

Commissioning of the CMS Pixel Barrel Detector

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Pixelo8
FNAL

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ETH



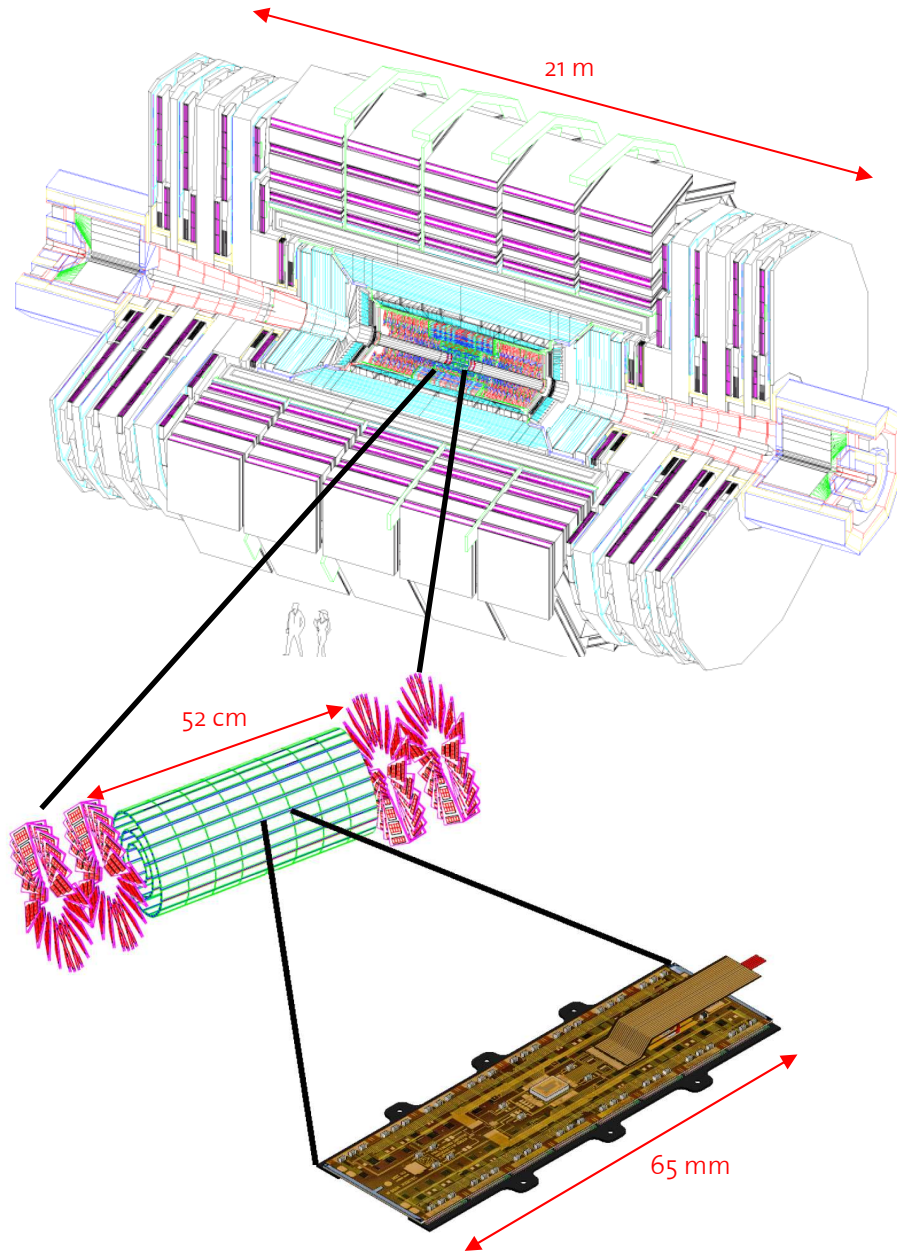
PAUL SCHERRER INSTITUT
PSI



Outline

- Overview on Detector and Readout System
- Commissioning and Testing at PSI
- Installation into CMS
- Commissioning at CERN
- Summary and Conclusions

CMS Barrel Pixel Detector

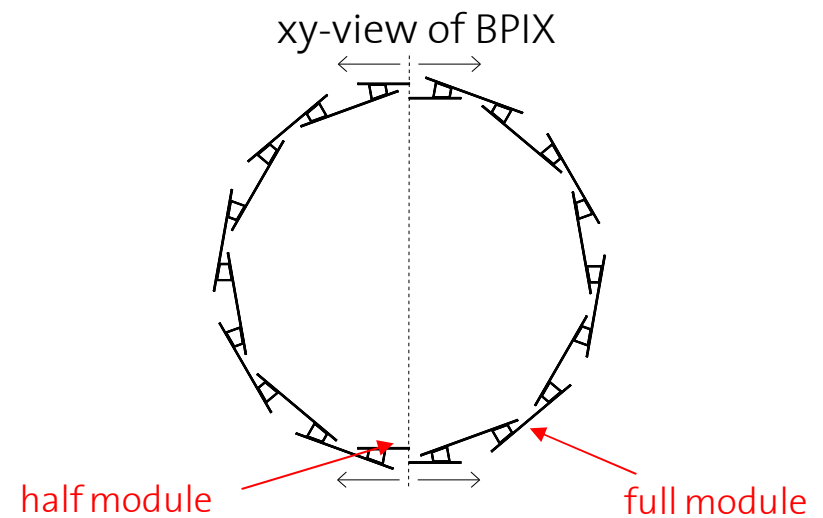


CMS Pixel Detector:

- 3 layers at 4, 7 and 11 cm
- 2 disks on each side at 34 and 46 cm

Barrel Pixel Detector:

- 672 full modules (16 ROCs)
- 96 half modules (8 ROCs)
- 48M pixels
- Pixel area: $100\mu\text{m} \cdot 150\mu\text{m}$

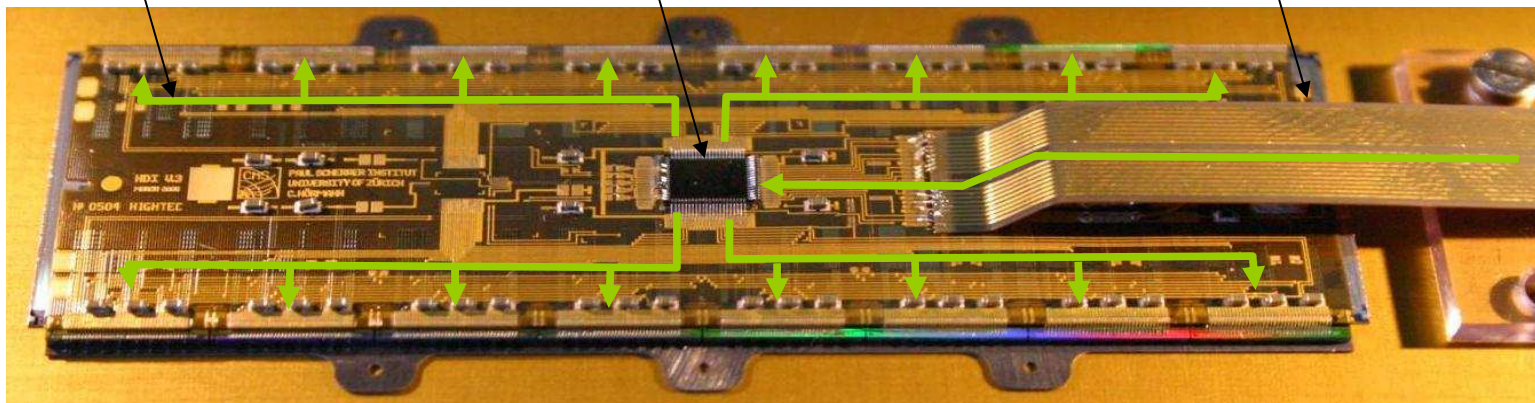


CMS BPIX: Control and Readout

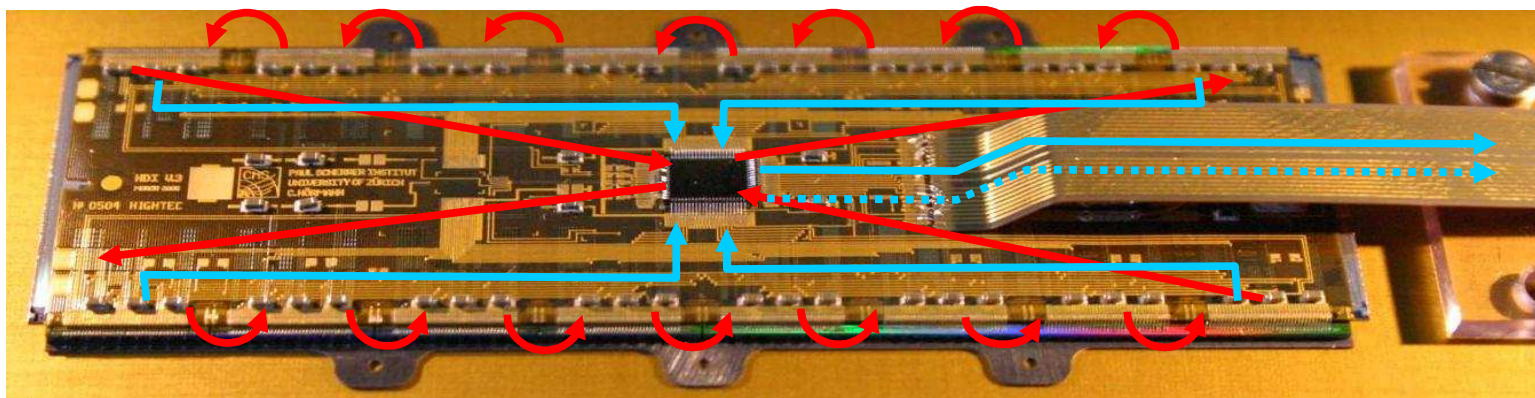
ROC

TBM

signal cable

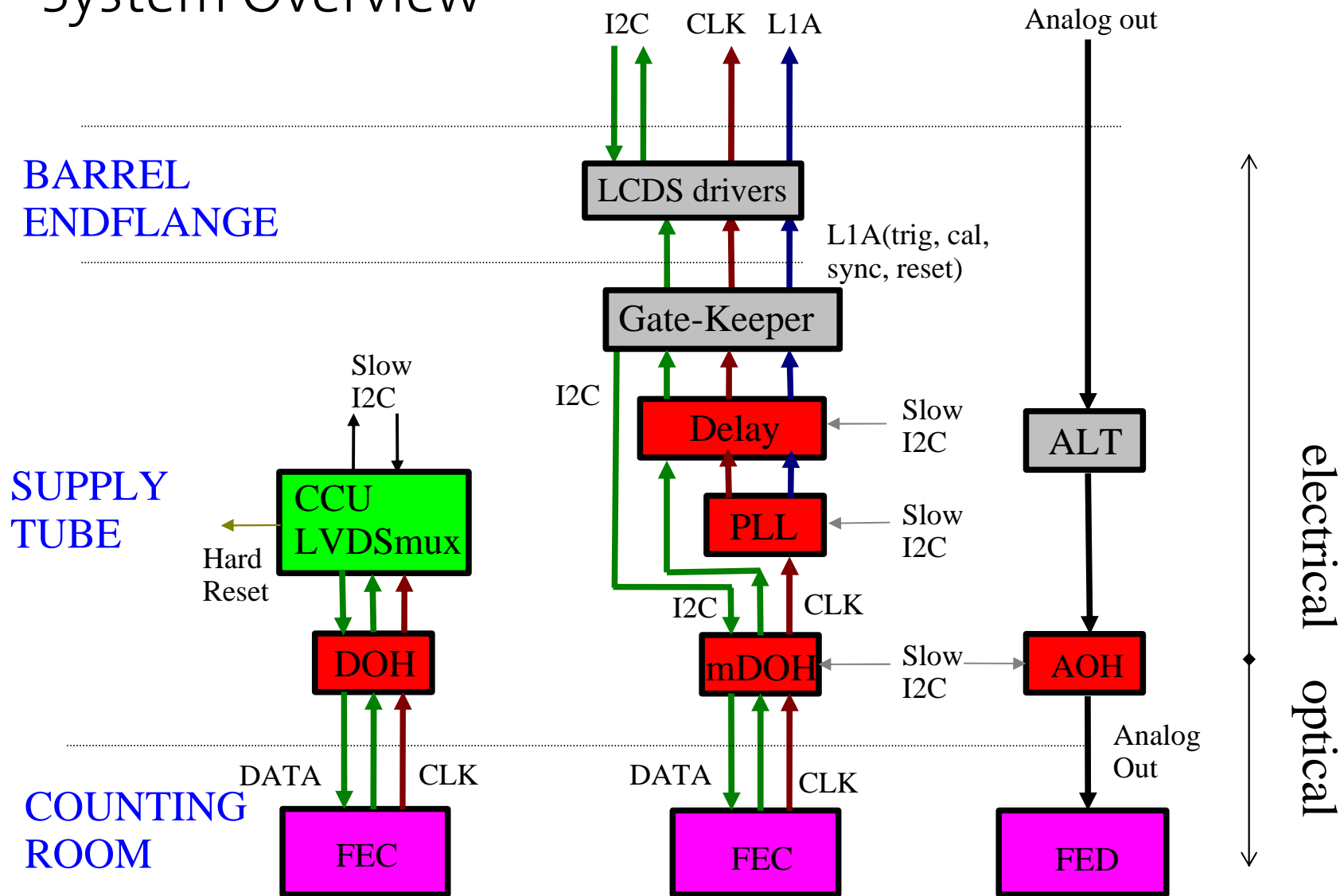


•control distribution: clock, trigger, i2c



•readout token: TBM→ROC₁→...→16→TBM
•analog readout

System Overview



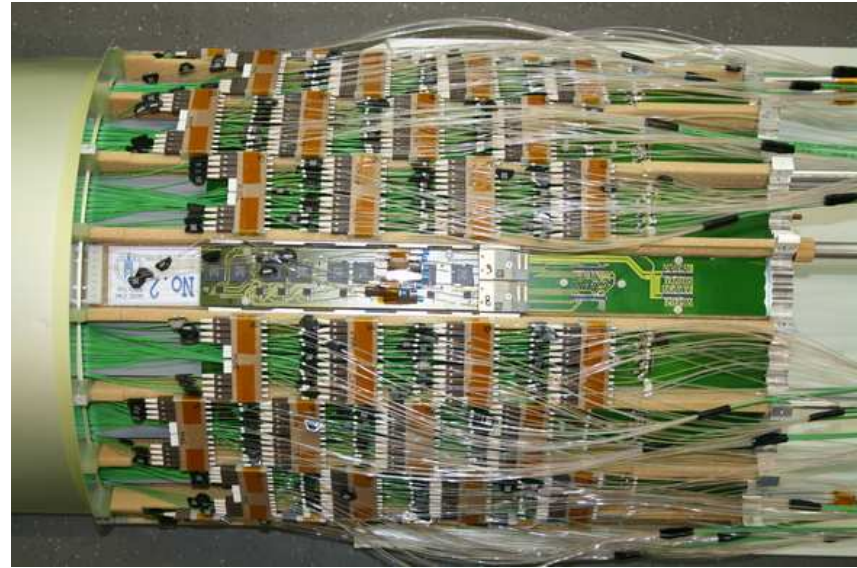
-> Christian Veelken's talk

Supply Tube

Detector side



Far side



4 supply tubes, 4 CCU boards for detector control

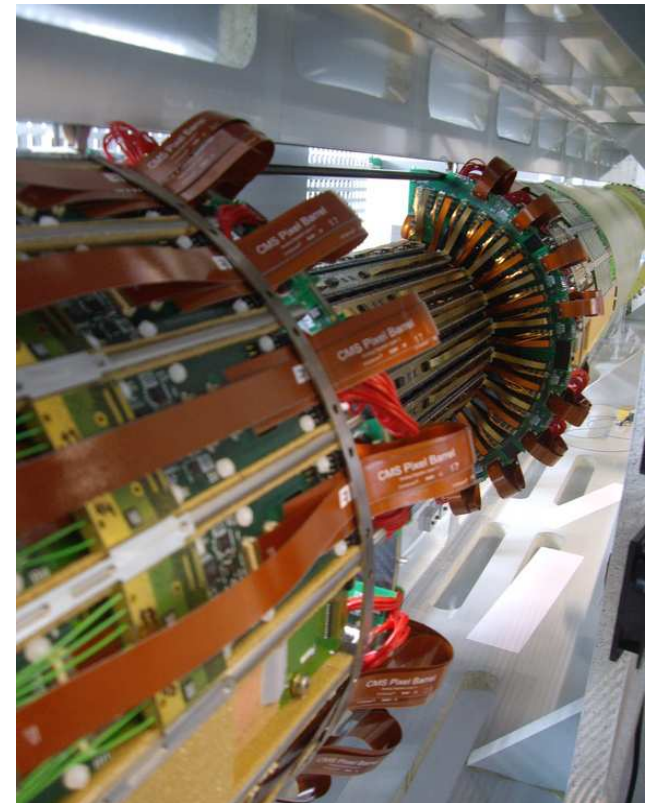
Each of the 32 sectors of the Barrel Pixel detector contains:

- 2 Delay25, PLL, DOH
- 6 AOH (with 6 lasers)
- 4 kapton cables which connect supply tube to detector end flange

Strategy for Assembly, Integration and Testing

- Assembly of detector at PSI, assembly of services at UZH
- Integration of complete system at PSI
 - “Commissioning system”: (final mechanics with only two sectors equipped)
 - Final system: 2 independent halves
- Testing at PSI
 - operating one sector at a time
 - storage of detector in transport box
- Transport to CERN
- Integration into CMS
 - Pixel Detector is last subdetector to be inserted into CMS
 - fast installation (~1 day for one half)
- Testing and Commissioning after Installation

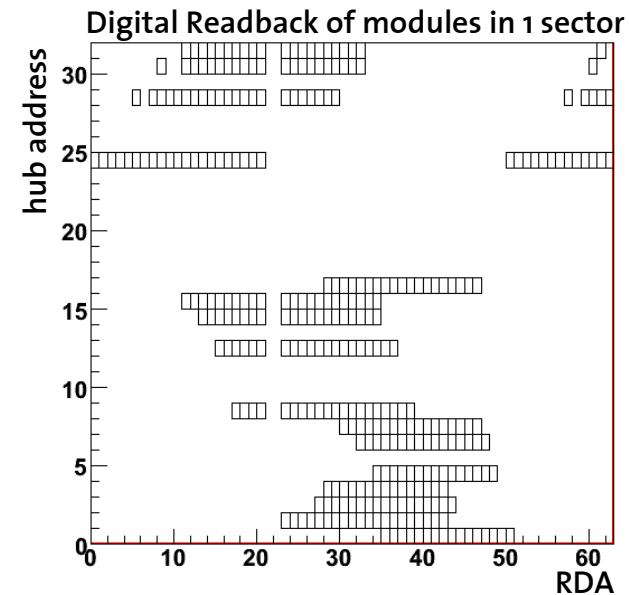
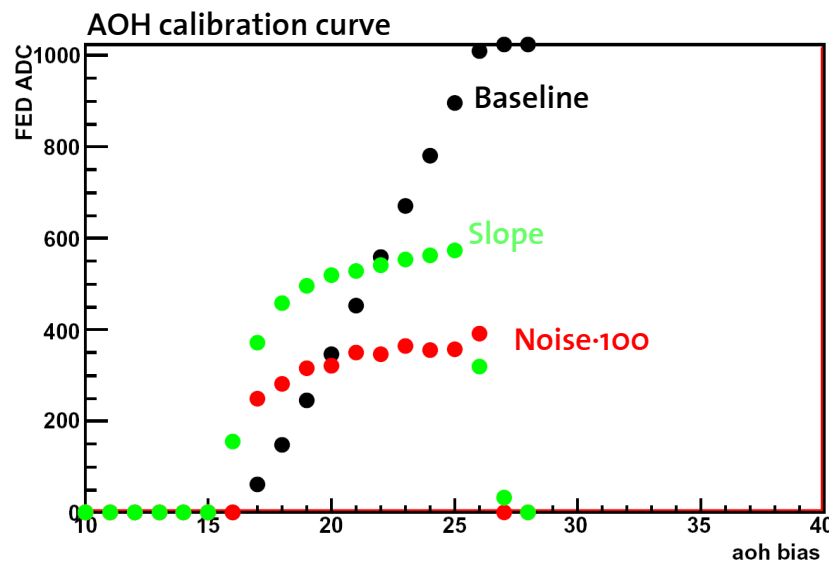
Detector with supply tubes connected



Short Tests

Test basic functionality of detector components and connections
(standalone software, ~1 day for full detector)

- Detector Control, Trigger, Clock
- Optical fibers for digital communication
- Optical fibers for analog readout: mapping, slope, noise
- Modules: programming, digital readback, token passage

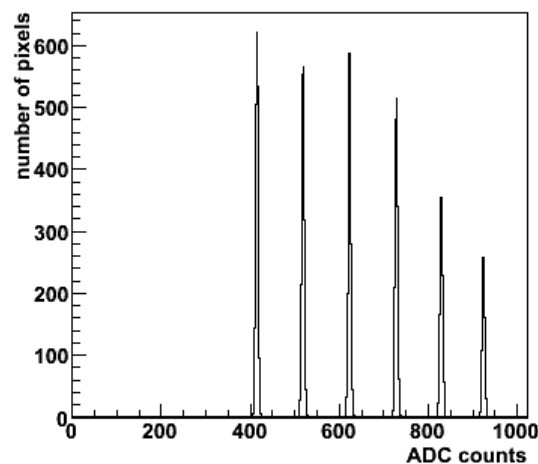


Performance Tests

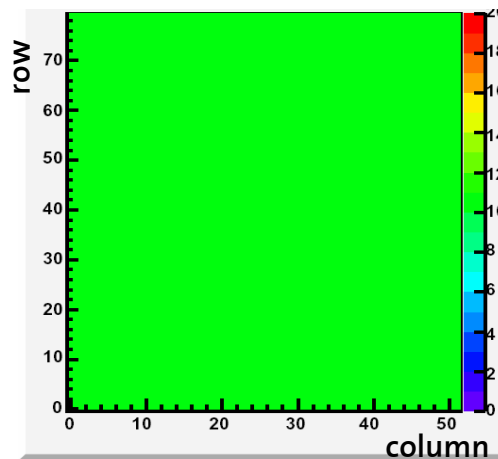
Extensive Tests of detector components with software used in CMS
(1 sector ~3h)

- Establish optimal settings (Delay25, PLL, DOH, AOH)
- Determine working region for each ROC
- Address Level Calibration
- PixelAlive
- HV test
- Pixel Noise and Thresholds (SCurve: efficiency as function of V_{cal})

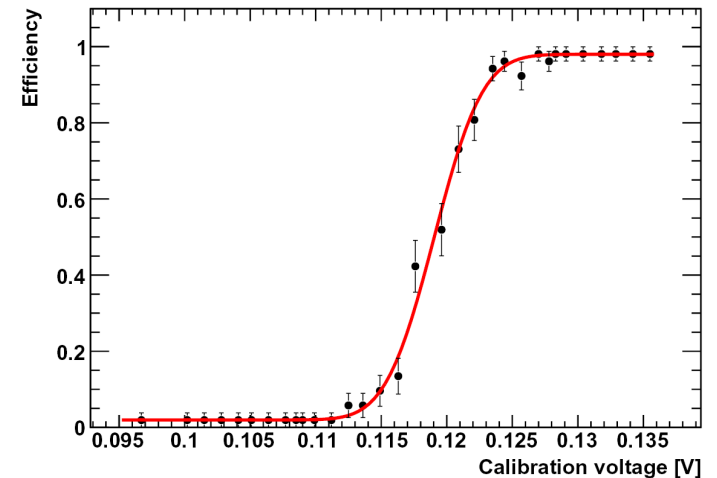
Results for 1 ROC:
Address Level Calibration



Pixel Alive



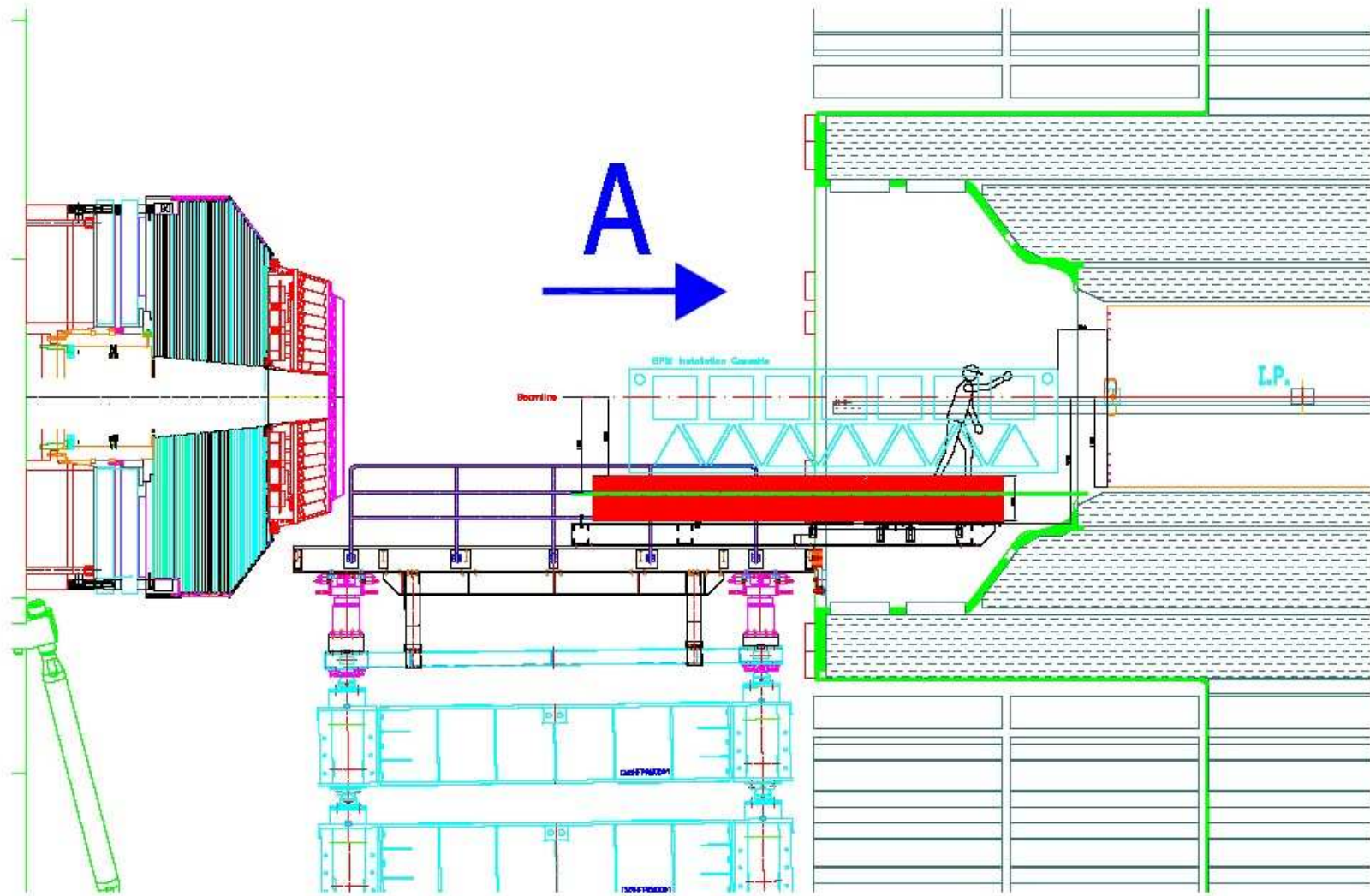
SCurve



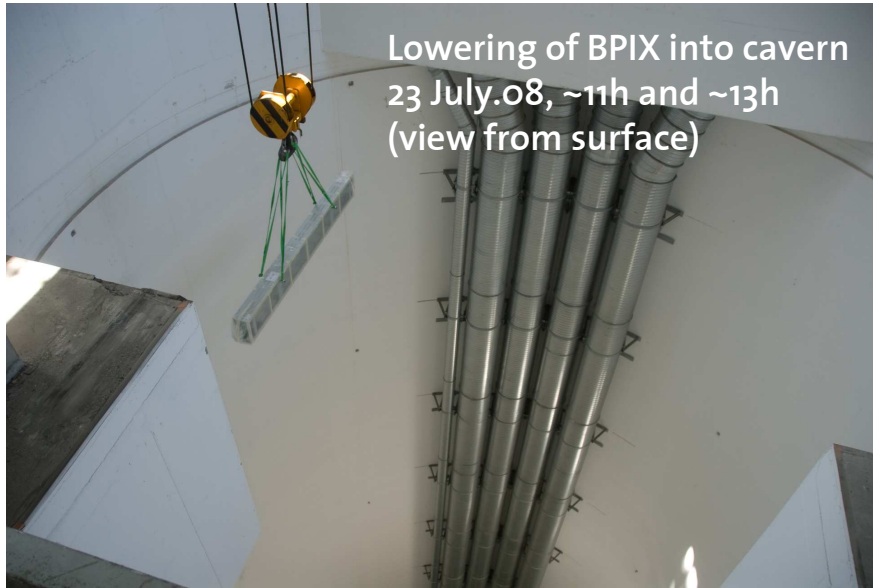
Results of Testing at PSI

- Detector control, trigger, clock: ok
- Optical fibers for analog readout:
 - 2 fibers broken (out of 1152): no ROCs lost, since data can be re-routed through other channel
- Modules:
 - 1 module without HV
 - 2 modules with token lost
 - 1 module with bad ROC header
 - 1 sector without digital readback (no channels lost)
 - in total: 40 non-working ROCs (out of 11520 => 0.3%)
- Transport to CERN:
 - system re-tested before installation: no additional damage found

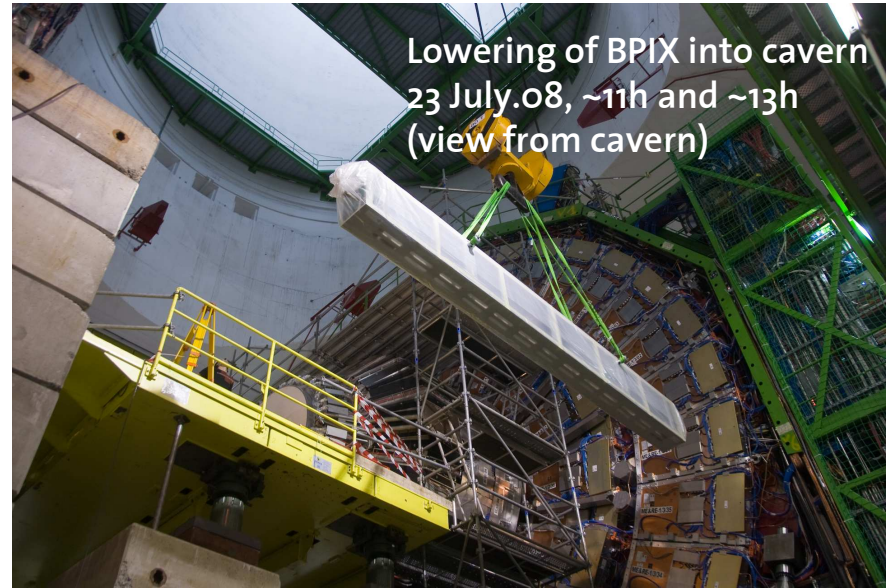
Installation into CMS



Installation into CMS



Lowering of BPIX into cavern
23 July.08, ~11h and ~13h
(view from surface)



Lowering of BPIX into cavern
23 July.08, ~11h and ~13h
(view from cavern)



Lifting of BPIX on installation platform
23 July.08, ~17h and 24 July.08, ~11h

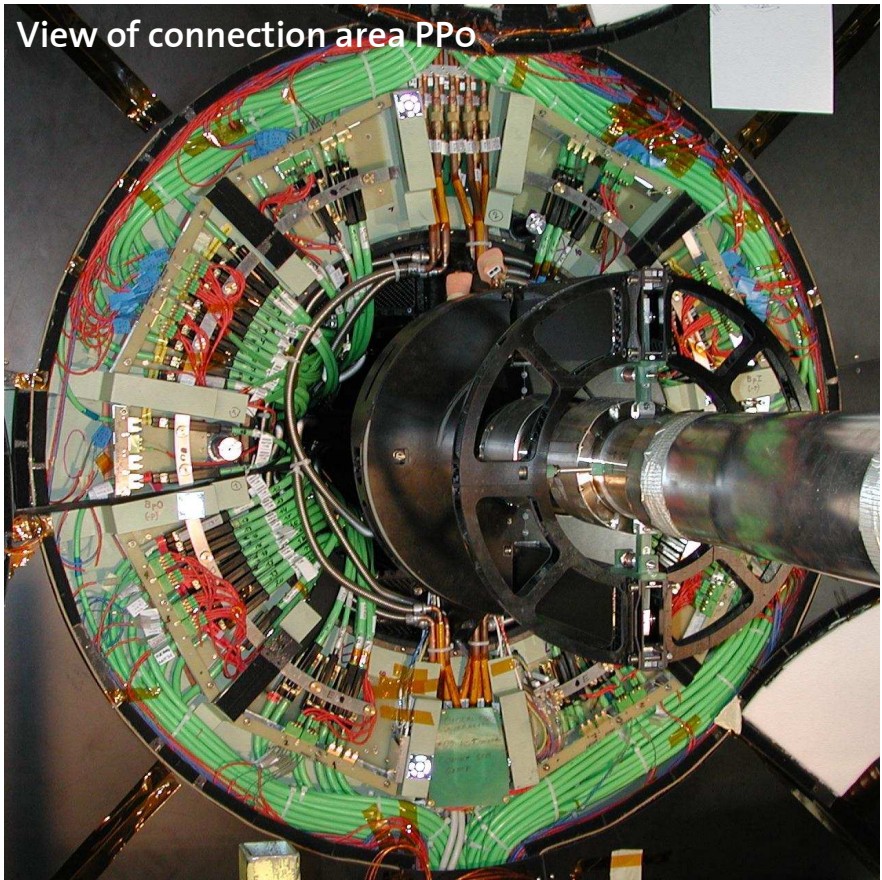


Placing of BPIX on installation table

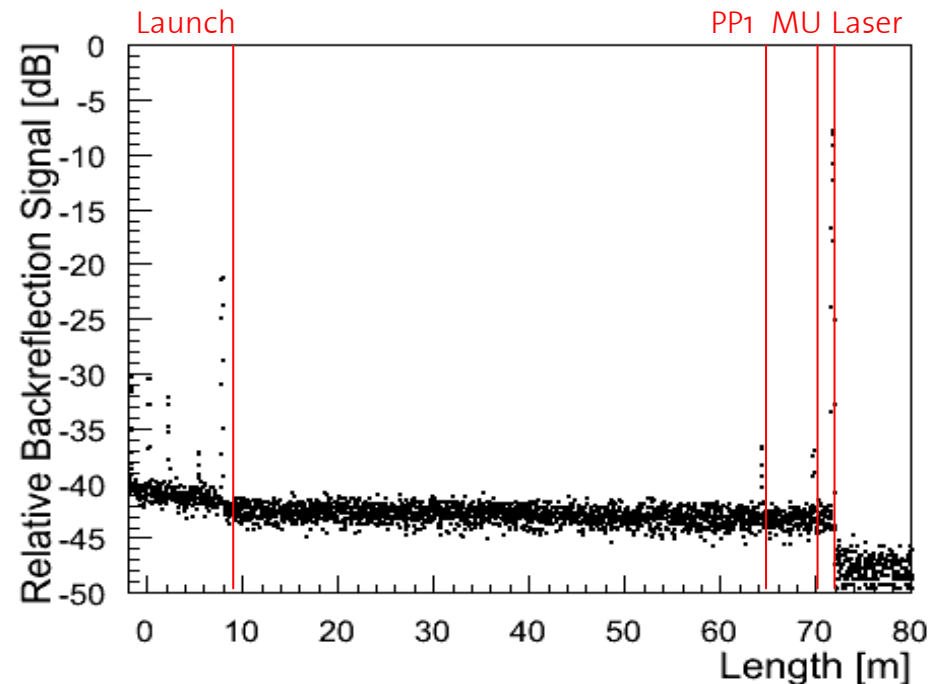
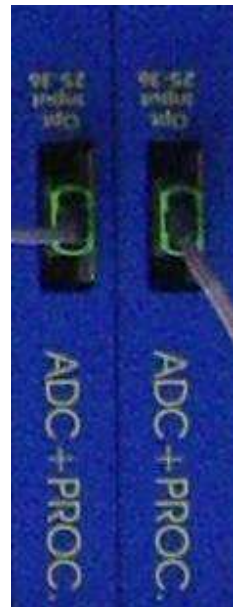
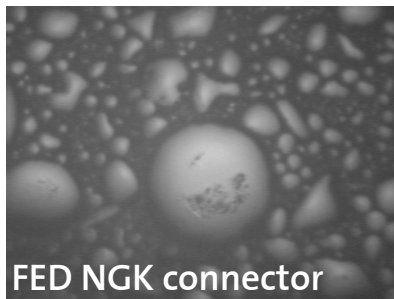
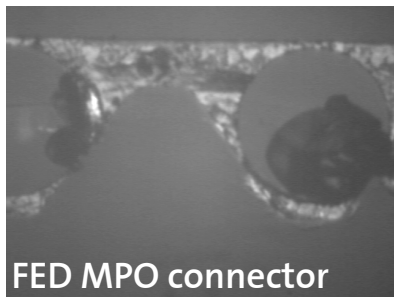
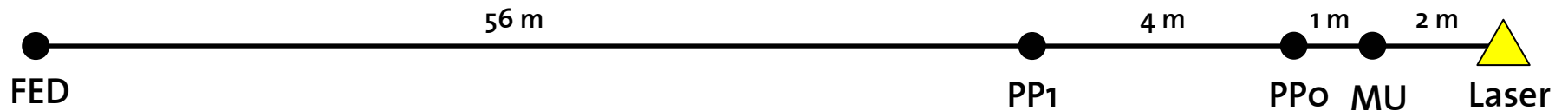
Installation into CMS



Installation into CMS



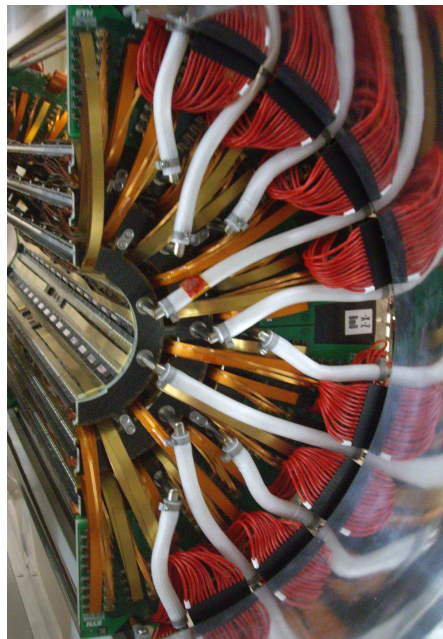
Optical Connections



- 29 ribbons investigated with OTDR and microscope
- all PPO connection good
- 1 bad PP1 connection => recoverd by using spare ribbon
- 19 fibers have reflection at MU connector (11 fibers => noisy, low slope)
- 10 fibers with permanent marks at FED connector
- no fiber lost during all operation

BPIX Cooling System

- C_6F_{14} used as cooling fluid
- 10 cooling lines for BPIX
- each module connected to cooling circuit via baseplate
- Analog and digital opto hybrids connected to cooling circuit by placing small aluminum plates on top of them
- Temperature dependence of AOH: 50 ADC counts/ $^{\circ}C$



10 cooling lines
(detector end flange)

AOH cooling plates

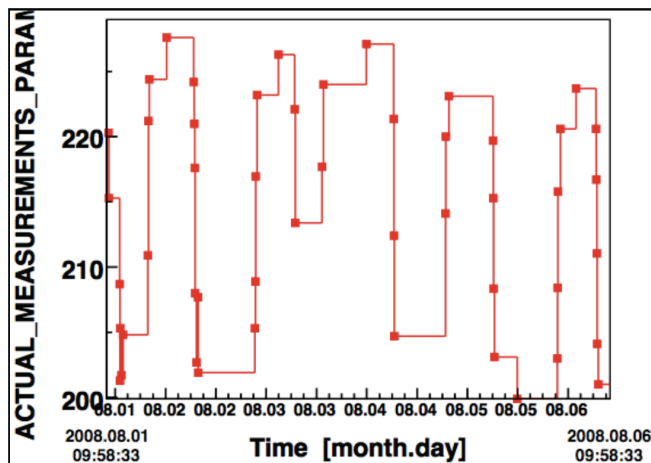


Commissioning of Cooling

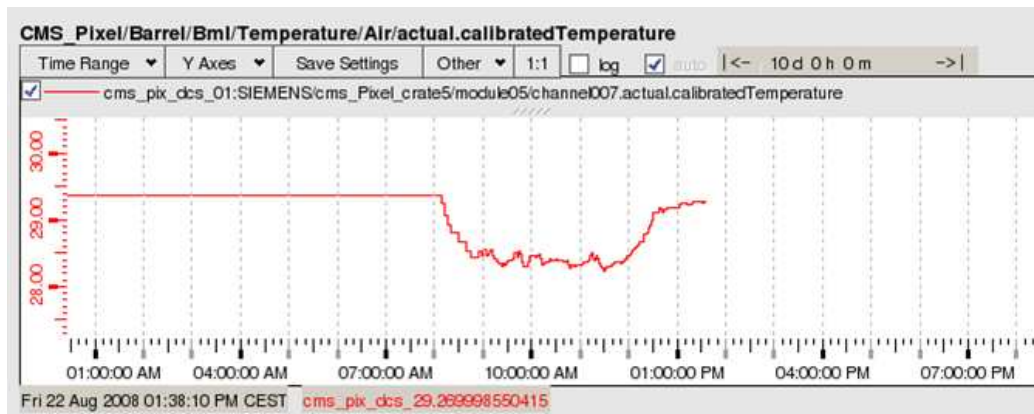
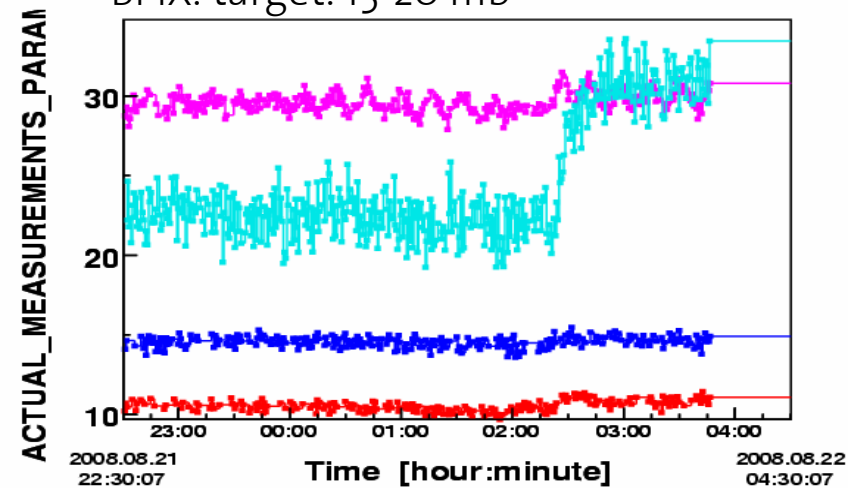
July 26/27: BPIX connected to cooling system

First weeks: daily switching on/off, since then running 24/7

Level of coolant => no leaks
(oscillations due to turn on/off)



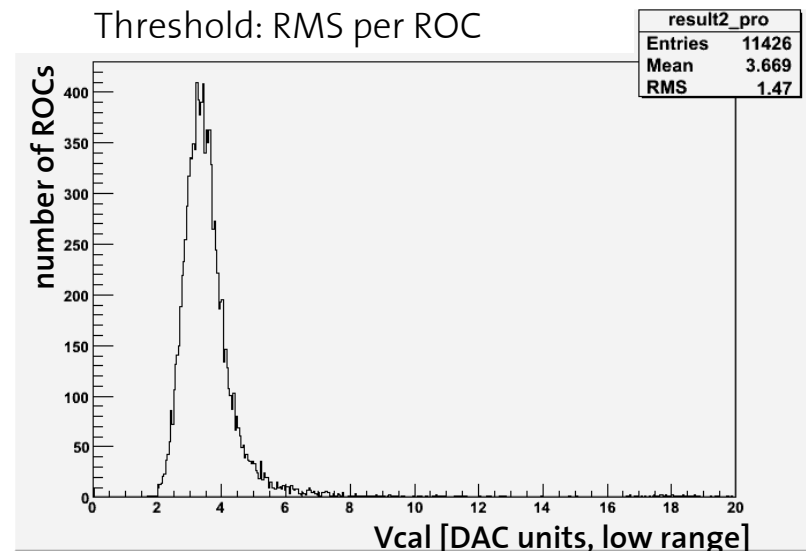
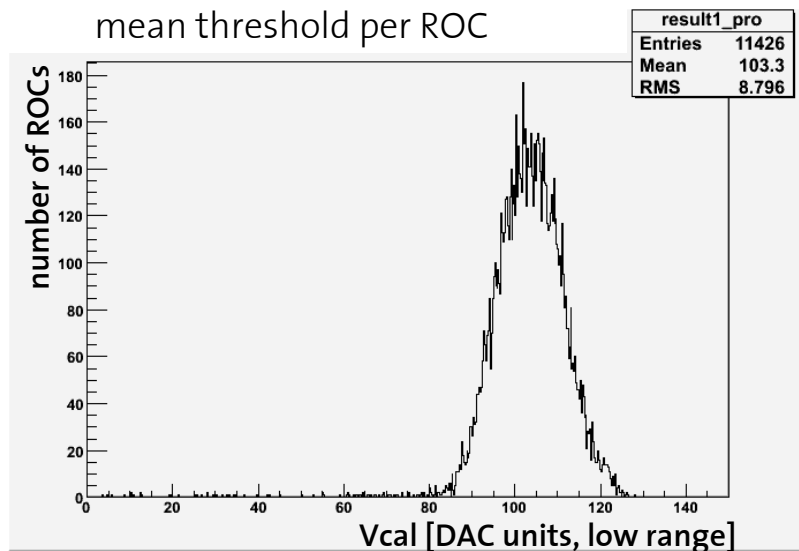
Measurement of differential pressure:
consistent with desired flow rate:
BPIX: target: 15-20 mb



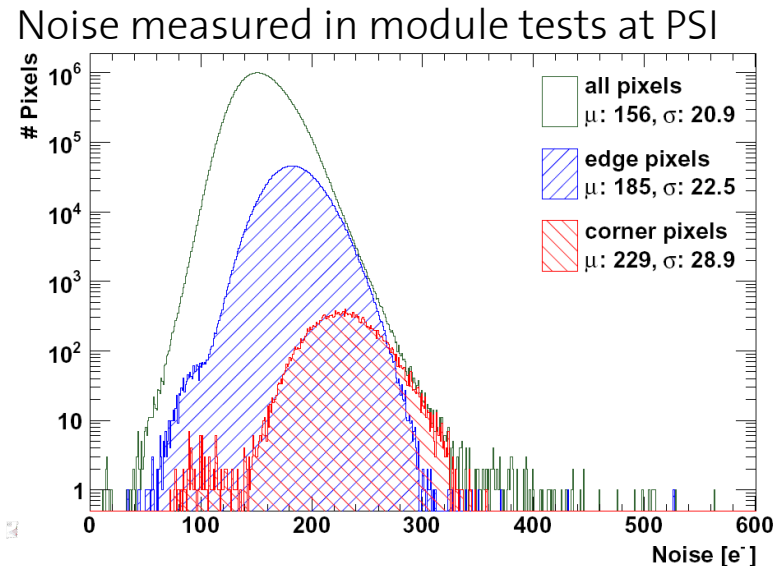
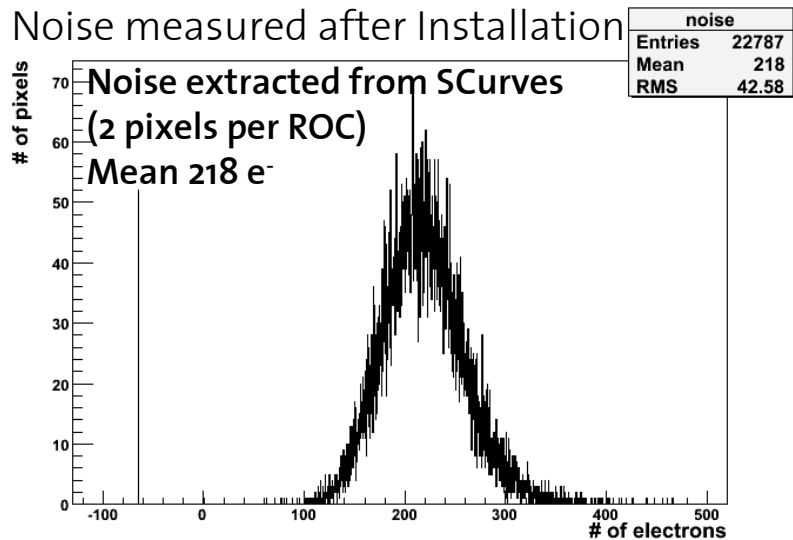
BPIX air temperature when
Strip Tracker is turning off:
Temperature drop of 1.5°C
=> Serious problem for BPIX
(AOH calibration)

Detector Status

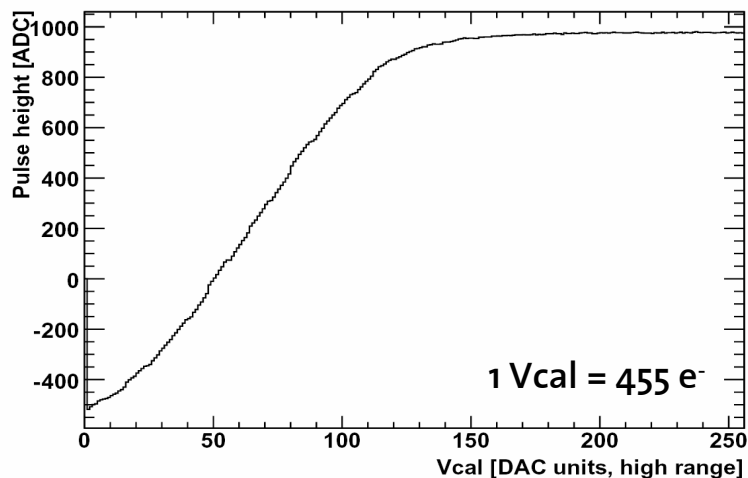
- 4 modules lost (3: no HV, 1: no token, 1: bad ROC header)
- 1 module with bad TBM header (recovered by re-routing)
- 4 individual ROCs that do not respond
 - => in total: 100 non-working ROCs (out of 11520 => 0.9%)
- Address level: RMS 2.5-6 (separation of levels ~100)
- Vcal thresholds extracted from SCurves: mean = 6693 e⁻, RMS = 585 e⁻
 - => thresholds not yet adjusted: need further calibration



Noise and Gain Calibration



Gain Calibration Curve



Gain Calibration:

- analog readout
=> measure pulse height as function of injection charge (linear range, non-linearity for small Vcal values, pedestals)
- done in module tests, needs to be redone after installation

Summary and Conclusion

- BPIX detector and supply tube assembly finished in July 08
- System fully tested at PSI
- Installed into CMS within 2 days
- Detector status: 99.1% working
- Calibration ongoing
- Getting ready for data taking

