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The Cockcroft Institute of Accelerator Science and Technology

Dielectric Wakefield R&D programme at Daresbury Lab.

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STFC, ASTeC & Cockcroft Institute

Daresbury Lab., UK

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Outline

- **CLARA** (**C**ompact **L**inear **A**ccelerator for **R**esearch and **A**pplications) : status

- Beam experimental area (BA1) upgrade
-
- First DWA structure

- CLARA dechirper

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CLARA Accelerator Layout Schematic v10

12 Sept 2016

Based on CLARA Lattice layout v10 & Drg. 256-10000-F

Revision Notes
v9.1 – added: quads in spectrometer arms & missing corrector S06-MAG-HVCOR-01

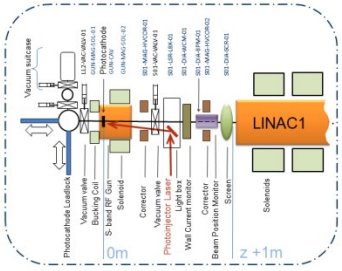
v10 – Lattice v10 + added missing ICT devices. SwissFEL quads denoted 'S' moved to nominal S04, S05 positions (but subject to change)

Approximate Component Count

Device	Quantity
Magnets	
Photo-injector gun solenoid	2
S–band linac solenoids	2
Dipoles (spectrometers, mainline, VBC, heater..etc)	14
Quadrupoles (mainline)	47
Dipoles radiator chicanes *(permanent magnets ?)*	17
Quadrupoles *(on spectrometer branches. dogleg & radiator sections *. . .etc)*	7+17*
H & V Combined Correctors	16
Radiator undulator – *0.75m array sets (type TBC)*	17
Modulator array – ~ *1m array sets (type TBC)*	2
Diagnostics	
Stripline beam position monitors	35
Cavity beam position monitors (inc. 2 reference)	19
Beam Arrival Monitors	5
Beam screens	28
Beam screens (radiator sections)	TBD
Current monitors	2
Transverse deflecting cavities	2
Integrating Current Transformers (phase2)	4
RF Accelerating Structures	
Linac cavities	4
4HC (4th Harmonic cavity)	1

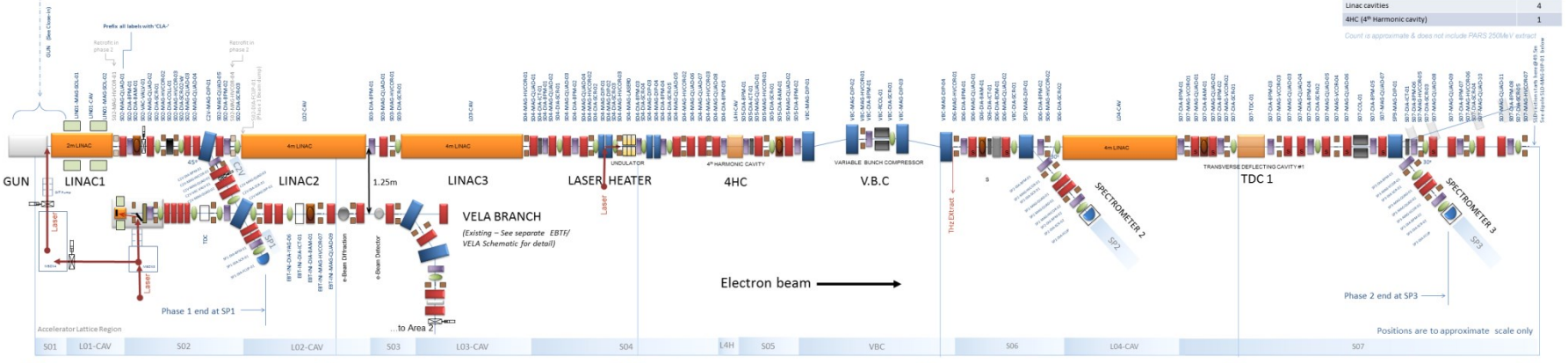
Count is approximate & does not include PARS 250MeV extract

CLARA Gun (close-in)

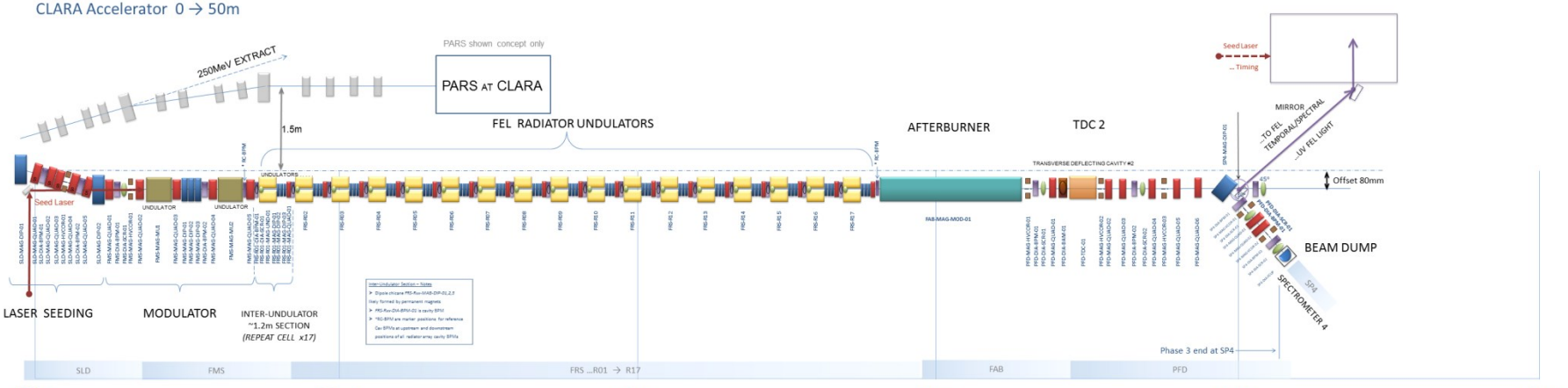


Key

- DIA-SCR (YAG screen)
- DIA-BPM (cavity BPM)
- DIA-BPM (stripline BPM)
- DIA-WCM (Wall current monitor)
- DIA-BAM (Beam Arrival Monitor)
- MAG-SOL (Solenoid)
- MAG-QUAD (Quad Magnet) (S = SwissFEL QFA type)
- MAG-DIP (Dipole Magnet)
- MAG-HVCOR (H/V Corrector Coil)
- DIA-ICT (Integrating Current Transformer)
- Misc
- DIA-FCUP (Faraday Cup & Beam dump)
- LINAC / TDC/ Cavity (RF Accelerating Structure)
- RAD-MAG-UND (Radiator Undulator)
- Gate Valve
- Collimator

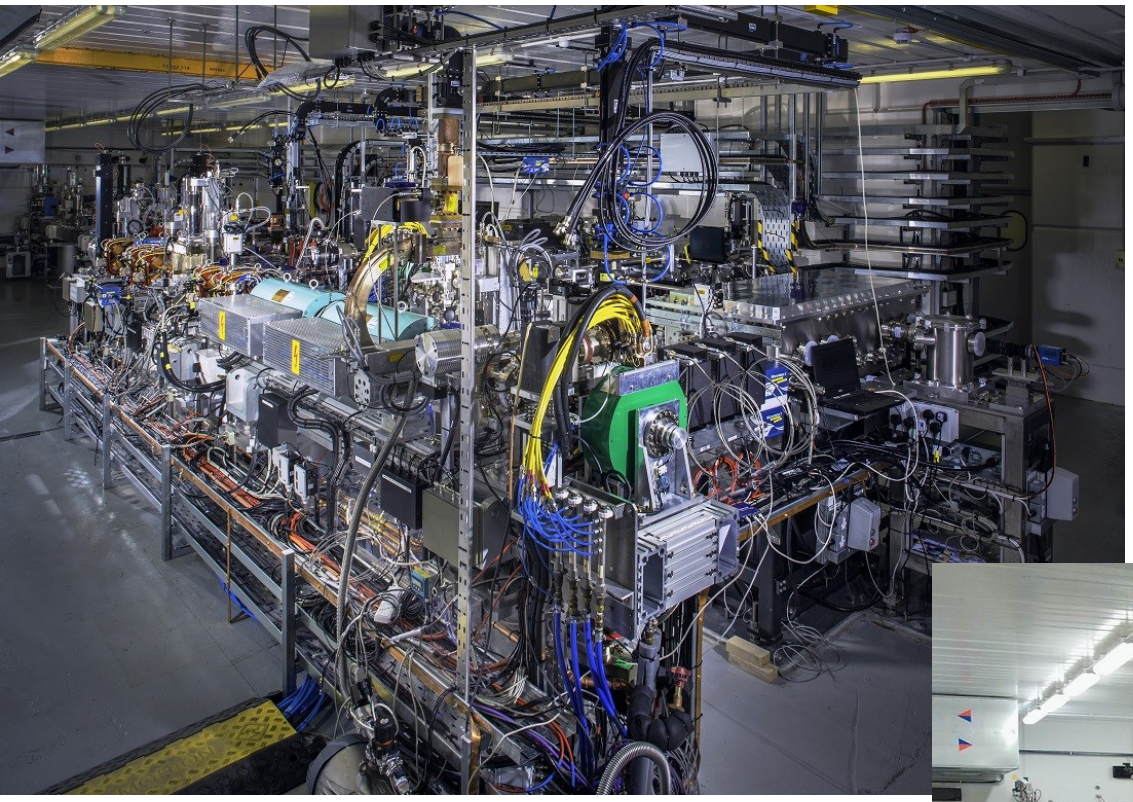


CLARA Accelerator 0 → 50m



CLARA Accelerator 50m+

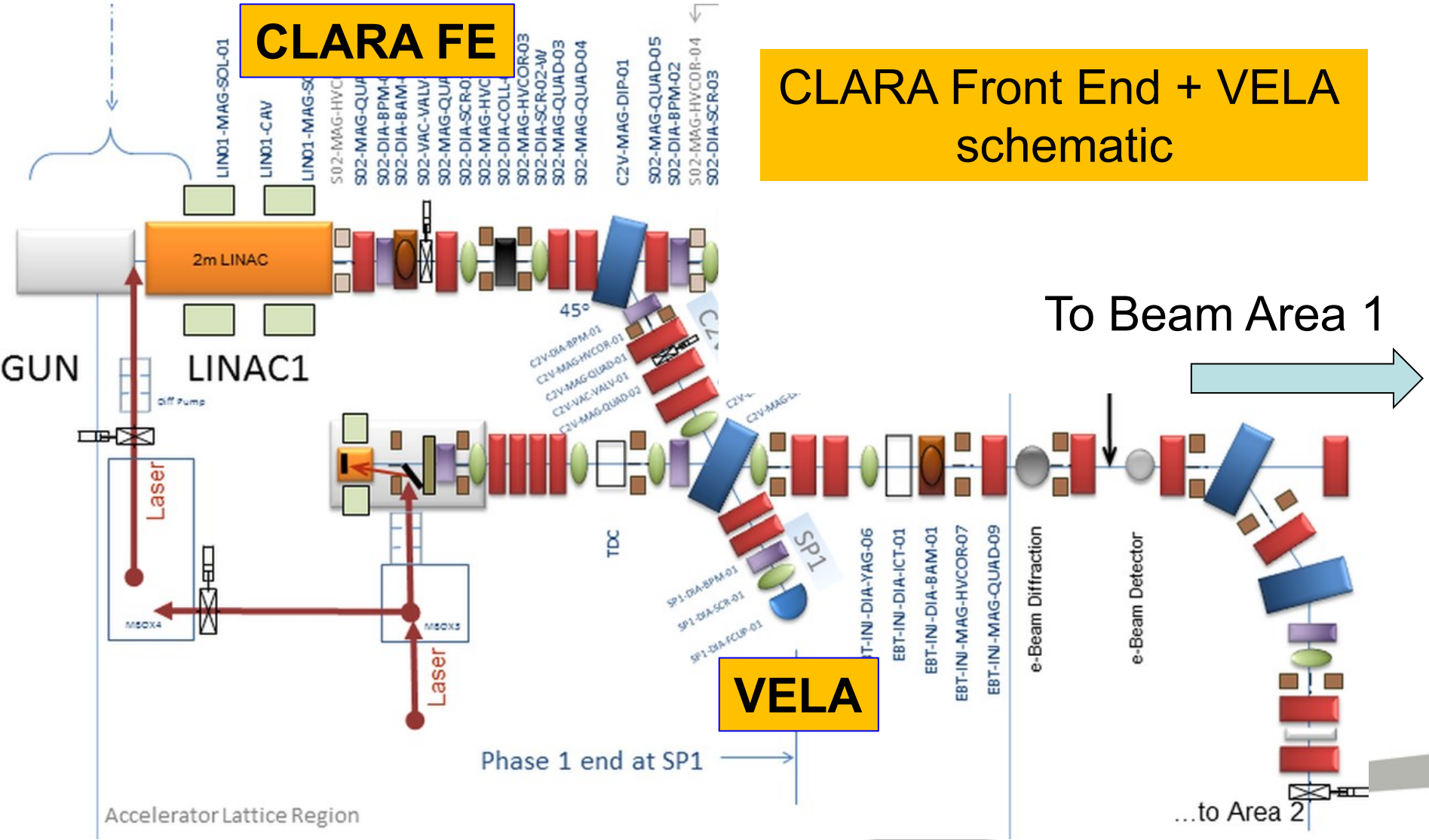
CLARA Front End & VELA



CLARA FE (2017)

VELA
(prior CLARA FE install)

CLARA Front End + VELA schematic



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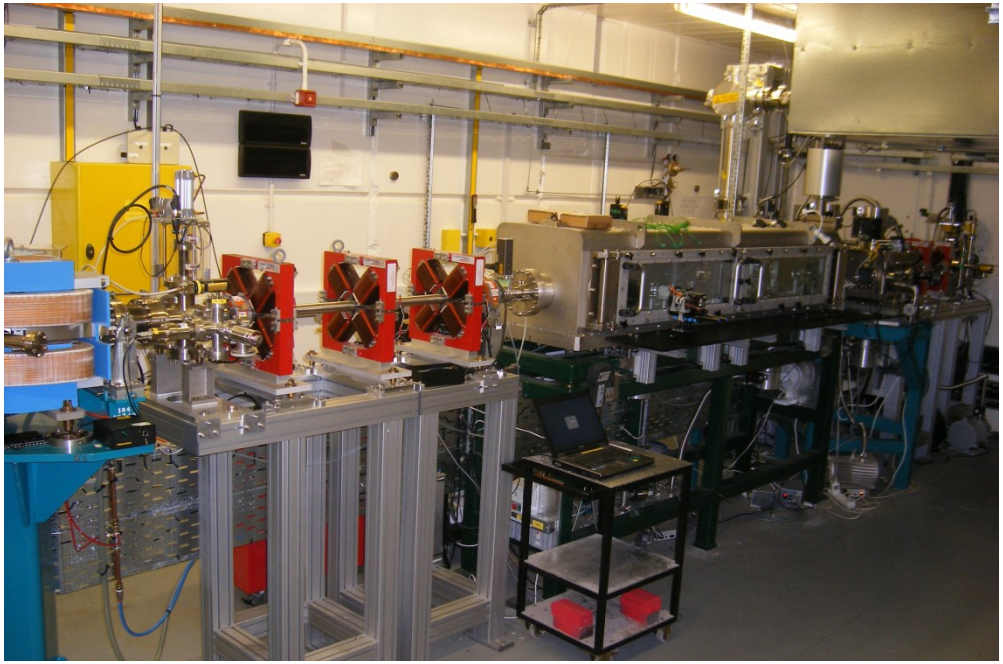
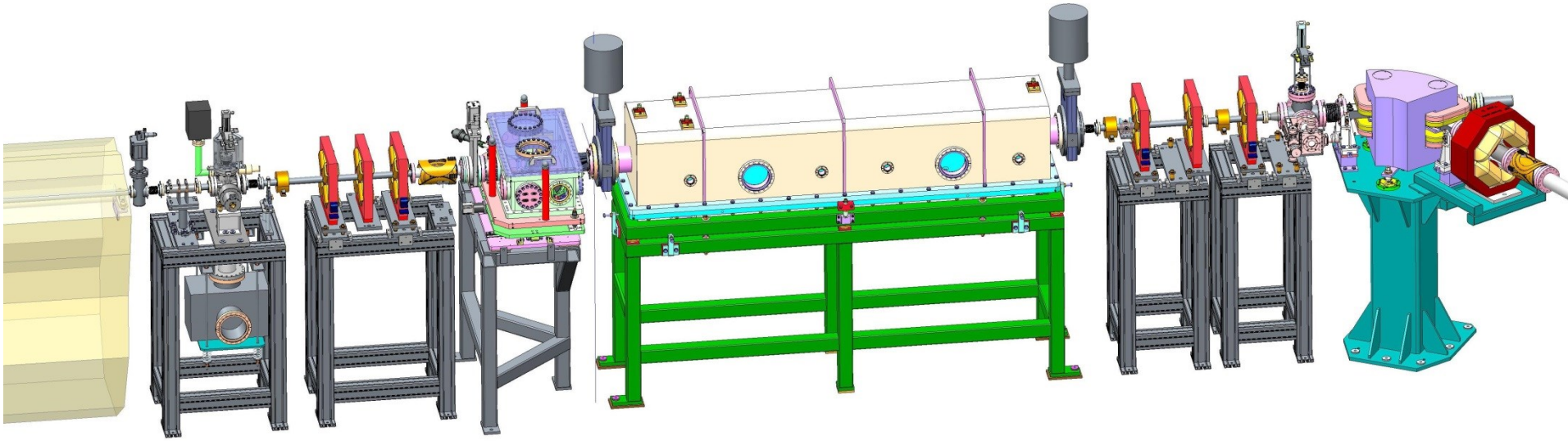
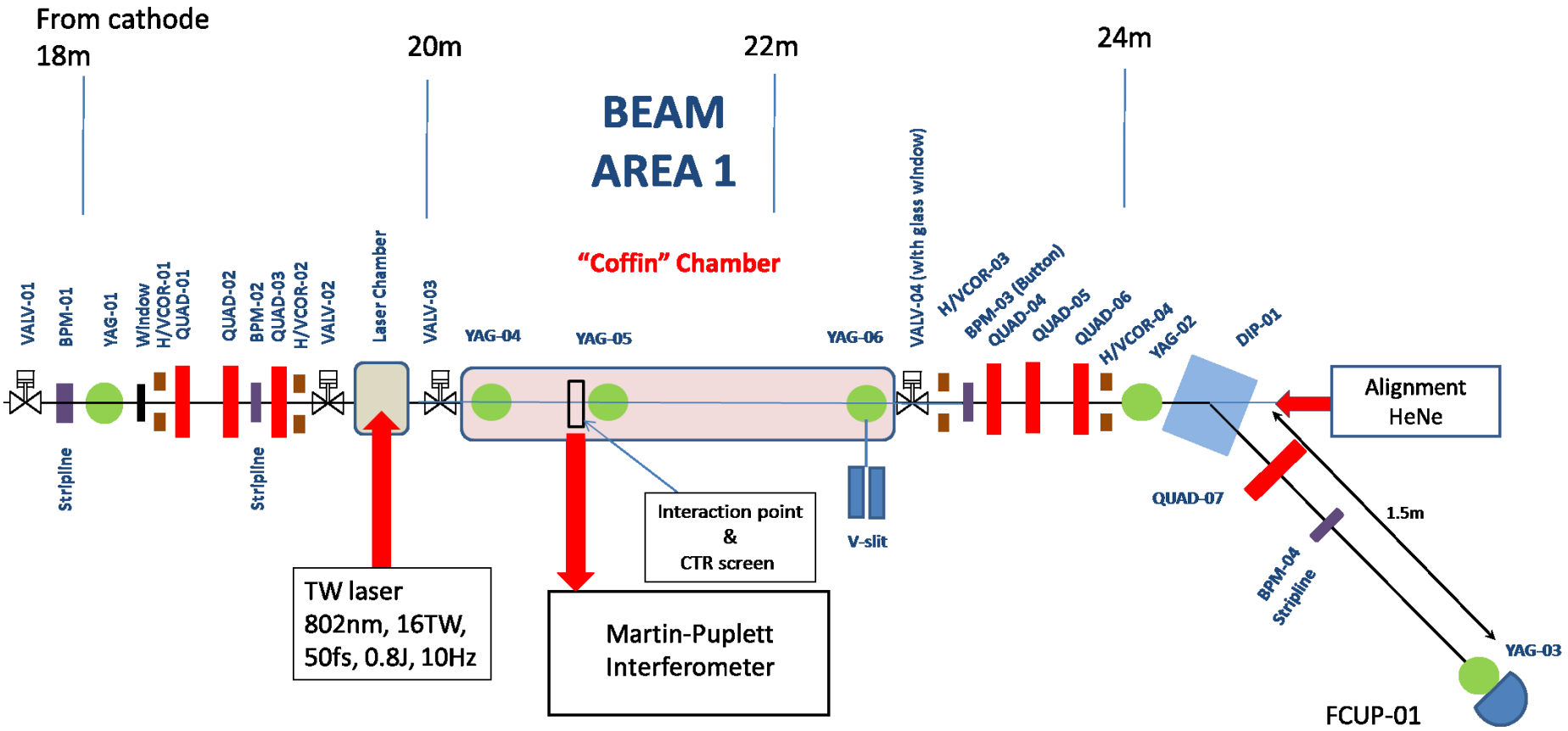
VELA BA1 beamline





VELA Beam Area 1 (BA1) beamline upgrade



- Long ~2m easy access multi-user vacuum chamber
- TW laser
- Martin-Puplett interferometer
- Set of conventional diagnostics (YAGs, slit, BPMs, energy spectrometer)
- Beam energies up to 50MeV

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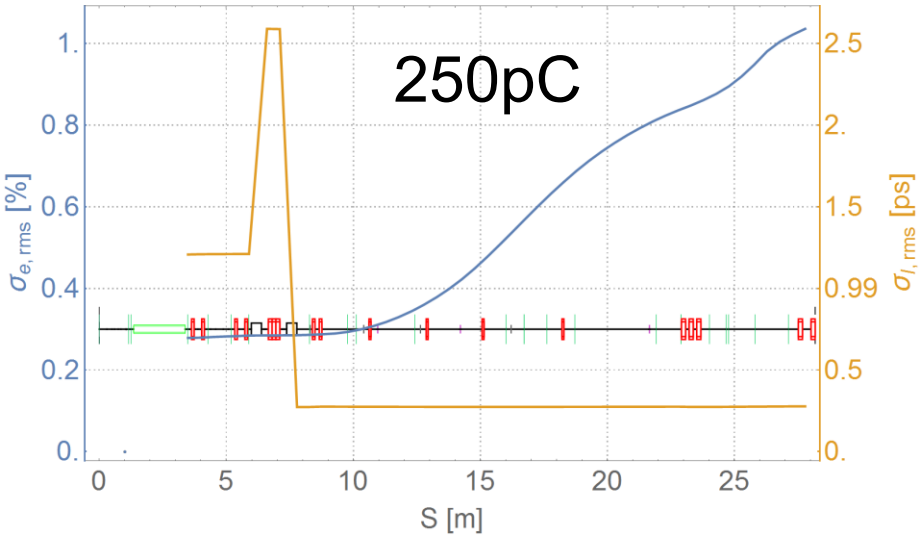
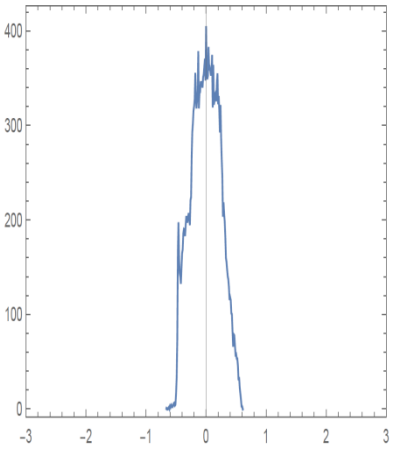
Electron bunches @ BA1 (GPT sims.)

- Bunch compression in the dog-leg section
- Strong effect of space charge on emittance and energy spread
- R_{56} : opposite sign to magnetic chicane





Longitudinal bunch profile at interaction point (0.6ps FWHM)

- Beam energy : ~50MeV
- PRF : 10Hz (up to 400Hz later)
- Emittance : several μm
- Bunch length ≤ 0.3ps RMS
- Momentum spread <1% RMS
- Minimal beam sizes : ≤ 0.1mm RMS

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DWA Programme at DL : current status

- CLARA FE is not yet commissioned
- BA1 upgrade : construction complete (… nearly)
- First beam to BA1 expected Dec'17 – Jan'18

First test structure :

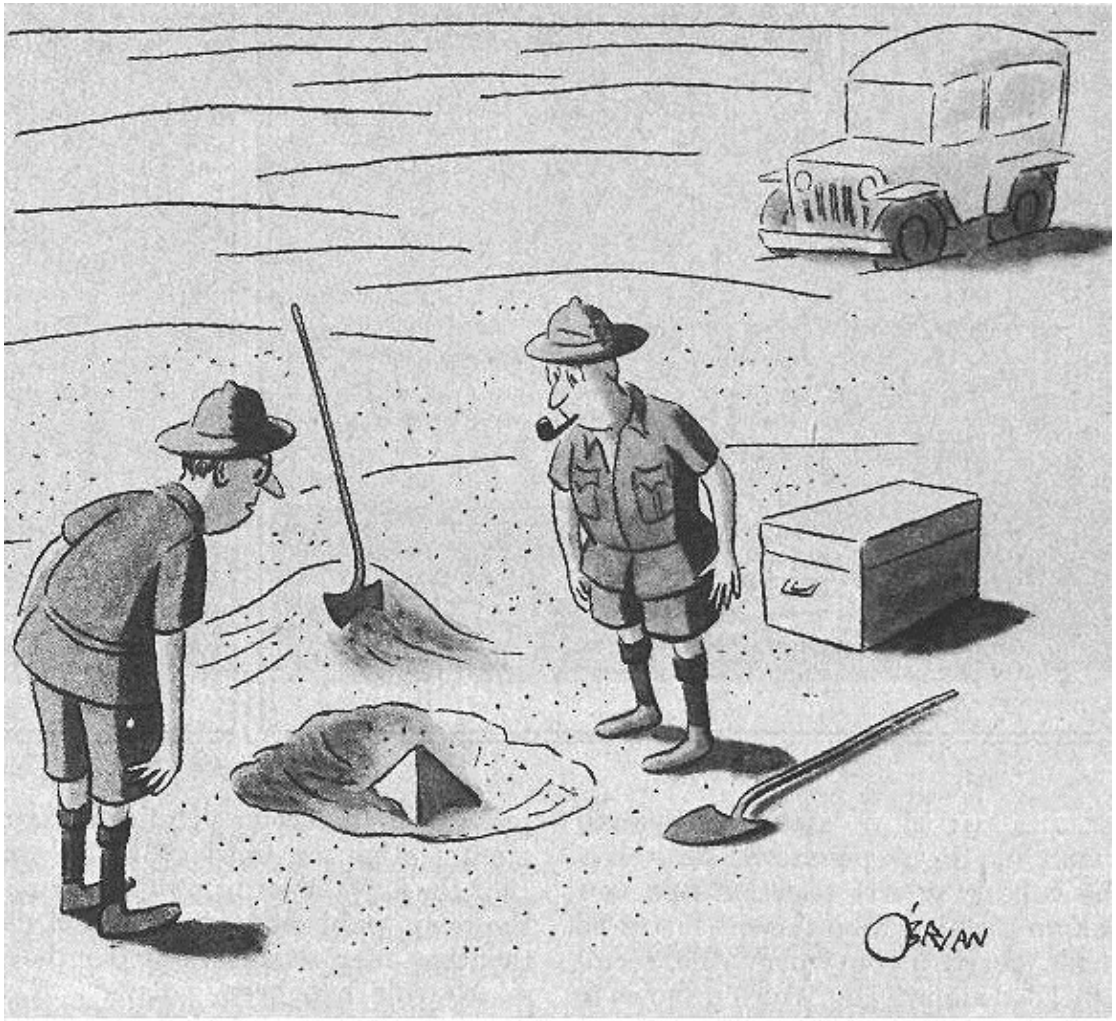
planar dielectric structure with variable gap

What we want to achieve first ….

- "proof-of-capability"
- Tunable THz generation
- Martin-Puplett interferometer commissioning
- Energy dechirping studies (part of future CLARA dechirper)
- Transverse effects
- Benchmarking computer models

Illustration of what we want to achieve first …

…. then we'll try to dig deeper



"This could be the discovery of the century. Depending, of course, on how far down it goes."

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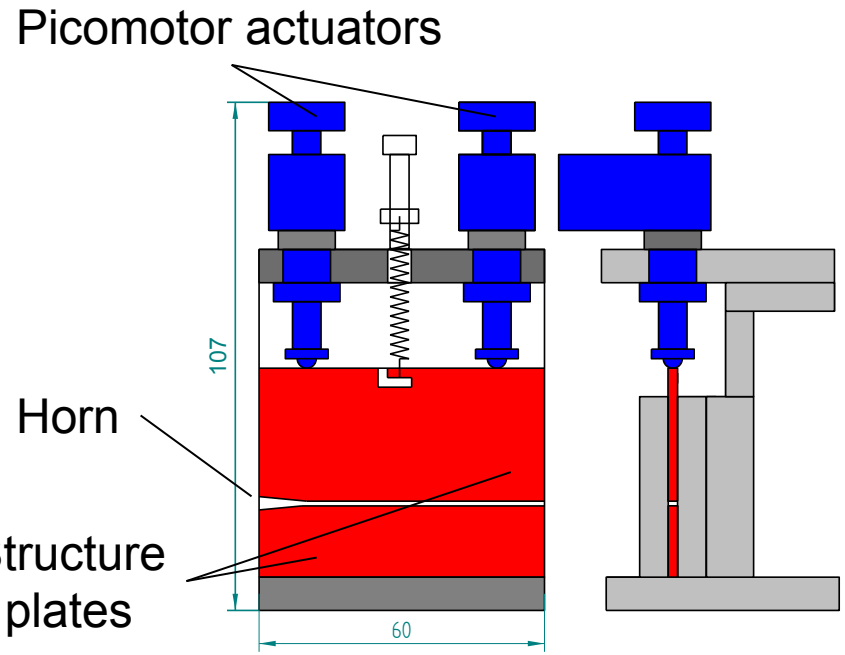
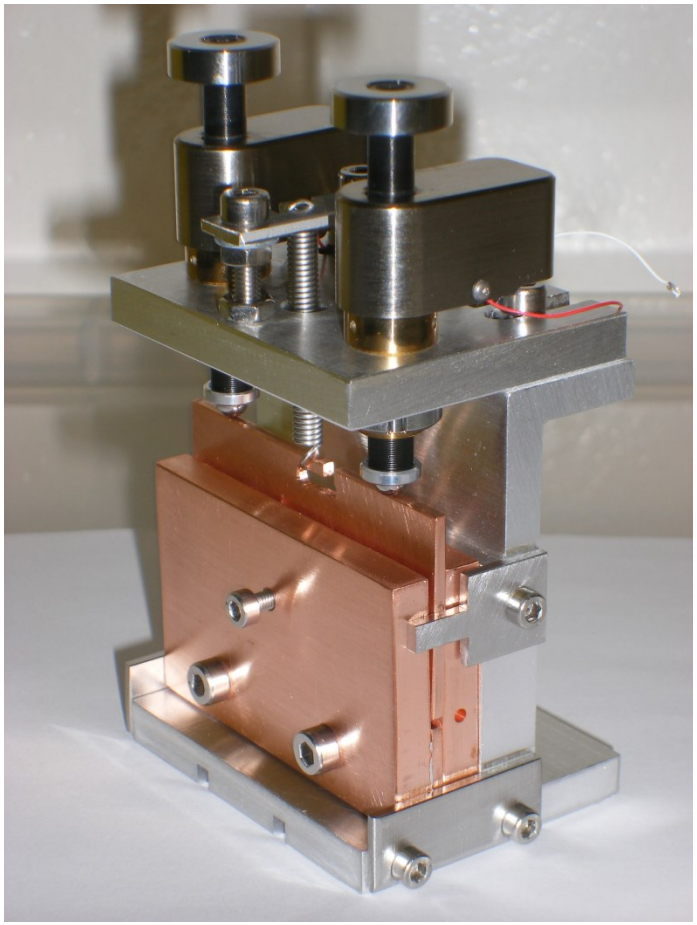
Variable gap planar DWA structure





Plates substrate :	copper
Total length (inc. horn) :	60mm
Dielectric length :	40mm
Dielectric thickness:	25um
Width :	2mm
Dielectric material :	Quartz

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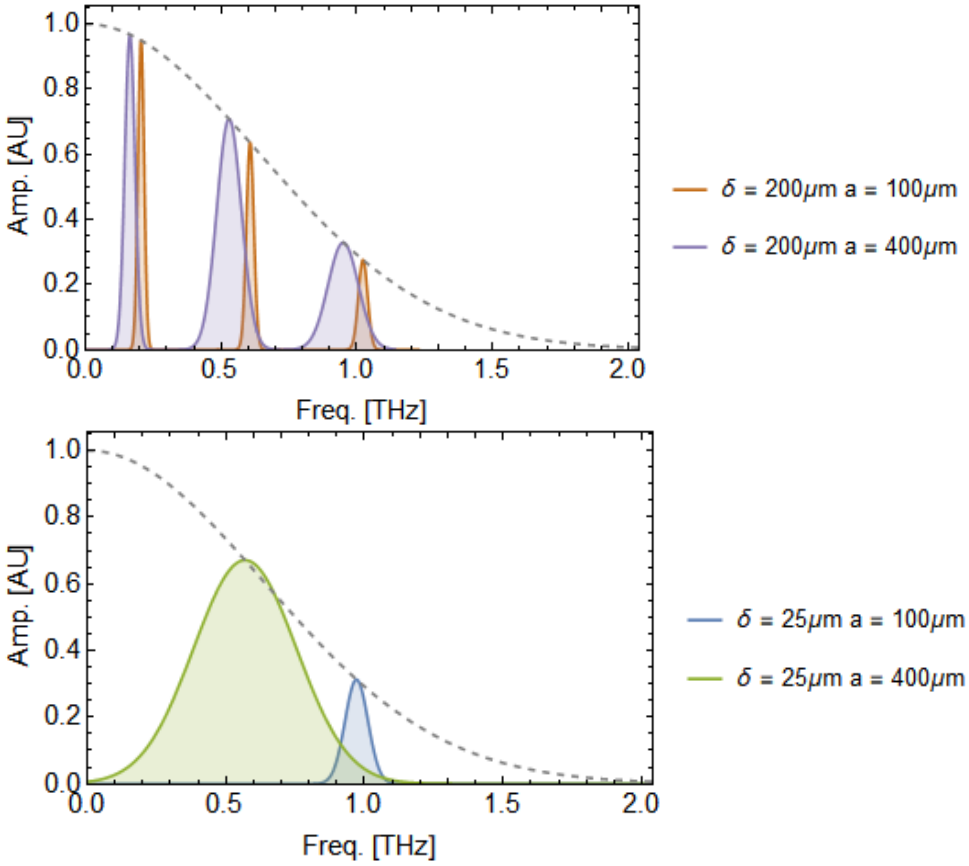
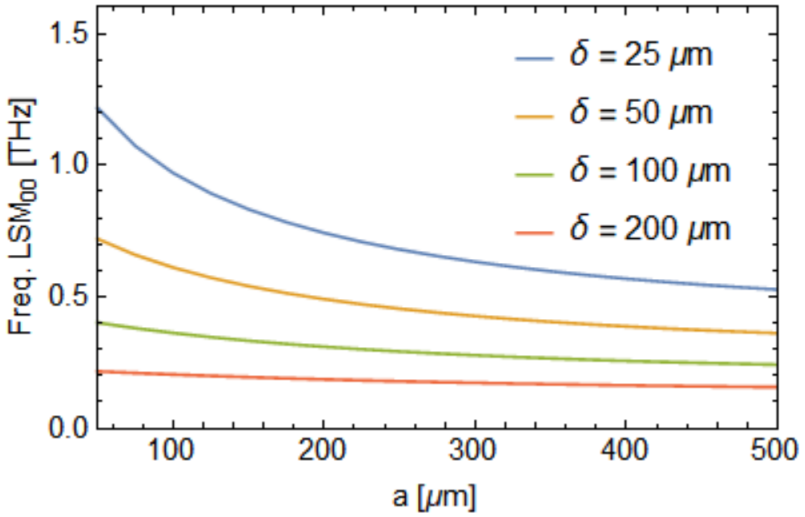
Rational for dielectric structure choice



Form factor – 250fs bunch



Thin 25μm planar dielectric :

- Single mode
- Appreciable tunability
- E-field decreases if <25μm

Bandwidth increases with gap

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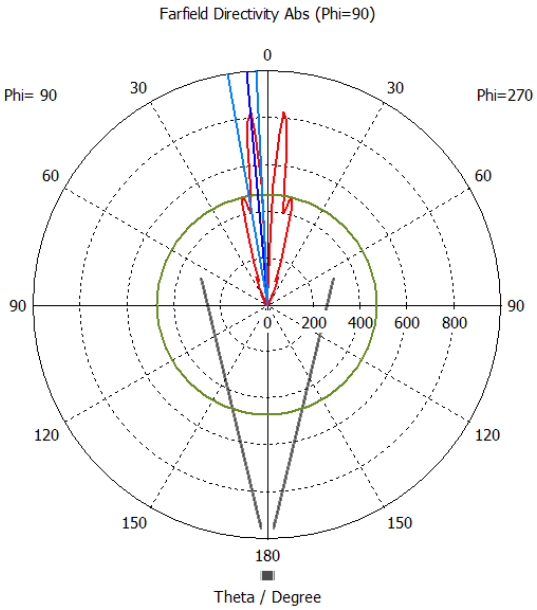
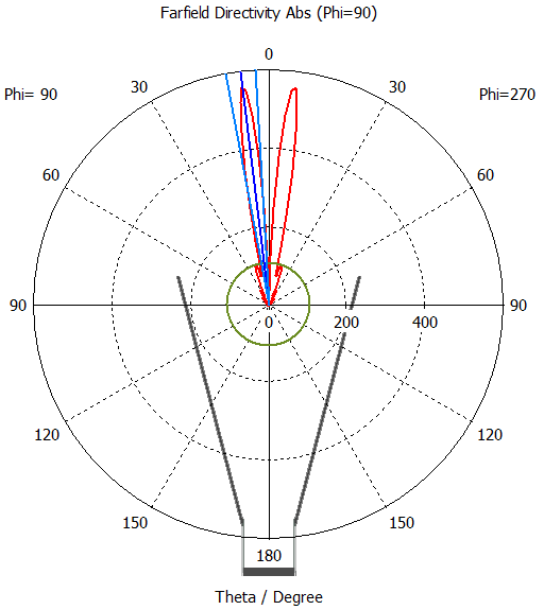
Variable gap DWA horn



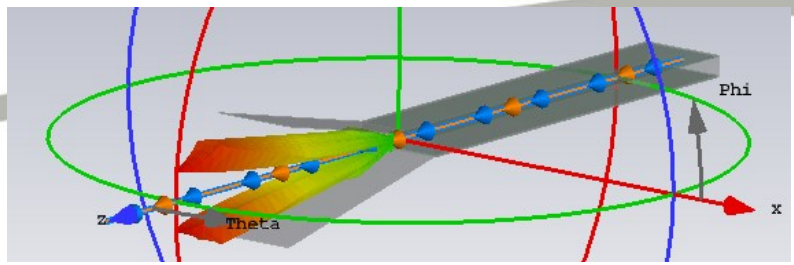


a=0.1mm a=0.5mm

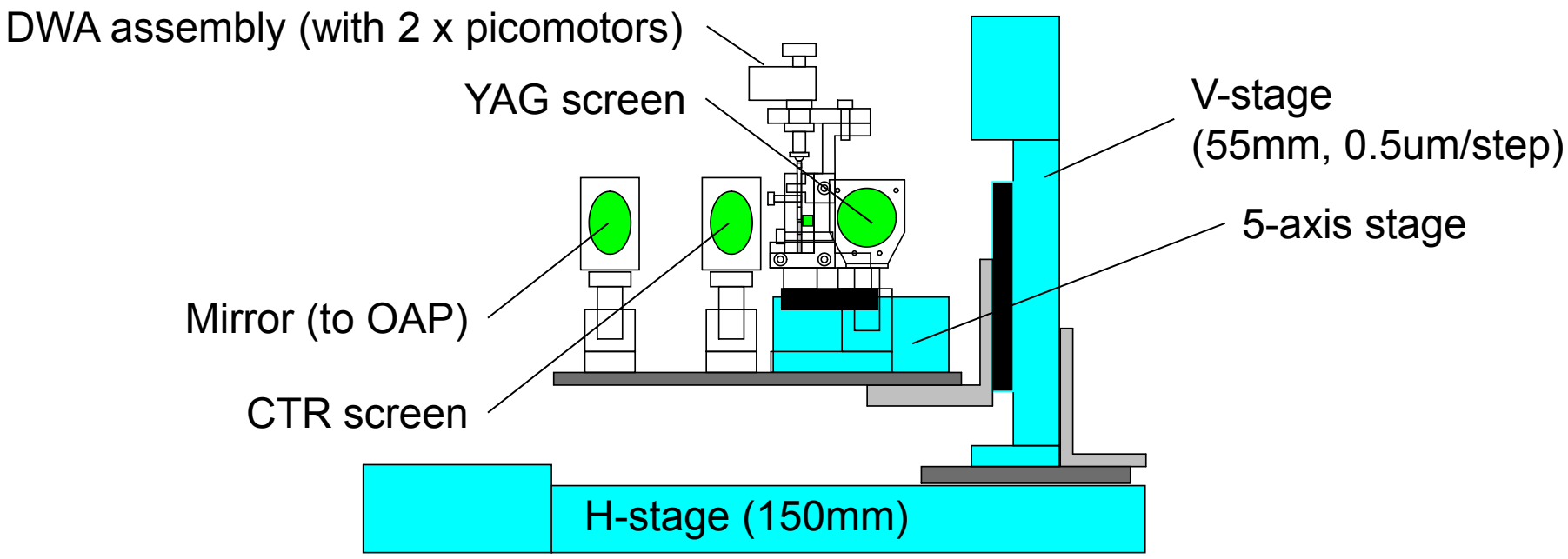
- Gap : a=0.1-0.5mm
- Open sides
- 0.025mm dielectric

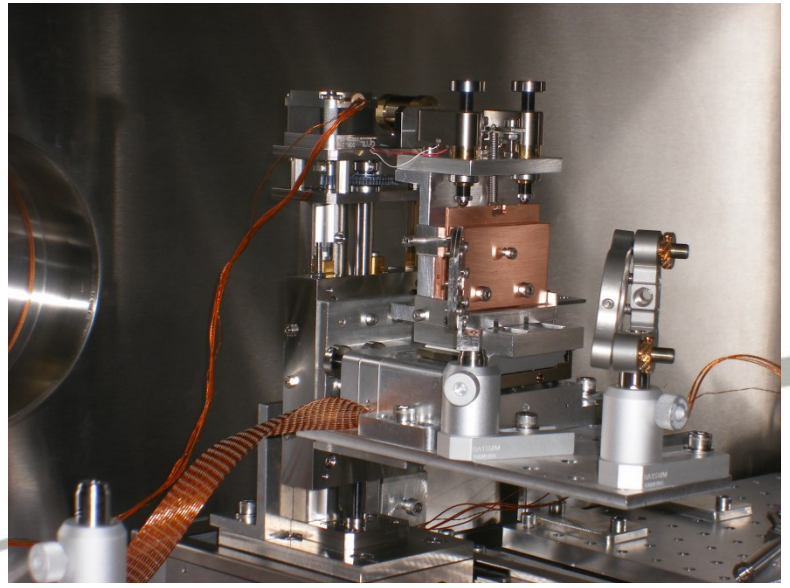
“Optimal” : ~10mm long ; 12^{o} angle

- main lobe angle : 6-9 deg
- lobe angular width : 6- 9deg



DWA structure motion controls





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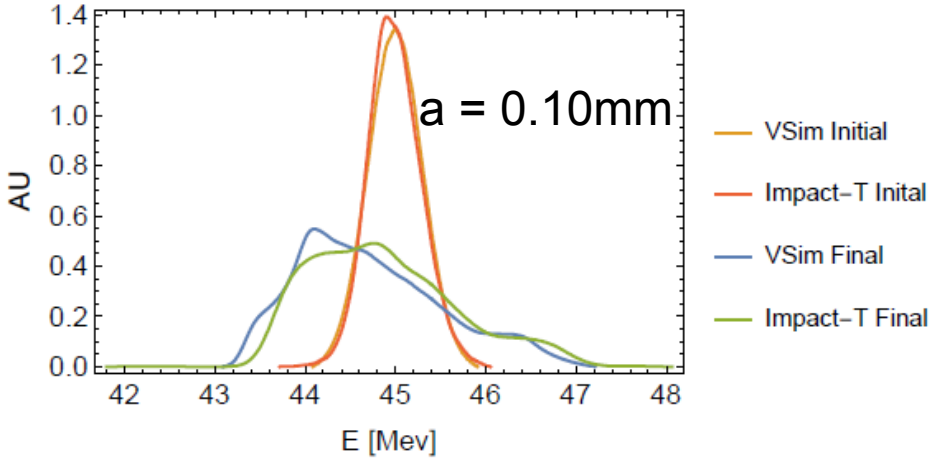
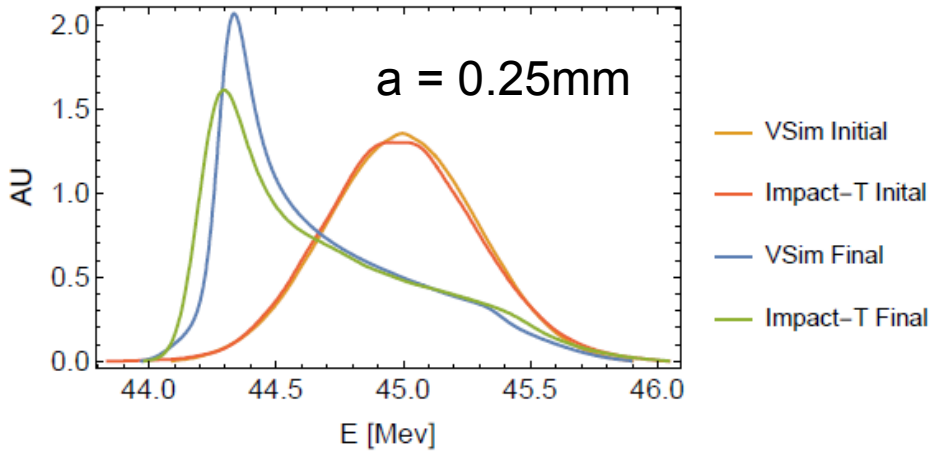
Expected effect on energy spectra

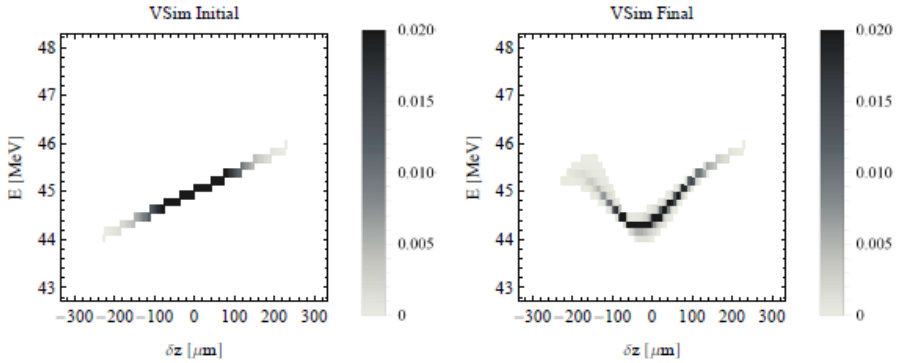
VSim and Impact-T simulations



Bunch : 45MeV; 250pC; 250fs ;
initial Gaussian distributions

Initial energy chirp : positive – head is of higher energy
(due to the sign of the dog-leg R_{56})





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Transverse phase-space evolution

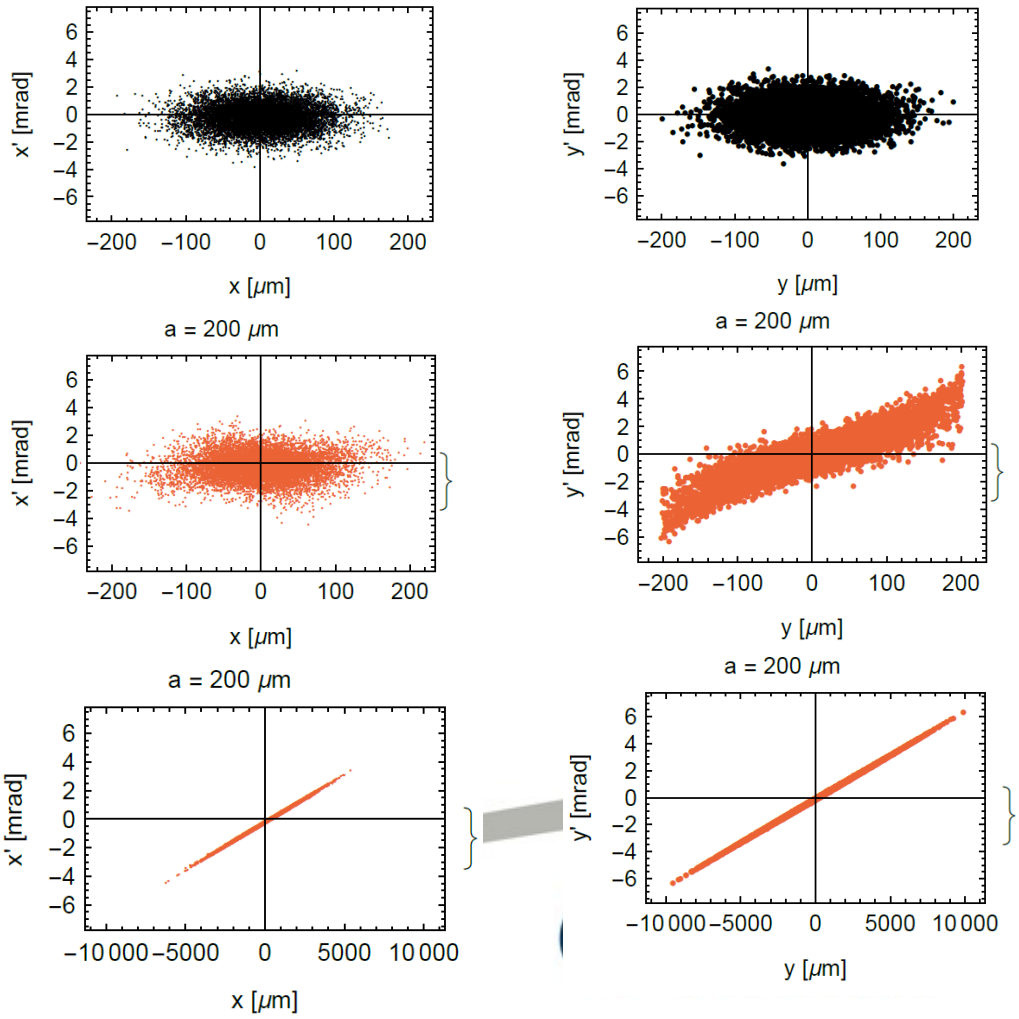
L=40mm; w = 2mm ; a = 0.2mm; δ = 25μm

Bunch : 100pC; 200fs; 45MeV

Entrance :
σ_x = 50 μm; σ_y = 50 μm

Exit:
(truncation in V-plane)

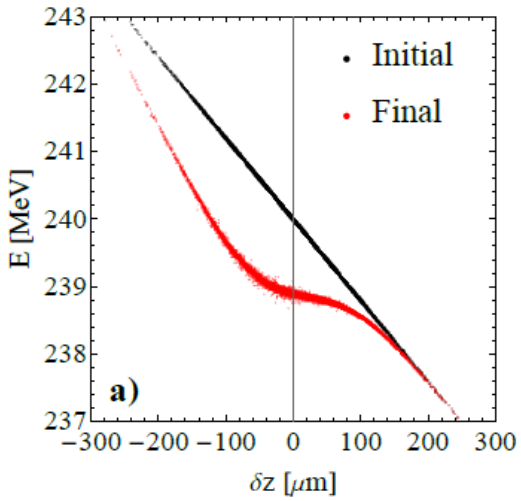
After 1.5m drift :
σ_x = 1.4mm; σ_y = 2.4mm

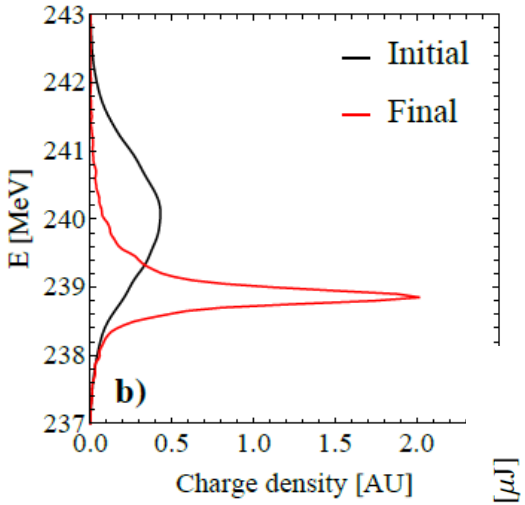


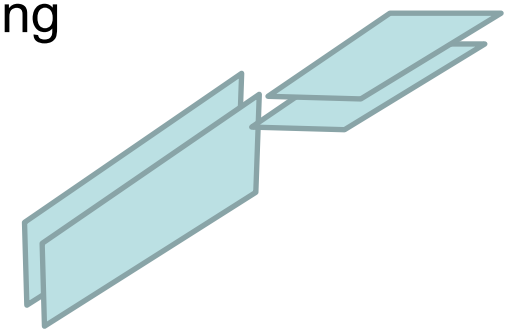
CLARA dechirper

Beam expected : 240MeV; 250pC; 250fs
(one of several modes)

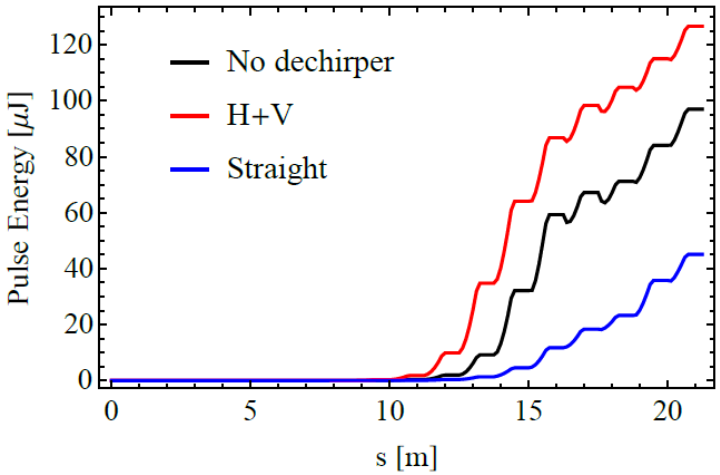
First look at dechirper design :
V-dechirper 10cm long + H-dechirper 10cm long
a = 0.6mm ; dielectric – 100 μm







GENESIS sims



Future design:
2 x 20cm long sections with variable gap

Summary

- CLARA FE constructed; technical commissioning underway; first beam in Nov'2017 expected
- 45-50MeV, 100-250pC; sub-ps electron bunches
- Experimental area (BA1) is ready for ~50MeV beams
- First DWA structure for "proof-of-capability" : planar, variable gap
- First goals:
  - tunable THz radiation
  - dechirping studies
  - transverse effects
  - codes benchmarking
- CLARA energy dechirper to be developed and implemented in 2019

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