Booster to AGS Matching Studies

L. Ahrens, R. Bonati,

K.A. Brown, *J.W. Glenn,*

D. Gassner, H. Huang, J. Morris, S. Nemesure, S. Nida,

P. Sampson, V. Schoefer,

N. Tsoupas, K. Zeno

Primary Motivations

- Polarized proton operation
  - Larger emittance = polarization loss
- Larger emittance in AGS than in BtA
  - Injection mis-match has been measured in FY09 run.
  - In the past: BtA model problems, measurements didn't match predictions.
  - New (& online) model of BtA needed to be tested.
- Improved emittance from LINAC
  - For Run FY09 LINAC will deliver an emittance that will be smaller by at least a factor of 2
  - Modified optics for Booster injection will reduce β functions at injection foil, minimizing emittance growth
  - We will be more sensitive to magnet stability in BtA (steering errors)

What is BtA?

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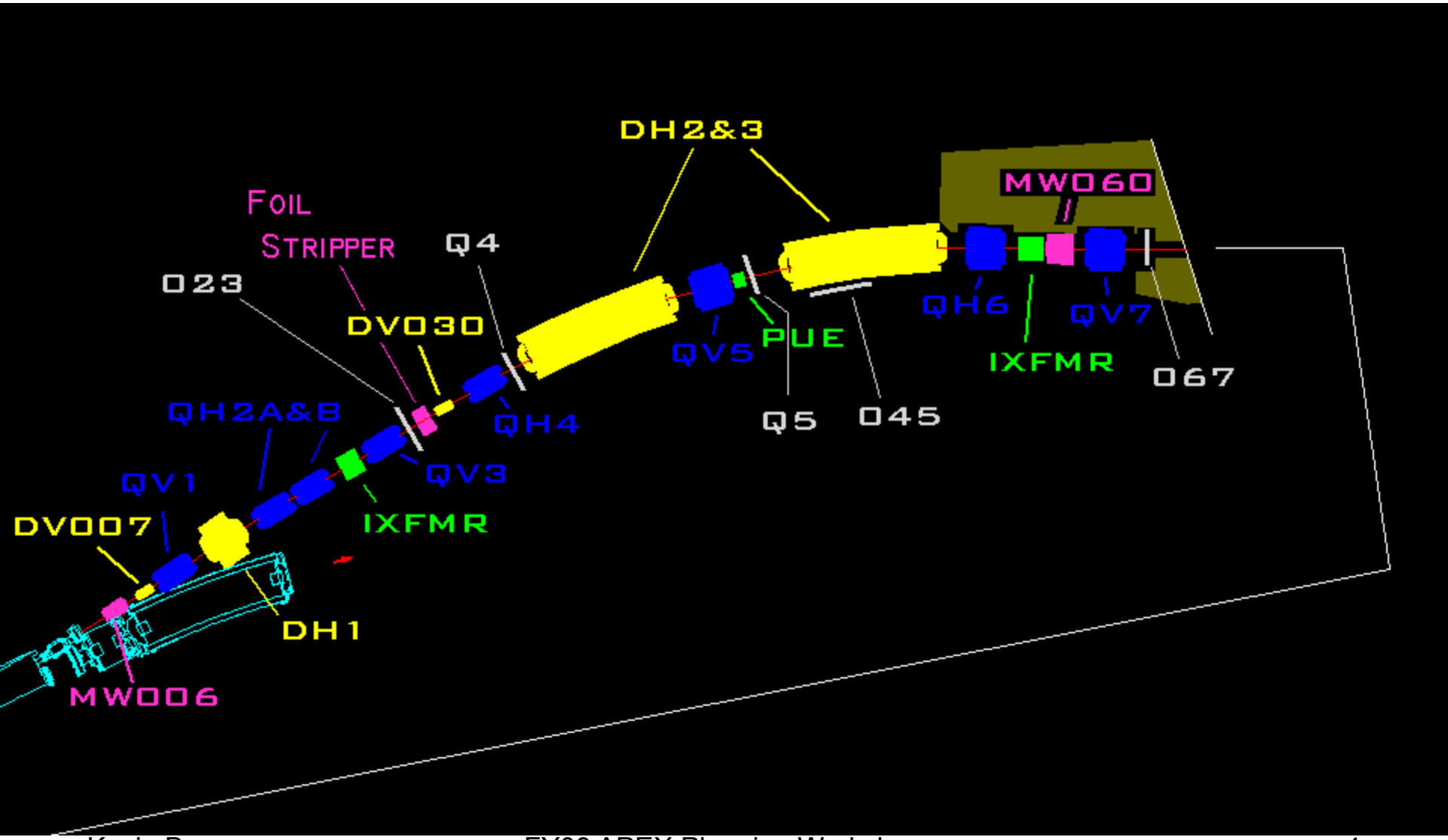

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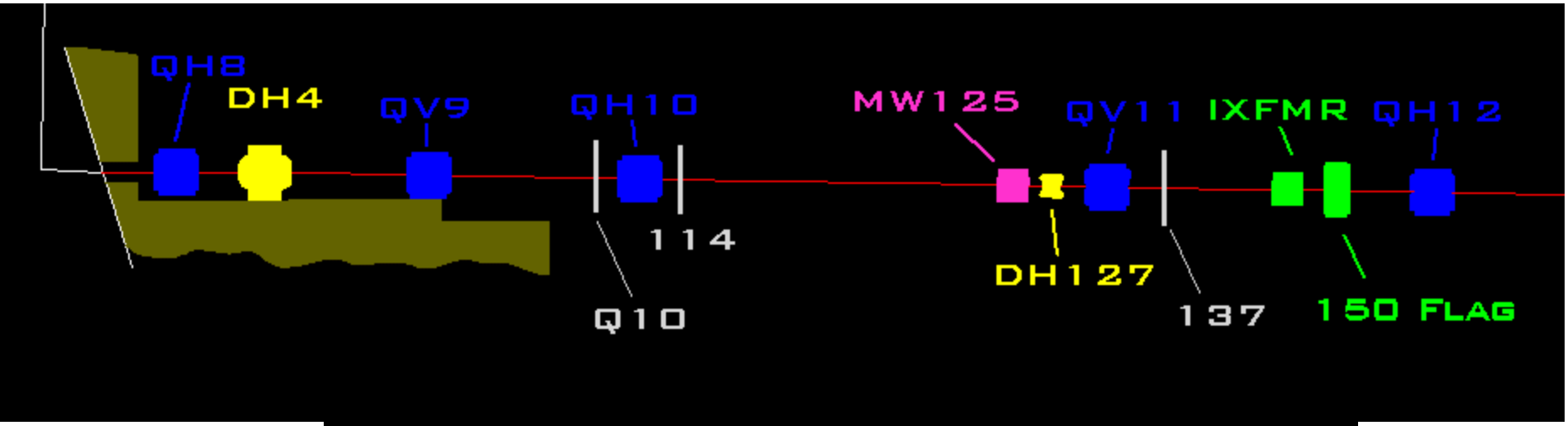
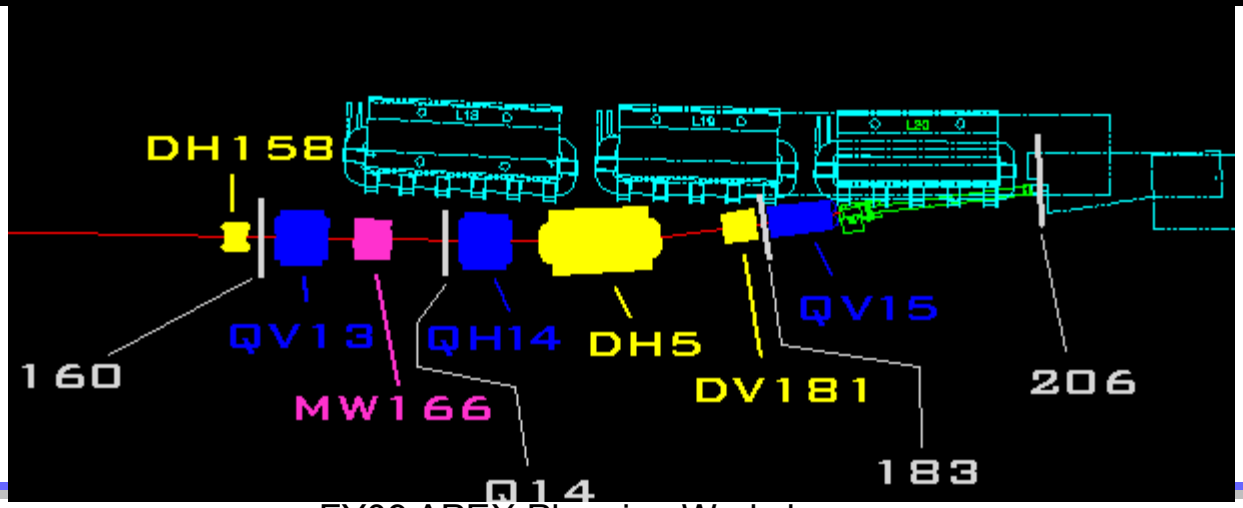
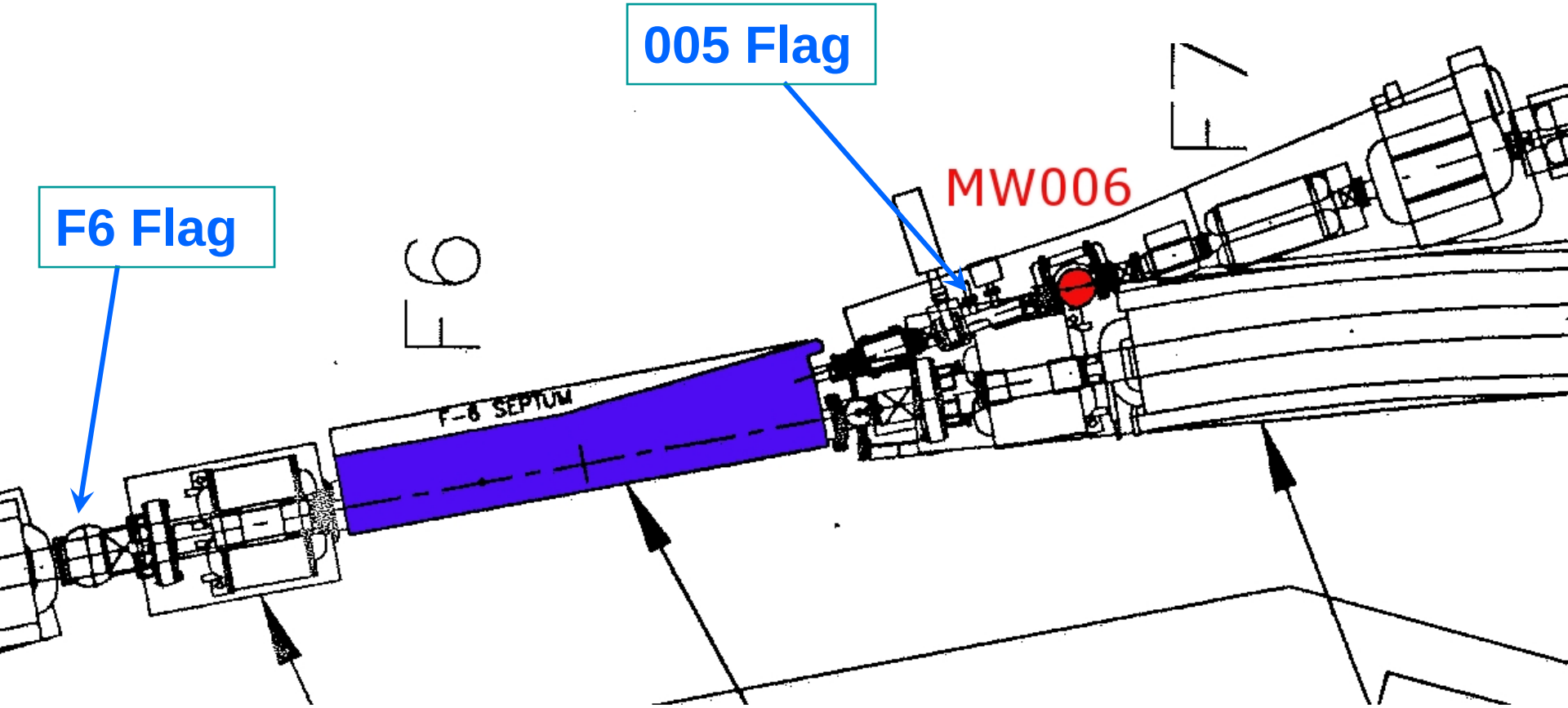
What is BtA?


QH8
DH4
QV9
QH10
MW125
QV11
IXFMR
QH12
114
Q10
DH127
137
150 FLAG


DH158
QV13
QH14
DH5
QV15
160
MW166
DV181
206
183
Q14


005 Flag
F6 Flag
MW006
F6
F7
F-6 SEPTUM

What was done?

- Measured R_{12} transfer coefficients for all steering magnets with 3 different beam optics to each Multi-wire, including A15
  - March 9, pol. protons optics
  - Quads off optics
  - "Strong Optics" based on N. Tsoupas optical match to Bare AGS.
- Measured momentum spread (multiple times)
- Measured dispersion for 3 sets of optics (multiple times).
- Measured temporal response of the wires for MW166 & MWA15
- Performed Quadrupole scans (beam size vs K1) for two narrow quads and two normal quads.
- Injected beam into AGS using two different optics
- Coasting beam in AGS studying multiple turns on A15 Multiwire.
- Tested match using March 9 optics and "Strong optics"
- Tested new controls for logging, orbits, loss monitors, profile display, orbit control, and data quality checks.
- Tested 3 "new" flag systems in BtA.
- Measured hysteresis in two types of quadrupoles
- Continued measurement program of BtA quadrupoles and shunts.

Things we have left to do.

Data Analysis:

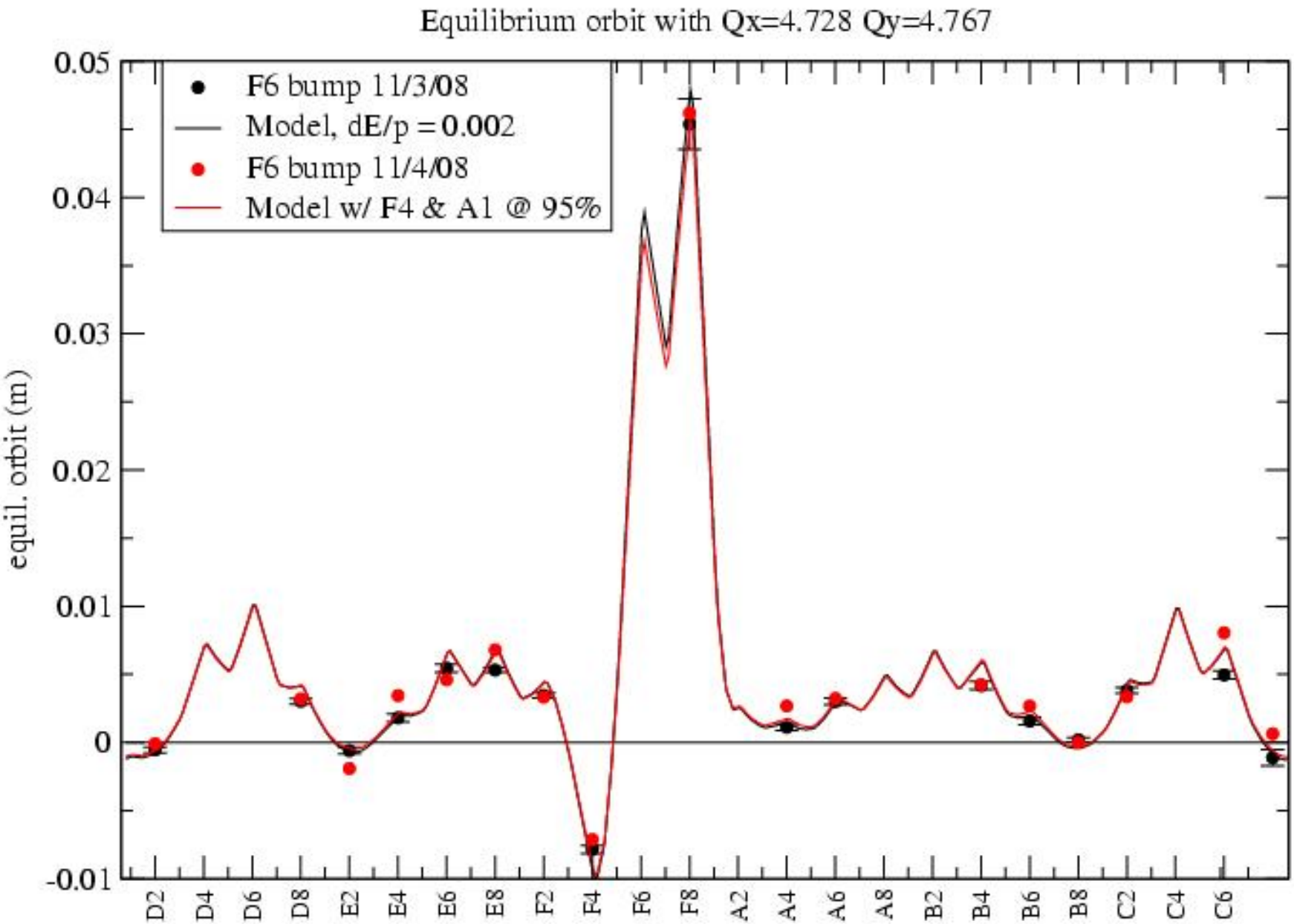
1. The person who collected a particular set of data is responsible for the first pass reduction and analysis of that data.
2. The product of this first pass analysis is to be a spreadsheet that contains:
   a. the data used for the reduction
   b. the time stamps corresponding to that data
   c. how the data was processed (e.g., calculated fits, how?)
   d. what data was removed and tagged as bad and why.
3. results of analysis will be put into special elogs.
4. We will discuss the data analysis every Thursday in the On-line modeling meeting. Each week (starting next week) someone will present results. This will also act as a way for people analyzing similar data sets to communicate and collaborate.

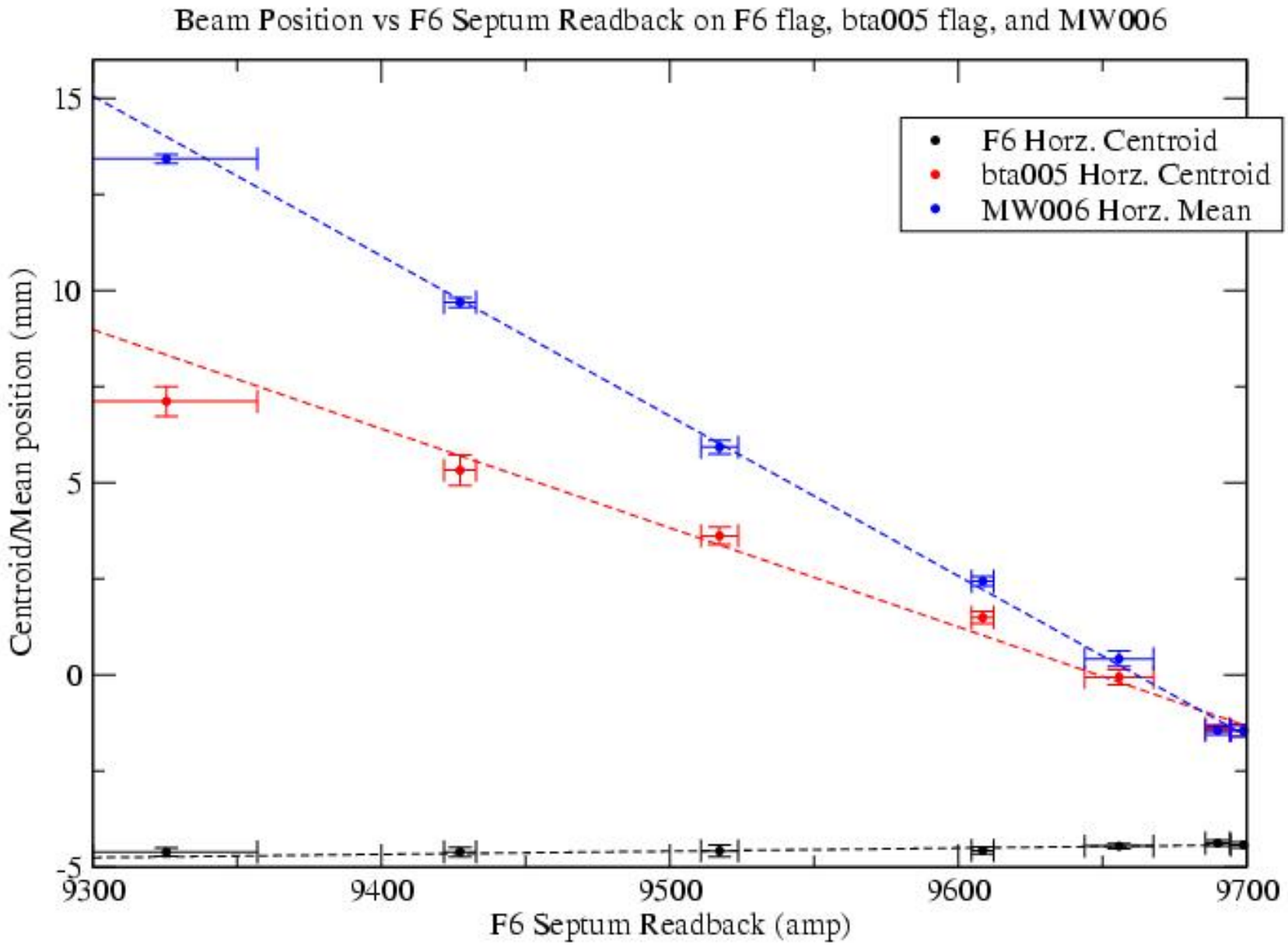
   Note: we meet every Thursday at 3pm in the Small Conf. room.

Analysis elogs

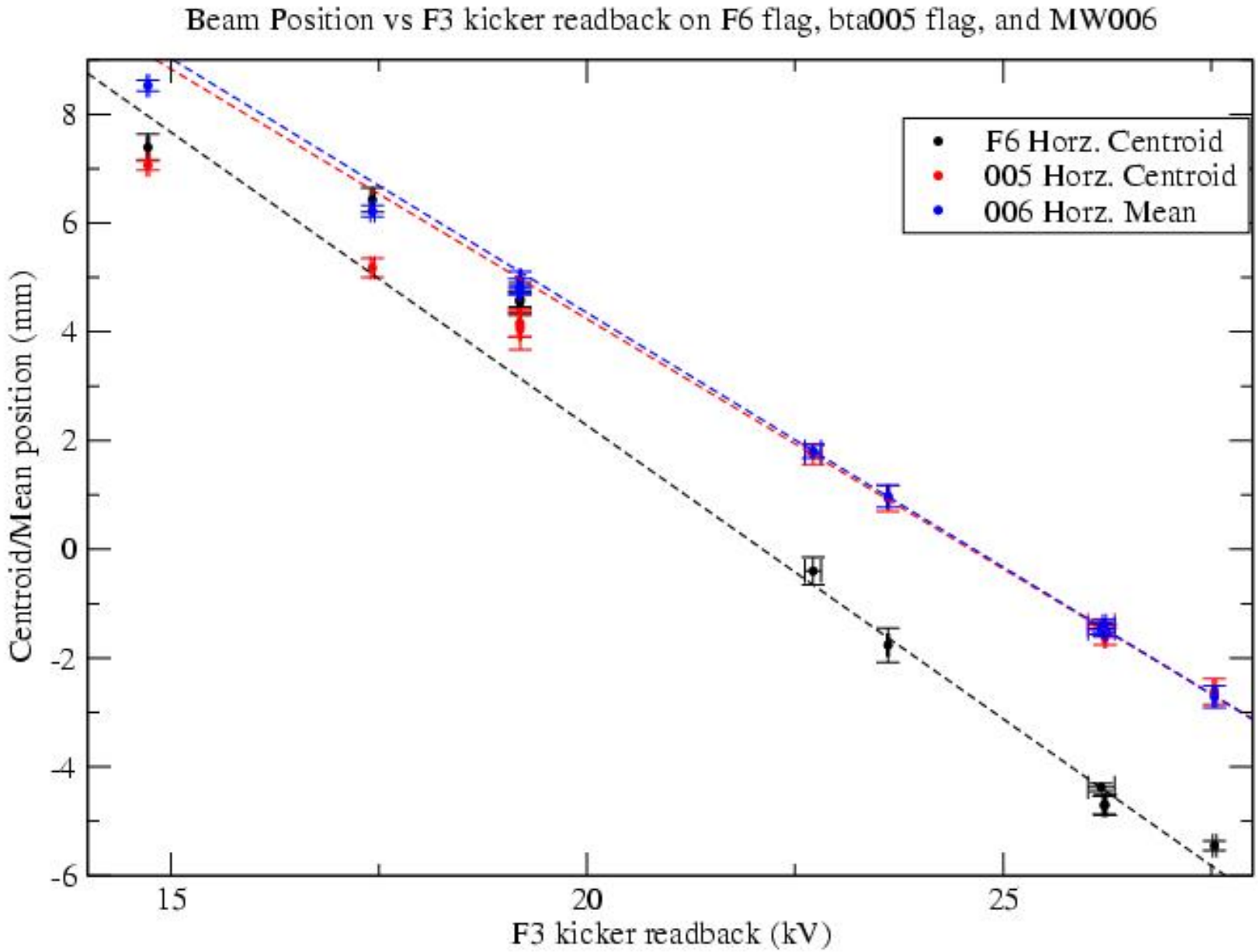
Tue_Nov_25_2008_11:03:24_AM		Tue Nov 25 2008	V. Schoefer
Mon_Nov_10_2008_14:42:04_PM		Mon Nov 10 2008 Fast Quad work on Quad #2	jwg, hh
Sat_Nov_8_2008_16:08:16_PM	Nov-10-2008 09:57:07	Sat Nov 8 2008	BtA08 Study - Booster Extraction Measurements -
Sat_Nov_8_2008_16:07:40_PM		Sat Nov 8 2008	BtA08 Study - Beam Size Measurements
Sat_Nov_8_2008_16:06:45_PM	Nov-13-2008 20:46:36	Sat Nov 8 2008	BtA08 Study - Power Supply (Quads) Measurements
Sat_Nov_8_2008_16:06:08_PM		Sat Nov 8 2008	BtA08 Study - Flag Measurements
Sat_Nov_8_2008_16:04:59_PM	Nov-10-2008 12:27:18	Sat Nov 8 2008	BtA08 Study - A15MW 1turn...many turn response
Sat_Nov_8_2008_16:04:23_PM		Sat Nov 8 2008	BtA08 Study - Hysteresis Measurements
Sat_Nov_8_2008_16:03:52_PM		Sat Nov 8 2008	BtA08 Study - Quad Current Scans
Sat_Nov_8_2008_16:01:30_PM	Nov-18-2008 15:05:41	Sat Nov 8 2008	BtA08 Study - Steering Measurements - Horizonta
Sat_Nov_8_2008_16:00:25_PM		Sat Nov 8 2008	BtA08 Study - Steering Measurements - Vertical
Sat_Nov_8_2008_15:58:34_PM	Nov-25-2008 14:03:58	Sat Nov 8 2008	BtA08 Study Dispersion Measurements
Sat_Nov_8_2008_15:31:17_PM	Nov-16-2008 21:03:55	Sat Nov 8 2008	BtA Study Oct08 Organization overview

Booster Extraction


Equilibrium orbit with Qx=4.728 Qy=4.767
F6 bump 11/3/08
Model, dE/p = 0.002
F6 bump 11/4/08
Model w/ F4 & A1 @ 95%
equil. orbit (m)
0.05
0.04
0.03
0.02
0.01
0
-0.01
D2
D4
D6
D8
E2
E4
E6
E8
F2
F4
F6
F8
A2
A4
A6
A8
B2
B4
B6
B8
C2
C4
C6



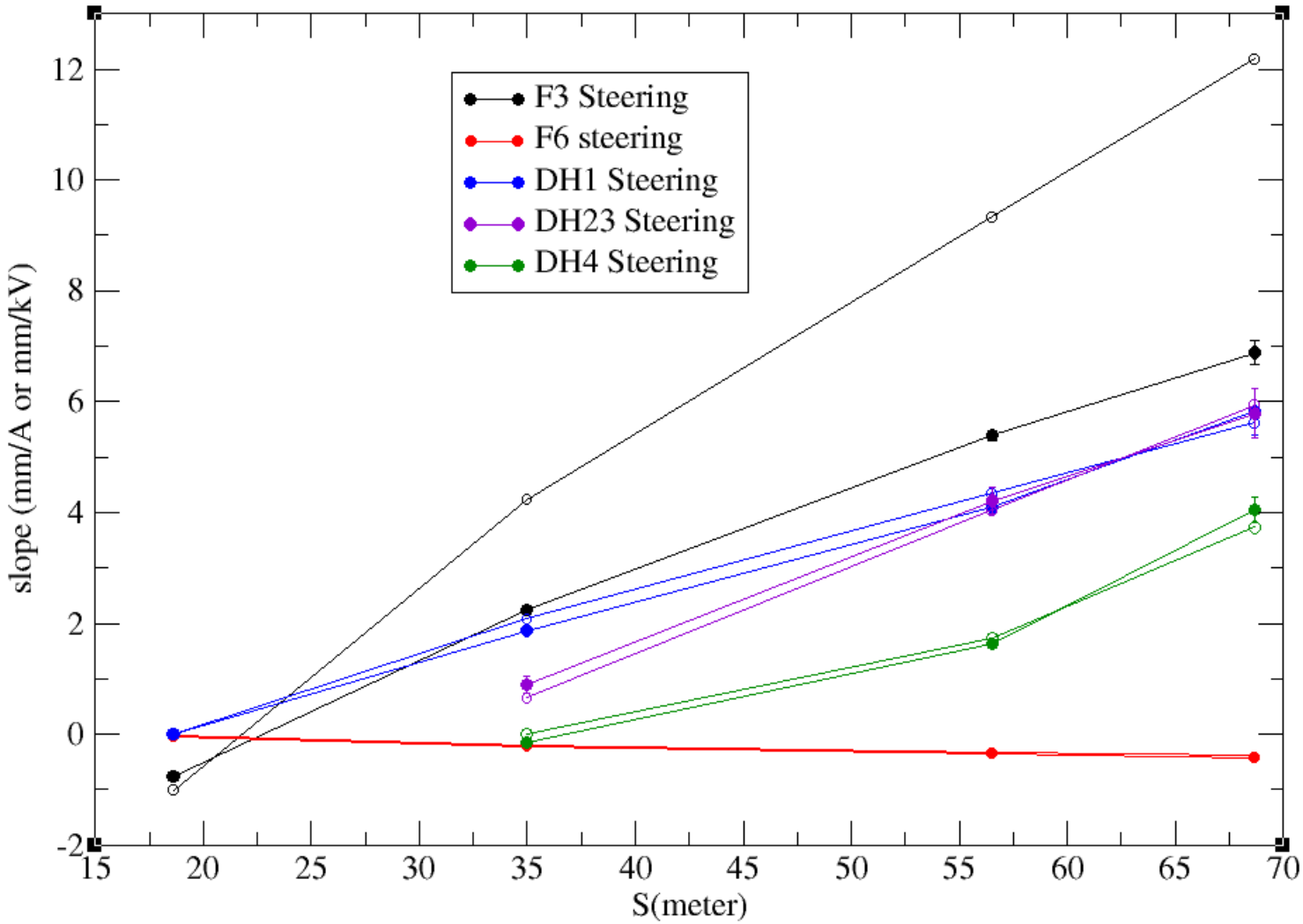
From November 4, 2008, 10 pm to 10:25 pm



From November 4, 2008, 10 pm to 10:25 pm

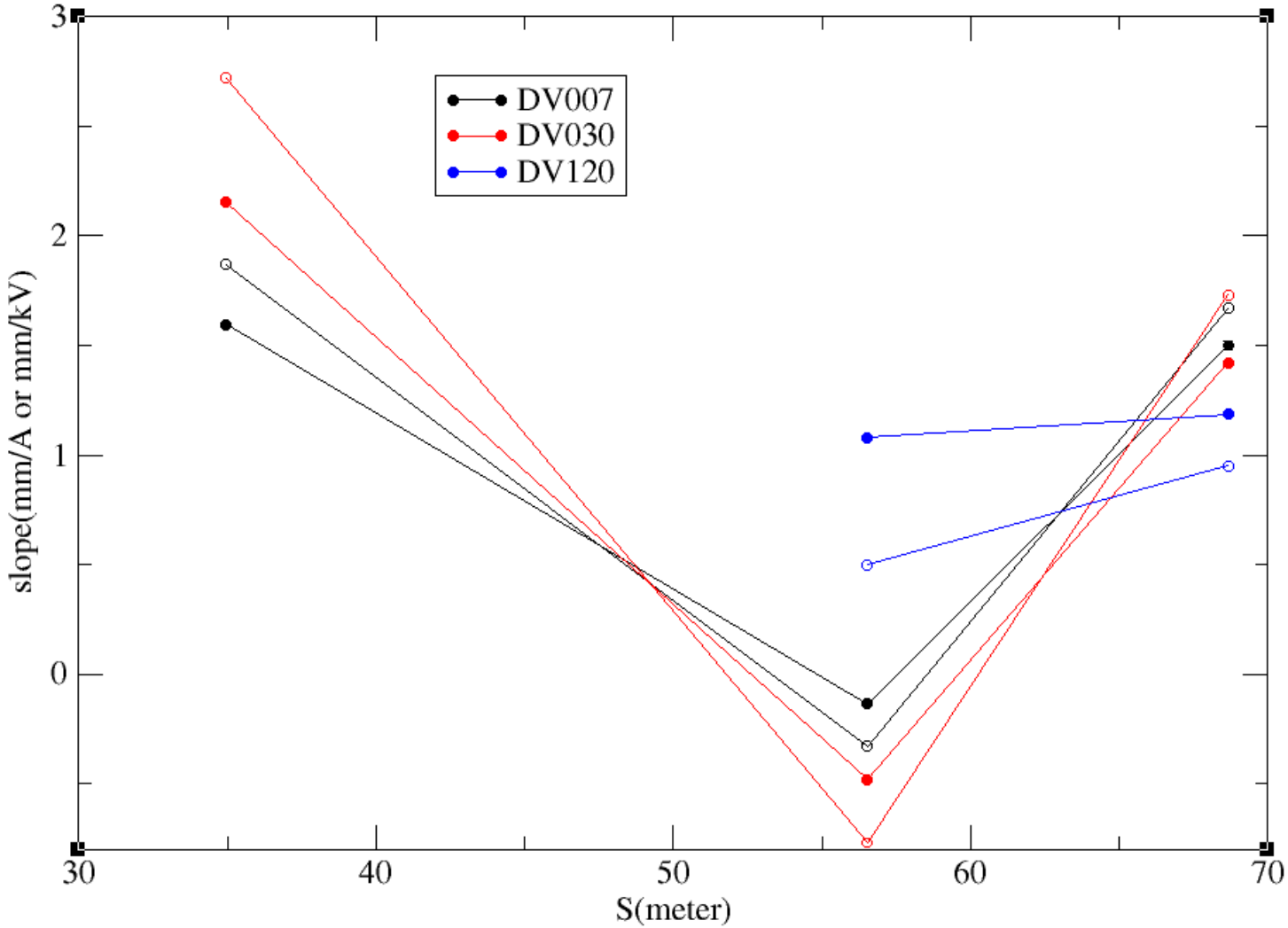
R_{12} transfer coefficients

Horizontal Steering with Quads off

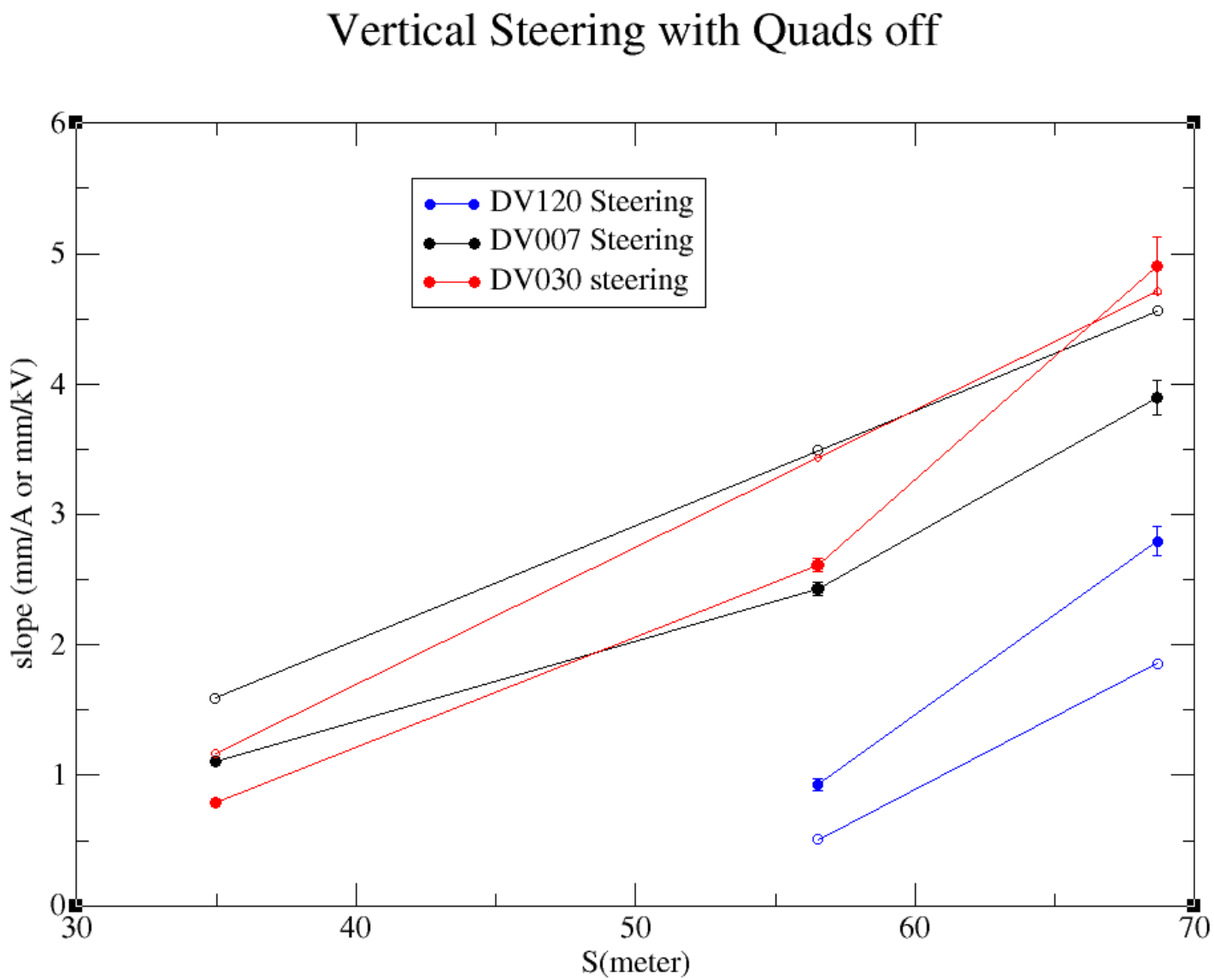


The model data are plotted using open circles.

Vertical Steering with Matched Optics

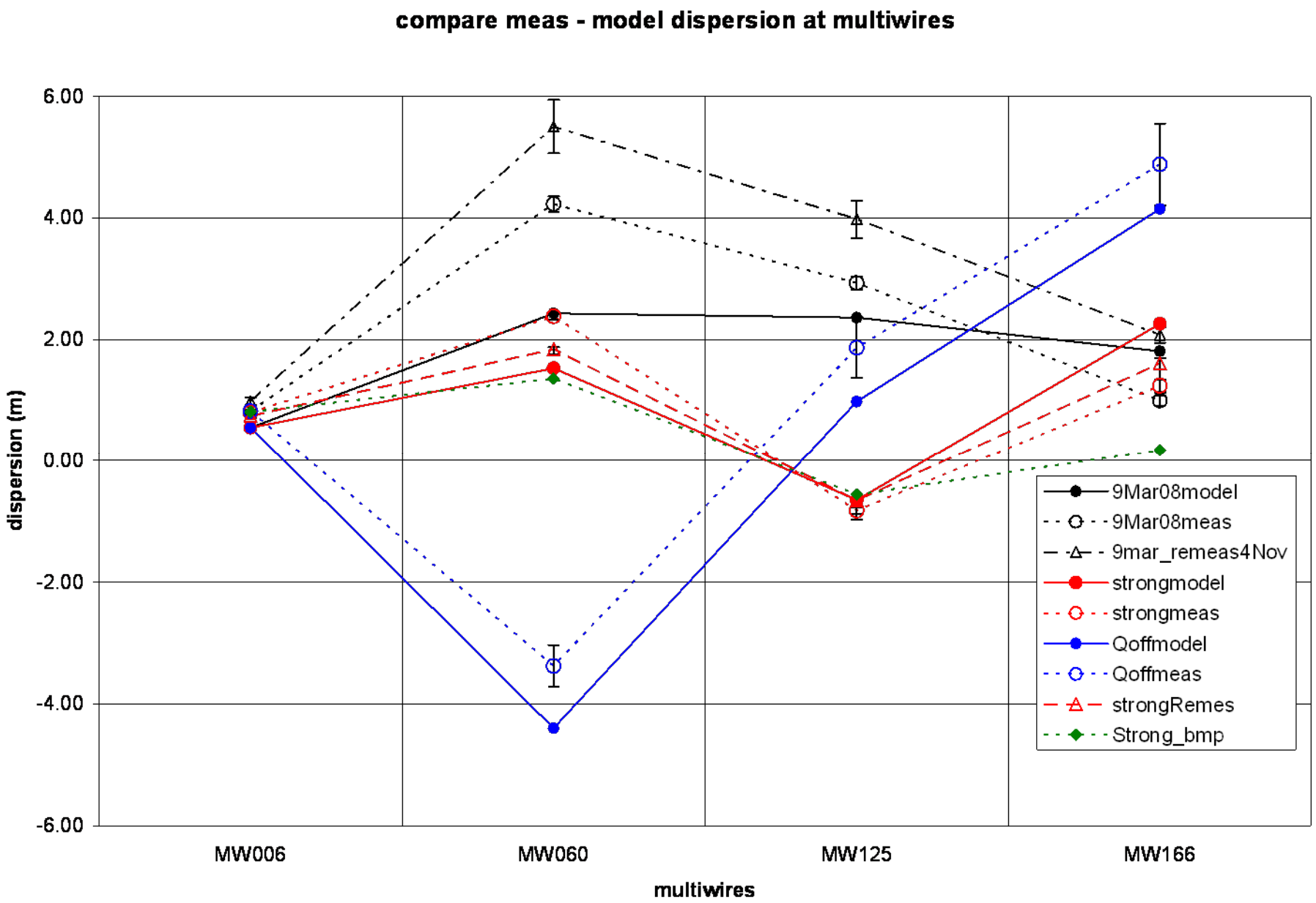


The model data are plotted using open circles.

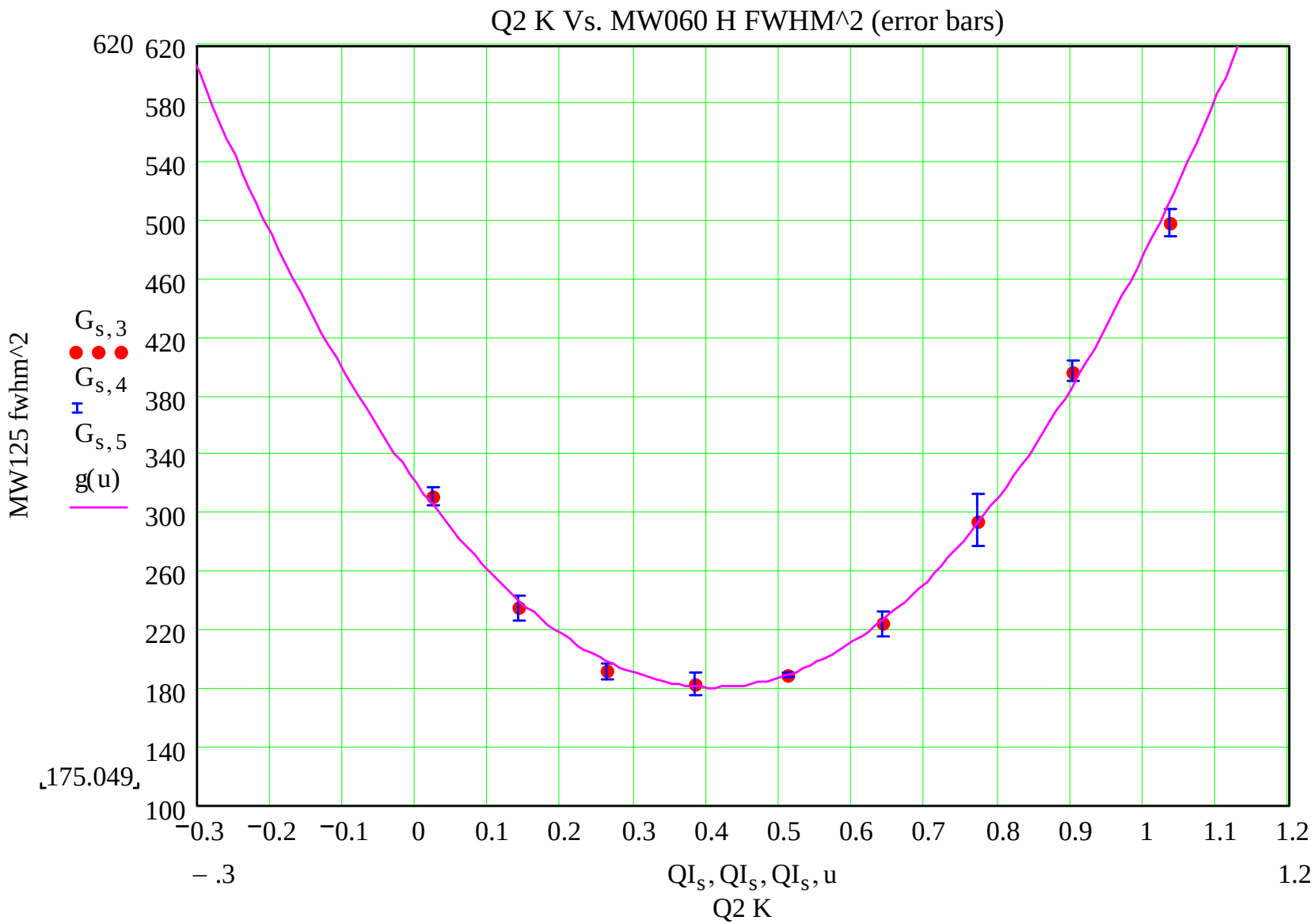


The model data are plotted using open circles.

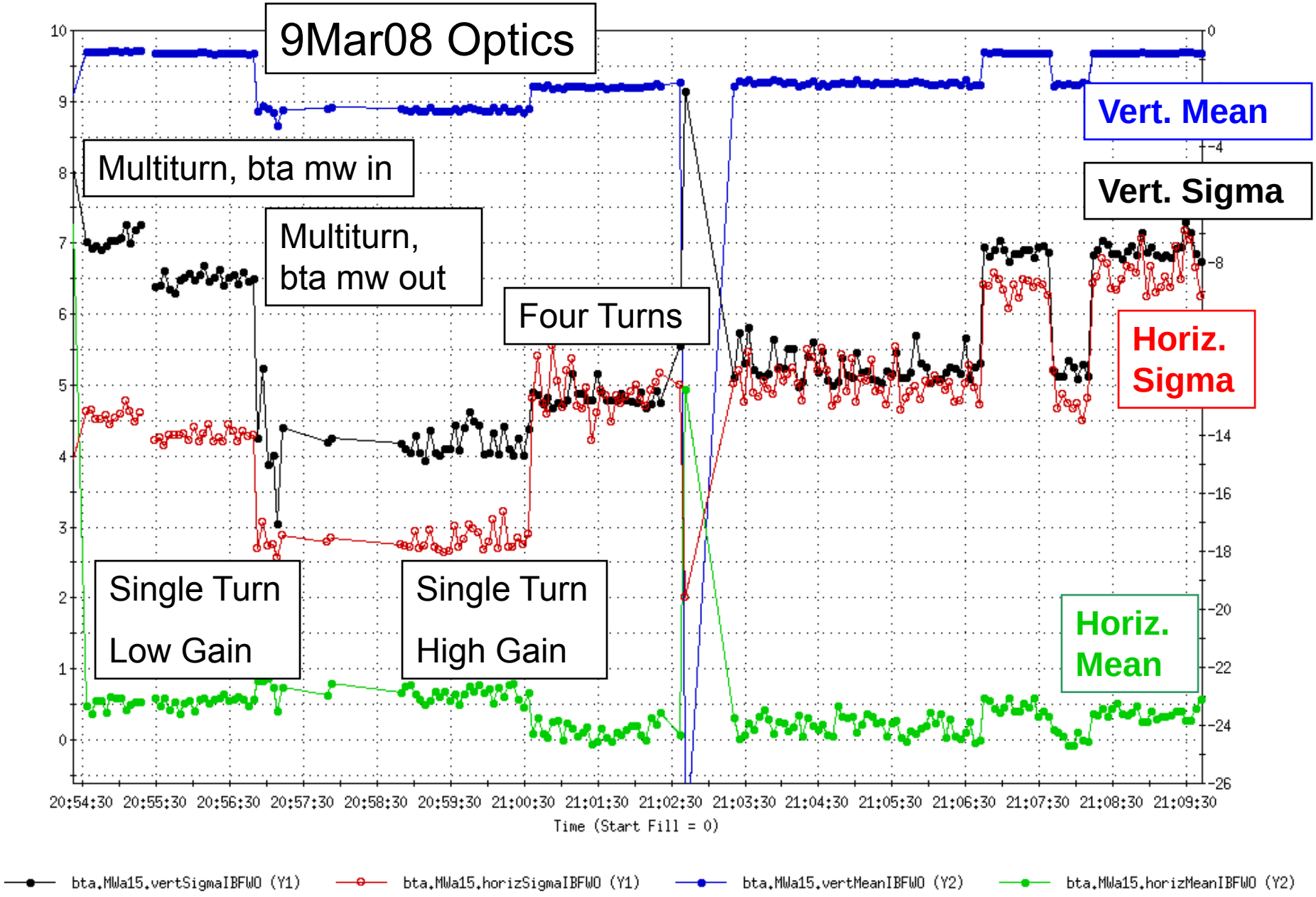
dispersion for 3 sets of optics


compare meas - model dispersion at multiwires
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
dispersion (m)
MW006
MW060
MW125
MW166
multiwires
9Mar08model
9Mar08meas
9mar_remeas4Nov
strongmodel
strongmeas
Qoffmodel
Qoffmeas
strongRemes
Strong_bmp

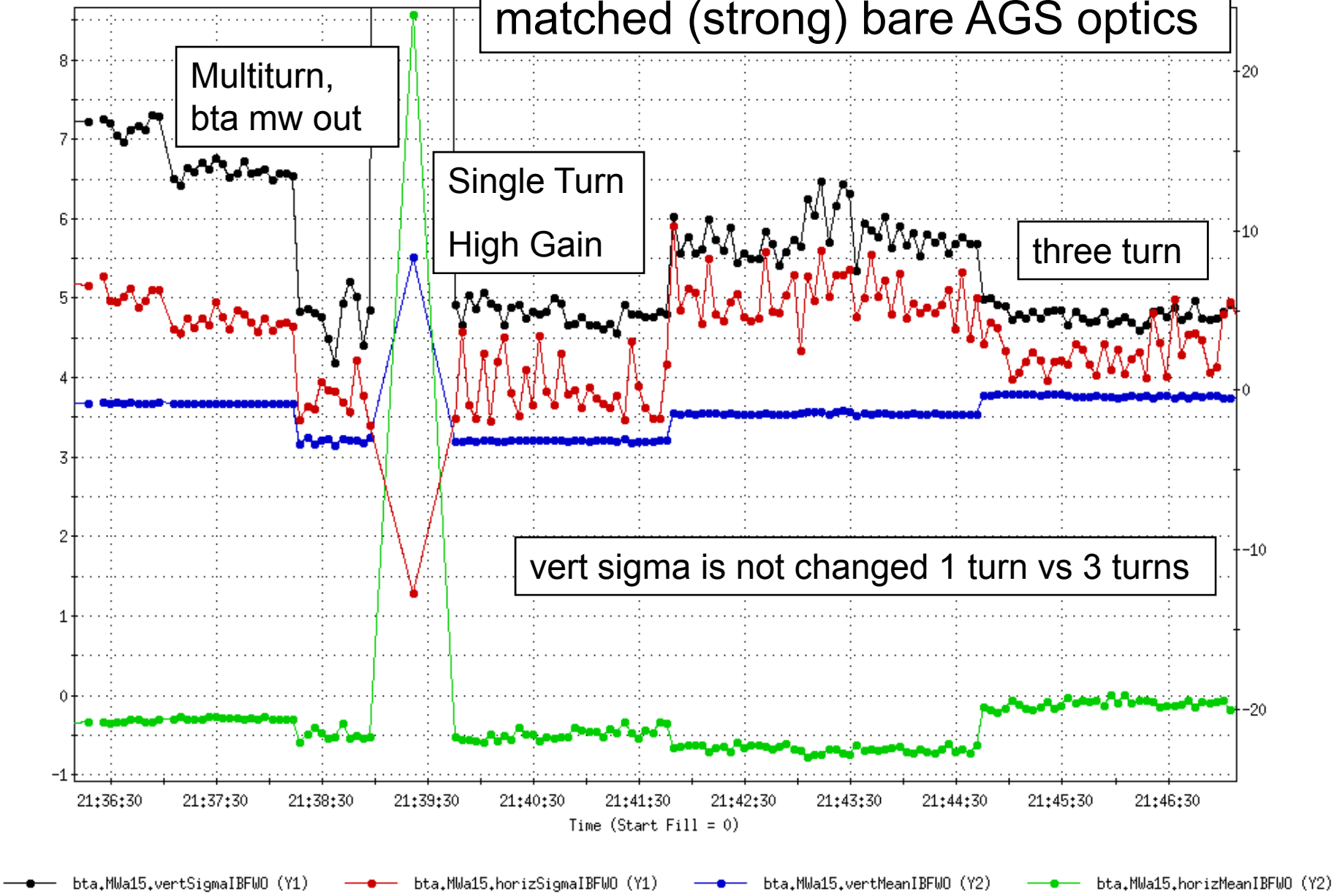
Quadrupole scans (beam size vs K1)


Q2 K Vs. MW060 H FWHM^2 (error bars)
620
620
580
540
500
460
420
380
340
300
260
220
180
140
175.049
100
MW125 fwhm^2
$G_{s,3}$
$G_{s,4}$
$G_{s,5}$
g(u)
−0.3
−0.2
−0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
− .3
QI_s, QI_s, QI_s, u
1.2
Q2 K

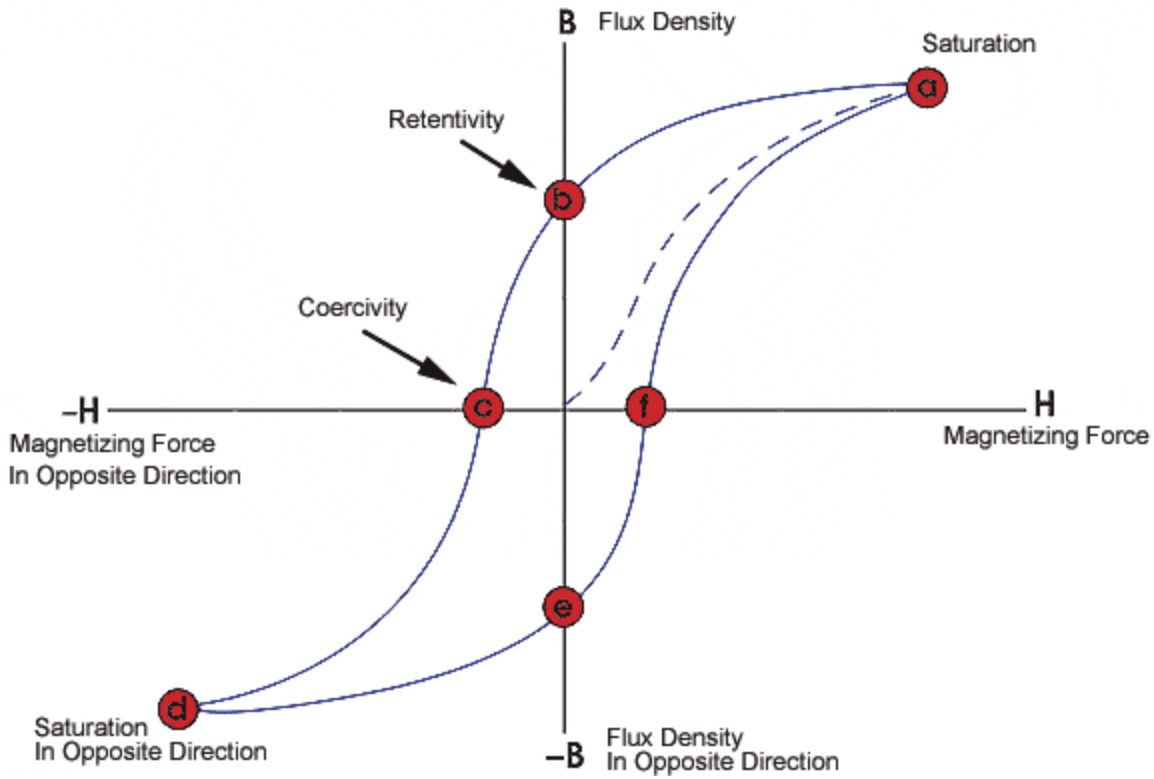
A15 Multiwire


9Mar08 Optics
Multiturn, bta mw in
Multiturn, bta mw out
Four Turns
Single Turn Low Gain
Single Turn High Gain
Vert. Mean
Vert. Sigma
Horiz. Sigma
Horiz. Mean
Time (Start Fill = 0)
bta.MWa15.vertSigmaIBFWO (Y1)
bta.MWa15.horizSigmaIBFWO (Y1)
bta.MWa15.vertMeanIBFWO (Y2)
bta.MWa15.horizMeanIBFWO (Y2)

matched (strong) bare AGS optics



hysteresis in two types of quadrupoles



Summary of measurements for Hyst. of VQ1 using MW166 Recycling: Nominal=> to 0A => Nominal

Measure Centroid_y and σ_y of Vert. beam profiles at MW166 just after "Recycling" the VQ1 Quadrupole

Meas#	Centroid [mm]	σ_x [mm]	Comments
1	5.86 0.073	9.85 ± 0.114	Initial
2	5.72 ± 0.120	9.48 ± 0.195	Nom. to 0A to Nom.
3	5.70 ± 0.083	9.35 ± 0.147	Nom. to 0A to Nom
4	5.71 ± 0.089	9.52 ± 0.101	Nom to 0 A to Nom.

Summary of measurements for Hyst. of VQ1 using MV166 Recycling Method:
Nominal=.800[A]=>Nominal=10[A]=Nominal

Meas#	Centroid_y [mm]	σ_y [mm]	Comments	
1	5.26+0.10	10.61+0.26	Nom=>10[A]=>Nom	2008-11-05 09:55:58
2	5.23+0.18	11.25+0.48	Nom=>800[[A]=>Nom	2008-11-05 09:53:36
3	5.32+0.06	11.13+0.21	Nom=>10[A]=>Nom	2008-11-05 13:19:444
4	5.16+0.09	11.37+0.18	Nom=>800[A]=>Nom	2008-11-05 13:37:20

Hysteresis Summary

- Both recycling methods show an initial hysterisis effect of ~0.6%
  - {Nominal=> to 0A => Nominal} shows initial decrease of +0.6% of VQ1 strength. Subsequently each new “recycle” yields same (error) strength
  - {Nominal=> to 800A => Nominal=>10[A]} shows initial increase of -0.6% of VQ1 strength. Subsequently each new “recycle” yields same (error) strength.

Controls Lessons Learned (from JTM)

Observing Real World Use	• ***Save Datasets*** option in graphs is convenient tool, but it needs improved correlation ***(done)*** • When possible, keep raw data. Postprocessing later provides opportunity to revise decisions, fix bugs. • People like profileDisplay Green Thumb as data quality indicator ***(but checks need to be enhanced)*** • Generic 'scanner' would be useful - can be built on top of Gpm correlation graphs.
Observing System Performance	• profileDisplay had many problems (esp. in logging) which had gone unnoticed. Also true for orbit logs. ***(Seth work in progress)*** • Data logging: Reliability issues with profileDisplay and flag data ***(being investigated)*****.** FEC data (ps,xfmr,etc.) logged reliably. • Data correlation: Apparent time stamp discrepancies from some systems. All understood **(*****and any problems are being corrected)*** General lesson – we need to pay attention to time/cycle stamps system by system in injector ados.

Summary

- A lot of good quality data has been acquired.
- Analysis is on-going, generally a first pass analysis of most of the data is complete.
- Detailed quantitative comparisons have yet to be done, but;
- Conclusions to be drawn?
  - There are still details in the model that need to be understood (disagreement with data).
  - A lot has been learned about instrumentation (e.g., how to get believable fits to BtA multiwire data) and the controls infrastructure for data collection and post analysis.
- Further studies? *Matching to AGS with Snakes*!