HEPTech Academia - Industry Matching Event on
Technology of Controls for Accelerators and Detectors

CLIC Two-beam Module controls issues

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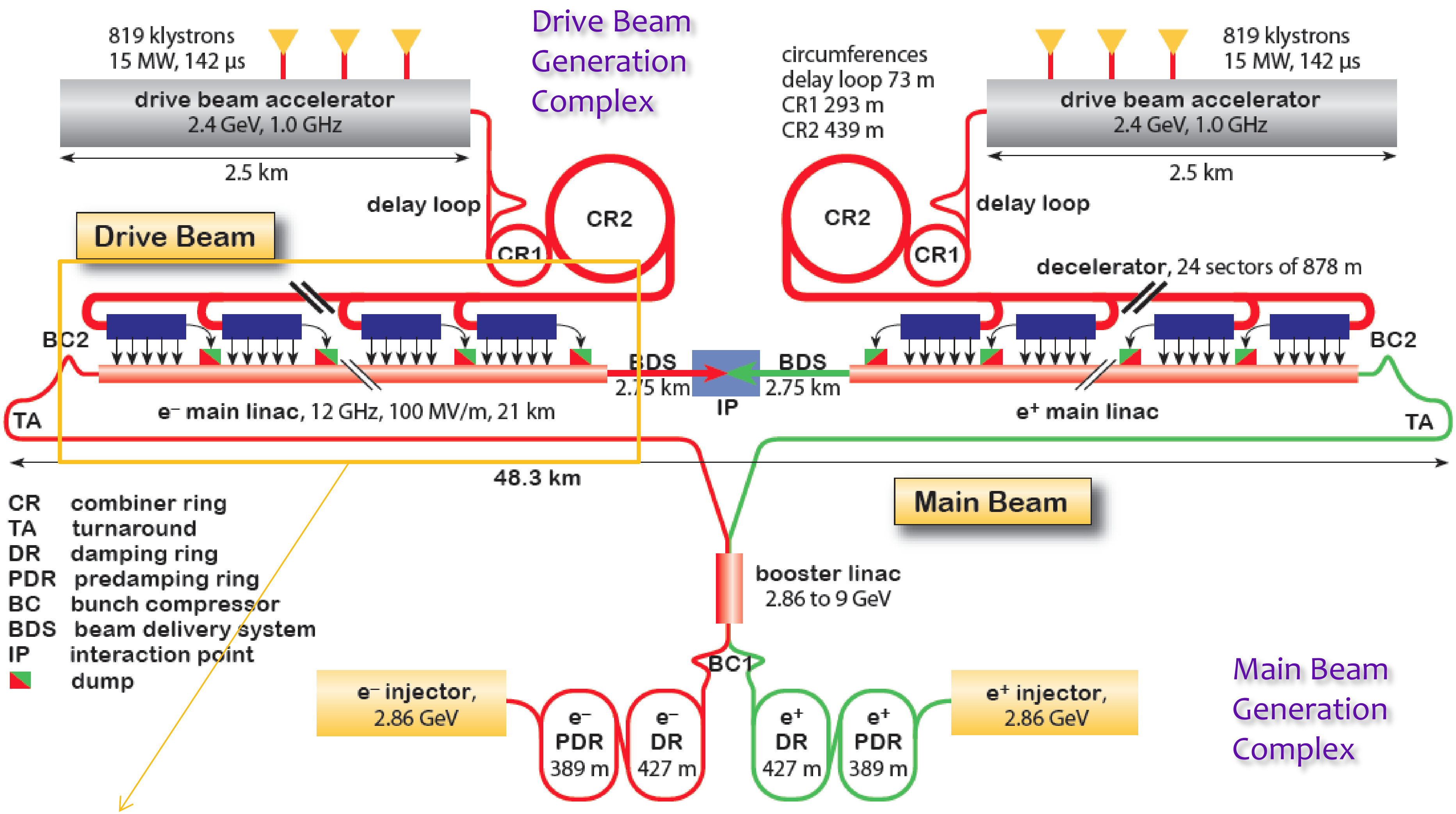
Content

- CLIC introduction and timeline
- Main requirements
- Main issues
- Solutions under study
- Conclusions and next steps

CLIC in few words

- Linear collider e+/e- with center-of-mass collision energy up to 3TeV
- Total length up to 48 km; main linac ~ 90 %
- Based on two-beam acceleration
  - Drive beam (RF decelerating structures – PETS – which transfer the RF power to the main beam via a complex RF network)
  - Main beam (RF structures which accelerates the beam – 100 MV/m)
- Main linac houses the 2-m long two beam modules (TBM)
- For the control of the TBMs, we have to develop a compact acquisition and control module (ACM)

CLIC Layout at 3 TeV

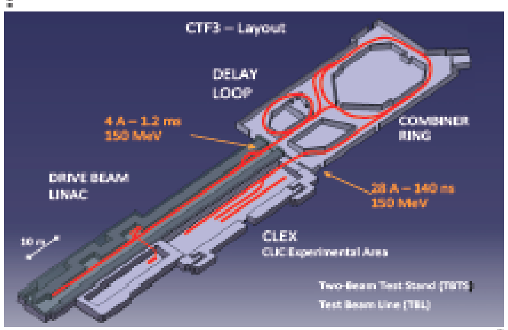


Main LINAC ➔ two-beam modules

CLIC project time-line

2012-16 Development Phase

Develop a Project Plan for a staged implementation in agreement with LHC findings; further technical developments with industry, performance studies for accelerator parts and systems, as well as for detectors.



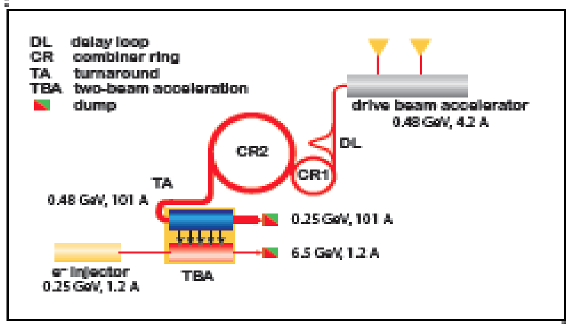
2016-17 Decisions

On the basis of LHC data and Project Plans (for CLIC and other potential projects), take decisions about next project(s) at the Energy Frontier.

2017-22 Preparation Phase

Finalise implementation parameters, Drive Beam Facility and other system verifications, site authorisation and preparation for industrial procurement.

Prepare detailed Technical Proposals for the detector-systems.



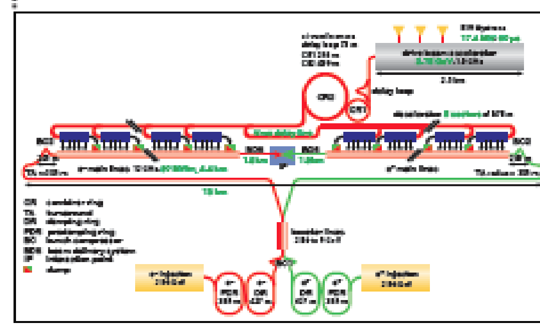
2022-23 Construction Start

Ready for full construction and main tunnel excavation.

2023-2030 Construction Phase

Stage 1 construction of a 500 GeV CLIC, in parallel with detector construction.

Preparation for implementation of further stages.

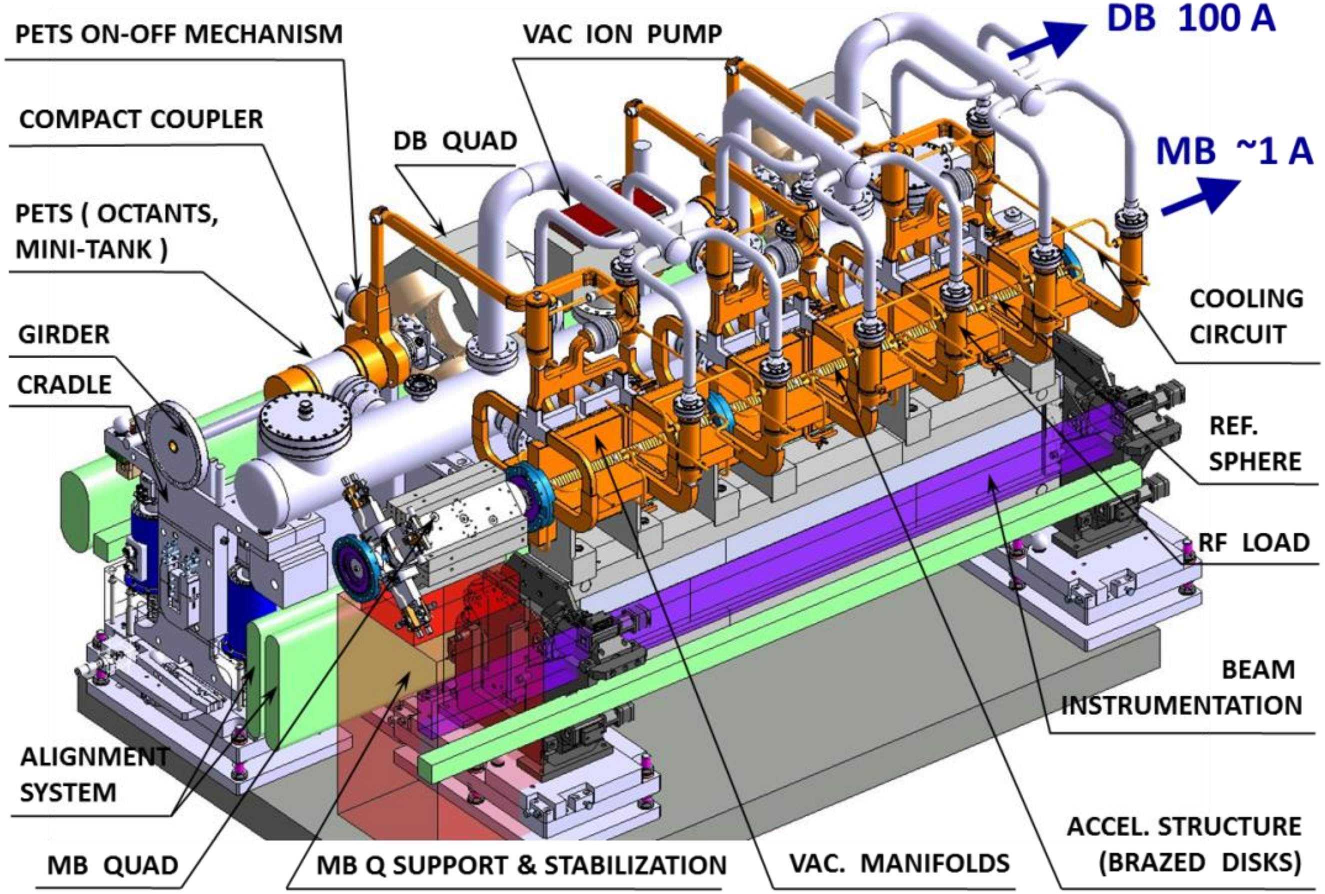


2030 Commissioning

From 2030, becoming ready for data-taking as the LHC programme reaches completion.

** S. Stapnes, CLIC Workshop 2013, CERN*

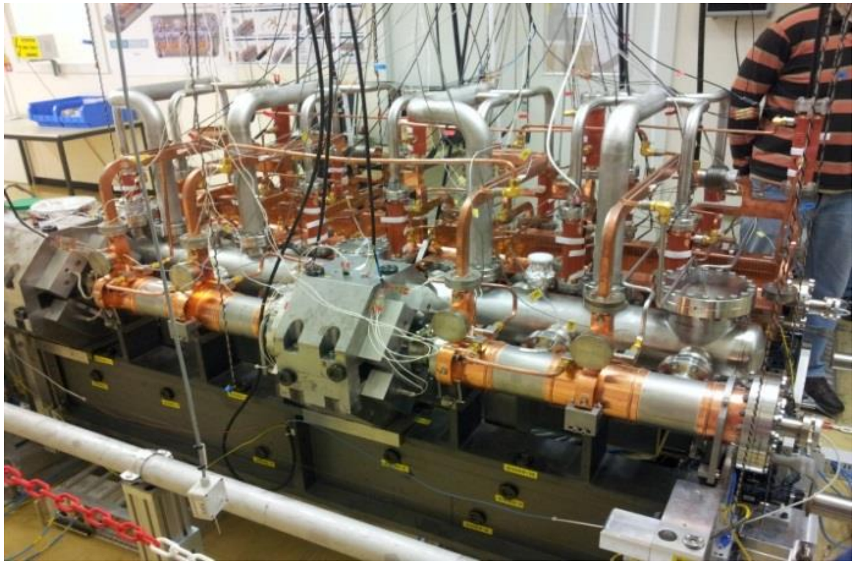
Two-beam module layout

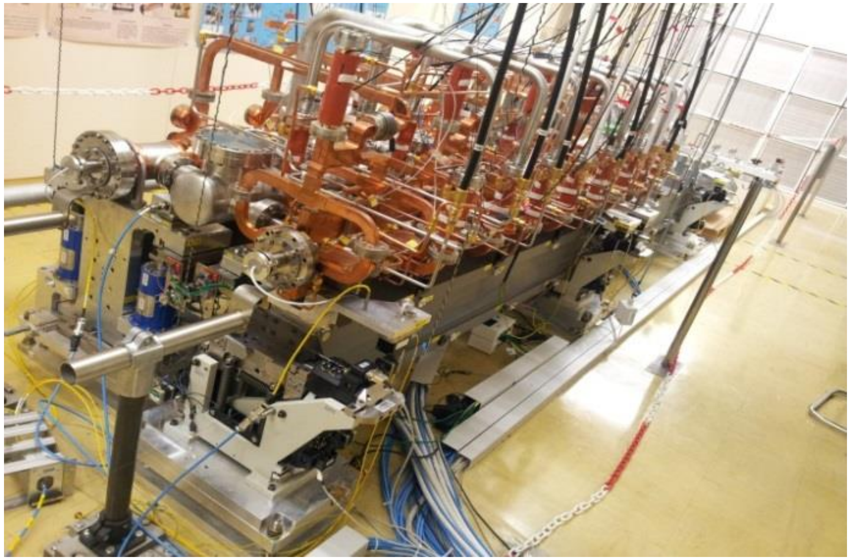


CLIC at 500 GeV (4232 modules)
26920 Accelerating structures
13460 PETS
~ 70000 RF components

CLIC at 3 TeV (21460 modules)
142760 Accelerating structures
71380 PETS
~ 400000 RF components

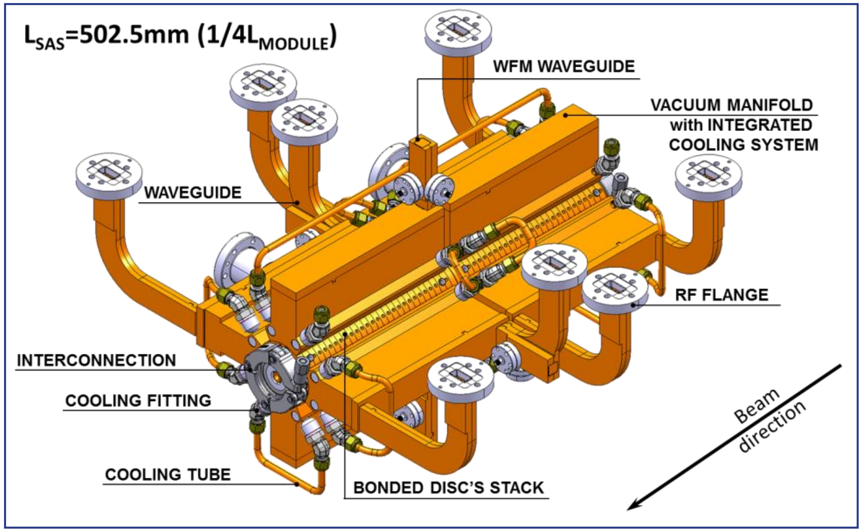
First TBM prototype



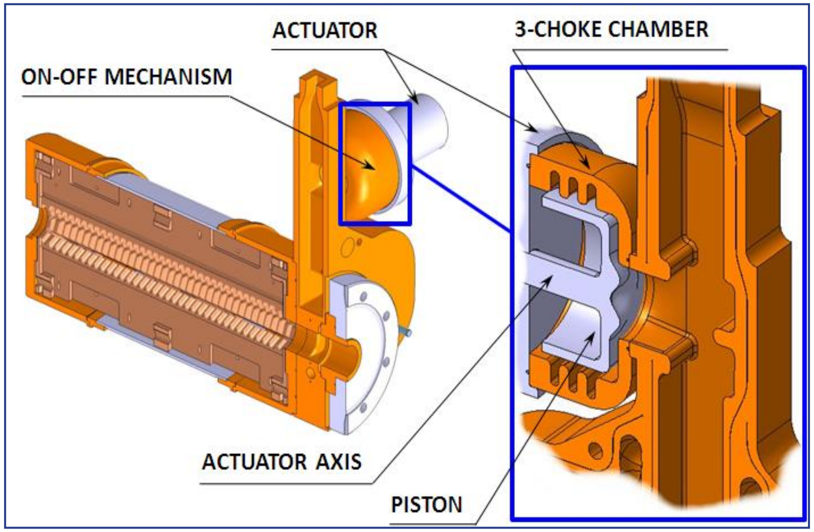


Collaboration with NTUA and other Greek institutes (PATRAS, Democritos,….)

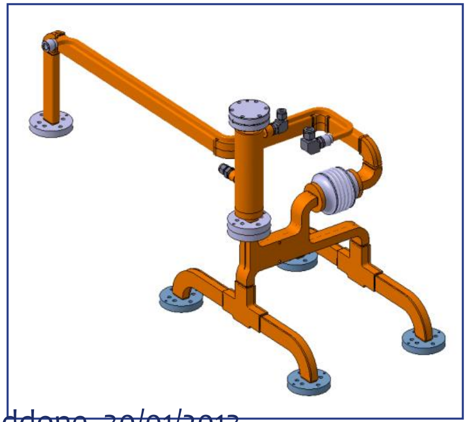
RF system – RF structures



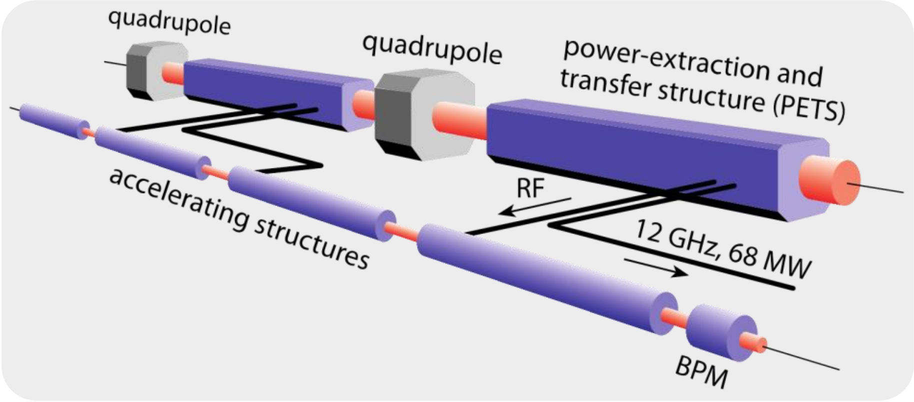
Accelerating structure (AS) – disks with 4 manifolds and all needed technical systems



PETS – octants housed in a tank and coupler

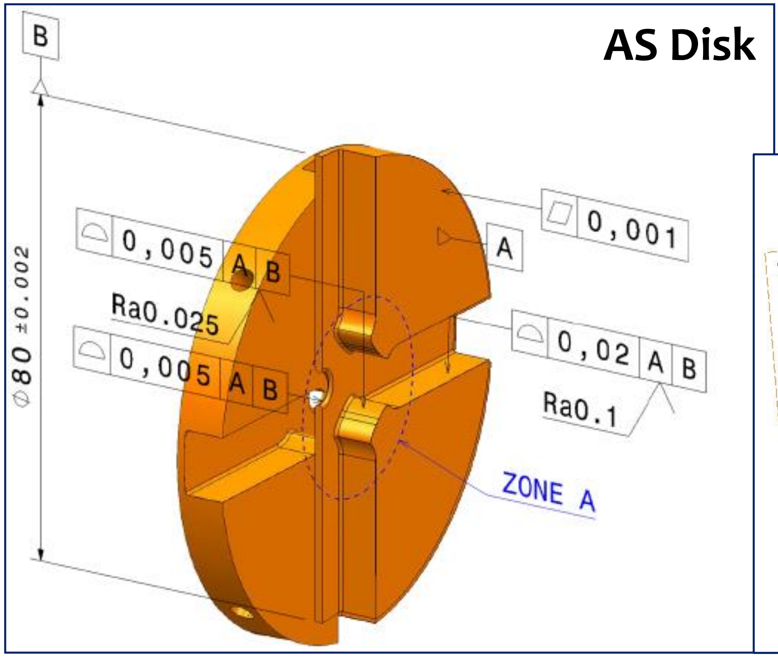


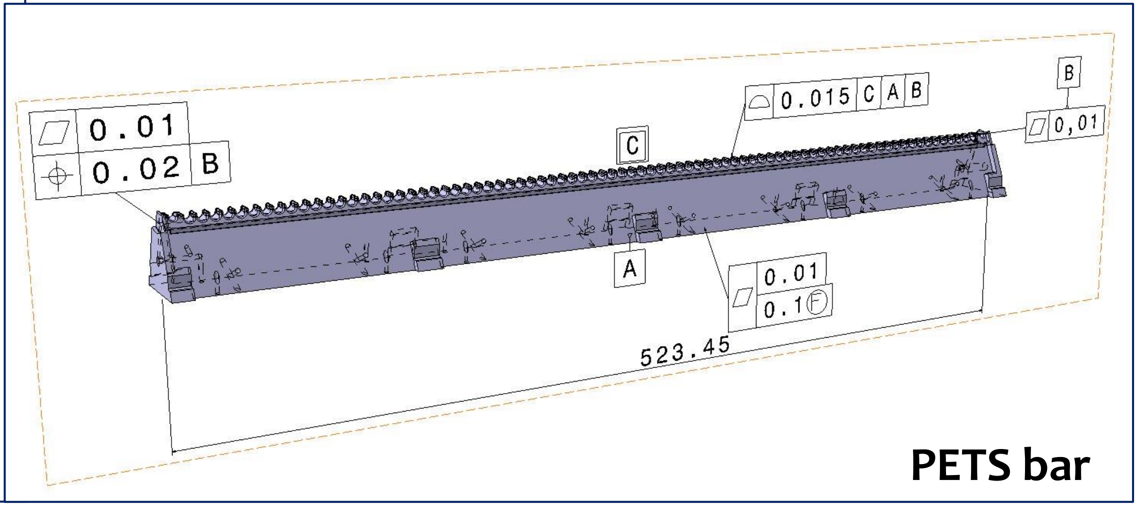
RF network: waveguides and several RF components



RF structures - Requirements

Requirements are dictated by beam physics and RF
➔ ultra high precision machining and positioning to allow the beam to pass through (beam emittance few nm in V)





Acquisition and Control Module

- For the TBMs, we have to develop a compact acquisition and control module (ACM)

- ACM: a device providing timing, data acquisition and control to the different systems (Alignment, Stabilization, Power, Vacuum, Cooling, …), communicates with Front End Computers (FECs) installed in alcoves.

Inventory of signals

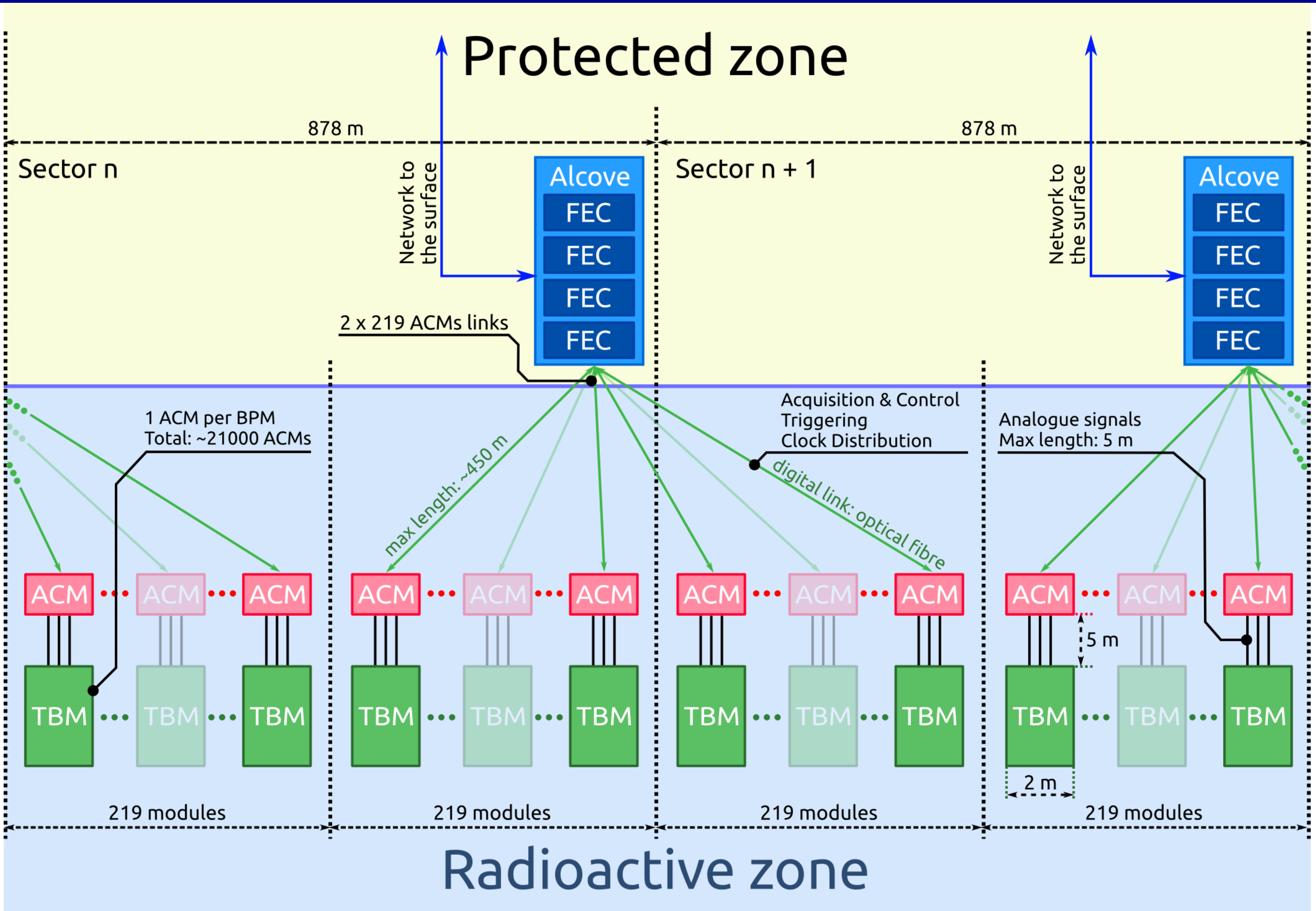
Ch type	S-rate [S/s]	Resolution [bits]	# ch
V. Fast ADC	2 G	8	0
Fast ADC	200 M	14	28
Slow ADC	1 k	16	105
Slow DAC	1 k	18	8
Raw DIO	1 k		146
Serial I/O			14
Total per TBM			301

Including spare: about 500 signals per modules,
In addition: to increase reliability, critical signals for machine operation (~50) could be duplicated in adjacent ACMs

ACM constraints and requirements

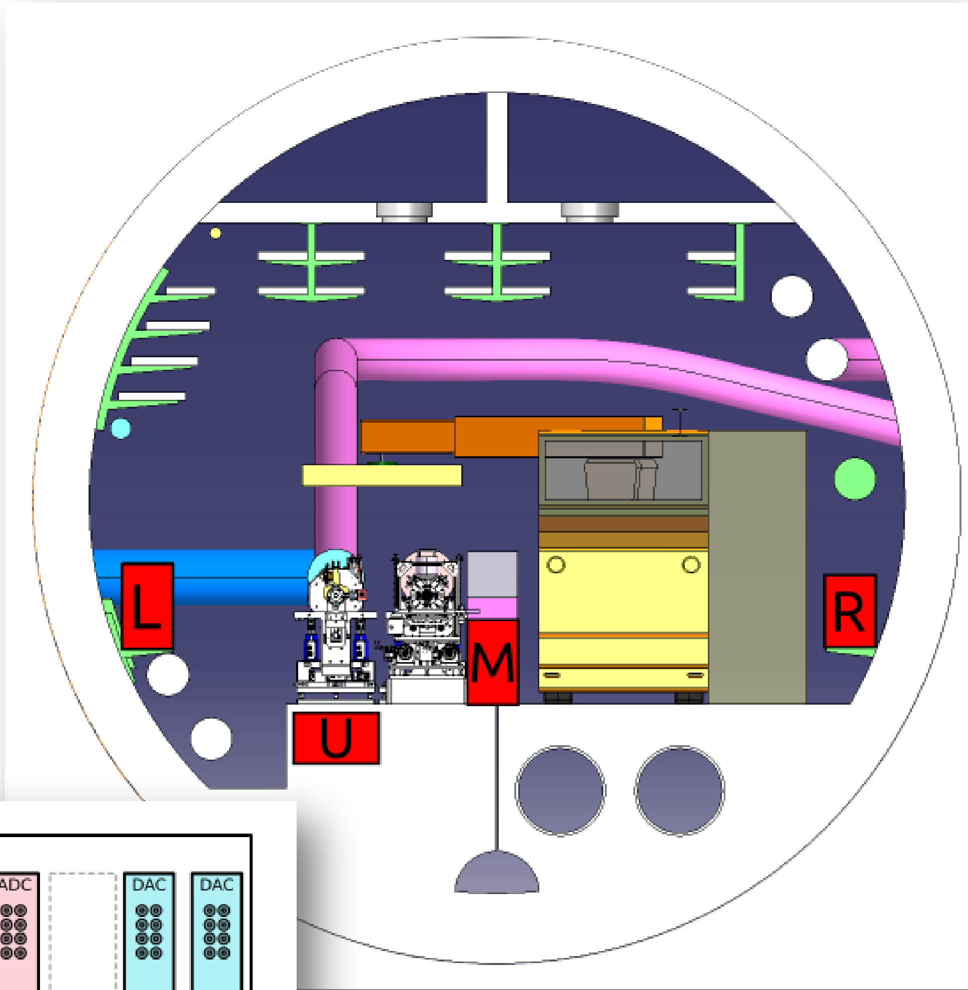
- CLIC have to concentrate all (or most of) data acquisition and setting through a single point (ACM) ➔ generic solution suitable to all technical systems
- Due to sector dimensions digitalization shall be done in place.
  - Sector length 878m
  - Considering central counting room the distance between TBM and counting room can be over 400m
- Common timing
- High reliability and easy maintainability
- Modular and compact design
- Power consumption < 50 W
- Cost (large series production)

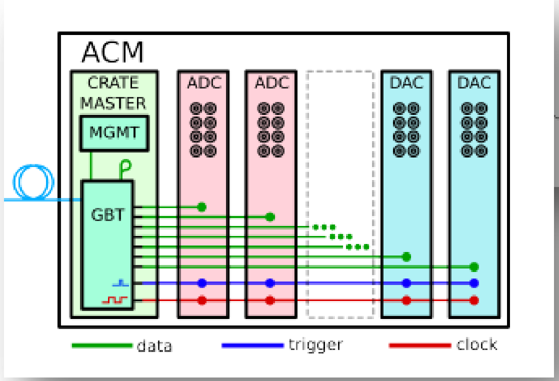
Possible layout



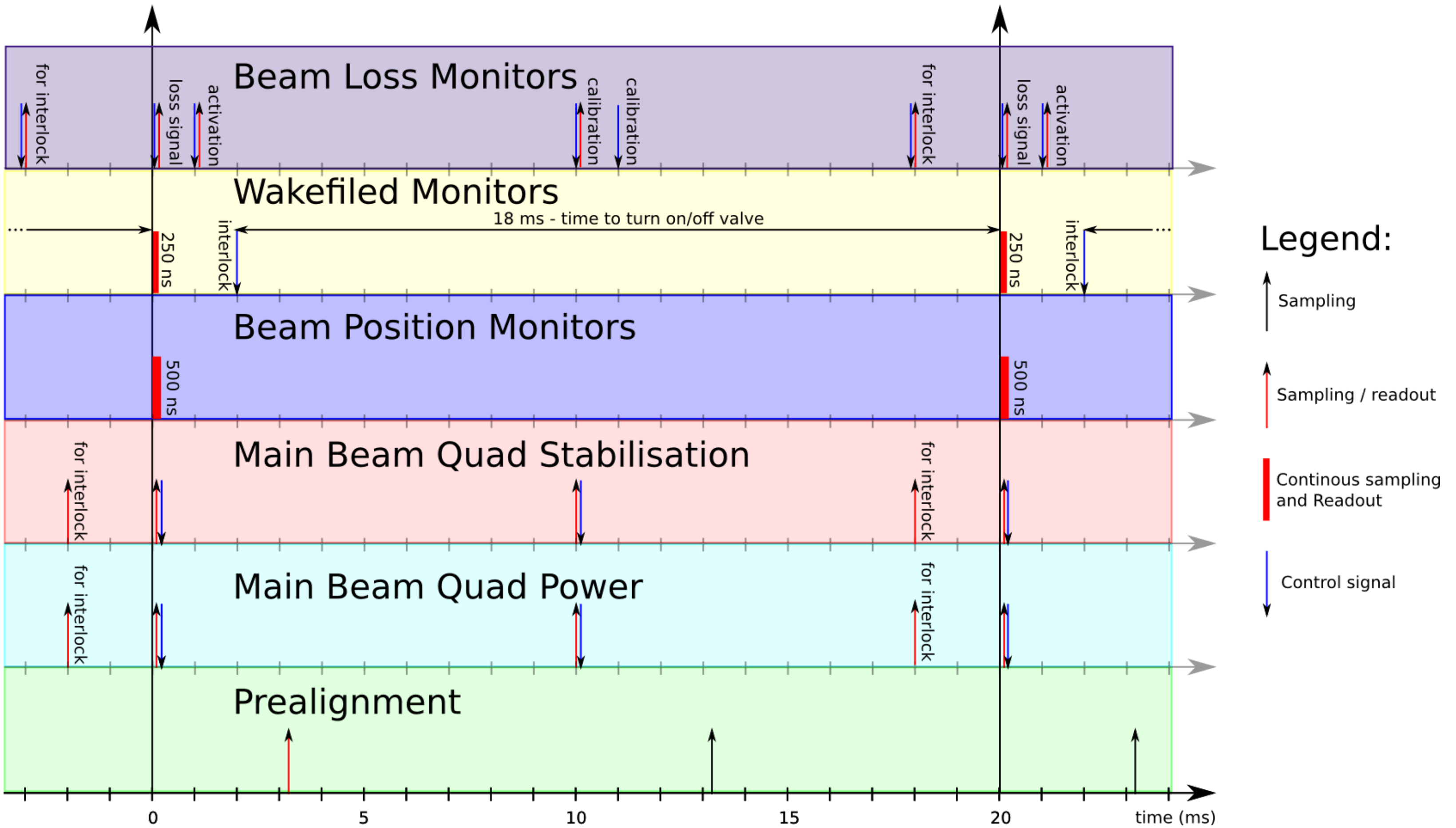
Tunnel integration

- Radioactive zone: TIDs, from 100 to 1000 Gy
- Tunnel integration; several options under study





Signals Timing Diagram



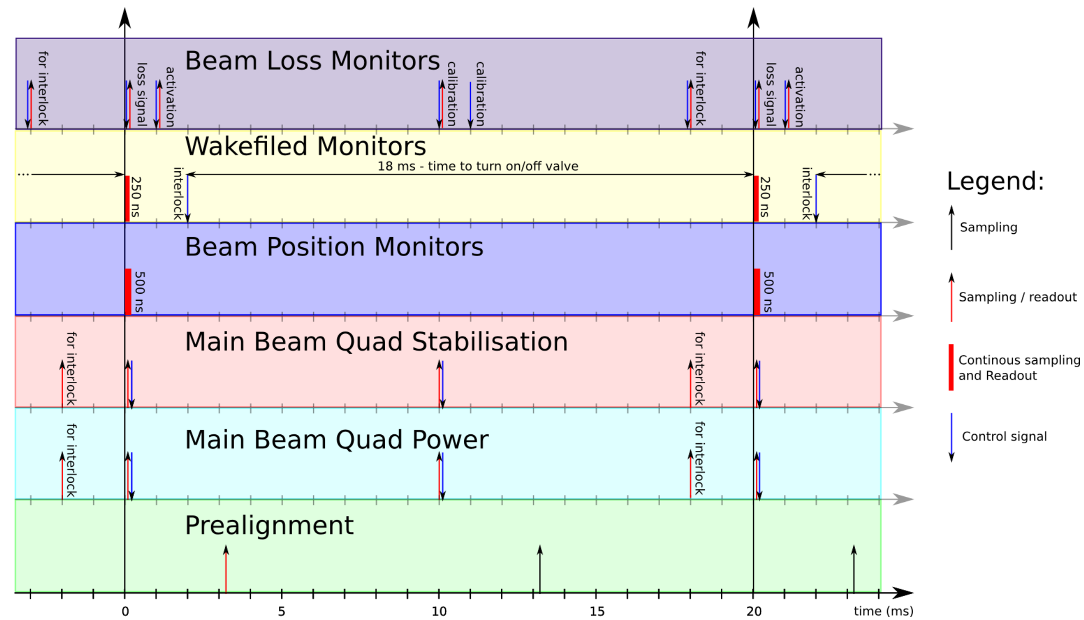
Total bandwidth per ACM (@50 Hz): < 5Mb/s

Common timing

- Data acquisition and digitalization is done at ACM level.
- Acquired data are then pushed to the control system.
- The control system needs to synchronize and correlate all this data.

- It is necessary to synchronize all the nodes and propagating a common timing to all the ACMs:

Sampling clock synchronization: ###### ns



Total bandwidth per ACM (@50 Hz): < 5Mb/s

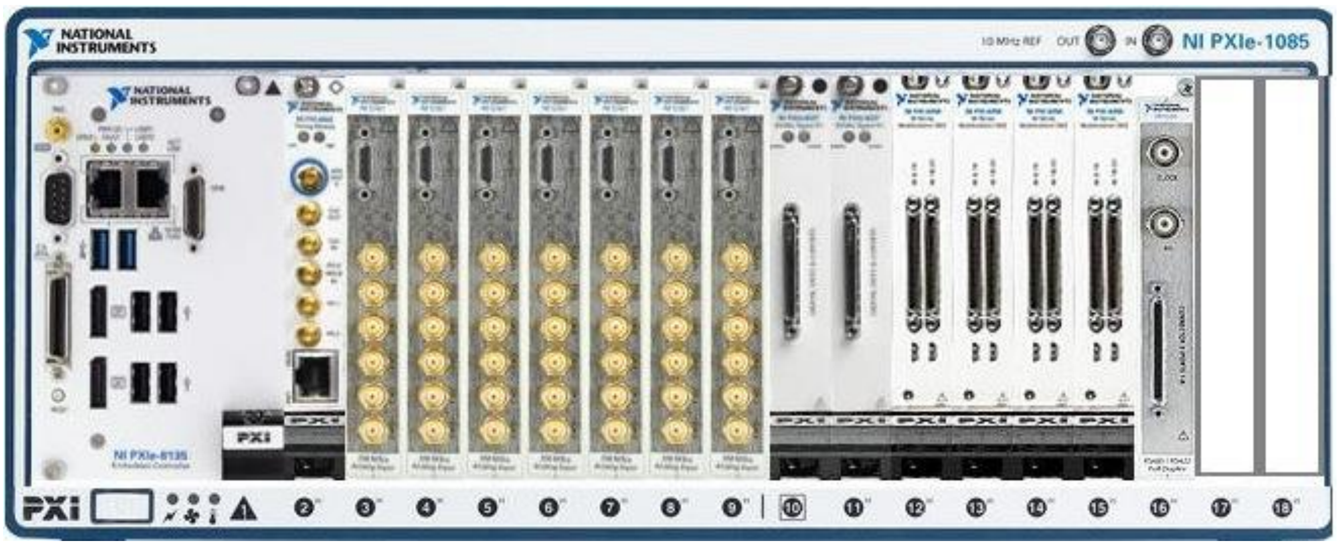
Radiation constraints

- Radiation issue is a key point to design the control infrastructure
  - high-level of radiation (100Gy .. 1kGy/y) although proper estimation is still needed (energy, spectrum, fluence)
- Radiation effects on electronics:
  - TID (Total Ionizing Dose), destructive. Electronics needs to be periodically replaced.
  - SE{L/GR/B} (Single Event {latchup/gate rupture/burnout}): if not destructive, can be addressed at design level via TMR (triple modular redundancy).

Alternative solution for ACM development

- Industrialized solution
- Development based on NI-PXI systems
  - Miniaturise 15 boards into 1 small box
  - NI has long experience with custom design

NI system overview



Controller

Synchro
IEEE-1588

DIO

Serial

Fast ADC

DIO + Slow ADC + DAC

FPGA controller

- Fiber-Optic MXI-Express x4 link, PXIe-PCIe8375
- 838 MB/s sustained transfer rate
- Remote control of PXIe crate

Conclusions and next steps

- Up to 20000 TBM, 500 signals each
- Modular system adapted to all module components
- Challenging development taking into account several requirements

- Prototypes to be procured and tested under accelerator conditions

Thanks for your attention

Acknowledgements to D. Gudkov, F. Locci, A. Rijllart, A. Samoshkin for their great contribution for the peparation of this presentation