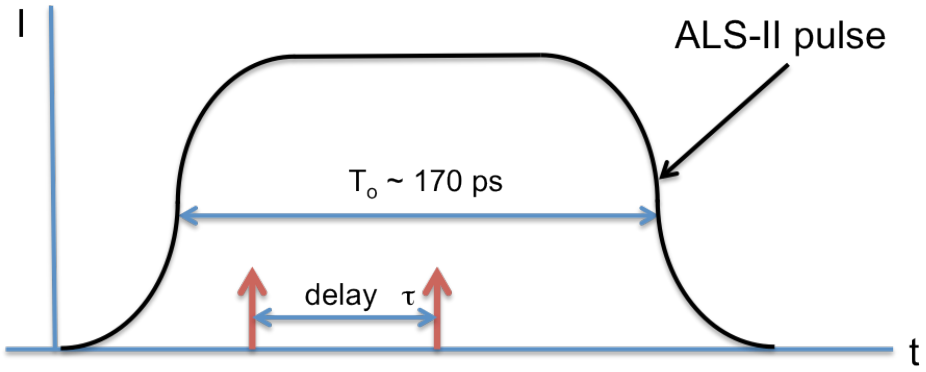
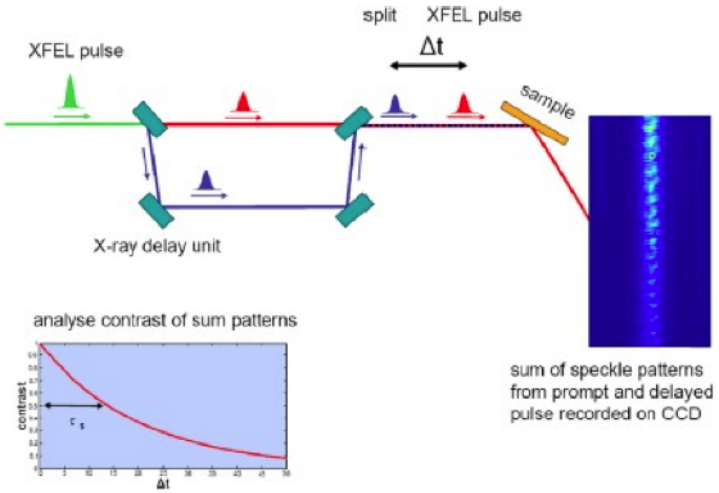
XPCS with “1 meV Resolution”?



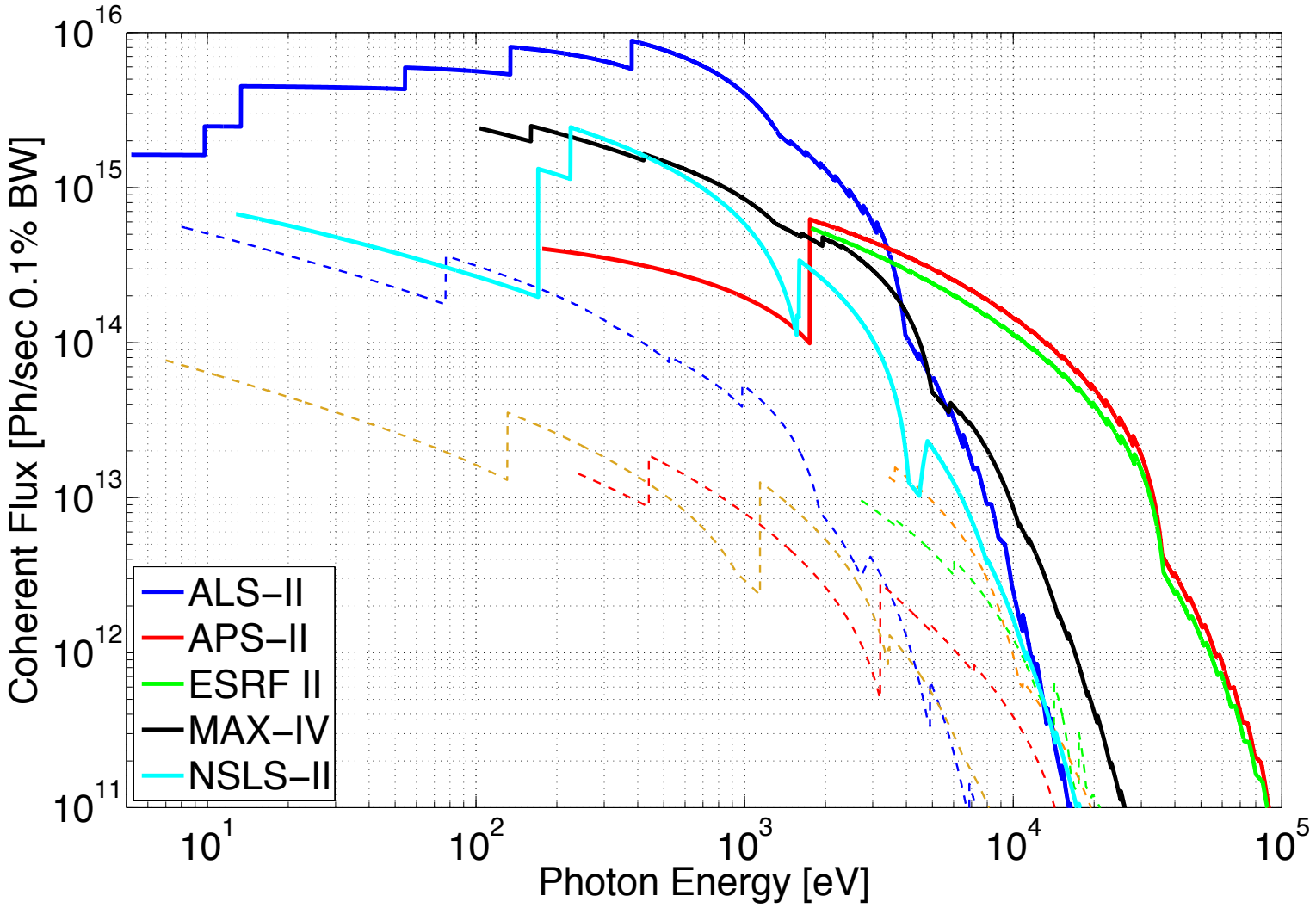
- Most pulses: 0 photons/speckle
- Some pulses: 1 scattered photon/speckle
- A few pulses: 2 scattered photons/speckle: measure the separation between these with a streak camera and bin the result
- Promising alternative to split-and-delay approach being developed on FELs
- Need to seek and measure delayed coincidences in all ALS-II pulses with ~1 ps resolution: fast (rf) streak camera

- 1 meV ~ k_BT/h: crossover between kinetics and dynamics
- Same formalism as RIXS
- XPCS measures decorrelation of delayed coincidences
- Natural limit is to measure coincidences from single SR pulses



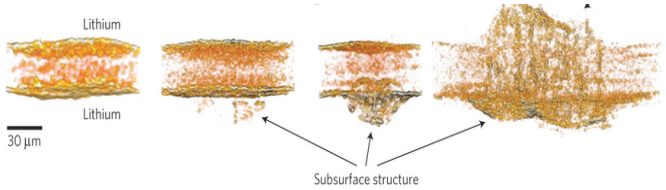
Hard X-ray XPCS with split-and-delay: LCLS and XFEL

It's All About Coherent Flux . . .



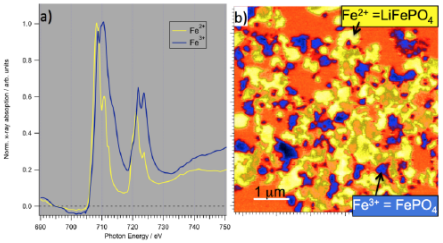
Addressing Challenges in Emerging Battery Materials: ptychography

K.J. Harry, doi:10.1038/nmat3793



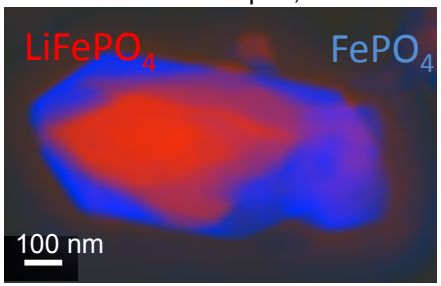
Battery dendrite structure with XT:
<1 μm resolution

W. Chueh, Nano Letters 13(3), 866-872 (2013)

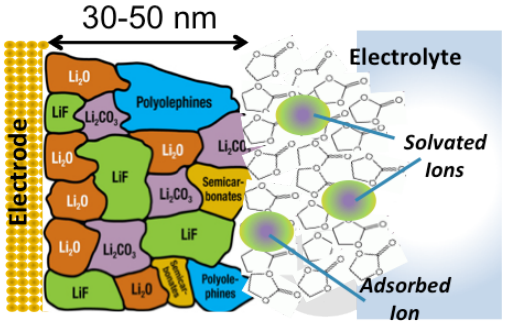


Battery oxidation states with STXM:
~30 nm resolution

David Shapiro, ALS



Battery grain with ptychography:
~10 nm resolution



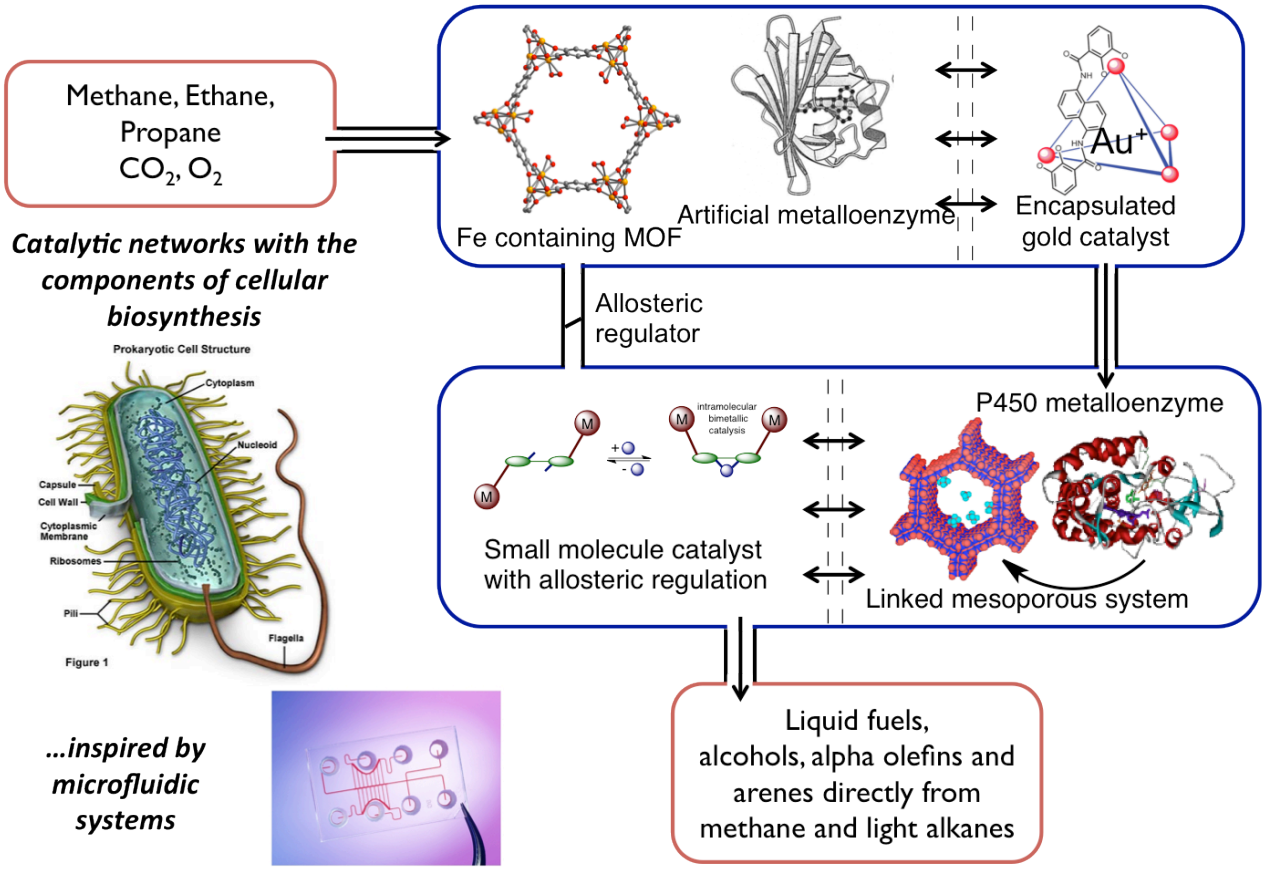
Many battery grand challenges start with understanding and controlling the solid-electrolyte interphase.

X-ray exposure time required to image 1 μm³ in 3D with 180 views

Resolution	30 nm	10 nm	3 nm
STXM w/ 25 nm zone plate @ **ALS**	180 s	-	-
Ptycho. w/ 60 nm zone plate @ **ALS**	180 s	4 hrs	21 days
Ptycho. w/ 60 nm zone plate @ **ALS-II**	1.8 s	146 s	5 hrs

Functional Mesoscale Networks: e.g., Catalytic Networks

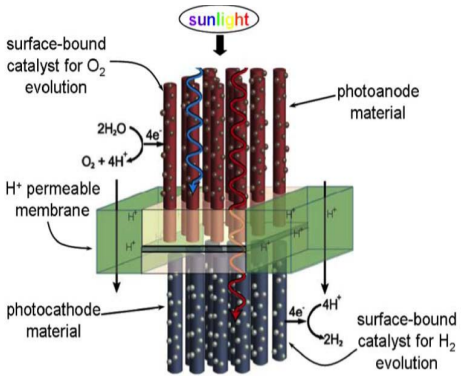
Probe the chemical structure and kinetics inside a mesoscale catalytic network with nanometer resolution and nanosecond sensitivity



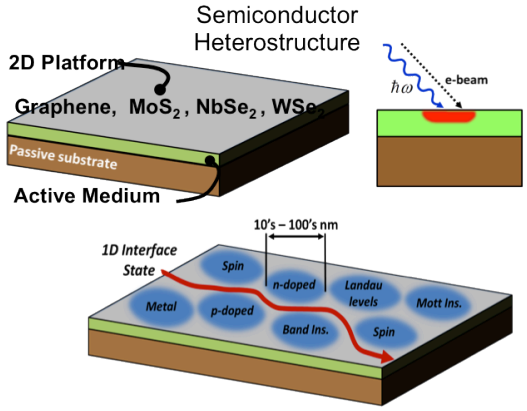
John Hartwig, Don Tilley, UCB/LBNL

Diverse Functional Mesoscale Networks

Use high coherent flux to probe the structure and kinetics of diverse functioning networks.



Artificial Photosynthesis Cell



Transport Networks

Compartmentalized

Functional

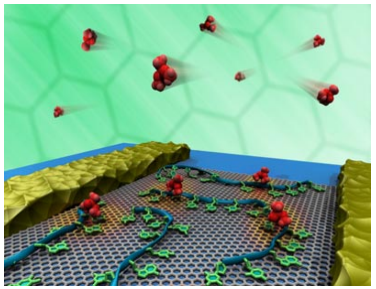
Nano-reaction-diffusion

Reconfigurable

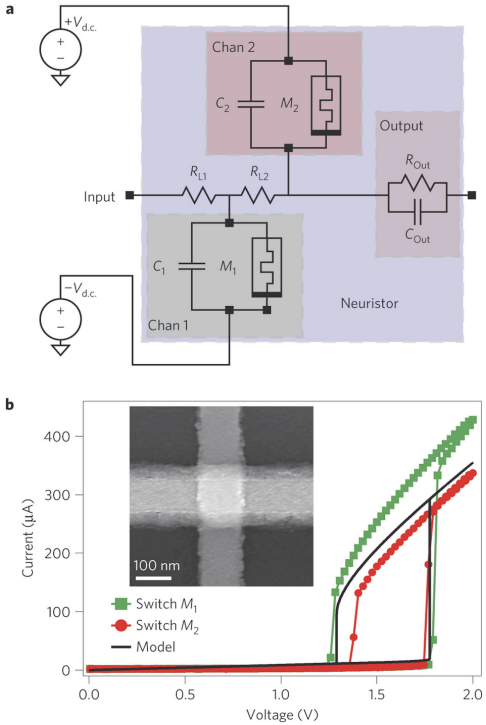
Feedback/Signaling

Regulated

Self-repair



(Bio)Chemical Sensor Networks
[Lu, *et. al.*, Appl. Phys. Lett. 97, 083107]



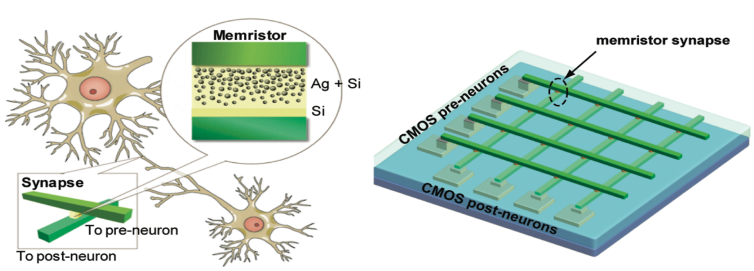
Memristor Networks
[Pickett, *et. al.*, Nature Materials 12, 114–117 (2013)]

Functional Mesoscale Networks: Analog Processors

High coherent flux will allow users to map the structure of diverse functioning analog processors – including memristor arrays.

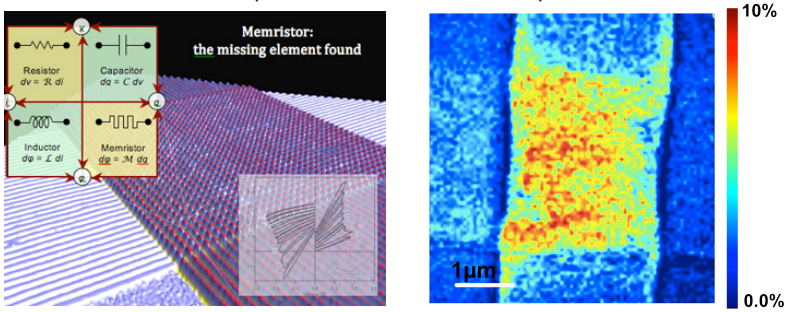
Memristor: analog of a synapse

Jo, et. al., Nano Lett. **2010,** *10,* 1297–1301



Memristor Crossbar Array

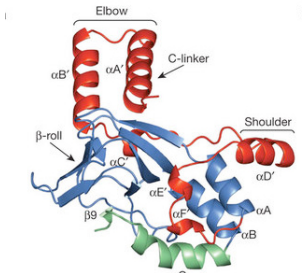
(Stan Williams, HP Labs)



- Memristor: resistance depends on current history
- Electromigration + local heating drives metal-insulator transition
- Resistance of memristor = strength of a synaptic connection →→→ learning
- Quiescent state has zero current: *low power (??)*
- Proposed for use in
  - - - digital memory and logic elements
  - - - neural networks and neuromorphic devices
  - - - field-programmable memristor arrays . . .

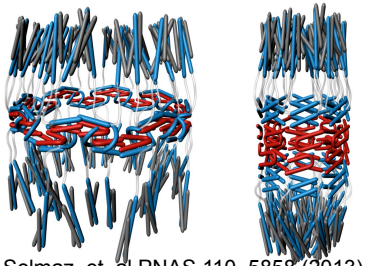
Tools to Connect Structural to Systems Biology

Use high coherent flux make multimodal maps to understand hierarchical biological systems



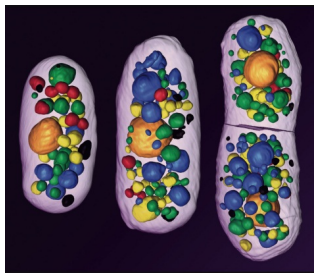
T.I. Brelidze, et al Nature 481, 530 (2012)

Gated ion channel



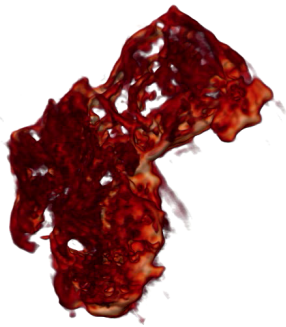
S. R. Solmaz, et. al.PNAS 110, 5858 (2013)

Protein complexes

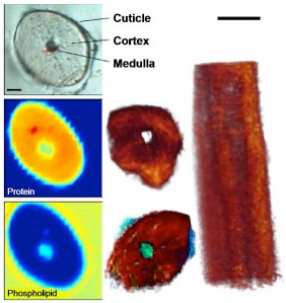


Carolyn Larabel, UCSF/LBNL

Cellular organization

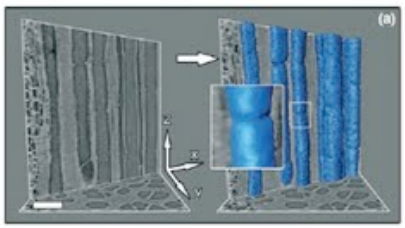


David Shapiro, ALS



M.C. Martin, e. al. *Nat Meth* **10**, 861 (2013)

Living tissues



Andrew McElrone, UCD

Plant vasculature

Soft X-ray Science on Ultrahigh Brightness Sources

- Leverage coherent flux to probe spatially and temporally heterogeneous systems
- Use soft x-ray spectroscopic contrast to make structural, chemical, magnetic, orbital maps: *where are the electrons?*
- Think about coherent flux
- *God made ~~the bulk~~ hard x-rays; ~~surfaces~~ soft x-rays were invented by the devil* (with apologies to W. Pauli)