

# TGV 150

## A multitude of results

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**ALSTOM**

**Moderne  
Schienenfahrzeuge**

**38. Tagung**

**Technische Universität Graz  
14. Bis 17. September 2008**



# A history of speed in France...

**1972 Gas turbine unit TGV001 achieved 318km/h (197.6 mph)**

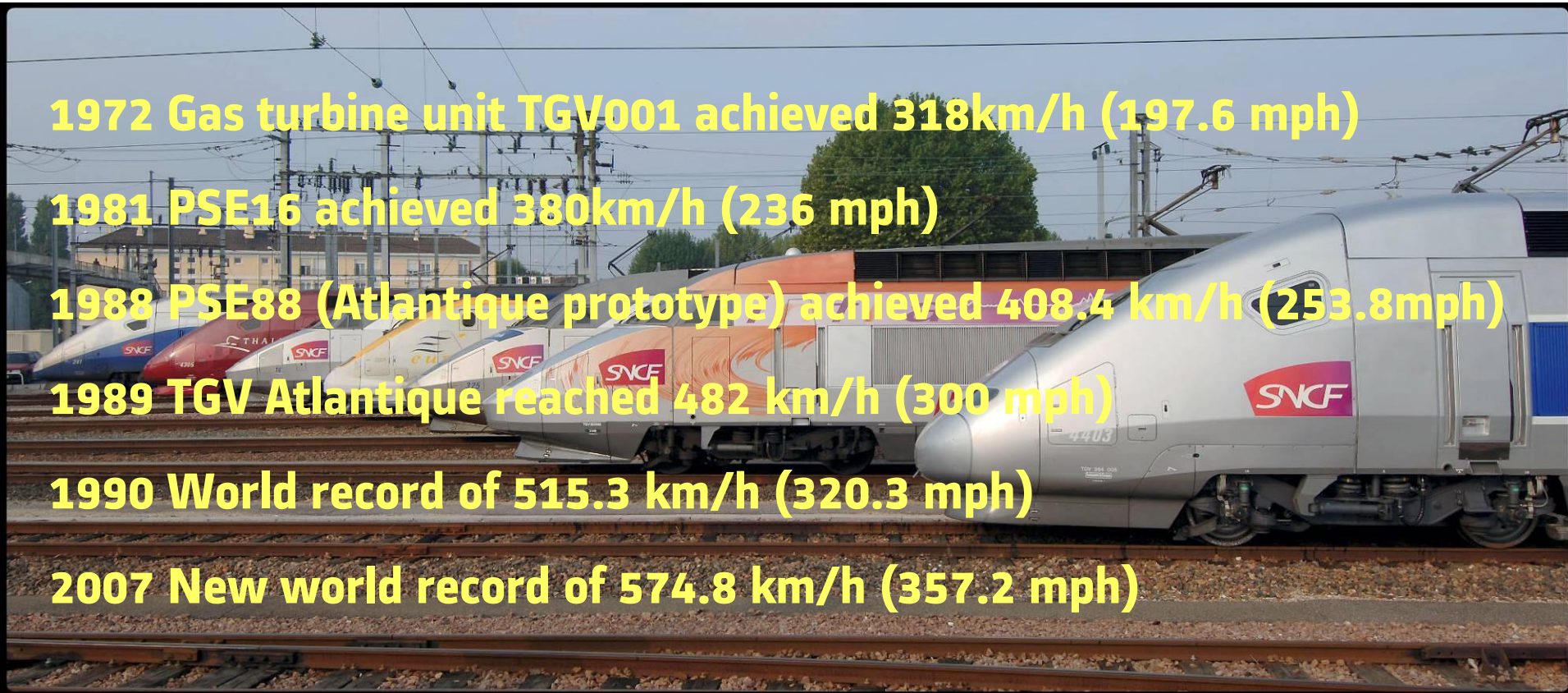
**1981 PSE16 achieved 380km/h (236 mph)**

**1988 PSE88 (Atlantique prototype) achieved 408.4 km/h (253.8mph)**

**1989 TGV Atlantique reached 482 km/h (300 mph)**

**1990 World record of 515.3 km/h (320.3 mph)**

**2007 New world record of 574.8 km/h (357.2 mph)**



# TGV 150 : The objectives

- ✓ **Explore for the first time the speeds beyond 500 kph**
  - measure and validate under real-life conditions : Aerodynamic, Acoustic, Dynamic and Vibratory phenomena
  - To continue to explore (modélisation & measurements) the field of very high speed



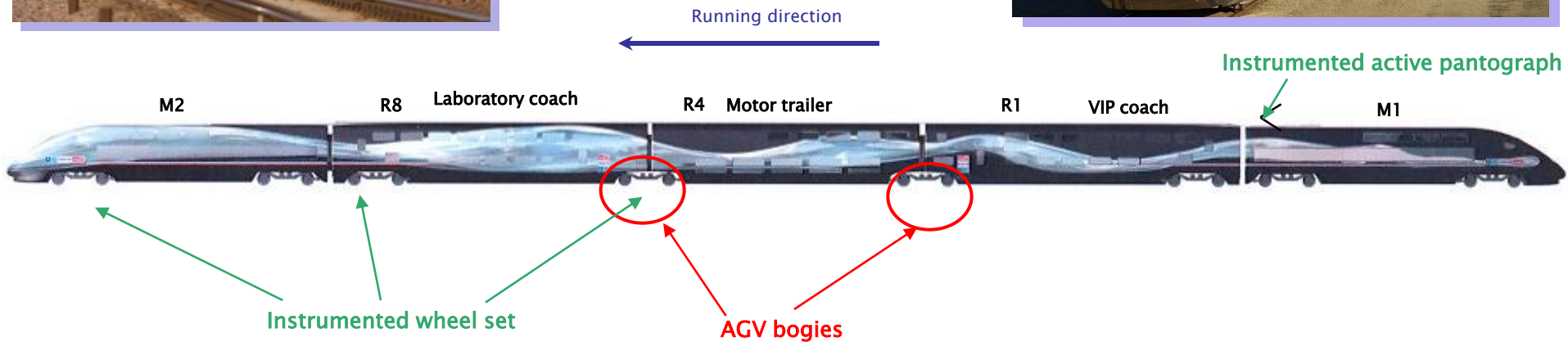
- ✓ **Validate the critical components of Alstom's two train platforms : the TGV Duplex and the AGV**
  - To demonstrate ALSTOM's technical competence in very high speed based on 25 years of experience
  - To promote and test in very extreme conditions our two very high speed Alstom platforms

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# TGV 150 : The Test Train

**The test train  
(the two platforms tested on the test train)**



- 2 TGV East power cars
- 3 TGV Duplex coaches
- 2 AGV bogies + traction components



standard production components

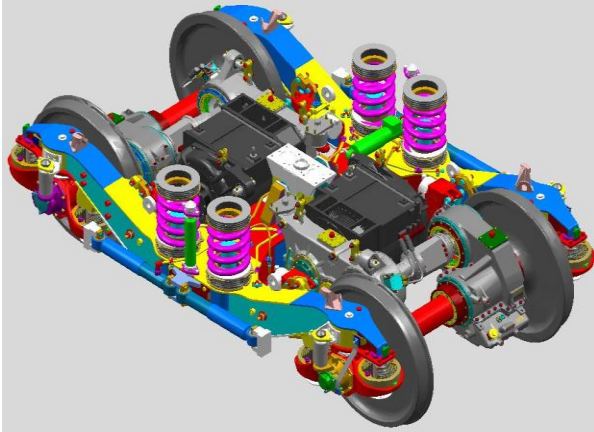
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# Motor bogies

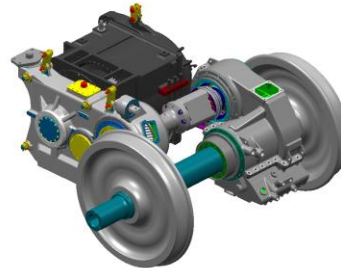
Power car : motor bogie

Weight : 7600 kg without motors



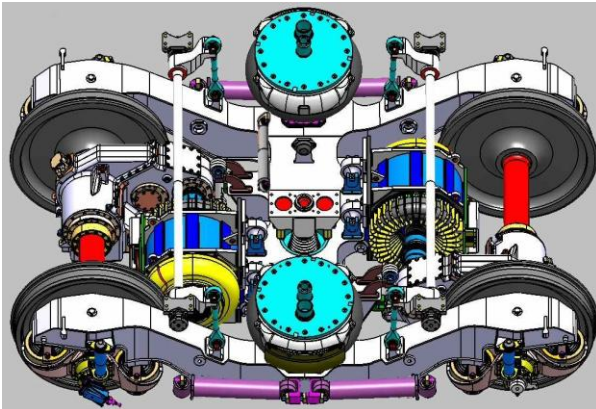
Gear box :

114,2 km/h per 1000 rpm



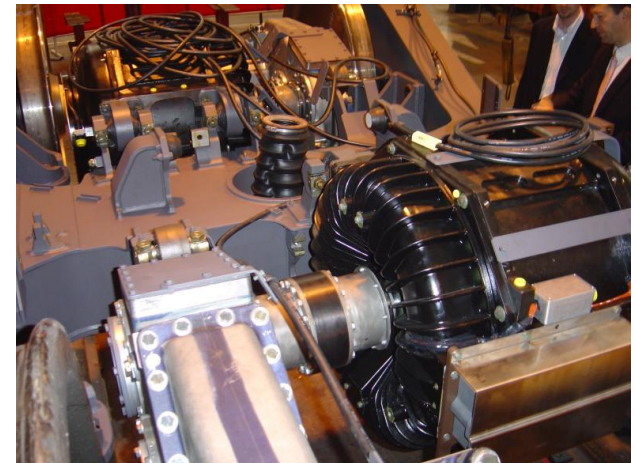
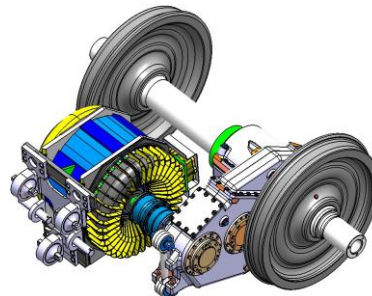
AGV motor Bogies

Weight : 8400 kg with motors



Gear box :

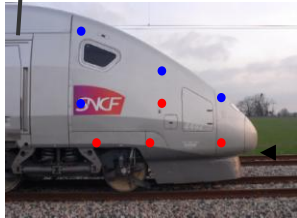
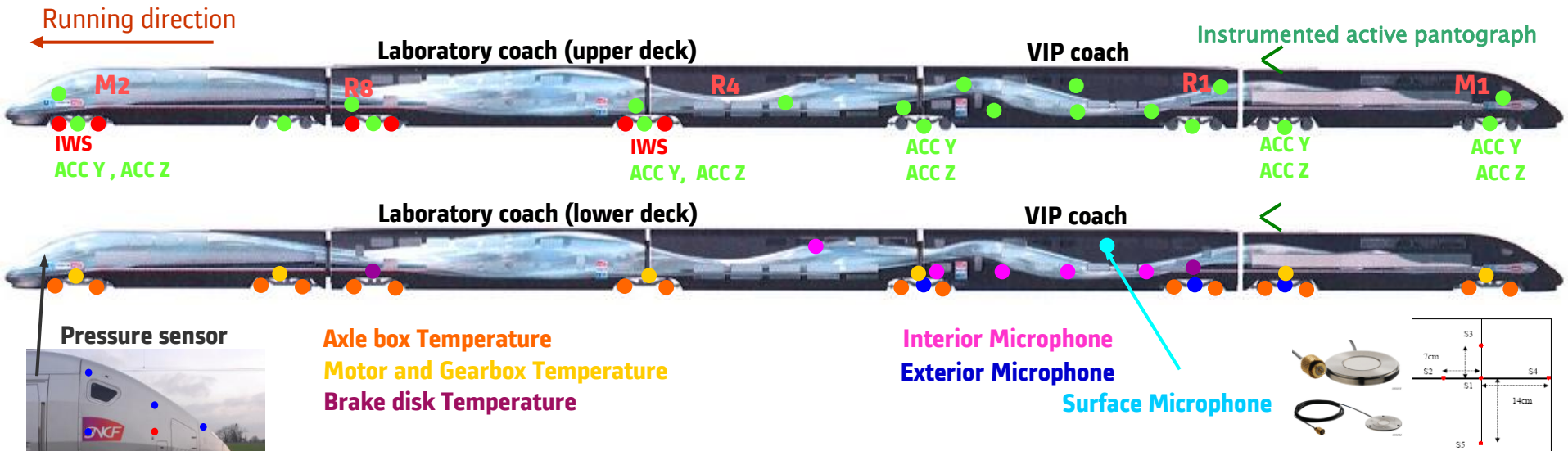
116,7 km/h per 1000 rpm





# Main measurements : On Board

## 350 sensors on board for Safety, Monitoring and Investigation



- ✓ Wheel/rail contact forces
- ✓ Trainset dynamics behaviour (Accelerations, Comfort)
- ✓ Aerodynamic
- ✓ Acoustic
- ✓ Pantograph dynamic and electrical behaviour
- ✓ Disk Brake, Motor, Gearbox and Axle box Temperature

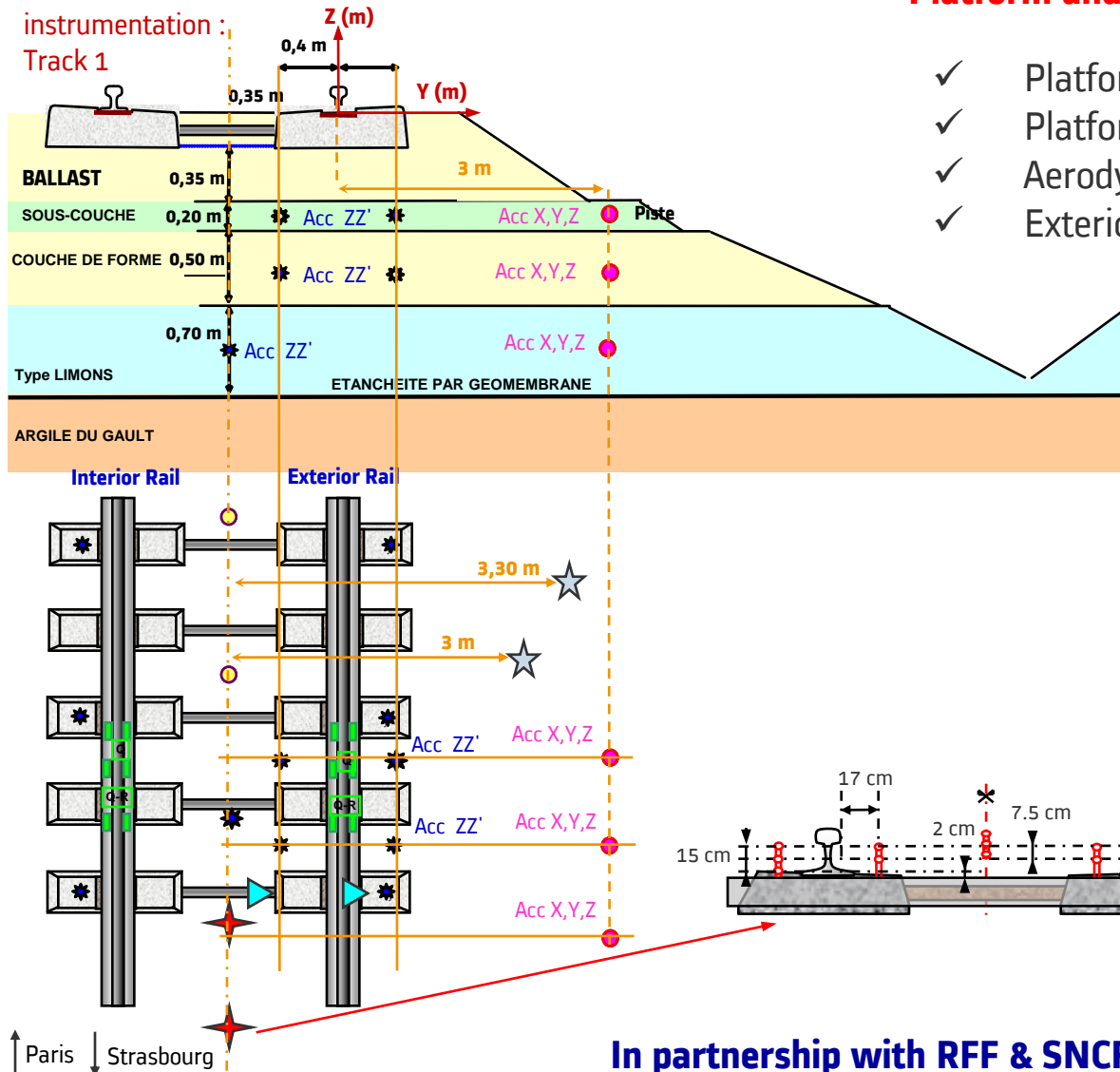
- ✓ Command / control traction system
  - East TGV equipment (concentrated power)
  - AGV equipment (distributed power)
- ✓ Electrical measurements (voltage, power, etc..)

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# Main measurements : Track Side (1/2)

Several track sections  
instrumentation :  
Track 1



## Platform and track support structures behaviour

- ✓ Platform and support dynamic behaviour
- ✓ Platform aerodynamic solicitations
- ✓ Aerodynamic under and along train
- ✓ Exterior Noise

- \* Vertical ZZ' accelerometer
- X, Y, Z accelerometer
- Wheel Load sensor (strain gauge)
- Pressure Sensor (KDA PA type)
- ★ Anemometer 3D : air speed along TGV150 (Metek type)
- ★ Pressure sensor : air speed under TGV150 (BD sensor DMD331)
- ▶ Camera and laser sensor : rail pad and sleeper displacement



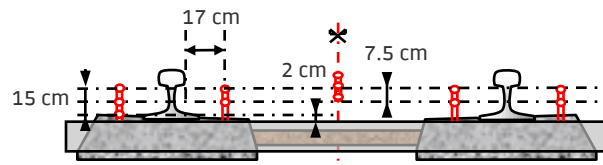
- ★ Anemometer 3D : air speed along TGV150 (Metek type)
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Acoustic Imaging



Pass By Noise



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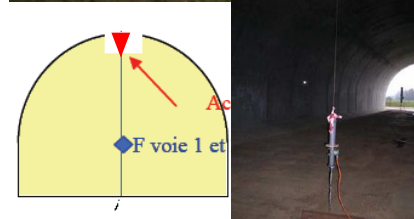
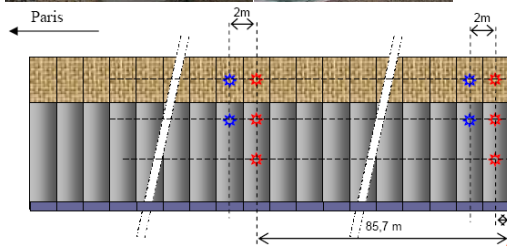
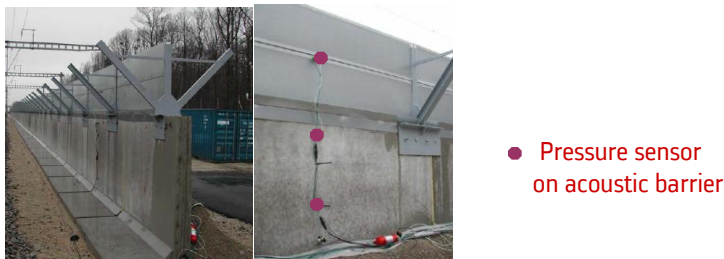
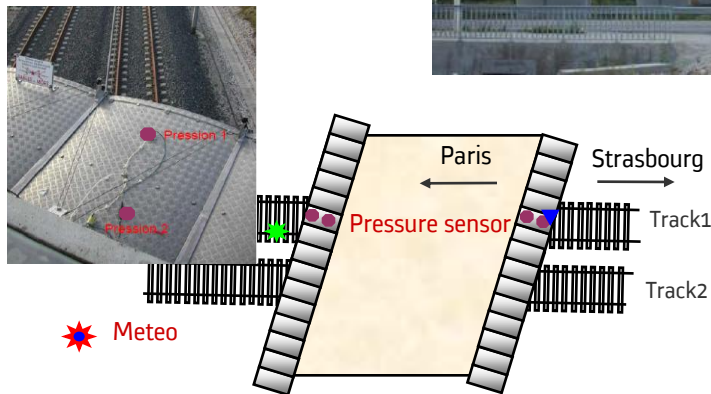
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# Main measurements : Track Side (2/2)



## Viaducts, Bridges and other structures behaviour

- ✓ Structures dynamic behaviour
- ✓ Vertical and torsion solicitation
- ✓ Aerodynamic solicitation



- ★ Meteo
- ▼ Accelerometer
- ▼ Ballast accelerometer
- ◆ Vertical displacement
- ★ Wheel Load
- 🌡 Temperature
- Pressure sensor

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# Speed and Track Profiles

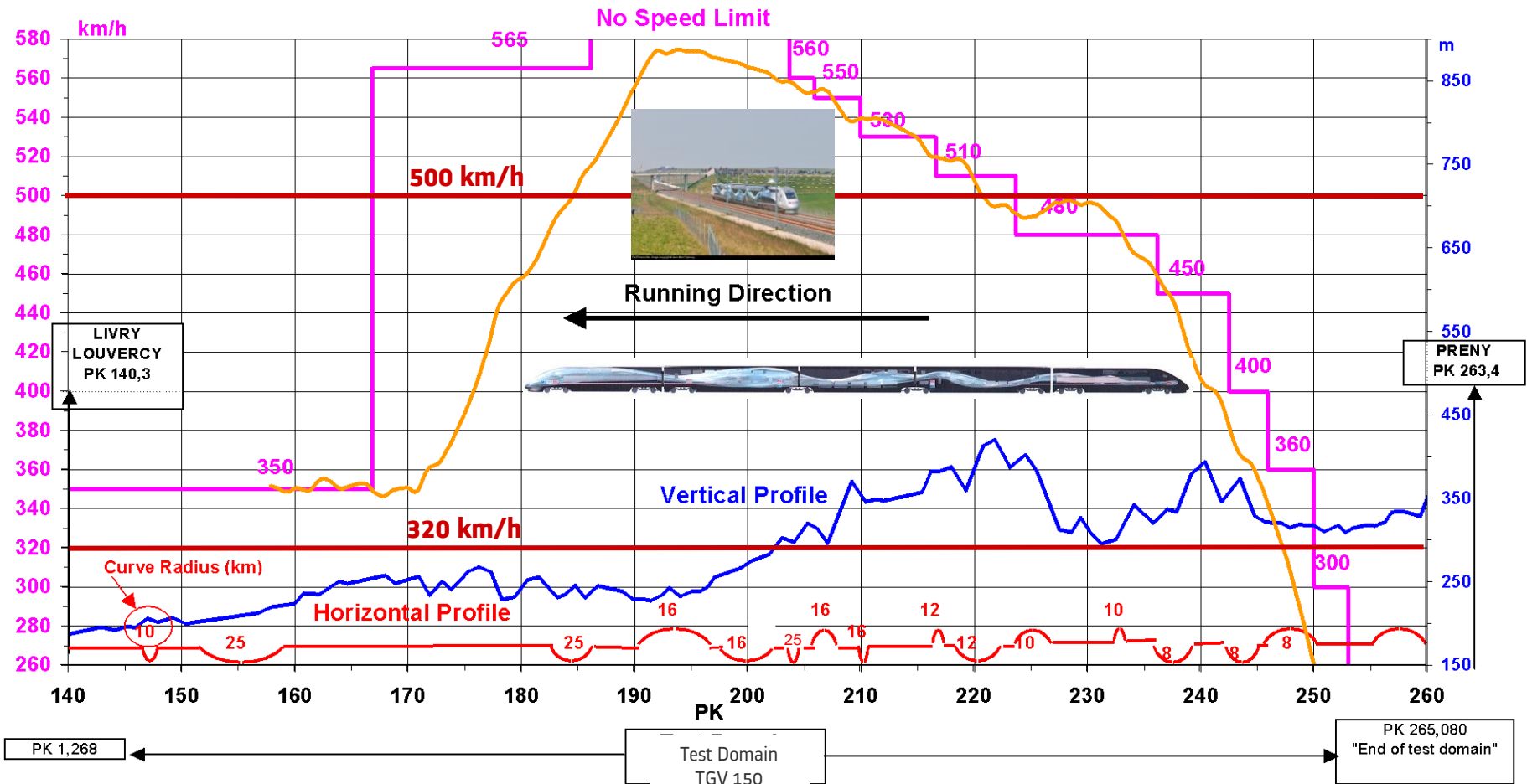


TGV 150 Operation

Speed Diagram & Track Profile

RUN n° 93-02

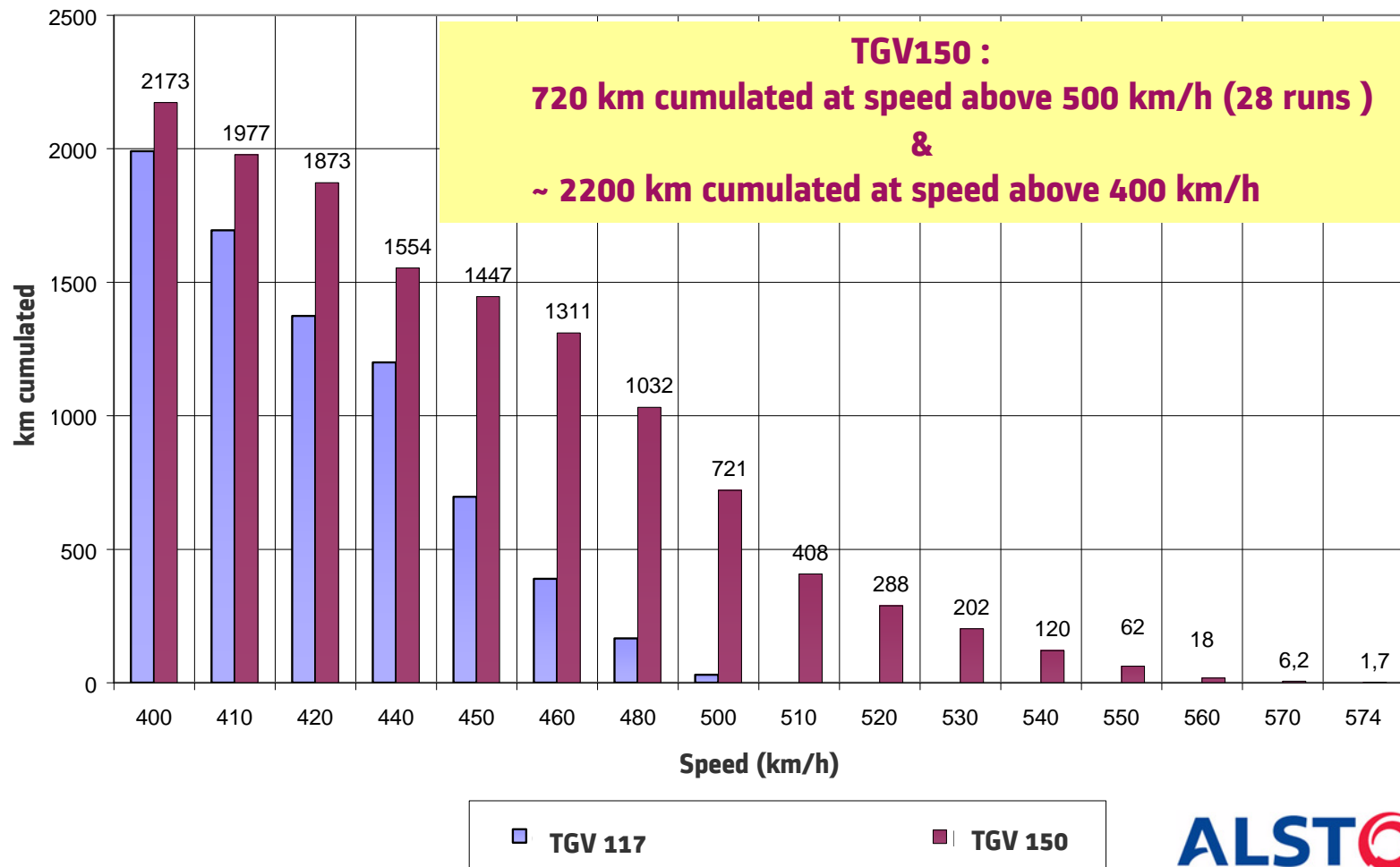
3rd of April 2007



# Runs at Very High Speed : TGV 150 vs TGV 117

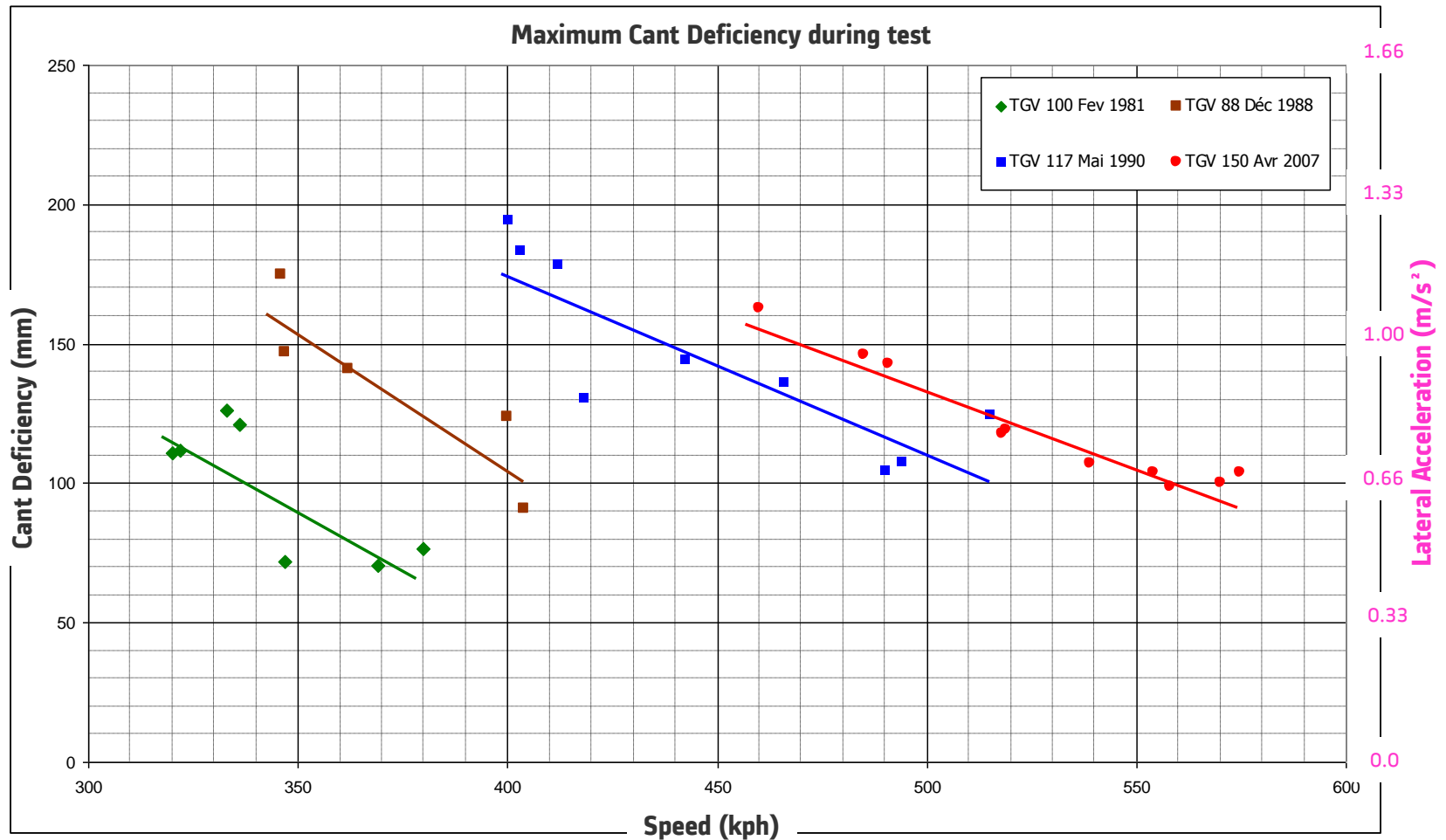
- TGV 150 : Test campaign for 2007 new world record
- TGV 117 : Test campaign for 1990 world record

Runs at Very High Speeds : TGV 150 vs TGV 117

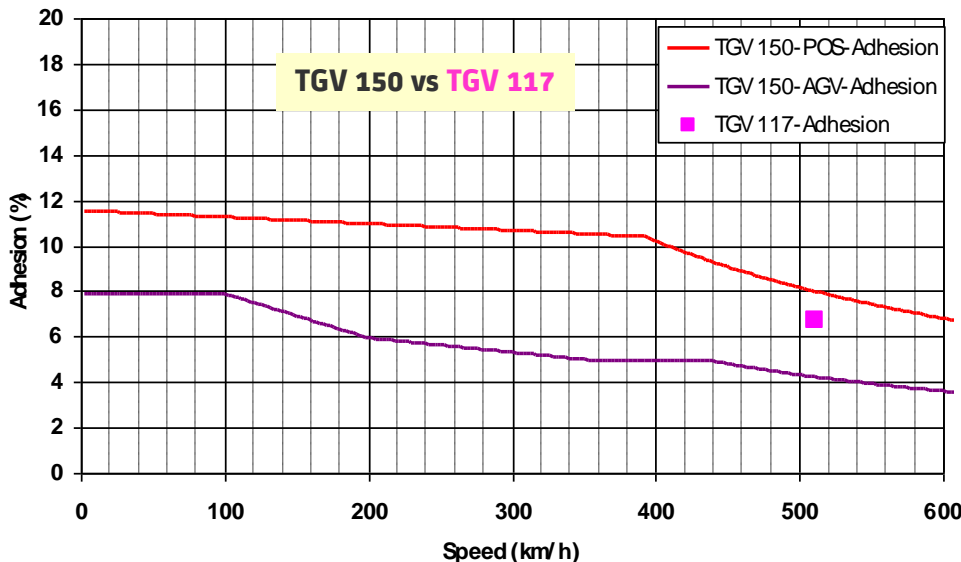
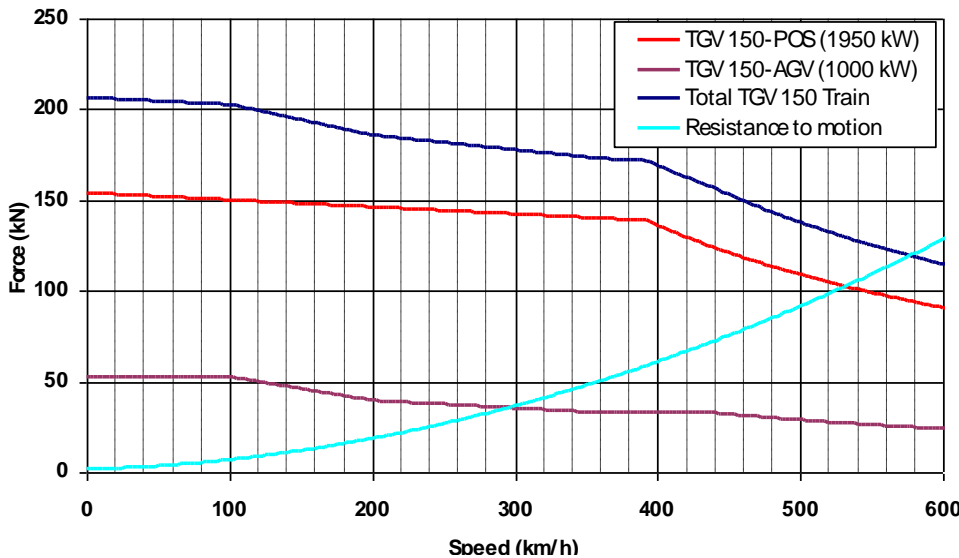




# Runs at Very High Speed and High Cant Deficiency : TGV 150 vs TGV 117

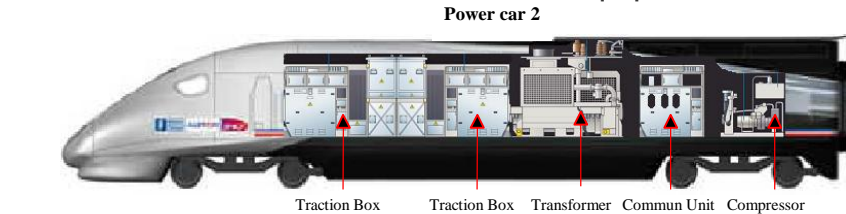


# Main results : Electrical results

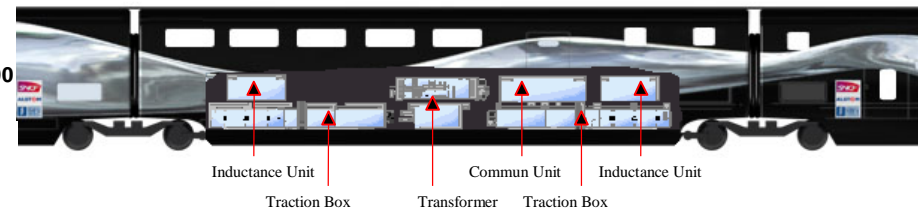


## Traction equipment layout

### TGV Traction Power Car Equipments



### Trailer R4



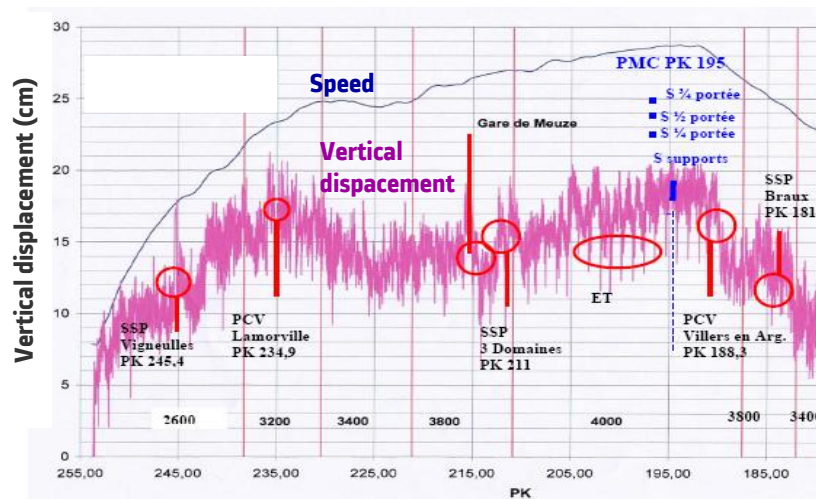
### AGV traction equipments for two bogies

Asynchronous motor	Nominal power (series train)	1160 kW
	Maximal power (TGV 150 test train)	1950 kW
Permanent magnet motor	Nominal power (series train)	800 kW
	Maximal power (TGV 150 test train)	1000 kW

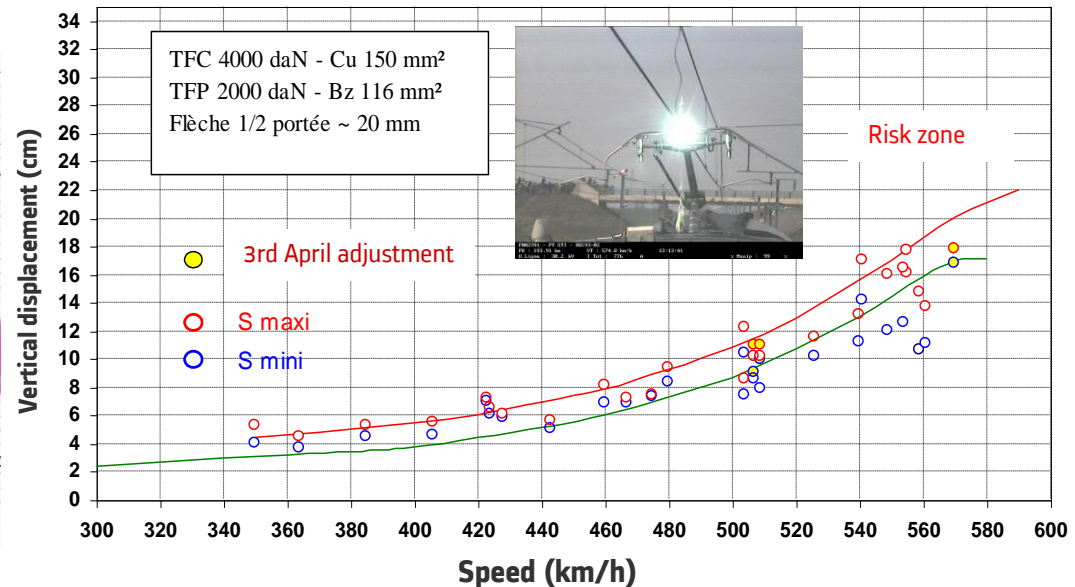


# Main results : Current Collection

Catenary vertical displacement : pk 254 to pk 170  
Run 93 - 02



TGV150 – Vertical displacement at support level  
LGVEE PMC Pk 195 54 m range

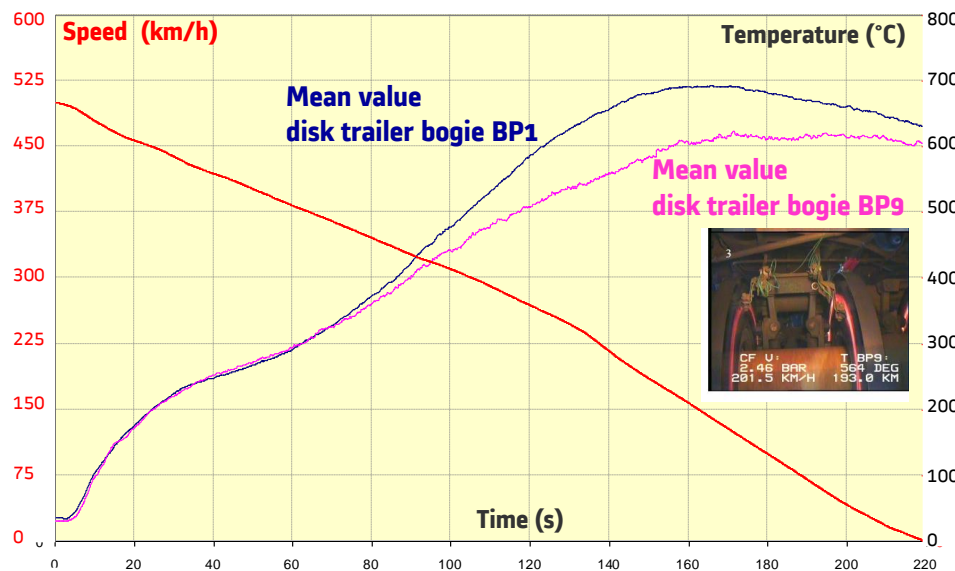


- ✓ The current collection is fully mastered : the monoband bow ability to collect 24 MW (800 A).
- ✓ No wear with the high intensity band.
- ✓ Full validation of numerical model for adjustment of current collection system : dynamic of catenary/pantograph and vertical displacement values.

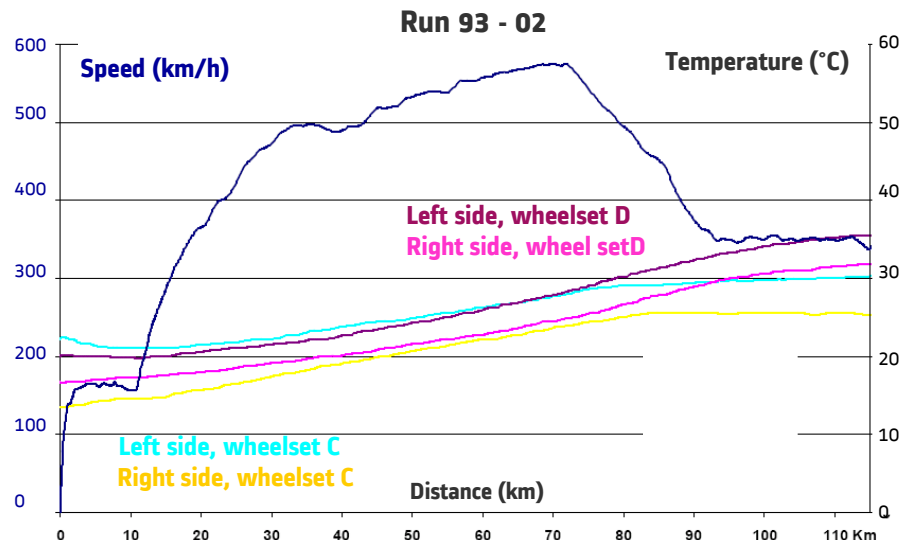


# Main results : Thermal behaviour

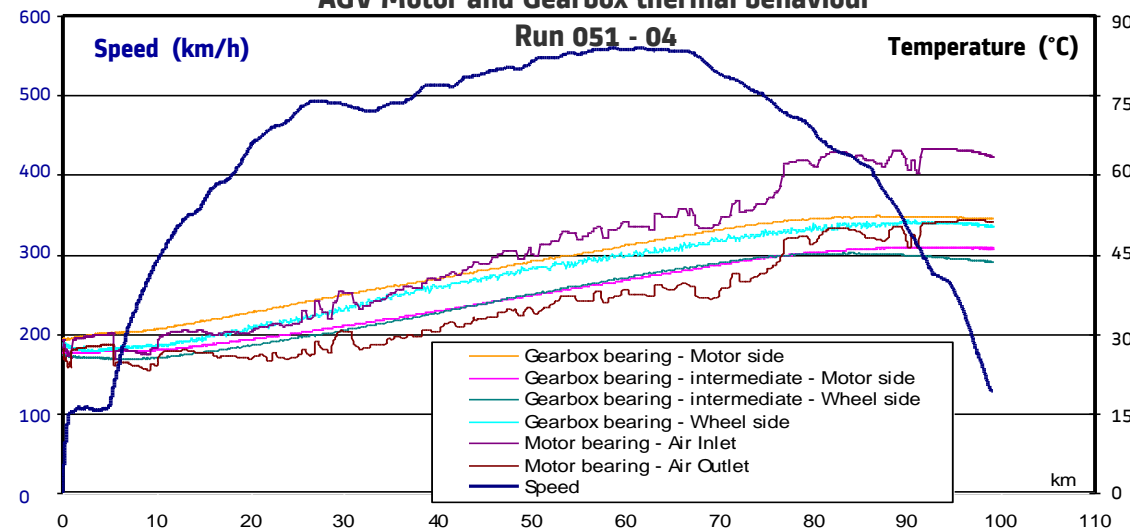
Brake disk temperature : emergency braking starting at 500 km/h



Power Car M1 : thermal behaviour of bogie B axle boxes



AGV Motor and Gearbox thermal behaviour



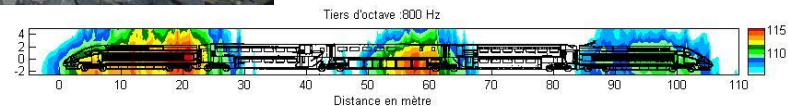
- ü Thermal capacity of critical components is fully mastered under extreme conditions
- ü Very good correlation between numerical simulation and test results



# Main results : Acoustics-exterior noise



ü **Acoustic Imaging**  
**Noise Source Characterization**

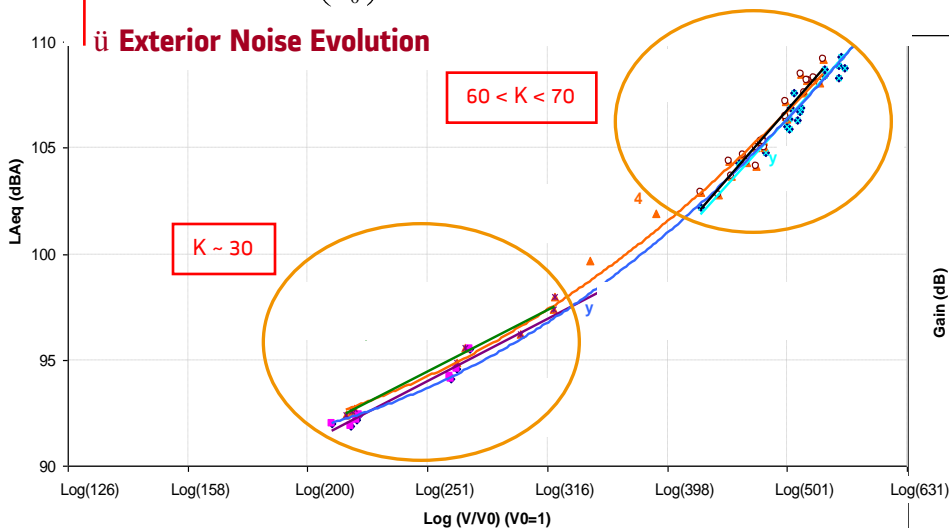


$$L \left( \frac{V}{V_0} \right) = K \times \log_{10} \left( \frac{V}{V_0} \right) + L_0 \left( \frac{V}{V_0} \right)$$

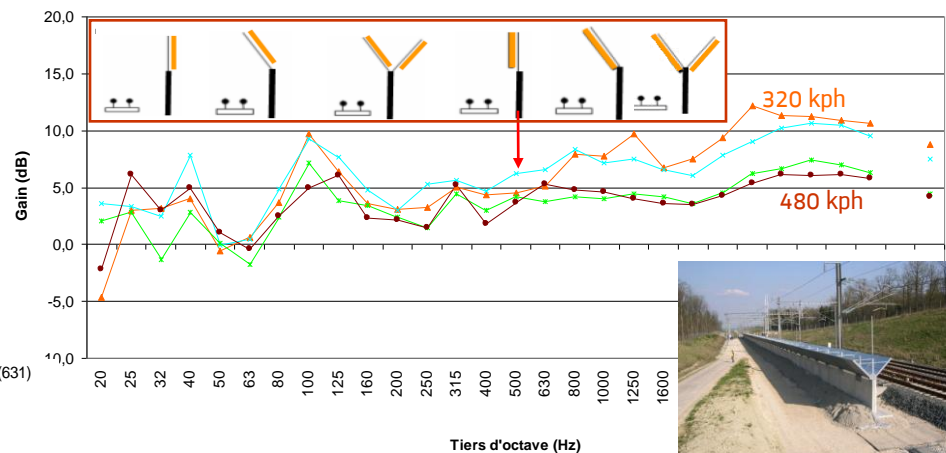
- K ~30
- K ~60-70

Rolling Noise.  
Aero-acoustic

ü **Exterior Noise Evolution**



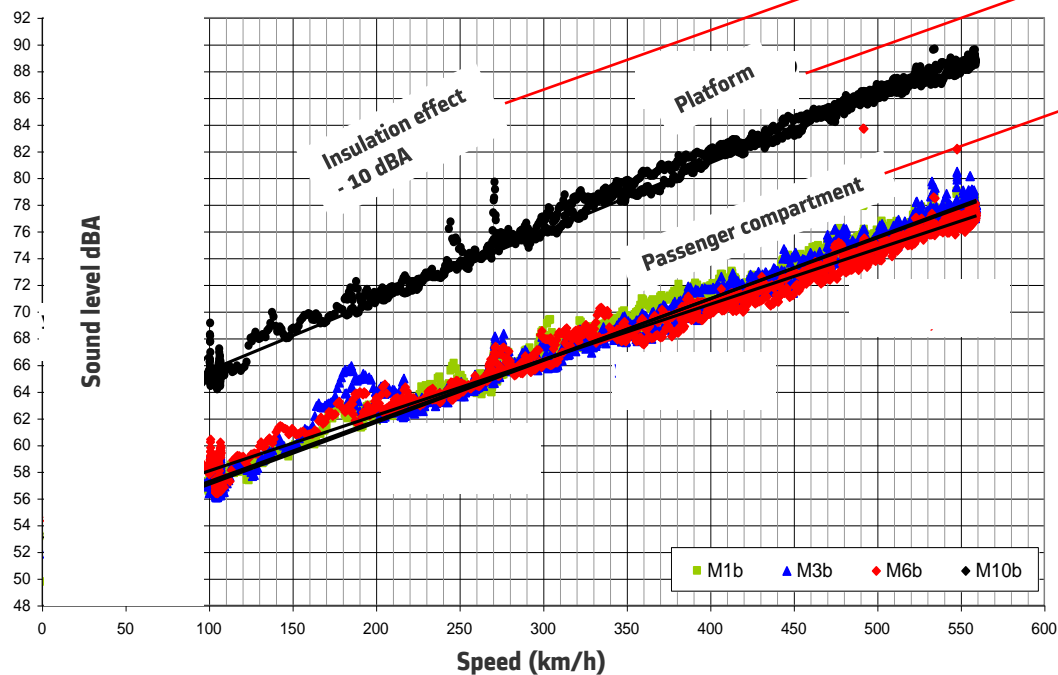
ü **Sound Barrier performances vs. speed and shape**



# Main results : Acoustics-interior noise



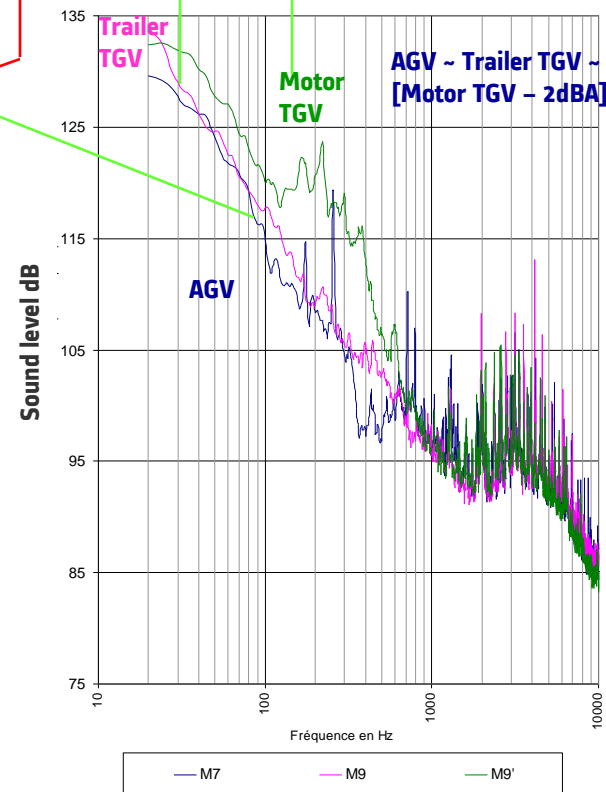
ü Interior Noise Evolution



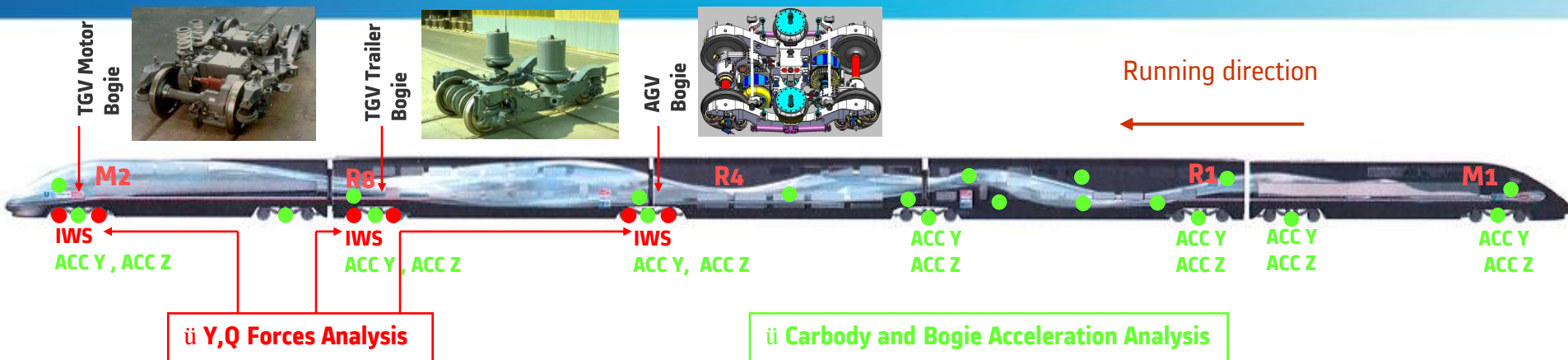
$$L_{\text{ext}} = K \times \log_{10} \left( \frac{V}{V_0} \right) + L_0$$

$K \sim 60$  for P150 vs  $K \sim 80$  for TGV117

ü Bogie Cavity Characterization at 300 to 575 kph



# Main results : Railway dynamics (1/2)



## Dynamic behaviour

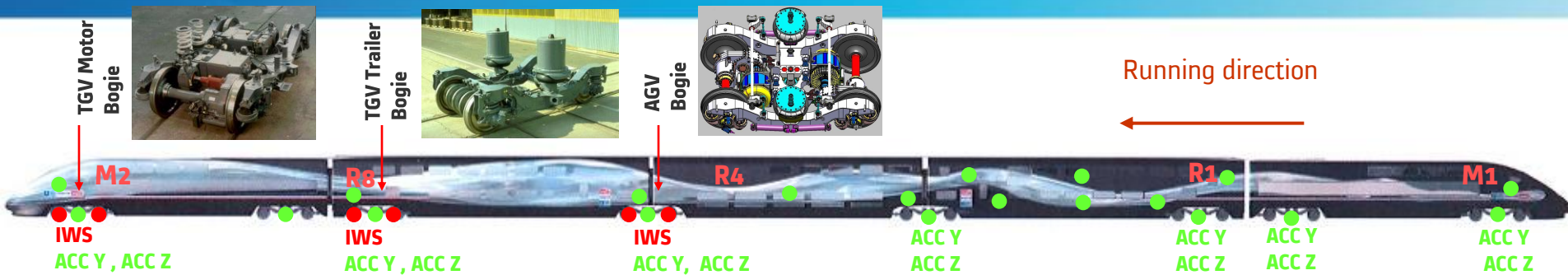
- Measured lateral Y and vertical Q forces remained well under safety limits (*50% of margin for Y forces and 25 % margin for Y/Q*), including in high cant deficiency (*163 mm at 450 kph*)
- Even at very high speed, the comfort level reached in the coaches was very good (*comfort level at 500 kph equivalent to the one of Corail coaches at 200 kph*)
- AGV bogies have lower level of acceleration than those of the TGV trailer bogies
- Good correlation between test and calculation is found for the full speed range

## Switch behaviour

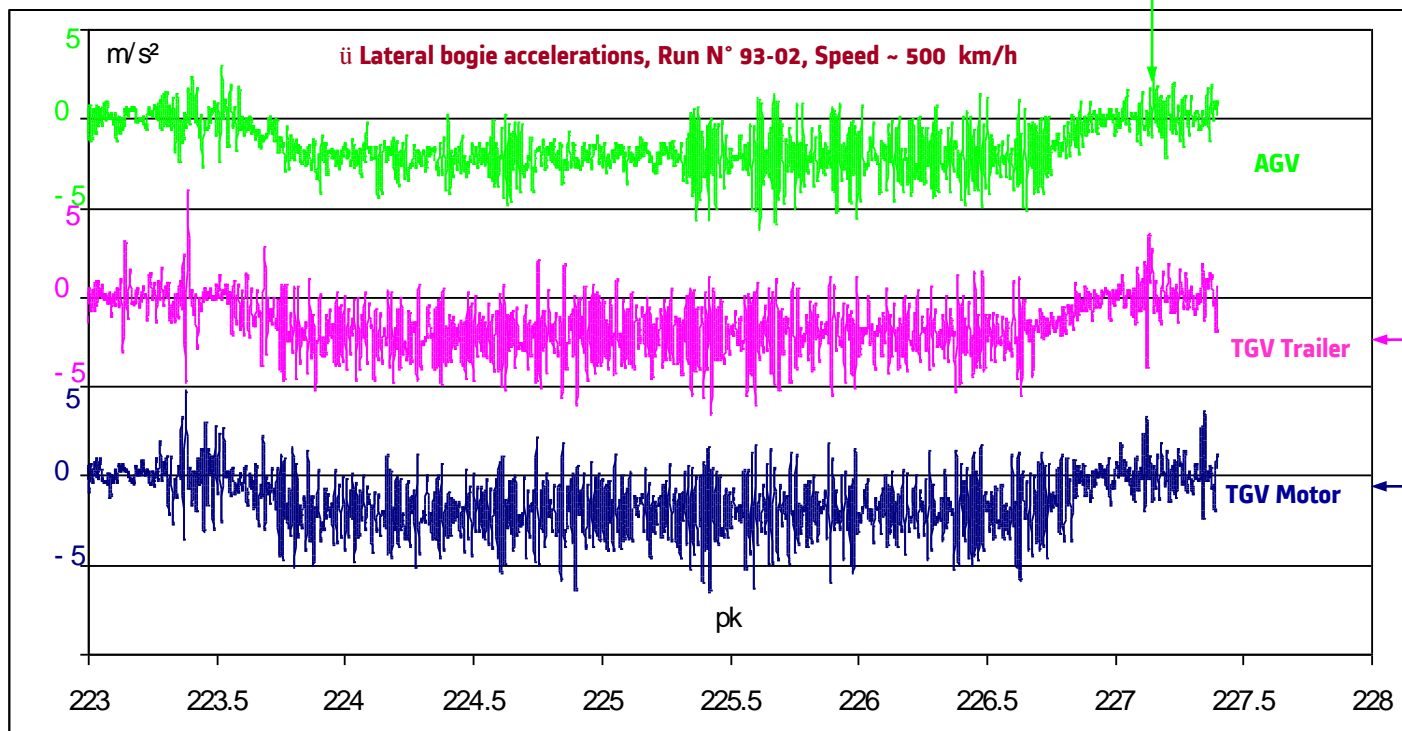
- Very good dynamic behaviour on switch point (28 runs at speed above 500 kph)



# Main results : Railway dynamics (2/2)



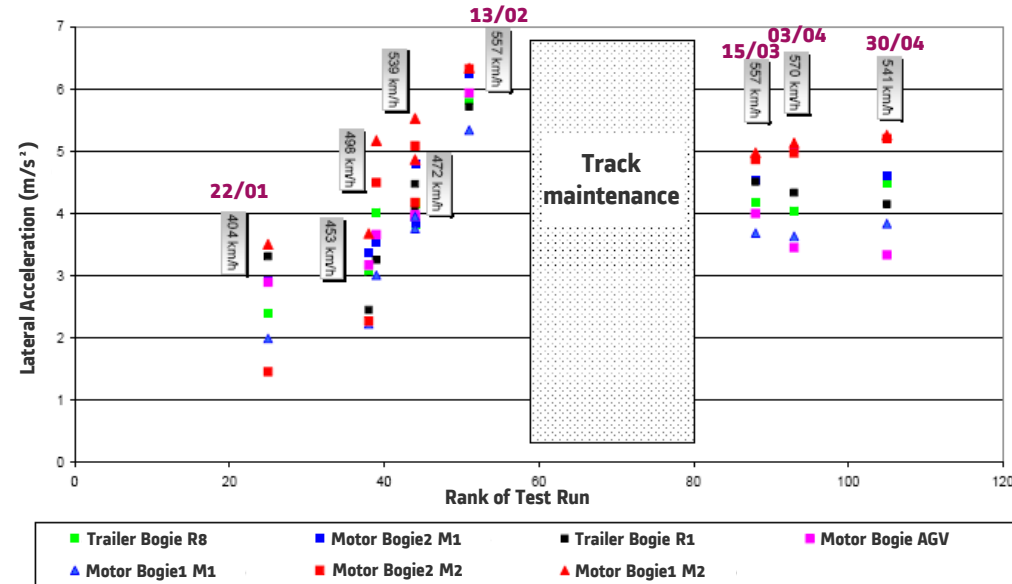
- **Dynamic behaviour**
  - Lateral bogie accelerations for the three bogie types.



# Main Results : Ballasted Track Behaviour

## Correlation between Track Quality and Dynamics of the Train

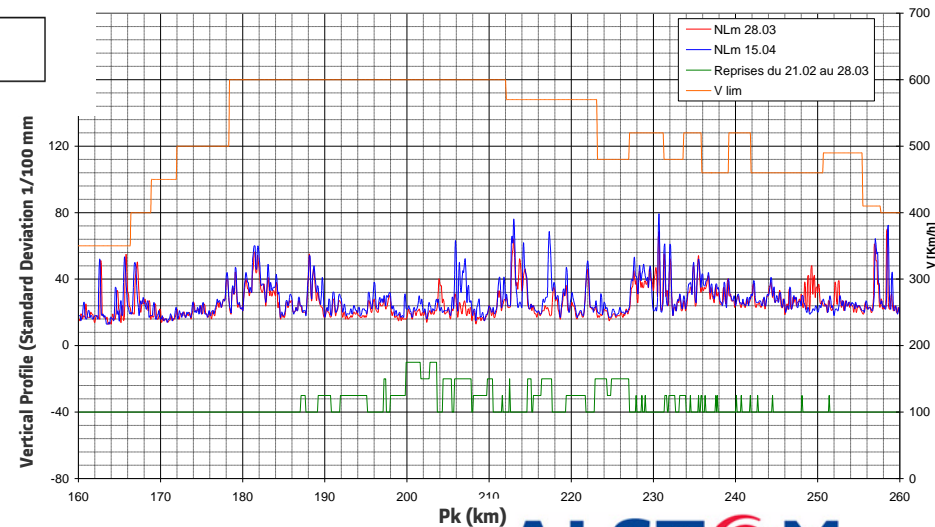
Evolution of Bogies Lateral Acceleration vs Track Quality



All along the test runs :

- ✓ Excellent behaviour of the track.
- ✓ No flying ballast observed.

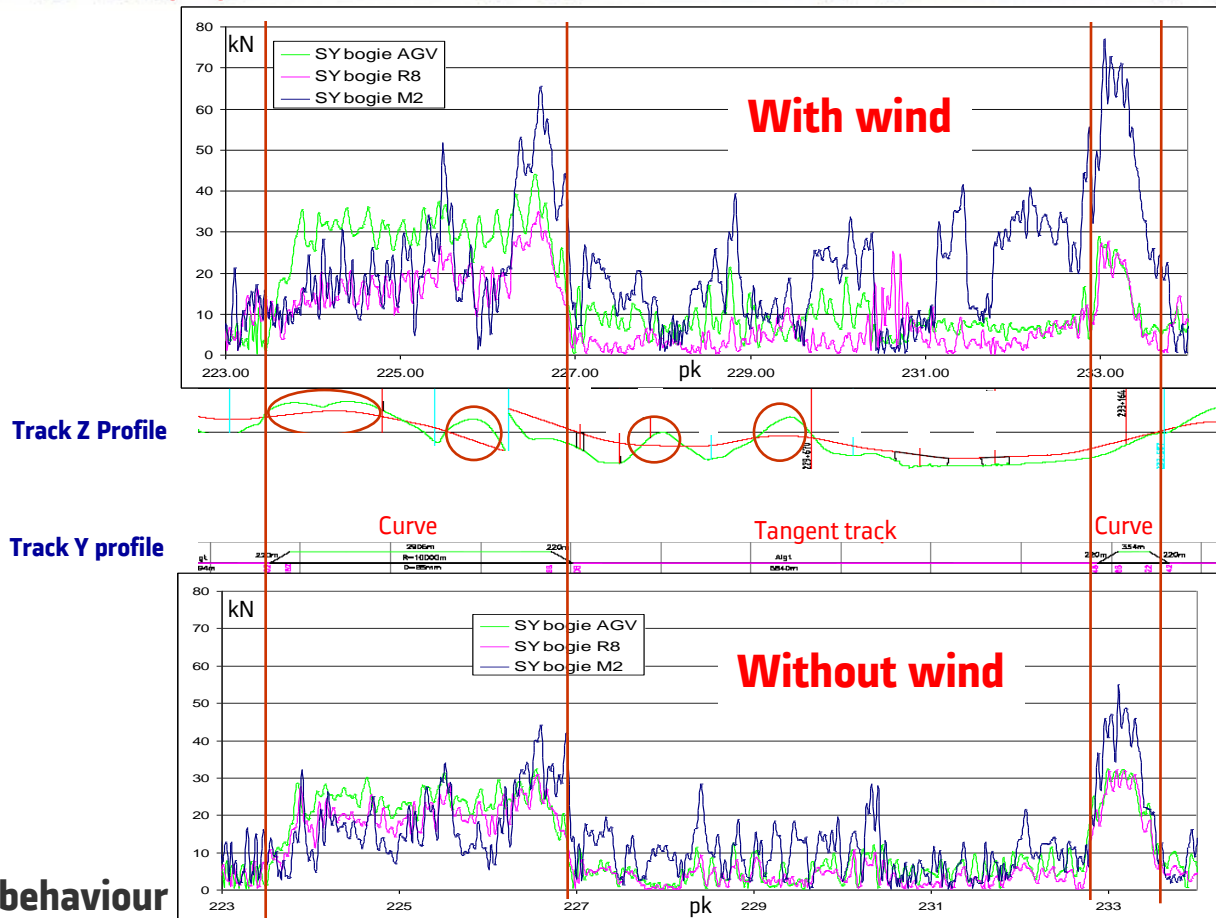
Evolution of Track Vertical Profile between Mars 28<sup>th</sup> and April 16<sup>th</sup>



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# Main Results : Cross Winds behaviour (1/2)



Running direction

ü Bogie Lateral Forces  
Train Speed 500 km/h

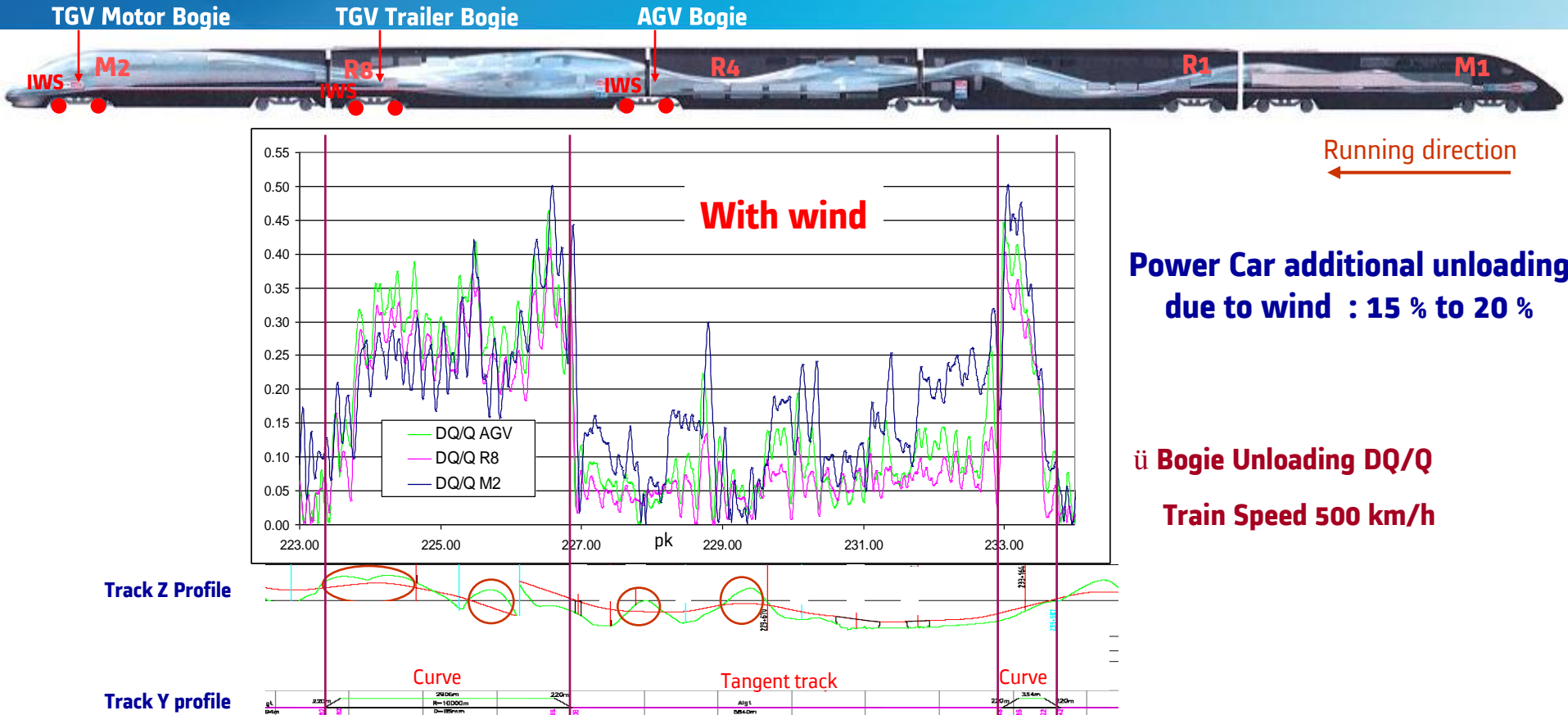
ü Bogie Lateral Forces  
Train Speed 500 km/h

**Cross-winds behaviour**

- ✓ Measurement results show that power car wind sensitivity is significantly higher than the other coaches
- > Double Deck TGV and Single Deck TGV are equivalent with respect to cross winds behaviour.



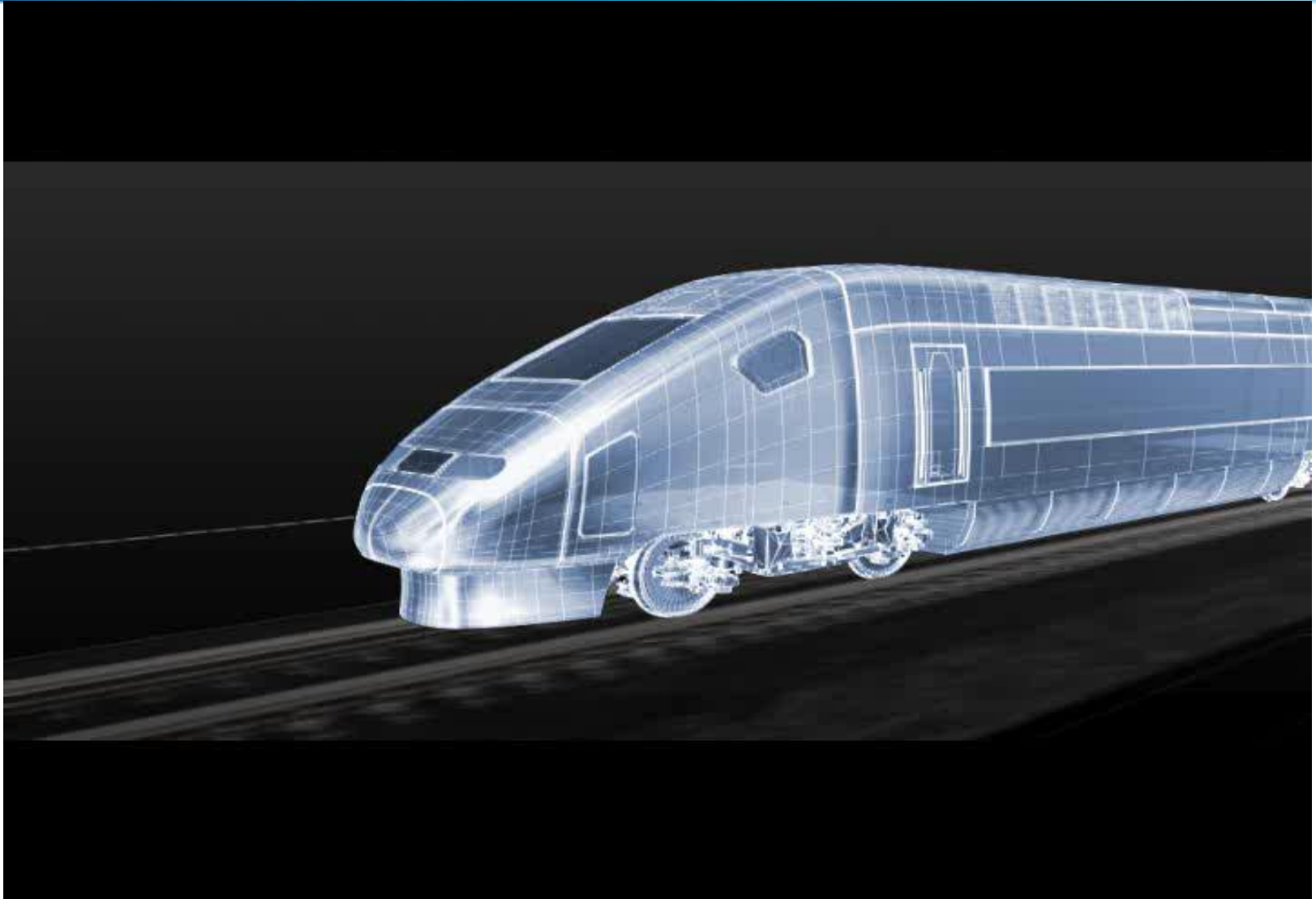
# Main Results : Cross Winds behaviour (2/2)



## Cross-winds behaviour

- ✓ Test results are in conformity with already achieved numerical simulations and wind tunnel test.
- ✓ But, a full numerical model validation is not possible due to lack of accuracy of wind characterisation

# The V150 train





Danke für Ihre  
Aufmerksamkeit !

*We are shaping the future*

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Technische Universität Graz  
14. Bis 17. September 2008

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