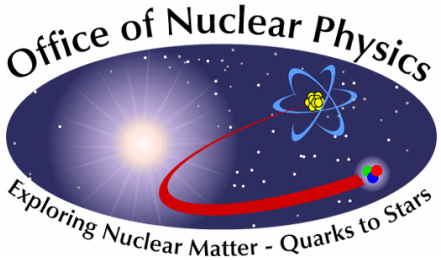


***Department of Energy***
***Office of Nuclear Physics***

Reviewer Excerpts from the

Technical, Cost, Schedule, and Management Review

of the

# Electron Beam Ion Source Project

**July 25-27, 2005**

**EXCERPTS FROM PANEL MEMBER REPORTS**

The Technical, Cost, Schedule, and Management Review of the Electron Beam Ion Source (EBIS) Project was held at Brookhaven National Laboratory (BNL) on July 25-27, 2005. Excerpts from the reports of the review panel members regarding their findings are provided below in their responses to the review criteria they were asked to address.

**The merit and significance of the planned project:**

**Reviewer:**

"An Electron Beam Ion Source (EBIS) traps ions that are injected into it, and then increases the ionic charge state by continuous bombardment with a large current(~10A) of high energy electrons, until the required charge state is reached, and then the ions are ejected. The process is cyclic in nature, and is very well suited for injection into the booster-AGS-RHIC complex after pre-acceleration in an RFQ and LINAC. The BNL test EBIS has shown performance with Au that is within a factor of two of that provided by the present tandems. The tandems have been operating well, but require considerable technical support to maintain operational readiness and reliability, and the effort required to maintain them will certainly require considerable funds as they age. Failure of the column structure of the machine, or damage due to chain failure, could cause considerable down time to repair. In view of this, construction of an EBIS with the goal of providing reliable beams to the AGS booster for further acceleration into NSRL and RHIC has great possibilities to increase reliability and reduce operating costs. Other potential benefits are a broadening of the scope of available beams to include the rare gases that cannot be accelerated with the tandems, and the ability to rapidly switch between different beams on a one second time scale, both of which are important for the National Space Radiation Laboratory, supported by NASA.

"In summary, the project has great promise to improve the capabilities of the RHIC complex and has the potential to reduce operating expenses when the tandem operations are curtailed. The BNL Collider-Accelerator Division has the technical capability and expertise necessary to complete the project."

**Reviewer:**

"Between the upgrade program that would be needed for the Tandems ($9M) and their operating cost (~$2M/yr); the pay back time is about 5 years past CD#4. In addition there would be an increased reliability, availability, and luminosity. From the NASA point of view, they will also get ions that are currently not available (Noble gasses)."

**Reviewer:**

"Replacing the aging Tandem by a new electron beam ion source (EBIS) injector system will significantly improve the overall RHIC performance and operation in many aspects.

The new injector will provide short high intensity heavy ion beams from deuteron to gold with the possibility to send different ion species to multiple users with switching time of 1 second. There are many other important features of the proposed injection scheme:

- Increased beam luminosity in the RHIC;
- Significantly reduced operating cost of the injector;
- Improved reliability and availability of the RHIC;
- Improved beam delivery to the NASA Space Radiation Laboratory (NSRL);
- Possibility to upgrade to higher intensities and extend available ion species."

**Reviewer:**

"Due to its age, the Brookhaven Tandem Injector for AGS/RHIC has entered a technical state where maintaining acceptable performance would require significant investments, specified by the BNL team as 9 M$. Reduced injector performance would mean a major loss in performance of the AGS/RHIC facility with severe repercussions on its user communities in the Nuclear Physics and High-Energy Physics areas. For this reason, BNL has proposed to build a new injector that will be based on much more modern technology, built around an EBIS ion source and RFQ and IH accelerators. Beams with the same or more intensity and significantly improved availability and reliability as compared to continued use of the Tandem injector are not only essential for these two user communities but also very attractive for the NASA-Space Research Laboratory (NSRL) program, to a degree that NSRL has offered to contribute 4.5 M$ to the project and sent three participants to this DOE Review. Especially the planned NSRL research activities are going to take advantage of the future availability of ions from noble gas and heavier elements such as iron or uranium that can easily be produced by the EBIS but cannot be produced by Tandems.

"Being able to replace the 860-m long transfer beamline used with the Tandems by a 30-m long transfer line will be a major advantage in terms of overall reliability and facilitating fast switching between various ion beams for different users. As an additional benefit, the number of injection turns into the Booster synchrotron would be reduced from 40 to a few turns, simplifying this injection process considerably.

"Maintaining or even improving the present capabilities of RHIC/AGS is a high-priority issue for BNL, following the opening statements of its director Praveen Chaudhari.

"On the cost side, in addition to the 9-M$ investment needed in the near future, the current operating expenses for the Tandem injector amount to about 2 M$, compared to about 250 k$ for the EBIS injector.

"Currently there are other users who utilize the Tandems to obtain beams of moderate energy during the times when no injection into the RHIC collider takes place, under a full cost-recovery arrangement with BNL. The planned injector upgrade does not directly affect this user group, other than precluding usage by the time when no Tandem will be available anymore due to component breakdown. This is a necessary consequence of realizing the savings in maintenance and upgrade efforts by pursuing the EBIS injector

project. Additional, independent funding could in principle save the Tandem facility for these users."

**Reviewer:**

"Brookhaven National Laboratory (BNL) proposes to design, build, and implement a new heavy ion pre-injector to supply beams of positive ions to the NASA Space Radiation Laboratory and to their booster ring, which feeds AGS, which in turn feeds RHIC. When the new injector matches or exceeds the beam intensity and beam quality of the existing Tandem injector, BNL will shut down the aging Tandem pre-injector.

"Brookhaven started to consider a compact heavy ion injector in the 1980ies. Electron Beam Ion Sources had better prospects than ECR ion sources or Laser ion sources for producing the quantity of highly charged ions required for the pulsed injection into RHIC. The 1988 Electron Beam Ion Source Symposium at Brookhaven made it clear that the RHIC requirements can only be met by significantly scaling up one of the existing EBISes, which was considered a significant technical challenge. In the early 1990ies, Brookhaven started their own EBIS program to demonstrate the feasibility of such an EBIS. BNL designed an EBIS test stand that could produce 50% of the required ions. A few years ago the implemented test stand exceeded the 50% requirement. This outstanding effort and success earned the first "Brightness" awarded at the $10^{th}$ International Ion Source Conference. To double the ion output, a new EBIS needs to be developed that is twice as long. The EBIS proposal includes a higher current electron gun and collector to improve reliability and possibly allow for higher ion output in the future.

"The operation cycle of the proposed EBIS injector is as follows: One of the 3 external ion sources on ground potential injects a beam into the EBIS. The ions are trapped for a small fraction of a second in a powerful electron beam, where they rapidly loose their electrons to reach the desired charge state. During this time the EBIS platform is raised to ~100 kV. A fast expulsion is used to extract all ions in a short pulse. That ion pulse is accelerated to ground potential and injected into an RFQ. A set of lenses matches the RFQ output into the LINAC. The accelerated beam is then transported and charge analyzed in dipole magnets before it is injected into the booster ring. When the AGS is filled, the injection yard can be switched to a different source, and the beam transport elements can be tuned to different beam rigidity within ~ 1s. This allows for delivering a pulse of the same or different ion specie to NSRL. After another ~1s period, the original conditions are restored and the cycle starts over.

"BNL and its funding agency, the DOE Nuclear Physics Division, have a significant interest in this project because it enables new opportunities with RHIC, it enhances RHIC's performance through increased intensity and improved beam quality. It reduces anticipated downtime, and it reduces labor cost for maintaining the aging Tandems. Accordingly, DOE has approved CD0 in August 2004.

"The broadened ion menu, the increased ion flux, and the increased scheduling flexibility is of significant interest to NASA. Accordingly NASA has committed 4.5 M$ to the

project in June 2005. This commitment allows for early procurement of long lead items, and therefore BNL is proposing an accelerated schedule.

"This proposal is based on the extended development of EBIS technology at BNL. The EBIS is the corner stone of this project. Its versatility will enable many new scientific and technical opportunities that are not possible with any existing injector.

"This proposal has very high merits because it will allow for a broad range of new scientific and technological opportunities. The new injector is practically certain to offer higher ion flux, better beam quality, higher reliability, higher availability, an increased number of ion species, and a reduction in operating cost. It will benefit RHIC as well as NSRL users. Especially the NASA users can expect significant benefits and drastically increased flexibility in scheduling runs with ion species of their specific interest. "

**The technical status of the project:**

**Reviewer:**

"The test EBIS has operated as an experiment, and has not been fully engineered and instrumented to be able to provide the required intensity, reliability, and ease of operation that is needed to be part of the routine operation of the RHIC complex. Several new issues must be addressed to be able to have a new, larger EBIS able to meet these goals. Some of these new challenges are listed below. They present varying degrees of risk of project delay or failure to meet performance goals.

1) The required performance that is needed is about a factor of two better than what has been produced in the test EBIS. However, the nature of the scaling with different parameters is well understood, so that increasing the length of the trap has an excellent probability to produce the required increase in intensity.

2) The required magnet is larger than the prototype. However, similar magnets have been constructed successfully, and a manufacturer has indicated their capability to build this magnet.

3) The test beams were not accelerated and injected into the booster. The proposed system is straightforward, but has many areas that must be carefully designed and executed to achieve this goal. First, the whole EBIS platform, including the superconducting magnet and all of the cooling water and power supplies for the electron gun, drift tube structure, electron collector and control system must be isolated from ground and pulsed to 100kV while the ions are being ejected from the trap. Although this is straightforward technology, it must be designed and built carefully to avoid problems. The accelerator division of BNL has extensive experience in these areas.

4) The pulse of high charge state ions must be matched into the RFQ by the LEBT, and then accelerated by the LINAC. The beam optics, both longitudinal and transverse for this process have been modeled, but there is no substitute for an

actual test. The planned test of injecting the RFQ with the test EBIS early in the project is important.

5) The RFQ and the LINAC are proposed to be purchased from an experienced company. However, the fabrication and testing plan must be closely monitored to ensure timely delivery."

**Reviewer:**

"The project is in excellent shape for pre-CD#1; their test EBIS basically eliminated all but some minor schedule risk.

"The technical design is very low risk due to the "Test EBIS" successful operation and the reuse of many existing hardware designs. While they are very advanced for CD#1, the requirement to have the complete technical detail design by end of FY06 (CD#3) will severely stress the FY06 manpower."

**Reviewer:**

"The project includes three main parts: EBIS with LEBT; RFQ and LINAC; MEBT and HEBT.

"The developers of the project have made well-founded decisions concerning the technical realization of the new injector. Among all known types of ion sources, the electron beam ion source developed at BNL will satisfy all the specifications of the new injector system. The demonstrated performance of the EBIS is a good starting point for this stage of the project. Twice higher beam intensities must be produced by the EBIS to meet the project scope. To achieve beam intensity specifications, the project team has proposed longer 6-Tesla SC solenoid and an electron gun with increased current in the EBIS. This proposal is based on experiments at BNL and other laboratories and has been widely discussed among the ion source community with positive response. The EBIS and LEBT are the most unique parts of the project. To avoid technical uncertainties, an extensive R&D work on EBIS and LEBT must be performed within the following year. There is a specific R&D plan with the goal to fully characterize EBIS beams at 100 kV ultimate voltage. Particularly, it is important to measure beam emittance, energy spread of each ion species at design peak current. The project team should be encouraged and supported to complete all scheduled R&D tasks.

"The RFQ and LINAC are devices that have been built and operated with similar parameters in several laboratories worldwide. The distinguished feature of the RFQ and LINAC for the EBIS injector is a simultaneous acceleration of several charge states of ion beam with noticeable space charge effects. To avoid an effect of the space charge on the quality of the main ion beam and possible increased beam losses, the design of both RFQ and LINAC must be done using realistic parameters of multi-component ion beam downstream of the LEBT. Therefore, complete characterization of ion beams during the

R&D stage is extremely important for the final design of the RFQ and LINAC. The project team will benefit from end-to-end beam dynamics simulations of the whole chain LEBT-RFQ-LINAC-MEBT with the code reflecting realistic conditions and possible errors. Using RFQ and LINAC operating at 101 MHz for acceleration of heavy ions up to 2 MeV/u has low technical risk if the detailed design of these structures will be made based on realistic beam parameters.

"The design of MEBT and HEBT is adequate for this project. Detailed analysis of all EBIS injector systems such as items 1.2 through 1.10 of the WBS shows very high level of technical design."

**Reviewer:**

"The technical state of the planned EBIS injector is in several areas much more advanced than many comparable projects in this phase (CD0 – CD1), due to careful planning, a significant R&D effort already spent, and the intended procurement of major components from outside vendors. While RFQ-based injectors are well established in accelerator facilities all over the world, the use of an EBIS ion source is somewhat more risky in principle but certainly not entirely novel either. In fact, the development of the Test EBIS carried out at BNL is considered world leading in the accelerator community, as evidenced by the award of several invited lectures to key researchers at international topical conferences and a technical award conveyed to two of them. The BNL ion source team has credibly established the scaling laws on which the final design and projected operational parameters of the Injector EBIS are based. Two primary ion sources are already in operation to feed the main EBIS with a variety of singly charged ions, and more options are being investigated; the layout of the EBIS complex facilitates the addition of such alternate primary ion sources.

"IH accelerators have been built and successfully operated in several accelerator facilities as well. Procuring the RFQ and IH accelerators from a well-established vendor, as intended by the project team, minimizes the technical risk.

"The beam dynamics calculations for accelerator and transport-line subsystems including the Booster Synchrotron have been carried out using standard simulation tools and do not point to any critical issues. Some details will still have to be addressed, for example, the planned use of a gridded lens in the low-energy beam transport.

"EBIS and beamline components such as superconducting solenoid and room-temperature magnets, power supplies, power rf systems, and diagnostic elements have already been specified in significant detail, and ancillary technical subsystems such as control system, mechanical support and alignment, power distribution, vacuum system, and cooling system have been sketched out in sufficient depth.

"Operation of the EBIS cathode at 20 A as compared to the nominal 10 A current promises increased ion-beam current capabilities beyond the performance seen with the

Tandem injector, but these expected gains cannot be quantified at this point, and the higher cathode current might adversely affect the time-between-services."

**Reviewer:**

"The EBIS test stand has demonstrated the feasibility of this project. The full RHIC requirements will be met with a proposed EBIS that is twice as long. The scaling of the ion output and the trap length of an EBIS has been experimentally tested, and is well accepted within the ion source community. The requirements for the proposed EBIS are moderate and should be met with minimal risk.

"A new technical feature is the EBIS platform that needs to be switched several times every second. BNL plans to build the needed HV supplies and switches in-house. This is an excellent plan considering these one-of a-kind requirements. The so developed in-house expertise will be very useful for improvements, trouble shooting, and repair.

"In the near future the test EBIS will be used to test the new gun, and the new collector with a new extraction region. Once the extraction region features an adequate bore, the beam emittance will be remeasured, which will allow for improved modeling of the low energy beam transport. This proposed R&D plan is aggressive and sufficiently addresses the emittance concerns raised by the external committee of a previous internal review.

"The technical design of the overall project is ready for CD-1, although some minor details mentioned below ought to be considered. The technical design of the new, modified EBIS is well beyond CD-1. The Electron gun design is complete and an accurately costed. The well-working drift tube structure on the test EBIS serves as conceptual design of the 2 times longer and slightly larger drift tube structure. The design of LEBT with adequate bore is in progress. The proposed diagnostics is minimal but adequate. The installation and testing scope and schedule have been defined and are reasonable."

**The feasibility and completeness of the budgets and schedules:**

**Reviewer:**

"The budget and schedule given are in reasonable detail for the current stage of the project."

**Reviewer:**

"The completion of the SNS project last April provides more than adequate manpower for the EBIS project. This in conjunction with the Lab and Division management acknowledging that this project is a critical step in the Laboratory's future, guarantees that the project can be expected to receive the priority required. The budget is solid.

"The project team acknowledged one schedule disconnect: the RF power for their Jun-07 RFQ test. The two RF transmitters are an $800K element which needs to be a phased procurement. In the view graphs it was not listed as a one year or longer procurement, but in the schedule it was listed as 18 month for first article; arriving 10 months after the RFQ test. A temporary RF source is being proposed as a fix; this needs to be hardened up ASAP.

"I recommend that the schedule be accelerated to reduce risks and to increase the schedule float by:

a) Request that the NASA deduct for the FY05 $0.5M be in FY08 not 06.

b) Accelerate the two remaining "critical path procurements" by phase funding; if possible phase fund all four "critical path procurements" in FY06 with NASA funds and complete the contracts with FY07 NASA funds. (This needs to be integrated with the RF transmitter schedule!!!)

c) Delay the contingency profile 0.75 years with respect to the planned obligation profile in order have more BA available in FY06 & 07and to better match the actual usage plan."

**Reviewer:**

"The proposed budget and schedule are adequate for the project. The project team consists of BNL staff who has gained wide technical and management experience in previous accelerator projects. Detailed technical description of the project sub-systems were presented during the Review. Particularly, I was involved in detailed inspection of two WBS items: 1.2. Controls and 1.6. RF Systems. Both sections are well advanced and ready for the construction phase of the project. For this stage of the project the cost estimate is well advanced and based mainly on historical data and vendors' quotes."

**Reviewer:**

"The proposed budget includes a part that is going to be funded by NSRL, fiscally independent from the DOE project. This is a fortunate circumstance that will be exploited by procuring several long-lead items ahead of the time when they could be acquired under a fully DOE sponsored project. The schedule has not yet been detailed nor fully resource loaded, which is acceptable at this phase of the project. The budget profile at this point shows a critical phase in July 2007 where the planned outlay exceeds the anticipated budget authority after subtracting contingency; it appears somewhat of a stretch assuming that midway through the project no significant calls on contingency will have been made. This bottleneck could most probably be avoided by careful planning.

"Standard project management tools have been selected and are in use, and a Work Breakdown Structure has been established. The cost estimates are based on a high percentage of reliable predictions such as catalog prices and vendor quotes. Examples for specific costs were given in many instances, but formal cost books have not been assembled at this time; they are not yet required, either.

"Adequate manpower appears to be available to this project, and BNL Management supported the notion that personnel shifts could be made if needed as the project progresses. Before the start of the project, significant R&D efforts were carried out using dedicated DOE funds, RHIC base funds, and CDR funds."

**Reviewer:**

"The budget range required for CD-1 is well established. A large fraction of the budget is based on quotes and estimates from previous projects. The project team is well aware of the budget constraint at the end of the FY'07. Shifting some of the FY'08 funding to FY'07 is highly recommended to the funding agency. The required manpower is a small fraction of the RHIC staff and therefore a non-issue. "

**The effectiveness of the management structure and project documentation:**

**Reviewer:**

**"**A set of proposed Functional requirements and Critical Decision 4 (CD-4) deliverables were included in the Preliminary project Execution Plan (PPEP). These needed to be more clearly defined and made reasonable achievable at the time of CD-4. Discussions at the review resulted in a table of agreed upon CD-4 deliverables as well as planned optimum performance specifications.

"The project is jointly funded by DOE and NASA but the management of the project is designated as the responsibility of DOE. At this time, the management of the NASA contribution to the project is unclear. The scope of work to be covered by the NASA contribution needs to be clarified in the project documentation. The Program Office has provided guidance following consultation with DOE Office of Engineering and Construction Management (OECM).

"A Project Management structure is established and documented in the PPEP. The Management structure appears reasonable overall and is integrated with the Brookhaven National Laboratory (BNL) management structure, but there are some minor concerns. The BNL Project Manager/Project Services personnel are only assigned to the project on a part time basis. There was no clear assignment of responsibility for project integration. The project will rely on procurement and other functions which are funded from lab overhead. Addressing these concerns would not likely have a cost impact to the project. It is more a matter of clarification of roles, responsibilities and accountability.

"The project is organized into a Work Breakdown Structure (WBS) for purposes of planning, managing and reporting of activities. The WBS appears reasonable and consistent with the discrete increments of project work. The WBS dictionary is comprehensive.

"The Baseline Change Control (BCC) process established in the PPEP appears to be appropriate with one exception, that being it only addresses Total Estimated Cost (TEC). The BCC needs to address Total Project Cost (TPC) per DOE requirements.

"A Project Management Control System (PMCS) is being established for baseline cost and schedule development and progress reporting. The PMCS appears to be appropriate for this size project and the individuals involved appear well qualified for the task.

"The project will be required to undergo an External Independent Review (EIR) from OECM within the next year (required for CD-2). It appears that no explicit preparations have been made to-date. EIR's have a history of requiring significant effort on the part of the project office as well as the site office. The project office, in coordination with the Federal Project Director, needs to proactively begin preparations for the EIR. There was a recent EIR conducted at BNL (CFN March 2004) which could serve as a data point for preparation and execution of the EBIS EIR.

"A Linac extension (building addition) is needed for the project. It is outside of the scope of EBIS. Funding for the work is from the State of N.Y. The Linac extension needs to be coordinated with EBIS to support the EBIS schedule. A set of integrating milestones should be developed and included in the EBIS schedule.

"An Alternative Analysis was performed and is provided in the PPEP. The Alternative Analysis appears to be reasonable and adequate for DOE requirements.

"The project has prepared a preliminary assessment of the risks associated with the project. A risk based contingency assessment process has been developed. The risk based contingency methodology appears appropriate for this project and a contingency assessment is expected to be completed to support the project baseline at CD-2.

"A Preliminary Hazard Analysis was prepared which indicated that further analysis of several hazards was necessary. None of these appears to be significant. A Safety Assessment Document (SAD) is to be completed by the first quarter of 2008. It is advised that the final integrated project schedule include appropriate safety approval milestones.**"**

**Reviewer:**

"Management of the project is currently handled part time by a scientist who has other responsibilities. It is important for BNL to evaluate whether this arrangement is appropriate, especially in view of the large amount of meetings and paperwork associated with the upcoming stages of the project."

**Reviewer:**

**"**The management account has three quarter time people for four years. These three people also have other duties on the project and therefore are really are costed as half time. The project manager should be full time (except possible in the middle of the project); in fact due to the CD#2 & 3 schedule in the 4QFY06, the entire Management Team will be working more than fulltime on EBIS for the first half of FY06.

"The documentation is off to a very good start. The only item that sub-standard was the "Costbook"; this was a format problem and not a content one. The "Costbook" was not a real costbook but the backup material for the cost estimate (this was very impressive, with 60% of the materials being Vendor Quotes or Catalog Prices). Cost rollup data at Level 2 & 3 was in the PPEP and the presentations. For the CD#2 EIR the project will need to provide roll ups from the entry level to the TEC and TPC. At each level of the WBS tree, the labor and material must be shown. The information has now been loaded into Microsoft Project; if one can get MSP to export the tree this becomes easy; otherwise they will need a parallel data base.**"**

**Reviewer:**

**"**The project team has developed effective management structure to proceed with the project implementation.**"**

**Reviewer:**

**"**Formally, the proposed management structure appears to cover all the important aspects of the project. The potential issue that surfaced at the review was that a number of the higher-level managers, including the Project Manager, will be assigned to the project in a part-time fashion. This would in all rule lead to major problems in the execution of such a project, but for two things: 1., most of the selected higher-level managers are very experienced in leading projects of similar nature and magnitude and used to working with each other, and 2., BNL management again made it very clear that assignments could be shifted if difficulties in the execution of this project required it. All in all, these statements can be judged as credible."

**Reviewer:**

"The proposed management team is highly qualified, highly experienced and is highly respected within the accelerator community. This is a working team that has already worked together successfully on numerous projects. "

**<u>Other issues related to project:</u>**

**Reviewer:**

"The challenge for the project is that their CD#2 & 3 is planned in 4QFY06."

**Reviewer:**

"While NSRL appeared to be fully committed to expend the announced amount of 4.5 M$ under a funding profile that greatly enhances the chances of the EBIS Injector project to succeed in a timely manner, the NASA representatives seemed to be somewhat surprised by the fact that the envisaged CD4 acceptance values for some relevant parameters of the new injector are well below the nominal performance values. This points more to a lack of familiarity on the side of NASA with the function of the CD4 acceptance criteria within the DOE approval process than to a real problem with the project's anticipated chances of ultimately reaching nominal performance. On the other hand, the voiced concerns underline the importance that this project has for NSRL"

**Reviewer:**

**"**Currently it is planned to install the new collector on the EBIS preinjector, which will disable the EBIS test stand. However, power collectors are often a concern when they are one-of-a-kind with a very long lead time. The new collector is being appropriately designed and there are plans to verify the design with thermal measurements, and therefore the collector can be expected to work well. There is, however, a residual risk that something could go wrong without being detected, and lead to a catastrophic failure, e.g. by changing the electron impact distribution. This risk should be mitigated before decommissioning the Tandem injector. A quote suggests that a spare collector could be acquired for ~60k$. This collector could be installed on the test stand which would turn the EBIS test stand into a Hot Spare Stand. Normally it would be available to develop new ion species, to develop higher ion output, to test new schemes and/or components. Most failures of an EBIS component could be quickly mitigated by swapping the broken part with the part from the Hot Spare Stand. The problem can then be properly resolved because downtime of the Hot Spare Stand is rarely an issue.

**"**The project team is well aware of several concerns and has integrated them in the project risk list. Some are mentioned here as a reminder:

1. Currently the proposal is based on a low cost RFQ and LINAC being fabricated at an University. The project team is encouraged to conduct a customer satisfaction survey with more customers. The proposal acknowledges this risk and plans to mitigate it through early procurement.
2. Installation of the HEBT requires the shutdown of the booster, which normally occurs in summer. Early acquisition of the needed elements and/or early installation is being considered.
3. A spare collector would mitigate the risk of extended downtime, and could also convert the EBIS test stand into a hot spare stand. The hot spare stand can be used for future developments.
4. The EBIS solenoid is a small risk that is mitigated by the proposed early procurement. **"**