TIME RESOLVED ENERGY MEASUREMENT ON THE TEST BEAM LINE AT CTF3

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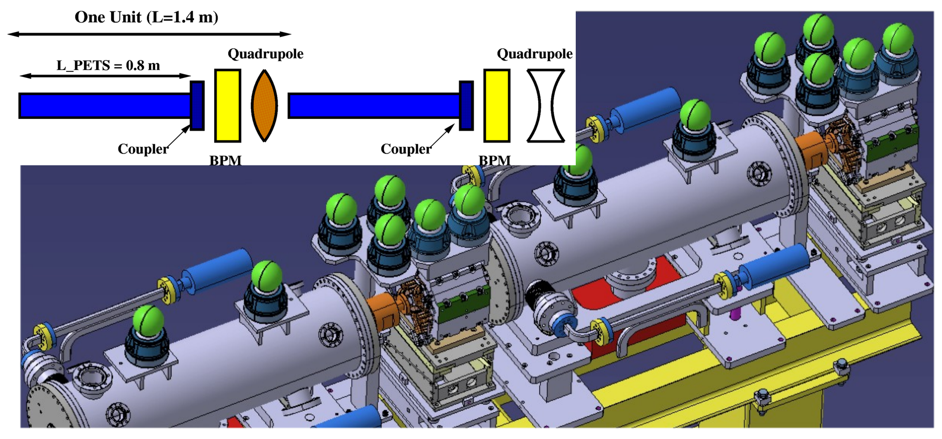
Abstract

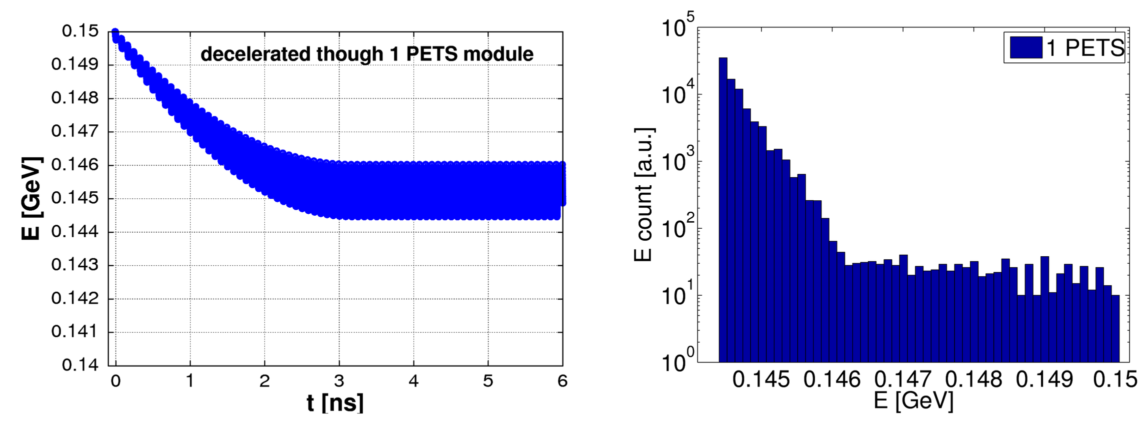
The CTF3 provides a high current (28A), high frequency (12GHz) electron beam, which is used to generate high power radiofrequency pulses at 12GHz by decelerating the electrons in resonant structures. A Test Beam Line (TBL) is currently being built in order to prove the efficiency and the reliability of the RF power production with the lowest level of particle losses. As the beam propagates along the line, its energy spread grows up to 60%. For instrumentation, this unusual characteristic implies the development of new and innovative techniques. One of the most important tasks is to measure the beam energy spread with a fast time resolution. The detector must be able to detect the energy transient due to beam loading in the decelerating structures (nanosecond) but should also be capable to measure bunch-to-bunch fluctuations (12GHz). This paper presents the design of the spectrometer line detectors.

Deceleration in the Test Beam Line

The Test Beam Line (TBL) is a test bench for the CLIC decelerator, where 12GHz RF power is generated when the beam passes through resonating RF structures, called Power Extraction and Transfer Structures (PETS) *(~5 MeV energy loss per PETS)*

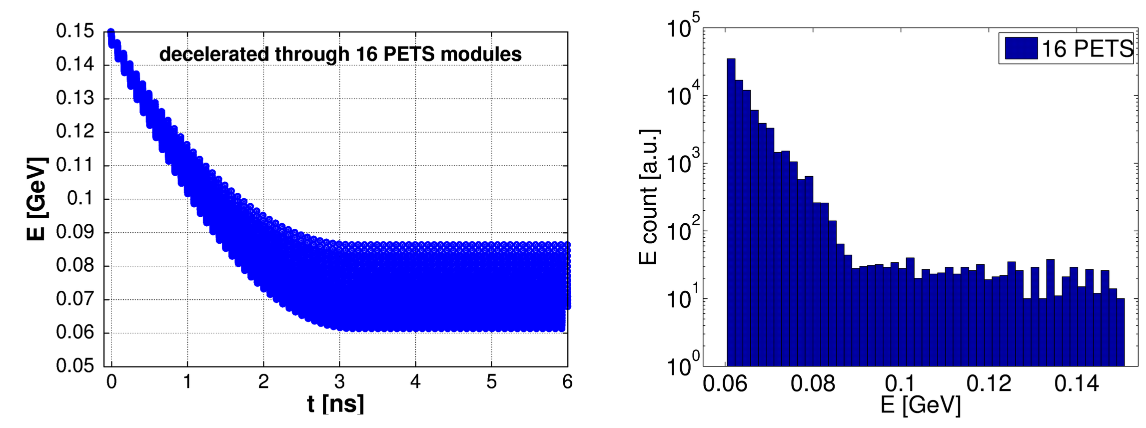


Layout of the TBL
- 16 modules in total (1 installed now)
- PETS, BPM, Quadrupole on movers



TBL energy spectrum after 1 PETS

PLACET simulations



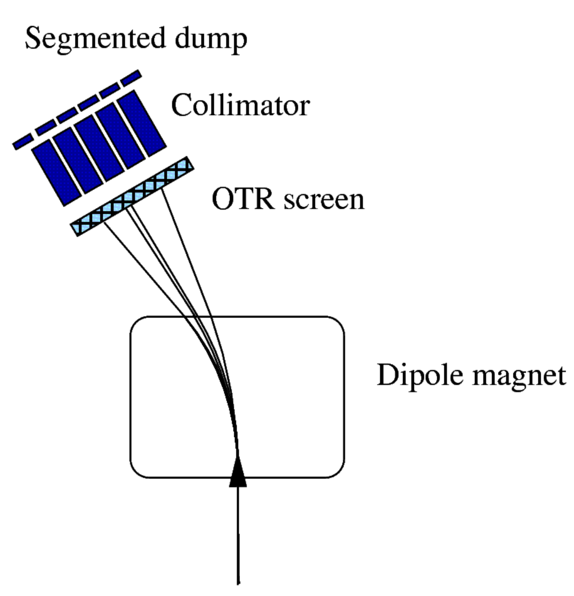
TBL energy spectrum after 16 PETS

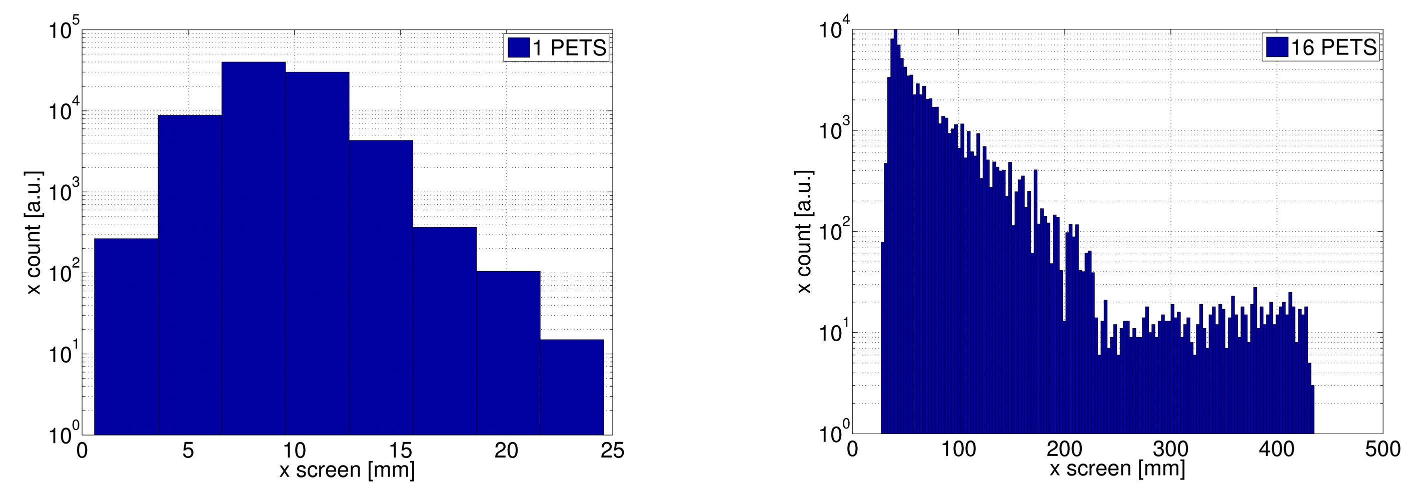
PLACET simulations

Spectrometer Beam line at TBL

The spectrometer line consists of a bending magnet which provides an energy dependent horizontal deflection to the particle.
By measuring the beam position and size one can thus estimate the beam energy and its energy spread

-Two types of detectors:
·High spatial resolution imaging system based on the use of an OTR screen
·Segmented dump for time resolved measurements

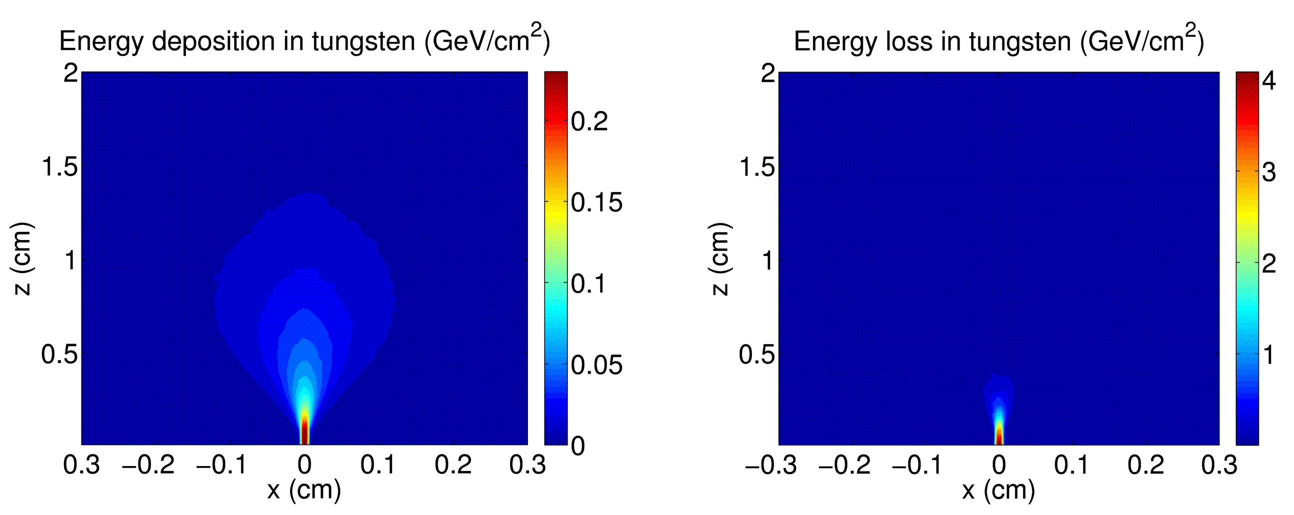


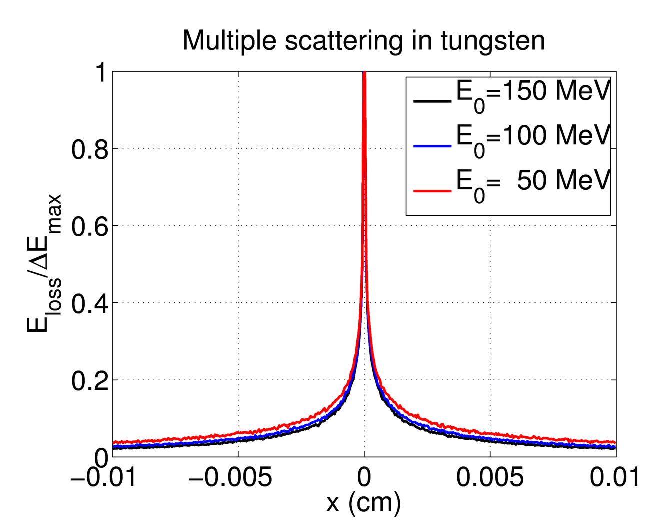


Typical transverse beam distributions downstream of the spectrometer dipole magnet (same L_{drift}, same B) for a beam of 1 PETS and 16 PETS

Design of a segmented dump for TBL

In order to estimate the deposited energy, the resulting temperature increase and the spatial resolution of the device, simulations were performed with the Monte Carlo code FLUKA

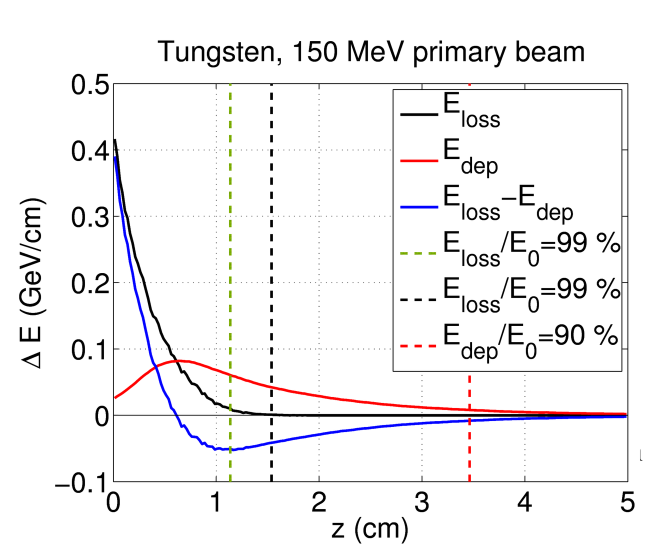




Material	Energy (MeV)	90% stopped e^- Δx (cm)	99% stopped e^- Δx (cm)
Tungsten	150	0.16	0.57
Tungsten	100	0.21	0.64
Tungsten	50	0.27	0.68

Parameter	Dimension
Tungsten collimator depth	10 cm
Tungsten collimator slit width	400 µm
Segment depth	2.0 cm
Segment width	3 mm

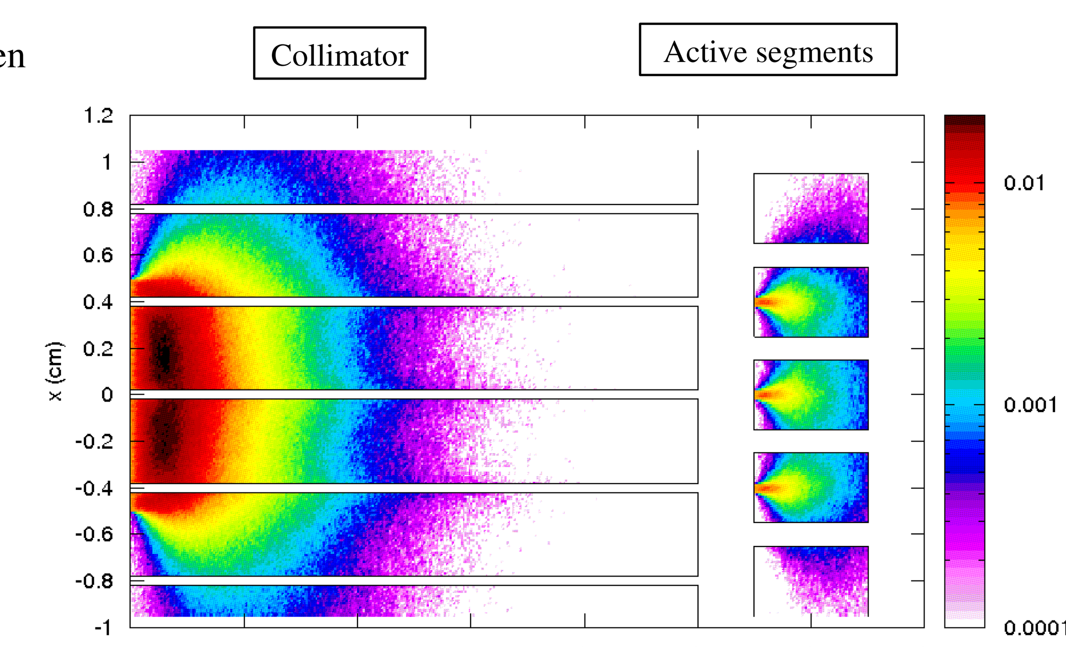
The choice for the dimensions of the segmented dump has been based on material properties.



Material	Energy (MeV)	70% energy loss (cm)	99% energy loss (cm)	99.9% energy loss (cm)
Tungsten	150	0.4	1.14	1.48
Tungsten	100	0.38	1.02	1.3
Tungsten	50	0.31	0.75	0.93
Graphite	150	14.09	30.72	35.79
Iridium	150	1.73	4.68	5.88
Iron	150	0.34	0.96	1.26

Material	Energy (MeV)	70% tot energy (cm)	99% tot energy (cm)	99.9% tot Energy (cm)
Tungsten	150	1.73	5.88	8.78
Tungsten	100	1.53	5.68	8.58
Tungsten	50	1.13	5.23	8.13

- Stop all particles inside the plate:
  - Longitudinal stopping power of material determines plate depth
- Avoid smearing effects due to multiple scattering (cross talk between plates):
  - Multiple scattering effect defines plate thickness
- Take thermal effects into account:
  - Range of EM shower (gammas and secondaries) gives collimator depth



FLUKA simulation of energy deposition in realistic geometry corresponding to a maximum local temperature increase of 5.7E4 K/cm³ in the dump and 6.2E4 K/cm³ in the collimator

Perspectives

- FLUKA simulations to quantify the impact of secondary particles on the measured charge.
- Continue studies of the thermal effects and radiation dose for the long-term response of the detector.
- Optimisation of drift length and B field for maximum resolution.
- Investigate other options in order to reach higher resolution both spatial and in time (e.g. Cherenkov radiation detector)

From the TBL to CLIC Decelerator

- Higher beam energy : 2.3 GeV (deceleration from 2.3 GeV to 0.23 GeV)
- Large energy spread : up to 90 %
- Extremely high current: ~180 A

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