22.04.2021

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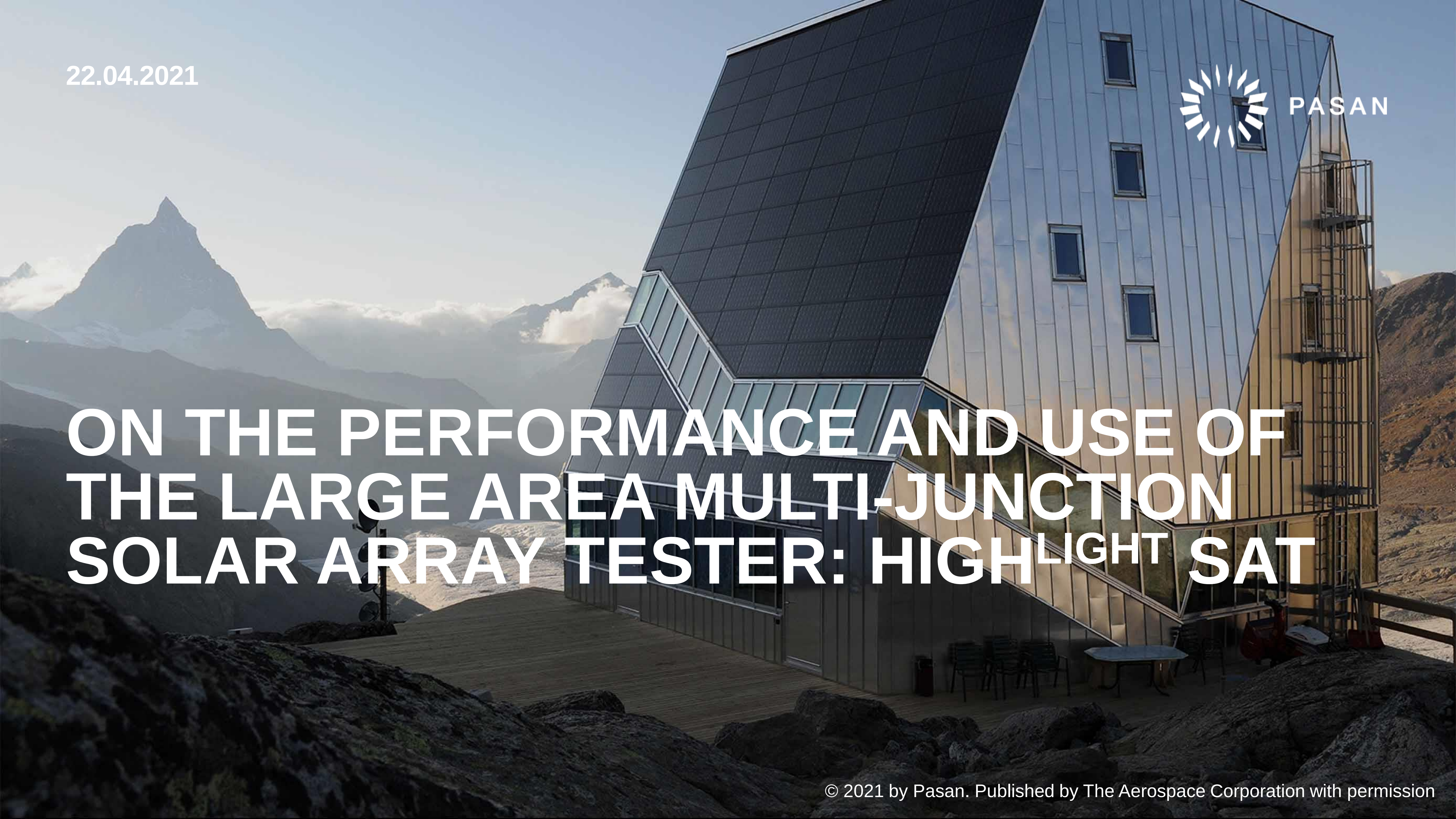
ON THE PERFORMANCE AND USE OF THE LARGE AREA MULTI-JUNCTION SOLAR ARRAY TESTER: HIGHLIGHT SAT



INTRODUCTION / TOC

CONCEPT

THE NEED

- Measure large area (circa 8 -12 m^2) multi-junction solar arrays
- Ensure that each junction is optically pumped as it would in space

- Ensure the highest uniformity of the light source over measurement area
- Simulate Solar spectrum in space AM0 or its equivalent

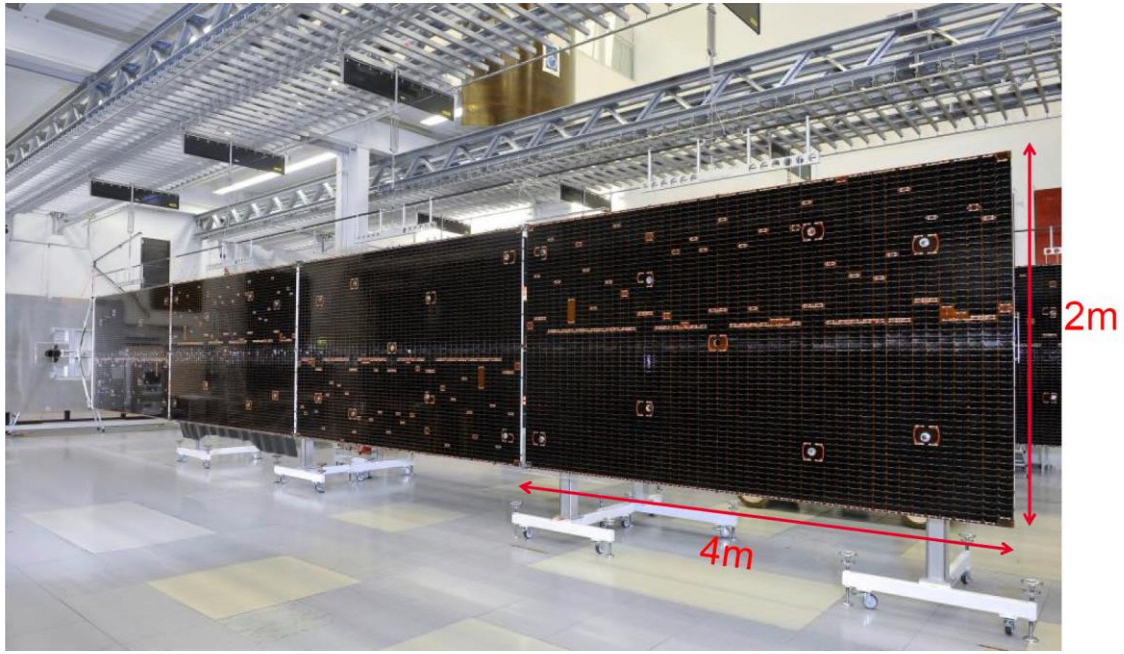


Photo courtesy of Airbus Space & Defence

THE BUILDING BLOCK - STANDARD 1 J TESTER

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Light box simulates the AM 1.5G spectrum

Spectral control & uniformity (< 1%)

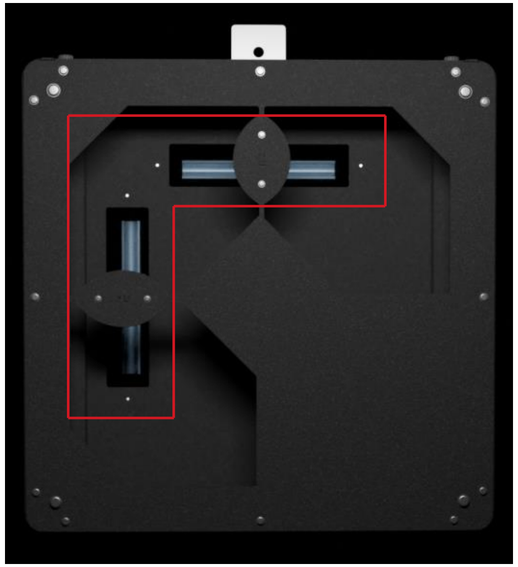
- Customized interferential filters
- High density plasma Xenon flash tubes

Uniformity of Irradiance (< 1%)

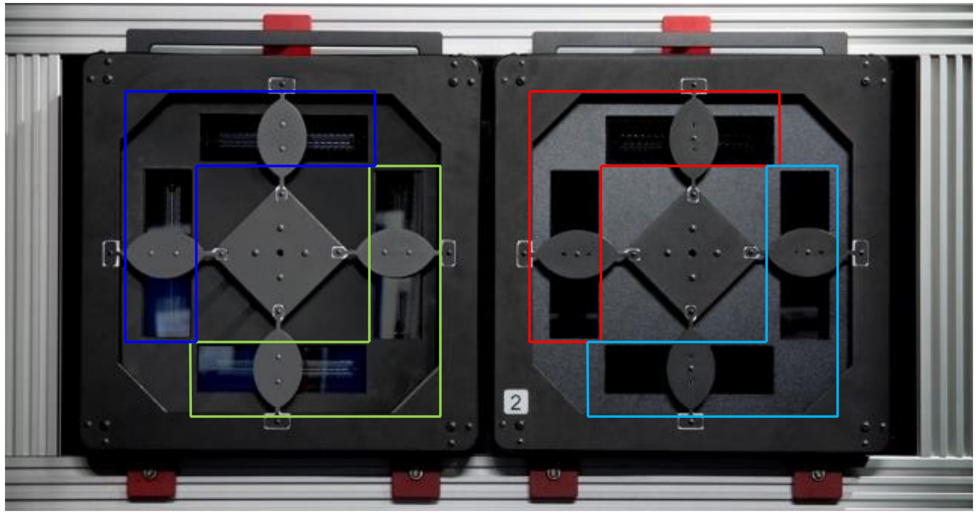
- Advanced uniformity mask (cross/rosette)

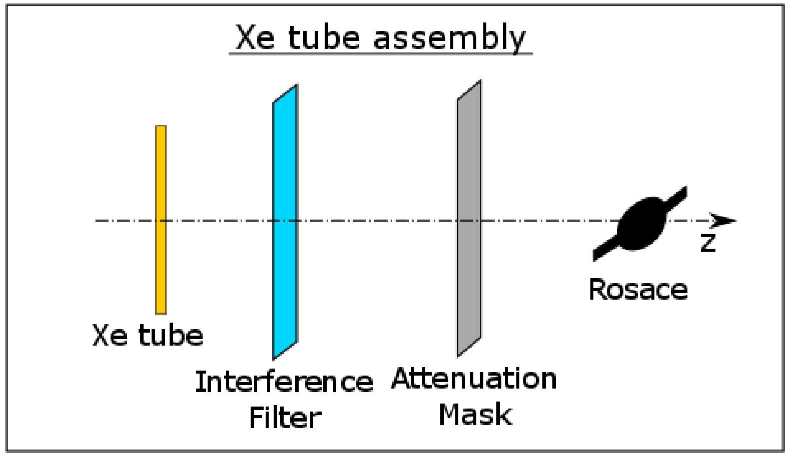
Pulse Stability (< 1% LTI)

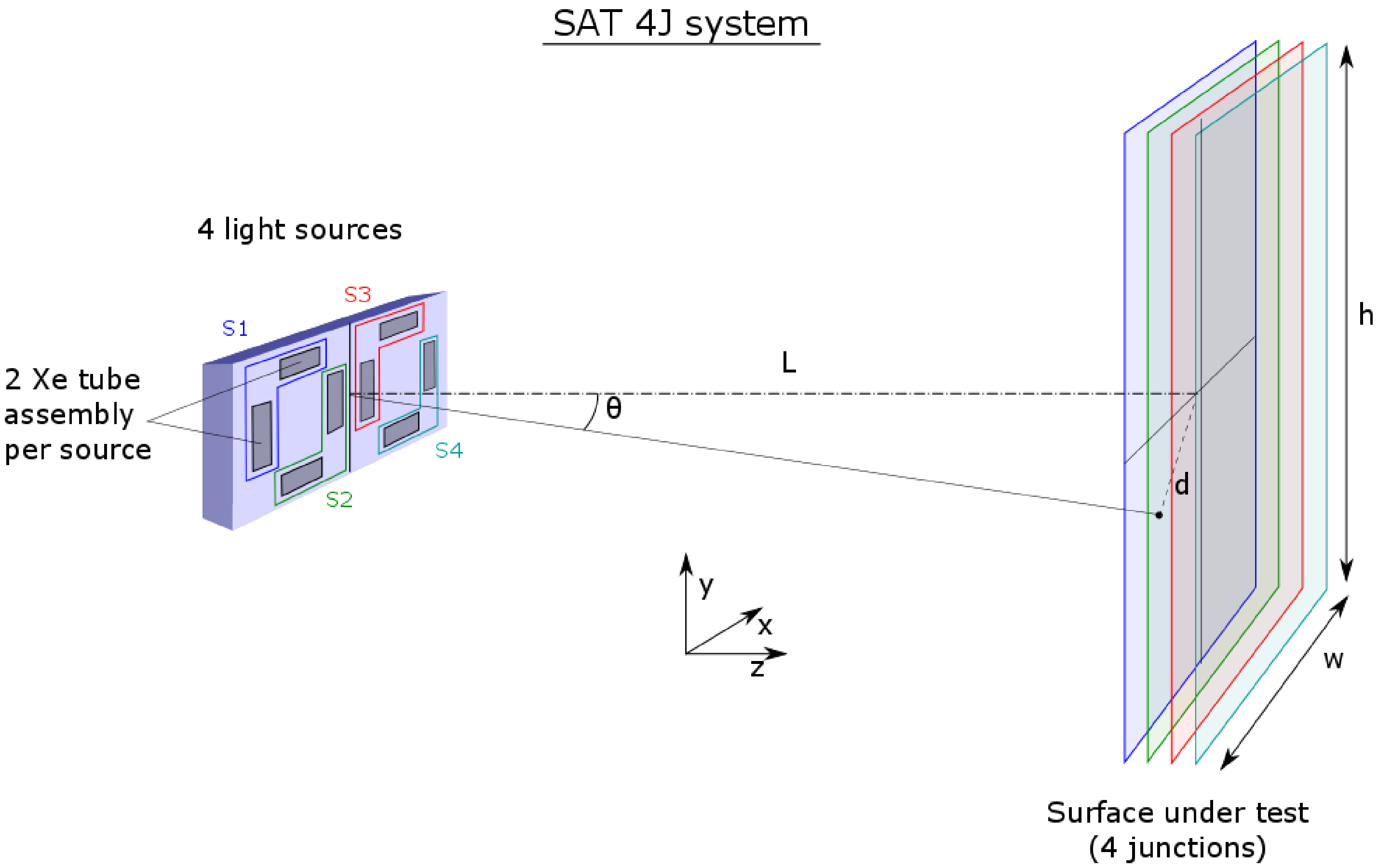
4 irradiance channel e-load with < 0.1% precision



THE 4J TESTER



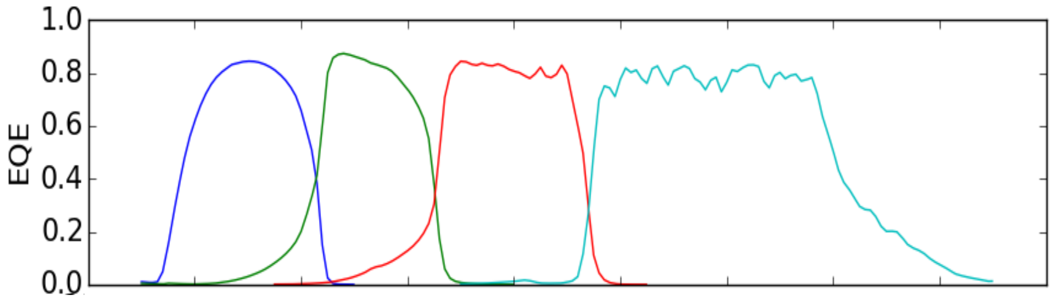


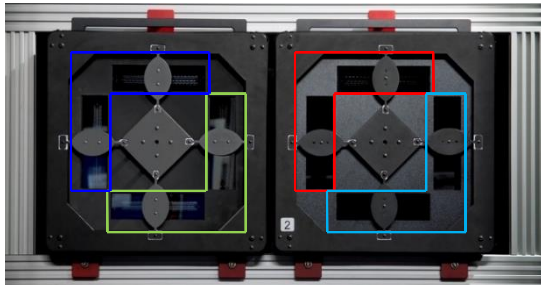


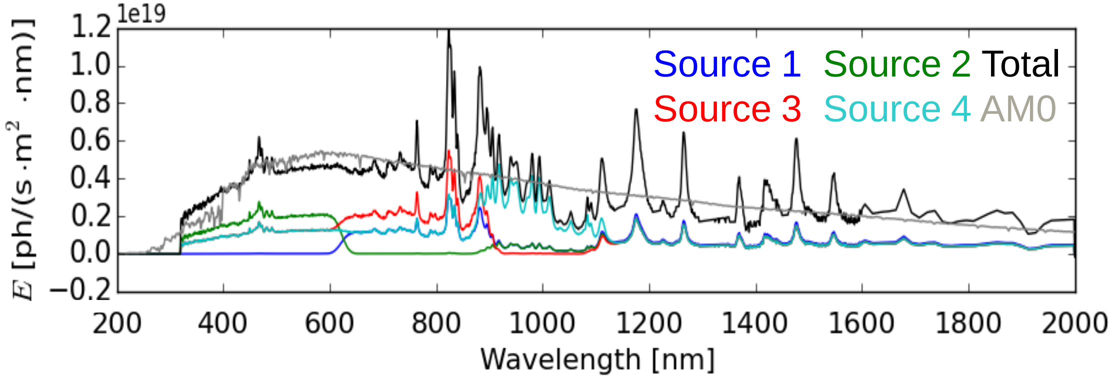
CHARACTERISTICS

TYPICAL DESIGN FOR A 4J SYSTEM

Simulator spectra matching 4 CoCell Ref. Currents







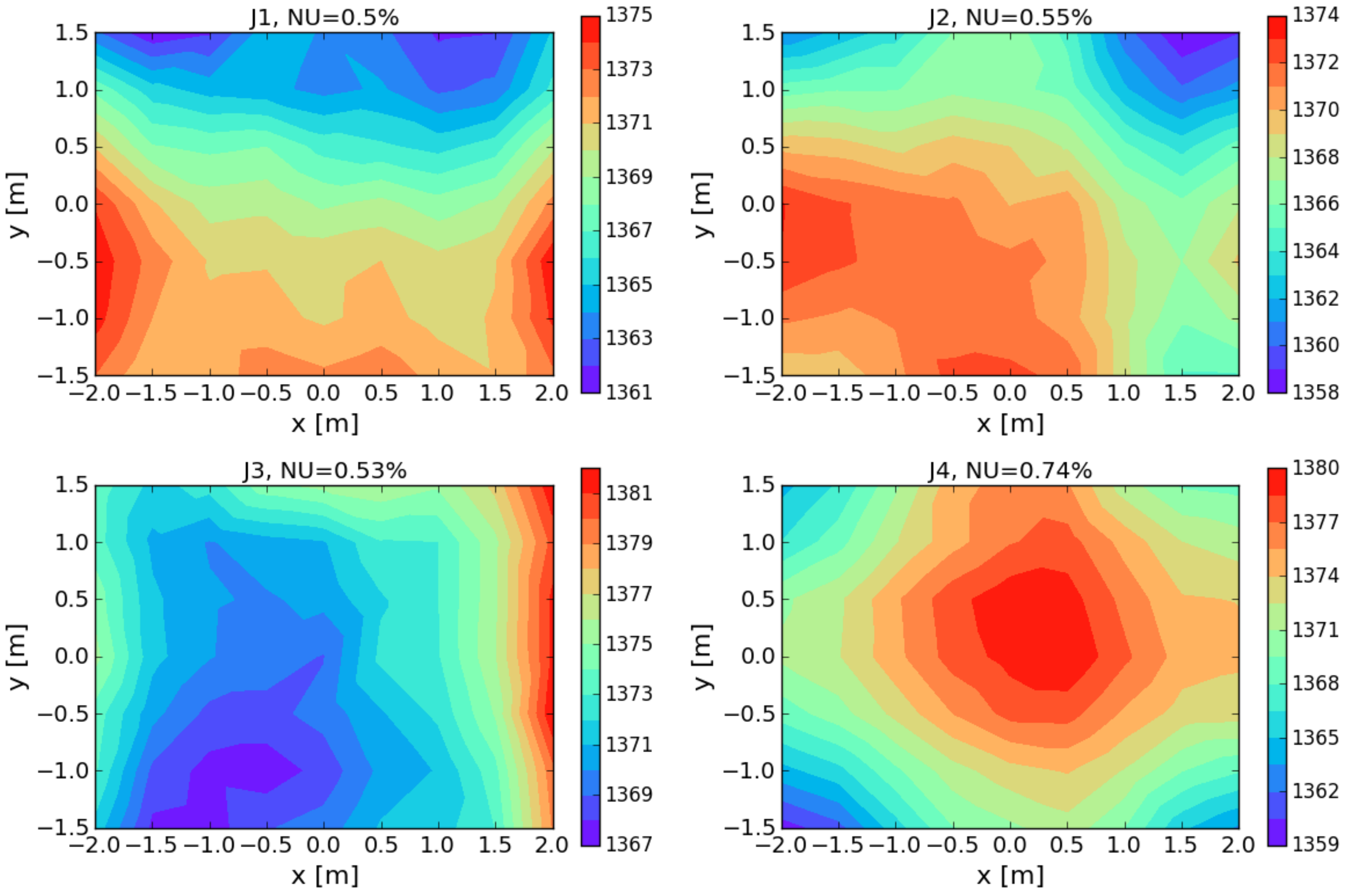
Spectrum calibration within 0.3% of target reference

	CoCell currents [mA]							
	1SUN at 8 m				0.1 SUN at 8 m			
	I_1	I_2	I_3	I_4	I_1	I_2	I_3	I_4
Reference	411.4	447.3	443.8	513.3	41.14	44.73	44.38	51.33
Measured	410.4	447.1	444.7	513.0	41.17	44.73	44.39	51.31
δI [%]	-0.25	-0.04	0.20	-0.05	0.08	-0.01	0.02	-0.04

NON UNIFORMITY (NU) OF IRRADIANCE

Measured by 4 junctions on a 4m x 3m surface

Measured non uniformities of 4 CoCells

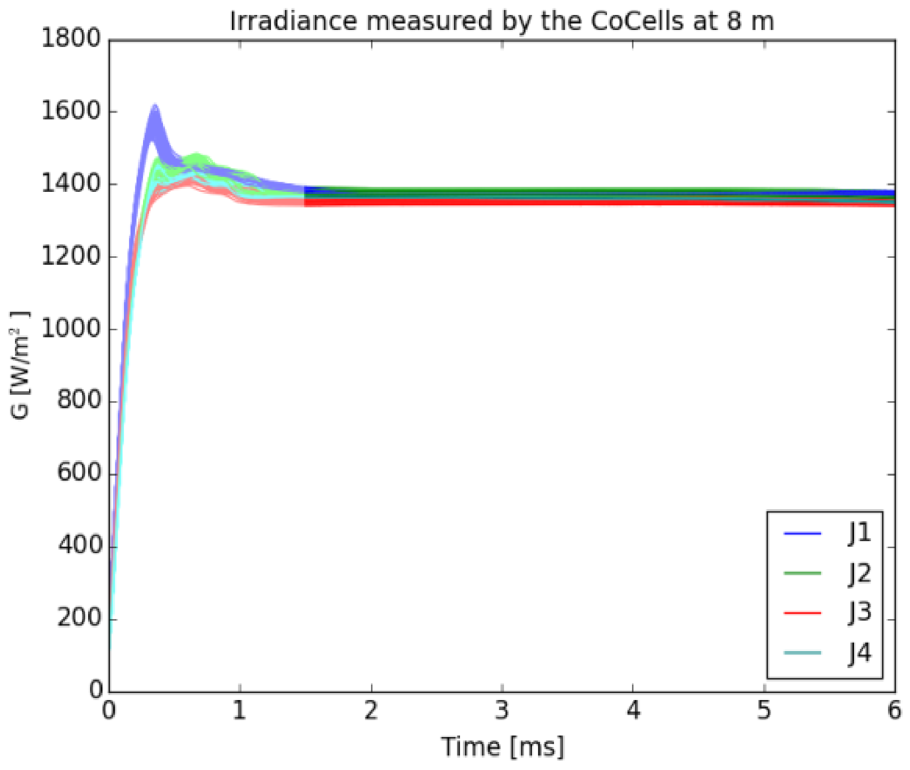


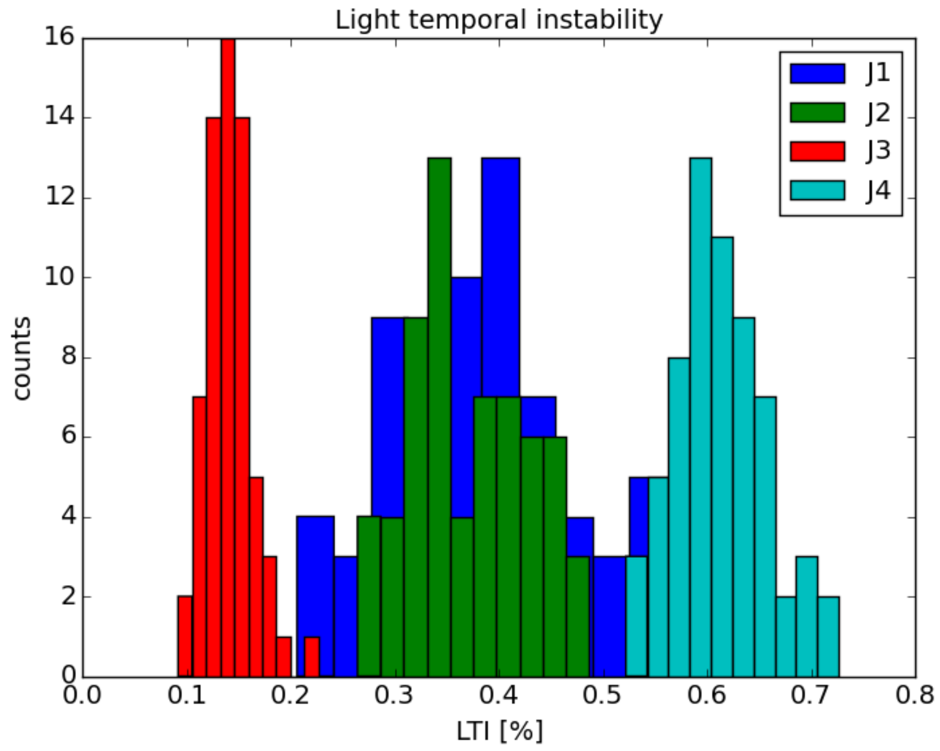
NU < +/- 1% for 3.0m x 4.0m surface

NU < +/- 2% for 3.0m x 4.5m surface

HIGH TEMPORAL STABILITY OF LIGHT PULSE
Light Temporal Instability < 1% for each junctions

Simulator light spectrally stable within 1% according to 4 junctions technology
4 sources controlled individually by feedback loop





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DESIGN & MANUFACTURING

THE MODEL BEHIND OUR SIMULATIONS

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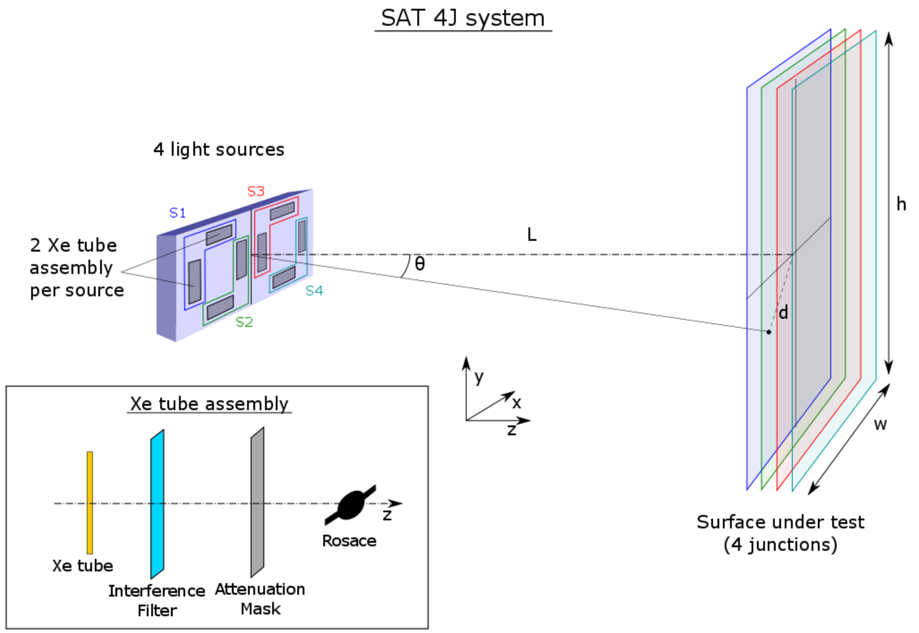
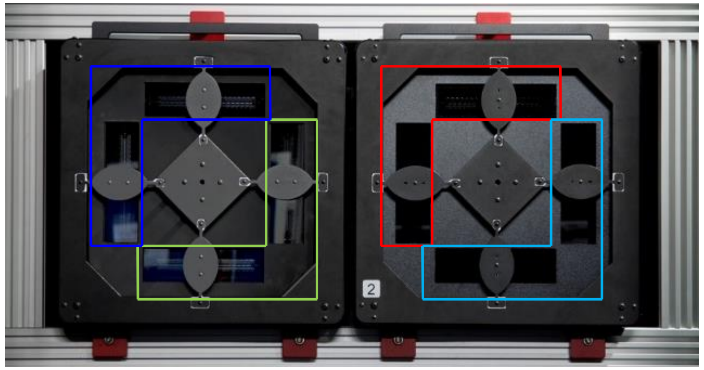
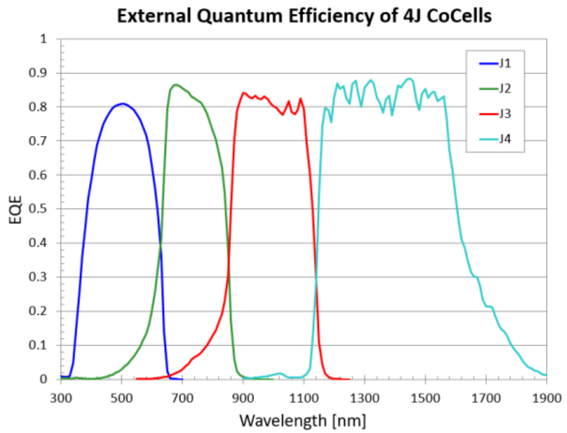
$$I_{j,\theta} = A_j \sum_i \int E_{Xe}(\lambda) \bullet T_i(\lambda,\theta) \bullet SRj(\lambda) d\lambda$$







DESIGN STEP 1 – INITIAL FILTER DESIGN

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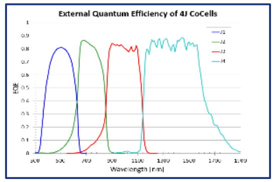
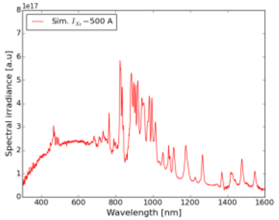
Inputs

Quantum efficiency of co-cells



Reference currents
I_{ref1}, I_{ref2}, I_{ref3}, I_{ref4}

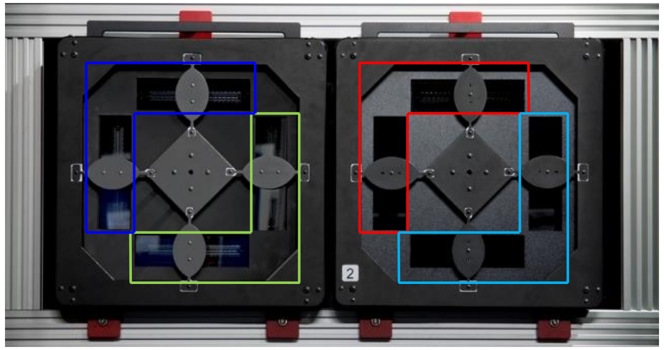
Xe spectral irradiance at fixed nominal operating point



Pasan's Simulation environment

- $I_{j,\theta} = A_j \sum_i \int E_{Xe}(\lambda) \bullet T_i(\lambda, \theta) \bullet SRj(\lambda) d\lambda$
- Set $\theta = 0$; Along optical axis
- Iterative algorithm Min(I_{refi} vs I_{calci})

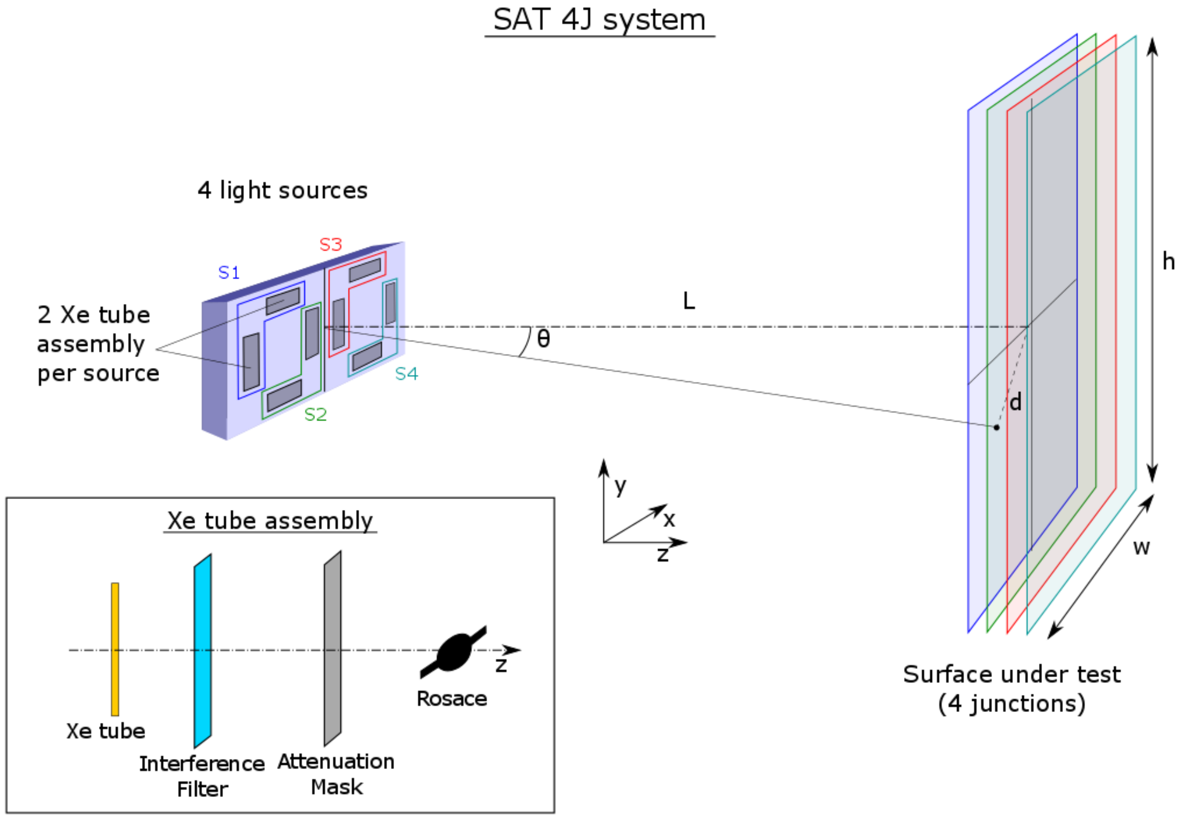
Outputs



An initial guess of the filter design parameters

ANGULAR DEPENDENCE OF FILTERS

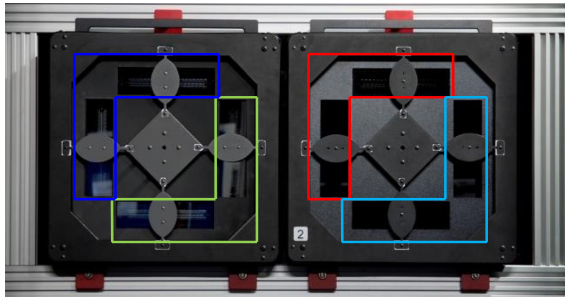
Non-uniformity due to angular dependence of interference filters modifies transmission at different points in the plane



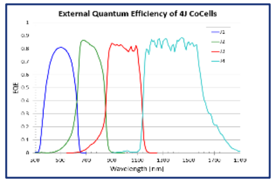
DESIGN STEP 2 – OPTIMIZED SPATIAL UNIFORMITY

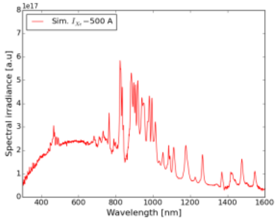
Inputs

Theta = 0



Reference currents
$I_{ref1}, I_{ref2}, I_{ref3}, I_{ref4}$



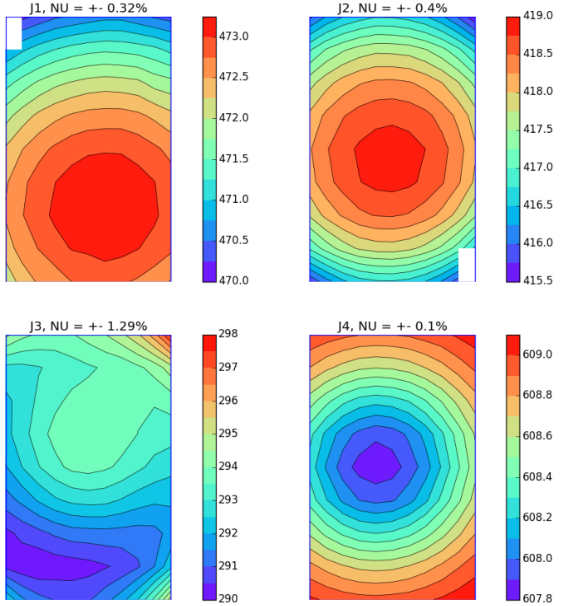


Pasan's Simulation environment

- ❖ $I_j = \int E_{Xe}(IXe, \lambda, \theta) \bullet T(\lambda) \bullet SRj(\lambda) d\lambda$
- ❖ Min(I_{rev} vs I_{calc}) as a function of θ

Outputs

- ➢ Final filter design
- ➢ *A map of the non-uniformity*
- ➢ **Simulated NU < 2%**



MANUFACTURING SYSTEM QUALIFICATION

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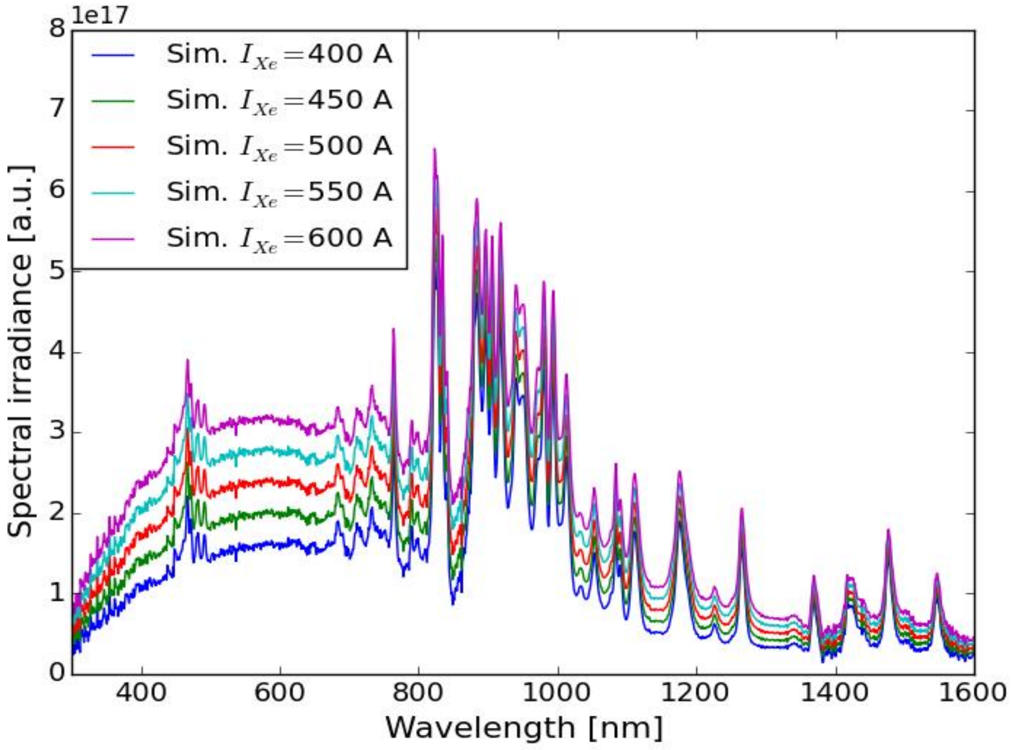
- Filter designed for sources nominal operation point (500 A current in Xe)
- Check with supplier simulations and measurements for achievement of design
- **Filters** and **model** have imperfections → Sources operate at actual set points (between 400 A & 600A)
- At factor acceptance of the tool find actual operation point with a calibration process



CALIBRATION & USE CASES

CALIBRATION OF TOOL ONCE IN USE

Calibration of the system :

1. Measure I_{SCJi} on a RefCells on the optical axis
2. Calibration acceptance criteria < **0.5 %** (I vs. I_{Ref1}) on measured RefCell
3. Requires 3 + 2N + 1 flashes (N = number of junctions)
4. If needed single flash adjustments to reach desired acceptance criteria.
5. Continuous calibration mode also available.

4 DIFFERENT USE CASES

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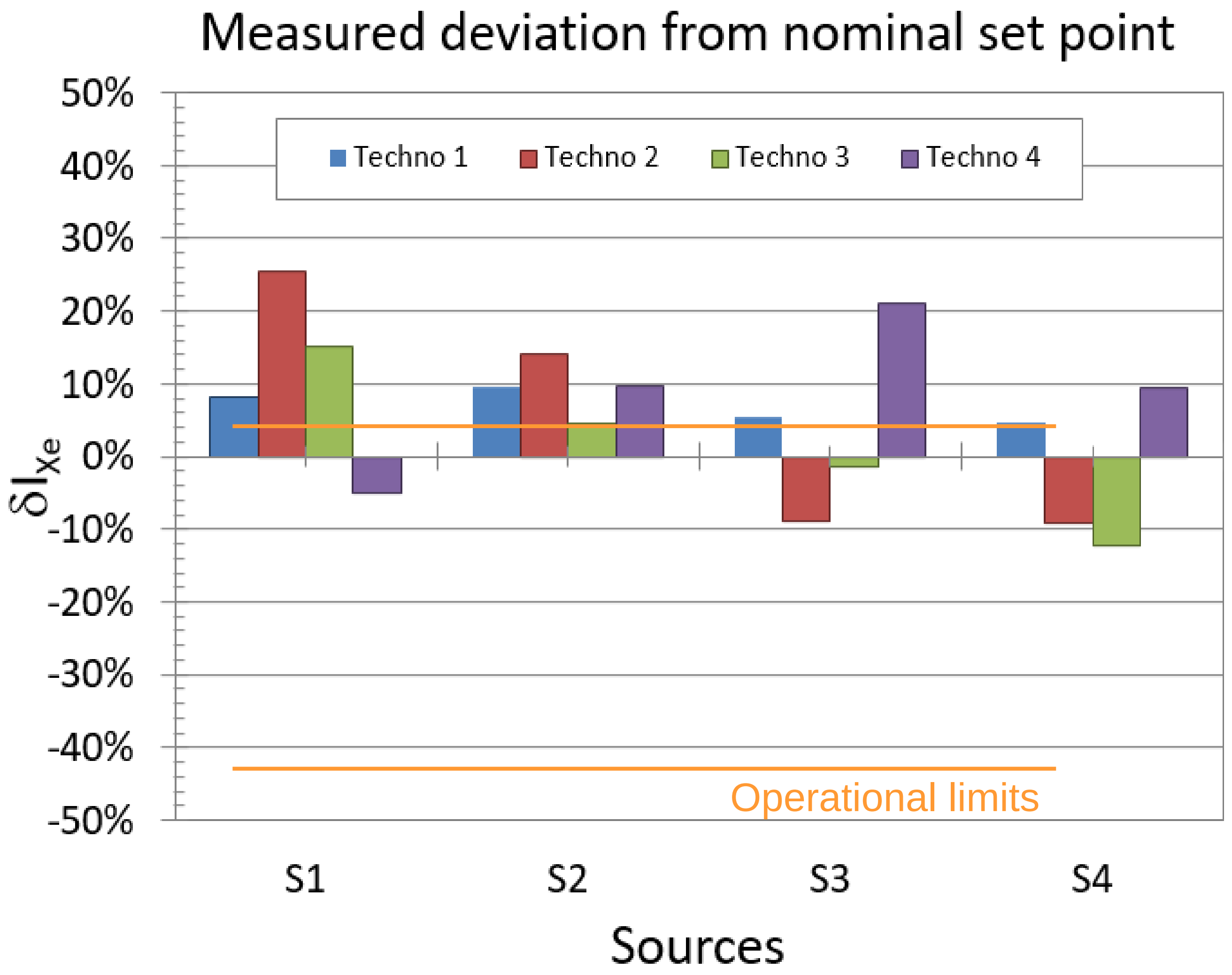
- Actual set points of the sources within operational limits for at least 4 designs of 4J technology
- → Robust design methodology (simulations)
- → Robust manufacturing process



OTHER JUNCTIONS & CHALLLENGES

SWITCHING BETWEEN 4J & 3J

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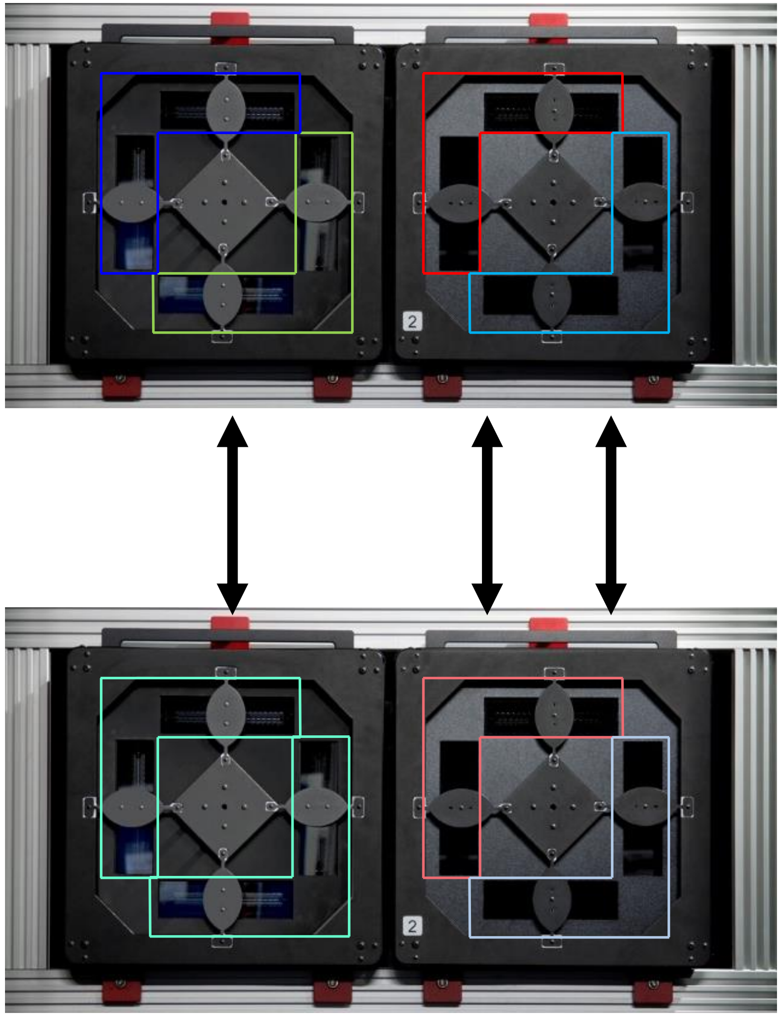
Simulation environment is the same

The light box geometry is the same

What changes is the filters (20 minutes to change)

Switch software from 4J to 3J mode



4J
4 Sources

3J
3 Sources

5J AND 6J CHALLENGES

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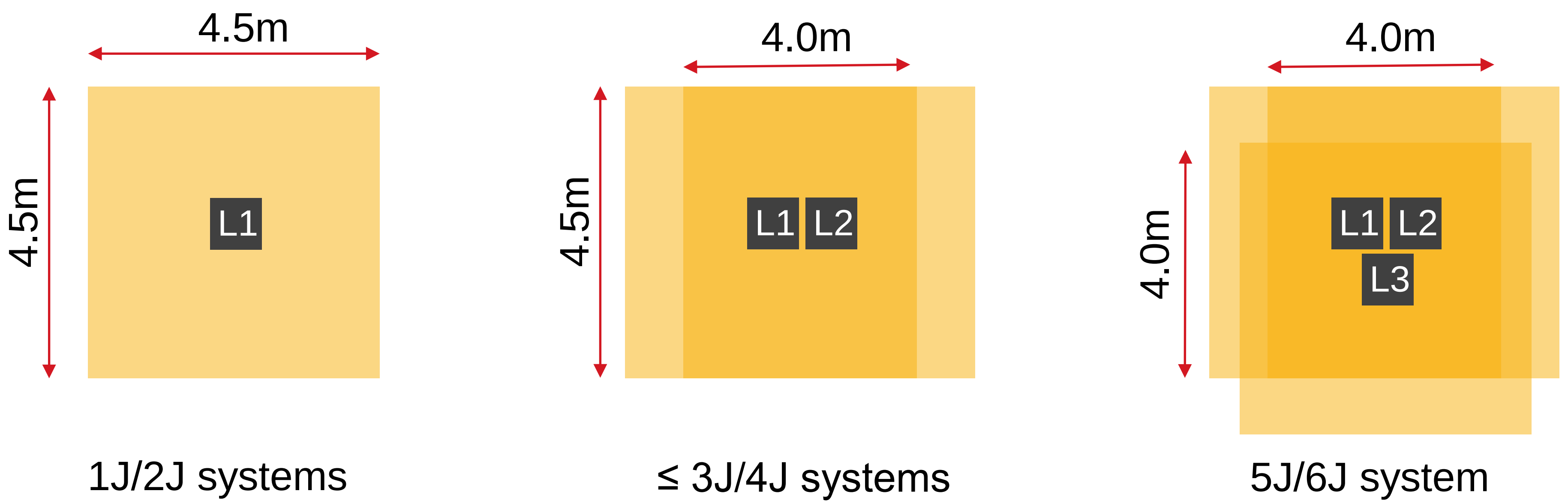
- Adapt simulation environment for 5J & 6J
- Higher number of sources (lamps L1, L2,…) means smaller uniform area
- Higher number of junction means more constraint on filter designs and its angular dependencies incidence on uniform area
- Additional channels needed on e-load (currently limited to 4 channels)



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THANK YOU