# QINCLOSING PLENARY SUMMARY OF WORKING GROUP E DIAGNOSTICS AND INSTRUMENTATION FOR HIGH-INTENSITY BEAMS

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## OVERVIEW

Working group E was charged with presentations and discussions on diagnostics and instrumentation of high intensity beams. We had 2 sessions, consisting of a total of 12 talks, each of 20 minutes for presentation followed by some discussion. One session was followed by a discussion session of two hours. All sessions took place in parallel with the sessions of WG-D (Commissioning, operations and performance), inevitably preventing some possibly useful overlap. In addition, seven posters, regarding beam diagnostics, were presented in the single poster session.

## PRESENTATIONS

The following **talks** were presented:

*T. Xu: "The Beam Diagnostics of CSNS"*, presented an overview on the progress on diagnostics for the Chinese spallation neutron source. This talk includes an overview of the CSNS accelerator, progress on the development of diagnostics and prototype testing and plans for commissioning the CSNS front-end starting next year.

*V. Scarpine: "Instrumentation Development and Beam Studies for the Fermilab Proton Improvement Plan Linac Upgrade and New RFQ Front-End"*, presented beam measurements from Fermilabs new front-end injector system, including proton beam energy from time-of-flight, delivered by the new 201 MHz RFQ.

*L. Nebot Del Busto: "Detection of Unidentified Falling Objects at LHC"*, described the detection of sudden beam loss around the LHC ring at millisecond time scales. These losses were detected exclusively by the LHC BLM system. The talk described the techniques employed to identify such beam loss events.

Specific beam instrumentation and methods:

*E. Holzer: "Fiber Based BLM System R&D at CERN"*, presented The application of a beam loss measurement (BLM) system based on Cherenkov light generated in optical fibers, where a longitudinal resolution of beam loss detection of ~1m over 100 m may be possible.

*P. Duperrex: "On-line Calibration Schemes for RF-based Beam Diagnostics"*, described improvements of BPMs and current monitors used in a high radiation environment.

*P. Saha: "Online Monitoring for the Waste Beam in the 3 GeV RCS of J-PARC"*, discussed the detection of a small fraction (about 0.4%) of un-stripped $H^0$ and $H^-$ waste beam in comparison to the full beam.

*R. Singh/O. Chorniy: "Measurement and Interpretation of the Betatron Tune Spectra of High Intensity Bunched Beam in the SIS18"*, described their two measurement system and compared their head-tail mode measurements with a simple model. The predicted modifications of tune spectra, due to space charge effects based on analytical models, were studied.

*W. Blokland: "Recent Developments on High Intensity Beam Diagnostics at SNS"*, reported on improvements of electron beam scanner that performs non-interceptive measurements of the transverse and longitudinal profiles of the proton beam in the SNS ring. Also presented are temperature measurements of the stripper foil and the target imaging system.

*F. Becker: "Beam Induced Fluorescence – Profile Monitoring for Targets and Transport"*, reported on the use of these monitors at higher gas pressures. Beam profiles from ionic transition N2+ appear unchanged from $10^{-3}$ to 30 mbar.

*B. Walasek-Hohne: "Optical Transition Radiation for Non-relativistic Ion Beams"*, reported on the first use of this technique at lower energy heavy ion beams, which was proposed by A. Lumpkin from FNAL. First results on OTR $q^2$ dependency were also presented.

*T. Maruta: "Longitudinal Beam Diagnostics with RF Chopper System"*, presented a measurement of the longitudinal bunch distribution with a large dynamic range (order of $10^{-6}$), obtaining the beam profile on the phase axis by measuring the beam loss in RCS with various RF settings of the chopper cavity.

*P. Kowina: "Momentum Spread Determination of Linac Beams Using Incoherent Components of the Bunch Signal"*, reported on the first, still preliminary, indications, that it may be possible to obtain a Schottky signal in a linac. Very preliminary spectrum were presented from different bunching conditions.

The following **posters** were presented:

*O. Chorniy: "A Method to Measure the Incoherent Synchrotron Frequencies in Bunches"*,

*M. Hempel: "Bunch-by-Bunch Beam Loss Diagnostics with Diamond Detectors at the LHC"*,

*Y. An: "The Study on Measuring Beta Functions and Phase Advances in the CSNS/RCS"*,

*S. Redaelli et al.: "A Tool Based on the BPM-interpolated Orbit for Speeding up LHC Collimator Alignment"*,

*H. Hassanzadegan et al.: "Beam Position Monitor System of the ESS Linac"*,

*R. Dölling: "Progress with Bunch-shape Measurements*

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*at PSI's High-power Cyclotrons and Proton Beam Lines"*, *Ch. Gabor: "Design of a Photo-detachment Emittance Instrument for FETS"*.

## DISCUSSION SESSION

The discussion session started with the question "Is it possible to know the beam (and the machine) in such detail, that we are able, with the aid of simulation, to fully understand the beam losses and are subsequently able to reduce them in a predictable way?" Speakers and poster contributors, from working group E and all other interested parties, were invited in advance, to present a short presentation (1 to 3 minutes with 0 to 3 slides), addressing some of the following topics (A-C), in the light of their own accelerator:

**Topic A: diagnostics performance**, providing the constraints (dynamic range, accuracy, spatial and temporal resolution) with which the beam parameters and beam losses can be measured (either with standard or more advanced tools) together with estimated numbers.

1) What diagnostics are used for loss detection?
2) What diagnostics are used for transverse/longitudinal beam distribution (core and halo)?
3) What diagnostics are used for other projections of the 6D-phase space?

(We of course could not have expected to reach a comprehensive and detailed statement from what is already a vast field, see e.g. Ref. [1]. But we intended to come to a consensus on what we believe to be both standard and feasible in the future.)

**Topic B: environment - how far we already come?**

4) Is there a need to improve beam losses?
5) To what degree are the beam losses understood? (Do you feel it is at all possible to get a sufficiently detailed understanding that will allow the prediction of beam losses?)
6) Are the diagnostics of 2) and 3) used to improve the understanding of beam losses which occur during standard operation? (Or mainly for empirical tuning or trouble shooting?)
7) Is there a clear plan regarding how to proceed with improving beam losses and to what extent are diagnostics involved?
8) Are your beam dynamics colleagues aware of the performance capabilities and constraints of the beam diagnostics? Is further improvement called for and do they provide well-founded specifications?

**Topic C: other**

9) Other points which complement the above.

Each contribution should be followed by a short discussion.

Topics A+B was delivered as a short version by the GSI people as a group, N. Hayashi for J-PARC/RCS and R. Dölling for PSI. A somewhat longer overview answering mostly Topic A for many CERN diagnostics was given by E. B. Holzer. During the discussion only few comments were given if prediction of losses is feasible. Some discussions evolved about what diagnostics are or may be needed for this.

Somewhat more detailed slides followed on BIF monitor performance (F. Becker), screen performance (B. Walasek) and halo measurement with adaptive mask (H. Zhang). This triggered a (not conclusive) discussion on the dynamic range (in one profile) of optical methods. Starter slides for fast current transformator and tune shift measurement (O. Chorniy) and wire monitor performance/wire-induced loss as test case for simulations (R. Dölling) were given also. D. Reggiani asked if better tail measurements are available for tomographic reconstruction.

P.A.P Nghiem from beam dynamics presented the unconventional IFMIF μ-loss-monitor strategy, which will deliver high dynamic range input for simulations (similar to dedicated halo monitors).

As an improvement for future discussion sessions, one can think of making a call, in advance, to all participants for questions to be discussed, and a second call to prepare small contributions to these questions. Also a joint session with other working groups should be planned at an early stage.

## REFERENCE

[1] K. Wittenburg, CERN Accelerator School 2008, Dourdan, http://cas.web.cern.ch/cas/France-2008/Lectures/Wittenburg-halo2.pdf



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