An Integrated Solid-State LED Luminaire for General Lighting

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The Department of Energy

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Principal Investigator: Kevin Dowling, Philips Color Kinetics

The Development Team

Kevin Dowling, PI

Philips Color Kinetics

3 Burlington Woods, 4th floor

Burlington, MA 01803

Tel: 781.418.9236

Email: kevin@colorkinetics.com

Team Members

Fritz Morgan

Ihor Lys

Houayda Chamoun

Brad Kolsky

Ron Roberts

Ryan Williamson

Thomas Yuan

Cree, Santa Barbara Technology Center

340 Storke Road

Goleta CA

Tel: 805 968 9460

Email: Thomas_yuan@cree.com

Team Members

Bernd Keller

Monica Hansen

Arpan Chakraborty

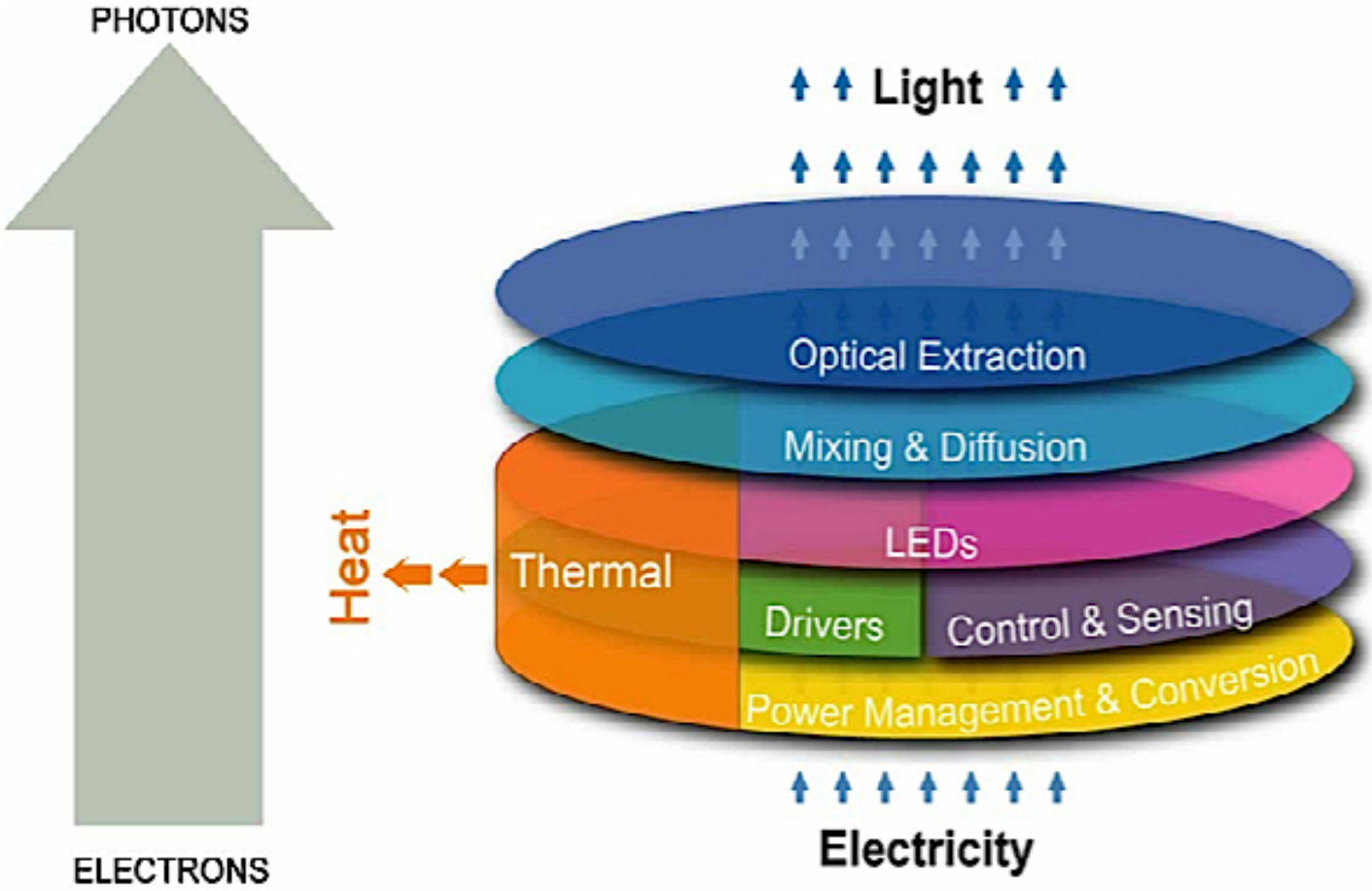
Goals

*This proposed program will address these issues by creating a high-efficiency light source **equivalent** to a 60W Edison-base A-lamp that will achieve substantial benchmarks in efficacy, cost, lifetime and performance.*

Program Goals

- 800 lumens
- 90 CRI
- 80 lpw

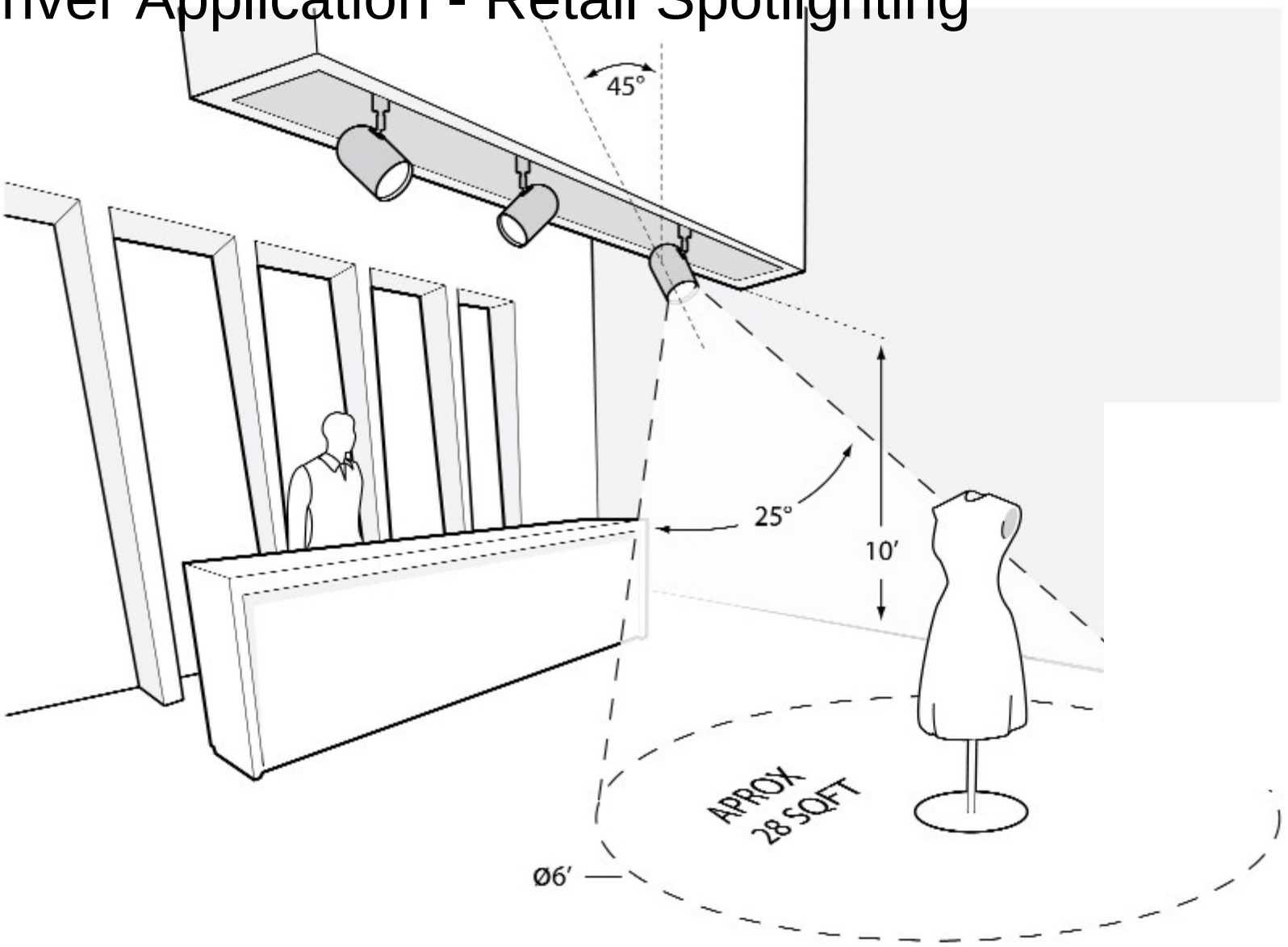
The Systems Approach



The System is the Product

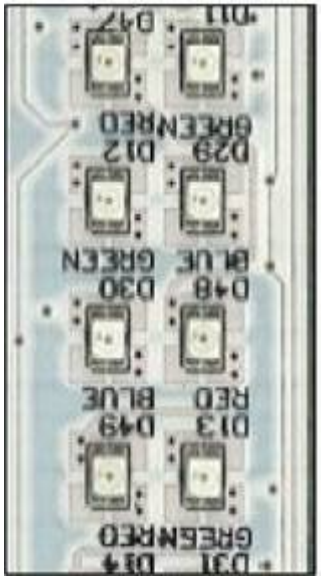
Adam Richardson – Frog Design

Driver Application - Retail Spotlighting



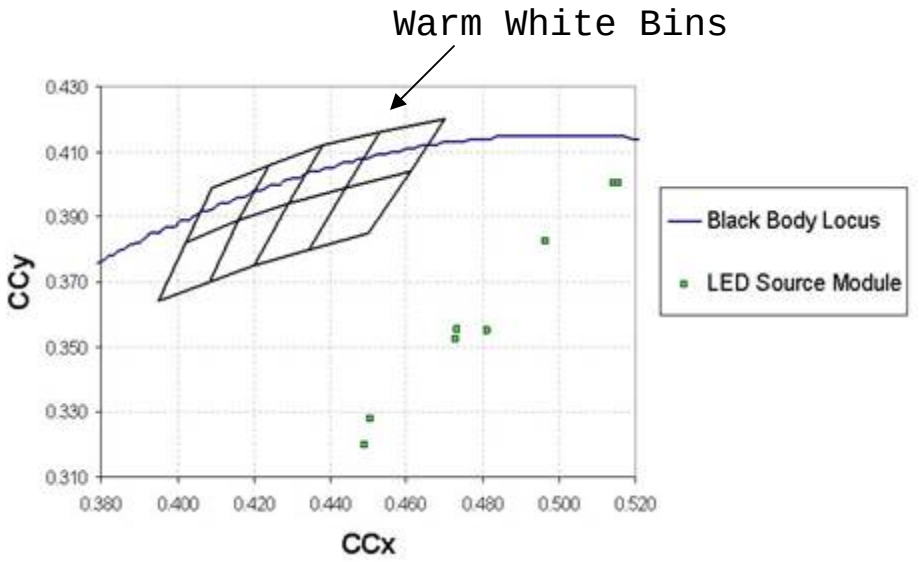
LED Approach - Larger Number of Small Die

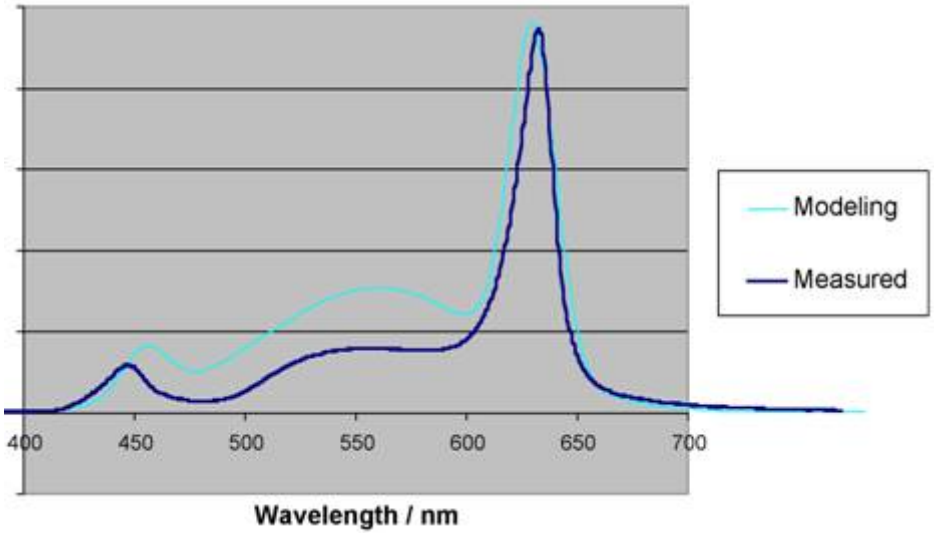
- Larger numbers of smaller die
- Benefits
  - **Optical** - Uniform light output
  - **Electrical** - Lower currents = lower cost LED drives
  - **Thermal** - Lower power density
  - **Packaging** - Potentially lower cost
  - **Efficiency** - Overall improved
- Downside
  - **Yield** - potentially lower due to parts count



Hybrid Approach

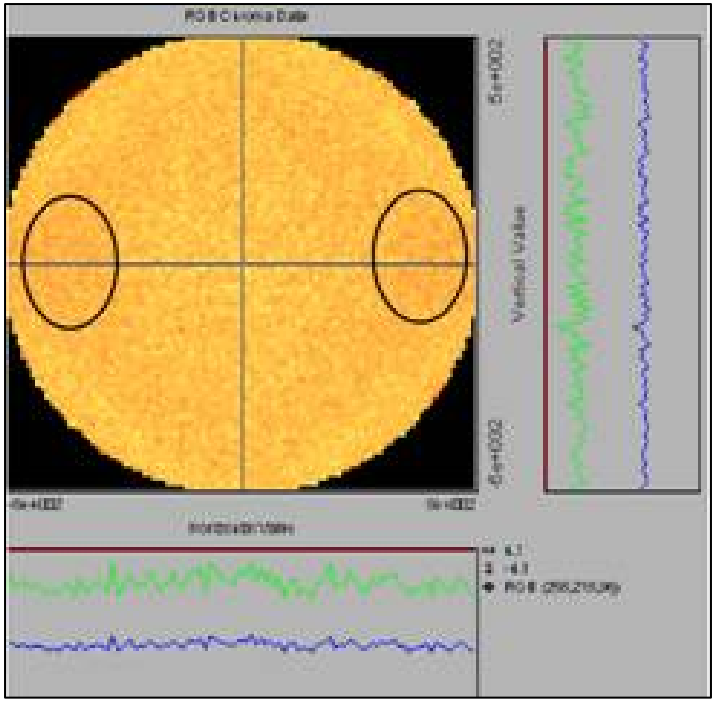
- Mix of phosphor coated and direct emission
- Developed selective phosphor coating process
- Resultant CCT dependent on
  - Phosphor quantity
  - Direct emission flux
- Closer to Black Body Curve
- Independent control of direct emission vs PC LEDs

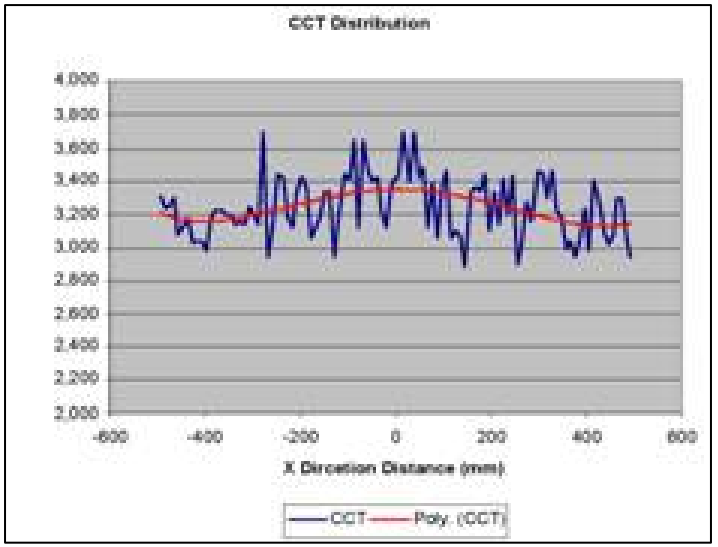




Hybrid Geometry

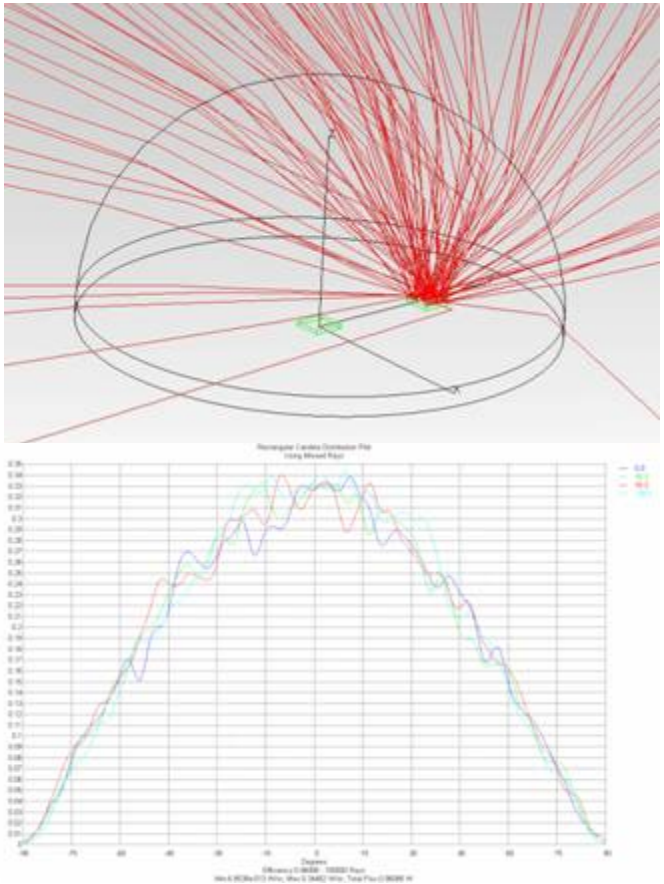
- Issues include
  - Placement geometry
  - Visual artifacts
  - Interconnects
  - Symmetry
- Example simulation and CT slice across aperture





Primary Optic

- Molded Silicone lens
- Large size risky
- Large size reduces stray losses due to sidewalls
- Registration issue between LED array & secondary optic
- Approaches
  - Dimensioned Primary lens
  - Ray trace loss determination
  - Distribution in cut planes



Power Conversion & Drivers

- From Line voltage to V_f w/ DSP control
- “Instant On” and dimmable.
- Achieving >92% efficiency
- Except transformer all COTS
- Small parts count
- Metal film caps and one electrolytic

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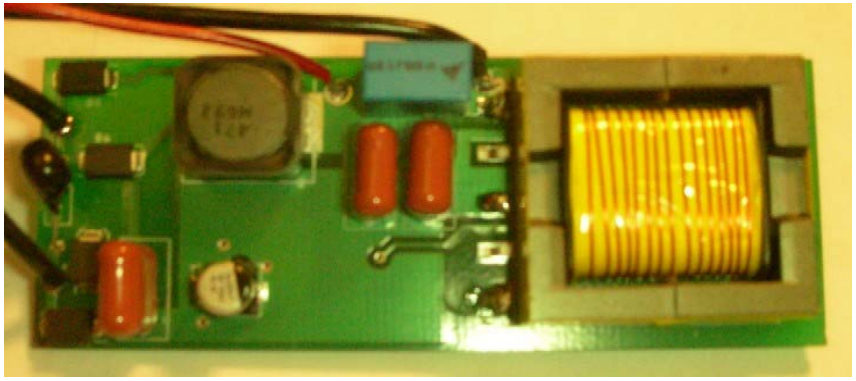

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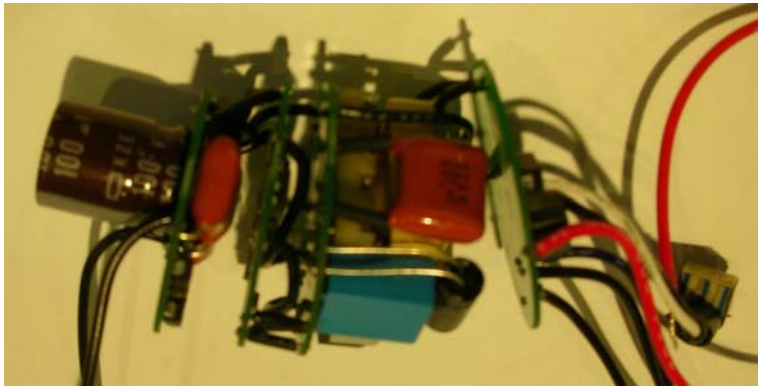

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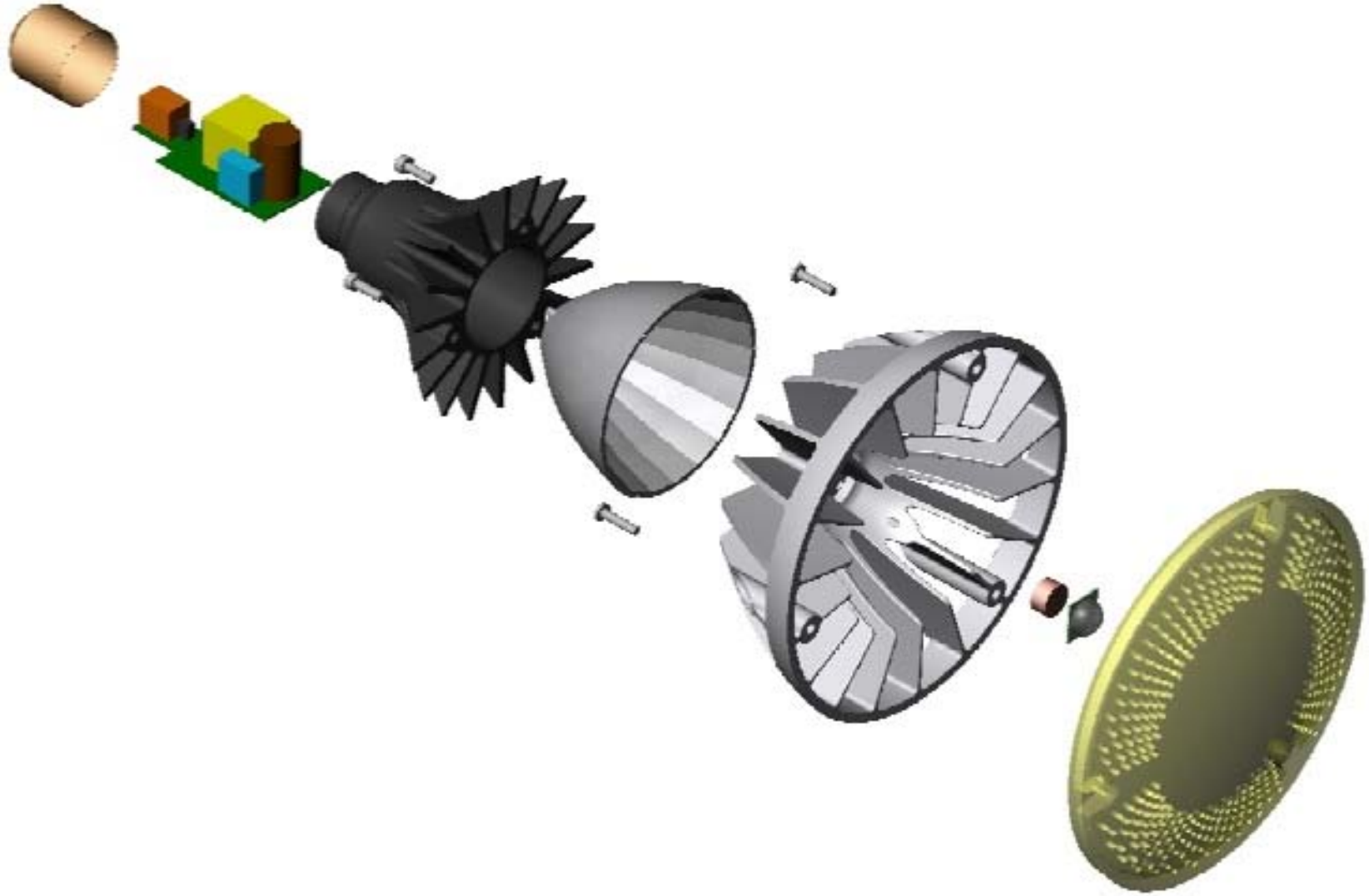
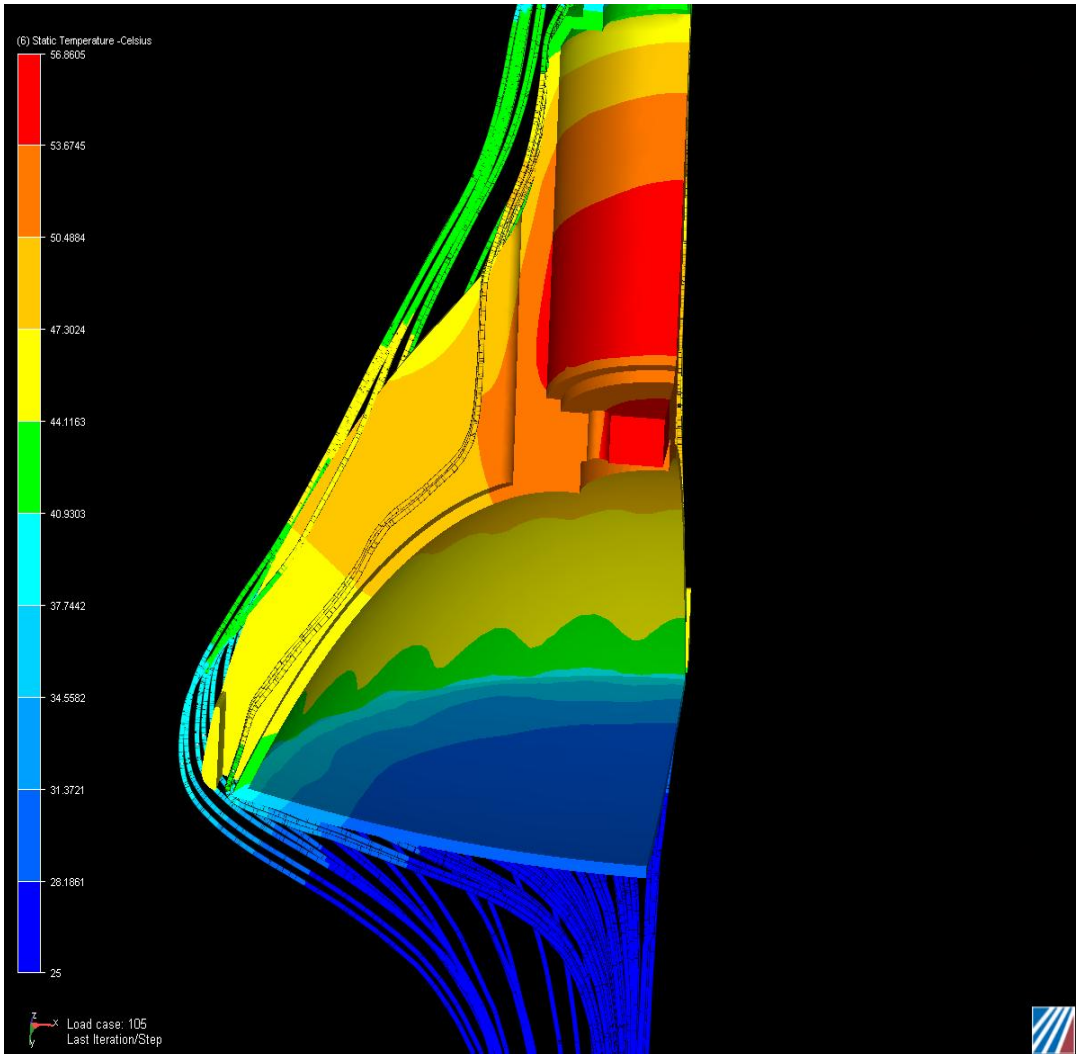
Configuration



Thermal Management



Heat is conducted, not radiated

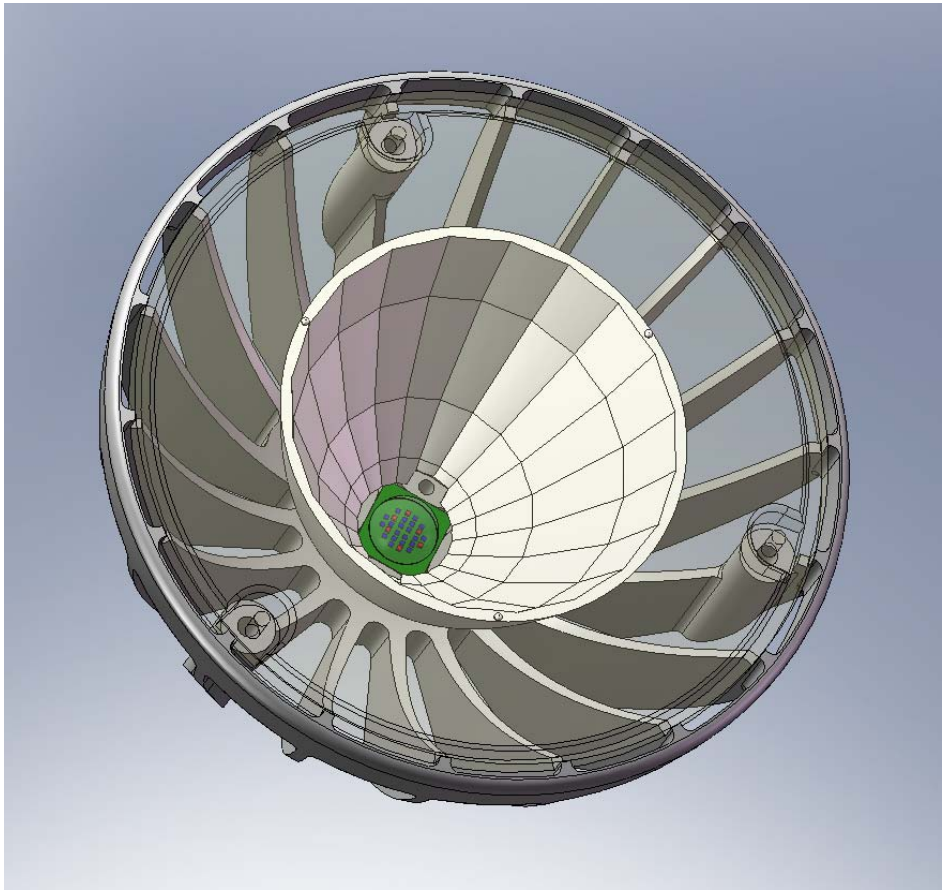
No Active Cooling

Determined effectiveness in many orientations and worst case scenarios

Issue lessens with improved efficacy

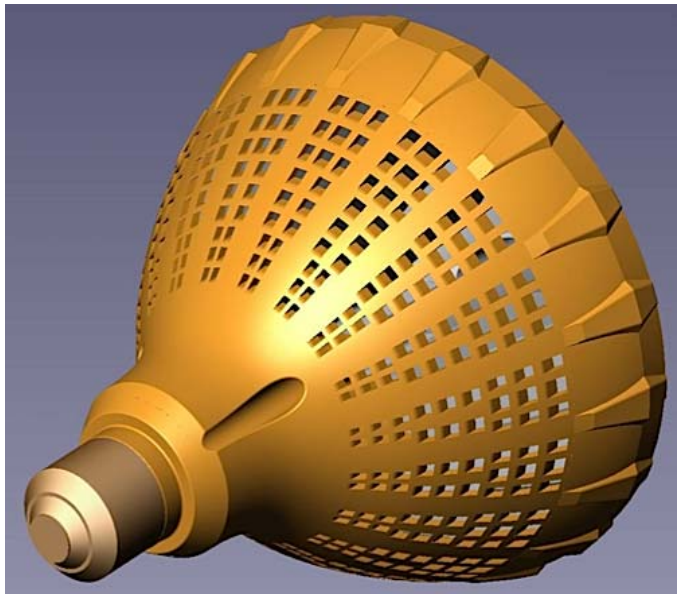
Secondary Optic

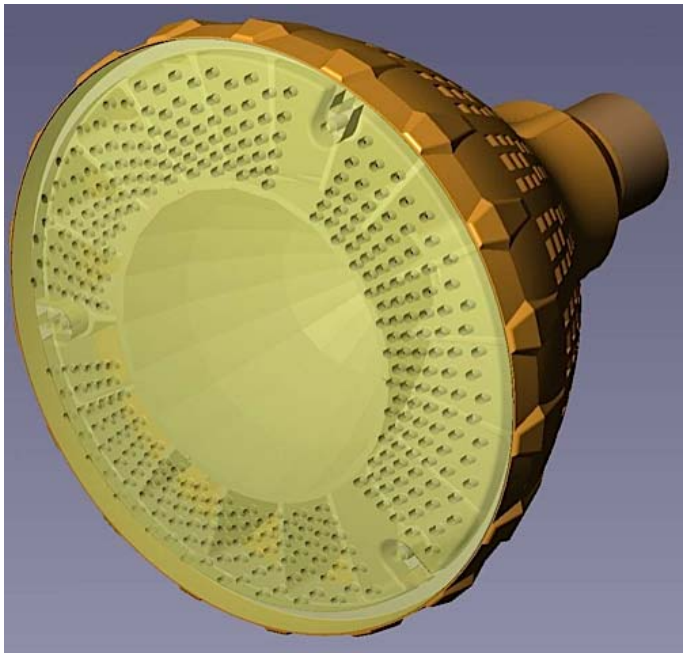
- Faceted CPC-type optic to capture and direct light
- Molded polycarbonate - metallized
- Low loss, high quality molding and coating
- Registration to mechanical features in LED module



LED-based PAR 38

- Tightly coupled system
- An inter-related combination of thermal, optical, electrical, mechanical, control and more.
- Analyzed all design element wrt ripple effect through the system
- Carefully analyzed with system model prior to any changes.

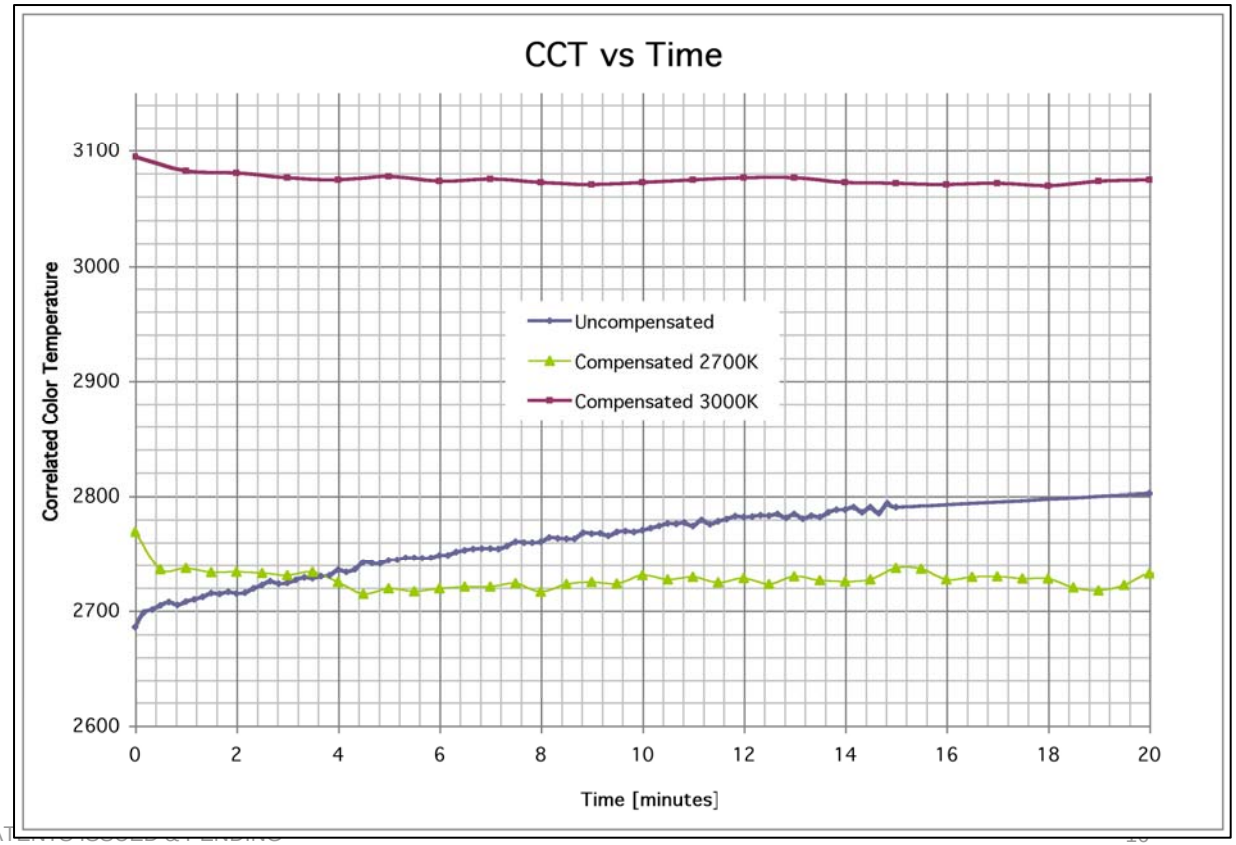


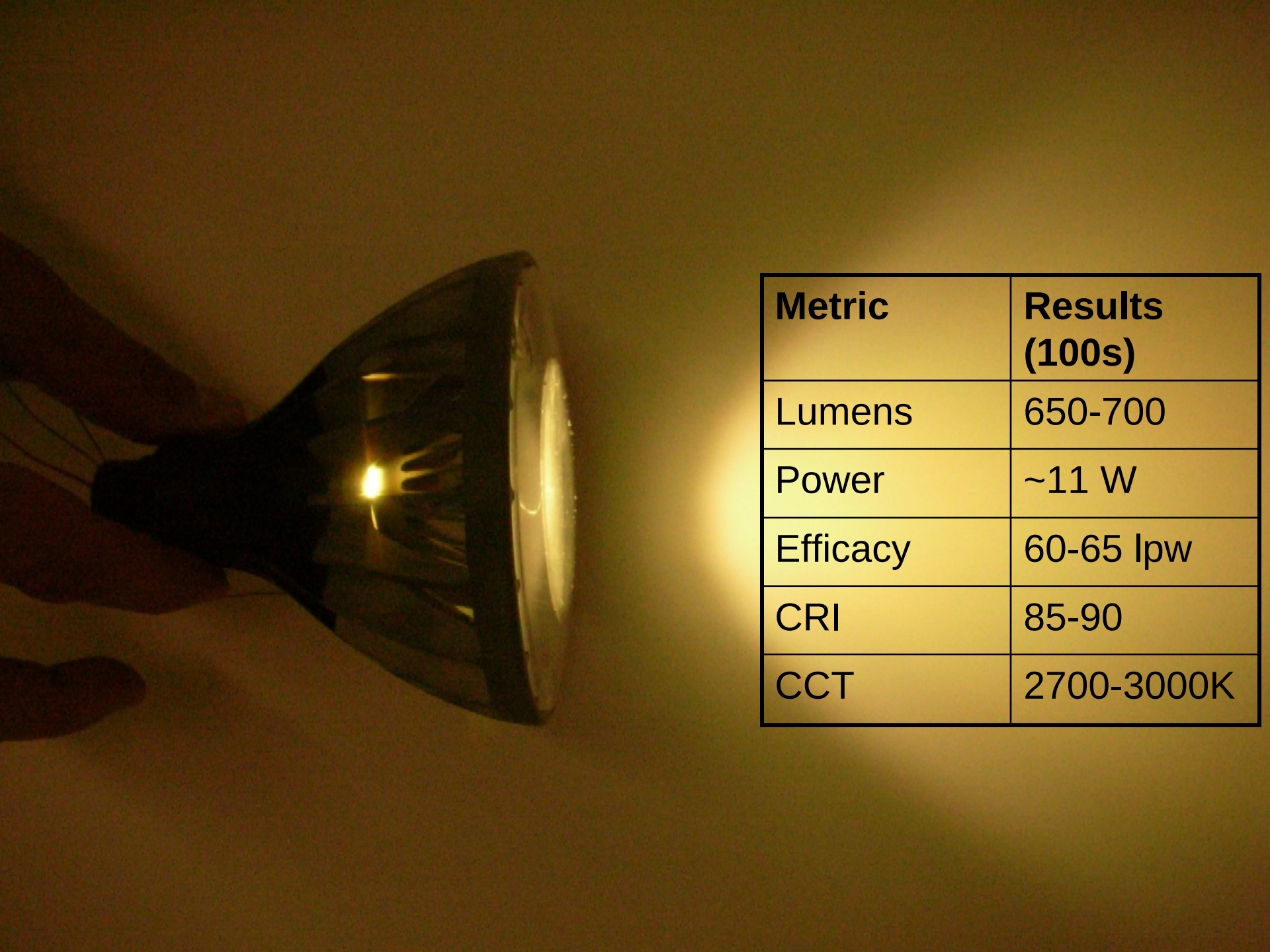


Feedback Control

Output based on thermal effects

- Model accommodates aging and thermal characteristics of system through modeling of system



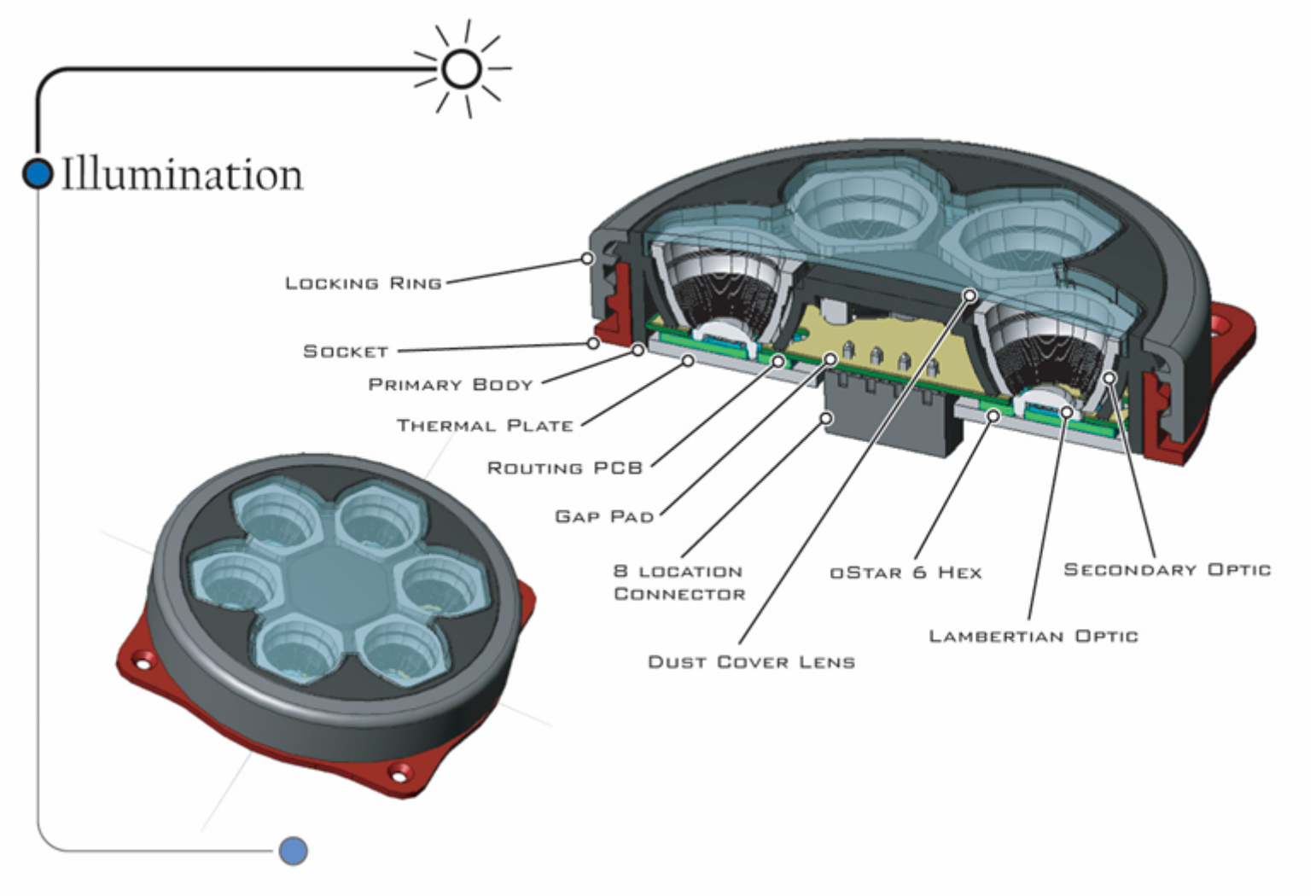


Metric	Results (100s)
Lumens	650-700
Power	~11 W
Efficacy	60-65 lpw
CRI	85-90
CCT	2700-3000K

Schedule and Milestones - Next

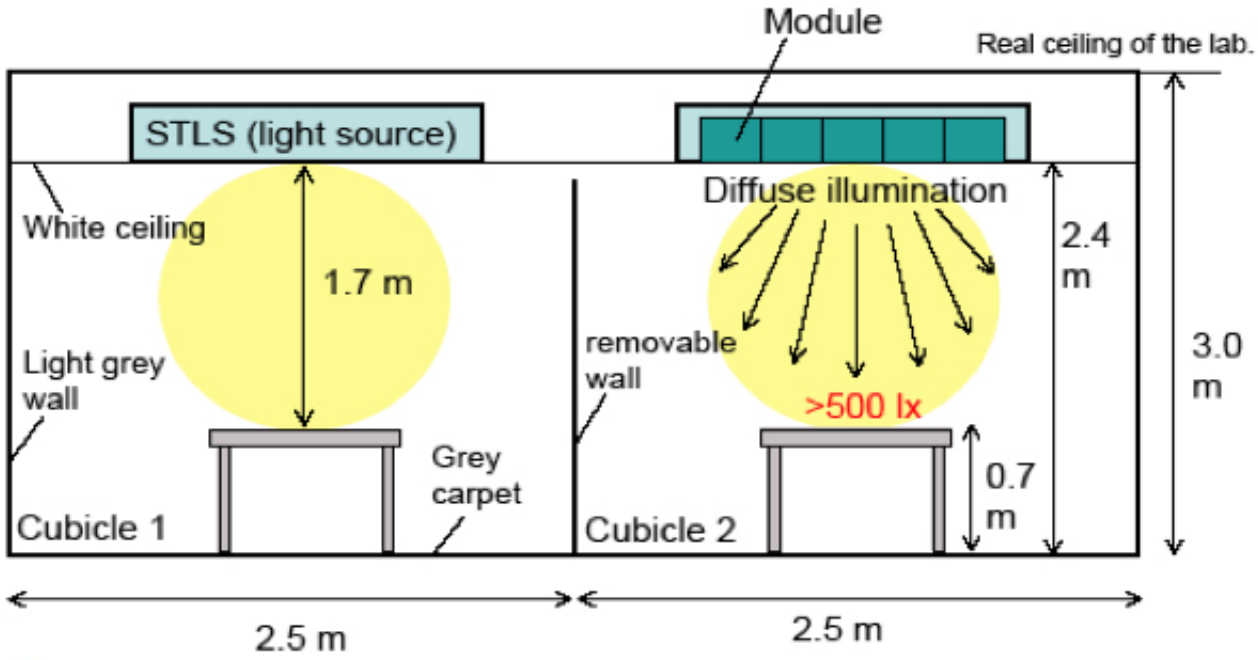
- Critical Pieces over coming months
  - Making a product
  - Getting to market
  - UL
  - Continued performance evaluation
    - Luminous flux
    - Power consumption
    - Efficacy
    - Light quality - distribution, CRI, color
  - Evolve mechanical configuration and thermal specs
  - Power supply reliability analysis

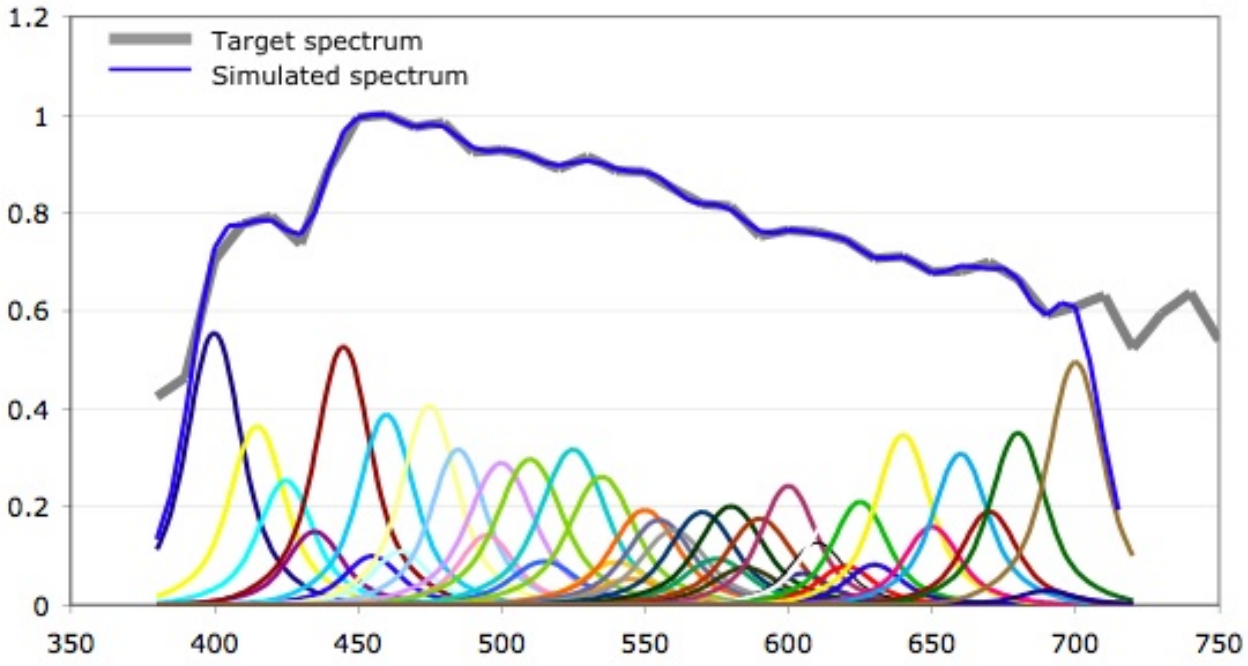
Sockets & Interconnects - NEMA LSD-45



Towards Improving CRI

NIST STLS





Spectrally Tunable Light Source