BPM system
Preliminary Design Review

Los Alamos, Feb. 27, 2001

by Michael Plum

Agenda

- Introduction – M. Plum
- BPM Pickups – J. O-Hara, D. Oshatz, P. Cameron
- BPM Processor Electronics – J. Power
- Data Acquisition Electronics – M. Stettler
- Lunch
- Committee Outbrief

Outline

- Design review process and charge to committee
- Usage scenarios
- Beam modes and parameters
- BPM system requirements
- Interfaces
- Cost and schedule

Review Committee

- Bob Webber, FNAL (chairman)
- Jim Crisp, FNAL
- Ron Johnson, SLAC

Design Review Process

- **Evaluate design against design criteria and functional requirements**
- **Items to address**
  - Assumptions
  - Relevant calculations
  - Options considered
  - Interface requirements
  - Manufacturing/Procurement plan
- **Consider committee's feedback**
- **Respond to the committee's written report**

Charge to committee

- **Review the design**
  - Are the design requirements adequately defined?
  - Is the BPM system design at PDR status? (I.e., ready to build and thoroughly test prototype units.)
  - Are the right analyses/tests being done/planned?
  - Does the work from PDR to FDR (Apr. – Aug. `01) look doable?
  - Are there “gaps” in the design?
  - Are the interfaces defined, understood, and addressed?
- **Categorize findings**
  - Critical (potential “show stoppers”)
  - Observations/recommendations
- **Consider key observations from audience participants**
- **Give us an outbrief**
- **Written report**

BPM system usage scenarios

- **BPM system design is ahead of requirements definition from commissioning and operations teams.**
  - Requirements and usage scenarios will be refined in parallel with commissioning and operations teams, where we have representation.
- **Commissioning**
  - Measure beam position for a wide range of beam parameters. Distinguish between ramp and flat top. Measure position along the macropulse.
  - Measure beam phase for delta-t method of setting rf phase and amplitude.
  - Measure beam phase for time of flight energy measurement.
  - Course measurement (~1%) of beam in the gap.
  - Course measurement of beam current.
- **Normal operations**
  - Measure beam position to ensure correct beam steering.
  - Input to closed loop beam steering corrections.
- **Troubleshooting**
  - Check of beam steering.
  - Check beam in gap.
  - Check beam intensity and beam transmission.
  - Check beam energy.
- **Development**
  - Same as commissioning.

Beam modes and parameters

- **The beam diagnostics must function under a variety of beam parameters, depending on the beam mode.**
  - *Commissioning mode beam parameters*
  - *Nominal beam parameters during normal operation*
  - *Troubleshooting beam parameters*
    - Same as commissioning beam parameters.
  - *Beam development beam parameters*
    - Same as commissioning beam parameters.

Beam parameters for commissioning

MEBT commissioning	1 – 10 Hz; 1 to a few minipulses or 10 – 100 us overall pulse length, 20 – 30 us ramp; 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
DTL commissioning	1 – 10 Hz; 1 to a few minipulses or 50 us overall pulse length; 20 – 30 us ramp, 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
CCL commissioning	1 Hz, 1 to a few minipulses or 50 us overall pulse length, 20 – 30 us ramp; 10 to 60 mA peak (as measured during mini pulse); 300 ns to unchopped mini pulses.
SCL commissioning	1 Hz; 1 to a few minipulses or 100 us overall pulse length, 100 us ramp; 10 to 60 mA peak (as measured during mini pulse; 300 ns to unchopped mini pulses.
Ring commissioning	1 – 10 Hz, 1 mini pulse, 10 to 60 mA peak (as measured during mini pulse), 300 to 700 ns long single mini pulses.

* All beams are H^-

Beam parameters for normal operation

Peak beam current	52 mA averaged over 690 ns mini pulse
Mini pulse period	~ 950 ns
Mini pulses per pulse	~ 1000
Pulse length	1 ms
Rep rate	60 Hz
Beam sizes	MEBT: x = 1.3 – 3.4 mm, y = 1.0 – 2.8 mm (1 σ) DTL: x = 1.8 – 2.7 mm, y = 1.0 – 2.7 mm (1 σ) CCL: 2.3 to 3.1 mm (1 σ, x and y sizes are same) SCL: 3.1 to 3.6 mm (1 σ, x and y sizes are same) HEBT: x = 0.5 – 2.0 cm, y = 0.5 – 2.0 cm (1 σ) Extreme sizes are about sqrt(5) times larger

- **Note: the BPM system will not be able to measure beam positions during the ramp when the mini pulses are shorter than about 300 ns.**

Beam diagnostics requirements

- The beam diagnostics requirements are divided into three parts: minimum requirements, target requirements, and desired requirements.
  - It is necessary to meet the **minimum requirements** to commission and tune the SNS facility at the most basic level. If the minimum requirements can not be met then fabrication and installation of the system should be reconsidered.
  - It is necessary to meet the **target requirements** for smooth commissioning and operation of the SNS facility and for maintainability of the diagnostics system.
  - The **desired requirements** provide further enhancements of the diagnostics system that would allow improved understanding of the beam dynamics or improved beam or instrument troubleshooting capability. These requirements should be considered only if they do not impact the reliability, cost, or schedule.

BPM system requirements

	Minimum	Target	Desired
Dynamic range	10 mA to 60 mA, > 300 ns pulse length, reduced performance at lower currents.	Same	1 mA
Bandwidth (MHz)	3	5	
Position measurement			
Accuracy[1]	± 3% of aperture radius	± 1% of aperture radius	
Resolution[1,2]	± 0.5% of aperture radius	± 0.1% of aperture radius	
Phase measurement at 402.5 and 805 MHz			
Accuracy	± 4 degrees	± 2 degrees	
Resolution	± 0.5 degrees	± 0.2 degrees	
Intensity measurement			
Accuracy[1]	5%	1%	
Resolution	3%	0.5%	

[1] For positions within 50% of aperture radius. Reduced performance for positions between 50% of 90% of aperture radius. Does not include alignment inaccuracies (est. 0.005").

[2] Relies on averaging several data points within a minipulse.

[3] For 52 mA peak beam current. Reduced performance at lower currents.

BPM system requirements (cont.)

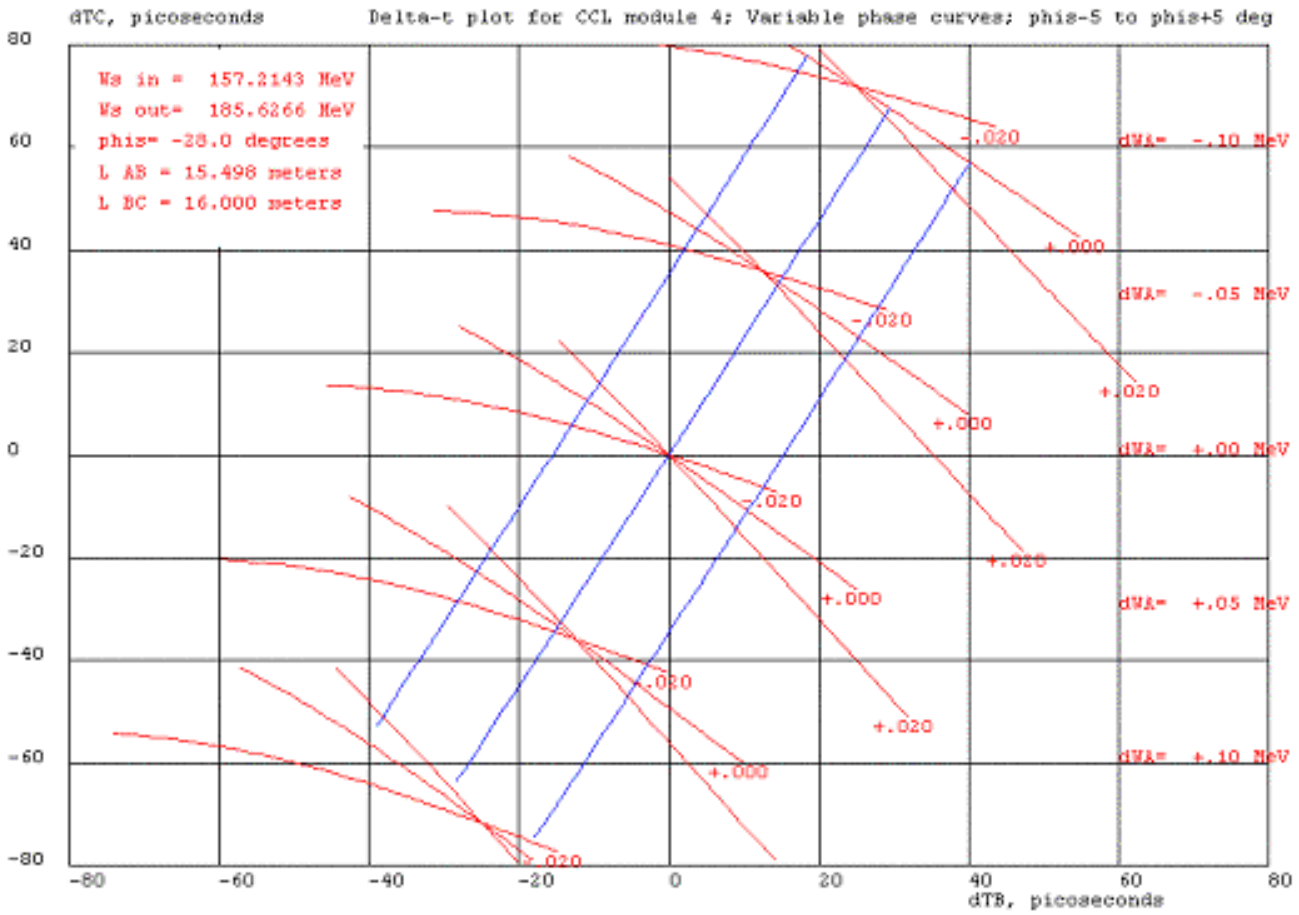
	Minimum	Target	Desired
Operating modes	Commissioning Operating Troubleshooting Development	See below	
Update rate (Hz)	4	10 (see note 4)	60

[4] All BPM instruments must be synchronized to sample the same macropulse.

Other target requirements are:

1. Single data take at given point on given mini pulse.
2. Sample given point on given minipulse for given range of minipulses.
3. Maximum acquisition rate for duration of several (~10) minipulses.
4. Auto test feature sufficient to check out cabling to pickup, and connection through control system to user interface.
5. No electronics in beam tunnel.
6. RTDL/event link monitor for timing.
7. Data sent to control system should have a date and time stamp for each data point, accurate enough to specify macropulse.
8. Measure beam in the gap at the 1% level.
9. Raw data output available on command, at reduced update rates (~1 Hz).
10. Robust mode that does not depend on beam energy or detailed timing parameters.

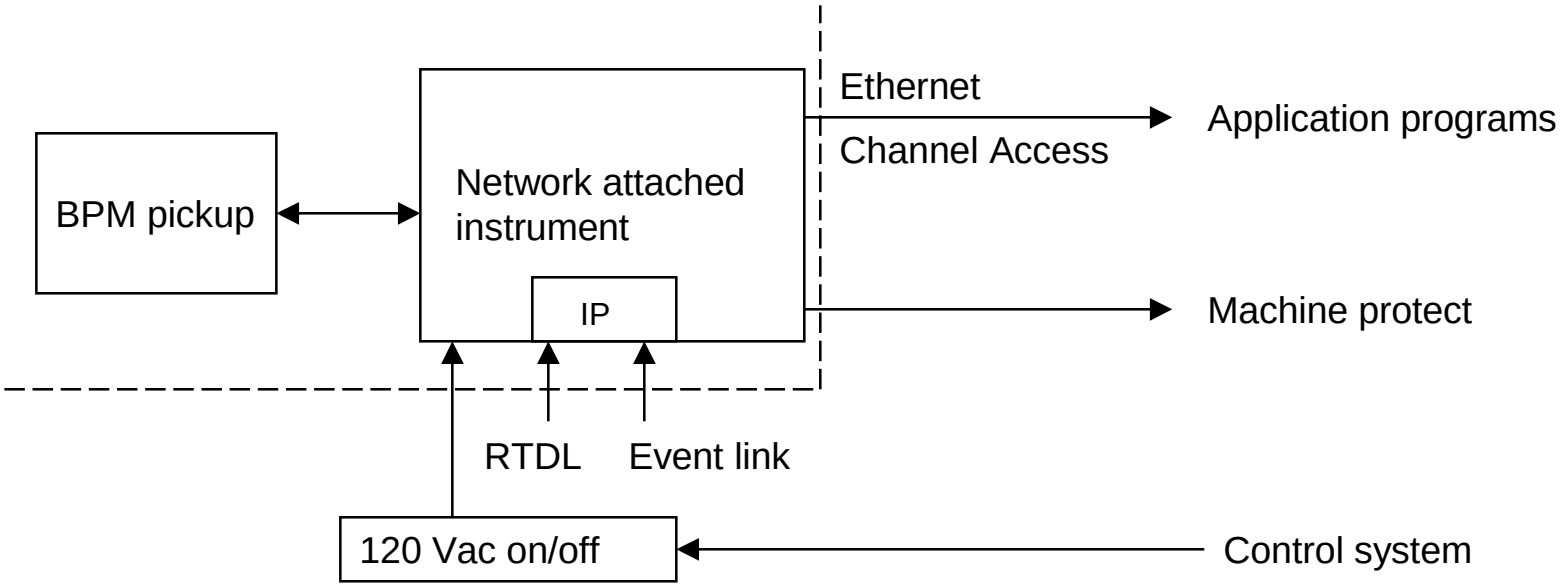
BPM system requirements (cont.)



Example of derivation of phase resolution requirement (in this case ±5 ps, or 0.72° at 402.5 MHz) derived from commissioning study (ref. R. Shafer, 19/Jan/01)

Interfaces

- **The mechanical interface occurs at the beam pickup flange or weld joint. The mechanical teams are responsible for installation and alignment of the pickup.**
- **The electrical interface occurs at the rack (except for pickup cables) where the electronics are mounted. I/O from the RTDL / event link, Ethernet, MPS, 120 Vac on/off.**



Cost

- **Estimated cost per pickup:**
  - MEBT $12k
  - DTL $9k
  - CCL $5k
  - SCL $5.5k
  - HEBT $5k
- **Estimated cost per electronics unit:**
  - $3.9k

Schedule

- Feb 2001 – Preliminary design review
- April 2001 – DTL pickup final design review
- July 2001 – Deliver pickups for DTL tank 3
- August 2001 – Electronics and rest of pickups final design review
- October 2001 – Deliver electronics packages to LBL
- April 2001 – Deliver MEBT pickups
- November 2001 – Deliver last DTL pickups
- March to July 2002 – Deliver CCL pickups
- March to July 2002 – Deliver SCL pickups
- Oct/01 to Feb/03 – Deliver HEBT pickups (instal. and test by Mar/04)
- July 2002* – Deliver electronics to ORNL

* Consider waiting for results of MEBT commissioning before procuring rest of electronics so we can apply lessons learned to our design.

Summary

- **We are on track to deliver, on schedule, a BPM system that meets all target requirements.**