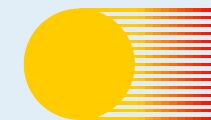




# Performance Analysis of Grid-Connected PV Systems

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**PVPS**

**21<sup>st</sup> EUPVSEC - Dresden - September 5<sup>th</sup>, 2006**



# Contents

- **Introduction**
- **IEA PVPS Task2**
- **Approach**
- **Performance Ratio over time**
- **Performance Ratio at identical climatic conditions**
- **Conclusion and outlook**



# Organisation

## IEA PVPS Task2 - „Performance, Reliability and Analysis of PV Systems“

- Network of 17 Experts from 12 Countries
- PV Performance Database Programme (for free)
- PV System Performance Analysis
- Economic Survey on PV Cost over Time
- National and International Workshops

### Activity 52

- Long-term Reliability of PV Systems



# Plants

Name	...	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	Years
P 1																	2
P 2																	2
P 3																	3
P 4																	6
P 5																	5
P 6																	6
P 7																	5
P 8																	5
P 9																	5
P 10																	5
P 11																	3
P 12																	5
P 13																	5
P 14																	5
P 15																	5
P 16																	4
P 17																	9
P 18																	3
P 19																	9
P 20																	11
P 21	84																3
<b>Total:</b>																<b>106</b>	



# Data

Parameter (general):	$G_i$ $T_{mod}, T_{amb}$ $P_{dc}, P_{ac}$
Parameter (special):	$G_h, G_{diffus}$ $I_{dc}, V_{dc}$ $I_{ac}, V_{ac}$
Time interval:	1 hour 5 min 30 sec
Observations:	Change of format/ units No time stamp Continuous minutes Missing data (4.9%) Abnormal data (2.0%)



# Approach

Monitoring data

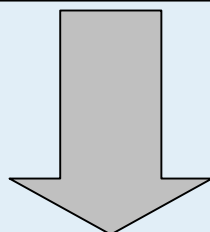


**Detection of failures:**

- Maintenance data
- Graphical analysis
- Failure detection routine (ENECOLO)



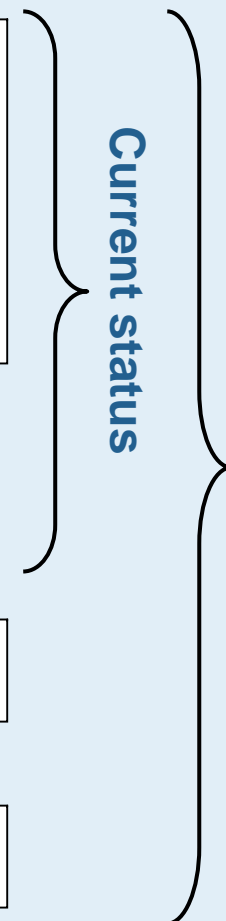
Performance of well working system



Failure statistic



Long-term system behaviour

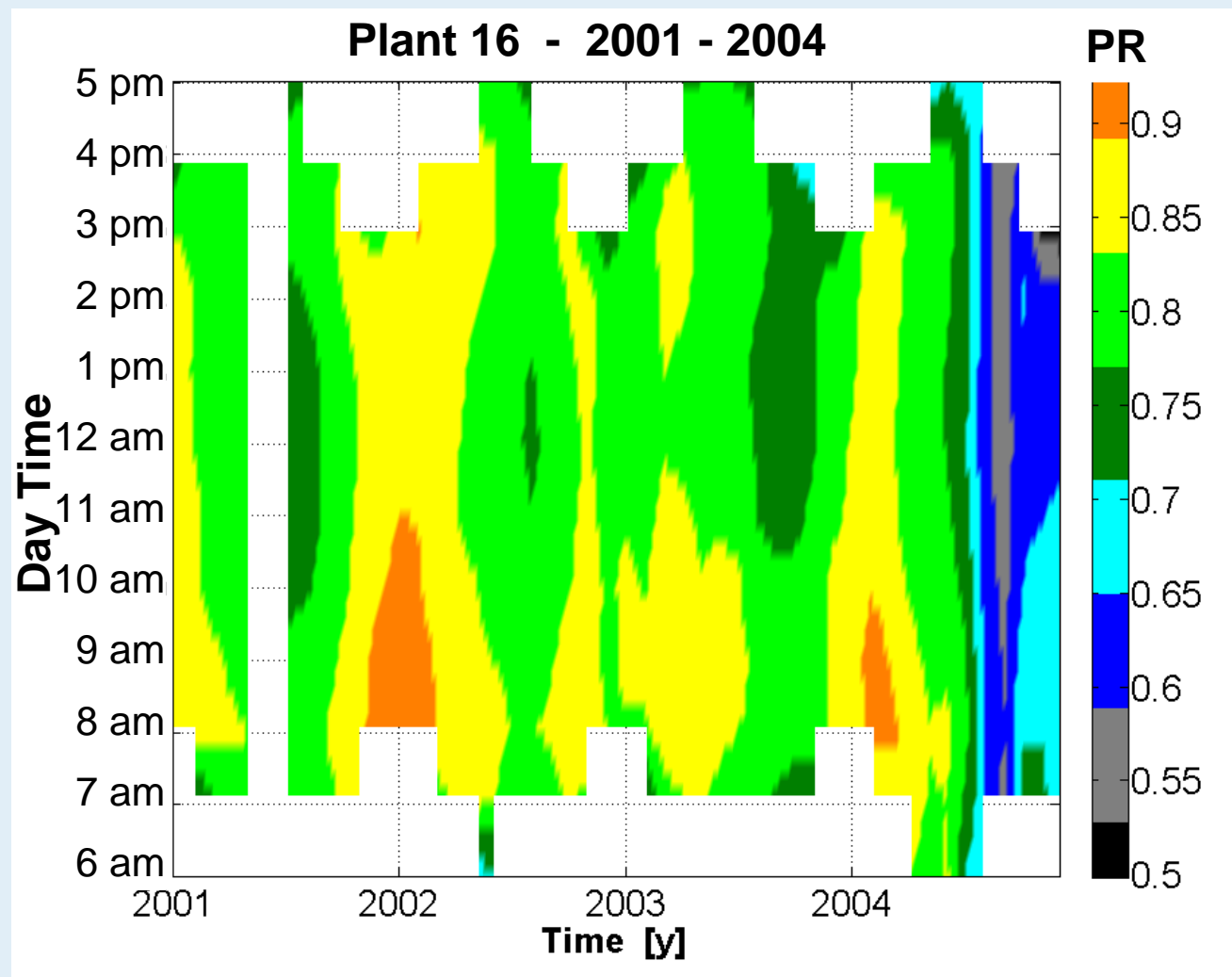


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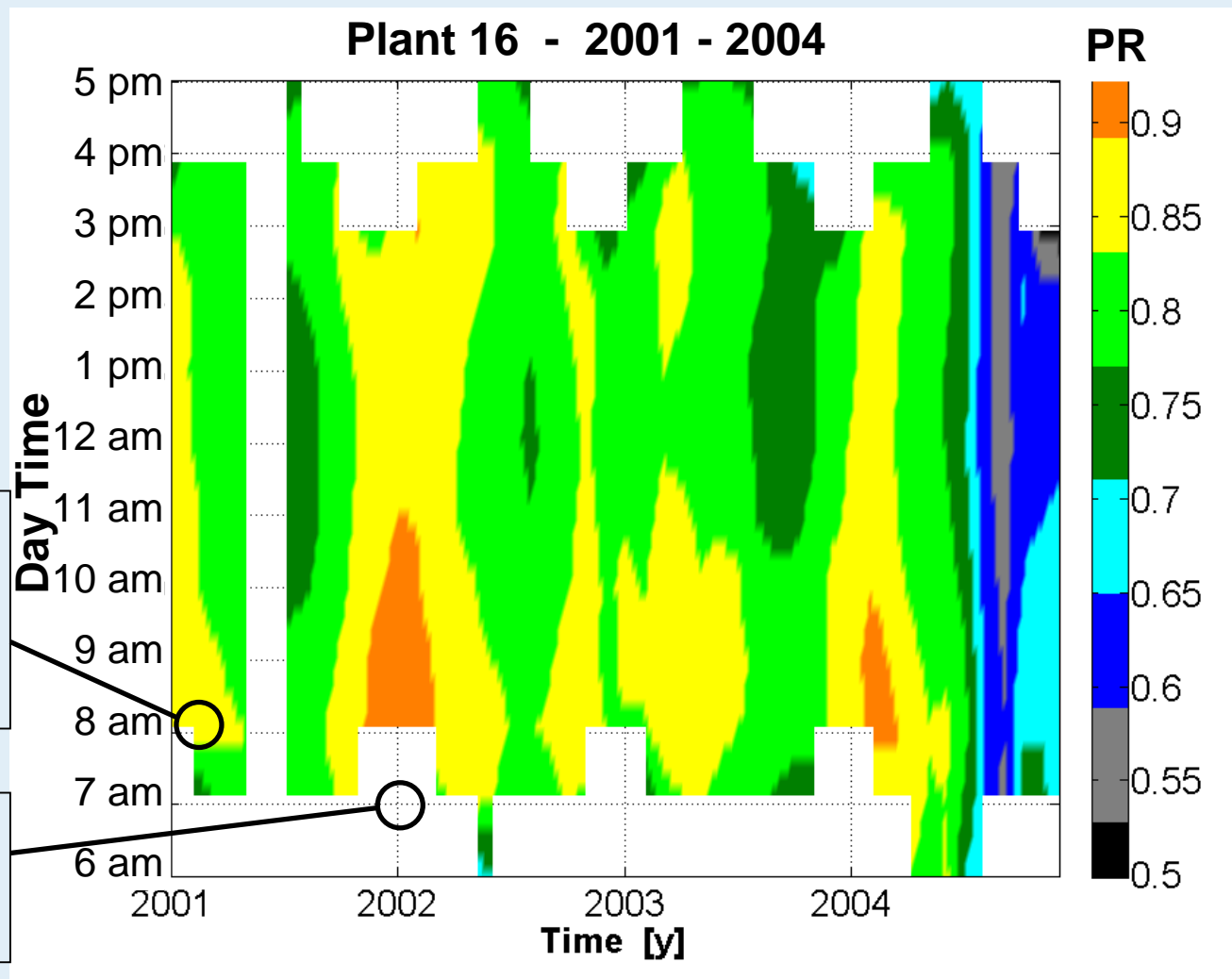


# Performance over time / 1





# Performance over time / 1



- 8 am
- Feb 1 to 28, 2001
- At least 3 values
- $G_i > 100 \text{ W/m}^2$

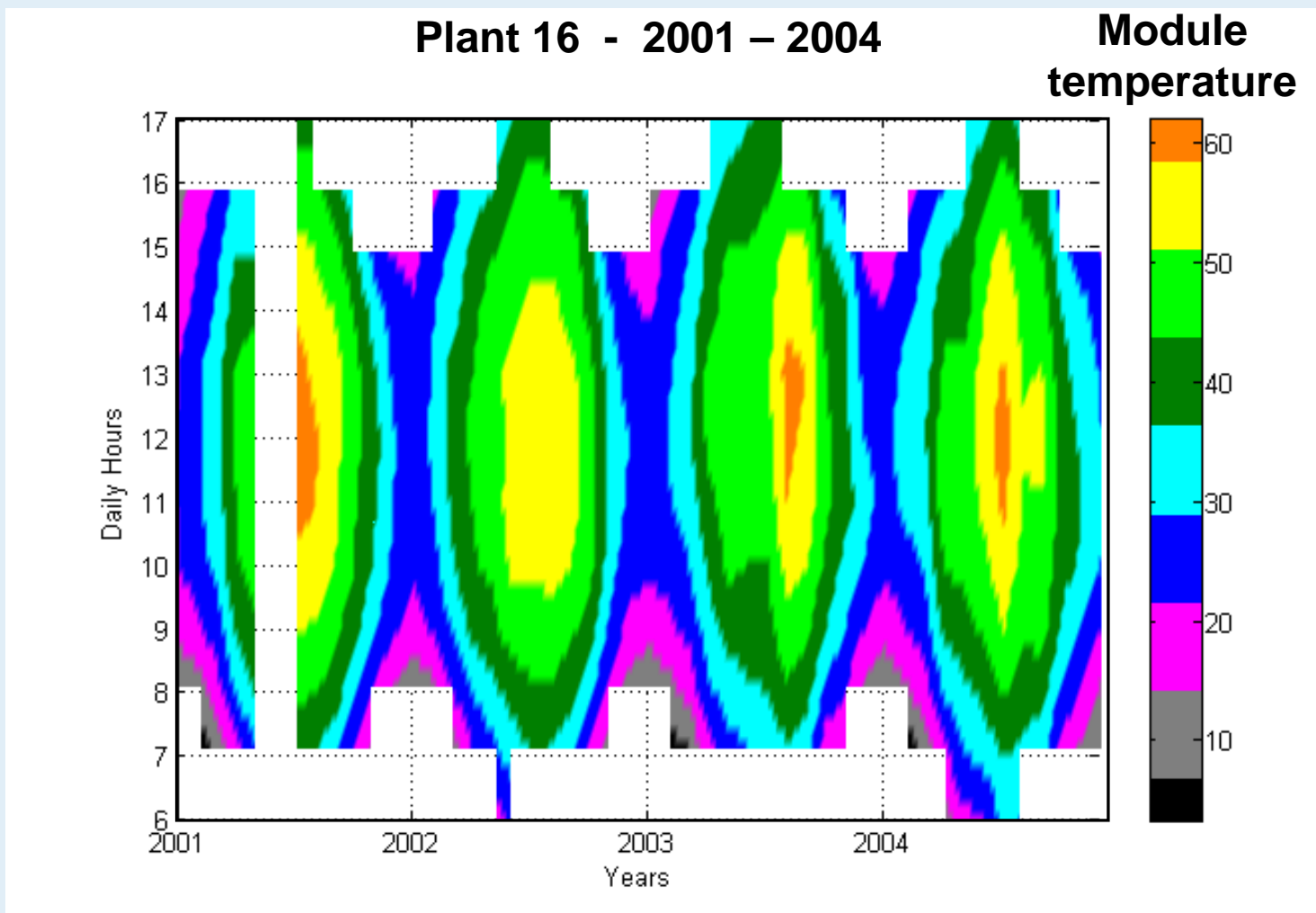
< 3 values  
with  
 $G_i < 100 \text{ W/m}^2$

PVPS



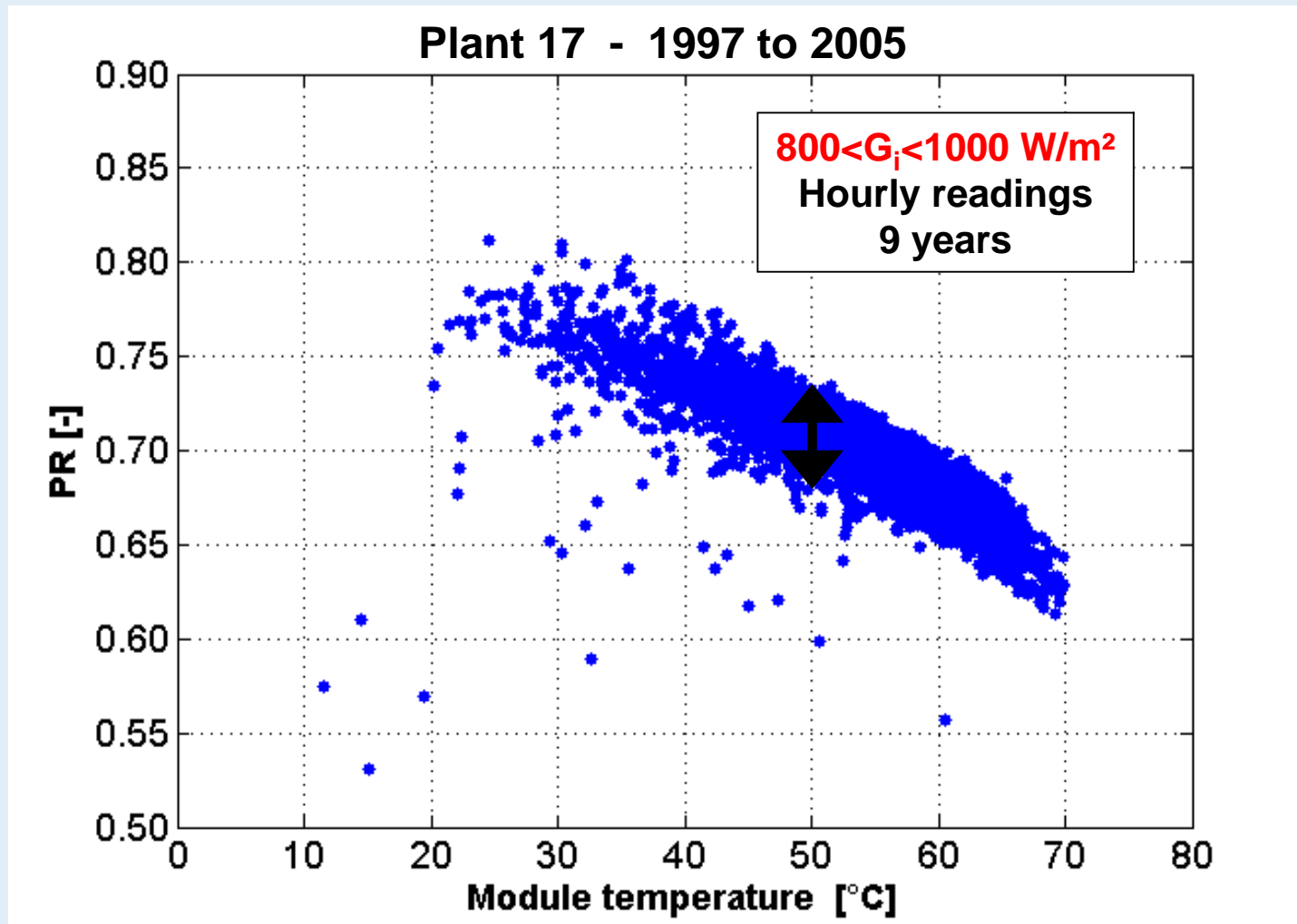


# Performance over time / 2



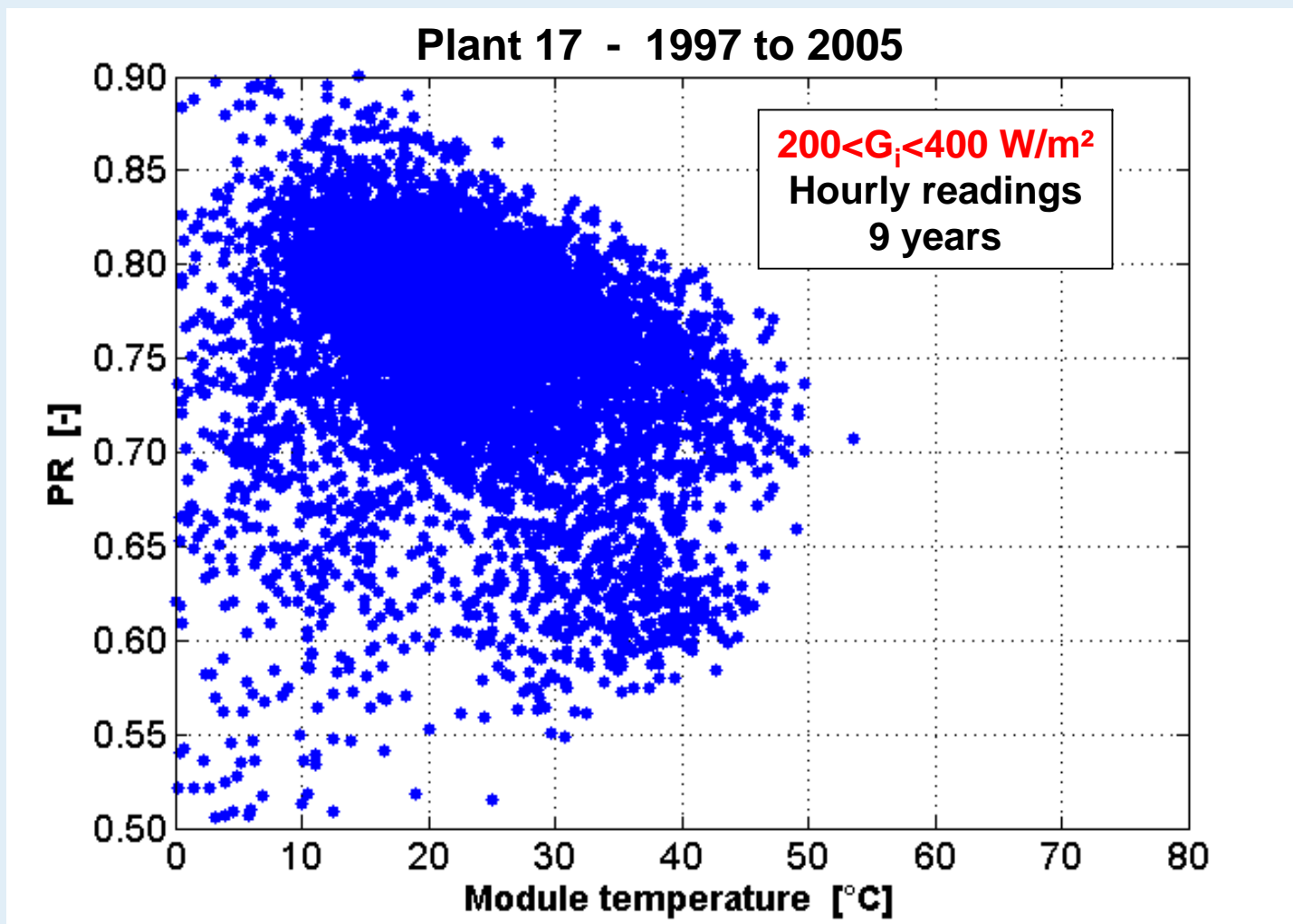


# PR at Identical Climatic Conditions / 1



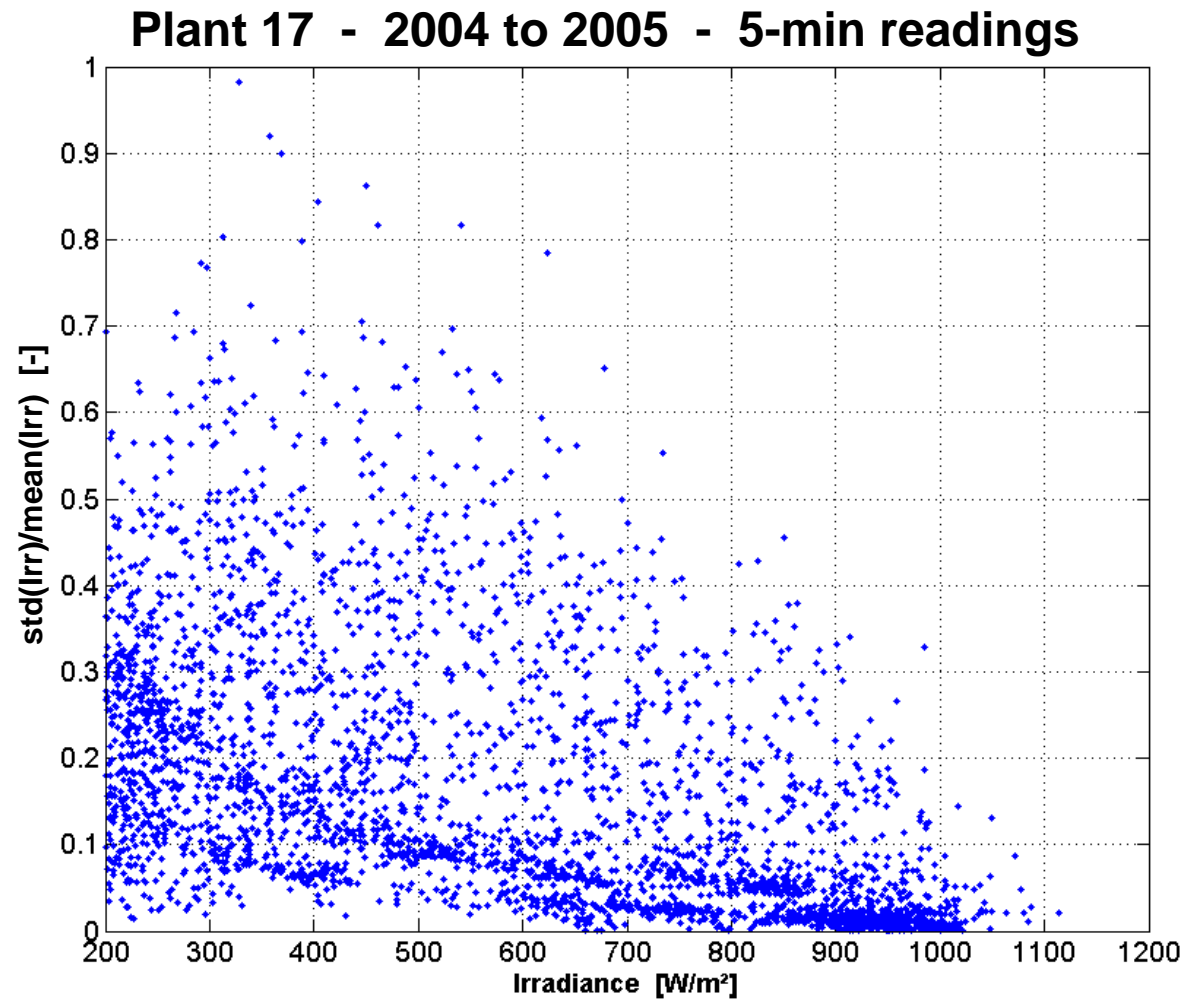


# PR at identical climatic conditions / 2



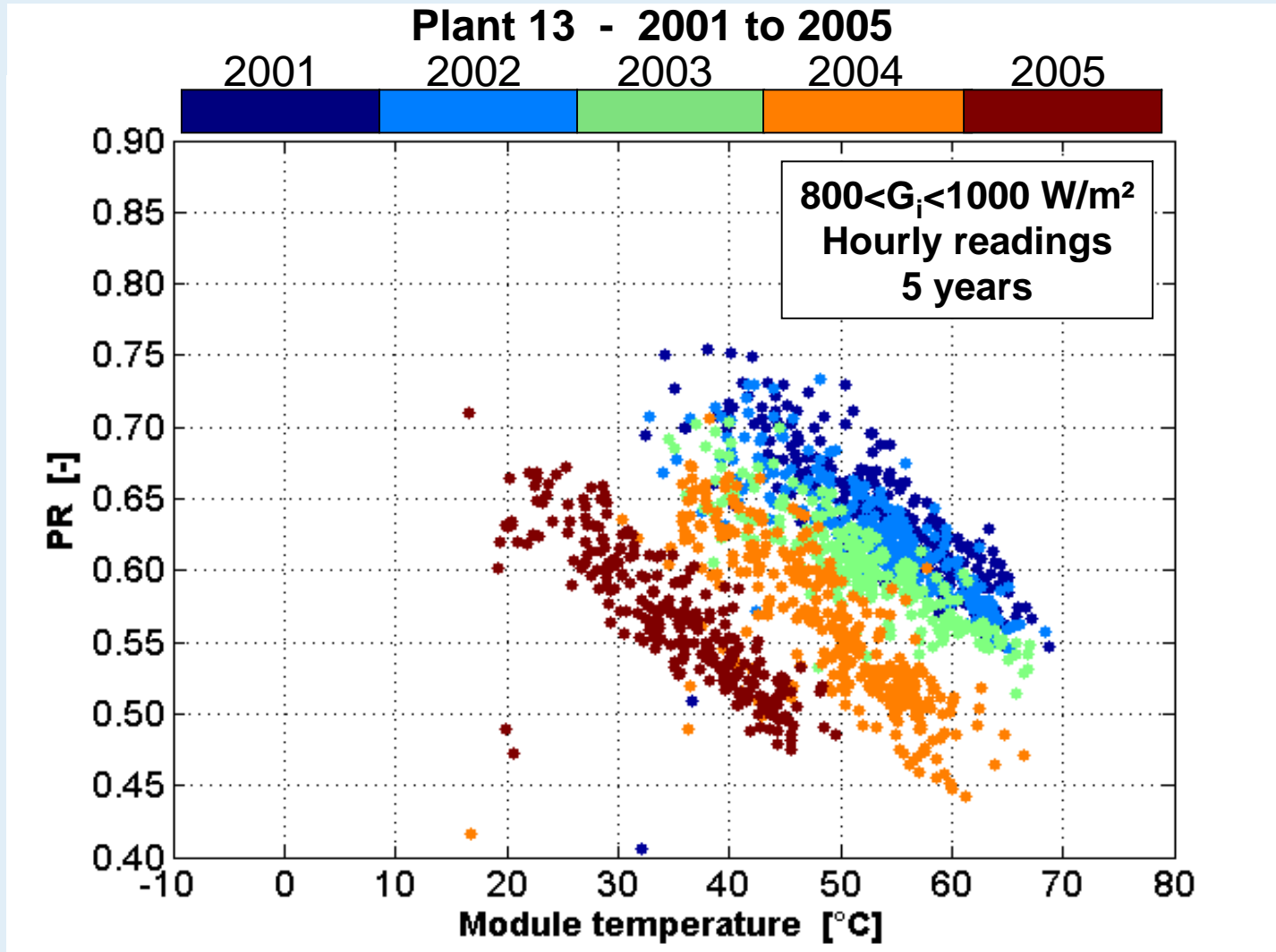


# PR at identical climatic conditions / 3



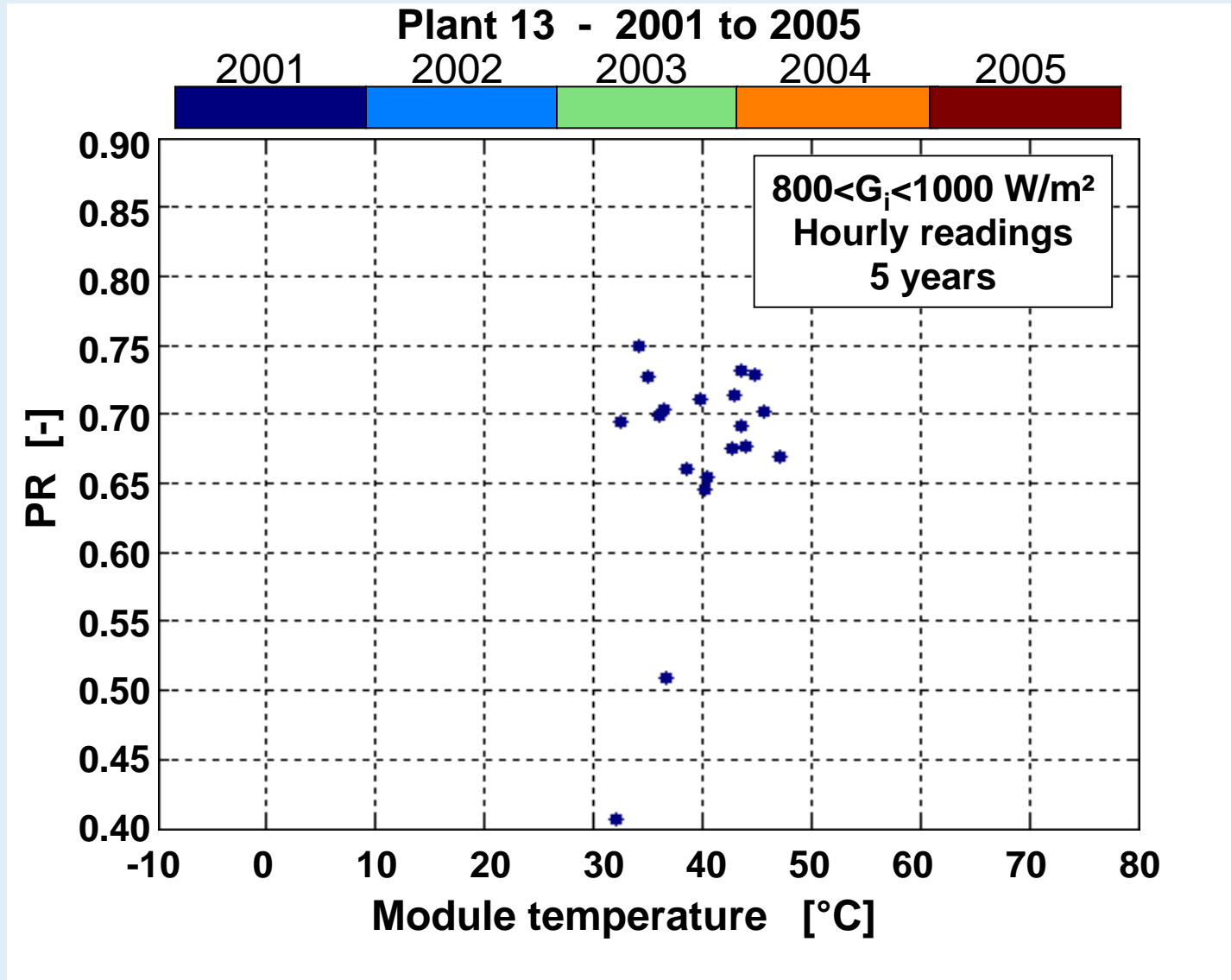


# PR at Identical Climatic Conditions / 4



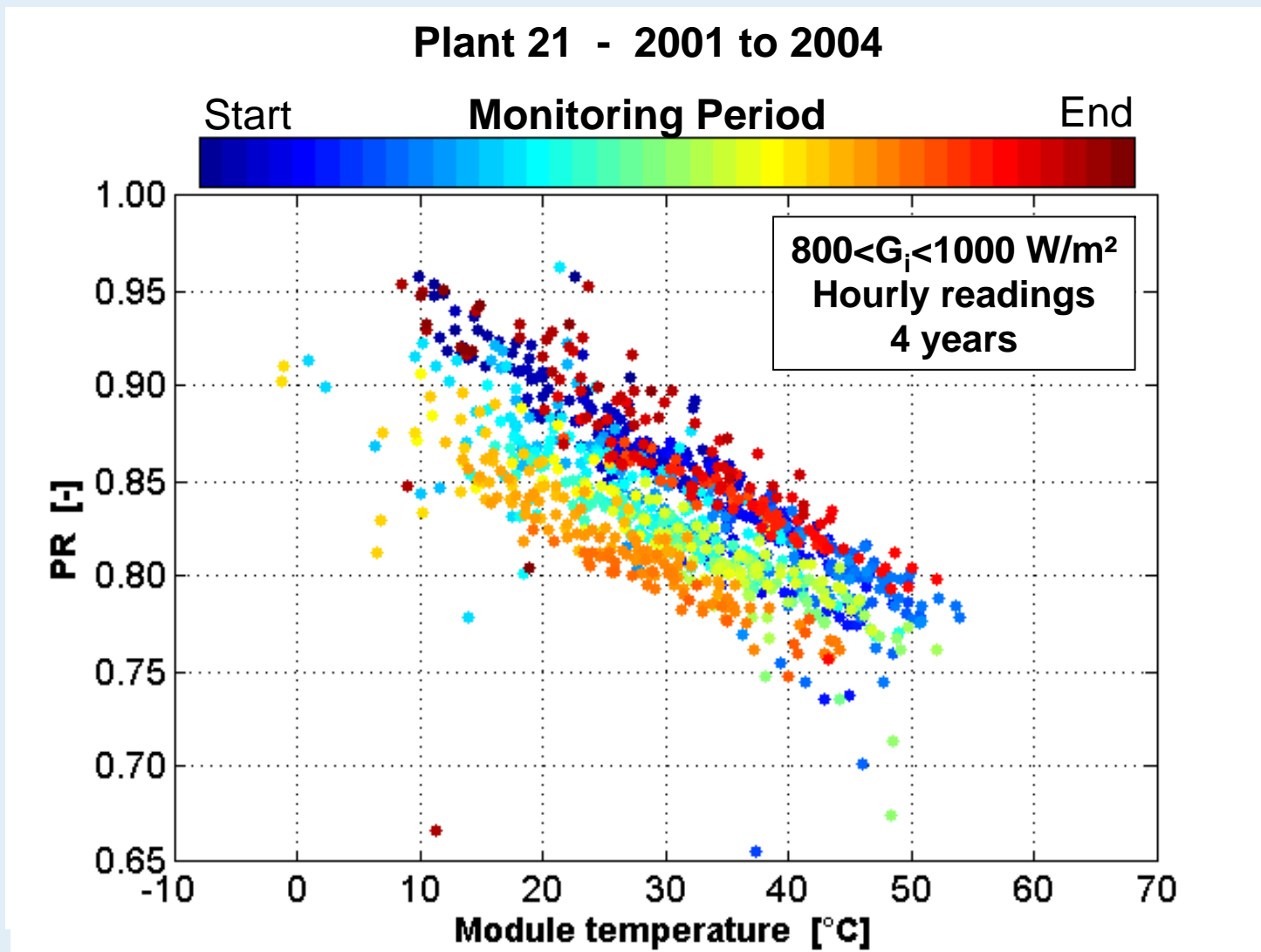


# PR at Identical Climatic Conditions / 5



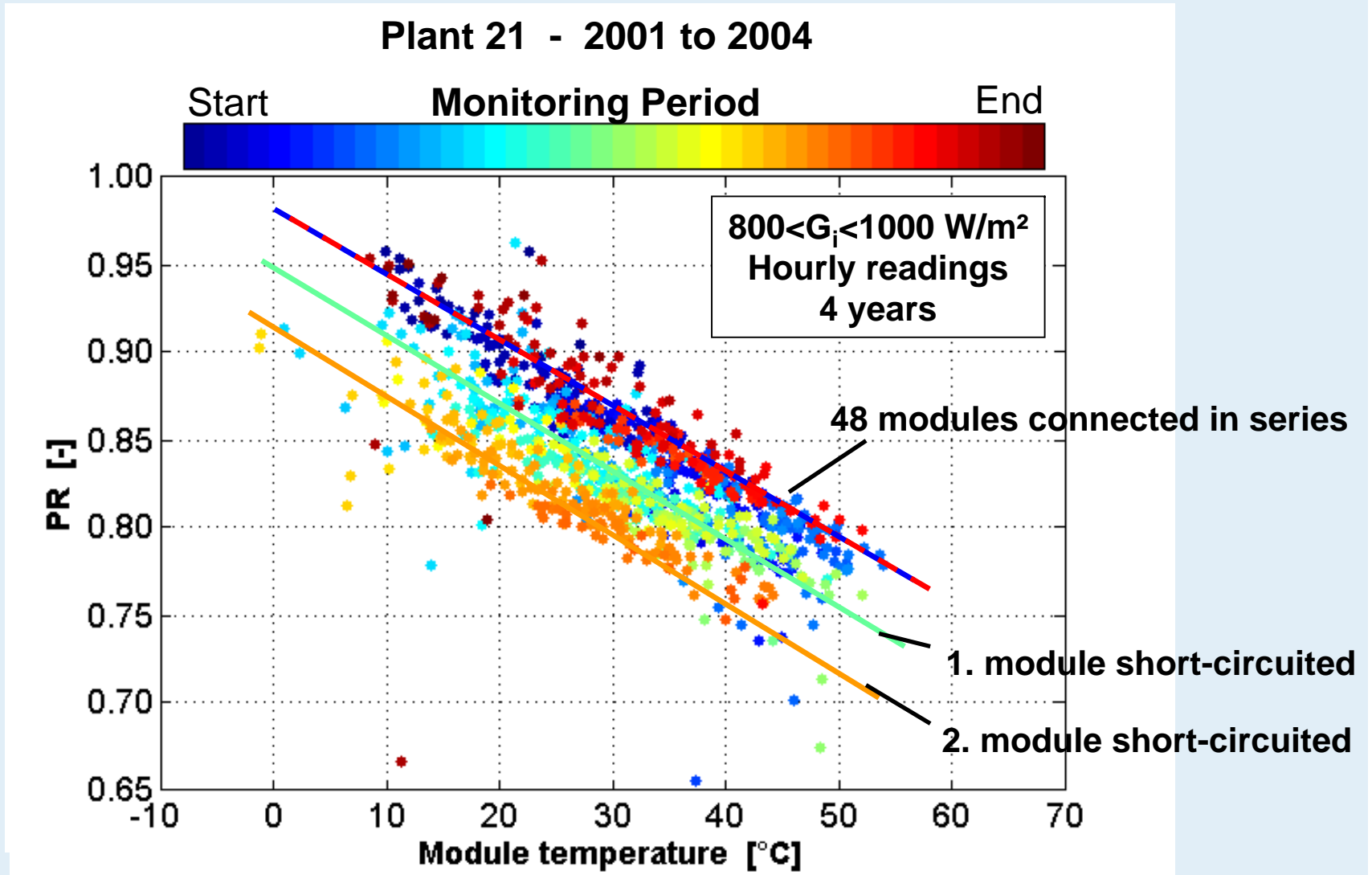


# PR at Identical Climatic Conditions / 7





# PR at Identical Climatic Conditions / 7







# PR at Identical Climatic Conditions / 8

Scattering of data for irradiance 800..1000 W/m <sup>2</sup>		
Plant	Original data	+ ENECOLO
P 17	± 3.2%	
P 19	± 4.2%	
P 20	± 11.2%	± 7.8%
P 8	± 11.6%	± 9.2%

Std(PR)/mean(PR), k=2

PVPS



PR vs.  $T_{mod}$  is useful for detecting small system failures



# RESULTS AND OUTLOOK

- Detailed performance analysis of 21 plants
- 11 plants show no long-term variations of PR
- Various defects were found and reported
- Footprint method valuable for temporary effects
- PR at identical climatic conditions suitable for detecting small system failures
- Clear sky index
- Performance data for larger PV Systems required



# Performance Analysis of Grid-Connected PV Systems

Paper available at:  
[www.iea-pvps-task2.de](http://www.iea-pvps-task2.de)

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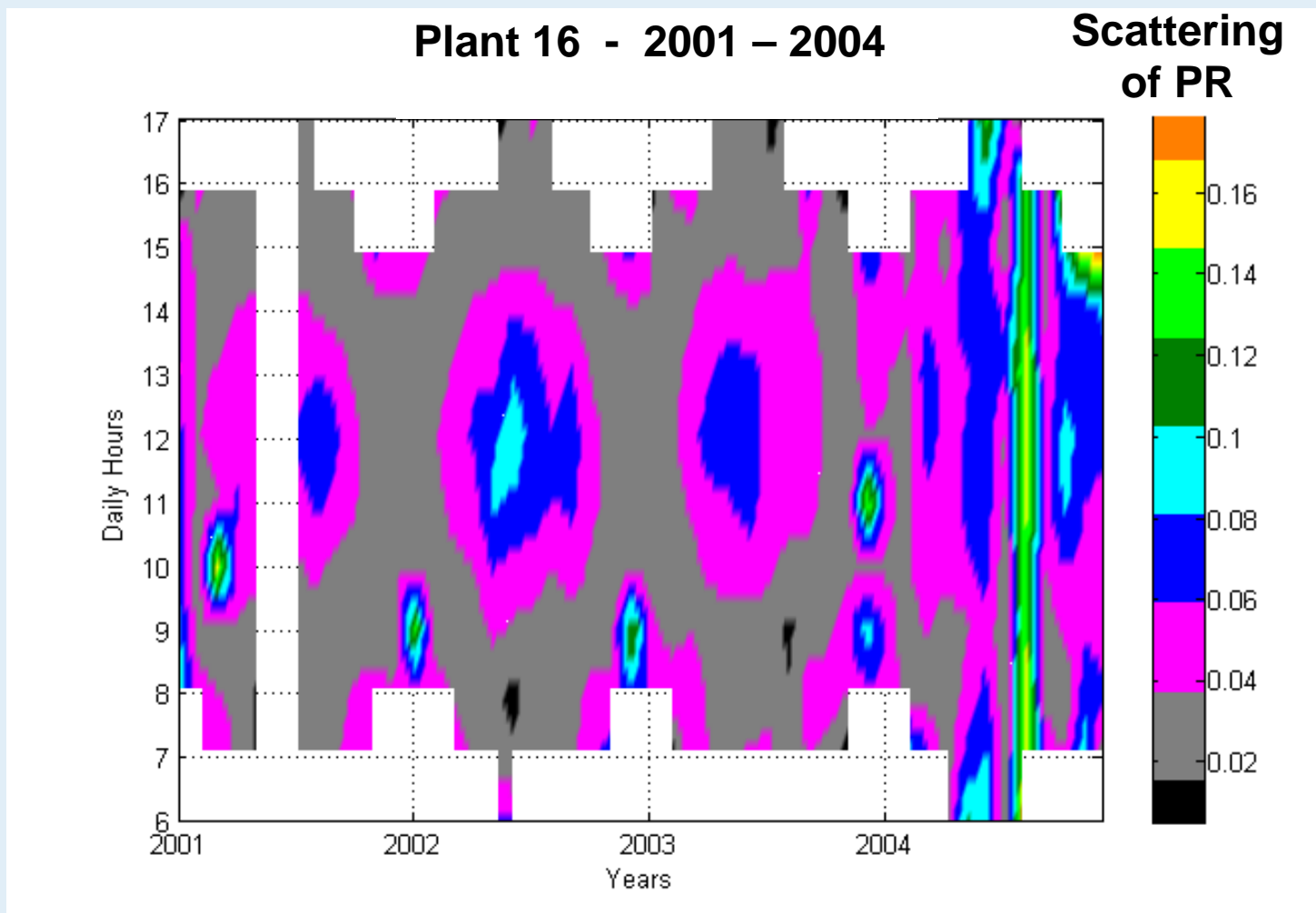


Stefan Mau





# PR over time / 3





# PR at Identical Climatic Conditions / 6

