CLIC Main Linac Quadrupoles

Preliminary design of a quadrupole for the stabilization bench

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Introduction

- Main Linac Quadrupole Parameters
- List of Open Issues
- Mock-up for Stabilization Bench
- CLIC Magnet Work Package

MLQ Requirements and Constraints

> 4000 Main Linac quadrupoles

Beam energy increase requires variation of integrated field gradient in the range between 15 Tm/m and 370 Tm/m

Aperture and field requirements

- Magnetic length: between 350 and 1850 mm
- Field gradient: 200 T/m
- Aperture radius: > 4 mm

Baseline: 4 types of different length

Alternative: several magnets of one type connected in series

Small aperture, long structure

- High mechanical precision
- Tight manufacturing and assembly tolerances
- Good mechanical stability

Open Issues

Cooling circuit

- Long term reliability
- Heat dissipation into tunnel
- Cooling efficiency
- Advanced insulation materials

➔ *Advanced coil design and cooling layout needed*

Manufacturing and assembly tolerances

- Small aperture requires a high mechanical precision to achieve required field quality
- Mechanical error analysis to quantify manufacturing, assembly and alignment tolerances

➔ *New manufacturing and assembly technologies required*

Open Issues (cont.)

Mechanical and thermal stability

- Long and slim structure
- Thermal expansion
  - Influence on field quality (shift of magnetic center)
  - Deformation and displacement of mechanical structure
- Cooling flow induced vibrations
  - Maximum allowed coolant velocity, flow rate and pressure drop

➔ *Mock-up for stabilization study*

Other issues

- Stability of magnetic centre (saturation, hysteresis, magnetic forces)
- How to measure field quality in small aperture quadrupole?
- Vacuum chamber integration
- Integrated (pulsed) steering coils or external corrector magnet

MLQ Mock-up

Quadrupole mock-up

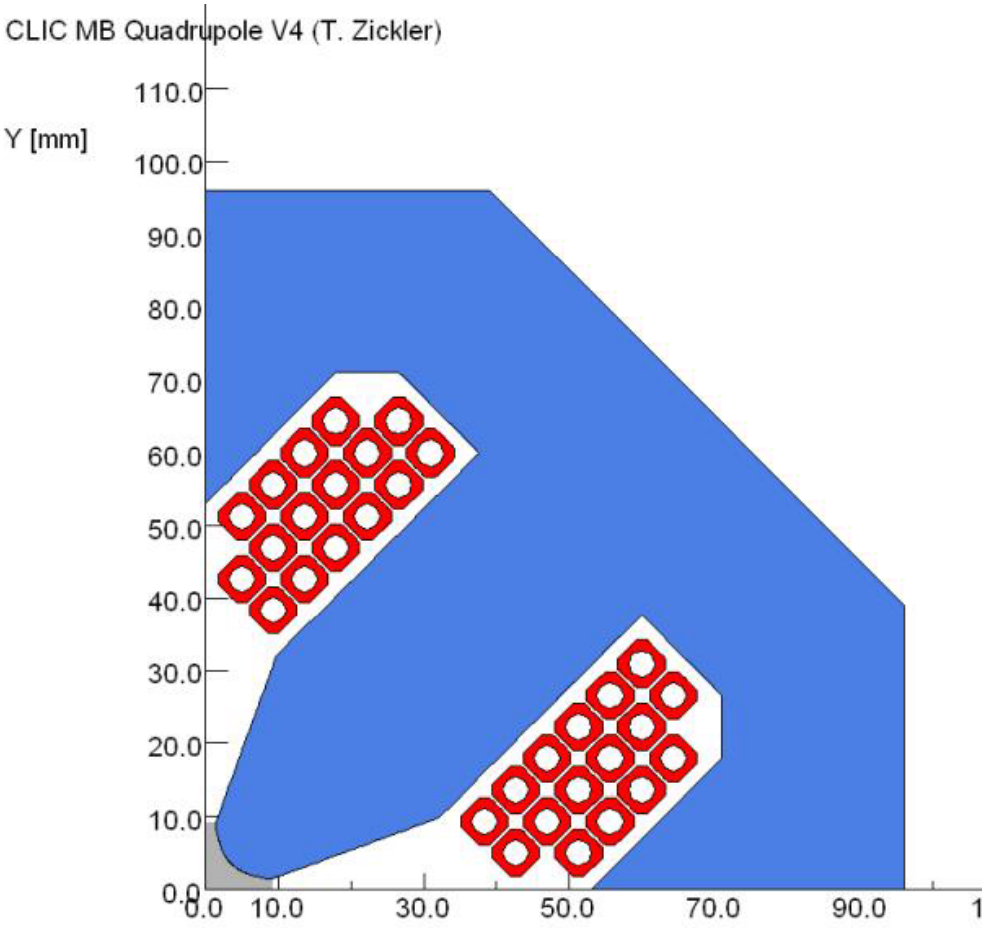
- Design and build a quadrupole mock-up for the stabilization bench
- Part of EuCARD – FP7
- Collaboration of TS/MME and AT/MCS
- Purpose of the mock-up:
  - Simulate mechanical, thermal, and magnetic effects
  - Model will not provide final magnetic field quality
  - Study stability issues
  - Investigate the performance of the stabilization equipment
  - Input for further studies
- Mock-up characteristics:
  - Classical design
  - Direct water cooled coils
  - Same length a longest MLQ type (‘worst case’)
  - Laminated or solid core (in study) made by machining or EDM

MLQ Mock-Up Layout

Accelerator Technology Department

CLIC Main Linac Quadrupole (V4e)

Magnet		
Nominal gradient	200.1	T/m
Nominal integrated gradient	370.0	Tm/m
Aperture radius	5.0	mm
Iron length	1844.0	mm
Effective length	1849.0	mm
Total magnet weight	393.3	kg
Total magnet length	1914.7	mm
Total magnet width	192.0	mm
Total magnet height	192.0	mm
Coil		
Conductor height	5.6	mm
Conductor width	5.6	mm
Cooling hole diameter	3.6	mm
Total number of turns	16	
Cooling		
Number of cooling circuits per coil	1.0	
Pressure drop	4	bar
Current density	6.59	A/mm2
Temperature rise	22.3	K
Coolant velocity	1.1	m/s
Total cooling flow	2.6	l/min
Electrical parameters		
Nominal current	140	A
Magnet resistance (hot)	201.0	mOhm
Power consumption	4108.5	W
Total stored energy	420.7	kJ
Inductance	42.9	mH
Voltage drop (R*I)	29.3	V



CLIC Magnet Work Package

- CDR end of 2010 asks for:
  - More detailed information, integration concepts, basic layouts and feasibility studies, preliminary cost estimates
- Detailed Work package description (draft)
  - Document defines scope, responsibilities and required resources
  - Work package split into 4 main tasks
    - Mock-up quadrupole for the stabilization bench
    - Drive Beam Decelerator Quadrupole study: Large number of magnets (> 40 000), heat dissipation, alternative solutions (hybrid magnet)
    - Beam Line and Injector Magnets: feasibility study, functional specification and preliminary cost estimate
    - Main Linac Quadrupole Study: Mechanical, thermal and magnetic stability, field quality, manufacturing and assembly tolerances, cooling layout