

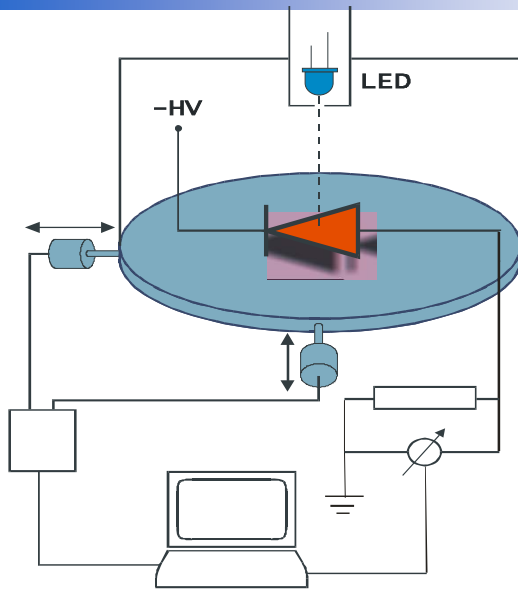
Uniformity measurements across the area of the multi-cell avalanche photodiodes

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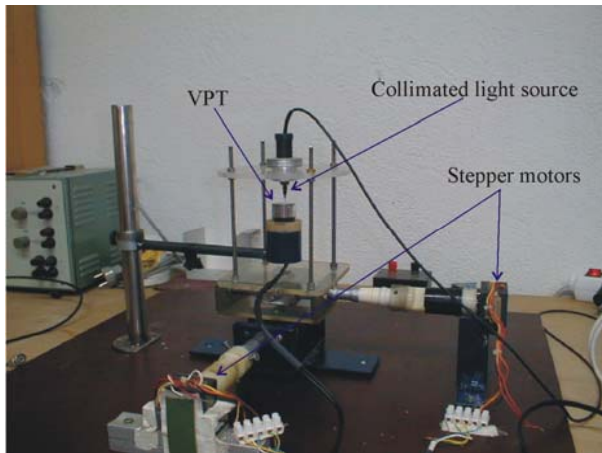
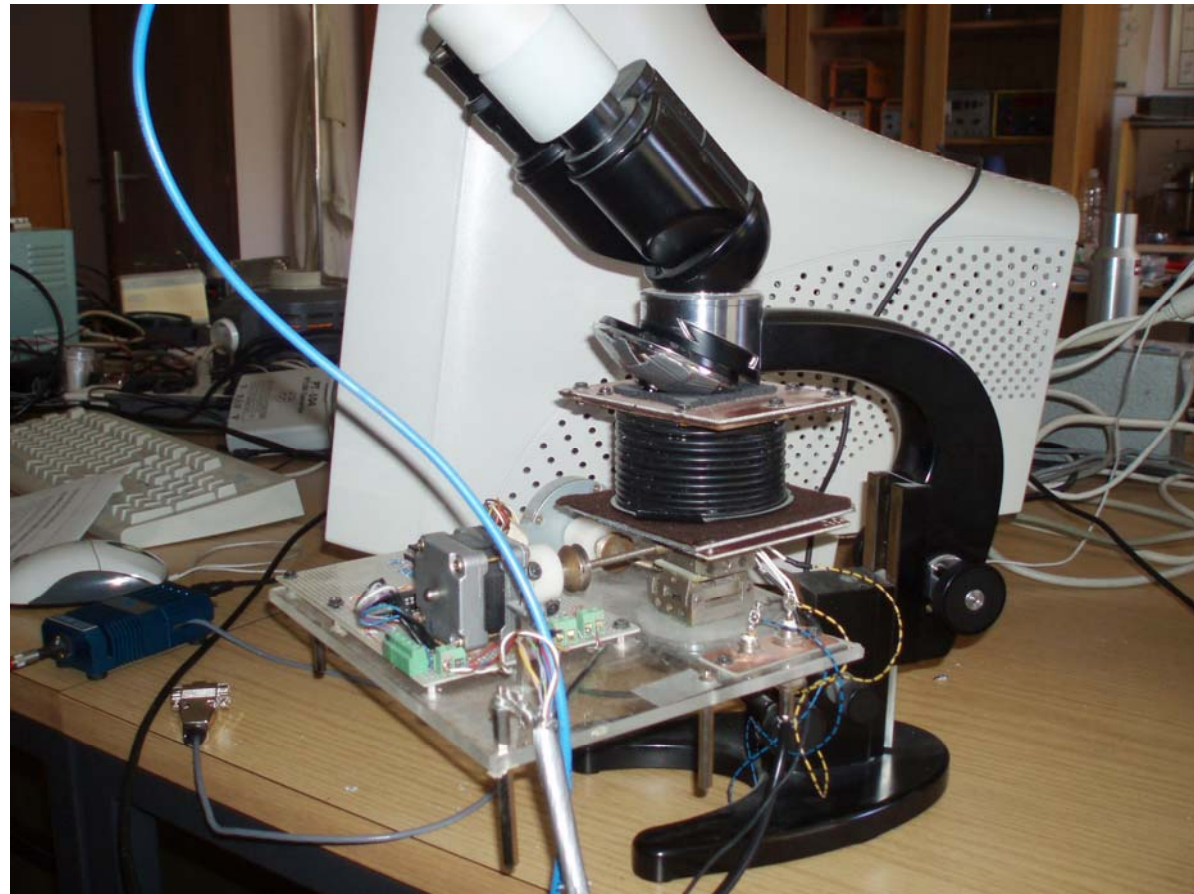
Outline:

- ✓ Setup(s) for uniformity scan
- ✓ Previous experience with uniformity scan
- ✓ Preliminary results of the spatial uniformity scan
- ✓ Summary

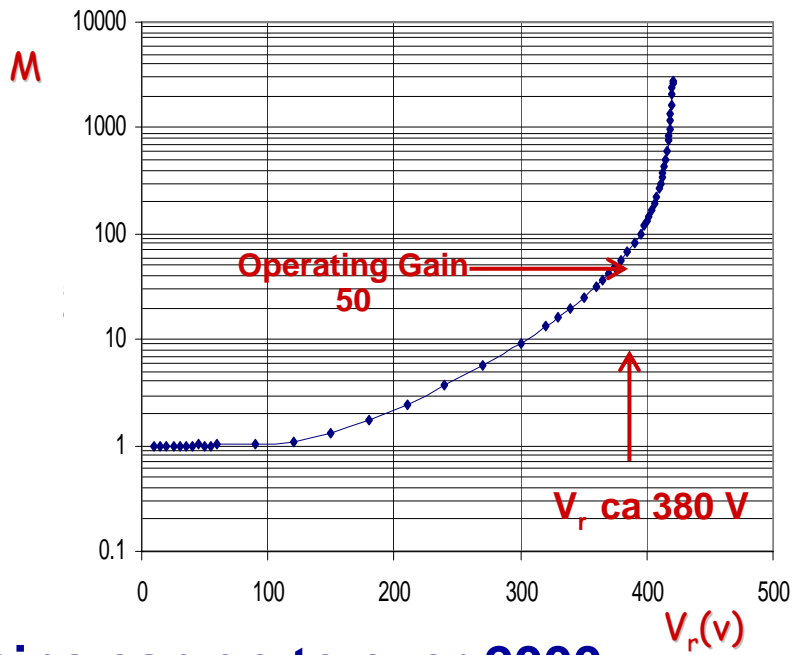
Set-up for uniformity measurements



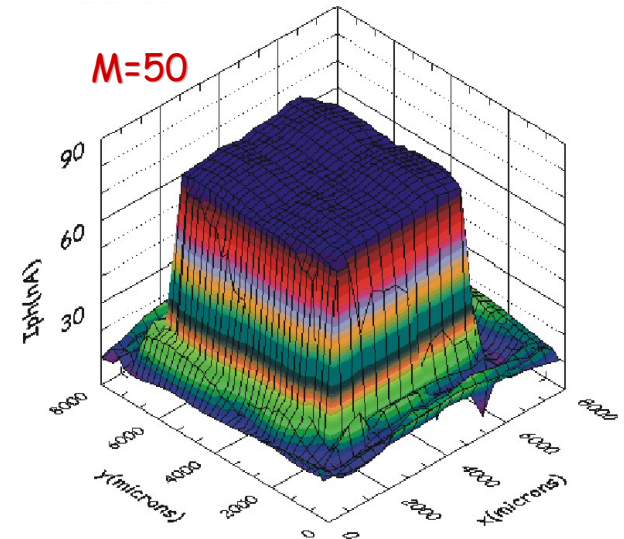
2,5 microns – minimum step



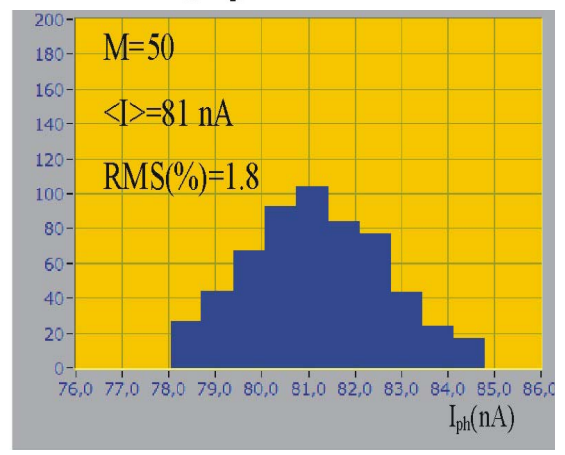
Previous experience: (CMS APD Gain uniformity)



Light spot (430 nm) ~200 μm diameter

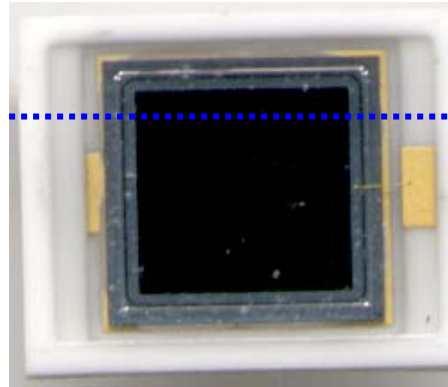
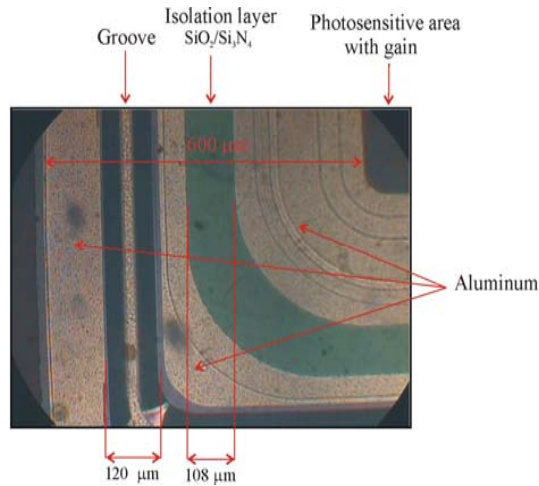


- Gains can go to over 2000
- We demand good behaviour up to gain 400
- Operating at gain 50 has excellent spatial uniformity



NIM A 545 (2005) 139-144

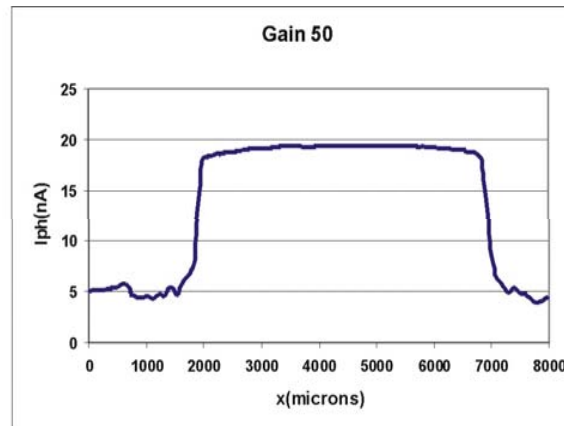
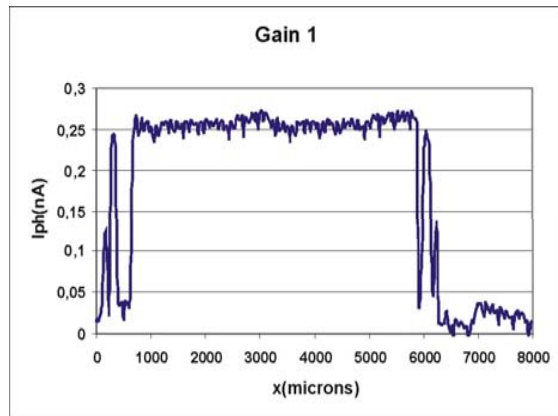
Previous experience: CMS APD Gain & Illumination



$$M(V_r) = \frac{I_{ph}(V_r)}{I_{ph}(V_o)} \quad V_o = 20V$$

$$\Delta V_r(M) = V_R^{full\ ill}(M) - V_R^{central\ ill}(M) \approx 3V, M = 50$$

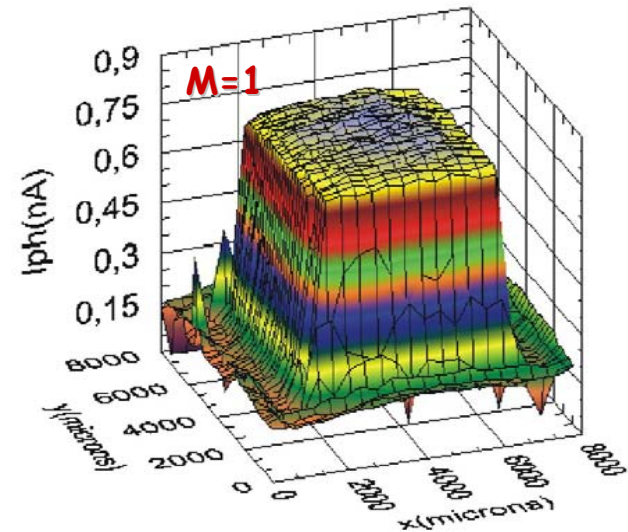
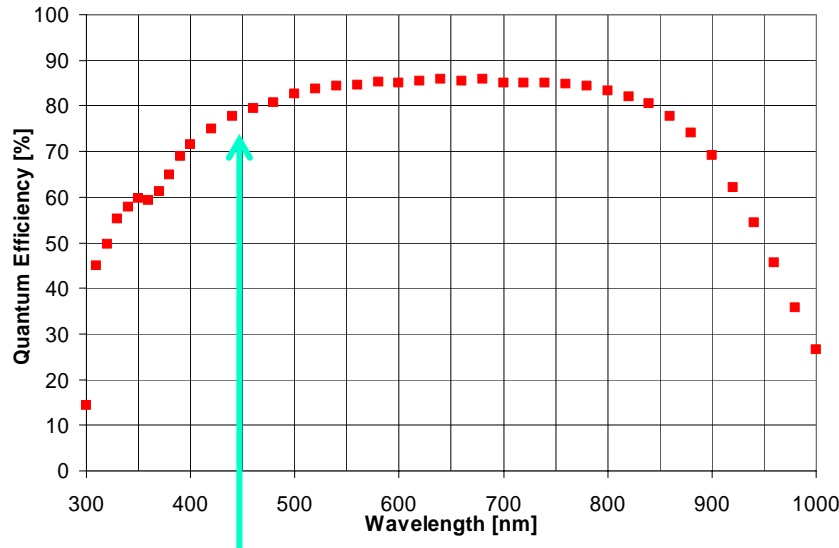
Light spot (430 nm) $\sim 25 \mu\text{m}$ diameter, step $25 \mu\text{m}$



Light sensitivity of the edge regions must be taken into account when determining the mean APD response

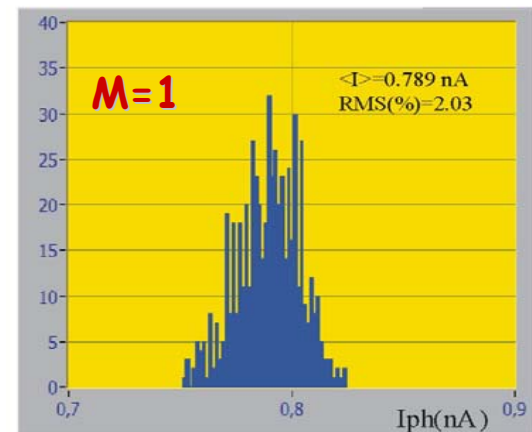
Previous experience: CMS APD - Quantum Efficiency

Light spot (430 nm) ~200 μm diameter

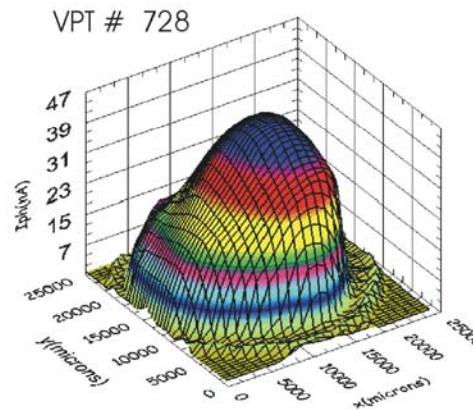
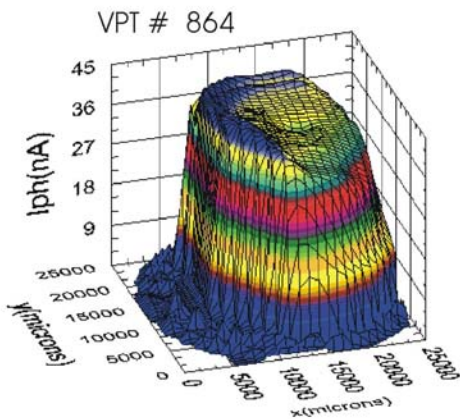
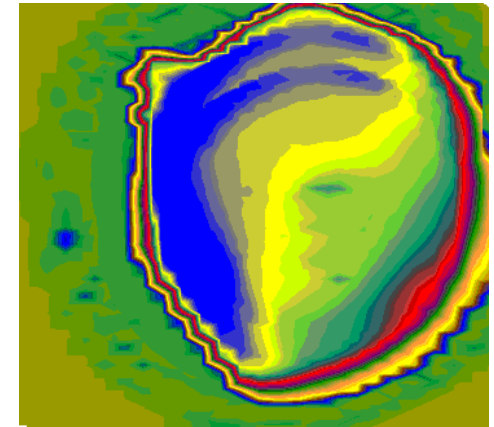
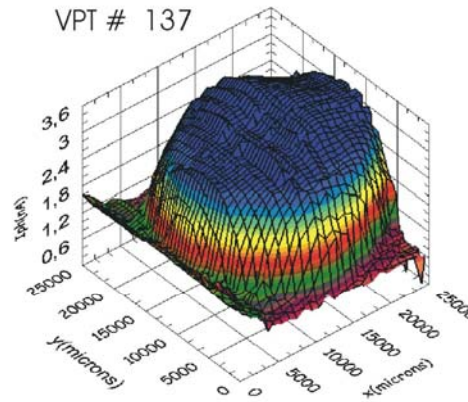
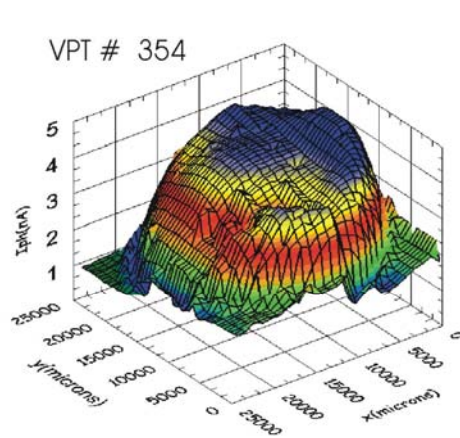


PbWO peak emission 430 nm

Q.E. is 75% at peak emission
QE has excellent spatial uniformity

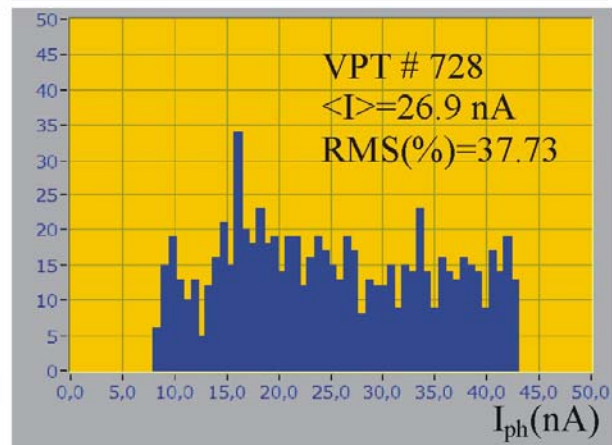
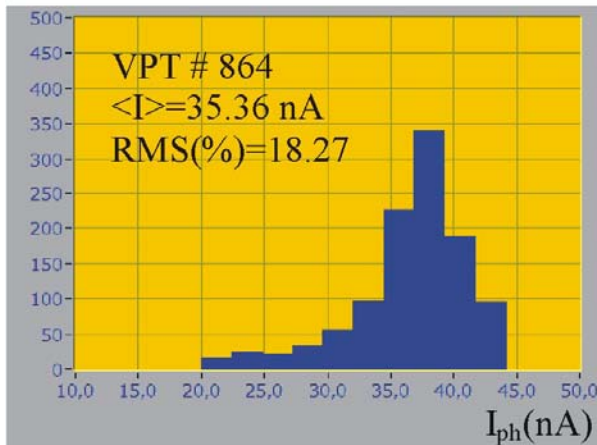
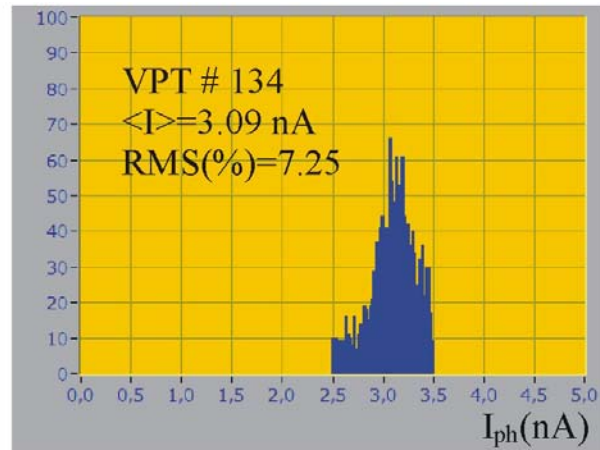
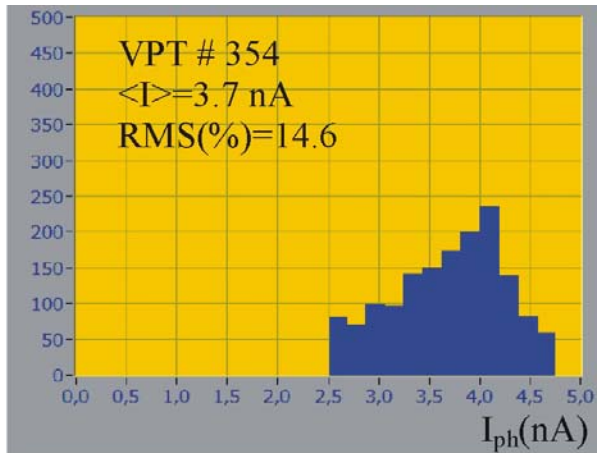


CMS VPT – QE spatial uniformity (1)



CMS Internal Note 2005/09

CMS VPT – QE spatial uniformity (2)



G-APD – working principle

- G-APD up to 1000 APD/mm²
- Single cell size 30-50 μm²
- Cell should be in principle electrically and optically isolated, each cell has ~1 MΩ resistance in series.
- Cells are connected in parallel
- Working bias few volts above breakdown voltage
- There is no proportionality between signal at the output and the incoming light signal. Output signal is the same for one photon or several photons entering the same cell

$$(A_i \sim C_i(V - V_b))$$

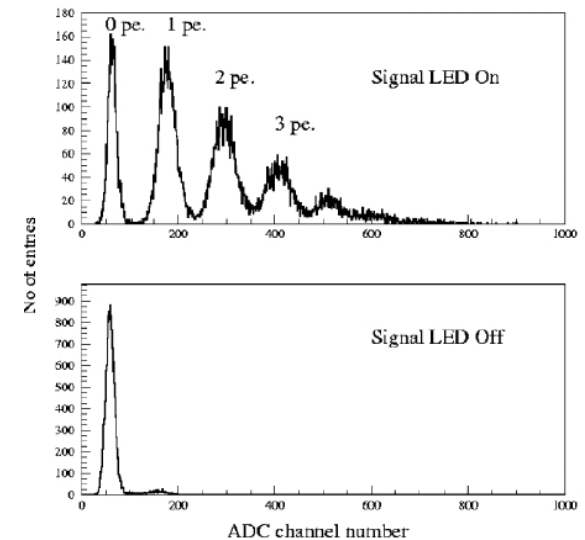
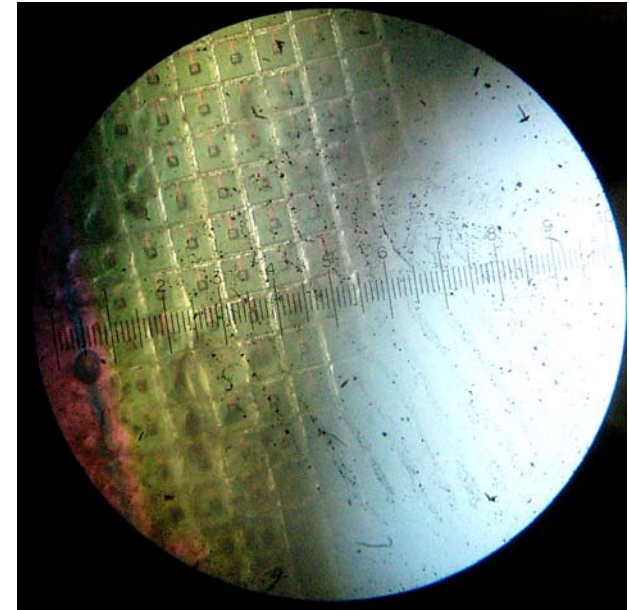
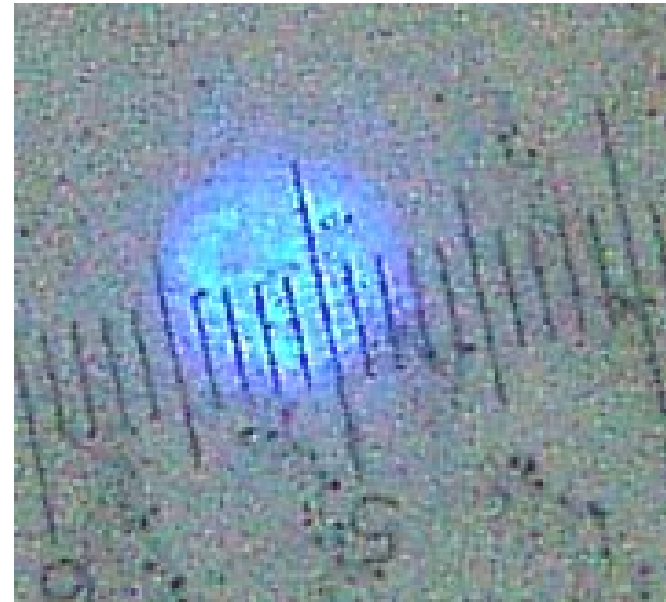
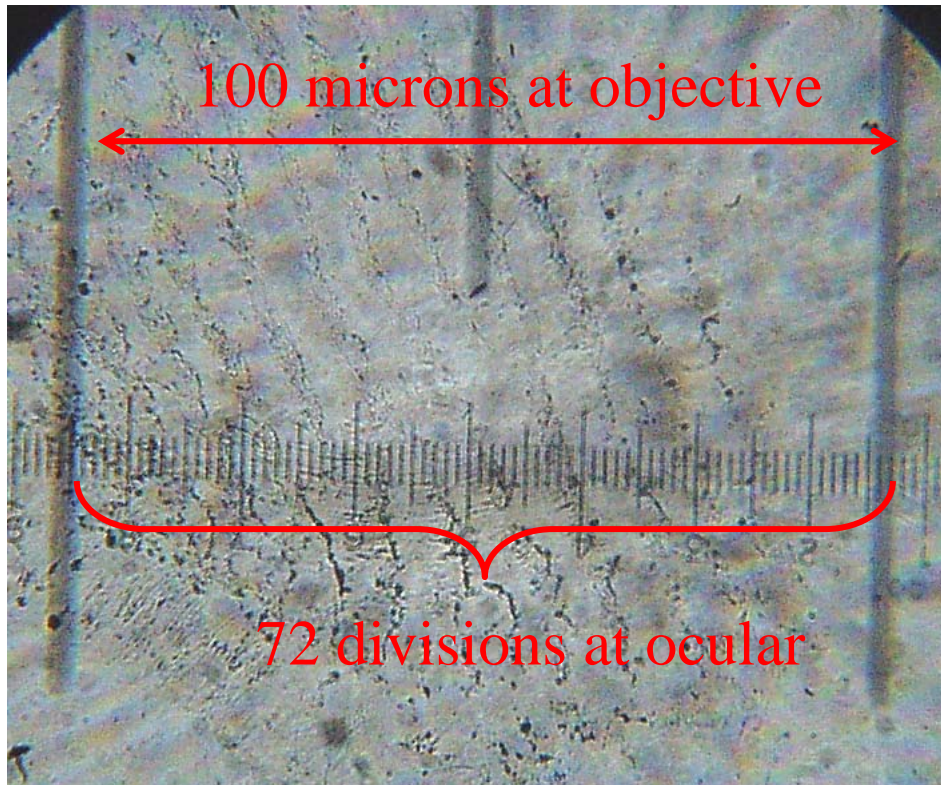


Photo of the light spot seen by microscope

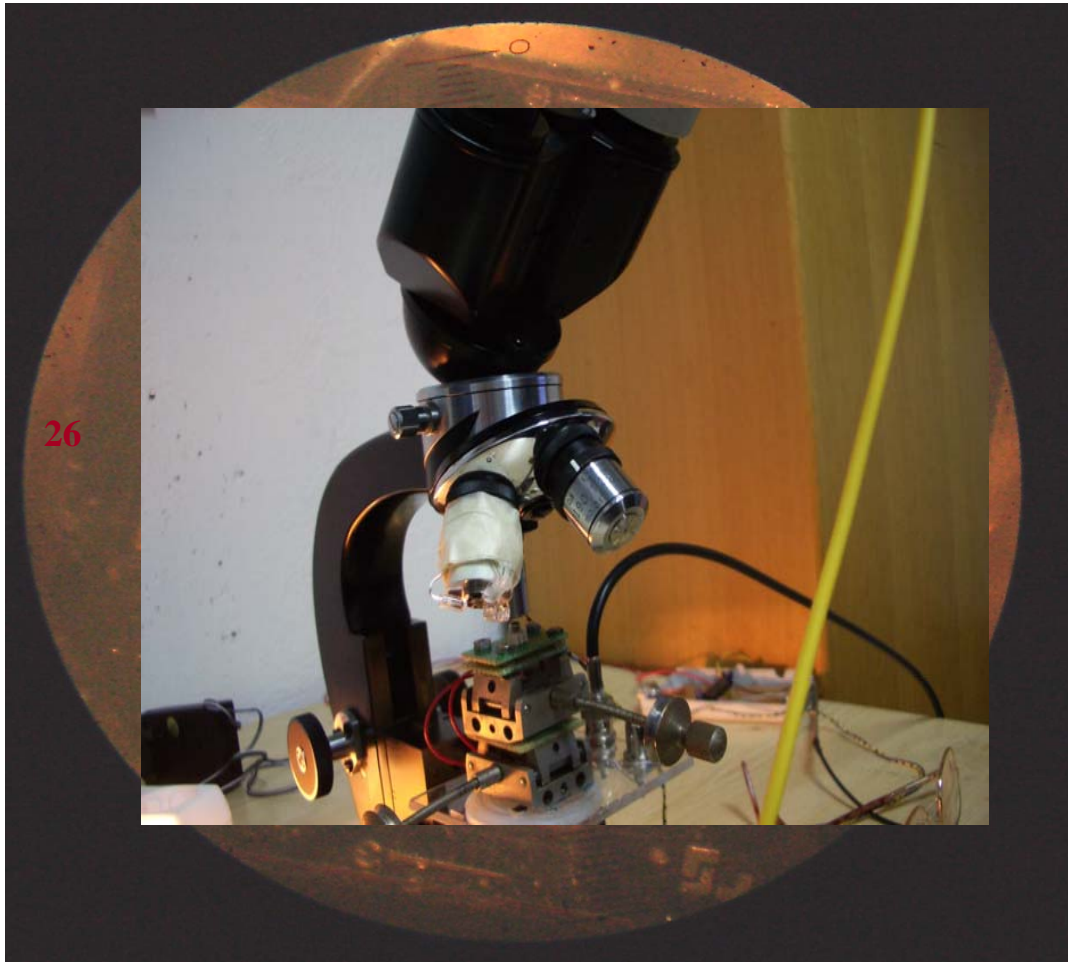
With the same magnification photo of the blue light spot has been taken. Light spot occupies 8 division at ocular, and from the previous measurement one division at ocular corresponds to 1,4 micrometer at objective plate.



$$100/72=1,4 \text{ microns}$$
$$8 \times 1,4=11,2 \text{ microns}$$

Light spot with microscope

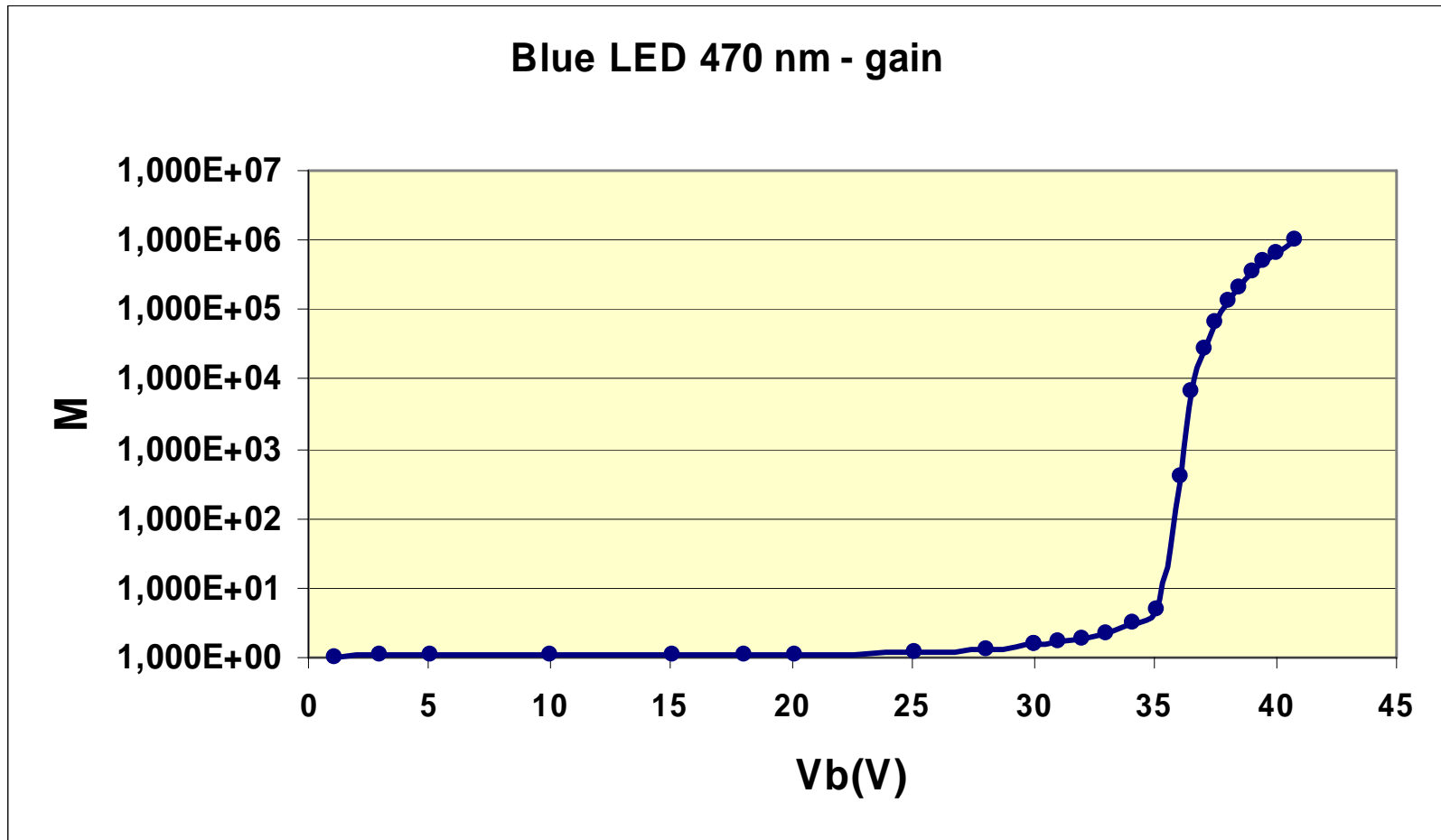
SSPM-050701GR-T028, provided by Photonique



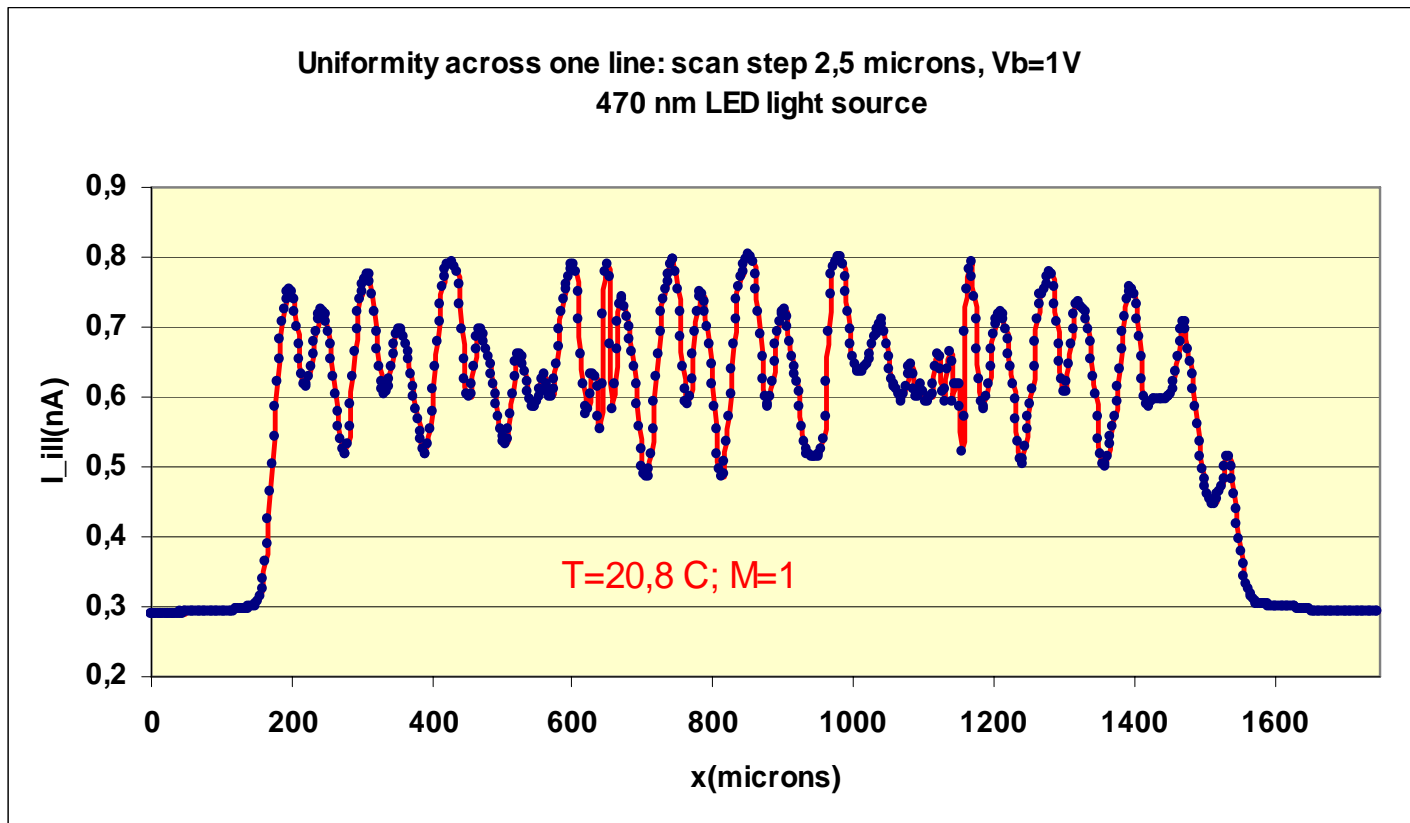
- Light spot with webcam
- We plan to built setup to measure uniformity inside one cell and between cells in order to estimate geometrical factor and to study the uniformity of the PDE, cross-talk, ...

Gain @ 470 nm, T=19 C

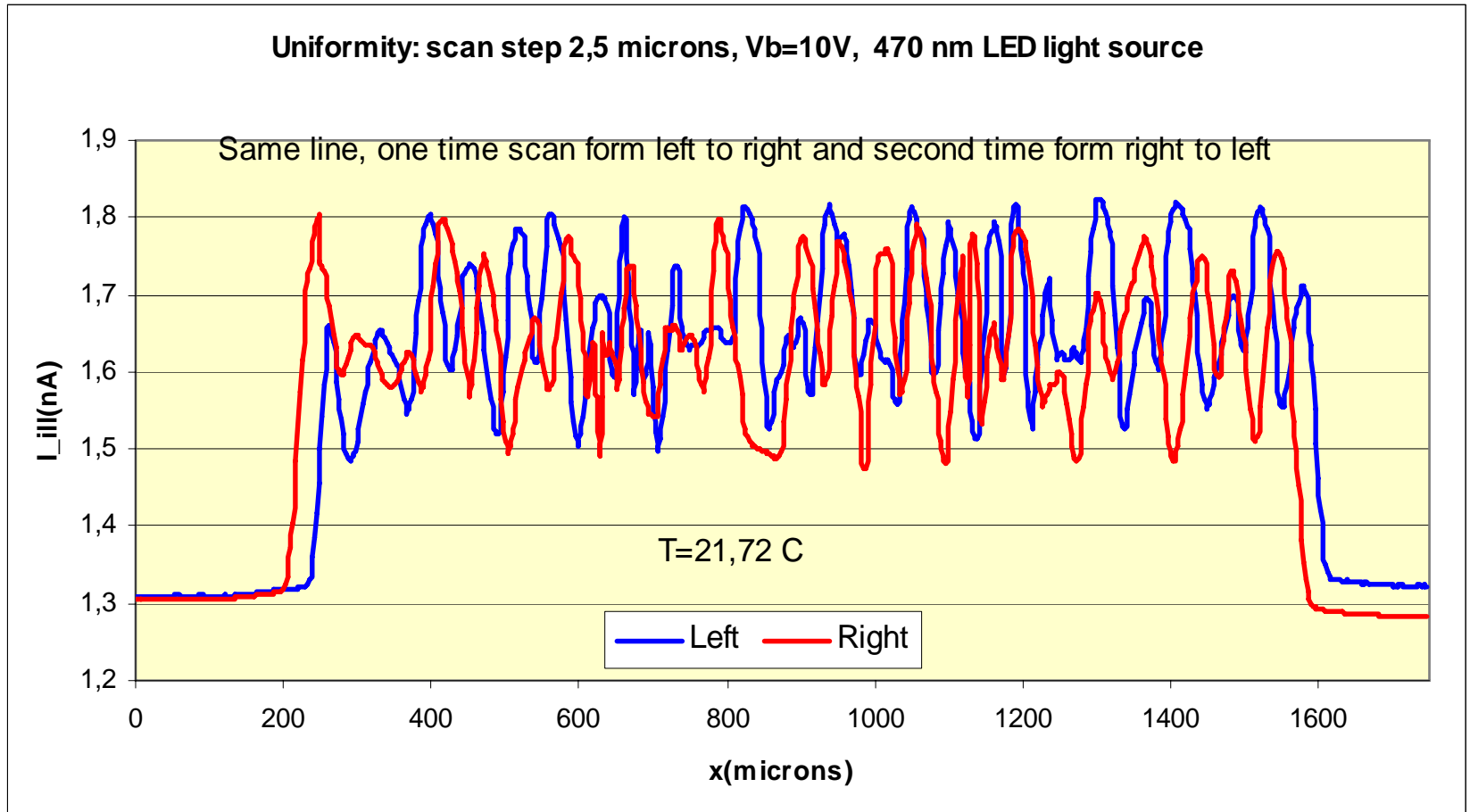
SSPM-050701GR-T028, provided by Photonique



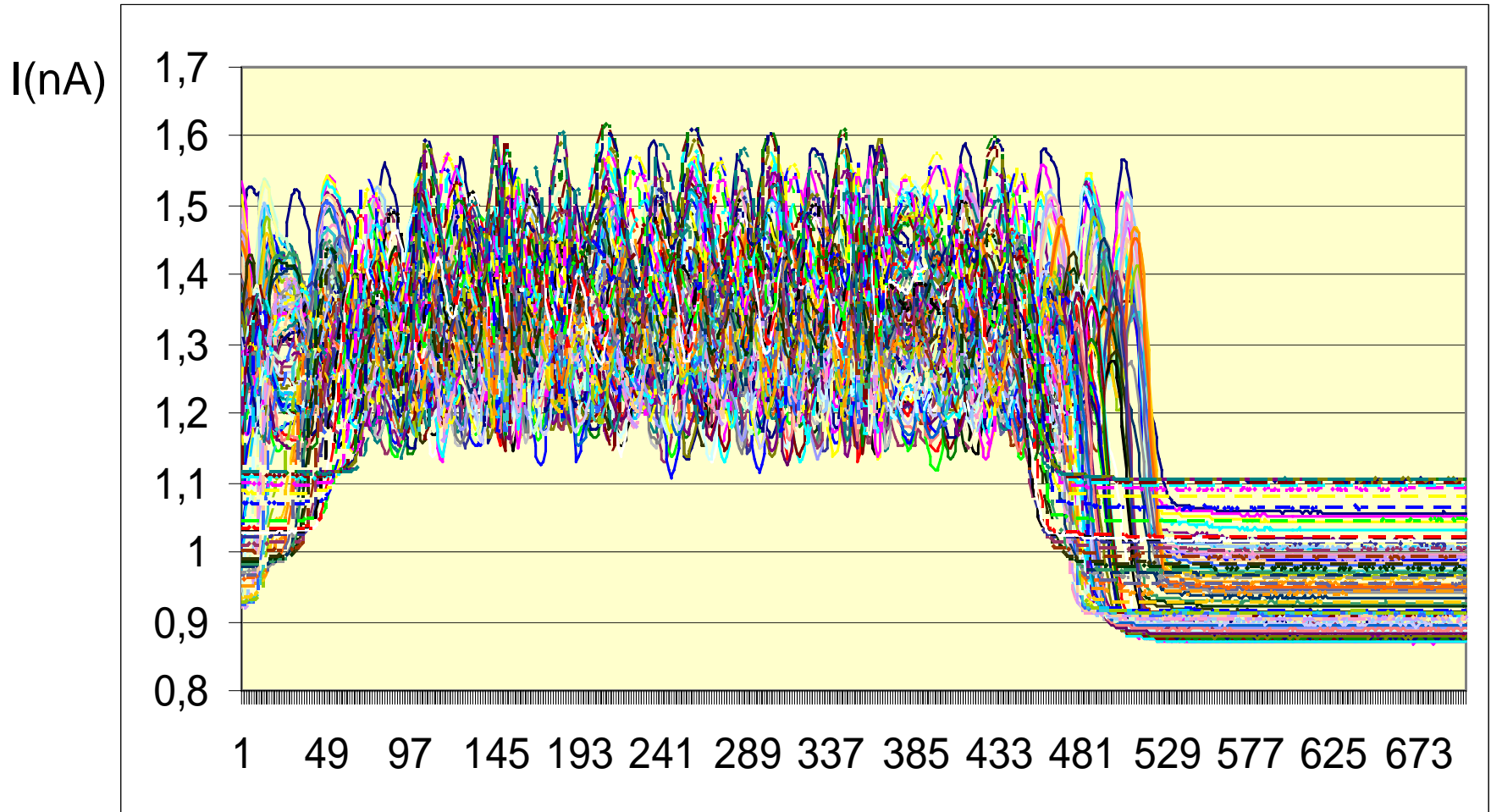
Uniformity with DC light spot, $V_b=1$ V



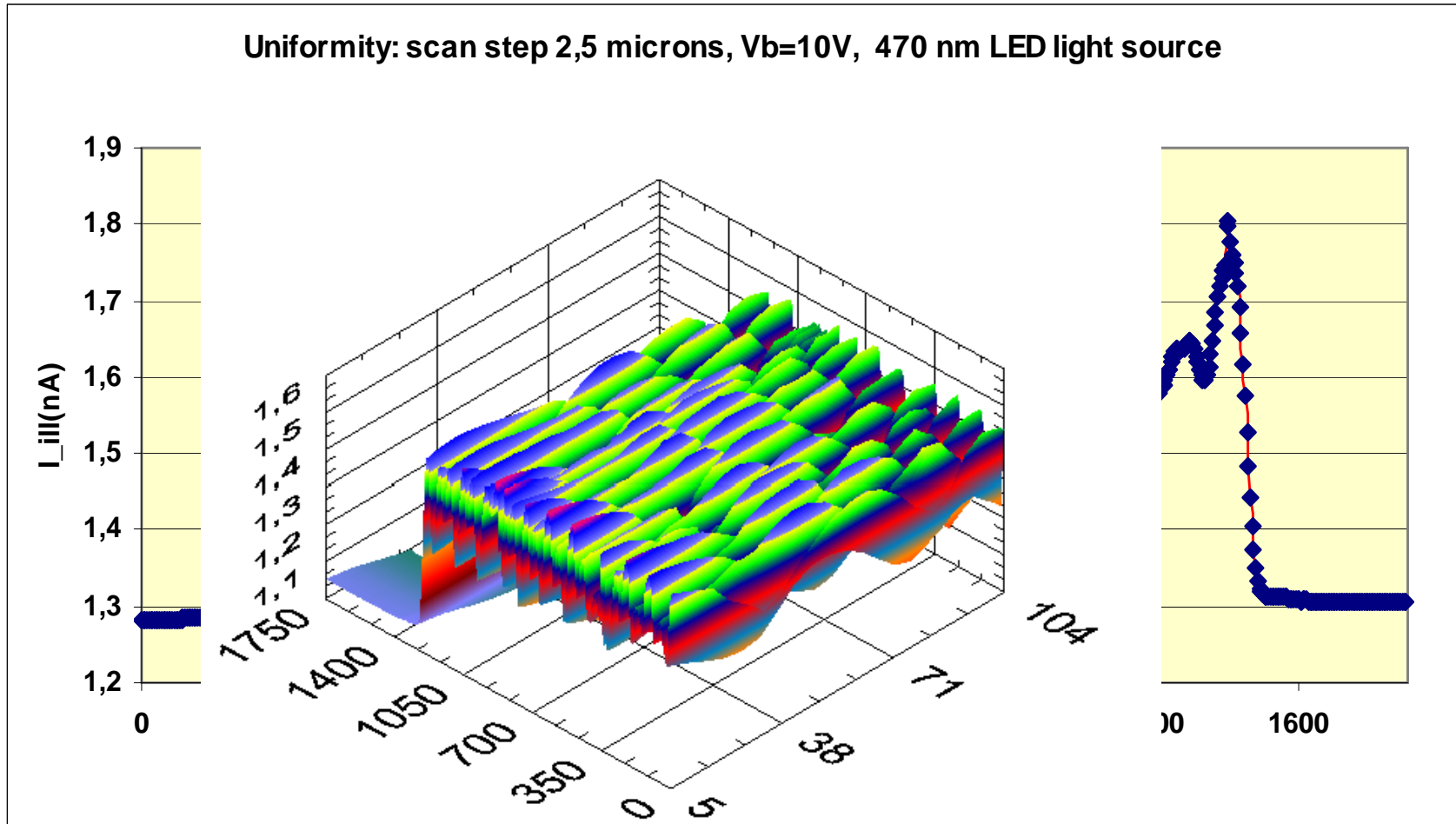
Reproducibility ?



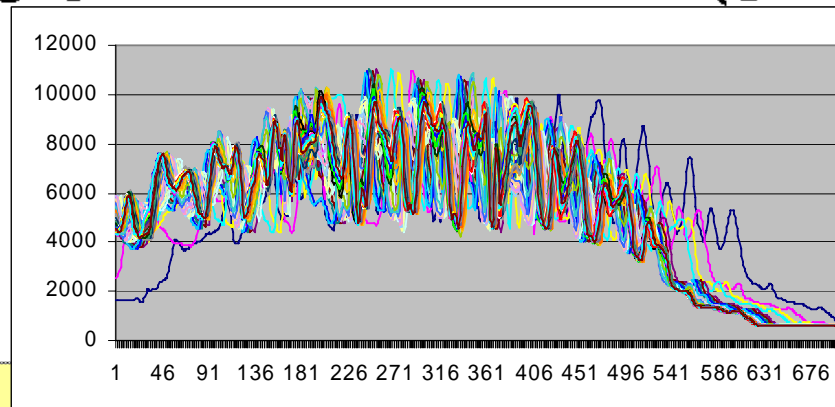
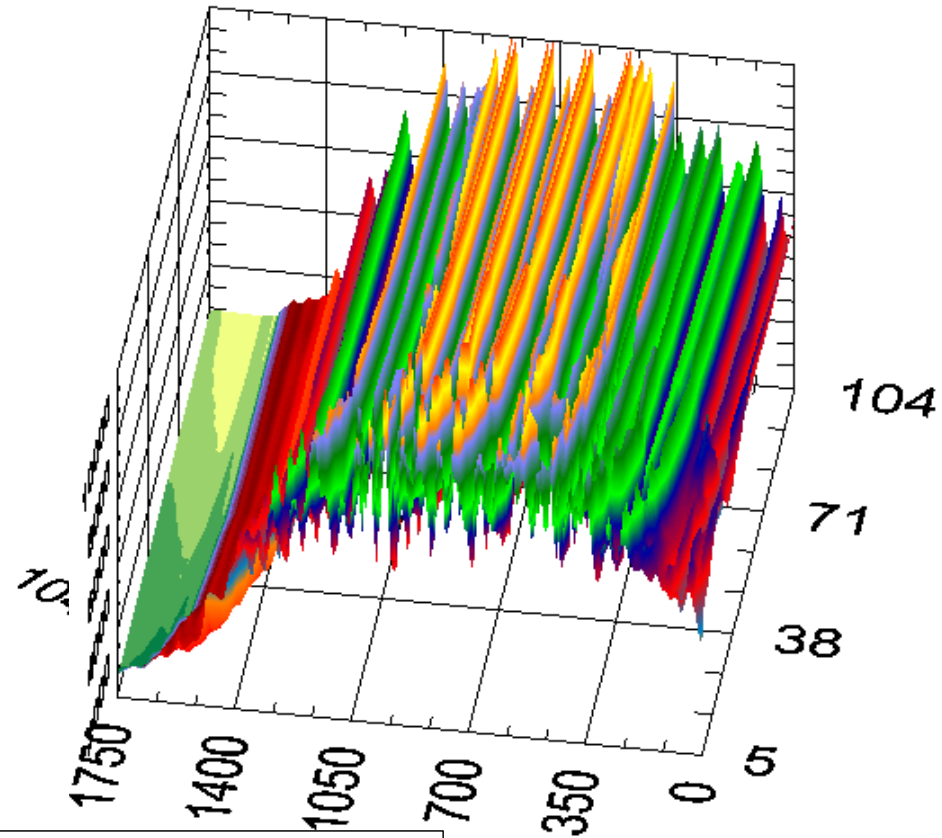
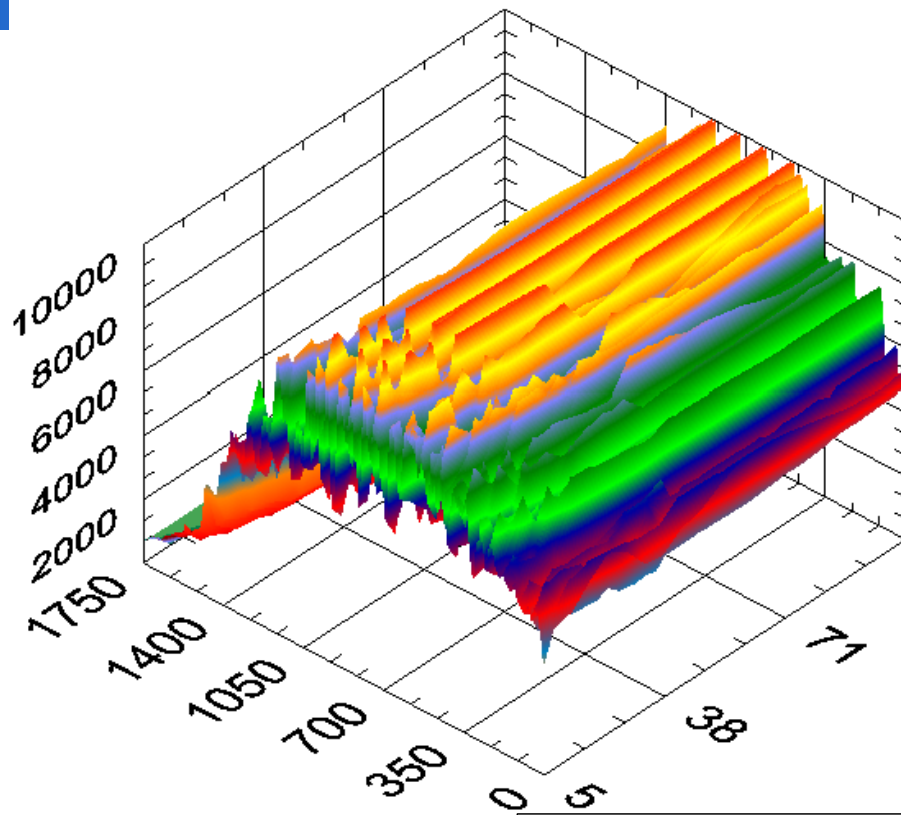
V=10 (V) M=1, LED light: 470 nm)



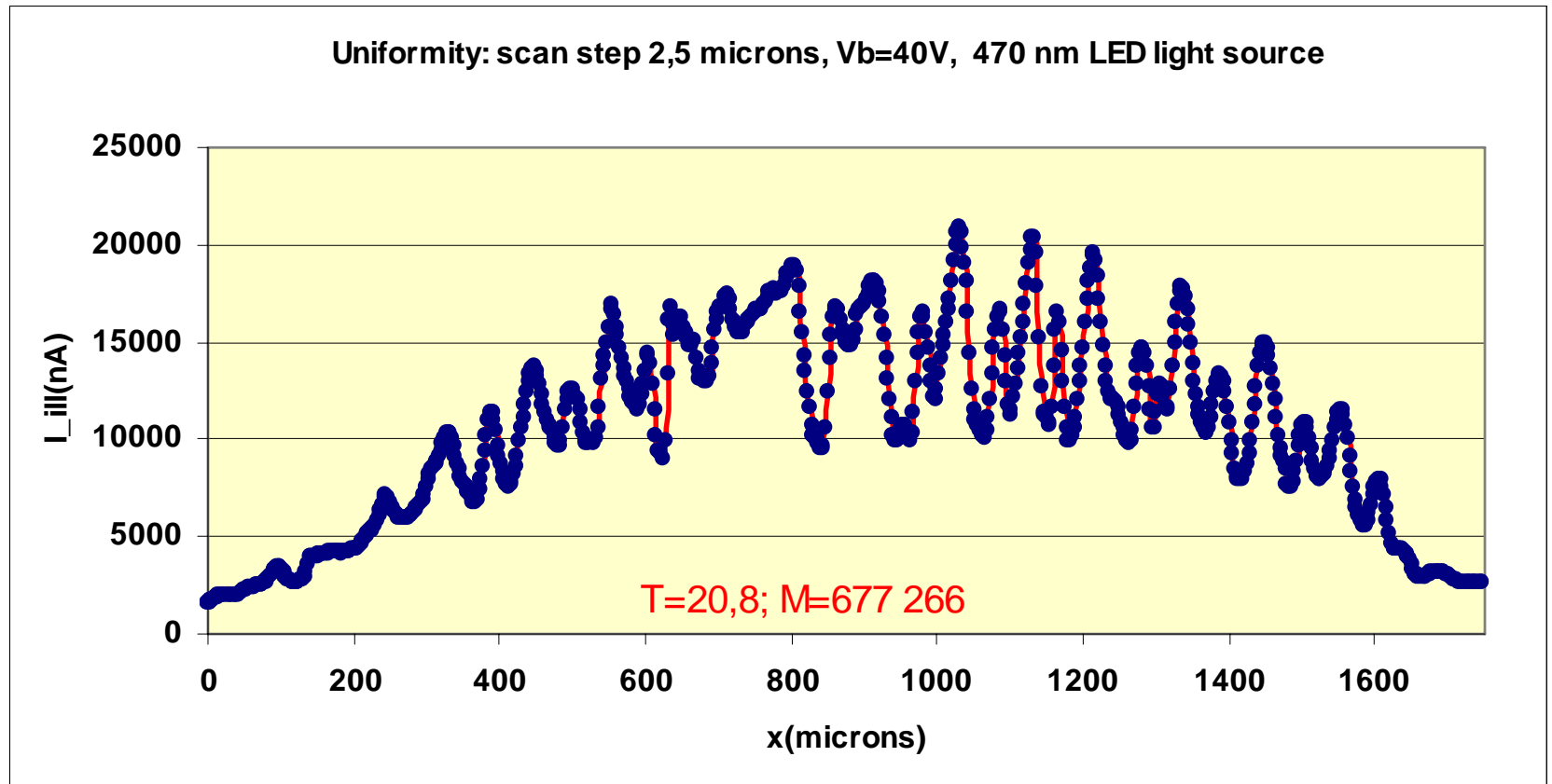
V=10 (V) M=1, LED light: 470 nm)



M=360 000 @ Vb=39 V, $\lambda=470$ nm

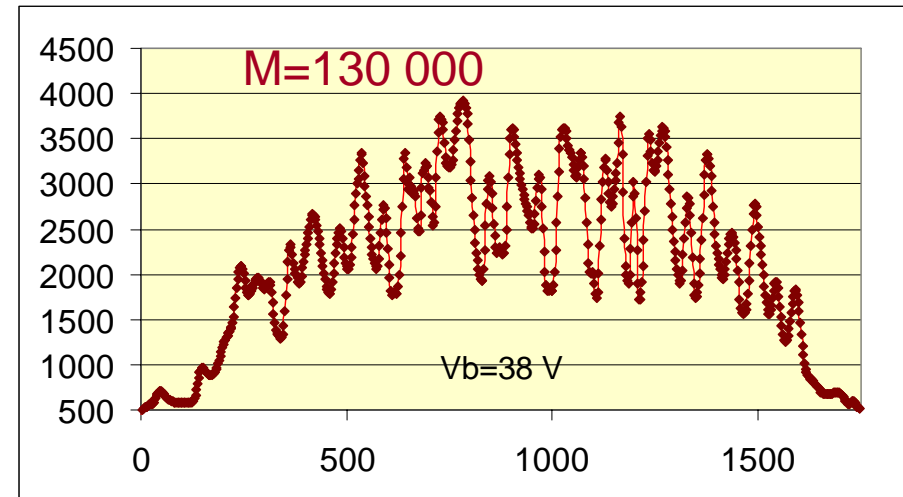
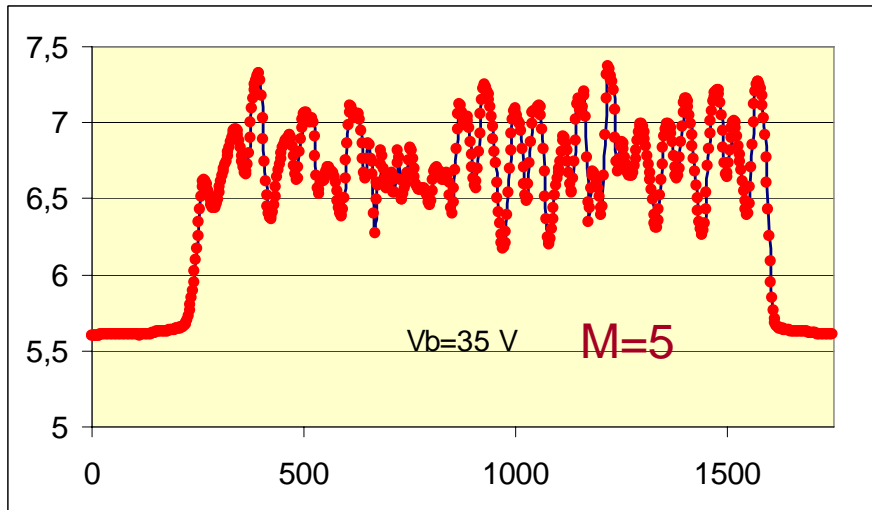
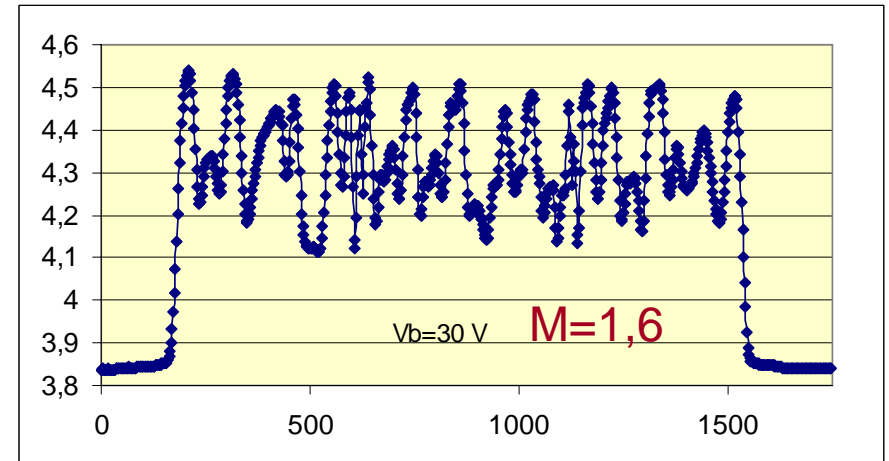
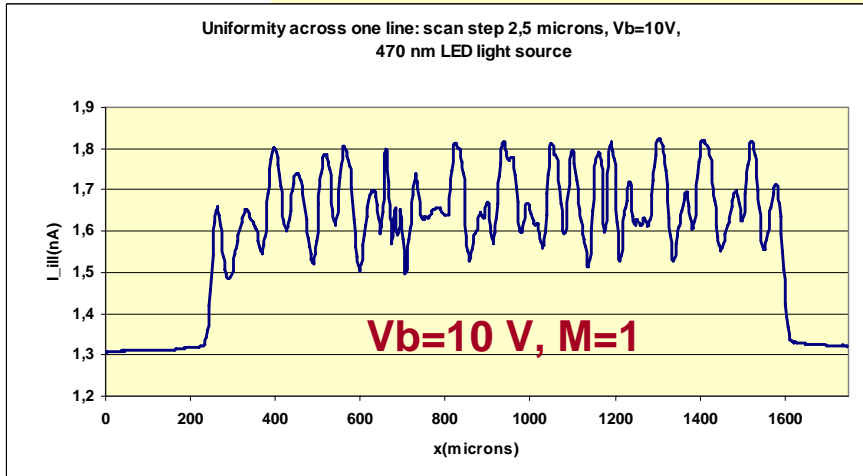


M=677 266 @ Vb=40 V, $\lambda=470$ nm



Uniformity at different gains with 470 nm

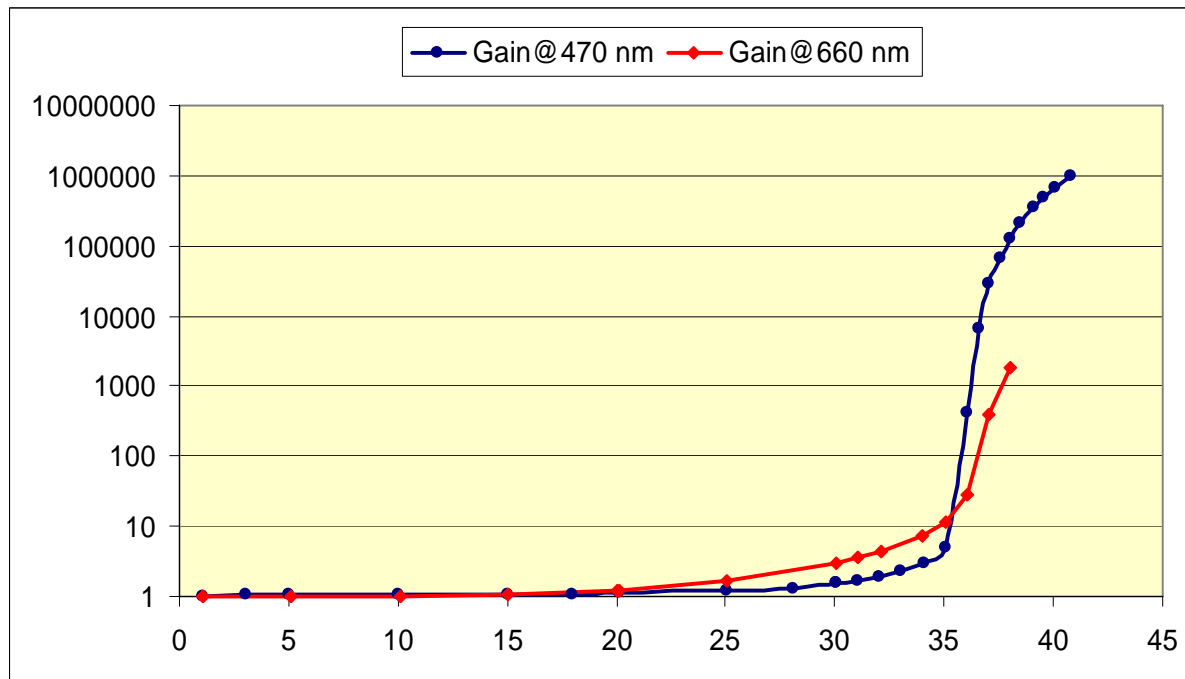
Photonique Green-Red SSPM-050702GR-T028



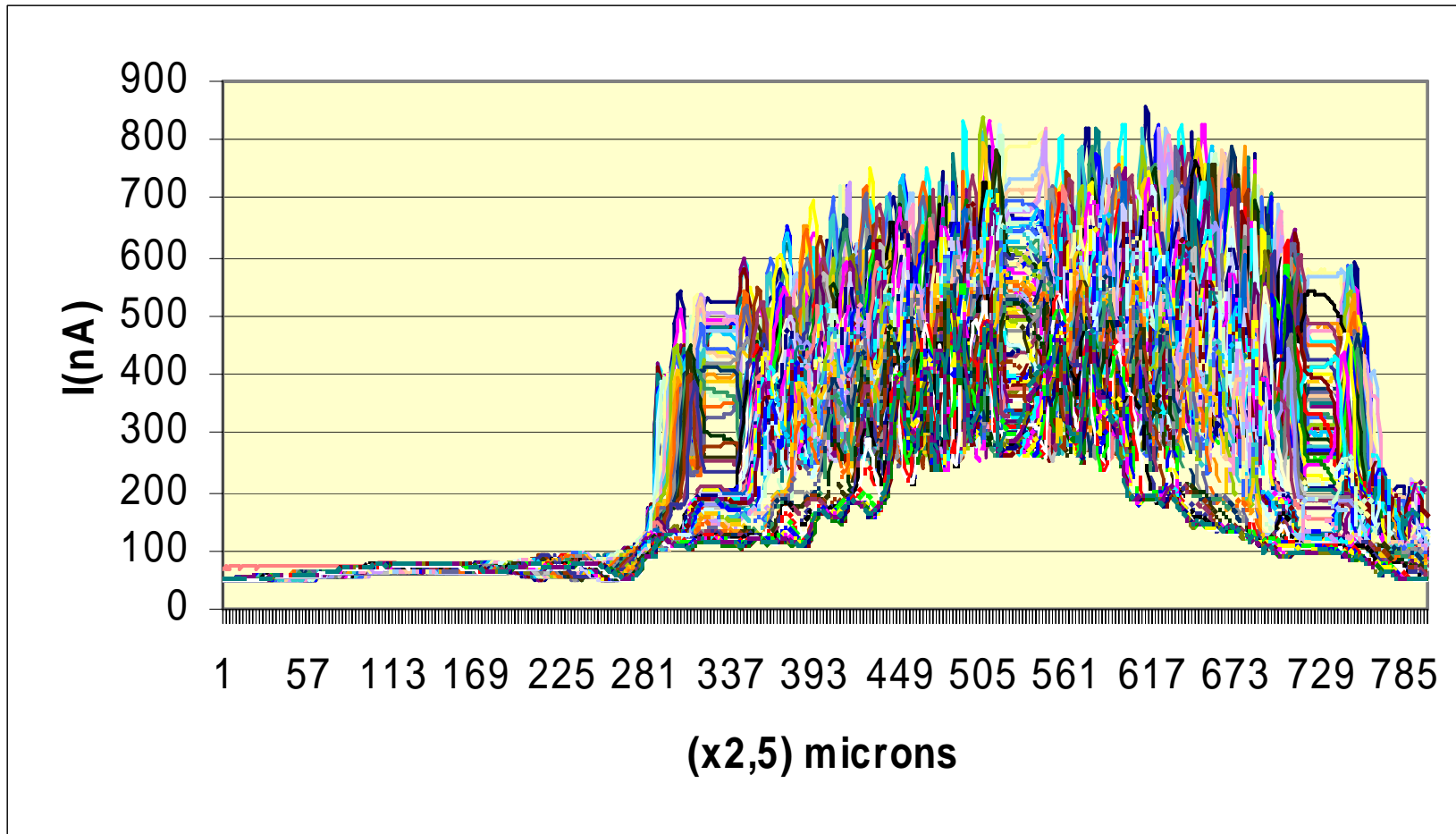
Summary

- Need more measurements to fully understand setup
- Improve setup:
 - check/improve the light collimation in order to perform scan inside one single cell
 - better and firm placement of the diode in order to have the light perpendicular to the photosensitive area.
- Web cam to take and record the photo of the light spot position before each measurements.
- Equip setup with collimated pulsed light of very low intensity and with MCA in order to study cross-talk, PDE, ...

Gain at 470 nm (LED), 660 nm (red laser)



V=37 (V) 470 nm (Blue LED light)



$V=37$ (V), 660 nm (red LASER light)

