HIC for FAIR-Workshop

Detectors and Accelerators

Follow up

26.02.2016

Darmstadt

1. Introduction

The main goal of the Follow-up Workshop was to discuss the present status of the main issues, which were identified last year in the meeting (28.07-31.07, Hamburg) within the same framework of the contributors (experimenters and accelerator physicists).

Friday 26.02.2016			
TIME	Titel	Speaker	ca. Min.
*******	**Registration starts at 08:30 a.m.**		*******
9:00	**Welcome+ Introduction**	O. Kester / O. Boine-Frankenheim	15 Min.
	Results and Findings at HIC4FAIR Workshop in Hamburg. Workshop Report. Goals for the present Meeting.	O. Kester / O. Boine-Frankenheim	30 Min.
	Slow Extraction Session:		
	* Input from Detectors (details about the exact measurement region in frequency diagram, possible mathematical model of the response).	HADES (J Pietrazko)	20 Min.
		R3B (T. Aumann)	20 Min.
10:30-10:45	**Break**		
	* Theoretical Aspects	S. Sorge /O. Boine-Frankenheim	20 Min.
	* Technical Aspects	D. Ondreka	20 Min.
	Discussion		30 Min.
12-13:30	**LUNCH**		
	HEST Status Report (transmission, planed upgrade activities)	C. Kleffner	30 Min.
	Discussion		30 Min.
	Ion Sources Status Report (2.7Hz operation, required by FAIR projectiles, Upgrade of source terminal area..)	R. Hollinger	30 Min.
	Discussion		30 Min.
15:30-16:00	**Break**		
	Interface model: SIS18 + UNILAC	S. Appel	10 Min.
	UNILAC Status and planed upgrade activities	S. Mickat	30 Min.
	Beam Dumps for the experiments: Status	K. Knie	15 Min.
	HEBT Charge State Stripper	S. Ratschow	15 Min.
	Discussion		10 Min.
	Discussion Session: The prioritized activities for the planed Machines Upgrade. Overview	O. Kester	20 Min.
	Discussion		40 Min.
18:00/18:30	**End**		

Figure 1: Agenda of the HIC for FAIR workshop “FAIR Detectors and Accelerators”

2. Slow Extraction Session

The quality of slowly extracted beams from SIS18 and SIS100 is of enormous importance for the effective data collection of the CBM/HADES and NUSTAR experiments.

In order to reduce a background signal from the gamma ->e^+e^- decay, HADES uses a very small and segmented Au target (around 2.5 mm). During beam extraction (SIS18, resonance extraction) time-dependent beam position offsets were observed (up to 1.8 mm), which are quite critical for such small targets.
First high intensity experiments with π-beams in 2014 caused radiation protection issues. The reasons have to be investigated and fully mitigated, as the next beam time is planned for 2018.
A beam aborting system for HADES and CBM is already planned for the SIS100. It shall protect the very sensitive and expensive detector from the direct interaction with the primary beam.
The spill microstructure was again pointed out as crucial. The present evaluation shows that with the present beam structure, only 30% of the data from the detectors can be used.

The NUSTAR community is already prepared for the beam time in 2018. The DESPEC experiment could take advantage of 2.7Hz operation with fast extracted SIS18 beams of moderate intensity. For slowly extracted beams, due to the present micro spill structure, the R3B detector will be 3 times less effective for the data acquisition. In discussion it was pointed out that the extraction channel (SIS18) will not have the final shielding required for FAIR beam operation in 2018 and hence will not be ready yet for the full performance of 2.7Hz operation with high intensities. Additionally, a required extraction time of 0.1xcycle time cannot be reached with KO extraction (neither from SIS18 nor from SIS100)[1].

Theoretical aspects of the possible sources of the micro spikes were presented and discussed. The modelling has not been done yet but potential candidates like ripple in magnet field (power converters) or time structure of RF KO-signal were pointed out.

Machine experiments have shown that the ripple of power converters signal may not be the main contributor to the particle clustering in the spill. Simultaneous measurements of the ripple in the spill and power converters are planned. At several machines feedback systems for slow extraction are in operation (HIMAC, HIT for the macro spill structure). The priority to find out the root cause of the spikes was emphasizes, as one has to understand what needs be controlled by the feedback. In a PhD work about stochastic extraction a similar micro structure was observed, though this method gives a very well-defined rectangular spill profile.
In order to increase the extraction efficiency of the SIS18 (only 50-60%, activation issue in 2014), a new position for the electrostatic extraction septum is foreseen.

The importance of the spill homogeneity on the µs level was recognised and investigated since several years at SIS18. The intense discussion within two last Workshops helped to emphasize the problem from the experimenter's point of view. The spectrometer in FRS could even help the accelerator physicists to investigate these issues at SIS18 further, as it gives the information on the beam position, angle and energy drift. Presently, a task group is appointed to explore this subject. In the beginning of June a dedicated Workshop will take place, where world experts should share their experience with slow extraction and solutions they apply on their machines.

[1] At highest intensities of heavy ions like U, the limit also applies to quad driven extraction, since the limit comes from the possible destruction of the septum wires due to beam loss.

3. HEST

An extensive upgrade program is planned for the HEST, which requires approximately 3.5 million euro. The effective discussion during the report presentation has helped to prioritize the upgrade activities as following:

1. Diagnostic is enormously important to control the transmission and detect the beam losses. Beam Loss Monitors and scintillator screens are required and have to be procured at first.
2. Vacuum Chambers of the quadrupole doublet (GHADQD11 and GHADQD12) and of dipole GTH3MU1 have to be exchanged. For the dipole the old chamber has the bake out sleeve which is not required and reduces the aperture. The new chambers in quads will have a star-form.

Additionally, the halo of the beam was discussed. There are no any detailed simulations for the beam dynamic to estimate it. It shall be done as well as the correspondent measurements. Moreover, as a less expensive alternative to the new vacuum chamber in dipole, a solution with halo collimators must be considered.

4. Ion Sources

A diverse R&D work of the Ion Source group was presented:

- Improvement of the MUCIS-2010 ion source, better plasma confinement with stronger magnets and external magnetic coil, new filament position
- New post acceleration gap (approved and tested on HOSTI): more reliable electrode positioning, reduced distances (between and Post acceleration) extraction and PA systems as well as b/w PA and LEBT. As the result, improved beam transmission b/w ion source and LEBT
- Operation with heavy elements: Au, Pb and Bi: due to the injection requirements of the RFQ, it is necessary to produce ion charge state of 4+ from the IS. Pure materials do not work due to the physical properties (low melting point, high metal vapor pressure). Using the composite materials (alloys) in the cathodes makes possible to provide a stable high current operation for all three elements (successful beamtimes in 2011-2015). However the operation duty cycle is limited at the moment to 1 Hz. In order to increase the operation duty cycle up to 2.7 Hz, additional investigations are required.
- Production of molecular beams from Terminal North: stripping of Hydro-carbonites shows enormous improvement of the protons yield compare to the operation with hydrogen. It is evaluated to be up to 25% of the FAIR design intensity (compared to the P-Linac). The beam emittance and momentum spread need to be determined as beam losses in front of the TK could be a result of the space charge effect after stripping.
- Operation with U: by using a new 7-holes extraction system more brilliant uranium beam has been achieved. As a result, a new intensity record for U-operation has been established. 2 Hz and 3 Hz operation modes with maximum performance have been tested. Observed problems were: bad stability (pulse-to-pulse repetition), failure arc triggering, sparking in the extraction system. Possible solutions: reduction of thermal load on the cathode (short pulse operation), improve the physical properties of the cathode material (using U-W composition). Project is ongoing; the additional tests are planned for the following beamtime.
- Increasing the beam brilliance: Possible ways to increase the brilliance of the beam core have been investigated on HOSTI with Ta-beam. The promising results have been achieved by optimization of the core with IS-parameters and with electrostatic compression in the PA-gap. Further investigations are required.

Requested by experimenters ^{9}Be, ^{203}Tl and ^{232}Th projectiles would require a special approval process and a treatment due to the very high toxicity and radioactivity. Also it is evident, that cathodes from pure thallium would not provide $^{203}Tl^{4+}$ ion beam.

5. UNILAC

The UNILAC is the injector linac for the whole FAIR accelerator chain. Concerning the quite ambitious beam quality and intensity requirements an extensive upgrade program is in progress.
For historical reasons the existing High Current Injector (HSI) is known as a bottleneck. All upgrade measures have to aim at the best possible IH beam matching. Therefore a redesigned MEBT, the matching line between the RFQ and IH, is worked out. Two triplet lenses are applied for transverse and one buncher is applied for longitudinal matching. The components are ready for tender. Allocation of budget is announced. A further step in optimising the HSI is the redesign of the RFQ electrodes. Together with the third uranium terminal and the C-LEBT the beam intensity and quality requirements in front of the gas stripper are expected to be full-filled.
The existing gas stripper (continuous nitrogen jet, 4bar) itself is planned to be upgraded with a pulsed system (Hydrogen, 250bar). First experimental investigations result in a higher stripper efficiency for U4+ to U28+ of about 22%. The integration of the pulsed gas stripper into the UNILAC-operation is in progress. As a further upgrade option the EMTEX-project is worked out in parallel. The flat beam profile with different phase space in x- and y-position generated by EMTEX in front of the post stripper linac would be preserved by matching the phase advance in x- and y-direction in the Alvarez linac.
The long-term part of the UNILAC upgrade program is the replacement of the existing Alvarez structures. There are two solutions, which are worked out by a collaboration of IAP and GSI: either a new Alvarez or IH structures. In-house activities are focusing on a new Alvarez post-stripper following the recommendation of an international review committee in November 2013 having the focus on keeping the beam quality and not on saving rf-power. Beam dynamical investigations are promising. The emittance growth in all three phase space planes are below few percent at about 5.3 MeV/u while for the IH-cavities the transverse emittance growth is about 25% and longitudinally is about 10% for the whole linac.
The discussion was focused on the advantages and disadvantages of both post stripper concepts (Alvarez and IH). The higher rf efficiency of IH cavities allows higher accelerating gradients, which saves about half of the installation length in the tunnel compared to an Alvarez structure. The more manageable size of the IH cavities simplifies the fabrication. The later mechanical installation using inter-tank triplets for transverse focusing is straight forward. Lower fabrication costs are expected. Concerning the total costs for both concepts the main part (~50%) is assigned to the rf supply. The upgrade of the rf-gallery has started already and fits both solutions.
Applying the synchronous phase beam dynamics instead of the KONUS beam dynamics as well as the strong periodicity is the reason for the high flexibility of the Alvarez in operation and its high robustness against changing beam input conditions and perturbations. A matching routine for the Alvarez settings for supporting operators is available (periodic solution).
A detailed comparison of both concepts is in preparation and will be presented and evaluated within the next MAC meetings.

6. Beam Dumps

The vast majority of the external beam dumps for the FAIR facility are not designed yet. For the proper constructions, only FLUKA simulations are not sufficient (comprises simulations of the prompt doses and

induced dose rate). Further ANSYS calculations are required to estimate the thermal and mechanical behaviour. Additionally, a large experience with different materials and their characteristics is an advantage. GSI does not have such expertise. In collaboration with CERN colleagues, one candidate from CERN was proposed to support GSI with the design.

7. Charge State Stripper (HEBT)

Originally, one charge state stripper was planned for the HEBT behind SIS18. It has only one foil and two states: in and out of beam. It serves the CBM/HADES requirements to have fully stripped ions (to reach the maximum energy from SIS100). As it is the only place foreseen for the stripper, it has to satisfy the requirements of the SPARC experiments in HESR or APPA cave as well (H-, He-, Li-, Be-like charge states). To fulfil it, one needs several different foils (depending on the production rate) on place with possibility to change them from pulse to pulse. An idea of such chamber was presented, where several foils could be moved in and out (hedgehog form). As impetus, similar solution was proposed as it is used in the stochastic cooling technique at ESR. Another proposal to have an additional stripper in T1S3 line was not favoured. The project is on hold due to missing manpower.