

# A UV sensitive integrated Micromegas with Timepix readout

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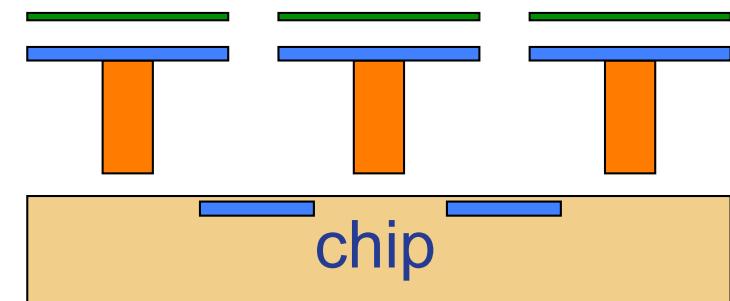


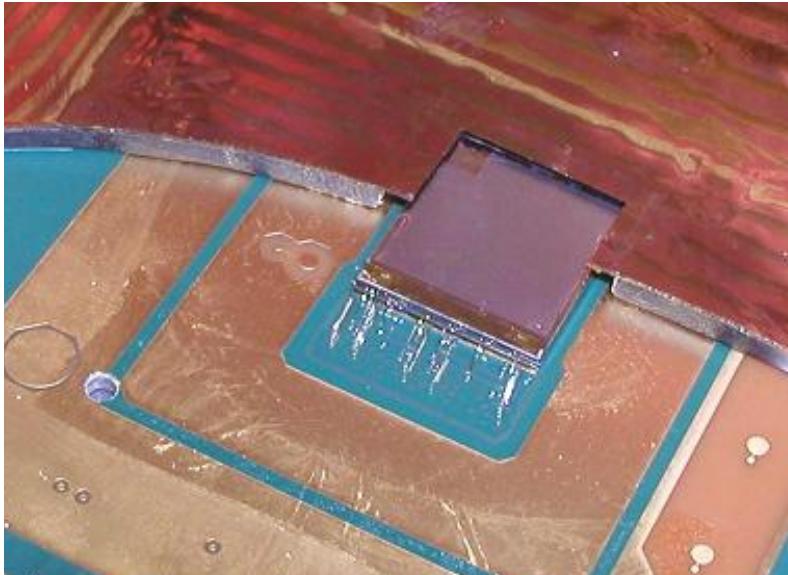
# Overview

- Aim
- The ingredients of our system
- Methods
- Results
  - Gain, feedback
  - Spatial resolution
  - Influence of mesh, images
- Conclusion

## Aim and realization

- Aim: complete integration of a UV photon sensitive detector
- Based on InGrid technology
- High resolution, high sensitivity, high rate
- 3 components:
  - CsI photocathode
  - Ingrid gaseous detector
  - Timepix chips





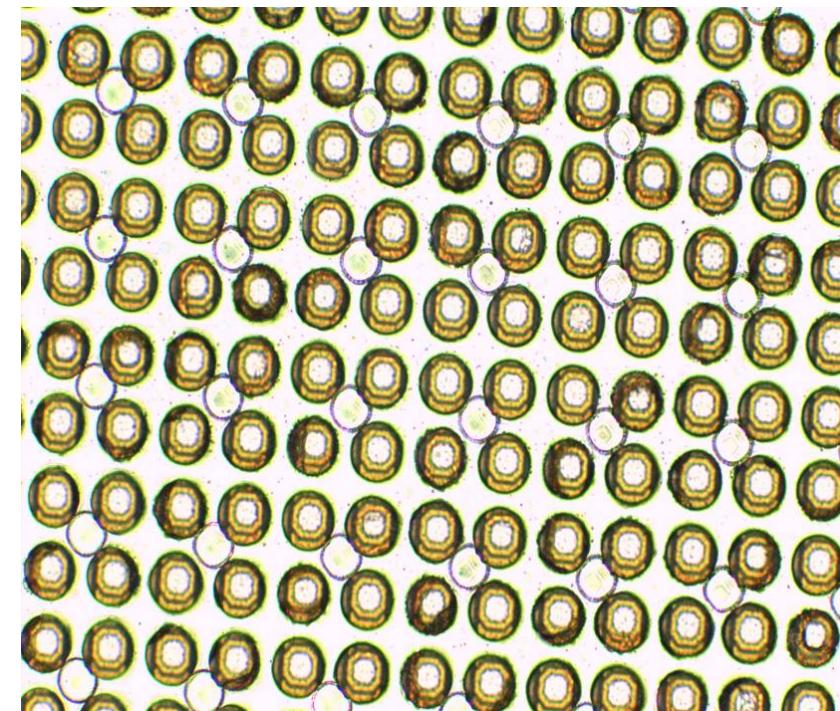
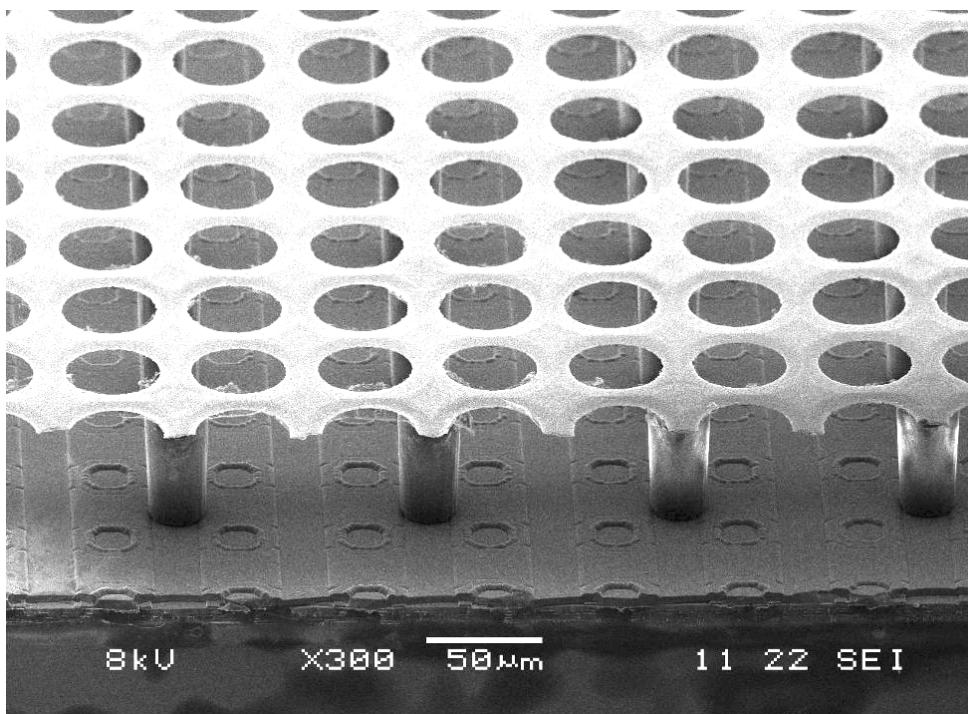
# TimePix

**variation of Medipix2,  
designed by the Medipix2  
collaboration headed by CERN**

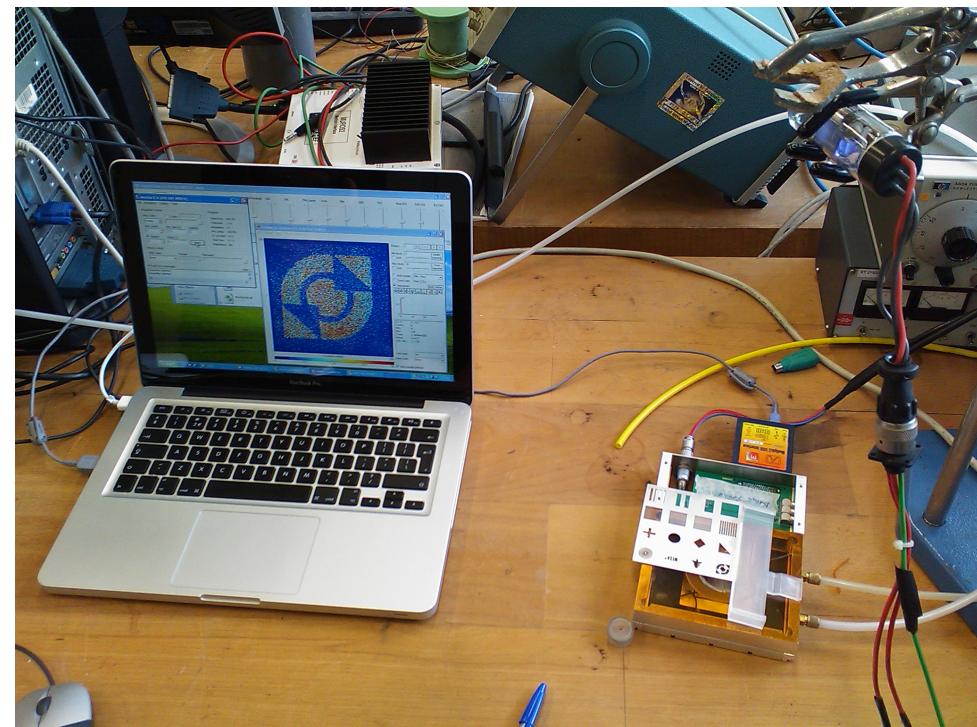
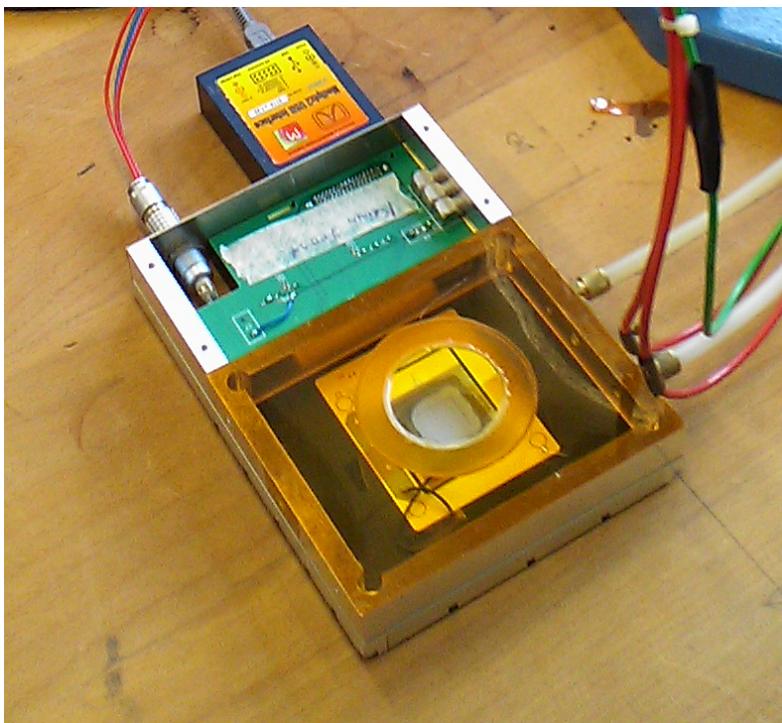
- 256×256 pixels of  $55 \times 55 \mu\text{m}^2$ , charge sensitive
- Different readout modes:
  - MediPix mode: nr of hits per pixel
  - TimePix mode: time of arrival within shutter window
  - TOT mode: estimation of total charge per pixel
- 0.25  $\mu\text{m}$  CMOS, size 14×16 mm
- Post-processing done on chip level or multi-chip cluster level

# InGrid: postprocessed Micromegas

- Highly resistive layer for spark protection
- Metal grid (Al) supported by insulating pillars (SU-8)
- Pillars in the middle of four pixels
- Perfect alignment hole to pixel, pillar to pixel
- Arbitrary hole geometry

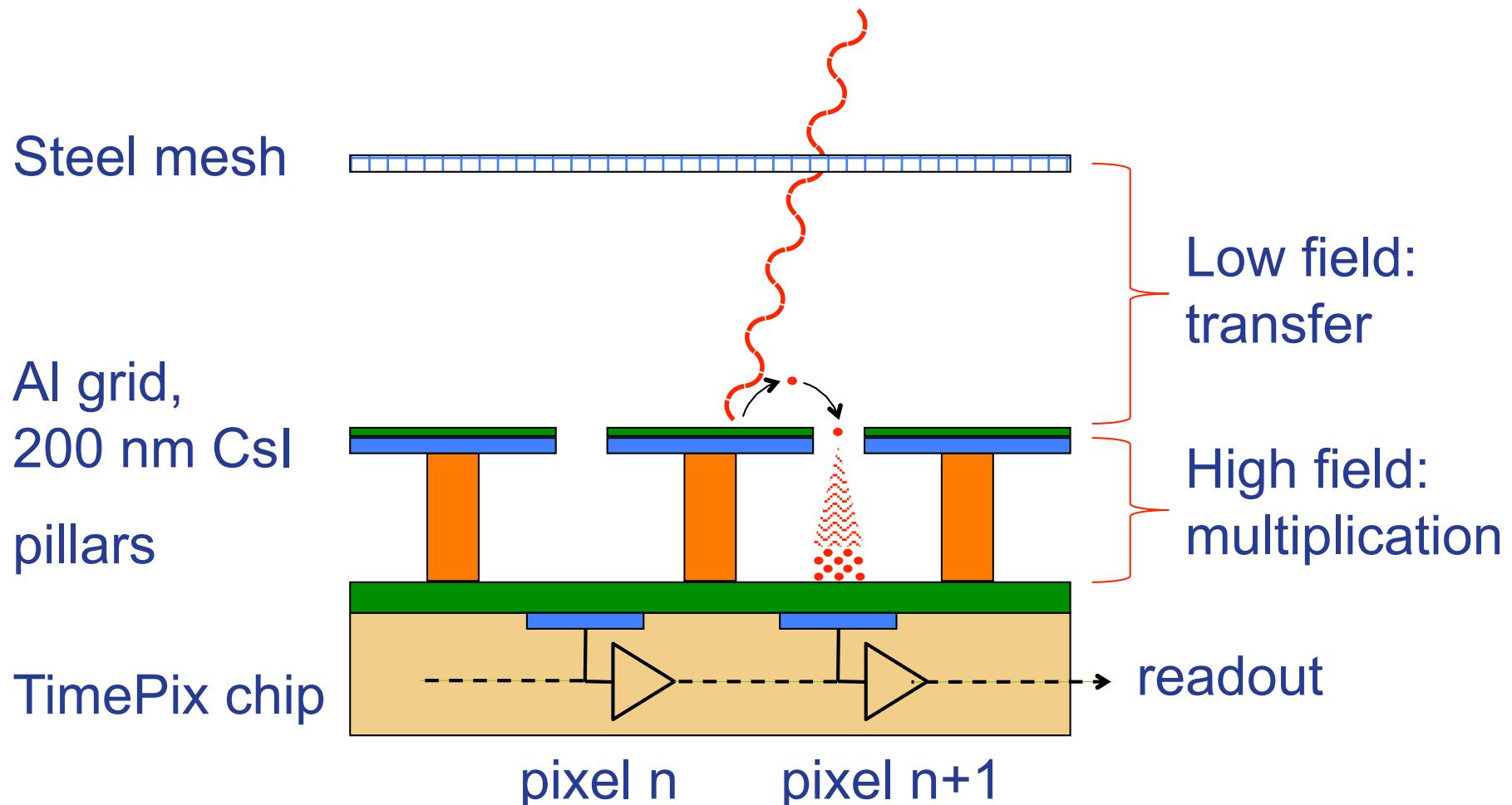


# Complete set-up

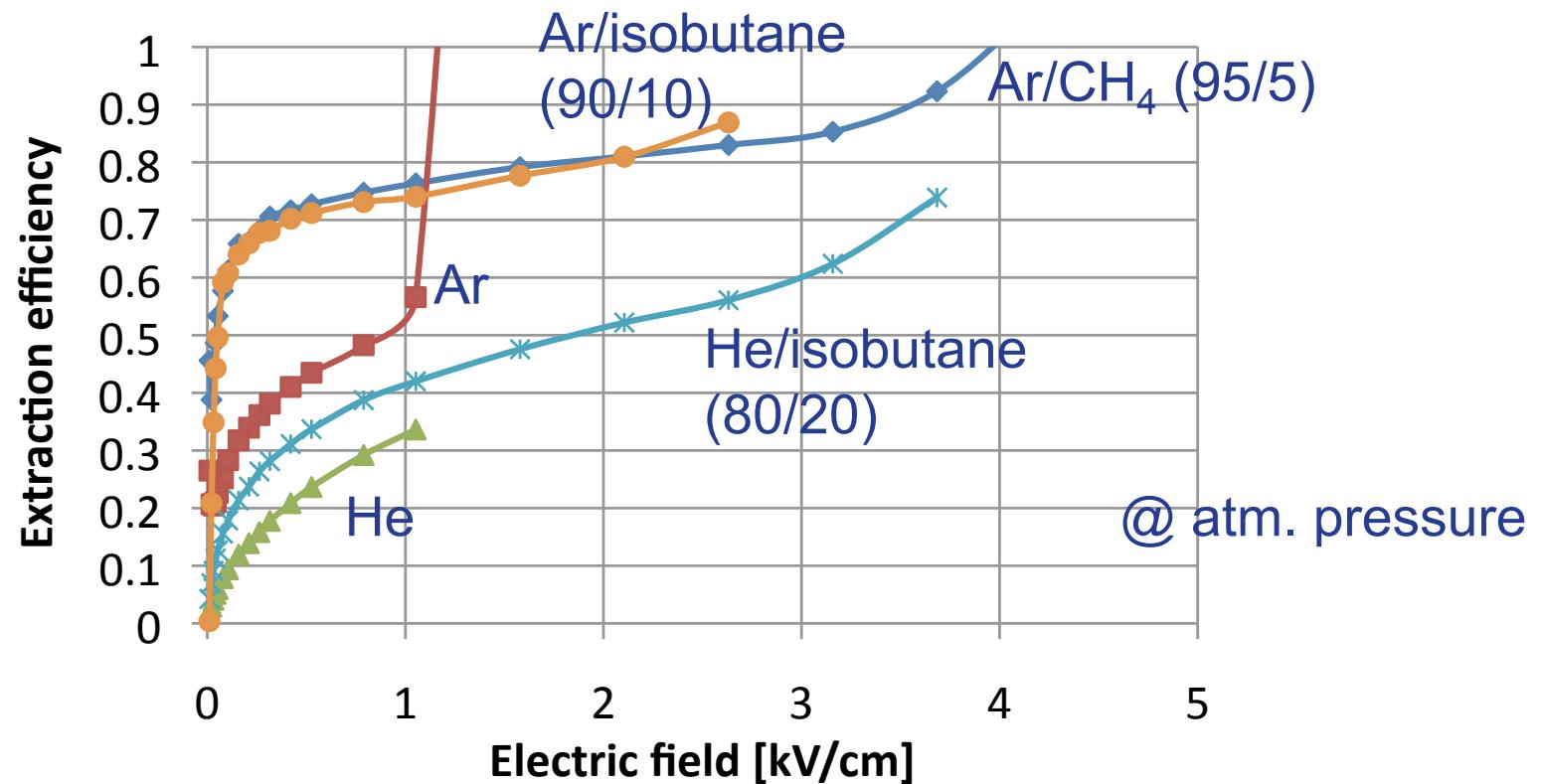


- Si-nitride spark protection of 8  $\mu\text{m}$
- Typical InGrid: 80  $\mu\text{m}$  gap, 25  $\mu\text{m}$  holes (OT: 19%)
- GOSSIP/NEXT chamber, USB readout
- CsI is deposited by thermal evaporation, after chip is processed and mounted on board

# Operation principle of a light sensitive InGrid

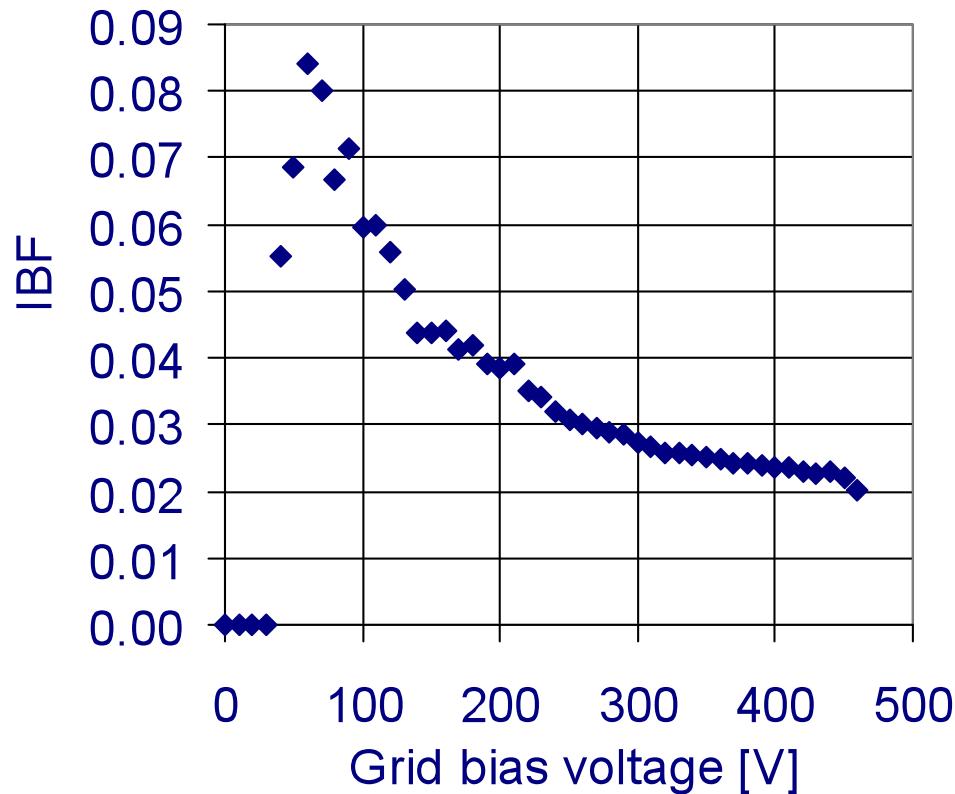


# Extraction of primary electrons into He/isobutane



- He shows increased backscattering (compared to Ar)
- Addition of quencher (isobutane) restores yield (partially)
- High concentration of isobutane leads to UV absorption

# Ion Back Flow (IBF) measurement



IBF:

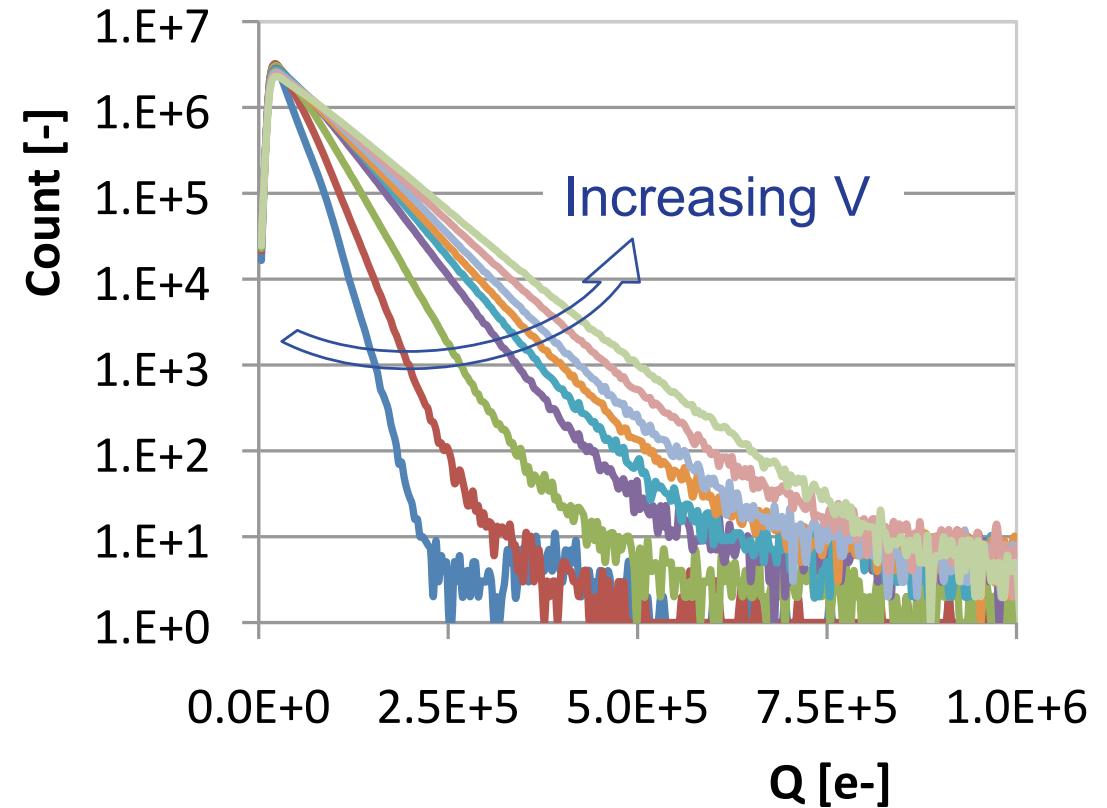
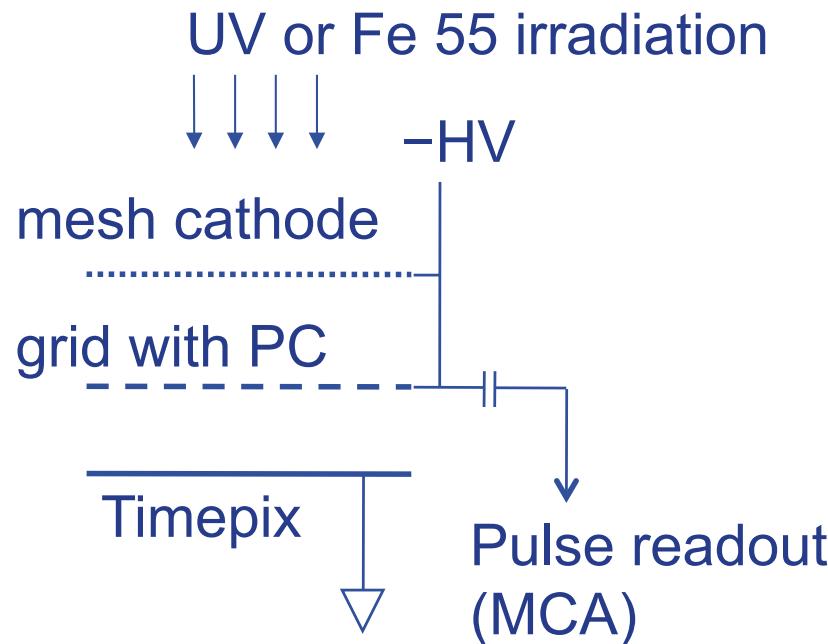
Fraction of anode current  
that flows back to cathode  
(as ions)

Ions can damage  
photocathode  
(surface reactions)

## Options for reduction

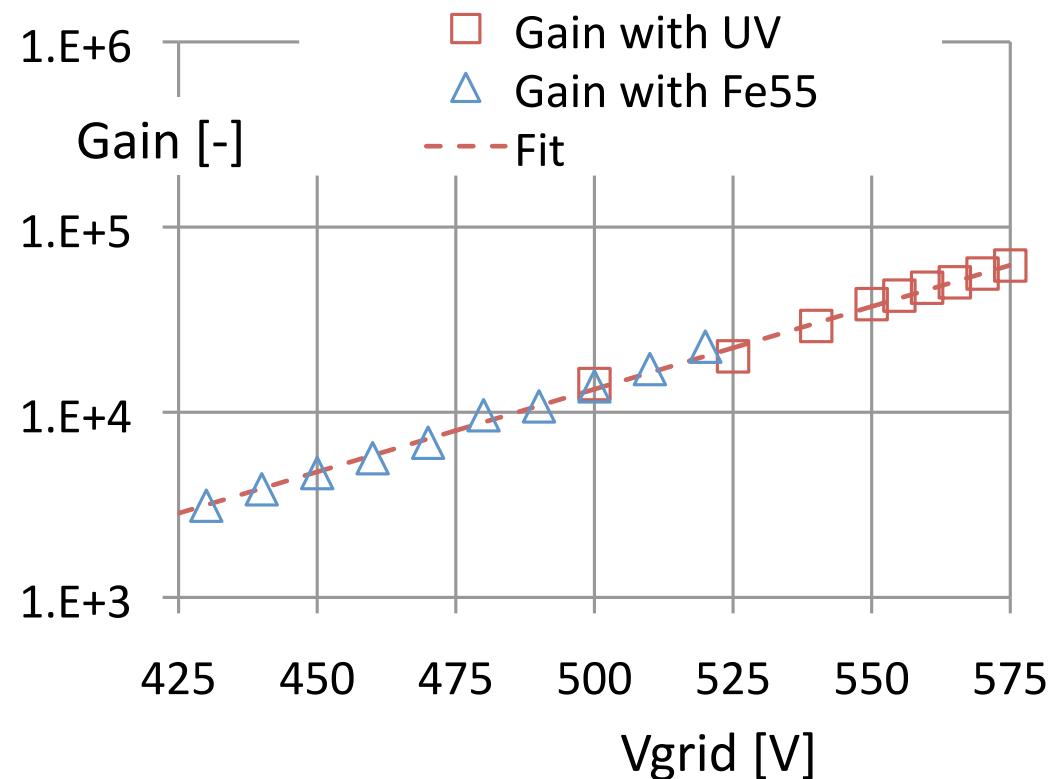
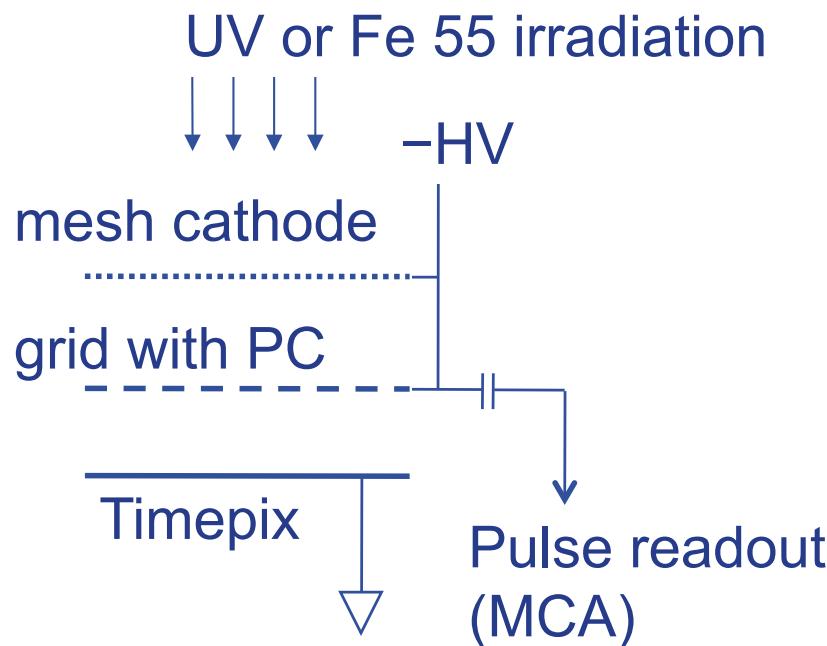
- Optimization of geometry, field ratio, gas  
Saclay (Colas et al.) reported IBF  $\sim 0.001$
- Multistage structures (IBF not known)

# UV pulses measured on grid



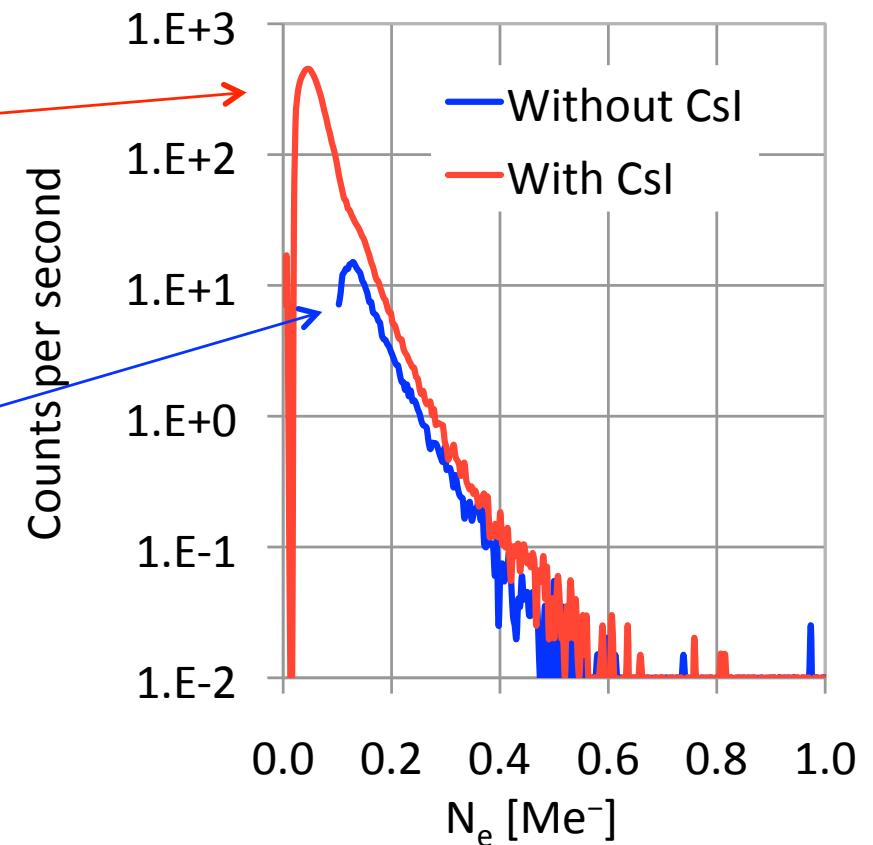
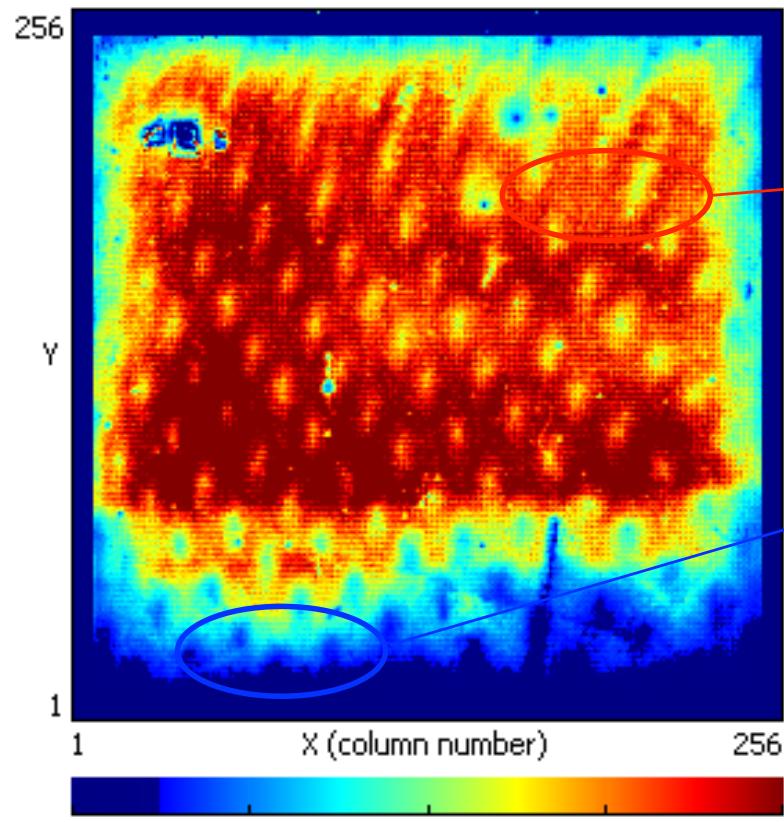
- He/isobutane (80/20), Al grid with 200 nm CsI
- Distribution  $G(Q) \propto C \cdot 1/G \cdot \exp(-Q/G)$
- Fit to distribution → extract  $G(V)$

# Gain of InGrid device with PC



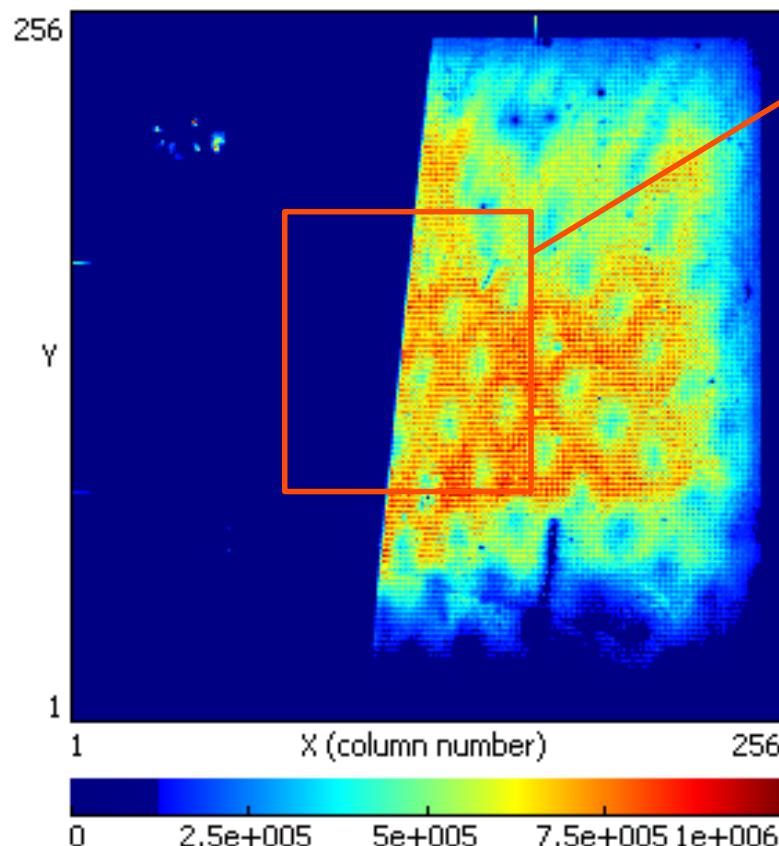
- He/isobutane (80/20), Al grid with 200 nm CsI, 80  $\mu\text{m}$  gap height, 25  $\mu\text{m}$  hole size
- slope  $\approx 100\text{--}110 \text{ V/dec}$ , max. gain  $\approx 8\cdot 10^4$

# Spectra with and without CsI



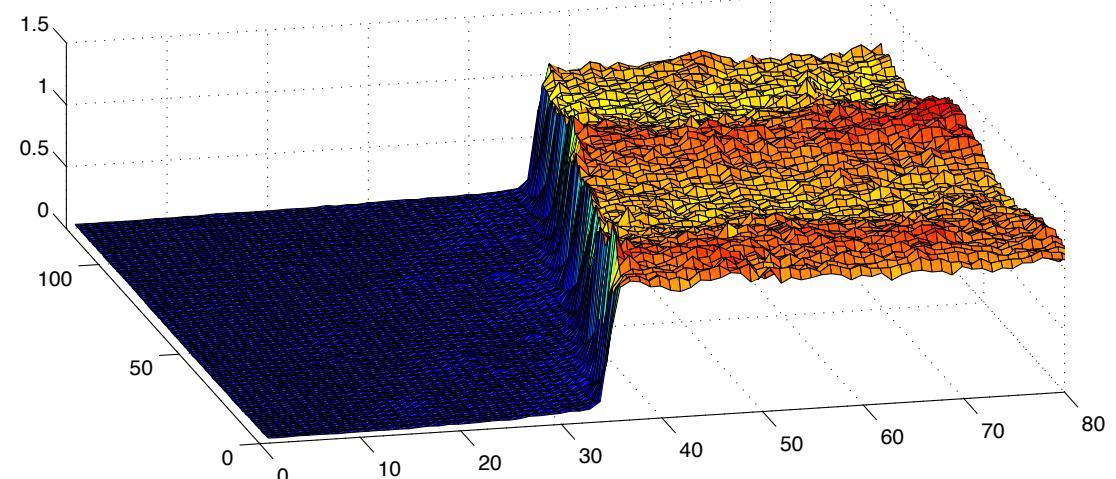
→ No increase in (photon) feedback

# Determining spatial resolution using slanted edge method

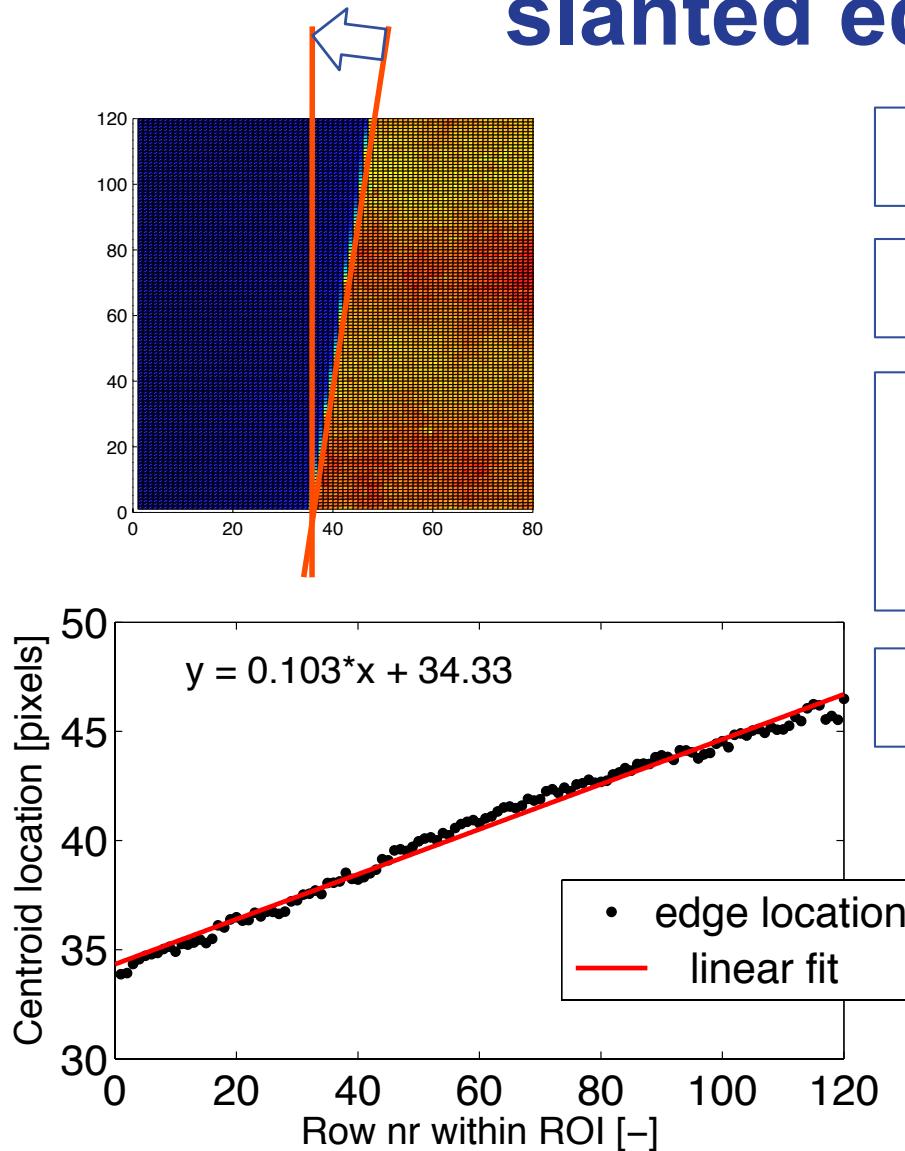


Select ROI

Correct using open frame



# Determining spatial resolution using slanted edge method



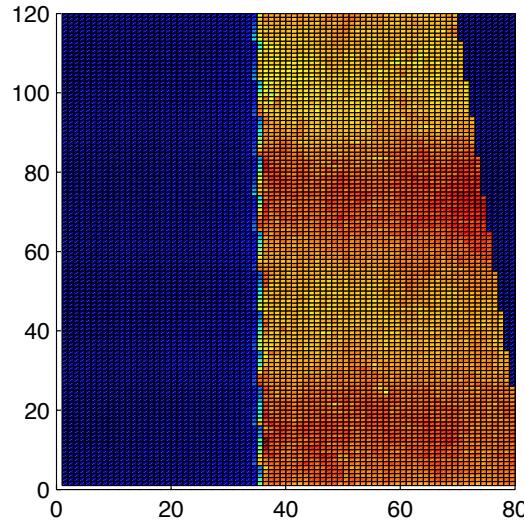
Select ROI

Correct using open frame

Find edge using derivation for all  
lines and fit a line

Shift line data accordingly

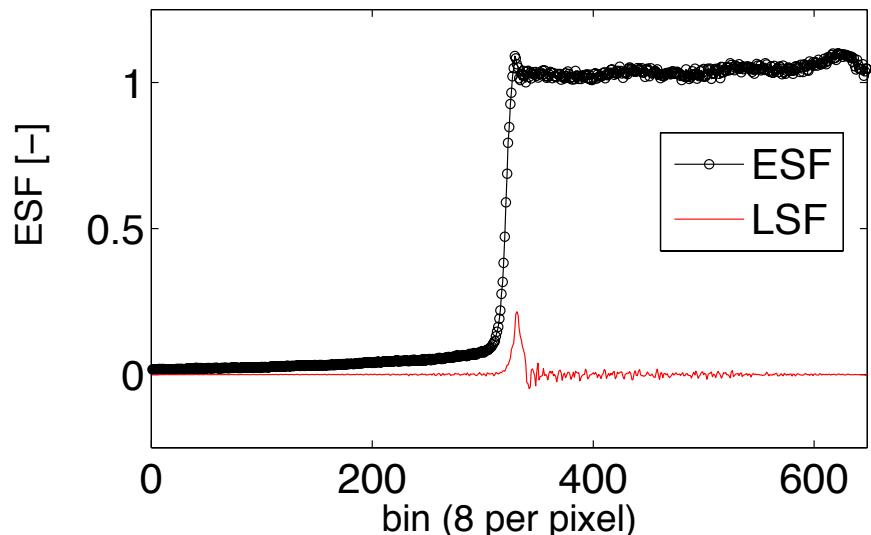
# Determining spatial resolution using slanted edge method



Select ROI

Correct using open frame

Find edge using derivation for all lines and fit a line



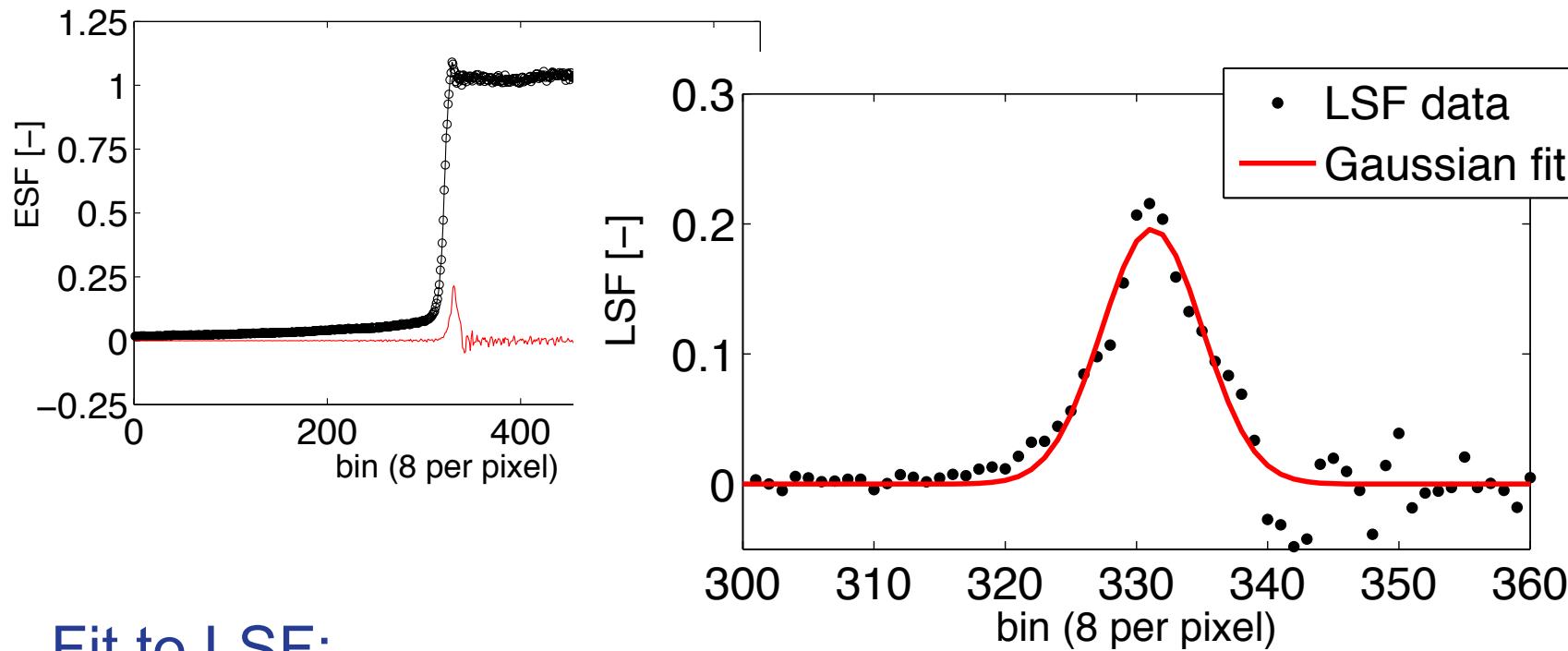
Shift line data accordingly

Combine and resample into 1 ESF

Calculate LSF

Determine resolution

# Determining spatial resolution using slanted edge method

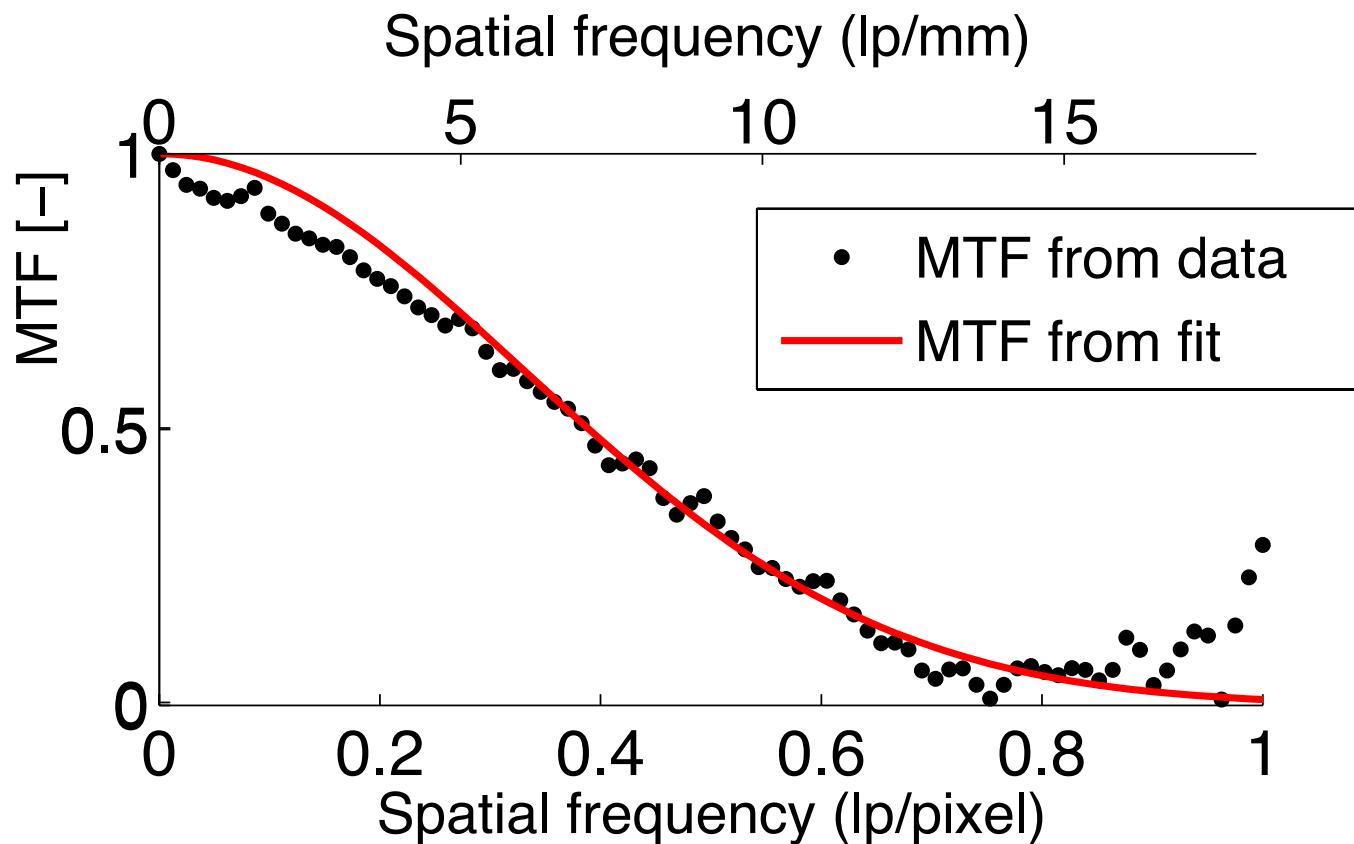


Fit to LSF:

- Gaussian with  $\sigma = 0.48$  pixel =  $26.4 \mu\text{m}$
- FWHM =  $1.13$  pixel =  $62.2 \mu\text{m}$

Fourier transformation of LSF → MTF

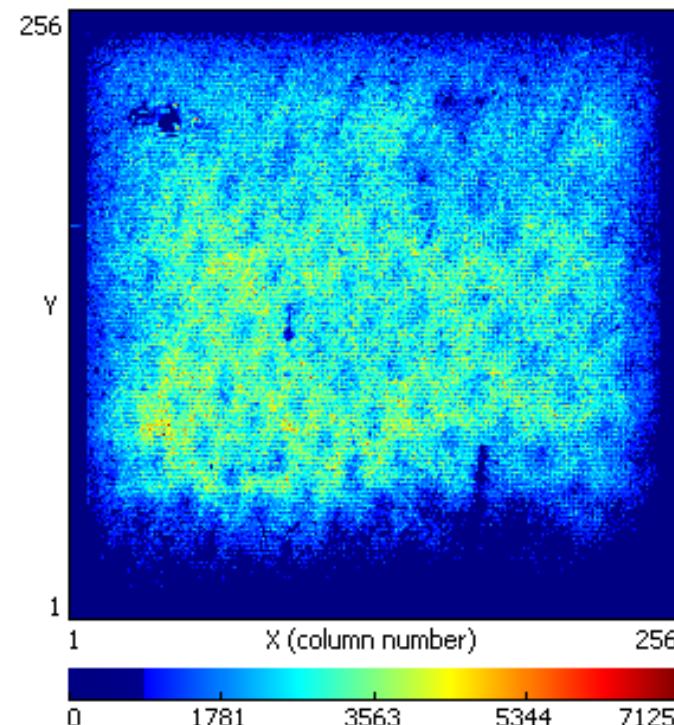
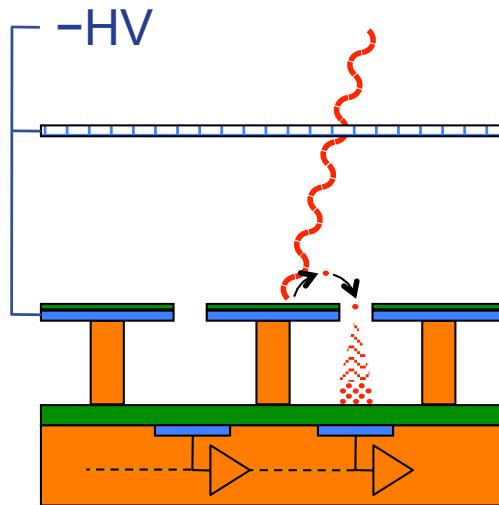
## MTF calculated from LSF



- $MTF_{50} = 0.4 \text{ lp/pixel} (\approx 7 \text{ lp/mm})$
- Limit  $\approx 0.8 \text{ lp/pixel} (\approx 14 \text{ lp/mm})$
- Resolution < pixel size ( $MTF = 0.32 @ f_{\text{Nyquist}}$ )

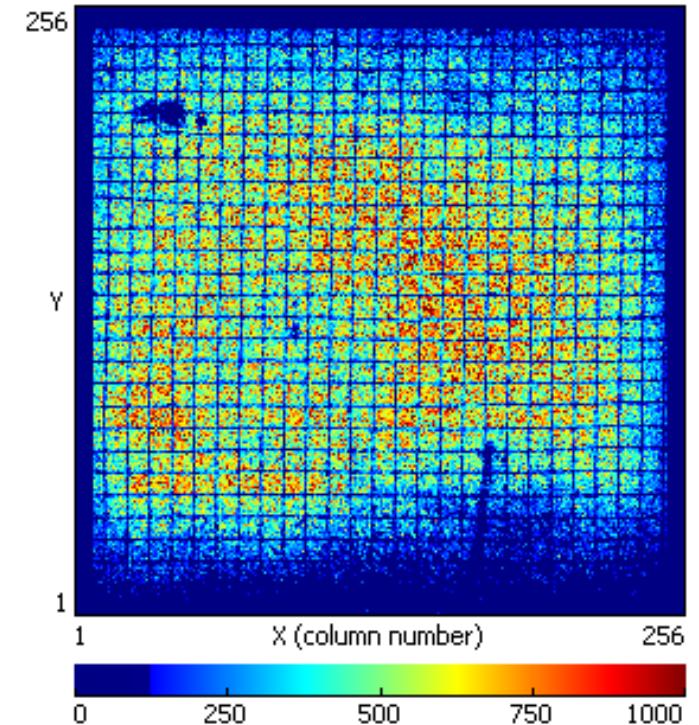
# Influence of cathode mesh

Mesh modulates light → non-uniform response,  
but also indication of resolution



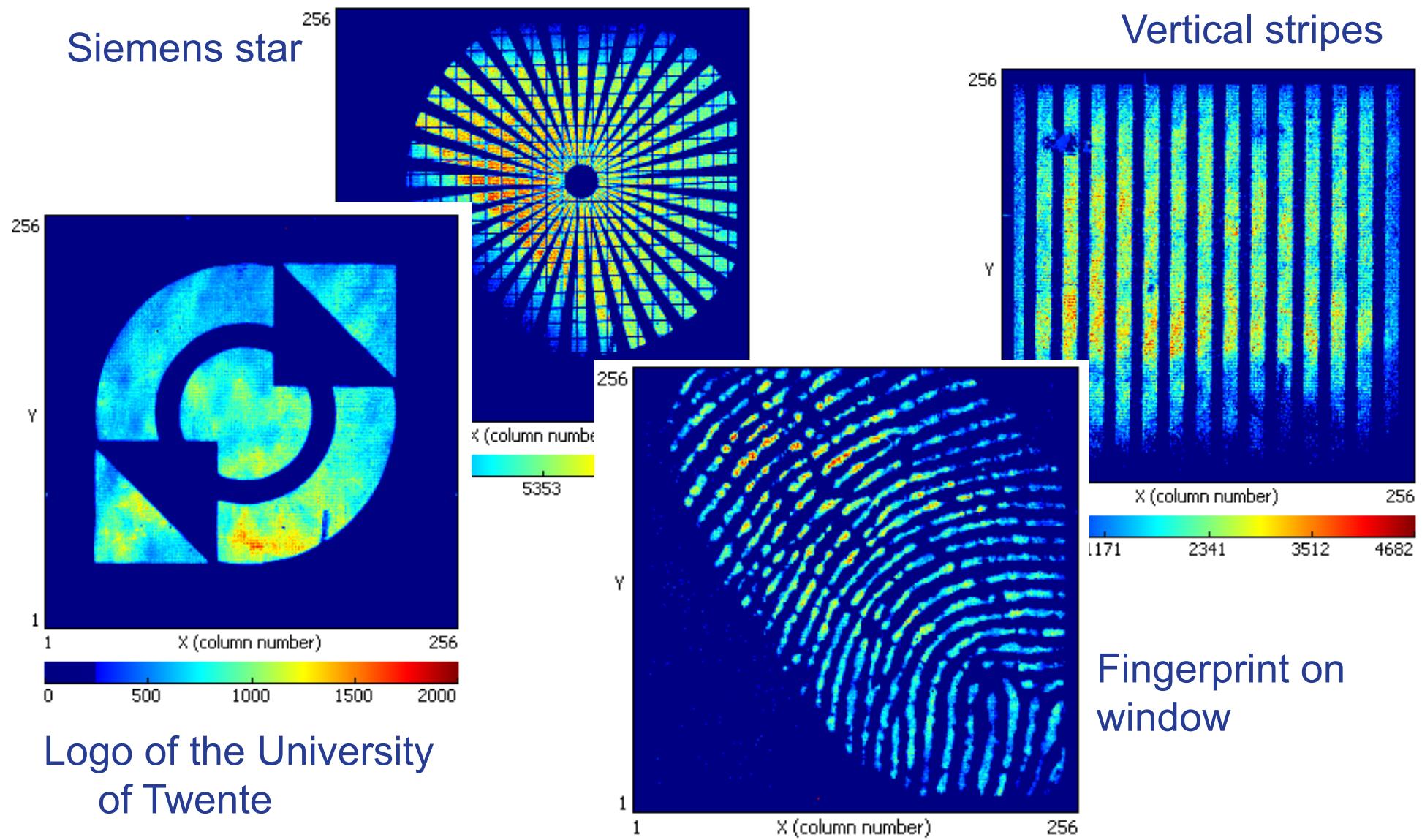
Pixel pitch = 55 µm

Fine mesh (56 µm)  
→ Moiré pattern



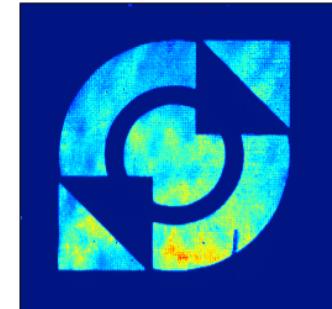
Coarse mesh (500 µm)  
→ Mesh is imaged

# More images



# Conclusions

- CsI deposition on InGrid is easy, CsI PC works successfully on InGrid
- Timepix fully operational with PC
- No photon feedback observed
- Max gain  $\approx 8 \cdot 10^4$
- UV photon imaging capability demonstrated, external cathode mesh
- Spatial resolution is very good, FWHM of LSF is  $62 \mu\text{m}$ , resolution limit above  $f_{\text{Nyquist}}$



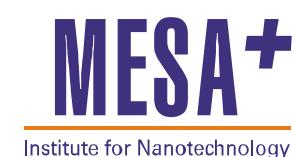
# Acknowledgement



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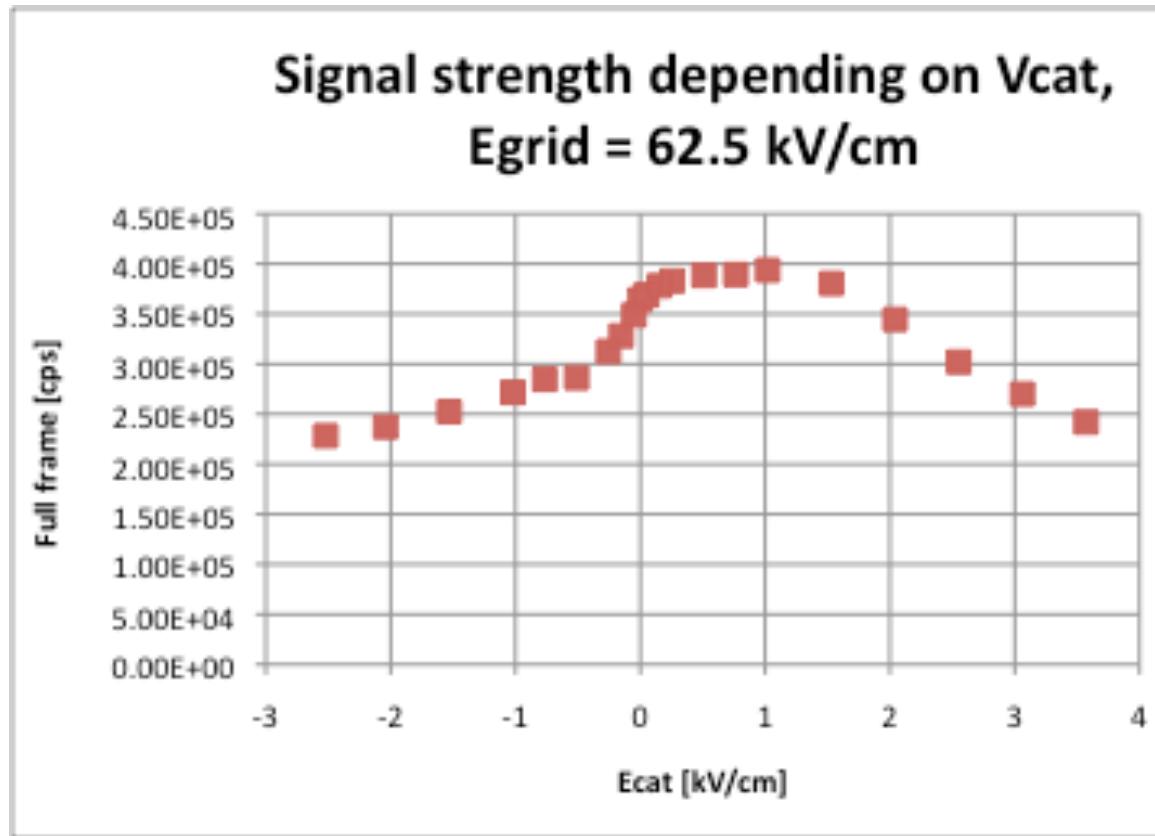


MESA+, University of Twente, the Netherlands:  
Sander Smits



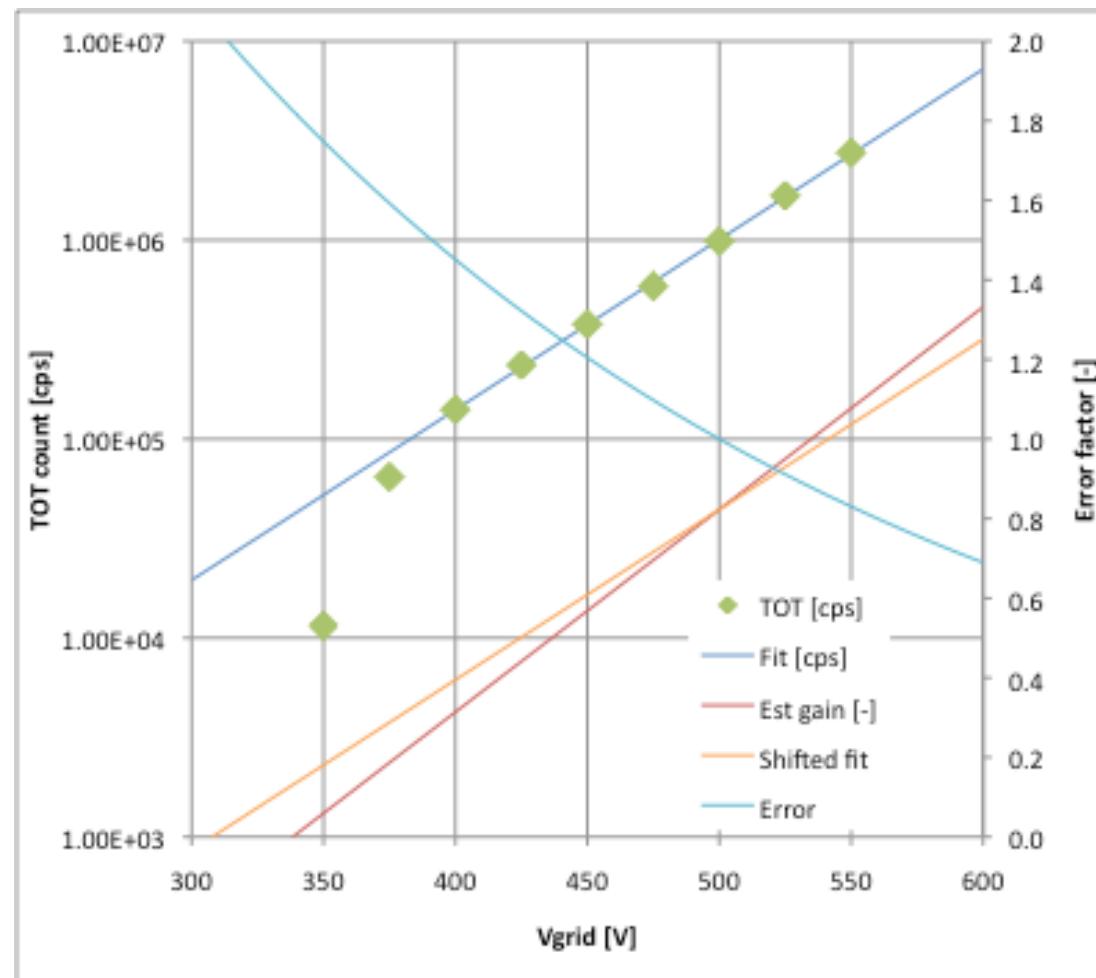
This project is sponsored by Dutch Technology  
Foundation STW

# Dependence on drift field



- TOT count of full frame (in cps)

# Gain curve based on TOT count



- Fe55: 99 V/dec; TOT: 117 V/dec

# TwinGrid

multistage structure to reduce IBF, increase gain

