RR BPM Project Overview

Bob Webber

Run II Luminosity Upgrade Review

July 2003

Status

- A multidivisional effort has successfully and effectively carried out Recycler BPM system improvement project since commitment to the project was made in January
- Project M&S costs have come in well within budget estimates made at that time
- Goal of system availability for beam measurements one month before summer shutdown is achievable subject to tunnel access to complete installation
- First beam tests indicate outstanding performance
- Loose ends that remain will be completed by end of upcoming August 25 shutdown

Project History

- First DDC-based design proposal July, 2002
- DDC hardware familiarization efforts continued thru summer 2002
- Collaboration with Computing Division established Fall, 2002
- Physics review with outside reviewers 11/25/2002
- Technical design and prototyping activity gets underway
- Requirements document generated in collaboration with Instrumentation Dept. engineering input delivered to BD HQ 1/12/2003
- Technical specification and design review 2/17/2003
- DDC hardware ordered early March, 2003
- Production of in-house designed components, hardware and software underway
- First house installation 6/17/2003
- First house delivered to Recycler physicists for beam tests 6/25/2003

Beam Structures Required to Be Measured

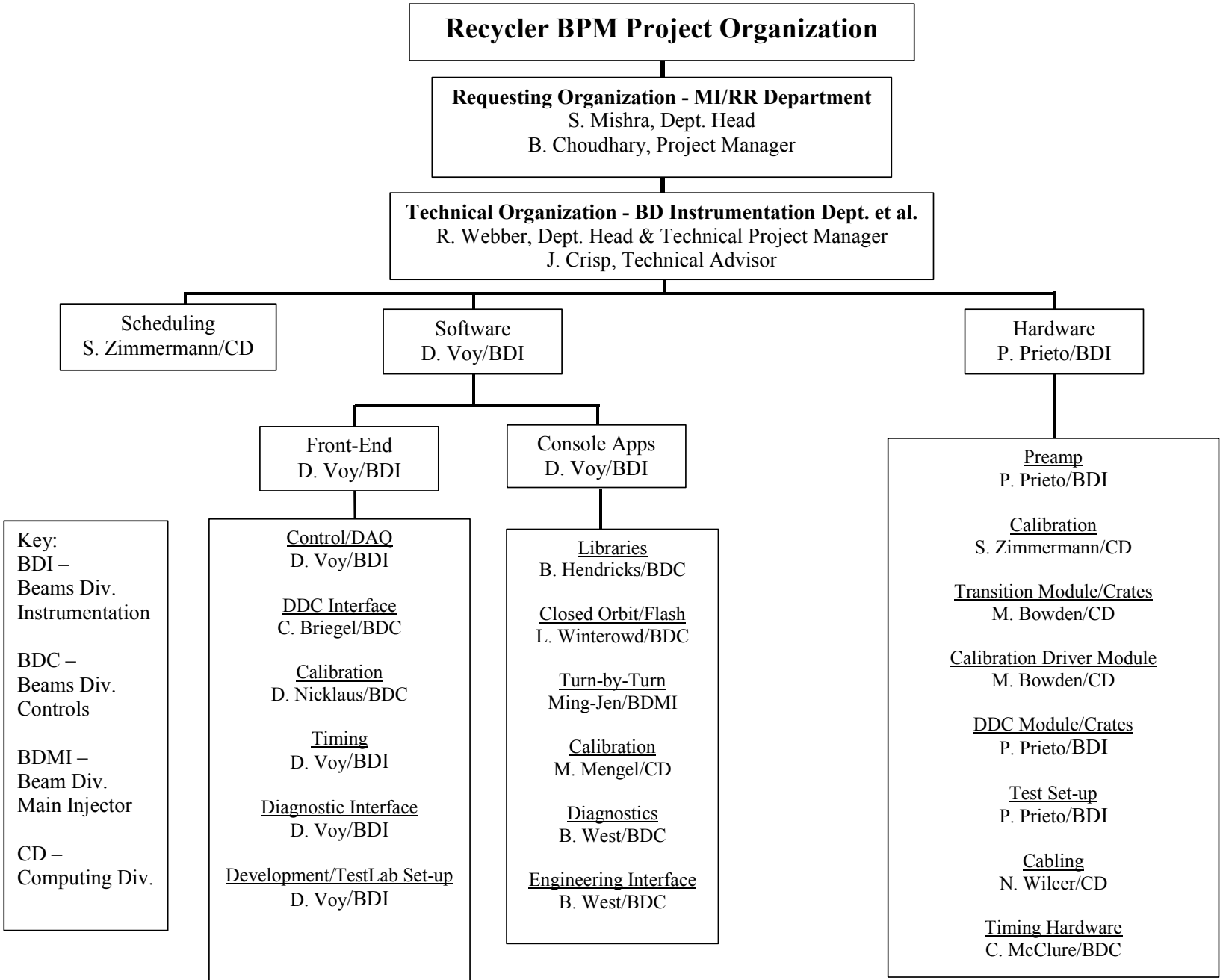
- Four bunches in consecutive 2.5MHz buckets
  - Bunch width sigma of 25 nsec to 50 nsec
  - Total charge 2E10 to 30E10
- Un-bunched (barrier bucket contained) beam
  - Total charge 20E10 to 400E10
  - Distribution width 1.8 usec to 11.2 usec
  - Distribution "rise/fall time" 340 nsec to 566 nsec
- 2.5MHz beam partition and one or two un-bunched beam partitions may be circulating at any time
  - Required to be measured separately but not simultaneously
  - Minimum partition separation is 680 nsec
- Must measure protons or antiprotons in each structure (signal polarity)
- No requirement to measure 53MHz beam
- No requirement for any measurement during simultaneous circulation of protons and antiprotons

System Picture

- Beam position and sum signal measurement at 104 horizontal and 107 vertical locations in Recycler ring and 26 locations in transfer lines.
- Digital down-convertor technology solution with VME based front-end ACNET interface
- Integrated calibration system for each location
- Attachments to the pick-ups accommodate application of ion clearing voltages to the electrodes

Design Philosophy and Initial Assumptions

- Philosophy
  - System design considerations aim to meet the spirit and scope of MI/RR Department requirement specifications
  - Nothing short of a well planned, documented, and organized effort with sufficient resources would produce results in a timely manner
  - No specific consideration taken for applicability to MI or Tev BPM upgrades during design development due to Recycler schedule
  - Software concerns would be represented in the detailed design planning at the earliest stages
- Initial Assumptions
  - Delivery of the system on a short, well-understood, schedule is high priority
  - Existing major cabling systems shall not be replaced
  - EchoTek receiver is the "shortest path" to functional system


Recycler BPM Project Organization
Requesting Organization - MI/RR Department
S. Mishra, Dept. Head
B. Choudhary, Project Manager
Technical Organization - BD Instrumentation Dept. et al.
R. Webber, Dept. Head & Technical Project Manager
J. Crisp, Technical Advisor
Scheduling
S. Zimmermann/CD
Software
D. Voy/BDI
Hardware
P. Prieto/BDI
Front-End
D. Voy/BDI
Console Apps
D. Voy/BDI
Key:
BDI – Beams Div. Instrumentation
BDC – Beams Div. Controls
BDMI – Beam Div. Main Injector
CD – Computing Div.
Control/DAQ
D. Voy/BDI
DDC Interface
C. Briegel/BDC
Calibration
D. Nicklaus/BDC
Timing
D. Voy/BDI
Diagnostic Interface
D. Voy/BDI
Development/TestLab Set-up
D. Voy/BDI
Libraries
B. Hendricks/BDC
Closed Orbit/Flash
L. Winterowd/BDC
Turn-by-Turn
Ming-Jen/BDMI
Calibration
M. Mengel/CD
Diagnostics
B. West/BDC
Engineering Interface
B. West/BDC
Preamp
P. Prieto/BDI
Calibration
S. Zimmermann/CD
Transition Module/Crates
M. Bowden/CD
Calibration Driver Module
M. Bowden/CD
DDC Module/Crates
P. Prieto/BDI
Test Set-up
P. Prieto/BDI
Cabling
N. Wilcer/CD
Timing Hardware
C. McClure/BDC

Project Team

- Recycler Department – Shekar Mishra, Brajesh Choudhary, Martin Hu
- BD Instrumentation - Bob Webber, Peter Prieto, James Crisp, Duane Voy, Stephen Pordes, John VanBogaert, John Seraphin, Brian Fellenz, Dallas Heikkinen
- BD Accelerator Controls - Charles Briegel, Craig McClure, Dennis Nicklaus, Brian Hendricks, Robert West, Lin Winterowd
- Computing Division - Mark Bowden, Timothy Kasza, Sergio Zimmermann, Marcos Turqueti, Neal Wilcer, Marc Mengel, Thomas Boes
- PPD - John Foglesong, Carl Lundberg
- And others whose names may have been overlooked

Present Status

- Three of eight 'houses', about 45% of Ring, installed and operating at less than full functionality (2.5 MHz mode only, by design, to offer utility for most common mode at earliest possible date)
- Hardware for remainder of system is in-hand and in final testing and calibration stages
- Installation now constrained by tunnel access time (three eight-hour shifts required for completion)
- Software efforts will continue through the summer to complete full system functionality
- Recycler personnel now performing system commissioning and performance tests in the installed houses

Histograms of Multiple (~300) Single Turn Measurements of Circulating Beam at 31.4E10

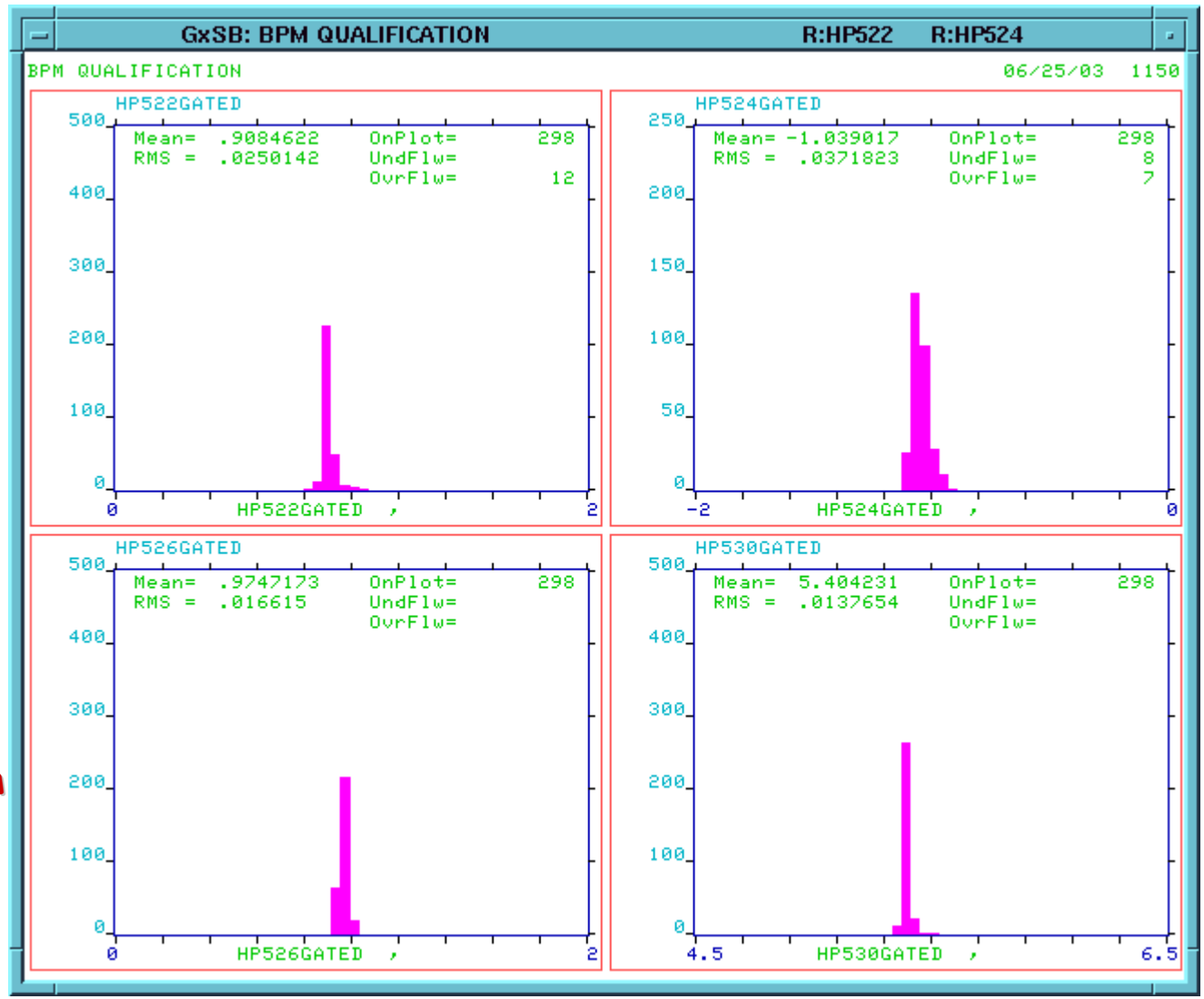
HP522

RMS 25 um

All x-axis ranges 2mm full scale

HP526

RMS 17 um



HP524

RMS 37 um

HP530

RMS 14 um

Histograms of Multiple (~300) Single Turn Measurements of Circulating Beam at 31.4E10

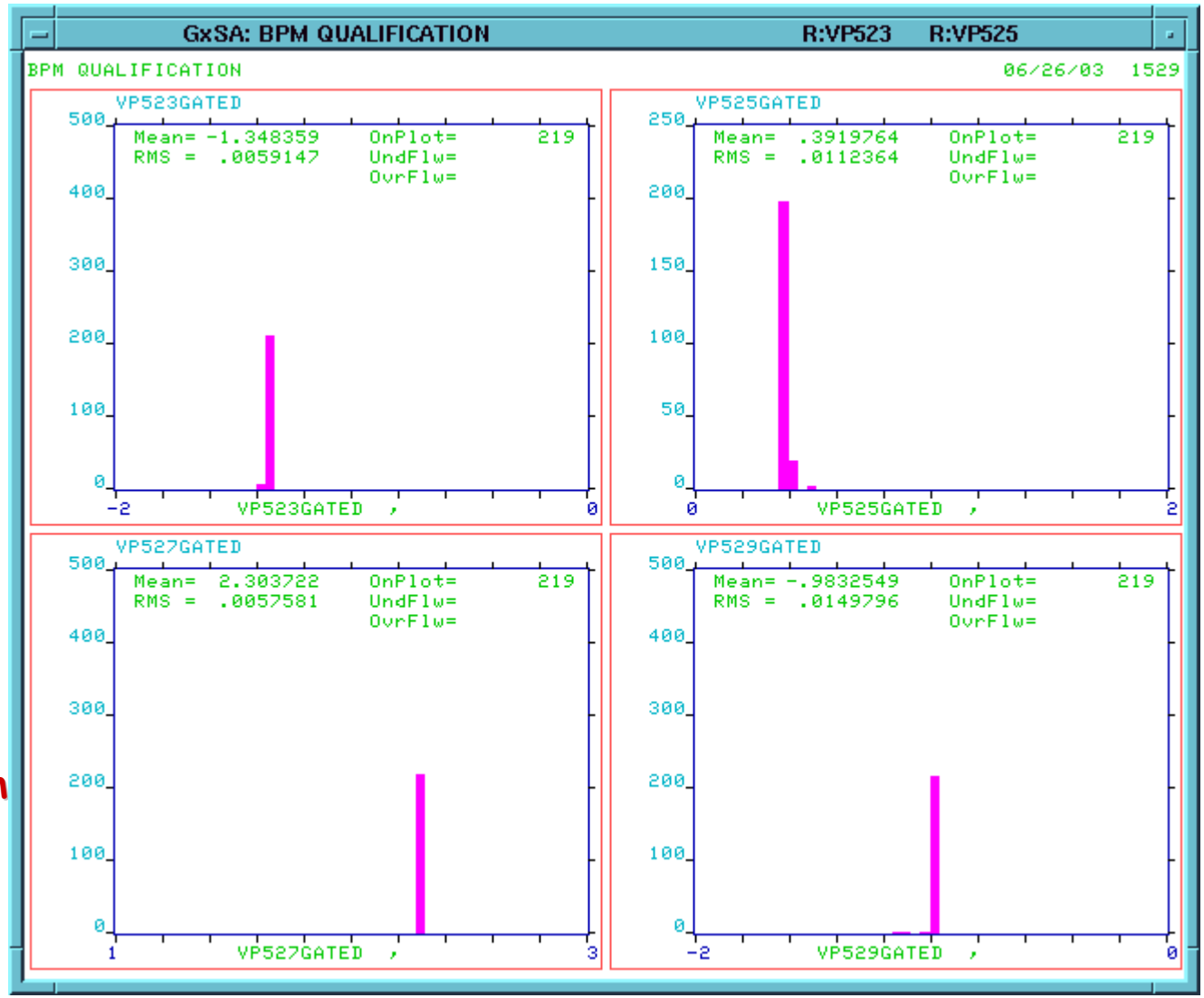
VP523

RMS 6 um

All x-axis ranges 2mm full scale

VP527

RMS 6 umm



VP525

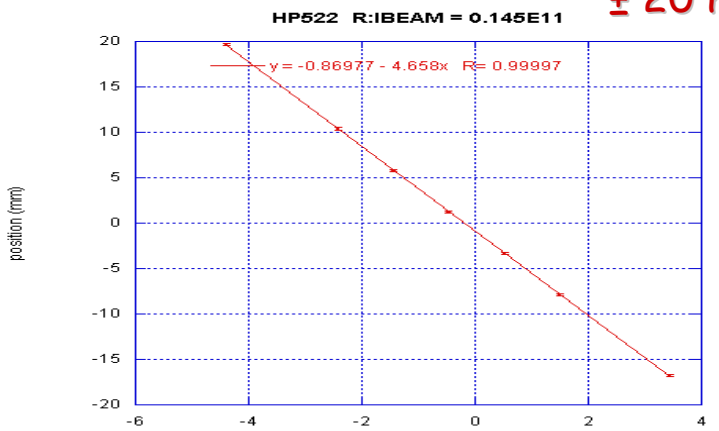
RMS 11 um

VP529

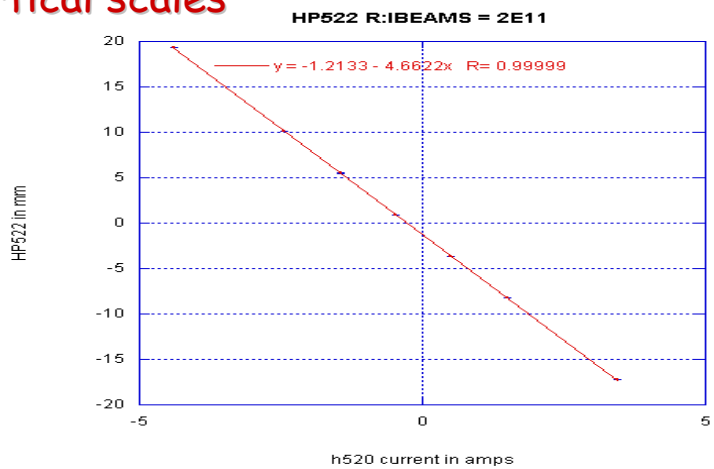
RMS 15 um

Linearity at Different Intensities - HP522

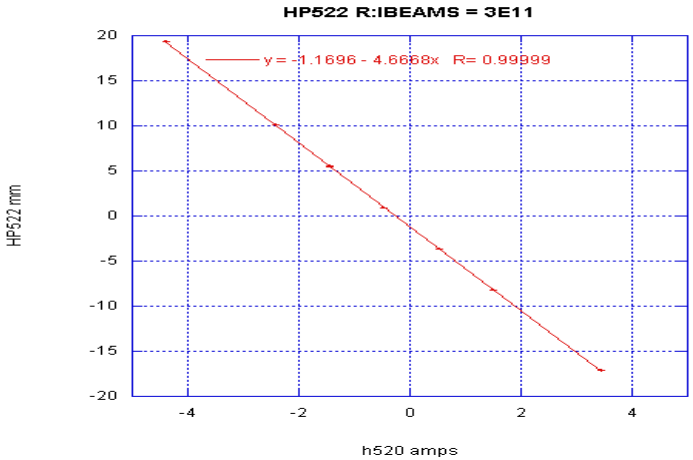
± 20 mm vertical scales



IBEAM = 1.5E10



IBEAM = 20E10

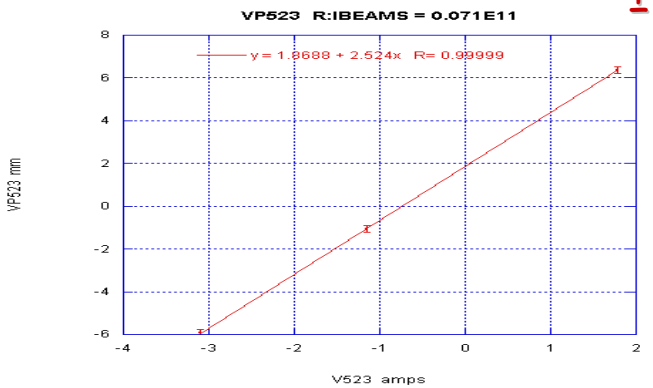


IBEAM = 30E10

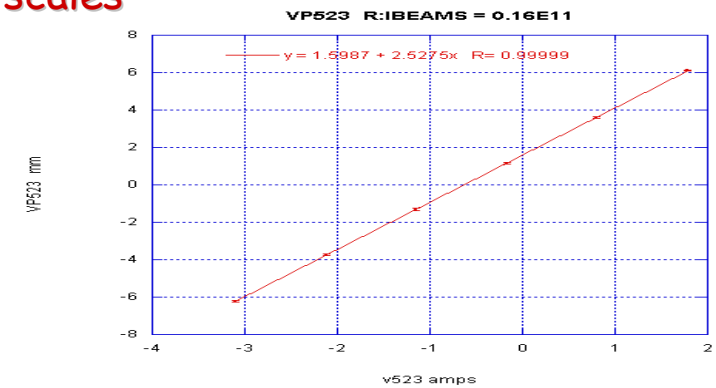
1. HP522 has the longest cable.
2. The response is linear over IBEAM range of ~20 and over position range of ~ ±20mm.
3. Data and lattice model differ by 12%.

Linearity at Different Intensities - VP523

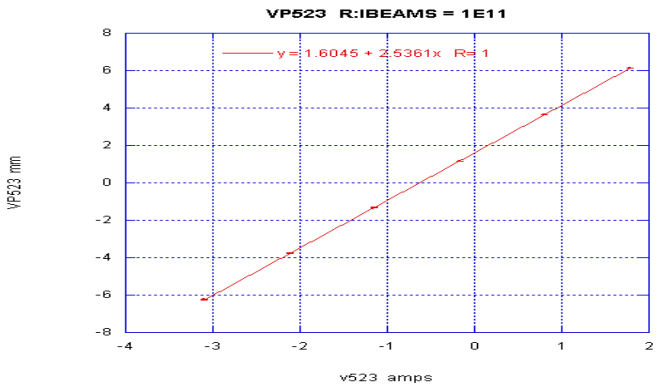
± 10 mm vertical scales



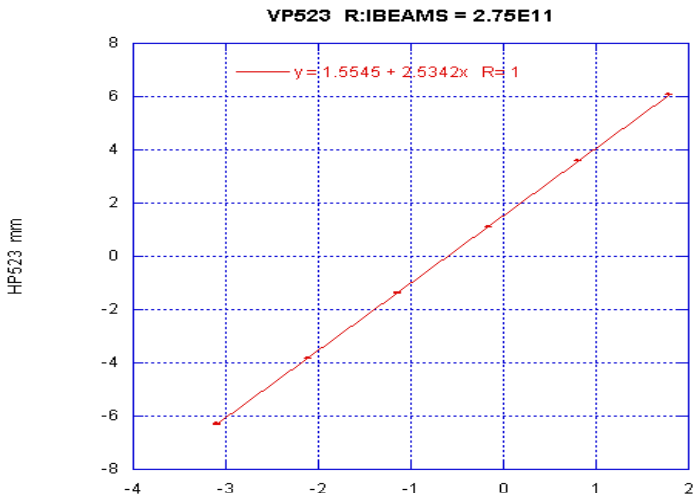
IBEAM 0.7E10



IBEAM 1.6E10

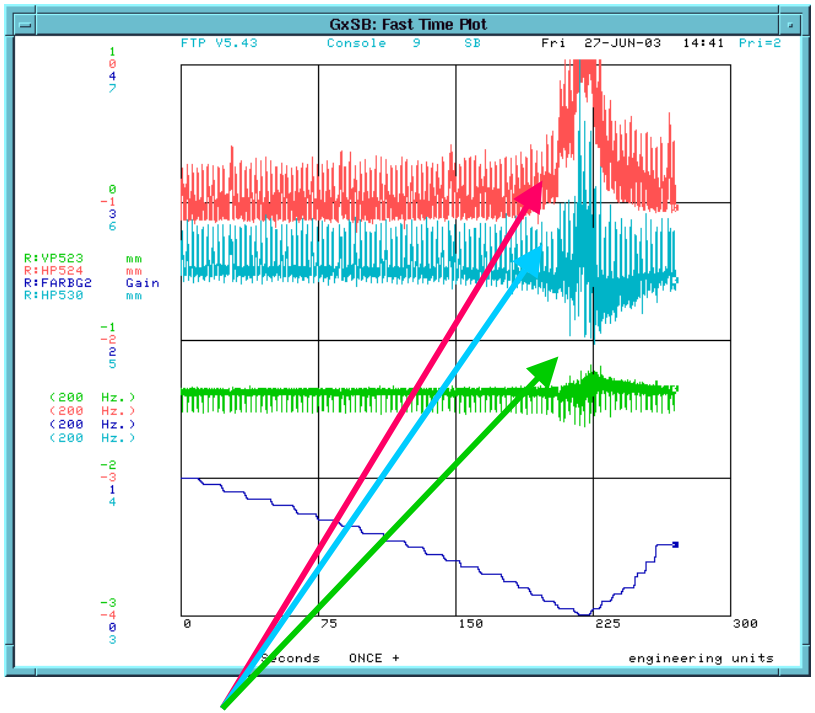


IBEAM 10E10

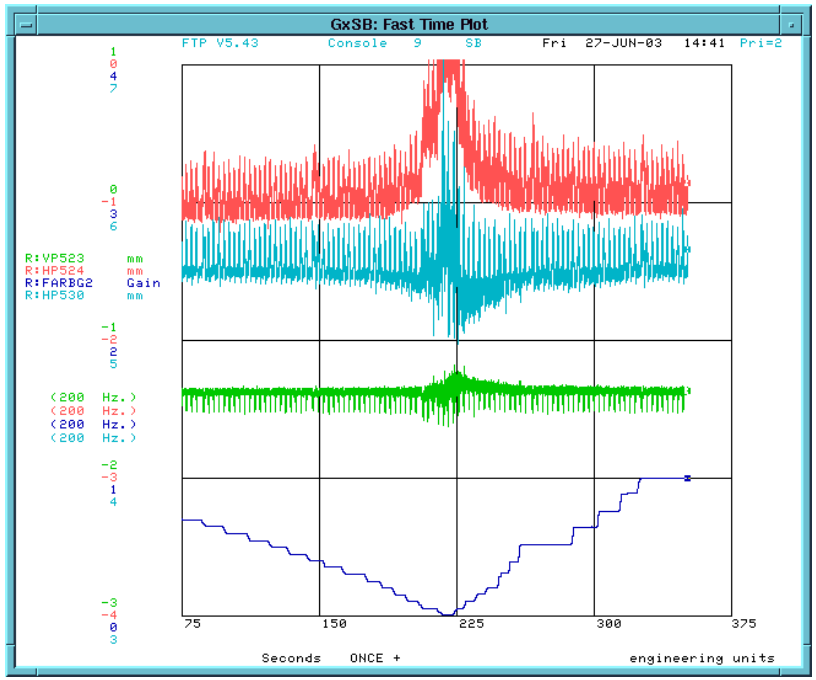


IBEAM 28E10

Effect of RF Voltage (Bunch Height) on Beam Position Measurement



At RF Voltage 15% of the usual Voltage, still beam position is measured precisely.



Beam re-bunched into 2.5MHz buckets and beam position is measured with the same precision.

What Remains to be Done?

- Pre-amps and DAQ systems must be installed in remainder of Ring. Three shifts tunnel time needed.
- Only 2.5 MHz beam measurement mode now operational, must implement barrier bucket mode.
- MDAT decoder and timing tracking facility must be debugged and implemented.
- Applications and front-end software completion efforts will continue through the summer.
- Conclusion: Everything in tunnel works as required and we are GO to complete installation as tunnel access permits.

Cost

ITEM	Quantity	Est. Unit Cost $	Est. M&S Cost K$	Actual cost	Variance	ETC 7/1/03		
VME Cpus	12	4000	48	30.3	-17.7	0		
VME Crates & PS	10	5000	50	49.8	-0.2	0		
Digital IO cards	8	1000	8	3.8	-4.2	0		
EchoTek DDCs (67)	67	7500	502.5	525	22.5	0		
DDC Clock Generators & Distribution	8	3000	24	24.8	0.8	0		
Tunnel Cable Extensions	500	25	12.5	2.398	-10.102	0		
Transition Crate (w/backplane & connectors)	10	3000	30	8.9	-21.1	0		
Transition Module PS	10	1500	15	11.1	-3.9	0		
Transition Modules	70	1000	70	38.598	-31.402	0		
Transition Module to DDC cables	500	25	12.5	6.62	-5.88	0		
Calibration switch boards (preamp)	250	50	12.5	12.046	-0.454	0		
Calibration Signal Genenerators	10	2000	20	4	-16	35		
Calibration Signal Drivers	10	1500	15	3.332	-11.668	0		
Test Setup costs	1	25000	25	0.944	-24.056	10		
TSG Ips and Carrier Modules				22.44	22.44	0		
Preamp signal channel modifications				1.19	1.19	0		
					0			
					0			
					0			
Contingency			75		0			
Total			920	745.268	-99.732	45		
					174.732	Remaining contingency		
% Contingency			20%					
(excluding EchoTek and CPUs)								

Conclusion

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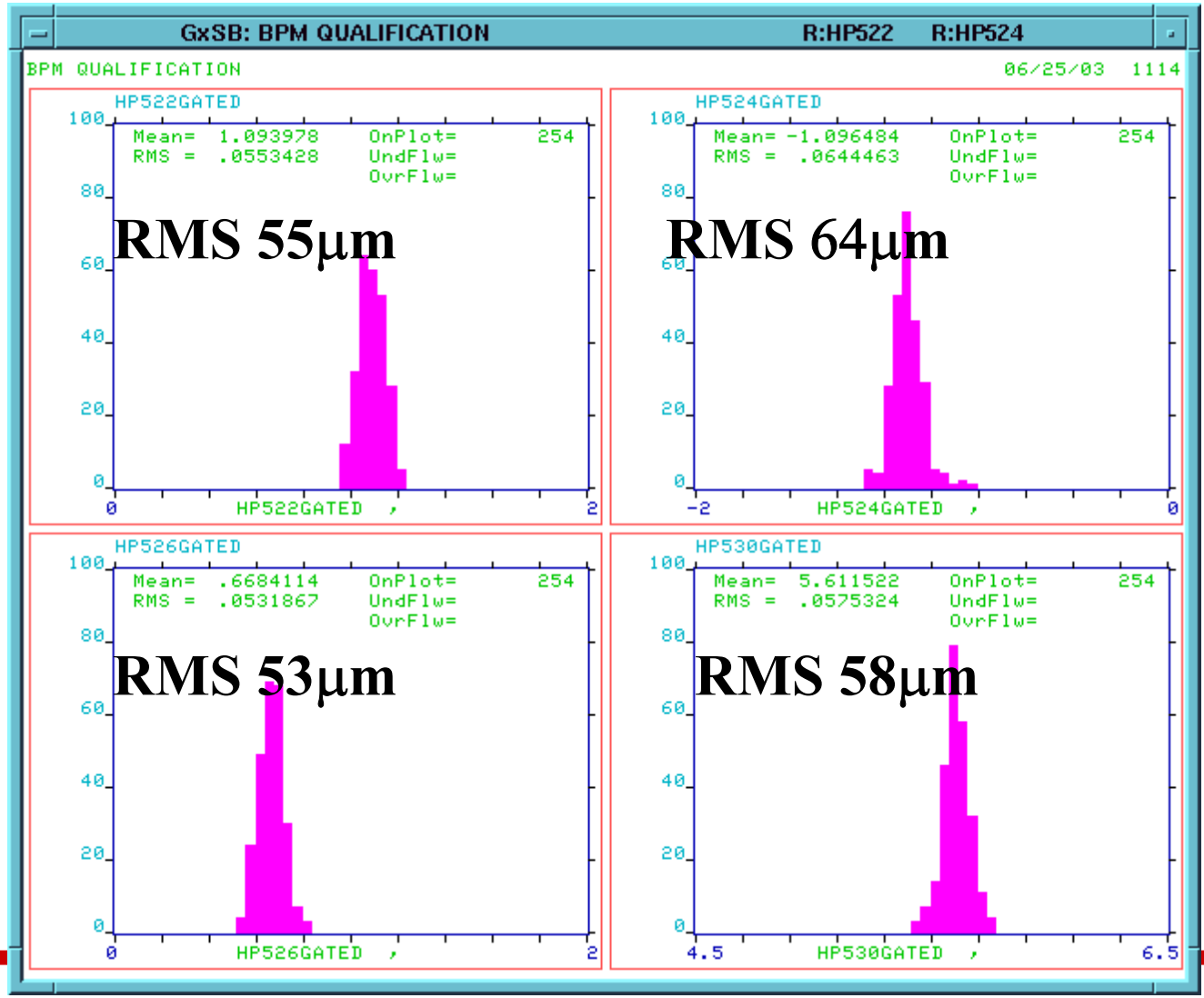
- The End

HP522, HP524, HP526 & HP530
IBEAM = 2.7E10



VP523, VP525, VP527, & VP529
IBEAM = 1.6E10