

Hardware Wim Hagen





Questions

Hardware

What are we missing?

What are we likely to get soon?

What will be the hardware challenges in achieving this vision? Goniometers?

Cameras?

Can current phase plates be part of a high throughput vision?

Are there new hardware solutions under development that will help in the future?



My tomo history

FEI 2000-2011

Pre-calibration (Koster lab/FEI).

NIH 2006

• The 'Subramaniam special' (200 nm instead of 400 nm reproducibility: freeze stage XY).

EMBL 2011-current

UCSF Tomo (Agard lab).SerialEM (Mastronarde).

Most versatile: SerialEM.

Best features: post-actions, continuous readout, dose-symmetric script.









Deflection coils

Deflectors need a range.
Large range, high noise.
Noise is filtered.

Filtering creates delay.

- Can we switch off the electronics filter to remove the delay?
- Does it remove delay?

How much deflector noise on deflector coils without filtering?





Lens hysteresis



Current



Relative focus change





Faster cameras

- High frame-rate cameras.
- Constant video stream into buffer.
- Out frames from buffer.

◎ Gatan K2 can do continuous acquisition through SerialEM, 40 fps, streams to RAM.

Thermo Fisher Falcon 3 has infrastructure for feedback though its CMTS (e.g. as used in EPU frame alignment), 40 fps, in bursts (max length?).

Direct Electron, 92 fps, streams to SSD.

Dectris can maintain continuous streams at 9000 fps.



Faster cameras





Phase plates

Setting up (conditioning) Volta phase plate is slower than continuous tilt series acquisition!

Phase plate contrast to gain speed or to gain alignment?

- Do we need the same dose we would use without phase plate?
- Should we first try Volta phase plate SPA experiment with phase plate, 4 e/Å^2 total dose in 40 frames?

Berkeley laser phase plate:

- No need to change phase plate.
- No need to condition phase plate.
- Constant phase shift.

Charging tilted samples will stil be a problem!





Phase plates







Goniometers

• TEAM 1 piezo stage at NCEM?



Figure 3. a: The TEAM stage is an all-piezo driven sample stage completely housed in the objective lens portion of TEAM I. It allows for five-axis movement and is a tilt-rotate $(\alpha - \gamma)$ design with a range of $\alpha = \pm 180^{\circ}$ and $\gamma = \pm 180^{\circ}$. The holder accommodates 1 mm samples glued into special pucks of either the (b) annular-style with 1 mm inner diameter or (c) tip style.



Figure 5. a: 3 mm Cu grid showing two round 1 mm holes from TEAM I sample preparation. **b:** The resulting 1 mm piece is then glued into (**c**) an annular-style puck.

180 degrees tilt.11 pm/min drift.Stepping motion 250 nm to 10 um.Piezo motion +/- 200 nm, 14 pm steps

Operation of TEAM I in a user environment at NCEM. Ercius P, Boese M, Duden T, Dahmen U. Microsc Microanal. 2012 Aug;18(4):676-83. doi: 10.1017/S1431927612001225.



Dedicated system: cryo TEAM-like project for new stage?

"TEAM" stands for Transmission Electron Aberration-corrected Microscope, and the project involved two separate instruments.

The **TEAM Project** was a collaboration led by **DOE**'s **Lawrence Berkeley National Laboratory** (Berkeley Lab) and including DOE's **Argonne and Oak Ridge National Laboratories**, the **Frederick Seitz Materials Laboratory** of the University of Illinois, and two private companies specialising in electron microscopy, the **FEI Company** headquartered in Portland, Oregon which built the TEAM microscopes, and **CEOS of Heidelberg**, Germany which developed the new aberration correctors. The project began in June, 2004 and was completed at a cost of **\$27.1 million**.



Hardware

What are we missing? 1) GOOD STAGE! 2) MEMS? 3) Cc correction? What are we likely to get soon? Just more microscopes.....



