Levitation force to Texture correlation in bulk Y-Ba-Cu-O

D. Chateigner, J. Ricote

LPEC (Le Mans, France)

X. Chaud

CRETA, CNRS (Grenoble,France)

C. Leblond, I. Monot

CRISMAT-ISMRA (Caen, France)

Summary

- Introduction
- Samples and texture experiments
- Levitation curves
- Neutron results for both phases
- $YBa_2Cu_3O_{7-\delta}$ to Y_2BaCuO_5 texture relationship
- Levitation force to texture correlation
- Conclusion

Introduction

- $YBa_2Cu_3O_{7-\delta}$ relatively easy to synthesise
- Tc ≈ 92K and relatively high Hc_2 ≈ 30-100T
- Low Hc_1 ≈ 0.1T ➪ flux penetration ➪ vortex pinning necessary
- Strong anisotropy: $Jc_{ab}(4.2K,0T) \approx 3.10^6 A/cm^2$ $Jc_c(4.2K,0T) \approx 2.10^5 A/cm^2$ ➪ texture necessary
- Application: magnetic bearings

Why textured samples ?

Magnetic bearing: $\mathbf{F}_L \propto \mathbf{M} \cdot \nabla \mathbf{H}$

$\mathbf{M} \propto A\, \mathbf{Jc}\, d$ Bean, *Rev. Mod. Phys. 36, 31 (1964)*

Grain boundaries: Jc ↘

Dimos et al., *Phys. Rev. Lett. 61, 219 (1988)*

Texture: Jc ↗ (GB ↘)

Pernet et al., *Physica C 235, 627 (1994)*

⇨

large grains needed

grain growth

texture

c-axes // F_L

a,b-axes aligned

pinning (Y_2BaCuO_5)

peritectic recombination

Which goals ?

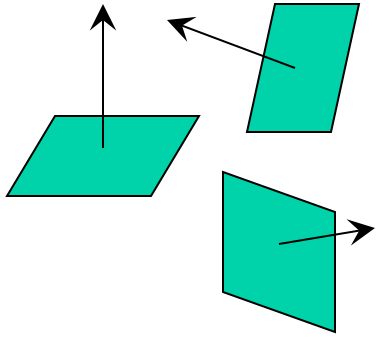
- Test top-seeding technique with:
  H or not ?
  ∇T or not ?

- Are ‘123’ and ‘211’ textures correlated ?

- Influence on levitation ?

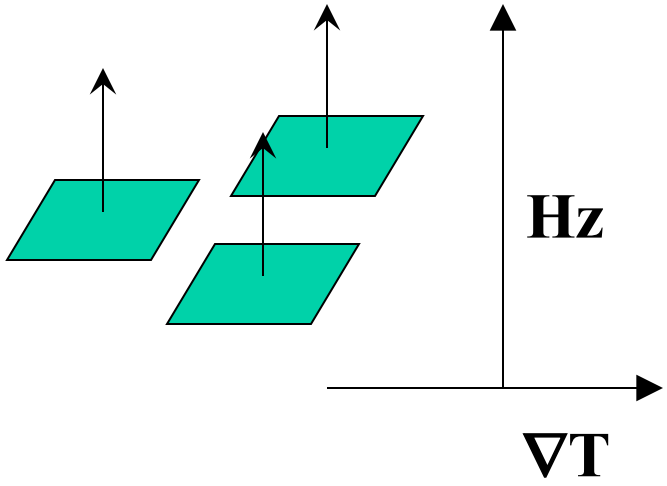
Elaboration

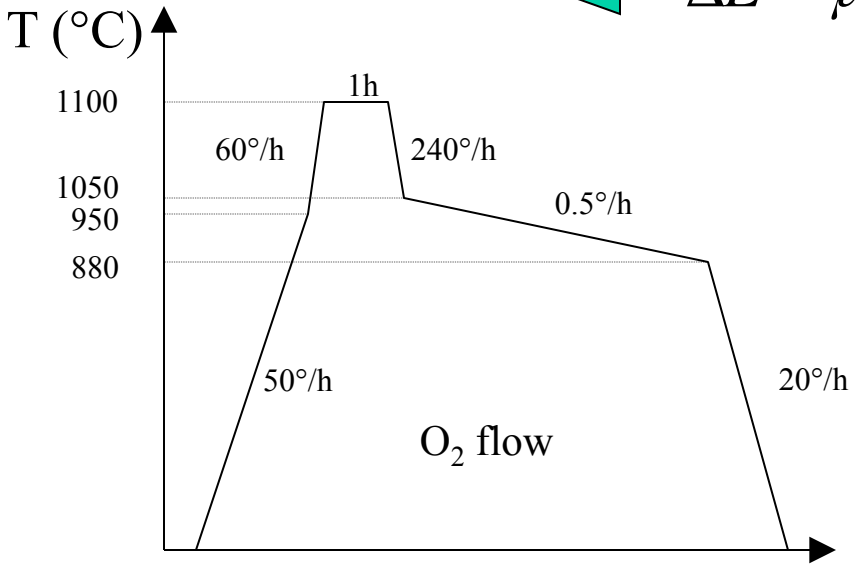
Melt-Magnetic field alignment: **c**-axes // $\mathbf{F}_z$

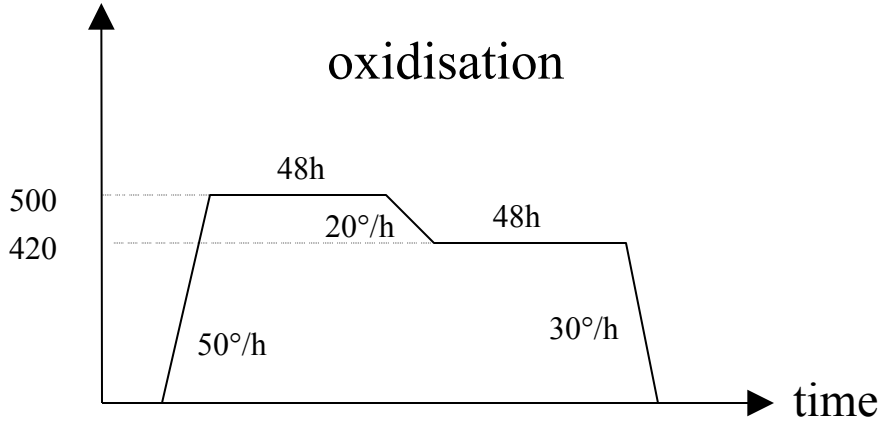


H = 8T

$$\Delta E = \mu_0 \Delta\chi V \frac{H^2}{2}$$

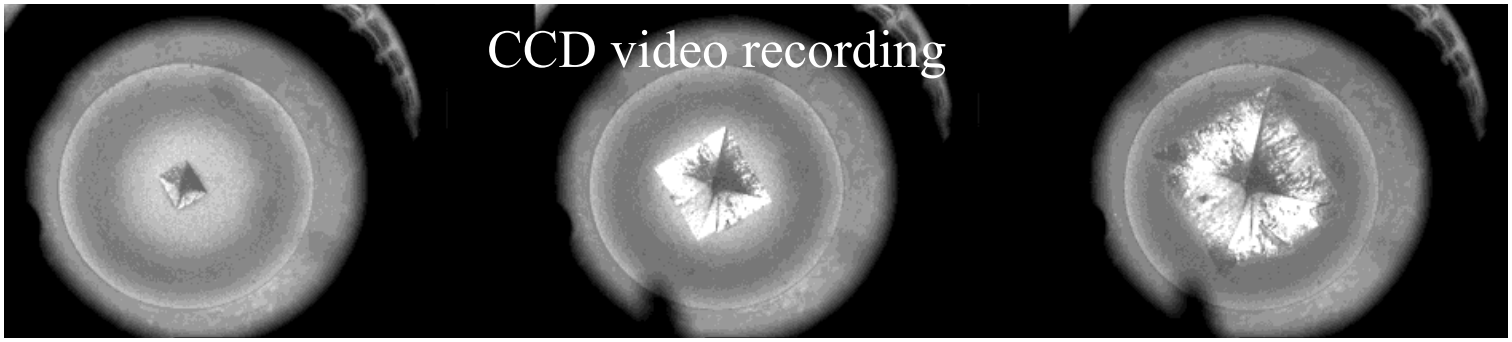


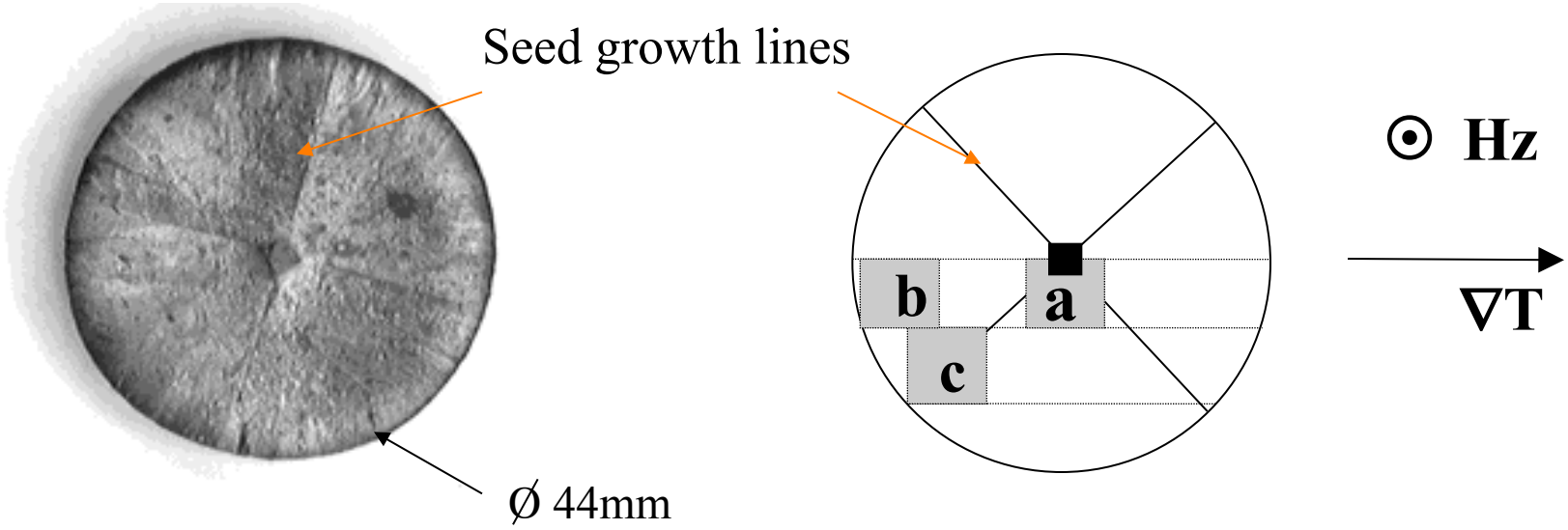




Elaboration

With “top-seeding” $SmBa_2Cu_3O_7$ control: **ab**-axes alignment





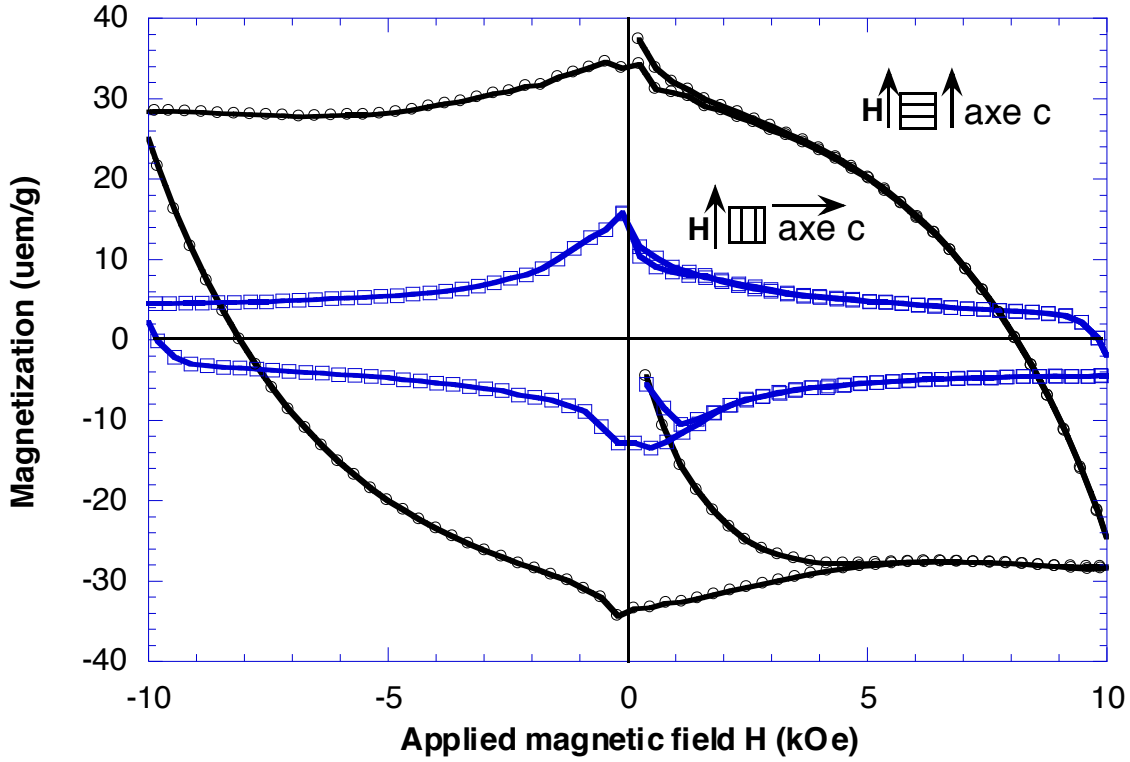
Samples

8 x 8 x 8 mm cubes:

- SHT: seed + H + ∇T
  - a: center
  - b: edge
  - c: growth line
- ST: seed + ∇T
  - a: center
  - b: edge
  - c: growth line
- S: only seed
  - a: center
  - c: growth line

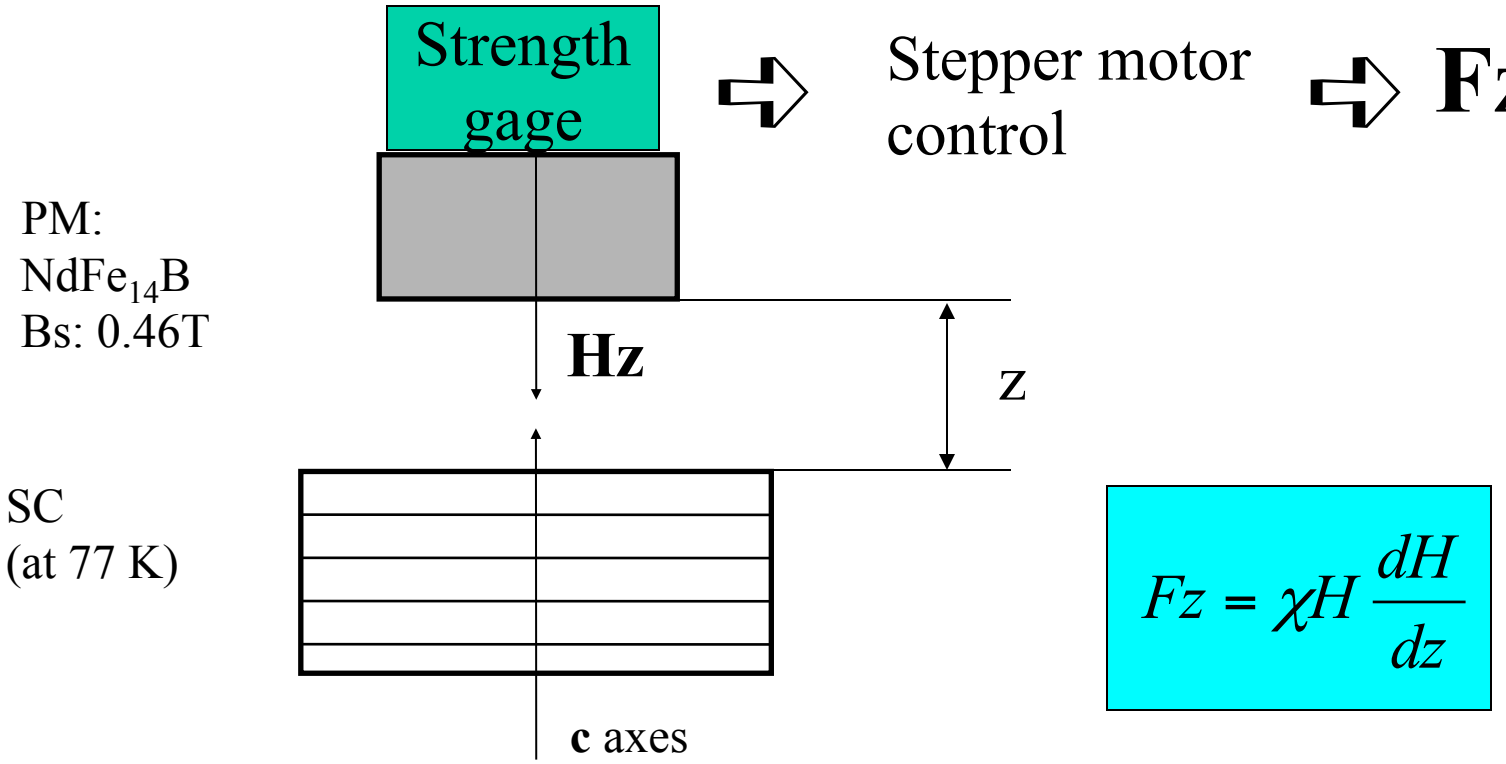
- '123': $YBa_2Cu_3O_{7-\delta}$ superconductor (Pmmm): a=3.813Å, b=3.881Å, c=11.66Å
- '211': Y_2BaCuO_5 insulator (25%) (Pnma), a=12.181 Å, b=5.658 Å, c=7.132 Å
- Sample: triclinic (WIMV)

Typical magnetisation curves (Y1a)



- Indicates strong preferred orientation
- Largest vertical force achieved for c-axes aligned with H (current flows within the (a,b) planes)

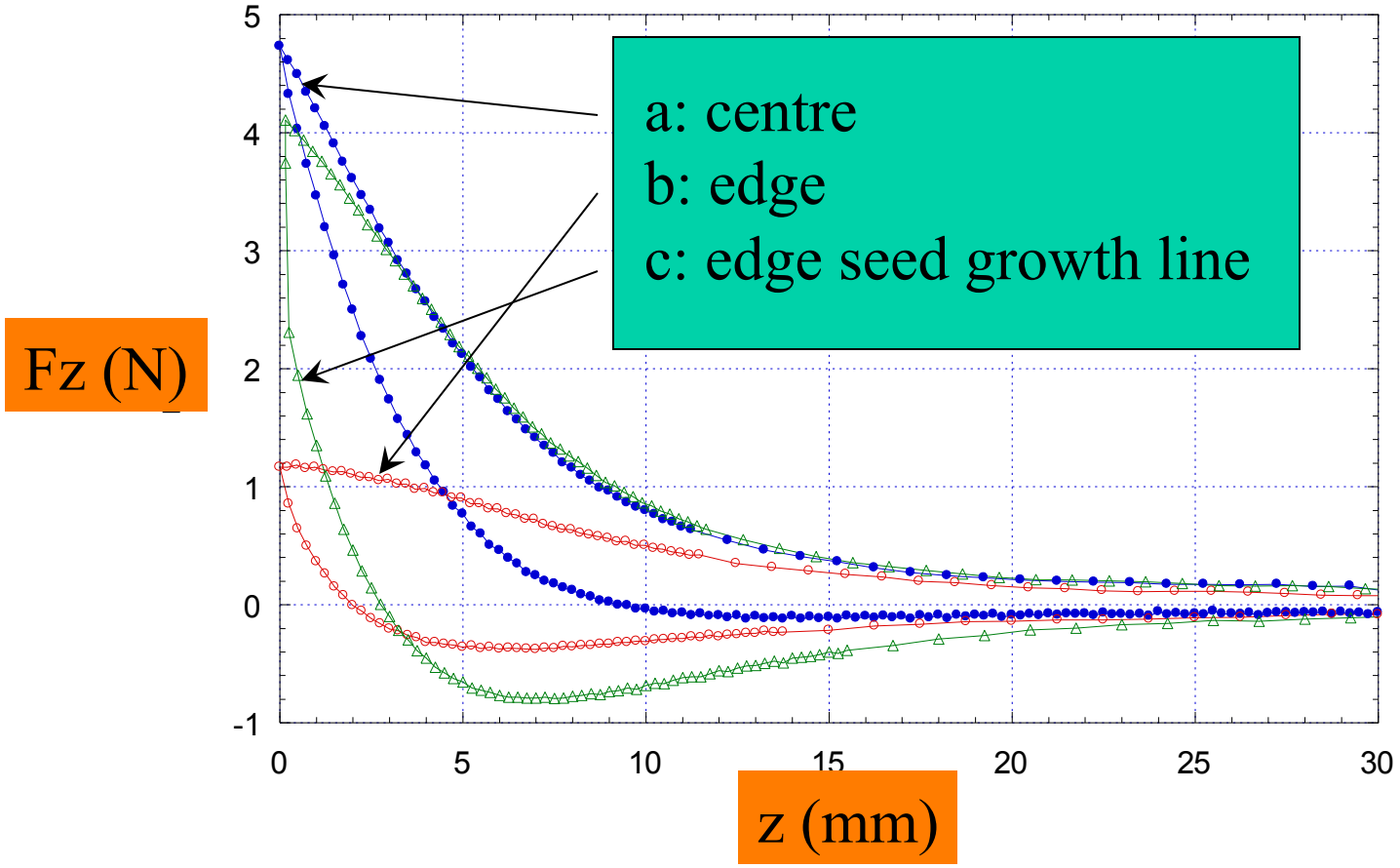
Levitation force measurements



$$Fz = \chi H \frac{dH}{dz}$$

Levitation curves

SHT sample



Neutron texture experiments

D1B line at ILL: Eulerian cradle + PSD (λ= 2.523 Å)

- $\omega = 30°$, $0 \leq \chi \leq 90°$, $0 \leq \varphi \leq 355°$, 5° x 5° grid, 15sec/point

'123' phase: {112} full coverage

{101/011} and {102/012} 10° blind area

tetragonal-like reflections, non '211' perturbated

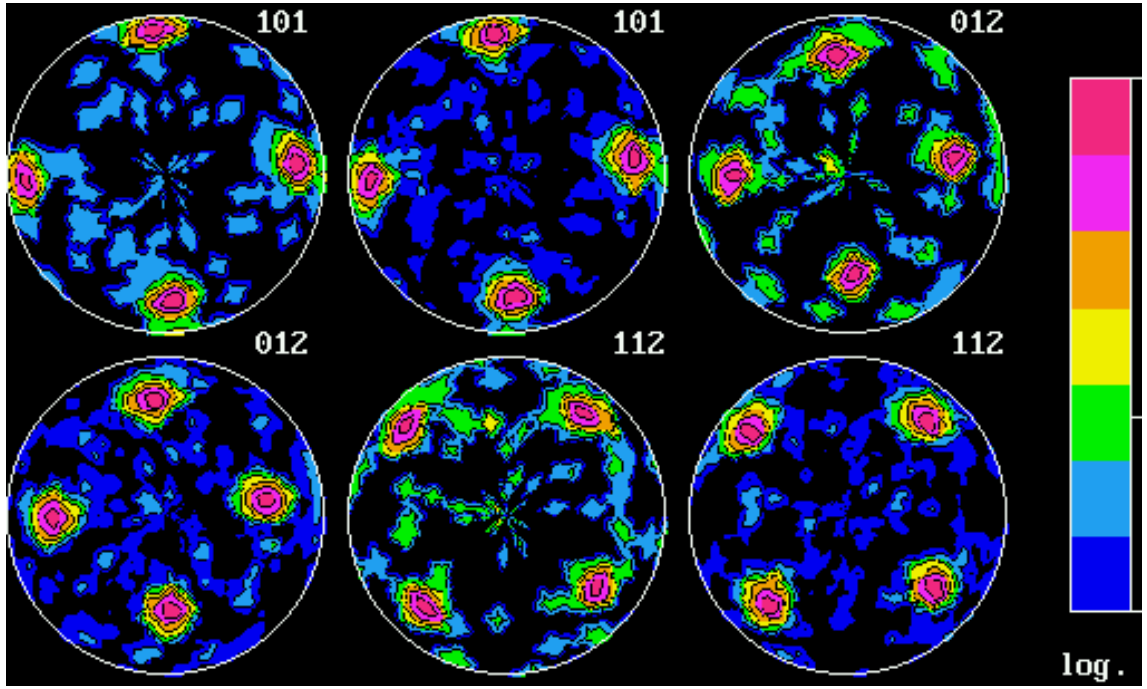
'211' phase: {101} 5° blind area

{201} and {111} full coverage

non '123' perturbated

- cyclic line profile integration

OD-reliability: ‘123’ phase
sample SHTa (centre, with seed, **H**=8T and **∇T**)



53

1 m.r.d.

0.1

$RP_{0.05} = 68\%$

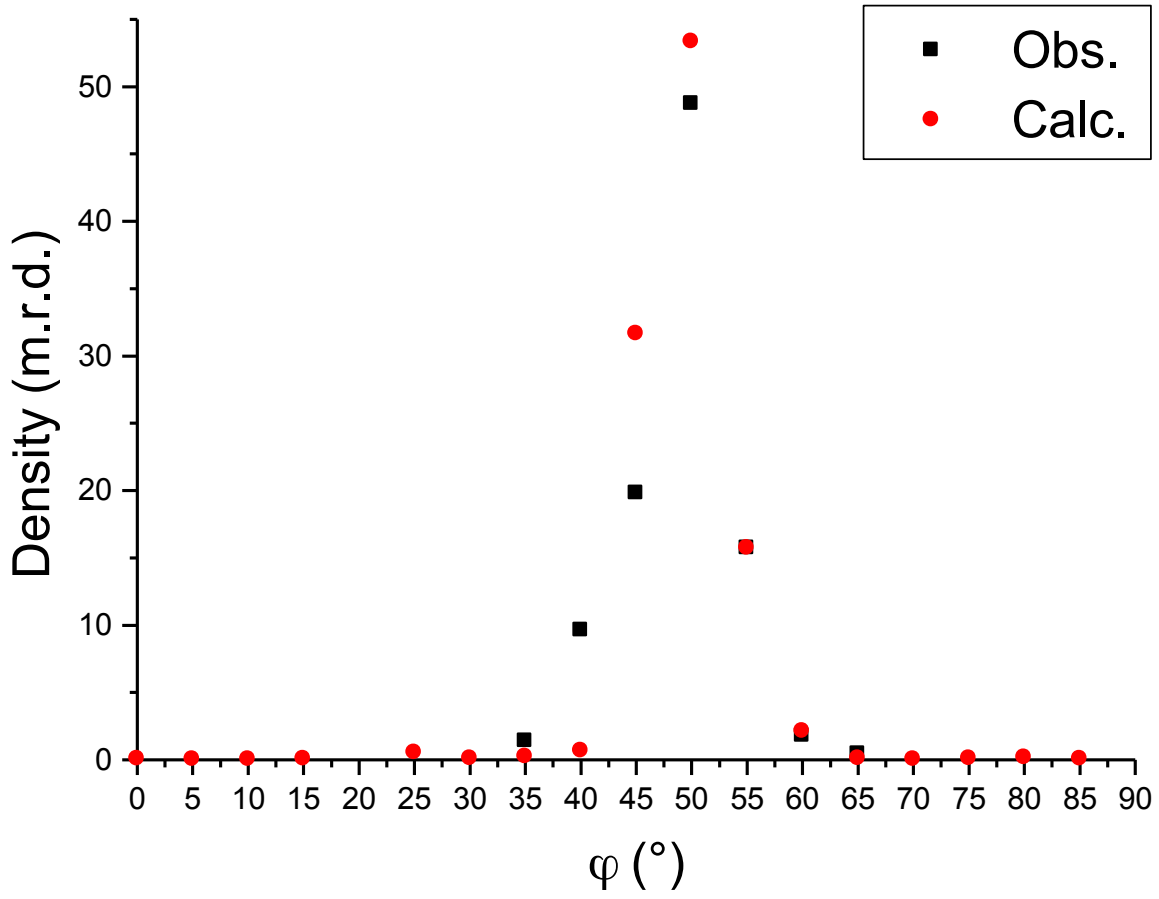
$RP_1 = 89\%$

$S = -5$

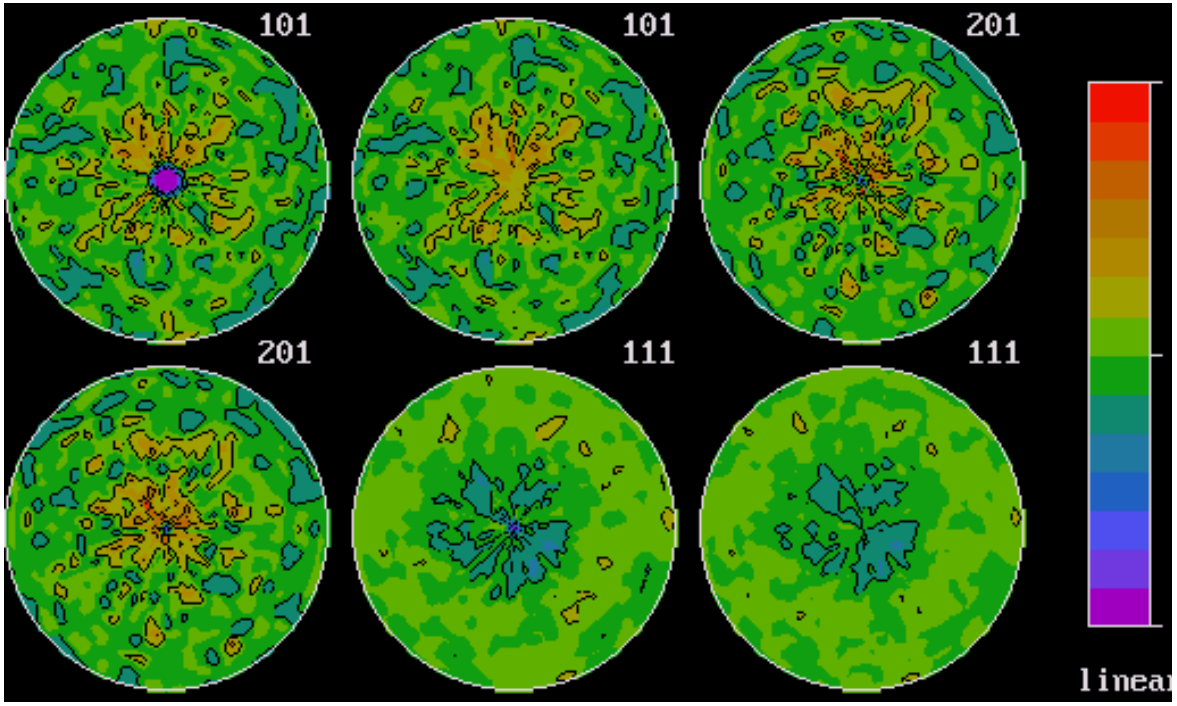
$F^2 = 810$ m.r.d.^{2}

$OD_{max} = 1990$ m.r.d.

φ-scan at the maximum of {112}‘123’



OD-reliability: ‘211’ phase



2

1 m.r.d.

0

$RP_{0.05} = 3.4\%$

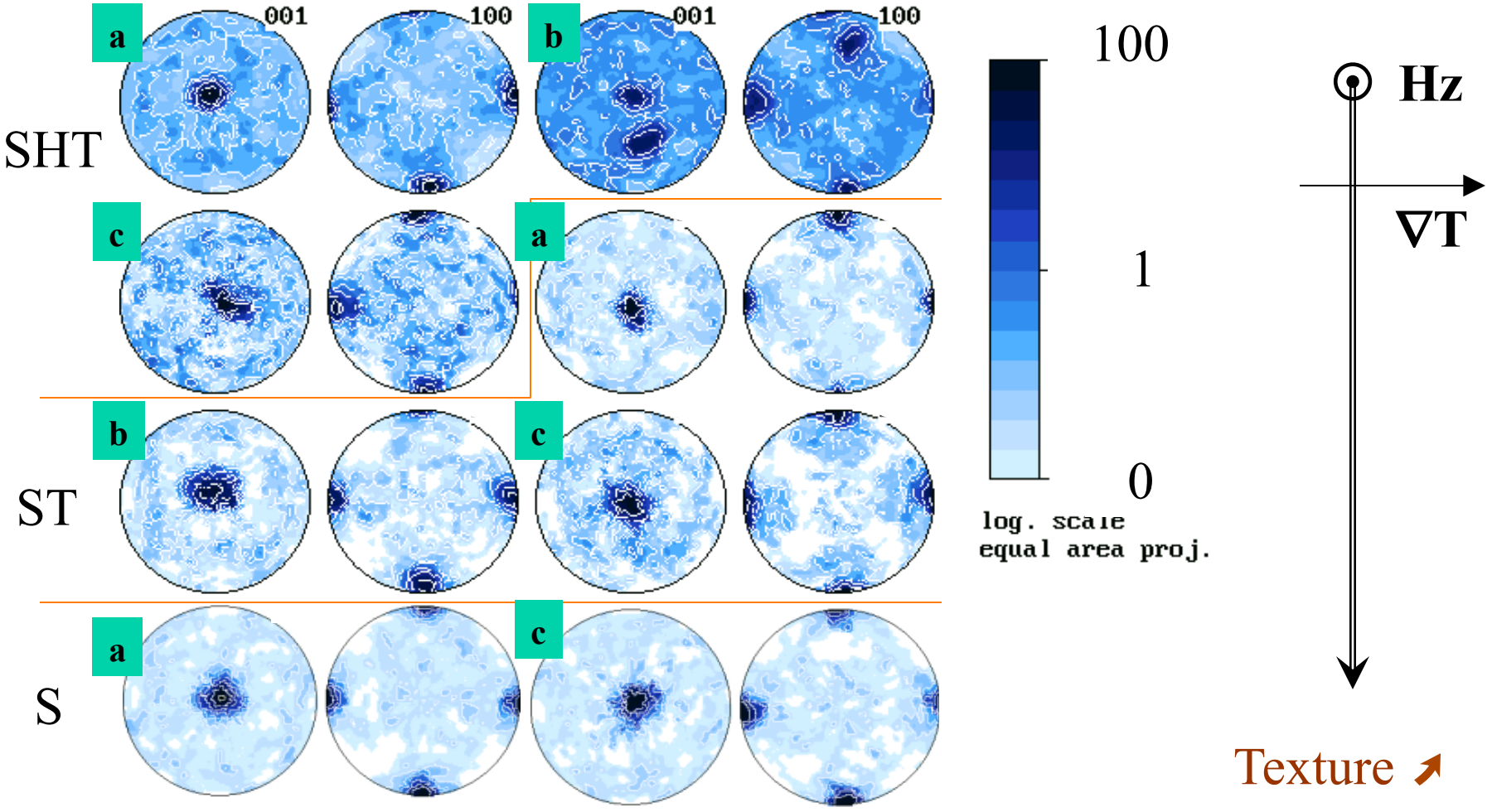
$RP_{1} = 3.4\%$

$S = - 0.15$

$F^2 = 1.4$ m.r.d.^{2}

$OD_{max} = 12$ m.r.d.

‘123’ phase: {001} and {100} recalculated pole figures

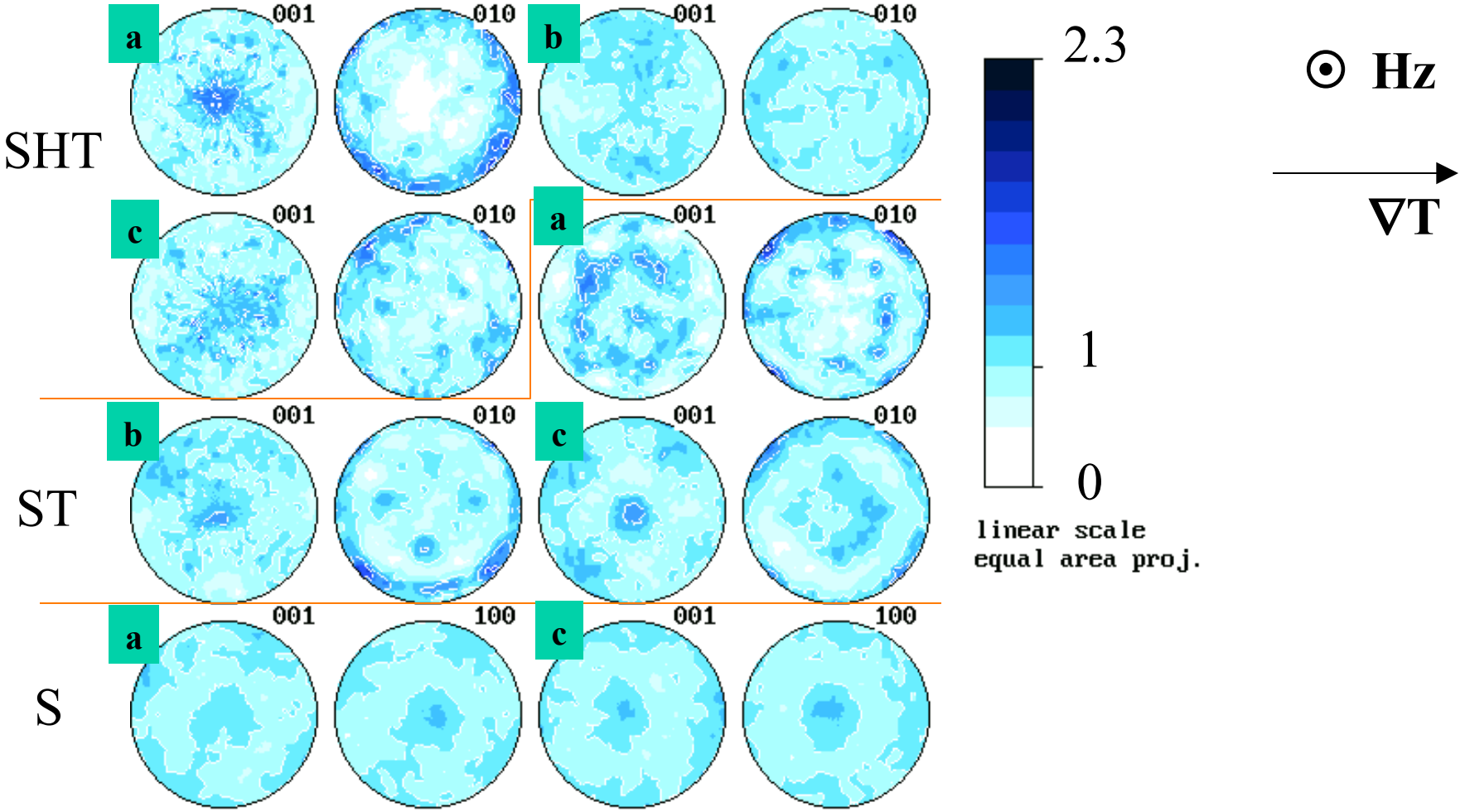


‘123’ phase textures

- Very high (at the limit of the program: 1° x 1° x 1° grid ?)
- In general:
  - **c**-axes aligned with **H**,
  - **a,b**-axes aligned with ∇**T**,
  - alignment coherent with seed alignment up to 20mm away
  - texture strength remains constant along the seed growth lines
- But:
  - Texture ameliorates with the suppression of **H**

    ⇨ $\nabla \mathbf{H}_{radial}$ perturbation (SHTb), diminishes texture, can split **c**-axis components
  - Texture ameliorates at a large scale without ∇**T** ! (S vs ST)
- Texture perturbations occur outside the seed growth lines, where the seed lost control

‘211’ phase: {001} and {010} recalculated pole figures



'211' to '123' texture relationship

- '211' phase exhibits very low textures compared to '123'
- The '211' growth is influenced by:
  - Heteroepitaxial-like relationship:

$$c_{211} \,//\, c_{123} \text{ and } b_{211} \,//\, \langle 110/103/013 \rangle_{123}$$

$\{010\}_{Y211}$ and $\{110\}_{Y123}$ d-spacing: relative mismatch of only 4%.

- with **H** (SHT), '123' texture ↘ with the one of '211'

- coherent with D. Chateigner et al. (J. Appl. Cryst. 30, 1997, 43)

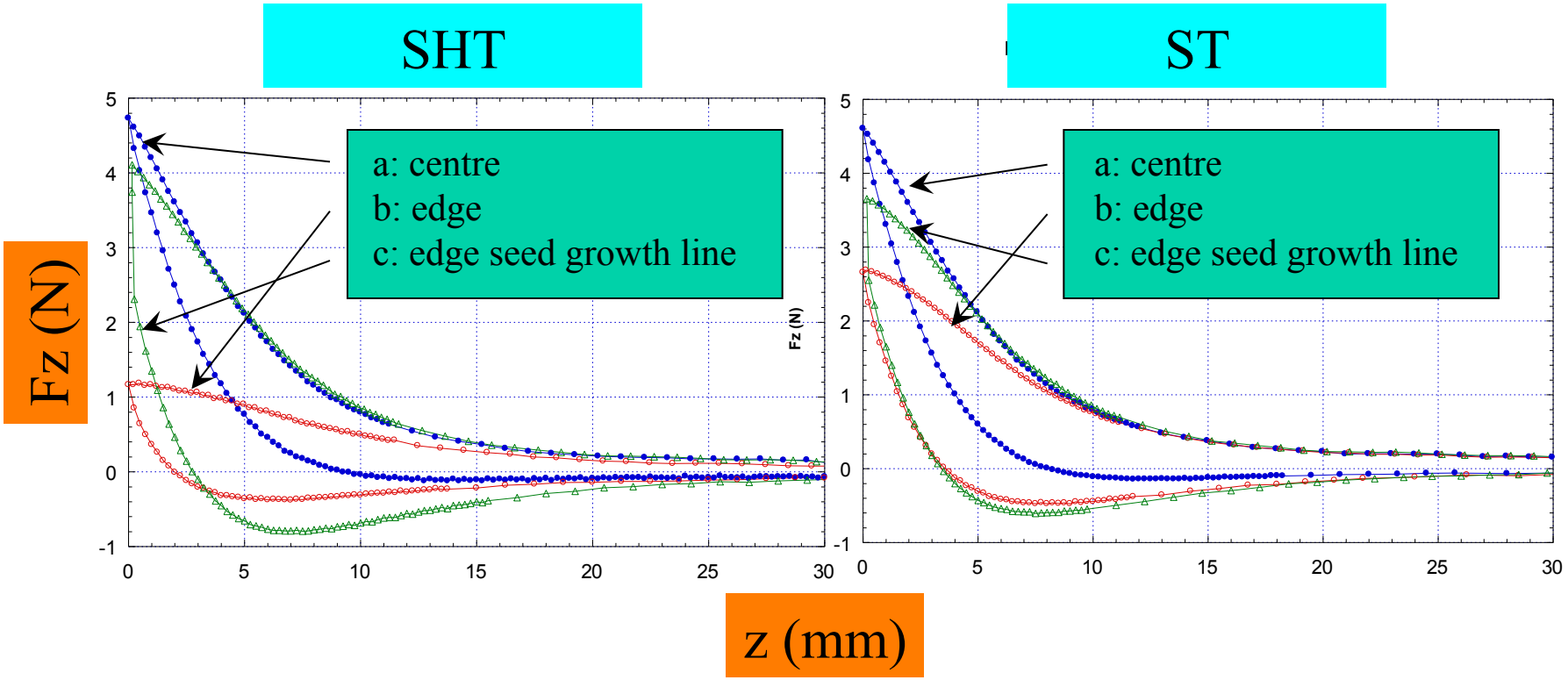
L. Durand et al. (Super. Sci. Tech. 8, 1995, 214)

  - **H**: in a polymer, '211' orients with **c** // **H**

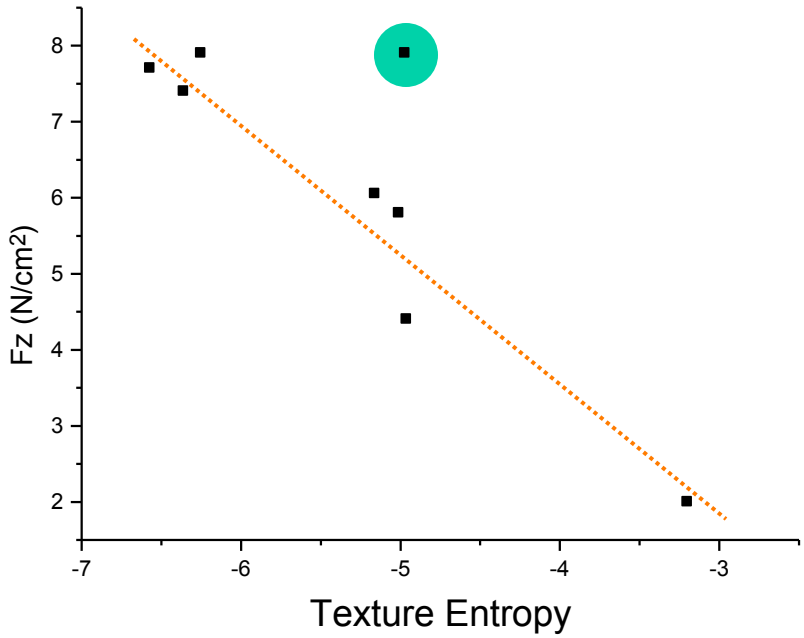
but here, epitaxy with '123' predominates (SHT)

  - **∇T**: without **∇T** (S), '211' texture is decreased compared with ST

Levitation force to Texture correlation



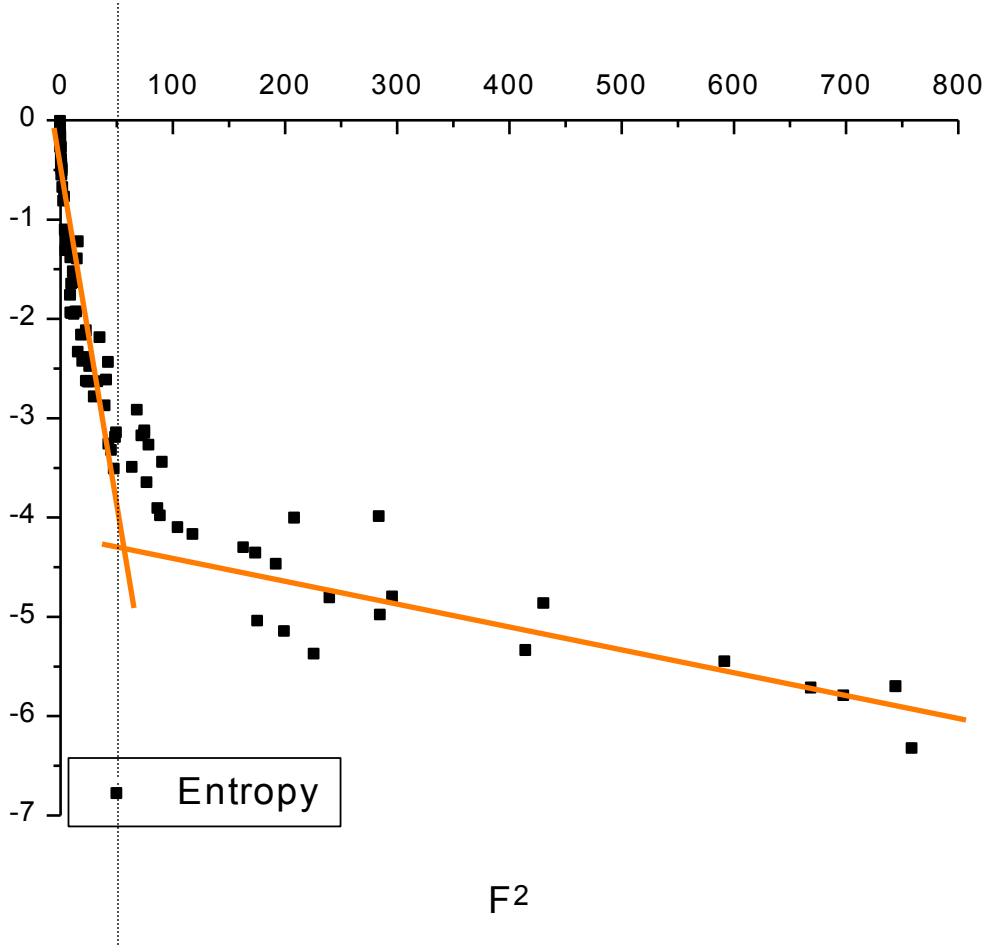
	P (z=0) (N/cm^2)	Entropy	
		Y123	Y211
Y1a	7.9	-4.97	-0.15
Y1b	2	-3.20	-0.03
Y1c	6.05	-5.16	-0.14
Y2a	7.7	-6.57	-0.11
Y2b	4.4	-4.96	-0.06
Y2c	5.8	-5.01	-0.04
Y3a	7.4	-6.36	-0.01
Y3c	7.9	-6.25	-0.01



Conclusions

- '211' and '123' phases textures are linked by heteroepitaxial-like relationship
  - c_{211} // c_{123} and b_{211} // $<110>_{123}$
  - provided by peritectic recombination
- There is a quantitative relation between Levitation Force and texture strength. Fz vs S correlation is quite linear

Entropy or Texture Index ?



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