Recent and Planned Improvements to APS Storage Ring Operation

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Outline

- Top-up operation
- Low-emittance configuration
- Beam stability
- Canted IDs
- Longer straight sections

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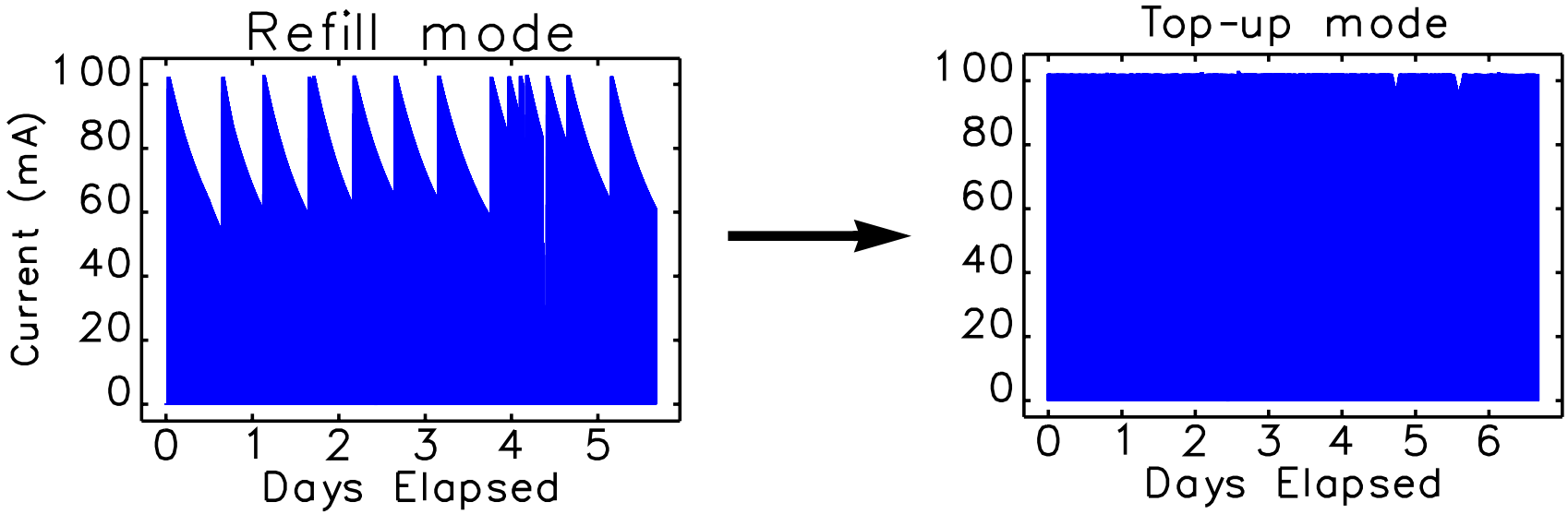
Top-Up Operation

- Top-up refers to adding current to the ring at 2 minute intervals.



- In FY2002, we will top-up 75% of the time.

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Top-Up Benefits

- X-ray beam stability improved due to constant heat-load on optics
  - less set-up and tune-up time
  - more demanding experiments made possible
  - easier to diagnose beamline problems
- Time-averaged flux is 15% to 100% higher
  - reduces time needed for experiments
  - increases the number of experiments per day

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Top-Up Benefits

- Flexible, enhanced operation, combining
  - higher x-ray brightness
  - small gap devices
  - timing experiments

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Low-Emittance Configuration

- Low-emittance configuration provides higher beam brightness

Configuration	**Brightness** $\text{photons}/\text{sec}/(mm \cdot mr)^2/0.1\%\text{bw}$	**Lifetime** (hours)
present	$9 \cdot 10^{18}$	22
low emittance	$2 \cdot 10^{19}$	7.4

- The shorter lifetime, inherent in low-emittance configuration, is not a problem with top-up.
- Top-up increases the time-averaged flux of low-emittance configuration by 100%.

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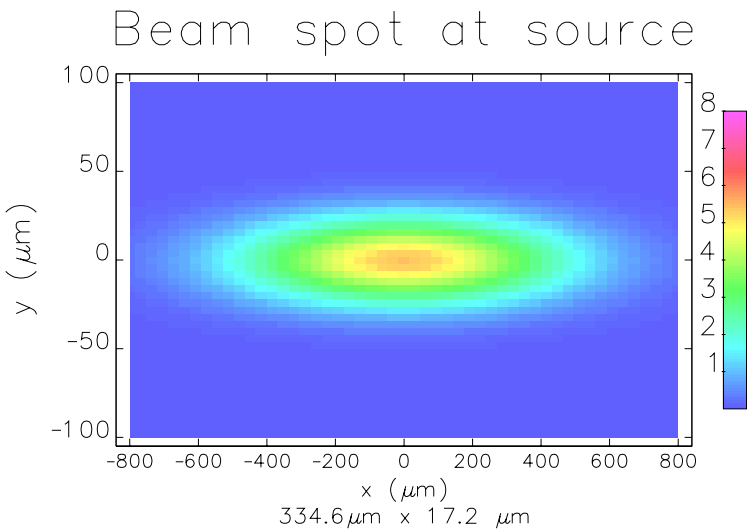
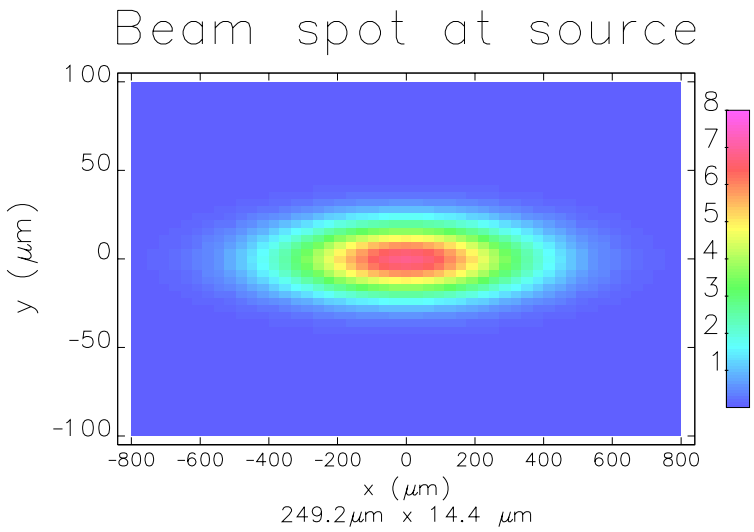
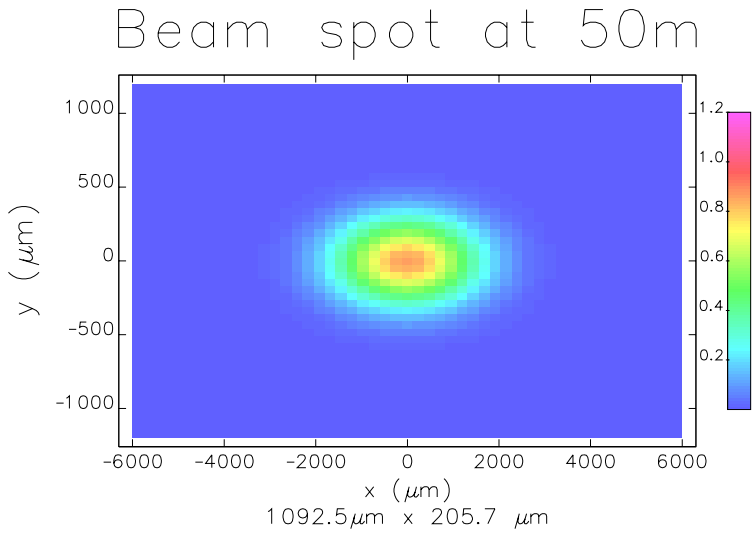
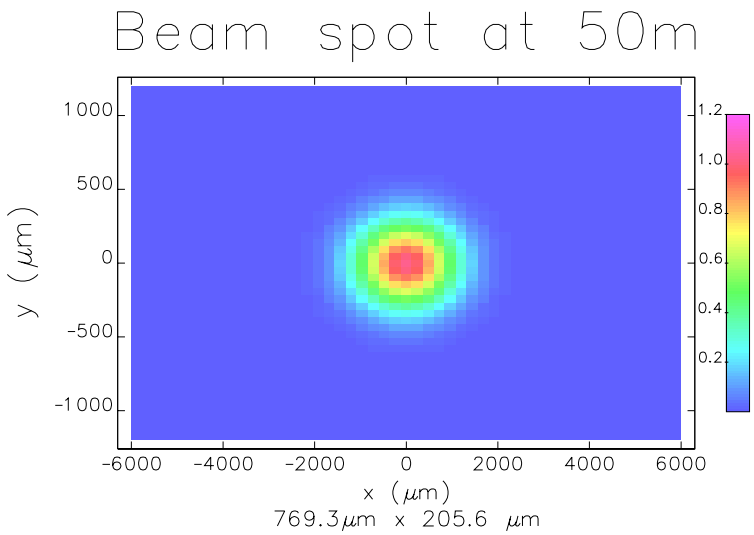
Spot Sizes for Present and Low-Emittance Configurations









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Low-Emittance Options

- We can push the low-emittance configuration further, but lifetime will suffer.
- Top-up can probably support another 2-fold brightness increase.
- Another 4-fold increase is possible but presently not considered as it requires
  - more bunches, or
  - more frequent top-up
- Further research may provide another way to realize some of this brightness increase.

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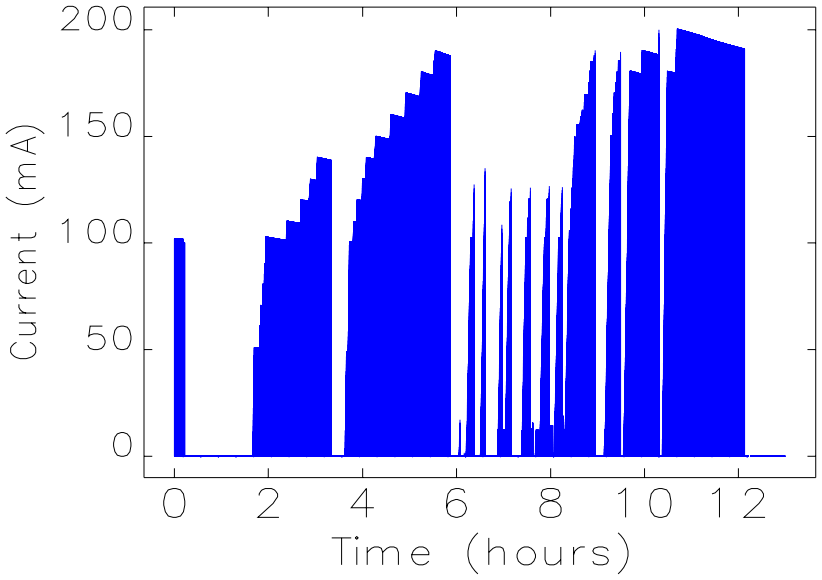
Higher Beam Current Study

- Accelerator was operated at 200 mA for a few hours



- Observations
  - More studies needed to assess accelerator performance
  - Requires more bunches for acceptable lifetime
  - Current front-ends can handle up to 150 mA

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Beam Stability

- APS is working toward submicron source position stability.
- Recent accomplishments
  - “Gang of 6” bunches eliminated
  - Improved vertical orbit feedback
  - Feedforward on switched wiggler

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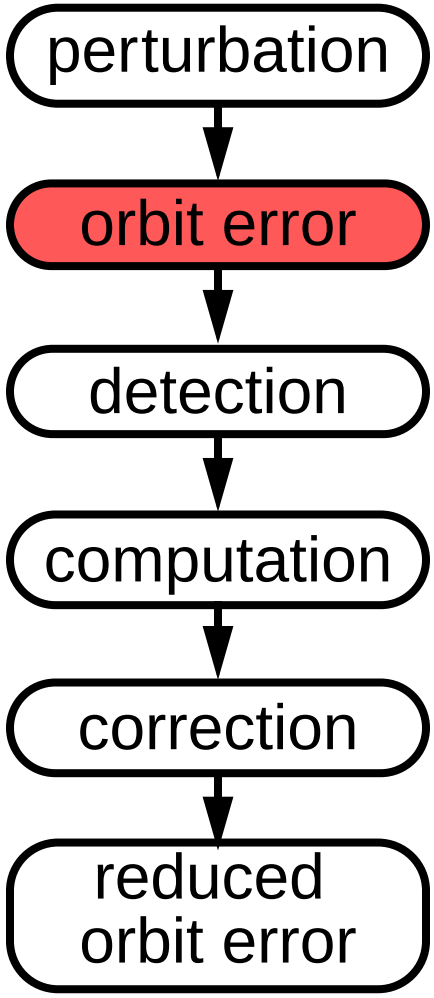
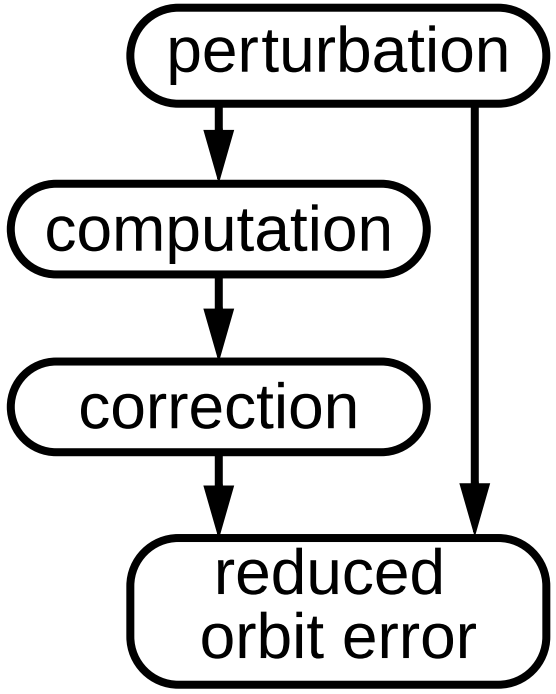
Feedback and Feedforward

Feedback is reactive



Feedforward is proactive



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Methods of Improving Beam Stability

- Use feedback only when feedforward isn't possible
- For feedback systems
  - Improve quality and speed of orbit measurement
  - Improve rate at which corrections are applied
  - Improve accuracy of corrections
- For feedforward systems
  - Precalculate/measure correction with high accuracy
  - Improve rate at which corrections are applied

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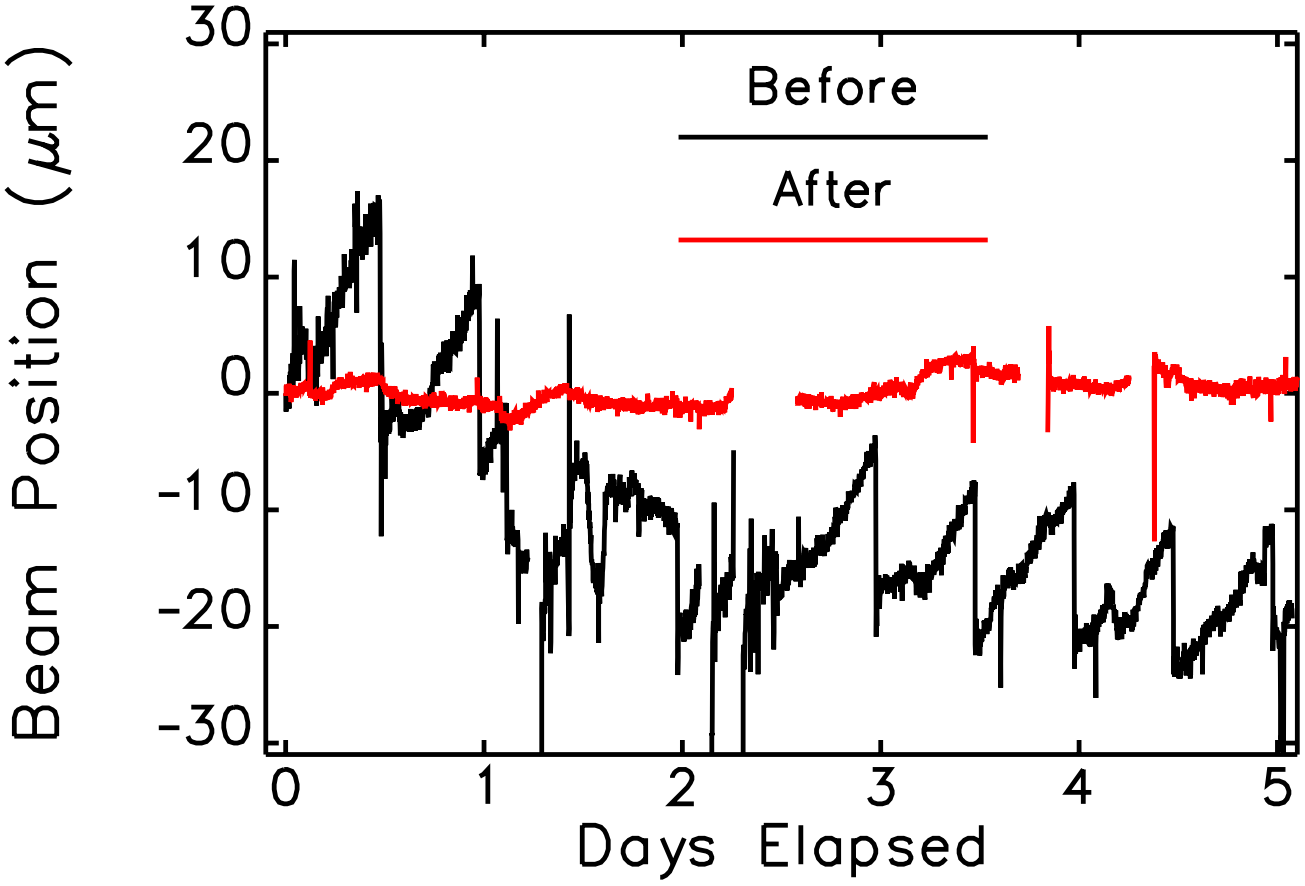
Beam Stability Progress

Vertical orbit correction now uses bending magnet (BM) x-ray BPMs and “narrow-band” rf BPMs.



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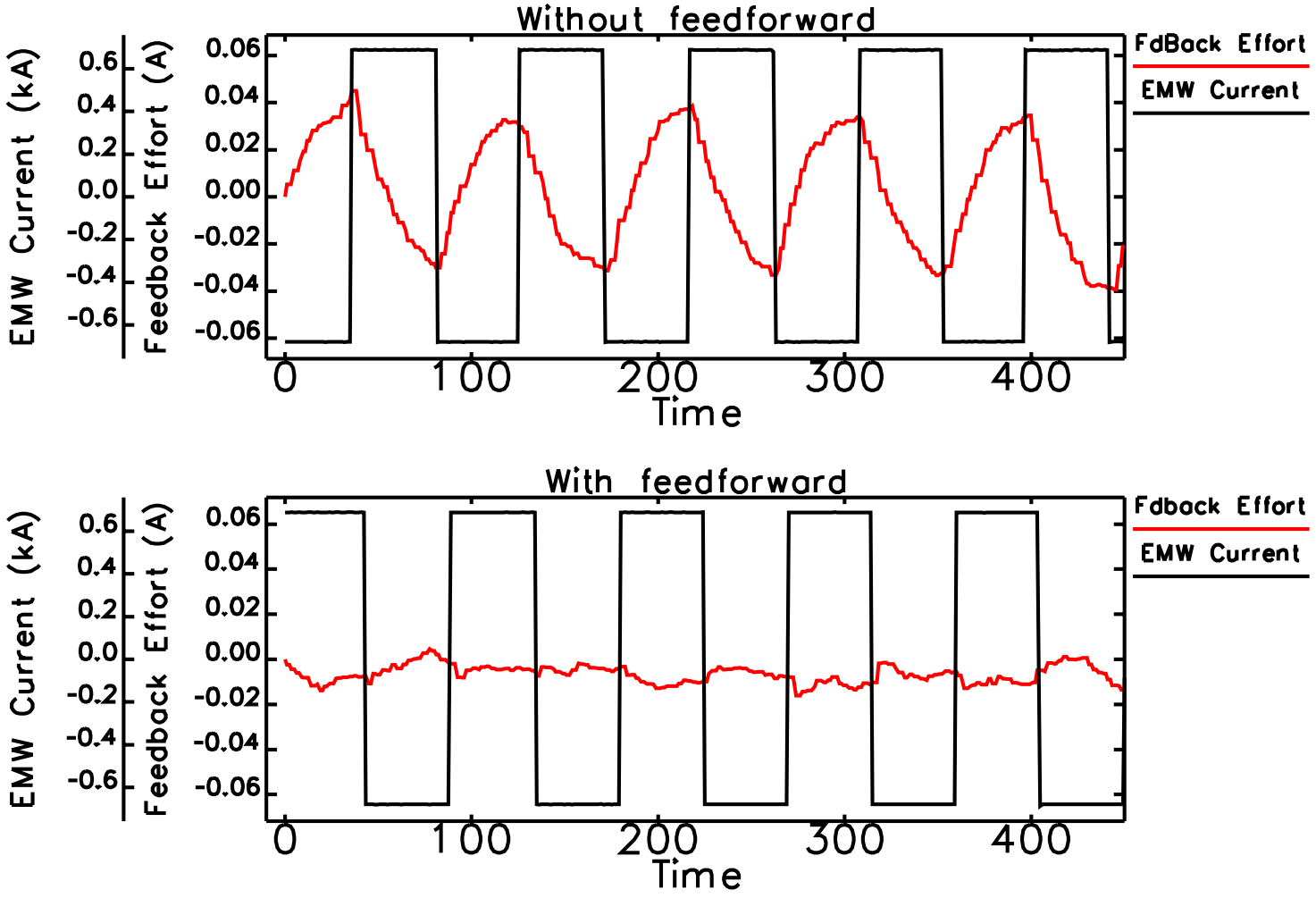
Beam Stability Progress

Feedforward Compensation of Switched Wiggler



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Beam Stability Work in Progress

- Work driven by 2001 APS User Survey: seconds-to-days time scale is most important.
- Hence, improving the DC orbit feedback
  - higher data rate: ~100 Hz instead of 0.4 Hz
  - higher correction rate: 10 Hz instead of 0.4 Hz
  - DSP-conditioned signals for lower noise
  - will allow accurately characterizing IDs for feedforward
- Also, integrating ID x-ray BPMs into feedback
  - less long-term drift
  - greater fill-to-fill reproducibility

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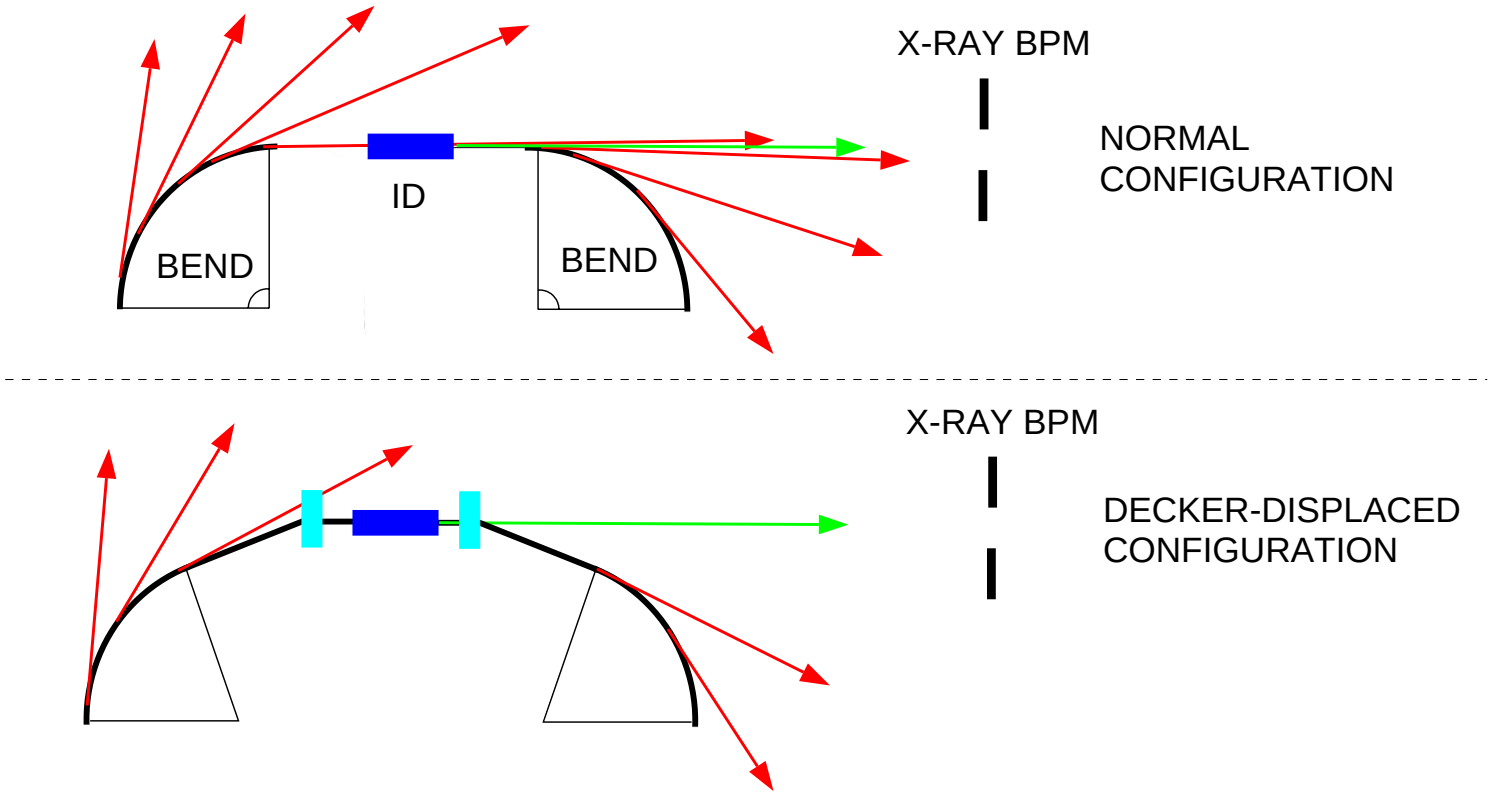
"Decker" Displacement

This is a method for reducing "pollution" of the ID x-ray BPM signals and making them useful



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Decker Displacement

- ID x-ray BPMs are important as they have a long “lever arm” that permits better control.
- Up to 10-fold reduction in pollution of ID BPM signals.
- Displacement has been performed in 10 sectors and is planned for 9 more.
- We are also pursuing
  - improved electronics
  - characterization of gap dependence

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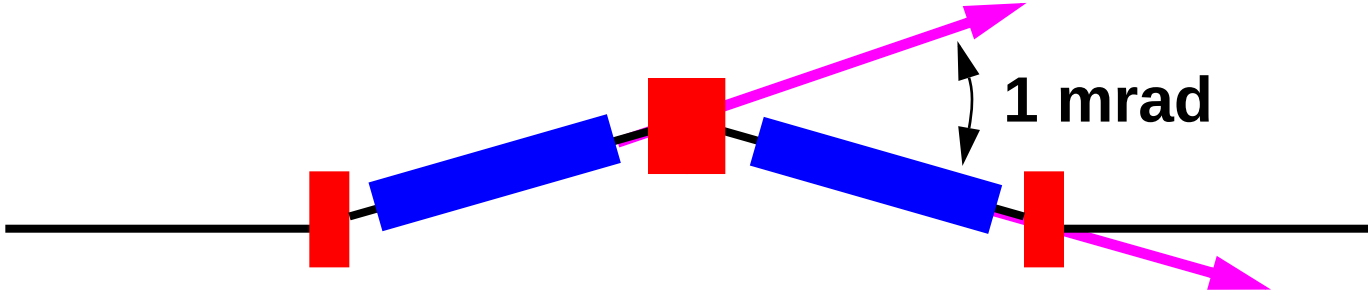
Multiple Sources in a Straight Section

- Planning to place two canted IDs in a straight section



- Similar beamline already in operation with 270μr angle.
- This would allow two nearly-independent hard x-ray beamlines in one straight section.
- Other beamlines of this type are planned

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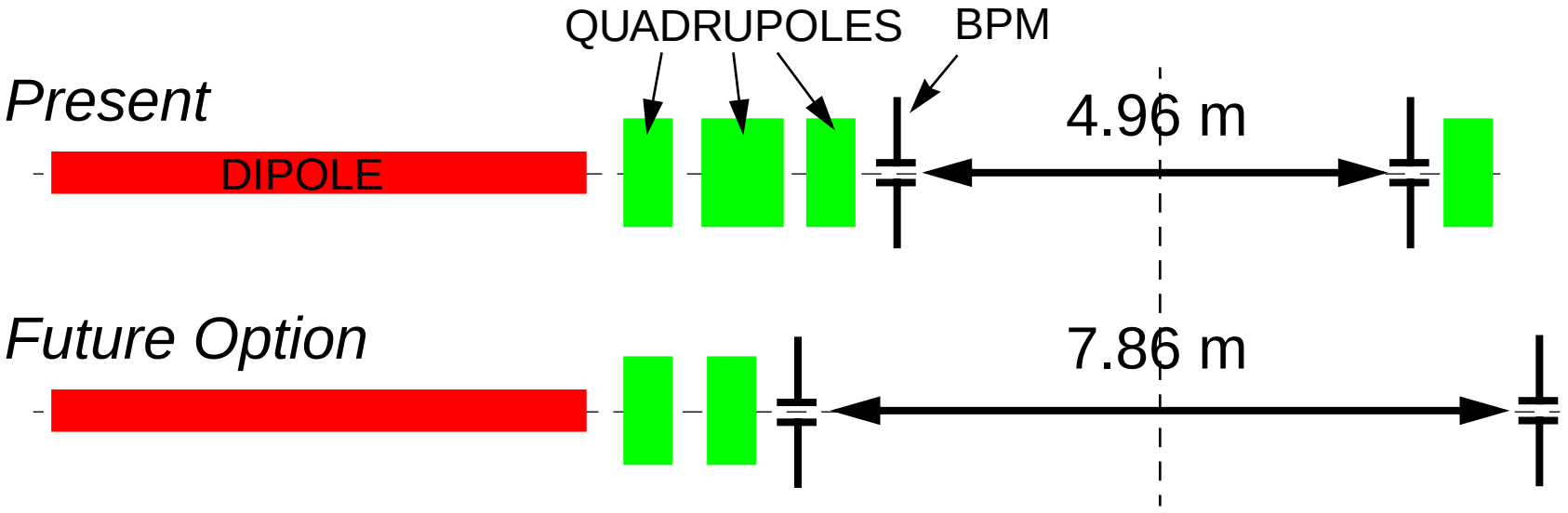
Longer Straights

Option for longer straight sections was part of APS design:



- Photon-limited application? Use longer ID for more flux.
- Time-limited application? Use several IDs for more stations.

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Summary

- Top-up mode yields many benefits
- Low-emittance configuration increased brightness significantly
- Beam stabilization effort
  - starting to show impact
  - significant progress expected in FY2002
- APS is a very flexible machine and provides many options
  - Canted IDs
  - Longer straight sections
  - Higher brightness