



# Data Types by

- Depth
- Channels
- and Dimensionality

# Depth/Bit Rate

- 1 bit (**binary digit**) allows two states 0 and 1

bit	grey values	4 Mpx file (monochrome) [MB]
8	256	4
16	65.536	8
32	4.294.967.296	16
64	18.446.744.073.709.551.615	32

- In images usually unsigned integers (no negative values)

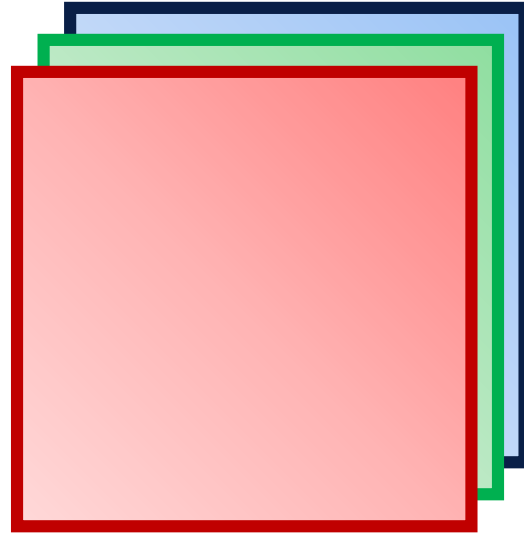
# Channels

- 1: Greyscale
- 3: **Red, Green, Blue** (screen colors, color receptors in the human eye)
- 4: **Cyan, Magenta, Yellow, Key** (black; printer colors)  
**Red, Green, Blue, Alpha** (transparency)
- (5: **Cyan, Magenta, Yellow, Key + Alpha**)

# Dimensionality



2D greyscale



2D RGB



3D greyscale  
(image series,  
spectrum image)

Image not found ☹️

4D greyscale  
(spectrum image series,  
2D data for a scanpoint  
(EBSD, 4D STEM))  
(5D in 4D series)

# Higher Dimensions and Data Structure

- Image: pixel x pixel
- Spectrum Images: pixel x pixel x n energy channels (n dependent on detector)
- Image Series: pixel x pixel x n frames (n dependent on experiment and exposure time)  
(order n,x,y or x,y,n dependent on byte order)
- Spectrum Images Series: pixel x pixel x energy channels x frame
- EBSD/4D-STEM: (pixel x pixel) x (pixel x pixel)

# Most Common Types

	Type	Depth and Channels	Dimensionality	Compression	Metadata
Primary	.emd (Velox)	1 - 64	N	No	Yes
	.ser (TIA)	32	3 (4?)	No	Yes
	.dm3 (DM)	1 - 64	4	No	Yes
	.tif (SEM)	16	3	No	Yes
Secondary	.tif	32 (64); 3x16 RGB; 4x8 RGBA/CMYK; 5x8 CMYKA	3	No	Yes
	.jpeg	8 - 16; 3x16 RGB	2	Yes	No
	.png	1 - 16; 3x16 RGB; 4x16 RGBA	2	Yes	No
	.bmp	1 - 16; 4x8 RGBA	2	No	Yes
	.gif	8, 3x8 RGB, 4x8 RGBA	3	Yes	No

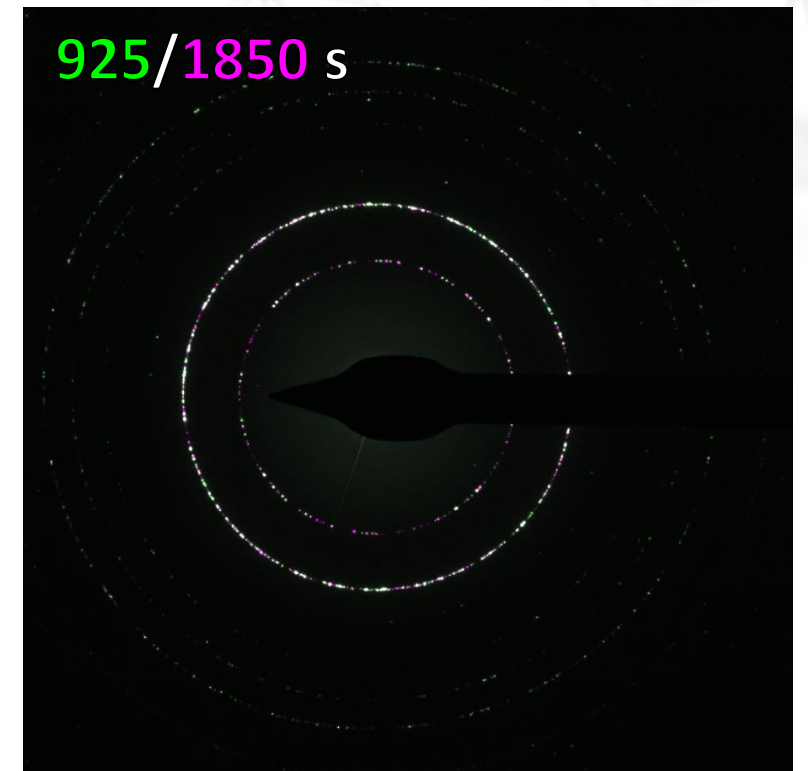
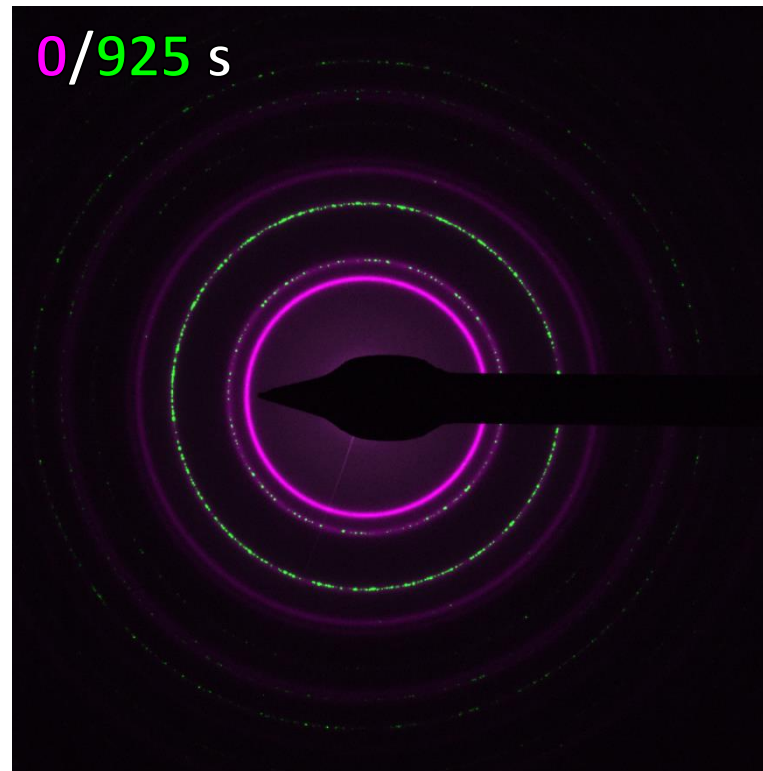
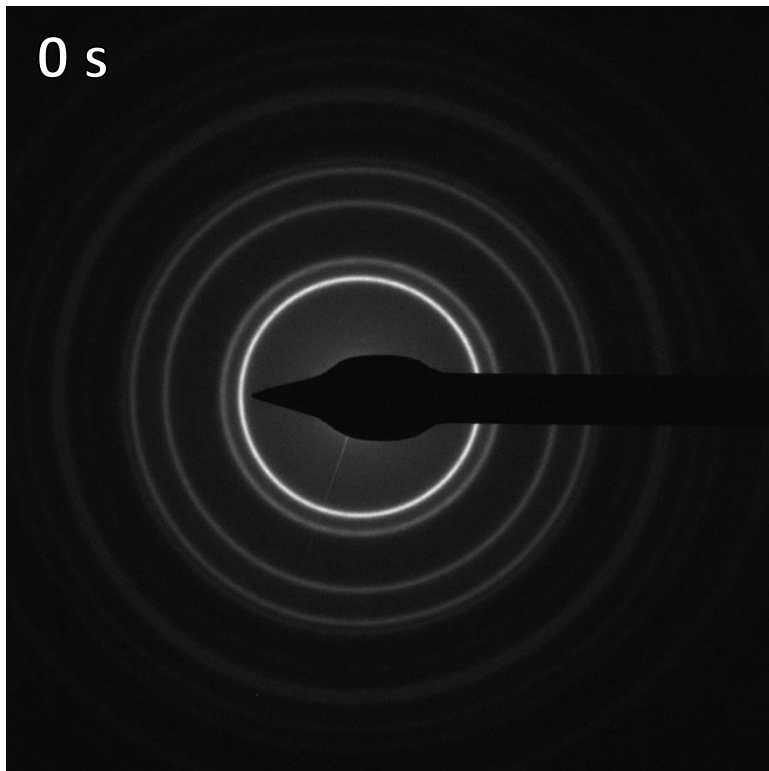
Special file types for EBSD are 4D

# The .emd Format

- Based on HDF5 (can be opened in according viewers)
- Developed for TEM by FEI and the NCEM
- Unfortunaetly different byte order chosen (n,x,y vs x,y,n)
- Still extremely accessible for scripting (Python packages available)!
- Datacubes for spectrum images recorded accumulatively in Velox, individual frames not readily extractable

# Usage of RGB channels

- Up to 3 greyscale maps/images remain rather interpretable
- Illustration of change between two points in time between two greyscale images



Development of [111] texture in Pt thin film due to heating



A decorative graphic in the top right corner of the slide, consisting of a network of interconnected nodes and lines, resembling a molecular structure or a data network. The nodes are small dark circles, and the lines are thin, light gray. The overall appearance is that of a complex, interconnected system.

**Thank you for your attention!**

# Take Home Message and Extras

- When choosing a file format, be aware of its potential and limitations
- Original data should always be saved and kept uncompressed
- Before you start an experiment choose how and what to store
- Location of Velox batch converter to export emd files:
  - ,Velox folder'\BatchExport.exe