Argonne NATIONAL LABORATORY

Anticipated Capabilities of the Upgraded Storage Ring

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Disclaimer

- The ring upgrade design is a work in progress
- Significant unresolved issues remain
- Nothing you are about to see should be taken as guaranteed

Boundary Conditions

- 7 GeV
- Use existing storage ring and booster tunnels
- All ID beamlines (sectors 1~35) will be preserved
  - Can continue operation with no changes and no degradation in performance if so desired
- Bending magnet beamlines (sectors 1~35) may require realignment
- Existing bunch patterns will be maintained
  - E.g., 24 bunch, 324, 1296, hybrid mode
- Single bunch current limit will be maintained
  - E.g., 16 mA in hybrid mode.

Goals for the Ring

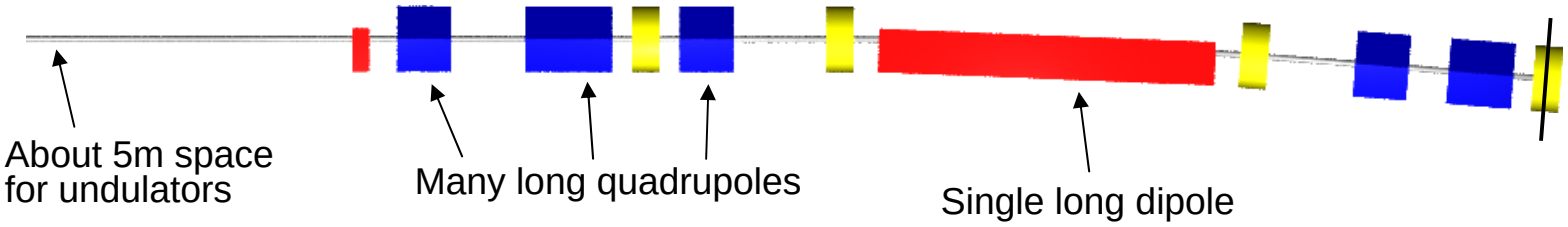
- Tailored to experimental requirements
- Use “crab” cavities to support experiments requiring
  - Short pulse x-rays, down to ~1 ps FWHM
  - Coherent imaging with large beam size
- Long straight sections to support innovative insertion devices
  - Variable-polarized high-energy x-rays
  - Rapidly-variable polarization for medium-energy x-rays
- Straight sections optimized for
  - Small beam size or
  - Small beam divergence
- Higher brightness (higher current+lower emittance).

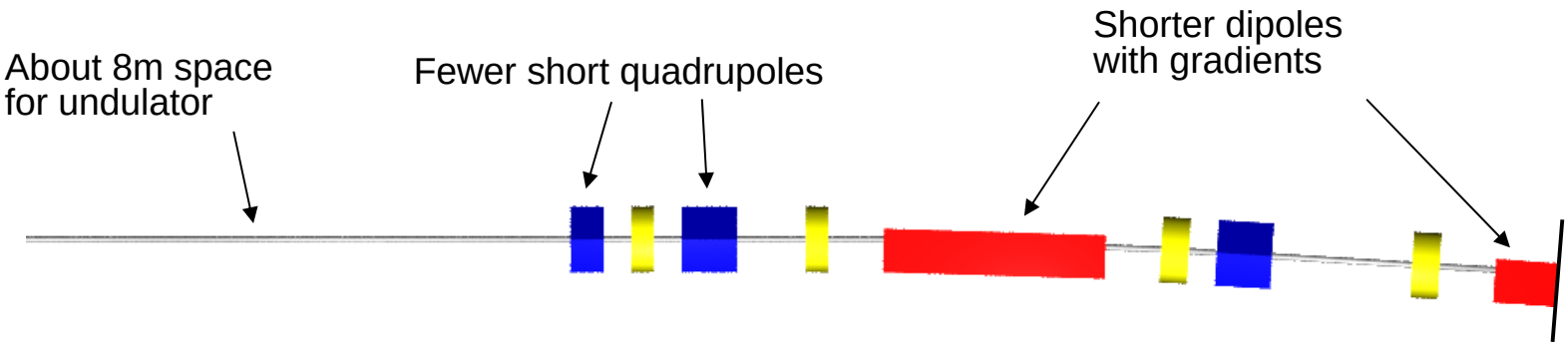
Mostly from E. Gluskin

How to Lower the Emittance?

- Increase the horizontal tune, ν_x
  - Generally requires more focusing magnets
  - Requires more, shorter dipoles so we can focus more frequently
- APS has two dipoles per sector
  - In recent years, we've explored designs with 3, 4, 5, and 7 dipoles per sector
- These were somewhat narrowly targeted at brightness only
- Goals for upgrade required something different
  - Bunch pattern flexibility
  - Long straights
  - Can be built in near future

Triple-Bend Design Compared to APS Now





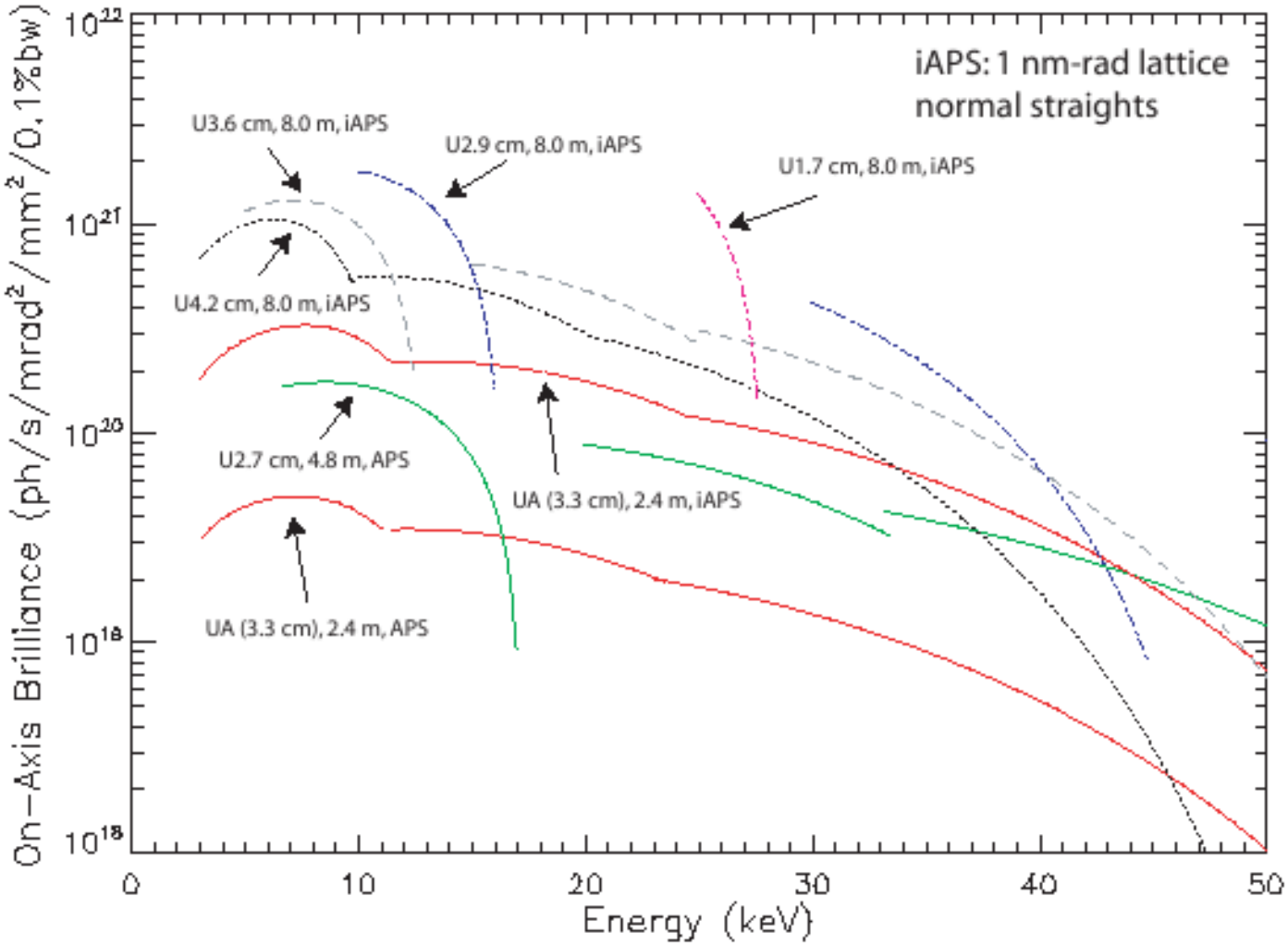
Graphics courtesy L. Emery.

Beam Size and Divergence

Case	*# of Sectors*	*x rms (microns)*	*x' rms (microrad)*	*y rms (microns)*	*y' rms (microrad)*
Today	40	275	11.4	8.5	3
Normal (long)	32	116	9.3	6.9	1.1
Small size	4	35	22	7.3	1.1
Small divergence	4	245	5.0	6.3	1.2

- New source is potentially diffraction-limited in vertical plane for 1 Å x-rays
- Small size/divergence sectors are symmetrically arranged

Spectral Brightness Predictions



Assumes 200mA beam current and 1% coupling.

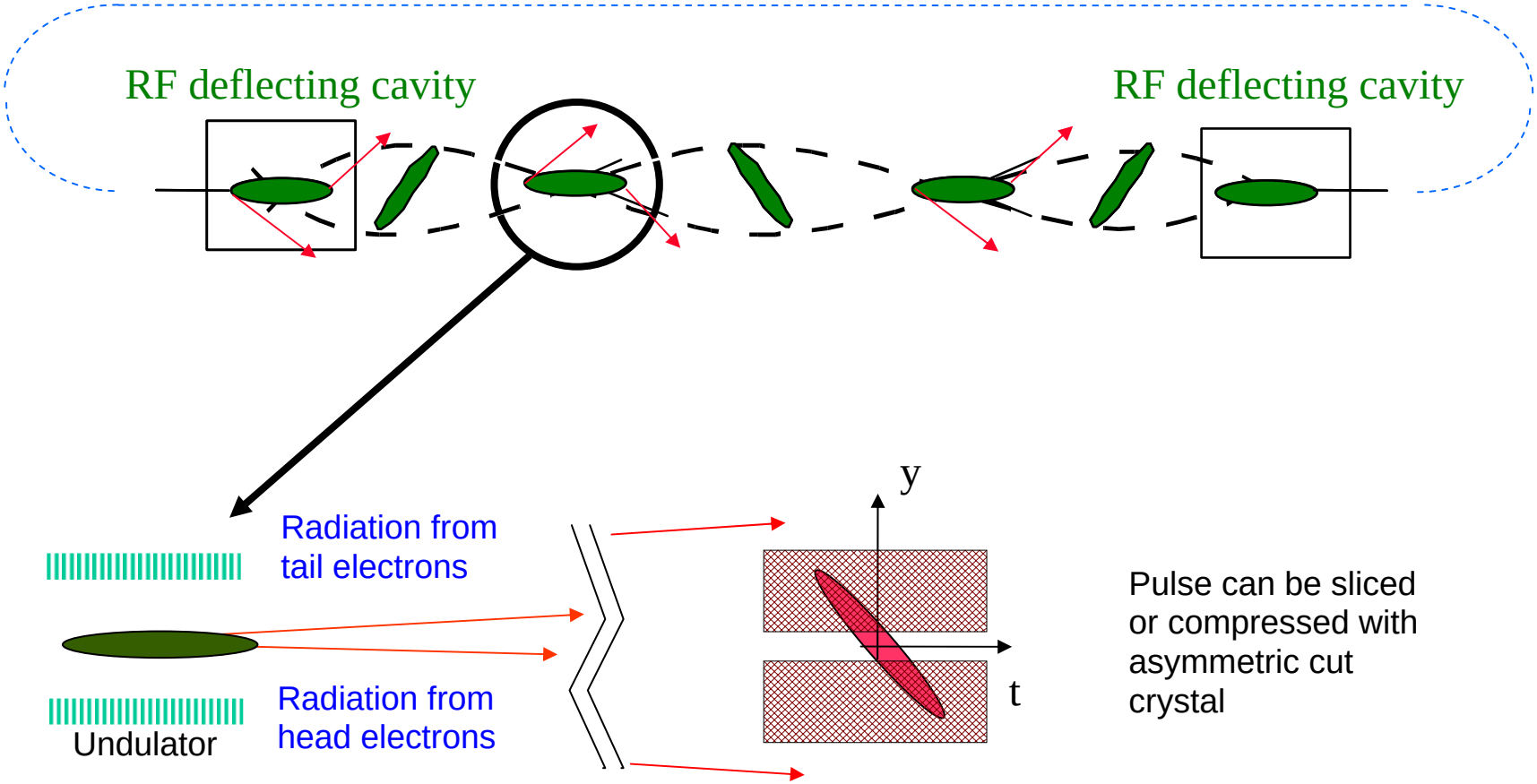
Care taken to ensure power and power density are within reasonable limits.

R. Dejus

Changes for Bending Magnet Beamlines

- Due to the three-bend design, bending magnet beamlines will be horizontally displaced
  - Displacement estimated at 8.5 cm to outboard side
- Dipole field will be 25% stronger
  - Critical energy will be 25% higher (24 keV)
  - Flux per mA will be 25% higher
- Flux will also increase due to 200 mA beam current

Zholents' Transverse Rf Chirp Concept



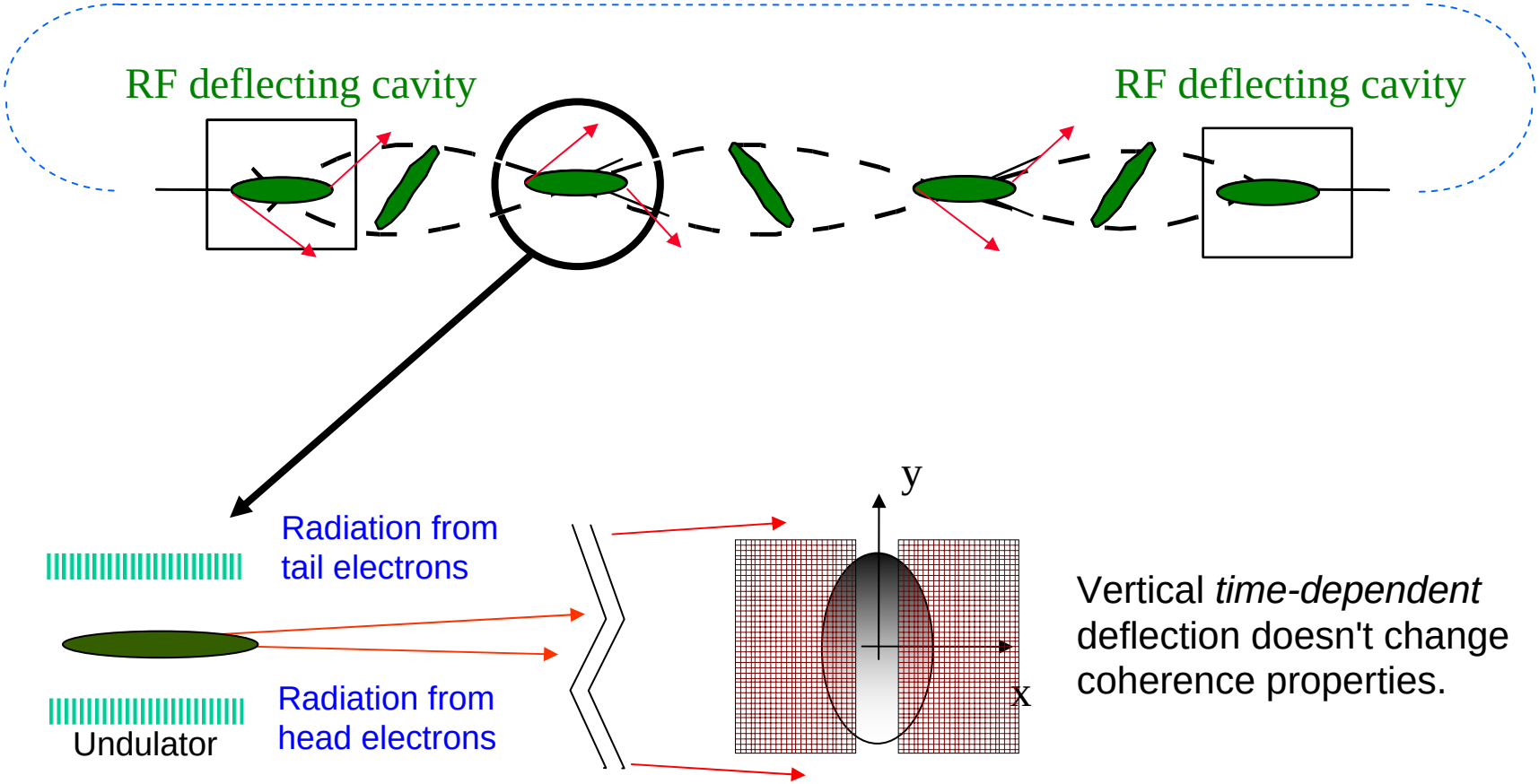
Pulse can be sliced or compressed with asymmetric cut crystal

~1ps FWHM possible for existing APS
(K. Harkay *et al*., PAC 05, p. 668.)

(Adapted from A. Zholents' August 30, 2004 presentation at APS Strategic Planning Meeting.)

Large Area Coherent Imaging

This is another concept for using a crabbed beam.



Vertical *time-dependent* deflection doesn't change coherence properties.

Will New Lattice Work?

- Many physics and engineering challenges in the new design
- Strong focusing leads to strong chromatic effects
  - Focusing varies with electron energy
- These must be corrected to ensure
  - Sufficient “dynamic aperture,” the stable region into which the beam is injected
  - Sufficient “momentum aperture,” which impacts beam lifetime
- We correct chromaticity using nonlinear elements (sextupoles)
  - This drives resonances in the single-particle dynamics
  - We add *more* sextupoles to control this
- Reduction of symmetry causes difficulties
  - Happens when we customize one or more sectors
  - Multiplies the number of resonances that are driven

Will New Lattice Work?

- Magnets are much stronger
  - Magnet gaps need to be smaller
    - *Vacuum pipe is smaller*
    - *Possible issues with pumping, electron cloud effects, beam instabilities*
  - Sextupole magnets are close to limit of conventional designs[1]
  - Alignment becomes more critical
    - *Will make commissioning more difficult*
    - *Anticipate having remote alignment capabilities*

[1]M. Jaski

Will New Lattice Work?

- Crab system appears feasible for this ring[1]
  - Have demonstrated < 1 ps FWHM in simulation
  - Have yet to make configuration that allows filling the ring
  - Optimistic that ~ 1 ps FWHM is feasible
- May need to lengthen the bunch[2]
  - Reduce collective effects and stabilize beam
  - Improve beam lifetime
  - Will impact the crab cavity system

[1]V. Sajaev

[2]Y.-C. Chae

Questions

- Which features do not enable significant new science?
- Which features enable the *most* significant new science?
- Which additional features or parameter changes would enable significant new science?

Goals for the Ring (Restated)

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