Ionization Profile Monitor for PS2

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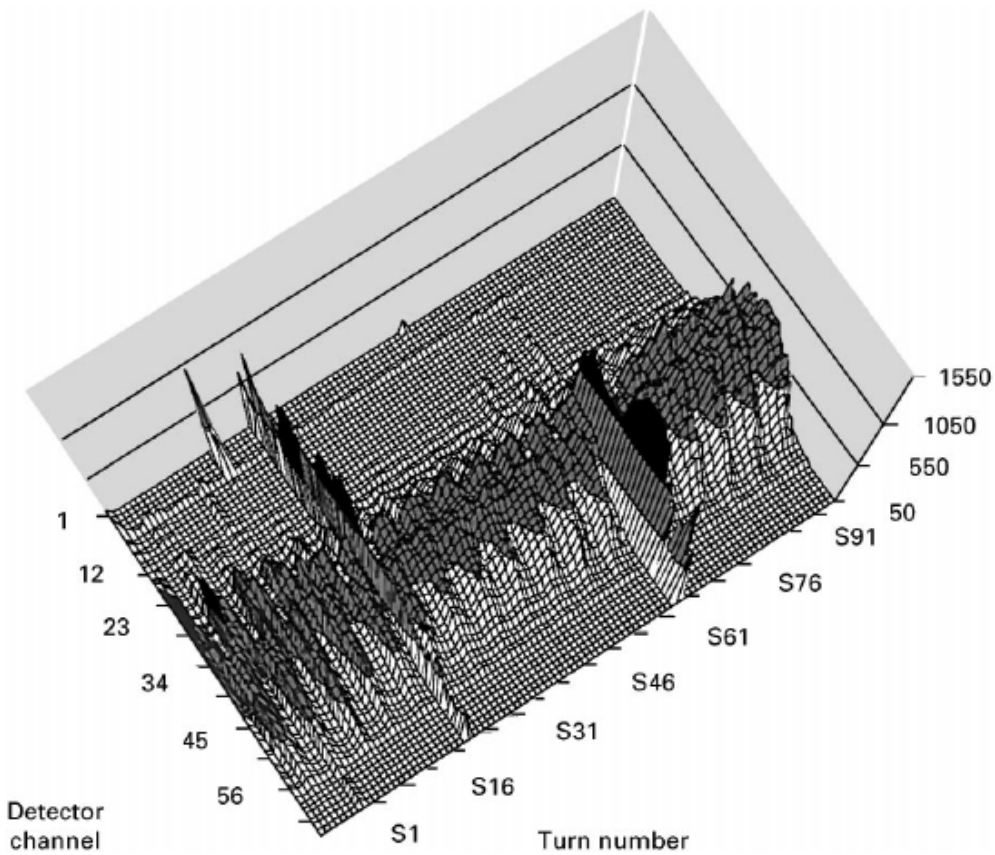
Introduction

Beam profile real-time evolution diagnostic is an area of great interest for machine operation (injection/extraction mismatch, paintings and other manipulations) and for high intensity beam physics (space charge, e-cloud emittance growth).

The PS2 machine will greatly benefit for a non destructive turn by turn profile measurements for high intense beam.

Previous results: BNL

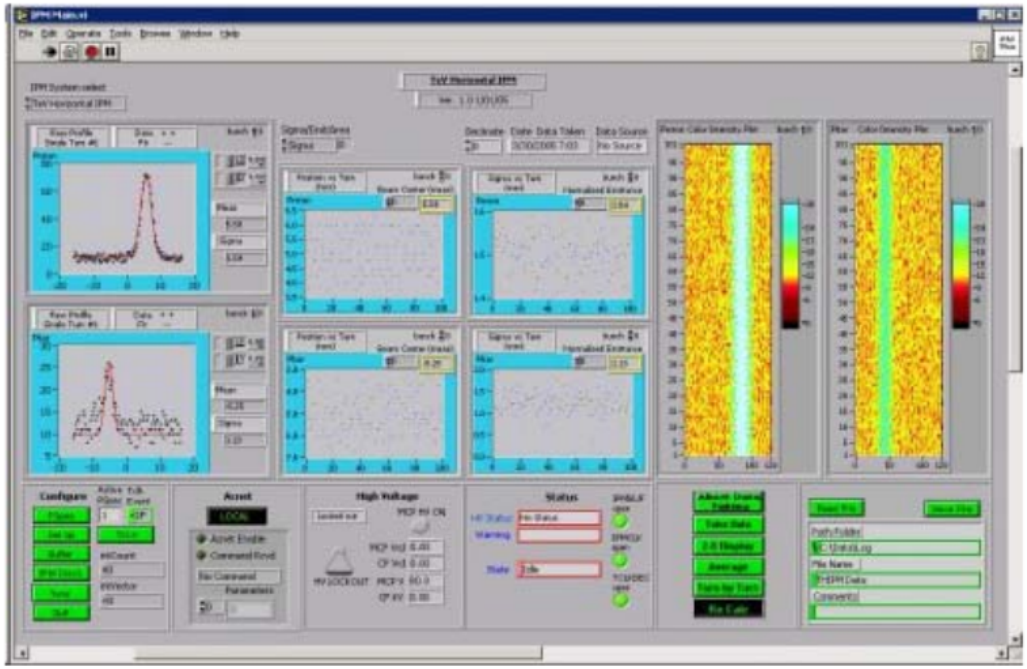
Successful turn-by-turn measurements in RHIC.
500 counting events are sufficient for a 3% accuracy of a profile measurement.



Beam profile measurements and transverse phase-space reconstruction on the relativistic heavy-ion collider, R. Connolly*, R. Michnoff, T. Moore, T. Shea, S. Tepikian, NIM h A 443 (2000)

Previous results: FNAL

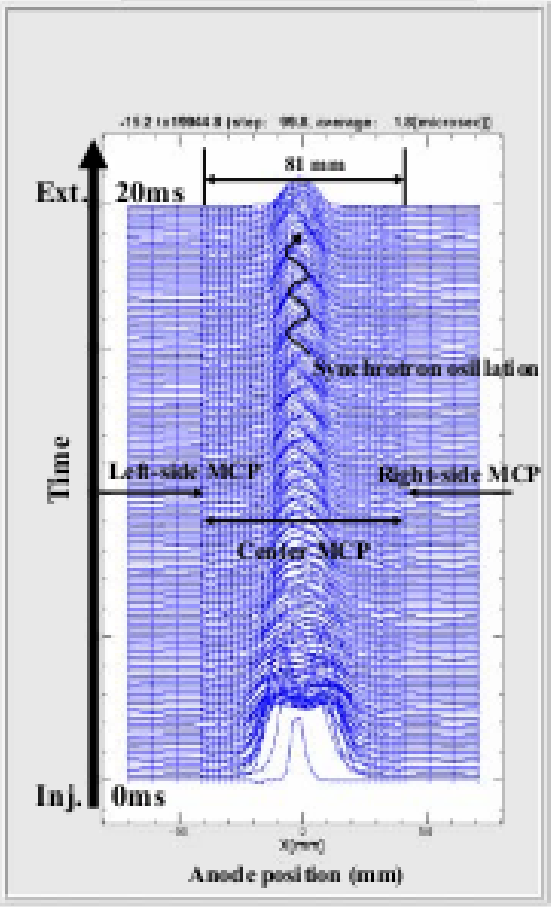
Operational bunch-by-bunch IPM at Tevatron. 1000 electron-ion pair. Fast and sensitive electronics 2fC and MCP gain 10^4 give 2 primary electrons per count.
Condition: 1e11 ppb and 1e-9 torr for proton profile and 1e10 ppb 1e-8 torr for pbar profiles. Vacuum is usually 60% H2 and 40% CO.

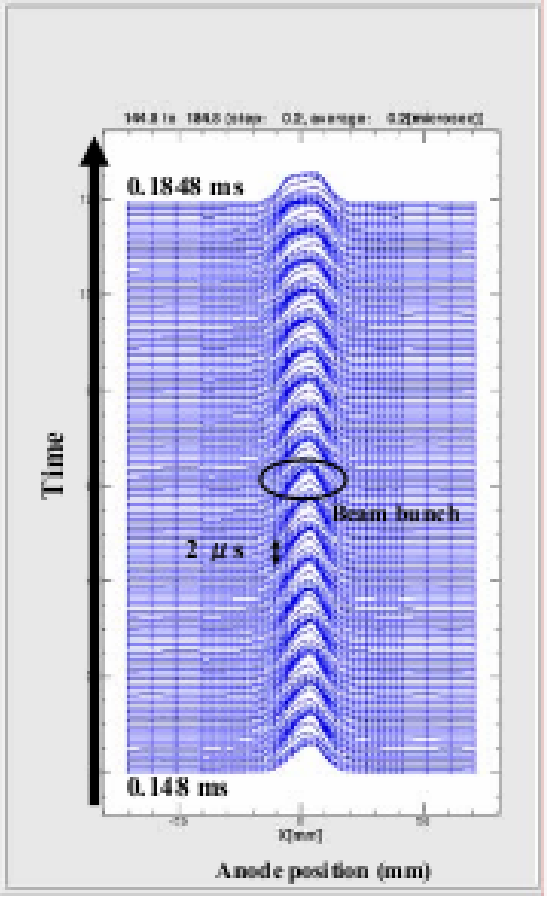


TEVATRON IONIZATION PROFILE MONITORING*, A. Jansson ea, Proceedings of EPAC 2006, Edinburgh, Scotland.

Previous results: JPARC

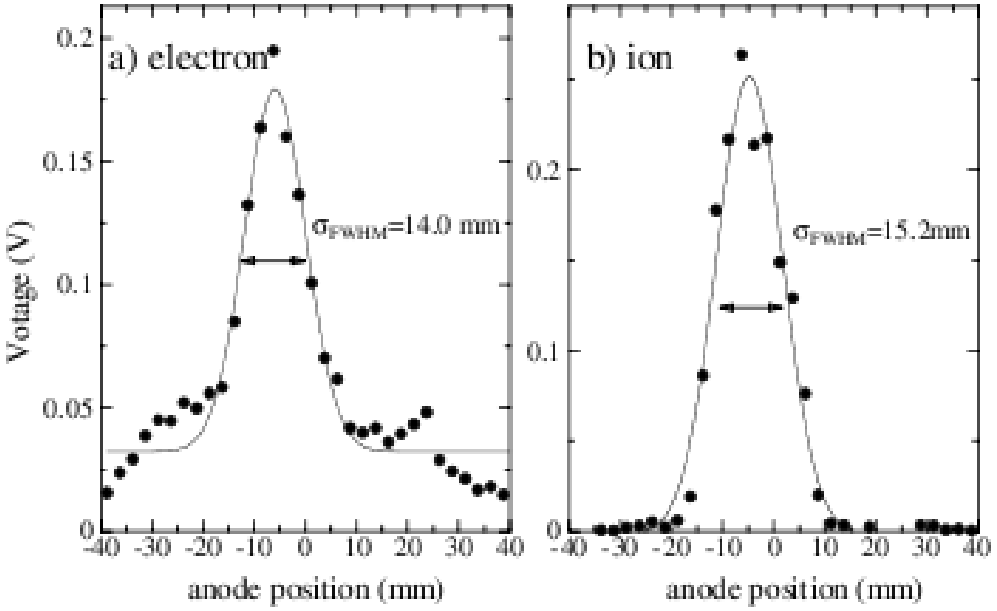
Successful turn-by-turn measurements in JPARC RCS.
Two long bunches 367ns, 4.15e13 ppb, 1e-9 torr, 20k electron per bunch.





Previous results: JPARC

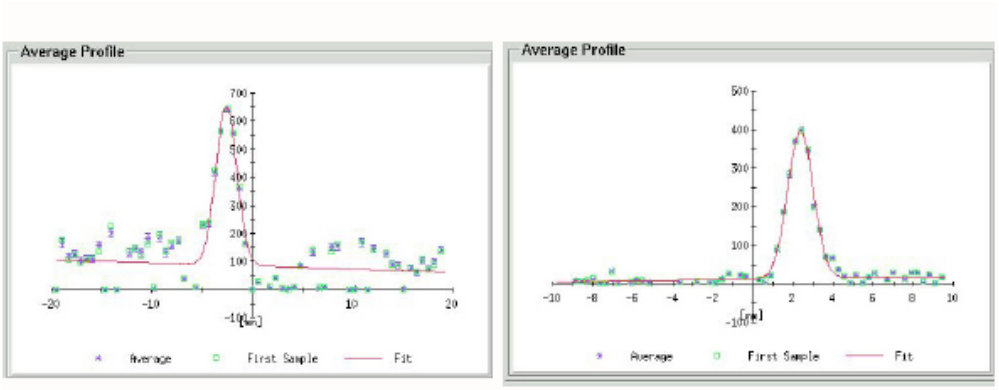
Electron collecting vs ion collecting mode.



A PROTOTYPE OF RESIDUAL GAS IONIZATION PROFILE MONITOR FOR J-PARC RCS, K. Satou, Proceedings of EPAC 2006, Edinburgh, Scotland.

Previous results: BNL

Electron background can be caused by xrays spray, secondary electron emission and e-cloud.
Successful electron background shielding BNL (2008).



R. Connoly, The RHIC IPM system, 2008.

IPM Features

State of the art distinctive features of the IPM designs:

- Electric shielding from ecloud (BNL)
- Fast and sensitive electronics (FNAL)
- Calibrating electron emitter (JPARC, CERN)
- Selectable Electron and Ion collecting mode (JPARC)
- Pressure bump (FNAL, KEK)

BNL program

BNL has an ongoing R&D program for turn by turn IPM technology for the AGS and RHIC.
250k$ have recently been spent to update the RHIC IPM.
Additionally 2FTE year and 50k$ will be invested in the next years.
The AGS has several similarities with PS2.
AGS and PS2 will be similar machines:

- Injection energy: 1.5GGeV , 4GeV
- Extraction energy: 28GeV , 50GeV
- Circumference: 860m, 1344m
- Cycle time: 4s, 2.4s
- Bunch intensity: 1.5e11 - 2.5e11, 4.2e11 - 7e11 ppb
- Harmonic number: 12, 180
- Bunch spacing: 225ns (minimum) otherwise 860m/c, 25ns
- Bunch length: 120ns, 10ns

Proposal for a study on a PS2 IPM

With LARP support, the BNL IPM program can be extended to develop IPM designs compatible with the PS2 specific requirements (vacuum, bunch length, bunch spacing, ecloud).
For adapting the AGS design to the PS2, we propose to:

- evaluate the vacuum requirements to ensure sufficient signal amplitudes for high resolution determination of the turn by turn beam profiles,
- study how the electron cloud could affect the signal and asses mitigating solutions,
- evaluate how shorter bunch lengths and spacings could affect the detector performance by em compatibility, the signal preservation and processing methods,
- experimental validation of the proposed solutions will be allowed by profiting the existing tools and infrastructure used for building the AGS and RHIC counter parts.

We propose LARP to contribute with 1FTE/year to support the work needed on these PS2 specific issues and 30k$/year for the laboratory equipment to perform bench and beam tests.

3 year plan

Responsible: R. De Maria (FY09-FY10), To be determined (FY11)

- FY09: Open a postdoc position. BNL will provide supervision and funding for the new postdoc for 0.5FTE/year in the instrumentation section of M. Minty. Resources: 5k$ for programmatic travels.
- FY10: White paper: Feasibility study for a turn-by-turn IPM for PS2. The white paper includes an analysis of the state of the art of the IPM designs, estimates for the specifications and performance of a PS2 IPM, a selection of subsystem that may be experimentally tested at BNL (e.g. em compatibility, sensitivity, signal preservation, vacuum compatibility, ...)
  Resources: .5FTE, 30k$ for lab equipment and travels.
- FY11: Conceptual design report with experimental validations. In case the design is feasible, deliver a conceptual design report with a design for a PS2 IPM and experimental evidence of the performance of the selected subsystems.
  Resources: .5FTE, 55k$ for lab equipment, tests and travels.

Additional motivation

I would like to mention that there are other possible area of mutual interests between the BNL and CERN programs that not necessarily belongs to the LARP context but puts this collaboration effort in a broader perspective.
Turn by turn diagnostic would allow the BNL AGS to gain experience and operation tools for injection matching optimization and emittance preservation for high intense beams which is relevant for the LHC beam operation in the PS2.
Turn by turn diagnostic would, in the BNL Booster, allow to gain experience on injection with foil stripping which is relevant for the normal LPSPL PS2 operations.
PS2 will use complex transverse phase space manipulation for CNGS beam. Non destructive turn by turn profile will definitely contribute to the further development of this state of the art technique.
The present PS relies on wire profile measurements that suffer from being single pass, not suitable for high intense beam. Turn by turn IPM will definitely helpful in the PS routine operations.
LARP contribution on the specific IPM program will make those area of collaboration expanding even if not directly supporting them.

Area of collaborations

Ideally this activity should become a multilab effort.

- Tevatron IPM, A. Jansson, Operational and instrumentation experience,
- SLAC, A. Fisher, Instrumentation experience,
- LBL, A. Ratti, Electronics.