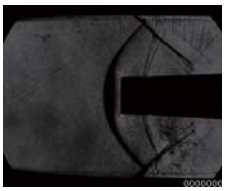


第2回EFD/CFD融合ワークショップ
宇宙航空研究開発機構　調布航空宇宙センター
2009年2月24日（火）

普段着のEFD/CFD連携
～超音速抗力低減を題材として～

This is Our Usual EFD/CFD Collaboration
- An Example in Supersonic Drag Reduction Study -

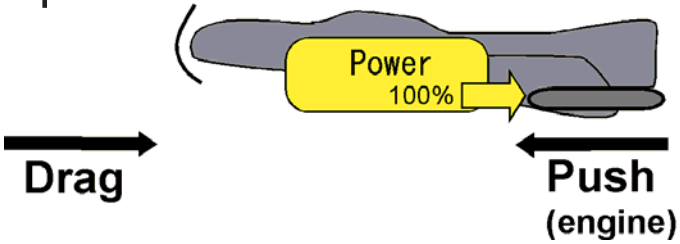
名古屋大学大学院工学研究科航空宇宙工学専攻
佐宗 章弘，酒井武治，松田淳，関谷洋平，Jae Hyung Kim
SASOH,　SAKAI,　MATSUDA, SEKIYA,　KIM
（EFD）（CFD/EFD）　（EFD）　（EFD）　（EFD/CFD）

Definition of Problem

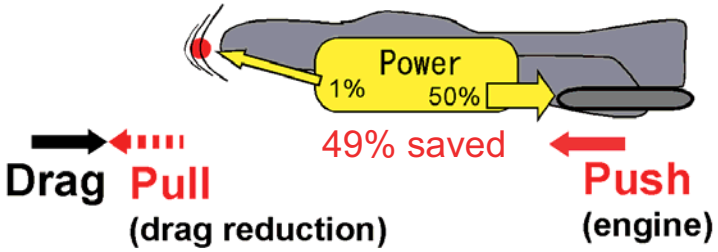
Push-Pull hybrid propulsion: A wave drag can be efficiently decreased with energy depositions ahead of a body.

(Power for propulsion) = (Drag) × (Speed)

-w/o energy deposition



-w/ energy depositions



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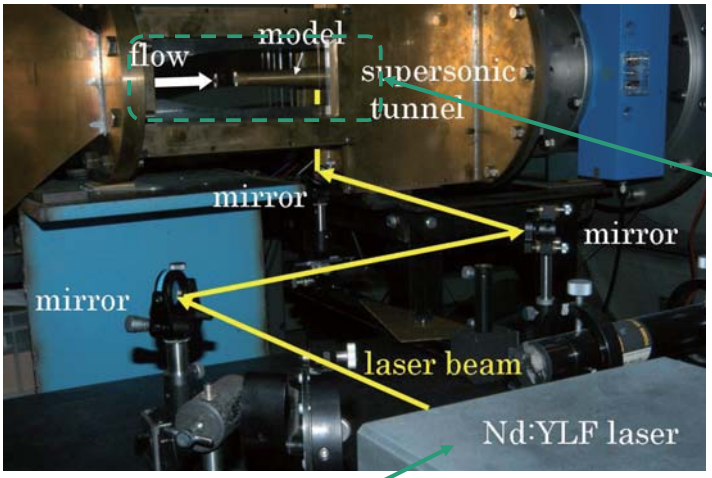
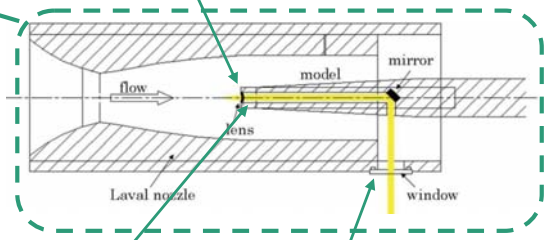
Configuration

Control parameters: Flow Mach number/Laser energy/ Laser pulse repetition frequency/Location of energy deposition

Results: Decrement in drag/efficiency of energy deposition





Plane-convex lens
(f=10-30mm)

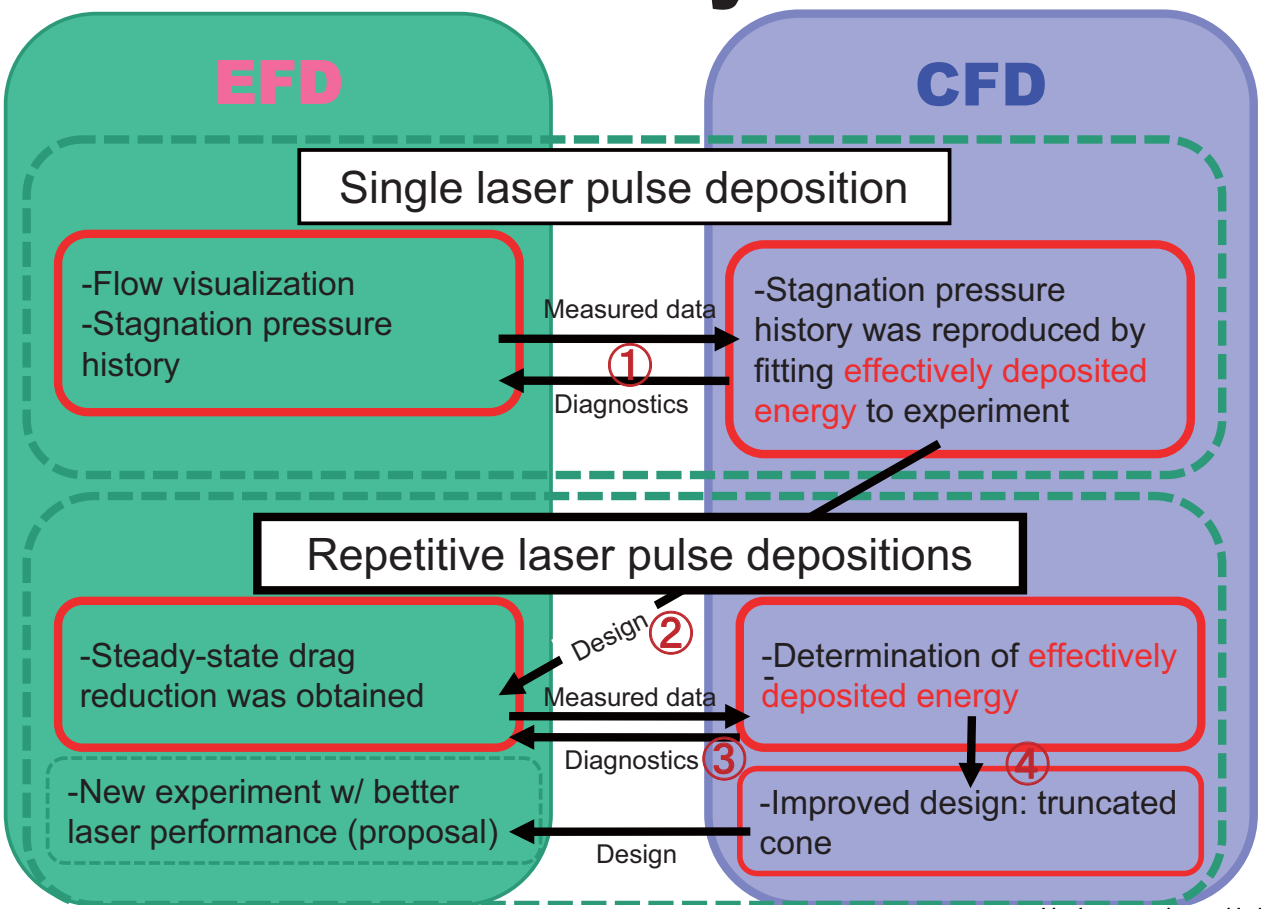
BK7 window

20mm-dia. cylinder

Nd:YLF laser (PowerEdge co., wavelength; 1047nm, repetition frequency; 10 kHz max., average power; 80 W max., 5mm × 5mm square beam)

3

History



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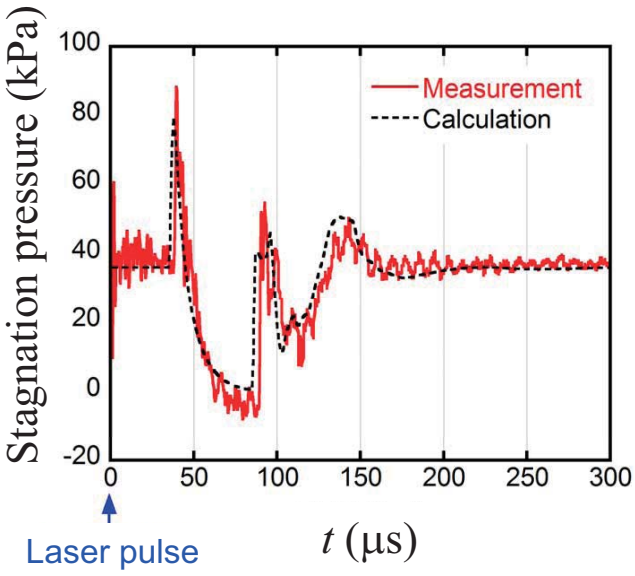
1st Step:
Single pulse operation
(presented @ last workshop)

Data Fitting in Stagnation Pressure History



EFD: @operation temperature out of guarantee (yet temporally accurate)

CFD: Effectively input energy should be given

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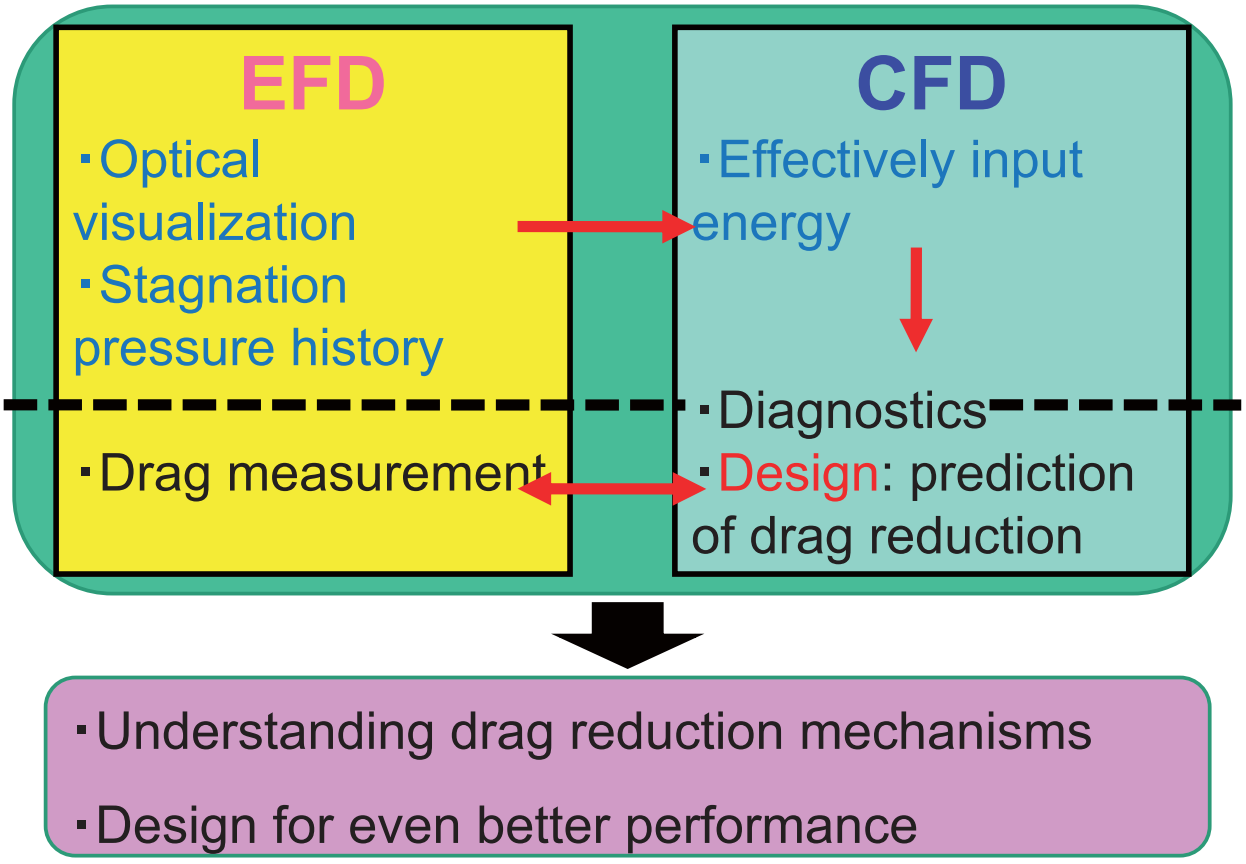
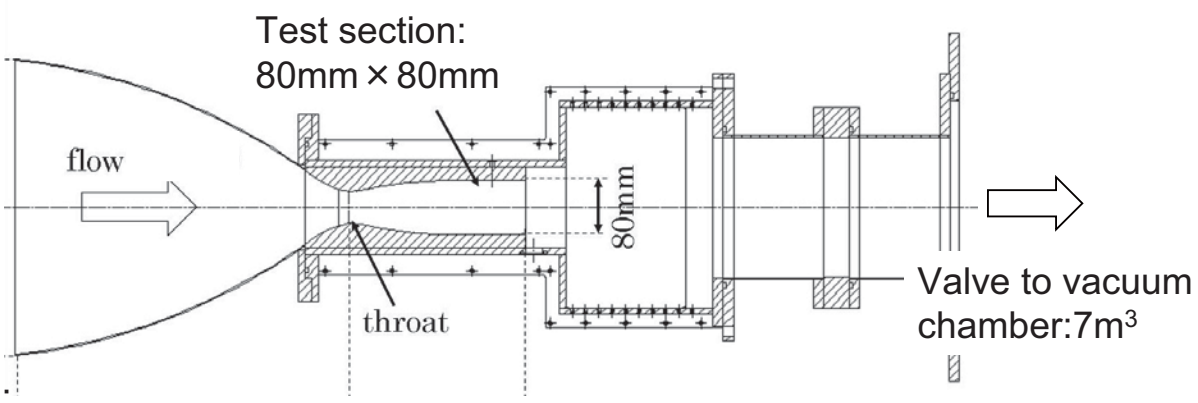
EFD/CFD Integration Gets More



2nd Step: In-Draft Wind Tunnel

Designed w/ method of characteristics
→ Boundary layer correction using CFD
→ Experimental performance examination



-Flow Mach number =2.0
-Run time = 5s
-Total pressure =101kPa
-Static pressure = 14.7kPa
(-Static temperature= 167K)

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3d Step: Steady-State Drag Measurement

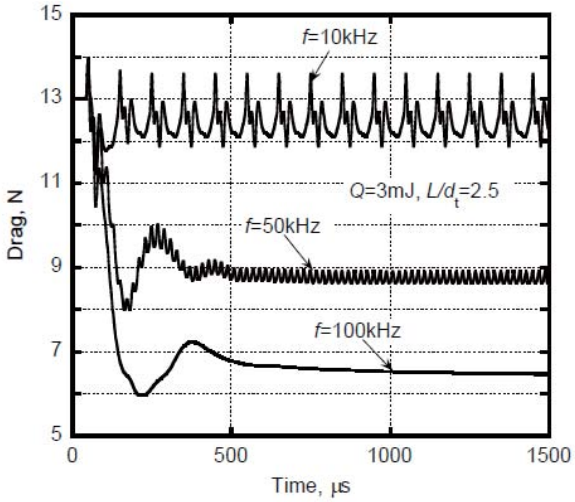
- Experimental evaluation of steady-state (time-averaged) drag reduction using up-to-10-kHz repetitive laser pulses.
  - **More accurate** than spatiotemporally integrating pressure field.
  - Real performance with **interactions among pulses**

- Understanding related flow mechanics through numerical & experimental **diagnostics**.

9

4th Steps: New Insight from CFD (Repetitive-Pulse Effect)

Single-pulse performance cannot be applied if the repetition frequency is high enough for interactions to be significant.



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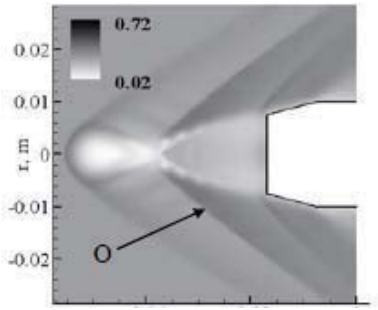
New Design by CFD: Truncated Cone (Sakai 2009):

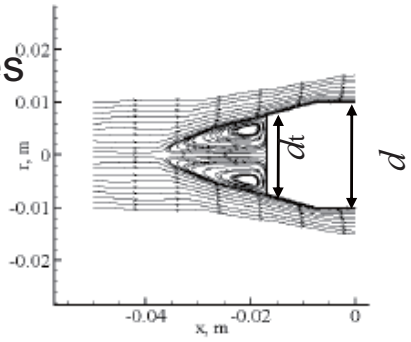
~Small drag & high efficiency~

Quasi-steady flowfield
(Q=3mJ, f=100kHz)

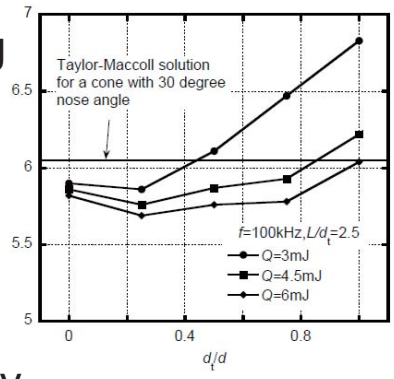
Isopycnics



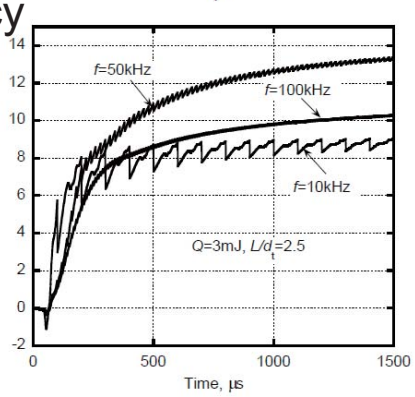
Streamlines



Drag



Efficiency



Summary: Do not forget/Let's start basic EFD/CFD interactions

Brief History truncated cone in four months:

- **Sakai** & **Sasoh** discussed **truncated cone** idea.
- **Sakai** ran a computer for truncated cone operation.
- **Sakai** numerically obtained the truncated cone performances, which were pretty good!
- **Sekiya** designed a truncated cone for experiment.
- **Sakai** already started writing a paper.
- **Sakai** predicted drag reduction available with existing facility (10 kHz was not high enough, 50 kHz would yield best efficiency)
- **Sekiya** conducted experiments (Large drag reduction w/ flat nose; drag reduction was too small w/ truncated cone – consistent to the prediction)
- **Sekiya** collected drag reduction data only with the flat nose, **Sakai** did numerical diagnostics, **Sasoh** started writing a proposal for a better performance laser, **Kim** proposed another idea for experiment, **Matsuda** supported arrangements for Kim's experiment

A Dairy on a day w/o any disturbance:

-Morning: Coming to the lab. w/ casual dresses (no ties), discussions in office, preparing for experiment in lab.

-Lunch: Together (students do not want to talk on research even in lunch time every day like Sakai & Sasoh do. Matsuda & Kim have their own lunch box which their wives cook)

-Afternoon: Experiment and discussions in lab.

-Evening: Staff go home (Sakai comes back), students stays longer if necessary.

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