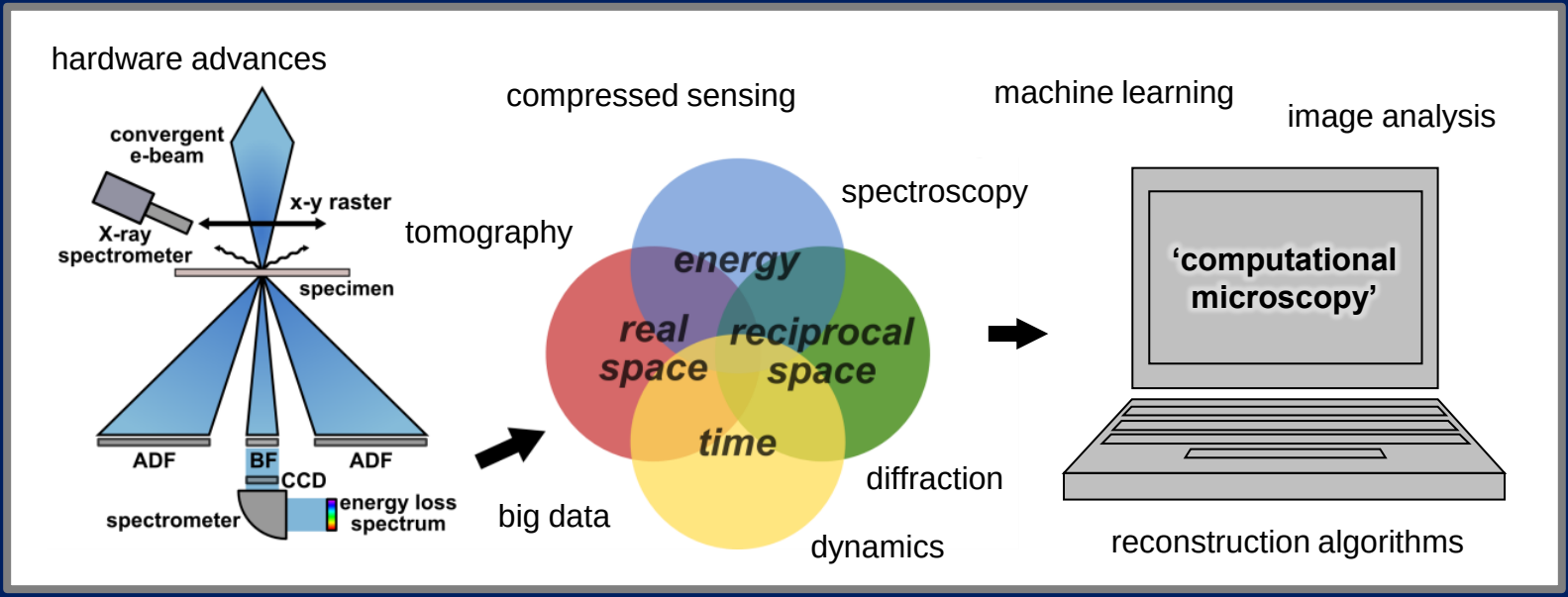
Big Data, Multimodality & Dynamic Models in Biomedical Imaging
Wednesday 9th March 2016, Isaac Newton Institute, Cambridge

Multi-Dimensional Electron Microscopy

Rowan K. Leary

Department of Materials Science and Metallurgy, University of Cambridge
Junior Research Fellow, Clare College

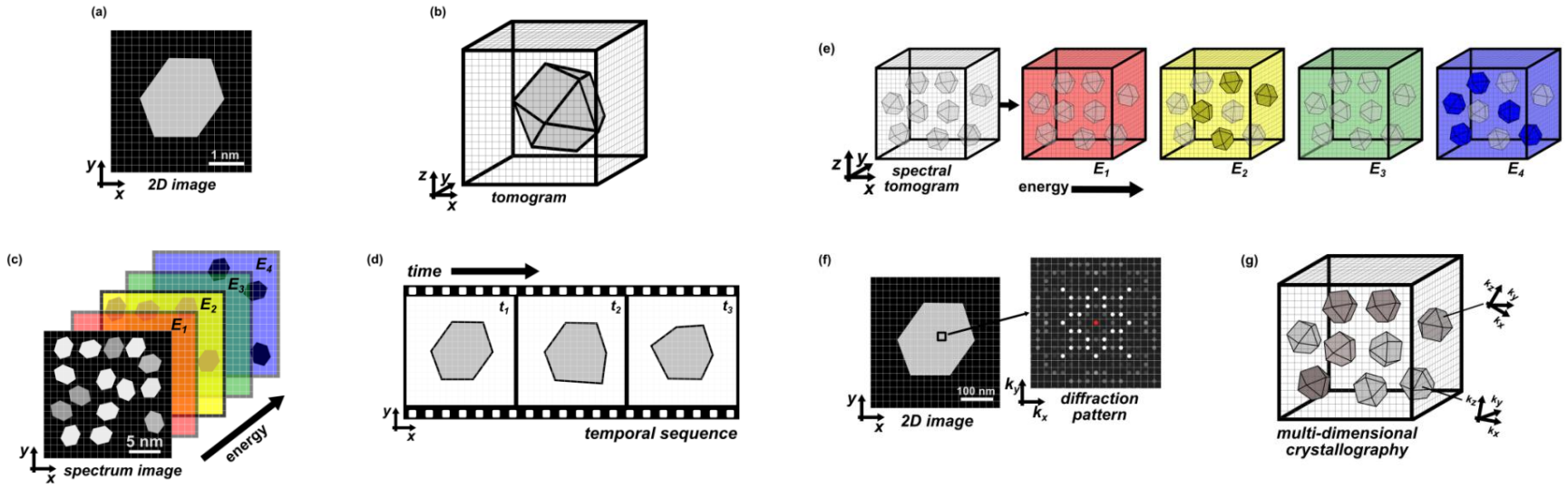


Chem. Phys. Lett. 631-632 (2015) 103-113

Email: rkl26@cam.ac.uk

Electron Microscopy Group

Burgeoning New Era



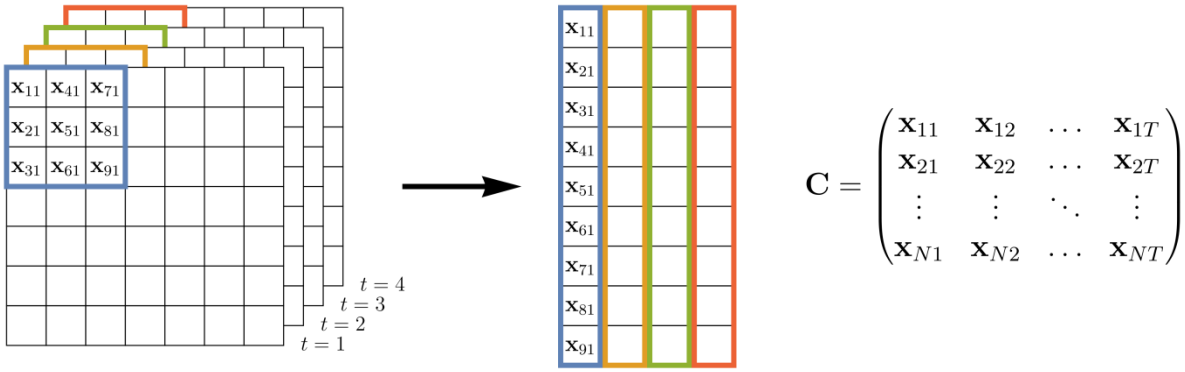
- **A flood of multi-dimensional 'big data'**
- **Yet extremely limited data in many aspects**
  - **Electron beam sensitivity**
  - **Hardware constraints**

} **Want the salient *information content***

J.M. Thomas, R. Leary, A.S. Eggeman, P.A. Midgley Chem. Phys. Lett. 631-632 (2015) 103-113

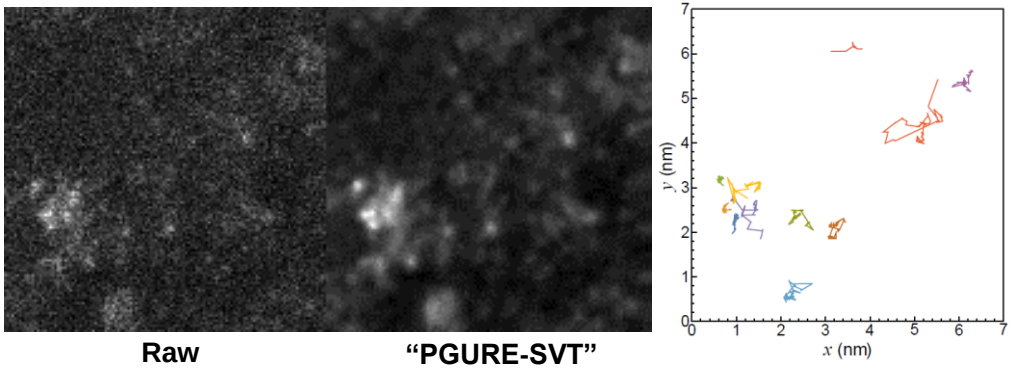
Dynamic Imaging + Spatio-Temporal Denoising

- **Successive frames often highly correlated**



- **Form (approx.) low rank 'Casorati matrix'**
  - → **Seek low rank to regularize noisy/incomplete sequences**

Tracking single atom random walks

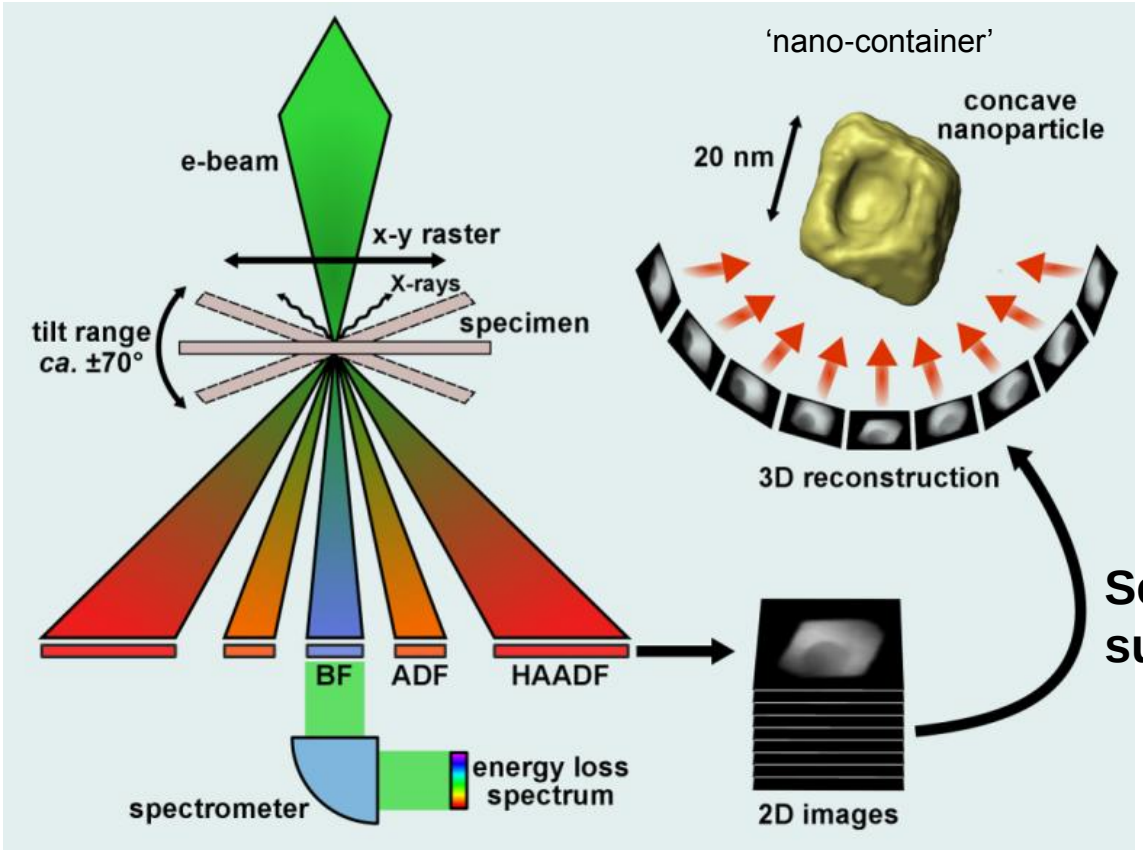


Raw **"PGURE-SVT"**

Poisson Gaussian Unbiased Risk Estimator Singular Value Thresholding

T. Furnival, R. Leary & P. Midgley (submitted)

Electron Tomography + Compressed Sensing



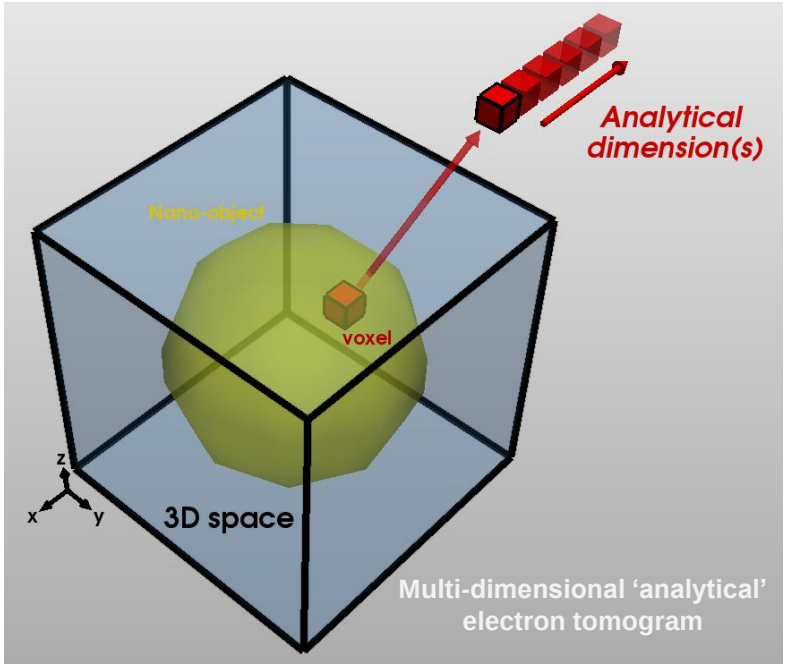
Sparsity is prevalent at the nanoscale

Seek a sparse solution subject to data fidelity

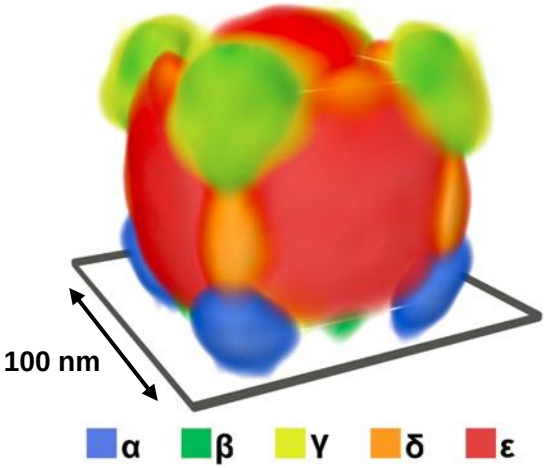
Leary *et al. Ultramicroscopy* 2013, *131*, 70-91
Saghi et al. *Nano Letters* 2011, *11*, 4666-4673

Multi-Dimensional Tomography + Machine Learning

HyperSpy
hyperspectral data analysis



- **Spectroscopic (EDX+EELS)**
- **Dynamic (time-resolved)**
- **Crystallographic**
- **Vector fields**



Silver nanocube localised surface plasmon resonances visualised in 3D

- Non-negative matrix factorisation
- Compressed sensing reconstruction

Nicoletti et al. Nature 502 (2013) 80-84

Pertinence to plasmonic:
- Bio-sensing
- Photo-thermal cancer treatment
- many more…

Leary & Midgley MRS Bulletin (in preparation)

Multi-Dimensional Tomography + Machine Learning

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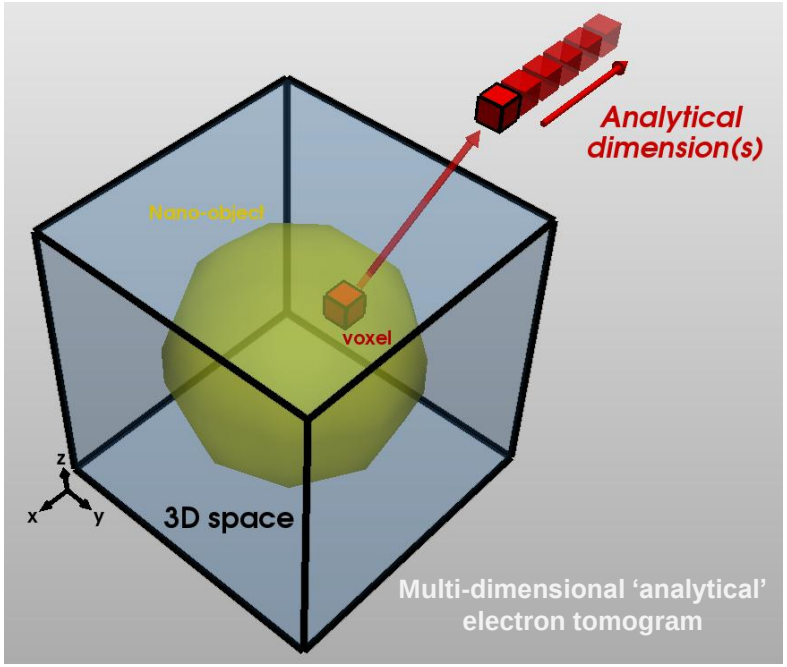

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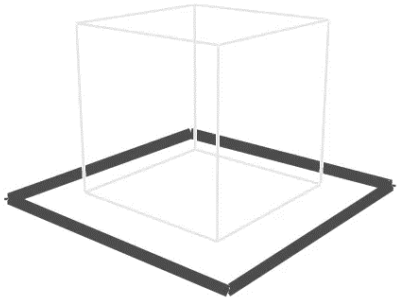

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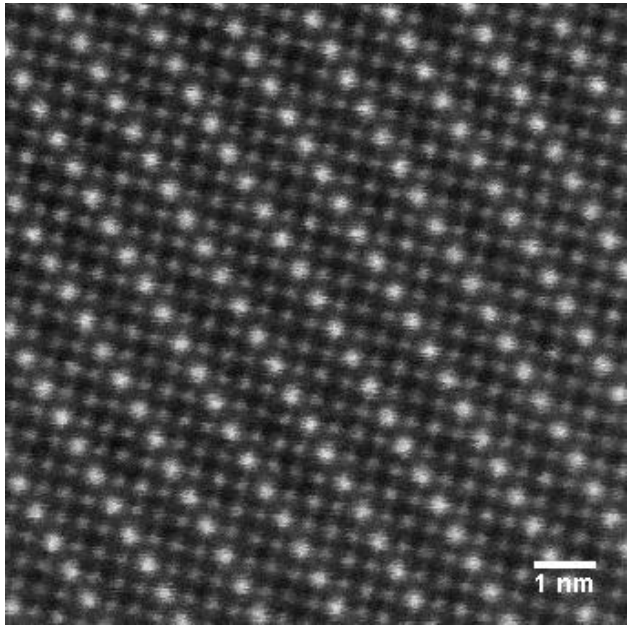
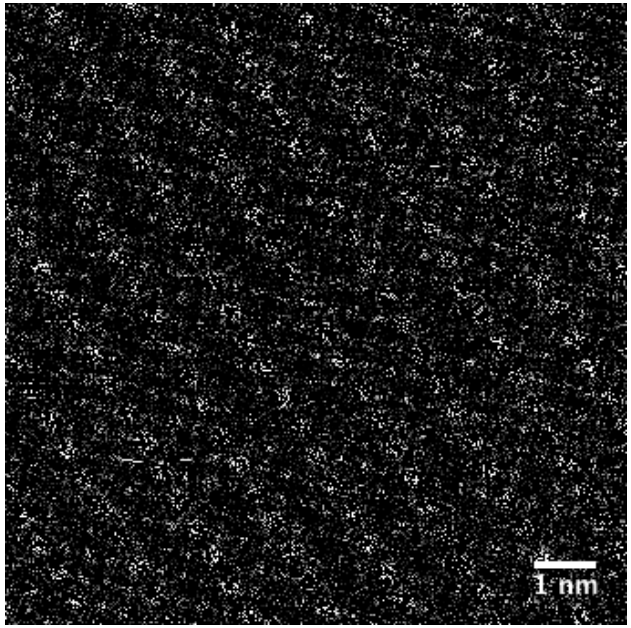
Pixel-Wise Sub-Sampled Acquisition + Inpainting



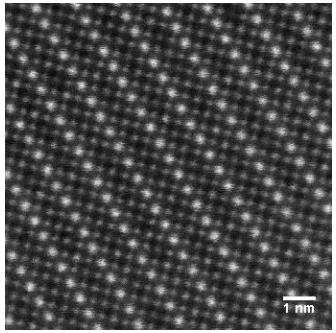


Conventional acquisition: record signal at every pixel

New thinking: sub-sample

↓

computational recovery



Electron tomography:
Saghi et al. *Advanced Structural & Chemical Imaging* 1 (2015) 7

Atomic-Resolution Imaging + Spectroscopy: (manuscripts in preparation)
Quentin Ramasse, Patricia Abellan, Dorothea Mücke-Herzberg, Iain Godfrey, Michael Sarahan (SuperSTEM)
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Jacki Ma, Gitta Kutyniok (TU Berlin)
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Paul Midgley
Electron Microscopy Group,
Department of Materials Science and Metallurgy
University of Cambridge

Quentin Ramasse
Patricia Abellan
Dorothea Mücke-Herzberg
Iain Godfrey
Michael Sarahan
superSTEM, STFC Daresbury Laboratories

Martin Benning
Carola-Bibiane Schönlieb
Anders Hansen
Bogdan Roman
Department of Applied Mathematics and
Theoretical Physics, University of Cambridge

Jackie Ma
Gitta Kutyniok
Institute of Mathematics,
Technische Universität Berlin

Daniel Holland
Andy Sederman
Department of Chemical Engineering and
Biotechnology, University of Cambridge

Andrew Stevens
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European Research Council

Clare College
Cambridge

esteem2
european network for electron microscopy

SuperSTEM DARESBURY