NEW EXPERIMENTAL SET-UPS FOR STUDIES OF PLUNGING JETS

International Workshop on overflowing erosion of dams and dykes

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CERG INGENIERIE EN MECANIQUE DES FLUIDES

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EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

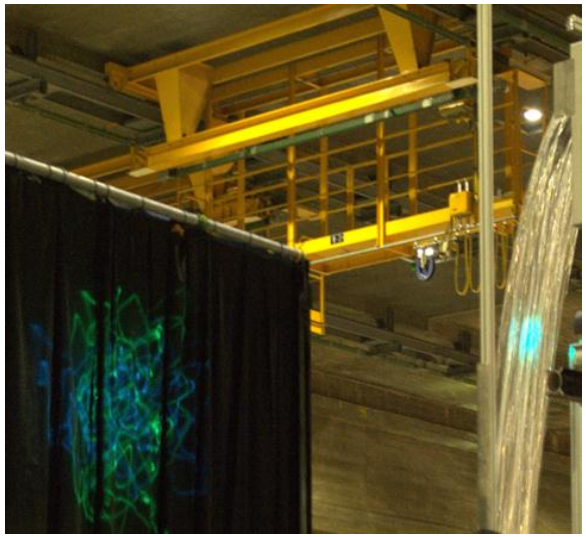
INTRODUCTION

What is the engineer problem to be solved ?

What is the current engineer approach ?

What is the research program ?

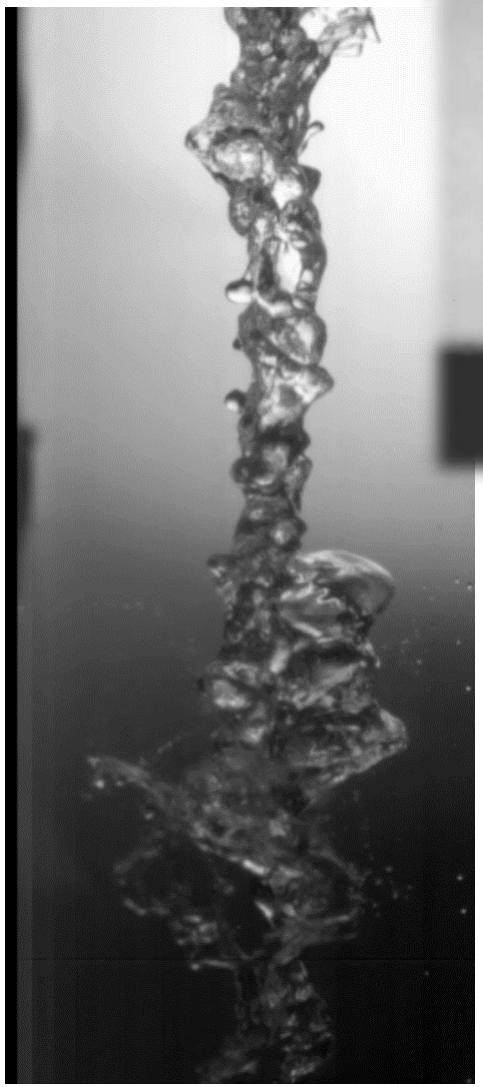
Overflowing at Lapalisse Dam



LDV Measurments

RESEARCH OBJECTIVES

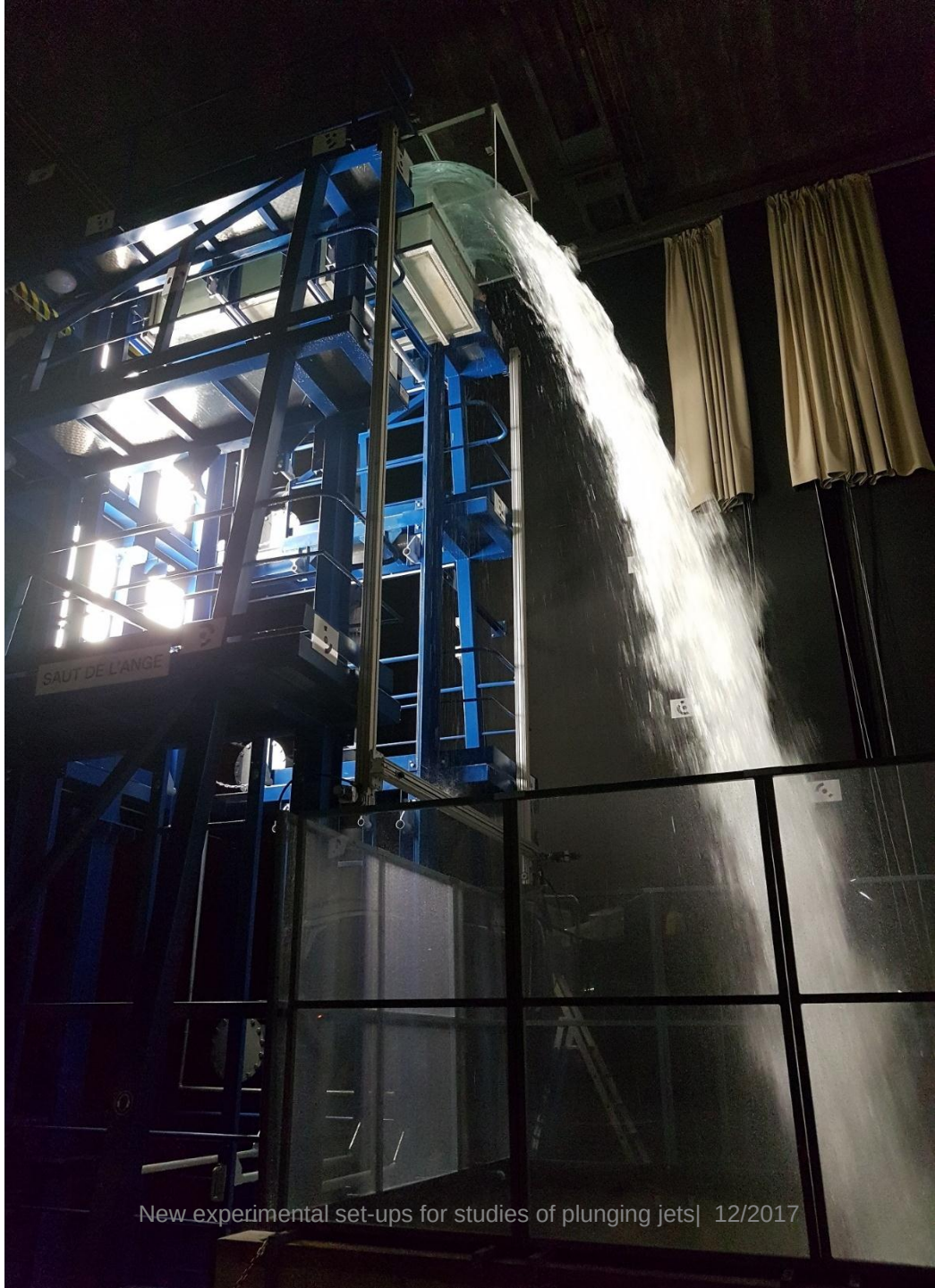
- Jet trajectory
- Interfacial instability evolution
- Impact power
- Impact velocity
- Kinetic energy distribution along the fall
- Energy dissipation into the plunge pool
- Diphasic mixture into the plunge pool



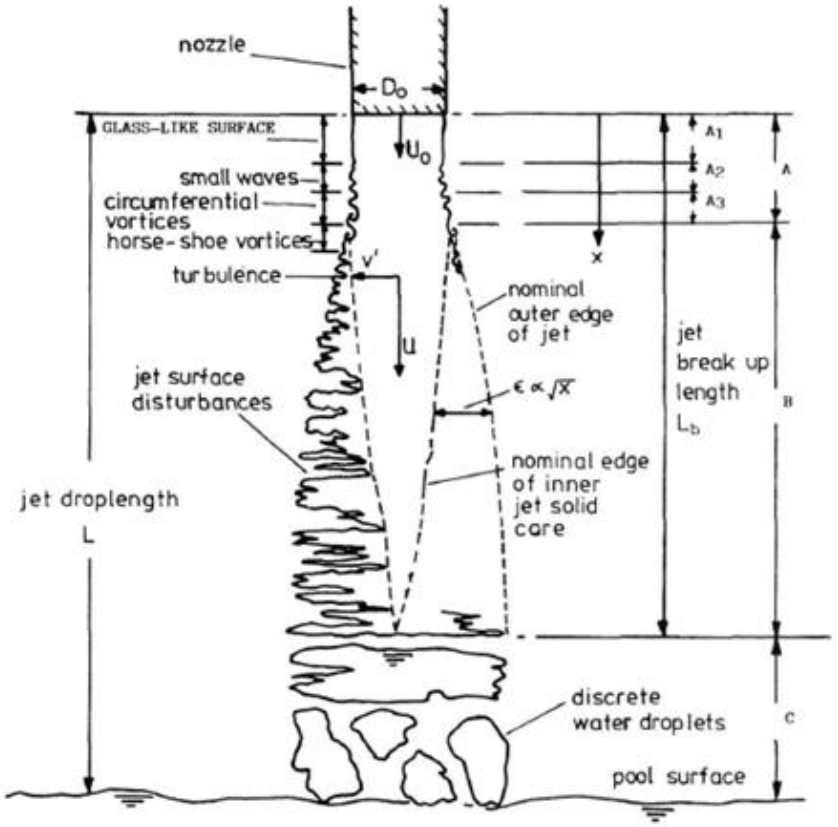
Jet diameter 89mm, height 6 m, flow rate 150 l/s, 5500fps

Jet diameter 135mm, height 1m, flow rate 110 l/s, 7200fps

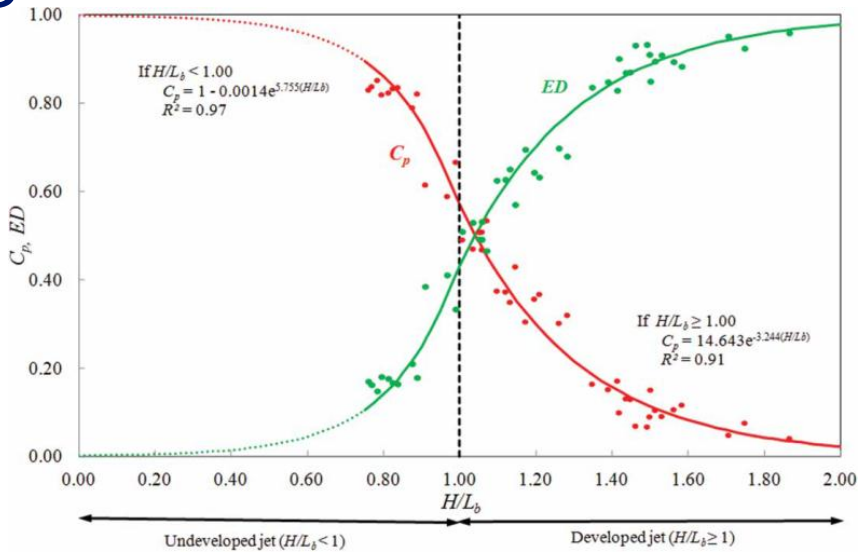
CONTENTS



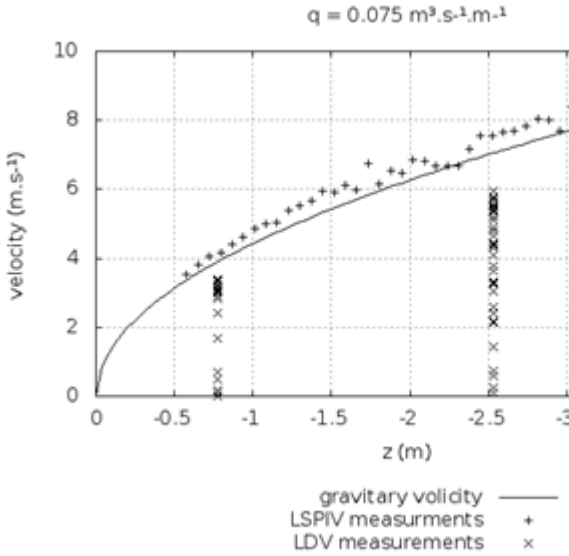
LATEST DEVELOPMENTS



Ervine et al. (1997)

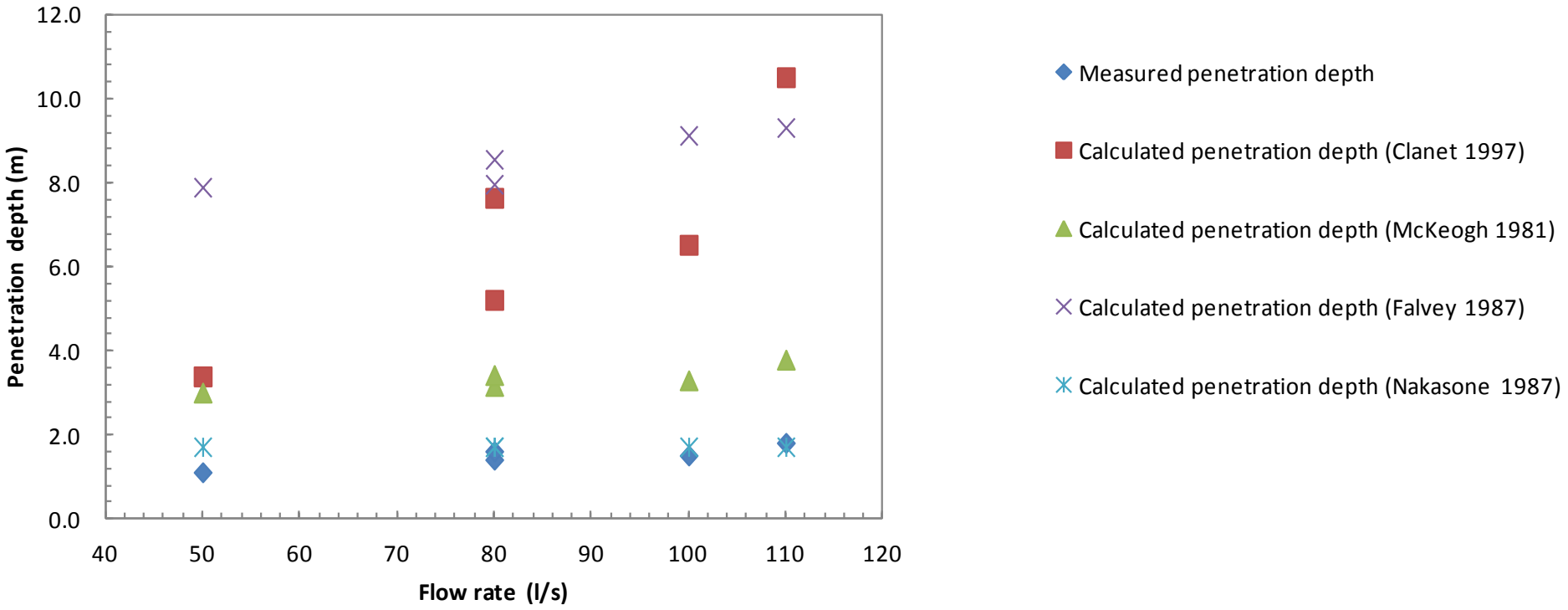


Castillo et al. (2015)



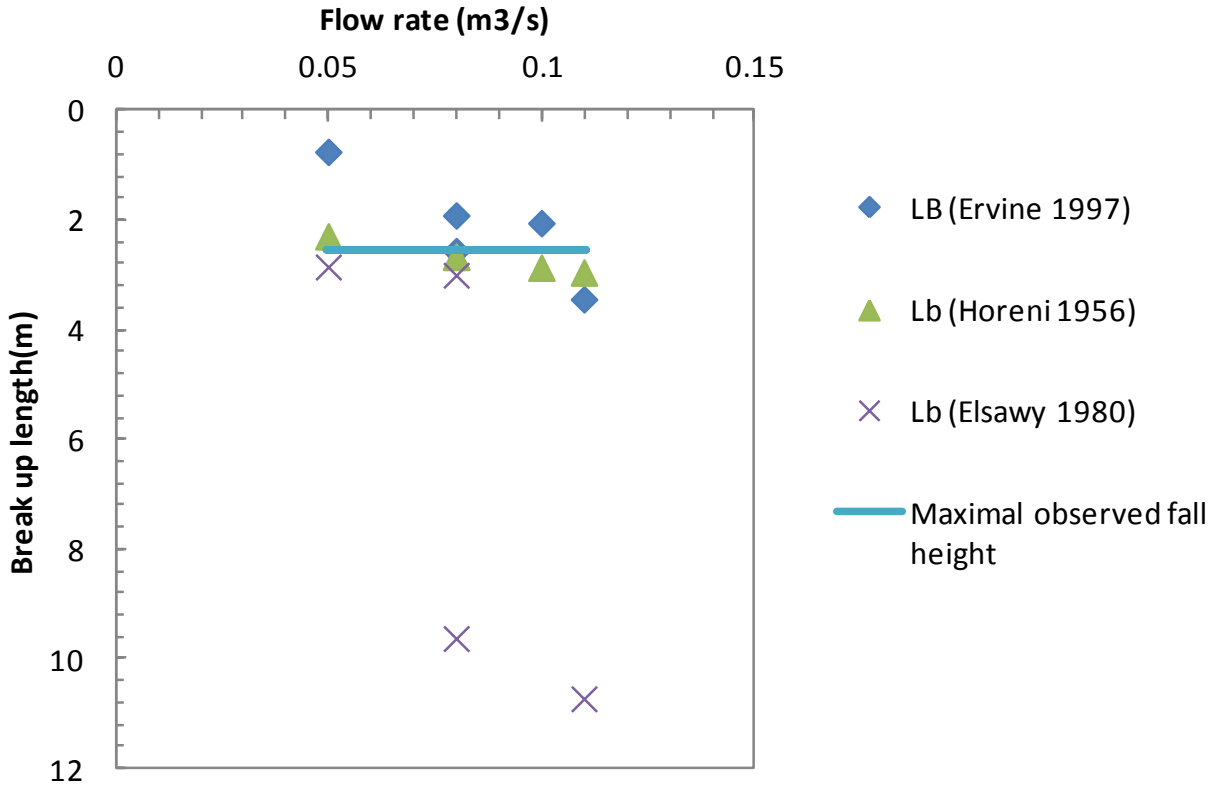
Bercovitz et al. (2016)

JET PENETRATION DEPTH



- Bubbles as jet penetration depth trackers
- Wide range results in the available predictions

ROUND SHAPED JETS BREAK UP LENGTH

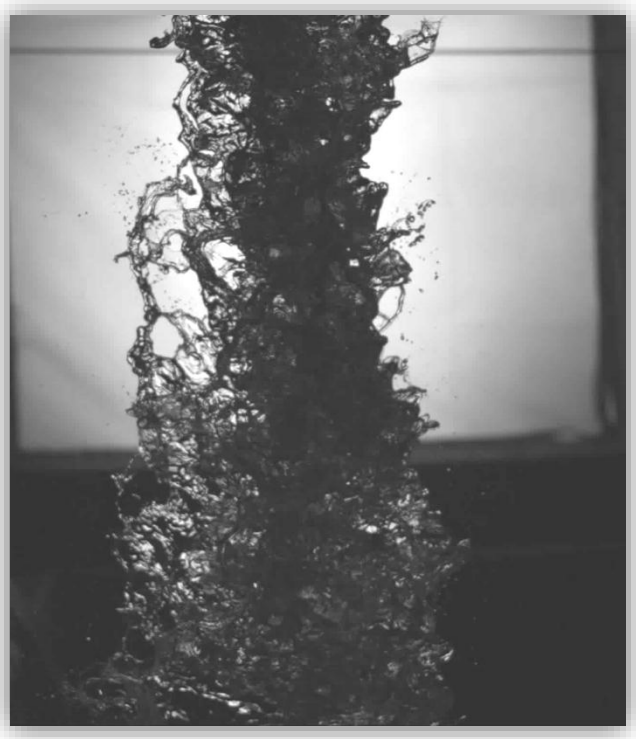


- The Ervine 1997 model indicted that the jets are broken or nearly broken at the maximal observed fall height for 3 cases out of 5.

ROUND SHAPED JETS BREAK UP LENGTH

- High speed videos show it’s not

Jet diameter 164mm, height > 2.5 m, flow rate 50 l/s, 1250 fps

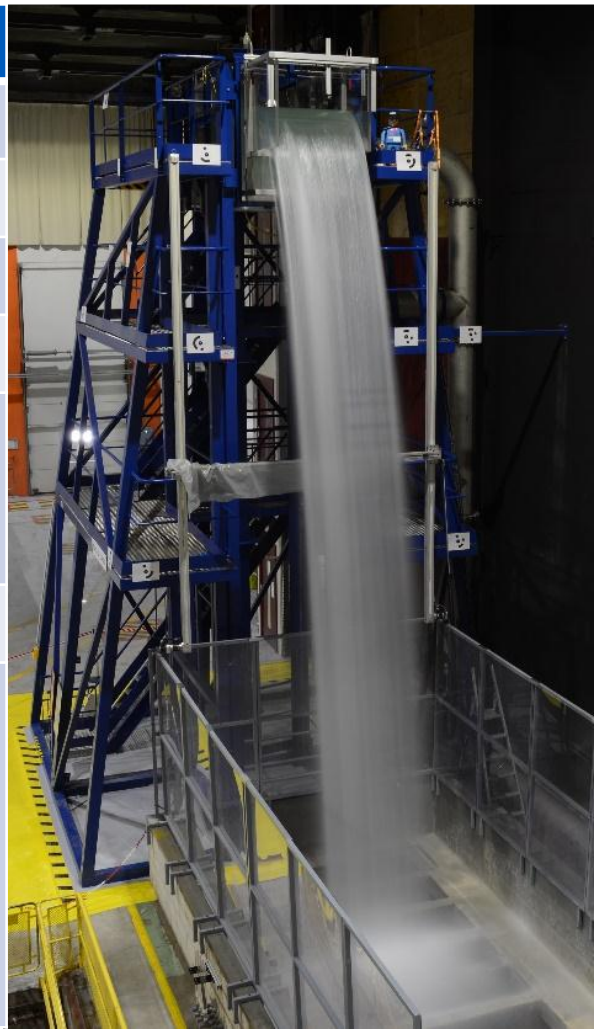


Jet diameter 135mm, height 2.57 m, flow rate 110 l/s, 5500 fps

- No reliable prediction based on the literature
- No available law of similitude

THE EXPERIMENTAL SET UP

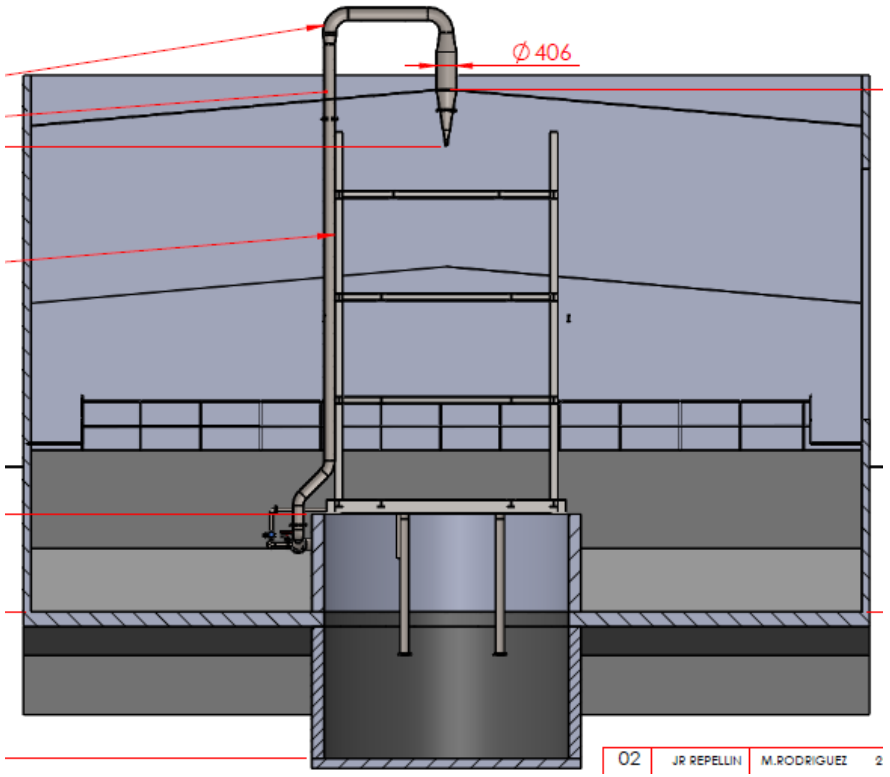
Typology	Characteristics
Weir	Thin crest
Overflowing length	1000 mm
Tray length	2.9 m
Calming means	Head lost + Honeycombs
Maximum height of fall	9.5m / slab 15 m / bottom of the pool (4 m of water heigth)
Q max	500 l/s
Measurment technics	ADV LS-PIV Photogrammetry 4 High speed cameras (1000 fps) 33 pressure sensors (100 Hz) LDV



Overflow for 220 l/s

THE EXPERIMENTAL SET-UPS : ROUND JETS

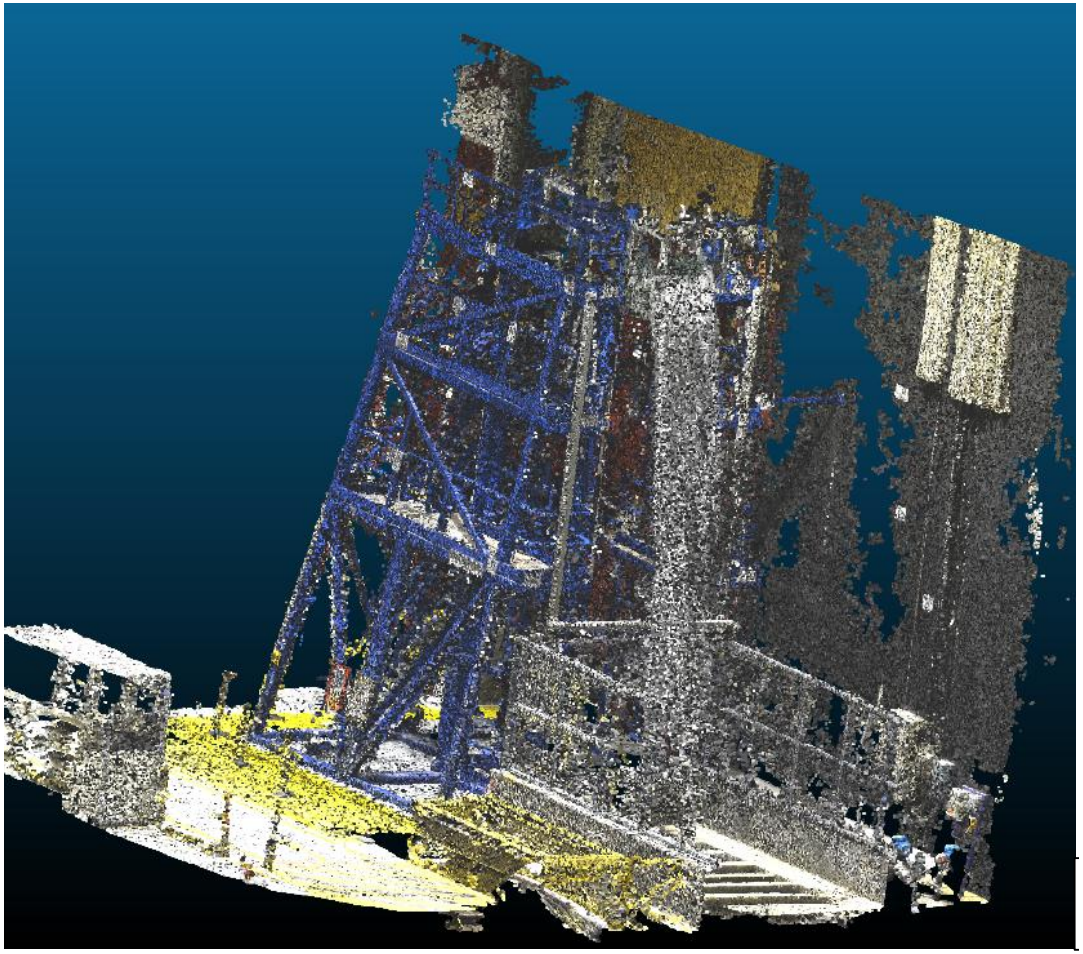
Typology	Characteristics
Nozzle	All kind /Round tested (Ø 26 – 213 mm)
Max Falling height	12,5 m
Plunge pool depth	22,5 m
Flow rate/ velocity	2-320 l/s / 1-35 m/s
Measurement technics	Optical measurement Pressure sensors High speed cameras Momentum advection measurement



THE EXPERIMENTAL SET-UPS

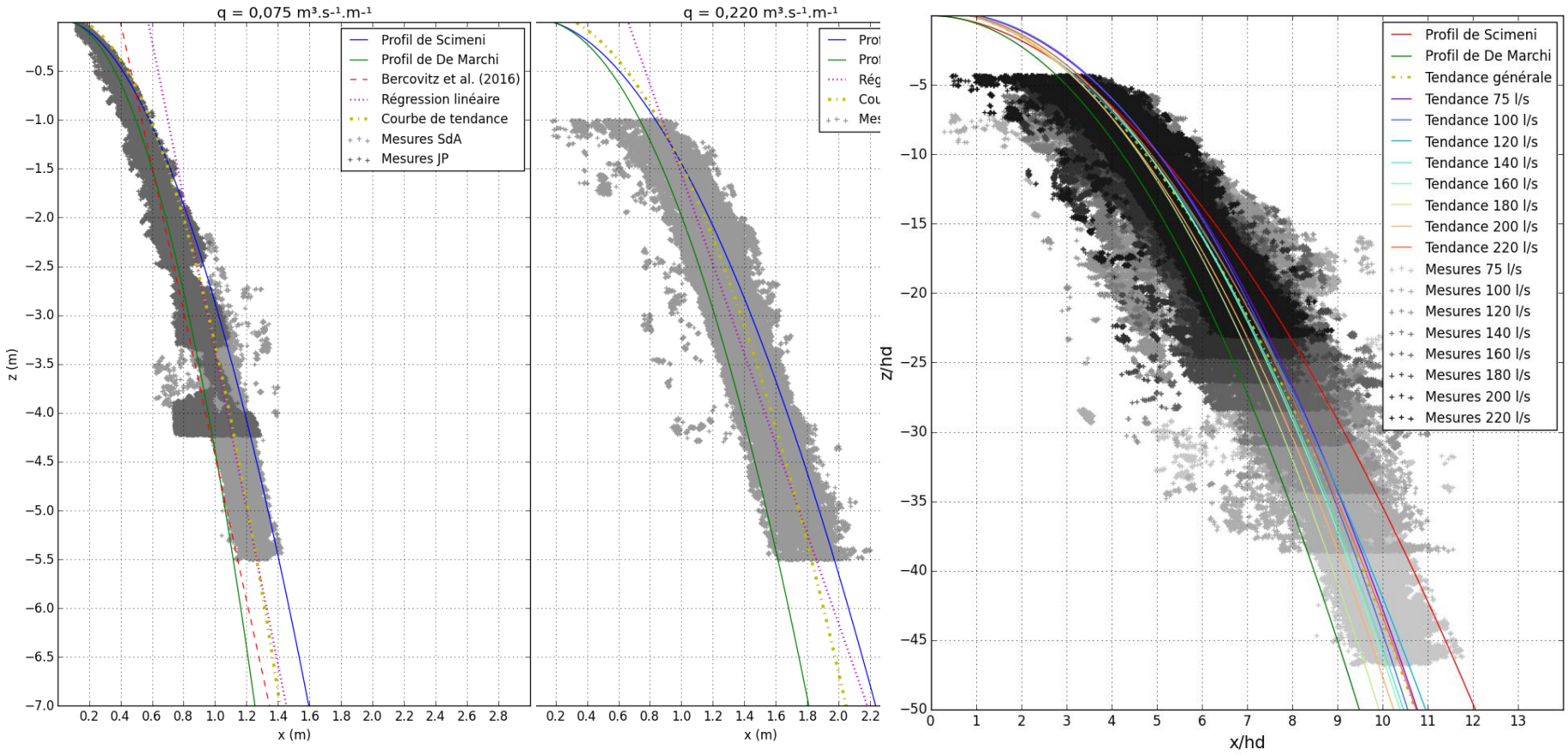
PHOTOGRAMMETRY – DATA TREATMENTS

White water – side view



3D reconstituion (Photoscan – Agisoft©)

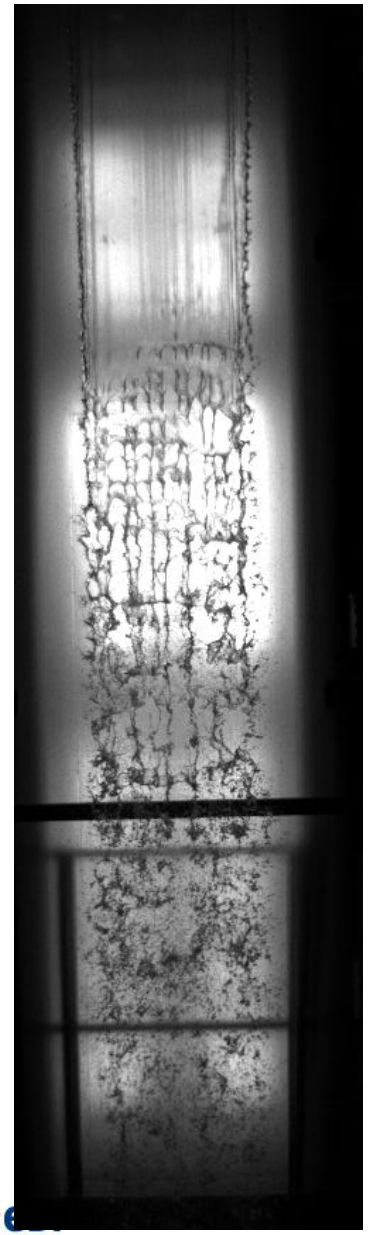
PHOTOGRAMMETRY - TRAJECTORY



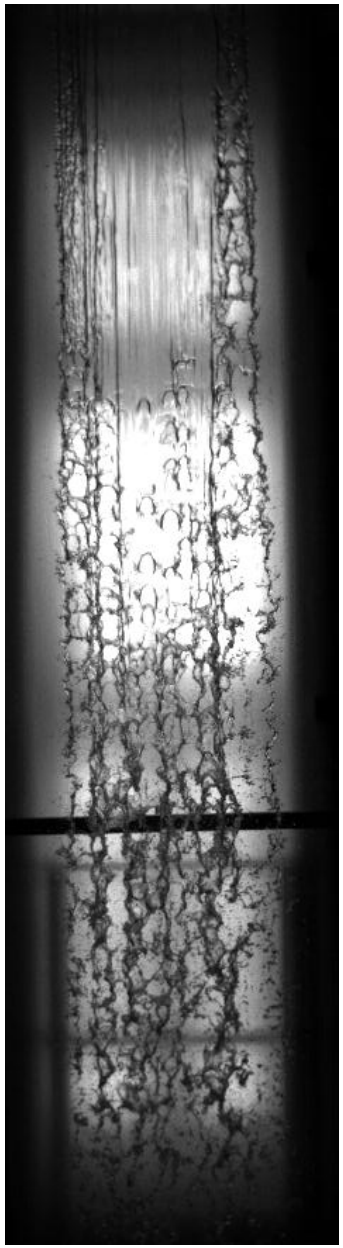
Trajectory measurments

$$\frac{z}{H} = -0{,}5\left(\frac{x}{H}\right)^{1{,}95} + 0{,}375H$$

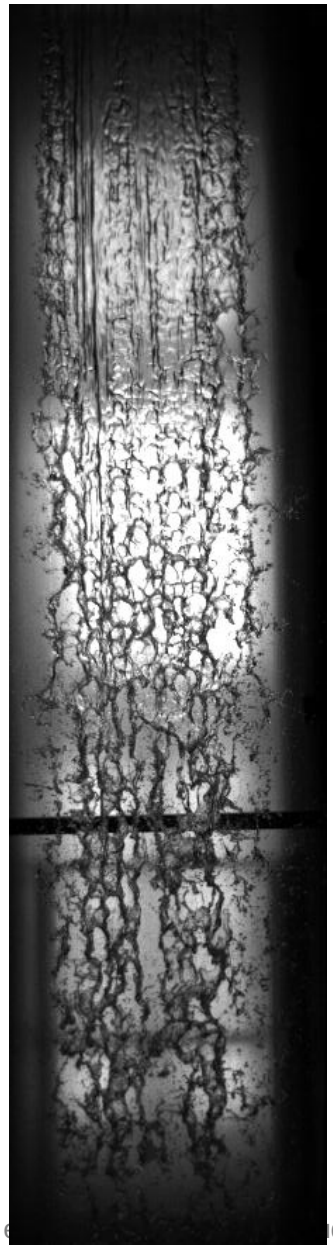
JET BREAK UP



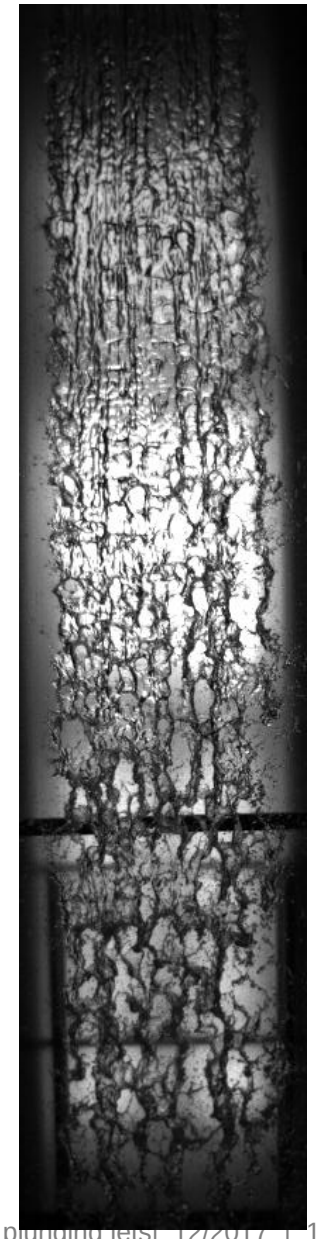
25 l/s



50 l/s



75 l/s



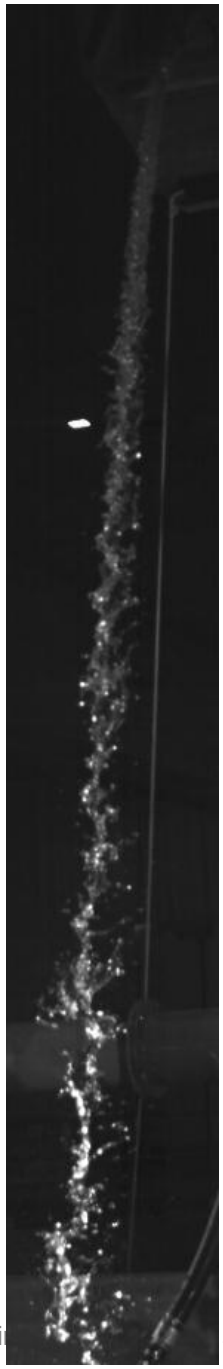
100 l/s

JET BREAK UP

D=213mm V_0=5,0 m/s **D=35 mm V_0=5,0 m/s** **D=23 mm V_0=5,0 m/s** **D=89 mm V_0=1,8 m/s**

CONCLUSION

- Insufficient literature
- No law of similitude available
- Need wide experimental set-ups
- High technology measurements
- Jet trajectory measument
- Jet break up not as expected
- First attempt numerical simulation (Neptune CFD, GPU SPH, OpenFoam)



Thank you

Feel free to joint the effort !