

Meeting on FCC dump systems

4th June 2015, 16:00-17:00

Present: Wolfgang Bartmann, Anton Lechner, Thomas Kramer, Tony Fowler, Mike Barnes, Brennan Goddard, Rüdiger Schmidt, Miroslav Atanosov, Linda Stoel, Laurent Ducimetiere, Florian Burkart

Agenda: <http://indico.cern.ch/event/398191/>

Start point: Anton Lechners slide from his presentation at the FCC dump meeting (30th of April 2015). Separation of 1.8mm between the bunches is needed to avoid local damage to the absorber. This directs the focus on the kicker specification in terms of rise time to get this separation. The 1.8 mm separation has a margin, as it is the first estimate. More realistic sweep (a constant sweep was considered) can be added and thermo-mechanical properties can be considered.

Required MKD rise time for TCDS/TCNQ survival (L. Stoel):

- Dependent on FLUKA simulations.
- Asynchronous firing of the kicker leads to a sweep. Parts can be absorbed by system cleaning, then TCNQ and TCDS will be hit before reaching the extraction aperture.
- 2 layouts were considered
 - with kicker and septum.
 - with kicker and septum and a Quadrupole (gives additional kick) in between.
- Kicker rise times calculated as a function of kicker strength with the distances from the 2 layouts. Rise times are in the order of a few 100 ns. Might be adjusted by increasing the required spacing → higher rise time.
- In case of a 1 μ s rise time a separation of min. 0.45 mm and max. 1.99 mm. Also this might be adjusted by distance change.
- In addition a segmentation of the system can be considered to gain a bit of margin in case of a failure.

→ Re-check the separation requirements with more realistic parameters; include increase of distances, realistic sweep (remember the type 2 erratic in January 2015).

Rise time considerations for FCC dump kickers (T. Kramer):

- Rise time requirements below 1 μ s are very challenging for the discussed system.
- Segmented system was considered with total kick strength of 0.15 mrad, 120 m length, beta function at Kicker (b0) and TCNQ (b1) as now.
- For rise times below 3 μ s Thyatron switches are used for magnetic field kickers at CERN so far.

- Studies for an inductive adder based on MOSFETs and IGBTs on-going.
- In addition, solid-state technology should be considered.
- Below 1 μs different magnet technology is required: transmission line kickers.
- For bunch separation related to MKD rise time different distances between kicker and TCDQ and TCDS were considered. Rise time below 300 ns is needed to separate the bunches by 1.8mm, this result is consistent with the assumptions.
- To make a 1 μs rise time acceptable (from bunch separation point of view):
 - Increase distances to 500m (MKD-TCDS).
 - increase kick strength (possibility to be evaluated, needs more magnetic length).
 - Vertical dilution by vertical oscillation with 1 sigma amplitude. In case of failure the beam is painted over the surface of the absorber by a vertical kicker (sinus oscillation). Further investigations needed.
- Faster rise time will have an impact on Kicker system (shorter magnet, segmented system becomes mandatory, switch technology, voltage increase, pulse transmission).
- Longer length of system will decrease the current per kicker → ease switch design.
- Total voltage needed is the sum of magnet voltage, resistive voltage and cable voltage. For small rise times the total voltage can go up to 28kV, depending on circuit design, impedance, etc. Technology limit is around 30kV (above 40 kV special cables needed). Plot (slide 11) is made for lumped inductance.
- New switches are under investigations, like employ inductive adder design in a hybrid system structure. Might be interesting to reuse the future design FCC injection combined with a standard droop compensation circuit.
- Reliability and MP issues have to be studied in detail. R2E problems have to be addressed.
- Challenging task in terms of technology and costs to reduce the rise time below to $\sim 1 \mu\text{s}$. Much better than 1 μs seems to be very challenging and subsequently inefficient.

→ Segmentation was calculated for 1 μs rise time. Might be interesting to check this for 1.2 μs and re-check impact on TCDS for this rise time.

Discussions:

- A bit of separation can be gained by optimisation of FLUKA simulation.
- Ideas of using multiple carbon fibres with μm diameter to decrease energy deposition density.
 - Small energy deposition in the fibre, the rest will be distributed.
 - Start simplified FLUKA simulations with thin plates with space in between. Can be verified with experiment in HiRadMat.
 - Full em - shower development has to be studied.
 - Previous studies showed that very long drift spaces are needed to gain in the energy deposition density.

- More effective might be to use magnetic fields to sweep low energy electrons out of the secondary particle showers.
- New kind of materials for TCDQ/ TCDS?
- Reduce damage by decreasing the energy deposition density using large beta function ($> \text{few } 100 \text{ km}$)? Increasing the beam size vertically might help for survival of TCDS.
- Massless septum / quadrupole to blow the beam up.
- Make elements like TCDQ and TCDS sacrificial, damage them and replace them.
 - Segment system and replace only a part of it.

Next meeting:

18th of June:

Agenda: Requirements for dilution kickers and beam dump line geometry. F. Burkart