# Studies for a prototype of a muon track fast tag (MTT) system for the CMS experiment

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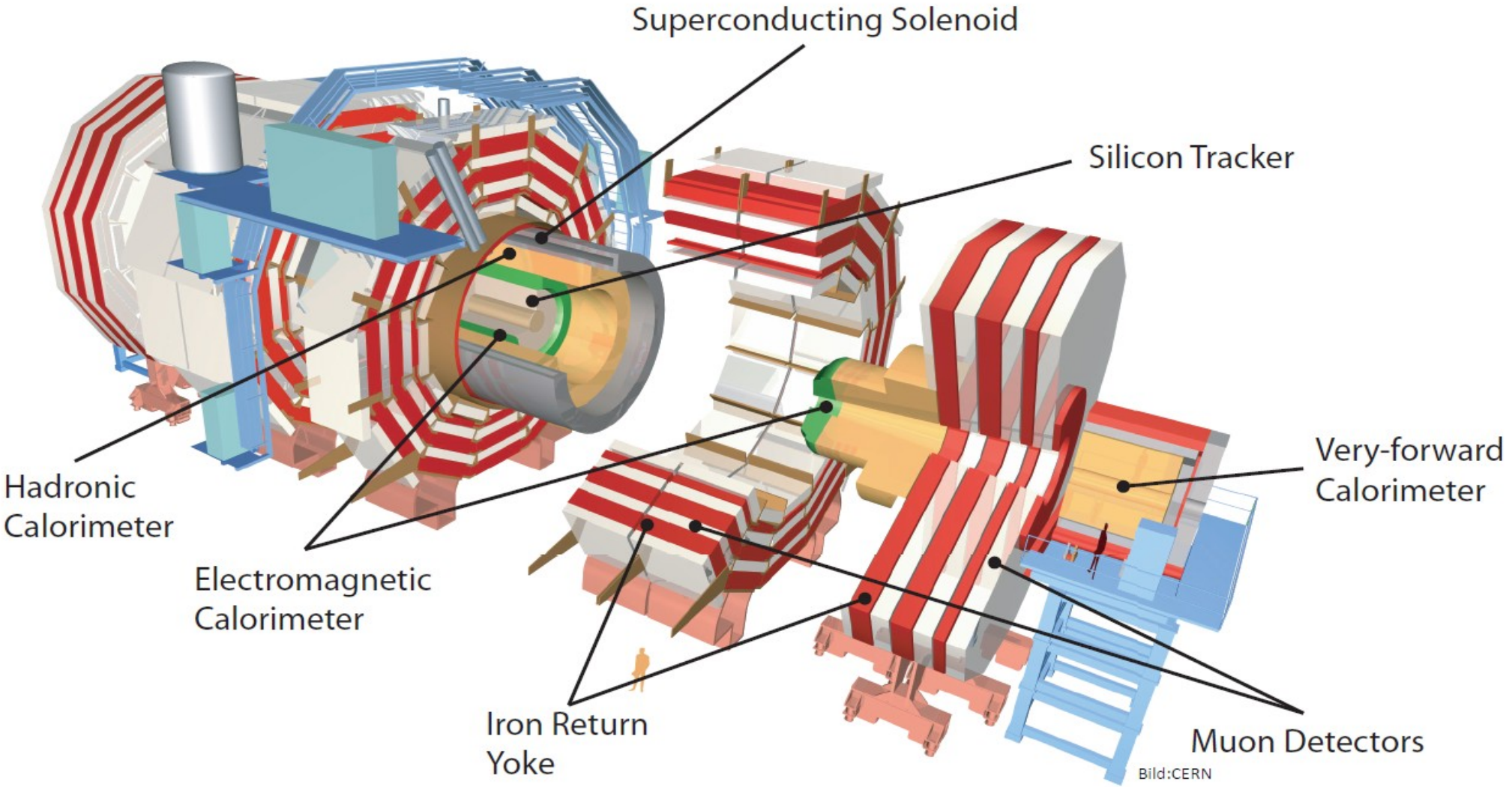
# Content

- Motivation & Concept of the MTT modules
- Presentation of the MTT prototype
- Determination of the gain
- Purity measurement
- Summary

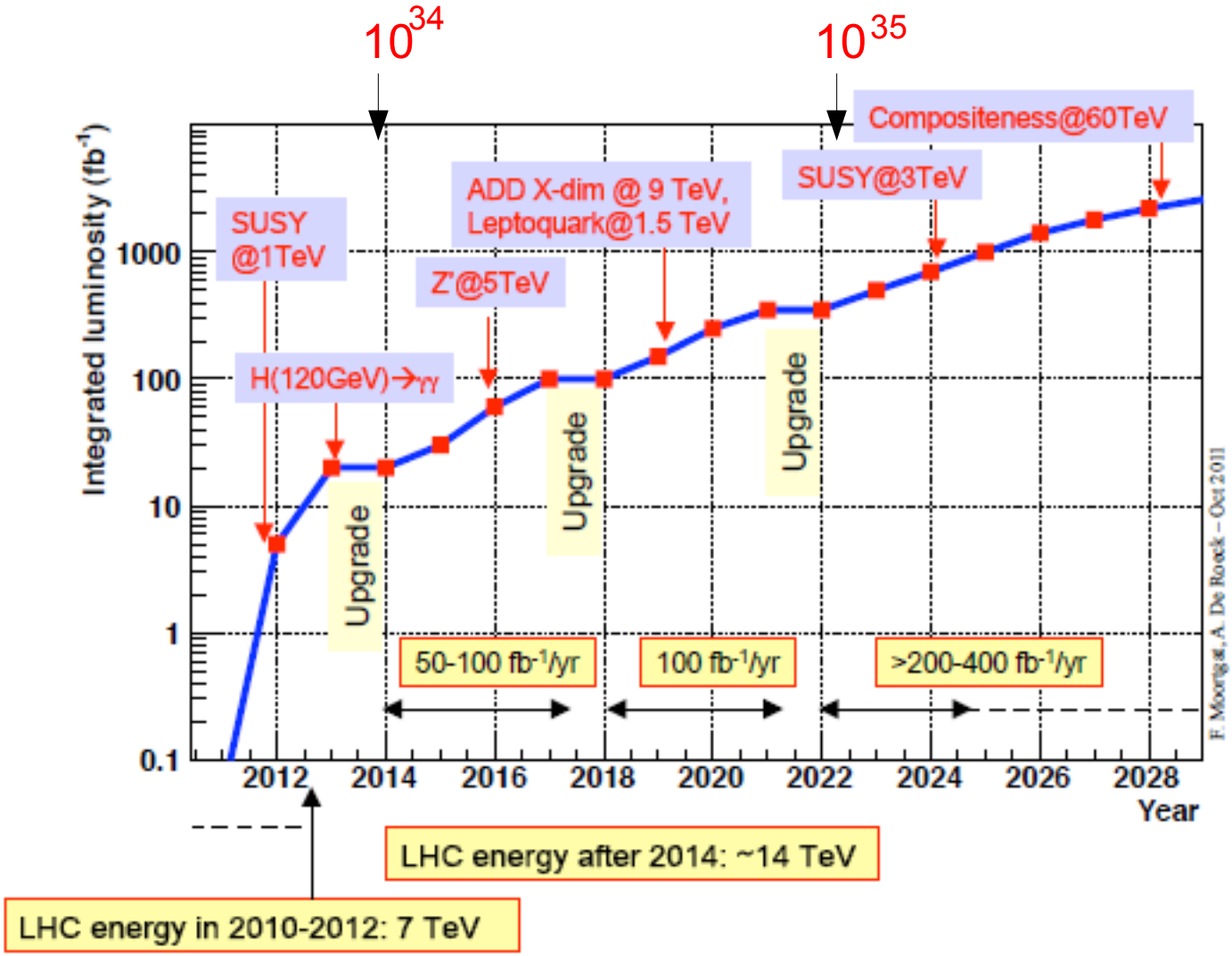
# Introduction



# Motivation

- **Current status:**

$\mathcal{L}_{int}$ = 5 fb$^{-1}$




- High Luminosity LHC → Luminosity factor 10x higher

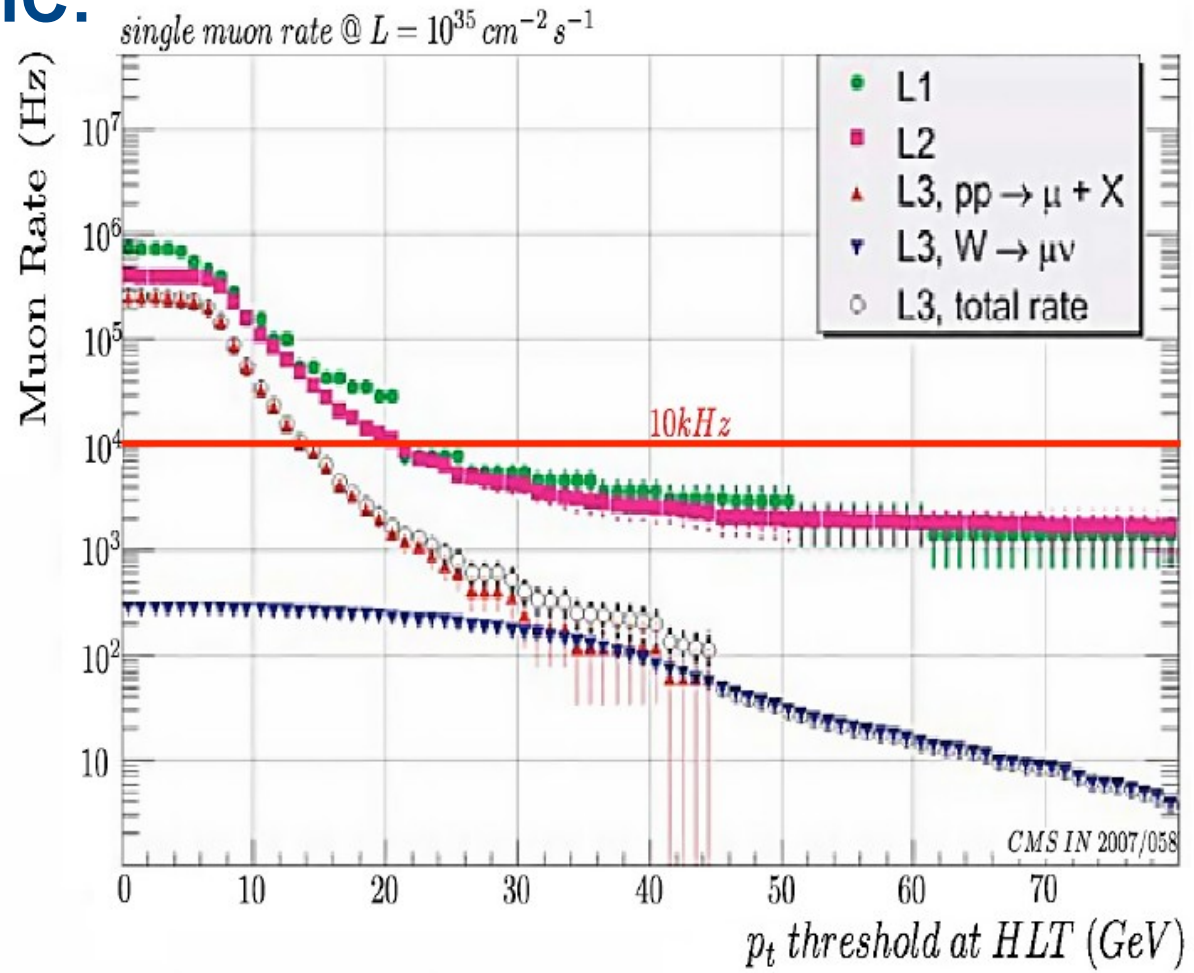
# Motivation

- **Problems arising at HL-LHC:**
  - More events,
  - Higher occupancy

  → Ambiguities in the muon chambers
- **Goal:**

  **keep muon trigger rate about constant**
- Increase $p_t$ threshold

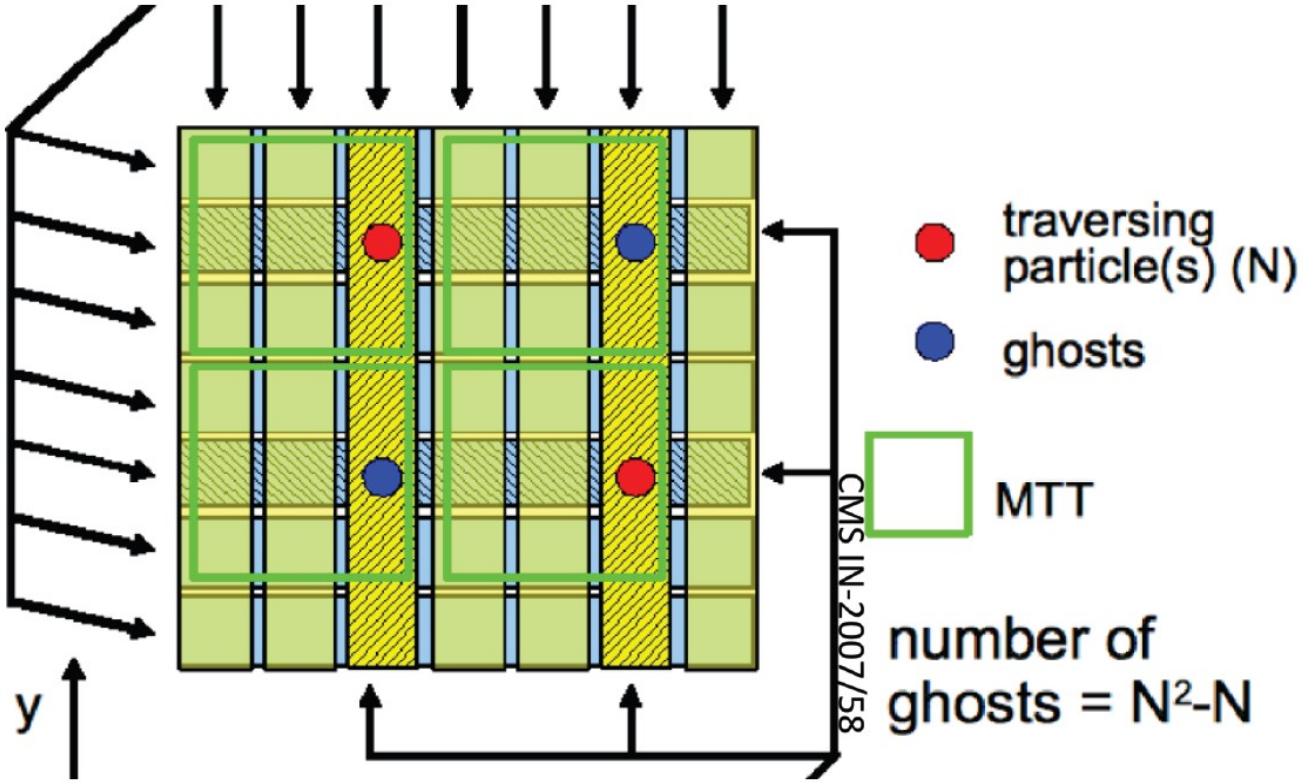
  → inefficient
- At high $p_t$ misidentification
- Include tracker information and improve $p_t$ resolution




| | |
|---|---|
| L1 | $p_T$, η, quality, # objects |
| L2 | $p_T$, # objects, MIP information, ECAL & HCAL isolation |
| L3 | $p_T$, # objects, track isolation |

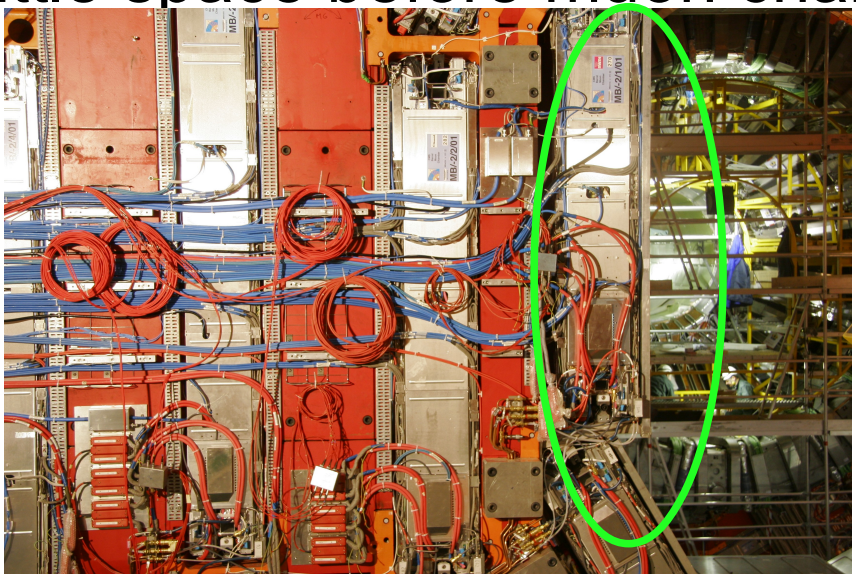
# Concept

- Enhance the trigger capabilities of the muon system
- Provide fast muon tag (to tracker / global muon trigger)
- Higher track density increases probability of ambiguities in the muon chambers → filtering
- Higher granularity as muon chambers



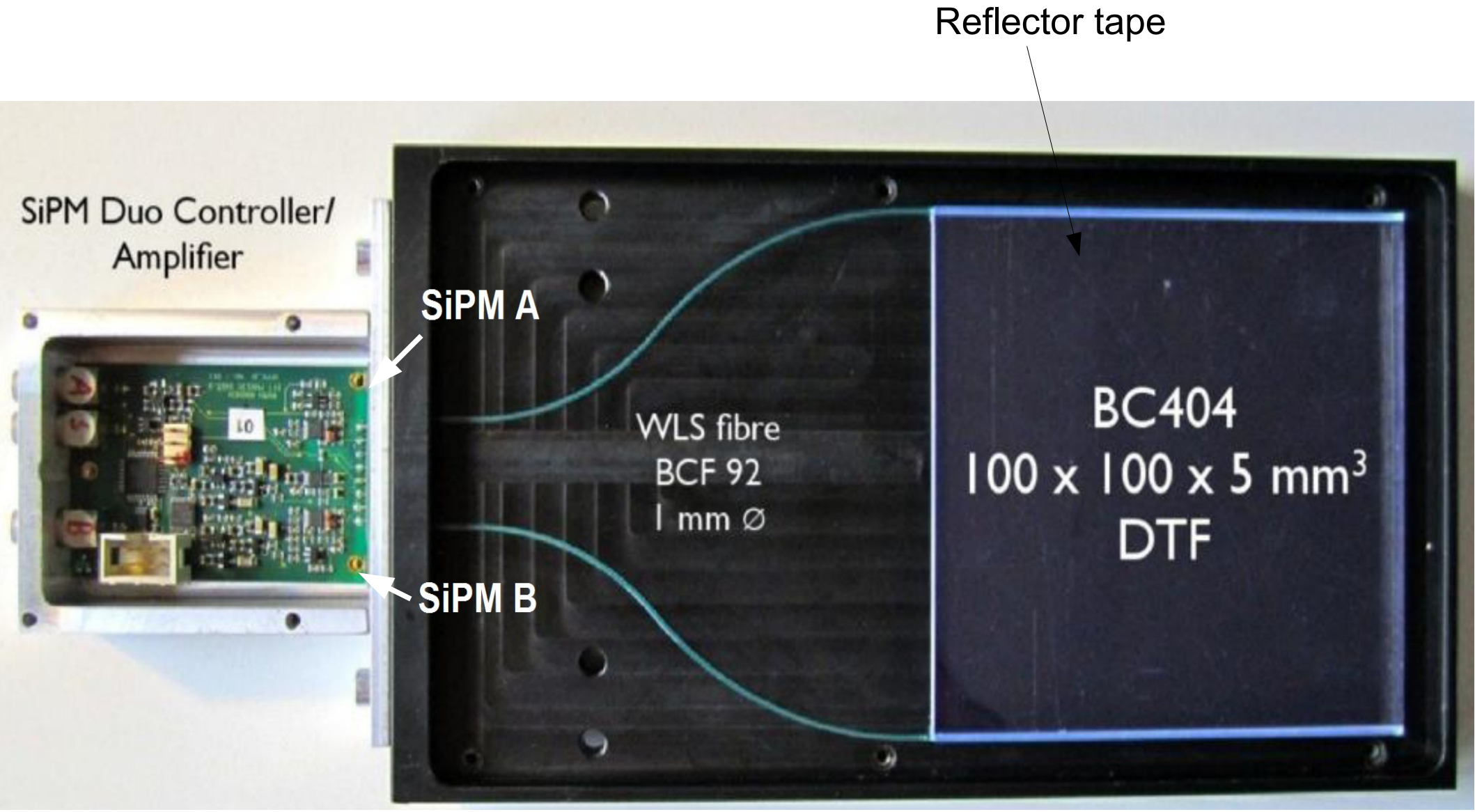
# Requirements

- Fast → 25ns bunchspacing
- Low priced → cover area of 300 m²
- Higher granularity → e.g: 10 x 10 cm² ( up to 25x25 cm²)
- Near the CMS solenoid → SiPM's
- Compact: little space before muon chambers → d < 1cm



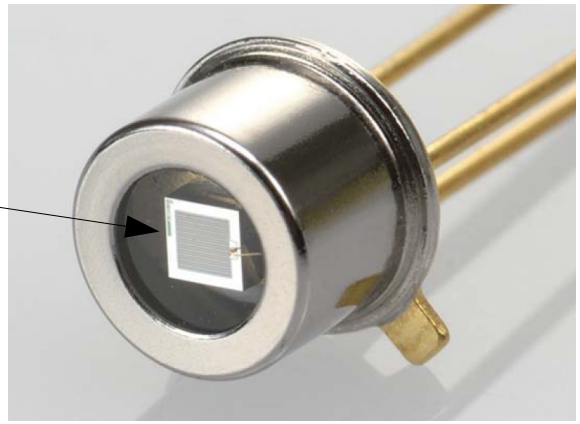
**→ scintillator tile + silicon photomultiplier**

# Trigger Detector



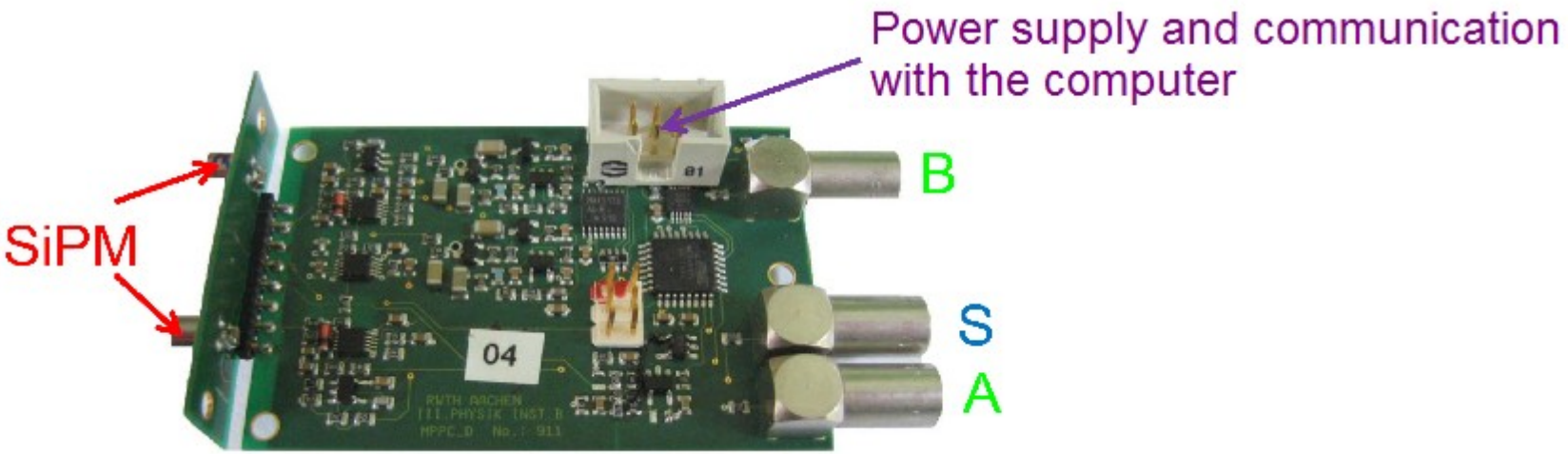
# Used Components

- Hamamatsu SiPM with 10 x 10 Pixel on 1mm²
- Gain of the charge: $10^5$ -$10^6$

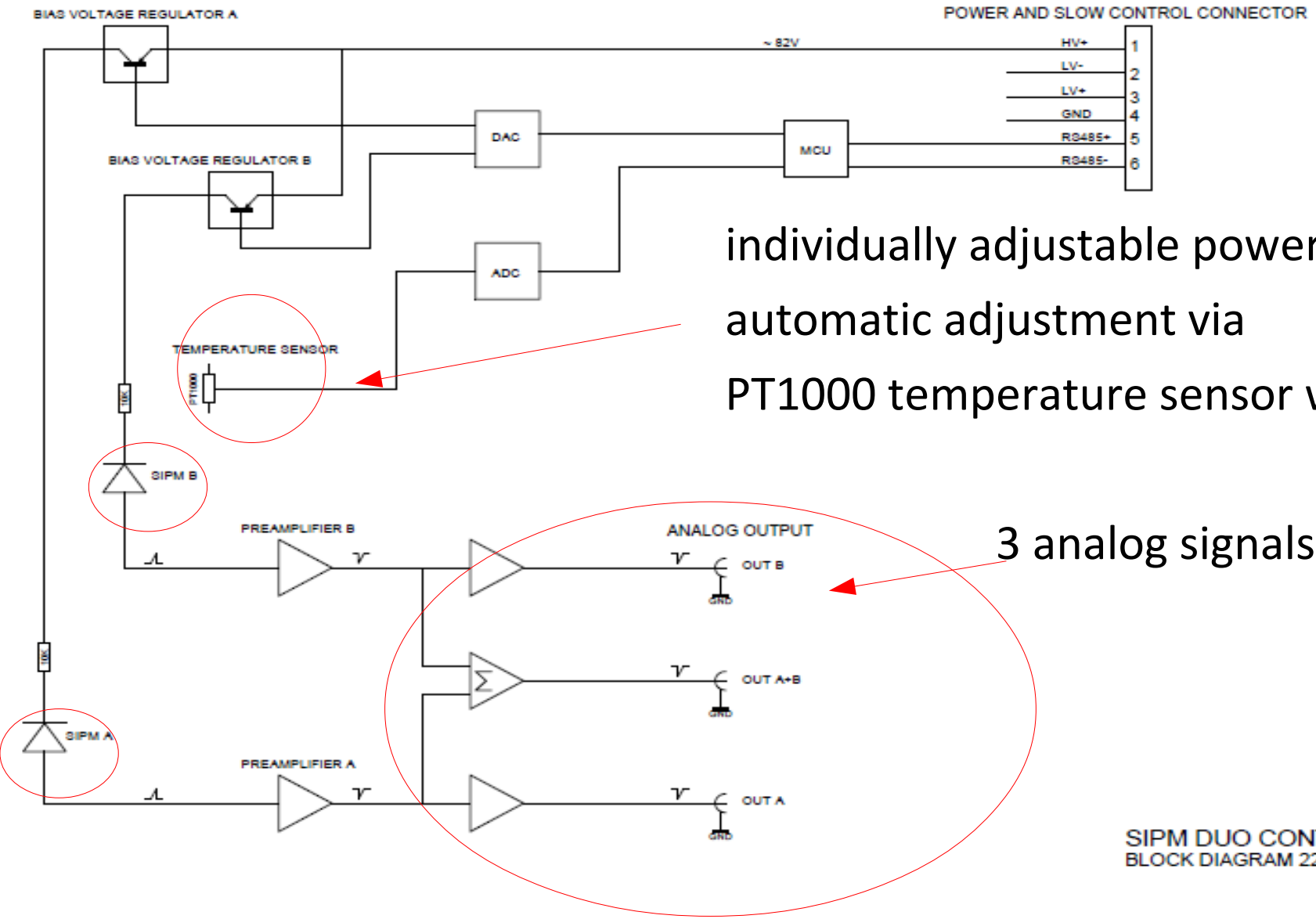


- Sum = SiPM A + B
  - Higher purity of the signal

    → better trigger conditions



# Circuit Diagram




individually adjustable power supply

automatic adjustment via

PT1000 temperature sensor with 57 mV/K

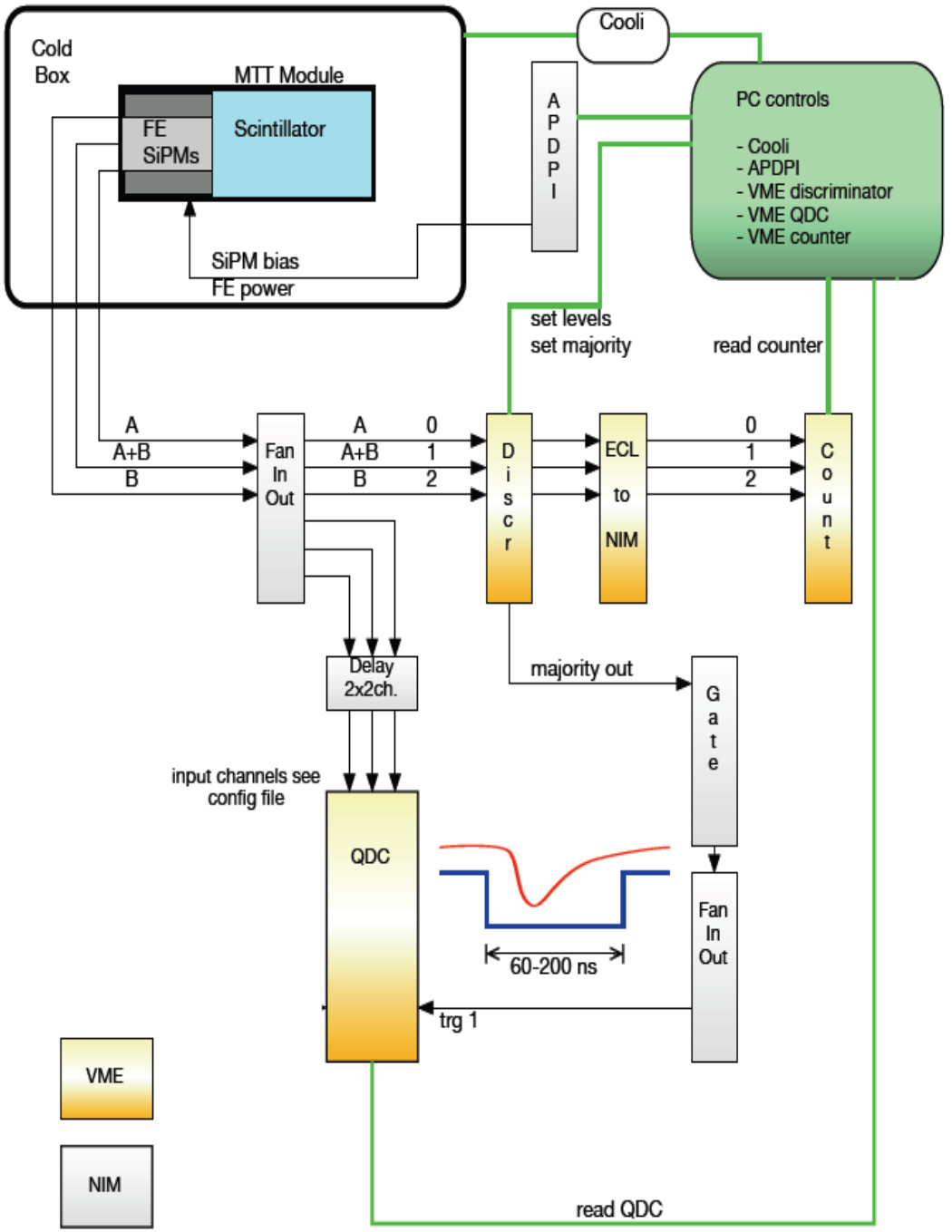
3 analog signals A, B, S

SIPM DUO CONTROLLER / AMLIFIER
BLOCK DIAGRAM 22.05.2011

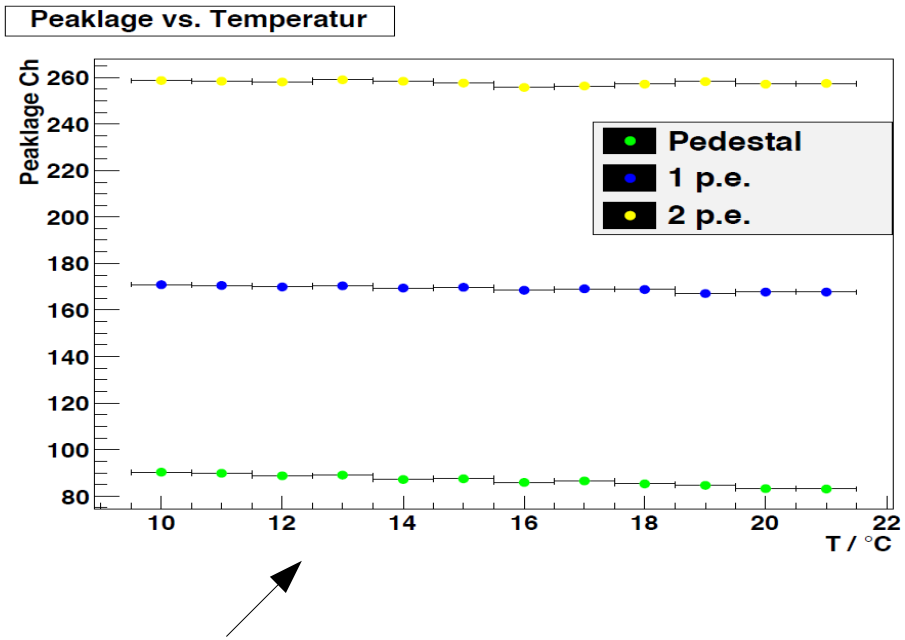
# Automatic Readout

- QDC spectra of all the 3 channels (QDC: CAEN V965)
- Pedestal spectra: random triggered (Wiener VMW-USB dashed line)
- Frequency vs. discriminator thresholds (CAEN V814)

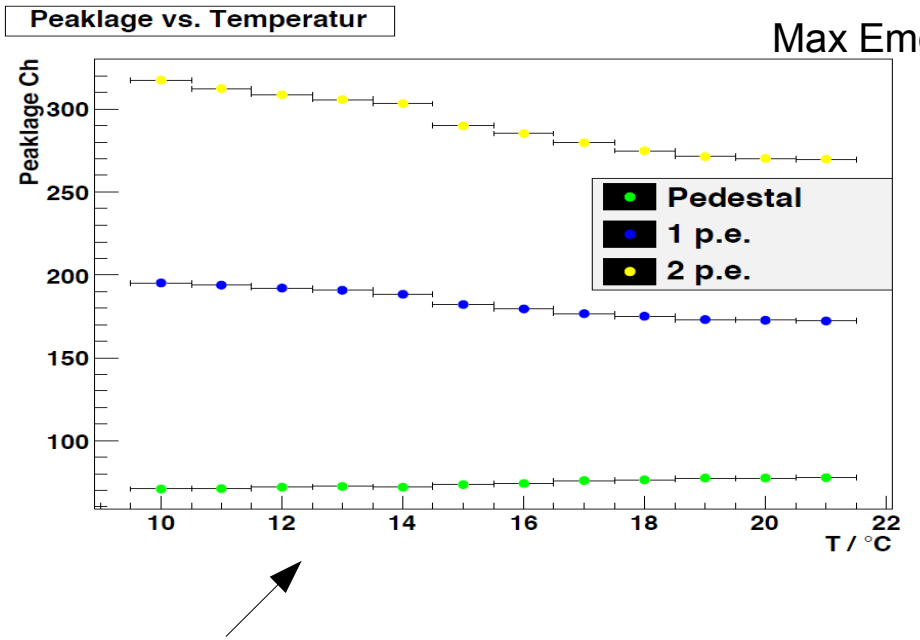
- For stable temperatures between -20°C.. 30°C



# Measurements




With temperature compensation




Without temperature compensation

Max Emde

- Automatic adjustment via PT1000 temperature sensor with 57 mV/K + cold box

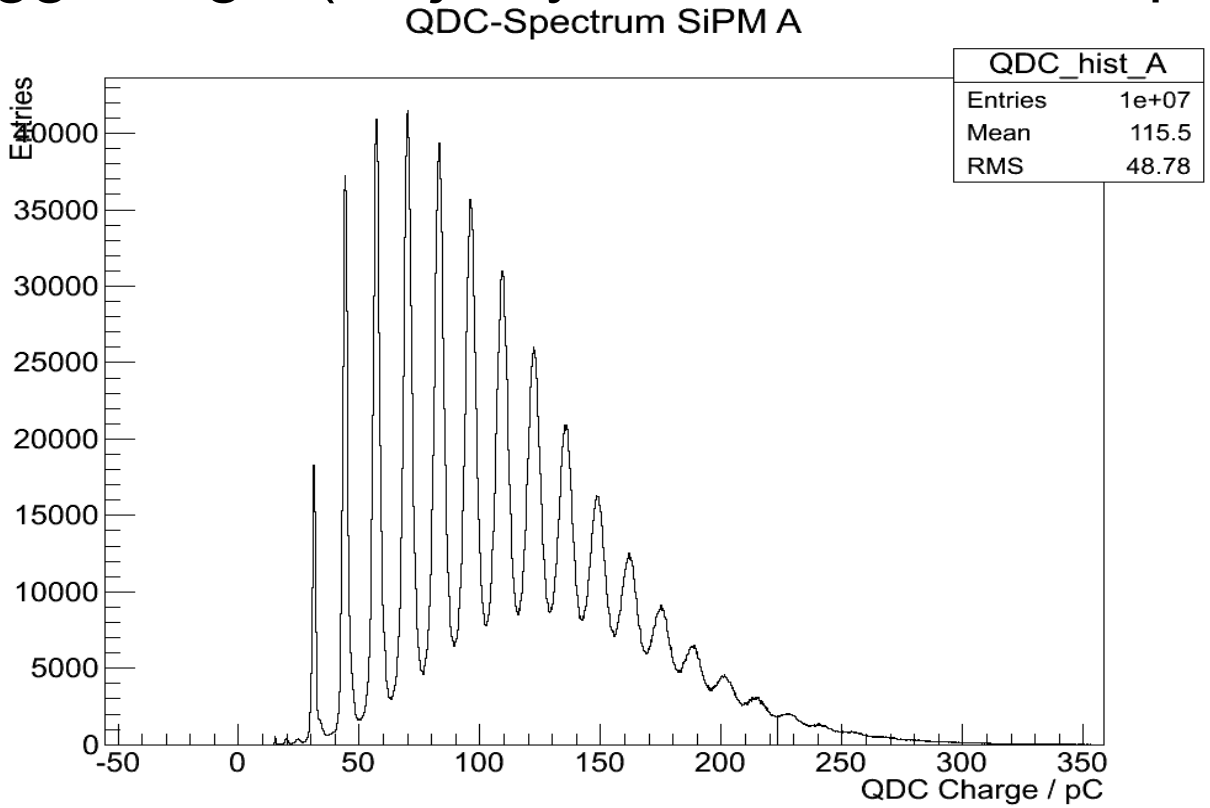
  → reduces temperature dependence

  → peak position is nearly constant

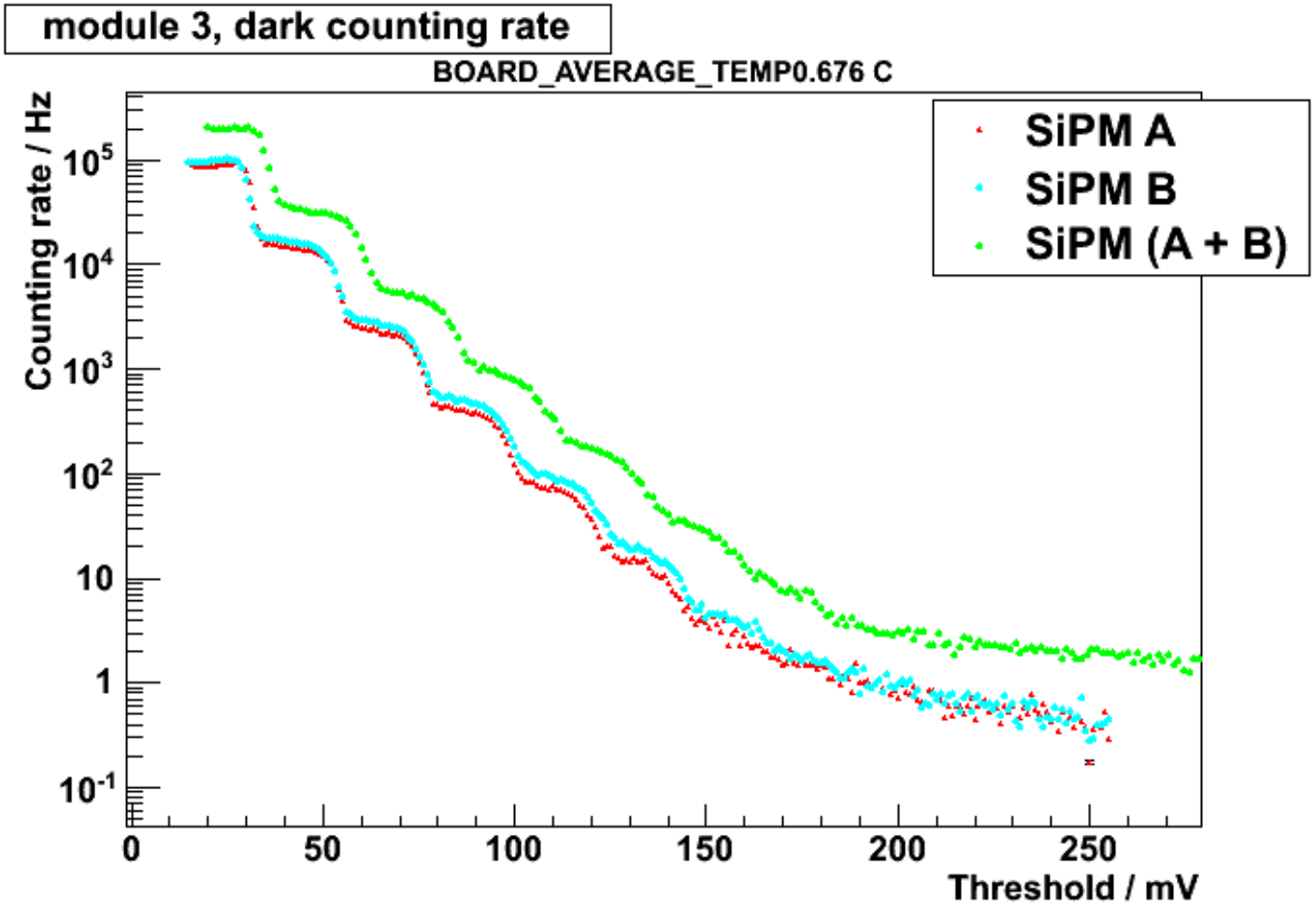
- Discriminator thresholds (S > 4.5 p.e./ A, B > 1.5 p.e.) reduce noise

# QDC-Spectrum

- QDC = charge to digital converter
- Integrated current of a pulse (gate 60ns)
- β-emitter: Sr-90, E ≅ 1 MeV, A= 4 MBq
- Finger spectrum after trigger logic (majority = 3, S, A, B > 0.5 p.e.)
- T= 5°C

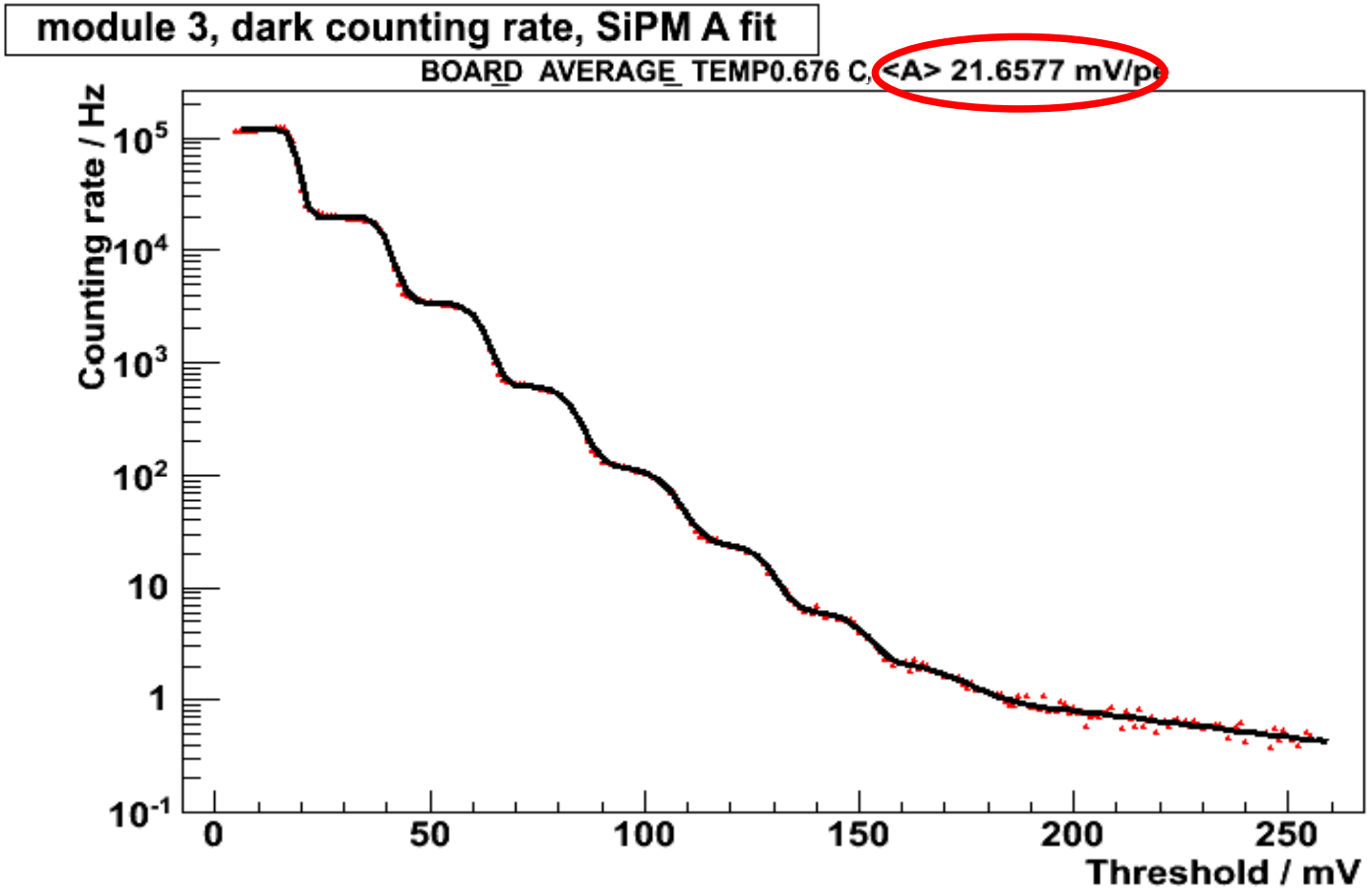


# Dark Counting Rate




- Frequency vs. discriminator threshold
- Rising discriminator threshold → falling frequency in steps

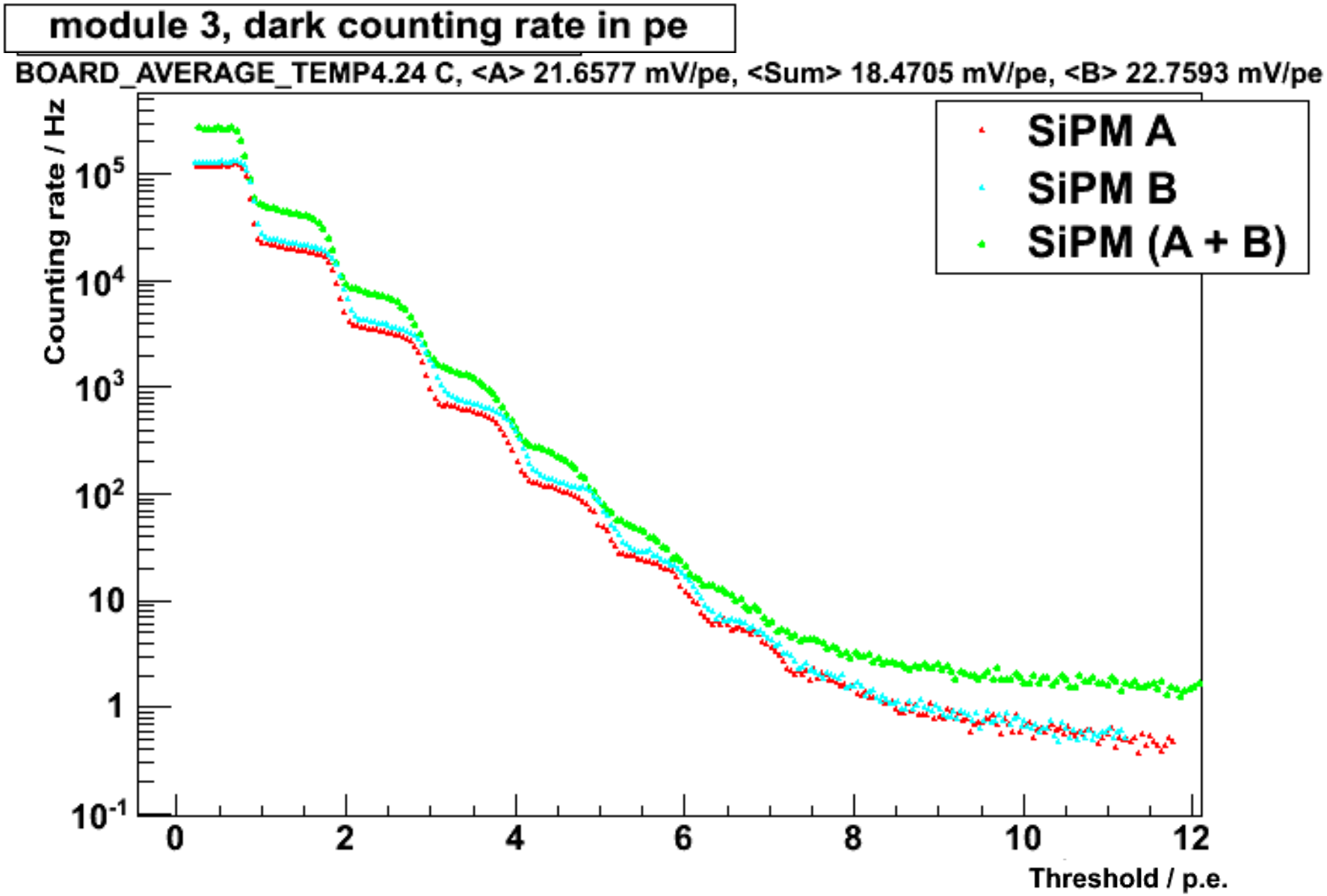
# Determination of the Gain



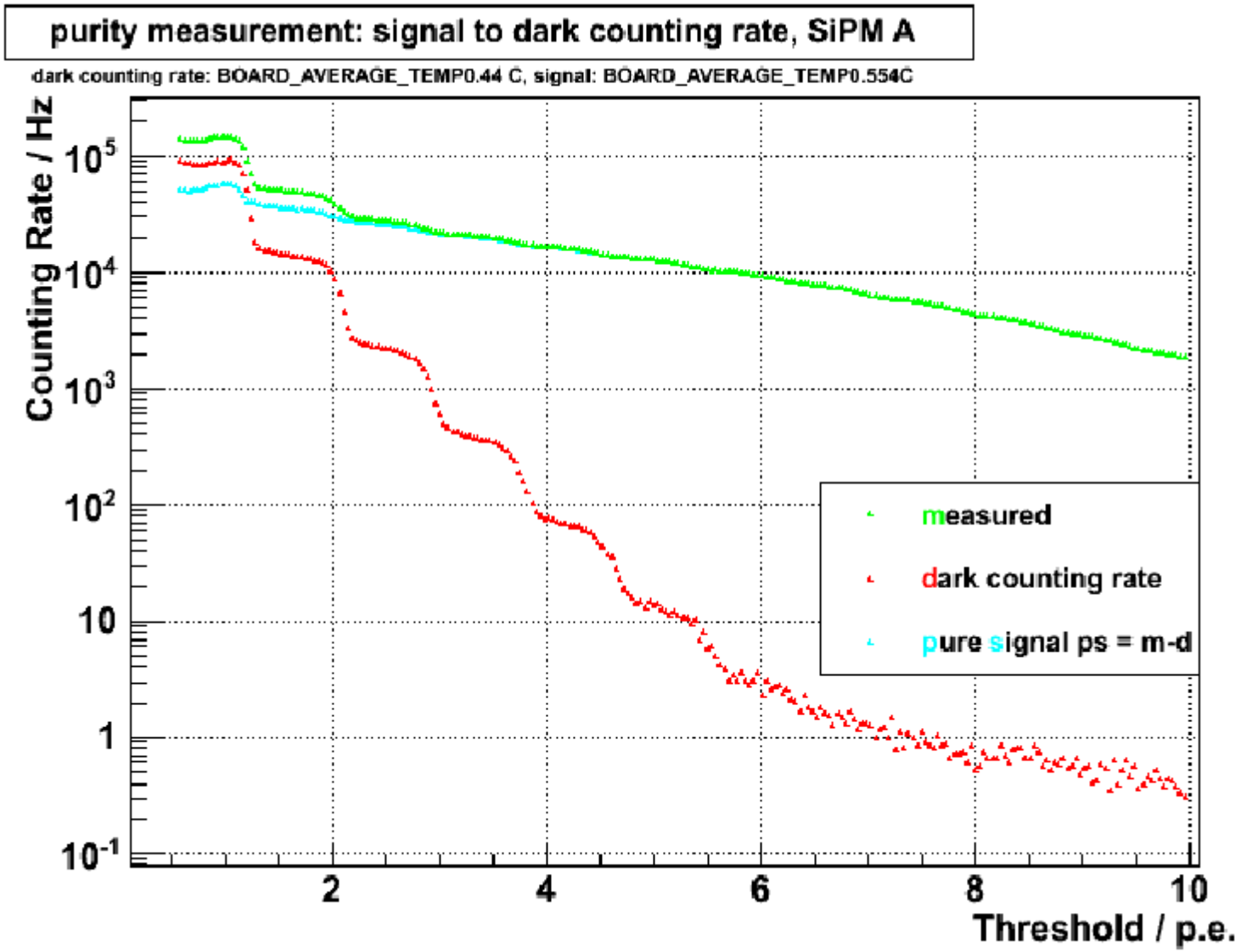

$$f(U_{th}) = f_0 + \sum_{i=0}^{nSteps} C_i \cdot erfc\left(\frac{U_{th}-\mu_i}{\sigma_i}\right)$$

$$< Gain >= \frac{1}{nSteps} \cdot \sum_{i=0}^{nSteps} \mu_{i+1} - \mu_i$$

# Gain in p.e.

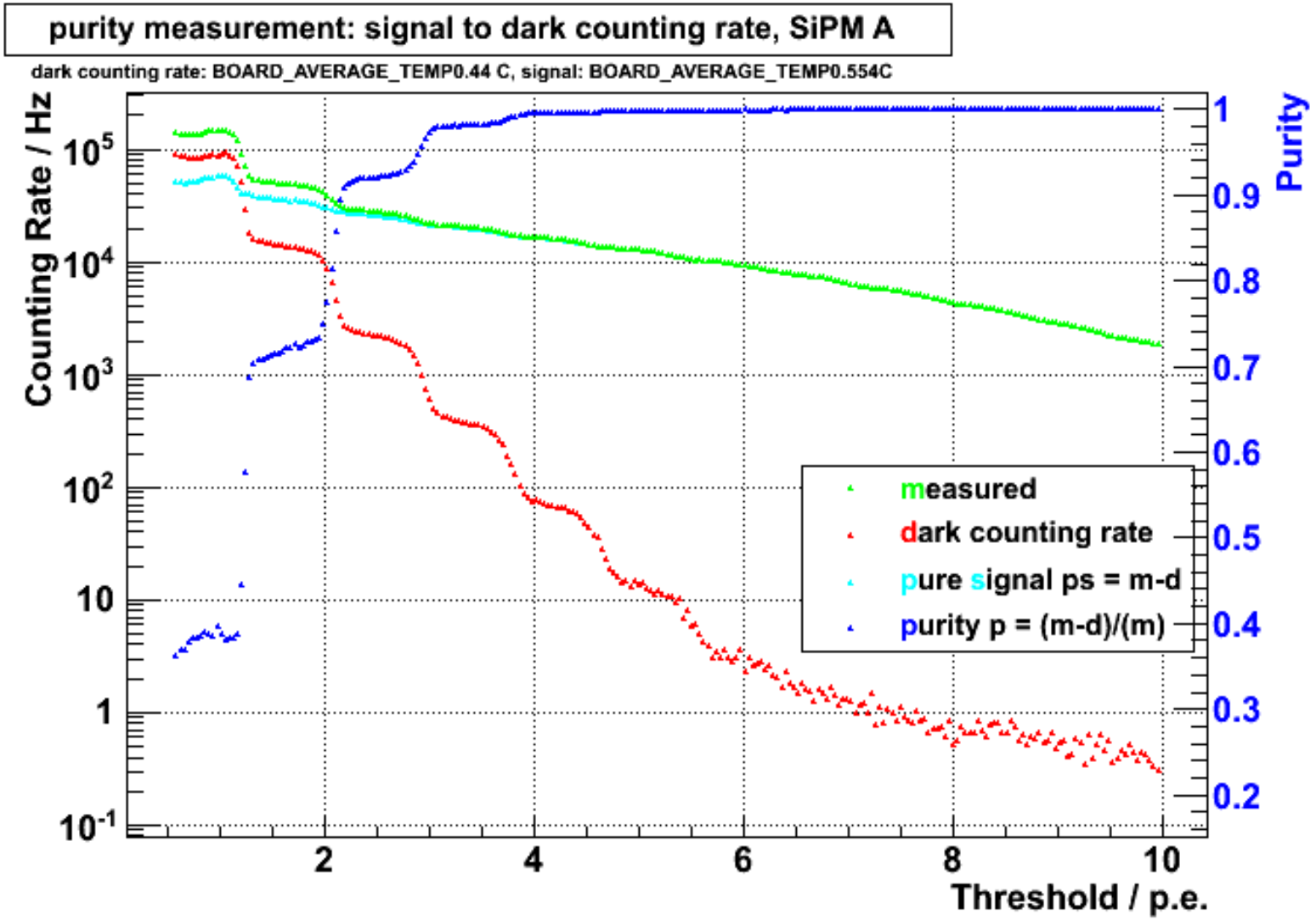

module 3, dark counting rate in pe
BOARD_AVERAGE_TEMP4.24 C, <A> 21.6577 mV/pe, <Sum> 18.4705 mV/pe, <B> 22.7593 mV/pe
Counting rate / Hz
$10^5$
$10^4$
$10^3$
$10^2$
10
1
$10^{-1}$
0
2
4
6
8
10
12
Threshold / p.e.
SiPM A
SiPM B
SiPM (A + B)

# Signal (Sr 90) vs. Dark Counting Rate



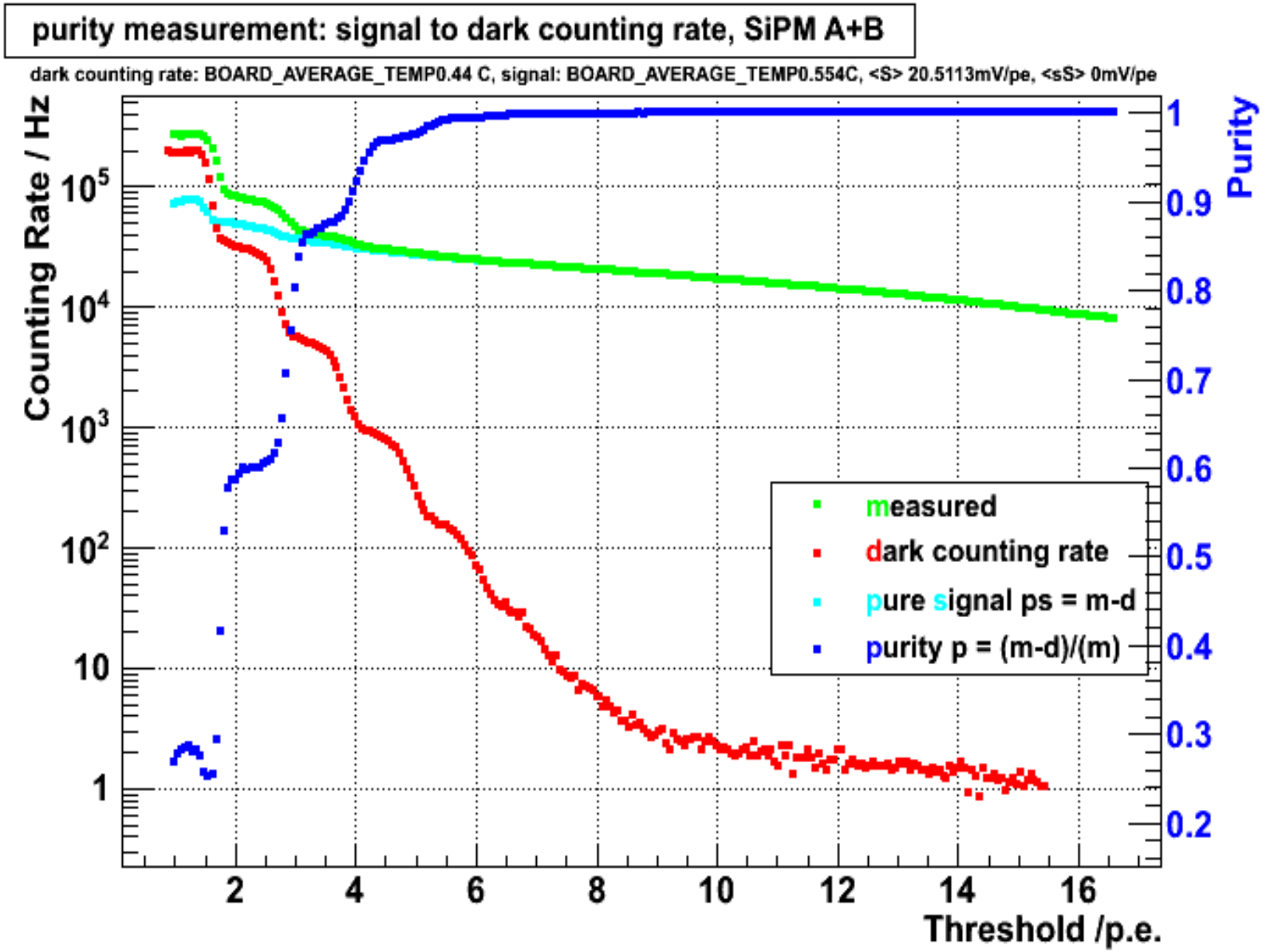

- Nearly same temperature

# Purity SiPM A

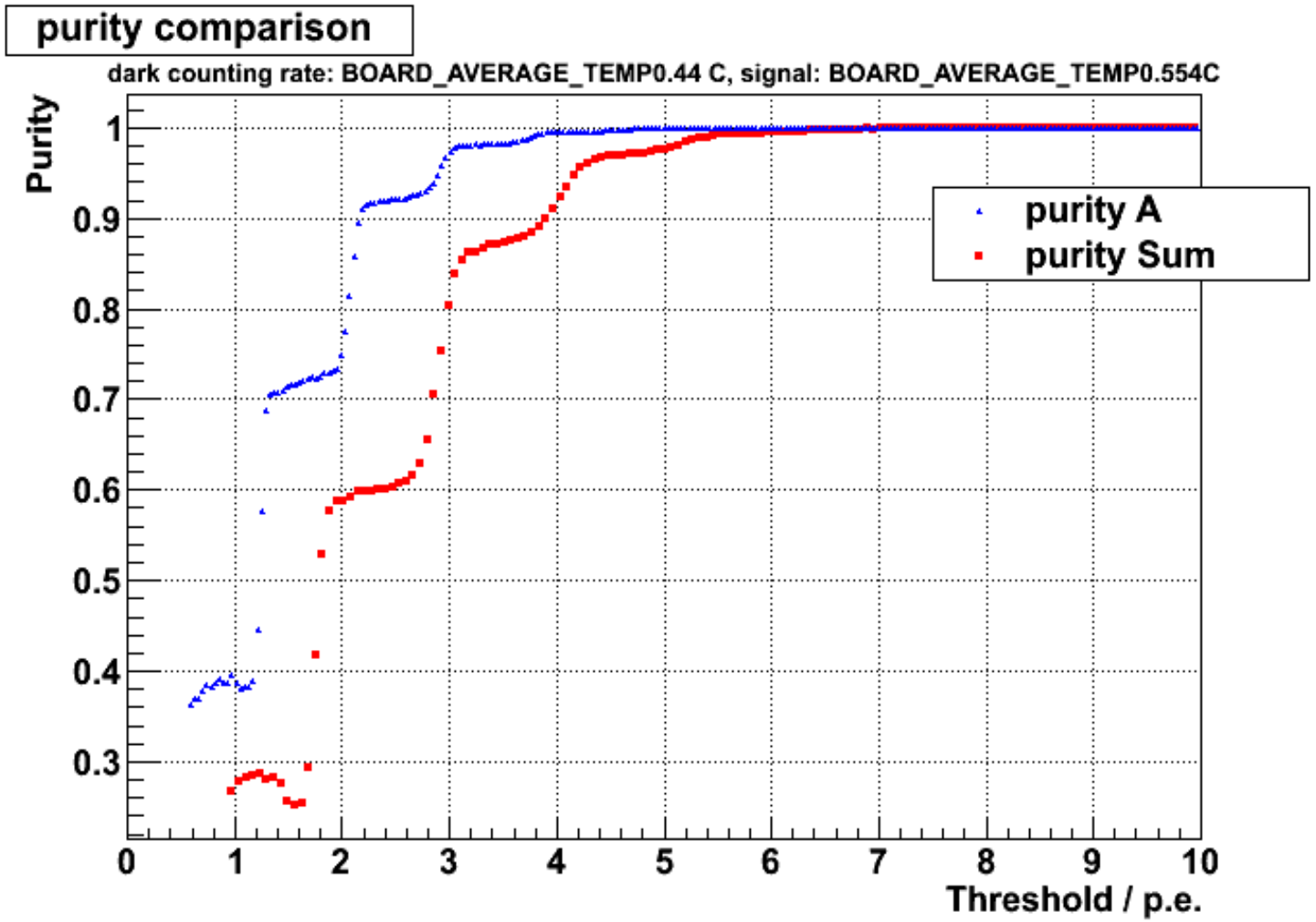



- Purity ≠ Efficiency → not knowing the exact activity
- **Amount of pure signal to dark current → trigger**

# Purity SiPM (A+B)



# Comparison




- Sum purity worse
- E.g. SiPM A signal and SiPM B just noise → purity worse
- From 6 p.e. on → purities indistinguishable

# Summary/ Next Steps

## Summary:

- Automatic measurement of the QDC, pedestal and frequency spectrum of a MTT modul
- MTT is a good proposal as a trigger for the muon system
- Measurements with a radioactive source

  and cosmic muons (not shown here)

## Next Steps:

- Efficiency measurement
- Full characterisation of the MTT modules
- Optimisation of the gain determination
- Further development of the MTT modules

# Thank you for your attention!

# Questions?

# Backup

# Motivation

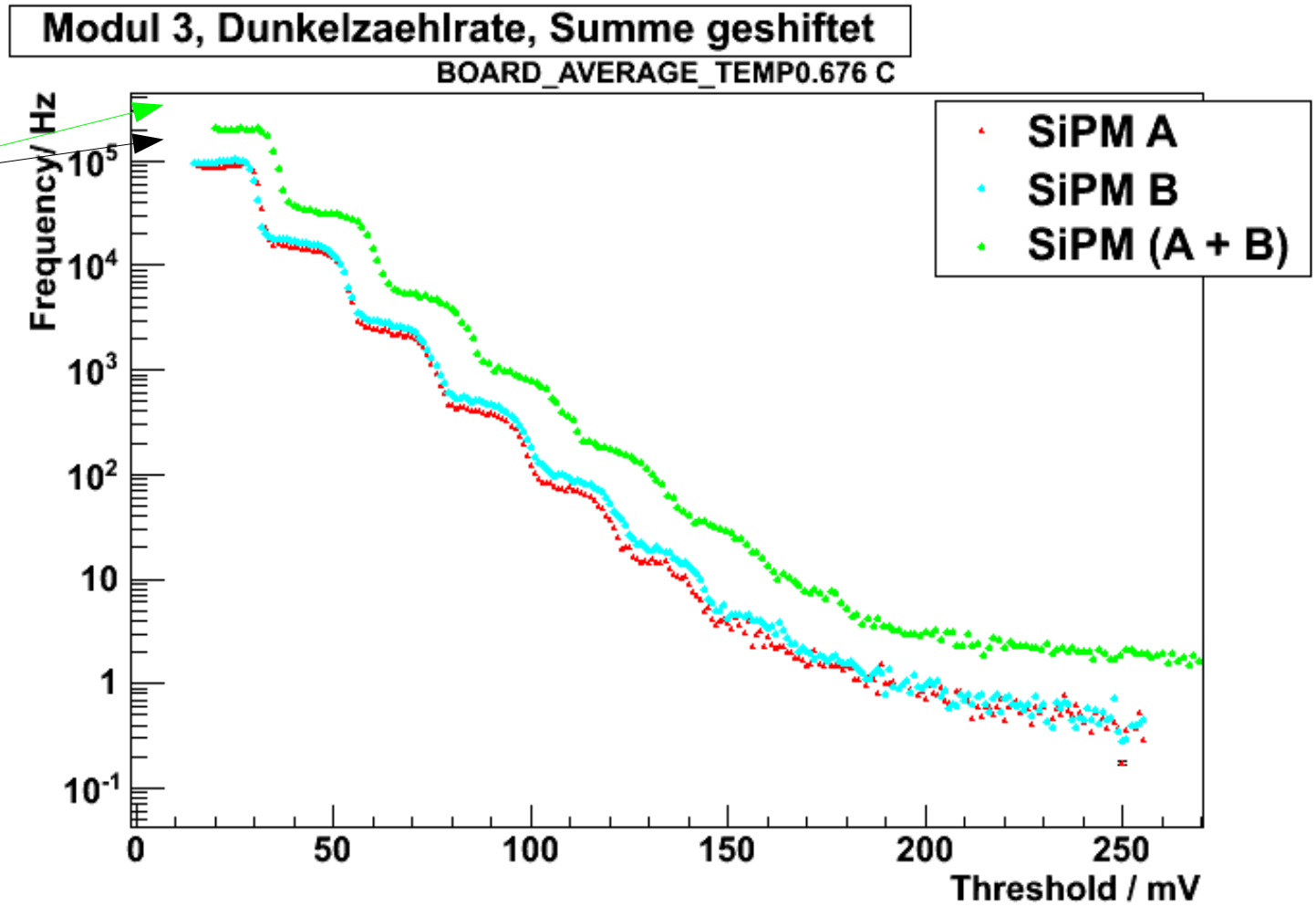
- **Current CMS L1 trigger:**
  - Latency: ~3 μs
  - Output rate: ~100 kHz
  - Single-μ trigger rate: ~10 kHz
- **Problems arising at HL-LHC:**
  - More pileup → bad calorimeter isolation
  - Higher occupancy

  → Ambiguities in RPCs and DT chambers
  - Larger event size

  → Bandwidth problems

# Correction of the 0.75-factor

ratio ca. 2




- Gain slightly different

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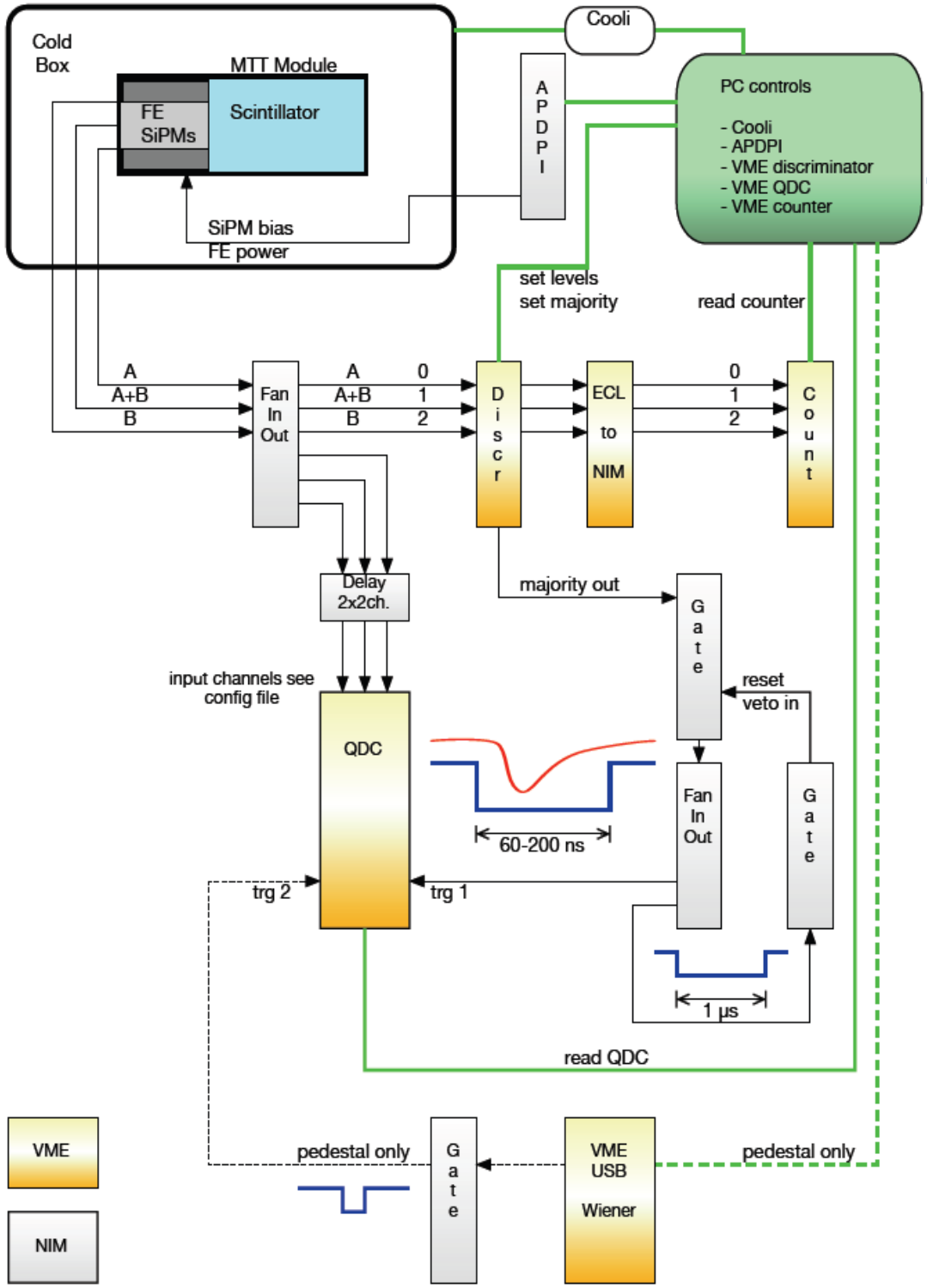

# Cold box

- Peltier elements for cooling
- Stabile temperature and humidity
- -20°C … 30°C
- Dry air intake →

no condisation at low temperatures