2nd March 2010

3rd FAIR Machine Advisory Committee held on 10-12 February 2010.

General remarks

The third FAIR MAC was held at GSI on 10-12 February 2010. As usual, the Committee was impressed with the quality of the documentation provided and the clarity of the presentations. The agenda of the meeting is appended.

The Committee was pleased to learn that the Project has now been split into modules with a start version compatible with the available budget. The Committee was also pleased to hear that the responsibility of GSI for the machine construction is in the process of clarification. A consequence of this is that GIS must now establish a manpower plan compatible with its obligations to the FAIR Project as well as the support of the on-going research programme at GSI.

Report on Project Status (D. Kramer)

The Committee was informed of the cost reviews of both civil construction and of the German contribution to the machine. As a consequence, the scope of the Project has been adjusted with a “modularized” start version agreed with the experimental collaborations. The Committee is convinced that the proposed start version makes sound scientific sense, maximizing the discovery potential within the current funding constraints.

Summary of the radiation safety Workshop (G. Fehrenbacher)

A one-day Workshop on radiation safety was held at GSI on 7th December 2009. The Committee heard a comprehensive report on the follow-up of that Workshop. One of the main outcomes was a study of the cost saving if access conditions to the SIS100 service tunnel are changed from free access as previously assumed to controlled access. Moving to controlled access would allow the distance between the two tunnels to be reduced, thereby saving on civil engineering cost.

The Committee also heard a report on a study of safety issues concerning an accidental helium spill into the tunnel. The Committee agreed that in general the quantity of helium and the stored energy in SIS100 are insufficient to cause any hazard. However this will no longer be the case when SIS300 is built. The study revealed one possible weakness

in the region where the helium distribution lines enter the machine tunnel. The Committee supports the small change in civil engineering needed to remove this weakness.

Proton Linac (L. Goening)

The design of the proton linac was certainly improved since the July 2009 MAC meeting. In particular, the beam dynamics simulation of the RFQ has been investigated with three different codes, delivering comparable results in terms of transmission and final emittance, and is fully convincing. The start-to-end beam dynamics (from the ion source down to injection into SIS18) was also started with a very reasonable approach: the committee recommends to just complete it by increasing the number of particles in the simulation by at least one order of magnitude, and using - more realistically - Gaussian initial distributions (in addition to the waterbag one) and rms emittances (instead of total ones).

As reported, there was no time to complete the simulations with a thorough error study, as it had been requested. This should regard both the relative misplacement among the RFQ vanes and the misalignment among the various accelerator components on the beam line, especially in the low velocity branch where misalignment errors have the largest consequences. The error study, the reference objective of which should be clearly identified, should be correlated with realistic construction and alignment tolerances of the various components.

It has been reported that a detailed investigation on the beam diagnostics tools on the beam line, including the possible interference with the RF field from the RFQ and the DTL cavities, will be performed in the next six months and will therefore be ready to be reported at the next MAC meeting as well.

Once the above study will be completed, the appropriate timing for a more detailed description of the proton linac, up to the level of the blueprints, depends strongly on the proton linac schedule within the overall FAIR project schedule.

Pbar target (K. Knie)

The Committee heard a presentation of the proposed diagnostics for the antiproton production target. The proposal is well-founded and corresponds well with what is done at other facilities. A presentation was made of simulations of pbar yield from a pulsed

target. The conclusion is that potential improvement (if any) is not justified by the increased complexity.

UHV CR/RESR (A. Kramer)

The vacuum requirements for these two rings have been thoroughly studied. The Committee agreed that it will not be necessary to do in-situ bakeout of the CR ring. Instead it will be replaced by thorough cleaning and bakeout at the manufacturer's premises. This brought up the issue of quality control procedures, which could be the subject of a future meeting.

SIS100 dipole magnet status

The team has made excellent progress on the final design of the dipole, thanks to thorough and detailed studies and measurements. Extensive testing of the BNG prototype (straight, with a 2-layer coil) has confirmed the need for reducing the hydraulic impedance, and the proposal to pass to a single layer coil with a proportionally larger conductor is endorsed by the committee.

The main issues remaining are:

1) Field quality. The high harmonic content at high field is a concern. The magnet team presented a number of studies showing good agreement between computation and measurements, and demonstrated a clear understanding as to the reasons for the harmonics. With this dimension of the magnet aperture it will be very difficult to improve matters significantly. However, during the discussion is was suggested that if the performance of magnets over the series was sufficiently uniform it may be possible to mitigate the problem by judicious use of correcting elements, so the recommendations are as follows:

    a. Careful evaluation of the random components, based on previous data and on tight control of component and assembly tolerances. The QA methods and actions required to ensure that such variations are minimized must be put in place;
    b. Urgently carry out a tracking campaign to be sure that the systematic and random harmonics are acceptable (eventually after local correction) for beam dynamics;
    c. If the harmonics cannot be tolerated, a mitigation measure such as widening the magnet bore should be considered - even at the cost of higher cryogenic consumption.

2) The next prototype will incorporate 3 important differences with respect to the successful BNG prototype:

   a. Single layer coil topology. Inevitable difference in the conductor, cable rigidity, feeder design, voltage breaker design, splices and all equipment associated with a current that is doubled, may reveal unexpected difficulties;
   b. The magnet will be curved (a first curved prototype from Russia is already in the test facility, but has yet to be tested);
   c. A vacuum chamber cooled by contact with the coil package and yoke, rather than by an independent circuit. This is good idea, as it simplifies design and operation, but certainly must be carefully implemented in the assembly process.

   These three new features call for an urgent launch of the purchase of the new prototype. In parallel it is urgent to acquire and test the conductor, which has a new lay-out and is based on a new strand that is quite different from the previous one, due to its larger diameter and the use of Cu-Mn to decouple the Nb-Ti filaments.
   It is recommended to use silicon steel of the type preferred for the final magnet series.

The progress on the main dipole is very good and when these issues are resolved the launch of a series production will be mature. The team displays all the necessary competence to follow the job (with the possible exception of access to sufficient manpower - to be evaluated in due course).

Suggested topics for future meeting(s) (in addition to the follow up of this MAC):

- Report from the sub-committee meeting on the design of the fragment separator magnet;
- Magnet test facility plan (also for production QA);
- Cryogenics (magnet cooling, thermal balance, plant, operation);
- Magnets other than main dipoles;
- Plan to realize the series magnet production;

Machine protection (P. Spiller)

The SIS100 will be a superconducting high-intensity accelerator with a short cycle time. Uncontrolled beam losses have the potential to damage machine components. In

particular, the energy deposition through uncontrolled heavy ion beam losses in the vacuum chamber could lead to local heating, and the resulting mechanical stress to a vacuum leak. This has been observed at the BNL AGS with ion intensities per pulse about two orders of magnitude smaller than those planned for the SIS100. The integrity of the vacuum system is of particular concern in a superconducting machine where repair times are long.

The committee noticed the long wish-list for the accelerator safety system. The list induces contributions from various domains ranging from beam physics considerations to equipment specifications and operational scenarios. The committee recommends creating quite soon a dedicated working group “machine protection” which has to analyze, coordinate and organize these contributions. A clear responsibility should be assigned to the working group leader. The group should have members from at least machine physics, controls, diagnostic, operations and radiation protection to ensure a reasonable adjustment of high operation efficiency versus sufficient machine protection.

The committee feels that not all critical problems are already discussed in the required depth and proposes these topics (+ wish list) to be addressed to the working group. This includes the study of possible failure scenarios and dangerous conditions (e.g. unequal heating of vacuum pipe and flanges) in all machines to define positions, thresholds, timings and dynamic ranges, etc. for important diagnostic instruments but also a robust beam collimation- and beam dump- concept handling normal and faulty beam conditions and extractions.

The Committee also heard presentations of the slow extraction system (N. Pyka) and of the design of the cryo-catcher to control ionization loss (L. Bozyk). The Committee noted that due to beam loss in the extraction septum wires, the doublet downstream of the extraction channel would be warm. This brings up the problem of how to avoid a pressure bump in this region, not yet solved.

Storage rings (M. Steck, H. Stockhorst, D. Prasuhn)

The Committee heard very comprehensive reports on progress in the design of the antiproton storage rings. As a consequence of the last MAC, a very detailed study of the possibility of running without the RESR ring has been undertaken. Various options were considered including the precooling and stacking of antiprotons in the CR and the reuse of the old antiproton accumulator magnets. For very good reasons, these options were discarded.

Instead, a very clever proposal of stacking in the HESR using barrier buckets was presented. This would allow the CR to be constructed as foreseen without any additional hardware and for the RESR to be staged. Very little modification needs to be made to the HESR and the luminosity would be adequate for the first stage of the experimental programme. The staging of the RESR would give some relief to the manpower problem and to the initial budget. The Committee strongly supports this proposal.

Finally, the requirements for the HESR vacuum system were discussed. In this machine, the average pressure is dominated by the PANDA internal target. Therefore there is little justification for an in-situ bakeout. The proposal is similar to that of the CR, with careful treatment of the chambers before installation. Although the Committee agreed with the conclusions as far as PANDA is concerned, it was considered nevertheless worthwhile to look at what has been done in the LHC with very thin home-made bakeout jackets. One day the HESR may have other proposals which will require much better vacuum.

The issue of ion trapping was discussed in depth. The Committee was informed that the beam pickups will also serve as clearing electrodes. One region that could give cause for concern is in the high-pressure region around PANDA. It was proposed that a long strip electrode deposited along the whole length of this chamber should be studied. CERN has already developed such electrodes.

Conclusions

The FAIR Project has made considerable progress since the last meeting. Appropriate steps have been taken to define a “start” version compatible with available funding without compromising the discovery potential unacceptably.

The main technical issue that the Committee would like clarified by the next meeting is the field quality in the SIS100 magnets, particularly the dipoles. This will require an intensive tracking campaign.

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Appendix 1

Agenda

Wednesday 10 February 2010

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14:00->*15:00* **Closed Session**

15:00->*15:45* **Report on Project Status (D. Krämer)** slides

15:45->*16:30* **Summary of the radiation safety MAC (G. Fehrenbacher)** PSpiller; Slides without blue; slides

16:30	coffee break

16:40->*16:40* **Actions arising from meeting #2**

16:41->*17:00* **p-Linac (L. Groening)** slides

17:00->*17:20* **pBar-Target (K. Knie)** slides

17:20->*17:40* **UHV CR/RESR (A. Krämer)** slides

19:00	DINNER (restaurant "Sitte"), by invitation only (Darmstadt)

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09:00->*09:00* **SIS-100**

09:01->*10:00* **Dipole Magnet (E. Fischer)** slides

10:00->*11:00* **Machine Protection (P. Spiller)** slides

11:00->*11:30* **Slow Extraction (N. Pyka)** slides

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11:30->*12:00* **Cryo-Collimator (L. Bozyk)** slides

12:00	LUNCH (GSI canteen (GSI canteen))

14:00->*14:01* **Storage rings**

14:01->*14:45* **Modified CR/HESR Storage Ring Scenario (M. Steck)** slides

14:45->*15:30* **HESR Accumulation of Antiprotons (H. Stockhorst)** slides

15:30->*16:15* **HESR Vacuum Requirements for Beam Stability (D. Prasuhn)** slides

16:15->*17:00* **Discussion**

19:00	DINNER (restaurant "Ratskeller"), by invitation only (Darmstadt)

Friday 12 February 2010

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09:00->*12:30* **Discussion, Closed session, Close-out**

12:30	LUNCH

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Appendix 2

MAC members present

Chairman: Lyn Evans

Members:

Accelerator Physics General	W. Fischer	BNL
Civil Construction Infrastructure	L. Miralles	Spain
Magnets	L. Rossi	CERN
	T. Taylor	ex-CERN
Power Supplies	K. Bürkmann	BESSY
HF	G. Bisoffi	Legnaro IT
Vacuum	A. Poncet	CERN
Diagnostics	K. Wittenburg	DESY
Controls	H. Schmickler	CERN