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# **“The Instrument”**

## **Part 1**

### **Lecture 4**

# Review of imaging modes

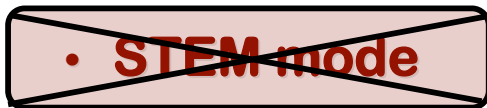
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## System overview

## Review of imaging modes

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

- TEM mode



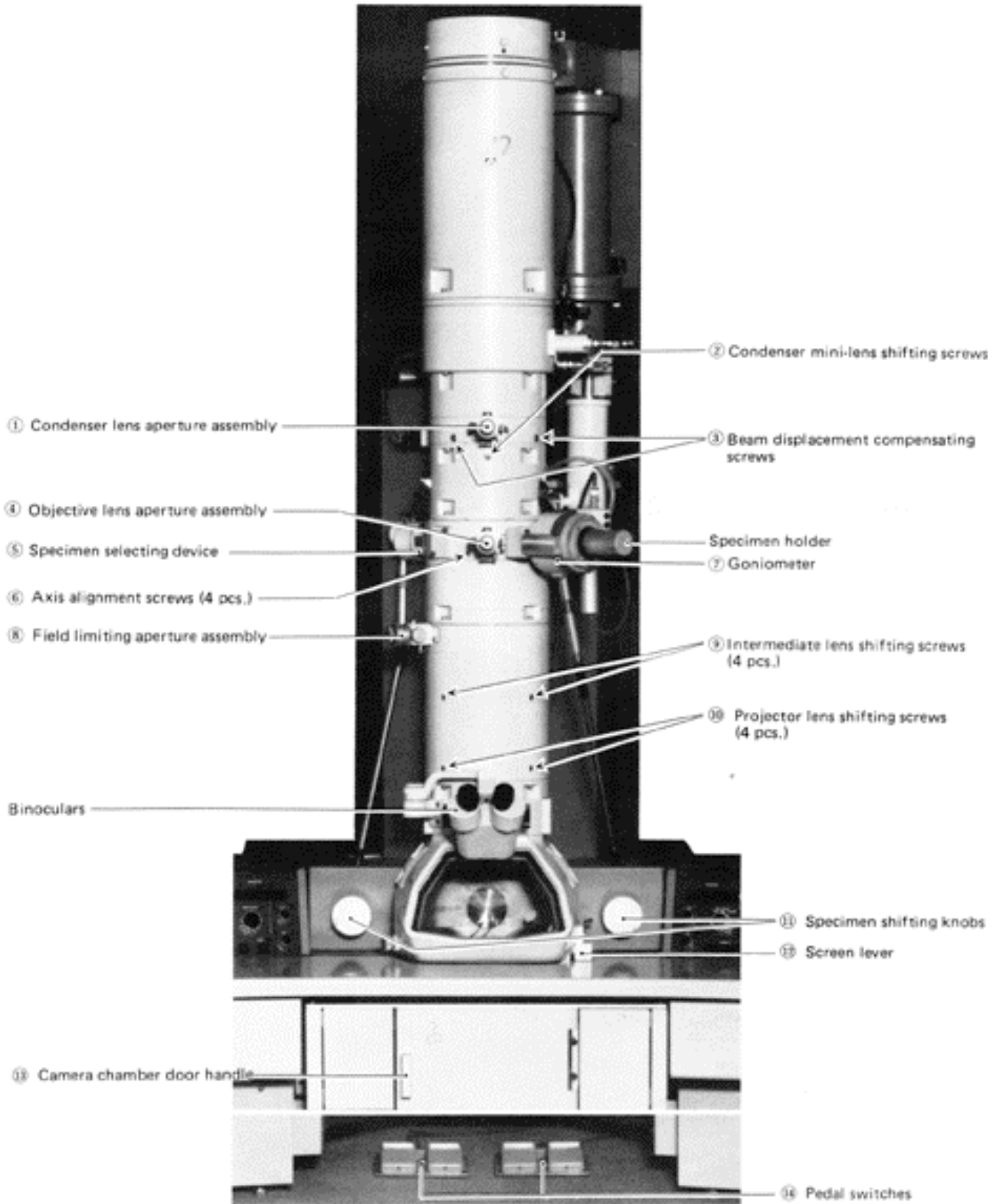
## Microscope alignment

- Philosophy
- Step-by-step

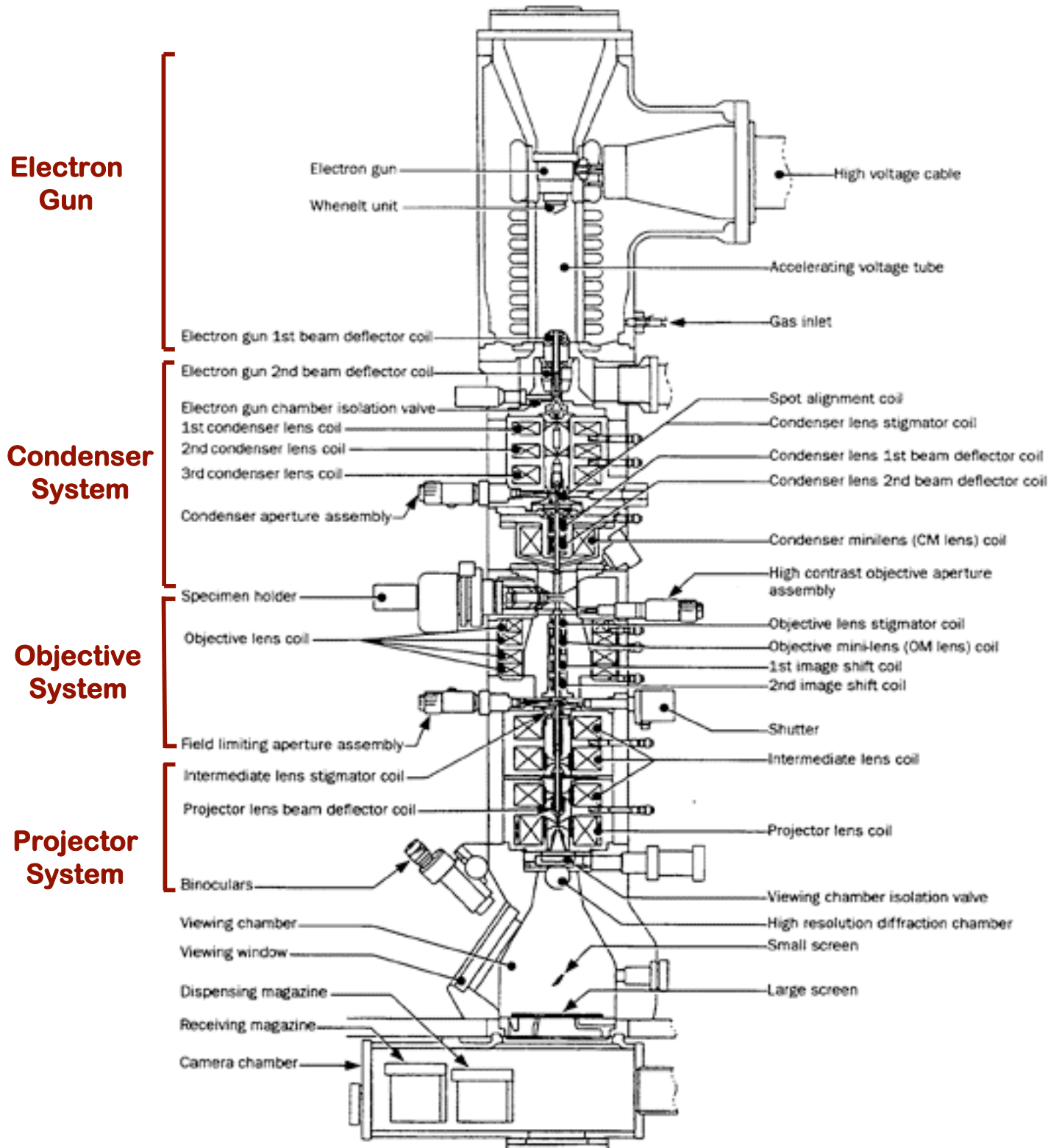
## Calibrations

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

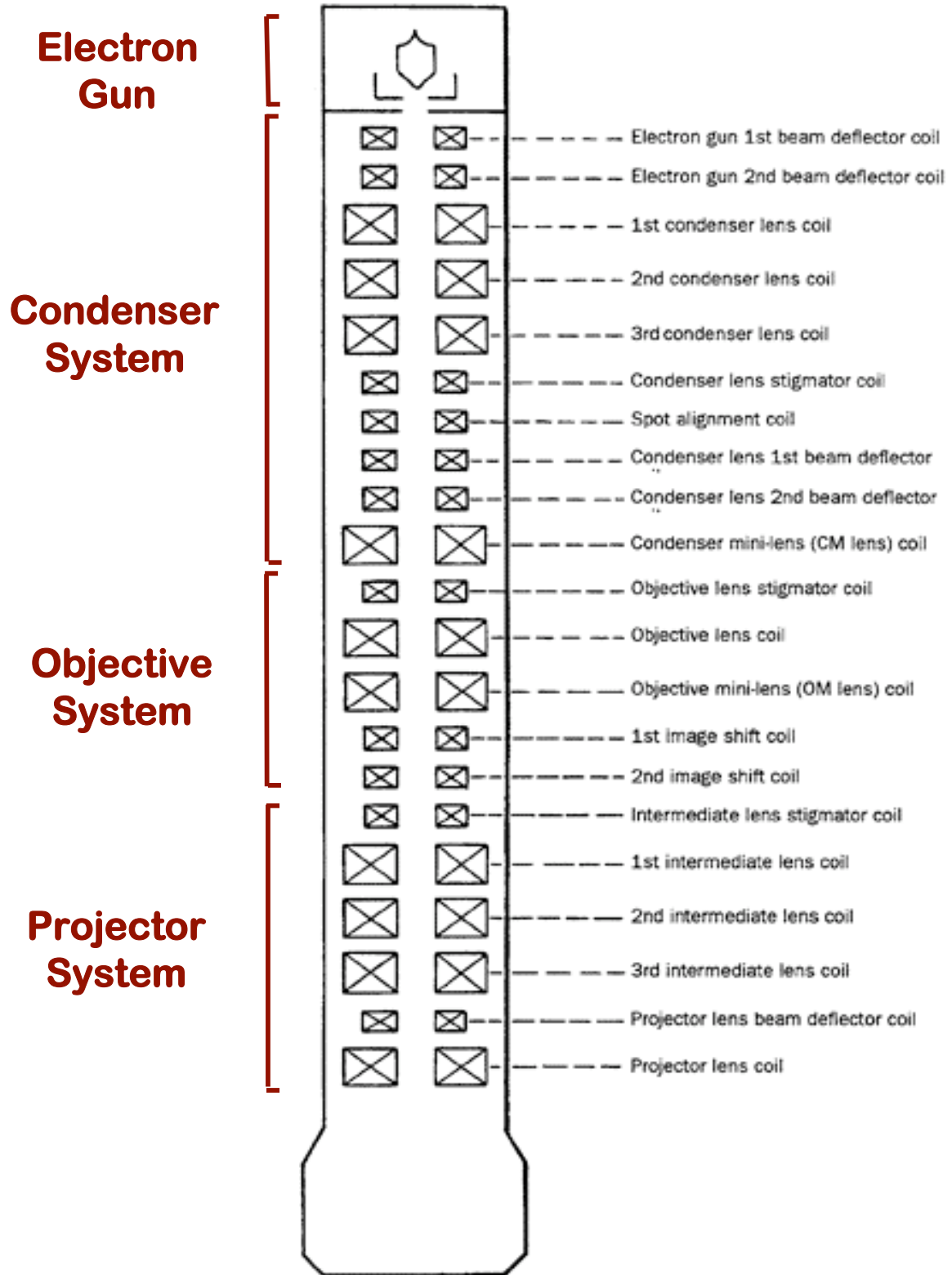
# TEM overview



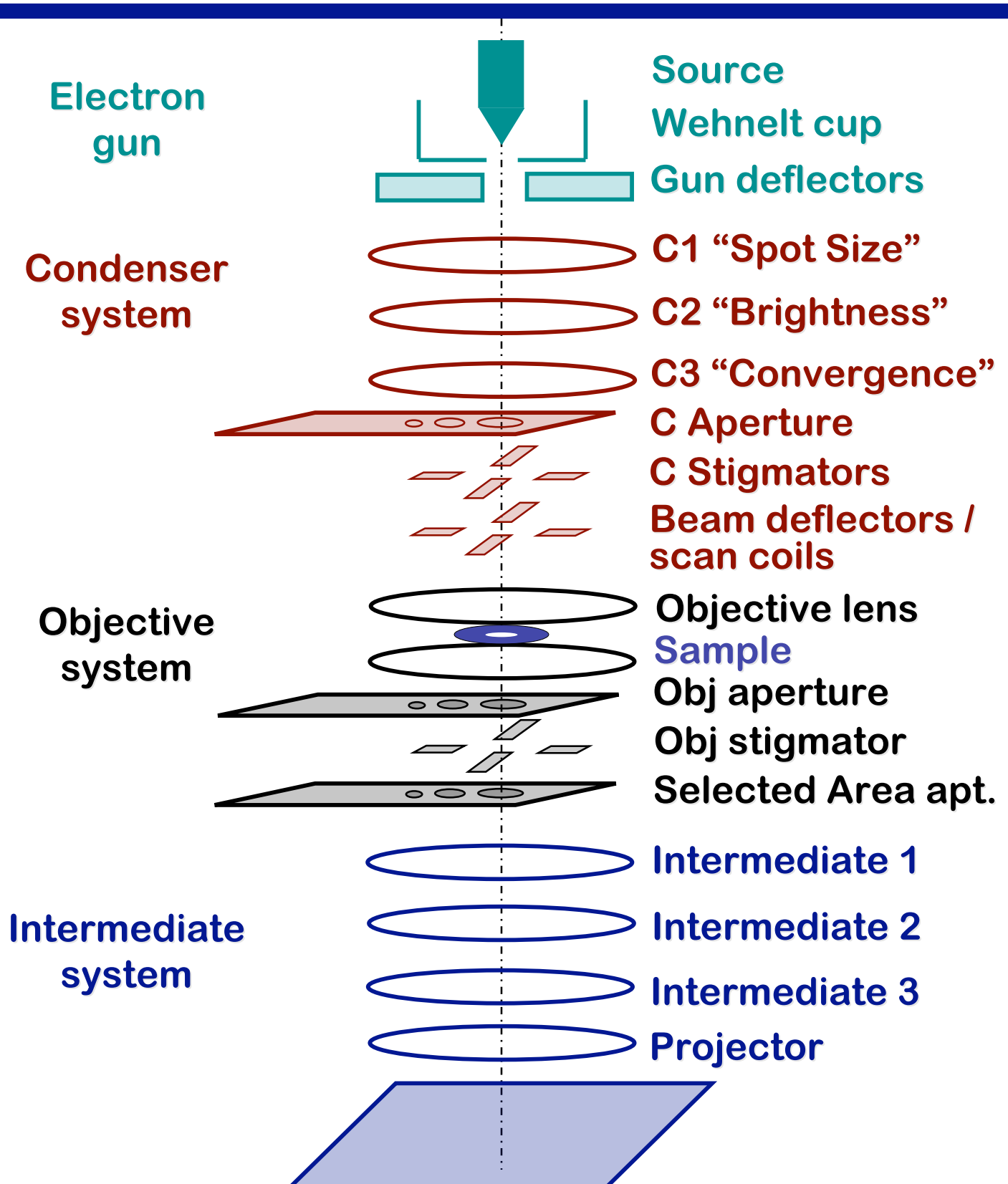
# TEM cross section



# TEM cross section (simplified - somewhat)



# TEM cross section



# Condenser system

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**Goal: place the beam on the sample**

**Variables:**

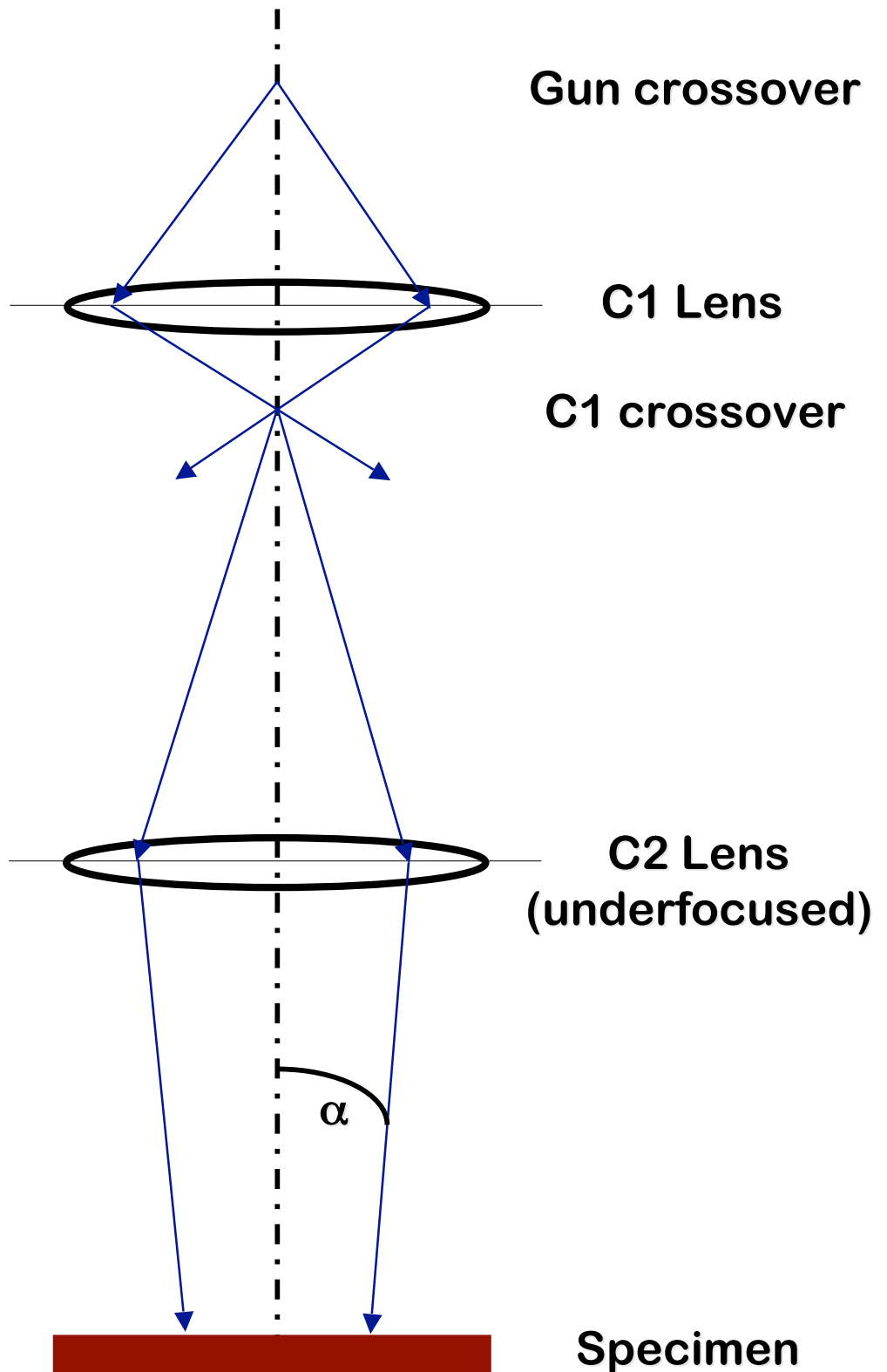
- **Probe size**
- **Convergence angle**
- **Intensity (brightness)**

**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**

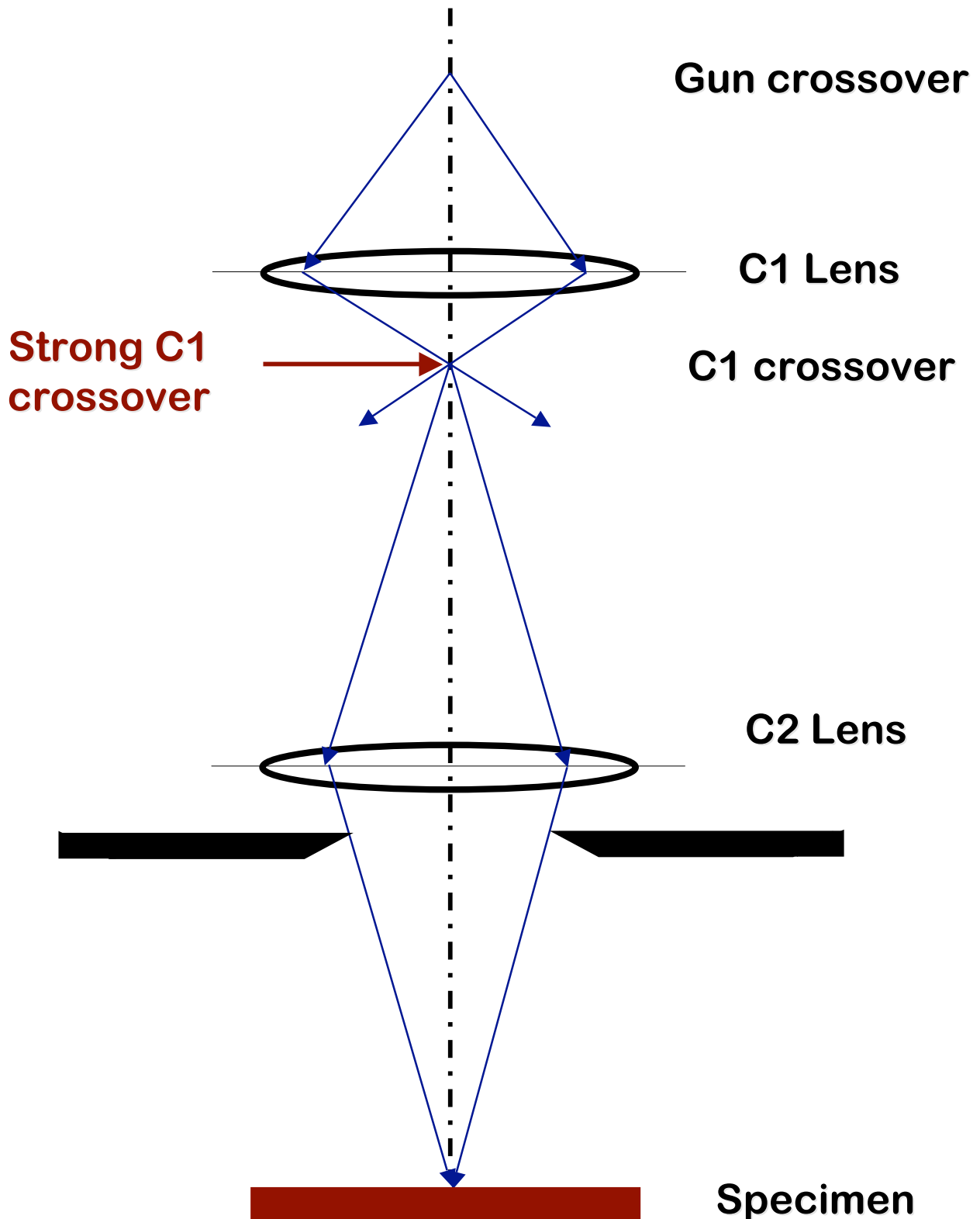
# Condenser system

## “parallel beam”



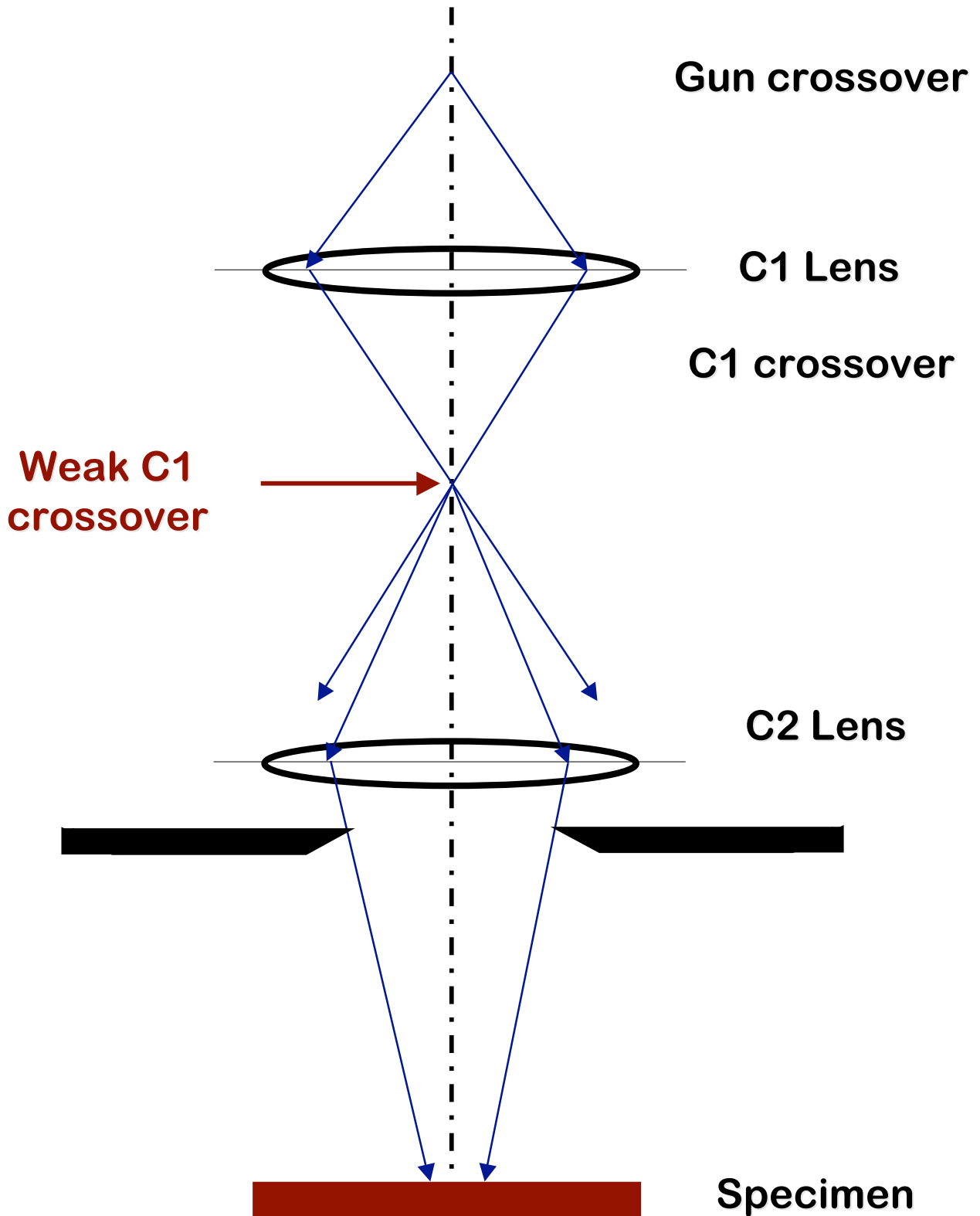
# Condenser system

## effect of C1 strength - "spot size"



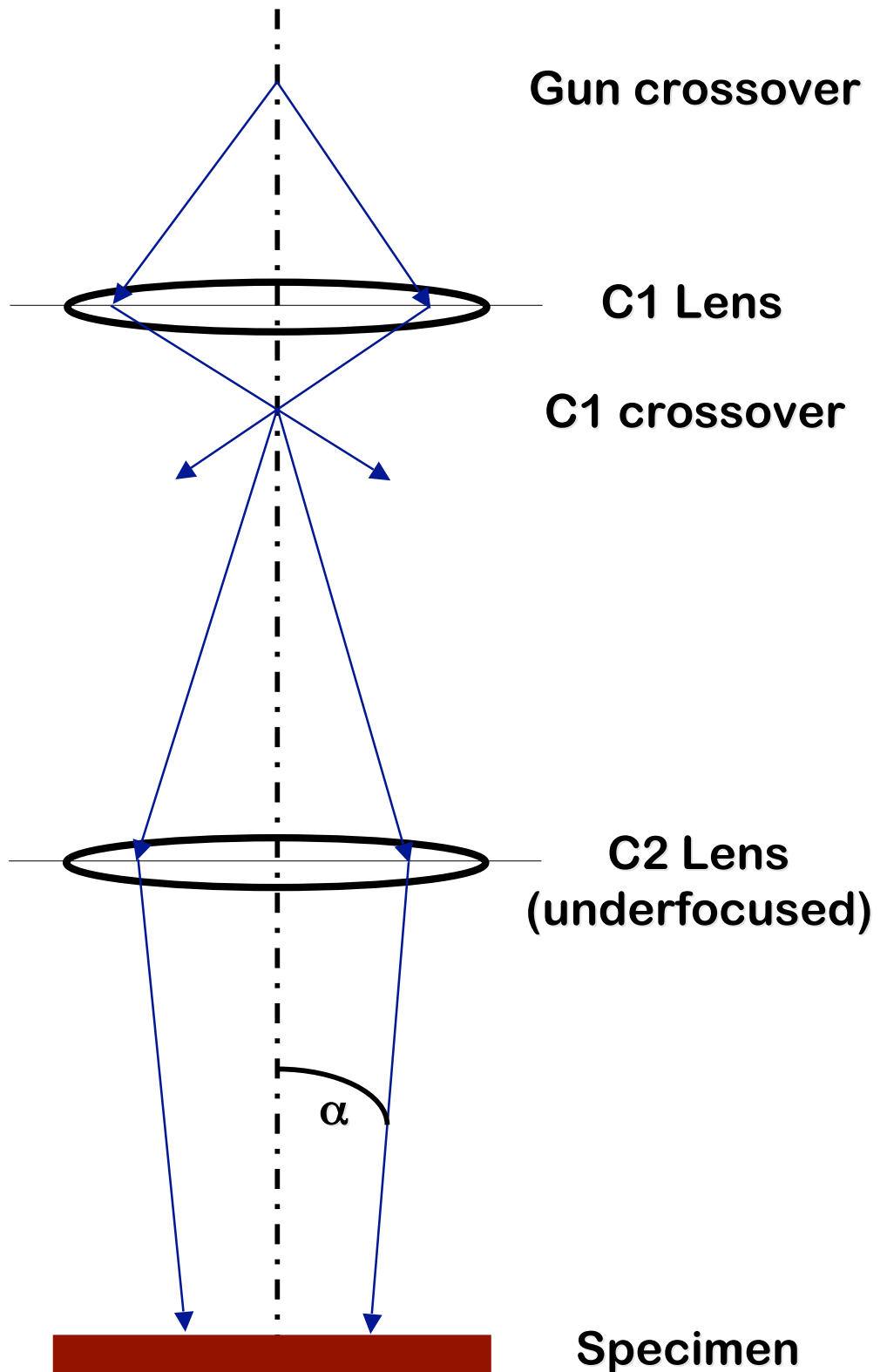
# Condenser system

## effect of C1 strength - "spot size"



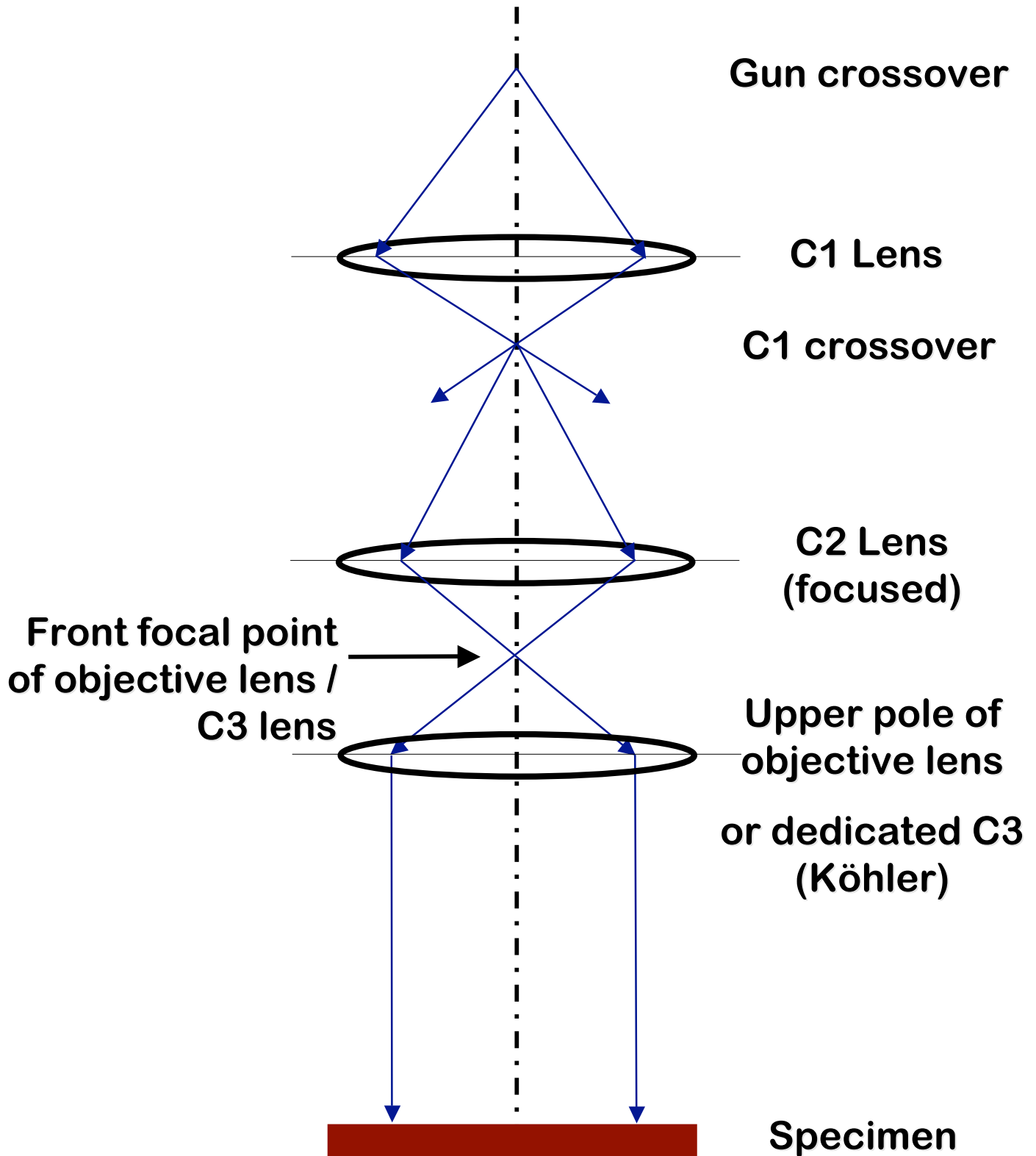
# Condenser system

## “parallel beam”



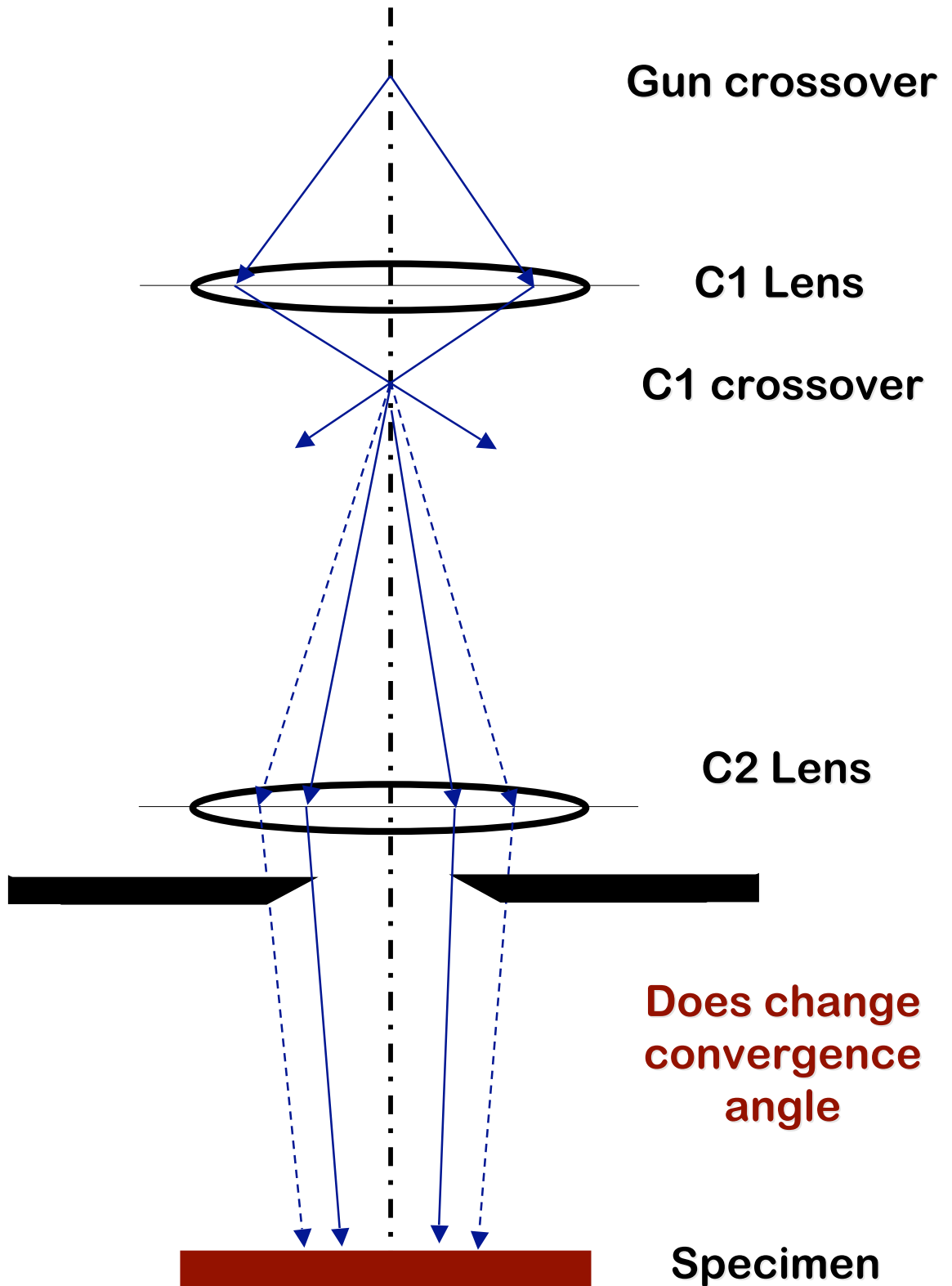
# Condenser system

## parallel illumination (Köhler)



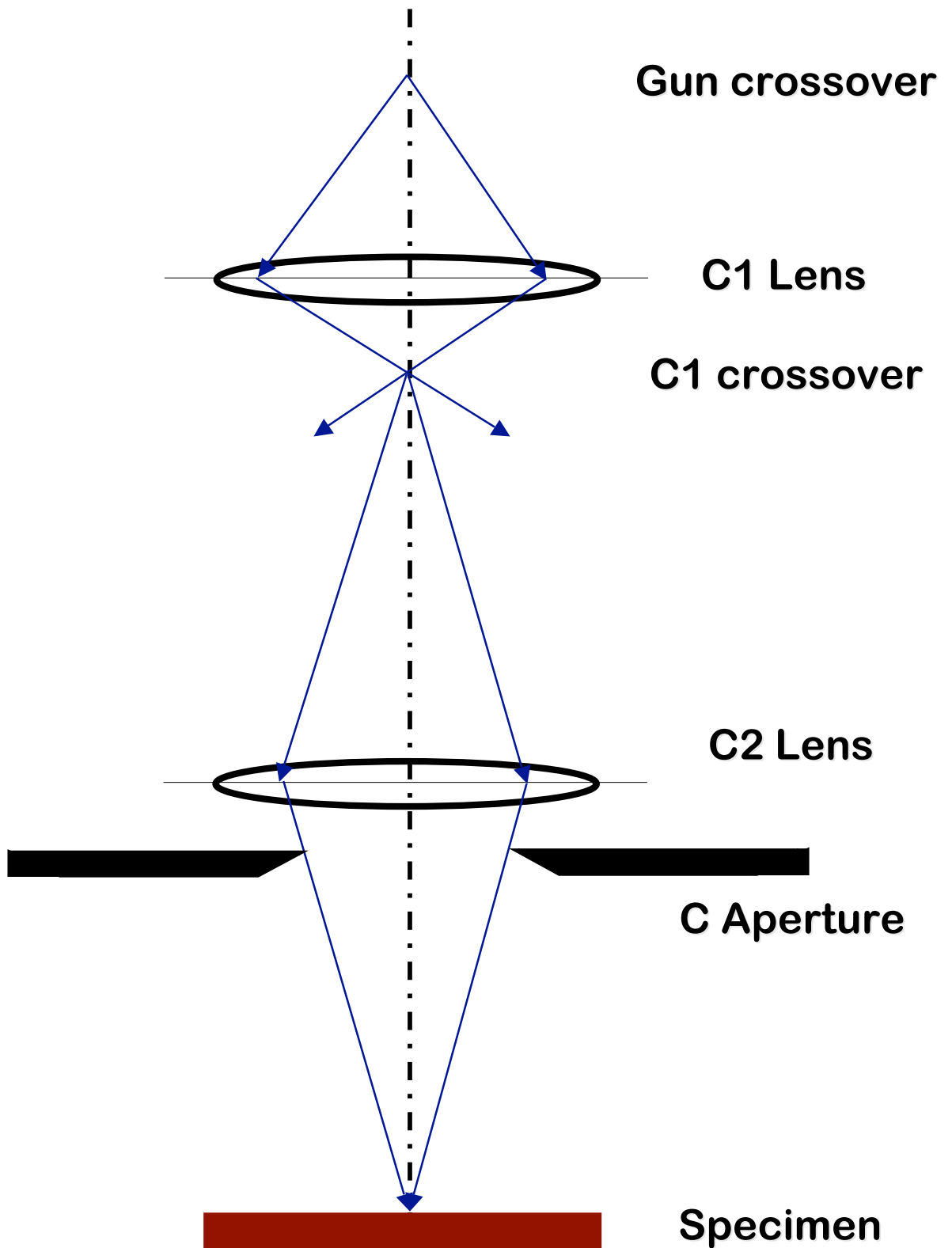
# Condenser system

## aperture effect



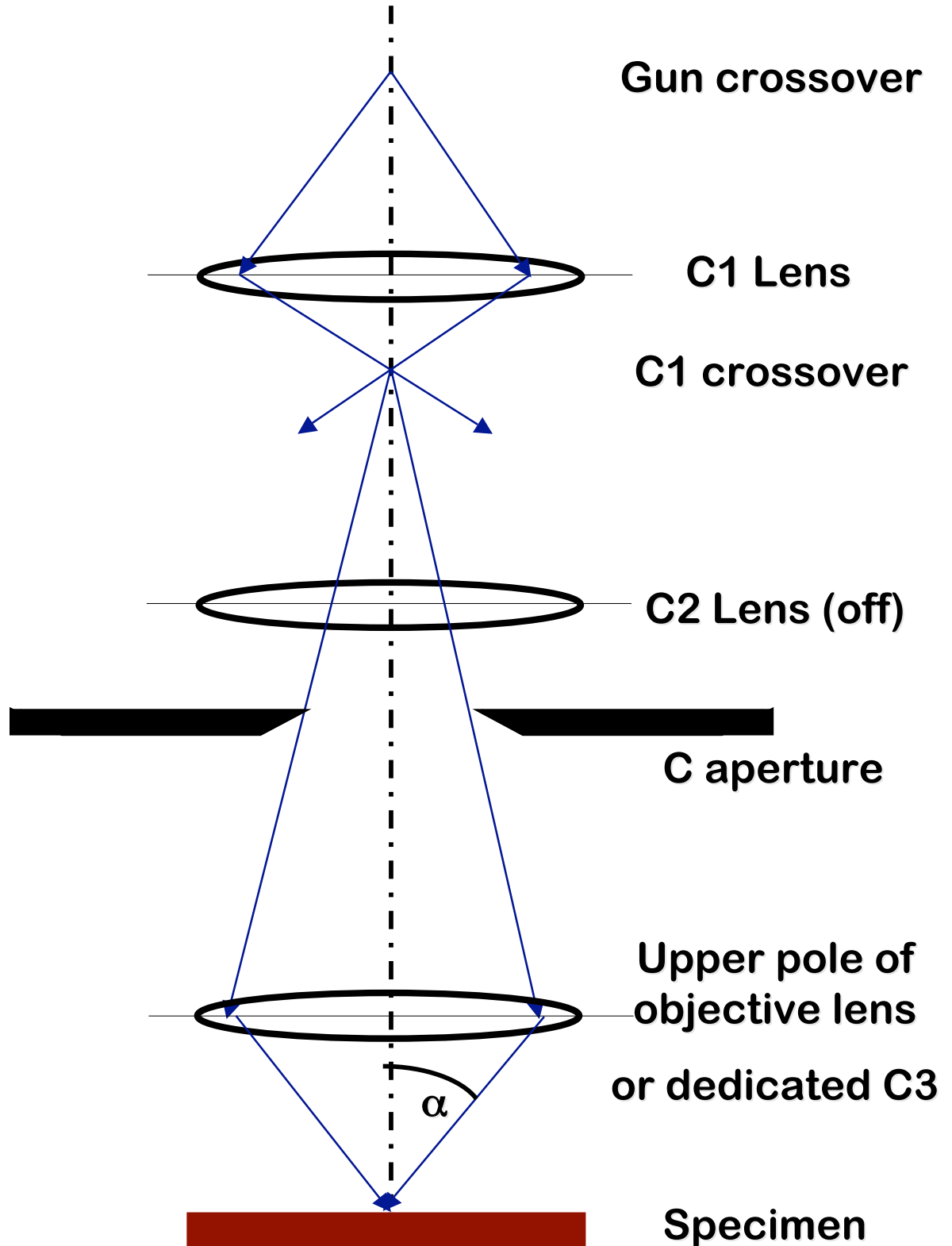
# Condenser system

## focused probe



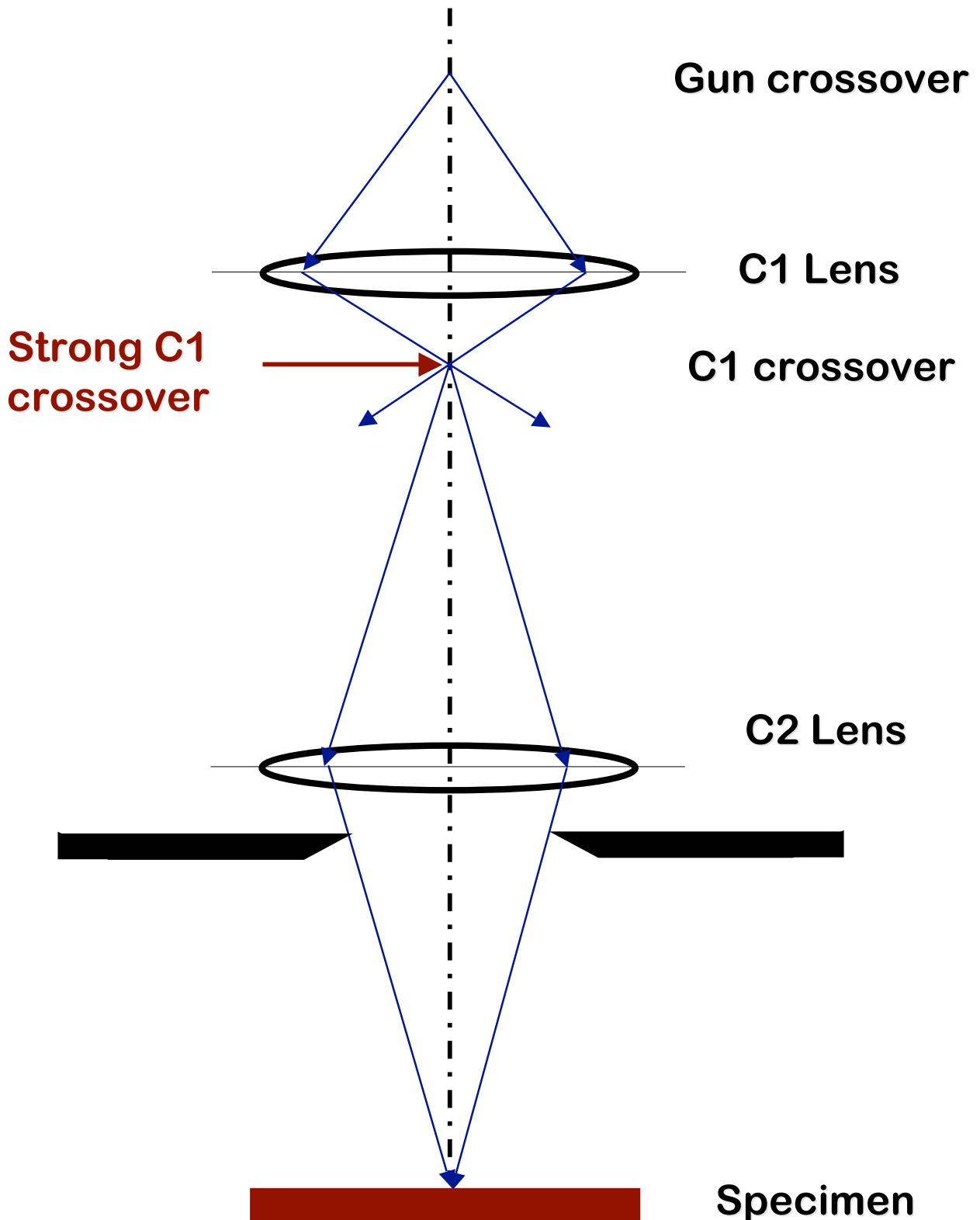
# Condenser system

'convergent beam' focused probe



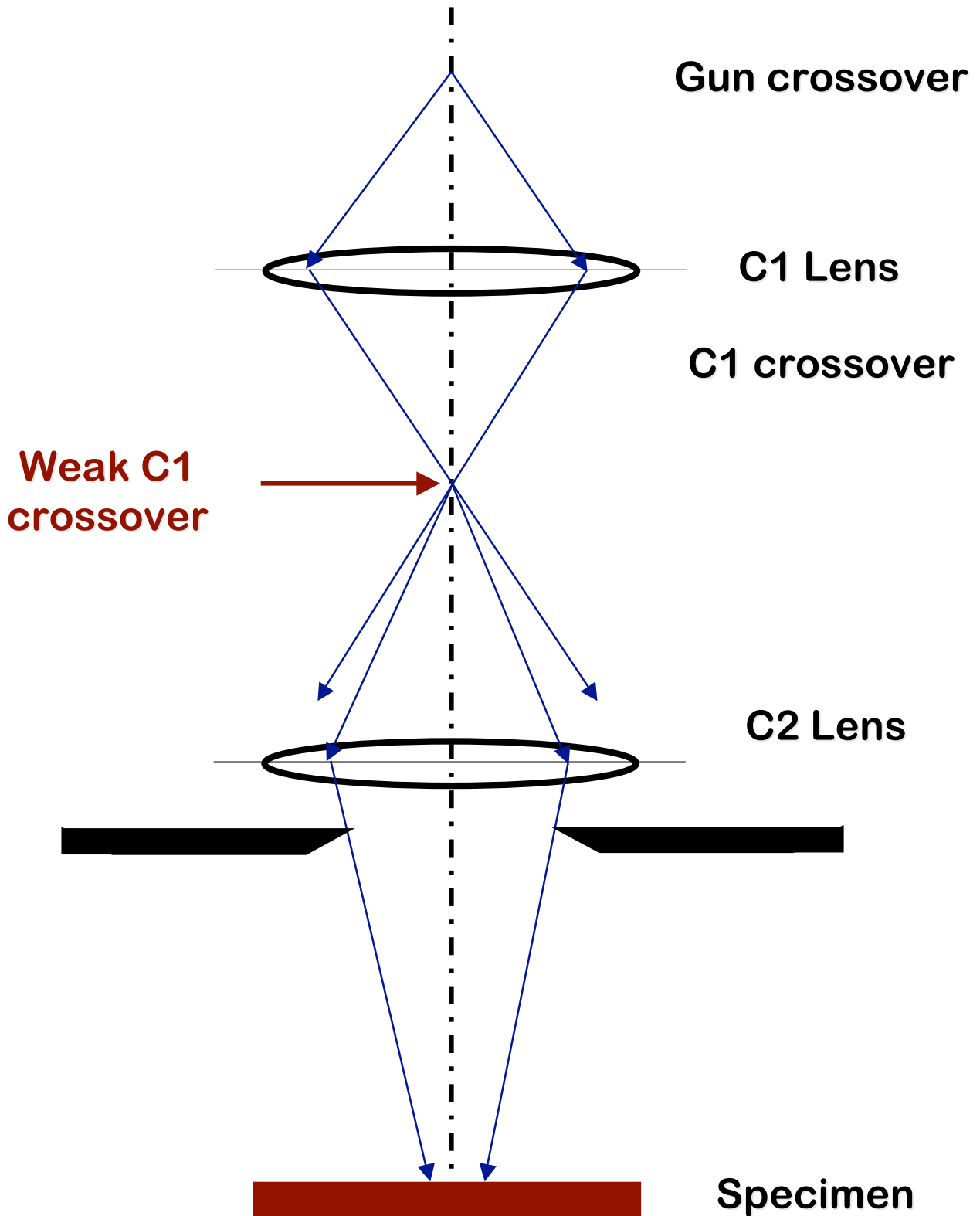
# Condenser system

## effect of C1 strength - "spot size"



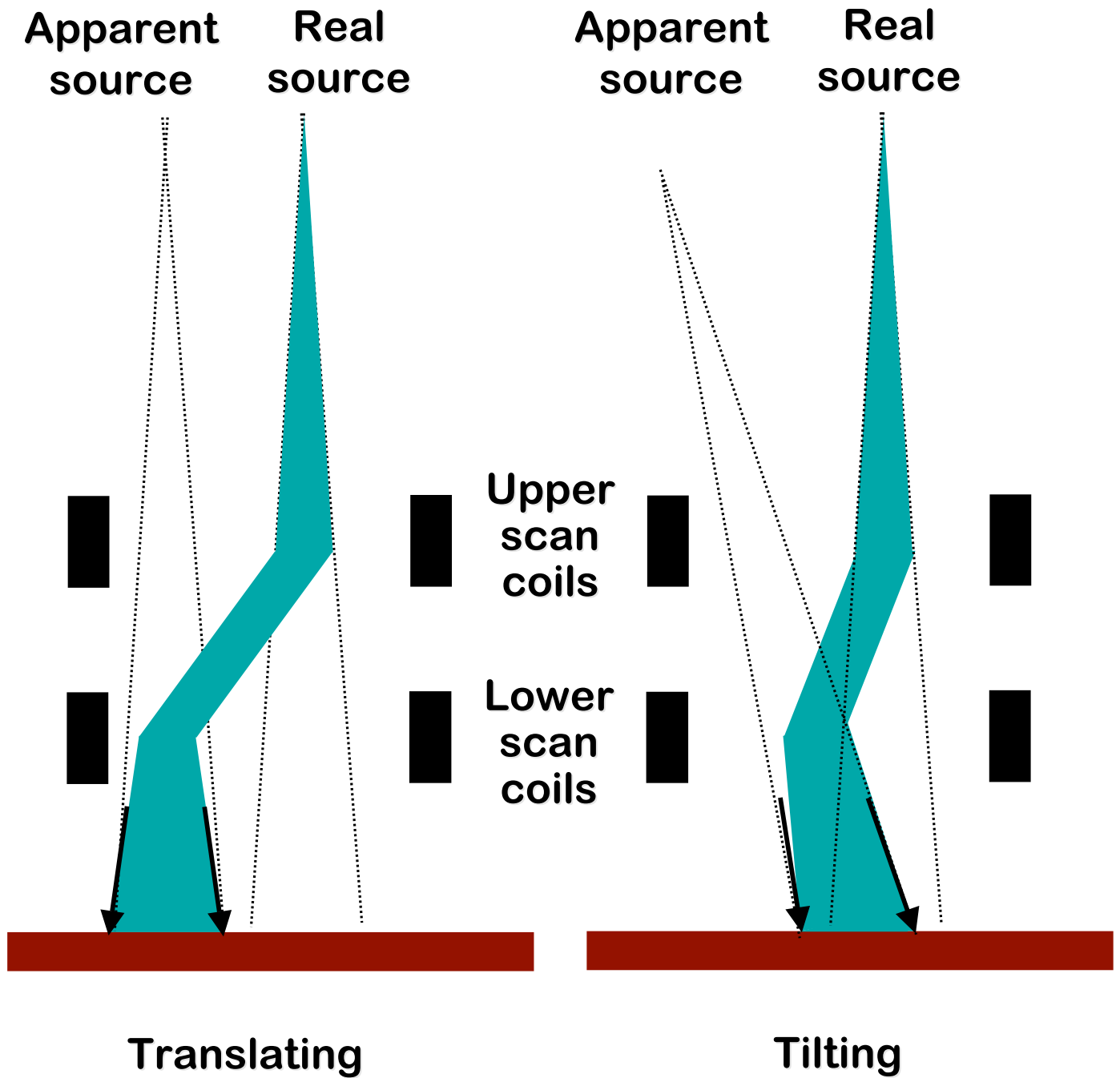
# Condenser system

## effect of C1 strength - "spot size"



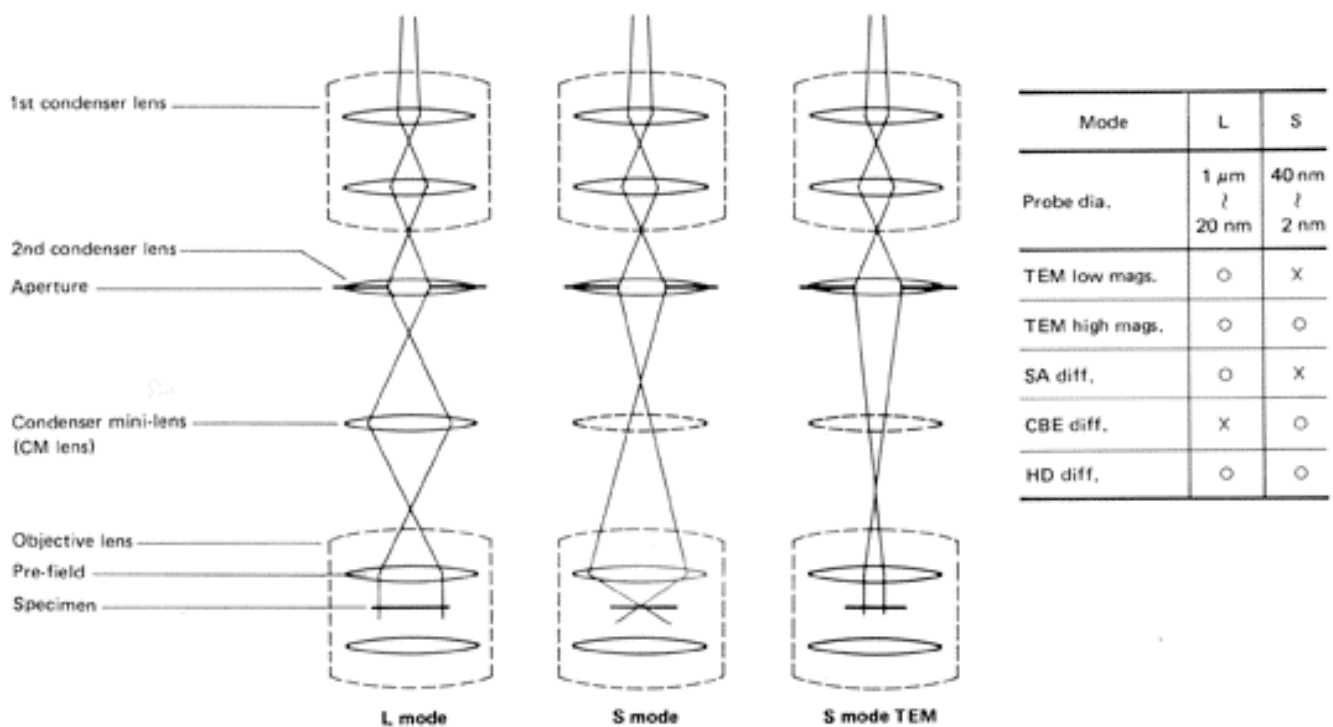
# Condenser system

## scanning / tilting & translating



# Condenser system

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



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

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## 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

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## Optimum position of sample

- Where it does not translate when you tilt

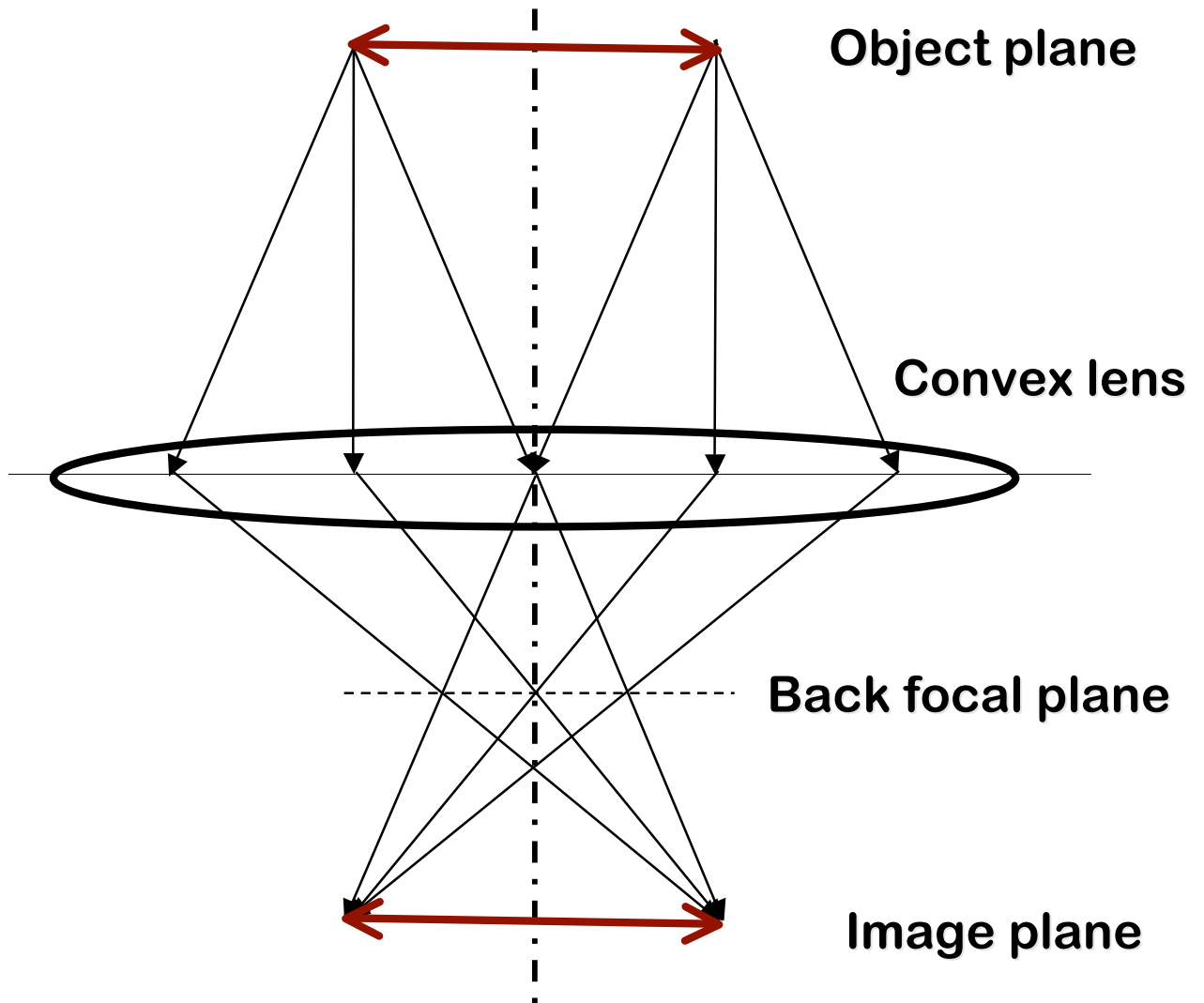
This defines the 'object' plane

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 ...



# Eucentric position

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## Optimum position of sample

- Where it does not translate when you tilt

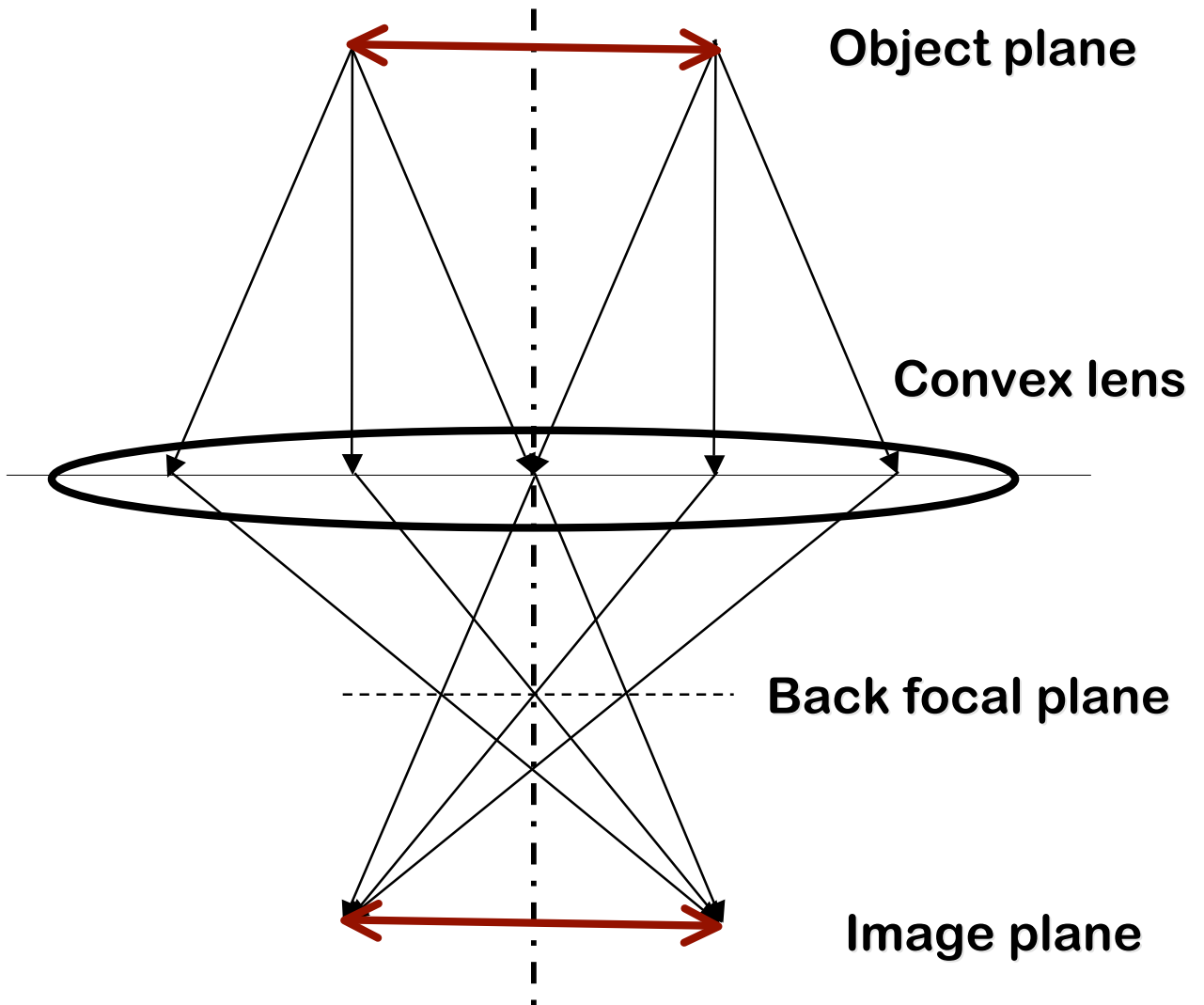
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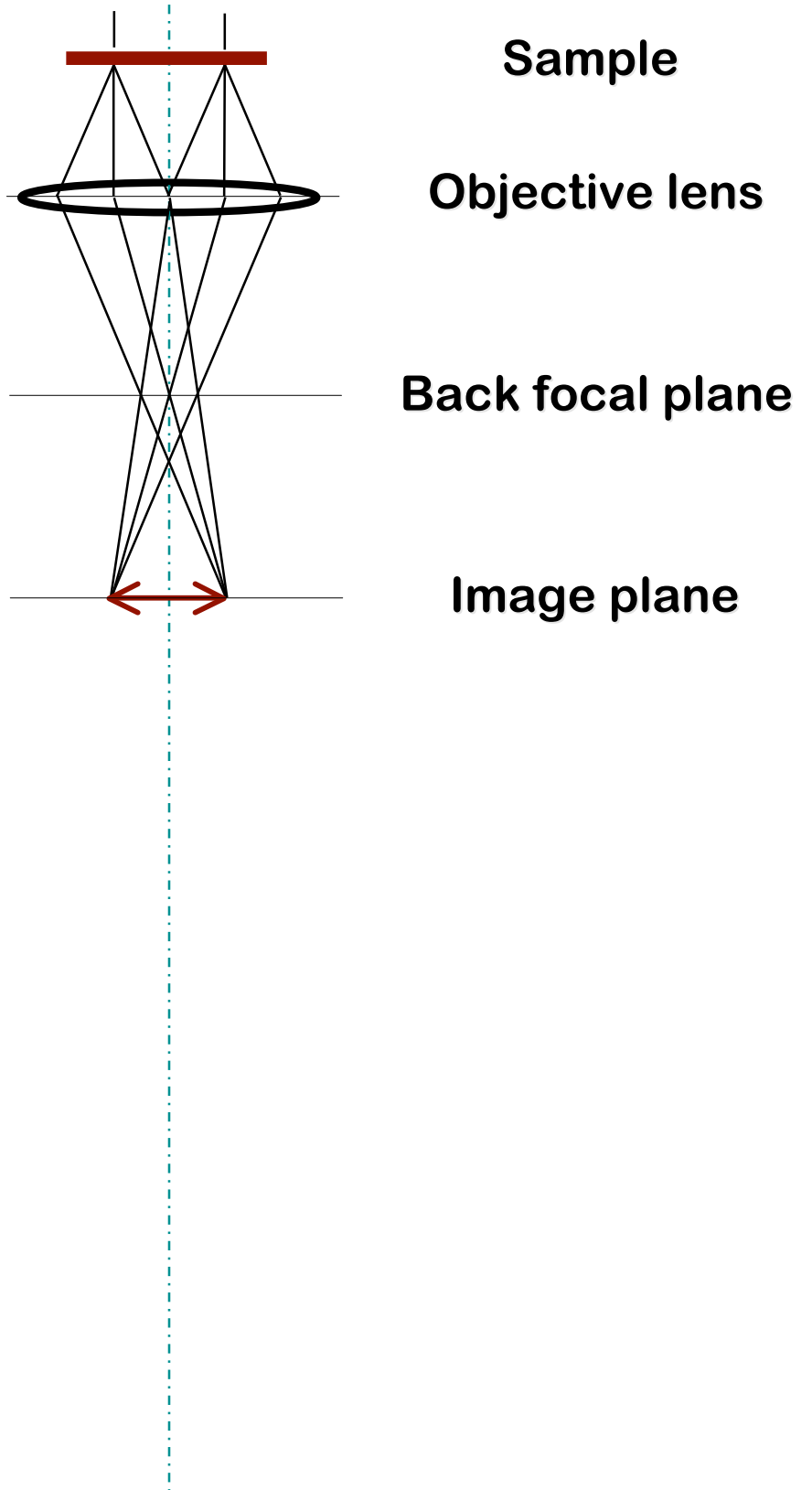
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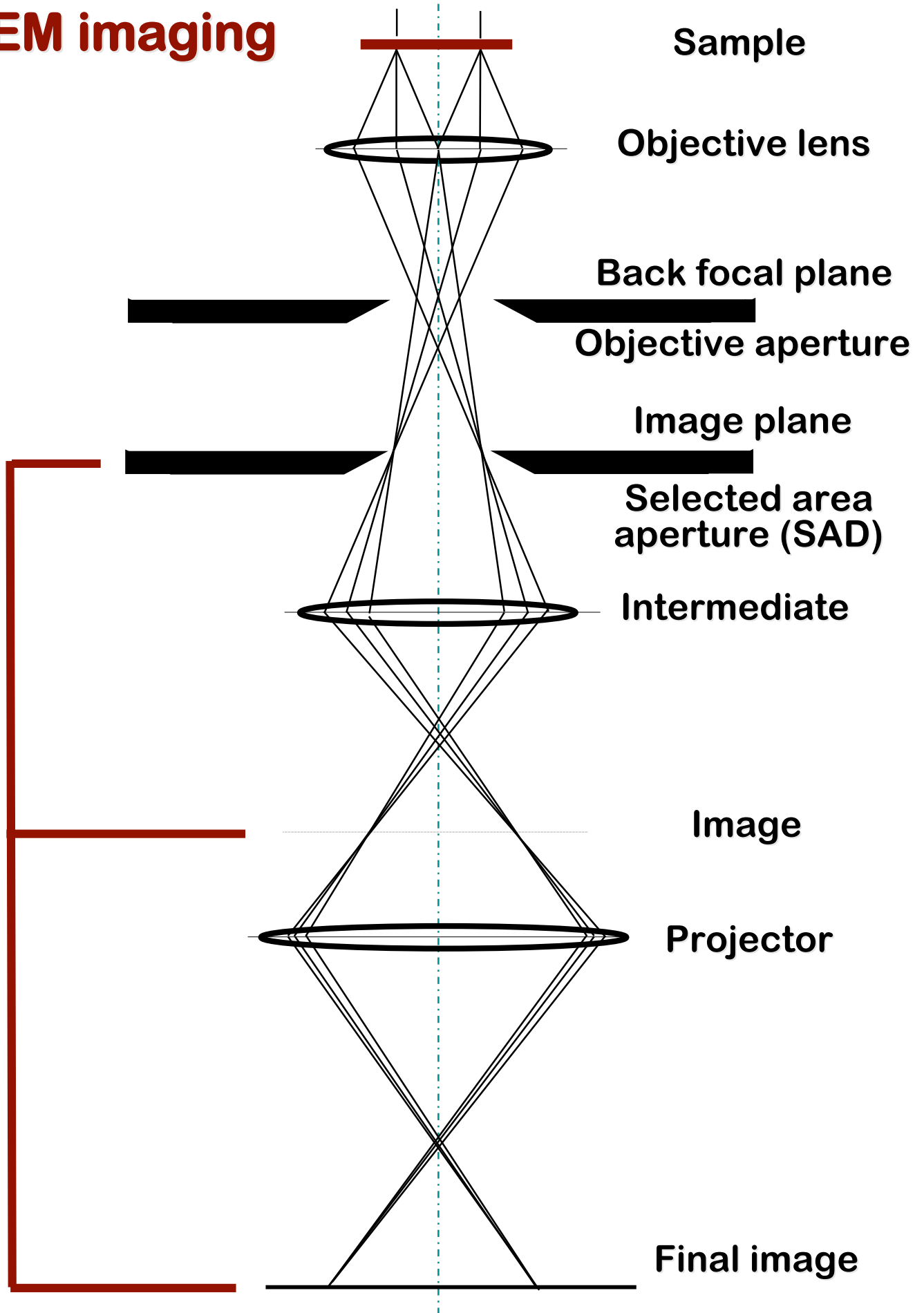
# Recall ...



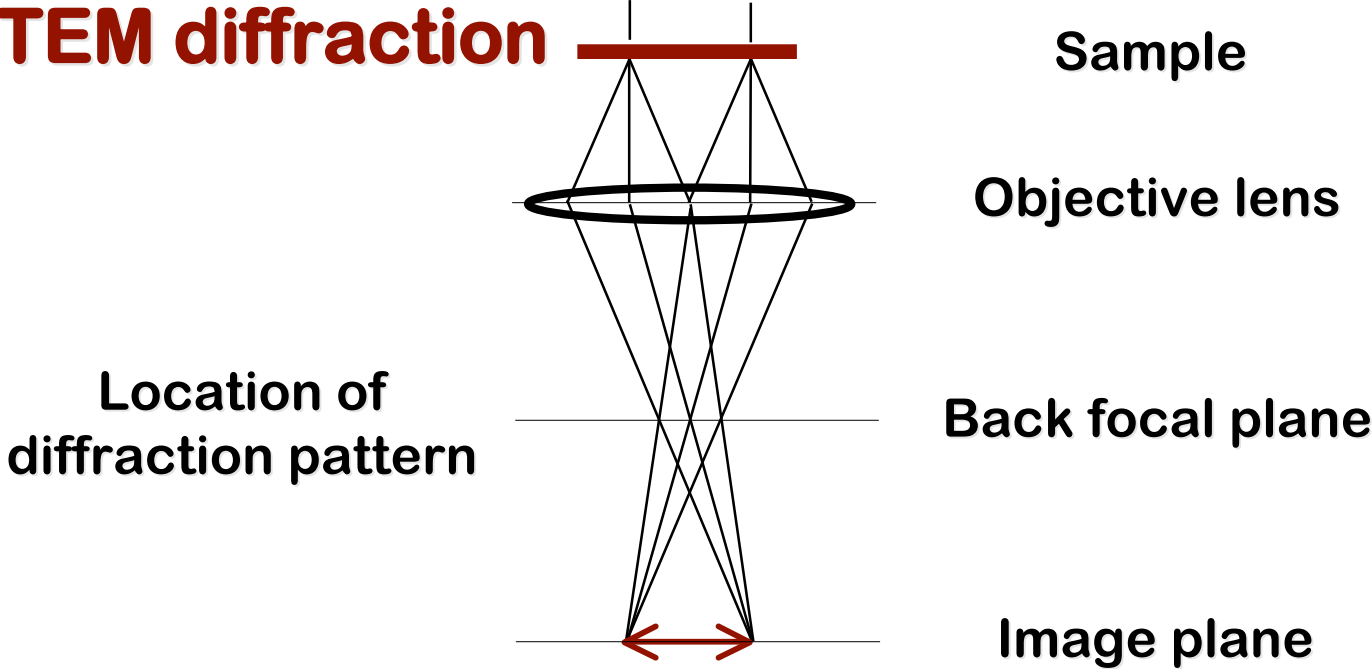
# TEM imaging



# TEM imaging



# TEM diffraction



# TEM diffraction

Sample

Objective lens

Back focal plane

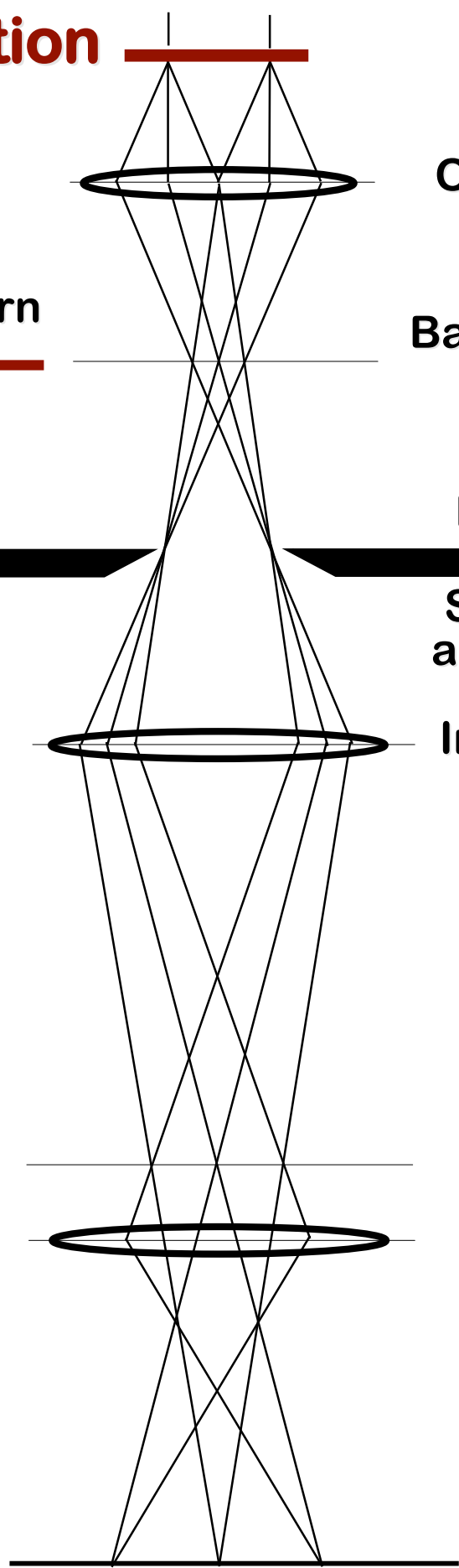
Image plane

Selected area aperture (SAD)

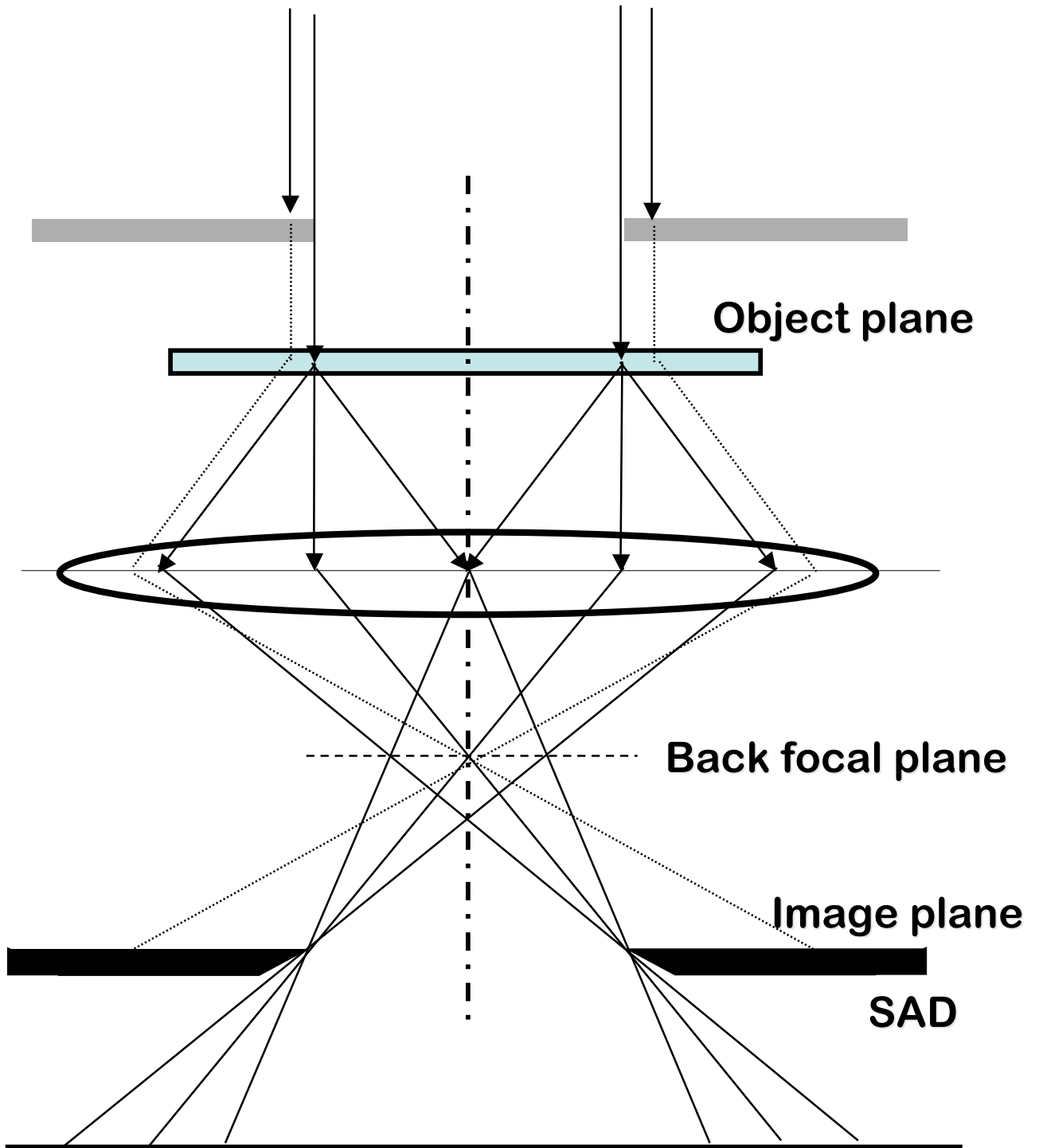
Intermediate

Projector

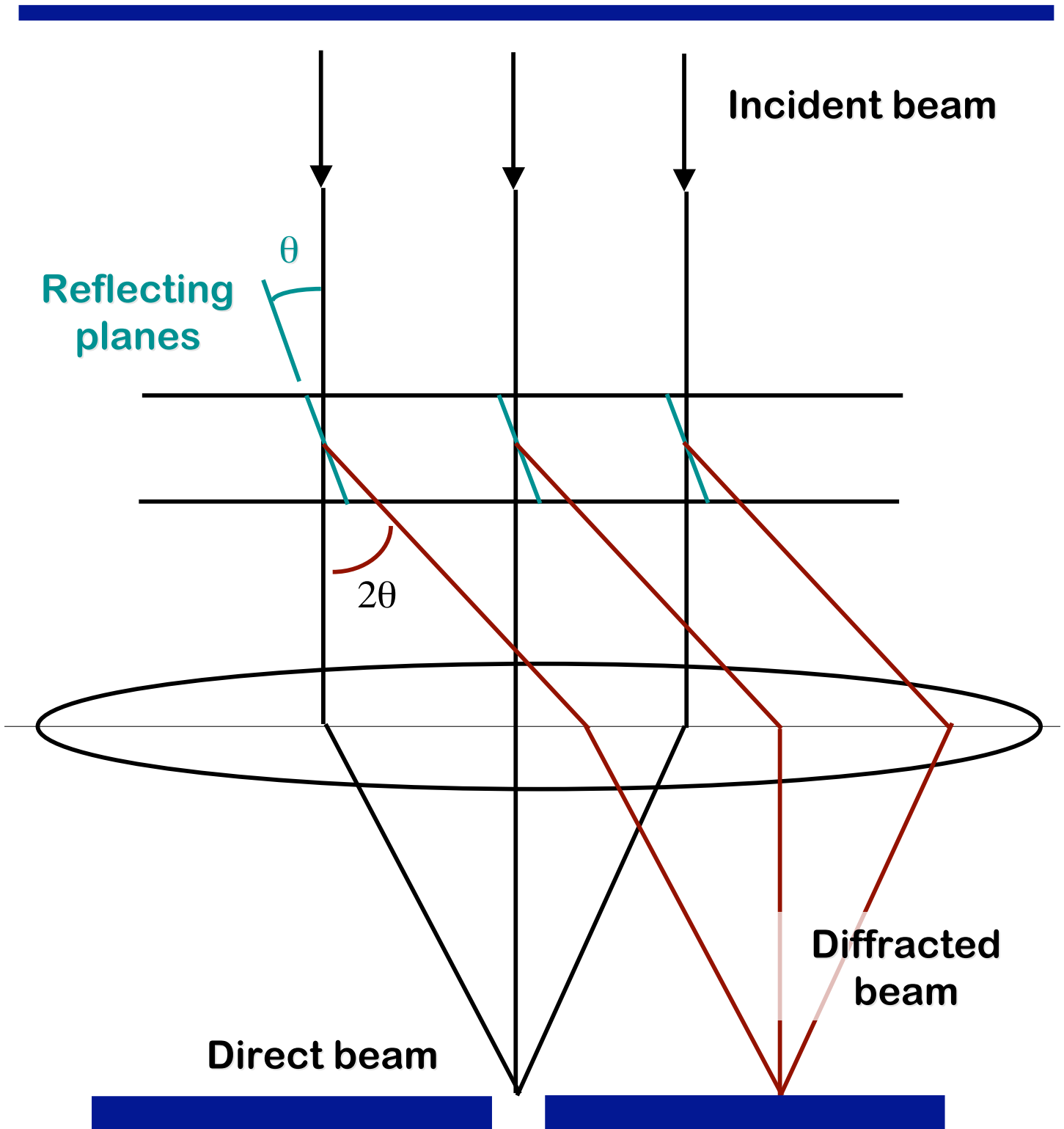
Location of diffraction pattern



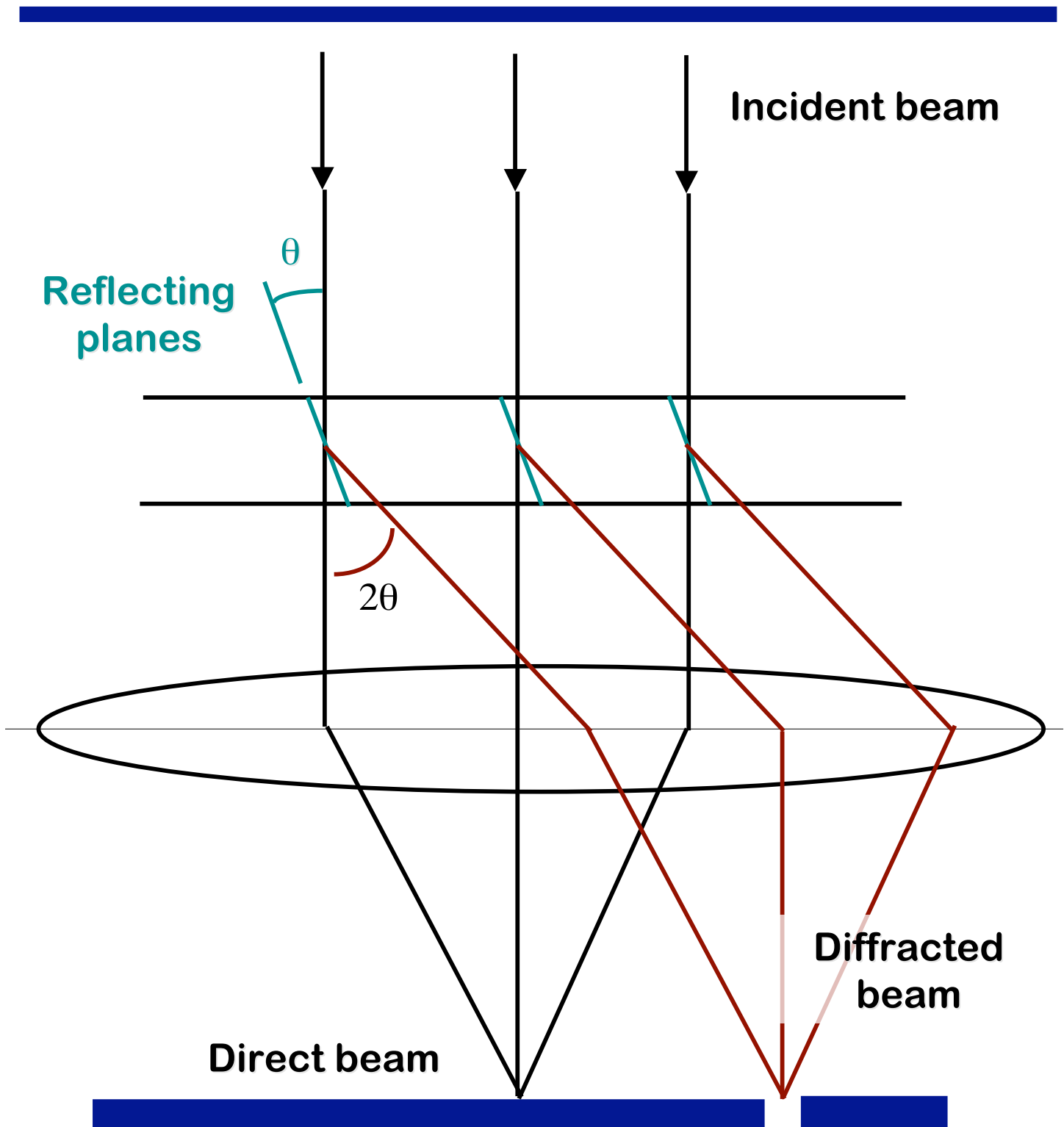
# Selected area diffraction aperture



# Bright field image



# “Dirty” dark field



# TEM diffraction

Sample

Objective lens

Back focal plane

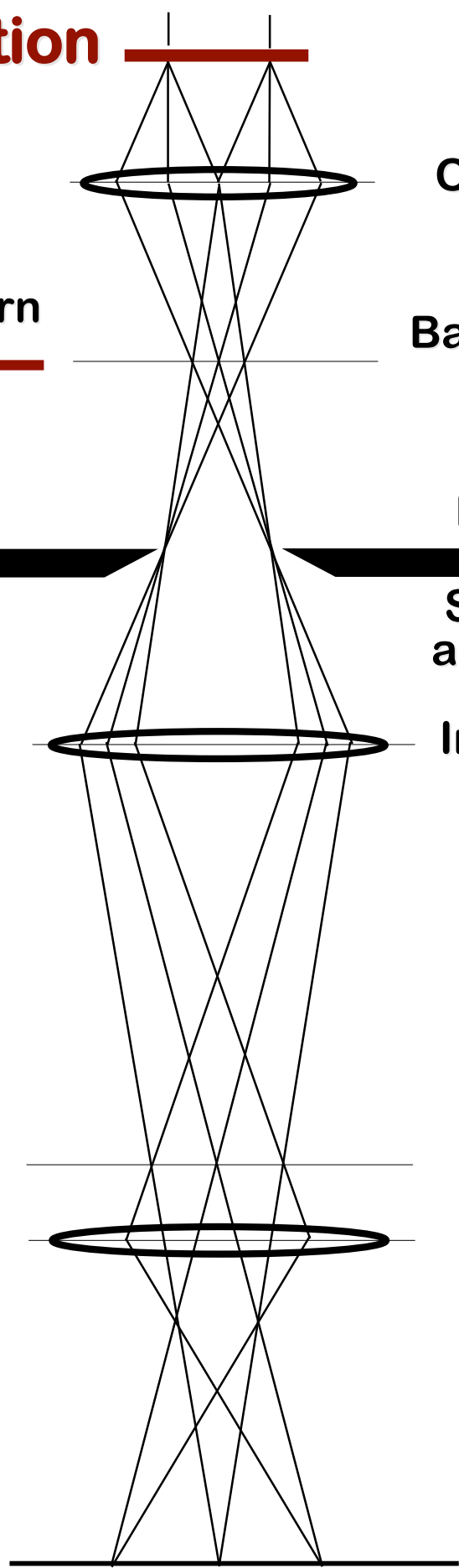
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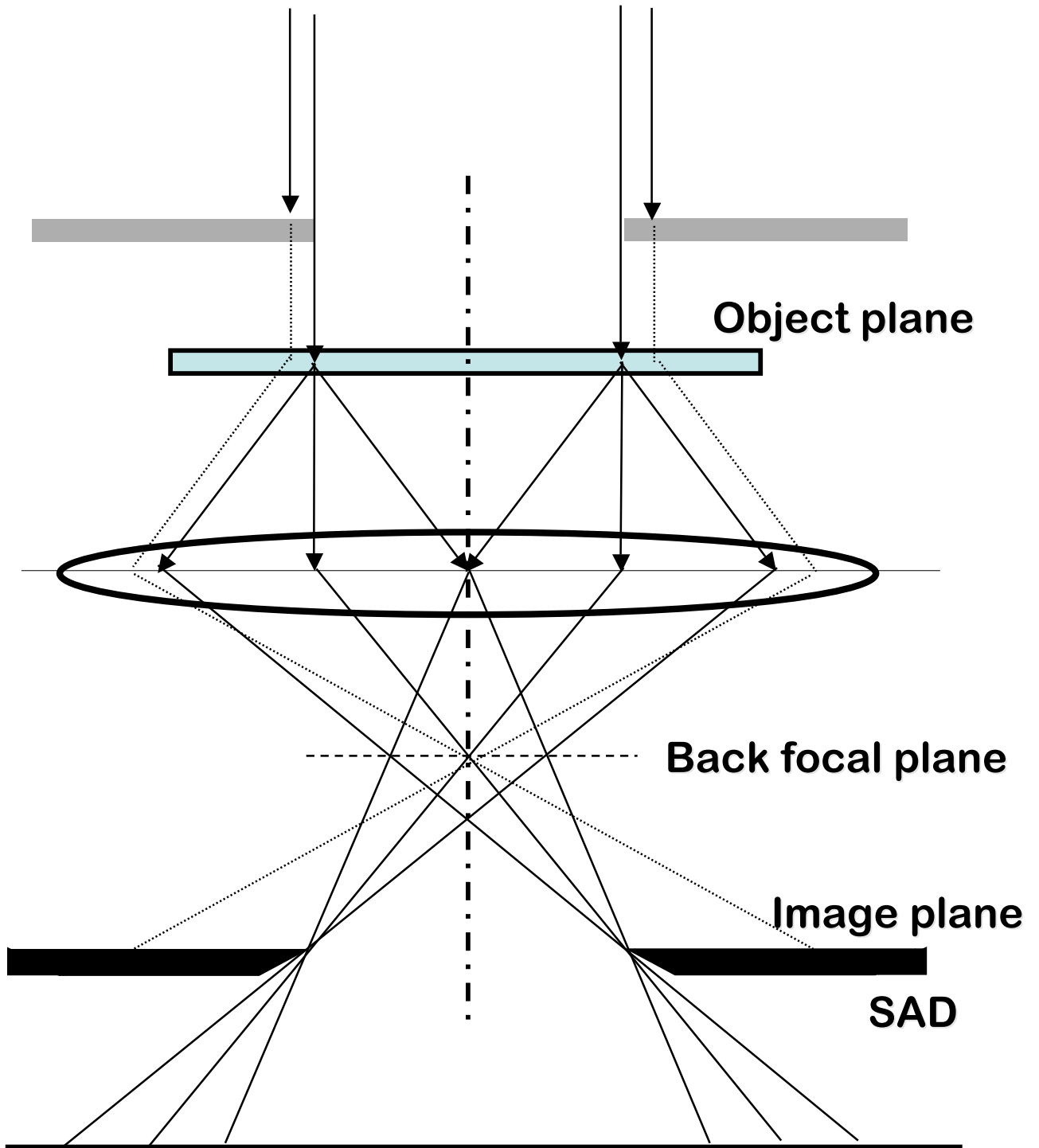
Intermediate

Projector

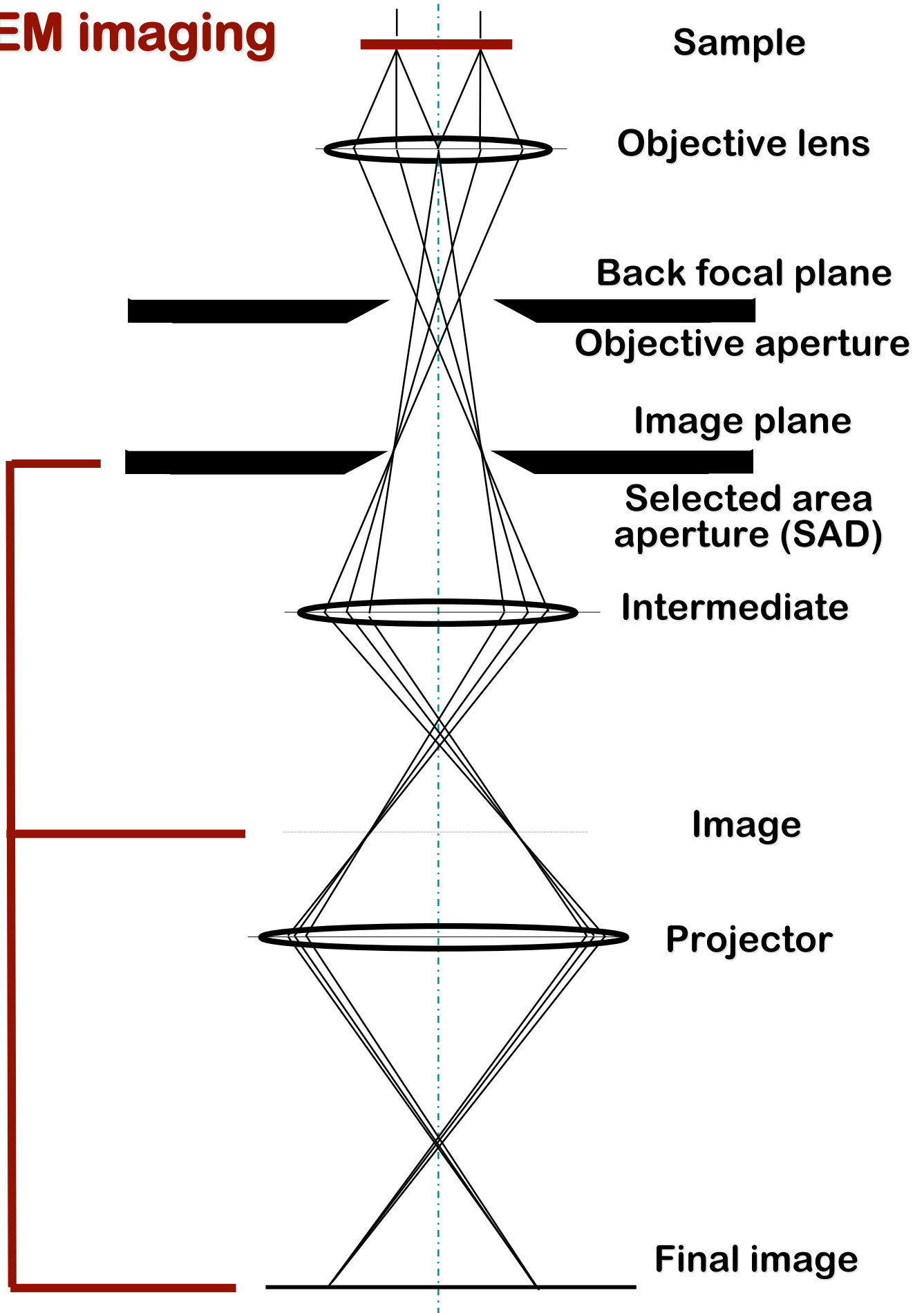
Location of diffraction pattern



# Selected area diffraction aperture



# TEM imaging



# TEM diffraction

Sample

Objective lens

Back focal plane

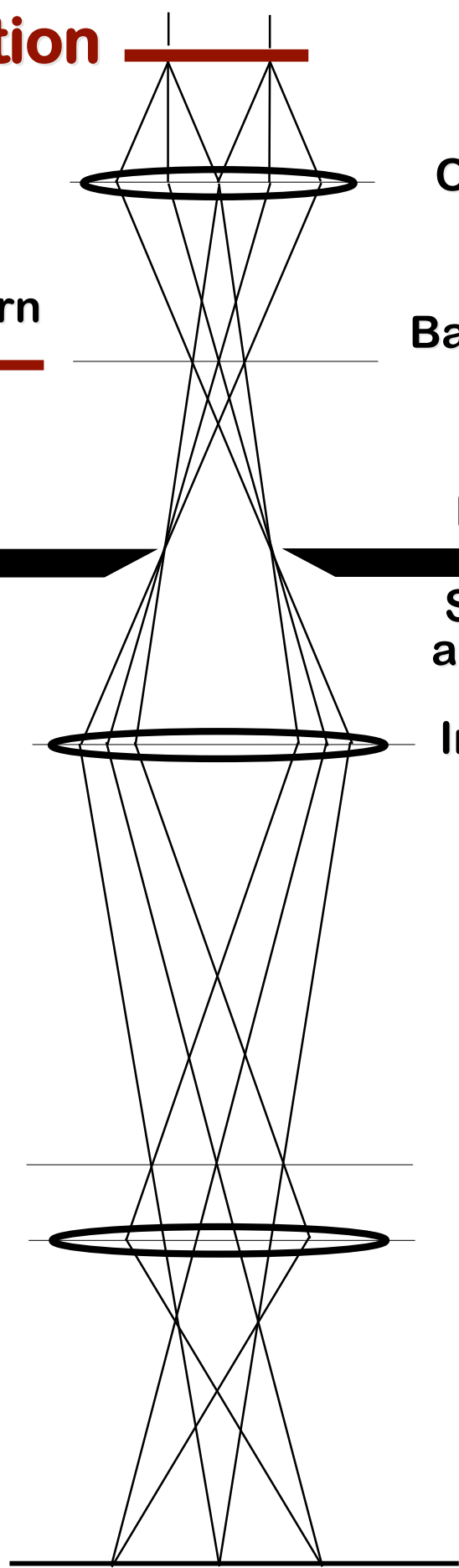
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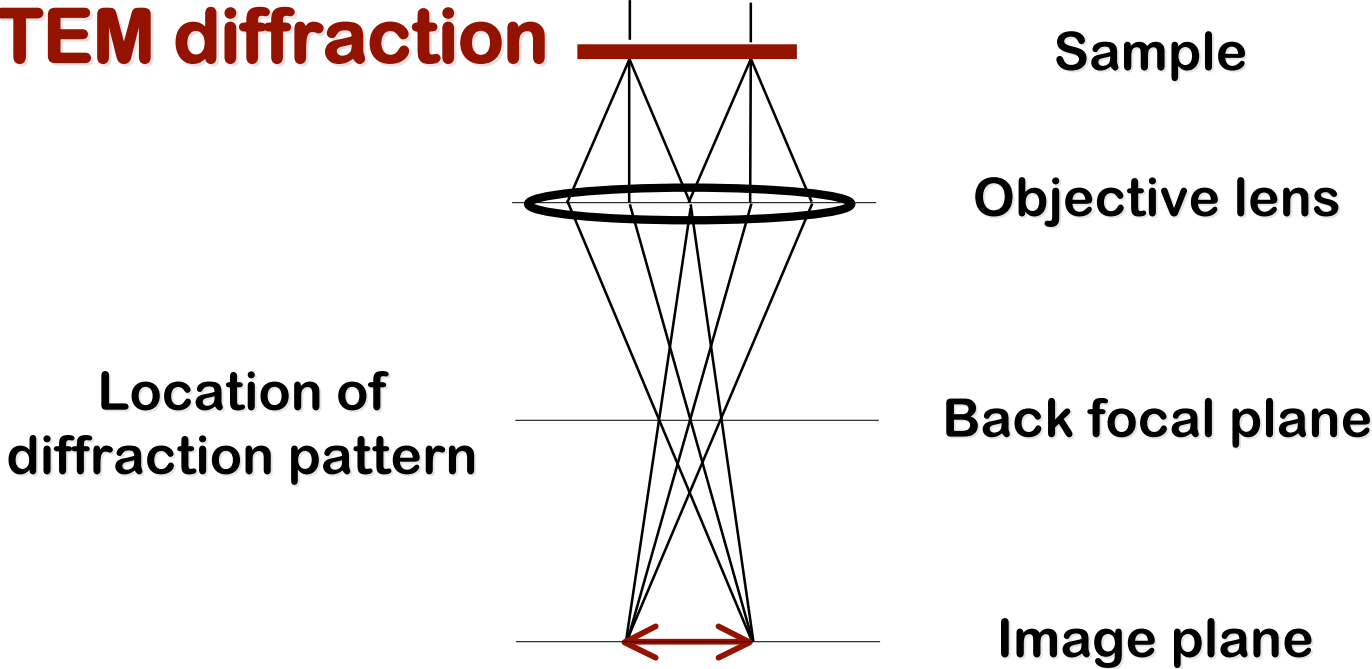
Intermediate

Projector

Location of diffraction pattern



# TEM diffraction



Sample

Objective lens

Back focal plane

Image plane

Location of  
diffraction pattern

# TEM imaging

