Updates from DESY

Günter Eckerlin, Jens Hansen, Carsten Muhl, Andreas Mussgiller & Jan Olzem

Tracker Upgrade Cooling and Mechanics Meeting
10/02/2010
Outline

- Module with long strixel
  - Refined results for standard design
  - Design with long cooling contact
  - Thermal & material budget comparisons

- Module with short strixel
  - Standard design
  - Design with long cooling contact
  - Thermal comparison

- Status of lab setup

All FE calculations carried out using **GetDP**: [http://www.geuz.org/getdp](http://www.geuz.org/getdp)
Standard Design with long Strixel

- Sensor
- CBC
- Hybrid
- Support
- Cooling block

Dimensions:
- 100 mm
- 14 mm

Updates from DESY
Tk Upgrade Cooling & Mechanics, 10/02/10
• Inner surface of **CO2 layer** kept at reference temperature

\[ q = 750 \text{ mW} \]

\[ q = f(T) \]
Standard Design with long Strixel (cont.)

CBC

Hybrid

Support

Sensor

Cooling block

Pipe 1.0 x 0.3 mm

CO2

CO2
## Standard Design - Material

<table>
<thead>
<tr>
<th>component</th>
<th>in-plane thermal conductivity [W/m*K]</th>
<th>out-of-plane thermal conductivity [W/m*K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensor and CBCs</td>
<td>148</td>
<td>148</td>
</tr>
<tr>
<td>glue</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>glue (sensor/support)</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>CF</td>
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<td>0.7</td>
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<tr>
<td>TPG</td>
<td>1500</td>
<td>20</td>
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<tr>
<td>G10</td>
<td>0.3</td>
<td>0.3</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Hybrid</td>
<td>30.8</td>
<td>0.37</td>
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<tr>
<td>Aluminum</td>
<td>240</td>
<td>240</td>
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<tr>
<td>Stainless Steel (pipe)</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

Heat transfer from cooling pipe to CO2 modelled by 200um thick layer on inner pipe wall with

\[
\lambda = h \cdot t = 5000 \frac{W}{m^2 K} \cdot 200 \, \mu m = 1 \frac{W}{mK}
\]
Fluence: 1.7e14
CBC power: 0.750 W
CO2 temp: -35°C
Long Cooling Contact Design with long Strixel (cont.)

- Inner surface of **CO2 layer** kept at reference temperature

$q = 750 \text{ mW}$

$q = f(T)$
Heat transfer from cooling pipe to CO2 modelled by 200um thick layer on inner pipe wall with

$$\lambda = h \cdot t = 5000 \frac{W}{m^2 K} \cdot 200 \mu m = 1 \frac{W}{mK}$$
Updates from DESY

Long Cooling Contact Design with long Strixel - Distributions

Fluence: 1.7e14
CBC power: 0.750 W
CO2 temp: -35°C
• Sensor power calculated for a fluence of $1.7 \times 10^{14}$ @ 600V bias voltage
• CBC power: 0.750 W
Sensor power calculated for a fluence of $1.7 \times 10^{14}$ @ 600V bias voltage
CBC power: 0.750 W
Long Strixel Comparison - Thermal Runaway

Fluence: $1.7 \times 10^{14}$
CBC power: 0.750 W (125 mW per chip)

- Thermal runaway
  - Standard: ~ -12 °C
  - Long Contact: ~ -6 °C
- No difference between Long Contact options
### Long Strixel Comparison - Material

#### Long Contact I

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume $cm^3$</th>
<th>Density $g/cm^3$</th>
<th>Weight $g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>2.000</td>
<td>2.330</td>
<td>4.660</td>
</tr>
<tr>
<td>Hybrid</td>
<td>0.420</td>
<td>2.000</td>
<td>0.840</td>
</tr>
<tr>
<td>CBC</td>
<td>0.072</td>
<td>2.330</td>
<td>0.168</td>
</tr>
<tr>
<td>CFModule</td>
<td>0.924</td>
<td>1.750</td>
<td>1.617</td>
</tr>
<tr>
<td>Kapton</td>
<td>0.140</td>
<td>1.850</td>
<td>0.259</td>
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<tr>
<td>GlueModule</td>
<td>0.316</td>
<td>1.200</td>
<td>0.379</td>
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<tr>
<td>CFBase</td>
<td>3.856</td>
<td>1.750</td>
<td>6.748</td>
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<tr>
<td>GlueBase</td>
<td>0.188</td>
<td>1.200</td>
<td>0.226</td>
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<tr>
<td>Pipe</td>
<td>0.147</td>
<td>7.800</td>
<td>1.147</td>
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<td><strong>sum</strong></td>
<td><strong>8.063</strong></td>
<td><strong>1.990</strong></td>
<td><strong>16.044</strong></td>
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</table>

#### Long Contact II

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume $cm^3$</th>
<th>Density $g/cm^3$</th>
<th>Weight $g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>2.000</td>
<td>2.330</td>
<td>4.660</td>
</tr>
<tr>
<td>Hybrid</td>
<td>1.232</td>
<td>2.000</td>
<td>2.464</td>
</tr>
<tr>
<td>CBC</td>
<td>0.072</td>
<td>2.330</td>
<td>0.168</td>
</tr>
<tr>
<td>CF</td>
<td>0.336</td>
<td>1.750</td>
<td>0.588</td>
</tr>
<tr>
<td>TPG</td>
<td>1.344</td>
<td>2.260</td>
<td>3.037</td>
</tr>
<tr>
<td>Glue</td>
<td>0.202</td>
<td>1.200</td>
<td>0.242</td>
</tr>
<tr>
<td>CoolBlock</td>
<td>0.820</td>
<td>2.700</td>
<td>2.214</td>
</tr>
<tr>
<td><strong>sum</strong></td>
<td><strong>6.085</strong></td>
<td><strong>2.075</strong></td>
<td><strong>12.628</strong></td>
</tr>
</tbody>
</table>

#### Standard

<table>
<thead>
<tr>
<th>Component</th>
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<td>0.820</td>
<td>2.700</td>
<td>2.214</td>
</tr>
<tr>
<td><strong>sum</strong></td>
<td><strong>6.006</strong></td>
<td><strong>2.227</strong></td>
<td><strong>13.373</strong></td>
</tr>
</tbody>
</table>

### Components on module

- **Standard**
  - **Design** + **Components related to cooling and support**

#### Components related to cooling and support

<table>
<thead>
<tr>
<th>Design</th>
<th>Weight $g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Contact I</td>
<td>10.4 g</td>
</tr>
<tr>
<td>Long Contact II</td>
<td>7.0 g</td>
</tr>
<tr>
<td>Standard</td>
<td>6.1 g</td>
</tr>
</tbody>
</table>
Short Strixel Designs

Standard

Long Contact 1
Short Strixel Designs - Temperature Distribution

Fluence: 4.3e14  
CBC power: 1.50 W  
CO2 temp: -35°C
Short Strixel Designs - Sensor Temperature Distribution

Fluence: 4.3e14
CBC power: 1.50 W
CO2 temp: -35°C
Short Strixel Comparison - Thermal Runaway

• Thermal runaway
  • Standard: ~ -12 °C
  • Long Contact: ~ -6 °C

Fluence: 4.3e14
CBC power: 1.50 W (125 mW per chip)
Status of Lab Setup

- Conventional cooling (silicon oil)
- 10 x 20 cm plate in vacuum (cold mass) with mounting grid
- Max. 10 temperature sensors (pt100)
- Additional feed-throughs for power sources
- Vacuum chamber under construction
Outlook - Lab Measurements

- Investigate heat transfer between components
- Make FE calculations more realistic
- Eventually test a prototype module
- Extension of setup allows deformation measurements
- Principle has been proven to work (see thesis by S. König, Aachen)
Summary

• Modelling heat transfer from CO2 to pipe increases max. sensor temperature by ~2 °C for Standard Design (at -35 °C and fluence of 1.7e14)

• Standard Design
  • Thermal runaway point at ~ -12 °C (both long and short strixel)

• Long Contact Design
  • Thermal runaway point at ~ -6 °C (both long and short strixel)

• **Remark:** Power of sensor is calculated from fluence, temperature and volume
  • All numbers given are valid only for a sensor thickness of 200 um

• Material budgets of both designs are compareable (long and short strixel)

• Long Contact Design
  • Further reduction of material without degrading thermal performance probably possible
  • Support bridge with cooling pipe also increases mechanical strength of rod structure