To cool or not to cool

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Temperature uniformity of the TPC gas

• Target uniformity is 0.1 K (see backup)

• TPC has cooling everywhere except in the central drum (ITS, MFT)

• The rms of several ‘skirt’ sensors inside the gas is used as reference
Status

- High precision calibration of many new temperature sensors
- Fix all cooling leaks
- Optimisation of electronics cooling water temperature and flows (new FECs, new cooling circuitry)
- Increase by 1 °C the solenoid air ventilation (18 °C)
- Assess influence of inner detectors
10 days trend: several effects
More sensors on IFC (different color scheme)
Tuned temperatures of all TPC cooling loops
Why 0.1 K uniformity

<table>
<thead>
<tr>
<th></th>
<th>$\Delta V_d$ [90-10]</th>
<th>$\Delta V_d$ [90-10-5]</th>
<th>$\Delta G$ [90-10]</th>
<th>$\Delta G$ [90-10-5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (per K)</td>
<td>0.37%</td>
<td>0.35%</td>
<td>0.9%</td>
<td></td>
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<tr>
<td>P (per mbar)</td>
<td>-0.15%</td>
<td>-0.15%</td>
<td>-0.34</td>
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<tr>
<td>[CO$_2$] (per 1%)</td>
<td>-7.6%</td>
<td>-6.4%</td>
<td>+67%/ -20%</td>
<td>+17%/-14%</td>
</tr>
<tr>
<td>[N$_2$] (per 1%)</td>
<td>-1%</td>
<td>-1%</td>
<td>+34%</td>
<td>+6.3%</td>
</tr>
</tbody>
</table>

Uniformity of $V_d$ is required to be at the $10^{-4}$ level in order not to affect the nominal position resolution.

In the GEM system (four amplification stages) the gain dependence on temperature might be even larger than in MWPC.

J. Wiechula et al. NIM A548 (2005)
TPC cooling and thermal screens

- Every heat source is water cooled
- Every outer surface is thermally screened, except the inner drum
- Dozens of temperature sensors are used to monitor