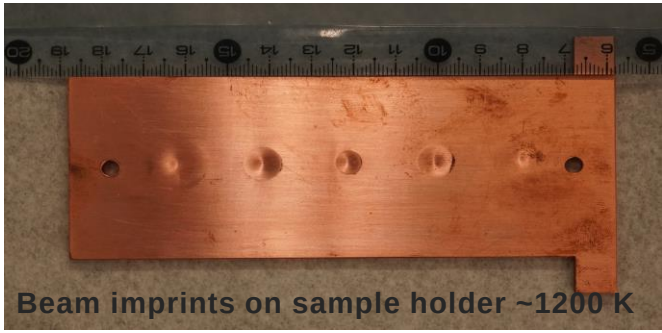
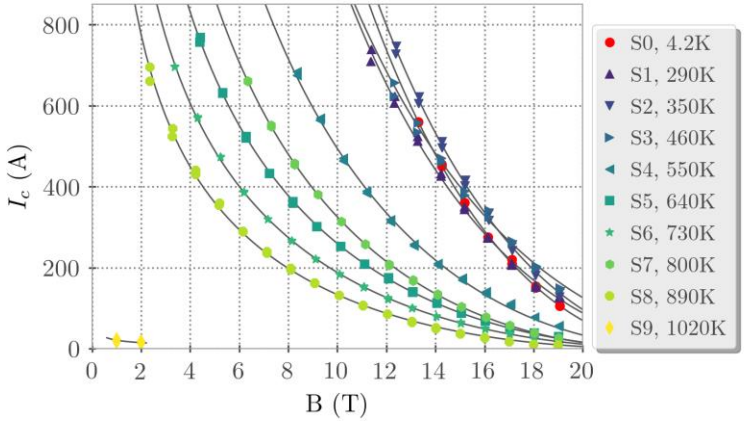
Damage limits of superconducting magnets due to instantaneous beam impact

- Increasing beam brightness and stored beam energy in HL-LHC **increase** significantly the **criticality of** fast and ultra-fast **failures**. In combination with the installation of **novel Nb_3Sn magnets** in the LHC tunnel, raises the question of the **damage limits** of superconducting magnets **due to the impact** of high energy charged particle beams
- Damage limits of sc. **magnet components** (insultation, sc. strands) have been **successfully studied at CERN** (with and without beam, at room temperature and 4.2 K) over the past 6 years (the last 3 years in collaboration with KIT)
- Important next step for research: **verify the damage** limits derived from the previous experiments with **stack of strands samples and test coils**
  - Design & build re-presentative samples / coils
  - Design & build experimental setup for beam experiment at 4.2 K
  - Perform experiment & analyse samples after the irradiation
  - Perform thermo-mechanical simulations of experimental setup and samples
  - Derive damage limits and mechanisms based on experimental and simulation results


Nb_3Sn strand after beam impact, hotspot ~ 800 K


Beam imprints on sample holder ~1200 K



Plot from A. Will et al. *Impact of 440~GeV Proton beams on Superconductors in a Cryogenic Environment*, Proceedings of EUCAS2019

Damage limits of superconducting magnets due to beam impact

- Overall Aim: Assist development of effective machine protection concepts for HL-LHC and FCC-ee
- Background:
  - Increasing beam intensity and energy → potential damage of sc magnets due to fast failures. Understanding of damage mechanisms is crucial
  - This project builds on CERN/KIT joint studies over the past 3 years
- Objectives
  - Irradiation experiments on specially designed and manufactured representative sample coils (at CERN HiRadMat, 4.2 K test stand)
  - Derive robust models for effective machine protection
- Partners: CERN, KIT-IBPT, KIT-ITEP
- Resources
  - 1 FTE 36 months (scientist), 0.75 FTE 36 months (PhD), 1 FTE 18 months (high-level technician)
  - Travel expenses: 30k€
  - Invest: Cryostat instrumentation 150k€