

The challenging pinning landscape in $\text{YBa}_2\text{Cu}_3\text{O}_7$ thin films

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**SUPERCONDUCTING MATERIALS
AND LARGE SCALE NANOSTRUCTURES**
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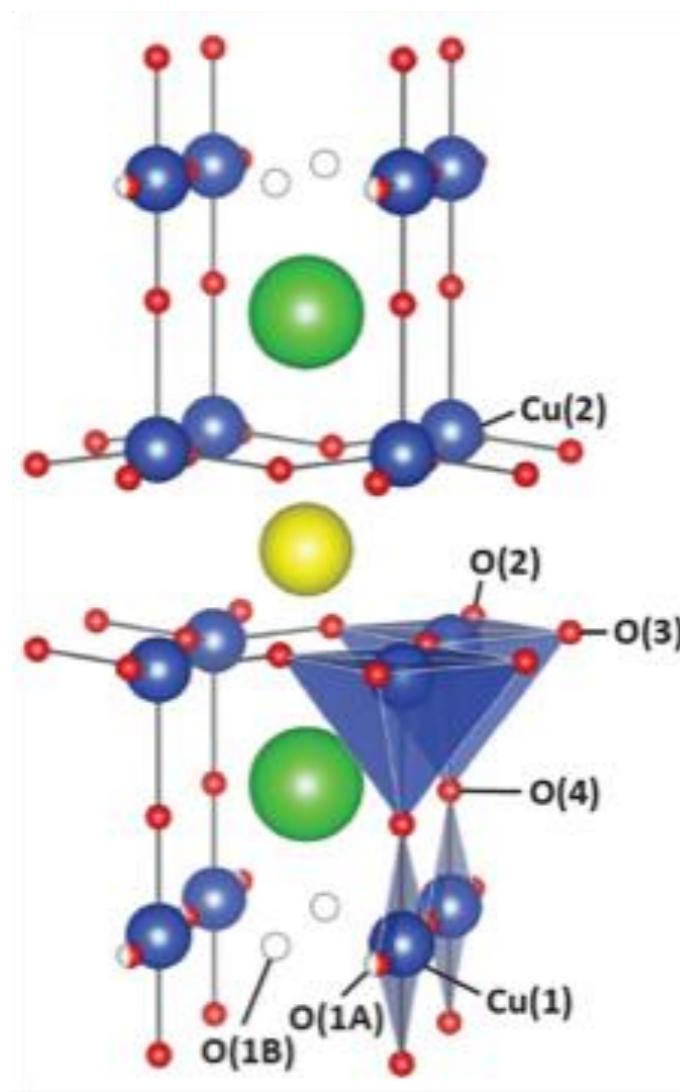
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EUCAS 2017

YBCO material

STEM imaging

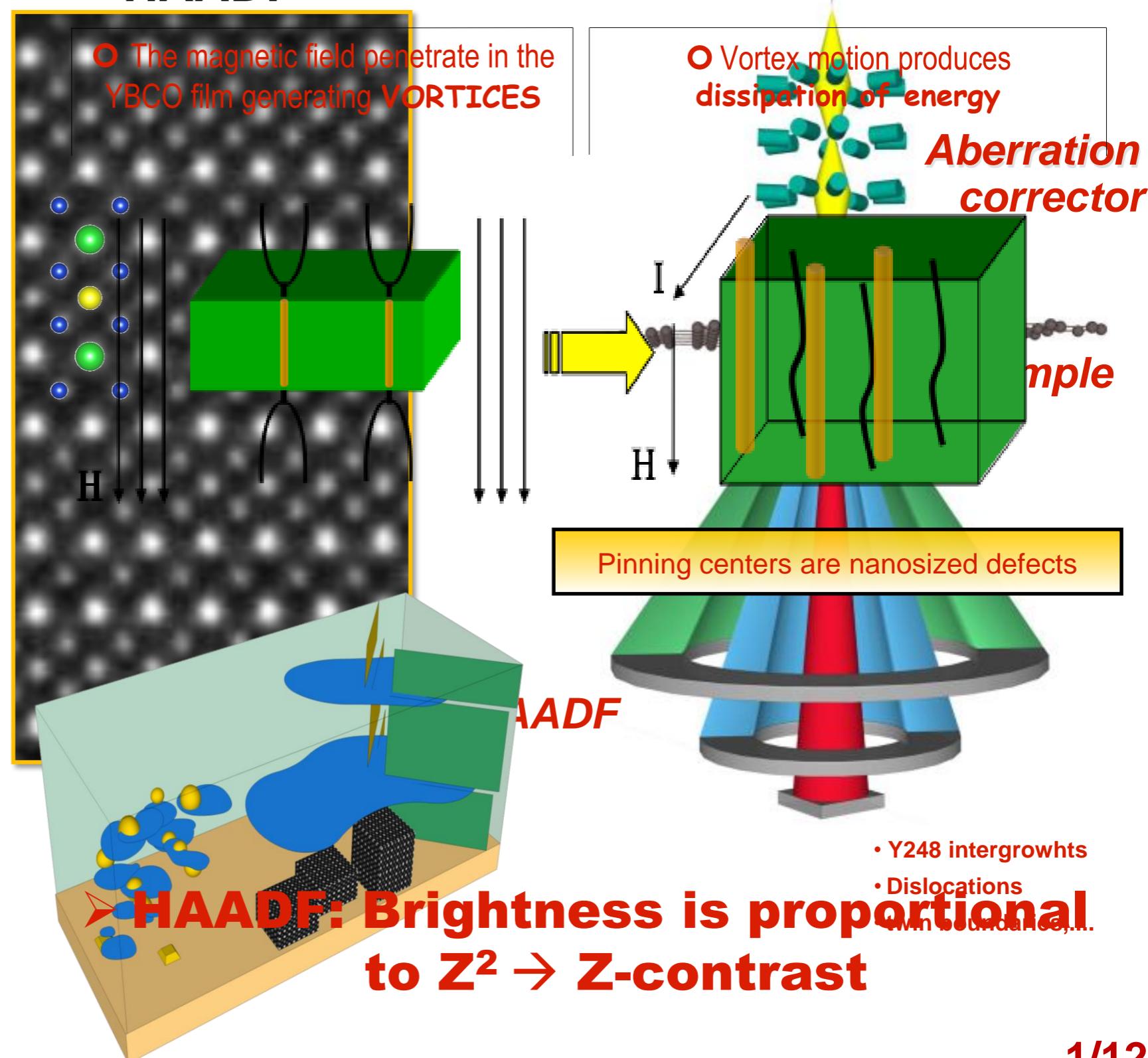
Unit cell

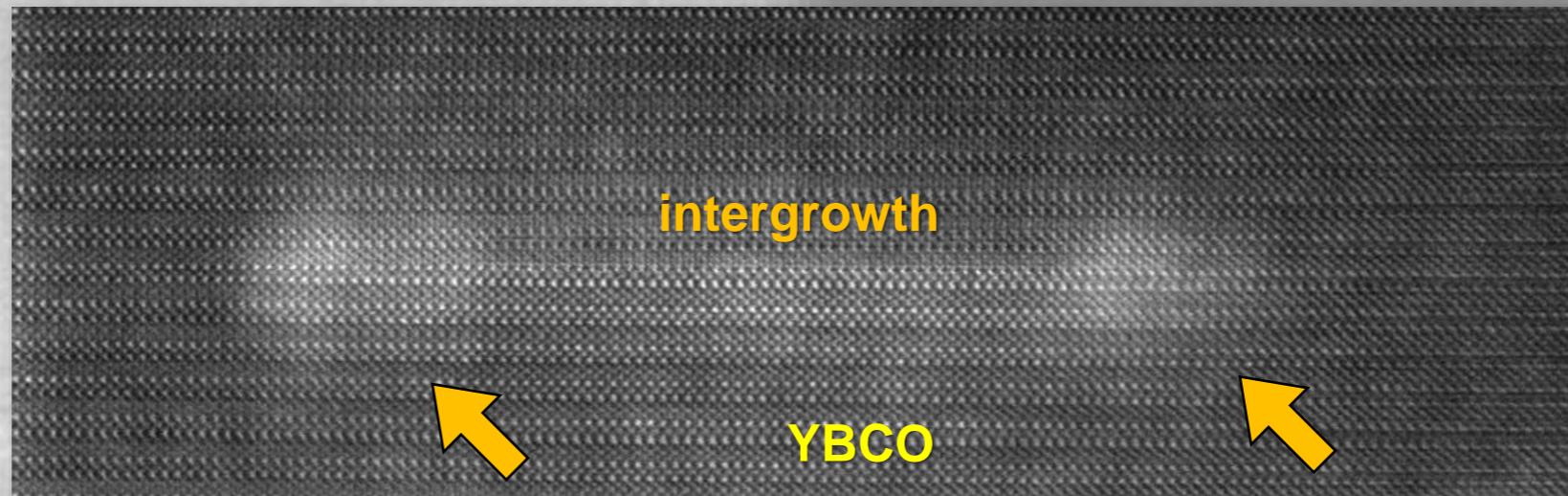
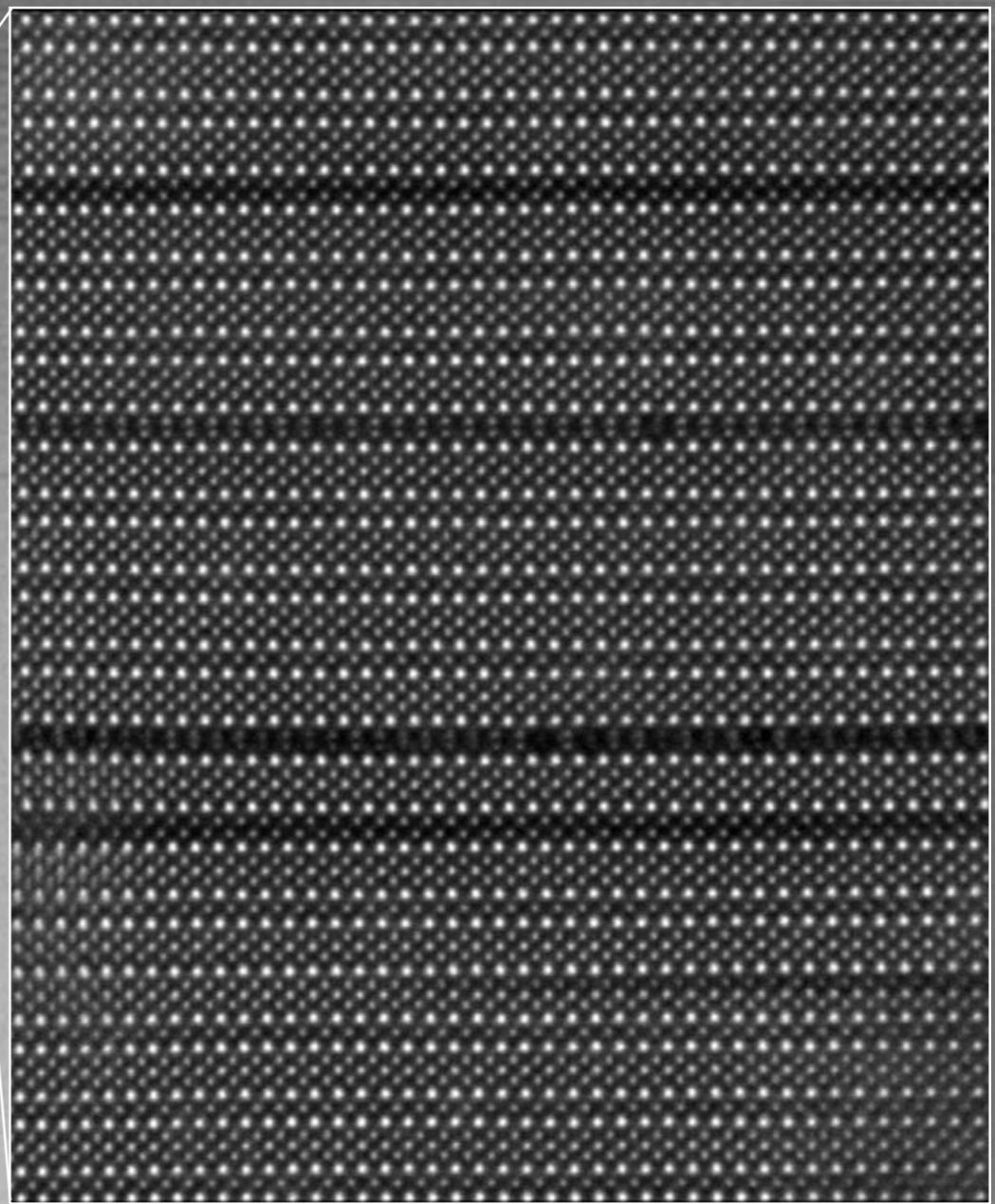
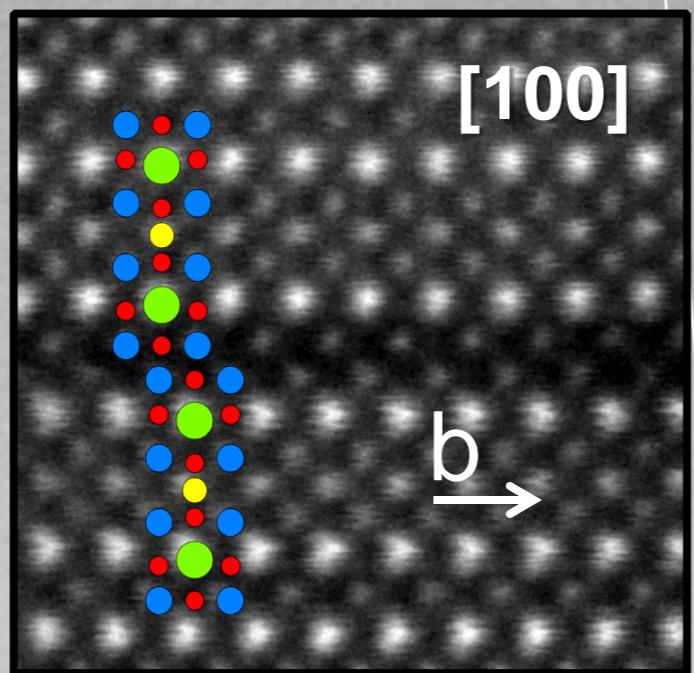
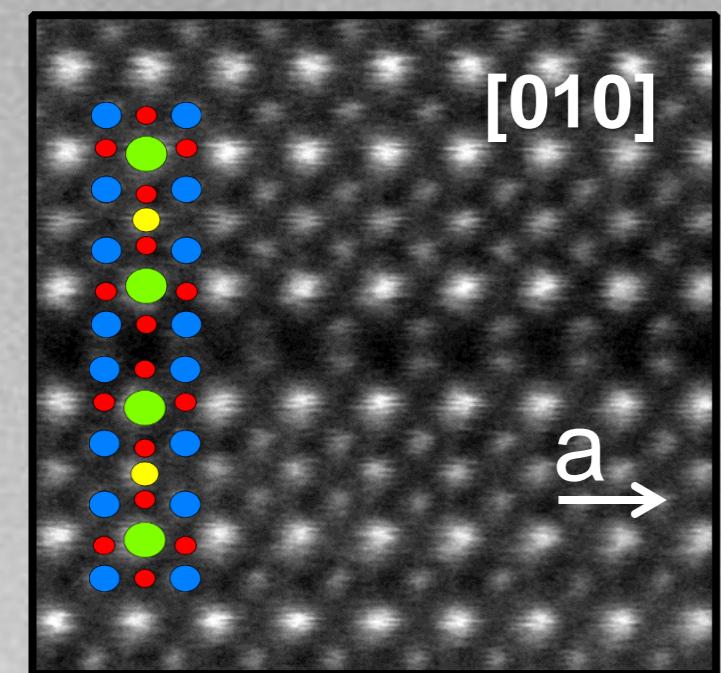
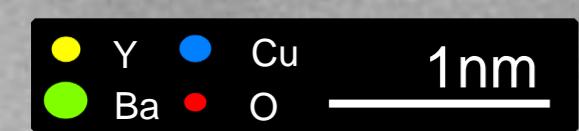


$a \neq b$
 $c \approx 3a$
orthorombic structure

● Ba ● Y ● Cu ● O

Flux pinning in type II superconductors such as $\text{YBa}_2\text{Cu}_3\text{O}_7$

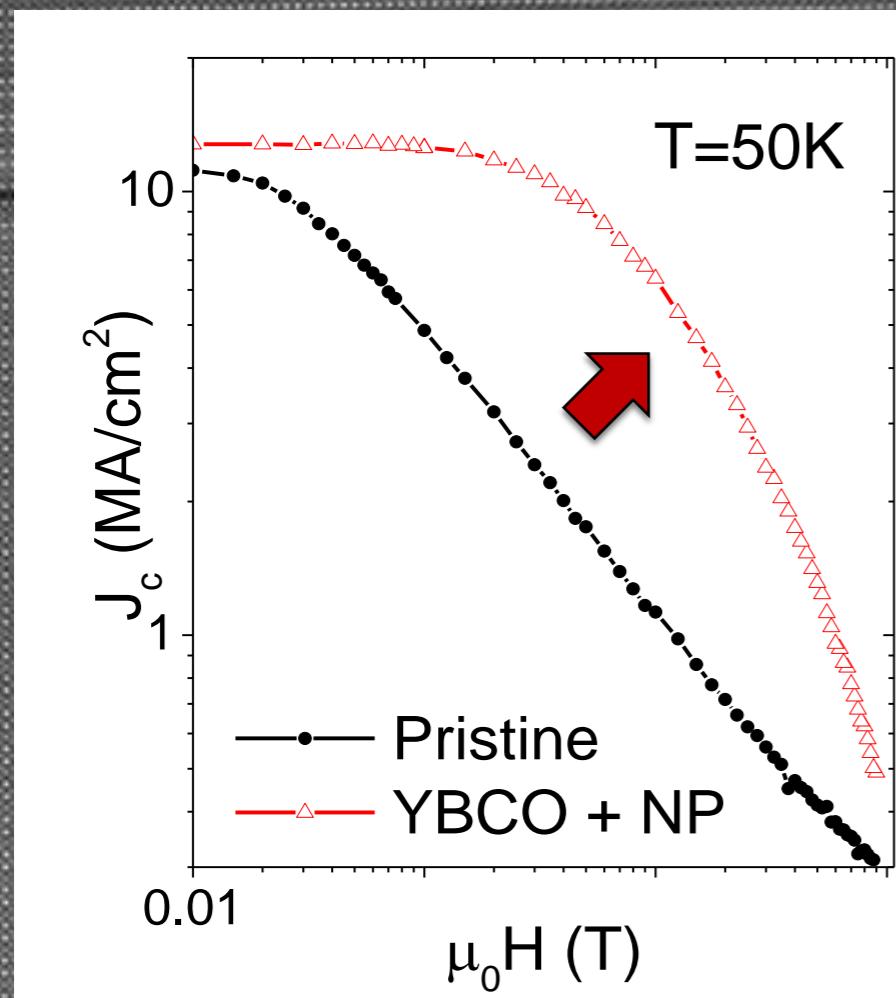




Pristine YBCO

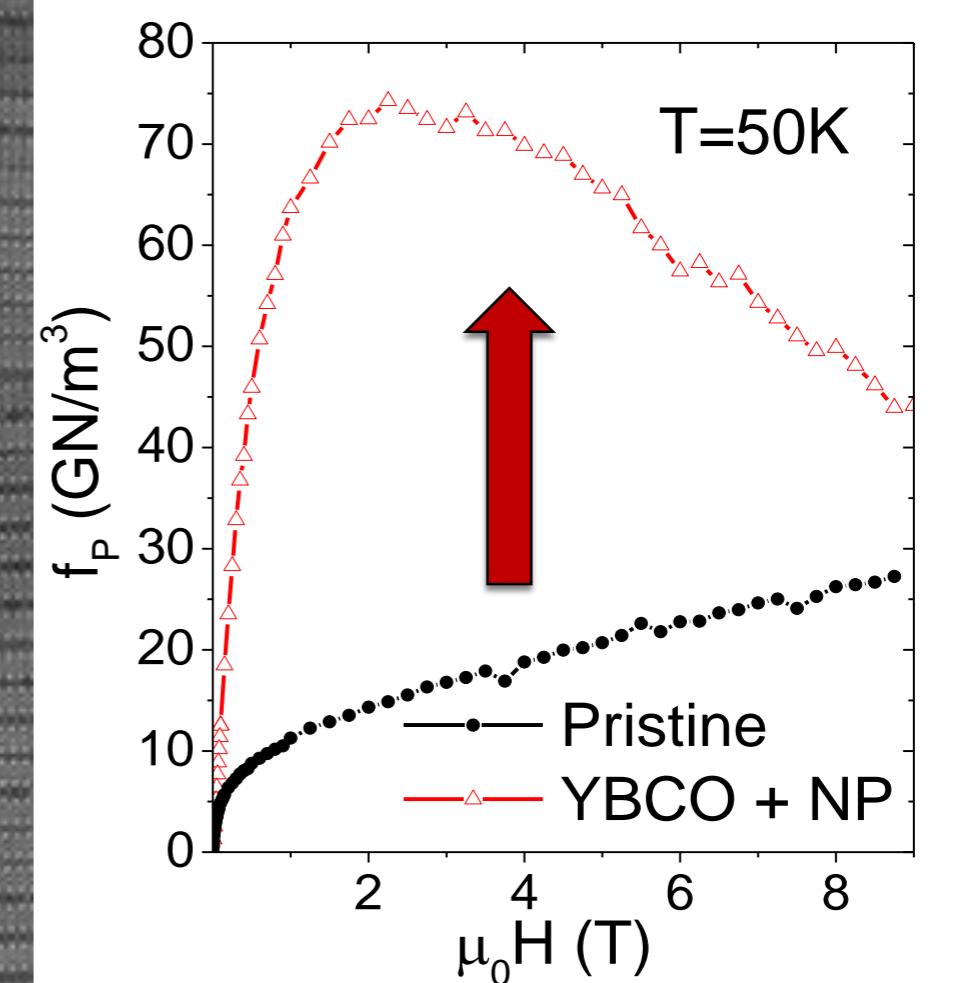
YBCO + NPs

Y124 highly desirable:
↳ Critical current density
↳ Pinning properties



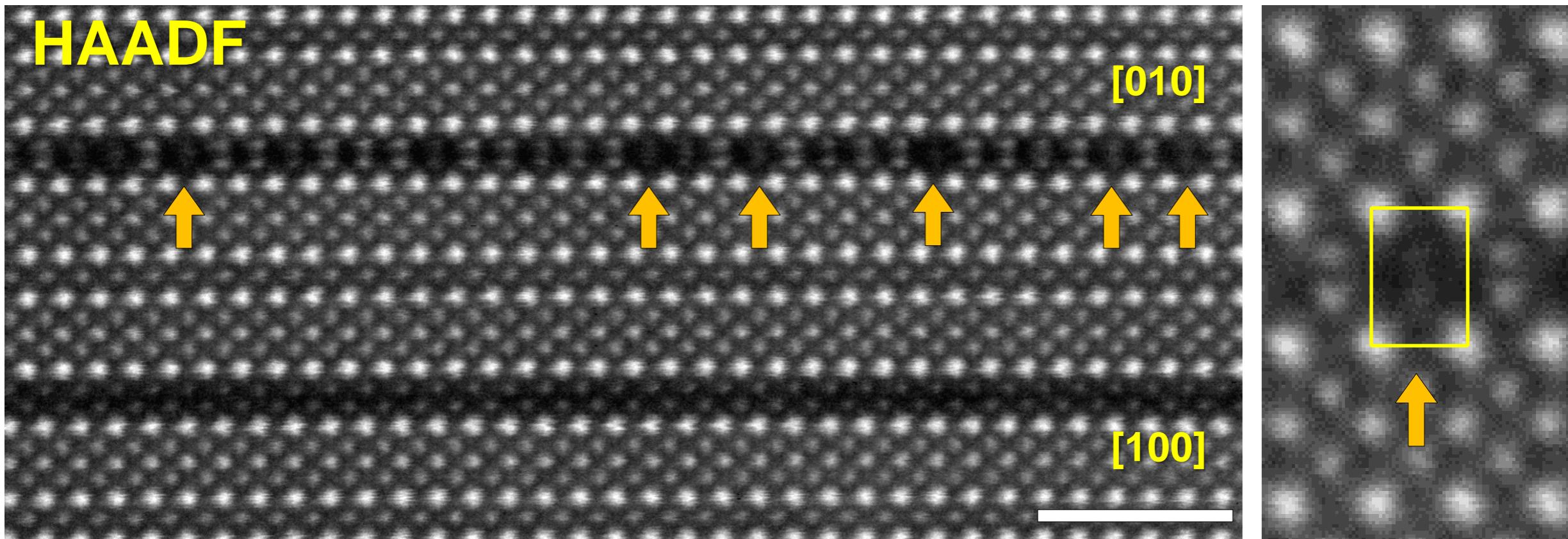
Y123

10nm

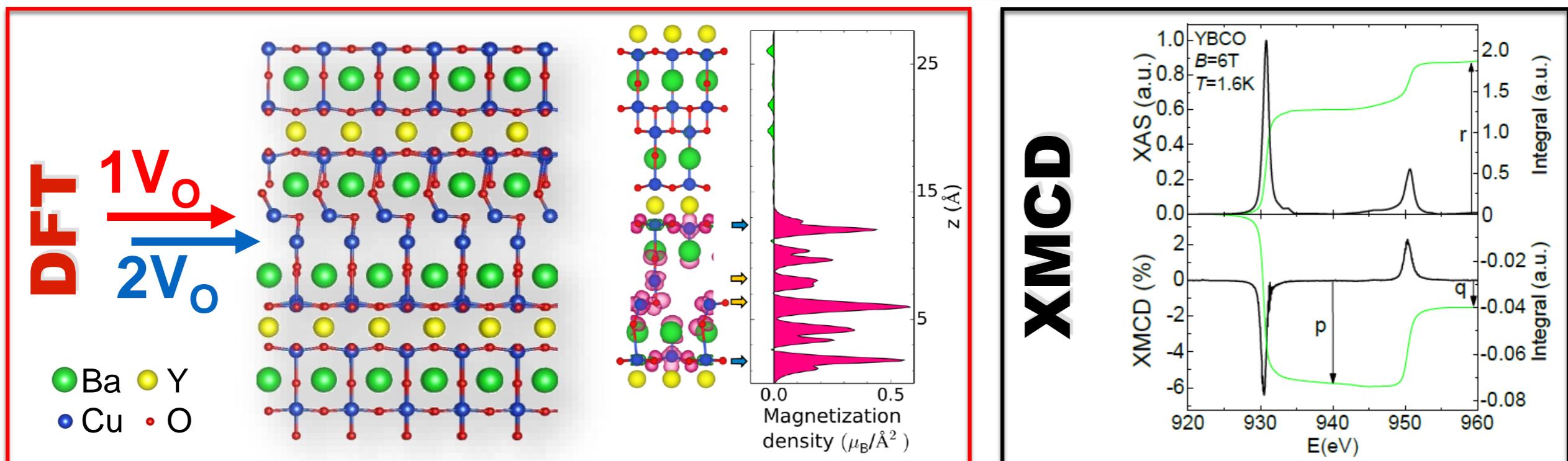


Y124

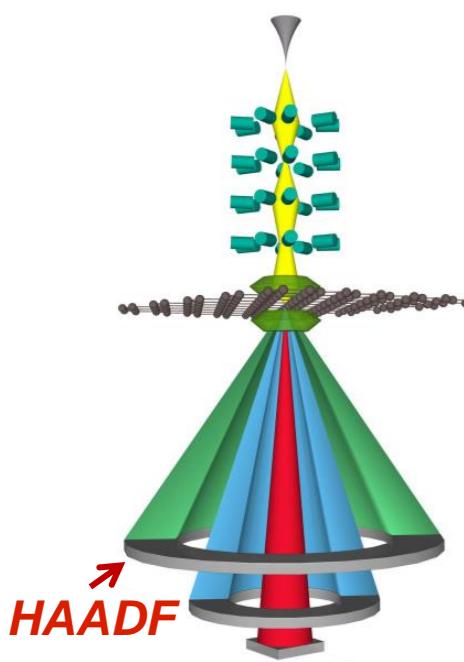
Probing point defects



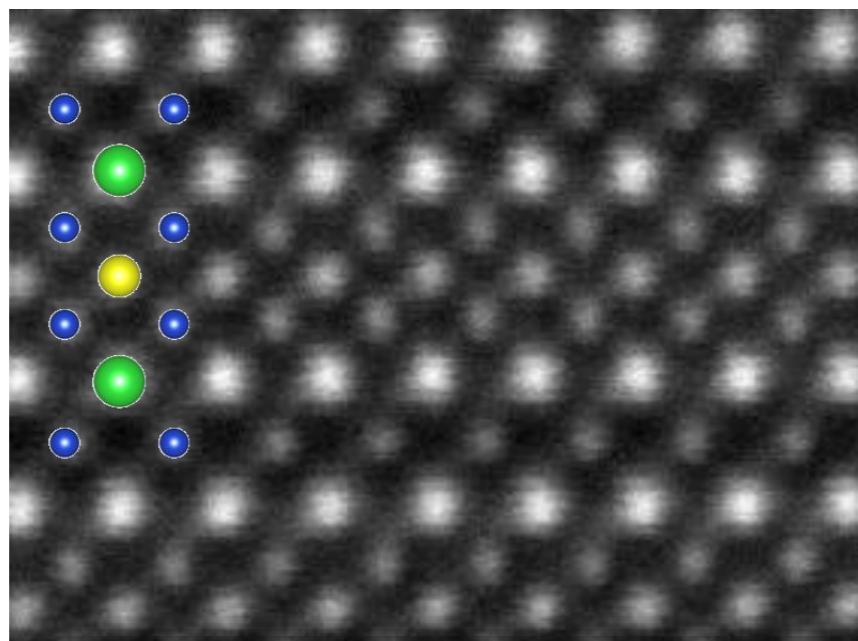
Pairs of Cu-vacancies along the *b*-axis



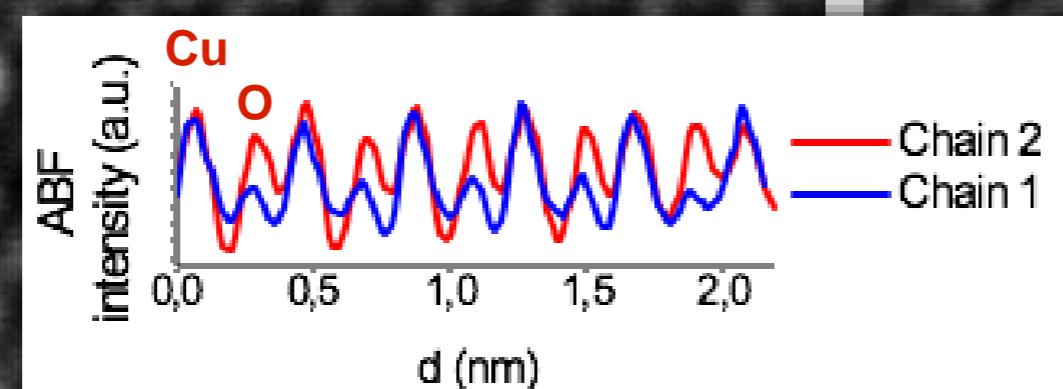
Annular Bright Field Imaging



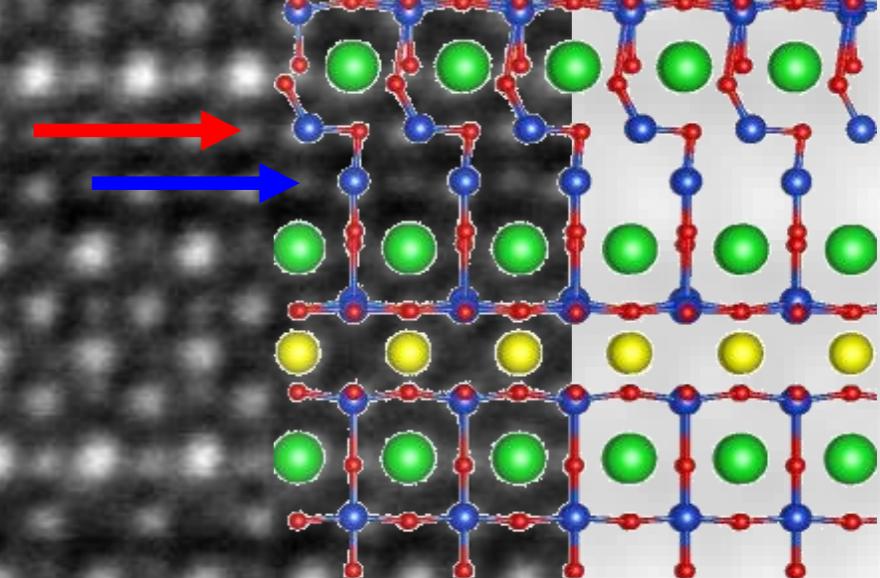
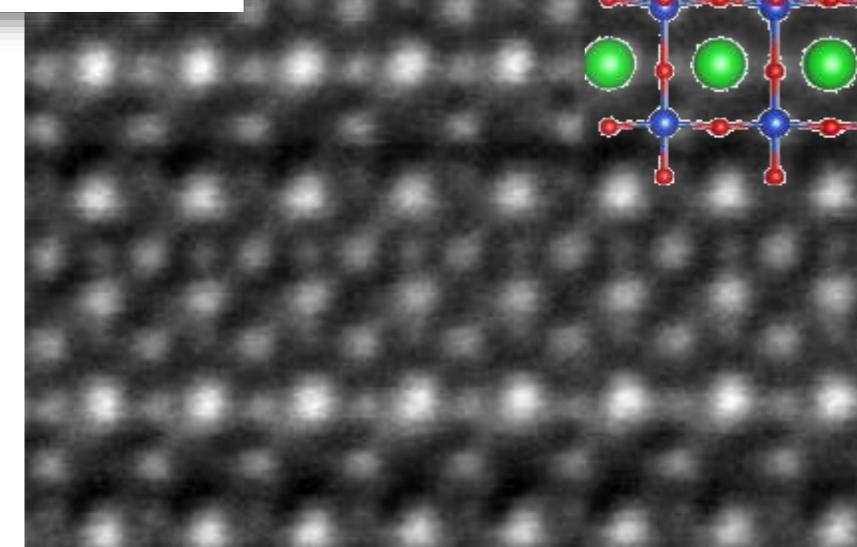
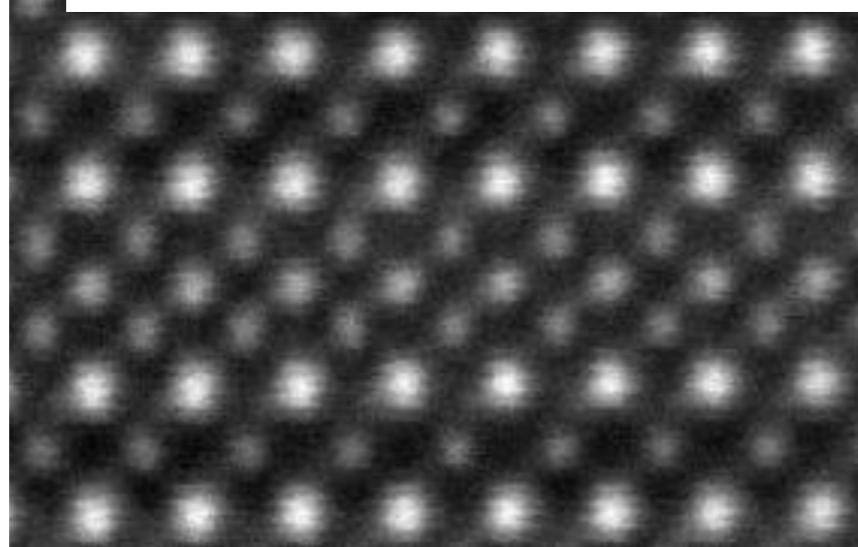
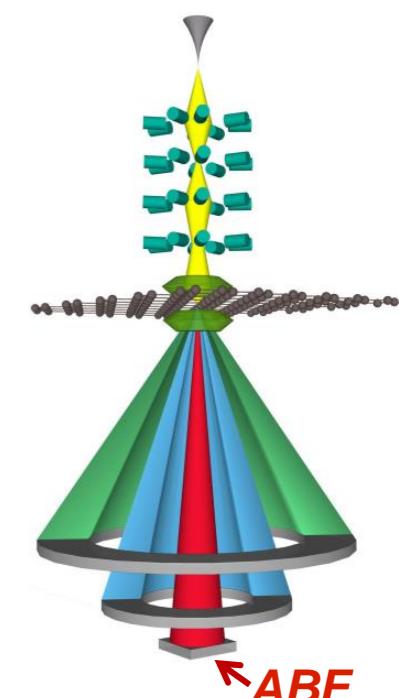
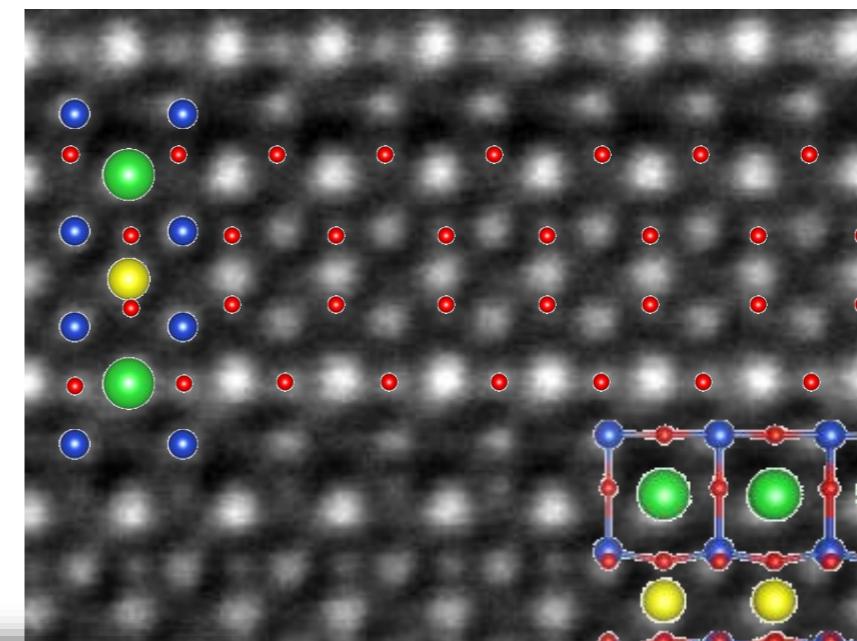
HAADF



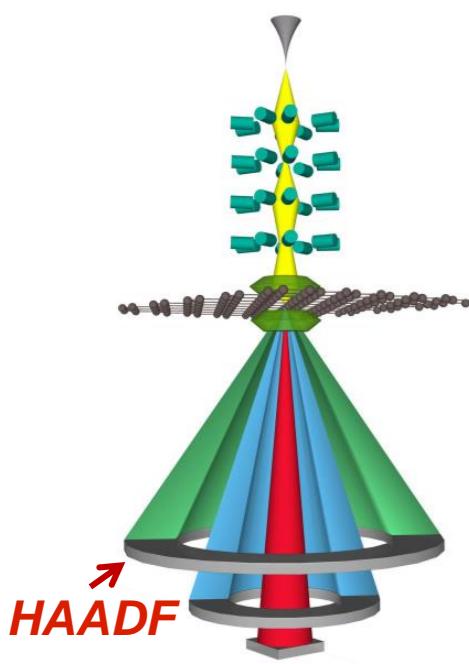
• O
• Cu
• Y
• Ba



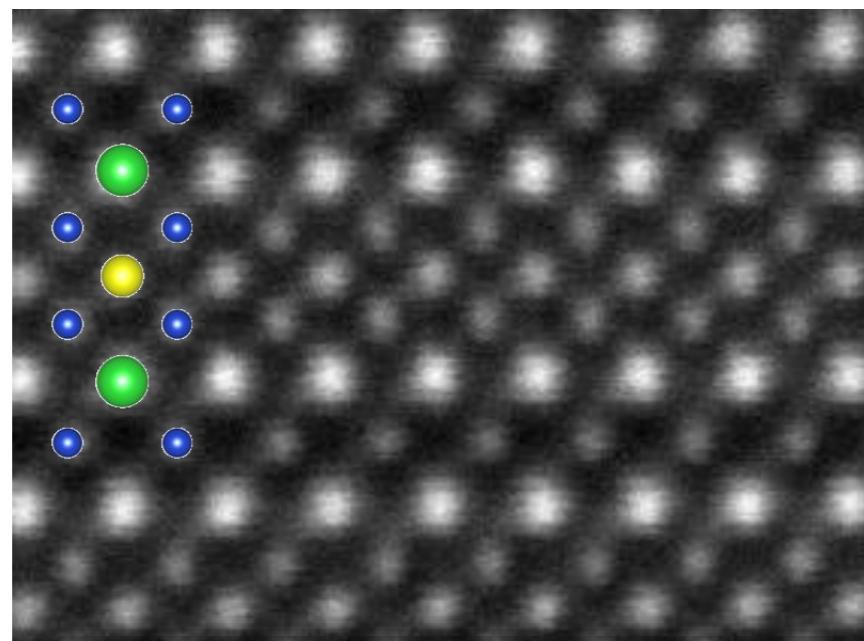
1/ABF



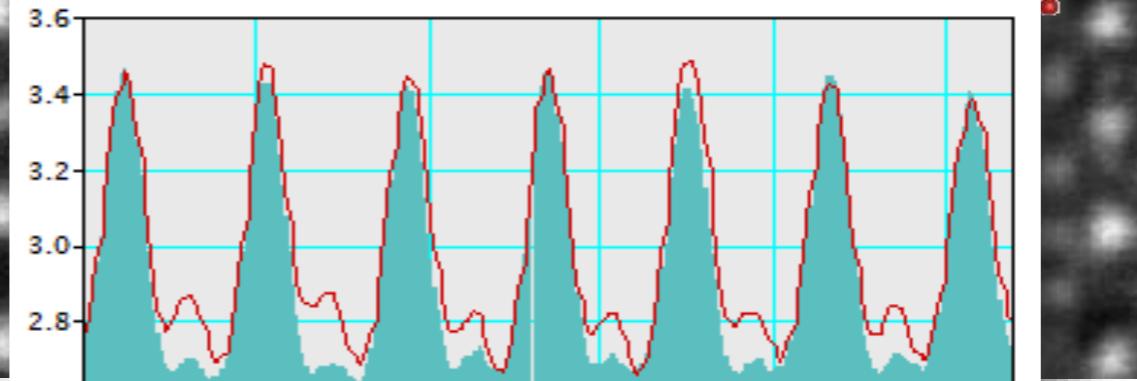
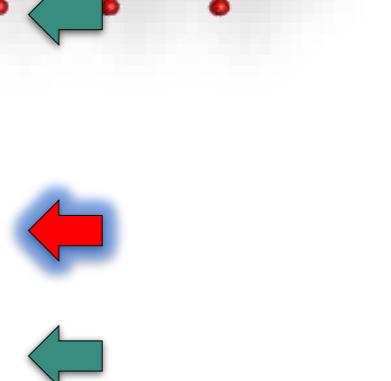
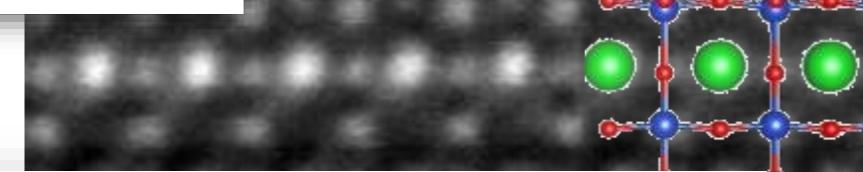
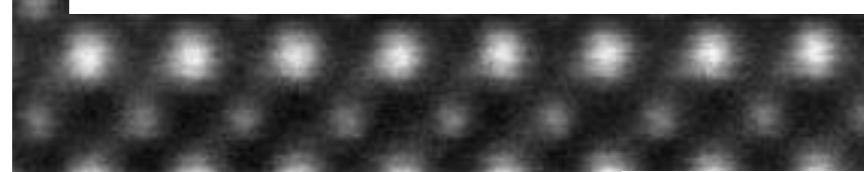
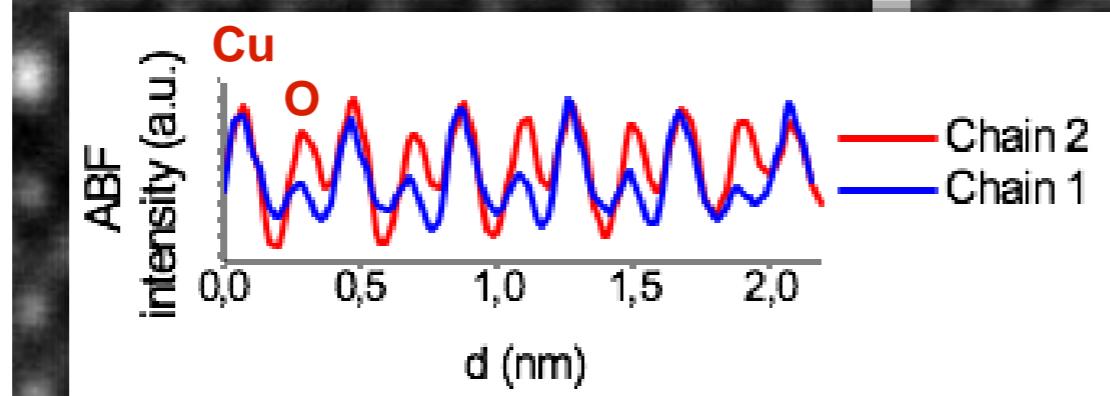
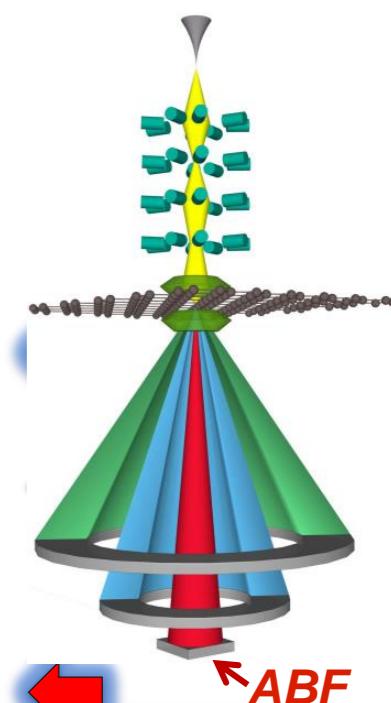
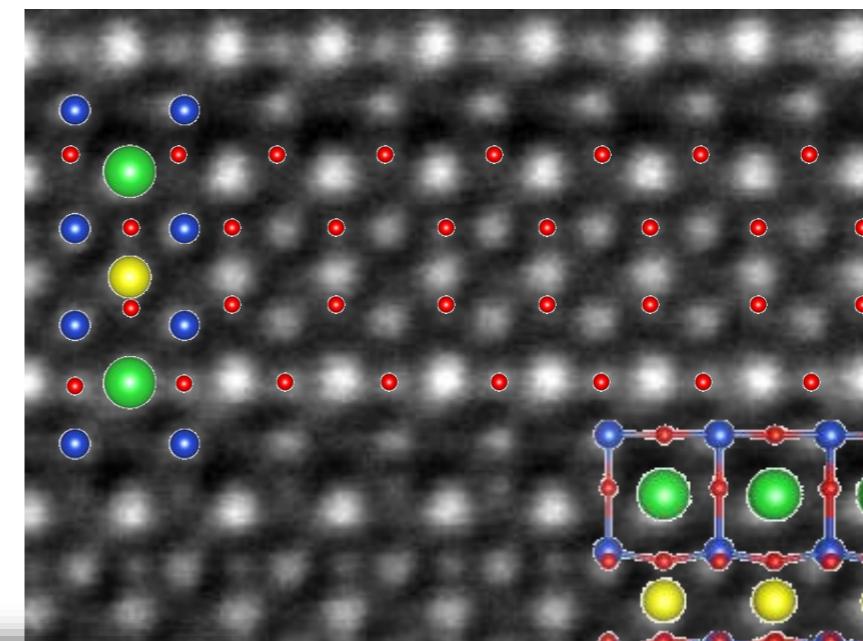
Annular Bright Field Imaging



HAADF

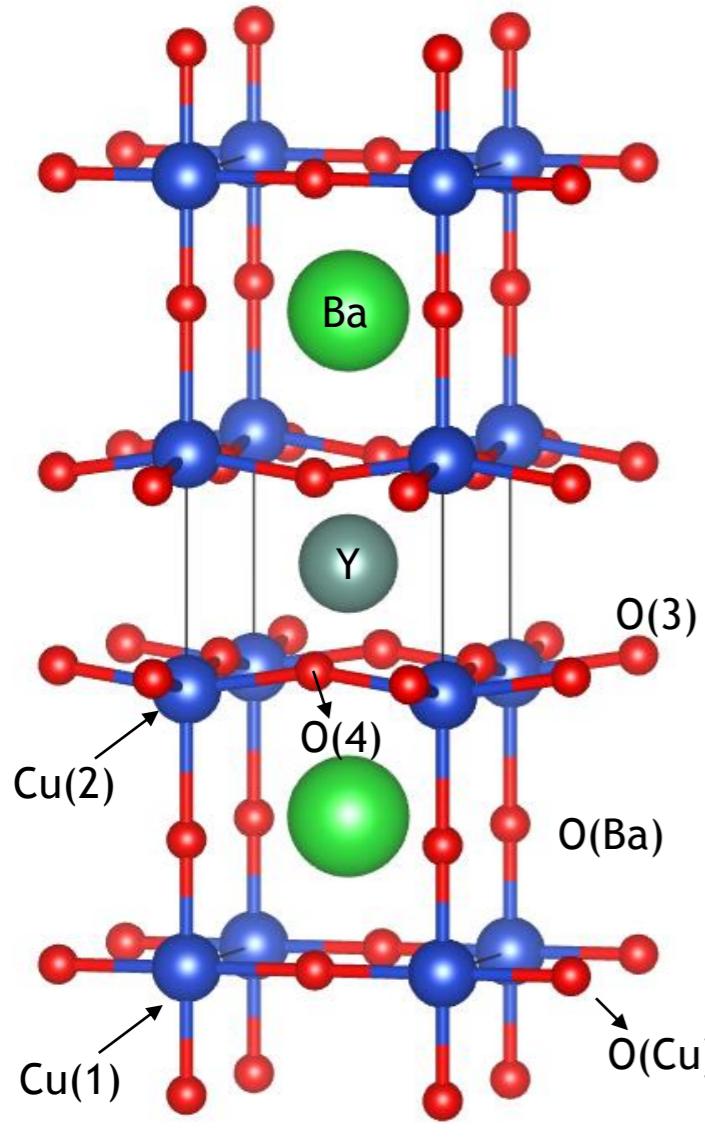


1/ABF



- ♦ O vacancies in the BaO plane!!
- ♦ They always present a periodical although uneven distribution

Stability of different V_O

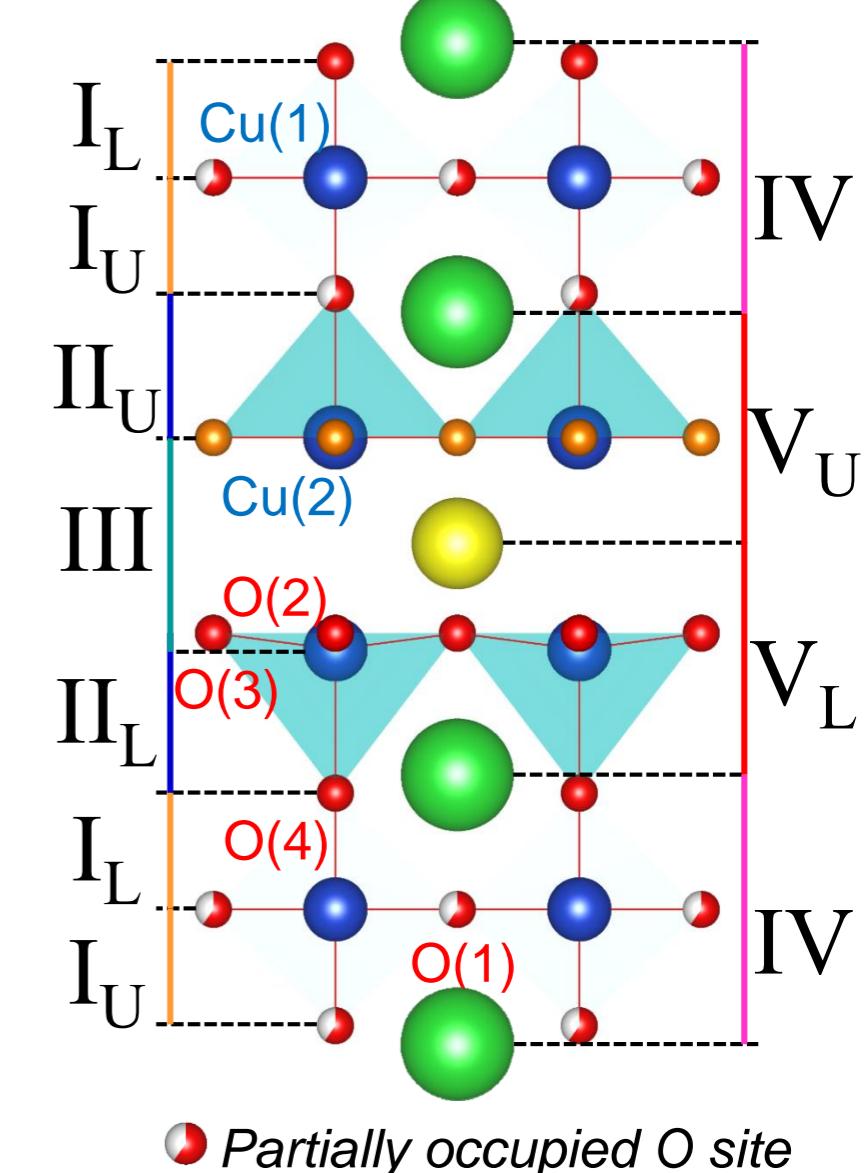
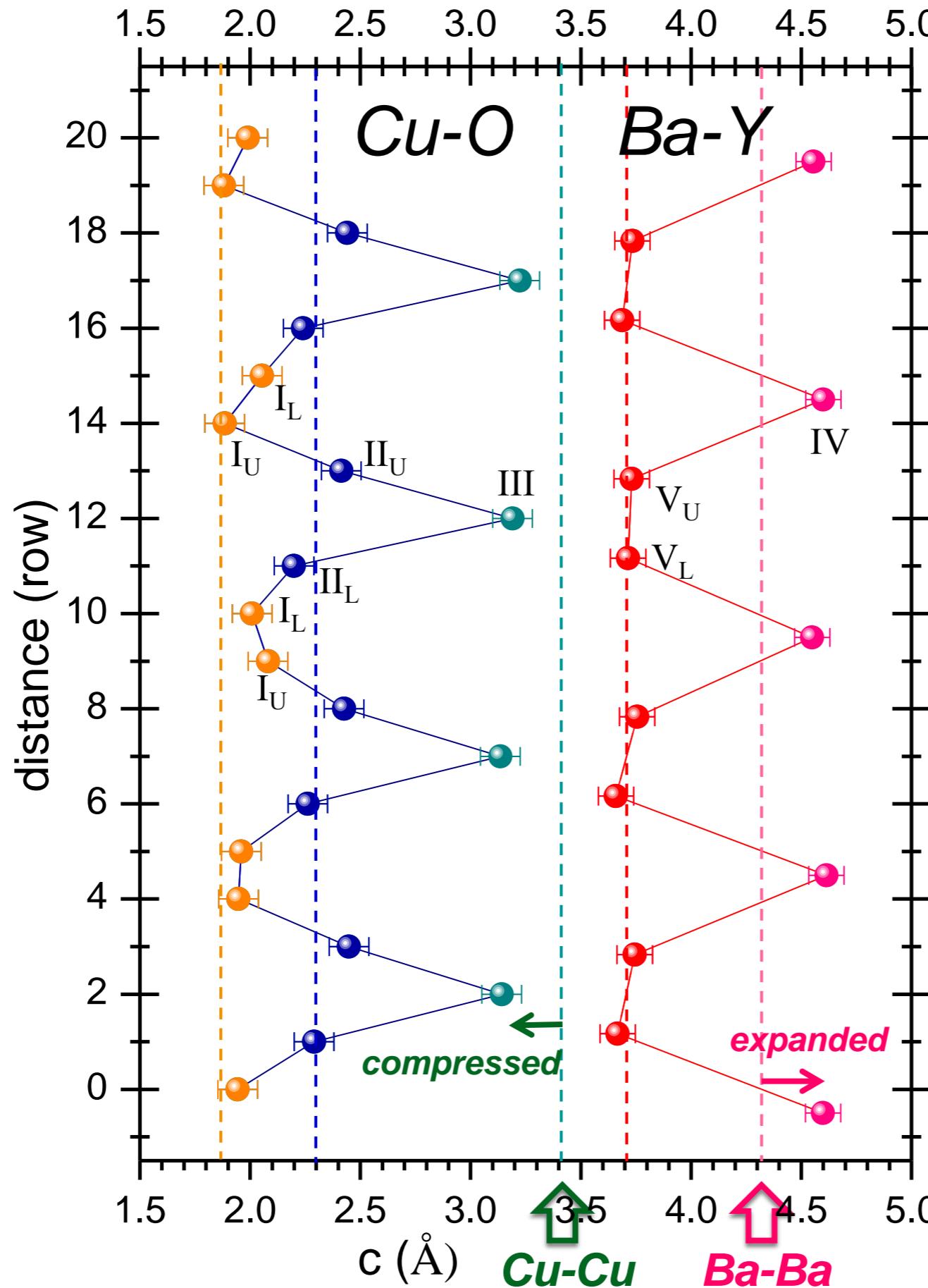
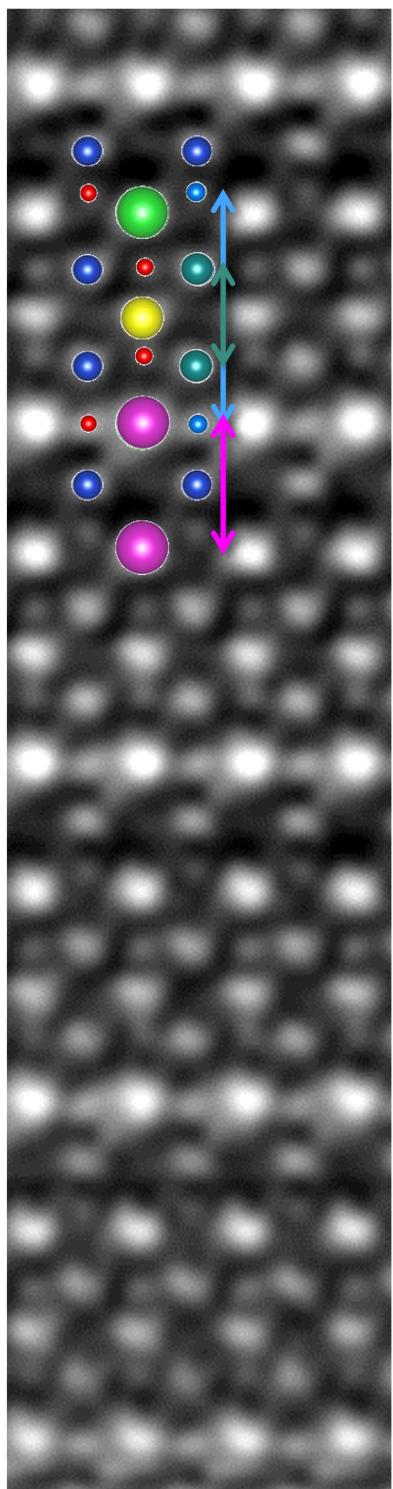


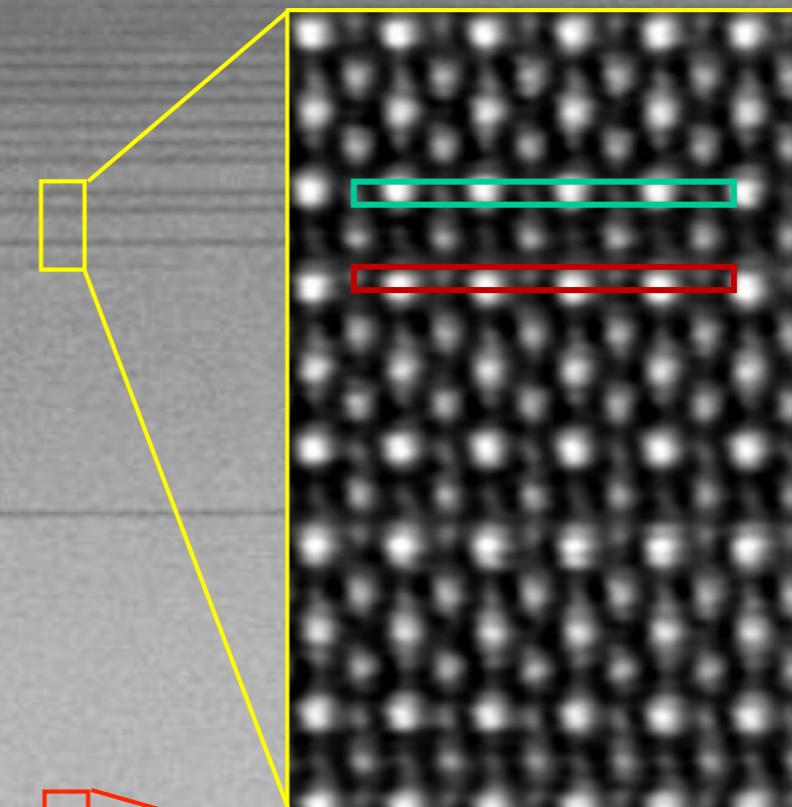
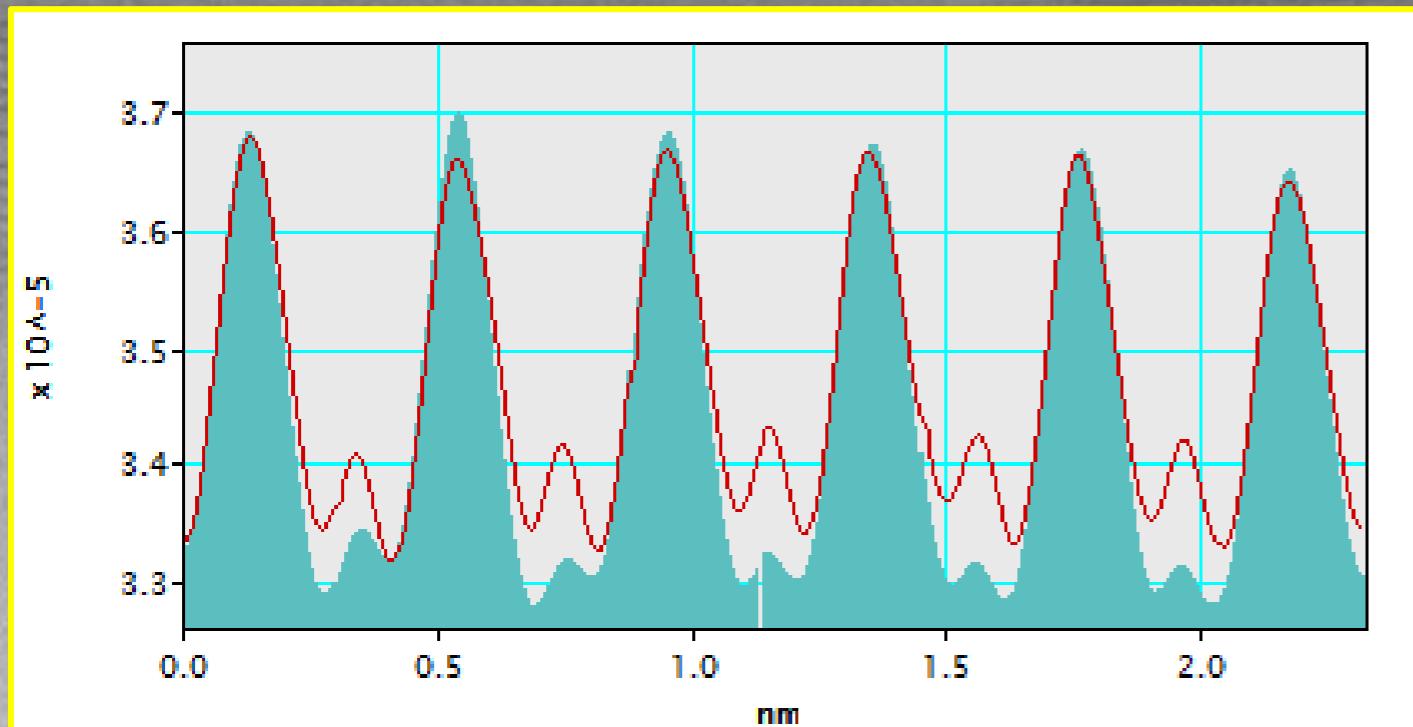
Defect	Expt. volume	Formation energy at 0 K (eV) Volume relaxed
$V_{\text{O}(\text{Cu})}$	1.11	0.92
$V_{\text{O}(\text{Ba})}$	1.13	0.98
$V_{\text{O}(3)}$	1.62	1.51
$V_{\text{O}(4)}$	1.59	1.51

The energy needed to introduce V_O at the BaO and CuO planes is almost the same

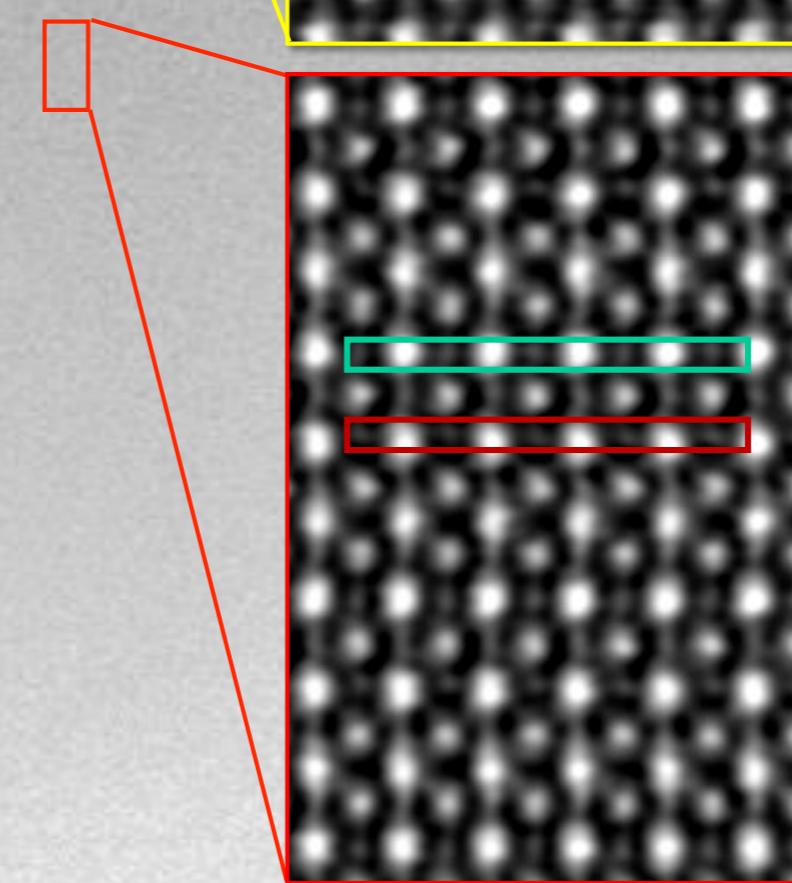
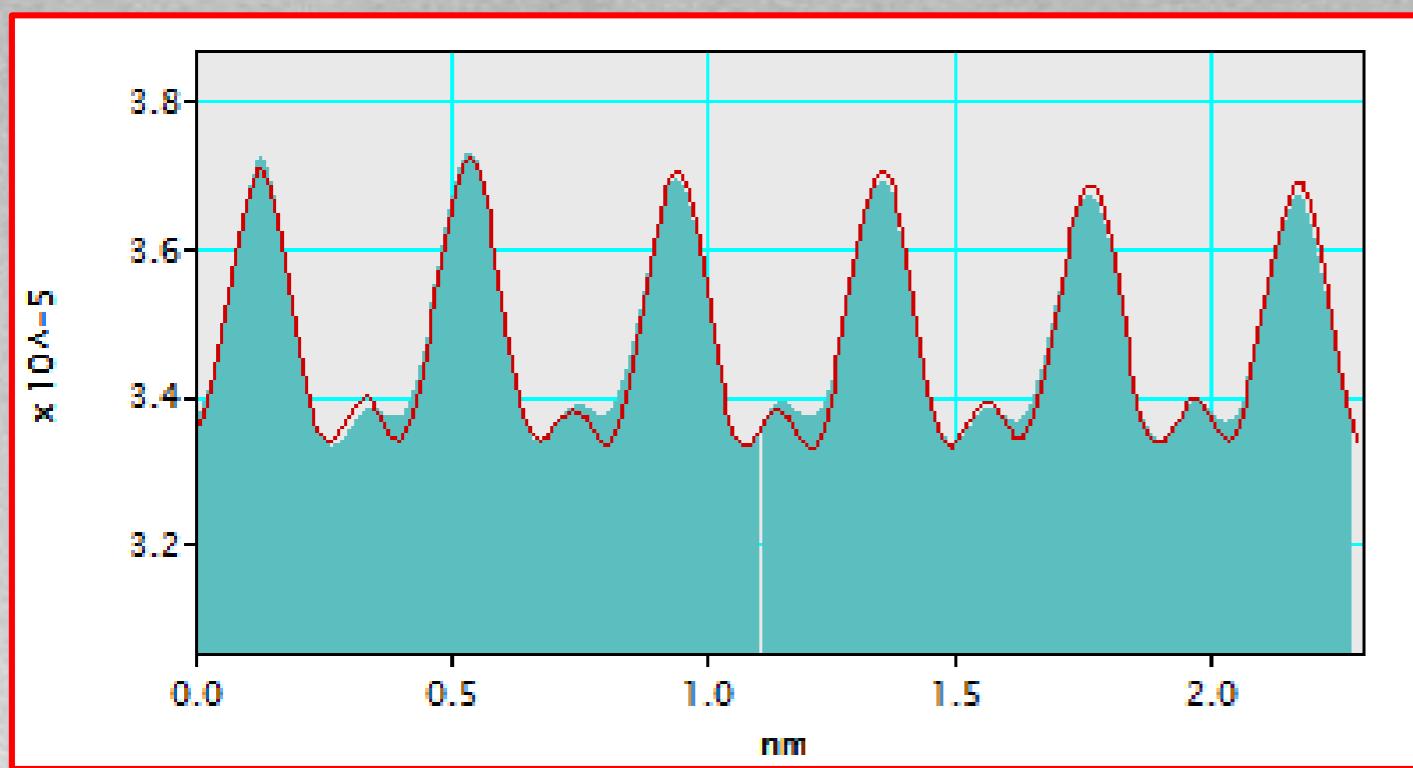
Quantification is possible

IV





Ba-O (2)
Ba-O (1)

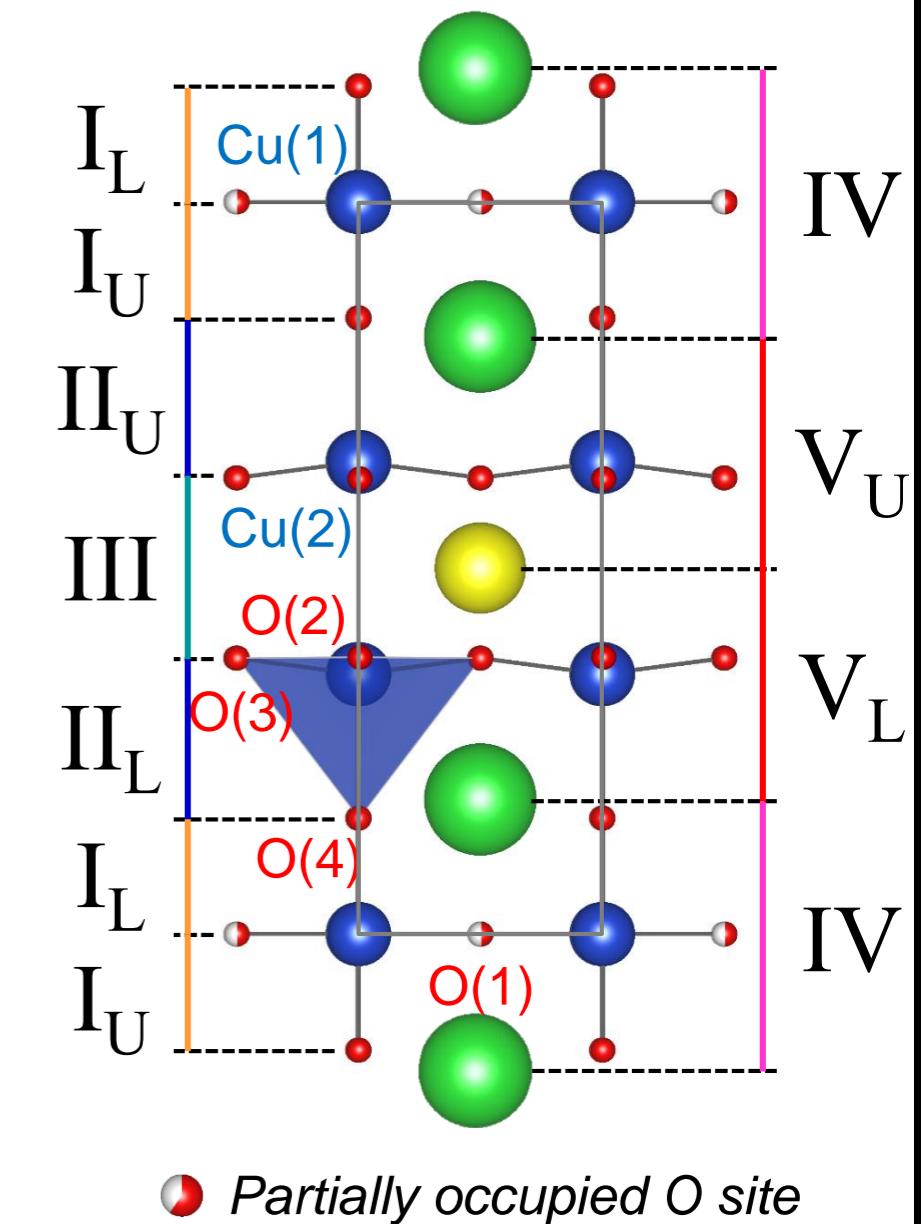
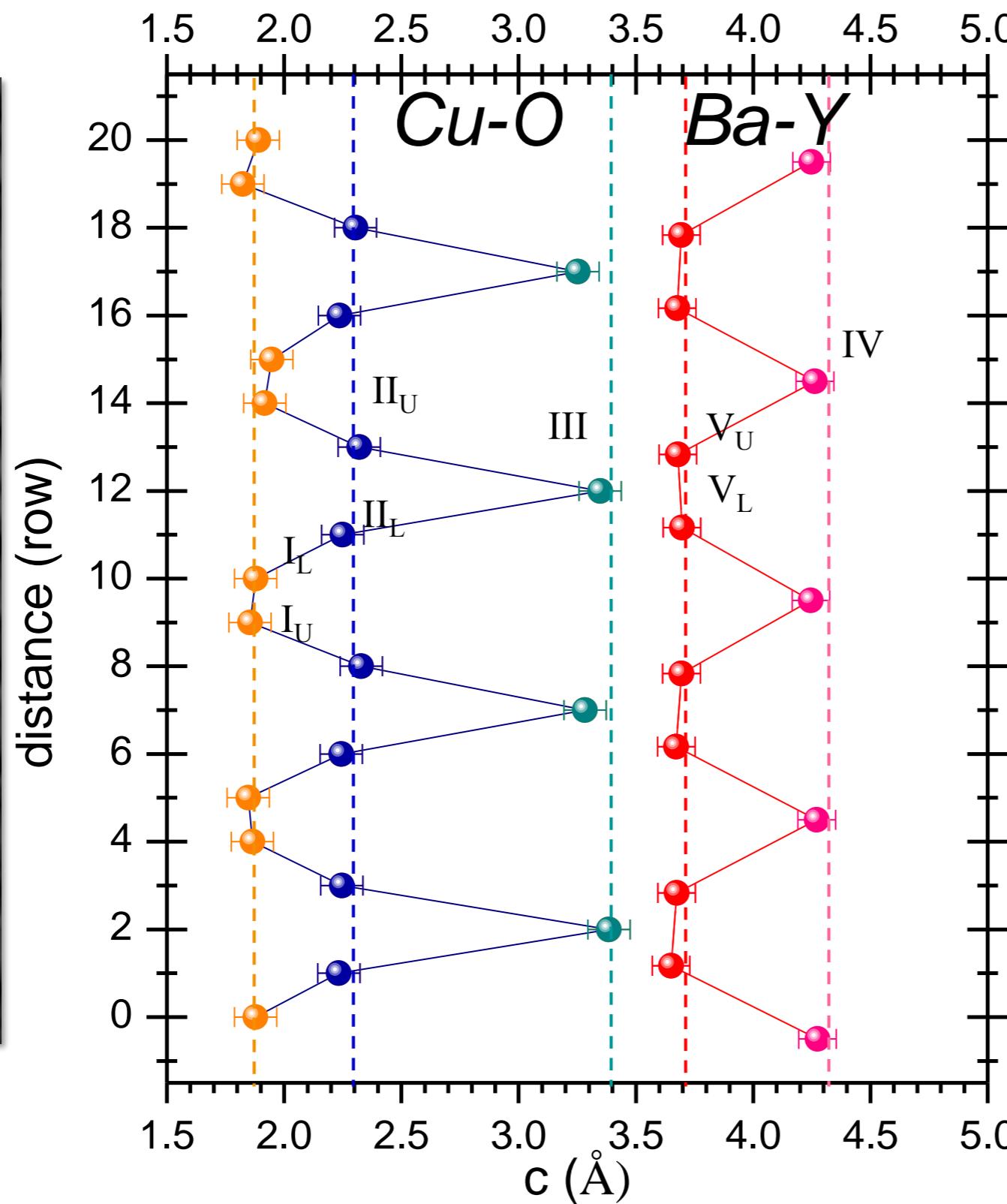


Ba-O (2)
Ba-O (1)

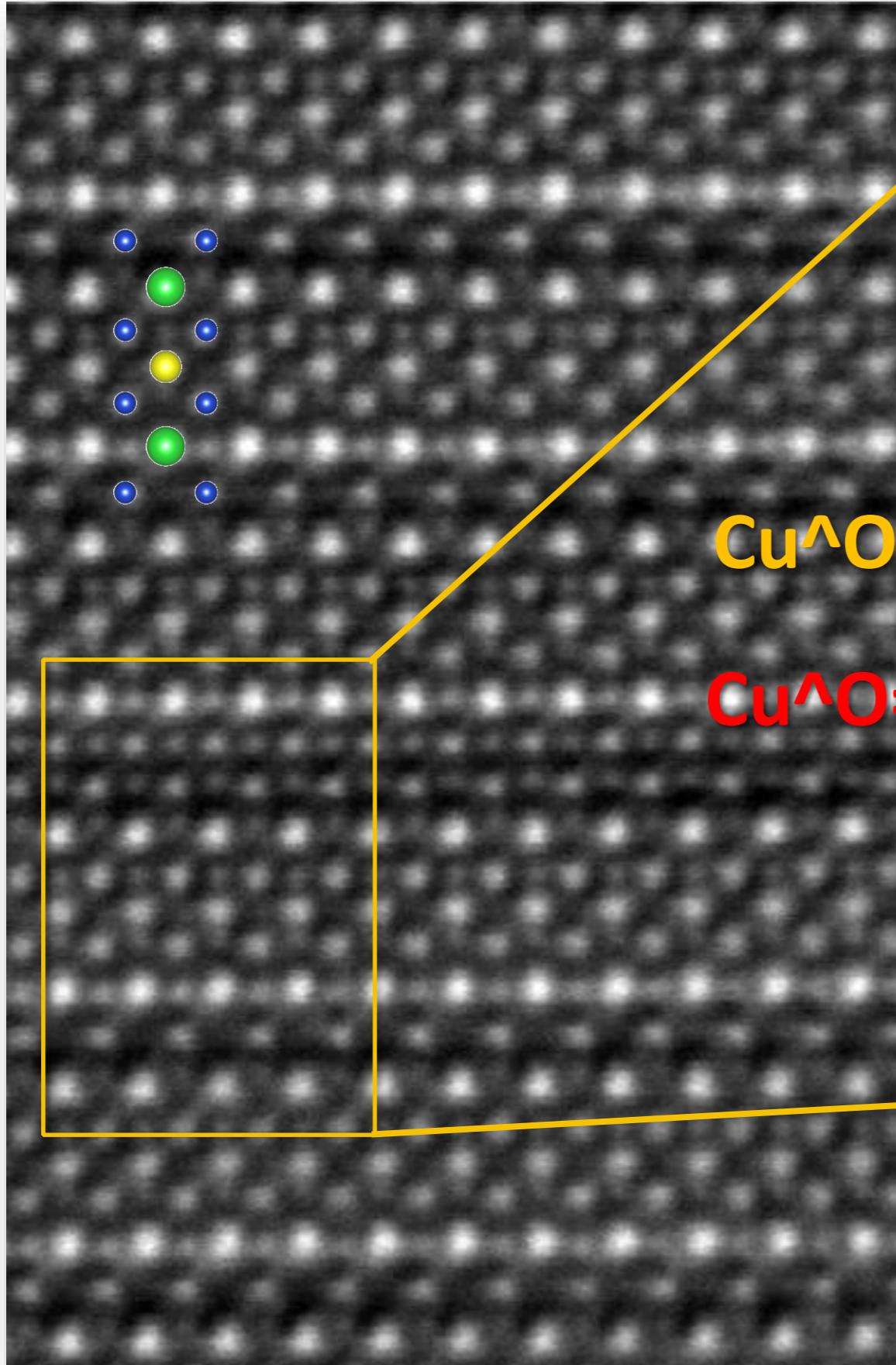
These unforeseen distortions appear only close to the Y124 intergrowths

Quantification is possible

Non-distorted film

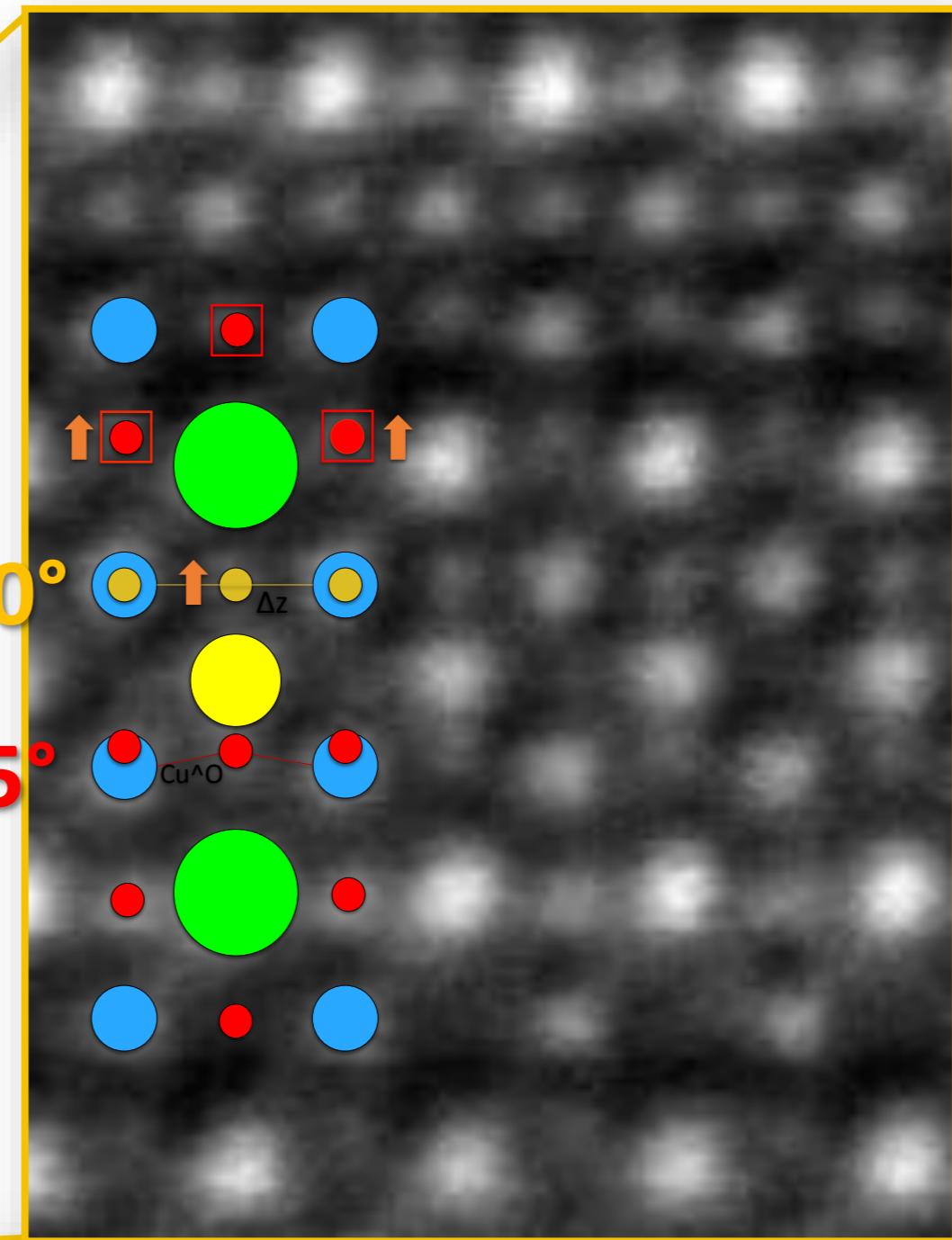


Yet Another Surprise !



$\text{Cu}^\wedge\text{O} \sim 180^\circ$

$\text{Cu}^\wedge\text{O} = 165^\circ$



Physical properties are strongly influenced by these parameters

- Y248 intergrowth is the most common defect in YBCO material (APCs)
- O decorated Cu vacancies are always present within these Y248 intergrowths
- New and unforeseen distortions within the YBCO unit cell are observed near the intergrowths
- These observed distortions can be precisely quantified by using aberration-corrected STEM
- The physical properties of the YBCO crystal might be strongly influenced by these distorted parameters



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Thank you for your attention!



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