

# Tevatron Ionization Profile Monitors

Andreas Jansson



# Team roster

## Accelerator Division

A. Jansson, C.Lundberg, D.Slimmer, L.Valerio, J.Zagel,  
T.Anderson, A. Chen, R.Dysert, S.McCormick, S. Suleimani,  
C.Rivetta, B.Hively, D.Miller, J.Volk

## Particle Physics Division

K.Bowie, T.Fitzpatrick, A.Bross, H.Nguyen, T.Zimmermann  
Z.Tang

## Computing Division

R.Kwarciany, M.Bowden

## Technical Division

H.Glass, D.Harding, V. Kashikin

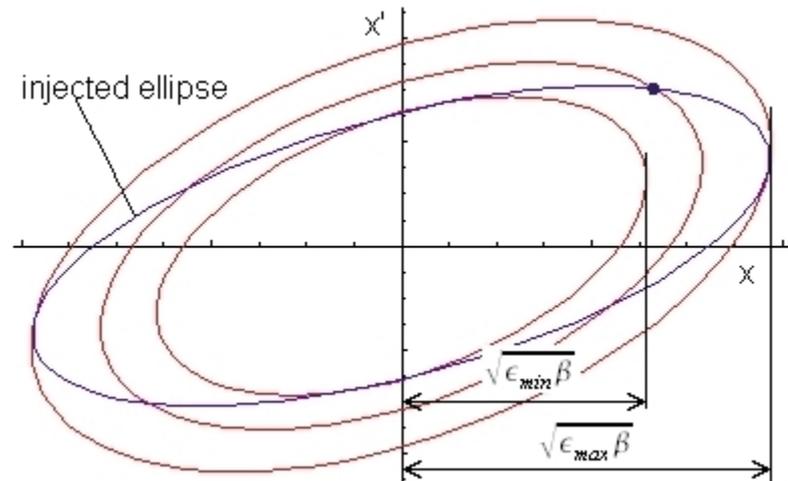
Also thanks to the DOE for the RunII upgrade money!



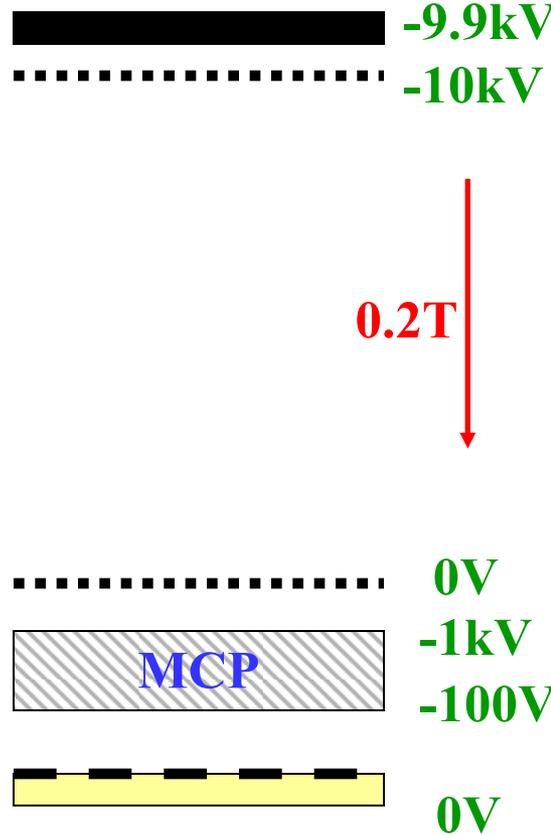
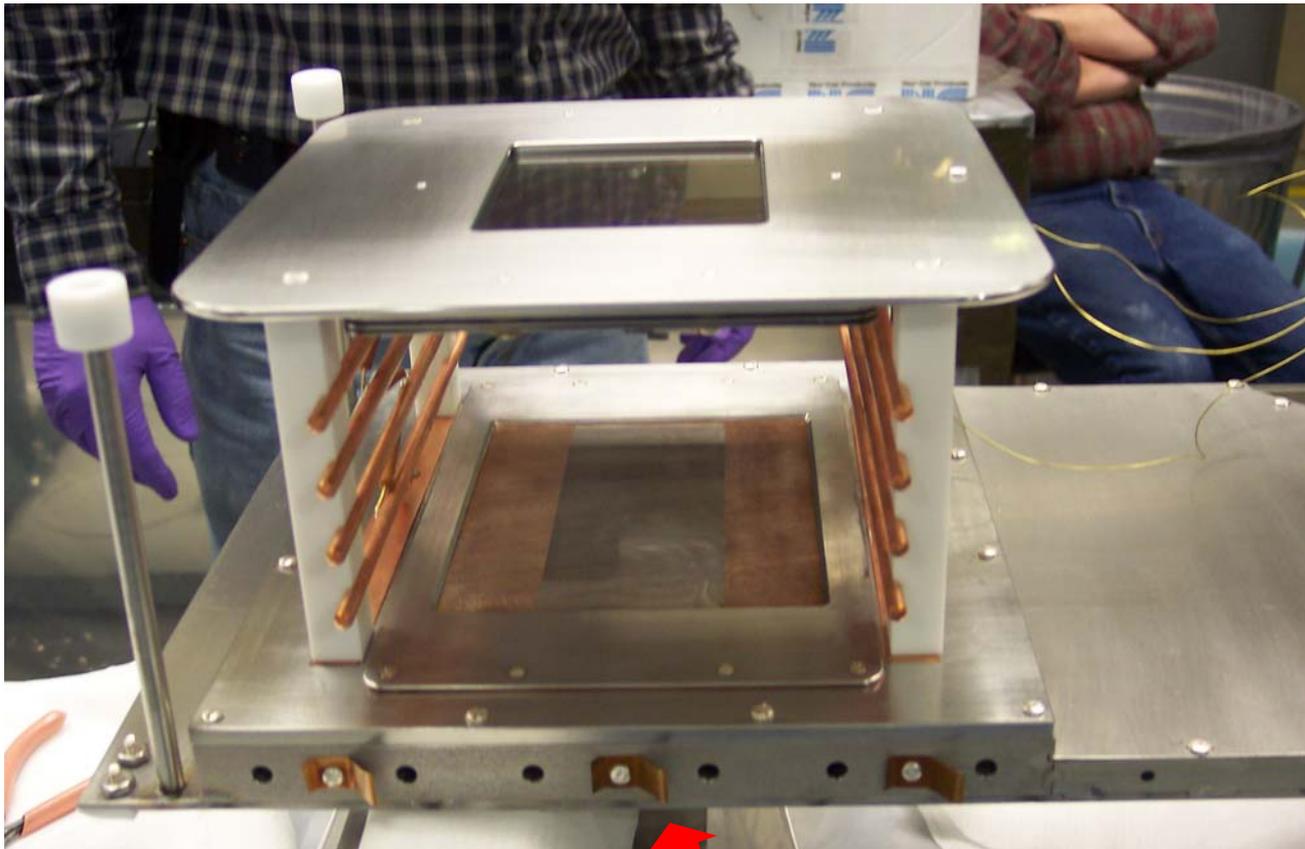
# Motivation

- Luminosity is inversely proportional to beam size.
- Don't dilute the emittance!
- Measure beam size turn-by-turn, especially at injection (to detect focusing errors).

$$L = \frac{10^{-5} f B N_p N_{\bar{p}} (6 \beta_r \gamma_r)}{2 \pi \beta^* \sqrt{(\epsilon_p + \epsilon_{\bar{p}})_x (\epsilon_p + \epsilon_{\bar{p}})_y}} H(\sigma_i / \beta^*)$$



# IPM detector

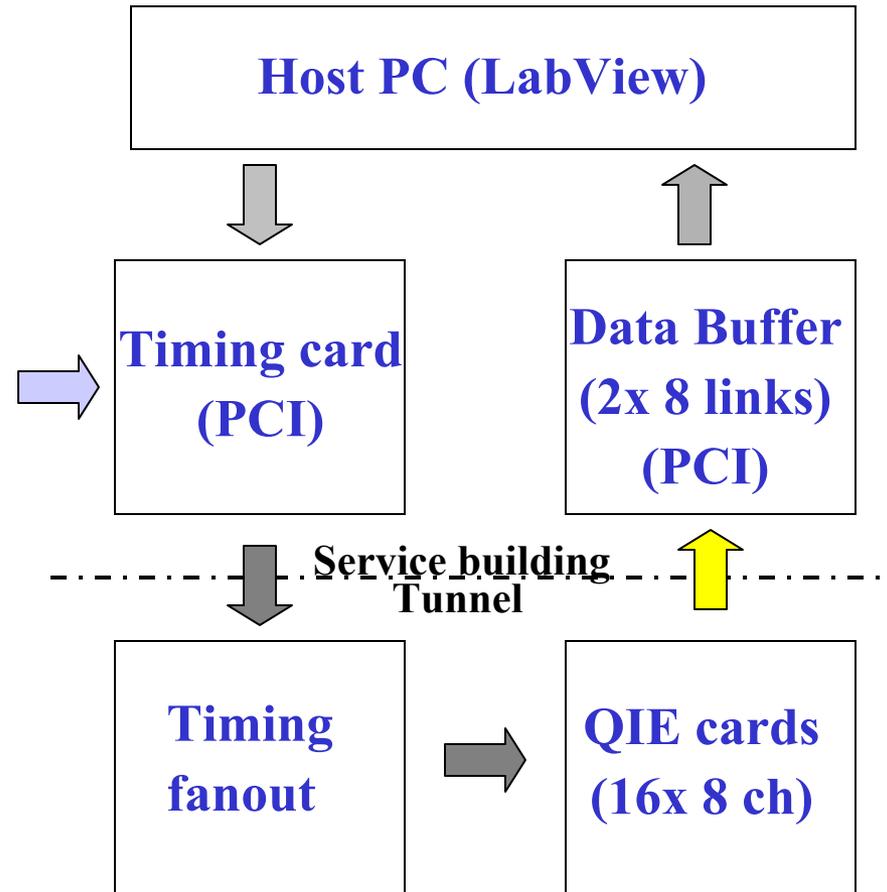


All signal cables are enclosed in a Faraday cage!

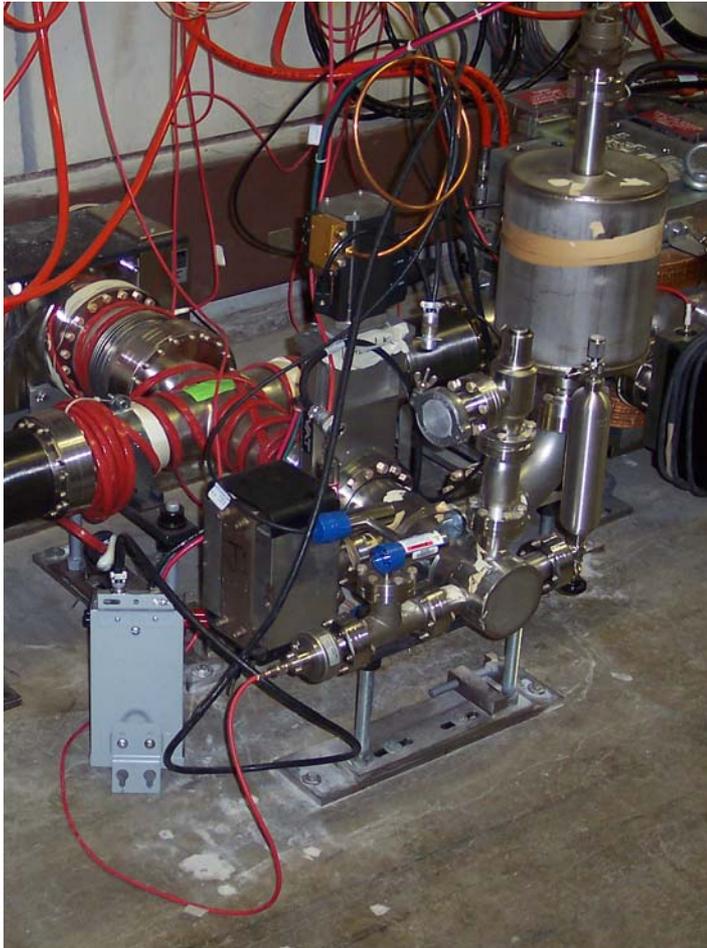


# DAQ system

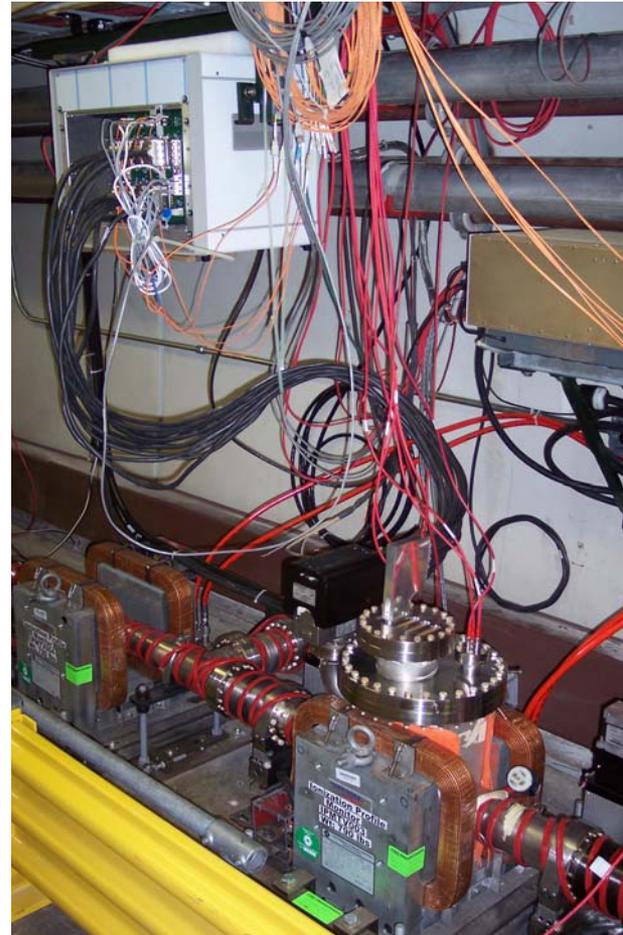
- CMS-QIE chip digitizes signal in tunnel.
- Serial data uplink on optical fiber.
- Receiver and data buffer in upstairs PC
- Timing + QIE clock + QIE clock supplied from PC thru cat-5E cable



# Setup



**Nitrogen injection system  
TeV E0 straight section**



**IPM detector and QIE boards  
TeV E0 straight section**



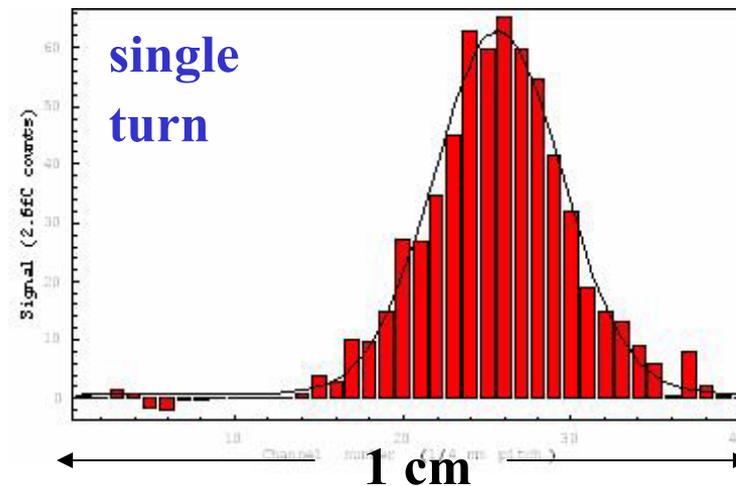
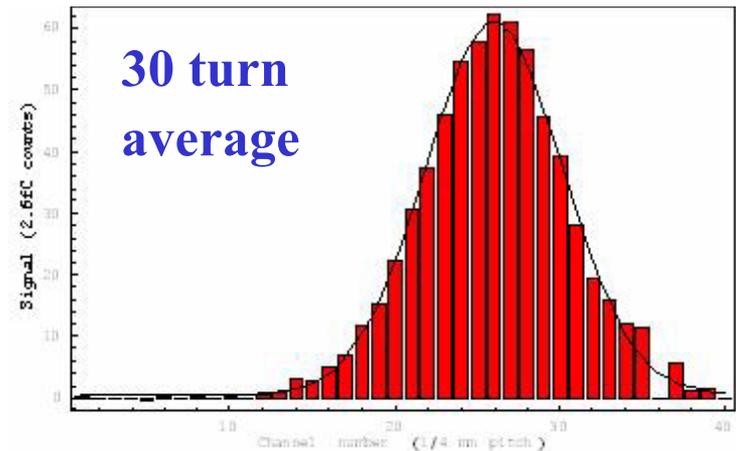
**Control PC  
E0 service building**



# Beam profile at 150GeV

- Proton bunch #22 at 150GeV during store #4772.
- Measured beam size 1.05mm, turn-by-turn variation  $\sim 50\mu\text{m}$ .
- Total signal per bunch  $\sim 1.7\text{pC}$ .

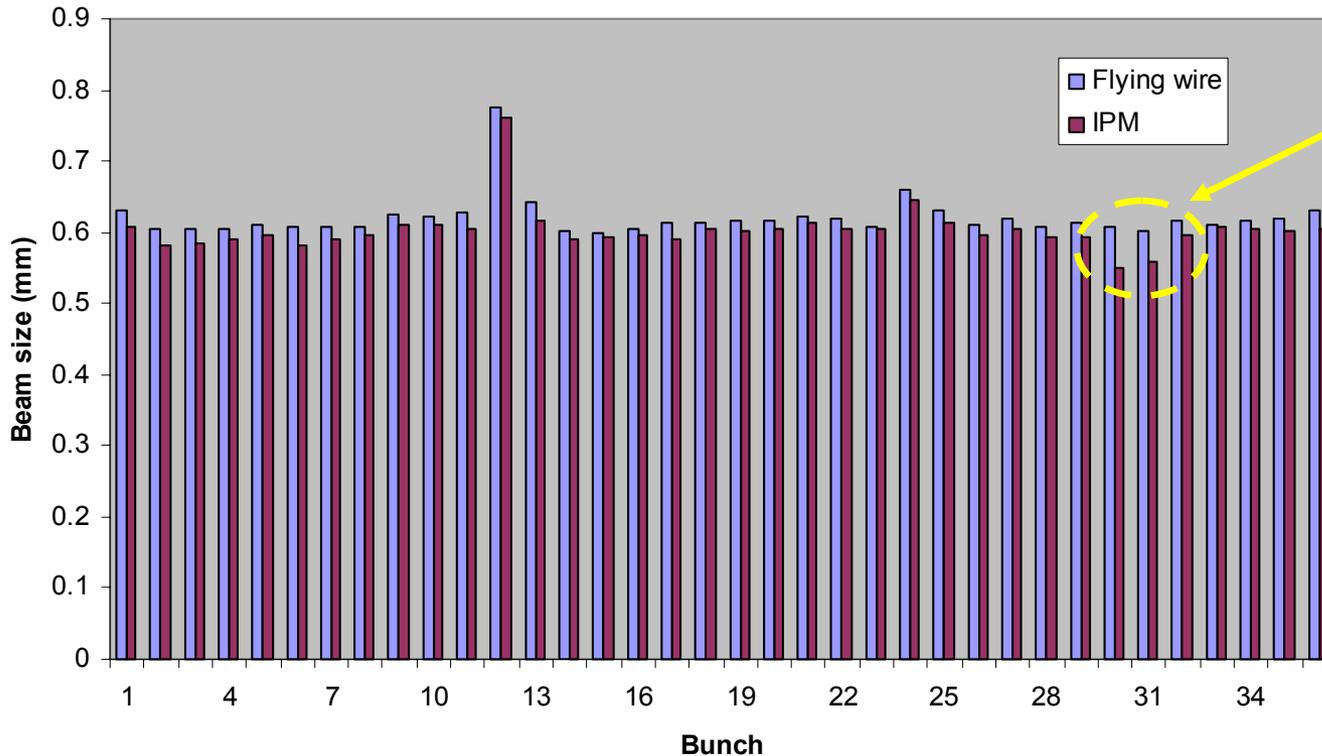
## Single bunch proton profiles



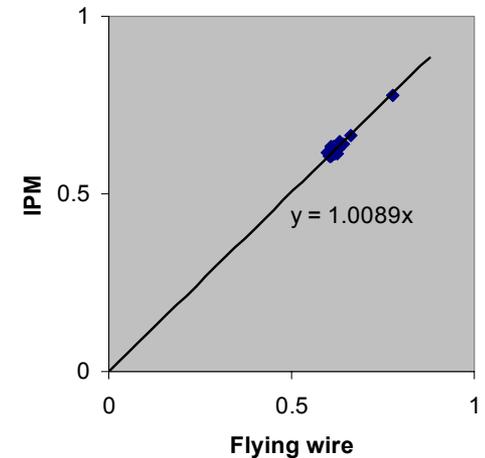
Magnet at 200A



# Flying wire comparison



Known electronics problem (cross talk from timing pulse)

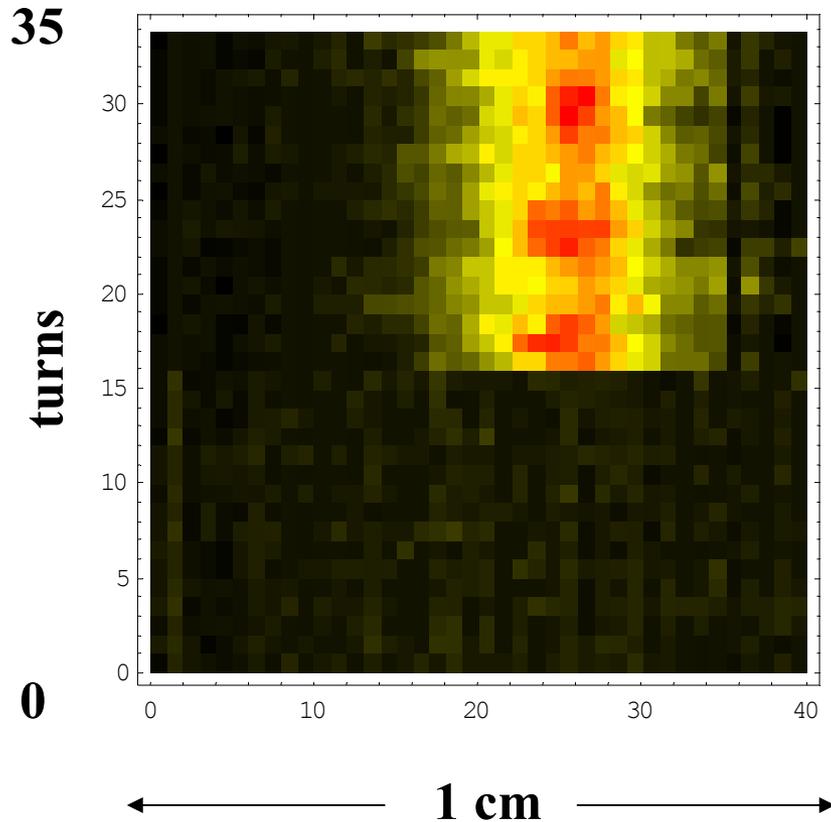


Comparison of vertical beam size from IPM and nearby Flying Wire. Tuning of abort cleaner timing had caused blow-up of certain bunches. From MAD lattice file, expect a 13% wider beam at Flying Wire. See ~1%.

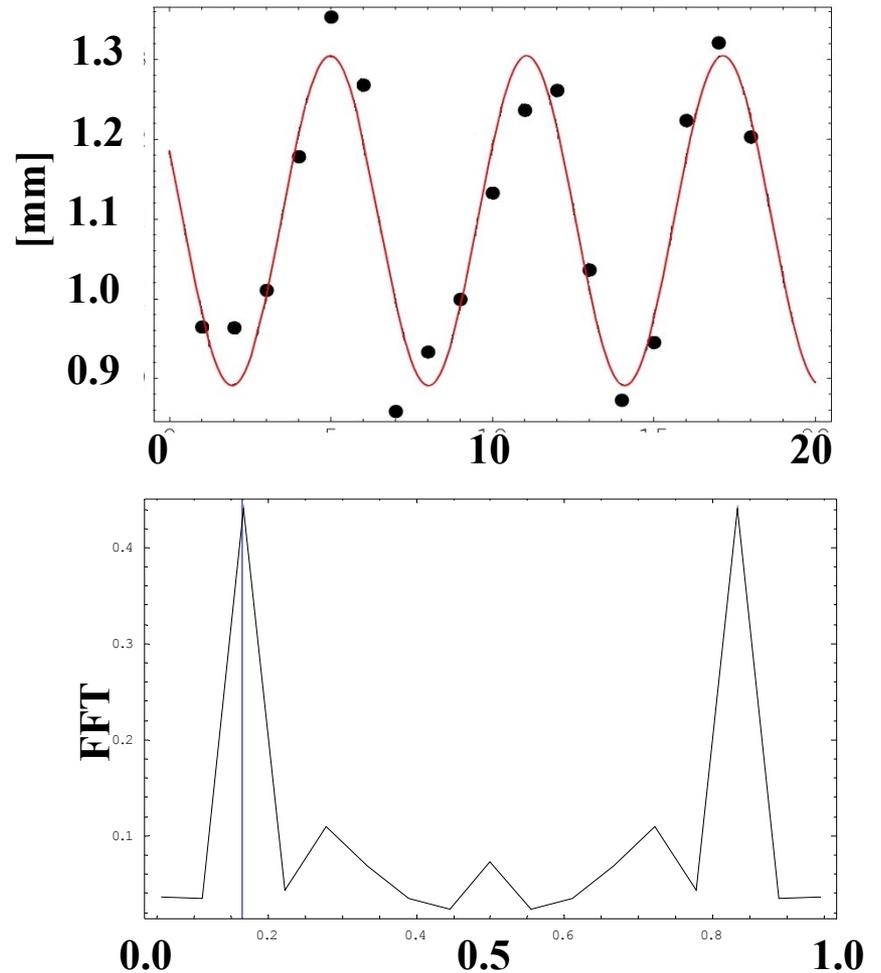


# Injection turn-by-turn

## Proton bunch #21 turn-by-turn



## RMS profile width



Store #4772

Magnet at 200A

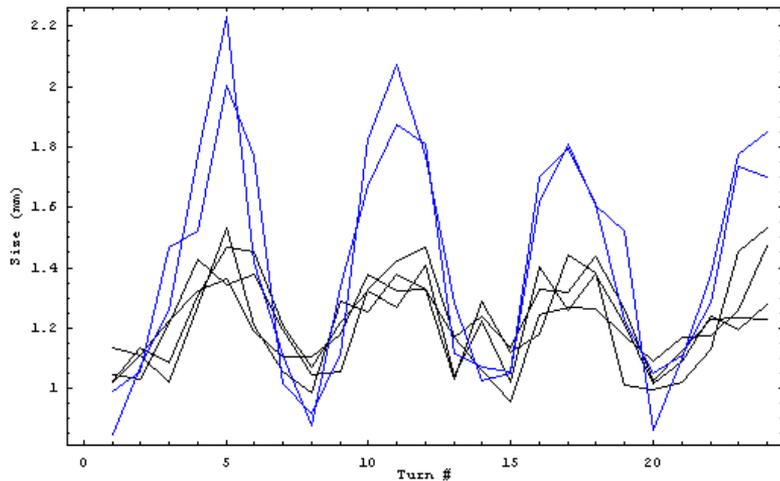
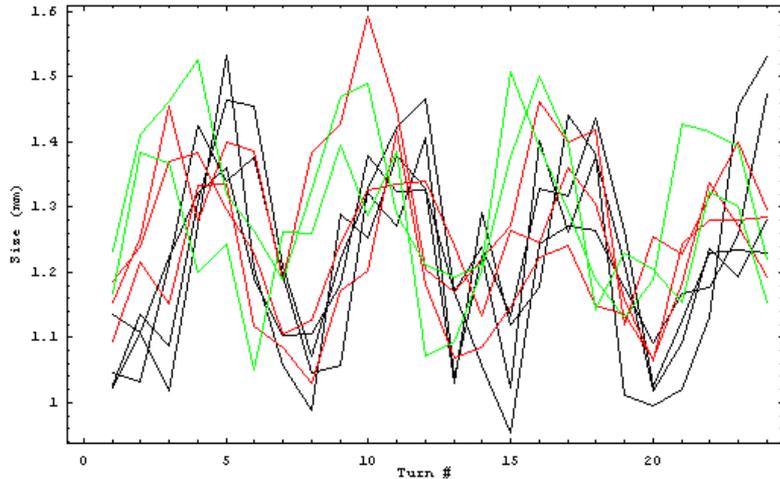
9/25/2006

All experimenters meeting

A. Jansson

9

# Transfer tuning study



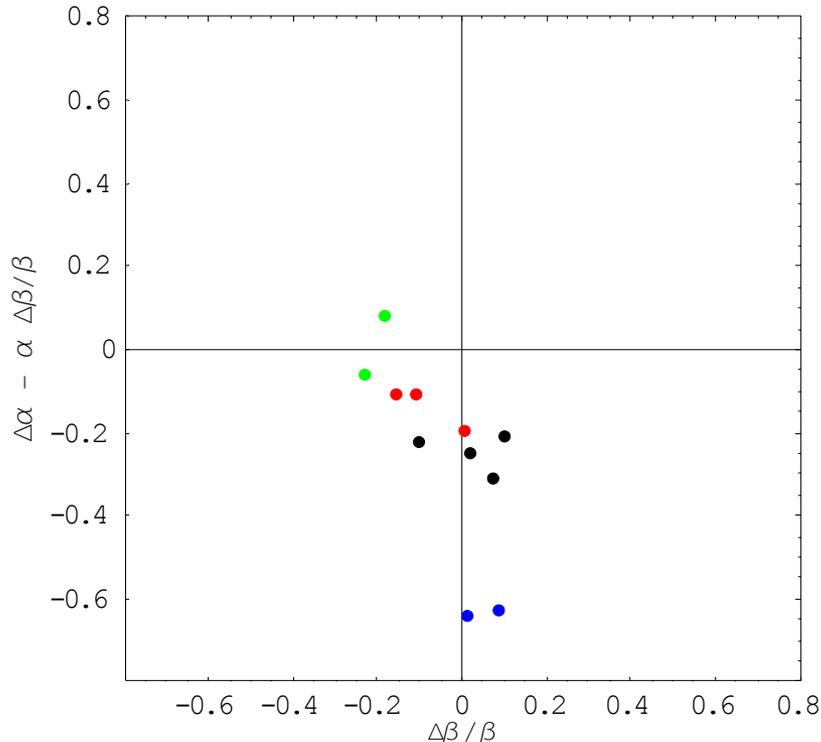
- September 20<sup>th</sup>: changed selected x-fer line quads

- Nominal settings
- Q701 at -22A
- Q701 at -42A
- Q711 at -25A

NB. Q711 was found to steer the beam significantly



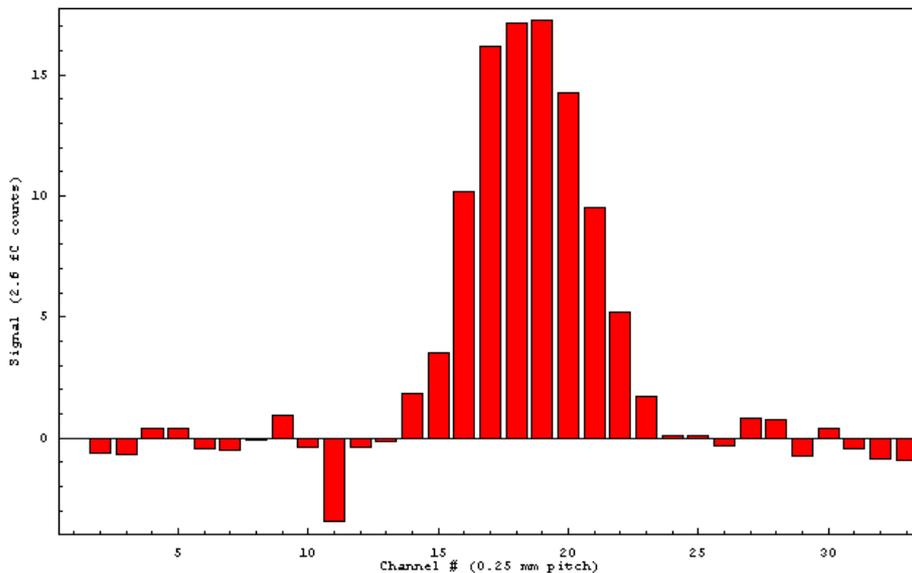
# Measured mismatch vectors



- Nominal settings
- Q701 at -22A
- Q701 at -42A
- Q711 at -25A
- Need to increase Q711 by ~15A (saturation?)
- Should result in 5-10% smaller vertical emittance
- Should have very little effect on horizontal plane.
- Should have been tested this morning...



# A first look at pbars



(average over 40 turns)

- First look at circulating pbars during store 4963 on Tuesday September 19<sup>th</sup> !



# Conclusions

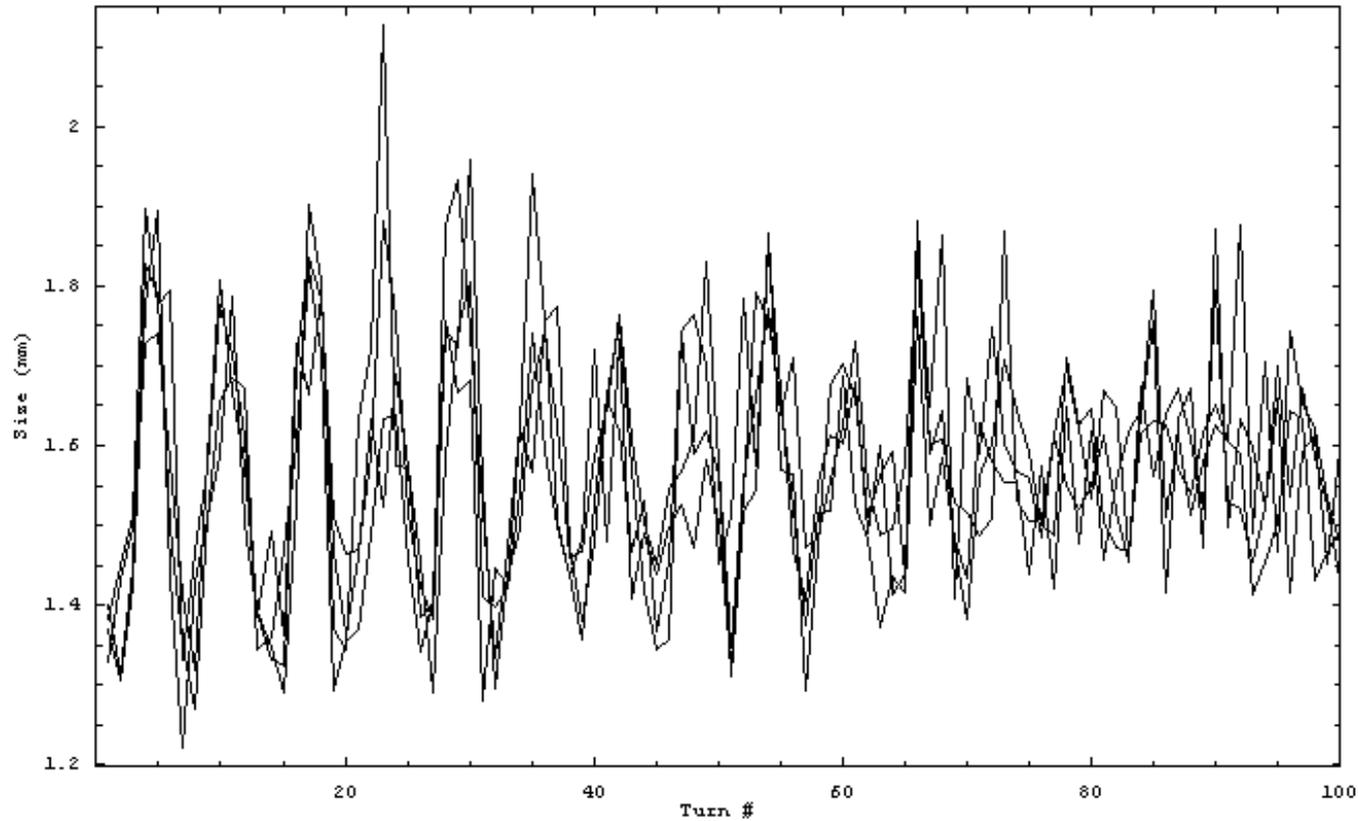
- Tevatron Ionization Profile Monitor see vertical injection mismatch, which can be mitigated with transfer line quad corrections.
- Should result in 5-10% smaller emittance, and corresponding increase in luminosity. May also alleviate beam-beam effect on protons.
- Still need to look at horizontal plane (need to fix tunnel hardware).
- Have seen coasting pbars, but pbar mismatch measurements (single turn) may need higher vacuum pressure.



Extra slides



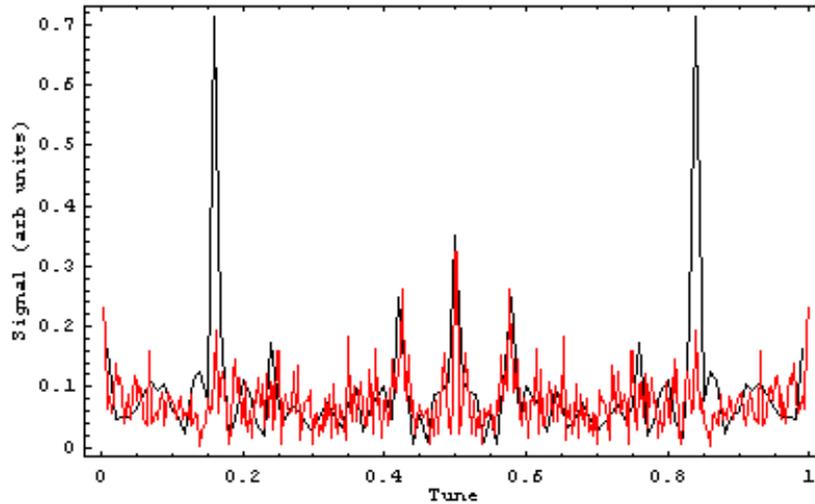
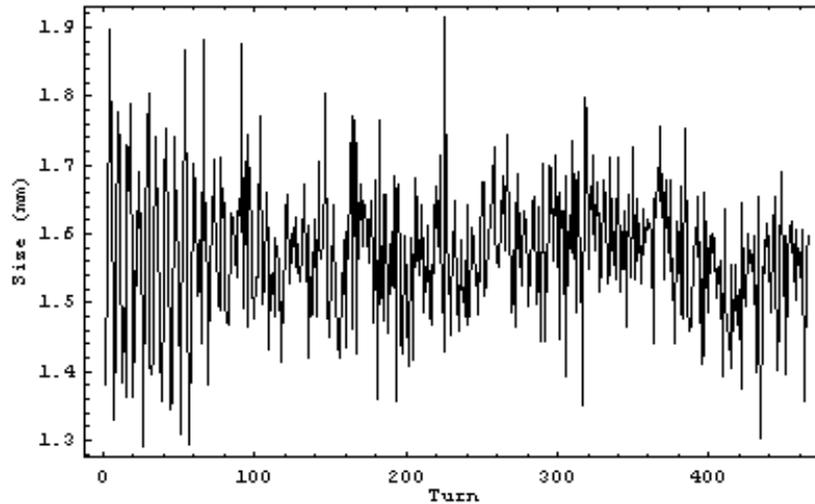
# 100 turns



Four injection measurements superimposed



# 500 turns



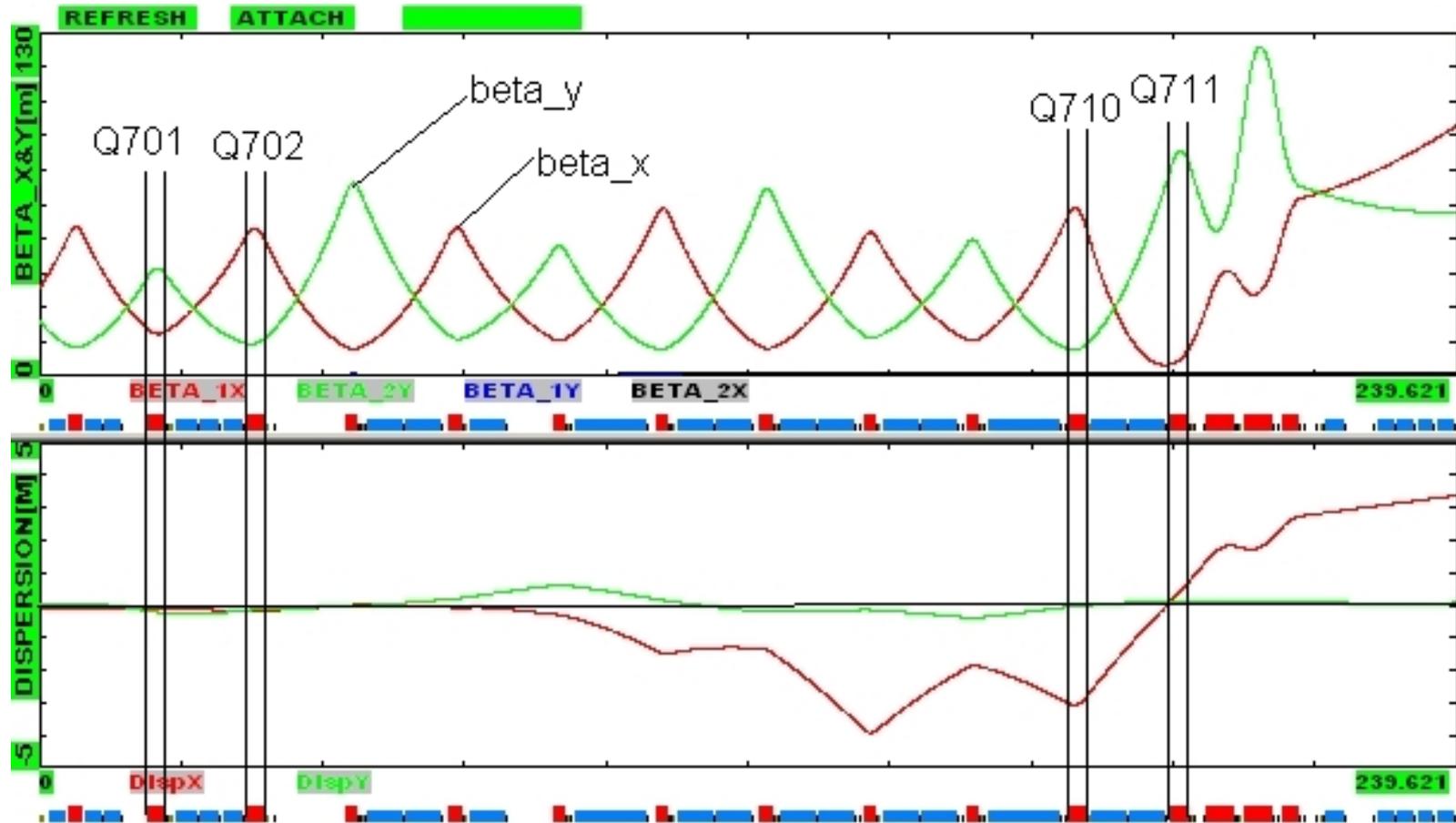
**FFT of:**

**First 100 turns**

**Turn 100-400**



# P150 transfer line

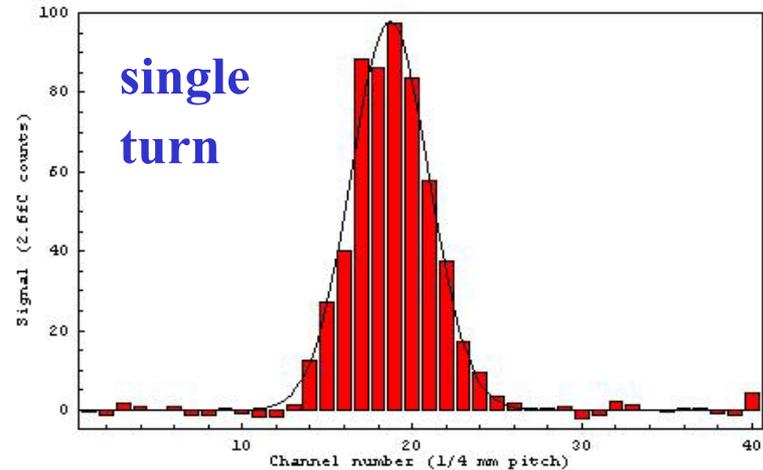
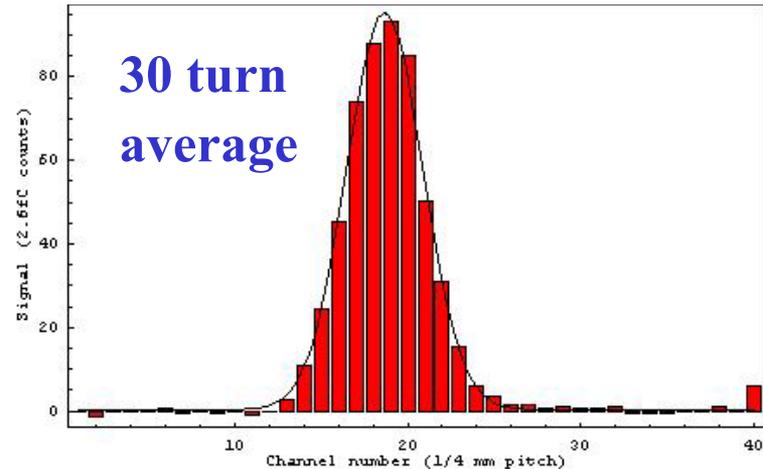


Plot from M. Berdnikov



# Beam profile at low beta

- Proton bunch #1 at low beta during store #4758.
- Measured beam size 0.55mm, turn-by-turn variation (noise) 20 $\mu$ m.
- Total signal per bunch ~1.3pC.

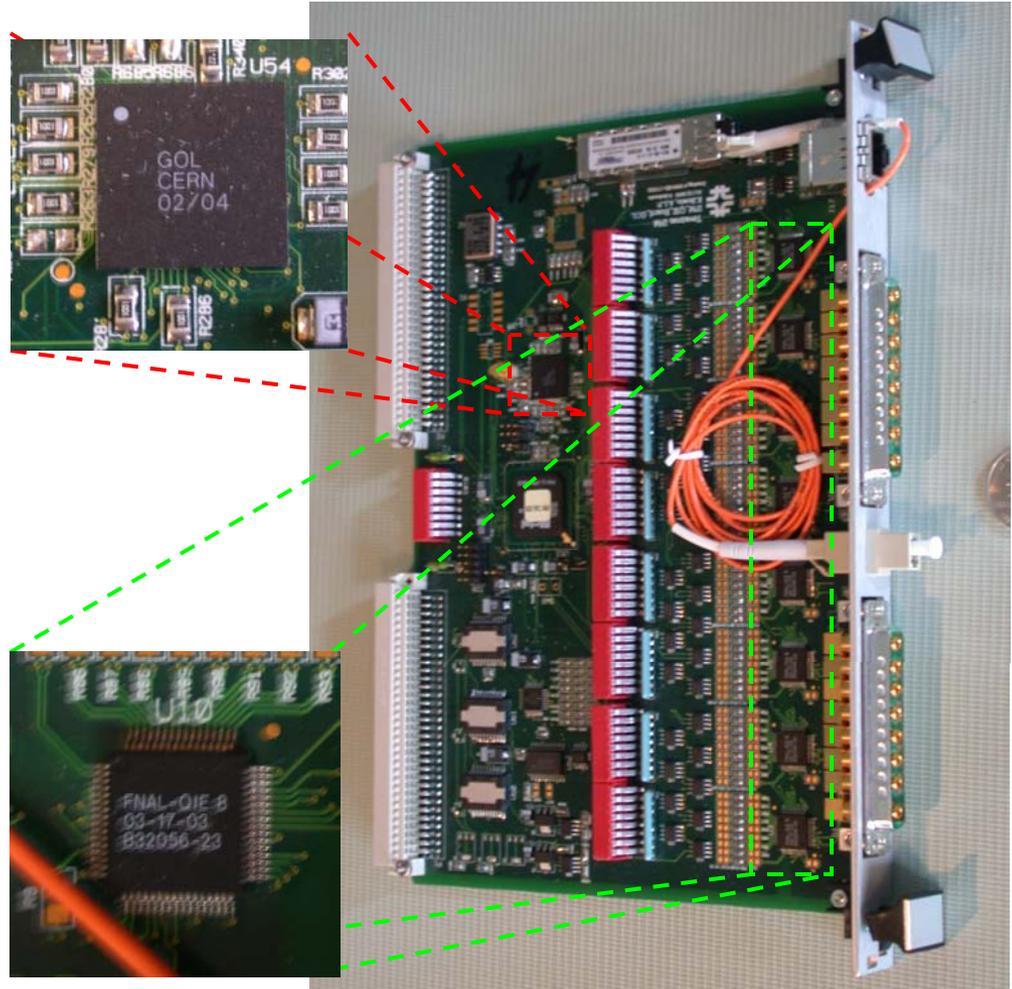


Magnet at 200A



# QIE card

- 8 channels (CMS QIE8) per board.
- Achieved noise  $\sim 1.8\text{fC}$  with 4' cable.
- Data is combined with timing information, serialized by CERN GOL ASIC (rad hard) and sent thru optical fiber at 1.1Gbps data rate
- Timing fanout board cleans up and distributes clock and timing signals



# Data buffer card

- Handles 8 incoming optical links (64 channels, 1.1 GB/s of data)
- Can sparsify data on-the-fly based on timing masks
- 512MB RAM allows for
  - 20.000 turns of continuous data
  - 90.000 turns for 72 bunches
  - 6 million turns for a single bunch
- Read out thru PCI64 bus.
- Two boards are used to handle 128 channels.

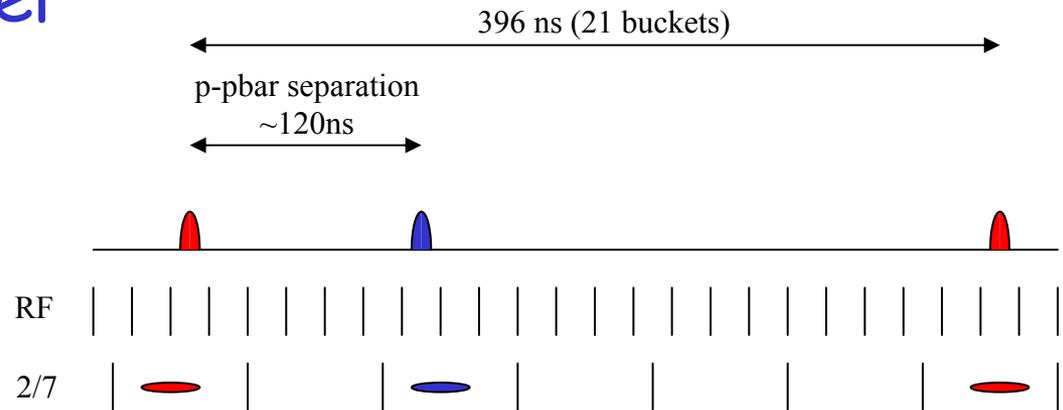


- IPM buffer board doubled as prototype for BTeV L1 data buffer.
- Considered for use in MICE experiment.



# Timing card

- Produces the 15MHz (2/7 RF) QIE clock
- Decodes and transmits beamsync revolution marker + injection and trigger events
- Controls QIE settings.



# Software

**NB. REAL DATA!**

- Both IPMs now have new software and firmware.
- Software/Firmware still being improved.
- Vertical IPM works pretty well.
- Horizontal IPM has some hardware problems (one dead FE board, one FE board with a sync problem, several broken channels) that require an access.

