“The instrument”

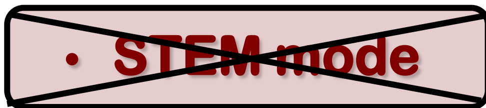
Lecture 4

Review of imaging modes

System overview

Review of imaging modes

- Condenser system
- Objective lens & sample stage
- Forming images and diffraction patterns
  - TEM mode



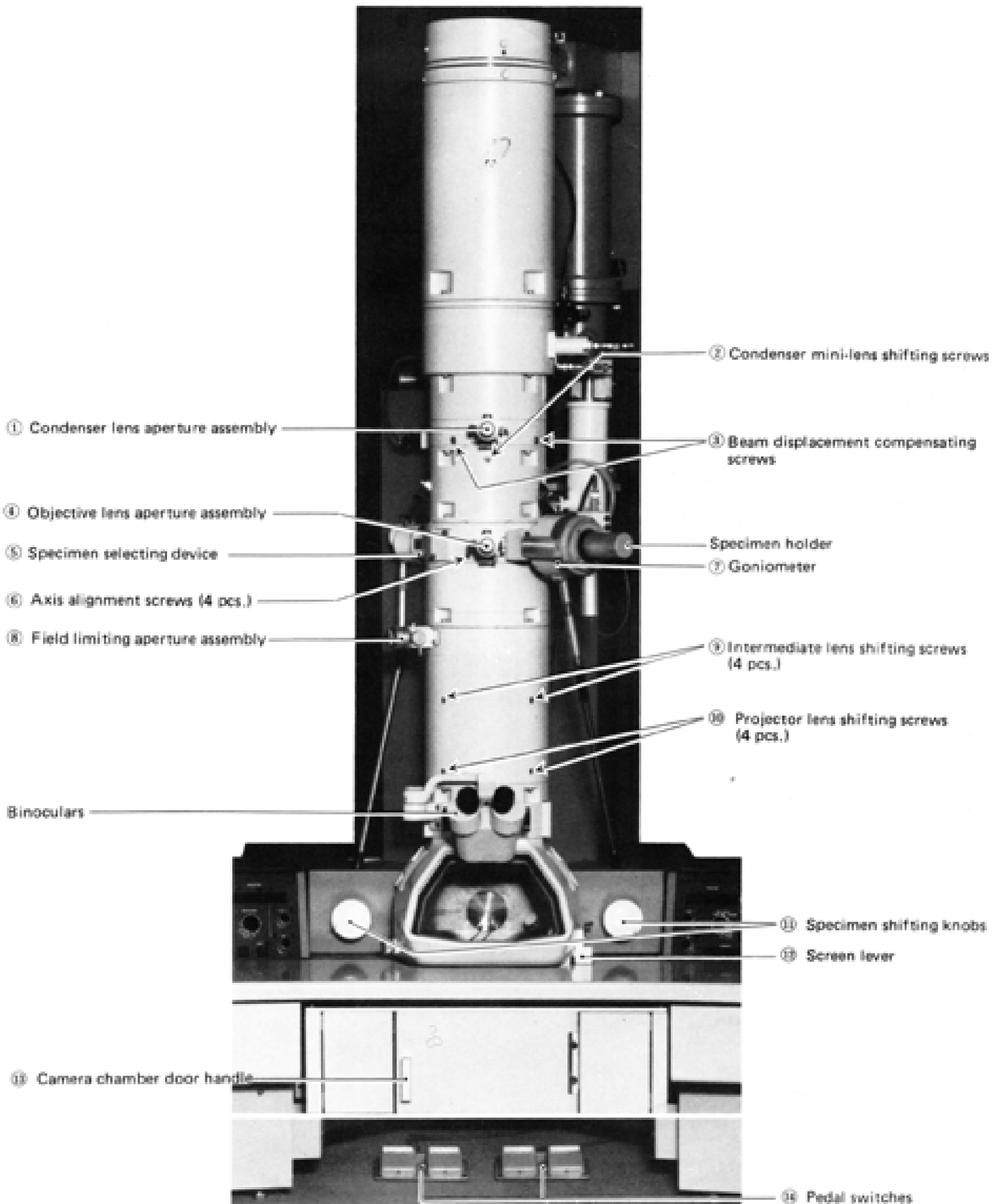
Microscope alignment

- Philosophy
- Step-by-step

Calibrations

- Magnification, camera length, rotation (if needed), convergence angle

TEM overview



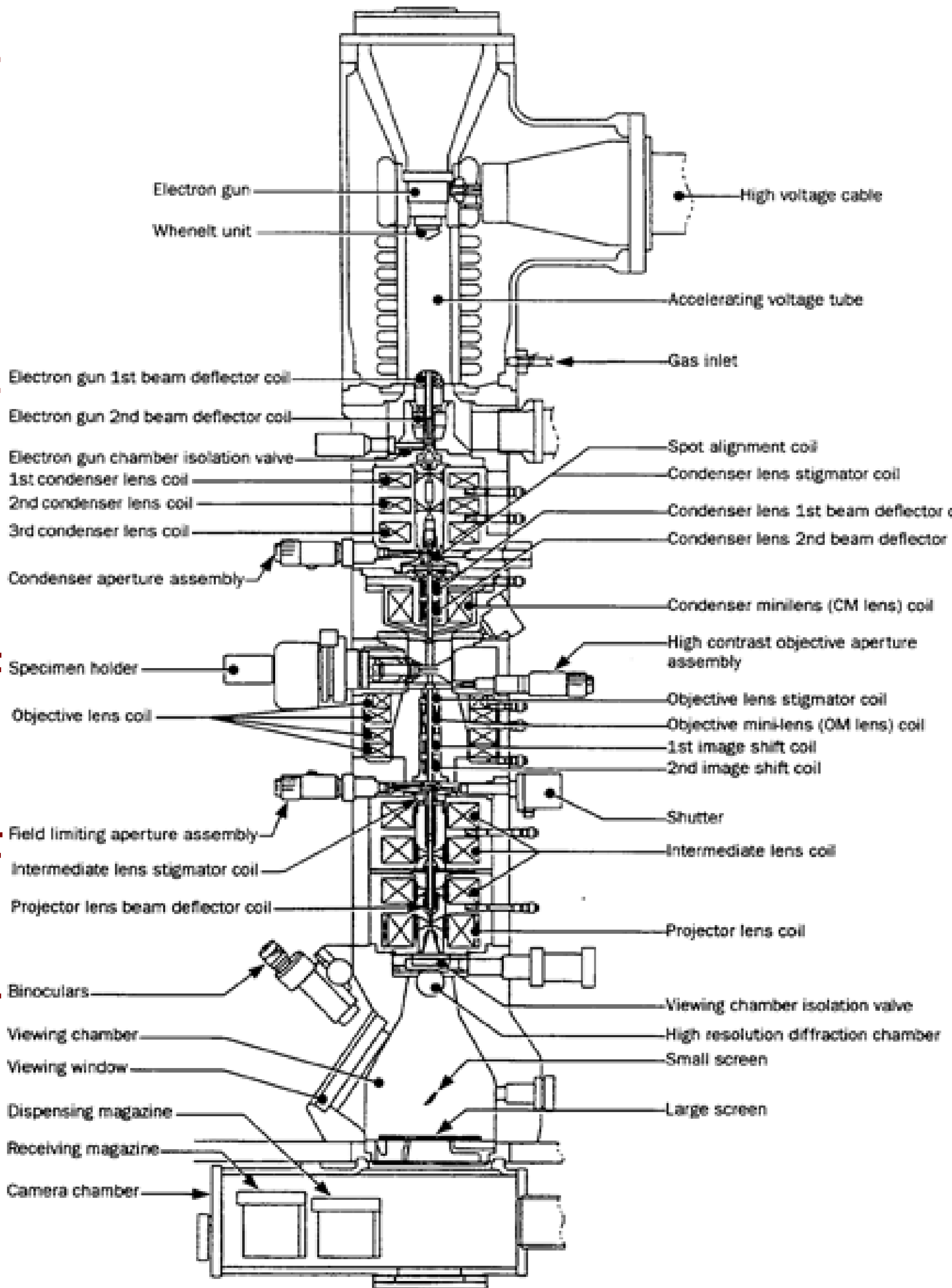
TEM cross section

Electron Gun

Condenser System

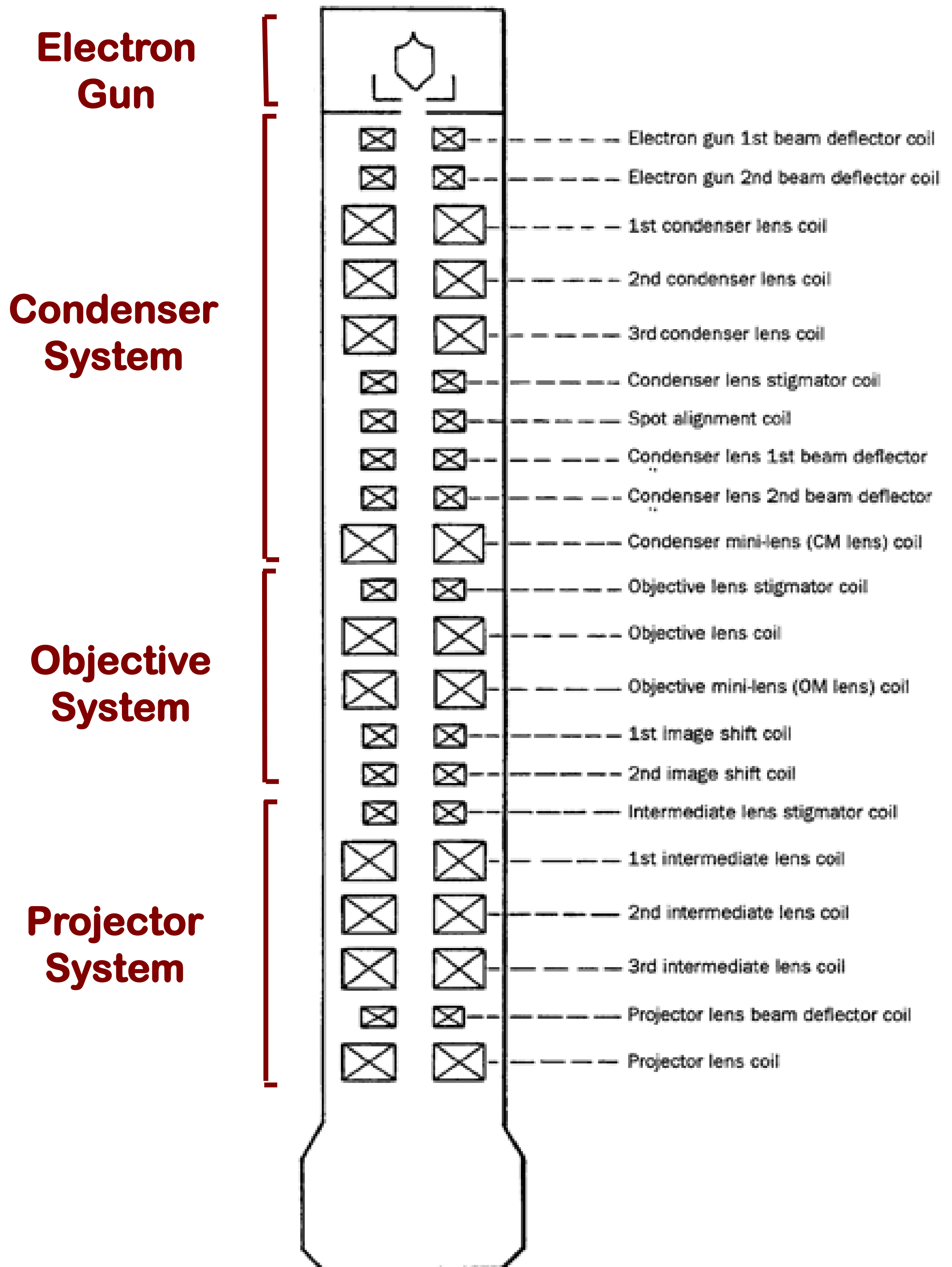
Objective System

Projector System

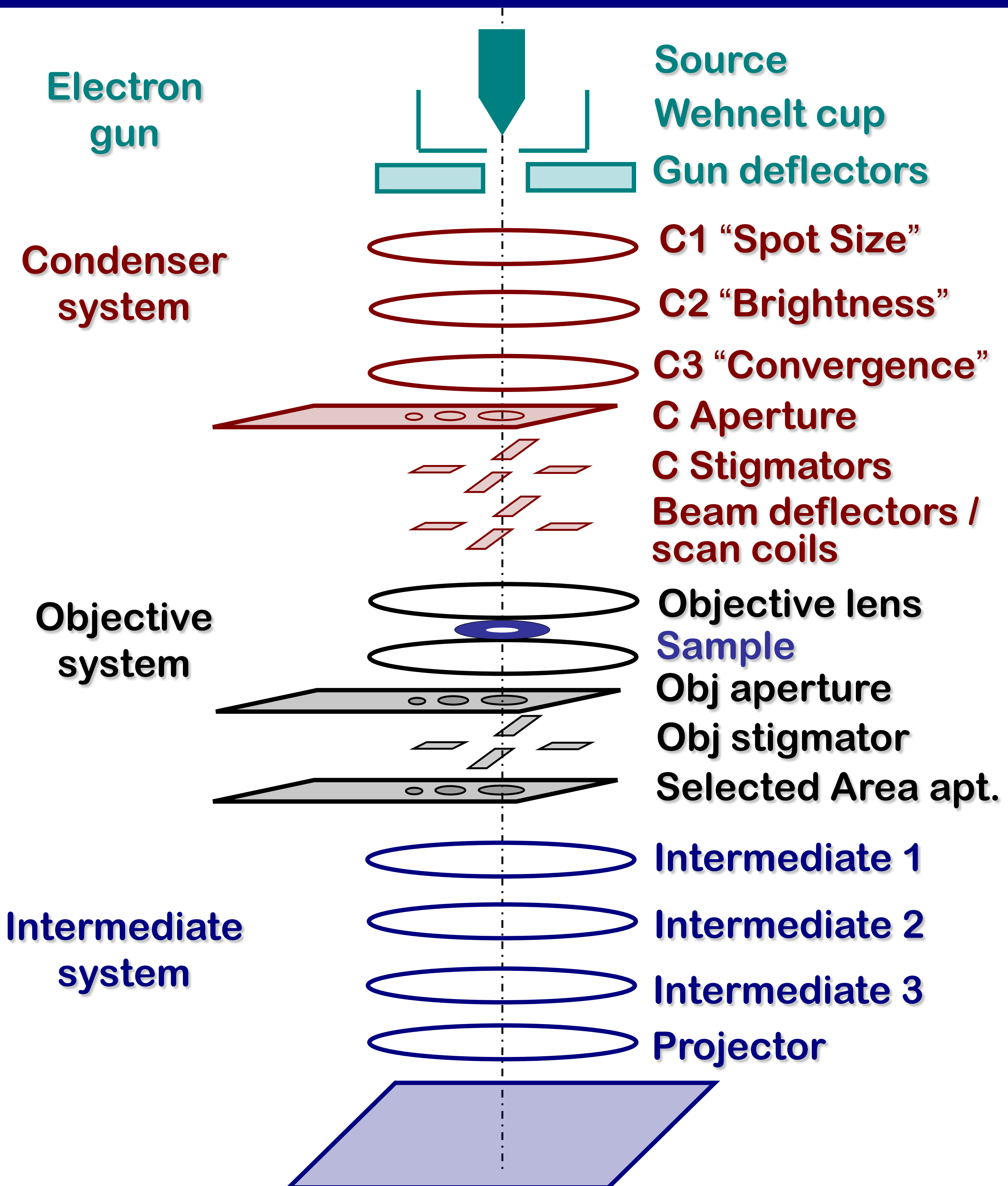


TEM cross section

(simplified - somewhat)



TEM cross section



Condenser system

Goal: place the beam on the sample

Variables:

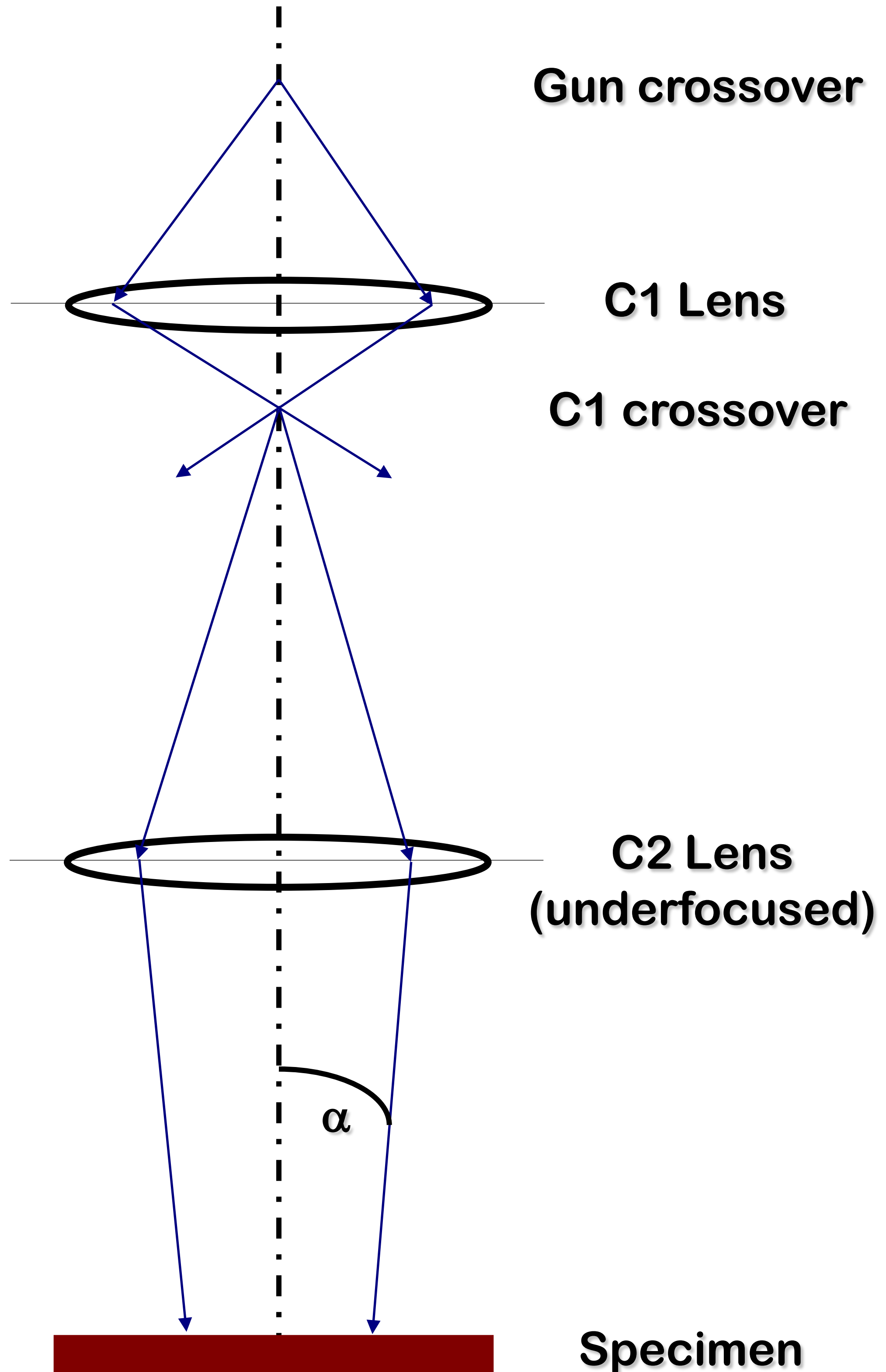
- Probe size
- Convergence angle
- Intensity (brightness)

Imaging modes & uses:

- Parallel illumination
  - Approximately - routine
  - Perfectly (Köhler)
- Focused illumination
  - Microdiffraction / EDS / EELS
  - Convergent beam diffraction
- Translating / tilting the beam
  - Bright field / dark field
  - Scanning TEM imaging

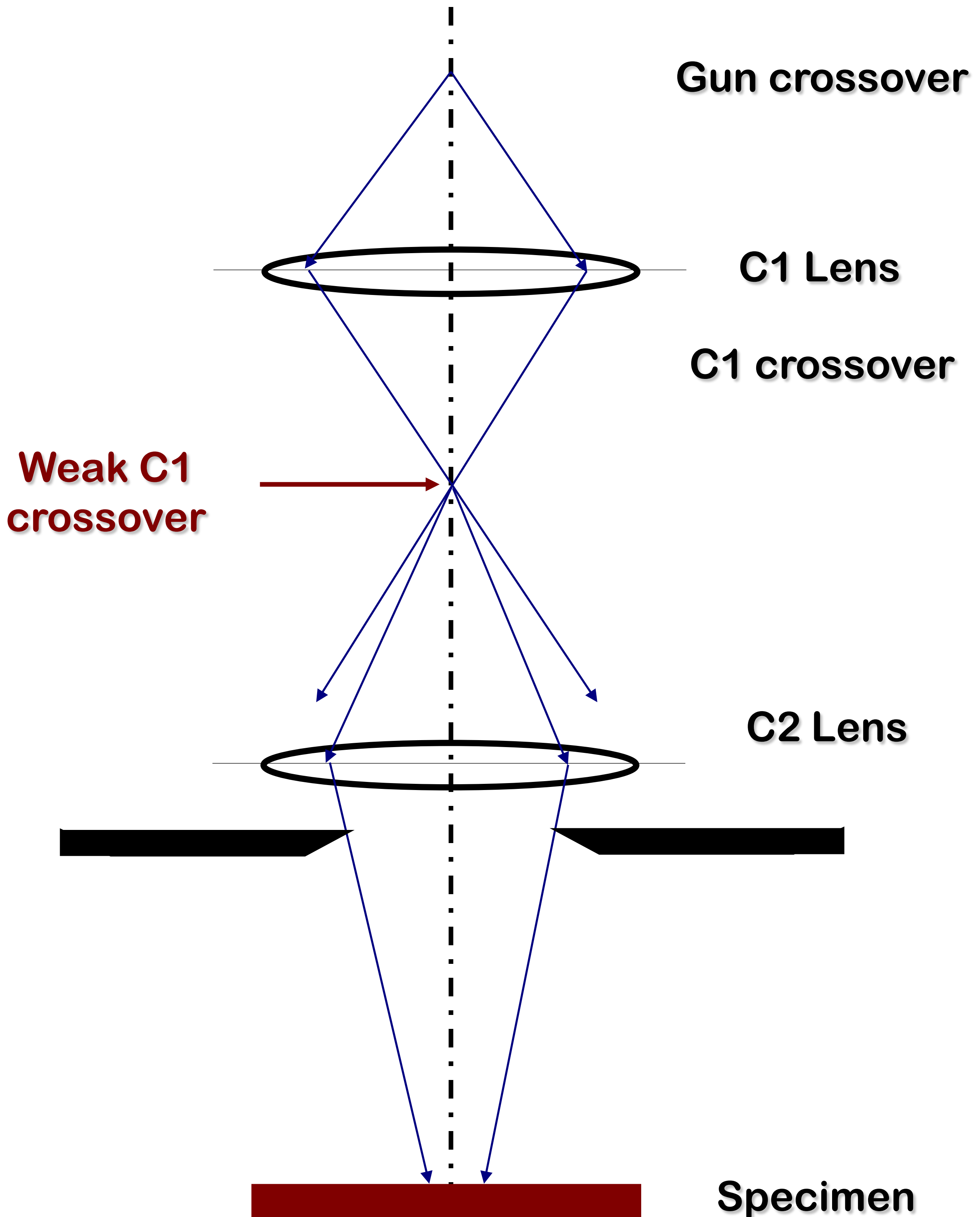
Condenser system

“parallel beam”



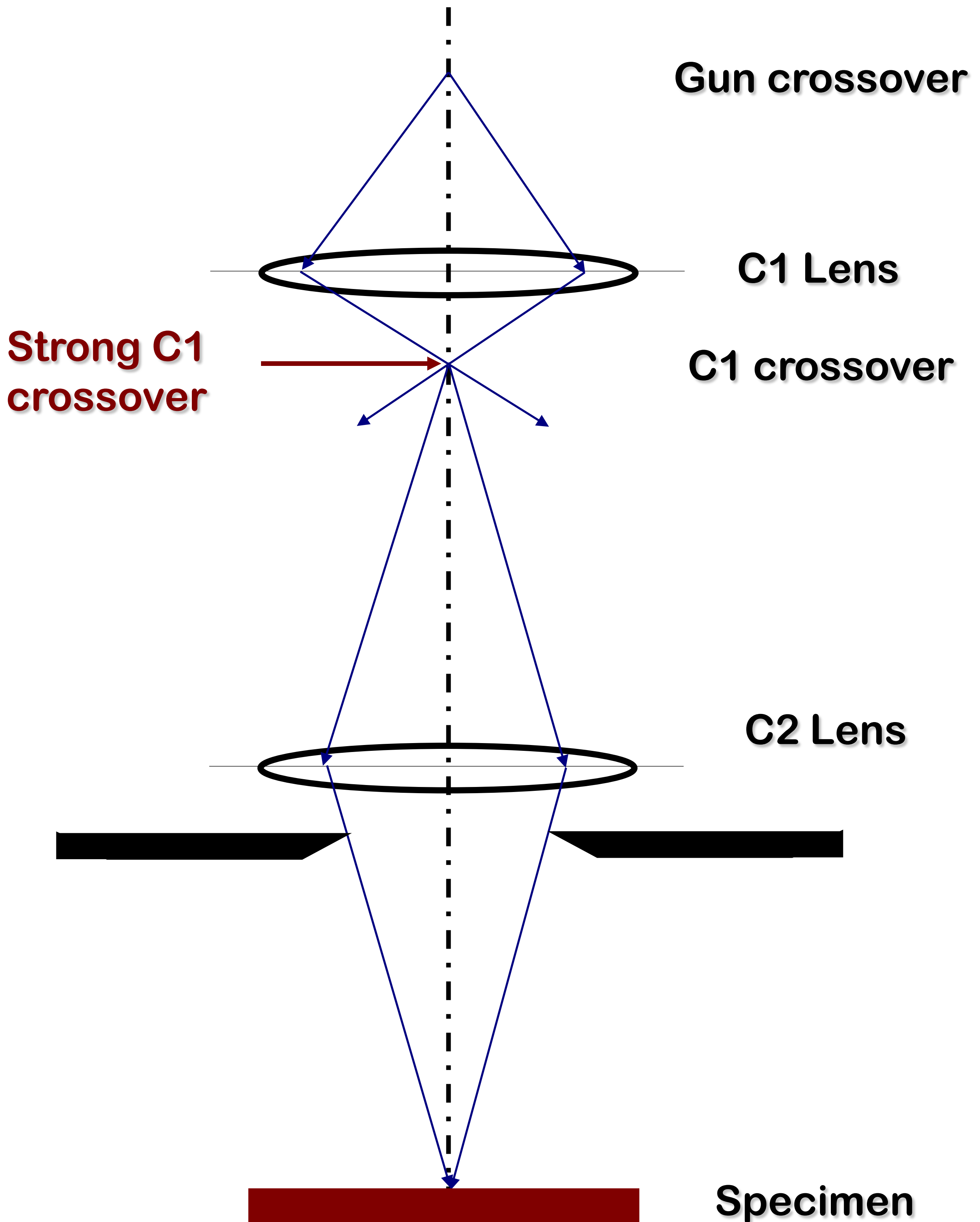
Condenser system

effect of C1 strength - “spot size”



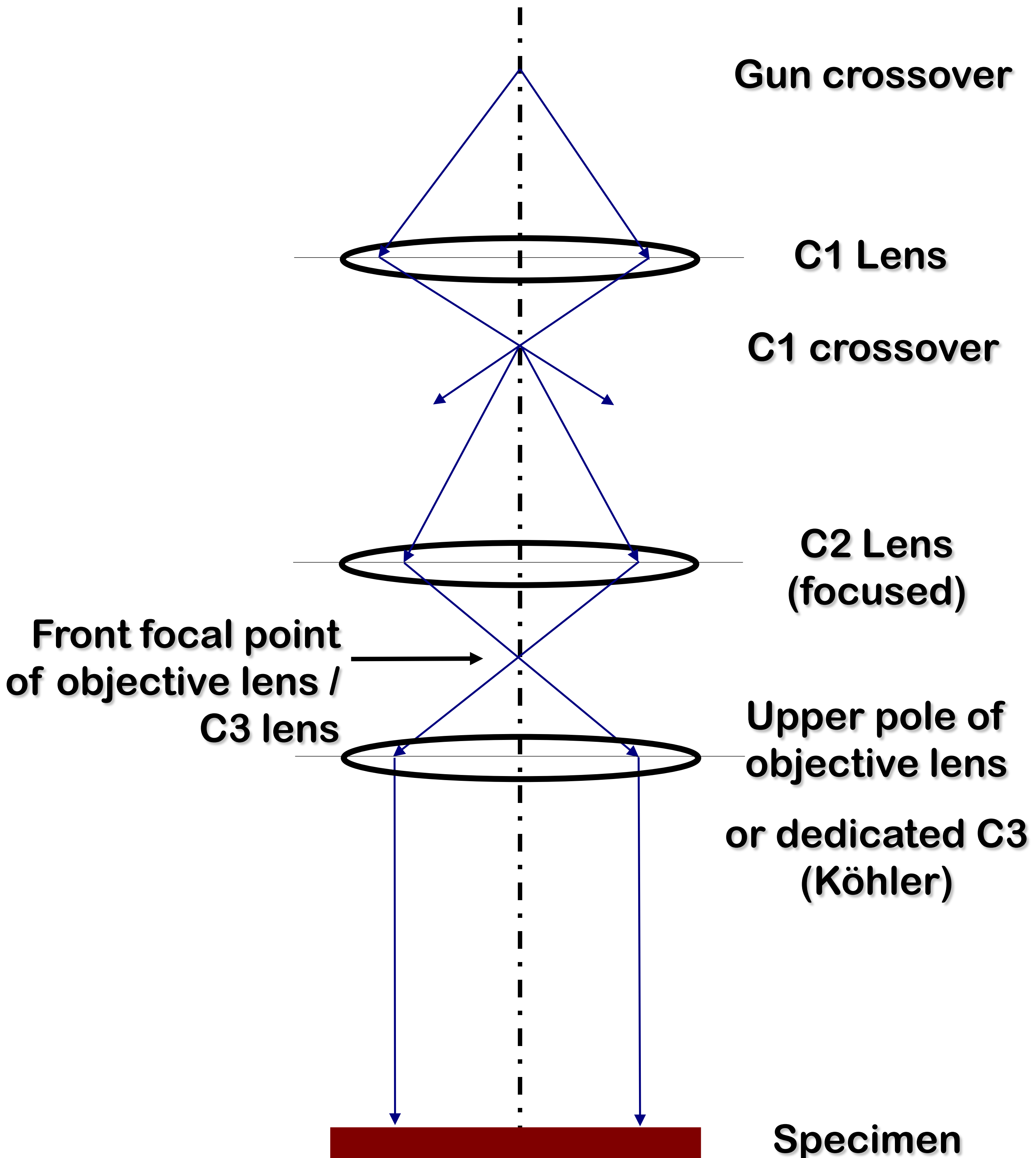
Condenser system

effect of C1 strength - “spot size”



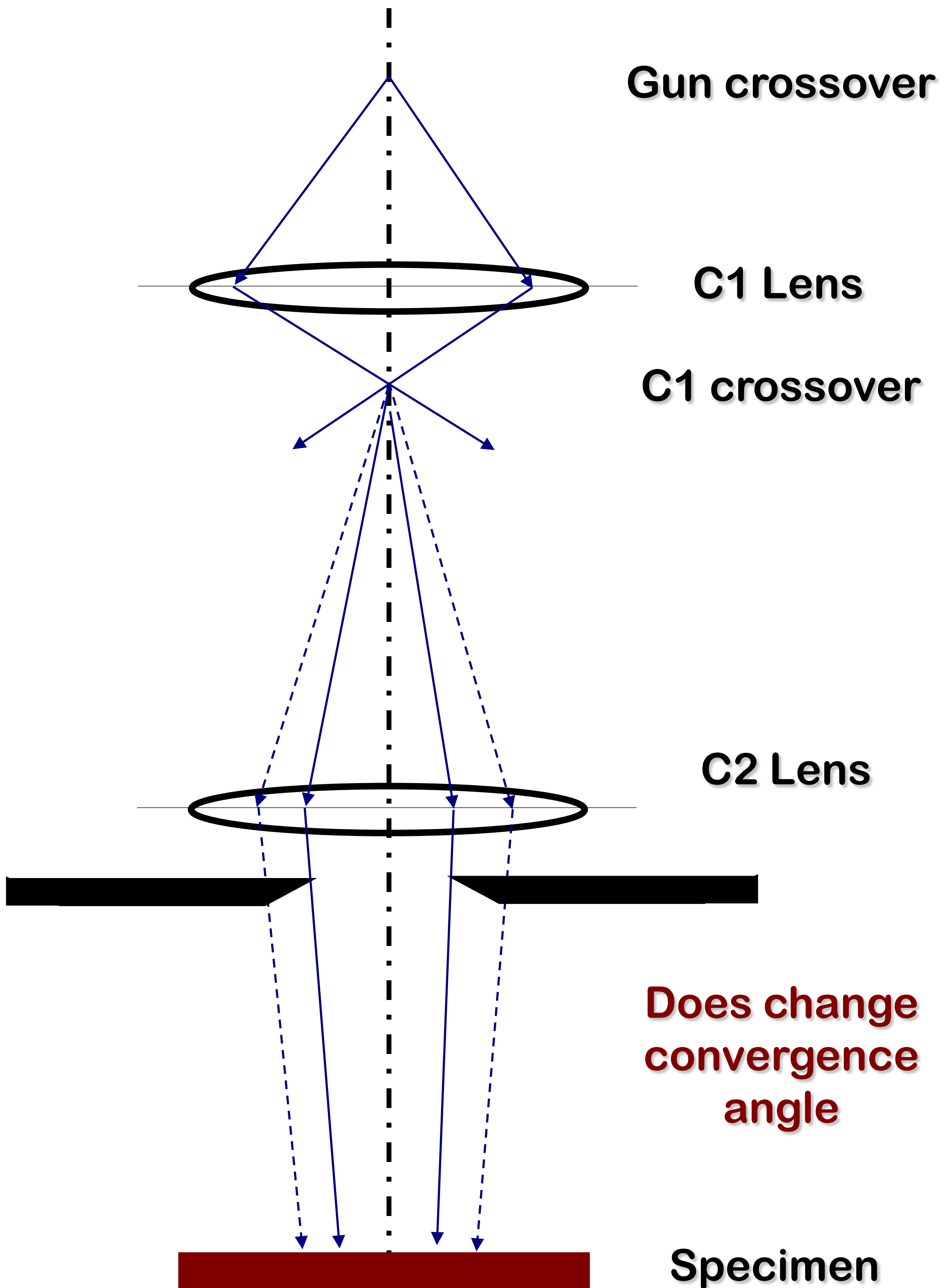
Condenser system

parallel illumination (Köhler)



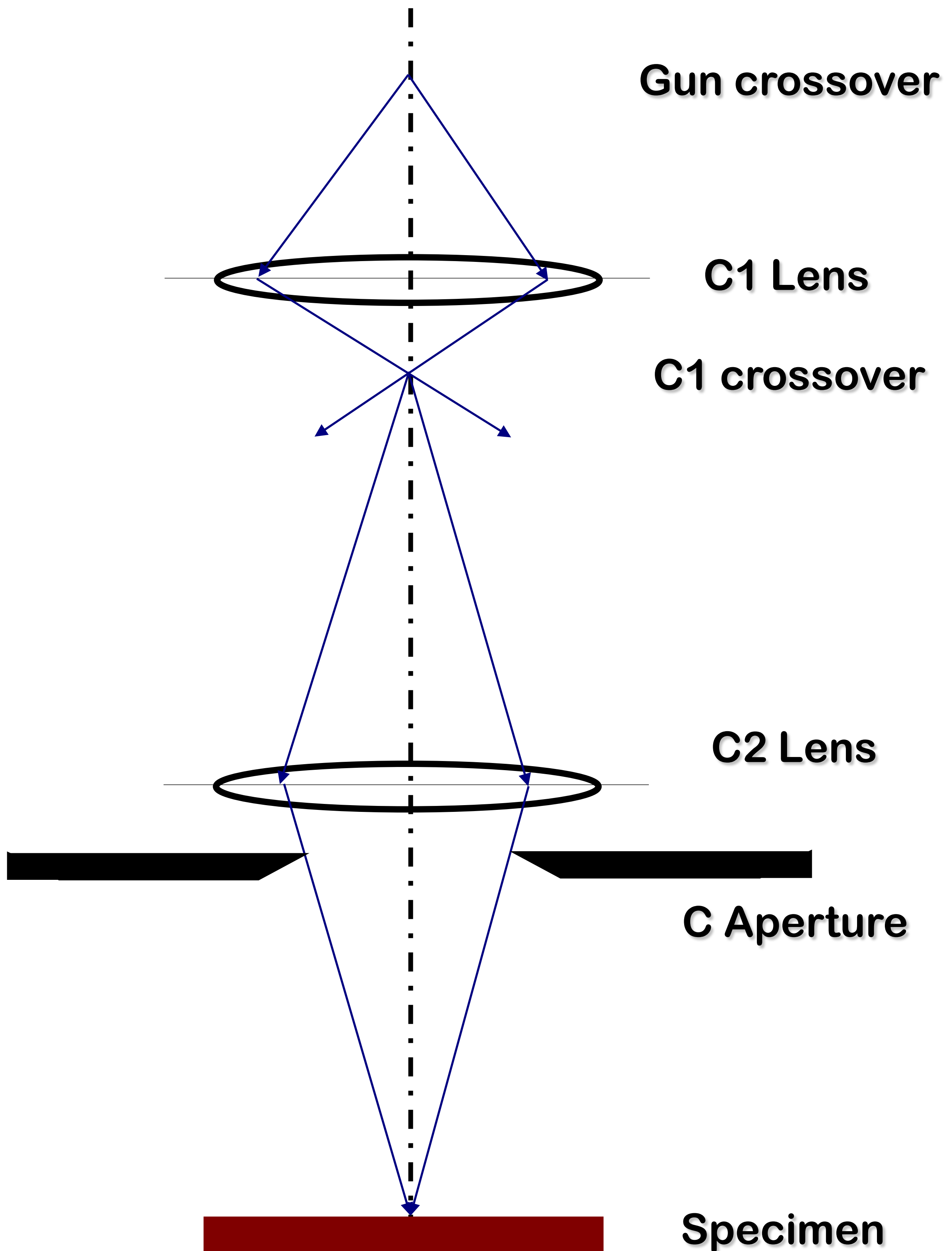
Condenser system

aperture effect



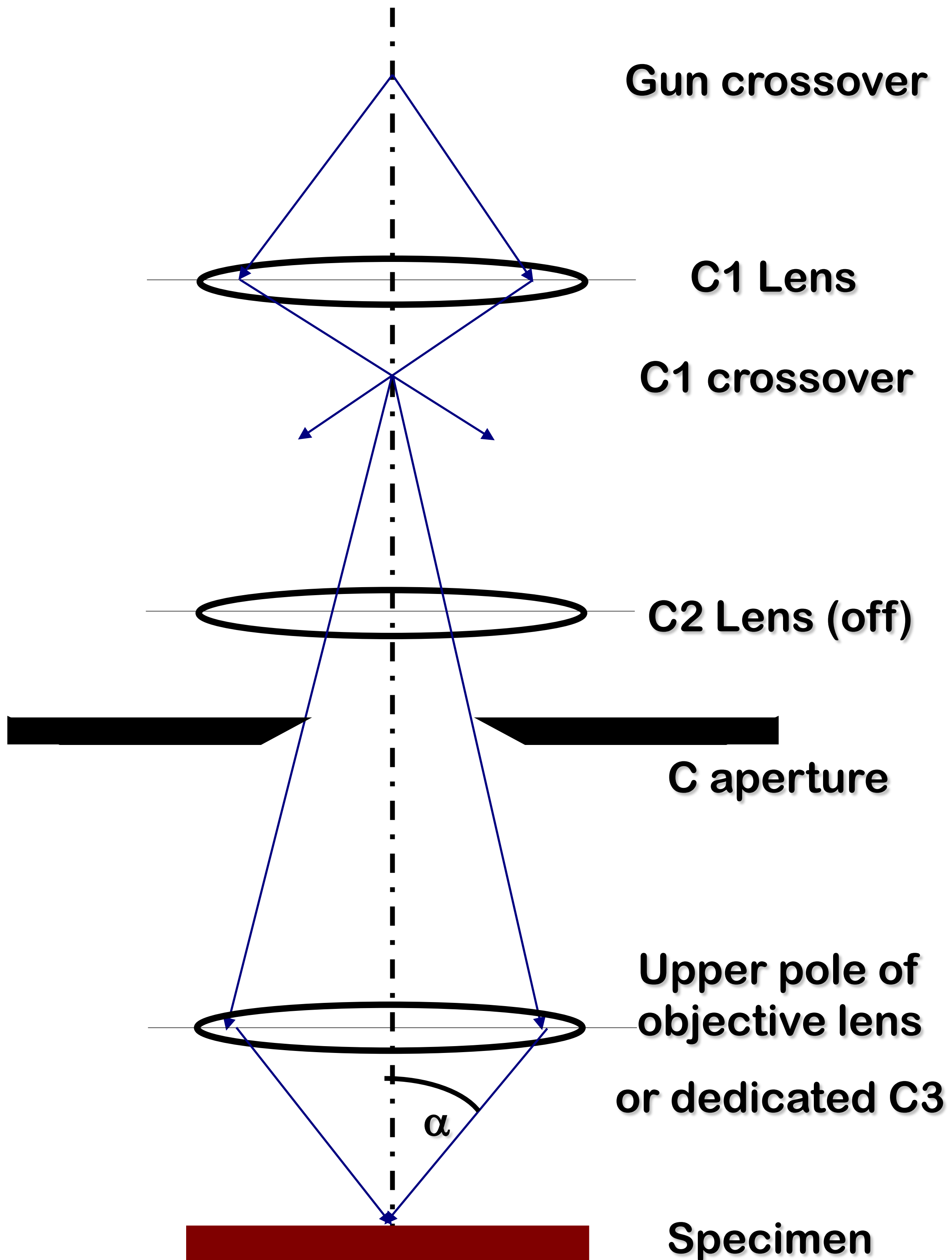
Condenser system

focused probe



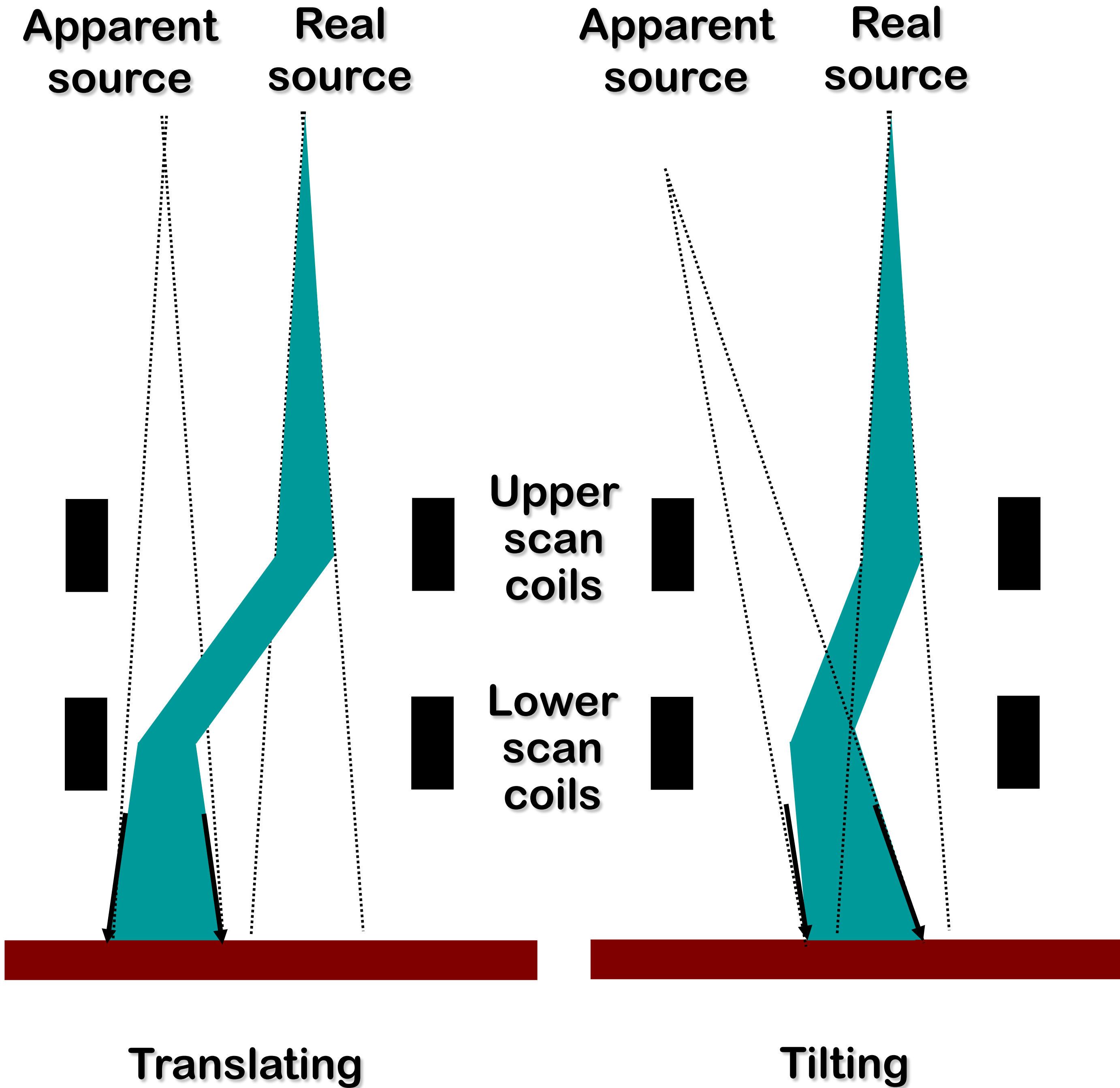
Condenser system

‘convergent beam’ focused probe



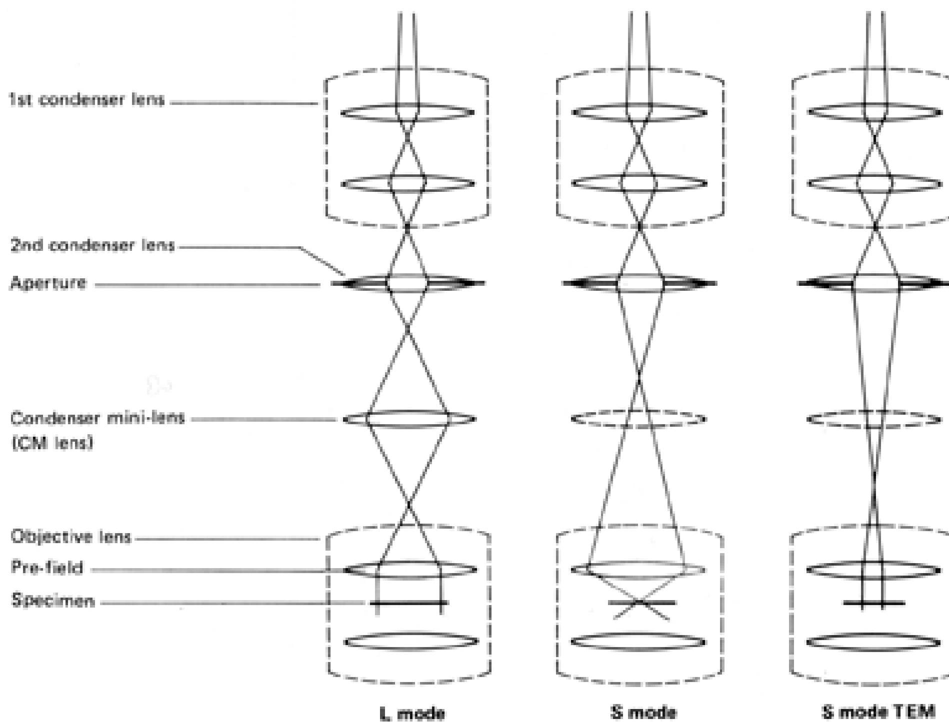
Condenser system

scanning / tilting & translating



Condenser system

Actual ray diagrams are always available in the operation manual of the microscope



Mode	L	S
Probe dia.	1 µm ~ 20 nm	40 nm ~ 2 nm
TEM low mags.	O	X
TEM high mags.	O	O
SA diff.	O	X
CBE diff.	X	O
HD diff.	O	O

L mode: Fine Probe mode. For TEM observation.
S mode: Super Focus mode. For analysis and convergent beam electron diffraction.
S mode TEM: For TEM observation in the S mode.

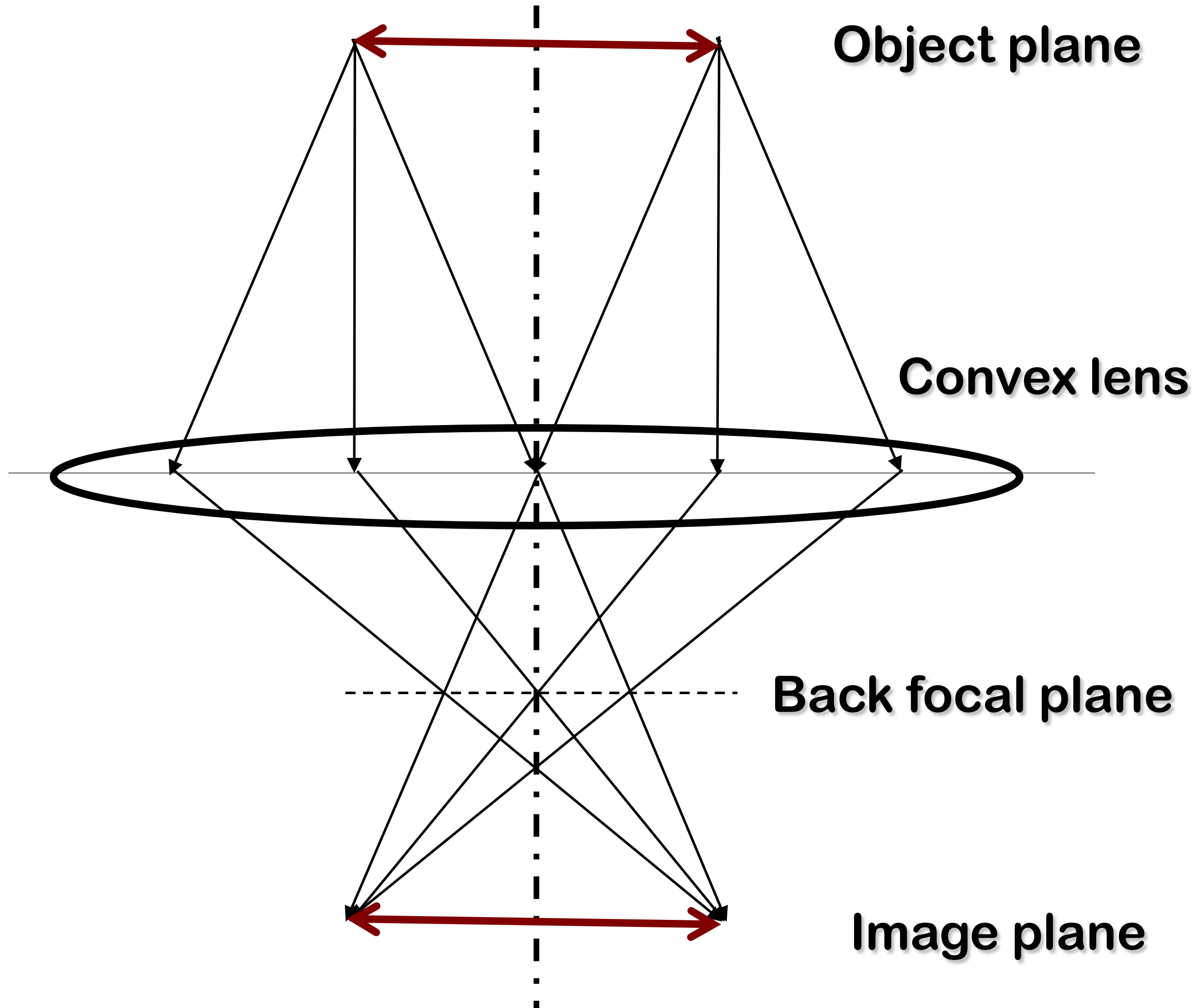
Objective & Imaging system

- Relationship between sample & object plane
- TEM mode
  - Forming images
    - Bright field
    - Dark field
    - HREM
  - Forming diffraction patterns
- STEM mode
  - Scanning
  - Bright field STEM
  - Dark field STEM
  - Annular dark field STEM

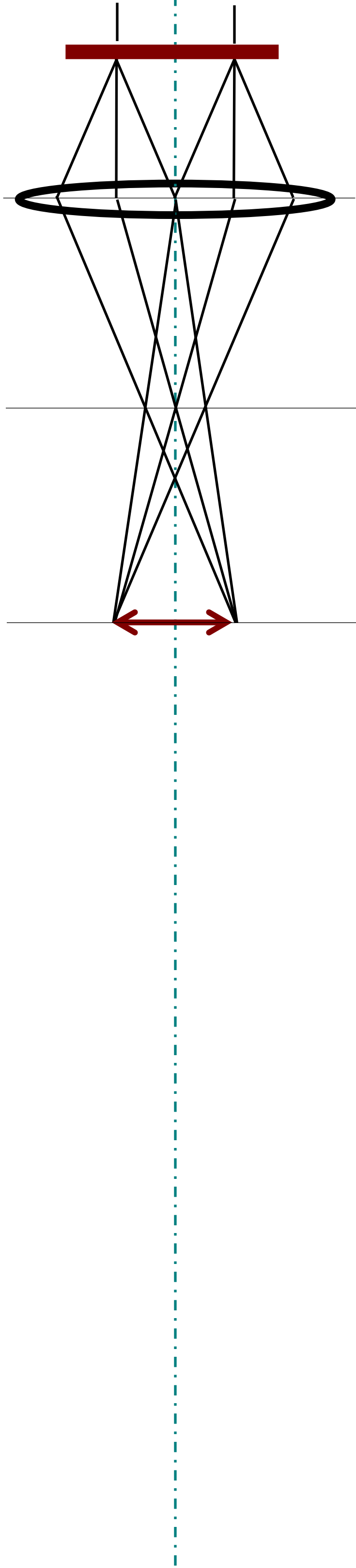
Eucentric position

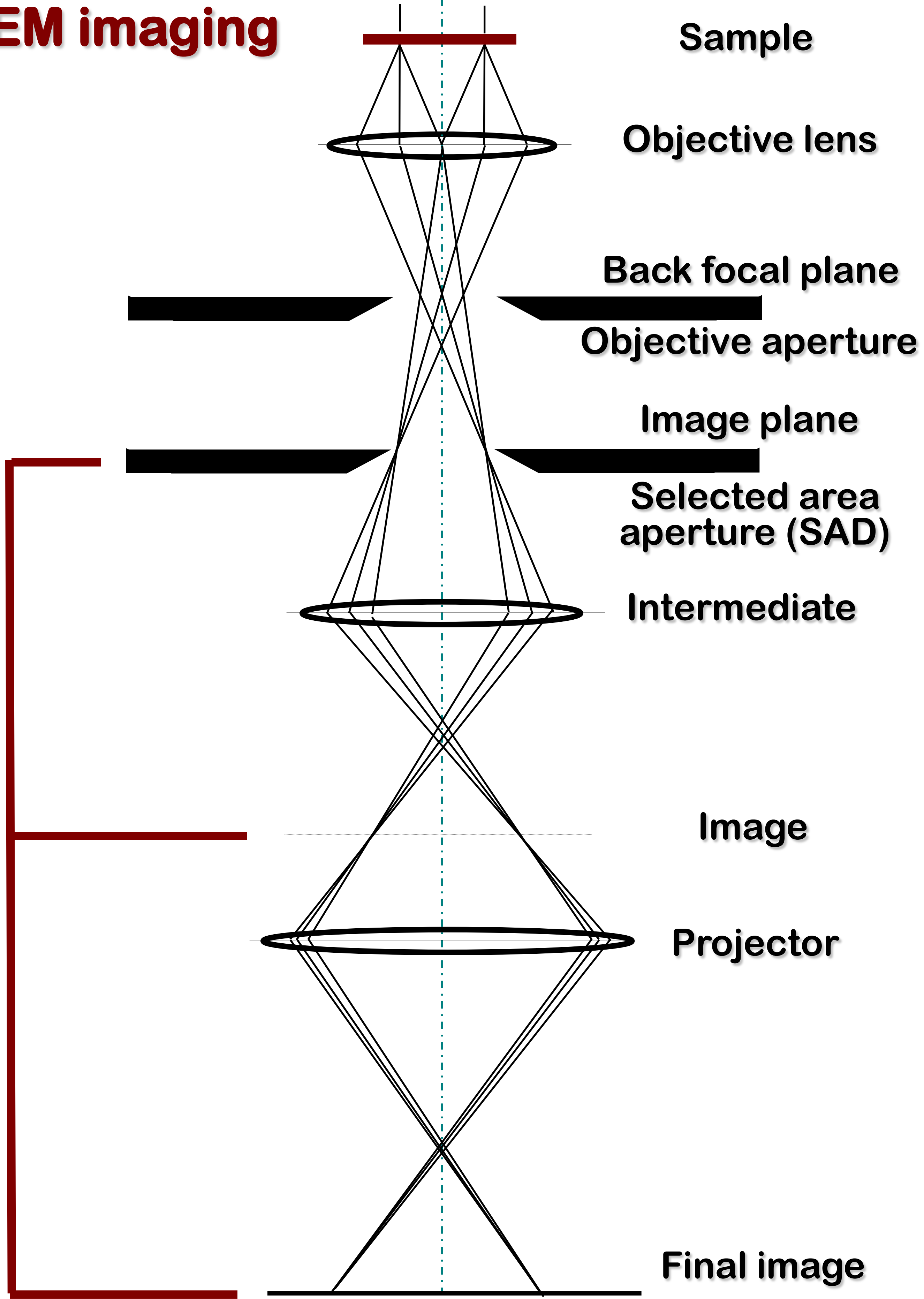
- Optimum position of sample
  - Where it does not translate when you tilt
- This defines the 'object' plane
- In older systems, you then set the microscope's lens strength to make it coincide with the object
- In newer systems, the physical location is known, yielding a fixed objective lens current
  - This is better
    - No need to change lens current during imaging
    - Greater stability

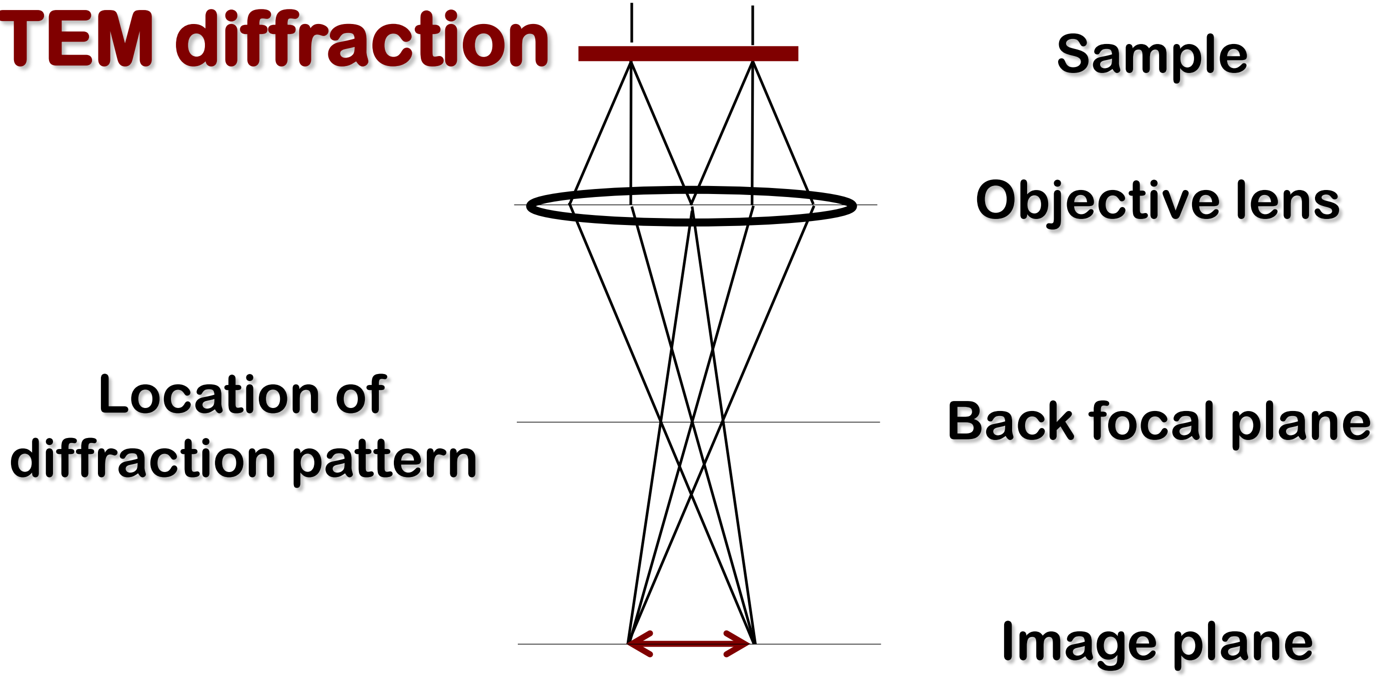
Recall ...

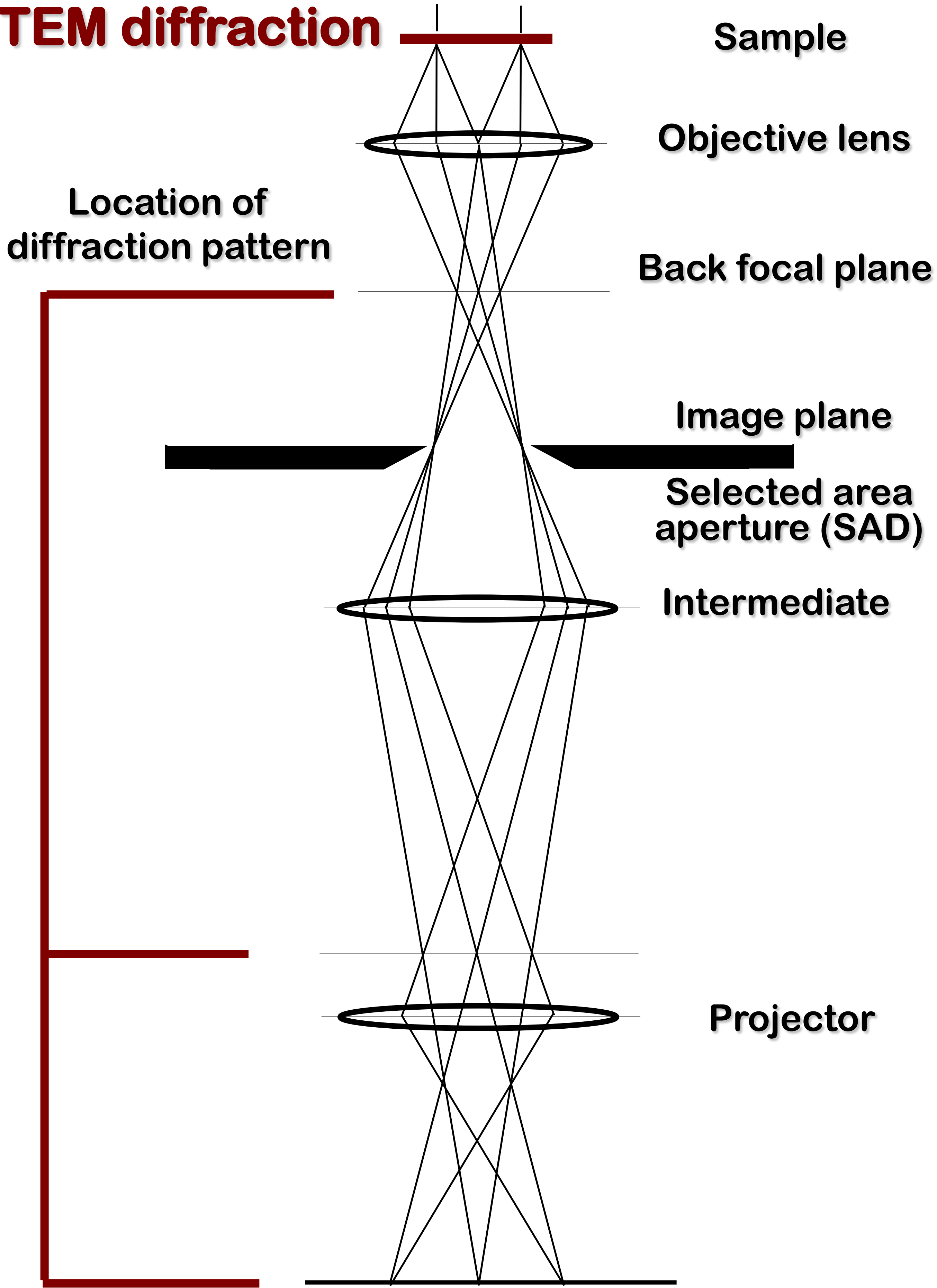


TEM imaging

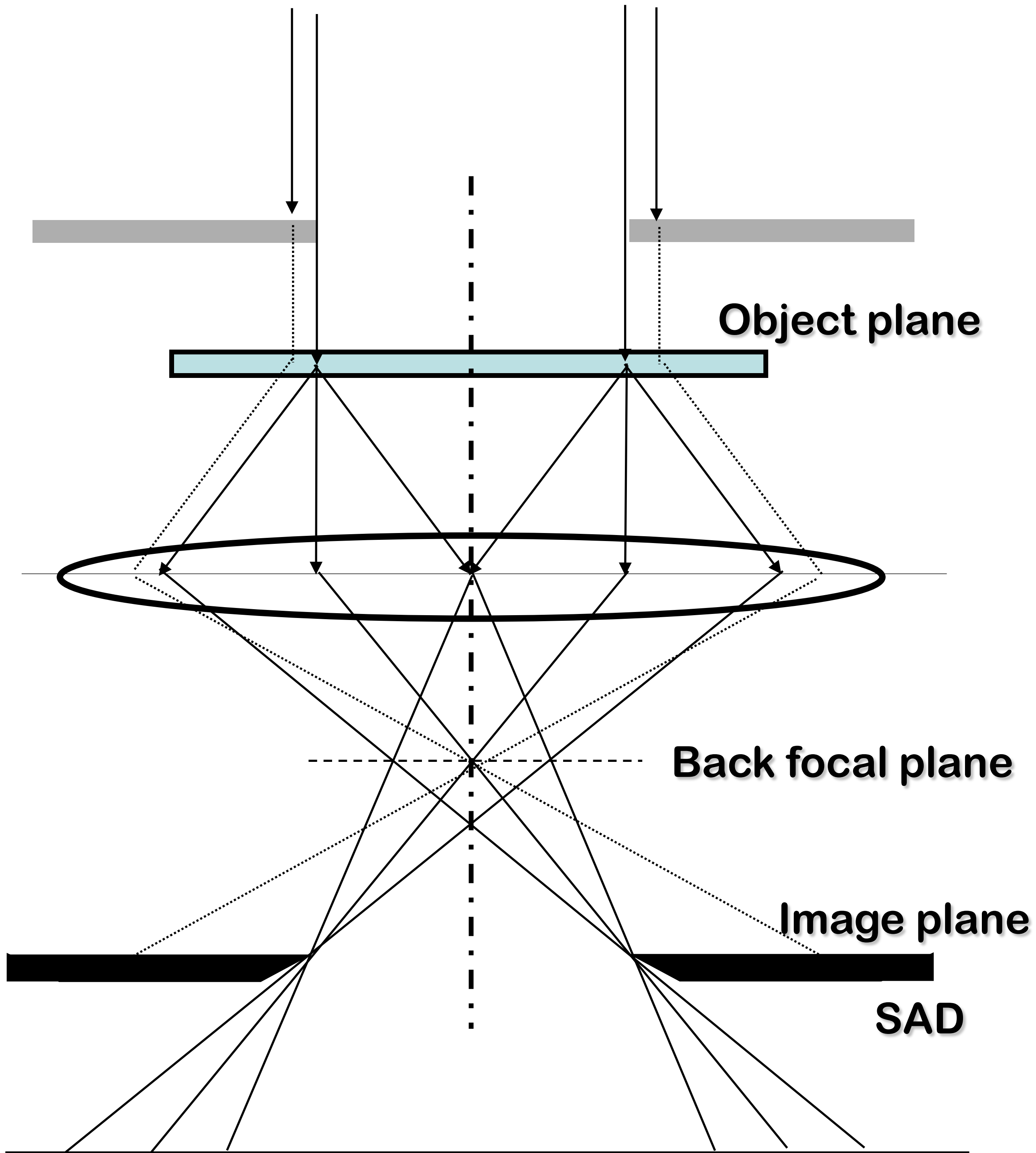



TEM imaging
Sample
Objective lens
Back focal plane
Objective aperture
Image plane
Selected area
aperture (SAD)
Intermediate
Image
Projector
Final image

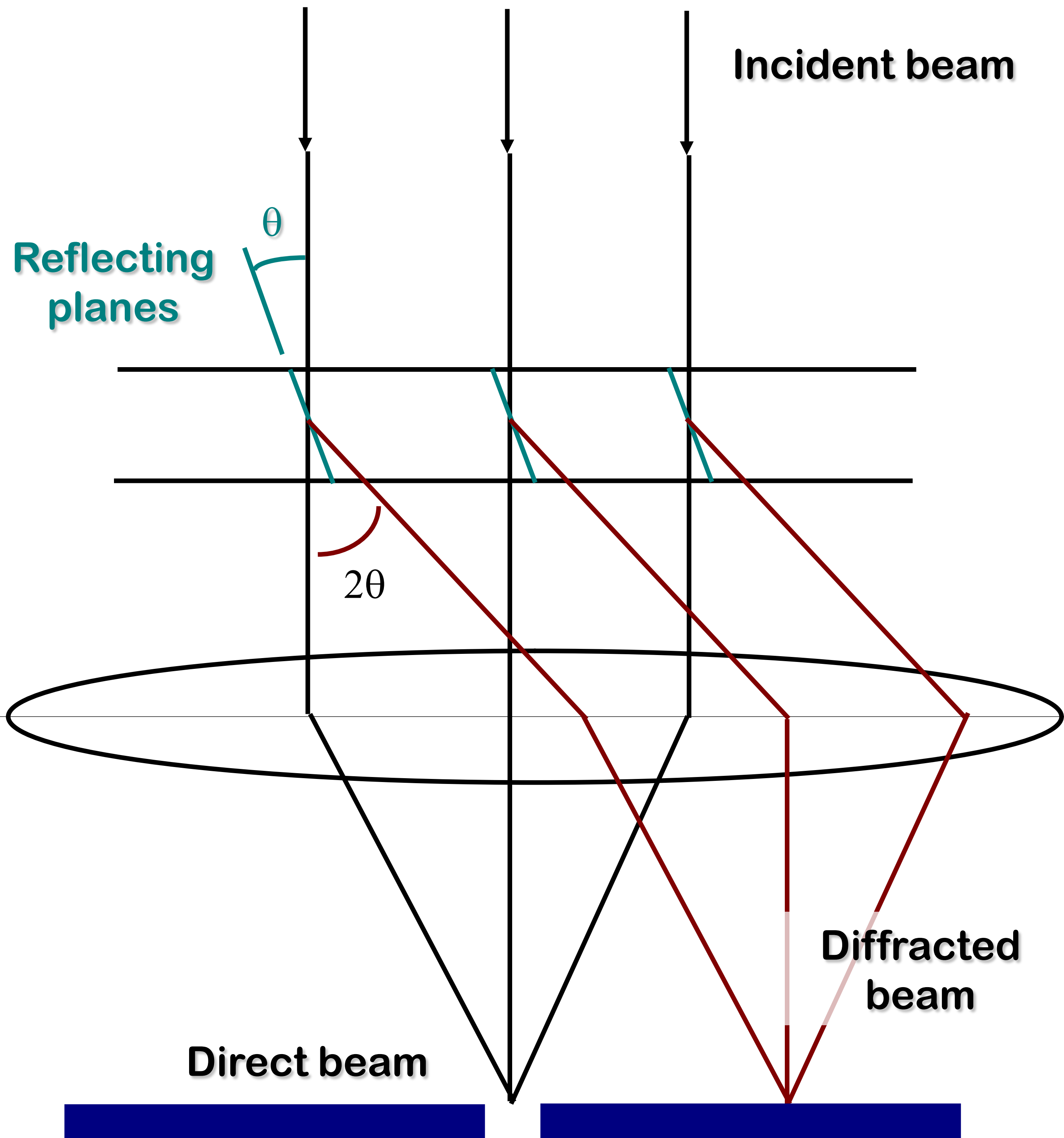

TEM diffraction
Sample
Objective lens
Location of
diffraction pattern
Back focal plane
Image plane


TEM diffraction
Sample
Objective lens
Location of
diffraction pattern
Back focal plane
Image plane
Selected area
aperture (SAD)
Intermediate
Projector

Selected area diffraction aperture



Bright field image



“Dirty” dark field