Strategy for Achieving Sub-micron Orbit Stability at the APS

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Systematic Effects Impacting APS Orbit Correction

RF BPM systematic effects

- Timing / trigger stability
- Intensity dependence
- Bunch pattern dependence
- The "rogue" microwave chamber modes
- Electronics thermal drift

X-ray BPM systematic effects

- Stray radiation striking X-bpm blade pickups
- X-bpm blade misalignment
- Electronics thermal drift
- ID Gap-dependent effects

  (e.g. sensitivity, steering)

Extrinsic systematic effects (noise sources)

- Magnet power supply noise / ripple
- RF system high voltage power supply
- Mechanical vibration
- Thermal effects (Tunnel air / water temperature)
- Earth tides
- Insertion device gap changes

APS Orbit Correction Hardware

1. Beam Position Monitors

- *Broadband BPMs (MpBpms)*
- *Narrowband BPMs (NbBpms)*
- *X-ray BPMs*

2. Corrector Systems

- *“Fast” corrector system*
- *“Slow” corrector system*

3. Orbit Feedback systems

- *“AC” (RTFB) orbit feedback system*
- *“DC” orbit feedback system*

Orbit Stability/ Improvement Strategy Summary

Source Point or Correction System	Types of BPMs used	Present Orbit Stability	Orbit Stability Improvement Strategy at APS
BM - Vert	X-Bpm	< 1 micron	Further improvement is not planned
BM - Hor	MpBpm	Few microns	1. Employ “cogging” - in progress
ID - Vert	NbBpm	* 1.1 microns	1. Add more NbBpms hardware - planned 2. Add XBpms in orbit config. - in progress
ID - Hor	NbBpm/ MpBpm	* 1.5 microns	1. Add more NbBpms hardware 2. Add XBpms in orbit config. - in progress 3. Employ “cogging” - in progress
DC Orbit Correction System			Increase DC BW - alleviate global orbit transients due to gap change effects
AC Orbit Correction System			1. Add 2nd Fast corrector - not planned 2. Add NbBpms/Xbpms in configuration

* RMS Motion computed at User sources from 0.01 Hz to 30 Hz

Cogging Mode - MpBpms

- **What is “Cogging”?**

  The “Cogging” mode sequences MpBpms electronics through all bunches to measure beam position as compared to measure at a fixed bunch (target bunch)

- **This results in reduced systematics such as bunch pattern and intensity dependence effects**
- **This will allow to use more MpBpms in orbit configuration**

Background Stray Radiation Effects on ID X-Bpms

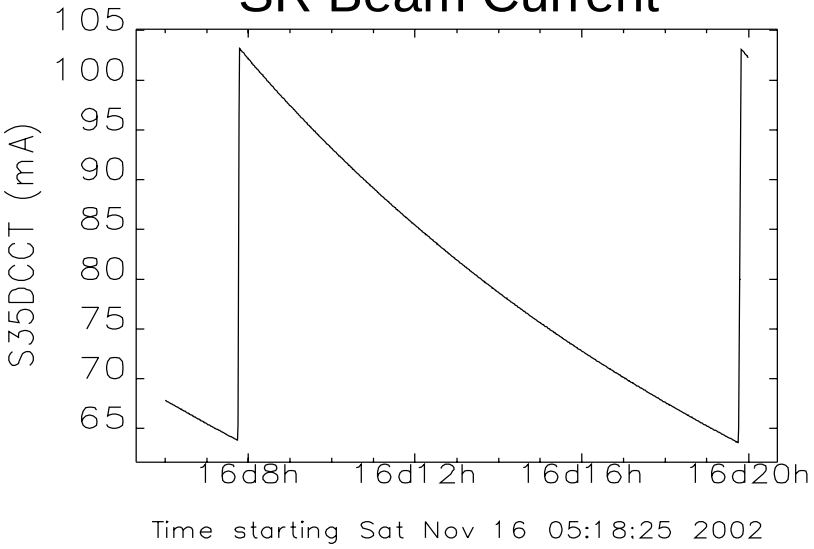
- **Contaminates insertion device radiation on the Xbpm blades**
- **“Lattice Modification” has reduced stray radiation by a factor of > 20**
- **About 1/2 SR Sectors have been modified**
- **ID Xbpm data, now, used routinely for user reference orbit at a fixed gap**
- **Study of ID X-Bpm data as gap varies in progress**
- **ID X-Bpm Feedforward with gap may be one solution which will allow to include ID X-Bpm in the orbit configuration**

ID Steering Effects with gap changes

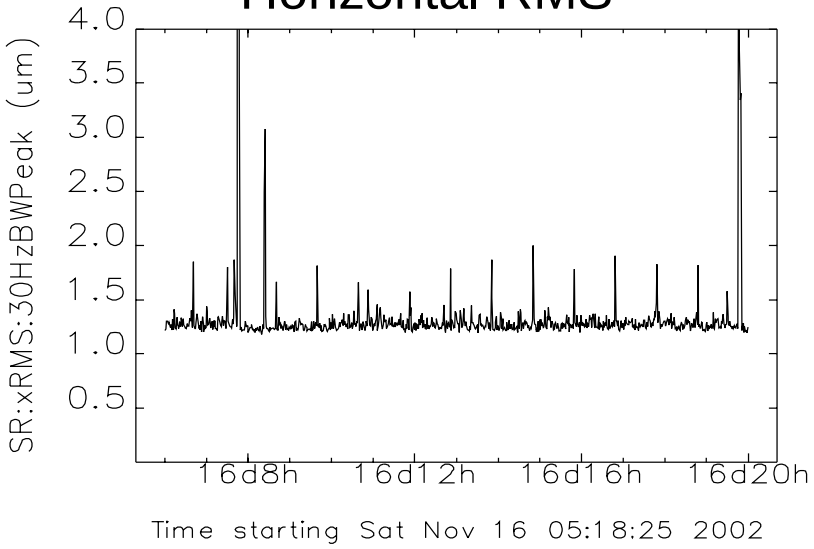
- **Causes global orbit distortion, if not corrected**
- **Causes global orbit transients as gap varies**
- **Causes X-ray centroid to vary which is unobservable by rfBpms**
- **May effect blade response due to centroid shape/ and or position changes**
- **Places fundamental limit of several microrad on DC pointing stability as gap varies**

ID Steering Global Transient Effects - 12 Hrs of Operational Run

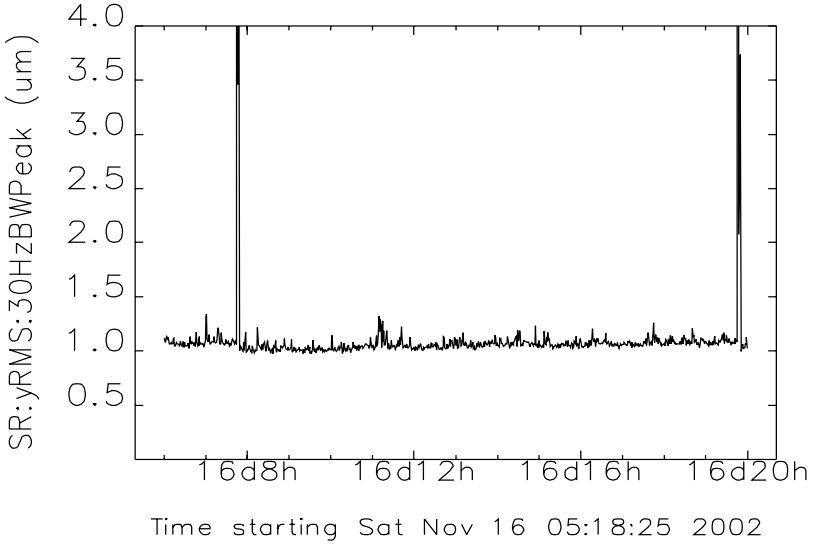
SR Beam Current



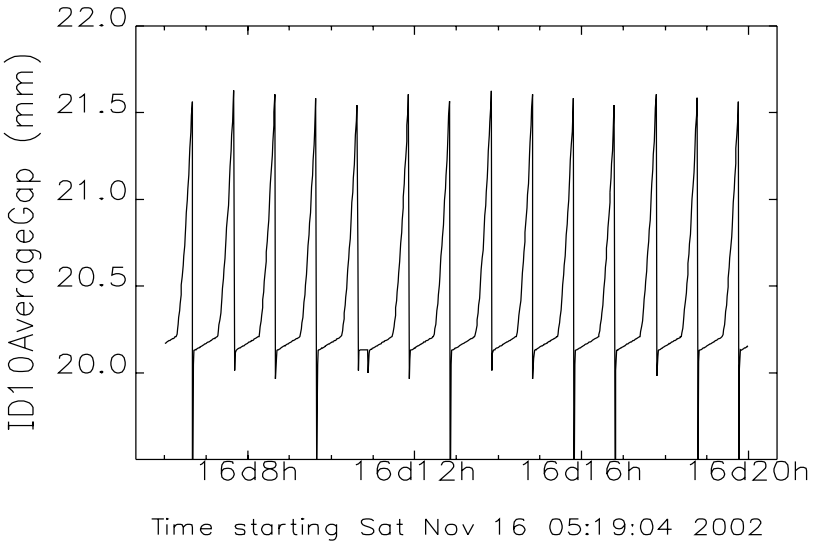
Horizontal RMS



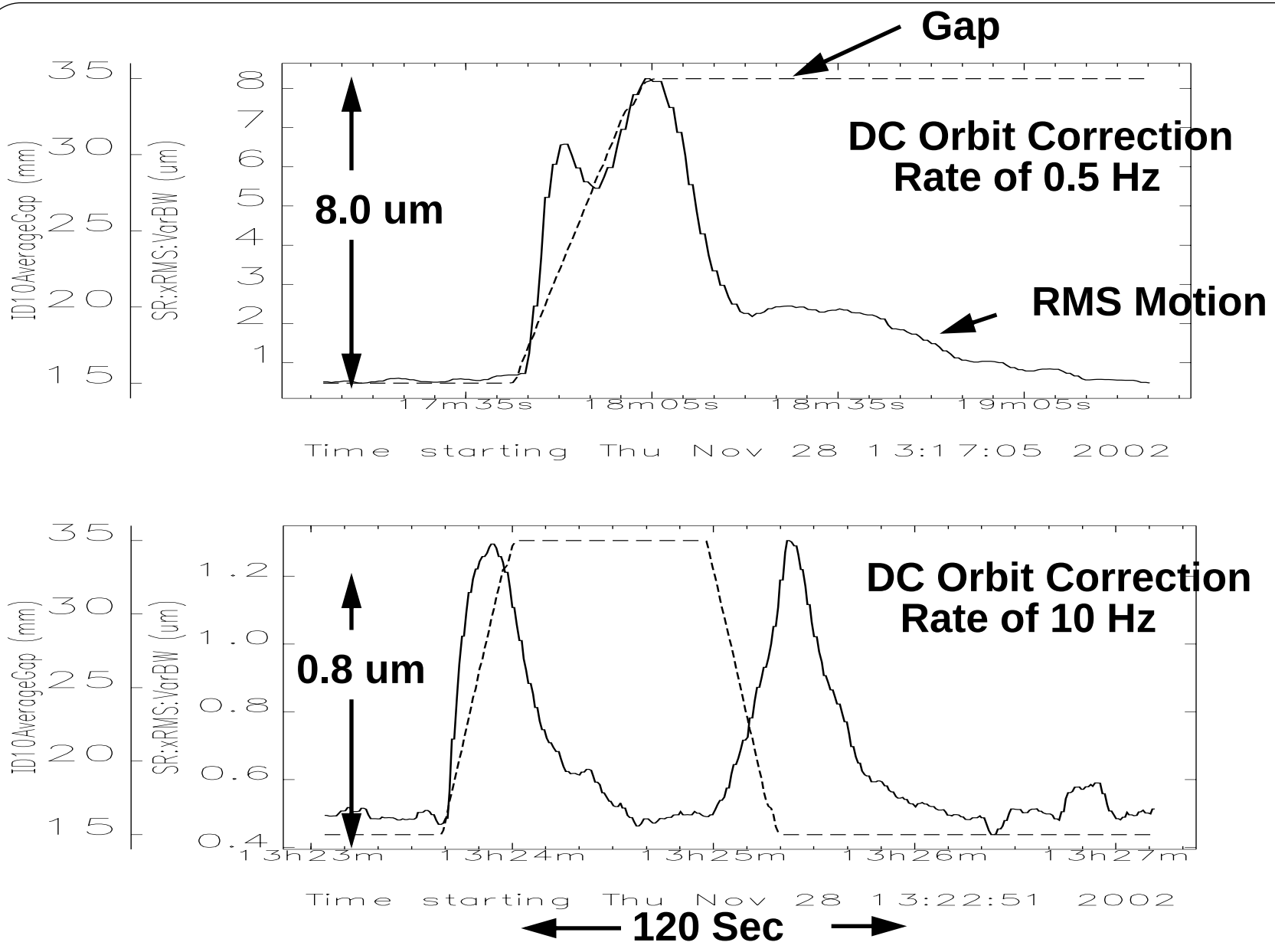
Vertical RMS



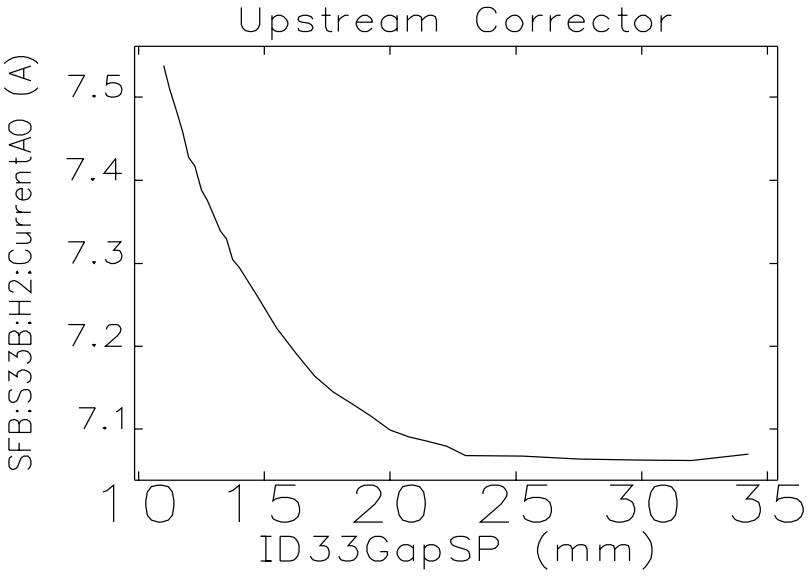
A User ID Gap Changes

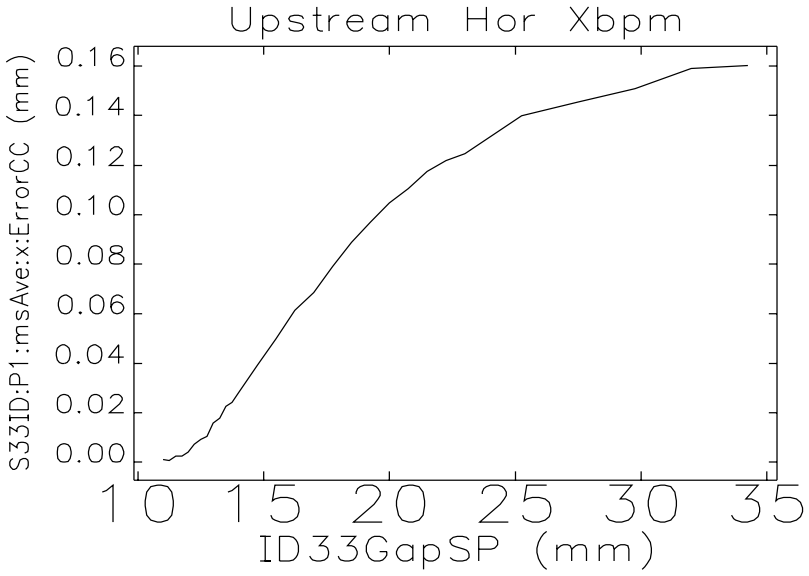


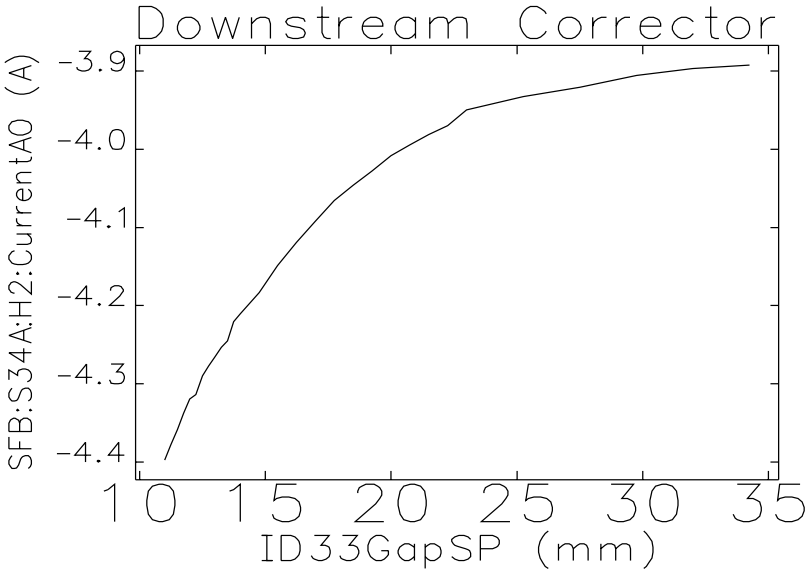
Global Horizontal RMS Motion (0.01 Hz to 1.0 Hz) as ID Gap varies

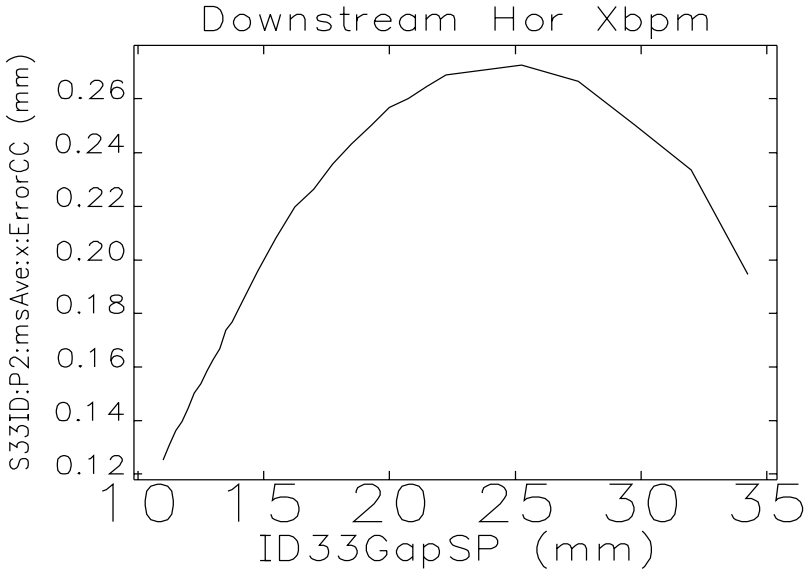


ID Steering Correction and Xbpm Feedforward Data as Gap varies









Increase DC Orbit Feedback BW

- **Strong Case to increase DC orbit Correction Bandwidth**

  - Reduces orbit noise by > 3 at a given frequency

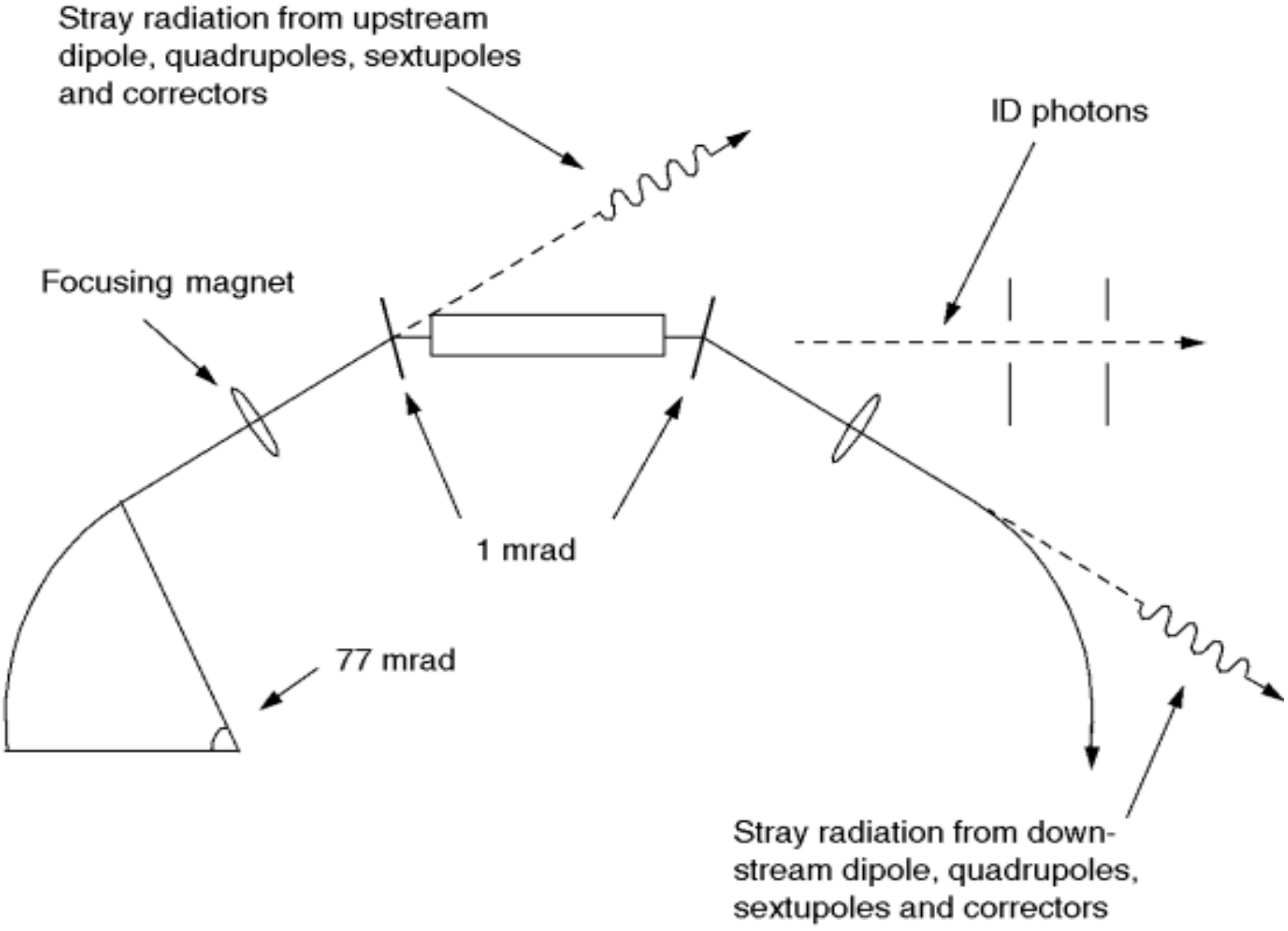
  - ID Steering effects shows up mostly in freq 0.1 Hz to 1 Hz

Table 1: Simulation Results

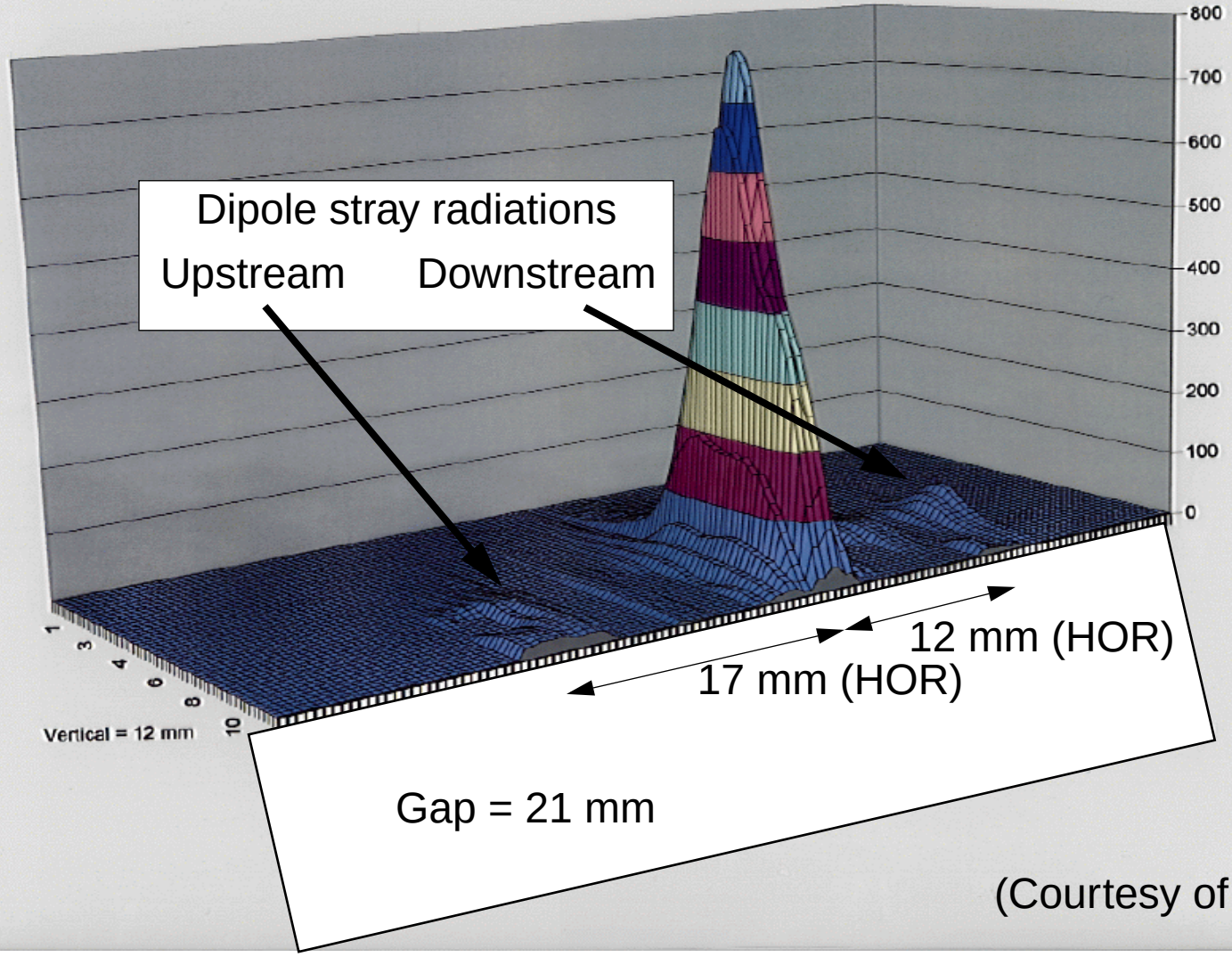
	1 Corr	2 Corr
No correction	1	1
160 BPMs	0.33 (AC)	0.13
320 BPMs	0.3	0.1(DC)

- **New DC orbit feedback system utilizes AC orbit feedback hardware concepts**
- **Added a 22nd VME IOC crate making use of high speed BPMs and corrector data available through reflective memory**
- **A 10 Hz DC orbit update rate is in test. Future plan is to increae the update rate to 50 Hz**
- **With 10 Hz DC orbit correction rate, ID steering transient effects has been reduced.**

Reducing Background Radiation by Lattice modification



ID 34 and background stray radiations after Lattice Modification



(Courtesy of D. Shu)

Summary

- **Add more MpBpms in orbit configuration - cogging mode**
- **Add more NbBpms**
- **Add ID X-Bpms in orbit configuration**
- **Increase DC orbit correction bandwidth - reduce ID Steering effects**
- **Add NbBpms and X-Bpms in the AC (rtfb) orbit correction system**