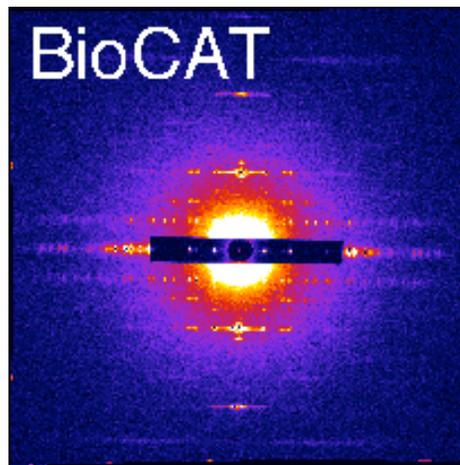


X-ray Diffraction Studies of
Drosophila melanogaster Indirect
Flight Muscle

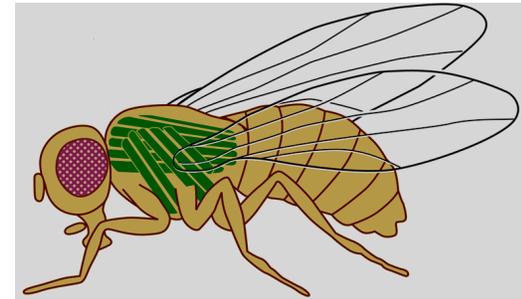


David Maughan, UVM

Tom Irving, IIT

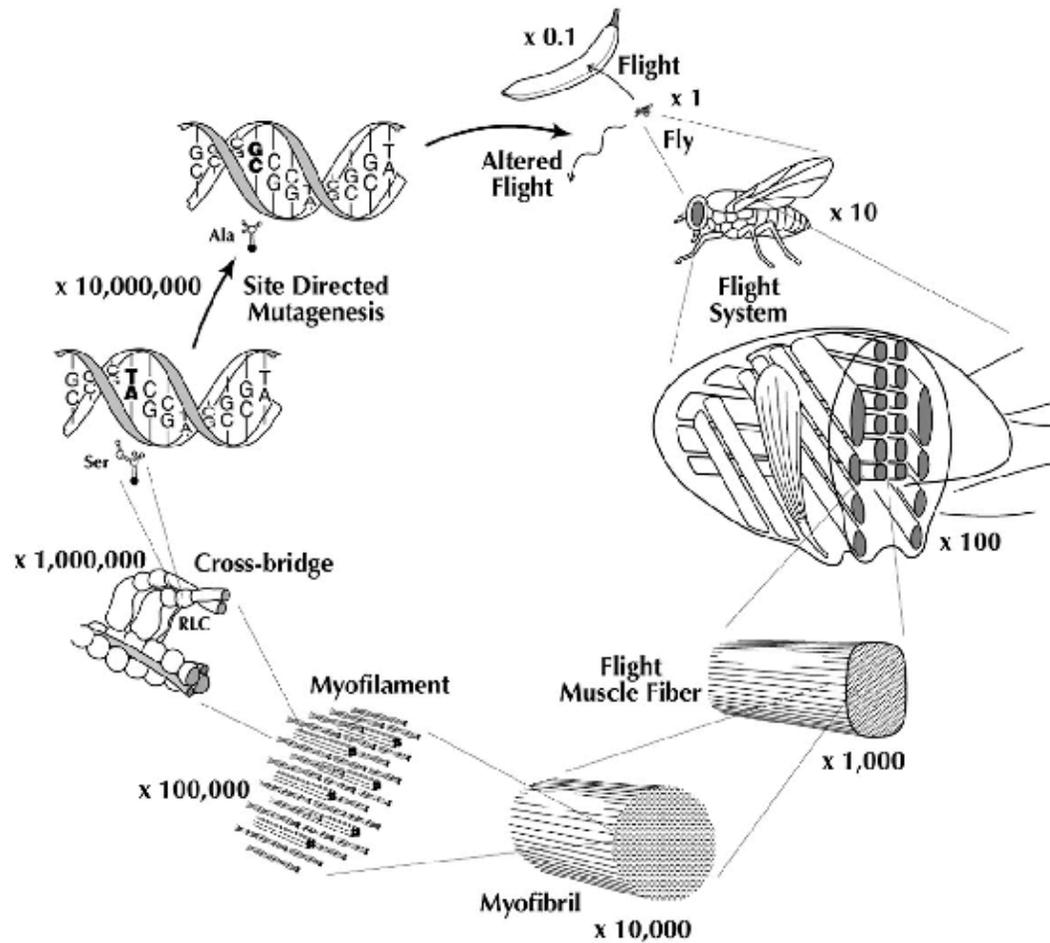
Significance and Overview (why flies?)

- Simple genetics
- Superb structure
- Can study integrated function
 - molecule to whole organism
- *In vitro* structure-function studies
 - demembration allows control of ionic environment
- *In vivo* structure-function studies
 - time-resolved measurements on working muscle
- Can compare with transgenic mouse models



Functional integration

– molecule to organism

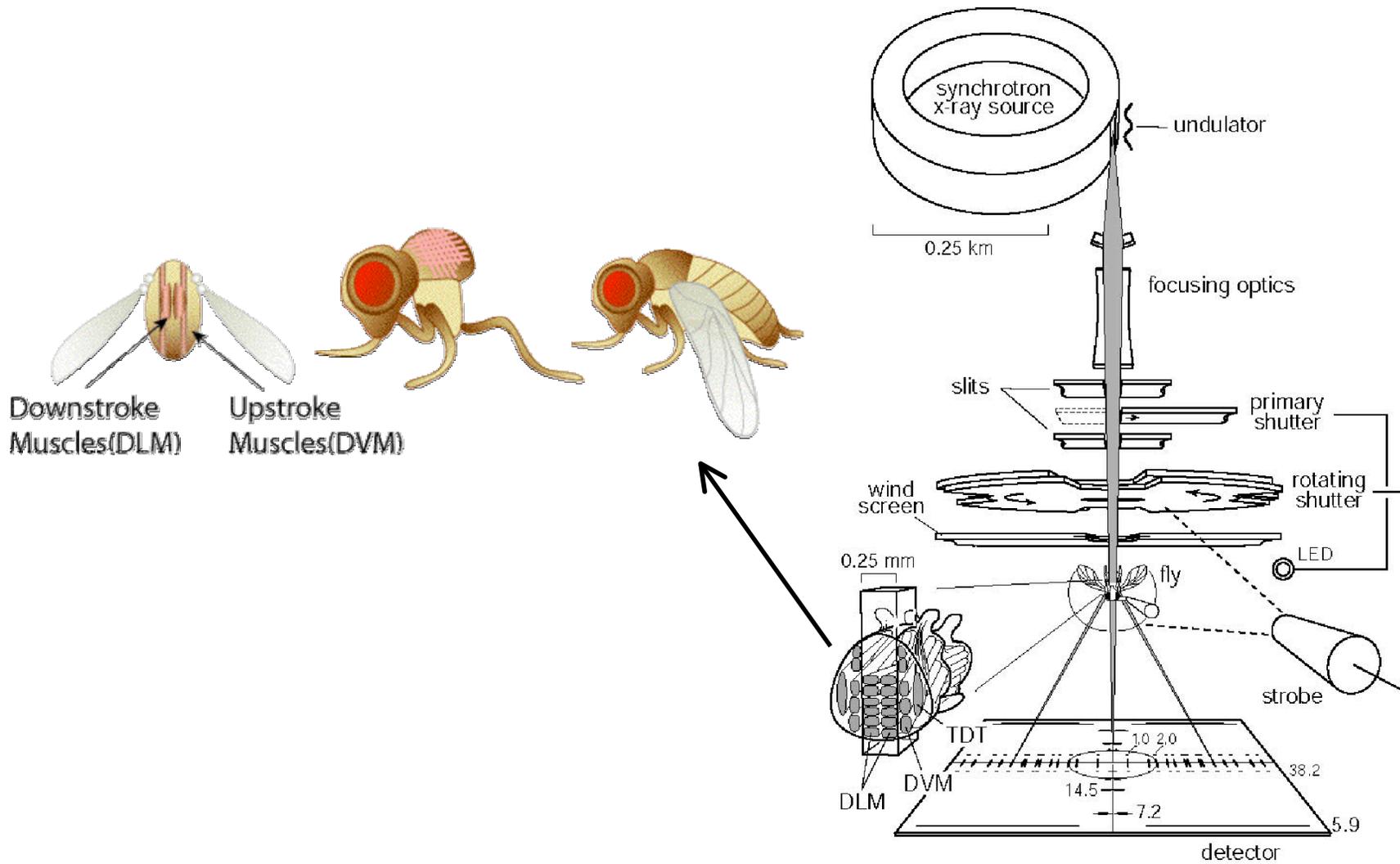


Maughan & Vigoreaux. *NIPS* 14, 87-92, 1999.

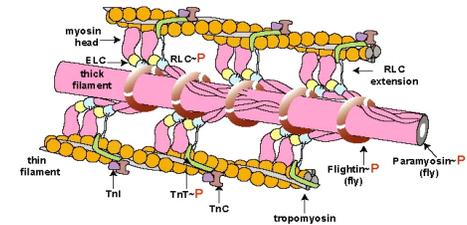
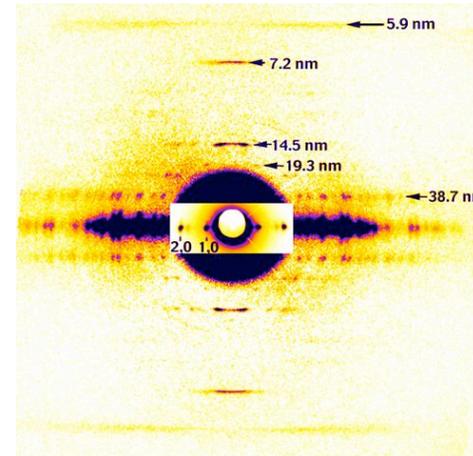
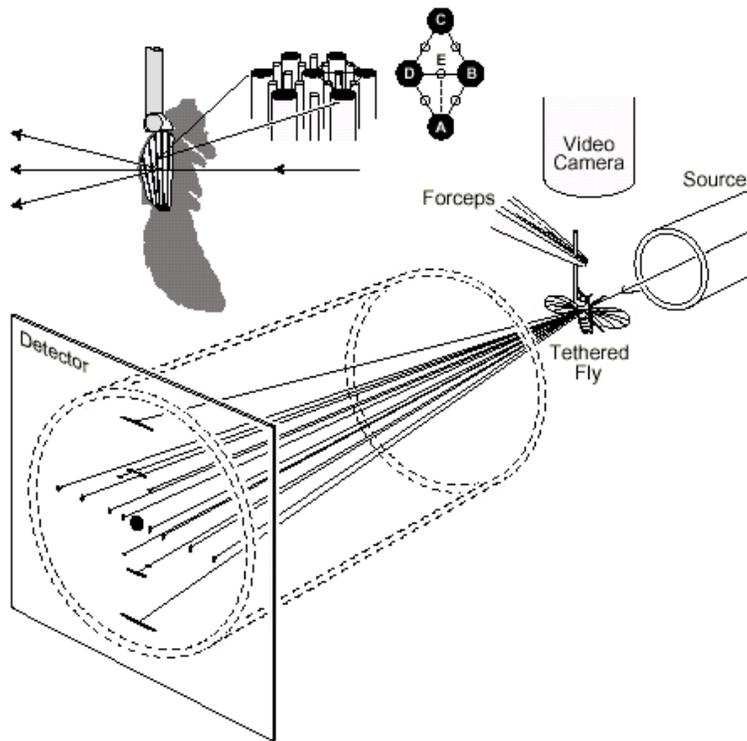
Tohtong et al. *Nature* 374, 650-653, 1995

Functional integration

– time resolved



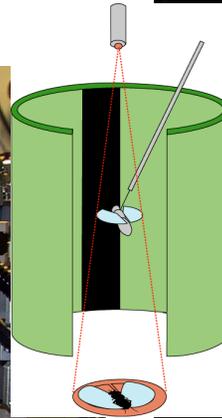
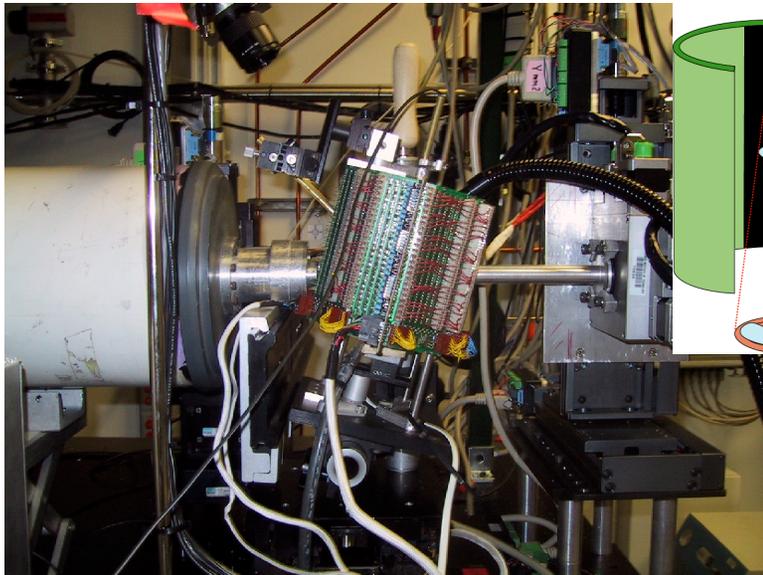
1st X-ray diffraction pattern from living fly



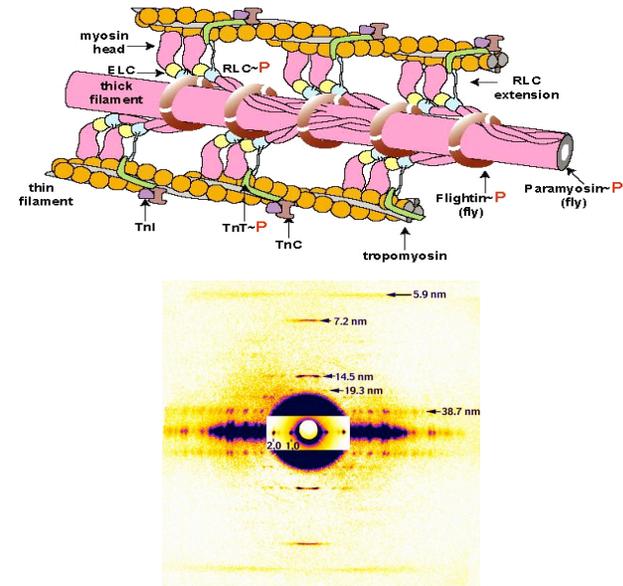
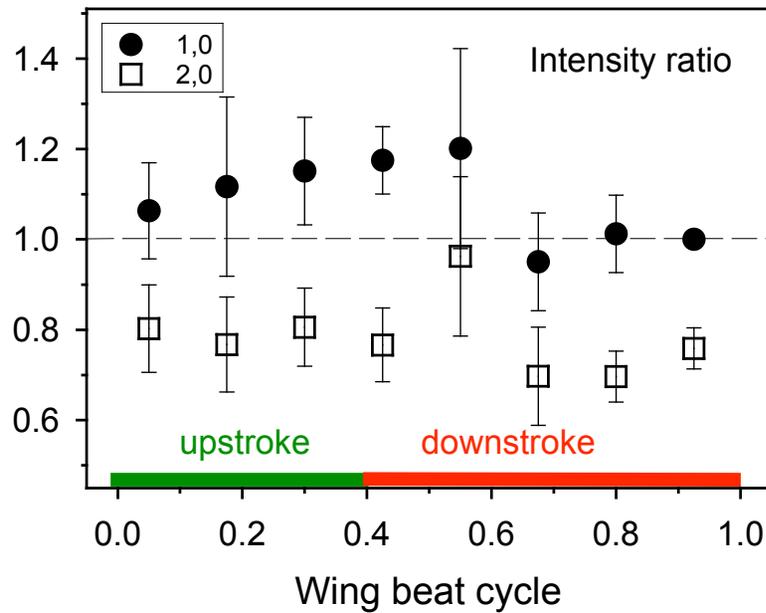
- *Drosophila* wing beat frequency ~ 200 Hz
- Obtained informative X-ray fiber patterns at the top and the bottom of the wing beat cycle (1 ms time resolution)
- Overturned the widely held ‘constant volume hypothesis’ of lattice spacing in intact muscle

Significant advances

- Methods and instruments
 - Visual field simulator
 - Wing-beat phase trigger
 - Rapid shutter

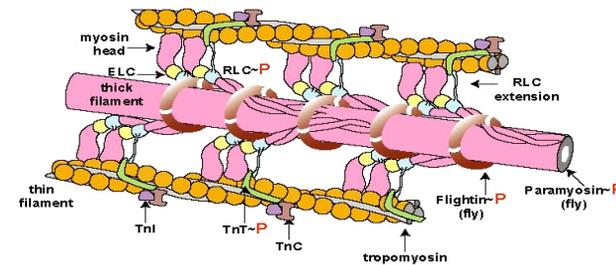
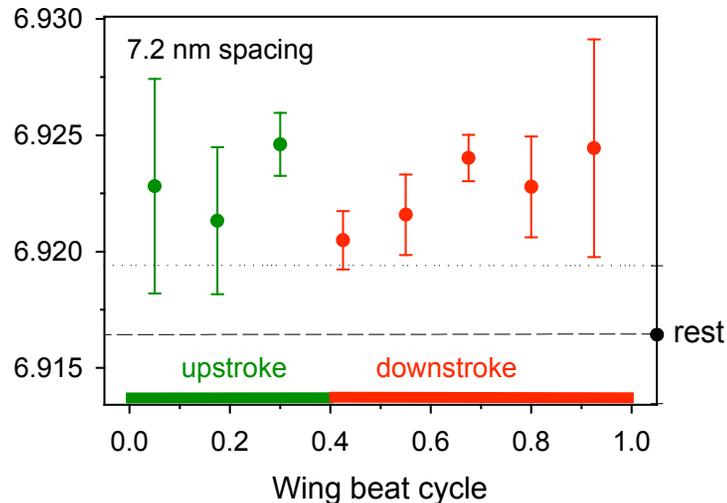


Time-resolved: 1,0 and 2,0 intensities



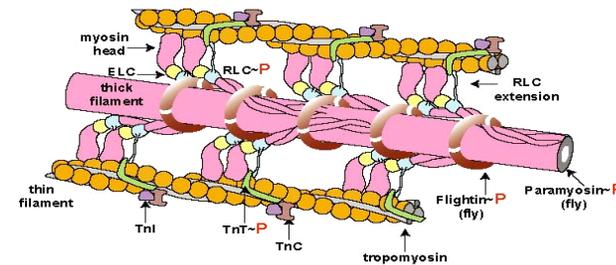
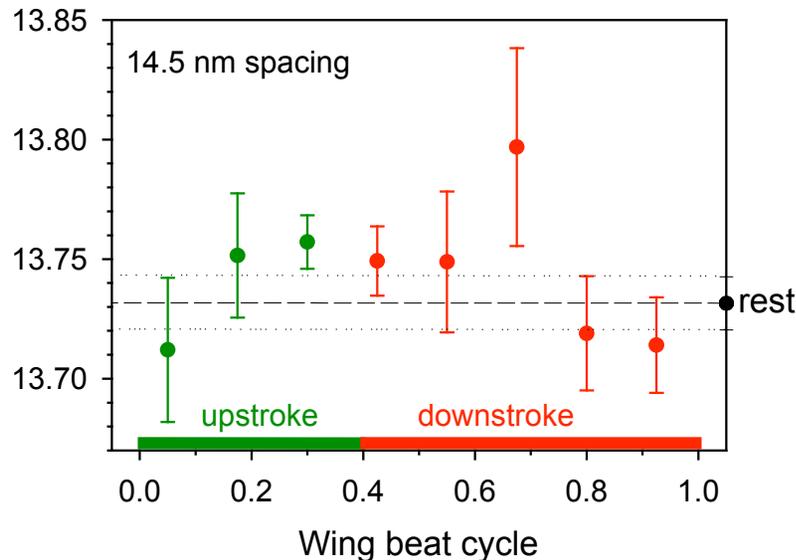
- Reflects mass movement between thick and thin filaments (radial motions/binding myosin heads)
- Cyclical

Time-resolved: 7.2 nm reflection



- Small changes in filament length index thick filament stiffness *in vivo*
- *Very* stiff ($\sim 0.09\%$ change upon activation vs. 0.3% in frog muscle)
- Cyclical, same period as (and in phase with) wing beat

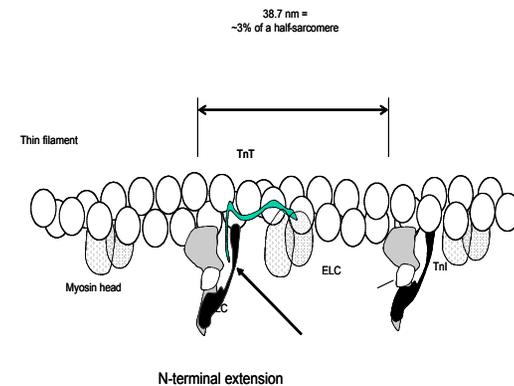
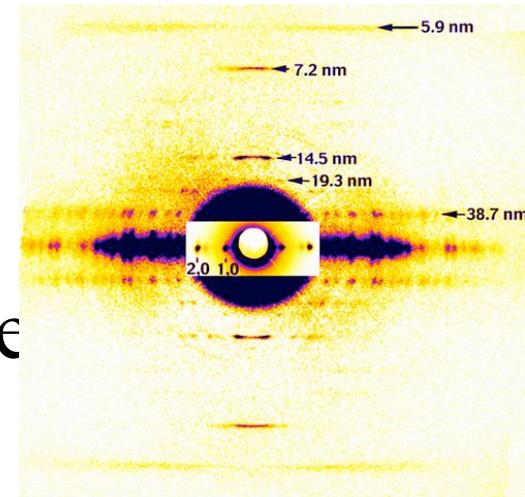
Time-resolved: 14.5 nm reflection



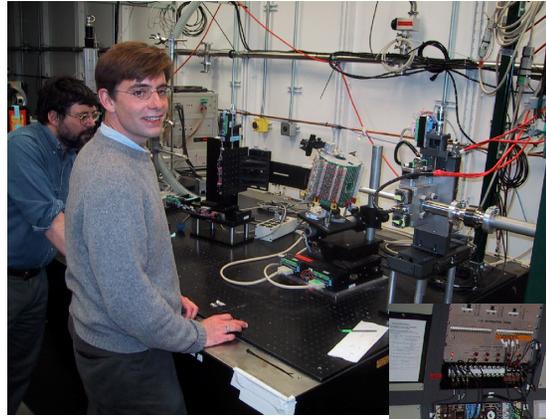
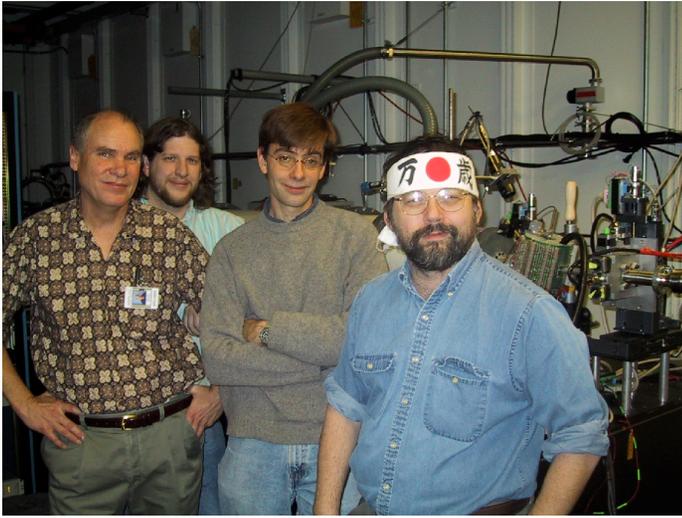
- Index longitudinal spacing of myosin heads *in vivo*
- Cyclical changes in spacing lead force production
 - ~0.6% change in center of mass upstroke to down stroke

Future....

- Time-resolved dynamics of crossbridge cycling in a invertebrate system
- Affect of mutants
- Need to get more X-ray patterns with more detail



Fly team..



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Michael Dickinson, Tom Irving
Mark Miller

BioCAT group

