# Effects of step in CFVN on Premature Unchoking Phenomena

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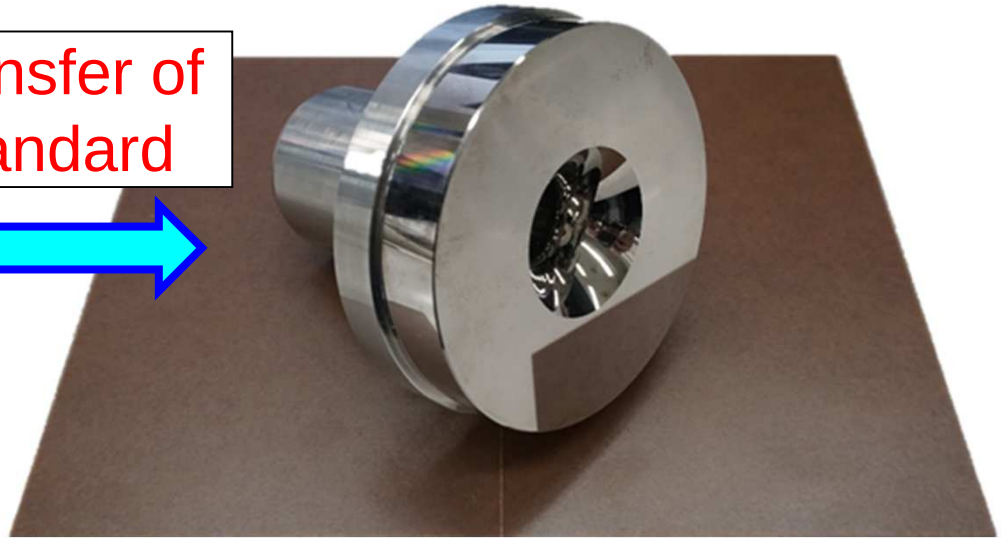
# CFVN (Critical Flow Venturi Nozzle)

CFVNs are widely used as transfer standards.

**PVTt system**

Transfer of standard

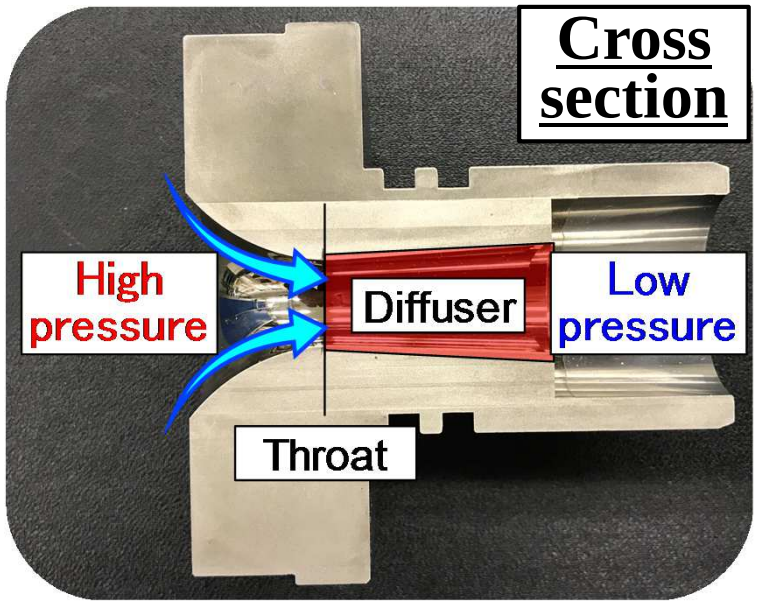
**CFVN**



# Characteristics of CFVN (Critical Flow Venturi Nozzle)

## ① Constant velocity at throat

flow velocity at the throat reaches the speed of sound (when the back pressure ratio is lower than a certain value).

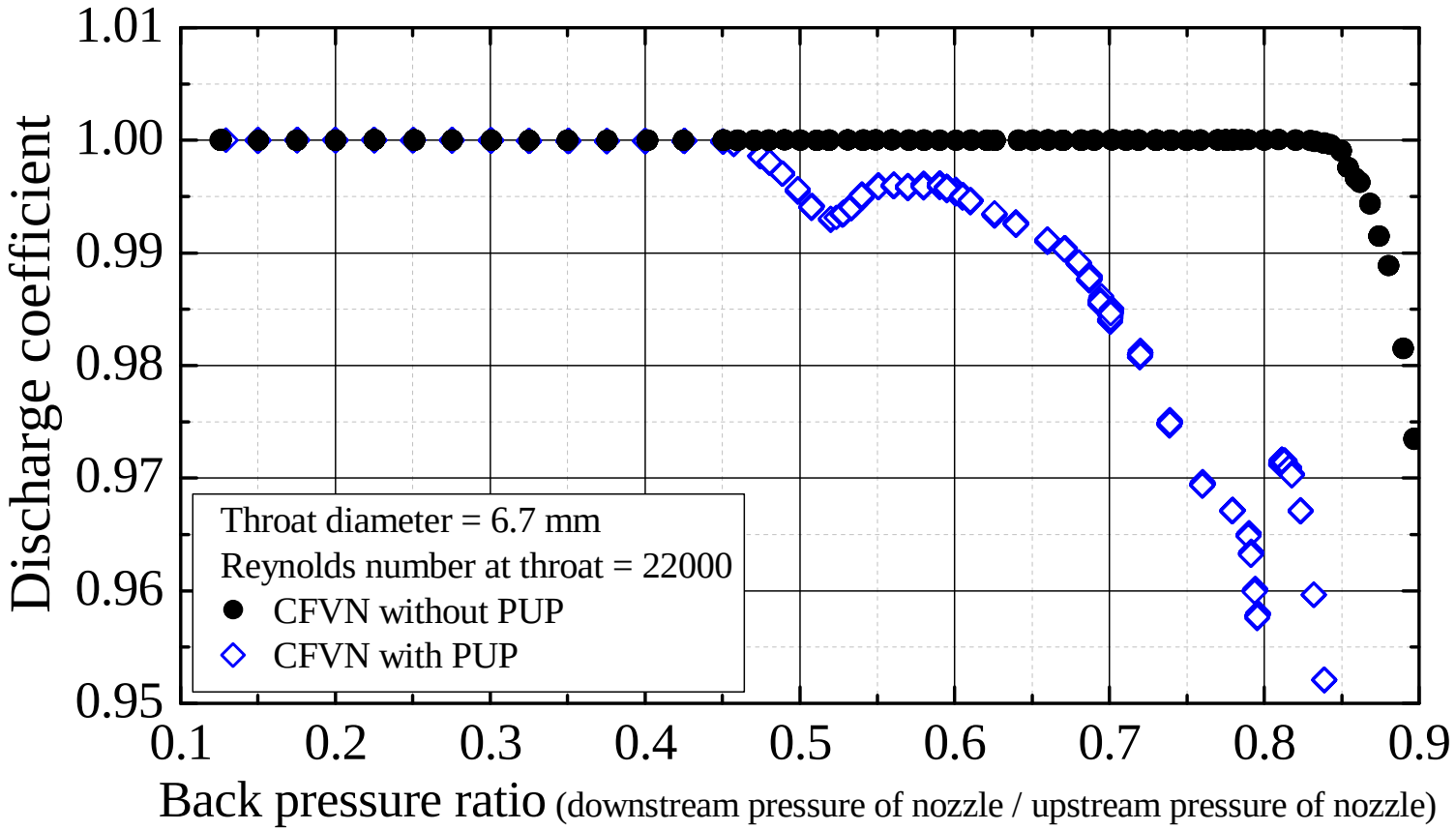



## ② Pressure recovery effect

However… in the CFVNs,
low back pressure ratio is required to produce choked flow.

→ the diffuser plays a role as a pressure recovery system, and it enable the CFVNs to choke at high back pressure ratio.

# PUP(Premature Unchoking Phenomena)




The discharge coefficient usually shows a constant value up to a certain back pressure ratio.

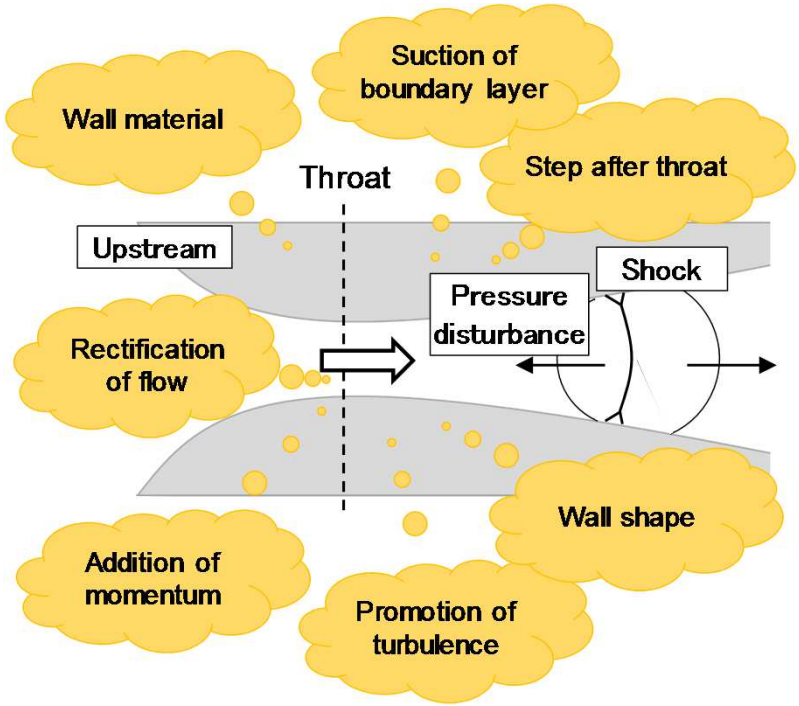
# Past research and purpose of this research

## Diffuser Length:

A diffuser length which is 10 times or more longer than the throat diameter is effective to suppress the PUP ($R_e > 14000$) .

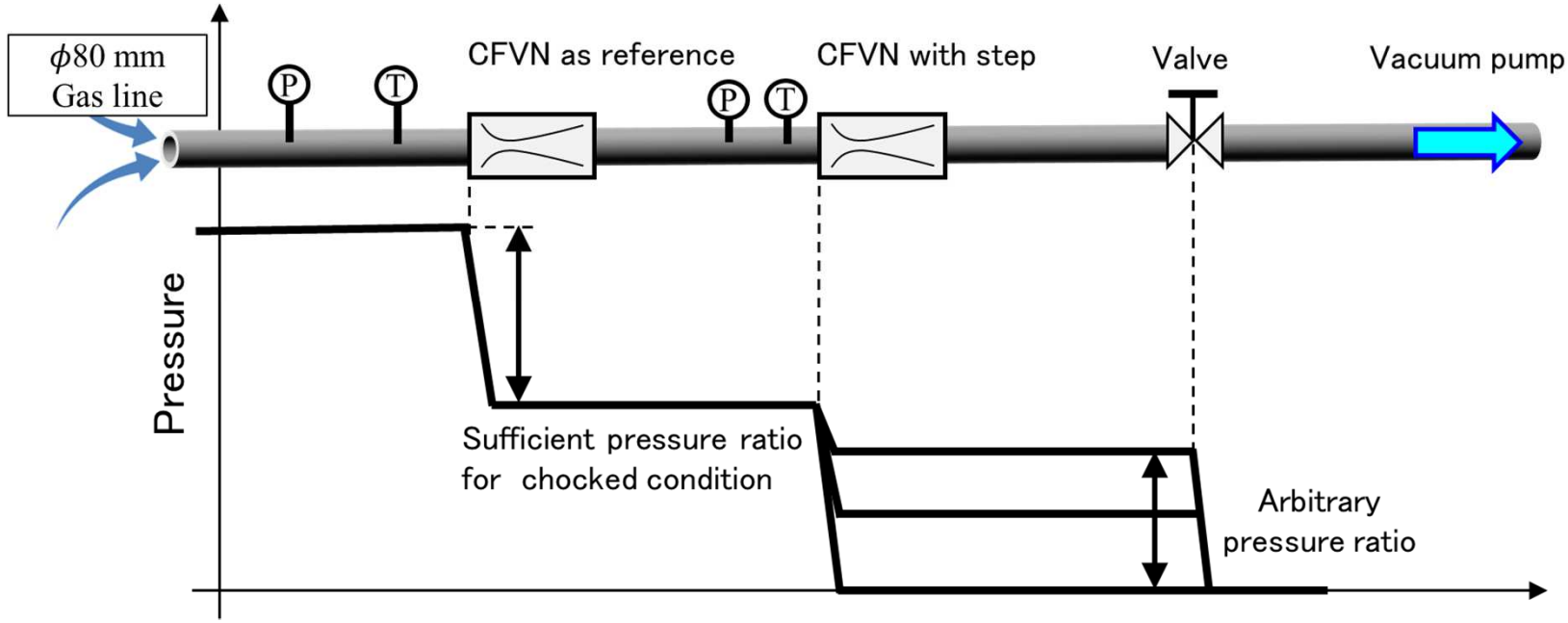
## Step after throat:

Critical back pressure is improved by the step after the throat at $R_e = 20000$. However, there is no study on the step at the various Reynolds numbers.




We examine the effect of "step" on the PUP in the various Reynolds numbers.

# Outline of experiment



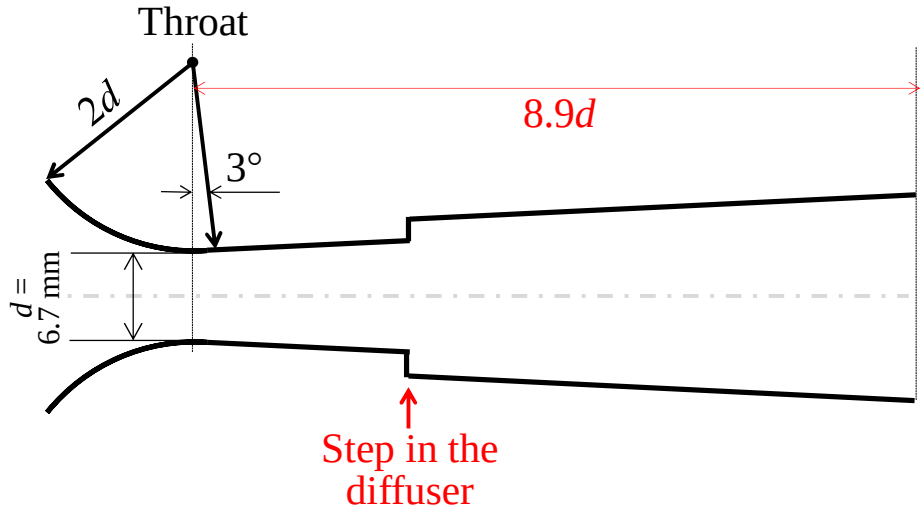

## Experimental procedure

On the upstream side, a reference CFVN whose discharge coefficient is known, and on the downstream side, a tested CFVN are installed in series.

① The discharge coefficient of the tested CFVN is calculated from the mass conservation law.
② The back pressure ratio where the discharge coefficient decreases by 0.1% is measured and defined as the CBPR (critical back pressure ratio).

# Experimental condition

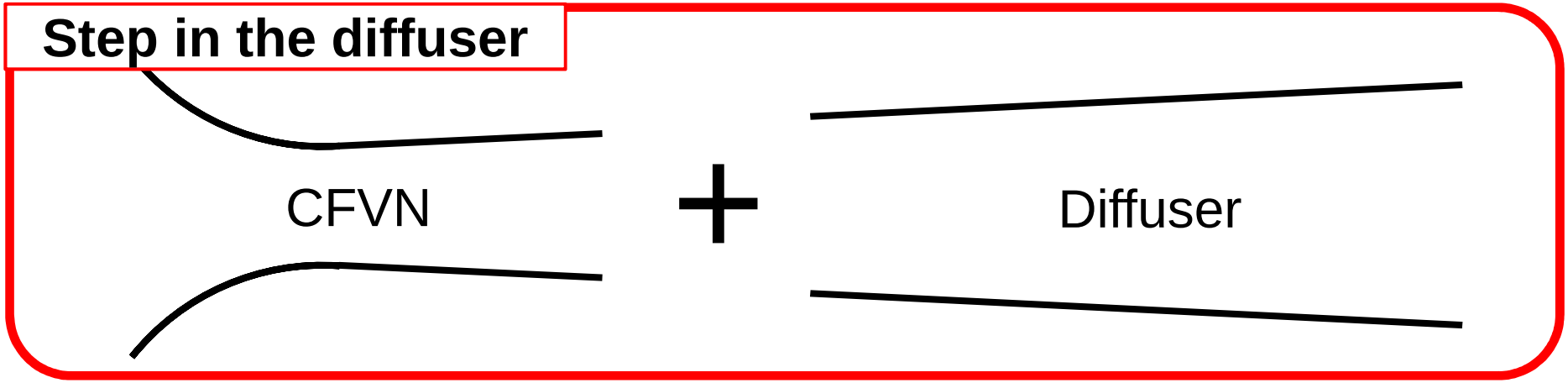
We examined effect of ①Diameter change ratio (step height)




**Diameter change ratio**

-10.0%, -5.0%, -2.5%, -1.25%, 1.25%, 2.5%, 5.0%, 10.0%

**Step in the diffuser**



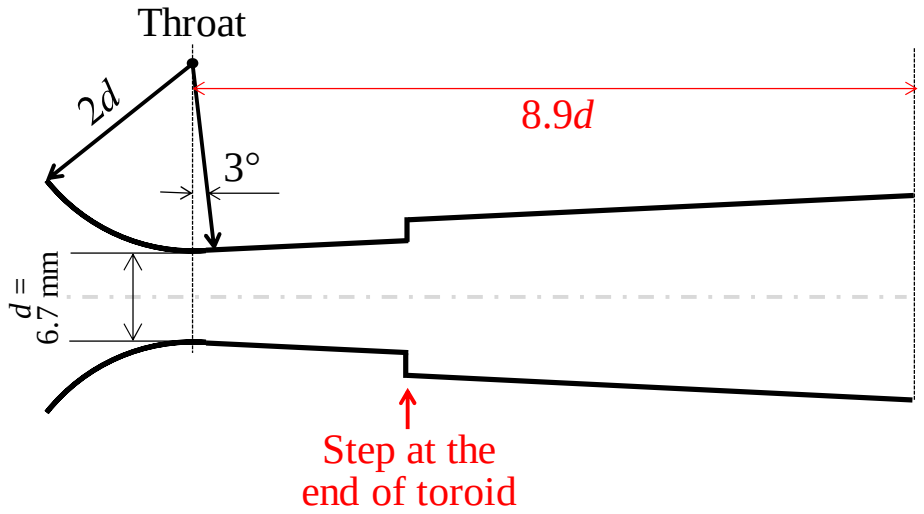
# Experimental Result

## Step in the diffuser

Throat diameter *d*: 6.7 mm (25 $m^3$/h)

Diffuser Angle: 3°

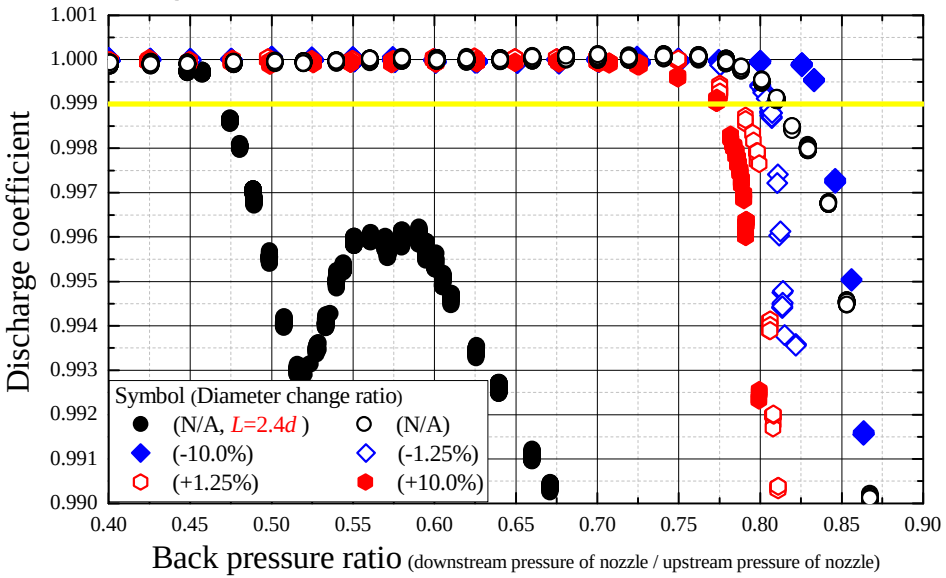
Diffuser Length: 8.9 *d*



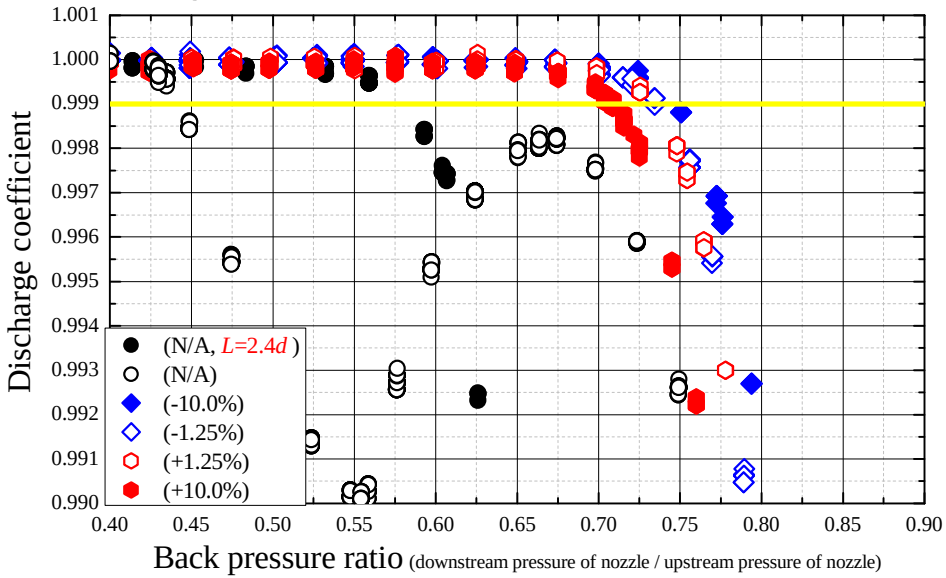
# Result (Step in the diffuser)

● Throat diameter *d*: 6.7 mm (25 m³/h) ● Diffuser Angle: 3° ● Diffuser Length: 8.9 *d*

Reynolds Number at throat: 22000




Reynolds Number at throat: 5500




○CFVNs without the step show low CBPR at $R_e$ of 5500.

○Step in the diffuser keeps high pressure recovery even in the low Reynolds number of about 5000, and the CBPR can be improved.

# Result (Step in the diffuser)

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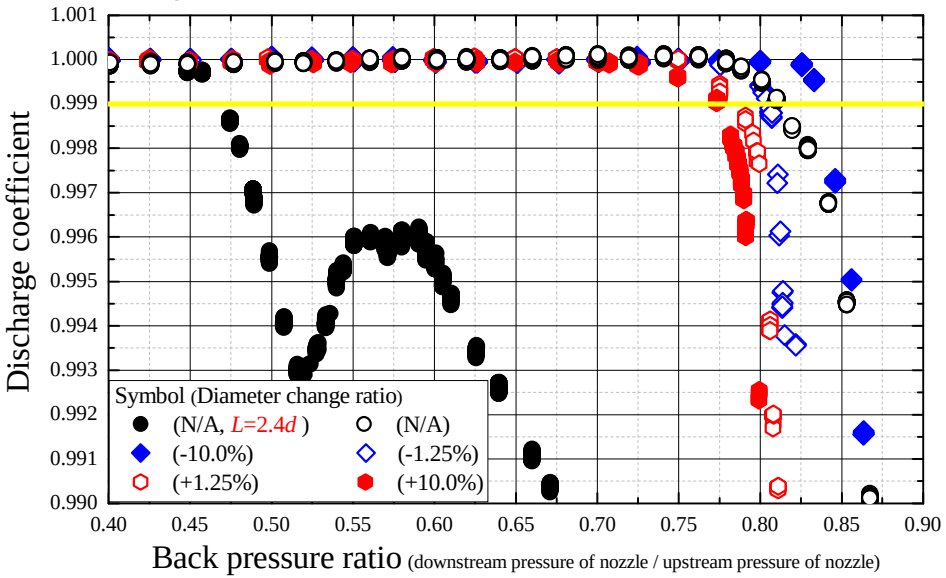
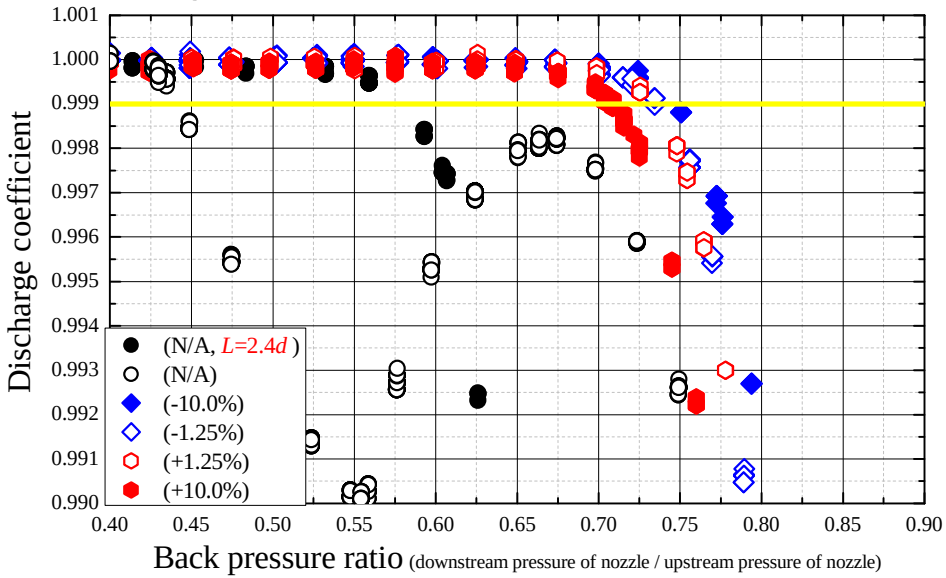
Reynolds Number at throat: 22000




Reynolds Number at throat: 5500

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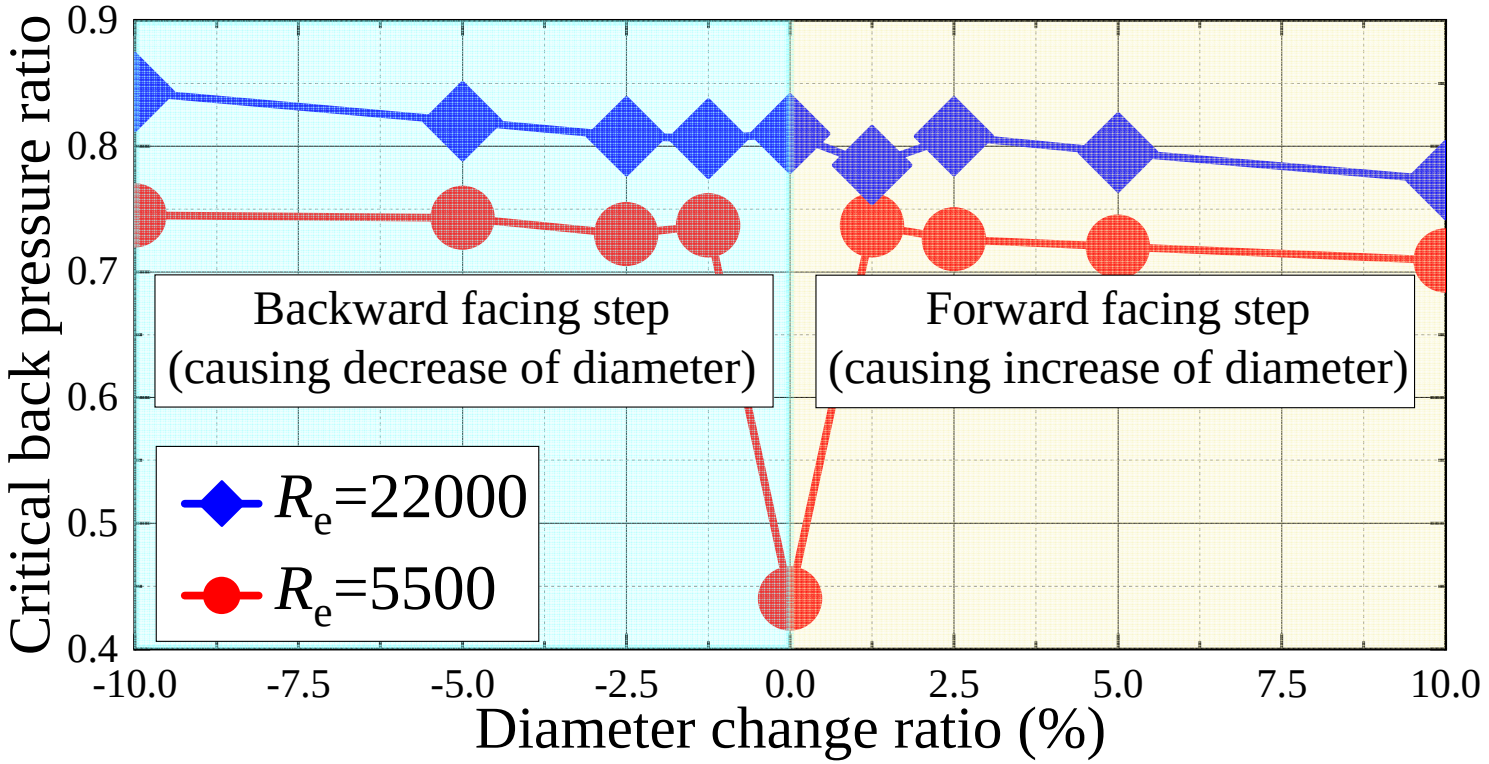
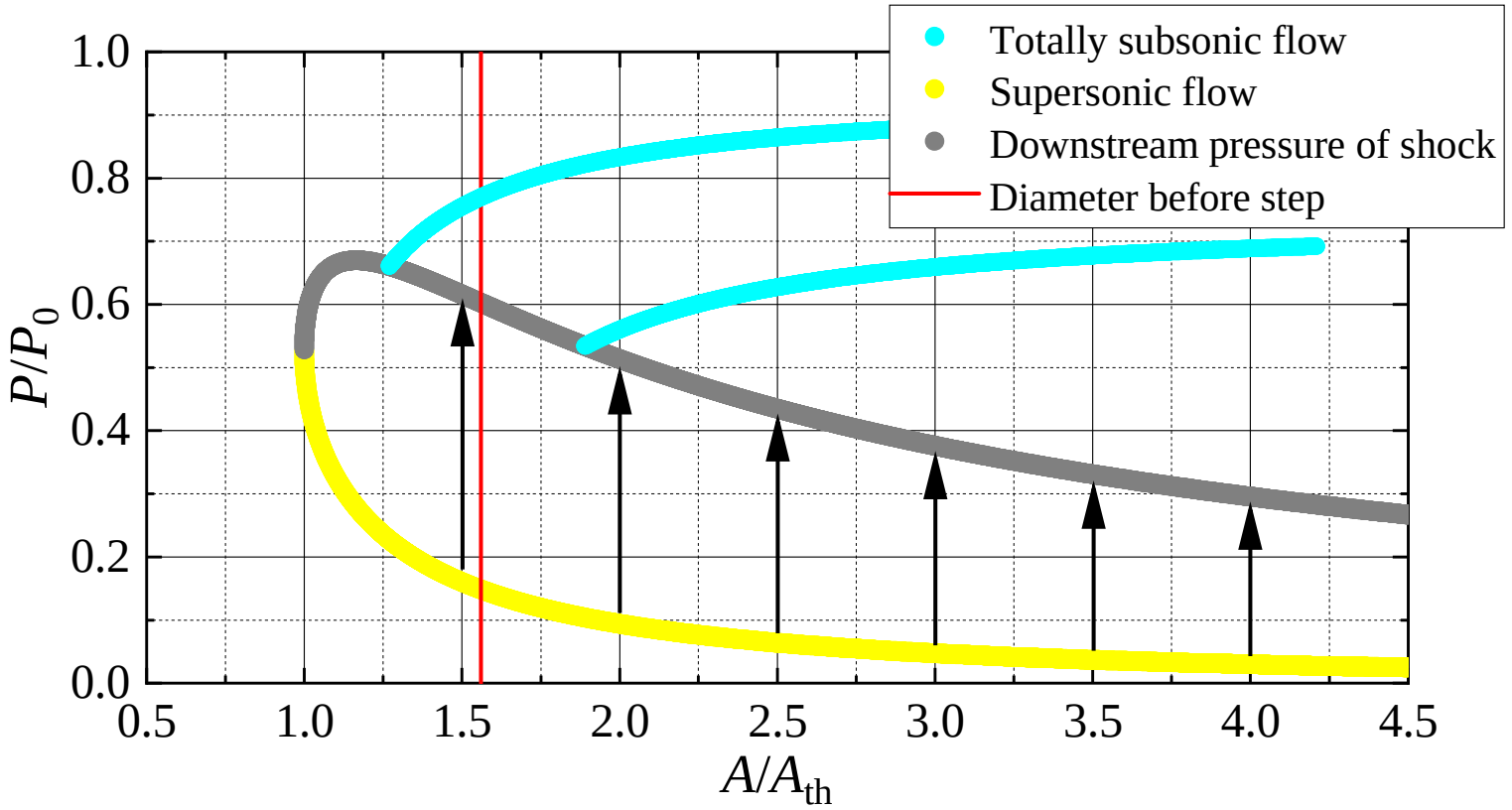
# Result (Step in the diffuser)

● Throat diameter *d*: 6.7 mm (25 m³/h) ● Diffuser Angle: 3˚ ● Diffuser Length: 8.9 *d*




There is no big difference between the diameter change ratios?

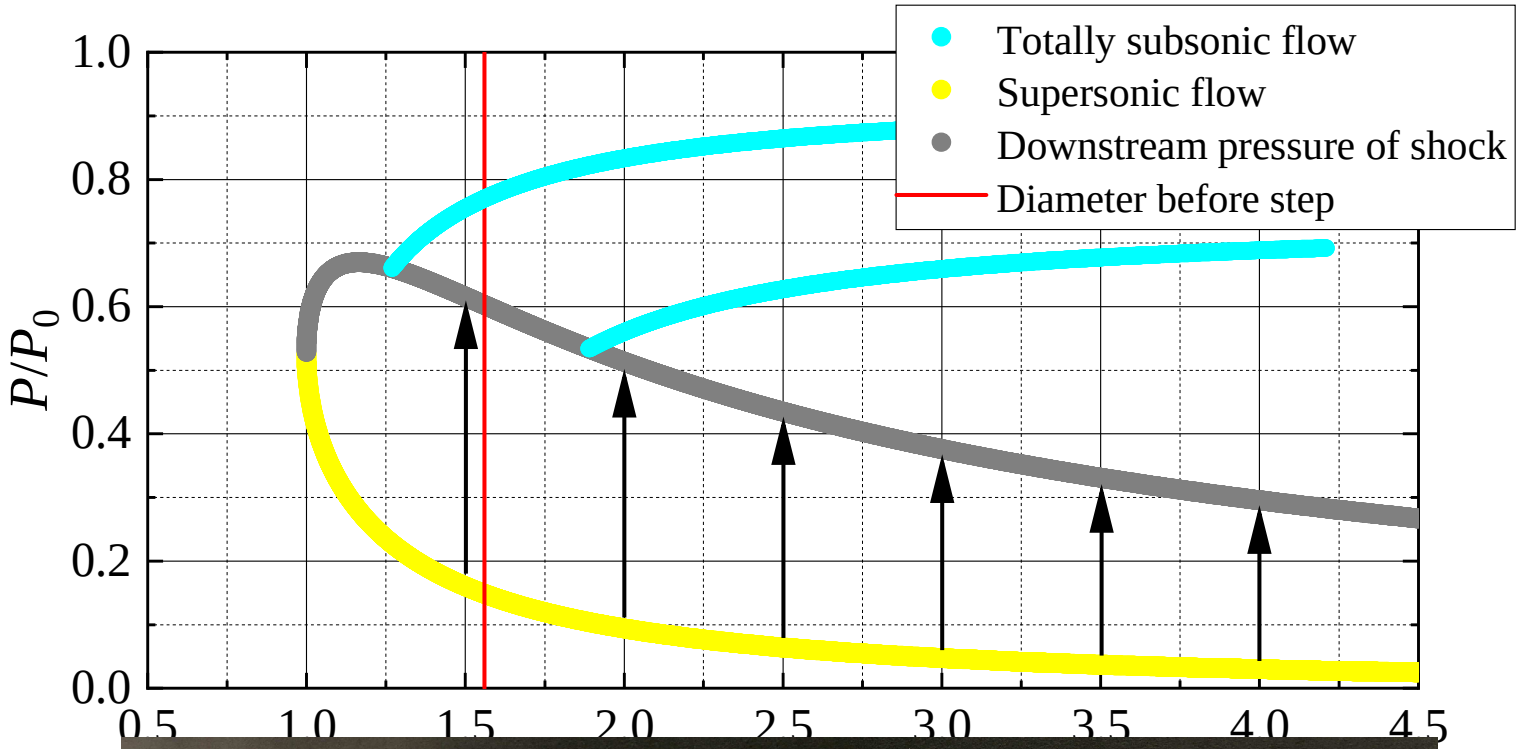
# Theoretical pressure distribution in the diffuser

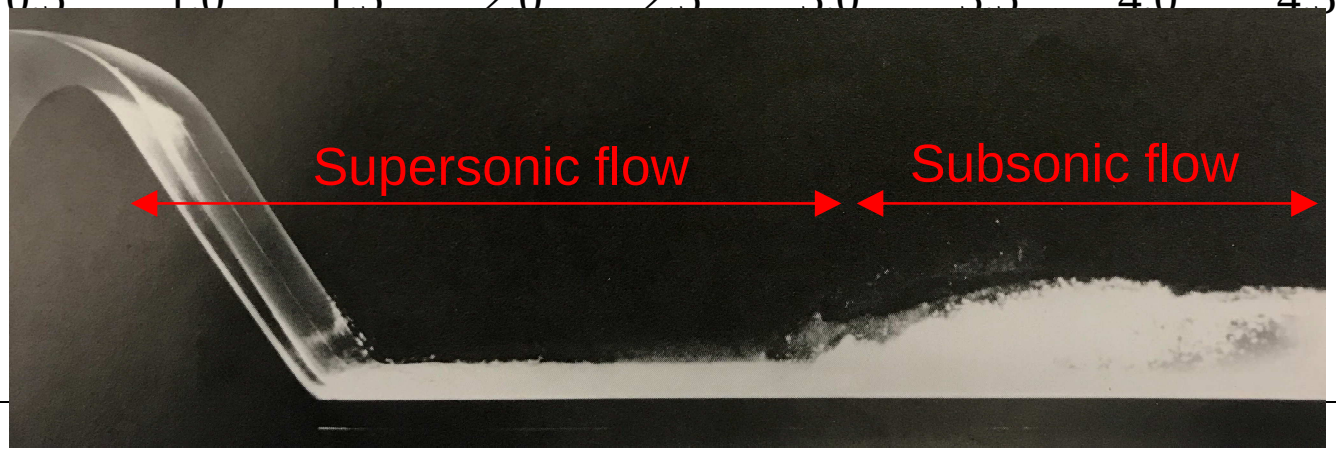



One possible reason…?

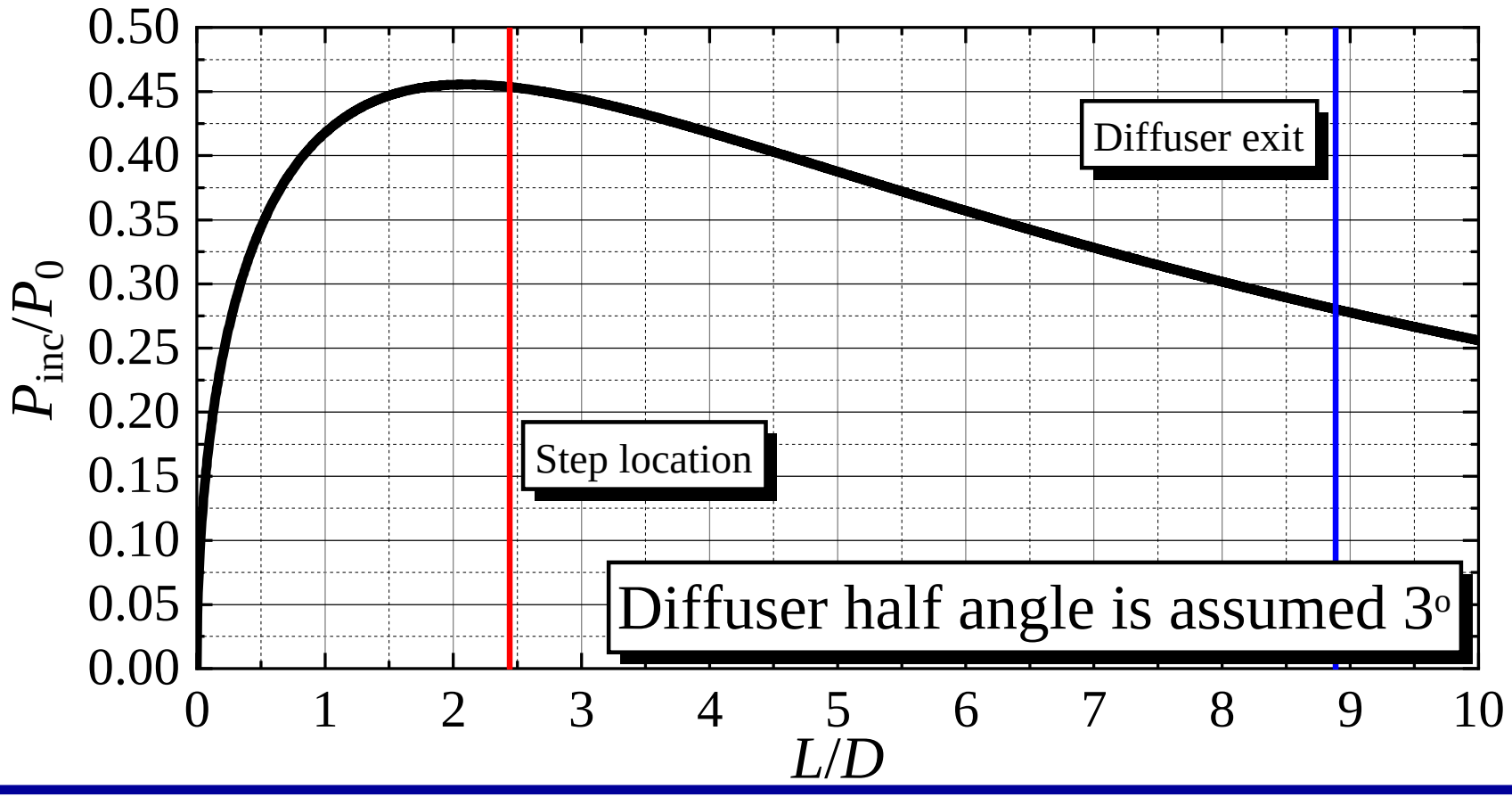
A step anchors the shock location and expands the region of subsonic flow for the pressure recovery.

# Theoretical pressure distribution in the diffuser



# Shock location and theoretical pressure increase




The adverse pressure gradient is large wherever the normal shock waves occur. Therefore, It is extremely difficult to prevent flow separation.

# Thank you for your attention!!