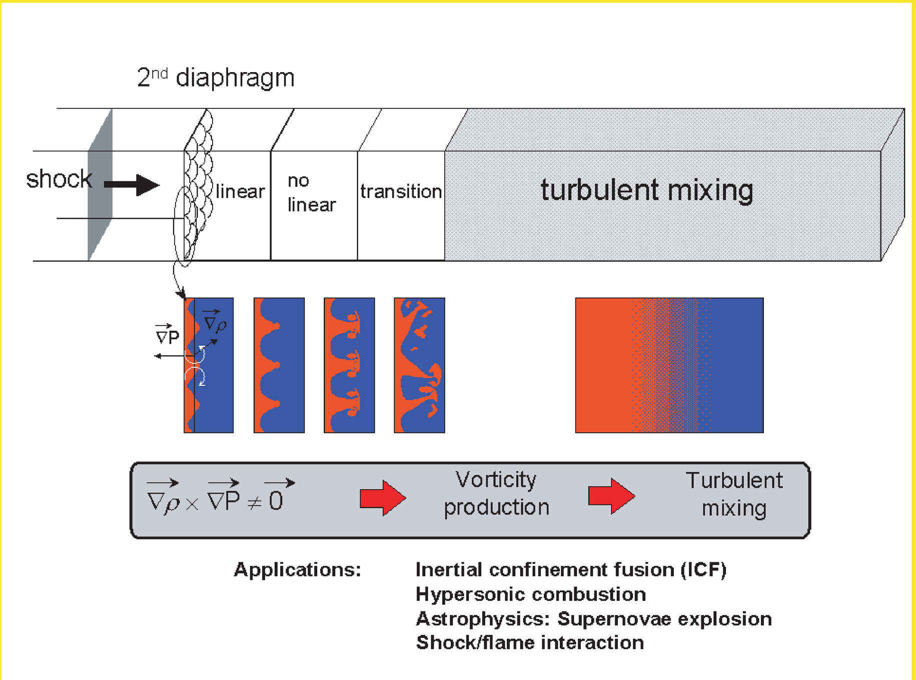
MEASUREMENTS WITHIN A RICHTMYER-MESHKOV MIXING ZONE USING A TRIPLE HOT WIRE PROBE TECHNIQUE

L. SCHWAEDERLE*, G. JOURDAN*, L.HOUAS* and J.-F. HAAS♣
*IUSTI, UMR CNRS 6595, Université de Provence, Technopôle de Château-Gombert, 5 rue Enrico Fermi, 13453 Marseille Cedex 13, FRANCE
♣CEA-DAM, Ile de France, BP 12, 91680 Bruyères-le-Chatel, FRANCE

I- INTRODUCTION

Present research topic: Characterization of a turbulent mixing zone (TMZ) induced by the Richtmyer- Meshkov instability (RMI) in a shock tube



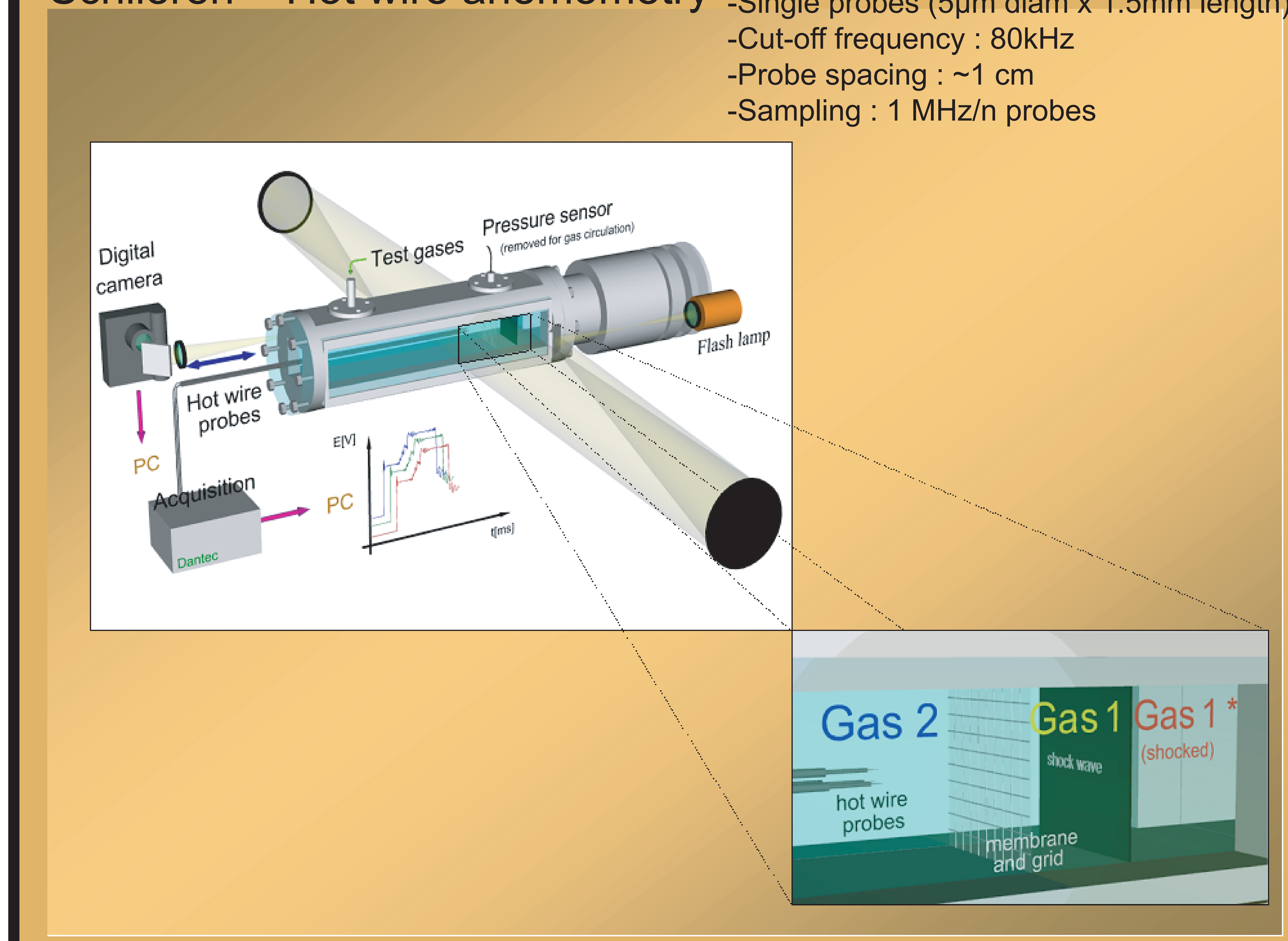
- Global characterization : visual structures, thickness
- Time evolution of local measurements (molar fraction and velocity)
- Turbulent energy level

Schlieren visualizations
+
Laser Doppler anemometry (CEA/DAM)
Constant temperature hot wire anemometry (IUSTI)

II- EXPERIMENTAL SET-UP

Schileren + Hot wire anemometry

- Constant temperature
- Single probes (5µm diam x 1.5mm length)
- Cut-off frequency : 80kHz
- Probe spacing : ~1 cm
- Sampling : 1 MHz/n probes

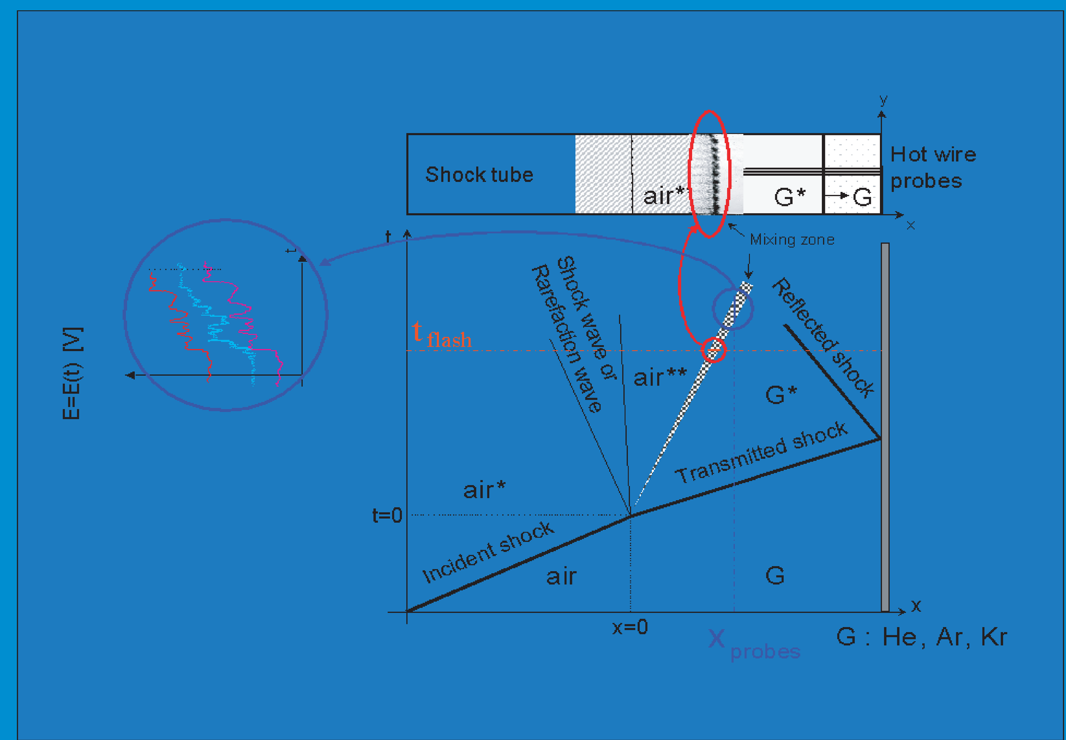


Double diaphragm shock tube
- Square cross section 85x85 mm2
- 1st diaphragm : aluminium membrane (0.8 mm thick)
- 2nd diaphragm : mylar (0.9 µm thick) or nitrocellulose (0.5 µm thick) film resting over a 100 cells or a 7225 cells grid

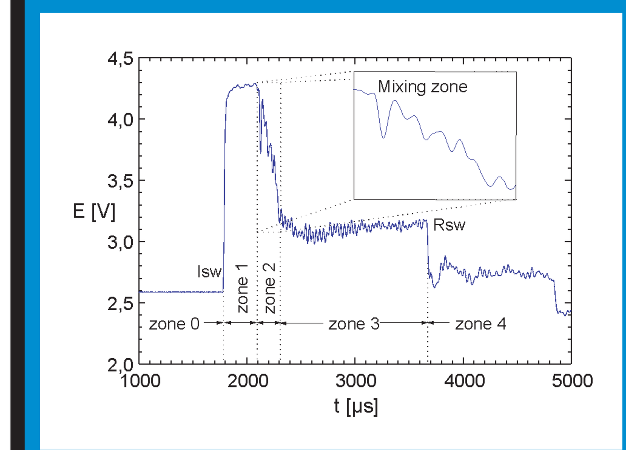
III- PRINCIPLE OF MEASUREMENTS

HWA output versus time

- **Reynolds number**
- **species molar fraction**
- **velocity**



Principle Heat transfer from the heated wire to the gaseous flow which depends on both the properties of the gas (μ, λ) and the parameters of the flow (U, T, ρ)



Infinitely long wire:

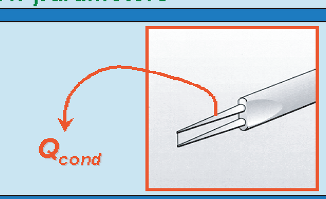
$$\frac{R_W}{(R_1+R_L+R_W)^2}\frac{E^2}{T_W-T}\frac{1}{\lambda}=\left[0{,}42\,\pi\, l\,Pr^{0.2}\right]+\left[0{,}57\,\pi\, l\,Pr^{0.33}\right]\left(\frac{\rho U d}{\mu}\right)^{0.5}$$

$$E=f(T,\rho,U,\lambda,\mu)$$

E depends on both the electrical bridge data (known) and the instantaneous variations of the flow parameters

Finite length wire:

$$\frac{R_W}{(R_1+R_L+R_W)^2}\frac{E^2}{T_W-T}\frac{1}{\lambda}=A'+B'\left(\frac{\rho U d}{\mu}\right)^{n'}$$



A', B' and n obtained by calibration

Hypothesis: constant temperature within the mixing

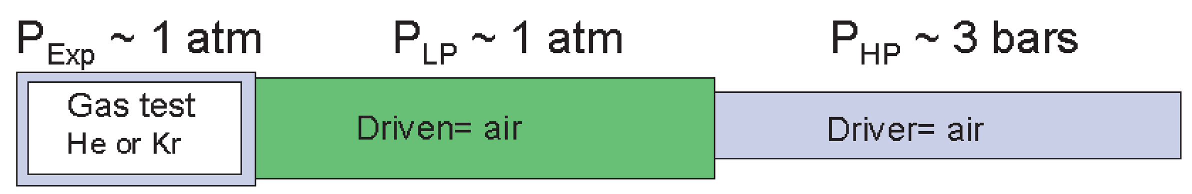
➡ E=f(x,U,A,B,n)

Two ways of calibration :
- graphical method (in pure and pre-mixed gases)
- direct method (A, B and n determined for each run)

➡ E=f(x,U)

- resolution of the system (inverse method)

IV- INITIAL CONDITIONS

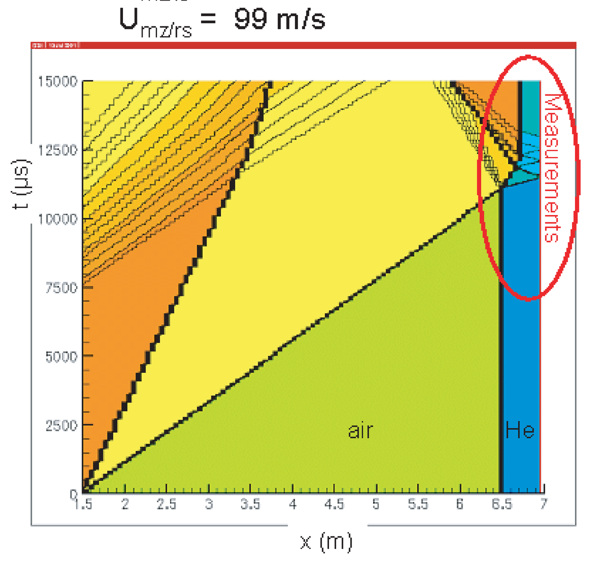


M_{is} ~ 1.32 in air W_{is} ~ 460 m/s

Heavy/light case (air/He)

$A_{air/He}=\frac{\rho_{He}-\rho_{air}}{\rho_{He}+\rho_{air}}=-0.7$

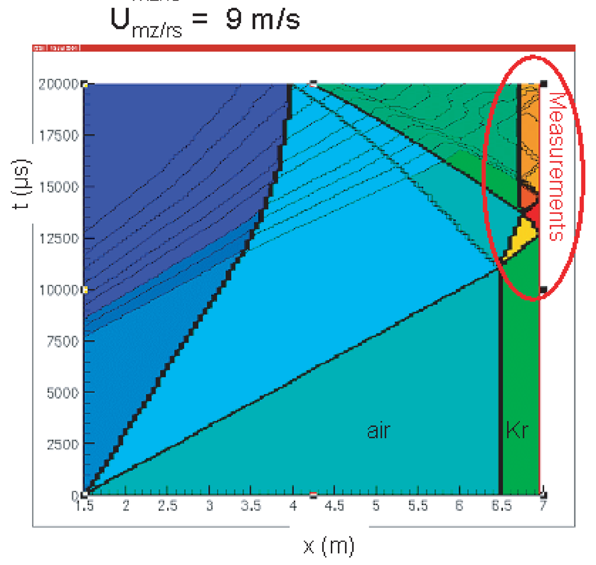
W_{ts}=1111 m/s
$U_{mz/is}$ = 226 m/s
$U_{mz/rs}$ = 99 m/s



Light/heavy case (air/Kr)

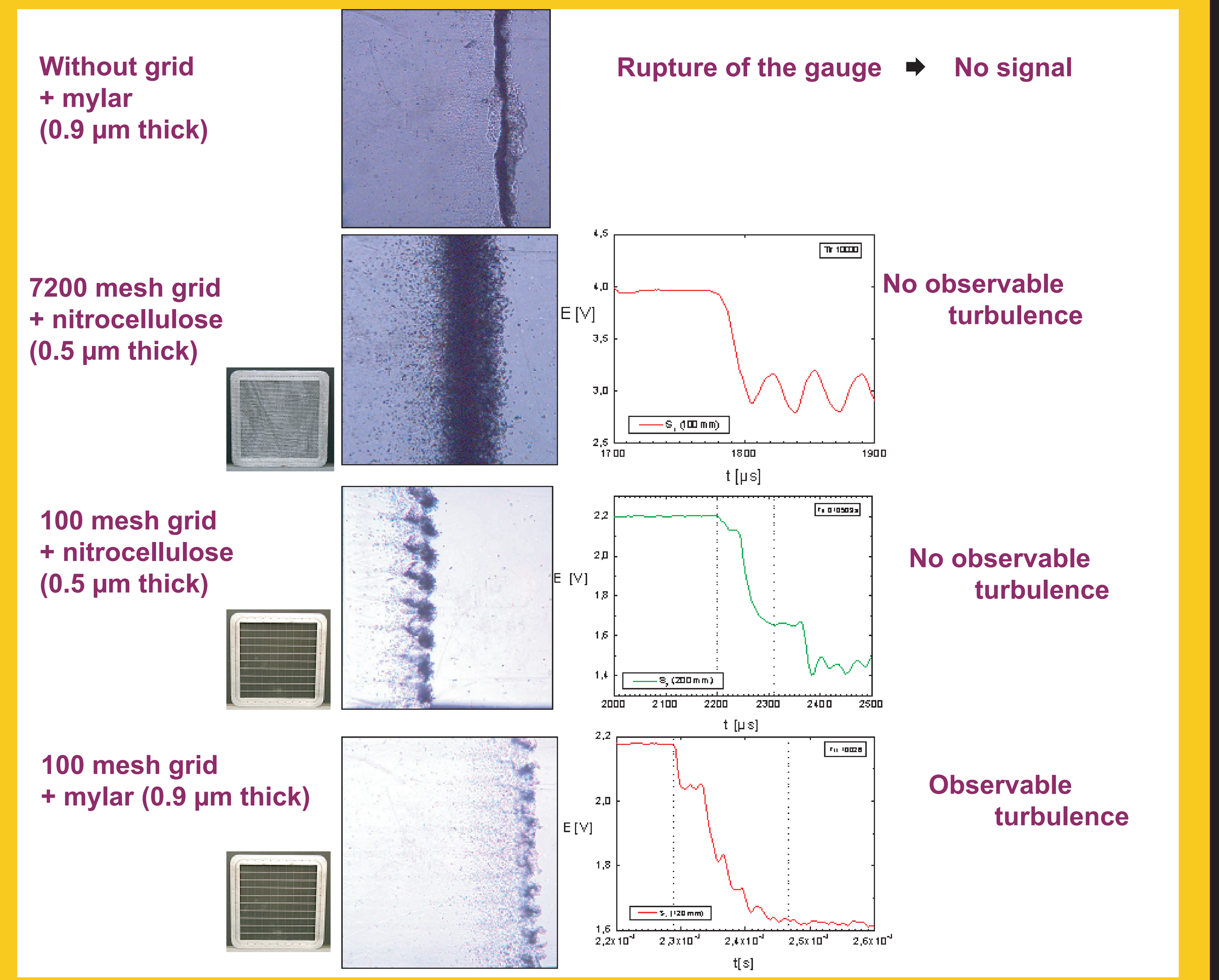
$A_{air/Kr}=\frac{\rho_{Kr}-\rho_{air}}{\rho_{Kr}+\rho_{air}}=+0.5$

W_{ts}=322 m/s
$U_{mz/is}$ = 115 m/s
$U_{mz/rs}$ = 9 m/s



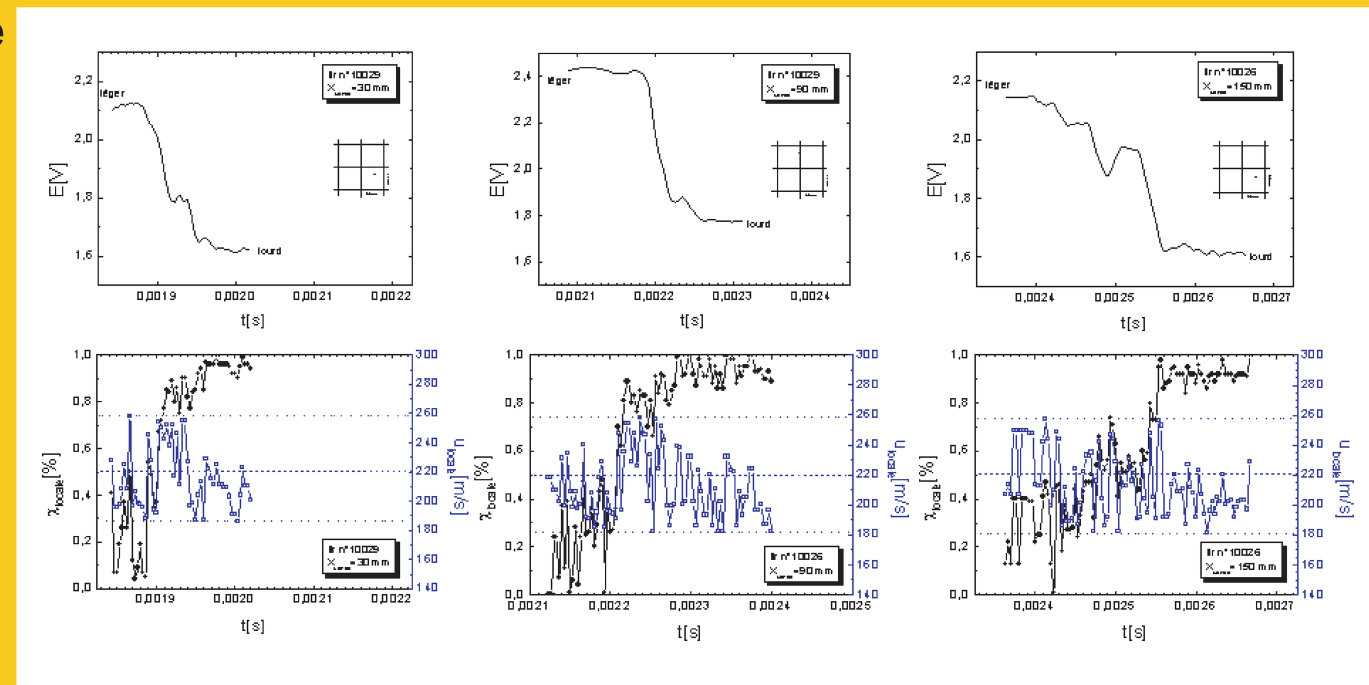
V- RESULTS

Optimal conditions

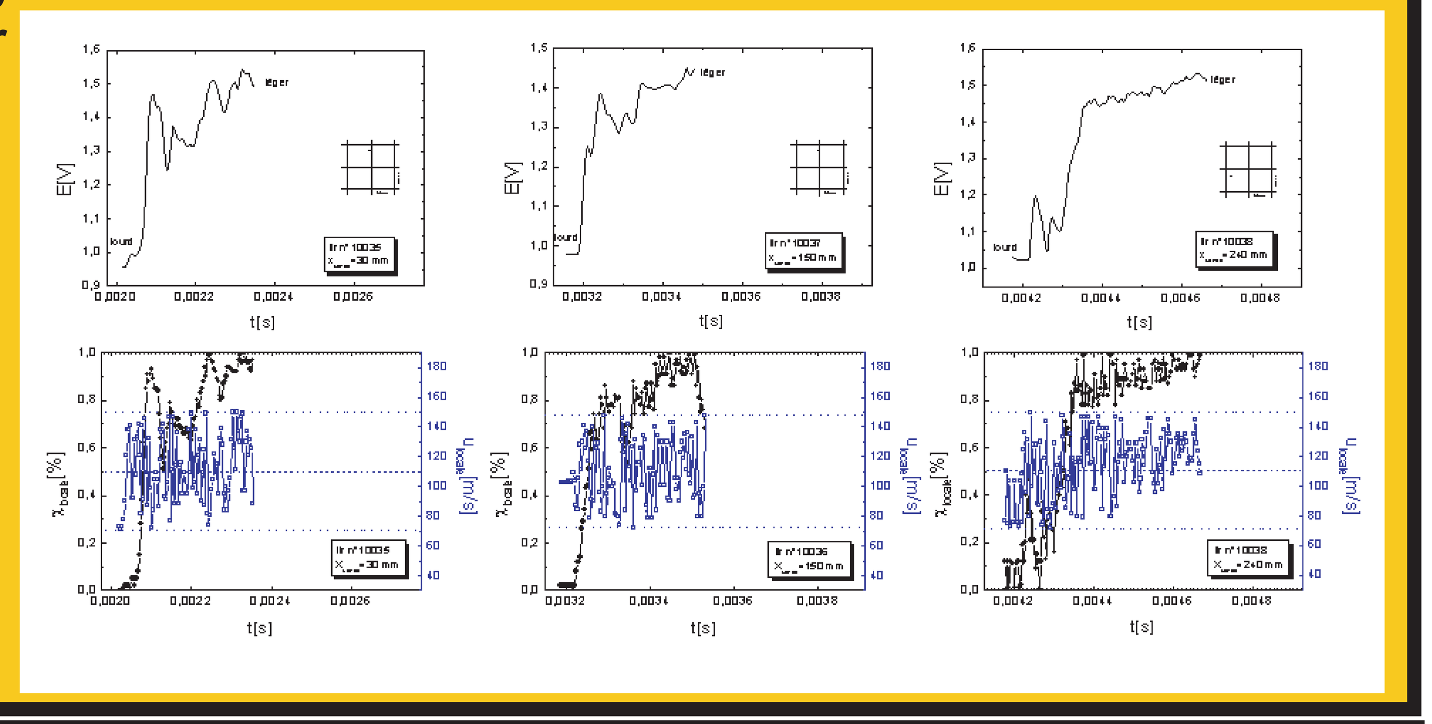


Species molar fraction and velocity profiles

Heavy/light case
air/He



Light/heavy case
air/Kr



VI- CONCLUSION

- **First exploitation of the constant temperature hot wire anemometry for the study of a turbulent mixing induced by Richtmyer-Meshkov instability in shock tube.**
- **Special experimental conditions have permitted the hypothesis of constant temperature within the mixing.**
- **Suitable calibration and signal data processes have allowed to determine the local species molar fraction and velocity within the mixing zone.**