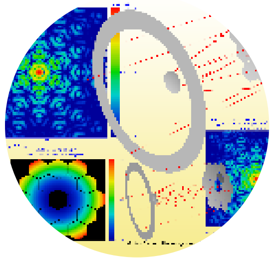
Designing LiDAR with CODE V and LightTools

EPIC Online Technology Meeting on LIDAR Technology and Applications

Presented by Rainer Födisch, Light Tec

LIGHT TEC ACTIVITIES

Synopsys Optical Simulation Software

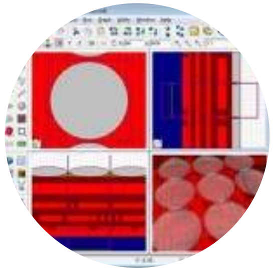


CODE V

Imaging optical design

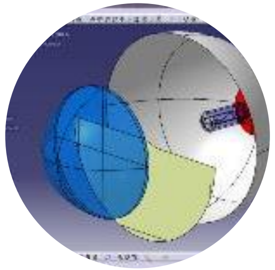
LightTools

Illumination design



RSoft

Micro & nano optics



LucidShape

Automotive Illumination

Scattering Measurement Instruments Services

Measurement service

Scattering measurement

Measurement Instrument

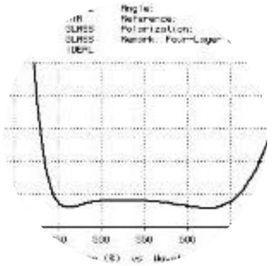
Mini-Diff V2 / Mini-Diff VPro

Reflet 180 S

Engineering & Training

Illumination design &

Imaging optical design



TF calc

Thin films, analysis, optimization

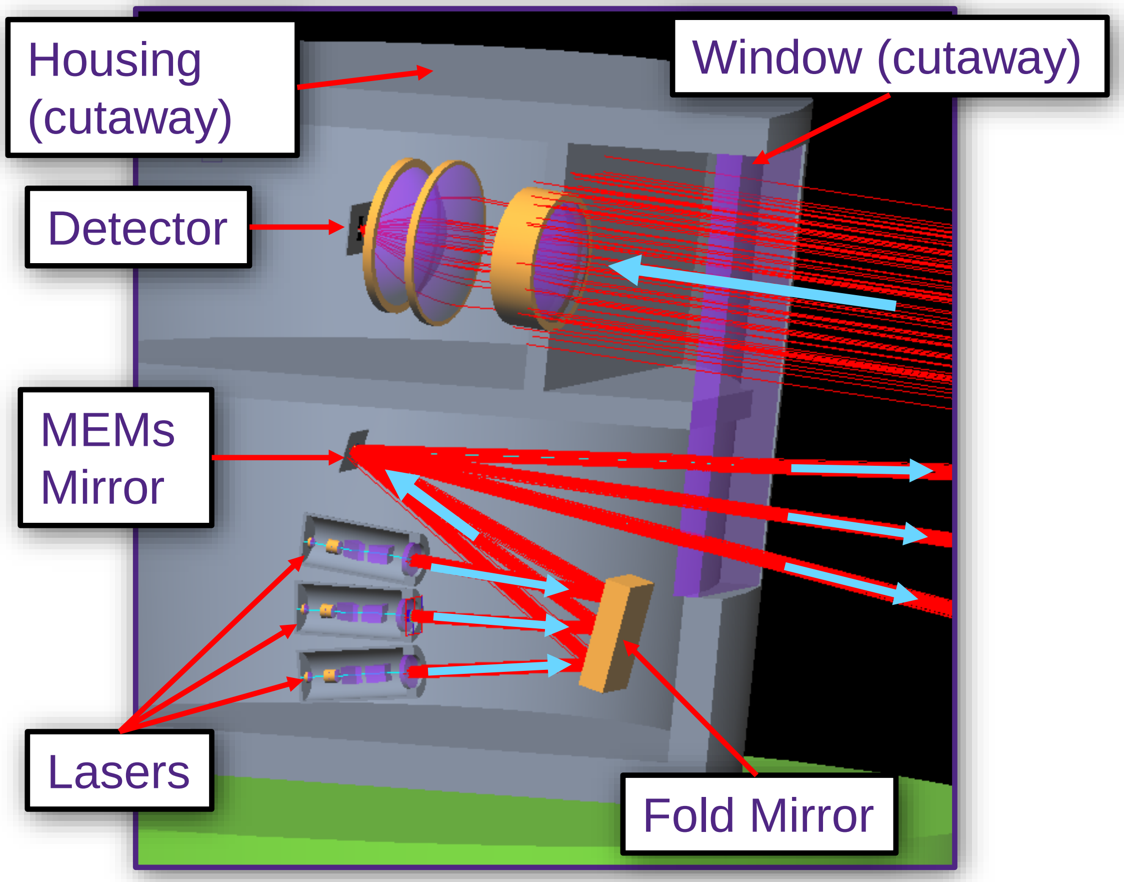
Modeling LiDAR with Synopsys CODE V and LightTools

- CODE V: Excellent features for designing the return image detection system
  - Unique beam propagation feature for accurately modeling the laser beam as it propagates through the launch and scanning system and through to the target
  - Needed to model laser launch optics, detector optics, and beam propagation to the target

- LightTools: Used to model the entire system, both launch optics, target properties, detector optics, filters, stray light, and atmospheric effects
  - Features support the propagation of the beam through the launch system and to the target
  - Can model scattering effects of the beam as well as any volume scattering effects caused by atmospheric conditions such as fog or rain

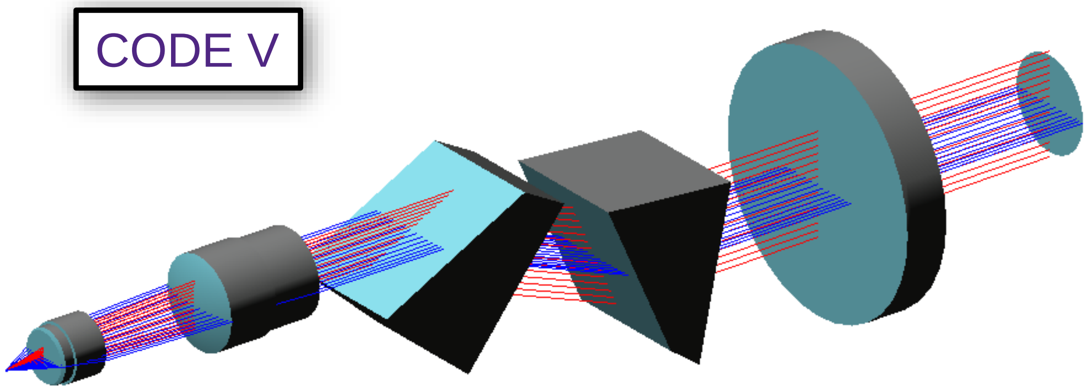
LiDAR Example Concept

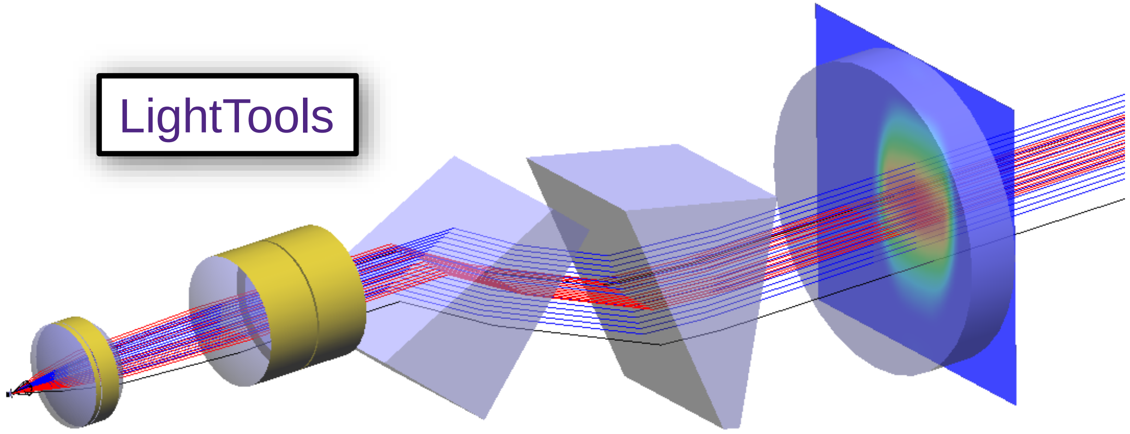
- In this example, we are modeling a scanning LiDAR for use in autonomous vehicles
- The goal is to design a spinning-body LiDAR with a large field of view and as few moving parts as possible
  - Vertical Field of View: +4°/-14° (total 18° V-FOV)
  - Horizontal Field of View: 360°
- The vertical field of view is accomplished using an array of 3 fiber lasers aimed at a MEMs mirror
  - Vertical laser separation = 6°
  - Mirror travel range = +/-1.5°
- The horizontal field of view is accomplished by spinning the body of the LiDAR through 360 degrees
- Return light is gathered by an 8-bin avalanche photodiode diode array fed by a 5-element lens designed using CODE V



Modeling the System in CODE V

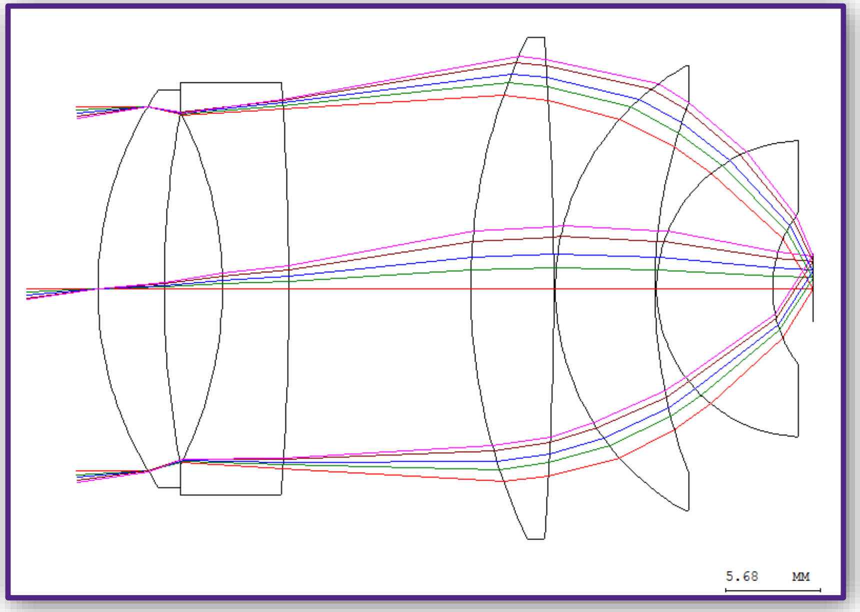
- CODE V was used to design the launch optic for the laser diode sources
- Initially a 4-element lens was used to design a collimator lens for a single, on-axis field point
- Once the collimation was achieved, two prisms were added to adjust the beam width in the direction along the emitting layer (with the small divergence angle)
- The resulting launch system was then transferred to LightTools

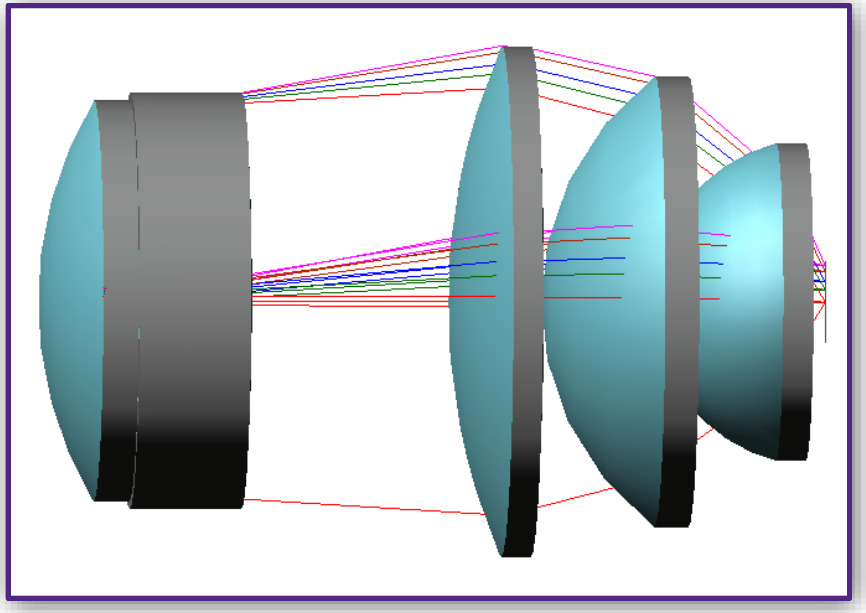




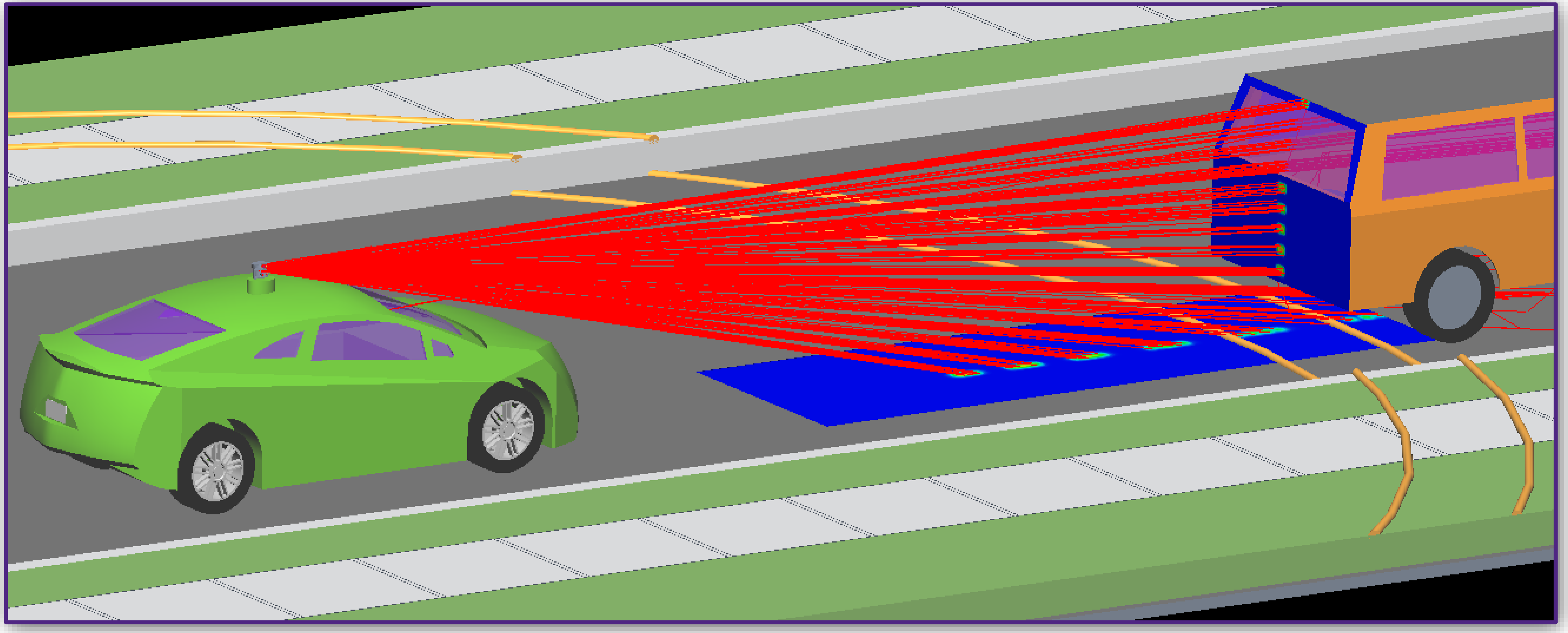
CODE V Detector Lens Design

- The design for the detector lenses was done with CODE V
- The lens was designed to cover the entire vertical field of view
  - All surfaces are spherical
  - All lenses are of Schott SF6HT glass chosen by Glass Expert for high index, good transmission and good availability
- Imaging quality is not critical, because the detectors detect only the presence of the light itself
  - However the 8-bins need to be able to distinguish between the returns from the three lasers so the imaging should be good enough to prevent cross-talk

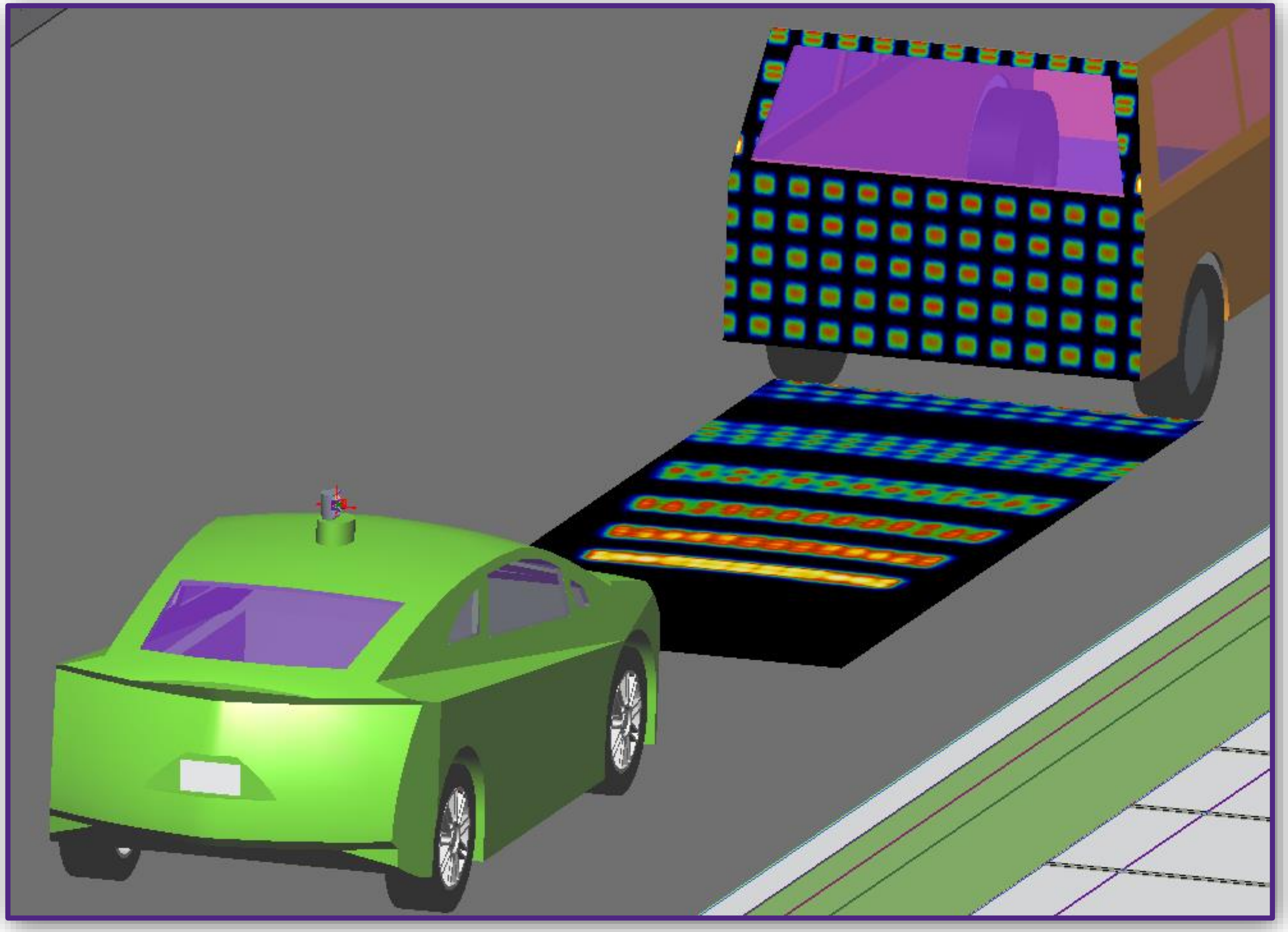




Full System, Single Vertical Scan, 1º Scan Interval



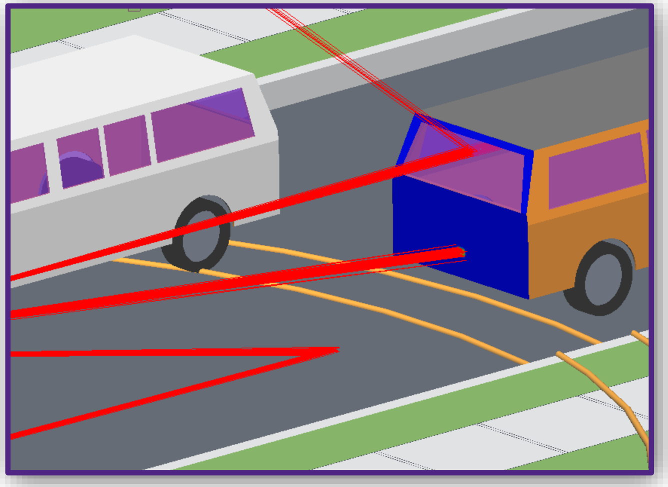
Full System, Vertical and Horizontal Scans, 1^o Spacing

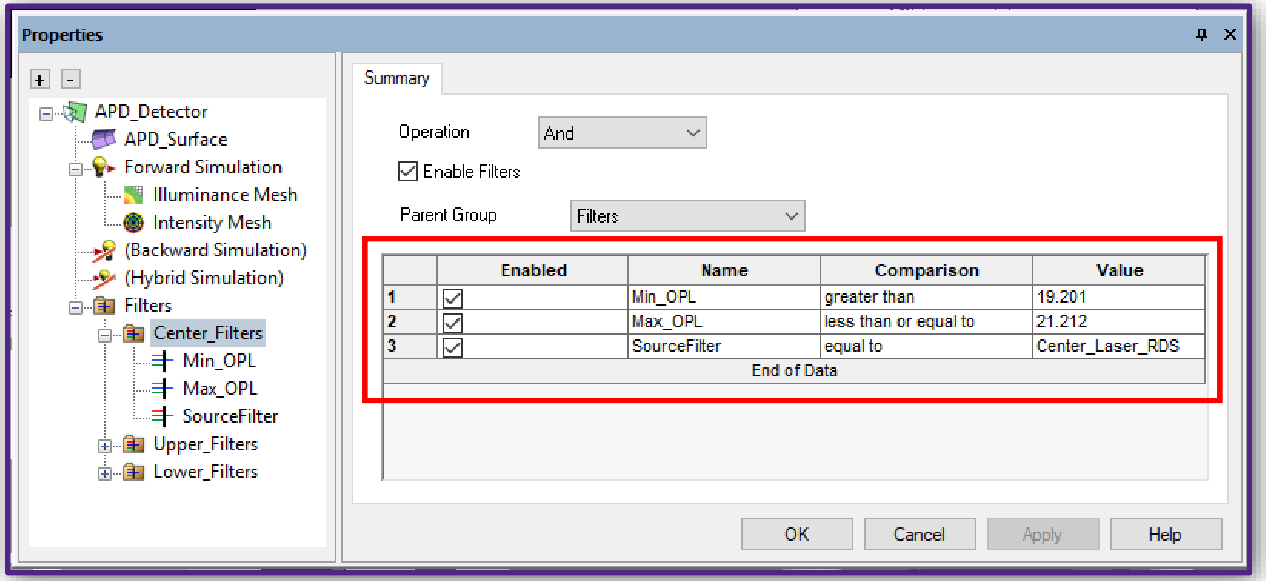


- The van is placed at 10m distance
- Spacing is set to 1^o for clarity
- Distant spots on the pavement show separation for the different laser cavities. These are more prominent because of the oblique angle

Filtering for the Time of Flight

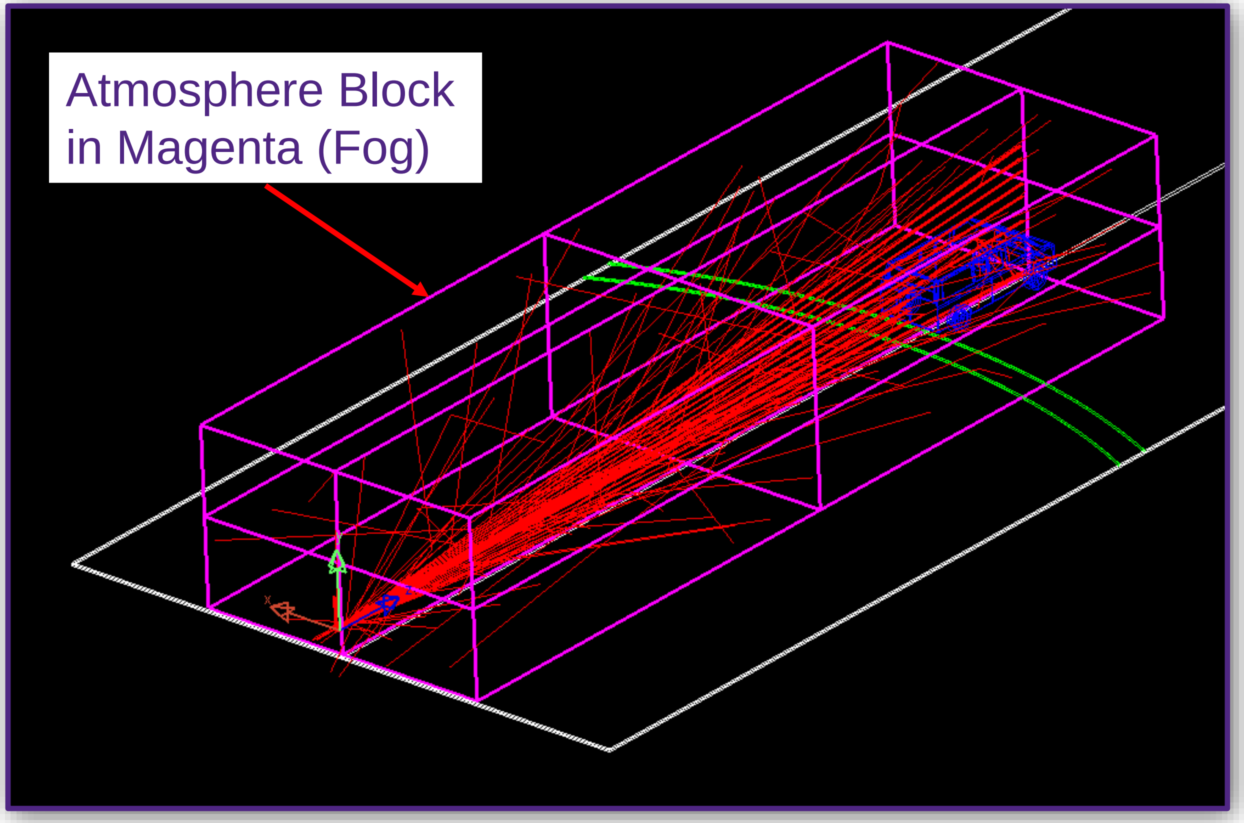
- In order to explore the signal-to-noise performance in various atmospheric conditions, it is important to be able to filter out the return signal by the time of flight of the rays
  - This is how the detector will find the range to the target
- For this, we used two Optical Path Length filters to set the minimum and maximum length traveled
  - Driven by numerical parameters for ease of use
  - Two dynamic, thin, yellow toroids were placed on the road surface as range markers
- A third source filter was also included in the filter group and three groups were created using the ‘or’ function to pass the three sources





Atmospheric Effects

- It is also possible to put in atmospheric effects such as rain or fog
- For this, we use the LightTools volume scattering feature
- The atmosphere is set up as an air-filled block containing randomly distributed scattering particles
  - The process is handled statistically; particles are not physically present in the model
  - Absorbing sides are used on the atmosphere block to enhance ray trace efficiency
- The density and size of the precipitation droplets can be freely adjusted



Return Values for Various Atmospheric Conditions