sMDT chambers in ATLAS

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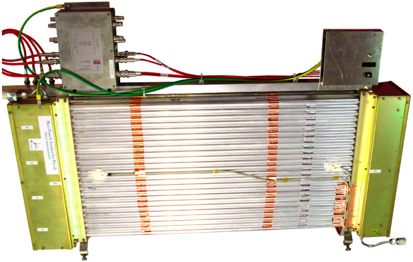
http://atlas.ch

sMDT chambers installed in the ATLAS cavern

Small Wheel A, CSC region



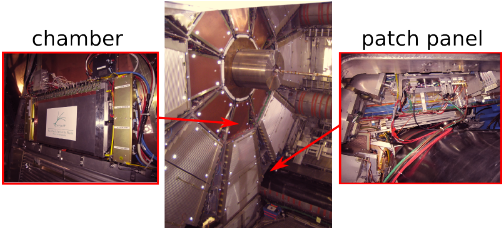
- 1 multilayer consisting of 4 tube layers
- 96 tubes in total
- 4 high voltage segments for rate measurement in the small wheel as a function of *r*

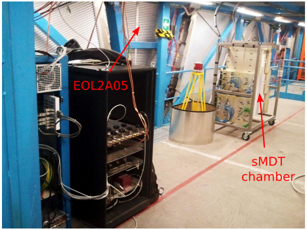
H0 structure, side A, level 6

- 2 multilayer consisting of 8 tube layers each
- 1152 tubes in total
- $^{2}/_{3}$ equipped with electronics

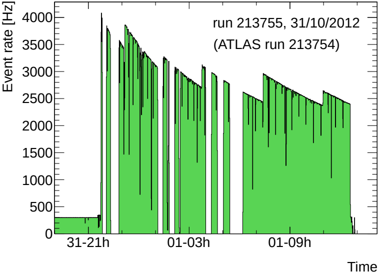
Installation and operation

Both sMDT chambers were installed during the last winter shutdown





- Data acquisition in a seperate partition
    - needs be started manually and synchronously to a combined ATLAS run in order to get same Level 1 IDs (for offline event matching).
- Running with Level 1 trigger and a pre-scale factor of 0.01 ⇒ several kHz during stable beams.
- Several runs taken two weeks ago. Went very smoothly, the only issue observed is some missing data files.



Rate measurement methods

Main goal:

Measure the rate in the CSC region with (s)MDT technology to better understand background sensitivities of different detector technologies and validate the rate extrapolation to small r and large $\mathcal{L}$.

Therefore use two independent methods:

Hit counting method:

- Count number of hits n_{hits} in a time window of length t_{window} in individual tubes
- n_{events}: total number of events/triggers, l_{tube}: tube length, d_{tube}: tube diameter

$$\Rightarrow \boxed{\text{Hitrate}[\text{Hz}/\text{cm}^2] = \frac{n_{\text{hits}}}{t_{\text{window}} \cdot n_{\text{events}}} \cdot \frac{1}{l_{\text{tube}} \cdot d_{\text{tube}}}}$$

High voltage current method:

- The current drawn by n_{tubes} tubes is: $I_{\text{tube}} = n_{\text{tubes}} \cdot R \cdot q_{\text{prim}} \cdot G$
- R: hit rate, q_{prim}: primary ionization charge, G: gas gain

$$\Rightarrow \boxed{\text{Hitrate}[\text{Hz}/\text{cm}^2] = \frac{n_{\text{tubes}} \cdot I_{\text{tube}}}{q_{\text{prim}} \cdot G}}$$

Rate measurement in the Small Wheel(s)

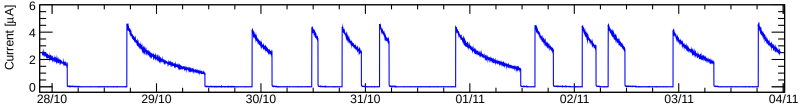
HV current method

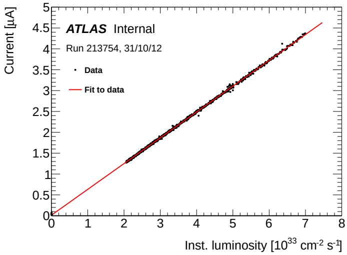
- The chambers were operated since their installation in February.
- Three high voltage modes, essentially automatically controlled by means of the LHC beam mode:

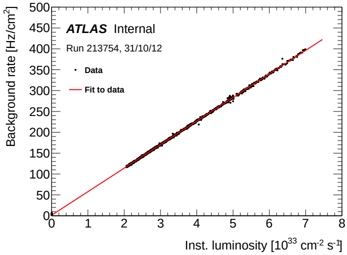
HV READY	2730 V, toggled by STABLE BEAMS
HV STANDBY	1000 V, toggled by PRECYCLE
HV OFF	0 V

Delayed transition to STANDBY for measurement of the cavern background afterglowing.

Example of HV current in tubes experiencing the highest rates:







Rate measurement in the Small Wheel(s)

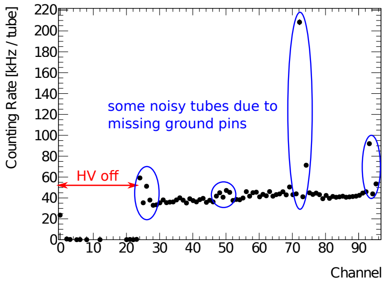
Hit counting method

Some workarounds in the assembly owing to the tight time schedule.

- wire crimping not perfect
- some missing ground pins

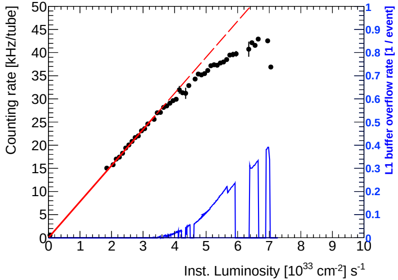
which resulted in

- probably 1 broken wire (⇒ short)
- noisy tubes where the ground pins are missing

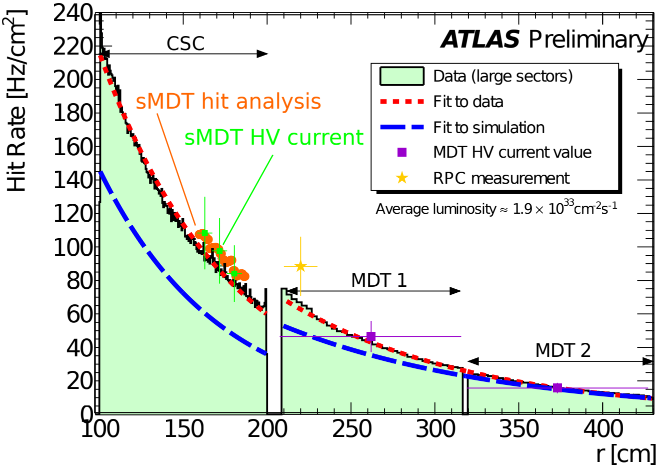


The few noisy tubes, together with the long search window (2.5 µs), causes L1 buffer overflows in the AMT.
⇒ loss of hits at high luminosity.

Can be cured by reducing the length of the search window or disabling the noisy channels.
For now: fit linear range ($\mathcal{L} < 3.5 \times 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$) and extrapolate

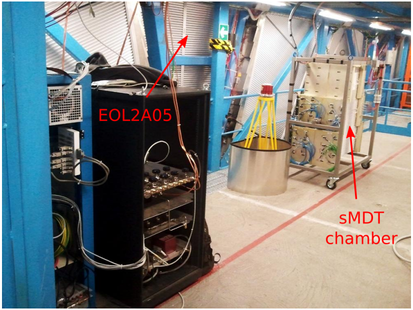


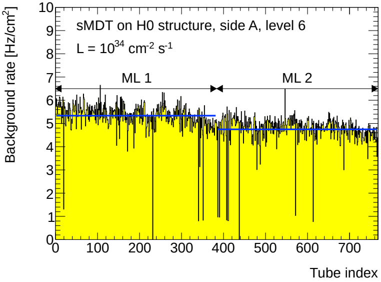
Background rate in the Small Wheel(s)



- The two measurement methods agree very well
- sMDT rate follows the CSCs and is slightly higher (expected, due to higher background sensitivity) . . .
- . . . however not as much as one would expect from the MDT
- Some uncertainties to be followed up (e.g. 2011 vs. 2012 data, primary ionization)

Background rate on the H0 structure





EOL2A05 rates from HV current measurement (J. Dubbert):

ML1: $12.96 \pm 1.07\,\mathrm{Hz/cm^2}$

ML2: $11.69 \pm 1.21\,\mathrm{Hz/cm^2}$

- Flux decreases from multilayer to multilayer.
- Factor 2 decrease in flux from EOL chamber to sMDT chamber (distance $\approx 2\,\mathrm{m}$).

$\Rightarrow$ EO chambers not a good reference for measuring background sensitivity in this place.

Afterglow measurement

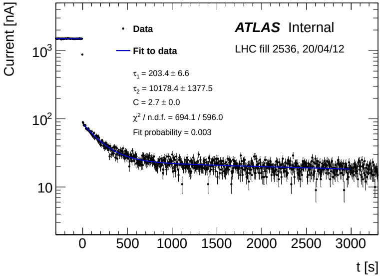
Measurement of the decay constant(s) of the cavern background

Fit the current before and after the beam dump ($t = 0$):

$t < 0$: with a 1st order polynomial $I_{\text{before}}(t)$ and

$t \geq 0$: with two exponential decay functions and constant dark current:
$I_{\text{after}}(t) = A \cdot \exp(-t/\tau_1) + B \cdot \exp(-t/\tau_2) + C$

Did this for several runs with the high voltage kept at its operating value for up to four hours after the beam dump.



Results:

$\langle \tau_1 \rangle = (204 \pm 3)\,\text{s}$

$\langle \tau_2 \rangle = (13755 \pm 577)\,\text{s}$

Afterglow rate $= \frac{I_{\text{before}}(0)}{I_{\text{afer}}(0)} = (5.5 \pm 0.1)\%$

Possible isotopes are $^{13}_{28}\text{Al}$ ($\tau = 194\,\text{s}$) and $^{56}_{25}\text{Mn}$ ($\tau = 13392\,\text{s}$). Both can be produced in fast and thermal neutron activation and occur in the steel parts of the mounting and shielding material.

Summary and Outlook

- Successful operation of two sMDT chambers in the ATLAS cavern for several months.
- First data used to measure the background rates, additional measurement with HV currents.
- Found surprising differences in the background rate with respect to neighbouring MDTs.
- Data taking has just started, hope to take some more runs during the next couple of weeks.
  - Take runs with shorter search window and noisy channels disabled
  - Match events with ATLAS data for efficiency measurement

- Thanks to: Tatiana Klioutchnikova, Preema Rennee Pais, Mathieu Aurousseau, Enrico Pasqualucci, Tiesheng Dai, Jörg Dubbert!