

IRTES

sciences & ingénierie

Institut de Recherche sur les Transports, l'Énergie et la Société

UNIVERSITÉ DE TECHNOLOGIE DE BELFORT-MONTBELIARD

Optimisation de l'injection avec un atomiseur bi-fluide pour le procédé de projection plasma de suspensions (SPS) en utilisant 3 outils de diagnostic non-intrusifs

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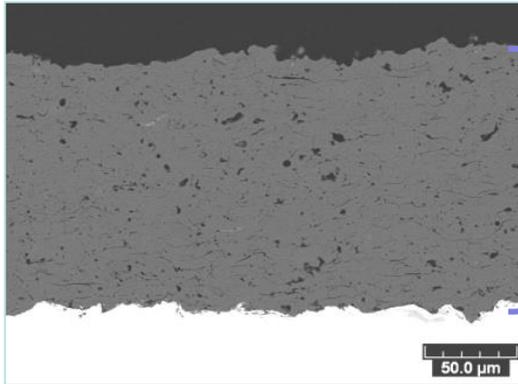
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Alain ALLIMANT, Dominique BILLIERES (Saint-Gobain Coating Solutions)

Laurent GIRARDOT, Yannick BAILLY (Institut FEMTO-ST)

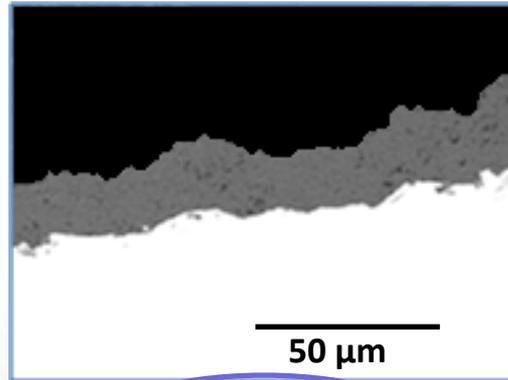
La projection plasma de suspensions (SPS)

Epaisseur et microstructure intermédiaires



Dépôt plasma conventionnel
 $d_{50} \approx 30 \mu\text{m}$

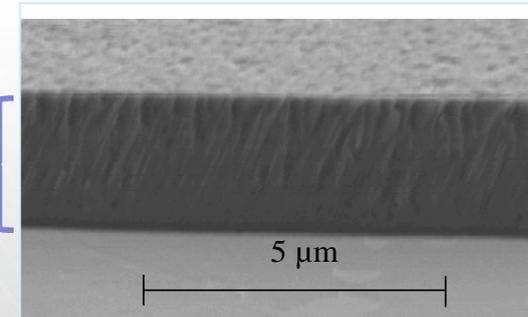
150 μm
 (en quelques minutes)



20 μm
 (en quelques minutes)

Dépôt SPS
 $d_{50} \approx 1 \mu\text{m}$

3 μm
 (quelques heures)

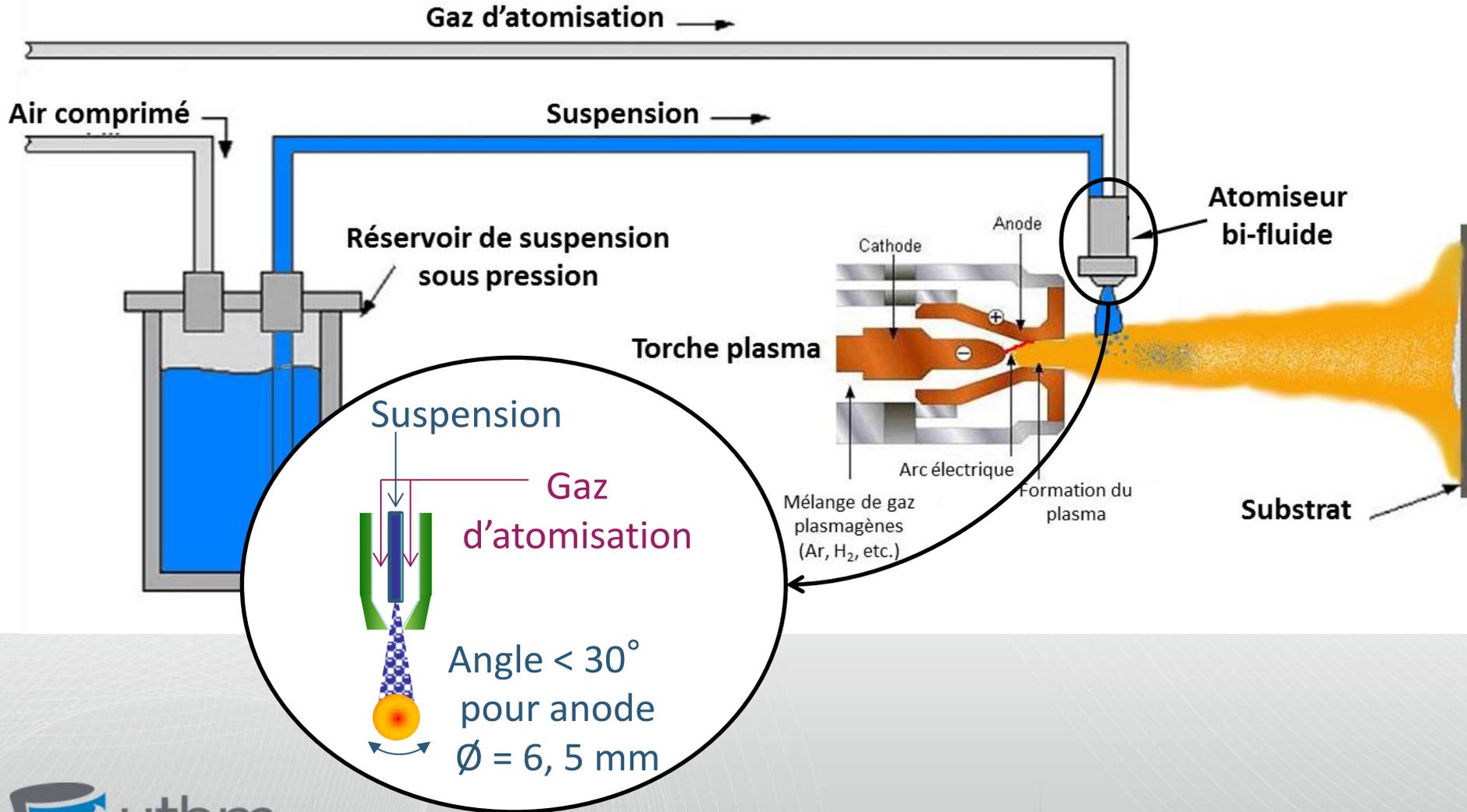


Couche mince PVD
 atomes

Injection *via* un liquide porteur

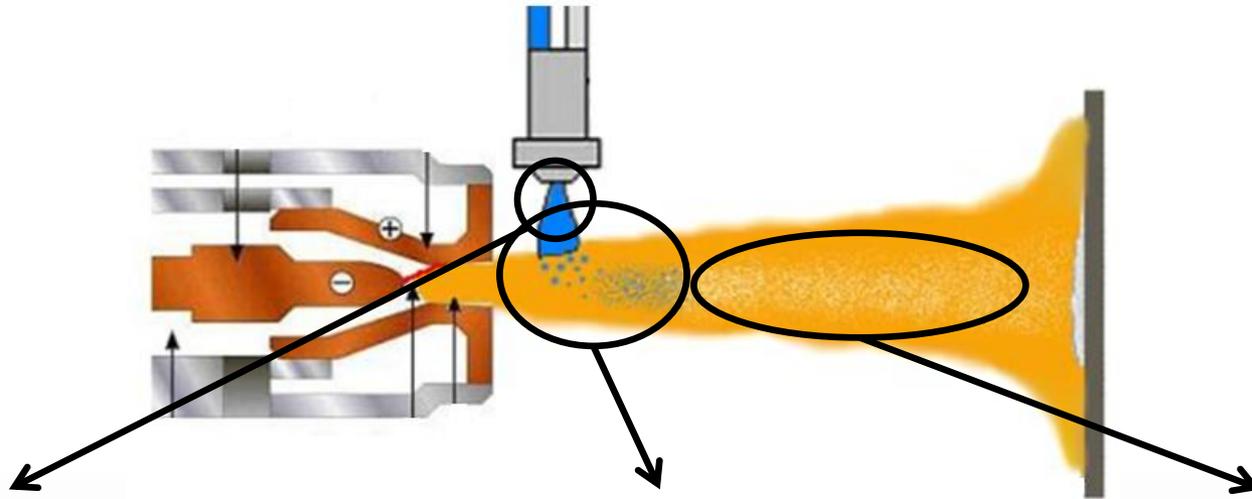
- injection mécanique
- atomisation

Le procédé SPS



Outils de diagnostic non-intrusifs

► Diagnostic à différentes étapes du procédé



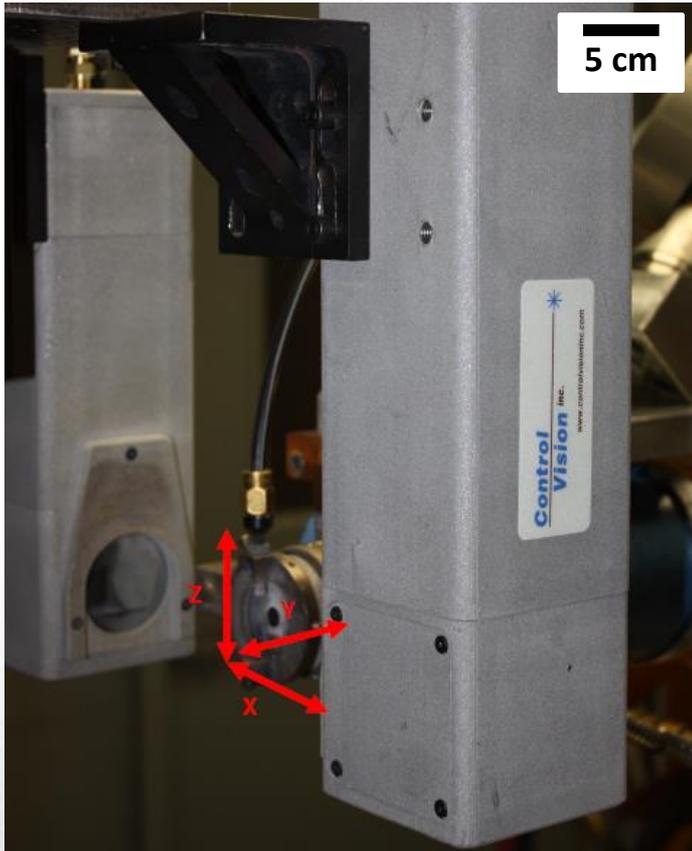
❖ Caractérisation hors plasma de l'atomiseur
 => ombroscopie
 => diffraction laser

❖ Caractérisation de l'injection
 => ombroscopie

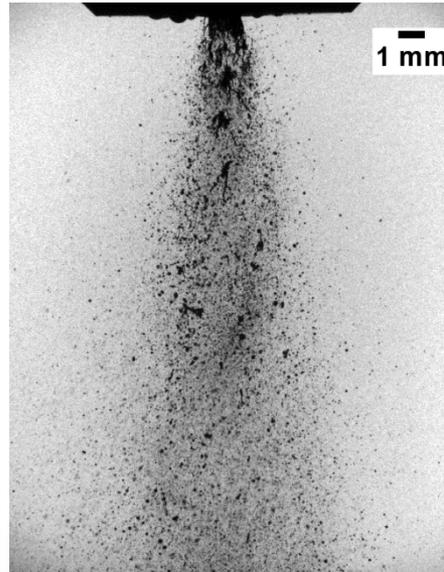
❖ Diagnostic en vol vitesse de particules
 => PIV

► Caractérisation de 2 injecteurs : atomiseur A et B

L'ombroscopie



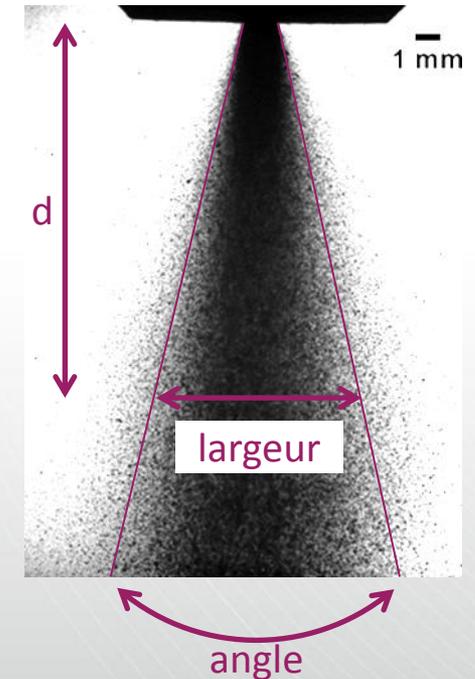
Géométrie du jet atomisé



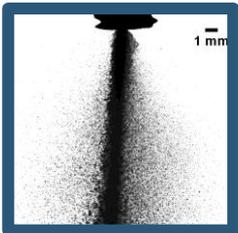
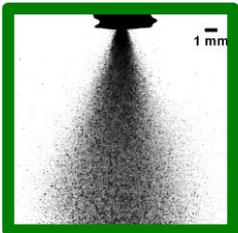
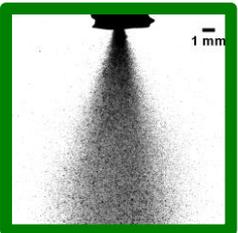
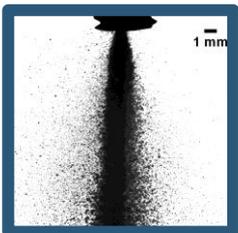
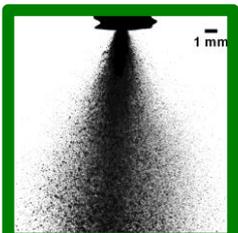
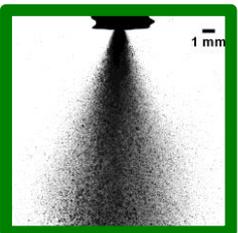
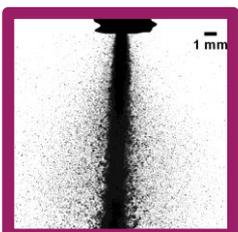
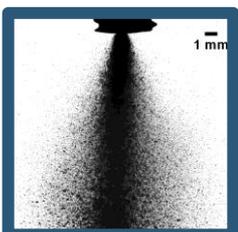
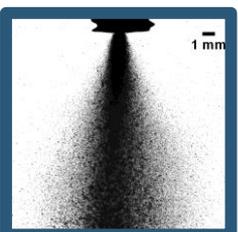
1 seule image

$$t_{\text{expo}} = 10 \mu\text{s}$$

Superposition de 100 images



Observations ombroscopiques du jet

P_{liq} \ P_{gaz}	$P_g = 0,02$ MPa	$P_g = 0,05$ MPa	$P_g = 0,065$ MPa
$P_l = 0,06$ MPa			
$P_l = 0,10$ MPa			
$P_l = 0,14$ MPa			

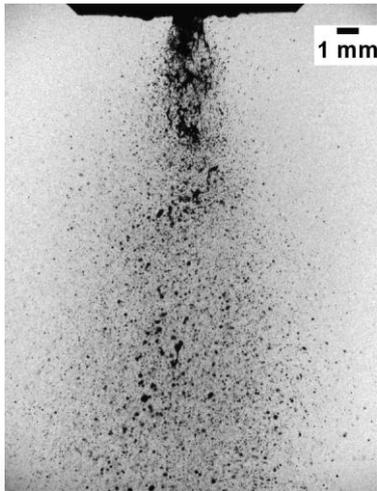
Jet quasi continu

Jet partiellement
atomisé

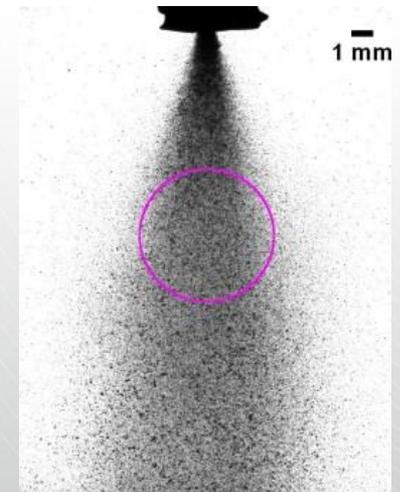
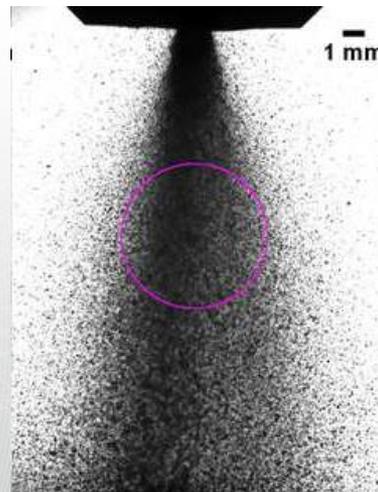
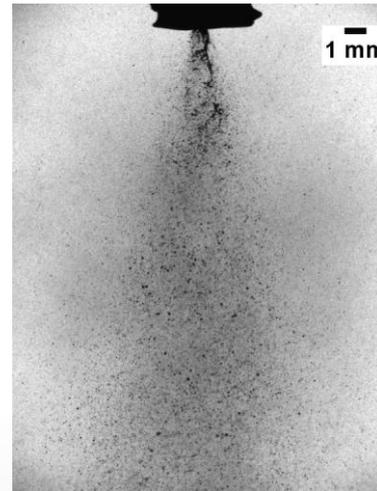
Jet atomisé

Observations ombroscopiques du jet

❖ Atomiseur A

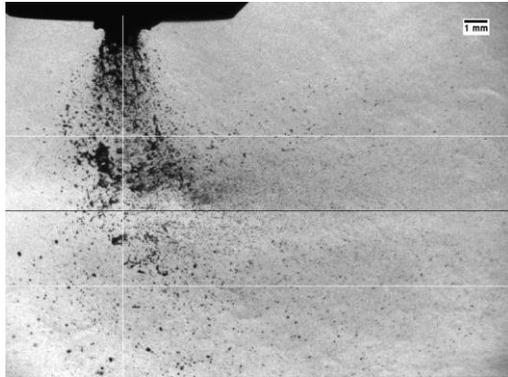


❖ Atomiseur B

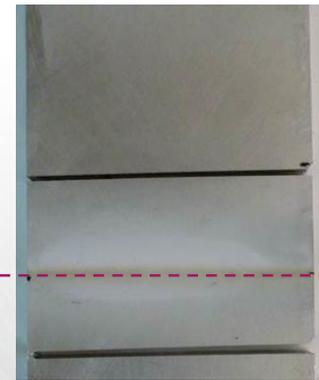
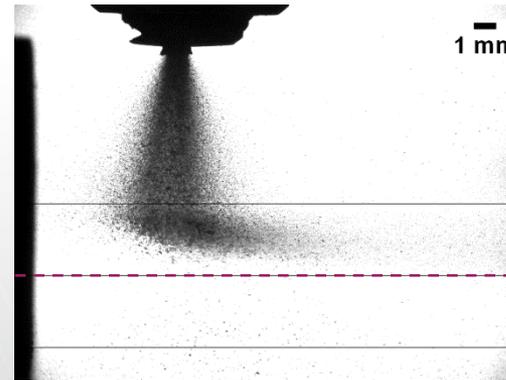
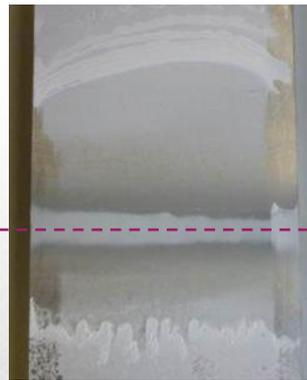
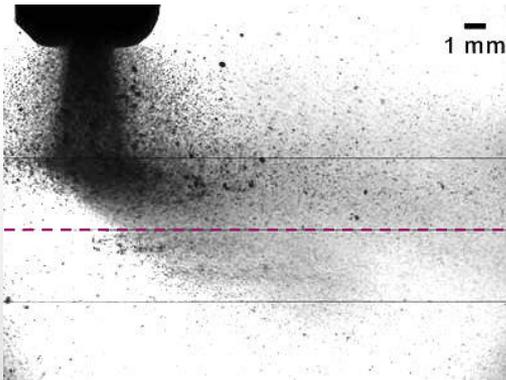


Observations ombroscopiques de l'injection

❖ Atomiseur A



❖ Atomiseur B



Rejet atomiseur A
Poursuite caractérisation avec atomiseur B

La diffraction laser



Mesure sur axe
injecteur, à 6 mm
de sa sortie

eau

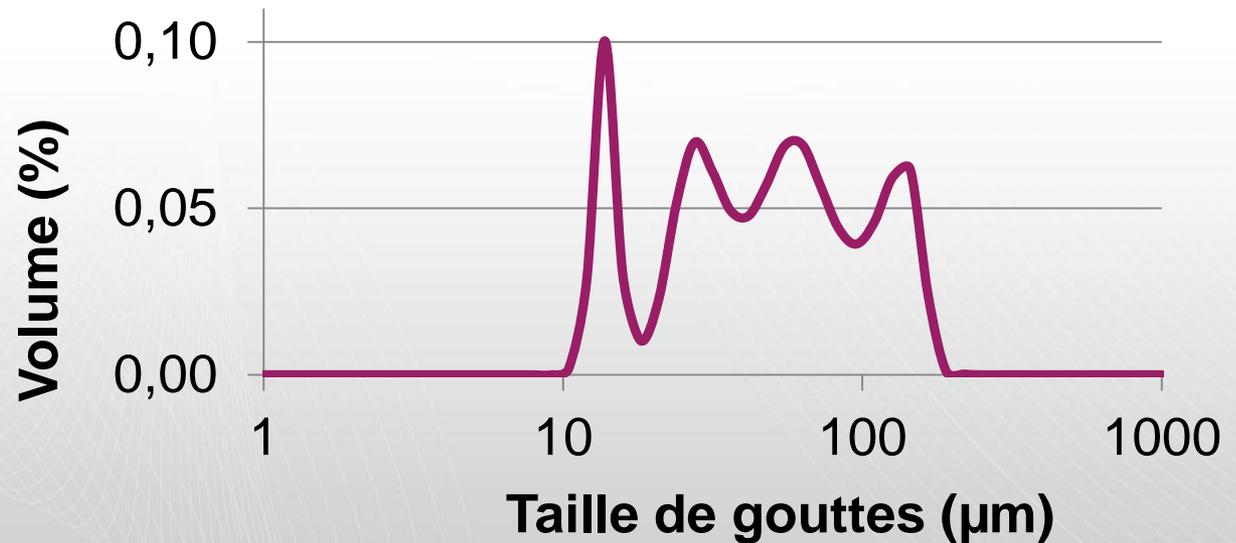
$P_g = 0,065$ MPa

$P_{liq} = 0,07$ Mpa

$d_{50} = 44$ μm

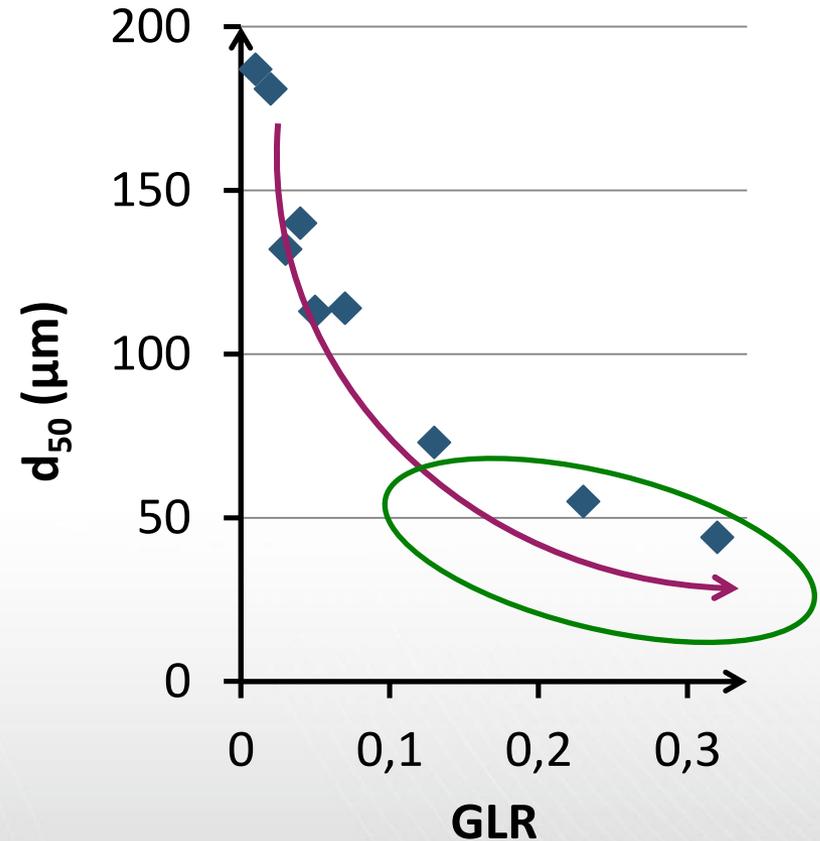


Distribution
tailles de
gouttes



Mesures de tailles de gouttes

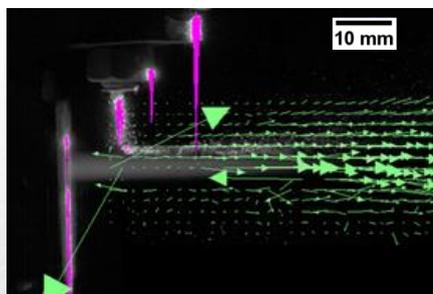
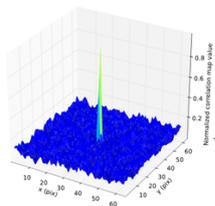
P_{liq} \ P_{gaz}	$P_g = 0,02$ MPa	$P_g = 0,05$ MPa	$P_g = 0,065$ MPa
$P_l = 0,06$ MPa	GLR = 0,04 $d_{50} = 140 \mu\text{m}$	GLR = 0,23 $d_{50} = 55 \mu\text{m}$	GLR = 0,32 $d_{50} = 44 \mu\text{m}$
$P_l = 0,10$ MPa	GLR = 0,02 $d_{50} = 181 \mu\text{m}$	GLR = 0,07 $d_{50} = 114 \mu\text{m}$	GLR = 0,13 $d_{50} = 73 \mu\text{m}$
$P_l = 0,14$ MPa	GLR = 0,01 $d_{50} = 187 \mu\text{m}$	GLR = 0,03 $d_{50} = 132 \mu\text{m}$	GLR = 0,05 $d_{50} = 113 \mu\text{m}$



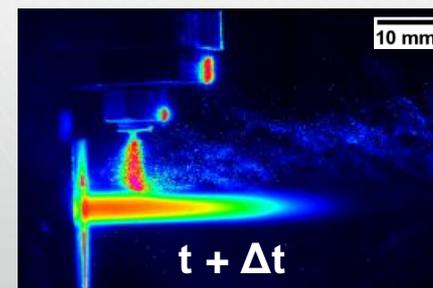
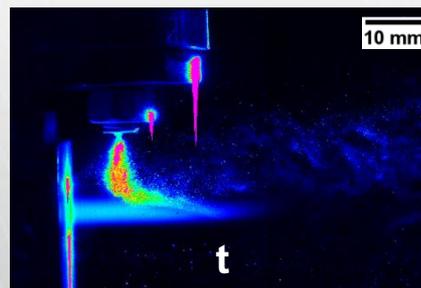
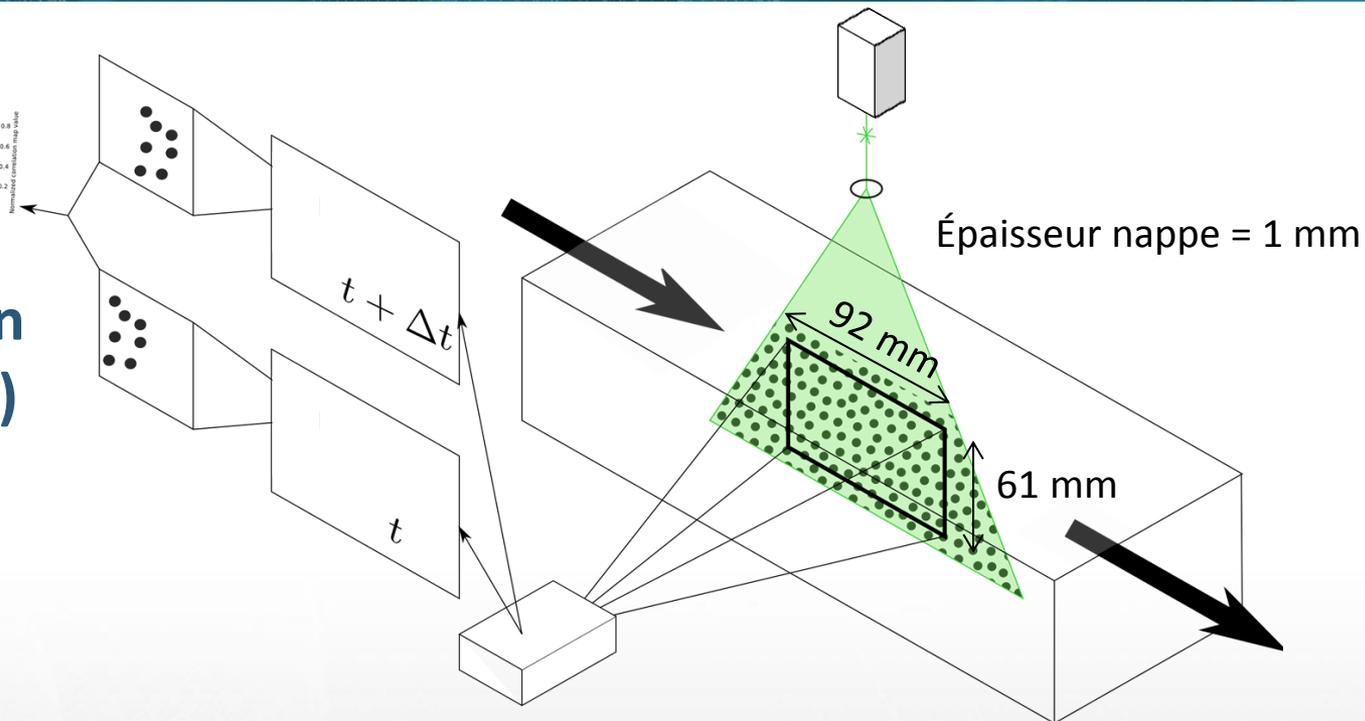
$$\text{“Gas liquid ratio” (GLR)} = \frac{\text{débit massique gaz}}{\text{débit massique suspension}}$$

Vélocimétrie par images de particules (PIV)

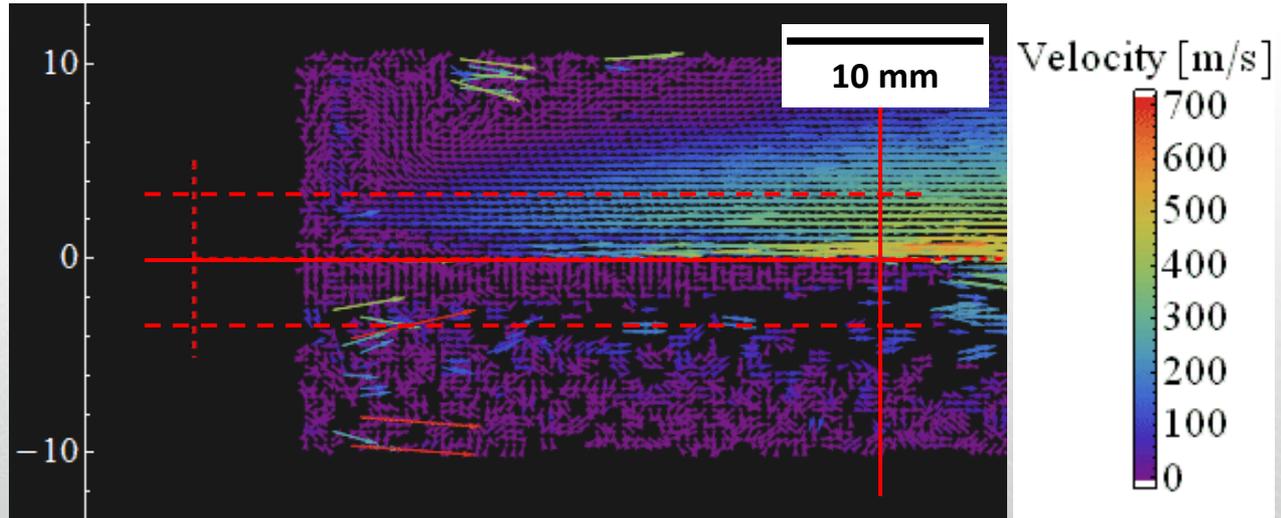
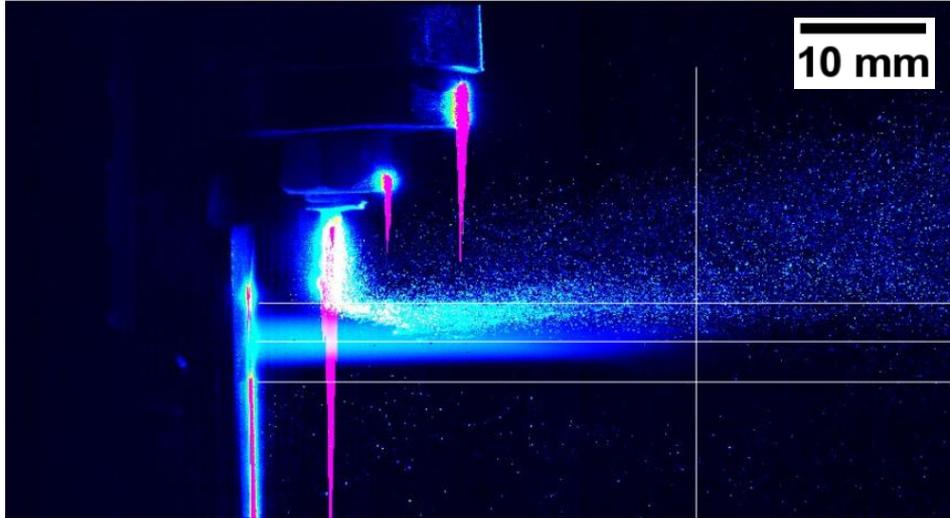
2) Intercorrélation (lorsque possible)



3) Calcul des vecteurs vitesse



Visualisation et champs de vecteurs vitesse par PIV



Conclusions

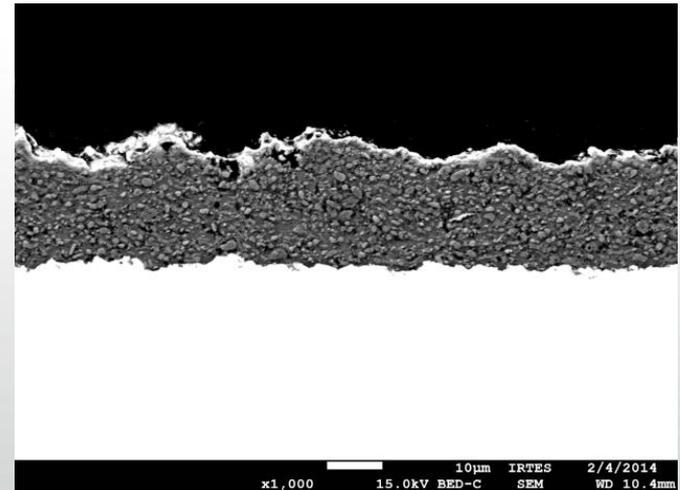
► Caractérisation d'un atomiseur basée sur

- Observations ombroscopiques (hors plasma et injection)
- => Rejet ou validation d'un atomiseur pour le procédé SPS
- Mesures de taille de gouttes
- Mesures de vitesse de particules

► Méthode validée par obtention de cordons/dépôts homogènes

► Diagnostic apporte

- Gain de temps
- Compréhension au procédé SPS



Merci pour votre attention !

