Off-axis integrating-sphere-based InGaAs radiometer

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Objectives

1. Develop a high-throughput integrating sphere receiver-based InGaAs radiometer
2. Achieve Si-trap type spatial and angular uniformity
3. Explore use of tilted-geometry spheres as radiance sources

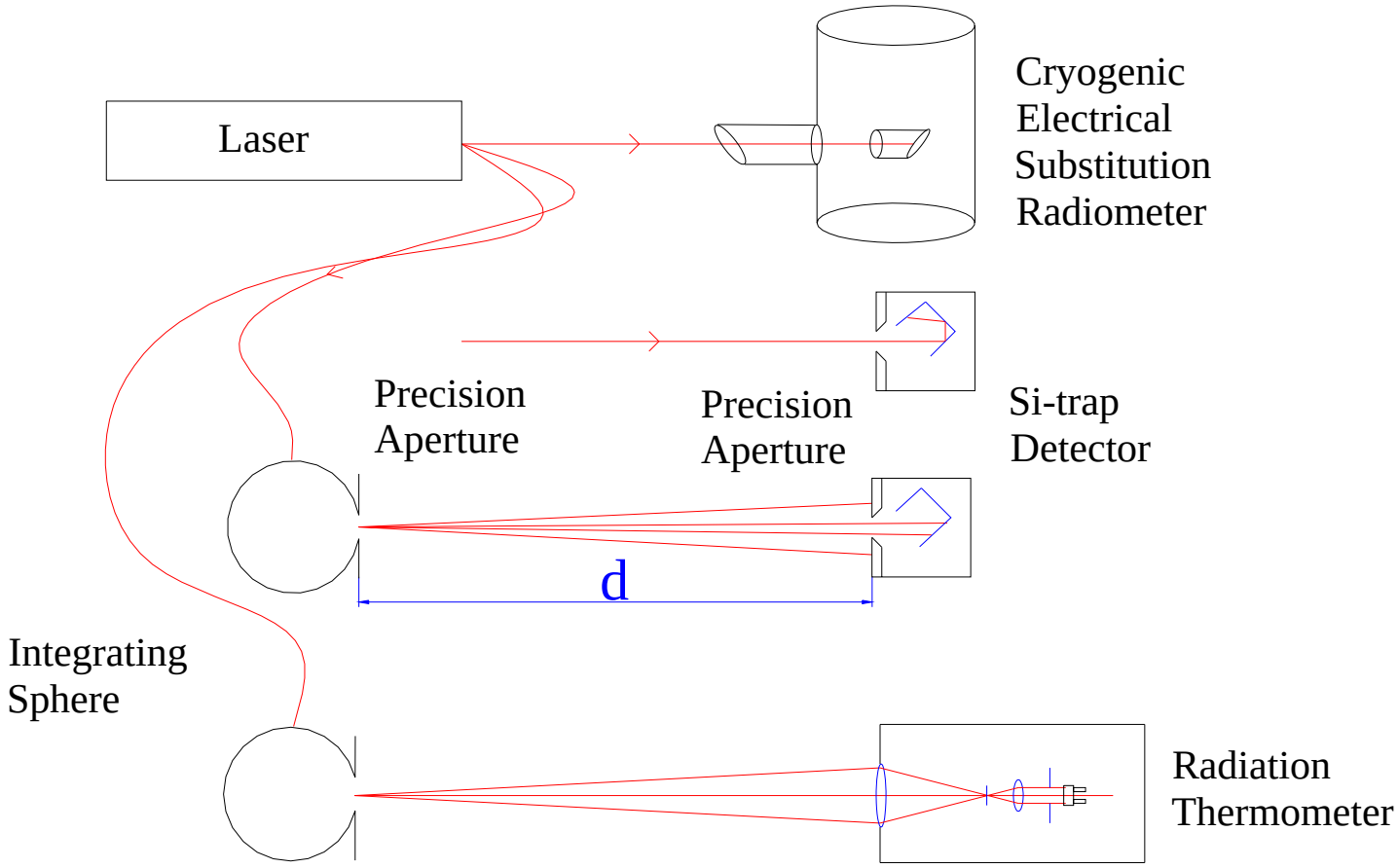
Ultimate Goal:

Development of compact integrating sphere designs which are spatially uniform and lambertian for use in sources and receivers.

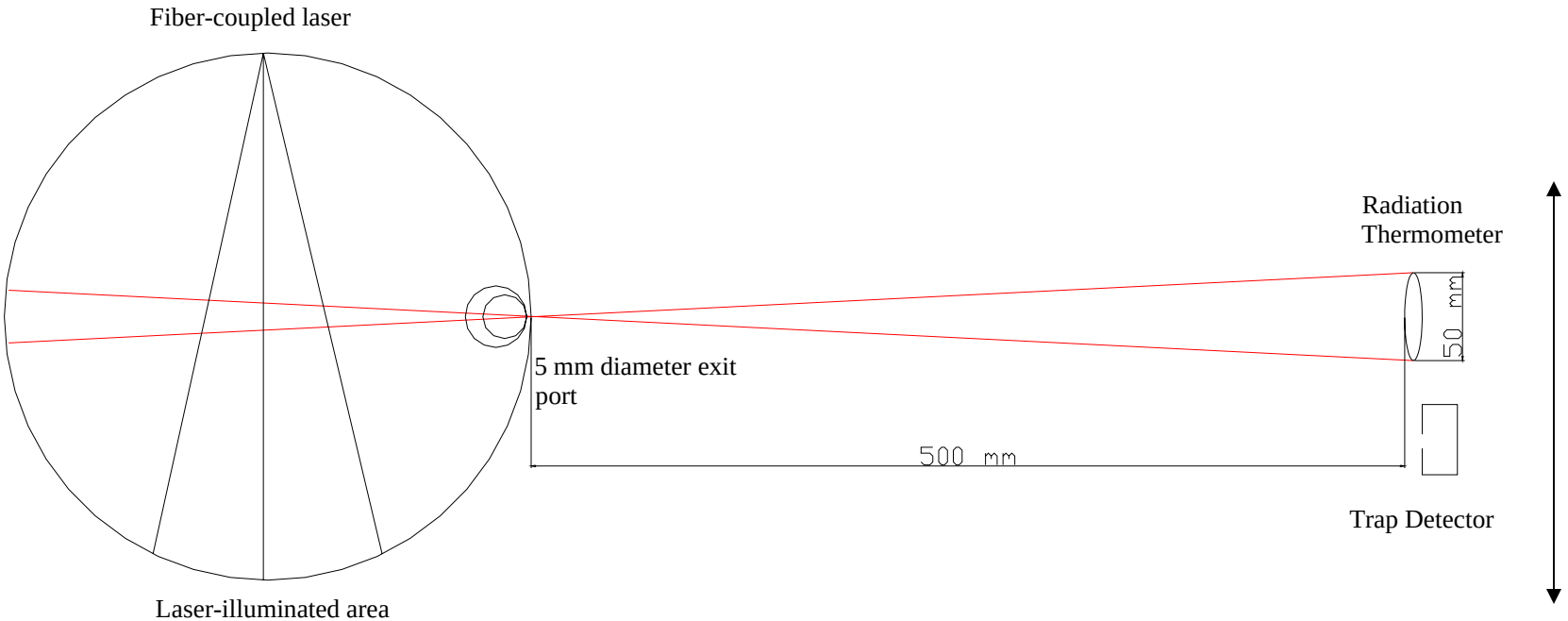
Outline

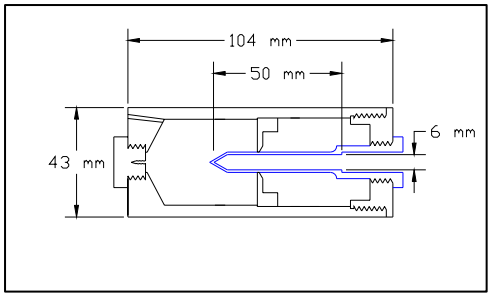
1. Spatial and angular uniformity of integrating sphere sources
2. Development of integrating sphere-based InGaAs radiometers for radiometric scale realizations
   A. Need for equivalents of Si-trap detectors in the infrared
   B. Use in fiber power measurements
   C. Use in realization of radiometric scales
3. Impact on integrating sphere sources

Detector-based temperature realization



Geometry of laser-irradiated spheres in SIRCUS (reproducing the fixed-point blackbody)

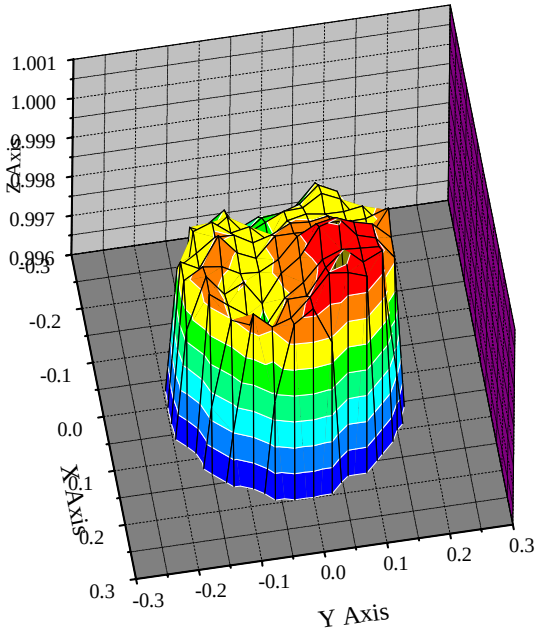




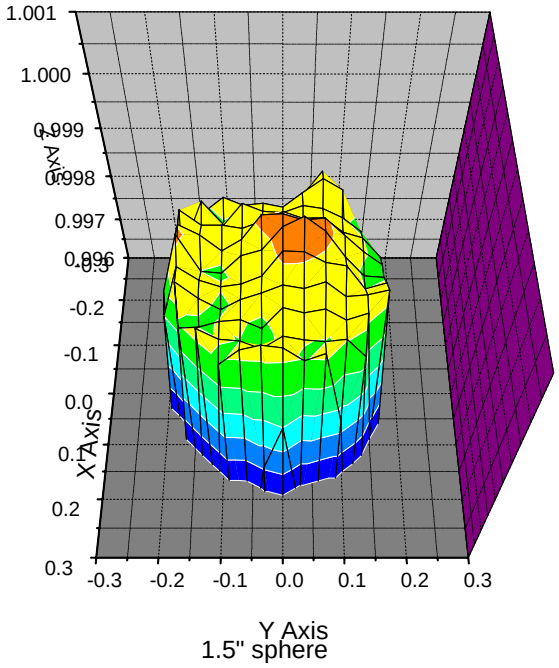
All spheres have machined, sintered PTFE interiors

SIRCUS spheres and their spatial uniformities (achieving 0.01 % transfer uncertainty ?)

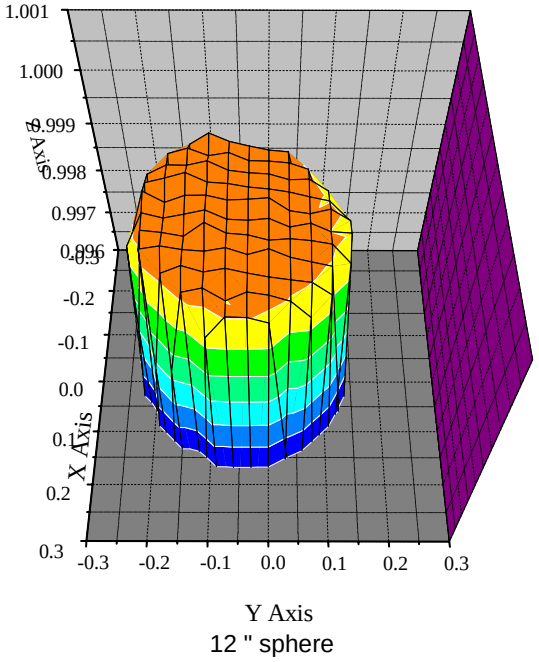
25 mm



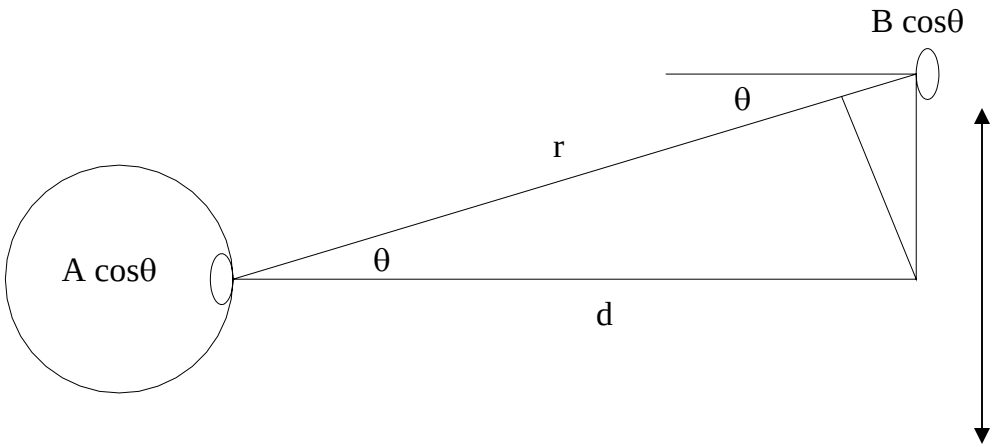
38 mm



305 mm



$\cos^4\theta$ dependence for lambertian sources



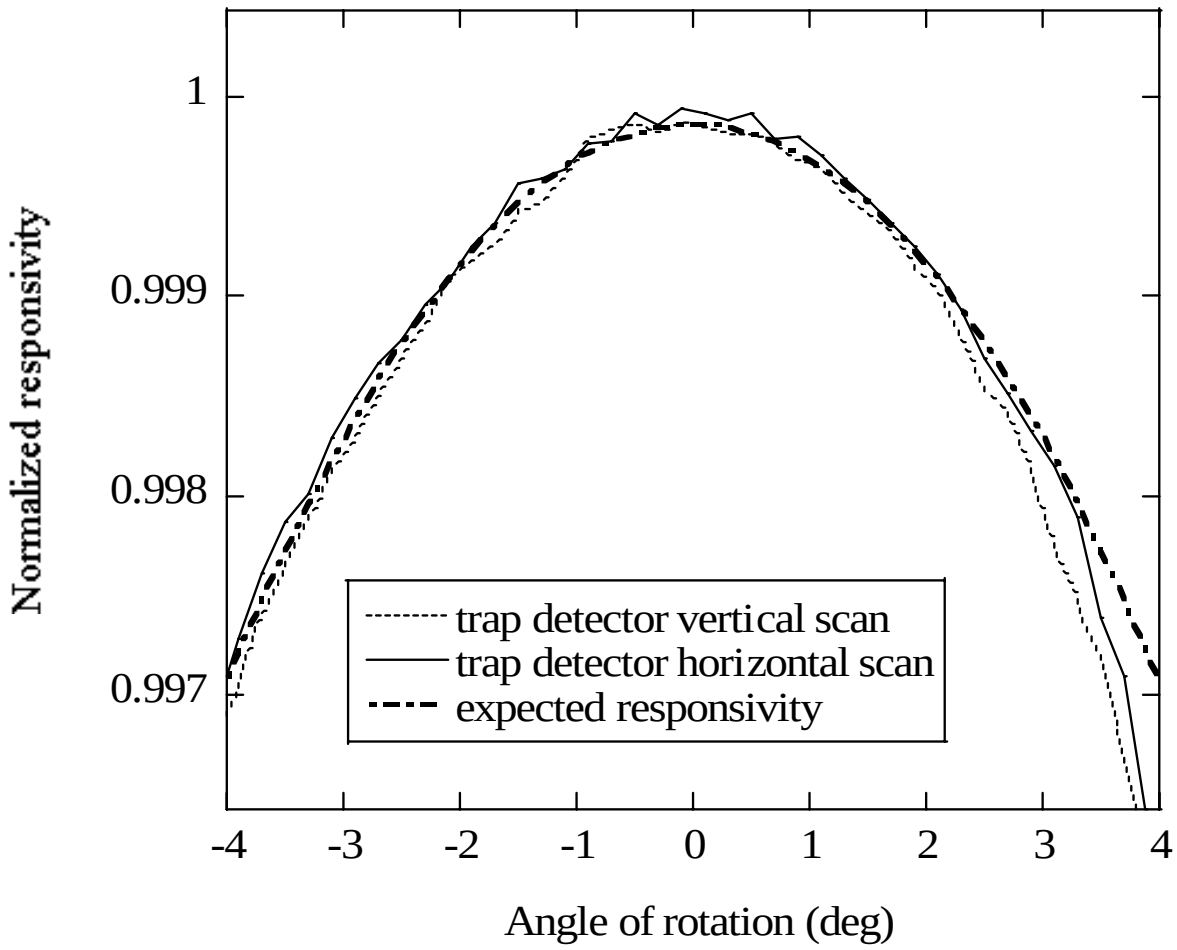
$$d = r\cos\theta$$

$$\frac{\cos^2\theta}{d^2} = \frac{1}{r^2}$$

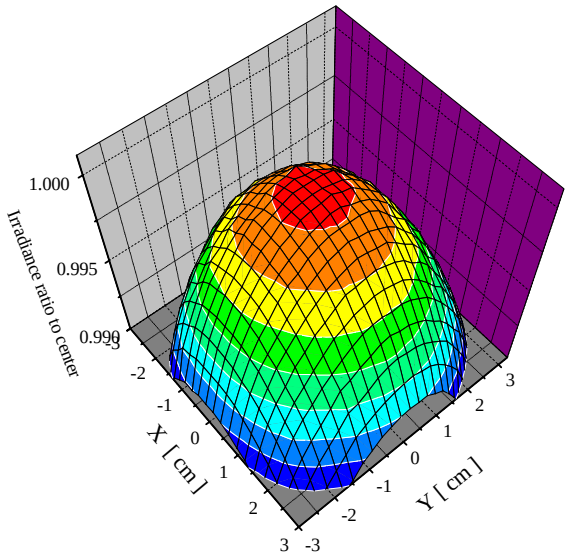
Lambertian source has irradiance out - of - plane dependence of

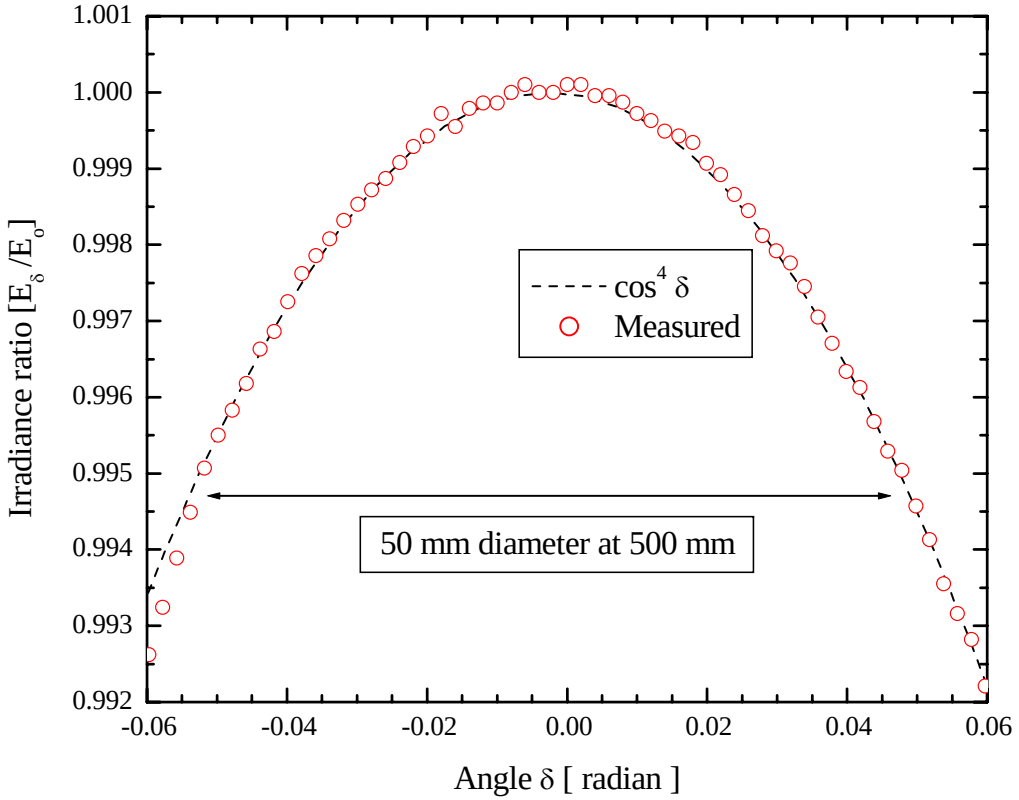
$$E(r) = E(d)\cos^4\theta$$

Angular responsivity of the tunnel-trap detector



Angular $\cos^4$ output of the NIST 308 mm diameter integrating sphere

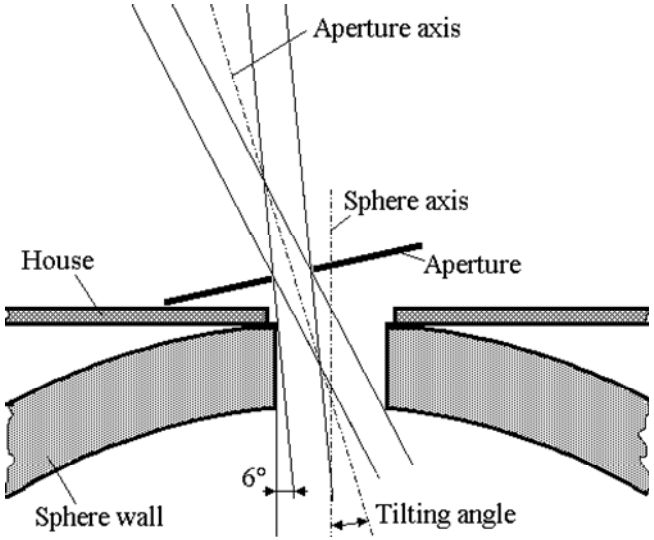


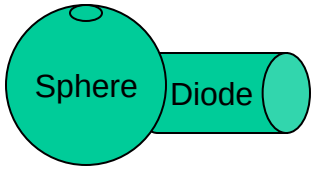


Development of sphere-based radiometers

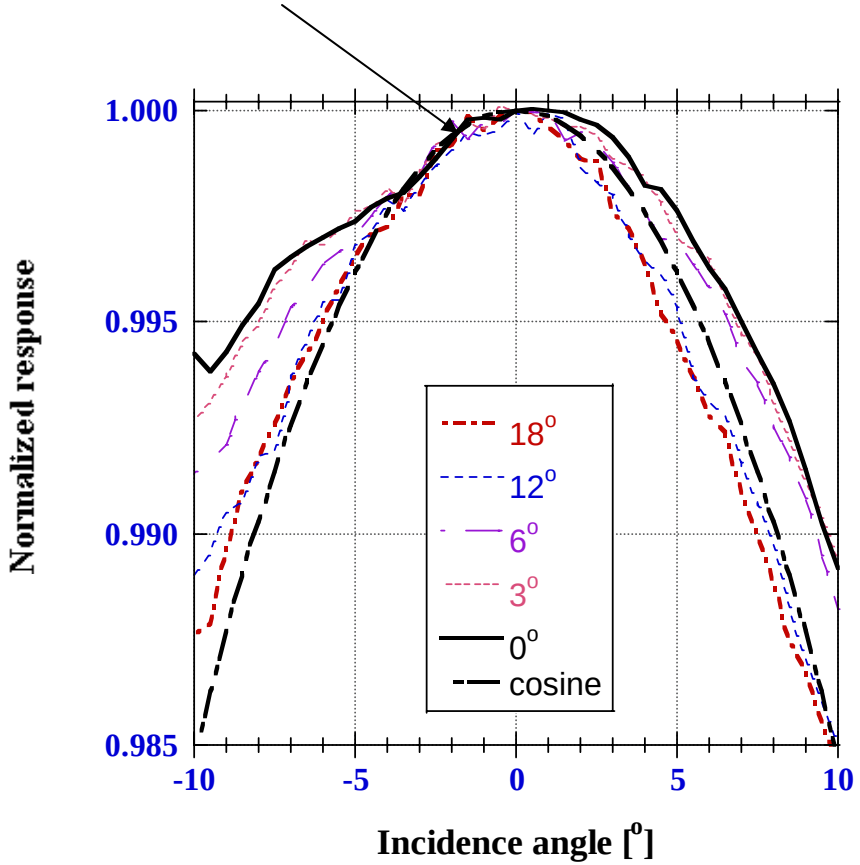
1. Angular- and spatial-dependent responsivities of a symmetric, single-detector-based sphere radiometer
2. Design, development and characterization of a 4-detector asymmetric sphere radiometer

Tilt dependence of input aperture

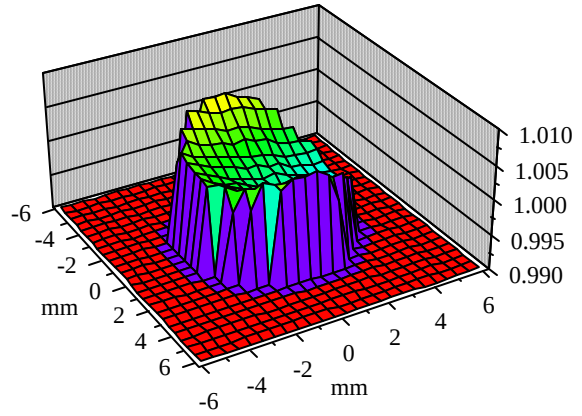


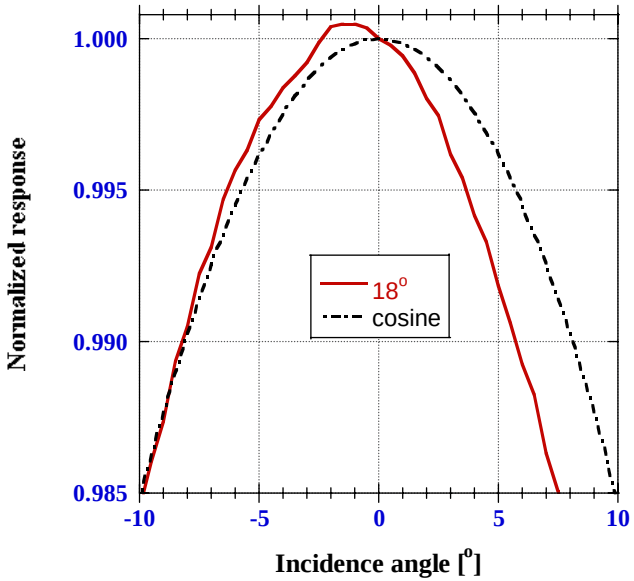


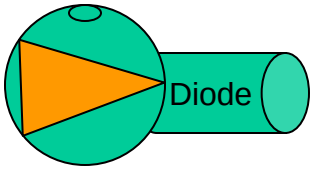
Flattened top at 0 deg due to back reflection from PTFE



Single detector leads to asymmetry of the spatial and angular responsivity

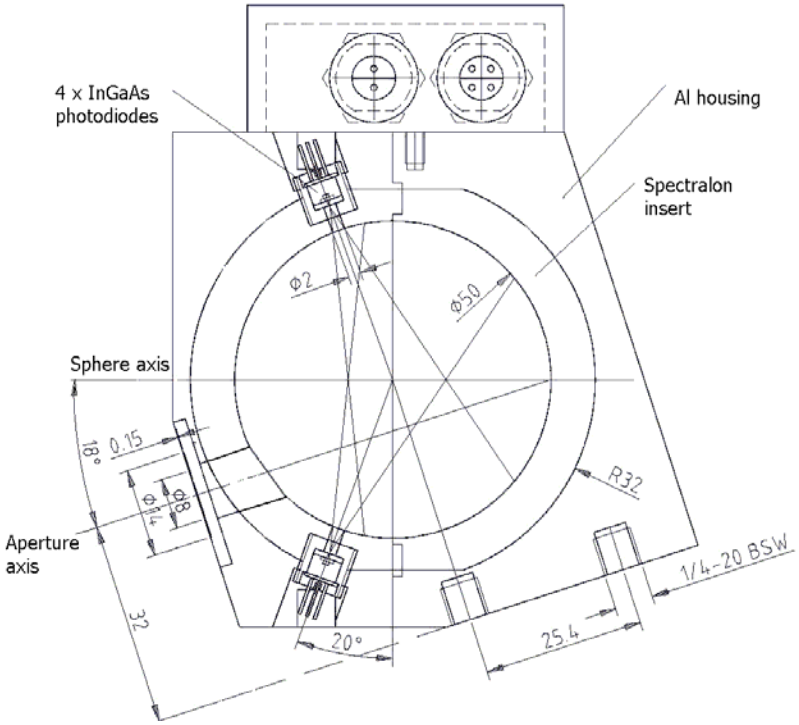






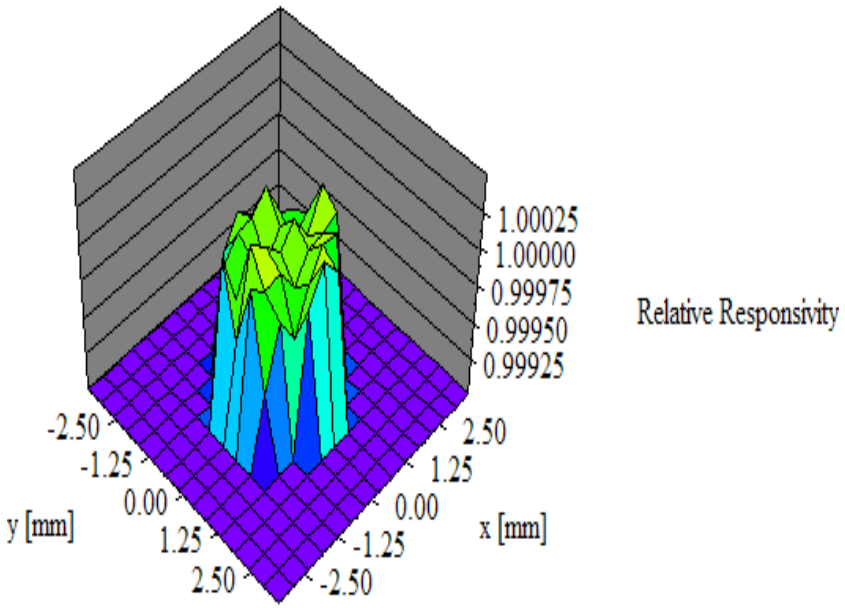
Flattened top is gone but now there is asymmetry

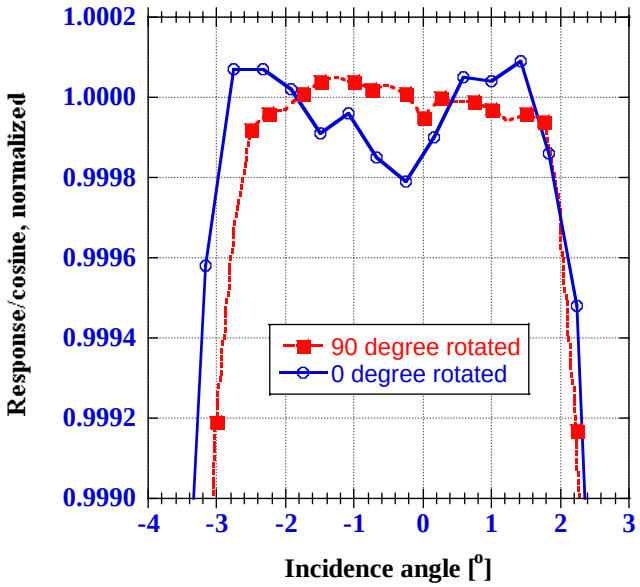
Design and physical realization of 4 detector integrating sphere radiometer



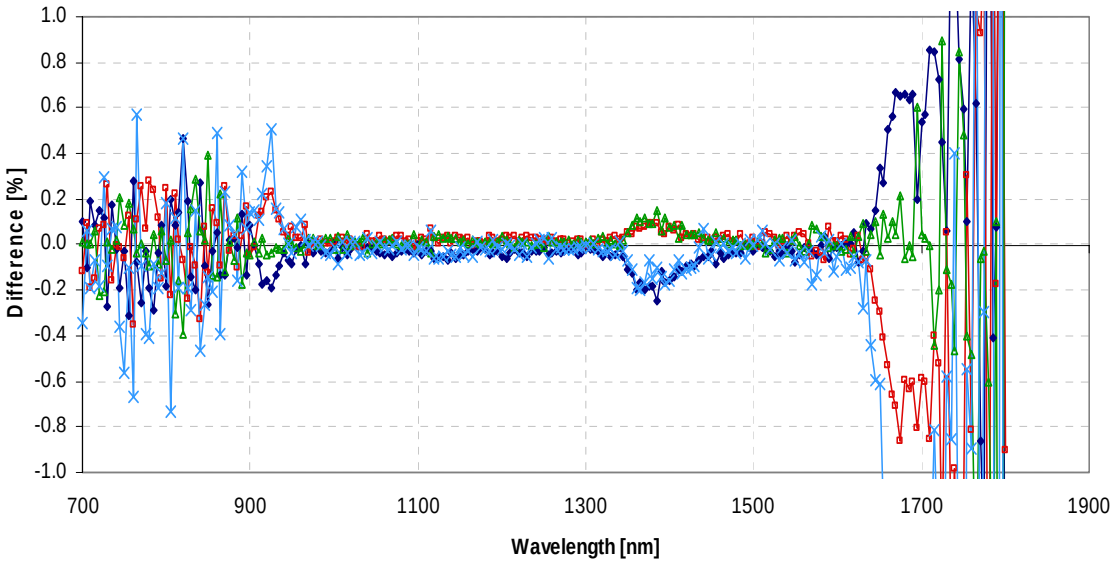
Two more detectors in-plane and out-of-plane

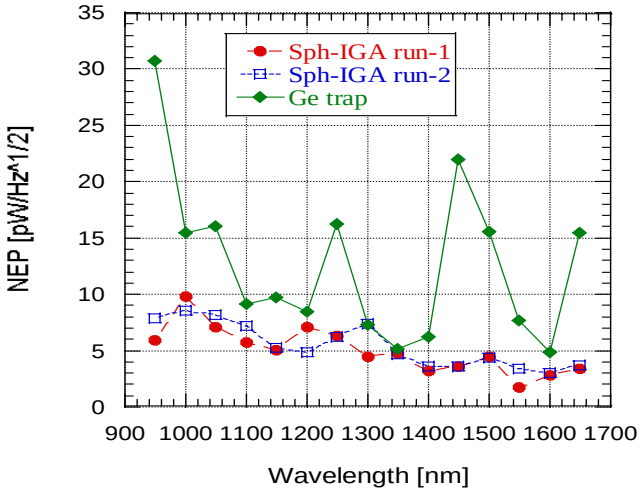
Spatial and angular uniformity of InGaAs radiometer



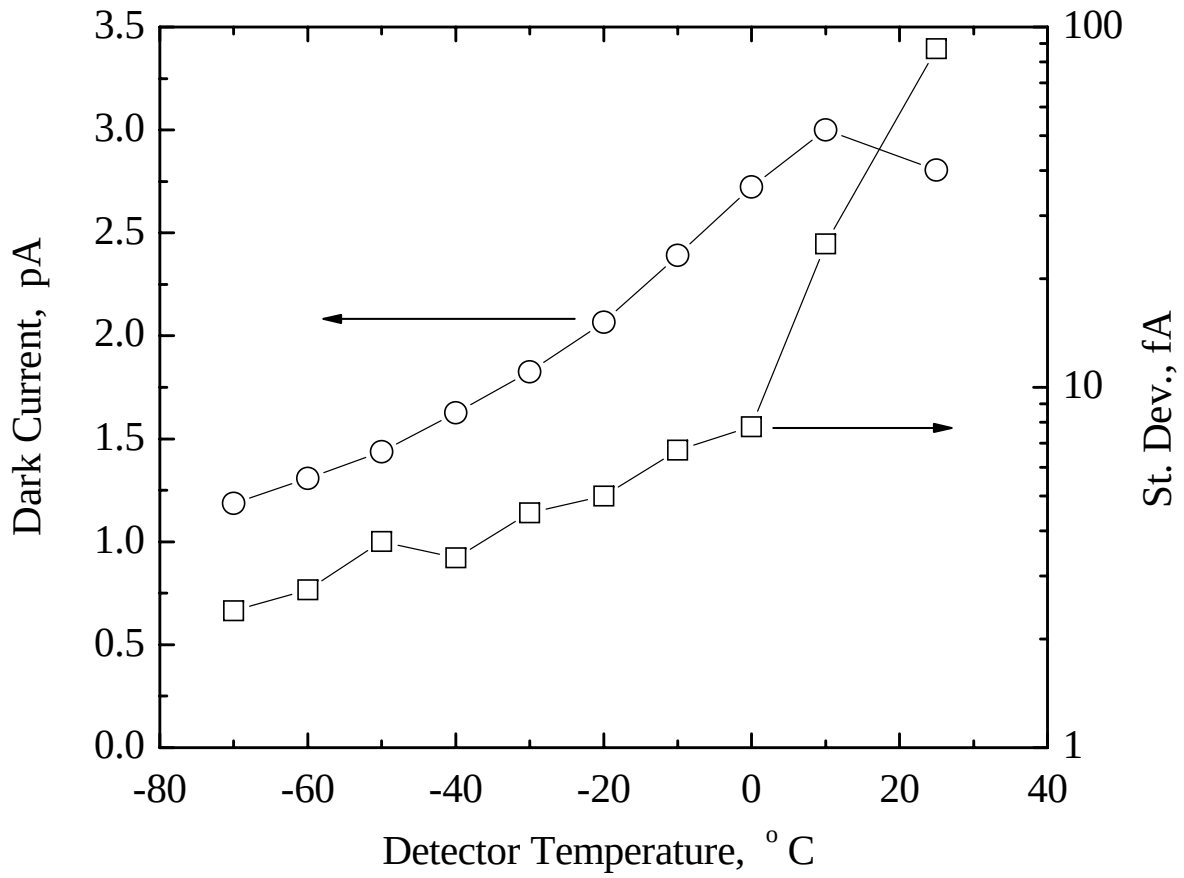


Spectral power responsivity of InGaAs radiometer

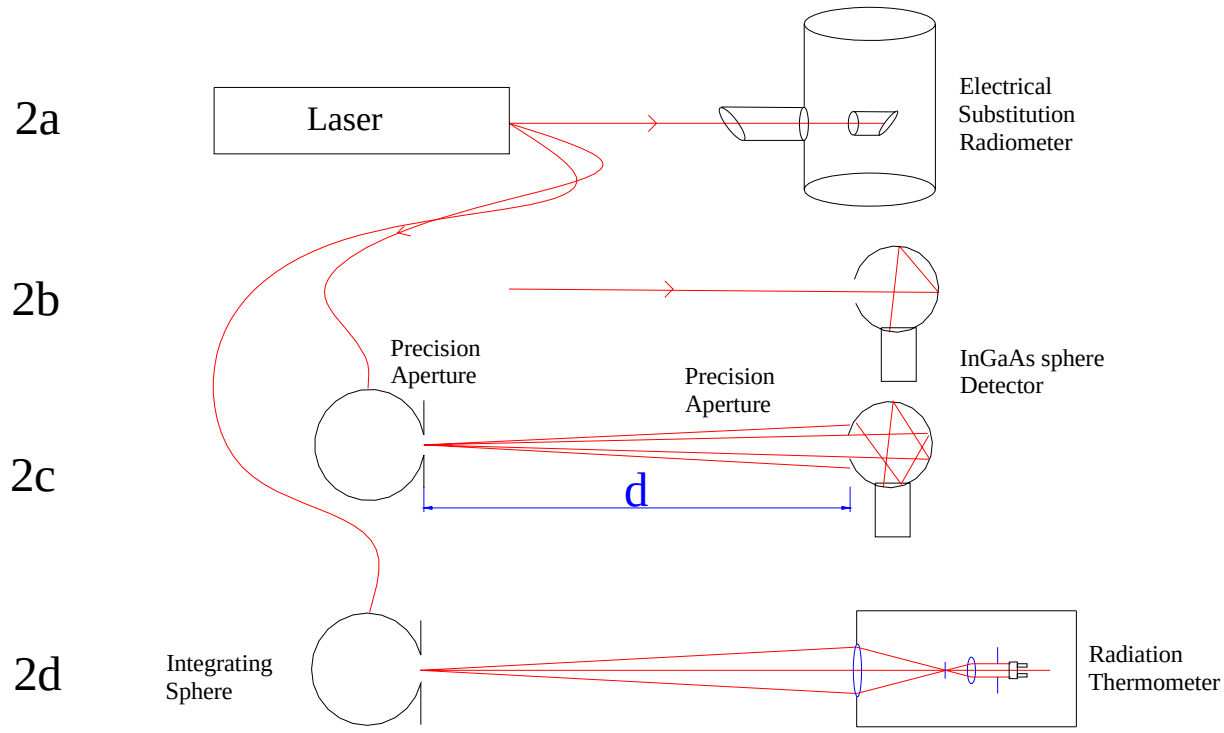




Decrease noise by x50 with cooling InGaAs detectors



Use of the InGaAs sphere radiometer in-place of the Si trap detector



Conclusions

1. Tilted spheres should be explored for use as both detectors and sources
2. Tilted sphere designs could lead to high-throughput, compact, spatially and angularly uniform sources and detectors