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Concentrating Photo-Voltaic Systems Using Micro-Optics

William Sweatt, Greg Nielson, Marat Okandan, Brad Jared, & Tony Lentine

Sandia National Laboratory, 1515 Eubank SE, Albuquerque, NM, 87185-0826

wsweatt@sandia.gov

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Abstract:

➔Molded plastic micro-optics with 50X solar gain are described.

➔The $\pm 4^0$ acceptance cone allows solar tracking with one-axis heliostats.

➔ The lenses produce achromatic, stationary images on the PV cells.

Flat panels with one-axis trackers are widely used

Nellis AFB installation
from Wikipedia

Modest efficiency
Simple clock drive
Unaffected by wind gusts

Parabolic mirrors on 2-axis trackers offer higher efficiency

Mirrors track the sun with ~0.3^0 accuracy.

Requires stiffer structures

Efficiency ~1.2X greater than flat panels

Dramatically reduces size of PV cell size so use of triple-junction is feasible

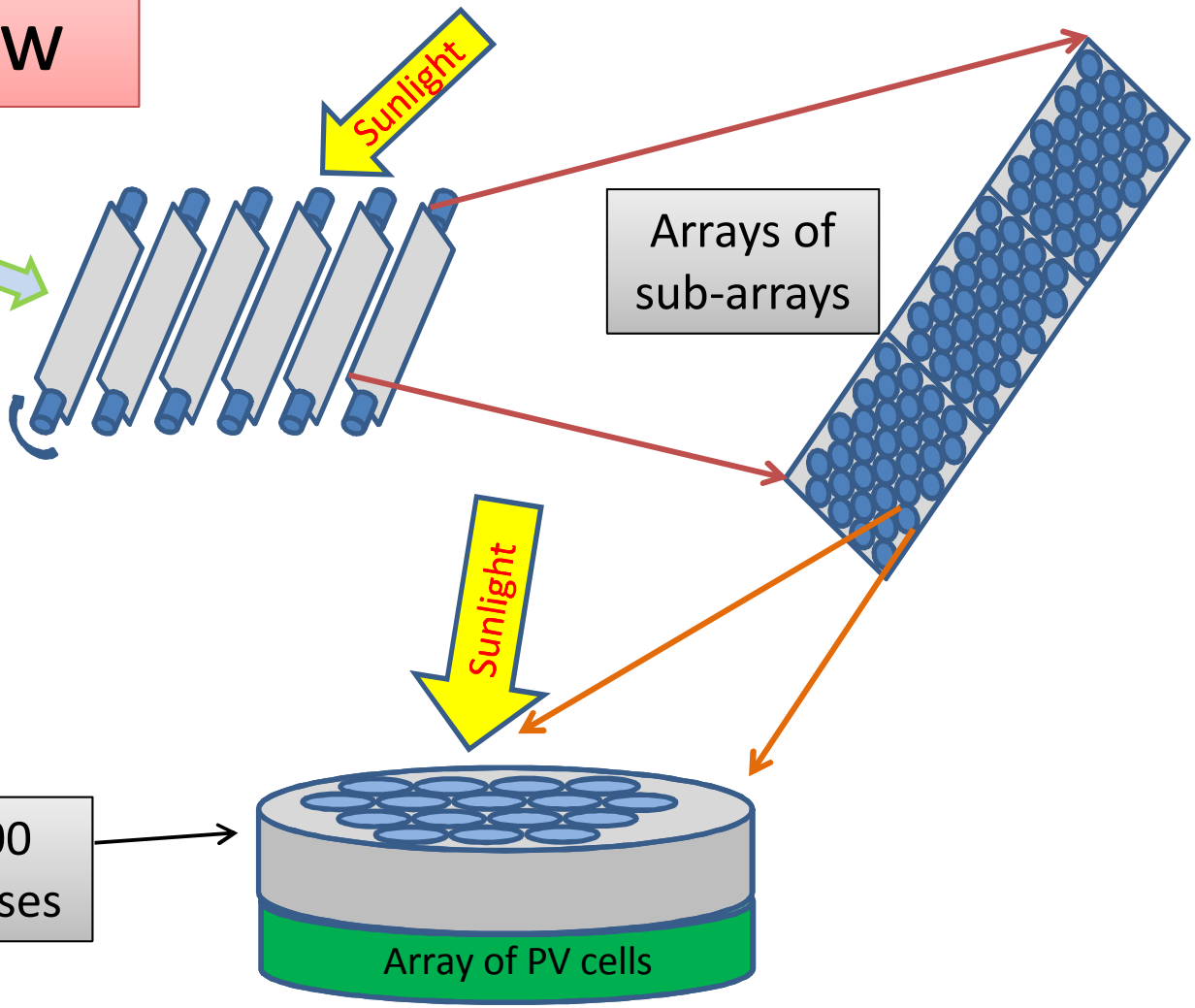
A second look at the Abstract:

➔Molded plastic micro-optics with 50X solar gain are described.

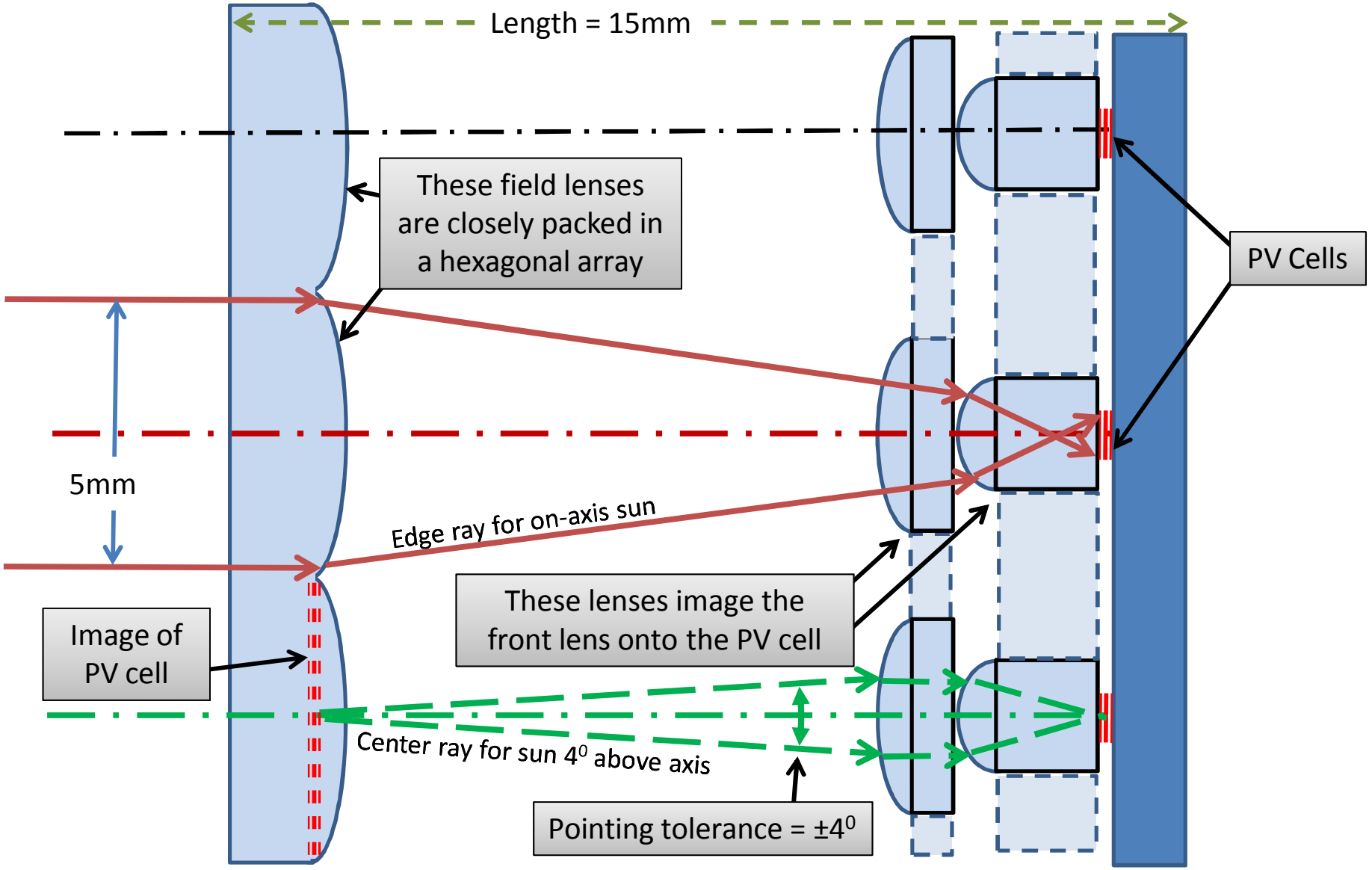
➔System has $\pm 4^0$ acceptance cone so single-axis sun trackers are good enough.

➔Lens columns create achromatic, stationary images on PV cells.

System Overview

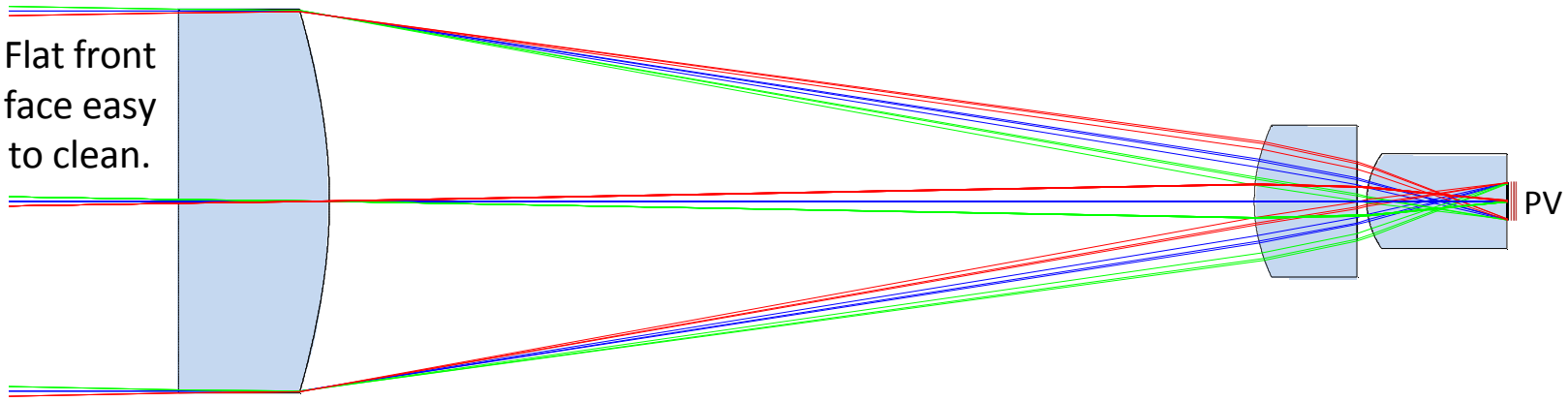


First order properties of micro-optics

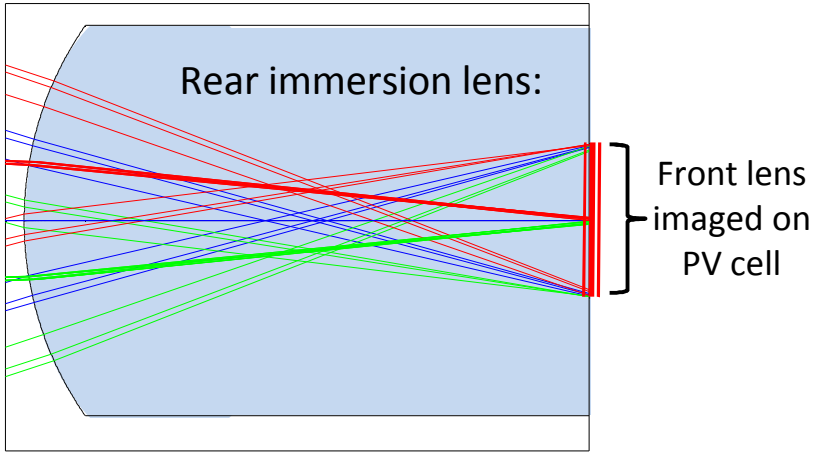


Zemax design of Lenses for micro CPV System

{ Colored rays come from the sun positions 0^0 and $\pm 4^0$ }



The lens arrays will be diamond-turned in Zeonex E48R. All lenses are plano-convex and aspheric.



3D La

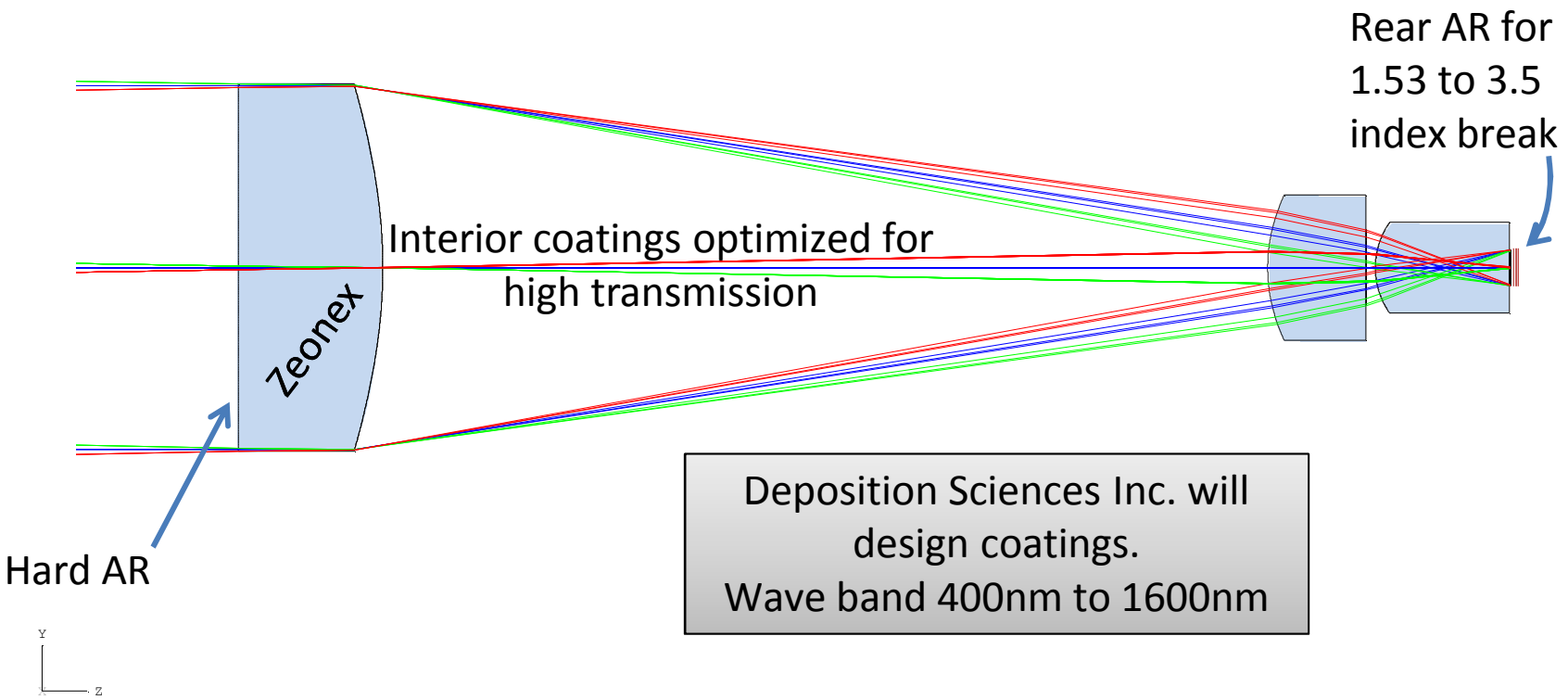
MEPV system showing 8-degree collect
6/25/2011

11-06-18-100X infinite object 4 degree.ZMX
Configuration 1 of 1

The Micro-Enabled PV (MEPV) offers the following:

- Initially we will diamond turn the lens arrays. Eventually we will mold them.
- Solar concentration of 50X or more
- High efficiency PV stacks can be economically used
- Solar tracking within $\pm 4^0$ allows us to use heliostats on simple clock drives
- System is tolerant to shock loads and wind gusts
- Weight < $8 kg/m^2$

Anti-Reflection Coatings



3D Layout

MEPV system showing 8-degree collection cone
6/25/2011

11-06-18-100X infinite object 4 degree.ZMX
Configuration 1 of 1

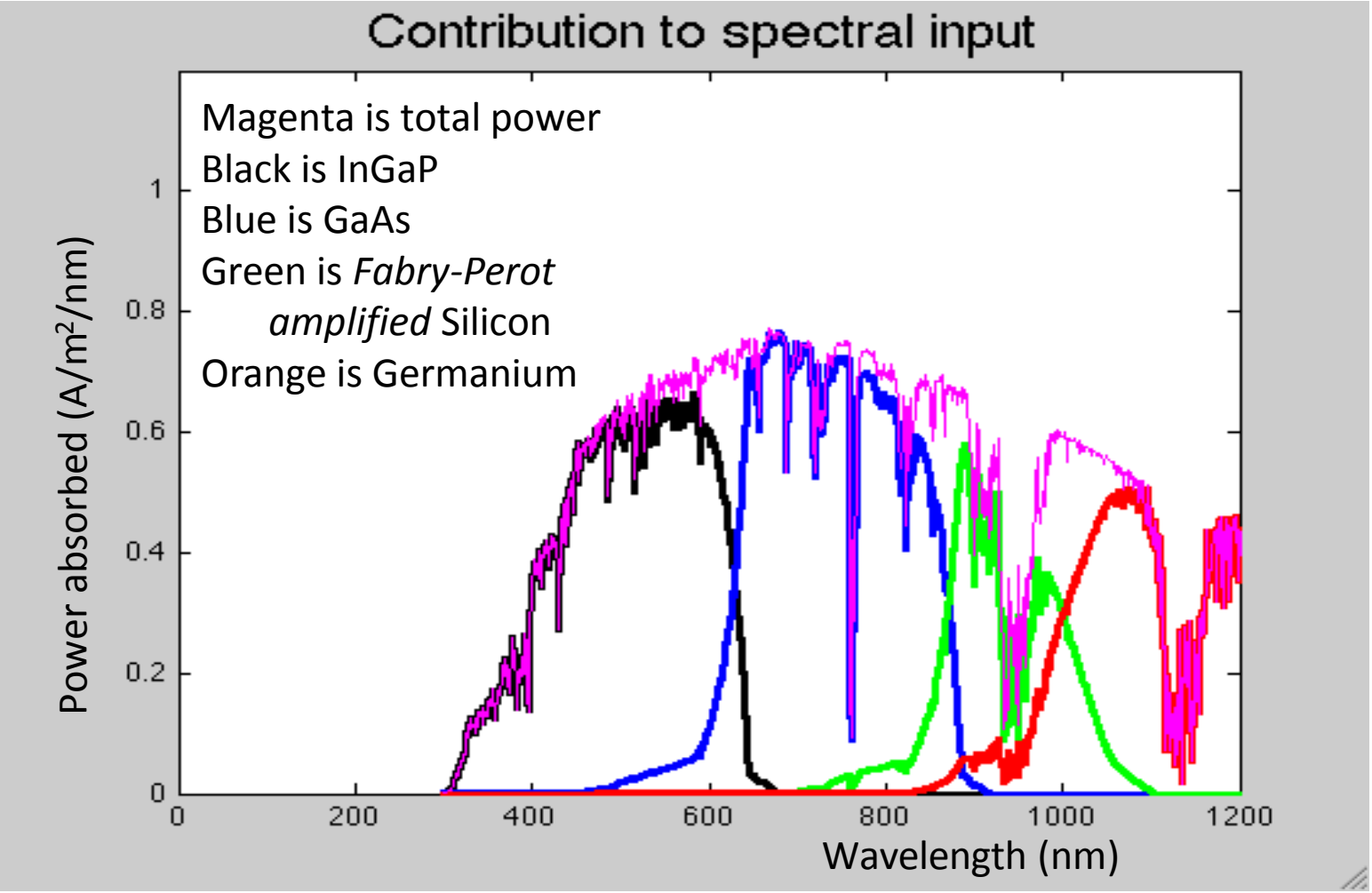
50X Magnification

Allows us to use smaller PV cells than required for a flat-plate detector. This saves III-V material

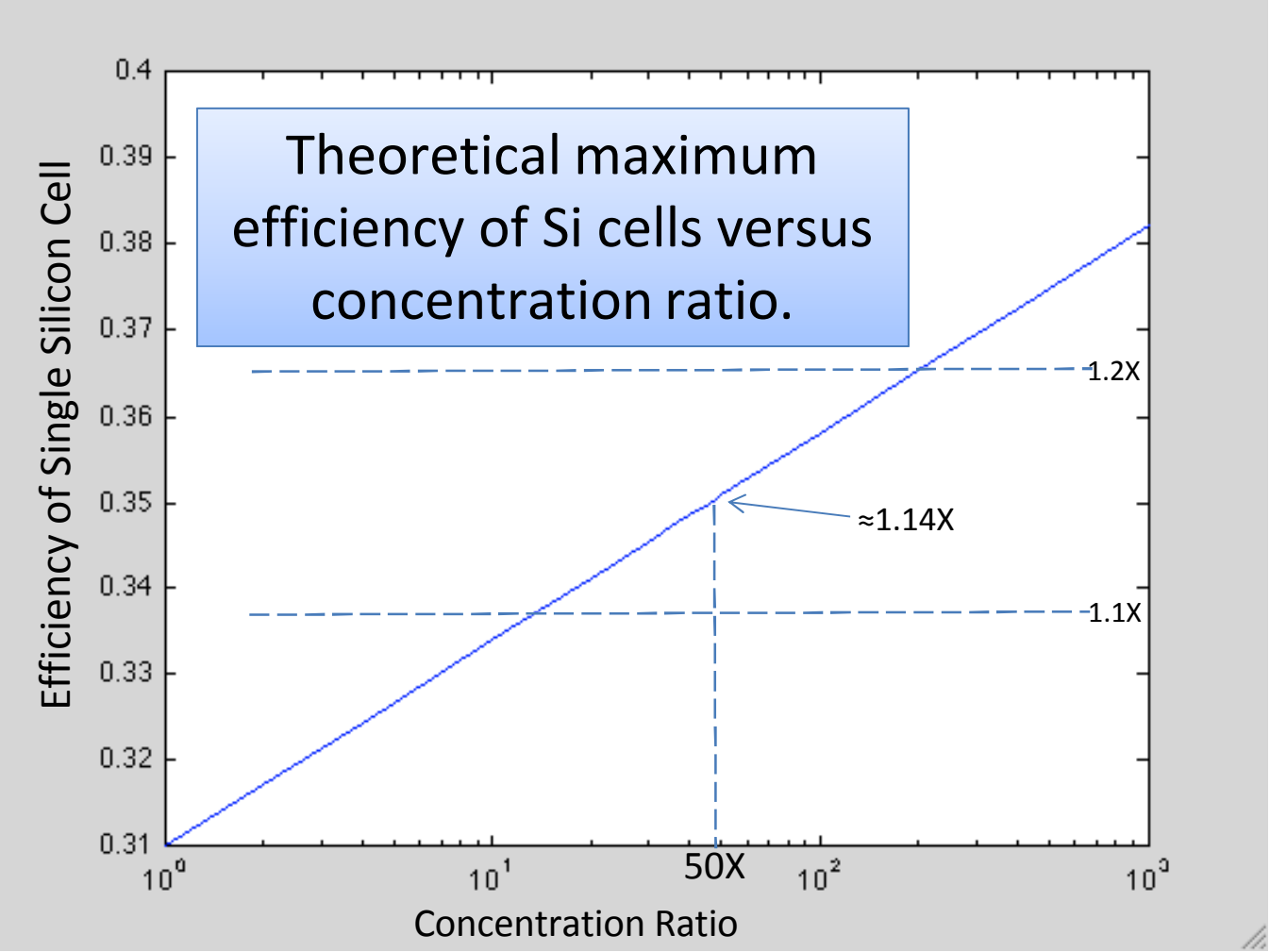
- Using 50X less PV material allows wider choice of PV materials, which can be better fit to the solar spectrum
- Magnification increases efficiency of the PV materials by ~1.15X

Spectral response of PV layers in stack

Our PV cells are wired in parallel so currents are independent of one-another

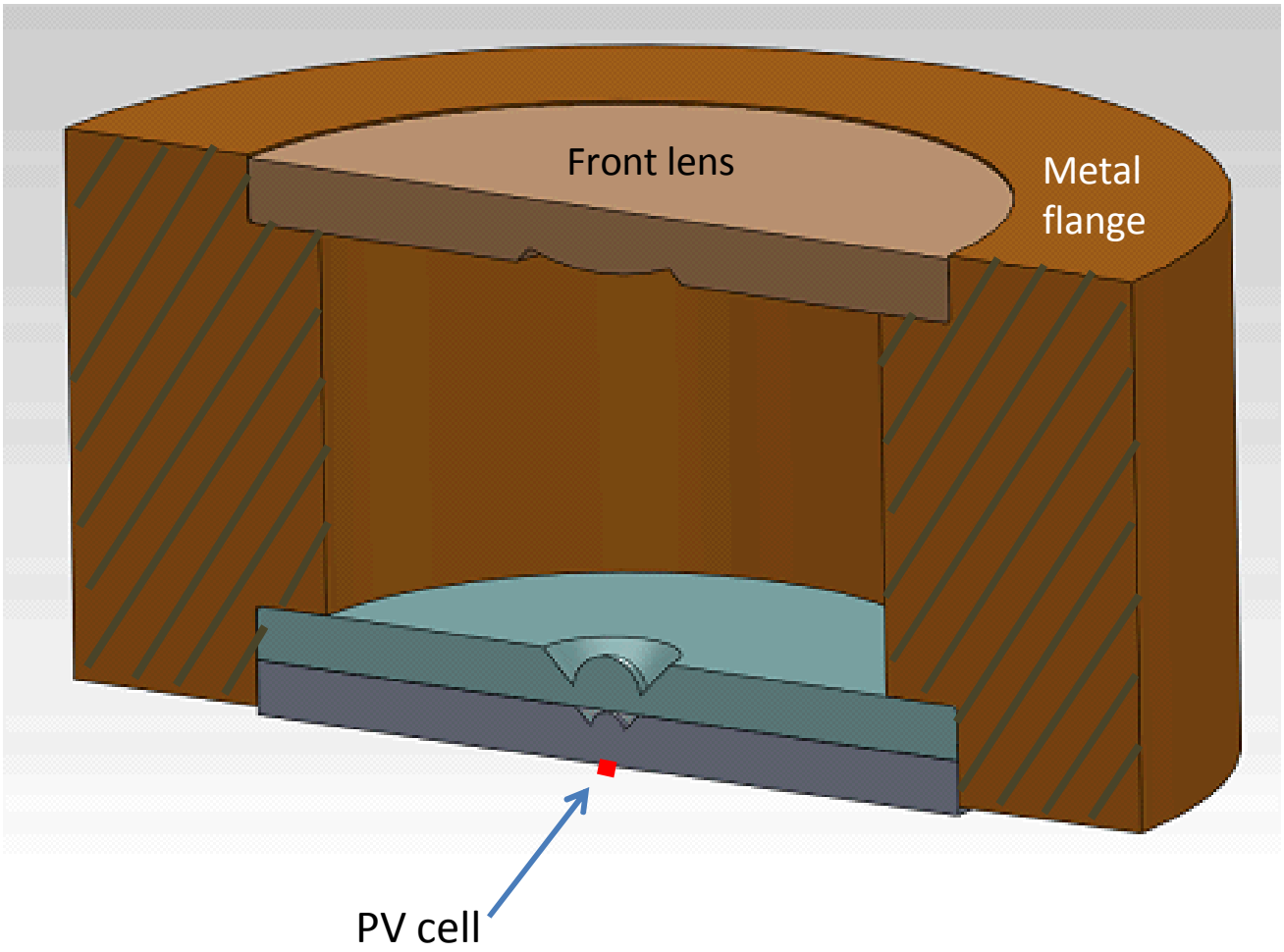


Solar concentration increases efficiency

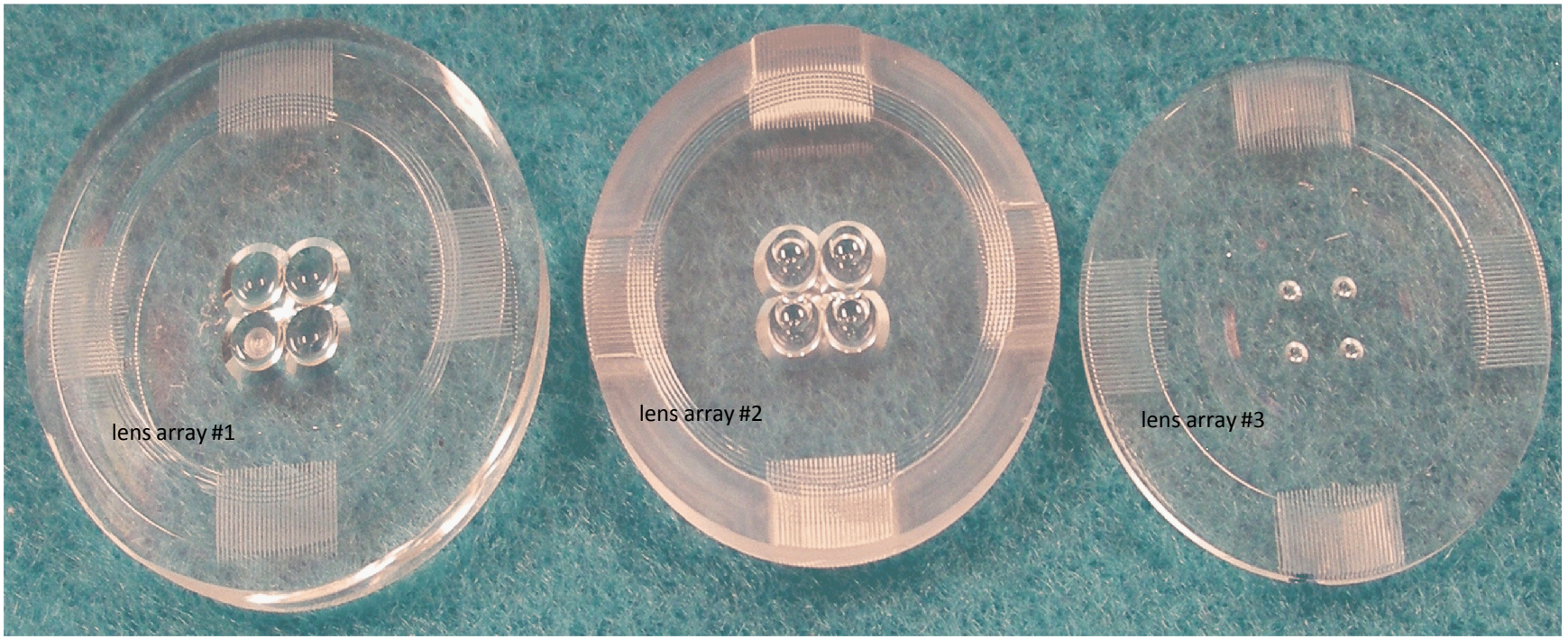


This is entirely due to the device voltage increasing with more current, in this case from 0.77V to 0.94V. This was calculated with AM1.5 spectrum.

First Prototype is being diamond-turned now



Diamond-turned lenses from a previous MEPV design



Micro-roughness RMS < 7nm
Surface error < 500nm

Summary

1. Lens design is nearly complete.
2. Fabrication of single column is under way with optical tests scheduled for January.
3. Small lens array will be completed by April.
4. Array of silicon PV cells available in April.
5. PV array with 2 or 3 materials scheduled for summer 2012.
6. System testing through the summer
7. Advanced designs studied during the following two years.