Calibration procedures for the Tracker

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KG, NM
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Scope

Preliminary procedures are given for the test and calibration required during start-up and running of the Tracker. The various elements of the detector and readout chain are considered in turn, with consideration of the different parameters to be calibrated. The procedures are outlined along with the beam, trigger and DAQ conditions, the frequency of calibration, the time required and the type and volume of data produced and the handling of the calibration data.

Intro

Readout chain overview
- Sub-elements
- Quantities
- comments on overall calibration requirements
  - overall self-calibrating with signals
  - special runs mainly during startup
  - few instabilities expected over short durations
  - desire to avoid much communication during running.

Control system overview
- Partitions
- Rings
- impact on calibration procedures

Trigger and DAQ overview
- Global (+partitions)
- Standalone
- impact on calibration procedures

During start-up (or re-start after shutdown)

System level

- Verify the functionality of standalone trigger/DAQ system ***(WB, PGV, RAL)***
- Test the electrical/optical connections and basic functionality of control system (***- AM***)
- Test electrical/optical connections and basic functionality of analogue readout chains (***- IC, CERN, RAL)***
  - Develop simple procedure for uniquely identifying analogue data from individual APVs.
    - *One idea could be to use different test-pulse patterns to mimic an 8-bit address.*
    - Exercise optical links to determine if errors are at level of optical link connection.
  - Correct wrong connections/addresses *(repair hardware or read/write database)*.
  - Store dead chip/link addresses *(read/write database)*.

Sensors *(-?)*

- Scan for noisy, dead strips - compare with production tests *(read/write database)*.
- Bias voltage scan [, leakage currents, temperature] - compare with production tests *(read/write database)*.

- Backplane (or incident laser?) pulses - compare with production tests *(read/write database)*.
- [Alignment - check/store initial references *(read/write database)*.]

APVs ***(IC, RAL)***

- Synchronize APVs at level of 25ns bin, using known cable lengths *(read/write database)* ***(NM, AM)***
- Measure pedestals and noise. Compare with production tests. *(read/write database)*
- Measure common mode noise. *(write database)*
- Measure/optimize Pulse shape. Compare with production tests. *(read/write database)*
- [Set appropriate analogue baseline. *(read/write database)*]

Optical links ***(-CERN)***

- Set laser bias-points *(read/write database)*
- Set laser gains *(read/write database)*
- Set receiver offsets *(read/write database)*
- Measure transfer characteristic? Compare with production tests. *(read/write database)*
- Measure noise. Compare with production tests. *(read/write database)*
- Measure linearity. Compare with production tests. *(read/write database)*
  - use APV pulses or laser dc bias?

FEDs ***(-RAL)***

- Measure pedestals and write lookup table
- [Check basic functionality - standalone/global analogue data transfer, algorithms]

During operation (in-between physics runs)

System level

- Verify the functionality of standalone trigger/DAQ system

Sensors

- Scan for noisy, dead strips - Compare with previous measurements *(read/write database)*.
- Bias voltage scan, leakage currents- Compare with previous measurements *(read/write database)*.
- Backplane (or incident laser?) pulses - Compare with previous measurements *(read/write database)*.
- Alignment - Compare with previous measurements *(read/write database)*.

APVs

- Measure pedestals and noise. Compare with previous measurements. *(read/write database)*
- Measure common mode noise. Compare with previous measurements. *(read/write database)*

Optical links

- Trim laser bias-points. Compare with previous measurements *(read/write database)*
- Trim laser gains. Compare with previous measurements *(read/write database)*
- Trim receiver offsets. Compare with previous measurements *(read/write database)*
- Measure noise. Compare with previous measurements. *(read/write database)*

FEDs

- Update pedestal lookup table

During operation (during physics runs)

System level

- Monitor the functionality of standalone DAQ system.

Sensors

- Find tracks and measure MIP response *(on-line fast algorithm, read/write database)*.
- [Leakage currents, Temperature - Compare with previous measurements *(read/write database)*.]
- [Alignment with tracks *(offline, read/write database)*.]

APVs

- Verify coarse synchronization using tracks *(use APV in multi-mode at low luminosity?) (read/write database)*
- Refine synchronization with MIP signal (shape) measurement *(use APV in multi-mode at low luminosity?) (read/write database)*
- Measure pedestals and noise - verify that they match pre-run measurements. *(read/write database) - how to do this, data normally compressed.*
- Measure common mode noise. Compare with previous measurements. *(read/write database)*

Optical links

- No calibration actions

FEDs

- No calibration actions
- [Monitor occupancy of FEDs?]

Calibration action summary

Element	Parameter	Action	Duration	Frequency	Trigger	Beam	DAQ type	Data volume
Silicon detector	Response	Measure Landau (+Check for dead strips)	Sample from continuous data-taking	every N1 runs	Physics	On	Global	1 value per Z1 strips
	Alignment with laser		12 evts/laser about 4MHz pulses	Every minute In the abort gap	Synchronous with laser	On/Off	Global	

APV	Pedestals and noise	Measure dc and rms values each pipeline location Record dead channels	X1 sec per chip, measure Y1 at once	Every N2 runs *(also sometimes during physics runs)*	Standalone Random T1	Off (special run)	Standalone (FED in scope mode)	8 bits per pipeline cell
	Pulse shape	Measure response to calibration pulse and sweep latency and fine clock delay Iterate until shape is correct	X2 sec per chip Y2 chips at once	Every N3 runs	Standalone (Calibrate request '11') *(APV in multimode?)*	Off (special run)	Standalone (FED in scope mode)	8 bits x 32 per Z2 channels if measurement over 100ns interval
	Common mode noise	Measure CM normally subtracted at the FED	Sample during data-taking	Every run	Physics and Standalone	On/Off	Standalone	8bits per chip
	Synchronization	Check and fine-adjust TOF and cable delays by tracking	X2 sec per chip Y2 chips at once	At start-up	Physics	On *(special run?)* *APV in multi-mode?*	*Standalone or global?*	Latency + PLL setting per chip

Element	Parameter	Action	Duration	Frequency	Trigger	Beam	DAQ type	Data volume
Optical link	Laser bias point	Sweep laser bias via I2C, use APV tick-mark amplitude to find appropriate offset.	X4 sec per laser Y4 lasers at once	At start-up or restart + every N4 runs	*Standalone*	*Off (special run)*	*Standalone, FED in scope mode*	1 setting per laser
	Gain	Measure dc			*Standalone*	*Off*	*Standalone,*	1 gain value

		transfer characteristic or scan APV test pulse amplitude. Record dead channels			*(calibrate request +) trigger*	*(special run*	*FED in scope mode*	per laser
	Reciever dc offset	Set Rx offset to maximize dynamic range	X5 sec per laser Y5 lasers at once	At start-up or restart + every N4 runs	None	*Off (special run)*	*Standalone, FED in scope mode*	1 setting per Rx
	Link noise	Measure rms without APV signals, from samples in between APV ticks	X6 sec per laser Y6 lasers at once	At start-up or restart + every N4 runs	None	*Off (special run)*	*Standalone, FED in scope mode*	8 bits per link

Element	Parameter	Action	Duration	Frequency	Trigger	Beam	DAQ type	Data volume
FED	System Functionality	Check cabling Check for dead channels		At start-up or after maintenence	Standalone	Off	Standalone	?
	Linearity	Inject pulses Or APV pulses		At start-up	Calibrate request '11'	Off	Standalone	?
	LUT	Check/update contents		Before physics run	None	Off	Standalone	-

Notes (not exhaustive! Please add additional comments):

(i) Programs for automatic optimization of parameters and synchronization need to be defined

(ii) Interfaces to be defined with database of tracker parameters, production database and reconstruction database.

(iii) Missing values X, Y, Z, N to be determined.