
30 YEARS CALLAB PV CELLS AT FRAUNHOFER ISE



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Heidler Training Moderation
1981-1997 Fraunhofer Institute for
Solar Energy Systems ISE
Founder of CalLab PV Cells in 1986

Intersolar 2016
Munich, June 22, 2016
www.ise.fraunhofer.de

Contents

- Reverence
- Calibration Basics
- Calibration Delicacies
- Pioneer Stories

REVERENCE



1978 Prof. Goetzberger

CALIBRATION BASICS

Calibration Benefits

- High precision benchmark and reproducibility for PV research, production, plant operation
- Know how good you are
- Save time – Know earlier if your are improving or not
- Save money – 0,5 % are equivalent to 2 Mio Euro/year for a 100 MW plant
- Increase trust in your promises – banks, customers, lawyers
- => Quality and confidence constantly grown during 30 years

How to get the sun standardised?

Standard Testing Conditions (STC, IEC 60904)

- Main sources of measurement uncertainty:

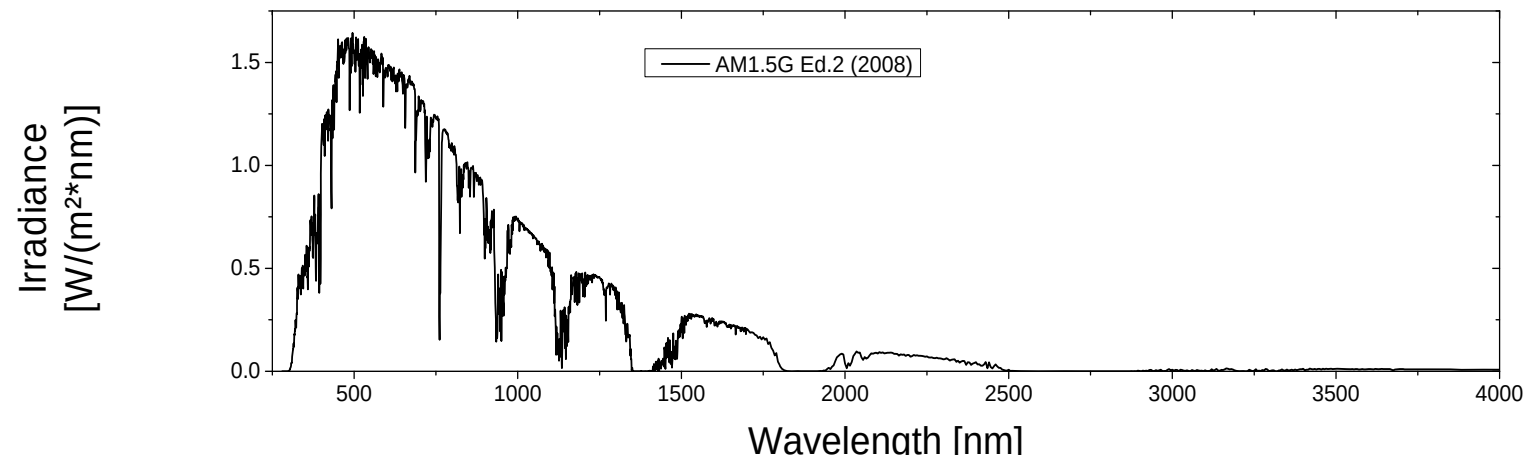
- Spectral dependent values
- Large areas

Temperature 25°C

Irradiance 1000 W/m²

Spectral distribution

AM1.5g

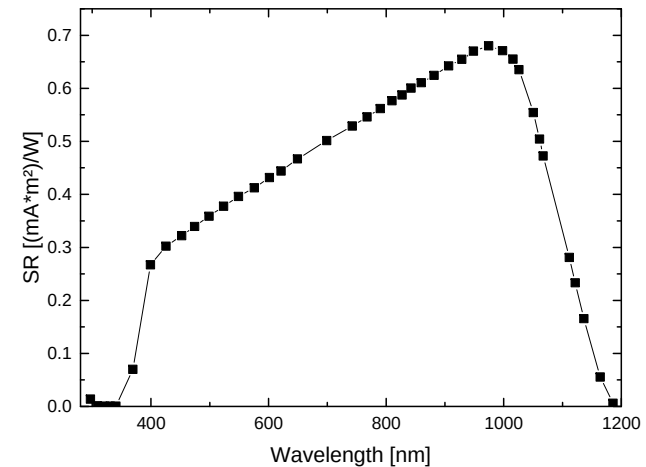


Two Step Measurement Process

Cell Calibration

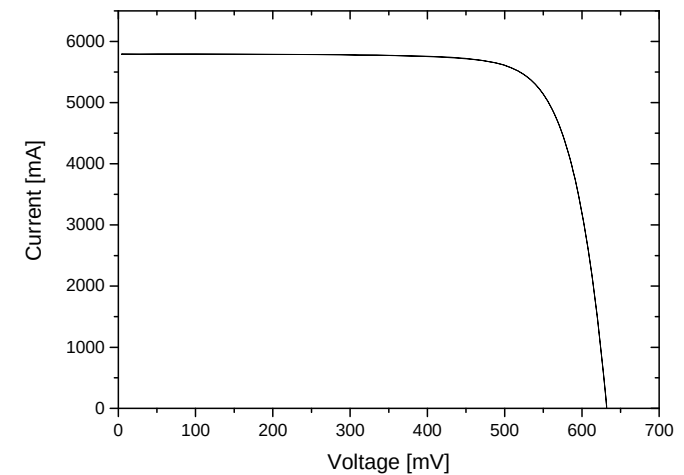
Short Circuit Current is spectrally selective and proportional to the irradiance.

→ Measurement of Spectral Response



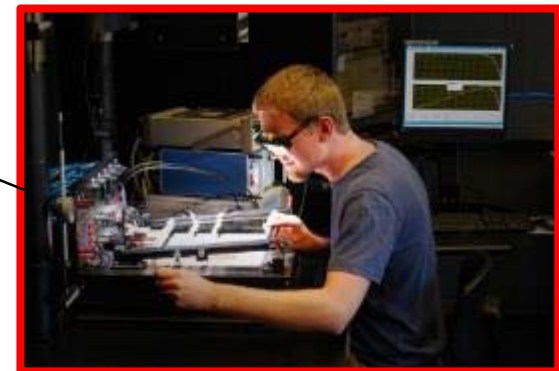
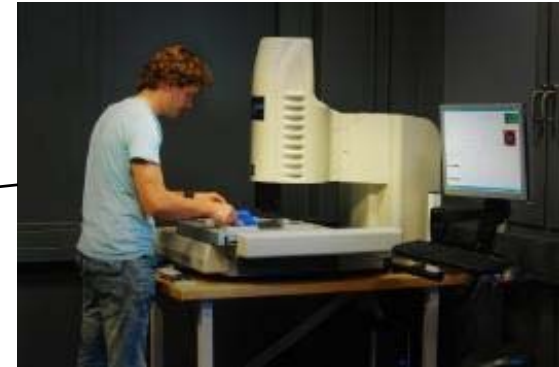
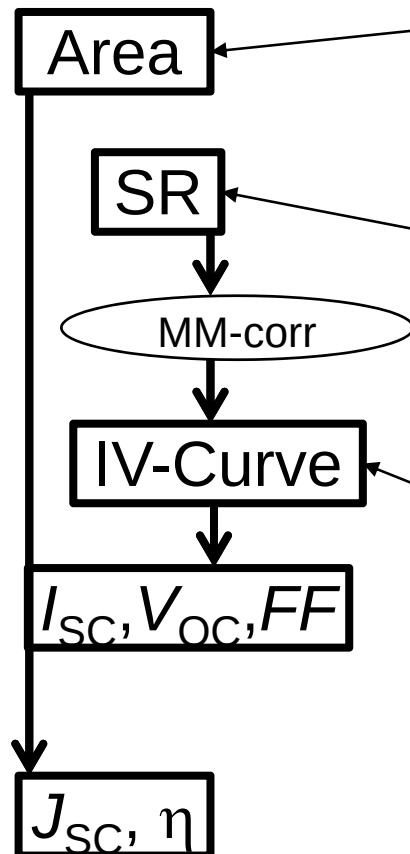
Power at Standard Test Conditions

→ Measurement of I-V characteristic to determine efficiency



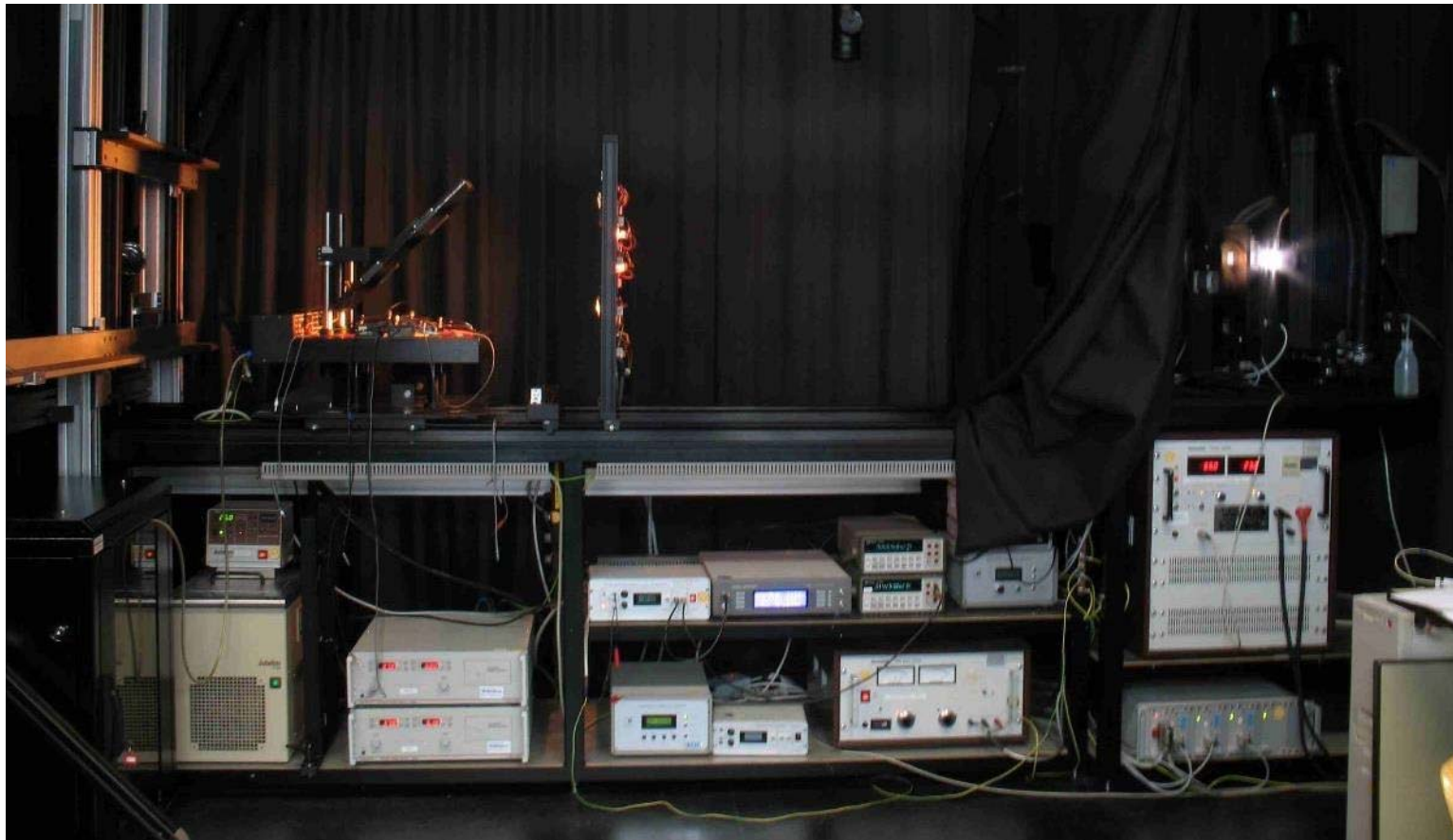
Measurement Process

Cell Calibration



Spectral Response Measurement on Large Cells

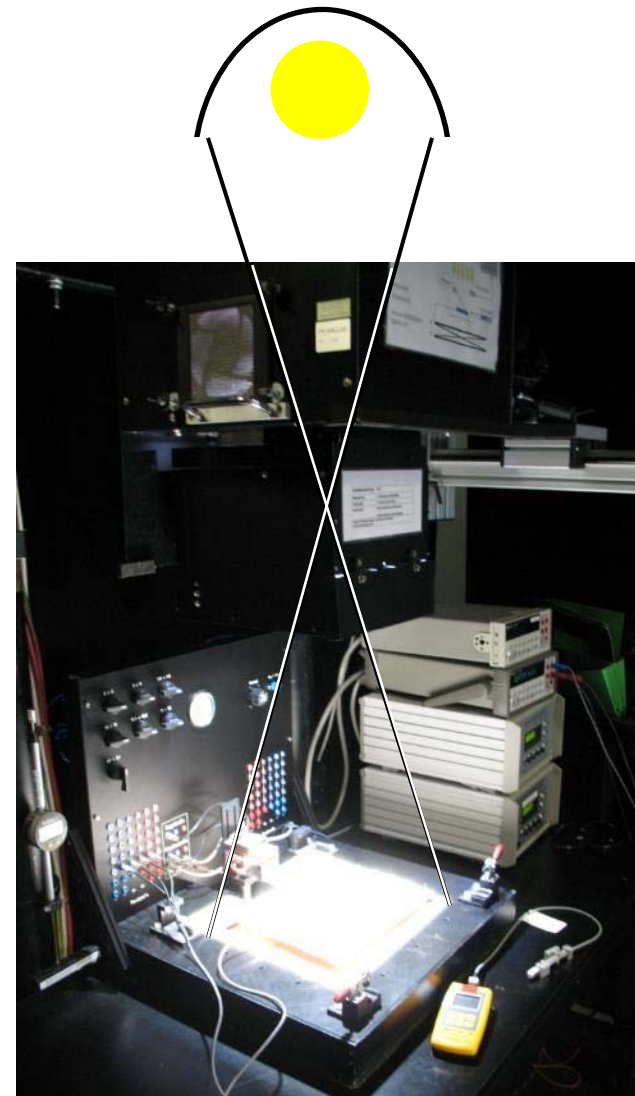
Filter-Monochromator



IV Measurements

Class A Sun-Simulator

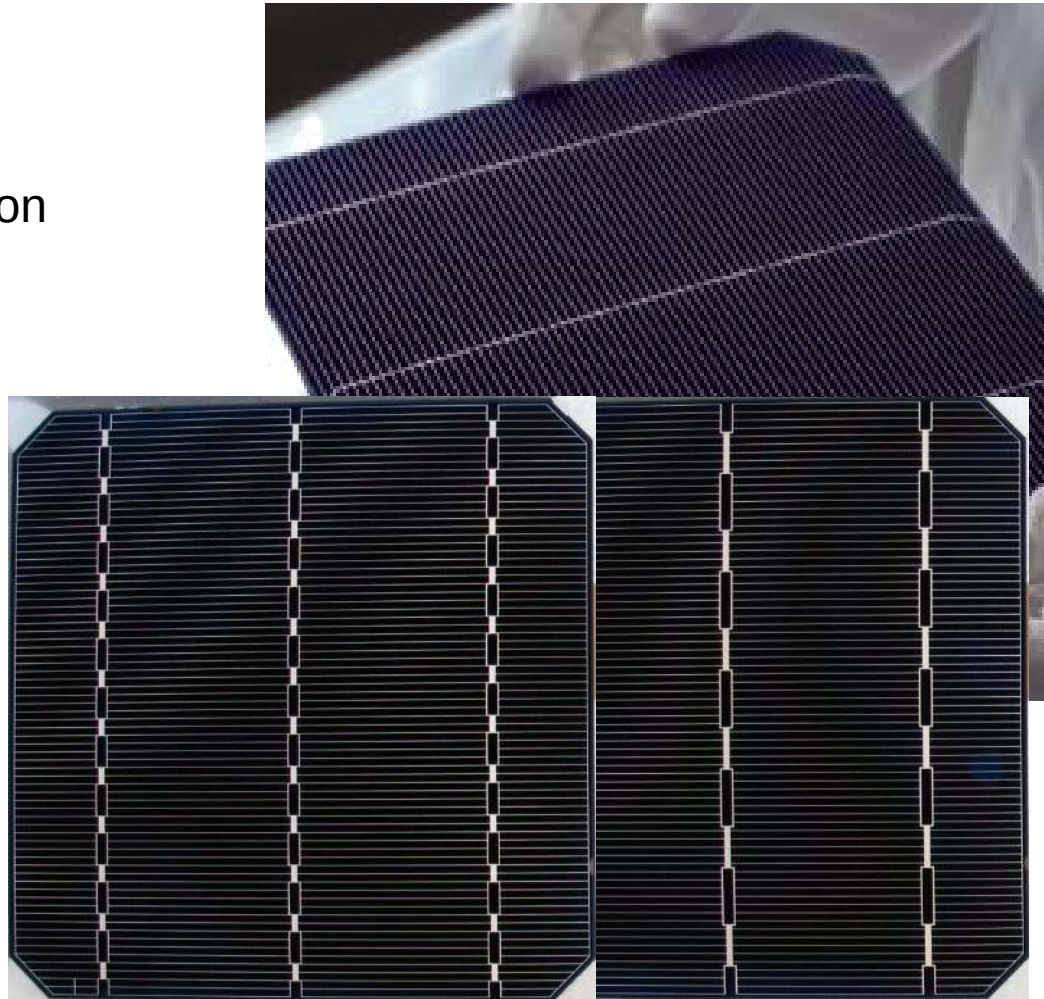
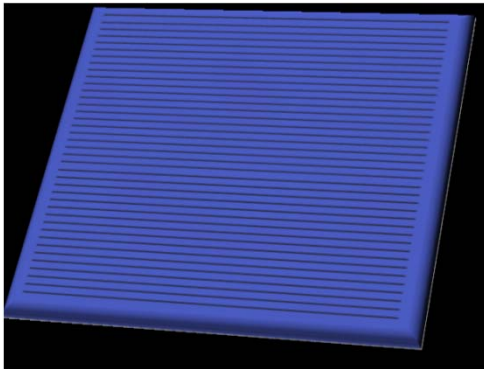
- Class A Simulator (continuous)
- Area: 6" (8")
- Stabilized Xenon Arc lamp
- Monitoring System
- AM1.5g, AM0, AM1.5 d
- Using Spectral Mismatch Correction



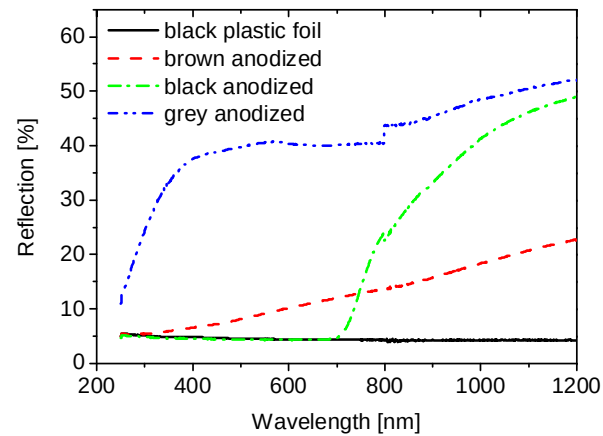
CALIBRATION DELICACIES

New Cell Types

- BCC (IBC, MWT,...)
- New Geometry of Metallisation
- Bifacial Solar Cells
- Thin-film Solar Cells

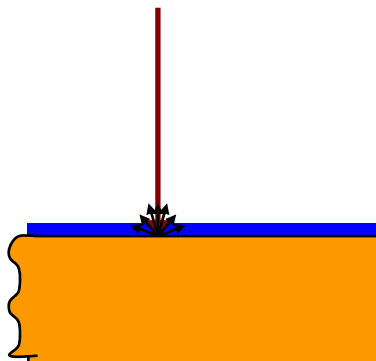


New Chuck for Bifacial Cells

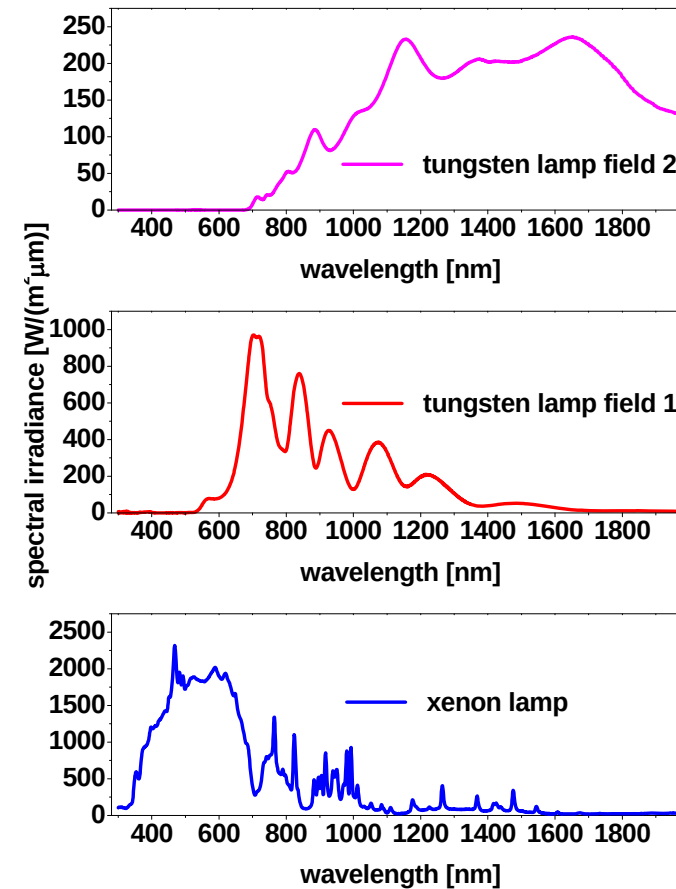
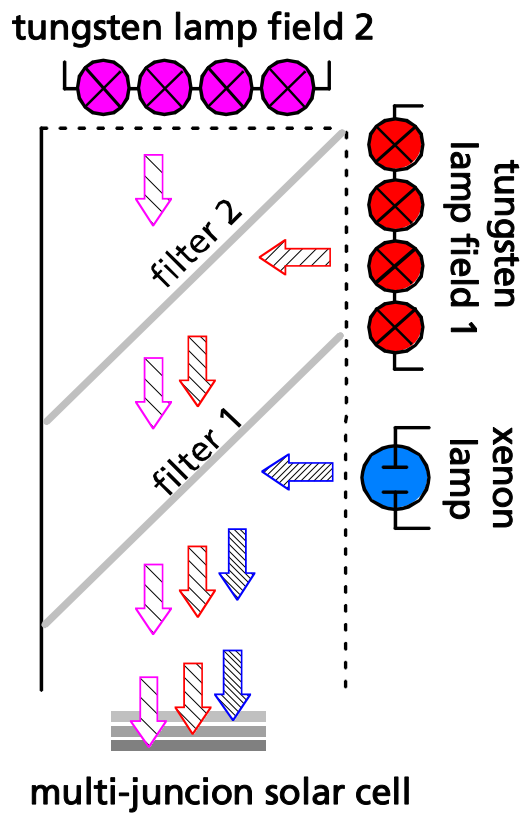


Solar Cell

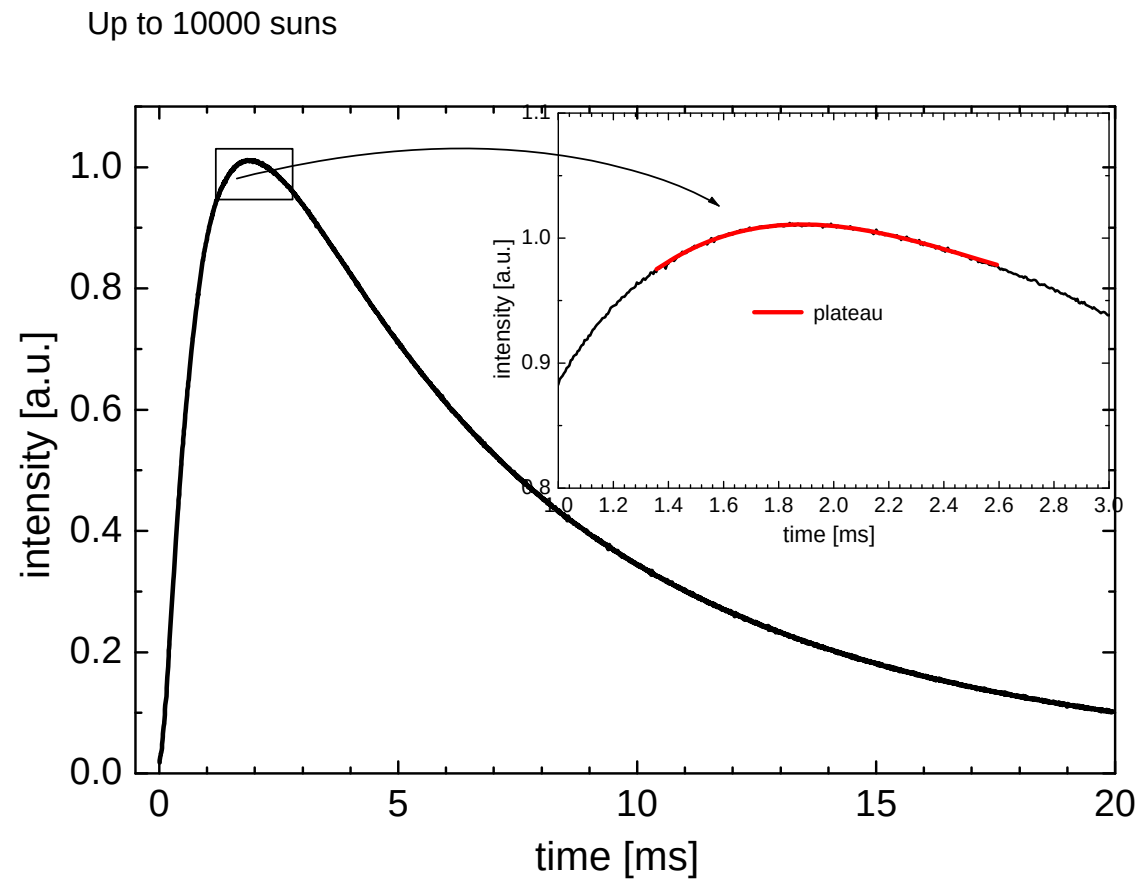
Chuck



IV-Measurement Multi-Junction 3-Source Simulator



Calibration under Concentration: Single Source Flash Simulator



New EQE Measurement Setup

Monochromatic Radiation – Novel Laser-EQE Setup

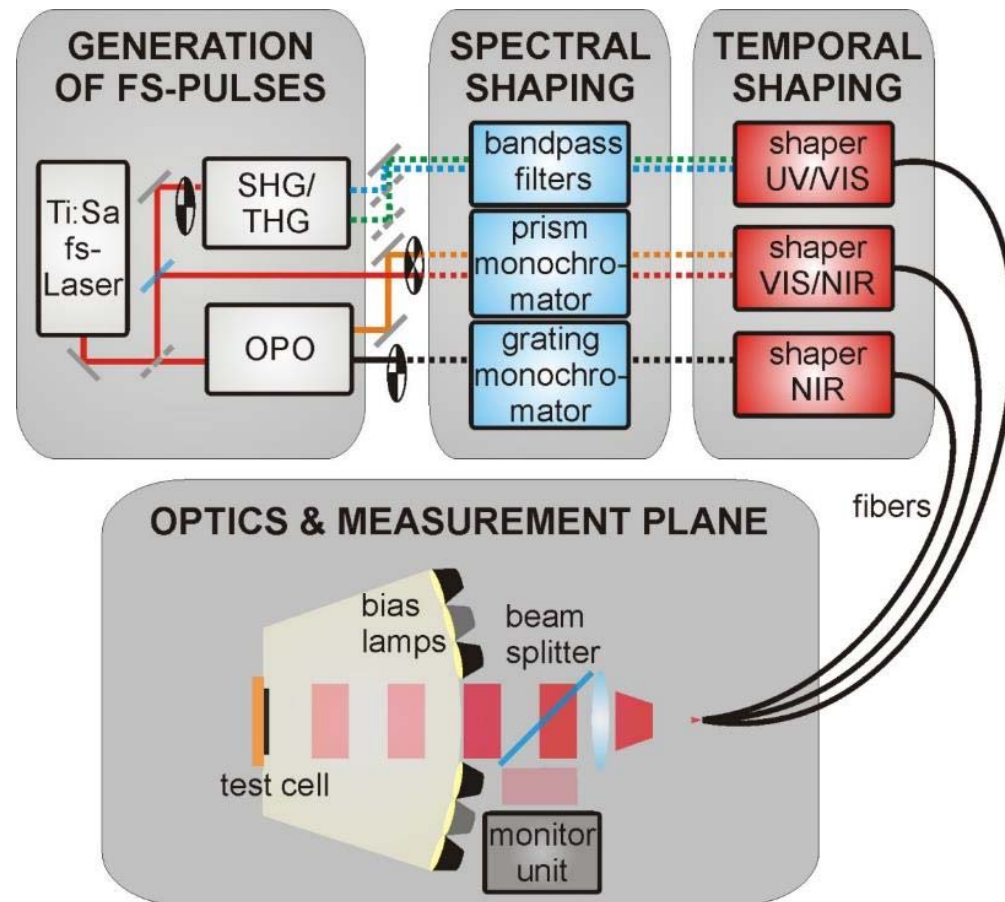
New EQE calibration facility at Fraunhofer ISE¹

WL-Range: 250-2500 nm

Enhanced spectral range

Enhanced spectral power

- Smaller bandwidths
- Improved uniformity
- Higher measurement signal
- Enabling further, new measurement concepts?



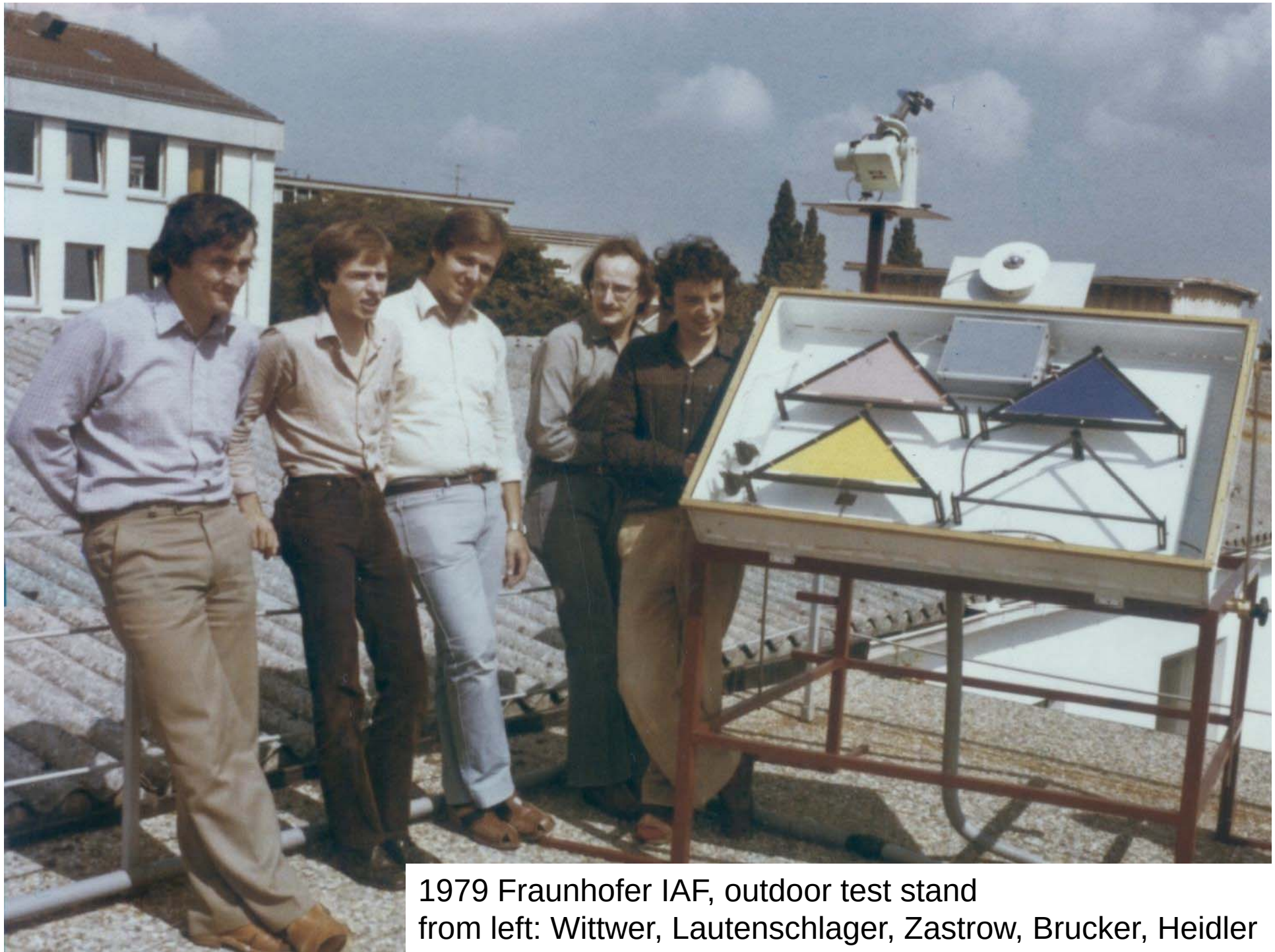
Outdoor Test Set-Up in Freiburg

Characterization of Concentrator Modules

- IV measurement of up to 20 modules
- Simultaneous recording of all relevant meteorological data

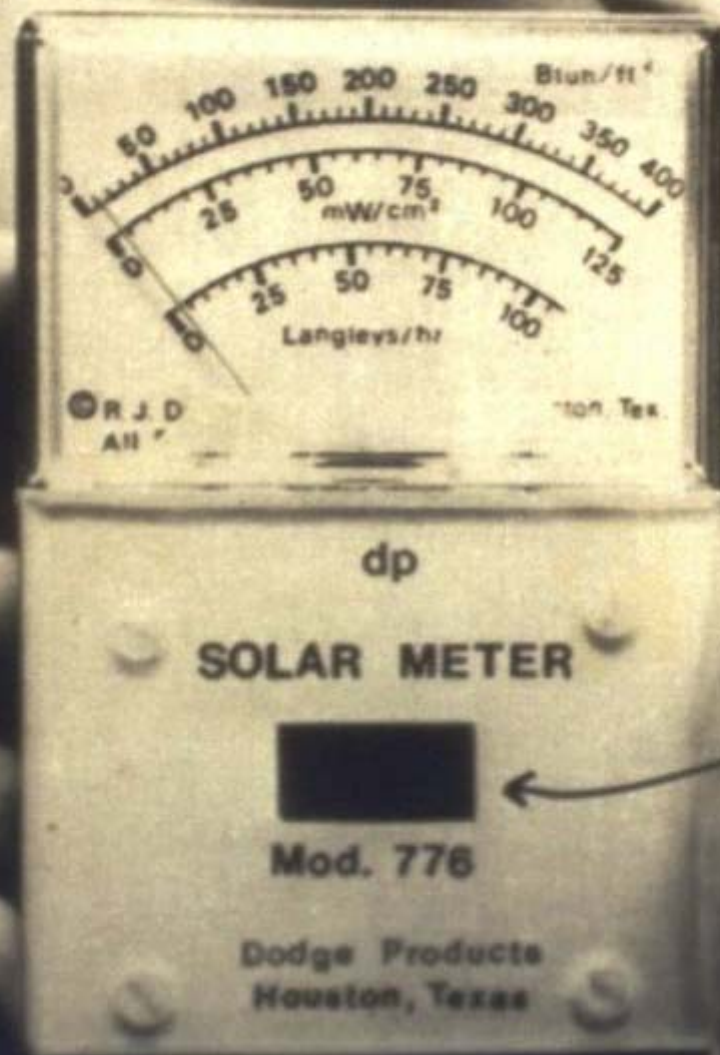


PIONEER STORIES



1979 Fraunhofer IAF, outdoor test stand
from left: Wittwer, Lautenschlager, Zastrow, Brucker, Heidler

1978 Low Precision Solar Sensor



How to protect humans and devices when doing outdoor measurements?



Source: www.sunliner.de

1979 Procurement of a Sunshade

Tabelle 1 informiert über die geschätzten Kosten der einzelnen Lösungsmöglichkeiten:

Lösungsmöglichkeit	Mat.kosten(in TDM)	Entwickl.dauer(Mannj)
3.2 Automat	40	2
3.3.1 xyz-Schlitten	20	1
3.3.2 Sonnenschirm	0,35	0

1979 Procurement of a Sunshade



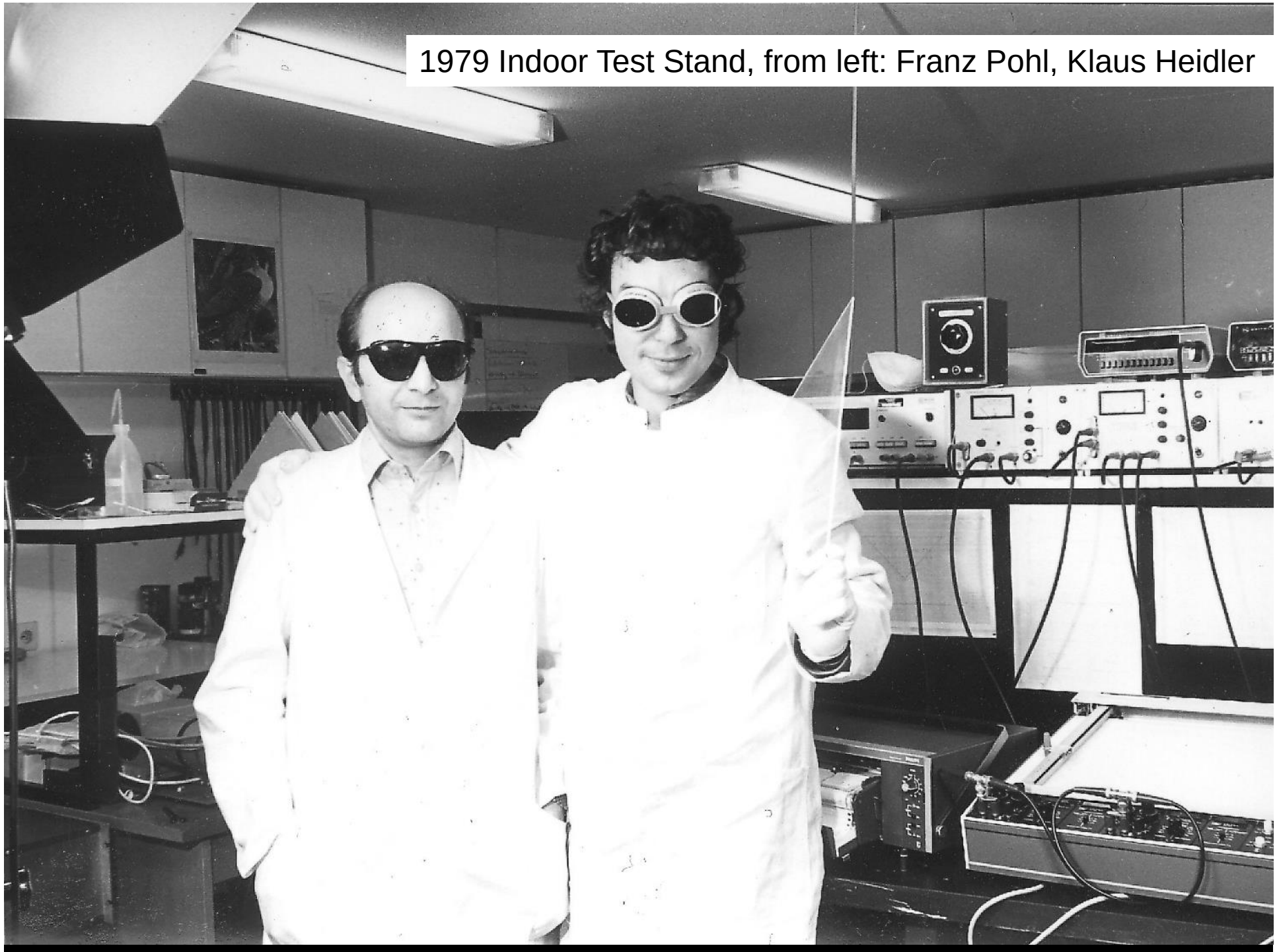
International PEP Round Robin – After Hour 1989





1989 CalLab; Siegfried Kunzelmann

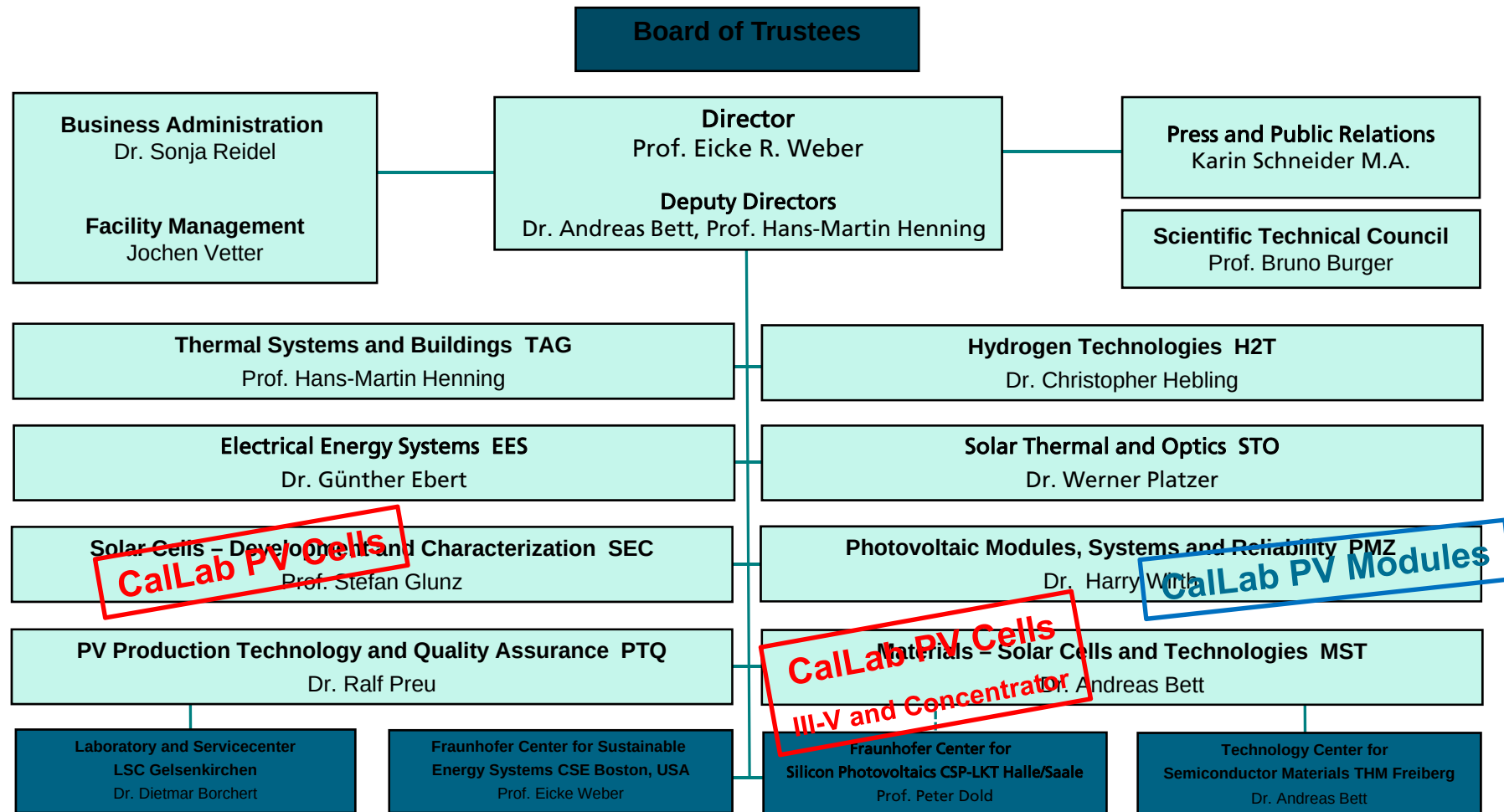
1979 Indoor Test Stand, from left: Franz Pohl, Klaus Heidler





Fraunhofer ISE

Organizational Structure



Status: March 2016



THANK YOU! (AM 38+)

Service Units

Accredited Test and Service Centers

TestLab
Solar Façades



TestLab
Power Electronics



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TestLab
Solar Thermal
Systems



CalLab
PV Cells



TestLab
PV Modules



CalLab
PV Modules

