TEC Integration Procedures

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Tracker Integration Review
October 27th, 2005
Outline

• Reception test of petals in the TEC Integration Center (TIC)
• Mechanical integration of petals into the TEC structure
  - Tooling for integration
• Tests of petals after integration into the TEC
• Additional tests foreseen for the first TEC+ sector
  - Cold test
  - Grounding & shielding studies
• Lessons learned from trial petal integration
• Status of TIC-Aachen
• Concerns
• Schedule
• Summary

Status of TIC-Lyon/CERN covered by D. Contardo
Petal Reception: Overview

- Fully qualified “perfect” petals will be delivered by the five petal integration centers (PICs) to the TICs

- **Purpose of the reception test:**
  - rule out transportation damages
  - add and test items that cannot be integrated by the PICs:
    * digital opto-hybrids plus their PCB for optical control communication
    * humidity sensors

  ⇒ **No in-depth qualification!**

- All tests performed at room temperature
- Each TIC has to test ≈150 petals
- Estimated petal delivery rate of 10 petals/week → **need to test 2 petals/day**
- No time and setup to repair petals → **faulty petals will be given to repair center**
  - for TIC-Aachen: 3. Physikalisches Institut, RWTH Aachen
  - for TIC-CERN/Lyon: PIC at CERN
Petal Reception: Test Sequence

• **Optical inspection:** look for scratches, obvious damage, dirt ...

• **Test of the control communication** (I²C protocol):
  - test of I²C communication to all devices,
  - special sequence known to lead to communication errors in case of hardware problems
  - functionality of optical control components (digital opto-hybrids) on back petals
  - test of the redundancy (= possibility to bypass bad CCUMs)

• **Temperature and humidity sensor readout,** comparison with external probes

• **Connectivity scan**

• **Full commissioning:**
  - optimisation of sampling time
  - adjustment of APV baseline
  - optimisation of laser settings

• **Pedestal runs in peak and deconvolution mode**

• **IV curves**
**Hardware:**
- Setup based on one PCI-FED, optical PCI-FEC, “Karlsruhe” multiplexer
- Interlock on Delphi PS implemented

**Software:**
- **Based on DAQ spring release** (Lyon) (xdaq version 2) and **run control** RCMS 1.1
- **Test software and GUI** (Aachen)
  - user friendly with high level of automation
  - runs all tests
  - takes care of data storage, logging of results etc.
  - starts data analysis
  - performs data base (DB) operations
- **Online monitoring with MonitorJAS** (Lyon)
- **AC1Analysis package** (Aachen) for **data analysis** (used in system test & test beam)
- **Comparison of number of bad strips and leakage current with longterm test results from DB**
- **Test results uploaded to DB**
Petal Reception

TEC Petal Reception

Overview panel
Use combo box to switch between displays

Flow

connectionscan task GUI

Run number: 40296 Events: 2679

Task connections can Status:


- Restarting the DAQ host
- Configuring host for connection run
- Setting parameters for connection scan
- Configuring applications for connection scan
- Creating run thread
- Starting run thread with timeout 40s and no max event number

Barcode Reader
- Unknown
- No summary

File Copy
- Unknown
- No summary

High Voltage
- ON
- On: 8 - Off: 0
- Ramp: 0 - Trip: 0

Program Starter
- Unknown
- No summary

Multimeter
- Unknown
- No summary

DAQ
- Enabled
- No summary
## Petal Reception: Time Estimate

<table>
<thead>
<tr>
<th>Task</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount petal in grill</td>
<td>10 min</td>
</tr>
<tr>
<td>Visual inspection</td>
<td>15 min</td>
</tr>
<tr>
<td>Install DOHM, H-sensor</td>
<td>15 min</td>
</tr>
<tr>
<td>Connect to cooling and read out</td>
<td>90 min</td>
</tr>
<tr>
<td>Readout test</td>
<td>90 min</td>
</tr>
<tr>
<td>Disconnect</td>
<td>45 min</td>
</tr>
<tr>
<td>Store petal</td>
<td>20 min</td>
</tr>
</tbody>
</table>

**Time to test one petal**: 4.8 hours

⇒ **Testing 1 petal/day is easy**

**Testing 2 petals/day is possible:**
- preparation of second petal during readout test
- read out second petal over night

**Contingency:** double man power and number of optical patch panels
→ could (dis)connect two petals in parallel
Petal Reception: Status

TIC-Aachen:

- Test stand is operational
- GUI ready, full test sequence implemented
- To be finalized after first experience with O(5) petals:
  - Analysis and grading
  - Data base operations
- First production petal tested, number of bad strips consistent with longterm test
- Training of electronics engineer has started
• **Petals will be integrated sector-wise**
• Back petal has to be inserted before “neighbour” front petal (mechanical reasons)
• Disks function as “desk”
• Minimise number of rotations

⇒ **Natural sequence of integration:**
- insert one tower of back petals
- rotate the TEC
- insert one tower of front petals
- connect cables, ribbons, cooling of whole sector
- perform readout tests
- disconnect cables, ribbons, cooling
- rotate TEC for next sector

1 sector (=18 petals):
1 tower of back petals (9 petals)
1 tower of front petals (9 petals)
Integration of Petals: Petal Insertion

- Petals are fixed on disks via 3 inserts using a 3-point fixation mechanism
- Silicon covers most of the petal area → handling is difficult
- Silicon on both sides of the petals (i.e. also facing the disk)

⇒ petal insertion tool to ease this task

Images showing the insertion tool with labels:
- Hold petal at manifold
- Hold petal at its side
- Camera to ease positioning in insert
- Foot to adjust the height
Status of petal insertion tool:

- Working prototypes for back and front petals exist
- One last iteration necessary:
  - optimise a few mechanical details
  - integrate holder for optical fibers
- Can be ready within one week
TECs need to be rotated during integration:

- Rotation cradles for both TECs are operational
- TEC rotation is an easy and fast operation
- Full rotation needs approximately 10 minutes

Status of rotation cradles:
Integration of Petals: Cabling

On the petal side:
- Plug optical connectors (∼60/petal)
- Plug power cables (∼8/petal)
- Connect cooling manifold
- Technically straightforward, no special tools needed

On the bulkhead side:
- Power cables / multi-ribbon cables / cooling pipes stored in false floor
  ⇒ connect them with bulkhead facing floor
- Connect the 4 cooling loops and check for tightness (vacuum)
- Connect 48 LIC power cables plus 9 control power cables
  - Cables need to be fixed in correct height and orientation with adjusted length to avoid stress
  - Status of cable fixation: can only be done properly once all cables are available
- Connect ribbons to 14 multi-ribbon cables
  - Tool prepared to hold and protect fragile optical equipment
Integration of Petals: Cabling

Tool to hold and protect fragile optical equipment:

- Ribbons from service channel
- Ribbon storage box
- Fixation for connectors
- Protection for unprotected parts of multi-ribbon cables
- Multi-ribbon cables

**Status:**
- Prototype tested and working
- One more iteration necessary to optimise dimensions
- Final cabling to be done
- **One more week for finalization and cabling**
### Integration of Petals: Time Estimate

<table>
<thead>
<tr>
<th>Task</th>
<th>Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotate TEC into position</td>
<td>0.5</td>
</tr>
<tr>
<td>Insert 9 petals</td>
<td>4.5</td>
</tr>
<tr>
<td>Connect cooling</td>
<td>2.0</td>
</tr>
<tr>
<td>Connect cables</td>
<td>2.0</td>
</tr>
<tr>
<td>Connect optical fibers</td>
<td>9.0</td>
</tr>
<tr>
<td>Data base operations (?)</td>
<td>4.5</td>
</tr>
<tr>
<td>Connect cables, ribbons, cooling at bulk-head</td>
<td>6.0</td>
</tr>
<tr>
<td>Disconnect cables, ribbons, cooling at bulk-head</td>
<td>3.0</td>
</tr>
</tbody>
</table>

*Insertion and cabling of one sector* \(\approx 7 \text{ working days}\)

- This assumes that tasks are performed in series
- **Contingency:**
  - speed up by increase of man power
  - work in two shifts
Test sequence:

- Connectivity scan 45 minutes
- Commissioning runs: optimisation of
  - sampling time 2 hours
  - optical settings 45 minutes
  - APV baseline 45 minutes
- HV test ?
- Pedestal runs 2 hours
- Cosmic muons for S/N measurement and alignment
  - commissioning of cosmic trigger 2 days
  - data taking 3 days

⇒ Rough time estimate: 1 week per sector

- Readout software (xdaq version 3) developed in DAQ test (Lyon)
- Commissioning & readout of 18 petals proven to work in the DAQ test
- Automation software à la reception test to be developed, Hyper DAQ until then
- Contingency: skip cosmic runs ⇒ 2 days per sector for readout test
The first sector shall be operated in the cold asap (Lyon cold room operational at CERN in March 06)
- put mechanical structure under realistic stress
- investigate if petals can be cooled effectively
- study system aspects

• Cooling system based on Lauda chiller (3.7kW@-20C);
  pipework, flow meter readout etc. under preparation
• Whole TEC must be thermaly isolated;
  plates are currently being prepared
• Interlock & slow control: “small system” to be finalized next week (tracker DSS/DCS group)

Pipework with flow meter, pressure sensor, bypass, connection to vacuum & dry air etc.
When first sector is integrated into TEC structure, it is the first time that 18 petals are operated with the
- final grounding and shielding scheme
- final TEC multi-service cabling
- LIC cables (prototypes) of final lengths
- connection of temperature and humidity sensors to CAEN PS

⇒ Study noise performance & sensitivity to grounding in the final TEC structure with close to final components
In June, two back petals were integrated into the TEC+ and cosmics were taken:

- ENC similar to test beam, S/N roughly as expected from cluster width distribution
  - Grounding, cabling, readout etc. not final
  - No time for debugging ⇒ no final conclusive results
- **However, very useful integration experience:**
  - Insertion of petals “easy” (no damage even without insertion tool!)
  - Proper cabling of optical fibers is quite time-consuming (rest is fast)
  - Need tool to unplug single optical fibers (now available)
  - Gained experience in setting up the cosmic trigger
Status of Aachen-TIC

- Petal reception operational, but need to gain experience with production petals
- Clean room (class 100000, 50m²) ready since June
- Cooling system far advanced, all components in hands
- Minimal DAQ system for 2 petals running (thanks to DAQ experts)
- Take over hardware (CAEN power supplies, FEDs, FEC, etc.) from DAQ test
- DAQ for full sector needs to be commissioned
- Cabling to be finalized (waiting for more LIC cables)
- Interlock system to be debugged next week
- All necessary tools developed; to be finalized

Huge effort is being made to be ready in time for integration of the first sector!
Concerns

- Quality of received petals; not enough experience yet to judge
- Possible damage of petals during insertion into TEC; removal of petals for repair is tricky and time consuming
- Readyness of DAQ setup in Aachen (we are still missing components!)
- System aspects (stability of communication and readout, noise)
- Services have probably to be mounted when first petals are in the TEC+
- Repair of broken ribbons to be organised (spliced samples irradiated last week)
Schedule

With the following assumptions:
- Reception test of petals for one sector: 10 days
- Integration and cold test of first sector: 30 days
- Integration and test of further sectors: 12 days/sector
- Priority for petal delivery to TEC+
- 40 days cold test of full TECs in Lyon cold room at CERN
- Petal delivery according to J.-Ch. Fontaines schedule

<table>
<thead>
<tr>
<th>TEC+</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First sector integrated &amp; tested</td>
<td>December 05</td>
</tr>
<tr>
<td>Petal integration completed in Aachen (incl. 20 days cont.)</td>
<td>June 06</td>
</tr>
<tr>
<td><strong>Ready for insertion into tracker support tube</strong></td>
<td><strong>September 06</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TEC-</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First sector integrated &amp; tested</td>
<td>February 06</td>
</tr>
<tr>
<td>Petal integration completed</td>
<td>June 06</td>
</tr>
<tr>
<td><strong>Ready for insertion into tracker support tube</strong></td>
<td><strong>September 06</strong></td>
</tr>
</tbody>
</table>
Summary

- Reception test is operational in TIC-Aachen
- Tools for petal insertion are almost ready
- Tools and reception test GUI can be cloned for TIC-Lyon/CERN
- Test procedures have been defined
- Expect 12 days for integration of one sector if
  - petals are working!
  - DAQ for full sector is available
- With assumptions mentioned: TEC+ and TEC- fully integrated in June 06
- Need to gain experience for more detailed and reliable time scales
- There is still contingency in the planning
The DAQ Test

**Purpose:**
- develop and test the DAQ software to be used for integration
- develop and test commissioning tools for commissioning of large sub-systems of the tracker
- test the final hardware and firmware for functionality and performance, e.g. 11 FEDs in one crate

**DAQ test:** running from spring to October 05
18 early production petals mounted in shelves
Results:

• DAQ software was successfully developed and released
• 18 petals can be commissioned in a reasonable time
• Readout rate 10 Hz, limited by bandwidth of VME adapter card
• Lots of hardware & firmware problems identified and partly solved:
  - crashes of CAEN VME adapter card
  - fixes in FEC firmware
  - problem with clock of TTCex
  - fixes in FED VME firmware
  - etc.

⇒ Very useful experience for the tracker integration, cosmic challenge and the 25% test