PADME Tracker System

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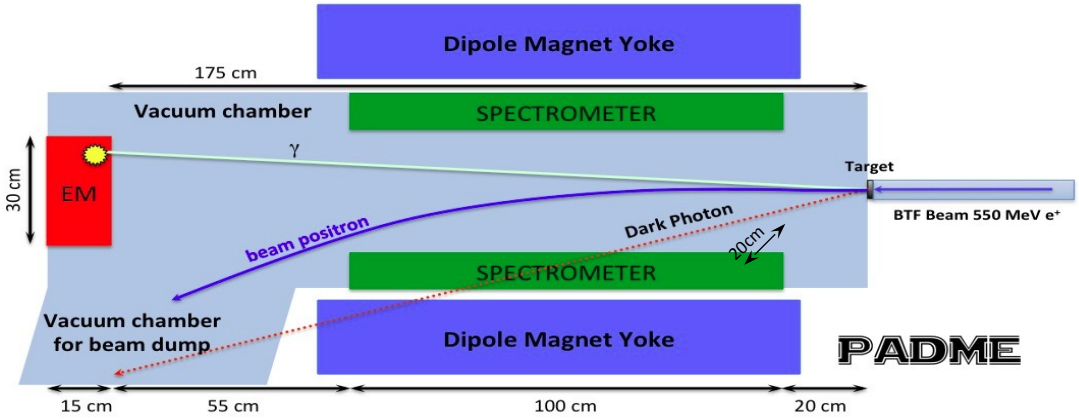
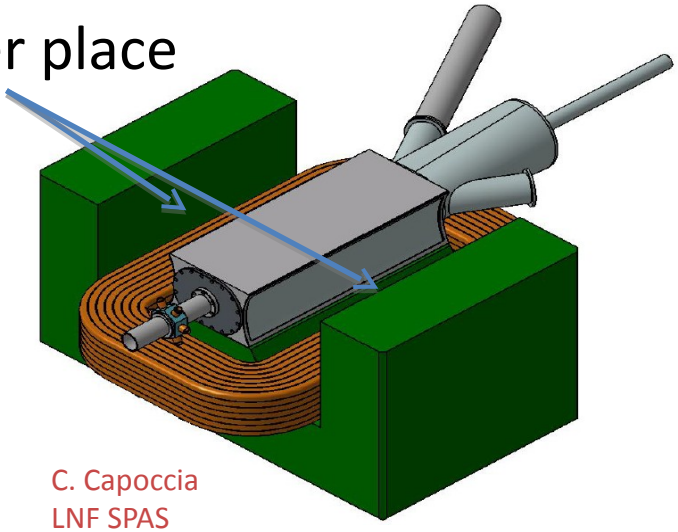
Introduction

- Charged particle beam e+/e-
- Part of interaction particles are also charged
- Decay products of U-boson (if any) are also e+/e-
- Charged particle detector needed
  - To suppress the background (bremsstrahlung)
  - Reconstruct U-boson decays in case of visible decays



Spectrometer technology

Tracker place



C. Capoccia
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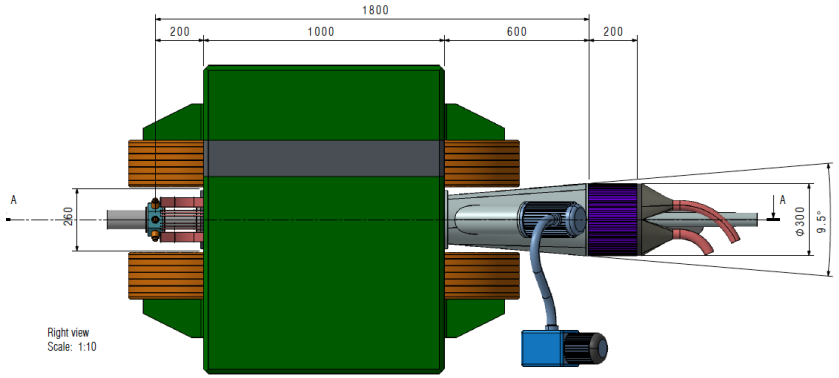


- New spectrometer (a charged particle detector) needs to be designed
  - Good position and time resolution
- Invisible phase – some quick-build solution is possible
  - Hodoscope
- Visible phase – a good spectrometer is needed
  - Provide the necessary resolution

Spectrometer technology

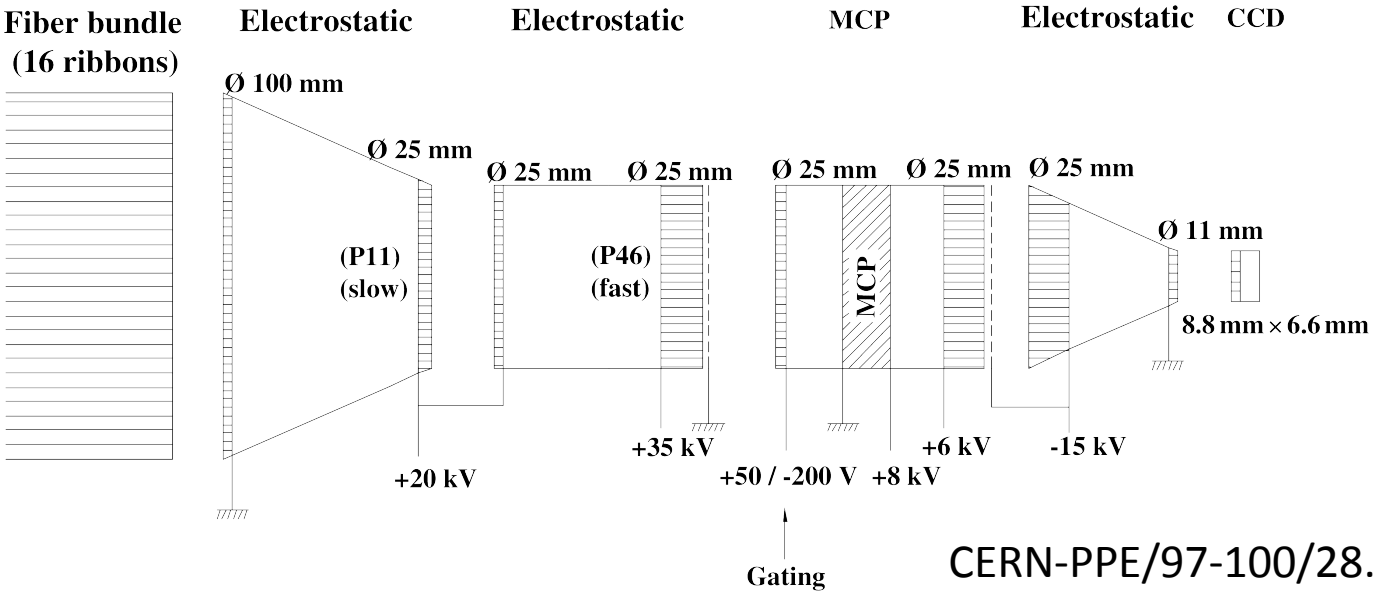
- GEM spectrometer
  - Good spatial resolution
  - Could even ask for a real TPC GEM based detector
  - However the construction is not that straight forward – real experts needed
  - Readout electronics might have to be custom

- Scintillating material spectrometer
  - Cheap material
  - Good time resolution achievable, better than 1ns
  - Several options
    - Scintillating fibers: many channels but with good position resolution
    - Scintillating bars: few channels
  - Should use numerous photodetectors which increases the price of the object
    - May be one can construct hybrid photoreadout?

- Alternatives …..

CHORUS Experiment

- 1.2 million fibres by 0.5mm
- 4 image intensifiers on a CCD
- 58 CCDs



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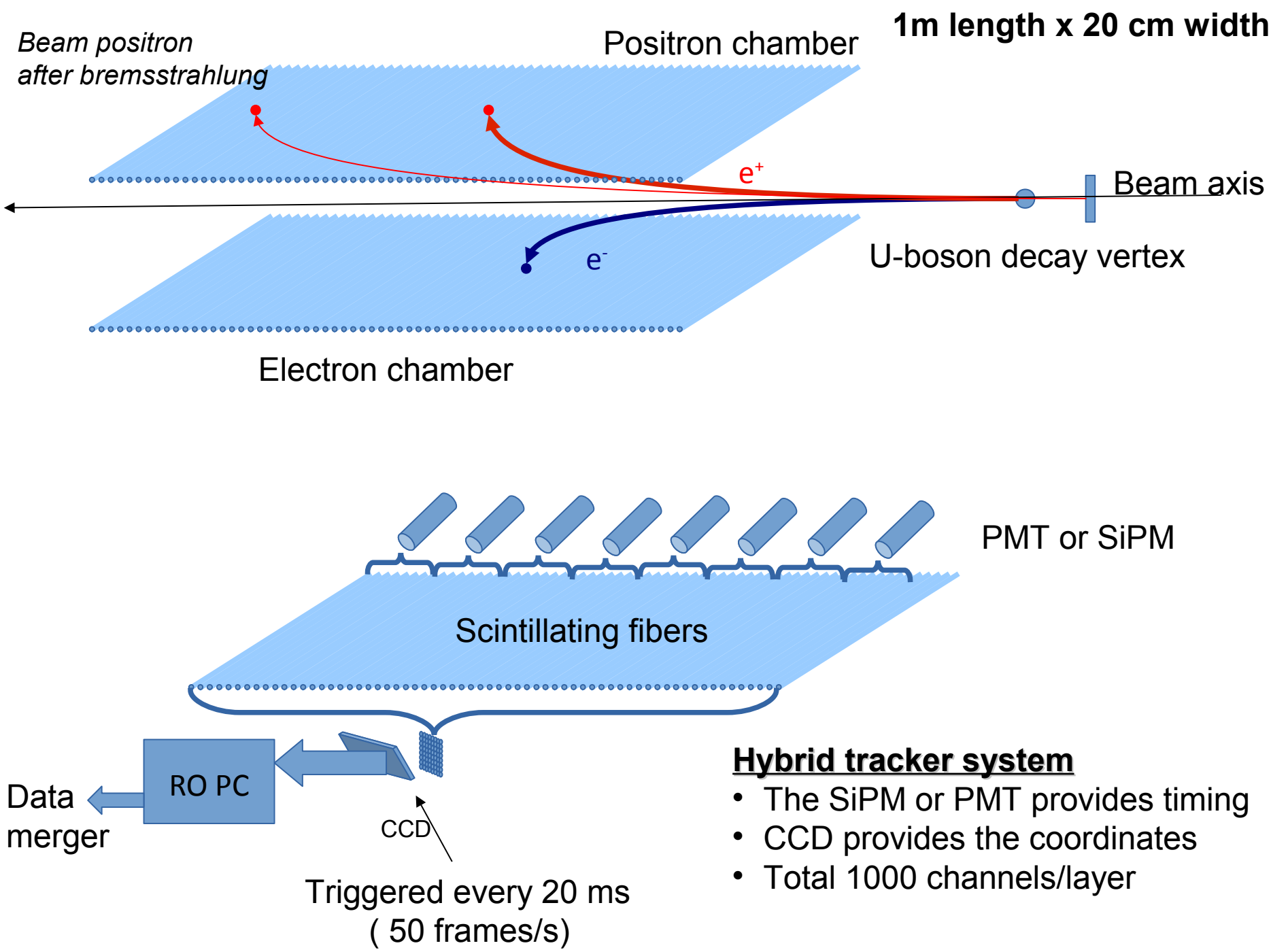
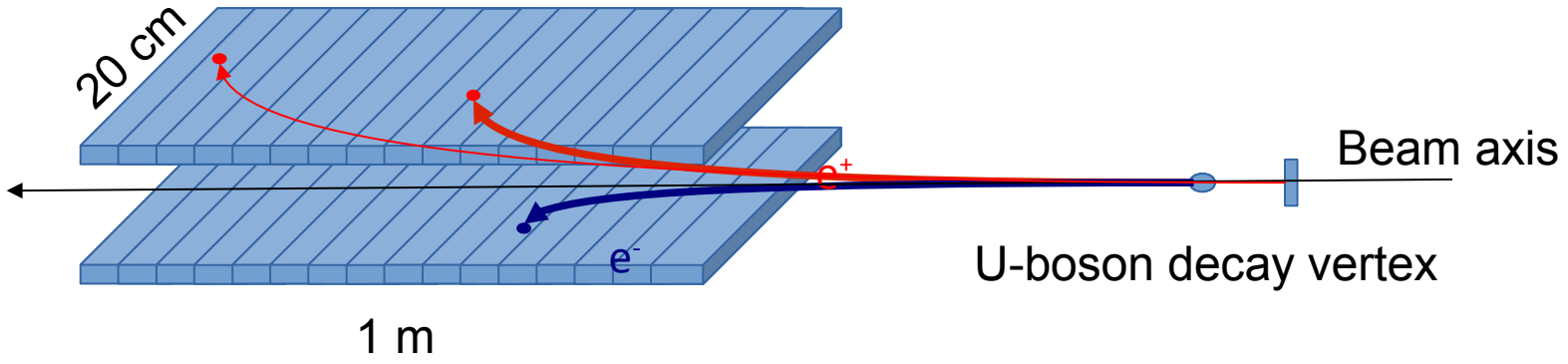
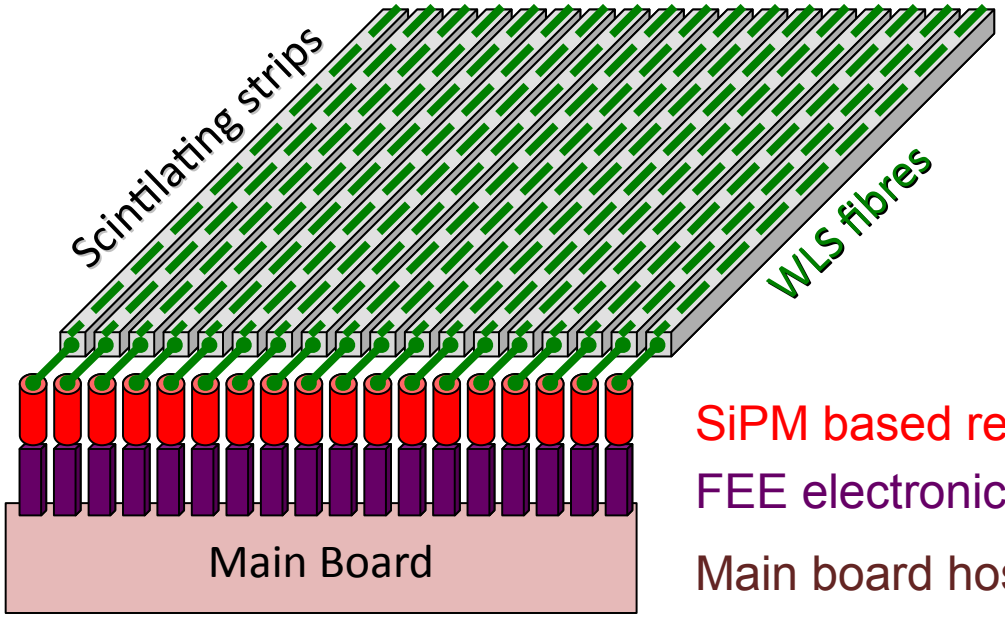


Hybrid tracker system

- The SiPM or PMT provides timing
- CCD provides the coordinates
- Total 1000 channels/layer

Scintillating strips consept





1x1 cm scintilating strips could provide good time and position resolution

SiPM based readout

FEE electronics & power supply

Main board hosting the FEE mezzanines

An idea

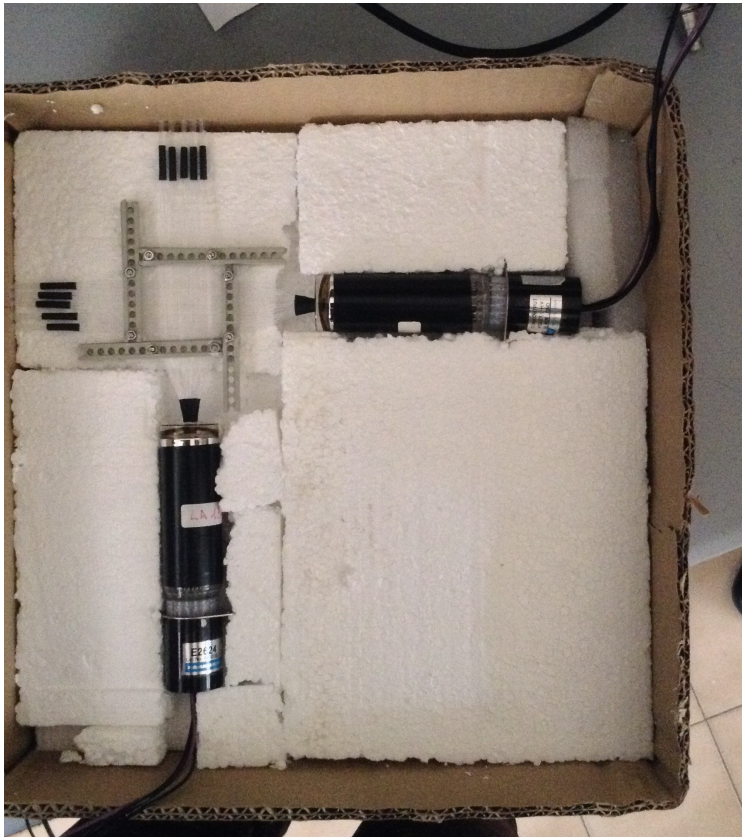
- 4 layer mesh of 1mm scintillating fibres
  - Resulting in 2500 fibres
  - Compaction factor due to the circular cross section 0.87
  - Which gives ~2200 mm^2
- 3 Full Frame CCD matrices 2592 mm^2
  - May be can go down to 1 CCD with optical lens
- No Image Intensifier
  - A costly and tricky to operate device (10-15k€)
- Few PMT just to time stamp the events in a scintillating fibre bundle (hybrid concept)

Verification if a CCD could do the job

- LED Driver
- CCD pattern recognition
- Building a small fibre tracker
- Data taking with the tracker
  - Cosmics
  - BTF

Scintillating fibre tracker
Preliminary tests

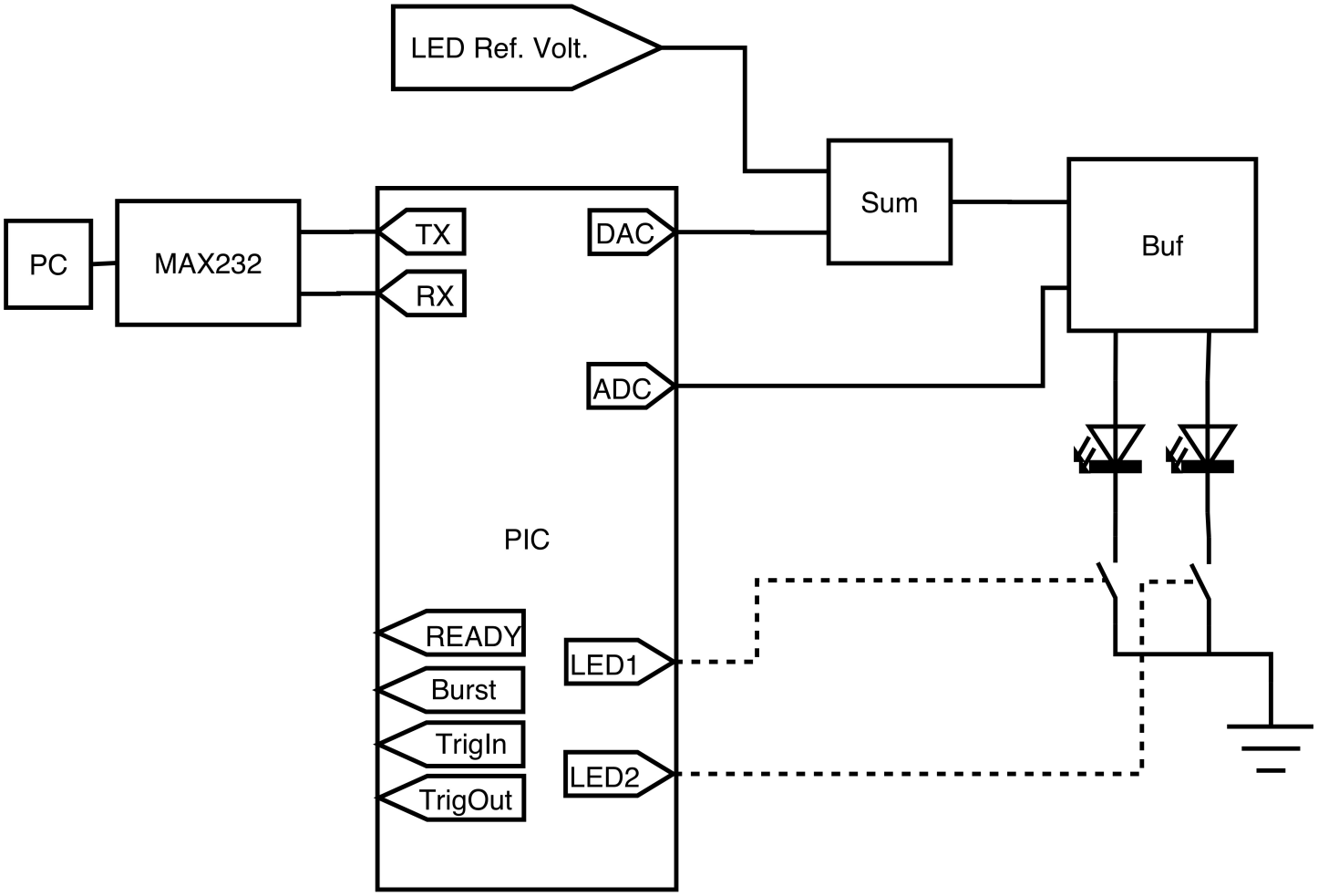
- 2 layer of few tens of fibres on 2 PMTs
- Cosmics
- No optical grease
- 100 photons by fibre ø1mm



LED Driver

- Based on Microchip's PIC16
- Generates sequence of hundreds of tiny blinks
- Precisely tunable cumulative light emission
- Verified by SiPM (almost 😐)
  - Instability caused by RF noise in the lab
- To be calibrated by PMT

Block scheme of LED driver

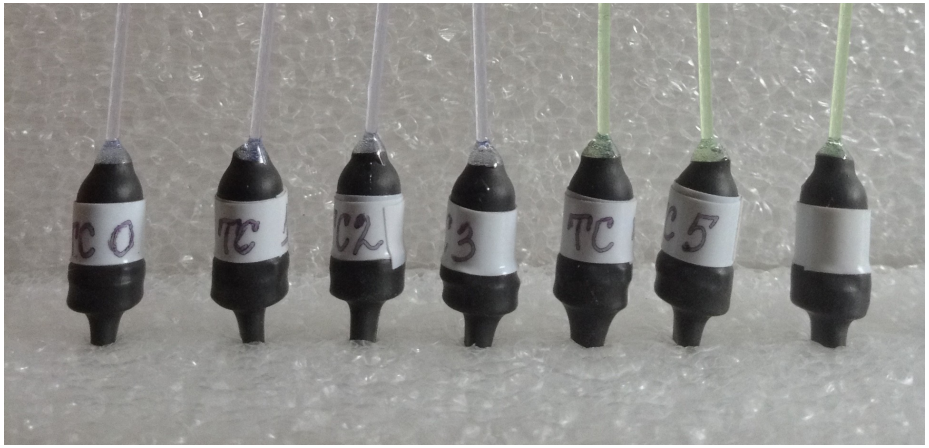


Some details for the LED Driver

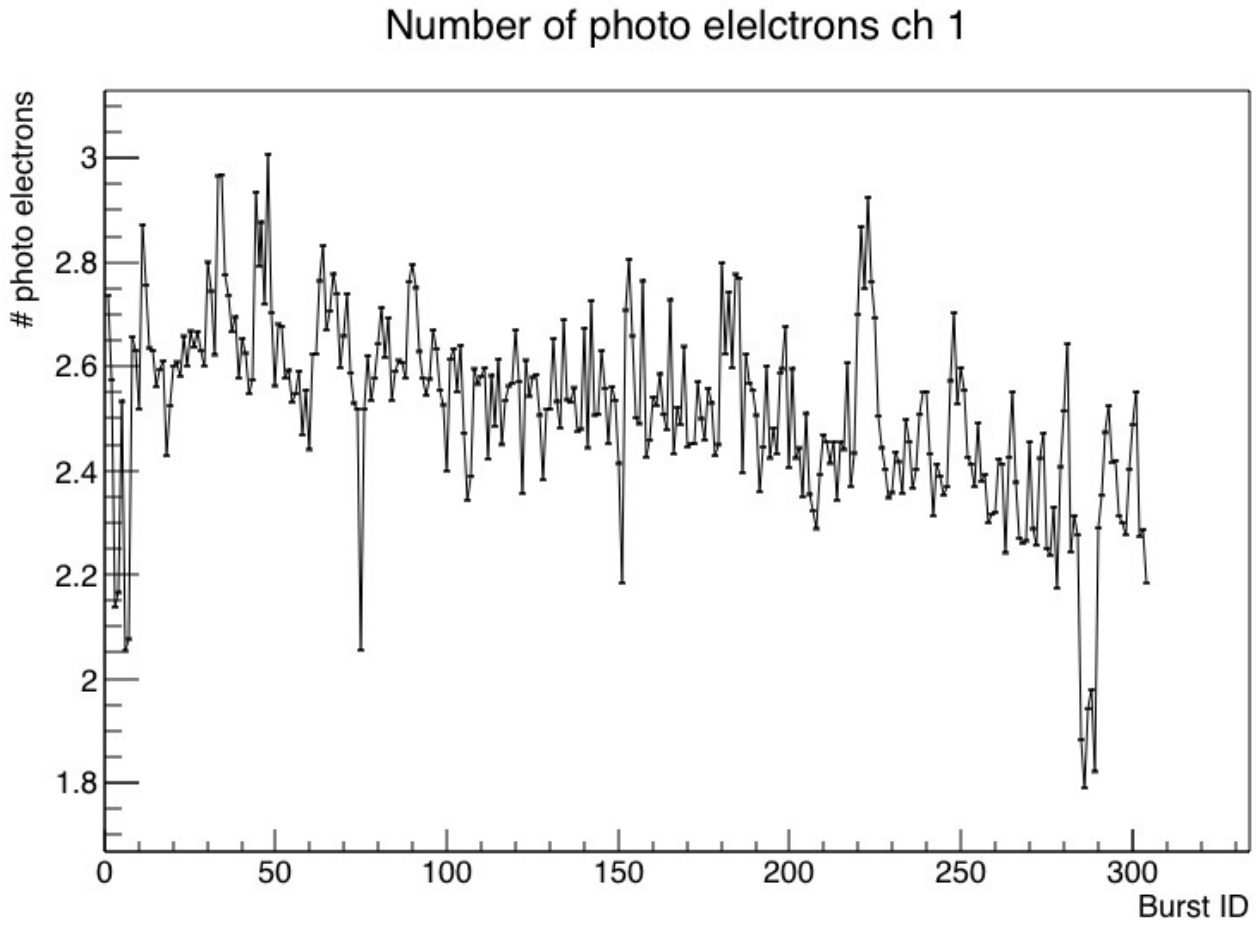
- Crystal resonator stabilised
- 1-65535 blinks per burst
- ~20 degree of light intensity
- Variable time delay between the single blinks 20µs-8ms
- Optional, pre- and post burst delays
  - For initialising the CCD
  - For collecting the pixel data from the CCD

LEDs and SiPM

- LED-fibre assembling technology
- CAEN 2 SiPM SP5600

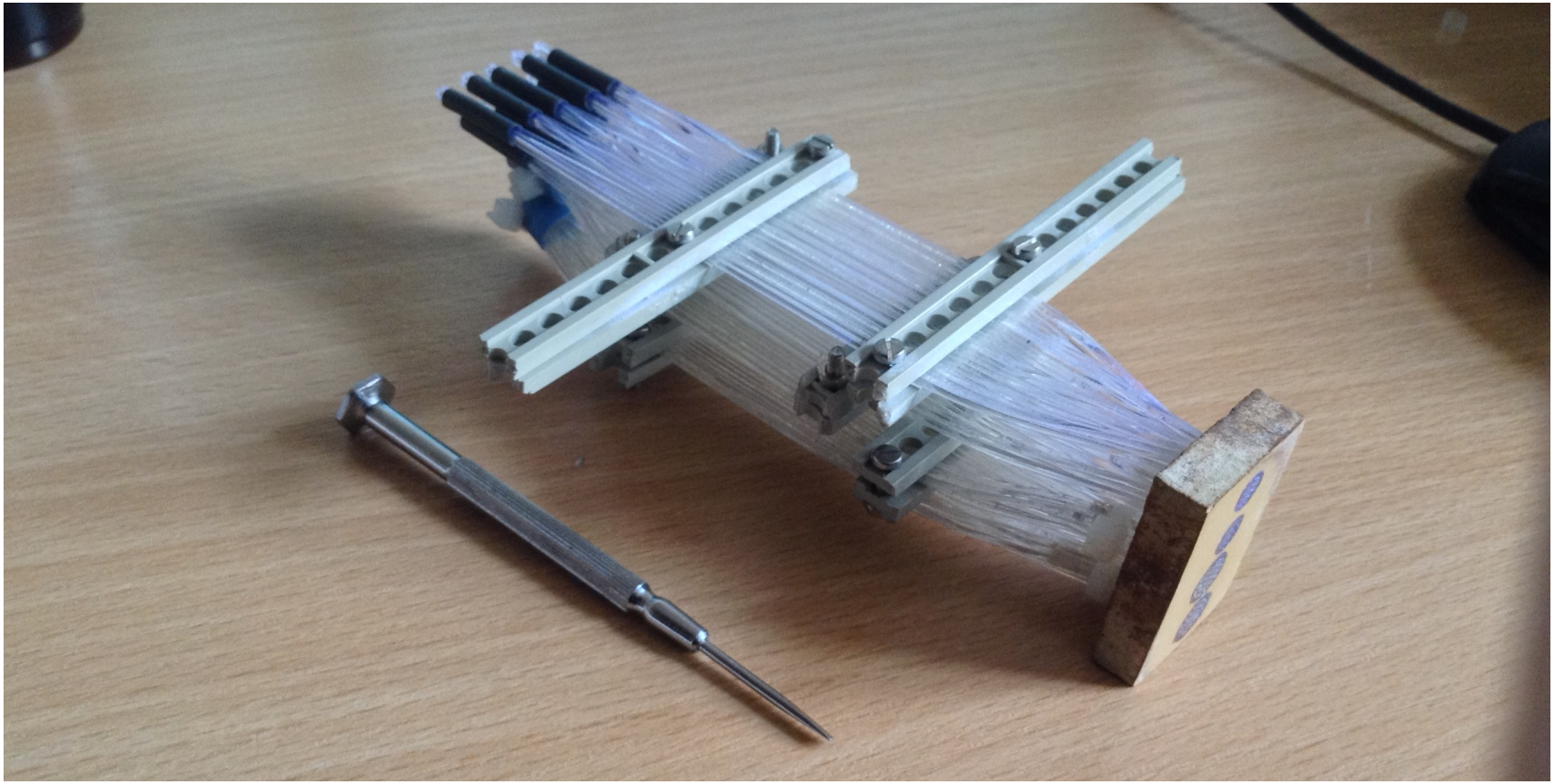


LED Driver stability by SiPM



No temperature/gain correction

Fibre tracker prototype



The CCD

- Tests with CCD Camera

  STL11000M

  – Dark Current

    0.5 e-/pixel/second at 0 °C

  – Pixel Array 4008 x 2672 pixels,

    36 x 24.7 mm

  – ~9500 pixels per fibre

What next

- Calibration of the LED Driver
- Verification if CCD could detect 100 photons (LED) emitted by scintillating and WLS fibres
- CCD Pattern recognition
- Data taking with tracker prototype, CCD
  - Cosmics
  - BTF

Summary

- LED Driver
- CCD pattern recognition
- Building small fibre tracker
- Data taking with the tracker
  - Cosmics
  - BTF