Workshop Summary

Summary of the Workshop in Muenster (*link to indico*)

The general consensus of the workshop is that the milling of holes into the TRD to access HV filter boards for repair is a feasible option and preferred over the full disassembly. The development of a manual mounting structure will be started in Muenster and further tests with a dummy set up will be done.

In addition to the HV, also the opportunity should be taken to continue the LV rework, this affects SM 0,1,2,6. On the other hand 7 and 10 have already LV reworked, which should be considered in the repair sequence.

The working conditions, possible working times and available space at low beta is seen very critically and the option of an overground repair area should be pushed for, also in the light of less stringent boundaries on the thermal conditions with the milling option.

The early (January?) removal of one supermodule for an extended repair and training period is considered very important.

In order to justify prioritisation of the TRD repair, it should be made clear that the TRD will play also an integral role for the performance of the TPC in Run3. In addition, the (repair) key personnel between both projects overlaps and coordination could be worked out effectively between TPC and TRD.

Detailed write up

Status

Talk by Alexander on TRD status. TRD has been very during the run. A number of the TRD chambers is showing problems, in particular with HV as already summarised in Yvonne's talk at the TB (November 2017 (*link*).

The up-to date status of TRD chambers is in a google doc: (*link*)

As of 19.02.

71/522 channels off due to Anode HV 20/522 channels off due to drift HV

Considering the 6 supermodules planned so far to repair, these have

SM	Anode	Drift
0	3/30	2/30
1	9/30	1/30/
2	4/30	0/30
6	4/30	1/307

SM	Anode	Drift
7	6/30	6/30
10	9/30	1/30
Total	35	11

Action item: Explore options of online repair for other problems (mainly FEE, Ethernet), started by Alexander and Tom

Time Frame and Place

(see e.g. talk by Tom (*link*))

Period from April - October. Earliest start date in fact April 8th (Arturo) which leaves us with 30 weeks (150 work days) from KW15 to KW44.

During the workshop is has been iterated many times that repairs at low beta will be very challenging due to the general working conditions, limitations in working hours by activity in the hall, space constraints (also given by additional space needed for parallel work on cable routing) etc.. A high priority should be given to identify/procure work space e.g. in SX2. Concerns on the temperature conditions on some days have been raised, but general consensus that these are not critical/can be overcome.

Action items

- **Clarify emphasise priority/criticality of TRD repair within the collaboration**
- **Identify slot for early removal of one SM**
- **Identify alternative repair space**

SM Removal and Installation

(see e.g. talk by Christian (*link*))

The removal and installation will be a major task which has to be done without the yellow platform (i.e. with concrete blocks). It hinges on the availability of some essential personnel (Bernd, Norbert, Kai, Tobias Herold, ...). About 4 days per SM should be planned for removal and reinstallation (24 work days). We need to clarify with Arturo on possible limitations on the working hours, due to other activities.

The removal of one super module before April and as early as possible is vital. It will provide the necessary training and establish procedures, as well as saving time from the available slot.

In the decision on the removal sequence (and choice of first SM) it should be considered that SM10 and SM7 already have their LV reworked

Action items

- **clarify availability of manpower in particular overlap with TPC activities**
- **search for time slot for 1 SM removal before April**

In case of the reinstallation after milling the side walls, the options have been discussed wether to cover the holes. In particular for SM 0,1,2 the holes will be on the bottom (sliding) side. The general consensus was that these do not need to be covered, since the risk of scrambling foil is given. However, the mechanical sliding itself is only at the foot of the SM and at the level of layer 5.

For the other SM covering foil could be considered to avoid things falling into the SM. In any case conducting foils are to be avoided, not to reach into the SM in case of damage.

SM Repairs

Two major repair/rework items have been discussed. The main reason for removal of the SM are the faulty capacitors on the HV filter boards, which need to be removed. To access these via the milling/opening of the side walls (see Daniel's talk (*link*)) is seen as the best possibility to avoid the complete disassembly and to achieve the repair of 6SM on the challenging time scale.

When the SM are removed, the LV should be reworked as well, this affects 4 of the discussed 6 supermodules.

Milling Procedure

The principal feasibility of the milling has been demonstrated (see Daniel's talk) milling down to 0.1 mm and *fish can opening*. A test without liquid and using the same material as the SM was also successful. The exact thickness should be checked since a general deviation from 2mm thickness has been observed.

The mounting structure/guide for the hand driven milling will be constructed and tested in Muenster including the removal of chips via vacuum cleaner.

A dummy setup will be used for testing and training and the final validation of the milling procedure in particular the feasibility for layer 5 (additional ledges) should be done with the first (early) SM. The fallback solution for layer 5 is the opening of the cover to access the filterboard, which involves careful moving of cooling pipes, which can be tested only with a full SM.

Tooling

- **Milling test stand, guide system (Muenster)**

HV Repair

The repair consists in removing the two 4.7 nF capacitors (anode and drift) from each filter board. Previously also the resistors has been removed, though it was not clear why this is needed.

Default repair is via soldering off the capacitors, they can also be removed mechanically (moving back and forth) if necessary. Endoscopic tools and a camera should be foreseen to check and work within the SM.

Test procedure

It was discussed that the HV tests could be done without LV applied (avoid cooling) and under safe conditions with CO2 flushing. It is essential to perform reference measurements under the same conditions (at the place of repair) and prior to the repair for comparison. Special care should be taken for the humidity when HV tests are performed.

If removal of capacitors does not yield HV stability in singular cases, explore other possible sources of failure (soldering of HV connections outside the SM, 2.2nF capacitors).

Action items

- **clarify with GSI detector lab/Chilo why removal of capacitors alone was not seen sufficient**
- **Explore options of a quick test for 2.2 nF**

Tooling

- **Endoscopic tools and camera**

LV Rework

This work has been done previously in about 4 days per SM and would have to be carried out in parallel/in sequence with 4 experienced people (From previous campaign: Bernd, Norbert, Daniel Muehlheim)

For the LV repair cables and patch panels have to be prepared. Costs about 4000 Euro.

Testing procedure needs LV PS.

Full Disassembly

A full run through the various steps for the assembly of the SM in Muenster was given by Philipp, including testing the average installation time for 1 Layer in the last 3 SM has been 9 days (7 work days). This was under ideal conditions (trained and experienced people, short ways for quick repair, spare parts (cooling pipes etc.), all tools at hand, ideal working and testing conditions). This makes the full disassembly of 6 supermodules an unrealistic scenario. However, it was agreed that the infrastructure/preparation should still consider the disassembly option to facilitate more complete repair for 1SM or just the easily accessible layer 5.

The various assembly steps have been discussed and are summarised in a table (*link*). Collected inputs have been been added to the updated version of the list: e.g. that individual chamber tests can be skipped, a general replacement of screws should be foreseen (SM Parts List by Bernd (*link*)), wires attached with hot glue need replacement and new crimping. In addition we should count on roughly a 10% replacement fraction for other parts.

Support Infrastructure

Based on Tom's talk (*link*)

Minimal

- HV supplies for short term testing without LV etc. (flushing with CO2)
- CO2 gas supply, (Orbissphere may come as inverstment from MS)
- Wiener PS for test and rough checks for shorts
- Wiener PS imply mixed water cooling
- Cables (MS?)

Additional (see Tom's talk for details)

- VME
- DAQ-CRU
- Shelves and plugs for chambers
- Software: Prepare and move from svn to CERN git

Most difficult infrastructure will be the cooling plant, though for the milling repair option this is the least critical since tests can be done without (layer by layer, short term) ,

- **Need to check back on parts and spares in CERN storage, in particular cooling pipes**
- **Need to check status of MS cooling plant**