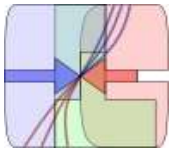


Monitoring system for the HCAL prototype

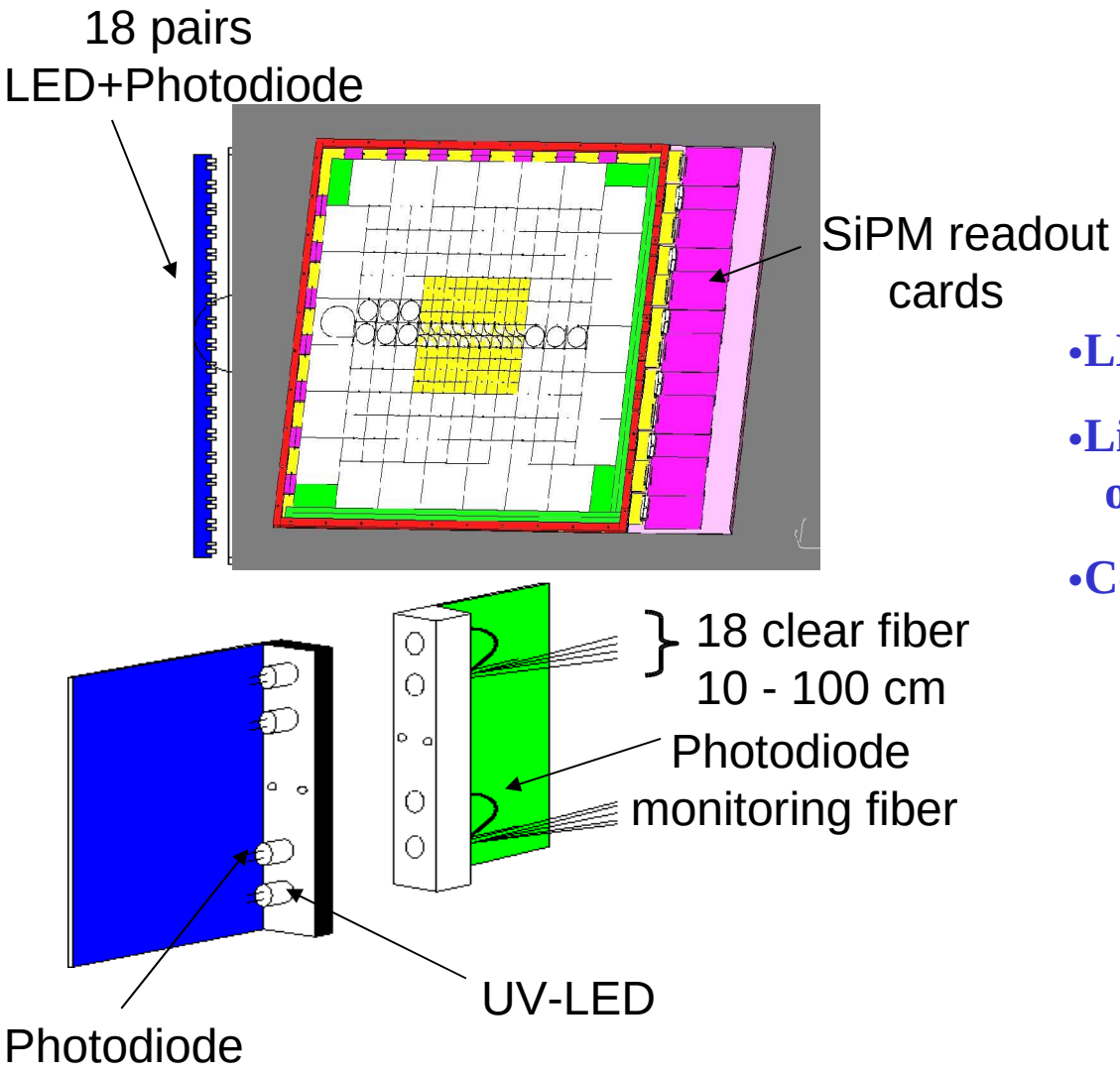
Preparation of the test beam for HCAL

- LED monitoring system

- monitor stability of tile-fiber system + SiPM
- cover the dynamic range of data taking
- maybe monitor the saturation of SiPM

- Temperature monitoring system

LED monitor design



Present status of design

- **LED + PD board easy to exchange**
- **Light-tight connection of the board on cassette frame**
- **Connections:**
  - **–1 LED voltage supply ~ 30-60V**
  - **–1 Photodiode voltage supply**
  - **–1 PD-preamp V supply**
  - **–1 Trigger input (NIM, neg.)**
  - **–18 signal outputs from the PDs, pos., ~ 500 ns shape**
- **1-2 Temp. sensors on board**

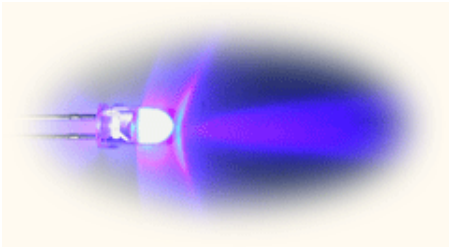
LED choice: Blue vs UV

UV LED: to monitor scintillator + WLS fiber + SiPM

- several types tested
- best one 30% above the others
- small LY spread over many fibers ±15%
- all of them very slow: ~20ns to max LY

Blue LED: monitor only WLS fiber + SiPM

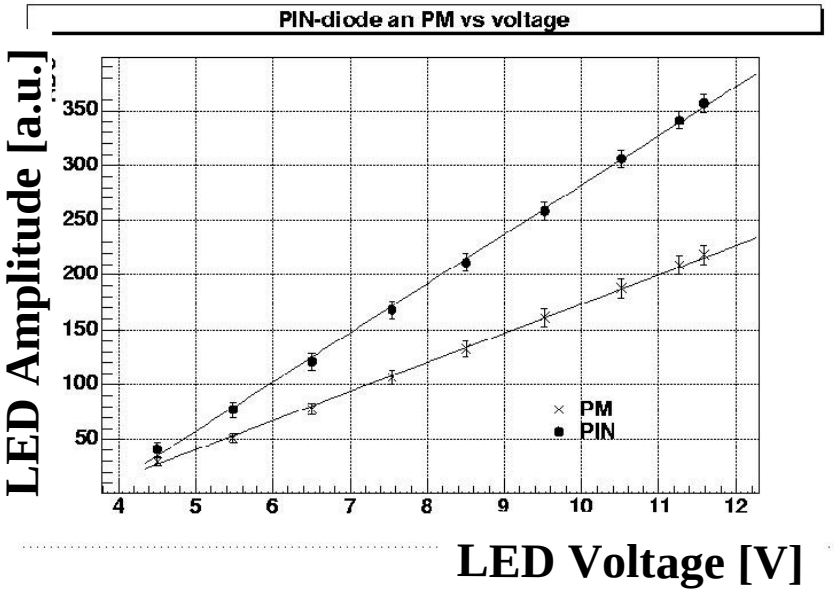
- slightly less LY than UV (~20 %) when shining on tile



LED from: www.roithner-laser.com and www.led-shop24.de
Best choice UV LED: LED405-02V (405 nm, 10mV @ 20mA, 12^{o})

LED stability

LED operated at high intensity ↙ light is linear with voltage



1 day @ 100kHz ↙ 16% LY decrease recovered after few hours off

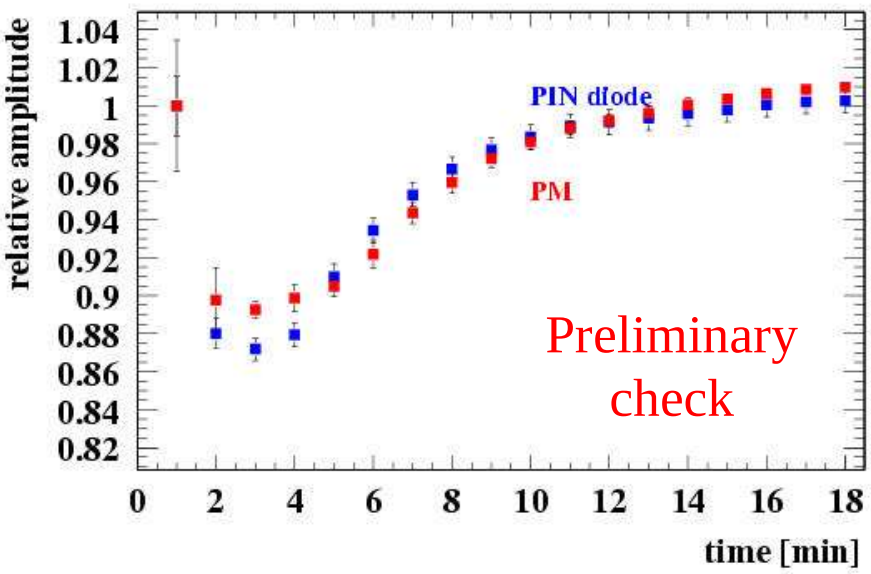
1 w.e. @ 100Hz ↙ LY stable at better then 2%

↗ LED "jumps" are critical

LED voltage

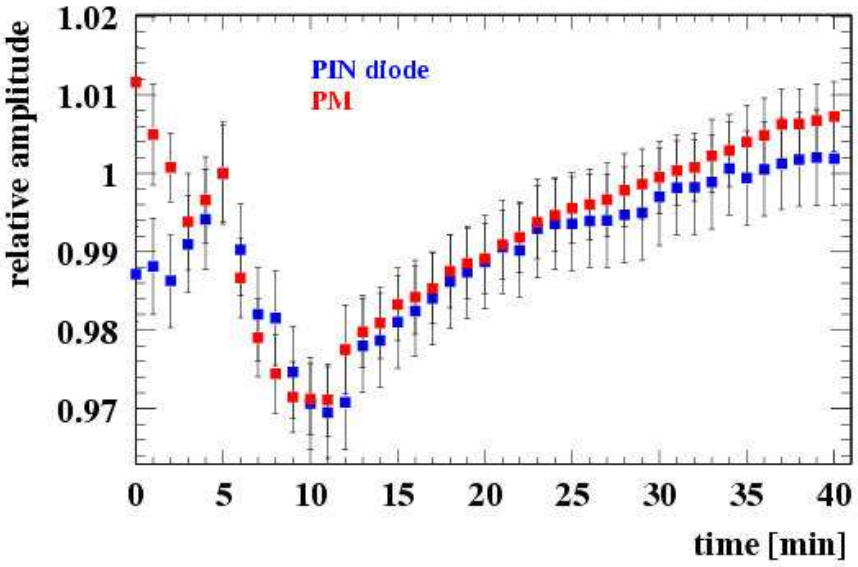
Temperature stability

Warm up LED directly



27°C↙? °C

Warm up LED in water



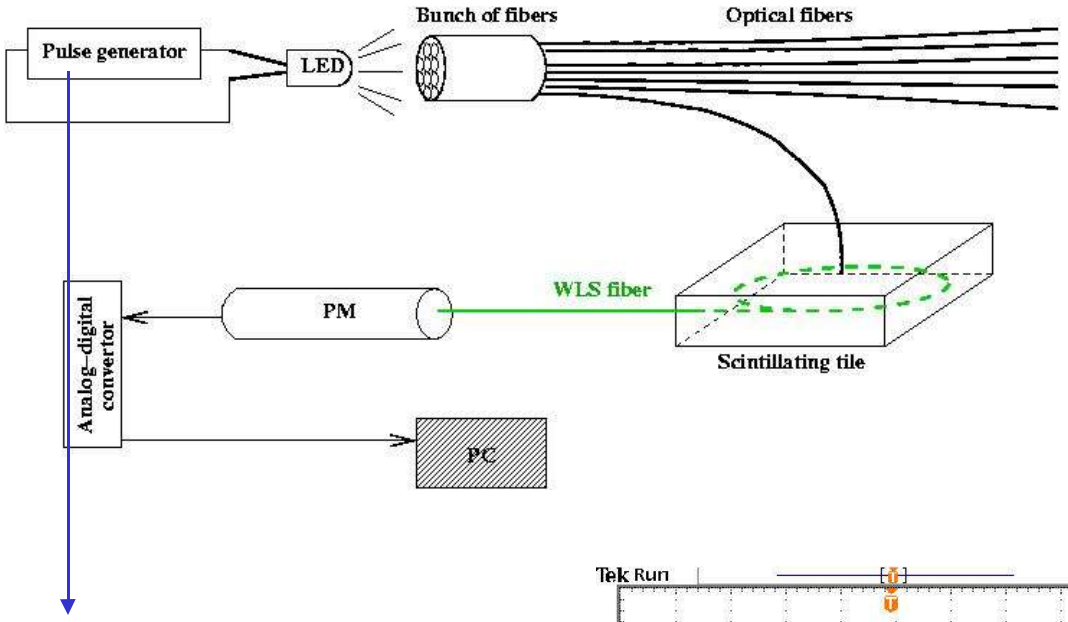
26°C↙41°C

Consistent response of PM and PIN diode

Direct warm up is too fast and T cannot be controlled

↙ LED variation < 0.5% / °C

Test setup

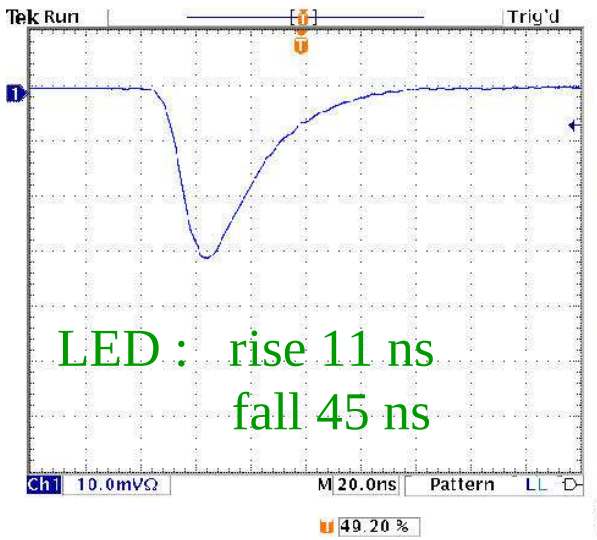


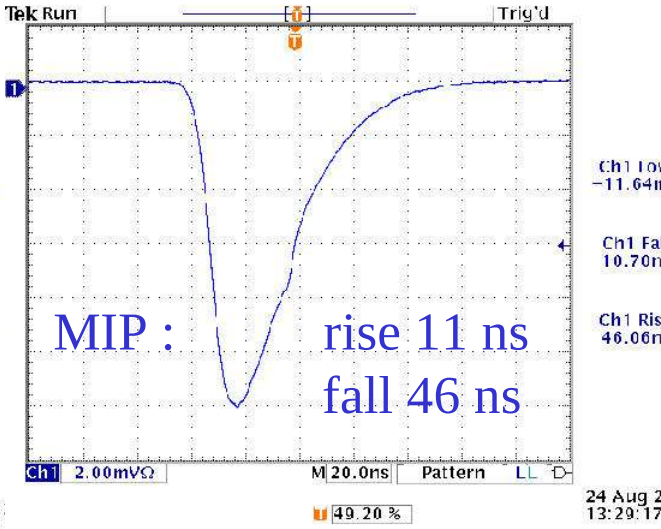
30 fibers, 0.5 mm
UV LED
LY spread on bundle
output ±15%

HCAL OSCI 24 Aug 2004 13:29:18

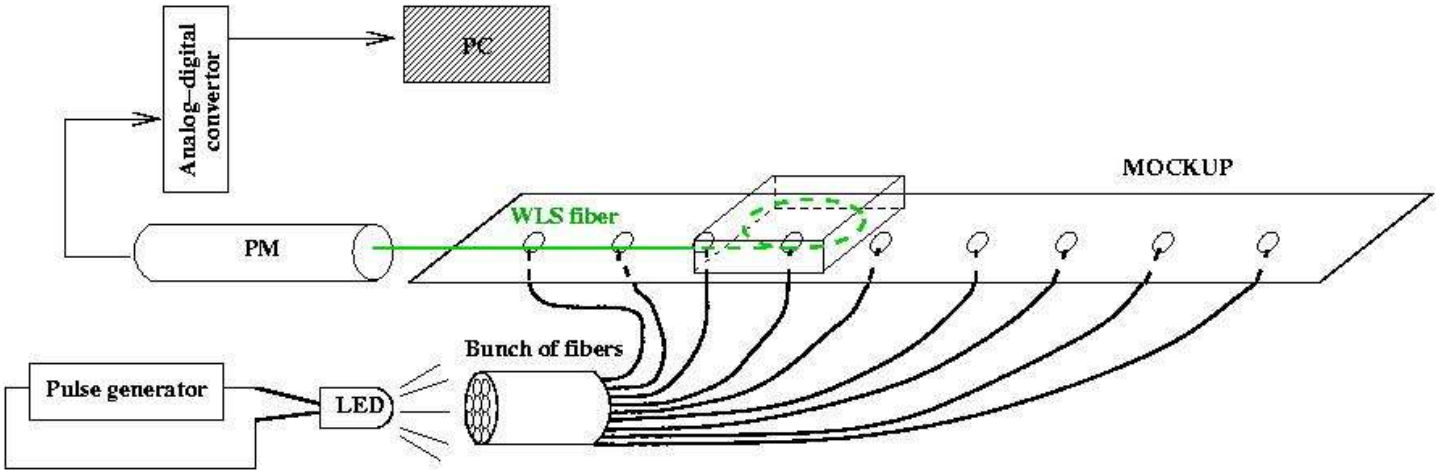
0-11 V, 20ns pulse
100 Hz

LED signal rise time
~ MIP rise time





Test on mockup



- G10 board + 3M reflector with 15 holes (0.5 cm) with
- 0.5 mm plastic fiber (SPACAL) glued to the hole
- fiber length from 20 to 100 cm
  - ↙ Max LY ~ 20-55 MIP
- large spread due to gluing technique
  - ↙ has to be improved, new mockup in preparation!

Test of various fibers

Ø 0.75 mm
soon available

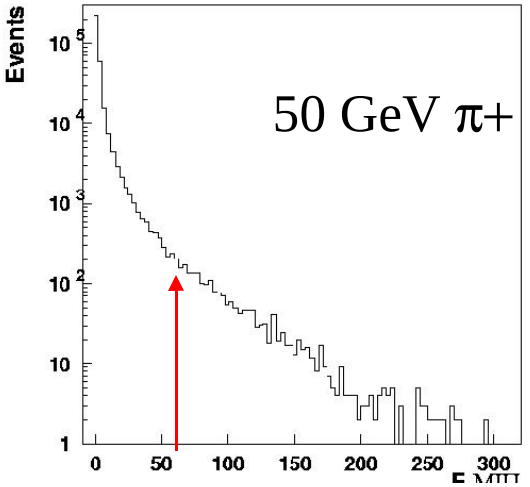
Name	Type	Diameter [mm]	UV LY[MIP] @ 1 m	Blue LY[MIP] @ 1 m
Luminus	Clear	0.5	51	24
Bicron	Double clad Clear	1	50	115
Kuraray	Unclad Clear	1	1.6	3.6
T 30	Quartz with scatter centers	1 (0.5 core)	21	11

special fibers for high side loss

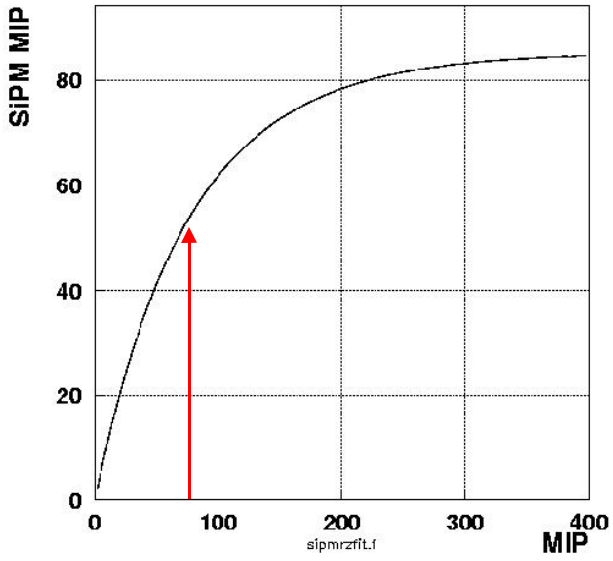
- Luminous strong attenuation for blue light
  ↙ our choice for UV monitoring
- A factor 3 LY can be gained using blue LED + Bicron

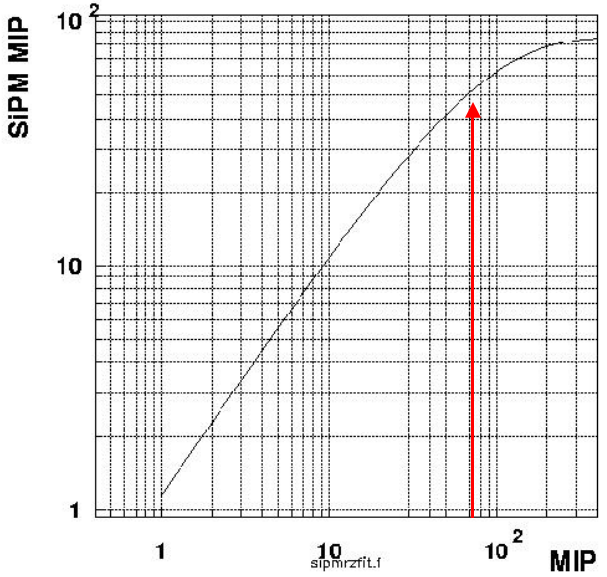
General considerations

- Maximum energy deposited in 1 tile:
  - 6 GeV electron ↙ 95% of events < 60 MIP
  - 50 GeV pion ↙ 99% of events < 60 MIP

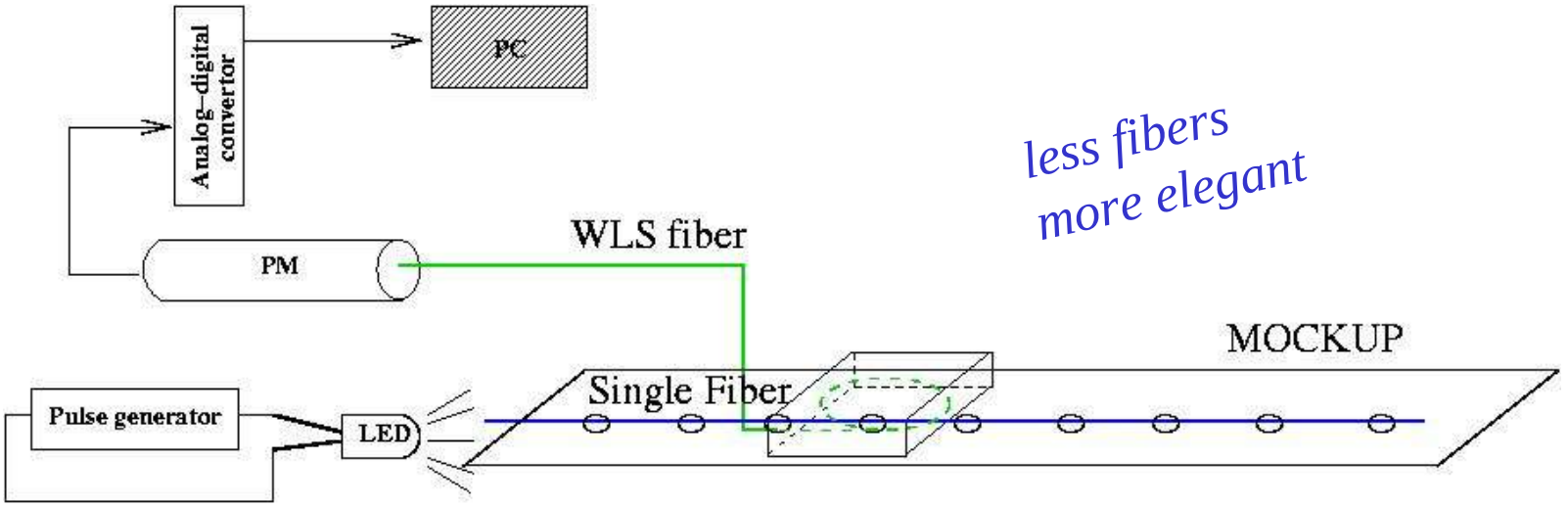


SiPM MIP = 25 pe, MIP = 200 γ



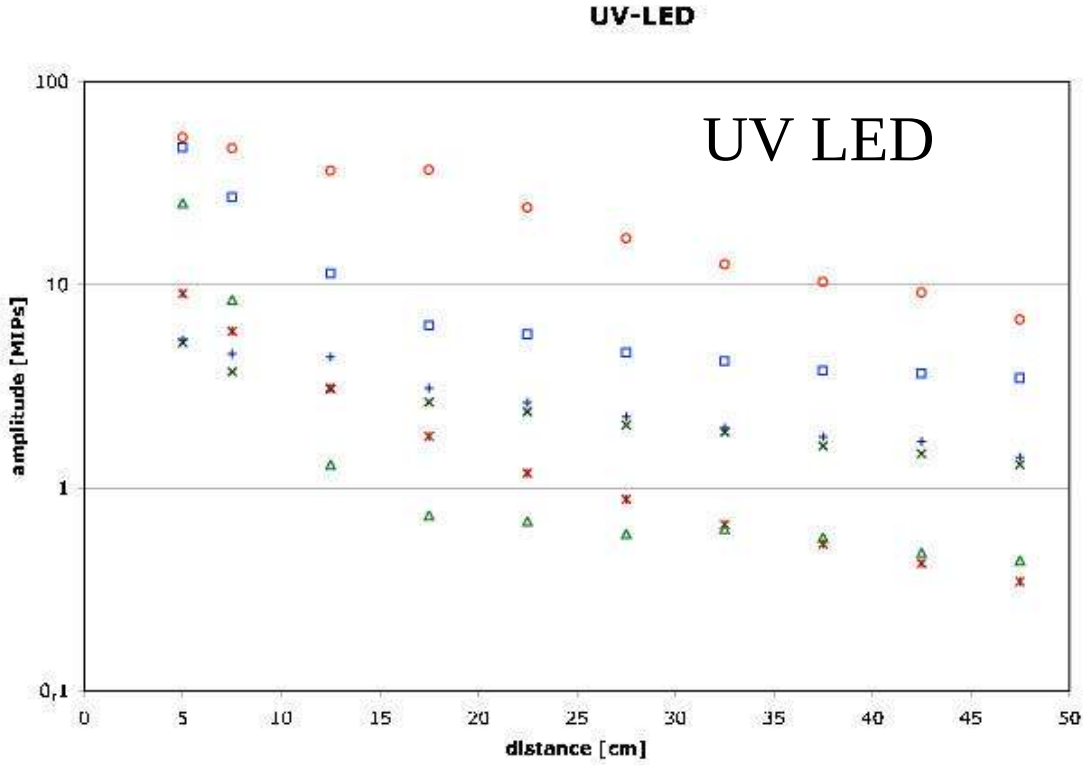


Configuration under study



- Single fiber for many tiles
- Max LY 50-1 MIP
- Attenuation along the fiber is important
  various fibers studied ↙

Light attenuation along a fiber



MIPs at the fiber end

T30 (21,2)
T12 (12,25)
T2 (0,46)
Luminous (51,05)
Bicron (50,4)
Kuraray (1,6)

Fibers:

0.5 mm quartz

0.5 mm plastic

1 mm plastic

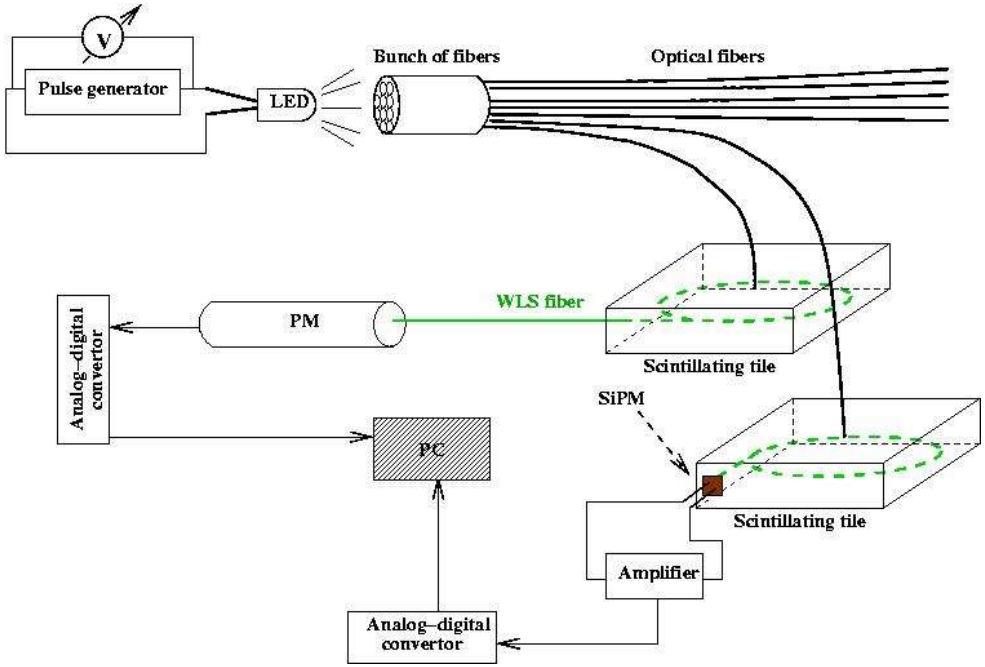
-Quartz fibers have smaller attenuation but less light is coupled

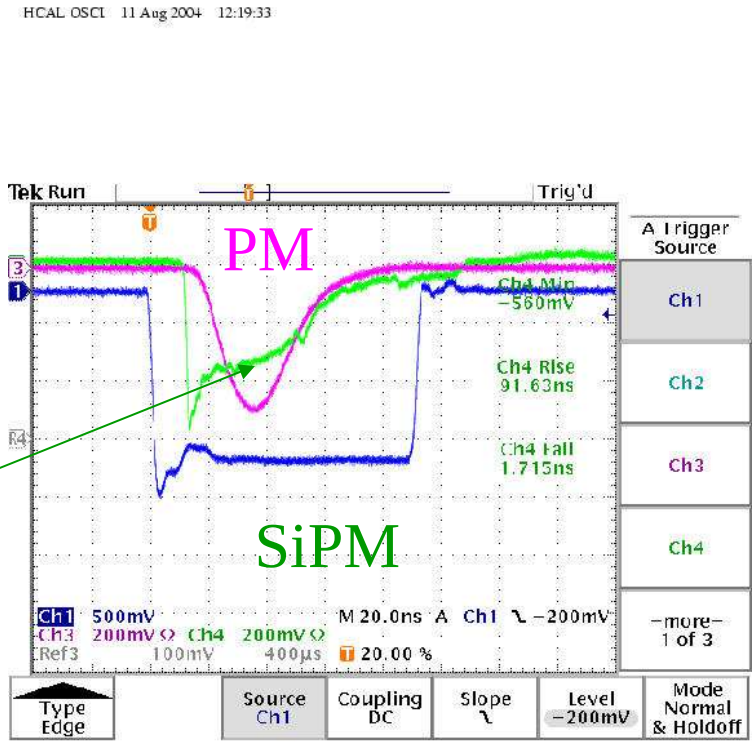
-Unclad Kuraray has highest LY but factor 10 attenuation / 50 cm

-BICRON and Luminous (SPACAL) ~ 50 MIP at fiber and

↙ BICRON has large attenuation for UV light

SiPM saturation curve





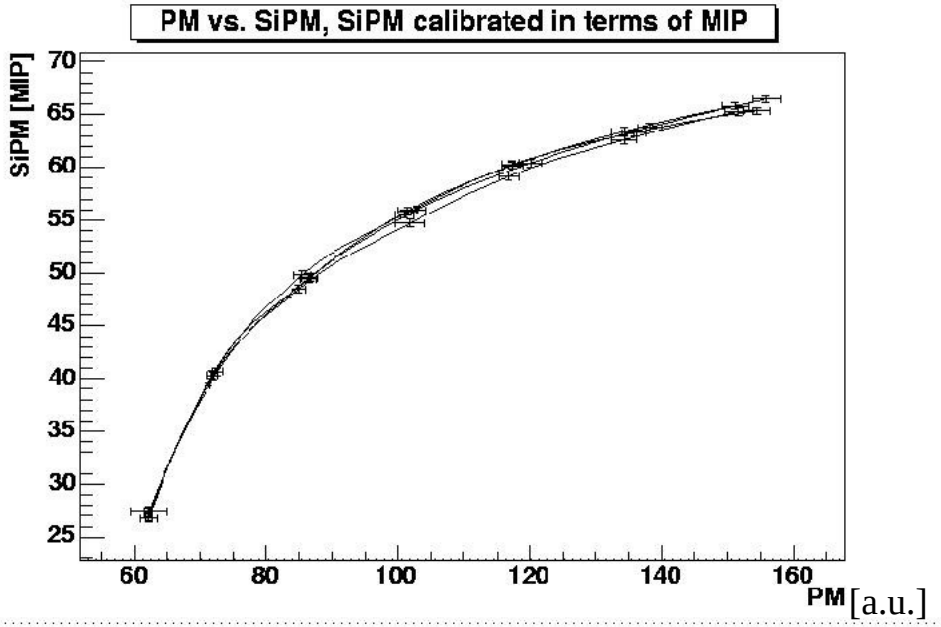
The plateau indicates SiPM in saturation

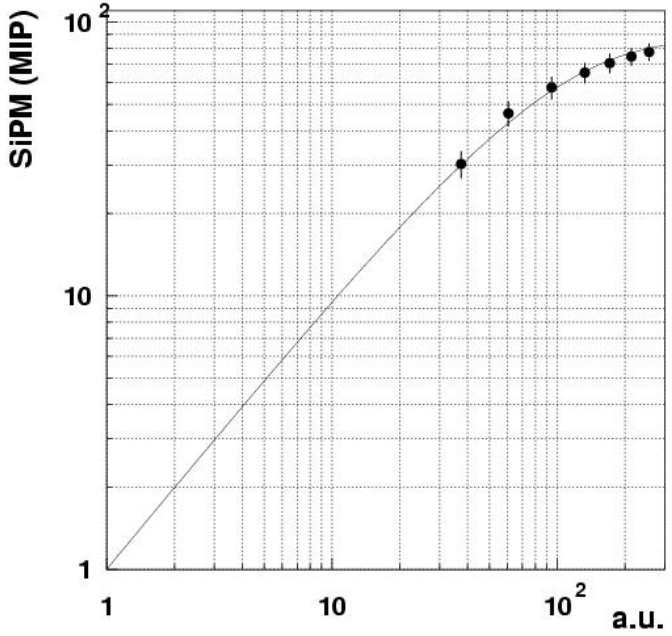
SiPM saturation curve

Response function of SiPM obtained with 3 LED fibers perpendicular to the tile

- good reproducibility
- good agreement with saturation curve with:

N_{pixel} =1500 , geom. eff. = 0.12 , xtalk = 0.15





LED/SiPM cross talk

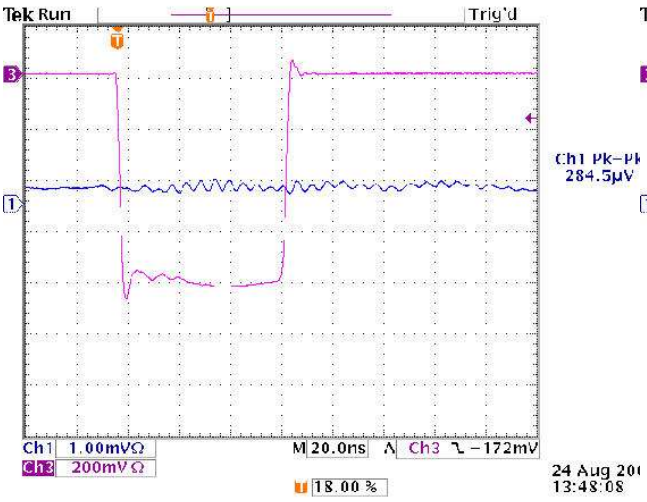
- measured SiPM signal with LED off
- compared to LED on but light screened

  0.25pC cross talk on SiPM with LED at < 1cm distance

  (MIP ~10mV ~2.5pC)

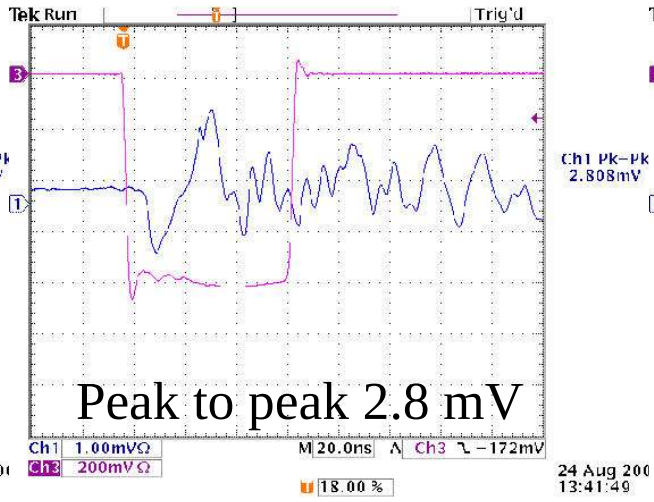
HCAL OSCI 24 Aug 2004 13:48:09

LED off



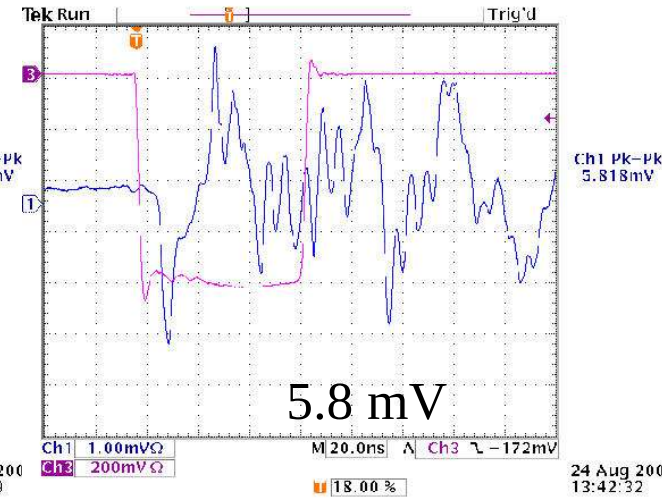
HCAL OSCI 24 Aug 2004 13:41:49

LED ~ MIP

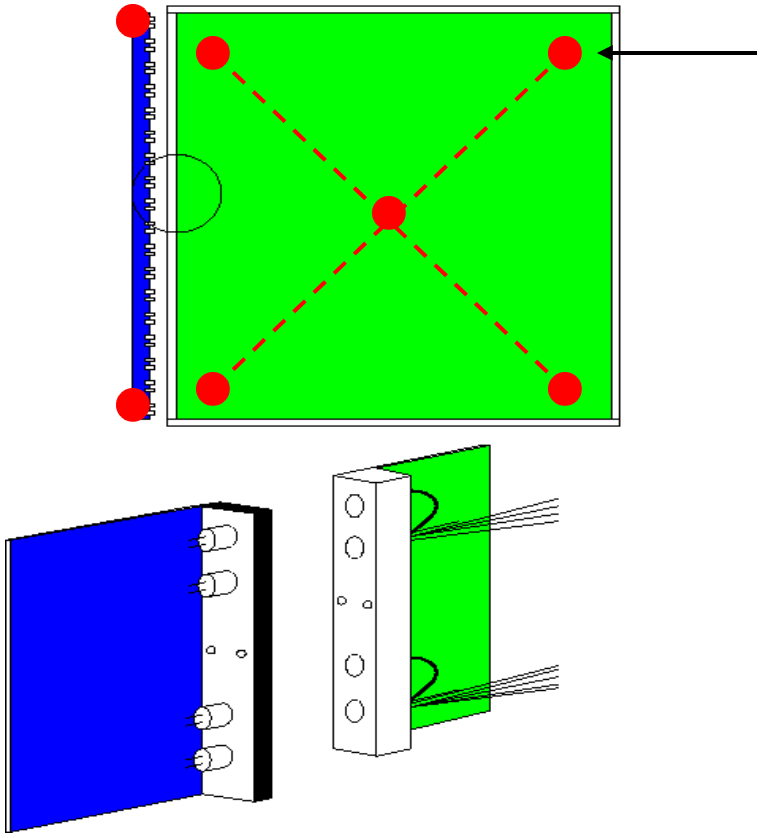


HCAL OSCI 24 Aug 2004 13:42:32

max LED LY



Temperature monitoring



Platinum resistors
- interpolate 5 readout points
- 2 points on LED board

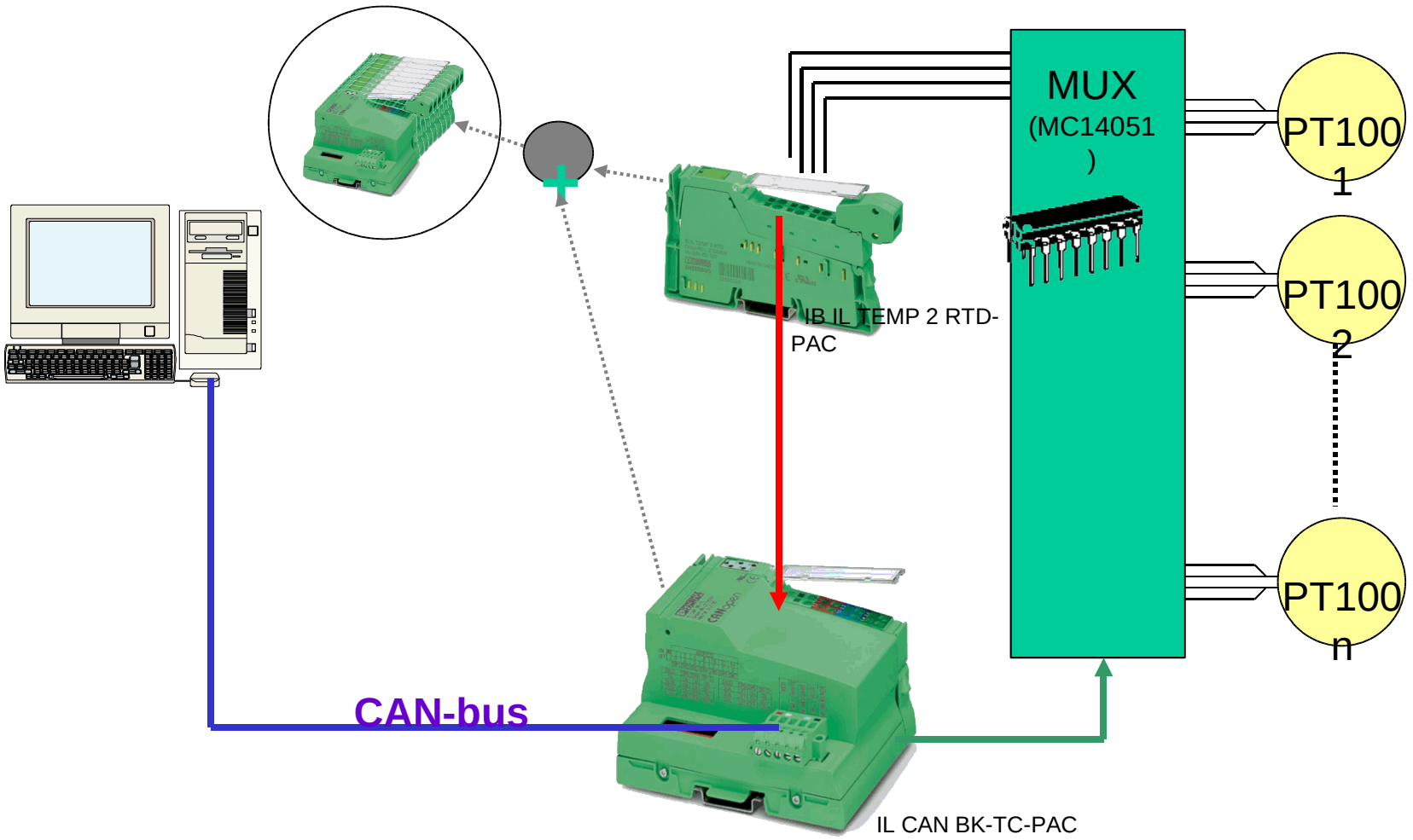
Total > 300 readout signals

↙ Multiplexed r/o

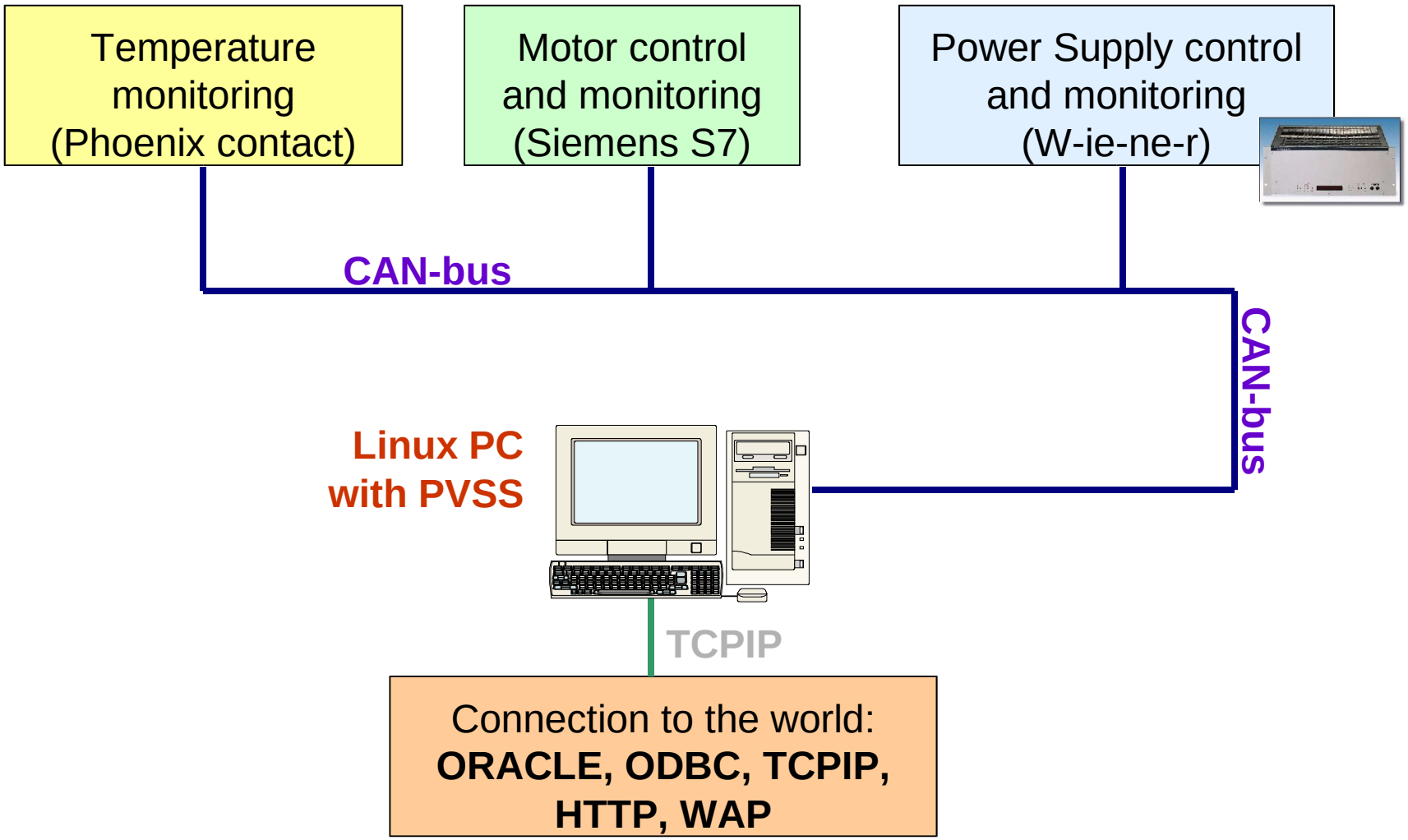
Project in collaboration
between Prague-DESY

Temperature monitoring

(scalable system)



Slow control schematic



Conclusion

- MIP calibration for all tiles achieved with ~1% accuracy

- Bridge the time between MIP calib. with LED monitoring sys.
  - LED needs monitoring (PIN diode)
  - present design not very elegant (many fibers) …
    … but ready and fulfills the needs (0-100MIPs)
  - more elegant solution (single fiber) will be tested
  - single LED on tile gives high crosstalk

- Temperature meas. complements the stability monitoring
  - can correct the amplitude variations at 1% level