Tevatron Upgrades

Vladimir Shiltsev
Fermilab BD/Tevatron

Content:

- Motivation, performance goals
- Subprojects:
  - WBS
  - Technical issues
  - Cost/labor estimates
  - Recent progress/Status/Plans
  - Missing Resources
- Milestones

Tevatron in Run IIU: Issues

- differences between now (L=45e30) and then (L=330e30):

  L gain

  - more protons x 1.3
  - more pbars x 5.3 (to $\frac{1}{2}$ of p's)
  - shorter bunches x 1.05
  - ~ same transverse emittances

  total: x 7.3

- as the result:
  - Stronger beam-beam on pbars
  - Beam-beam on protons

  eam-beam interaction

  ties … in both beams

  nsity and emittances

  ing chromaticities

  00Q?)e30 s-1 cm-2

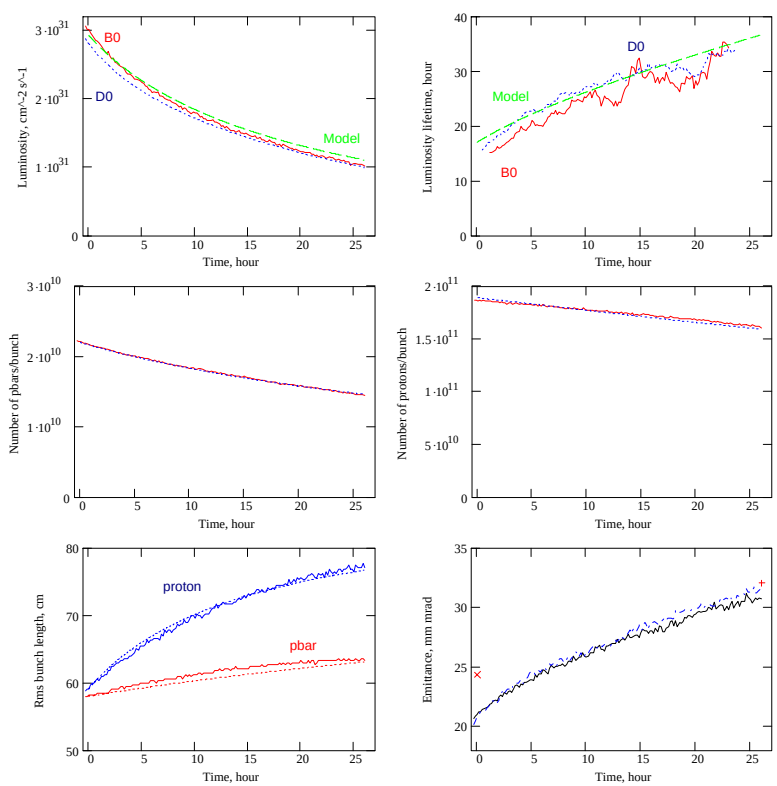
Tevatron Subprojects: Overview

WBS	Subproject	In Charge	Finish date	M&S Est (K$)	Contingency
1.3.4	**Tevatron High Luminosity**	**V.Shiltsev**		**5,142**	**42%**
1.3.4.1	**Tevatron Task Force**	**V.Lebedev**	**3/20/2007**	**0**	
1.3.4.2	**Beam-Beam Limitations**	**T.Sen**	**3/20/2007**	**0**	
1.3.4.3	**Active Beam-Beam Compensation**	**V.Shiltsev**	**5/23/2007**	**1,385**	**54%**
1.3.4.3.1	BBC: Tevatron Electron Lens	V.Shiltsev	5/23/2007	1,250	53%
1.3.4.3.2	BBC: Wires	T.Sen	4/23/2007	135	60%
1.3.4.4	**Increased Helix Separation**	**B.Hanna**	**3/30/2007**	**1,747**	**26%**
1.3.4.4.1	Optimize separation with present Separators	Yu.Alexahin	12/18/2003	0	
1.3.4.4.2	Tevatron Polarity Switches for Separators	B.Hanna	8/19/2004	237	41%
1.3.4.4.3	Separator Upgrade (longer/coated)	B.Hanna	12/28/2006	40	60%
1.3.4.4.4	Additional Separators	B.Hanna	3/30/2007	1,470	23%
1.3.4.5	**Luminosity Leveling**	**M Martens**	**1/31/2006**	**0**	
1.3.4.6	**Control and Diagnostics** *(* in review)*	**J.Steimel**	**10/29/2004**	**1,500**	**53%**
1.3.4.6.1	Abort Gap Monitor	H.Cheung	1/6/2004	30	60%
1.3.4.6.2	Tevatron Dampers	J.Steimel	1/12/2003	0	
1.3.4.6.3	Tune Meter	C.Y.Tan	1/8/2004	30	40%
1.3.4.6.4	Tevatron BPM Upgrade	J.Steimel	1/7/2004	900	60%
1.3.4.6.5	Tevatron IPM	A.Jansson	1/8/2004	300	40%
1.3.4.6.6	1.7 GHz Schottky Detector	R.Pasquinelli	1/2/2004	30	40%
1.3.4.6.7	Head-tail monitor	V.Ranjbar	1/2/2004	50	40%
1.3.4.6.8	Fast lattice functions measurements	V.Lebedev	1/2/2005	0	
1.3.4.6.9	B-field diagnostics	P.Bauer	5/5/2005	160	53%
1.3.4.6.10	Luminous region analysis on-line	J.Slaughter	1/8/2004	0	
1.3.4.7	**Tevatron Vacuum Improvements**	**B.Hanna**	**10/18/2005**	**90**	**40%**
1.3.4.8	**Tevatron Alignment** *(* in review)*	**R.Stefanski**	**12/27/2005**	**420**	**26%**
1.3.4.8.1	Orbit/aperture optimization	J.Annala	12/27/2005	0	
1.3.4.8.2	Tev on-line level system	J.Volk	1/10/2004	300	20%
1.3.4.8.3	Magnet alignment	R.Stefanski	12/27/2005	120	40%
1.3.4.8.4	SC coil realignment/smart bolts	D.Harding	1/12/2004	0	

Tevatron Task Force

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.1	**Tevatron Task Force**			**$0.00**		**1/1/2003 8:00**	**1100 days**	**V.Lebedev**
1.3.4.1.1	Tevatron Task Force Work			$0.00	B	1/1/2003 8:00	1100 days	V.Lebedev

Lebedev V.[0.6],Alexahin Y.[0.8],Johnstone J.[0.8],Sen T.[0.2],Physicist[1.5],Syphers M.[0.5]

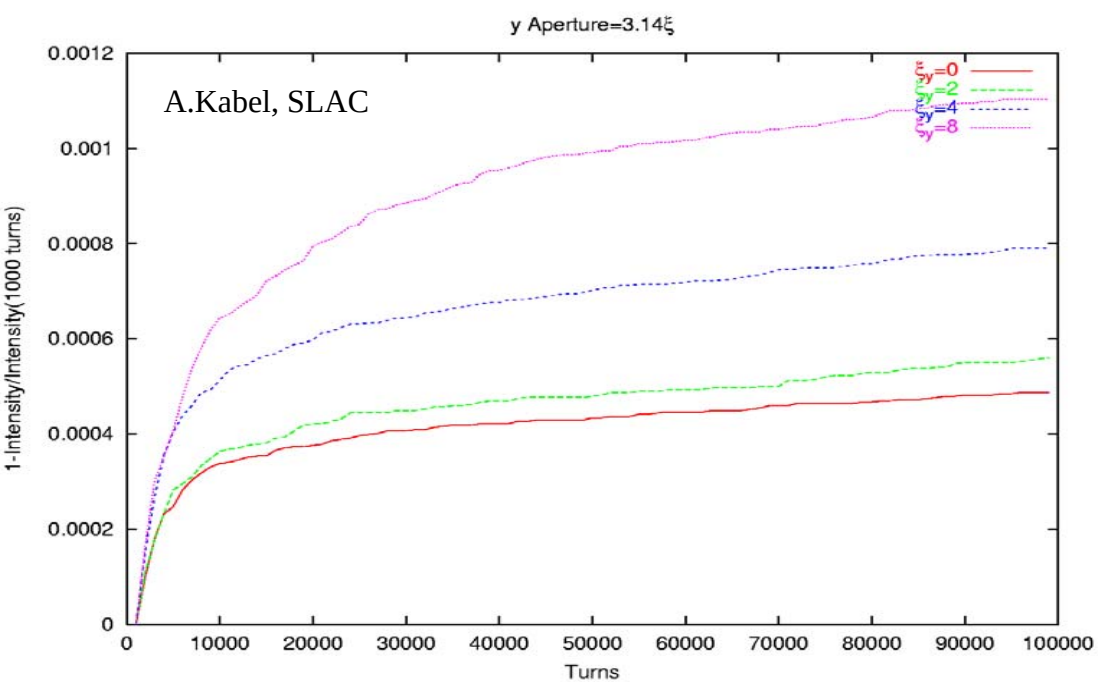


- Addresses accelerator physics issues in Tevatron, e.g., optics, luminosity lifetime, stability, etc
- Status/progress/plans:
  - Modeling report for DoE review
  - Helix optimization - in FY'04
- Tight on people (1.5 Physicist)

Beam-Beam Limitations

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.2	**Beam-beam Limitations**			**$0.00**		**1/1/2003 8:00**	**1100 days**	**T.Sen**
1.3.4.2.1	Beam-beam tracking			$0.00	B	1/1/2003 8:00	260 days	T.Sen
1.3.4.2.2	BB Studies and Analysis			$0.00	C	1/1/2003 8:00	1100 days	T.Sen

LBL Physicist[1.5],SLAC Physicist[2]
Zhang X.[0.2],Shiltsev V.[0.1],Sen T.[0.2],Tevatron Study Shifts[2],Physicist[0.5]



- Theory/observations of beam-beam effects in Tevatron
- Progress:
  - Pbar lifetime simulations with SLAC code
  - DA and "clothed" orbit close to observations
- Lack of study time, 6 shifts needed now

Beam-Beam Effects: Summary

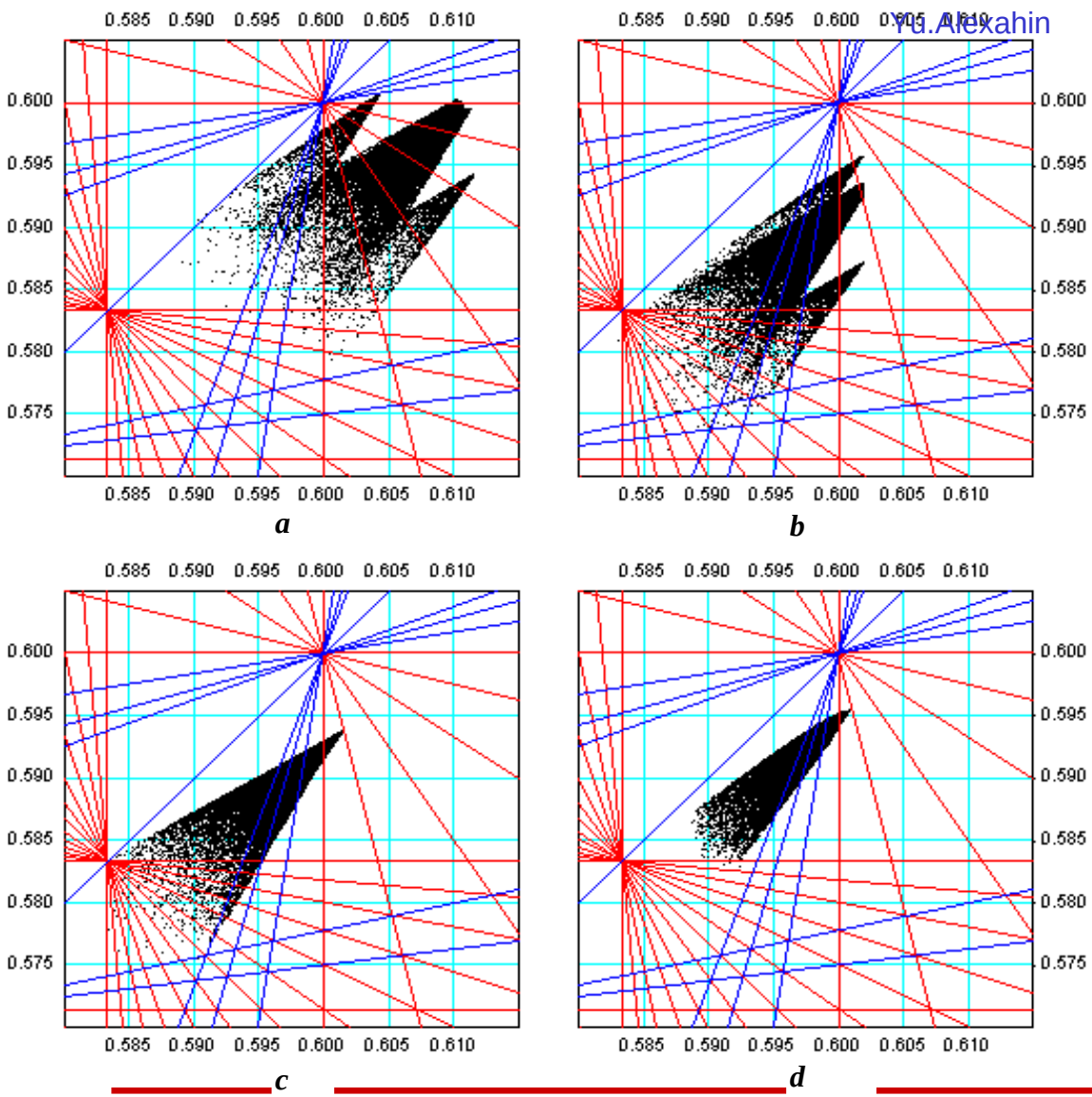
- see details Tevatron Task Force Report
- p's on pbars:
  - reduced lifetime at 150
  - losses on ramp, in squeeze
  - bunch-by-bunch variations of tunes, C_v.h and emittances
  - Very sensitive to tunes, coupling, and chromaticities
- pbars on protons:
  - Losses while cogging, squeeze
  - bunch-by-bunch variations of tunes and emittances
- ongoing work to perfect models, codes

Attacking Beam-Beam Effects

- Beam-Beam Compensation
  - With Tevatron Electron Lenses (TELs)
  - Wire Compensation
- Larger Beam-Beam Separation

  (open aperture, optics, add separators)

Beam-Beam Compensation

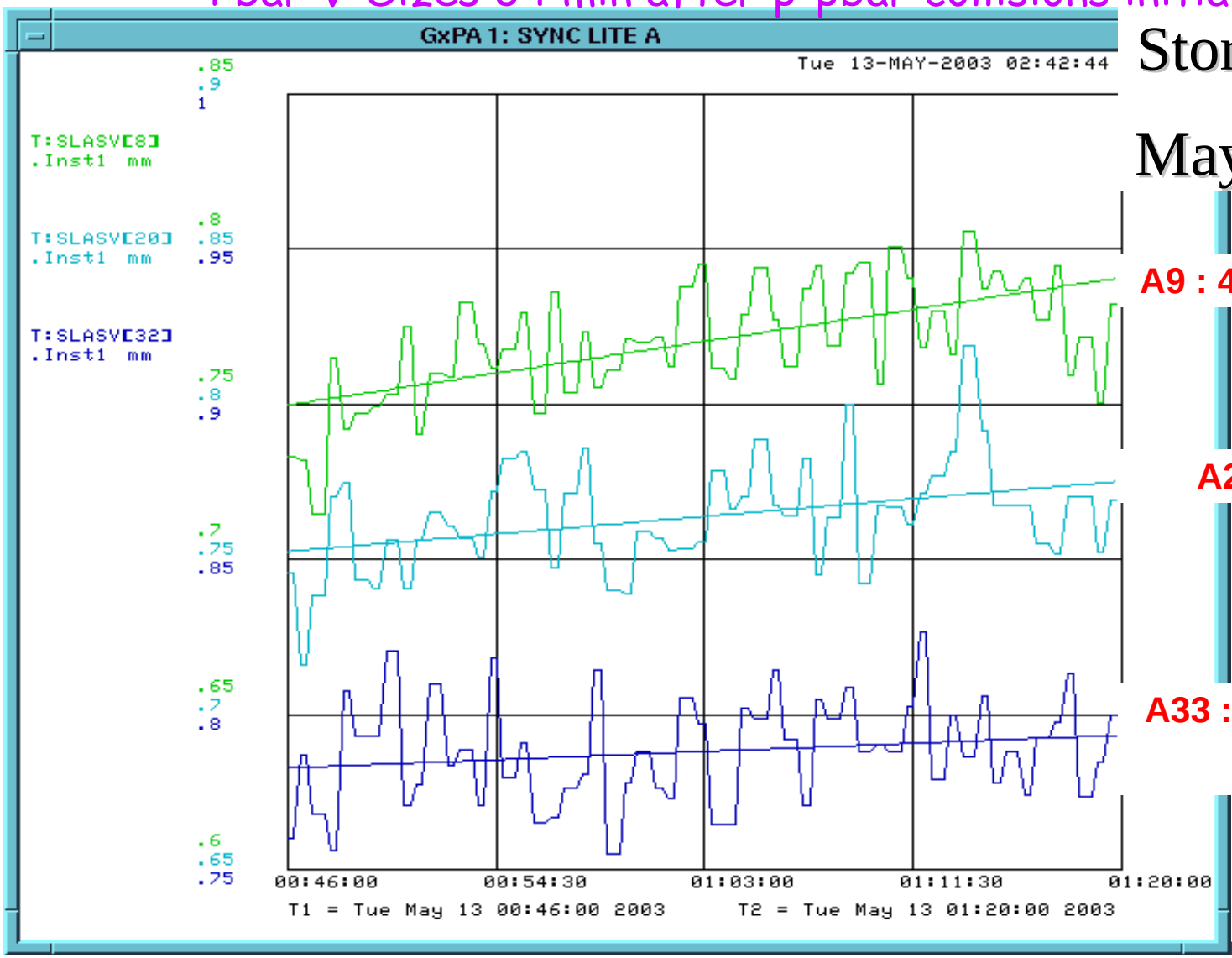


- compensate beam-beam tune shifts
  - a) Run II Goal
  - b) one TEL
  - c) two TELs
  - d) 2 nonlinear TELs
- requires
  - electron current √
  - stability ?
  - centering ⊗
  - shaping ⊗
- other considerations
  - use at 150 GeV, ramp, squeeze - ?
  - chromaticity ?
  - abort gap cleaning

Tevatron Electron Lens #1

First Indication of Beam-Beam Compensation

Pbar V-Sizes 34 min after p-pbar collisions initiated



Store #2540

May 12, '03

A9 : 4.1 □ mm mrad/hr

A21 : 2.2 □ mm mrad/hr

A33 : 1 □ mm mrad/hr

-TEL on it

BBC: Tevatron Electron Lens

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.3	**Active Beam-Beam Compensation**			**$0.00**		**1/1/2003 8:00**	**1146 days**	**V.Shiltsev**
1.3.4.3.1	**BBC: Tevatron Electron Lens**			**$0.00**		**1/1/2003 8:00**	**1146 days**	**V.Shiltsev**
1.3.4.3.1.1	TEL-1 beam studies			$0.00	C	1/1/2003 8:00	320 days	V. Shiltsev
1.3.4.3.1.2	TEL-1 upgrades			$0.00		1/1/2003 8:00	423 days	V. Shiltsev
1.3.4.3.1.2.1	TEL vacuum modifications			$70,000.00	B	1/1/2003 8:00	260 days	V.Sidorov
1.3.4.3.1.2.2	TEL spare collector			$20,000.00	B	3/3/2003 8:00	44 days	V. Sidorov
1.3.4.3.1.2.3	TEL spare HV modulator			$30,000.00	B	3/3/2003 8:00	66 days	H. Pfeffer
1.3.4.3.1.2.4	TEL spare magnets			$250,000.00	B	4/1/2003 8:00	220 days	V. Shiltsev
1.3.4.3.1.2.5	TEL 16kV modulator			$70,000.00	B	4/1/2003 8:00	260 days	Yu.Tereshkine
1.3.4.3.1.2.6	TEL BPM upgrade			$10,000.00	B	3/3/2003 8:00	88 days	J.Crisp
1.3.4.3.1.2.7	modify TEL-1 at F48			$20,000.00	C	7/26/2004 8:00	15 days	V. Shiltsev
1.3.4.3.1.3	testing at E4R facility			$80,000.00	C	2/3/2004 8:00	260 days	V. Shiltsev
1.3.4.3.1.4	Upgraded TEL-1 beam studies			$0.00	C	8/13/2004 17:00	88 days	V. Shiltsev
1.3.4.3.1.5	Decision on second TEL (Milestone)			$0.00		3/23/2004 17:00	0 days	
1.3.4.3.1.6	Decision[2] on second TEL (Milestone)			$0.00		12/15/2004 17:00	0 days	
1.3.4.3.1.7	build TEL-2			$0.00		12/16/2004 8:00	260 days?	V. Shiltsev
1.3.4.3.1.7.1	labor TEL-2			$0.00	C	12/16/2004 8:00	260 days	V. Shiltsev
1.3.4.3.1.7.2	M&S TEL-2			$600,000.00	C	2/16/2005 8:00	1 day?	V. Shiltsev
1.3.4.3.1.8	installation prep two TELs			$100,000.00	C	12/15/2005 8:00	60 days	V. Shiltsev
1.3.4.3.1.9	Installation two TELs			$0.00	C	5/29/2006 8:00	22 days	V. Shiltsev
1.3.4.3.1.10	TEL system beam studies and commisioni			$0.00	C	1/19/2007 17:00	88 days	V. Shiltsev
1.3.4.3.1.11	TEL System Operational (Milestone)			$0.00		5/23/2007 17:00	0 days	V. Shiltsev

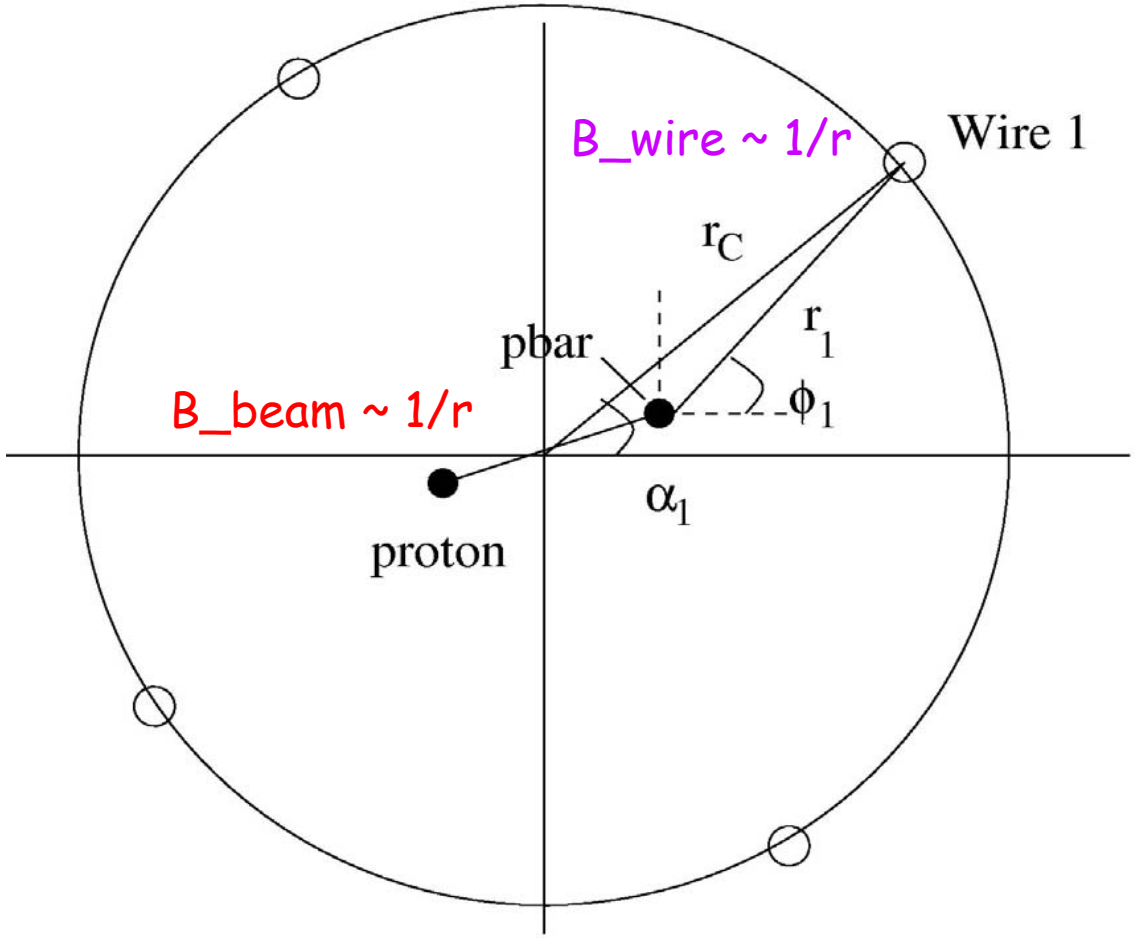
Zhang X.[0.6],Shiltsev V.[0.1],Tevatron Study Shifts[1.5]
Physicist
Sidorov V.[0.2]
Pfeffer H.[0.2],Saewert G.[0.2]
Terechkine I.
Crisp J.
Mechanical Engineer[2],Mechanical Tech.[2]
Physicist[0.5]
Zhang X.[0.2],Shiltsev V.[0.1],Physicist[0.5],Tevatron Study Shifts
Mechanical Engineer,Electrical Engineer,Physicist,Shiltsev V.[0.1],Mechanical Tech.[2]
Mechanical Engineer,Physicist,Shiltsev V.[0.1],Mechanical Tech.[2]
Mechanical Engineer,Physicist,Shiltsev V.[0.1],Mechanical Tech.[2]
Shiltsev V.[0.1],Zhang X.[0.6],Physicist,Tevatron Study Shifts[2]

- Cost estimates provided by D.Wolff, D.Wildman, N.Solyak, Yu.Tereshkine, IHEP(Protvino), V.Sidorov, V.Shiltsev
- Based on cost of TEL-1 fabrication

BBC: Tevatron Electron Lens

- Focused on active compensation of beam-beam effects with use of high-current low-energy electron beams
- Status/plans:
  - Promising results with TEL-1
  - Need study time to understand modifications
  - Proceed with TEL-2
- Project is <u>extremely tight</u> on people, e.g., currently there is ~0.3FTE, need 1 full time Physicist and 1 Engineer to boost project
- Need of study time, too

Wire Compensation



T.Sen

B.Erdelyi

- Wire mimics long-range B-field of proton beam, compensates
- ~ 200A in ~ 4 wires at ~ 4 locations around the Tevatron

B-B Compensation with Wires

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.3.2	**BBC: Wires**			**$0.00**		**4/1/2003 8:00**	**1060 days**	**T.Sen**
1.3.4.3.2.1	Wires simulations/analysis			$0.00	B	4/1/2003 8:00	66 days	T.Sen
1.3.4.3.2.2	Plan wire implementation			$0.00	B	7/2/2003 8:00	44 days	V. Shiltsev
1.3.4.3.2.3	Decision to proceed with wire station protot			$0.00		9/1/2003 17:00	0 days	
1.3.4.3.2.4	Design+Build prototype wire station			$40,000.00	C	11/3/2003 8:00	130 days	Physicist???
1.3.4.3.2.5	Prototype wire bench tests			$10,000.00	C	5/3/2004 8:00	44 days	Physicist???
1.3.4.3.2.6	Install prototype wire station			$15,000.00	C	7/26/2004 8:00	15 days	Physicist???
1.3.4.3.2.7	Wire prototype beam studies			$0.00	C	9/17/2004 17:00	88 days	T.Sen
1.3.4.3.2.8	Decision on wire BBC (Milestone)			$0.00		1/19/2005 17:00	0 days	
1.3.4.3.2.9	Design Wire BBC system			$0.00	B	11/16/2004 8:00	66 days	Physicist???
1.3.4.3.2.10	Build wire stations			$60,000.00	C	2/16/2005 8:00	130 days	Physicist???
1.3.4.3.2.11	Install Wire stations			$10,000.00	C	5/29/2006 8:00	30 days	
1.3.4.3.2.12	Wire BBC studies and commissioning			$0.00	C	1/19/2007 17:00	66 days	T.Sen
1.3.4.3.2.13	Wire BBC Operational (Milestones)			$0.00		4/23/2007 17:00	0 days	

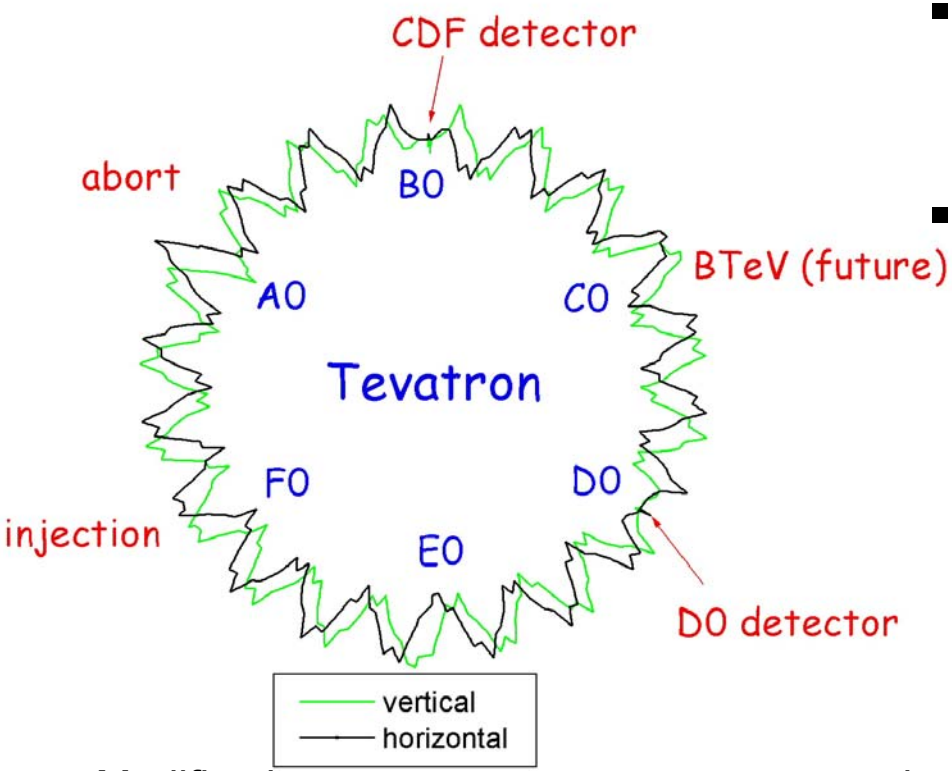
Sen T.[0.2]
Sen T.[0.2]
Physicist[0.3],Mechanical Engineer[0.5],Electrical Engineer[0.3],Mechanical Tech.
Physicist[0.5],Mechanical Engineer[0.2],Electrical Engineer[0.5]
Physicist[0.3],Mechanical Engineer[0.2],Electrical Engineer[0.2],Mechanical Tech.[2]
Zhang X.[0.2],Sen T.[0.1],Tevatron Study Shifts[1.5]
Physicist[0.5],Mechanical Engineer[0.3],Electrical Engineer[0.3]
Physicist[0.3],Mechanical Engineer[0.5],Electrical Engineer[0.3],Mechanical Tech.[2]
Physicist[0.3],Mechanical Engineer[0.2],Electrical Engineer[0.2],Mechanical Tech.
Zhang X.[0.2],Sen T.[0.1],Tevatron Study Shifts[1.5]

- Cost estimates provided by V.Shiltsev on base of TEL cost, and cost of collimators

BBC: Wires

- Focused on active compensation of long-range beam-beam effects with use of number of conductive wires carrying high current in vicinity of pbar beam
- Status/plans:
  - Physics analysis underway
  - Decision on prototype - soon
- Enough people for now, will require engineers and techs for prototyping
- Will need study time

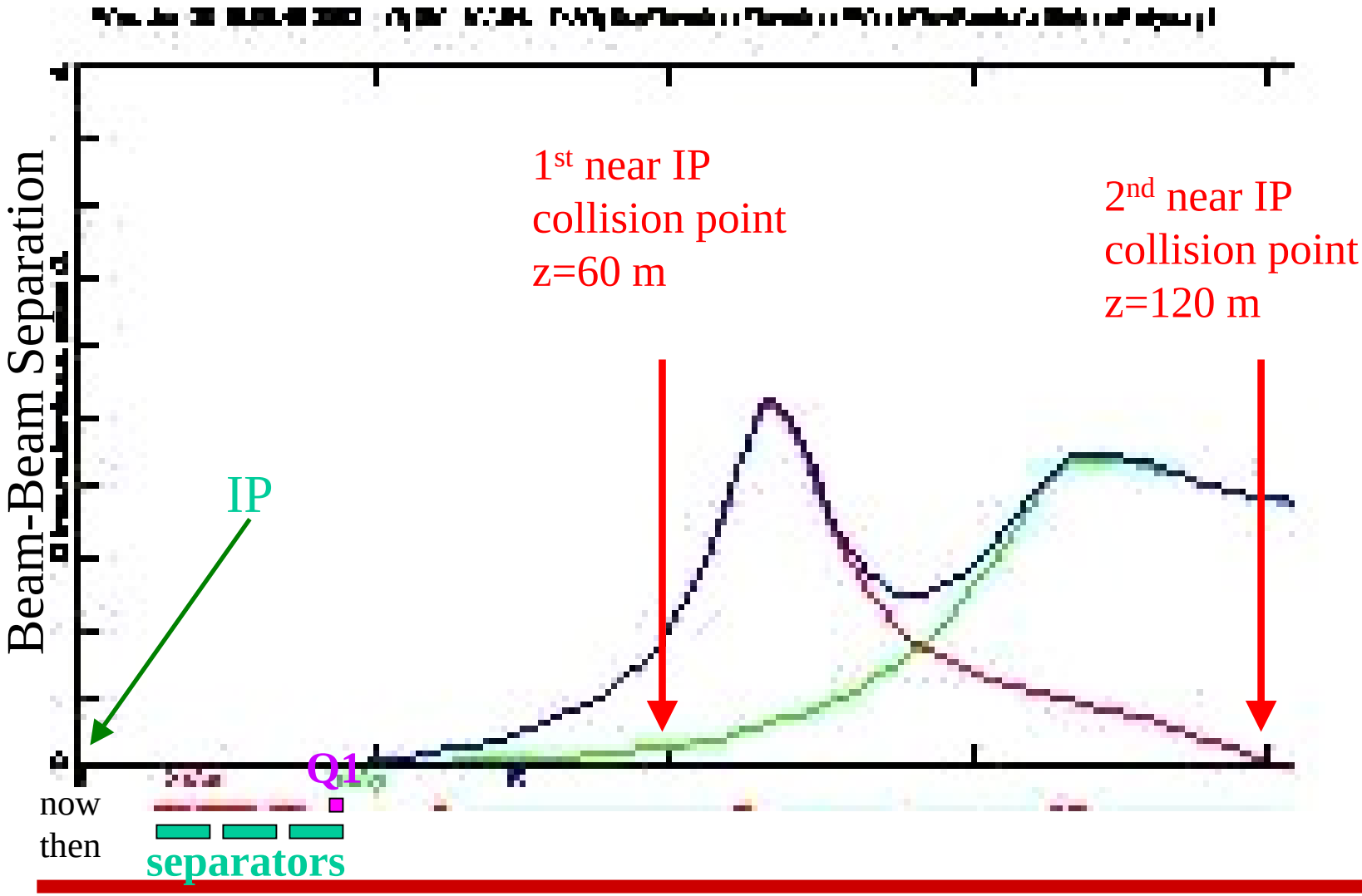
Improve Helix



- Quantative improvement:
  - Increase minimum separation in ♦'s
- Qualitative improvement:
  - Decrease strength of resonances
  - Decrease maximum separation in mm

Modification	near-misses gain %	Ringwide gain%
10% separator voltage increase	10	10
50❍rad half-crossing angle	21.5	~0
Additional arc modules	7.7	15
Increase IR separator strength	19	19
TOTAL GAIN	71	50

Longer Separators



Increased Helix Separation

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.4	**Increased Helix Separation**			**$0.00**		**4/1/2003 8:00**	**1044 days**	**B.Hanna**
1.3.4.4.1	**Optimize separation with present Sepa**			**$0.00**		**5/1/2003 8:00**	**166 days**	**Yu.Alexahin**
1.3.4.4.1.1	Design new Helix and investigate Separato			$0.00	C	5/1/2003 8:00	66 days	J Johnstone
1.3.4.4.1.2	Implement new separator Protocol			$0.00	C	11/19/2003 8:00	22 days	J Johnstone
1.3.4.4.2	**Tevatron Polarity Switches for Separat**			**$0.00**		**11/3/2003 8:00**	**209 days**	**B.Hanna**
1.3.4.4.2.1	Purchase parts			$165,000.00	B	11/3/2003 8:00	1 day	J.Walton
1.3.4.4.2.2	Assemble and test switches			$64,000.00	B	1/5/2004 8:00	88 days	J.Wlaton
1.3.4.4.2.3	Install switches in service buildings			$8,000.00	C	5/6/2004 8:00	66 days	J.Walton
1.3.4.4.2.4	Commission with beam			$0.00	C	8/5/2004 17:00	10 days	B.Hanna
1.3.4.4.3	**Seperator Upgrade**			**$0.00**		**5/1/2003 8:00**	**956 days**	**B.Hanna**
1.3.4.4.3.1	R&D on high voltage separator design			$40,000.00	C	5/1/2003 8:00	260 days	G.Romanov (TD)
1.3.4.4.3.2	Decision on high voltage separators (Milest			$0.00		4/28/2004 17:00	0 days	
1.3.4.4.3.3	retrofit spare separators			$0.00	C	4/29/2004 8:00	130 days	Bruce Hanna
1.3.4.4.3.4	replace separators -1			$0.00	C	5/29/2006 8:00	33 days	
1.3.4.4.3.5	retrofit separators			$0.00	C	7/13/2006 8:00	88 days	Bruce Hanna
1.3.4.4.3.6	replace separators -2			$0.00	C	11/14/2006 8:00	33 days	
1.3.4.4.4	**Additional Seperators**			**$0.00**		**4/1/2003 8:00**	**1044 days**	**Physicist???**
1.3.4.4.4.1	develop lattice/helix concept			$0.00	C	4/1/2003 8:00	66 days	V. Lebedev
1.3.4.4.4.2	develop magnet/separator concept			$0.00	C	4/1/2003 8:00	88 days	J Kirby (TD)
1.3.4.4.4.3	Decision on separators/magnets (Milestone			$0.00		7/31/2003 17:00	0 days	
1.3.4.4.4.4	**Long Separators**			**$0.00**		**8/1/2003 8:00**	**780 days**	
1.3.4.4.4.4.1	design long separators			$0.00	A	8/1/2003 8:00	66 days	R Bossart
1.3.4.4.4.4.2	procurement 14 long separators			$1,300,000.00	A	11/3/2003 8:00	132 days	J Walton
1.3.4.4.4.4.3	setup separator production			$100,000.00	B	2/3/2004 8:00	22 days	R Bossart
1.3.4.4.4.4.4	fabrication+testing first long separator			$0.00	A	5/5/2004 8:00	88 days	R Bossart
1.3.4.4.4.4.5	fabrication+testing 12 long separators			$0.00	A	9/6/2004 8:00	440 days	R Bossart
1.3.4.4.4.4.6	installation design			$0.00	B	11/3/2003 8:00	132 days	D. Still
1.3.4.4.4.4.7	installation fabrication			$50,000.00	C	5/5/2004 8:00	44 days	Mech Eng???
1.3.4.4.4.4.8	long separator installation			$0.00	B	5/29/2006 8:00	44 days	Mech Eng???
1.3.4.4.4.5	commission high voltage separators			$20,000.00	C	12/29/2006 8:00	22 days	Bruce Hanna
1.3.4.4.4.6	new helix commissioning			$0.00	B	1/29/2007 17:00	44 days	M. Martens
1.3.4.4.4.7	increased BB separation operational (miles			$0.00		3/30/2007 17:00	0 days	

Increased Helix Separation: Resources

Johnstone J.[0.3],Hanna B.[0.2],Syphers M.[0.1],Lebedev V.[0.1],Martens M.[0.5]
Johnstone J.[0.2],Martens M.[0.3],Hanna B.[0.3]
Mechanical Tech.[2],Bossert R.[0.5],Walton J.[0.1],Hanna B.[0.1]
Mechanical Tech.[2],Bossert R.[0.1],Hanna B.[0.1],Walters J.[0.1]
Hanna B.[0.2],Annala G.[0.2],Tevatron Study Shifts[2]
TD Mechanical Engineer[0.5]
Mechanical Tech.[2]
Mechanical Tech.[2]
Lebedev V.[0.2],Alexahin Y.[0.5],Johnstone J.[0.5]
TD Mechanical Engineer[2]
TD Mechanical Engineer[0.5],Drafter/Designer
TD Mechanical Engineer[0.5],TD Mechanical Tech.
TD Mechanical Engineer[0.5],TD Mechanical Tech.[3]
TD Mechanical Engineer[0.5],TD Mechanical Tech.[4]
TD Mechanical Engineer[0.5],Drafter/Designer[0.5],Physicist[0.5]
TD Mechanical Engineer[0.5],TD Mechanical Tech.[2]
Mechanical Engineer[0.5],Hanna B.[0.5],Mechanical Tech.[2],Survey Crew[0.2]
Mechanical Engineer[0.2]
Annala G.[0.6],Martens M.[0.3],Tevatron Study Shifts[4]

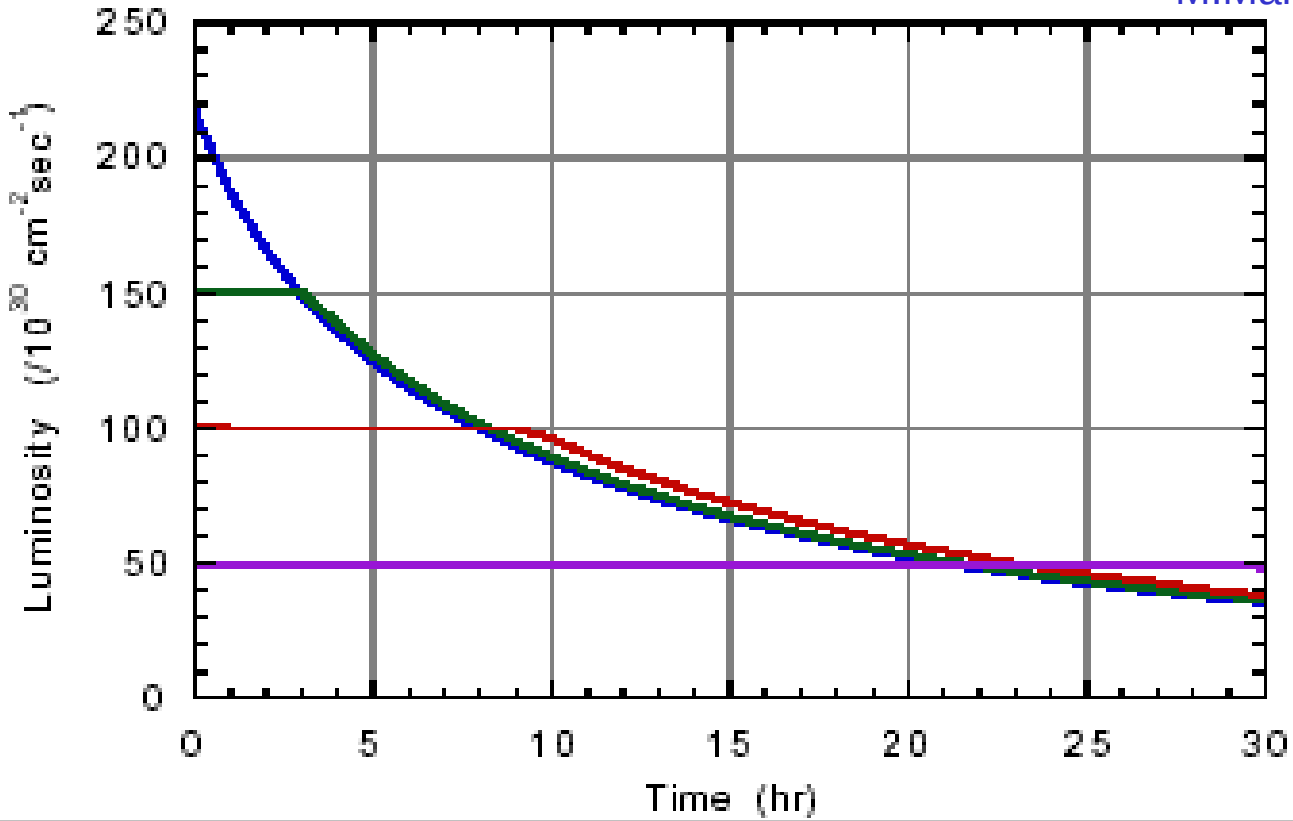
- Cost estimates provided by B.Hanna, J.Walton, R.Bossert (TD) - quotes

Increased Helix Separations

- Goal of the project is to reduce strength of beam-beam resonances by increasing beam separation ring-wide
  - Will not reduce head-on beam-beam interaction
  - Will not help much at 150 GeV (aperture limited)
- Status/plans:
  - Injection/squeeze helices modified mid-02
  - New (5*) helix proposed at 150, ramp, 980
  - Aperture studies ~complete
  - Need study time to implement
  - "Coated" electrode R&D started (TD)
- Enough people for now, closely linked to Tev Task Force work, TD help essential, require study time

Luminosity Leveling

M.Martens, V.Lebedev



WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.5	**Luminosity Leveling**			**$0.00**		**12/1/2004 8:00**	**305 days**	**M.Martens**
1.3.4.5.1	luminosity leveling beam studies -1			$0.00	B	12/1/2004 8:00	44 days	M.Martens
1.3.4.5.2	luminosity leveling beam studies -2			$0.00	C	12/1/2005 8:00	44 days	M.Martens

Improved Control & Diagnostics

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.6	**Improved Control and Diagnostics**			**$0.00**		**5/1/2003 8:00**	**392 days**	**J.Steimel**
1.3.4.6.1	**abort gap monitor**			**$30,000.00**	**C**	**4/1/2004 8:00**	**152 days**	**H.Cheung**
1.3.4.6.2	**Tev Longitudinal Dampers**			**$0.00**		**12/1/2003 8:00**	**88 days**	**J.Steimel**
1.3.4.6.2.1	Develop PLL and notch filter			$0.00	C	12/1/2003 8:00	44 days	J Steimel
1.3.4.6.2.2	Commission Longitudinal Damper			$0.00	C	1/29/2004 17:00	44 days	J Steimel
1.3.4.6.3	**P/pbar Tune Tracker**			**$30,000.00**		**11/3/2003 8:00**	**88 days**	**CY Tan**
1.3.4.6.3.1	Reassemble tunemeter			$0.00	C	11/3/2003 8:00	44 days	CY Tan
1.3.4.6.3.2	Improve measurement technique			$30,000.00	C	1/2/2004 8:00	44 days	CY Tan
1.3.4.6.4	**Tevatron BPM Upgrade**			**$900,000.00**		**8/1/2003 8:00**	**220 days**	**Jim Steimel**
1.3.4.6.4.1	Do Tev BPMs in parallel with MI (Tev has h			$0.00		8/1/2003 8:00	0 days	Physicist
1.3.4.6.4.2	Tev BPM system design			$0.00	B	8/1/2003 8:00	44 days	Physicist
1.3.4.6.4.3	Tev BPM: Review (Milestone)			$0.00		10/1/2003 17:00	0 days	Physicist
1.3.4.6.4.4	Tev BPM system fabrication			$900,000.00	C	10/2/2003 8:00	110 days	Physicist
1.3.4.6.4.5	Tev BPM system installation			$0.00	C	3/4/2004 8:00	22 days	Physicist
1.3.4.6.4.6	Tev BPM system commissioning			$0.00	C	4/5/2004 8:00	44 days	Physicist
1.3.4.6.5	**Tevatron IPM**			**$300,000.00**		**5/1/2003 8:00**	**335 days**	**A.Jansson**
1.3.4.6.5.1	mechanical design: magnet and vacuum			$0.00	B	5/1/2003 8:00	88 days	L.Valerio
1.3.4.6.5.2	spec and test DAQ scheme			$0.00	C	5/1/2003 8:00	110 days	H.Nguyen
1.3.4.6.5.3	Design Review, decision to proceed			$0.00		10/1/2003 17:00	0 days	
1.3.4.6.5.4	order magnets and parts			$300,000.00	B	10/2/2003 8:00	88 days	Andreas Jansso
1.3.4.6.5.5	assemble and test instrumentation and DA			$0.00	C	2/3/2004 8:00	132 days	Andreas Jansso
1.3.4.6.5.6	Installation			$0.00	B	8/5/2004 8:00	5 days	Andreas Jansso

Physicist[0.3],Tevatron Study Shifts[0.3],Electrical Engineer[0.1],Computer Professional[0.1
Steimel J.[0.8],Tan C.[0.4],Koch K.[0.6],McCormack J.[0.6]
Steimel J.[0.4],Tan C.[0.4],Koch K.[0.2],McCormack J.[0.2],Tevatron Study Shifts
Tan C.[0.5],Koch K.[0.2]
Physicist[0.5],Electrical Engineer,Computer Professional[2],MI Study Shifts[4]
Physicist[0.2],Electrical Engineer[1.5],Electrical Tech.[3.2],Computer Professional[2]
Electrical Tech.[2],Electrical Engineer,Computer Professional
Physicist[0.8],Electrical Engineer[0.8],Electrical Tech.[1.6],Computer Professional[2]
n
Valerio L.[0.5],TD Mechanical Engineer[0.5]
Physicist,Electrical Engineer[0.5]
Mechanical Engineer[0.25],Electrical Engineer[0.25]
Computer Professional,Electrical Engineer[0.5],Physicist,Mechanical Engineer[0.5],Mechanical Te
Mechanical Engineer[0.5],Mechanical Tech.[2],Electrical Engineer[0.5],Physicist[0.5]

- Cost estimates provided by project leaders

Improved Controls and Diagnostics

- Status/progress/plans:
  - New 1.7GHz Schottky operational
  - New BPM specs reviewed, design review in Oct
  - Several new instruments for better control of tunes, chromaticities, coupling, emittances
  - Continue improvement of existing instruments
- Tight on people (physicists, engineers, computer pro's), CD, TD and PPD are greatly involved, require a lot of study time, access
- See Steimel @Tev/Phys breakout session

Vacuum Improvement

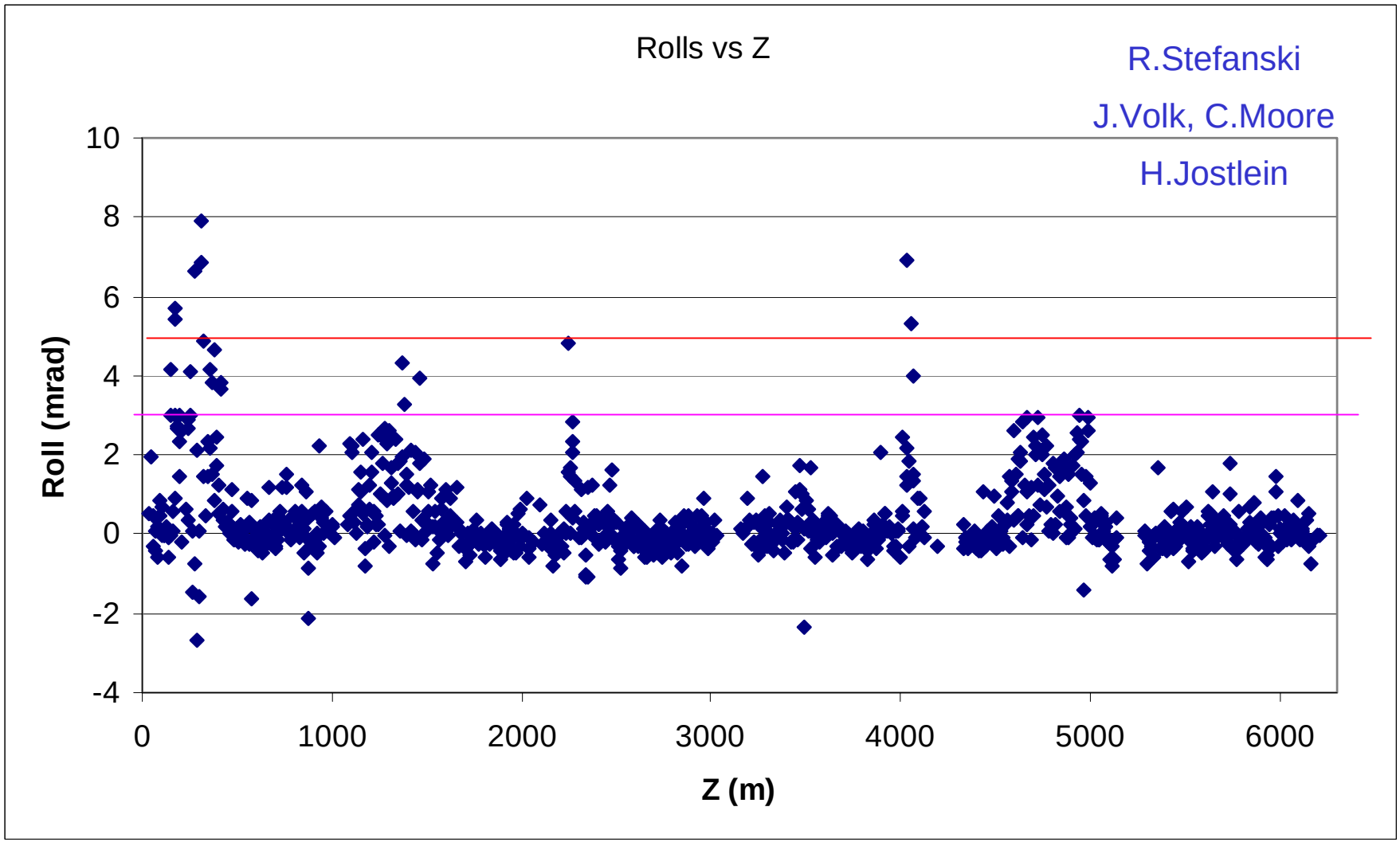
WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.7	**Tevatron Vacuum Improvements**			**$0.00**		**10/17/2003 17:00**	**522 days**	**B.Hanna**
1.3.4.7.1	FY03 plan includes FY03 shutdown (Milest			$0.00		10/17/2003 17:00	0 days	B.Hanna
1.3.4.7.2	FY04: purchase additional ion pumps			$45,000.00	B	3/24/2004 8:00	1 day	B.Hanna
1.3.4.7.3	FY04: Install ion pumps			$0.00	B	7/27/2004 8:00	22 days	D.Allen
1.3.4.7.4	FY05: purchase additional ion pumps			$45,000.00	B	3/23/2005 8:00	1 day	B.Hanna
1.3.4.7.5	FY05: Install ion pumps			$0.00	B	9/19/2005 8:00	22 days	D.Allen

Hanna B.[0.2],Allen D.[0.2],Mechanical Tech.,Electrical Tech.[0.2]
Hanna B.[0.2],Allen D.[0.2],Mechanical Tech.[0.2],Electrical Tech.[0.2]

- Cost estimates provided by B.Hanna

- Goal is maintain and improve Tevatron vacuum
- Progress/plans:
  - F11 RWM outgassing fixed in 2002
  - Bad vacuum in P1 and A1 line → Tev F0 – shutdown'03
  - Fix known leaks
  - "Licensing" every new piece
- Resources are adequate

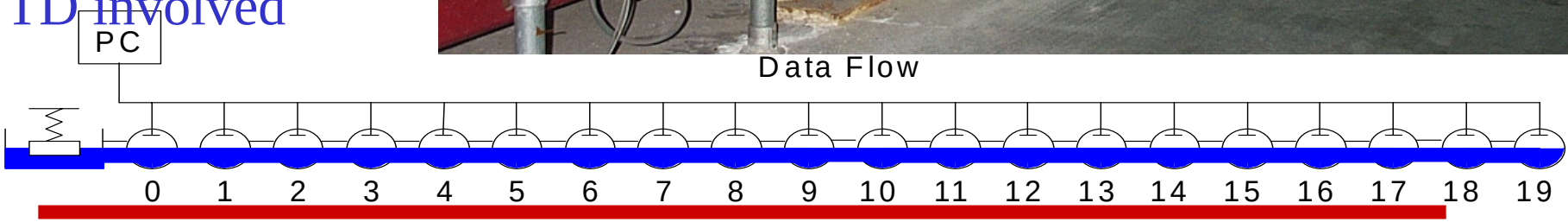
Alignment : Tevatron Magnet Rolls



Tev On-Line Survey System: Elevations and Rolls

J.Volk, BINP(Novosibirsk), V.Shiltsev, D.Plant

- need ”200(800) water level/roll sensors, accuracy 5 ❍m, 0.2 mrad
- 20 sensors 600 m system works fine in MI-8 tunnel for year (0.05 ❍m resol’n) → to be moved to Tevatron B-sector
- TD involved



Tevatron Alignment

WBS	Task	Add	Lab	M&S Est	Conti	Start	Duration	In Charge
1.3.4.8	**Tevatron Alignment**			**$420,000.00**		**1/1/2003 8:00**	**780 days**	**R.Stefanski**
1.3.4.8.1	Helix optimization, aperture and alignment			$0.00	C	1/1/2003 8:00	780 days	G.Annala
1.3.4.8.2	Tevatron Level System			$300,000.00		3/3/2003 8:00	395 days	J.Volk
1.3.4.8.2.1	on-line survey preparations			$20,000.00	C	3/3/2003 8:00	240 days	R.Stefanski
1.3.4.8.2.2	on-line survey installation -1			$0.00	C	8/25/2003 8:00	30 days	R.Stefanski
1.3.4.8.2.3	on-line survey installation -2			$280,000.00	C	7/26/2004 8:00	30 days	R.Stefanski
1.3.4.8.3	Magnet Alignment			$120,000.00		8/25/2003 8:00	540 days	R.Stefanski
1.3.4.8.3.1	Tev alignment 03			$0.00	C	8/25/2003 8:00	40 days	R.Stefanski
1.3.4.8.3.2	Tev alignment 04			$0.00	C	7/26/2004 8:00	40 days	R.Stefanski
1.3.4.8.3.3	Tev alignment 05			$0.00	C	7/25/2005 8:00	40 days	R.Stefanski
1.3.4.8.4	Smart Bolts			$0.00		1/1/2003 8:00	708 days	D.Harding
1.3.4.8.4.1	smart bolts 03			$0.00	C	8/25/2003 8:00	40 days	D.Harding
1.3.4.8.4.2	smart bolts 04			$0.00	C	7/26/2004 8:00	40 days	D.Harding
1.3.4.8.4.3	smart bolts 05			$0.00	C	7/25/2005 8:00	40 days	D.Harding
1.3.4.8.4.4	B-field diagnostics			$160,000.00		1/1/2003 8:00	500 days	P.Bauer
1.3.4.8.4.4.1	B-field diagnostics (initial)			$60,000.00	B	1/1/2003 8:00	200 days	P.Bauer
1.3.4.8.4.4.2	B-field diagnostics (continuing)			$100,000.00	C	10/8/2003 8:00	300 days	P.bauer

Volk J.[0.2],Stefanski R.[0.1],Mechanical Tech.
Volk J.[0.5],Stefanski R.[0.3],Survey Crew,Mechanical Tech.[2]
Volk J.[0.5],Stefanski R.[0.3],Survey Crew,Mechanical Tech.[2]
Physicist[0.5],Survey Crew
Physicist[0.5],Survey Crew
Physicist[0.5],Survey Crew
Physicist[0.5],Survey Crew,TD Mechanical Tech.[2]
Physicist[0.5],Survey Crew,TD Mechanical Tech.[2]
Physicist[0.5],Survey Crew,TD Mechanical Tech.[2]
TD Physicist[2],TD Mechanical Engineer[2]
TD Physicist[2],TD Mechanical Engineer[2]

In review (to be finished by DoE review)

Cost estimates provided by D.Harding, J.Volk, BINP(Novosibirsk)

Tevatron Alignment

- Goal of the project – keep Tev magnets aligned and correctors not saturated
- Status/plans:
  - 10 tiltmeters report on-line
  - 26 HLSs in B-sector in '03, ring-wide in 2004
  - Upgrade survey system
  - Fix smart bolts in '03-'04
  - Unroll and realign where necessary
- Tight on people to do analysis, closely linked to Tev Task Force work, TD and PPD help essential, may require access time

Summary on Tev Projects Milestones

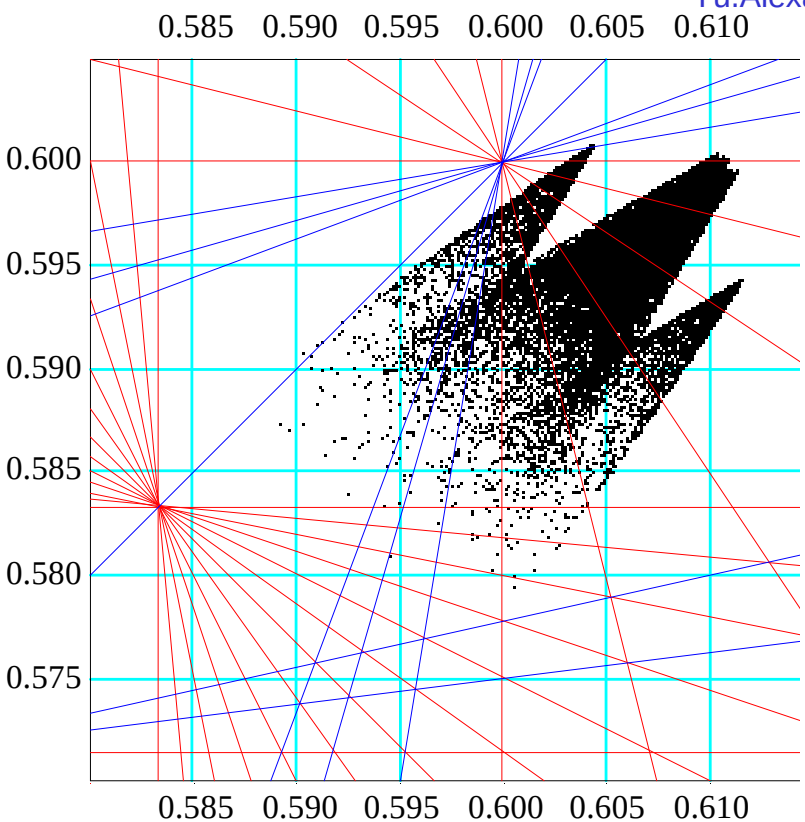
WBS	Subproject/Milestone	MS Class	MS Date
1.3.4	**Tevatron High Luminosity**		
1.3.4.3	Active Beam-Beam Compensation		
1.3.4.3.1	BBC: Tevatron Electron Lens		
1.3.4.3.1.5	Review TEL R&D (Milestone)	C	3/23/04
1.3.4.3.1.6	Decision on second TEL (Milestone)	B	12/15/04
1.3.4.3.1.11	TEL System Operational (Milestone)	A	5/23/07
1.3.4.3.2	BBC: Wires		
1.3.4.3.2.3	Decision to proceed with wire station prototype (Milestone)	C	9/29/03
1.3.4.3.2.8	Decision on wire BBC (Milestone)	B	1/19/05
1.3.4.3.2.13	Wire BBC Operational (Milestones)	A	4/23/07
1.3.4.4	Increased Helix Separation		
1.3.4.4.3	Long Separators		
1.3.4.4.3.11	increased BB separation operational (milestone)	A	3/30/07
1.3.4.4.4	Coated Separators		
1.3.4.4.4.2	Decision on high voltage separators (Milestone)	B	4/28/04
1.3.4.4.5	Additional Seperators		
1.3.4.4.5.3	Decision on separators/magnets (Milestone)	B	9/1/03
1.3.4.5	Luminosity Leveling		
1.3.4.6	Improved Control and Diagnostics		
1.3.4.6.4	Tevatron BPM Upgrade		
1.3.4.6.4.3	Tev BPM: Review (Milestone)	C	10/1/03
1.3.4.6.5	Tevatron IPM		
1.3.4.6.5.3	Design Review, decision to proceed	C	10/1/03
1.3.6.2	**Project Milestones**		
1.3.6.2.1	Review: Tevatron Upgrade Plan (Milestone)	B	9/29/03

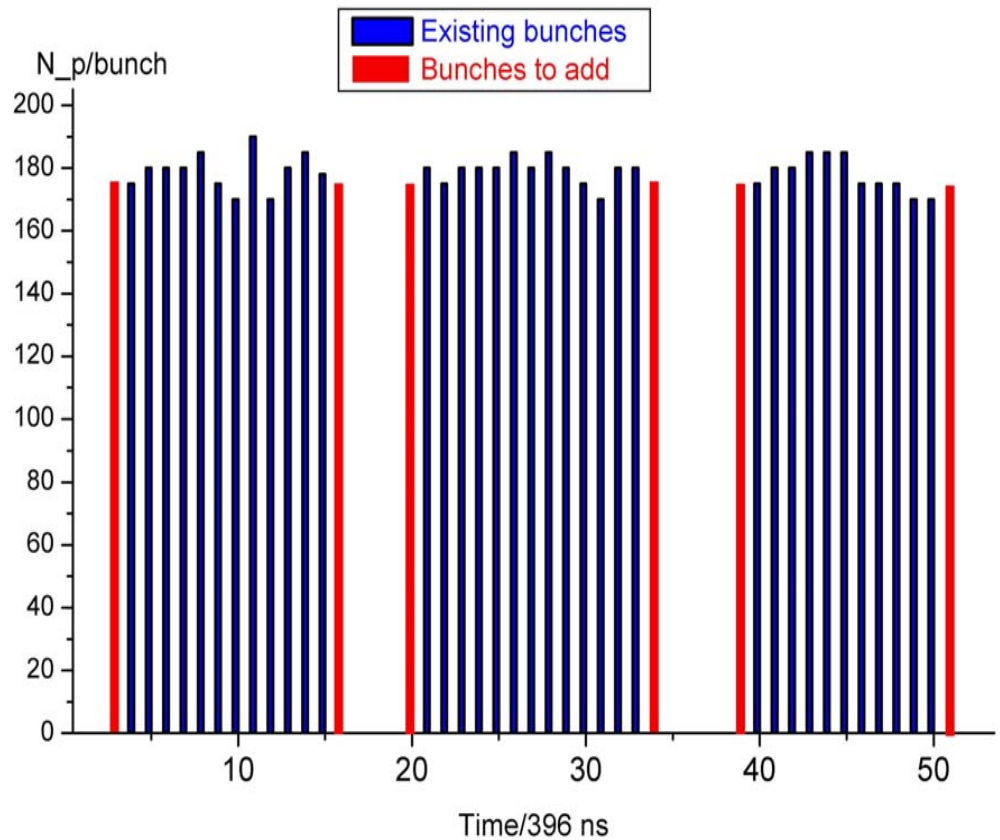
Back-up slides

- Beam-beam
- BBComp
- Instabilities
- misc

Add 6 Proton Bunches

Yu.Alexahin



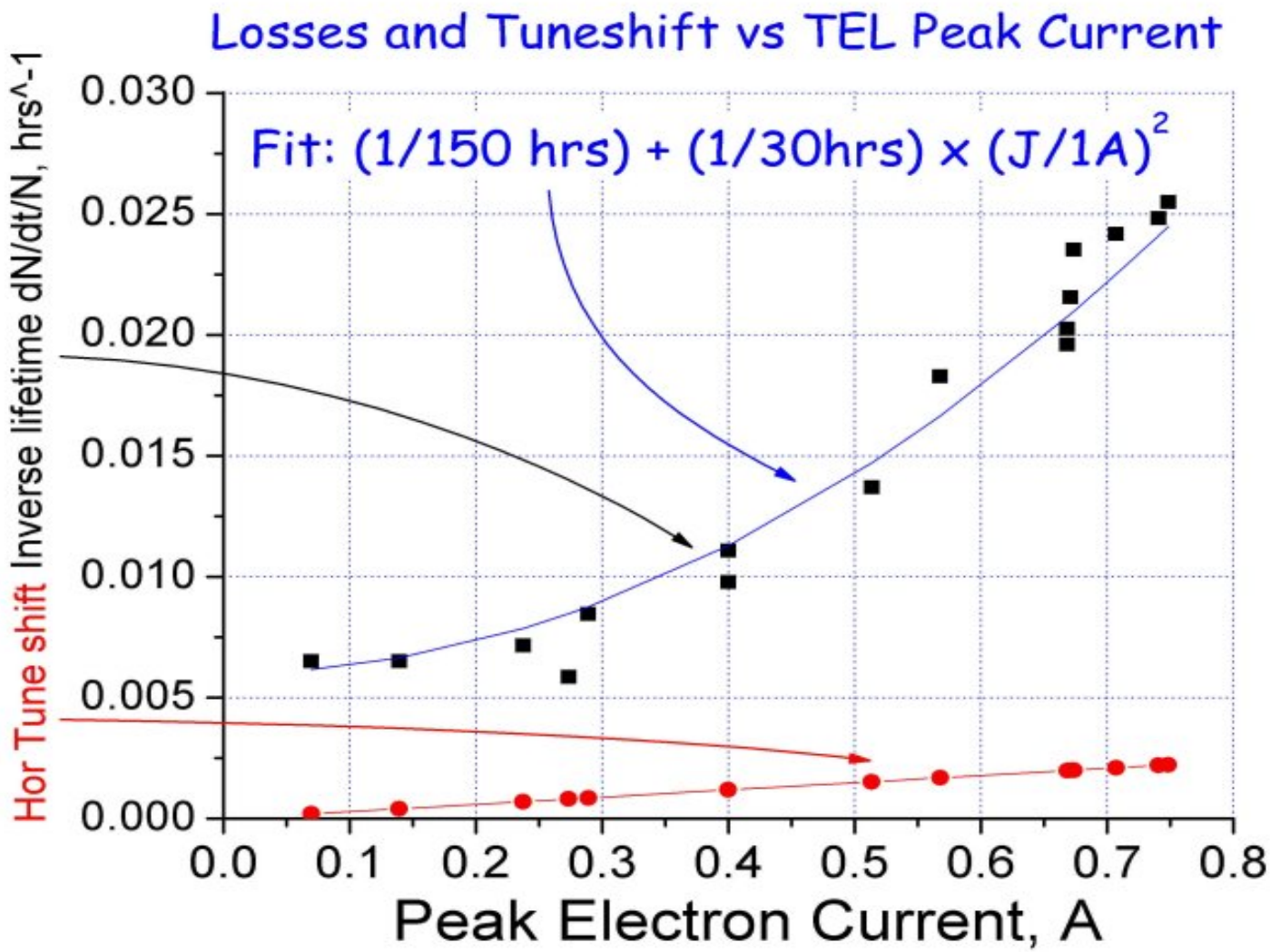


- Will help at HEP only – reduce pbar bunch tune spread
- Will make beam-beam worse at 150 GeV, ramp, squeeze; faster kicker
- Plan: consider details and, perhaps, perform beam studies

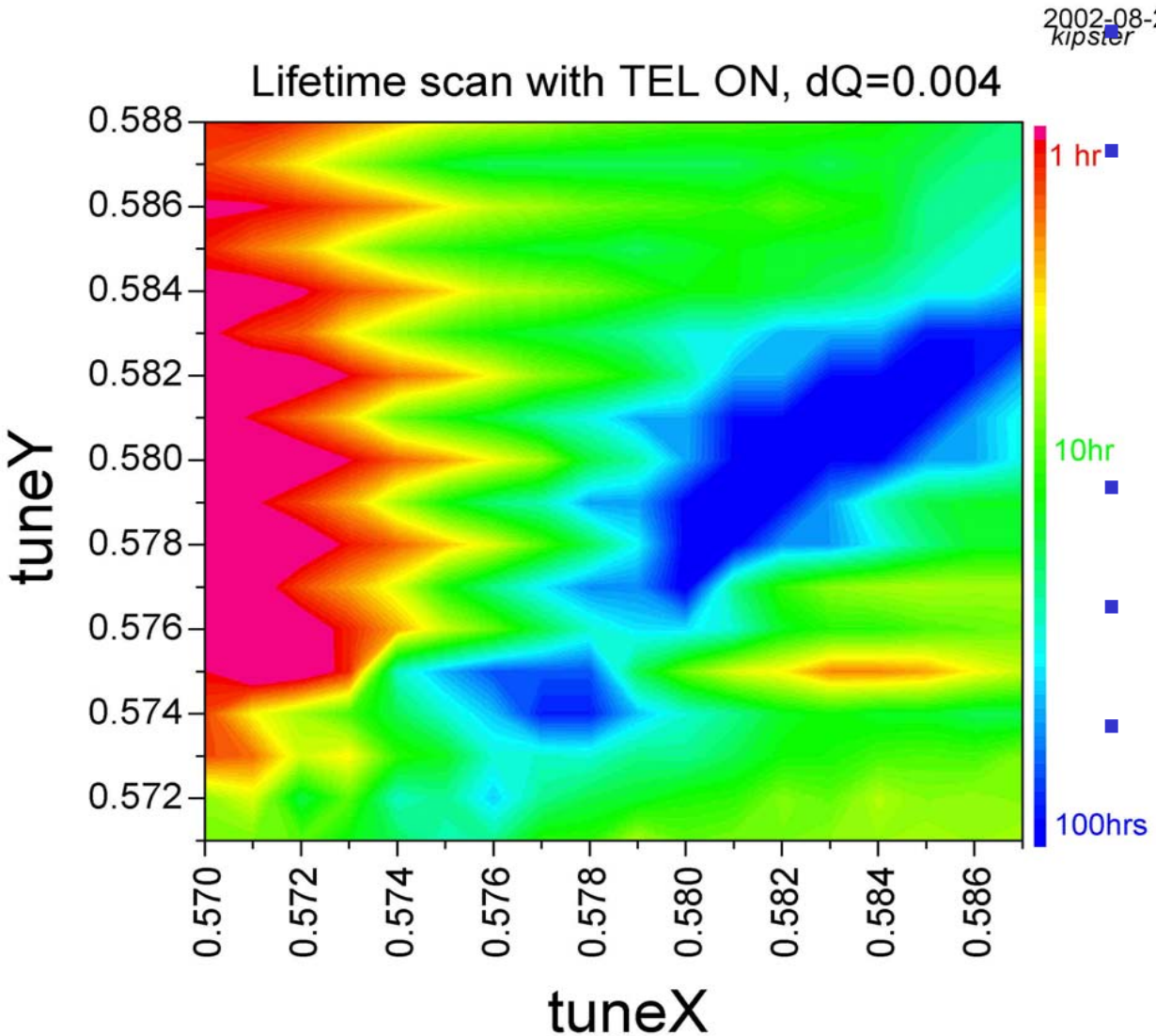
Comments on B-B Compensation

- Status:
  - dQ~0.009 tuneshift achieved
  - the best p-beam lifetime of ~100hrs achieved
  - lifetime strongly dependent on tunes = N-L B-B
- Plan:
  - need wider or Gaussian e-beam, center better
  - better beam current and position stabilization
  - new HV modulator
  - spares
  - TEL-2

Beam-Beam Compensation - I

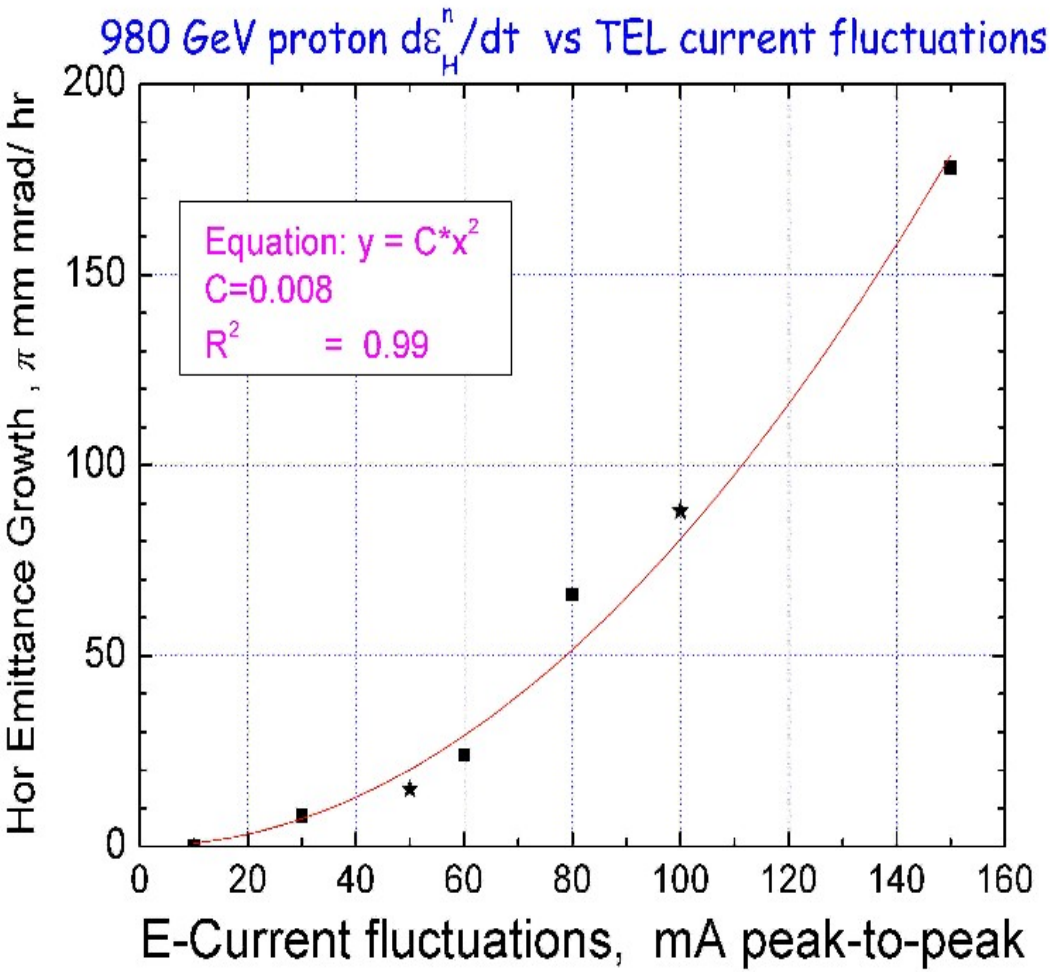


Beam-Beam Compensation - II



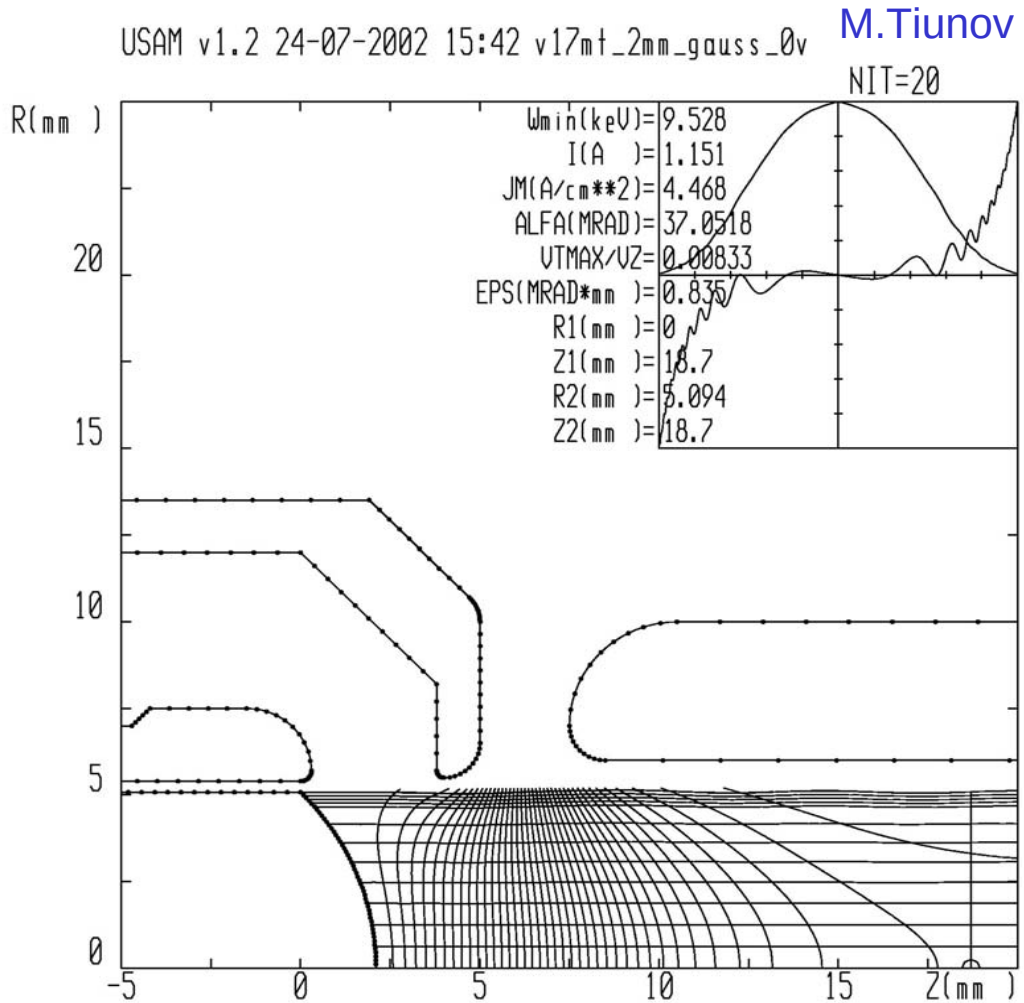
- TEL e-current noises are small
- p(pbar) lifetime reduction due to TEL comes from non-linear beam-beam effects - "donut collimator"
- Lifetime at good WPs is about 100 hrs
- e-beam positioning is important
- Smoother edge e-beam is needed → Gaussian gun

Beam-Beam Compensation - III



- TEL e-current turn-by-turn noise amplitude while operating for BBC with dQ > 0.005 dJ_e ~3-5mA p-p
- → 0.1-0.2 □/hr
- That is comparable with "natural" emittance growth of 0.2-0.5 □/hr
- → we plan to consider possibilitie for dJ_e and dX_e stabilization

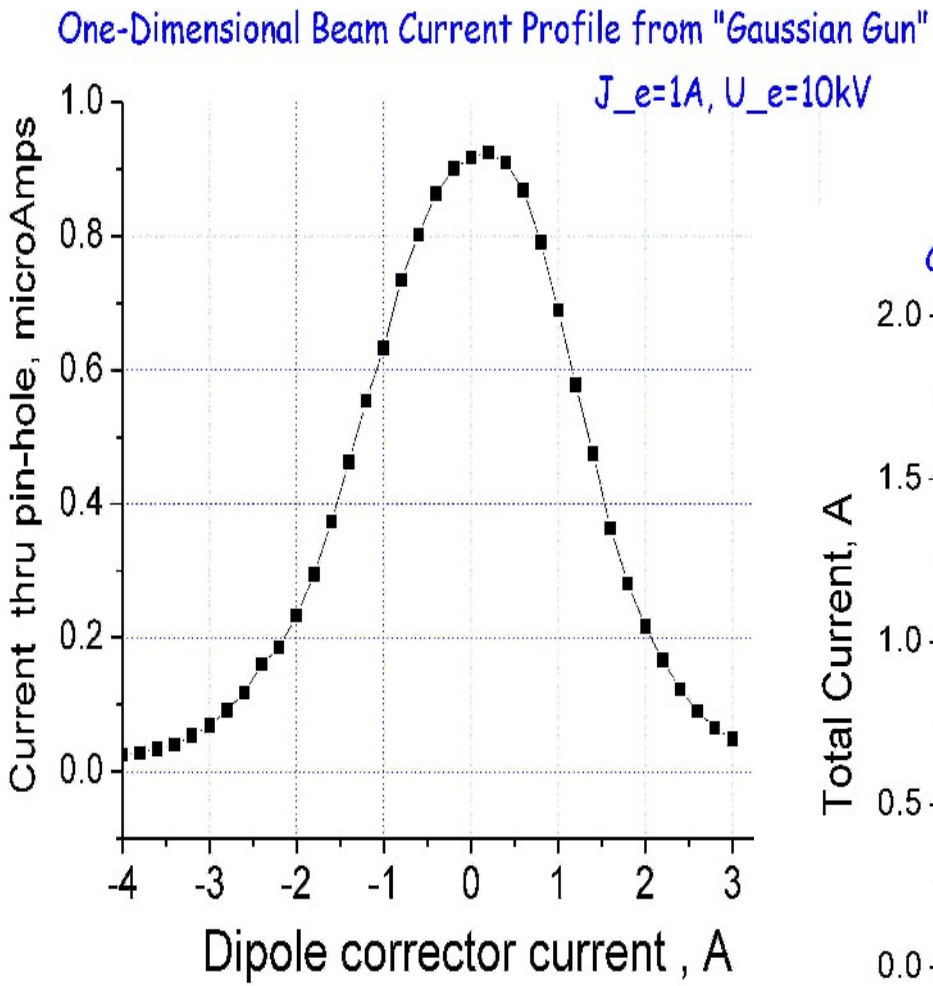
Gaussian Gun for TEL

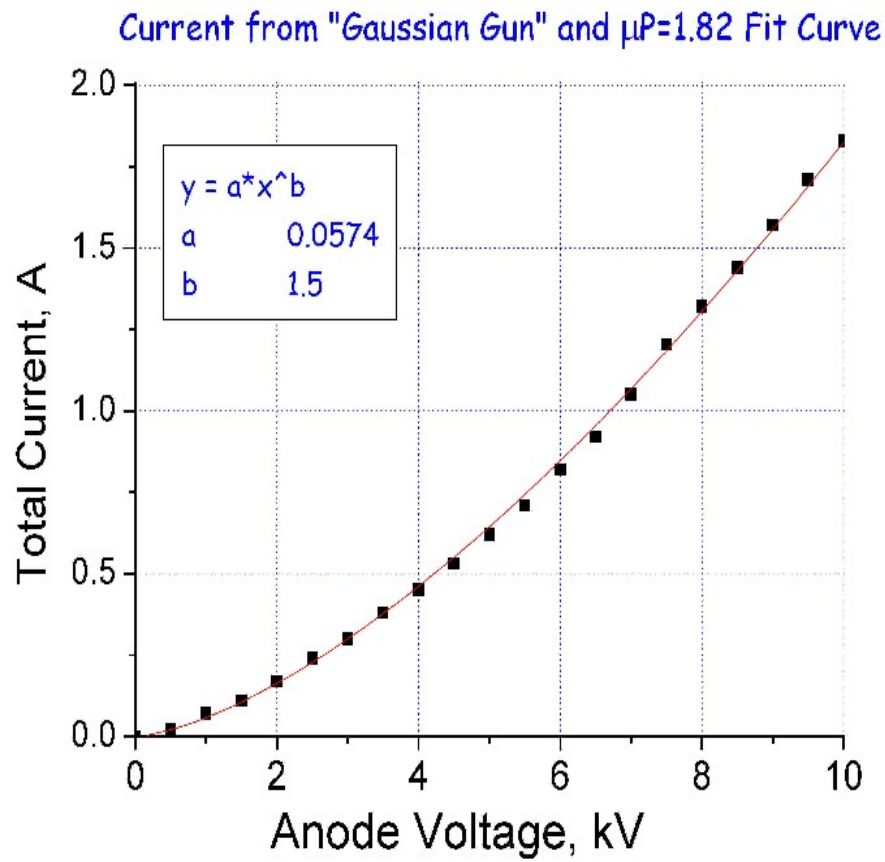


- Profile controlled by special electrode
- Somewhat reduced current density in the center → need of higher voltage
- Installed Jan

Gaussian Gun for TEL - II

G.Kuznetsov,
K.Bishofberger
N.Solyak



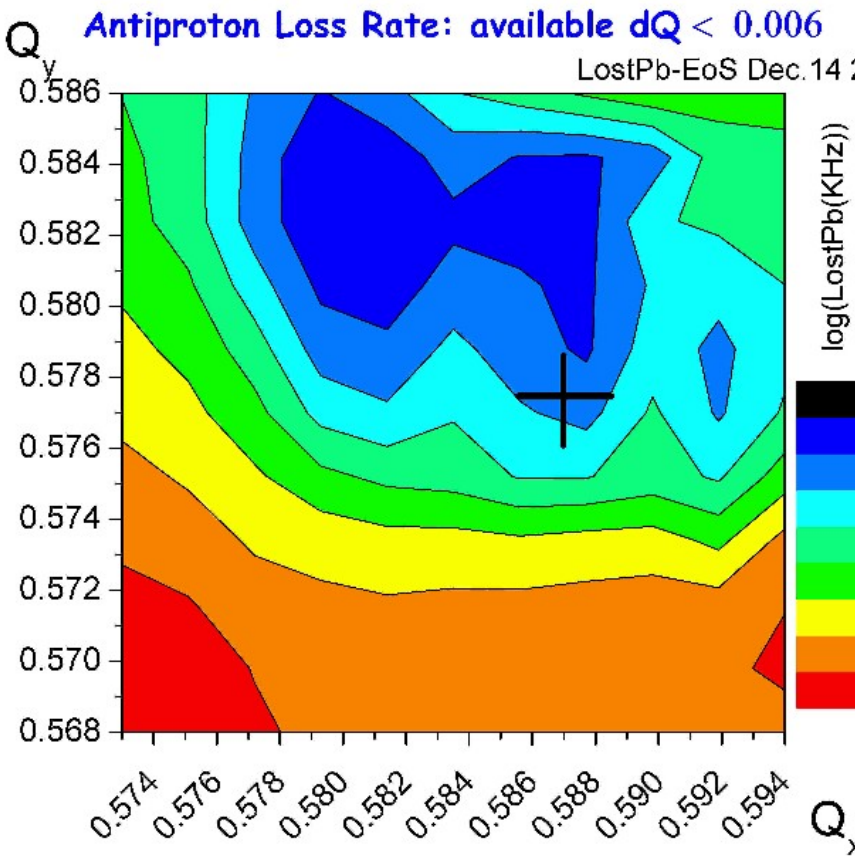


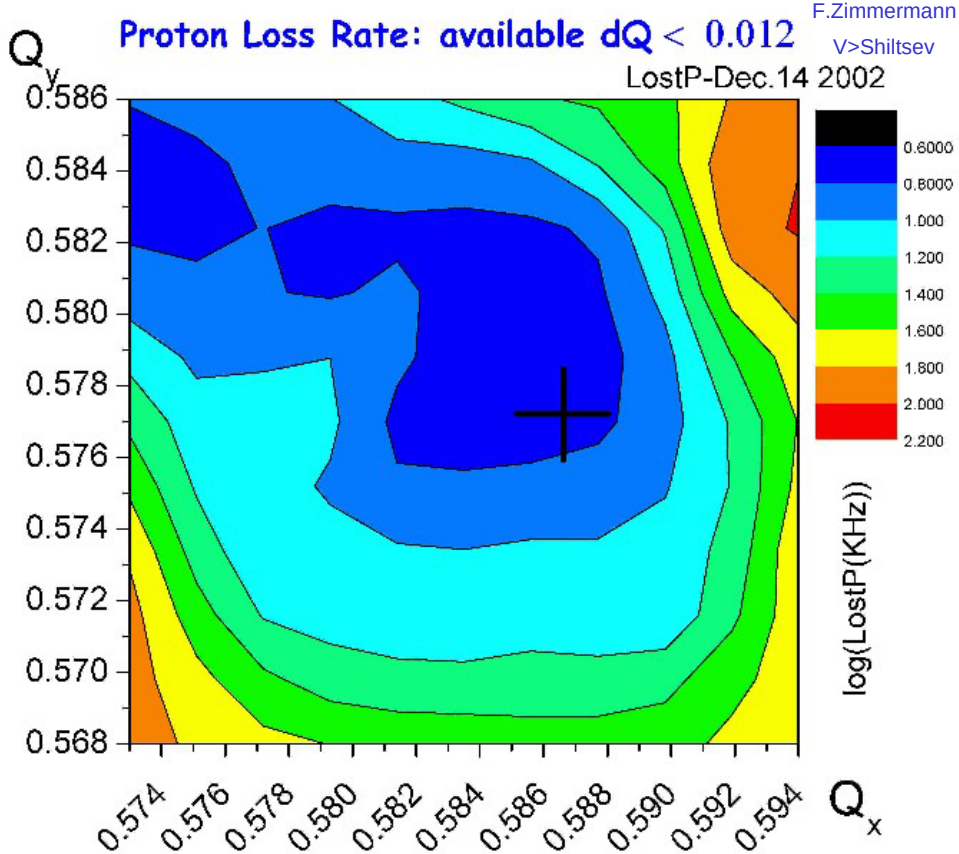
Comments on Wire Compensation

- "One wire per parasitic IP" – only few can be installed
- Few(4?) wires can handle near IP crossings if installed at proper locations (near IP)
- That will leave unaddressed beam-beam issues at 150, ramp and squeeze and will not fix "head-on"
- Pulsed wires - tough vs DC
- Plan:
  - Consider gain (simulations) and technical details
  - Closely watch progress with wires at CERN

Beam-Beam Effects Now: HEP

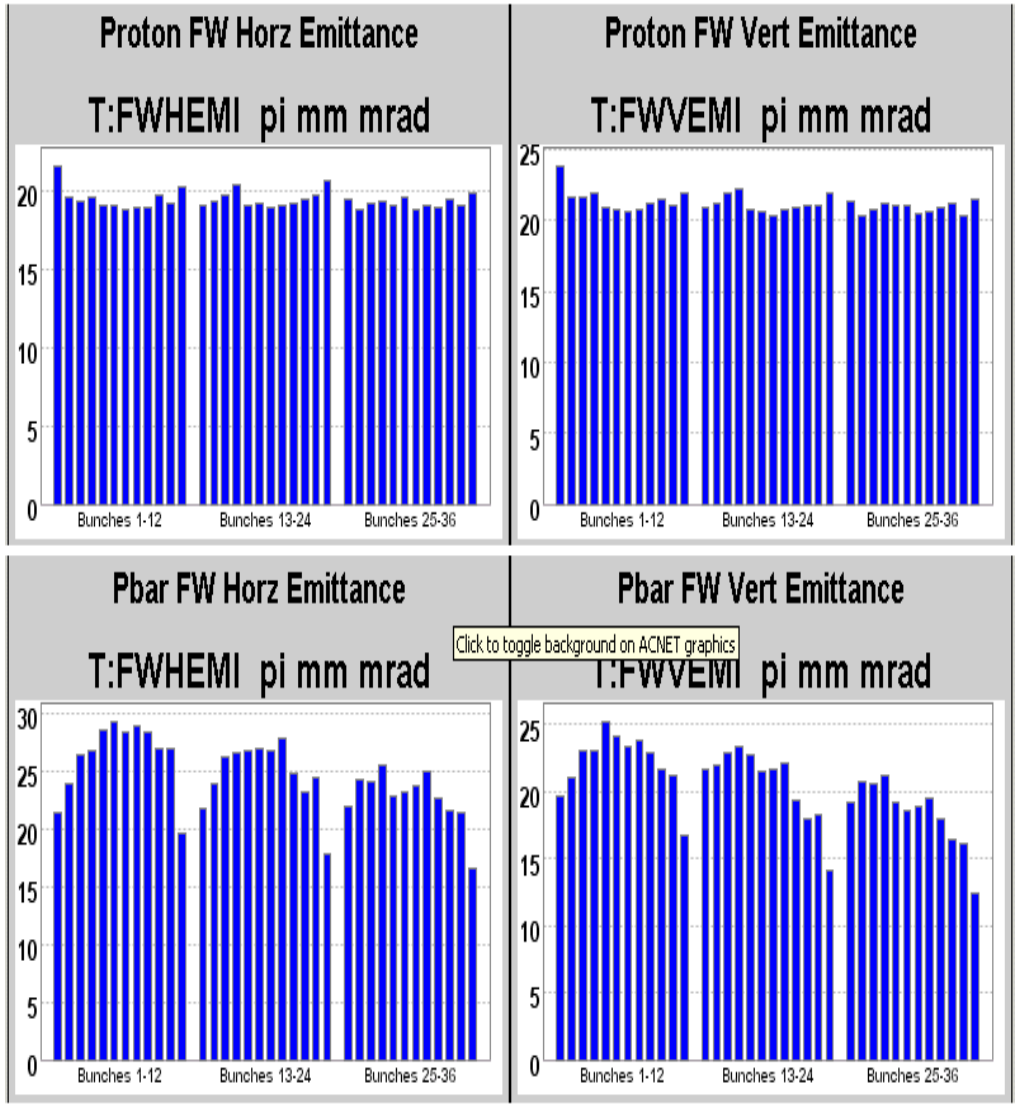
hang, M.Xiao
K.Bishoberger,
F.Zimmermann
V>Shiltsev





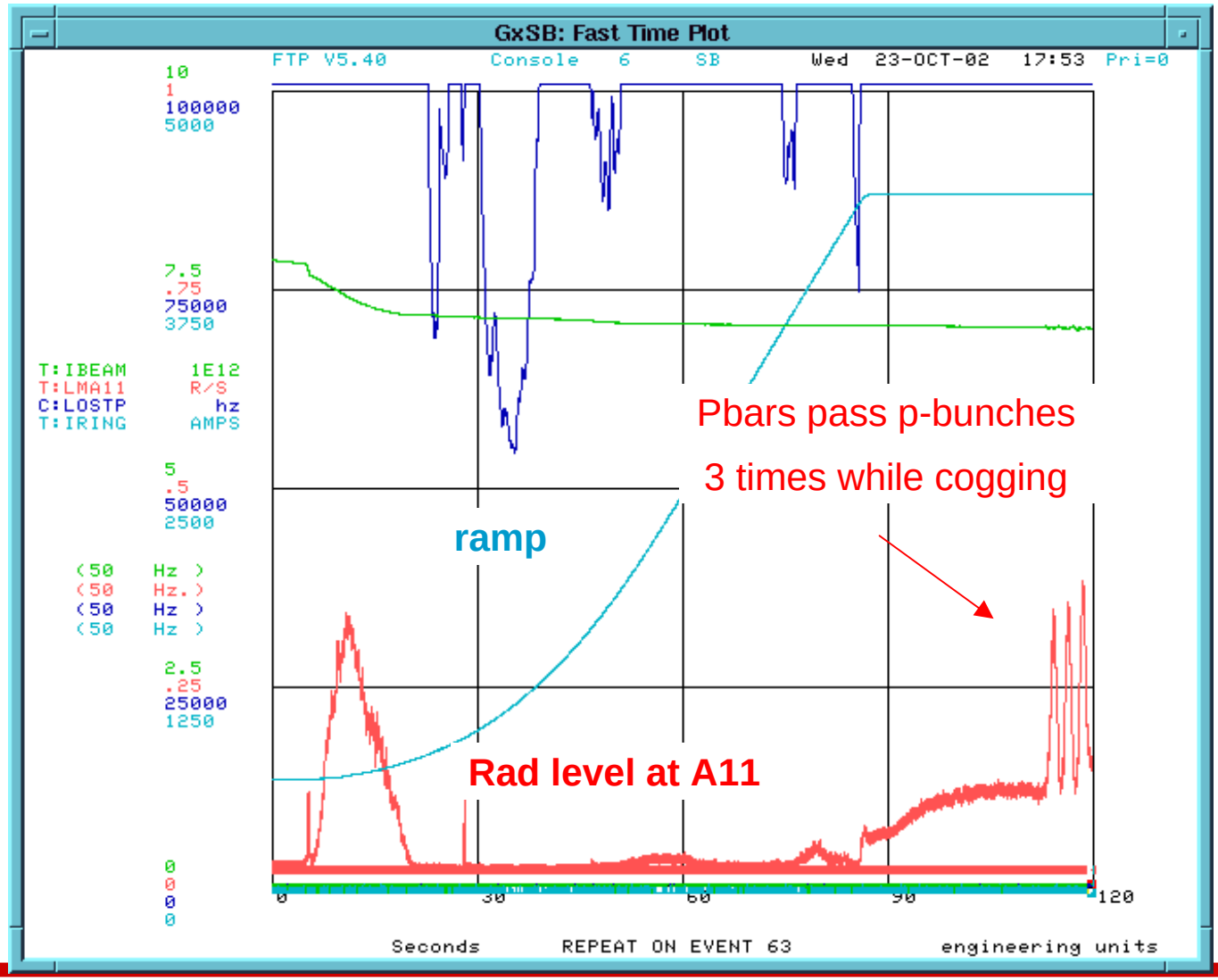
- At the beginning of the store available WP area is even smaller dQ < 0.004 … and this is at N_p=180e9
- No available tune WP space expected above 240e9

Beam-Beam: Bunch-by-Bunch

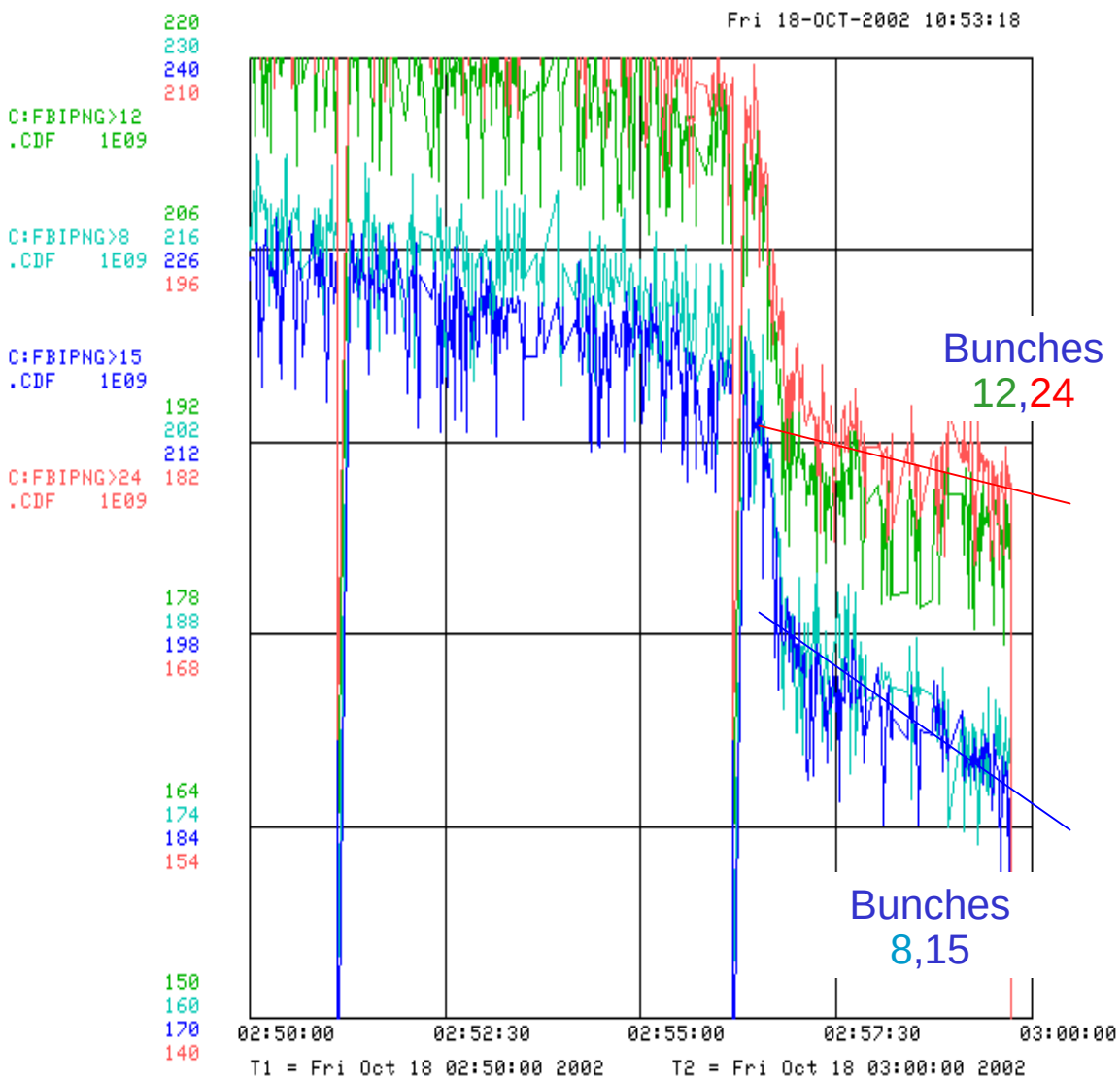


- "Scallop" profile of bunch emittances
- At the beginning of the store

Proton Losses While Cogging Pbars



Beam-Beam Effects in Protons



See losses in squeeze in store #1868

- Losses of bunches #12,24,36 were small (1e9/min)
- All other bunches lost intensity very fast (4e9/min)
- That resulted in quench at A11

We have small "anti-scallop" ("smile") effect in proton emittances at HEP

- Bunches #1,12,13,24,25,36 have 1-2 pi larger emittances than others after being 1-few hours in collisions
- Their intensity lifetime is smaller, too

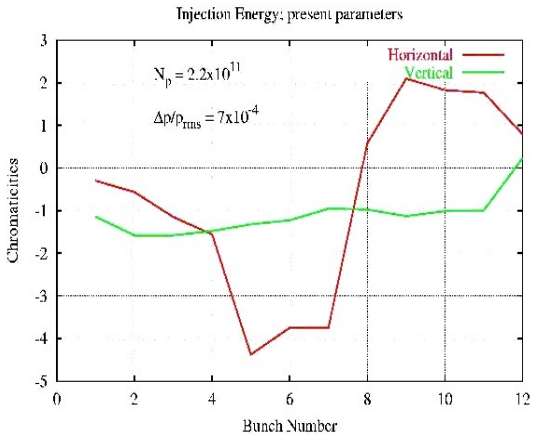
Antiprotons also help to make protonbeam more stable on ramp and squeese

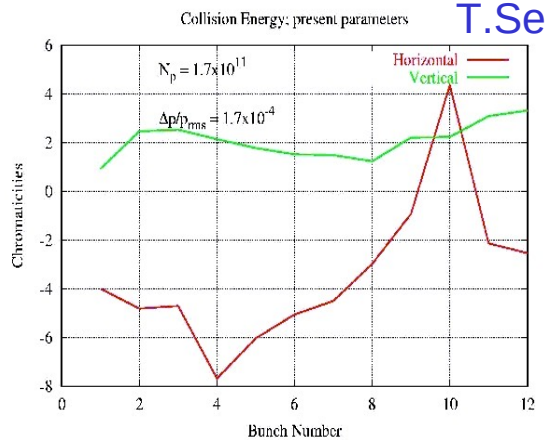
- Proton instability is rarely observed in 36x36 stores compared to the same intensity 36x0 stores
- Tune spread due to pbars is about (few)e-4

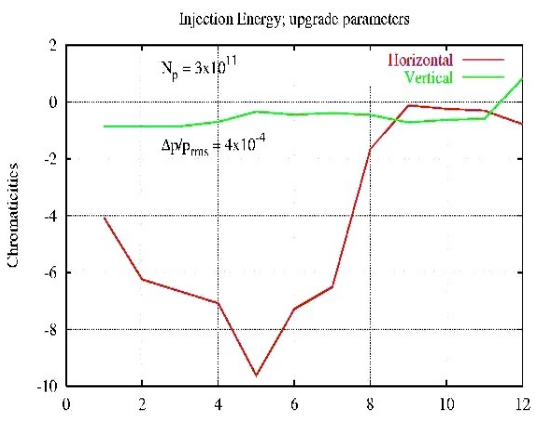
Comments on Beam-Beam Issues

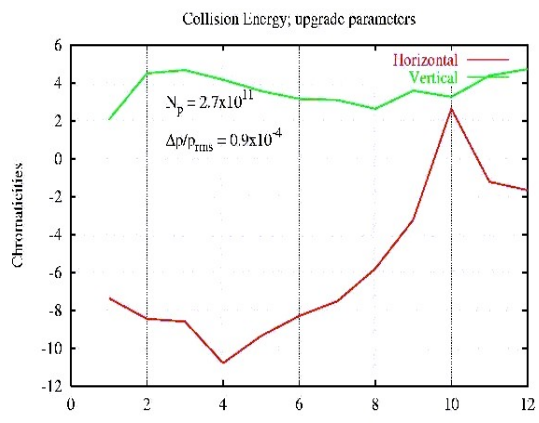
Small amplitude beam-beam chromaticities

T.Sen



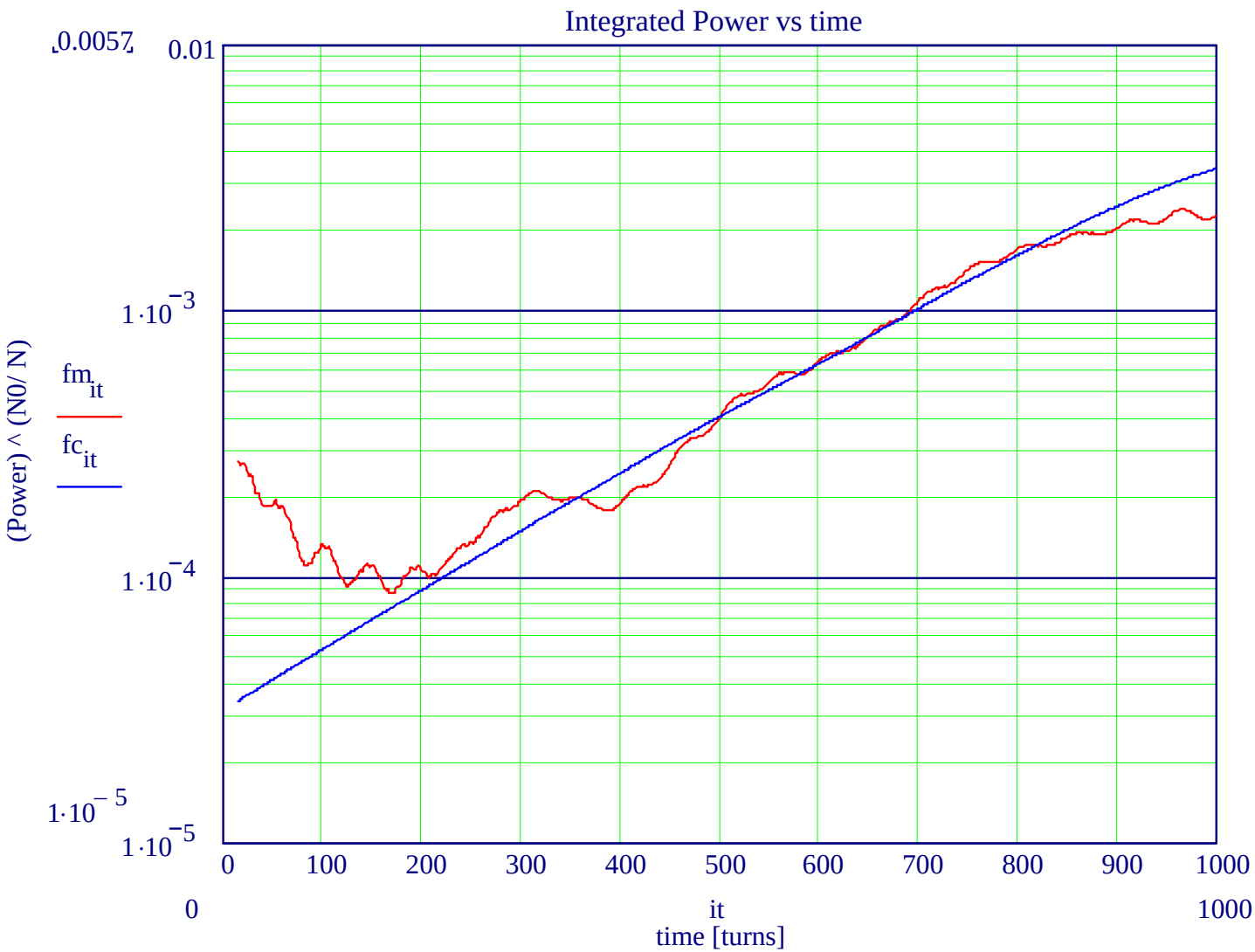






- So far numerical tracking can not explain beam lifetime, DA simulations qualitatively agree with observations but do not have quantitative predictive power
- Phenomenological models are simple ("soft collimator", Valery's model) and not backed up by theory
- We are aware of parameters important for beam-beam other than N_p, tunes, emittances : chromaticities, coupling

Control of Beam Instabilities



P.Ivanov,

A.Burov,

V.Scarpine

150GeV, 270e9/bunch

Chromaticity = -2.6

1/♦ = 130 ±15 1/sec

or 370 turns

Comments on Beam Instabilities

- Status (see also Mike Martens talk):
  - Transverse "weak head-tail instability" identified
  - Dampers "semi - helpful": only at 150 GeV, still +C_v,h
- In Run IIU
  - damping time should be 50% faster (i.e., 300 turns→200)
  - need dampers for both proton and pbar beams
  - damper modification for better control of higher modes
  - remove sources of impedance where possible
- Plan:
  - Learn more from current experience

Injection Issues

- Status:
  - BLT operational (<0.5 mm error)
  - A1→ Tev emittance mismatch not fixed
  - Injection dampers are coming soon
  - Strange blowup on ramp
- In Run IIU
  - challenge is to deliver much higher intensity beams with the same or smaller emittances
  - smaller transfer losses require smaller emittances at injection
  - does not seem that there is much that can be done in the Tev if injection dampers work and A1/Tev mismatch fixed
- Plan:
  - Learn more from current experience
  - Study noise effects

Control of Machine Parameters

- Status:
  - Control of orbit, tunes, chromaticity, coupling quite an issue now (see M.Martens talk)
- In Run IIU
  - Need fast on-line diagnostics of tunes, chromaticity and coupling; p/pbars; bunch-by-bunch - NOW
  - Need of on-line data on magnetic fields in the Tevatron magnets – *in situ* or reference dipole(s), quad(s)
  - On-line measurements of magnet rolls, quad positions
  - faster alignment, fix stands
- Plan:
  - Involve TD, CD, other labs

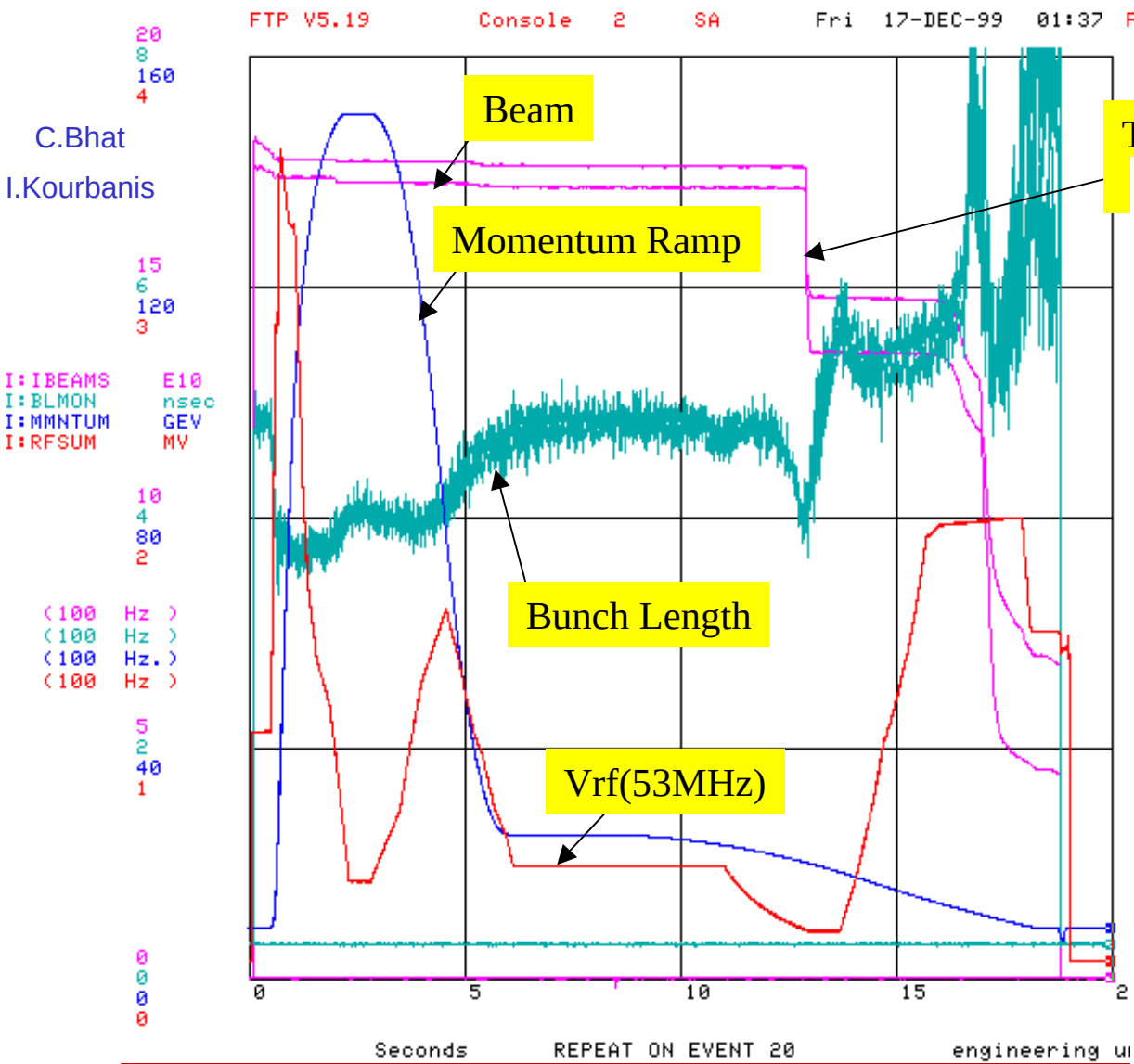
Lumi-Leveling Issues

- Needed (?) for detectors to reduce number of interactions per crossing:
  - still not certain at what level
  - not an issue now
- will impact the integrated luminosity
- There are operational concerns such as tune and orbit control over a range of β^* values and control of the beam halo rates and beam halo scraping during the leveling process.
- Plan:
  - some experiments possible

Recycling Issues in the Tevaron

- Needed (?) if recycling beneficial for integrated *L*
- proton removal:
  - dog-leg exists at E0
  - few unsuccessful attempts
- pbar deceleration:
  - tried in Run I, no problem
- pbar extraction:
  - b_2 drifts at extraction porch need to be compensated
- larger emittances wont allow 100% decel and extr
- Plan: attempt fast p-removal in FY - operational

Deceleration in MI



- p-deceleration attempted in MI
- issues: MI will accept only 3eVs from Tev
- at 25 GeV switch from 53MHz to 2.5MHz to reduce dP/P, then go thru transition→ extract to RR

Diagnostics/Hardware for Run IIu

- Need to improve existing diagnostics and hardware

  (see M.Martens talk)
- Besides that:
  - On-line chromaticity, tune, coupling, etc
  - DC beam diagnostics
  - Magnetic measurements
  - On-line survey system
  - Better/stronger dampers …

Beam Studies for Run IIU in FY03:

- If the study time wont be reduced, in the remaining 8 mos of FY03 we will have 160 shifts for beam studies
  - subtract maintenance (~60 shifts) and after shutdown recovery (~20 shifts)
- Out of remaining 80 we can dedicate upto 20% (1 shift a week, or total of 10-16 shifts) to Run IIU issues:
  - perfect beam models: 6
    - Beam-beam vs N_p, separation, sigma_s, cogging
    - Long. and transv. IBS vs noise in $d\mathcal{M}/dt$
    - Multibunch instabilities (longitudinal)
  - TEL 5
  - β^* variation (35cm→25cm or 35cm→100cm) 2
  - proton removal (deceleration? extraction?) 2

Run II Upgrade Summary Table

Compared to now

x1.5 ➡ Protons/bunch

x5 ➡ Pbars/bunch

x3.5

x5.7 ➡ Avg. Pbar Prod.Rate

	Typical Run Ib	Store 1953	Goal: FY03	Run II Target	
Peak Luminosity	1.6	3.7	6.6	33.0	$x10^{31} cm^{-2} sec^{-1}$
Integrated Luminosity	3.1	6[1]	12.0	70.0	pb^{-1}/wk
Store hours per week	84	86[1]	81[3]	98	
Interactions/crossing	2.5	1.0	1.7	8.5	
Pbar Bunches	6	36	36	36	
Form Factor	0.59	0.60	0.63	0.63	
Protons/bunch	23.0	16.3	24.0	27.0	$x10^{10}$
Pbars/bunch	5.6	2.5	3.1	13.5	$x10^{10}$
Total pbars	33.6	91.0	113.0	486.0	$x10^{10}$
Peak Pbar Prod. Rate	7.0	11.5[2]	18.0	45.0	$x10^{10}$/hr
Avg. Pbar Prod.Rate	4.2	6.9	11.0	40.0	$x10^{10}$/hr
Pbar Transmission Eff.	50	60	80	85	%
Stack Used	67	152	141[4]	572	$x10^{10}$
$\beta*$	35	35	35	35	cm
MI extraction Long.Emit.		3.5	2.5	2.5	eV s
Bunch Length (rms)	0.6	0.6	0.54	0.54	m
Proton Emittance (at coll)	23	19	20	20	π-mm-mrad
Pbar Emittance (at coll)	13	14	15	14	π-mm-mrad
Store Length	16	22	15	9	hr

(1) typical for Dec-Jan 03 (other numbers in this column are for store 1953)

(2) best stacking rate achieved $13.1x10^{10}$/hr

(3) excluding studies

(4) additional pBar stack used for RR commissioning