The New SURF Beamline–3

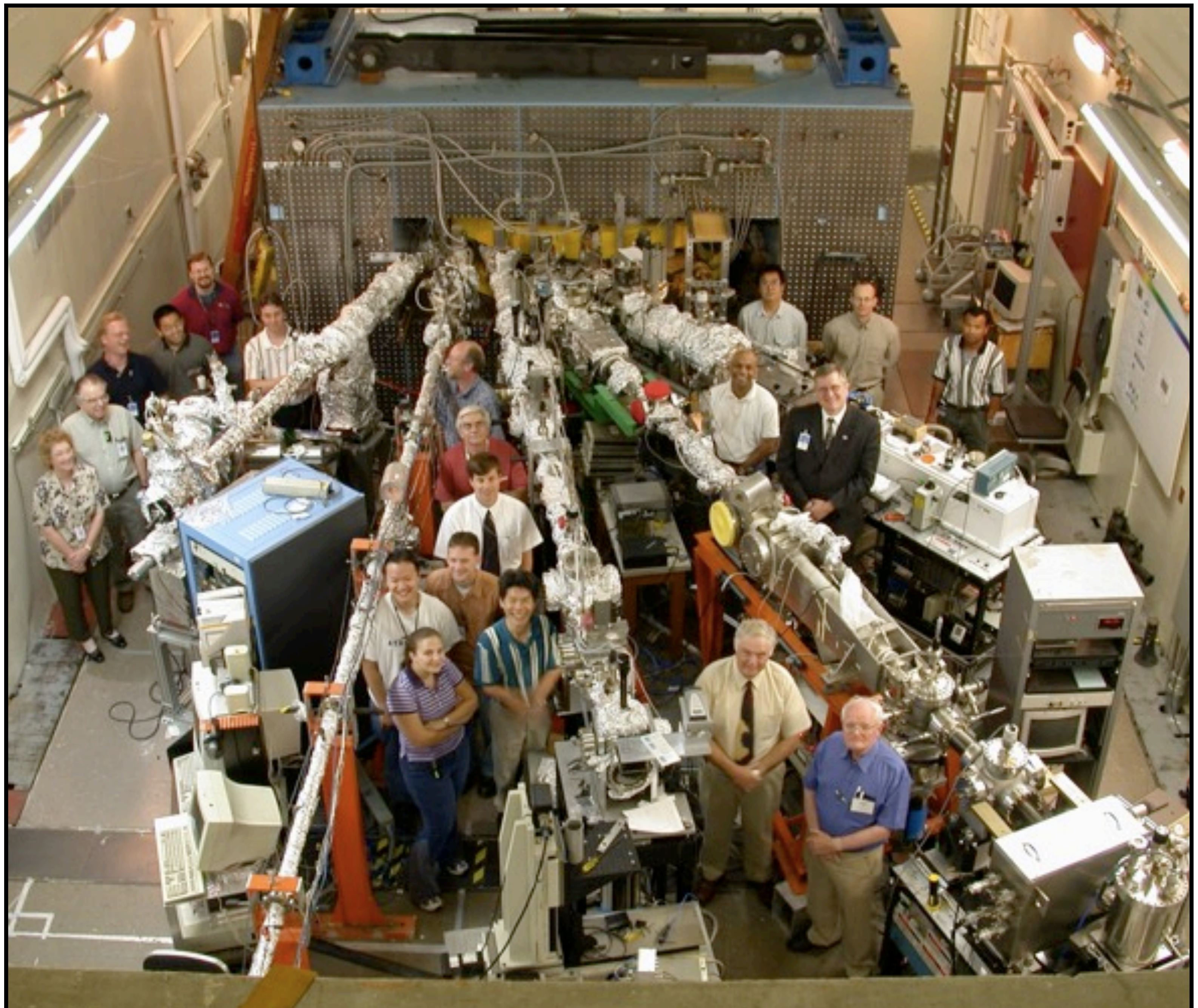
Rob Vest
UV Radiation Group, Sensor Science Division, NIST

SURF BL–3

- Introduction to synchrotron radiation
- Beamline design
- End stations
- Scale realizations
- UV radiometry program

SURF III

Synchrotron Radiation Ultraviolet Facility

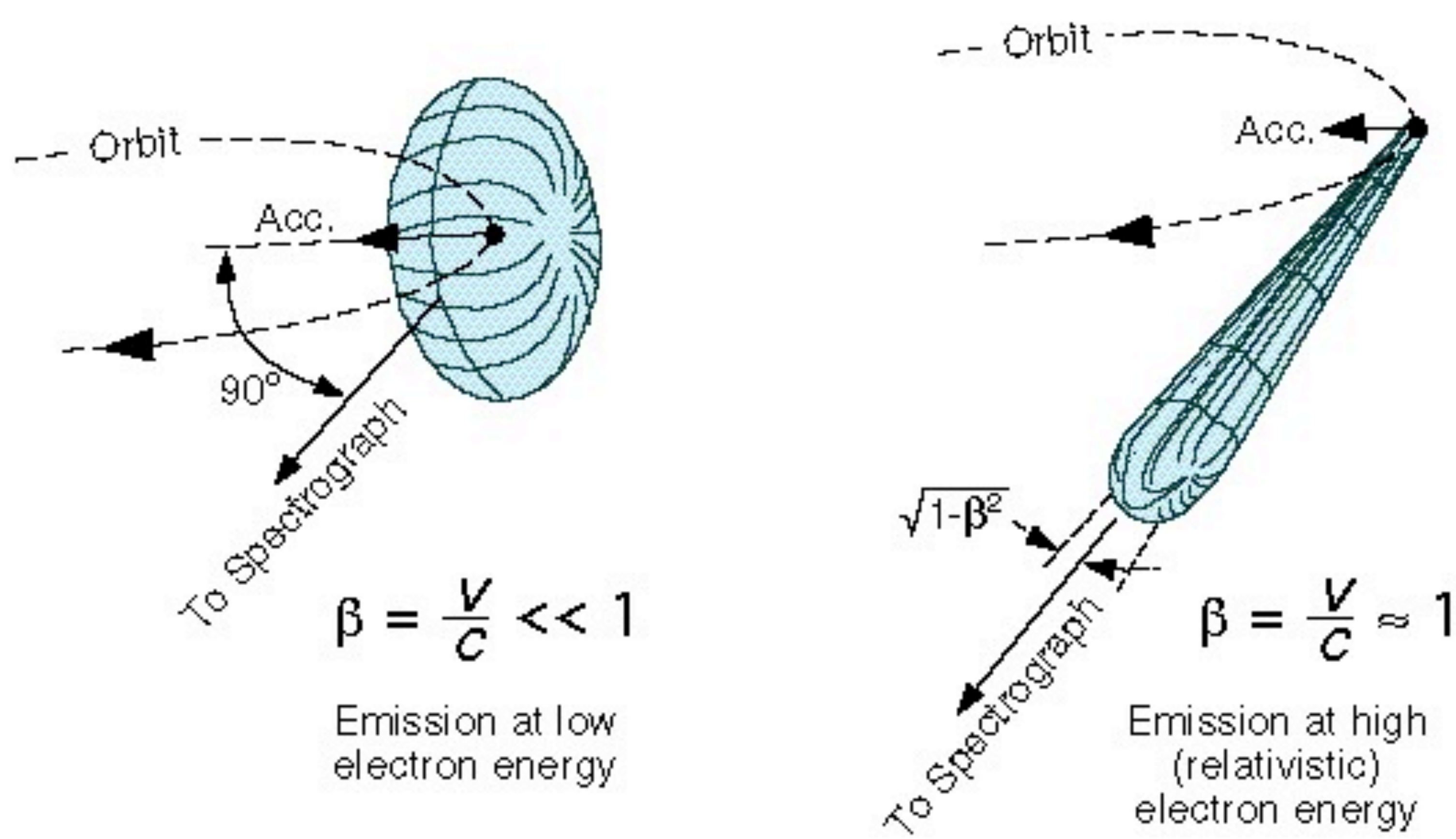


- Single-magnet synchrotron with highly uniform magnetic field and truly circular electron orbit
  - Optimized for radiometry
- 13 bend-magnet beamlines
- Electron energy from 10 MeV to 408 MeV
  - Optimized for VUV 2 nm to 400 nm 3 eV to 600 eV
- Injection current = 1 A
  Typical current = ~200 mA

Synchrotron Radiation

An orbiting electron undergoes acceleration and radiates according to Maxwell's equations.
The emission must be corrected for relativistic effects.

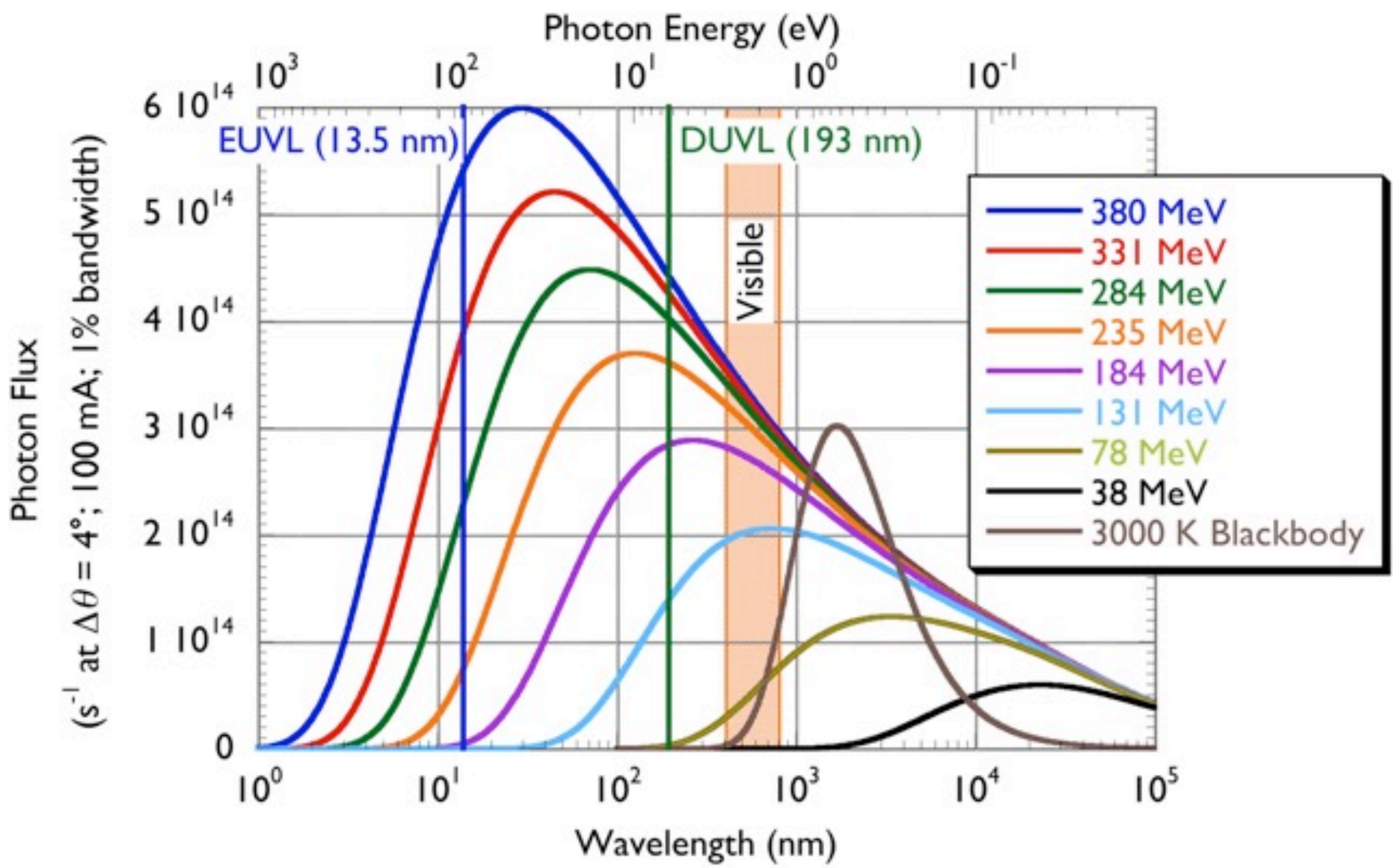
Angular Emission Patterns of Synchrotron Radiation



Properties of Synchrotron Radiation

- Spectral distribution of absolute radiance can be calculated from first principles
  - Need to know:
    - any two of:
      a) electron energy
      b) bending radius
      c) magnetic field strength
    - Beam current (number of electrons)
  - Only other absolute source is blackbody radiator.
- Continuum source
- Linearly polarized in orbital plane
- Peak wavelength can be tuned by selecting the electron energy
- Essentially a cw source (actually pulsed at 114 MHz with 10% duty cycle)

Synchrotron Radiation Spectrum



- Continuum source
- Broad-Band
- Peak wavelength is controlled by selecting electron energy
- Only practical, calculable source in the ultraviolet

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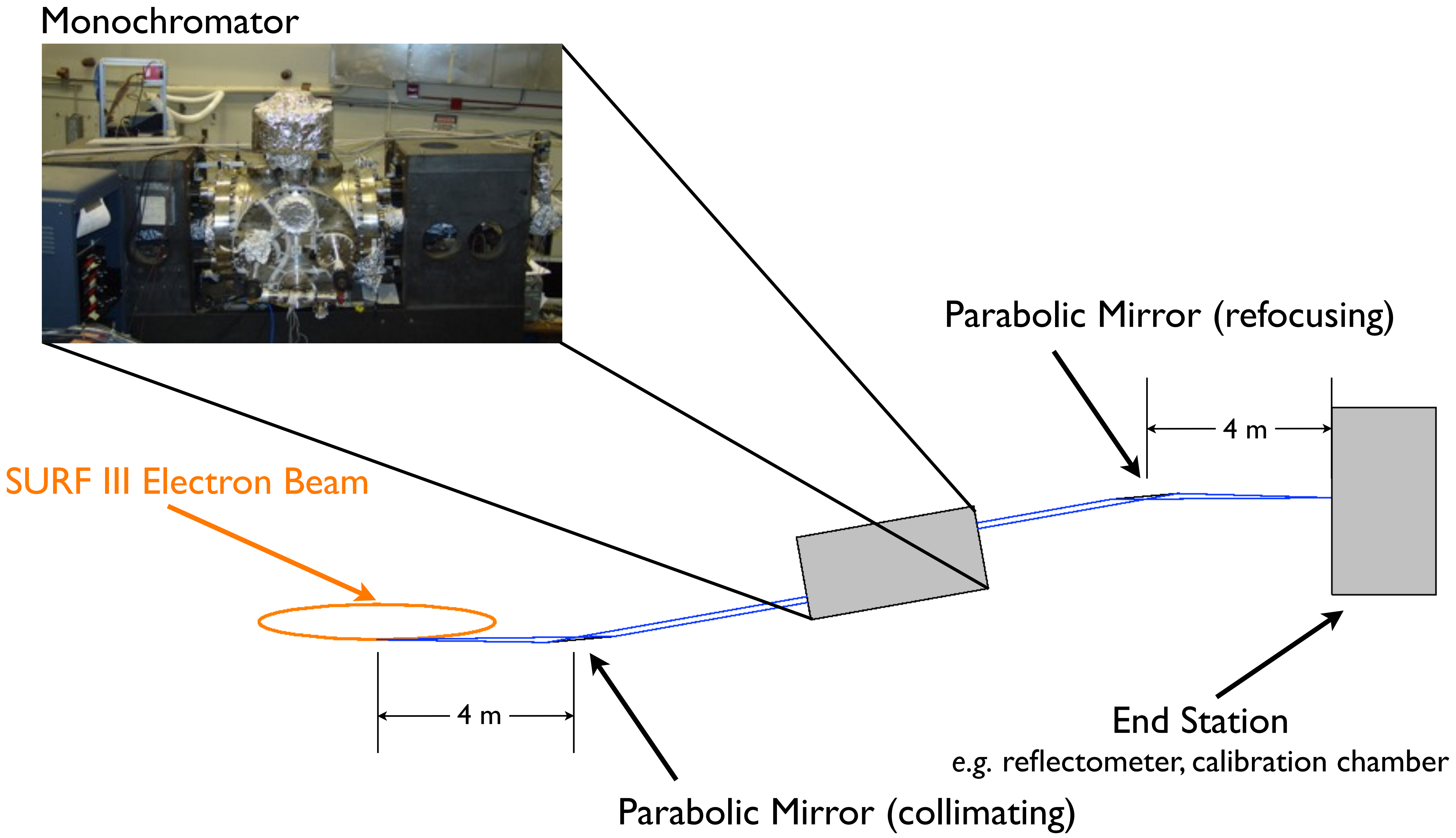
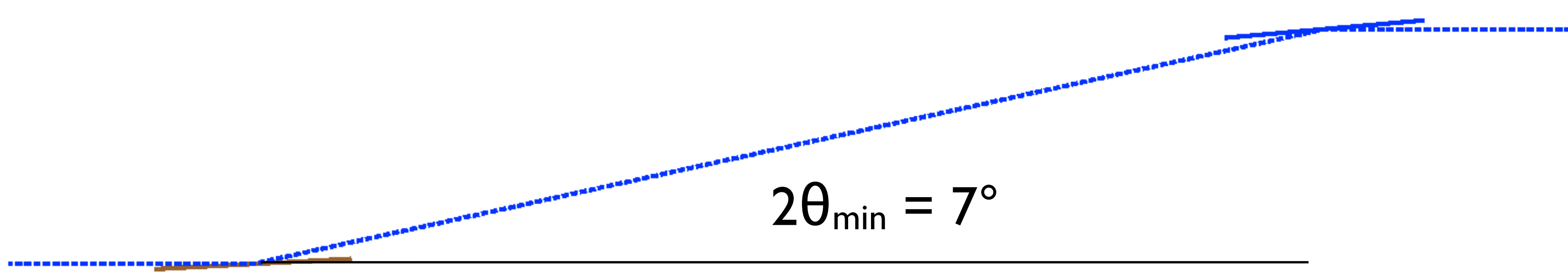
Beamline Layout



Monochromator

- Two elements that can be translated and rotated
- Choice of six elements for each position
- Elements can be grating, mirror, multi-layer mirror, crystal, etc.
- Standard condition now:
  - First element: Au-coated mirror
  - Second element: 600 mm^{-1} NN-coated grating with 2° blaze angle

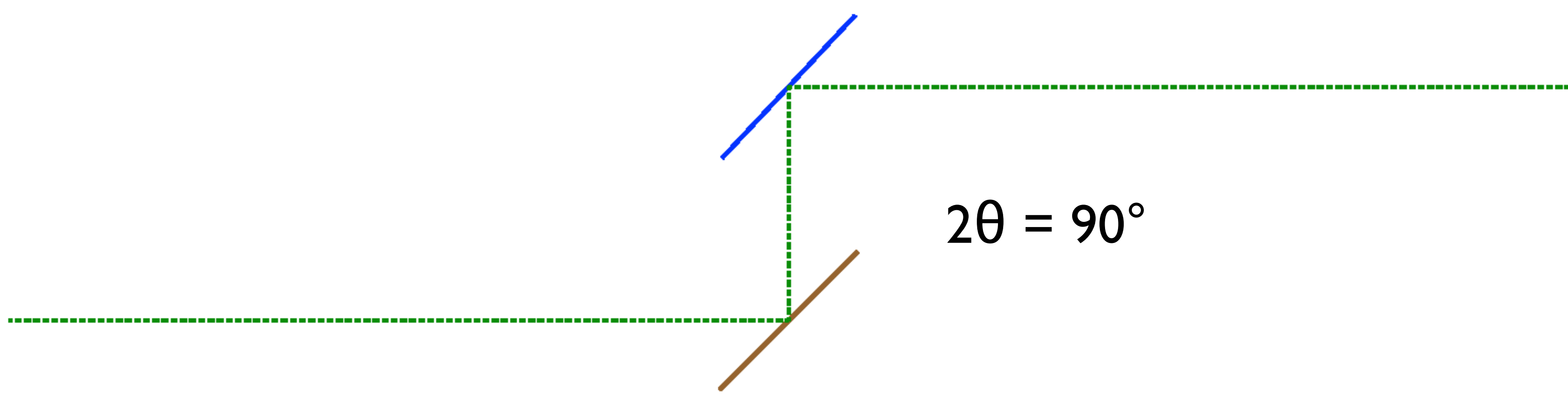
Monochromator



Short wavelengths require grazing incidence optics.

For a 600 mm^{-1} grating with 2° blaze angle:
Minimum on-blaze wavelength: 7.1 nm
Wavelength = 2 nm requires φ_2 = 0.56°, which is 1.44° off blaze.

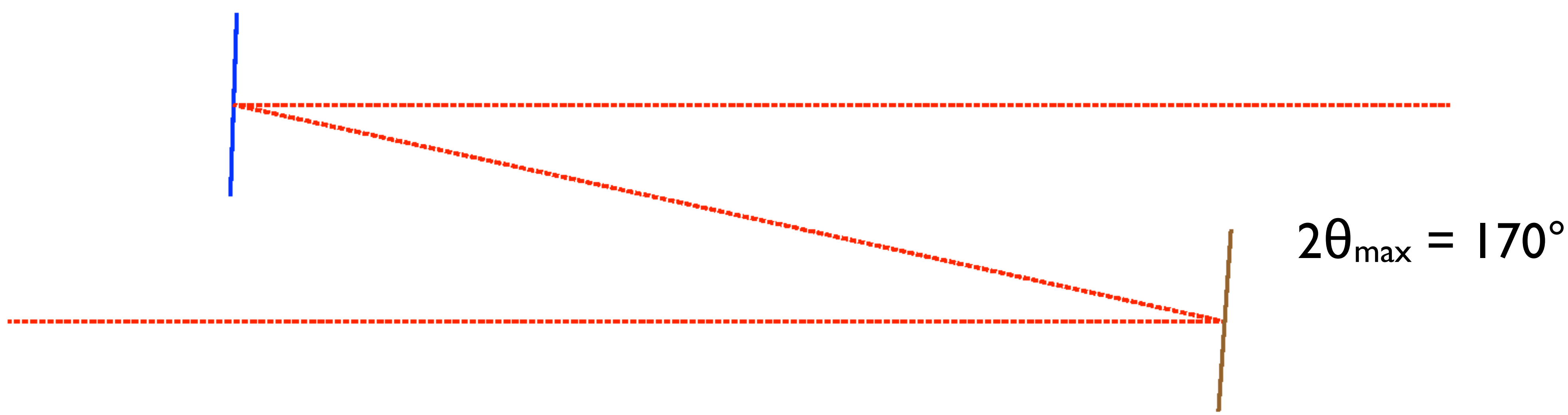
Monochromator



Intermediate wavelengths reached near mid-point travel.

For a 600 mm^{-1} grating with 2° blaze angle:
Wavelength at $2\theta = 90°$ is 82.3 nm

Monochromator



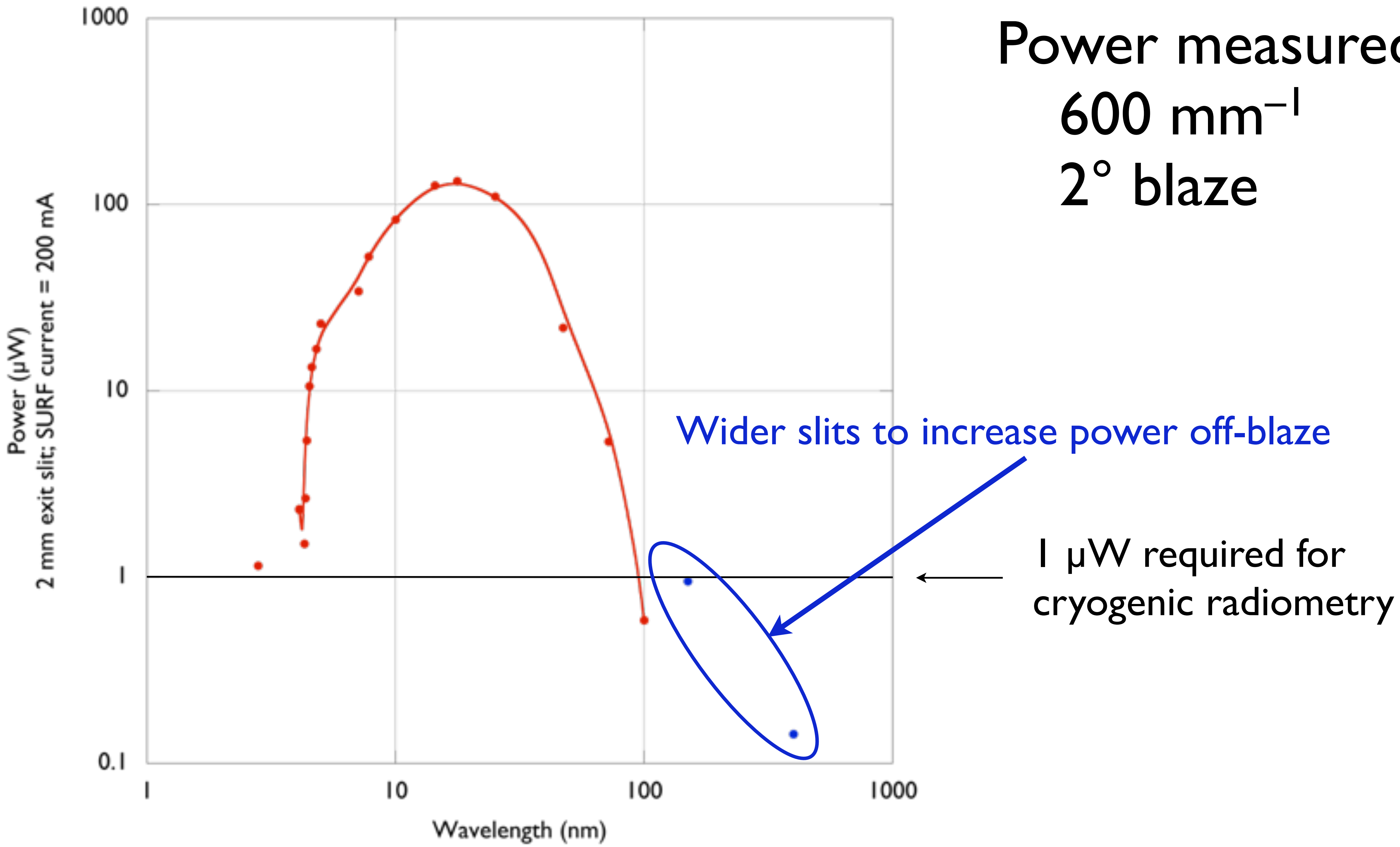
Long wavelengths utilize normal incidence optics.

For a 600 mm^{-1} grating with 2° blaze angle:
Maximum on-blaze wavelength: 115.9 nm
Wavelength = 400 nm requires φ_2 = 6.9°, which is 4.9° off blaze.

Monochromator

- Standard on-blaze wavelength range is 7 nm to 116 nm with 600 mm^{-1} grating.
- Extending to shorter and longer wavelengths by going off-blaze reduces throughput.
- Use of gratings with different ruling densities can maintain the on-blaze condition for different wavelength ranges:
  - 150 mm^{-1} grating: 28.4 nm to 464 nm
  - 2400 mm^{-1} grating: 1.78 nm to 29.0 nm

Power to Experiments



Power measured with:
600 mm^{-1}
2° blaze

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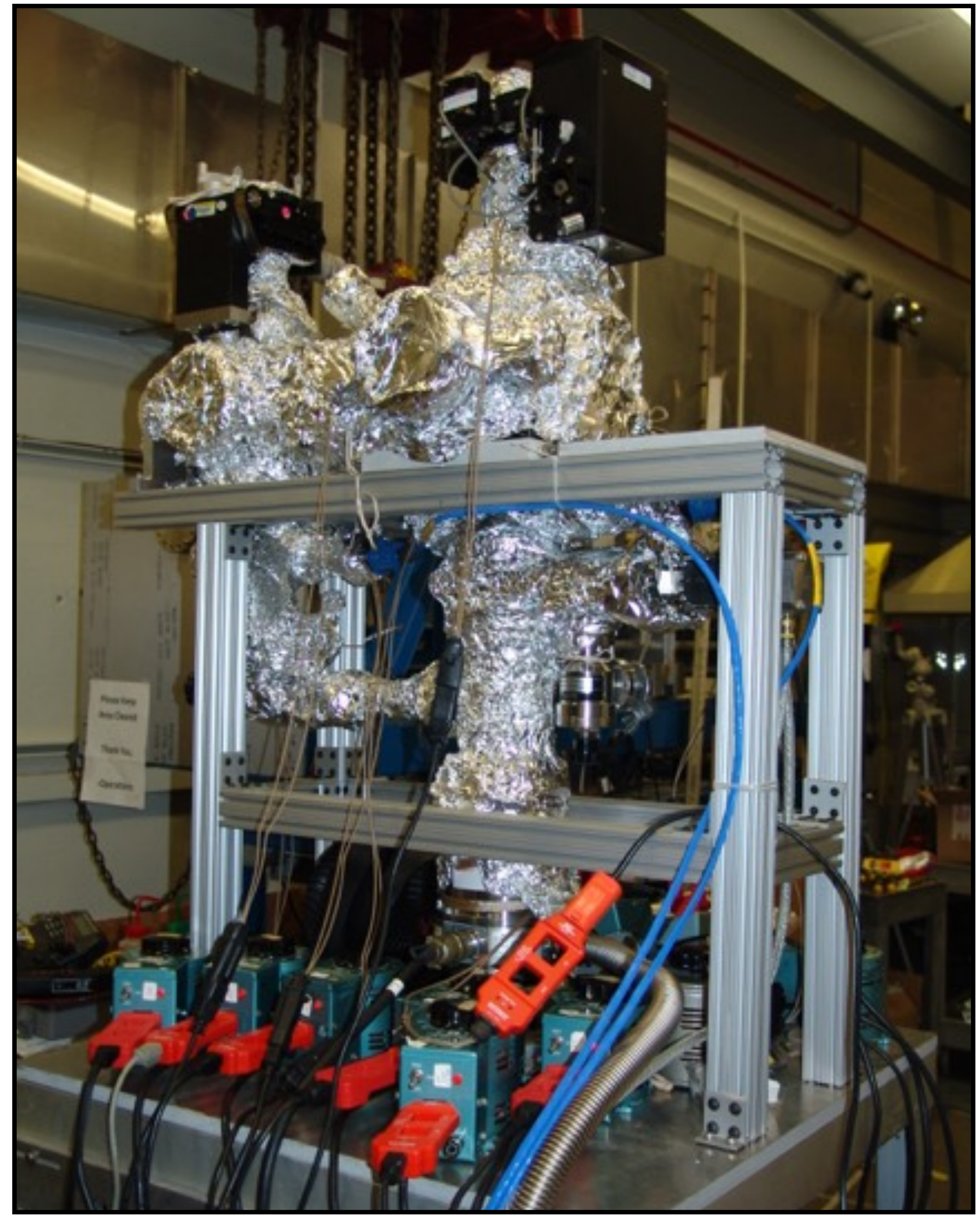
Reflectometer

- Planar samples up to 25 mm diameter
- Independent detector motion in azimuth and elevation
- Reflectometer rotates 90° without breaking vacuum to change polarizations

Calibration Chamber

- Calibration of:
  - detector responsivity
  - filter transmission
  - spatial uniformity
  - linearity
- Load-lock for rapid sample exchange
- Clean, high-vacuum environment



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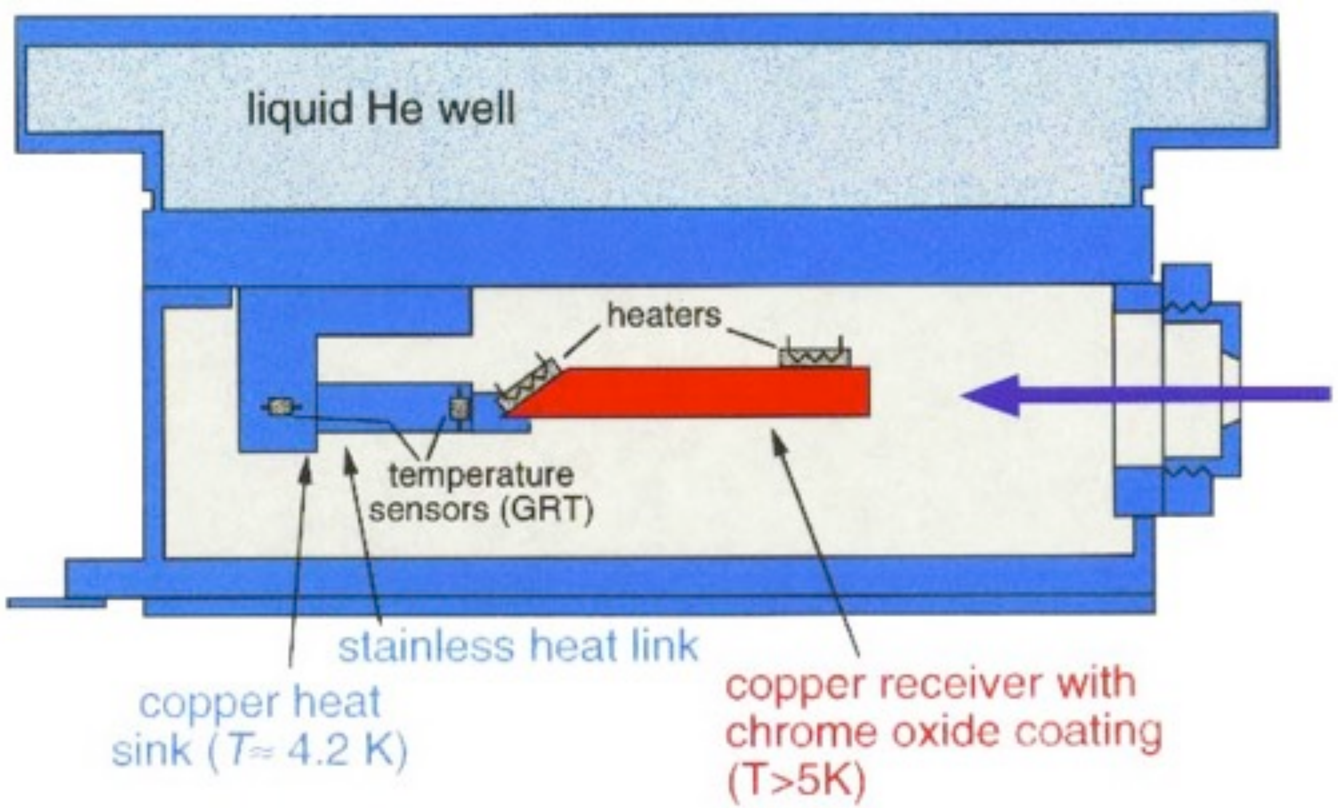
Cryogenic Radiometry



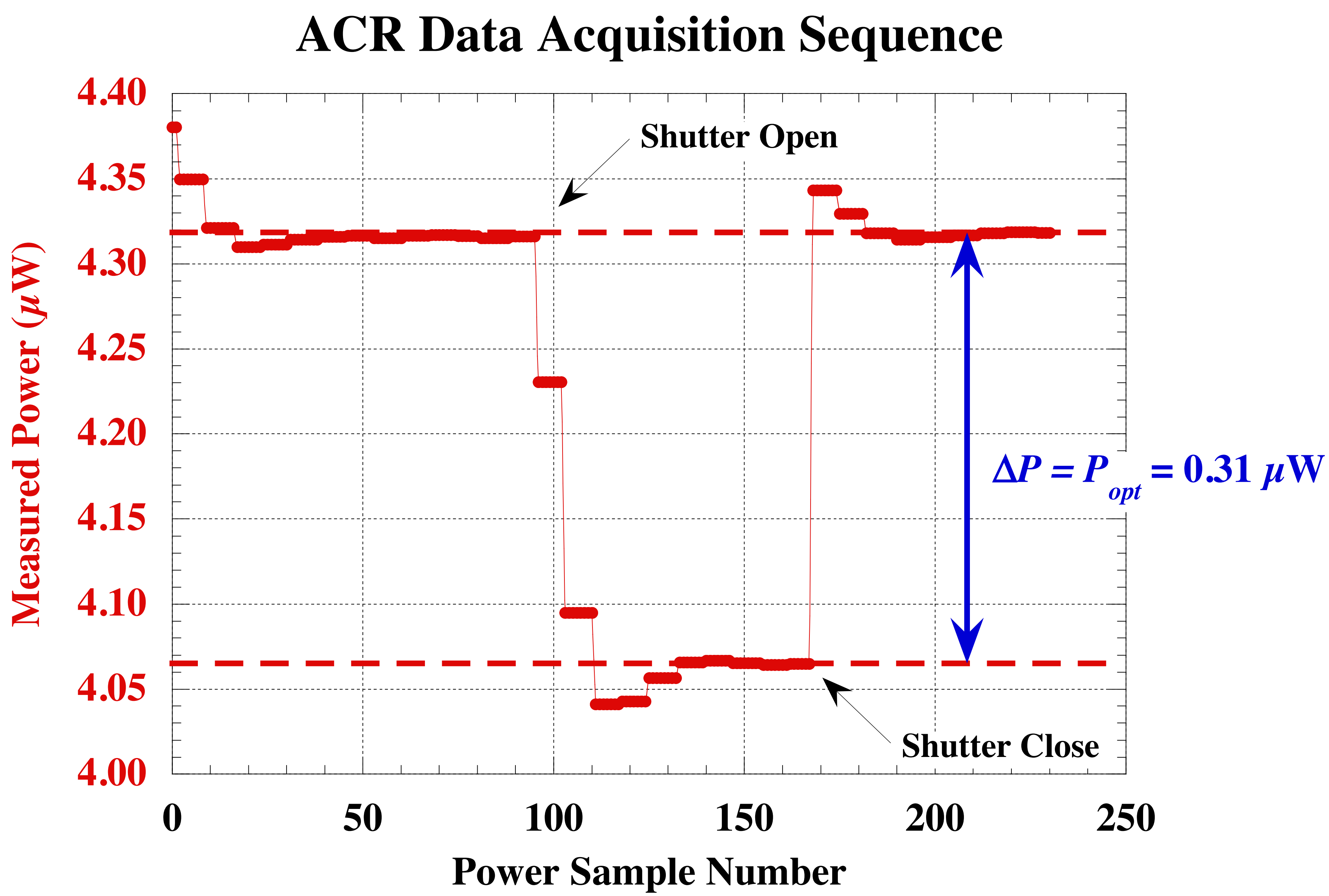
Maintain receiver at temperature *T* above liquid He temperature.

Electrical power *P* required is measured with shutter open and closed.

Power difference is the optical power.

$$\Delta P = P_{closed} - P_{open} = P_{opt}$$

Cryogenic Radiometry



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UV Radiometry at NIST on SURF III BL–3

- Single facility covering 2 nm to 450 nm spectral range
- Calibrations of detector responsivity, filter transmission, mirror reflectivity
  - expected responsivity uncertainty of <1% over this entire range
  - fills a gap in current coverage from 92 nm to 116 nm
- Consolidation of several existing facilities into one, improving efficiency (one set of instrumentation, one software system, etc.)