



Institut  
für  
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# A Muffler For Large Guns

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# Overview

- ⇒ Introduction
- ⇒ The Idea
- ⇒ The Construction
- ⇒ Acoustical Measurements
- ⇒ Why it Works



# Introduction

- ⇒ In co-operation with Rheinmetall and MAN the IfL did the acoustical measurements and developed a muffler for the 120 mm gun of the Leopard 2.
  
- ⇒ The goal of this investigation was to reduce the noise load from shots with large guns
  - in the vicinity of military testing facilities
  - and other facilities where shooting is done from defined positions.
  
- ⇒ A similar approach was tested earlier by USA CERL at Aberdeen proofing ground using foam in a large muffler for howitzer shots.
  
- ⇒ In parallel to the IfL muffler, Rheinmetall developed its own concept for the inner part of the muffler.



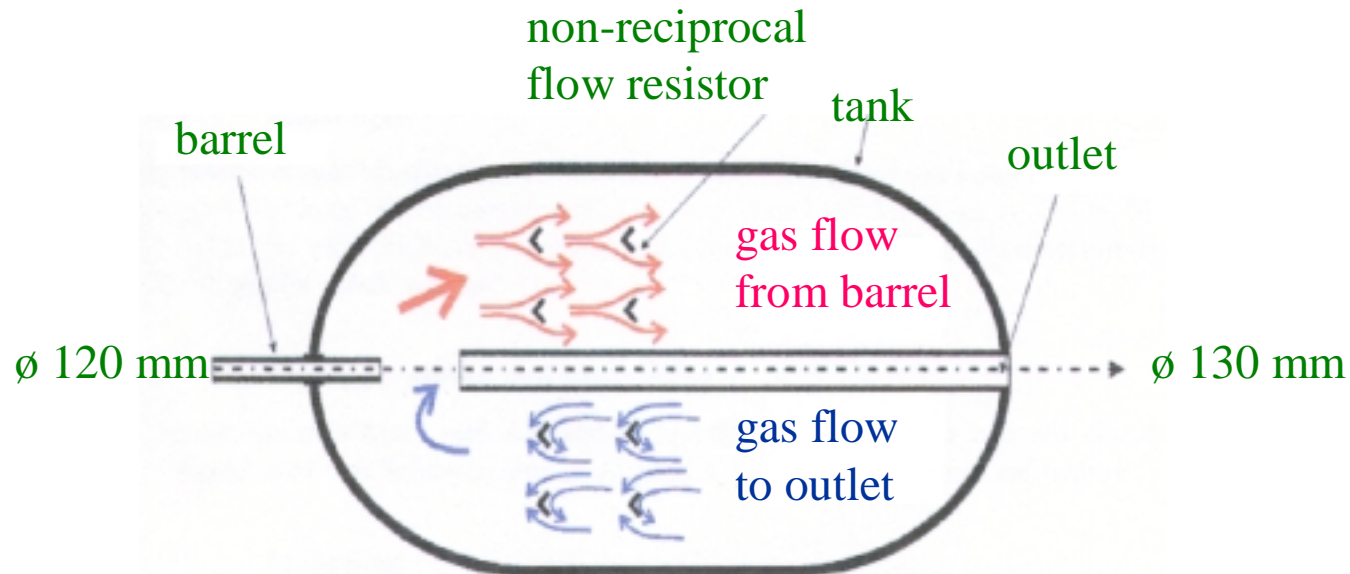
# The Idea

- ⇒ The general idea of this type of muffler is to expand the propellant gases into an appropriate tank and store the gas there until pressure and motion are low enough that they can leave the tank in a steady subsonic flow into the surrounding air.
- ⇒ We must let the projectile out. (No question about that.)
- ⇒ We cannot close the tank quick enough behind the projectile. (At least, we were not able to.)
- ⇒ The gases in the tank will start a pipe-like periodic motion. (that is our view on what happens.)



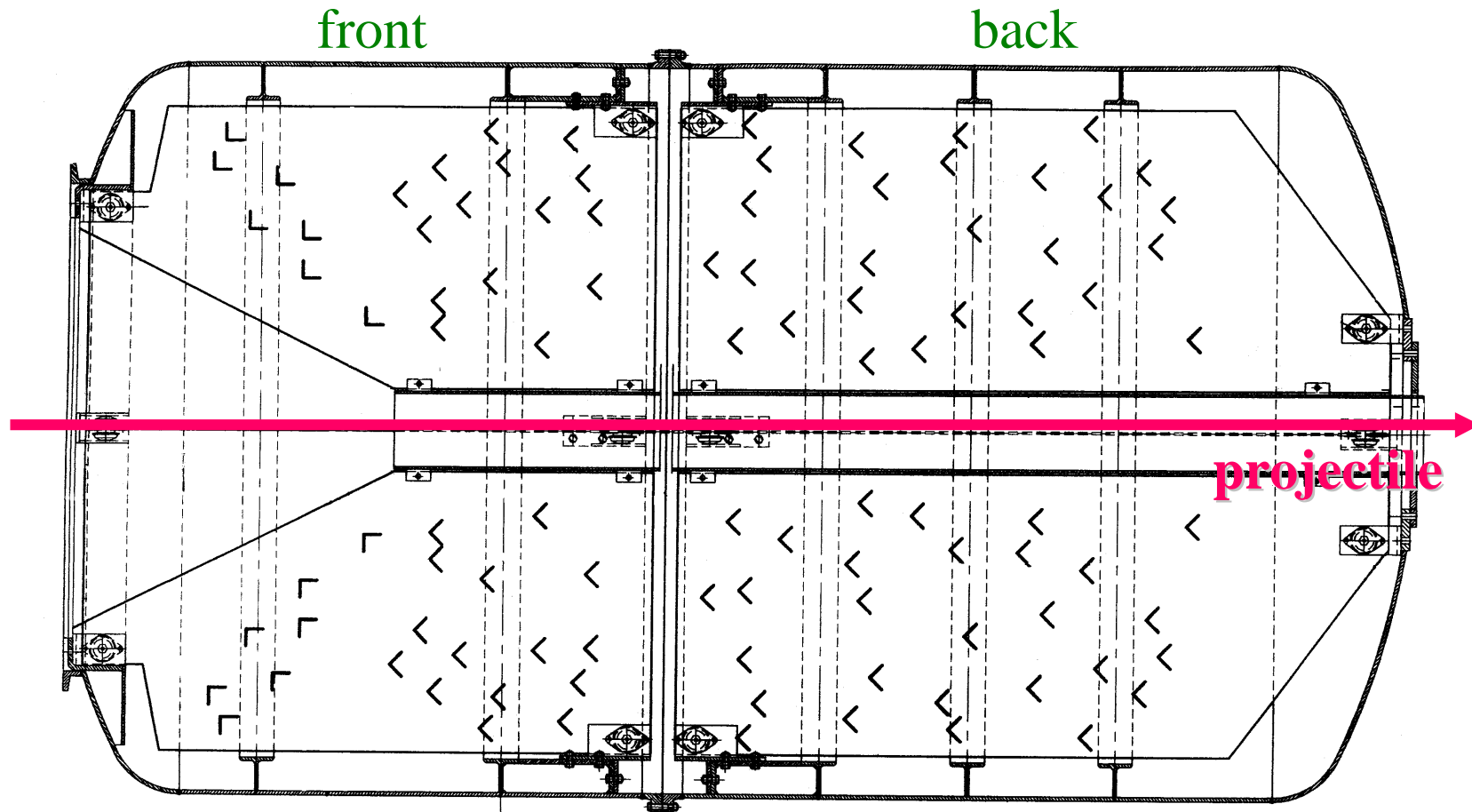
# The Approach

- ⇒ Try to build a dynamic ,door‘ in the tank so that the gases can go in easily but when they try to leave make it as difficult as possible for them.
- ⇒ We tried a system of wedges and use them as ,non-reciprocal‘ flow resistors.





# The Construction





# The IfL-Muffler I







# The IfL-Muffler II

## inner construction







# The IfL-Muffler III

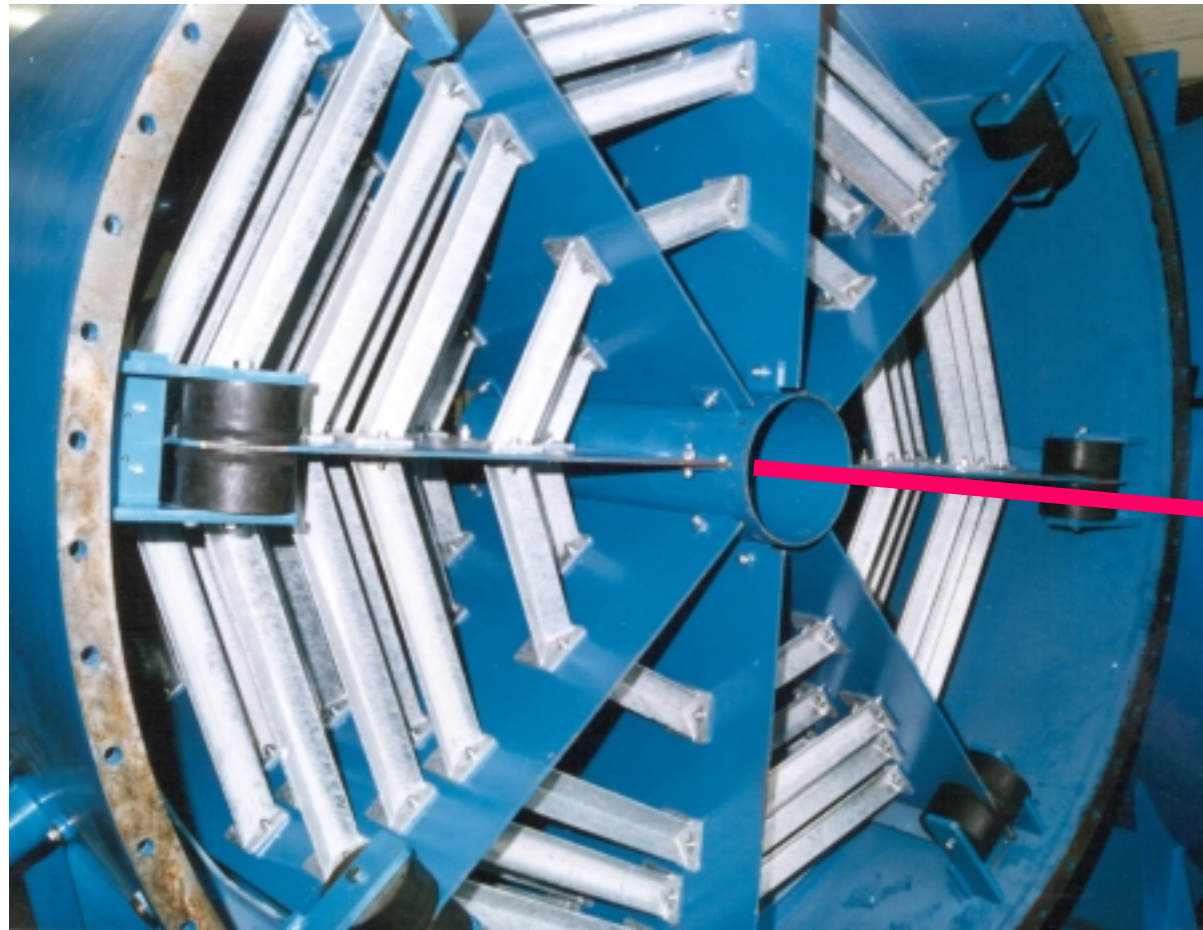
‘the front door‘





# The IfL-Muffler IV

## front part



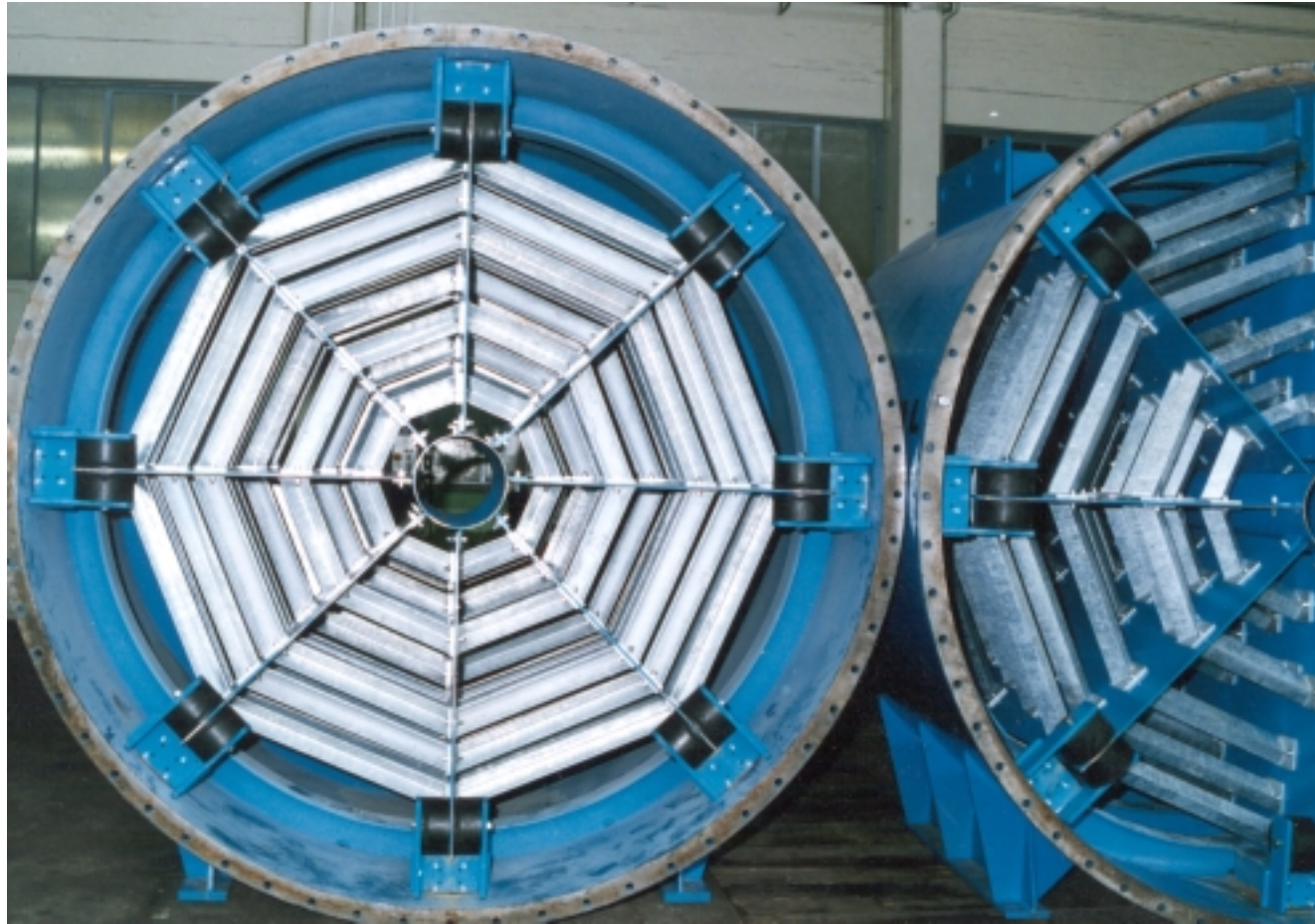
projectile





# The IfL-Muffler V

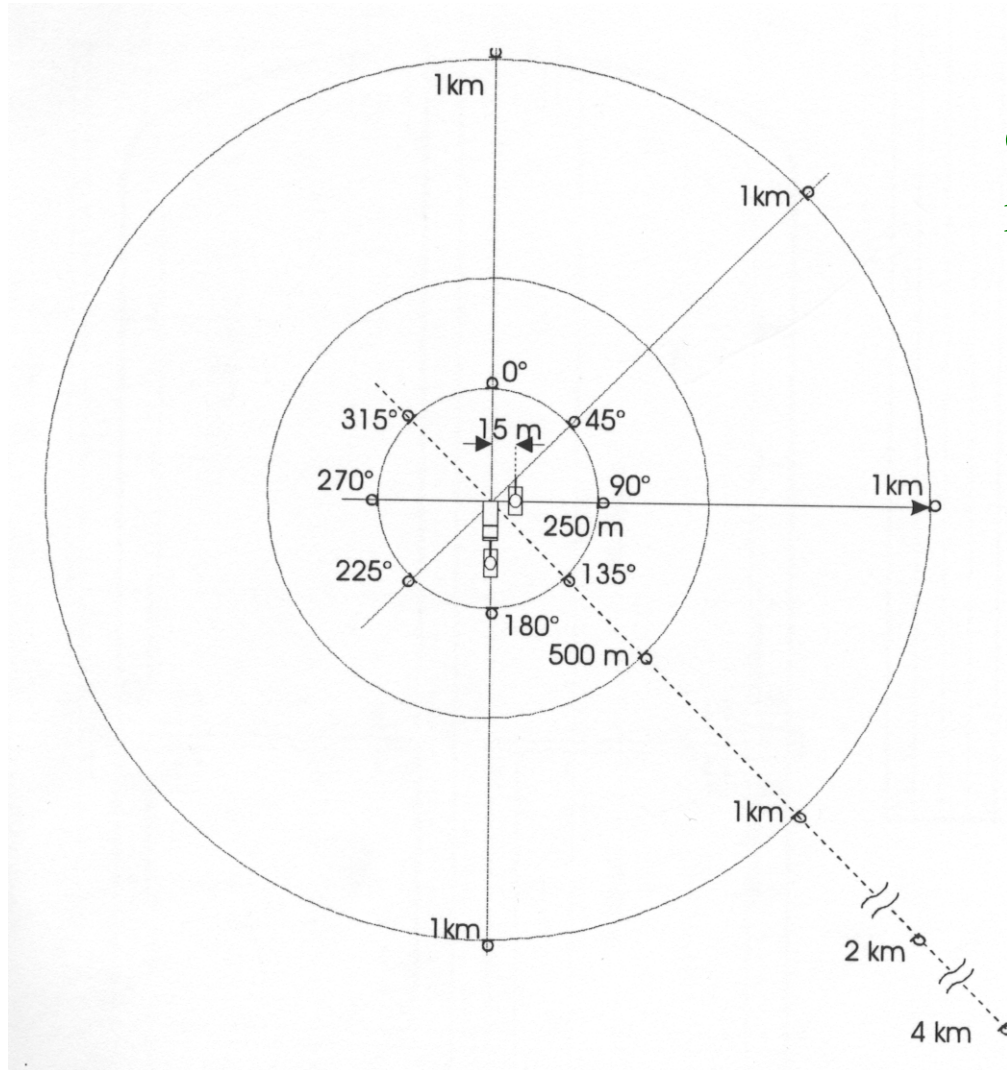
‘the closed door’



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# Acoustical Measurements



on a circle  
radius 250 m

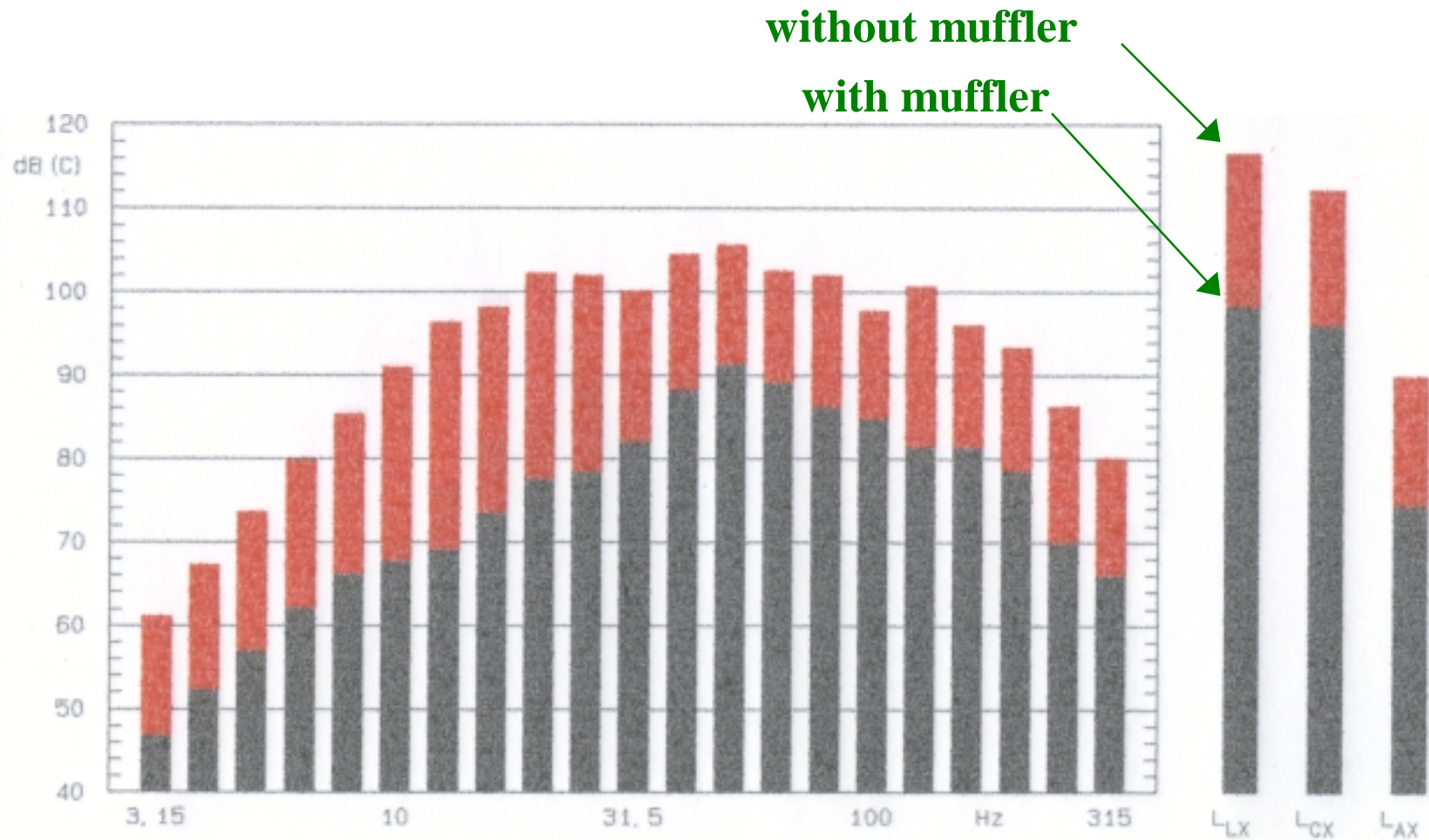
on a circle  
radius 1000 m

on a line 135°  
behind the barrel



# Results I

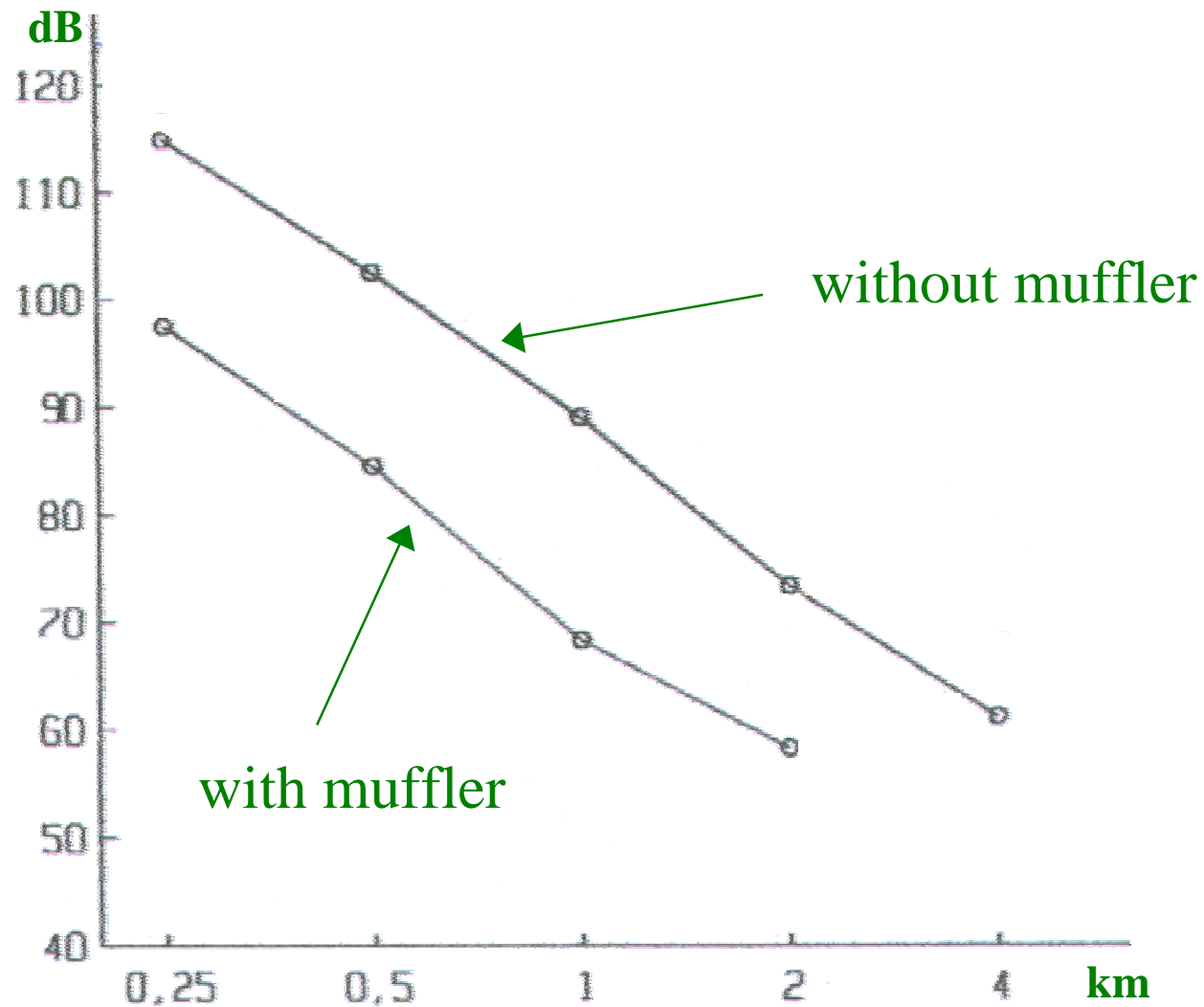
one-third octave spectra at 180°, 250 m





# Results II

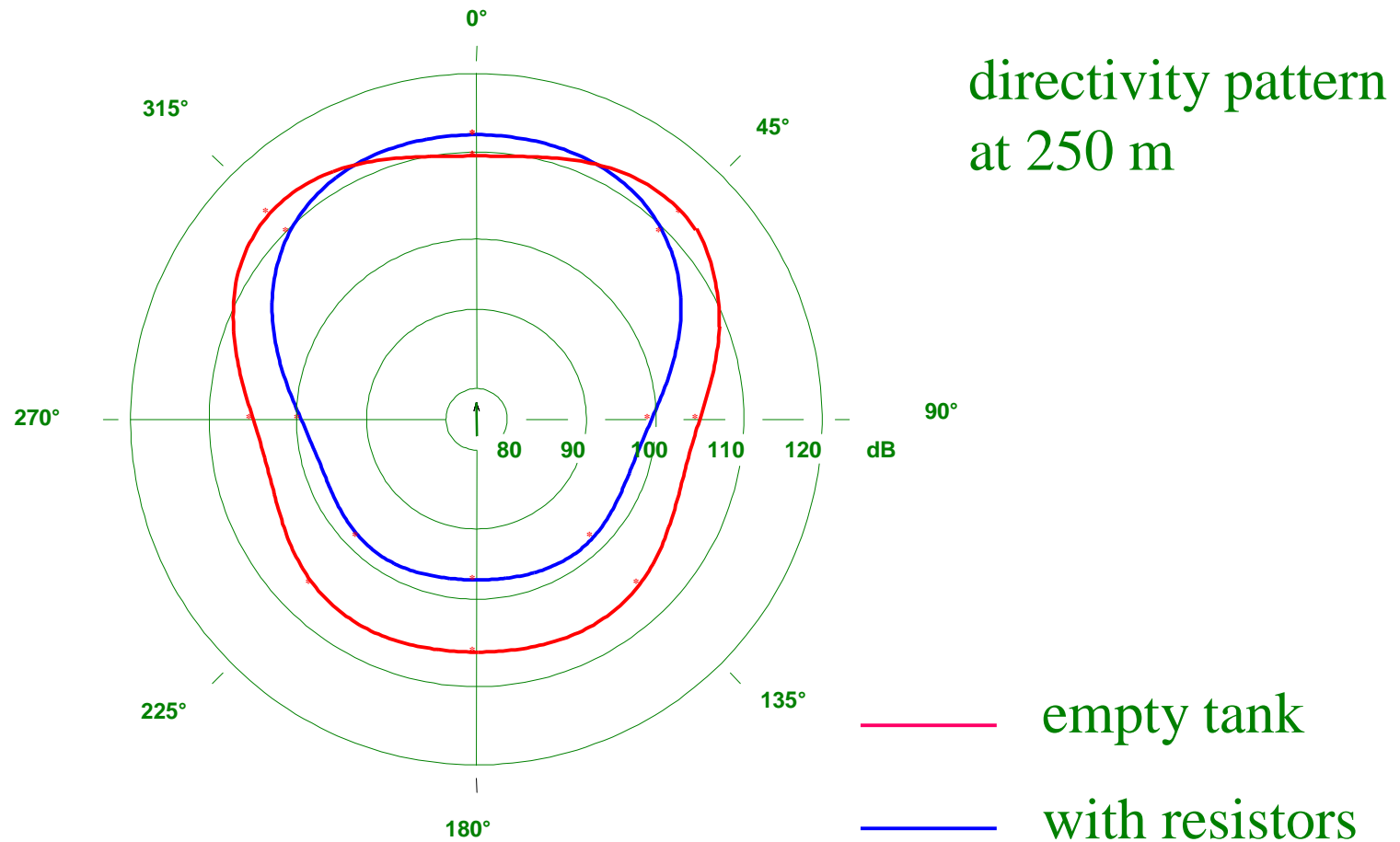
CSEL along the line  $135^\circ$  behind the muzzle





# Results III

## the effect of the flow resistors





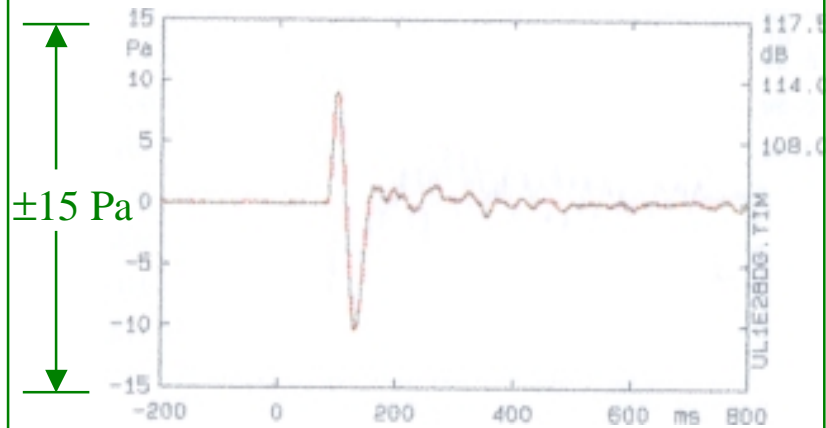


# Results IV

pressure time history at 135°, 1000 m

without muffler

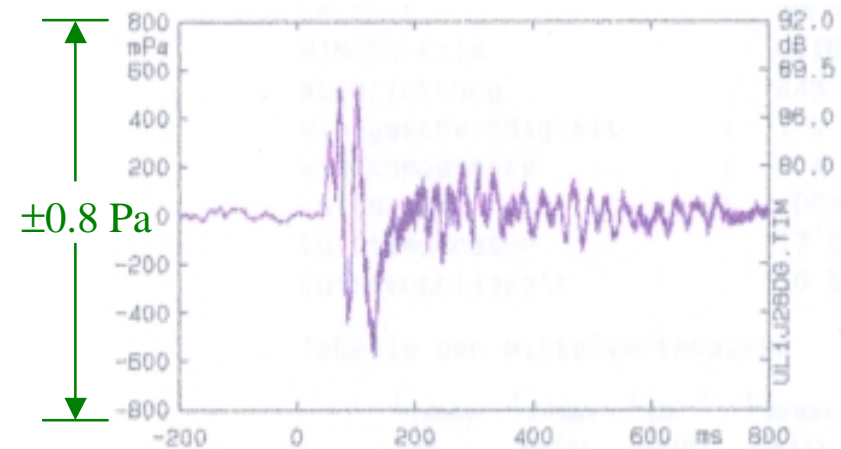
one clear blast



1 s

with muffler

multiple blasts



1 s



# High Speed Photography <sup>Rheinmetall</sup>

first  
blast



second  
blast



continuous flow



# There is evidence that ...

- ⇒ the muffler works because it splits the gas into two main blasts and a steady flow that is vibrating internally.
- ⇒ the muffler does not ,absorb‘ acoustical energy but modifies the radiation of sound by changing the geometry.
- ⇒ with a muffler there are multiple sources smaller in size compared to a big one without a muffler.
- ⇒ due to smaller sources and their different radiation impedance compared to a big one these sources cannot radiate the low frequencies efficiently.
- ⇒ the change in radiation impedance is the key to understand the muffler.



# Conclusion

- ⇒ The ‚non-reciprocal‘ muffler reduces the total radiated energy by round about 8 dB.
- ⇒ The level reduction in some selected one-third octave bands can exceed 30 dB.
- ⇒ The muffler works well in particular in the low frequency range.



# Enhanced Muffler



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