

GridPix

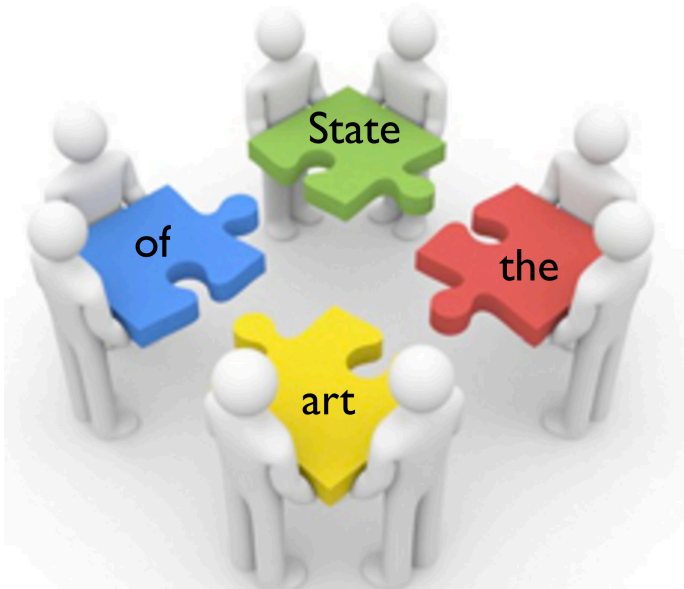
Gaseous pixel detector development @ Nikhef

*Stergios
Tsigaridas*



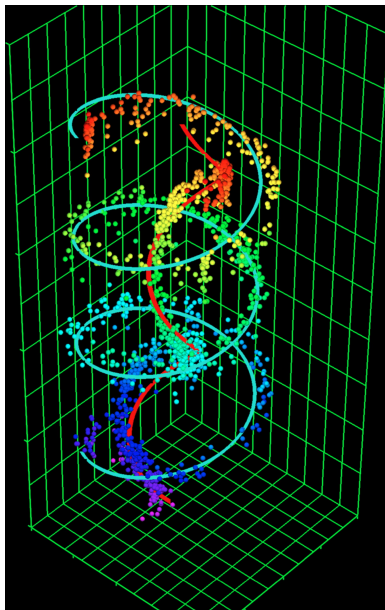
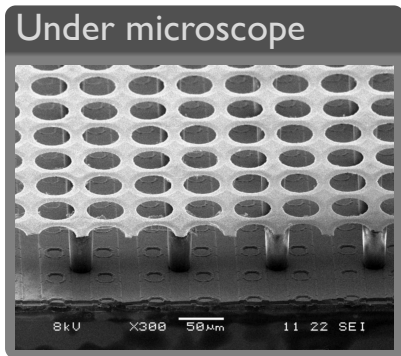
Nikhef Jamboree, 14 December 2015

Bringing the pieces together...



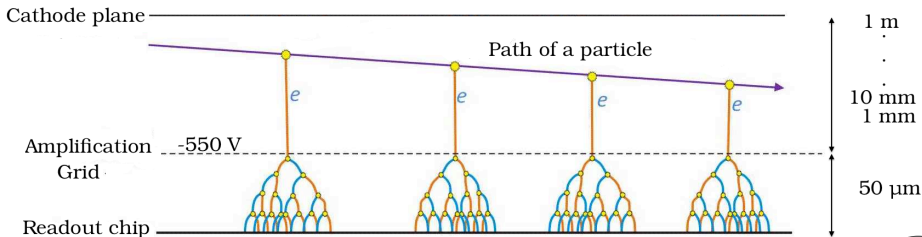
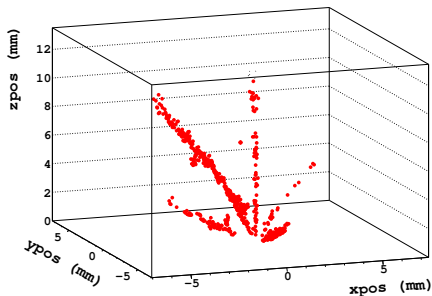
GridPix: a micropattern gaseous pixel detector

- Low material budget
- Less radiation damage
- Single electron detection
- High position resolution
- 3D track reconstruction

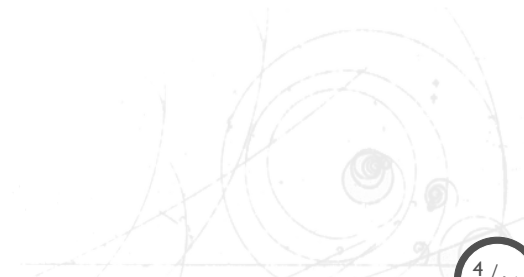


Working principle

- Ionisation in drift gap
- Electrons enter amplification gap
- Induced signal on pixels
- Pixel position gives (x,y)
- Time coordinate gives z

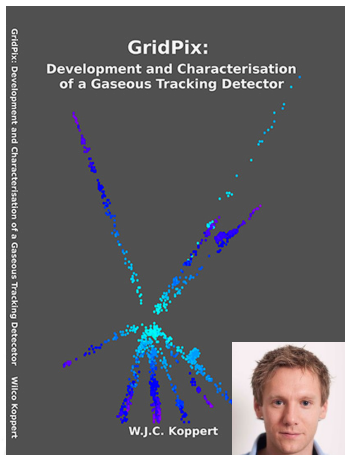


What's new?



What's new?

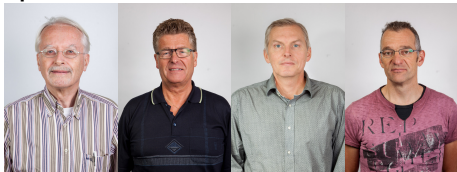
- PhD thesis published



What's new?

- PhD thesis published
- Most precise gaseous detector for measuring the position of individual ionisation electrons

Special thanks to:



Nuclear Instruments and Methods in Physics
Research Section A: Accelerators,
Spectrometers, Detectors and Associated
Equipment



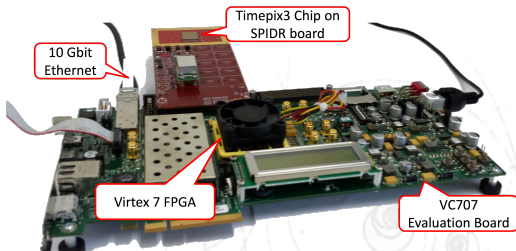
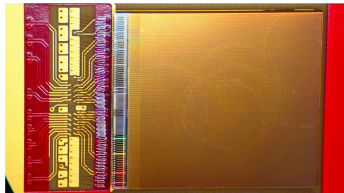
Volume 795, 21 September 2015, Pages 309–317

Precision tracking with a single gaseous pixel detector

What's new?

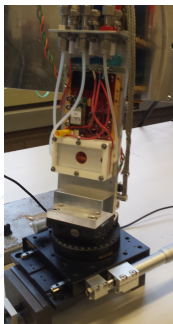
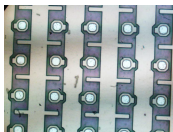
- PhD thesis published
- Most precise gaseous detector for measuring the position of individual ionisation electrons
- Timepix3 chip available
- Nikhef
 - Chip design
 - Spidr Readout

Special thanks to:



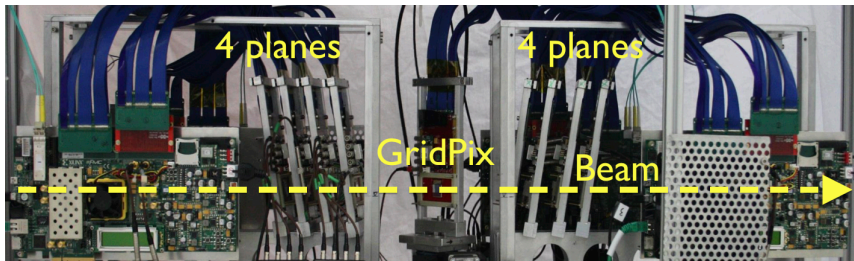
GridPix based on Timepix3 chip

- Timepix3 chip
 - Successor of Timepix chip
 - Designed by Cern, Nikhef, Bonn
 - 256×256 pixels, $55 \mu\text{m}$ pitch
 - Simultaneous time and charge measurement
 - Very precise timing ($10\times$ improvement)
 - Huge readout rate
 - Low threshold
- Chamber
 - Drift gap of 13.5 mm
 - CO_2/DME gas mixture (50/50 %)



Testbeam at Cern/SPS

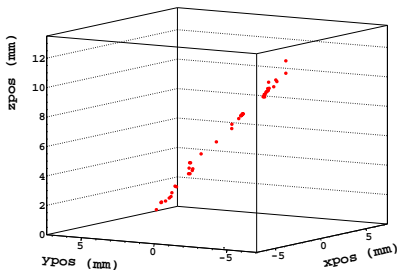
- End of August 2015
- Muon and hadron beams
- Two GridPix detectors tested
- Tracks recorded > 20 M



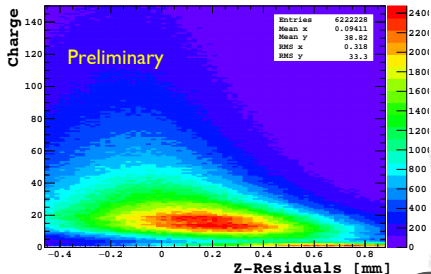
Timepix3 silicon telescope (LHCb VELO group)

Main goals and challenges

- Timewalk, well known effect
- Timepix3 has less timewalk compared to previous
- Use charge and arrival time to correct for timewalk
- Better z precision

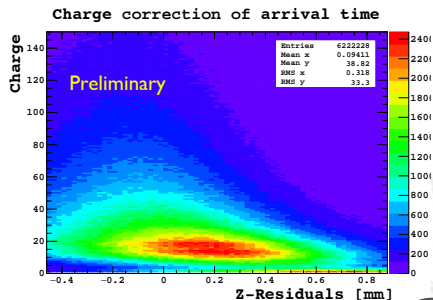
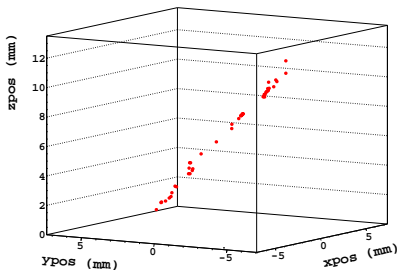


Charge correction of arrival time



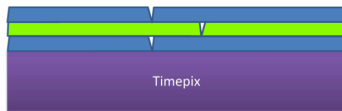
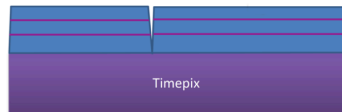
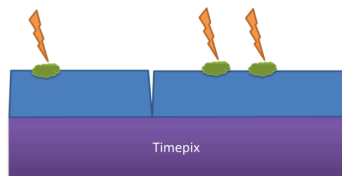
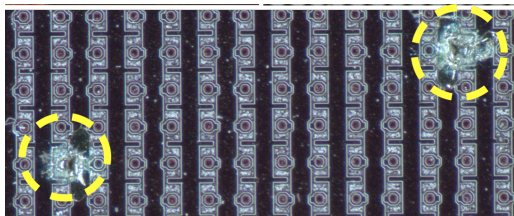
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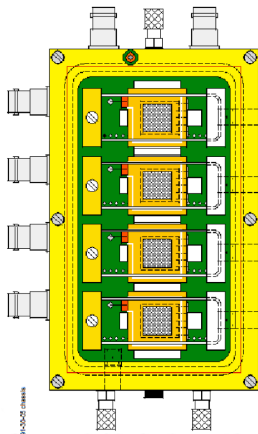
Discharges

- Occur in the gas
- One of the chips died in testbeam
- Pinhole effect well known in industry
- Multiple layers of different materials might be the solution



Further improving of spark-proofing GridPix

- Test setup for sparks
- MEMS labs produce protection layers (SiN, SiO₂, SiC)
- Deposition on dummy chips
- Can test up to 4 chips simultaneously
- Easy to install/uninstall samples

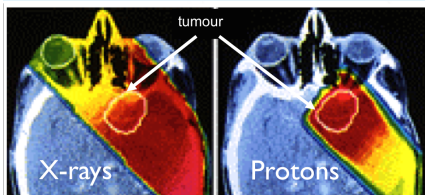
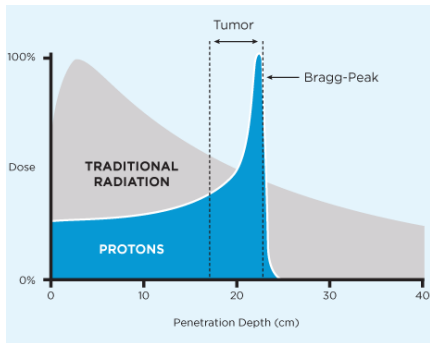


The background features a complex, abstract pattern of thin, light-colored lines and circles. Some lines are solid, while others are dashed. The circles vary in size and some contain smaller concentric circles or dots. The overall effect is a technical or scientific aesthetic, reminiscent of a network diagram or a complex geometric construction.

Applications

Treatment: Protons vs X-rays

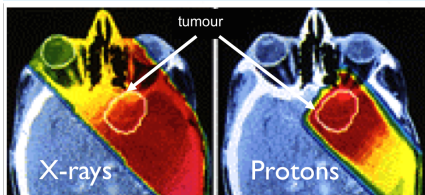
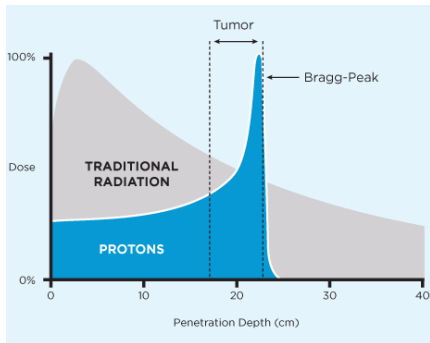
- Energy deposition matters
- X-ray treatment
 - High dose in healthy tissue
 - Physically not optimal
- Proton beam treatment
 - Protons stop in tumour
 - Need precise information for stopping power
 - Improved treatment plan



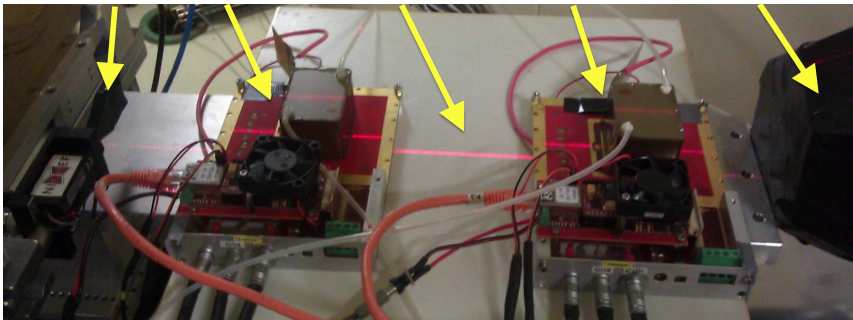
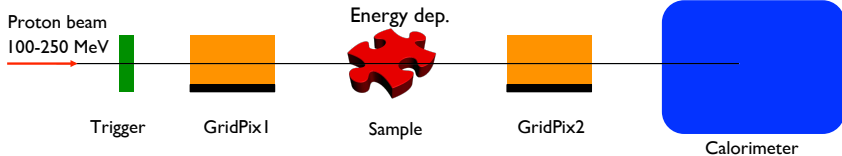
Treatment: Protons vs X-rays

- Energy deposition matters
- X-ray treatment
 - High dose in healthy tissue
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GridPix comes in the game!

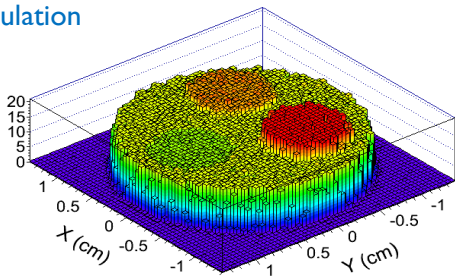


Proton radiography setup @Nikhef

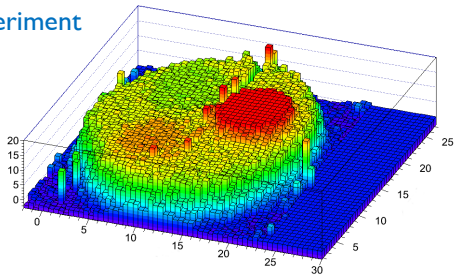


Deposited energy reconstruction

Simulation



Experiment



university of
 groningen

kvi - center for advanced
 radiation technology

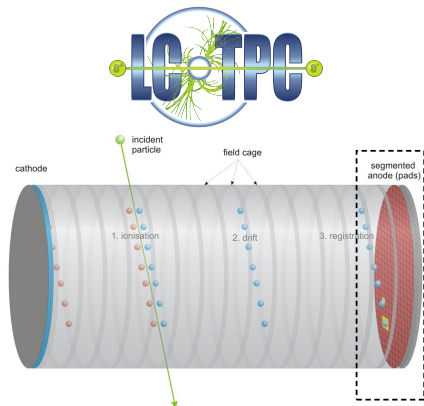
Nikhef



- IEEE paper
- 2 M.Sc. Theses

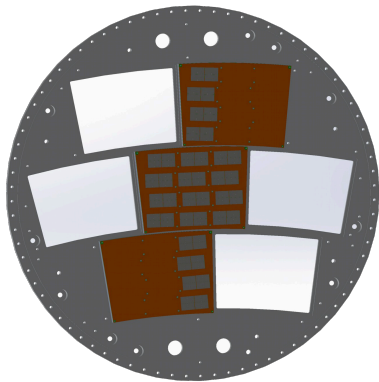
Covering large areas

- Proposed time projection chamber of ILD@ILC
- GridPix is an excellent candidate for the readout
- Improved position and timing resolution
- Record all electrons \Rightarrow Better $\frac{dE}{dX}$

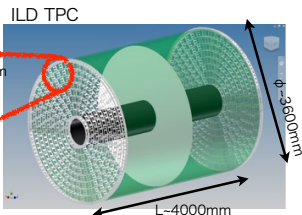
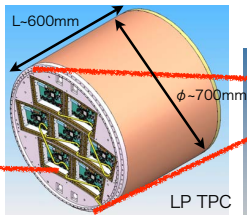
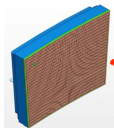


Covering large areas

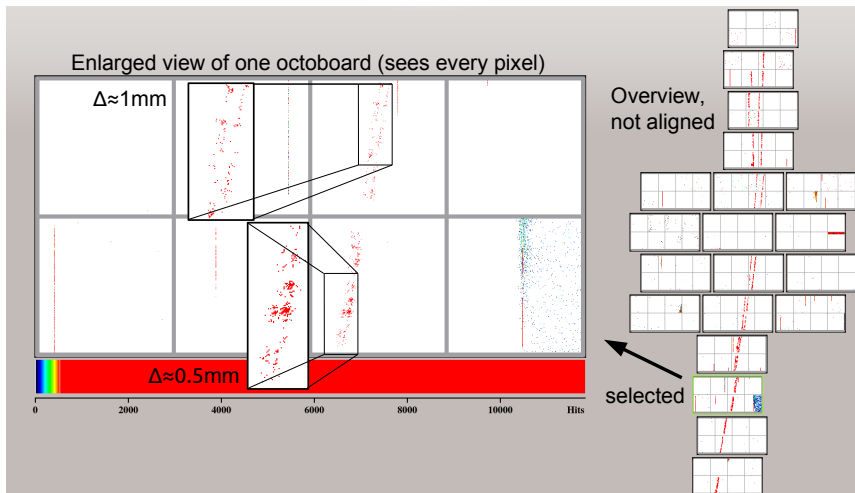
- 3 modules built in Bonn
- 160 GridPixes in total
- Active area of 320 cm²



7 readout modules
with the size of $\sim 230 \times 170\text{mm}^2$
can be installed.

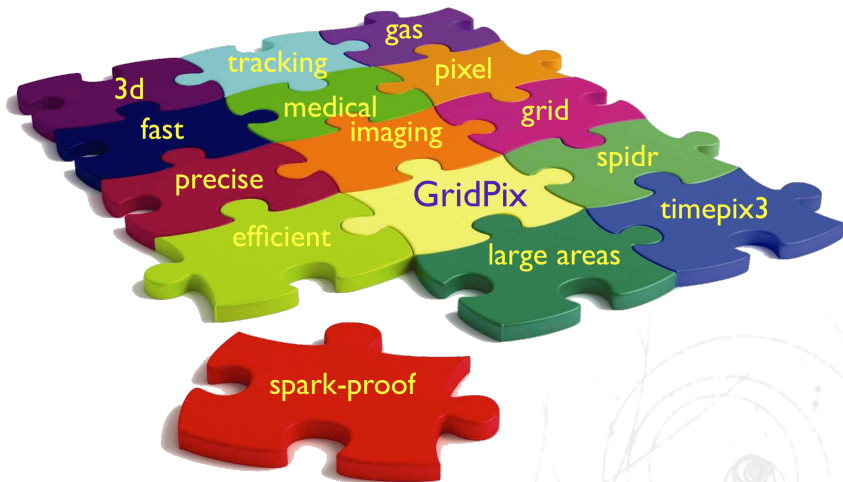


Prototype tested at DESY



For more information follow Peter Kluit's talk tomorrow!

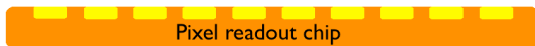
Summary



The background features a complex, abstract design. It consists of numerous thin, intersecting lines in shades of red and blue. These lines form various geometric shapes, including circles, spirals, and irregular polygons. Some lines are solid, while others are dashed. The overall effect is a dense, layered pattern that resembles a technical drawing or a network diagram. The colors are muted and blend into each other, creating a soft, textured appearance.

Thank you for your attention!

Backup



Backup



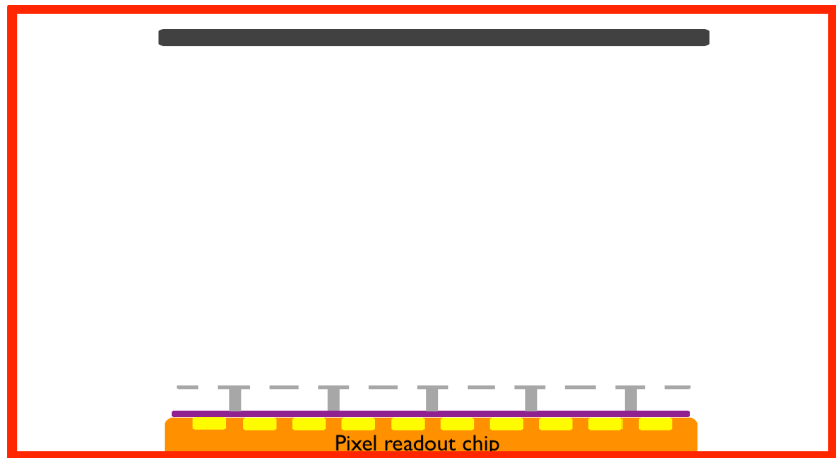
Backup



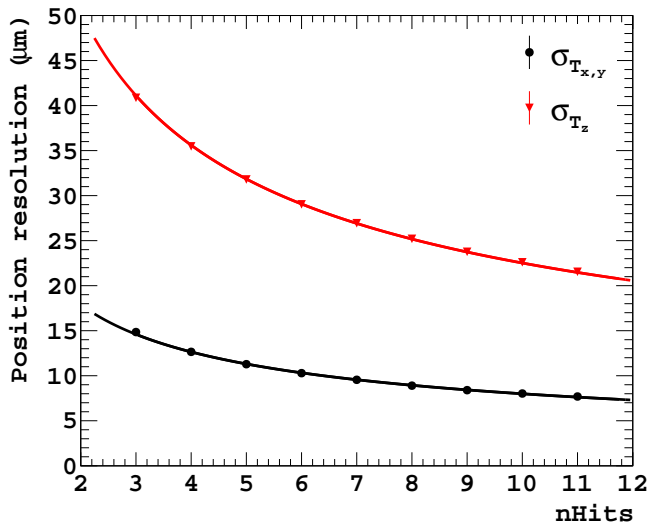
Backup



Backup



Backup



Backup



1. Analysis, probing and cleaning of wafer surface



2. Formation of protection layer



3. Deposition of SU-8



4. Exposure and baking of SU-8



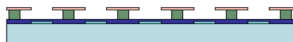
5. Deposition of Al thin film



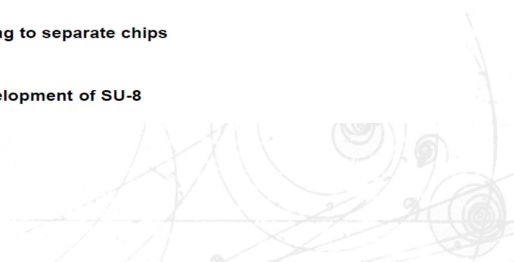
6. Patterning of Al to form the Grid



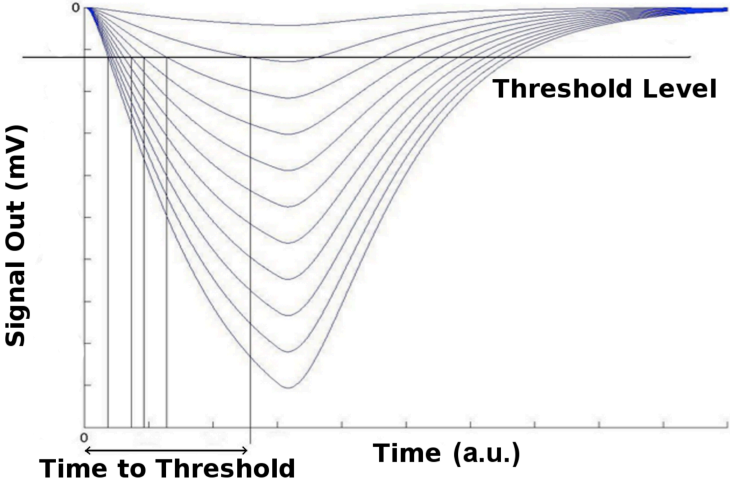
7. Dicing to separate chips



8. Development of SU-8



Backup



Backup

- Millions of triggers with muons to get timewalk correction (high gain, $\text{thr} = 600 e^-$, $\theta = 30^\circ$)
 - Millions of triggers at $\theta = 90^\circ$ (tracks // chip)
 - Runs (100k triggers) at several rotation angles for resolutions and systematics ($\theta = -15^\circ, \dots, 45^\circ$)
 - 200k triggers at $-\theta = -15^\circ$ and $\theta = 15^\circ$ for drift velocity measurement
 - Data at several drift fields (3 kV/cm, 2 kV/cm, 1 kV/cm, 0.5 kV/cm)
 - Many runs at various thresholds down to $\text{thr} = 430 e^-$ (5σ of noise + 1σ for channel to channel variations)
- 