Quench protection circuit and quench analysis of PANDA Target Solenoid system

Outline

✧ Quench protection circuit of PANDA Target Solenoid system

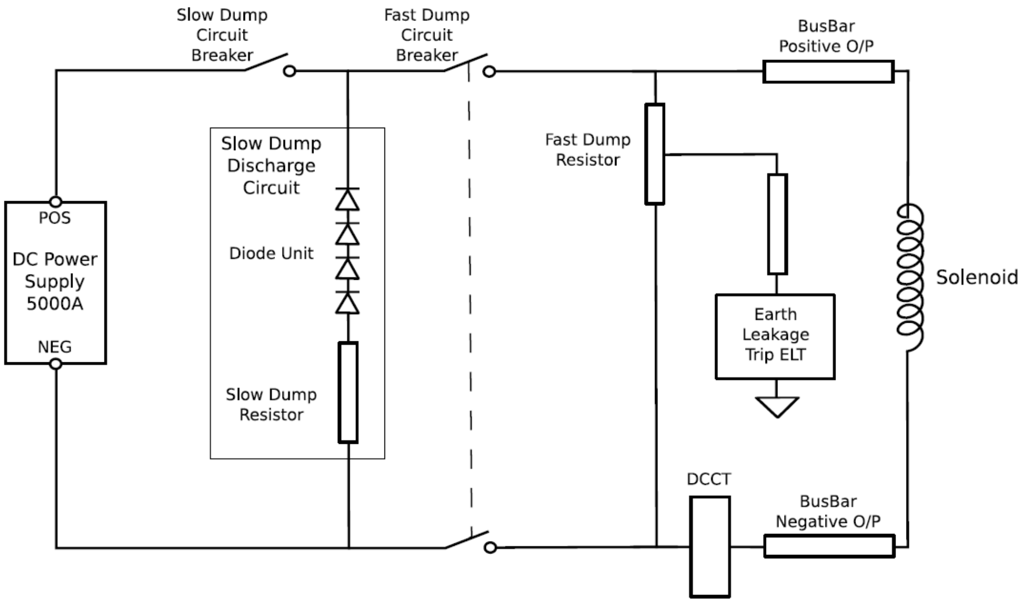
- Quench protection circuit presented in the TDR[1]
- Updated quench protection circuit

✧ Quench analysis of PANDA Target Solenoid system

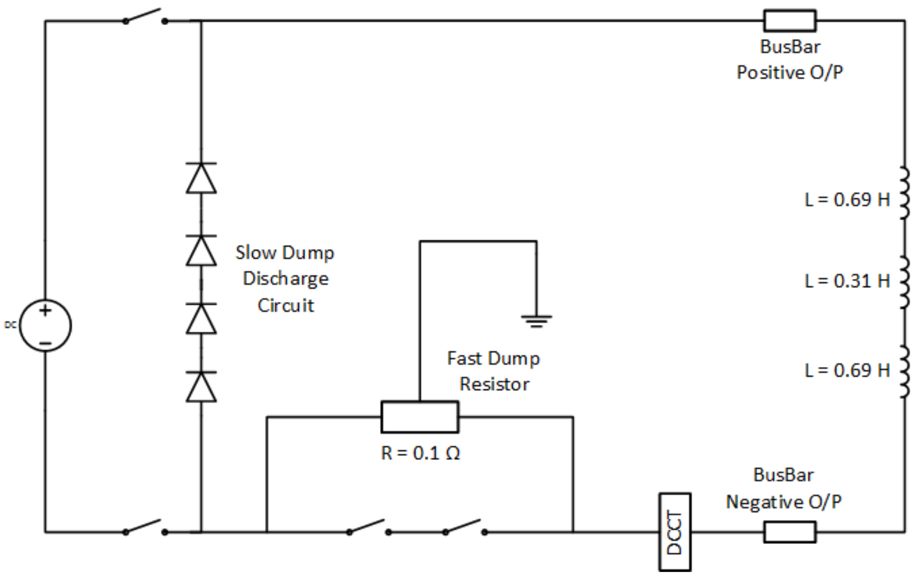
- Geometry of the solenoid presented in the QSR[2] and Updated design
- Material composition of the solenoid presented in the QSR and Updated design
- Quench simulations with Quench2.4[3]

1 TDR: Technical Design Report
2 QSR: Quench Simulation Report
3 Quench2.4: Home made quench simulation code

Quench protection circuit of the PANDA Target Solenoid



Quench protection circuit of the PANDA Target Solenoid according TDR [1].

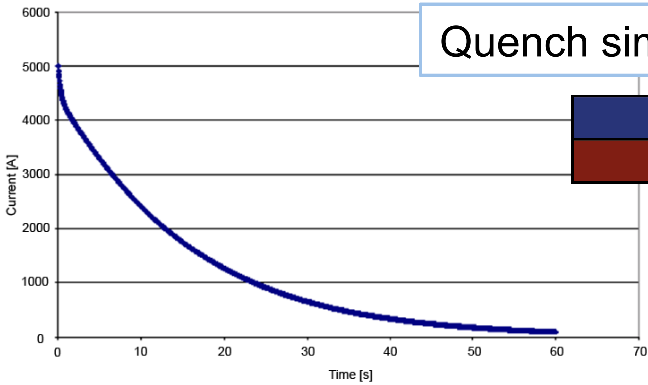


Updated quench protection circuit of the PANDA Target Solenoid.

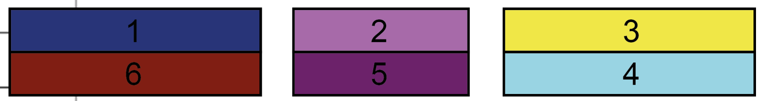
Advantages of this circuit:

- With diodes only there is a constant dI/dt, so a linear discharge;
- With a double switch the power supply is protected;
- The fast dump resistor is placed differently to avoid the time constant drop of a parasitic unit;
- There is only one high precision DCCT necessary.

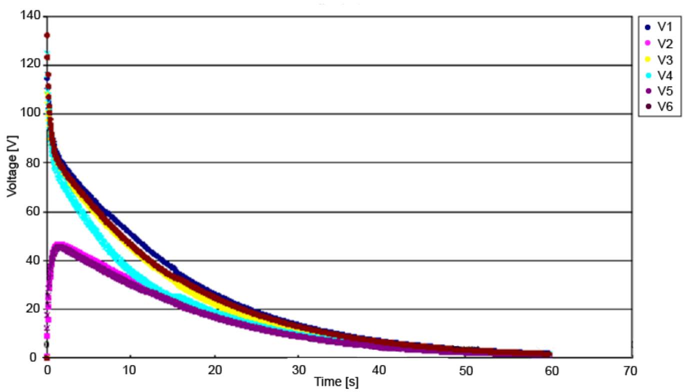
Quench Simulation Report (QSR) and Technical Design Report (TDR) results

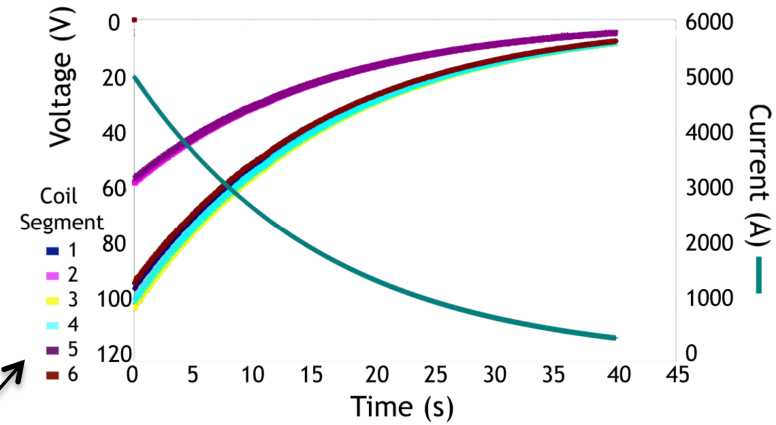


Quench simulated in sector 4 (internal downstream).



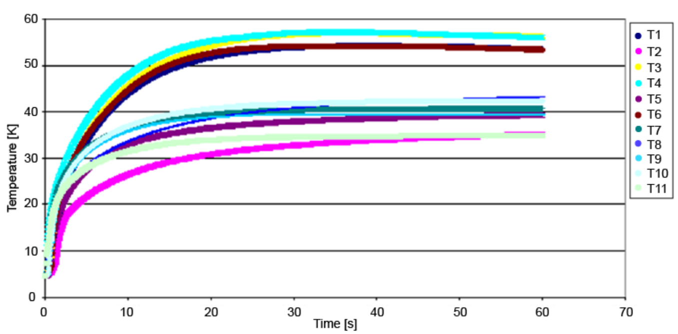
Quench back in the first second.



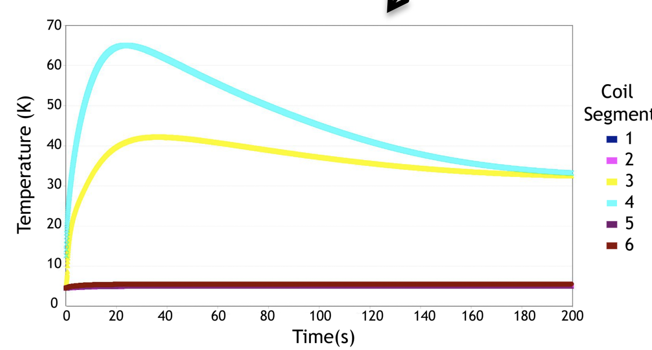


No quench back, discharge simular to that of RL-circuit.

Coils 1,2,5 and 6 do not heat up when there is a coil former.
20 K temperature differene between two layers of the same coil

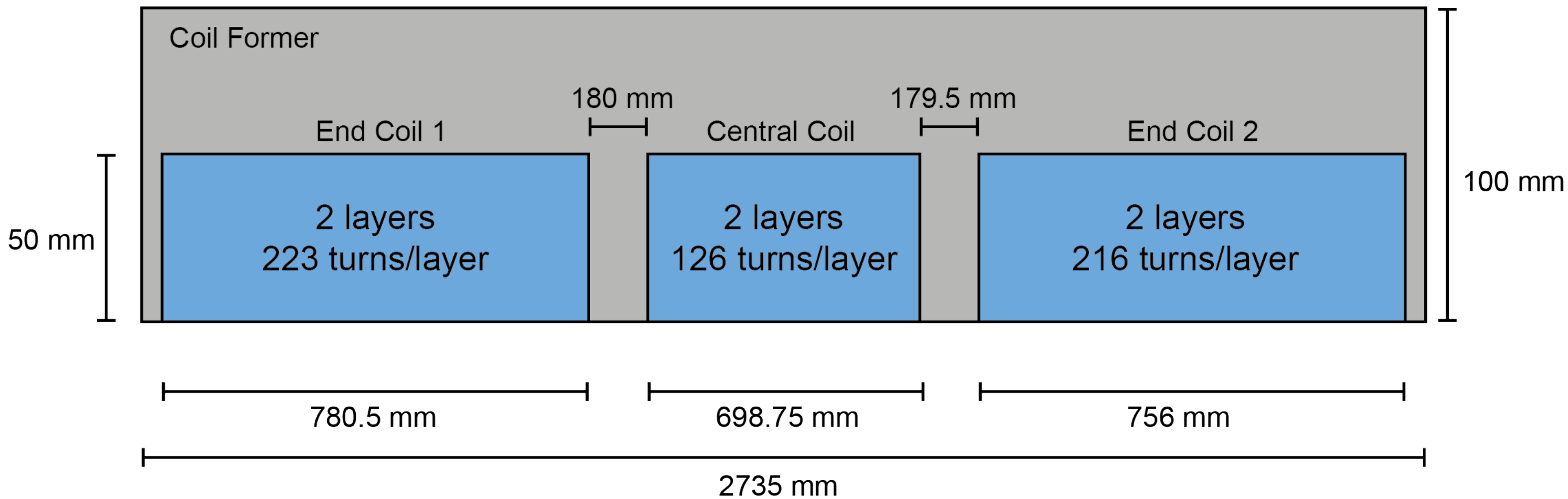


A quench in sector 4 but sector 2 and 5 do not heat up as much as 1,3,4 and 6. No equilibrium temperature between the coils.

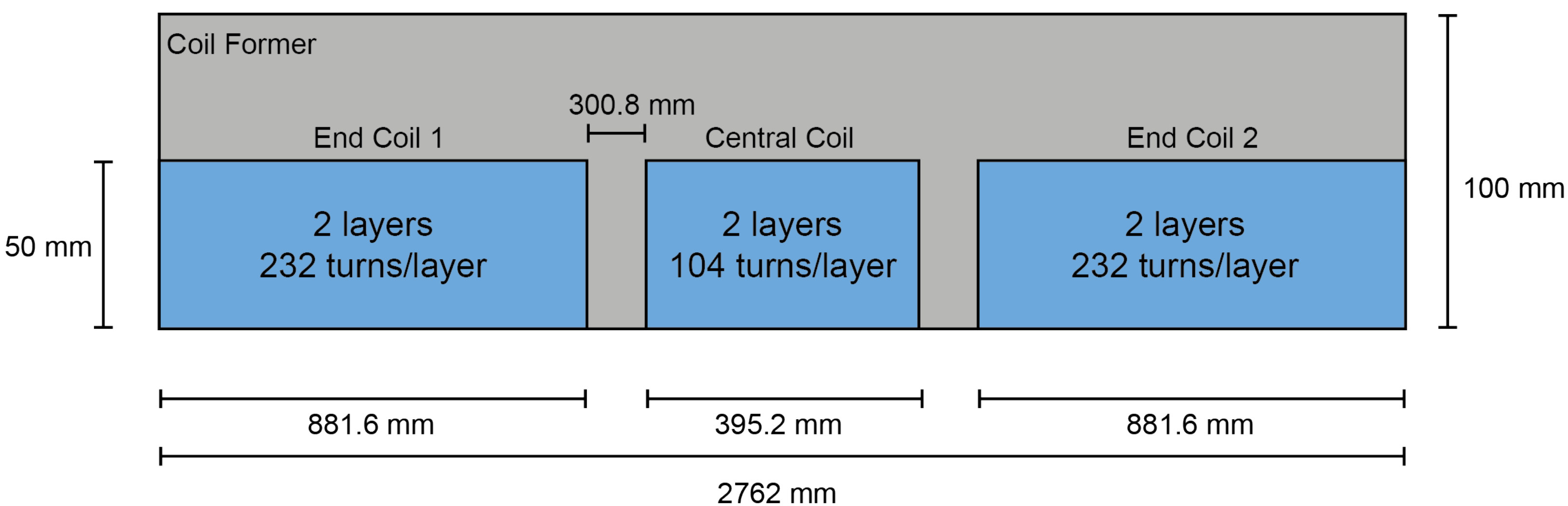


Geometry of the PANDA Target Solenoid

PANDA Target Solenoid according to the QSR [2].



PANDA Target Solenoid according to the TDR [1].



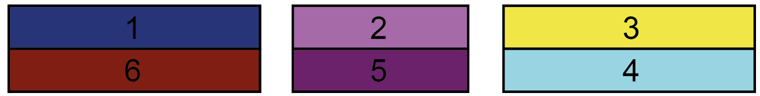
Material composition of the PANDA Target Solenoid

Parameter	Value		
	QSR; Coils 1,3,4,6	**QSR; Coils 2,5**	**Updated Conductor Design with 26 strands**
Superconducting cable	Rutherford type	Rutherford type	Rutherford type
Superconducting material	NbTi	NbTi	NbTi
Amount of SC	8 %	5 %	8 %
Matrix material	Copper (RRR80)	Copper (RRR80)	Copper (RRR150)
Amount of matrix	10 %	6 %	9 %
Stabilizer material	Pure Aluminum (RRR500)	Pure Aluminum (RRR500)	Pure Aluminum (RRR1000)
Amount of stabilizer	82 %	89 %	83 %
Insulation material	Fiberglass Epoxy	Fiberglass Epoxy	Fiberglass Epoxy
Insulation thickness	0.5 mm	0.9 mm	0.4 mm
Former material	Pure Aluminum (RRR2)	Pure Aluminum (RRR2)	Aluminum 5083-O
Coil insulation material	Fiberglass Epoxy	Fiberglass Epoxy	Fiberglass Epoxy
Coil insulation thickness	?	?	1 mm

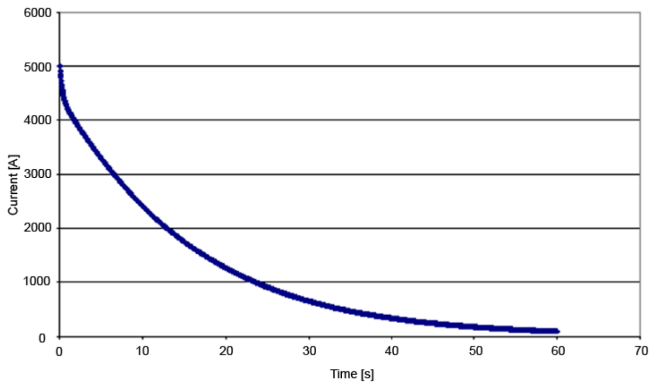
Material composition of the PANDA Target Solenoid according to the different reports [1], [2].

Quench simulation of the PANDA Target Solenoid: Current

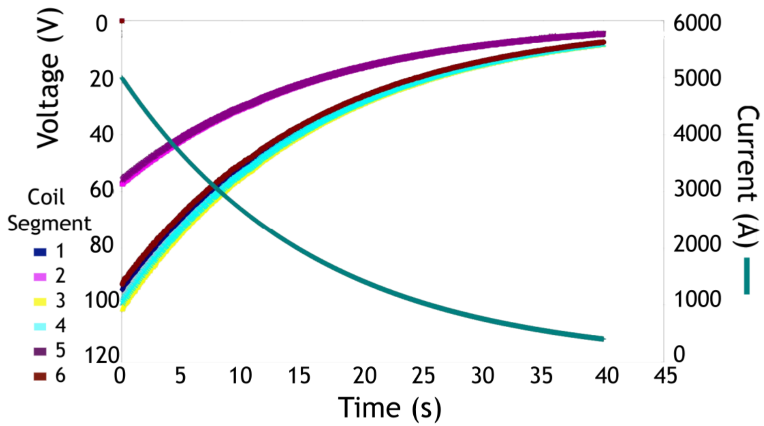
Quench simulated in sector 4 (internal downstream).



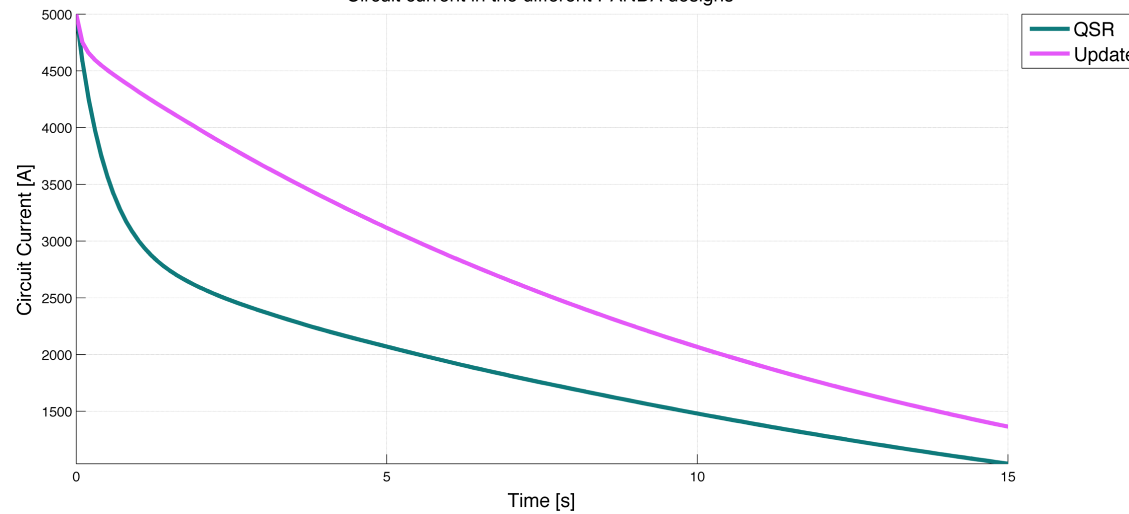
QSR results



TDR Results

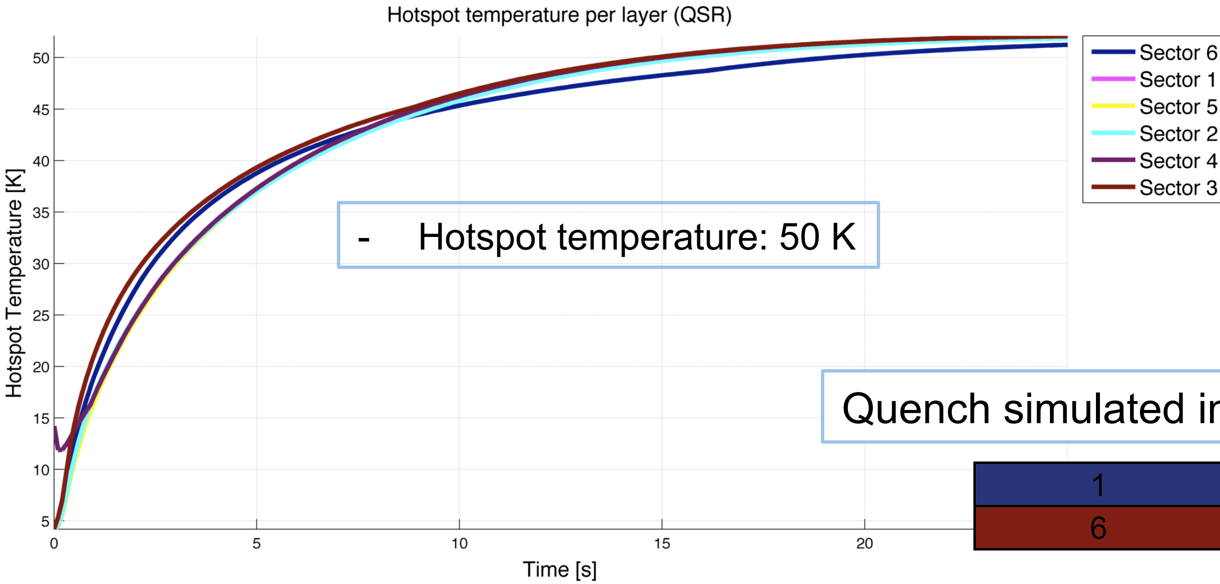


Circuit current in the different PANDA designs



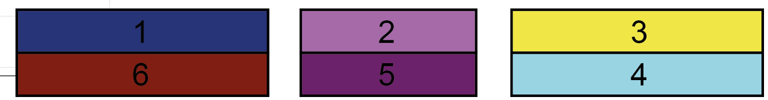
- More quench back simulated with Quench2.4
- In Quench2.4 there is a big difference in quench back between QSR and Update most likely because of different material properties
- Decay looks exponential after quench back period for QSR and TDR
- No resistance build up in the coils during quench

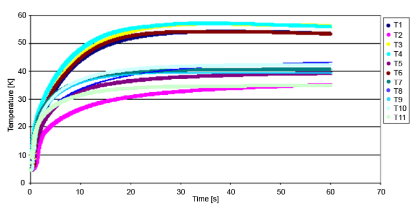
Quench simulation of the PANDA Target Solenoid: Temperature



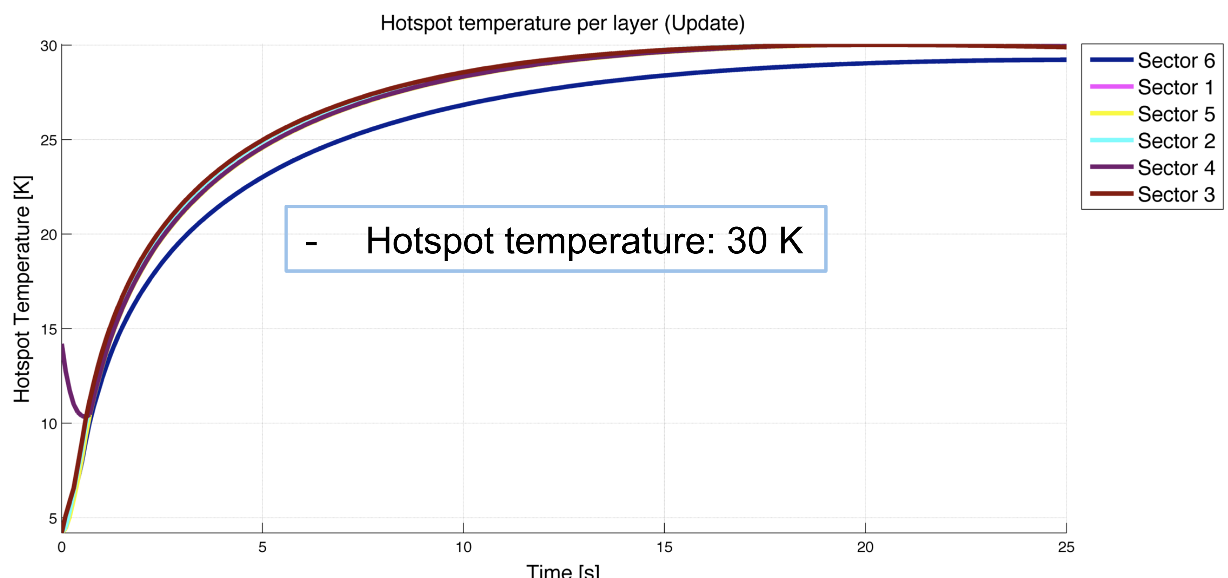
- Hotspot temperature: 50 K

Quench simulated in sector 4 (internal downstream).



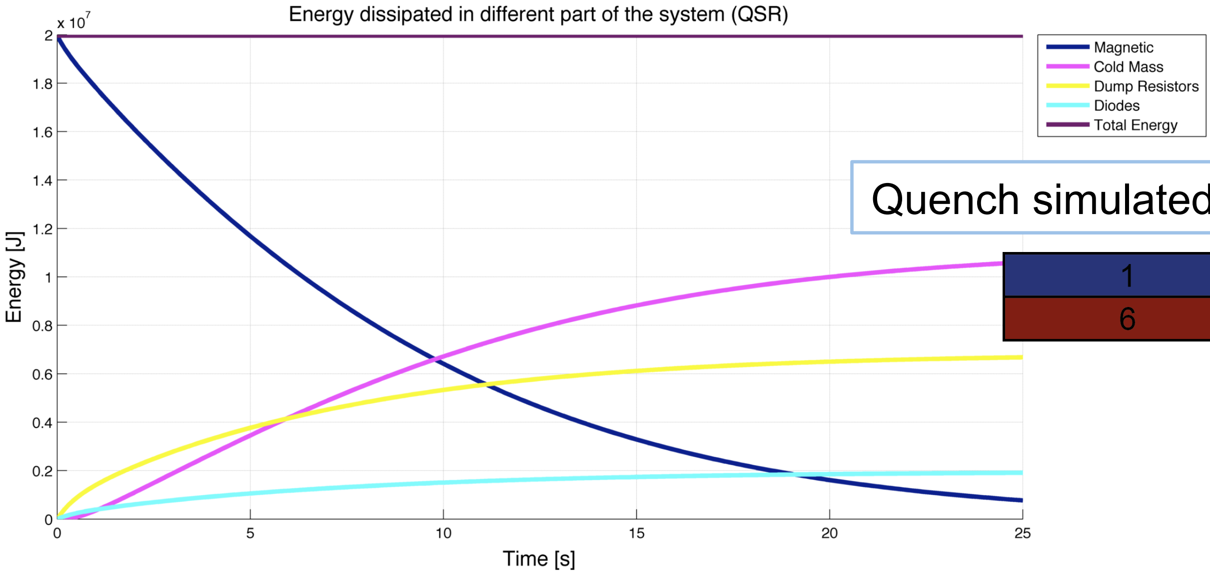


Quench2.4 give narrower temperature sistribution between the coils than QSR. In QSR no equilibrium temperature is reached.

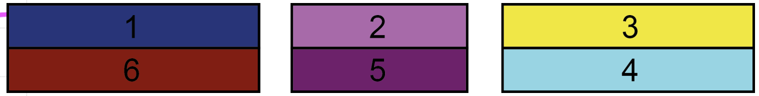


- Hotspot temperature: 30 K

Quench simulation of the PANDA Target Solenoid: Energy

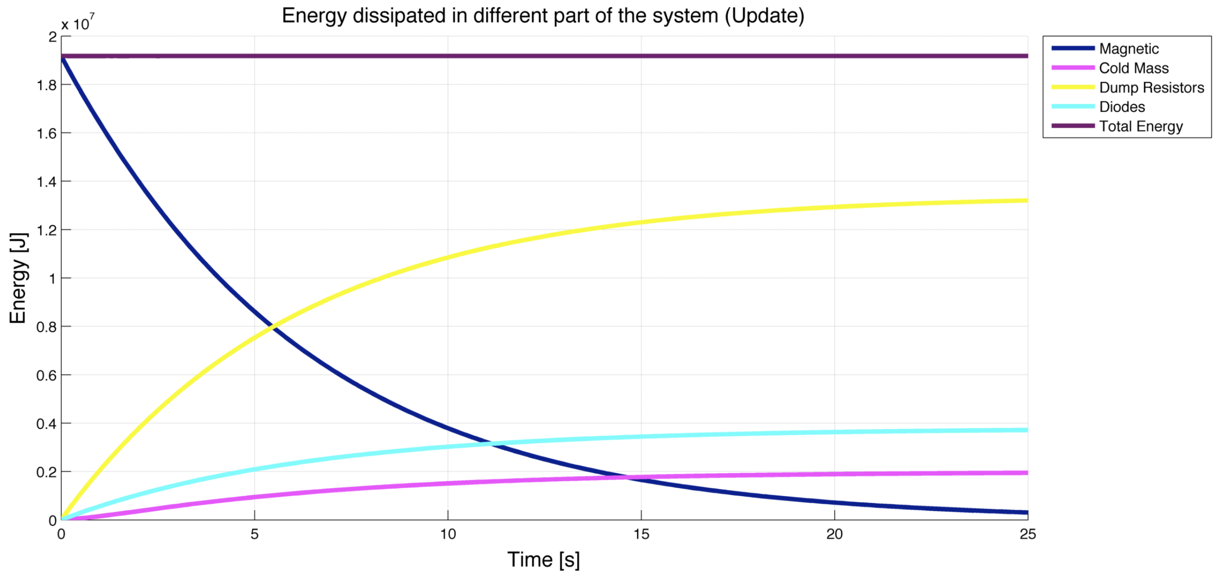


Quench simulated in sector 4 (internal downstream).



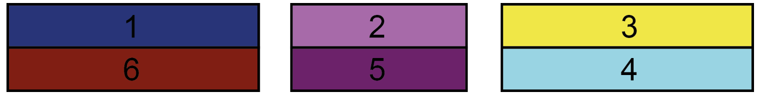
- In QSR most energy is dissipated in the cold mass
- In Update most energy is dissipated in the dump resistor

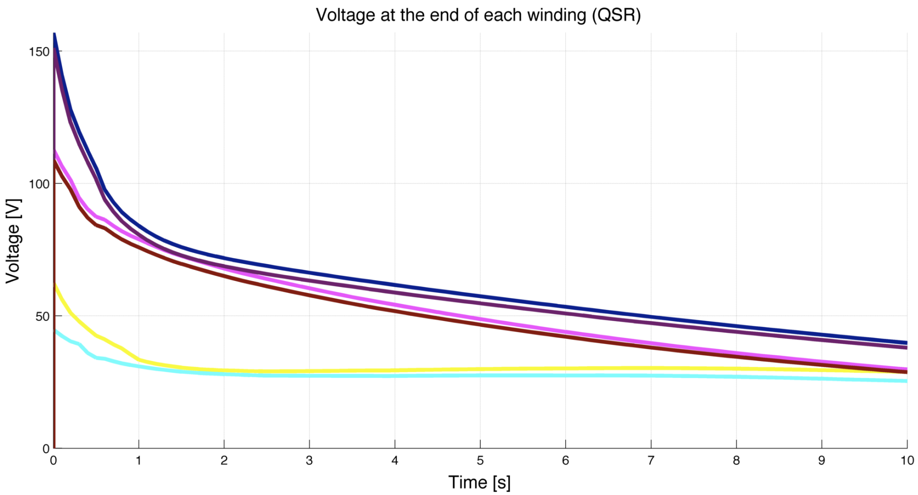
- This is most likely because of the difference in material compositions

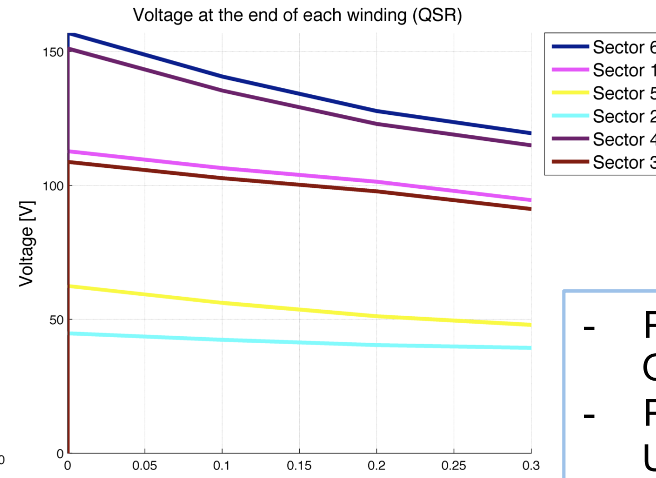


Quench simulation of the PANDA Target Solenoid: Voltage

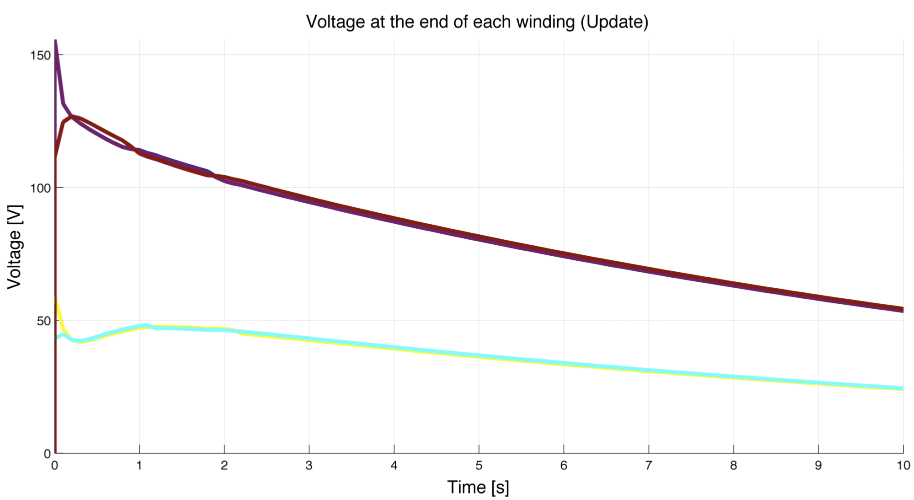
Quench simulated in sector 4 (internal downstream).

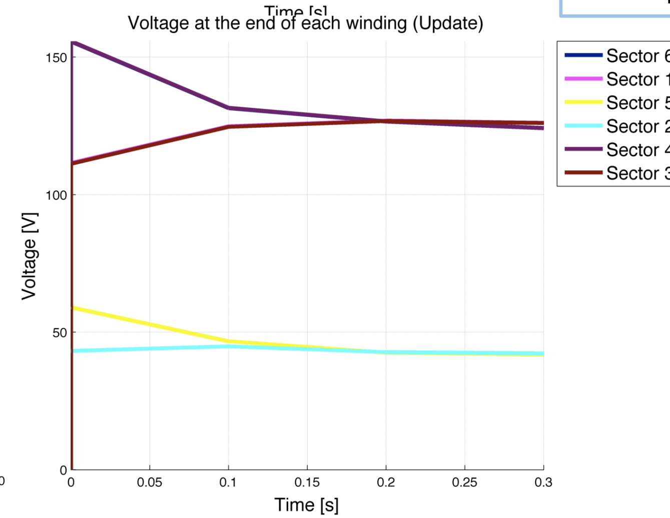






- Peak voltage in QSR is 150 V
- Peak voltage in Update is 150 V





Conclusions

- ✧ Some QSR and TDR results are not yet understood (discharge, hotspot temperature)
  - Possible explanation: difference in normal zone propagation?
- ✧ Discharge is faster than 17s reported in the TDR, is this an issue for the surrounding detectors?
- ✧ With material properties of present conductor and casing designs, the hotspot temperature is only 30 K
- ✧ Peak voltage during quench is around 150 V

- ✧ Next:
  - quench simulations for different quench start locations

References

[1] Technical Design Report for the PANDA Solenoid and Dipole Spectrometer Magnets, The PANDA Collaboration, 2009, arxiv:0907.0169.
[2] PANDA Magnet – Quench Simulation, The PANDA Collaboration.