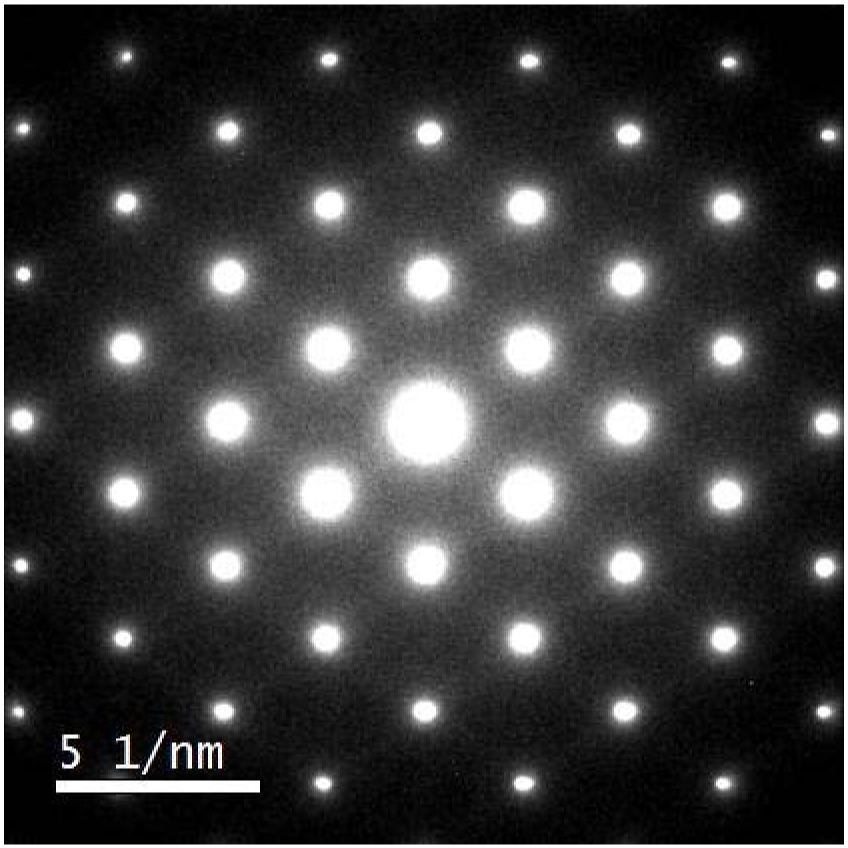
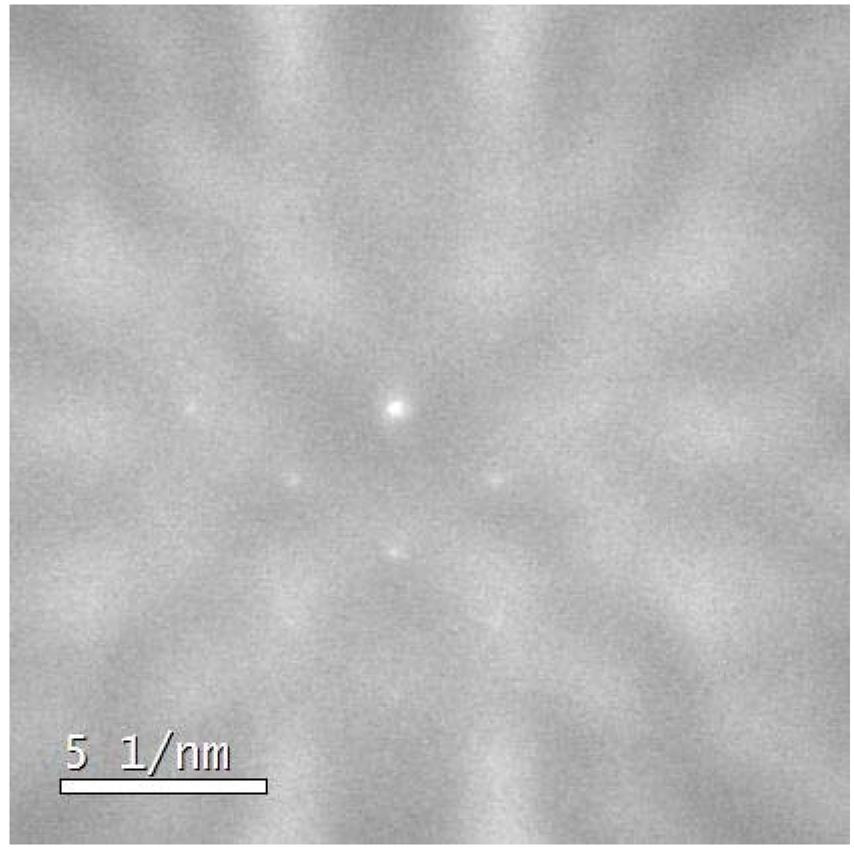
Selected area-diffraction: Influence of thickness

GaAs - thin

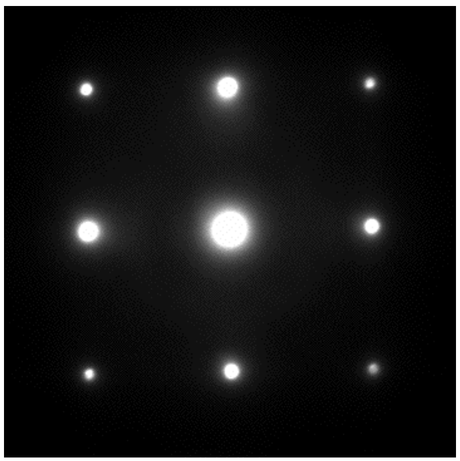


GaAs - thick



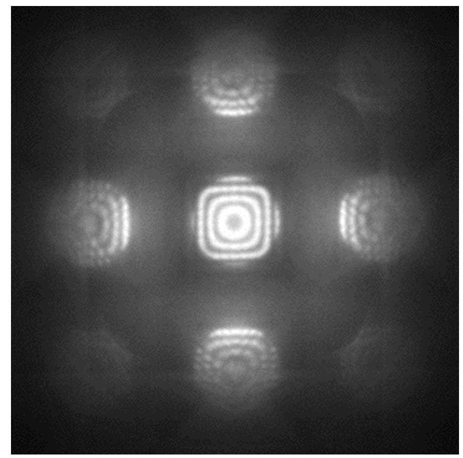
Selected-area vs. convergent-beam diffraction

Si



Selected-Area Diffraction Pattern

Si

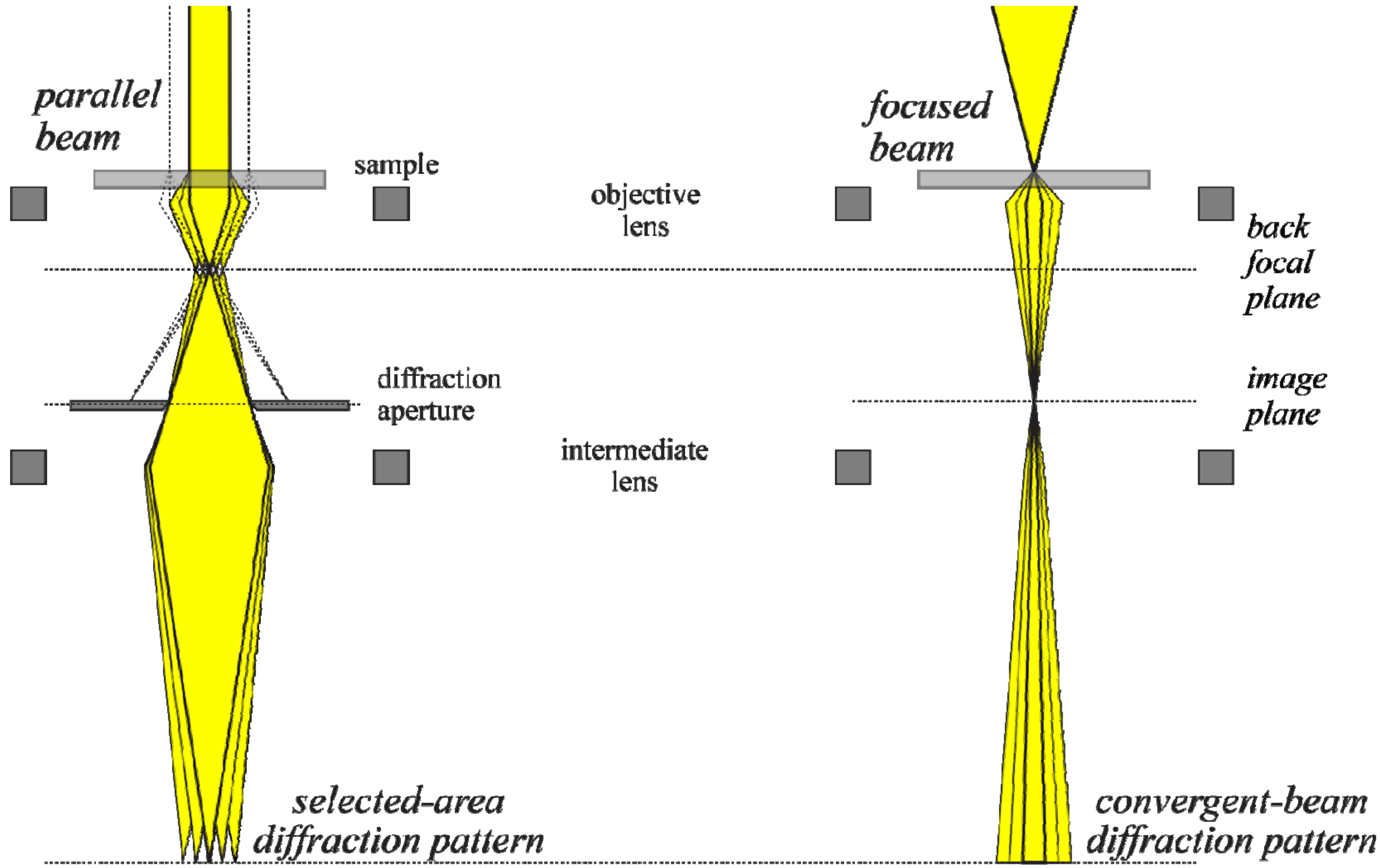


Convergent-Beam Diffraction Pattern

- Easy to index
- Easy to measure *d*-spacings
- Can isolate low-angle features

- More information (even 3-D)
- Samples a specific area
- Sharper Kikuchi lines

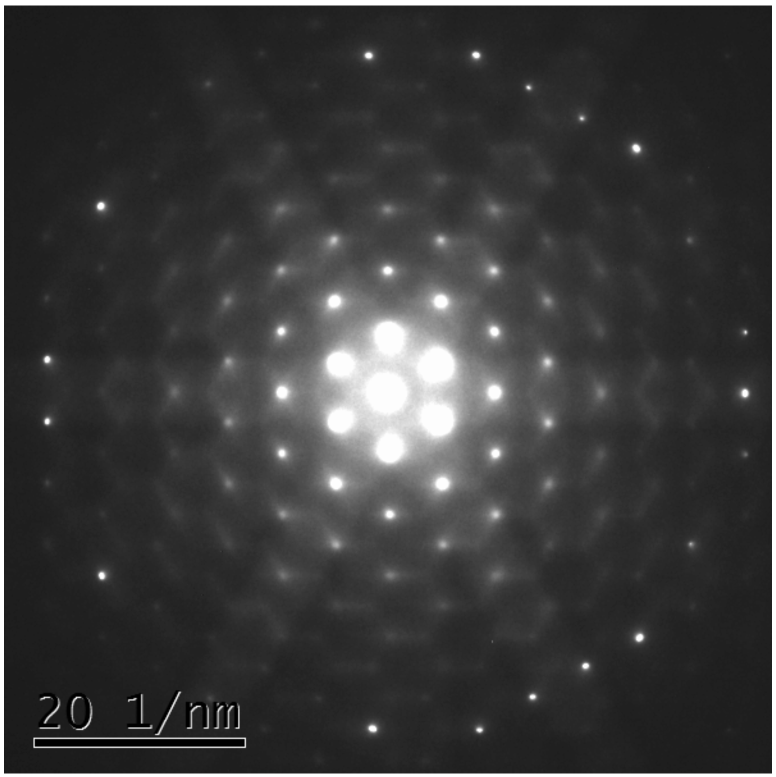
Ray diagrams for SA and CB diffraction



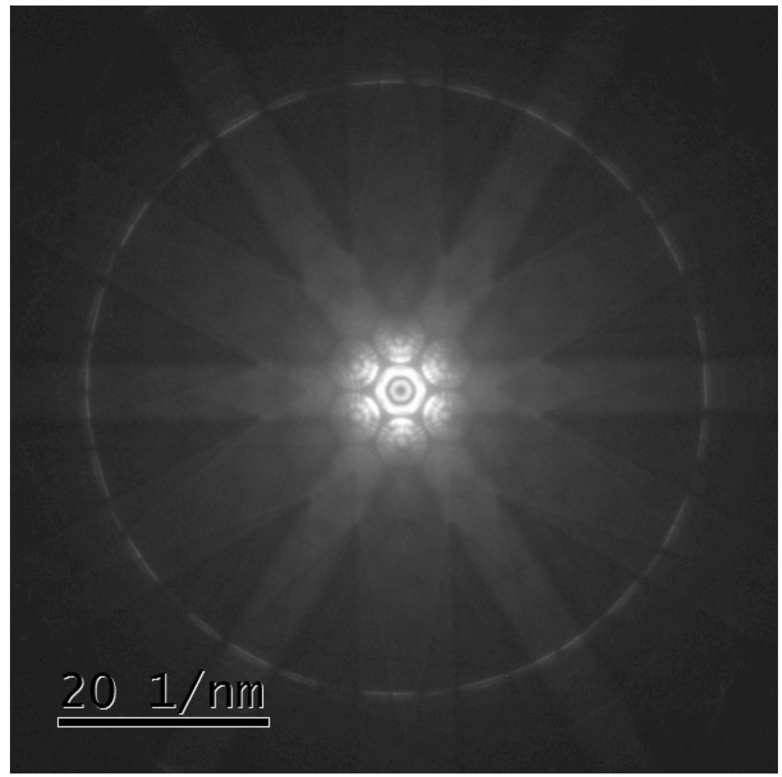
both modes:
IL focused on BFP
OL focused on Sample

Example: Si<111>

selected-area electron diffraction

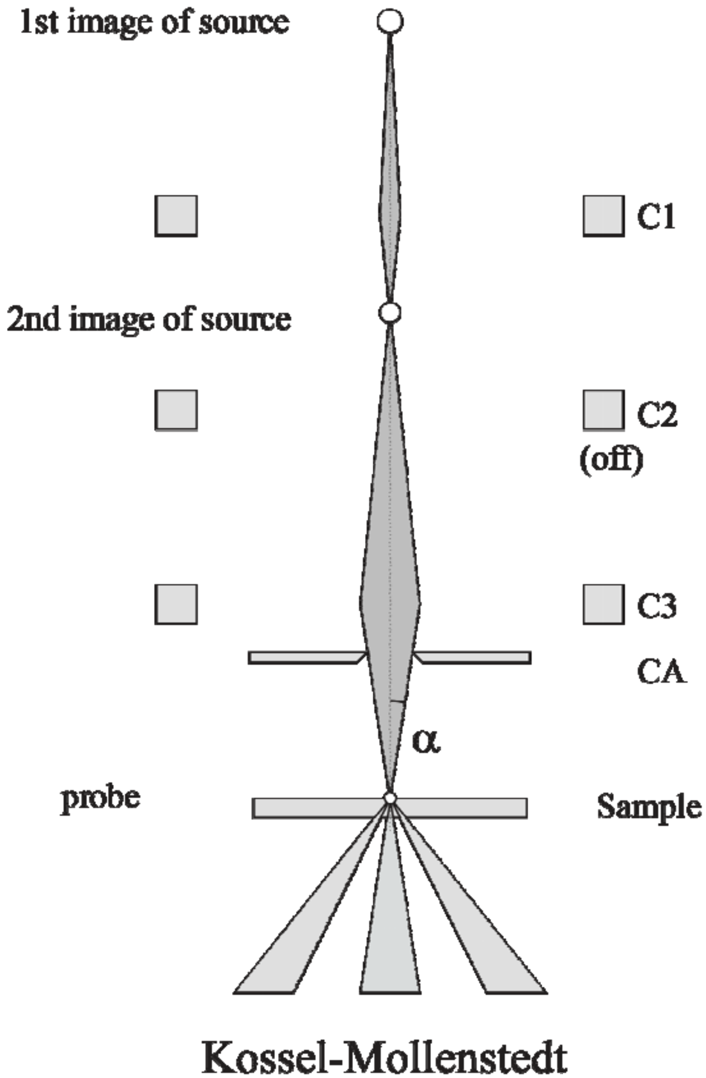


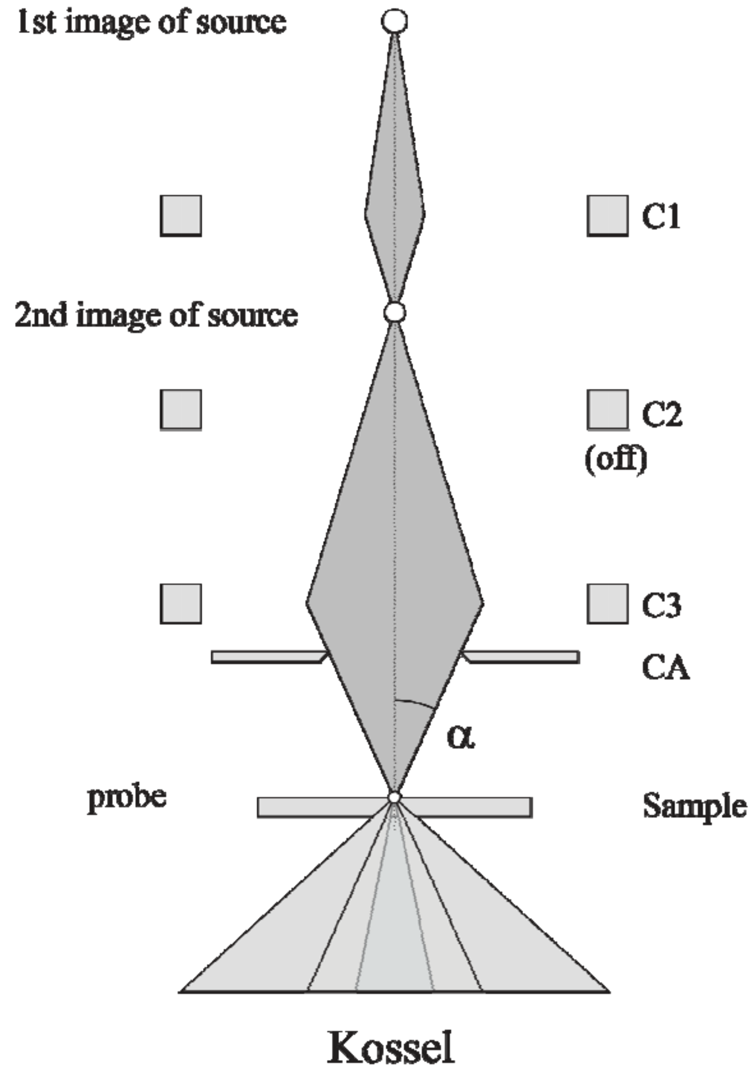
convergent-beam electron diffraction



stronger Kikuchi lines
sharper HOLZ rings

Influence of convergence angle

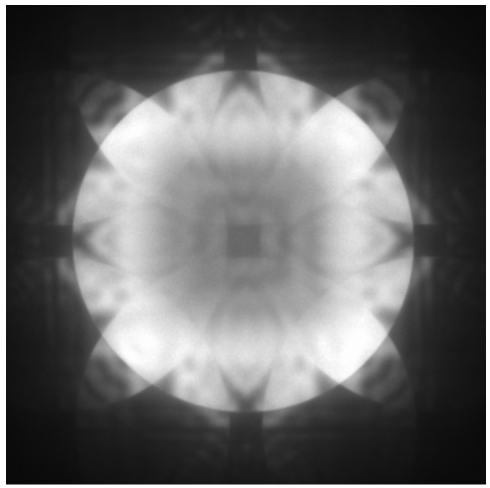




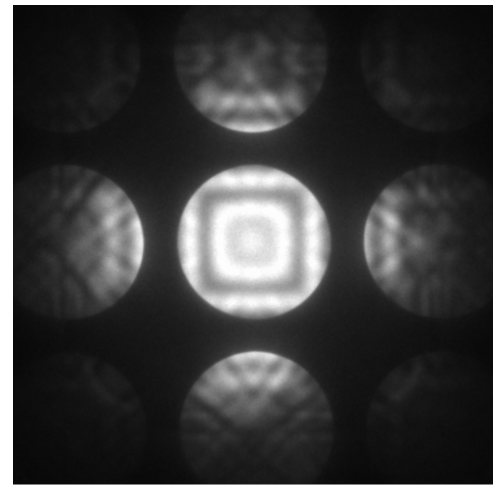
CBED disk diameter proportional to condenser aperture size

Influence of condenser aperture size

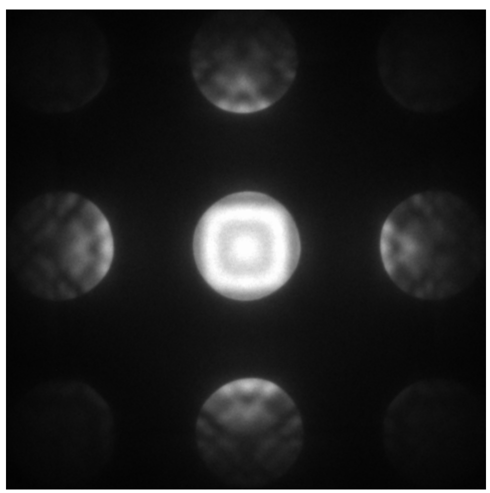
CA #1
150 μm



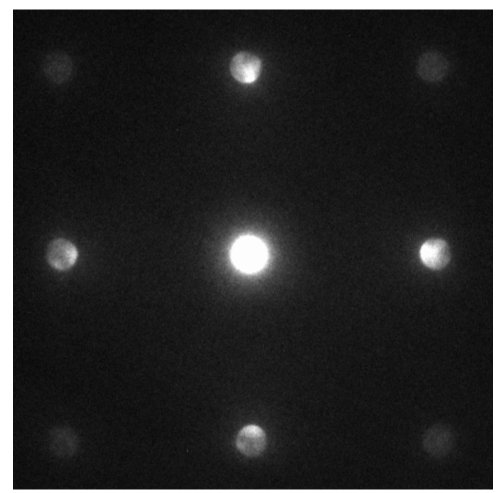
CA#2
70 μm



CA#3
50 μm



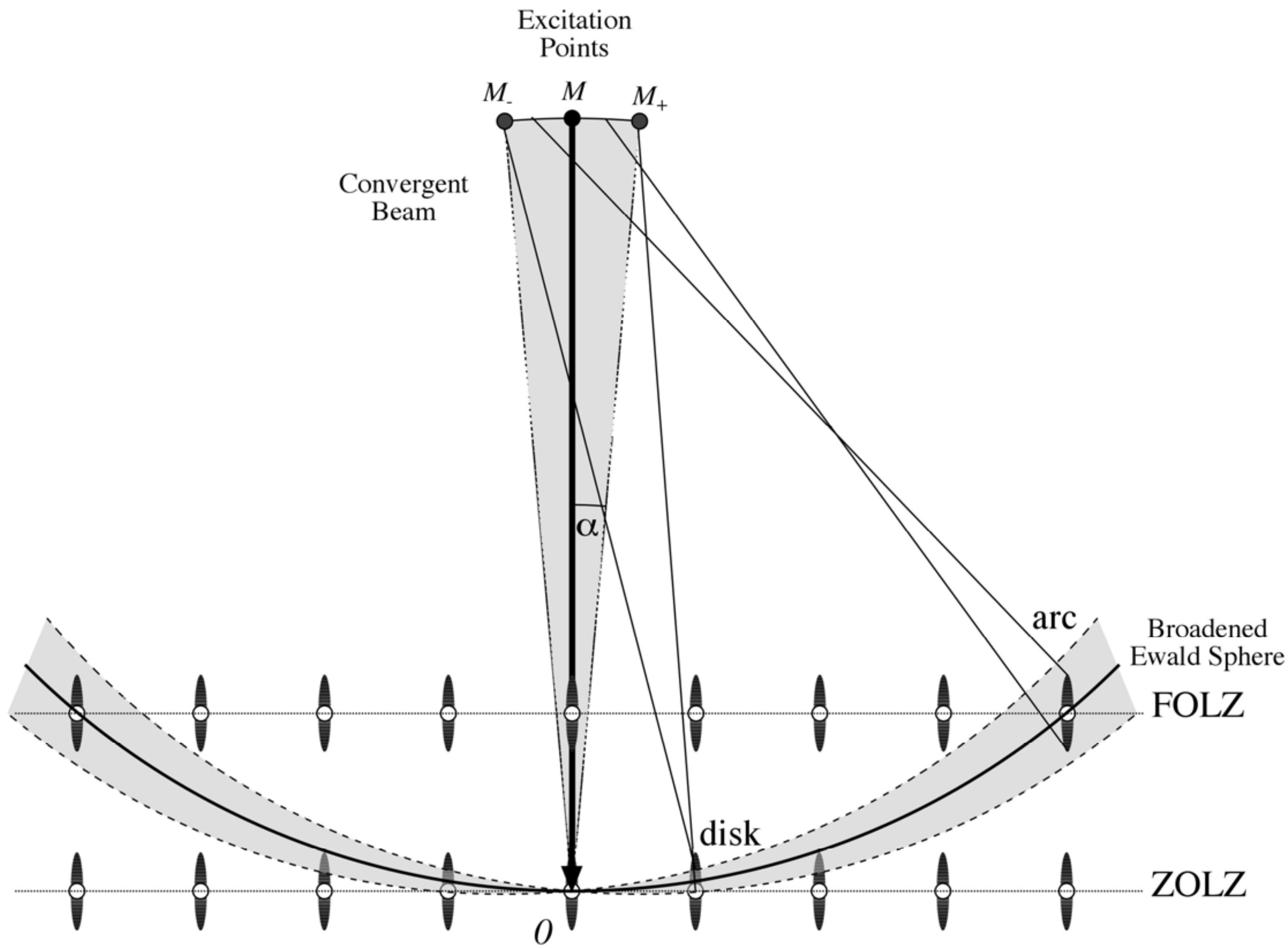
CA#4
10 μm



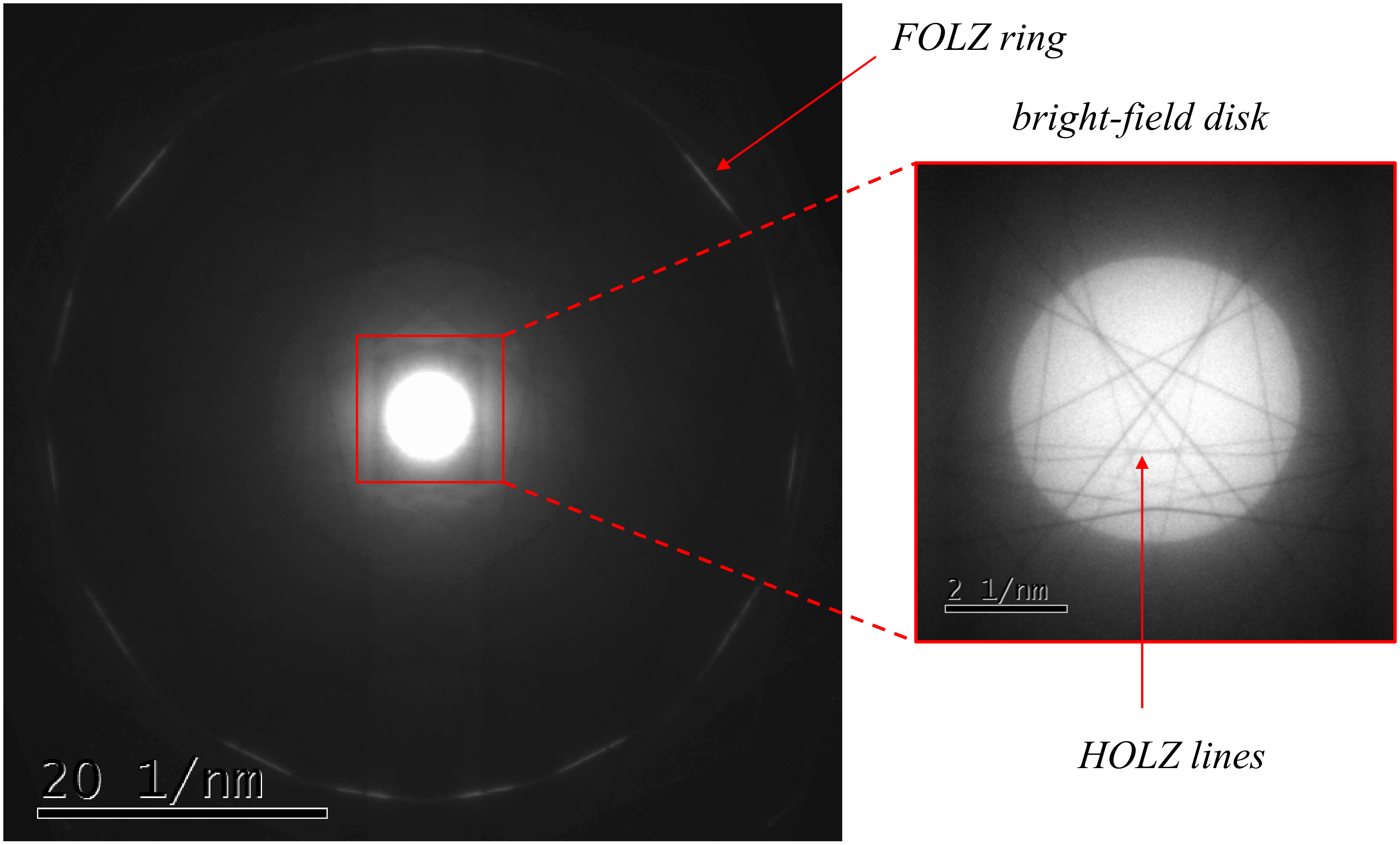
Determines the diameter of CBED disks

CBED disks and HOLZ rings

Broadened Ewald sphere intersects relrods over a range of angles



CBED features (I)

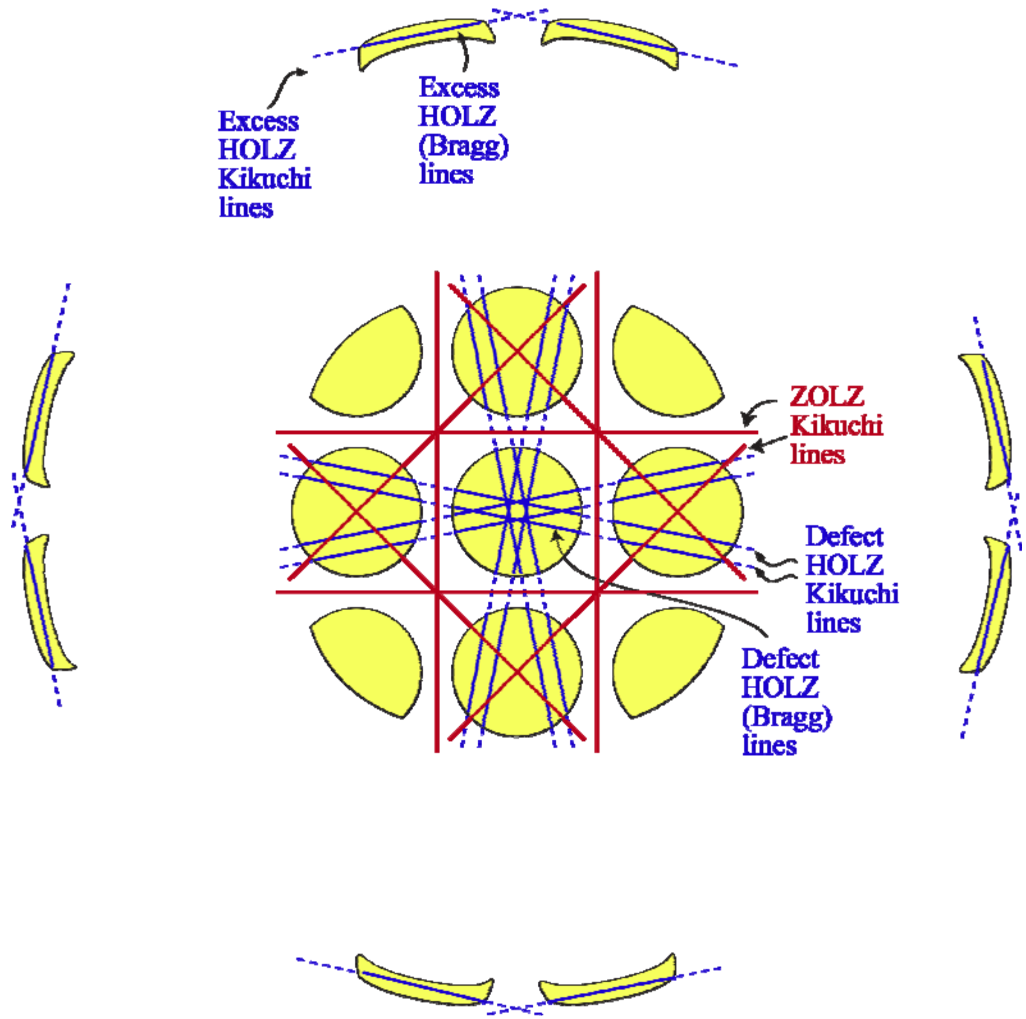


CBED features (II)

HOLZ Kikuchi lines: from diffuse scattering (between disks)

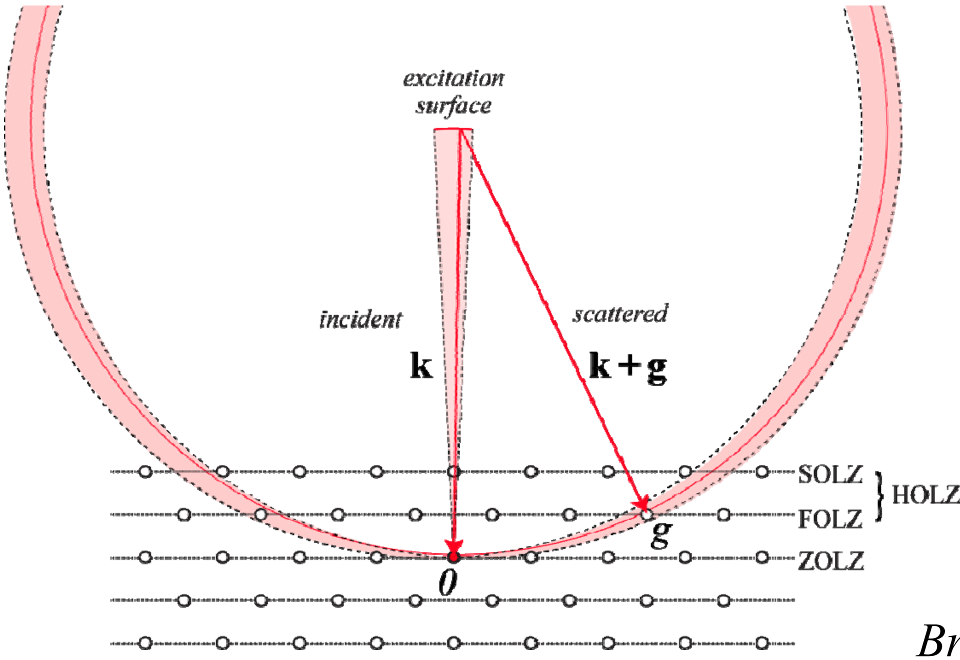
HOLZ (Bragg) lines: coherent scattering only (within disks)

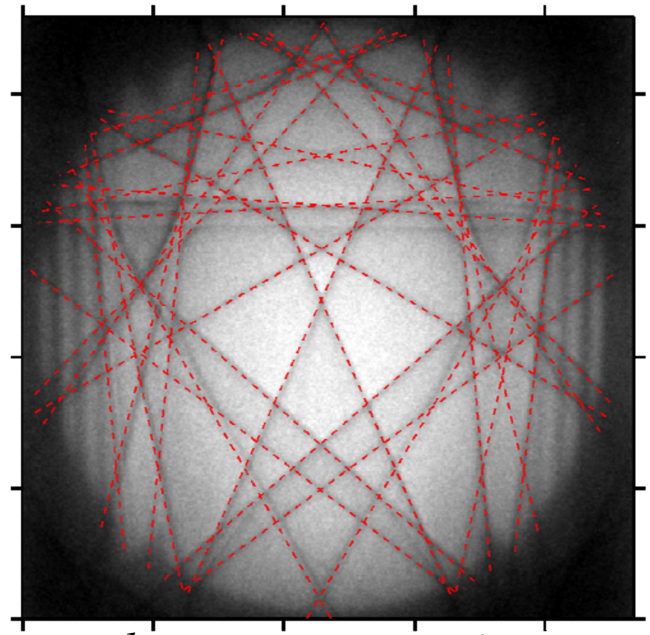
Line positions highly sensitive to strain



HOLZ line analysis

Determine coordinates of HOLZ line





Bragg condition:

$$k = |\mathbf{k} + \mathbf{g}|$$

High energy:

$$k_z \approx -k$$

$$g_x \cdot k_x + g_y \cdot k_y = -g_z \cdot k - \frac{g^2}{2}$$ ← *describes a line*

k: incident wave vector

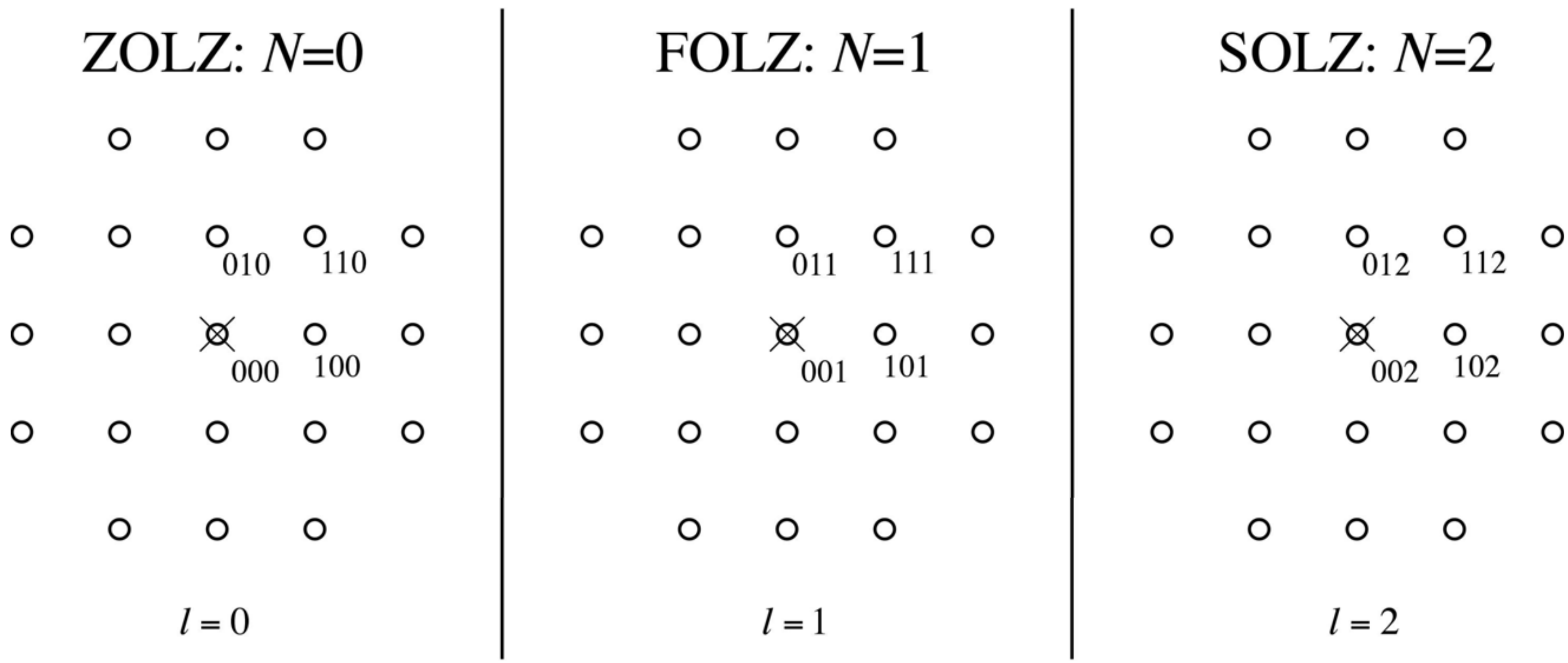
g: lattice vector

Measure $\mathbf{g}$ → *Refine crystal structure*

ZAP indexing example: sc [001]

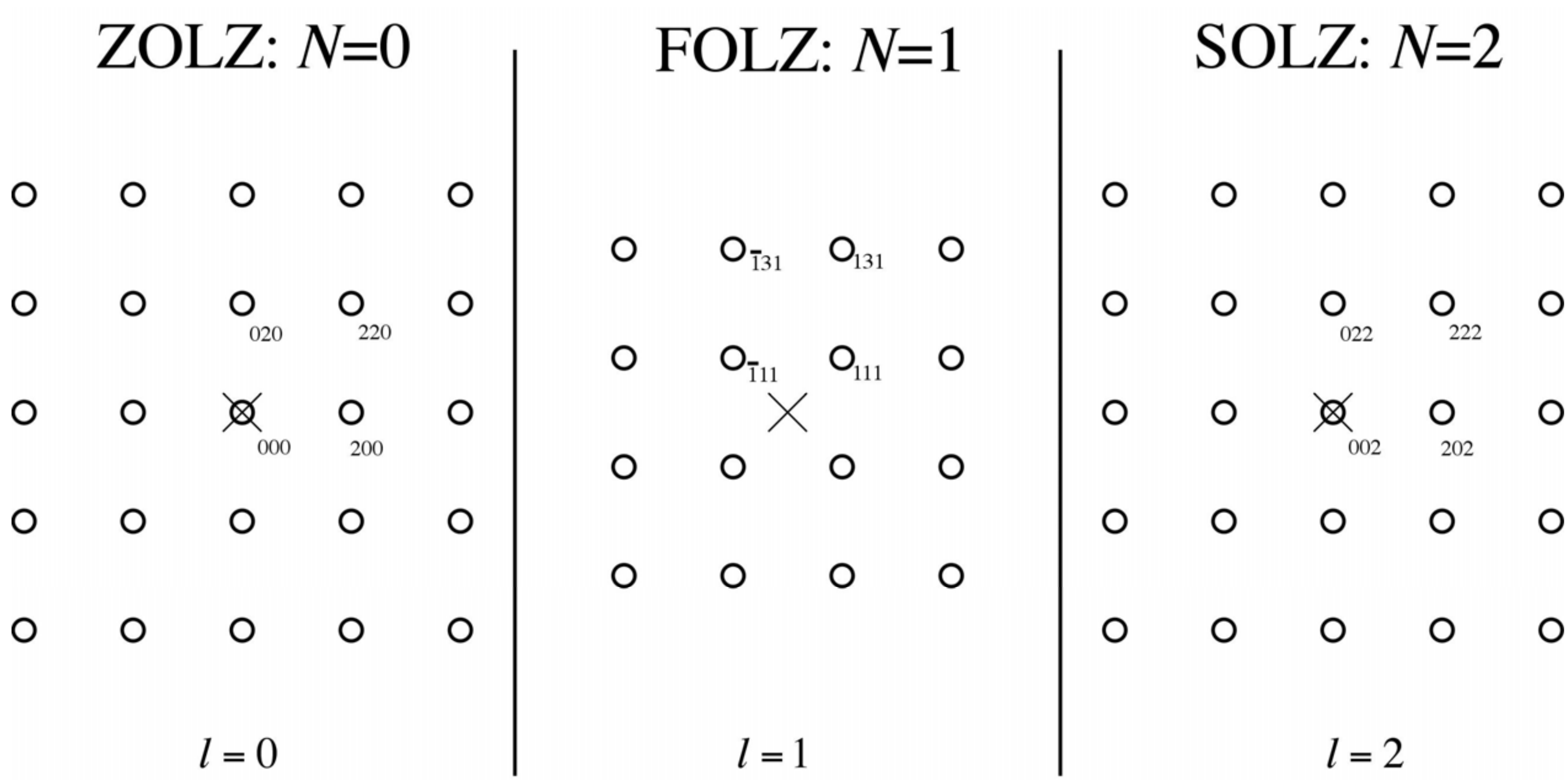
$$hu + kv + \ell w = N$$

sc: no restriction on *hkl*



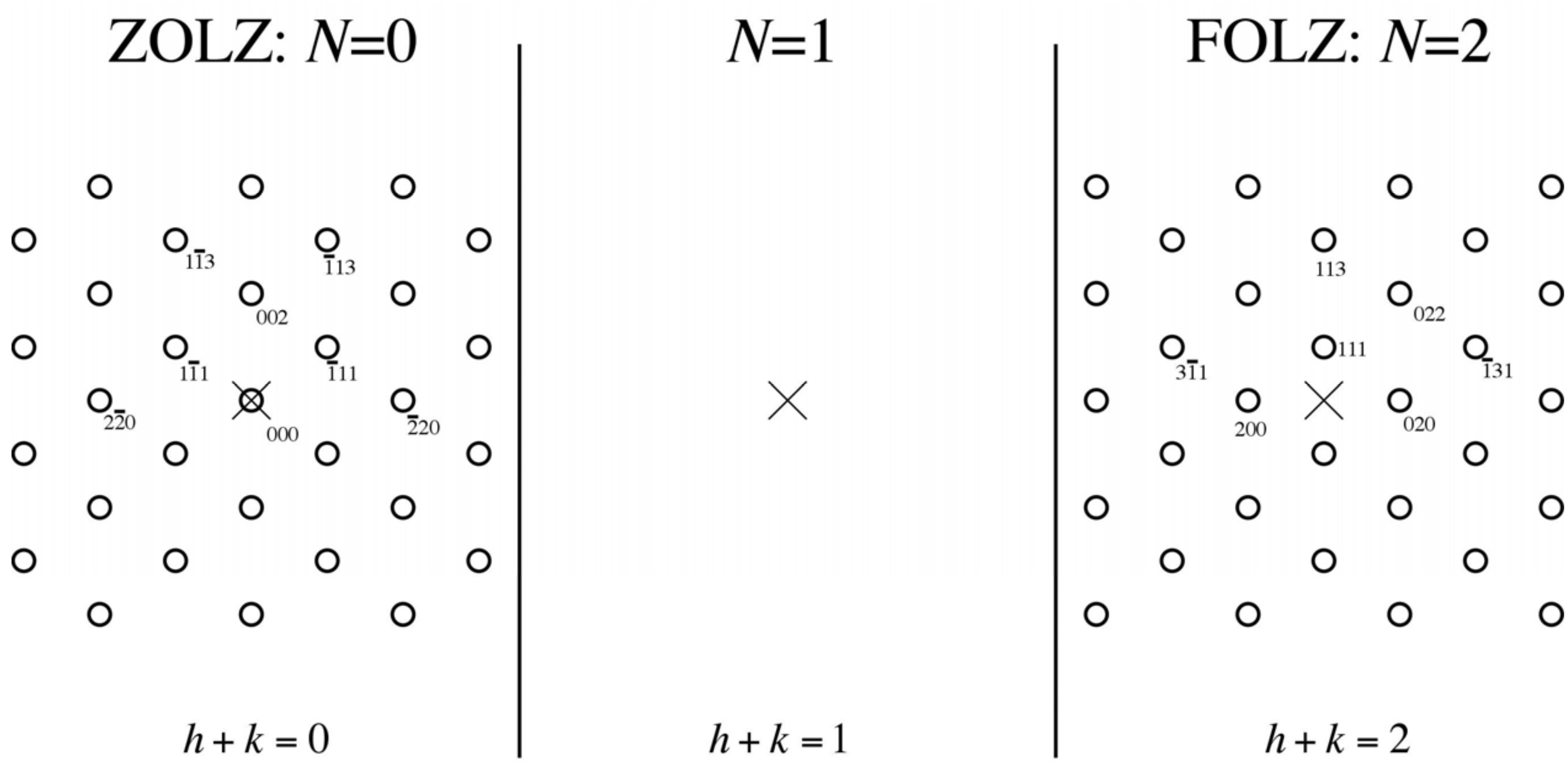
ZAP indexing xample: fcc [001]

fcc : h, k, l all even or all odd

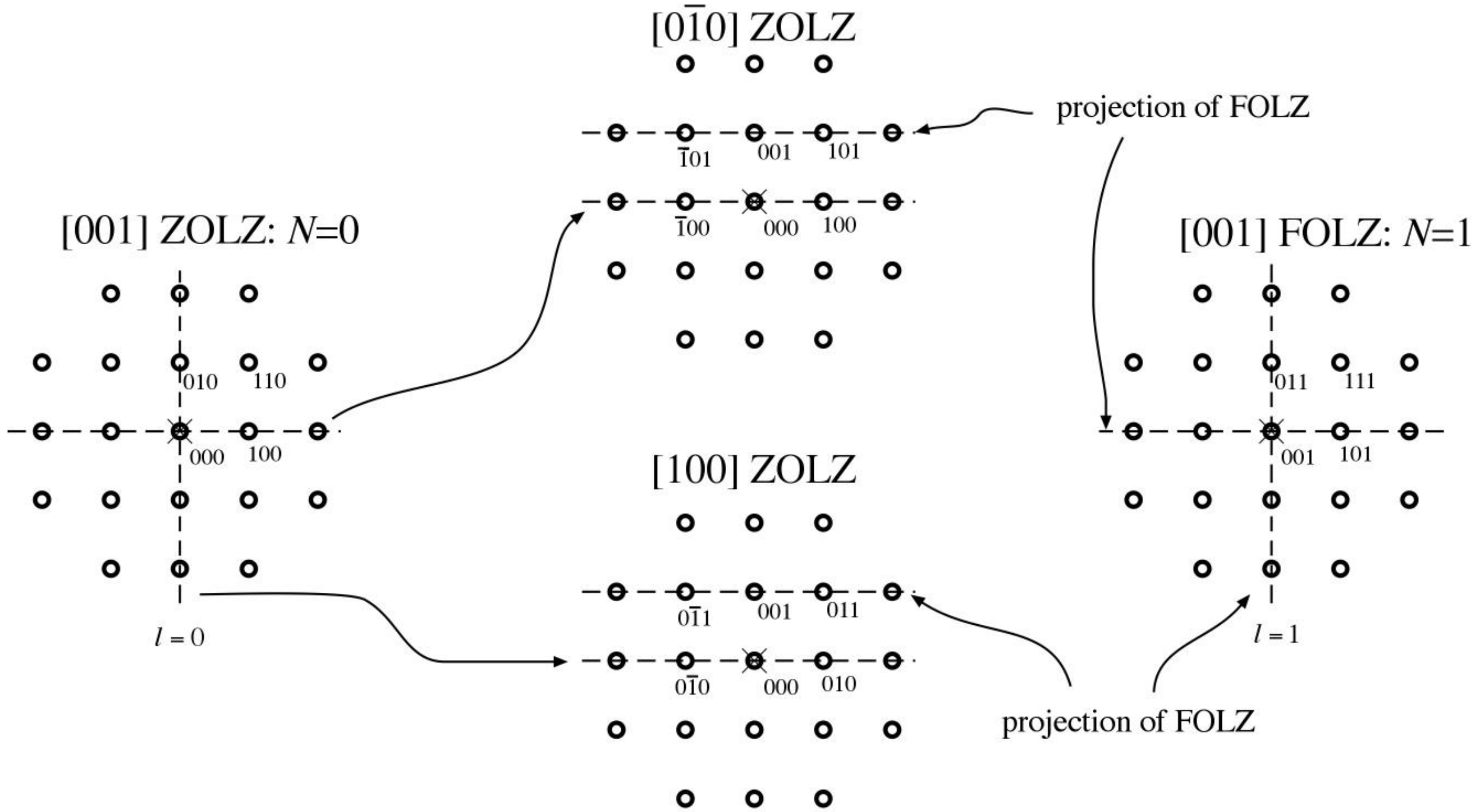


ZAP indexing example : fcc [110]

fcc : h, k, l all even or all odd



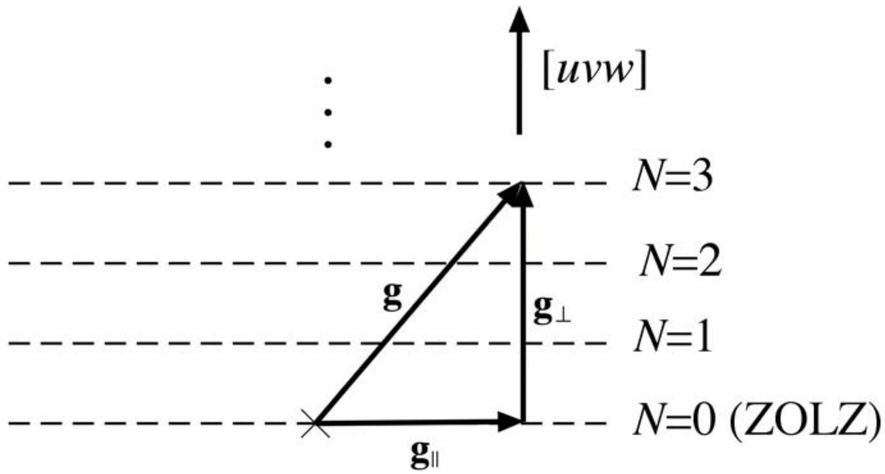
Constructing HOLZ patterns (Example: sc)



ZOLZ side views

- Construct ZOLZ patterns on orthogonal axes
- Identify reflections present in HOLZ

Projecting onto the ZOLZ



$$\mathbf{g} = \mathbf{g}_{\parallel} + \mathbf{g}_{\perp}$$

$$\mathbf{g}_{\perp} = H \cdot \hat{\mathbf{r}}_{uvw} = H \cdot \frac{\mathbf{r}_{uvw}}{|\mathbf{r}_{uvw}|}$$

$$\mathbf{r}_{uvw} \cdot \mathbf{g}_{\perp} = N = H \cdot |\mathbf{r}_{uvw}|$$

$$\mathbf{r}_{uvw} \cdot \mathbf{g} = N$$

$$\mathbf{r}_{uvw} \cdot \mathbf{g}_{\parallel} = 0$$

$$\mathbf{r}_{uvw} \cdot \mathbf{g}_{\perp} = N$$

$$H = \frac{N}{|\mathbf{r}_{uvw}|}$$

Cubic ZOLZ projection

$$\mathbf{r}_{uvw} = u\mathbf{a}_1 + v\mathbf{a}_2 + w\mathbf{a}_3$$

$$\mathbf{r}_{uvw} = a^2 \cdot (u\mathbf{b}_1 + v\mathbf{b}_2 + w\mathbf{b}_3)$$

$$\mathbf{a}_1 = a^2 \cdot \mathbf{b}_1$$

$$\mathbf{a}_2 = a^2 \cdot \mathbf{b}_2$$

$$\mathbf{a}_3 = a^2 \cdot \mathbf{b}_3$$

$$\mathbf{g}_\perp = \frac{N \cdot \mathbf{r}_{uvw}}{|\mathbf{r}_{uvw}|^2} = \frac{N \cdot \cancel{a^2} \cdot (u\mathbf{b}_1 + v\mathbf{b}_2 + w\mathbf{b}_3)}{\cancel{a^2} \cdot (u^2 + v^2 + w^2)} = h_\perp \mathbf{b}_1 + k_\perp \mathbf{b}_2 + \ell_\perp \mathbf{b}_3$$

Vertical offset of a HOLZ pattern:

$$(hk\ell)_\perp = \frac{N \cdot (uvw)}{u^2 + v^2 + w^2}$$

Projection onto ZOLZ:

$$(hk\ell)_{||} = (hk\ell) - (hk\ell)_\perp$$

Projection of origin onto ZOLZ:

$$(hk\ell)_0 = (hk\ell)_\perp$$