The Legacy of X-ray Line Profile Analysis for neutron Diffraction in VULCAN

Complex microstructure in terms of
(i) Lattice strain, (ii) Dislocation density, (iii) Burgers vector population,
(iv) Planar defects and (v) Active slip systems

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Celebration of VULCAN Commissioning
January 21-22, 2010, Spallation Neutron Source
Oak Ridge National Laboratory

The heritage of X-ray line profile analysis

4 typical examples of X-ray line profile analysis:

(i) conventional diffractometer

(ii) high resolution equipment

(iii) synchrotron powder diffraction

(iv) combination of angular and spatial resolution

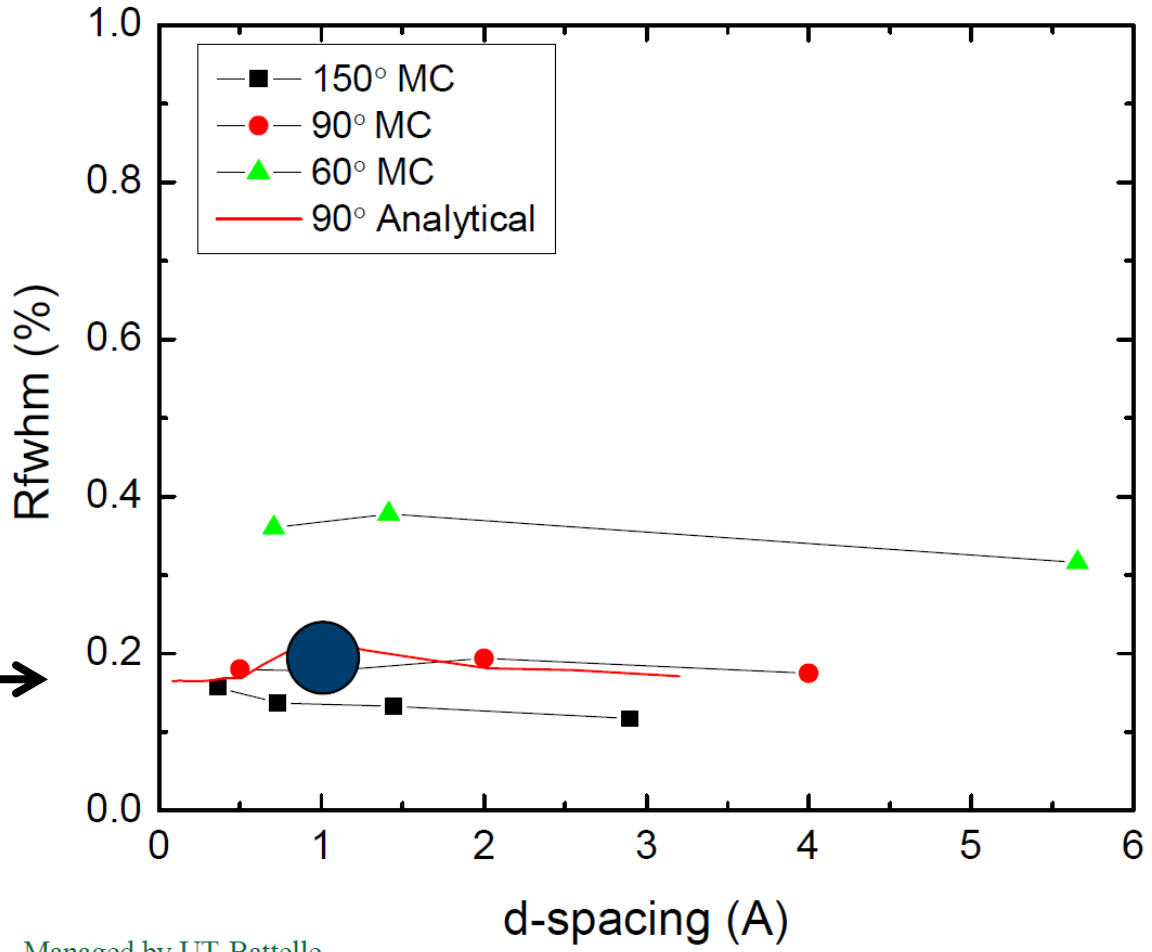
Angular resolution of "VULCAN"

Figure taken from: "VULCAN Summary.pdf"

High resolution mode

Keep in mind

$$\frac{\Delta d}{d} = 2\text{x}10^{-3}$$

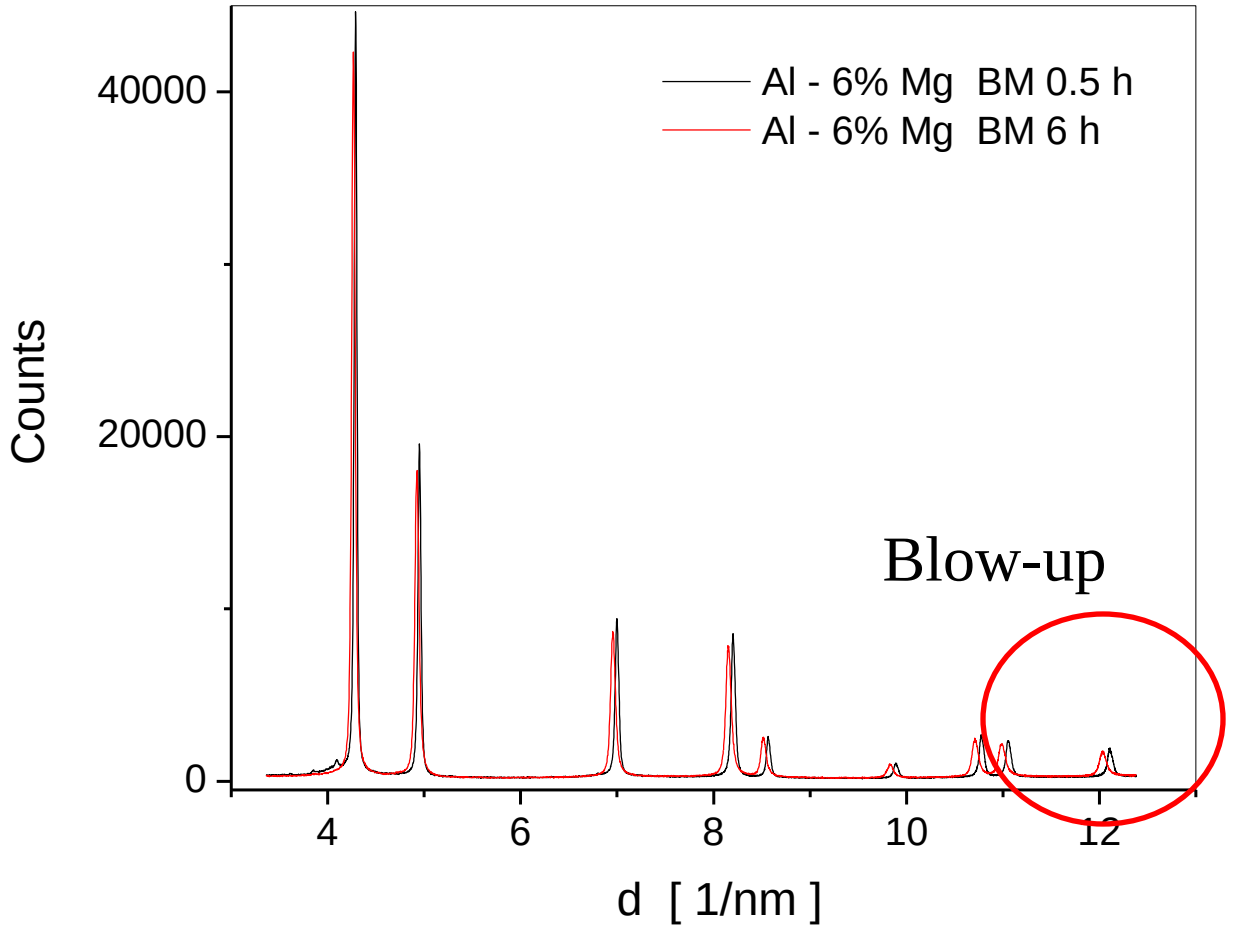


(i) Conventional X-ray diffractometer

The microstructure of mechanically alloyed Al–Mg determined by X-ray diffraction peak profile analysis

J. Gubicza, M. Kassem, G. Ribárik, T. Ungár, *Mat. Sci. Eng. A,* 372 (2004) 115–122

Two typical X-ray ray diffraction patterns



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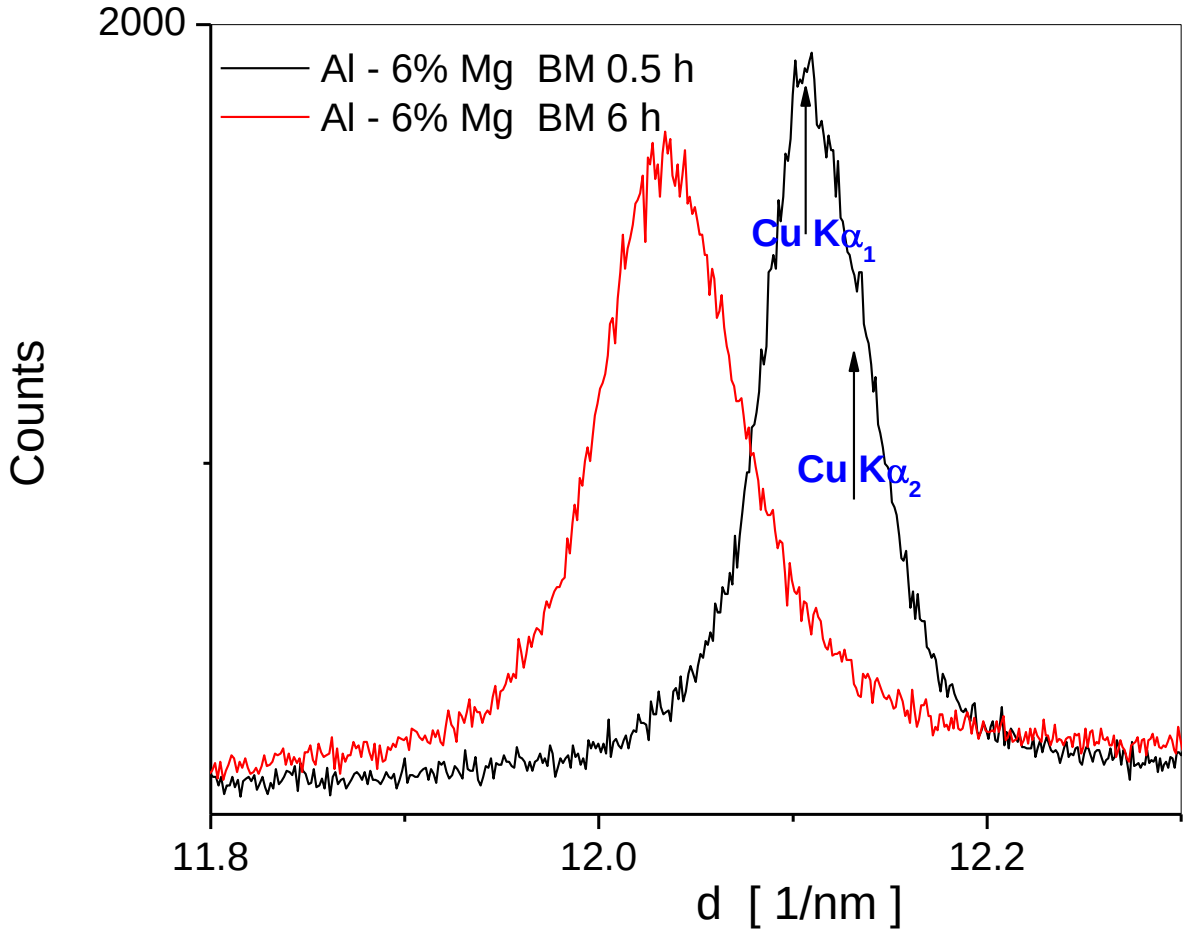
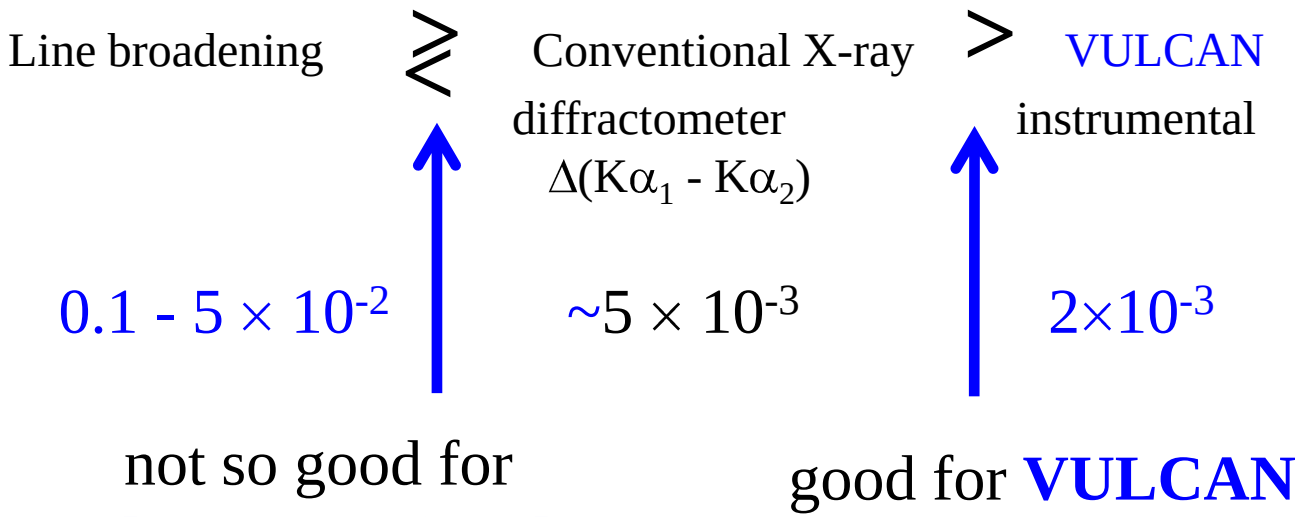


$$\frac{\Delta d}{d}$$



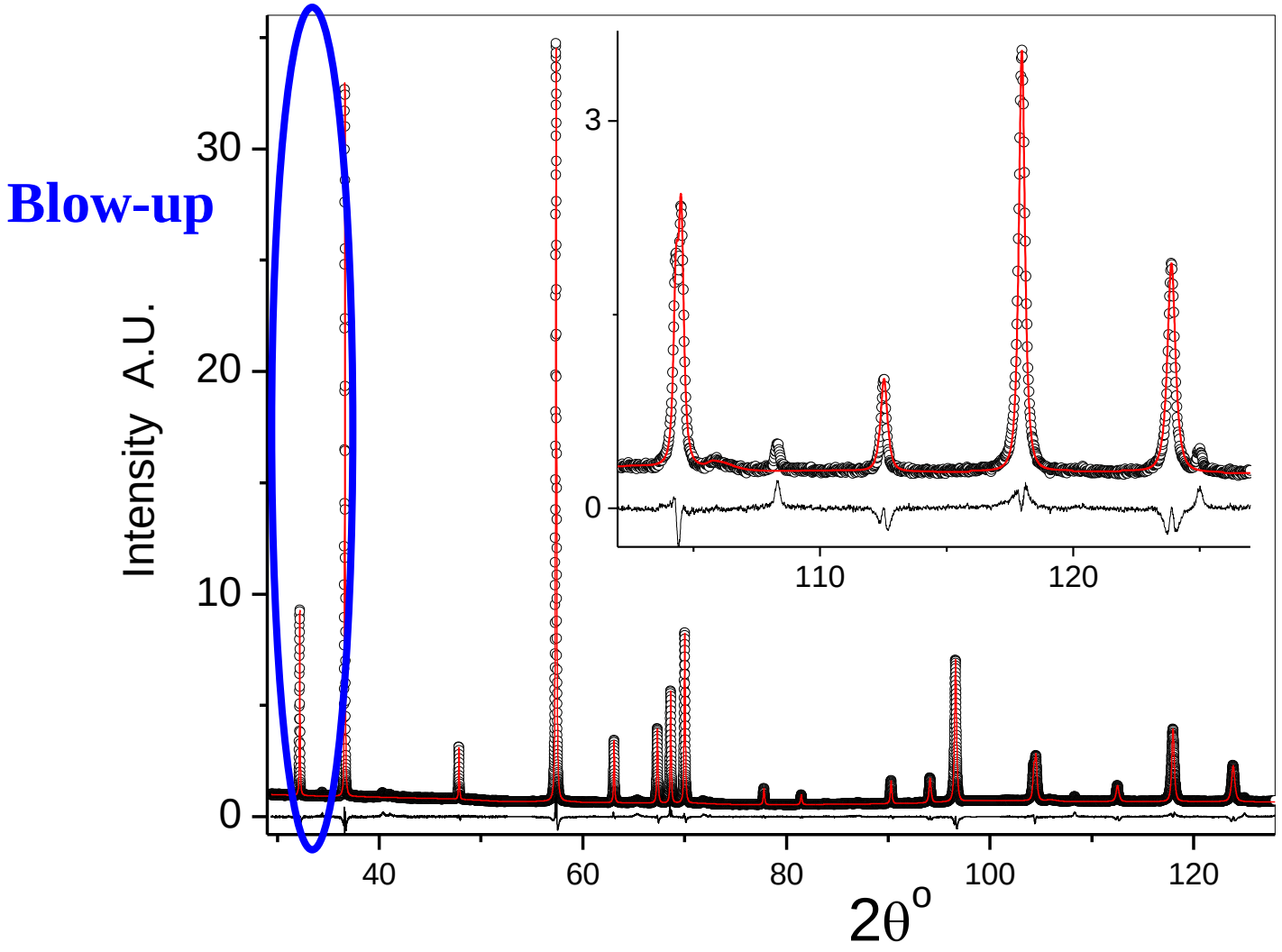
(ii) high resolution equipment

dedicated for line profile analysis

1 x ECAP Mg-ZK60

R. Figueiredo, L. Balogh et al. *unpublished*

{11.1} tensile &
{11.2} compressive twins



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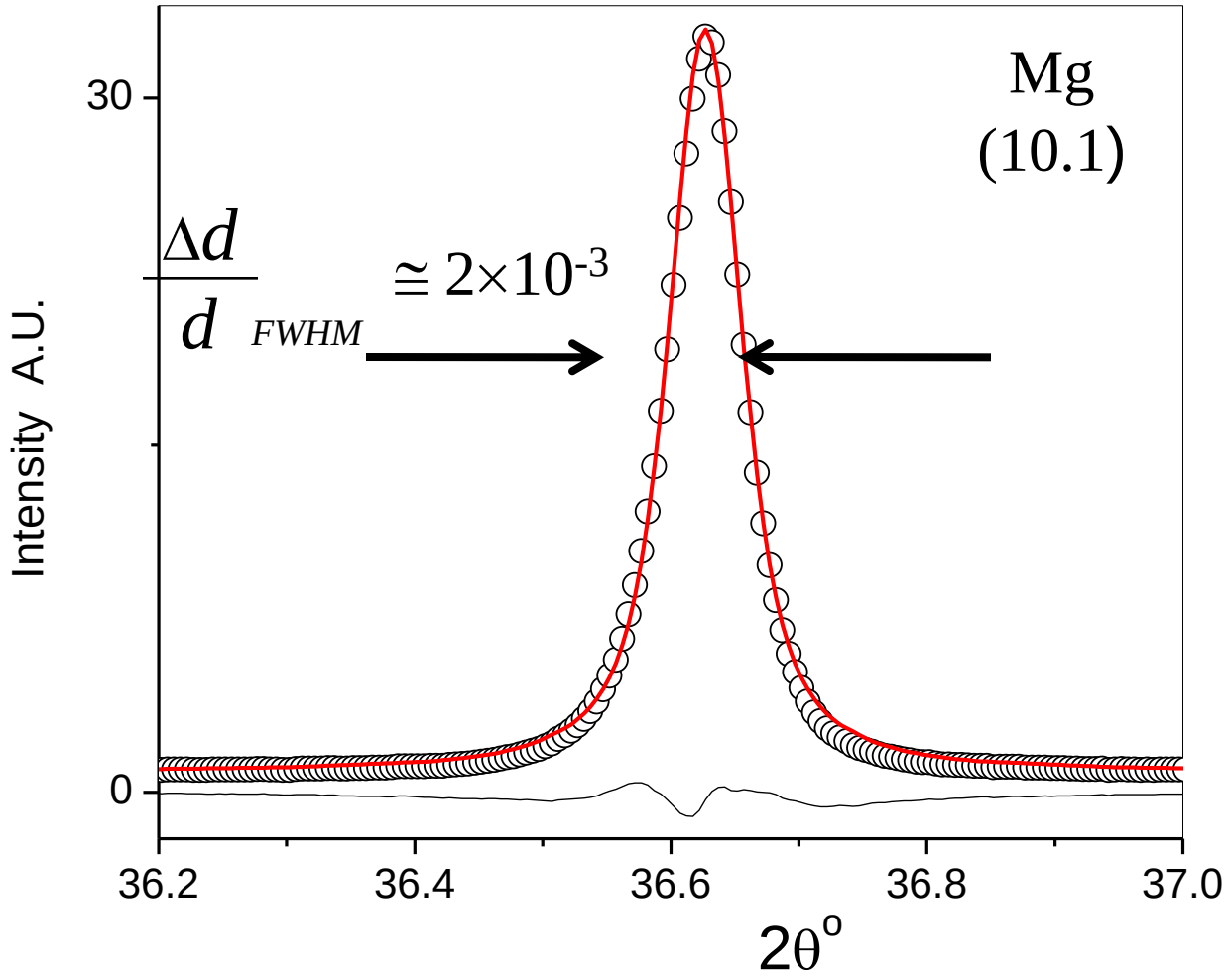


Instrumental

$$\frac{\Delta d}{d} \cong 2\times10^{-4}$$

$$\frac{\Delta d}{d}$$

Line broadening $\gtrsim$ VULCAN instrumental $>$ Dedicated high-resolution diffractometer

$0.1 - 5 \times 10^{-2}$ 2×10^{-3} 2×10^{-4}

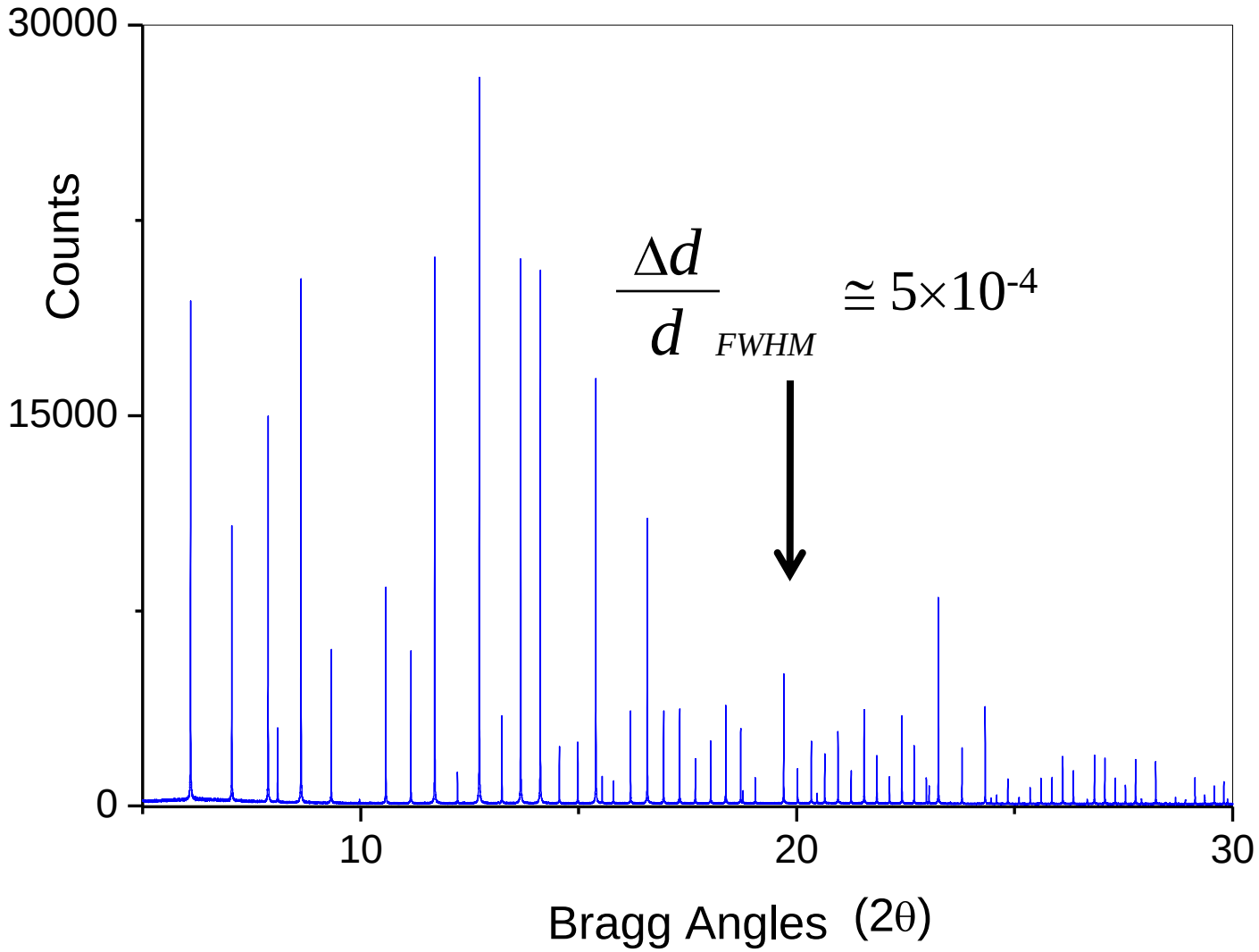
acceptable for
VULCAN

(iii) synchrotron powder diffraction

LaB_6 standard for instrumental effect

ESRF Grenoble, France

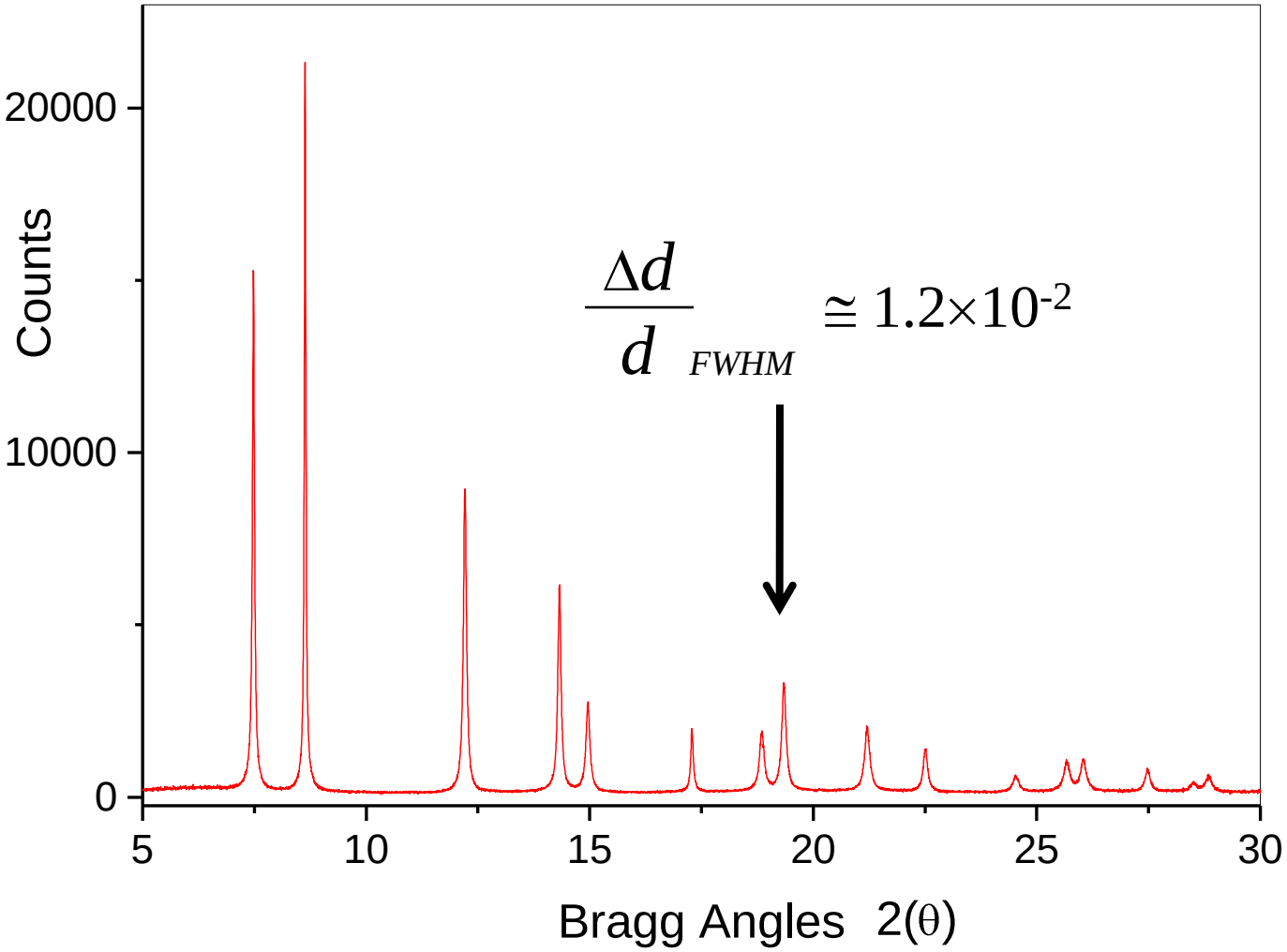
High-resolution powder diffractometer



PbS (Galena) ball-milled for 12 h

ESRF Grenoble, France

High-resolution powder diffractometer



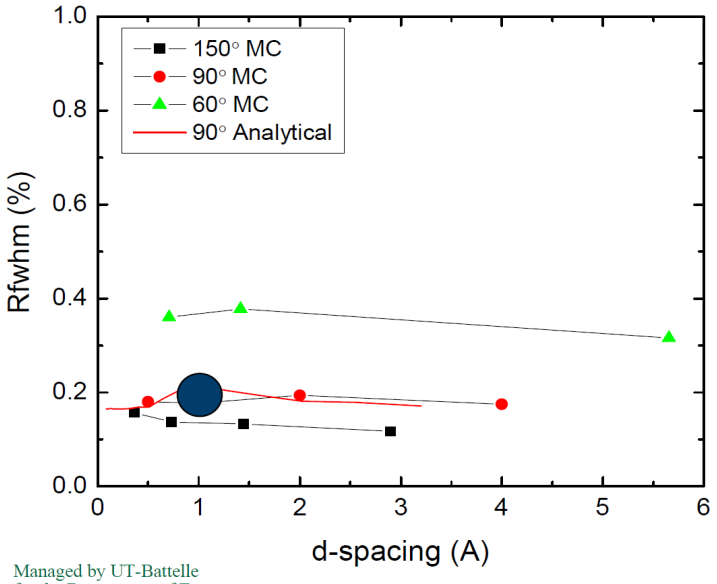
$$\frac{\Delta d}{d}$$

Line broadening	$\gtrsim$	VULCAN instrumental	$>$	X-ray (ESRF) instrumental
$0.1 - 5 \times 10^{-2}$		2×10^{-3}		5×10^{-4}

acceptable for
VULCAN

(iv) **combination** of angular and spatial resolution

High resolution mode



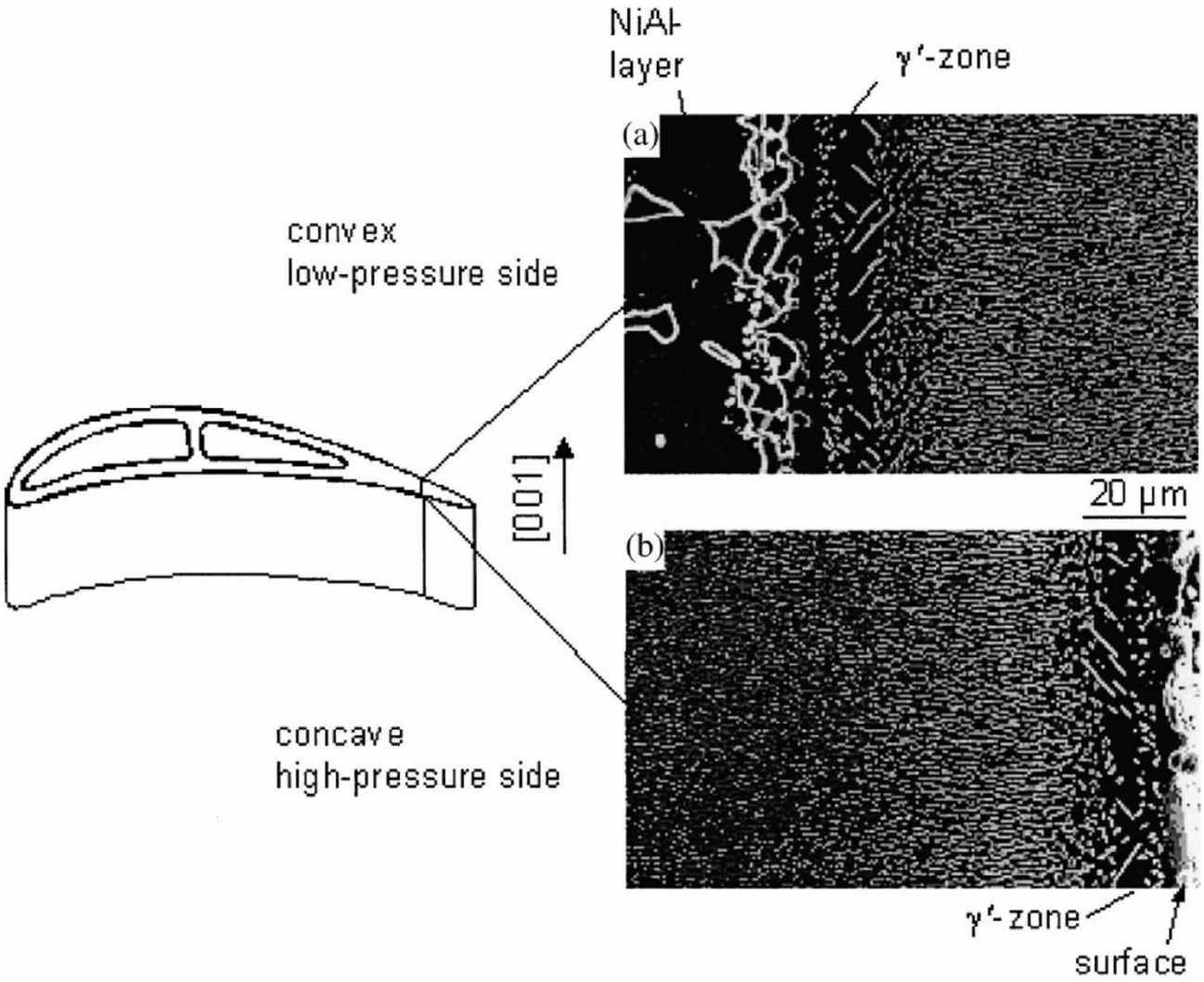
+

- ~~Rapid~~ volumetric (3D) mapping with a sampling volume of 1 mm^3 ~~and a measurement time of minutes~~

Figure + text taken from: "VULCAN Summary.pdf"

Rafting in γ/γ' Ni-base superalloy turbine blades

H. Biermann, B. von Grossmann, T. Ungár, S. Mechsner, M. Souvorov, M. Drakopoulos, A. Snigirev, H. Mughrabi, *Acta. Mater.* 48 (2000) 2221-2230.



The effect of **rafting** on the **line profiles** of a γ/γ' **Ni-base superalloy**

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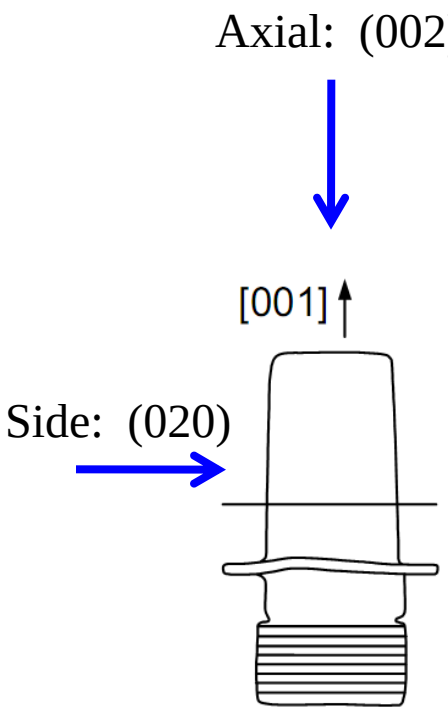
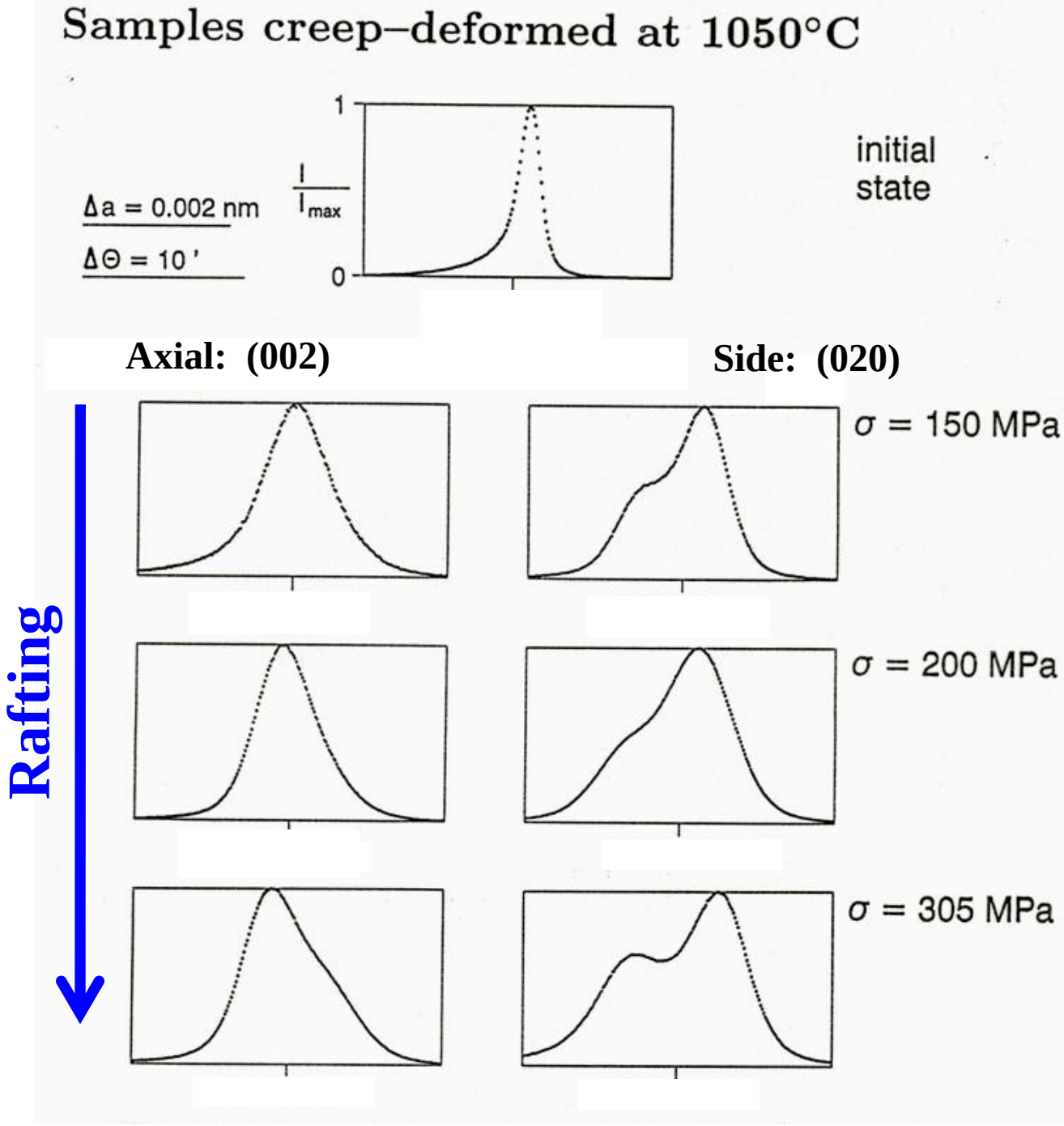
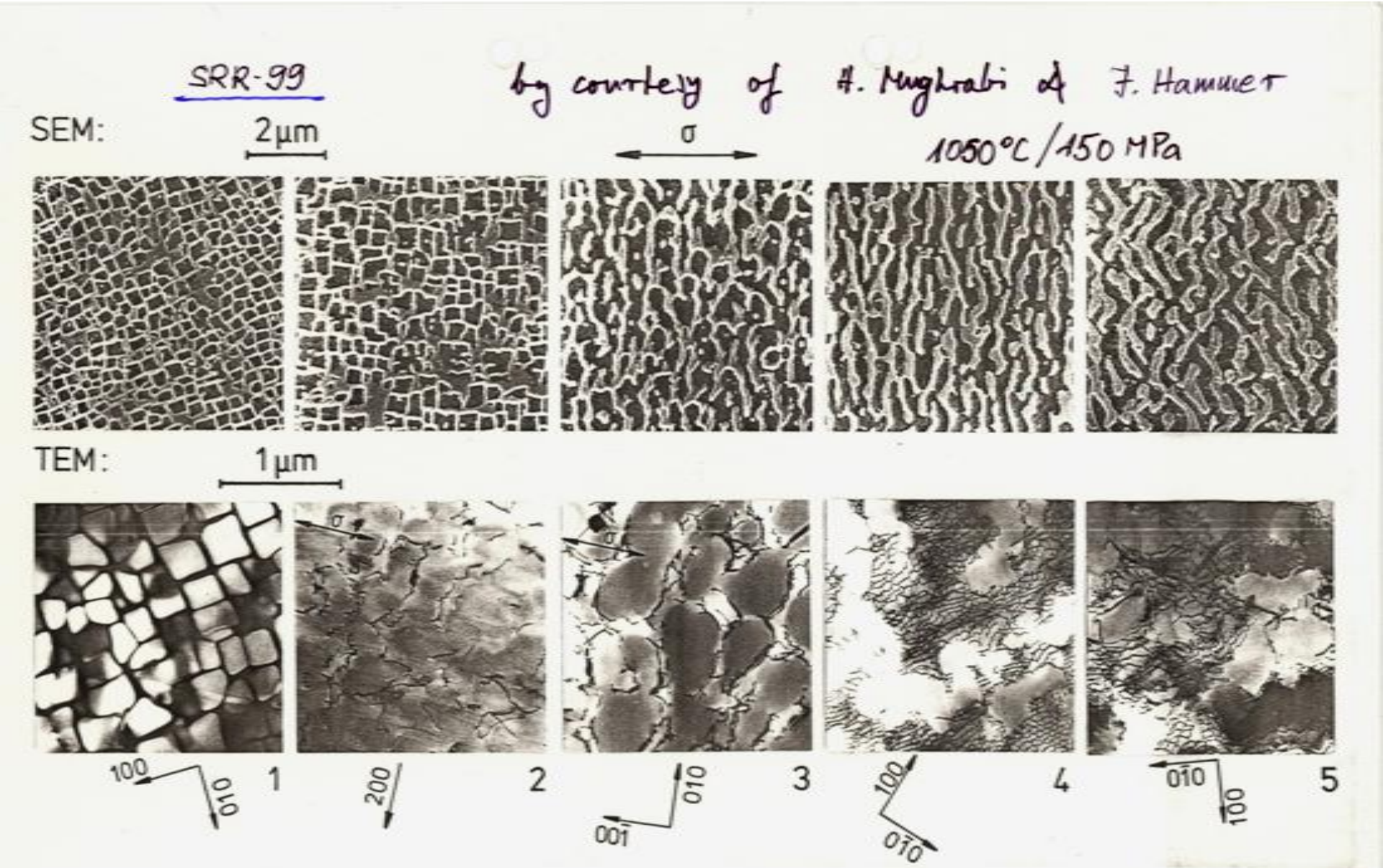
SRR-99

creep deformed





Rafted structure evolution in an SRR-99 alloy

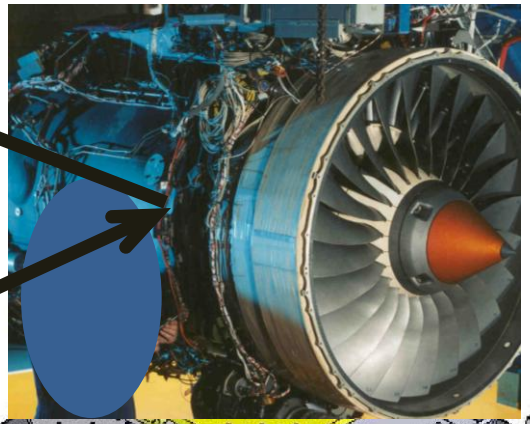


Airbus jet-engine

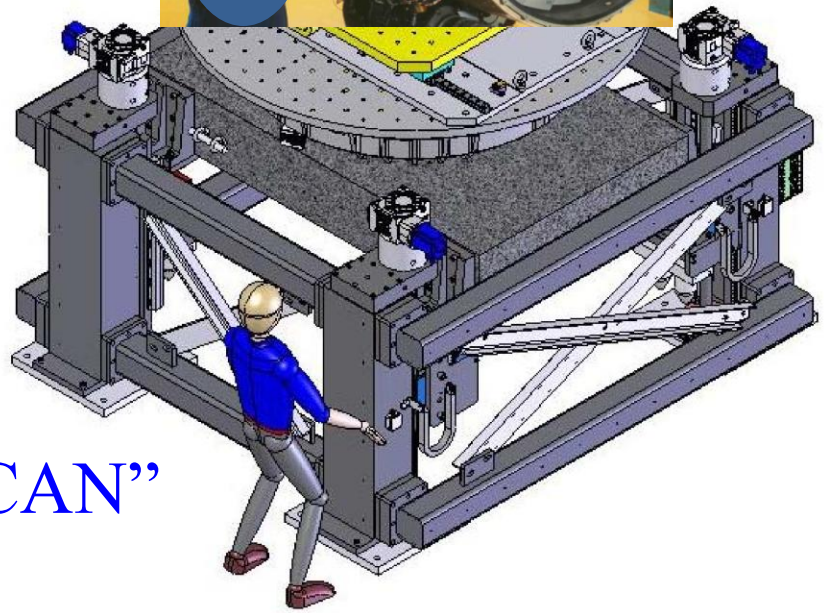
Rolls-Royce

Damage in turbine blades

Airbus jet-engine
Rolls-Royce



neutrons oriented to specific positions and confined down to 1 mm^3



"Large" sample holder of "VULCAN"

Figure taken from: "VULCAN Summary.pdf"

Conclusion

VULCAN enables

to **transfer** the **heritage** of **X-ray line profile analysis**

to **neutrons**

along with **bonuses**