Second Generation Linear Focus Sun Simulator OptiRec

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Knowledge for Tomorrow

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Introduction

- PTR - key component in CSP plants
- Optical performance - an important property
- Established nondestructive methods to determine optical efficiency:
  - Spectrophotometric (CENER)
  - Calorimetric applied in sun simulators (JFCC, DLR)
  - Outdoor tests (NREL, CIEMAT)

- DLR: Calorimetric measurement system using a sun simulator with linear focus
  - 1st generation test bench: ElliRec
  - 2nd generation test bench: OptiRec – recently validated and new DLR standard

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Set-Up
- Measurement principle
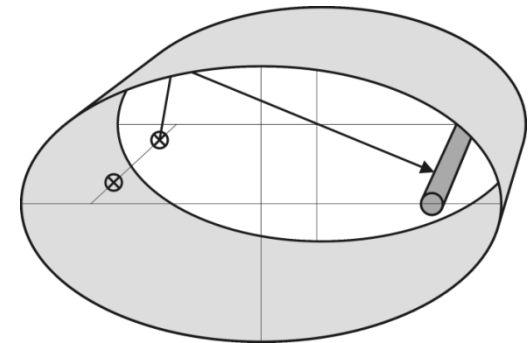- Differences of both DLR sun simulator test benches
- Optical efficiency

Characterization
- Influence of receiver shields
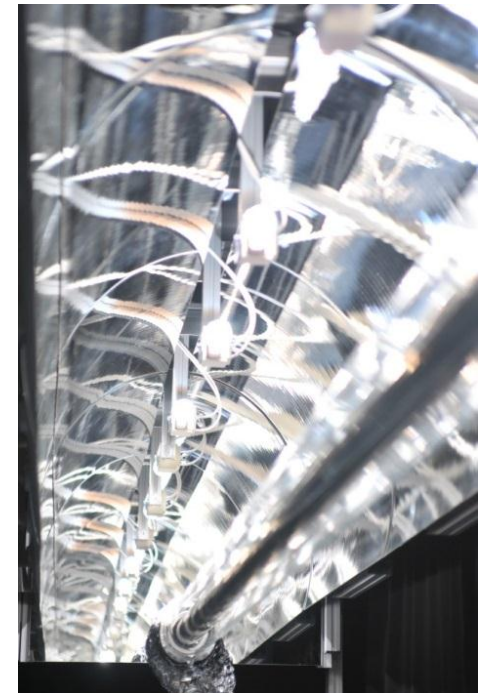- Repeatability
- Validation

Conclusion

Set-Up – Measurement Principle

- Elliptical trough with flat mirrors at both ends
  - 1st focal line: metal halide lamps
  - 2nd focal line: sample receiver
- HTF: water at room temperature
- Determination of absorbed power by measuring ΔT and $\dot{m}$
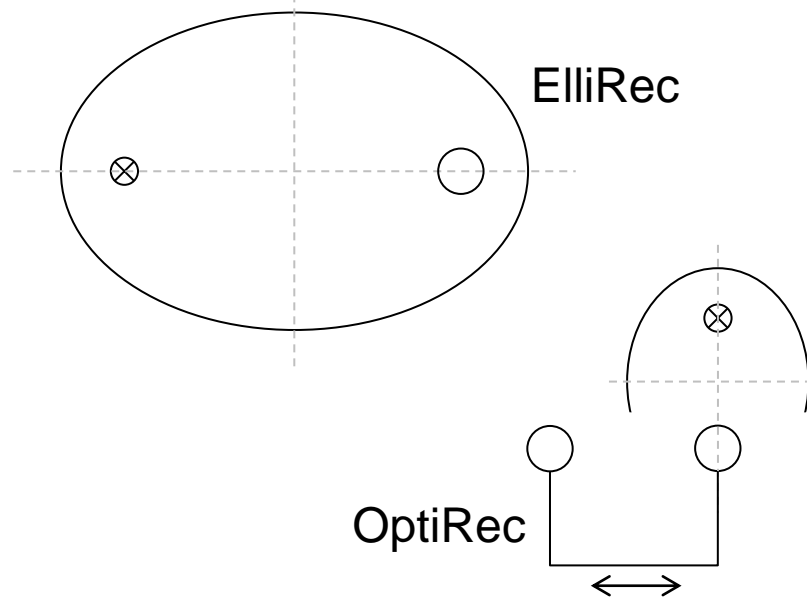

ElliRec
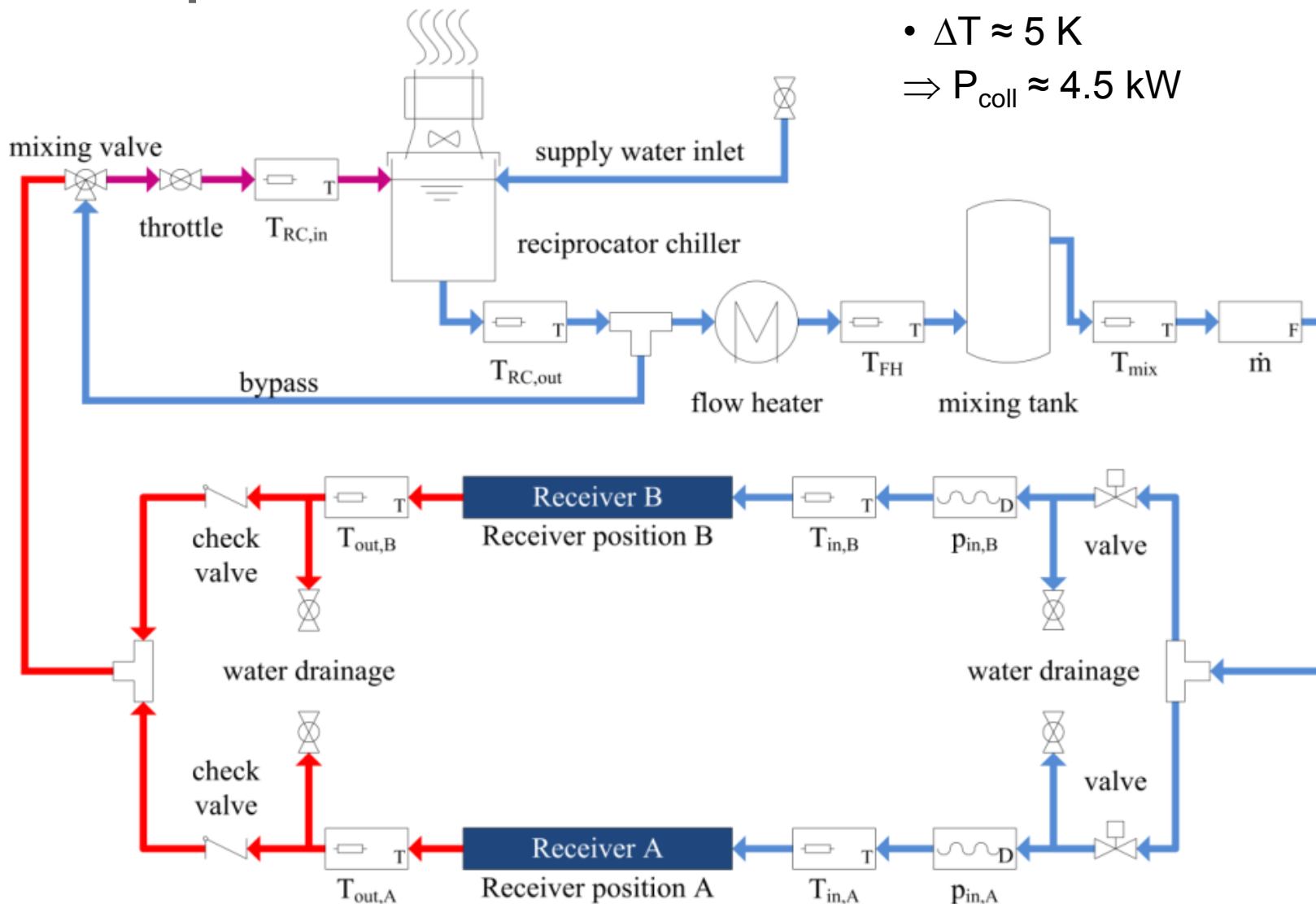(1st generation)

OptiRec
(2nd generation)

Set-Up – Concentrator

ElliRec

OptiRec

	ElliRec (1st gen.)	OptiRec (2nd gen.)
receiver change During operation	no	yes
ellipse orientation	horizontal	Vertical
semi major axis	1026 mm	500 mm
semi minor axis	700 mm	400 mm
numeric excentricity	0.73	0.6
mirror material	aluminum	glass
lamps	metal halide, 4x 4kW	metal halide, 6x 2.5 kW

$\Rightarrow$ change in incidence angle distribution and spectrum

Set-Up – Water Circuit

- $\dot{m}$ = 850 kg/h
- Temp. stability = ±20 mK
- $\Delta T \approx 5$ K
- $\Rightarrow P_{coll} \approx 4.5$ kW

Set-Up – Optical Efficiency

Optical efficiency relative to DLR70-1 (reference):

$$\eta_{rec,opt}(sample, RT) = \frac{P_{coll}(sample)}{P_{coll}(DLR70-1)}\eta_{rec,opt}(DLR70-1, RT)$$

Typical measurement sequence:

1. DLR70-1
2. Sample
3. DLR70-1

Index

Set-Up

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- Optical efficiency
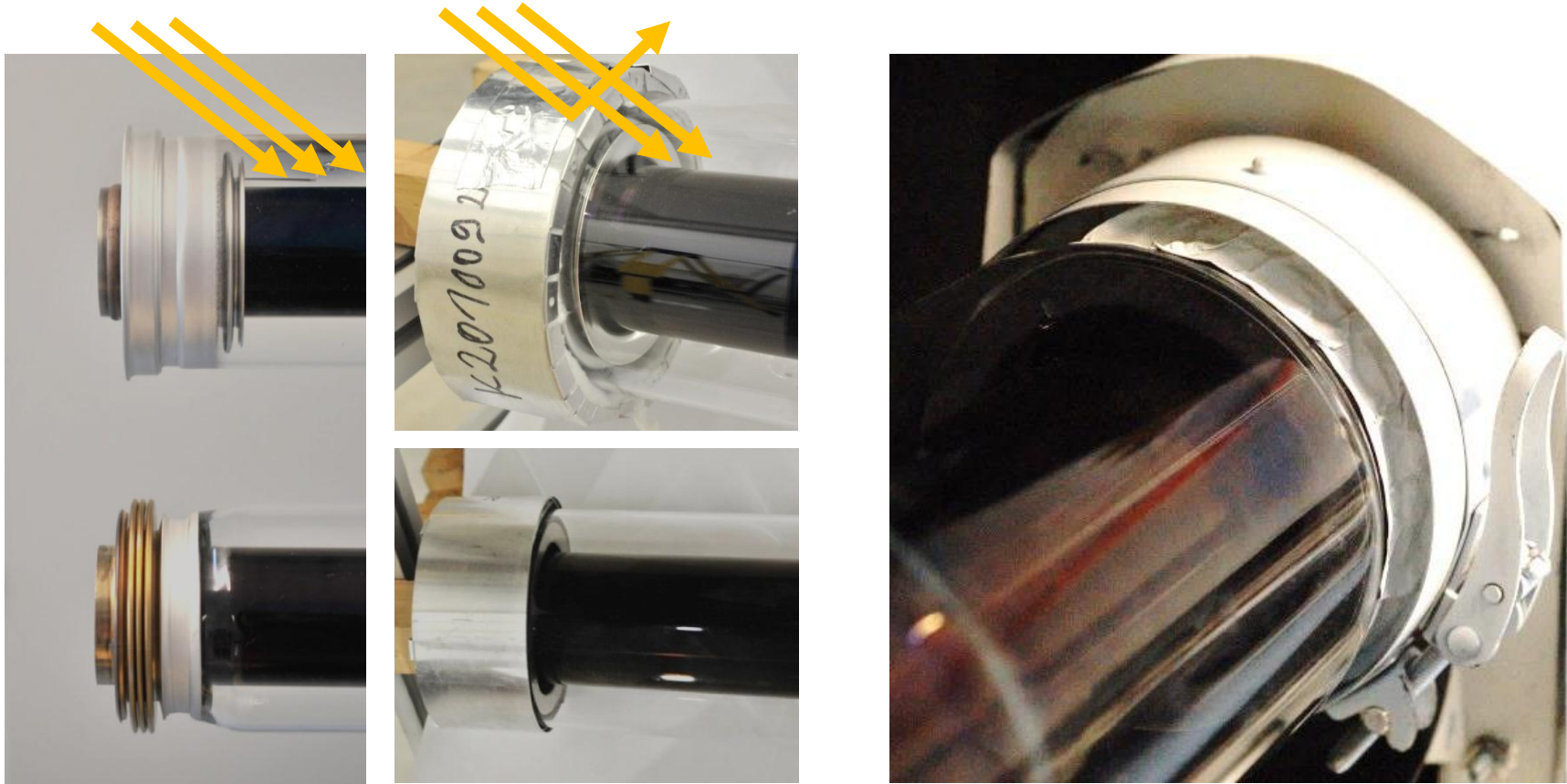
Characterization

- Influence of receiver shields
- Repeatability
- Validation

Conclusion

OptiRec Characterization – Receiver Shields
Distorting Effects Shadowing & Focal Straylight

OptiRec Characterization – Receiver Shields
Influence on Results

Receiver	Manufacturer	Manufacturer shields		OptiRec shields		Deviation
		$\dfrac{\eta_{opt,rec,MS}}{\eta_{opt,rec,mean}}$	Stdv	$\dfrac{\eta_{opt,rec,OS}}{\eta_{opt,rec,mean}}$	Stdv	$\dfrac{\eta_{opt,rec,OS} - \eta_{opt,rec,MS}}{\eta_{opt,rec,mean}}$
i	a	0.996	0.007	1.003	0.002	0.007
ii	a	0.992	0.002	1.008	0.001	0.015
iii	b	0.999	0.004	1.001	0.000	0.001

- Stdv. larger with manufacturer shields
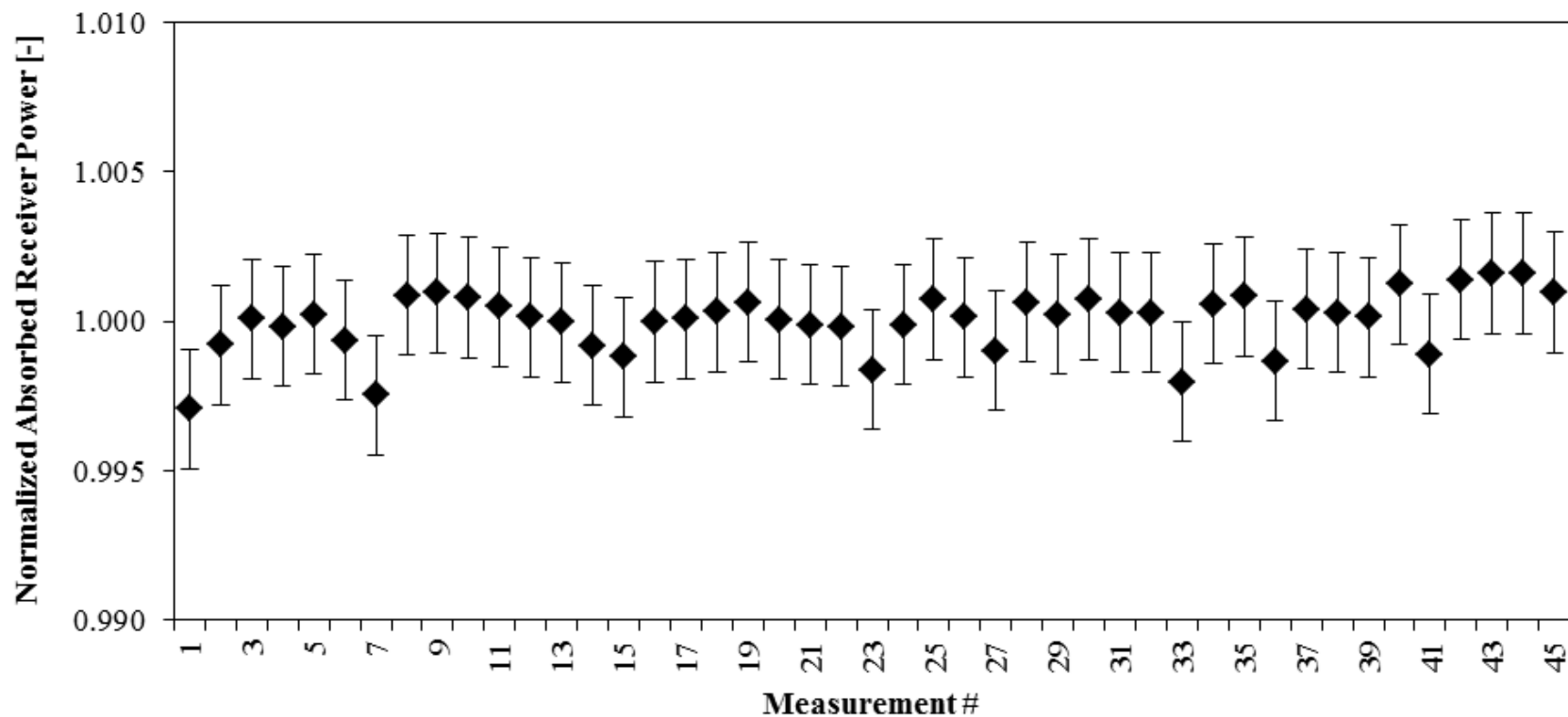- Manufacturer shields decrease optical efficiency

$\Rightarrow$ OptiRec shields will be used in OptiRec

The impact of a particular shield on the performance in the solar field must be analyzed separately!
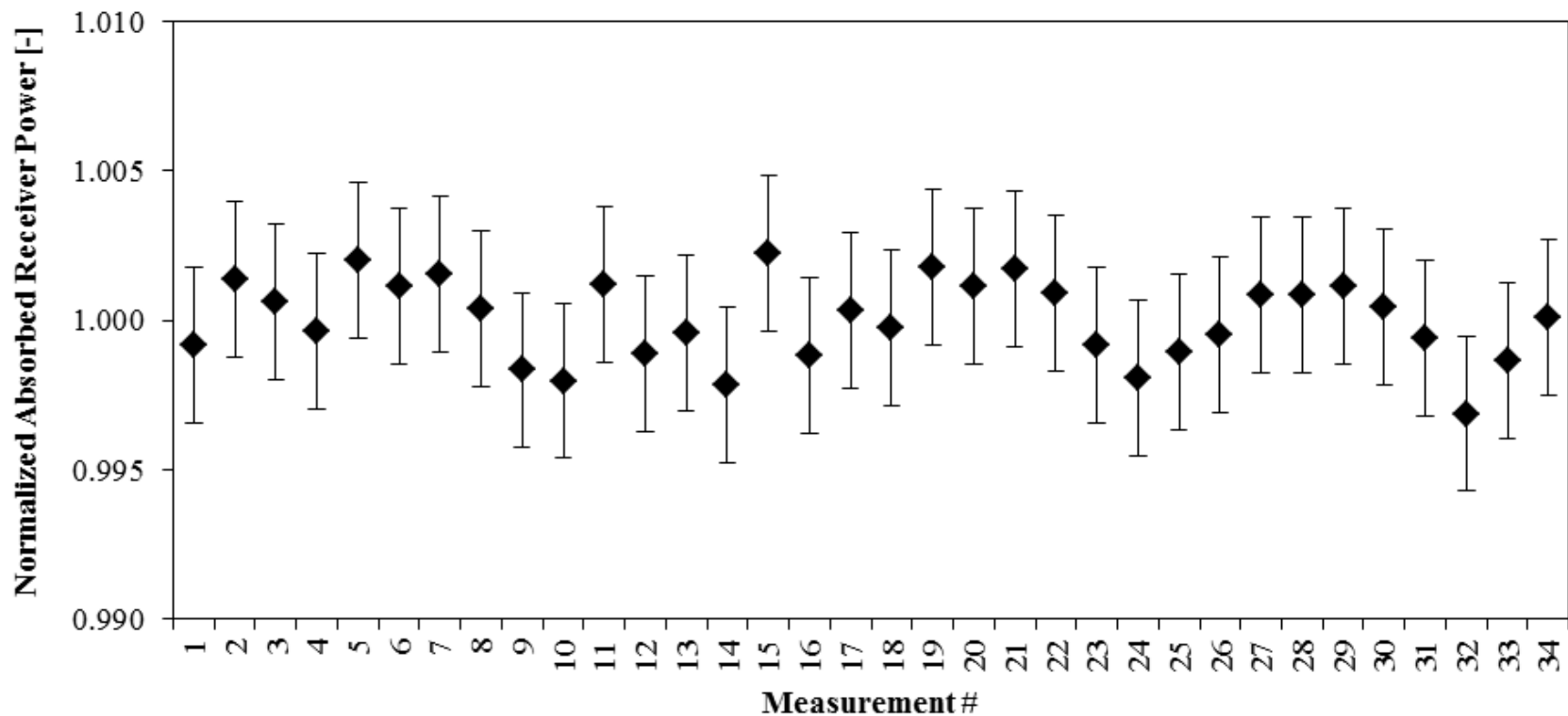
OptiRec Characterization – Repeatability
Receiver Remaining in Test Bench

- Stdv: 0.10%
- error bars: 2σ measurement repeatability

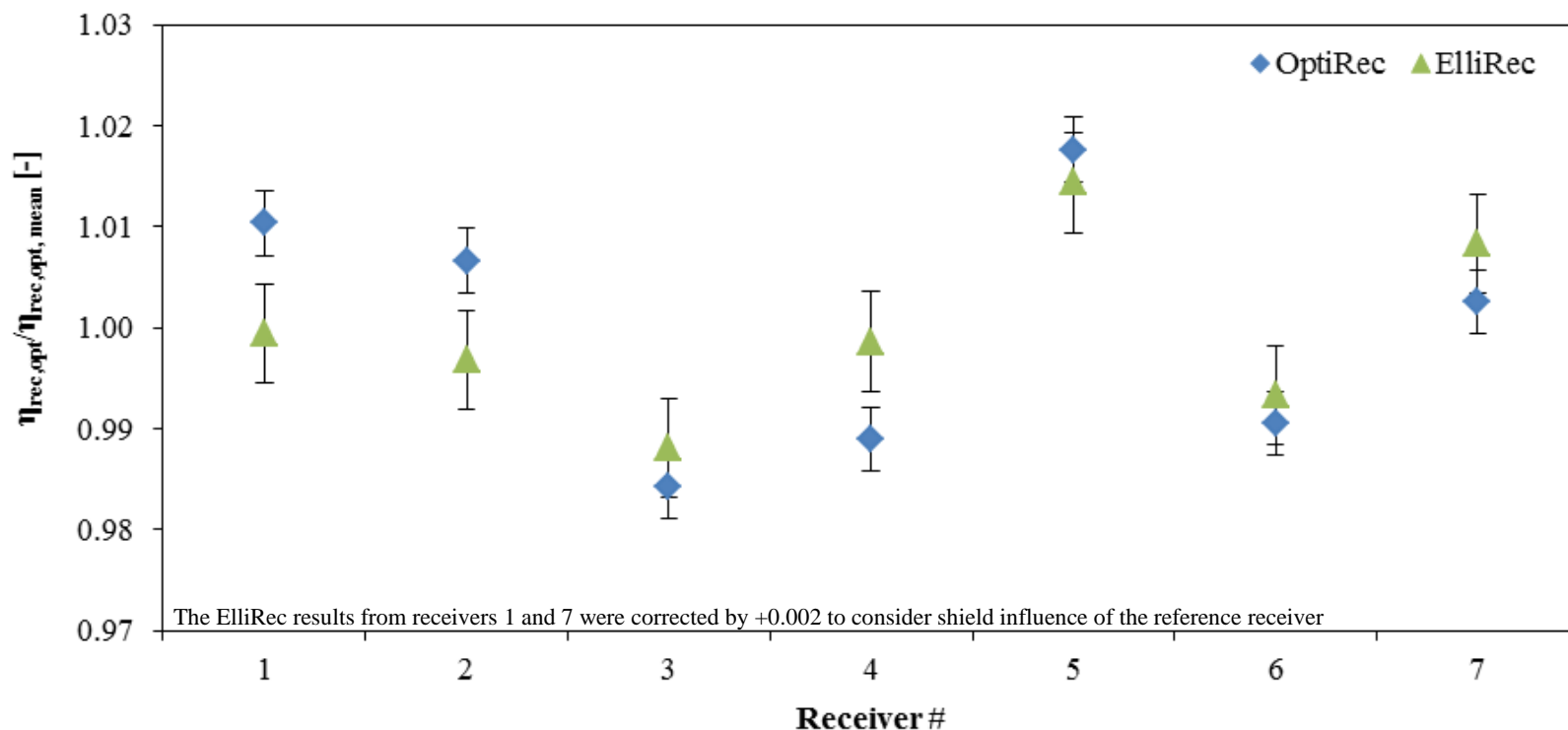# OptiRec Characterization – Repeatability
Including Receiver Mounting

- Stdv: 0.13%
- error bars: 2σ measurement repeatability
- For comparison - Stdv ElliRec: 0.2%

OptiRec characterization – Validation
OptiRec Compared to ElliRec

- Maximum deviation of optical efficiencies is 1.1%
- Error bars (2σ) overlap for 4/7 of the receivers
- No systematic shift
- Wider spread for OptiRec results

Conclusion

- OptiRec commissionig finished

- Measurement time is approx. one hour

- OptiRec shields used for standard measurements

- The repeatability of the test bench is 0.13% (1σ)

- Validation campaign to ElliRec:
  max. deviation 1.1% and no systematic shift

=> OptiRec replaces ElliRec as optical efficiency test
bench at DLR

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Thanks for your attention.