# LHC Beam Loss Monitor System

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# Idea

detect shower particles outside cryostat induced by beam particle losses

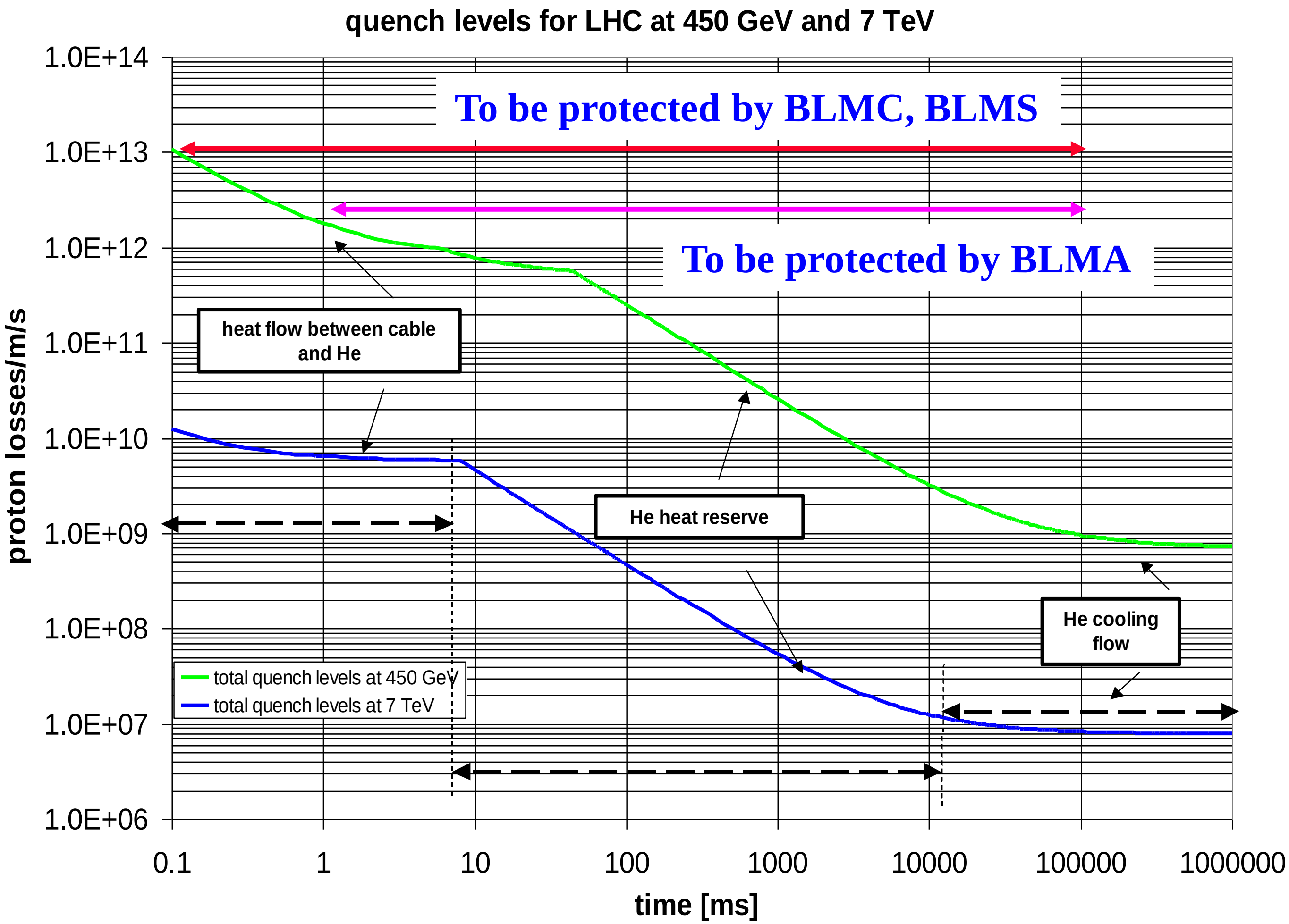
- **relation between beam particles and quenchlevels**
  - » J.B.Jeanneret et al., LHC Project Report 44,CERN (1996)
- **correspondance between particle fluence outside cryostat and quenchlevels**
  - » E. Gschwendtner et al., EPAC 2002, Paris
  - » A. Arauzo-Garcia et al., CERN-SL-2001-027-BI, CERN (2001)

# Outline

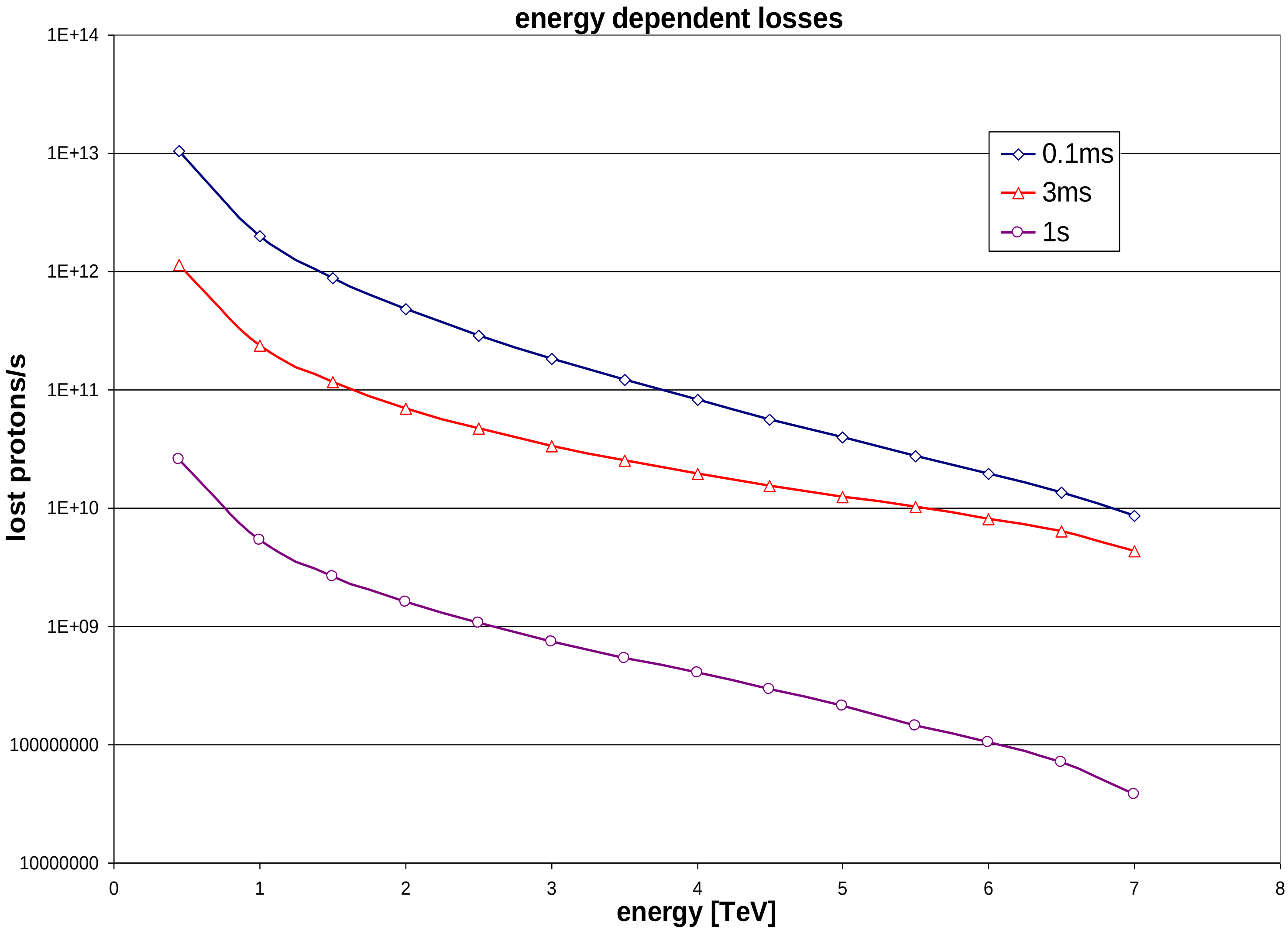
- define quench levels
- get proton loss distribution along the magnets
  - misalignment, $\beta_{max}$
- perform proton loss shower simulation in the magnets
  - to get expected detector signals, positions and dynamic range
  - Aim:
    - distinguish between 2 beams
    - find out where loss has happened
- develop monitors

- Some words on reliability

# Quench levels (I)



# Quench levels (II)-energy dependence



# Proton loss distribution

**Primary and secondary halo of the beam is absorbed by the collimation system.**

**Tertiary halo will be lost at aperture limits in the ring.**

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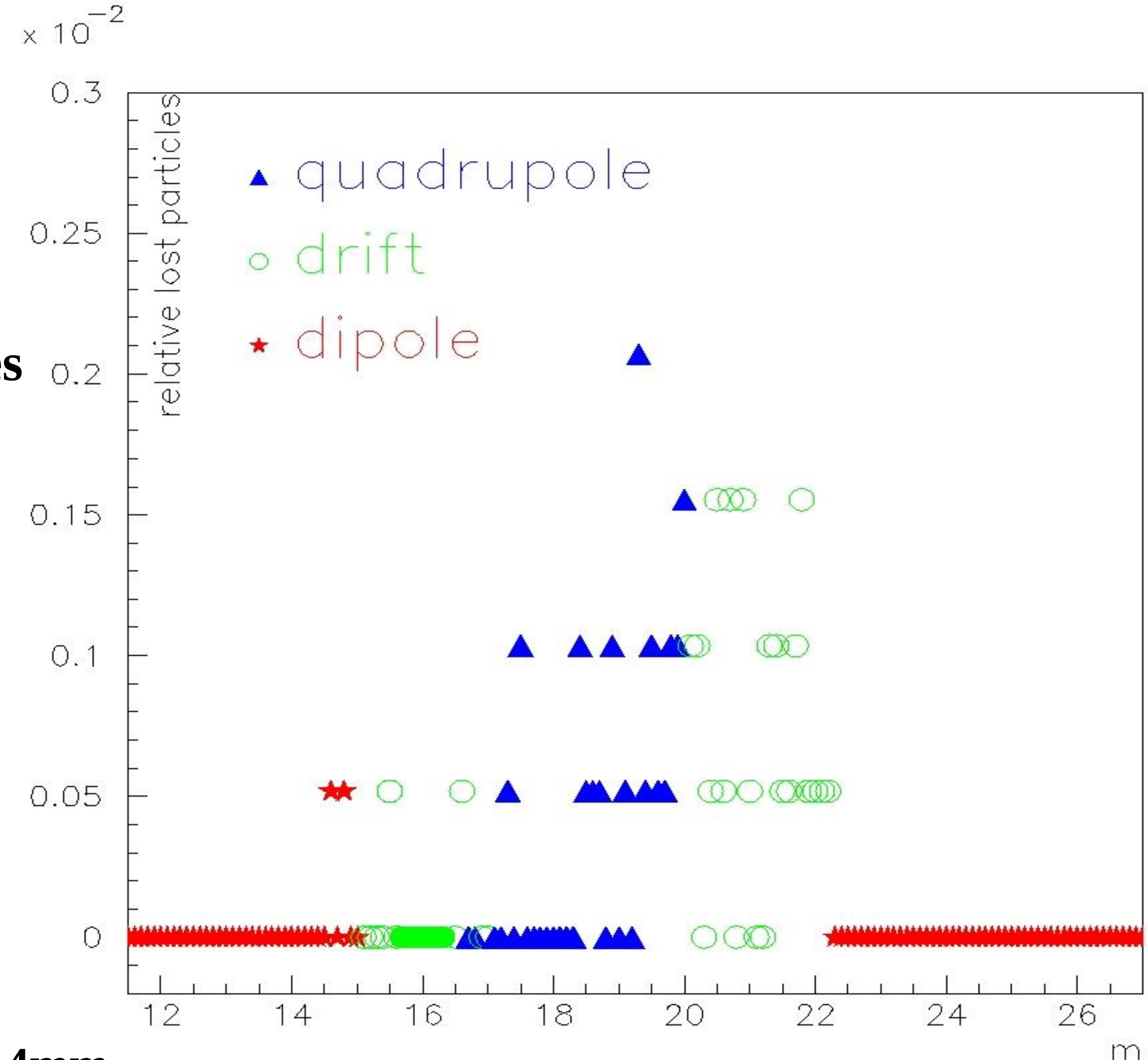
other types of printers.

# Beam loss distribution along a part cell of the LHC for 450GeV.

- **Halo from collimator to first element of interesting structure with transfer-matrices**
- **Tracking through each element**

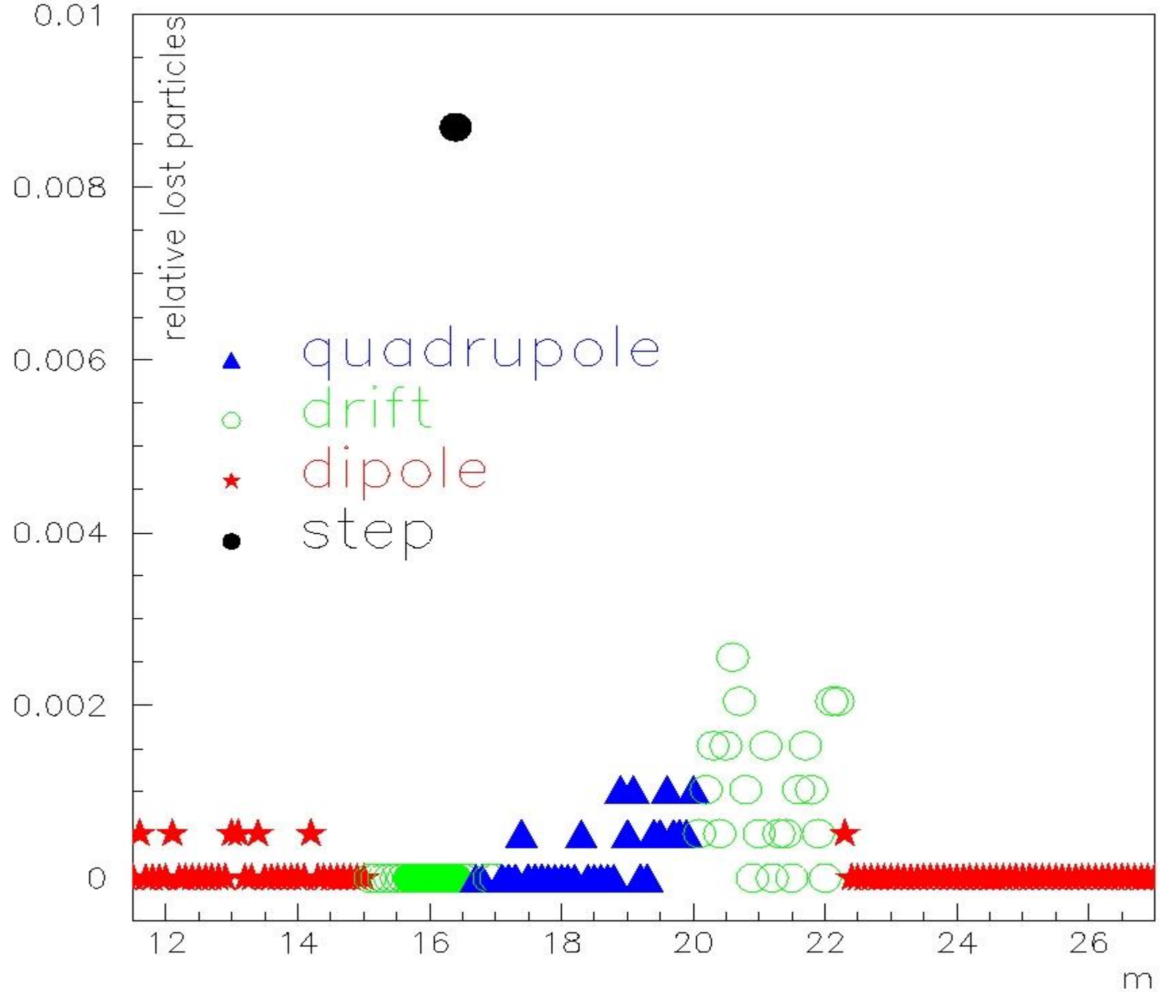
**(V. Kain)**




**Vertical orbit excursion of 4mm.**

# Beam loss distribution along a part cell of the LHC for 450GeV.

**Beam screen misalignment error of 2mm in Y between the dipole and the quadrupole.**



# Proton loss shower simulation

## Geant 3.21

## Dispersion Suppressor

➔ **Detailed simulation of magnet geometry, Version 6.3**

**MB,MQ,MQM, MQML,MQMC,MQTL,**
**MCBCB,MSCBA,MCDO,MCS,BPOM,**

➔ **magnetic field maps for Quadrupoles, Dipoles (Roxie)**

- **incident angle of 0.25mrad (other angles vary only marginally)**
- **losses in horizontal (QF) and vertical plane (QD) of beam screen**
- **100 events with same impact parameters**

# MQML in Q10

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# Impact of beam1 and beam2

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fig2dev Version 3.2 Patchlevel 1
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other types of printers.

# Expected shower particles/lost proton

- **Signals very high when losses between magnets (bellows)**
- **Lower when in magnet:**
  - Point-like
  - Distributed
- **3 monitors/beam around quadrupole**
  - For location of losses: combine several monitor signals

| | **min:** ch/p/cm$^2$ | **max:** ch/p/cm$^2$ |
|---|---|---|
| **450 GeV** | $5 \cdot 10^{-4}$ | $3 \cdot 10^{-3}$ |
| **7 TeV** | $4 \cdot 10^{-3}$ | $6 \cdot 10^{-2}$ |

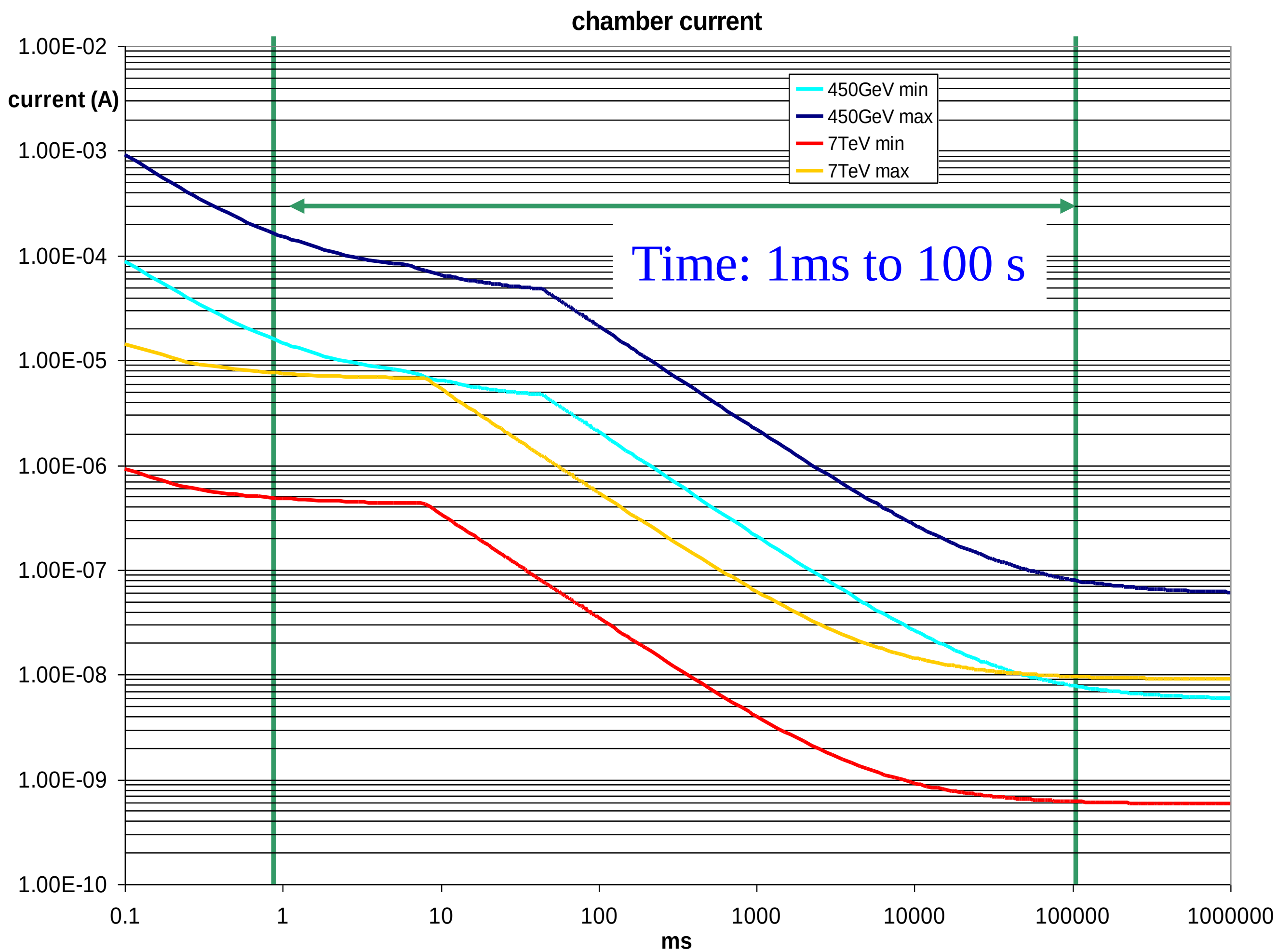
# Detector

**Baseline detector:**

**Ionisation chamber**

**$N_2$ filled cylinder, 80 $cm^2$, 19cm length, bias voltage of 800V**

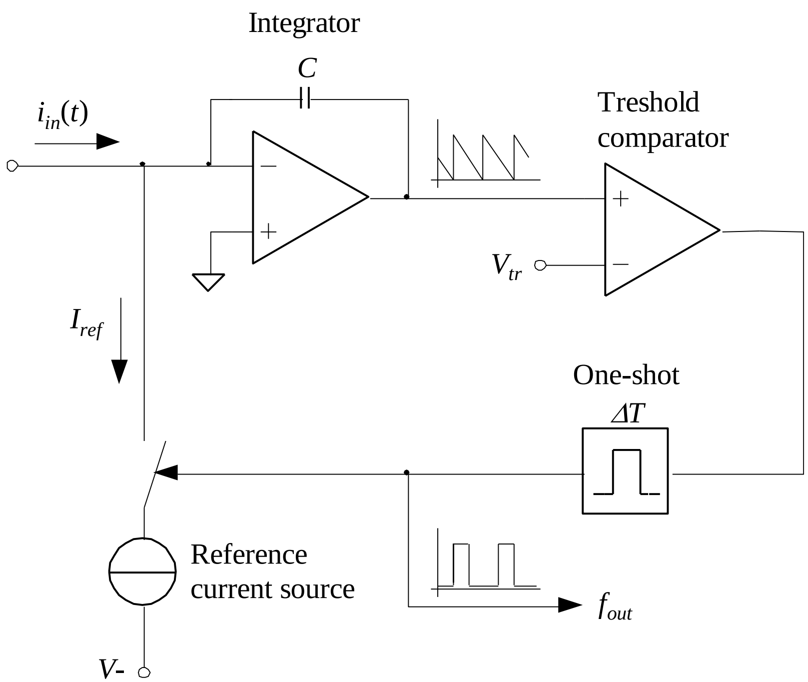
# Detector current

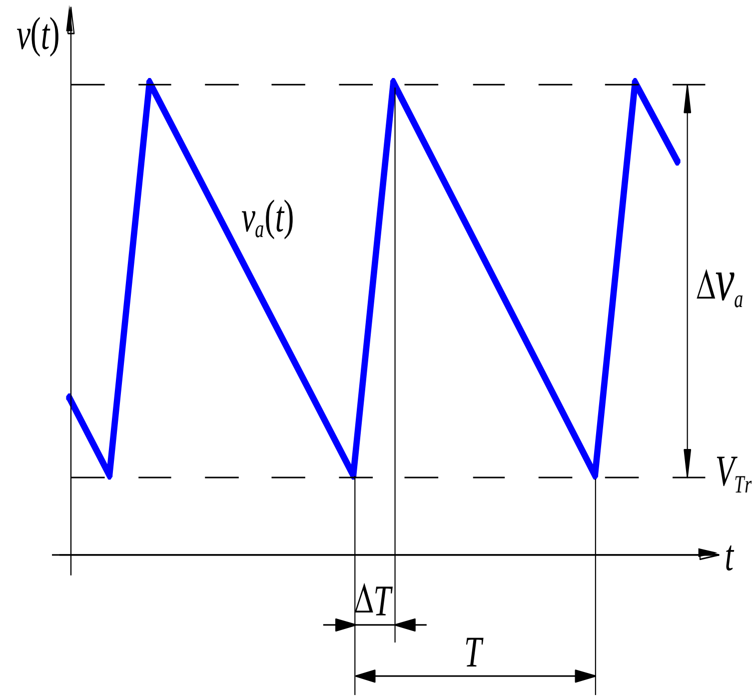



**Chamber current varies between 60pA and 150µA**

# Readout electronics

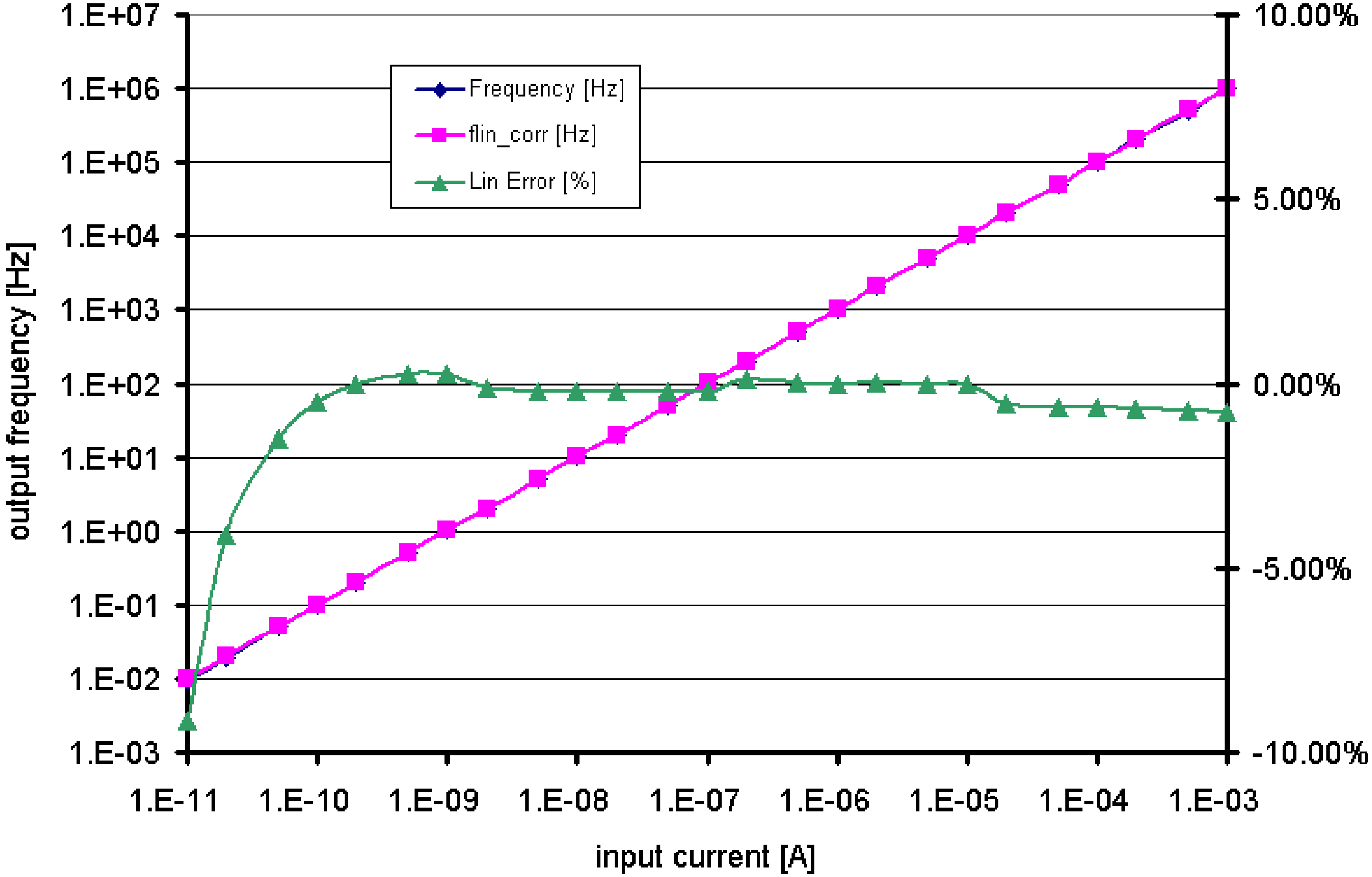
## Charged balanced current-to-frequency converter (CFC)



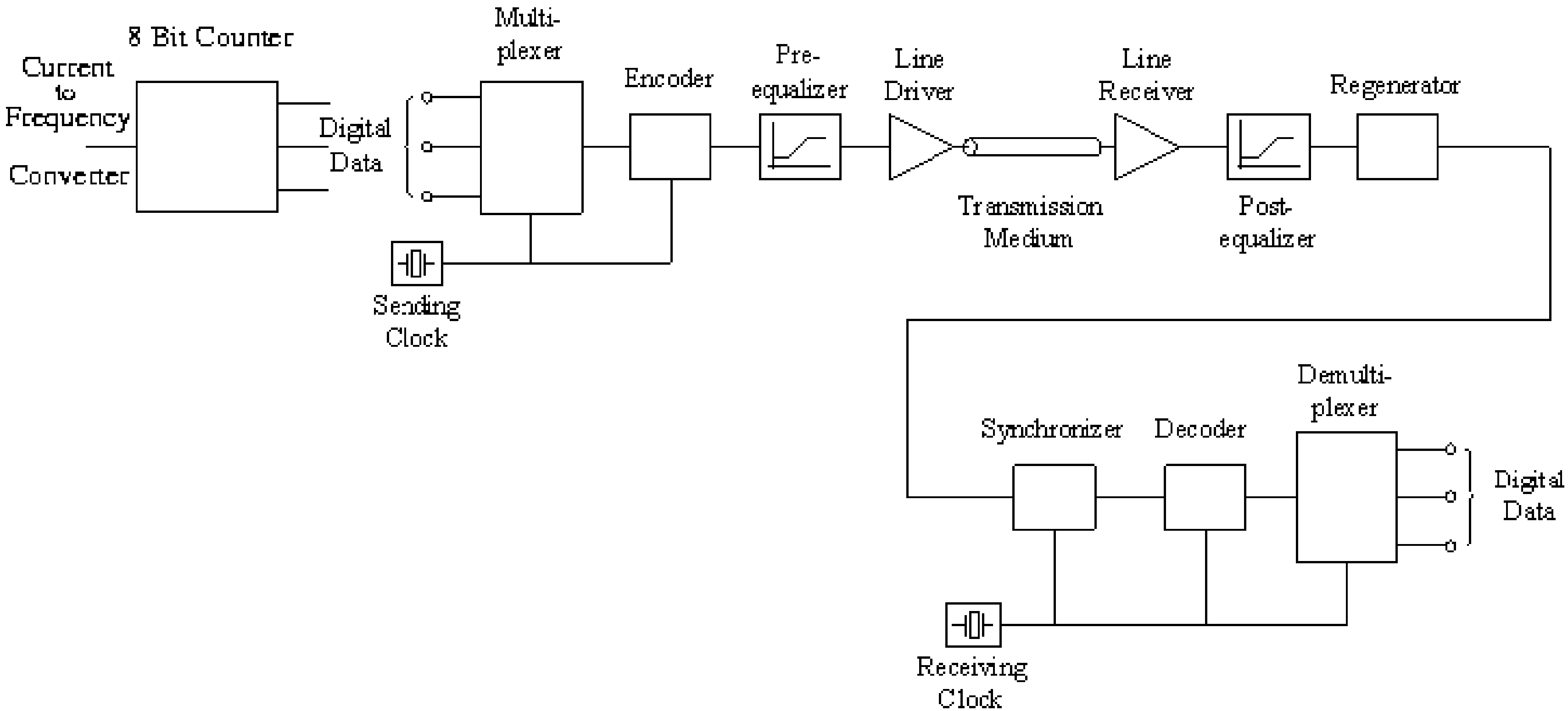




$$f = \frac{\bar{i}_{in}}{I_{ref}\,\Delta T}$$

# performance



# frequency evaluation circuit

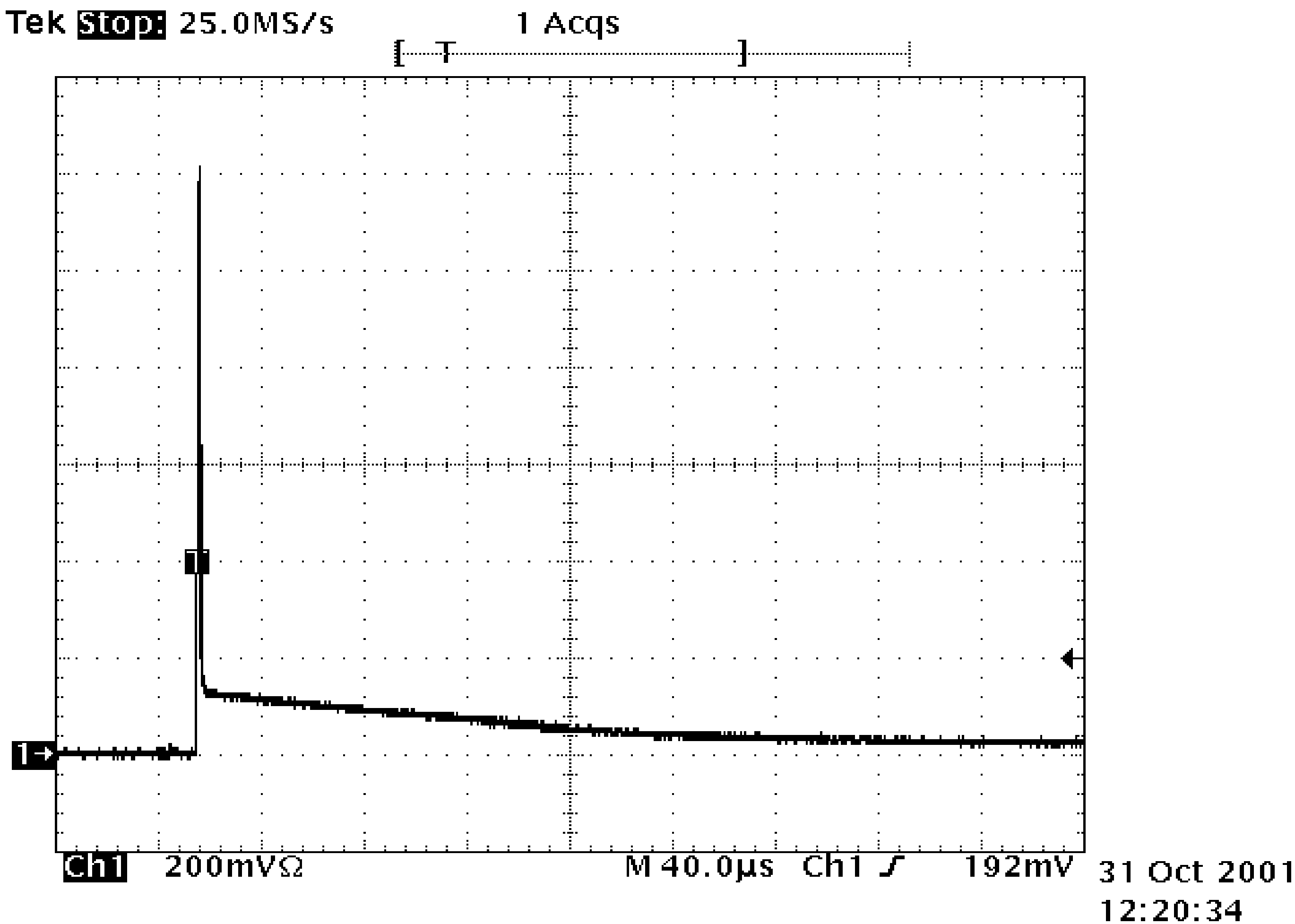


# Tests with detectors

- **Tests in SPS dump**

**High current (24mA)**

**From theory:**
**collection time of**
- **ions: 100 µs**
- **electrons: 100 ns**



# Some words on reliability

- **Monitor design criteria:**
  - ➔ **Electronics: same concept for BLMC, BLMS, BLMA.**
    - **I.e. same dynamic range: 1 turn, although for BLMA only ms range demanded.**
    - **Reduces complexity and increases reliability**
  - ➔ **From 8-bit counter on: everything is twice**
- **In specifications: for each magnet 2 monitors**
  - ➔ **We have 6 monitors**
    - **Additional reliability**
    - **Distinguish loss locations**

# Summary

- **Loss distribution & shower simulations:**
  - **More studies for detector locations and geometry.**
- **Monitors:**
  - **Front end electronics finished, circuits will be built and testet soon**
  - **Signal transmission: twisted pair or fibre optics, will be decided in a few weeks.**
  - **Dump controller: starting of design in a few weeks.**
    **Timescale: 1.5-2 years**
  - **High intensity behaviour of detectors will be tested this summer at PS**
- **Reliability studies:**
  - **PhD student this summer**