Charles University Prague
Institute of Particle and Nuclear Physics

Laser test progress in Prague

Peter Kodyš, Zdeněk Doležal, Jan Brož,
Peter Kvasnička, Pavel Řezníček,
Zbyněk Drásal

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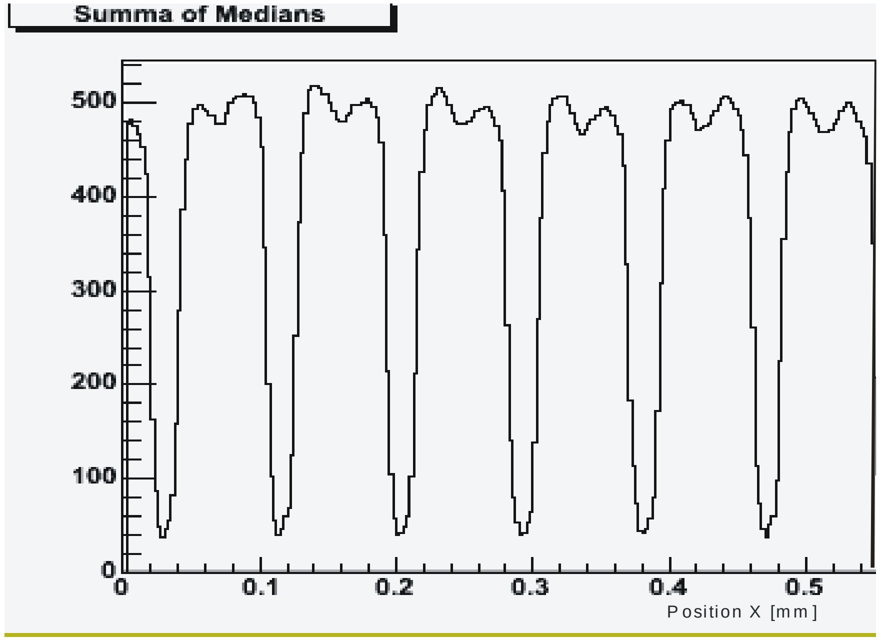
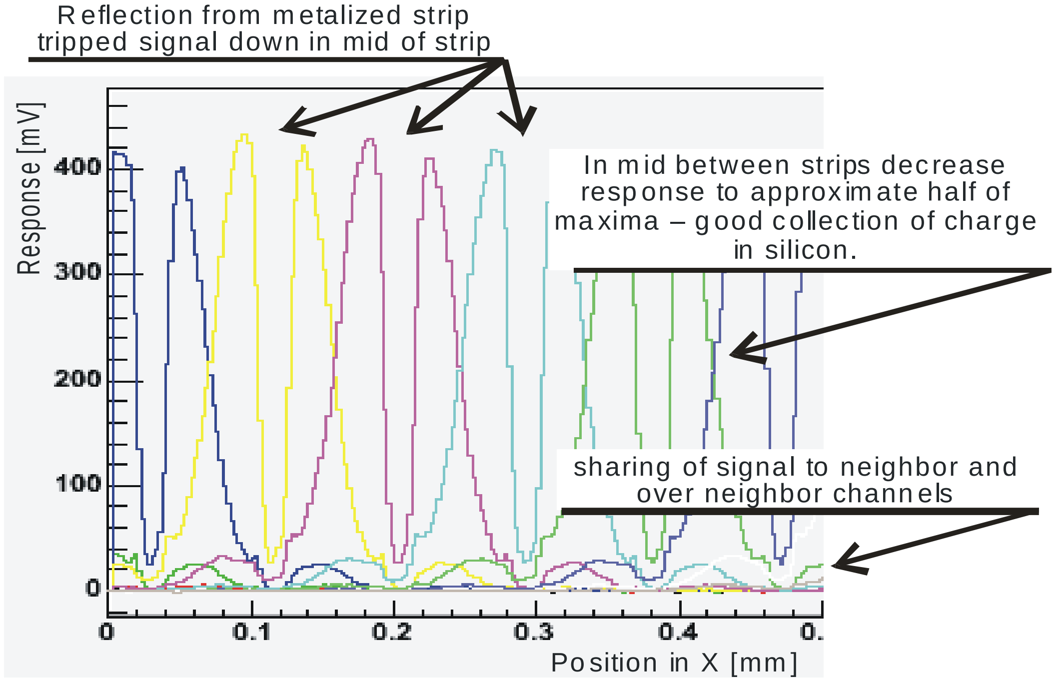
Response of tested modules



Sum of signal of 12 adjacent strips show that collected signal in one channel is 85% from whole collected charge in detector.



Typical response from few channels if laser beam moves across strips in best focused point.

Monitoring = optical head

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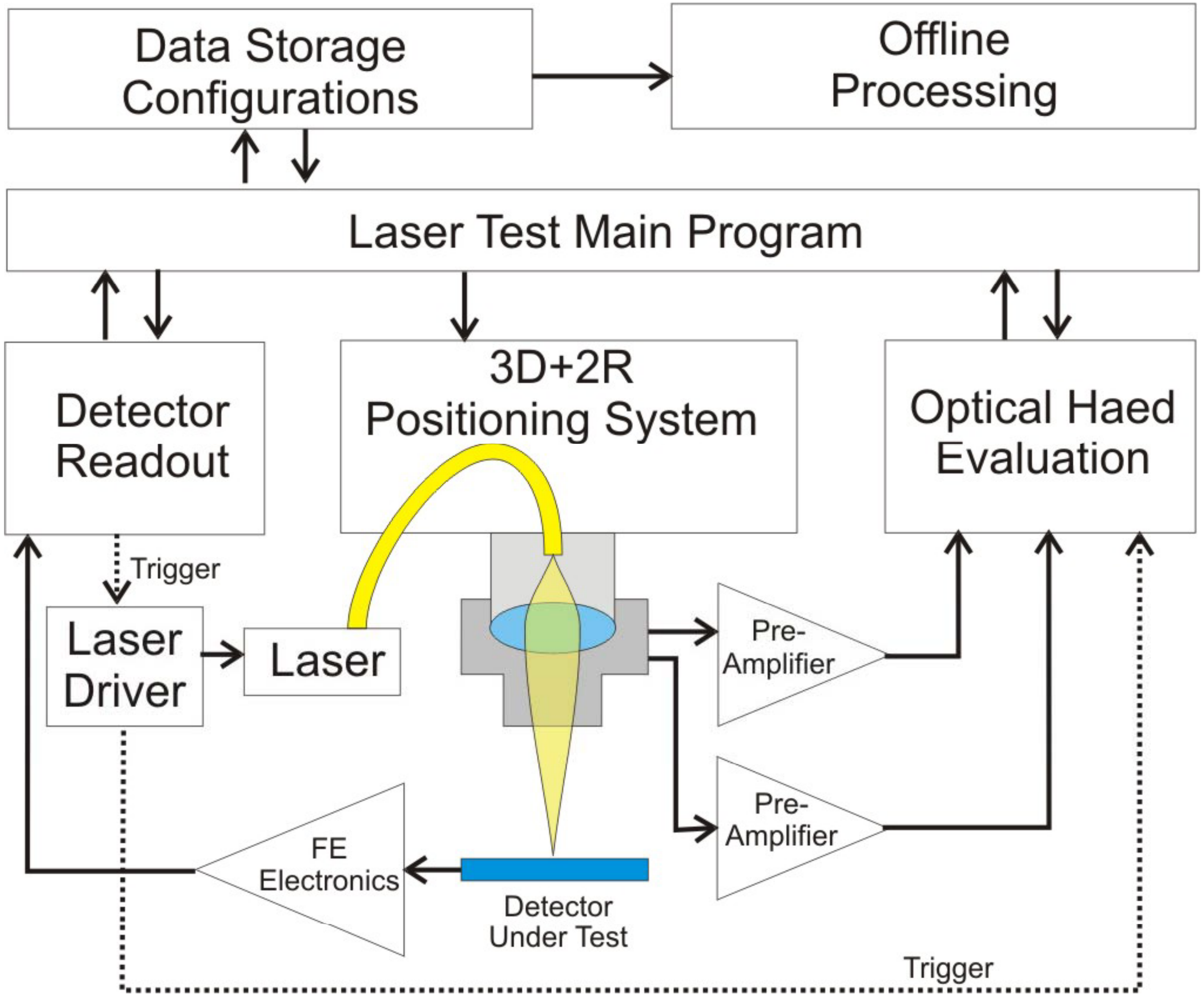
Note on the end

Precision of results presented here is better 5%, higher precision is possible with higher statistics of measurements and finer steps of scans, but it is time consuming, for example of confirmation of how it is possible on this work we did not go to maximal possible precisions.

Last slide from October 2006 RD-50 CERN

Optical Head – Measurement Scheme



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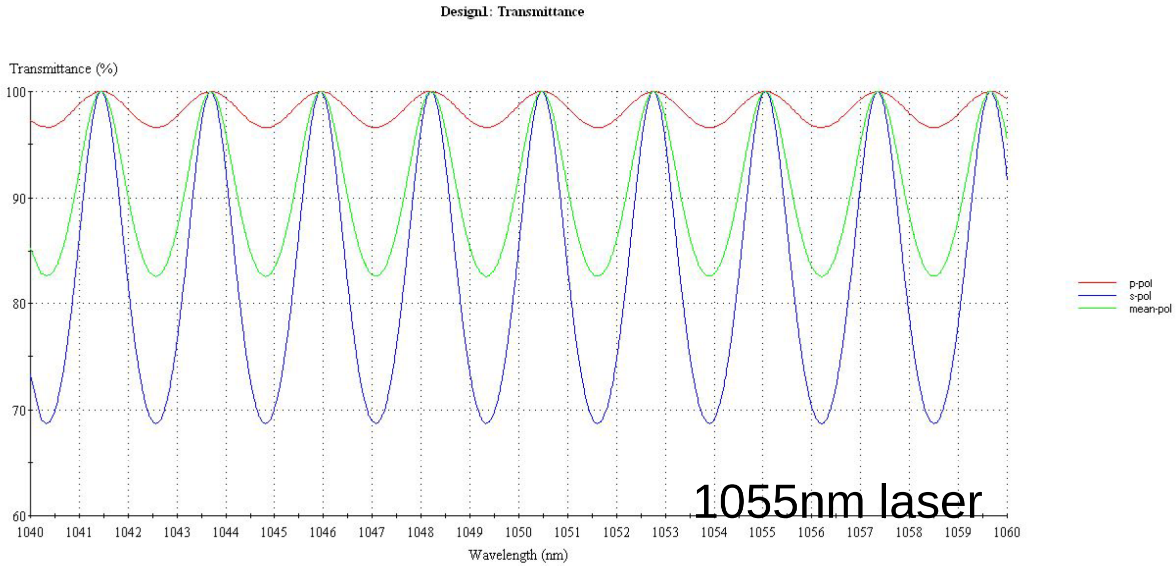
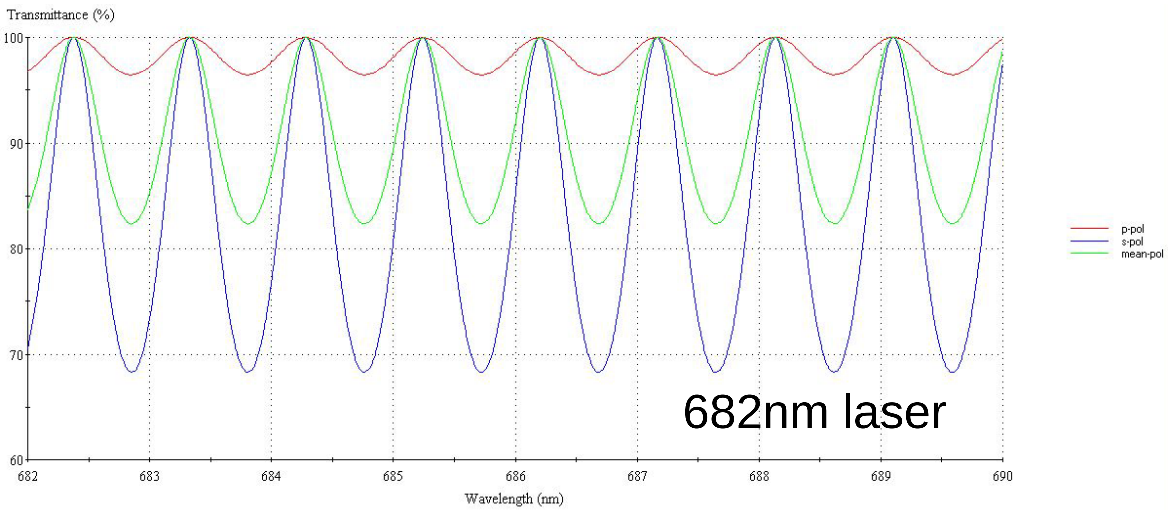
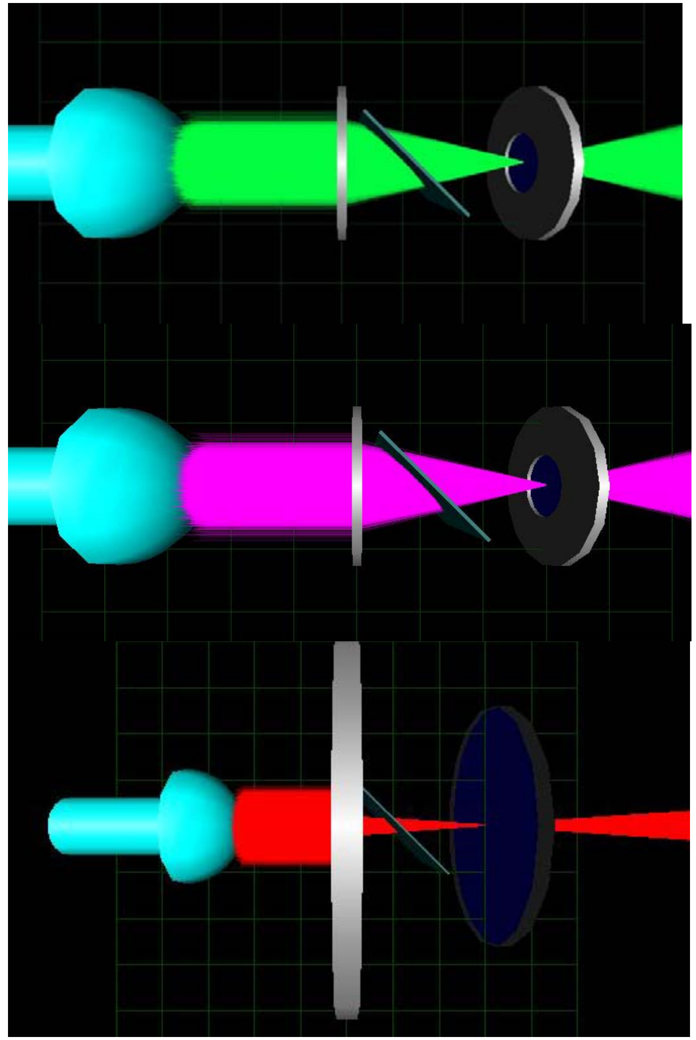
Optical Head – Calculation And Simulation







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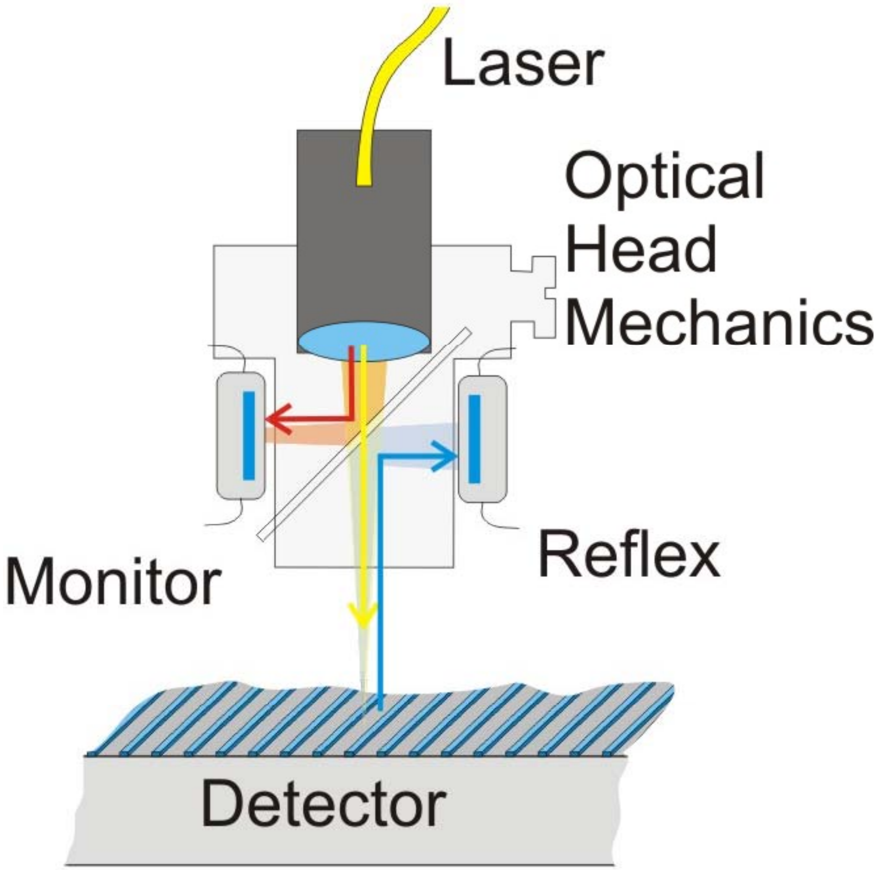
Optical Head - mechanics



Original light beam from focusing lens is split by glass plate with thickness 180 μm without additional coating. Monitoring part of light is ~4% from power and the same part of reflected light from perpendicular surface is detected. Power of laser is measurable on level of 4fC of collected charge in detector in pulse ~2ns width up to few 100ns pulse width. Tested surface reflected signal back to optical head in perpendicular direction. Splitter and detectors are integrated in optical head 8mm thick on output of laser (focus distance 12mm).

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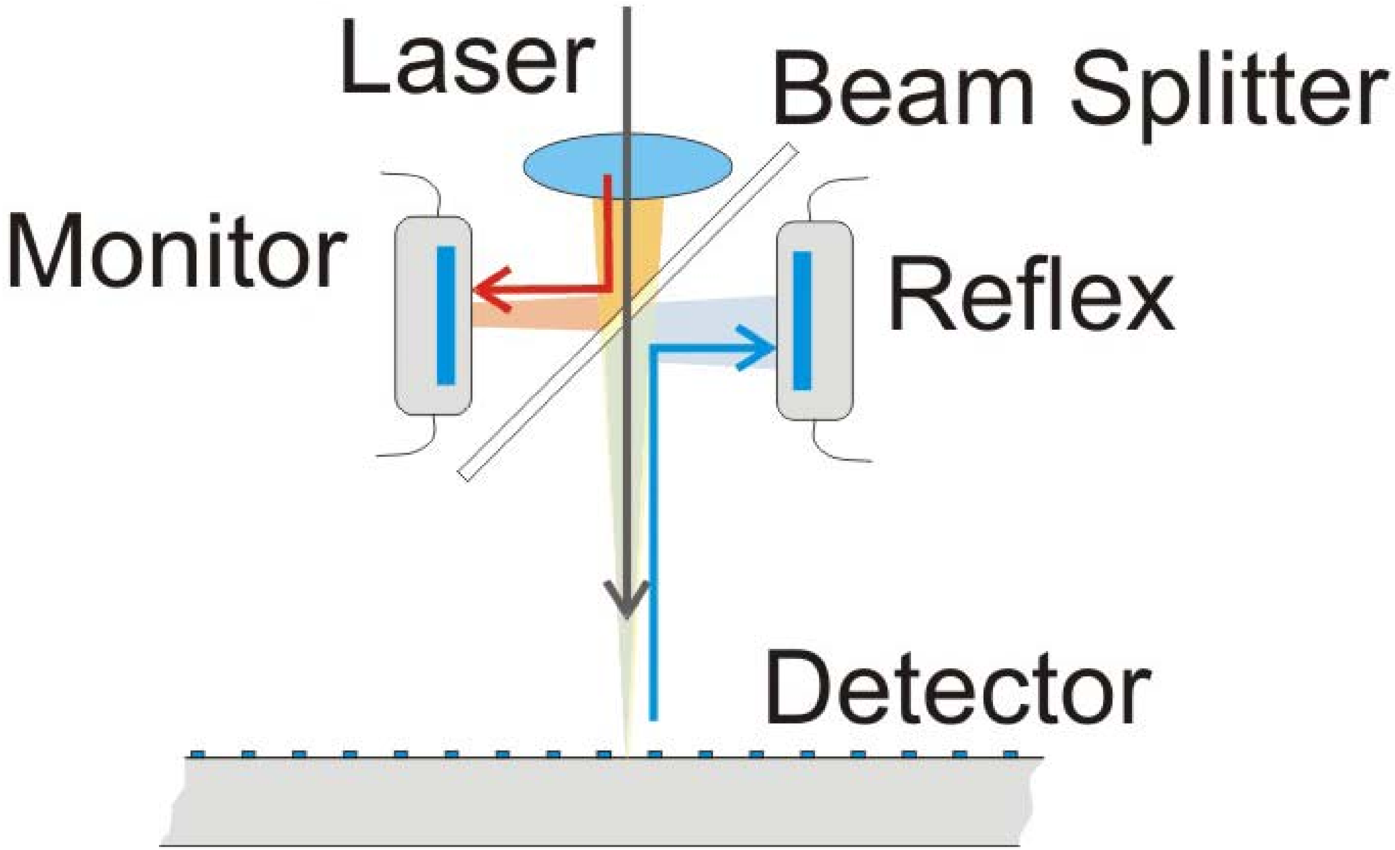
Optical Head - mechanics



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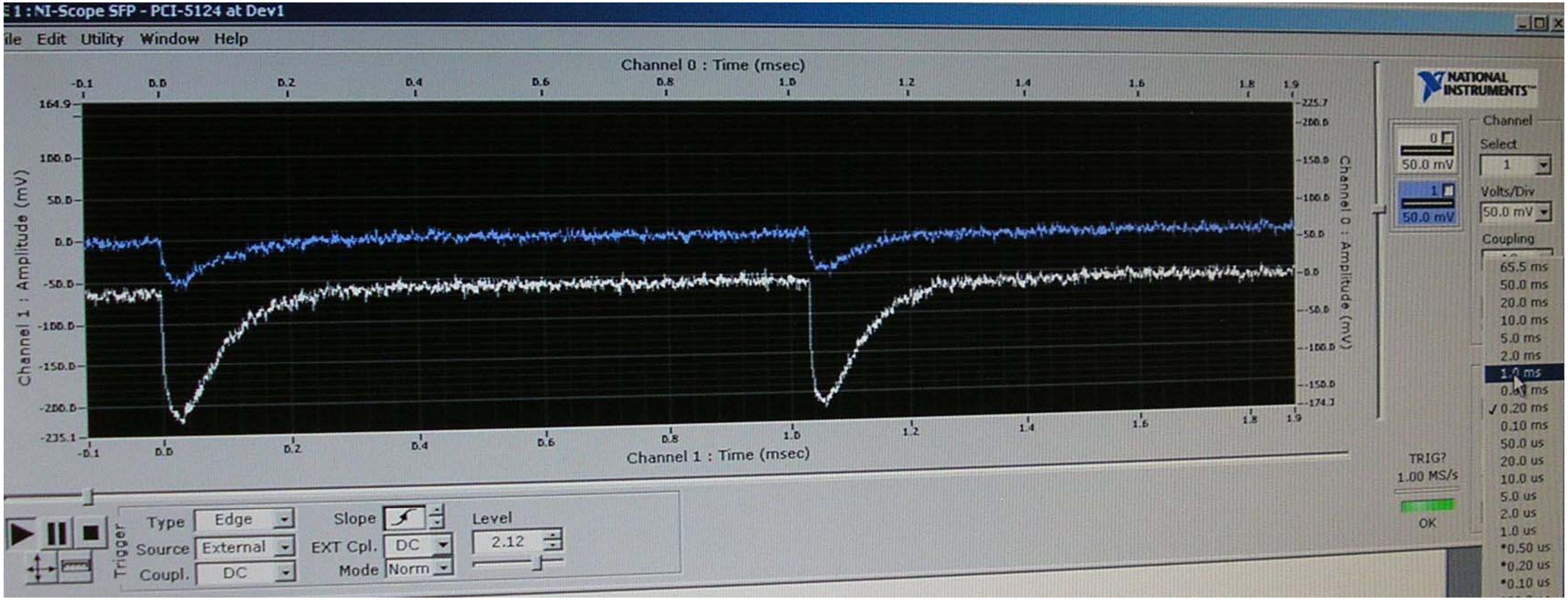
Optical Head - electronics



Evaluation is on scope board PCI-5124, 200 MS/s 12bit two-channels digitization 32 MB/ch on PC and C++ macro to acquire signals from 1000 pulses and saving to file.

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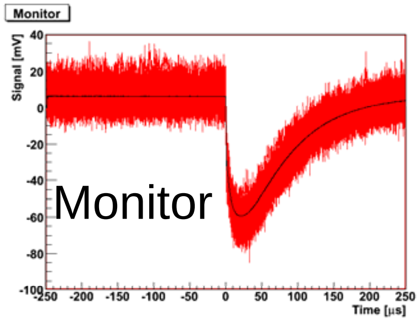
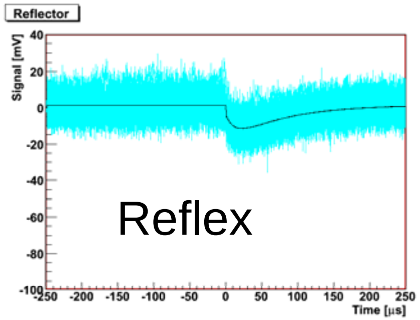
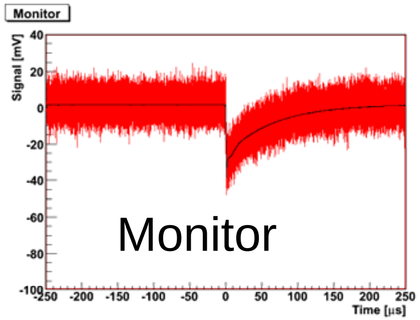
Optical Head – electronics and properties

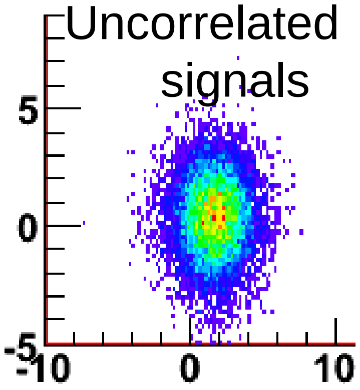


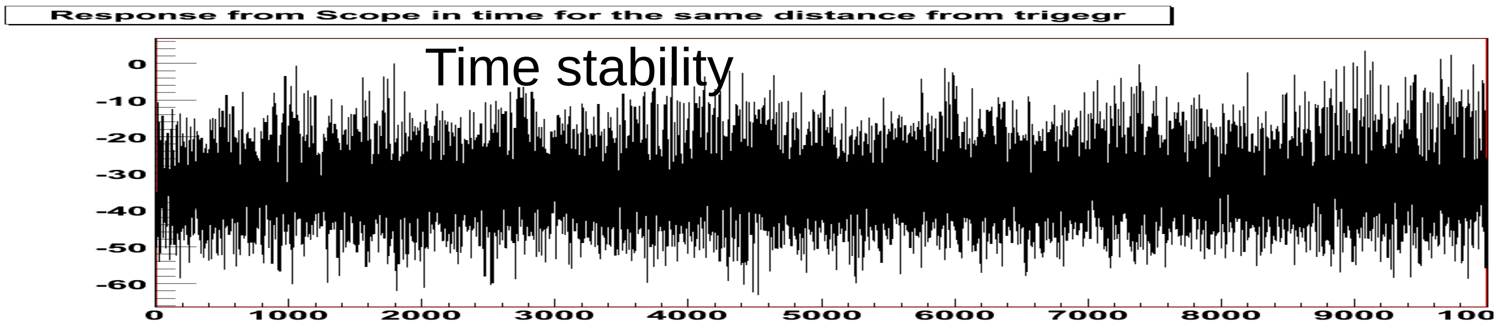


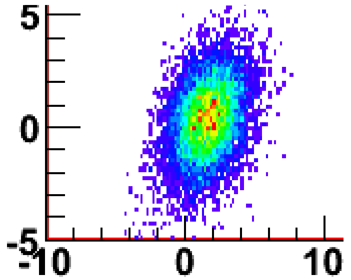
1055nm laser pulse



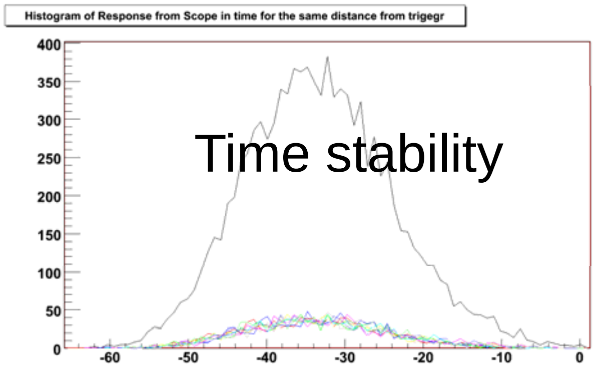
682nm laser pulse

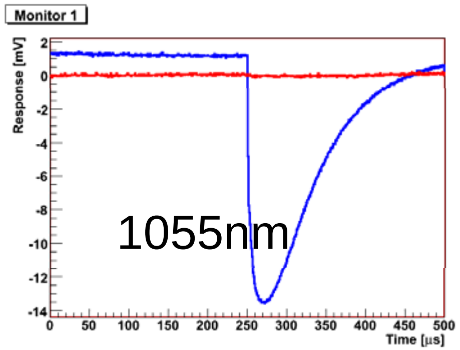


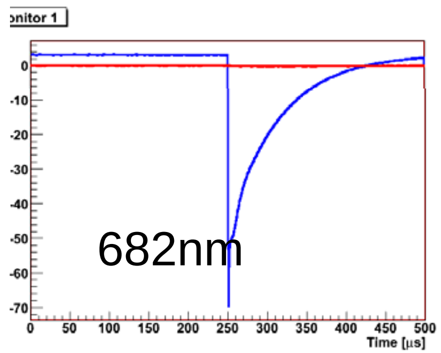




Correlated signals







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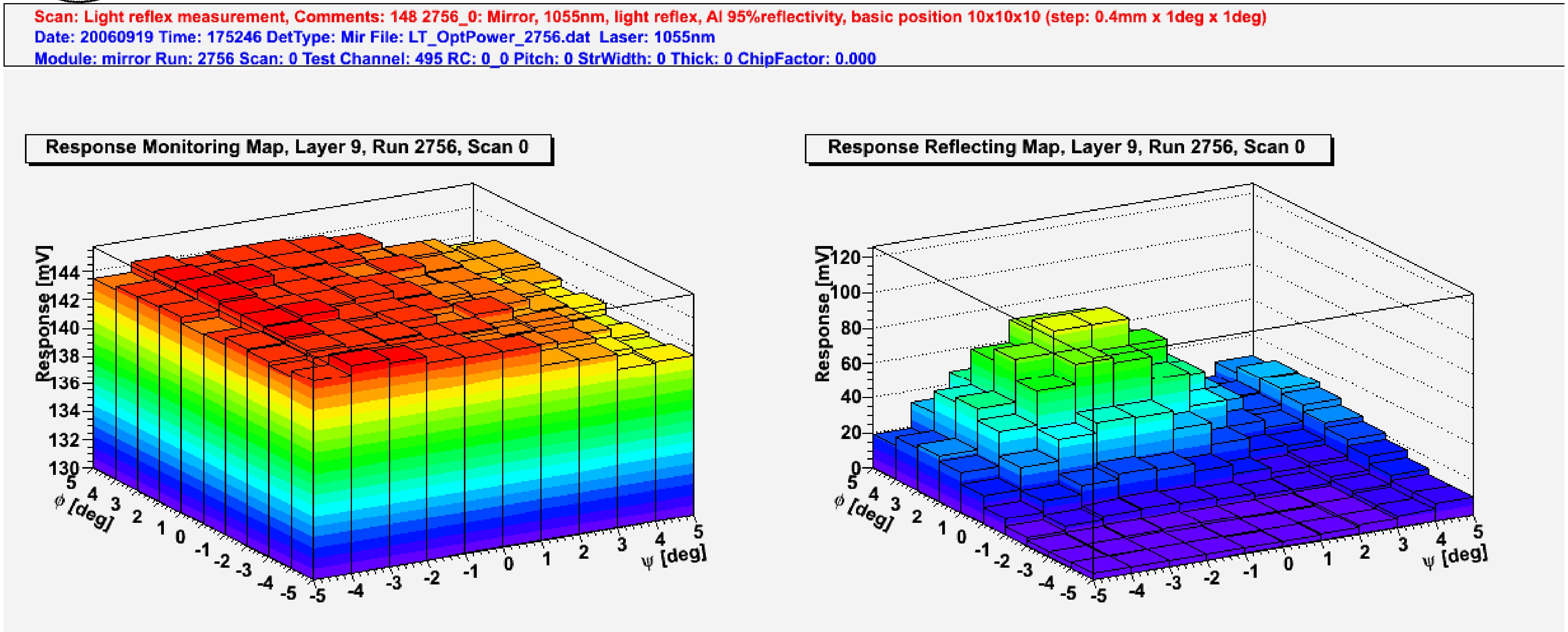
Perpendicularity and reference calibration on a mirror



Reflectivity of known material on perpendicular direction (maxima in angle scan).
We use 95% reflective Alumina mirror with results:

132mV/148mV@1055nm@100ns_puls@95%reflectivity --> **138mV/148mV@1055nm@100%reflectivity**

10.1mV/24mV@682nm@100ns_puls@95%reflectivity --> **10.6mV/24mV@682nm@100%reflectivity**

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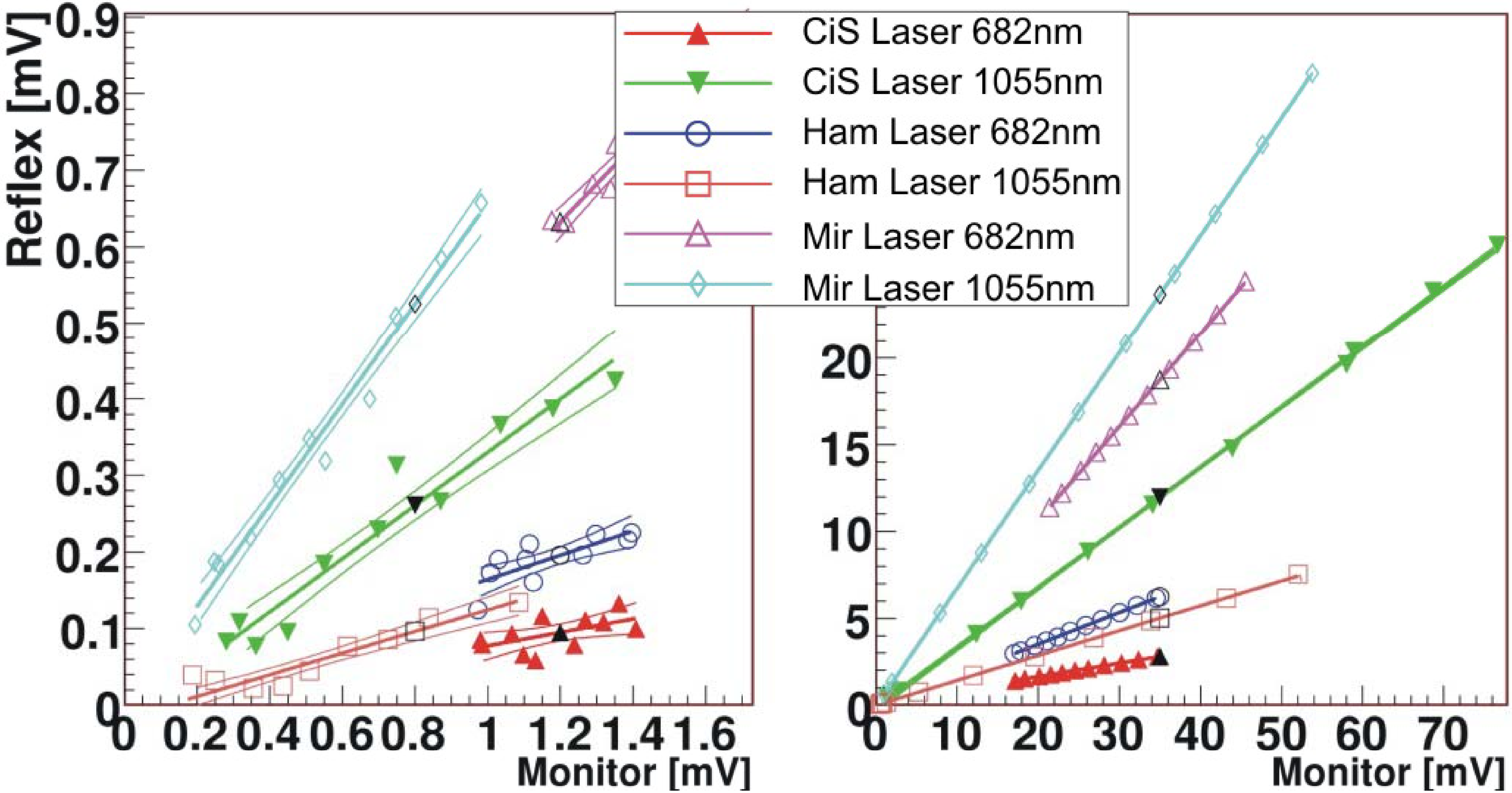
Calculation of absolute laser power, photon counting, quantum efficiency



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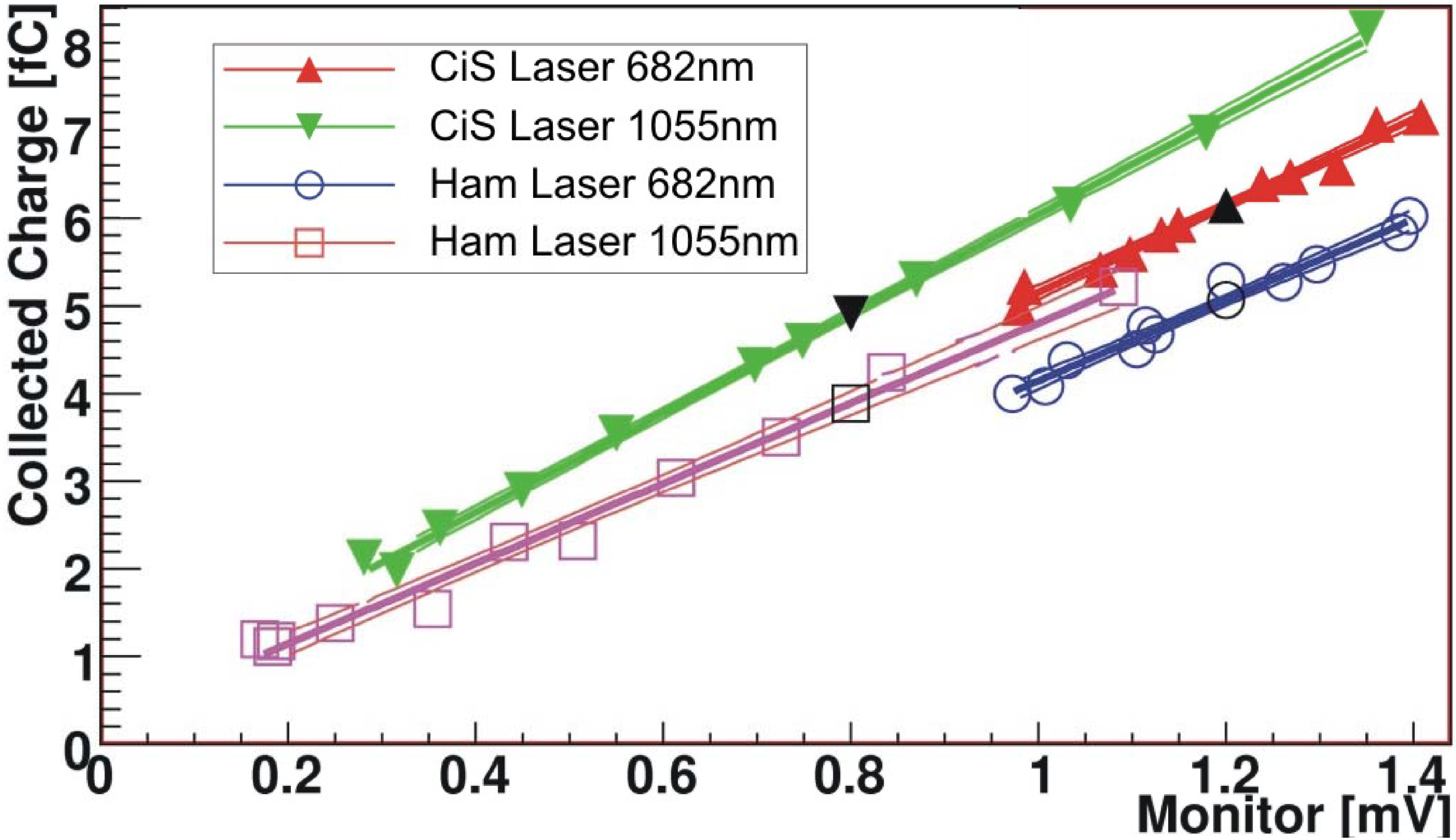
Calculation of absolute laser power, photon counting, quantum efficiency



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Calculation of absolute laser power, photon counting, quantum efficiency

	Laser wavelength: 682 nm			Laser wavelength: 1055 nm		
Detector	Transmittance Low power	Transmittance High power	Charge [fC]	Transmittance Low power	Transmittance High power	Charge [fC]
CiS	0.860	0.861	6.98	0.522	0.514	5.41
Ham	0.712	0.690	5.53	0.824	0.797	3.89
CiS/Ham	1.21	1.25	1.26	0.63	0.65	1.39

Table 1
Measured signal from reflectance detector and collected charge for Hamamatsu (Ham) and CiS detectors for two laser wavelengths and two laser power settings. High power is about forty times the low power

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Calculation of absolute laser power, photon counting, quantum efficiency

$$R = R_{\mathrm{mirror}} \langle \frac{m_{\mathrm{mirror}}}{r_{\mathrm{mirror}}} \rangle \frac{r}{m} \qquad (1)$$

Here m and r are the signals from the monitor and reflex photodiode, respectively, and R is reflectance. Index $_{\mathrm{mirror}}$ refers to the reference mirror, and values without an index refer to the detector. Angle brackets denote averaging over a calibration run.

$$Q = \langle \frac{Q_0}{m_0(1 - R_0)} \rangle m(1 - R) \qquad (2)$$

where Q is charge and the meaning of other symbols is the same as in Eqn. 1. Index $_0$ refers to the reference detector and values without an index refer to the tested detector.

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Calculation of absolute laser power, photon counting, quantum efficiency

Final based on **calibration** power meter NEWPORT 2832C + calibrated Si detector we have photon counting and quantum efficiency (QE):

Conditions:

Laser wavelength:	1055nm	682nm
Nominal pulse widths:	15ns	15ns
Real Pulse width:	3.8ns	7.5ns
Pulse driver amplitude:	2400mA	2050mA
Energy per pulse:	90aJ	20aJ
Photons in pulse:	565000	126000
Maximal charge:	90.6fC	20.2fC
Measured charge:	33.1fC	11.3fC
QE of silicon detectors:	**0.365**	**0.561**

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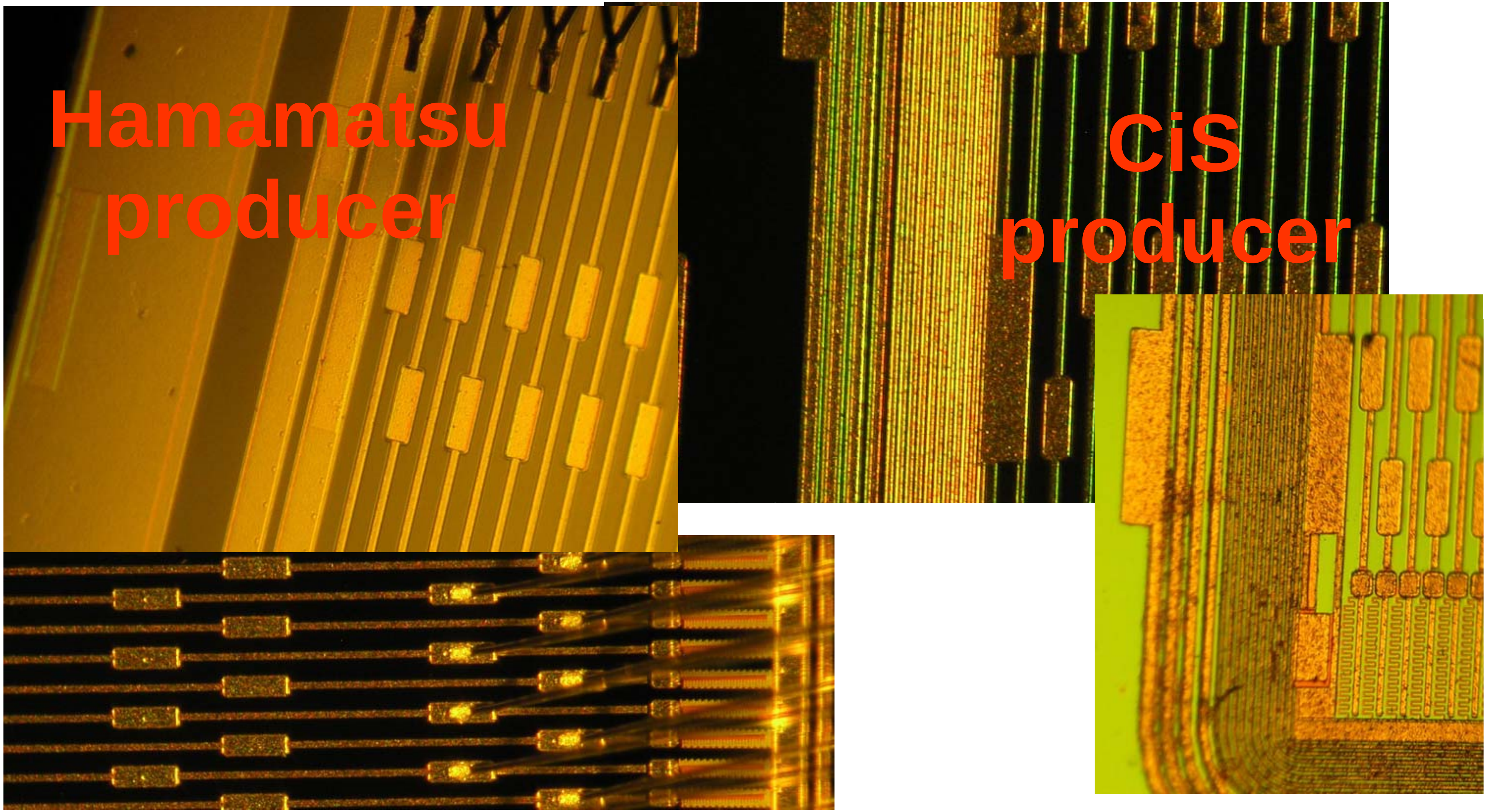
Application: ATLAS SCT Strip Detectors



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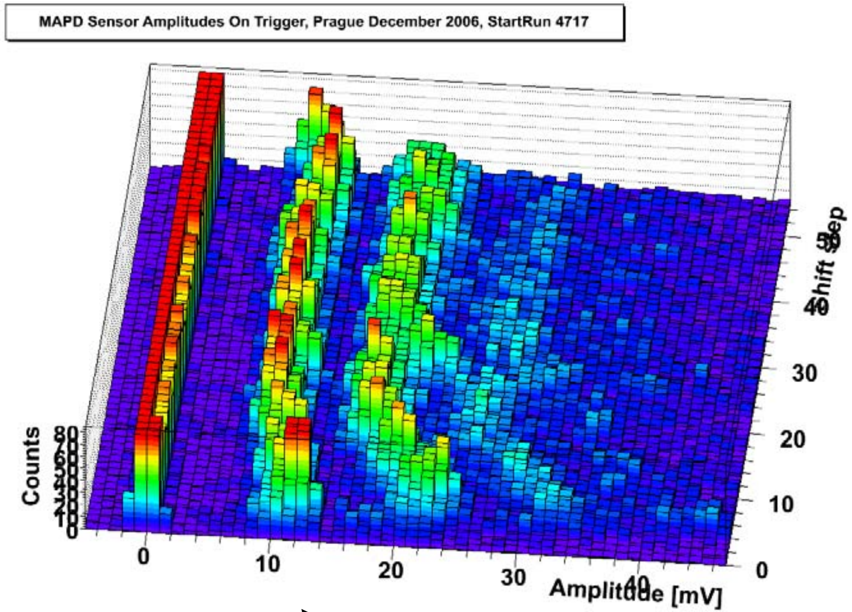
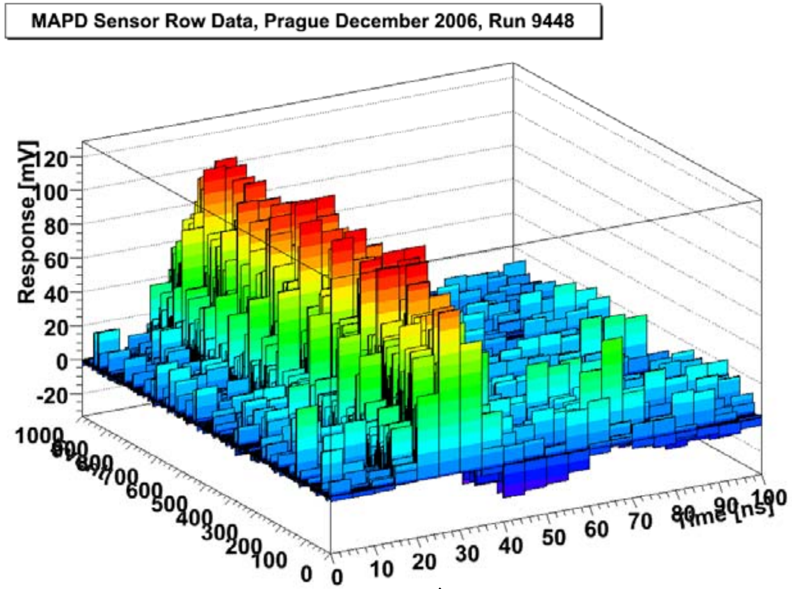
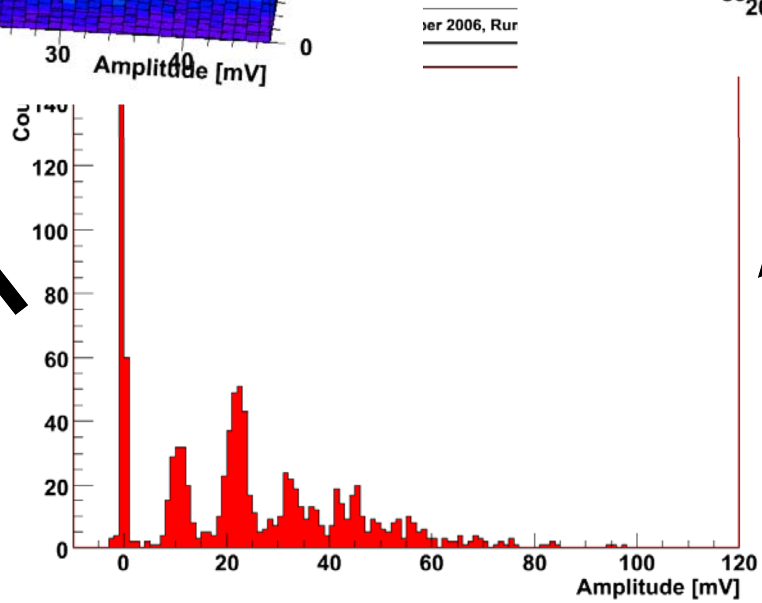
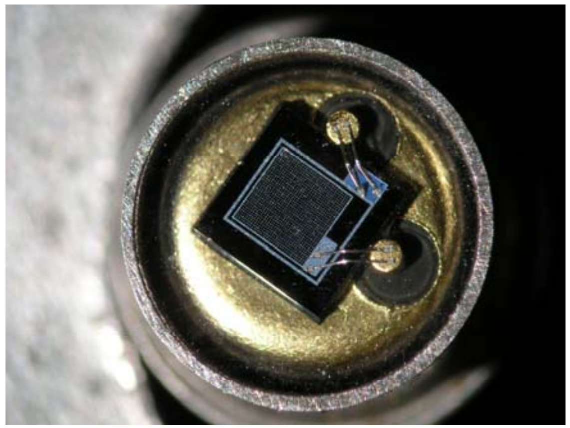
Application: MAPD

Micro-pixel Avalanche Photodiode









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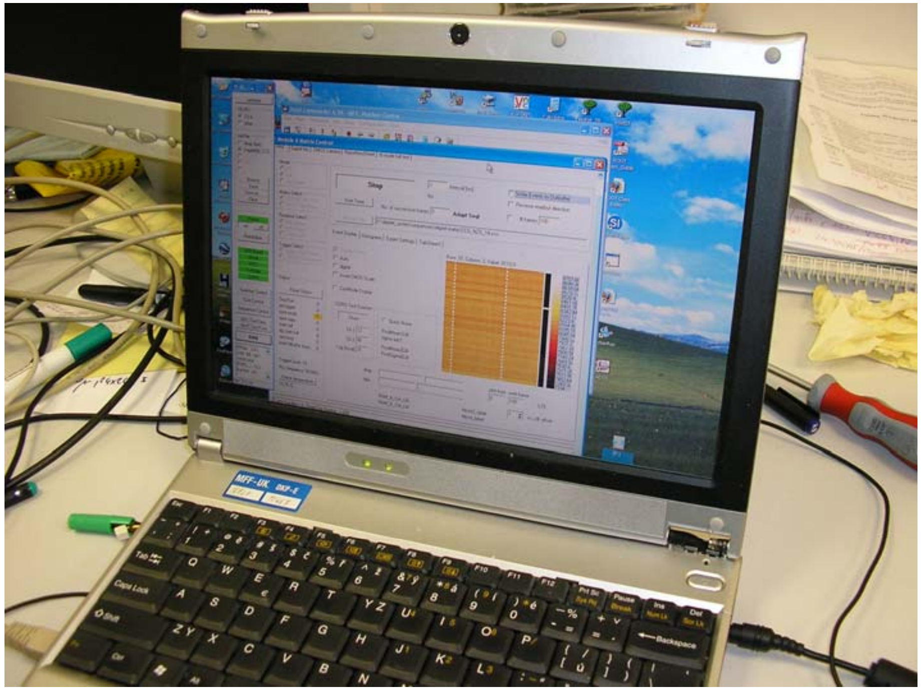
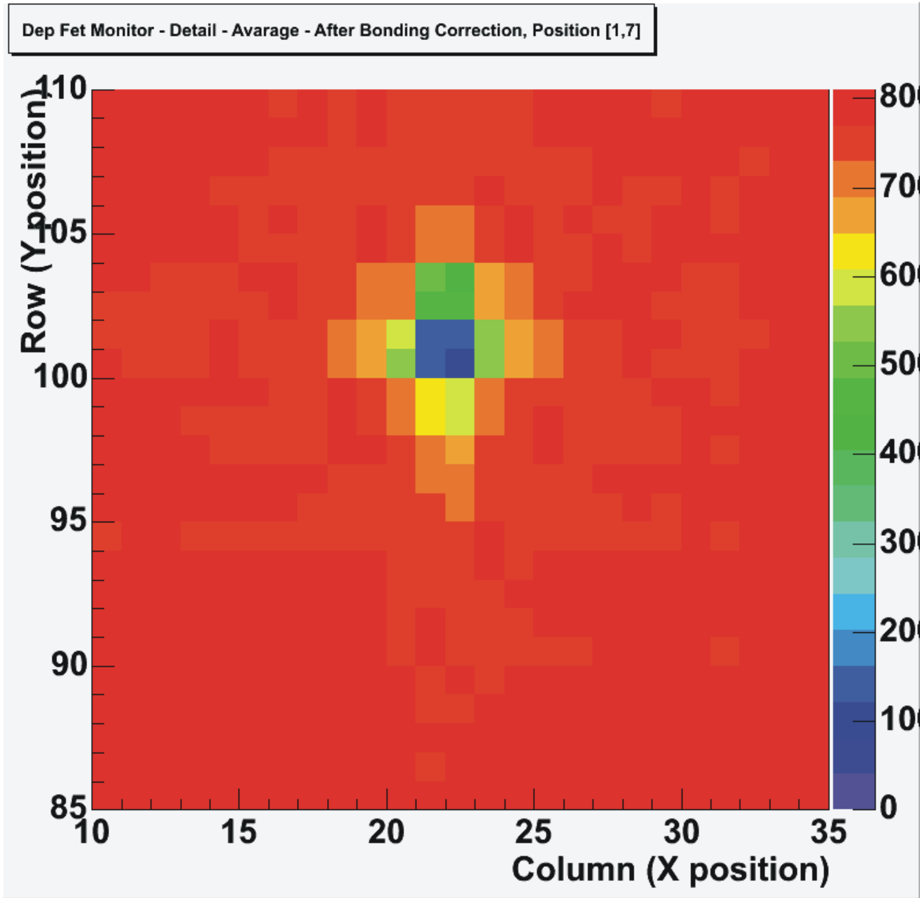
Application: DEPFET active pixels

The Depleted P- Channel Field Effect Transistor





Response of DEPFET detector

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Deeper understanding of laser beam interaction with Si detectors and conclusion

Next possible effects influencing laser tests:

- For 1060nm wavelength – thickness of silicon substrate changes: minima-maxima on interferences give about 30% changes in charge collection in ½ wavelength inside Si (~150nm) – only in large area scans, distribution of dopants over thickness of silicon, additional dopants for decreasing of leakage current, quality of surfaces – additional scattering/diffusion

- For 650nm not fully depleted silicon in collecting time range – charge is created in layer <4μm in pure electric field – depended also of properties of coating layers (electric field gradients, conductivities, lost charge vacancies,…)

Good news: MEASUREMENTS IN RED LIGHT ARE RELIABLE AND ROBUST

4% precision of collected charge determination

Predictions of collected charge for the Hamamatsu detector based on surface reflectance measurements on both detectors and collected charge measurements on the CiS detector differs by 0.25 fC and 0.07 fC at reflectivity measured at 1 mV and 40 mV monitor signal respectively, from the actual value of 5.53 fC.

Quantum efficiency of silicon for given laser was measured