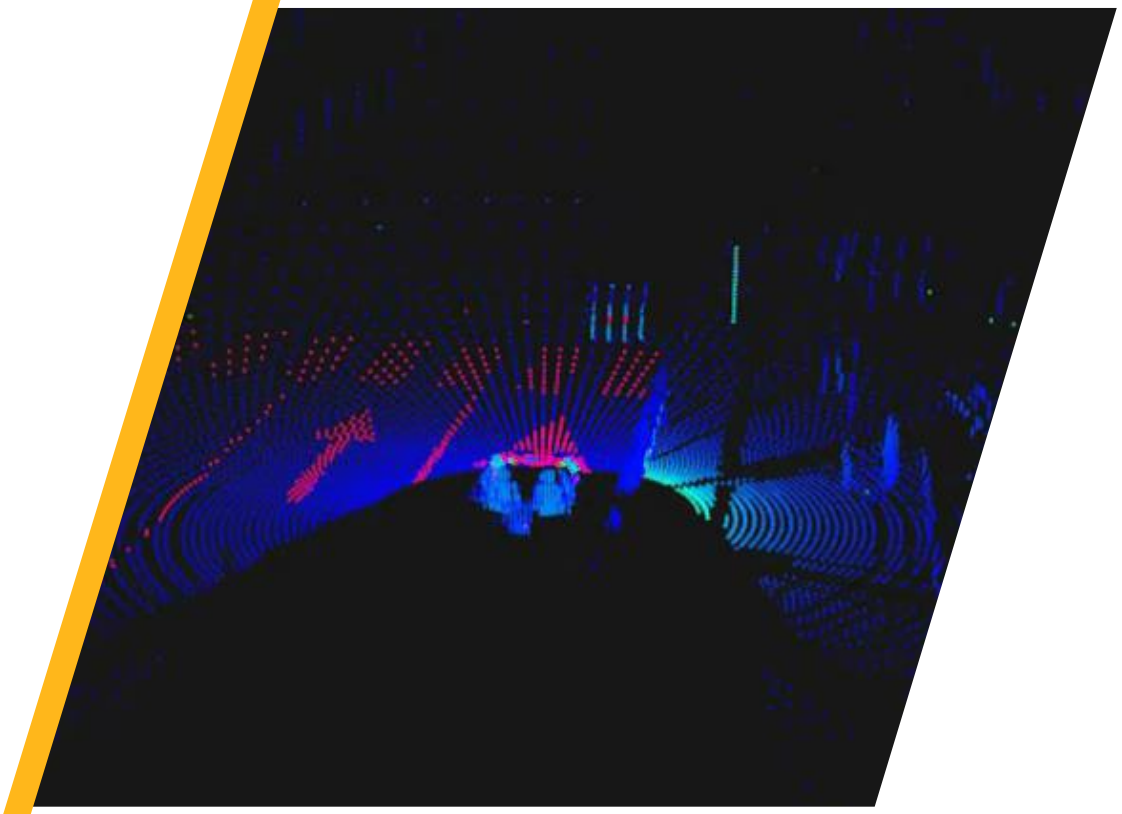
Virtualizing Autonomous Driving Testing: Simulating Lidar Sensors with Ansys

David Auger – Senior Application Engineer

Dr. Petr Fomin – Lead Application Engineer

Agenda

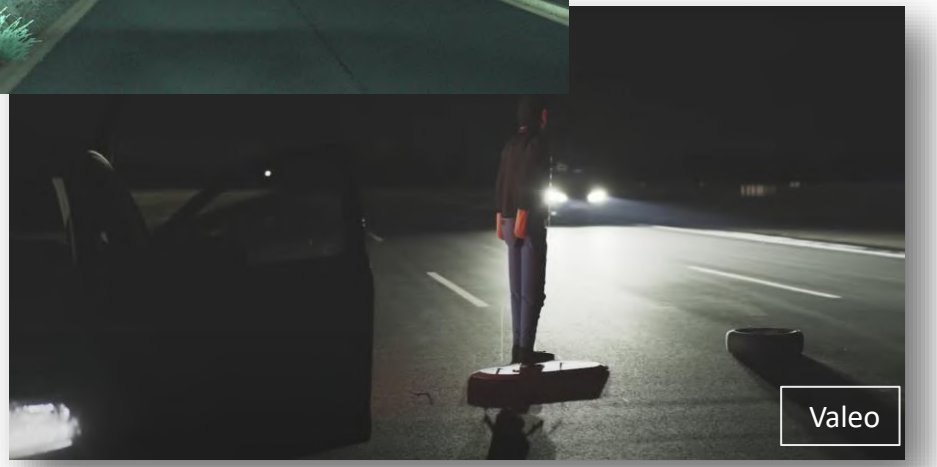
- Next-Gen AD and related LiDAR Challenges
- End-to-end optical simulation workflow
- LiDAR sensor components design
- LiDAR perception training and validation



Next Gen AD and related LiDAR Challenges

- AD/ADAS evolution toward L3 & full Highway speed ALKS drives requirements on sensors and perception performances
  - **Performances and detection range**
    - Detect a lost cargo in all conditions at highway speed at 200-300m range
  - Extended ODD - **Explosion of scenario** numbers and variety
    - Traditional test methods based on real drive recording cannot scale.
  - Extended ODD - Performance under **adverse weather**.
    - Impact of integration with blind spots and influence from environmental perturbations
    - SAE-DIN released in 2023 and next steps.

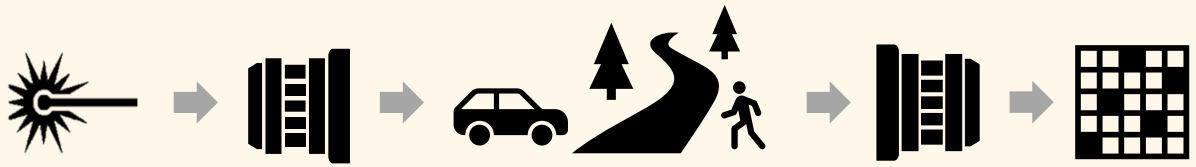
- **LiDAR sensors technology is well positioned** to efficiently answers next-gen AD requirements, with the help of **simulation**



End-to-end optical simulation workflow for LiDAR challenges

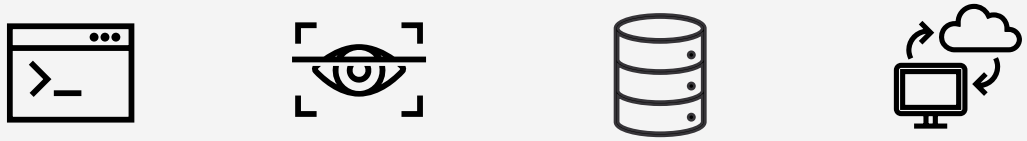
LiDAR Sensor System

Emitter → Optics Tx → Environment → Optics Rx → Receiver



Algorithm & ADAS Function

Algorithm → Perception → Scenarios → SiL / HiL



CAE / CAD Component centric → Sensor Virtual Twin → Scenario management, Perception algorithm centric

Sub-components Suppliers

- Analyze manufacturing defects on photonic component
- Designing and tolerancing optical components
- Sensor integration & packaging, blind spots identification
- Stray light studies, LiDAR cross talk impact on performances

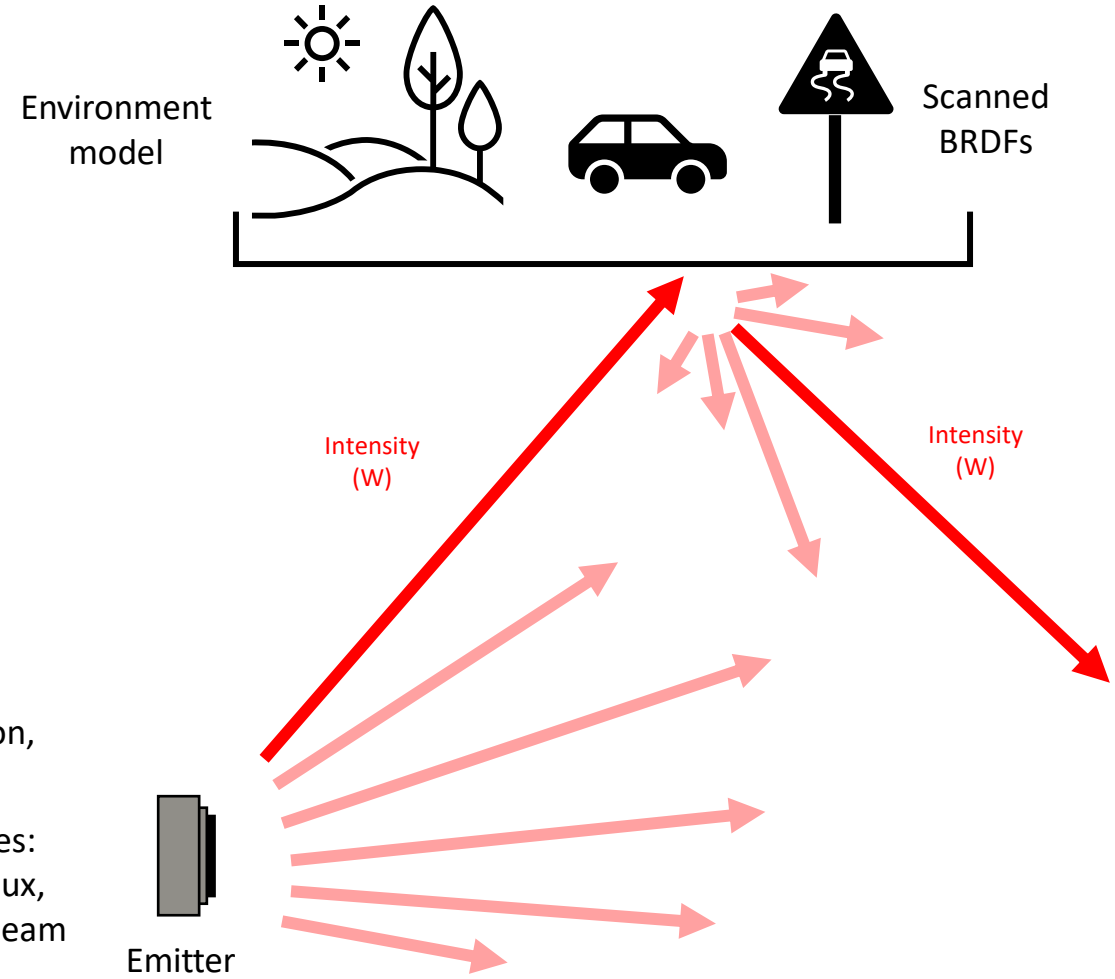
Sensor Makers

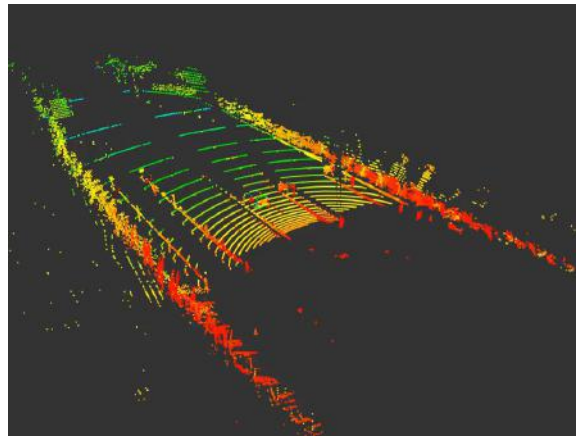
OEM

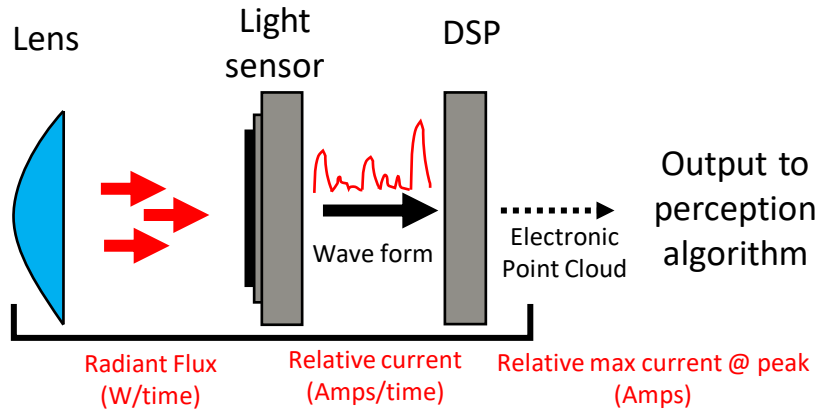
- LiDAR DSP development and testing
- Perception training and testing
- LiDAR specific AD/ADAS Perception Testing (lost cargo, etc.)
- ADAS/AV function validation (HiL)

End-to-end physically-accurate simulation workflow for LiDAR

Emitter | Scene | Receiver





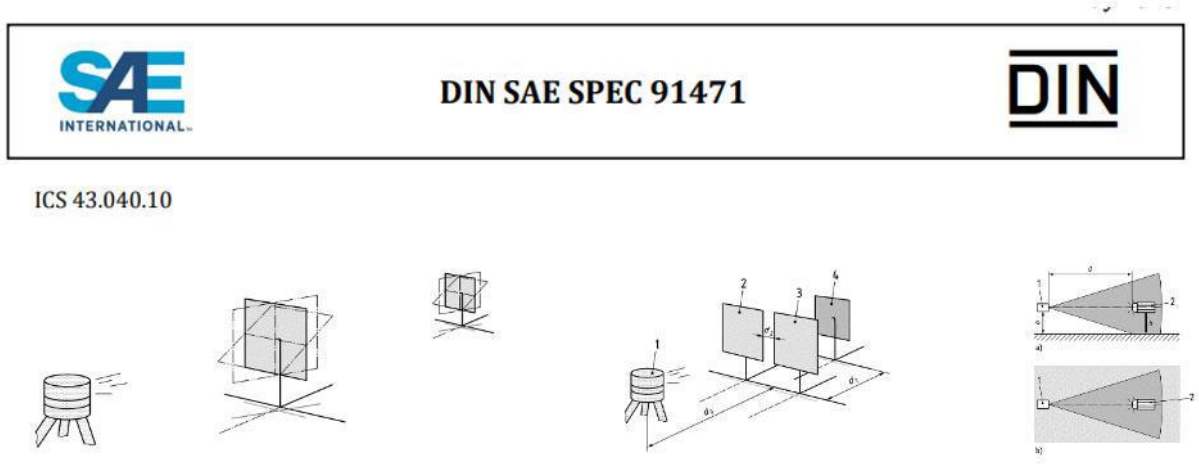


LiDAR Sensor Components Design and Qualification/Testing

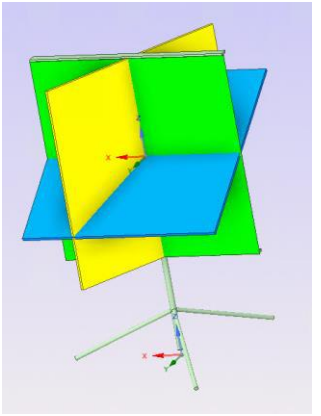
Ansys

DIN-SAE Standard for LiDAR Performance Tests

- Inspired from base framework of DIN-SAE n°91471 scenarios
- Provides common sensor specification and characterization guidelines
- Set of 7 static environmental scene test methods
- Measurements covering and presenting Key Performances Indicators (KPI)
- Specification measurements is based on point cloud data level



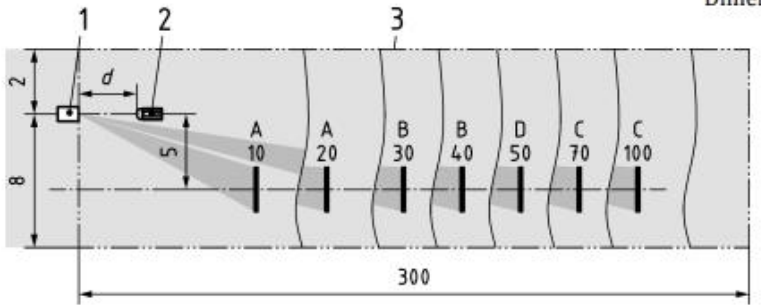
- <u>Material</u>
  - Target A : 1x1m, 10% Lambertian
  - Target B : 1x1m, 50% Lambertian
  - Target C : 1x1m, 80% Lambertian
  - Target D : 1x1m, retro reflector
  - Target E : 15x50cm, 10% Lambertian
  - Target F : 15x50cm, 50% Lambertian



Focus on: Cross domain test method

- Multiple targets with different materials at play, KPI being calculated by averages of each target results
- Different perturbations
  - Reference test,
  - Artificial light in the Field of View of the sensor,
  - Water spray deposit on the sensor outer surface.
- Measurements applicable
  - True/false positive detections
  - Radial & Angular accuracy

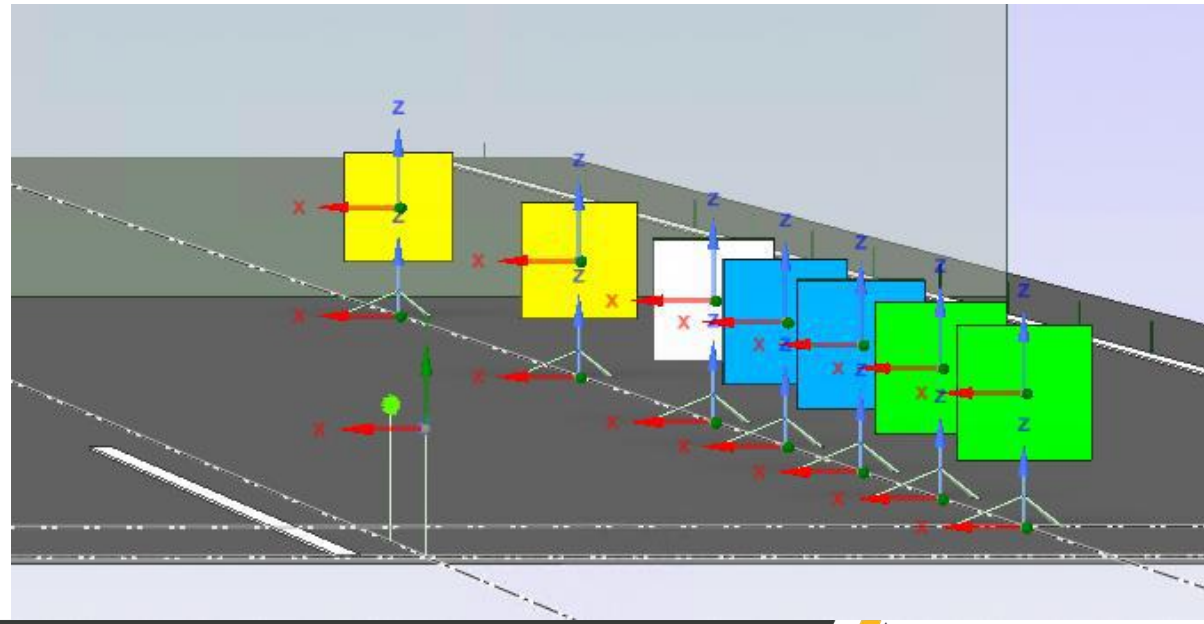
Dimensions in metres



Key

1 SuT
2 artificial light source
3 control volume
A target type A with 10 % reflectivity
B target type B with 50 % reflectivity
C target type C with 80 % reflectivity
D target type D, retro-reflector

Figure 22 — Top-view of cross-domain test setup



Weather impact evaluation methods

Weather Laboratory

Real Weather Simulator
(e.g. CARISSMA, CEREMA)

Rain simulator

Fog simulator

- Reproducible data generation for testing and validation
- Limited to idealized weather and traffic conditions

On-Road Testing

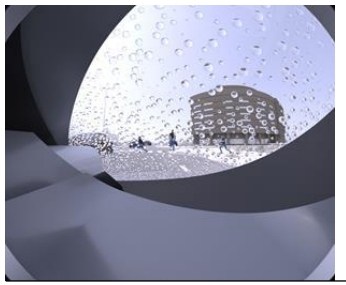
On-road Test vehicles
(CEREMA, Dense)

- Useful for testing and validation
- Not good for rapid technology development, not scalable

Analytical or Stochastic Weather Data Generation

Simplified physics simulation results

Rain fall model



Droplets on windshield

- Allow quick analysis on specific sensor contamination edge cases
- Lack fidelity and cannot be relied on for safety-critical applications

Multi-Physics & Animations

Ansys / FLUENT

Rain droplets size and coordinates

Ansys / SPACECLAIM

Scene and sensor coordinates

python

- Move sensor coordinates
- Call Speos

Ansys / SPEOS

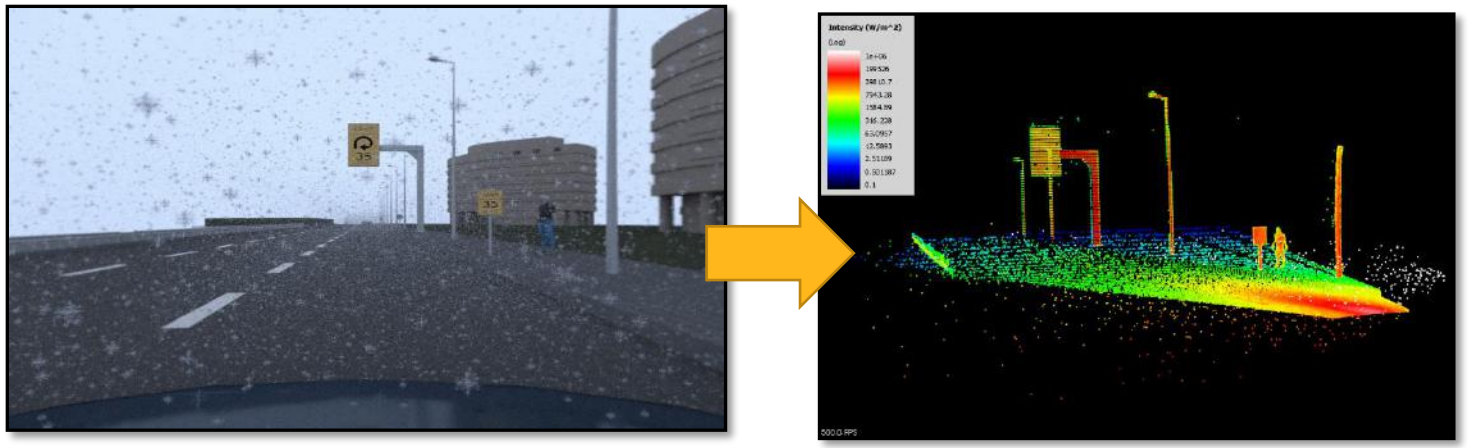
- Run camera and LiDAR simulation

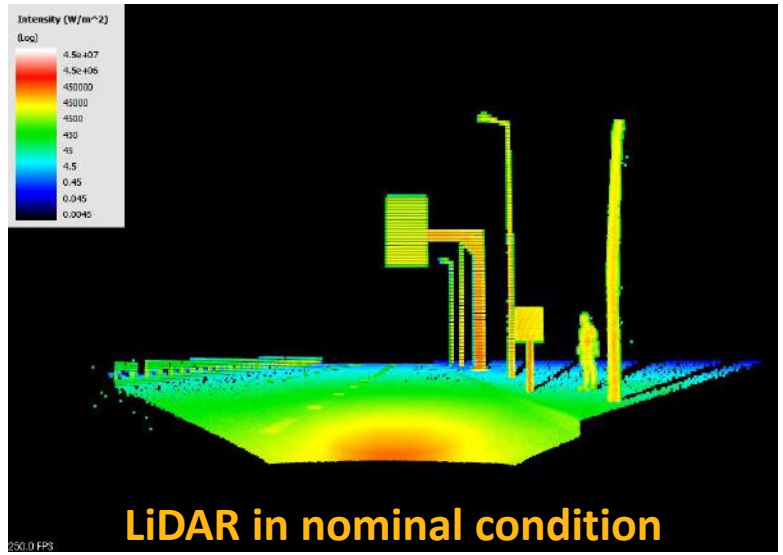
Description

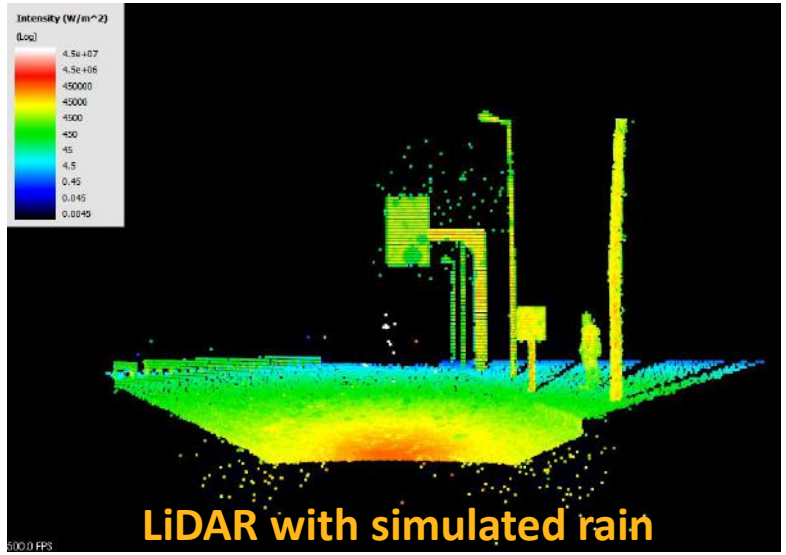
- A dynamic scenario of a vehicle going on a 100 m track under rainy condition is generated.
- The ego vehicle equipped with sensors is driving towards the target car and pedestrian ahead.
- The rain droplets data are generated using Ansys Fluent.
- The camera and LiDAR simulation is computed at every 2 m.

Environment Integration & Weather Impact on LiDAR

- Validate LiDAR deployment in various weather conditions.
- Rapid prototype and “what if” scenario testing reduce dependence on physical testing, lowering development costs.







LiDAR Perception Training and Validation

Ansys

Use Accurate Physics-based sensor models to test perception

AVxcelerate provides trustable synthetic sensor simulation in scenario

Complement recorded sensor data with reproducible dataset including edge cases scenarios

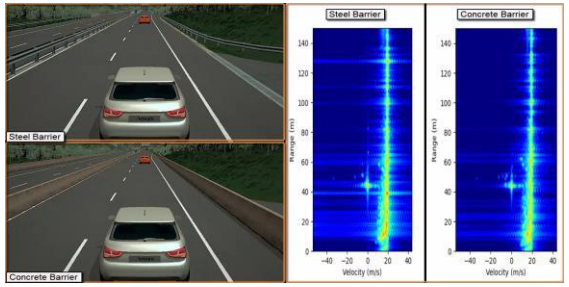
Use accurate physics-based virtual simulation to train and validate AI/ML-based perception

Continuously ensure perception stack safety of intended functionality from chip to mission

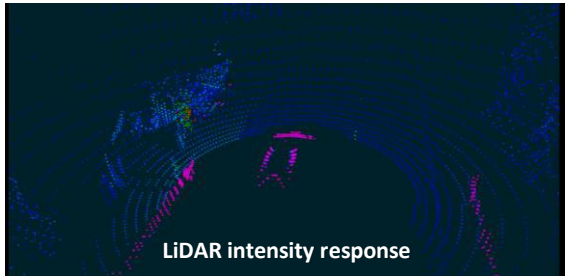
Benefit from open solution scalable from Hardware-in-the-Loop (HiL) test benches to Software-in-the-Loop (SiL) in Cloud

Camera

Radar



LiDAR



Thermal Camera

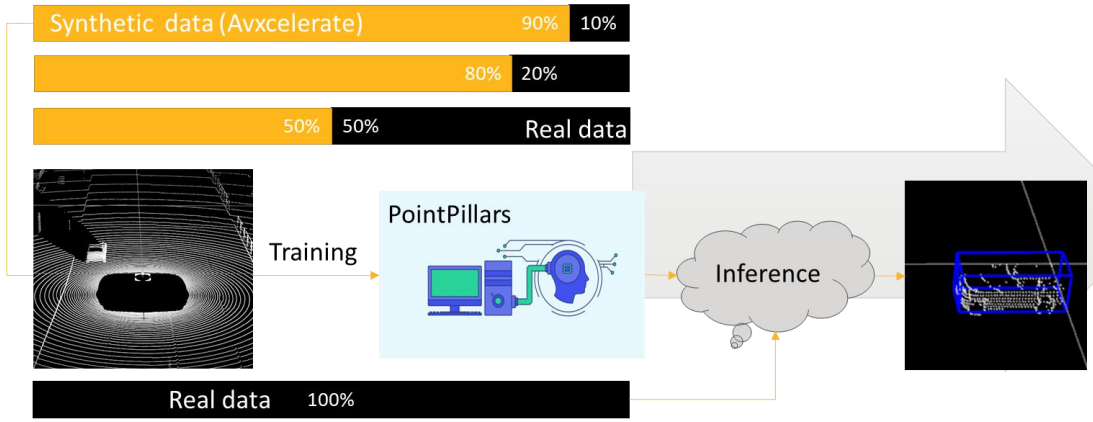
- **100x reduction of physical testing** leads to significant cost & time savings
- **Reduce time to market** by using proven physically accurate sensor simulation

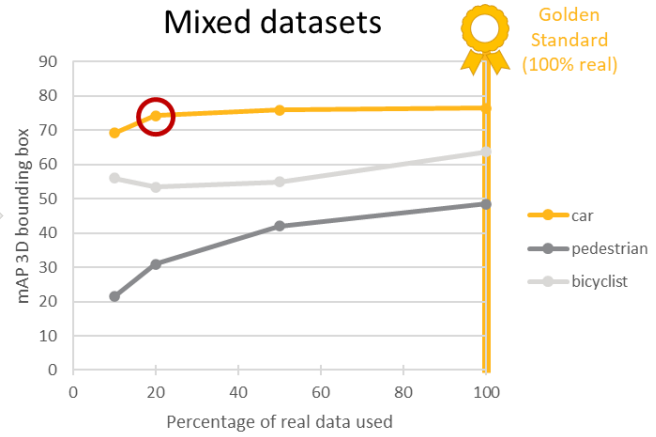
"Our biggest pain today is to spend time on the road to collect and store data where simulation can help us to generate the synthetic sensor data earlier in a cheaper way"

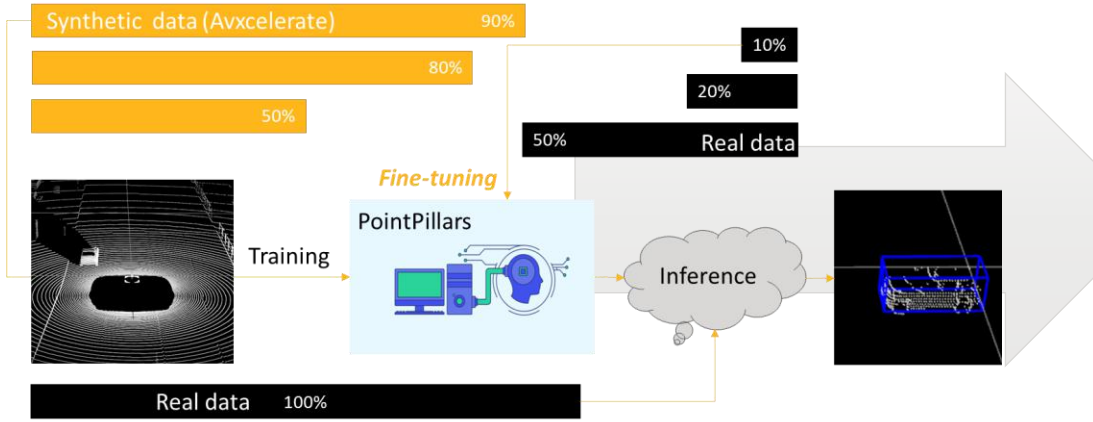
LiDAR Perception Training with synthetic data

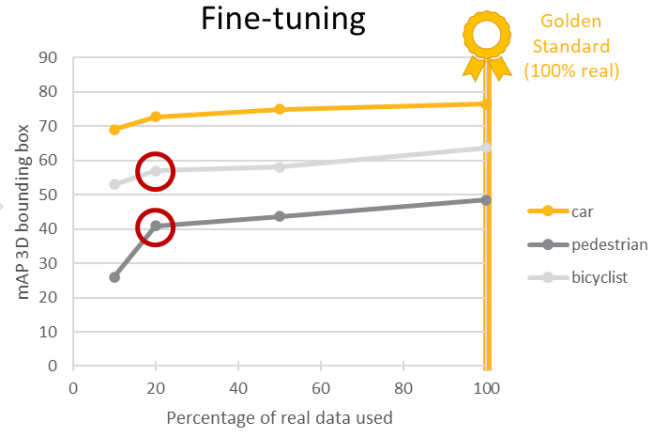
The need for proven and correlated synthetic sensor simulation

- 2 trainings strategies to reduce real testing (reduce time, complexity, cost) compared



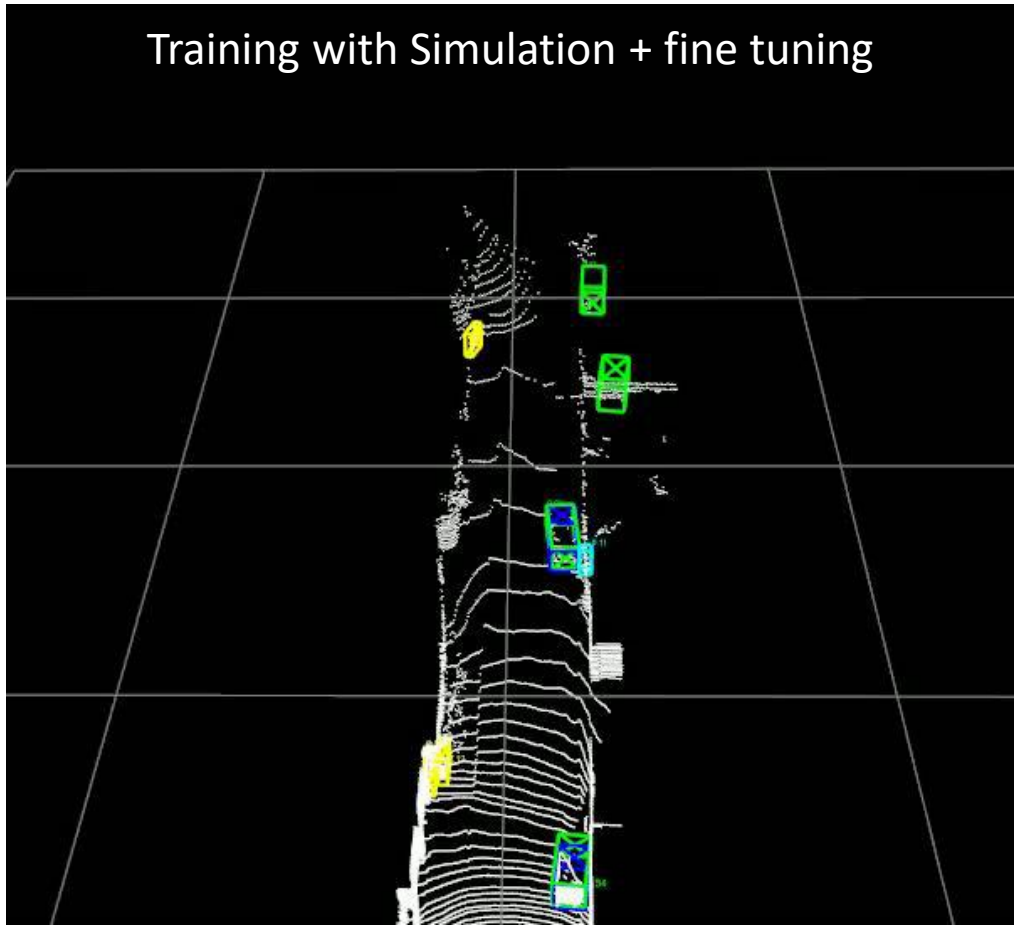




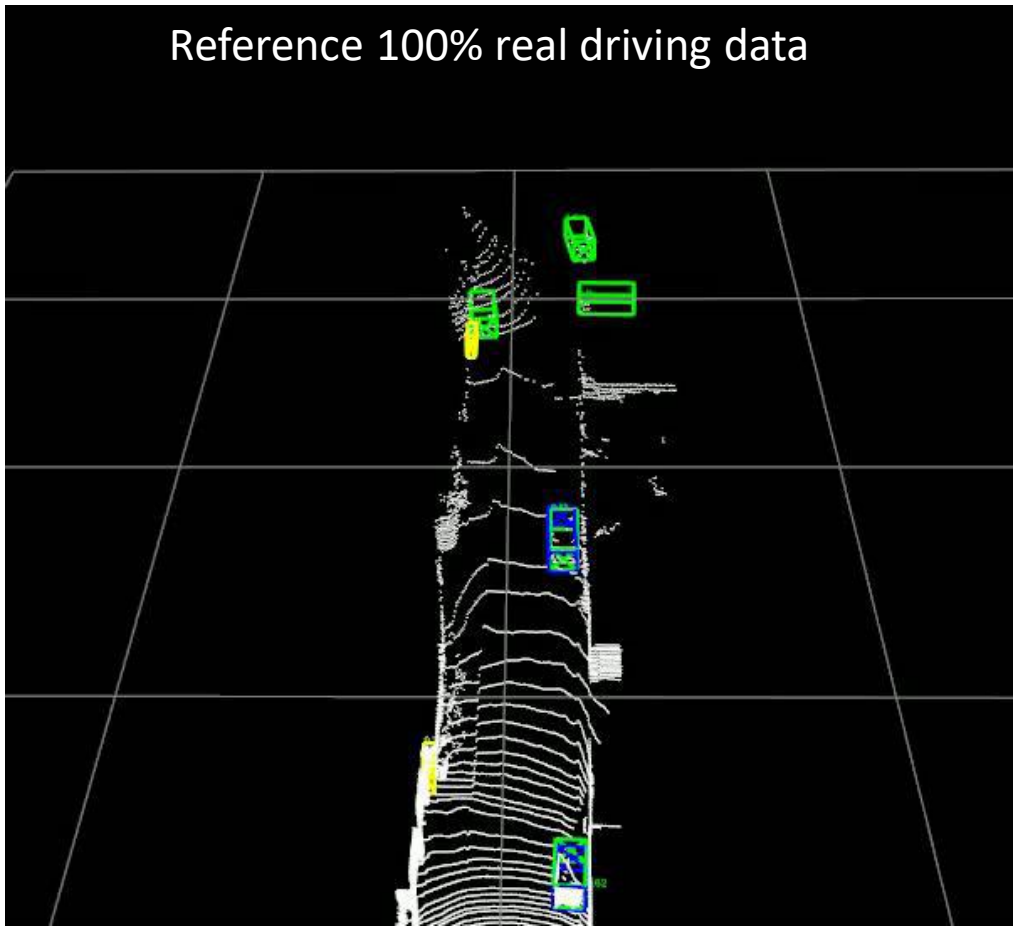


- **Reduction of real data by 80%** without significant performance loss in car detection.
- Pedestrian and Bicyclist are more difficult to detect.

Qualitative Analysis: Test on Real-World KITTI Data

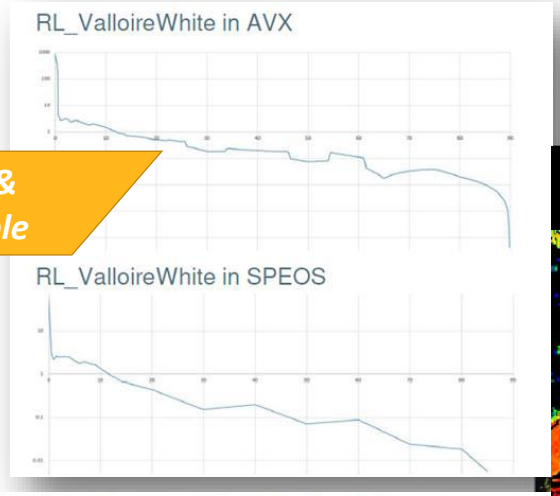


Pretrain on AVX, fine-tuning on 20% KITTI
Test set: KITTI

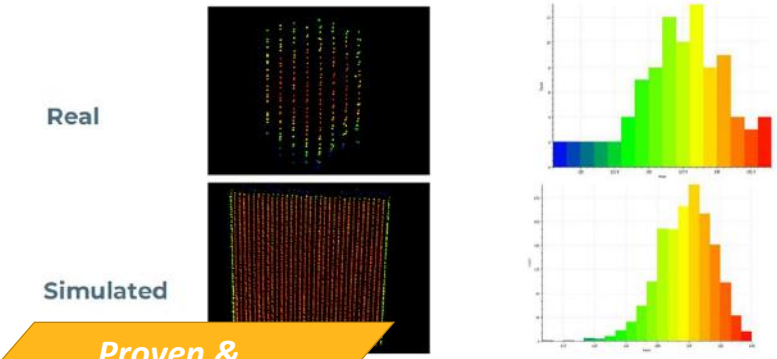


Train set: KITTI
Test set: KITTI

Towards AD/ADAS software and system validation using accurate virtual twins
Then need for accuracy & speed

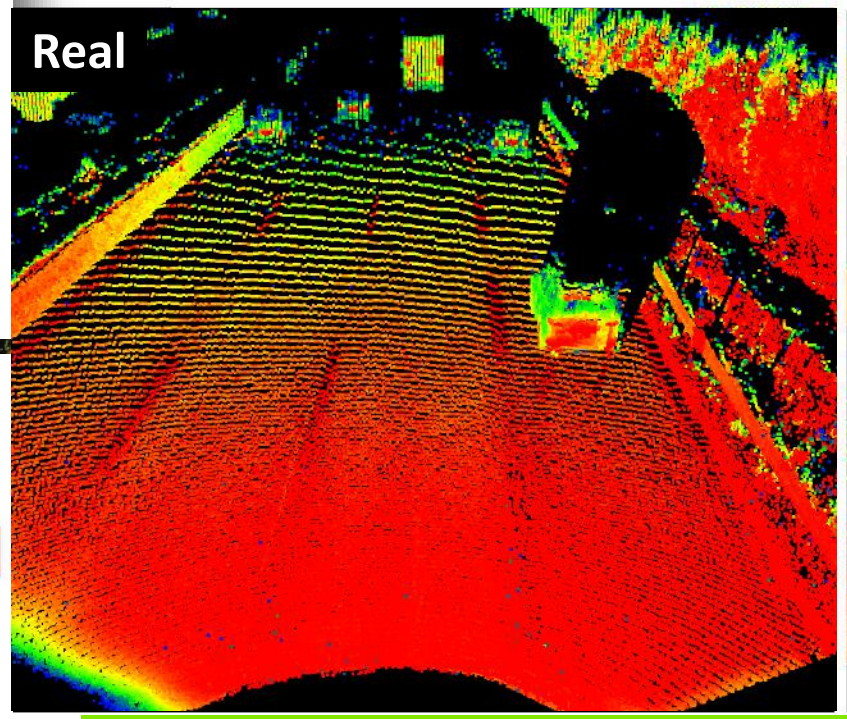


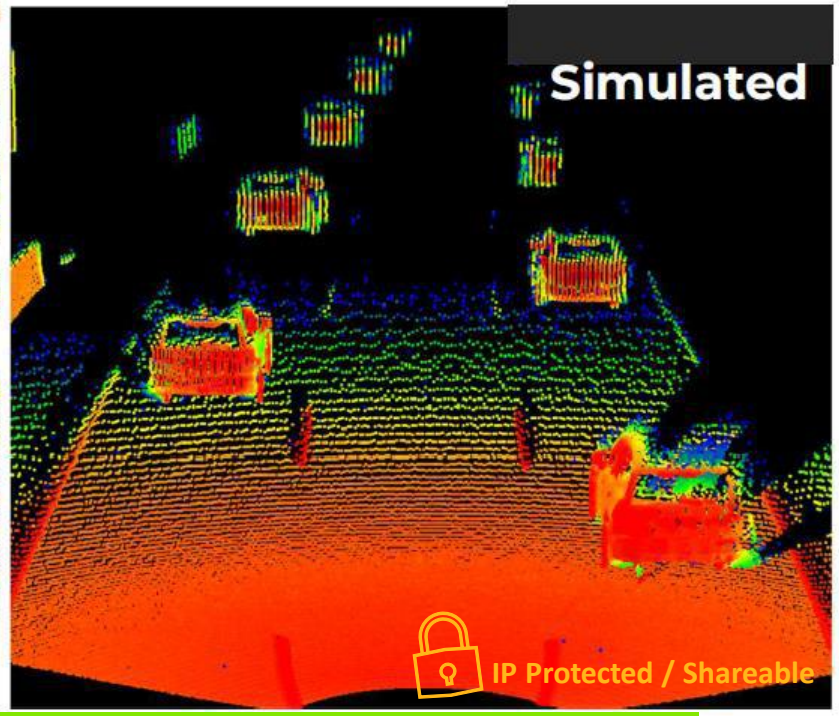
Credible & Measurable



Proven & Trustable

Valeo

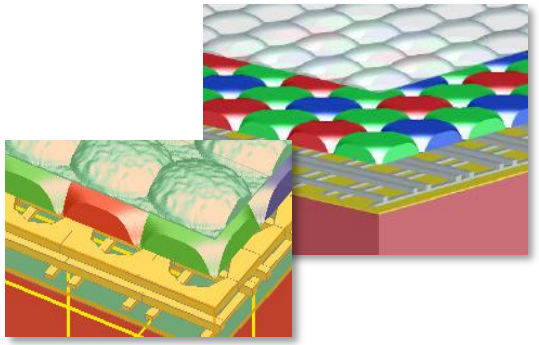




Ansys AVxcelerate data can be used as input for Valeo Sensor Model

Takeaway - From “Chip to Mission” with Ansys Simulation

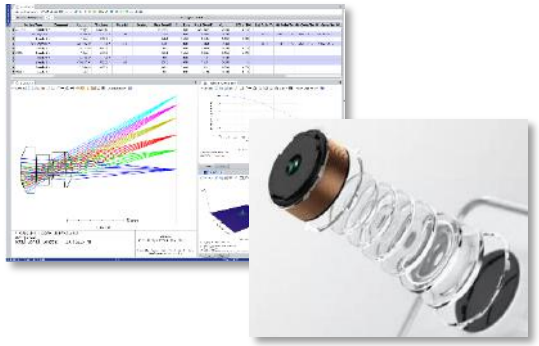
Ansys LUMERICAL



Photonic Component Modeling

Chip Level (waveguides, sensors, micro lenses)

Ansys ZEMAX OPTICSTUDIO



Optical Component Modeling

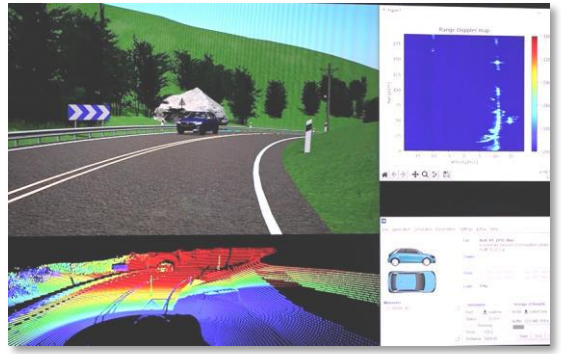
Lens stack optimization
Optical/Mechanical Tolerancing

Ansys SPEOS

Sensor Level Modeling

3D Environment Integration,
Lighting,
Human Vision Perception

Ansys AVXCELERATE SENSORS



ADAS Function development

Perception in the loop testing
SiL / HiL / Massive simulation.
Reduce time to market with proven physically accurate sensor simulation


Ansys