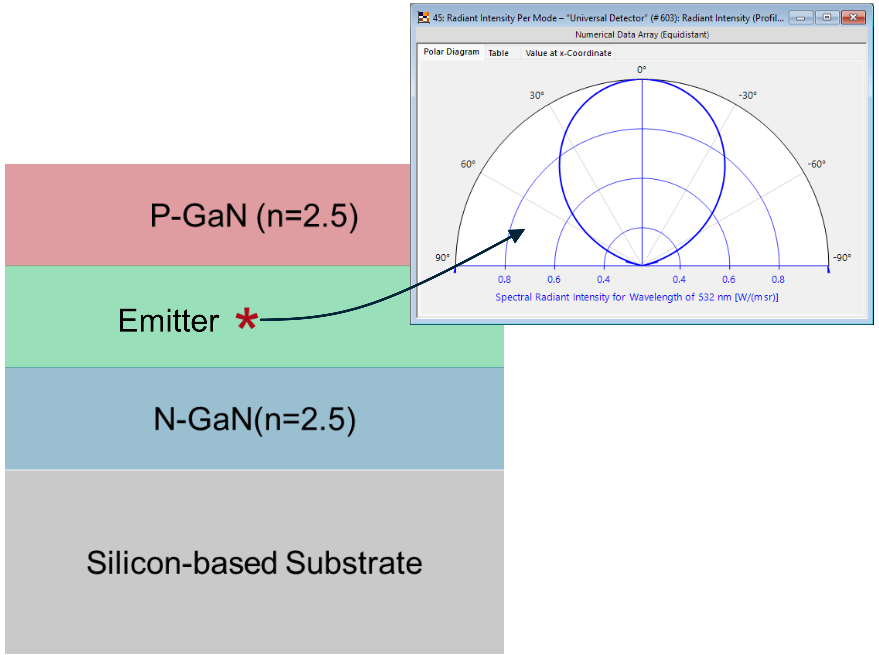
Basic structure-based source model for an OLED

Part I: Emitter Mode Selection

Optimized version with lower CPU usage coming soon!

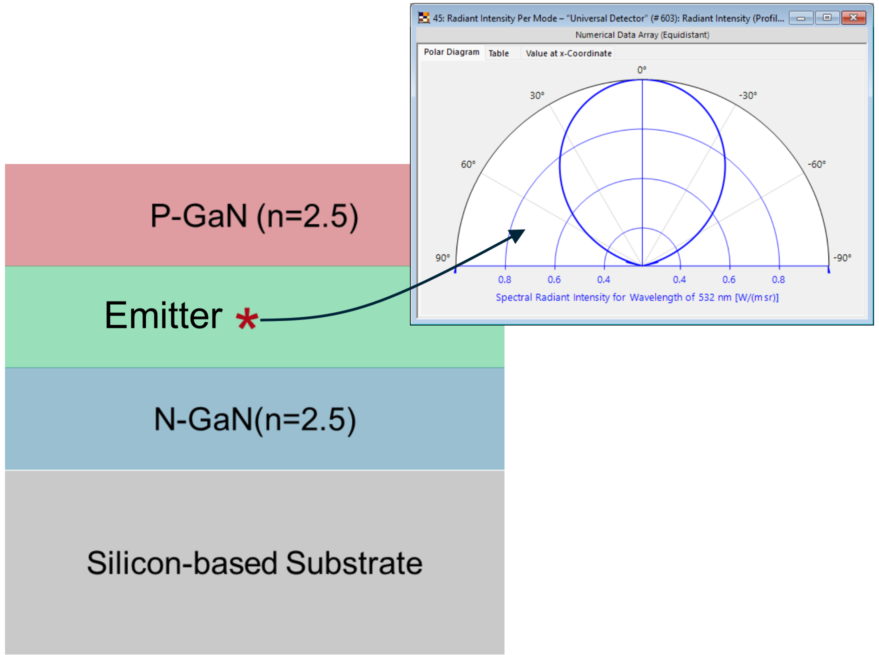
Structure-Based Source Modeling in Virtuallab Fusion

- Traditionally, source models in VirtualLab Fusion have been function-based, representing light emission by assuming specific analytical modes, such as a Gaussian beam for a laser or Lambertian modes for an extended source.
- We are now beginning to introduce a more powerful paradigm: structure-based source modeling. This technique derives the emitted light not from analytical assumptions, but from the physical source structure itself.
- This approach calculates the emitted light by, for example, simulating a laser resonator, calculating the eigenmodes of a waveguide, or by placing fundamental emitters like dipoles inside the source structure and simulating the resulting light output.
- In this first use case, we launch this initiative by demonstrating a basic structure-based source model for an OLED.
- This is the first step in building a comprehensive new library of digital twins that will seamlessly integrate into optical system modeling across all scales.



Structure-Based Source Model for an OLED

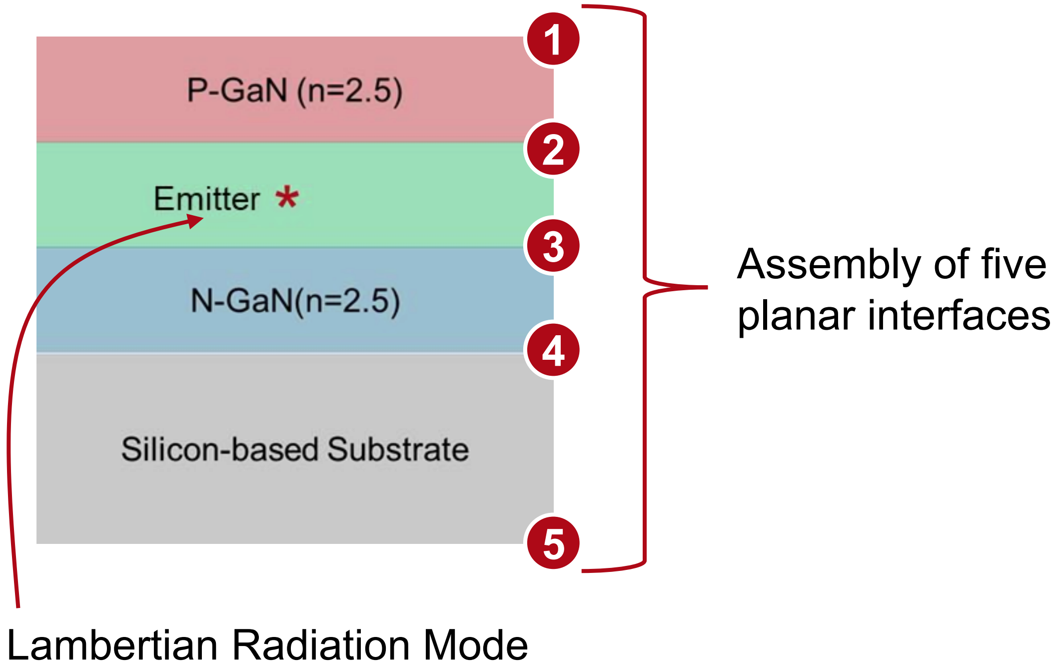
- An accurate structure-based model for an Organic Light-Emitting Diode (OLED) must fundamentally capture the interaction between the emitters within the emitting layer and the surrounding thin-film layers of the device stack.
- To achieve this, a comprehensive model must account for the following key aspects:
  1. **Emitter Mode Selection:** The choice of emitter modes to correctly represent the unpolarized nature of the intrinsic light emission.
  2. **Emission Characteristics:** The spatial extent and geometry of the emitting area within the layer.
  3. **Spectral Properties:** The effects of chromatic dispersion and the limited temporal coherence of the emitted light.
- This document begins to showcase the structure-based OLED modeling capabilities of VirtualLab Fusion through a series of use cases addressing the aforementioned topics.



- The inclusion of complex three-dimensional (3D) pixel geometries, such as sidewalls, is identified as a direction for future research into advanced structure-based OLED digital twins.

Structure-Based Source Model for an OLED: Emitter Mode

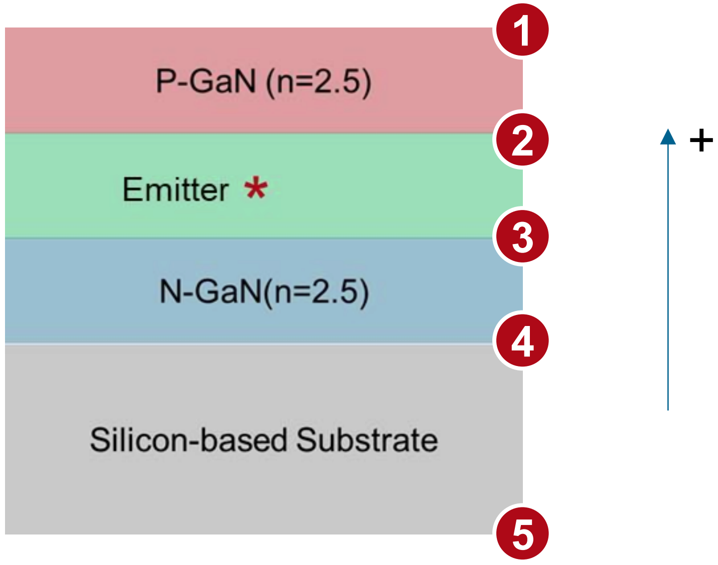
- This use case specifically addresses the first requirement: the selection of appropriate emitter modes, following the theoretical framework established in [1].
- Based on this theory, we define an unpolarized Lambertian electromagnetic mode, which is implemented as the function-based *Lambertian Radiation Mode* in VirtualLab Fusion.
- This source is positioned within the emitting layer of the OLED stack.
- The multilayer stack itself can be constructed in two ways:
  - Using two *Stratified Media Components* to sandwich the emitting layer.
  - Alternatively, assembling the entire structure as a sequence of *Planar Interface Components*. This approach is selected here, as it provides deeper insight into non-sequential modeling and offers greater flexibility for modeling temporal coherence (see the related use case).



[1] Tervo, J., Turunen, J., Vahimaa, P., Wyrowski, F., 2010. Shifted-elementary-mode representation for partially coherent vectorial fields. J. Opt. Soc. Am. A 27, 2004.

Structure-Based Source Model for an OLED: Non-sequential

- Each *Planar Interface Component* features four modeling channels (++, +-, –, -+) that adhere to the standard S-matrix convention. These channels can be individually opened or closed.
- By selectively opening these channels, the influence of the thin-film stack on the final light distribution can be thoroughly investigated.
- Light detection and analysis are performed using both an *Irradiance Detector* and a *Radiant Intensity Detector*.



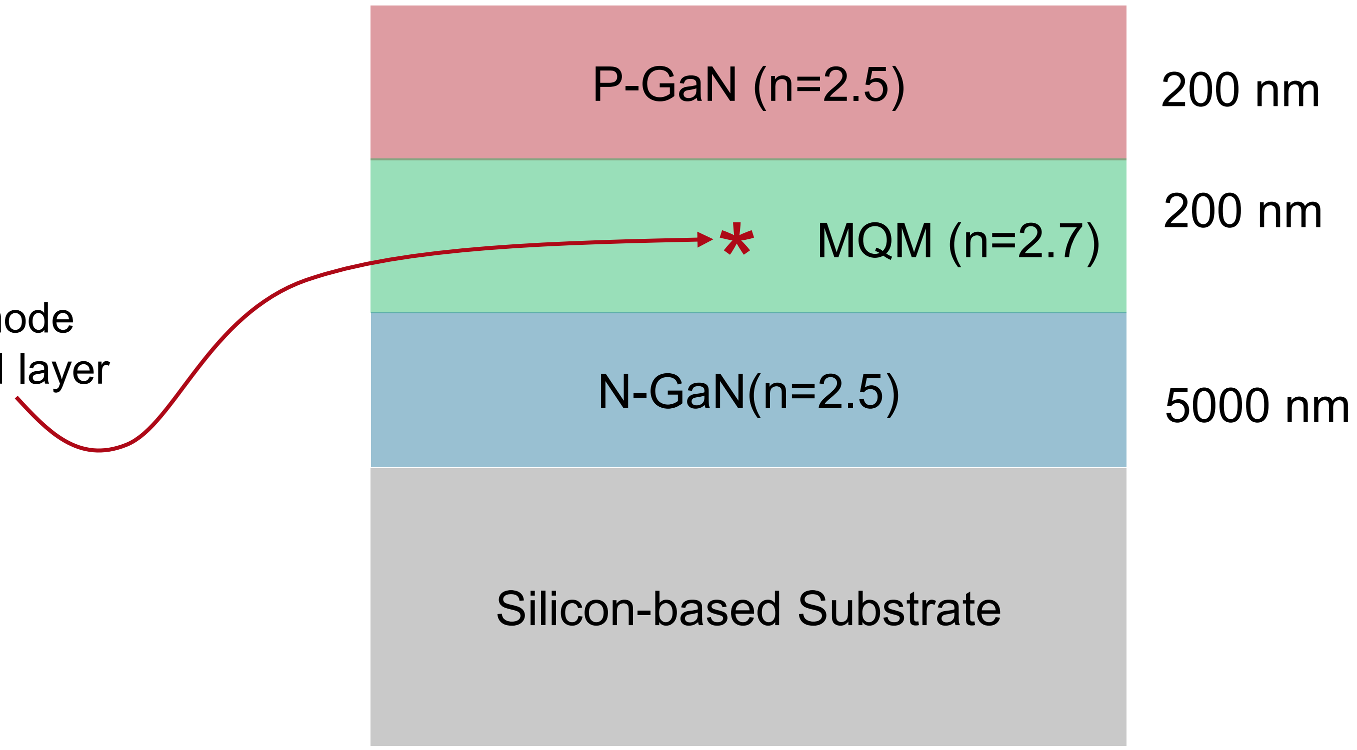
Interface	+/+	+/-	-/-	-/+
1			x	x
2				
3				
4				
5	x	x		

Channels available for selection to control non-sequential modeling.

Application Scenario

Application Scenario: Structure-Based Source Model

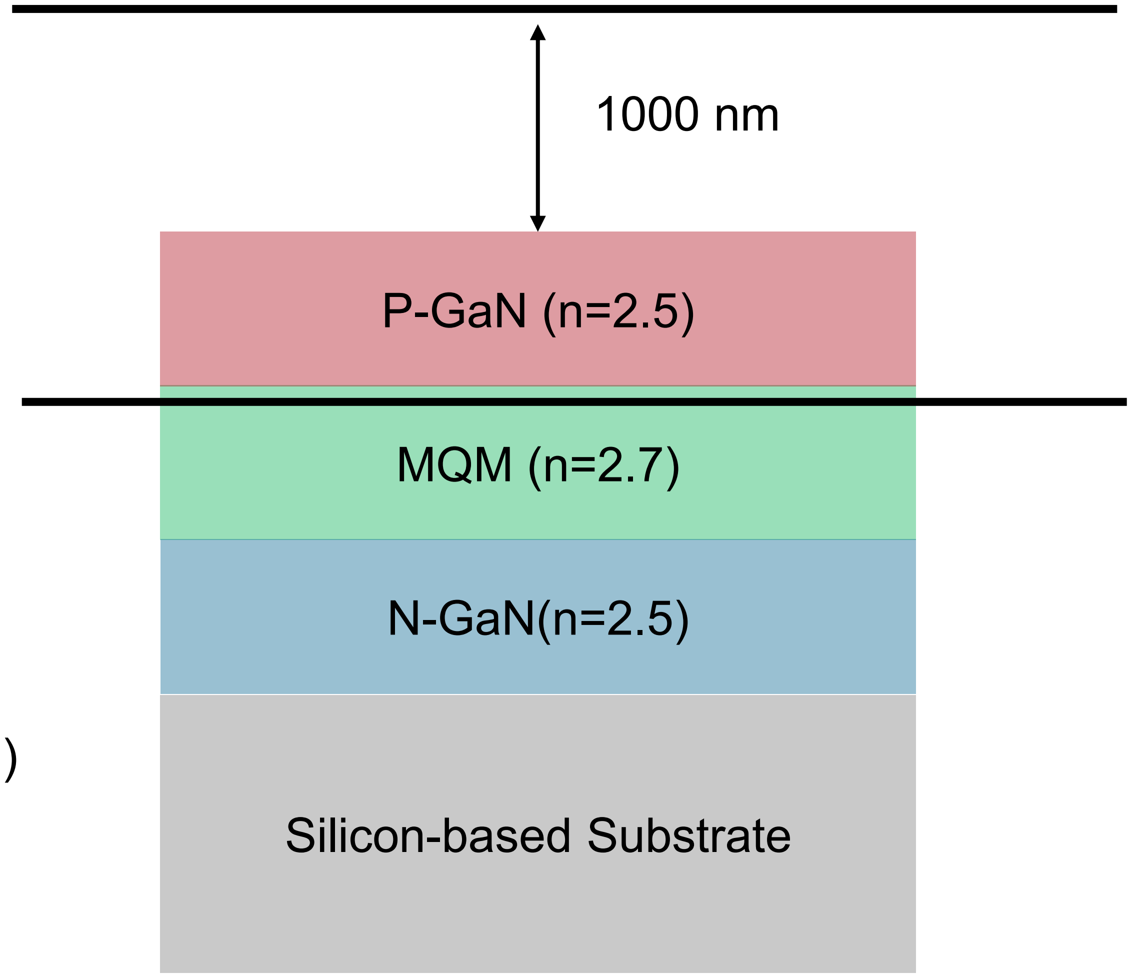
Source (*)
- Lambertian radiation mode
- Positioned inside MQM layer



Application Scenario: Task

Detector 2
- Irradiance
- Radiant intensity

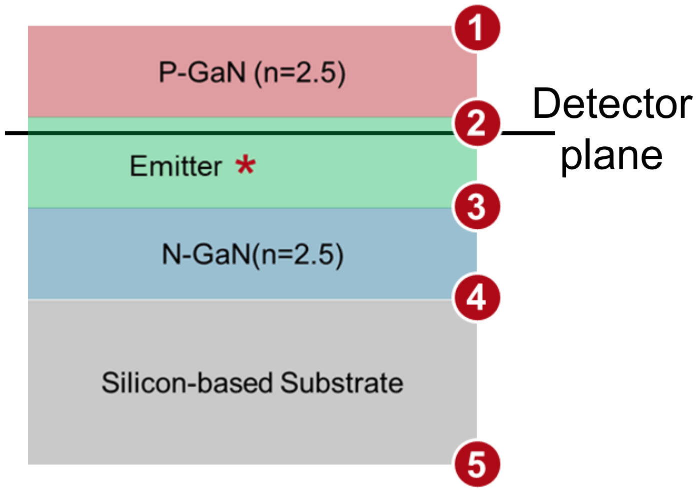
Detector 1
- Irradiance
- Radiant intensity



Task: Calculate irradiance and radiant intensity inside (detector 1) and outside of the structure (detector 2).

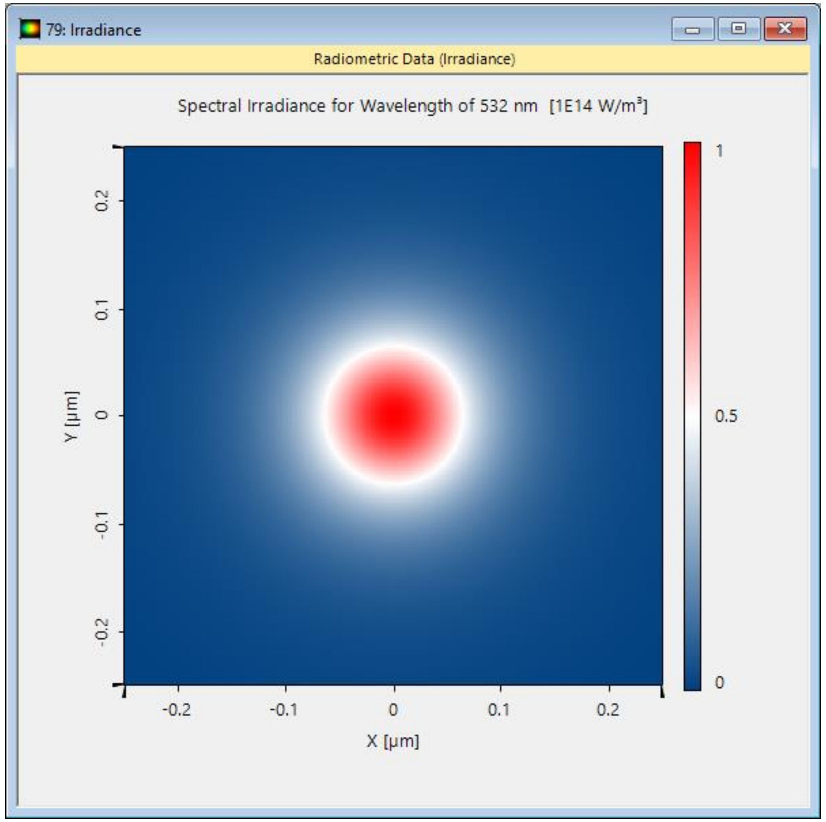
Simulation Results

Results Inside Structure without Multiple Internal Reflections

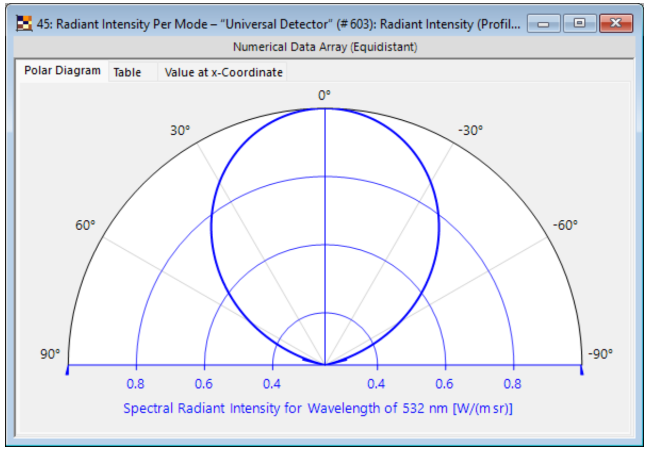


Interface	+/+	+/-	-/-	-/+
1	✓	X	X	X
2	✓	X	X	X
3	X	X	X	X
4	X	X	X	X
5	X	X	X	X

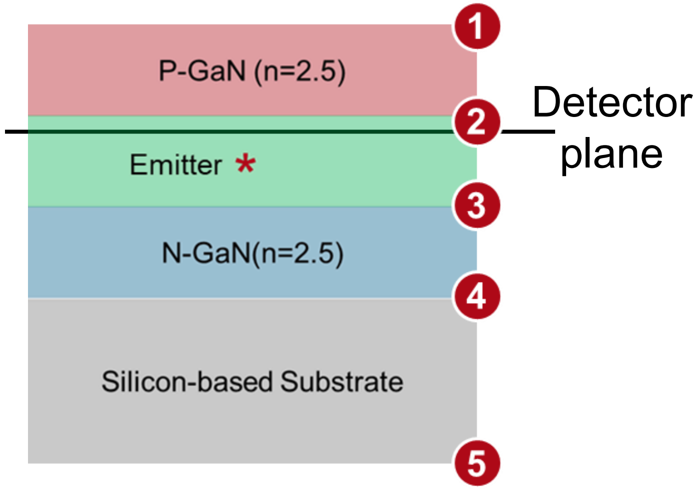
Irradiance



Radiant intensity

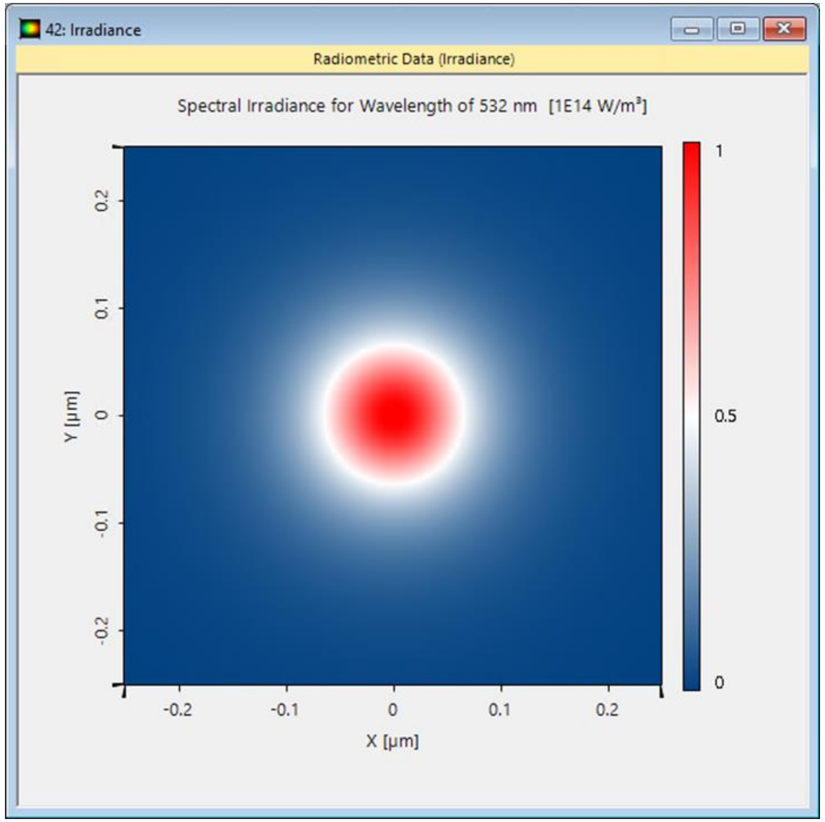


Results Inside Structure with Multiple Internal Reflections

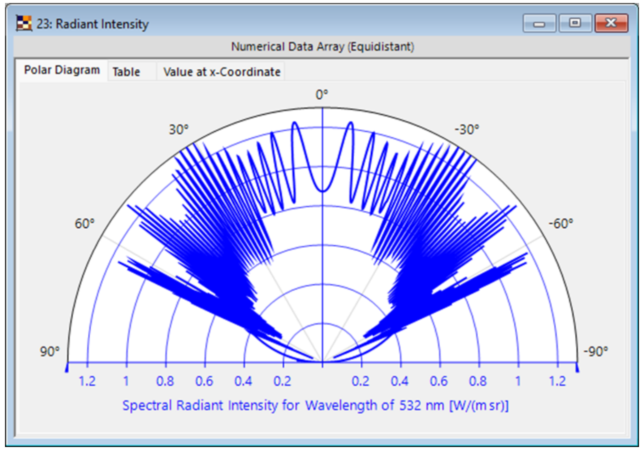


Interface	+/+	+/-	-/-	-/+
1	✓	✓	X	X
2	✓	✓	✓	✓
3	✓	✓	✓	✓
4	✓	✓	✓	✓
5	X	X	✓	✓

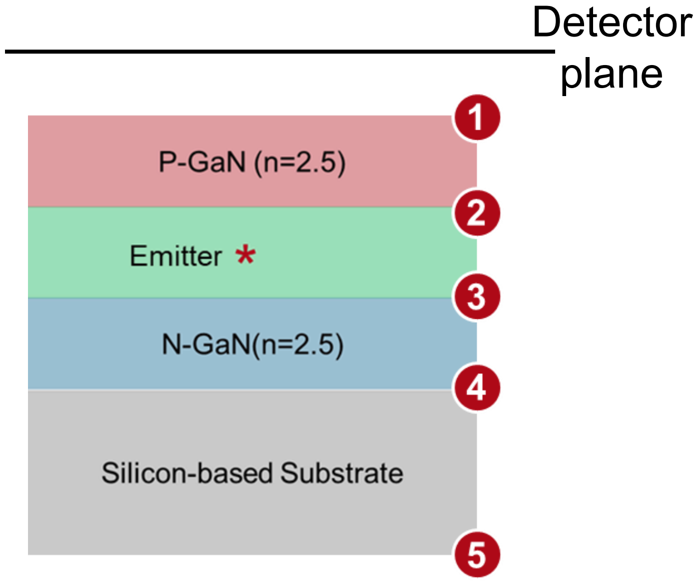
Irradiance



Radiant intensity

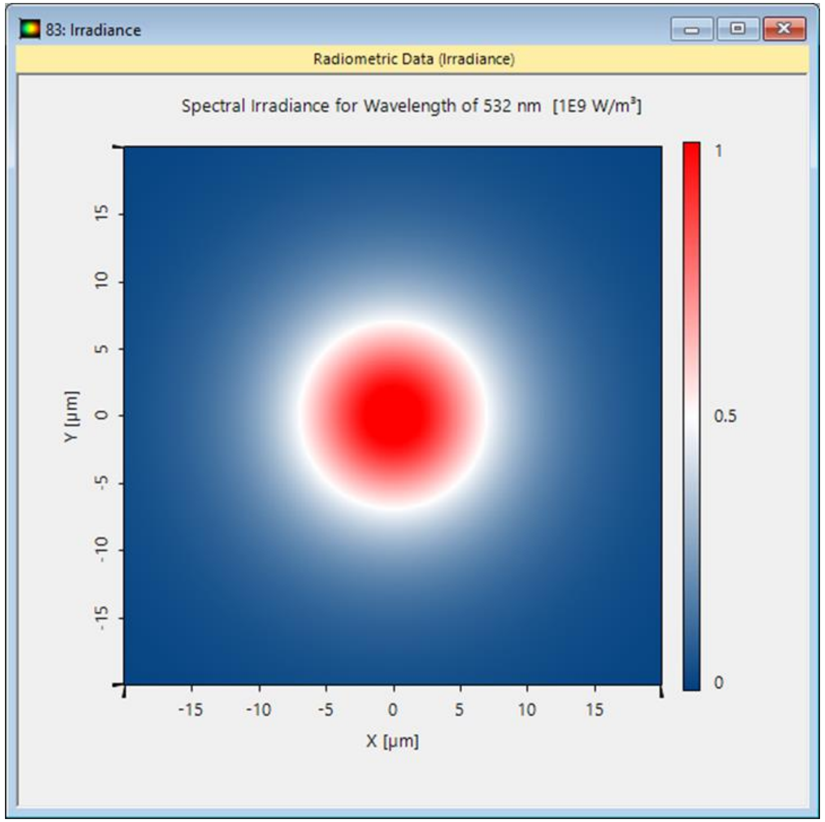


Results Outside Structure without Multiple Internal Reflections

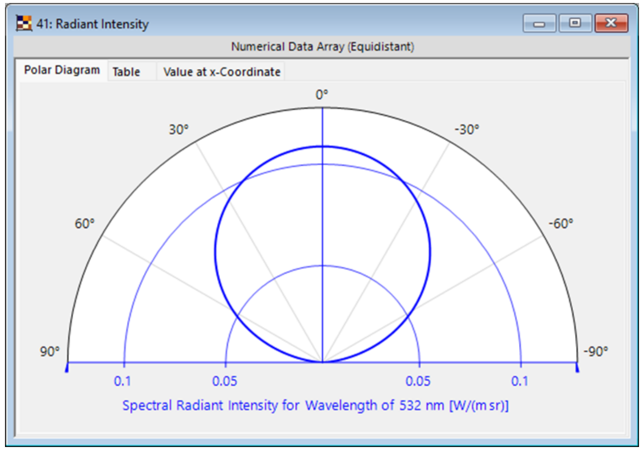


Interface	+/+	+/-	-/-	-/+
1	✓	X	X	X
2	✓	X	X	X
3	X	X	X	X
4	X	X	X	X
5	X	X	X	X

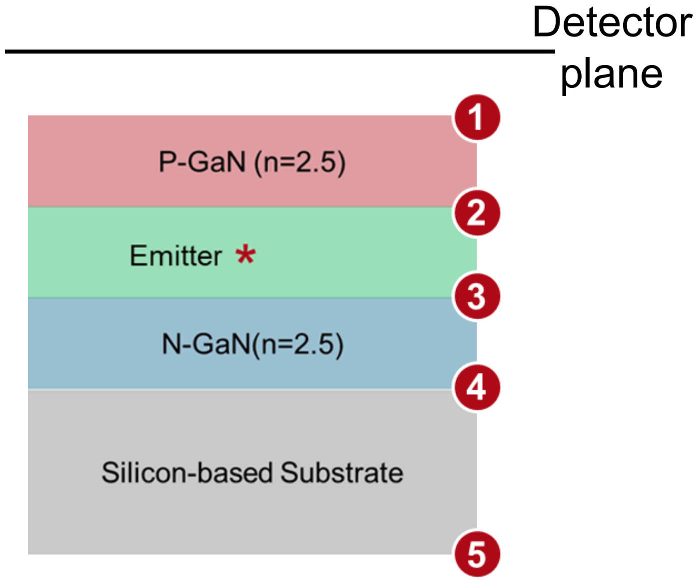
Irradiance



Radiant intensity

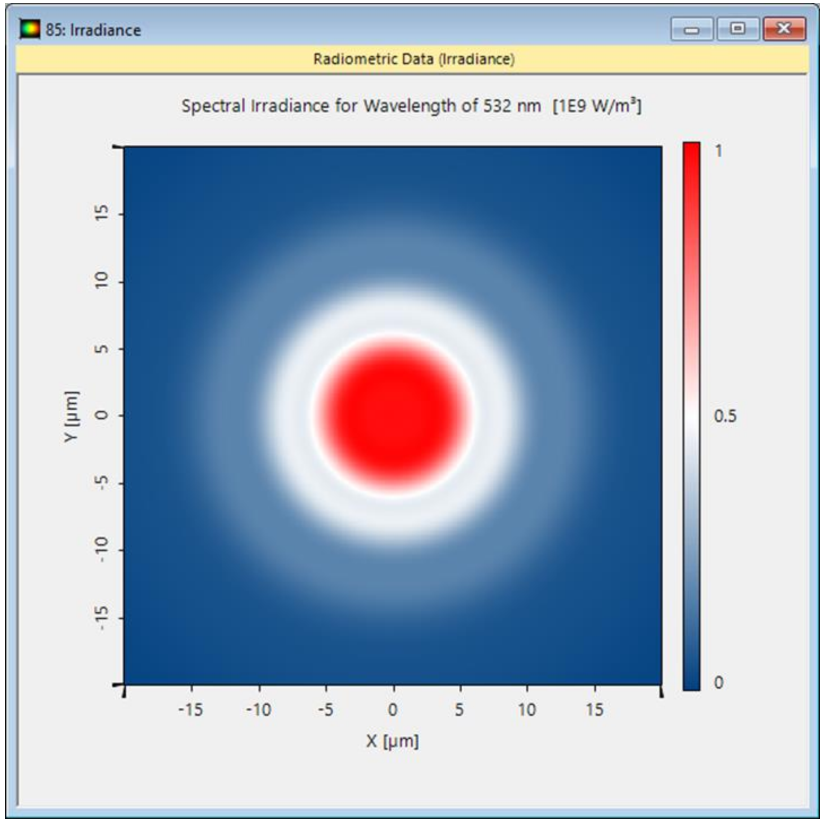


Results Outside Structure with Multiple Internal Reflections

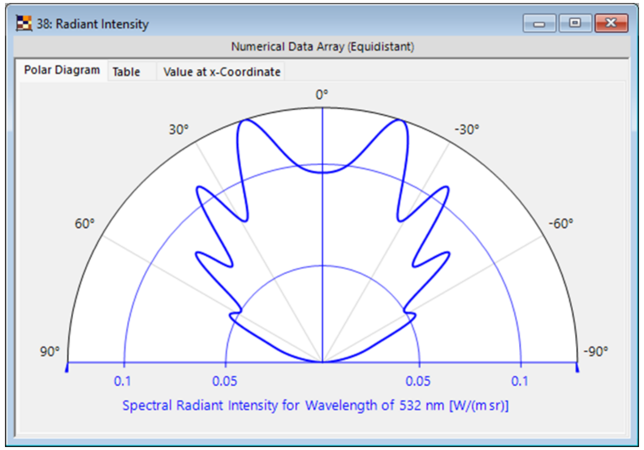


Interface	+/+	+/-	-/-	-/+
1	✓	✓	X	X
2	✓	✓	✓	✓
3	✓	✓	✓	✓
4	✓	✓	✓	✓
5	X	X	✓	✓

Irradiance



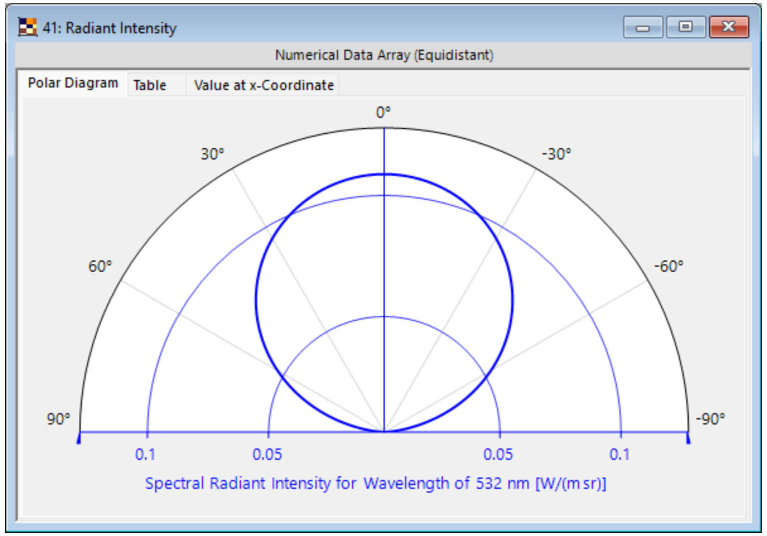
Radiant intensity



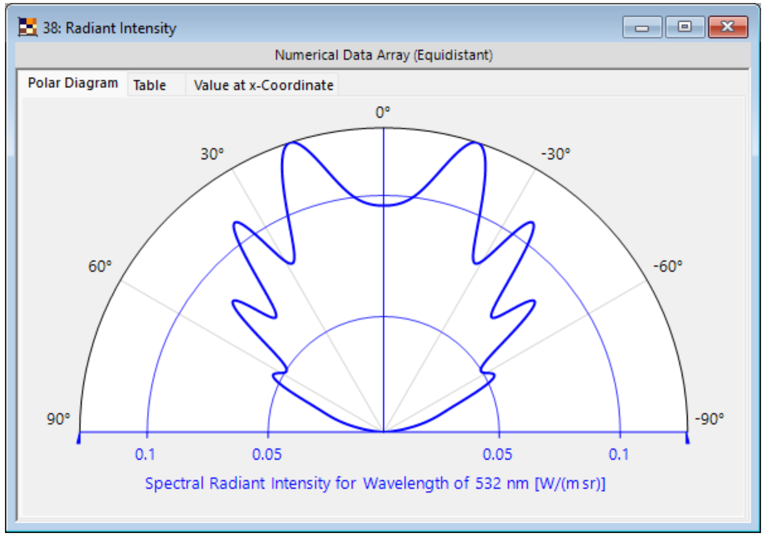
Conclusion

- Without internal multi-reflections, the Lambertian mode largely preserves its overall shape.

- Including them introduces strong interference patterns at the detector plane. Thought it has to be mentioned, that this results from the use of a monochromatic source with infinite coherence length. With finite bandwidth, these effects may disappear – a topic addressed in the next use case of this series.



Radiant intensity outside structure without consideration of multi-reflections.



Radiant intensity outside structure with consideration of multi-reflections.

Workflow Steps

Basic Workflow Steps

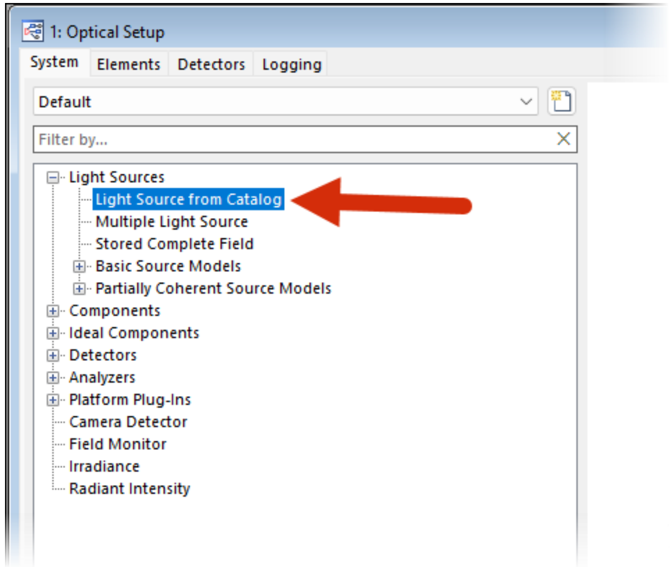
Source selection

System setup

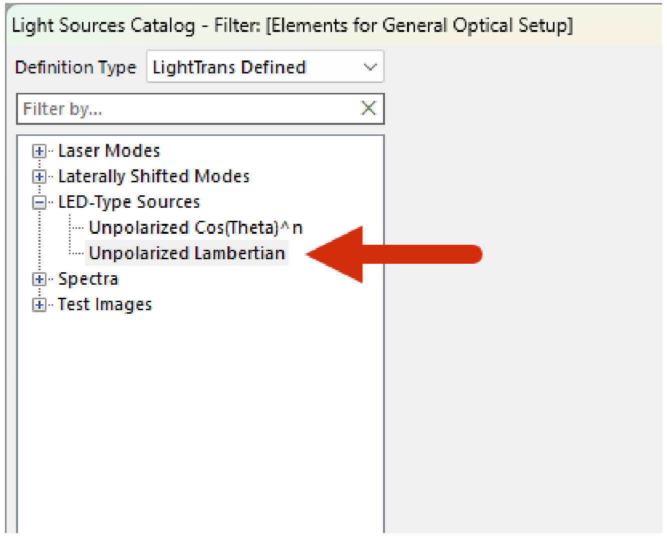
Detector selection

Getting it done in VirtualLab Fusion:

- Load *Lambertian Radiation Mode* from our source catalog



Optical setup



Source catalog

Basic Workflow Steps

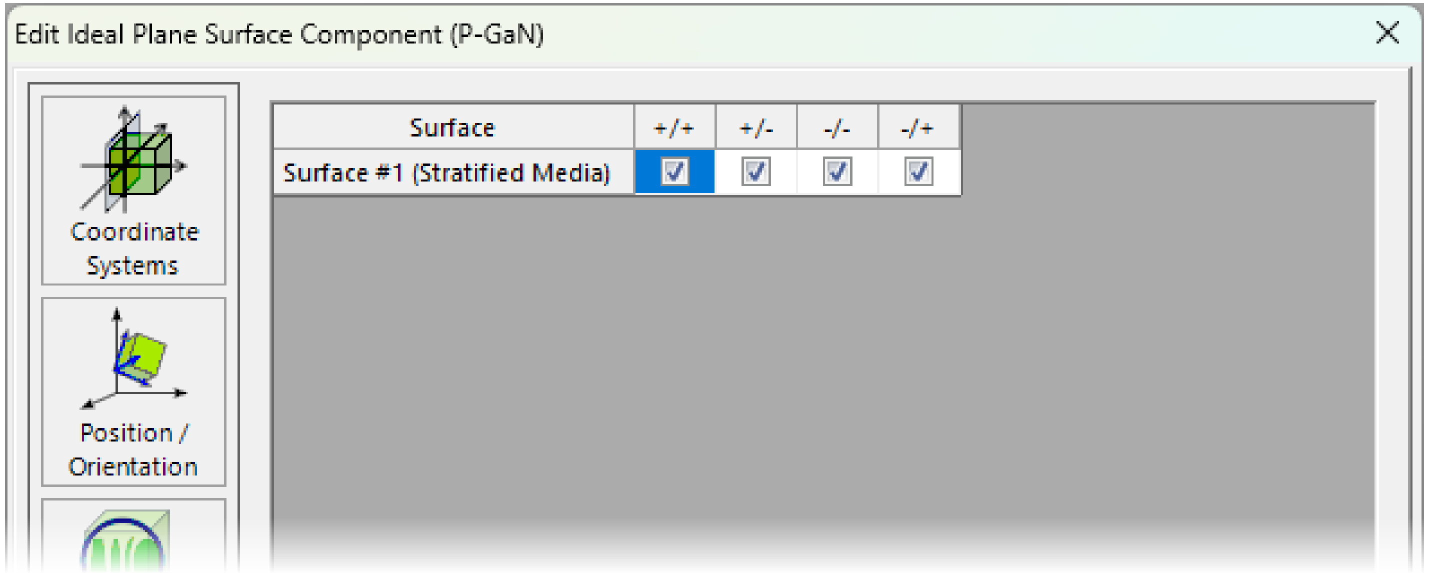
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Channel configuration for surfaces and grating regions



Basic Workflow Steps

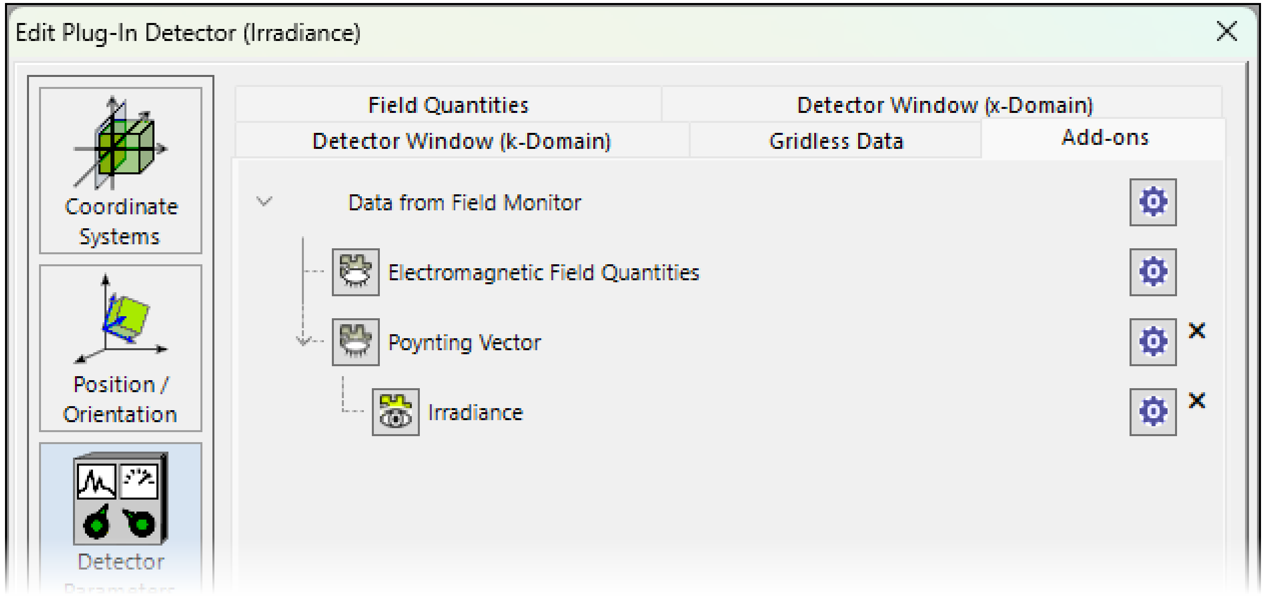
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Irradiance Detector
- Radiant Intensity Detector



Detector add-on selection

Document Information

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Category	Use Case
Further reading	

** The files attached to this document require the specific version or later.*