Charles University, Prague

Laser Tests of Silicon Strip Sensors

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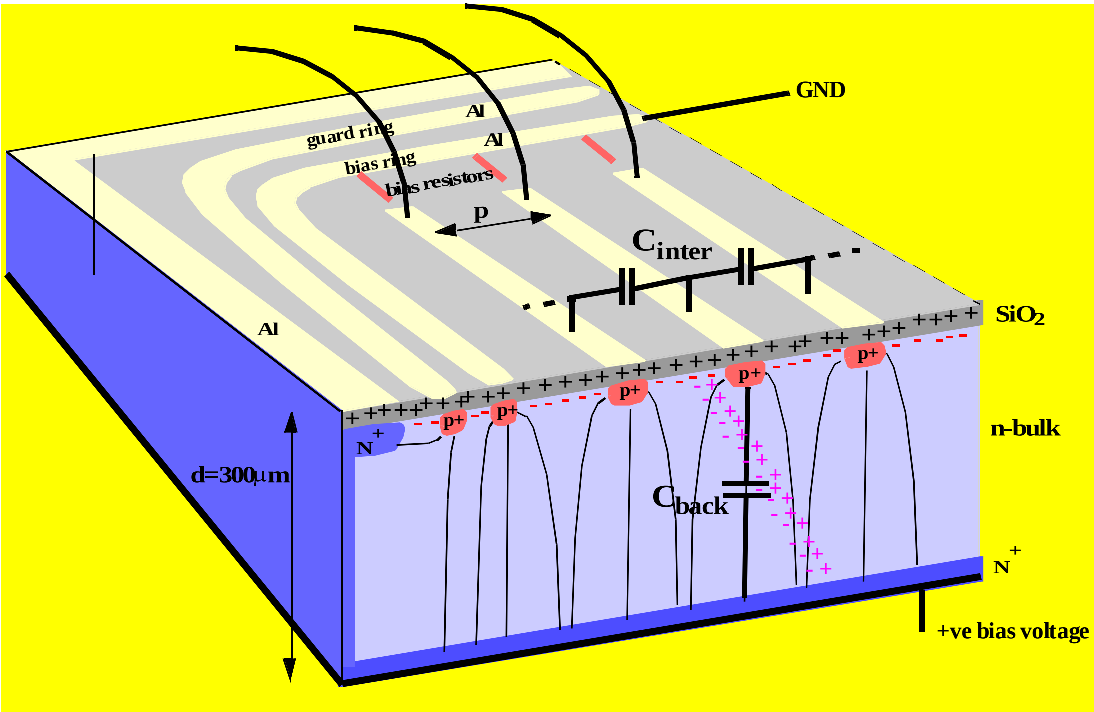
Cooperation of IFIC, Valencia and Charles University, Prague

SEMICONDUCTOR DETECTOR

- Silicon, 280 μm, V_D < 100 V, max. 500 V
- 768 aluminum strips
- I_L < 6 μA@150 V
- 99% efficiency
- typical signal 25000 electrons



STRIP DETECTORS: TESTING METHODS

Tests on beam <-> beta tests <-> laser tests

- Tests on beam of high energy particles (beam tests):
  - **Most similar conditions to real experiment**
  - Available only few times in year and complicated organization
  - High coast
- Tests used β particles from radioactive sources:
  - **Lower coast and good availability, used real particles**
  - Wide spectra of energies without their measurement possibility
  - Unknown interaction point between particle and sensor, no space resolution information
- Tests with laser light:
  - **Exact precise space resolution, lower coast, good availability**
  - **Depth penetration setting using different light energy (wavelength)**
  - Complication on absolute efficiency measurement from energy from photon beam

SCHEME OF ARRANGEMENT

Laser: CERN product (Maurice Glaser)

Laser energy of photon: 1.170 eV

Wavelenght of light: 1060 nm

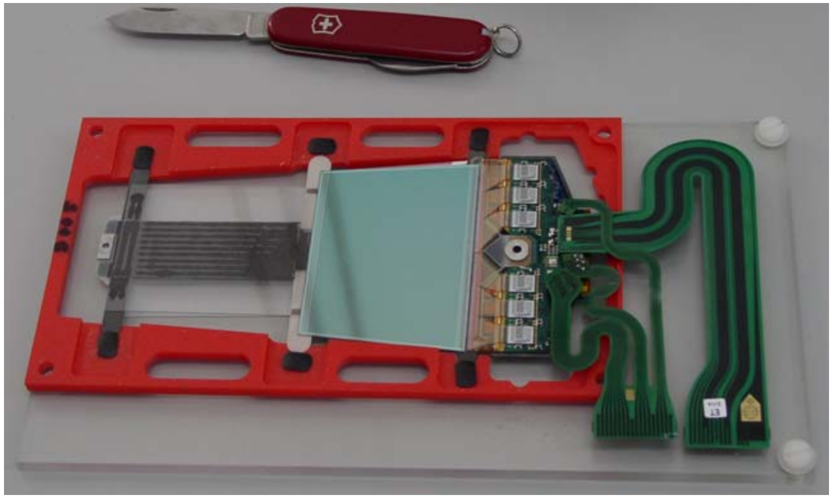
Module: ATLAS SCT end caps

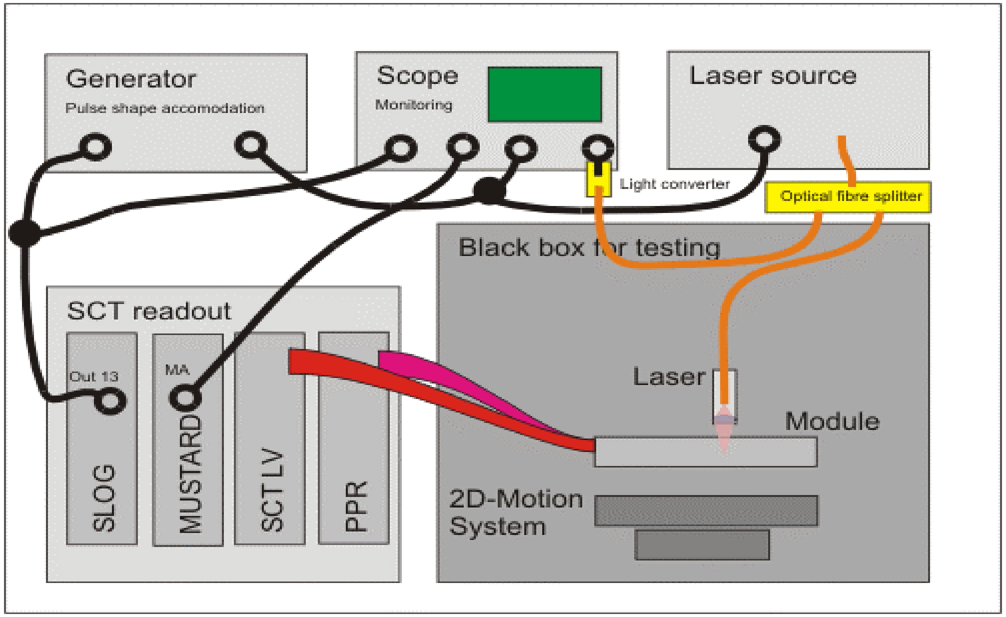
Detector: Hamamatsu & CiS silicon 0.27mm wedge-shaped, single-sided, p-in-n type

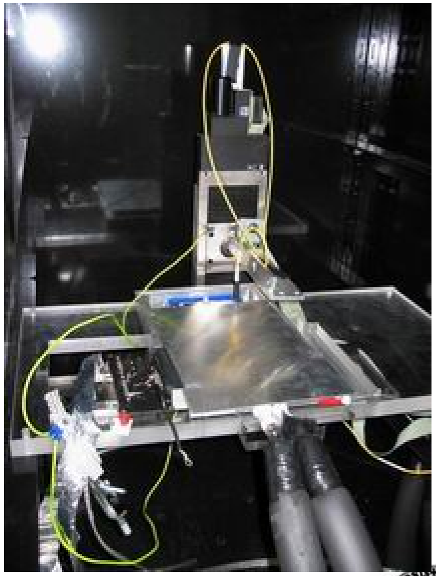
Microstrips: pitch 80μm 2x60mm length

Readout: analogue/digital binary ABCD chips with 128 channels, 12 per module, MUSTARD/SLOG electronics in VME crate, PC, SCTDAQ sw

2D motion system, step <1μm







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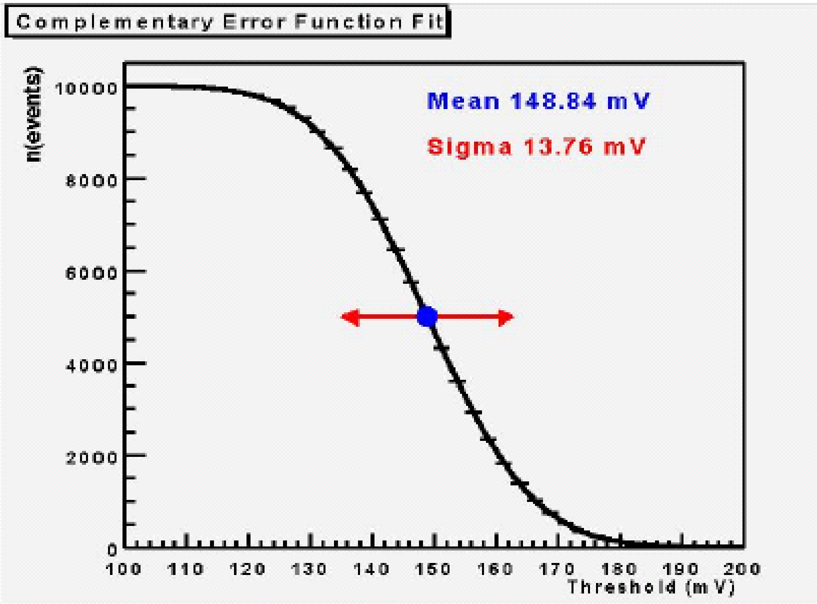
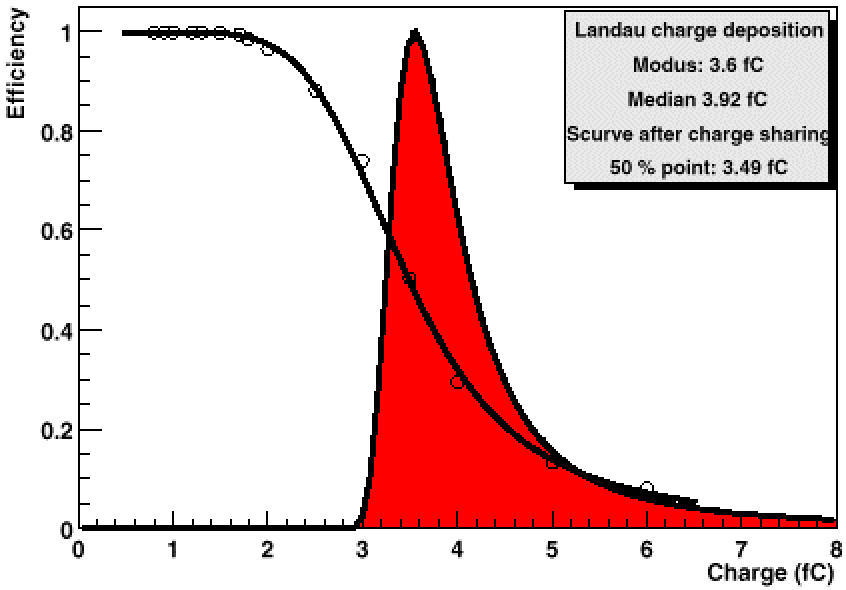
SIGNAL IN BINARY READOUT SYSTEM

Calibration or laser pulse

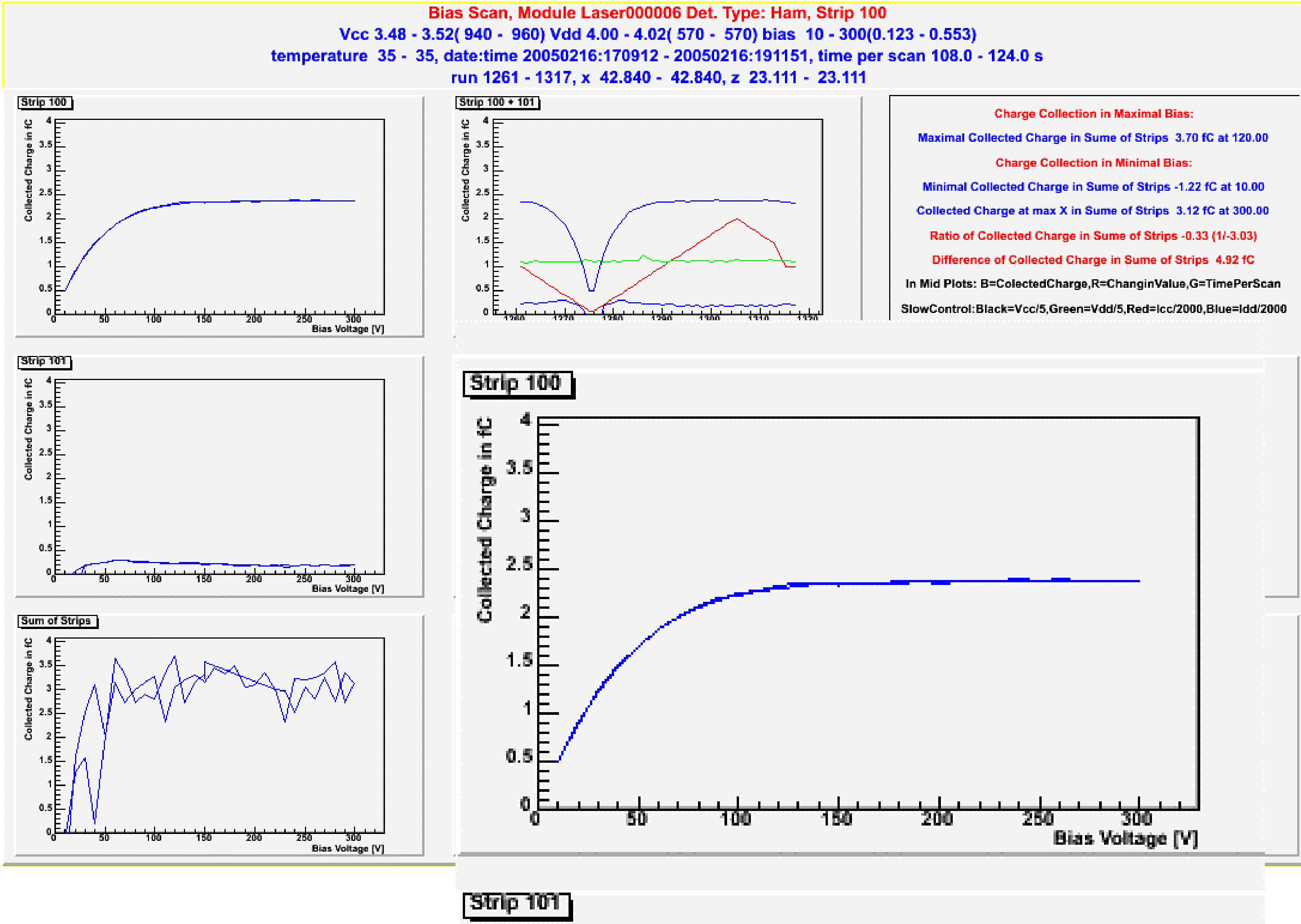


Real MIP signal



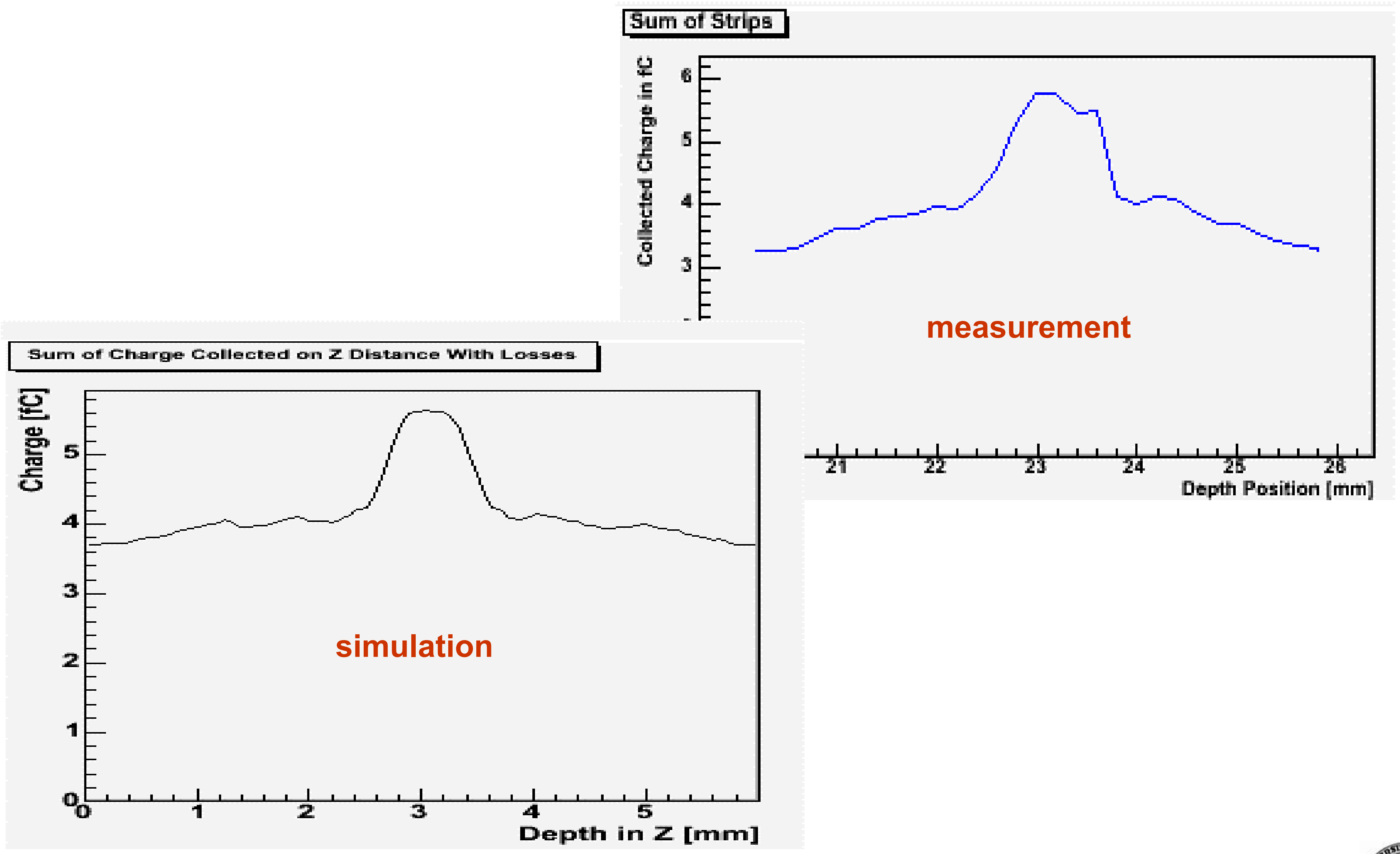
To know properties of input signal needs always threshold scan

BIAS SCAN



Bias Scan, Module Laser000006 Det. Type: Ham, Strip 100
Vcc 3.48 - 3.52(940 - 960) Vdd 4.00 - 4.02(570 - 570) bias 10 - 300(0.123 - 0.553)
temperature 35 - 35, date:time 20050216:170912 - 20050216:191151, time per scan 108.0 - 124.0 s
run 1261 - 1317, x 42.840 - 42.840, z 23.111 - 23.111
Strip 100
Strip 100 + 101
Strip 101
Sum of Strips
Collected Charge in fC
Bias Voltage [V]
Charge Collection in Maximal Bias:
Maximal Collected Charge in Sume of Strips 3.70 fC at 120.00
Charge Collection in Minimal Bias:
Minimal Collected Charge in Sume of Strips -1.22 fC at 10.00
Collected Charge at max X in Sume of Strips 3.12 fC at 300.00
Ratio of Collected Charge in Sume of Strips -0.33 (1/-3.03)
Difference of Collected Charge in Sume of Strips 4.92 fC
In Mid Plots: B=ColectedCharge,R=ChanginValue,G=TimePerScan
SlowControl:Black=Vcc/5,Green=Vdd/5,Red=Icc/2000,Blue=Idd/2000
Strip 100
Collected Charge in fC
Bias Voltage [V]
Strip 101

DEPTH SCAN – MEASUREMENT VS. THEORY (HAMAMATSU)



REFLECTIVITY OF MODULE – THEORY

Module CiS

Chip calibration factor 1.041

Strip: pitch 74 um, width 18 um, reflectance 1.000

Collected charge in focus 12.37 fC, defocus 9.34 fC

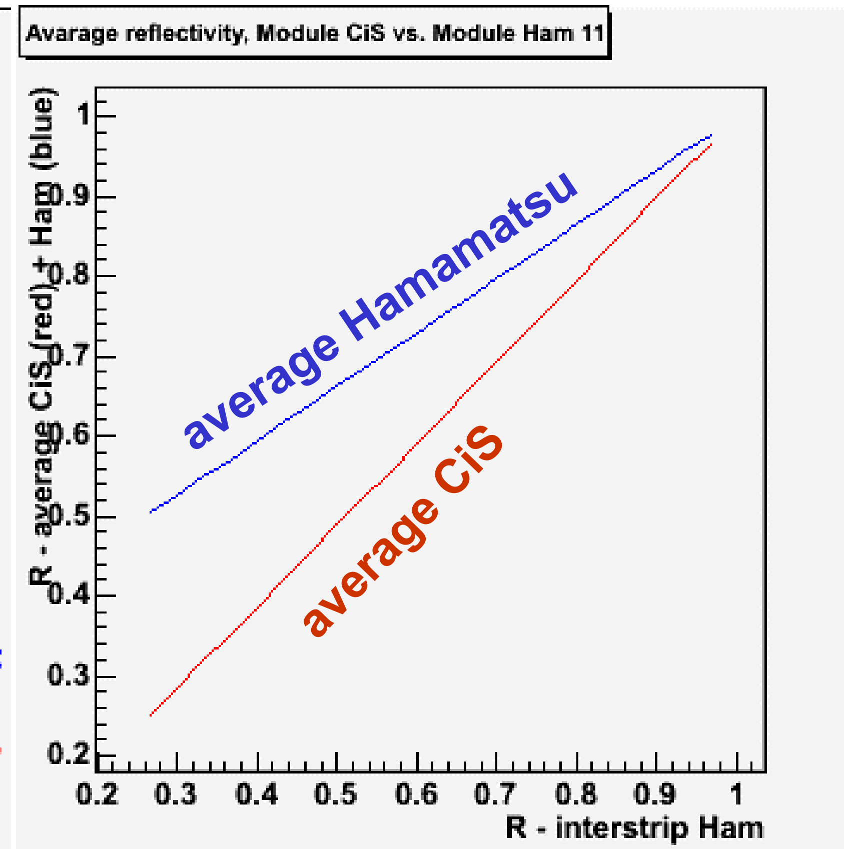
Module Ham

Chip calibration factor 1.026

Strip: pitch 74 um, width 24 um, reflectance 1.000

Collected charge in focus 16.60 fC, defocus 11.22 fC

Ratio of defocus collected charge CiS / Ham = 1.513



Calculation and simulations of differences between two types of modules with including of some factory and experimental values

BETA TESTS FOR CONFIRMATION OF PROPERTIES OF COMPARING MODULES

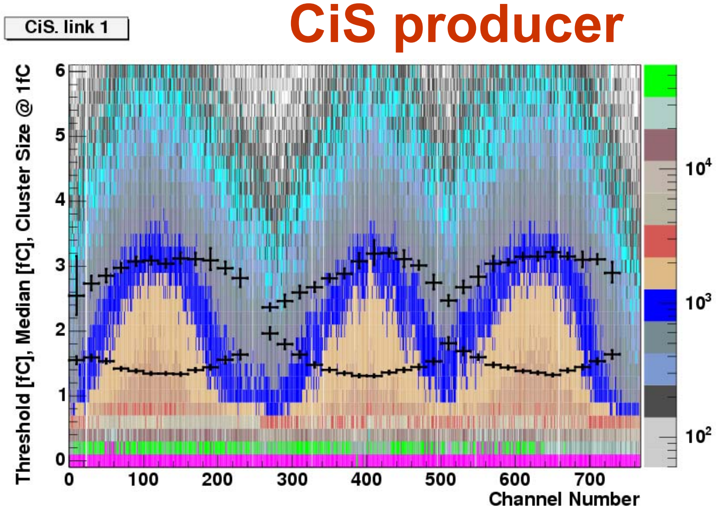
6 scans, 20000 ev./scan + 100k events confirmation

Basic scans full beam error ~ 0.02

	L1 left	L1 spine	right 31,36
Ham	**3,02**	2,91	2,99
CiS	**3,02**	2,88	3,05

Ham L1 right	CiS L1 left
3,03	3,01
3,03	3,02
3,05	3,00
3,03	**3,03**
3,04	3,00

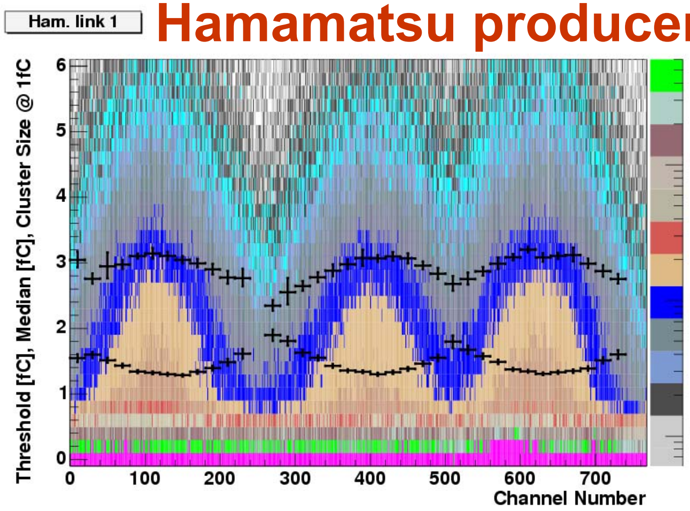
CiS producer



Median Point

Cluster Size

Hamamatsu producer



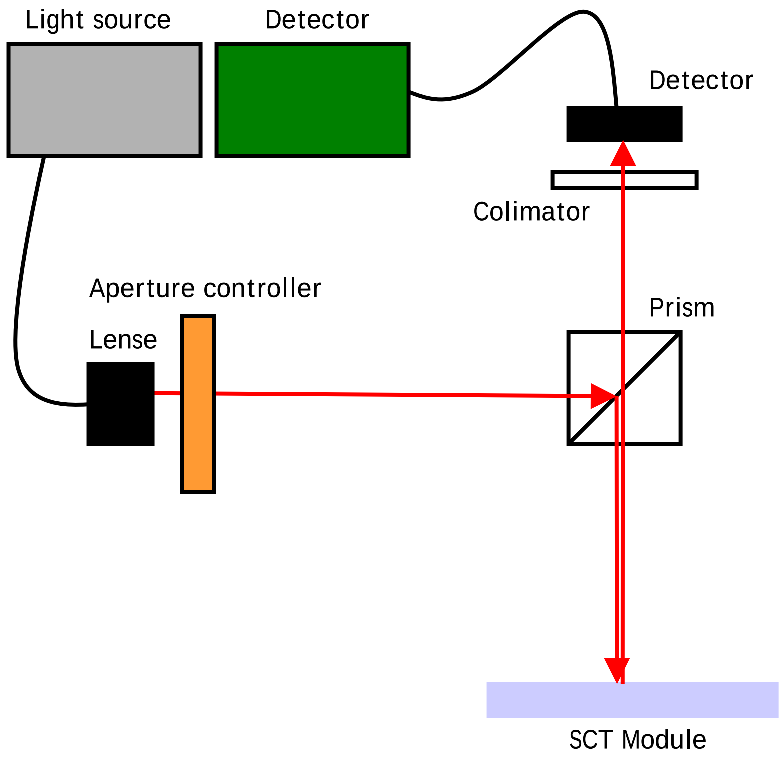
Median Point

Cluster Size

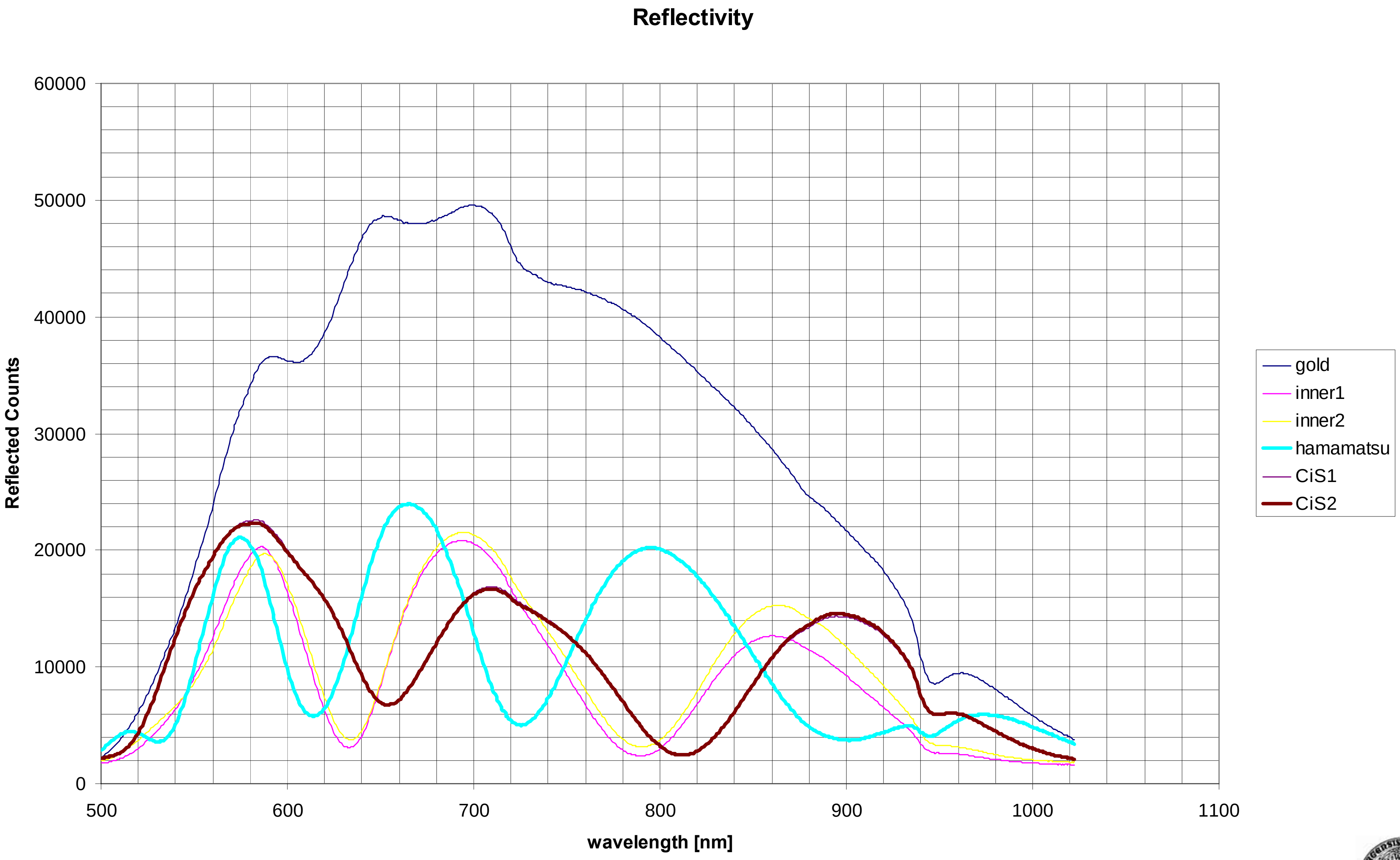
MODULES HAVE THE SAME PROPERTIES OF PARTICLE DETECTING

REFLECTIVITY MEASUREMENT - ARRANGEMENT

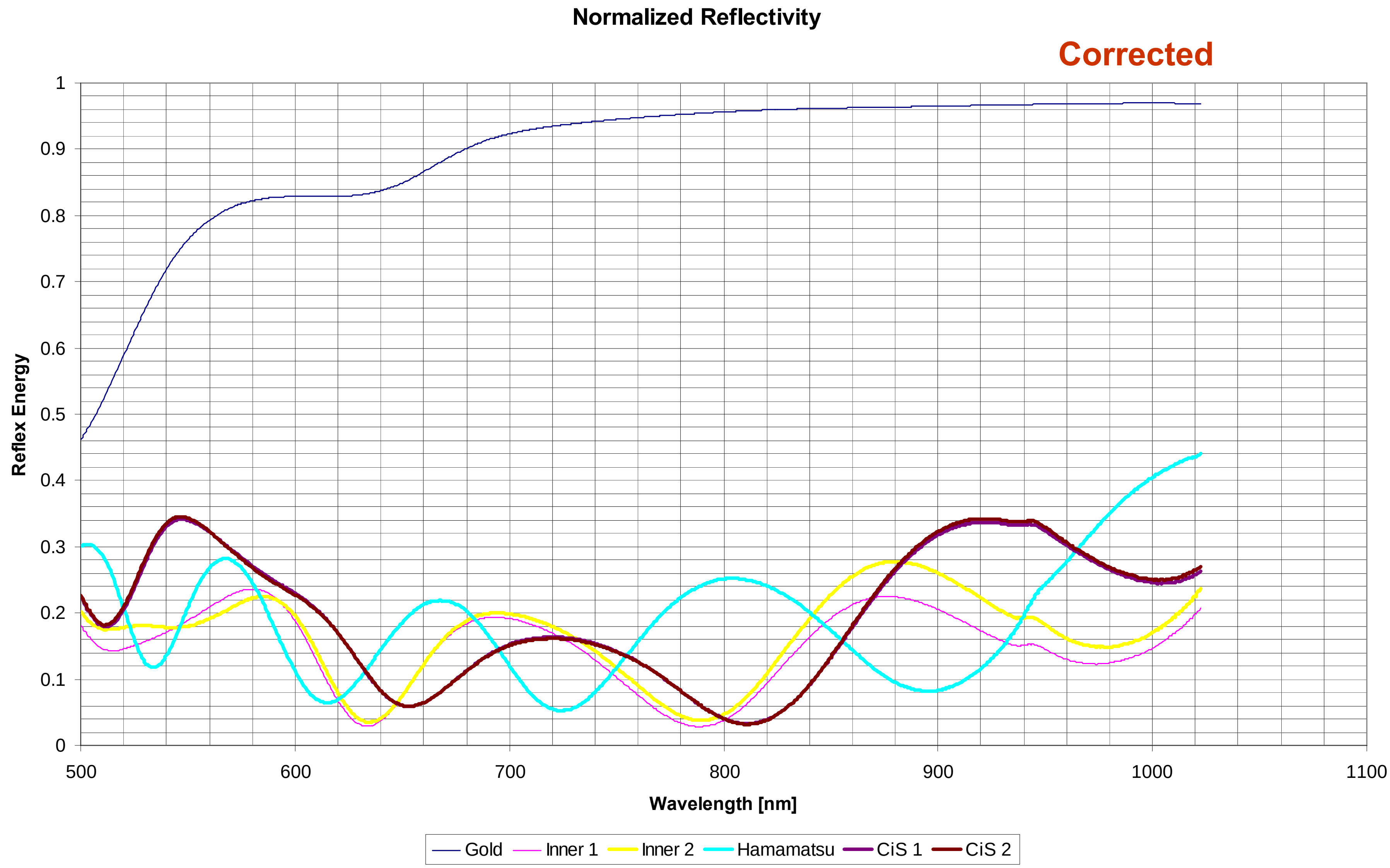
System used:



REFLECTIVITY MEASUREMENT IN URE AVCR, CiS / HAMAMATSU

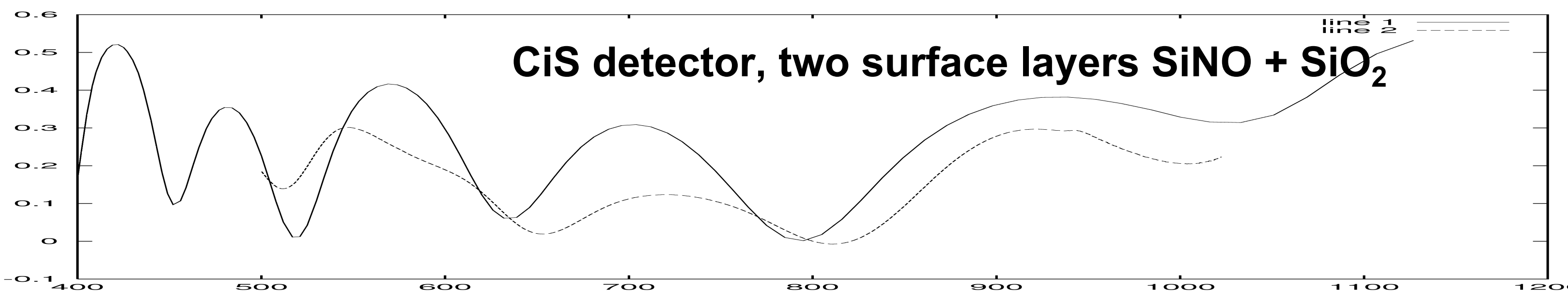


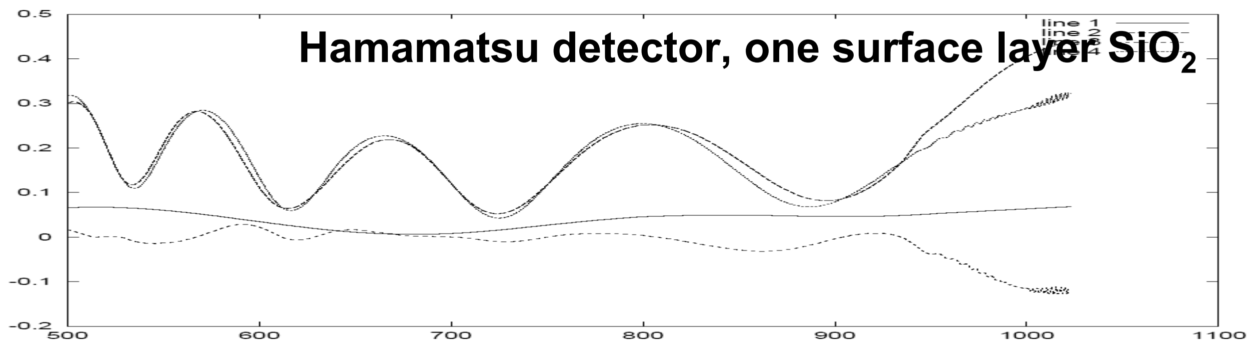
REFLECTIVITY – MEASUREMENT, CiS & HAMAMATSU

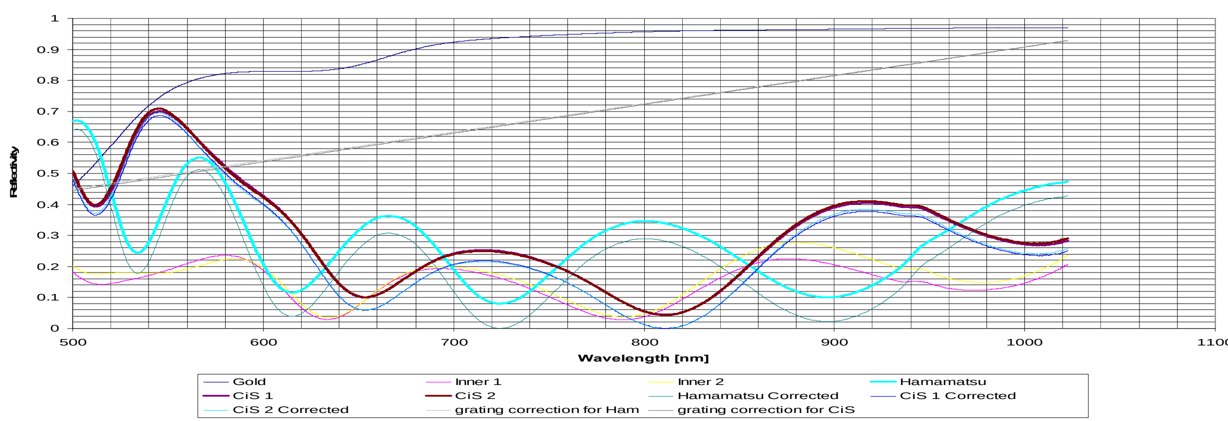


REFLECTIVITY – SIMULATION VS. MEASUREMENT, CiS & HAMAMATSU

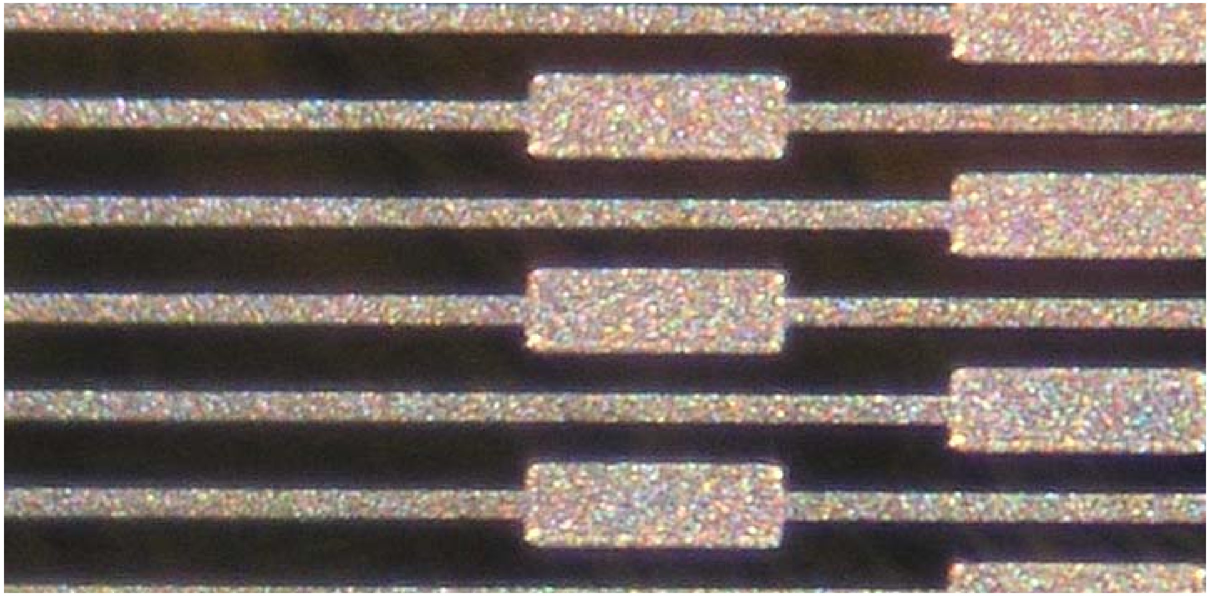
Simulation based on thin layers on detector surface (Pavel Bažant)



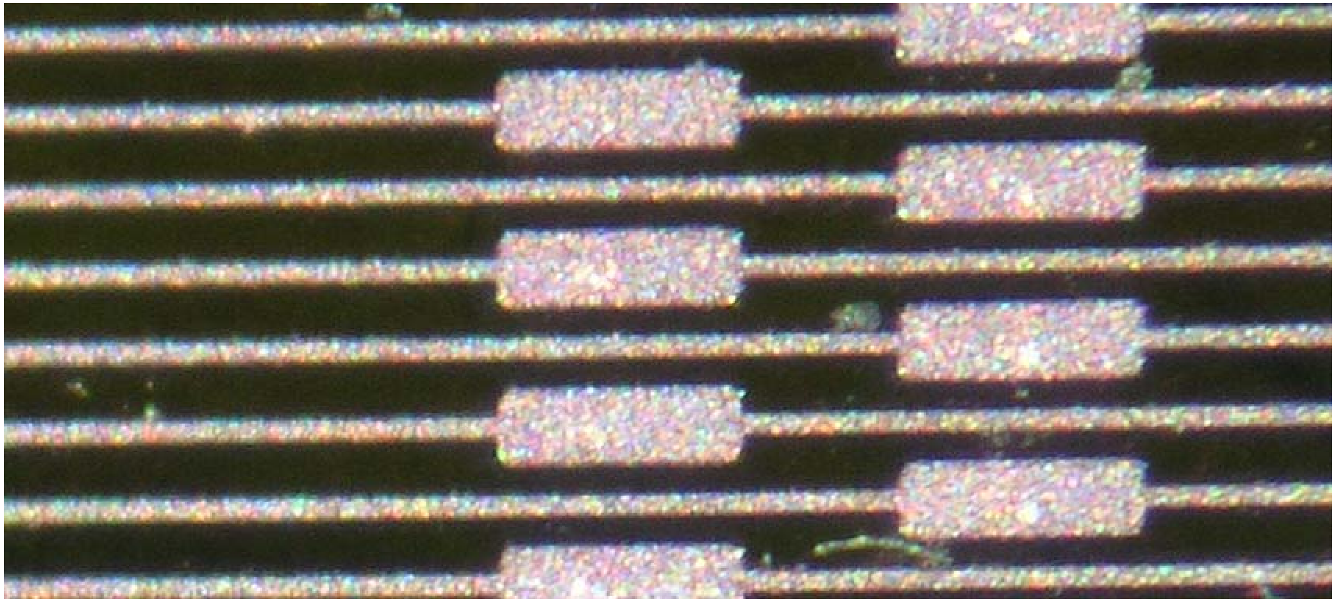




STRIPS IN SCOPE – GRANULATION OF SURFACE



Hamamatsu
strip reflectivity < 22%



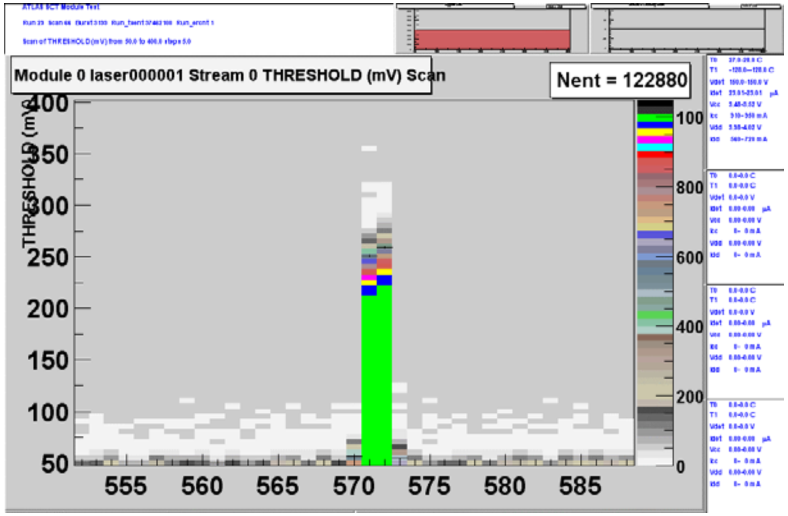
CiS
strip reflectivity < 30%

STATUS

- Test setup built in IFIC Valencia (fully working) and Charles University Prague (in progress)
- Stable mechanical arrangement
- Laser detection in only one side (metal back side of detectors – no transparent for light).
- Strip position detection working up to 1 minute
- Few method of focusing was tuned
- Automatic focusing done up to 20 minutes with precision 40um in z and 4 um in x
- No effect of interference between chip channels is observed
- Testing at low temperatures was tuned and is done up to –20 deg in chillers (4 deg in T-hybrid of ALTAS SCT module) in dry air or nitrogen
- Special atmosphere is possible
- Automatic logbook generated and saved with all important information
- Quality of laser focusing (sigma $< 3.3\mu m$)
- Many systematic effects under control (thickness, refractive index, surface quality)

TESTS PERFORMED

- The bond mixing test done up to 30 minutes per detector – test for production modules
- The channels from mask file (bad channels) tested independently using two methods
- Punch through (pin hole) channels test (gain confirmation) for response done
- Other special channels tested
- Pulse shape reconstruction done
- Different wavelength for different depth of bulk penetration is used
- Test of homogeneity of response from detector in full area is possible
- Detail response from inter-strip position is measured
- Bias scan of detector is simply possible and is setting depletion voltage
- Temperature scan is possible and done
- Pulse shape for ATLAS detectors was measured via strip for checking of response properties
- Space resolution of noise bumps on CiS ATLAS detectors was checked and measured



Laser Spot on Threshold Scan
(No focused spot, two channel signal, first historical detection of laser on SCT module in IFIC)

CONCLUSIONS - USABILITY

Laser tests are useful in:

- precise space resolution studies
- time walk and time shape measurements
- functionality of problematic part of detectors (response measurement)
- surface charge collection and also deep charge generation from ~µm@650nm up to 300µm@1060nm

Quality of tests depends from:

- top layers: thickness, refractive index, surface quality
- geometry of pads on top, their material, surface of them, protected layers
- back layers: material, quality, thickness (only if sensor is transparent for using wavelength of light)
- laser light beam quality, coherent properties, long time stability, aperture, wavelength

⇓

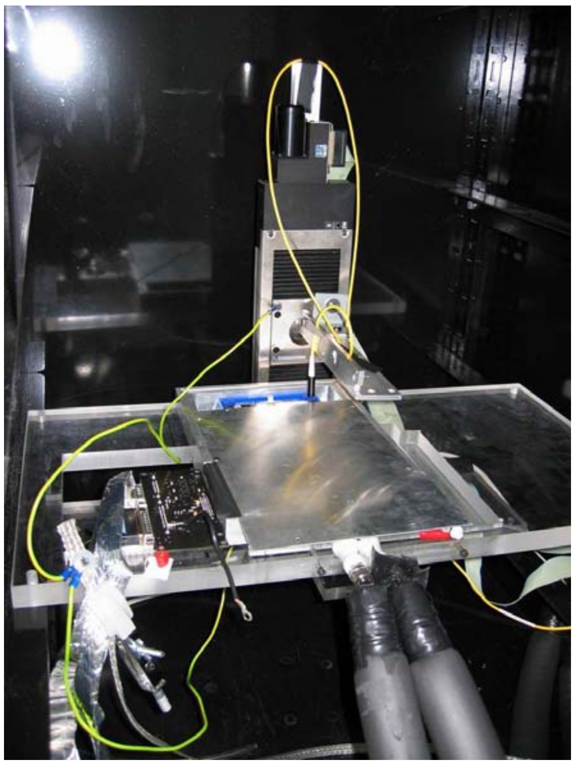
Laser test are:

- extremely useful for **tuning of individual sensor** and **readout settings to find optimal working parameters**
- good for **comparison between the same type of detectors** with exactly the same top surface properties
- of **limited use in absolute measurement of efficiency** of semiconductor detectors, this field area is under study

Next tasks? …

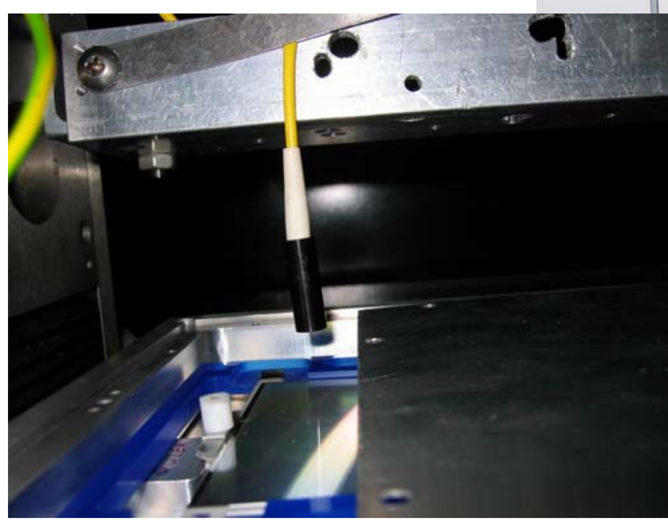
PHOTOS 1

First arrangement of workspace



Module in test box with window for laser spot, optical fibre for laser light (yellow cover), insulated plastic support for module

Laser end with focusing lens above module sensor



Black box with 2D stages inside and chiller below them

PHOTOS 2

Final arrangement of workspace

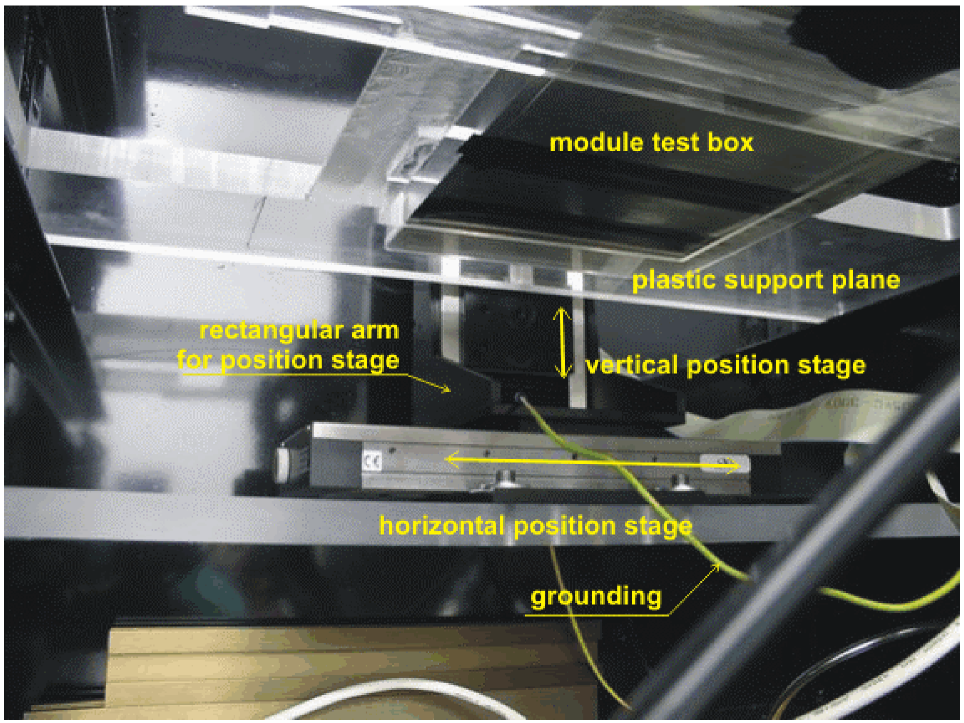
General view to laser tests workplace with black box (left) with 2D stages inside and chiller below them, readout electronics (right) and DAQ computer

Black box with module box connecting to cooling and DAQ electronics

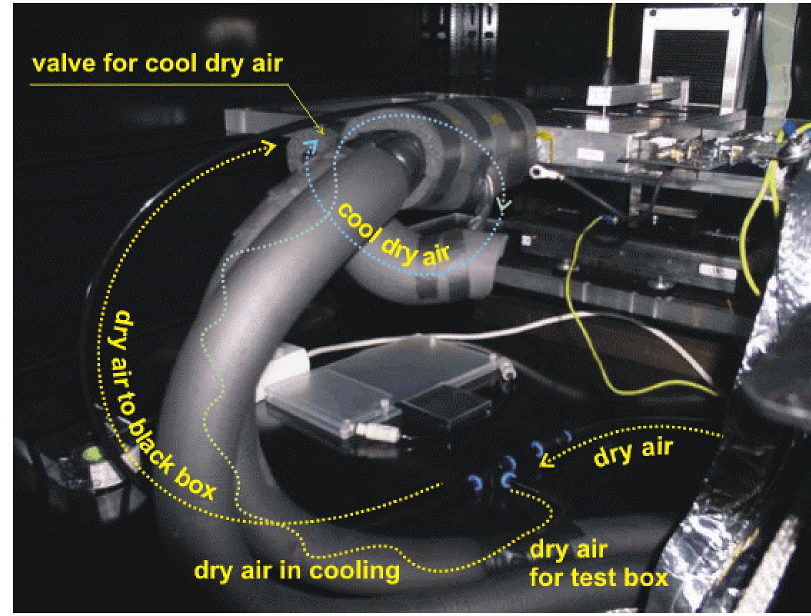
Block of connectors for in/out puts of cooling, air or nitrogen, optical fibre of laser light and command wires of position stages

PHOTOS 3

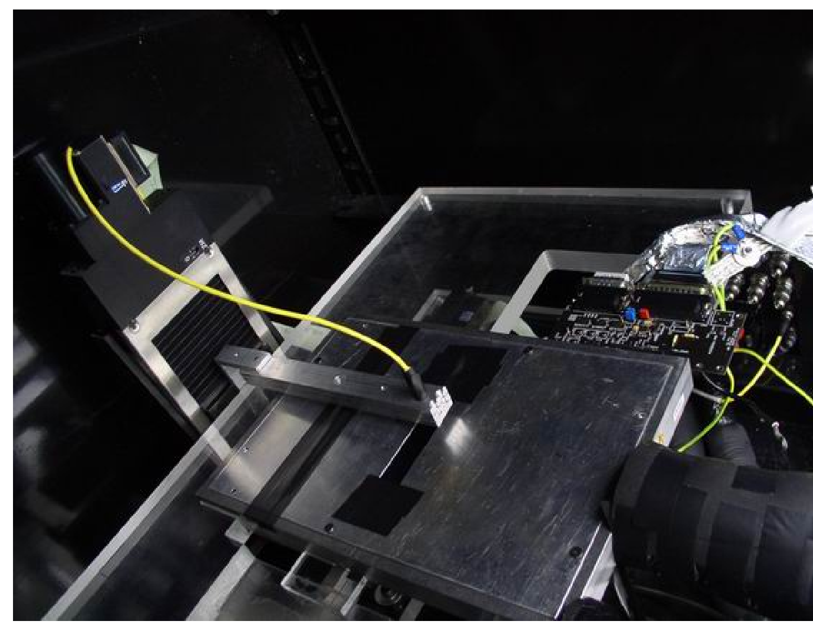
Final arrangement of workspace



Position stages arrangement



Production of dry cool air for module



Laser end with focusing lens above module sensor and module test box with two windows for testing of both sensors (one is closed for save cool dry atmosphere inside)