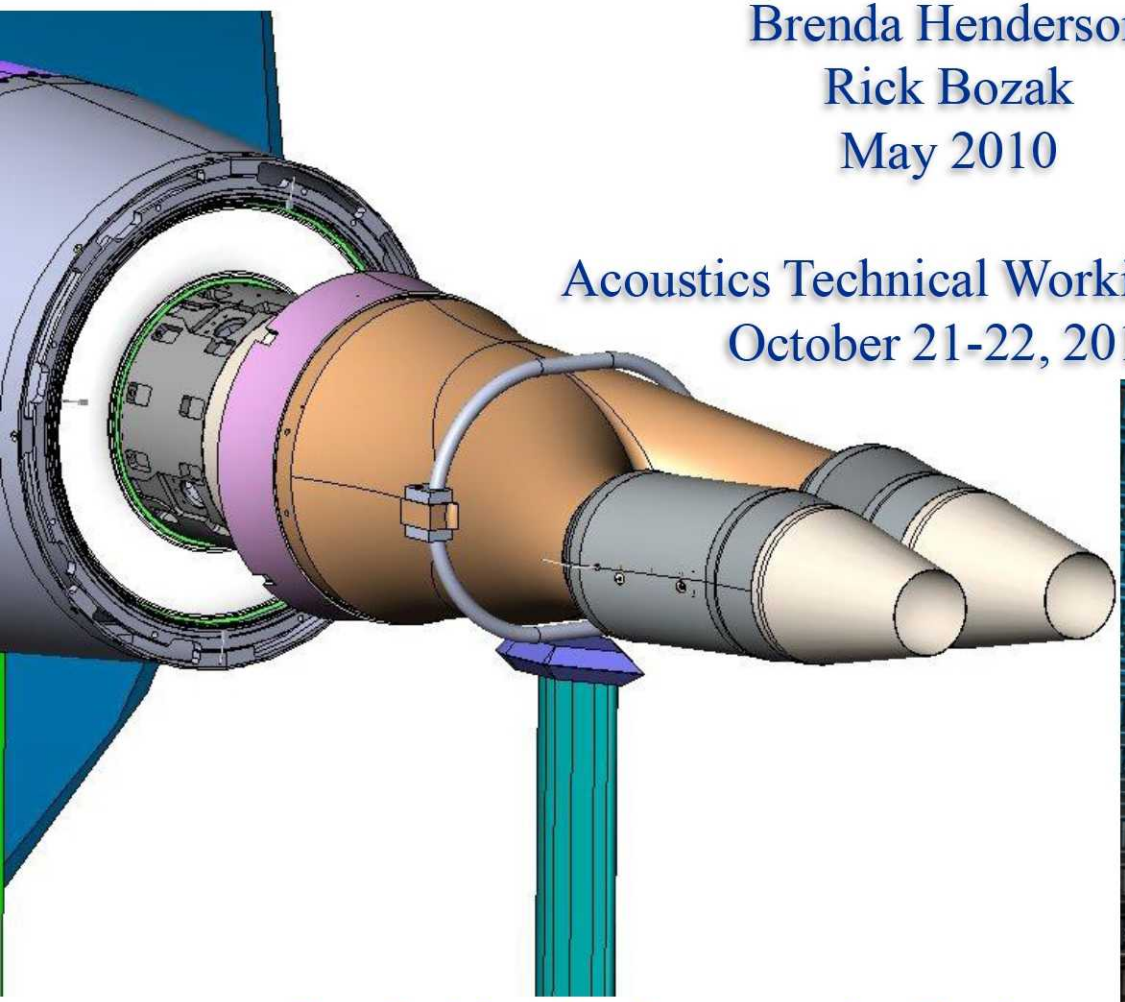
TWIN JET

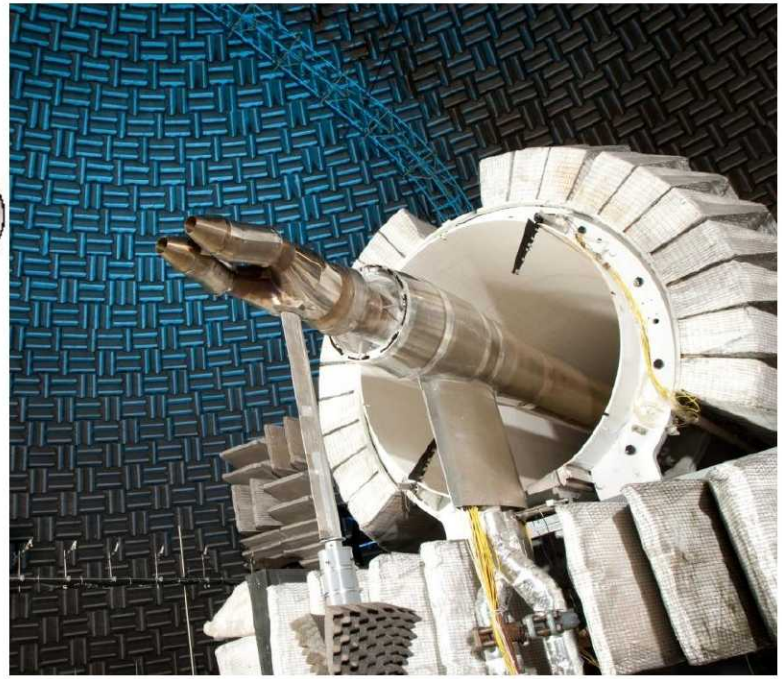
Many subsonic and supersonic vehicles in the current fleet have multiple engines mounted near one another. Some future vehicle concepts may use innovative propulsion systems such as distributed propulsion which will result in multiple jets mounted in close proximity. Engine configurations with multiple jets have the ability to exploit jet-by-jet shielding which may significantly reduce noise. Jet-by-jet shielding is the ability of one jet to shield noise that is emitted by another jet. The sensitivity of jet-by-jet shielding to jet spacing and simulated flight stream Mach number are not well understood. The current experiment investigates the impact of jet spacing, jet operating condition, and flight stream Mach number on the noise radiated from subsonic and supersonic twin jets.

TWIN JET

Brenda Henderson
Rick Bozak
May 2010

Acoustics Technical Working Group
October 21-22, 2010

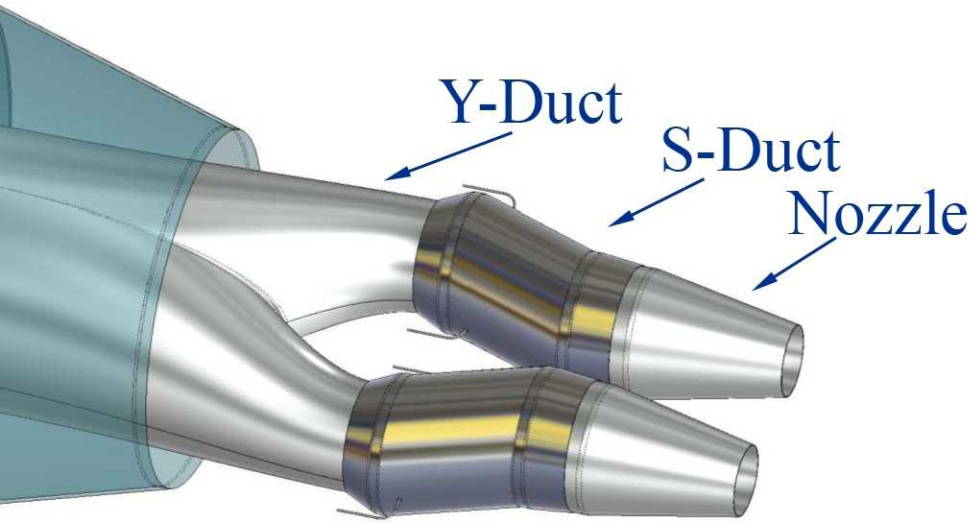




Funded by the Supersonics Project

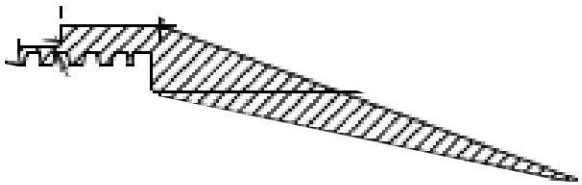
Range of Aircraft

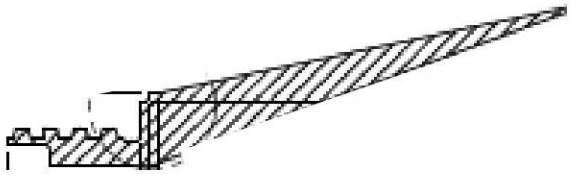
Twin Jet Configurations



Nozzles

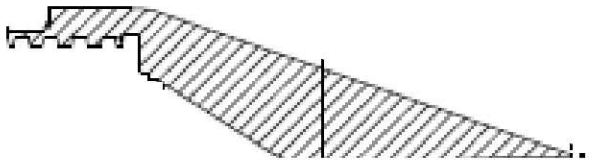
Conical Nozzle

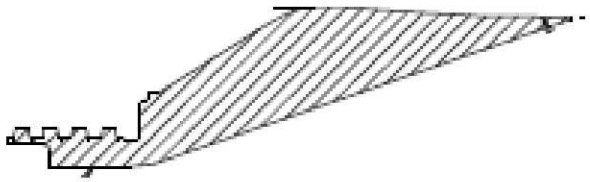




Contoured CD Nozzle

Md = 1.51



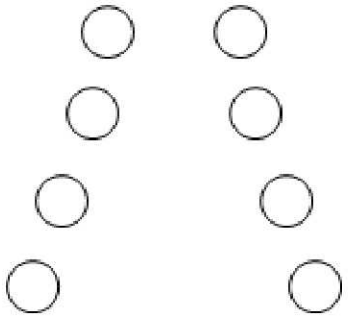


(Bi-conic CD Pictured)

Twin Jet Spacing Effects

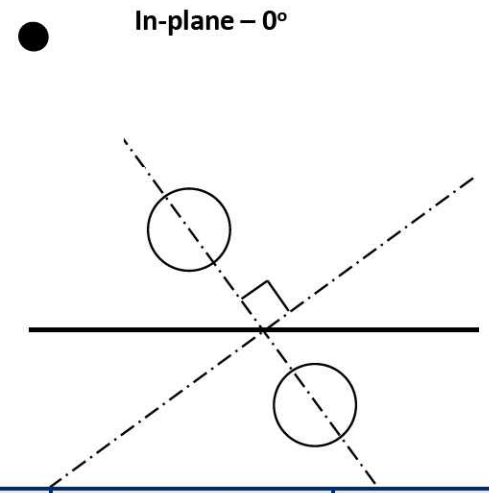
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54



Twin Jet Spacing Effects

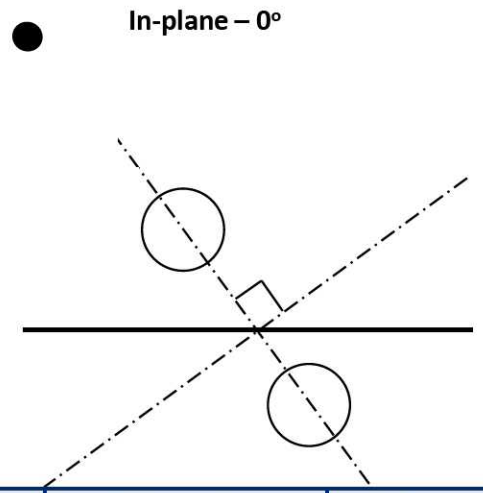
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction



Nozzle Pressure Ratio	Nozzle Temperature Ratio	Free Jet Mach Number
NPR	**NTR**	**Mfj**
1.89	1.00	0.10
1.88	2.37	0.10
1.87	3.12	0.10

Twin Jet Spacing Effects

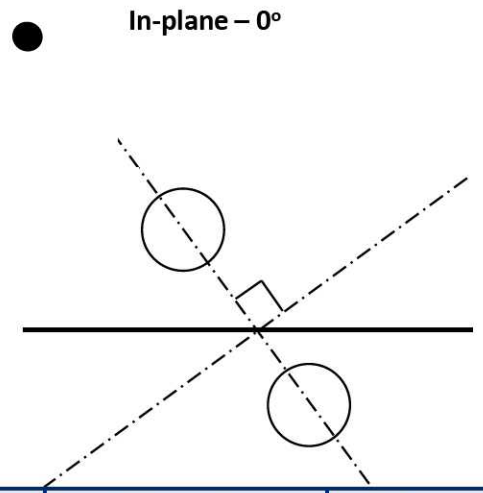
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction



Nozzle Pressure Ratio	Nozzle Temperature Ratio	Free Jet Mach Number
NPR	**NTR**	**Mfj**
1.89	1.00	0.10
1.88	2.37	0.10
1.87	3.12	0.10

Twin Jet Spacing Effects

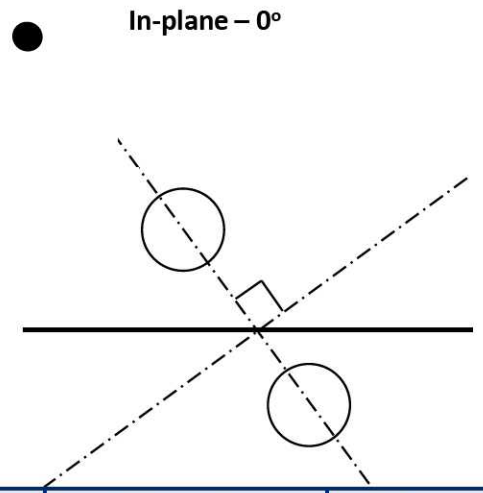
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction



Nozzle Pressure Ratio	Nozzle Temperature Ratio	Free Jet Mach Number
NPR	**NTR**	**Mfj**
1.70	3.11	0
1.87	3.12	0.10
1.87	3.12	0.30

Twin Jet Spacing Effects

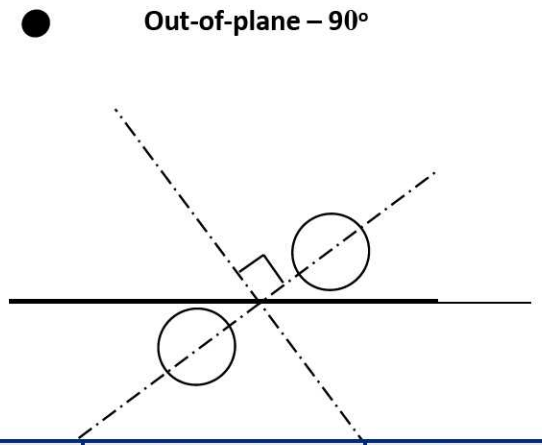
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction



Nozzle Pressure Ratio	Nozzle Temperature Ratio	Free Jet Mach Number
NPR	**NTR**	**Mfj**
3.50	3.00	0.10
3.50	3.00	0.30

Twin Jet Spacing Effects

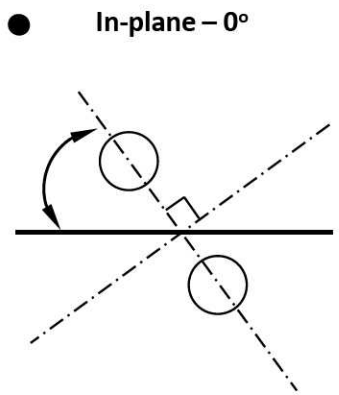
- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic
- Interaction

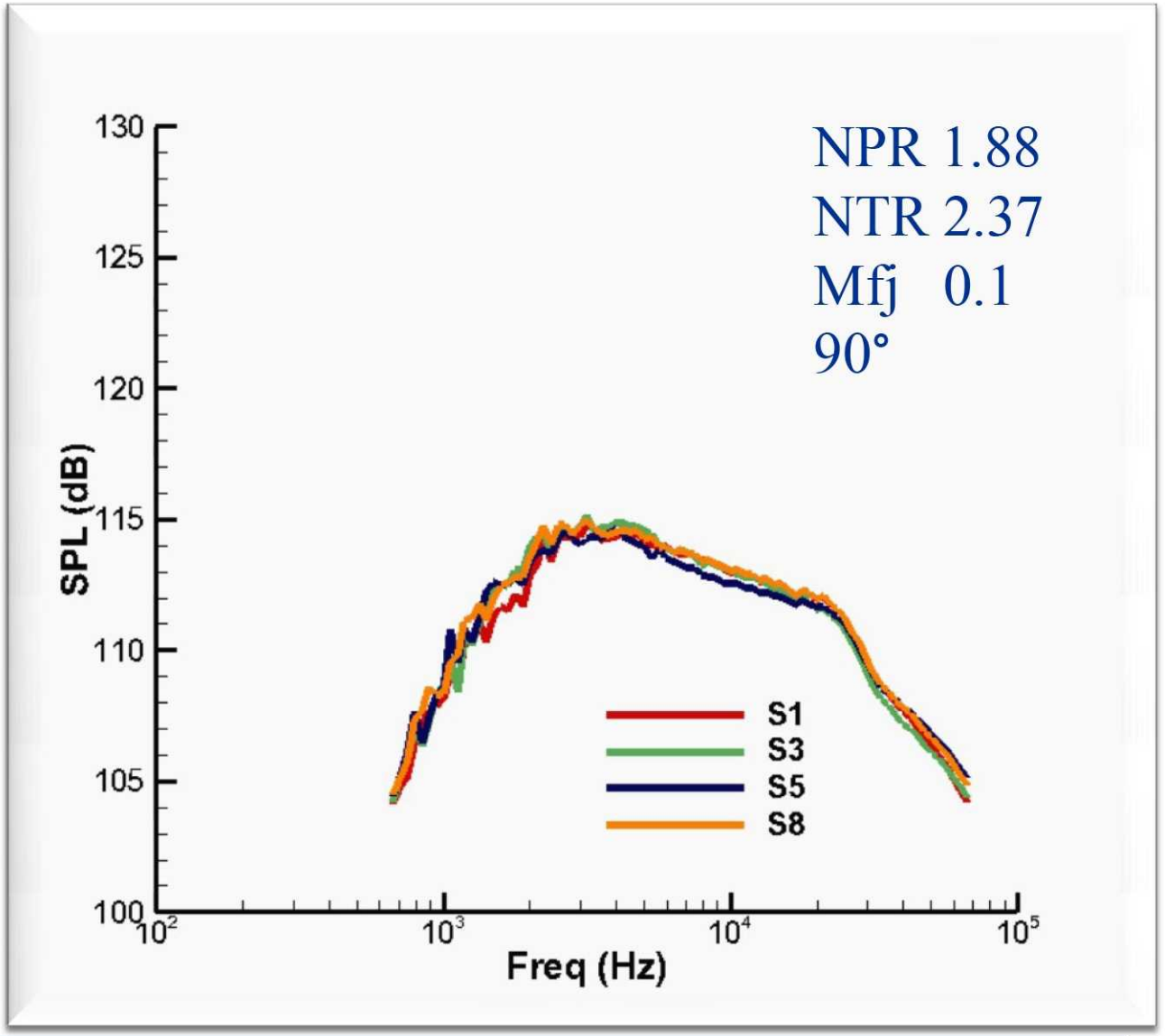


Nozzle Pressure Ratio	Nozzle Temperature Ratio	Free Jet Mach Number
NPR	**NTR**	**Mfj**
1.88	2.37	0.10
1.87	3.12	0.30
3.50	3.00	0.10
3.50	3.00	0.30

Effect of Spacing on Shielding

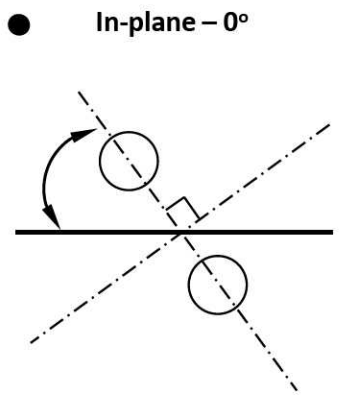
Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

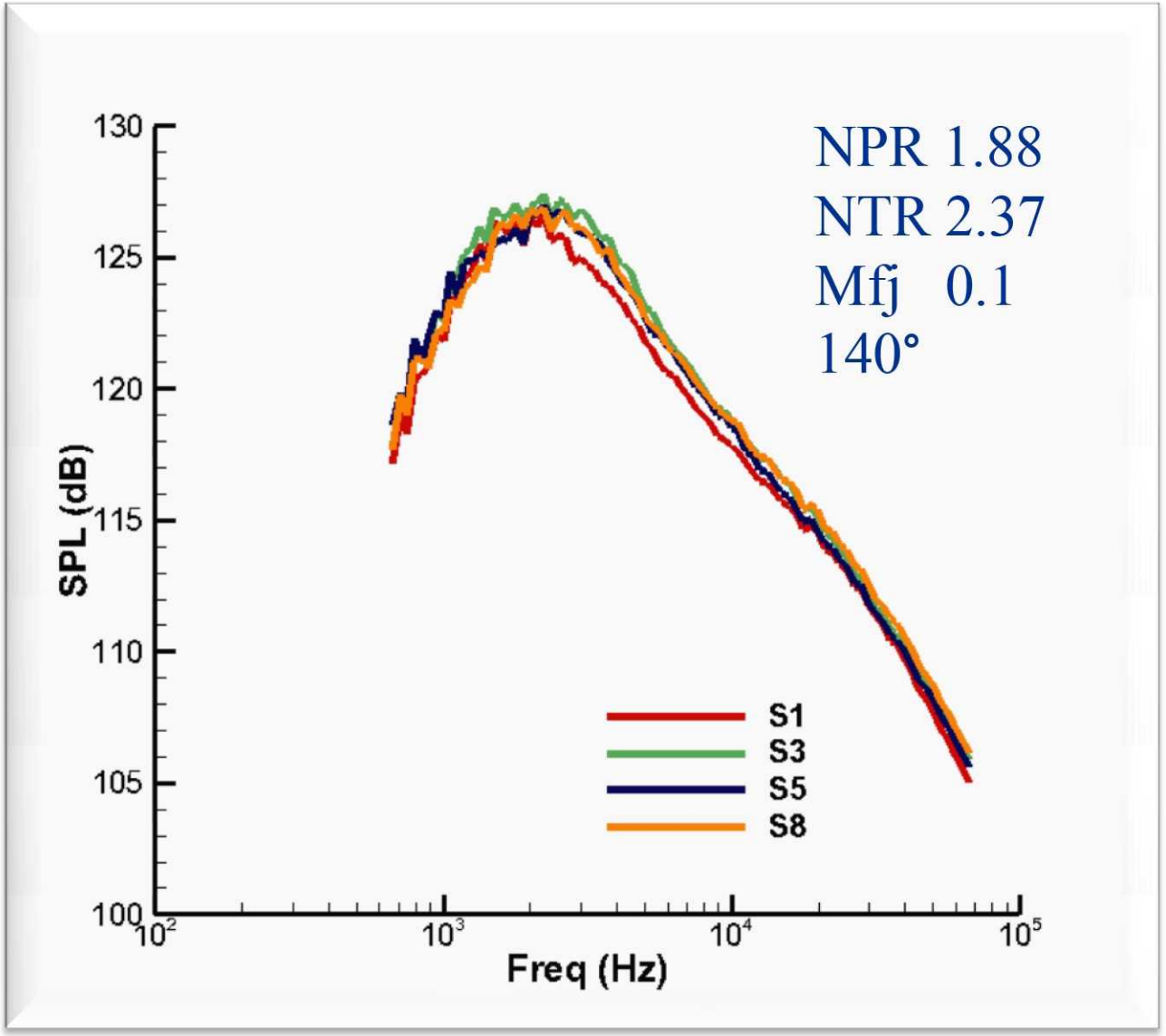




Effect of Spacing on Shielding

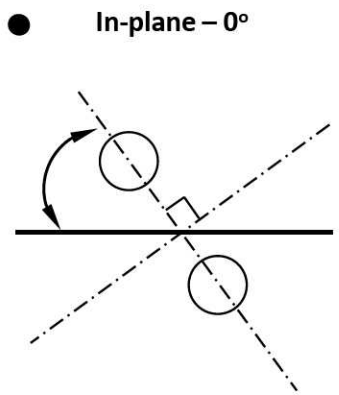
Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

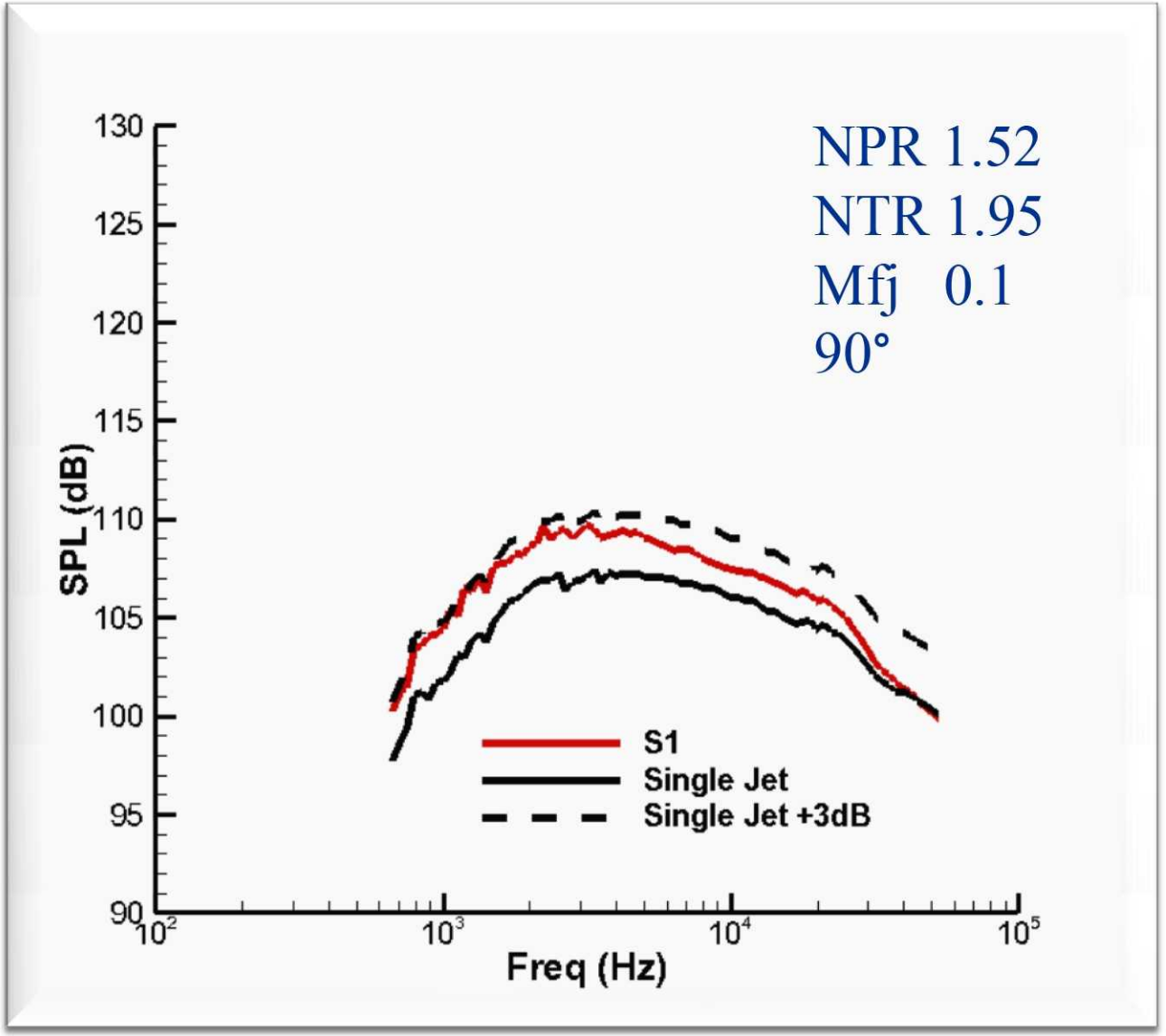




Shielding – Low Speed

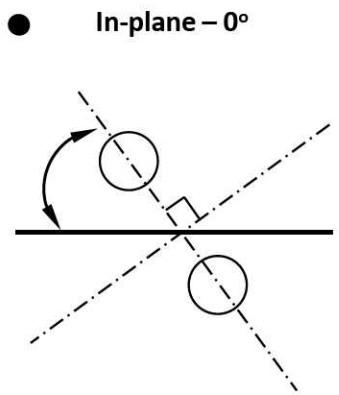
Spacing	S/D
S1	2.625

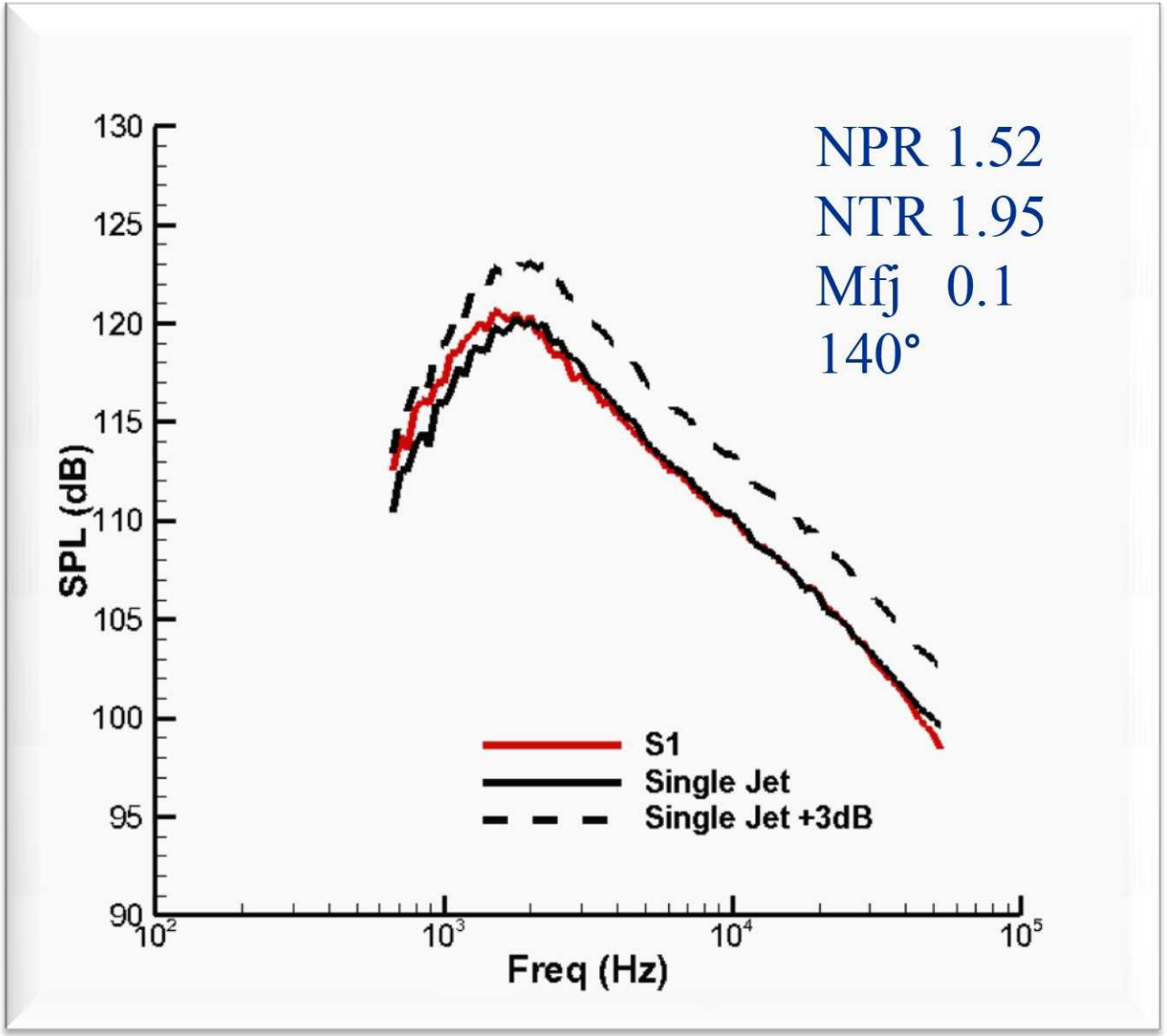




Shielding – Low Speed

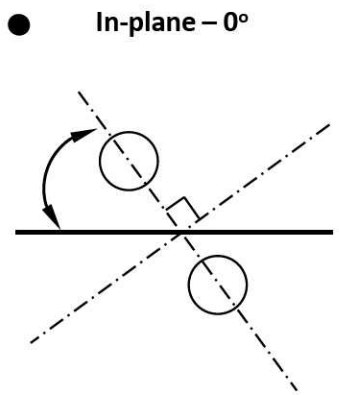
Spacing	S/D
S1	2.625

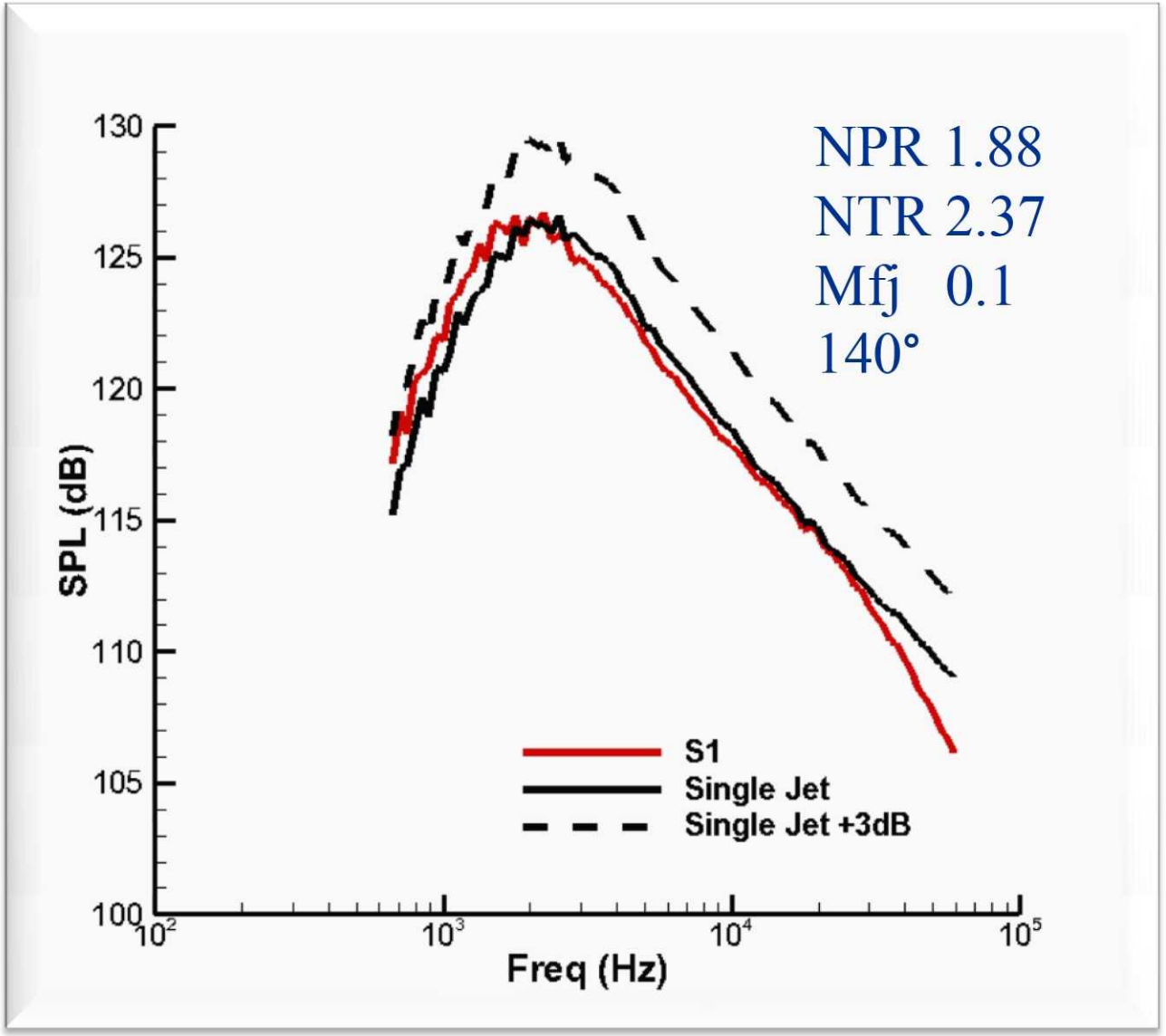




Shielding – Middle Speed

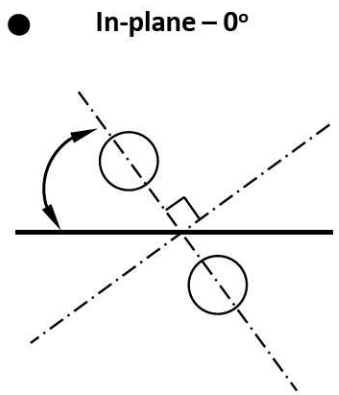
Spacing	S/D
S1	2.625

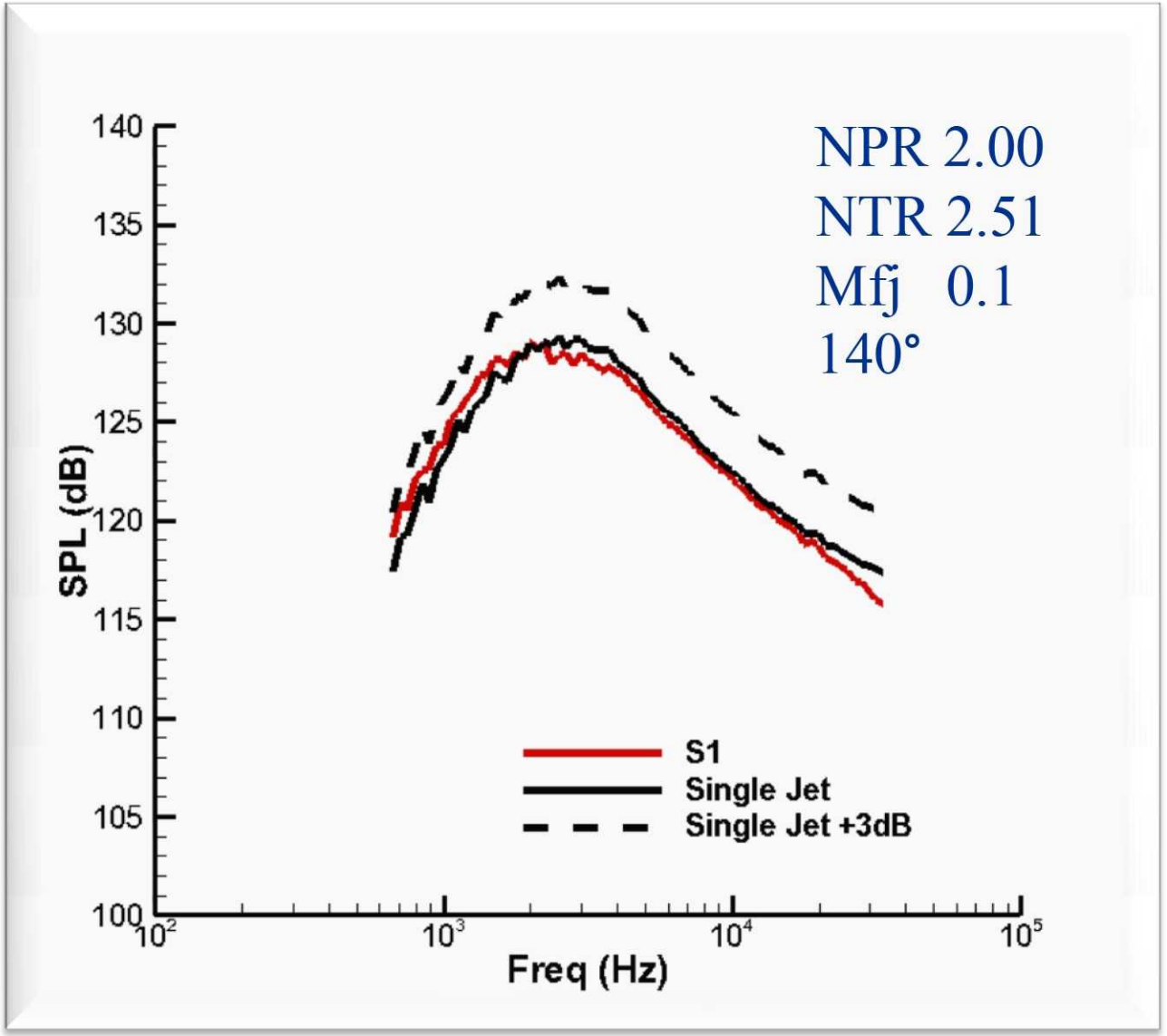




Shielding – High Speed

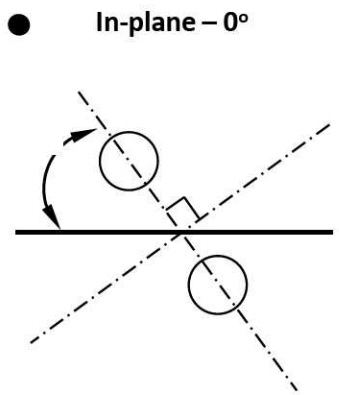
Spacing	S/D
S1	2.625

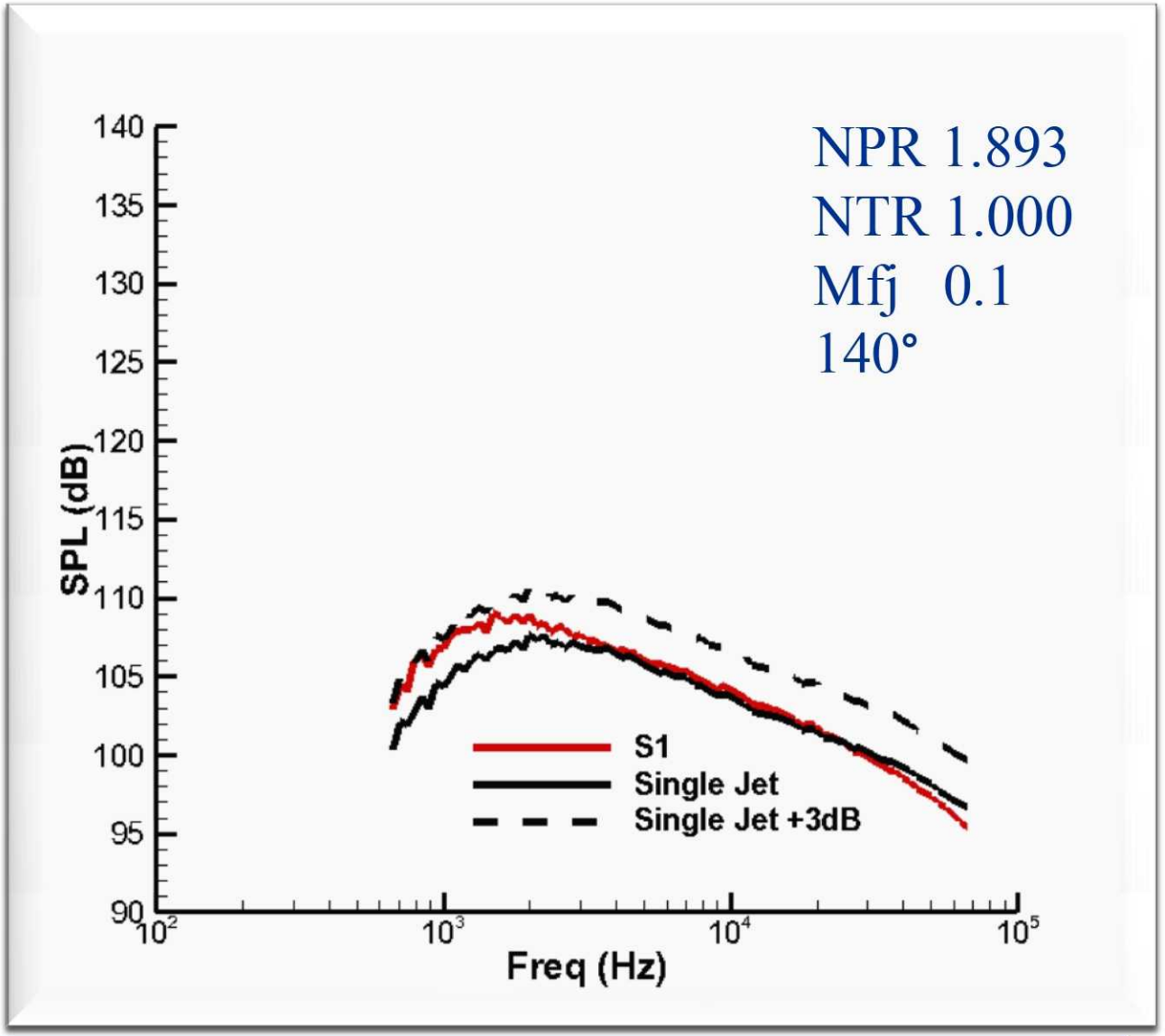




Heating Effects

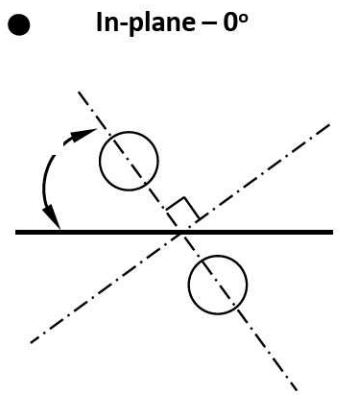
Spacing	S/D
S1	2.625

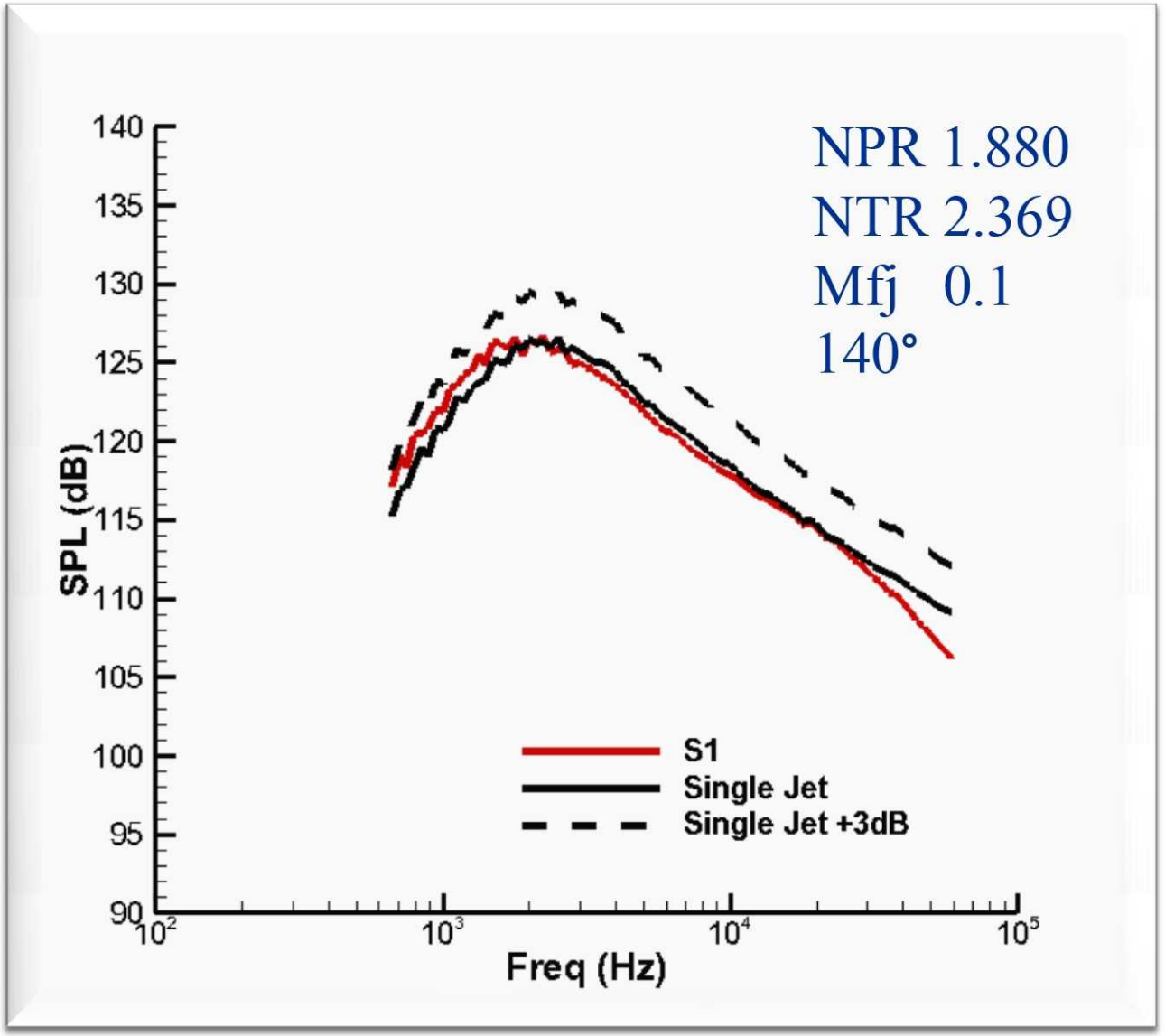




Heating Effects

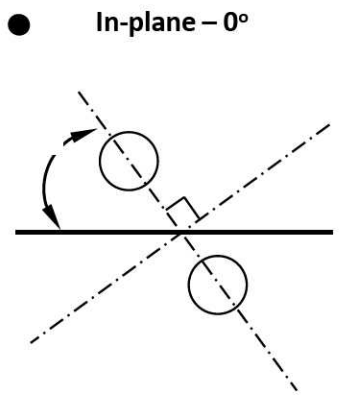
Spacing	S/D
S1	2.625

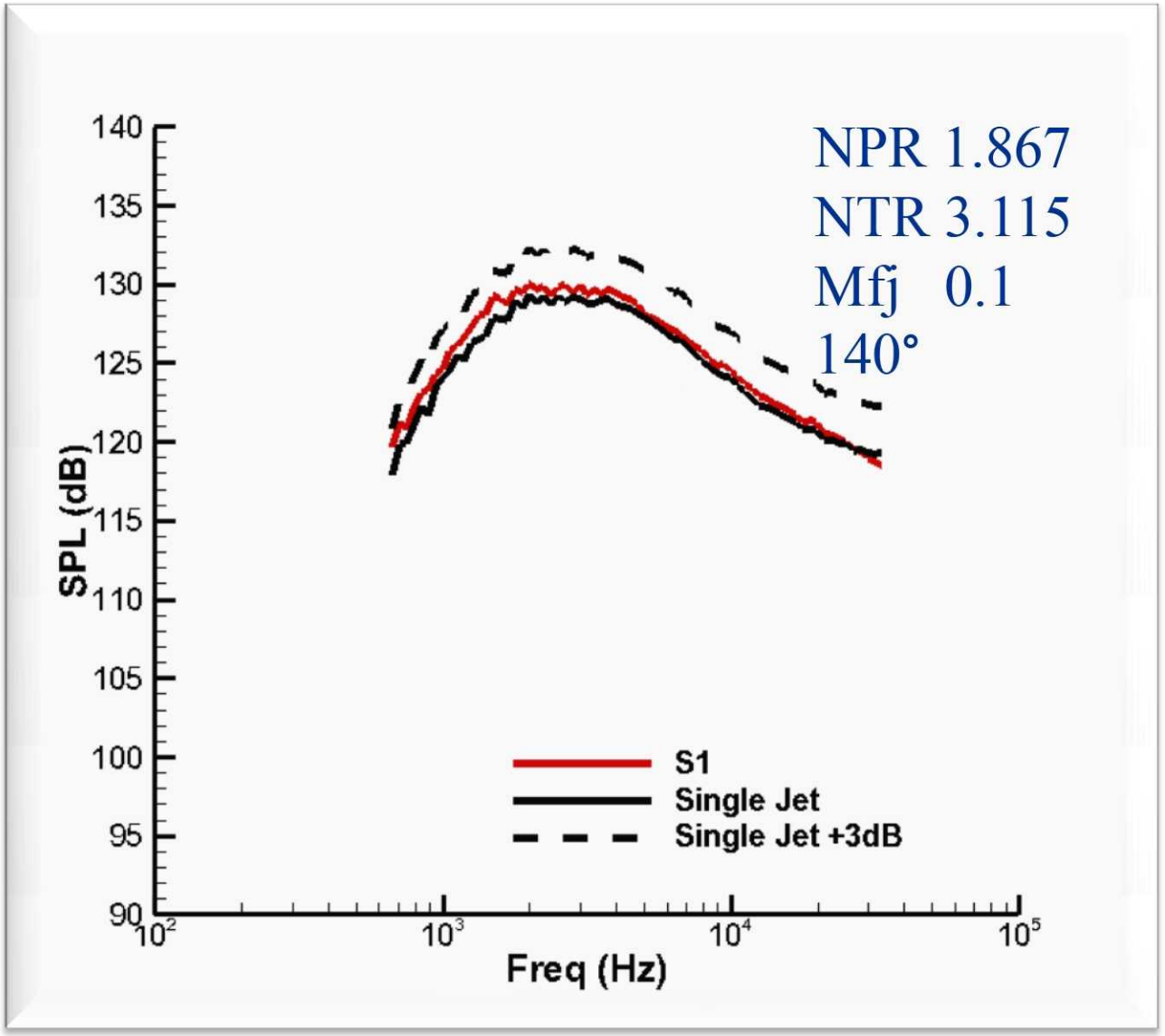




Heating Effects

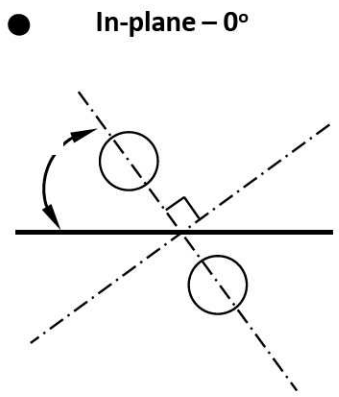
Spacing	S/D
S1	2.625

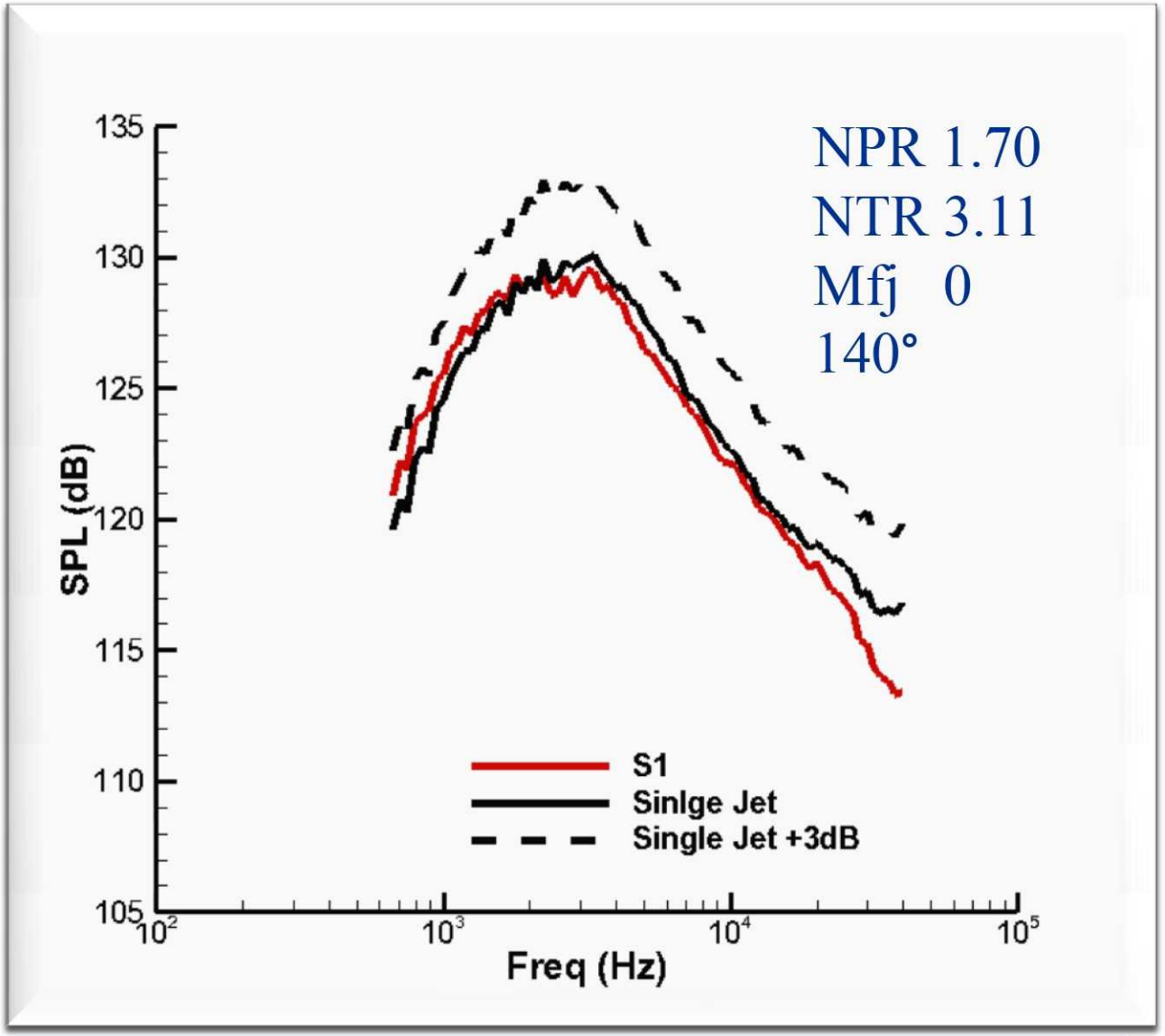




Free Jet Effects

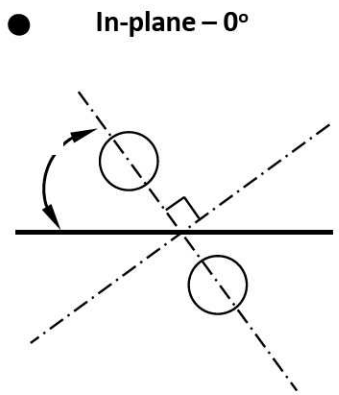
Spacing	S/D
S1	2.625

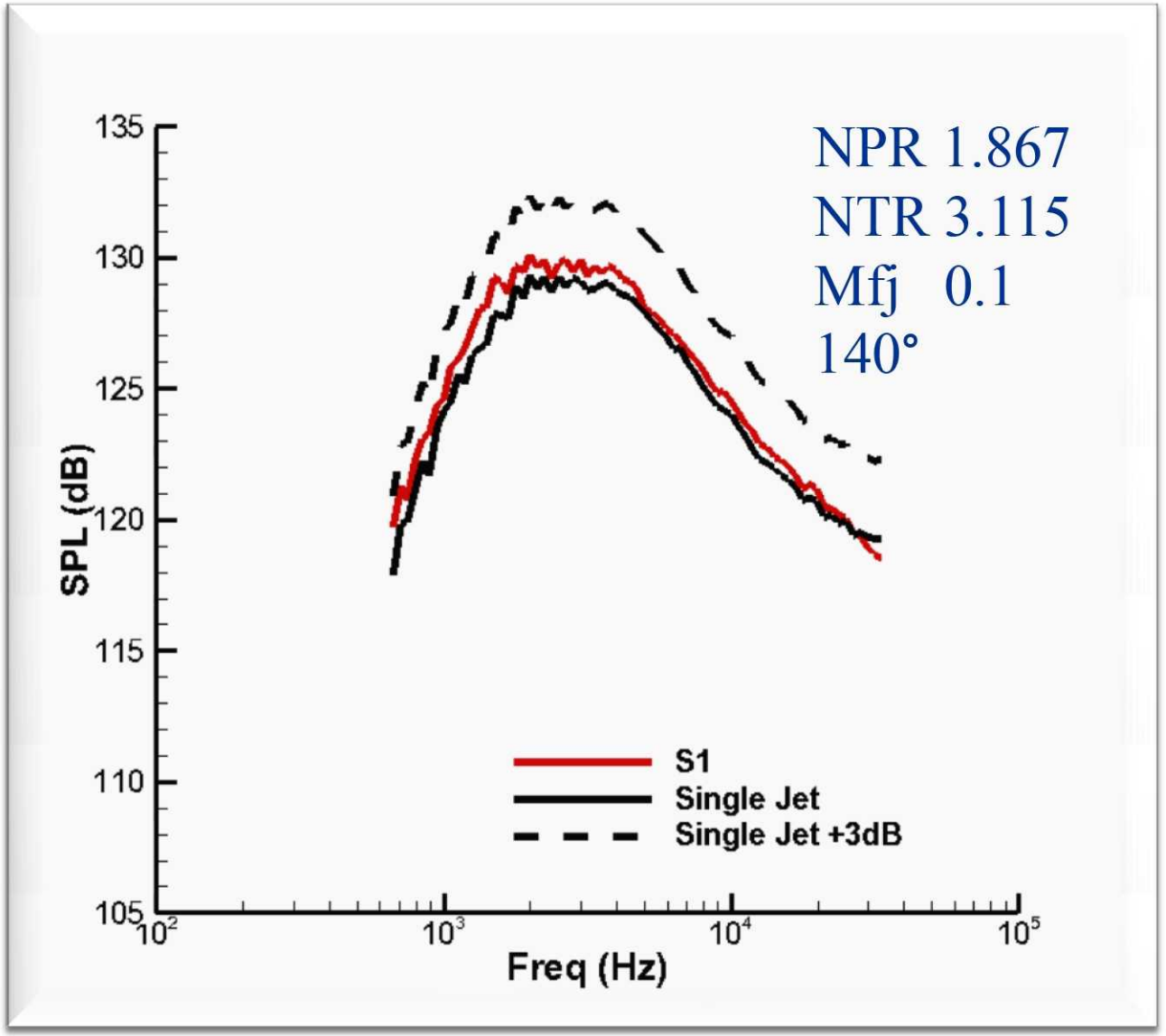




Free Jet Effects

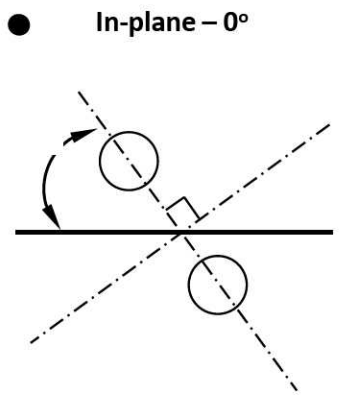
Spacing	S/D
S1	2.625

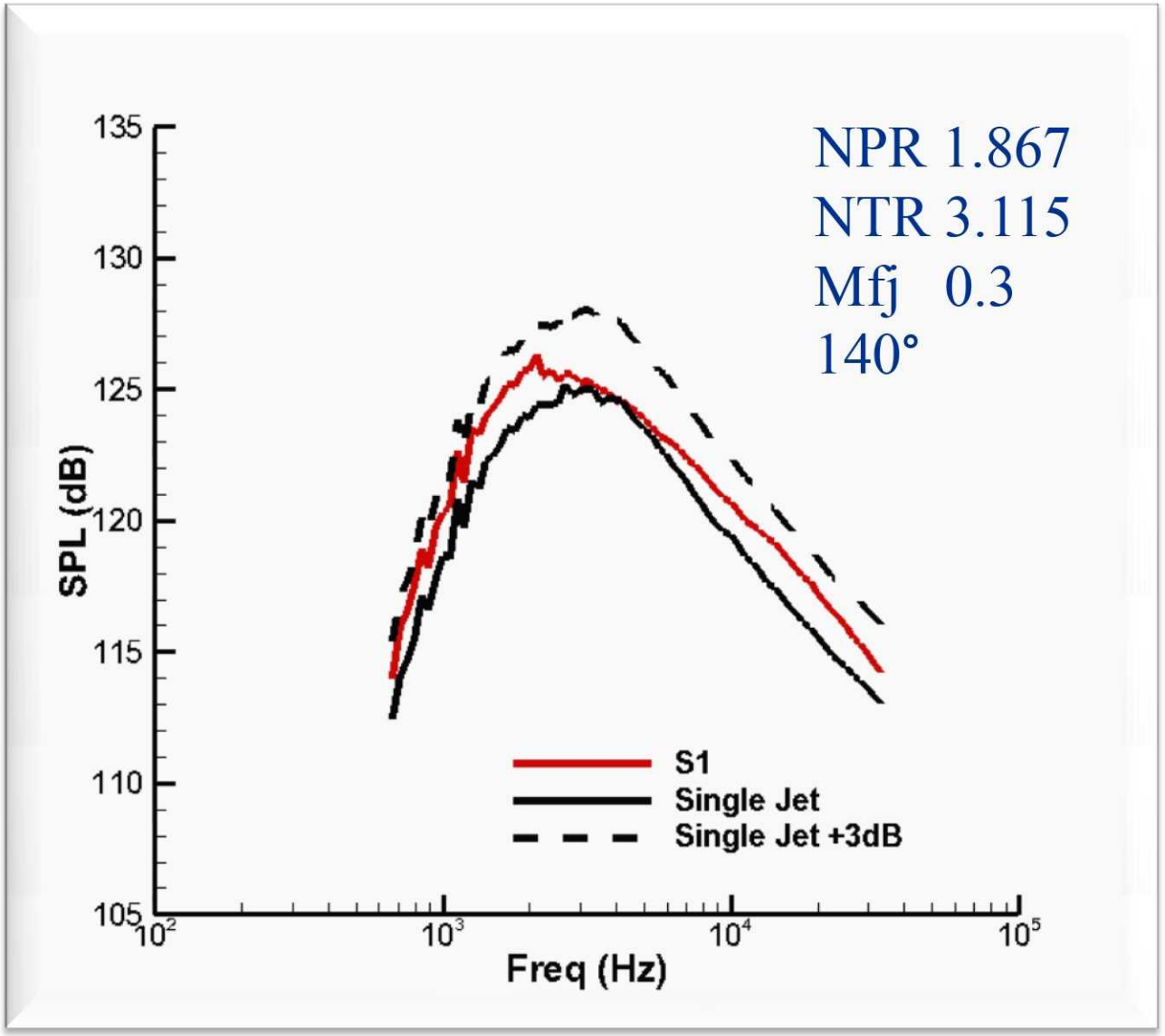




Free Jet Effects

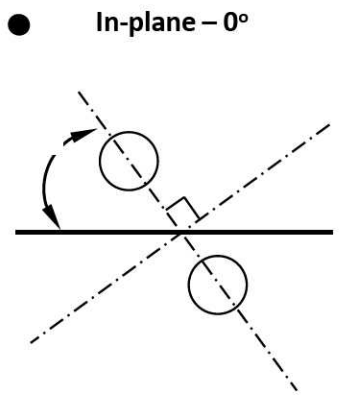
Spacing	S/D
S1	2.625

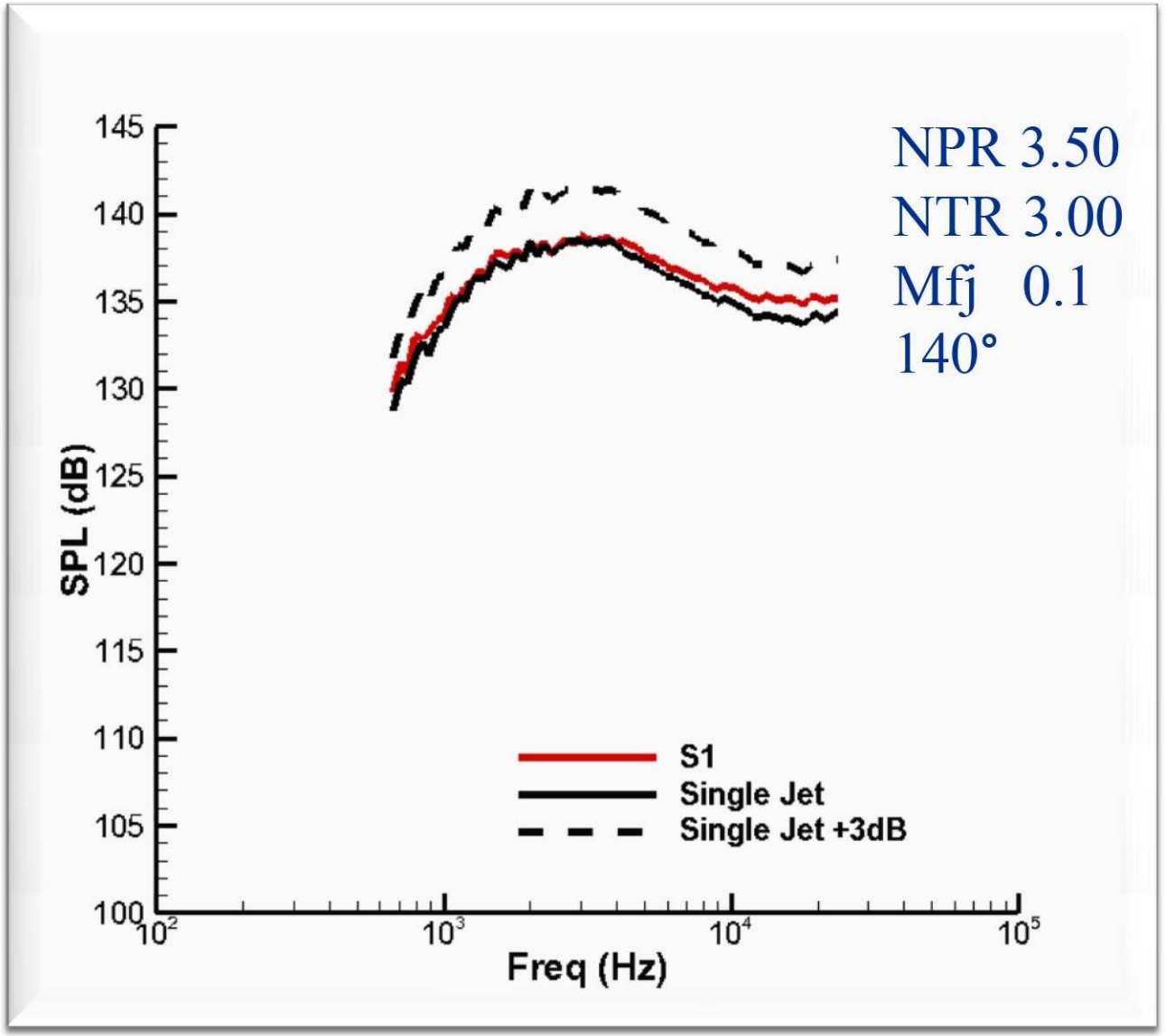




Supersonic Shielding

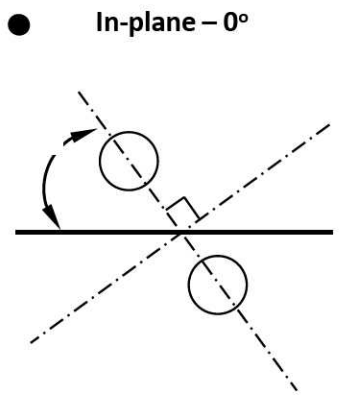
Spacing	S/D
S1	2.625

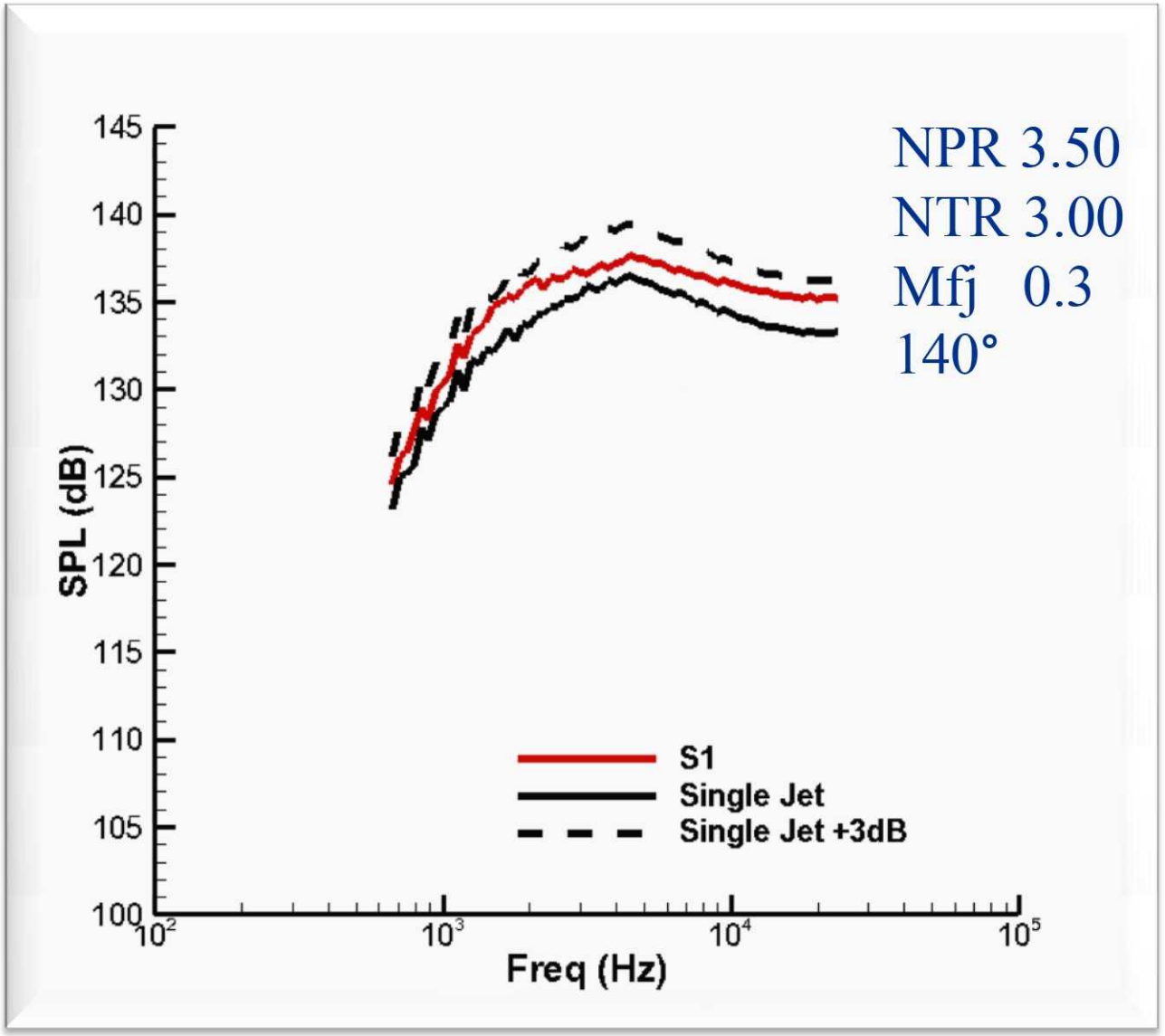




Supersonic Shielding

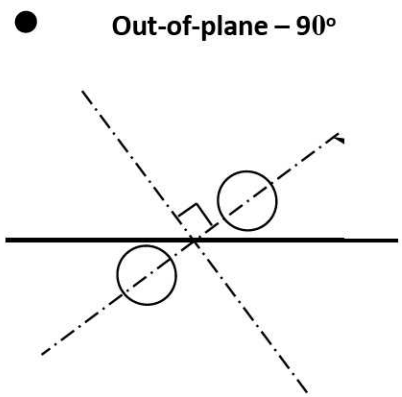
Spacing	S/D
S1	2.625

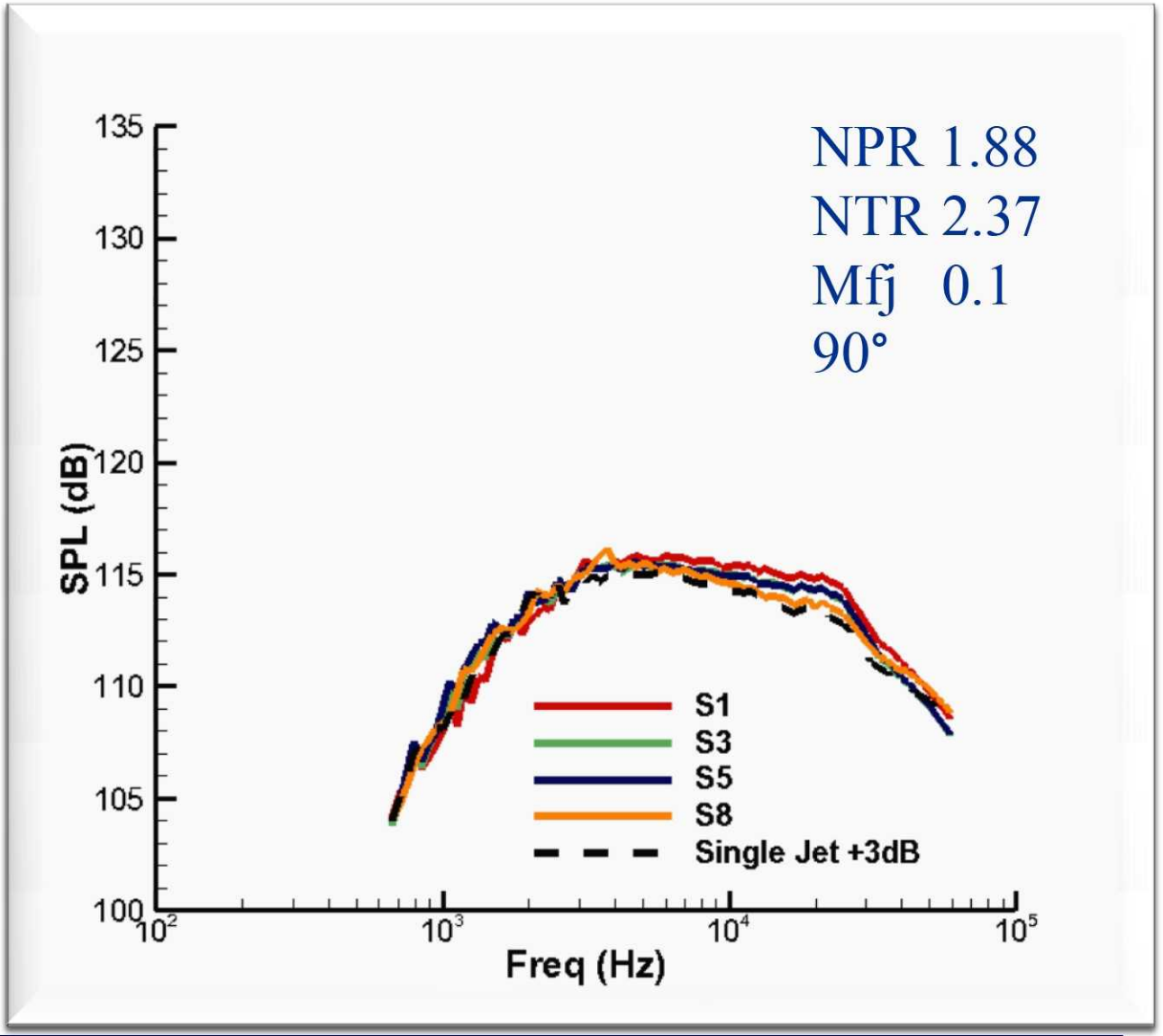




Interaction

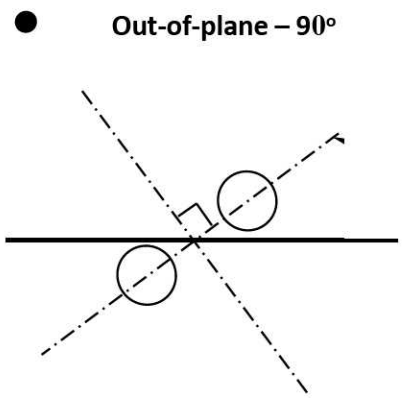
Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

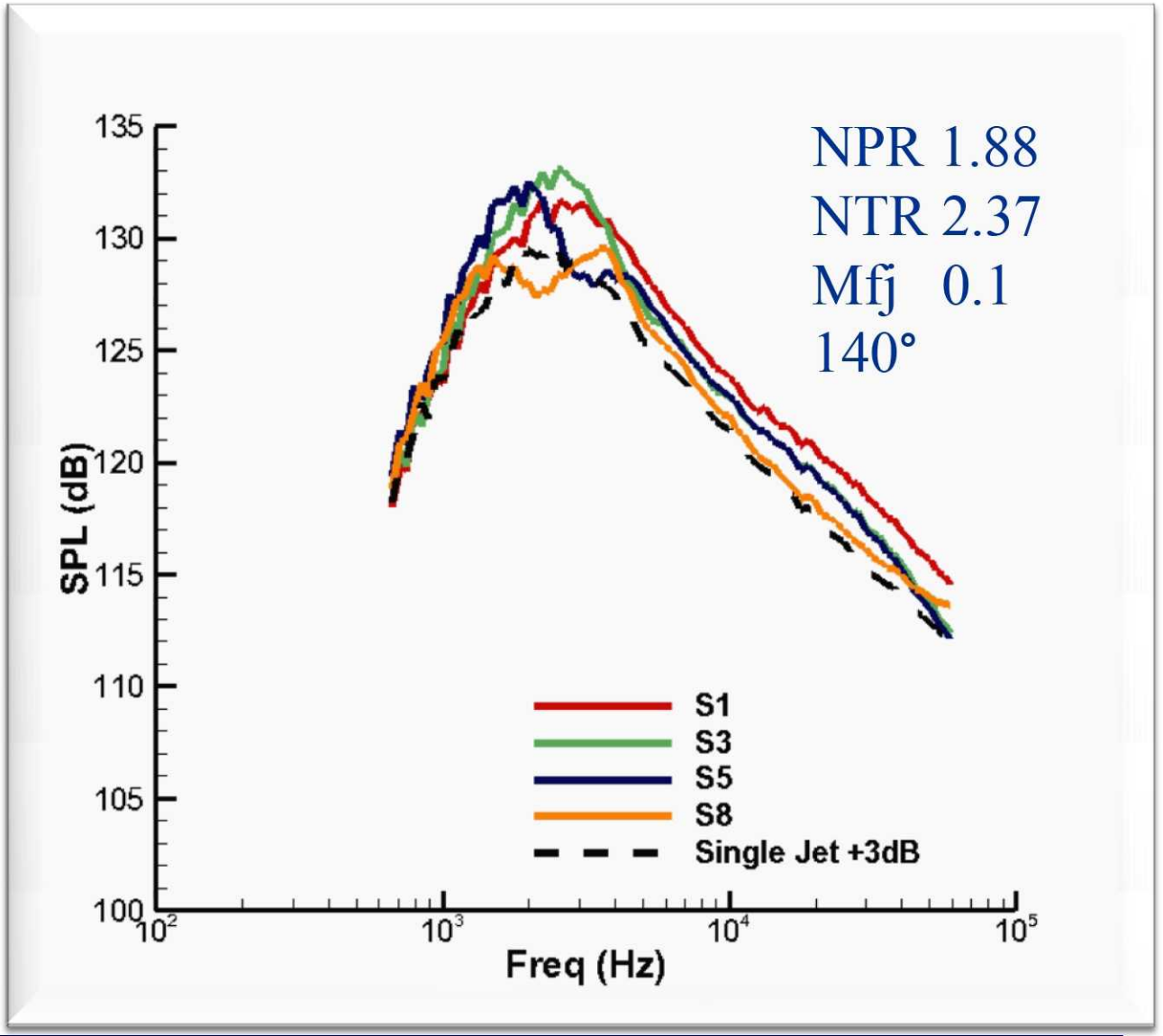




Interaction

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

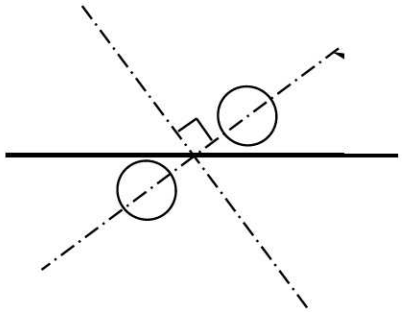


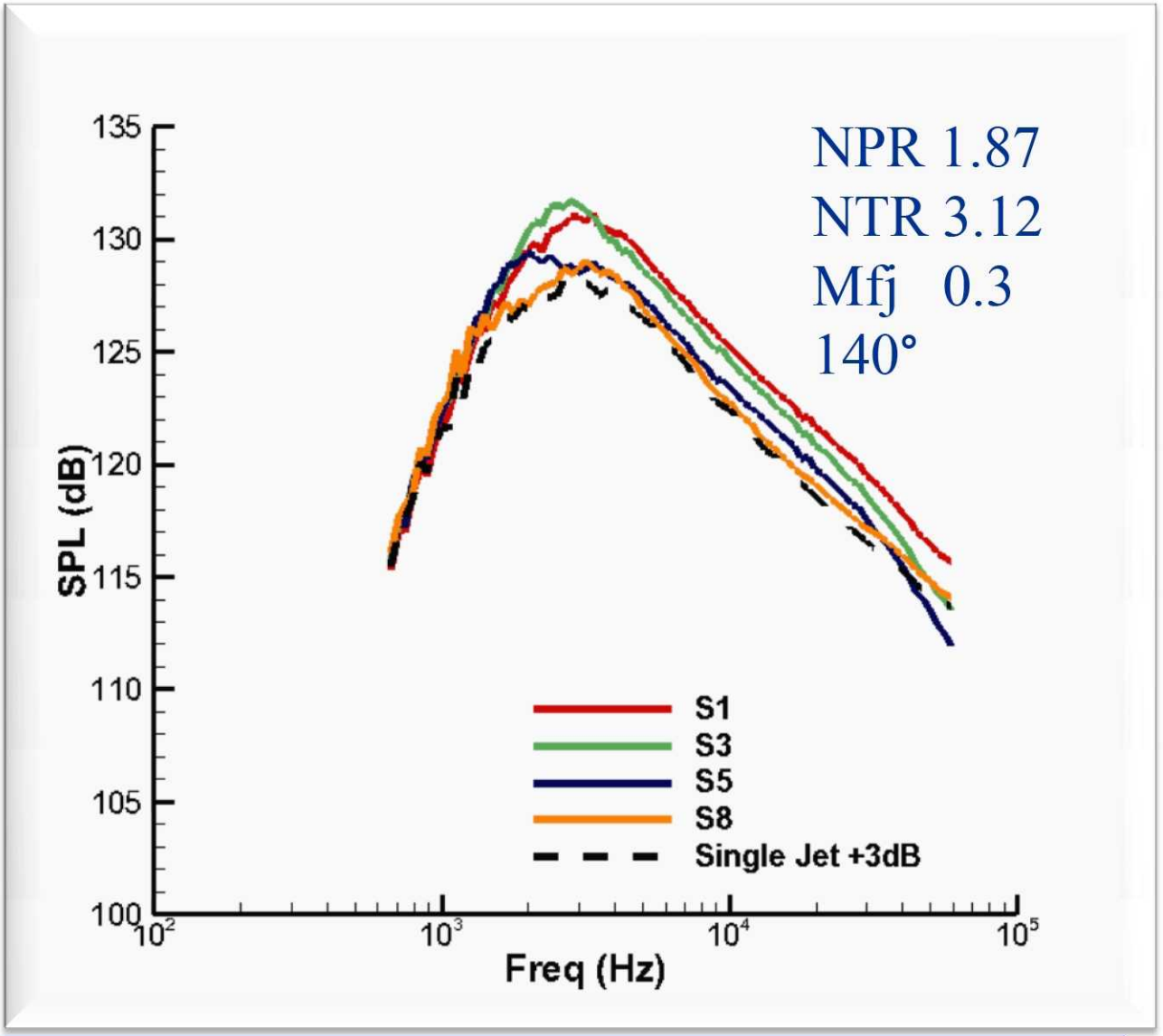


Interaction

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

● Out-of-plane – 90°

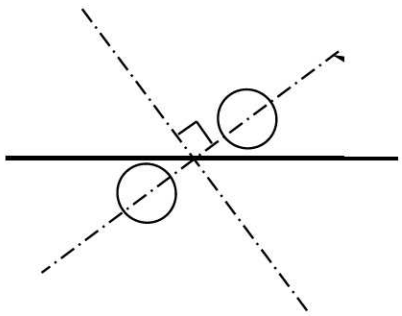


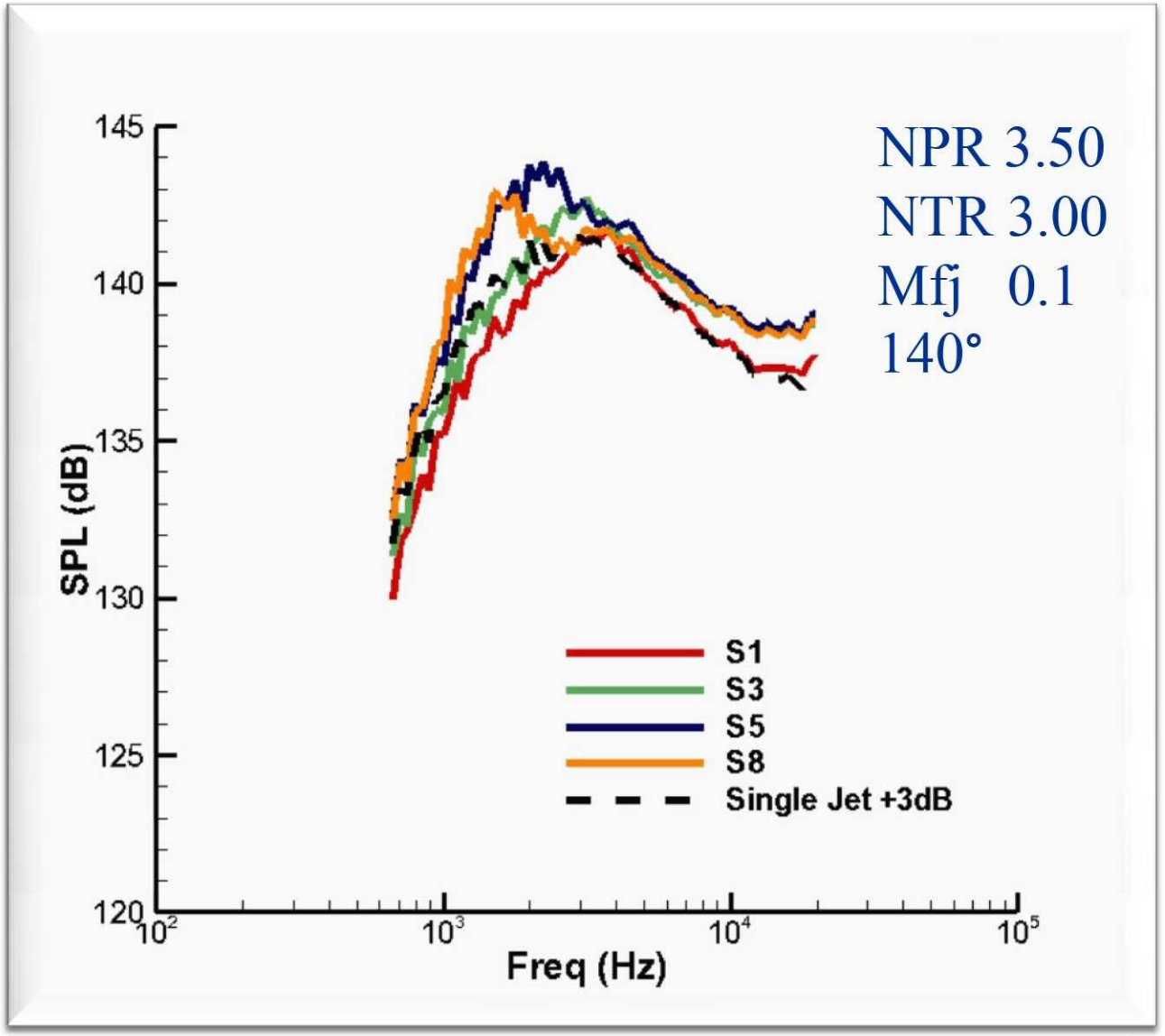


Supersonic Interaction

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

● Out-of-plane – 90°

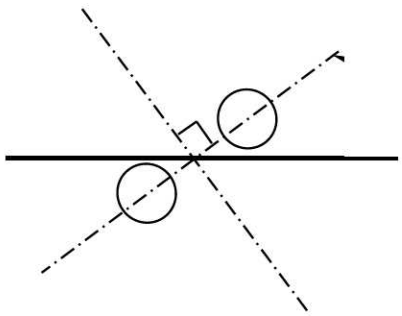


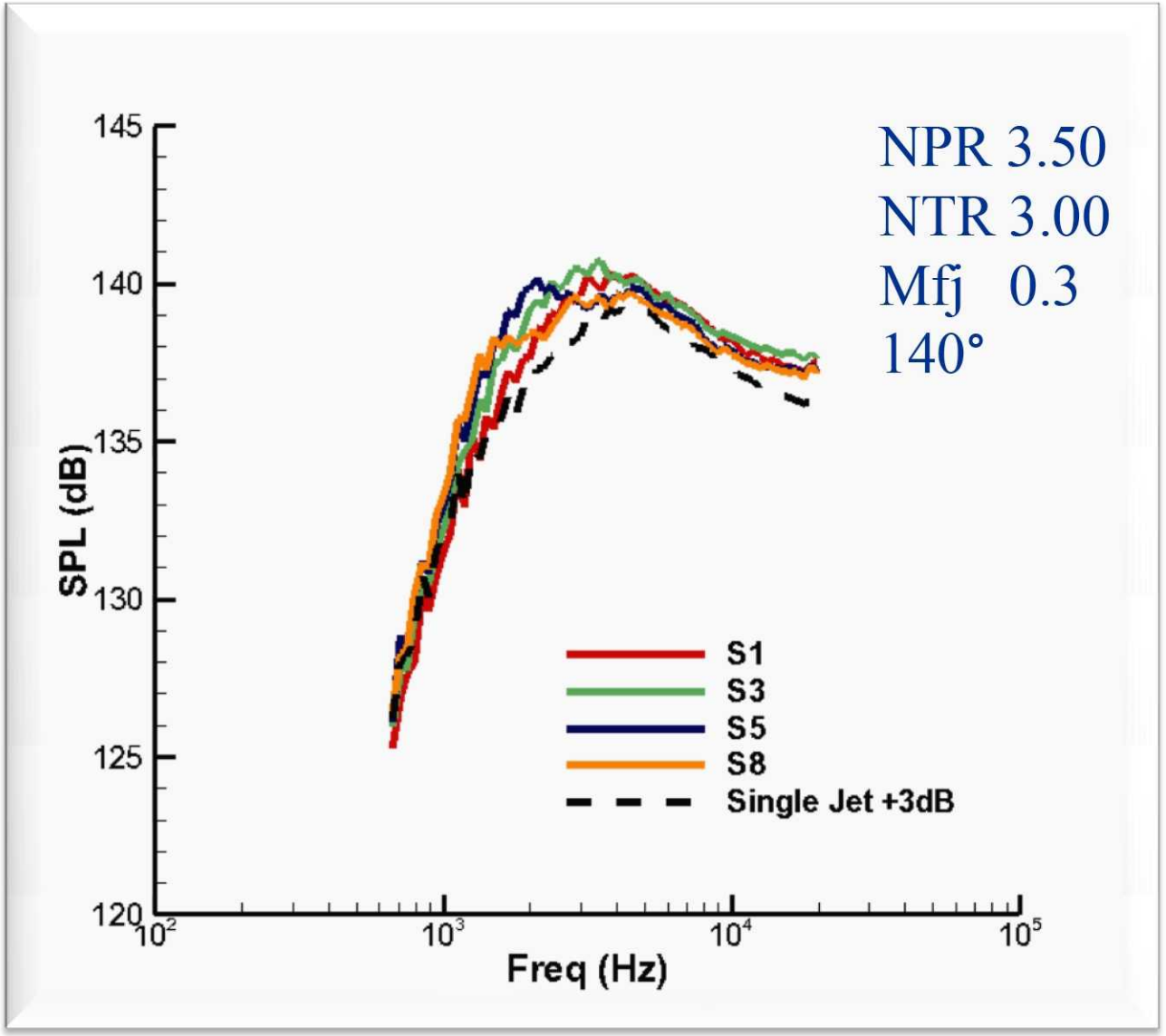


Supersonic Interaction

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54

● Out-of-plane – 90°





Summary

Shielding

- Most effective in the peak jet noise direction
- Most sensitive to flight speed, less sensitive to jet conditions

Interaction

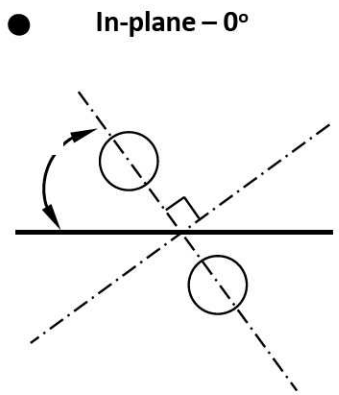
- For peak jet noise, secondary peak grows with increasing spacing

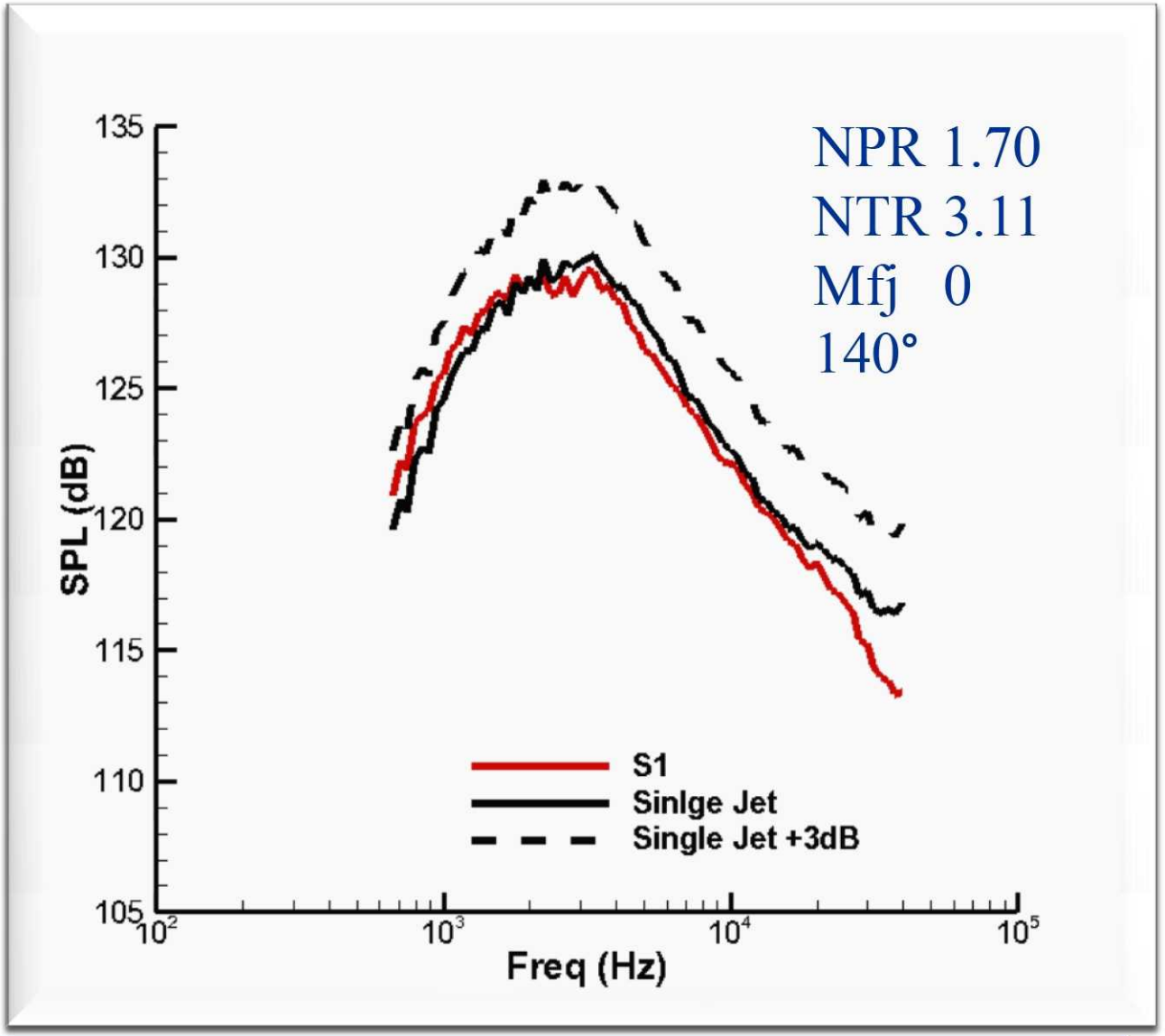
Further investigation needed: Acoustics (Langley JNL), PIV, Phased Array

Backup Slides

Free Jet Effects

Spacing	S/D
S1	2.625





Interaction – Effect of Spacing

Spacing	S/D
S1	2.625
S3	3.245
S5	4.39
S8	5.54