

Solar Thermochemical Pilot Plant Operation at PROMES-CNRS MegaWatt Solar Furnace

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Outline

100 kW Pilot Plant at MWSF

- Installation
- Commissioning

Scientific Background

- Solar ZnO dissociation at 2000 K
- Solar reactor technology

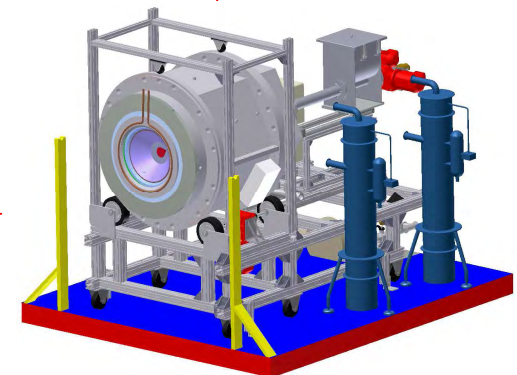
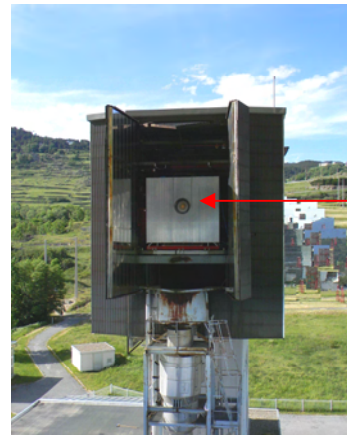
Experimental Results

- Solar reactor experiments
- Flux measurements

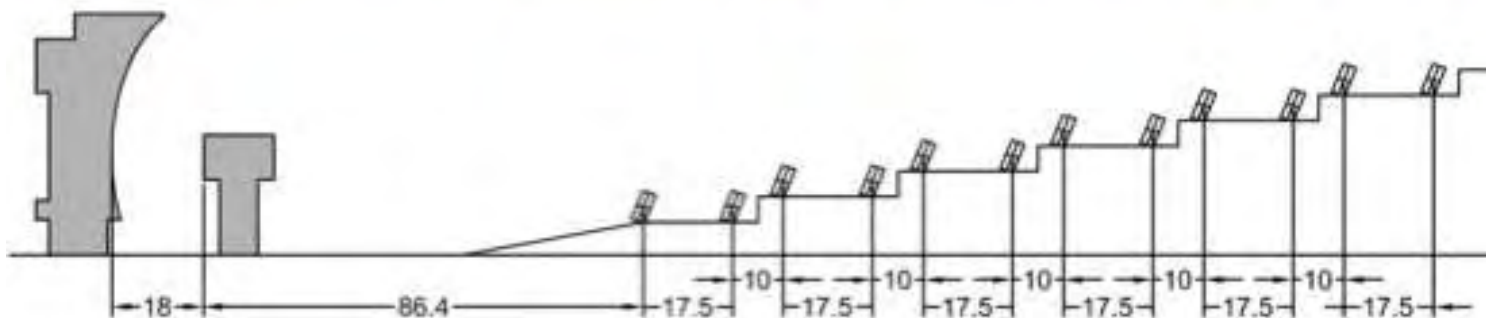
Outlook / Acknowledgements



CNRS 1 MW Solar Furnace
Odeillo, France



PROMES-CNRS Odeillo: 1 MW Solar Furnace (MWSF)



Elevation view of the Odeillo MWSF facility

100 kW Solar Pilot Plant for Thermal Dissociation of Zinc Oxide

Installation

- Moved to solar tower of MWSF (1)
- Mounted on mobile carriage (2)
- Installed in focus of the MWSF (3)



(2)



(3)

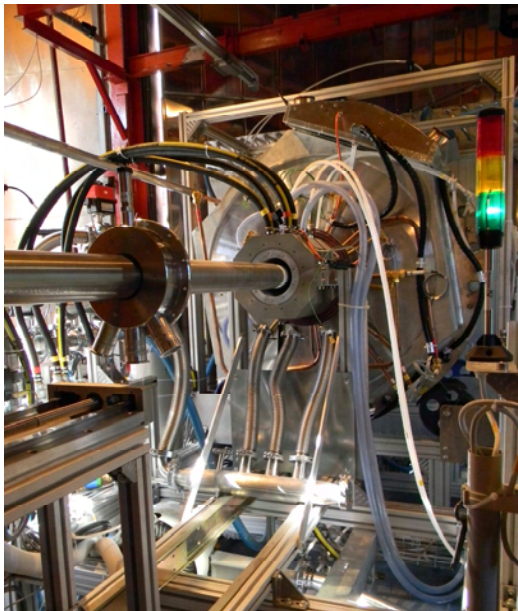


100 kW Solar Pilot Plant for Thermal Dissociation of Zinc Oxide

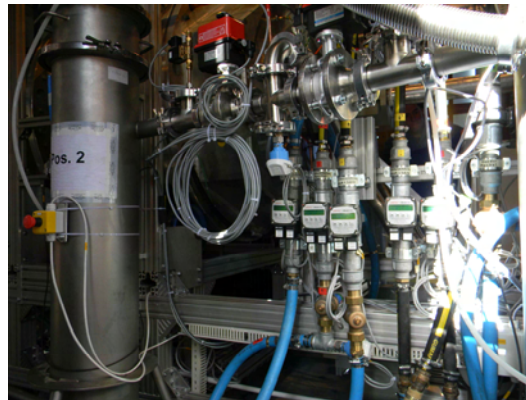
Commissioning

- Gas supply and off-gas system (1)
- Cooling water supply (2)
- Electrical and electronic connections (3)
- Process control and DAQ systems (4)

(1)



(2)



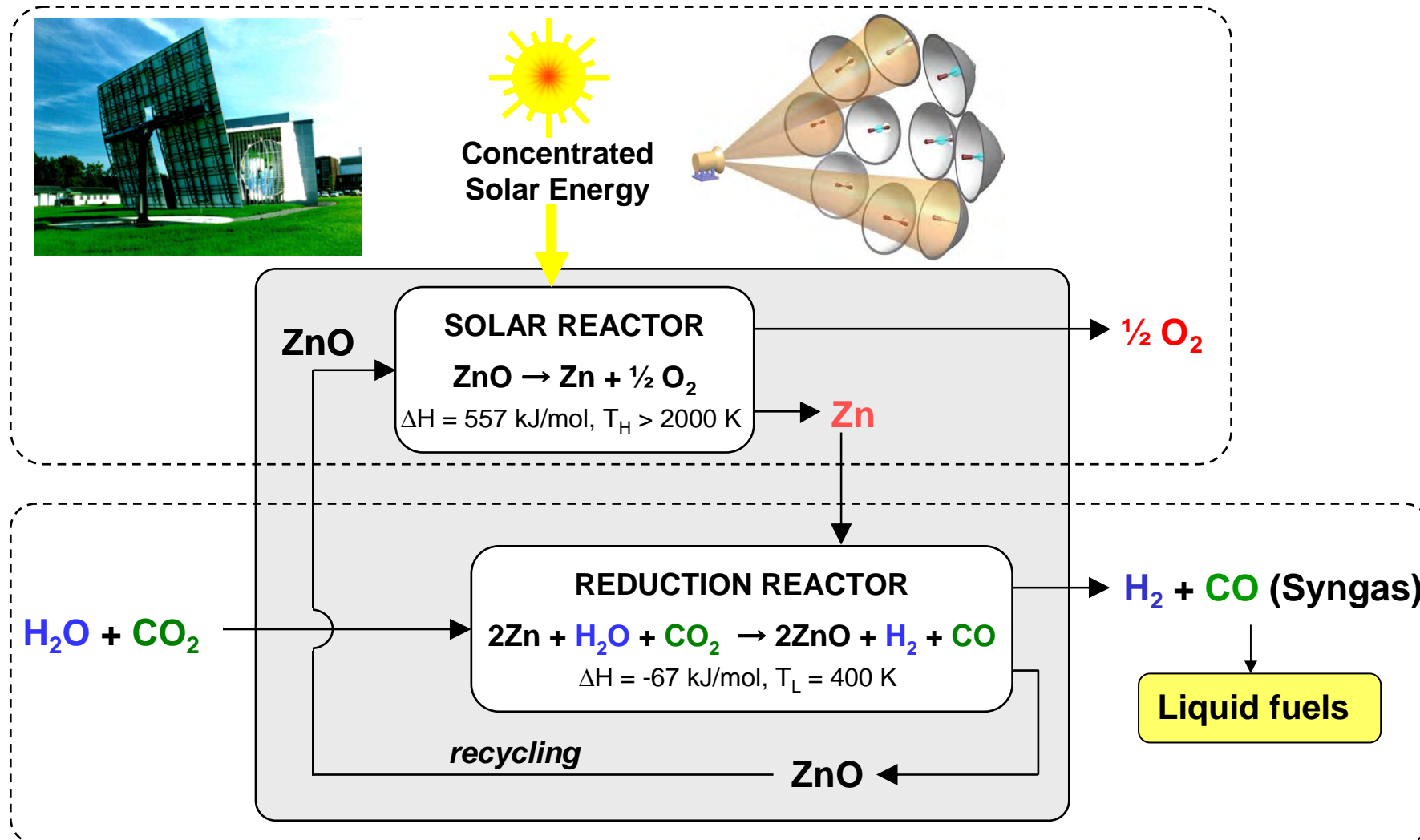
(3)



(4)



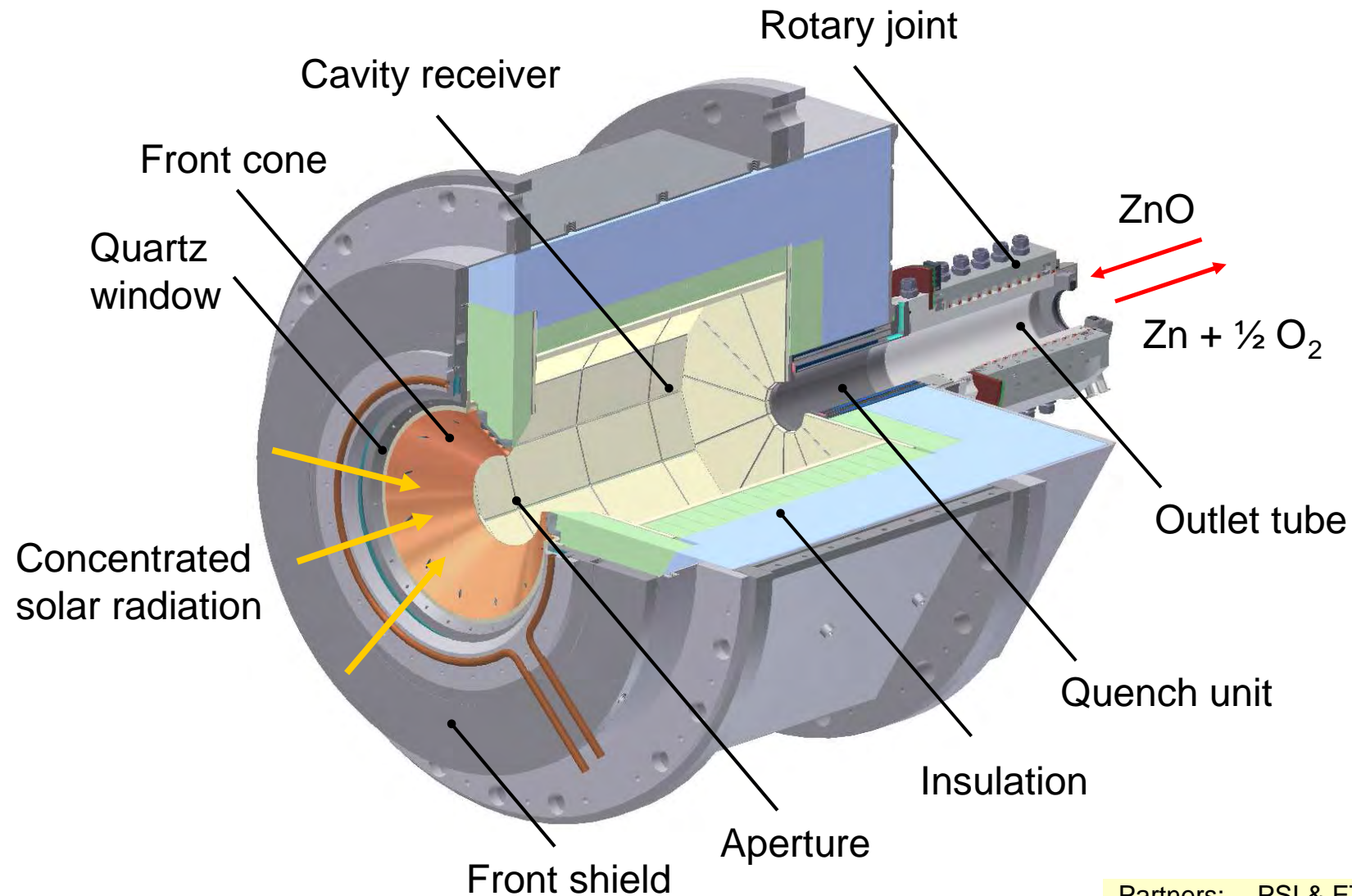
Solar Thermochemical Splitting of H₂O and CO₂



▪ Materials 3, 4922-4938, 2010.

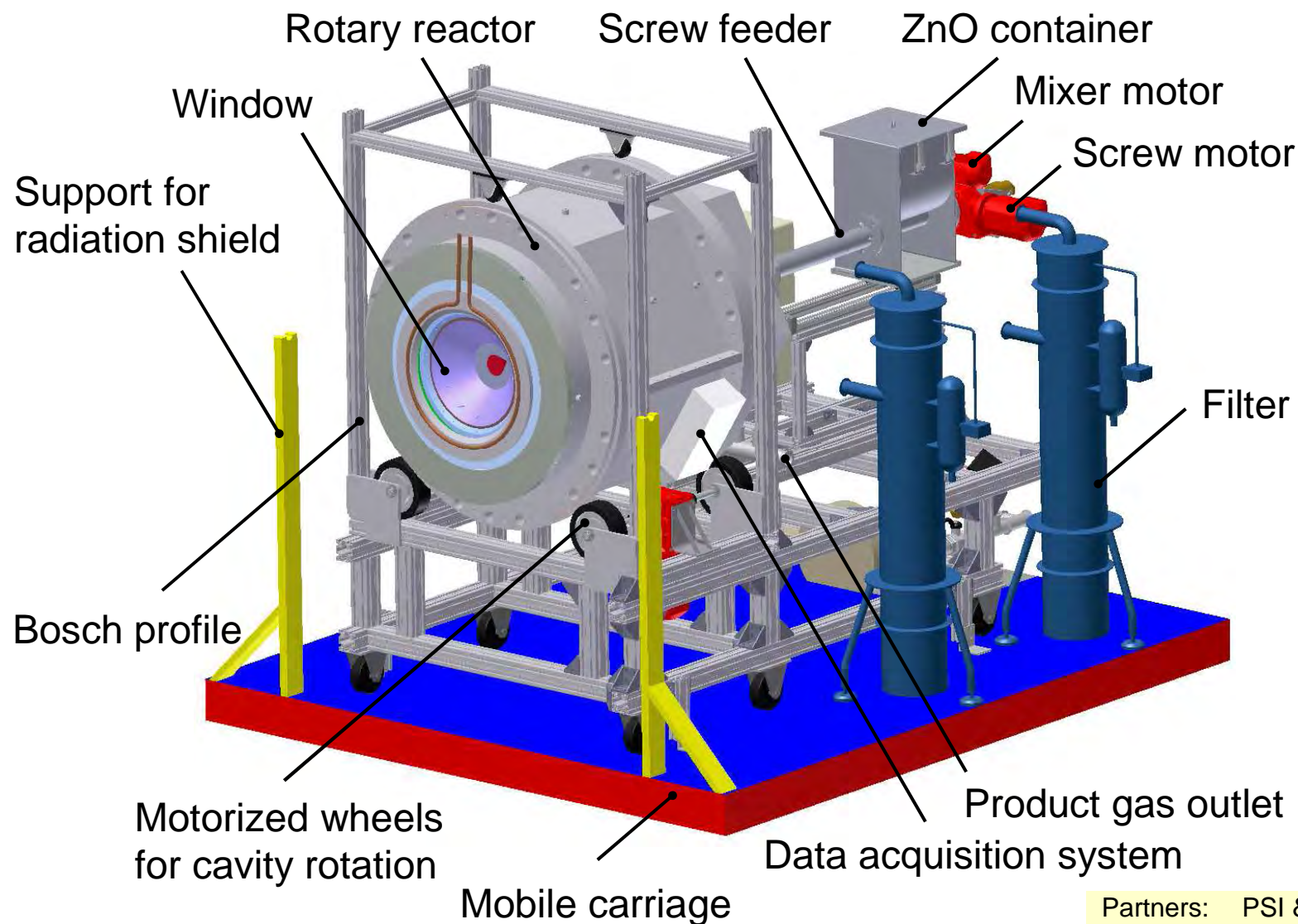
Partners: PSI & ETH Zurich
Funding: SFOE, PSI, ETHZ

Solar Reactor Technology



Partners: PSI & ETH Zurich
Funding: SFOE, PSI

100 kW Solar Pilot Plant Layout



Partners: PSI & ETH Zurich
Funding: SFOE, PSI

Solar Experimental Campaign 2012

Timetable

	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Activity									
Transport/Installation	■								■
Commissioning		■	■						
Solar Experiment			■		■		■		
Maintenance/Analysis			■	■	■	■	■	■	
Flux Measurement			■	■	■	■	■	■	
Decommissioning								■	■
Weather		☀	☀	☀	☀	☀	☀	☀	☀

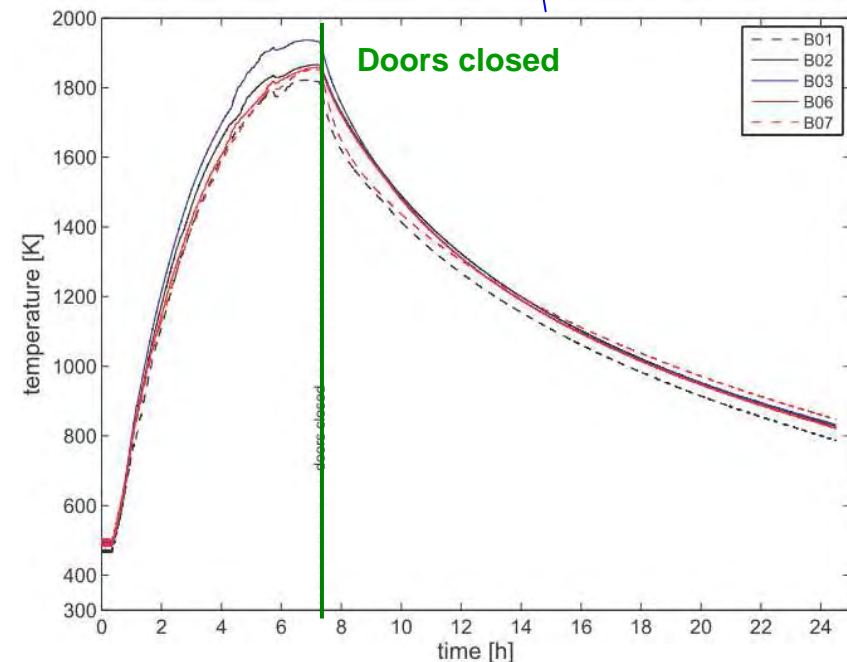
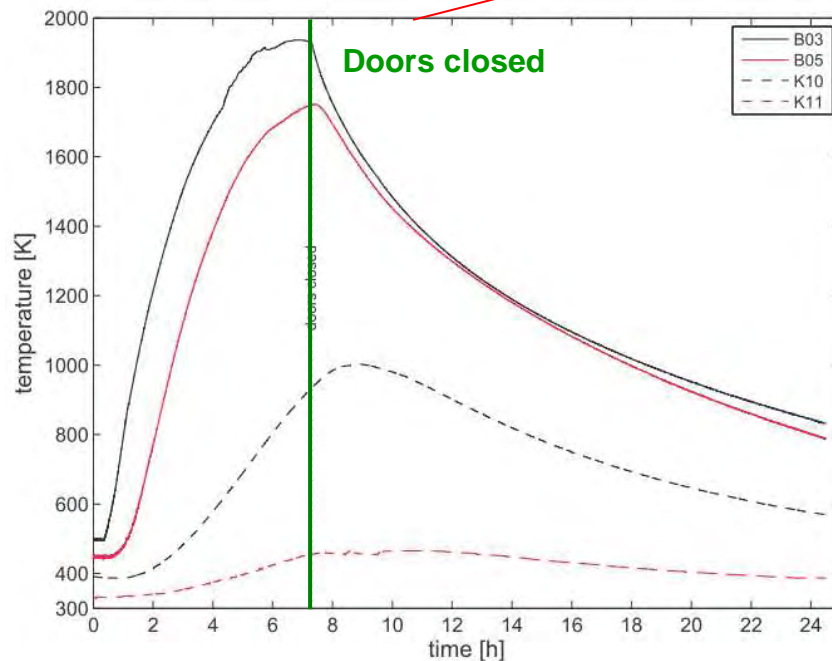
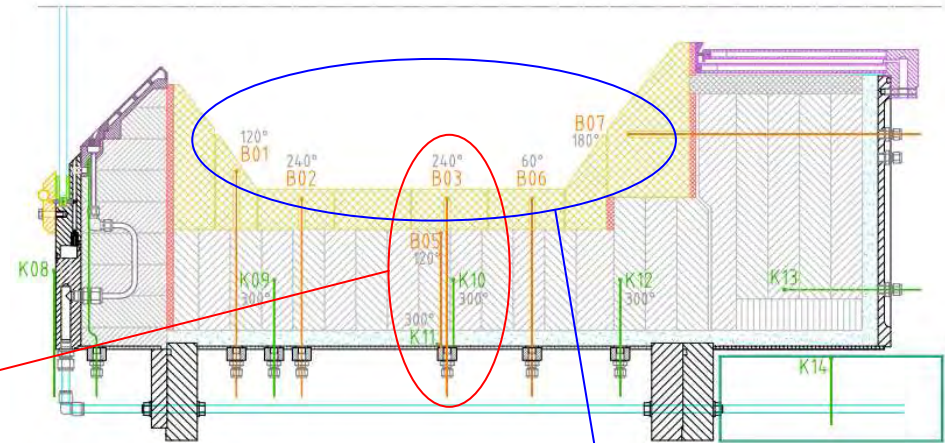
- Installation (1 day)
- Commissioning (3 days)
- Solar Experiments (11 days)
- Maintenance/Analysis (19 days)
- Flux Measurements (9 days)
- Decommissioning (2 days)



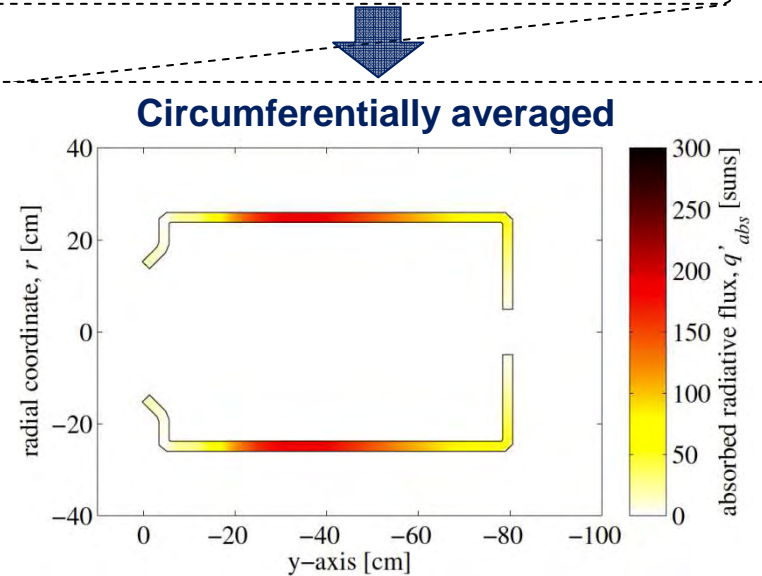
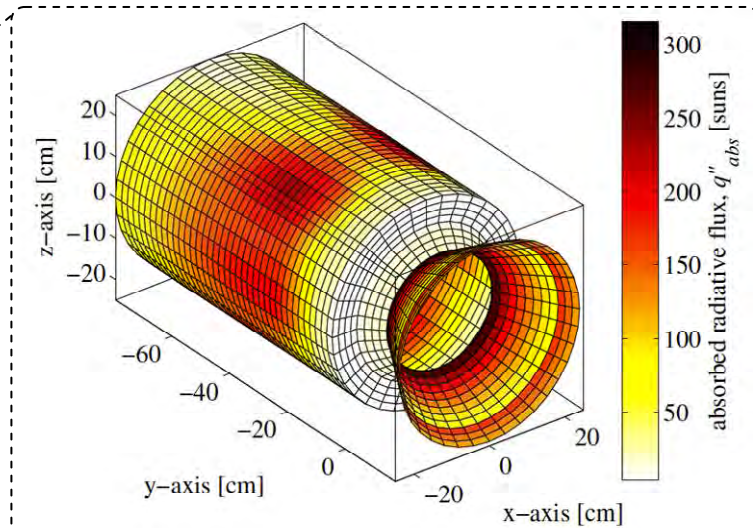
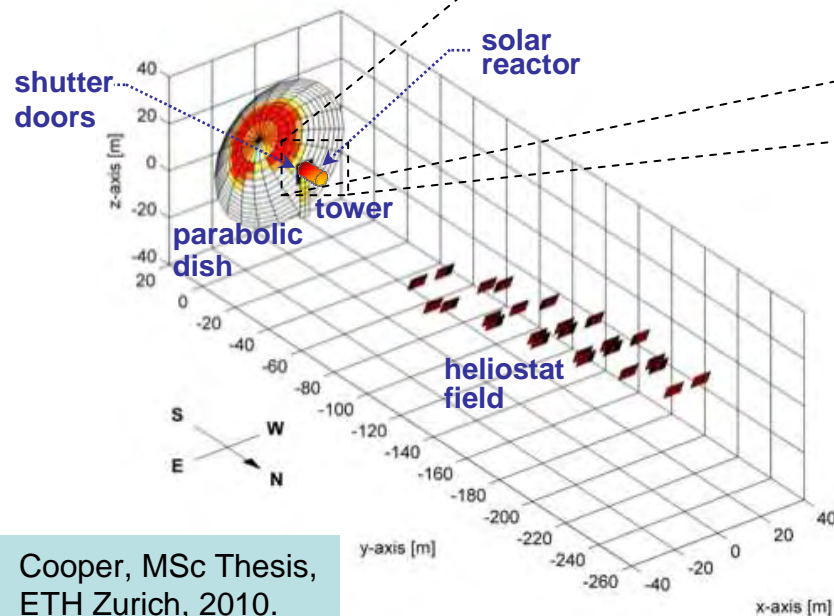
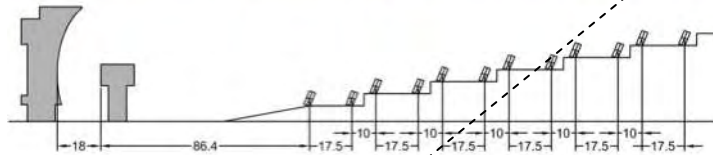
Preliminary Results

Temperature Devolution

- Typical run (July 12, 2012)
- 7 B- and 9 K-type thermocouples installed throughout the reactor



Ray Tracing and Transient Heat Transfer Modeling

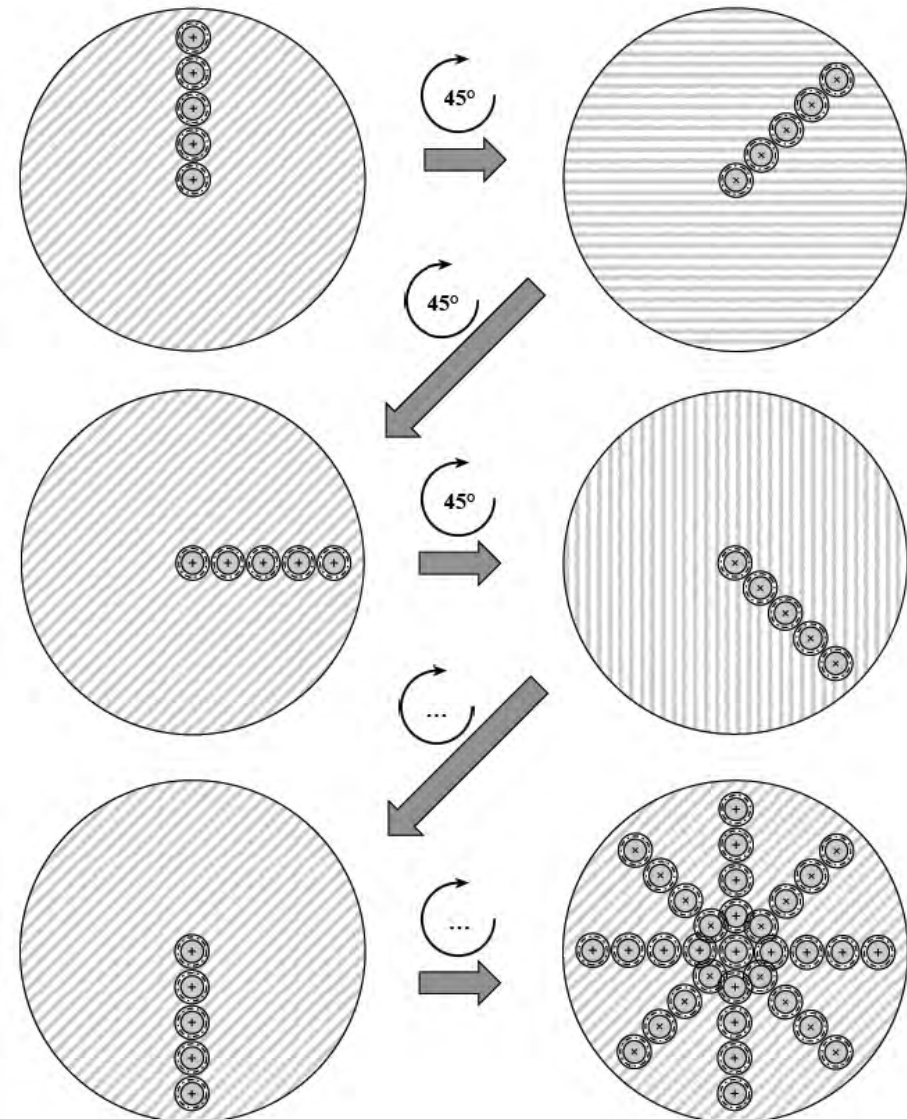
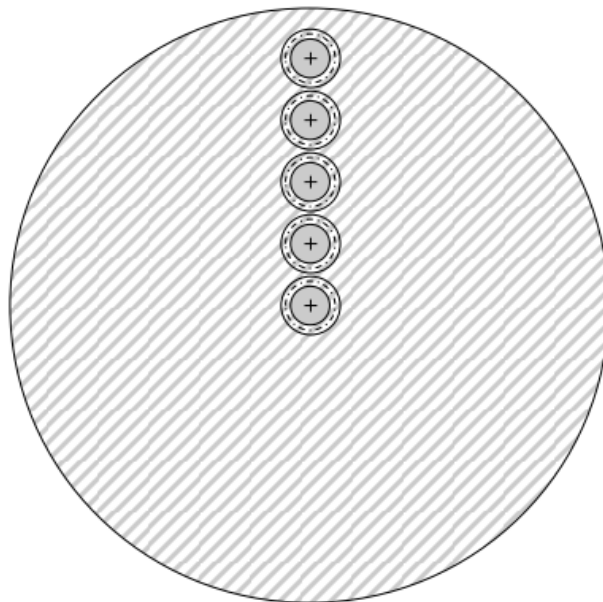


Cooper, MSc Thesis,
ETH Zurich, 2010.

Flux Measurement

Flux Measurement Scheme

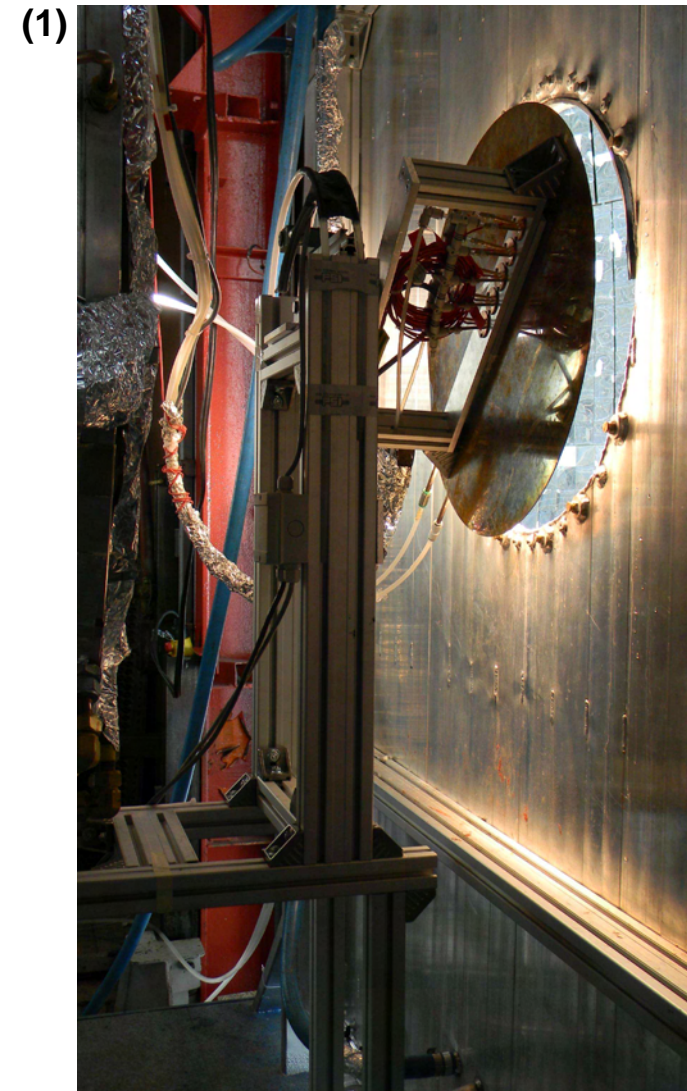
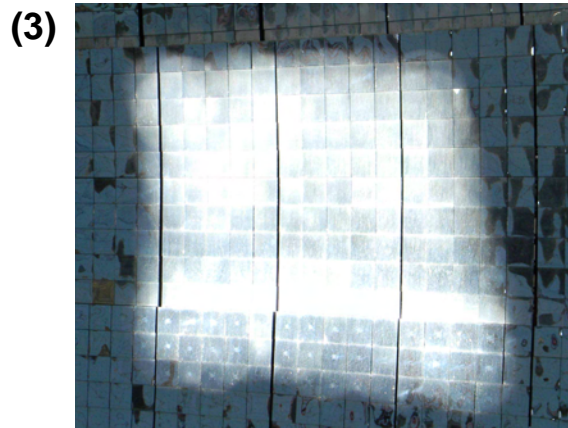
- Array of 5 thermogages (Vatell) arranged on a 600 mm dia. disk (corresponding to window dia.)
- By rotating the disk in steps of 45 degrees, 33 data points are measured per heliostat



Flux Measurement

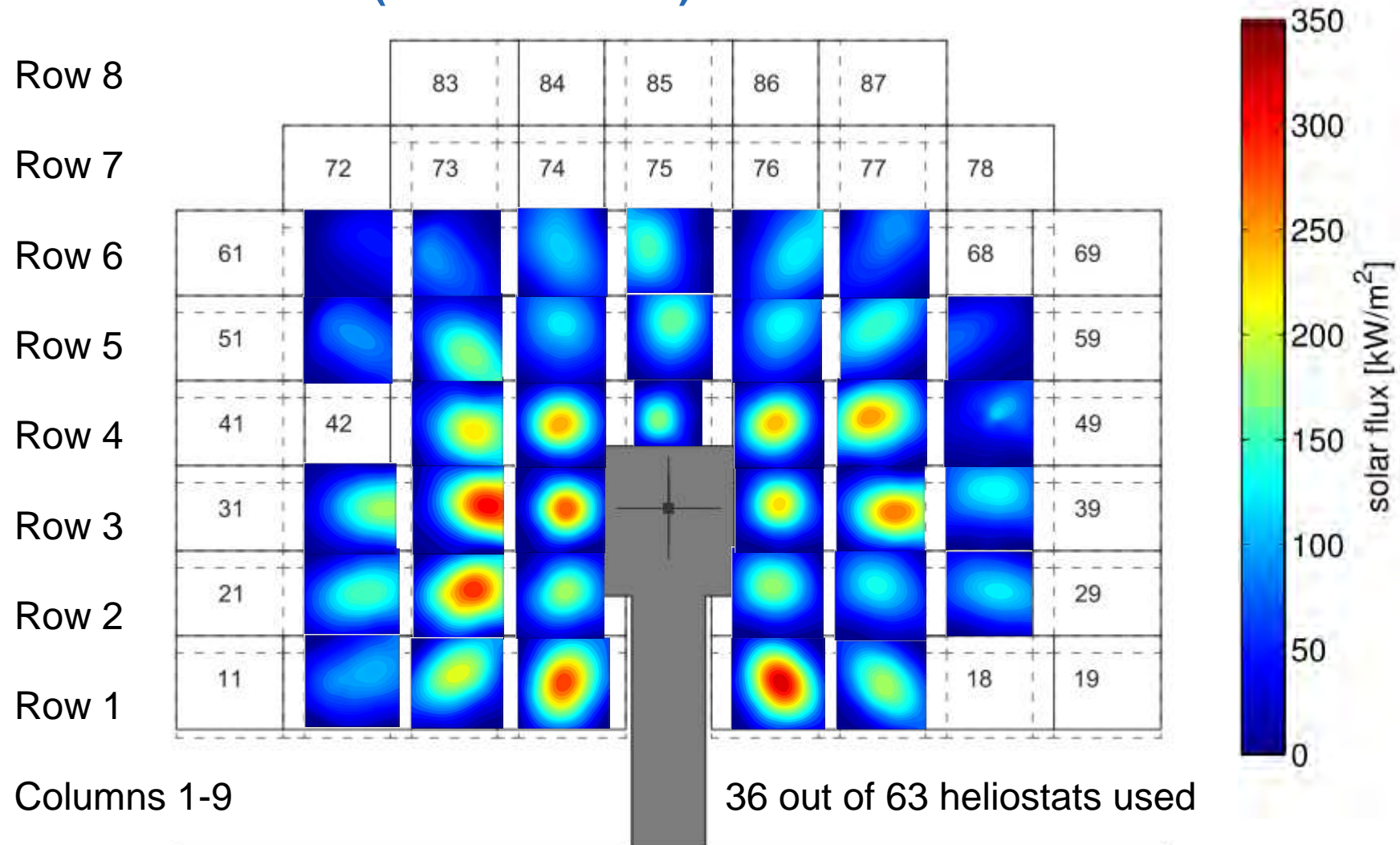
Flux Measurement Device

- Automatic rotation of disk in steps of 45 degrees → DAQ (1)
- Image of concentrated sunlight from heliostat on rotating disk and radiation shield (2)
- Image of heliostat on parabolic mirror (3)



Preliminary Results

Flux Measurement (Heliostat Field)



Conclusions and Outlook

Experimental Campaigns at MWSF

Year	SFERA	PSI	Spare
2011	3 weeks	3 weeks	2 weeks
2012	3 weeks	3 weeks	1 week

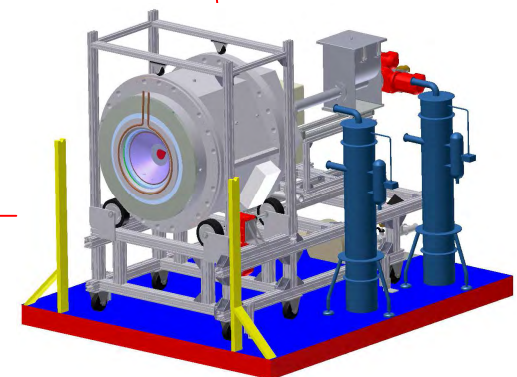
- Valuable operational experience in unique solar facility
- Data evaluation → Publication

Future Objectives

- 100 kW reactor optimization
- Conceptual design for MW plant (Next experimental campaign in 2014 ?)



CNRS 1 MW Solar Furnace
Odeillo, France



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 - Alwin Frei
 - Daniel Meyer
 - Peter Schaller
 - Willy Villasmil
 - Daniel Wuillemin
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 - Emmanuel Guillot
 - Jean-Louis Sans; Nicolas Boulet

Hosting

- Gilles Flamant, Marie Prouteau



PROMES-CNRS 1 MW Solar Furnace
Odeillo, France