Workshop on coupling simulation of beam impact on accelerator components (11.12.2018)

Summary of Discussion

Next simulation cases (2-3 years)

It was agreed to perform a set of follow-up simulations

1. 7 TeV benchmark study FLUKA/Autodyn comparing to previous FLUKA/BIG2 results (with equation of state for graphite from Naeem Tahir)
   - 6 – 9 months
   - This study should be primary to implement and test new simulation features and to optimize simulation time and precision
2. Impact of full HL-LHC beam on low density graphite
   - By end of LS2
   - Opens path for detailed TDE/TCDQ studies including thermo-mechanical studies (coherence and complementarity with ongoing studies needs to be ensured)
   - Without or with MKD overshoot → evaluate impact of MKD overshoot on simulation results (if greater than one order of magnitude, specific simulations required)

Which tools to be used

- Co-simulation and frameworks like STEAM allow to couple specialized codes from different domains (e.g. magneto-thermal and mechanical simulations). Thus, complex cases covering multiple domains can be simulated. The existing STEAM framework could possibly be complemented with an energy deposition and tracking code (e.g. FLUKA)
- Energy deposition simulations for beam impact on accelerator materials (hydrodynamic tunnelling studies): FLUKA
- Hydrodynamic code: Autodyn
  - Full 3D code (BIG2 is limited to 2 D)
  - Full hydrodynamic code
- Coupling of FLUKA energy deposition map and Autodyn density map via STEAM framework and MpCCI:
  - Implement automatically reading of 3D FLUKA energy deposition output into STEAM (possibly via existing FLUKA-ANSYS coupling)
  - ANSYS APLD is supported by MpCCI
  - Estimate with FLUKA and Autodyn experts what needs to be done to implement coupling via MpCCI (starting from existing coupling)

Other items (1/2)

- Equation of state (EoS) for low density graphite: possibility to start with artificially lowering the material density
- EN-STI is currently setting up collaboration with NTNU to study the properties of the low density carbon sheets of the TDE with the goal to derive EoS → is parameter range also going to cover the hydrodynamic tunnelling case?
- Sensitivity study: dependence of hydrodynamic tunnelling simulation results on equation of state accuracy
- HiRadMat or GSI facilities could be used to explore the EoS of materials, where the EoS is not available and which are relevant for CERN equipment
- Simulation time of hydrodynamic tunnelling cases is currently dominated by the energy deposition simulations (FLUKA) → investigate if meshing and precision requirements can be optimized to reduce total simulation time (ATS server?!).

Other items (2/2)

- Required simulation accuracy needs to be carefully defined before the start of simulations:
  - higher precision for validation of experimental results or future equipment,
  - lower precision for feasibility studies on future machines and worst case beyond design failure cases.
- Along with the consequences also the probability of a failure scenario needs to be estimated
- It is crucial to reduce the required simulation time
- Scenarios, which requiring less precise results can possibly be derived by extrapolations from earlier simulations
- Studies need to be motivated by the fact that the results of the simulations will effect the machine protection layout or the infrastructure design.

Who does what and in which time frame

The groups involved are: EN-MME, EN-STI and TE-MPE

- Coupling of FLUKA energy deposition map and Autodyn density map via STEAM framework and MpCCI:
  - TE-MPE in collaboration with EN-STI
  - 3 months (by mid February 2019)
- Benchmark study 7 TeV:
  - Energy deposition maps: TE-MPE (supported by EN-STI)
  - Hydrodynamic simulations: EN-MME
  - 6-9 months (by June / September 2019)
- Impact of full HL-LHC beam on low density graphite (TDE / TCDQ)
  - Details to be defined after benchmark study
  - To be finalised by end of LS2
- Workshop follow-up meeting in spring 2019 to review status of first steps and detail second part of studies
- First preparation meeting for HL-LHC beam impact on low density graphite foreseen for June 2019 to allow sufficient preparation time before studies can start