

Online calibrations and performance of the ATLAS Pixel Detector

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On behalf of the ATLAS Collaboration







- Tuning of the optical link
- Tuning, calibration and performance of the front-end electronics
 - Threshold and noise
 - Charge measurement
 - Timing
 - Single-pixel leakage current



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The ATLAS Pixel Optical Link



- Data to and from the detector is transmitted over optical links
- Electro-optical conversion is done
 - On-detector in the optoboards, ~ 1m from the IP
 - Off-detector in the readout crates (back-of-crate cards)
- Optical link tuning:
 - Mainly adjustment of the parameters of the Rx(data)-link



- Parameters to be adjusted:
 - On-detector laser power
 - Sampling threshold and phase
- Bit error rate measurement for full parameter space to find the best parameter settings
- Difficulty: one common laser power setting for 6 or 7 modules
- All modules tuned at 40 Mb/s
- Inner 2 layers and discs tuned at 80 Mb/s





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The Front-End Pixel Cell





- Threshold scan: inject varying test charges and measure response curve: error function fit yields threshold and noise
- Threshold tuning: inject fixed test charge (threshold target) and vary the in-pixel threshold DAC. 50%-point gives optimal value
- In 2008 started with setting of 4000 e, working out of the box
- Setting now is 3500 e, resulting in an increase in number of masked pixels, but still negligible (0.1%)
- Next: optimise tuning algorithms for lower thresholds



• Typical threshold dispersion after tuning: $\sigma \sim 40 \text{ e}$

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- Very few outliers in all pixel classes
 - To be checked whether this can be improved in the tuning algorithms
- Noise for normal pixels

 170 e, higher in ganged
 pixels (~300 e) due to
 higher load capacitance
 - Reflected in threshold over noise, but still >10 for "worst" pixel class, ~20 for normal pixels





- Pixels with hit rate higher than 10⁻⁵ in dedicated noise runs are masked online (0.1% @ 3500 e)
- A few additional noisy pixels (1-2*10⁻⁵) are masked offline on run-by-run basis
- After offline masking noise rate ~10⁻¹⁰ corresponds to 0.4 hits per event with 5 BC readout in 80 million channels





Hit-to-track association • efficiency for the different parts of the detector

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- **Disabled modules have** ۲ been excluded, dead regions not
- (Full efficiency of the B-layer due to track selection)
- Efficiency ~99% for nearly all parts
 - Slightly lower efficiency in the outermost discs due to individual modules (cf. talk by Joshua Moss)





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- Time-over-threshold (ToT, length of discriminator signal) depends on
 - deposited charge
 - discriminator threshold
 - feedback current
- Information of the ToT (in units of 25 ns) is read out together with the hit information → measurement of the deposited charge





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- Time-over-threshold tuned pixel by pixel to 30 BC @ 20ke
- Calibration by means of test charge injections to reconstruct amount of deposited charge offline
- Example: Distribution of cluster charges
 - More examples in talk by Lidia dell'Asta





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Timewalk and In-time Threshold

- Hits with lower charge suffer timewalk
- This leads to an "In-time threshold" higher than the discriminator threshold for a hit detection "in time"
- At 3500 e threshold:
 - 4800 e for normal pixels
 - Higher load capacitance has been compensated for in ganged and interganged pixels
- Timewalk can be compensated for by on-chip hit doubling (using ToT information)
 - In-time threshold 200 e above threshold
 - Data volume increases (Testbeam: 10%)





- Several steps for adjustment of timing:
 - Trigger delays: from cosmic ray data
 - Cable lengths: values measured during installation
 - Final adjustment: timing scans with collisions
- After all adjustments: module-tomodule dispersion: 0.007 BC (corresponds to 0.17 ns)
 - Measured from average detection time for large charges
- Stability can be measured from stability of delay edge in Rx-scan
 - For most modules maximum delay band position changes ≤ 2 ns





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06/09/2010

AMS: indium

IZM: solder

11111

- FE-Chip has the possibility to ۲ measure leakage current pixel by pixel ("Monleak")
- Currently majority of pixels at 0 ٠
 - Measurement range and resolution ٠ optimised for after irradiation: LSB ~0.125 nA
- Single-pixel leakage current will be monitored with time
- In addition: we will soon equip our ٠ DCS hardware with the possibility to measure the single-module leakage current with 20 nA precision
 - First channels in 2010, rest in • shutdown 2011





- The ATLAS Pixel Detector has been calibrated and tuned to a stable working point
 - 3500 e threshold
 - Time over Threshold of 30 BC for 20 ke charge
- Performance at this working point is good
 - Threshold Dispersion ~ 40 e, average noise ~ 170 e
 - 4800 e average in-time threshold
 - Charge measurement resolution < 1000 e
 - Efficiency 98% 99%
 - Online noise occupancy O(10⁻⁸)
- Some tasks for the (near) future will be
 - Define working points for higher luminosity and (for the somewhat further future) lower signals
 - Use the available calibration measurements to monitor detector properties over time (e.g. leakage current, bump connectivity)

Conclusions



Backup

06/09/2010 Pixel 2010, Grindelwald, Switzerland



The ATLAS Pixel Module



06/09/2010 Pixel 2010, Grindelwald, Switzerland

