Minutes of the Technical Board Meeting December 4, 2017

Indico page of the meeting

Present: Vincent Andrieux, Franco Bradamante, Oleg Denisov, Nori Doshita, Alain Magnon, Gerd Mallot, Stephane Platchkov, Caroline Riedl, Fulvio Tessarotto, Annika Vauth.

Remotely connected: Vladimir Anosov, Jens Barth, Michela Chiosso, Andrea Ferrero, Jan Friedrich, Igor Konorov, Angelo Maggiora, Daniele Panzieri, Bakur Parsamyan, Marcin Ziembicki.

Communications. Stephane Platchkov is welcome as new TB member. He is replacing Andrea Ferrero.

In 2018, all traditional phones present on the CERN site will be replaced with phone applications. See this webpage for more information.

New from EHN2. The hadron absorber cage, the hadron absorber, the two additional steel plates, and the concrete shielding around the absorber were installed November 20-22, 2017 in the exact same configuration as in 2015. Extra shielding and the 6Li absorber will be installed before the start of the 2018 run. Before hadron absorber installation, the 2015 aluminum plug (7 cm long) was pulled upstream by 10 cm to improve the vertex separation between the tungsten plug and the aluminum. No vertex detector will be installed in 2018.

A spare fitting was installed on the pump affected by the water leak incident on September 30, 2017.

News from the 92nd EATM. Indico page
Robert Froeschl from Radio Protection reported that currently two RP buffer zones are missing in the North Area: one in EHN1 (test beam hall) and one in EHN2 (888). A compromise for EHN2 will have to be found. Lau Gatignon summarized the PBC workshop November 21/22. Serge Mathot updated the status of the CEDAR upgrade from CERN side. The procurement of the thermal housing components is on a critical path. Philippe Gayet from TE-CRG reported on the busy schedule for the cryogenic group in the North Area. The cooling water shortage affecting the commissioning of the COMPASS polarized target magnet in early 2018 was addressed upon request of COMPASS, see next section.

Commissioning of target magnet in 2018 (Caroline Riedl). A meeting with Yann Lechevin and Marc Nas from the CERN fire brigade (HSE) took place immediately after the TB meeting on Nov 7. COMPASS had requested the investigation of the use of firefighting water to cool the cryo compressor for the target magnet. Normally the Prevessin cooling tower is used to operate the compressor, however it will be upgraded between December 19, 2017 and February 23, 2018 to satisfy the increased need for cooling water in the North Area in particular due to the new EHN1 extension. HSE investigated the amount of available water and came back to us on Nov 27: the maximum flow rate is 51 m^3 / hr, while the (early 1970s) compressor needs $\sim$ 45 m^3 / hr. HSE will not be able to support our request because it would significantly affect their operational capability also on the Meyrin site.

This was the status discussed at the 92nd EATM in the presence of Philippe Gayet from TE-CRG and Bill Bannister from CV, considering (a) the delivery of dewars with liquid helium, (b) using the available tap water to cool the compressor, (c) using an external rental chiller to cool the compressor. Option (a) was excluded by Johan Bremer from TE-CRG the day after this TB meeting (Dec 5). (b) and (c) were basically excluded by Bill on Dec 6 due to manpower reasons at CV. COMPASS has to squeeze, parallelize, and skip components of the magnet commissioning schedule. Two weeks can be "recovered" by not performing the empty-target TE calibration and by performing the loaded-target calibration after the start of the beam, during the spectrometer commissioning phase and preferably without beam. Performing the empty-target calibration only after the 2018 run will mean that there will be again, as in 2015, no online polarization values available. If the target breaks irrecoverably during the run, none of the 2018 data can be used for physics that relies on the knowledge of the target polarization. As recommended at the TB meeting, Giovanna Lehmann from EP-DT has been informed about the issue. The five weeks of commissioning with the helium-cold magnet, and the planned "dry" commissioning prior to cooling the magnet were again discussed with her on Dec 7. There is no realistic margin of squeezing the schedule with the cold magnet. **This leaves COMPASS with a serious delay of target commissioning, with the anticipated start of physics not before May 21 (while beam is arriving on April 9).**

Target (Nori Doshita.) The pipes for 3He and 4He were installed on Nov 8/9 in collaboration with TE-CRG. Cables for the dilution refrigerator, the microwave (MW) system, and the magnet (signal cables) were installed on Nov 23. The isolation vacuum pumping system was started on Nov 10. The diffusion pump was started on Nov 15 in collaboration with EP-DT. No leak was found at the downstream flange and green light could be given for the hadron absorber installation. Leak checking of the isolation vacuum is performed using a newly purchased leak detector with high sensitivity. Leak checking continued in other parts of the system after the hadron absorber installation.

Attenuation tests on the MW system have started. An issue with the grounding was identified and is currently being investigated. The installation of the new air conditioning system in the target pump room has started in mid-November and is anticipated to be completed by the end of the first December week, at which date the cooling water line has to be modified and the isolation vacuum has to be temporarily stopped.

The 2015 target cell has been disassembled and the attachment of the new inner six NMR coils has started. In 2015, there were only four inner coils. A small concrete bunker next to the caged area of the 2015 magnet PLC location was built and the isolation-vacuum- and magnet-PLCs were moved into this bunker, inside a shell of polyethylene and boron-carbid to reduce radiation effects to a minimum. It is planned to migrate the PLCs to the CERN-produced UNICOS system, which will also improve the control via the DCS in 2018. The support of Christophe Pires from the Lisbon group for the PLC upgrade is very important.

2018 radio protection (Angelo Maggiora). Angelo presented his final FLUKA simulations in preparation of the 2018 run. These results had been discussed in a meeting with Heinz Vincke on Nov 24, who agreed to discard the disfavored "umbrella shielding" covering part of the polarized-target setup, and to go for the "balcony shielding" of 160 cm height instead. Over a length of 16 m, additional concrete blocks will be placed on top of the Saleve-side wall separating the experimental area from the barrack aisle. The blocks will be 240 cm wide so that they will "hang over" the 160 cm thick wall into the area by 80 cm (→ "balcony").

The non-designated area outside of 888 accessible without dosimeter is subject to two rules: the yearly integrated radiation dose may not exceed 1 mSv, and the hourly dose, if not more than 400 hrs / year are spent there, may not exceed 2.5 μSv. The recent simulations indicate that this limit was exceeded at certain times during the 2015 run, however there is no measurement on the Heisenberg road between 888 and the clean area (neither in 2015, nor does RP plan to install a radiation monitor in 2018).

In 2018, 23% more integrated radiation dose is expected compared to 2015. The increase comes from a combination of more beam days (+7%, 217 days instead of 203) and a better SPS efficiency (extrapolated from 2017). Effects from lowering the beam intensity during the initial 2018 commissioning phase (30 days) have been taken into account. From the known total pions of $1.66 \cdot 10^{14}$ in 2015 it is therefore assumed that there will be $2.05 \cdot 10^{14}$ pions in 2018. The hourly doses are based on the worst-case scenario (18 sec supercycle with 200 spills per hour), while the integrated radiation doses per year are based on the 2015 average.

With 160 cm balcony shielding, the hourly radiation dose for a person standing on Heisenberg road at the location of the target is (2.48 ± 0.12) μSv. Supported by RP, Angelo chose to integrate over a volume (COMPASS coordinates) of $\Delta z = 1$ m, $\Delta x = 5$ m, and $\Delta y = 7$ m. The integrated dose at the radiation monitor installed at the far-Saleve-side fence towards public terretory is estimated to be (0.76 ± 0.05) mSv in

2018 with 160 cm balcony shielding. For the 2015 run, it was simulated to be (0.72 ± 0.09) mSv, in excellent agreement with the measurement. The presented numbers from FLUKA are afflicted with a +(4-5)% systematic uncertainty since they stem from simulations with electromagnetic showers turned off ("EMF off"). Without the parallel computing capacities of Blue Waters, the decision about the best shielding for 2018 could not have been obtained in such short time.

The values obtained for both hourly and integrated radiation doses with 160 cm balcony shielding are considered to be acceptable by RP and thus this shielding will be installed. It is planned to make the target pump room and the technician's workshop a radiation-controlled area, since they are amongst the areas receiving the highest radiation doses outside of 888. This will further decrease the potential dose that a person without dosimeter can catch.

CEDAR upgrade 2018 (Marcin Ziembicki). The remaining 16 (of 18) PMTs are expected to be delivered to WUT in December. The Time Interval Counter arrived damaged and will be repaired in place. The construction of the test stand at WUT has been completed and data taking is planned to start in the week of this TB meeting. The PMTs will be tested up to a 40 MHz trigger rate using a UV laser. A voltage divider will be designed once the characterization is complete. The pieces for the PMT mounting will be 3D printed or CNC-milled possibly in-house.

FEE: the TDC specifications were estimated by Igor. It will be possible to time both leading and trailing edge. The time bin will be ≈250 ps and the minimum pulse width is 4 ns at ≈500 EUR/32 channels. One unit is expected to be delivered to Warsaw in Jan 2018, the remaining FEE have two months lead time. The discriminator is designed and manufactured by WUT. Working prototypes of the divider and test discriminator will be sent to CERN for evaluation by the BE-BI group.
The *PMT gain* will be measured using light pulses of constant intensity in off-spill time using a pulsed light source calibrated with a 470 nm LED flasher and a multimode fiber splitter. *Need to decide on format and power supplies of the discriminator card (VME, something else?) → action: Caroline will talk to Christophe. Need information on transmission standard to CERN electronics (50 Ohm cable?) → action: Marcin will talk to Johannes.*

CERN BE-BI works on the thermal housing are scheduled to start in January. Currently the necessary materials are being procured. Workshops and technicians have been booked and all drawings are now available. The gallery towards the beam line close to gate 1 has been cleared off unused MWPCs to make space for the installation of the heat exchangers and chillers by EN-CV.

Future upgrades (Caroline Riedl, Franco Bradamante, Fulvio Tessarotto, Igor Konorov). A proposal for extending the COMPASS-II program into 2021 / 2022 for a transversely polarized deuteron run (d-quark transversity) / elastic muon-proton scattering (proton radius measurement) was submitted to the SPSC in October 2017. If approved, the **2021 SIDIS run** will be based on the 2010 SIDIS run with ^{6}LiD $\uparrow$ in 3 target cells. In 2010, the LAS trigger was firing in 50% of the events, flooding the Inner Trigger IT. Both triggers are desirable for the 2021 run. The IT allows to access small x_B. The LAST has been working fine in later years and no issues are expected. The critical points are:

- The existing 2010 PT material can fill a target cell of 3 cm diameter. A 4 cm cell would increase the statistics by 20%. Should more ^{6}LiD material be produced?
- Pure C4F10 gas is needed to operate RICH-1, which constituted a problem during the 2017 run due to a lack of supply. It is estimated that 800 kg of pure C4F10 will be needed for the 2021 run. While 300 kg can be retrieved from a batch to be exchanged with LHCb, 500 kg have to be purchased. The only existing supplier to date is *F2 Chemicals* in the UK and due to the current good exchange rate GBP to CHF it would be advantageous to soon proceed with the procurement.

It is suggested by Vladimir and Gerd to immediately change over from the Drell-Yan setup to the SIDIS setup after the end of the 2018 run, if the 2021 SIDIS program will be approved. This involves moving the target platform downstream by 2 m. The cryogenic piping was modified for the 2014 Drell-Yan run (bending in pipes to reach target moved upstream). Some of the modifications are irreversible and thus some new piping will be needed. Vladimir points out that close attention has to be paid to the replacement and thus unavailability of the cranes in 888, which is planned for LS2.

A first response from the SPSC requests to limit the extension of the COMPASS-II program to only one year, which is why the proton radius measurement will be stripped off in the proposal to only a feasibility measurement in 2021. It is planned to test the TPC of the A2 experiment at MAMI in parasitic mode in the 2018 beam halo at the downstream end of COMPASS together with four silicons stations exploiting the muon contamination of the DY pion beam and potentially with a dedicated muon beam (see Sebastian Uhl's talk at AM December 8). The data of the TPC and the silicons will be read out in triggerless mode (read everything) and will be correlated offline using the common time stamp. Contact at MAMI is Alexei Vorobyev, with whom a discussion took place on December 6. For the 2021 run, it is planned to build a new TPC.

The full proton radius measurement will be inserted into the **Letter of Intent (LoI)** for a *Fixed-target "COMPASS-like" experiment at the CERN M2 beam line beyond 2020.* The LoI is currently in preparation by COMPASS and collaborators and is scheduled to be submitted by the end of 2017. It will contain nine more or less distinct programs for running in or after 2022 using standard muons beams (proton radius, GPD E), "conventional" hadron beams (anti-matter cross section, spectroscopy with low-energy anti-protons, Drell Yan), or RF-separated hadron beams after LS3 with enhanced kaon- and anti-proton admixtures (Drell Yan, Primakoff, prompt photons, spectroscopy with K^-). High-intensity muons will not be available any longer after the RF upgrade of the M2 beam line.

The R&D for hardware upgrades is naturally at a more or less very early stage. Apart from generally desirable upgrades, each program has its unique requirements. It is important to identify whether some of them can be combined to create a common effort and to increase the probability of each program. Which institutes are interested in and able to contributing concretely to which program in the nearer future, before the programs will be approved?

Existing COMPASS spectrometer. All LoI projects assume the continued existence of the COMOPASS apparatus, to a lesser or greater extent. It is therefore of great importance to identify aging components and to prepare their replacement or upgrade. The existing RICH-1 will be required by the spectroscopy programs and the anti-matter cross section measurement.

General upgrades.

- New type of FEE and trigger logic compatible with triggerless readout including an FPGA-based TDC with time resolution down to 100 ps (iFTDC) and digital trigger, capable of higher trigger rates: 90-200 kHz (factor of 2.5-5). *See summary of below.*
- New large-size PixelGEMs are planned to be built (B. Ketzer / Bonn) by 2021 as replacement and spares for the existing large-area GEMs.
- New large-area multi-pattern gaseous detectors (MPGD) based on GEMs or MicroMega technology to replace the aging MWPCs.
- High-rate-capable CEDARs for beam PID for all hadron-beam programs. Based on the experience collected with the upgraded CEDARs (new: PMTs, gain monitor, read-out, thermalization) during the 2018 run, it will be decided whether further upgrades will be necessary for the future programs.
- High-aperture RICH0 for spectroscopy with low-anergy anti-protons and anti-matter cross section for hadron separation at low momenta (DIRC, Large-Area Picosecond PhotoDetectors)?

Specific upgrades beyond 2021 - list might not be exhaustive. RICH-1, RICH0, and CEDARs are not mentioned in this list. They are treated in the two paragraphs above.

- Proton radius: high-pressure active TPC target (similar to A2 at MAMI) or hydrogen tube surrounded by SciFis; SciFi trigger system on scattered muon; silicon trackers to veto on straight tracks (kink trigger).
- GPD E: 3-layer silicon detector inside the existing but modified PT ($NH_3 \uparrow$) at very low temperature, for tracking of the recoil proton in DVCS and PID via dE/dx. Alternatively: SciFis.
- Anti-matter cross section for cosmic ray studies: recoil TOF detector; targets: LH2 and LHe.
- Spectroscopy with low-energy anti-protons: target spectrometer (tracking, barrel calorimeter) similar to WASA at COSY; target: LH2, foil, wire.
- Drell Yan general: high-purity and efficiency di-muon trigger; dedicated precise luminosity measurement; dedicated vertex-detection system; beam trackers; targets: ^{6}LiD $\uparrow$, or C & W.
- Drell-Yan RF-separated beams: due to the lower beam energy, need wide aperture, up to ±300 mrad; high-rate and high-multiplicity capability; "magnetized spectrometer" a la Baby MIND at JParc ("3-in-1" detector, SM, absorber)?; TPCs? GEMs?
- Prompt Photon Production: shielder (20-30cm steel) upstream of target; new hodoscope upstream of ECal0; transparent setup.
- Spectroscopy with K^-: uniform acceptance; ECals; good vertexing; recoil TOF detector.

FEE upgrade for 2020++. Igor summarizes the DAQFEET workshop (Prague, 9.-11. November 2017), which had the following goals: to learn about future physics programs and requirements for read-out electronics; to review existing read-out and trigger systems; to look at the developments carried out within COMPASS; to learn about developments for future experiments; to define the needs and strategy for the further development; to identify interested groups within the collaboration to participate in this R&D; to distribute tasks.

There were various presentations about ASICs, many of which feature triggerless read out, high speed serial link data transmission, and internal digitization. The bottom line is that a **triggerless read-out** solution exists for every detector type. While an adaption of all detectors to triggerless readout by the beginning of 2021 is out of reach, the TB suggests to use the readout of the proton radius TPC as prototype for testing the triggerless readout during the 2021 run. This approach would also benefit the approval of this program.

Most of the intended future programs will have **trigger rates** of at most 25-50 kHz. The prominent exception is the proton radius measurement with 100 kHz. Moreover, a trigger based on the recoil proton signal at very low Q^2 is not compatible with APV and F1 chips. The existing COMPASS main **trigger logic** element is of limited flexibility. It is based on analogue coincidence and uses NIM logic. An **FPGA-based digital trigger logic** has been developed at TUM.

Limits of current COMPASS readout system:

- APV25 (micro pattern detectors, RICH). Trigger latency limited to 4μs. The 20 MHz read out of some of the detectors limits the trigger to 40 kHz.
- F1 TDC (scintillating detectors, wire chambers, RICH). Trigger latency limited to 3 μs (MWPC: 4μs). Reliable conditions only up to 40-50 kHz.
- GANDALF (recoil TOF)
- MSADC (calorimeters). Trigger latency limited to 5 μs.
- FPGA TDC (newest drift chamber).

The Technical Board expresses the interest to **launch an R&D plan for the future FEE upgrade and to form a dedicated group**. The TB acknowledges the work done by Igor so far and recommends to the Collaboration Board to endorse and support the plan, and to ask the individual groups to enter into dedicated commitments. This discussion will be made a point on the agenda of the next CB meeting in January 2018. What is needed is (a) a task list, (b) the definition of priorities, (c) the definition of milestones (in 2018, 2019, ...) and (d) the definition of required manpower. It would be good if such compilation could be available for / prior to the CB meeting.

Igors points out that there are two general steps to be taken: (1) the upgrade of the existing FEEs in order to overcome issues with aging and latency, and (2) the migration to triggerless readout. He asks for an dedicated expert to support or ideally manage part (1) so that he can focus on (2). He will need feedback from the collaboration which detectors to upgrade first.

Some more general considerations are discussed. Should the "FEE upgrade task force" aim rather for a maintenance, or for the "big solution" of a trigger logic compatible with triggerless readout and 100 kHz (from currently $\sim$ 40 kHz) trigger rate? The answer here must be that while planning programs for beyond LS3, modern solutions must be adapted and 20-year-old FEEs (in 2021) must entirely be eliminated. In this context, the FEE upgrade efforts should be bundled as much as possible and the chip(s) should be found that satisfy as many as possible detectors, with unified data format. This would also ease the task of providing a FEE on-call expert.

The next TB meeting is scheduled for Tuesday, February 20, 2018.