U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

DOE Solar Energy Technologies Program Peer Review

Cell and Module Performance

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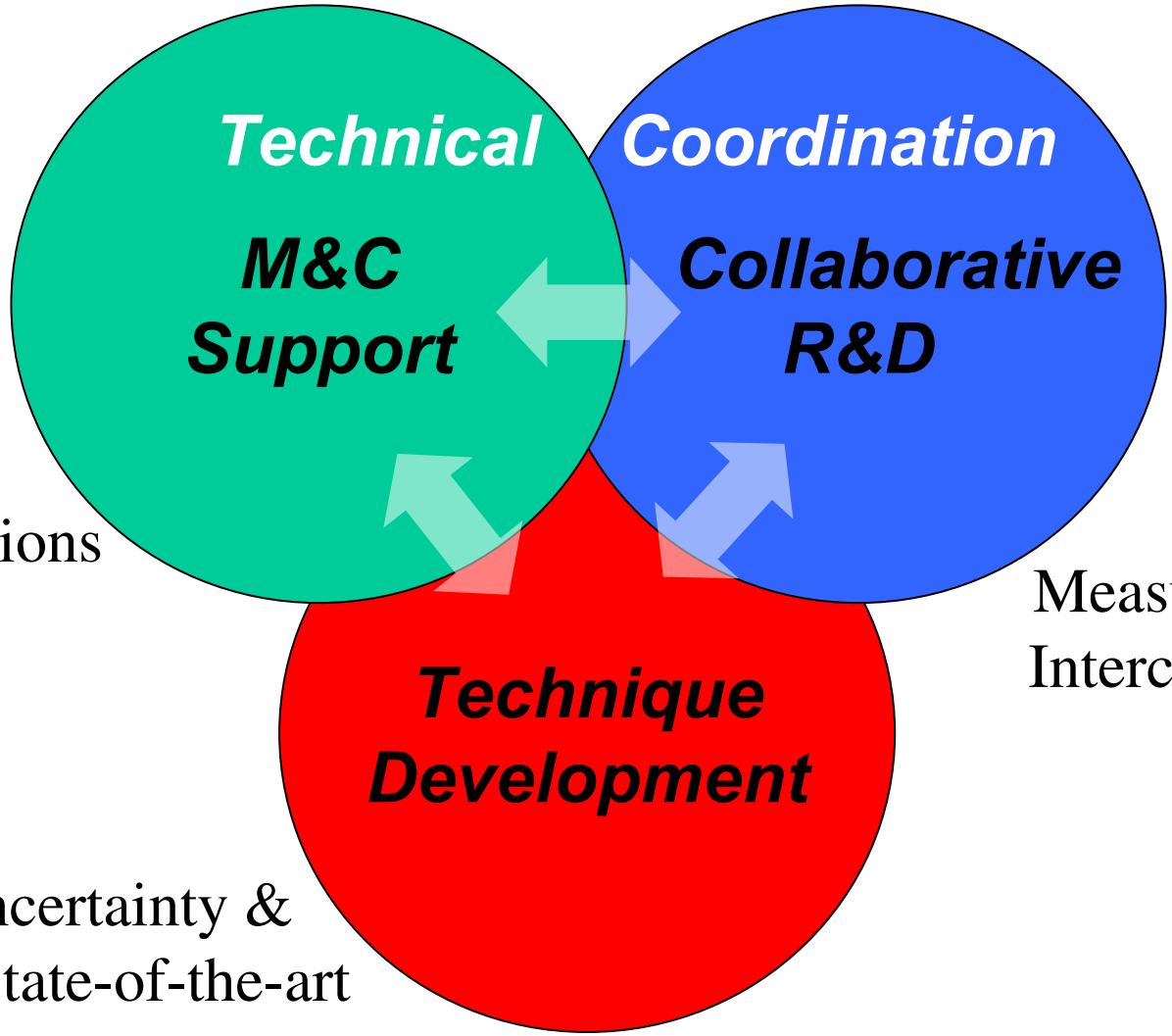
NREL

Denver, Colorado

April 17-19, 2007

Customer Support



PV Calibrations

Specialized Measurements & Intercomparisons

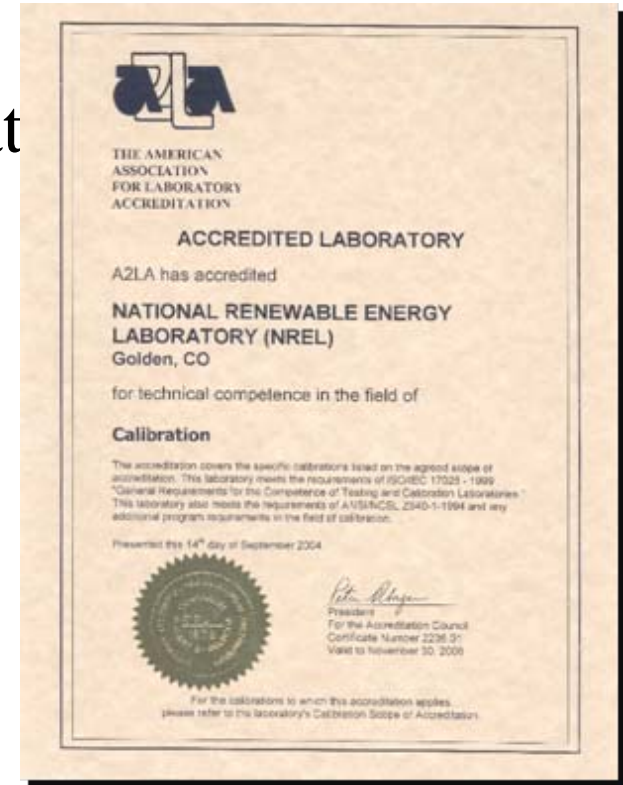
Reduce Uncertainty & Advance State-of-the-art

Overview

- Provide EERE with accurate and traceable calibrations for a technology independent assessment of photovoltaic cell and module performance milestones
- Prevent community from being inundated with unverified claims of "breakthroughs"
- Transfer PV performance measurement technology to the PV community to improve the quality of measurements, research and product
- Standardize performance assessment metrics through active participation in IEC and ASTM standards development

Overview

- Improve the state-of-the art in performance assessment measurements through ongoing technique development and comparison of proposed assessment methods
- Provide calibration traceability path
  for manufacturers, module qualificat
  and module certification labs
- Scope of ISO 17025 Accreditation
  - Primary reference cells
  - Secondary reference cells
  - Secondary Modules


THE AMERICAN
ASSOCIATION
FOR LABORATORY
ACCREDITATION

ACCREDITED LABORATORY

A2LA has accredited

NATIONAL RENEWABLE ENERGY
LABORATORY (NREL)
Golden, CO

for technical competence in the field of

Calibration

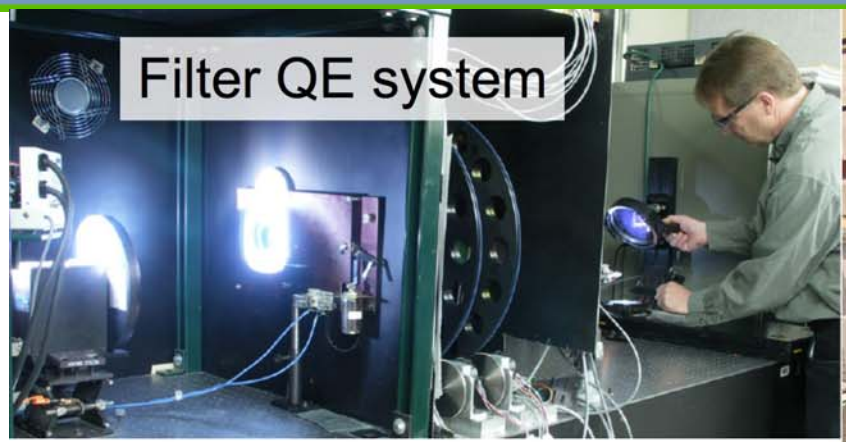
The accreditation covers the specific calibrations listed on the agreed scope of accreditation. This laboratory meets the requirements of ISO/IEC 17025 - 1999 "General Requirements for the Competence of Testing and Calibration Laboratories." This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration.

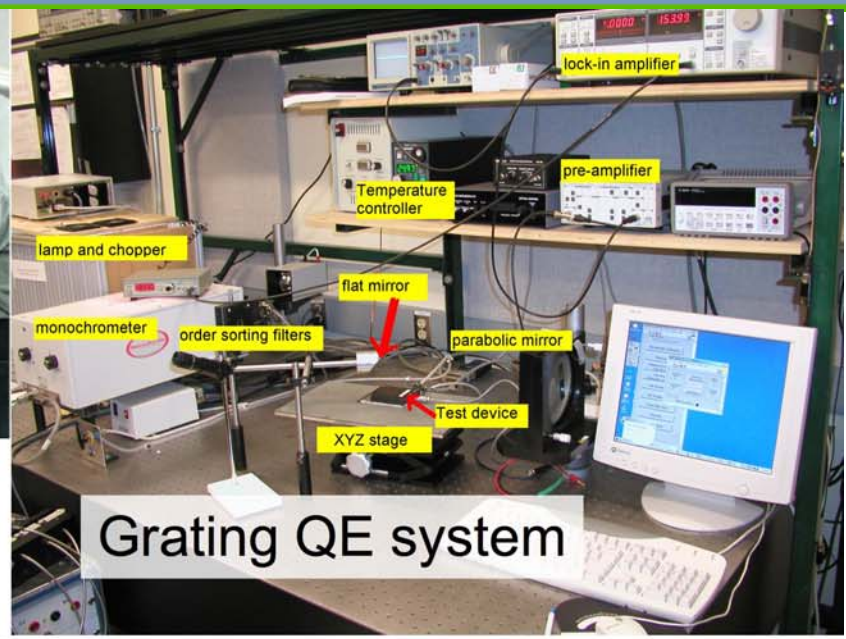
Presented this 14th day of September 2004

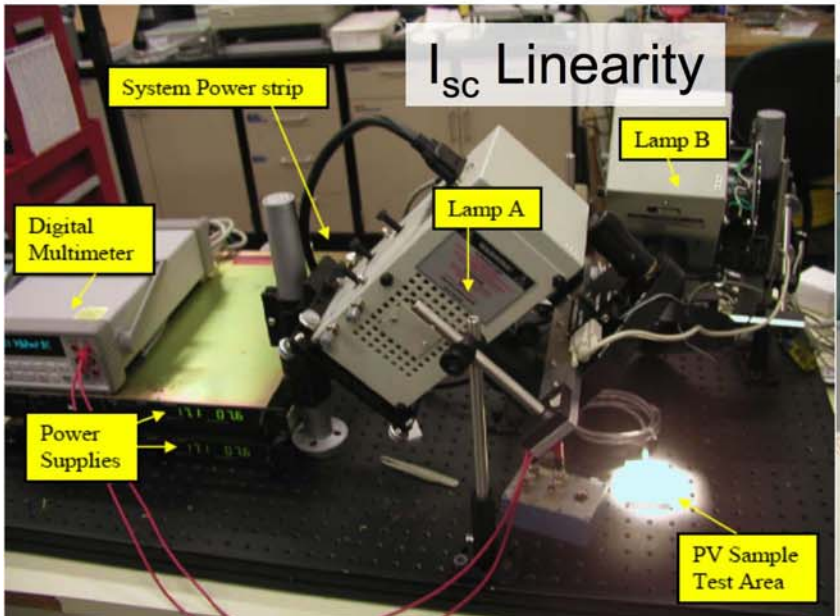
President
For the Accreditation Council
Certificate Number 2236.01
Valid to November 30, 2006

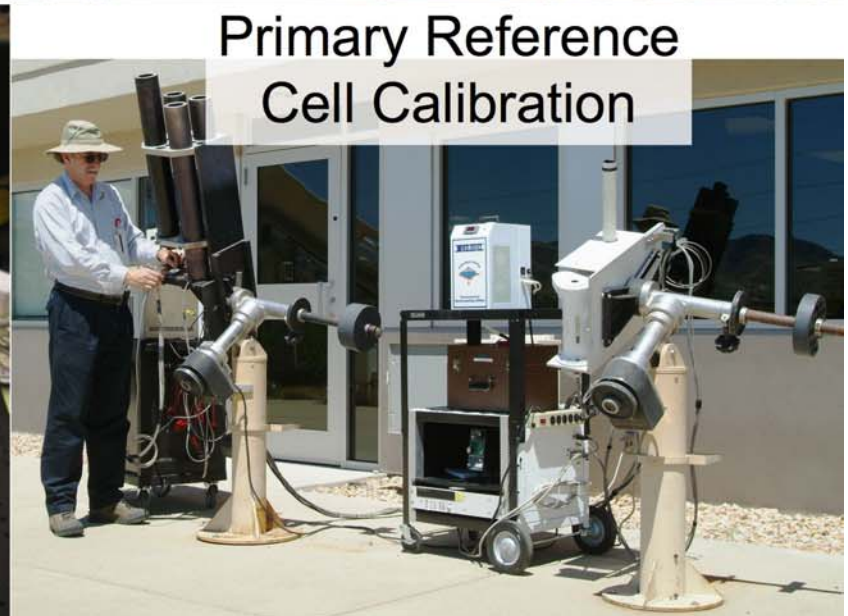
For the calibrations to which this accreditation applies, please refer to this laboratory's Calibration Scope of Accreditation.

Summary of Capabilities

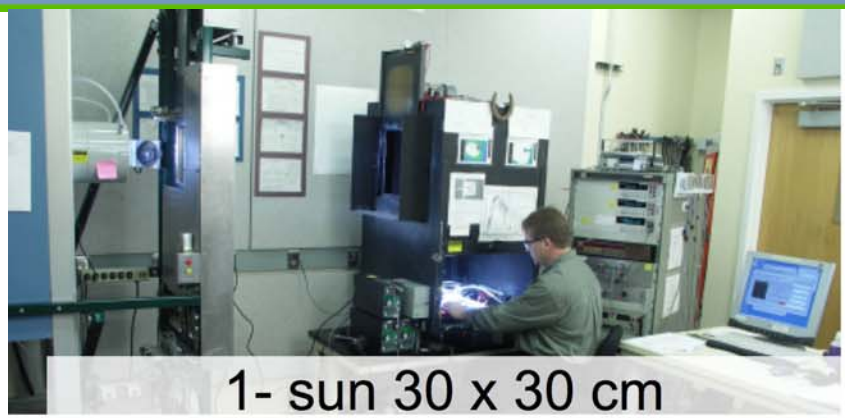






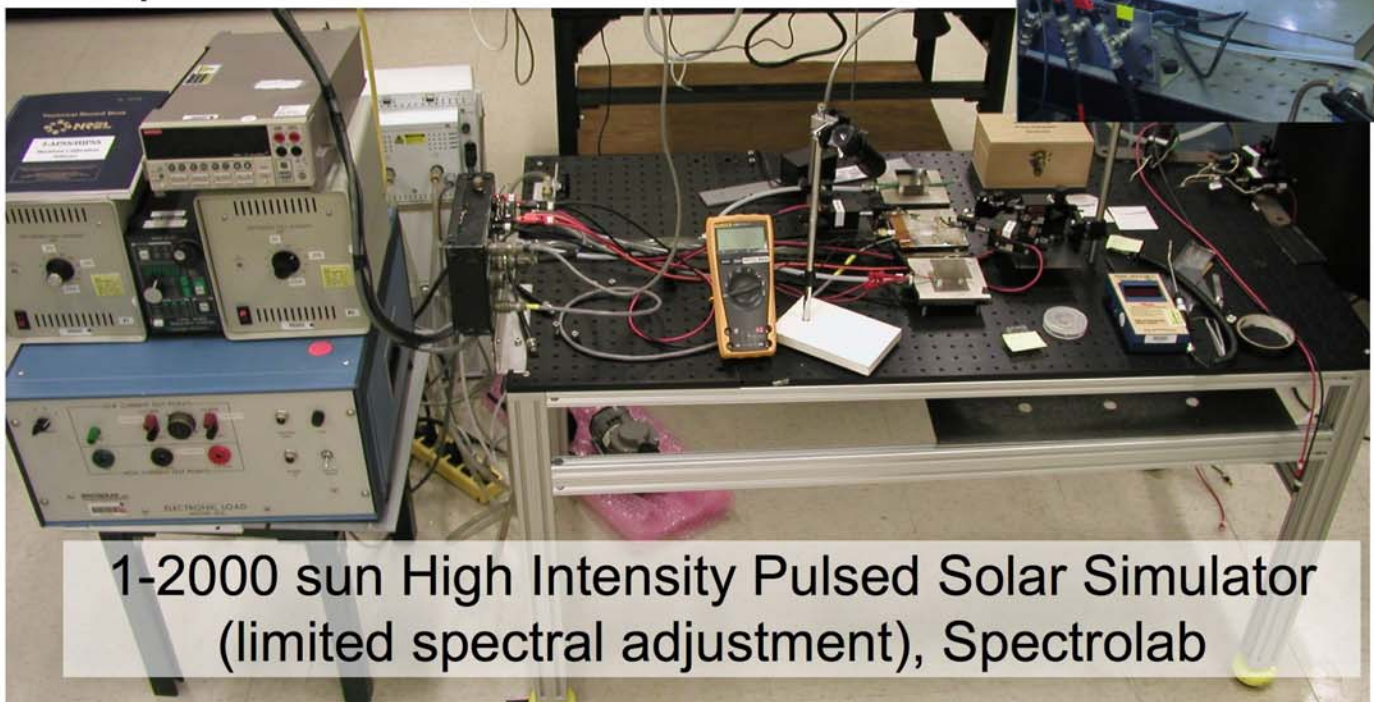


Summary of Capabilities



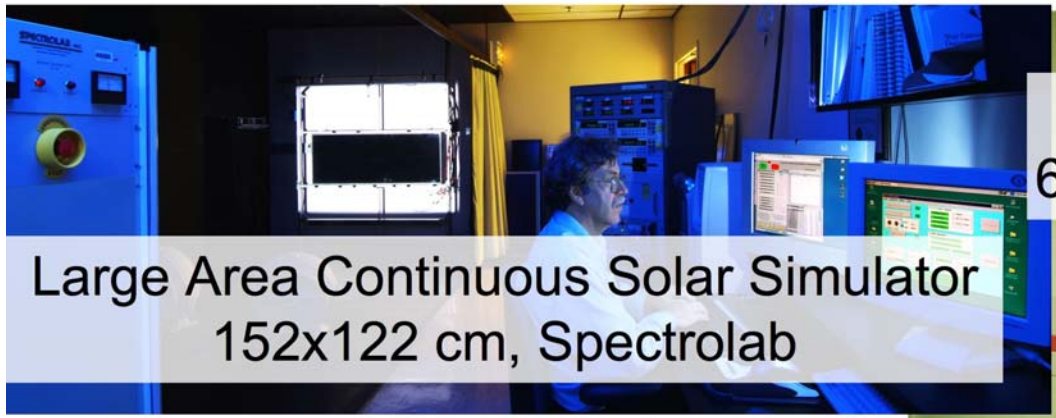
1- sun 30 x 30 cm
(limited spectral adjustment)
Spectrolab X25

1-200 sun Continuous concentrator, 1kW Xe

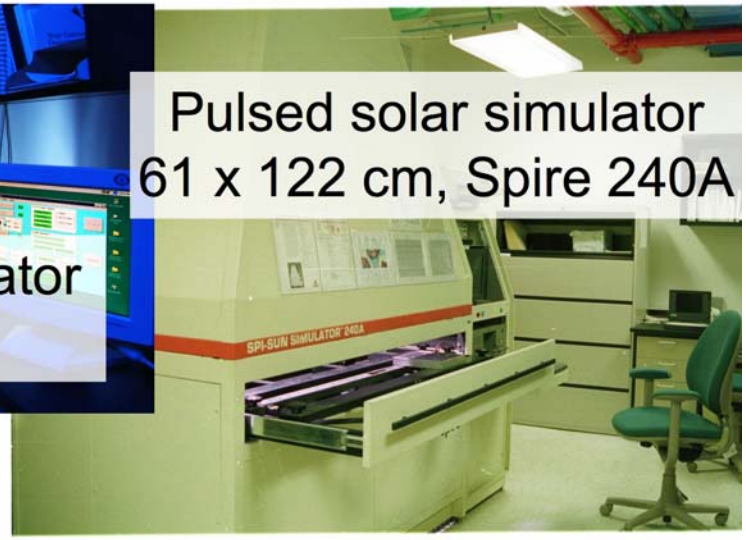


1-2000 sun High Intensity Pulsed Solar Simulator
(limited spectral adjustment), Spectrolab

Summary of Capabilities



Large Area Continuous Solar Simulator
152x122 cm, Spectrolab



Pulsed solar simulator
61 x 122 cm, Spire 240A

Concentrator Module test bed

Outdoor Module test bed

Summary of Service Support

Characterization Support Measurements

October 1, 2005 to January 1, 2007

- 151 Cell and module ISO calibration certificates
- 4912 cell calibrations on 2528 samples
- 2433 module calibrations on 1610 modules
- 44,467 concentrator IV curves on 7 different concentrator cells and prototype modules.
- Samples were measured from 176 organizations

Summary of Activities

- PV performance measurement technology transferred to PV community through phone calls, emails, and visits to NREL on PV performance, hardware, procedures, standards and calibration issues
- Authored or co-authored 16 conference and journal publications
- Maintain NREL IV and QE user facility

Budget History

October 1, 2005 to January 1, 2007

Project Task(s)	Total Value
PVA6.3401	1,268,000
PVB6.6134	142,000
PVB7.7401	189,934
PVA7.3401	56,140
Grand Total	1,656,074

service contracts, equipment repair & calibration part of technical management and are not included. FY07 task list amount available on continuing resolution

Accomplishments

- ASTM and IEC standards to determine linearity under revision based upon new technique developed by group
- First concentrator performance consensus standard shepherded by member of group adopted (ASTM E2527)
- ISO 17025 Accreditation maintained after comprehensive 2-day bi-annual audit.
- Consolidated concentrator facility from 2 buildings to a single lab.
- Moved user QE facility to S&TF and brought to operational status

Schedule of Major Events/Milestones

- *FY06 key milestone – "Complete capability to evaluate multiple-junction concentrator cells and modules to 1000x with lowest practical uncertainty"*- Hardware and software modified to allow spectral adjustment, and relaxation of linearity assumption. Stage-gate analysis determined a spectrally adjustable solar simulator would be needed to reduce uncertainty of near current matched high efficiency multi-junction PV technologies.

Schedule of Major Events/Milestones

- Planned FY07 capital equipment for spectrally adjustable concentrator cell solar simulator, spectrally adjustable 1-sun simulator, and pulsed module simulator will require a substantial effort to bring the units calibration procedures, hardware and software up to the groups quality system.
- It is expected that the scope of ISO 17025 calibrations will be expanded to include measurements on the new module simulator.
- Spectrally adjustable simulators will allow accurate energy calculations under varying spectra, total irradiance and temperature. Currently the SAM model does not properly account for spectral effects or multi-junctions. These simulators will allow quantitative assessment of the energy difference with and without spectral effects accounted for. ▪ ▪

Future Directions

- Continue to support the PV community with accurate and traceable PV performance calibrations.
- Continue to support energy ratings R&D. There is no consensus standard for energy rating. The EERE is basing the levelized cost of energy on energy models validated for single junction flat-plate Si technologies and is applying it to all conceivable PV technologies.
- Continue to transfer PV performance measurement technology to the community.

Future Directions

- Purchase Spectrally adjustable concentrator simulator- Reduce Multijunction Uncertainty, Allow temperature and spectral effects *versus* concentration to be quantified for various climates.
- Purchase Spectrally Adjustable 1-Sun simulator - Reduce Uncertainty, Allow temperature and spectral effects *versus* irradiance to be quantified for various climates.
- Purchase Large - Area Pulsed Module Solar Simulator - Reduce Uncertainty, Allow temperature and Irradiance coefficients to be measured on current module designs.
- Increase staff by 2 to support industries increased characterization needs.