Beam loss monitors

- Why ?
- Where ?
- How ?
- Difference between CLIC and CTF3
- CTF3 system

Beam loss monitors ' Why ? '

- Qualitative measurements for machine optimization

- Quantitative measurements :

  Controlling the radiation level

  Machine protection

  Beam halo-loss study : Emittance dilution, Instabilities, ..

Beam loss monitors ' Where ? '

Identifying the 'sensitive parts' of the CLIC accelerator complex

	Drive Beam injector	Drive Beam decelerator	Main Beam accelerator
Electrons energy	→ 1.18 GeV	1.18 → 0.15 GeV	9 → 1500 GeV
Beam current /charge	7.5A / 690μC	140A / 31μC	1A / 0.1μC
Total beam energy	→ 812 kJ	37 → 4.7 kJ	0.09 → 148 kJ
Number of electrons for 1‰ loss	$4\ 10^{12}$	$2\ 10^{11}$	$7\ 10^{8}$
Typical beam size (mm)	1	0.2	0.02

' You need to protect the beam dump '

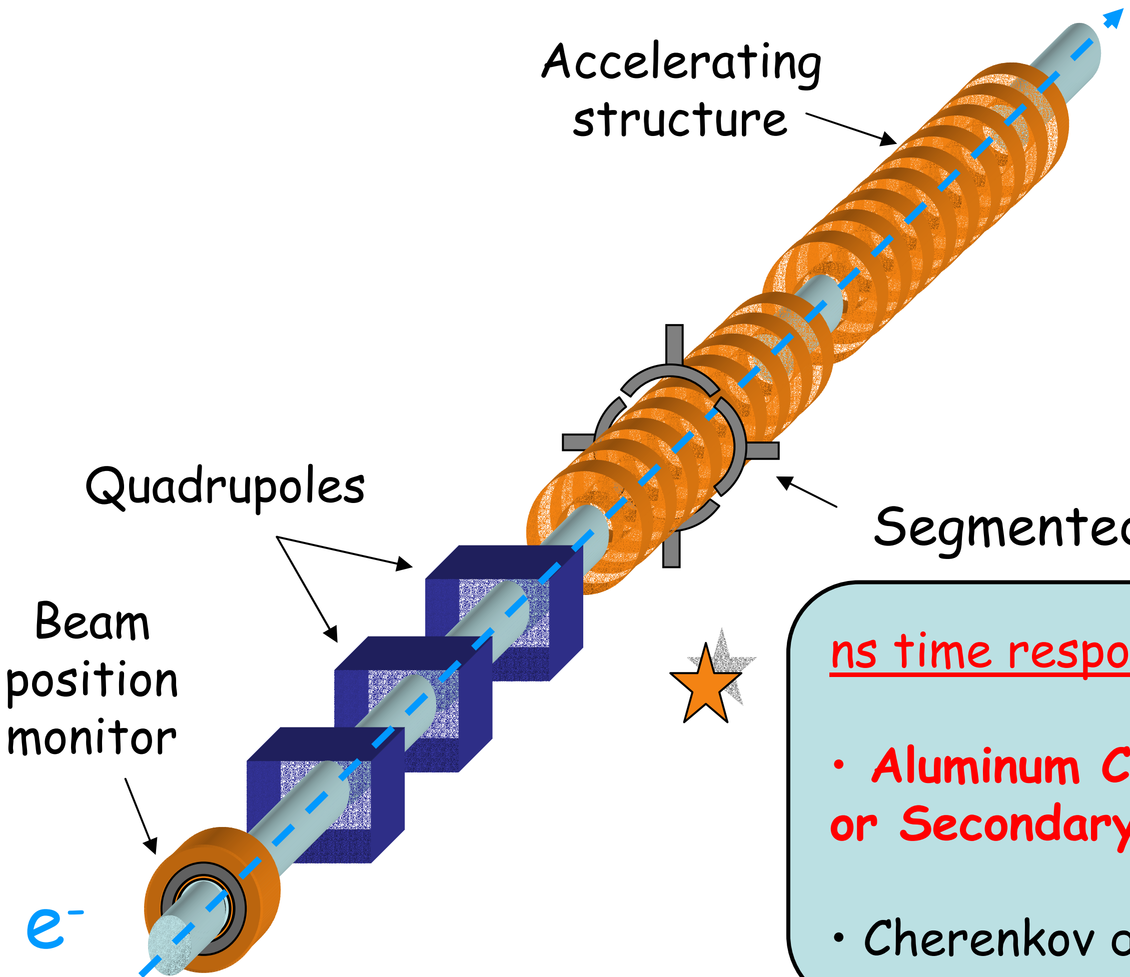
Protection system for
- *Accelerating cavities*
- *Rings injection and extraction system (RF deflectors,...)*

Protection system for
- PETS
- 30 GHz accelerating structures
- Collimator and BDS

Requirements:

- Fast time response (ns) :
  - Machine protection issue: Fast Feedback response within the pulse duration
  - Beam loss - beam halo study, ….
- Radiation hardness :
Even if the beam losses are kept small, the radiation level will be high
- Position sensitivity : Important to localize where the losses occurred
- Integrated calibration system : to ensure a good reliability

Beam loss monitors ' How ? '



ns time response, radiation hard detector :

- **Aluminum Cathode Electron Multiplier or Secondary emission monitor**

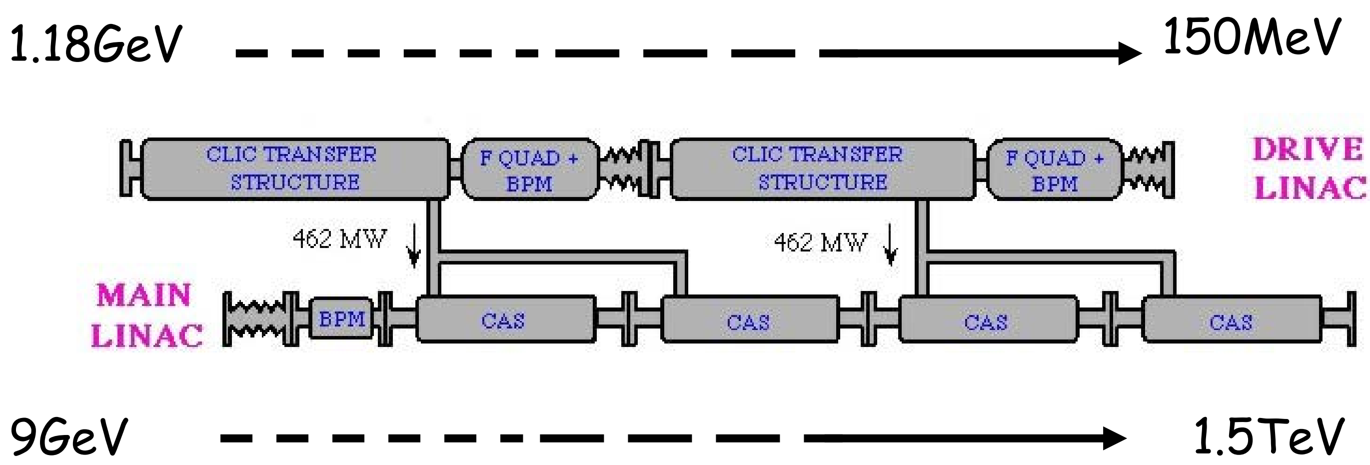
- Cherenkov detector

- Electronic can be based on the BPM's electronic providing Σ and Δ

Beam loss monitors 'CEKOMENKONFE'

• In the CLIC main linac, the flux of lost particles will be presumably dominated by the losses in the drive beam decelerator

• The arrival time of the two beams does not exceed the pulse duration so that there will be an overlap between the beams

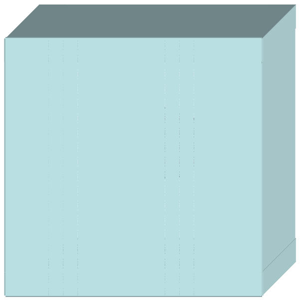


• Need a detector with the capacity of eliminating the huge background of 'low energy' (>1GeV) showers from the Drive Beam losses

(Potential problem for laser wire scanner systems which are supposed to detect few (~10^4) 'degraded' electrons)

Beam loss monitors ' How ? '

Shielding



with tungsten (W) (19.25g/cm^3):
CSDA range for 1GeV electrons (35g/cm^2) ~ 1.8cm

with Lead (Pb) (11.34g/cm^3):
CSDA range for 1GeV electrons (34g/cm^2) ~ 2.9cm

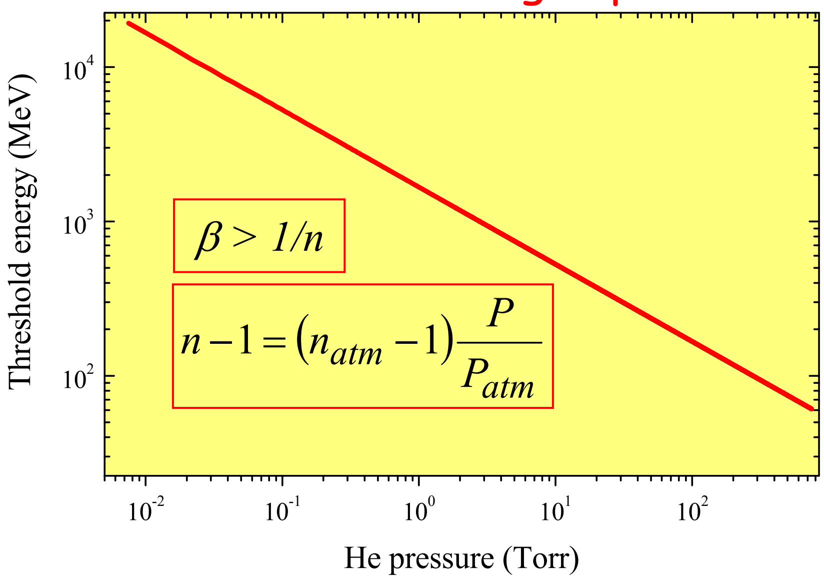
Easy to suppress the 'low energy' charged particles

Detector could be based on secondary electron emission or Cherenkov light

Threshold Cherenkov detector : $\beta > 1/n$

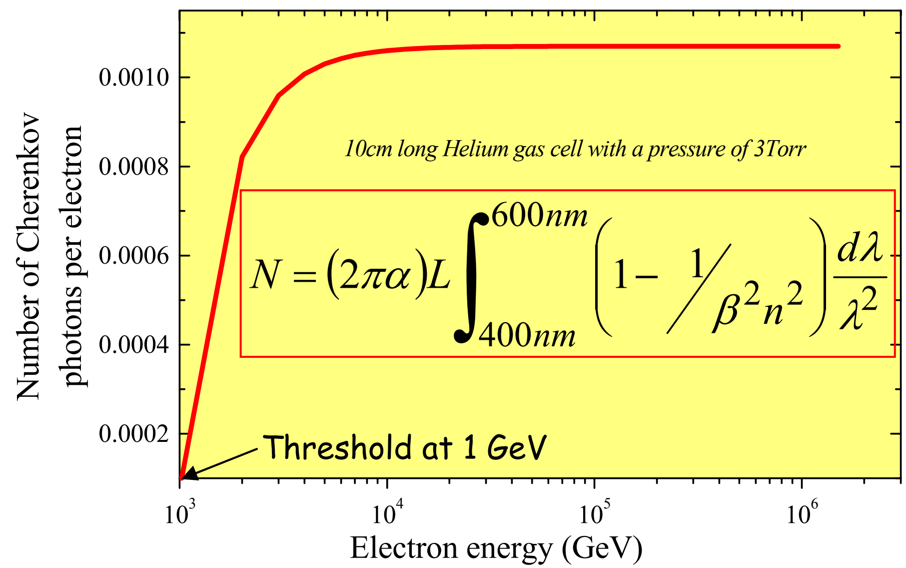
Cherenkov radiator (1atm)	Silica aerogel	Pentane C_5H_{12}	Ethane C_2H_6	Argon Ar	Neon Ne	Helium He
Index of refraction (n-1)	$8.4\ 10^{-3}$	$1.7\ 10^{-3}$	$7.1\ 10^{-4}$	$2.8\ 10^{-4}$	$6.7\ 10^{-5}$	$3.5\ 10^{-5}$
Cherenkov threshold (MeV)	3.5	8.2	13.1	20.9	43.5	60.4

Evolution with the gas pressure



$$\beta > 1/n$$

$$n - 1 = (n_{atm} - 1)\frac{P}{P_{atm}}$$



$$N = (2\pi\alpha)L\int_{400nm}^{600nm}\left(1 - \frac{1}{\beta^2 n^2}\right)\frac{d\lambda}{\lambda^2}$$

• <u>CTF3 :</u> Develop a ' **beam loss position monitor**' based on SEM or Cherenkov (radiation hard, position sensitive, ns time resolution)

• *<u>Main beam detection system</u> : not required for CTF3*

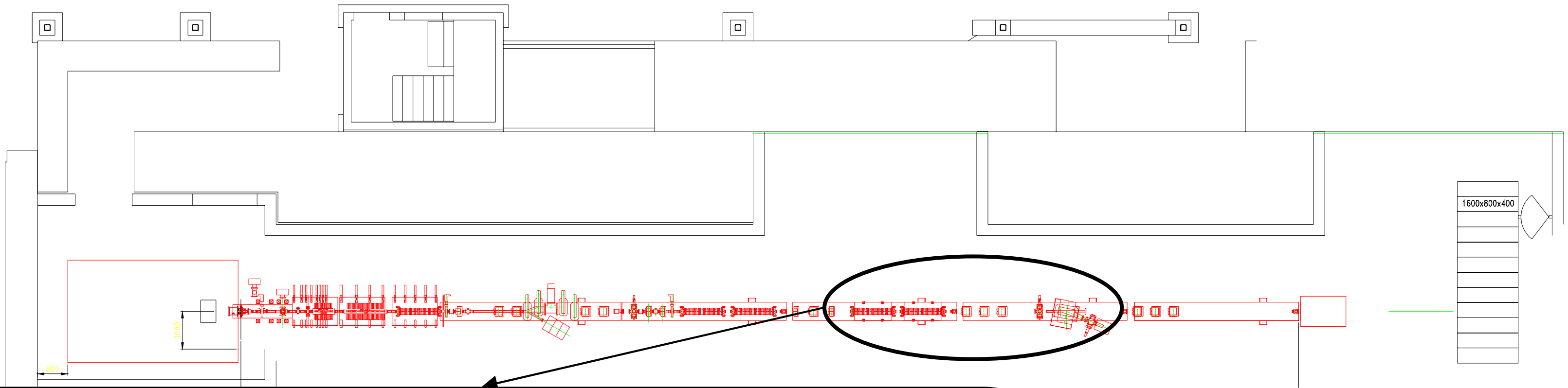
- Simulations to evaluate the impact of the DB losses on the MB detection system
- Simulate the different options for the design of the detectors

<u>Cost and Reliability issues :</u> *'Keep the system as simple as possible'*

• Online calibration procedure for quantitative measurement and machine protection system (will be easier with an optical system)

• Radiation hardness issue for the long term maintenance

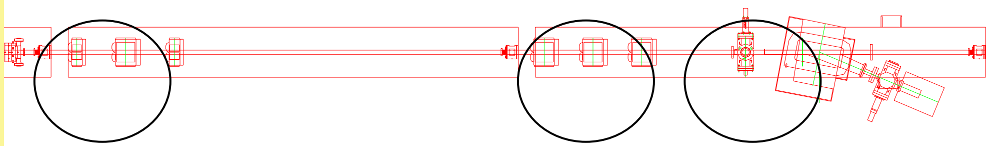
Beam loss monitors ' CTF3 today '



Benchmarking Geant simulations

' Measuring the induced showers for a controlled and measured beam loss '

Well equipped region with beam position and beam profile monitors



Testing different equipments

- Scintillators + PMT
- ACEM

- <u>Benchmarking experiment</u>

  - Set-up a clean beam transport between two BPM's at low current (very low)

  - Deflect the beam using a steerer to intentionally loose the beam in a known place with a defined angle.

  - Detecting the corresponding showers using the beam loss detectors and comparing the results with the other beam measurements and simulations