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Synlight User Facility Opportunities

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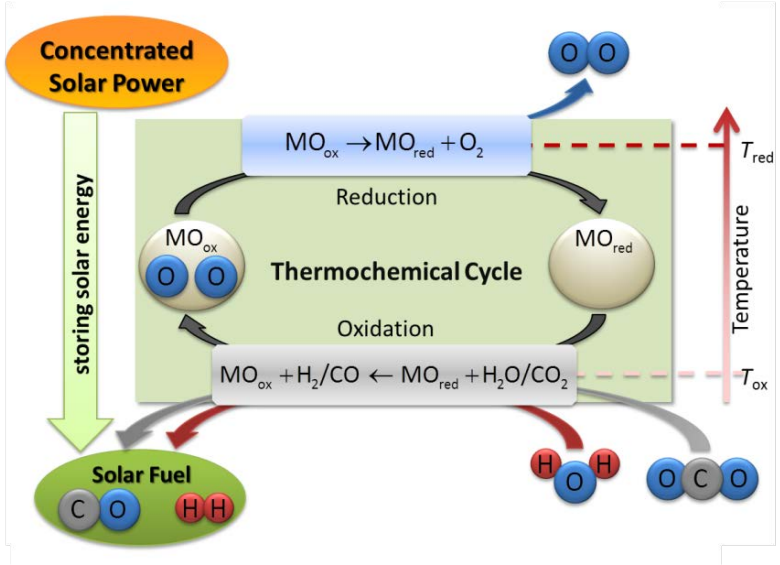
Jülich, 2017-Sept-14

DLR

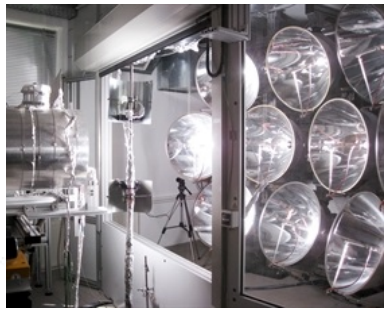
Large-Scale High-Flux Solar Simulator (HFSS)

Purpose:
Generation of precisely adjustable and consistent sunlight in a new magnitude for research and industry



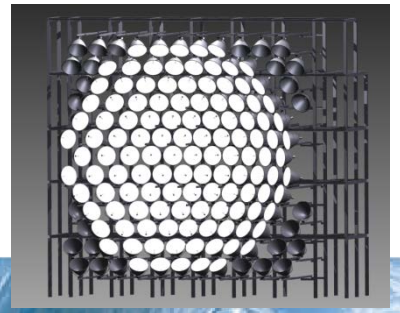
Application: Testing and qualification of
- Solar thermochemical processes and reactors
- CSP components (receivers)
- Components exposed to high solar / UV radiation
- Applications with extremely high temperatures

Bridging solar laboratory scale with large demo and commercial plants for **faster technology developments** and a **reduction of scaling risks**



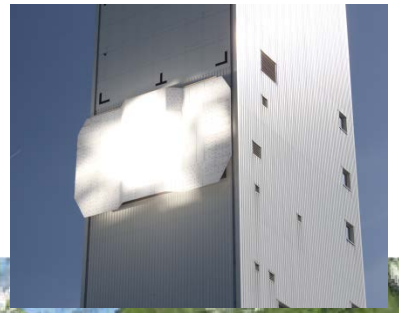
— Factor ~10 →

DLR High-Flux Solar Simulator HLS, Cologne, up to 20kW$_{rad}$



— Factor ~10 →

Synlight, Jülich, up to 310 (400) kW$_{rad}$



Large demonstrators and commercial applications >2000kW$_{rad}$

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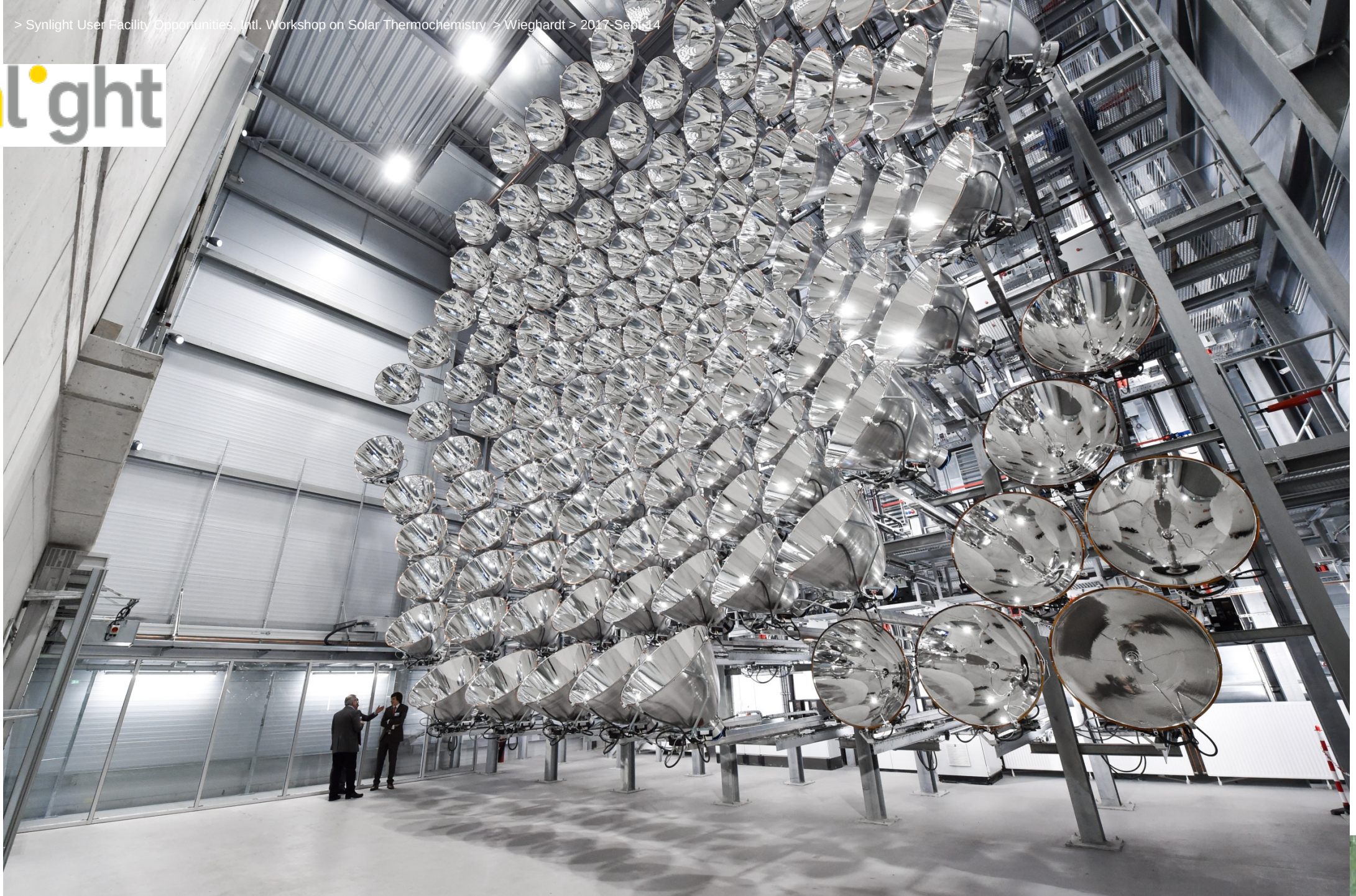

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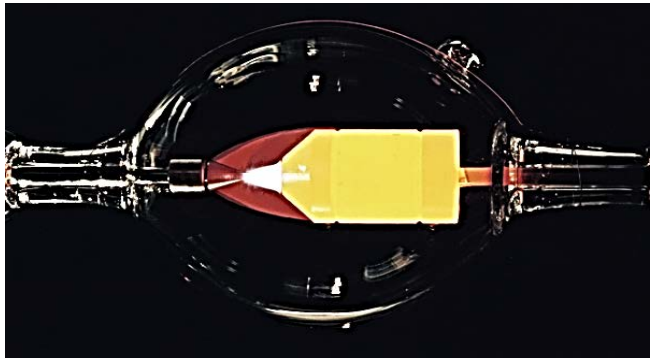
Synlight Facility Construction

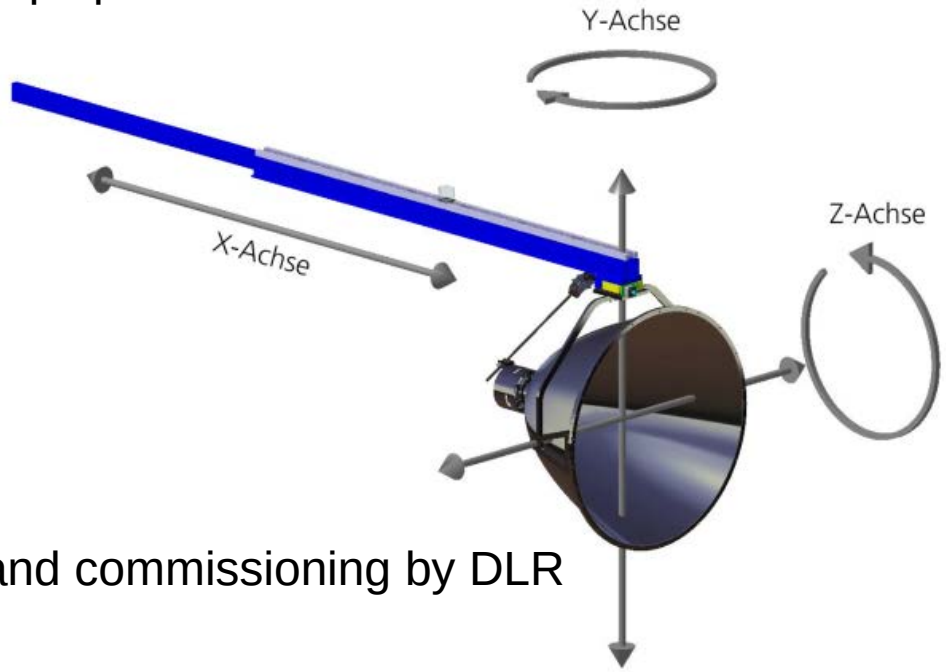


Benefit from long-term experience in HFSS design and operation

- Contribution to design of PSI's 50kW$_{rad}$ HFSS (K.-H. Funken, 2003/04)
- Design and successful operation of own 20kW$_{rad}$ HFSS (started 2007)

Xenon lamps as light source

- Punctual light, very close to solar spectrum in visible and UV region
- Current use of 7kW$_{el}$ lamps (lowest costs of light), up to 10kW$_{el}$ lamps possible
- Ellipsoid-shaped reflectors with 8m focal length



Modular HFSS design

- 149 equal radiator modules in a flat honeycomb-shaped array
- Each module individually moveable in 3 axis, computer-controlled
- Module design for compact arrangement

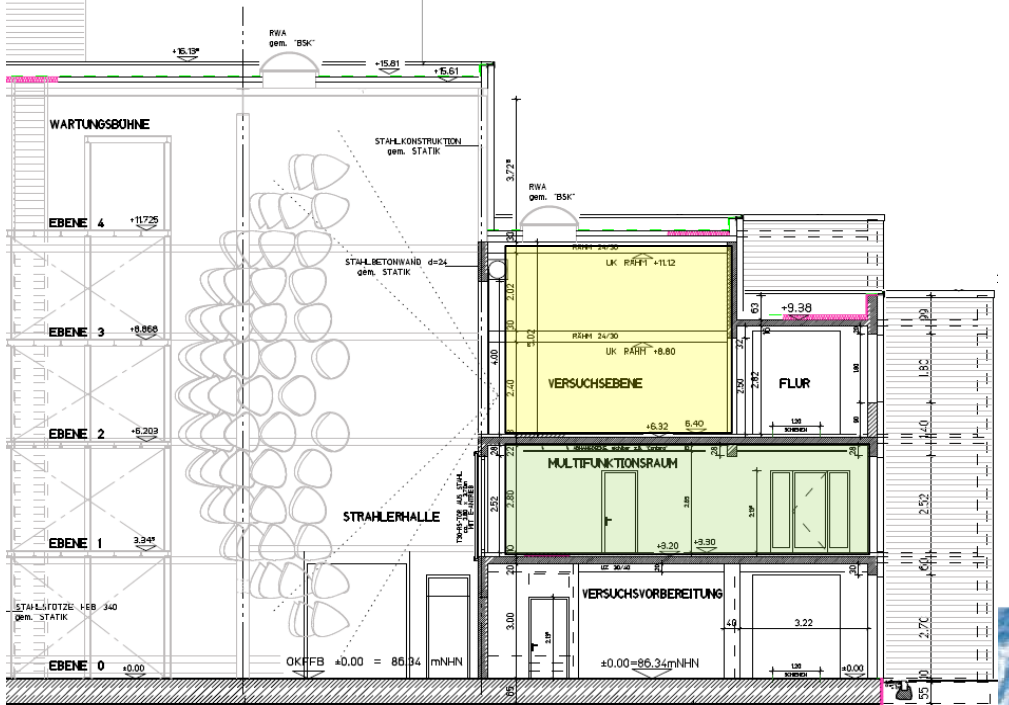
Project 2014 – 2017

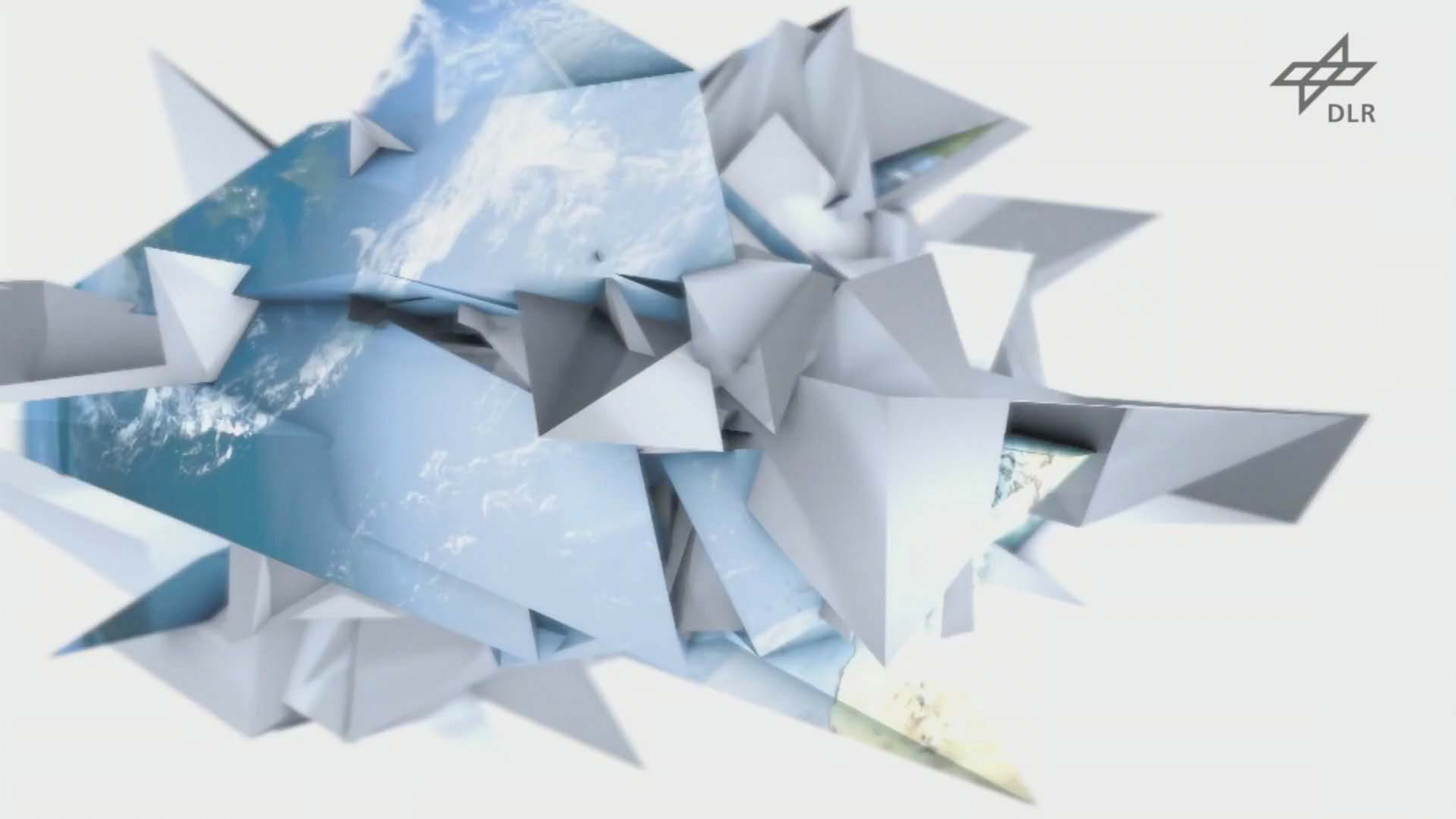
- Concept, engineering, prototype testing, procurement, assembly and commissioning by DLR

Synlight Building

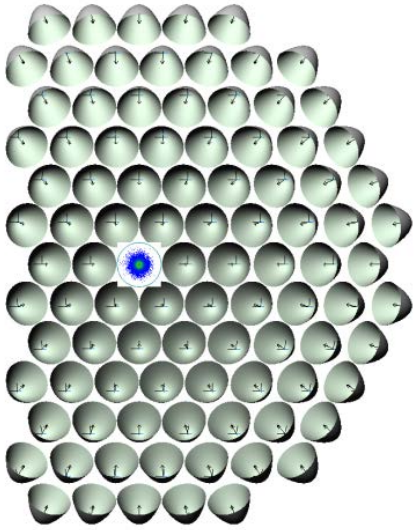
Special building with three test chambers

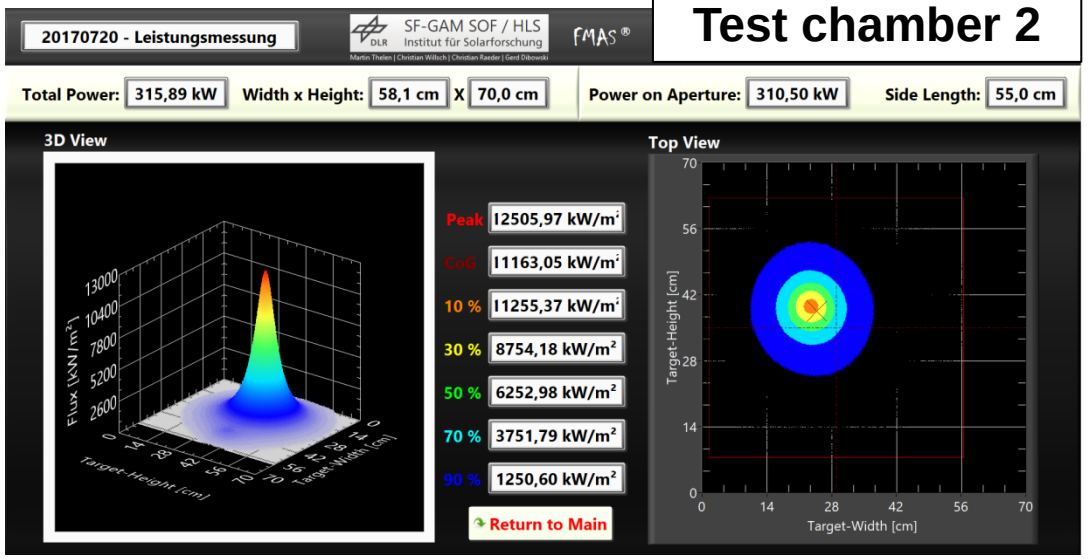
- Most modules can be directed into multiple test chambers – Facility resources are shared
- Independent operation / preparation work in the test fields due to light & fire proof roller shutters (4m x 4m)
- Test chambers with different dimensions and equipment. All with air cooling, 440V AC power and water suppliers
- Each chamber with separate control room, connected by Ethernet LAN
- Camera monitoring – no humans exposed to light radiation
- Workshop for test preparation & conference room
- Trolleys for transport and positioning of test objects

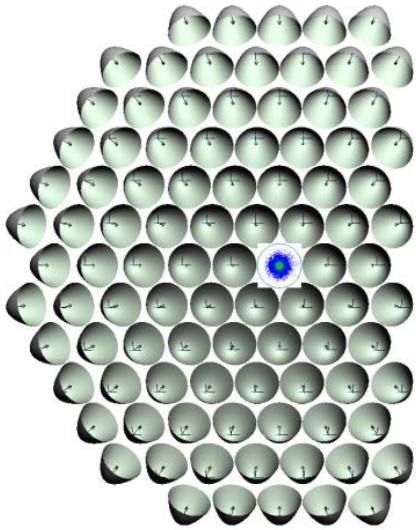


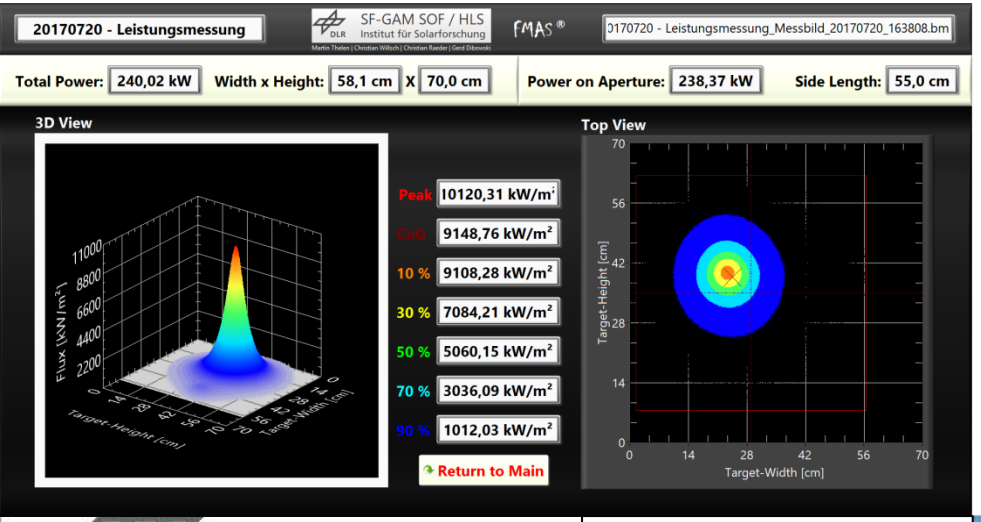


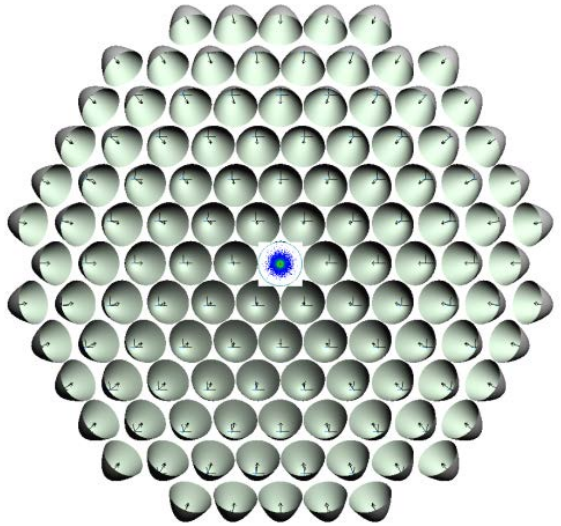
Validation of Radiation Powers and Peak-Fluxes in the Test Chambers

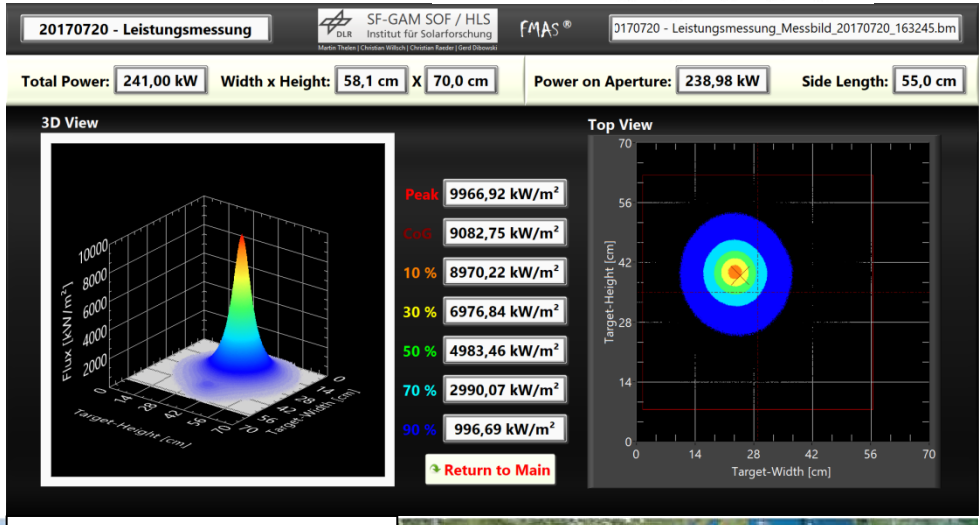












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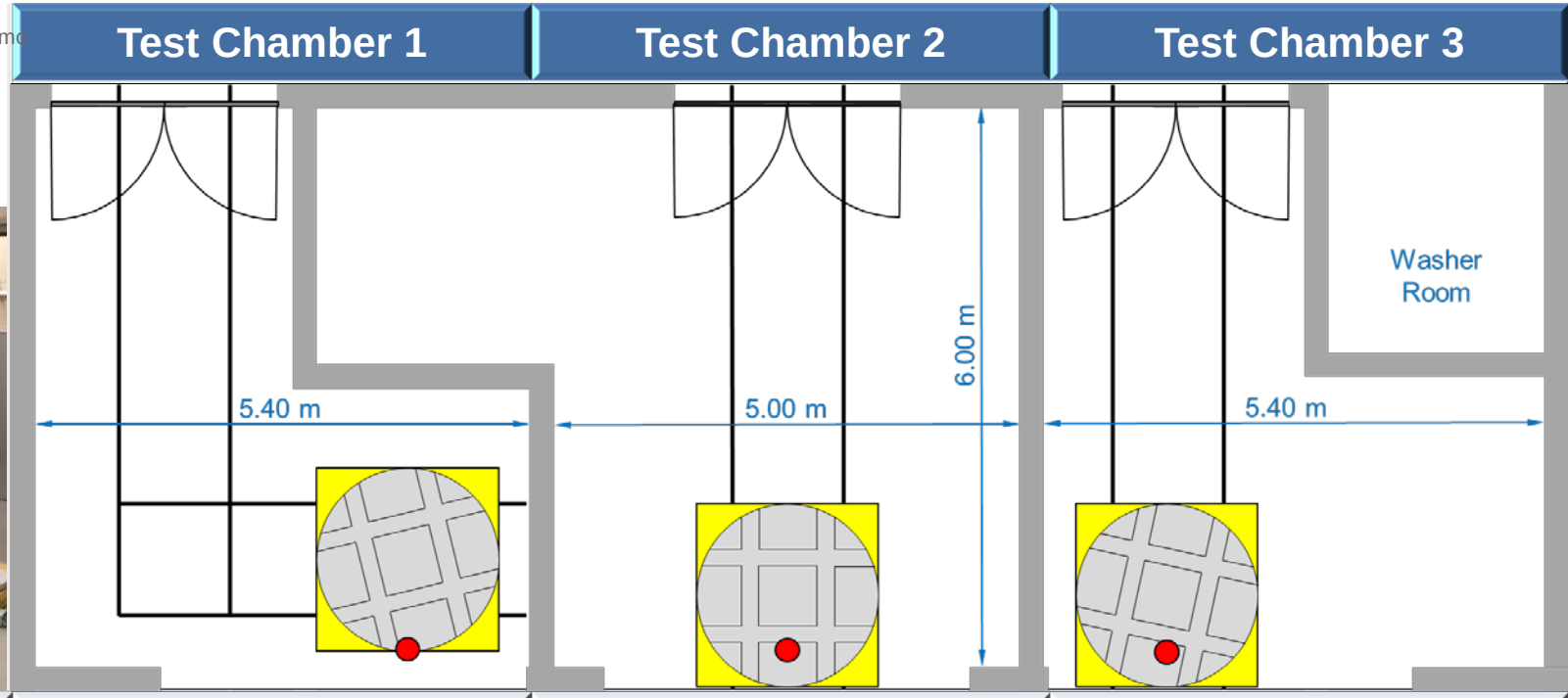
Test chamber 3

Test chamber 1

Technical Profile



	Test Chamber 1	Test Chamber 2	Test Chamber 3
# of Xenon lamps to be focused on reference points	96	121	96
Max. solar radiation power with 7kW$_{el}$ standard lamps	240kW$_{rad}$	310kW$_{rad}$	240kW$_{rad}$
Expected max. radiation power with 10kW$_{el}$ lamps	320kW$_{rad}$	400kW$_{rad}$	320kW$_{rad}$
Peak flux with 7kW$_{el}$ standard lamps	10.0MW/m²	12.5MW/m²	10.0MW/m²
Maximum aperture size of a test object	4m x 4m*		
Maximum weight of a test object	>4t*	>6t*	>4t*
Test chamber dimension	25m² x 4.5m	38m² x 4.5m	26m² x 4.5m
Standard features in each test chamber	AC power up to 400V/63A, Ethernet 1Gbit/s, ventilation air flow 5m³/s, water 100L/min		
Special feature	High UV proportion	Connection to washer room for solar chemical applications	

* Test objects up to 2.5t and 2m x 2m x 2m can be transported and positioned on manually moveable trolleys

Worldwide existing High-Flux Solar Simulators

Point-focusing >10kW$_{rad}$, Data to the best of our knowledge & from latest publications

High-Flux Solar Simulator		Start of Operation	Solar Power [kW]	Electric Power [kW]	Lamps	Peak Flux [MW/m²]	SB Temp.** [°C]
DLR, Synlight, Jülich		2017	**310 (400)* 240 (320)* 240 (320)***	149 x 7 (149 x 10)	Xe	**12.5 10.0 10.0**	3580 3370 3370
Paul Scherrer Institute, Villigen/Zürich		2005	**50**	10 x 15	Xe	**11.0**	3460
Niigata University, Beam-down HFSS		2013	**30**	19 x 7	Xe	**3.2**	2470
DLR, HLS, Cologne		2007	**20**	10 x 6	Xe	**4.2**	2660
Aristotle University, Thessaloniki		2013	**20**	11 x 6	Xe	**4.8**	2760
North China Electric Power Univ., Beijing		2016	**20**	7 x 10	Xe	**4.0**	2630
KTH Stockholm, Fresnel lens HFSS		2014	**19.7**	12 x 7	Xe	**6.7**	3020
University of Florida, Gainesville		2011	**14**	7 x 6	Xe	**5.0**	2790
IMDEA, Móstoles/Madrid		2013	**14**	7 x 6	Xe	**3.6**	2550
Swinburne University, Melbourne		2015	**12**	7 x 6	MH	**0.9**	1740
EPFL Lausanne, LRESE	Same design	2015	**11.3**	18 x 2.5	Xe	***21.7***	*4150*
Australian Nat. Univ., Canberra	Same design	2015	**10.6**	18 x 2.5	Xe	**9.5**	3320
University of Colorado, Boulder		2016	**10**	18 x 2.5	Xe	*	*

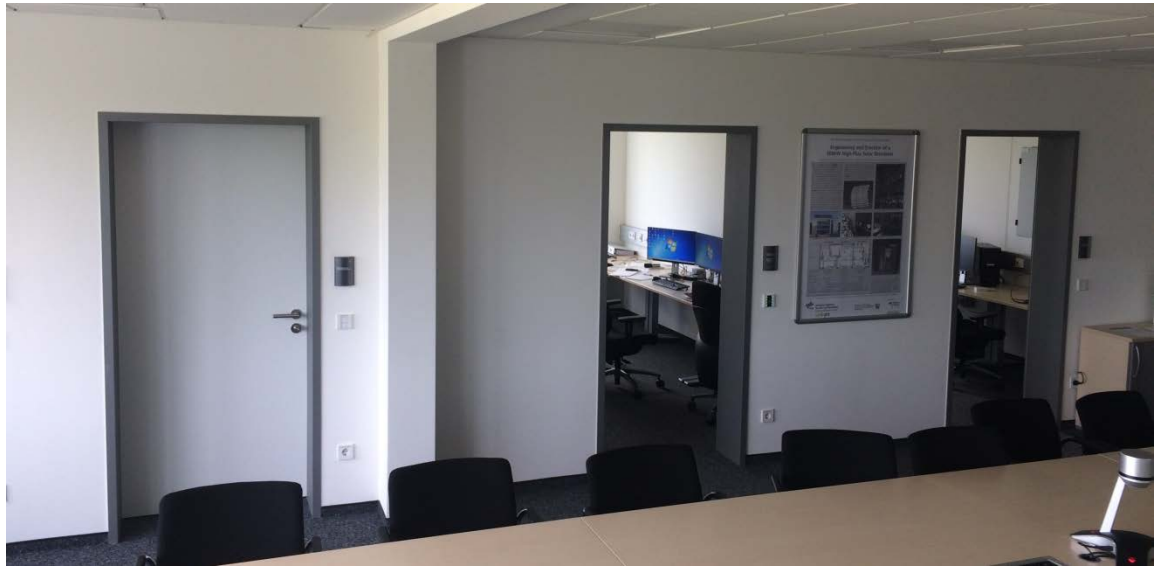
* Design values, not yet been demonstrated / published

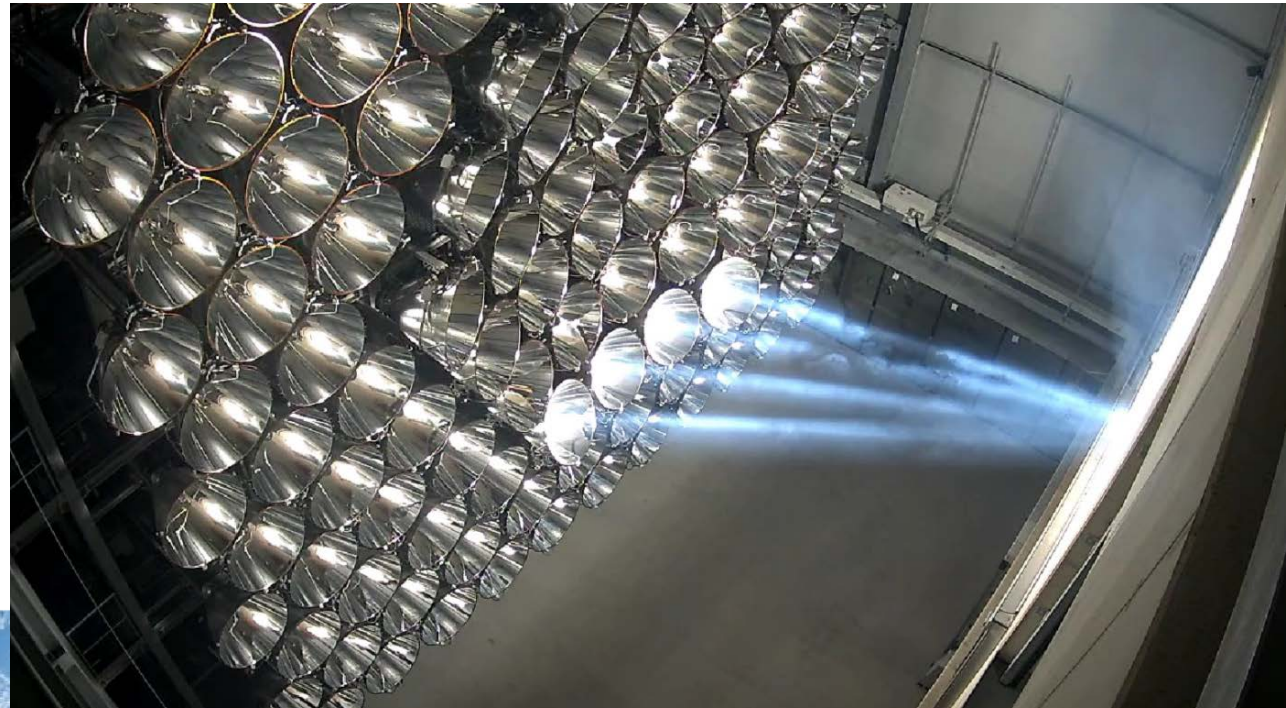
** Max. total temperature on ideal black body acc. to Stefan-Boltzmann law

Test Operation

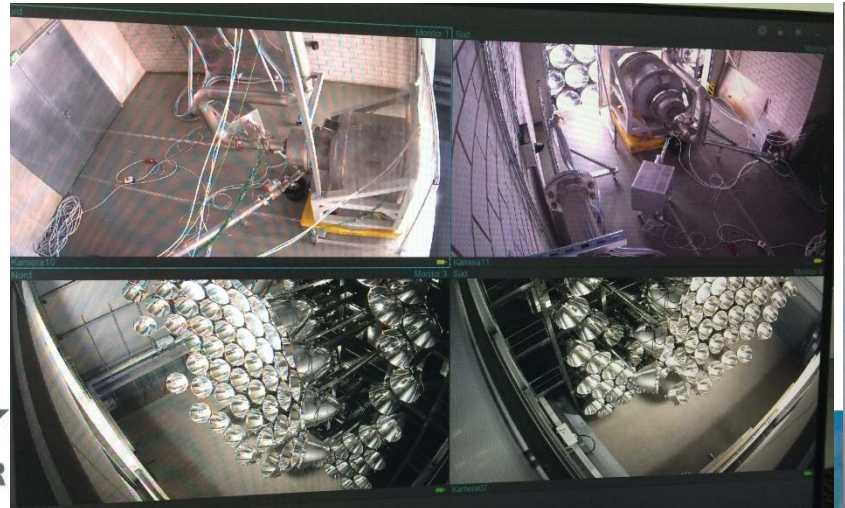
- Each test chamber with separate control room
- Test campaigns can work with allocated modules
- Exclusive data access via Ethernet LAN
- Exclusive camera views on own experiment

- Fees: Chamber occupancy + module use + operator
- Cooperative research for first 5 years of operation





First Solar Hydrogen Reactors in Synlight



Summary

Synlight is a unique new tool, a high-flux solar simulator of a new performance class

The facility was particularly built for solar thermochemical applications

Up to three test campaigns can use Synlight in parallel. Their knowhow and test results are protected

The recent validation showed solar radiation powers of up to 310kW and peak fluxes of up to 12.5MW/m².
Upgrades will be possible with larger Xenon lamps

Synlight shall help to push solar technology developments and reduce future scaling risks.
It is open to the entire global solar research community

Get your enlightenment in Jülich!

DLR

synl ght

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