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Phylaktou, HN, Na'inna, A and Andrews, GE (2014) The influence of obstacle separation distance on explosion severity. Is our design database conservative enough? In: UKELG 51st Discussion Meeting, Ignition and Explosion Hazards of industrial gas and fuel mixtures, 01 Apr 2014, Imperial College.

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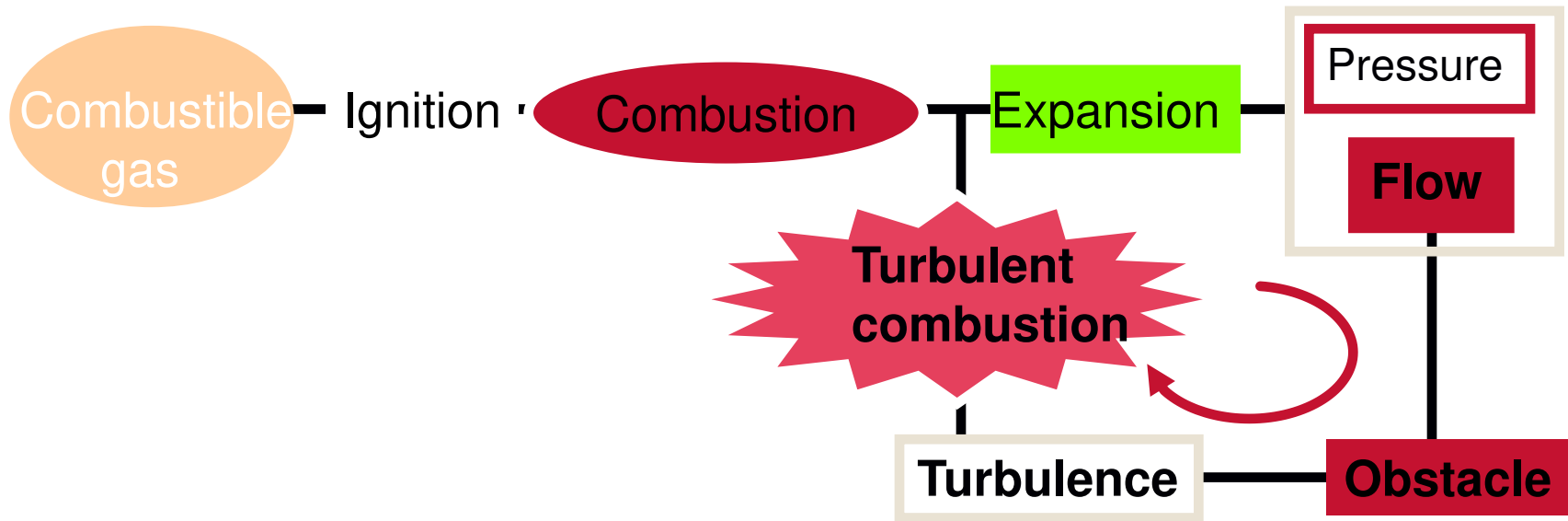
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51<sup>st</sup> UKELG meeting, 1<sup>st</sup> April 2014

**The influence of obstacle separation distance on  
explosion severity.  
Is our design database conservative enough?**

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Energy Research Institute  
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# Turbulent explosion enhancement as a gas dynamic feed-back loop



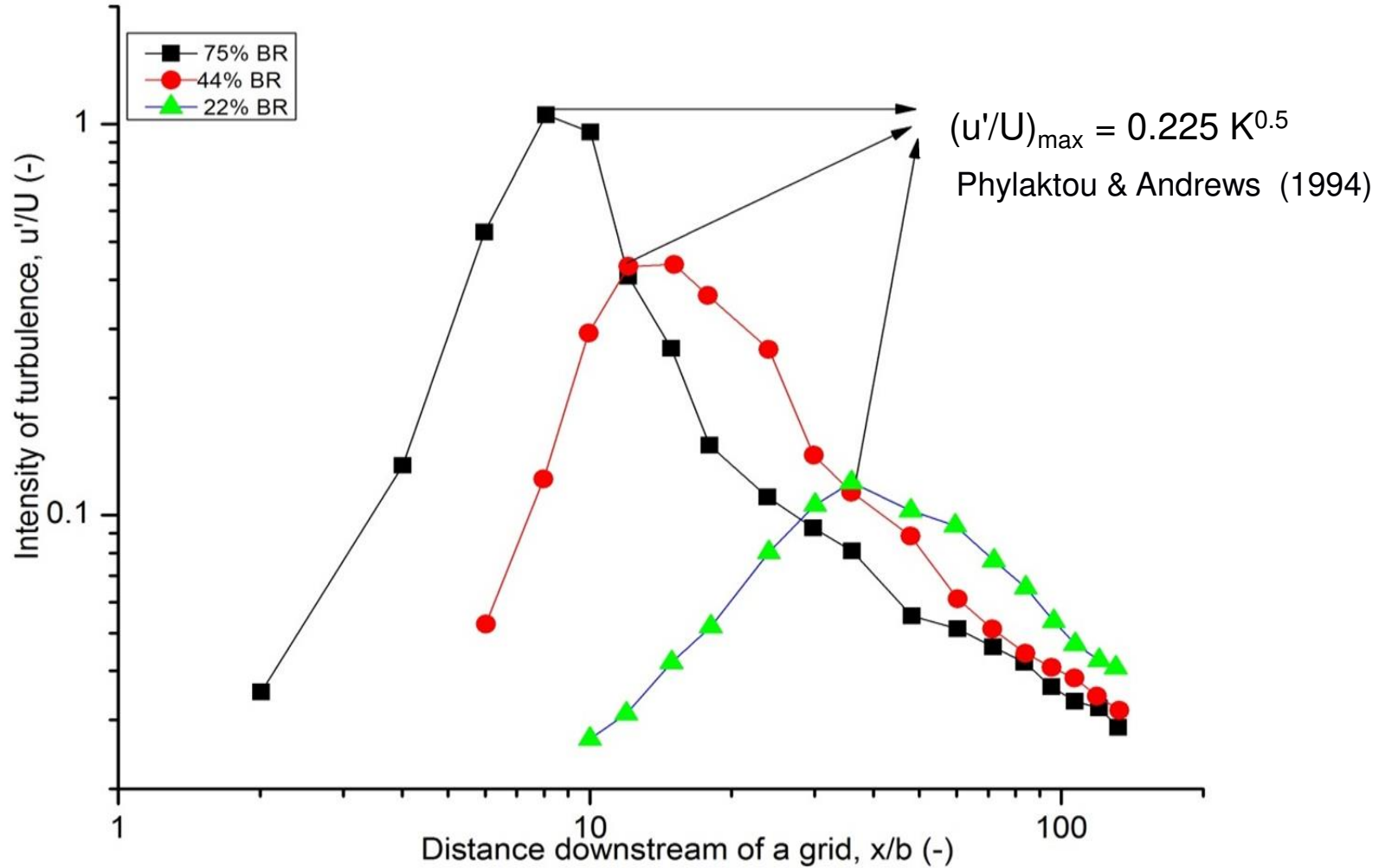
Much work has been done with multi- obstacles investigating this mechanism to understand

- increased explosion severity in congested areas
- transition to detonation

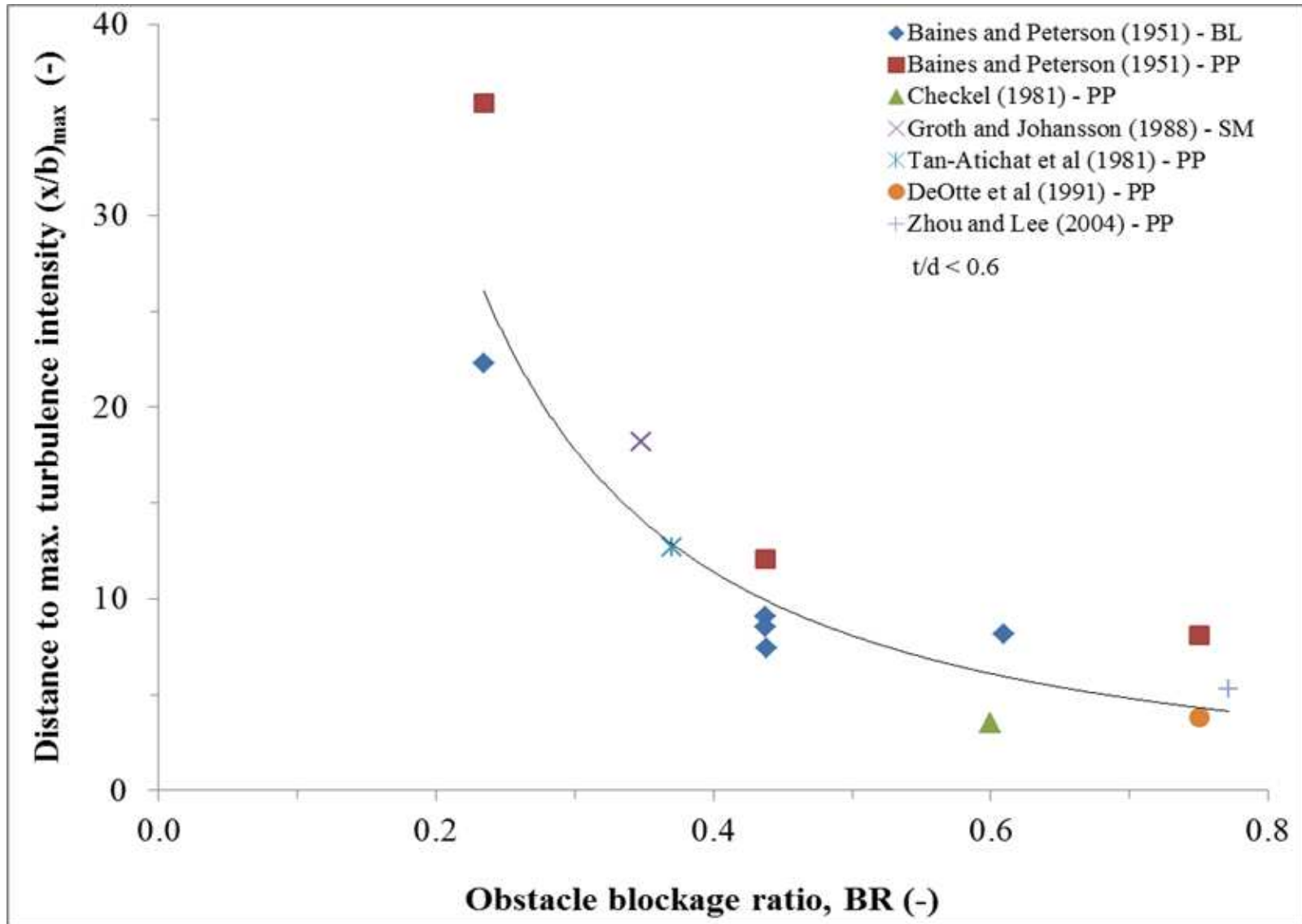
Limited work on the effect of **obstacle separation distance**

# Cold flow turbulence

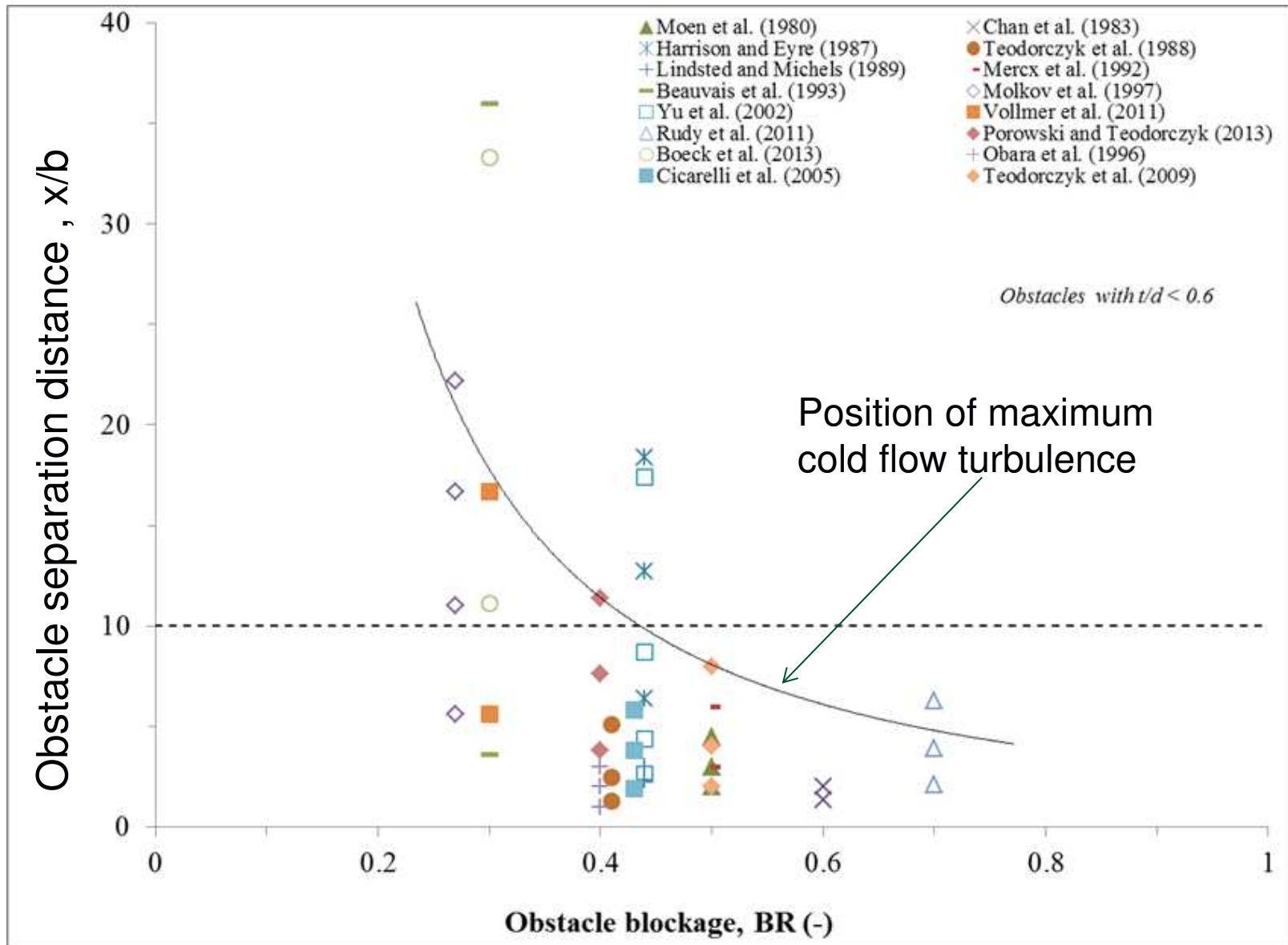
Baines and Peterson (1951)



# Position of maximum cold flow turbulence



# Explosion & Detonation studies with variable obstacle spacing

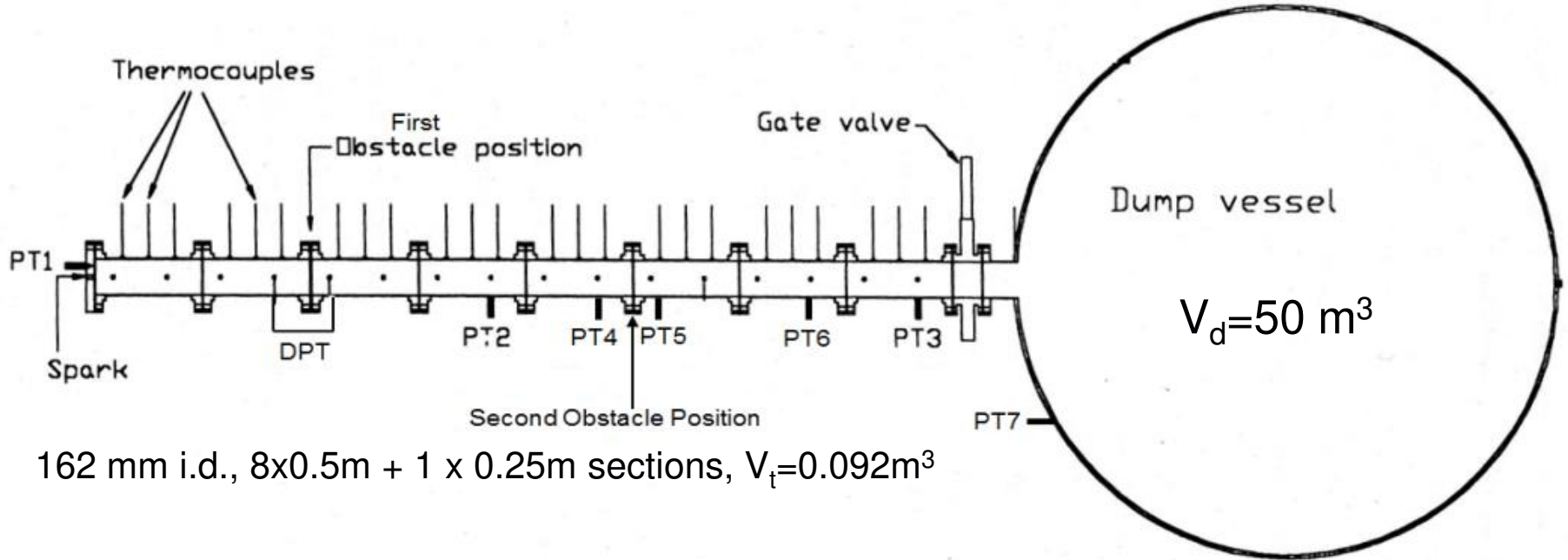


# Objectives

To systematically vary the obstacle separation distance in gas explosions in order to

- identify the worst case interaction distance and
- relate this to the cold flow turbulence generation and decay profile.
- Relate findings to other explosion studies and explosion safety

# Experimental – test rig



162 mm i.d., 8x0.5m + 1 x 0.25m sections,  $V_t = 0.092 \text{ m}^3$



# Experimental – obstacles

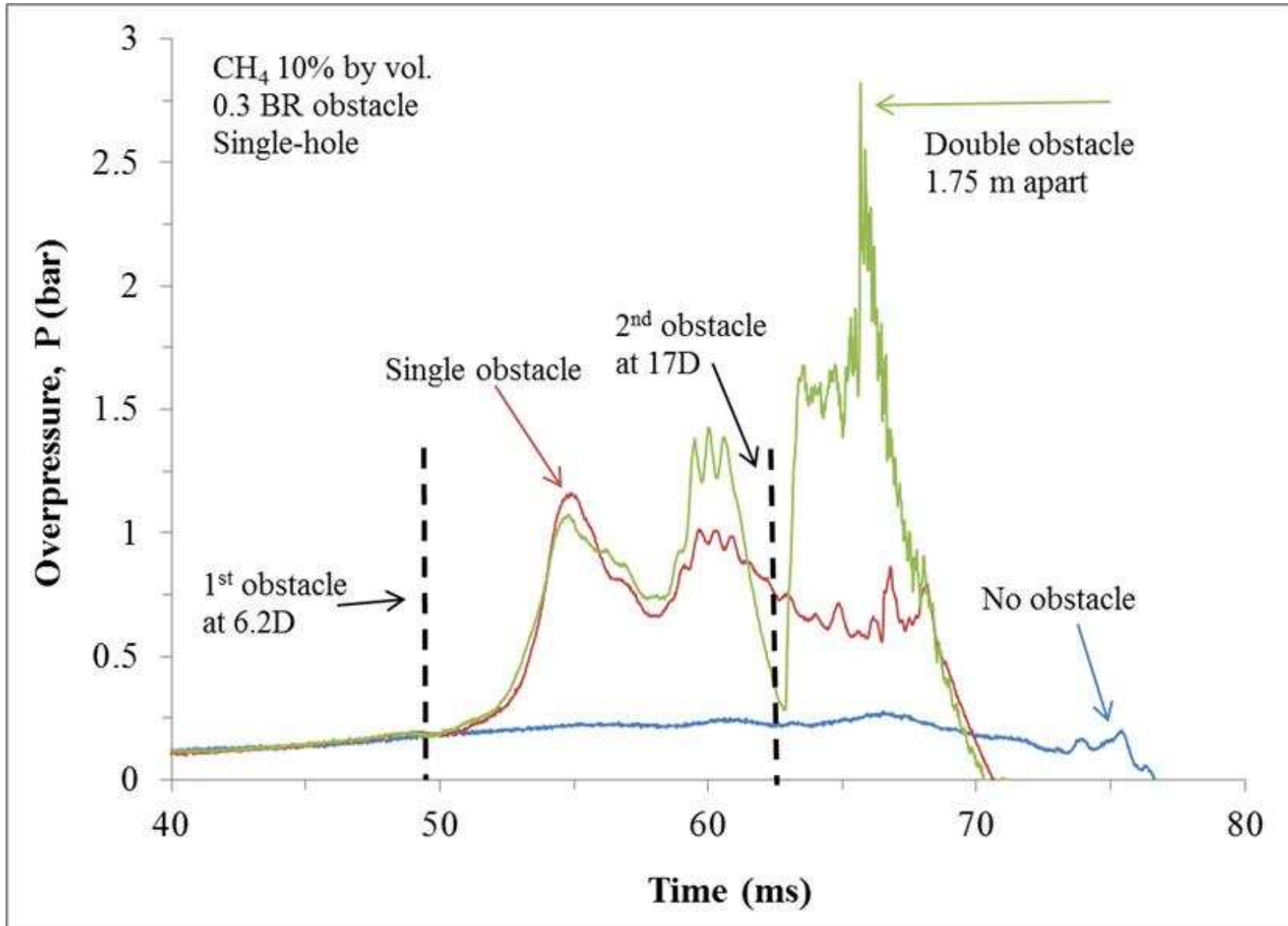
Hole grid plates



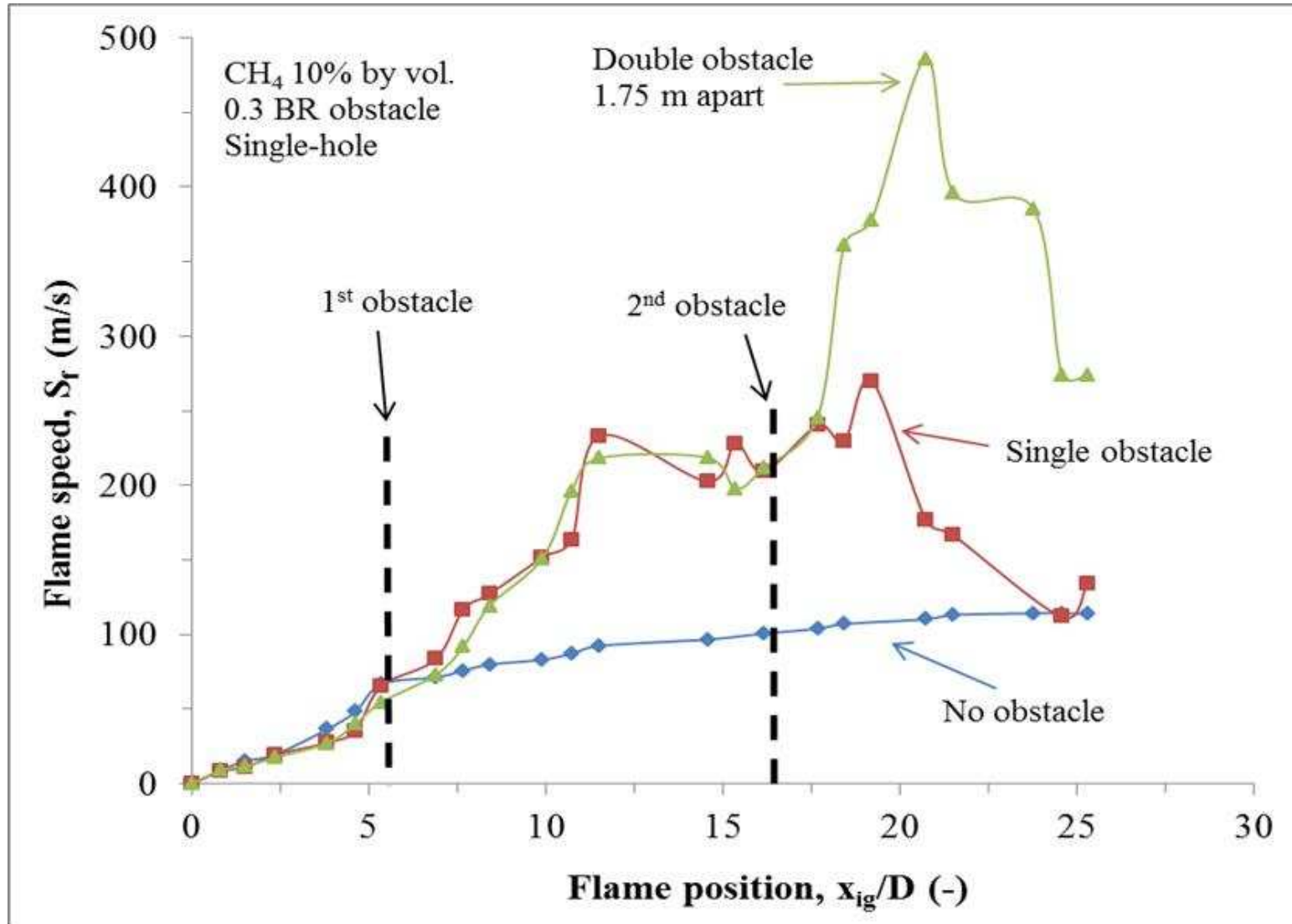
Flat bars



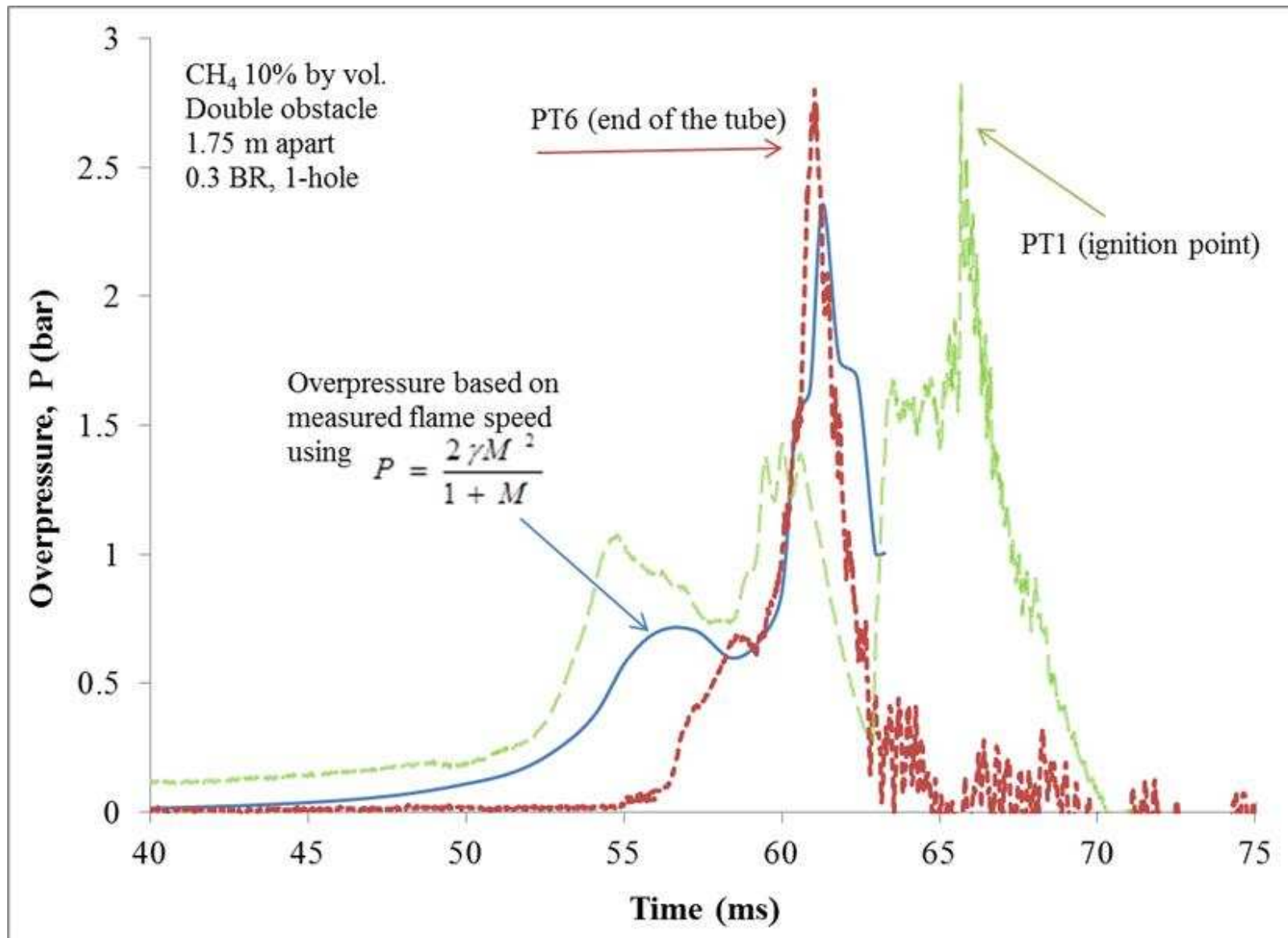
# Results – General - Pressure



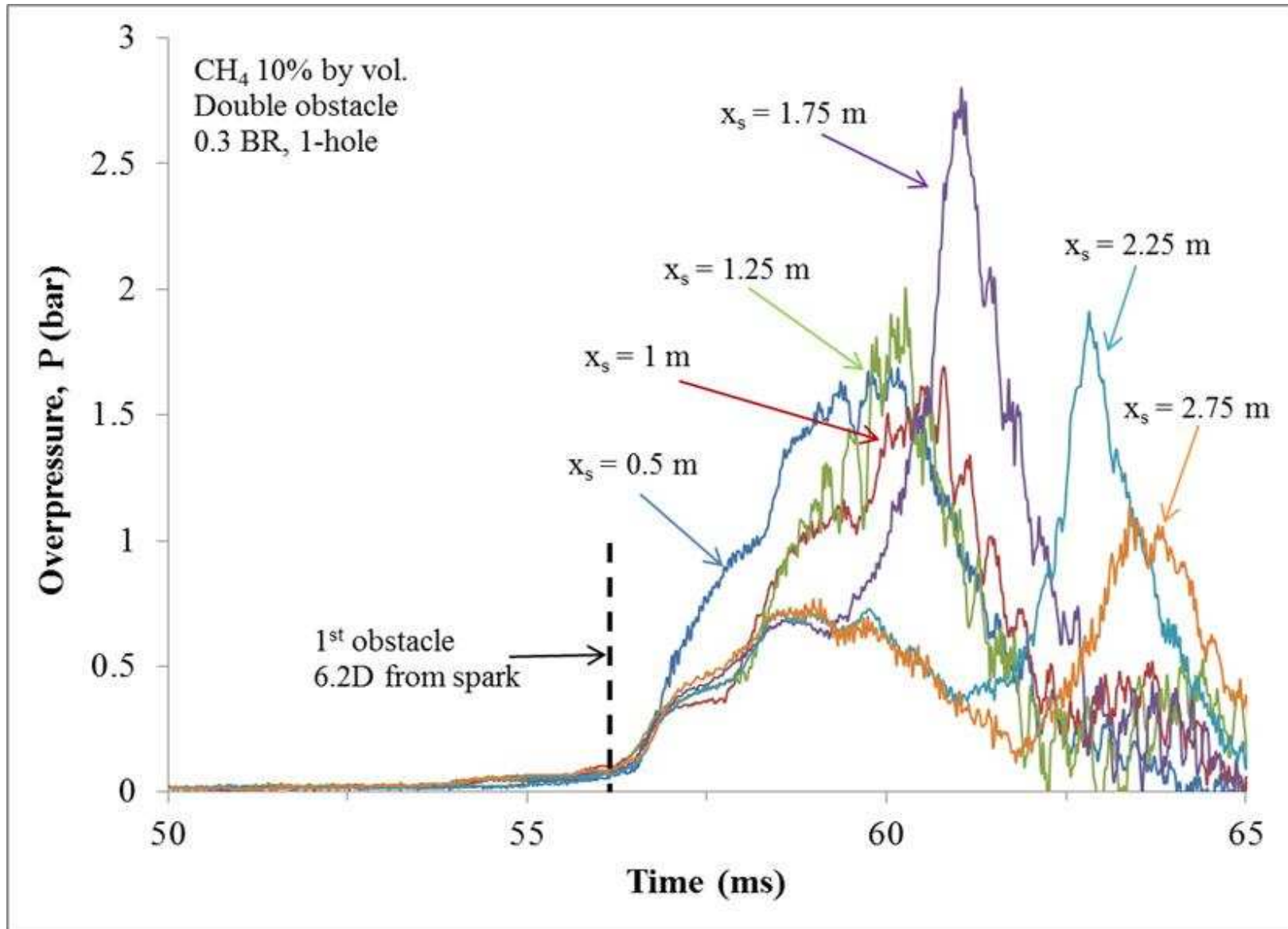
# Results – General – Flame speed



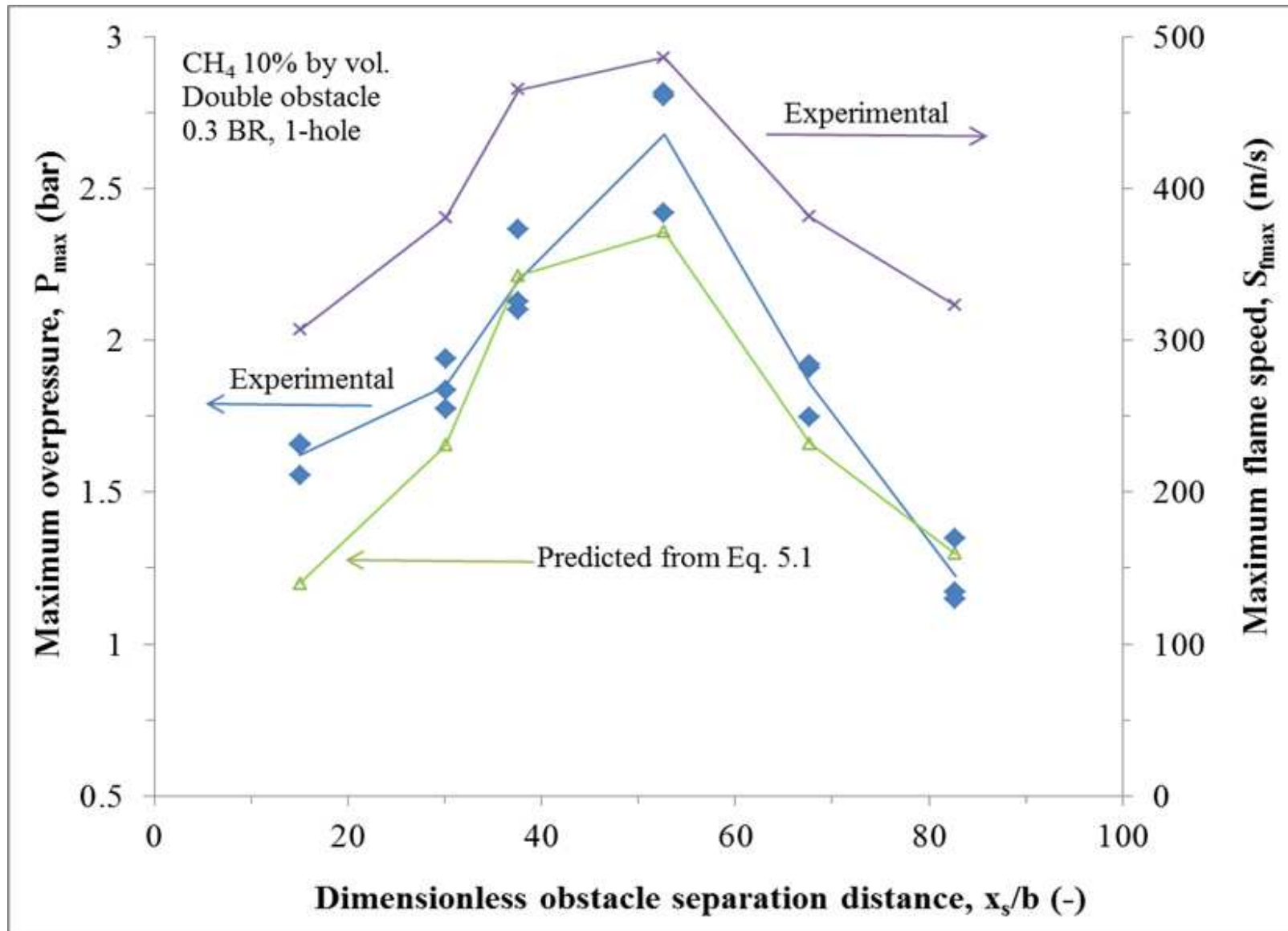
# Flame speed generated pressure



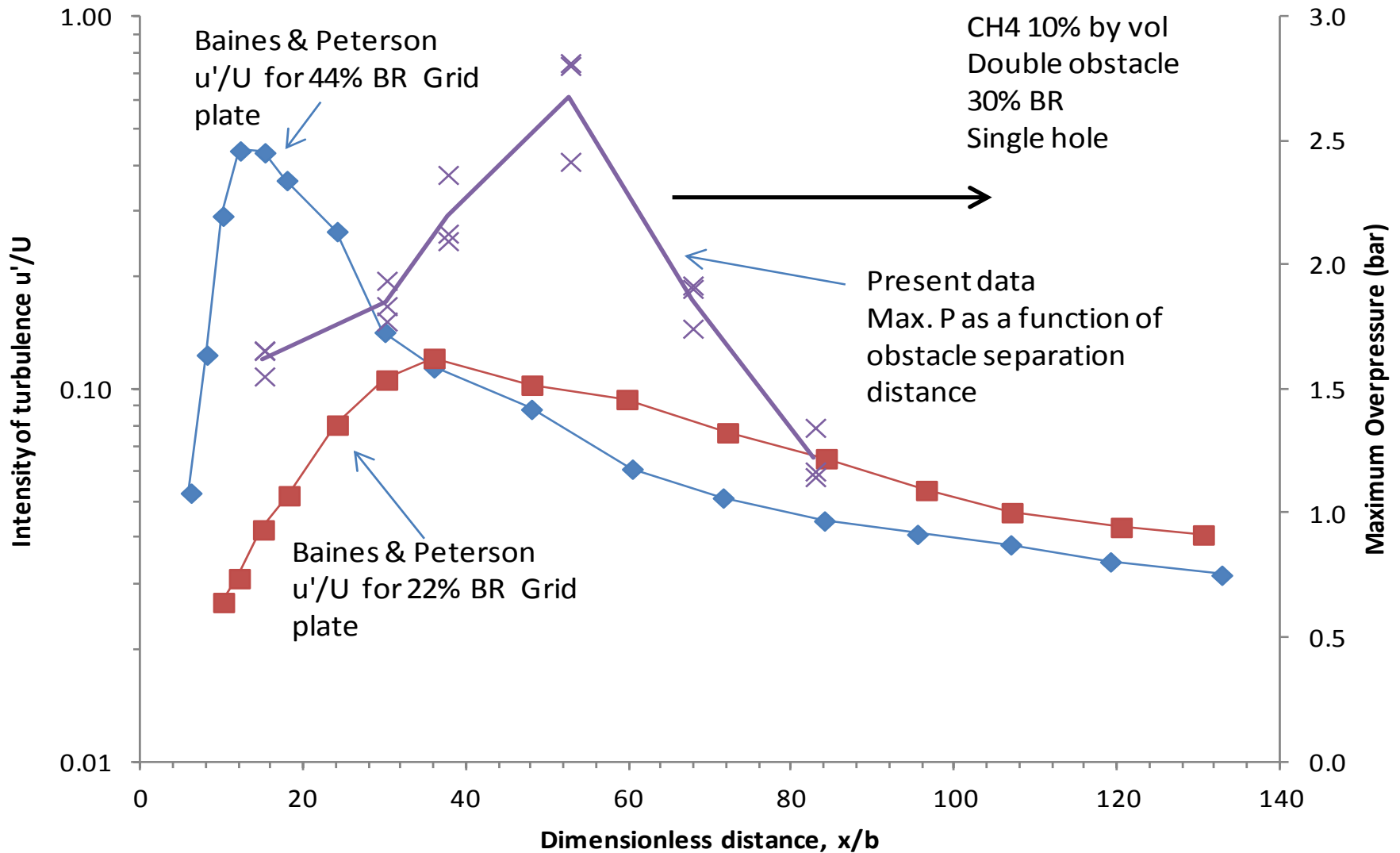
# Pressure development with separation distance



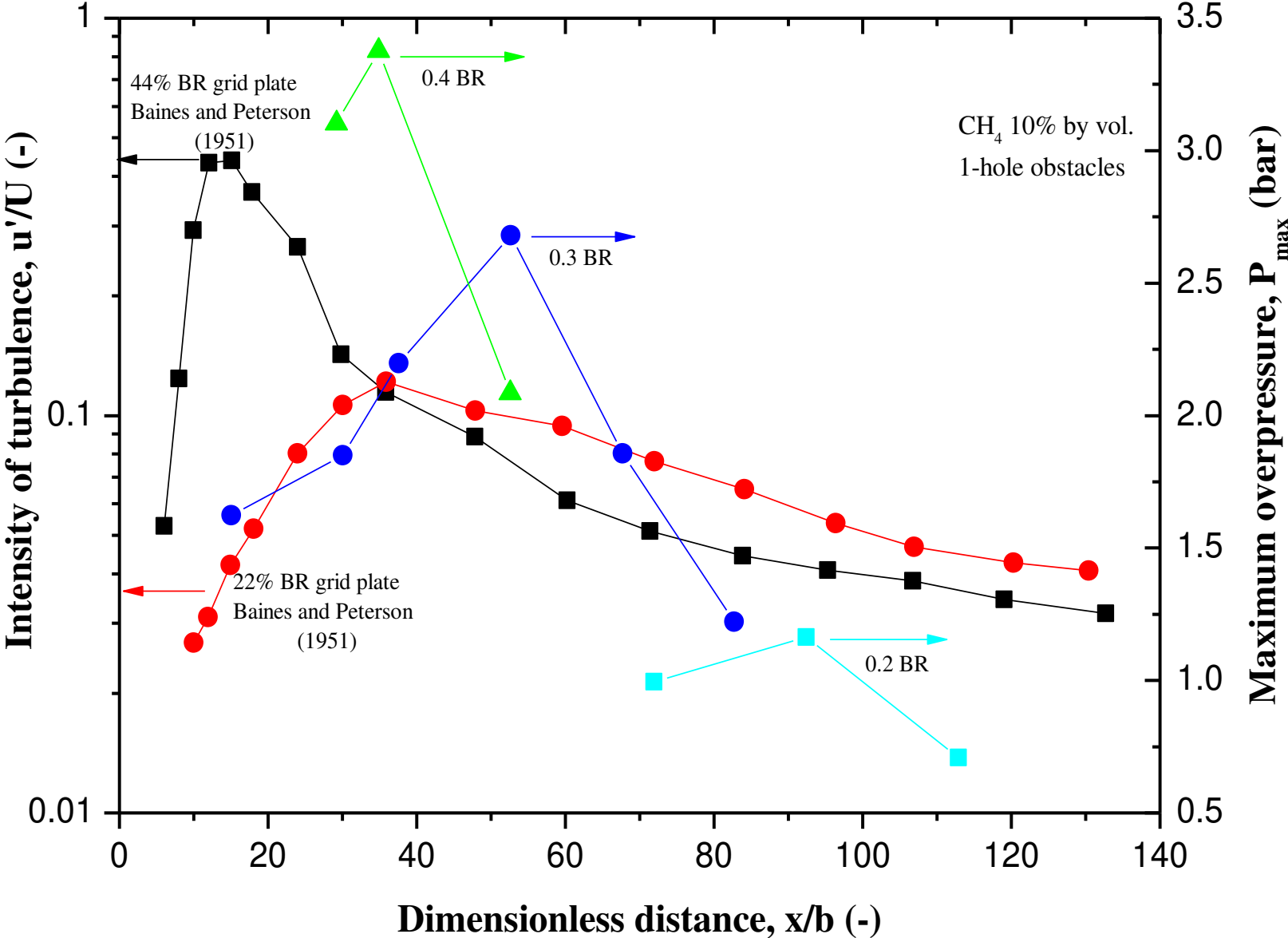
# Maximum overpressure and flame speed as a function of dimensionless separation distance



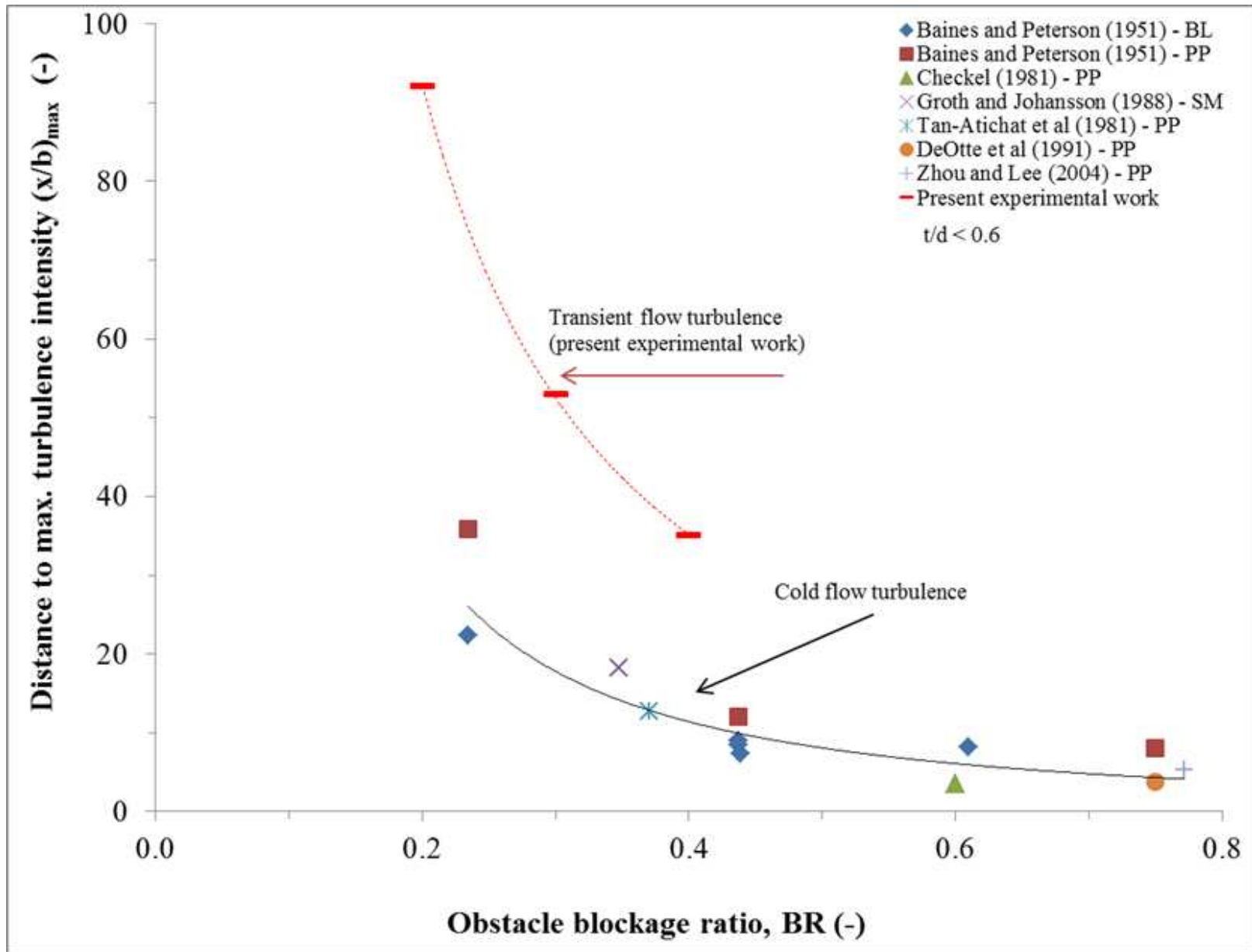
# Comparison with Cold Flow Turbulence

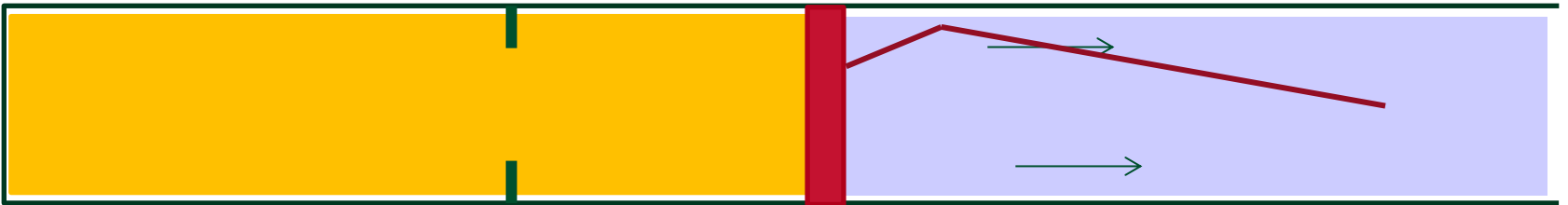
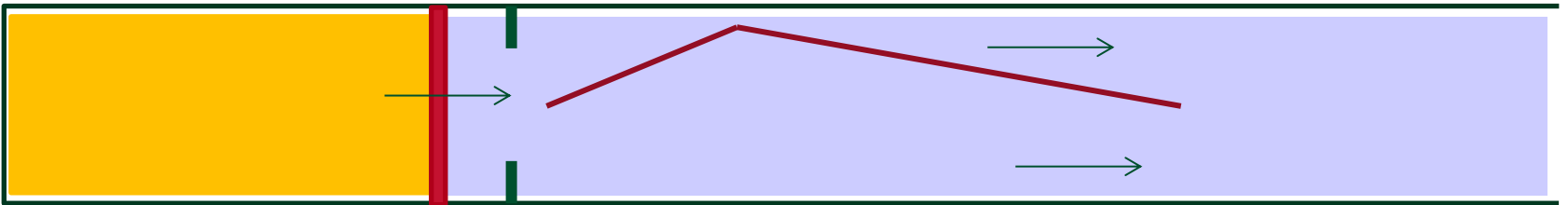
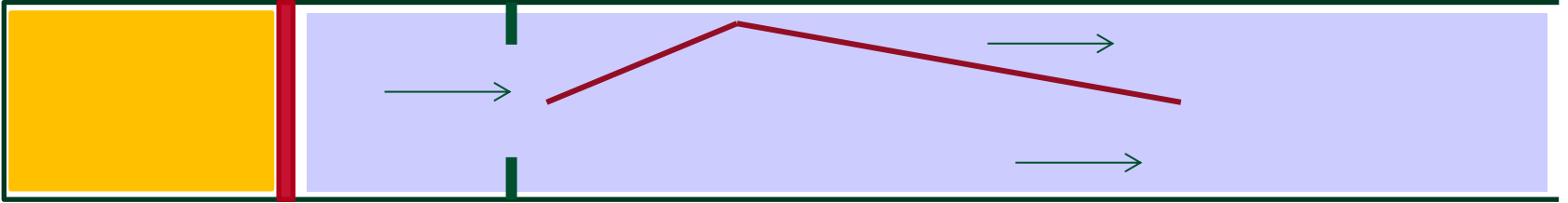


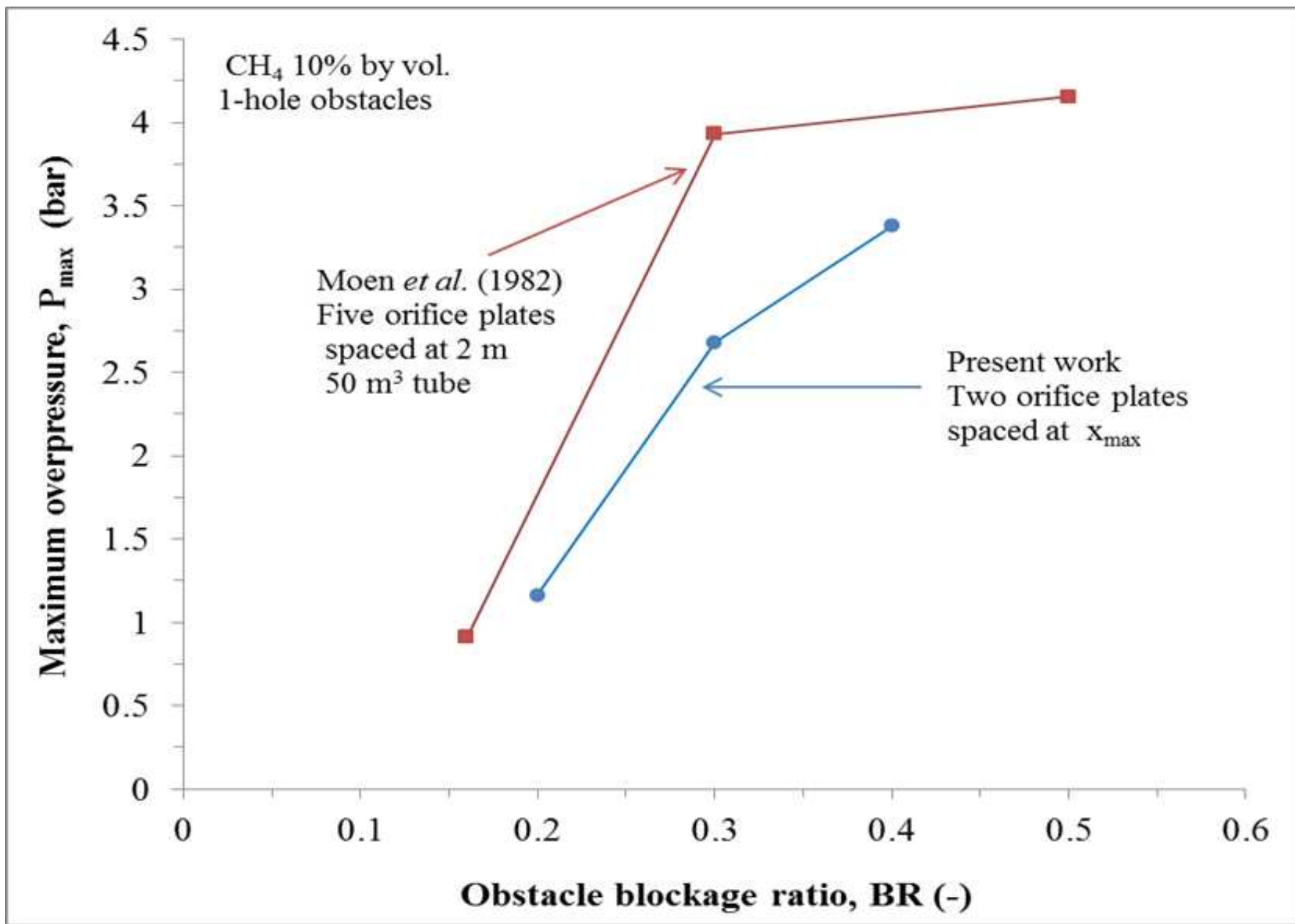
# Effect of blockage ratio



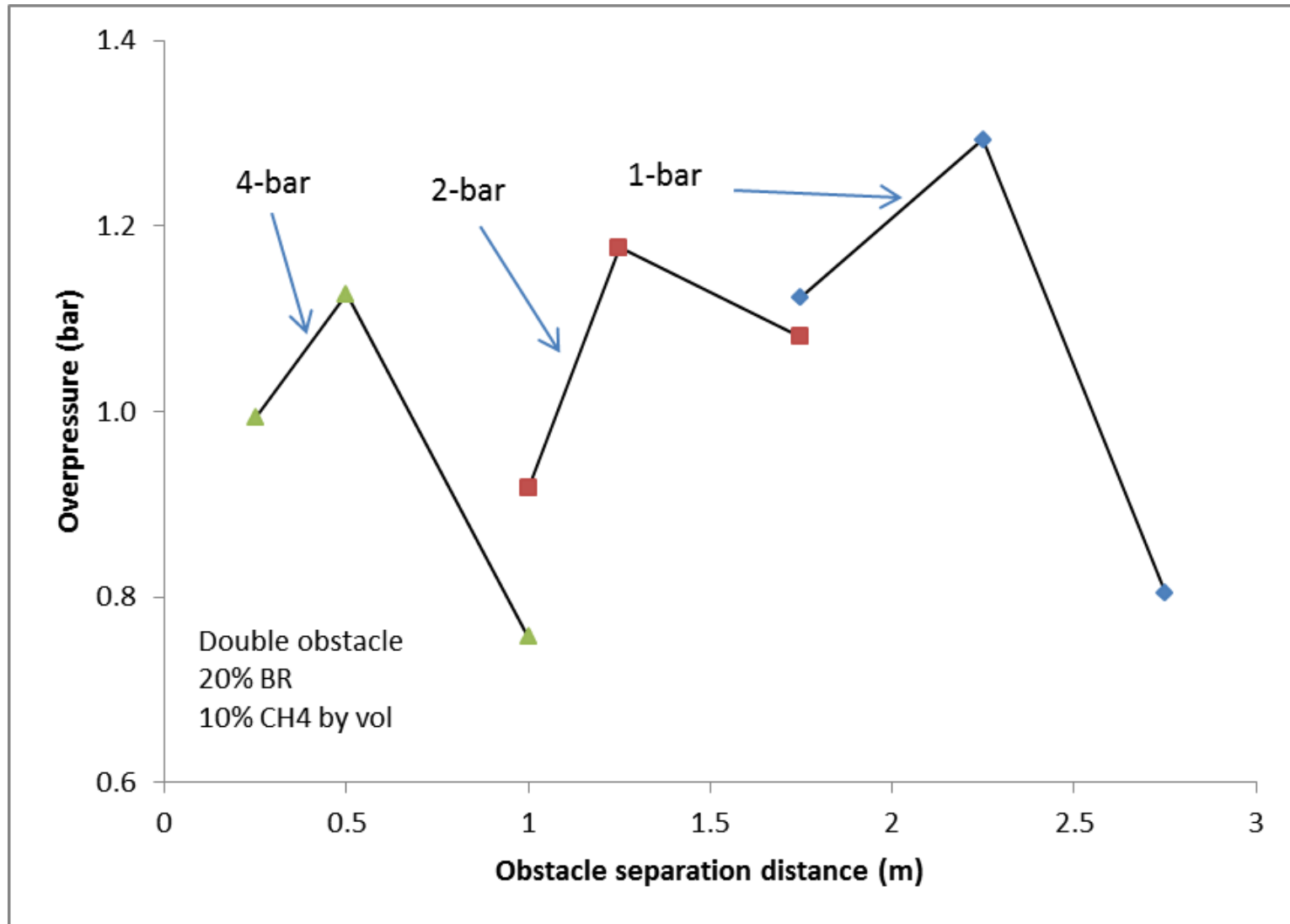
# Optimum separation distance compared to position of maximum cold flow turbulence

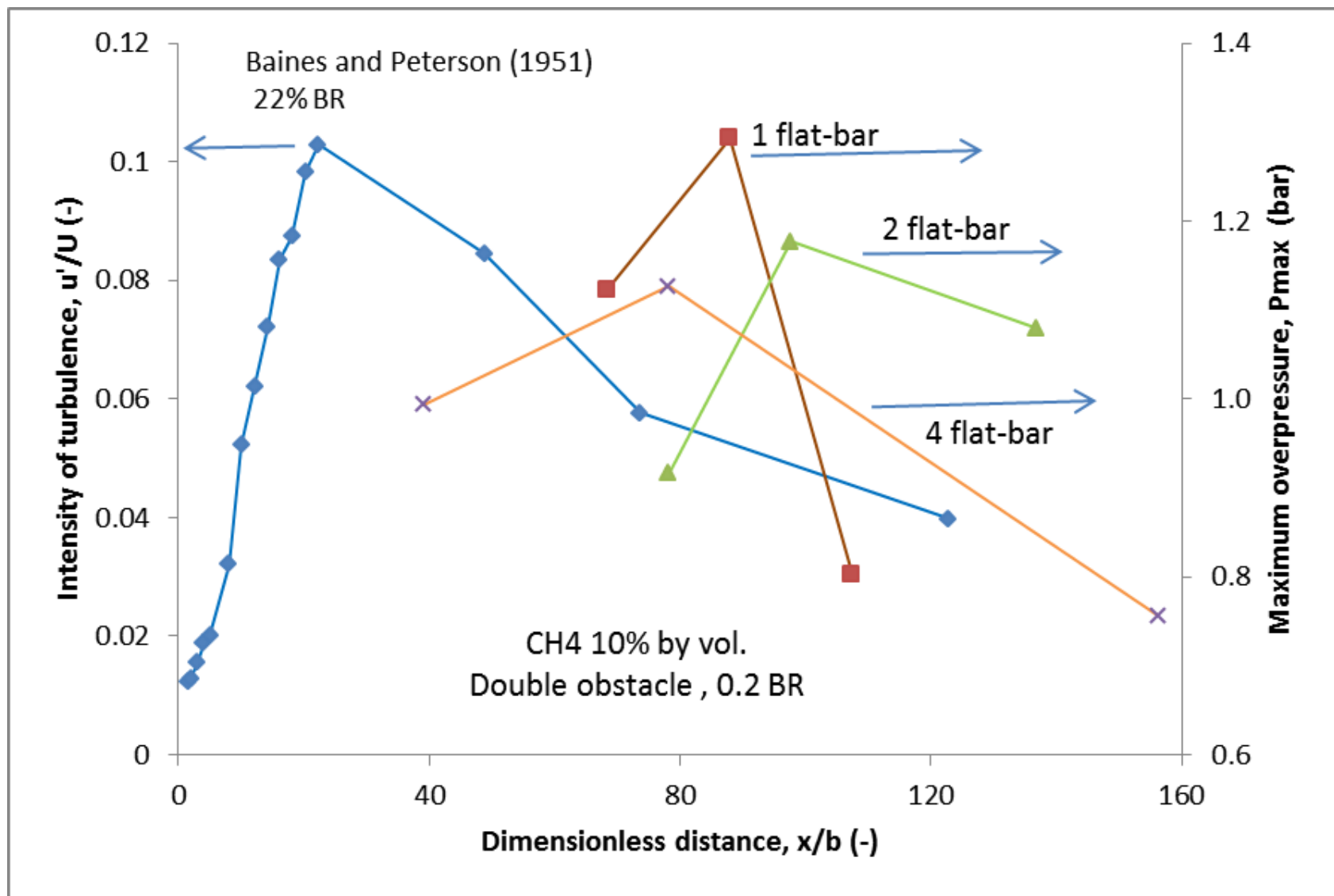




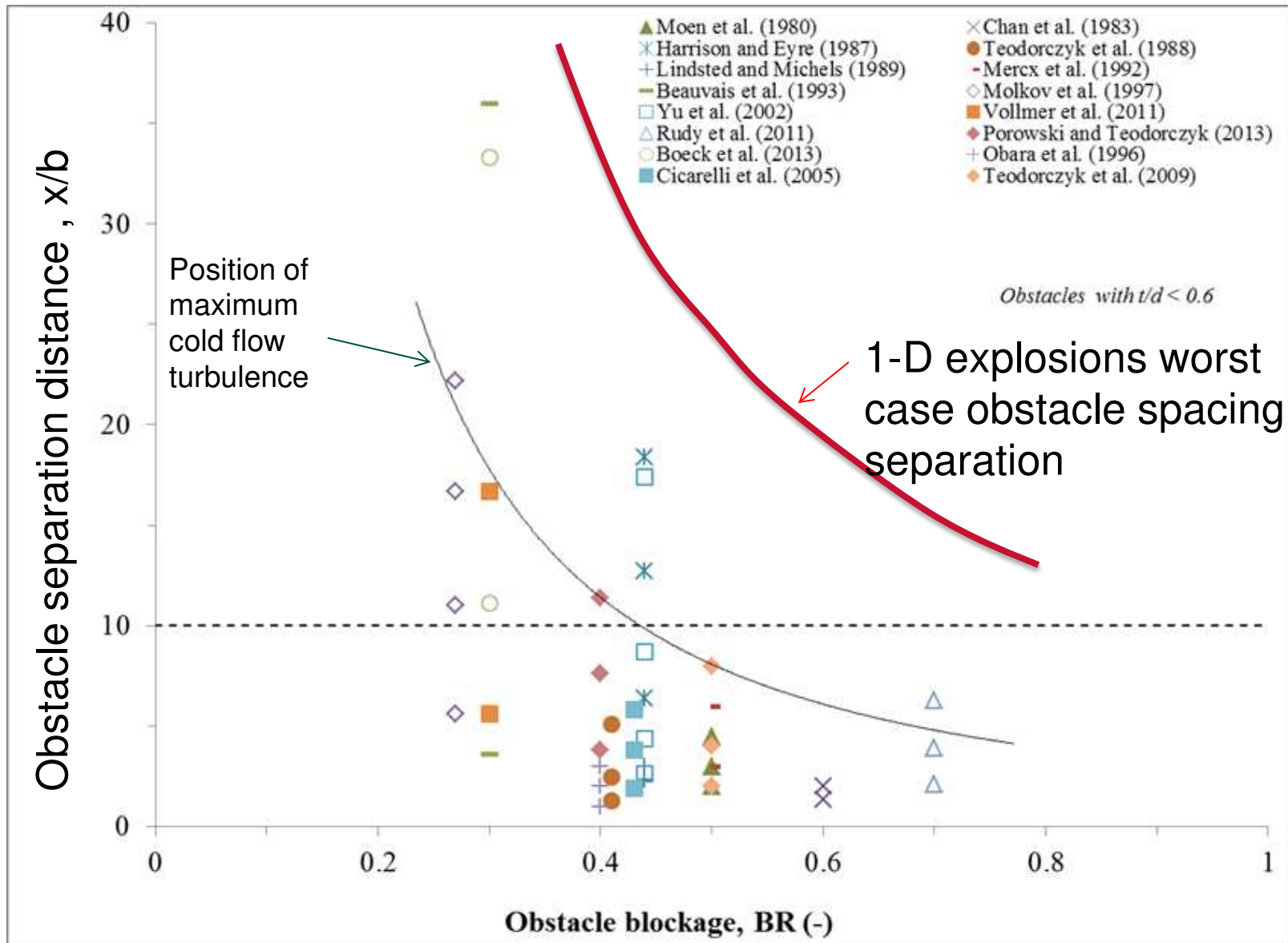


# Effect of obstacle scale, (flat-bars)

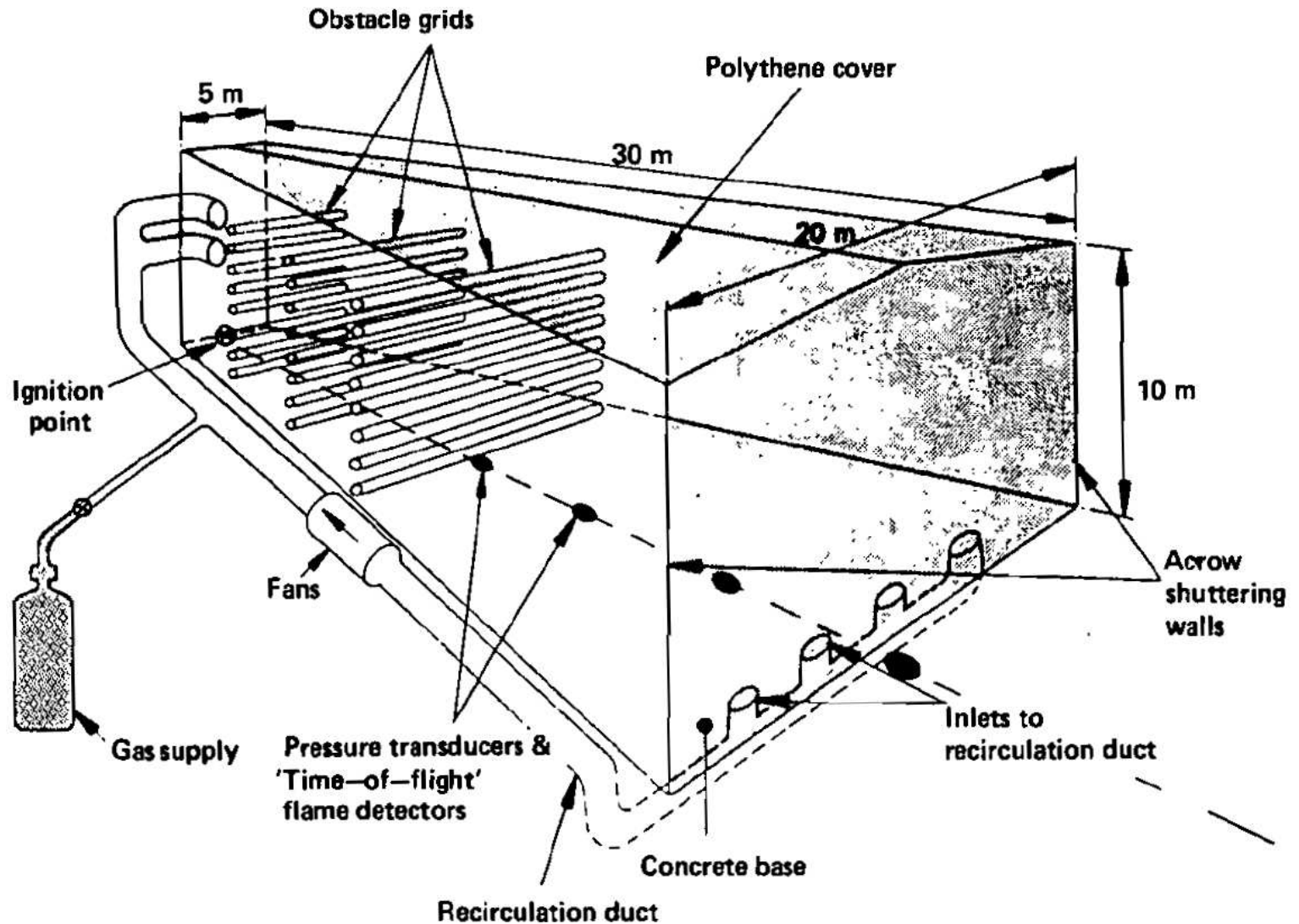




# Explosion & Detonation studies with variable obstacle spacing



# Harrison & Eyre (1987)



# Conclusions

Importance of the obstacle separation distance in a simple double obstacle configuration clearly demonstrated.

- Profile of influence of separation distance consistent with cold flow turbulence profile
  - Position of maximum effect shifted further downstream in the explosion tests approximately by a factor of 3. This may be dependent on freedom of expansion directions
- Characteristic obstacle scale shown to be an appropriate scaling parameter.
- In practical applications the worst case separation distance needs to be avoided and in designing suitable experiments the worst case has to be incorporated.
- The results would suggest that in many previous studies of repeated obstacles the separation distance investigated may not have included the worst case set up, and therefore existing explosion protection guidelines may not account for worst case scenarios.
- Findings also have application in the critical separation distance between congested areas.

<b>Fuel type</b>	<b>Conc.(v/v)</b>	$\phi$	<b>S<sub>L</sub></b>	<b>E</b>	<b>Le</b>	<b>Ma</b>
(-)	(%)	(-)	(m/s)	(-)	(-)	(-)
CH <sub>4</sub>	10	1.06	0.45	7.49	1.0	3.5
CH <sub>4</sub>	7	0.72	0.24	6.26	1.0	-0.2
C <sub>3</sub> H <sub>8</sub>	4.5	1.12	0.53	8.10	0.8	2.6
C <sub>3</sub> H <sub>8</sub>	3	0.74	0.25	6.37	1.8	6.0
C <sub>2</sub> H <sub>4</sub>	4.3	0.65	0.30	5.82	1.3	3.0
H <sub>2</sub>	18	0.52	0.97	5.09	0.5	-0.8
H <sub>2</sub>	15	0.42	0.41	4.65	0.7	-1.2

