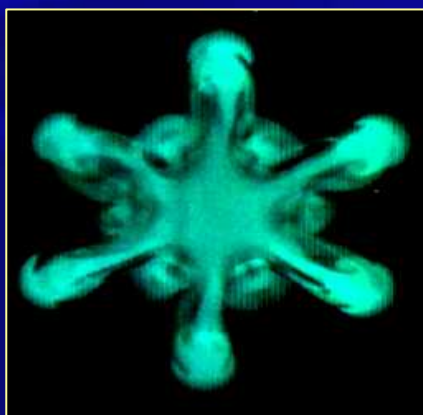
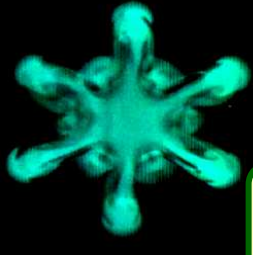


INDUBAT: Diffuseur à haute induction dans le bâtiment

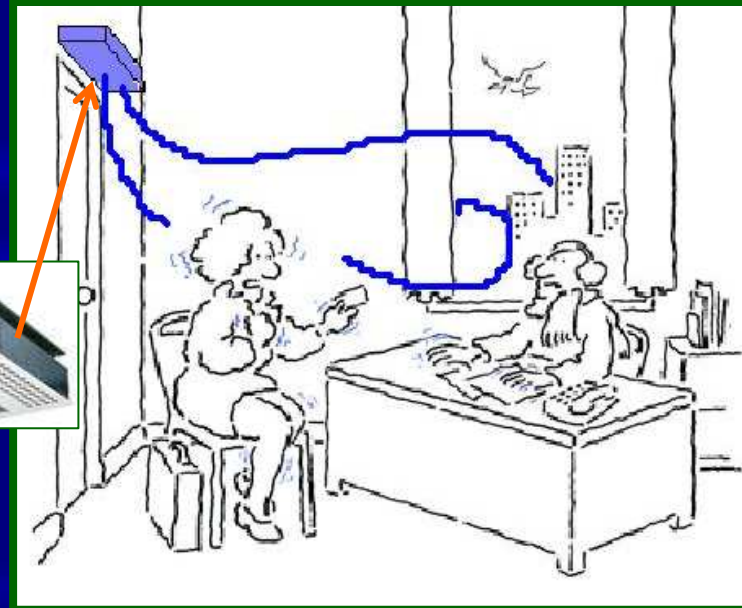
Amina MESLEM, Laboratoire d'Etude des Phénomènes de Transfert et de l'Instantanéité :
Agro-industrie et Bâtiment (LEPTIAB) – Université de La Rochelle
Colloque PREBAT – Perpignan 3-5 juin 2008





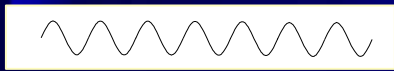
Problématique

Inconfort des usagers du traitement d'air



Besoin de nouveaux moyens de contrôle des jets d'air

→ Moyens actifs : Excitation acoustique ou mécanique

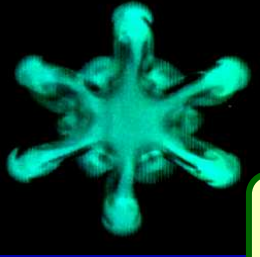


→ Moyens passifs – de mise en œuvre pratique et moins coûteuse:

Soufflage par des buses asymétriques



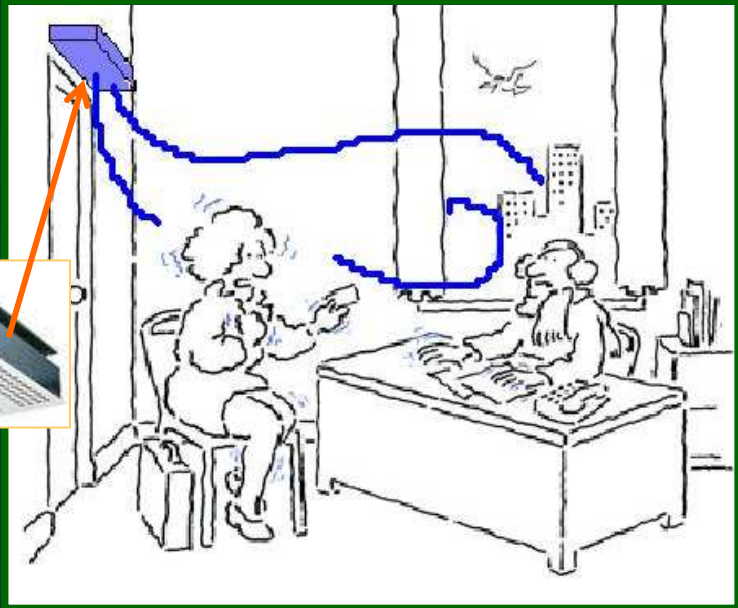
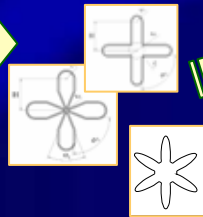
grosses structures tourbillonnaires génératrices de mélange



Problématique

~~Inconfort des usagers du traitement d'air~~

diffuseurs asymétriques



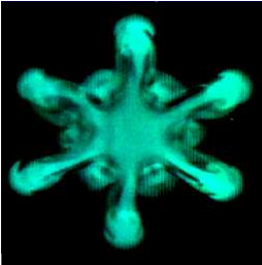
forte induction

UTDa – haute induction

→ amélioration du confort thermique

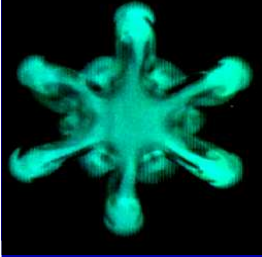
→ réduction de la taille des systèmes

Economie d'énergie



Objectif :

Rechercher des moyens efficaces et peu coûteux permettant l'amélioration de l'auto-induction des jets en vue de leur intégration dans les Unités Terminales de Diffusion d'air

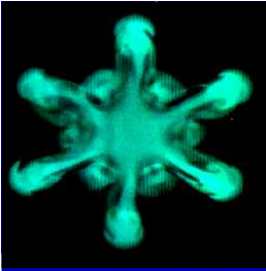


Repères bibliographiques

→ Données disponibles dans la littérature non exploitables dans le domaine du bâtiment

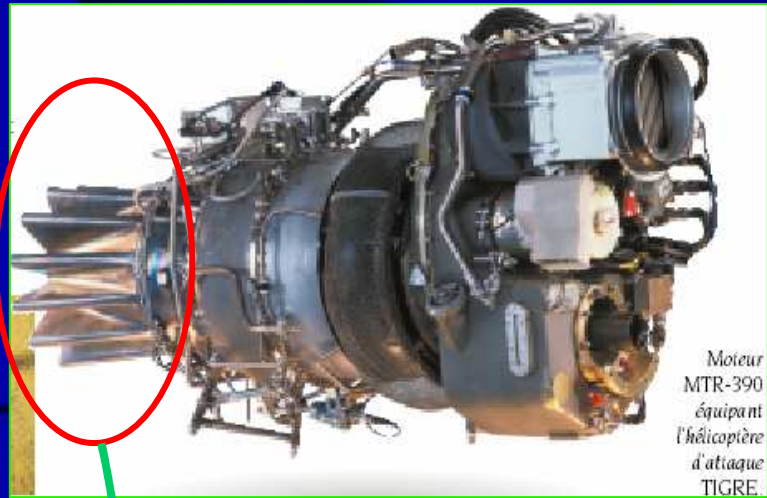
→ La littérature permet de dégager des géométries lobées de base que nous avons adaptées au double objectif fixé:

- Introduire ces géométries dans les UTDa du bâtiment
- Analyser le phénomène d'auto-induction du jet pour son exploitation optimale dans notre domaine



Buses lobées étudiées

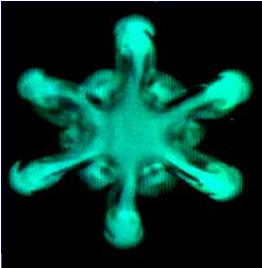
Applications actuelles :
éjecteurs et injecteurs



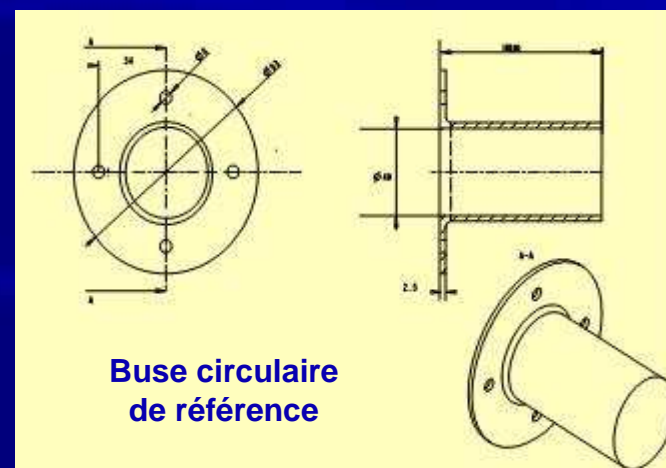
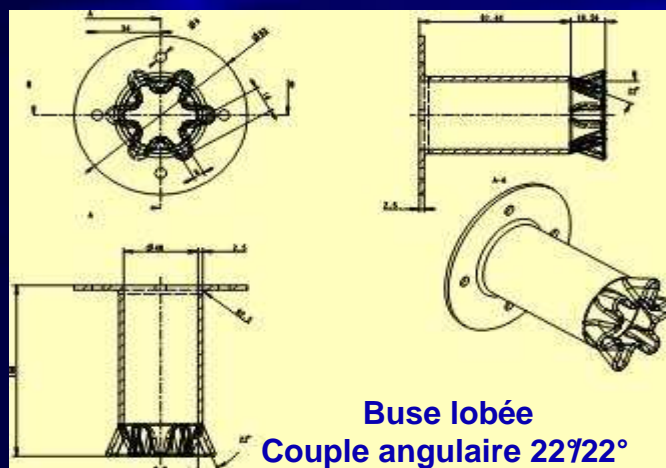
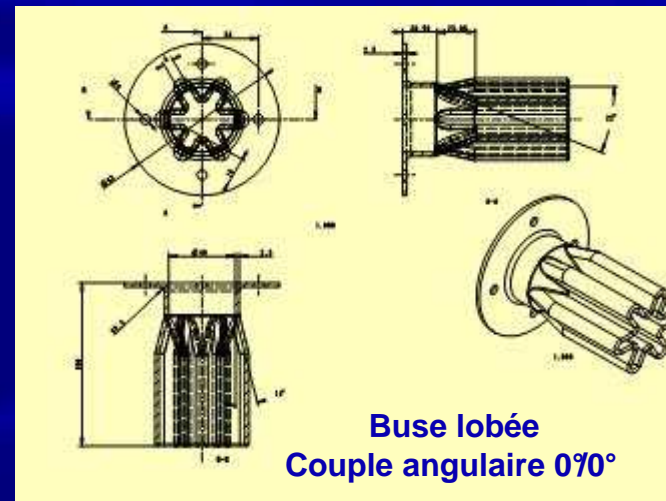
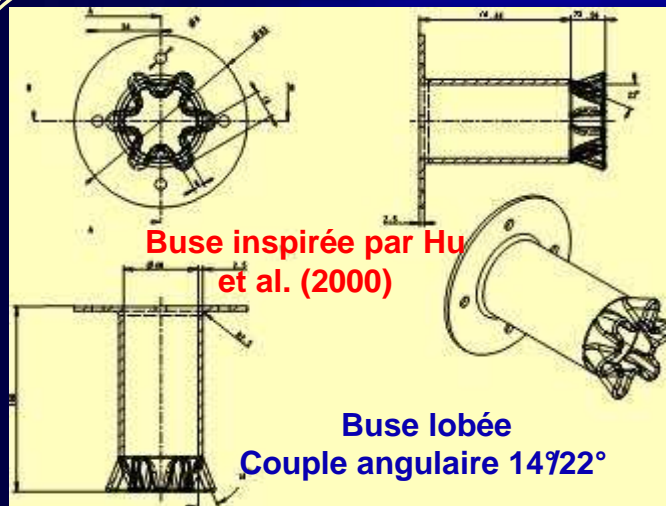
Moteur
MTR-390
équipant
l'hélicoptère
d'attaque
TIGRE.

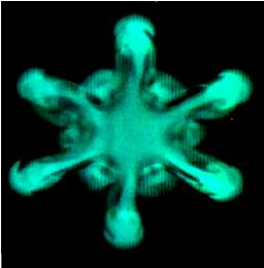
Application proposée :
UTDa à buses lobées





Buses lobées étudiées

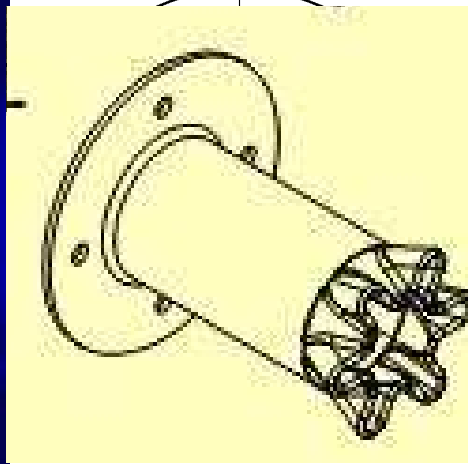




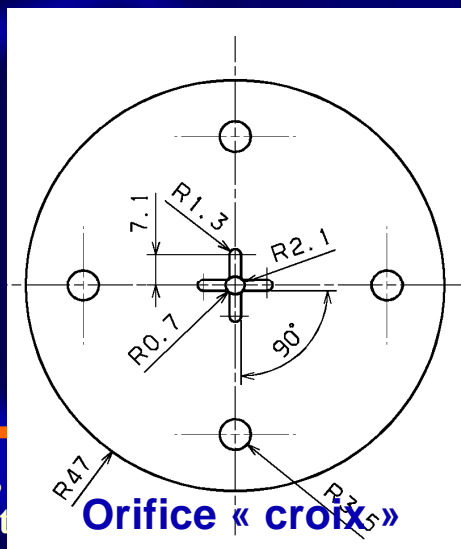
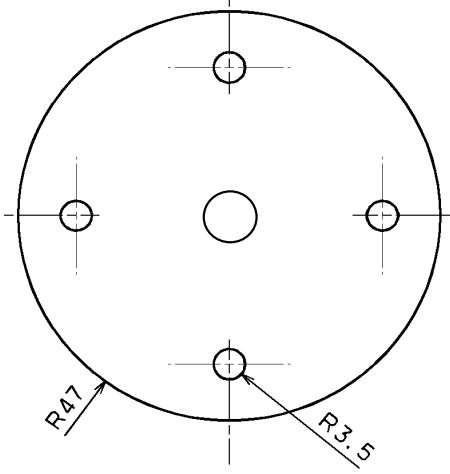
Orifices lobés étudiés

→ une idée en accord avec les critères d'esthétique dans les espaces de vie : passage de BUSE à ORIFICE

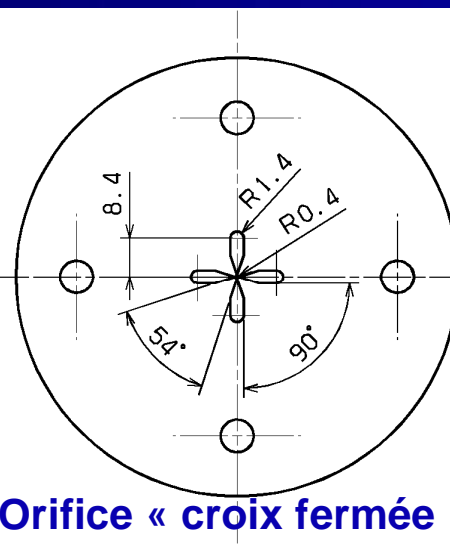
Orifice « marguerite »



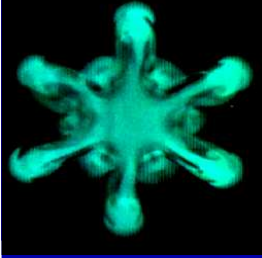
Orifice circulaire



Orifice « croix »

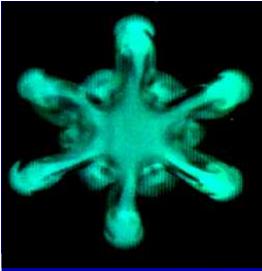


Orifice « croix fermée »



Démarche expérimentale et moyens

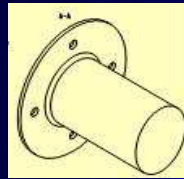
- ★ Tomographie Laser rapide - caméra Nanosense MKII, $f_{\text{acq}}=500-5000\text{Hz}$ pour une fenêtre de 512×512 pixels², laser Nanopower 4W, 795nm
- ★ Anémométrie à fil chaud 1 composante
- ★ Anémométrie à Laser Doppler 2 composantes, laser solide Yag 25mW, 514.5nm et laser solide Saphire 22mW, 488nm
- ★ Vélocimétrie par images de particules 2 composantes classique grand champ
- ★ Et depuis peu, vélocimétrie par images de particules rapide 3 composantes



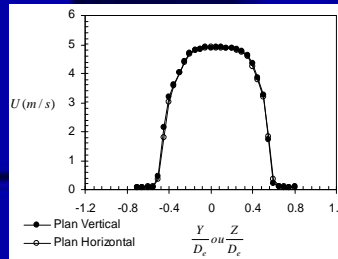
Jets lobés de Buses

Conditions de soufflage

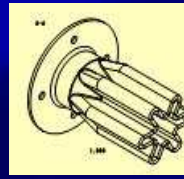
Buse circulaire de référence



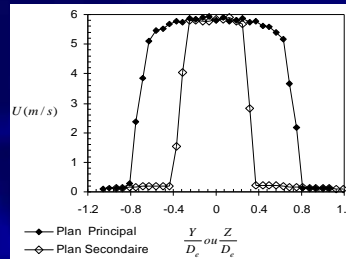
JC



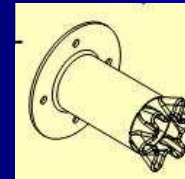
Buse lobée « droite »



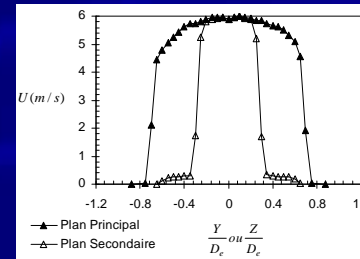
JL1



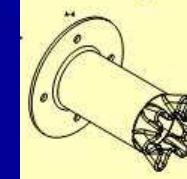
Buse lobée « inclinée » 14°/22°



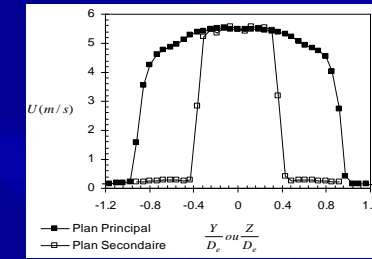
JL2



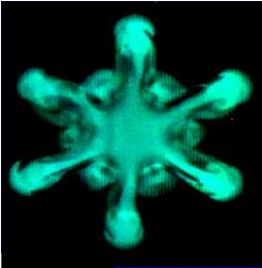
Buse lobée « inclinée » 22°/22°



JL3

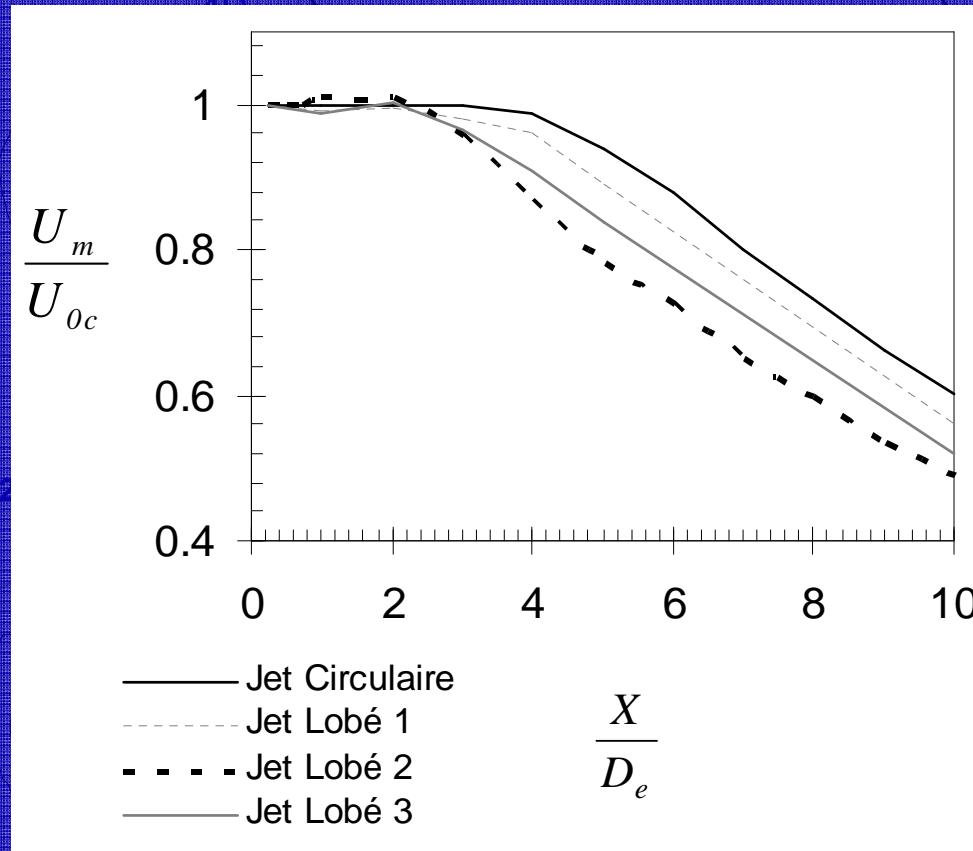


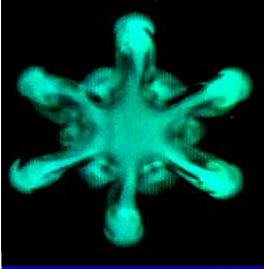
Buse	Q_0 (m ³ /s)	U_0 (m/s)	U_{0C} (m/s)	Re_0	Re_{0C}	V_{0max} (m/s)	W_{0max} (m/s)	$\sqrt{u'^2}_{0C}$ (m/s)	$\sqrt{v'^2}_{0C}$ (m/s)	$\sqrt{w'^2}_{0C}$ (m/s)
Buse 0	4.82 10 ⁻³	3.84	4.88	9 785	12 400	0.25	0.25	0.16	0.13	0.13
Buse 1	4.75 10 ⁻³	3.78	5.82	9 600	14 800	0.13	0.31	0.20	0.12	0.12
Buse 2	4.70 10 ⁻³	3.74	5.89	9 520	15 000	1.30	0.53	0.15	0.11	0.14
Buse 3	5.02 10 ⁻³	3.97	5.57	10 137	14 200	1.94	0.41	0.20	0.19	0.20



Jets lobés de Buses

Analyse globale de la région initiale et intermédiaire

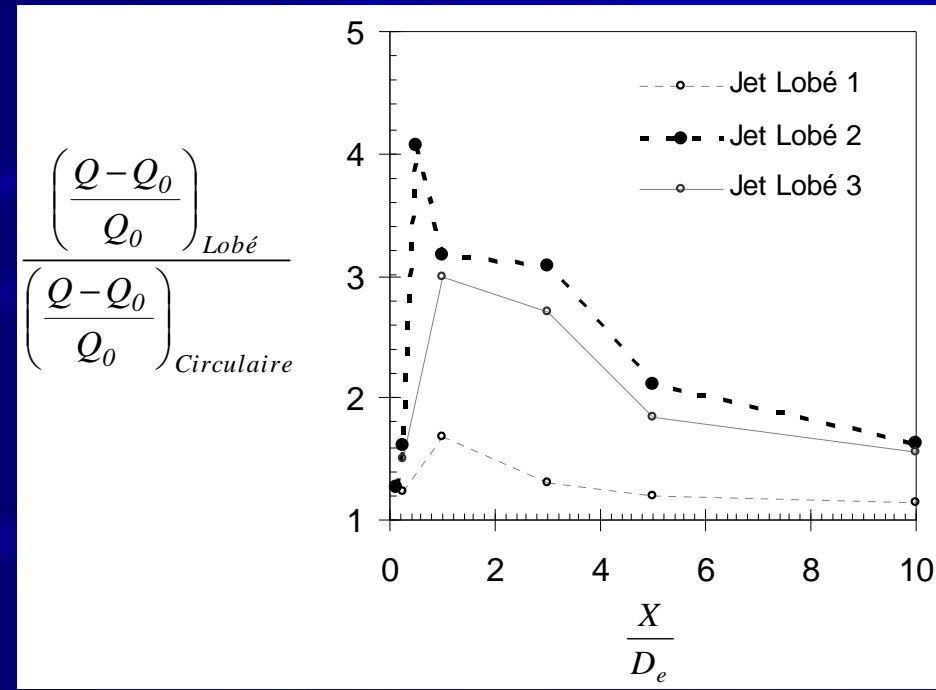
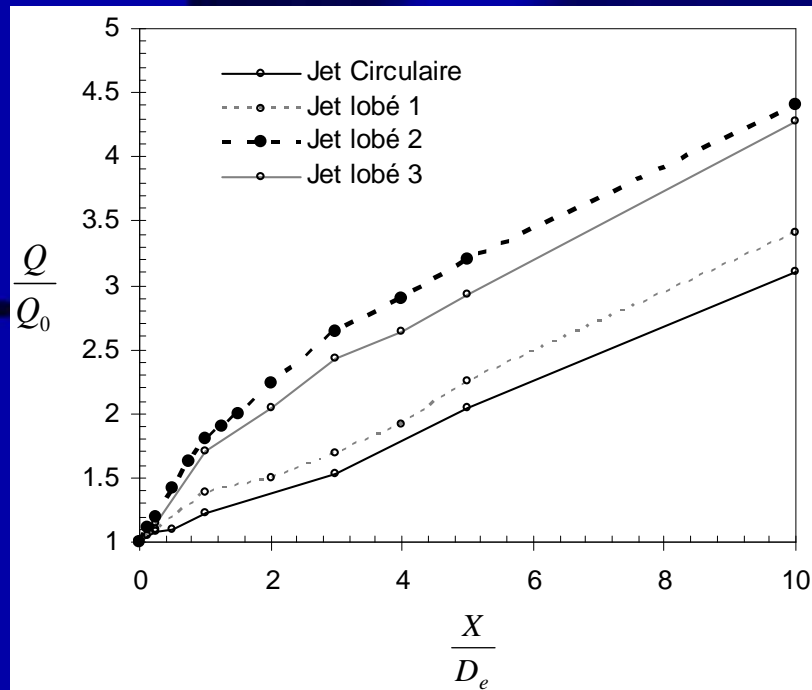


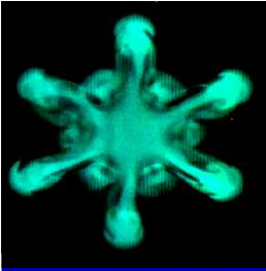


Jets lobés de Buses

Analyse globale de la région initiale et intermédiaire

Débit volumique et débit entraîné

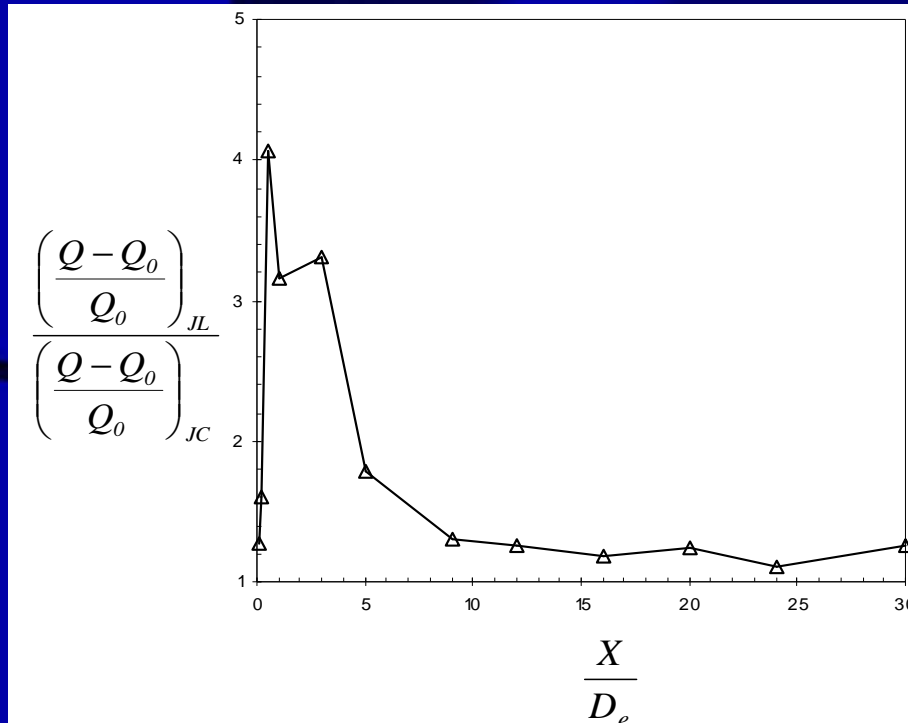




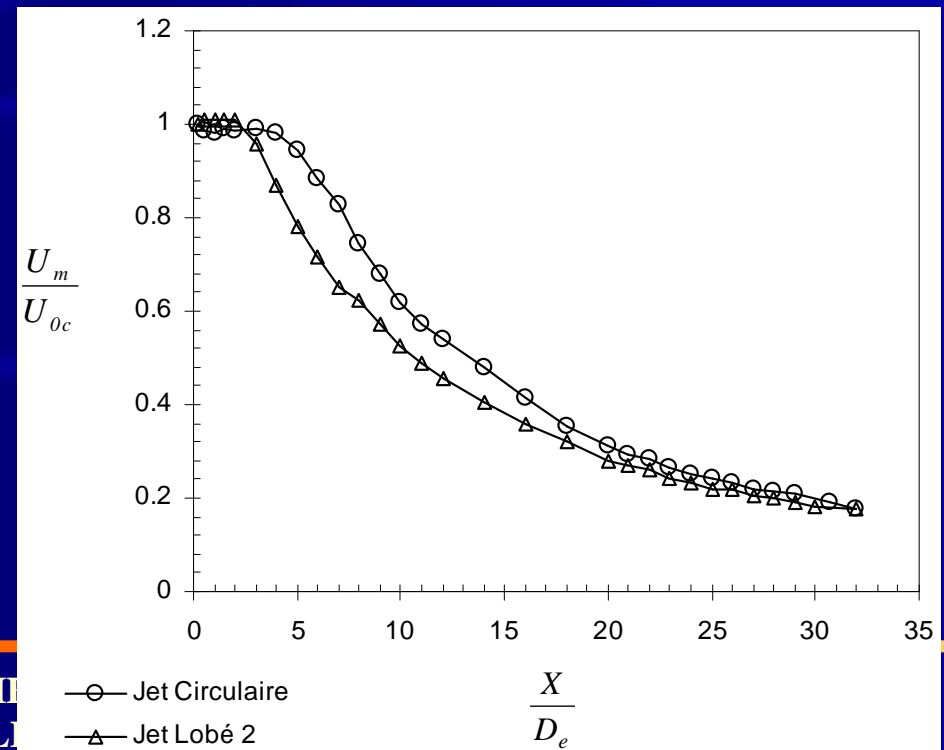
Jets lobés de Buses

Etude de la région lointaine

Débit d'entraînement

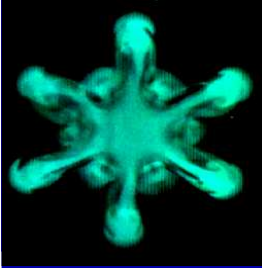


Décroissance axiale de la vitesse longitudinale

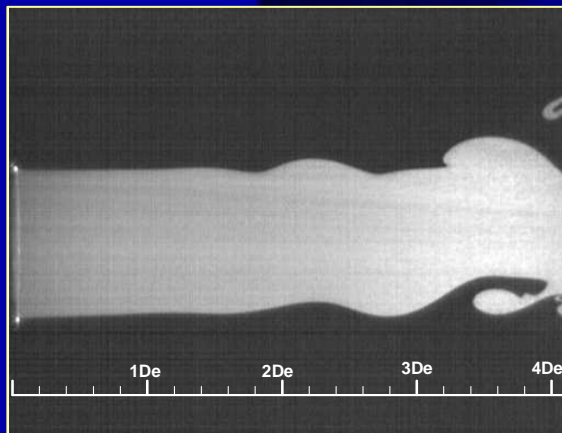
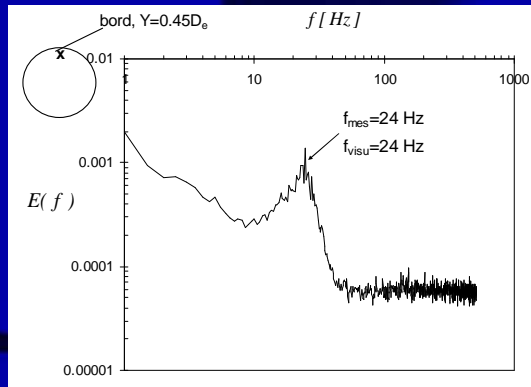


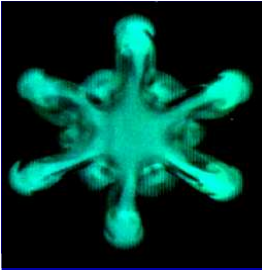
Jets lobés de Buses

Mécanismes tourbillonnaires de la région initiale



Spectre de la vitesse longitudinale
au fil chaud ($f_{acq}=2\text{kHz}$)

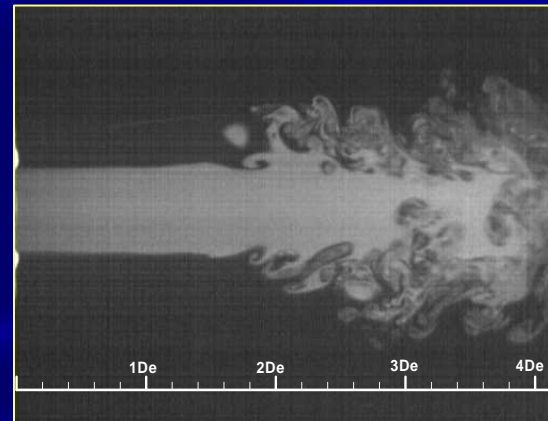
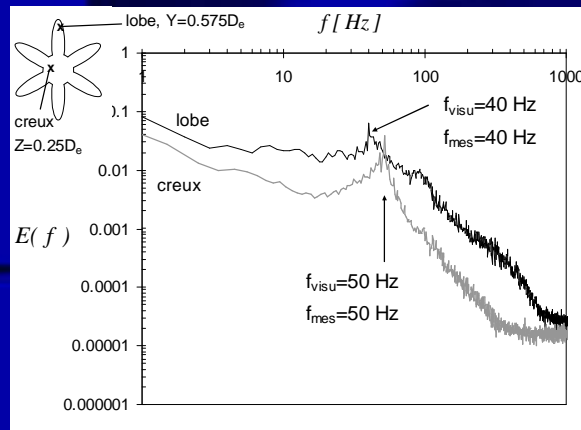




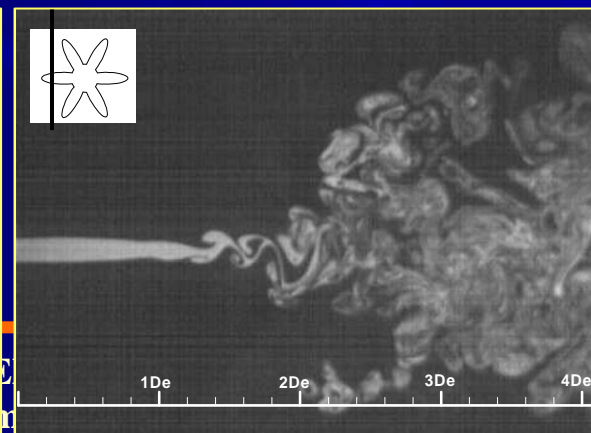
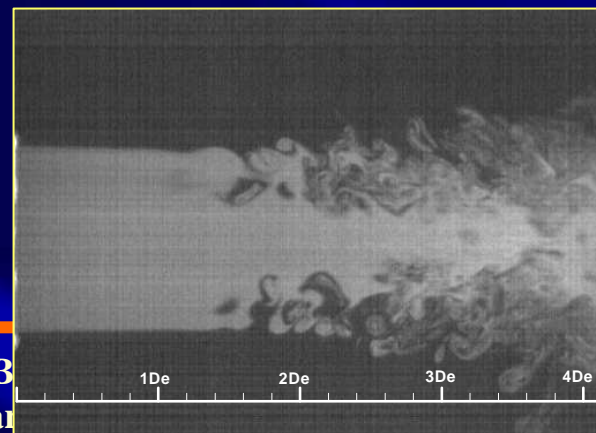
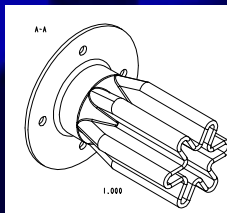
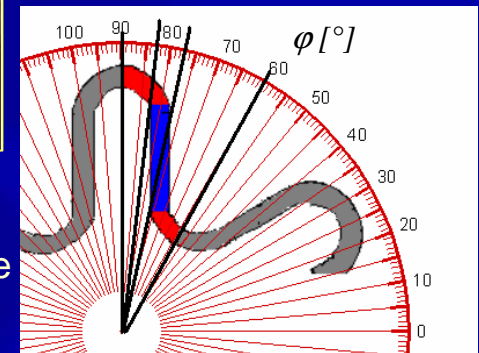
Jets lobés de Buses

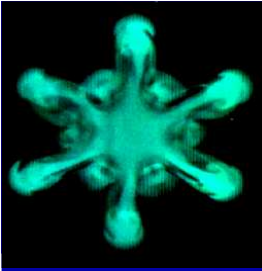
Mécanismes tourbillonnaires de la région initiale

Spectre de la vitesse longitudinale au fil chaud ($f_{acq}=2kHz$)



Visualisation par imagerie laser haute cadence ($f_{acq}=1kHz$)

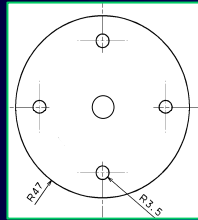




Jets lobés d'Orifices

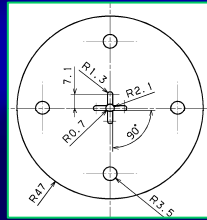
Conditions de soufflage

Orifice circulaire



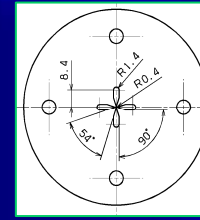
JC

Orifice croix



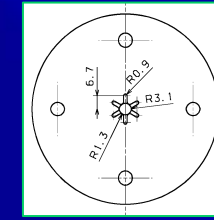
JL1

Orifice croix fermée

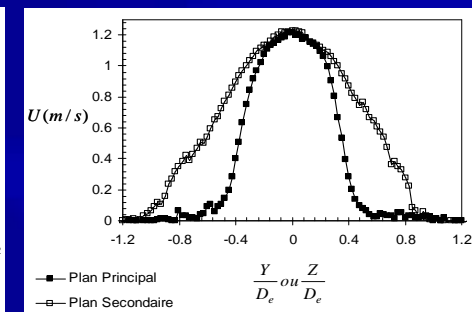
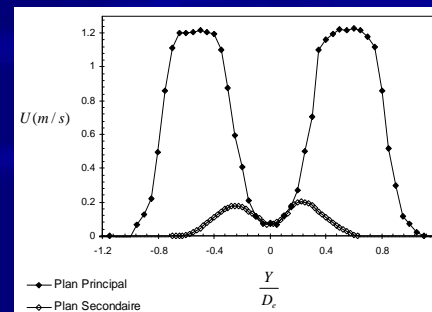
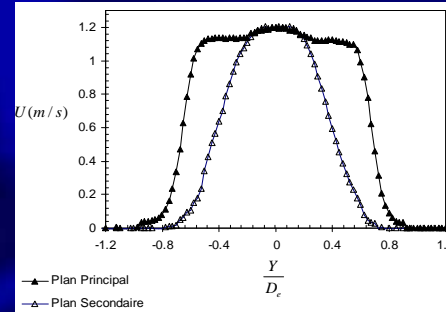
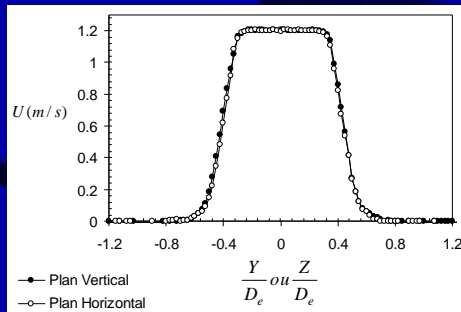


JL2

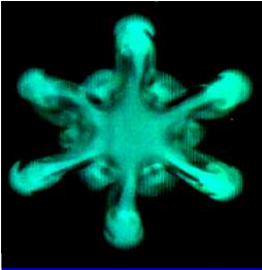
Orifice marguerite



JL3

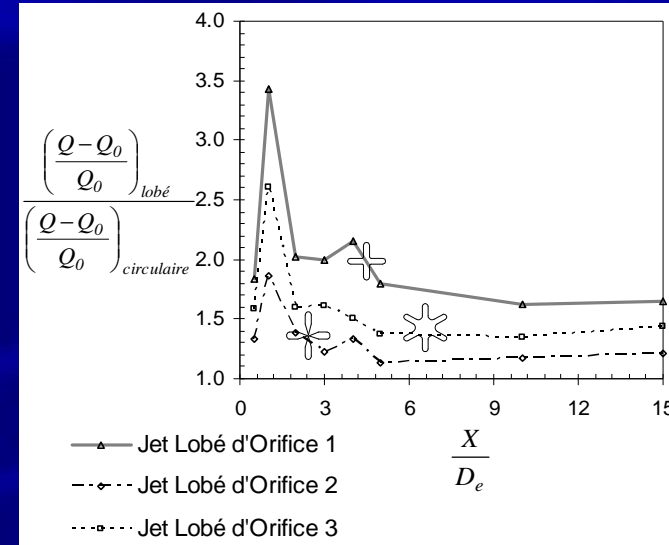
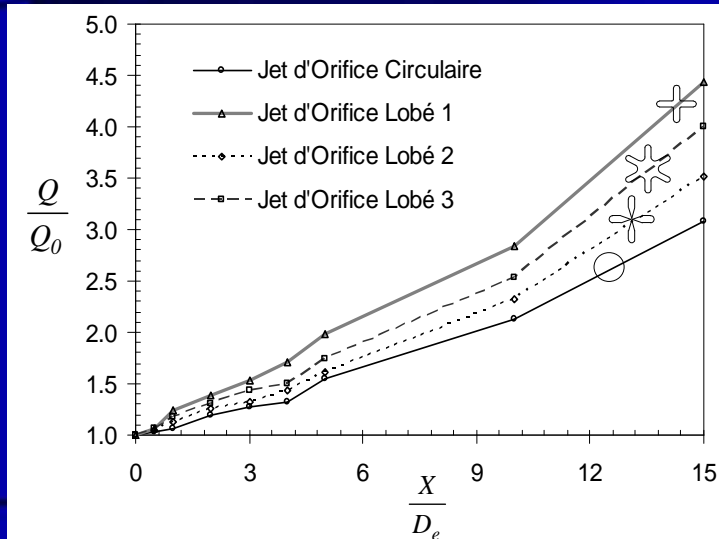


Orifice	Q_0 (m ³ /s)	U_0 (m/s)	U_{0C} (m/s)	U_{0max} (m/s) PP PS	Re_{0m}	Re_0	V_{0max} (m/s) PP PS	$\sqrt{u'^2}_{0C}$ (m/s)	$\sqrt{v'^2}_{0C}$ (m/s)
Orifice 0	7.87 10 ⁻⁰⁵	1.00	1.22	1.22	813	668	0.05	0.01	0.01
Orifice 1	7.26 10 ⁻⁰⁵	0.92	1.22	1.22	813	610	0.24 0.21	0.02	0.01
Orifice 2	8.11 10 ⁻⁰⁵	1.03	0.07	1.23 0.26	820	686	0.18 0.06	0.01	0.01
Orifice 3	7.63 10 ⁻⁰⁵	0.99	1.19	1.19	793	657	0.27	0.02	0.01

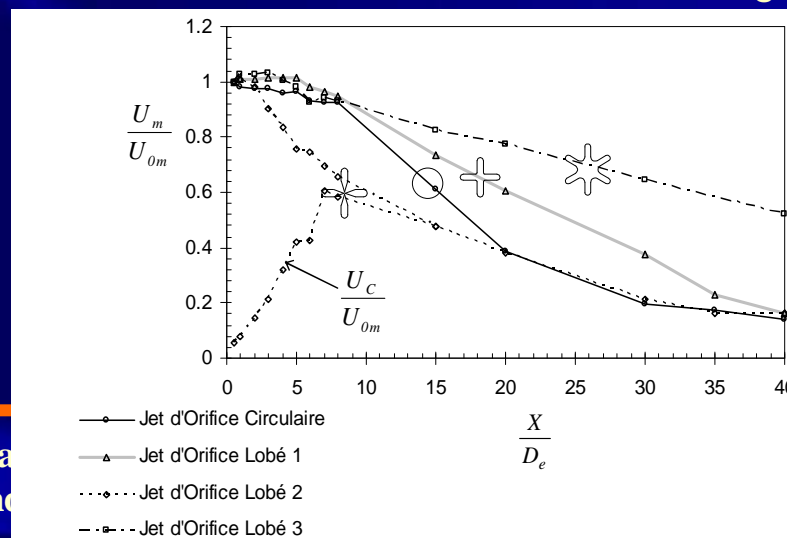


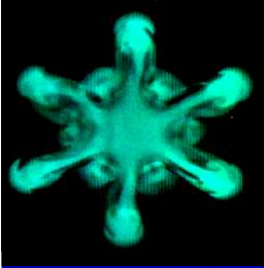
Jets lobés d'Orifices

Débit volumiques et débit entraîné



Décroissance axiale de la vitesse longitudinale

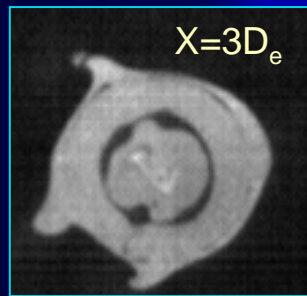




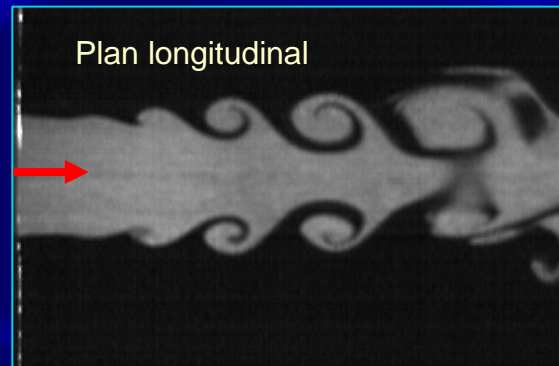
Mécanismes tourbillonnaires et entraînement

Orifice circulaire

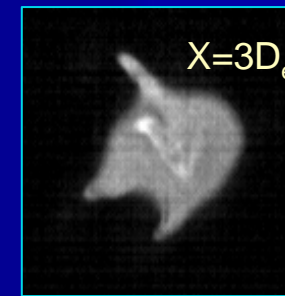
Anneau

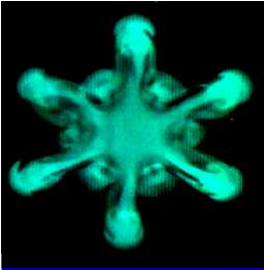


Plan longitudinal



Mèche

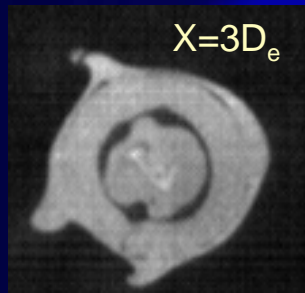




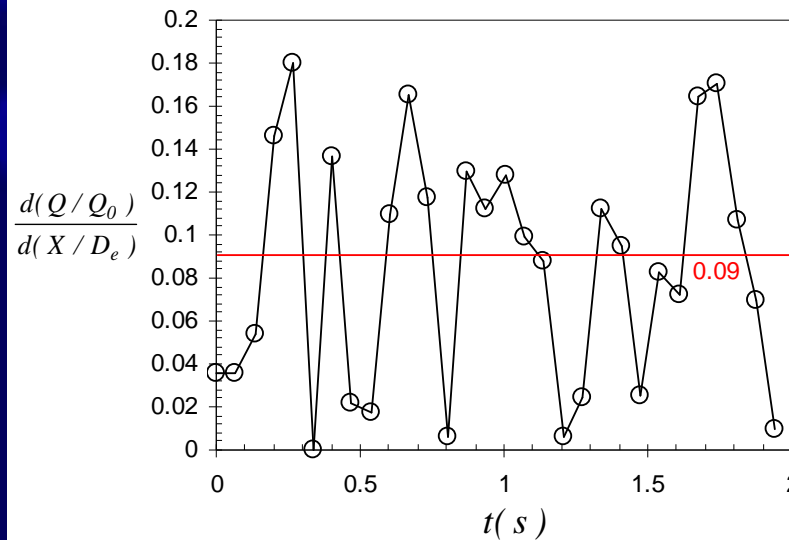
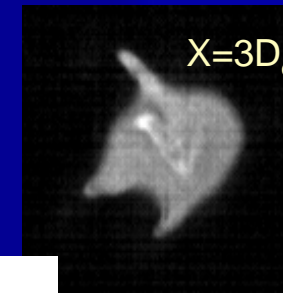
Mécanismes tourbillonnaires et entraînement

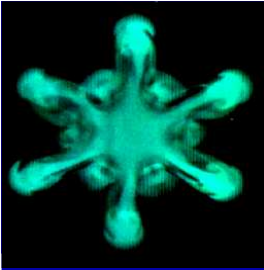
Orifice circulaire

Anneau



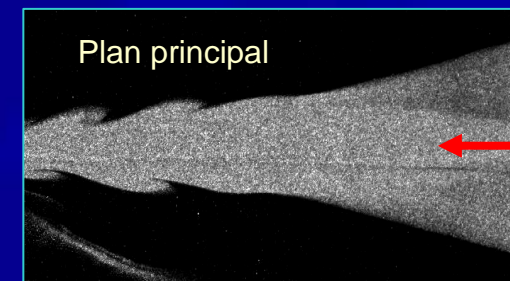
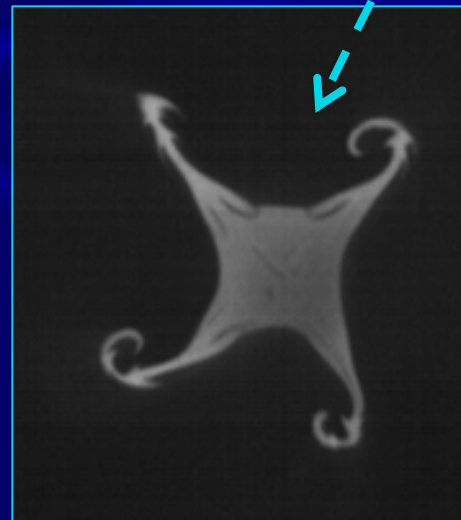
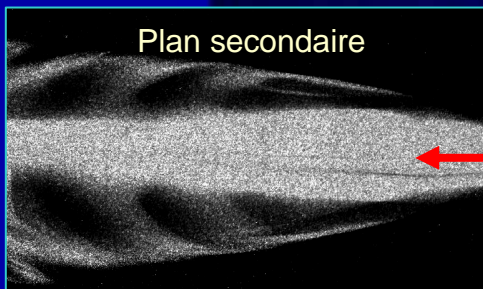
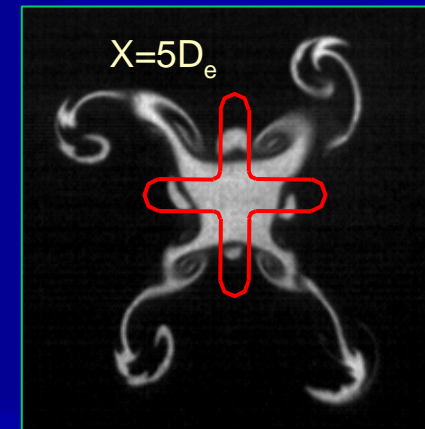
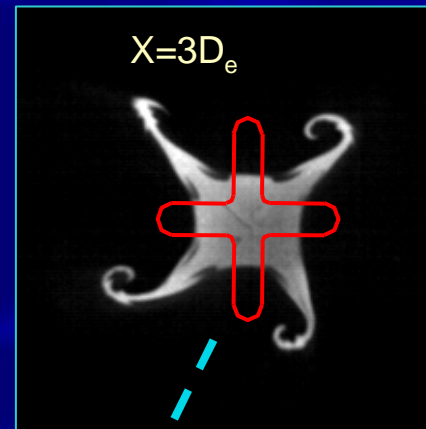
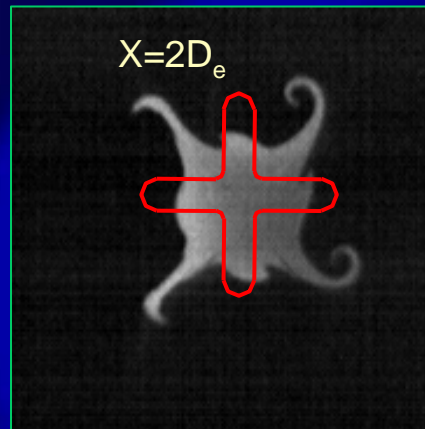
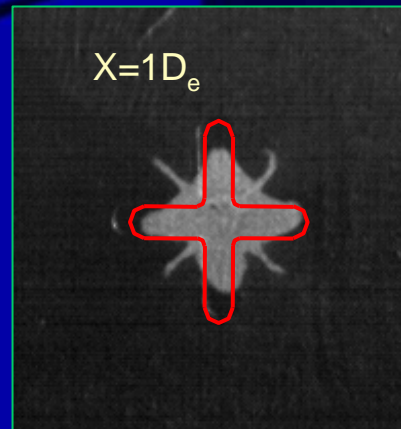
Mèche



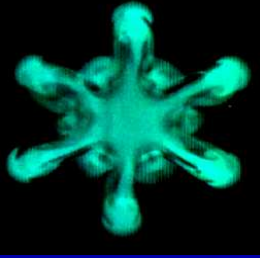


Mécanismes tourbillonnaires et entraînement

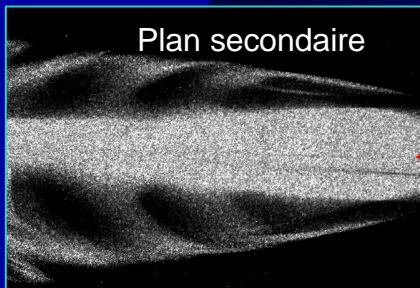
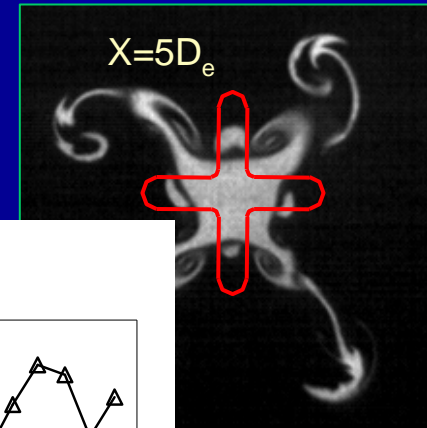
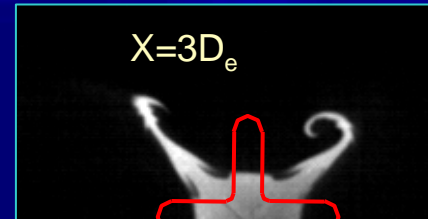
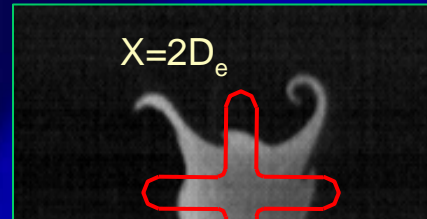
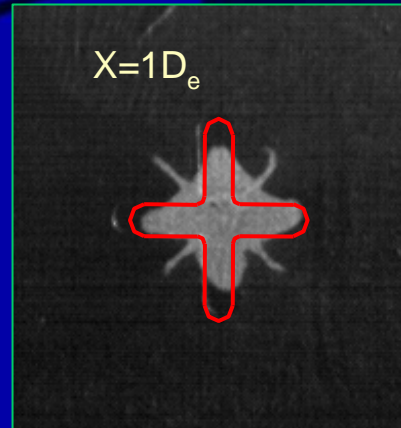
Orifice Croix



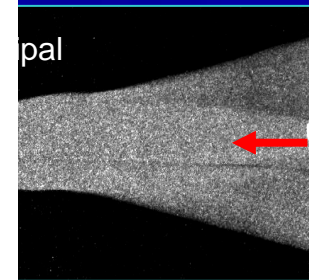
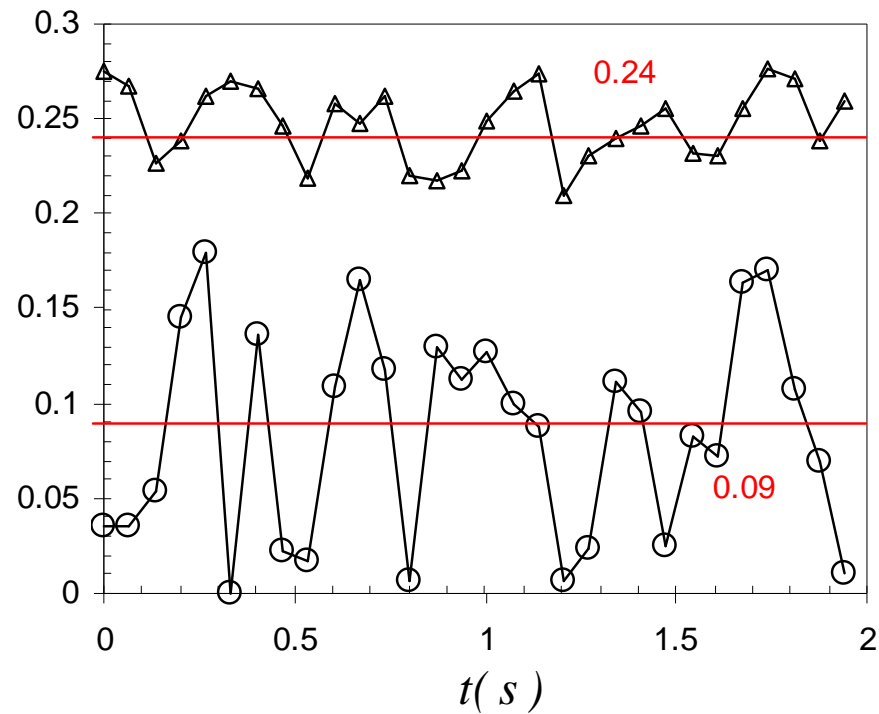
Mécanismes tourbillonnaires et entraînement



Orifice Croix



$$\frac{d(Q/Q_0)}{d(X/D_e)}$$

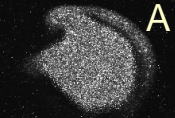




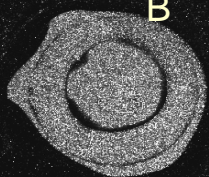
Mécanismes tourbillonnaires et entraînement

Mesures PIV

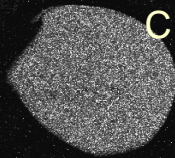
$f_{acq} = 15\text{Hz}$



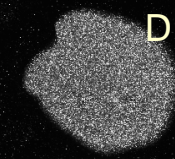
A



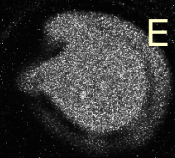
B



C



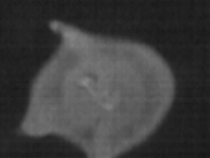
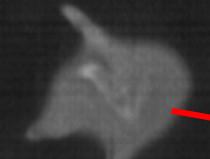
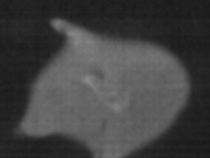
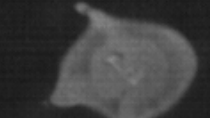
D



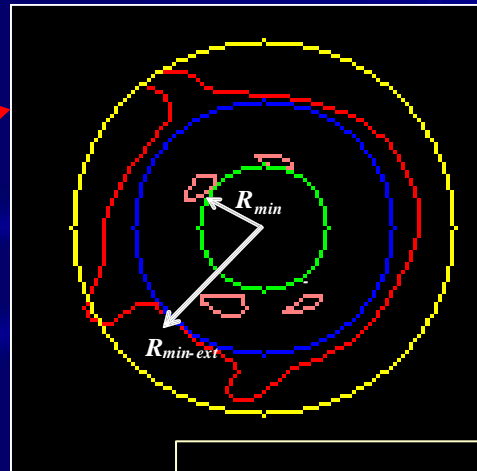
E

Visualisations

$f_{acq} = 2000\text{Hz}$



Reconstruction d'une période de passage d'une structure de Kelvin-Helmholtz



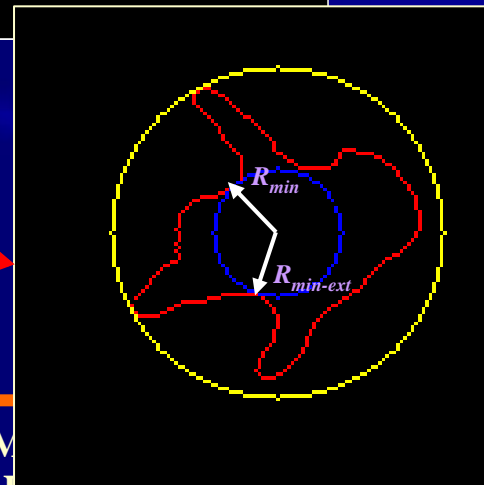
PIV classique et Imagerie résolue en temps

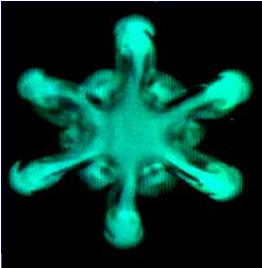
+

Extraction des contours du jet au moyen de traitement bas niveau

=

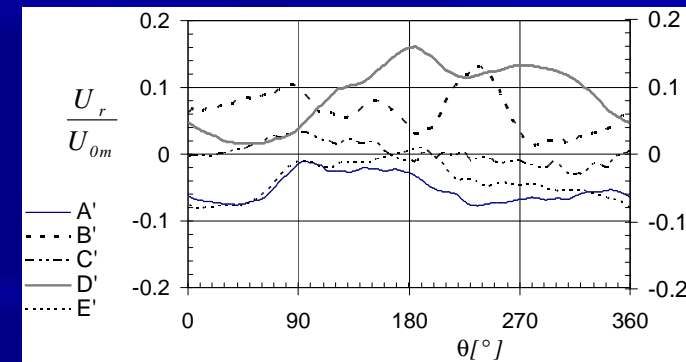
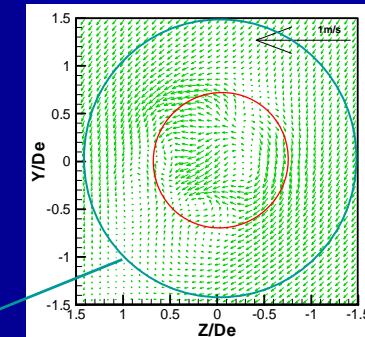
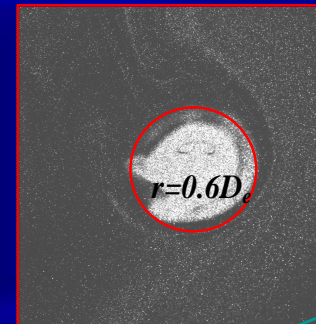
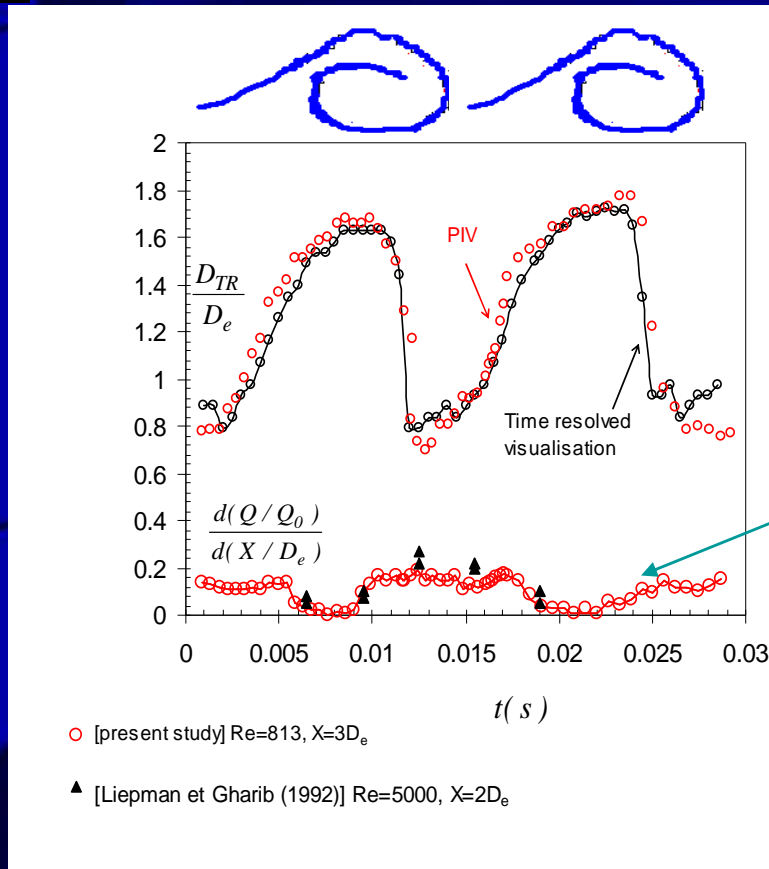
Comparaison objective des images et reconstruction d'une série d'images PIV « pseudo-résolue en temps »



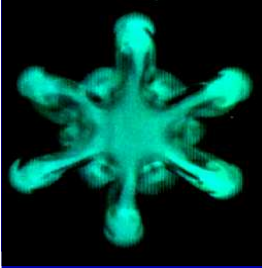


Mécanismes tourbillonnaires et entraînement

Orifice circulaire

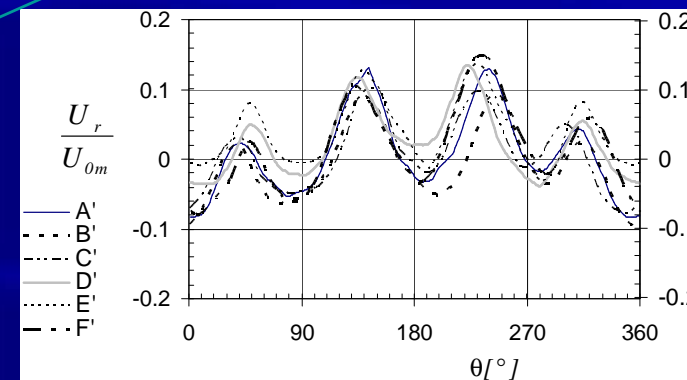
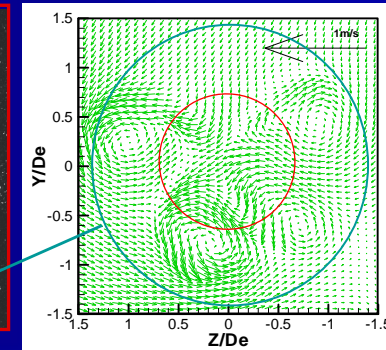
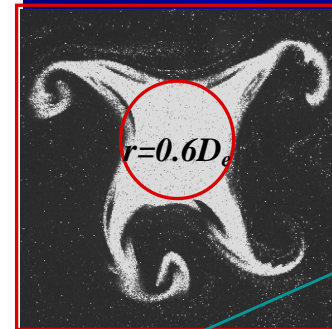
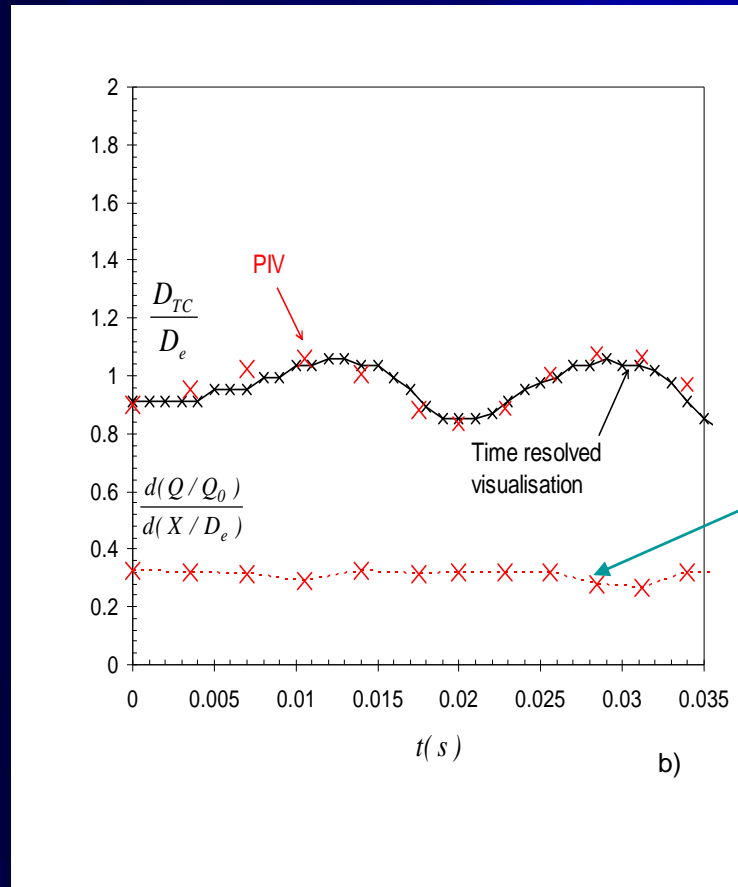


Nastase, Meslem et al. (2008), Exp. in Fluids (44) 6 : 1027-1033

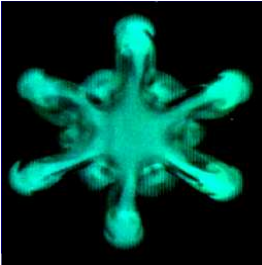


Mécanismes tourbillonnaires et entraînement

Orifice lobé croix



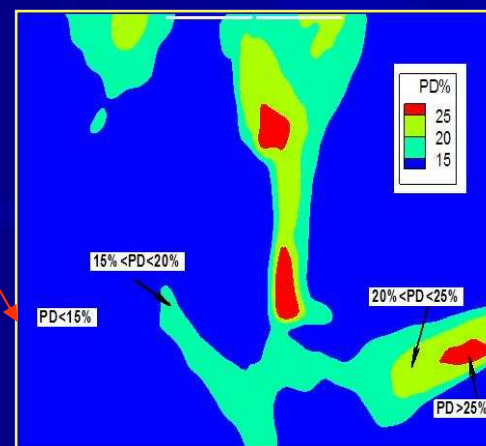
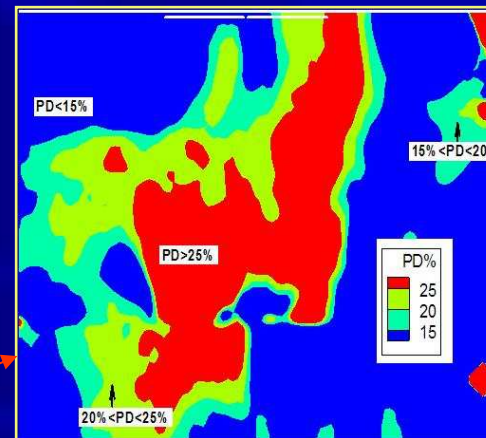
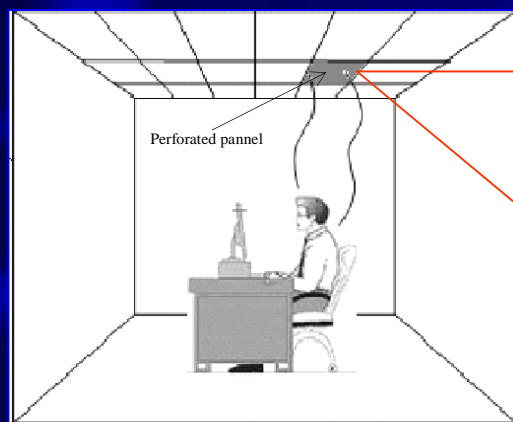
Nastase, Meslem et al. (2008), Exp. in Fluids (44) 6 : 1027-1033

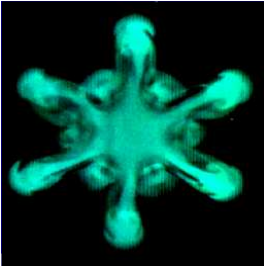


Grilles perforées - Analyse du confort

$$PD=(34-T_a)*(U-0.05)^{0.622}(0.37U T_u +3.14)$$

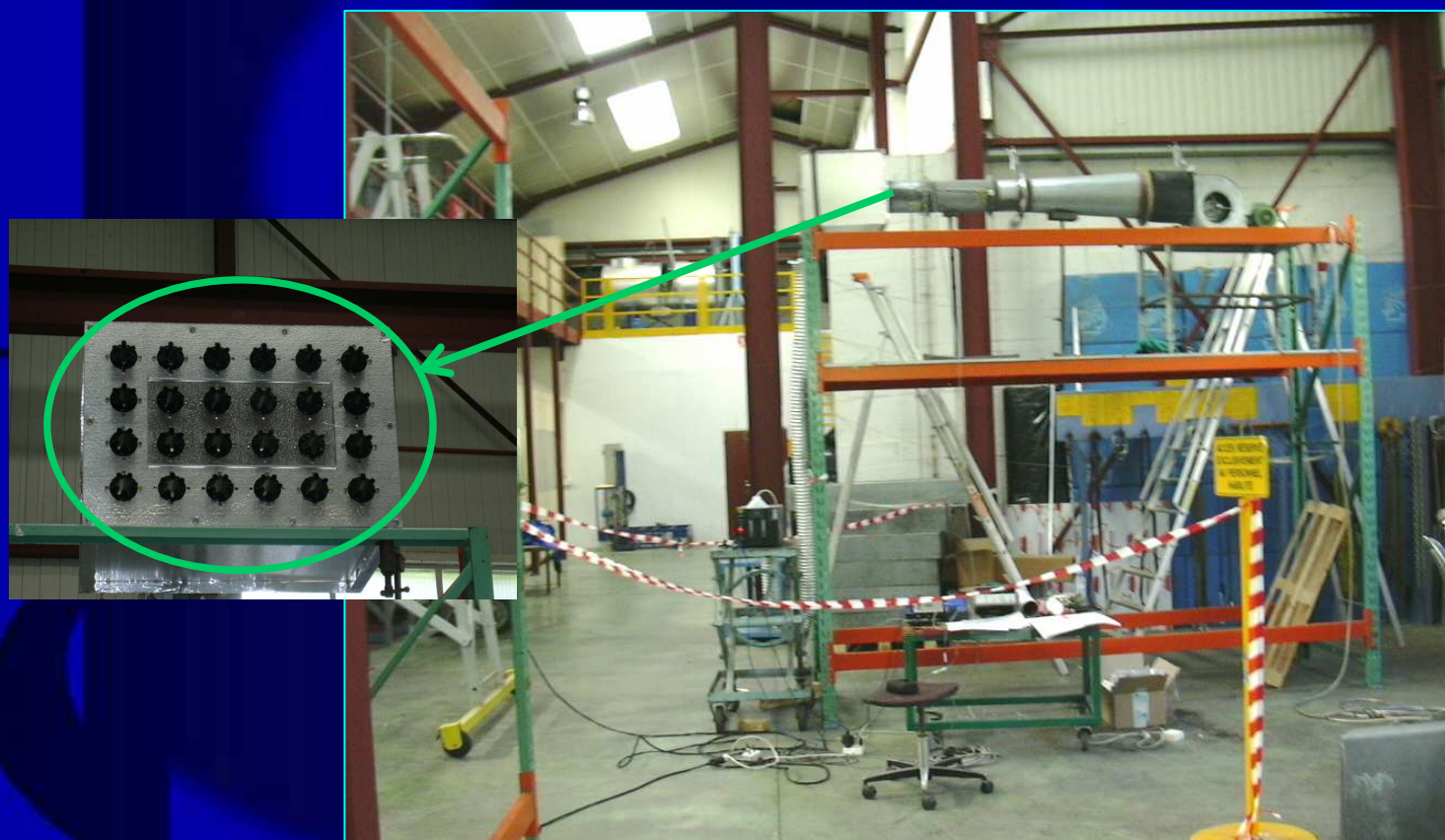
	Classe			
	A	B	C	D
PD	<15%	<20%	<25%	≥25%
Grand standing		Moyenne	Minimale	Inacceptable

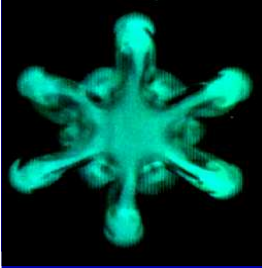




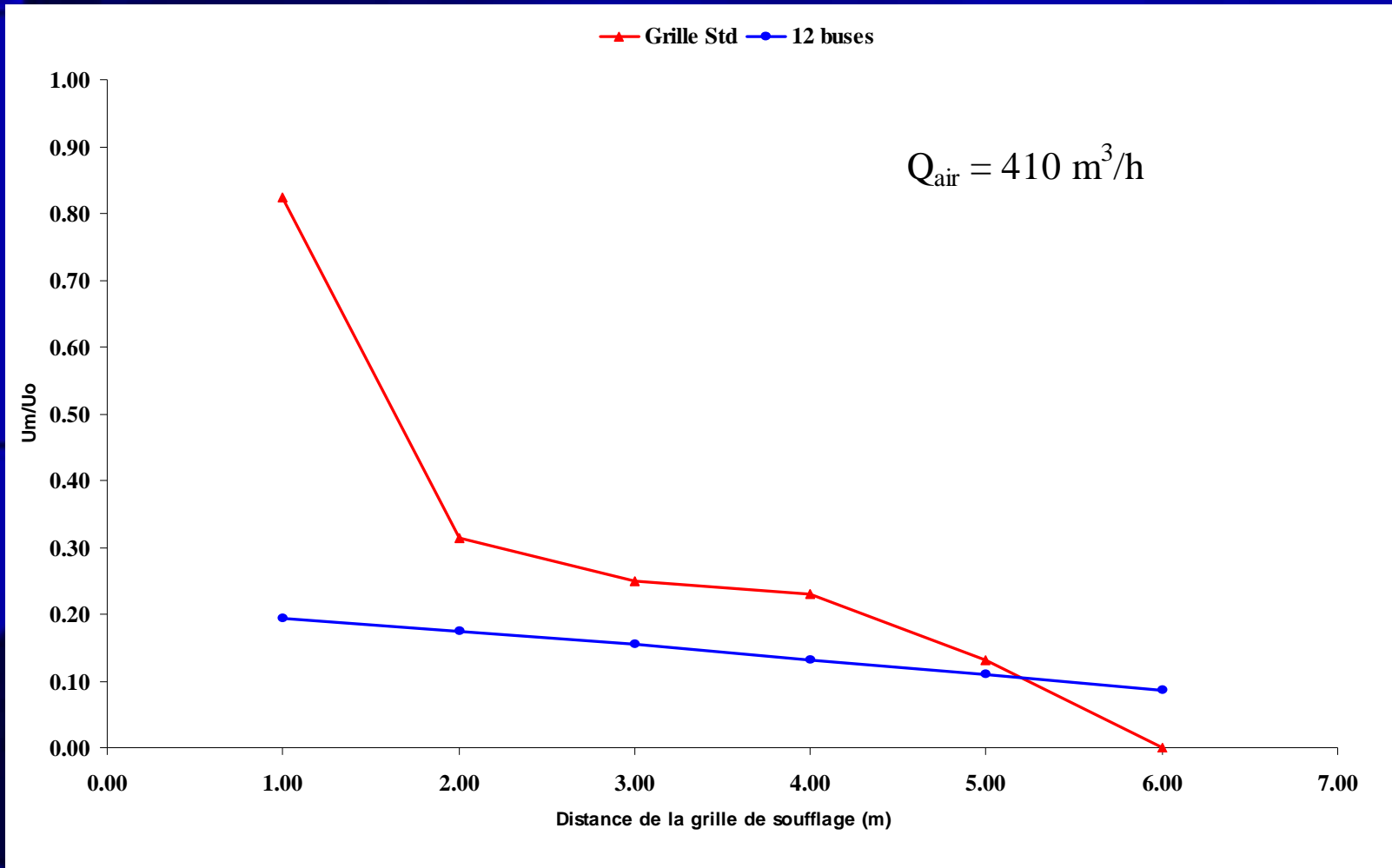
UTDa CIAT à buses lobées

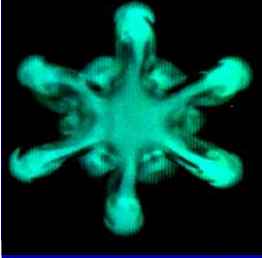
Essais réalisés par CIAT sur un ventilateur-convecteur





UTDa CIAT à buses lobées



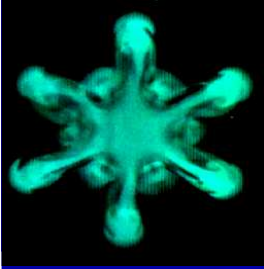


UTDa CIAT à buses lobées

De plus il a été conclu que :

→ les taux d'induction du diffuseur à buses lobées sont de 30 à 50% supérieurs à ceux d'une grille standard

→ cela conduirait à une économie d'énergie comprise entre 10 et 33 %



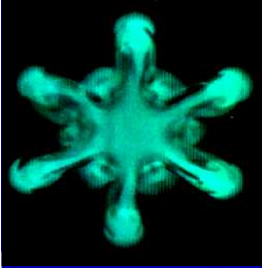
Conclusions

- Jet lobé en région initiale :
 - jet lobé présente une induction jusqu'à 4 fois celle d'un jet circulaire
 - mise en évidence des phénomènes à l'origine de la performance de mélange
 - vortex de Kelvin-Helmholtz (K-H) discontinus
 - favorisant le développement de tourbillons longitudinaux

- Jet lobé en région lointaine :
 - gain d'induction conséquent de 30% à 90%
 - portée plus grande ou égale à celle du jet circulaire

- Grilles perforées Croix :
 - gains en confort

- Grille à buses lobées :
 - plus forte induction qu'une grille standard
 - plus grande portée
 - économie d'énergie

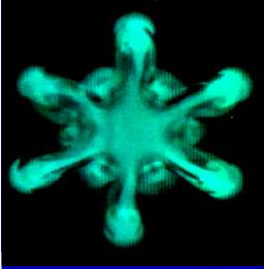


Perspectives immédiates dans le cadre du projet INDUBAT

→ Intégrer les jets lobés d'orifices dans les UTDa d'appareils CIAT



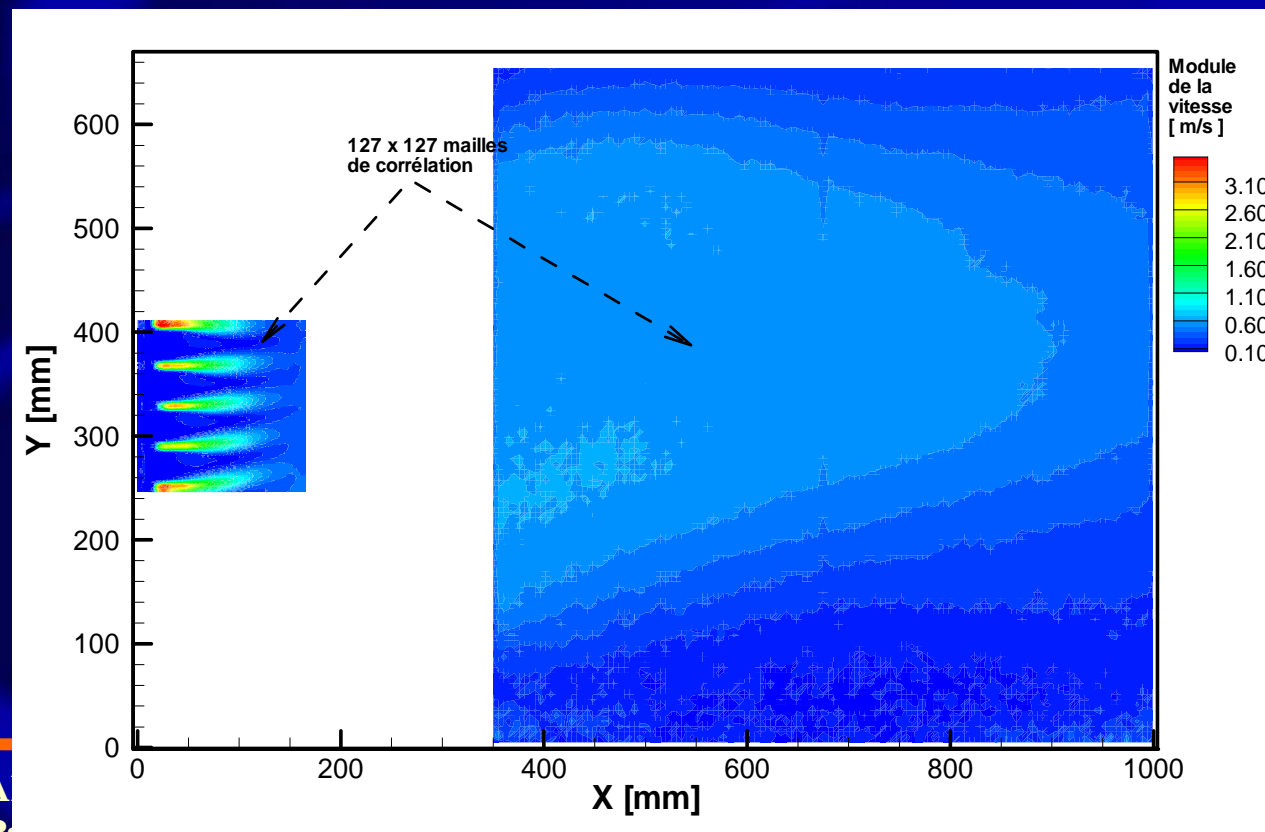
→ Etablir les diagrammes de fonctionnement de ces appareils en intégrant les paramètres « Confort » et « Economie d'énergie »

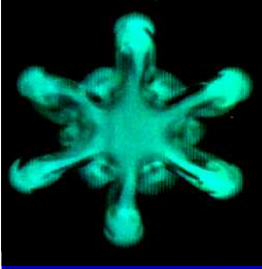


Perspectives de recherche inspirées par INDUBAT et soutenues par l'ADEME

→ affiner les paramètres géométriques des diffuseurs lobés au moyen de calcul numérique / validation expérimentale

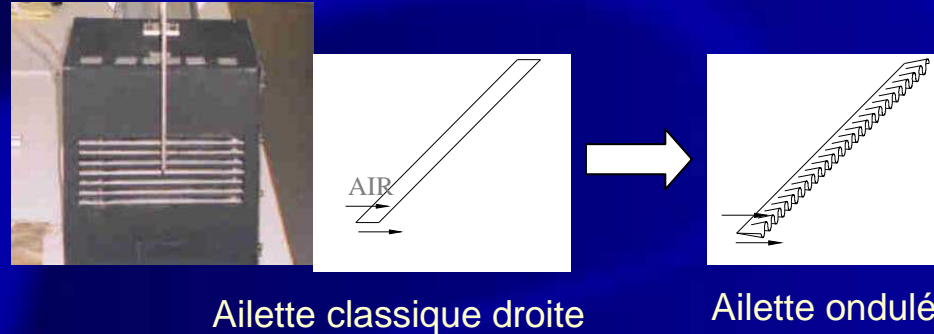
→ étude des phénomènes d'interaction de jets coalescents et optimisation de l'entre-axe pour une meilleure induction globale de la grille de diffusion d'air



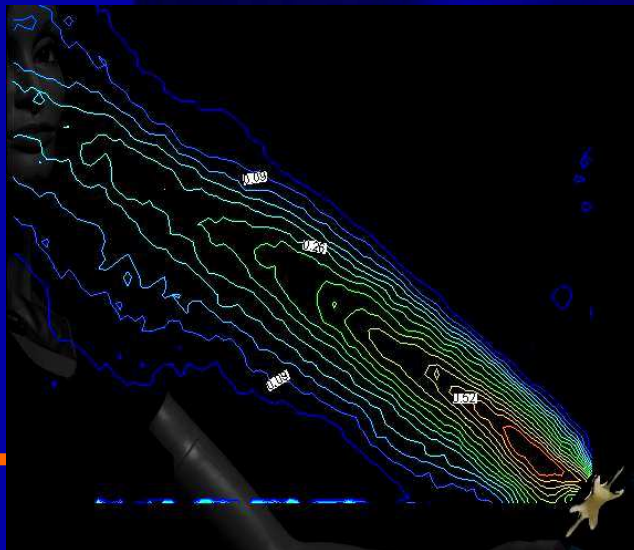


Perspectives de recherche inspirées par INDUBAT (collaborations internationales en préparation...)

→ Amélioration des appareils de traitement d'air à grilles linéaires (UTCb, Roumanie)



→ Introduction du contrôle passif des jets dans les dispositifs de ventilation/climatisation individuelle (DTU, Danemark)



- maîtrise du panache thermique émis par le corps
- interaction fluide : panache/jet de traitement d'air
- interaction solide : corps/jet de traitement d'air
- effet de la température d'air, de l'humidité, du rayonnement (couplage avec l'enveloppe)