Fast Photon Detectors (SiPM)

Jelena Ninkovic
Max Planck Society Semiconductor Laboratory

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- SiPMs & SiMPl concept
- MPS Semiconductor Lab
- Fast particle and photon imagers – DSiMPl concepts

Silicon photomultiplier

Needs of the community: **High energy physics** : ultra fast particle detectors
Astroparticle physics: fast UV sensitive detectors
Photon science: single photon position sensitive fast detectors

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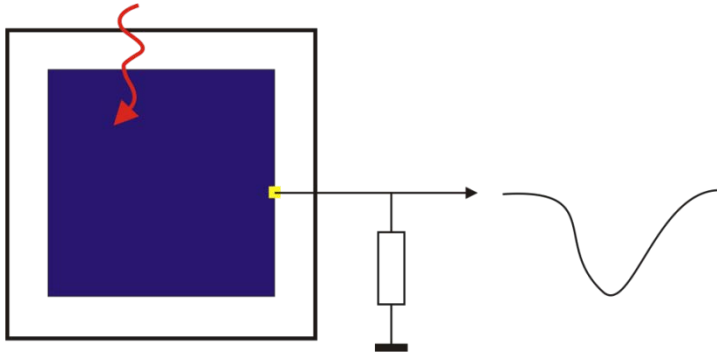
Avalanche photodiode



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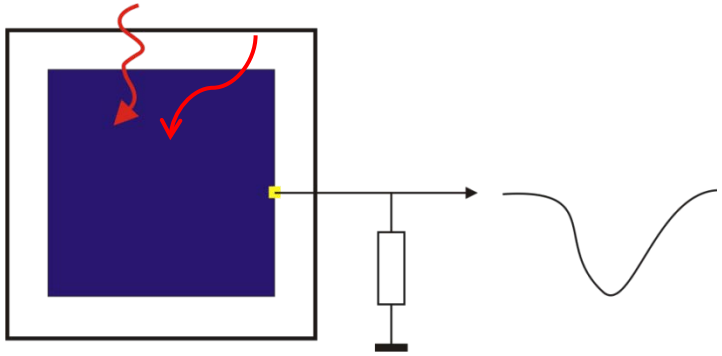

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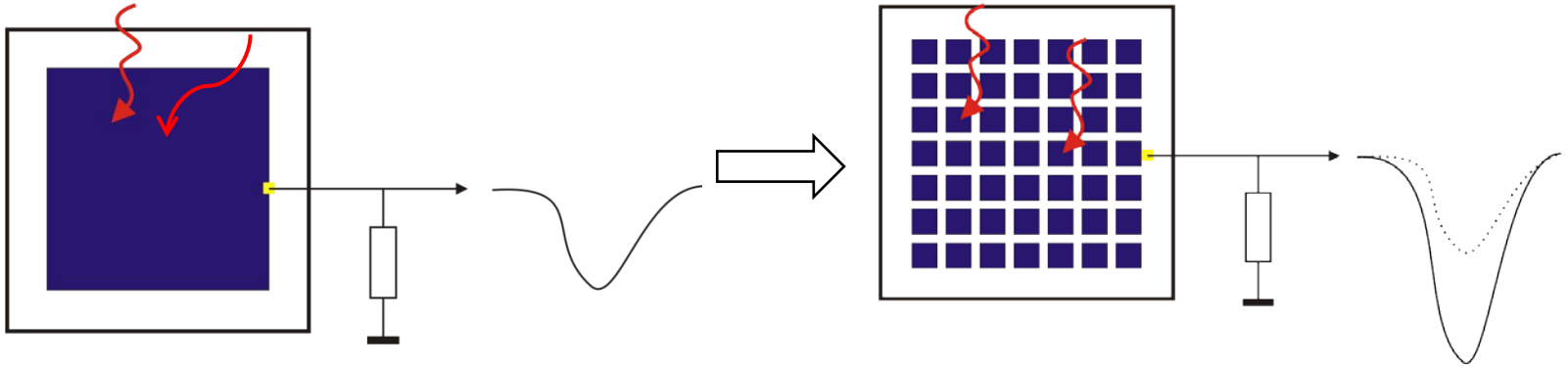

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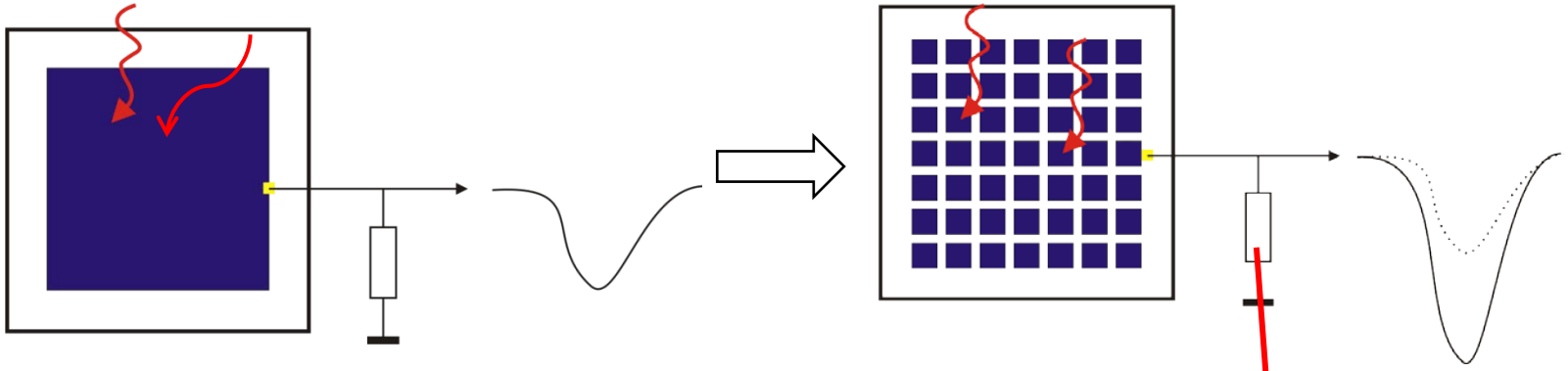
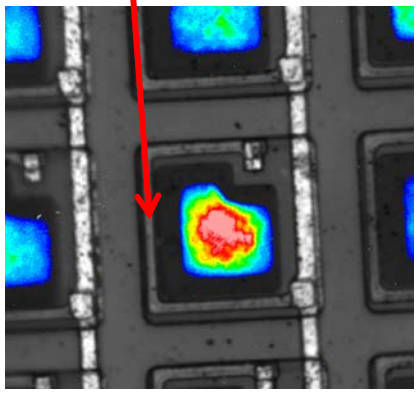


Conventional SiPMs



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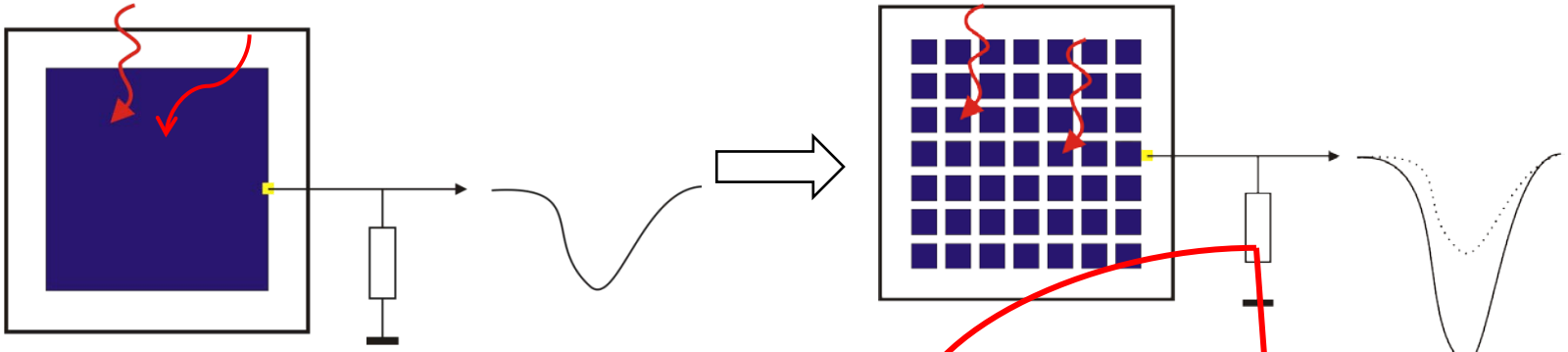
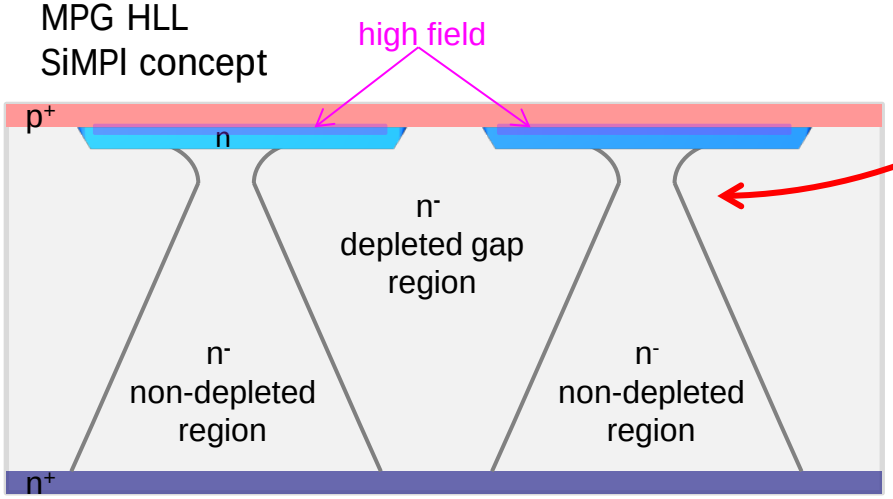


MPG HLL
SiMPl concept



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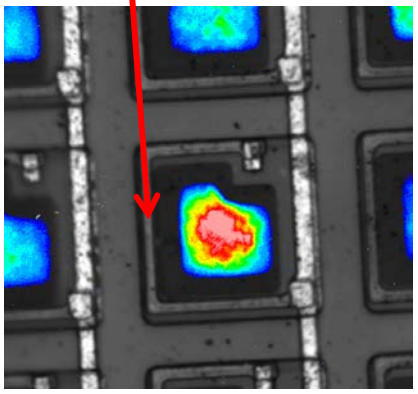

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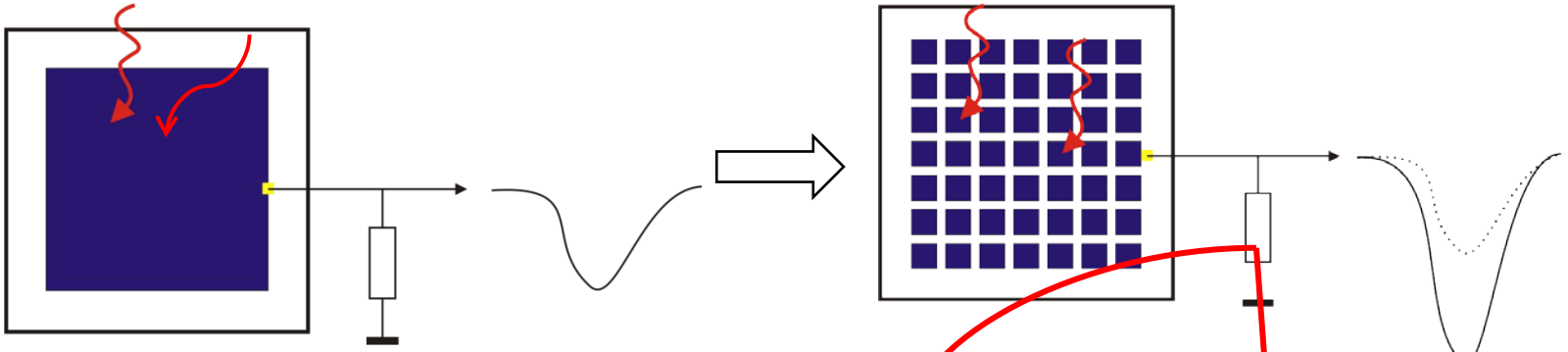

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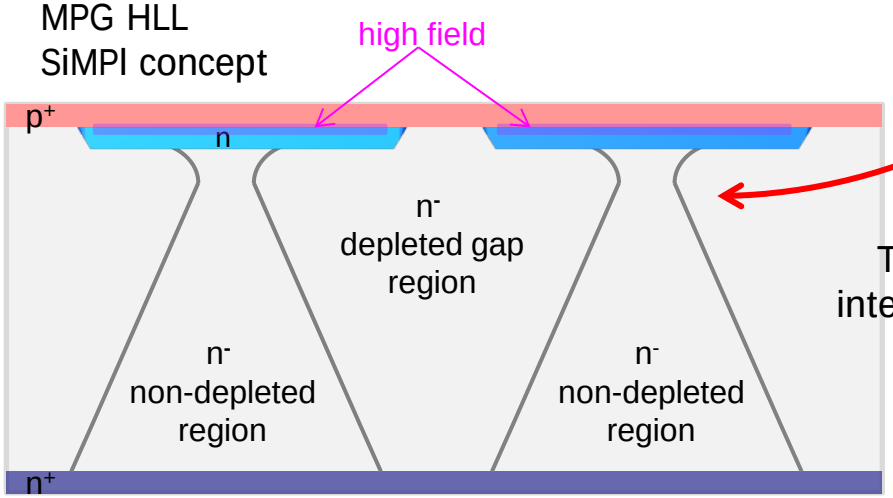

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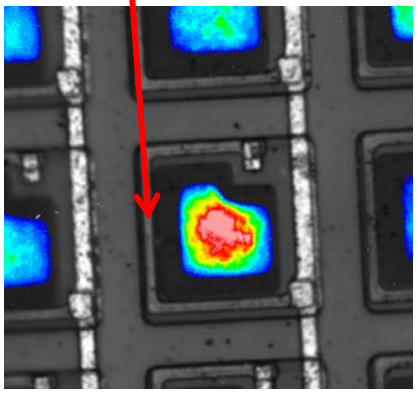


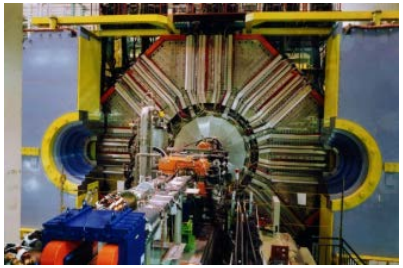
The only vertically integrated SiPMs in the world

The MPG Semiconductor Laboratory – Central unit of MPG

Located in the south-east of Munich on the Siemens Campus in Neuperlach
Unique place in the world: the only place where DEPFETs and SiMPl are being produced

Some of the projects

MAGIC, CTA
(SiPM)



Belle II
(DEPFET)

XFEL, FLASH, LCLS
(pnCCD, DEPFET)

XMM, eRosita, BepiColombo
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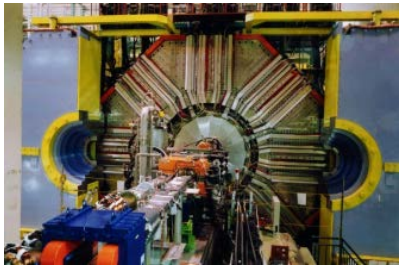

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Partnership with Helmholtz Association on many projects - here only SiPM work

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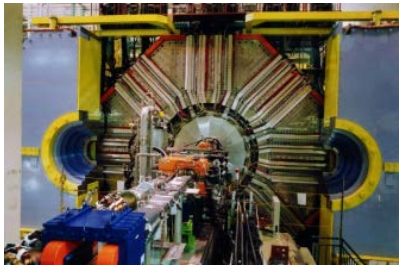

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Inside HLL

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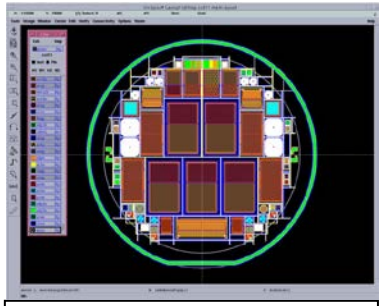
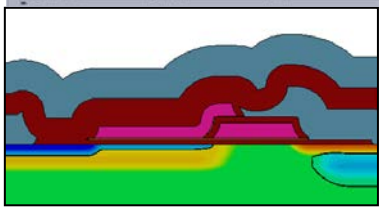
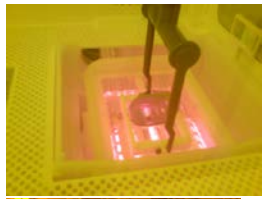
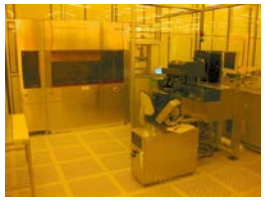
Layout and simulation

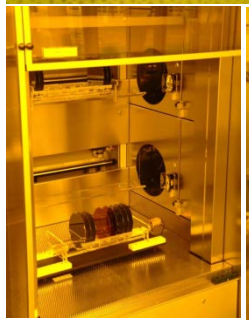


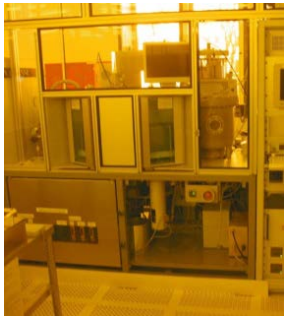


6" Si full processing line





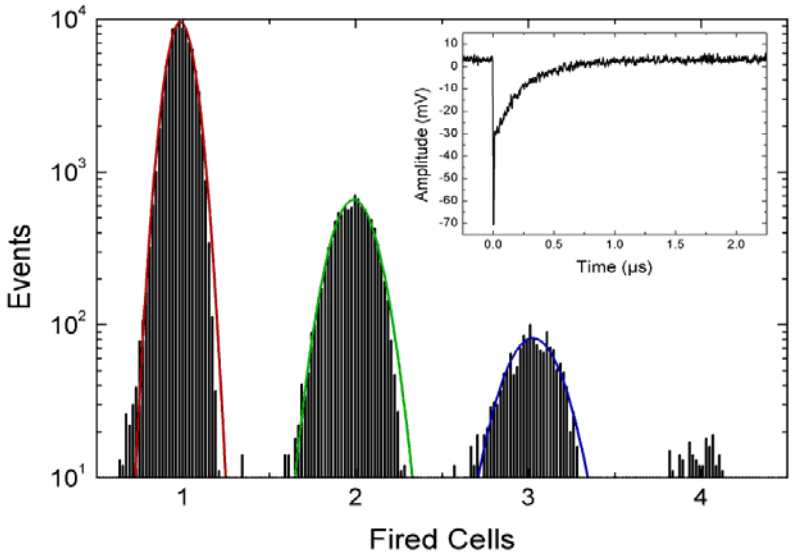


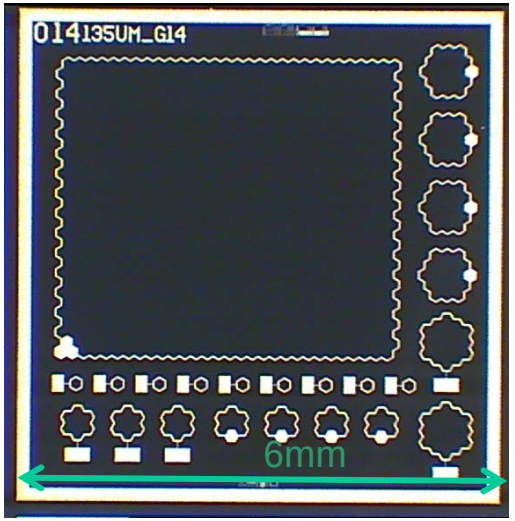


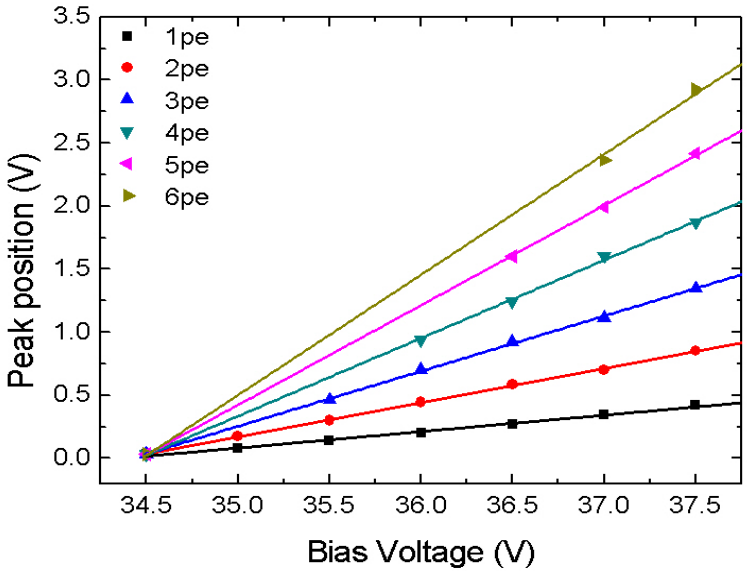
Cu and flip chip

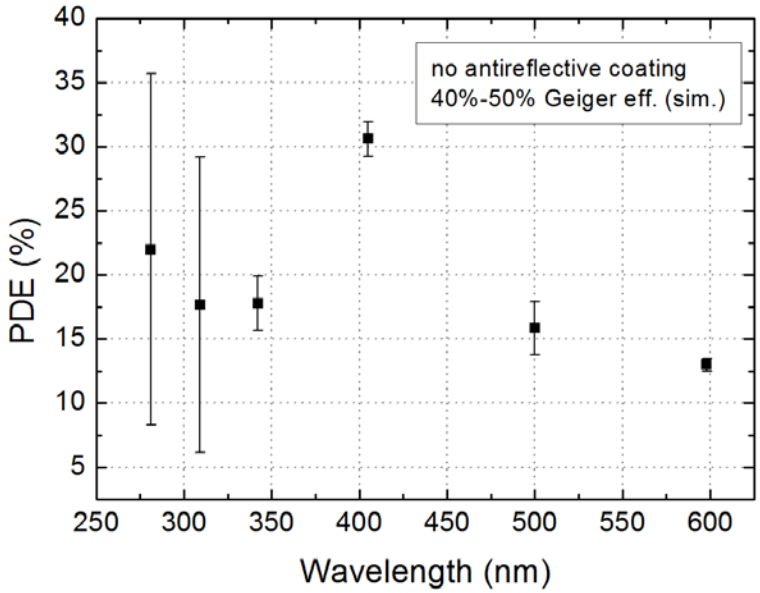
Assembly and test

SiMPL - Prototype production









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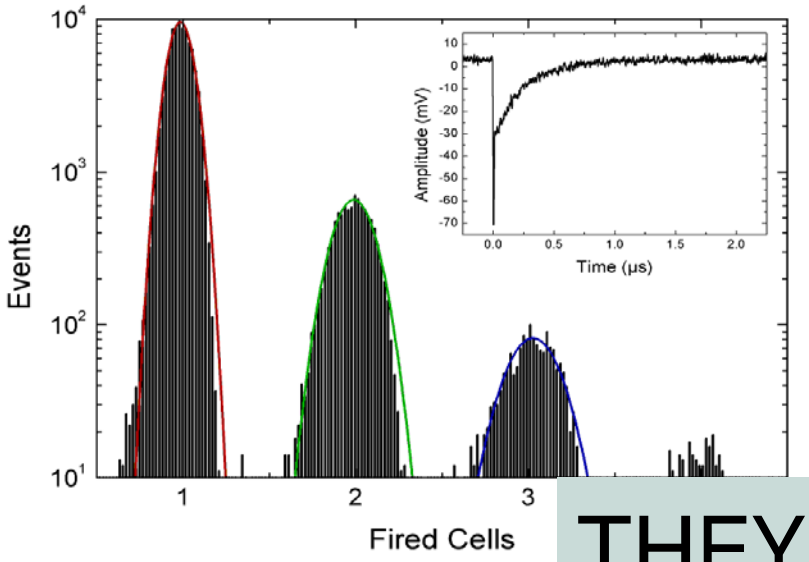
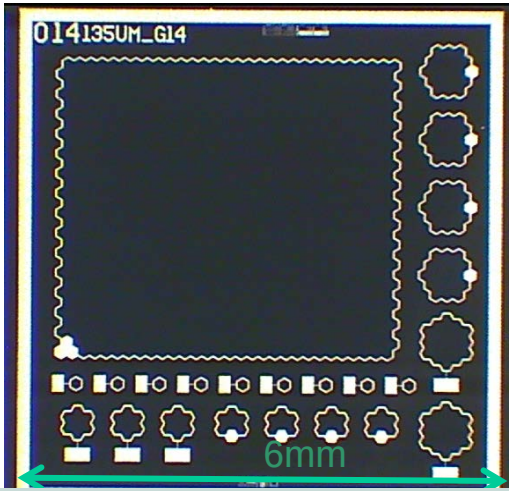
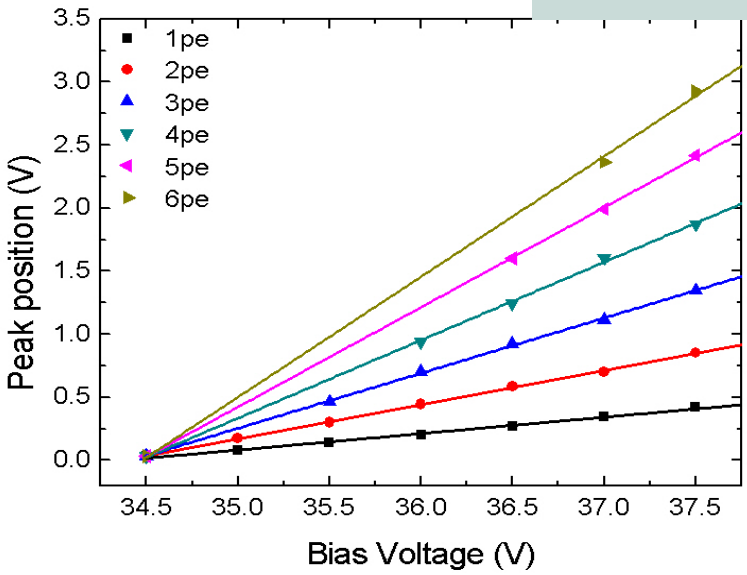
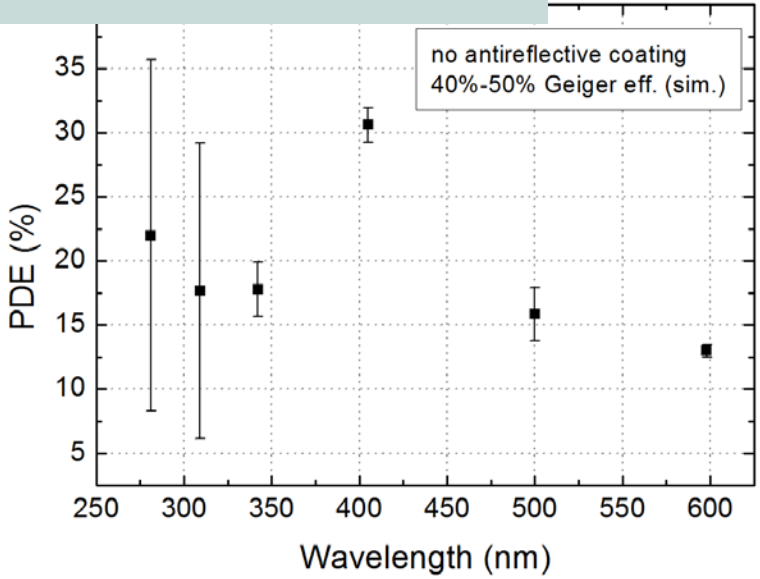




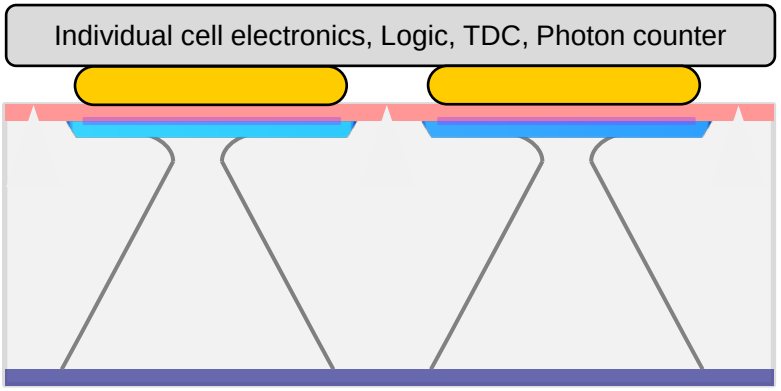
THEY DO WORK !





Next generation SiMPl devices - DSiPMl – collaboration with HGF

*Ultra fast particle tracker - **High energy physics application***



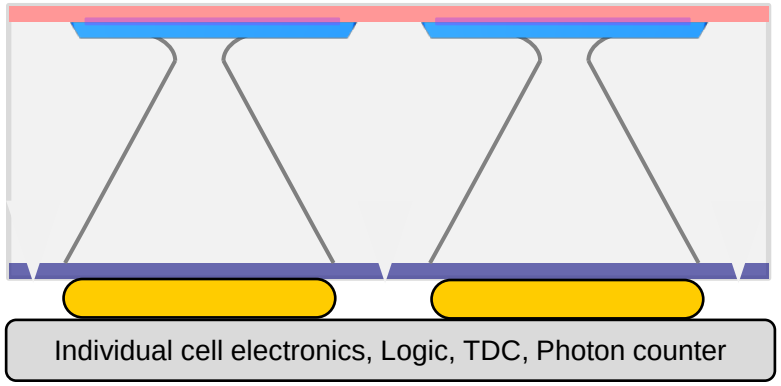
Sensor @ MPG HLL:

- Topologically flat surface
- High fill factor
- Adjustable resistor value
  Low RC -> very fast
- Single pixel readout
- Position sensitivity

ASIC @ DESY:

- Active recharge
- Ability to turn off noisy pixels
- Fast timing
- Pitch limited by the bump bonding
- Position resolving signal processing

*Ultra fast single photon sensitive imager – **Photon science***



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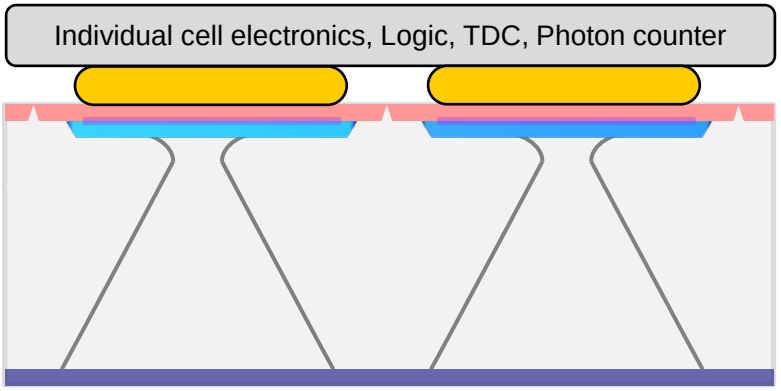

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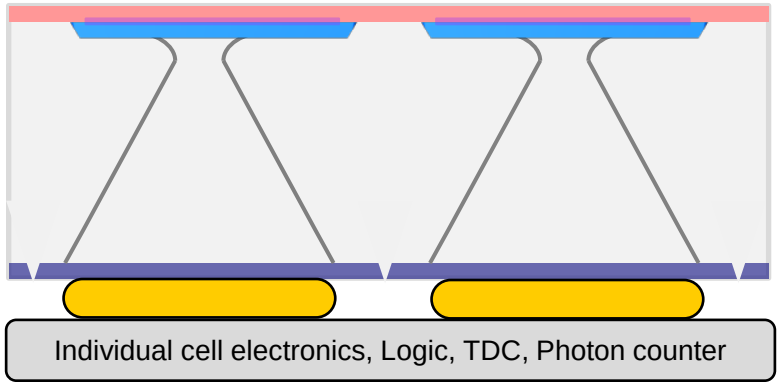


Possible applications:

- Sensor for Helmholtz cube
- Future trackers at colliders
- Detectors for hadron therapies
- X ray detectors
- PET detectors
- Adaptive optic sensors

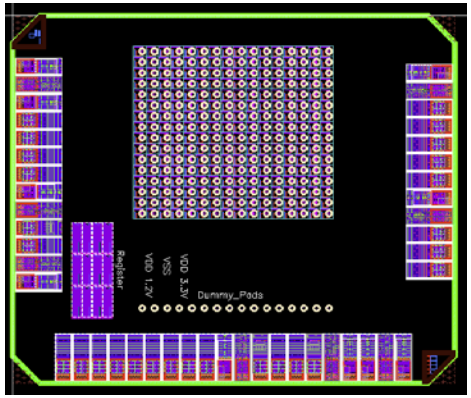
ASIC developments at Helmholtz Association

Staged approach:

1. Particle tracker prototype with 50μm pitch
2. Further reduction of pitch size and overall thickness of both sensor and ASICs for particle detection
3. Development of fast imager prototype

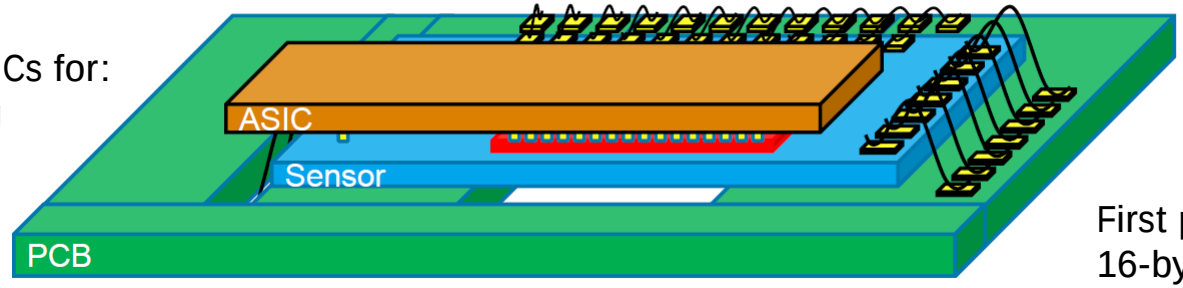
Challenges:

- small pitch flip chip ≤ 50μm
- Fast ASICs - 5-MHz Frame Rate;100-ps Timing Resolution; <1-ns Fast Trigger
- Cell electronics: Active quenching, Switch ON/OFF



Development of ASICs for:

- Photon counting
- Imaging
- Fast timing



First prototype:
16-by-16 Pixel Unit
50x50μm^2

Summary

- We have very fruitful collaboration between **MPG HLL and HFG** groups
- Together we are developing very attractive detectors for **both particle and photon science** applications