Extraction Kickers

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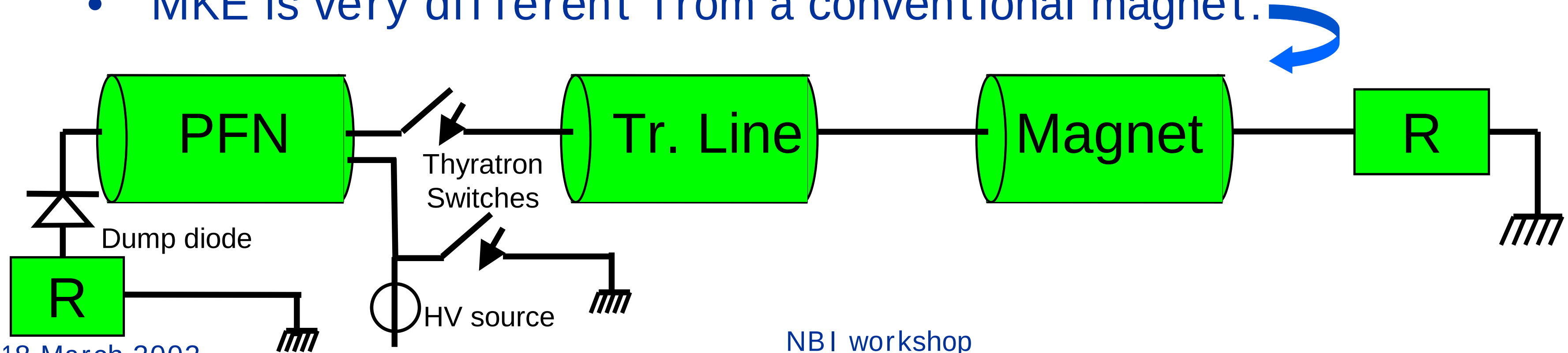
Outline

- The Job of the Extraction Kicker Magnet
- Parameters Determining the Kicker Design
- The Heating Problem
- Summary

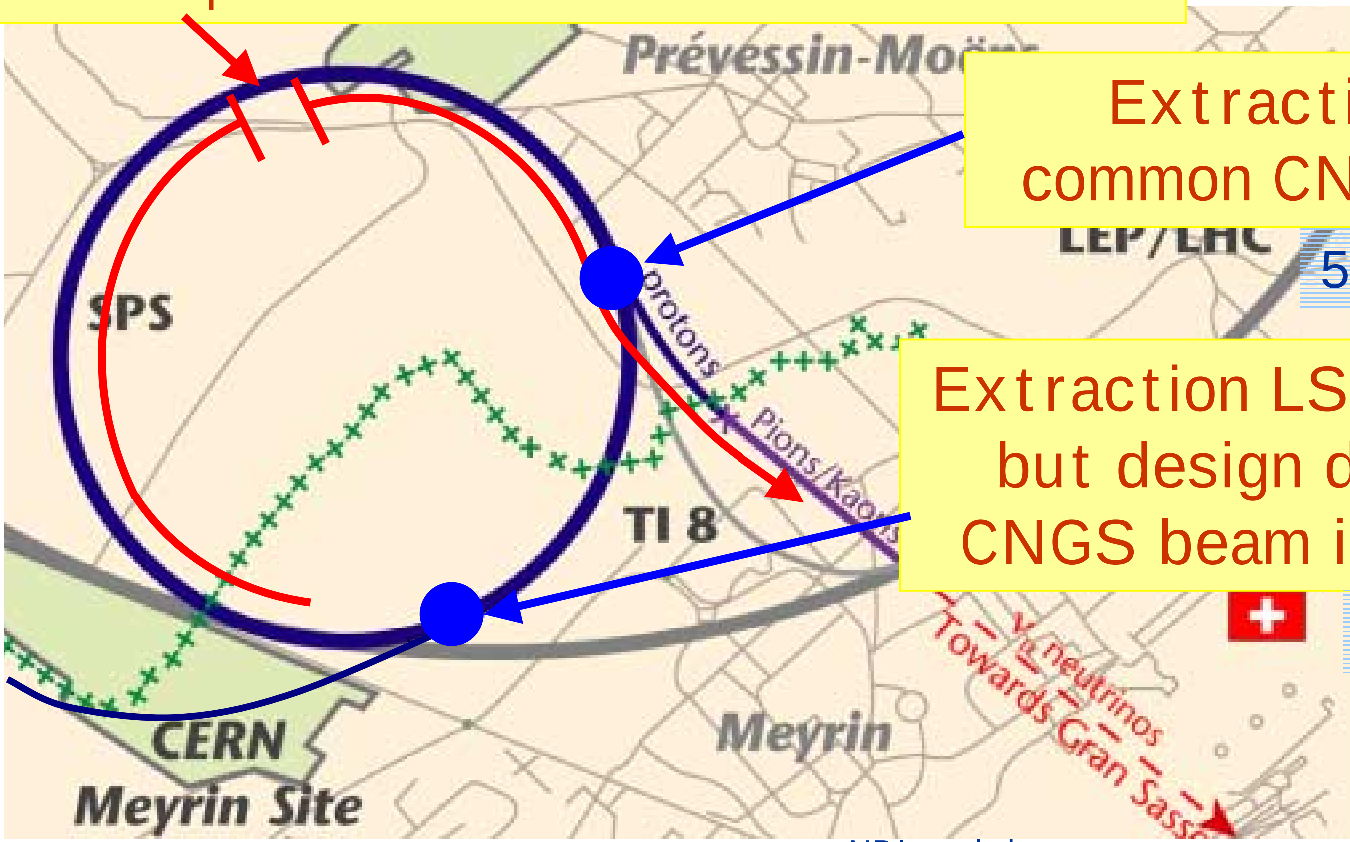
The Job of the Kicker Magnets MKE

- Fast extraction from the SPS into the extraction channels towards CNGS and towards the LHC is performed by a DC bump, extraction kicker magnets (MKE) and septa (MSE). This talk is about the kickers MKE.
- The parameters of the kicker magnets are largely determined by the CNGS requirements in contrast to the 'slower' elements.
- MKE kicker magnets and their Pulse Forming Networks (PFNs) are already existing but need to be modified to comply to the LHC and CNGS requirements.
- MKE is very different from a conventional magnet:



The Job of the Kicker Magnets: extraction from the SPS

Hole for kicker rise time and fall time of 1.1 μs, only needed for CNGS. The LHC beam has “no” requirements on rise- and fall time



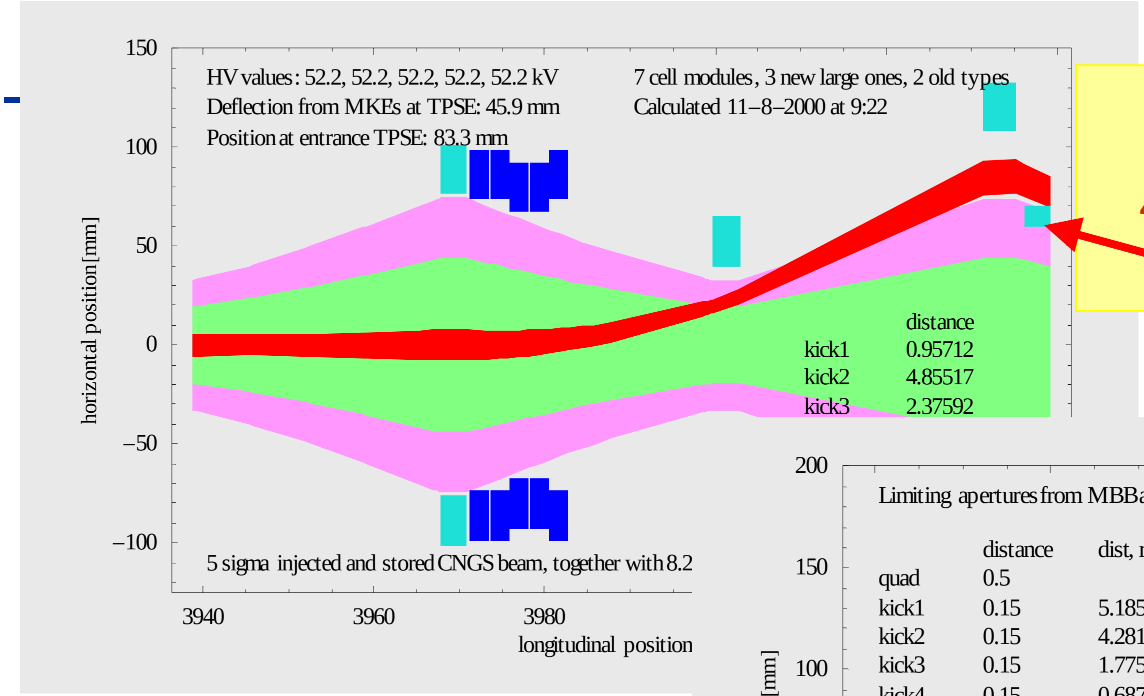
Extraction LSS4: common CNGS and LHC

5 MKE magnets

Extraction LSS6: For LHC but design depends on CNGS beam intensities...

2 MKE magnets

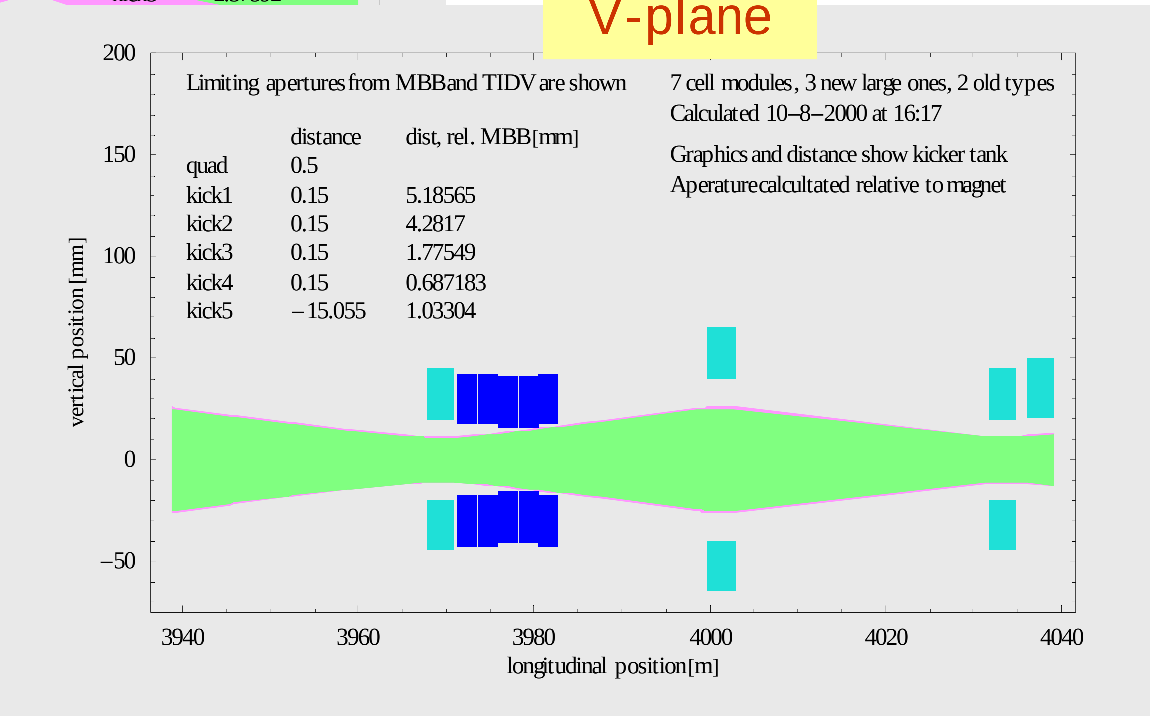
LSS4: 5 kicker magnets



H-plane

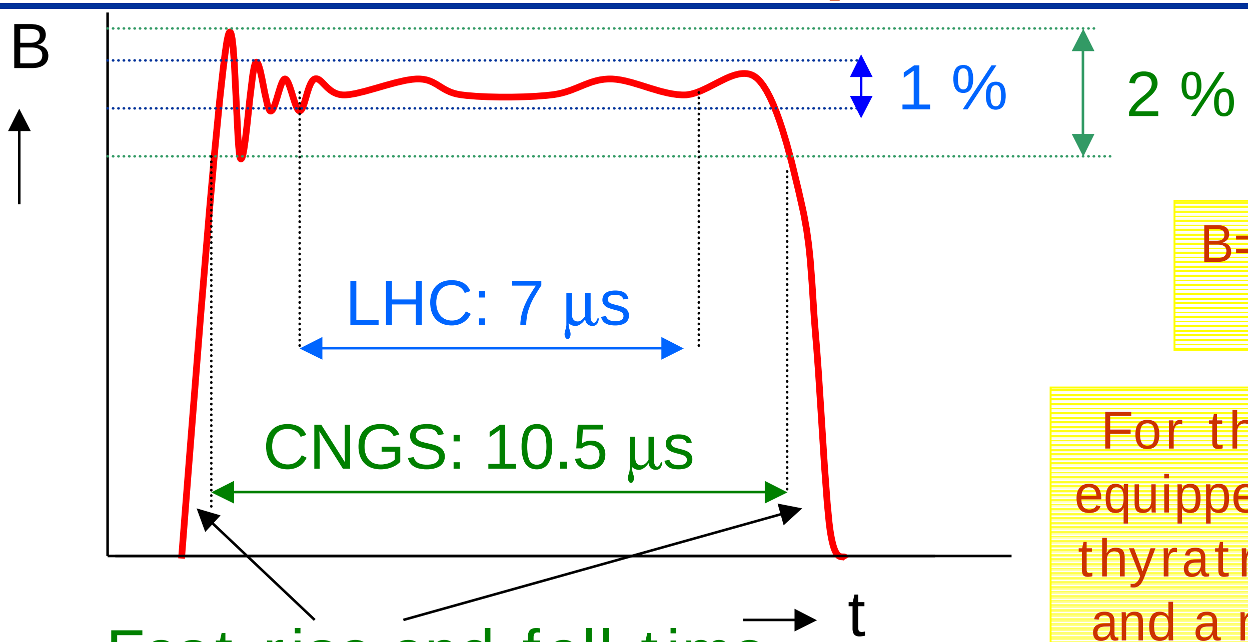
45.9 mm deflection at septum shield

V-plane



- Very tight horizontal and vertical apertures
- Constant relationship between H- and V-apertures to have same inductance for both magnet types

Timing foreseen for 10.5 μs CNGS pulse



Fast rise and fall time required by CNGS only

B= 0.1 T for 52 kV on the PFN

For this the PFNs will be equipped with an additional thyratron as clipper switch and a new system of a HV diode stack instead of a dump switch thyratron

Two of those pulses are required within an SPS cycle: need a second Resonant Charging Power Supply because of CNGS

Parameters Determining the Kicker Design

- 45.9 mm deflection at septum entrance
- 1.1 μs rise and fall time of the kicker field

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- Use existing 10 Ω traveling wave ferrite kicker magnets and their PFNs
  - Enlarge the apertures of 3 out of 5 magnets
  - Modify PFNs to obtain required rise- and fall times
  - Continuous coils in the PFNs to reduce the field ripple
  - Modify the switches to be reliable & installation of diodes instead of dump switches

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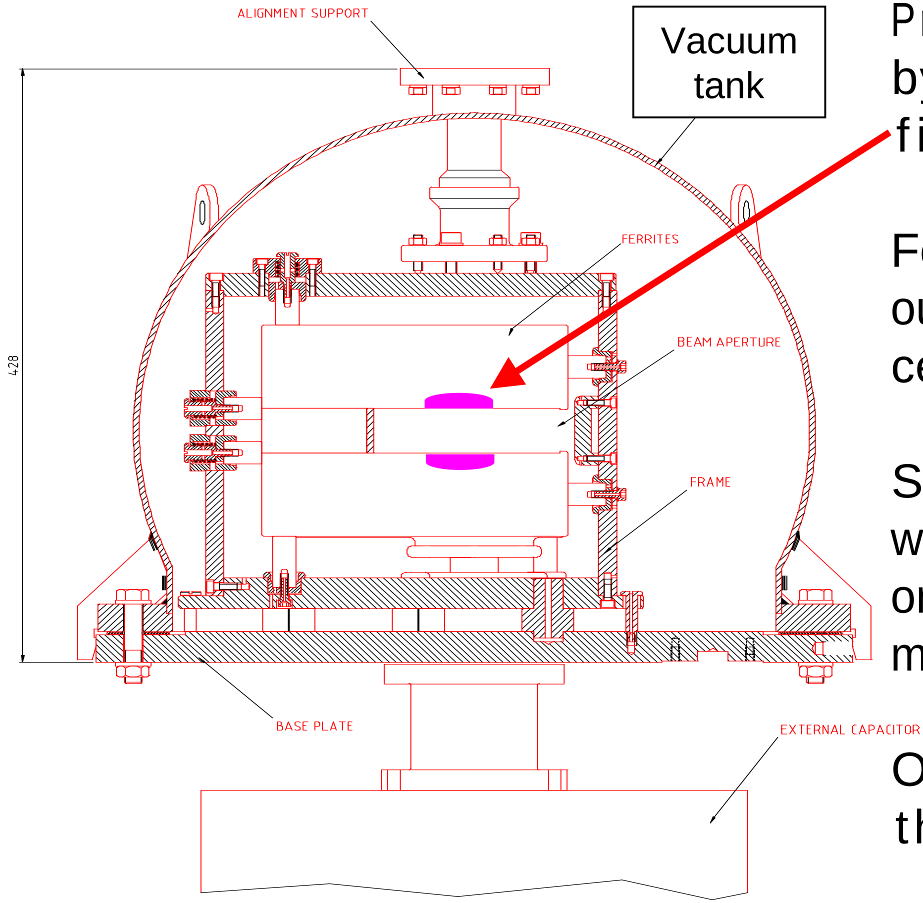
Heating Problem

The Heating Problem



Problem is that the ferrites get heated by the high frequencies of the induced field of the beam.

Ferrites are in contact with the outside world mainly with isolating ceramic spacers.

Spacers make contact with the frame which is in contact with the base plate only by three points for the whole magnet for alignment reasons

On top of this: the ferrite is a bad thermal conductor

Time constant > 24 hours

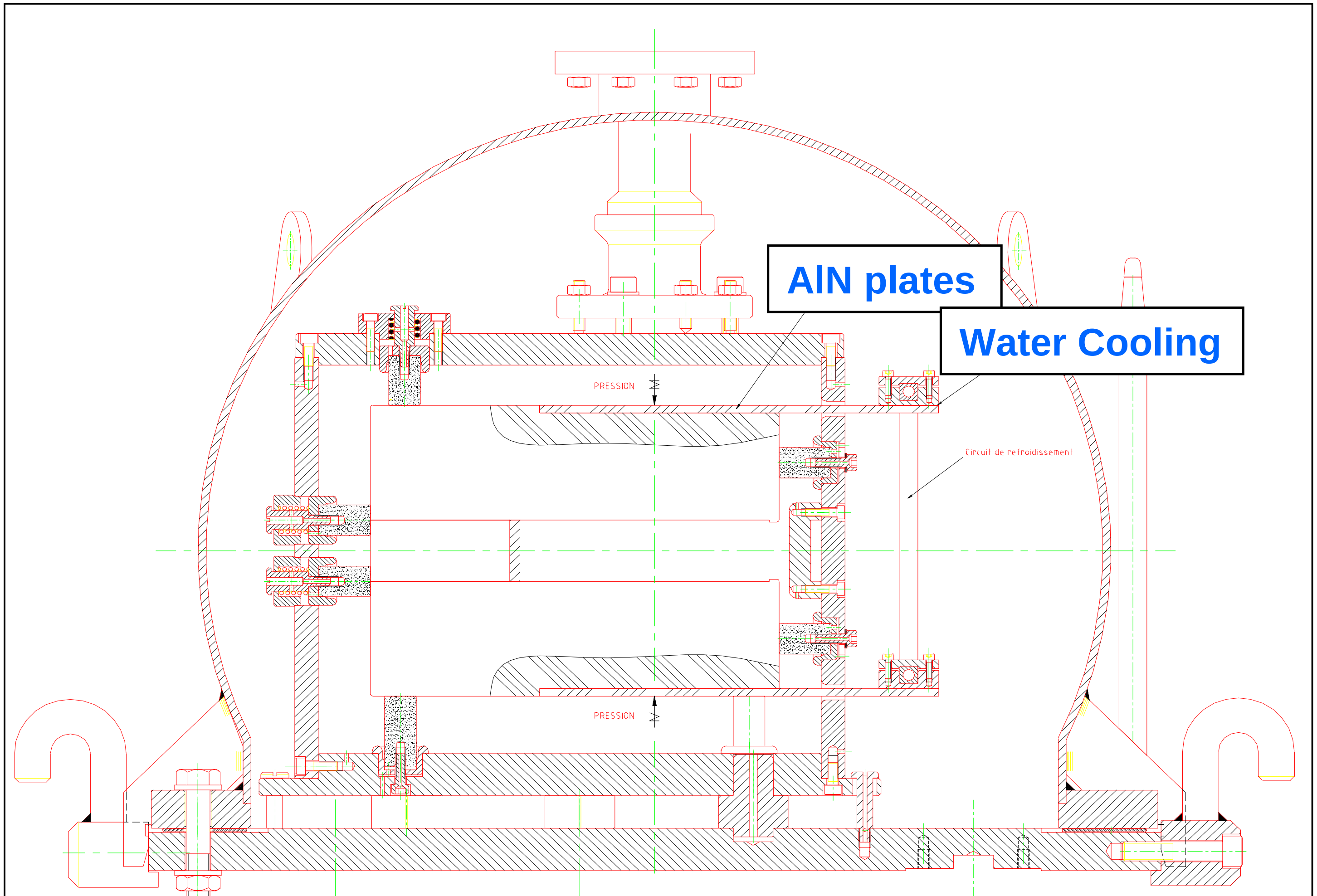
The Heating Problem Quantified

- The Curie Temperature above which the ferrites become nonmagnetic is 130 ^{o}C.
- Without any cooling measures a temperature of 100 ^{o}C is expected to be reached with a power deposition of 250 W. Above this temperature the field will start to degrade significantly
  - This corresponds to a CNGS type of beam with $3.5*10^{13}$ particles, the nominal beam intensity is $5.0 *10^{13}$. At the nominal intensity the power deposited is expected to be 510 W.
  - This power assumes continuous CNGS cycles of the SPS with no down time.
- Measurements in the machine with a real MKE magnet have confirmed a ΔT of 25 K with a reduced intensity on a fixed target machine cycle, which fits the applied theories.

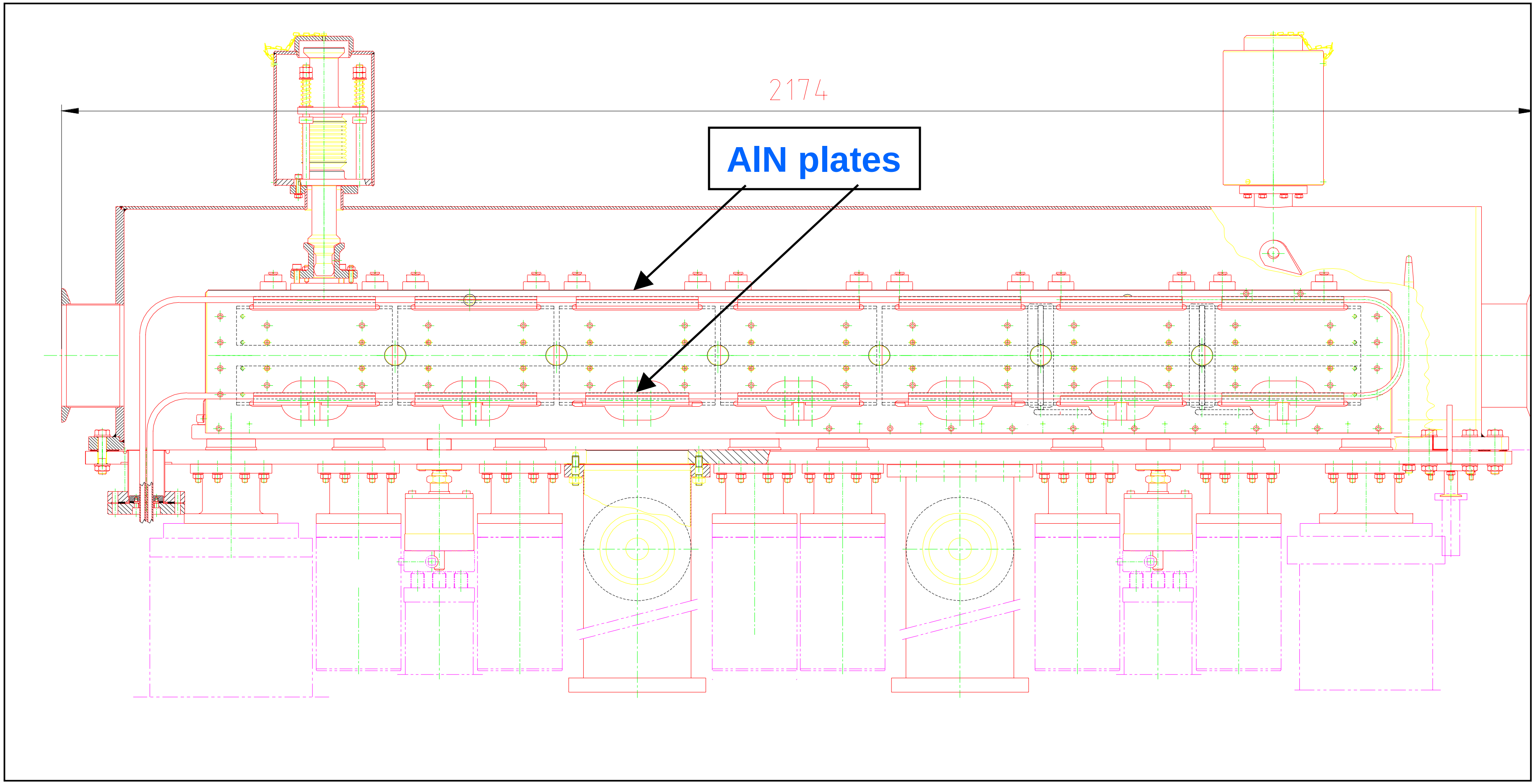
The heating Problem: Solution part I: Bunch Lengthening

- Calculated power depends critically on the bunch length
  - assume bunch blow up so it fills the complete RF bucket
    - natural blow up because of higher intensities
    - artificial blow up by inserting RF noise or higher harmonic signal
- Estimate for a blown up CNGS beam gives a maximum bunch length of 0.49 ns instead of the previously assumed 0.35 ns.
  This scales the previously estimated power by a factor of 0.42
- Using the same scaling for a nominal beam of 5×10^{13} particles reduces the power from 510 W to 215 W and make the resulting ΔT just acceptable, *without any safety margin*.
- For 8×10^{13} particles CNGS beam, this reduces the power from 1310 W and $\Delta T = 485$ K (0.35 ns) to 550 W and $\Delta T = 204$ K (0.49 ns)

The heating Problem: Solution part II: Cooling



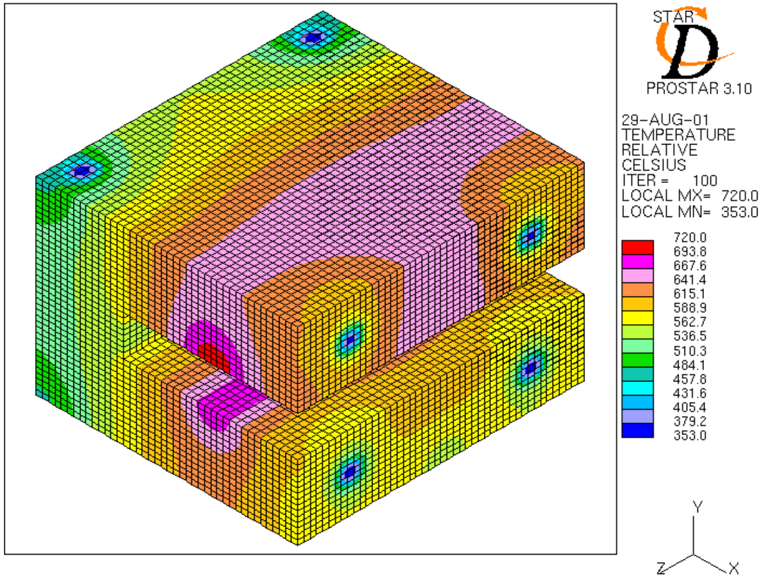
Cooling....



Calculation for Heating with 1700 W

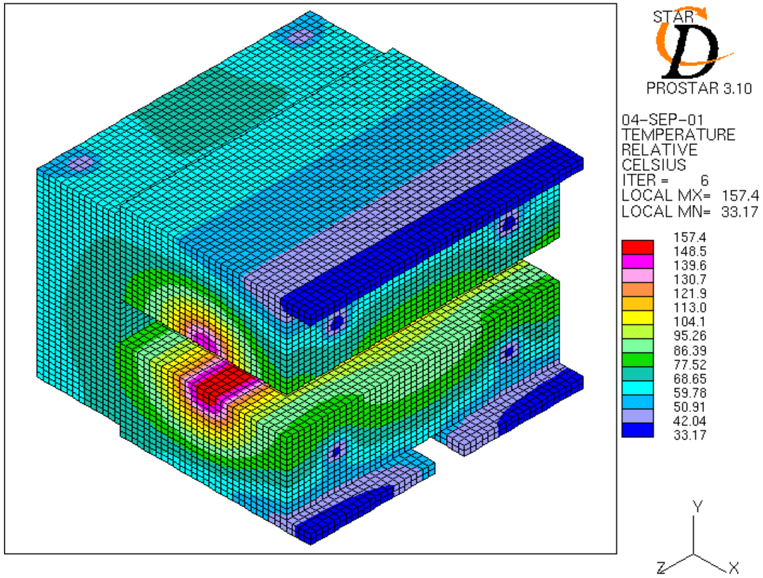
Present Situation, no Cooling

Max Temp 720 °C



With AlN Cooling Plates

Max Temp 157 °C



Summary

- Five fast kicker magnets need to be installed for the extraction of the CNGS beam from the SPS
- Existing magnets will be used, but physical aperture needs to be modified and the Pulse Forming Network and switches need to be adapted to obtain the requested fast rise and fall times
- Without measures a stored CNGS beam of nominal intensity in the SPS heats the ferrites of the kickers above the Curie temperature and would render them nonmagnetic. Remedies:
  - Try to blow up the bunches longitudinally
  - Water-cooling of the ferrites by AlN plates
- This cooling will be applied to the 2 new kickers in LSS6 as well