CLIC08 workshop

CLIC module layout and main requirements

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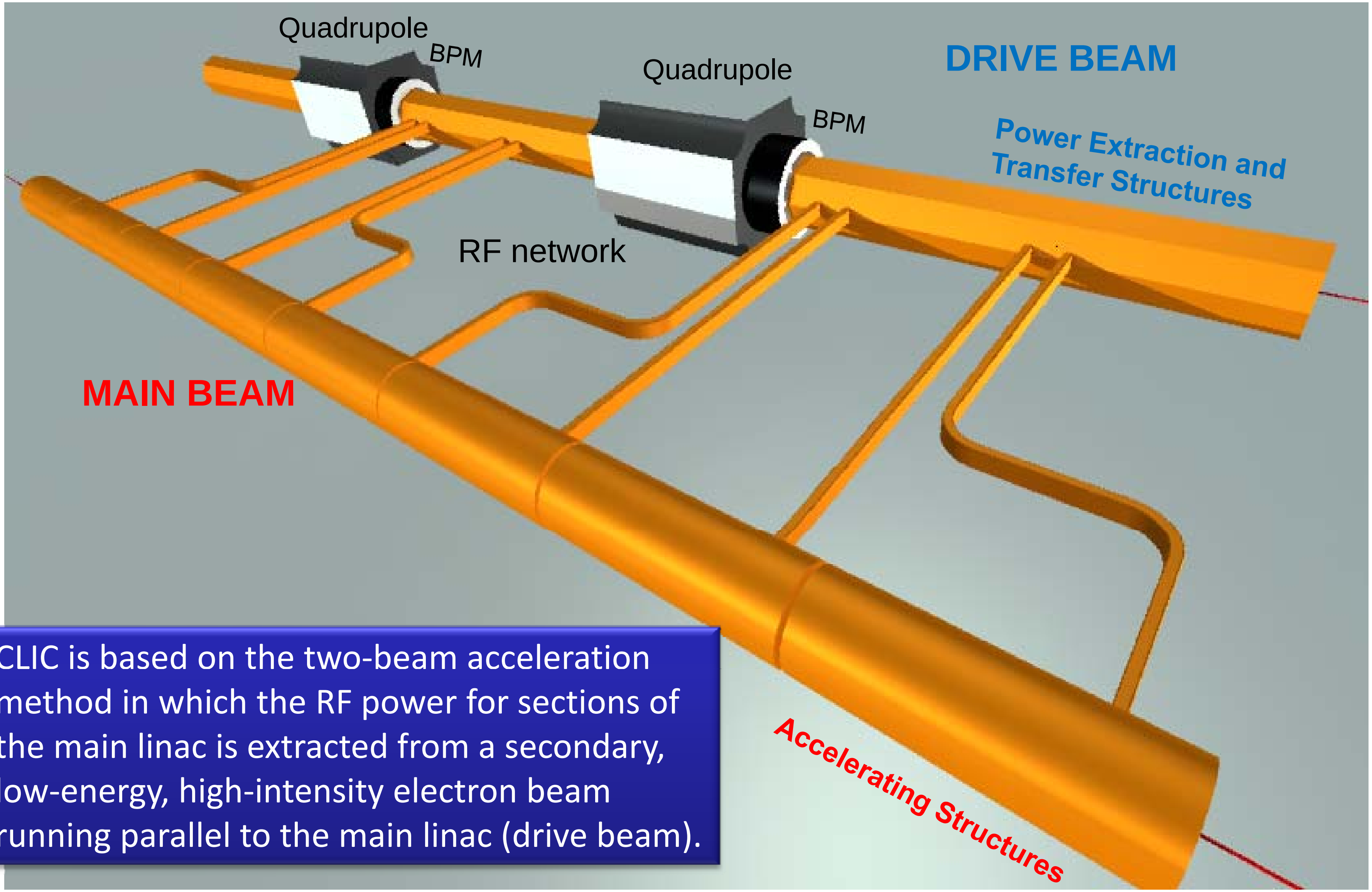
Home page of the TBM WG: http://clic-meeting.web.cern.ch/clic-meeting/CLIC_Module_Wkg/index.htm

Content

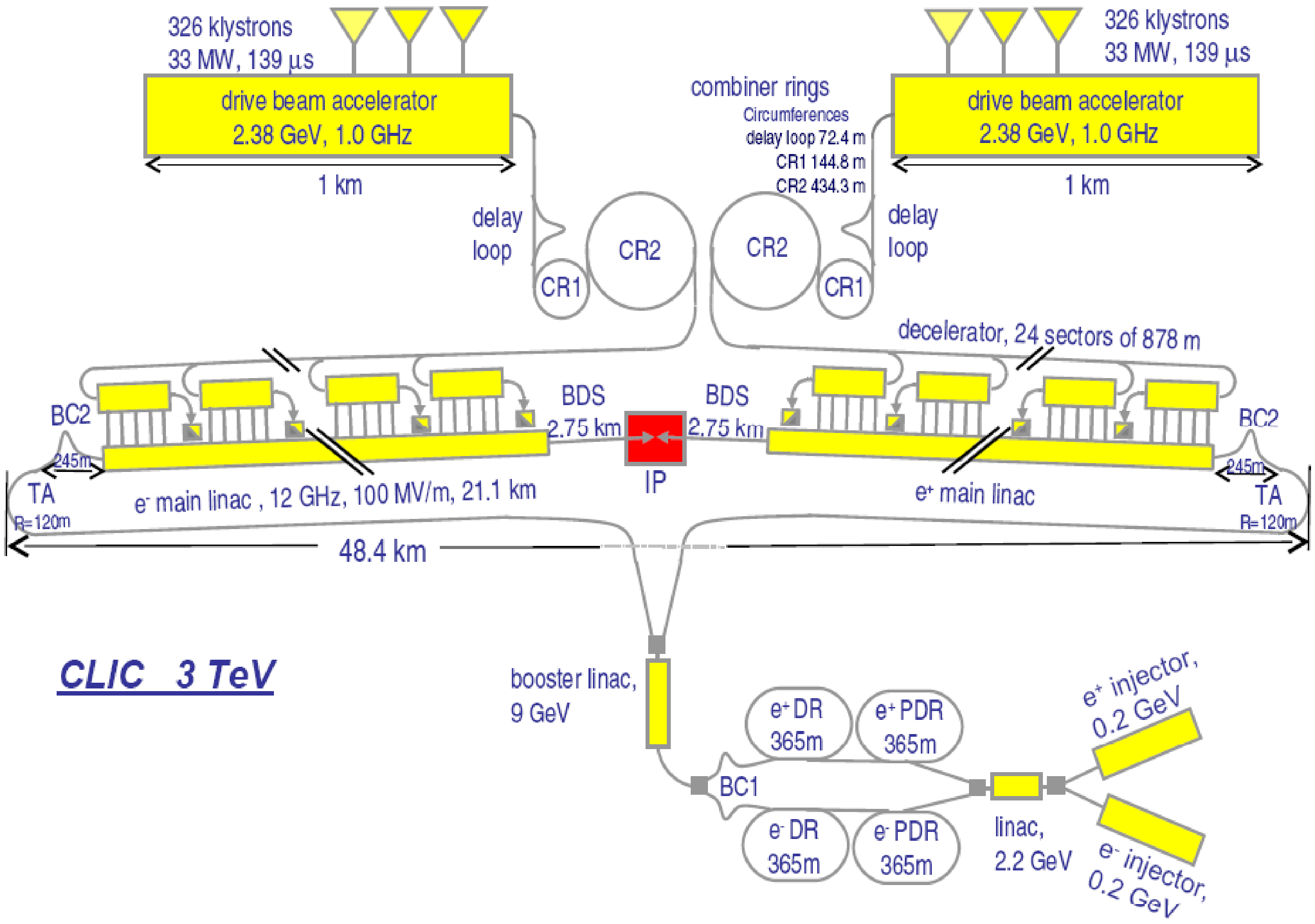
- Introduction and general CLIC parameters
- Layout
- Main components
- Module configurations
- Main system requirement
- Conclusions

CLIC two-beam scheme

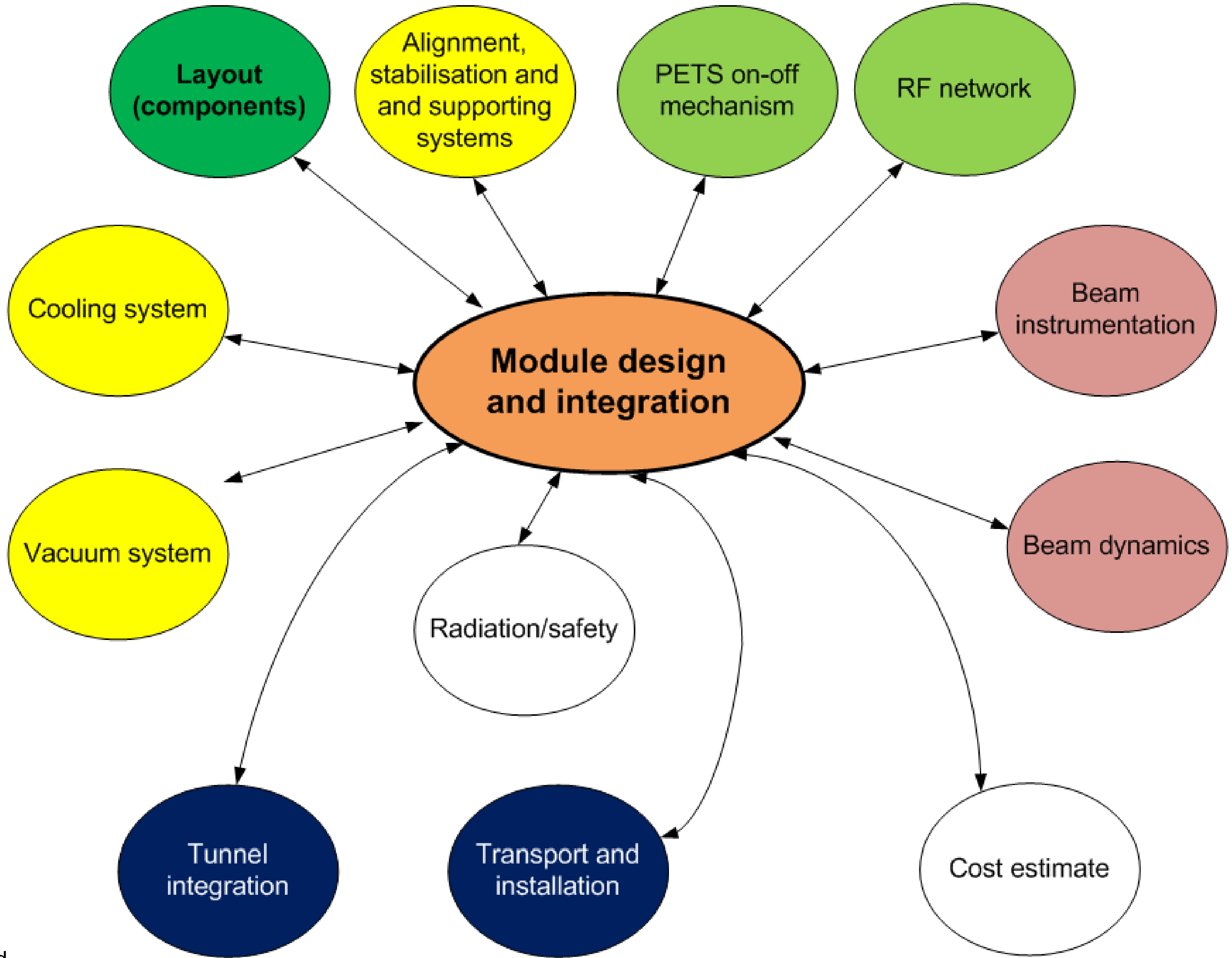


CLIC is based on the two-beam acceleration method in which the RF power for sections of the main linac is extracted from a secondary, low-energy, high-intensity electron beam running parallel to the main linac (drive beam).

CLIC layout


326 klystrons
33 MW, 139 μs
drive beam accelerator
2.38 GeV, 1.0 GHz
1 km
combiner rings
Circumferences
delay loop 72.4 m
CR1 144.8 m
CR2 434.3 m
326 klystrons
33 MW, 139 μs
drive beam accelerator
2.38 GeV, 1.0 GHz
1 km
delay loop
CR1
CR2
CR2
CR1
delay loop
decelerator, 24 sectors of 878 m
BC2
245m
TA
R=120m
BDS
2.75 km
IP
BDS
2.75 km
BC2
245m
TA
R=120m
e⁻ main linac , 12 GHz, 100 MV/m, 21.1 km
e⁺ main linac
48.4 km
CLIC 3 TeV
booster linac,
9 GeV
e⁺ DR
365m
e⁺ PDR
365m
BC1
e⁻ DR
365m
e⁻ PDR
365m
linac,
2.2 GeV
e⁺ injector,
0.2 GeV
e⁻ injector,
0.2 GeV

Several activities



CLIC Main parameters

Module design based on latest CLIC parameters

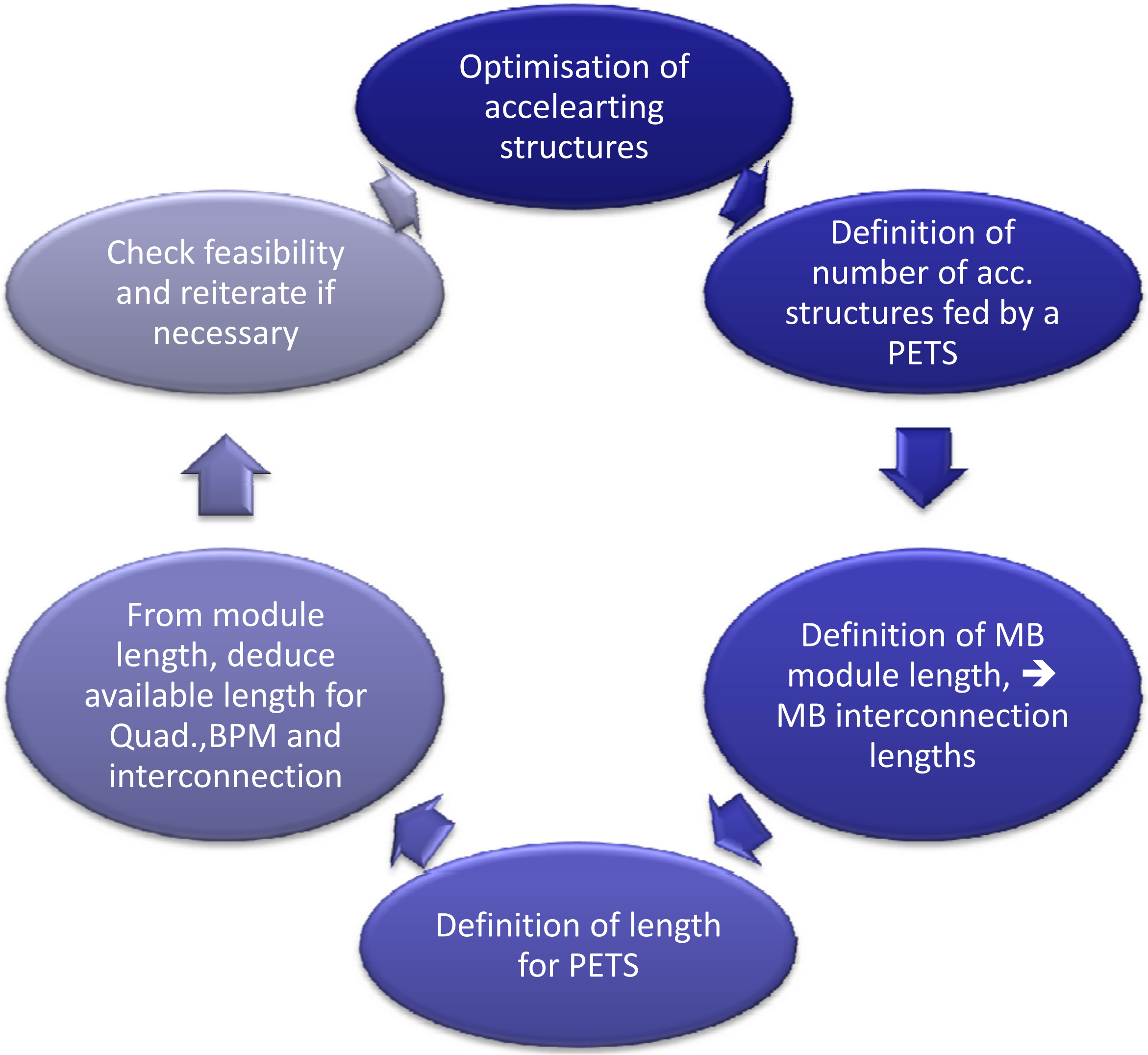
Overall parameter		
center of mass energy	3	Tev
main linac RF frequency	11.994	GHz
luminosity	5.9×10^{34}	$cm^{-2}s^{-1}$
linac repetition rate	50	Hz
beam power/beam	14	MW
unloaded/loaded gradient	120/100	MV/m
proposed site length	~48	km
overal two linac length	~42	km
Main linac		
filling factor	78.6	
accelerator structure length (active)	229	mm
Decelerator		
No. of drive beam sector/linac	24	
No. of PETS per sector	1488	
Length of PETS (active)	213	mm
Nominal output RF power /PETS	136	MW
Transfer effeiciency PETS - acc. structure	93.8	%
No. of acc. structure / PETS	2	
Main beam acc. power / PETS	2x63.9	MW
Energy (injection	2.38	Gev
Energy (final)	238	MeV

Sector length based on the same number of PETS per sector

Sector #	Ac. structures	PETS	Modules
1	2976	1488	523
2	2976	1488	467
3	2972	1486	445
4	2974	1487	432
5	2976	1488	454
6	2974	1487	441
7	2974	1487	441
8	2972	1486	428
9	2974	1487	429
10	2974	1487	432
11	2976	1488	438
12	2976	1488	439
13	2976	1488	438
14	2976	1488	430
15	2976	1488	429
16	2976	1488	429
17	2976	1488	428
18	2976	1488	422
19	2976	1488	422
20	2976	1488	423
21	2976	1488	423
22	2976	1488	418
23	2976	1488	418
24	2976	1488	413
Total	**71406**	**35703**	**10462**

Total per linac
Accelerating structures: 71406
PETS: 35703

Layout definition

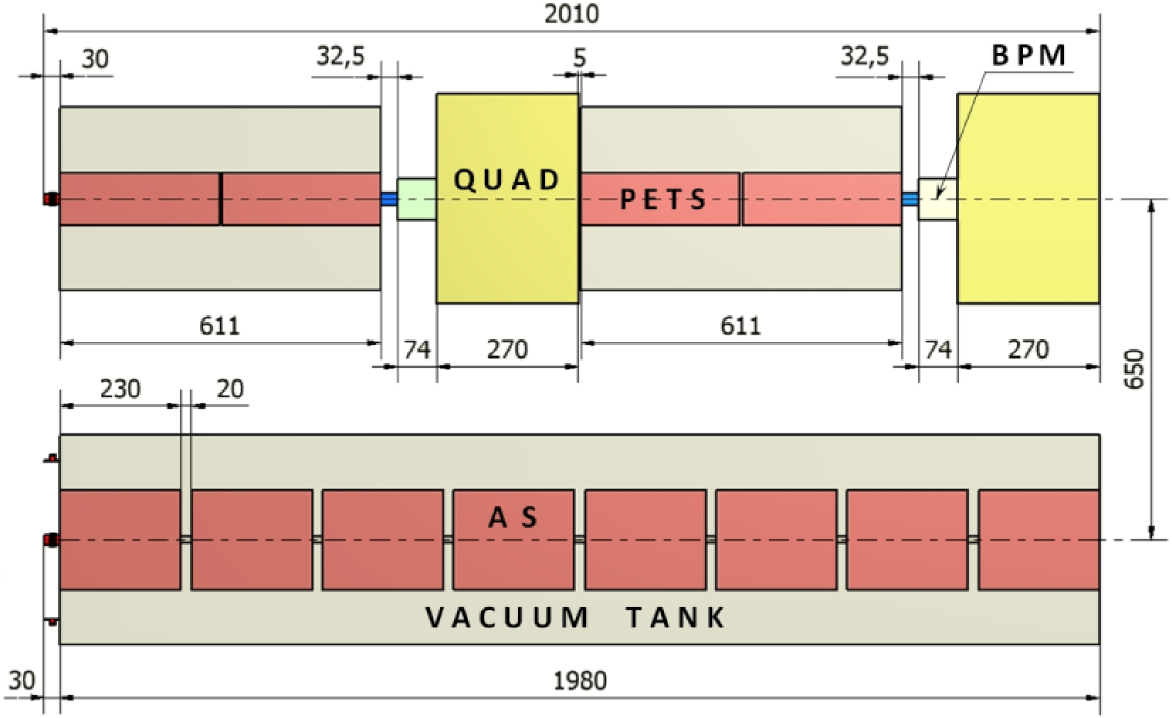


-Module length driven by acc. structure length

- Layout optimisation important for filling factor ➔ high filling factor ➔ higher efficiency

Module main types and numbers

Standard module



CLIC STANDARD MODULE LAYOUT

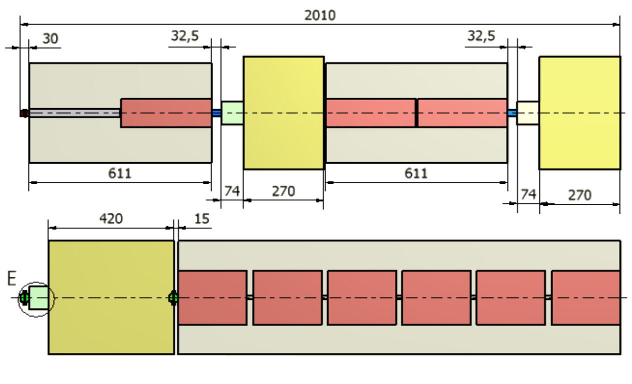
Total per module
8 accelerating structures
8 wakefield monitors

4 PETS
2 DB quadrupoles
2 DB BPM

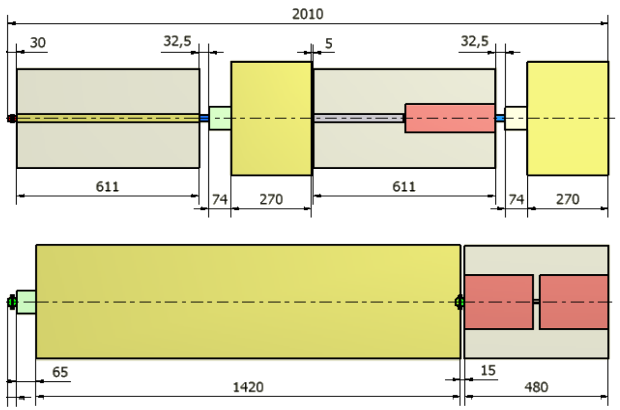
Total per linac
8374 standard modules

Module main types and numbers

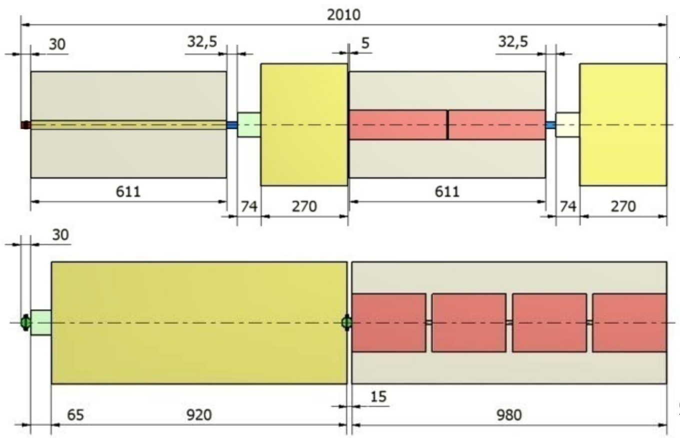
Special modules



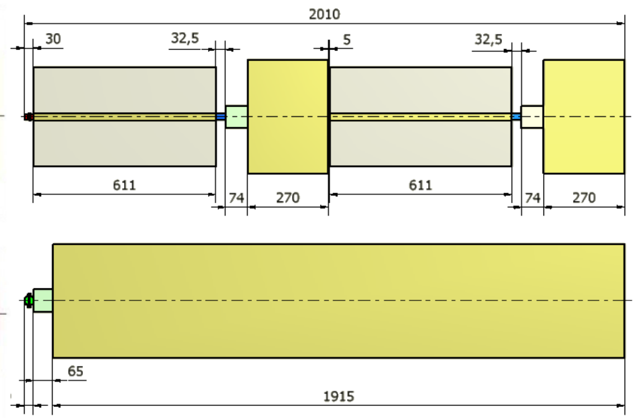
CLIC SPECIAL MODULE 1



CLIC SPECIAL MODULE 3



CLIC SPECIAL MODULE 2



CLIC SPECIAL MODULE 4

Total per linac

Quadrupole type 1: 154

Quadrupole type 2: 634

Quadrupole type 3: 477

Quadrupole type 4: 731

Other modules

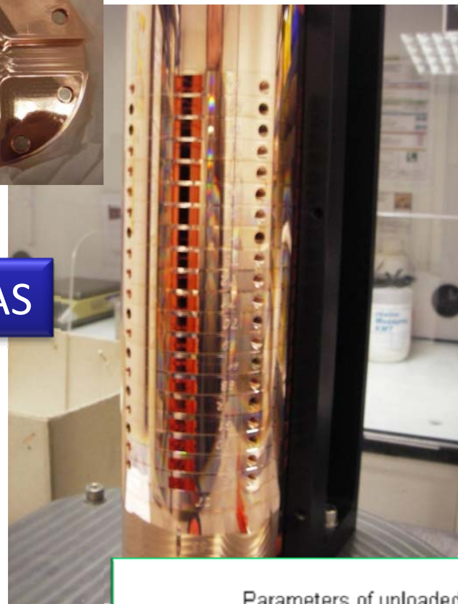
- modules in the damping region (no structures)
- modules with dedicated instrumentation
- modules with dedicated vacuum equipment
- …

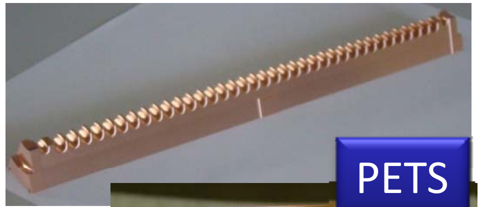
Main components: structures

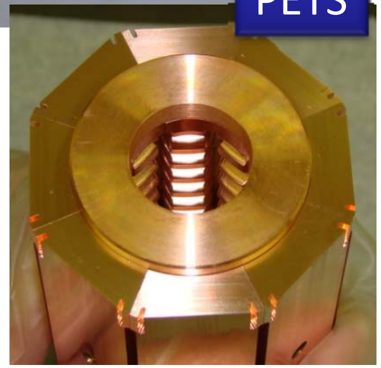
PETS (I. Syratchev)

Accelerating structure (A. Grudiev)

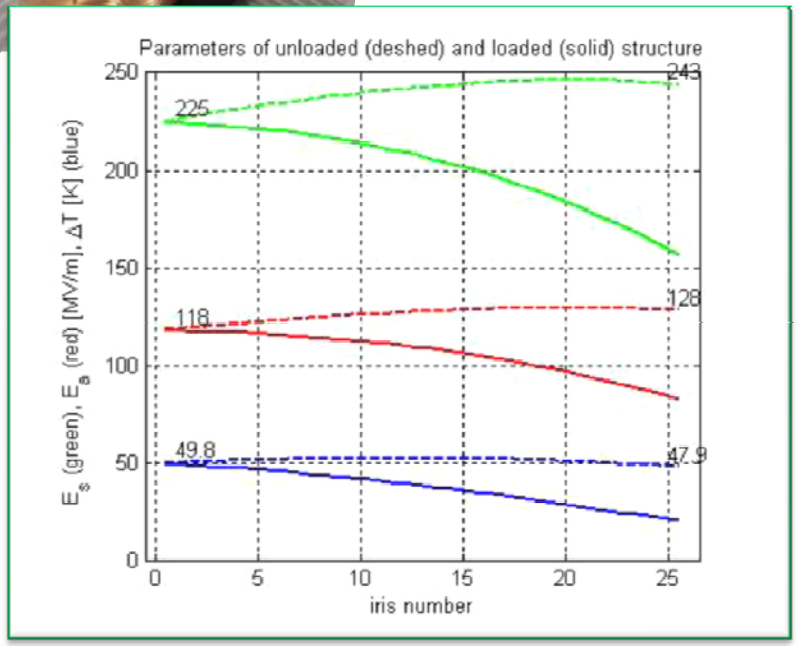
	PETS	CLIC_G
Aperture [mm]	23	6.15-4.7
Phase advance	π/2	2π/3
V_g/c	0.45	.017-.012
R'/Q [kΩ/m]	2.2	15-16
Length [mm]	210	229
P_{max} [MW]	136	64
$Esurf_{max}$ [MV/m]	56	245
$P_{in}/Ct^{P}{}_{p}^{1/3}$[MW/mm ns$^{1/3}$]*	13	18
ΔT (°K) *	2	56
Allowable breakdown rate (Daniel's talk)	O(10^{-7} to10^{-6})	O(10^{-7})
moding	overmoded	single







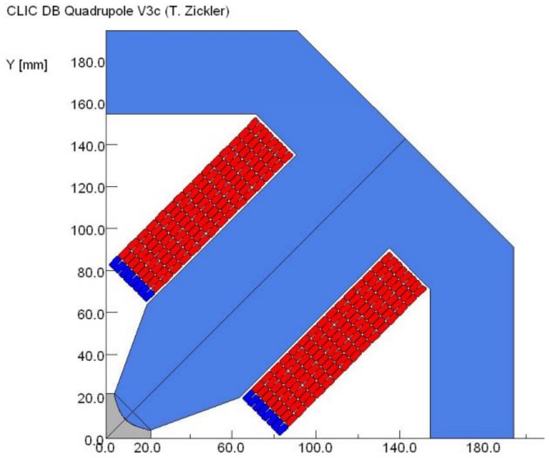
ACS: Pulsed surface heating temperature rise, accelerating gradient and maximum surface electrical field



Main components: RF network

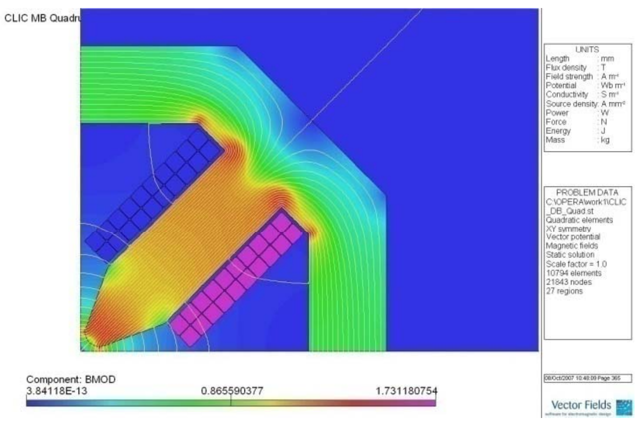
- PETS and accelerating structures are connected via waveguides and choke mode flanges → choke mode flanges allows the power transmission without electrical contact between waveguides. This device should be flexible in order to permit independent alignment of two waveguides.
- Waveguide length optimised based on losses, phase advance and RF to beam timing considerations
- High power load are needed at the outlet of the accelerating structures (1 load per two accelerating structures)

Main components: quadrupoles



Drive beam

Aperture radius: 13.0 mm
Integrated gradient: 14.3 Tm/m
Nominal gradient: 67.1 T/m
Total length: 270 mm
Magnet width: 390 mm
Magnet weight: 180 kg
Distance between opposite coils: 118 mm
Water cooling



Main beam

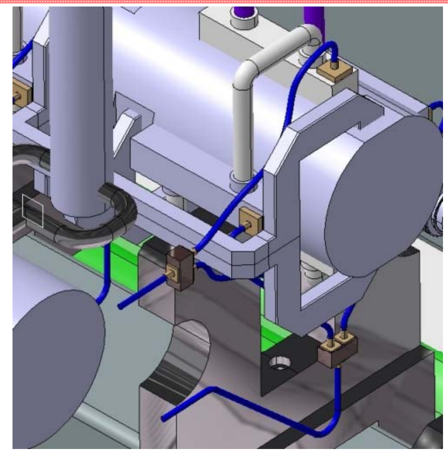
Aperture radius: 4.00 mm
Integrated gradient: 70 (170, 270, 370) Tm/m
Nominal gradient: 200 T/m
Total length: 420 (920, 1420, 1920) mm
Magnet width: < 200 mm
Magnet height: < 200 mm
Magnet weight: ~ 75 (110, 135, 270) kg
Water cooling

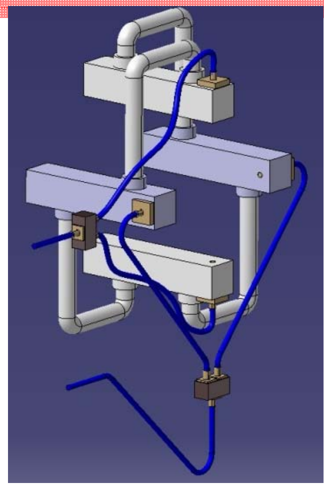
Main components: Instrumentation

Parameter	Requirements		Devices	
	From	Parameters	Method	Performances
Drive Beam				
Position	Decelerator	Precision ~10 µm Resolution ~1 µm	Inductive pick-up Re-entrant Cavity	Resolution ~ 200nm (lab) Resolution ~ 3.2r µm (lab)
Energy	Turn-around	Resolution ~ 10-5	Precision BPM	See position monitor
Bunch Length	Decelerator	Resolution ~ 0.5ps	Streak camera RF Deflector RF pick-up	> 0.2ps better than 0.5ps > 0.5ps
Phase Stability	Turn-around	0.1° @12 GHz	RF methods	0.1° @12 GHz (electronic)
Main Beam				
Position	Main Linac	Precision ~ 1 µm Resolution ~ 100nm	Inductive pick-up Cavity BPM	Resolution ~180nm (lab) Resolution ~ 15nm (beams)

CLIC note 764

WFM integrated in acc. structure: resolution 1 µm, precision: 10 µm



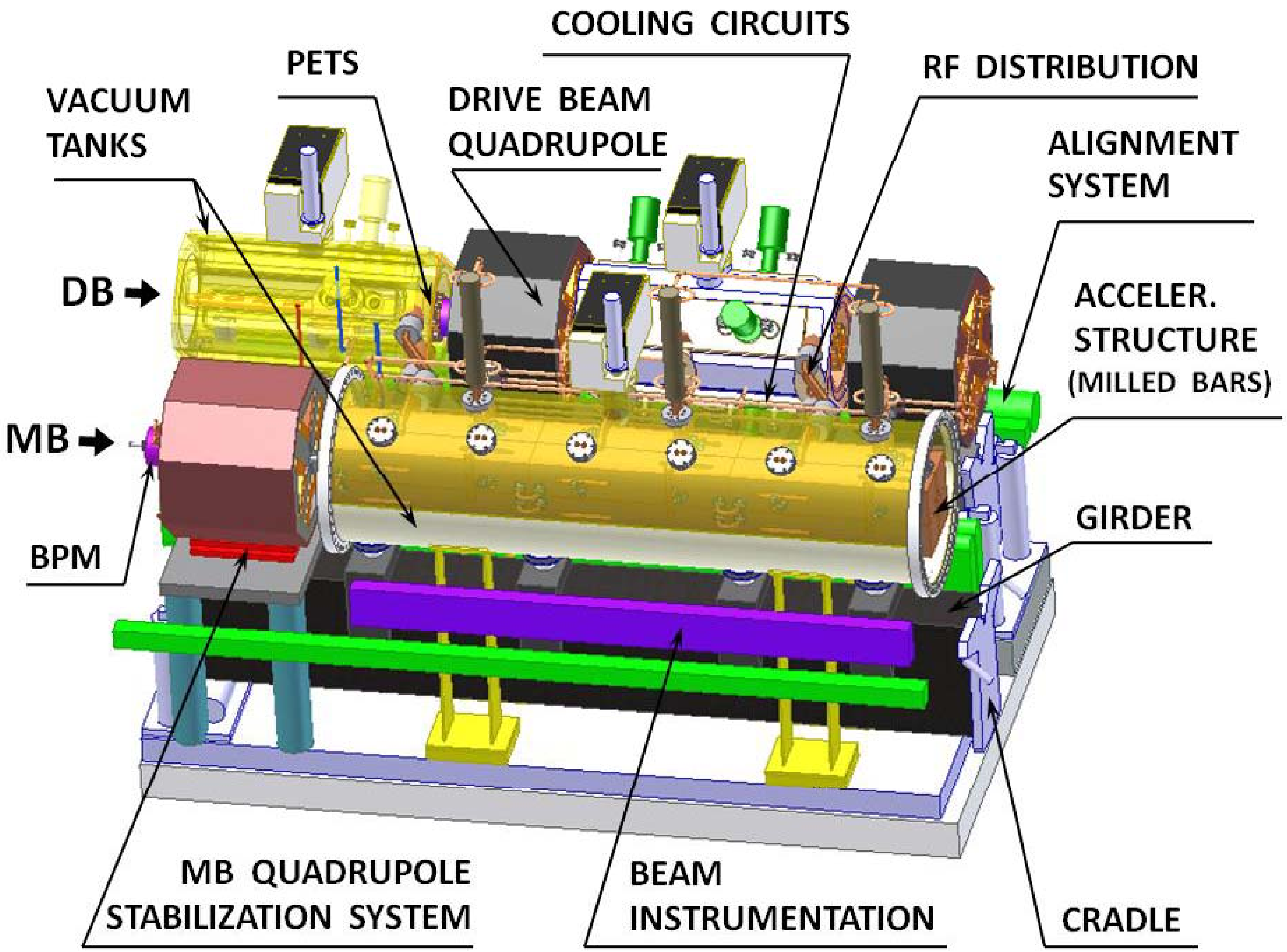


Drive beam: ~ 47000 devices
Main beam: ~151500 devices
(142800 WFM)

Module configurations

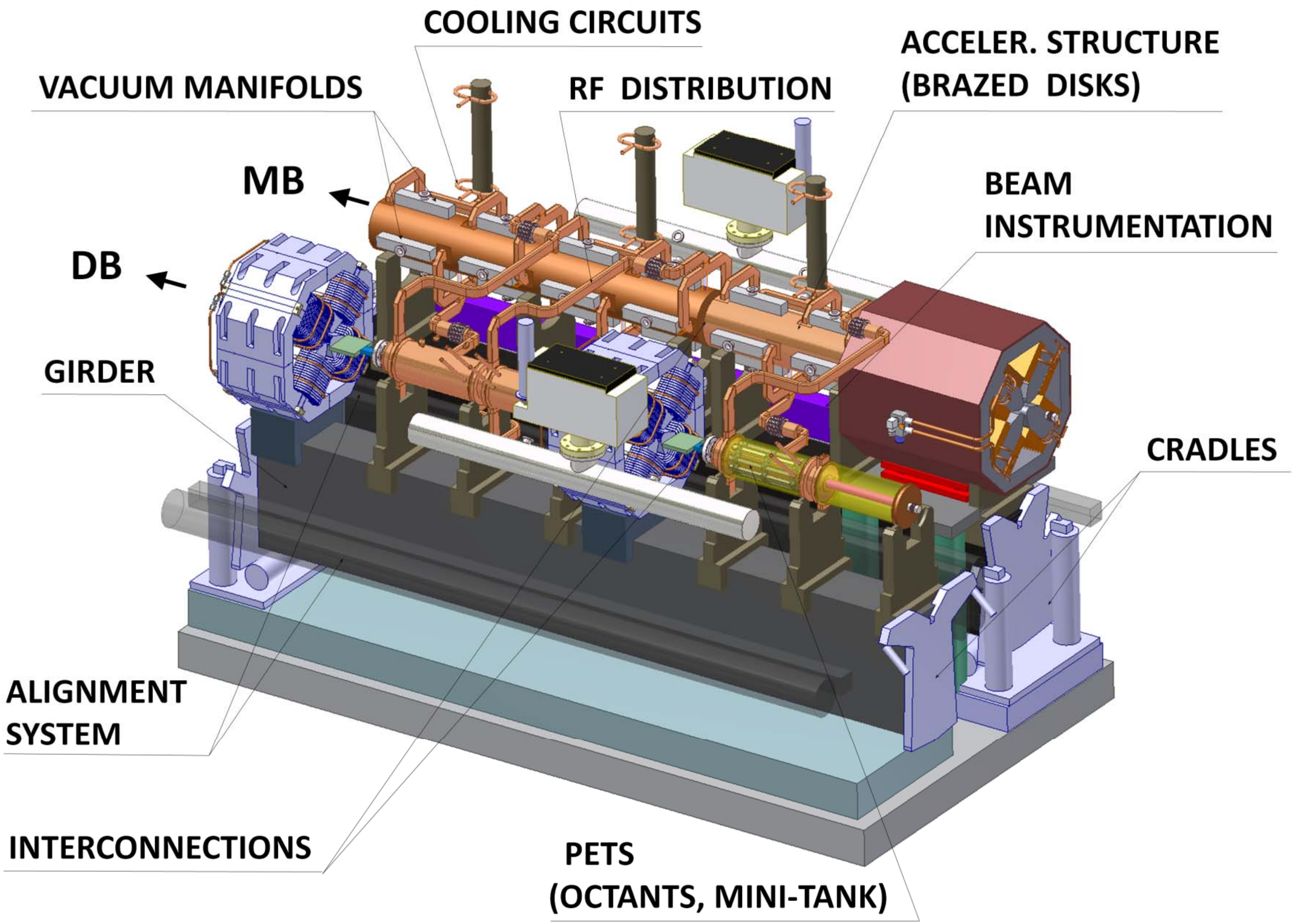
- Several configurations are possible depending on structure technologies and design
  - Accelerating structures can be made in quadrant or in disks
  - Structure can be sealed or mounted inside a vacuum tank
- Two configuration has been studied
  - In configuration #1, the accelerating structures are formed by four high-speed milled bars which are then clamped together, and the PETS bars and couplers are all clamped and housed in a vacuum tank.
  - In configuration #2, the ACS are made of discs all brazed together forming a sealed structure, and the PETS are made of octants and “mini-tanks” around the bars.

Configuration #1



Collaboration with Dubna-JIRN, CEA-Saclay, HIP

Configuration #2



Collaboration with Dubna-JIRN, CEA-Saclay, HIP

Main technical requirements

- **Structure fabrication and assembly (CERN, HIP, CEA)**
  - Shape accuracy for acc. structures: 5 μm
  - Shape accuracy for PETS: 30 μm
- **Alignment/supporting system (CERN, HIP, DUBNA, NIKHEF):** possibility to align separately main beam and drive beam independently
  - Main beam
    - Accelerating structures on girders (cradles mechanically attached to a girder and linked by rods to the adjacent one): alignment system integration
    - Main beam quadrupole on dedicated supports: stabilization and alignment system integration
  - Drive beam
    - PETS and quadrupoles on the same girders
    - Alignment system integration
- **Tolerances for pre-alignment**
  - accelerating structure pre-alignment transverse tolerance 14 μm at 1σ
  - PETS pre-alignment transverse tolerance 30 μm at 1σ
  - quadrupole pre-alignment transverse tolerance 17 μm at 1s

Main technical requirements

- **Stabilization system (CERN , LAPP, SLAC, Monalisa, DESY, CEA-IRFU/SIS,..)**
  - 1.3 nm at 1 Hz in vertical direction
  - 14 nm at 1 Hz in horizontal direction
- **Vacuum system**
  - 5.10^{-9} mbar for main beam (simulation under way to confirm the requirement);
  - dynamics of the H_2O pumping in limited conductance systems must be better understood: an experimental set-up is being implemented to study H20 pumping dynamics
- **Cooling system (CERN, HIP, WUT)**

  Dissipated power:
  - AS: 600 W
  - PETS: 110 W
  - 7.7 kW for a module

  Most stringent requirement comes from accelerating structures

  Different operation modes to be taken into account with different thermal loads

All these systems have to be studied taking into account acceleration environment and tunnel integration

Conclusions

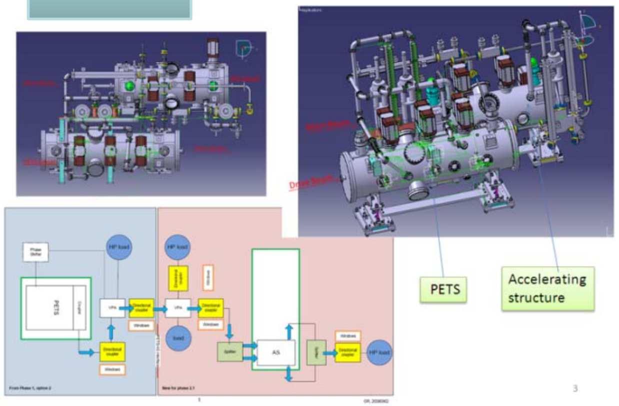
- The CLIC study is carrying out a number of specialized development programs of subsystems such as high-power rf structure and micron precision alignment, the specification for the CLIC module is being finalized.
- Based on it module design and integration have to be studied for different configurations, identifying thus areas needing dedicated study and design.
- Potential advantages and drawbacks are being evaluated for each configuration.
- Important aspects of cost are raised and basic parameters provided for other areas of the study.
- The module study is important as it raises feasibility issues and provides basic parameters for other areas of the CLIC study ➔ synergy with several other working groups, such as beam physics, stabilization, CES, cost and schedule,..
- Integration of the systems in terms of space reservation has been done for all the module types and detailed design started for the main systems, such vacuum, cooling, alignment, stabilisation…

  ➔ work from collaborations is indispensable and highly appreciated

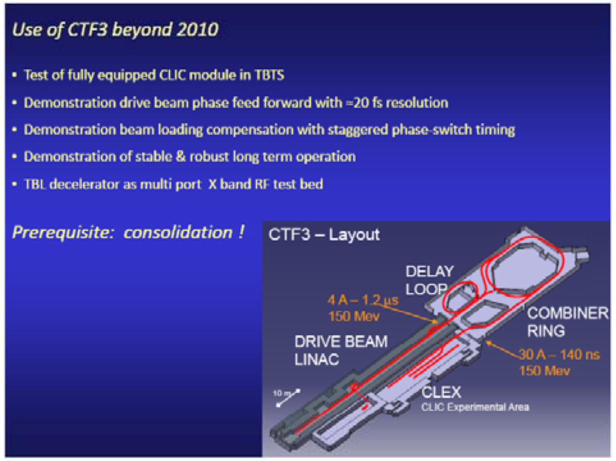
- CLIC module in CLEX from 2010
  - Test/CLIC modules
  - String of modules

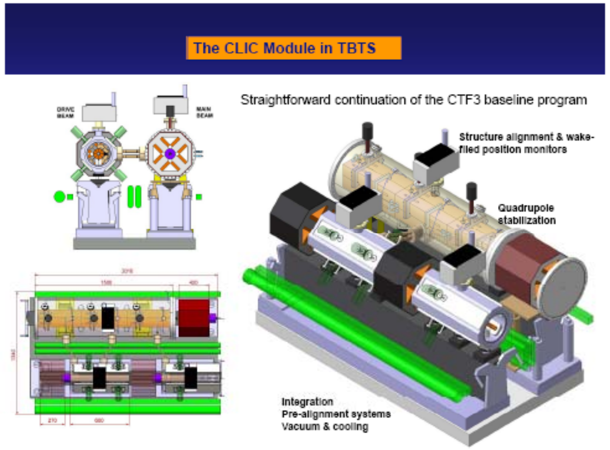
Future : from TBTS to TBA

TBTS



Test module (FP7) and CLIC modules in CLEX





Two-beam module strings in next CLIC facility