Charged particle vetoes

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PADME Collaboration meeting

LNF-INFN

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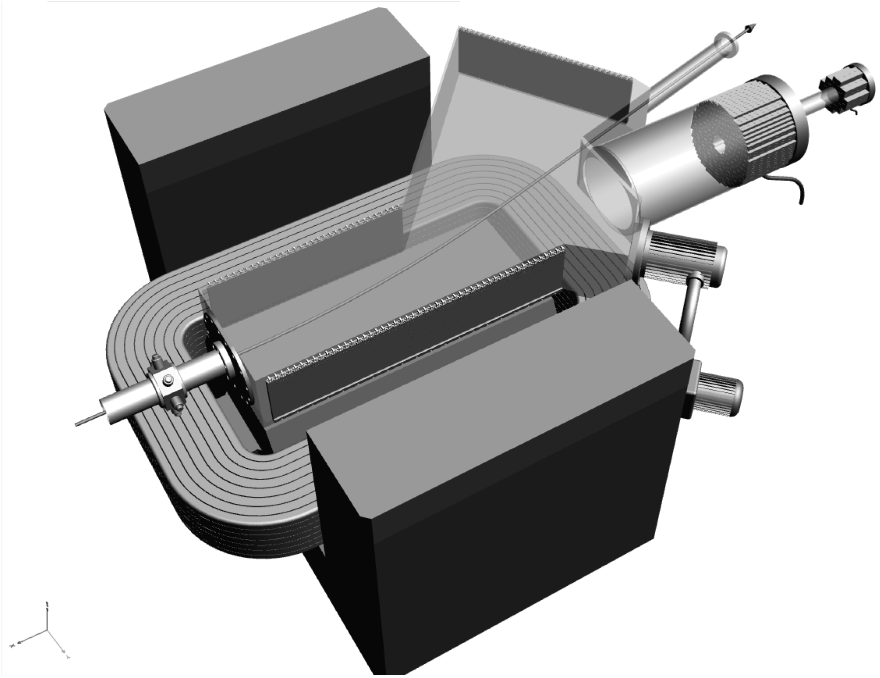
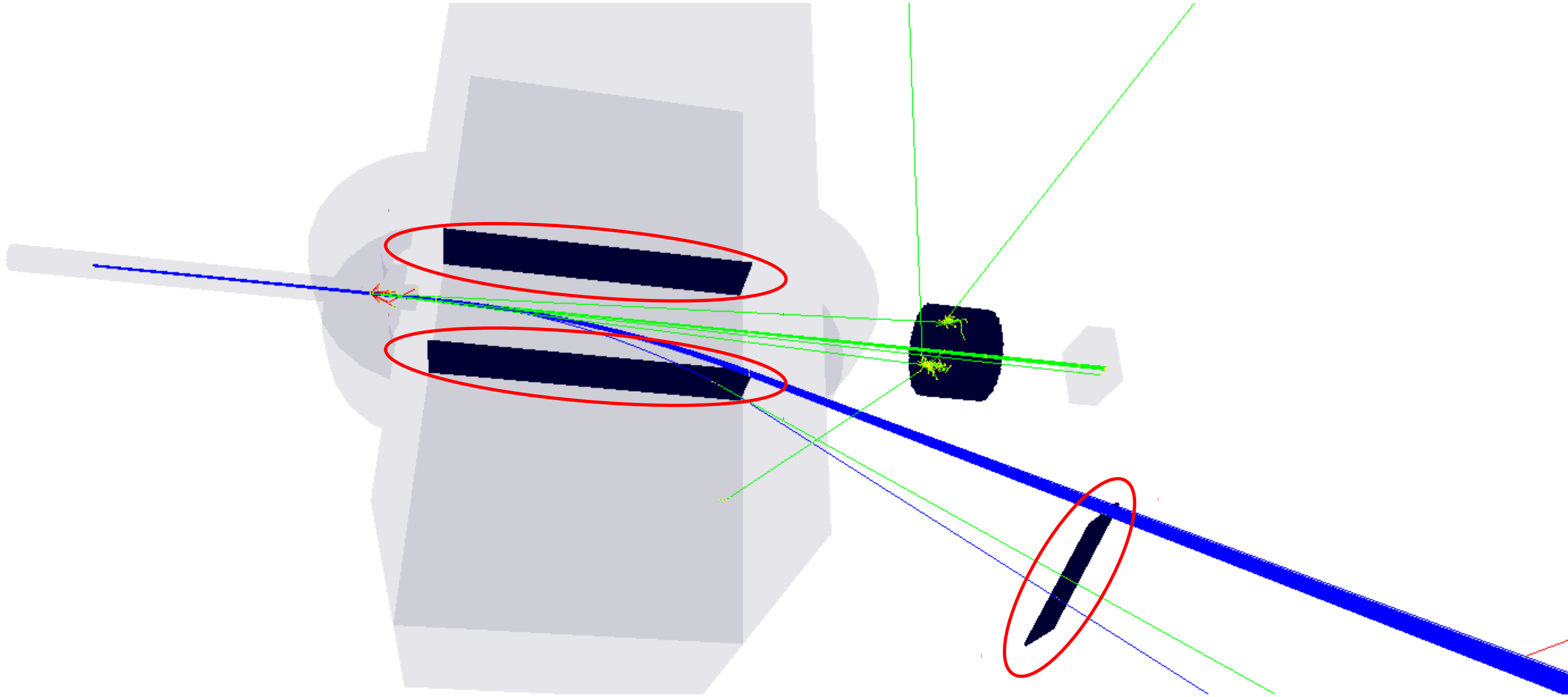
Outline

- Role
- Requirements
- Design
- Estimations



Charged vetoes

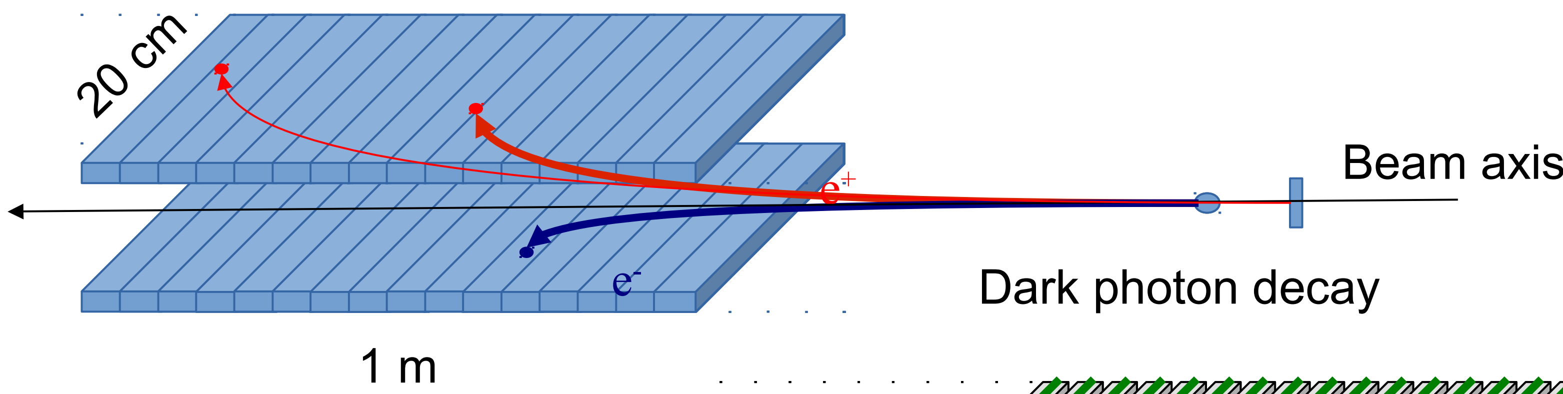


- Three detectors with practically identical goal – detect any charged particle passing through them

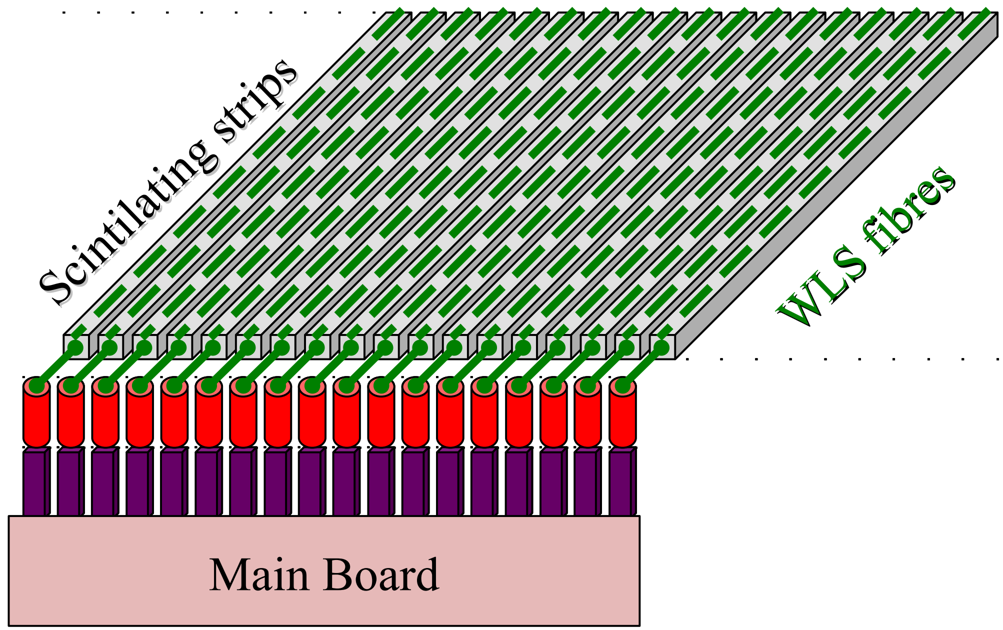
Charged vetoes

- Positron veto
  - Provide information for tracks with momentum > 400 MeV
  - Rate vs maximal momentum
    - May need to exclude the part close to the deflected beam
  - Size: 20cm by 50 cm
- Spectrometer/Tracker/Veto
  - Detect e+/e- with momentum 50 – 450 MeV
  - In magnetic field
  - Two stations
    - Single layer (hodoscope) vs multi-layer
  - Preliminary efficiency requirement - > 99%
  - Size: 20 cm x 100 cm each station
  - Time resolution - ~1ns

Possible design



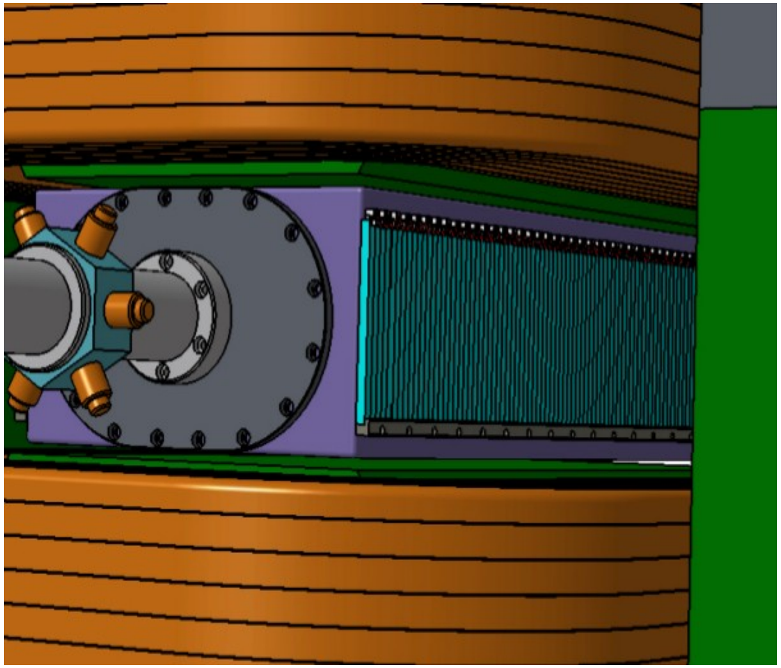
- Plastic scintillator bars
- Light read out by SiPM
  - WLS vs direct coupling
- O(1000) photons
- 0.5 – 1cm thickness
- Bars width to be optimized

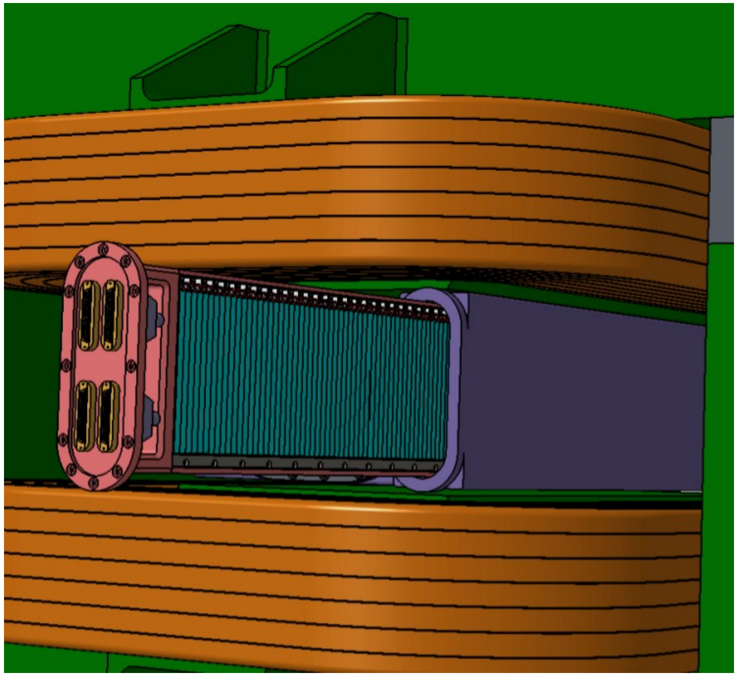


Positron veto

- Quite a simple design
- A good detector to start with and perform tests and/or R/D
  - WLS vs glued SiPM
  - Mechanical design
  - SiPM PCB
  - Determine the ph.e. yield/MIP, time resolution
- Get some experience with the SiPM electronics
- Possibility to make few prototypes and choose the best

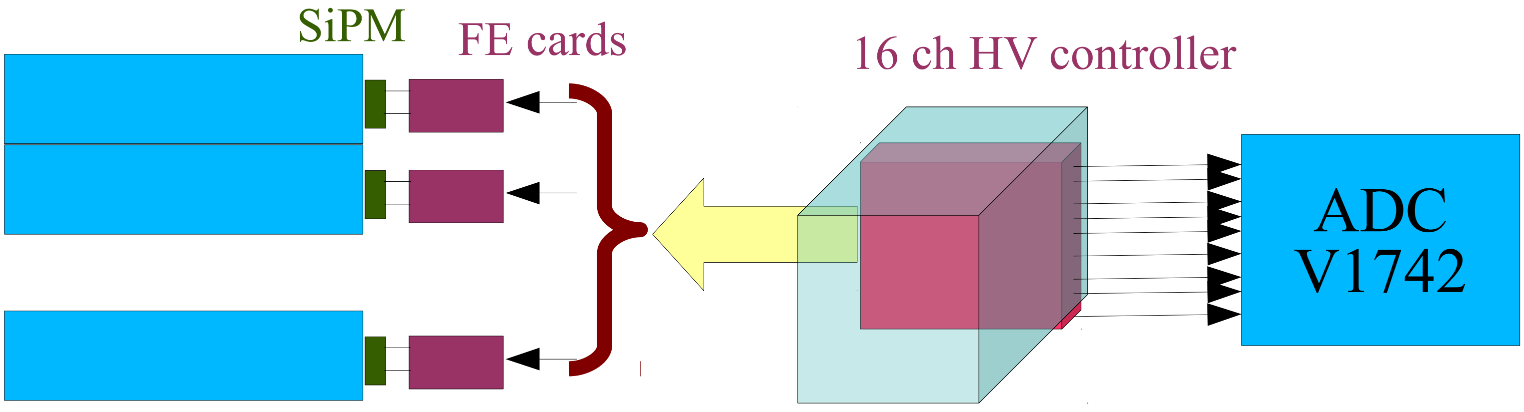
Hodoscope/tracker





- Possible integrations
  - Outside the vacuum chamber
    - Easily accessible for maintenance
  - Inside the vacuum chamber
    - Minimize the MS, feed through

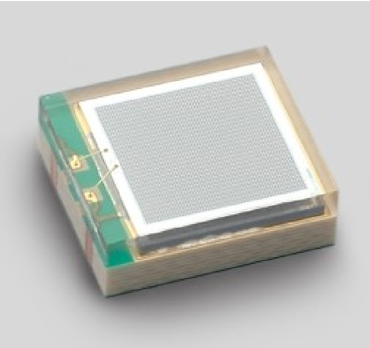
Readout



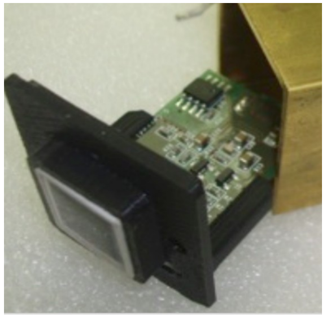
- Possibility to use electronics already on the market (developed at LNF)
  - Custom low noise NIM crate (±5 V, ±12 V) (2500 e)
  - HV controller, NIM based, 16 ch (3000 e)
  - FEE card (50 e/ch)

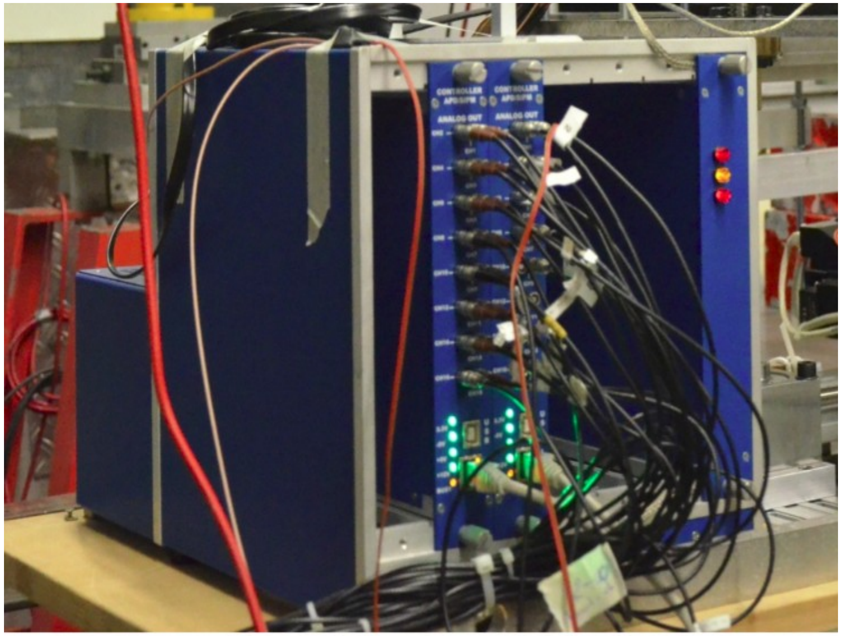
    About 300 e/ch for HV & FEE
  - Custom cables & connectors
- ADC or ToT-TDC readout

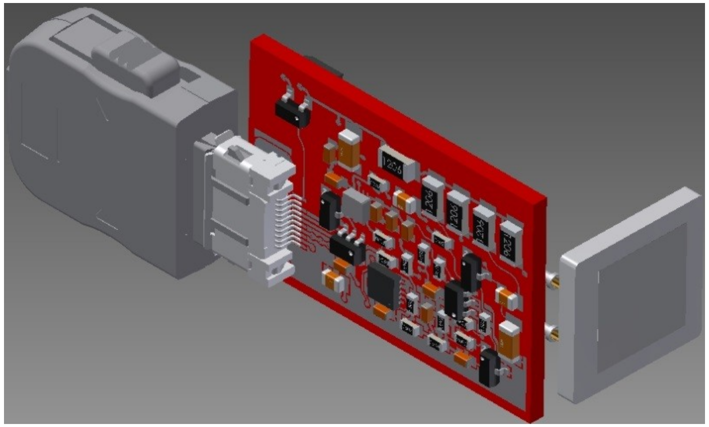
Hodoscope/tracker



- SiPM: 3x3 mm,   25 um pitch, ~14k pixels
  - Dynamic range enough for a hodoscope/tracker

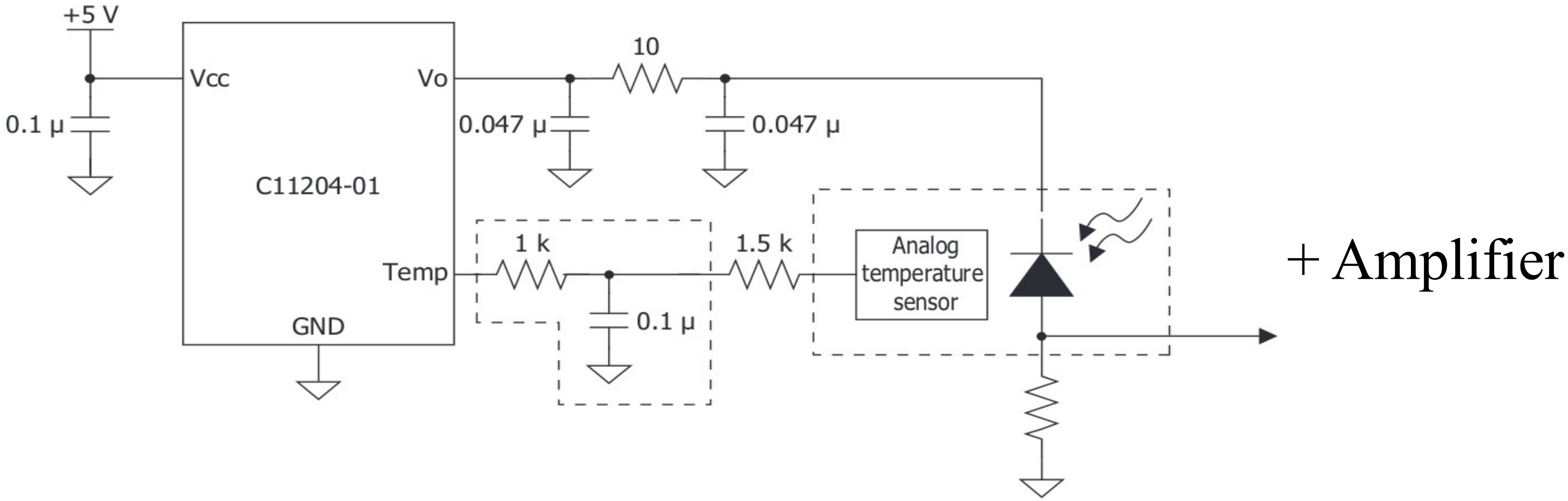






Alternatives

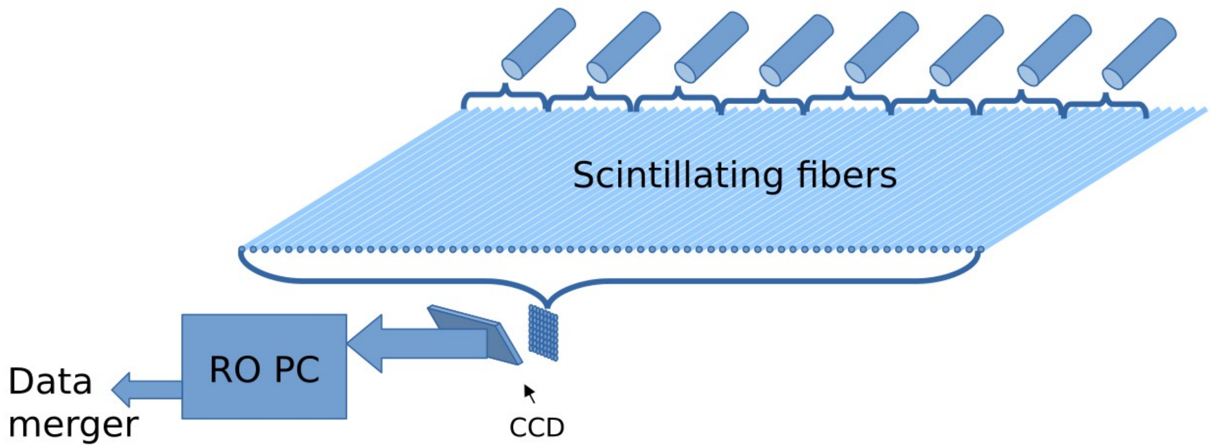
- Hamamatsu itself provides an HV PS
  - C11204-01
- UART (serial) interface to a PC
- How straight forward is to use it?
- CAEN alternatives?



Alternatives

From G. Georgiev M.Sc. Thesis
G.G., V.K., Ludmil Tsankov

- Scintillating fibers tracker/hodoscope
  - > 1000 channels



- Hybrid spectrometer
  - Position from a slow coordinate sensitive detector (CCD)
  - Get the time from a fast photodetector (SiPM, PMT)
    - Bundling many fibers into few
    - Demultiplexing (occupancy is relatively low O(5)/bunch)

Alternatives

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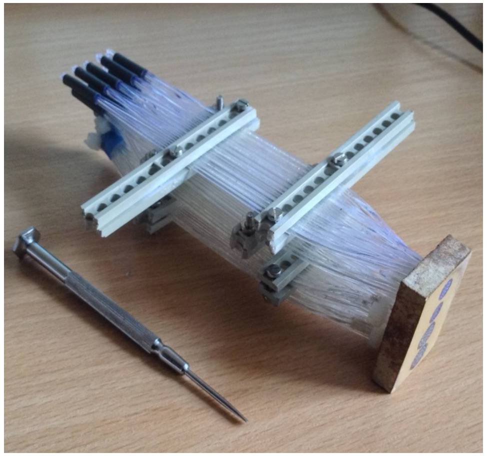
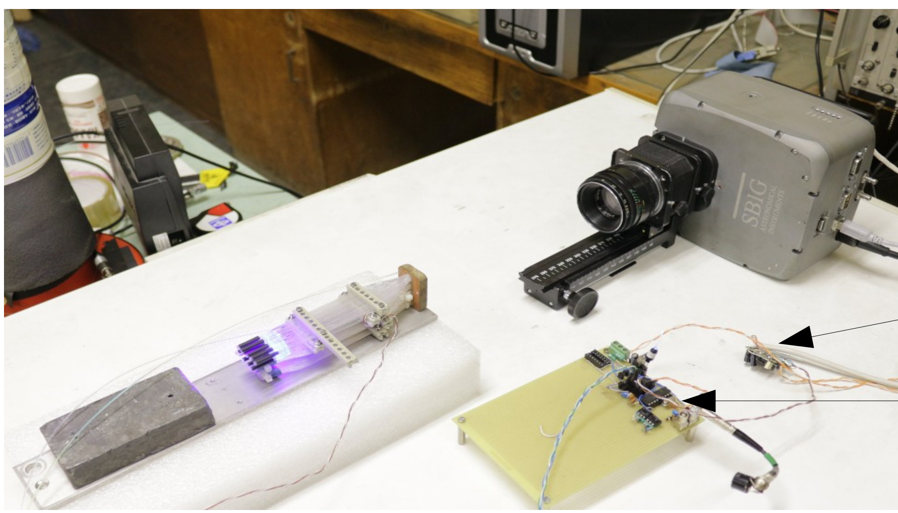


SciFi prototype
Kuraray SCSF 81
1mm diameter

SBIG 11000M CCD
Astronomy



Control/communication module
RS232

Pulse generation

PIC controlled

LED driver

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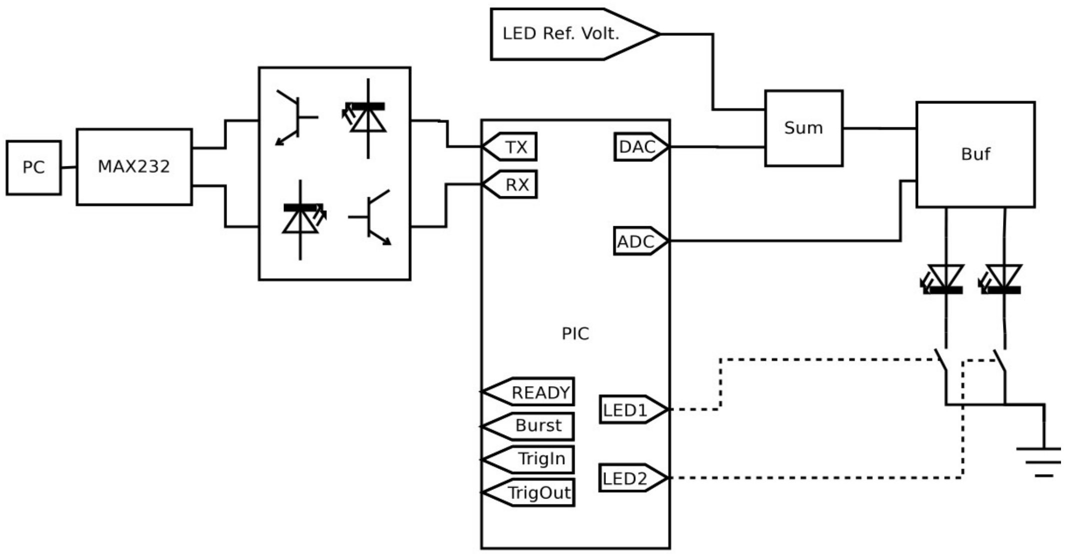
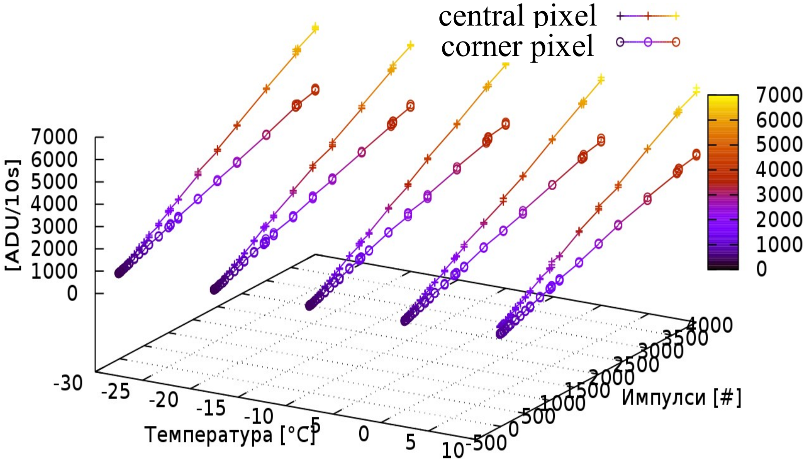
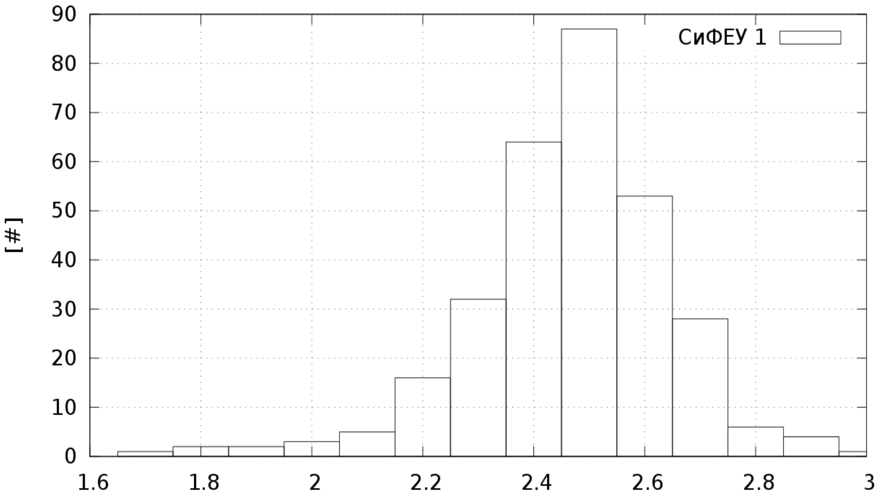


CCD/driver linearity





- Low light intensity LED driver
- PC controlled, different regimes (self triggered, external trigger)
  - Could also provide bunches of pulses

CCD operation

From G. Georgiev M.Sc. Thesis
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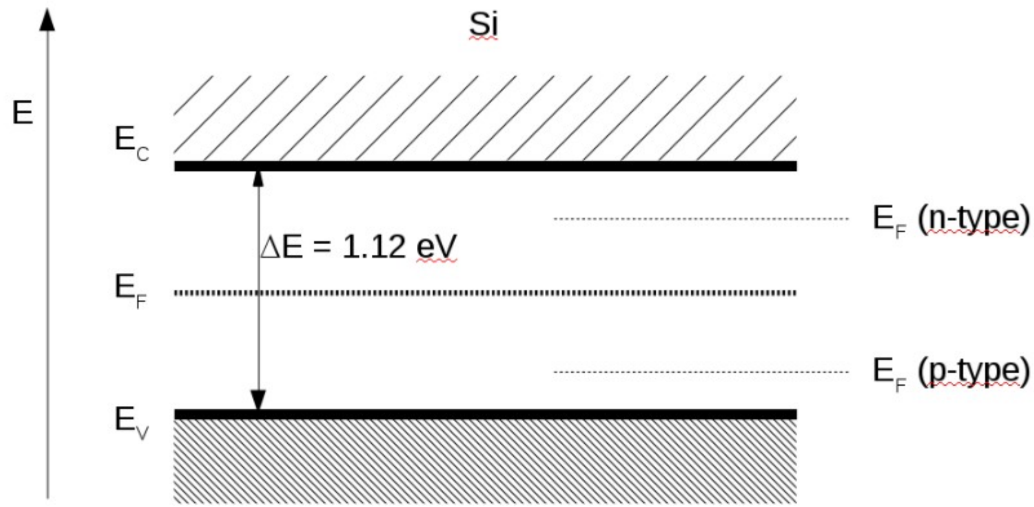
$$A\,(t,T,L) = Q_{bias} + I_{dc}\,t + Gain\,L$$

$$Q_{bias} = Q_{inj} + N_{e^-/px}\,e^{-\frac{k'}{T[K]}}$$

$$I_{dc} = I_{max}\,e^{-\frac{k'}{T[K]}}$$

$$k' = \frac{\Delta E_{FC}}{k}$$



- Assuming that both the dark current and the bias depend on temperature (Fermi-Dirac distribution of electrons)

CCD operation

From G. Georgiev M.Sc. Thesis
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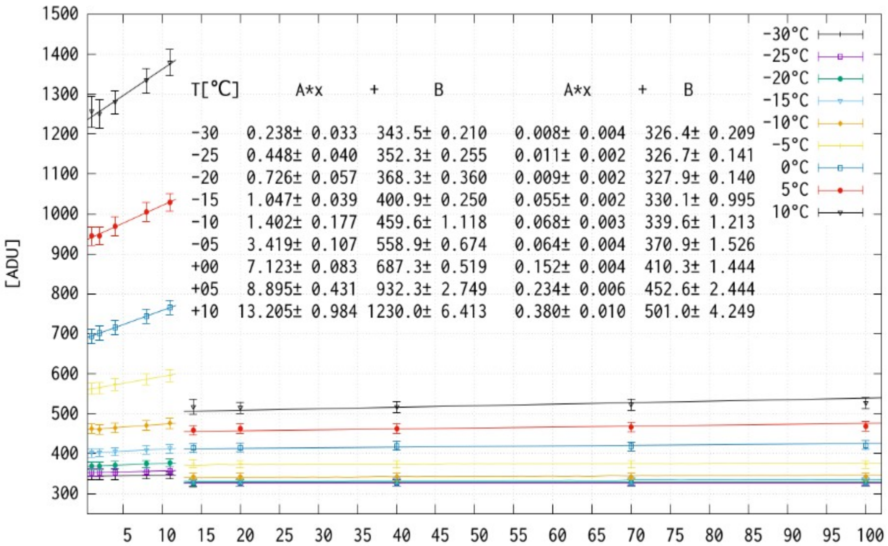
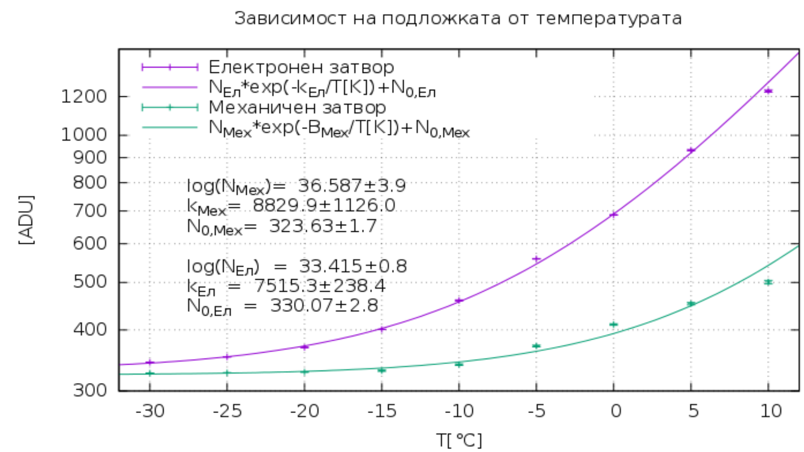
$$\langle Q_{bias}(T) \rangle = N_{e^-/px}\, e^{-\frac{k'}{T[K]}} + N_{inj}$$





- Different operational regimes depending on the exposition
  - Buffering before digitizing induces additional noise
  - Can be a problem for high speed imaging

CCD operation

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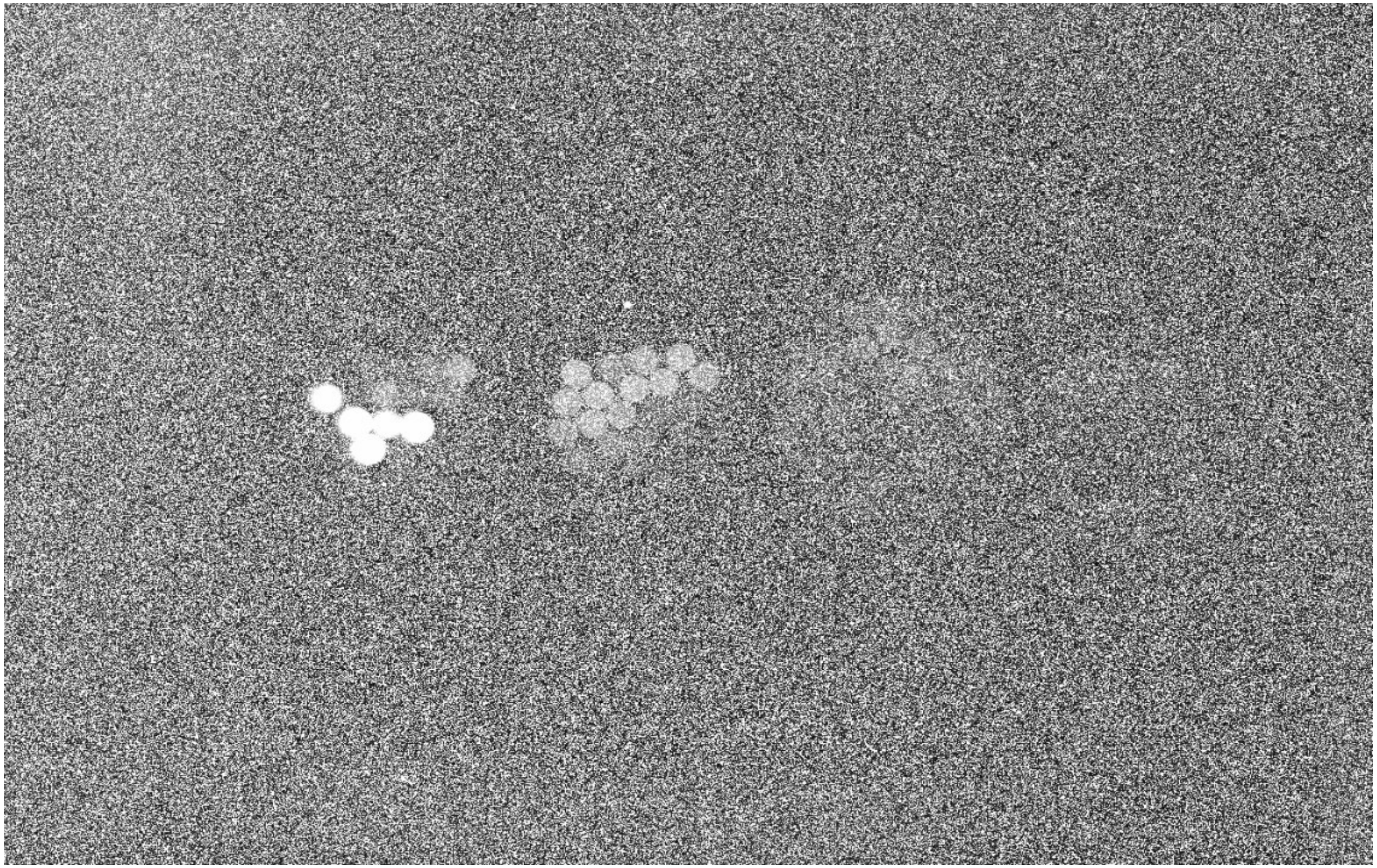

- A fiber projects onto ~200 pixels
- Optics imperfections – loss of light due to acceptance
- Not able to reach single particle sensitivity with the present setup

Conclusions

- The simplest solution for the charged particle vetoes seem straight forward
- However few things to be figured out
  - Optimal size of the bars
  - Efficiency and necessary number of layers (1, 2?)
  - Readout electronics
    - Available but at some cost or new solutions?
- Aim for first production of a prototype early next year
  - To be able to test it and learn
- Off-mainstream solutions also under test