

LANSCE PROTOTYPE BEAM POSITION AND PHASE MONITOR (BPPM) MECHANICAL DESIGN *

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Abstract

A prototype Beam Position and Phase Monitor (BPPM) beam line device is being designed to go in the LANSCE 805-MHz linear accelerator. The concept is to install two beam line devices in locations where their measurements can be compared with older existing Delta-T loop and wire scanner measurements. The purpose for the new devices is to measure the transverse position, angular trajectory, and central beam phase and energy of the LANSCE H+ and H- beams. The mechanical design of the new devices will combine features from previous LANL designs that were built for the LANSCE Isotope Production Facility, LANSCE Switchyard project, and those done for the SNS linear accelerator. This paper will discuss the mechanical design and fabrication issues encountered during the course of developing the BPPM.

LANSCE PROTOTYPE BPPM

Two new BPPMs are being fabricated as prototypes for possible replacement of the existing LANSCE 805 MHz BPMs, which also contain an additional capacitive pick-up. The capacitive pick-up is used to measure the beams central phase and time of flight between accelerating structures. These measurements are used to set the accelerating modules RF phase and amplitude. There are problems with the reliability of these position measurements such that wire scans and beam loss measurements are used to determine beam position which has the effect of longer time periods being dedicated to beam tuning. A number of BPMs have been designed in the recent past at Los Alamos for both LANSCE and the SNS project. The new design for the LANSCE BPPM [1] incorporates many features from these previous designs.

MECHANICAL DESIGN

Design Requirements

The BPPM project team established a number of requirements which helped to narrow down the focus of the design. These requirements were:

- Consider both a shorted electrode and an isolated electrode.
- Utilize the Meggitt Safety Systems, Inc. (MSSI) [2] SMA style feed-through or equivalent.
- Make the connection between feed-through and electrode a "hard" electro-mechanical one, i.e. The feed-through center-pin connection to the electrode shall be either welded, brazed, or soldered.
- Provide mechanical protection for the feed-throughs so that they will not be damaged during handling.

- Make provisions for alignment consideration and tooling so that the FARO [3] LASER Tracker can be used to position or locate the device.
- Use the immediate upstream bore diameter for the BPPM bore diameter, 44.32-mm.
- The overall BPPM length must allow the new device to fit within the confines of the previous BPM/Delta B-dot loop locations.
- Provide one design for all locations throughout the LANSCE 805 MHz linear accelerator.
- Design the electrode to be as long as possible and no shorter than 40-mm.
- Use a 60° subtended angle for the width of the electrode.
- Beam line interface flanges shall match the existing BPM/Delta B-dot loop devices.
- Provide mechanical support and alignment capability if needed or possible depending upon location and interfacing equipment.
- Consider provisions for the new BPPM cable strain relief.

Design Concepts

There were two primary design concepts considered. The first was based on the LANSCE Isotope Production Facility [4] (IPF) BPM featuring an isolated electrode. A longitudinal section view of the IPF BPM is shown in figure 1.

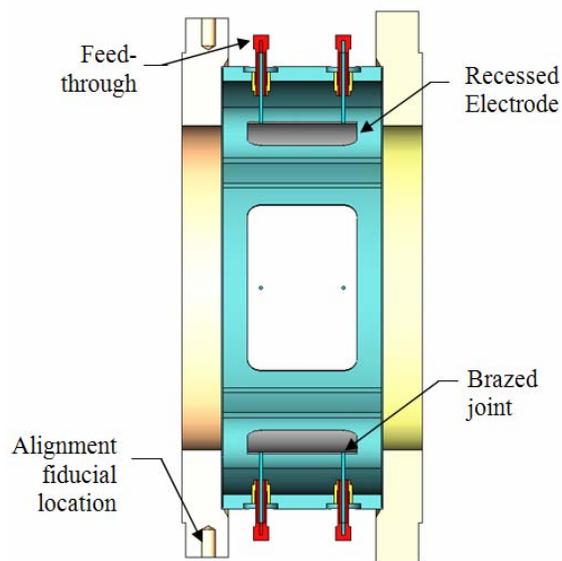


Figure 1: IPF BPM with Isolated, Recessed Electrode.

This type of design meets some of the requirements specified for the LANSCE BPPM such as the use of the MSSI feed-through and a brazed connection between the

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feed-through and electrode. It also has the electrodes positioned slightly beyond the aperture of the device in recessed pockets. A disadvantage of this design is that it is difficult to precisely position the electrodes since they are held in place by the two feed-through center-pins. Although to counter this problem any error induced by out of tolerance electrode positioning can be corrected for during the calibration or “mapping” process. The scale of this error can also be quite small and depending on the application may not be an issue at all. For example this offset error for the IPF BPMs was found to be 0.006-in X and 0.010-in in Y.

The second concept was based on the BPMs designed for the Spallation Neutron Source (SNS) [5] linear accelerator at Oak Ridge, which in turn was based on the RHIC BPM [6] designed at Brookhaven National Laboratory. A longitudinal section view of one of these BPMs is shown in figure 2.

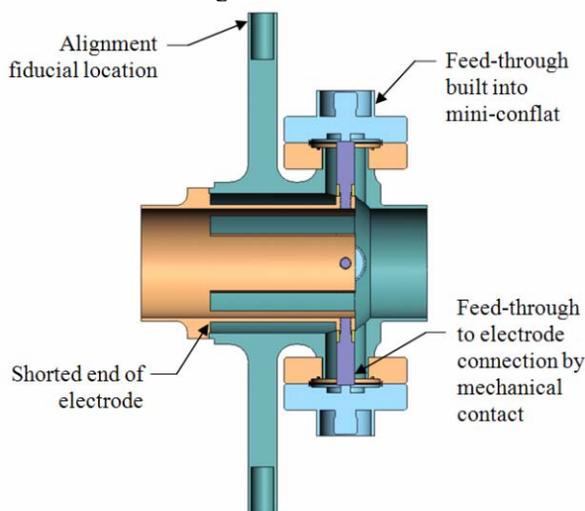


Figure 2: SNS CCL BPM.

This type of design features a shorted electrode on one end. It also utilizes the same SMA feed-through, except this time the feed-through is built into a mini-conflat flange. The center-pin of this feed-through contact a “signal pin” as the conflat flange is made up. By careful sizing of the signal pin and by careful assembly of the conflate flange the SNS BPM electrode can be placed very accurately. This type of design also meets many of the specified requirements, such as the use and protection of the MSSSI feed-through. One potential disadvantage of this design is that the connection between the feed-through and electrode is achieved through mechanical contact and is not soldered, brazed, or welded. Another disadvantage is the somewhat complicated assembly process required to achieve the accurate electrode position.

A combination of the two concepts was developed for the LANSCE BPPM prototype. Figure 3 is an exploded section view of this hybrid design. Some of the features of this design are:

- The MSSSI feed-through is silver brazed to the electrode.

- The feed-through is protected from accidental damage by a ring.
- The beam-line length of the device is minimized by building the vacuum flanges into the body of the device.
- The beam-line vacuum seal will be made using the “LAMPF” standard, aluminium wire vacuum seal.
- The electrodes are mad as one piece and are then welded into the cover.
- The overall device length is 76.2-mm.
- The electrode length is 44.5-mm.

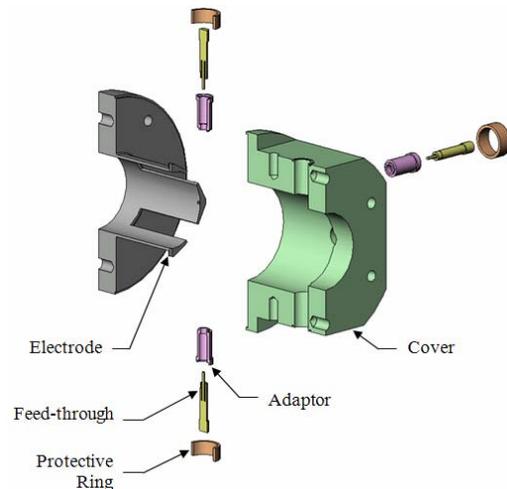


Figure 3: LANSCE BPPM Prototype.

Fabrication Plan

The fabrication plan is to fabricate the individual pieces, the electrode part, the cover part, the adaptors, and the protective ring. The main area of concern with the electrode part is to hold tolerance when the slots are cut out leaving the four electrode “fingers”. Wire electric discharge machining (wire EDM) was considered and a sample part was fabricated using this method. There were some issues with being able to get the proper wire angle for the slot edges and so the prototype parts were actually milled. The cover part was basically a straight forward machining procedure except that close consideration of the tolerance scheme was needed. The flats on the outside of the cover are what the BPPM will become the reference surfaces during the mapper calibration and beam line installation alignment, so it is important to register these surfaces to the electrodes as precisely as possible.

The biggest difficulty fabricating this device is the connection between the MSSSI feed-through and the stainless steel electrode. The feed-through center-pin is TZM Molybdenum and this material is difficult to join to stainless. Past experience, such as with the IPF BPMs, a method of silver-brazing has been used successfully. The braze alloy used is BAg-13a with AWS FB3C Flux. The advantage with the IPF design was that the braze joint was done on the bench and then welded into the BPM. In the LANSCE BPPM this braze joint is one of the last

operations and will have to be done after the electrode and cover have been welded together. Figure 4 shows the MSSI SMA feed-through with the center-pin pre-tinned and having been welded to the weld adaptor.



Figure 4: Meggitt Safety System SMA Feed-through.

Assembly Sequence

In order to produce this design as desired a formal assembly sequence is followed. The sequence is:

- Modify the MSSI SMA feed-through by trimming the center-pin to the specified length, such that it will end up being flush with the inside radius of the BPPM. The feed through shall also be pre-tinned with the Bag-13a silver solder to facilitate brazing to the stainless electrode.
- The modified feed-throughs are then welded into the weld adaptor pieces.
- The electrode part is then welded to the cover part. The proper angular alignment between these two pieces is critical. Once welded to the cover, the electrode will no longer be accessible. It is necessary that the alignment features machined into the cover are precisely located with respect to the electrodes. In order to achieve a precise alignment between these two parts two dowel pins are installed between them to control the clocking of the two parts. The dowel pin holes are located at a radius of 1.875-in from the center BPPM and have a positional tolerance of 0.003-in. This in effect gives a possible angular alignment error of ± 0.046 -radians.
- At this point the holes are drilled in the electrode end to accept the feed-through center-pin. Some sample parts were tested and a 0.065-in diameter hole was found to produce a proper fit for the pre-tinned 0.060-in diameter center-pin.
- The center-pins are now brazed to the electrodes.
- The weld adaptor is welded to the cover.

Testing

Throughout the course of the fabrication dimensional inspections are done on each part as it is manufactured. Vacuum leak checks are done at strategic points through the process. The MSSI feed-throughs are one of the perceived likely failure points so they are leak checked at the factory and again upon delivery. They are also checked any time heat is applied to them such as after being welded to the adaptors and after being pre-tinned. An intermediate leak check is done when the electrode is welded to the cover. A final leak check is then done on the fully assembled device.

Once the BPPM is assembled there will be another series of tests done measure the BPPMs response and to calibrate that response. A network analyzer S21 test is planned and the fixturing for that test is being designed. The other type of testing will be to develop a map of the BPPMs response to a signal injected along a taught wire using the LANSCE Beam Position Monitor mapping fixture [7],[8] shown in figure 5. The taught wire will be positioned at various locations within the inner diameter of the BPPM and the response of the BPPM will be measured.

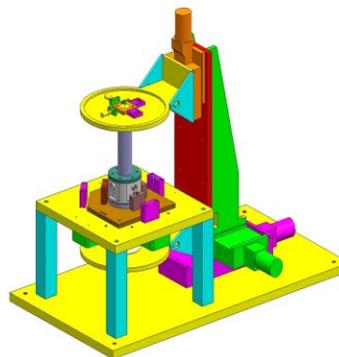


Figure 5: LANSCE BPM Mapper.

Current Status

At the time of this conference the LANSCE BPPM is in the final stages of fabrication. The last steps to be completed for the first prototype are to braze in the feed-throughs to the electrodes and then to make the final seal welds to the cover.

REFERENCES

- [1] Gilpatrick, J.D. et al., "Proposed Beam Position and Phase Measurements for the LANSCE LINAC", to be published at the 2007 Particle Accelerator Conference, Albuquerque, NM, June 25-29, 2007.
- [2] Meggitt Safety Systems, A Meggitt Group Company, 1915 Voyager Avenue, Simi Valley CA, 93063-3349 USA, <http://www.meggittsafety.com/index.asp>
- [3] FARO Technologies Inc., 125 Technology Park - Lake Mary, FL 32746, USA, <http://www.faro.com/>
- [4] Heaton, R.C., and Peterson, E.J., "Construction of a New Isotope Production Facility", *LANSCE Division Technology Review*, LALP-01-258.
- [5] Plum, M. A. et al., "Beam Diagnostics in the SNS LINAC", Beam Instrumentation Workshop, 2002, Tenth Workshop, Upton, New York, 2002
- [6] Cameron., et. al. "RHIC Beam Position Monitor Assemblies", Proceedings of the 1993 Particle Accelerator Conference, Washington D.C., USA, May 17-20, 1993
- [7] Gilpatrick, J.D. et al., "LEDA & APT Beam Position Measurement System: Design and Initial Tests", LINAC '98, Chicago, IL, August 23-28, 1998.
- [8] Shurter R.B., et. al. "An Automated BPM Characterization System for LEDA", Beam Instrumentation Workshop '98, Stanford, CA, May 4-7, 1998.