Prospective on instrumentation and new data for Thermal Hydraulics

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THE GEORGE WASHINGTON UNIVERSITY

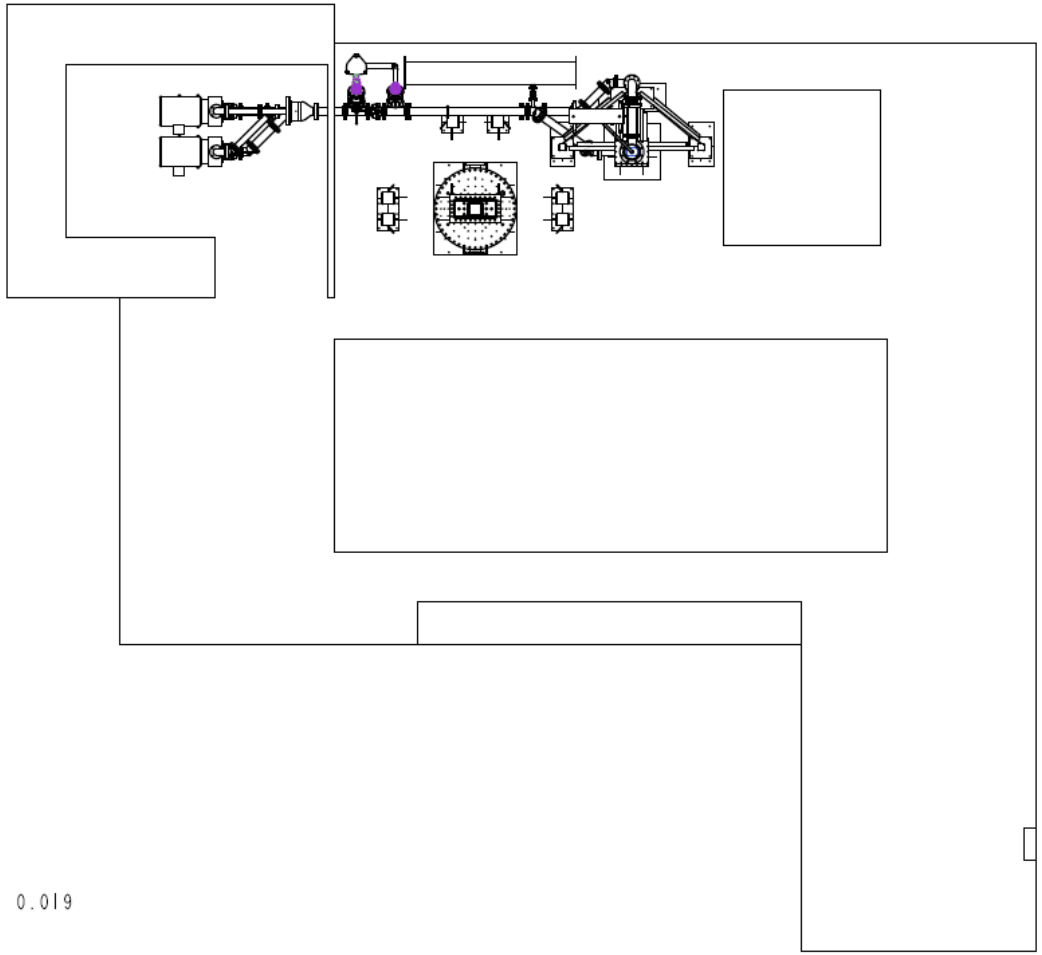
WASHINGTON, DC

TF Lab: Laboratory Spaces

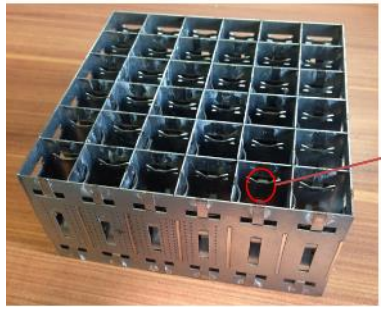
The George Washington University is located in downtown DC, the laboratory being 6 blocks away from the White House.

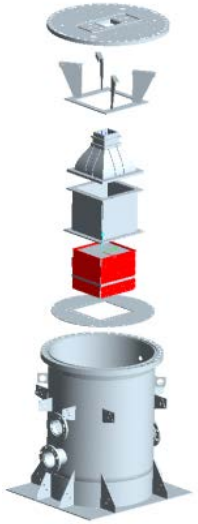
The Thermo-Fluids Laboratory, TF Lab, is located over 3 lab spaces:

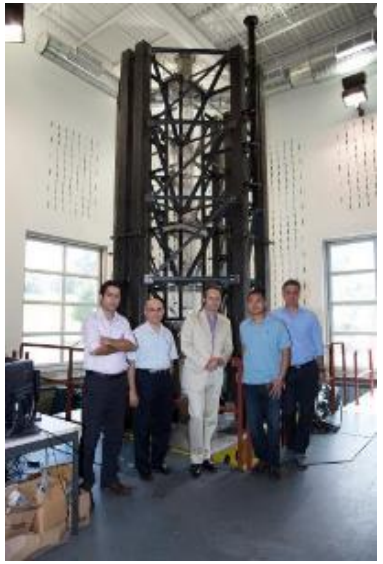
- Downtown DC
  - High Bay and Strong floor: 1350 sq ft
  - laser lab: 1320 sqft
- Virginia (by Dulles airport)
  - two phase flow lab: 750 sq ft



FSI - Seismic Response of Fuel Assemblies

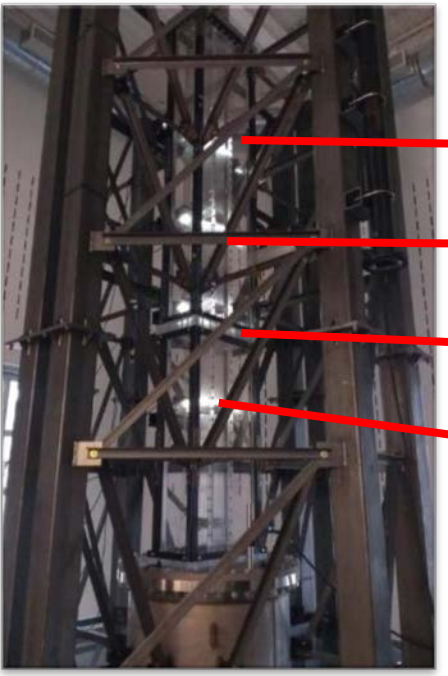


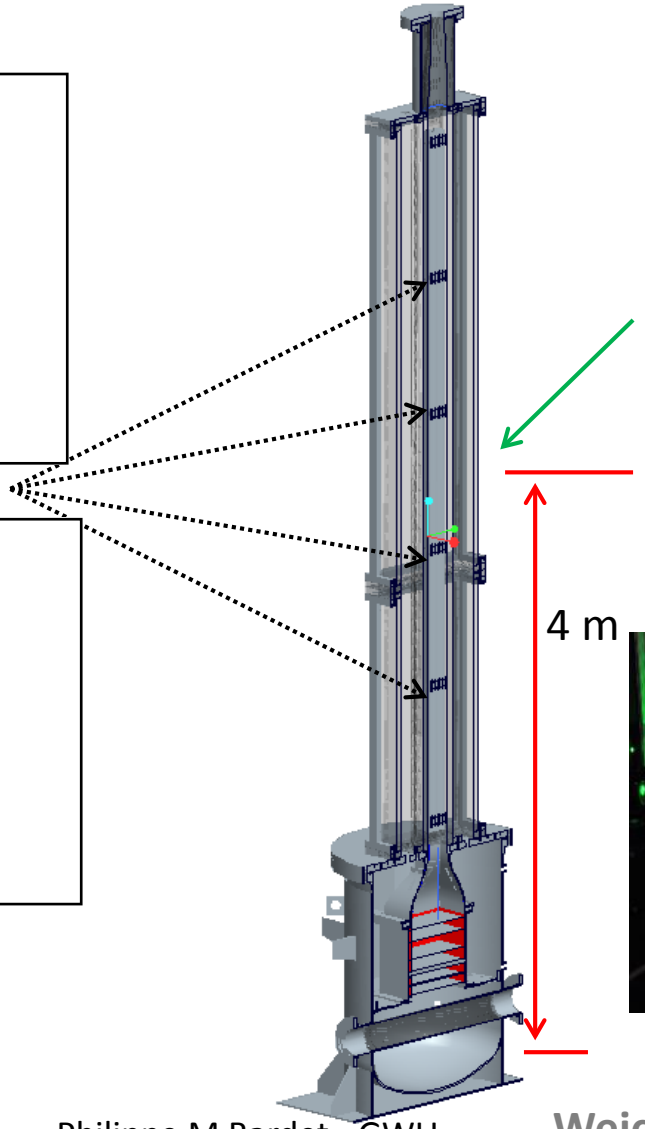




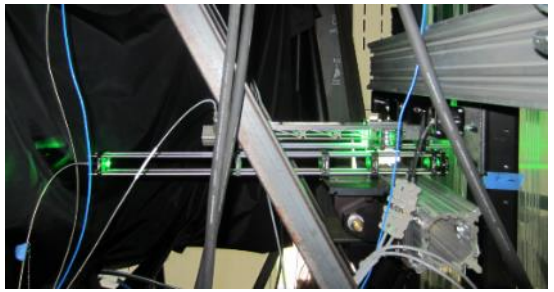
FSI - Seismic Response of Fuel Assemblies

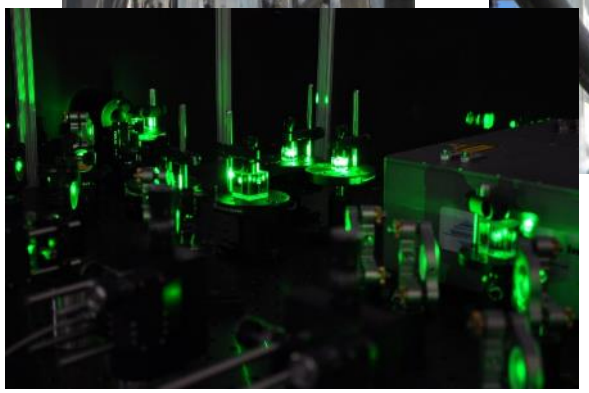
6 Camera DIC system





6 Simultaneous Flying PIV Measurements





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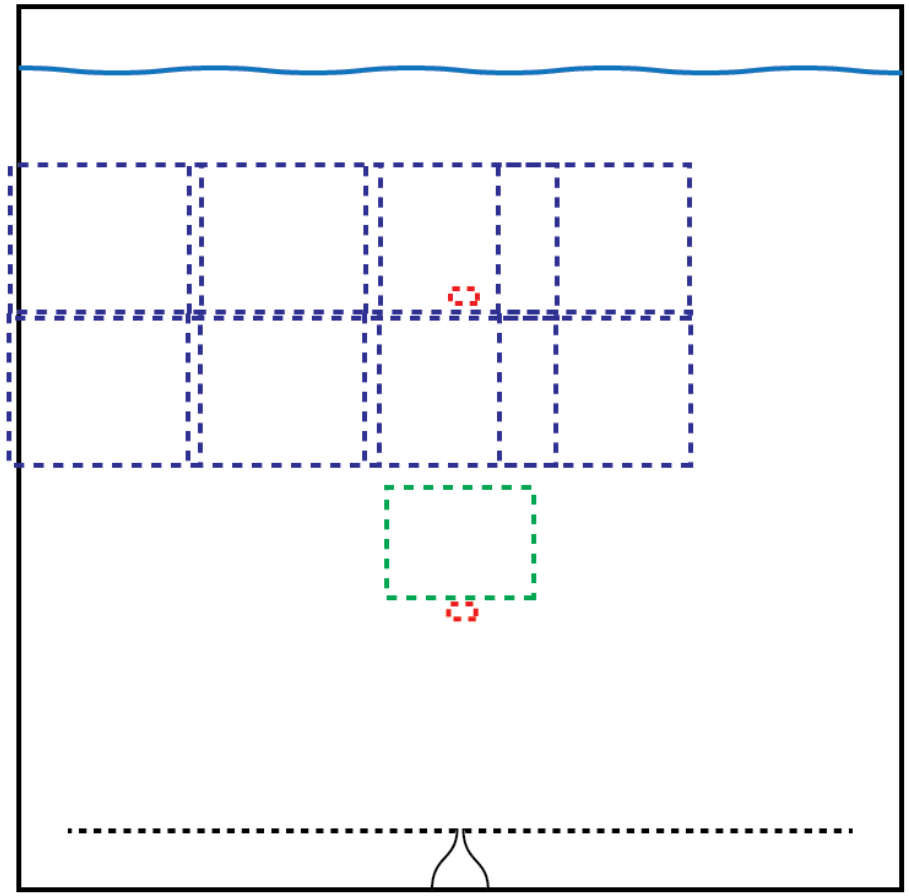
Weichselbaum et al, *Nuc Tech*, 2016, *Exp Fluids*, 2016

FSI - Seismic Response of Fuel Assemblies

Weichselbaum et al, *J Fluid Mech, in progress*
Hussain et al, *J Fluid Mech, in progress*

Canonical experimental facility designed for tight control of test conditions and extensive instrumentation



Pushing to
17 (21?) cameras
3D + t

Magnification	0.031	0.106	0.63
Laser sheet thickness (mm)	2.5	2.5	0.180
Frame rate (Hz)	100	400	~4,000

Cameras record for tens of minutes (~10^6 frames) acquired during previous NEUP

Continuous recording of:

- Initial conditions
- Boundary conditions
- Flow evolution
- Containment effect

High dynamic range:

Spatial: 100 µm – 1 m, **η - L**

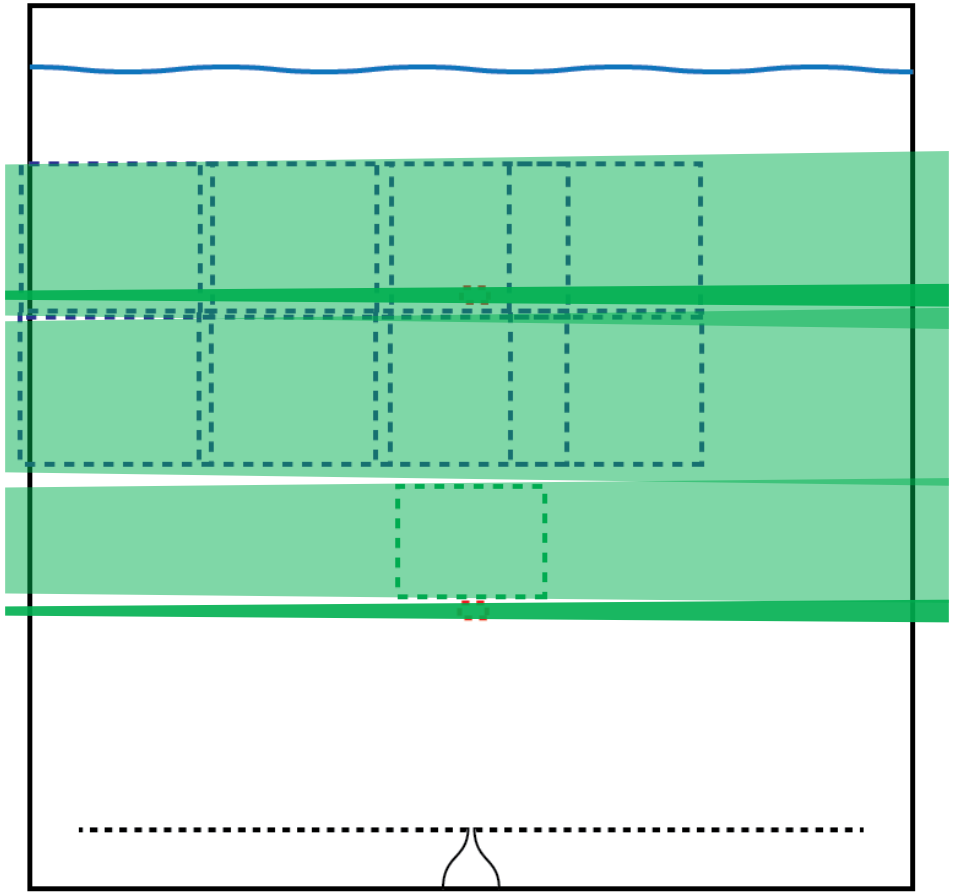
- ie ~10^4

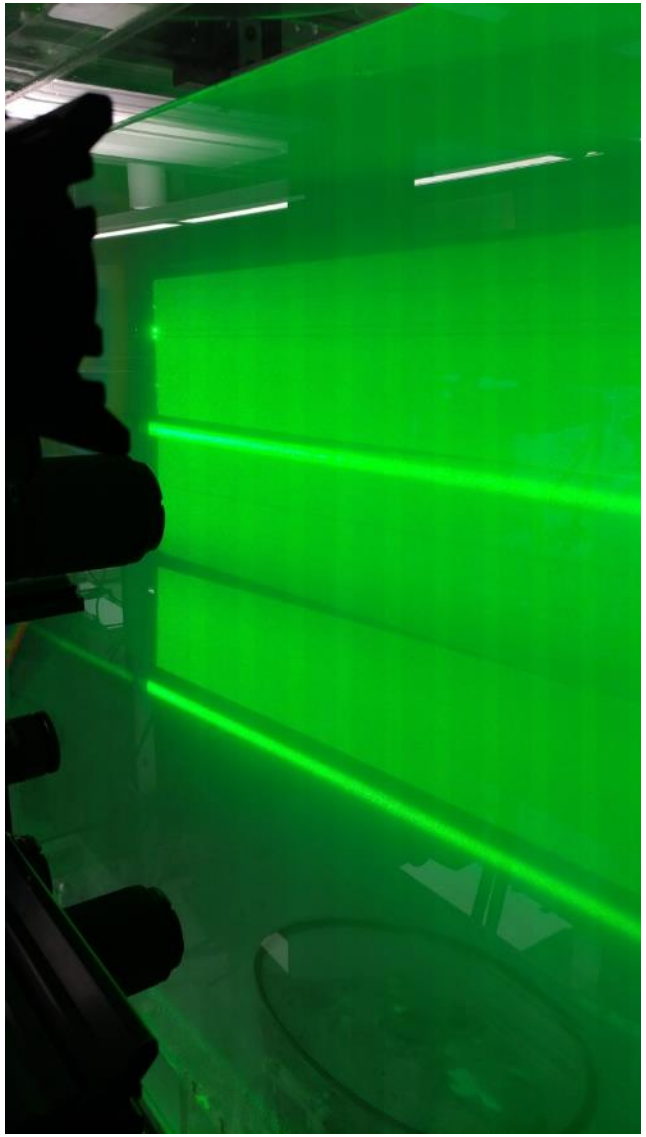
Temporal: 4,000 – 0.1 Hz, **η - L**

- ie ~10^5

Clément et al, *Exp Fluids, under review*
Clément et al, *Exp Fluids, in progress*

5 laser sheets illuminate the test section





Clément et al, *Exp Fluids, in progress*

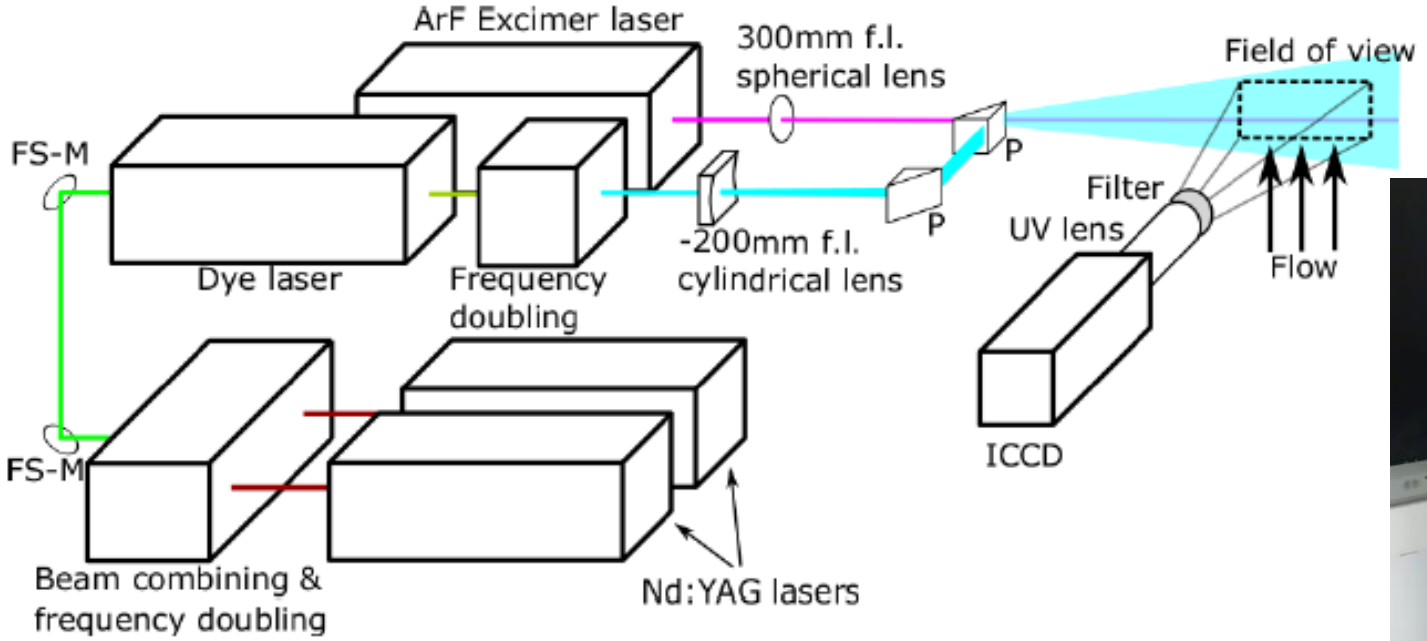
Velocity spectra evolve temporally

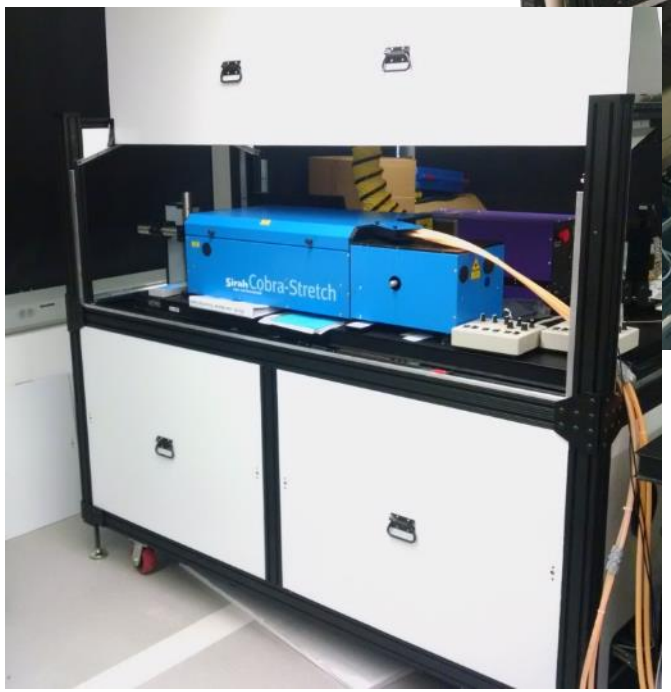
Clément et al, *Exp Fluids, in progress*

IN-SITU MEASUREMENT OF VELOCIMETRY

Laser system mounted on a cart for deploying on the field

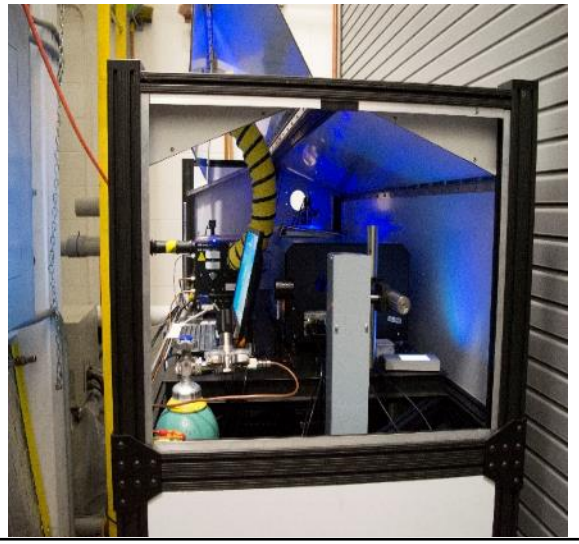
Tunable dye laser (200 to 800 nm) for “Read” (10 193 nm Excimer for “Write” (8 ns pulse)
ns pulse)

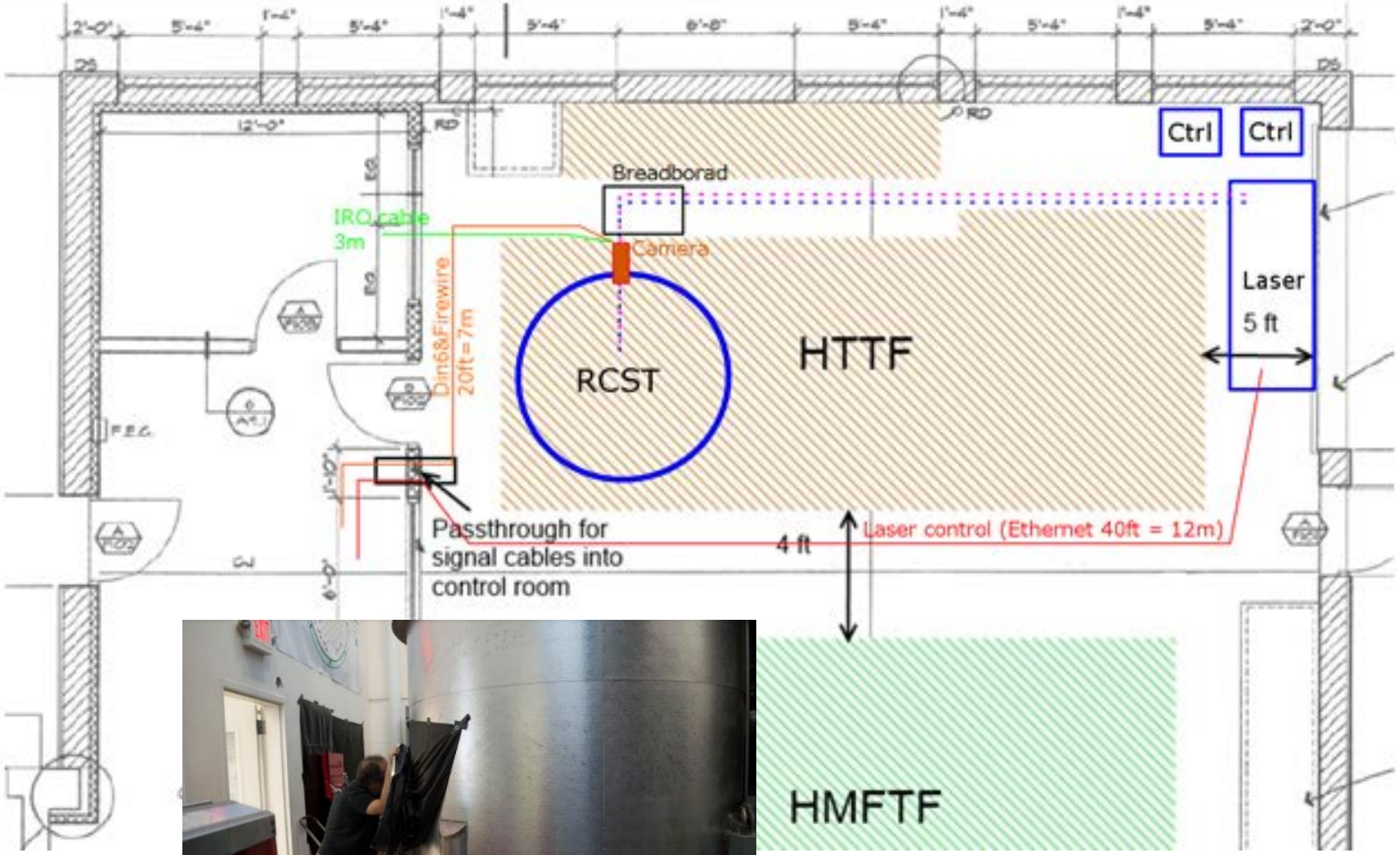




André et al, *Meas Sci Tech*, 2017, *Exp Fluids, in progress*

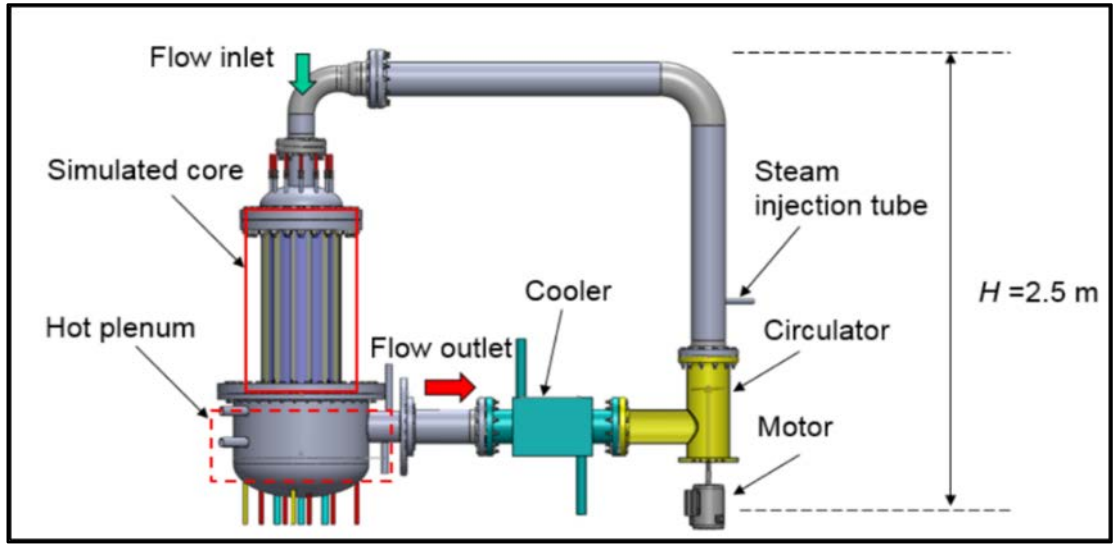
HTTF SETUP & VELOCIMETRY RESULTS

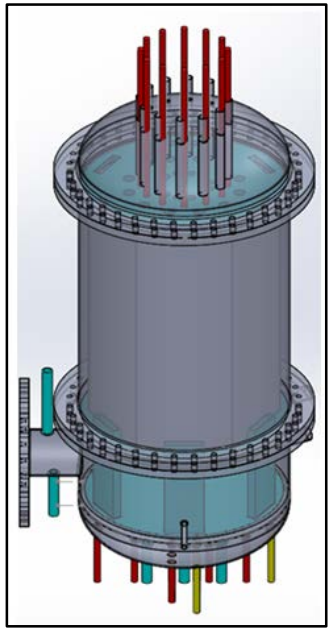


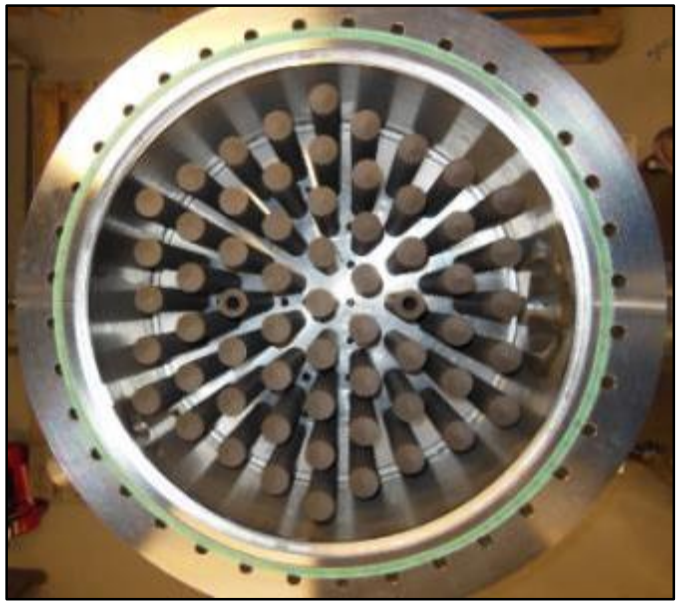


André et al, *Meas Sci Tech*, 2017, *Exp Fluids, in progress*

Laser spectroscopy in IET facility at U. Michigan



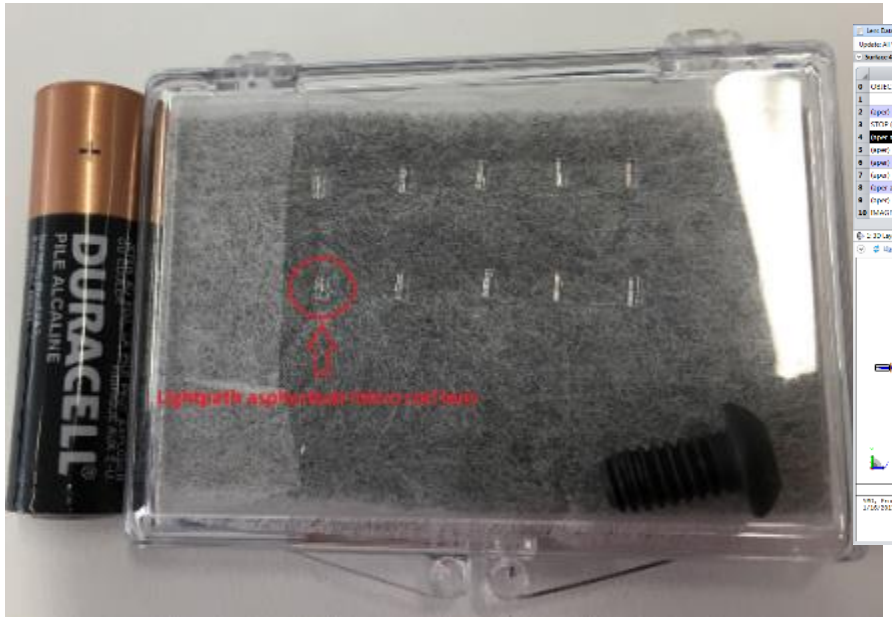


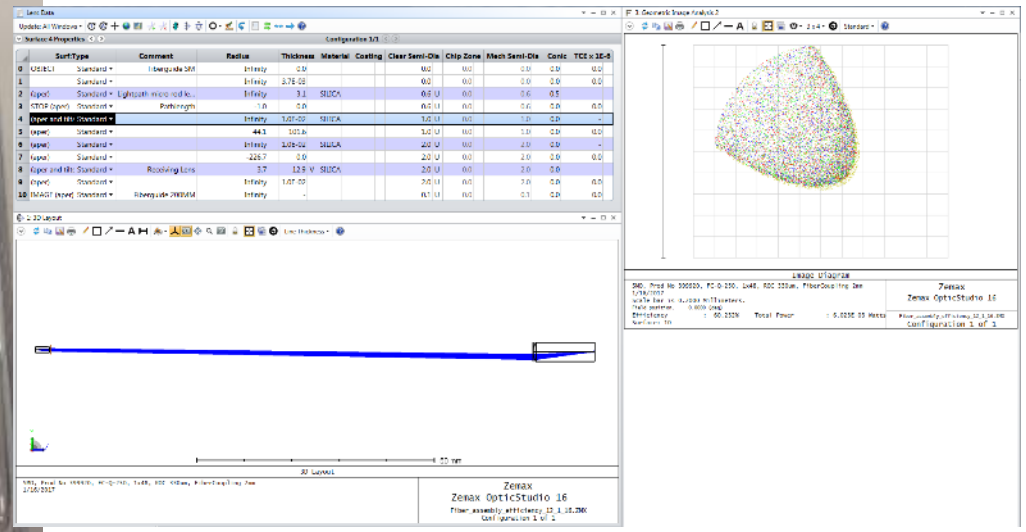


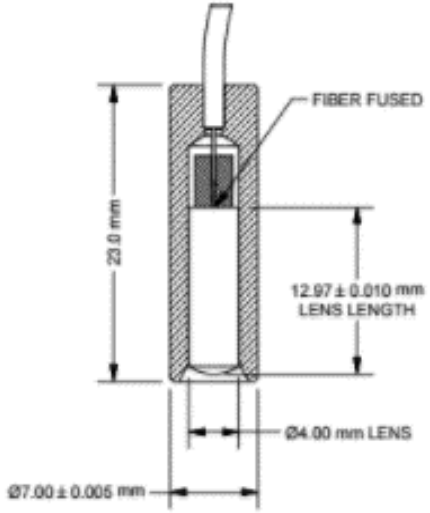
HTGR Environmental Conditions:

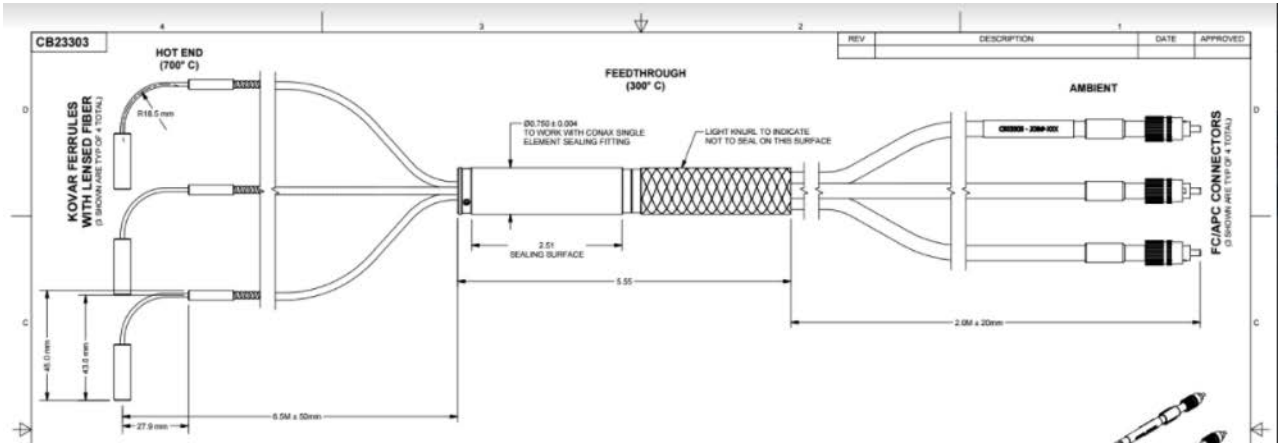
- T = 200 - 700 ºC,
- P = 0 - 50 psig
- $[H_2O]$ = 0.01 - 0.90
- x = 3.7 – 10.2 cm

High Temperature Fiber Optic Assemblies



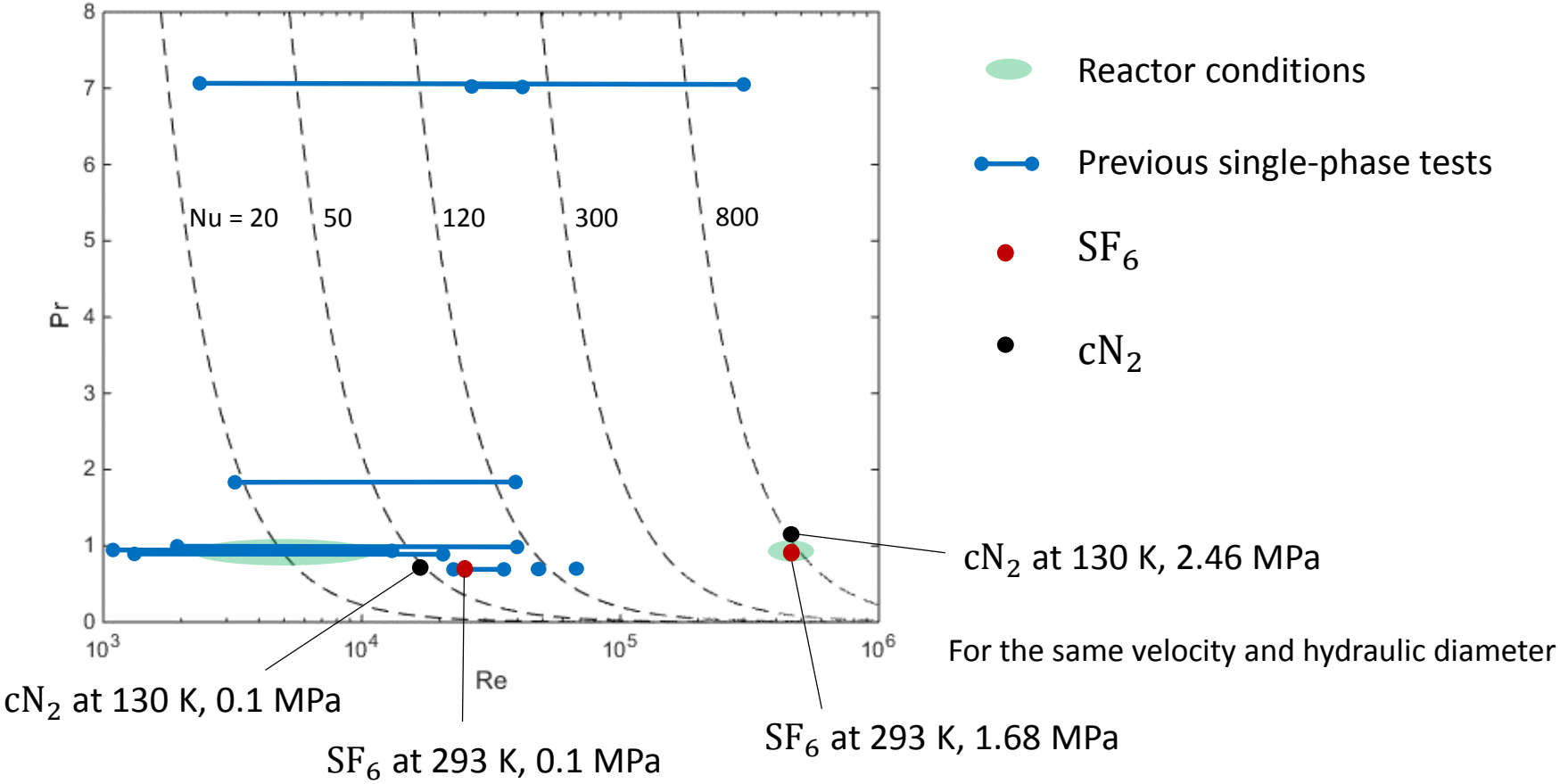






New Surrogate Gases:
Sulfure Hexafluoride and Cryogenic Nitrogen

$$Nu = 0.023 Re^{0.8} Pr^{0.4}$$

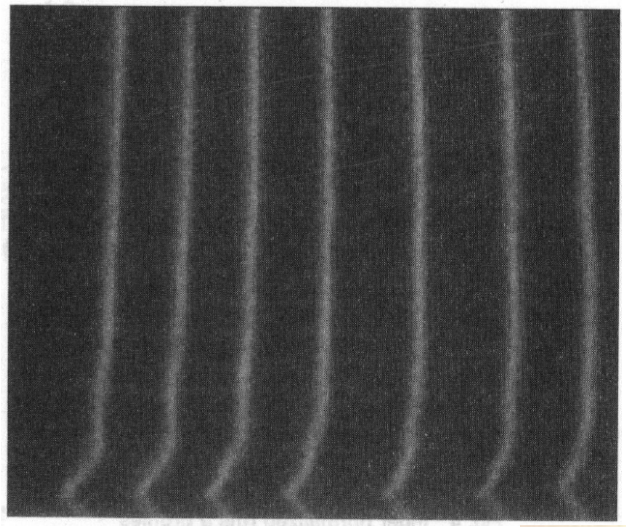


For the same velocity and hydraulic diameter

Possibility to modify the velocity of course, in addition to the pressure

Clément & Bardet, *Nuc Tech*, 2017

Future Opportunities for Thermal Hydraulics



- Temperature
- Velocity
- Wall shear stress
- Pressure fluctuations

- Many Opportunities abound in Two-Phase Flow