Infrared Microspectroscopy & Imaging

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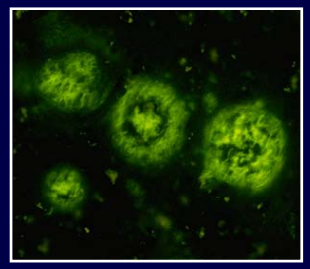
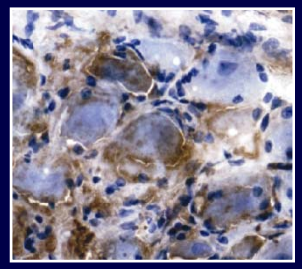
BNL-NSLS

Scientific Need: What can we do today?

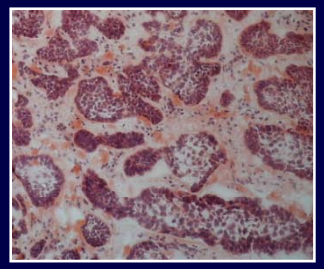
Bone disease



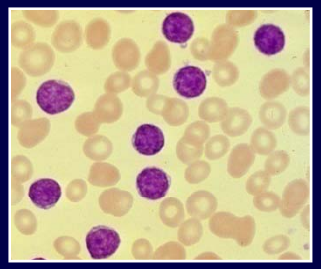
Alzheimer's disease



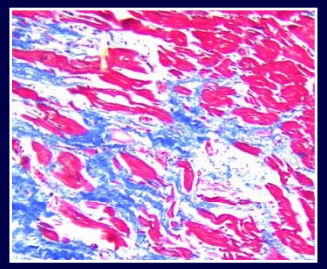
Prion diseases



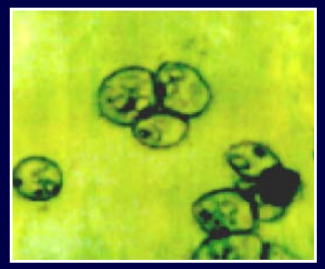
Cancer



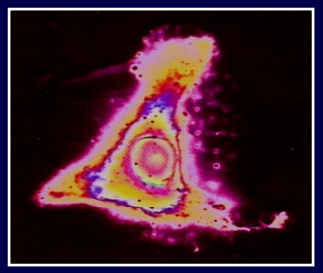
Leukemia



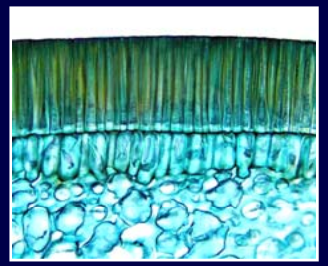
Heart disease



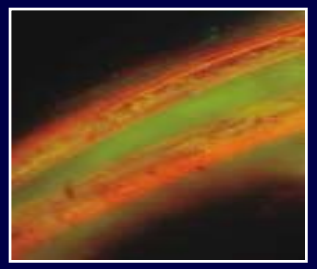
Apoptosis



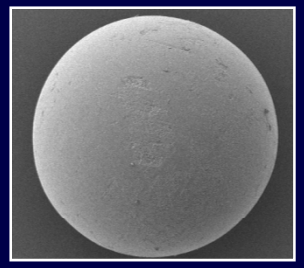
Melanoma



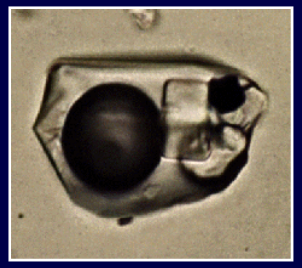
Biofuels



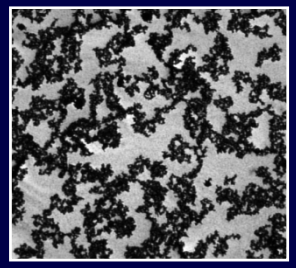
Bioremediation



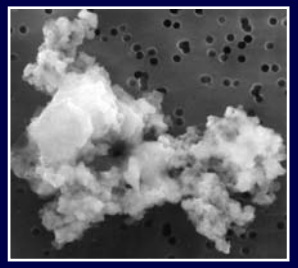
Biopolymerization



Fluid inclusions



Carbon sequestration



Interplanetary dust

Cosmetics

Scientific Need: What cannot be done today?

Data collection is slow

- Single pixel collection rate: 1-2 pixels/min (hours for small areas of tissue)

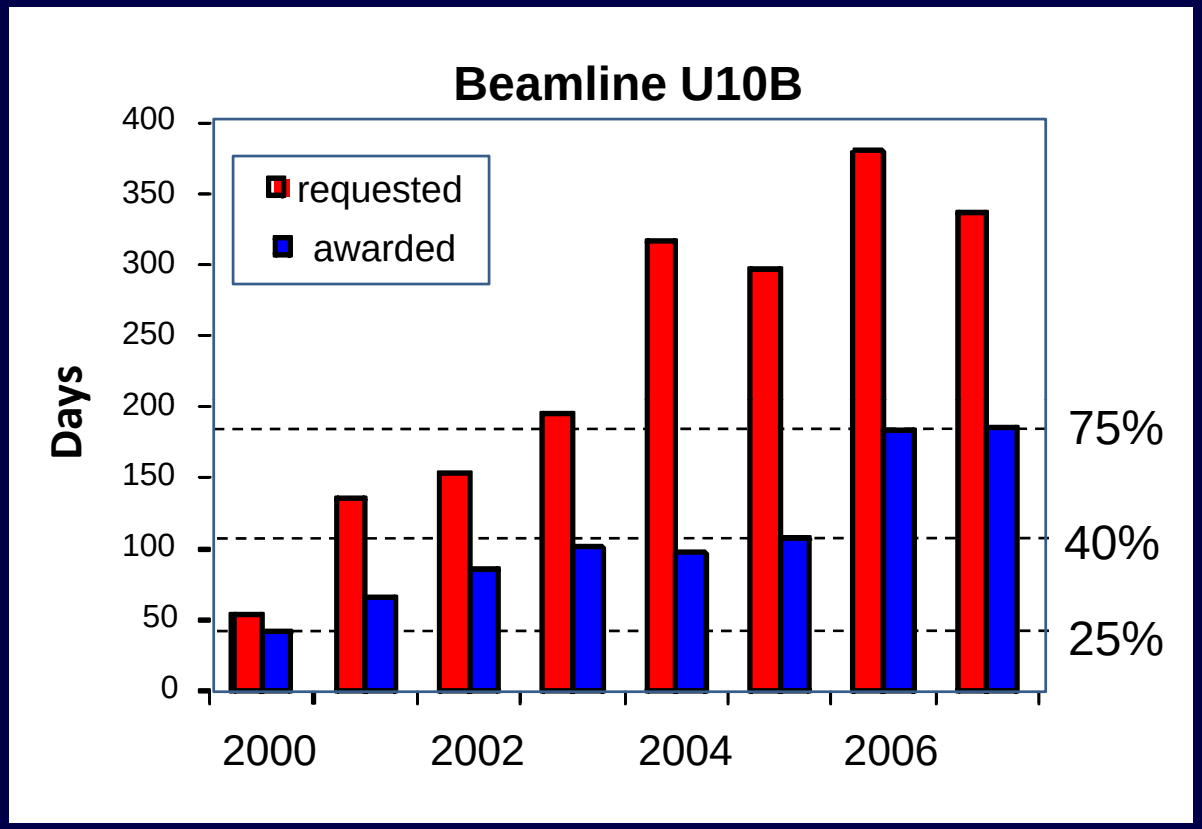
Long wavelengths limit spatial resolution

- Diffraction-limited to 3-10 microns (mid-IR)

Samples are "static" - live cell dynamics are difficult

- Today: samples typically dehydrated; need good S/N!

User Demand



- As General User fraction increases, beamtime requests increase
- All new synchrotron facilities are including IR beamlines in construction plans

IR Beamlines Worldwide
SRC, Daresbury
LURE, France
ALS, Berkeley (USA)
Aladin (USA)
NIST (USA)
NSLS, Brookhaven (USA)
Max-Lab (Sweden)
UVSOR (Japan)
Anka (Germany)
Bessy II (Germany)
CAMD (USA)
Daphne (Italy)
SRRC (Taiwan)
NSRC (China)
Spring 8 (Japan)
UVSOR (Japan)
CLS, Saskatoon (Canada)
SLS (Switzerland)
Soleil (France)
ESRF (France)
Australian Light Source
Diamond (England)

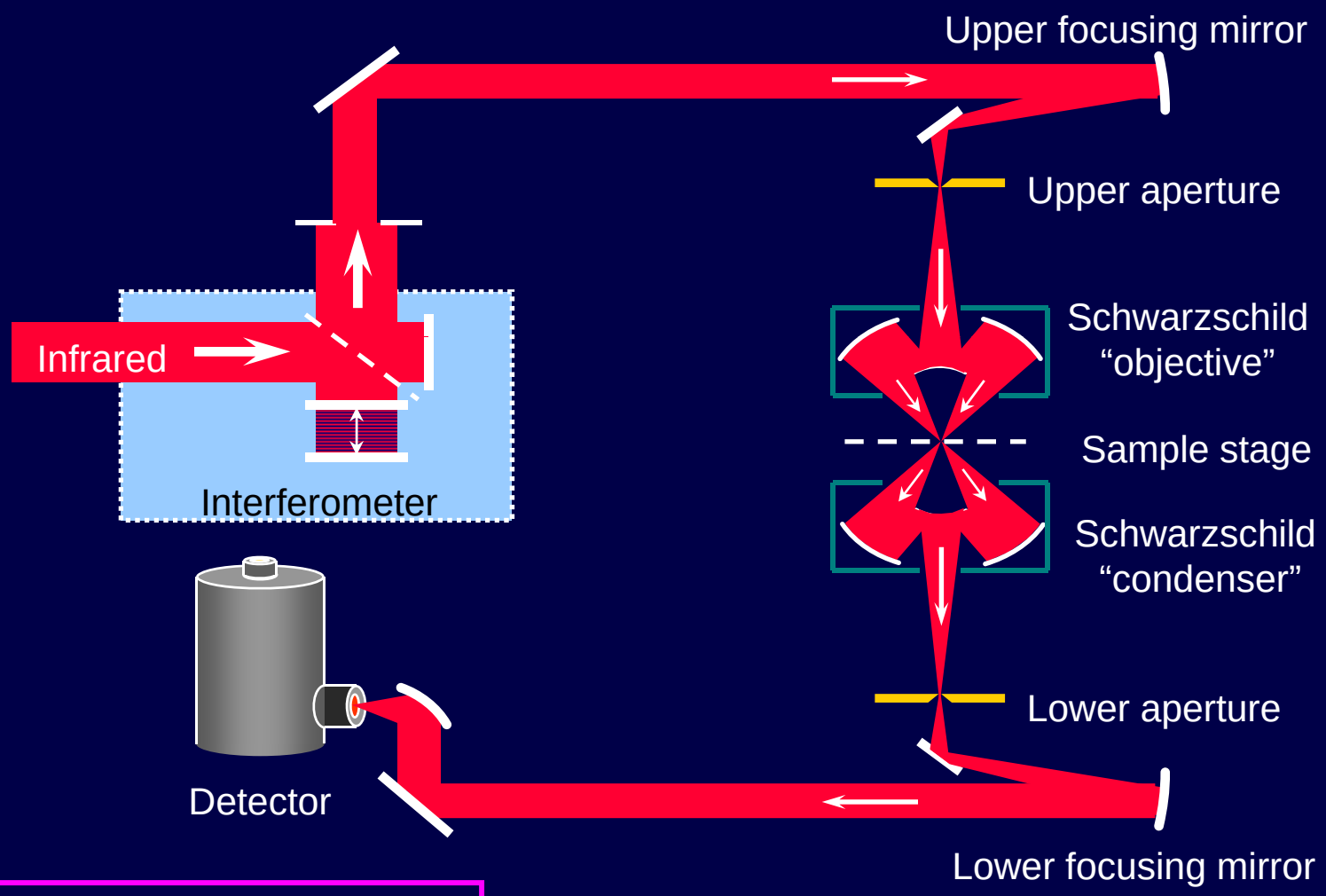
Infrared Microspectroscopy at NSLS-II

2 Infrared Beamlines for Life Sciences

- Full-field infrared imaging system*
- Confocal microspectroscopy system*

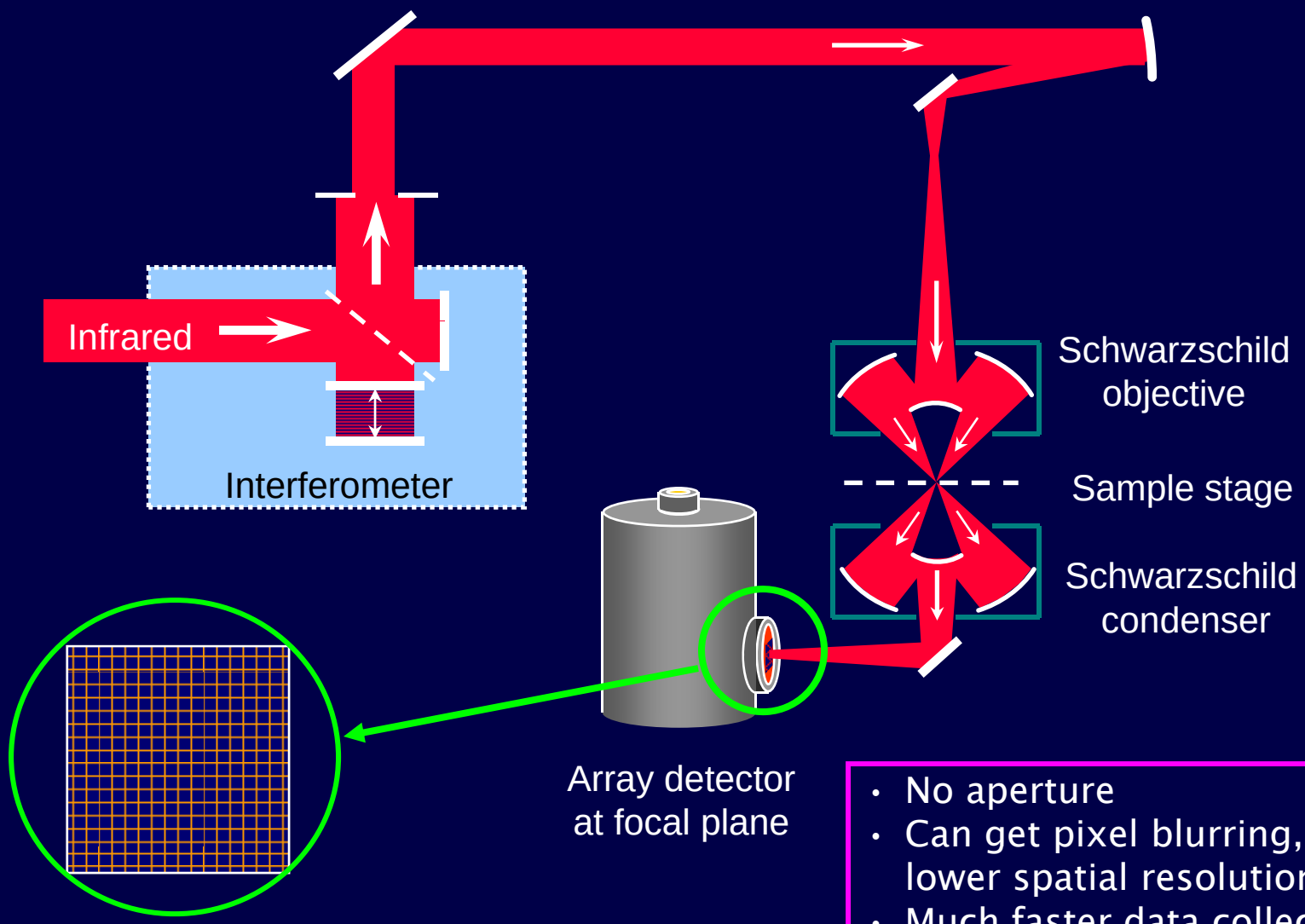
*will transition from NSLS

Confocal FTIR Microspectroscopy



- Dual aperture
- Maximum spatial resolution
- Single-pixel data collection

FTIR Imaging with a Focal Plane Array Detector



- No aperture
- Can get pixel blurring, i.e. lower spatial resolution
- Much faster data collection

Current NSLS Programs

U2B

- Case Center for Synchrotron Biosciences PRT
- Confocal microspectroscopy system
- Fully subscribed (25-35% GU time)

U10B

- BNL-NSLS facility beamline
- Confocal microspectroscopy system
- Oversubscribed by 1.5x (75% GU time)

U4IR

- BNL-NSLS facility beamline (time-share now)
- Full-field infrared imaging system
  - 128x128 pixel array (0.54 µm pixel resolution)
- Funded by NIH Shared Instrumentation Grant (2007)
- In commissioning; operational June 2008

Also **U2A** confocal microscope (CIW, high-pressure geoscience) & **U10A** far-IR microscope (BNL-NSLS; multipurpose)

Transition Status of NSLS Programs

U2B

- Case Center for Synchrotron Biosciences PRT
- Confocal microspectroscopy system
- Will continue to operate until NSLS turns off
- Will not transition to NSLS-II

U10B

- BNL-NSLS facility beamline
- Confocal microspectroscopy system
- Program will transition to NSLS-II bending magnet

U4IR

- BNL-NSLS facility beamline (time-share now)
- Full-field infrared imaging system
- Program will transition to NSLS-II bending magnet

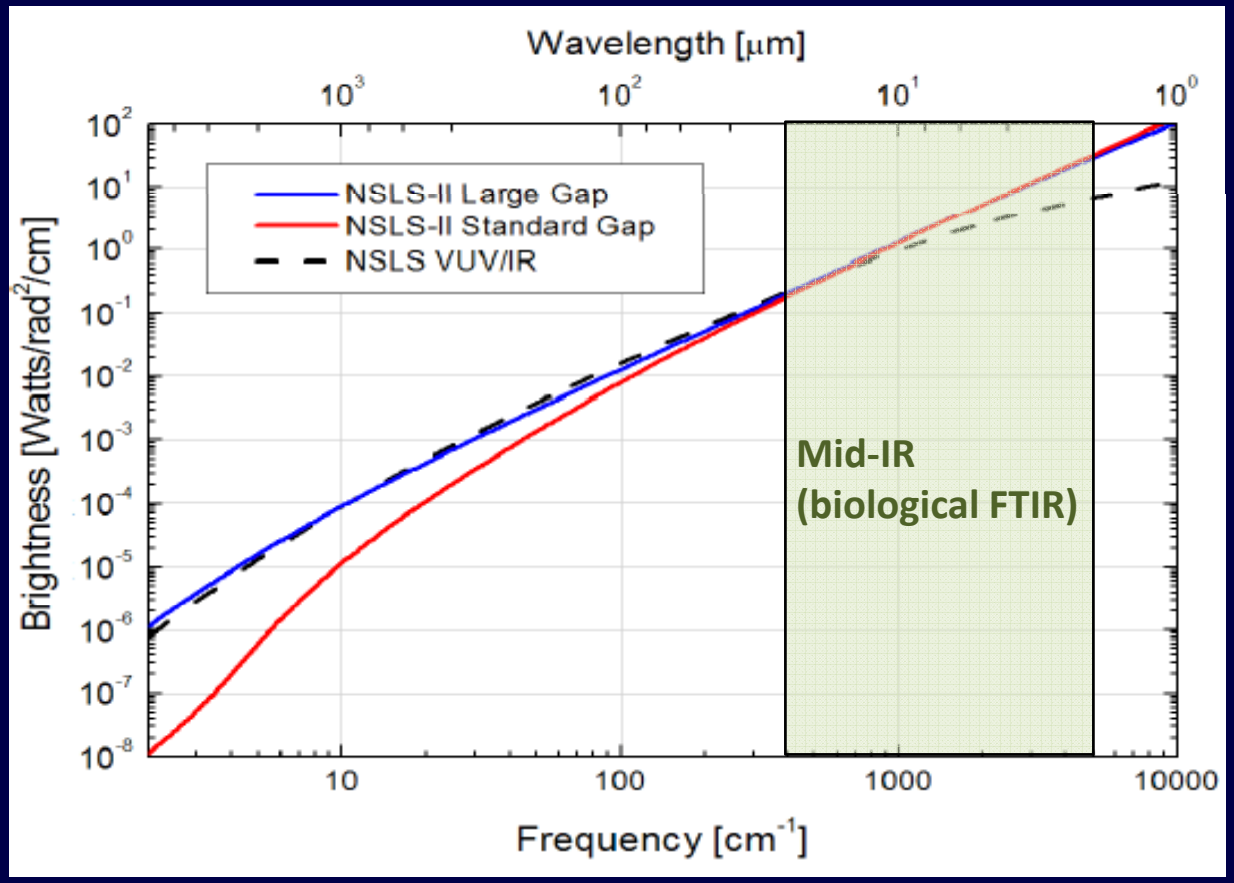
Additional future upgrade option at NSLS (pending funding):

- Modify U15/U16 ring chambers (accept ~200 mrad beam)
- Full field microscope will move to U15/U16
- U10B, U10A confocal microscopes will remain unchanged

TRANSITION TIMELINE:

- New ring chambers and front ends will be built at NSLS-II.
- Moving infrared endstations can be completed in 2-4 week time frame.
- Therefore, IR beamlines will remain at NSLS until the last photons are emitted.

How will NSLS-II improve IR imaging?



- FLUX & BRIGHTNESS: equal or better in mid-IR region
- STABILITY: expected to be 10 – 1000 times better

Scientific Need: What cannot be done today?

Data collection is slow

- Focal plane array detector will increase data collection rate by 3 orders of magnitude

Long wavelengths limit spatial resolution

- At NSLS-II, improved signal-to-noise (from increased ring stability) will enable oversampling and image deconvolution for ~1 micron spatial resolution (or better?)

Samples are "static" – live cell dynamics are difficult

- At NSLS-II, faster data collection and improved S/N will enable dynamics to be studied in living cells

Funding

- Keep infrared endstations state-of-the-art at NSLS
- Use NSLS-II operating funds to cover the costs of transitioning the two IR beamlines to bending magnets on the new ring.