ASAC Review

Accelerator Systems Division Overview

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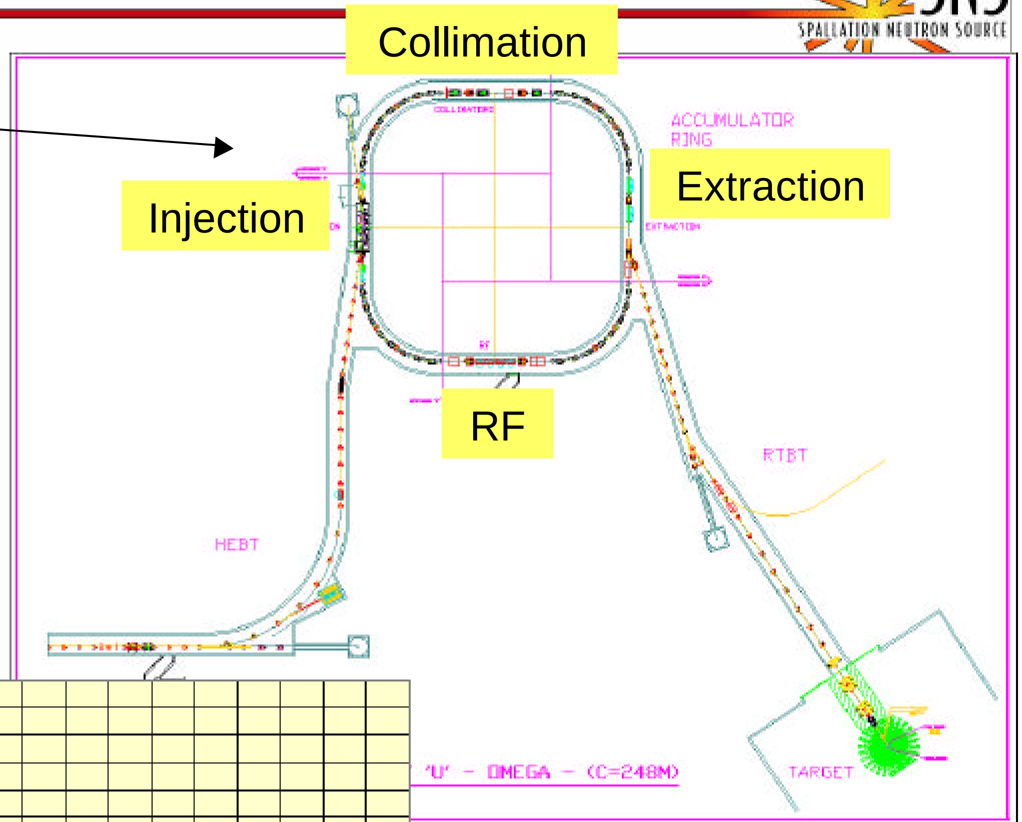
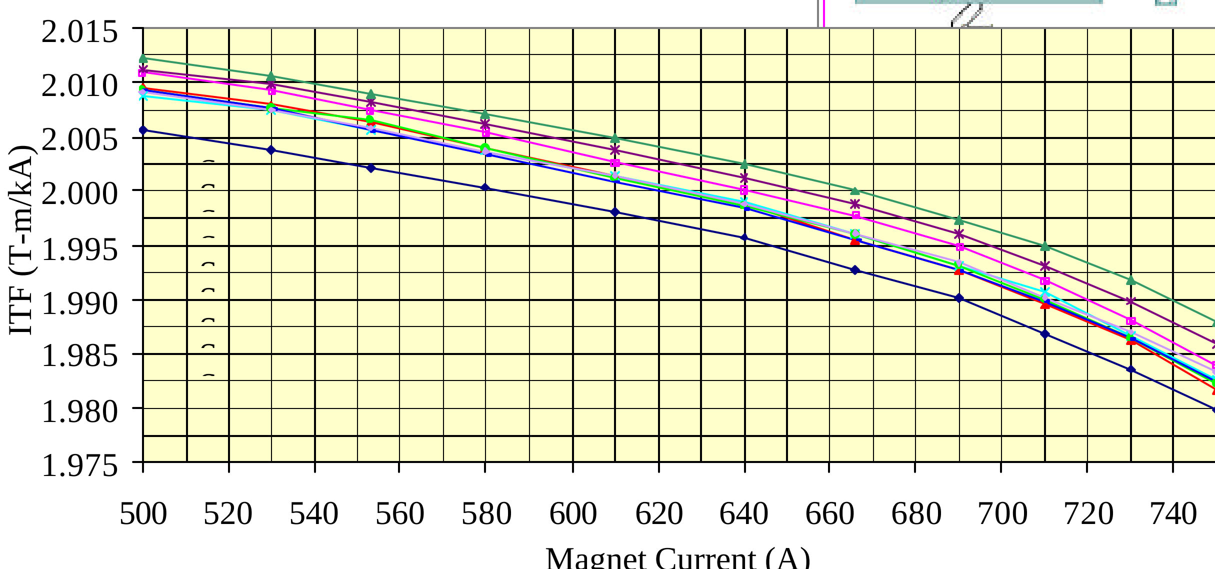
March 10, 2003

Ring Lattice Progress Since the Last Review

- Working with survey/alignment/drafting to incorporate global coordinates
- Magnet measurement results evaluated
- Ring/HEBT dipoles and Ring quads sorted
- Lattice tuning (local tune control)
- BPM offset measurement method



8D533 Excitation Curves



HEBT Dipole Measurements

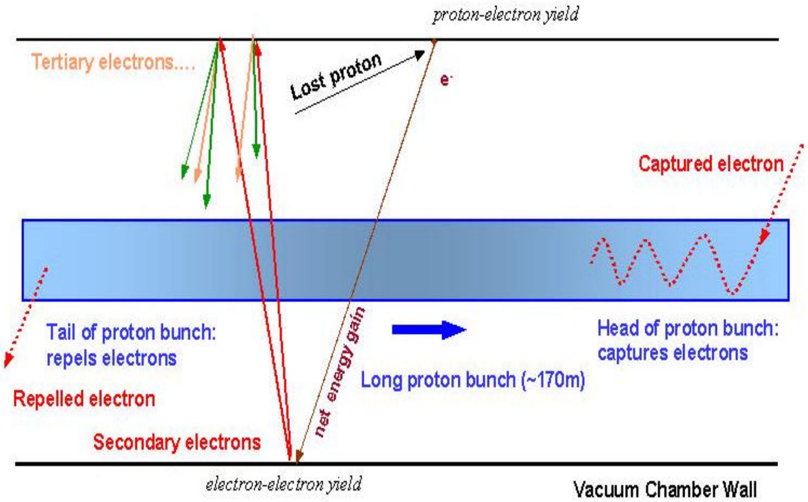
(courtesy J. Wang)

Electron Cloud Instability Mitigation Plan

(detail in Ring session)

Reduce Electron Production

- Baseline:
  - TiN coated vacuum system
  - Stripped electron collection on C-C absorber w/ viewport
  - Beam-in-gap cleaning system
  - Good vacuum
  - Electron Detectors around the ring
- Baselined since last review
  - Clearing electrodes in injection region
  - Low-field solenoids in collimation region
  - Electron catcher viewing system



Enhance Damping:

- Baseline:
  - Momentum painting with Energy Spreader Cavity
  - High RF voltage 40 kV (h=1) + 20 kV (h=2) for large momentum acc.
  - Chromaticity control with 4 sextupole families
- Under Study:
  - Wideband (200 MHz) feedback system

TiN Coating of Ring Vacuum Chambers

Goal: low SEY, good adhesion and low outgassing Q

Use Magnetron DC with permanent magnets

higher sputtering rate due to dense plasma

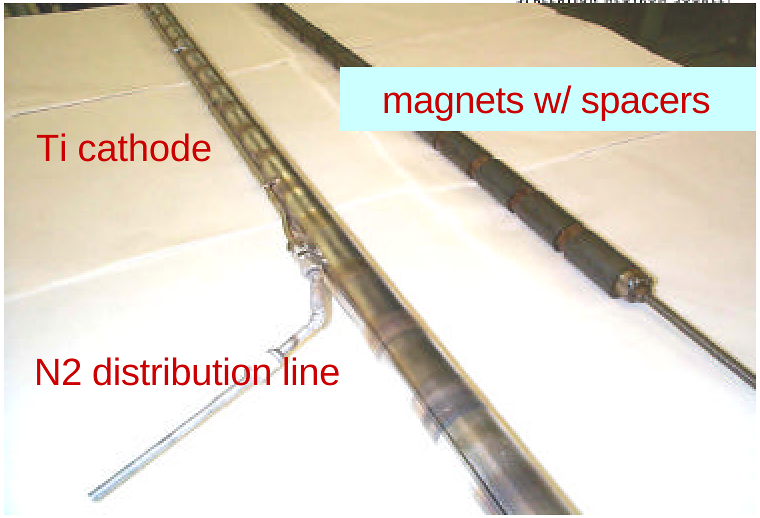
Bake & coat @ 250 C to ~ 100 nm of TiN

to minimize impurity & improve adhesion

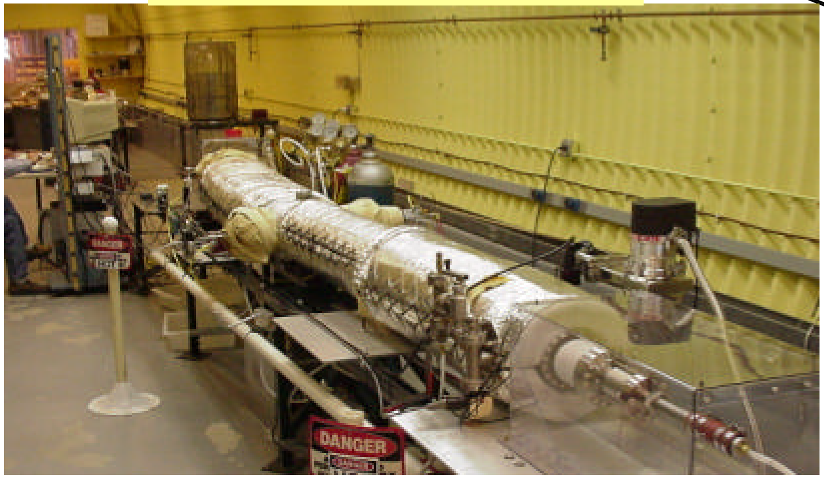
Need uniform gas flow along the length

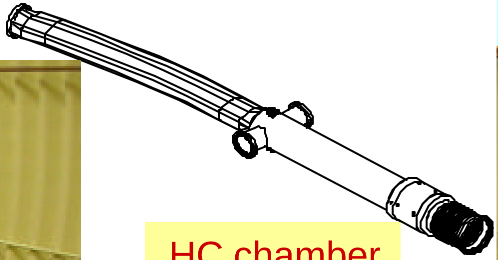
to get correct stoichiometry (0.95 – 1.03)

SEY ~ 1.9 by Hilleret (CERN) and by Kato (KEK)

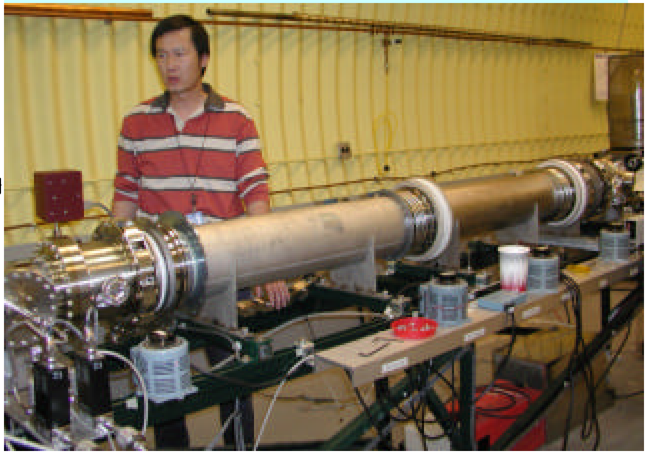


HC chamber being coated





RF cavity assembly being coated



Coating of Inj. Kicker Ceramic Chambers

Conductive coatings w/ end-to-end resistance of ~0.04O

(S. Henderson, 10/15/2001)

Ti (37 µm), TiN (18 µm) w/ rate ~ 0.1nm/s

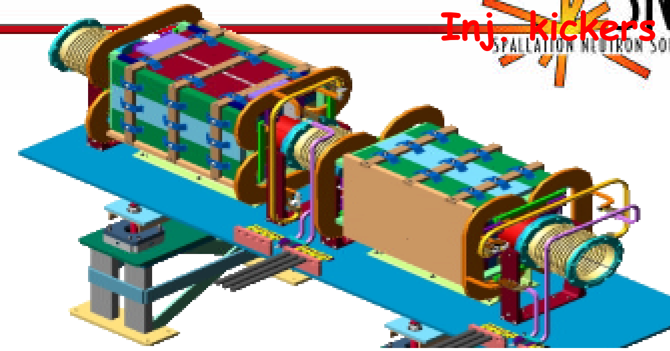
Cu (~ 0.7 µm) + TiN (0.1 µm) w/ rate ~ 0.5nm/s

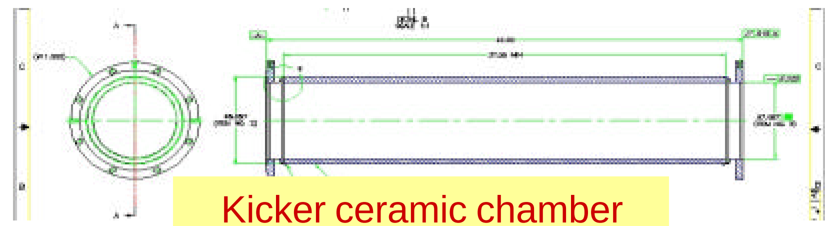
Good adhesion & thickness uniformity

Coating w/ anode screen (to smooth out the E field)

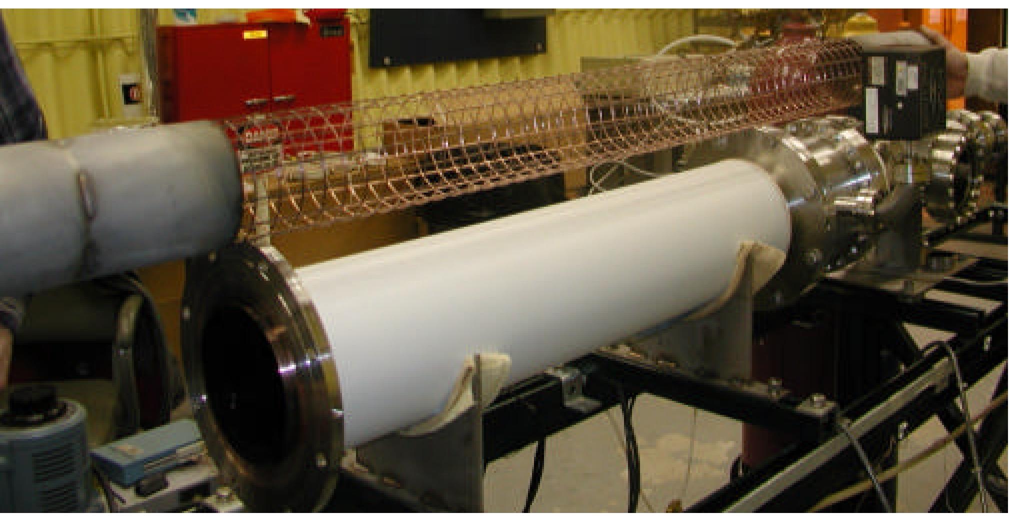
0.06 O on prototype tube, ±20% thickness uniformity,

Production coating started

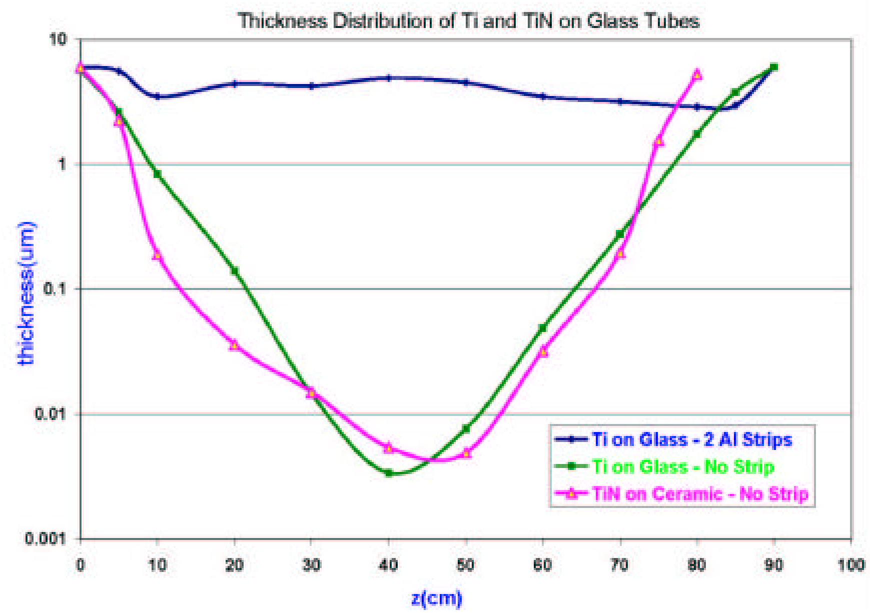




Kicker ceramic chamber



Ceramic tube and anode screen

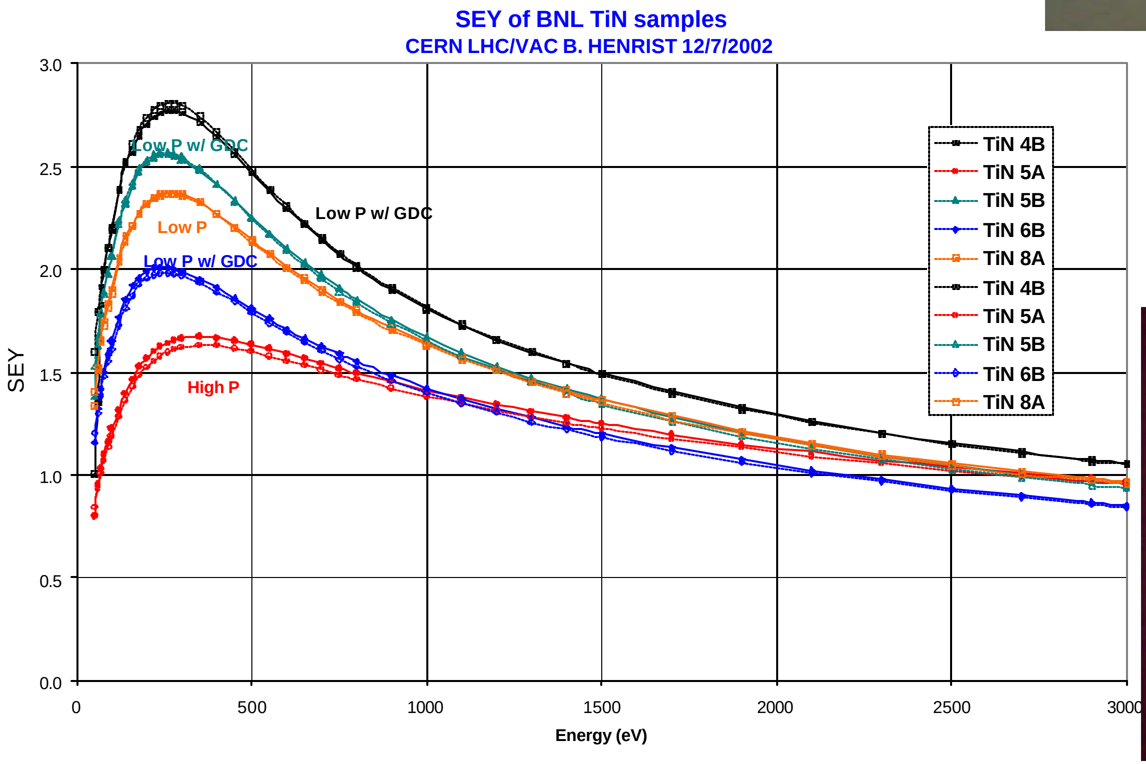


TiN Coating of HC Chambers

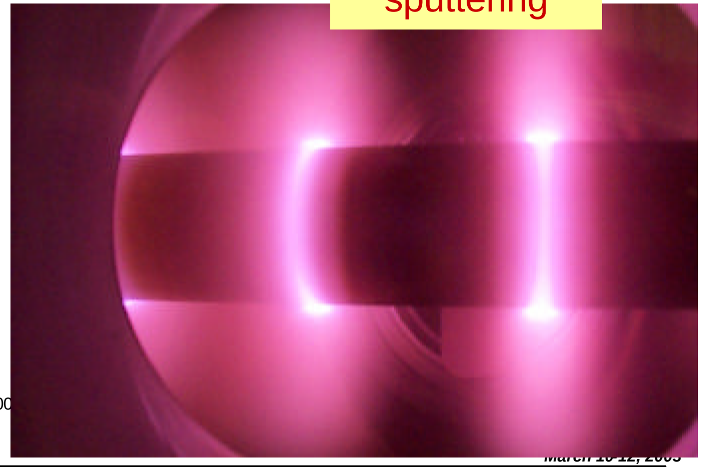
Coating pressure for HC Chambers

- @ ~ 5 mTorr Þ darker color & high Q
  but low SEY
- @ ~ 1.5 mTorr Þ gold color, low Q
  but high SEY

coupon color vs coating parameters

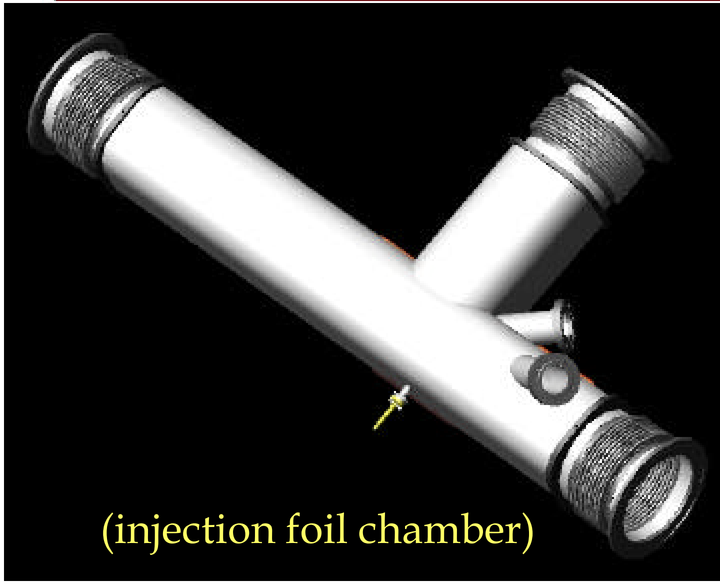


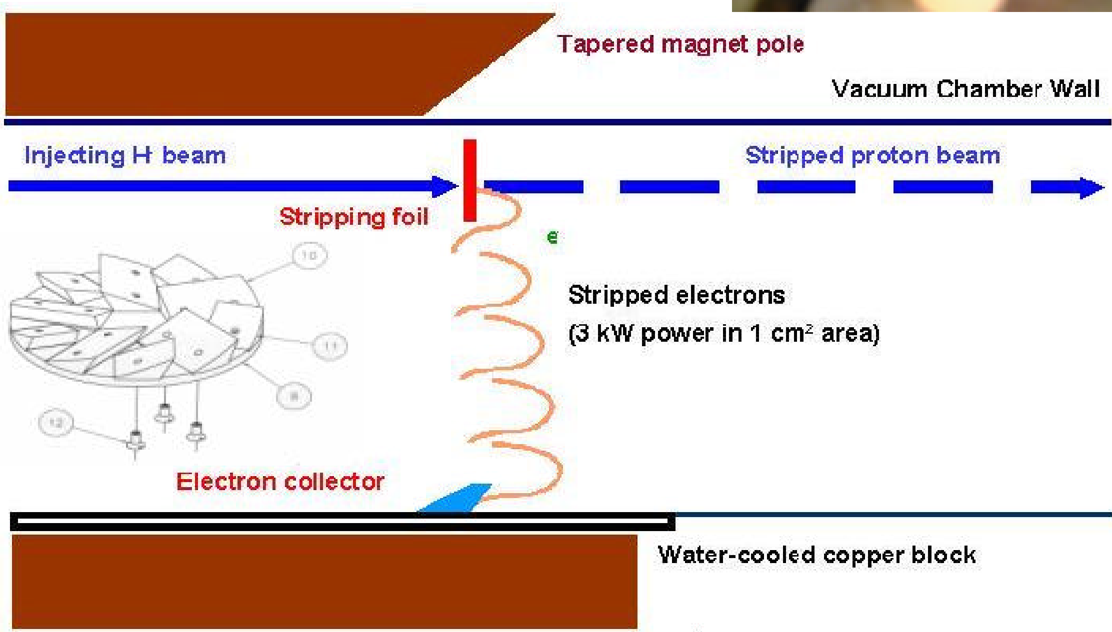
plasma during sputtering



Injection area
electron collection & monitoring

(J. Brodowski, C. J. Liaw, W. Meng, Y. Y. Lee …)





Start to implement ASAC recommendations
- Tapered magnetic field to guide stripped electrons
- Collector: C-C block on water-cooled Cu plate
- Add window & video to monitor e^- collection
- Add clearing electrodes to collect reflected/re-generated electrons

ORBIT: Developers and Collaborators

- SNS at ORNL
  - Sarah Cousineau (previously Indiana University), Slava Danilov, John Galambos, Yoichi Sato (Indiana University), Andrei Shishlo
  - Stuart Henderson, Dong-o Jeon
  - Josh Abrams (Knox College), Steve Bunch (University of Tennessee)
  - Kathy Woody (Tennessee Technological University)
- Fermilab
  - Leo Michelotti, Francois Ostiguy
  - Weiren Chou, J. MacLachlan
- SNS at Brookhaven
  - Joanne Beebe-Wang, Alfredo Luccio
  - Mike Blaskiewicz, Alexei Fedotov, Jie Wei
- Indiana University
  - SY Lee
- LANL
  - Bob Macek
- TRIUMF
  - Fred Jones

ORBIT: Inventory of Models

- ORBIT is designed to simulate real machines: it has detailed models for
  - Injection foil and painting
  - Single particle transport through various types of lattice elements
  - Magnet errors, Closed orbit calculation, orbit correction
  - RF and acceleration
  - Longitudinal impedance and 1D longitudinal space charge
  - Transverse impedance
  - 2.5D space charge with or without conducting wall beam pipe
  - 3D space charge
  - Feedback for stabilization
  - Apertures and collimation
  - Electron Cloud Model

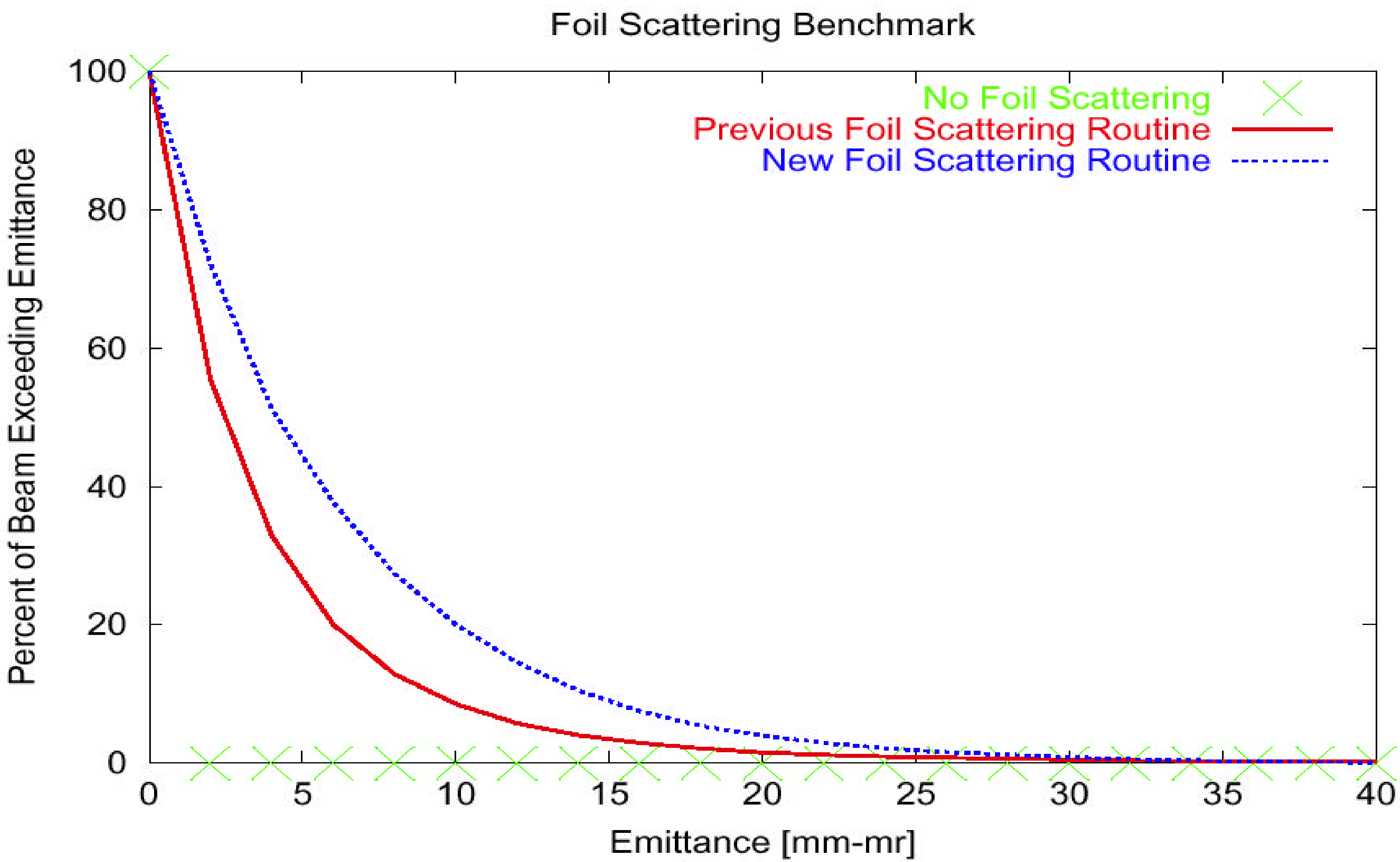
- ORBIT has an excellent suite of routines for beam diagnostics

ORBIT: Injection Foil

- **Original model:**
  - Repeated small angle Coulomb scattering
  - No energy losses
  - No nuclear processes
  - Only lost particles are those that miss foil at injection

- **New alternate foil model incorporates the physics of the collimation routine:**
  - Multiple Coulomb scattering
  - Rutherford scattering
  - Ionization energy loss
  - Nuclear elastic and inelastic scattering
  - In addition to particles that miss foil at injection, losses include particles with energies below 20 MeV and particles that undergo inelastic nuclear scattering

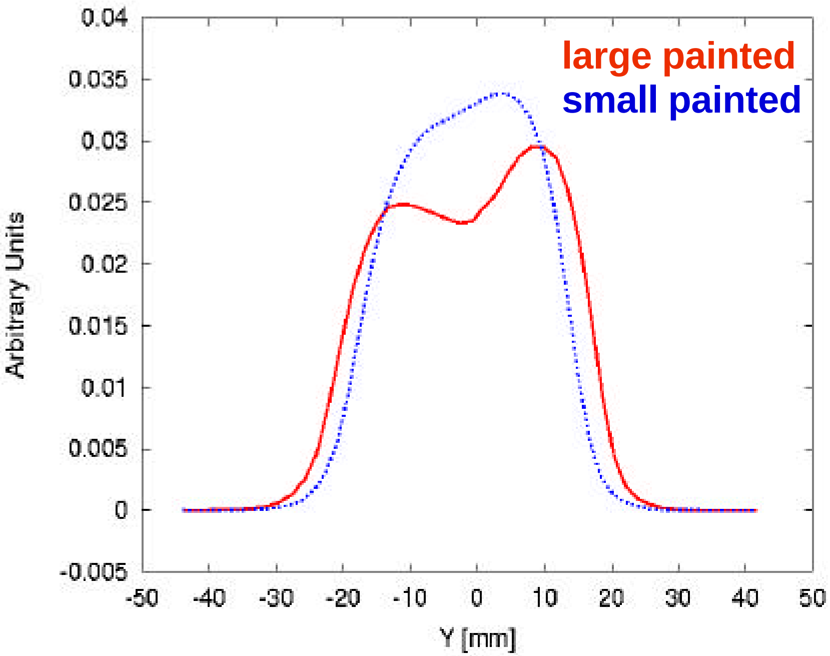
ORBIT: Benchmark Injection Foil Model



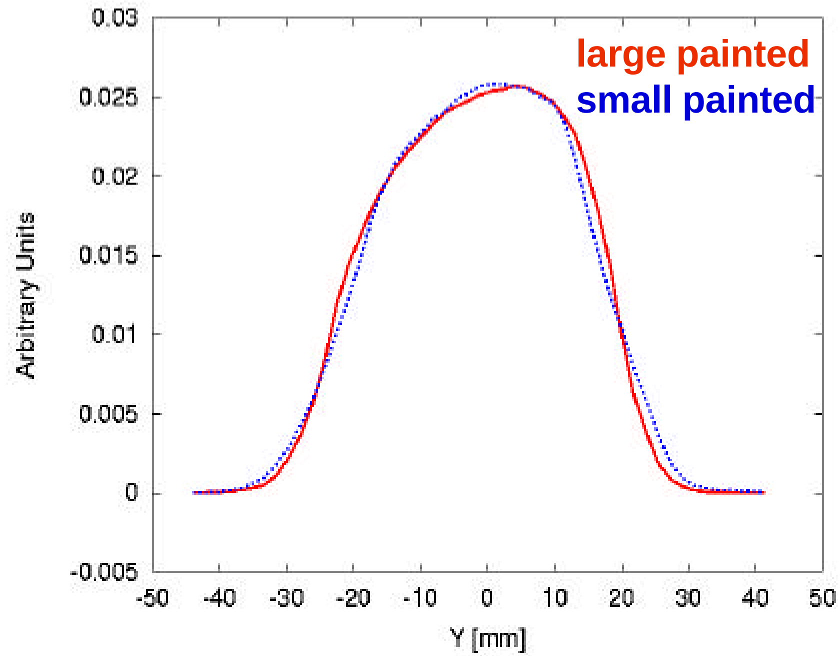
Effect of Space Charge on Profile Distribution (another example)

- Two painting schemes: Large beam injection, and small beam injection
  - Low intensity: distribution depends on painting scheme
  - High intensity: distribution independent of painting scheme

Vertical beam profile: 1.56 ´ 10^{13} ppp



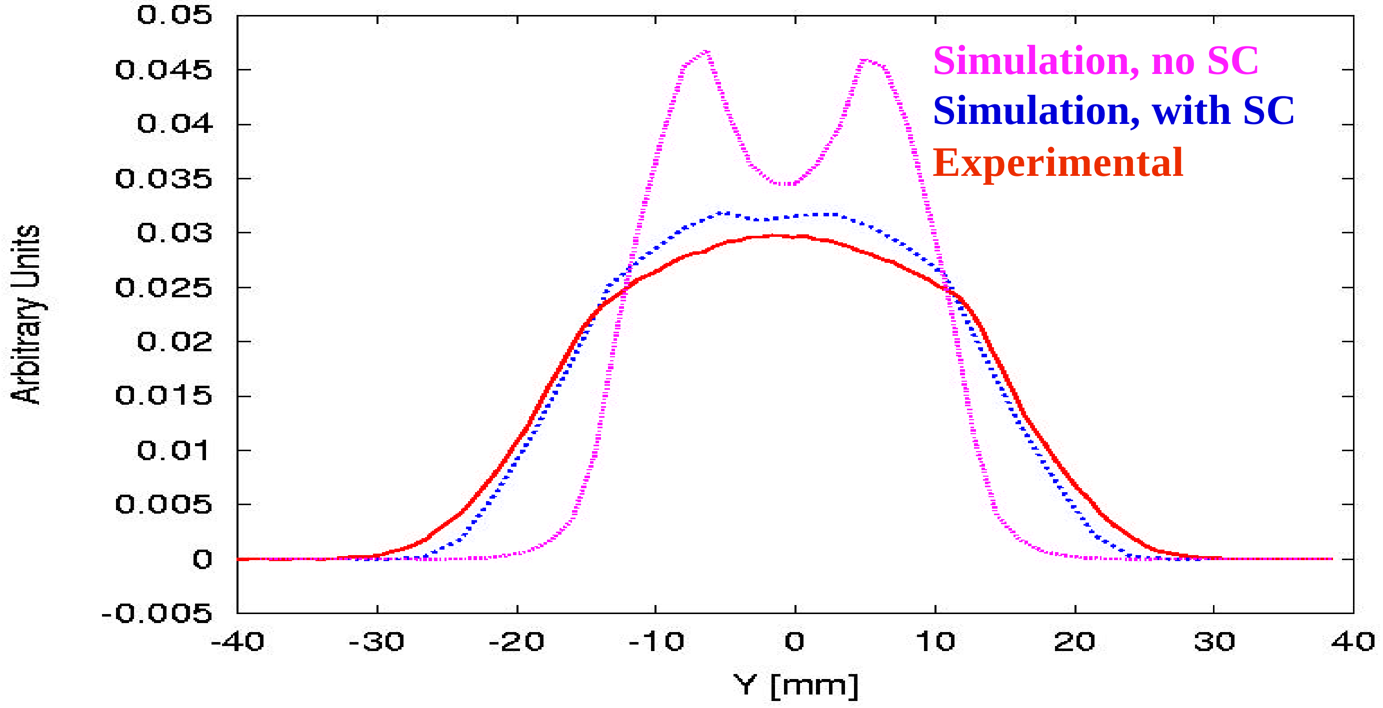
Vertical beam profile: 3.13 ´ 10^{13} ppp



Transverse Benchmarks with the ORBIT Code

- ORBIT simulations: Important to benchmark low intensity case to ensure injection modeling is correct
- ORBIT can perform detailed tracking of beam in high intensity machine, including space charge effects

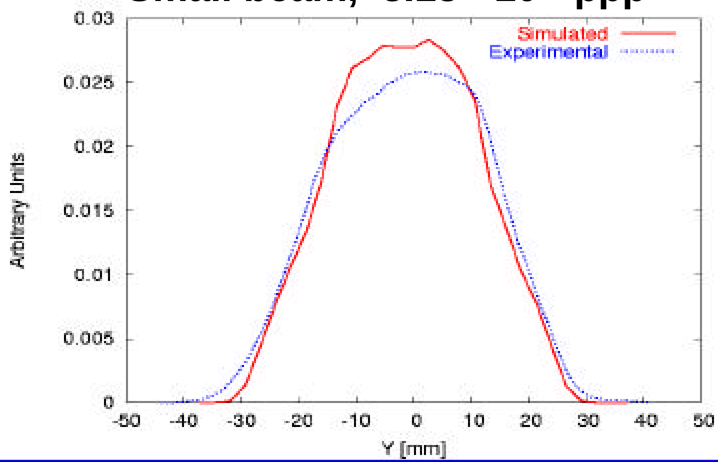
Transverse benchmark of 4.37×10^{13} ppp beam



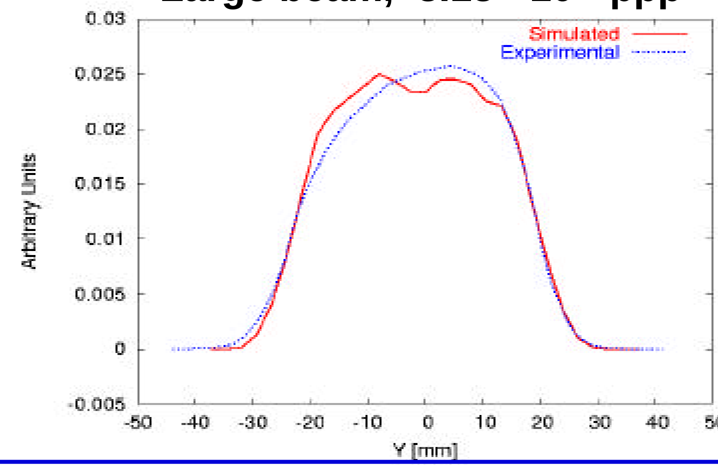
More Transverse Benchmarks...

Injection painting experiment benchmarks

Small beam, 3.13 ´ 10^{13} ppp

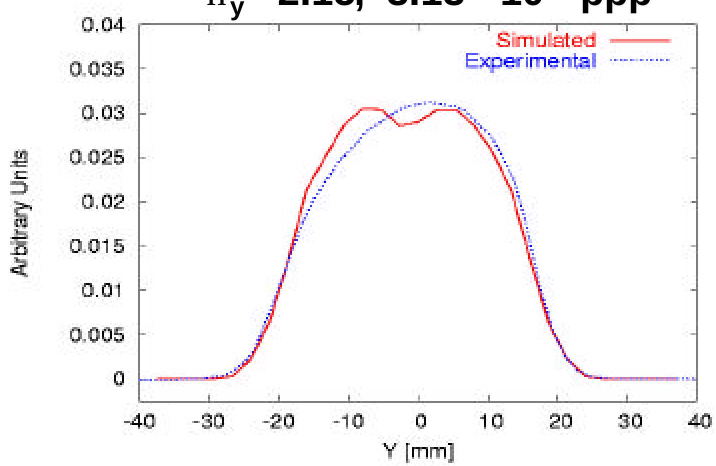


Large beam, 3.13 ´ 10^{13} ppp

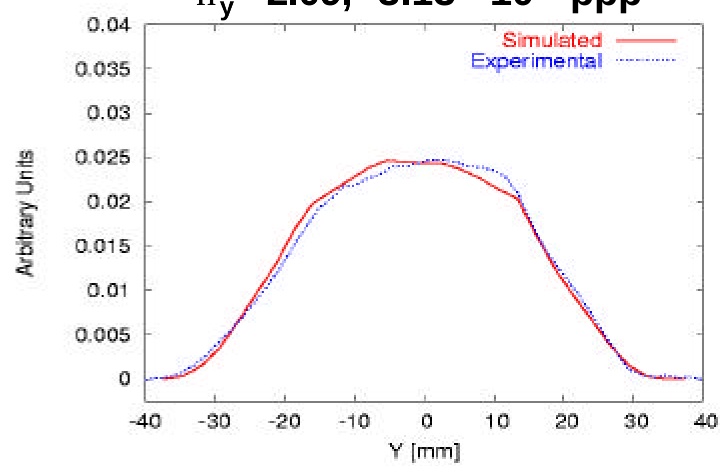


Tunescan experiment benchmarks

n_y= 2.15, 3.13 ´ 10^{13} ppp

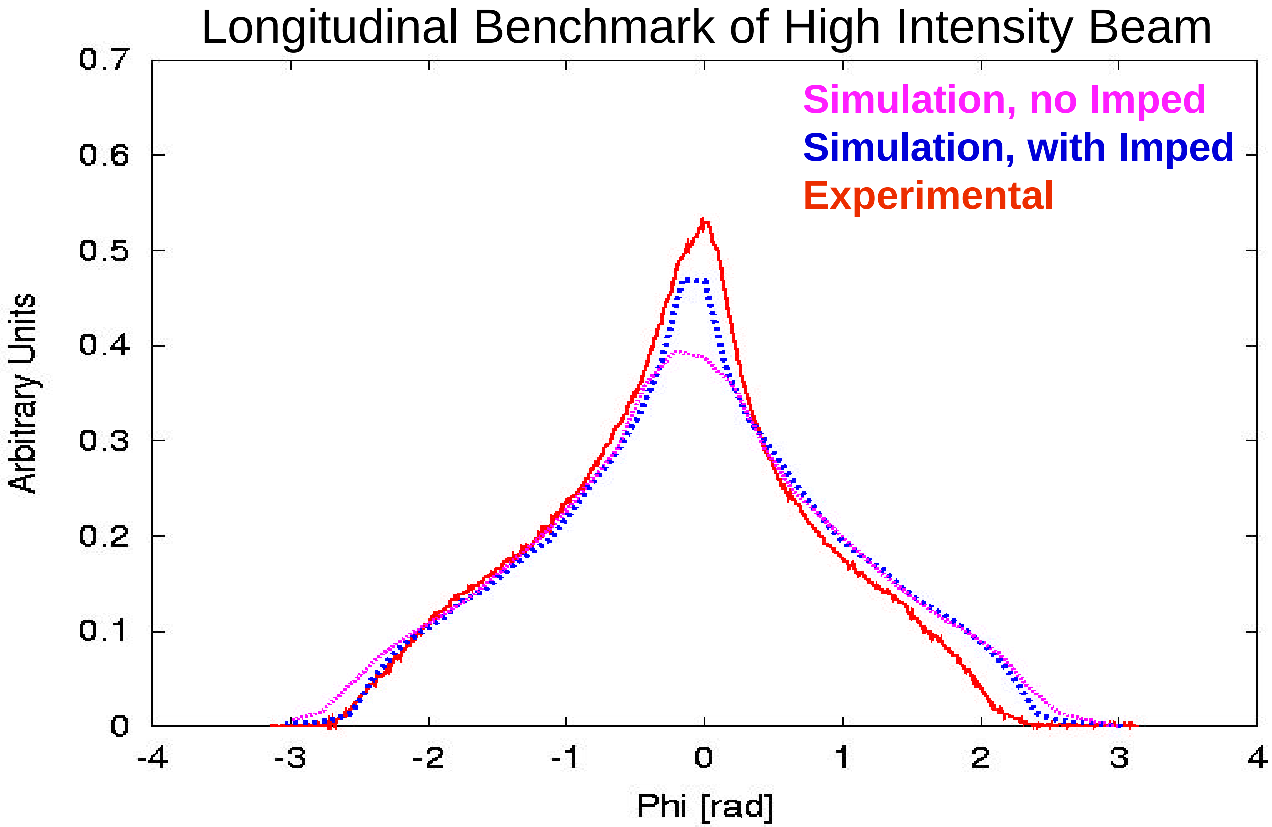


n_y= 2.09, 3.13 ´ 10^{13} ppp



Longitudinal Benchmarks with the ORBIT Code

- Longitudinal impedance and space charge are necessary to accurately portray physics of the high intensity PSR beam
- In this study, space charge and longitudinal impedance are the only nonlinearities

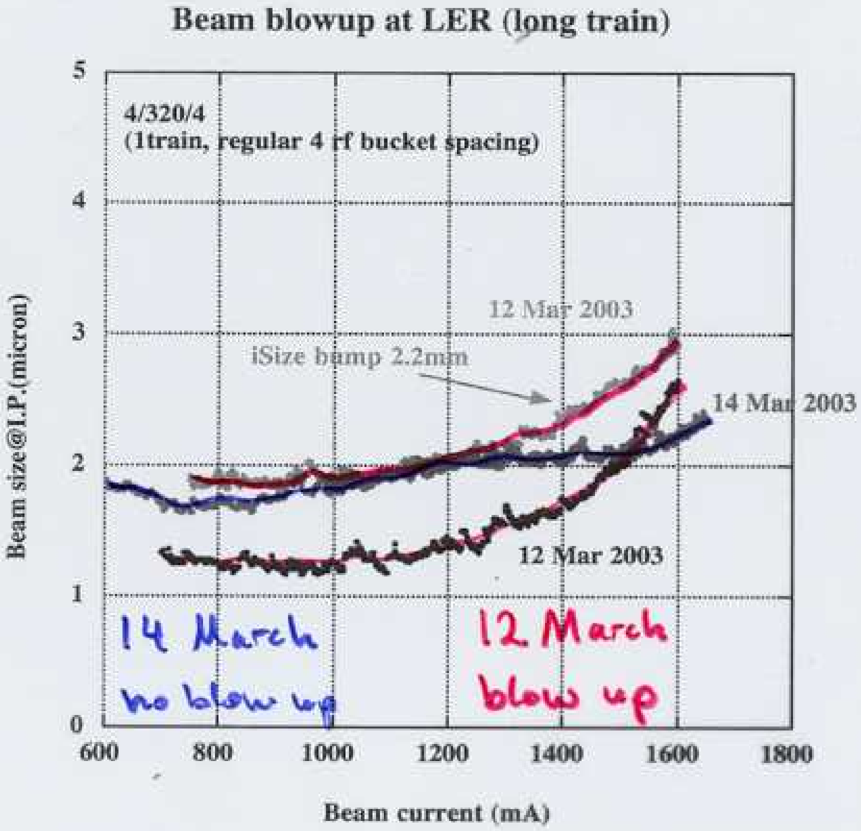


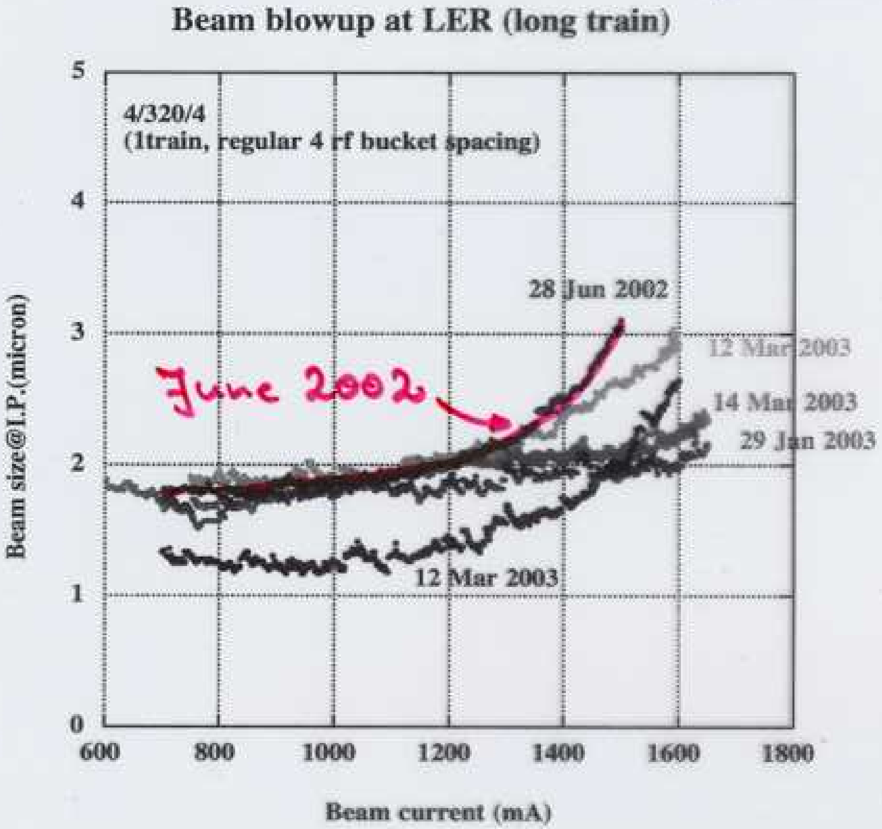
Blow up was not observed at 1300mA where it started in the measurement at 12/Mar.

Chromaticity was same at 12 and 14/Mar.

$\xi_{x,y}$=(1.05, 0.63) 12/Mar/03, (1.05, 0.63) 14/Mar/03

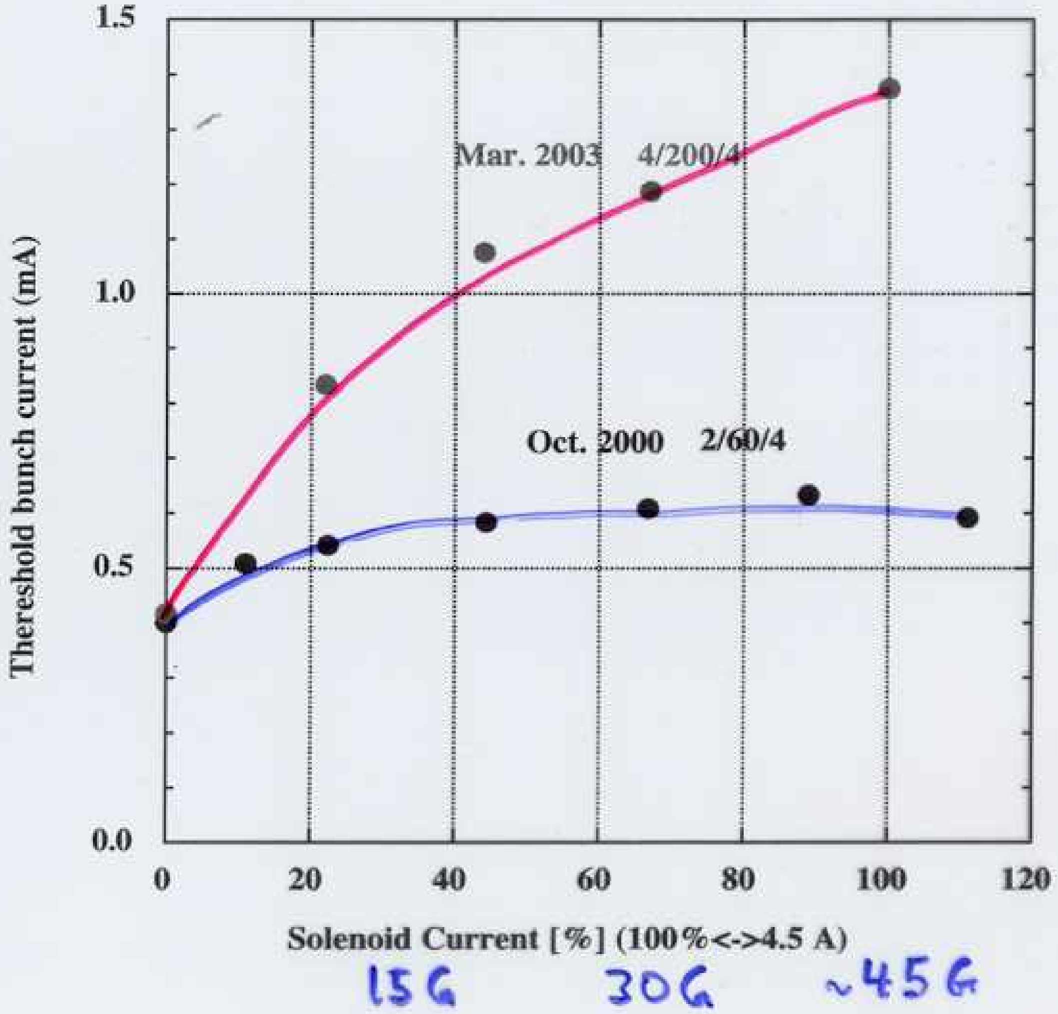
H. Fukuma





blow-up threshold depends on unknown parameter
($\neq$ initial beam size)

Threshold current of blowup did not saturate even at 4.5 A of solenoid current.



blow up does no longer saturate as a function of solenoid strength

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BPM

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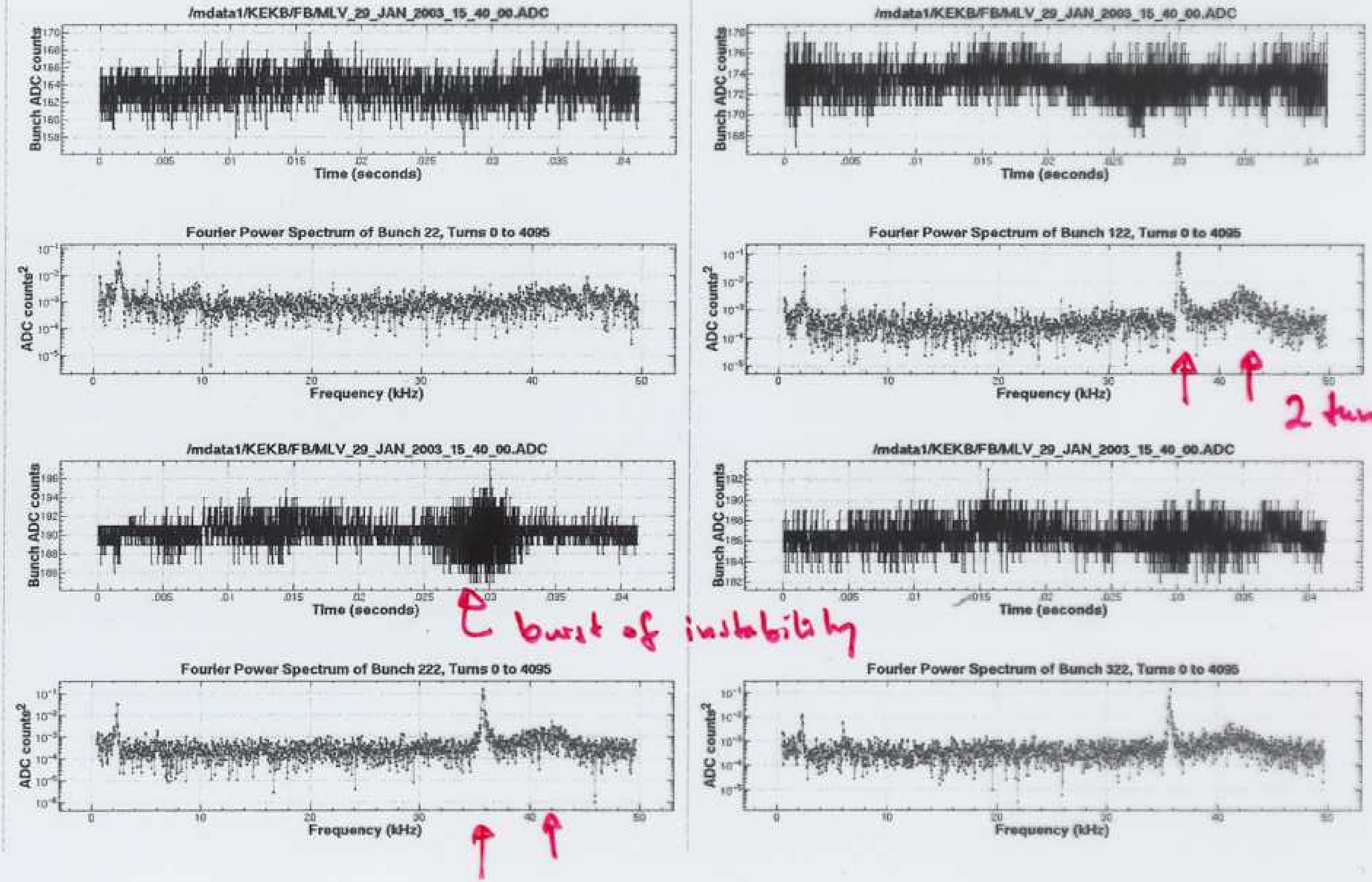
BPM Example Bunch Time Series and Single-Bunch Spectra



burst of instability

2 tune lines separate for increasing current

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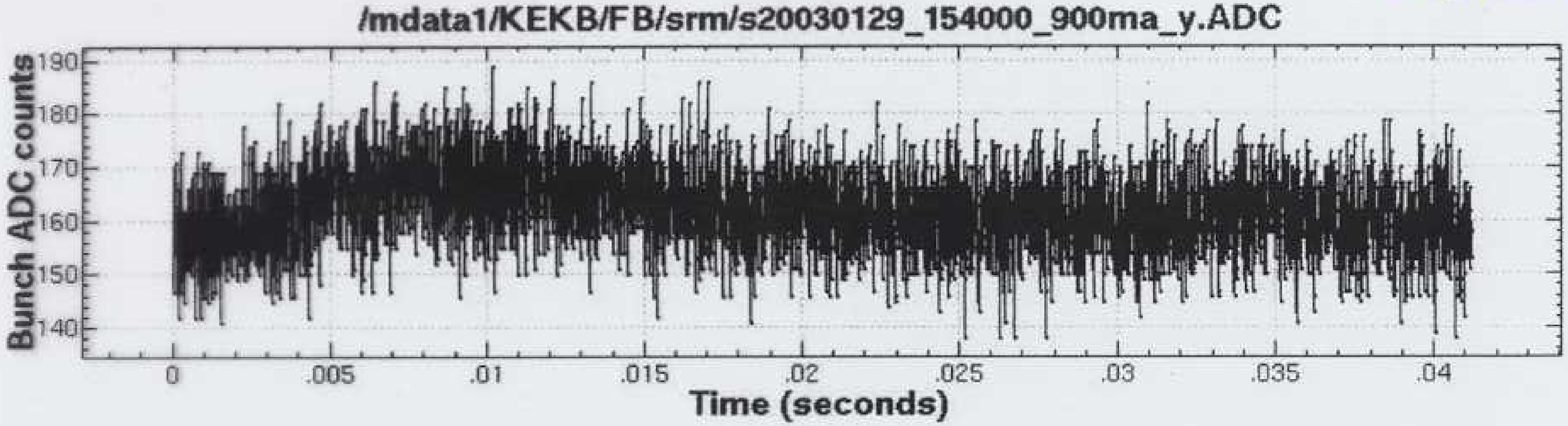
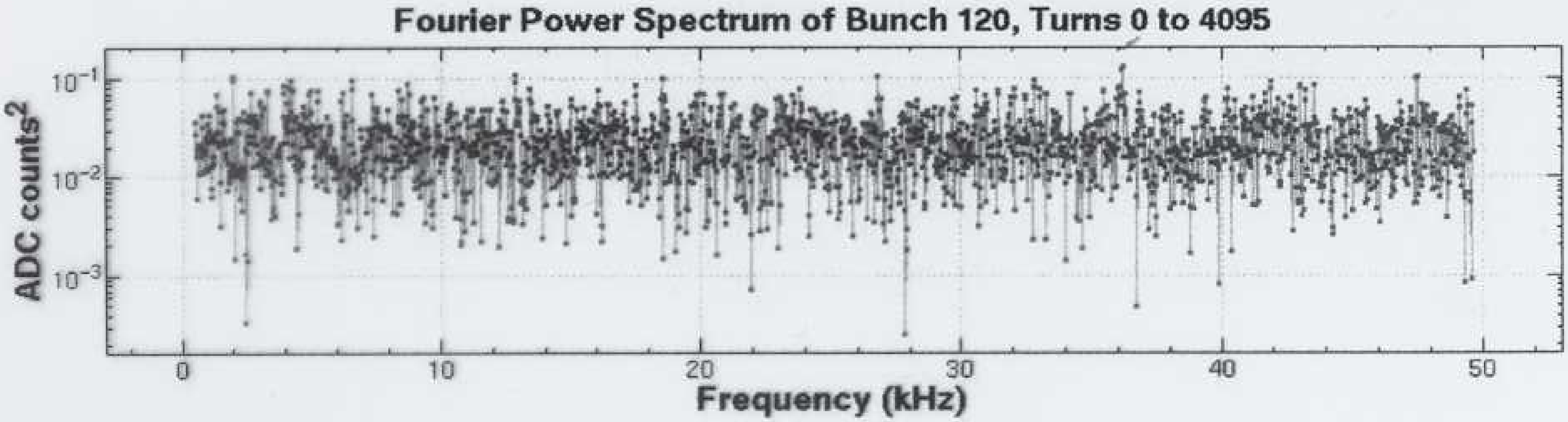
Example showing blow-up decay time ~1500 turns

<, ≪ transverse damping time ~ 9000 turns





SR & PMT with cardboard cover

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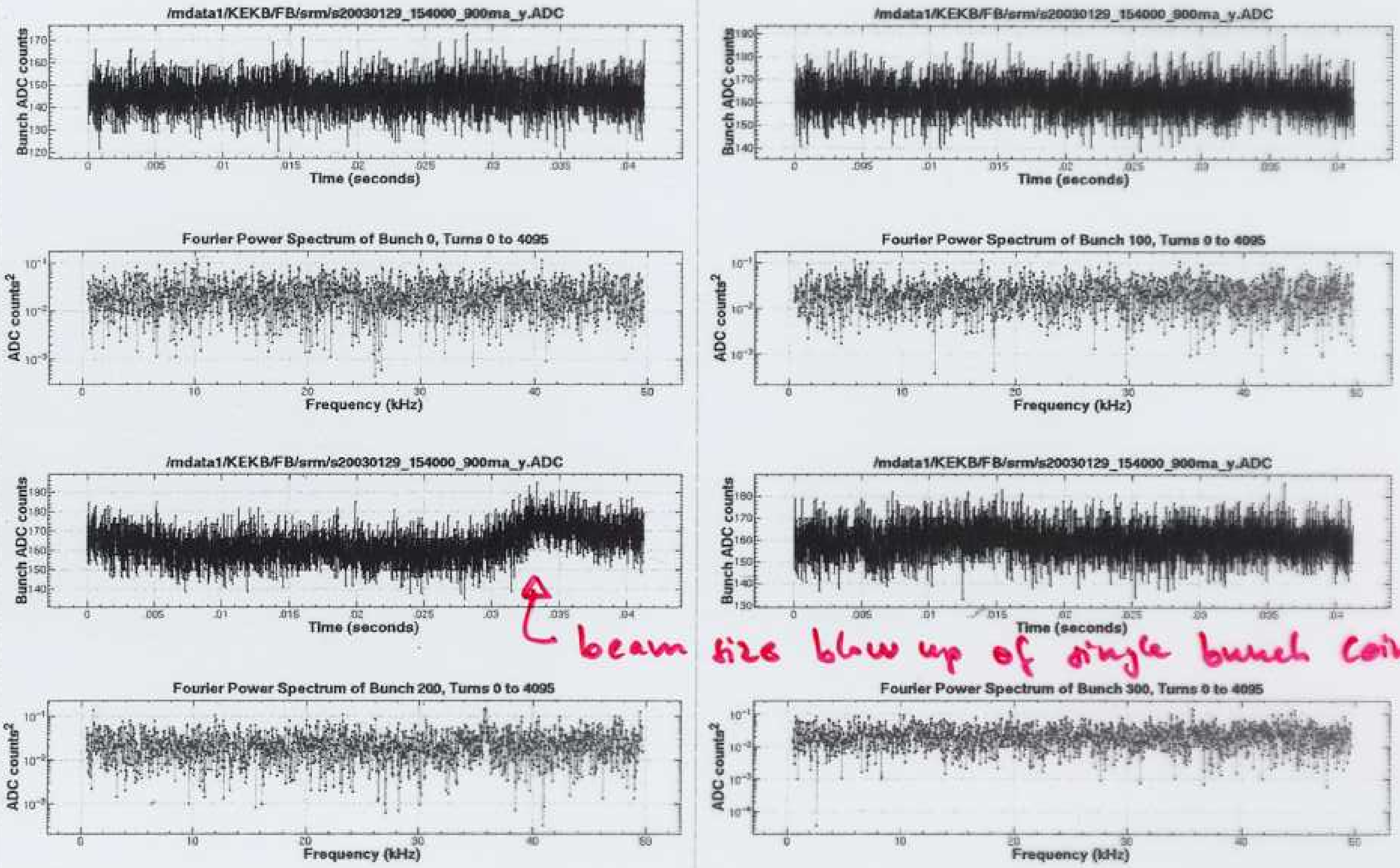
PMT Example Bunch Time Series and Single-Bunch Spectra



beam size blow up of single bunch coincides with instability