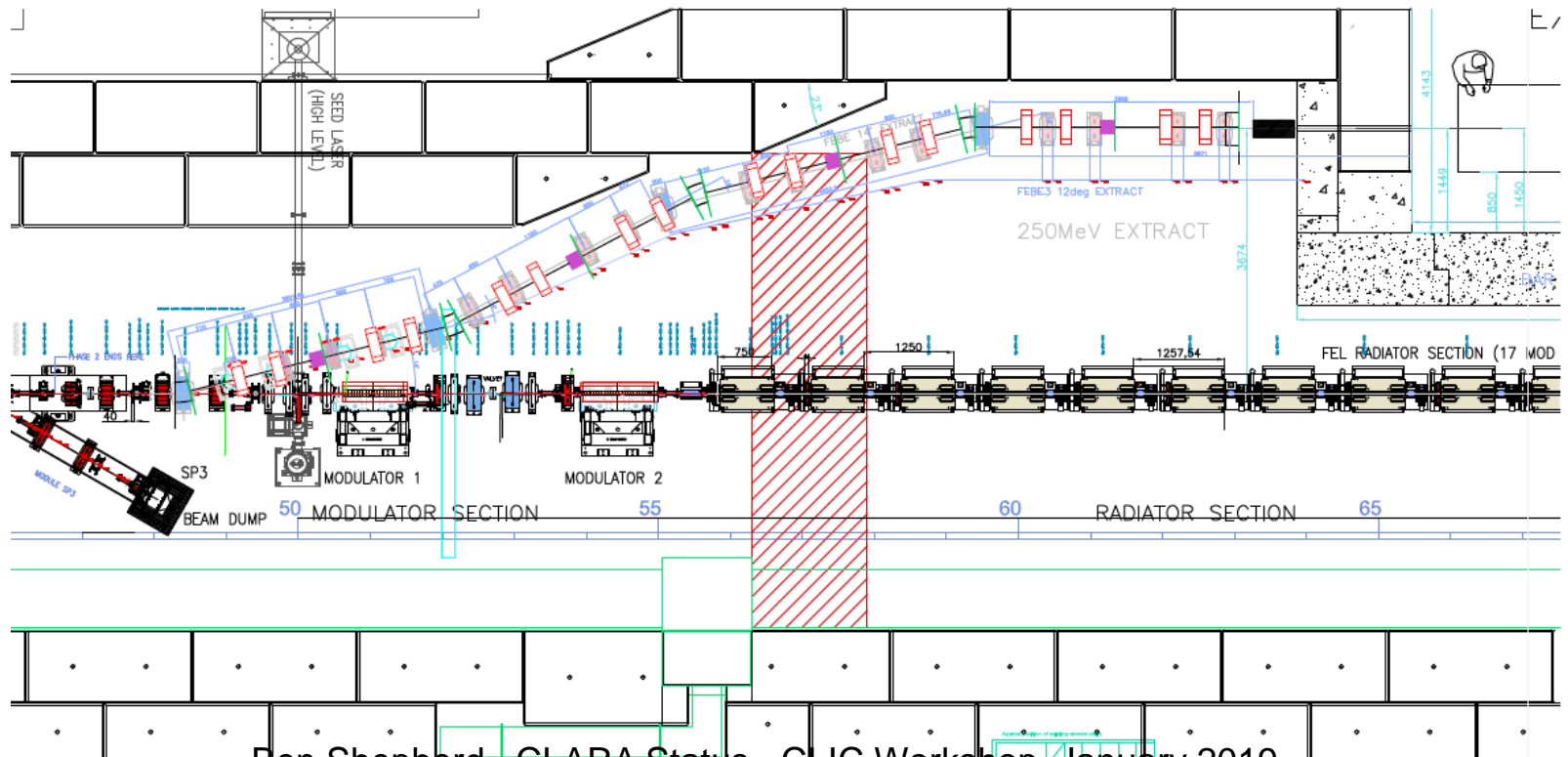
FEBE – Full Energy Beam Exploitation



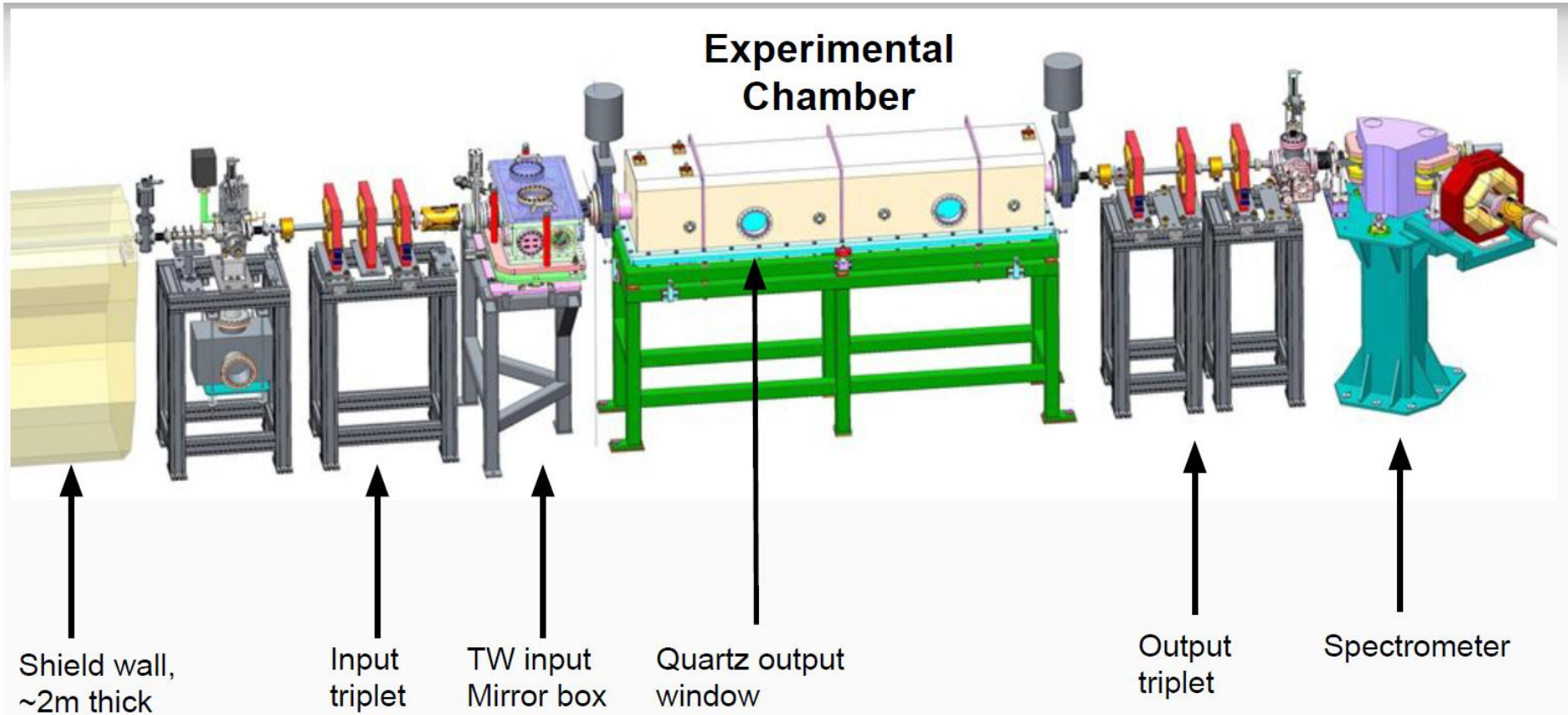
- There are also a few locations reserved within CLARA itself for online testing of items such as novel diagnostics or undulators

FEBE

- Beam extracted (DC) before the FEL
- After consultation we have decided to have a separate hutch for FEBE so experiments can be built up and adjusted whilst CLARA is operating
 - Efficient use of valuable beam time
 - Previously FEBE was planned to be within the same tunnel as CLARA



CLARA Exploitation: Beam Area 1

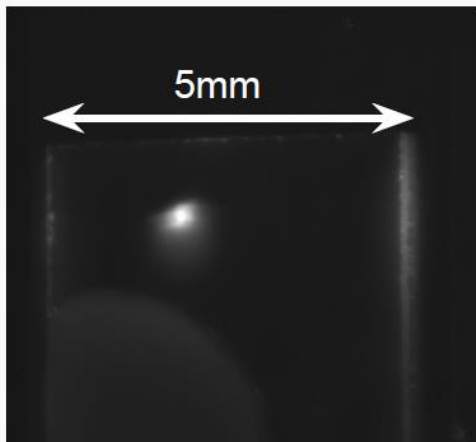


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Beam Area 1 bunch parameters

Still optimising machine setup

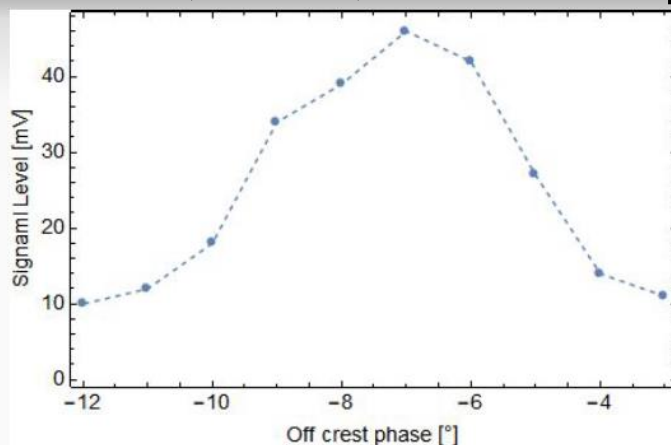
New diagnostics: 3 YAGs, CTR, Martin-Puplett interferometer



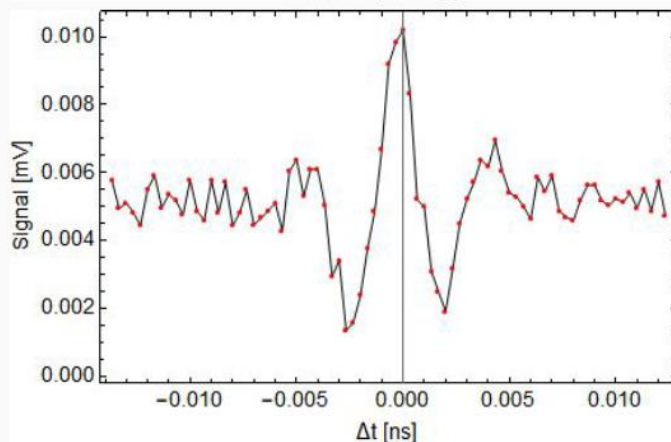
Beam focus at IP:

$$\sigma_x = 150 \text{ } \mu\text{m}$$

$$\sigma_y = 100 \text{ } \mu\text{m}$$



- CTR Power
- Bunch compression monitor
- Pyroelectric detectors



- Commissioned Martin-Puplett interferometer
- Crude data taken
- Indication of sub-picosecond RMS bunch length

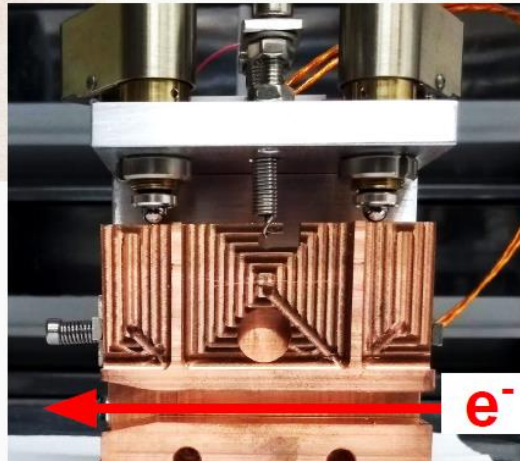
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CLARA Exploitation: Dielectric Wakefield Acceleration (DWA)



Dechirper

- 10 mm wide
- 40 mm dielectric length
- 100 μm & 200 μm thick fused silica

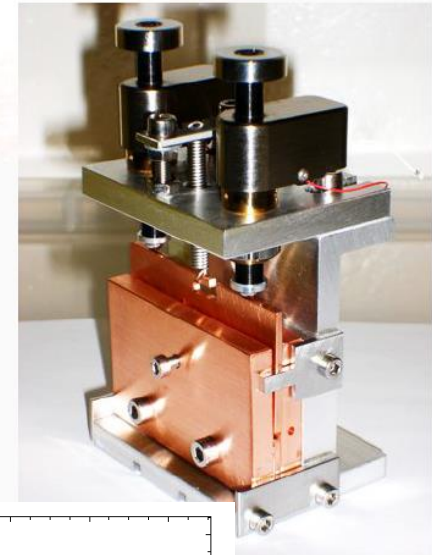


Gap = $695\mu\text{m}$ $\phi_{OC} = -16$

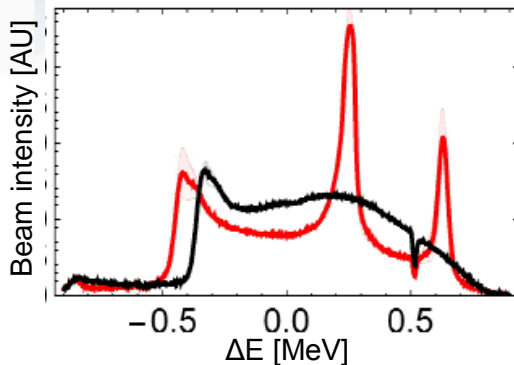


THz source

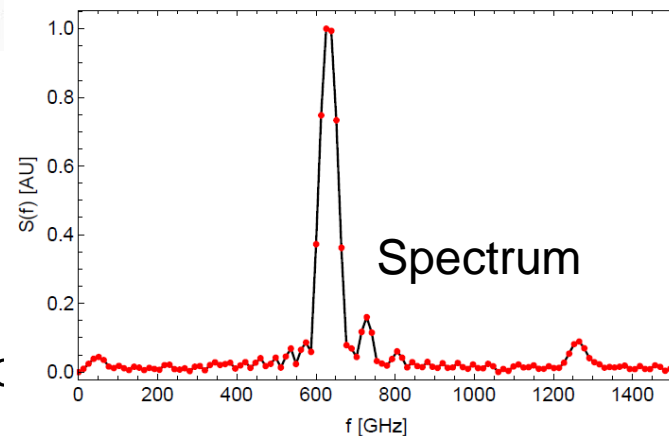
- 2 mm wide
- 40 mm dielectric length
- 25 μm thick quartz
- Tunable 0.55-0.95 THz



Results **without** /
with structure

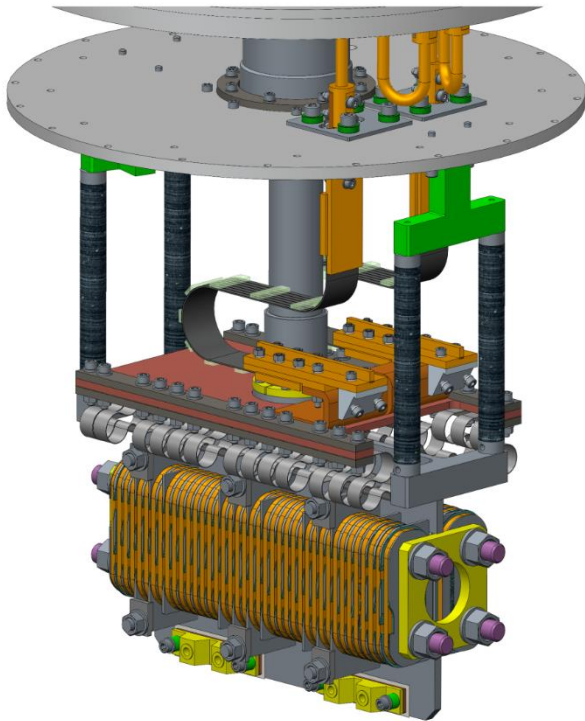


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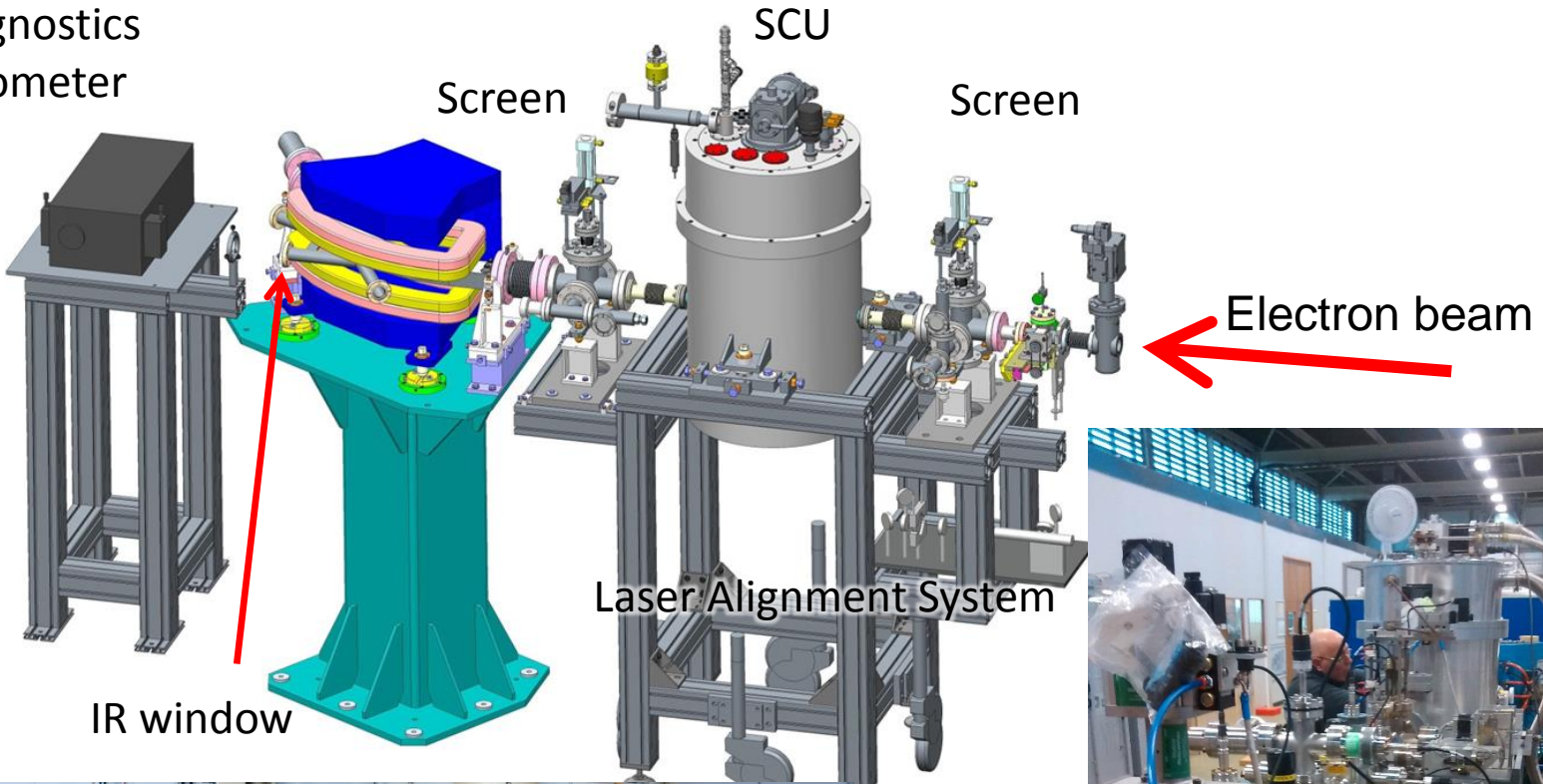
CLARA Exploitation: Superconducting Undulator

- We have assembled a **30 cm** in-vacuum SCU Prototype
- **15.5 mm** period, **7.4 mm** gap, $B_{max} = 1.25 \text{ T}$, $K = 1.8$
- To be installed on CLARA at end of **Jan 2019**
- Beam time: 2 weeks in **Feb 2019**



Superconducting Undulator

Photon diagnostics
Incl. spectrometer



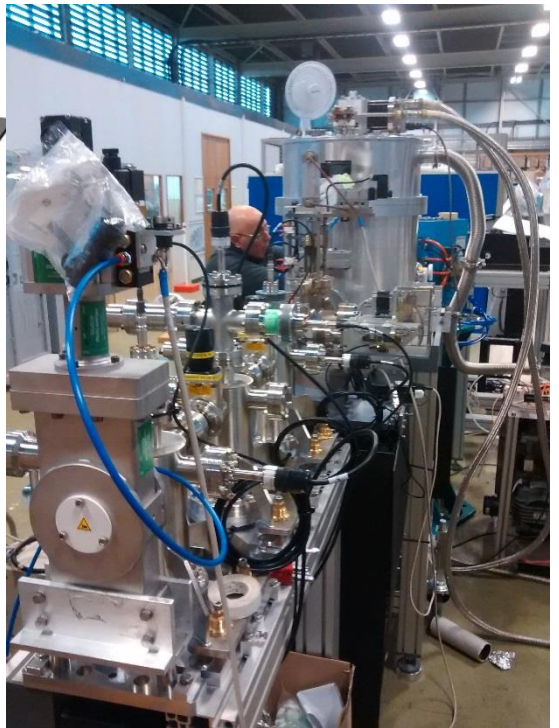
IR window

Laser Alignment System

Electron beam



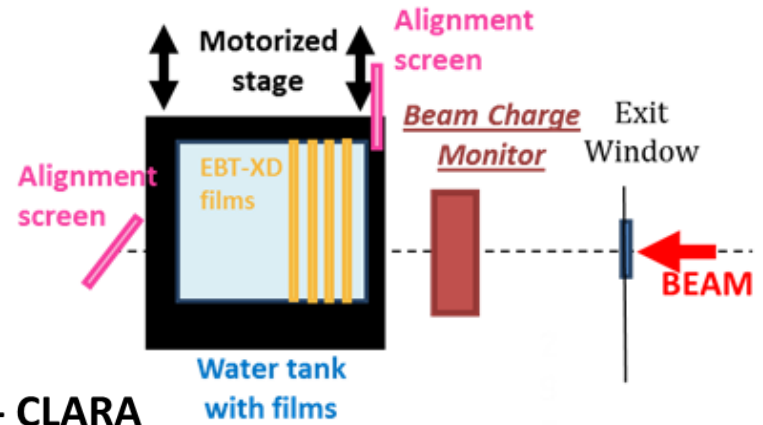
Offline
Assembly



Very High Energy Electron Dosimetry on CLARA Front End

(PI: Prof Roger Jones, University of Manchester)

- CLARA beam was used to resolve an earlier observed discrepancy in Gafchromic film-based calibration experiments at Christie Hospital and experimental dose ICT-based measurements at CERN's CLEAR facility.
- Better than **90%** agreement between two very distinct measurements – excellent result!



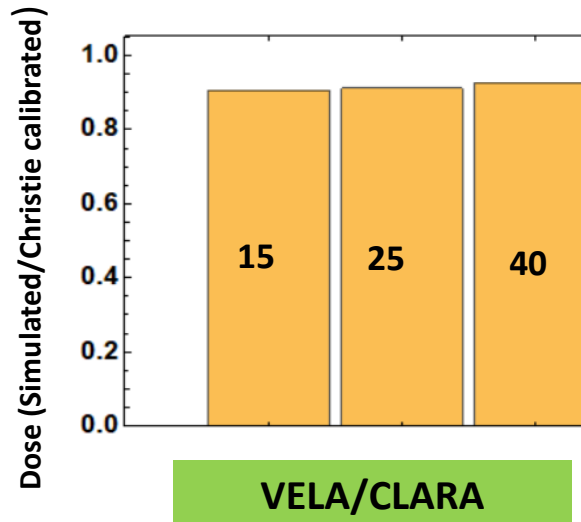
40 MeV e- CLARA

25 MeV e- CLARA



Christie Hospital (ELEKTA) CLARA (DL)

CLEAR (CERN)



Summary

- CLARA Phase 1 has achieved the design charge and energy
- Successful beam exploitation has taken place with many different experiments making good use of the CLARA beam
- Longer term plans: we will have a separate beamline and hutch (**FEBE**) at 250MeV
- Phase 2 is being assembled offline

- Thanks for the slides:
 - Jim Clarke
 - Deepa Angal-Kalinin
 - Tom Pacey

