TEC+ Status Report -
Experience from Integration of Sector 1

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Outline

- General status
- Experience from mechanical integration and cabling
- Experience from commissioning & debugging
- Noise behaviour
- Summary & outlook
1 sector (=18 petals):
1 tower of back petals (9 petals)
1 tower of front petals (9 petals)
= 9 control loops
= 4 cooling loops

- Petals are integrated sector-wise
- Integration with TEC in upright position
- Disks used as “desk” during insertion → need to rotate the TEC after insertion of 1 tower
- Readout test of 1 complete sector
• First sector mechanically integrated and cabled
• All petals checked for I²C access and connectivity
• For petals of disks 1-8 (not enough trigger signals to run with 18 petals):
  - commissioning done
  - noise with bias voltage studied
  - bias voltage checked
• To be done:
  - commissioning and noise tests of petals of disk 9
  - I²C stress tests, redundancy etc.
  - study of temperature and humidity sensors
  - in-depth study of few remaining problems (see later)
Mechanical integration

- Petal insertion tools developed to handle petals safely
- Petal insertion trained with dummy petals
- Started integration with most difficult sector
- Insertion is fast: 40-60 minutes per petal

Largest difficulty:
- Handling and save storage of optical fibers during insertion
- Two fibers (on two different petals) were broken;
  some precautions taken, but reason not completely understood;
  petals were exchanged
Step 1: optical fibers

- Roughly 50 fibers per petal to be plugged into "fiber mechanics"
  - cleaning of fiber and connector
  - disentangling of fibers so that mechanics can be moved easily
  - fibers to be plugged in correct order according to Nicks table
  - closing of fiber mechanics with upper carbon fiber cover

- Very time consuming task!
Cabling

**Step 2: electrical cables**

- 2-3 MS cables per petal
- 1 control power cable plus 2 control link Kapton cables per control loop
- 1 grounding braid per petal
- No specific problems

**Step 3: cooling**

- Two manifold screw connections per petal
  - difficult to access behind item beam
- Leak test before coolant is circulated
Step 4: connections at the bulkhead

- 48 LIC cables to be plugged at the bulkhead
  - tension of cables can lead to bad electrical contact
- Ribbons to be connected to 14 multi-ribbon cables
  - one flaky optical contact observed
- 8 cooling pipes to be connected to cooling circuit
First Sector integrated in TEC+

Lessons learned from insertion and cabling:

- more care is necessary during handling of fibers
- time for connecting fibers has been underestimated
Setup

- 11 VME FEDs, only 10 in the readout
- 1 VME FEC with 8 control rings
- 24 A4601 CAEN PSMs for analog power + HV
- 50m long LIC cables
- 5 A4601 CAEN PSMs for control power
- Selfmade cables for control power
- Trigger via TSC, TFB, TTCex
  (10 channels + 1 optical from TSC)
- Interlock system commissioned, interlock on external PT100 sensors implemented
- DAQ: most recent release (rc1205) used
- 4 PCs: 1 for RootAnalyzer, 1 for FEC & FED, 1 for analysis, 1 for slow control
- HyperDAQ used as run control
- Offline analysis with AC1Analysis package (Richard)
1.) Control ring and I²C communication

- All control rings ok, communication stable
- No instabilities in I2C communication observed up to now
  (stress tests still to be done)
- However:
  - I2C communication to 2 AOHs lost after 2 days, comm. to 1 PLL after few weeks:
    - BP disk 4 position 2.1: AOH
    - BP disk 5 position 2.2: AOH
    - BP disk 5 position 2.1: PLL
    → all located on ring 2 on backpetals for disks 4-6 (BP46)!
  - two AOHs lost in DAQ test, same location
  - low voltage and I2C signals measured in situ - look fine
  - LV overshoot studied in Aachen, no differences to other rings observed
  - faulty AOHs from DAQ test have been studied, ok (?)

Further debugging impossible without extracting petals.
Commissioning

LV group 1 (ring 2)

LV group 3 (rings 5,7)

2.5V
1.25V
2.) Optical connections

- Studied with Laurents connection scan
  (lasers switched on one-by-one, all FED channels checked for signal)
- Output xml files need to be checked for presence of all channels
- 1 TEC sector ⇔ 400 modules ⇔ 237 056 strips ⇔ half of CDF SVX II detector!
  ⇒ Impractical to check xml files "by hand" → dedicated commissiong tool developed by Richard (see next talk)
- Very useful exercise: several bad channels found
  - several bad optical contacts → fixed by cleaning/replugging
  - 4 fibers on ribbons broken → "fixed" be re-ordering of fibers;
    change of order to be implemented in data base
  - only two analog fibers had wrong order!

Issues:
- For debugging, electrical cables need to be unplugged and fiber mechanics to be opened
- Very dense environment, risky and time consuming operation
- Iterative procedure with long turnaround time
3.) Tick marks

- Timing runs and gain scans performed
- Ticks studied for low gain channels (code by Christoph Bloch)
- Several channels with lowish gain found

- Cleaning still to be done
- What is the minimal necessary height?
4.) Noise

- Check if bias voltage is arriving, by comparing runs with HV off/on
  - Five modules without HV found, three of them fixed (problems with cables), two still to be studied

- Problems on single APVs typically only visible in the noise

What happened to these two APVs? Probably not recoverable.
Lessons learned from commissioning and debugging:

- Experience was gained and some problems will not appear for the next sectors

But:

- Not realistic to assume that everything works perfectly after inserting petals!
- Debugging is very time consuming: several hours easily lost for debugging of one module or optical channel
- Problems with chips cannot be debugged at all without huge risk to cause further damage
First runs showed a very high and sometimes irregular raw noise, but a flat and sensible common mode subtracted noise (Cms noise):

Modules within power groups behaved in a similar way.
Standard debugging (swapping of cables etc.) turned out to be useless since common mode was not reproducible.

5 runs under identical conditions

Problem was traced back to three problems →
Problem 1: thermal pedestal drift

Typical "running" of the common mode during a run (5000 events):

- Power consumption at start of run, after reset: 184W
- Power consumption during run: 580W
Noise behaviour

Verified by measurement:
Temperature of the chiller varied by 5°C, T on hybrid measured via DCU

\[ T_{\text{hybrid}} = 34.7^\circ C \]
\[ T_{\text{hybrid}} = 36.7^\circ C \]
\[ T_{\text{hybrid}} = 38.6^\circ C \]
\[ T_{\text{hybrid}} = 39.7^\circ C \]

- Pedestal drifts by roughly 10 ADC counts per 1°C!
- No saturation even after ~30 minutes.
- Pedestal drift dominates raw noise for large event ranges, proper offline treatment to be implemented
Problem 2: oscillation on power supplies

- 600 Hz oscillation observed by TOB also present in TEC setup
- Slow sensing leads to oscillations on 1.25V and 2.5V line (see doc by Marvin & Christoph)
- Amplitudes ~ 20-100mV depending on the power group (i.e. current)
This oscillation leads to an oscillation in the common mode:

Trigger frequency $f = 5\text{kHz} \Rightarrow T = 0.2\text{ms}$
8-9 triggers per period of the PS oscillation ($T=1.7\text{ms}$)
Noise behaviour

- Power supplies have been modified by Giuliano Passuello and Simone Selmi according to the TOB recipe (i.e. one capacitor removed)
- Small oscillation still visible on PS front panel, but gone on detector side
- No oscillation visible in the common mode anymore
- One EASY crate found to be noisy, to be exchanged
- Could have saved a lot of time if perfect power supplies would have been supplied as soon as problem became known at CERN
Problem 3: constant events in "sir" files

6.1 grey: raw noise
    color: cms noise

6.2 common mode vs. events number
Noise Behaviour

• Constant events are an artefact in the sir files, not present in RU files
• Means that there is a problem with the FED buffer: "corrupted event"
• If included in data analysis (pedestals), they dominate the raw noise
• Present in first 22 events of spill
• Only sometimes, only on some (varying) channels
• Always whole FED affected
• Close discussion with Laurent, not yet fully conclusive
• They can be excluded from the analysis
Dramatic improvement with modified power supplies, taking only events at end of the run and excluding periods with constant events:
Noise of FP1

Module position

Ring number (1-7)
Noise of FP2

Module position

Ring number (1-7)
Noise of FP4

Module position

Ring number (1-7)

Powered via noisy EASY crate
Noise of BP6

Module position

Ring number (1-7)

1 fiber with low gain
Noise of BP8

Module position

Ring number (1-7)

Katja Klein

The CMS Silicon Strip Tracker
• Noise is uniform between petals
• Noise increases with ring number (= strip length)
Mean APV Noise

Relative common mode noise - run 20456

Relative RMS of raw noise - run 20456

⇒ Grounding scheme works
Single Strip Noise

Noise ring 1

Ring 1

Noise ring 6

Ring 6

Noise ring 5

Ring 5

Noise ring 7

Ring 7

no HV

bad fiber
Deconvolution mode

Mean CMS noise - run 20451

Relative RMS of raw noise - run 20451

Relative common mode noise - run 20451

CM noise/cms noise
• Laurent for extensive DAQ tests, debugging & advice
• Machi & Piero Giorgio for setting up the interlock
• Frederic for FEC support
• CAEN for support and modification of power supplies
• Osman & Jonathan for FED support
• Anybody I might have forgotten......
Summary & Outlook

- First sector has been integrated and almost completely debugged
- Lots of problems had to be understood and solved
- Low common mode & flat noise everywhere, grounding works
- First grounding & shielding studies performed, no conclusions yet

Next steps:
- Finalize basic testing, including petals of disk 9
- Continue grounding & shielding studies
- Patch DAQ software and take cosmics (trigger is almost ready)
- Cold test
Appendix:

Noise of all modules on all petals of disks 1-8
Noise of FP1

Module position

Ring number (1-7)
Noise of FP3

Module position

Ring number (1-7)

no HV
Noise of FP4

Module position

Ring number (1-7)

Powered via noisy EASY crate
Noise of FP5

Module position

Ring number (1-7)

1 APV faulty
Noise of FP6

Module position

Ring number (1-7)
Noise of FP7

Module position

Ring number (1-7)
Noise of FP8

Module position

Ring number (1-7)

Powered via noisy EASY crate

1 APV dead
Noise of BP1

Module position

Ring number (1-7)

no HV
Noise of BP2

Module position

Ring number (1-7)
Noise of BP3

Module position

Ring number (1-7)

Powered via noisy EASY crate
Noise of BP4

Module position

Ring number (1-7)

AOH dead
Noise of BP5

Module position

Ring number (1-7)

PLL dead

AOH dead
Noise of BP6

Module position

1 fiber with low gain

Ring number (1-7)
Noise of BP7

Module position

Ring number (1-7)

fiber?
Noise of BP8

Module position

Ring number (1-7)