

Results from the Second International Module Inter-comparison

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History

1987 to 1989 - PEP '87

Cells, cell in module package and module of identical type
2 day meeting of participants, PTB issued formal report,
1990 presented at 21 IEEE PVSC

Range Si Modules; $I_{sc} = 2-5\%$, $FF = 1-2\%$, $V_{oc} = 2-5\%$

Range a-Si tandem Modules $I_{sc} = 8\%$, $FF = 2.5\%$, $V_{oc} = 1\%$

Final Report analyzed data using 2 standard deviations,

I_{sc} 2-6% for Si, 3-10% for a-Si, FF 1-2%, V_{oc} 0-5%

1992 to 1994 - ASTM E1036 Interlaboratory Test Program

encapsulated cells provided, (Range in $P_{max} \sim 5\%$)

P_{max} 95 % repeatability limit (within laboratory) = 0.7%

P_{max} 95 % reproducibility limit (between laboratory) = 6.7%

Manufacture sponsored intercomparisons -

often only 2 labs & results usually not published.

Goals

Evaluate differences in module IV parameters With Respect to Standard Reference Conditions between National Calibration facilities

ISO-17025 Accredited PV

Qualification or Calibration Labs

Modules Chosen to –

Identify differences in participants scope

Flat-plate, Concentrator

Single-junction, Multi-junction

Crystalline Si, Thin-film

“Typical” Quantum Efficiency supplied by the manufacturer

No reference cell is provided

Include Samples that have had measurement related problems

Bias Rate, Current Matching for Multi-junction,

Sensitivity to Spatial Nonuniformity, Tracking for concentrator

AstroPower
S/N#200205740248
7/30/2002

The Sample Set - crystalline Si

mono-Si

multi-Si

720 kWh m^{-2} of sunlight prior to circulation
No significant change in modules during intercomparison
except ~3% for amorphous Si

Siemens Solar
S/N#460100586

The Sample Set - CdTe & CIGS

BP Solar S/N# 0815303 8/9/2002

CdTe

Cu(Ga,In)(S,Se)

Siemens Solar CIGSS
S/N# 310108817
3/13/2002

BP Solarex
S/N# 1084313
3/13/2002

The Sample Set - amorphous Si

a-Si/a-Si

USSC S/N#19240
3/13/2002

a-Si/a-Si/a-Si:Ge

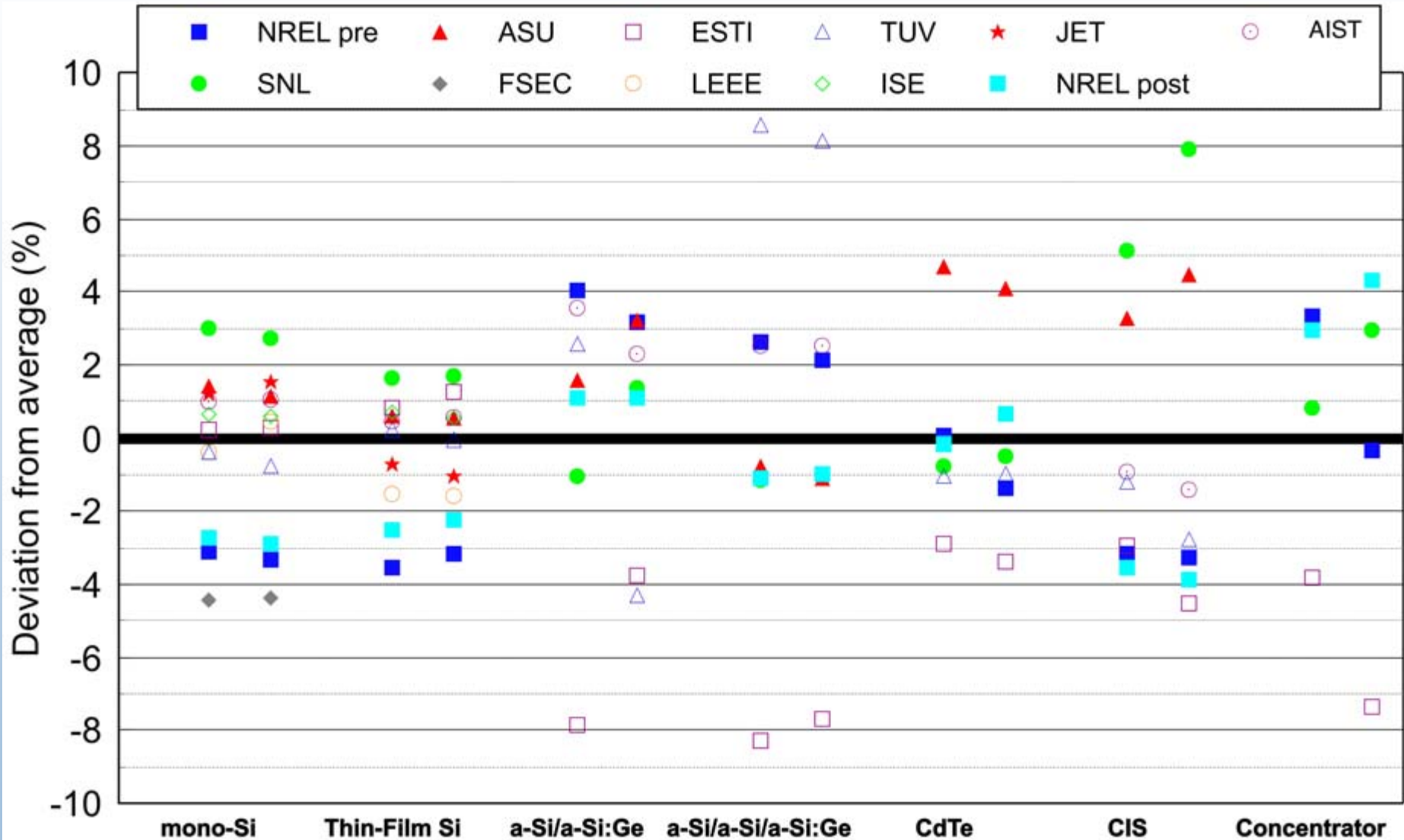
The Sample Set - PEP '87 Concentrator



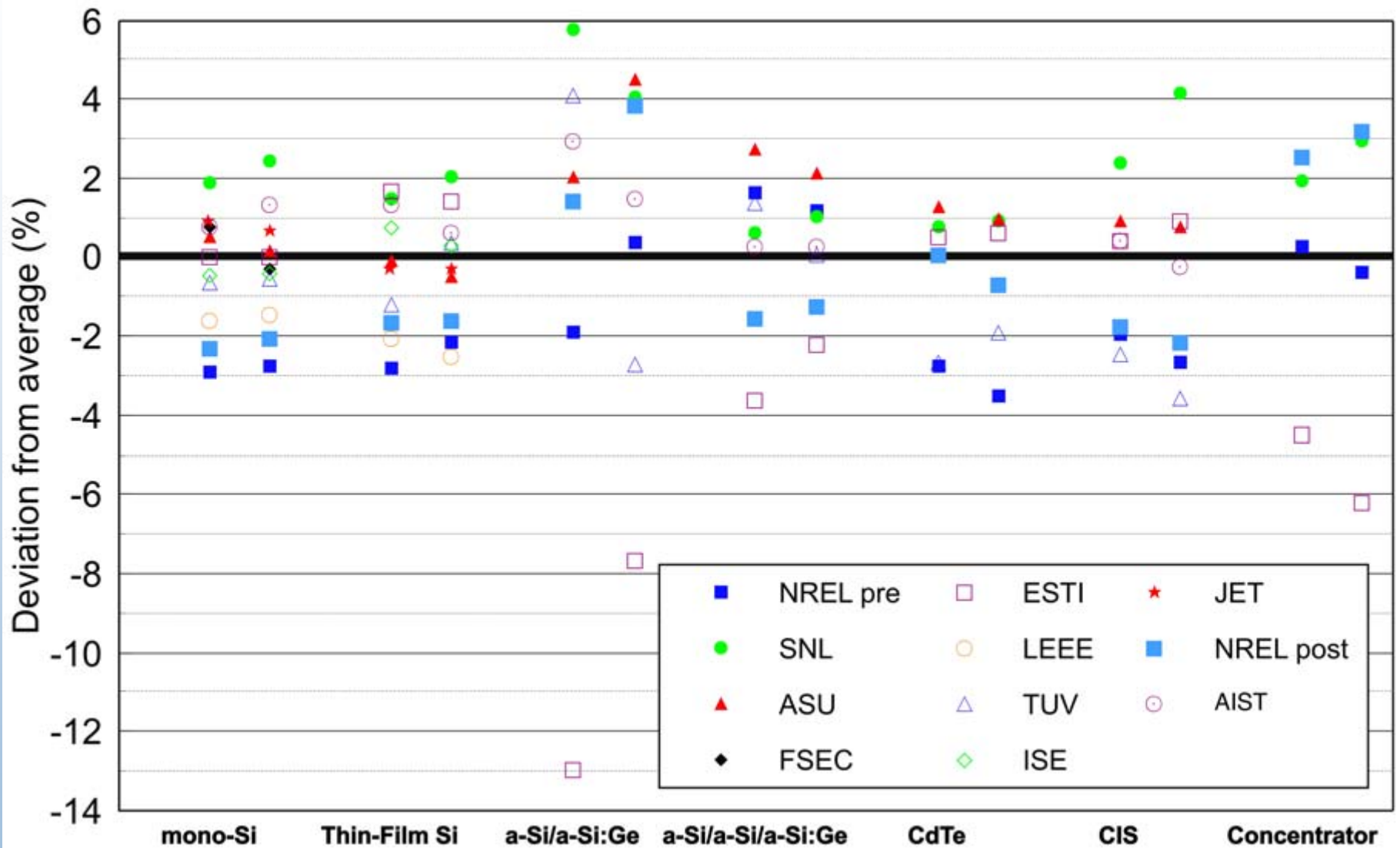
GaAs

**Varian Research Center
1000X Concentrator Module
PTEL#1152
10/8/2002**

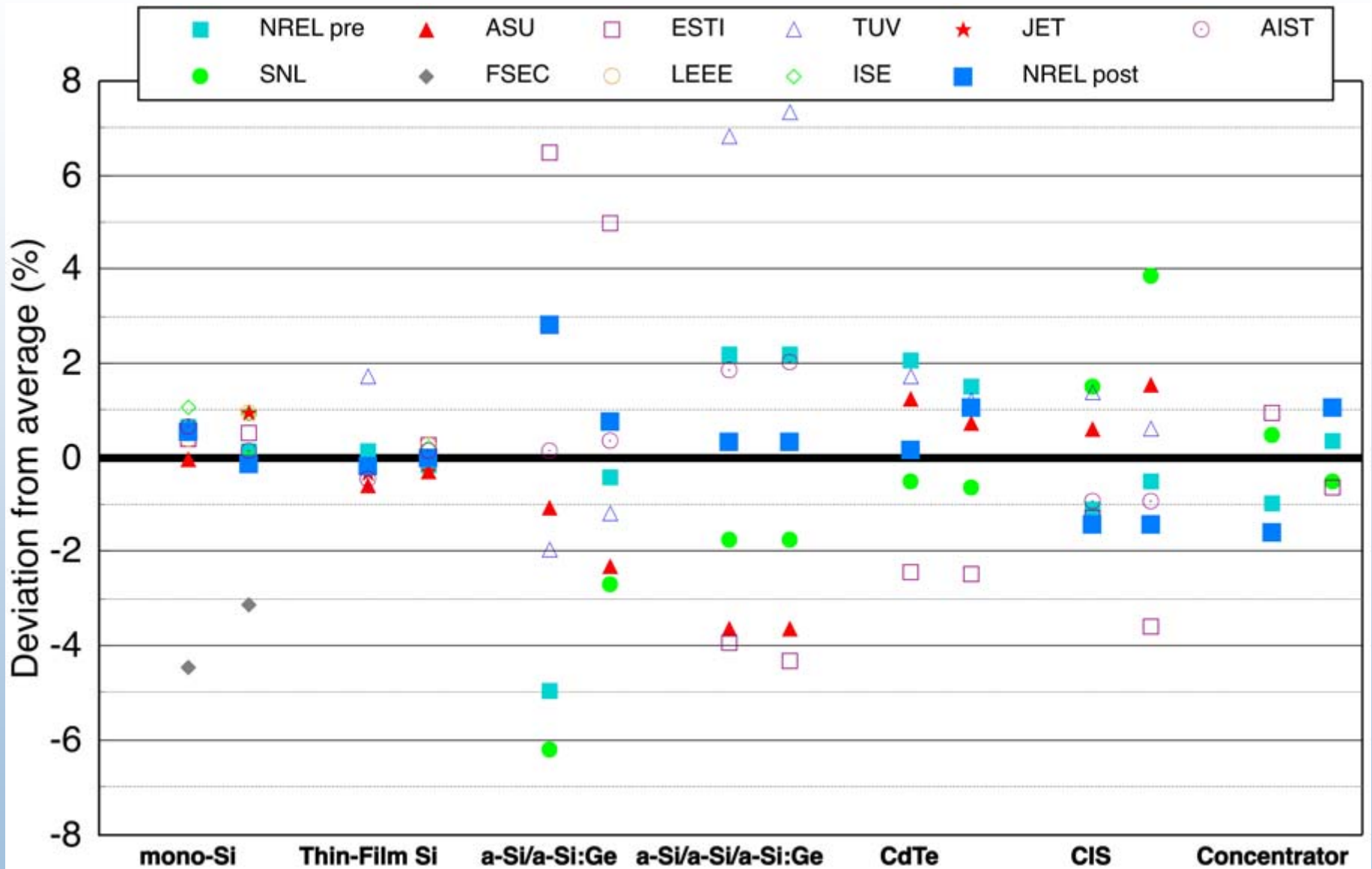
Results - P_{max} @ 25 C, 1000 Wm^{-2} , IEC Global Reference spectrum



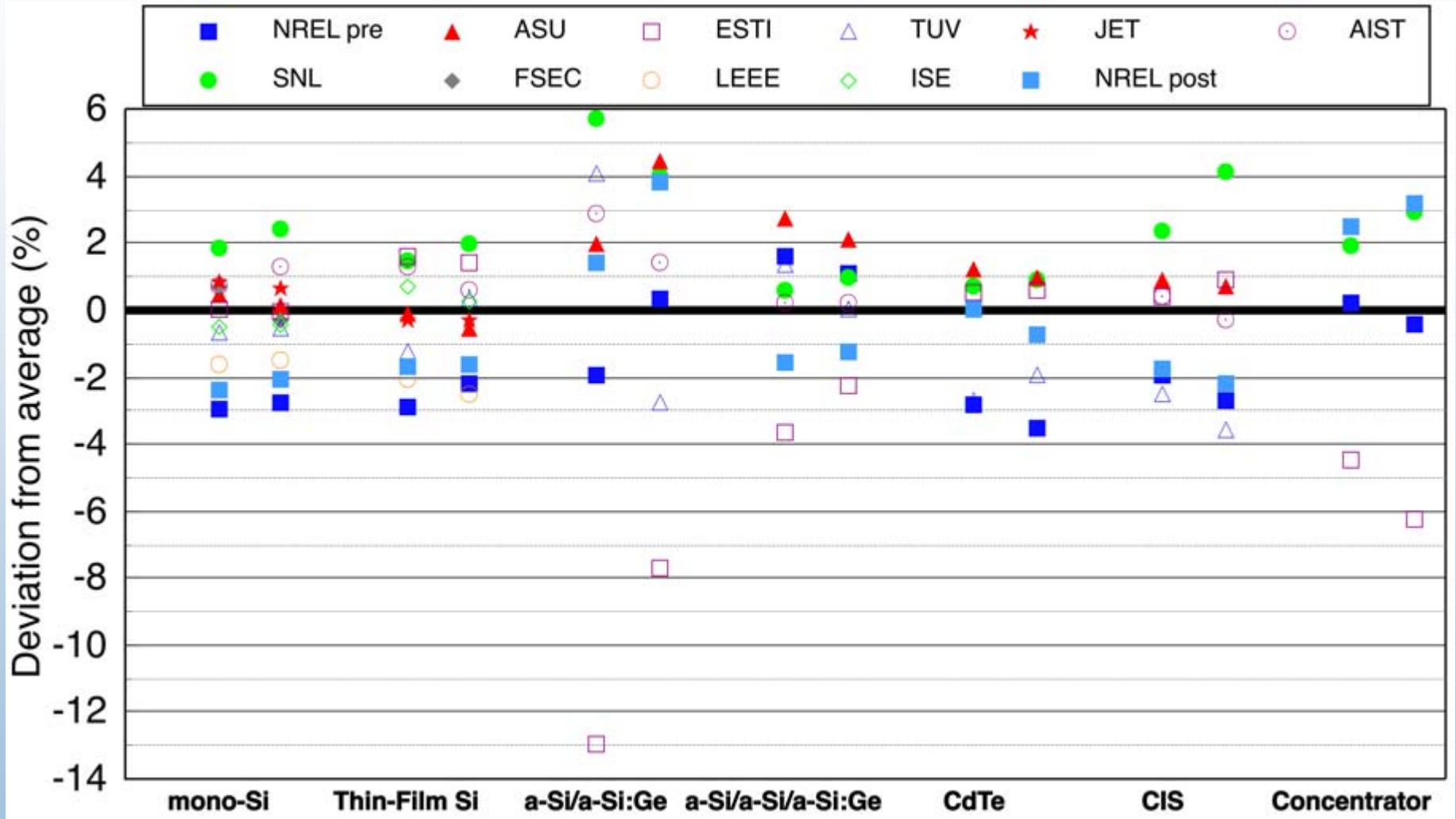
Results - I_{sc}



Results - Fill Factor



Results - Voc



Summary

- Range in I_{sc} for Si 5%, CIS 5 & 8%, CdTe 4%,
Multijunction range 4 to 19% depending on module.
Not having the luxury of a matched reference cell,
Representative cell, or the Measured Module spectral
responsivity may be the cause of larger differences
than previous module intercomparisons.
- Range in P_{max} for Si 6 & 7%, CIS or CdTe 8%,
Multijunction range 7 to 17% depending on module.
- Range in V_{oc} for Si 4 to 5%. About an 8 C temperature
range would be required to account for a 5% V_{oc}
difference.
- Several participants didn't measure concentrator or thin-
film modules because they were outside their scope.