Vacuum requirements and preliminary design of vacuum system for module and transfer lines

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Outline

Scope of the presentation

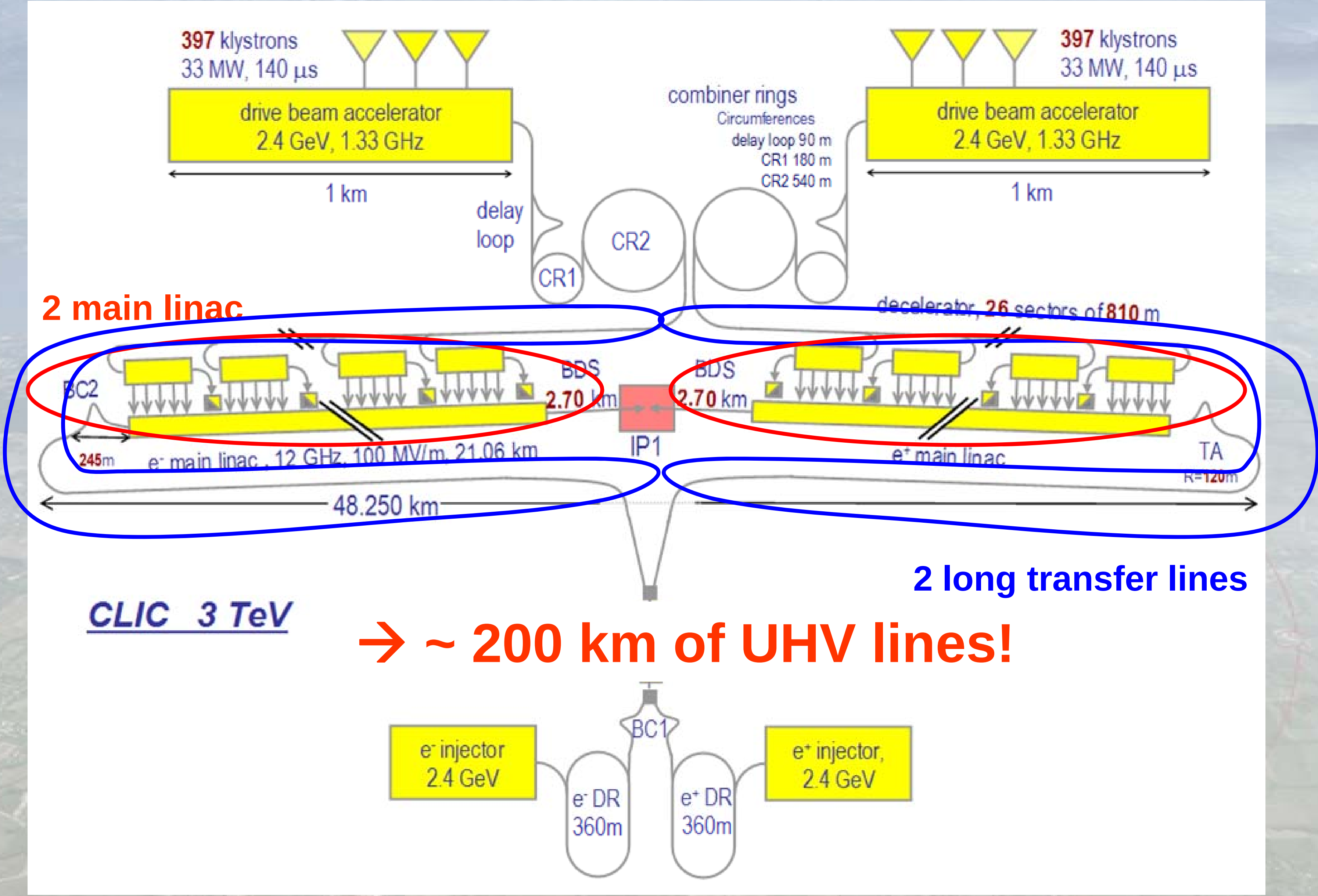
Main linac vacuum system

- Layout and vacuum requirements
- Sectorisation
- Vacuum system
- Dynamic vacuum in accelerating structures
- Specific issues: vacuum chamber of the main quadrupoles, waveguide flanges

Long transfer lines

- Vacuum requirements
- Sectorisation
- 3 vacuum technologies under study

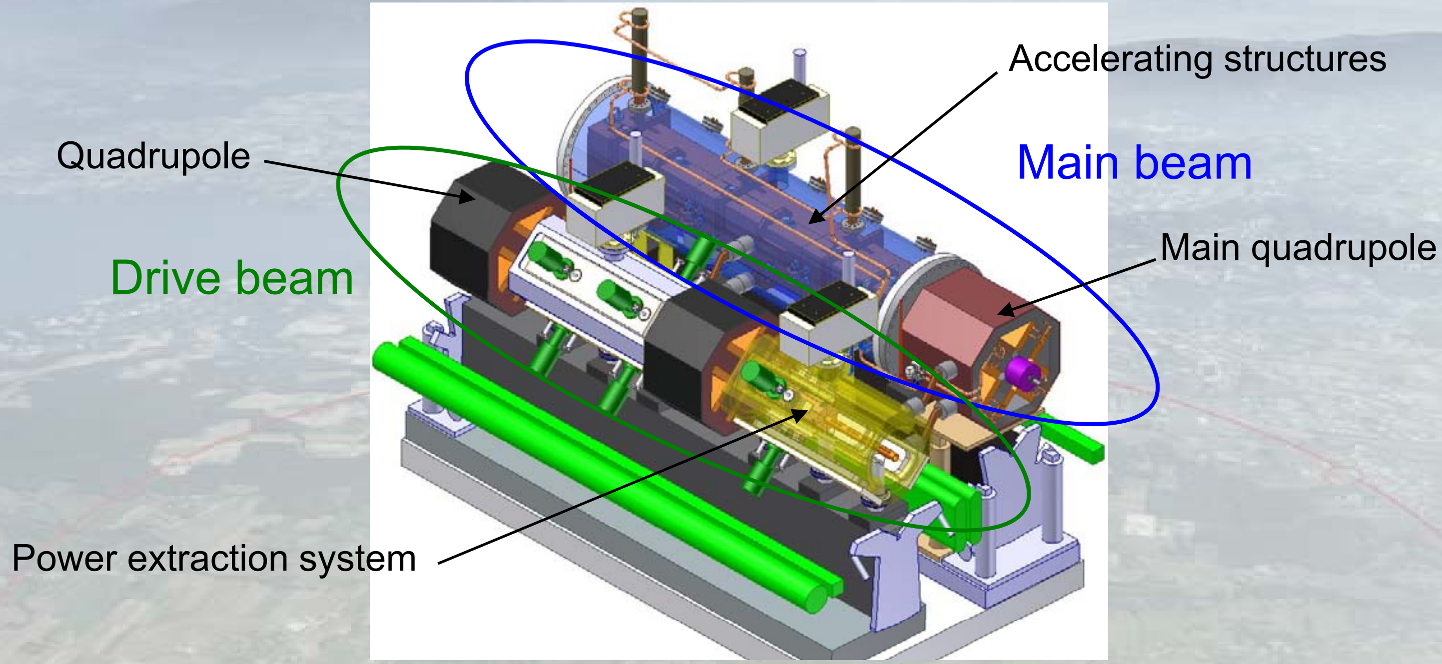
CLIC complex



→ ~ 200 km of UHV lines!

Main linac layout & vacuum requirements

1 main linac is composed of 10462 two beam modules, mainly of 4 types.



Type 1 module

Beam dynamics requirements:

- pressure : ~10^{-8} mbar
- inner diameter of vacuum chamber (main quadrupole) ≥ 3mm
- copper beam line (or copper coated)

Main linac

Vacuum system sectorisation

Why a sectorisation?

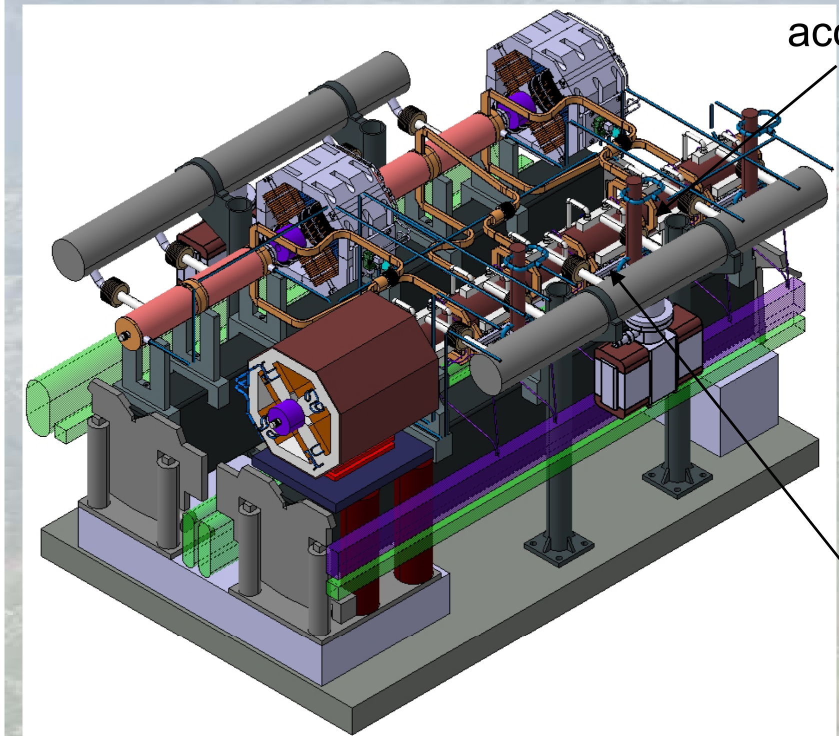
- Piece wise installation/commisionning
- Ease local intervention for machine maintenance
- Ease localisation of leak
- Containment of accidental vacuum degradation

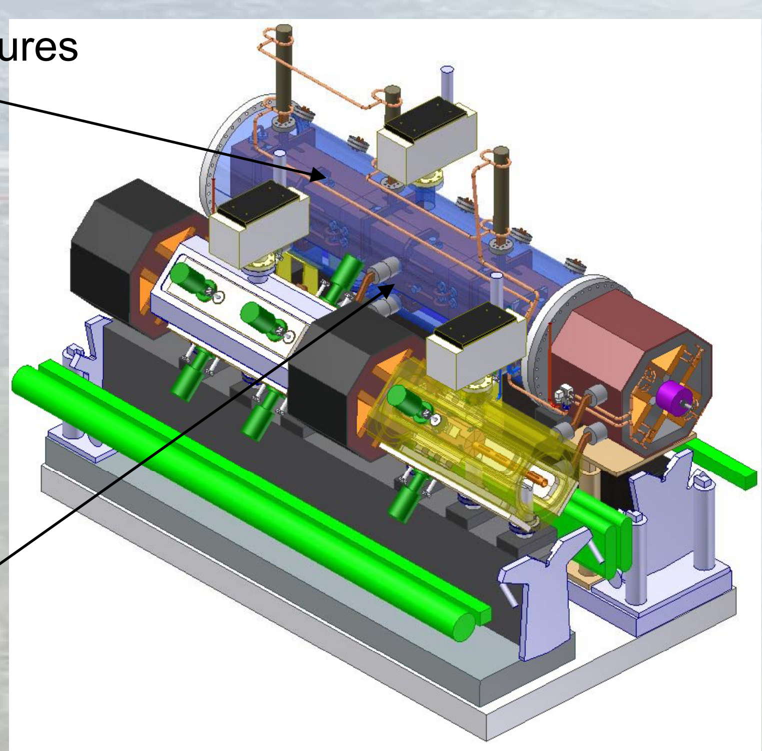
A manageable sector of 200m is proposed for the main linac.

Main linac

Several versions being studied:

Disk/quadrant
accelerating structures





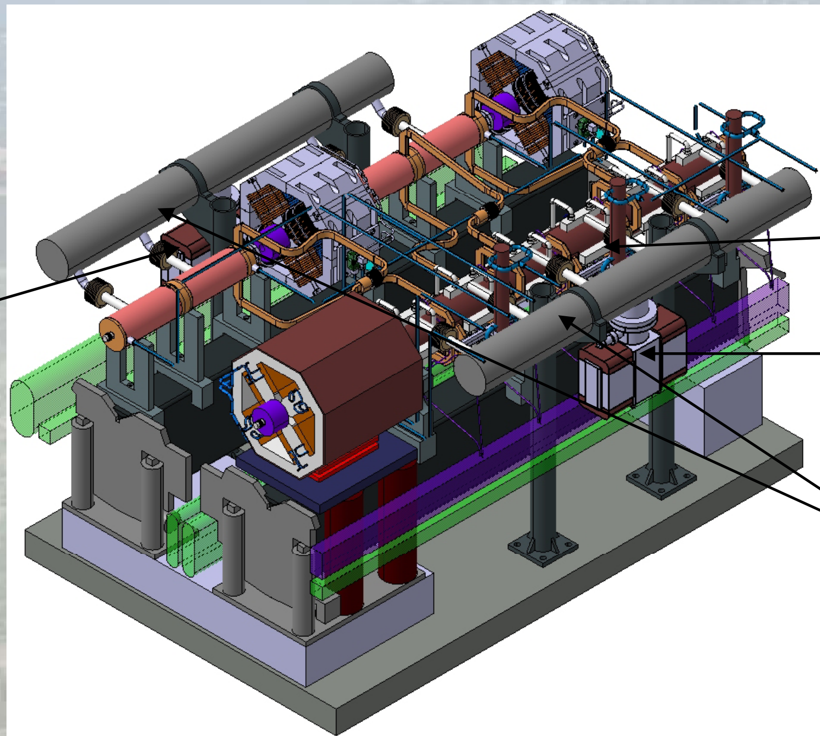
Sealed/tank

Main linac

Vacuum equipment (version sealed disk):

→ manifolds around the accelerating structures linked to a common tube

→ pumping system: mobile turbomolecular station + holding ion pumps

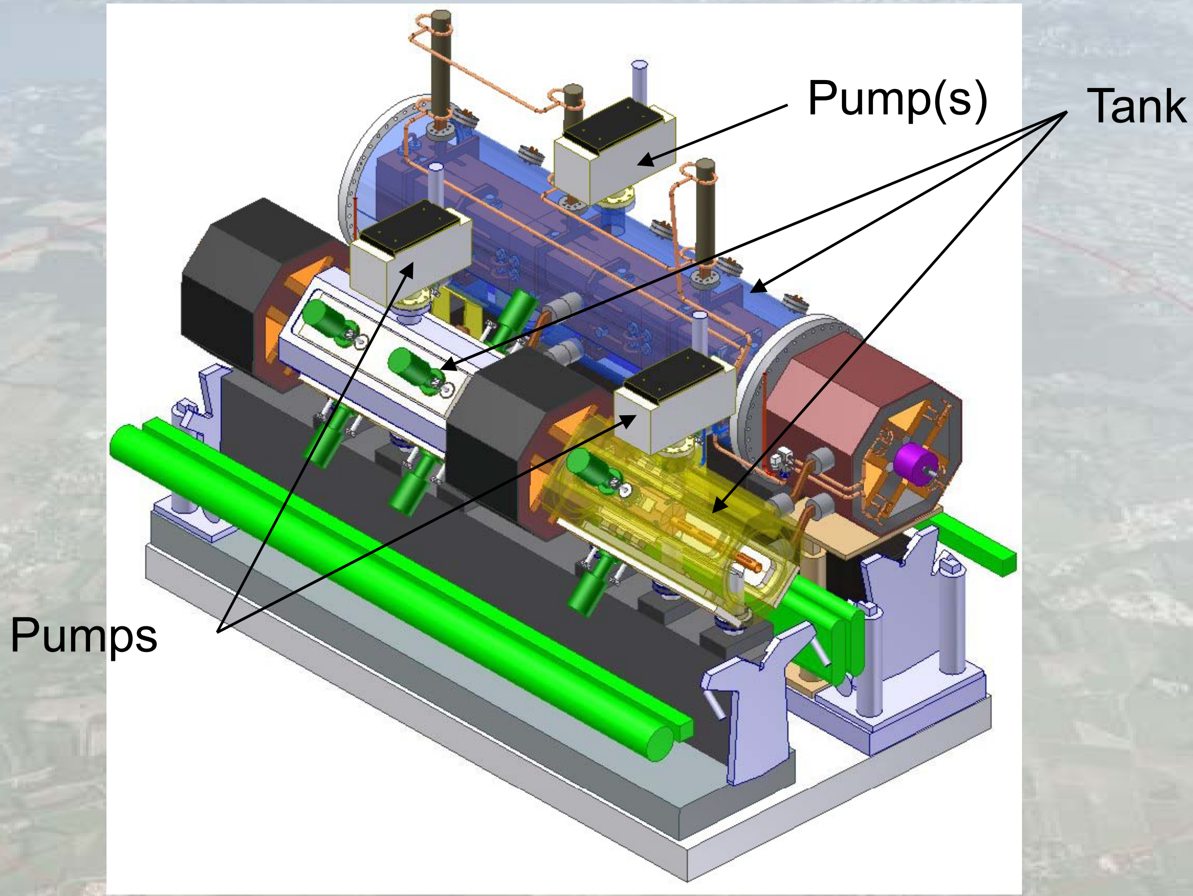


Main linac

Pumping system (quadrant accelerating structures with tank):

→ static vacuum: mobile turbomolecular station + holding ion pump (+ sublimation?)

→ dynamic vacuum (breakdown of the cavities): tank around the accelerating structures

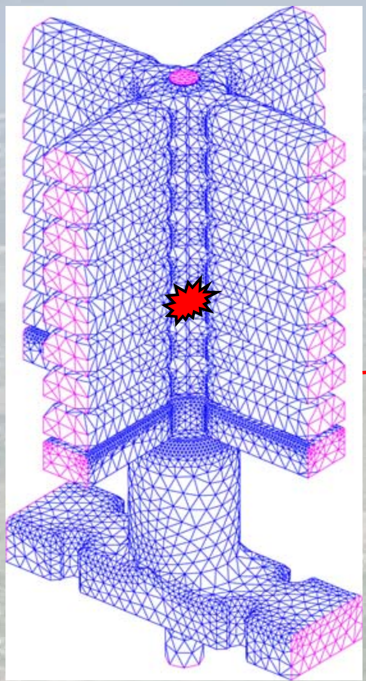


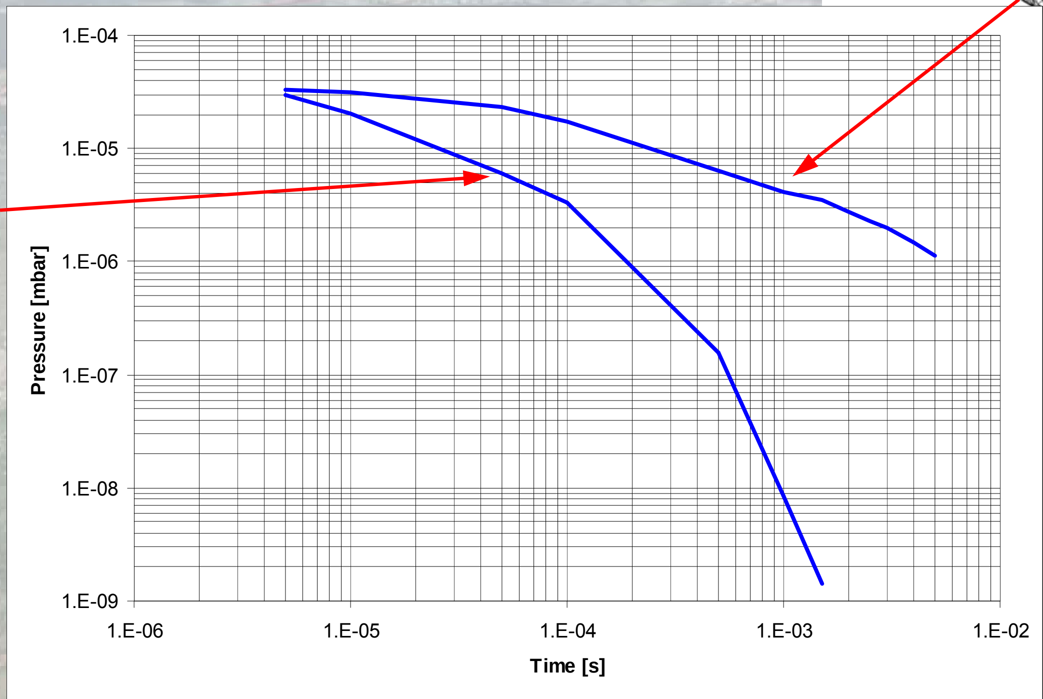
Main linac

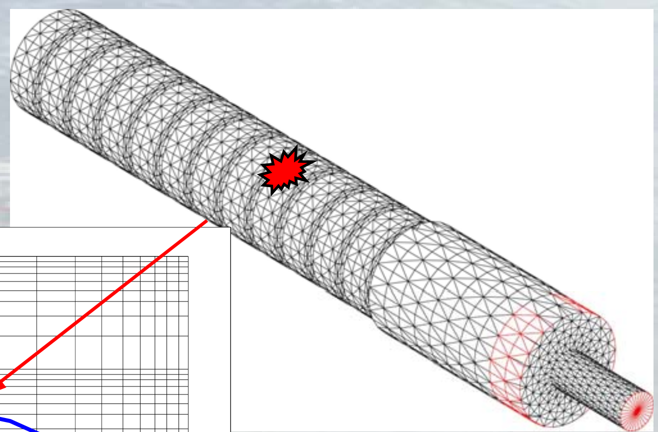
Dynamic vacuum in the accelerating structures

Assumption: 10^{12} H_2 molecules released during a breakdown
Gas load depends on the surface pretreatment and has to be confirmed (measured)

Monte Carlo simulation implemented in a FE code (Castem)





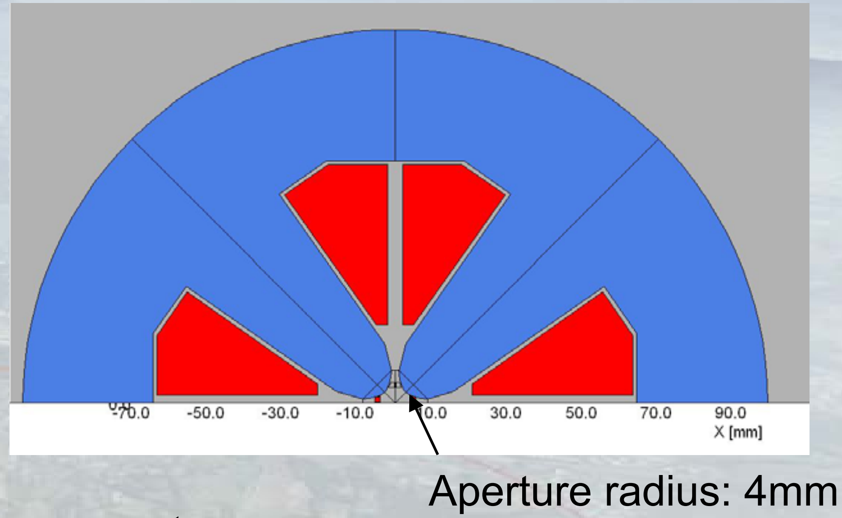


Main Linac

Vacuum chamber of the main quadrupoles

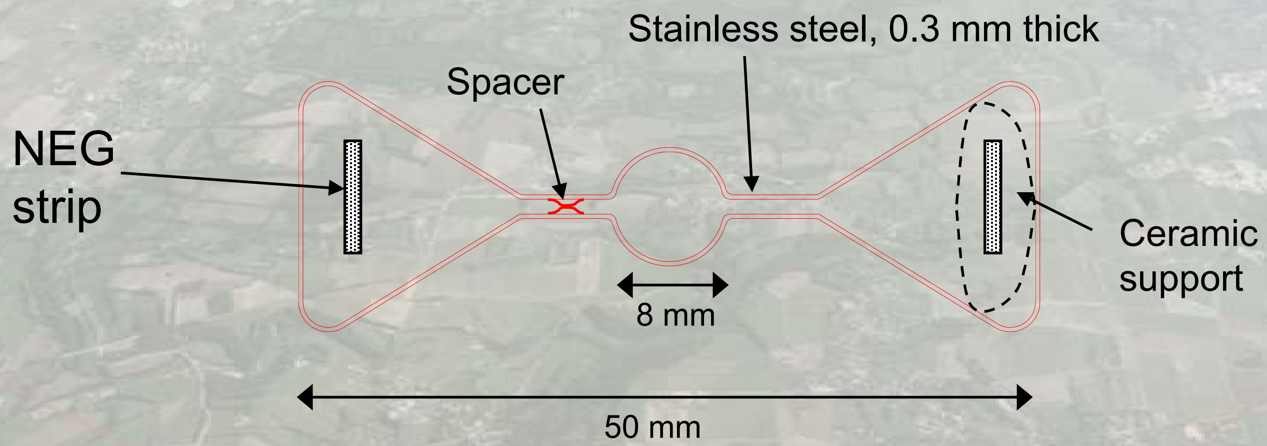
Constraints

- Very tight space available → low conductance
- Unbaked system → vacuum is driven by water pumping



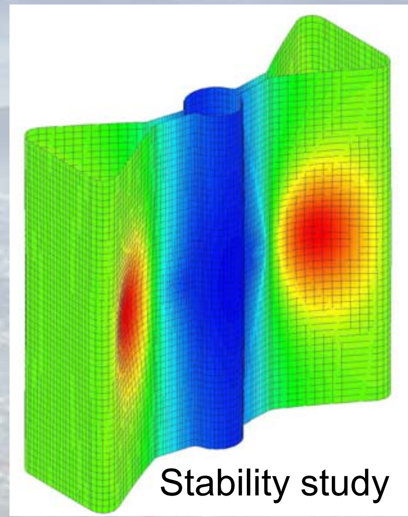
Proposal:

- Stainless steel vacuum chamber, squeezed in the magnet
- NEG strips sited in 2 antechambers



Main Linac

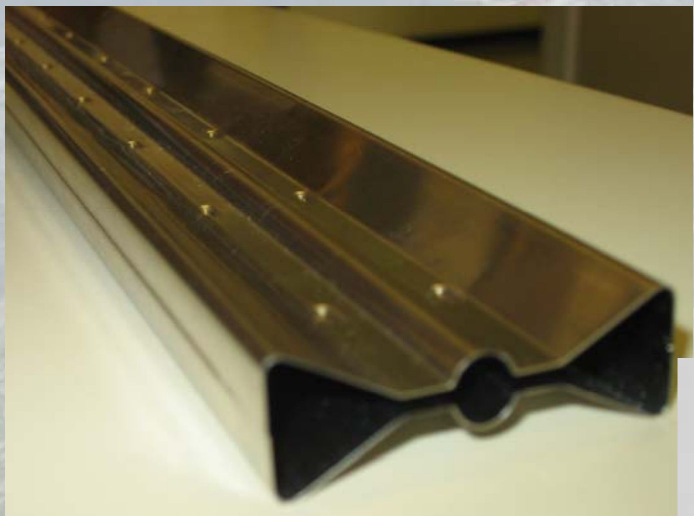
Vacuum chamber of the main quadrupoles

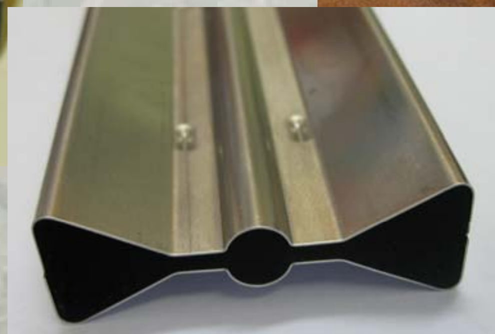


Design

Pressure in the central part is determined by the gap
→ reduce the sheet thickness

Experiment in progress on a 1.5m prototype

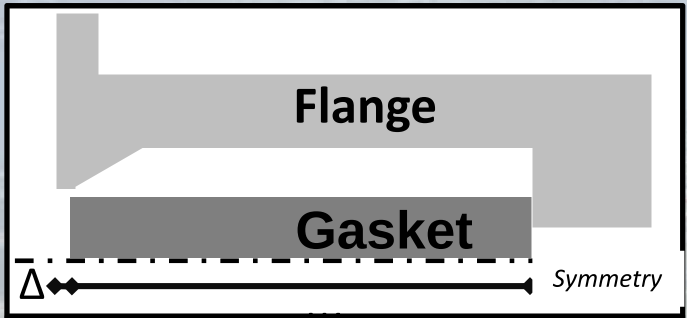




Main Linac

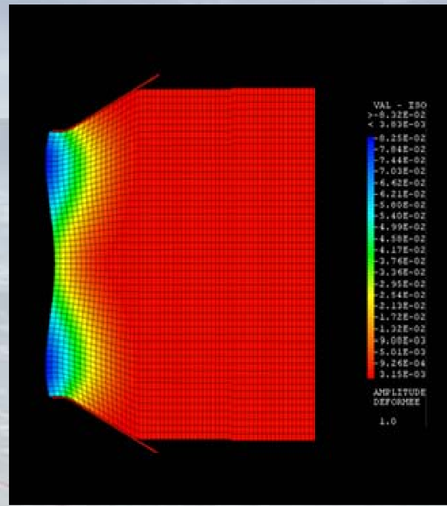
Waveguide flanges

- A new design has been proposed to reduce the RF attenuation (smooth transition) and the cost

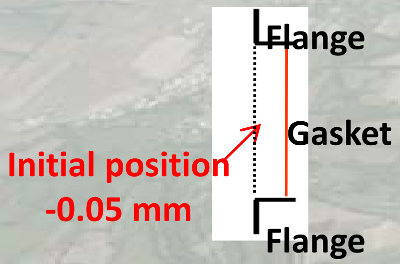


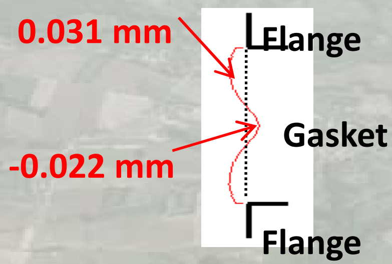
New CLIC design concept

- FE model
  - →Gasket deformation
  - →Plastic strain field
  - →Contact pressure



- Tests and optimization are in progress





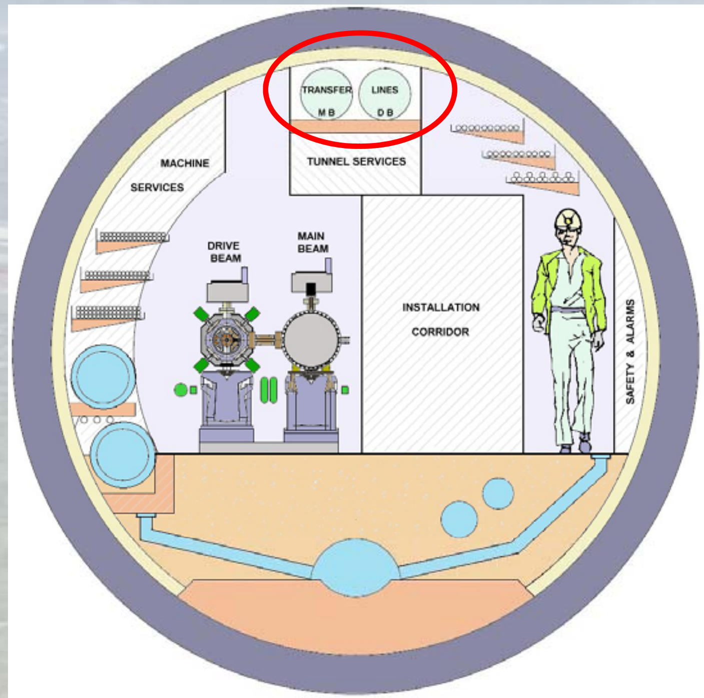
Long transfer lines

- Layout:
  - Mainly FODO cells with quadrupoles and drift tubes (L_{cell_main}=438m, L_{cell_drive}=109.6m)
  - sectors of ~400m (→ 438m)

- Beam dynamics requirements:
  - Pressure: 10^{-10} mbar
  - copper beam line (low resistive wall)
  - Inner diameters: 6 cm for the main beam and 10 cm for the drive beam

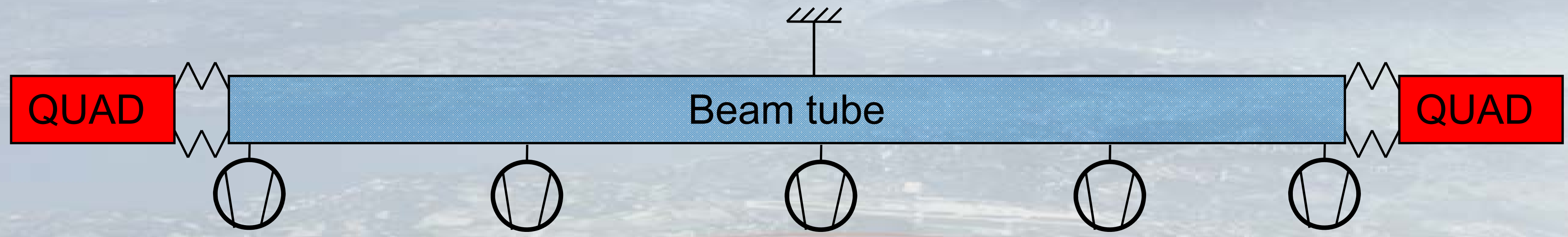
- ~80 km→ cost optimized solution is required

→ 3 possibilities have been considered:
  - ion pumps,
  - NEG coated vacuum chamber + ion pump
  - NEG strips + ion pump



Long transfer lines

Holding ion pumps: 1 ion pump (60l/s/10m)



Advantages:

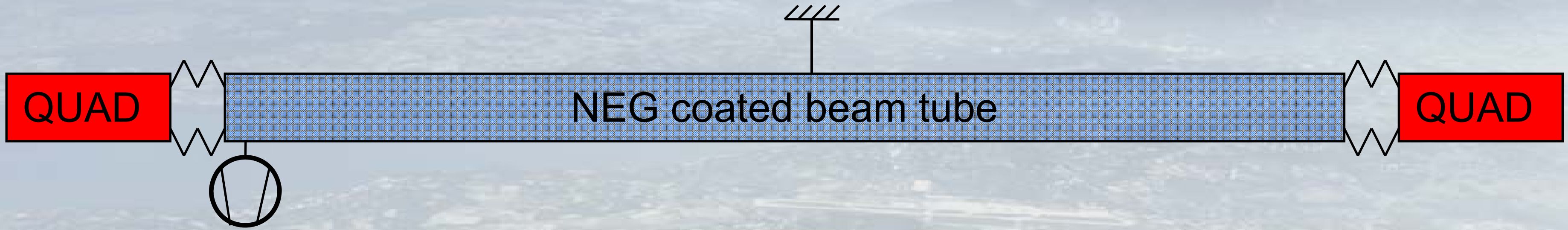
- Simple tubes → no influence on the beam
- No bake out needed
- Easy for the operation/maintenance
- Good control of the pressure along the line

Drawbacks:

- Discrete pumping
- Price

Long transfer lines

Coated vacuum chamber + ion pump (60l/s/10m)



Advantages:

- Distributed pumping

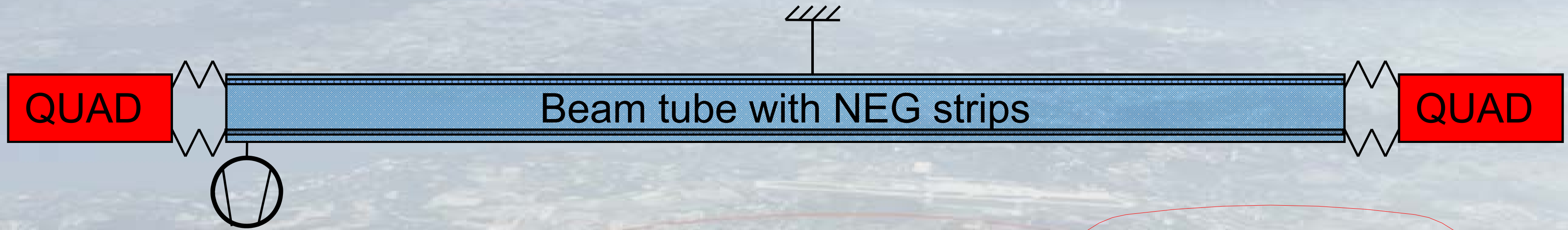
Drawbacks:

- Time/cost for the conditioning.
- Thermal strain during bake-out and activation (additional bellows required)
- Influence on the beam → under study

Long transfer lines

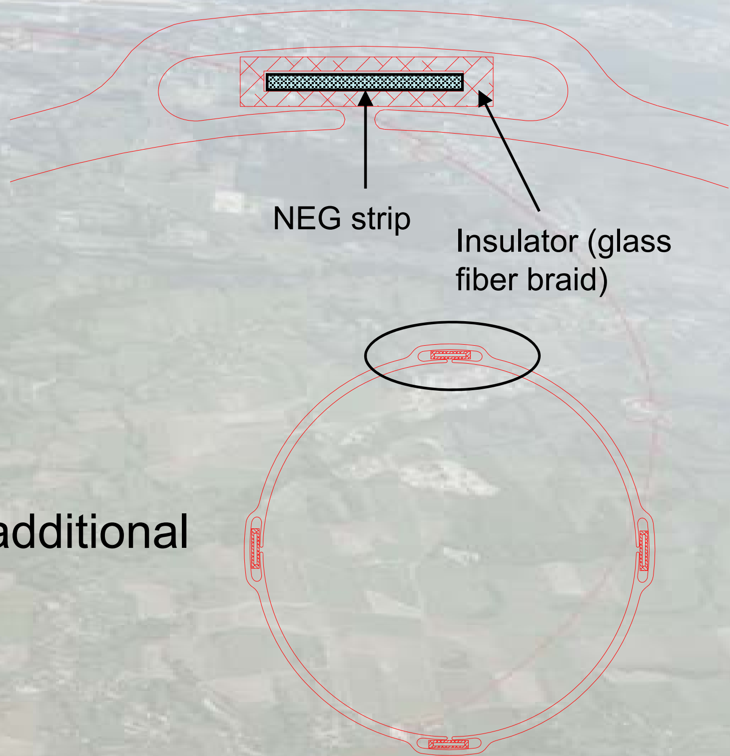
NEG strip:

NEG strip is used as a pump but also as an heater



Advantages:

- Distributed pumping
- Reduced time/cost for the conditioning.
- Low influence on the beam



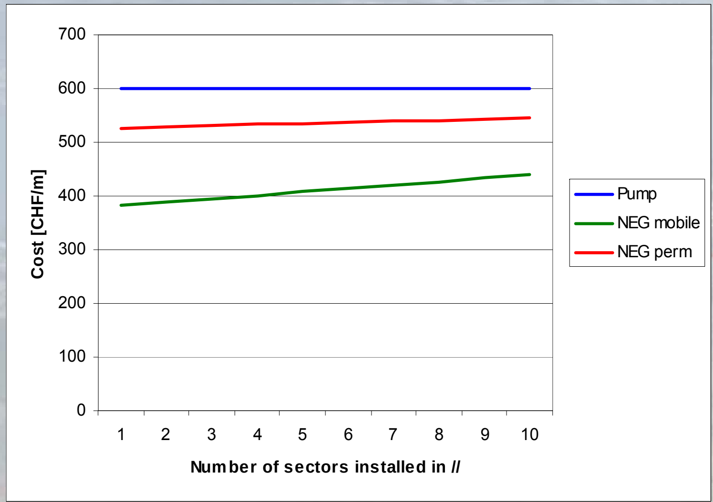
Drawbacks:

- Thermal strain during bake-out and activation (additional bellows required)
- Reduced pumping capacity

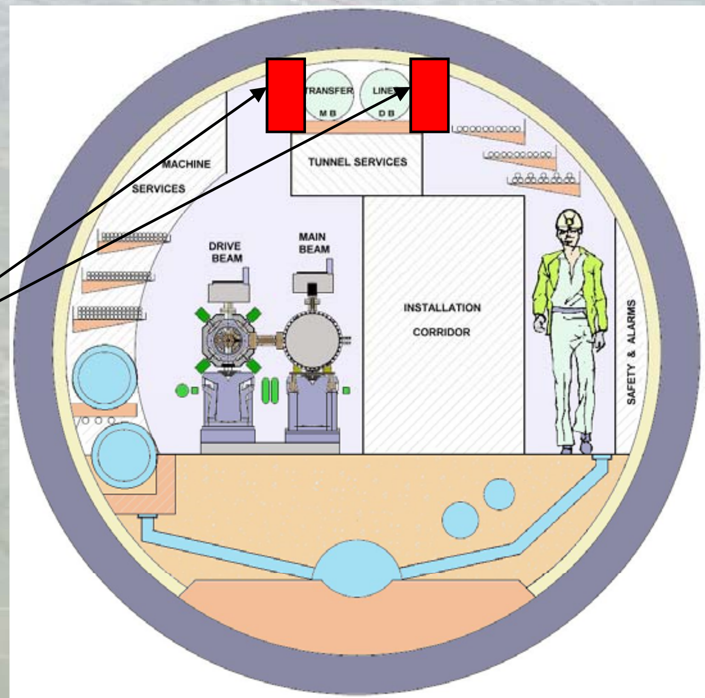
Long transfer lines

Preliminary results:

Over cost of one solution with respect to the others (does not include supports, tubes, flanges, valves, bellows…)



Integration: space has to be reserved for the vacuum equipment (pumps, sector valves)



Conclusions & perspectives

A first layout of part of the vacuum system has been proposed for the main linac.

Dynamic vacuum due to a breakdown in the cavity is being analyzed for different accelerating structure configurations. Study of the composition and the amount of gaz has to be done as well as the comparison of the time constant in the actual CLEX test stand.

Study and tests are on going for the main quadrupole vacuum chamber and the waveguide flanges.

Sectorisation of the transfer line has been defined. The technological solution for the pumping system remains to be defined. (If the NEG strip version is promising, make a mock up)