Minutes form the meeting with Sasha Feschenko (21-22 Jan. 2016) - NOT FINAL - check (??)

1. **Deflector**
   a. **Old deflector configurations**
      PIC1
      In the past focusing and deflecting parts were separated. This however caused problems with multipacting, therefore they later decided to join these two functions which solved the problem.
   b. **A standard BSM** (ex. linac4) has now a deflector like this
      PIC2
   c. **The new deflector,** which we want to have at ESS, should provide better field quality (less fringe fields). It will be based on 2 ($\lambda/2$) parts, with deflection in the middle.
      PIC3
   d. **Range of RF deflecting field phase adjustment**
      Sasha says this should be >360^o and he uses 3 phase shifters to achieve that.
      PIC8 ???
      The reason for having the phase range >360^o is that the path of the electrons forming the 2 images separated by 180^o is different (for one image electrons are reflected downwards and for the other upwards).
      PIC6
      Note that the two peaks separated by 180^o will not be identical due to different paths of the electrons (small geo. differences causing EM field differences) and party due to differences in calibration for the two different phases. Phase shifters need to be calibrated with respect to the supplied voltage U (phase difference and amplitude as a function of U)
      PIC10
   e. **Power**
      The new deflector will use twice as much power as the standard one, like the one at linac4.
      Note that the resolution depends on power and that there is optimal power which gives best resolution - there is a minimum in the curve which describes the phase difference as a function of power.
      PIC9
   f.

2. **Wire overheating**
   Sasha/INR will make proper calculations with specific beam parameter estimations specified by us in order to determine wire overheating.

   Note: regarding the thermionic emssion and maximum acceptable temperature on the wire, Sasha from his experience sets the limit to 1700K (he was not 100% that this is K).

Note: from one of Sasha's experiences, where the wire was destroyed due to overheating, he says that it is possible to see this overheating during the measurements and react on this in time. If one looks in a 2D plot of $I(\varphi,t)$ one can see that the tail on the right part of the peak starts to increase with time (see fig ??). Here φ marks the phase difference, I the measured current and t time.
PIC13

3. **Beam energy**
We decided to leave it as it is in the in the draft offer as it makes no benefit to limit ourselves to a particular energy range.

4. **Duration of the measurements**
Signal is digitised every 1μs

In the offer it is mentioned that there is one phase point per beam pulse. Since according to current plan the ESS pulse length can vary, starting from 5μs Irena was wondering about statistics. Sasha's answer was that this was written only to make sure we are not talking about bunch-by-bunch measurements. Otherwise, if needed that statistics can be increasing by repeating the measurements at each phase point (or extending it over many pulses).
From Sasha's notes: 10us integration gives 0.5% statistical error (see fig.)
PIC12

Note: Sasha confirms that halo is possible to measure with BSM - but statistics needs to be improved by increasing the number of measurements or extending the measurement time.

5. **Repetition rate**
Our current commissioning plan includes both 1Hz and 14Hz repetition rates. Sasha advises to run BSM only with 1Hz. The reason is potential overheating of the amplifier (part of RF def.), since it is working in pulsed mode. We checked with ICS (Daniel, Timo, Han) that it is possible to get 1Hz trigger from the timing unit even if we run at the beam repetition rate of 14Hz.

6. **Pulse length**
However, regarding the pulse length, Sasha puts the limit to 200μs due to the overheating amplifier in deflector (note that the new deflector will require double power compared to the standard one at linac4).
If pulses longer than 200μs are expected, they can be measured with the use of by external triggering, where the measurement is divided in 2 steps (or more, depending on the pulse length).

7. **Measurement phase range**
Normally the measurement phase range of BSM is 180°. Sasha mentions that this can be increased to 360°, which was desired in the case of BSM at GSI

(Peter Forck). It can be performing the measurement in 2 steps, first for phase difference 0°-180° and then for 180°-360°. During each of the steps corresponding block is manually inserted in order to stop the unwanted electrons.

PIC7 - draw

We decide not to go for that due to 2 reasons:

i) Manually inserting the block will most likely not be possible as it requires access to the tunnel.
ii) In Peter Forck's case the BSM is operating at lower frequency (108 MHz???). This means larger deflector compared to our case and thus easier to cut away the unwanted electrons - ie. smaller error in the geometrical sense which results in smaller overlapping of the electrons resulting from the two different paths.

8. Dimensions

Estimated dimensions provided by Sasha already in March/April 2015 to Bilbao

PIC4

Note that in our case bending magnet is not needed (like in linac4, where they use H-). Instead this magnet will be replaced by a quad and dipole. The reason is that the image on the screen is titled, so the idea is to use those to magnets to rotate it.

PIC5

9. Flanges

From discussions with Marcelo:
- BSM1 (in MEBT): DN40
- BSM2 (after DTL): DN63

10. Beam aperture

Beam apertures from flanges:
- BSM1: 40mm
- BSM2: 63mm

11. Mechanical support

Mechanical support consists of 2 parts:

i) one that is provided by ESS ("*ESS mechanical support*"),
ii) and one which is part of the BSM device ("*BSM mechanical support*"). This one is mounted on the ESS mechanical support.

ESS shall provide the information on the ESS mechanical support, which is needed for the design of the BSM mech. support.

We agreed that this info should be provided in 3 months after the start of the agreement. In the case of the BSM2 this will probably not be an issue (Irena can check this with Marcelo). But might be a problem in case of the BSM1, since there are uncertainties with Bilbao mechanical integration in MEBT.

The important part is to know the height to see if deflector (bottom arm) fits in. Benjamin sent Sasha presentation (https://indico.esss.lu.se/event/413/)

about LWUs from Daresbury, which contains some sketches with dimensions that are relevant for the case of BSM2 (and maybe LBM3 if we go for the BSM in this case).

No special mechanical alignment is needed since BSM mechanical support will include possibility to adjust the device during installation in the beam line.

12. Commissioning

There are 2 stages of BSM commissioning:

a. Stage 1: tests at the vaccum test bench

b. Stage 2: tests with the beam

13. Vacuum requirements

Since all the components have to be compliant the ESS Vacuum Handbook, Marcelo sent Sasha this document for the reference.

In general, there are no problems with BSM1 and BSM2 (if this one is positioned in the LEDP so that it sits closer to the DTL than Spokes).

However, there are several restrictions in the case of BSM3 since this needs to be a "*particle free device*":

i) No welded bellows allowed, only convoluted ones.

ii) During installation Marcelo's team puts up a "*clean room tent*" around, it is also required that it is them that do the installation. This means extra problems in case something gets connected wrong. Also accessing the device or changing something is almost not possible once it is installed.

iii) Different actuator would be needed.

iv) ???

Regarding the cleaning procedure: this can be done at ESS (at our current location, Marcelo also showed us the room) upon the arrival of the BSM to ESS.

There 2 phases of BSM commissioning at ESS

1. Stage 1: tests at the vacuum test bench
2. Stage 2: test with the beam

The tests at the vacuum test bench will happen at the current ESS location, Marcelo has a room her.

<u>Problems with vacuum at J-parc (??):</u>

At J-PARC they had problems with vacuum, when they noticed that the dark current started increasing. In time they discover that there were 3 things needed in order to avoid this problems. First part of the problem was the pin for holding the wire, which has to be properly coated (xxKxxO2xx???). The problems were also aggravated if the pin was made of Cu. On the other hand, using Ni (???) did not display these problems. The third thing needed in order to cure the problems is that this holder needs to be sealed. Sasha says

he is confident that now they understand this problem and have it under control.
Strangely enough they didn't encounter these type of problems before J-PARC.

14. Electronics

a. Schematics of the ESS BSMs

Fig1 shows the schematics from August 2014. In order to port the INR electronics inot uTCA an extra board is needed to interface the crate - "*Interface board*". Here it was assumed that this Interface board is the ICS standard board (probably IOxOS). It is also assumed that one Interface board per BSM is used to connect to and control the INR electronics crate. Whether we need 1 or 2 IOxOS boards depends on list of signals.

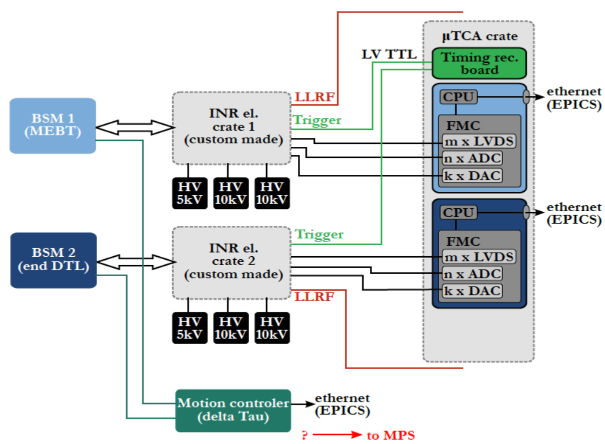

Figure 1: ESS BSM electronics

b. List of signals from INR electronics

3 types of signals needed: ADC, DAC and I/O. The list of those was provided by Sasha on 28. Jan. (see Table 1).

c. Input trigger for INR electronics

An external TTL trigger pulse of 2-5μs length with adjustable delay of about 2ms in advance of the beam pulse is required. Checked with Daniel, Timo and Han that this is possible, and that the trigger length and delay adjustments are possible within the timing unit - this means that the NI DAQ provided by INR does not need to include controlling the trigger delay and length (recheck this???)

d. Input RF reference signal from LLRF to INR electronics (?? recheck that it is really needed by electronics and not defelctor)

BSM electronics needs an RF reference signal with the following requirements: 10dBm, CW, 352.2MHz - this was discussed with Rihua, and no problems here.

e. Control and DAQ system

Currently it is planned that the ICS makes the SW to control the BSM through the Interface board sitting in the uTCA crate. Depending on the list of signals 1 or 2 of these boards will be needed - Irena will check with Daniel.

INR will provide Labview based control system based on Labview with the use of commercial NI control equipment. This will be used during the lab tests and possibly also during either first or both stages of the BSM commissioning - depending on when the ICS is ready with their control system replacing the NI system from INR.

Regarding the NI control equipment, it was decided that (if possible than??) both BSMs have common control. The same will be done with ICS Interface board (ie. 1 board per BSM) if list of signals fits with this.

INR will require at least 30U (or 17U??) space in a 19" electronics rack with 800m depth electronics for both BSM. This will house the INR electronics crates (2, one for each BSM), NI control equipment (also for motion control?).

15. Stepper motor, actuator and motion control

Sasha suggested to use the same actuator and stepper motor as he did with linac4 BSM. This actuator (VG Scienta ZLTM50ME) comes together with a stepper motor. ICS would like to verify that this stepper motor fits with their requirements on motion control. If it fits, we can proceed with this actuator and stepper motor. Initally the motion control from INR will be used to control the wire position, later when ICS is ready with their motion control, the INR one will be replaced with the ICS one.

Sasha was asked to provide the info in ID of the stepper motor. However, since this stepper motor comes in package with actuator and is not sold separately it does not have any ID, which was checked by Sasha (and Uli) after the meeting. Sasha therefore sent us (28.jan) a manual including some info on this stepper motor. Waiting for Daniel to say whether this stepper motor is ok or if he needs more info.

16. Limit switches

At least one extra (mechanical) limit switch is required (in addition to the 2, which should already be on the actuator marking the extreme positions) for the MPS. The connector type will be defined by ICS/MPS (not clear when).

17. BSM3

We decide that the focus of the current offer and following contract should be only on BSM1 and BSM2, due to the following 2 reasons:

i) There are extra complications connected to the fact that BSM3 must be a particle free device (see 10))

ii) The expected theoretical resolution (ie. no SC and maximum SEE delay set to 6ps with flat distribution) which can be achieved with this new design is ~0.5^o (~4ps) . This is on the limit for the required resolution in case of LBM3 (1RMS bumch length before entering the Medium Beta section is ~12ps, and drops to ~9ps after the second cryomodule).

Irena will try to run he simulations to see how much extra distortions is expected due to SC. This should help the decision on wether it makes sens fro the LBM3 to be a BSM.

BSM3 is supposed to be located after the frequency jump. Sasha sees no problems her. Since the 352.2MHz line will be close, we can use this one to connect to BSM.

PIC11

18.

19.

##	Signal Name in Software Description	Signal Name in Internal Wiring	NI BOARD SMCU*	Comments
1	RF Phase	PHASE MEAS.	ADC	0 to +10V DC
2	Deflecting Field	DEFL. RF. SYGN	ADC	0 to +10V PULSE detected covering of deflector RF field
3	RF Field	RF AMP. OUT	ADC	0 to +10V PULSE detected covering of RF amplifier output
4	Steering magnet (mA)	SM CURR. MEAS.	ADC	0 to +10V DC measured current of SM
5	Correcting magnet (mA)	CM CURR. MEAS.	ADC	0 to +10V DC measured current of CM
6	Steering Voltage	STEER. MEAS.	ADC	0 to +10V DC measured steering voltage of lens
7	Lens HV	LENS HV MEAS.	ADC	0 to +10V DC measured focusing voltage of lens
8	Target HV	TARG. HV MEAS.	ADC	0 to +10V DC measured voltage of target
9	SEM HV	SEM HV MEAS.	ADC	0 to +10V DC measured voltage of SEM
10	Intensity	MAIN SIGN.	ADC	0 to +10V PULSE (amplified signal from SEM)
11	Synchronization	TRG. ADC	ADC	TTL PULSE (duration equal to synchro pulse from timing system)
12	RF Phase	RF PH CONTR.	DAC	0 to +10V DC RF phase 0 to 540 degrees
13	Target HV	TARG. HV CONTR.	DAC	0 to +10V DC measured voltage of HV source
14	Steering Voltage	STEER. CONTR.	DAC	0 to +10V DC measured voltage of steering HV source
15	Lens HV	LENS HV CONTR.	DAC	0 to +10V DC read back voltage of lens HV source
16	SEM HV	SEM HV CONTR.	DAC	0 to +10V DC read back voltage of SEM HV source
17	Steering magnet (mA)	SM CURR. CONT	DAC	0 to +10V DC control voltage to SM current source
18	Correcting magnet (mA)	CM CURR. CONT	DAC	0 to +10V DC control voltage to CM current source
19	Correcting magnet polarity	CM POL. ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (correcting field direction)
20	RF Power ON/OFF	RF ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of RF power modulator)
21	Target HV ON/OFF	TARG. HV ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of target HV)
22	Lens HV ON/OFF	LENS HV ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of lens HV)
23	Steering Voltage ON/OFF	STEER. ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of steering HV source)
24	SEM HV ON/OFF	SEM. HV ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of SEM HV source)
25	Calibrator ON/OFF	CAL. ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of amplifier test)
26	Steering magnet polarity	SM POL. ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (steering field direction)
27	Steering magnet ON/OFF	SM ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of SM current)
28	Trigger External/Internal**	MODE OF TRG.	DIO	TTL level HIGH/LOW DIO out to BSM (choice of trigger source)
29	Remote/Manual**	MODE OF OPER.	DIO	TTL level HIGH/LOW DIO out to BSM (choice of operation mode)
30	Correcting magnet ON/OFF	CM ON/OFF	DIO	TTL level HIGH/LOW DIO out to BSM (enable of CM current)

Table 1: Preliminary list of ESS BSM control signals (from S. Feschenko, 28. Jan. 2016)