

Next Generation Train

Meilenstein

Bericht mit quantitativen
Aussagen zum
Geräuschniveau und
Spektrum der NGT-
Fahrwerke

AP 4201



**Next Generation Train
Meilenstein
Bericht mit quantitativen Aussagen zum
Geräuschniveau und Spektrum der NGT
Fahrwerke**

Freigabe:

Die Bearbeiter:

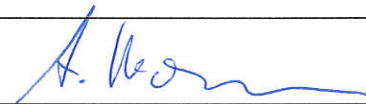
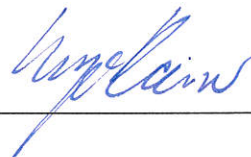
Unterschriften:

Ingo Kaiser

Abteilungsleitung
Dr. Andreas Heckmann

Institutsdirektor:
Dr. Johann Bals

Dieser Bericht enthält



Blatt davon

Bilder

Diagramme

Deutsches Zentrum für Luft- und Raumfahrt e.V.

Institut für Systemdynamik und Regelungstechnik
 Dr.-Ing. J. Bals
 Münchner Straße 20
 D-82234 Wessling-Oberpaffenhofen, GERMANY
 Tel +49 (0)8153/28-2461
 Fax +49 (0) 8153/28-1441

Dipl.-Ing. Ingo Kaiser
 Tel +49 (0)8153/28-2409
 Fax +49 (0) 8153/28-1441
 E-Mail Ingo.Kaiser@dlr.de

Titel		Bericht mit quantitativen Aussagen zum Geräuschniveau und Spektrum der NGT-Fahrwerke
Thema MS		Meilenstein
Schlüsselwörter		NGT, Fahrwerk, Akustik, Kurvenquietschen
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Untersuchung der Akustik des NGT-Fahrwerks

➤ **Szenario: Kurvenquietschen**

- Dominierendes Geräusch in engen Bögen, z.B. Bahnhofsvorfeld
 - ➔ *Bewohntes Gebiet* ➔ *Lärmbelästigung*
- Auftreten bei großen Anlaufwinkeln zwischen Rad und Schiene
 - ➔ *Zweiachser mit großem Radstand besonders anfällig*

➤ **Modell: Einzelnes Radpaar**

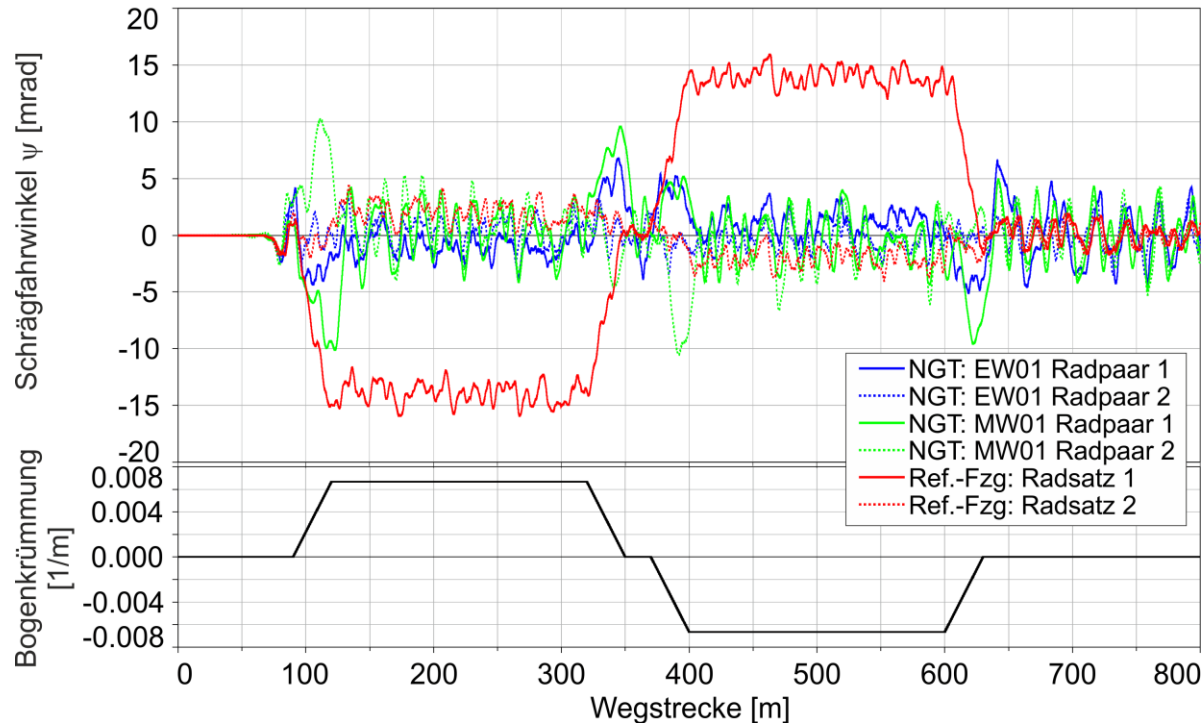
- Räder: flexible Körper
- Gleis: Relativbewegung zwischen Schiene und Schwelle essentiell
- Vorgabe des Schräglaufwinkels





Problemstellung

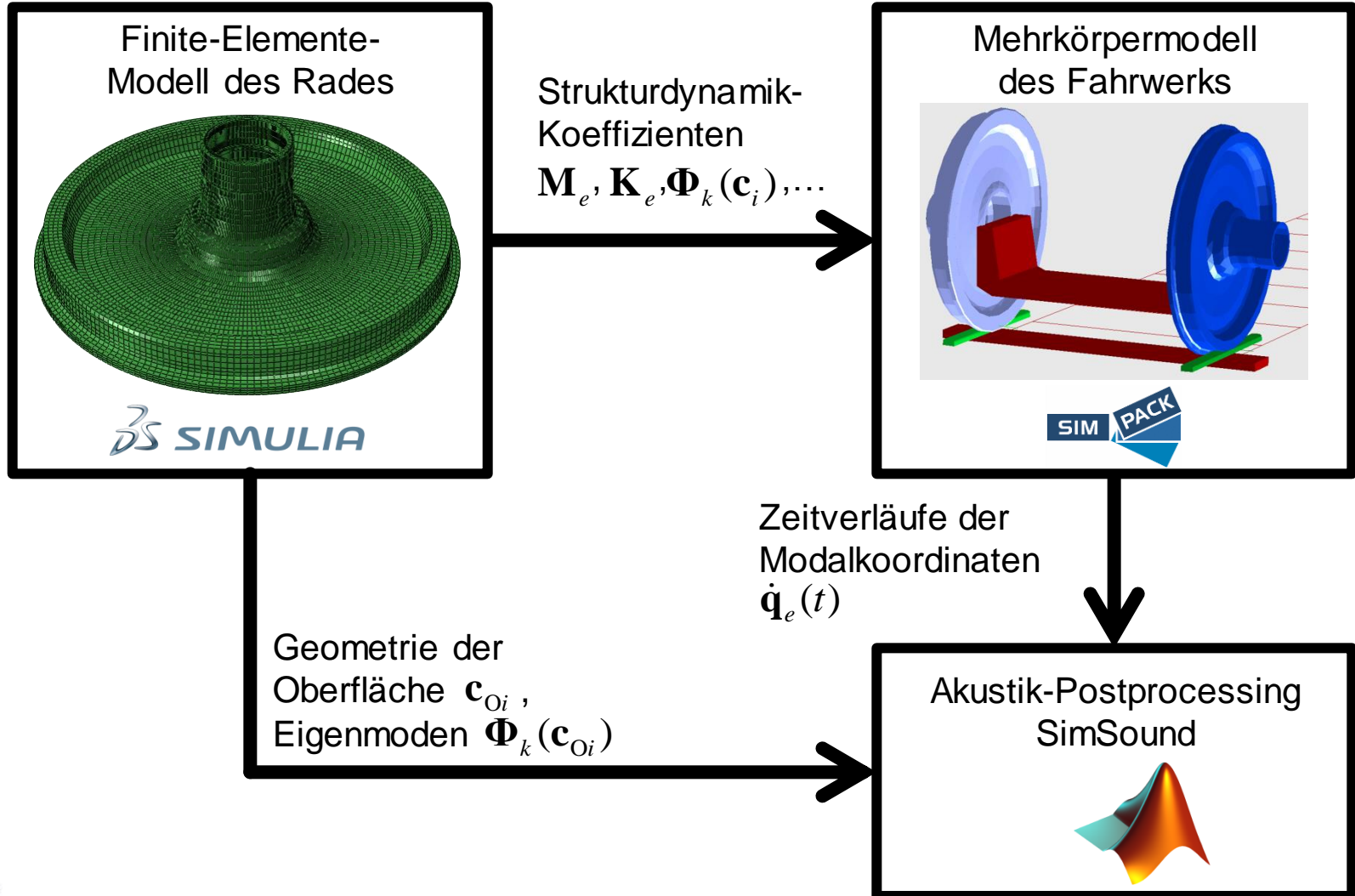
Bogenradius 150 m, $v = 44$ km/h



- **Vergleich von NGT und konventionellem Fahrzeug zeigt deutlich kleinere Anlaufwinkel beim Bogenlauf**
- ***Führen die kleineren Anlaufwinkel zur Reduktion des Kurvenquietschens und damit zu geringerer Lärmemission?***



Untersuchung des akustischen Verhaltens

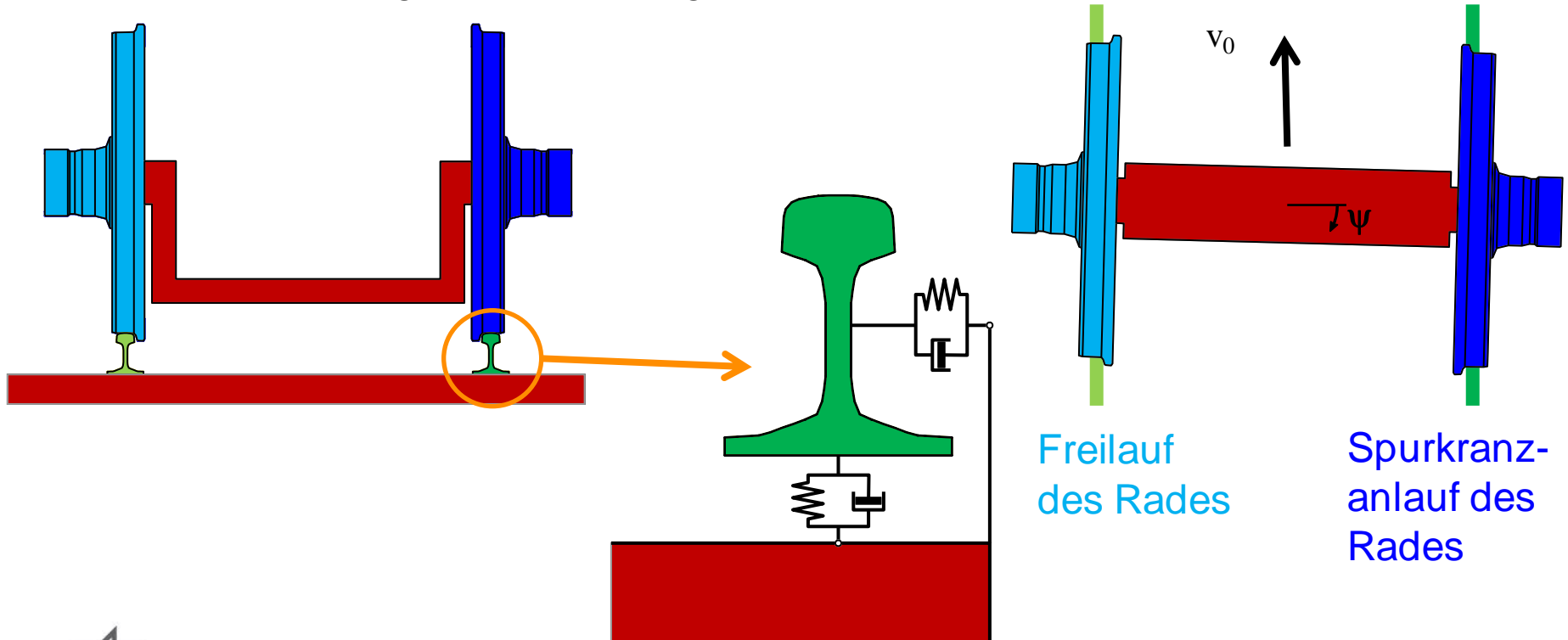




Akustik des NGT-Fahrwerks: Modell des Fahrwerks

➤ Modell: Einzelnes Radpaar

- Räder: Flexible Körper
- Gleis: Relativbewegung zwischen Schiene und Schwelle essentiell
- Vorgabe des Schräglaufwinkels ψ



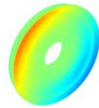


Eigenmoden des NGT-Rades

1 (87.0258 Hz)



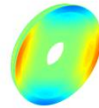
2 (87.0258 Hz)



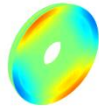
3 (124.099 Hz)



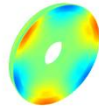
4 (200.599 Hz)



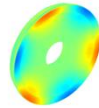
5 (200.599 Hz)



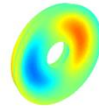
6 (548.774 Hz)



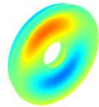
7 (548.774 Hz)



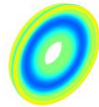
8 (869.808 Hz)



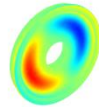
9 (869.808 Hz)



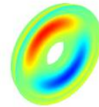
10 (912.657 Hz)



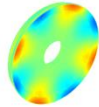
11 (950.217 Hz)



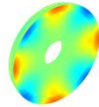
12 (950.217 Hz)



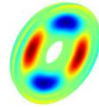
13 (1020.03 Hz)



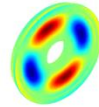
14 (1020.03 Hz)



15 (1191.5 Hz)



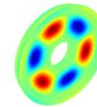
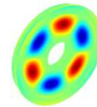
16 (1191.5 Hz)



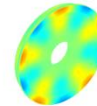
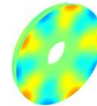
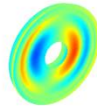
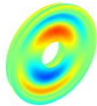


Eigenmoden des NGT-Rades

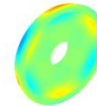
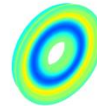
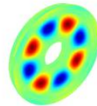
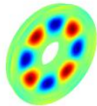
17 (1395.02 Hz) 18 (1395.02 Hz) 19 (1397.82 Hz) 20 (1397.82 Hz)



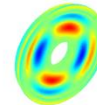
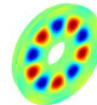
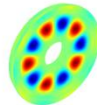
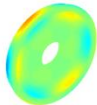
21 (1449.38 Hz) 22 (1449.38 Hz) 23 (1571.21 Hz) 24 (1571.21 Hz)



25 (1629.18 Hz) 26 (1629.18 Hz) 27 (1708.6 Hz) 28 (1807.4 Hz)



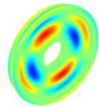
29 (1807.4 Hz) 30 (1912.14 Hz) 31 (1912.14 Hz) 32 (2044.42 Hz)



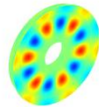


Eigenmoden des NGT-Rades

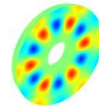
33 (2044.42 Hz)



34 (2139.7 Hz)



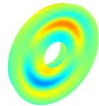
35 (2139.7 Hz)



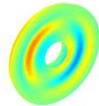
36 (2177.88 Hz)



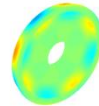
37 (2182.67 Hz)



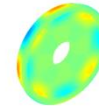
38 (2182.67 Hz)



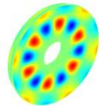
39 (2236.05 Hz)



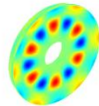
40 (2236.05 Hz)



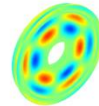
41 (2287.7 Hz)



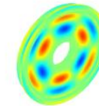
42 (2287.7 Hz)



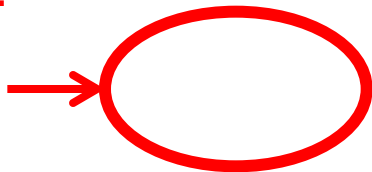
43 (2435.45 Hz)



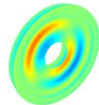
44 (2435.45 Hz)



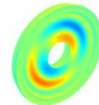
45 (2492.77 Hz)



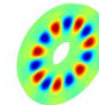
46 (2566.63 Hz)



47 (2566.63 Hz)



48 (2577.13 Hz)



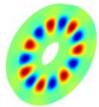
Torsionsmode:
Keine Normal-
Verformung
→ **Akustisch**
irrelevant



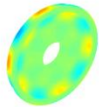


Eigenmoden des NGT-Rades

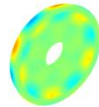
49 (2577.13 Hz)



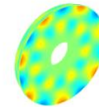
50 (2701.5 Hz)



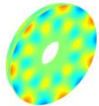
51 (2701.5 Hz)



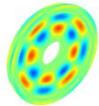
52 (2881.35 Hz)



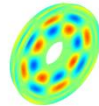
53 (2881.35 Hz)



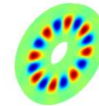
54 (2913.22 Hz)



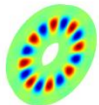
55 (2913.22 Hz)



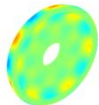
56 (3002.31 Hz)



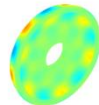
57 (3002.31 Hz)



58 (3212.76 Hz)



59 (3212.76 Hz)



60 (3220.93 Hz)



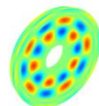
61 (3220.93 Hz)



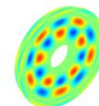
62 (3345.32 Hz)



63 (3427.3 Hz)



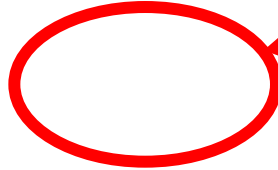
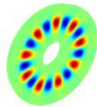
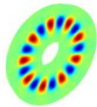
64 (3427.3 Hz)





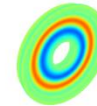
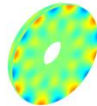
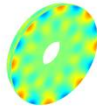
Eigenmoden des NGT-Rades

65 (3458.43 Hz) 66 (3458.43 Hz) 67 (3504.36 Hz) 68 (3545.34 Hz)

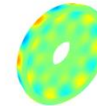
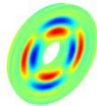
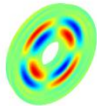


**Torsionsmode:
Keine Normal-
Verformung
→ Akustisch
irrelevant**

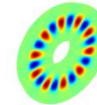
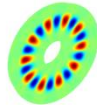
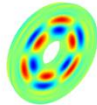
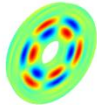
69 (3545.34 Hz) 70 (3554.74 Hz) 71 (3554.74 Hz) 72 (3648.27 Hz)



73 (3693.3 Hz) 74 (3693.3 Hz) 75 (3769.5 Hz) 76 (3769.5 Hz)



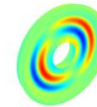
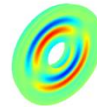
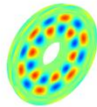
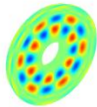
77 (3908.3 Hz) 78 (3908.3 Hz) 79 (3945.52 Hz) 80 (3945.52 Hz)



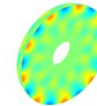
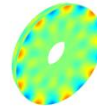
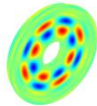
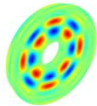


Eigenmoden des NGT-Rades

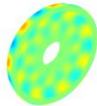
81 (3956.86 Hz) 82 (3956.86 Hz) 83 (4048.95 Hz) 84 (4048.95 Hz)



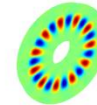
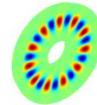
85 (4216.7 Hz) 86 (4216.7 Hz) 87 (4249.2 Hz) 88 (4249.2 Hz)



89 (4367.1 Hz) 90 (4367.1 Hz) 91 (4414.79 Hz) 92 (4414.79 Hz)



93 (4427.99 Hz) 94 (4427.99 Hz) 95 (4461.07 Hz) 96 (4461.07 Hz)





Kurvenquietschen

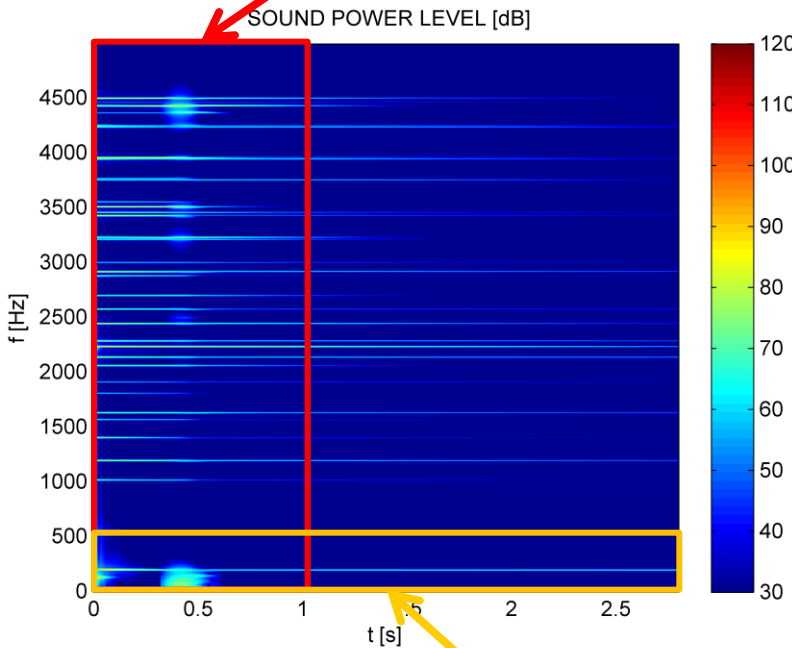
Niedriger Reibwert, kleiner Schräglaufwinkel

$$\mu=0.2, \psi=0.2^\circ=3.45 \text{ mrad}$$

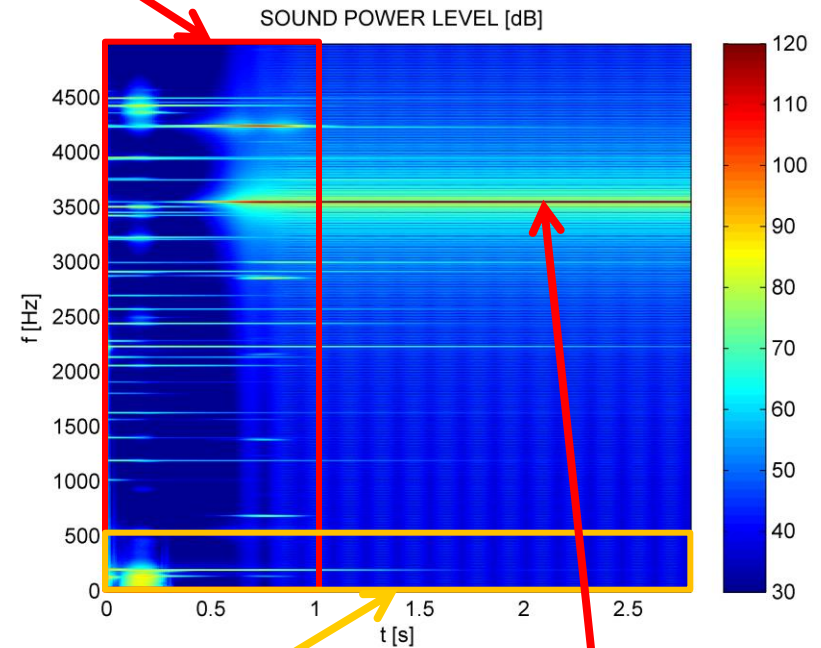
Hoher Reibwert, großer Schräglaufwinkel

$$\mu=0.4, \psi=0.5^\circ=8.73 \text{ mrad}$$

Einlauf- und Einschwingvorgang



Akustisch irrelevanter Bereich:
Keine Abstrahlung für $f < 500 \text{ Hz}$

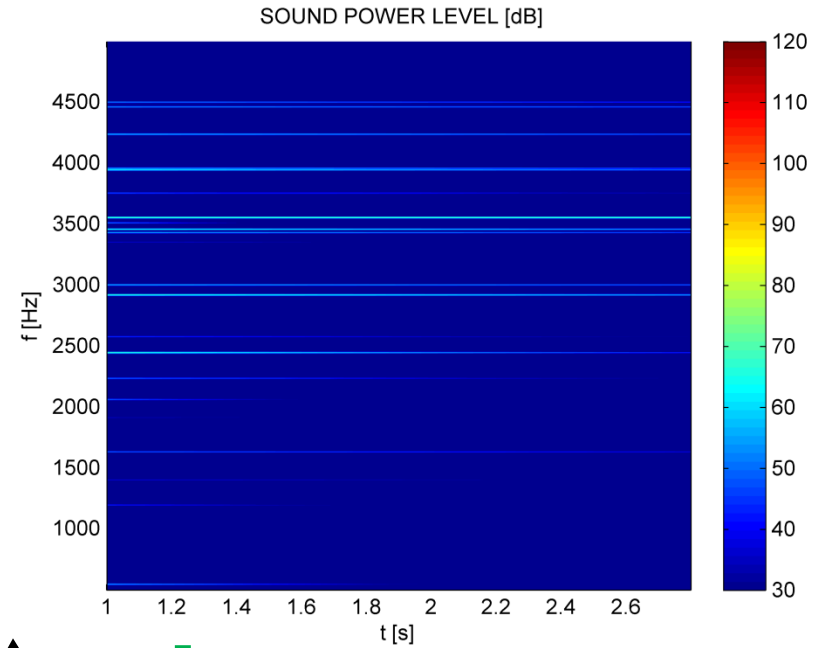
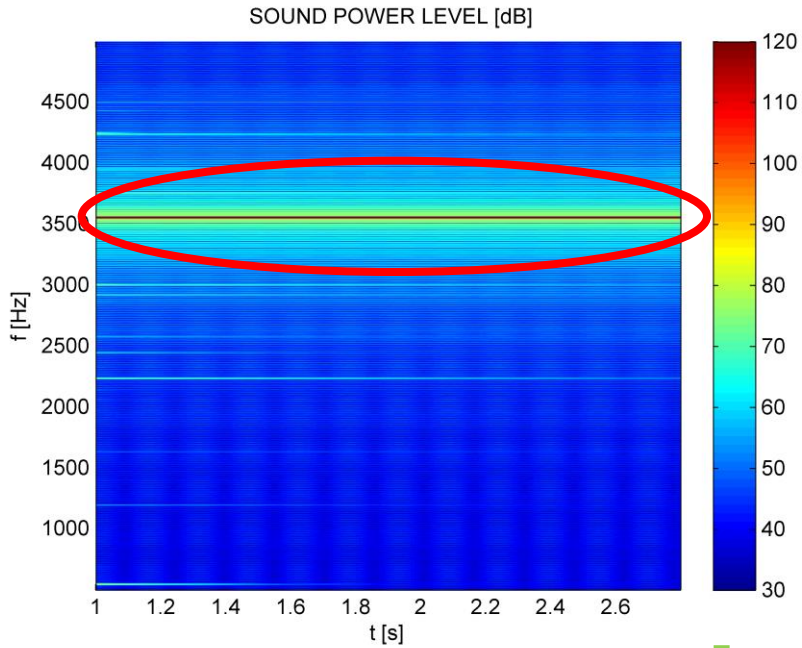


Quietschen: Ausgeprägtes
hochfrequentes Geräusch

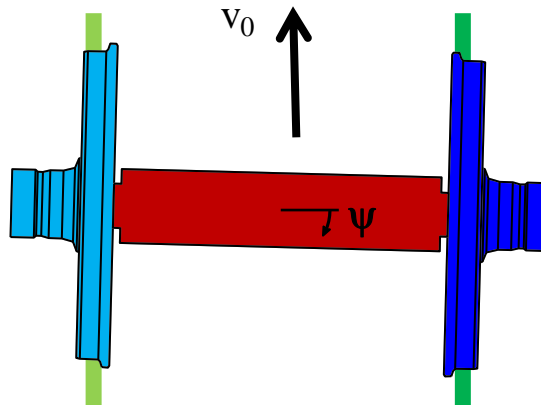


Kurvenquietschen

$$\mu=0.4, \psi=0.5^\circ=8.73 \text{ mrad}$$



Freilauf des Rades
 → Quietschen



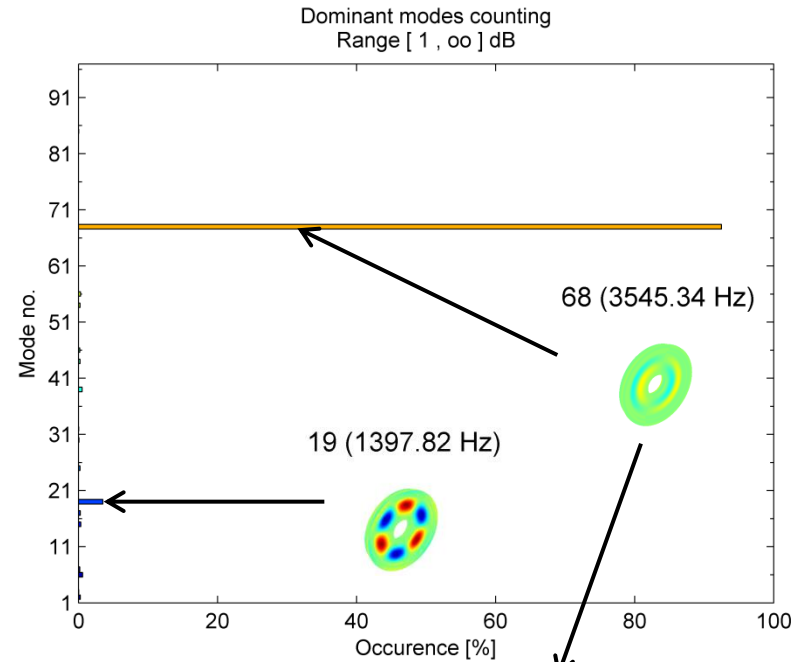
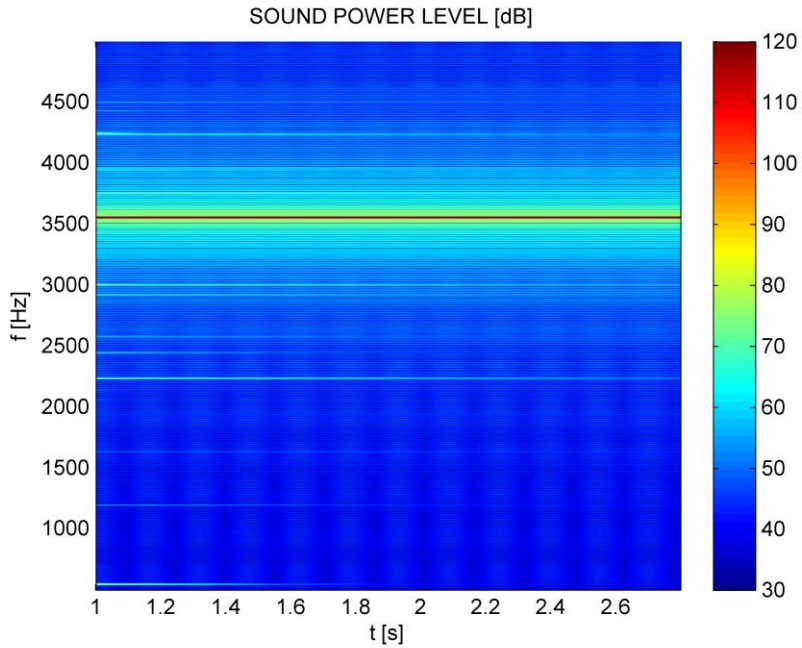
Spurkranz anlauf
 des Rades
 → Kein Quietschen



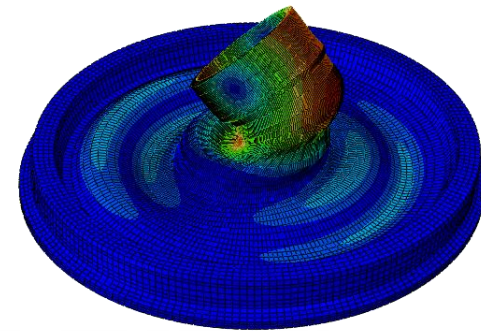


Kurvenquietschen

$$\mu=0.4, \psi=0.5^\circ=8.73 \text{ mrad}$$



Kritische Eigenform





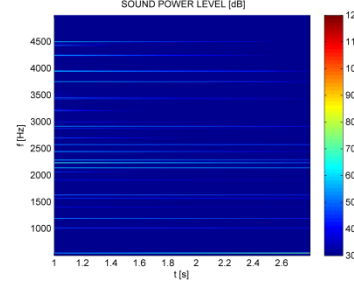
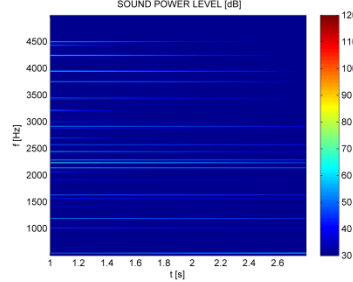
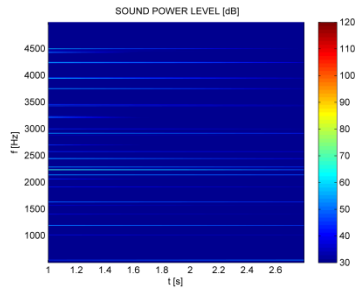
Einfluss von Schrägfahrwinkel und Reibwert

$\psi=0.2^\circ=3.45 \text{ mrad}$

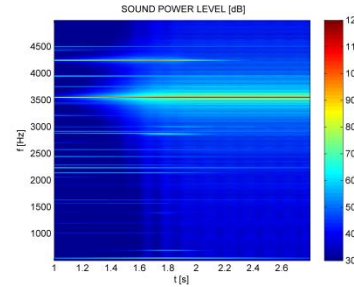
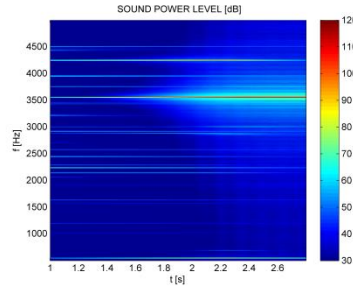
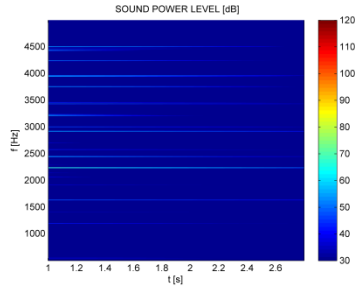
$\psi=0.3^\circ=5.24 \text{ mrad}$

$\psi=0.4^\circ=6.98 \text{ mrad}$

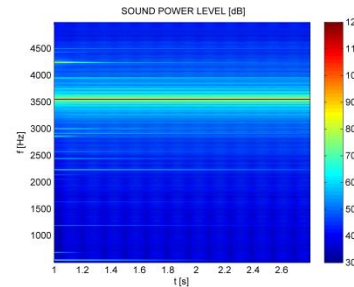
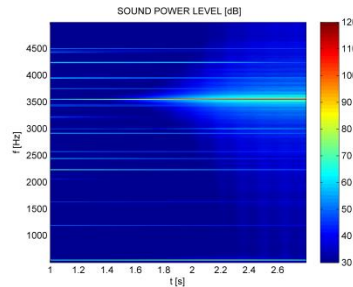
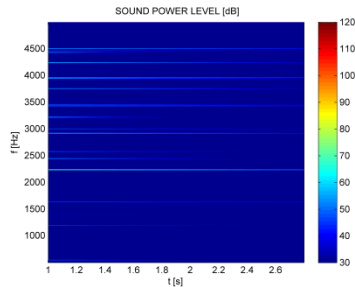
$\mu=0.2$



$\mu=0.3$



$\mu=0.4$



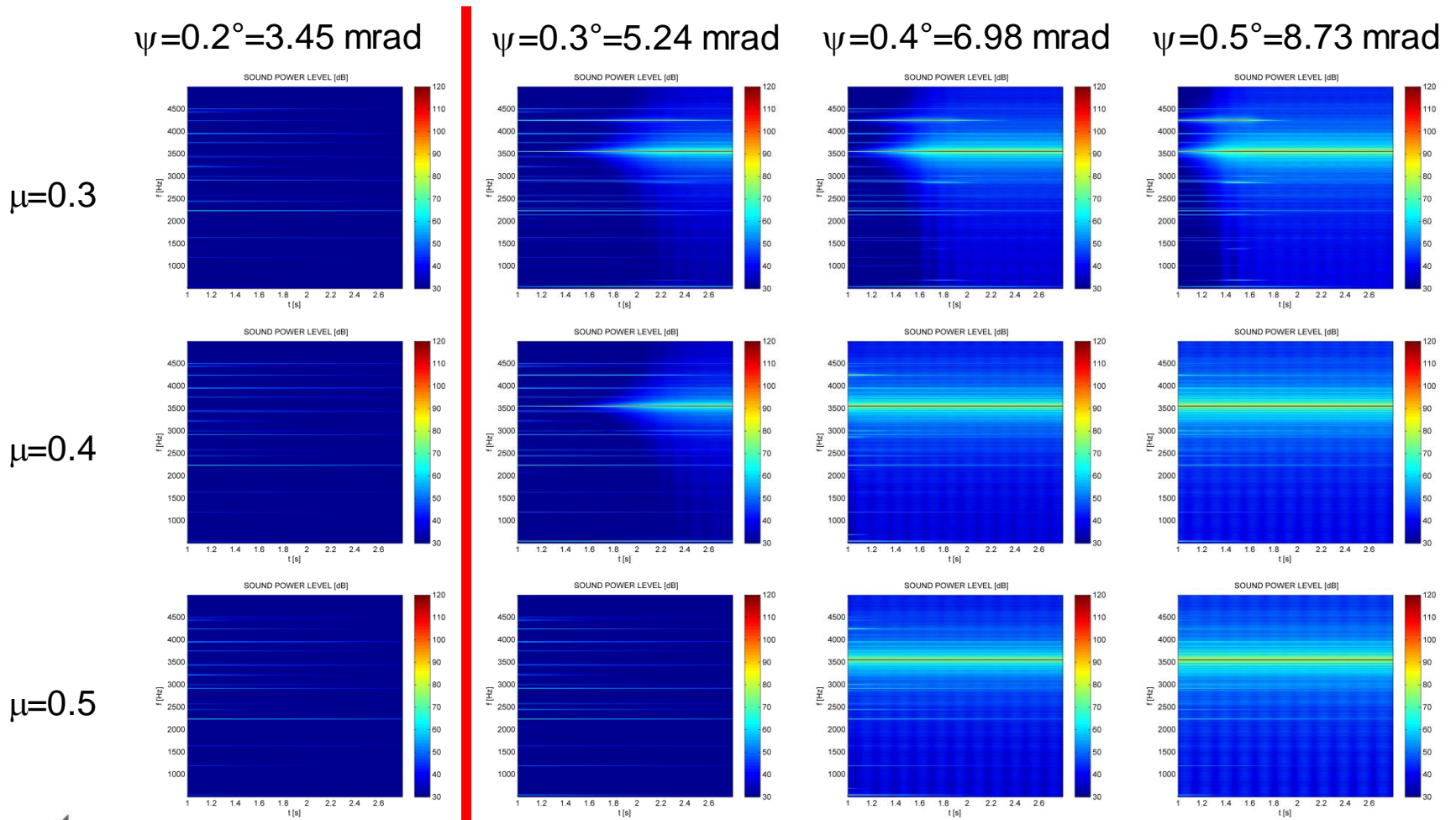
**Quietschen
für $\mu \geq 0.3$**





Einfluss von Schrägfahrwinkel und Reibwert

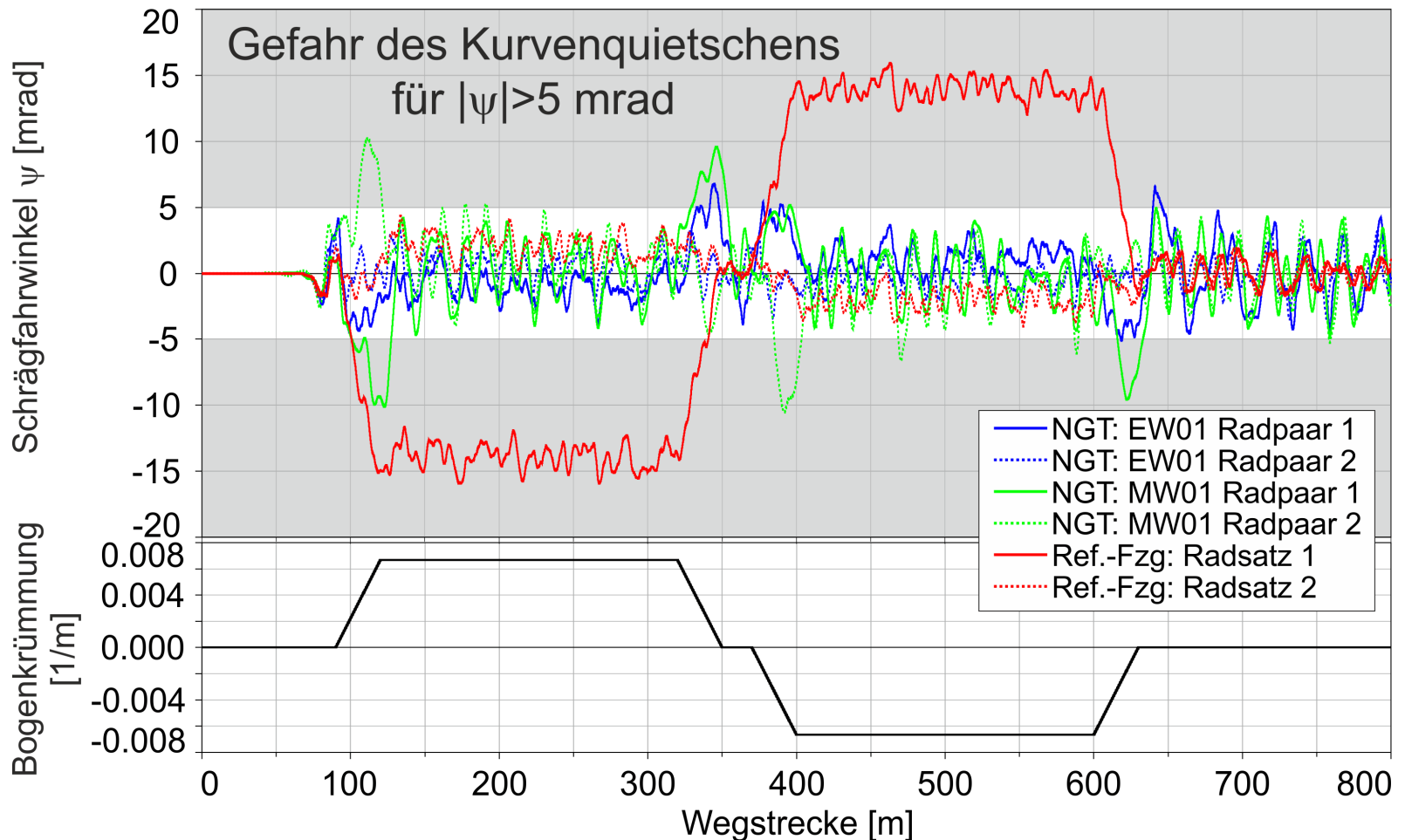
Quietschen für $\psi \geq 0.3^\circ = 5.24 \text{ mrad}$





Vergleich mit Fahrzeugverhalten

Bogenradius 150 m, $v = 44$ km/h





Next Generation Train – TP 4000

[AP 4201: Rollgeräusch]

➤ Ergebnis:

- Analyse des akustischen Verhaltens mit SIMPACK und SimSound (Postprocessing)
- Simulation des Szenarios des Kurvenquietschens → *akustisch hochgradig relevantes Phänomen, da sehr unangenehm*
- Kurvenquietschen tritt auf für
 - Schrägfahrwinkel $\psi \geq 0.3^\circ = 5.24 \text{ mrad}$
 - Reibbeiwert $\mu \geq 0.3$
- Vergleich mit Fahrsimulationen
 - Schrägfahrwinkel $\psi \geq 5 \text{ mrad}$ tritt bei Referenzfahrzeug im Bogenlauf fast ständig auf
 - Schrägfahrwinkel $\psi \geq 5 \text{ mrad}$ tritt für NGT nur sehr kurzzeitig auf, d.h. Kurvenquietschen wird weitgehend vermieden
 - *Vorteil der radialen Einstellbarkeit der Fahrwerke*