INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

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SMR/382- 20

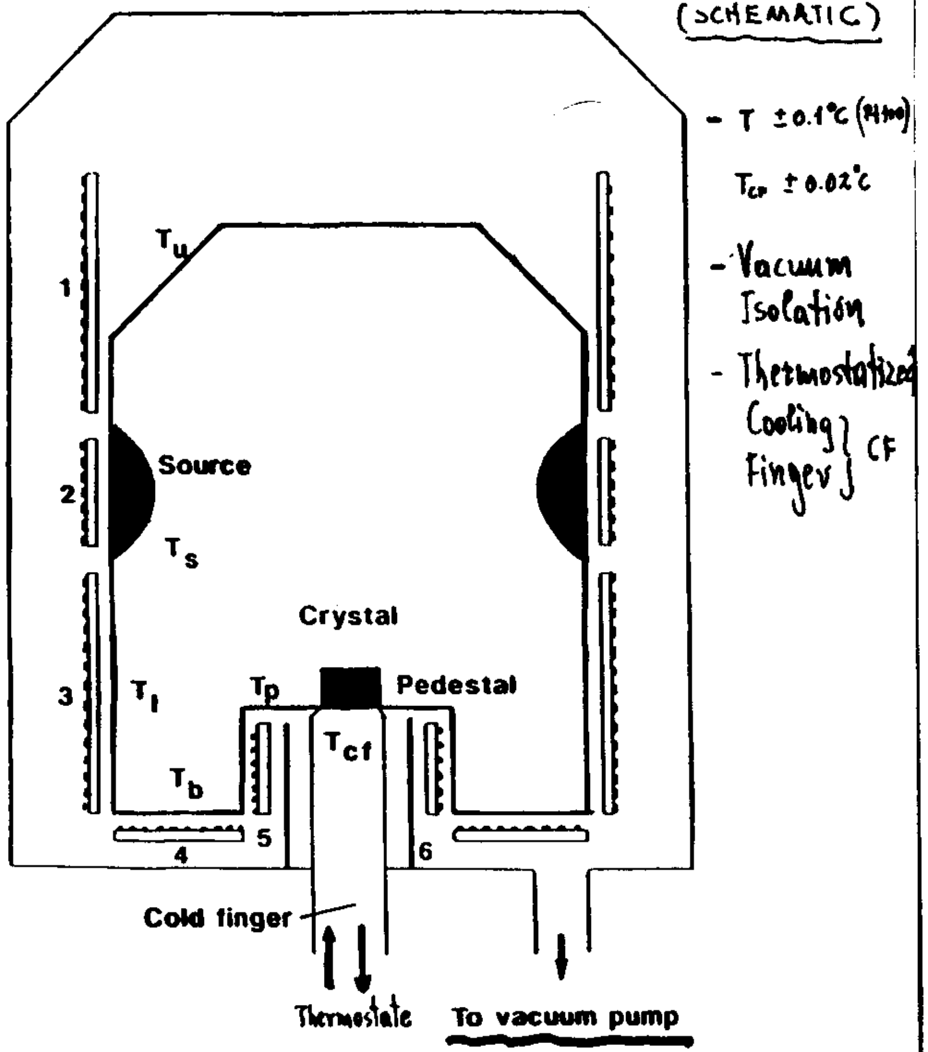
WORKSHOP ON SPACE PHYSICS:
"Materials in Micorgravity"
27 February - 17 March 1989

"Growth Rate: Ground Based"

E. KALDIS
ETH
Zurich, Switzerland

VAPOUR GROWTH TRANSPARENT FURNACE

(SCHEMATIC)



1 Upper heater
2 Source heater
3 Lowerheater
4 Bottom heater
5 Pedestal heater
6 Radiation shield

Fig. 17

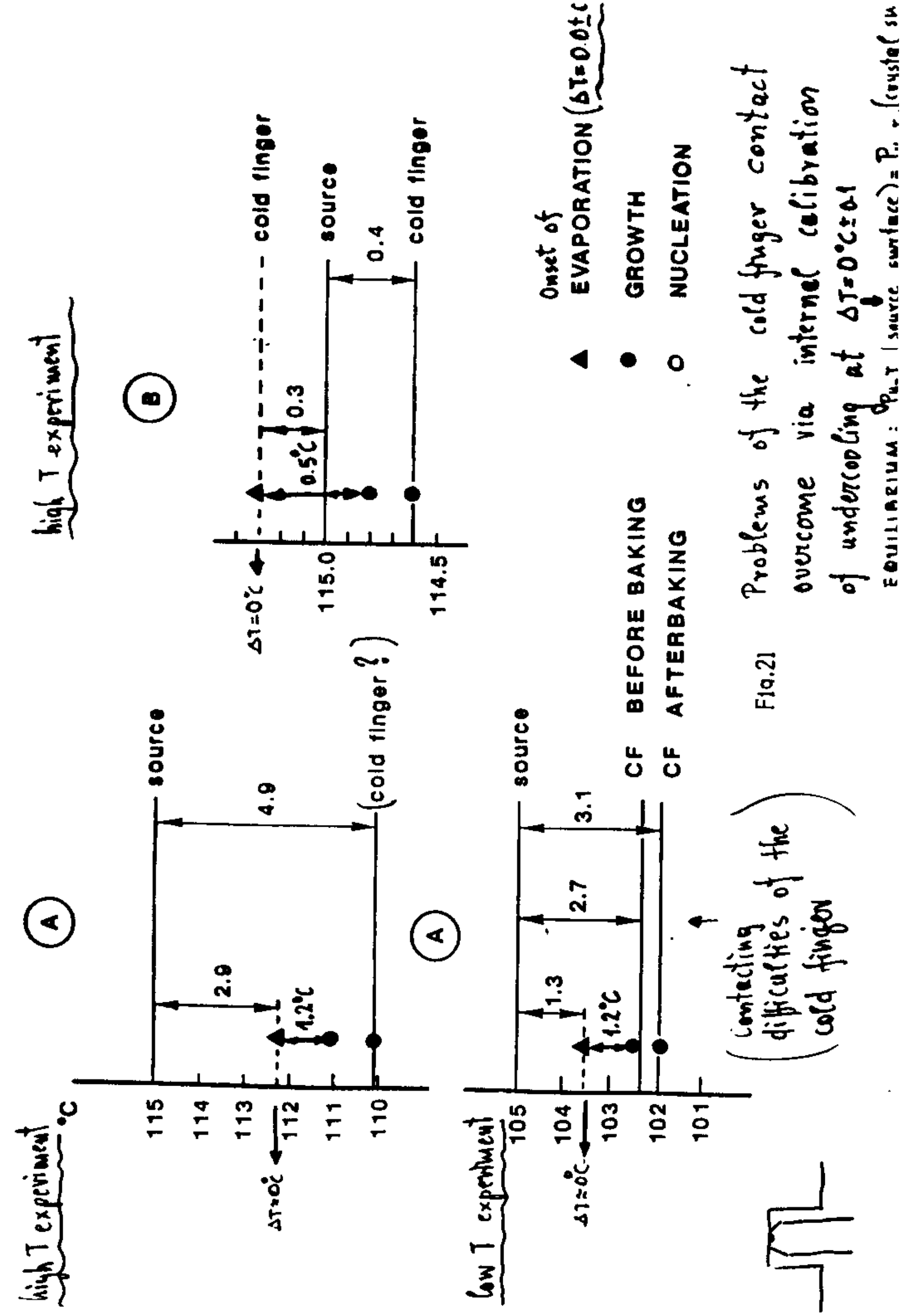


Fig. 21

TEMPERATURE MAPPING INSIDE THE AMPOULE.

Rotating T-sensor System introduces some slight errors } Drawback

Advantages:

1) T-mapping
   First panoramic view inside the ampoule.
2) Rather easy to perform.

Thermistors (Calibration with Pt-100)

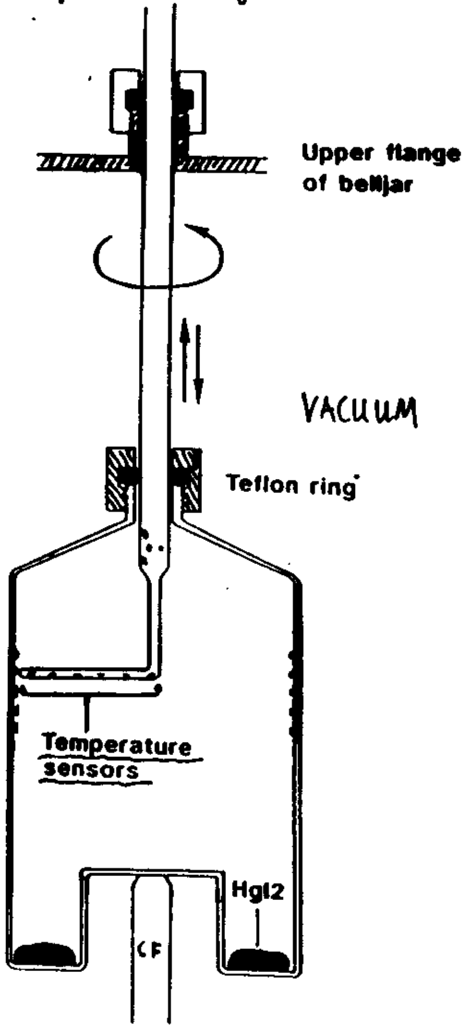
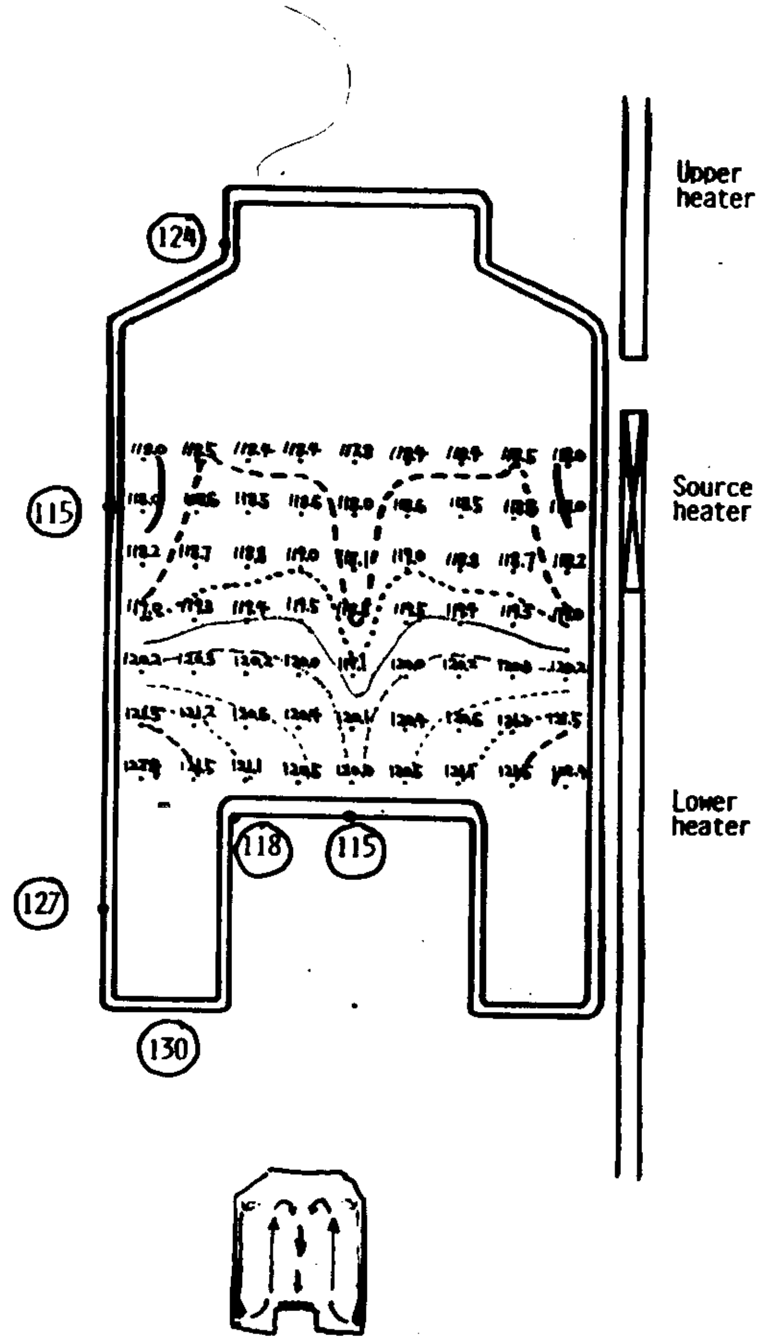


Fig.20

IN α-HgI_2 ATMOSPHERE



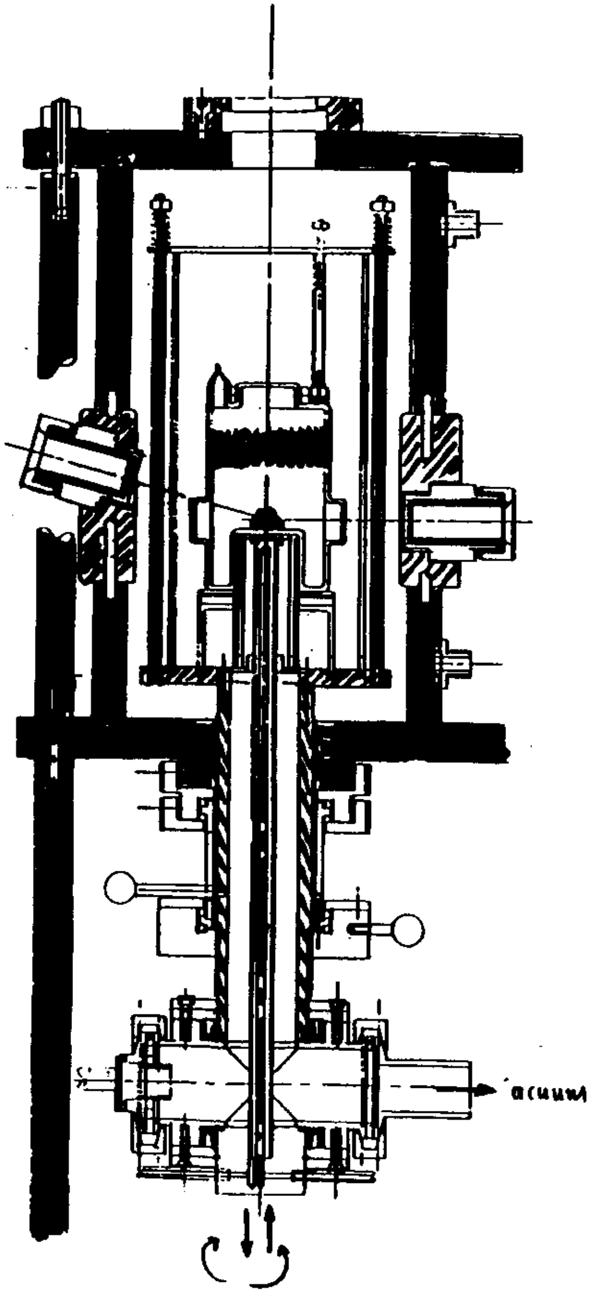

acuum

Fig.18

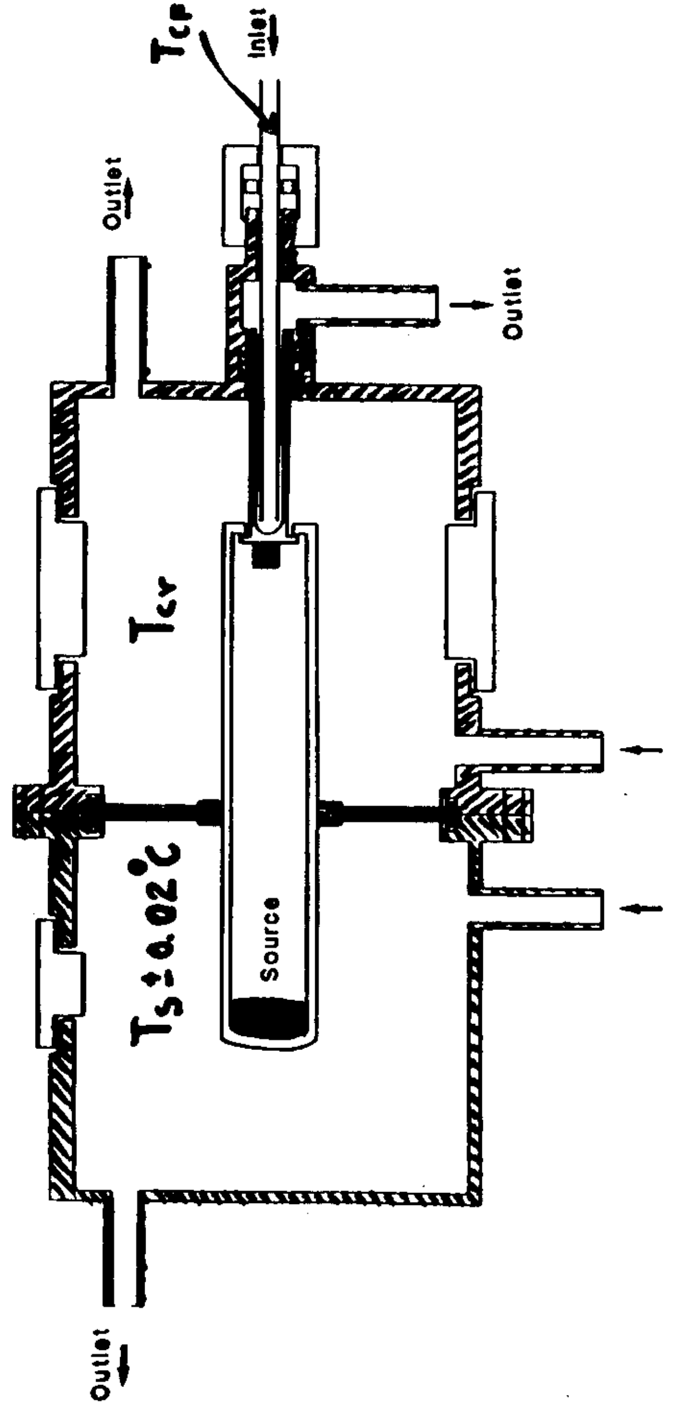

T_{cp}
Inlet
Outlet
Outlet
T_{cv}
Inlet
Inlet
Source
$T_s \pm 0.02°C$
Outlet

Fig.19

Growth rate vs time

DECREASING

1. α-HgI_2 Kobayashi et al, Cadoret et al 1983

2. Hg_2Cl_2 Singh et al 1987

This work : long term experiment (1100 hrs).

lateral + vertical } crystal size photographically measured.

- Growth rate stops after ≃ 60 hrs
- Growth curve saturation → Surface macroscopically rough (irregular multifaceting).
- Growth can continue after increase of undercooling.
- Partial evaporation → reproducible growth curve

STEPWISE GROWTH

↓

No surface cleaning effect to move growth step.

GROWTH → SIZE DEPENDENT

↓

THERMAL CONDUCTION PROBLEM ? (Anisotropy due to layer structure)

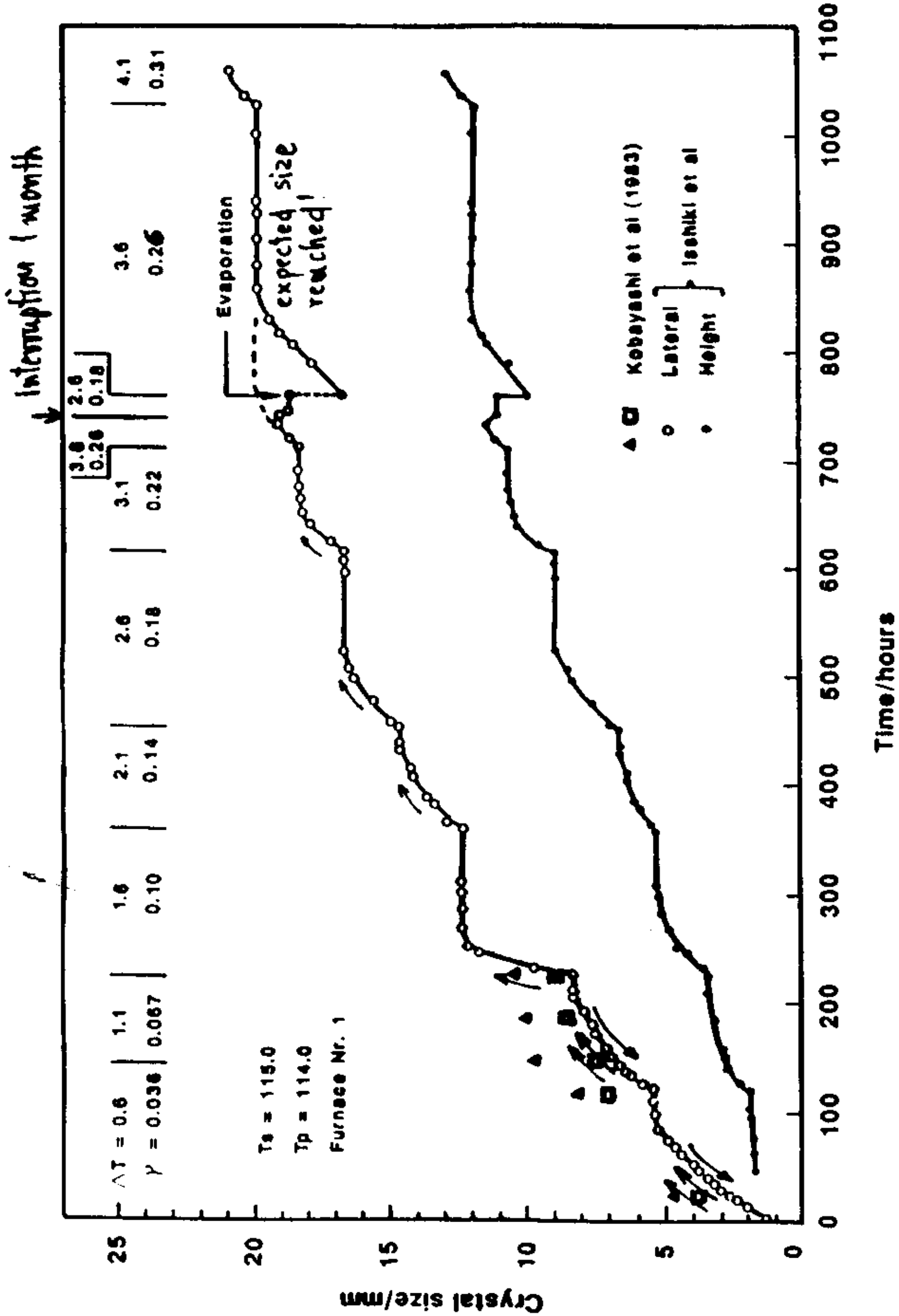


Fig.22

Thermal conductivity α-MgI_2

(De Groer et al., J. Phys. Chem. Solids 43 (1982) 311)

T=300K ‖ c-axis 0.4 W/mK

⊥ c-axis 2.0 W/mK

Assumption of calculation : Crystal surface temperature, also supersaturation, depends on heat dissipation rate → Crystal size

↓

- crystal habit → cube
  c-axis ⊥ pedestal
- growth rate vs supersaturation - parabolic.
- heat of condensation dissipated via the crystal-pedestal contact.
- Fitting to the first exp. point

Good agreement calculation ↔ experiment till the roughening stage.

Roughening (microfaceting) → Change from kinetically stabilised to equilibrium faces?

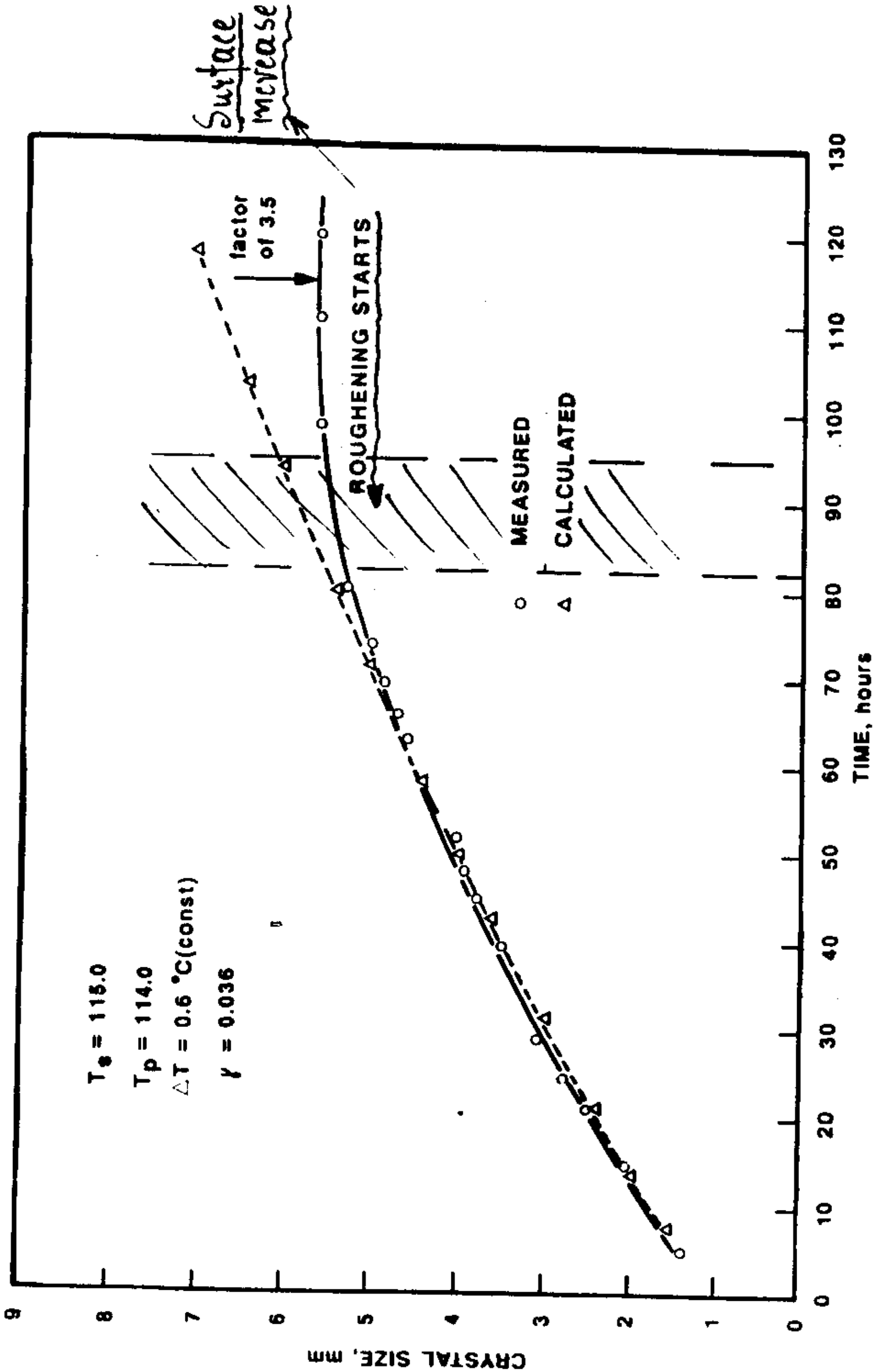
↓

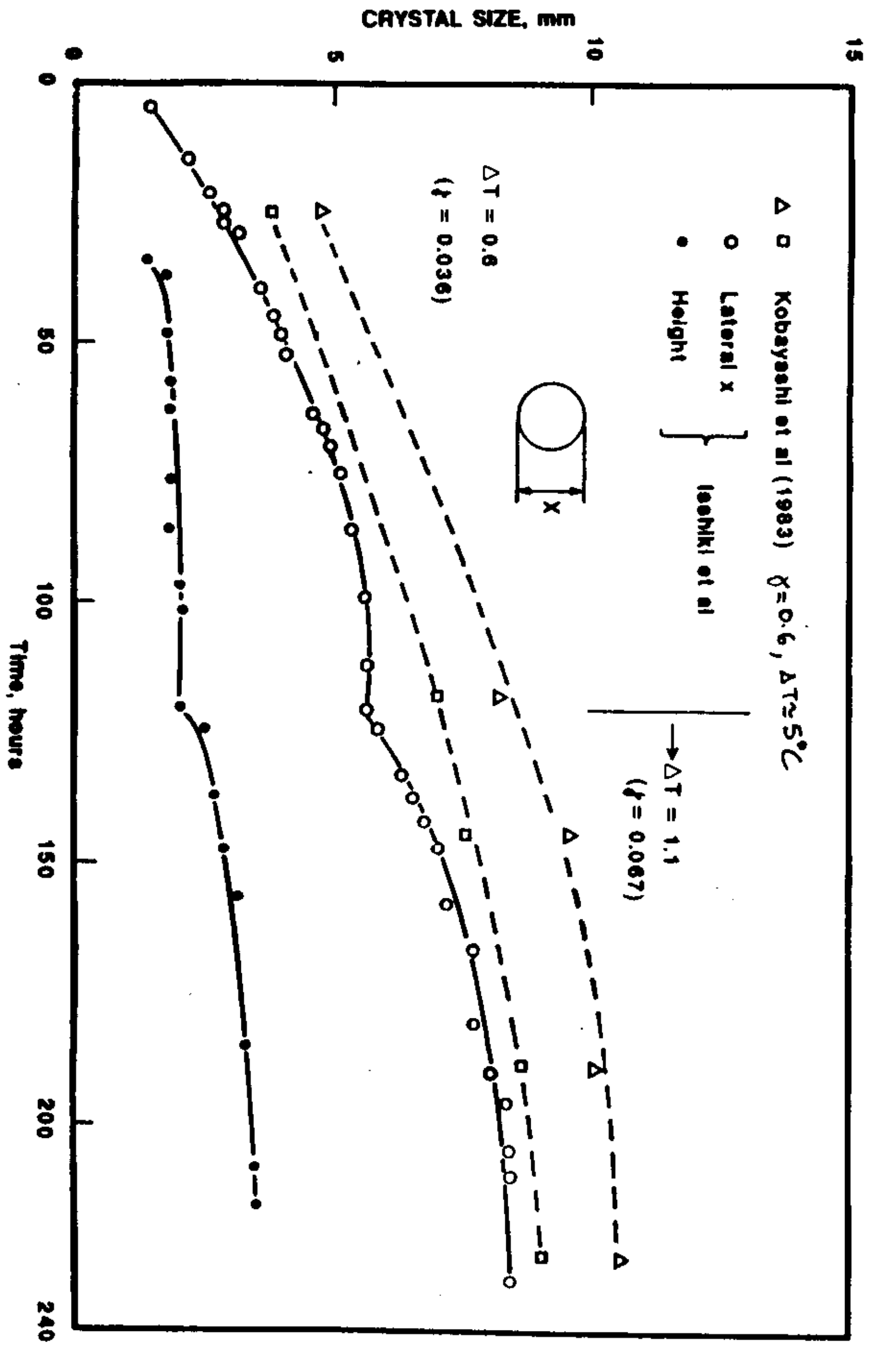
increases the condensation surface + heat of condensation

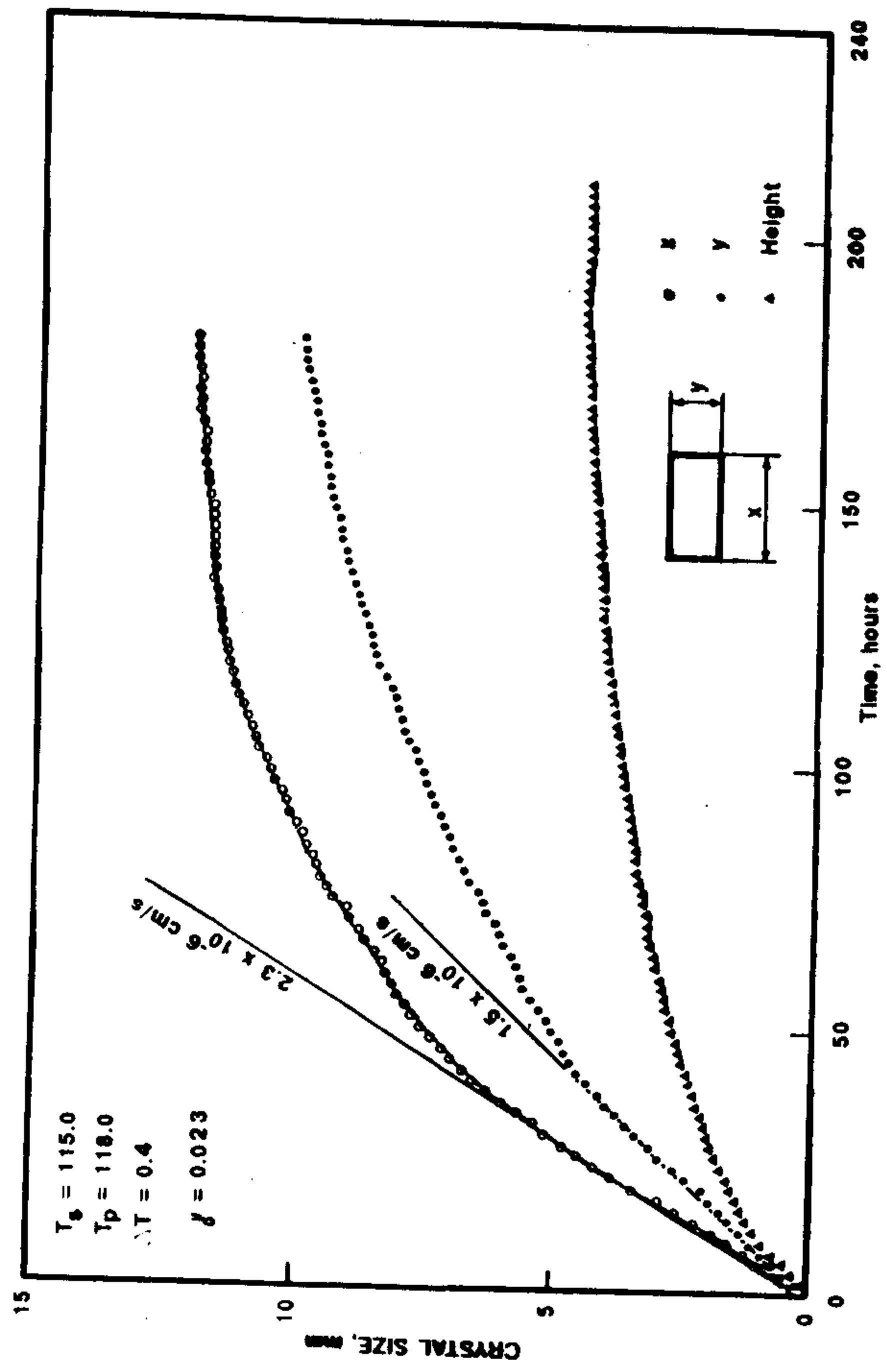
Faktor 3.5 → Agreement calculation → experiment

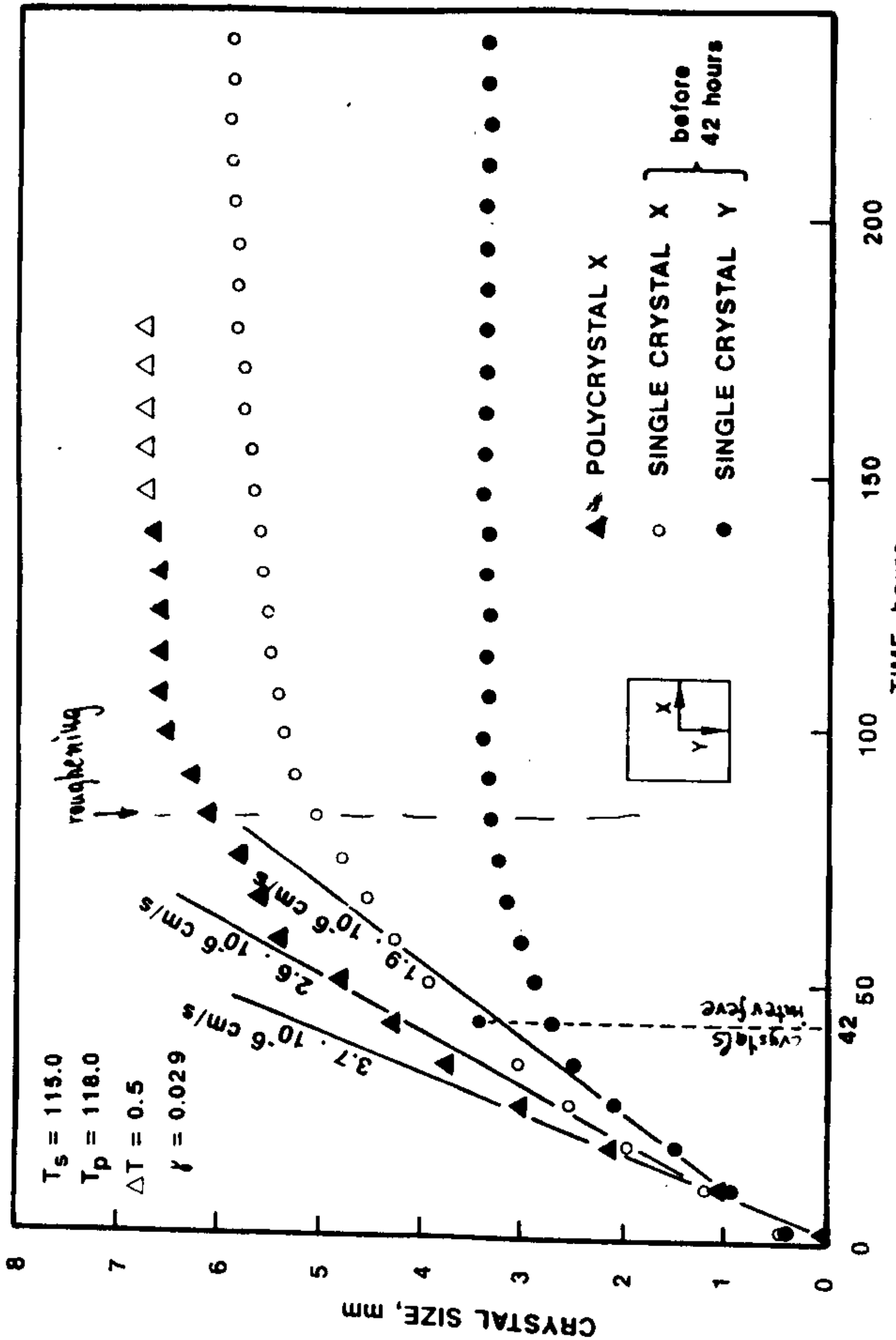
After $\Delta T_{surf} = 0$, why no relaxation and then growth?

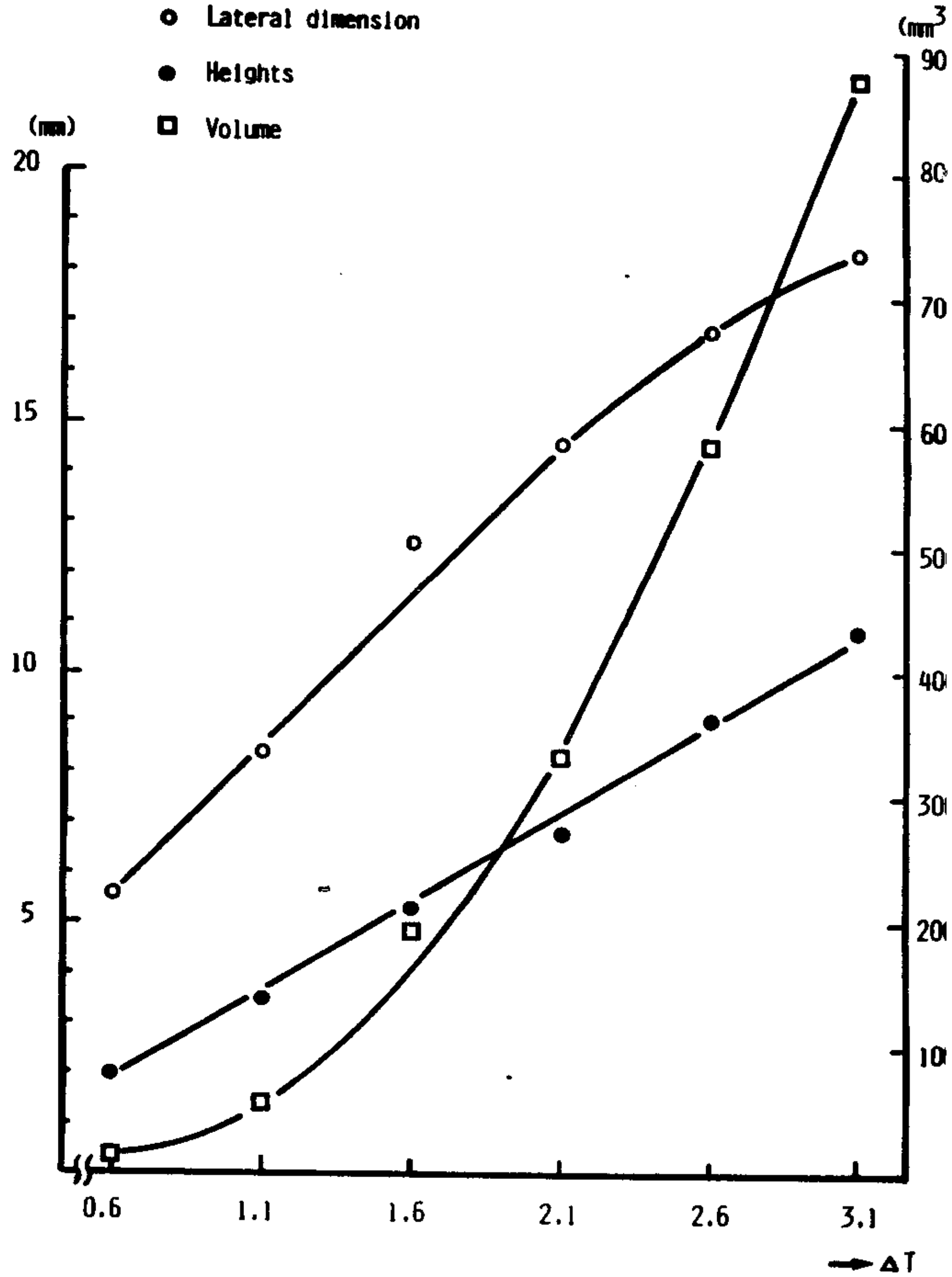
Possibly because gas heat dissipation continuous.



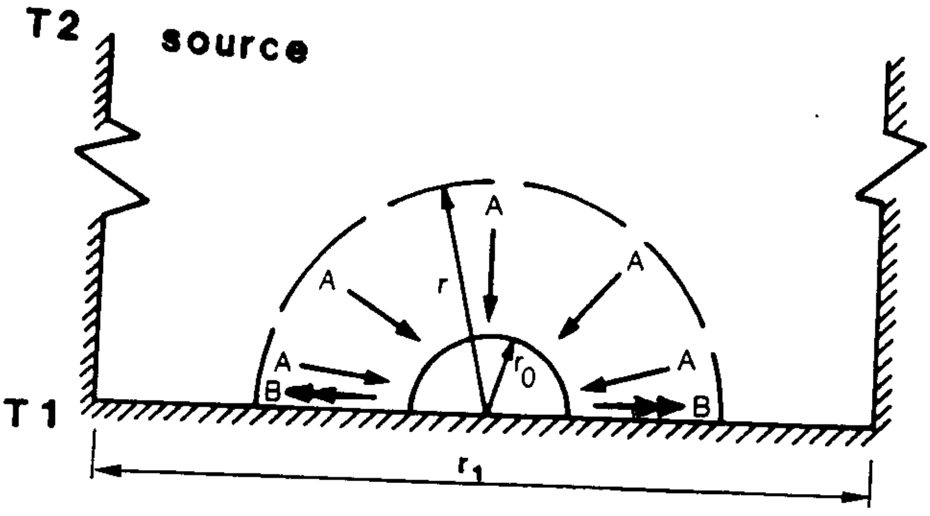

CRYSTAL SIZE, mm
Time, hours
Kobayashi et al (1983) γ=0.6, ΔT≈5°C
Lateral x
Height
Ieshiki et al
ΔT = 0.6
(γ = 0.036)
ΔT = 1.1
(γ = 0.067)
x


CRYSTAL SIZE, mm
Time, hours
x
y
Height
2.3 x 10-6 cm/s
1.5 x 10-6 cm/s
Ts = 115.0
Tp = 118.0
ΔT = 0.4
γ = 0.023

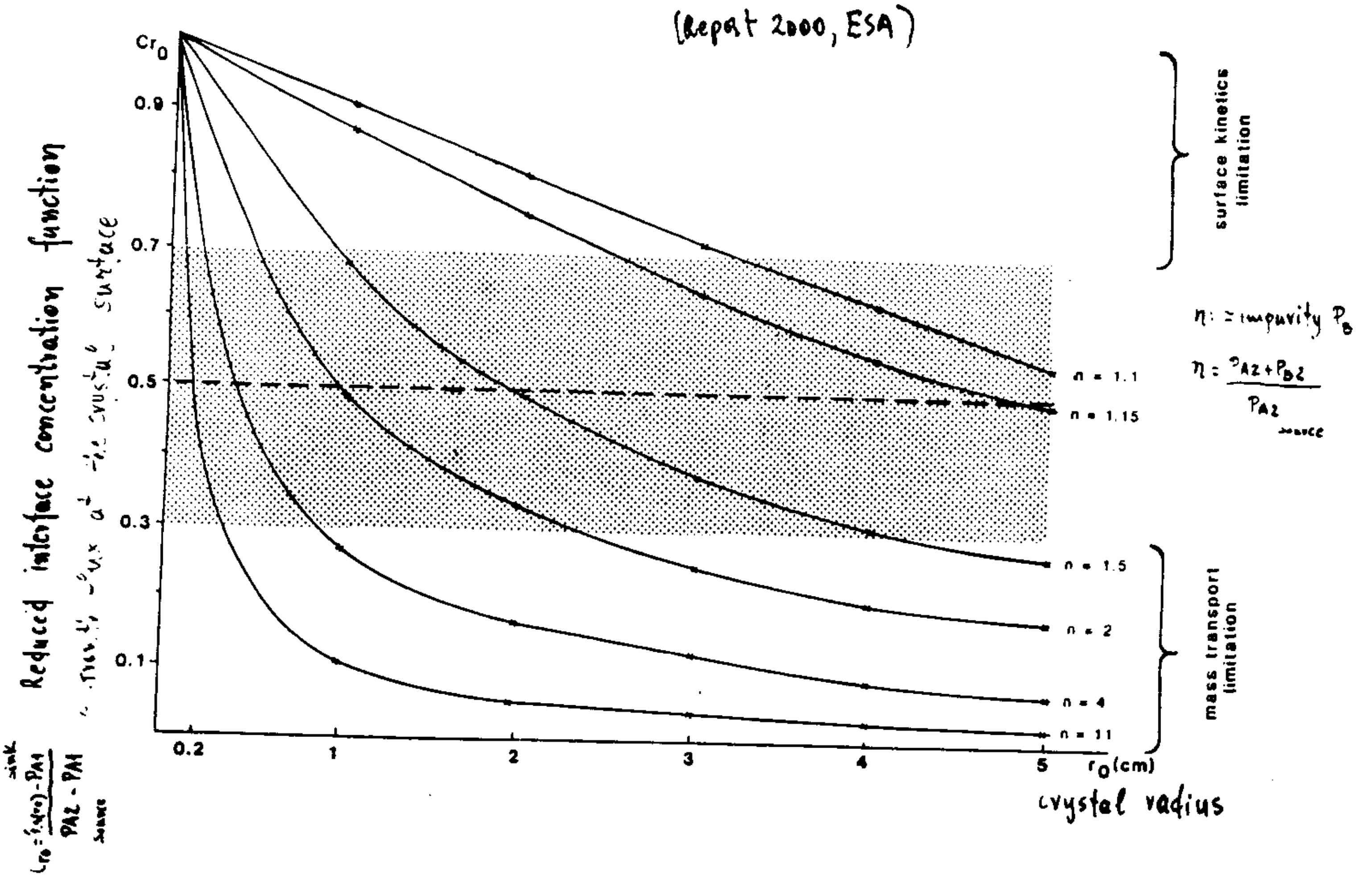

CRYSTAL SIZE, mm
TIME, hours
POLYCRYSTAL X
SINGLE CRYSTAL X
SINGLE CRYSTAL Y
before 42 hours
T_s = 115.0
T_p = 118.0
ΔT = 0.5
γ = 0.029
1.9 . 10^6 cm/s
2.6 . 10^6 cm/s
3.7 . 10^6 cm/s
roughening

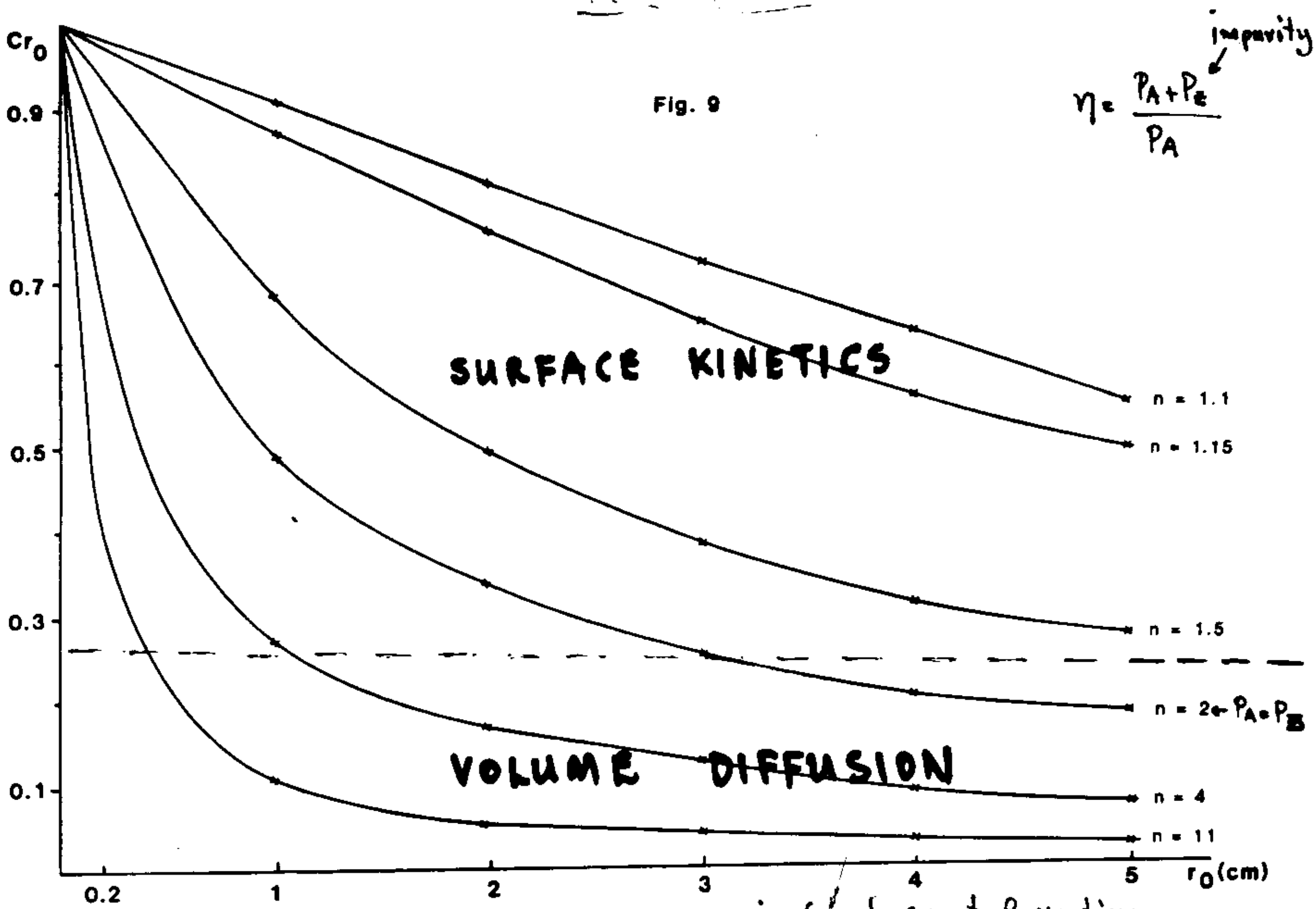

Lateral dimension
Heights
Volume
(mm)
(mm^3)
ΔT

After Cadoret (ESA Report 2000)



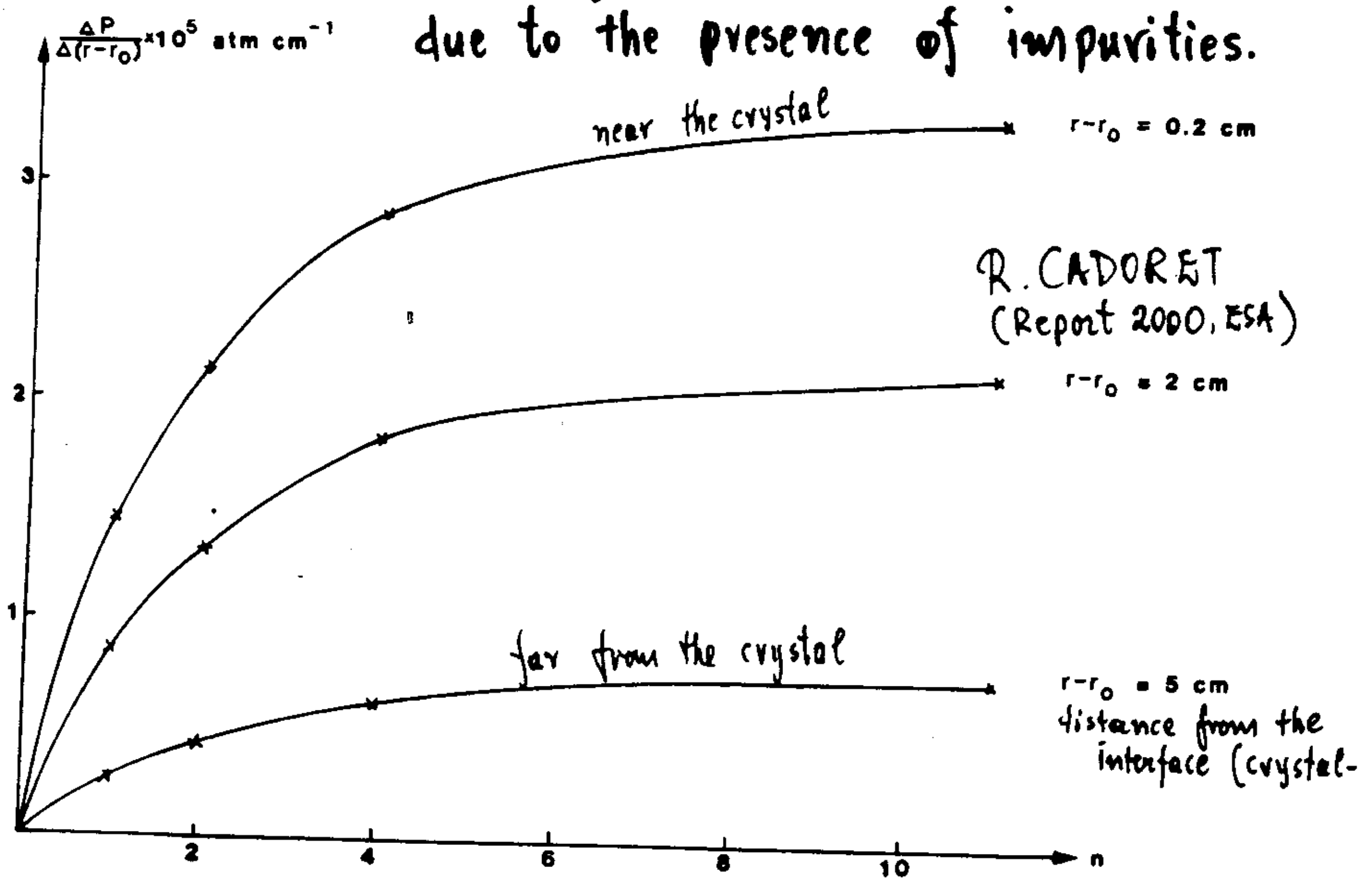
R. Cadoret
(Report 2000, ESA)





at the crystal interface as f' of crystal radius

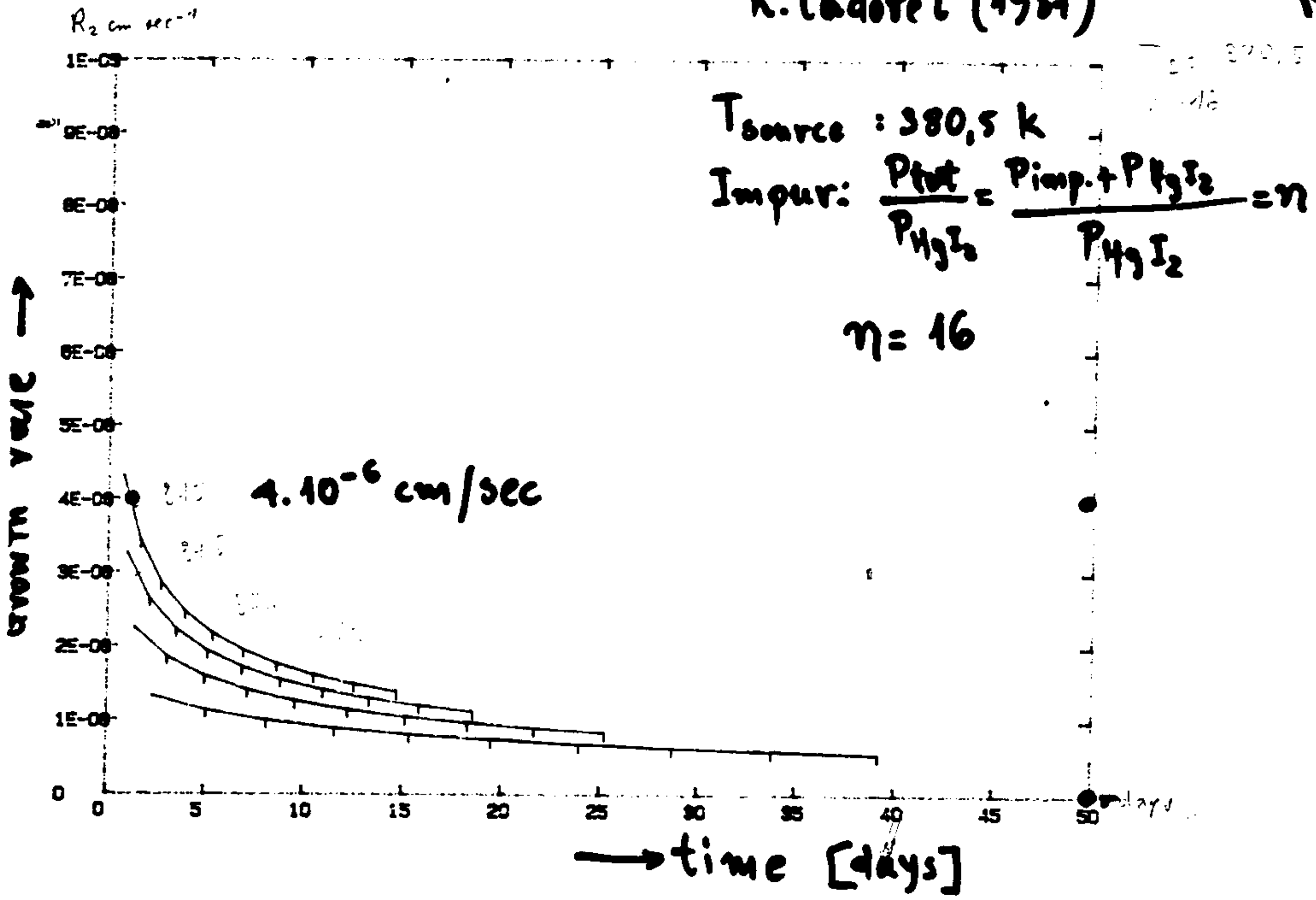
Pressure gradient of the α-HgI_2 molecules due to the presence of impurities.



R. CADORET
(Report 2000, ESA)

→ increasing impurities concentration

R. Cadoret (1987)



R. Cadoret (1987)