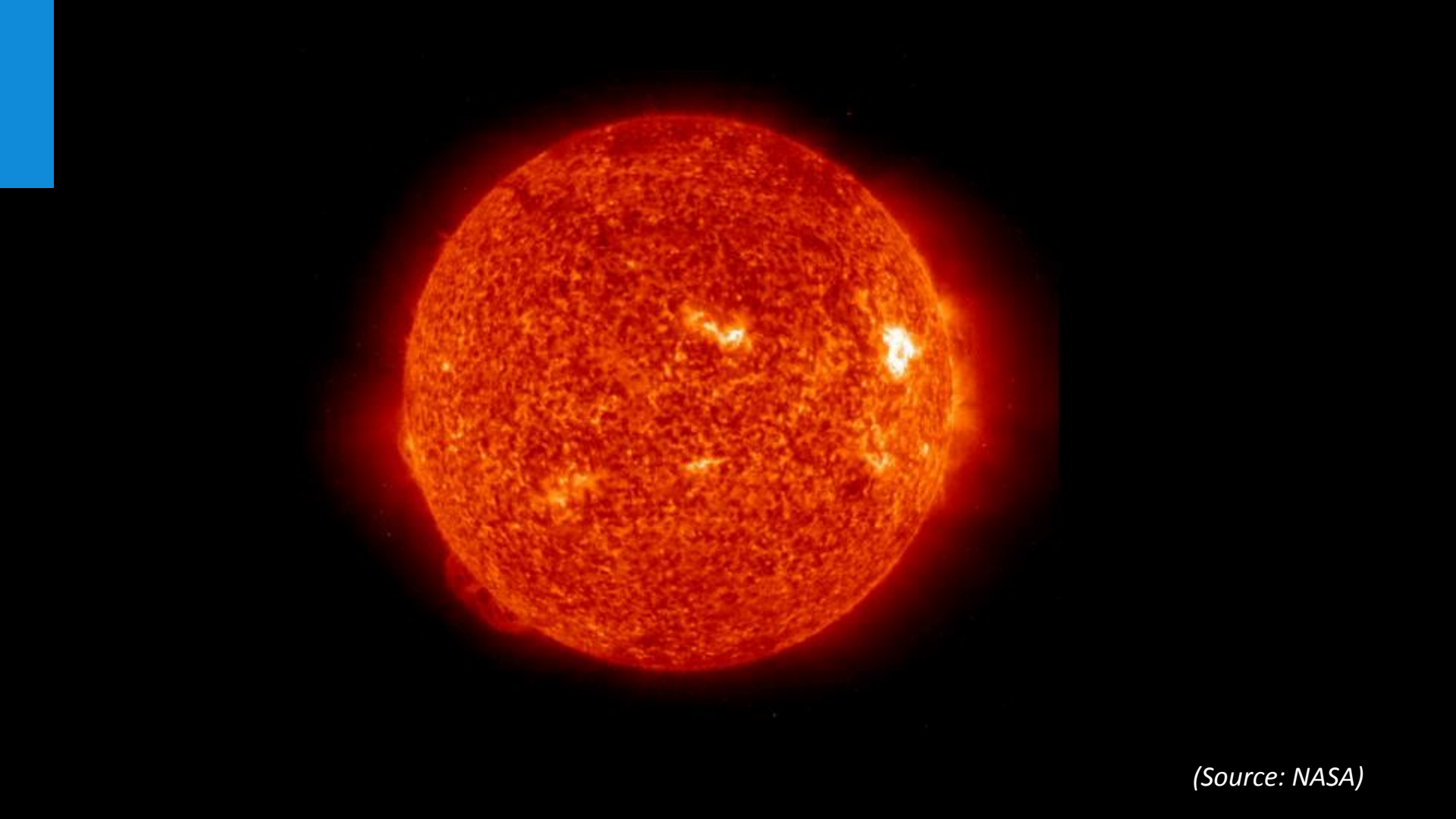
Third Generation PV and Other Ways to Utilize Solar Energy

Third Generation PV Technologies

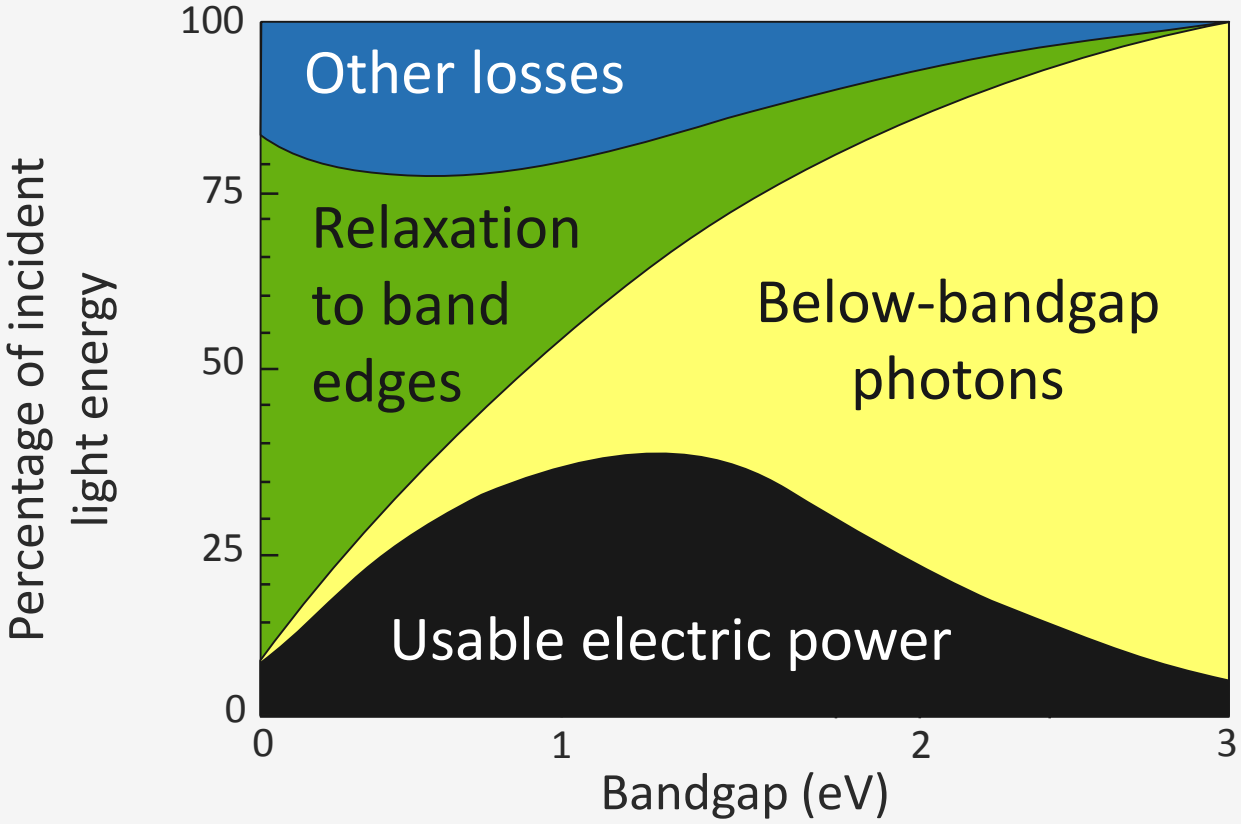
Week 6.1

Arno Smets



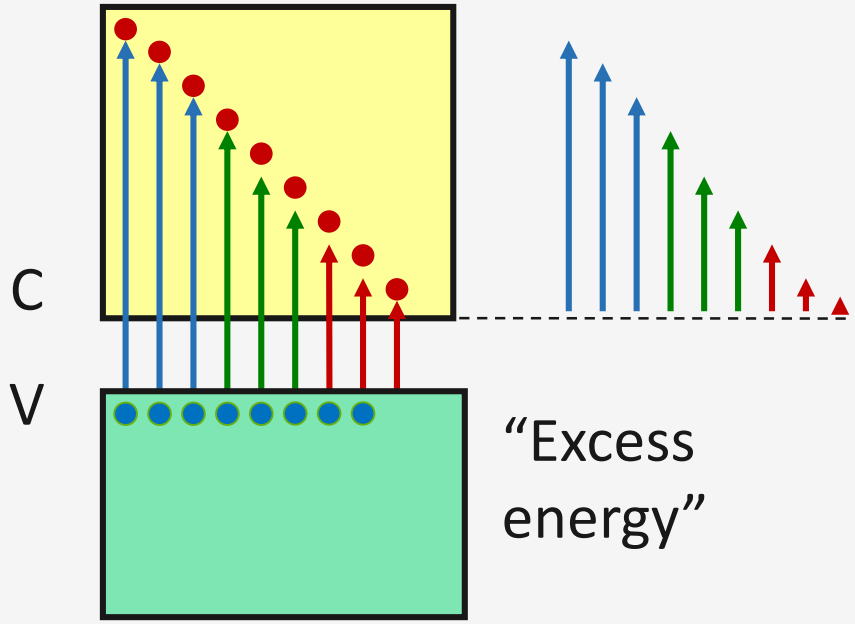
(Source: NASA)

Shockley-Queisser limit



Limitations

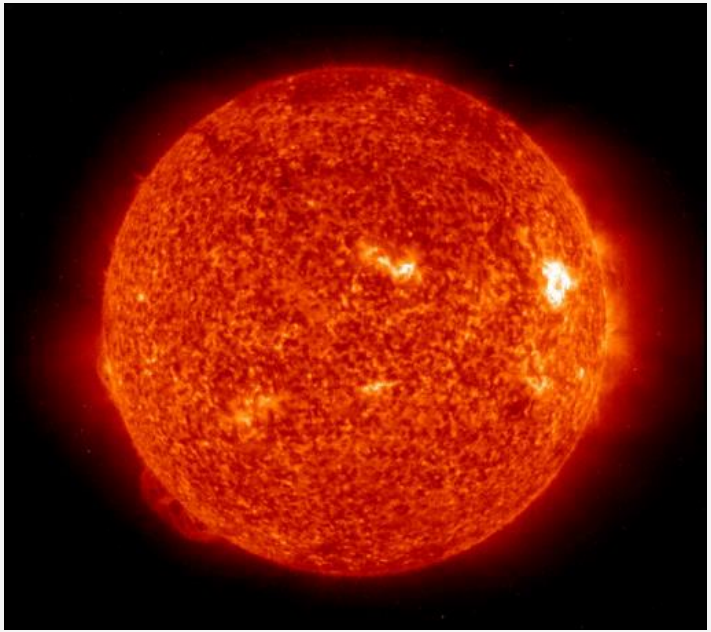
Single bang gap energy



Limitations

Single bang gap energy

1-Sun irradiance

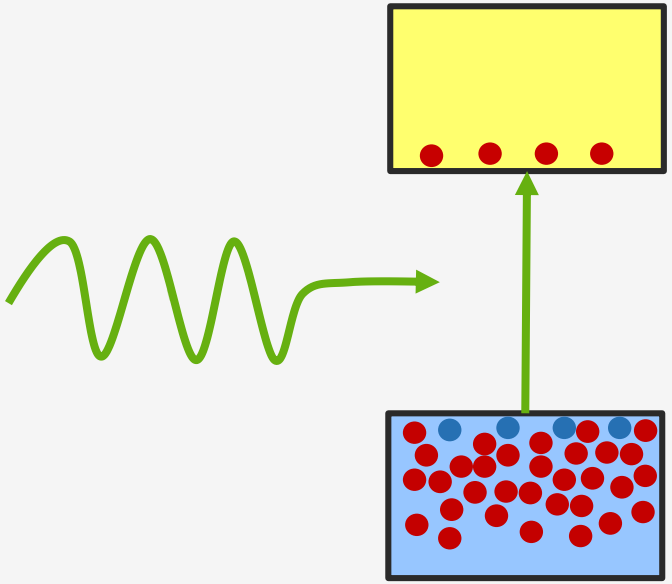


Limitations

Single bang gap energy

1-Sun irradiance

One *e-h* pair per photon



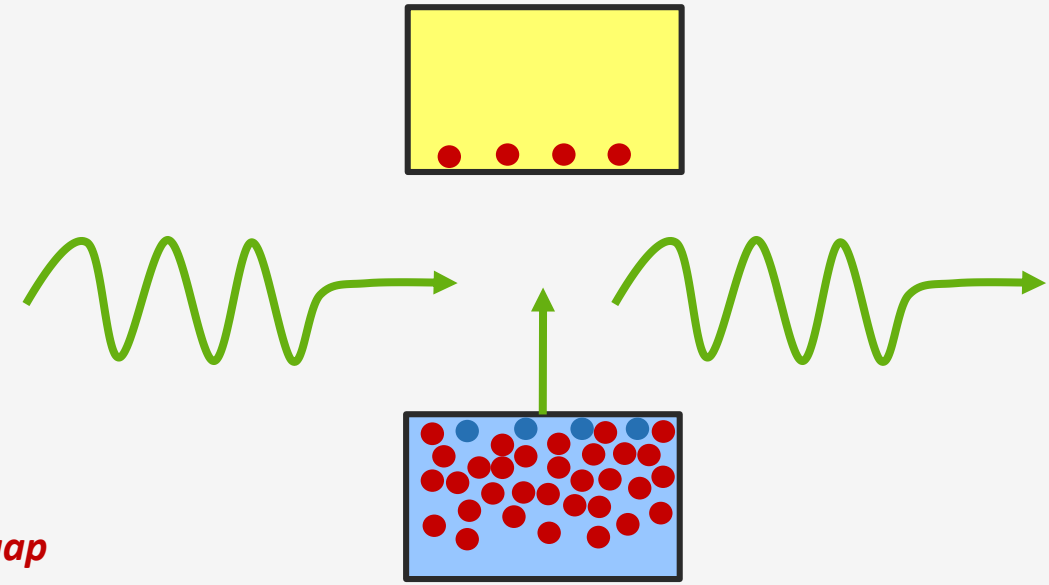
Limitations

Single bang gap energy

1-Sun irradiance

One *e-h* pair per photon

No use of photon with $E<E_{gap}$



Limitations

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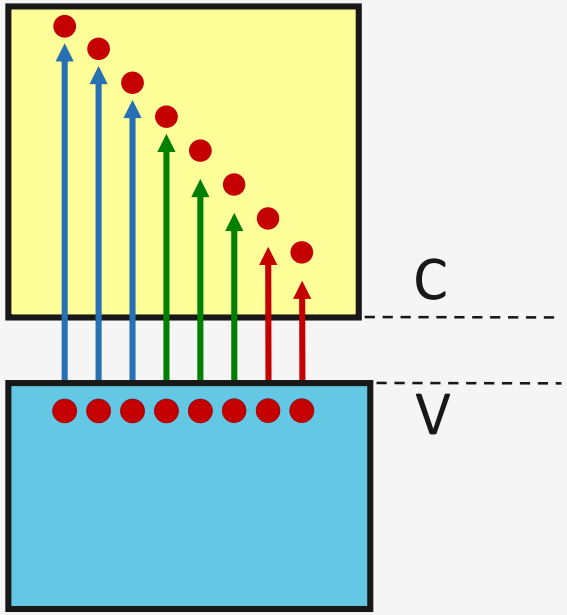
Single population of *e* and *h*



Limitations

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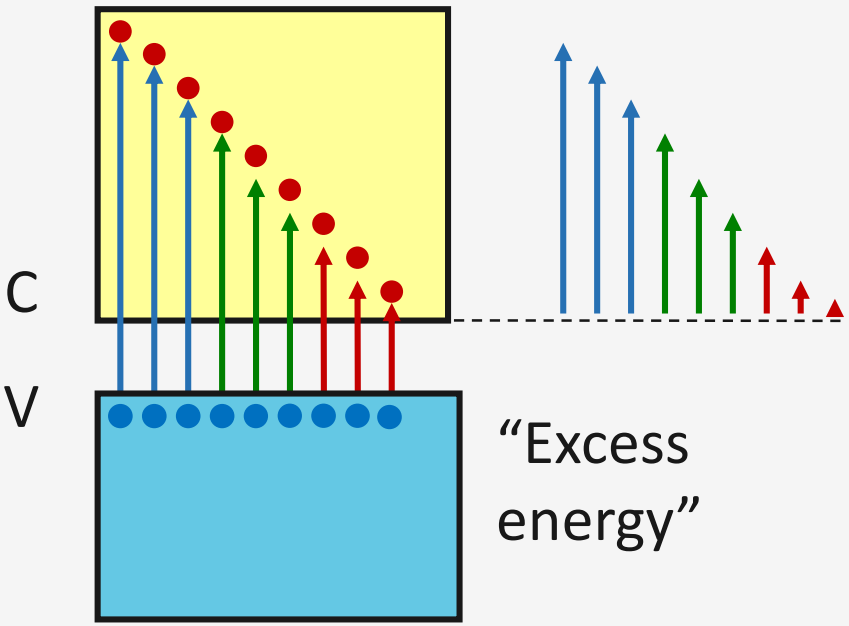
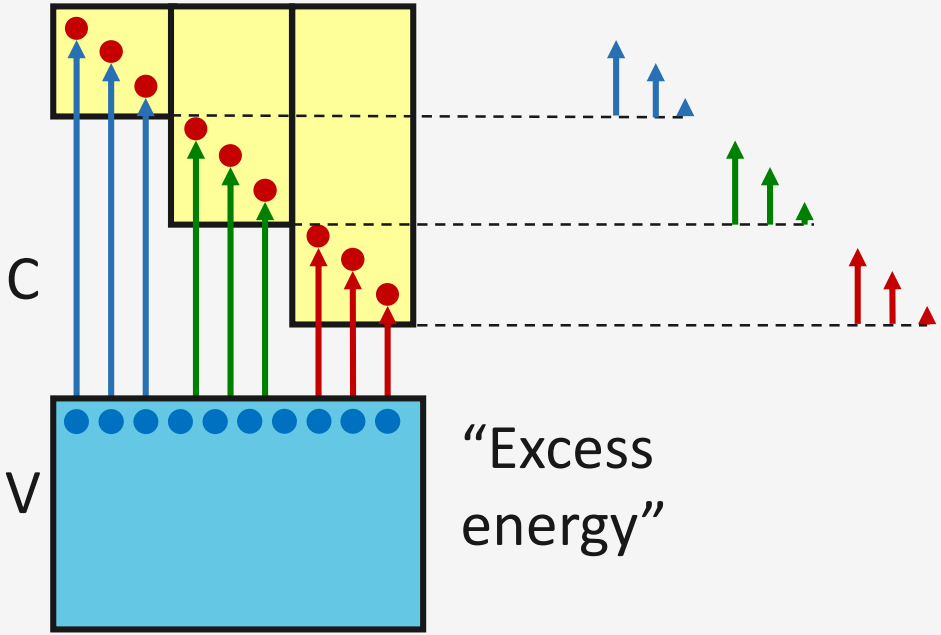
Single population of *e* and *h*

Opportunities

Multijunction





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Single population of *e* and *h*

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Concentrator Solar Cells

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Concentrator Solar Cells

Down Conversion
Multiple Exciton Generation

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Up Conversion

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Opportunities

Multijunction

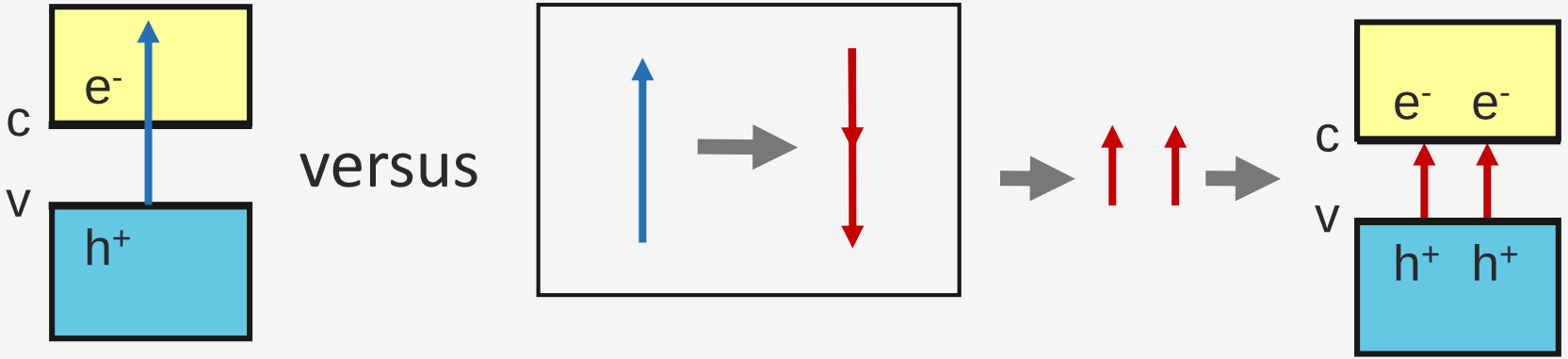
Concentrator Solar Cells

Down Conversion
Multiple Exciton Generation

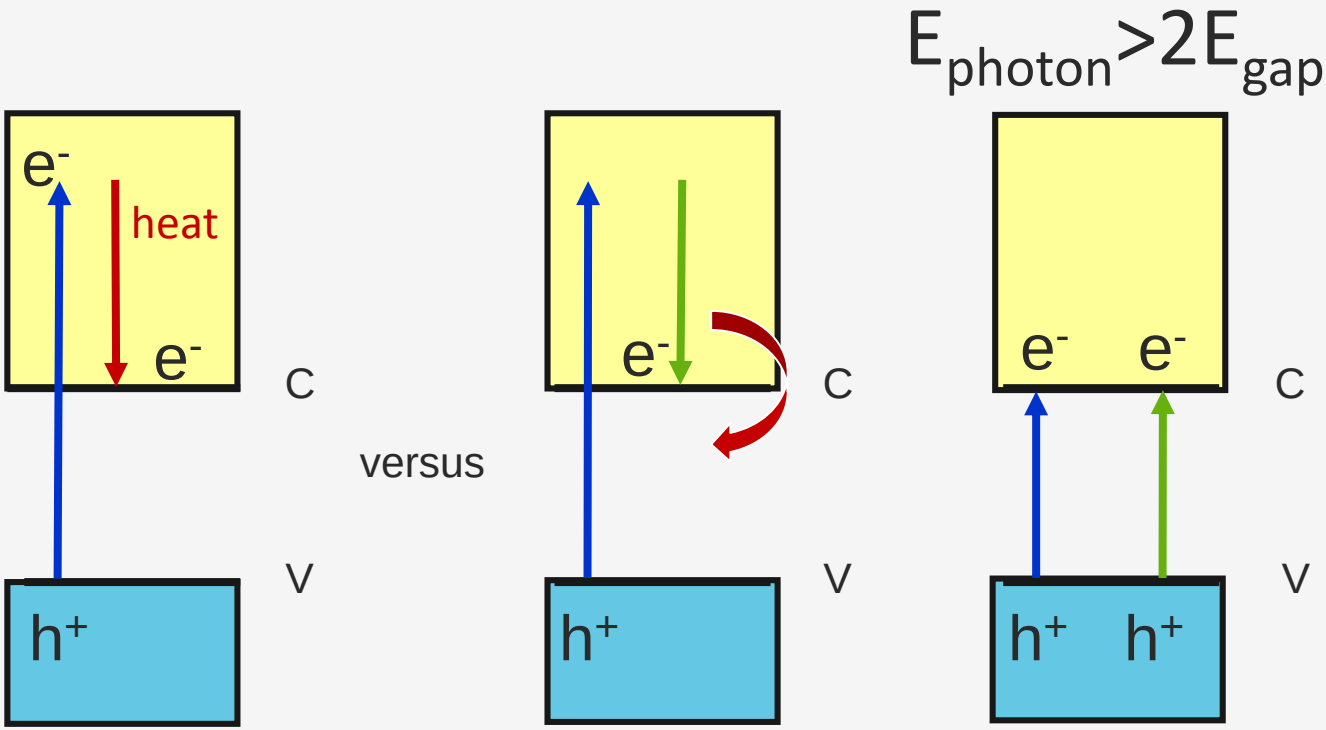
Up Conversion

Intermediate Band Solar Cells
Hot Carrier Solar Cells

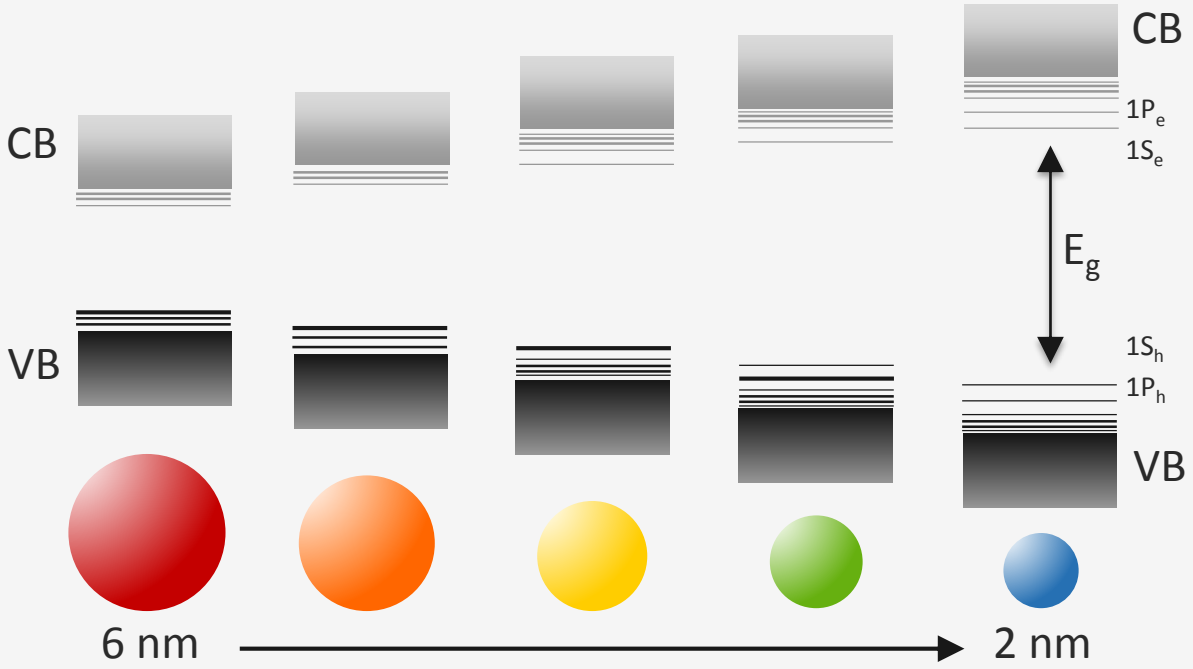
Opportunity: *down conversion*



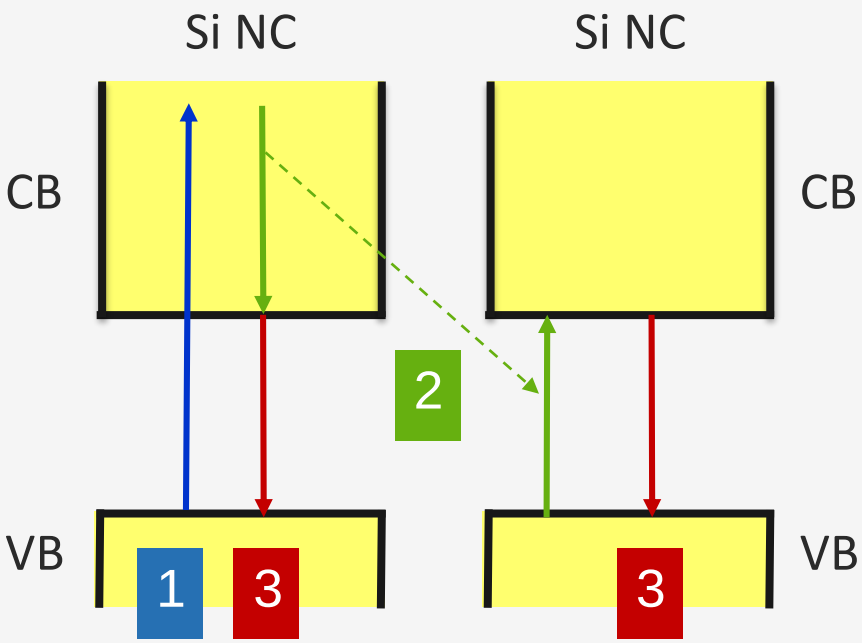
Opportunity: *Multiple Exciton Generation*



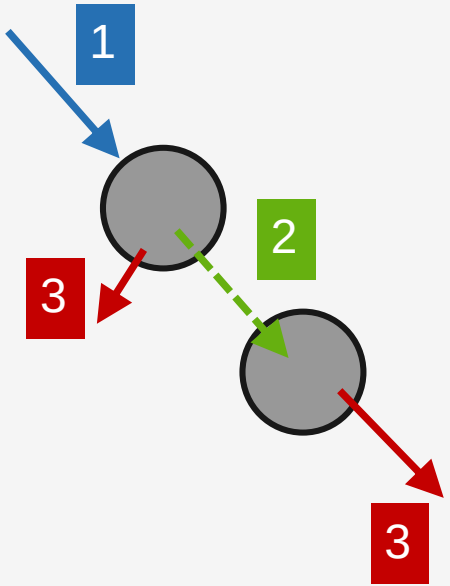
Quantum Dots



Down conversion: *based on QDs*



Process:



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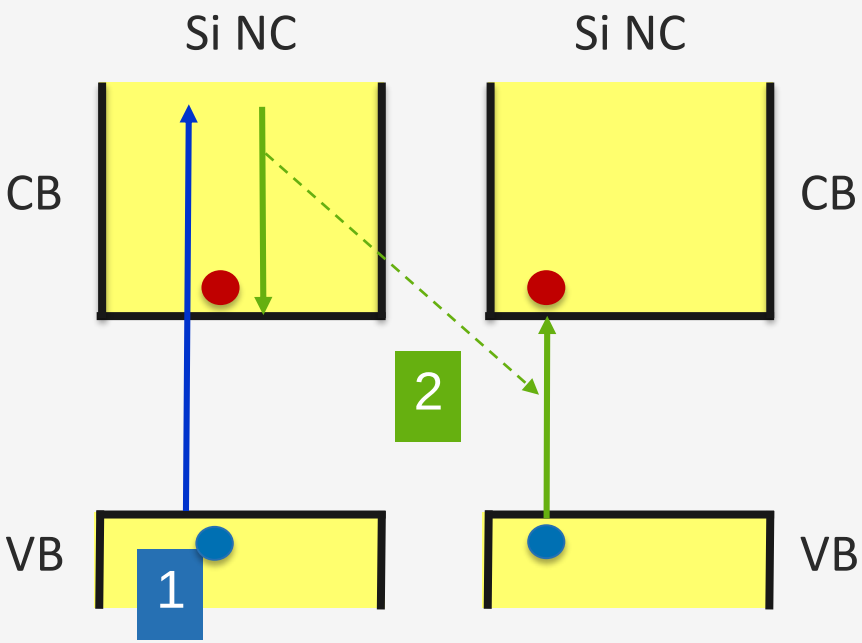

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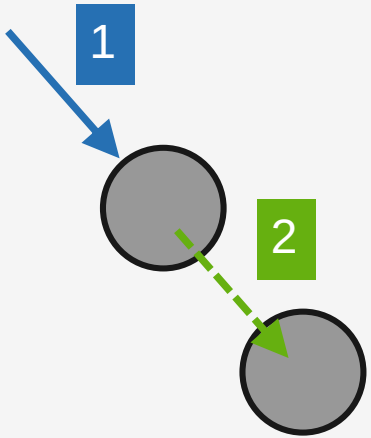
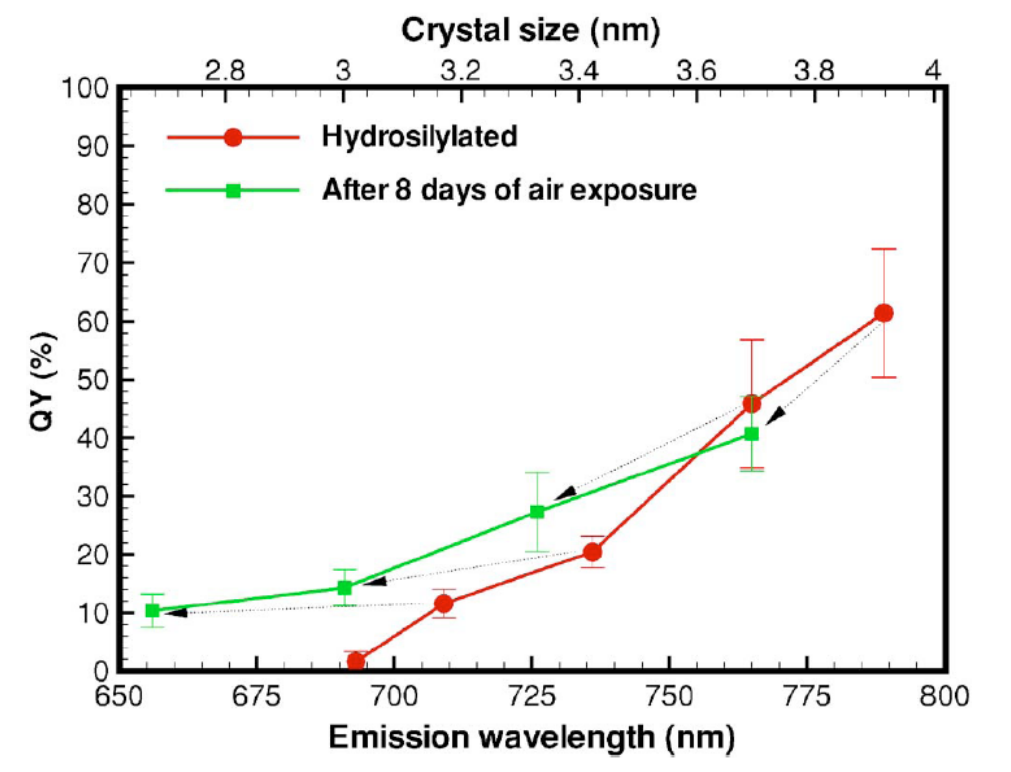
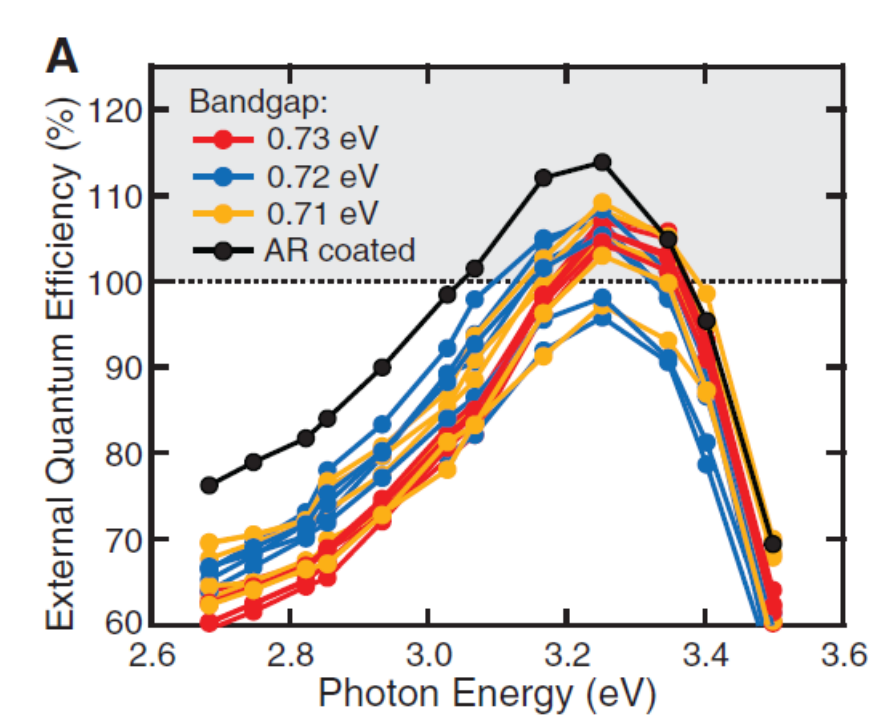


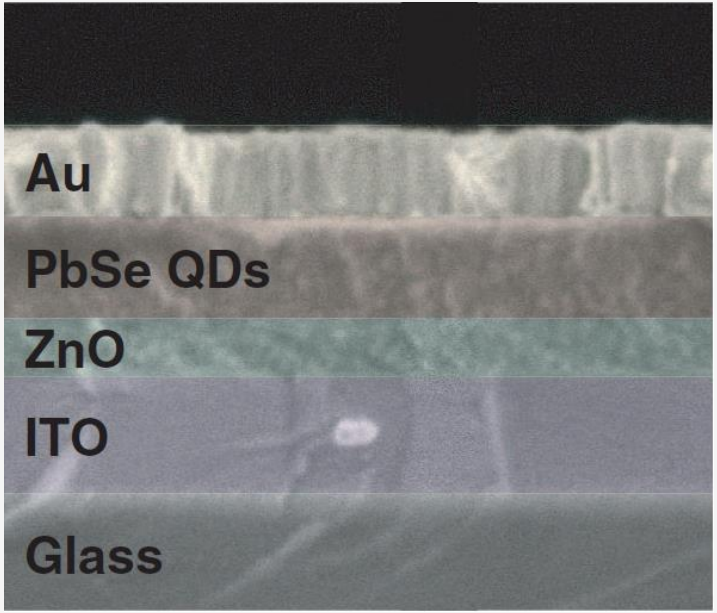
Down Conversion in QDs structures



Jursberg et al, Appl. Phys. Lett. 233116 (2008)

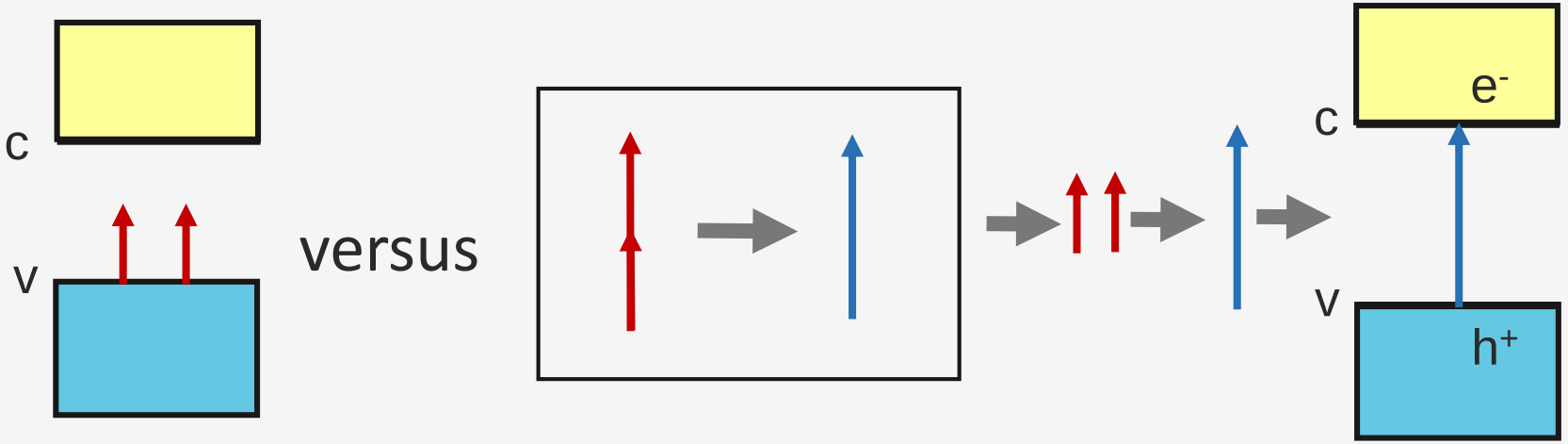
Multiple Exciton Generation in QDs structures



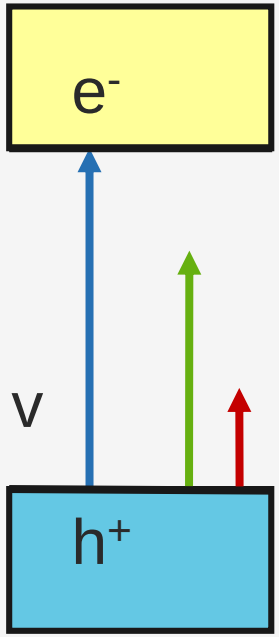


Semonin et al., Science 334, 1530 (2011).

Opportunity: *up conversion*



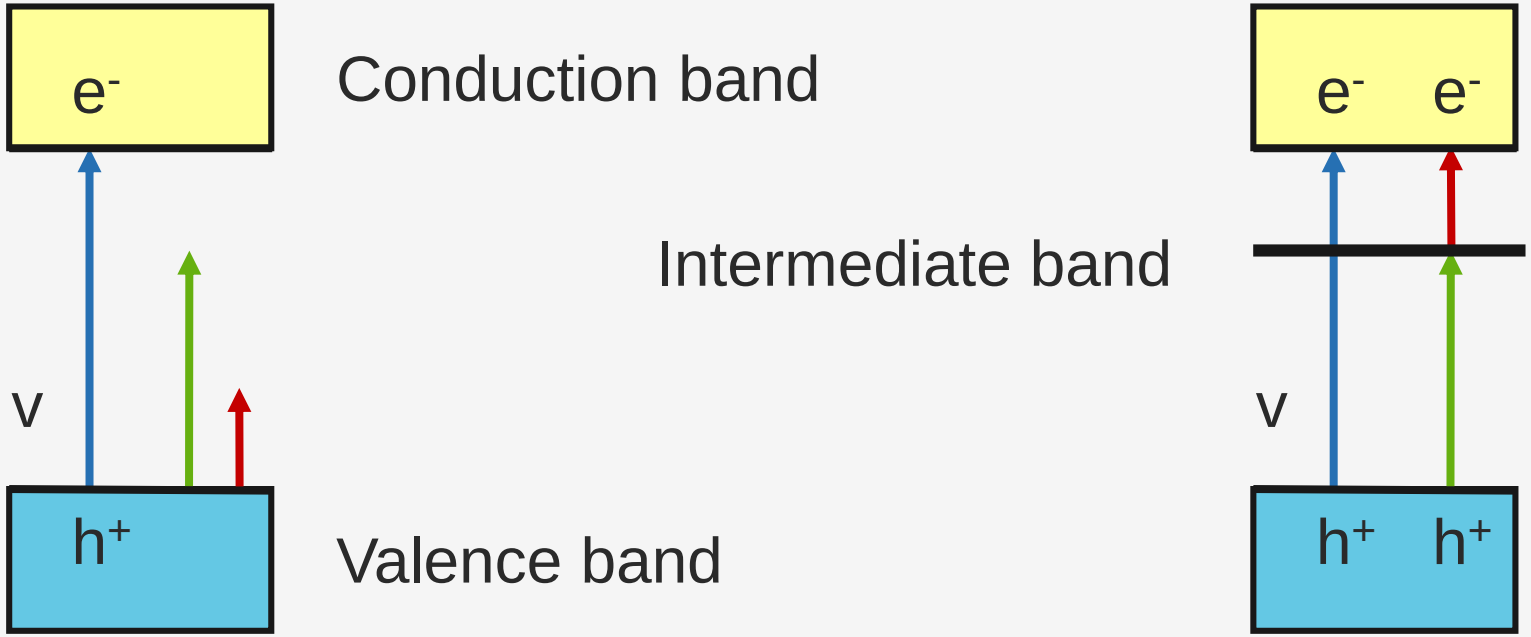
Opportunity: *intermediate band solar cell*



Conduction band

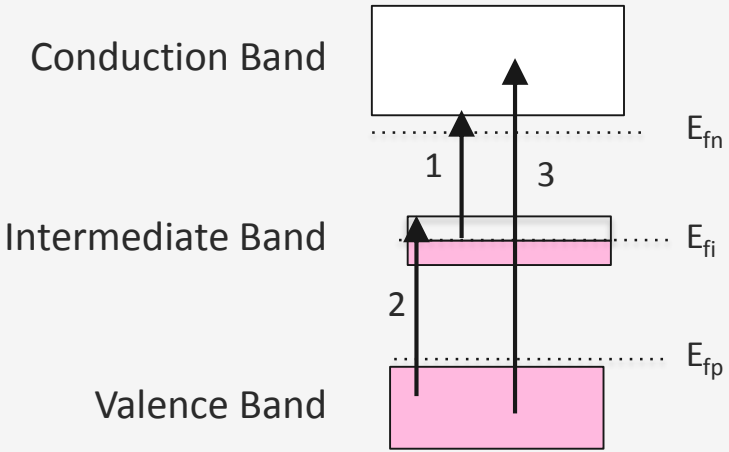
Valence band

Opportunity: *intermediate band solar cell*

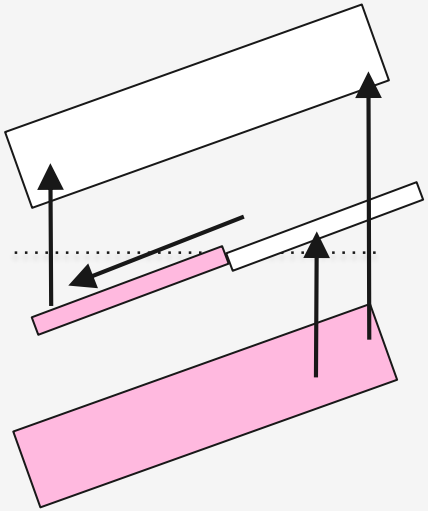


Opportunity: *Intermediate band solar cells*

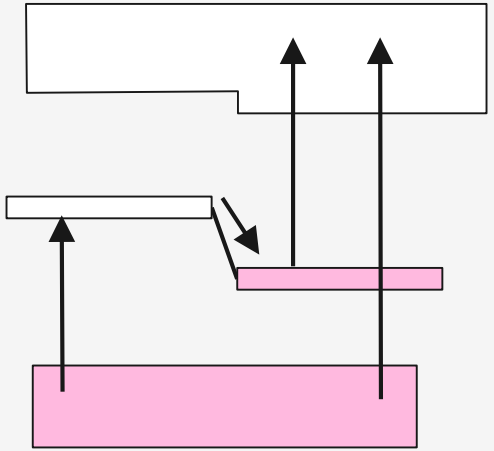
metallic



Built-in field



Band-edge engineering



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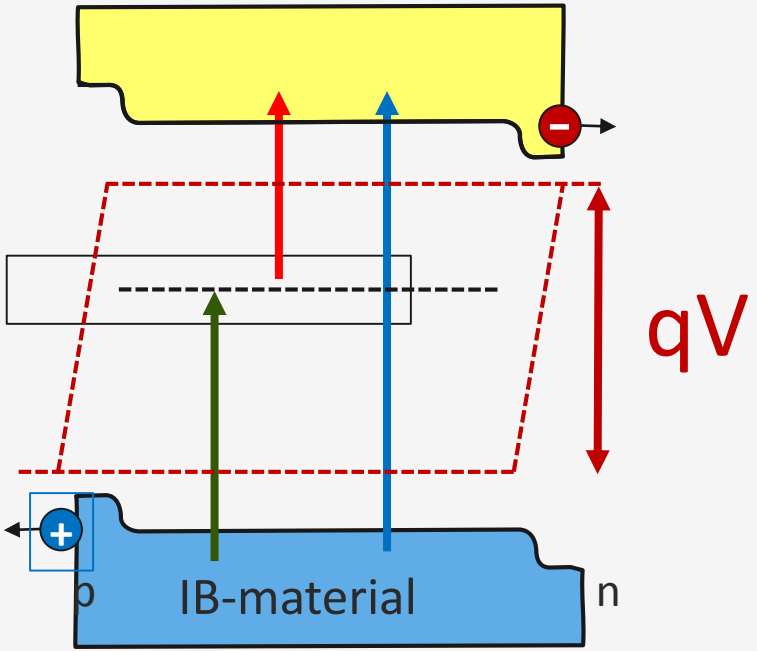
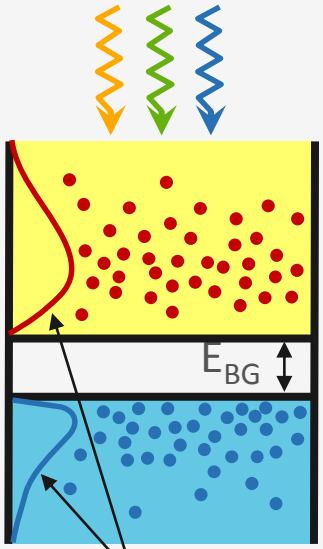


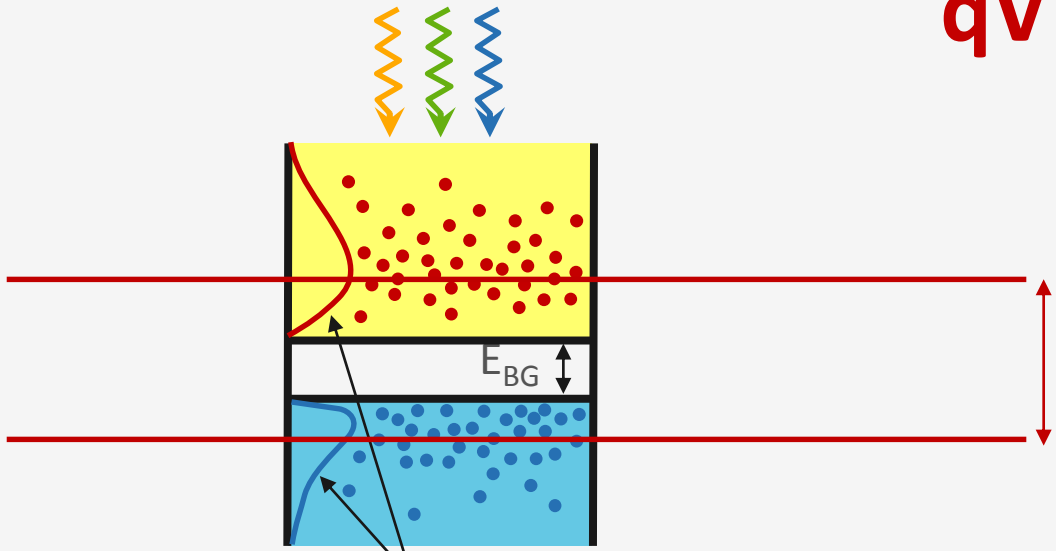
Hot Carrier Solar Cell



hot electron and hole
Energy distributions

Hot Carrier Solar Cell

$qV > qE_{gap}$



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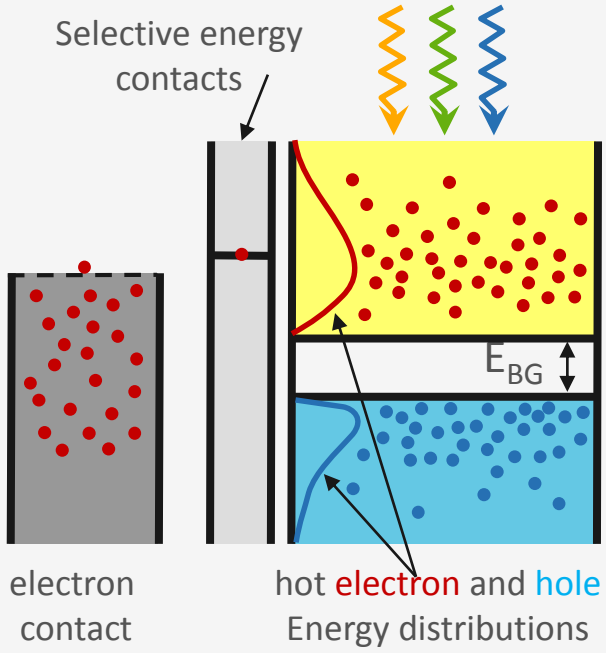

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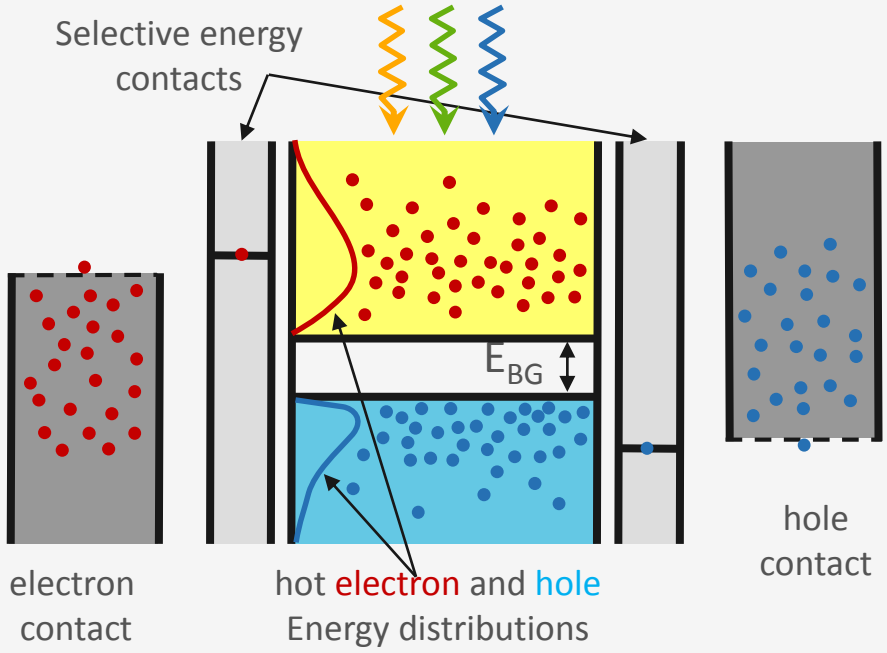

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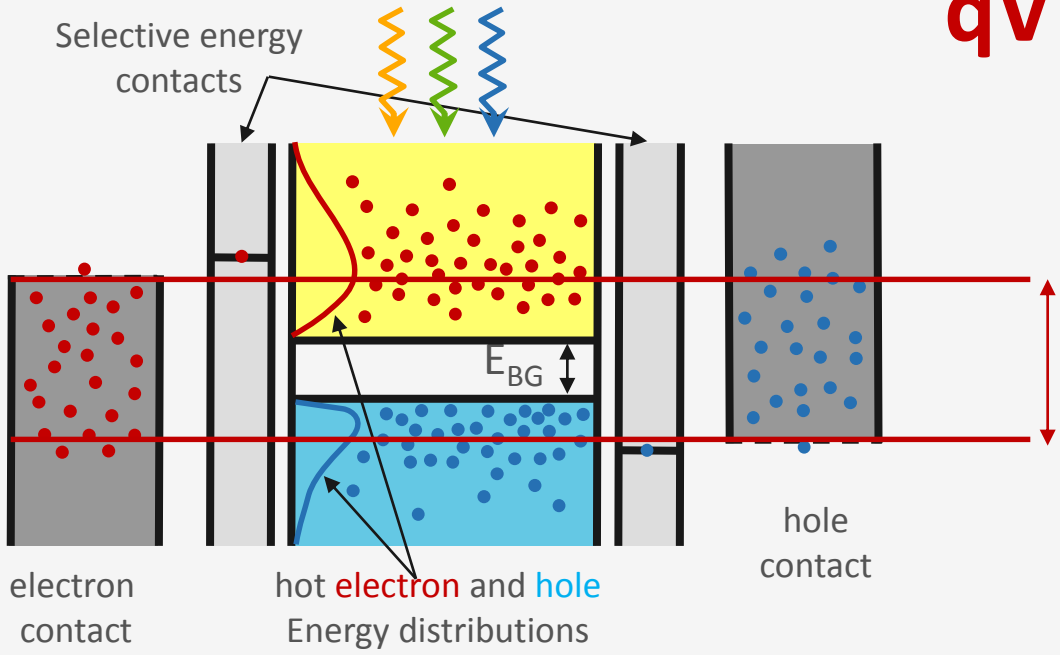
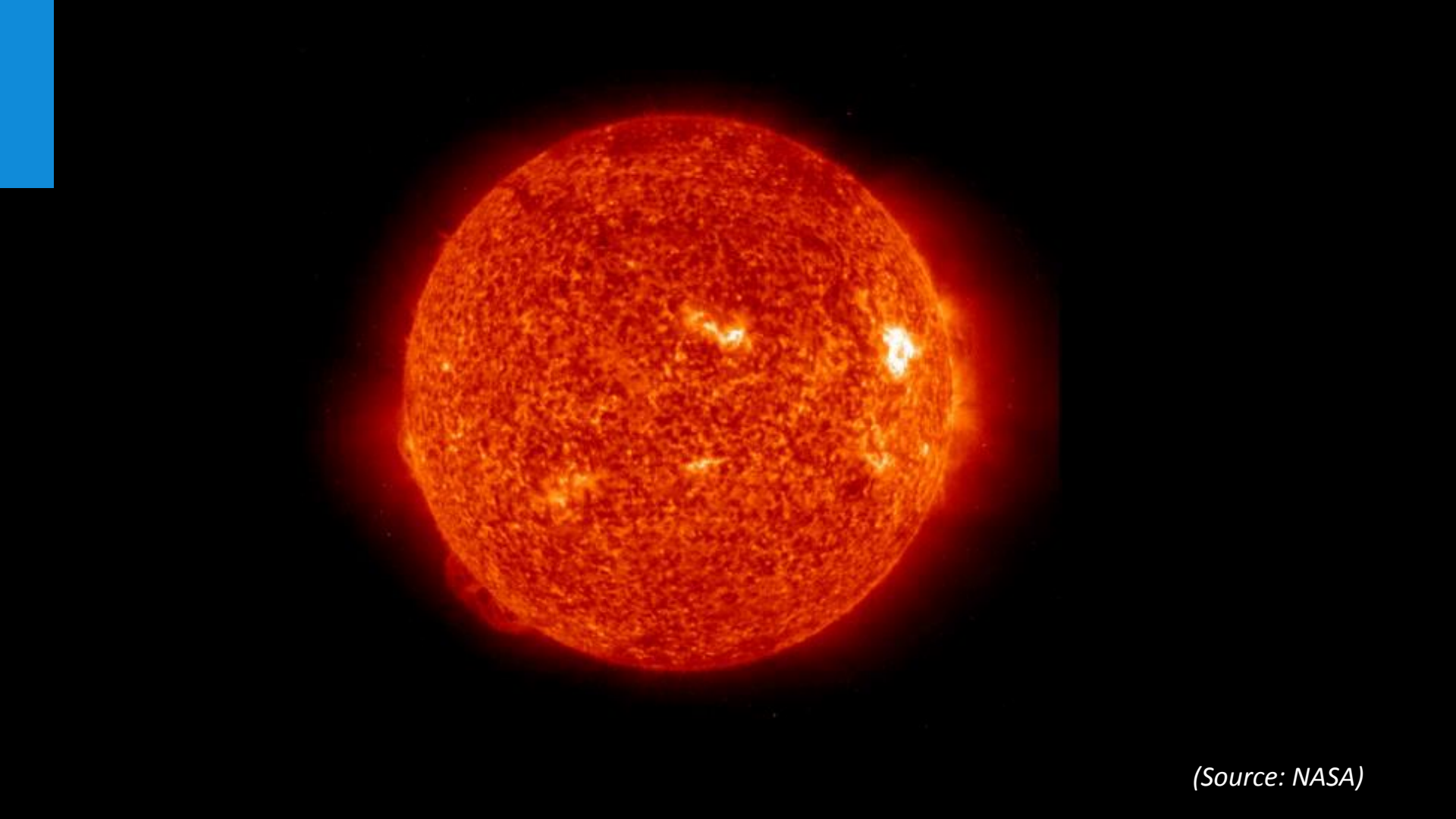


$qV > qE_{gap}$



(Source: NASA)

Thank you for your attention!