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VELA/CLARA as Advanced Accelerator Studies Test-bed at Daresbury Lab.

Yuri Saveliev

on behalf of VELA and CLARA teams

STFC, ASTeC, Cockcroft Institute

Daresbury Lab., UK

The Cockcroft Institute of Accelerator Science and Technology

Outline

- **VELA** (**V**ersatile **E**lectron **L**inear **A**ccelerator)
- **CLARA** (**C**ompact **L**inear **A**ccelerator for **R**esearch and **A**pplications) – ongoing project
- **CLARA Front End** – near future developments
- Machines suitability for advanced accelerators studies

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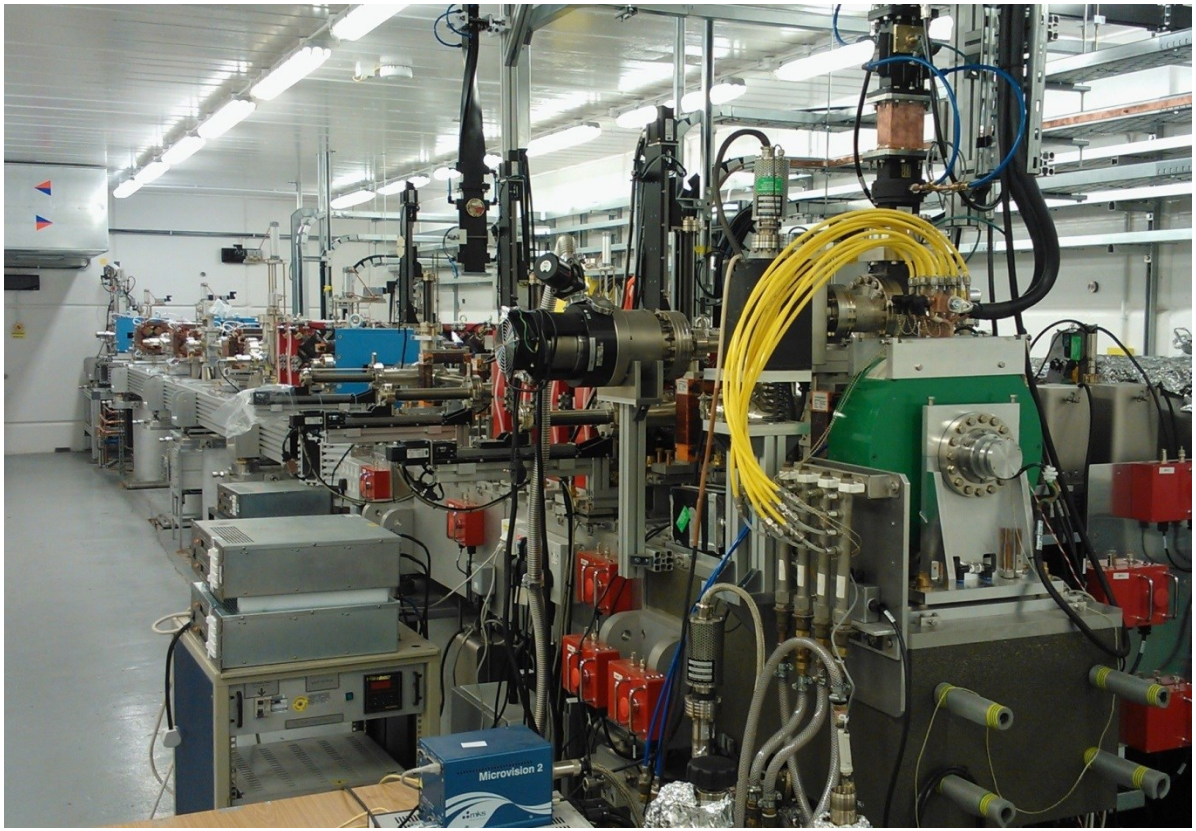
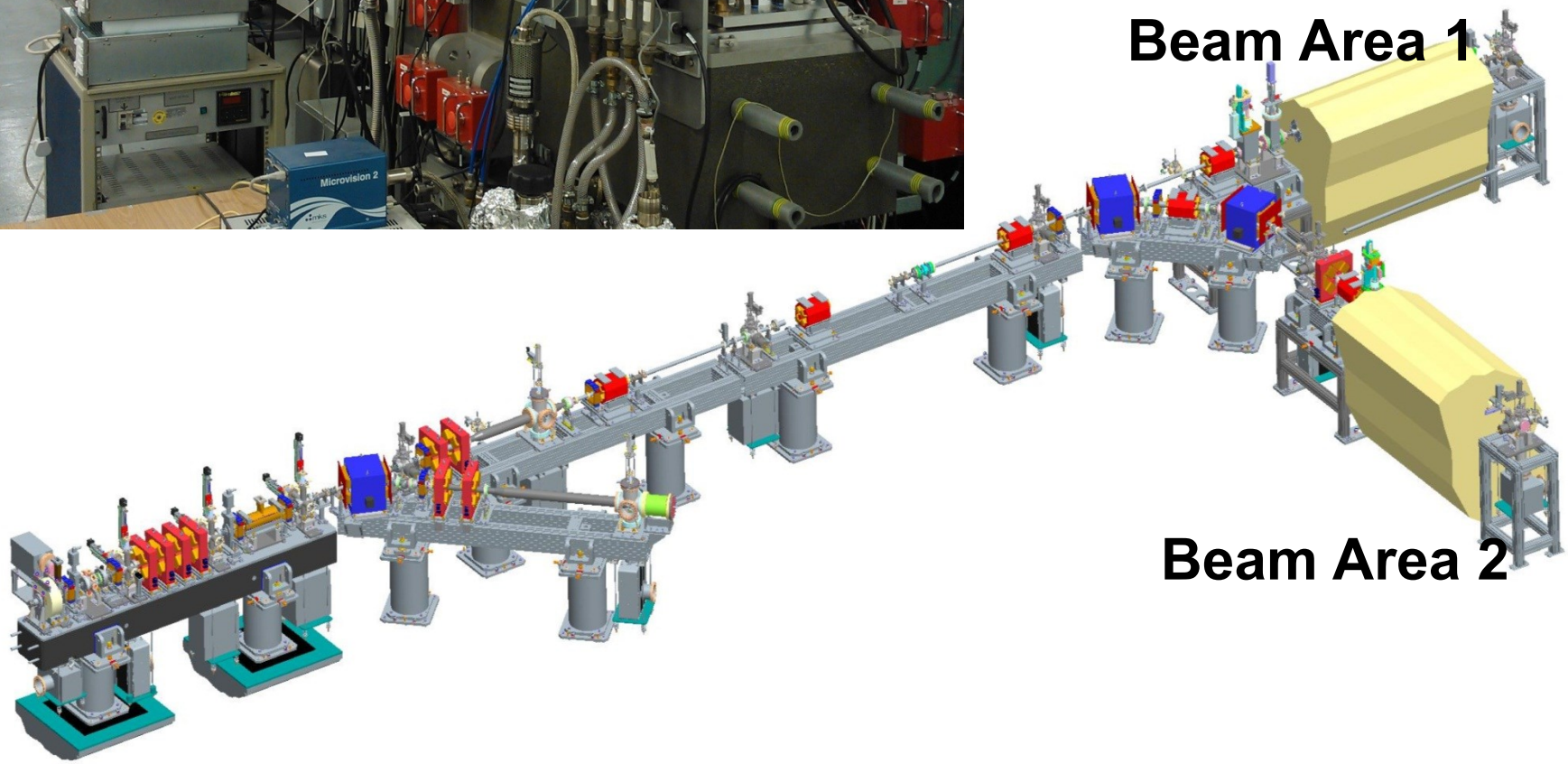
VELA

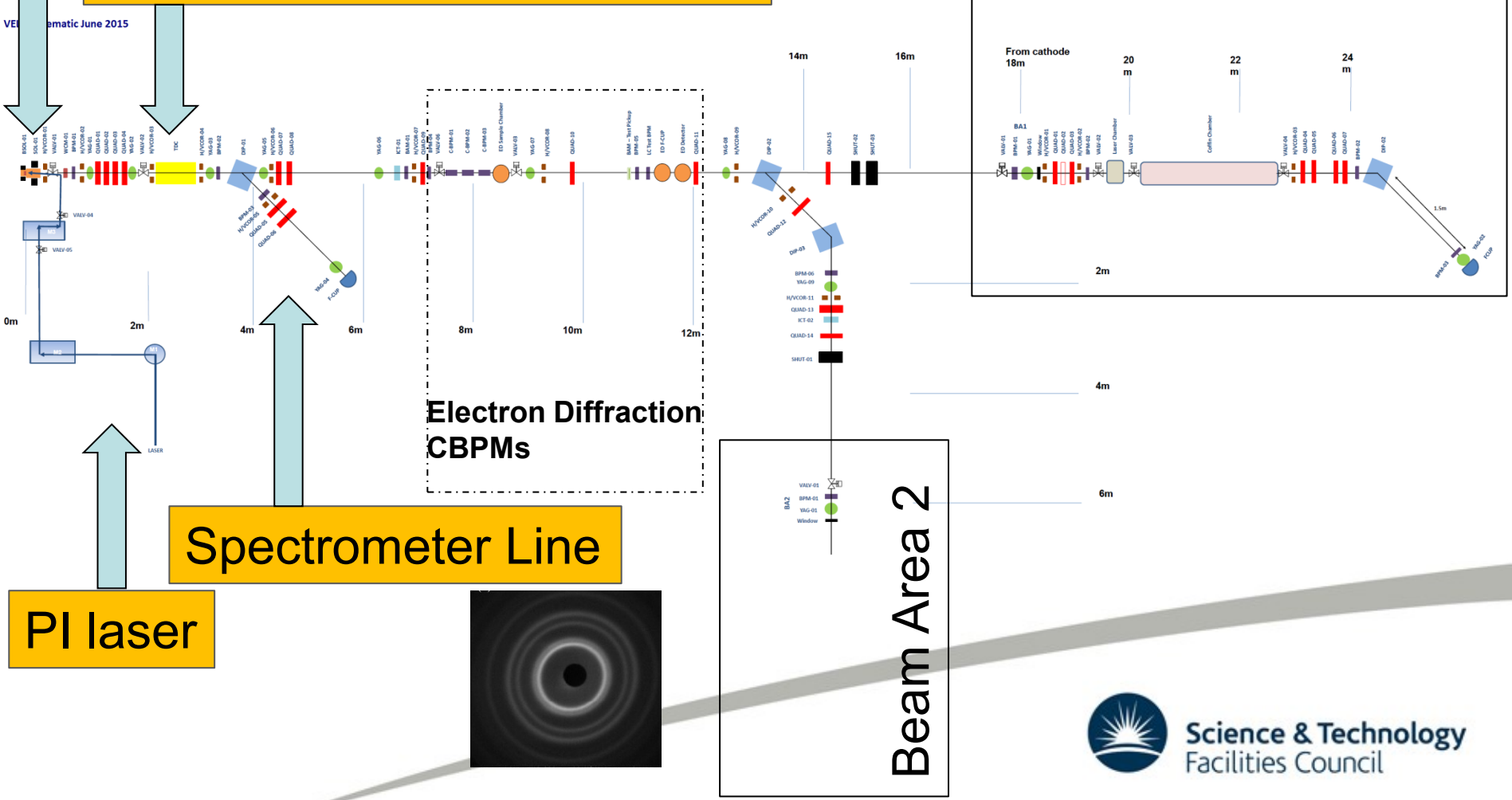




VELA schematic

RF Photo Gun

Transverse Deflecting Cavity



Spectrometer Line

PI laser

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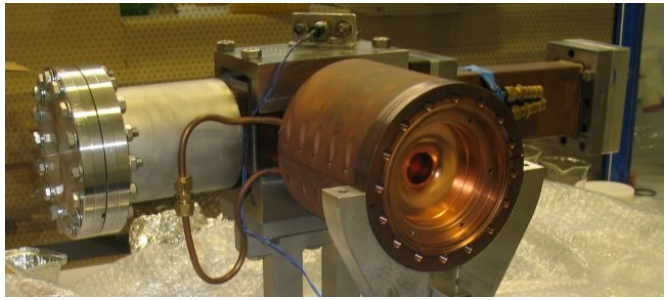
RF Photoelectron Gun



- former Alpha-X 2.5 cell S-band cavity;
- 3GHz;
- Cathode - Copper ;
- Beam momentum : up to ~5.1MeV/c
- Bunch charge : up to 250pC

PI laser

- Ti:Sapphire ; 266nm; 0.2-200uJ on cathode (500uJ after upgrade);
- 10Hz nominal; 1-400Hz available
- 180fs FWHM; laser spot size on cathode ~0.5mm

RF source

- Thales TH2157 klystron; 10MW
- Scandinova modulator : solid state, 250kV, 0.5-3us, 1-400Hz

TDC (Transverse Deflecting Cavity)

- S-band 3GHz; copper; 9-cell
- Transverse kick ~ 5MV

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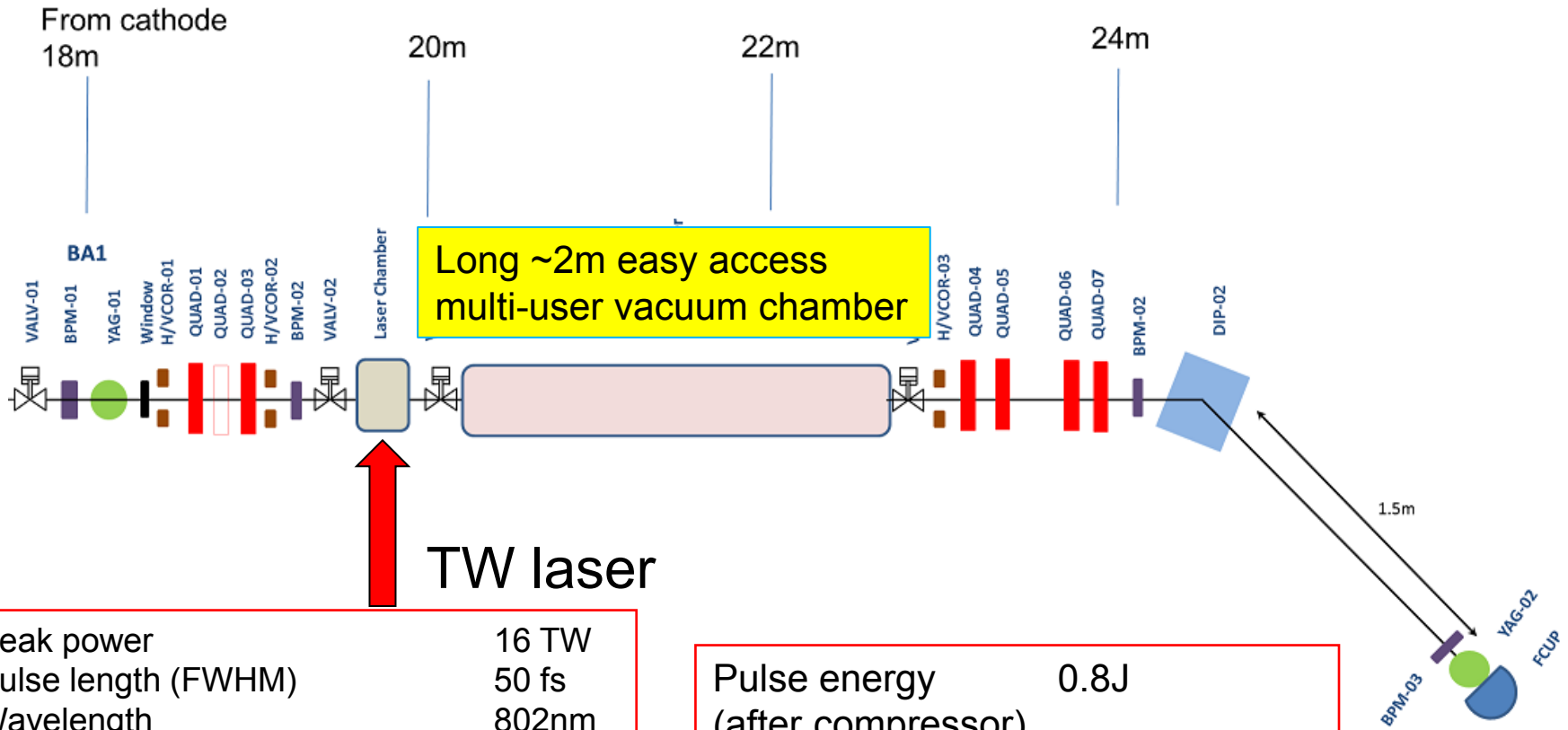
VELA – BA1 (Beam Area 1)



TW laser

Peak power	16 TW
Pulse length (FWHM)	50 fs
Wavelength	802nm
Bandwidth	13nm
PRF	10Hz

Pulse energy (after compressor)	0.8J
Average power	8W
Focal spot	~30μm
Peak power density	~10^{18} W/cm^2

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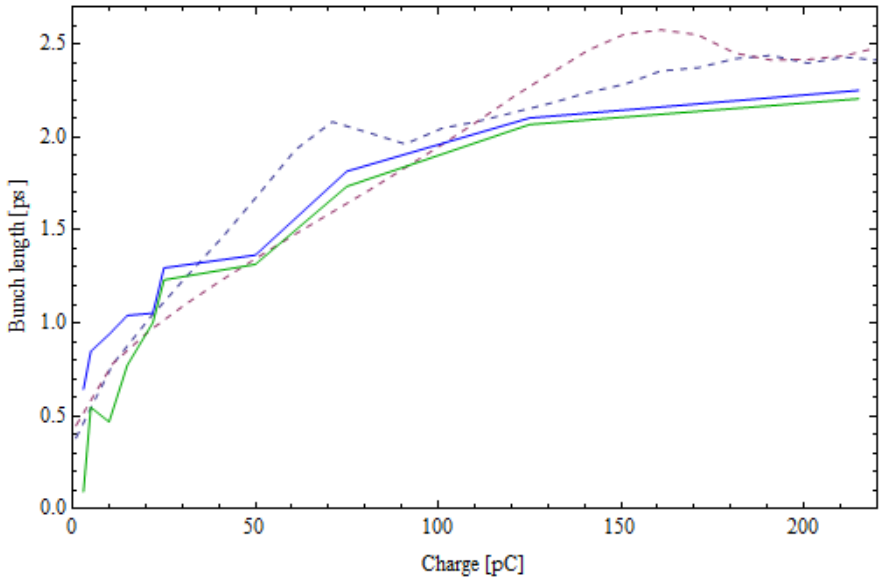
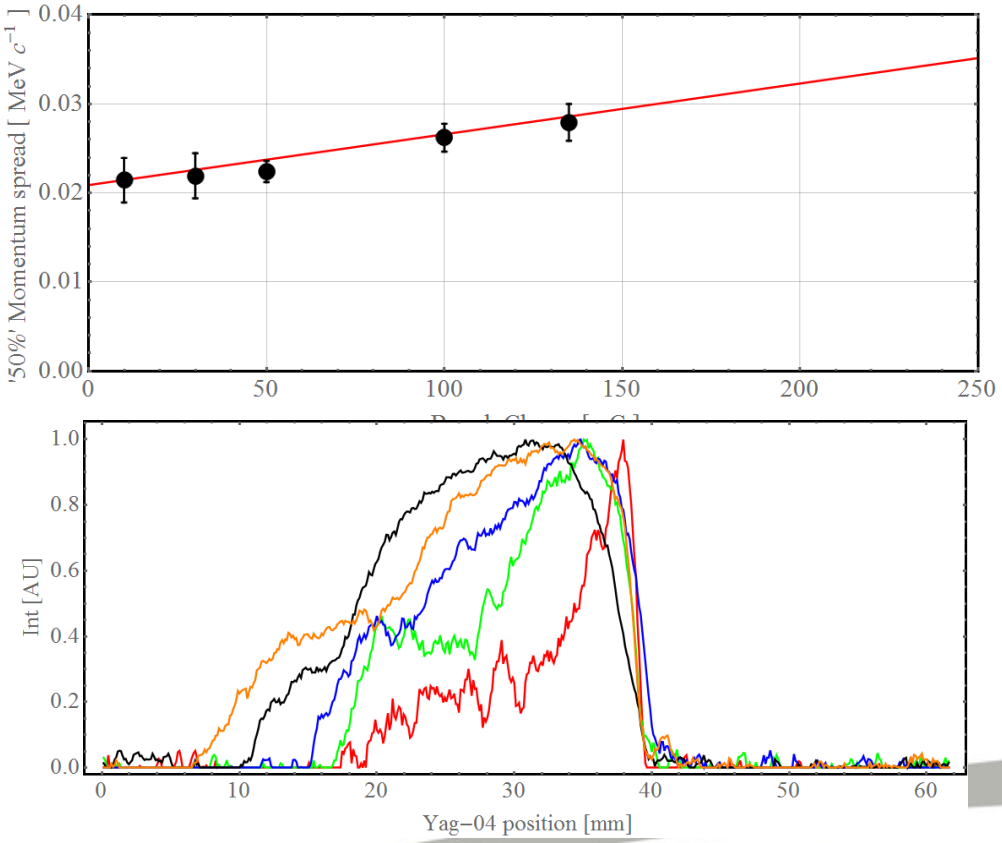
VELA: some experimental data

Bunch length (RMS) vs charge



Energy spread (FWHM) vs charge



Dashed : ASTRA sims at laser spot sizes 0.4 and 0.6mm;
Solid blue : measurements
Solid green: beam transverse size subtracted

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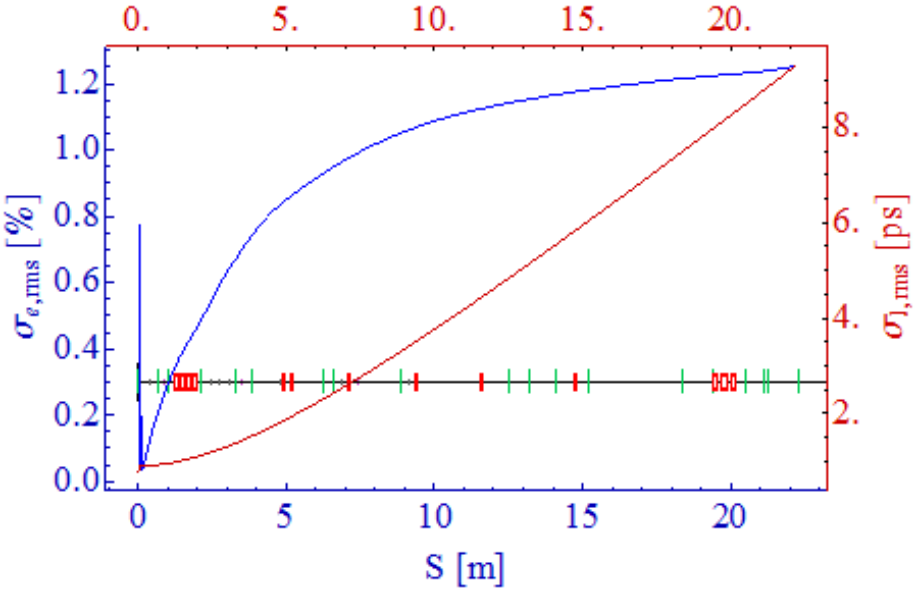
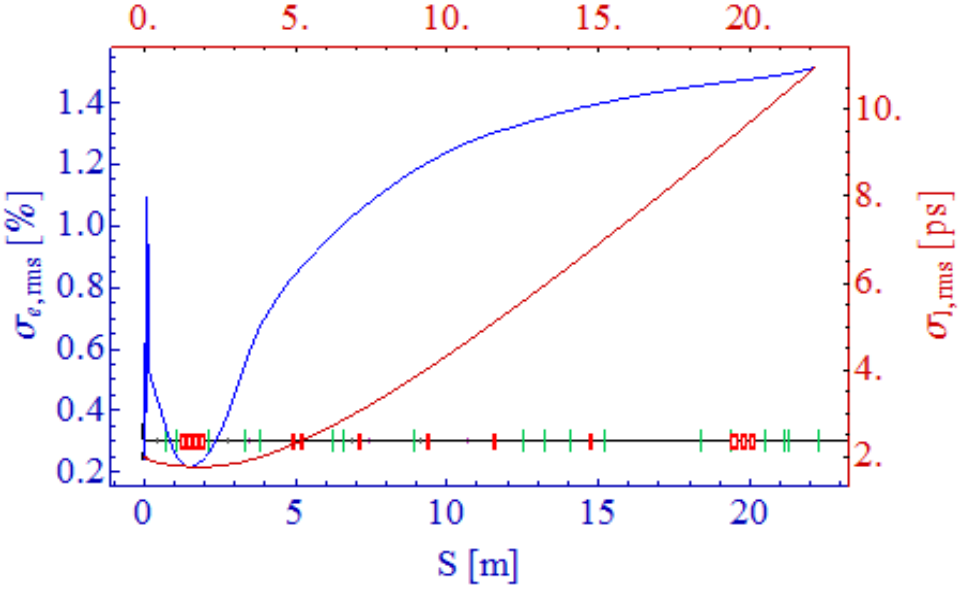
VELA: bunch parameters in Beam Area 1 (GPT sims.)

100pC



250pC



- Bunch is very much dominated by space charge
- Emittance : 2-3um at 100pC and 6-7um at 250pC
- Bunch length ~10ps RMS
- Momentum spread 1.2-1.4% RMS
- Minimal beam sizes : ~0.2mm (100pC); ~0.5mm (250pC)

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VELA summary :

- beam parameters are not particularly exciting for advanced accelerator tests at the moment
- Experimental beam area is far away from the RF gun and the beam is space charge dominated
- No means for bunch longitudinal compression
- Still …. Several experiments on advanced acceleration techniques are ongoing and planned

… and the good news :

- CLARA front end is coming soon

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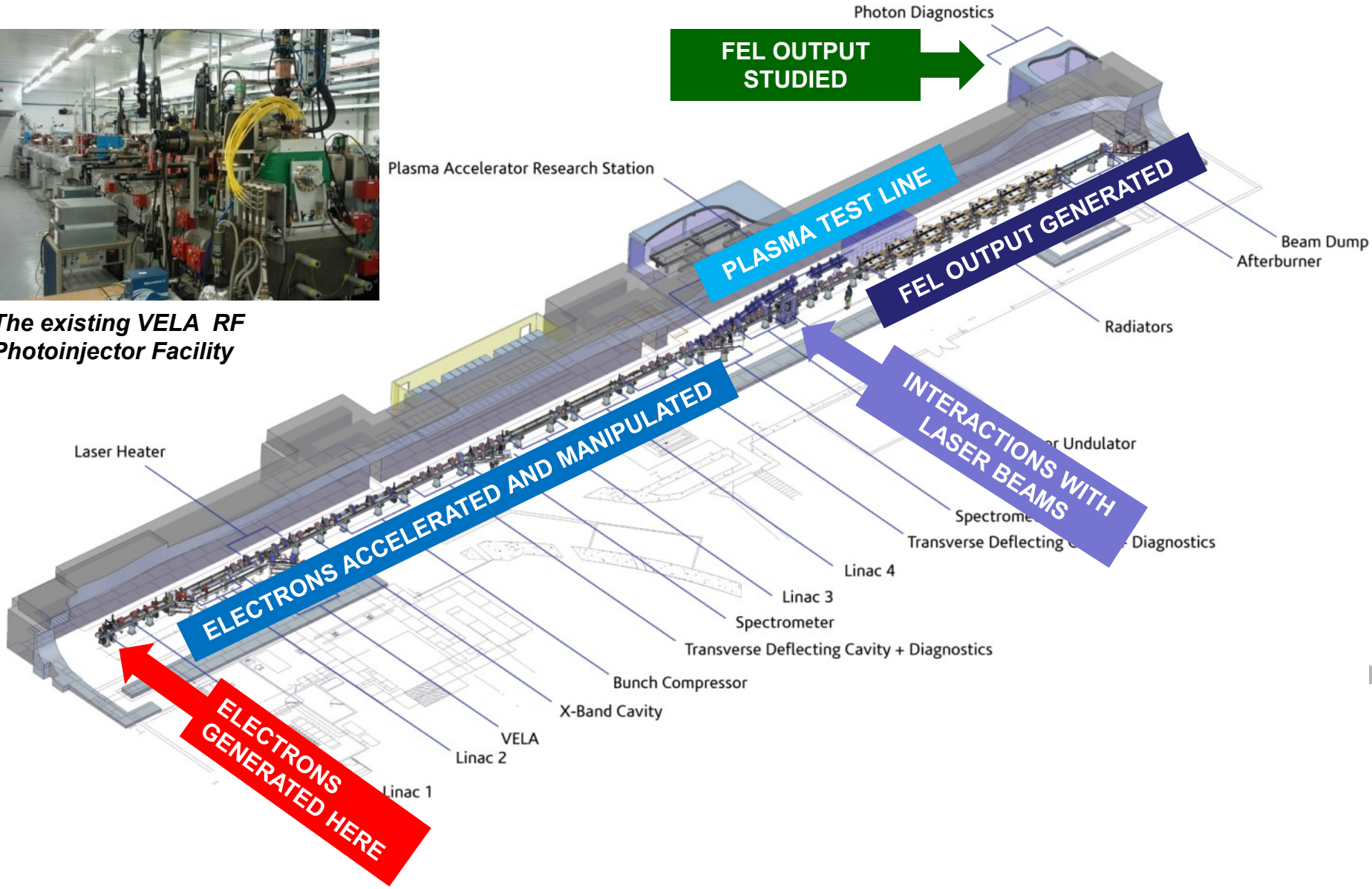
CLARA Layout

The existing VELA RF Photoinjector Facility



CLARA Parameters

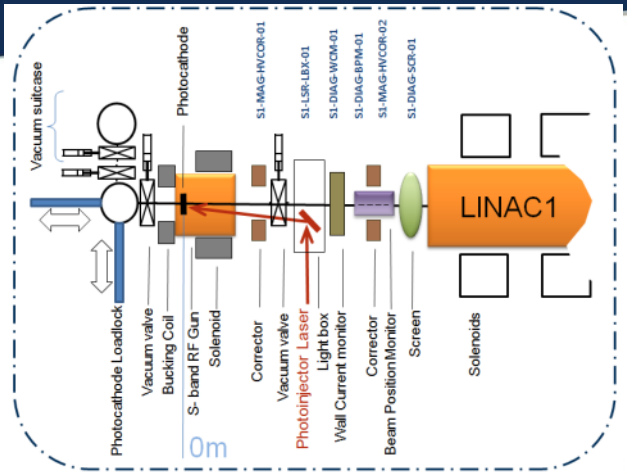
Parameters have been generated to cover **3 different operating modes**.

	Operating Modes		
Parameter	**Seeding**	**SASE**	**Ultra-short**
Max Energy (MeV)	250	250	250
Macropulse Rep Rate (Hz)	1–100	1–100	1–100
Bunches/macropulse	1	1	1
Bunch Charge (pC)	250	250	20–100
Peak Current (A)	125–400	400	~1000
Bunch length (fs)	850–250 (flat-top)	250 (rms)	<25 (rms)
Norm. Emittance (mm-mrad)	≤ 1	≤ 1	≤ 1
rms Energy Spread (keV)	25	100	150
Radiator Period (mm)	27	27	27

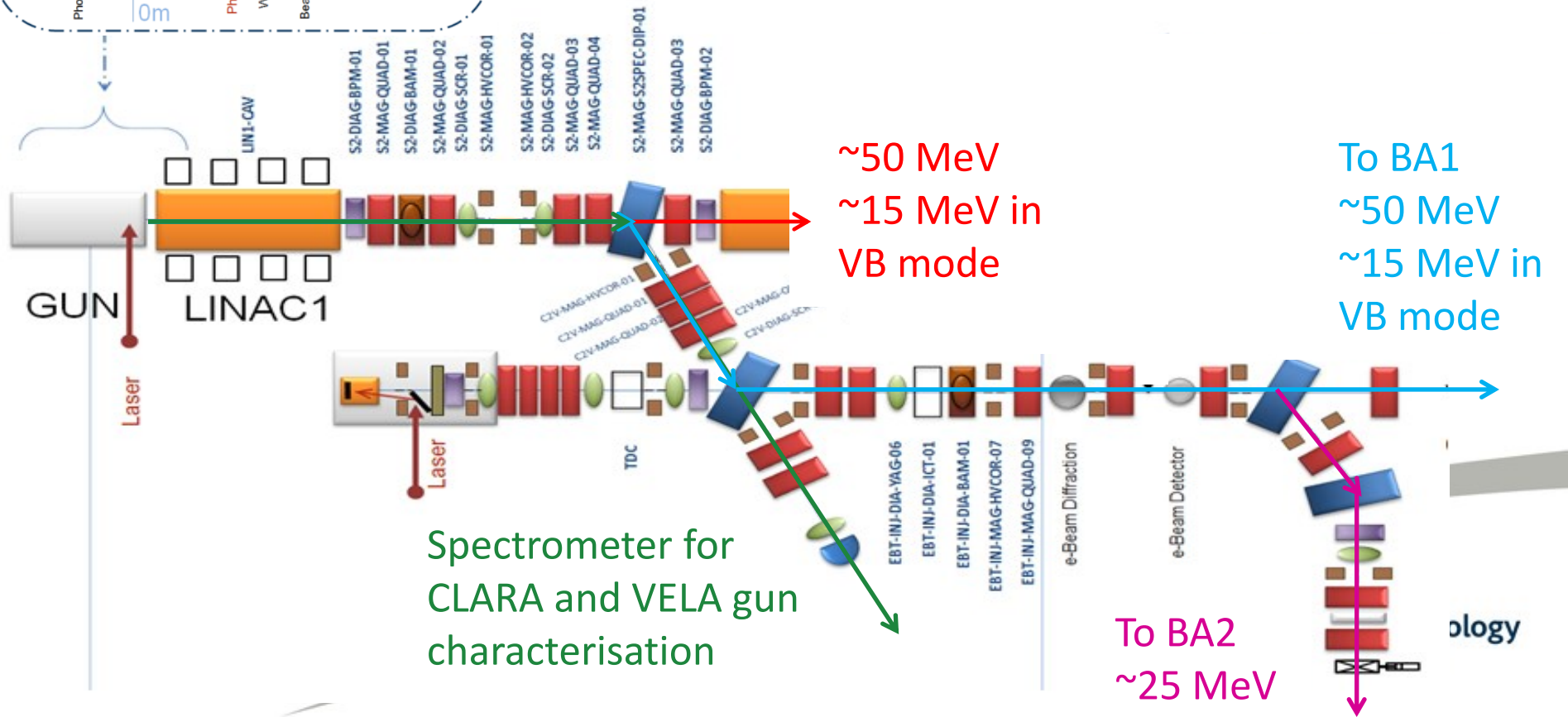
FEL output wavelengths from 400 nm to 100 nm

- Can make use of 800 nm laser for harmonic generation experiments
- Can use well established laser diagnostics for single shot pulse length measurements
- No need for long photon beamlines, can deflect by 90°

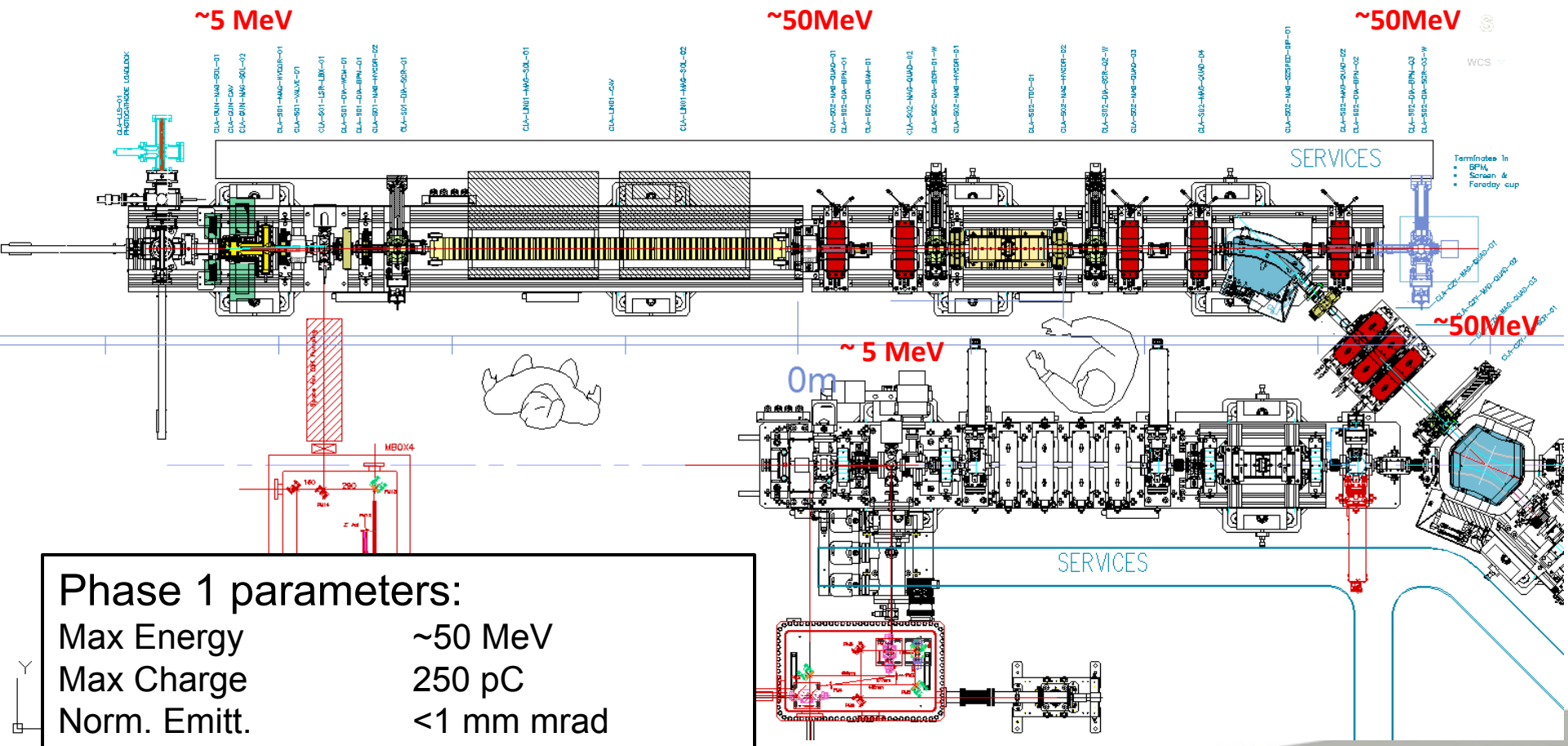
CLARA Front End Schematic



Possible operating modes with CLARA Front End



VELA + CLARA Phase 1 (2015)



Phase 1 parameters:

Max Energy	~50 MeV
Max Charge	250 pC
Norm. Emitt.	<1 mm mrad
Min Bunch Length	50fs (rms), (10 MeV)
Max Peak Current	2kA
Bunches/RF pulse	1
Pulse Rep Rate	10 Hz (400Hz later)

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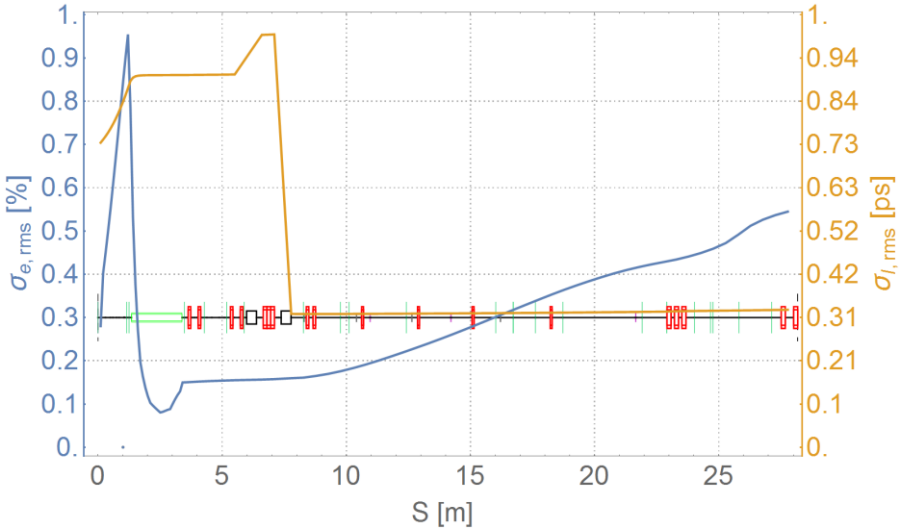
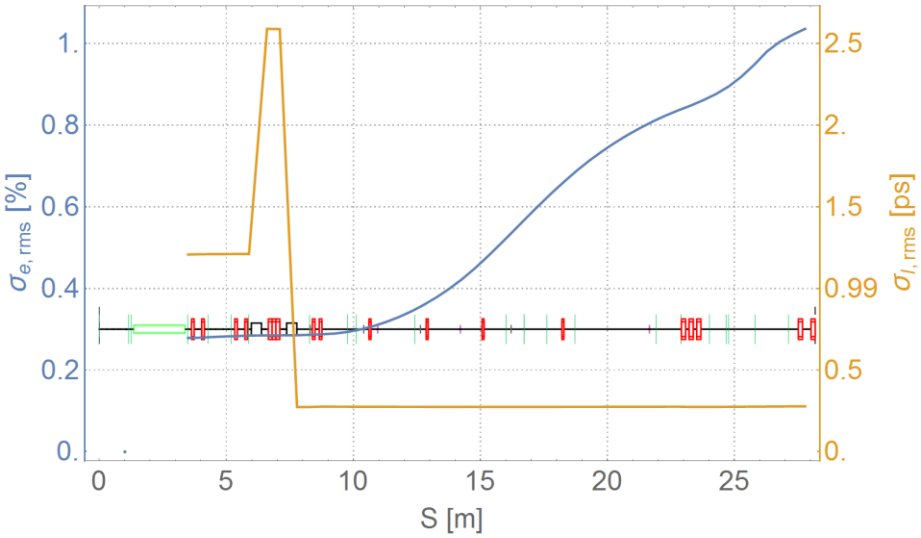
VELA+CLARA FE: bunch parameters in Beam Area 1 (GPT sims.)

100pC



250pC



- Bunch compression in the dog-leg section
- Bunch is still influenced by space charge
- Emittance : 2-4um at 100pC and ~10um at 250pC
- Bunch length ≤ 0.3ps RMS
- Momentum spread ~1% RMS
- Minimal beam sizes : ≤ 0.1mm

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CLARA FE / VELA beam at 55MeV/c; 250pC

(GPT simulations)

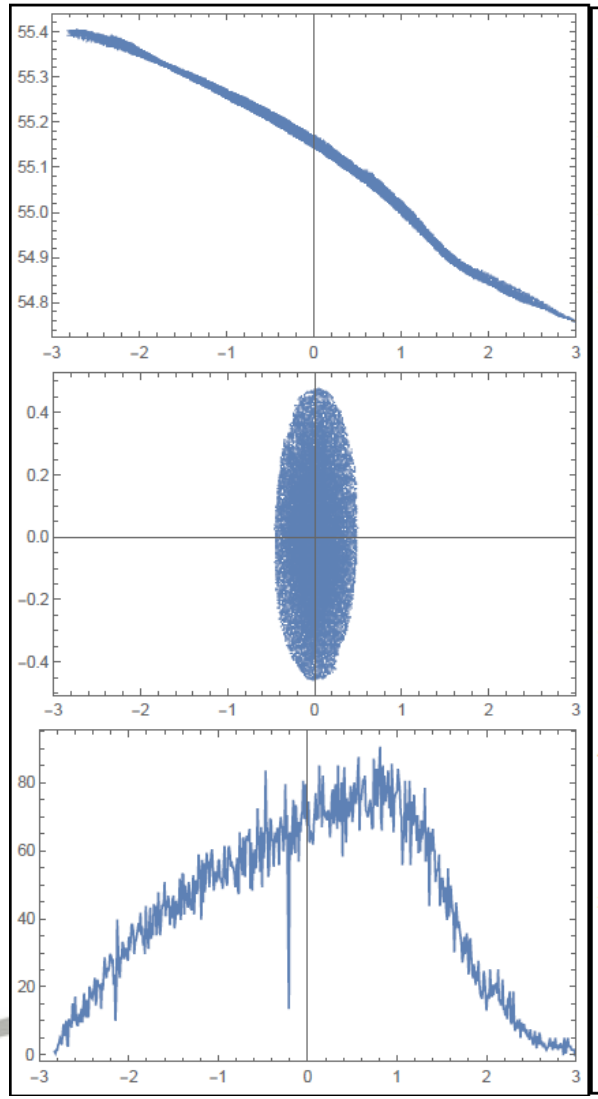
Linac exit

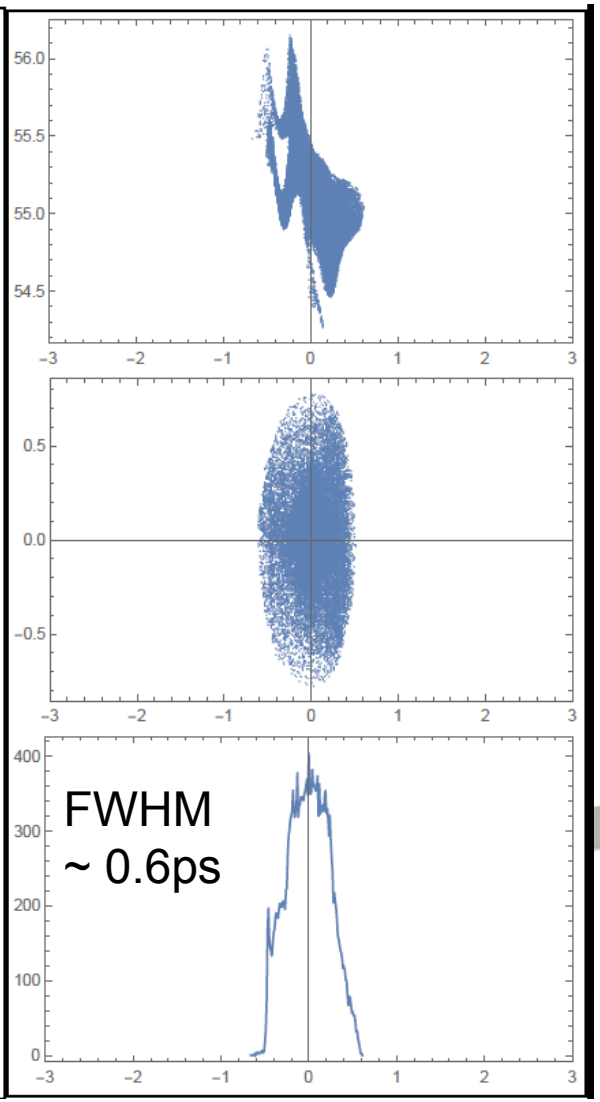
Interaction Point

Longitudinal phase-space
[MeV/c v ps]

Transverse shape
[mm v mm]

Longitudinal profile
[A v ps]





Summary

- Experimental facilities at Daresbury : **VELA** now and **VELA+CLARA FE** in near future (commissioning in 2016)
- Both are not designed specifically for advanced accelerators studies but both can be used for those studies
- Sub-ps, >100pC electron bunches can be generated
- Multi-TW laser is available in user area for a variety of laser and laser/e-beam based experiments
- Large easy access vacuum chamber can fit a variety of experimental arrangements
- Second beam area (BA2) is also available for development to accommodate a range of experiments
- ASTeC and CI aim to pursue a programme of advanced accelerator studies