Temperatures in the TDE core for 2017 beams

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Beam Parameters and Filling Schemes

- Temperature studies for the following filling schemes:

Filling scheme	BCMS	8b4e
25ns_2556b_2544_2215_2332_144bpi_20inj	Yes	No
25ns_1916b_1909_1042_1560_112bpi_20i8b4e	No	Yes
25ns_1868b_1866_1089_1749_128bpi_17inj_800ns_bs200ns_8b4e	Yes	Yes
25ns_1836b_1824_1052_1688_96bpi_20inj_800ns_bs200ns_8b4e	Yes	Yes

  → Filling scheme with 2556 bunches achieved in June 2017
  → 1916 bunch scheme successfully deployed in August and September 2017 due to 16L2 issues
  → 1868b- and 1836b-schemes possible options for future operation

- For the sake of simplicity, all simulations carried out with **BCMS emittance of 1.4 μm rad** (peak temperatures in the TDE show only weak dependency on transverse bunch emittance)
- All calculations assuming a **bunch intensity of 1.2×10^{11} protons**

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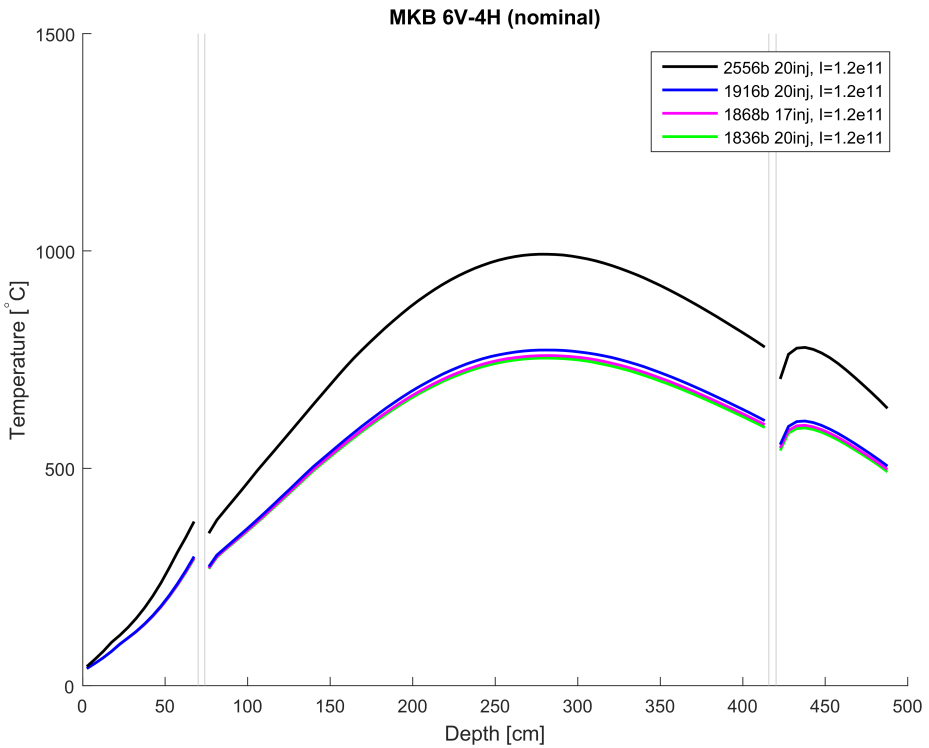
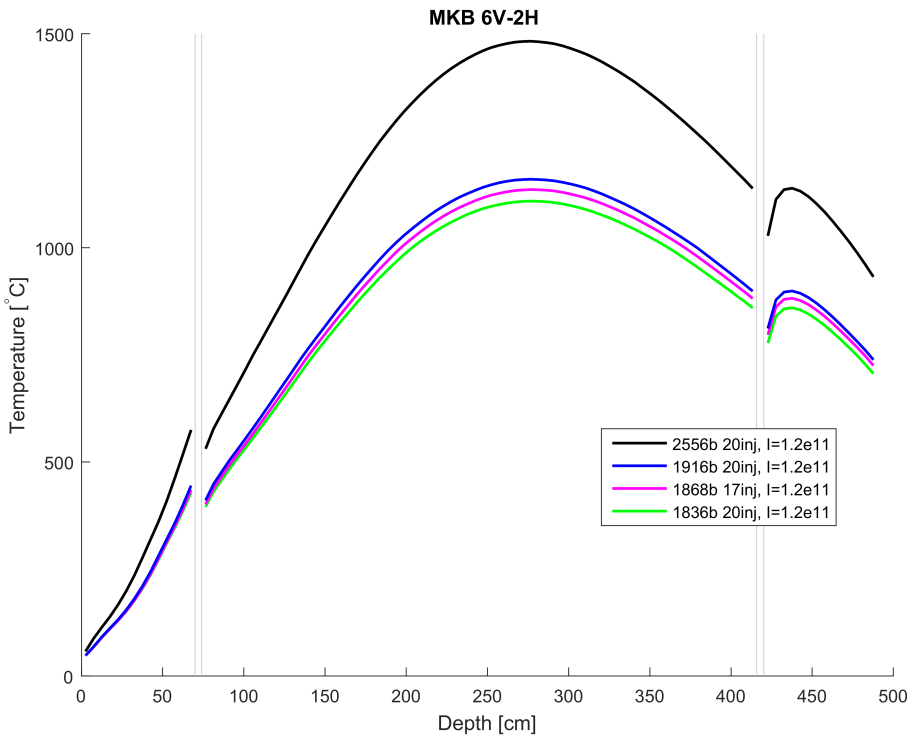
Longitudinal Distribution of Peak Temperature

- **Peak temperatures** calculated in the **low-density graphite segments** and the **two adjacent high-density blocks** for two cases:
  - **Regular beam sweep** (MKB 6V-4H)
  - **Two horizontal dilution kickers providing no kick** (MKB 6V-2H)
- **Longitudinal distribution** of peak temperatures **for different filling schemes**:



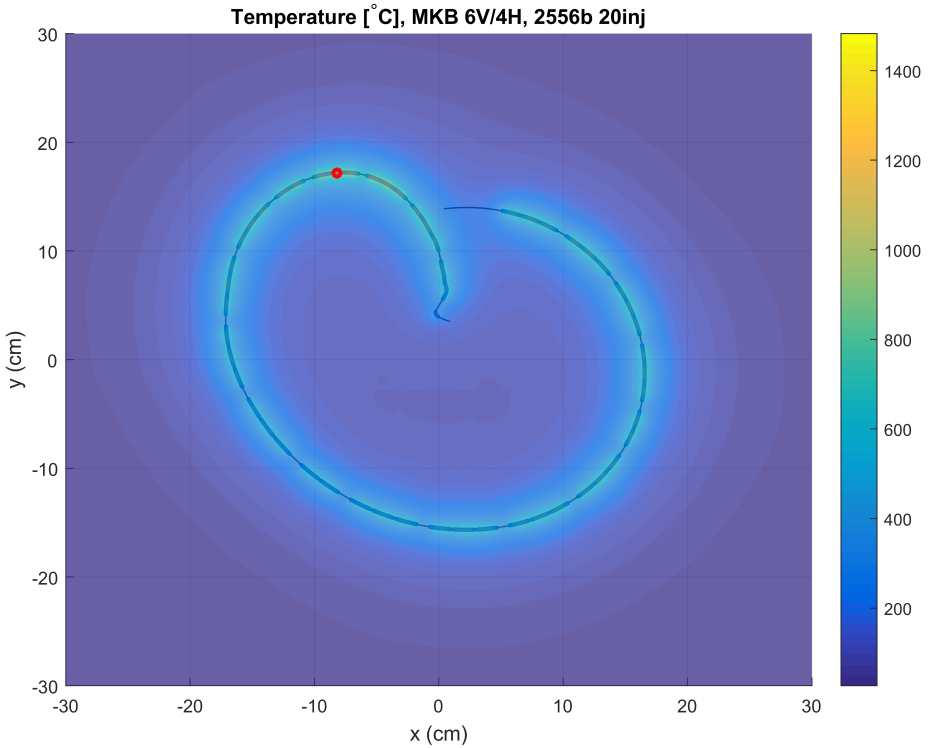
Regular beam sweeps



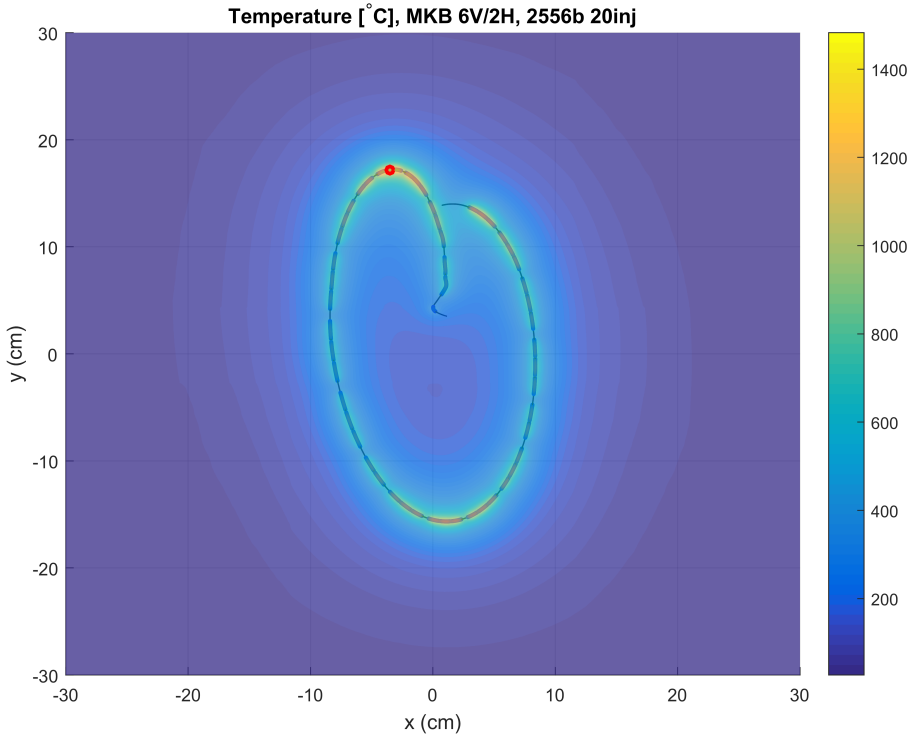
Two horizontal kickers missing

2556 bunches: Transverse temperature distribution

- **Peak temperature** occurs at a **depth of around 2.8 m**
- The **location of the peak temperature** coincides roughly with the **lowest sweep velocity**
- This occurs after about 15 μsec with the **vertical dilution changing direction**
- **Transversal temperature distribution** at depth of 280 cm **for the filling scheme with 2556 bunches**:



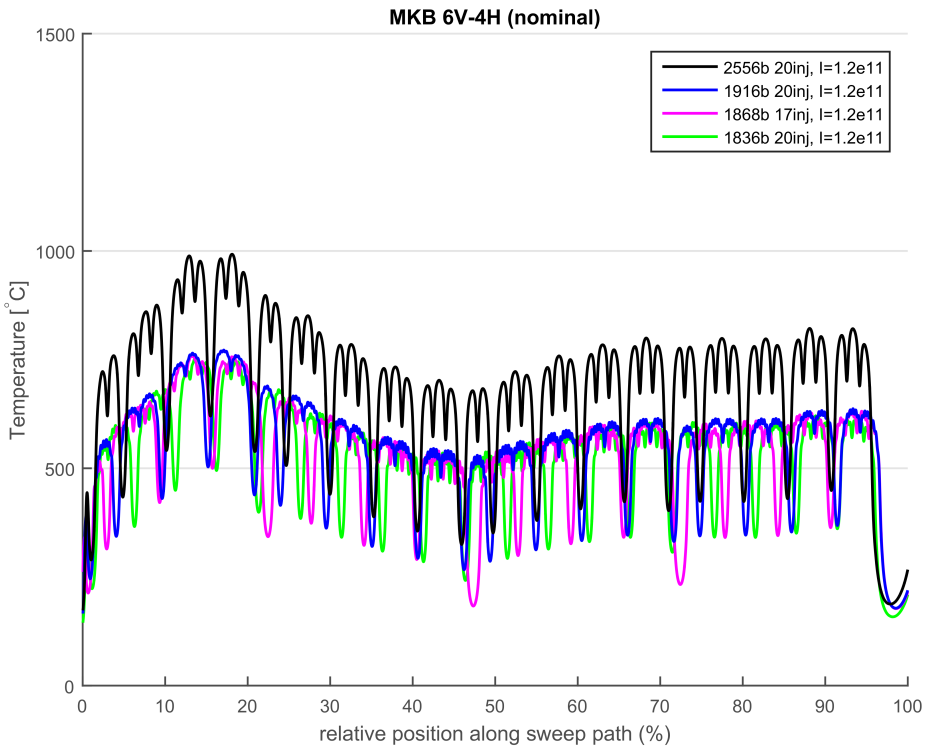
Regular beam sweep



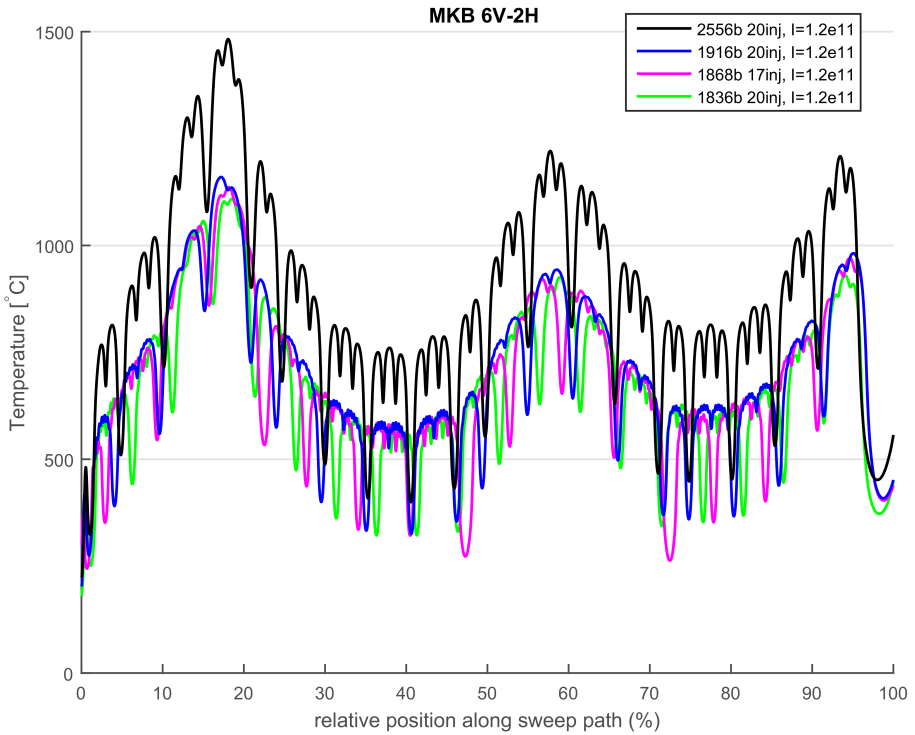
Two horizontal kickers missing

Temperatures along Sweep Paths

- Temperature distributions along sweep paths (at 2.8 m depth) **for the different filling schemes**:



Regular beam sweeps



Two horizontal kickers missing

Maximum Temperatures - Overview

	Regular sweep		Two horizontal dilution kickers not firing	
Number of bunches	**Max. temperature in low-density core**	**Max. temperature at surface in contact with N_2**	**Max. temperature in low-density core**	**Max. temperature at surface in contact with N_2**
2556	990 °C	780 °C	1480 °C	1140 °C
1916 (8b4e)	770 °C	610 °C	1160 °C	900 °C
1868 (8b4e)	760 °C	600 °C	1140 °C	880 °C
1836 (8b4e)	750 °C	600 °C	1110 °C	860 °C

- The maximum temperature **at a graphite surface** in direct contact with nitrogen atmosphere is $\sim$ **20 % lower than** the peak temperature **inside the low-density block**
- Temperatures for **8b4e-based schemes** are **similar**, for the **2556 bunch scheme** they are $\sim$ **30 % higher**

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Summary & Conclusions

- For regular sweeps the maximum temperature in the graphitic LHC dump core is estimated to be
  - around **1000°C** for **a 2556 bunch filling scheme**
  - less than **800°C** for **8b4e schemes** containing 1916, 1868 or 1836 bunches, respectively.
- In case two horizontal dilution kickers provide no kick, the temperatures rise to
  - about **1500°C** for the **a 2556 bunch filling scheme** and
  - **1100-1200°C** for the **8b4e-based schemes**
- **Accuracy of temperature estimates**
  - Error of **energy deposition** calculations estimated as **10 %**
  - Error due to **assumed material properties** (density, specific heat) **10-15 %**

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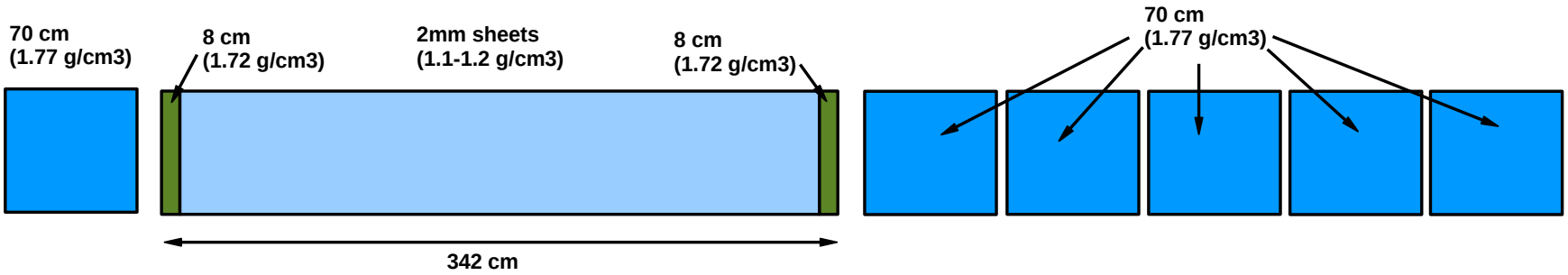
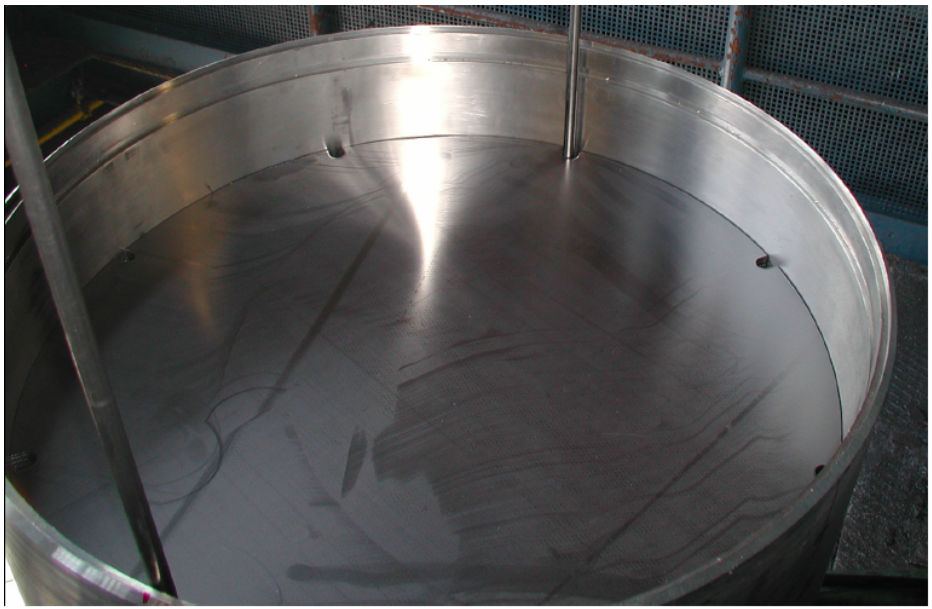
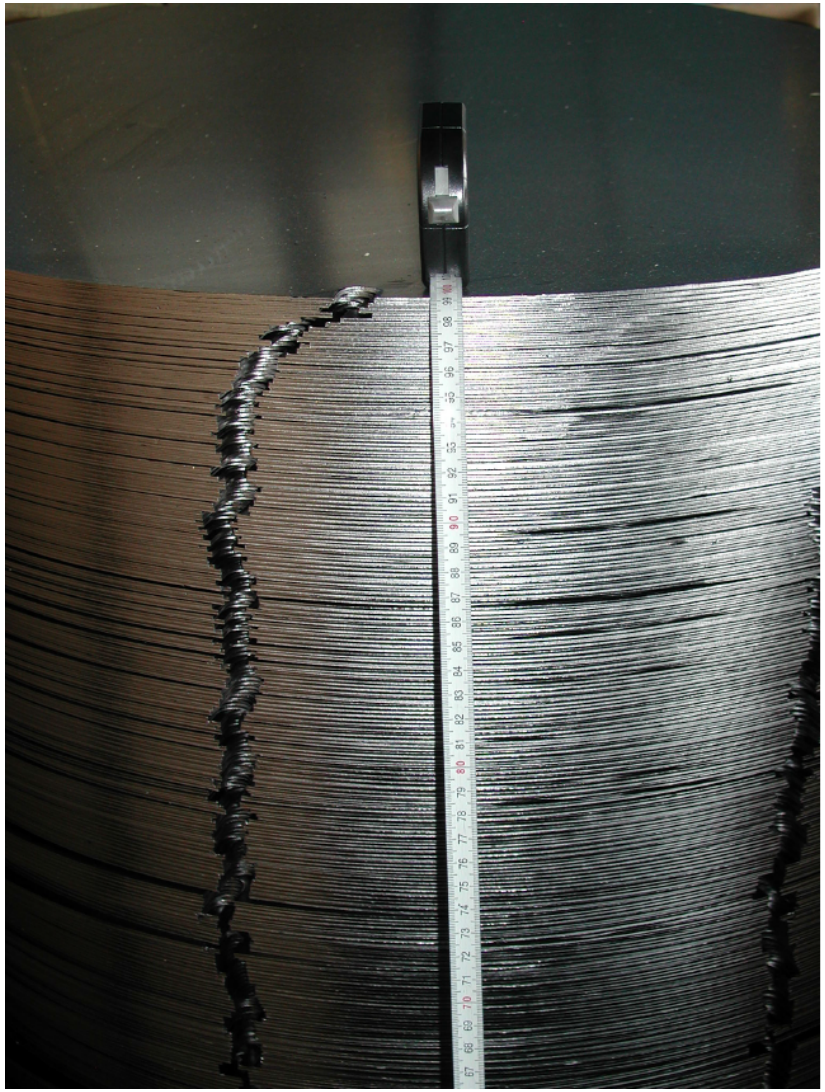
TDE Graphite core



- LHC dump core consisting of high- and low-density graphite absorbers
- Diameter of 70 cm and a total absorber length of $\sim$7.6 m
- Low-density graphite absorber made of 2 mm thick, flexible graphite sheets
- Other absorber blocks consist of polycrystalline graphite
- Graphite segments are shrink-fitted into a 12 mm thick stainless steel jacket
- Presence of outgassing groves, also providing passage for the N_2 along the core

Low-density flexible graphite sheets





Specific Heat

- Calculation of a temperature increase based on the obtained distribution of the energy deposition
- Important: Taking into account the temperature dependency of the specific heat of graphite