synl'ght

A New Facility for Large-Scale Testing in CSP and Solar Chemistry

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DLR

synlight Large-Scale High-Flux Solar Simulator (HFSS)

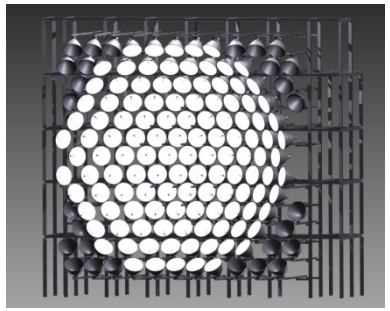
Purpose:
Generation of precisely adjustable and consistent sunlight in a new magnitude for research and industry

Application: Testing and qualification of
- Solar thermochemical reactors and processes
- CSP receivers and components
- Components exposed to high solar / UV radiation (UV-ageing, desert conditions, aerospace components)
- Applications with extremely high temperatures, e. g. from material sciences

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

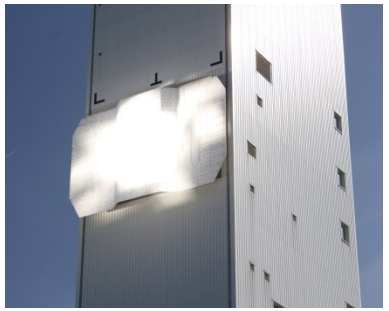
— Factor ~10 →

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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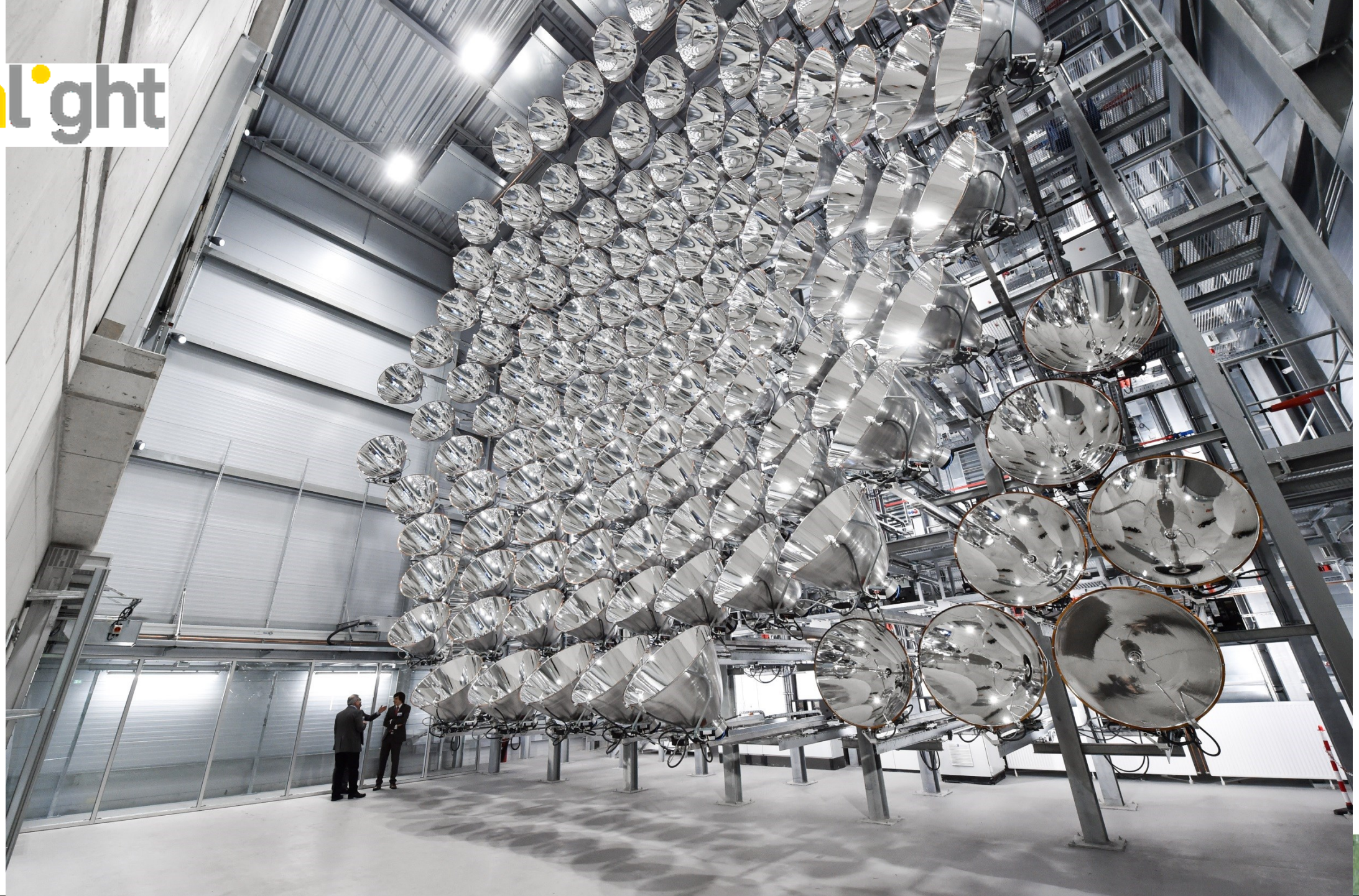

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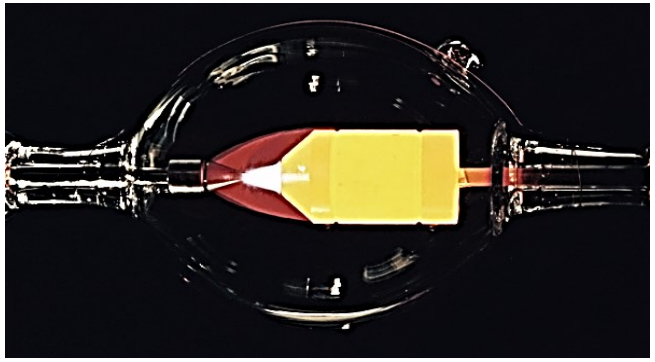
Synlight Technology and Project

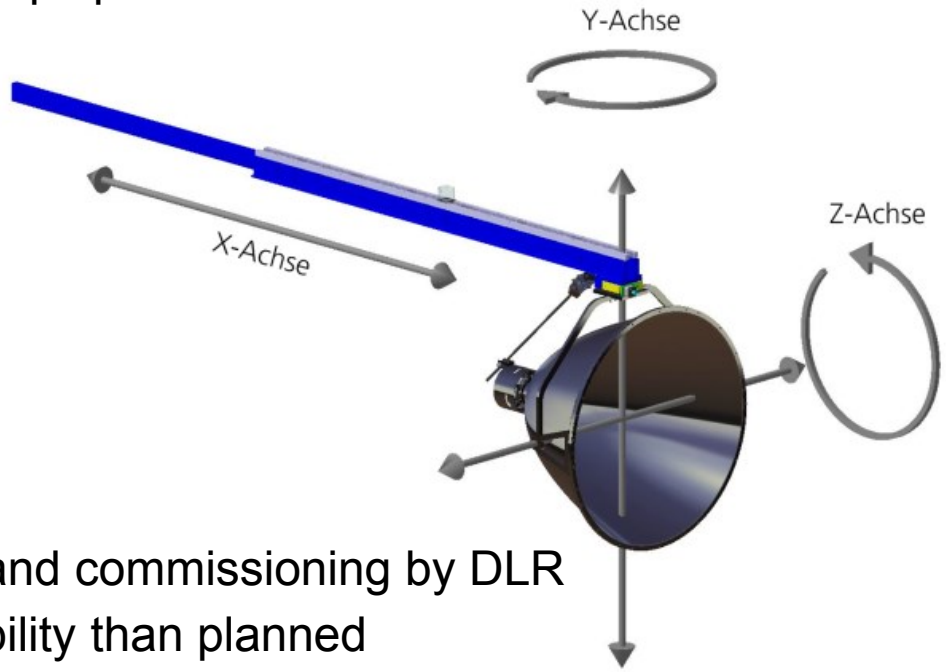


Benefit from long-term experience in HFSS design and operation

- 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

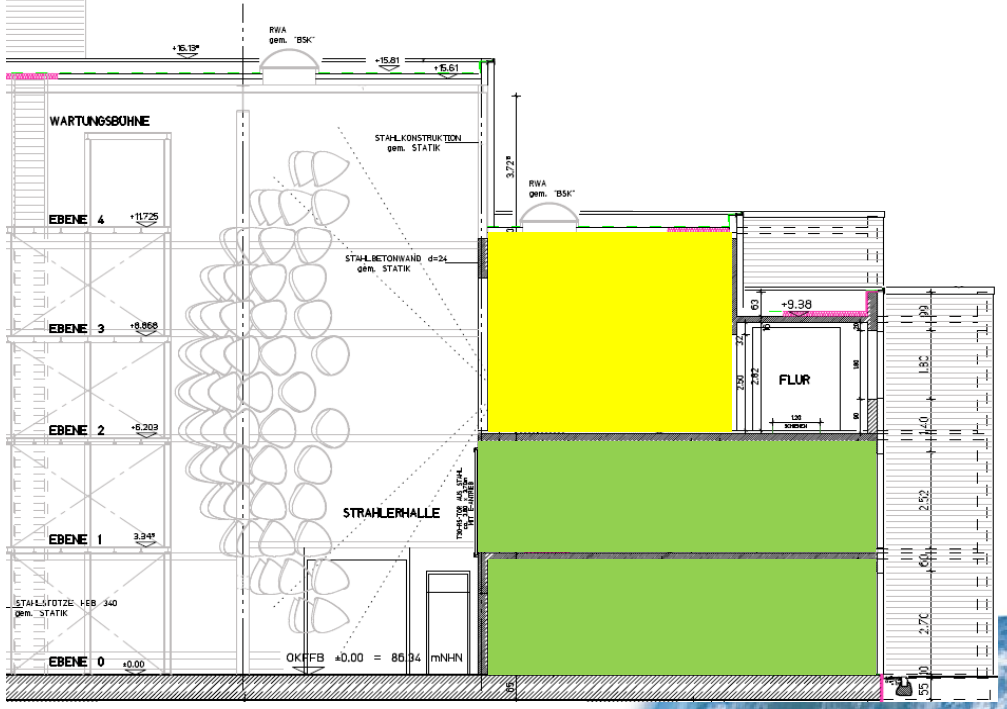
- 149 equal radiator modules in a flat honeycomb-shaped array
- Each module individually moveable in 3 axis, computer-controlled
- Module design for compact arrangement

Project 2014 – 2017

- Concept, engineering, prototype testing, procurement, assembly and commissioning by DLR
- Project within time and budget. Facility with more power and flexibility than planned

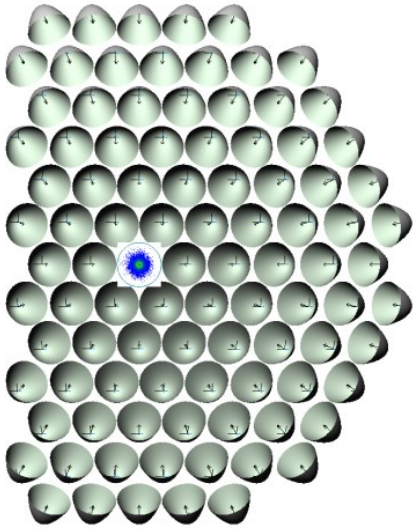
Synlight Building

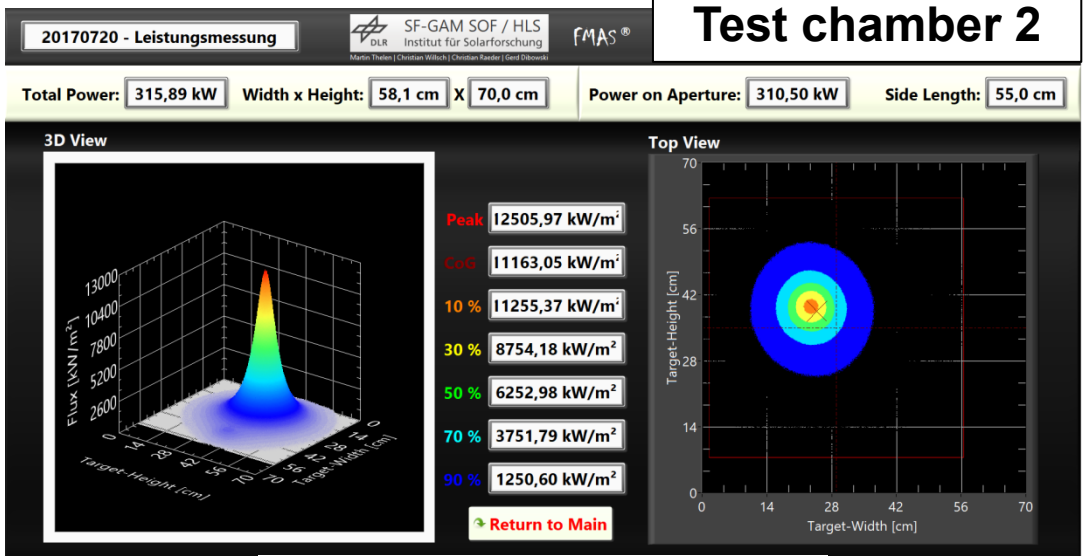
- Three test chambers, sharing the facility resources. Fast and computerized re-direction of the modules
- Independent operation / preparation works in the test chambers due to light & fire proof roller shutters (4m x 4m)
- Test chambers with different dimensions and equipment. All with air cooling, 400V AC power and water suppliers
- Three separate control rooms, connected by Ethernet LAN with corresponding test chambers
- Camera monitoring – no humans exposed to light radiation
- Workshop for test preparation. Own machinery (milling, turning, welding, …) in neighboring building
- Trolleys for transport and positioning of test objects
- Conference room

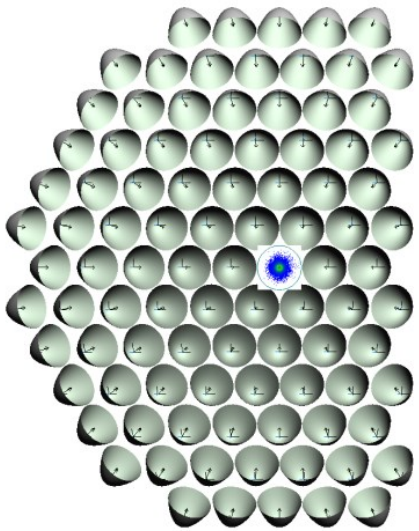


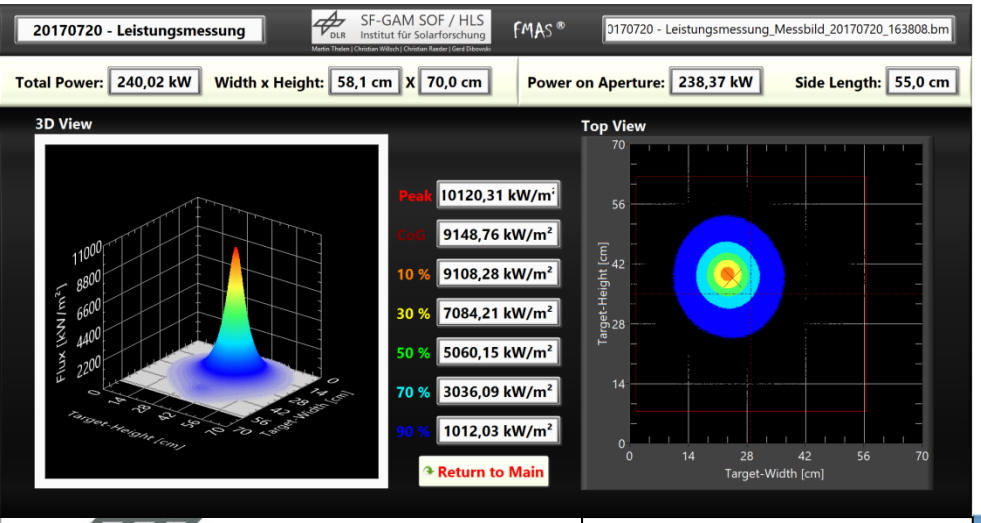
DLR

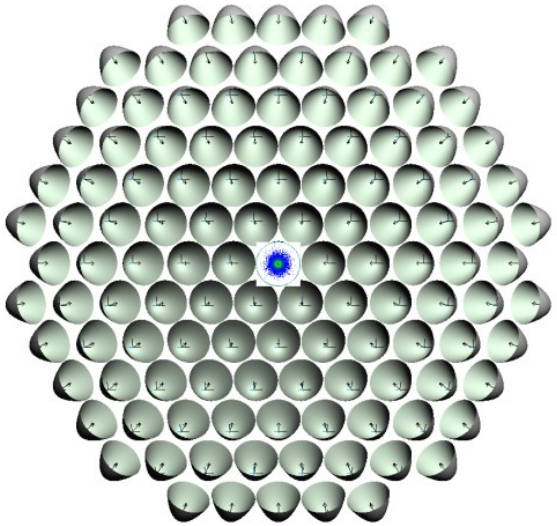
Validation of Radiation Powers and Peak-Fluxes in the Test Chambers (06/2017)

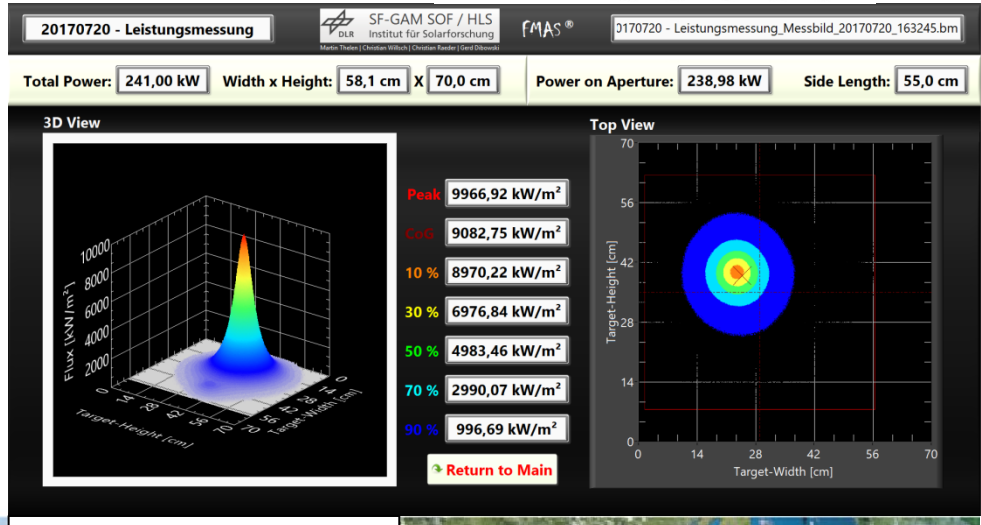








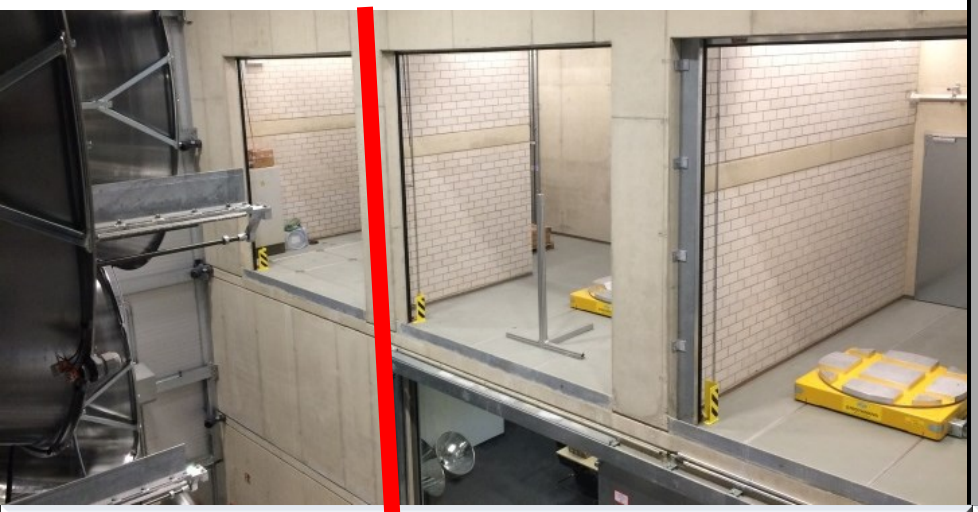


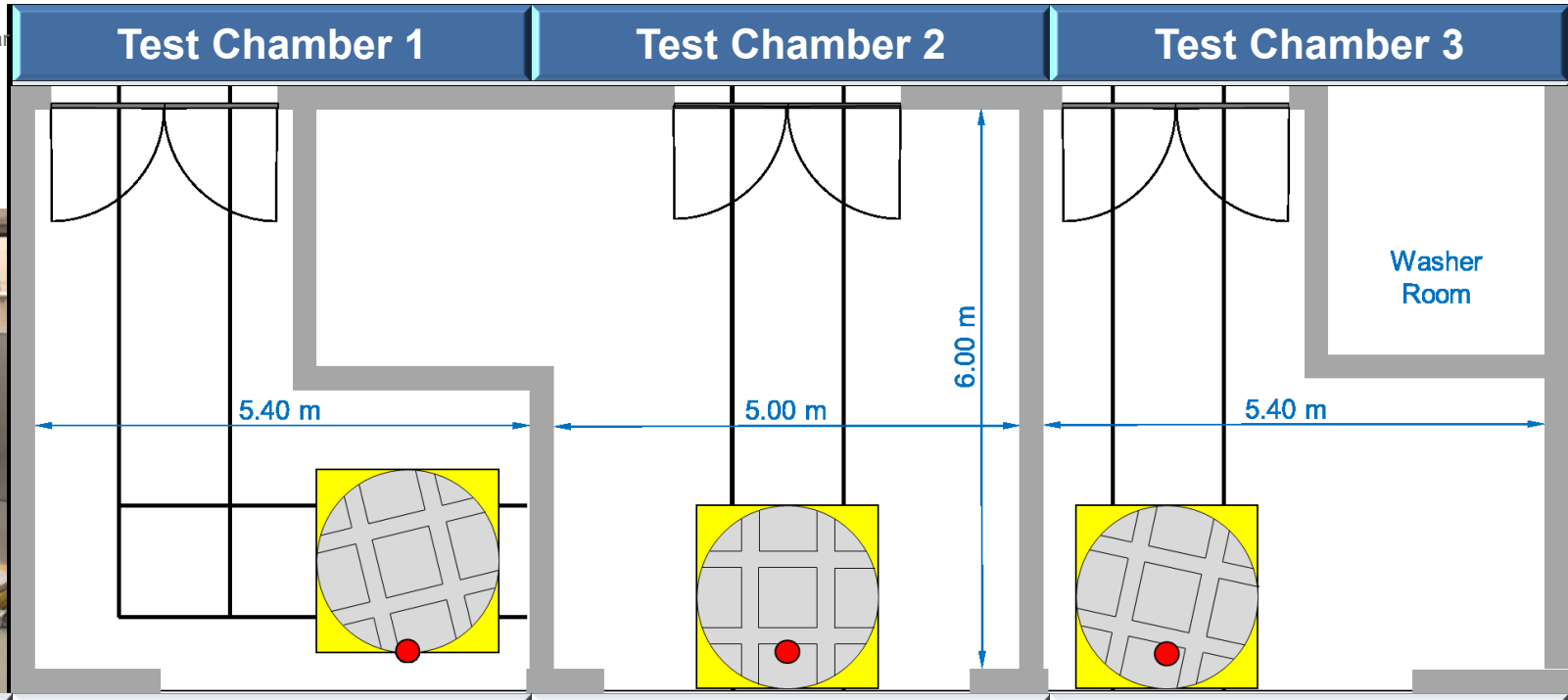


Test chamber 3

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 equipment in each test chamber	AC power up to 400V/63A, Ethernet 1Gbit/s, ventilation air flow 5m³/s, water 100L/min		
Special equipment	Lamps w. high UV proportion	Solar chemical applications w. connection to washer room	

* 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

≥10kW$_{rad}$ point-focus. Data from latest publications and to the best of our knowledge

High-Flux Solar Simulator		Started	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
KTH Stockholm, Fresnel lens HFSS		2014	**20**	12 x 7	Xe	**6.7**	3020
CERTH, Thessaloniki		2013	**20**	11 x 6	Xe	**4.8**	2760
DLR, HLS, Cologne		2007	**20**	10 x 6	Xe	**4.2**	2660
North China Electric Power University, Beijing		2016	**20**	7 x 10	Xe	**4.0**	2630
EPFL Lausanne, LRESE	Same design	2015	**15**	18 x 2.5	Xe	***21.7***	*4150*
Australian National Univ., Canberra	Same design	2015	**15**	18 x 2.5	Xe	**9.5**	3320
University of Minnesota, Minneapolis		2010	**15**	7 x 6.5	Xe	**7.3**	3100
Georgia Tech, Atlanta	Same design	2011	**14**	7 x 6	Xe	**6.8**	3030
University of Florida, Gainesville	Same design	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
University of Colorado, Boulder		2016	**10**	18 x 2.5	Xe	*	*

* Design values, not yet been demonstrated / published

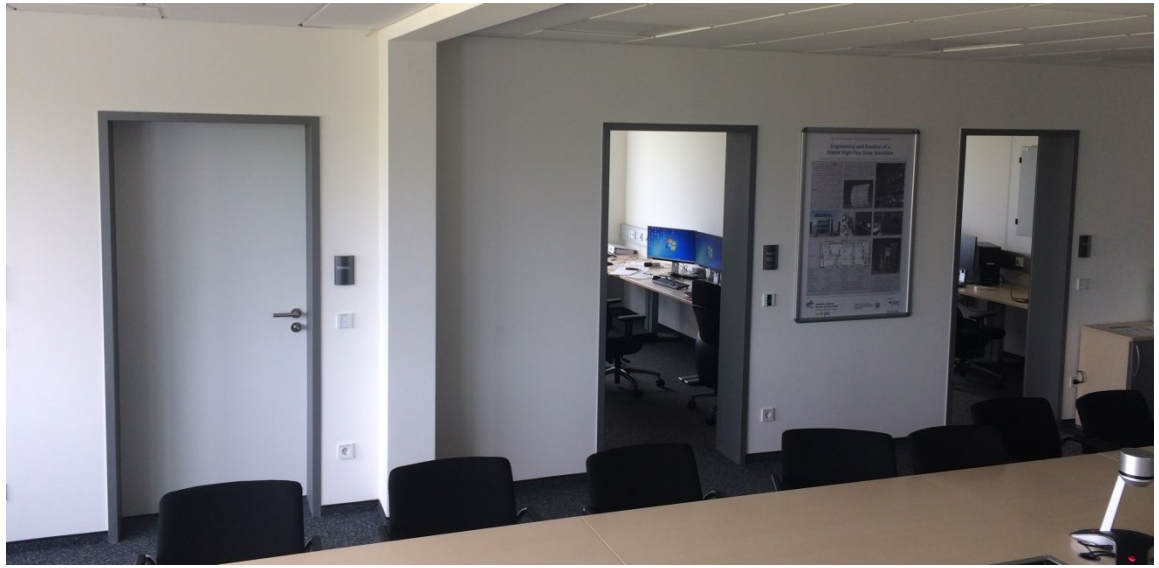
** Max. total temperature on ideal black body acc. to Stefan-Boltzmann law

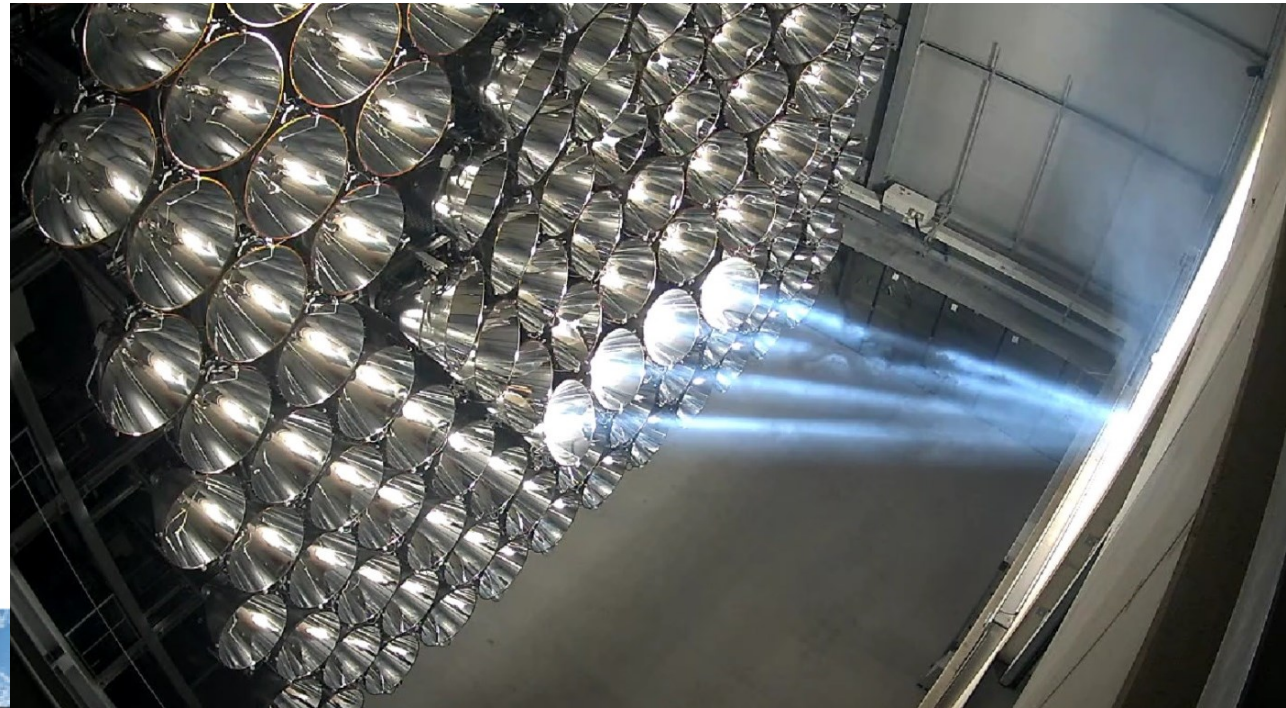
Test Operation

Up to 3 independently operating test campaigns

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

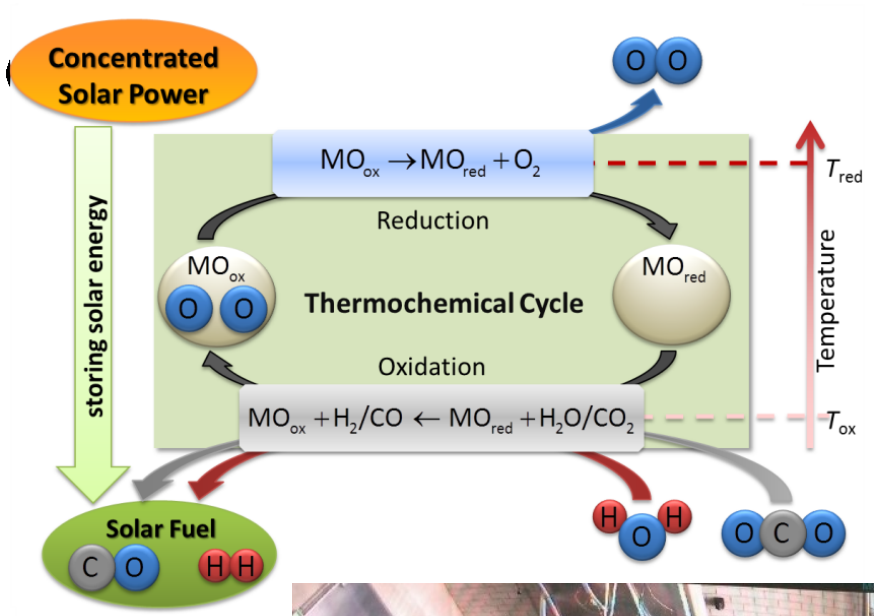
Fees: Chamber occupancy + module use + operator
Cooperative research for first 5 years of operation

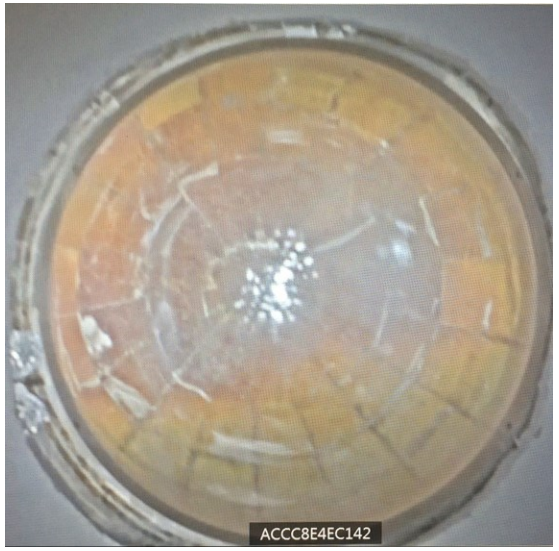


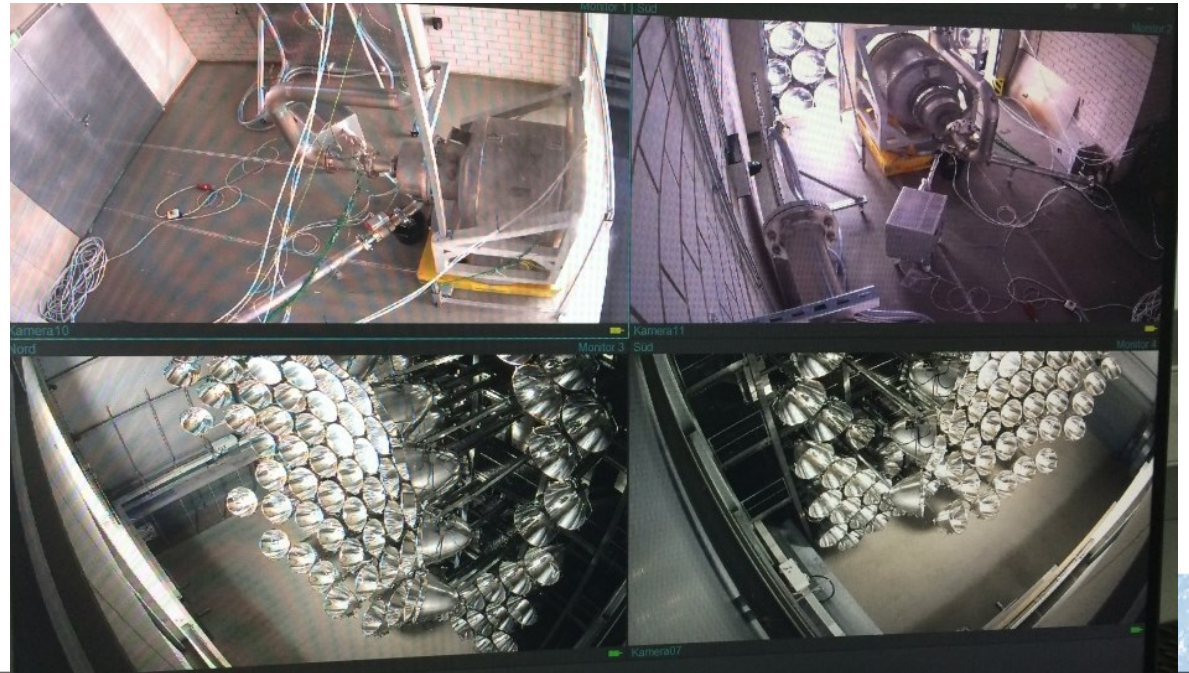


First Test Reactor for Commissioning (100 kW_{rad})

Current Application: Solar Hydrogen Reactor (250 kW_{rad})







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 and CSP testing

Up to three test campaigns can run Synlight in parallel with exclusive access to own experiments and test results

Validation showed radiation powers of up to 310 kW at a peak flux of 12.5 MW/m². Upgrades will be possible with larger Xenon lamps

Synlight shall help to push solar technology developments and reduce scaling risks

The new facility is open to the entire global solar research community

DLR

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Die größte künstliche Sonne der Welt

Gefördert durch:

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