IBS and Instrumentation in IOTA

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Goals and Objectives

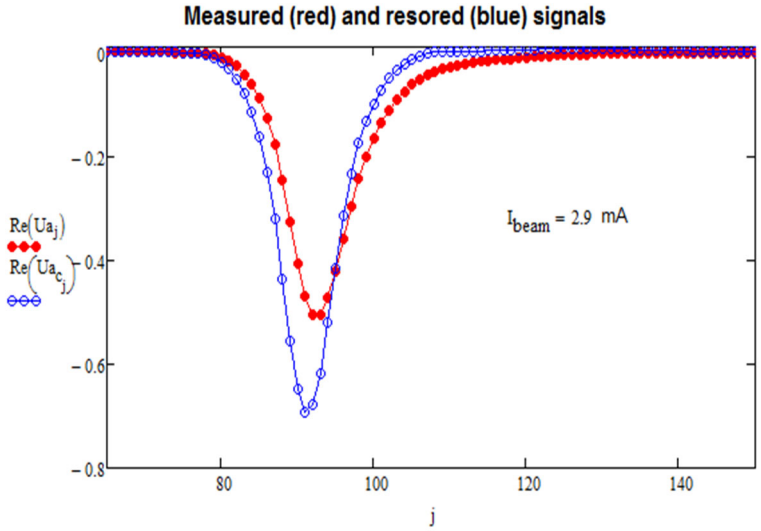
- Goals
  - Verify accuracy of our instrumentation
    - Bunch length
    - Beam emittances
    - Momentum spread
    - Bunch and beam current measurements
  - Optics verification as a byproduct of beam size measurements
    - Coupling
  - Measurements/calibration of RF voltage
    - Beam deceleration due to interaction with vacuum chamber and RF
  - Characterization of longitudinal impedance
  - Characterization of vacuum: measured by gages versus actual
- The above measurements/parameters are related through: IBS, Touschek scattering, scattering at the residual gas, longitudinal impedance, RF voltage calibration

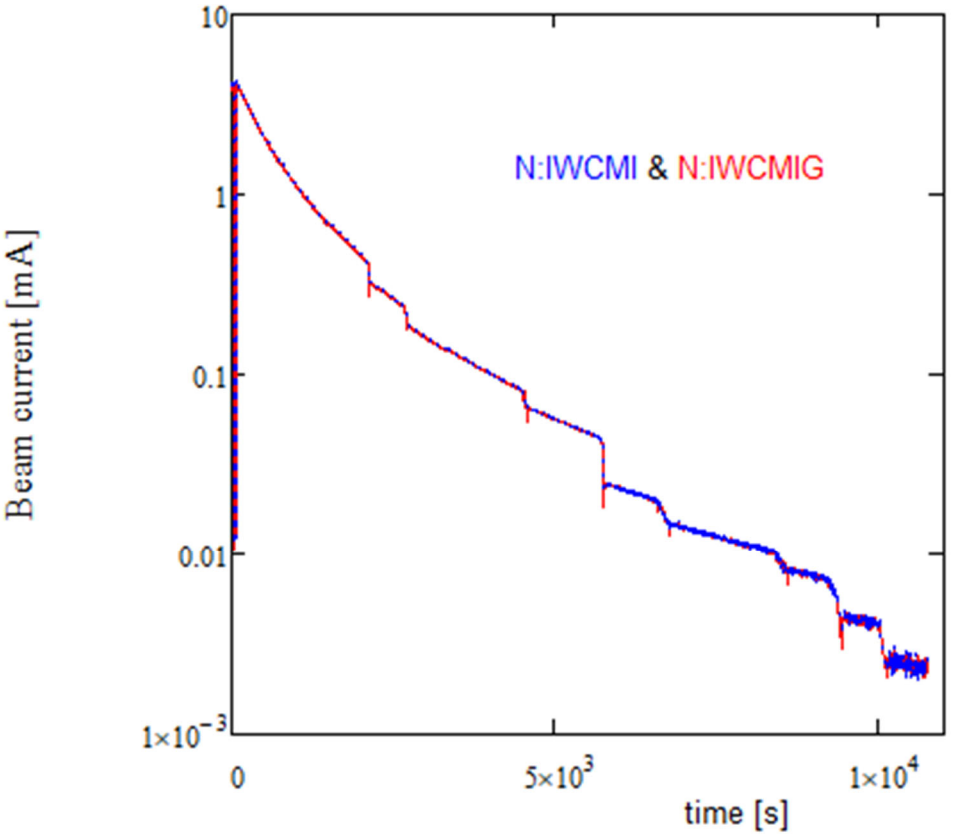
Beam Current and Bunch Length

- DCCT (N:IBEAM)
  - Beam current range: > **100 μA**
  - Typical offset: up to 10 μA
  - Rms noise: 2.5 μA
- Wall Current Monitor (N:IWCMI & N:IWCMIG)
  - Dispersion in the cable is corrected online
    - Beam current range: > **5 μA** (100 turn average on the scope)
    - Typical offset: none
    - Rms noise: 0.16 μA
  - Two types of computations: (1) Computations with the base line and (2) fitting to a Gaussian
    They yield close results for the beam current but
    Are not identical for the bunch length
- Photomultiplier
  - Entire range from single electron to maximum beam current
  - Non-linear response on beam current
  - Absolute calibration is done using WCM and DCCT
    - Questionable from countable number of electrons (<1000) to ~5 μA

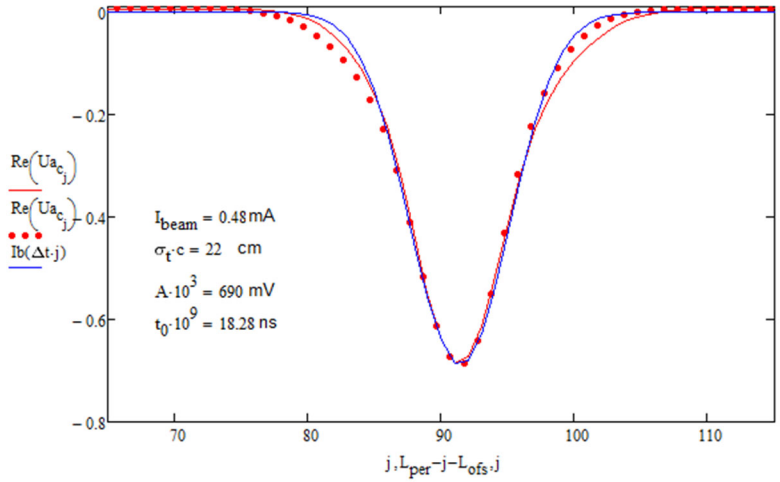
Wall Current Monitor

- Bunch self-compression with the current increase
- Non-gaussian tail



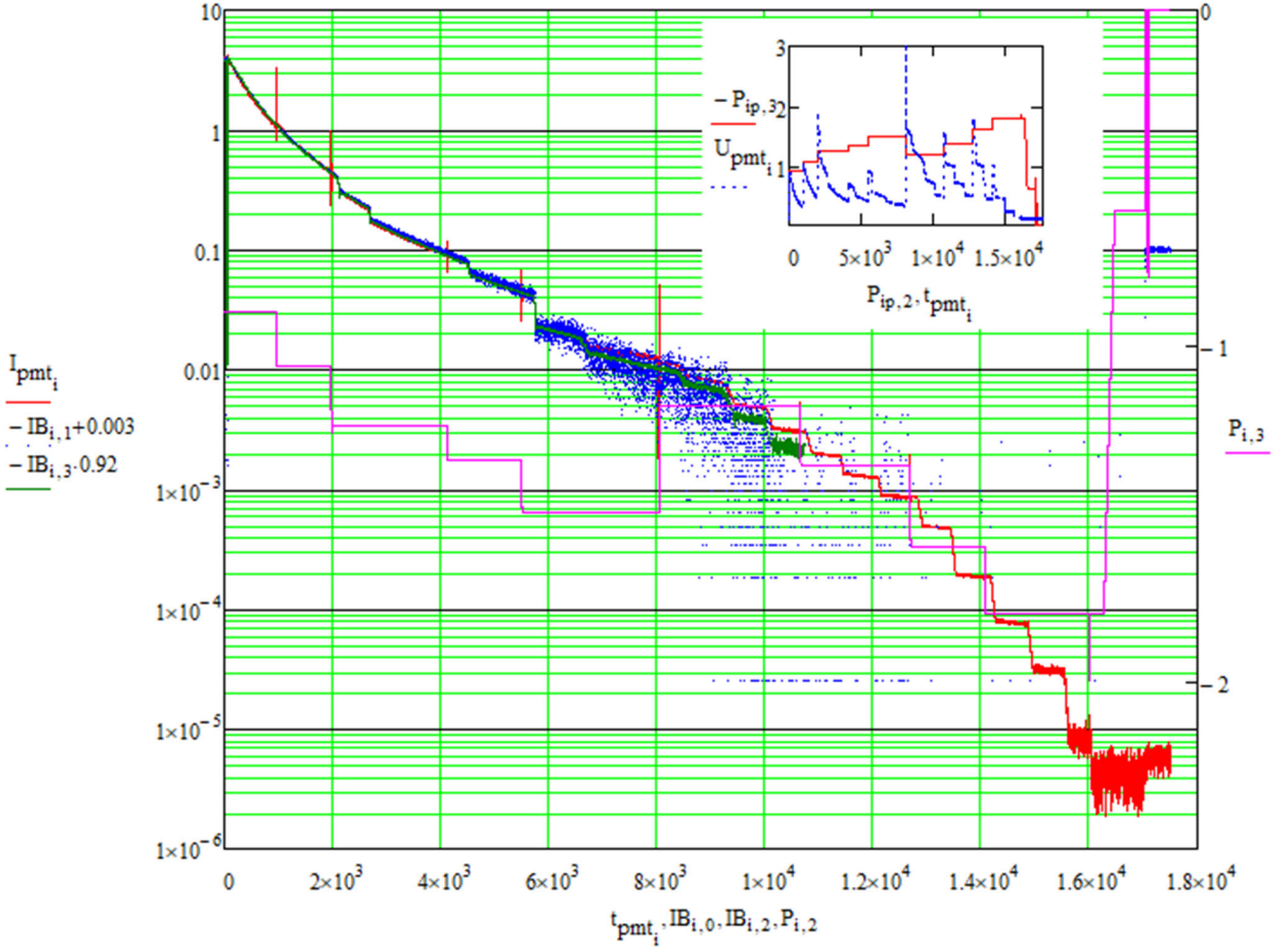


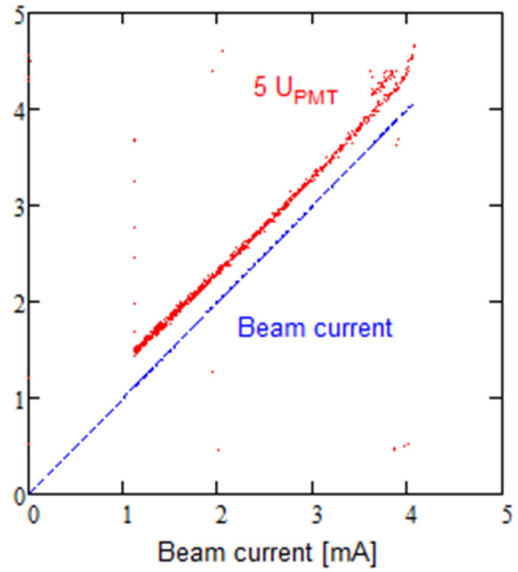
- close results for the beam current beam current measurements for two types of beam current computation



PMT

- N:IBEASL – PMT current (∝IBEAM)
- N:ISHV2 – proportional to the PMT voltage





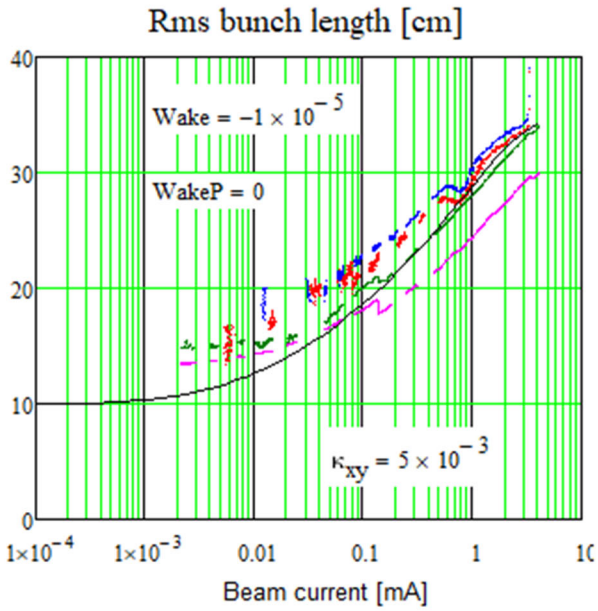
Combination of DCCT, WCM and PMT beam currents

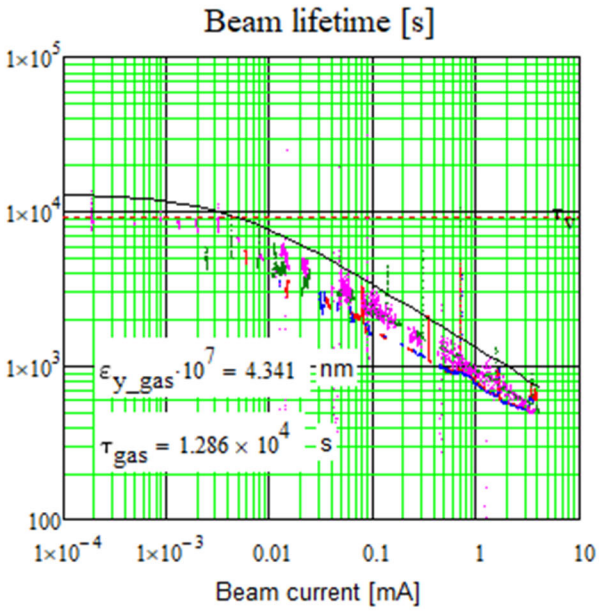
Simulations of beam parameters evolution

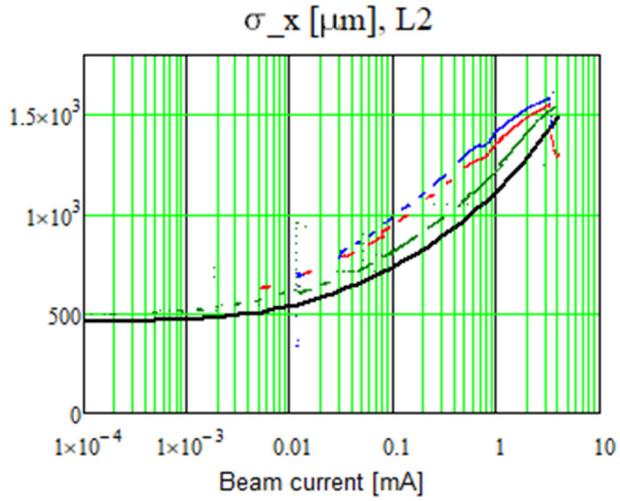
- What is accounted
  - SR damping and heating
  - Single and multiple scattering at the residual gas
  - Single (Touschek) and multiple IBS
- RF voltage was calibrated to good accuracy
- Machine acceptances are measured with the beam kicks
- Beam optics should be in good shape
- Other things to be looked in
  - Inelastic scattering at the residual gas
  - Bremsstrahlung

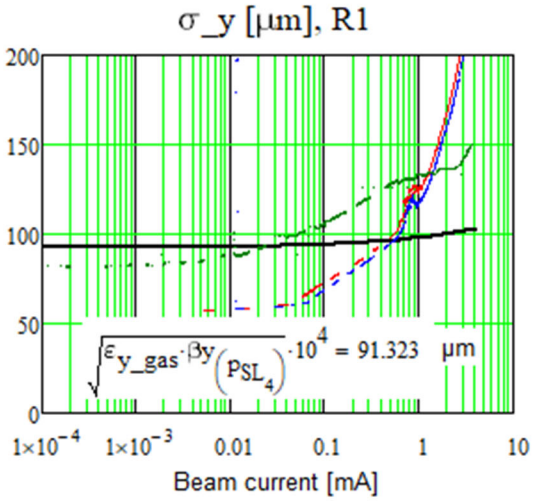
Preliminary Results of Simulations

- We acquired 3 measurements
- They are not identical while formally were taken in the same conditions
- Coupling change is a probable reason
- Possible accumulation of ions in the first two measurements which have smaller coupling









Preliminary Results of Simulations

- Measured bunch length at small beam current is longer than in the model
  - Need to determine heating mechanism
    - Energy loss due to residual gas ionization
    - Energy loss due to bremsstrahlung
- Measured beam lifetime at large current is worse (smaller) than in the model
  - For now, no idea why
- Discrepancy between the measured vertical emittance and beam lifetime at small beam current
  - Possible reason: unaccounted contributions from
    - energy loss due to residual gas ionization
    - energy loss due to bremsstrahlung