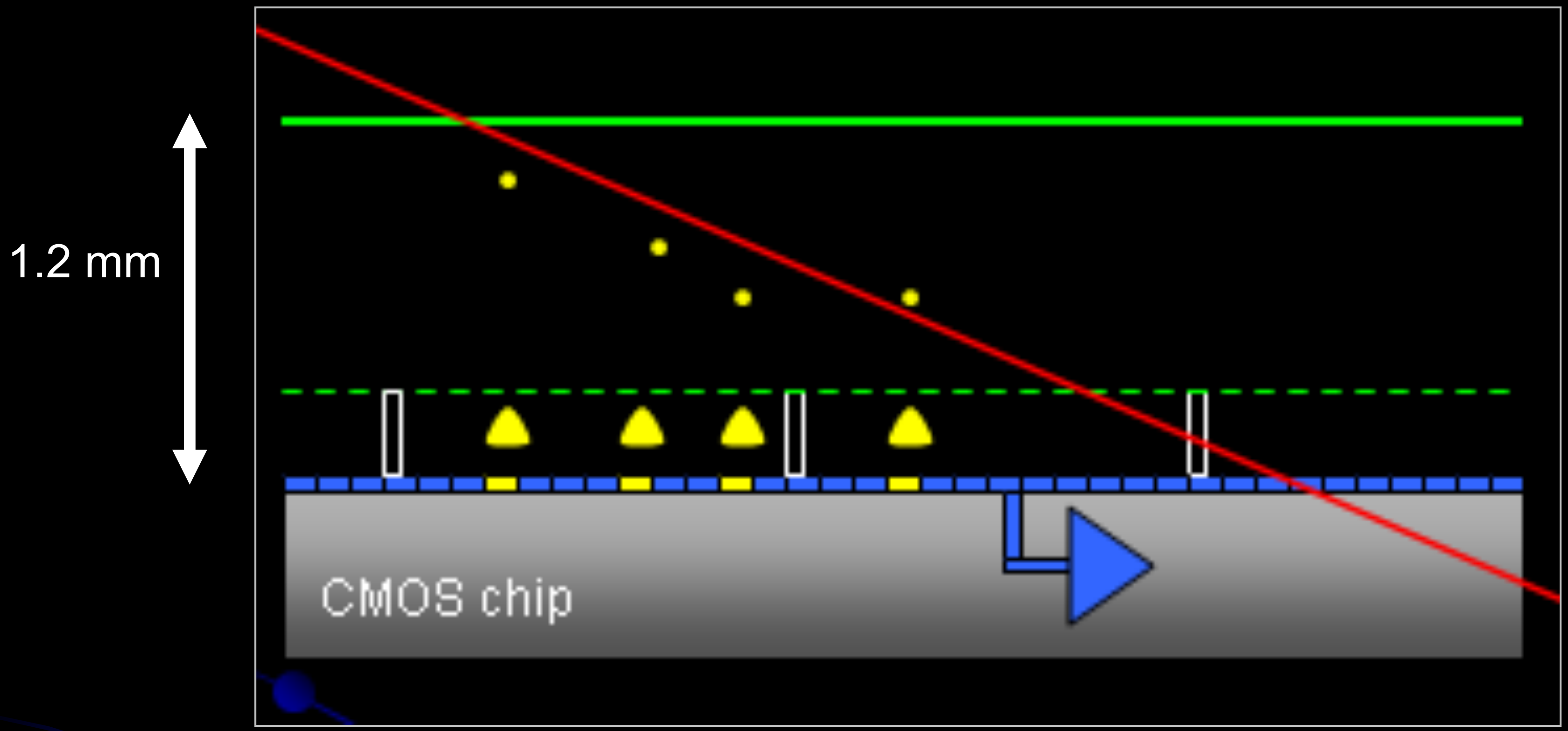
Results of and plans for new tracking detectors

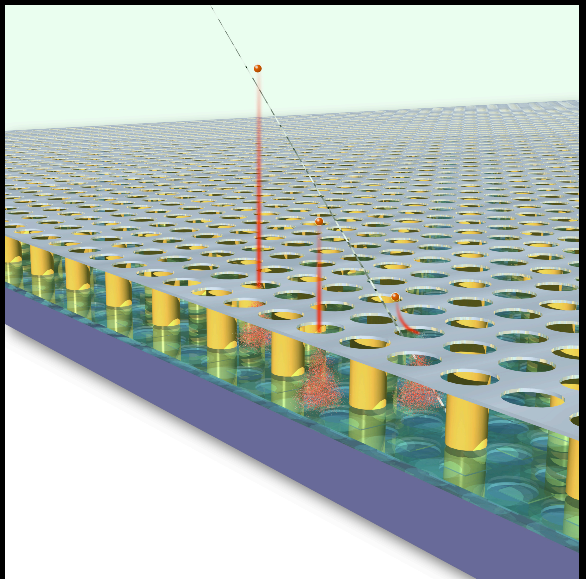
Harry van der Graaf
Nikhef Detector R & D
LHeC Workshop, Divonne-les Bains, Sept 2, 2009



GridPix and Gas On Slimmed SIlicon Pixels

Gossip: replacement of Si tracker

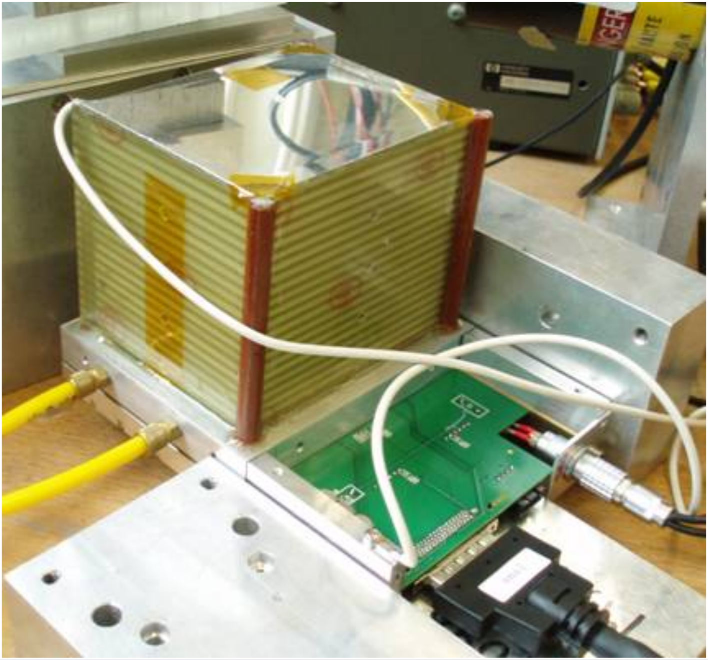
Essential: thin gas layer (1.2 mm)

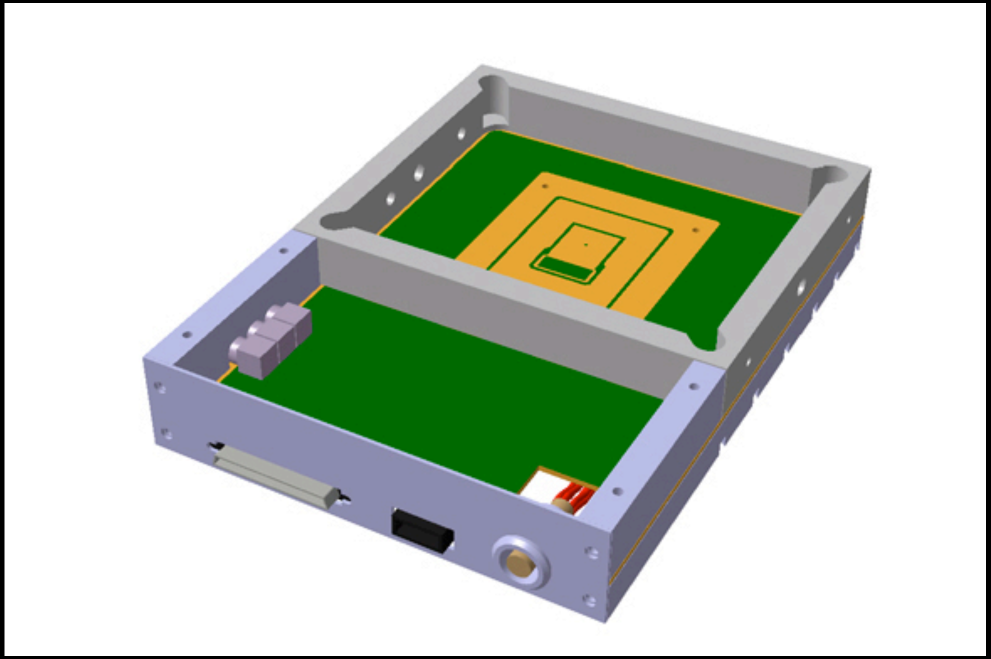


Construction of test chambers

prototypes Next-1,2,3,4,5
Next Quad (EUDET deliverable)
Next-64 (ReNexd, ReLaXd) (EUDET deliverable)

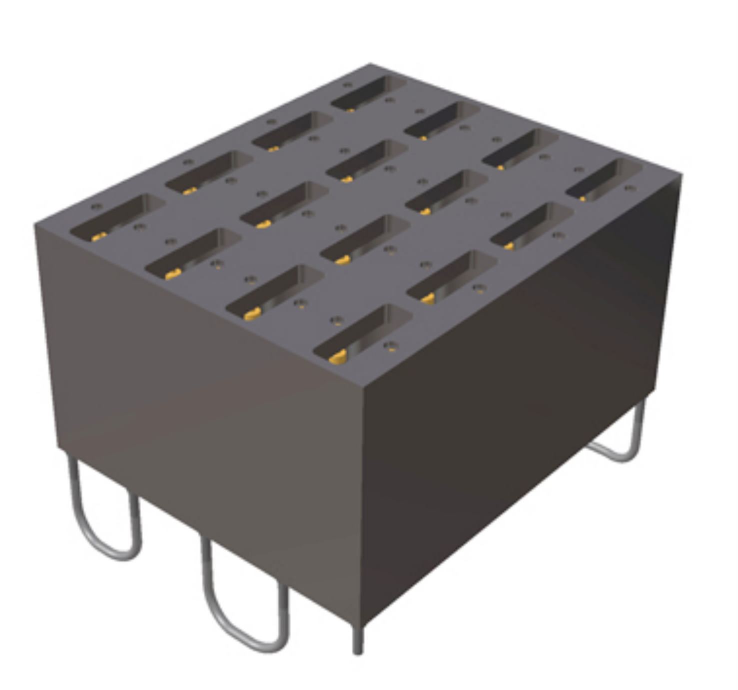
DICE
Ageing Chambers

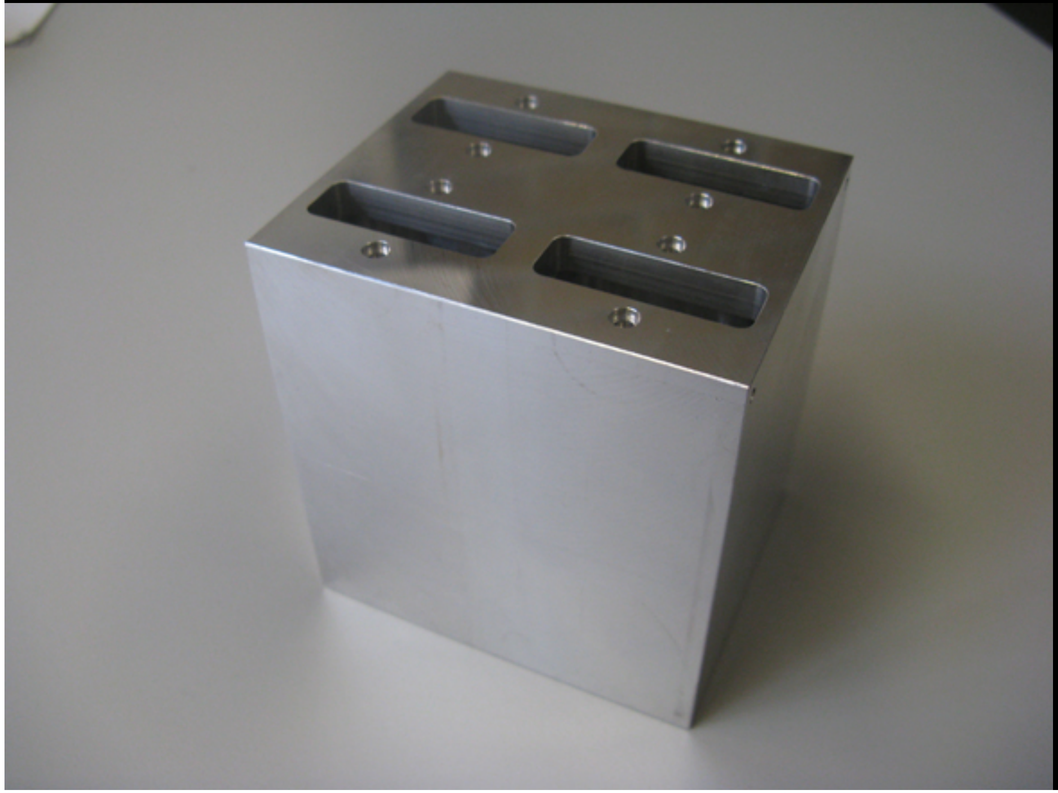


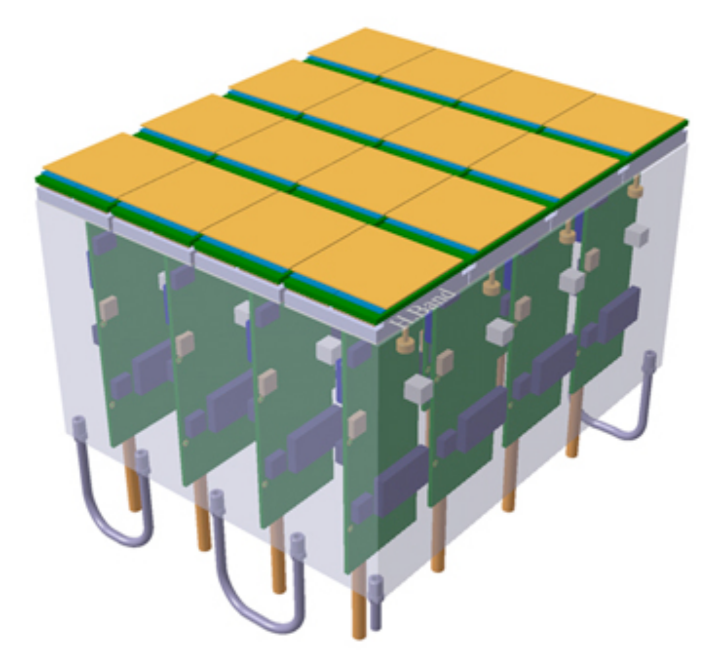


Next-64 / ReLaXd / ReNexd

CO_2 cooling!

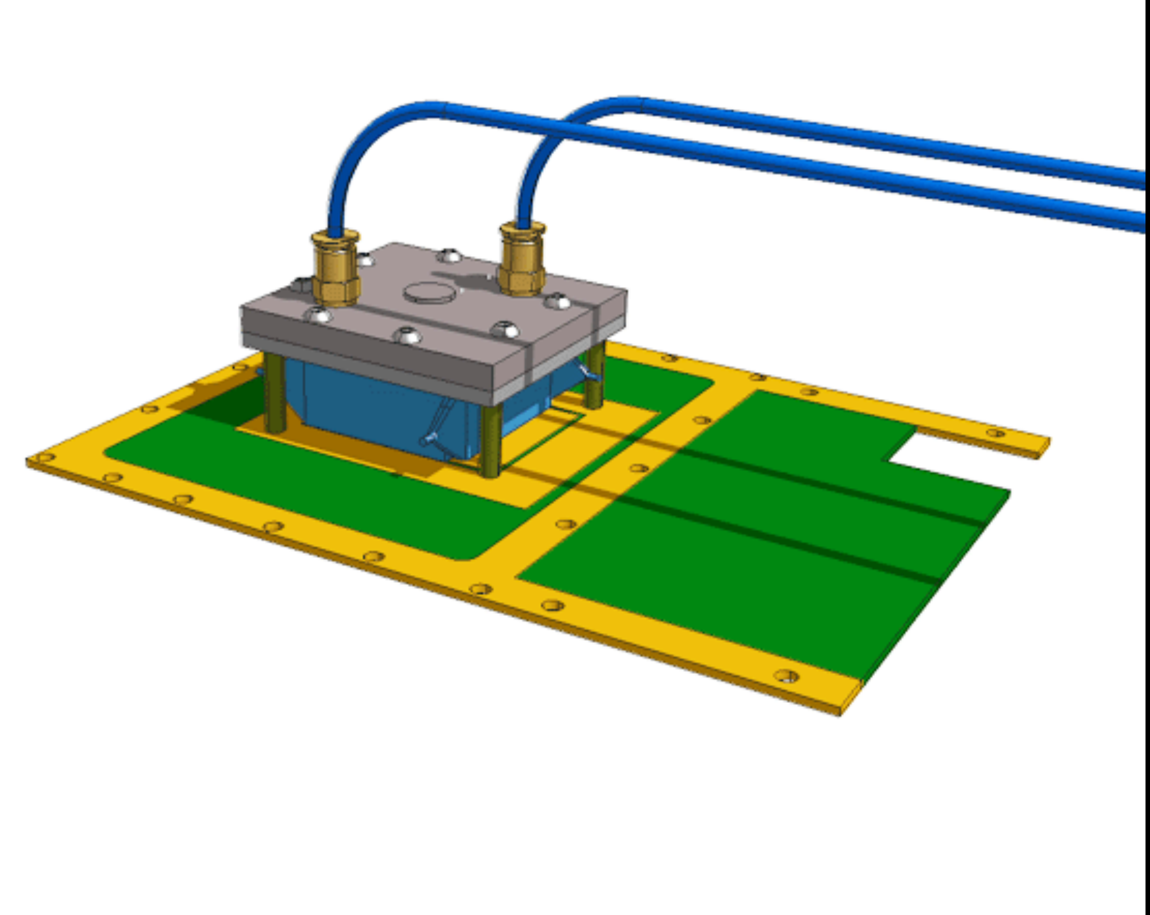






DICE

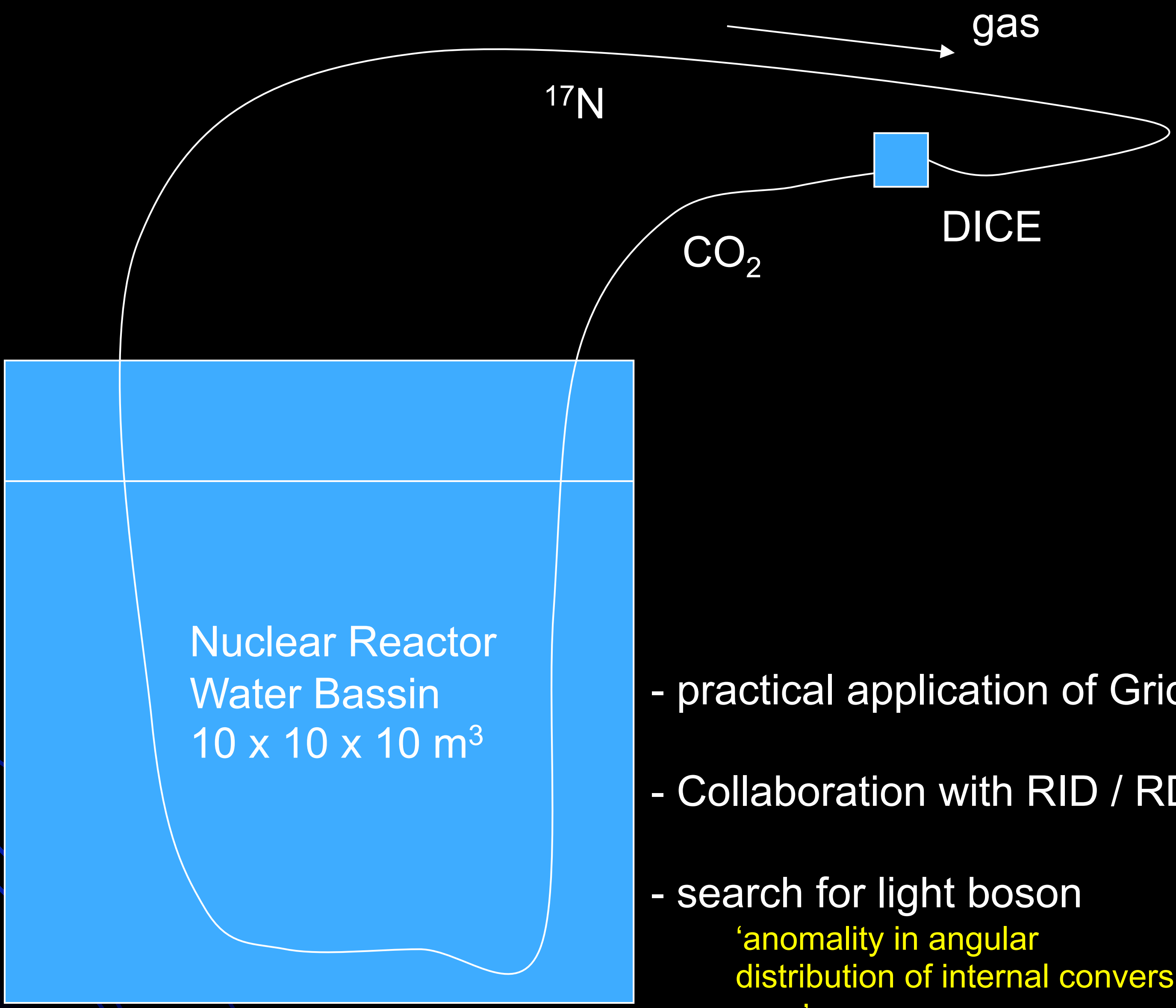
Delft Internal Conversion Experiment



Measurement of angular correlation of e+ e- Internal Conversion in Nuclear Decays

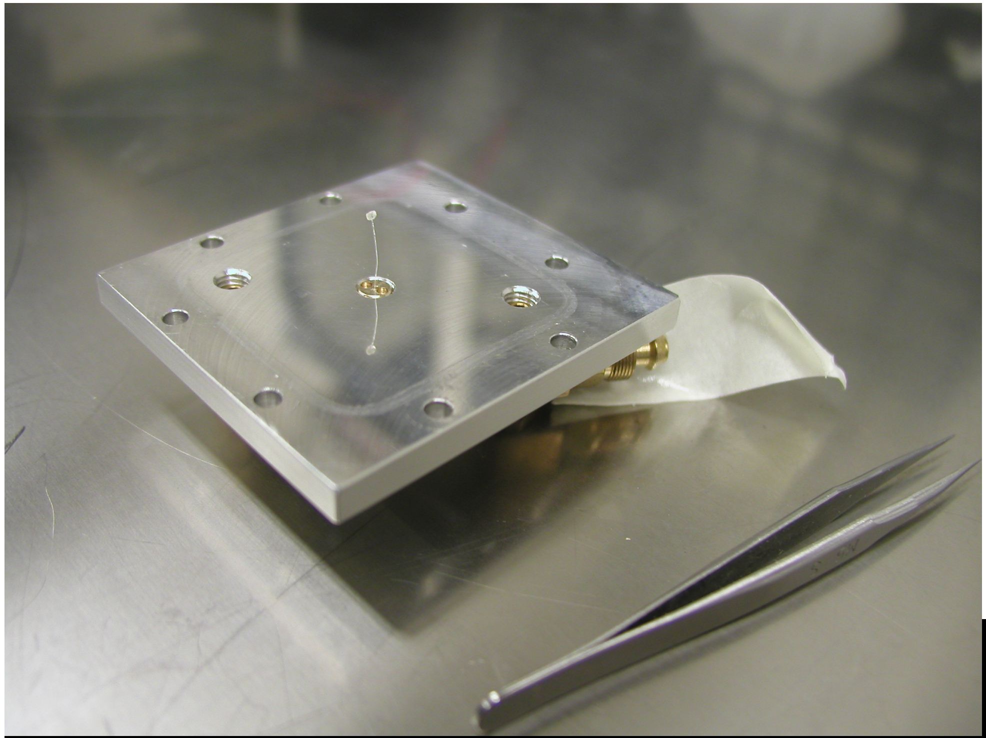
RID

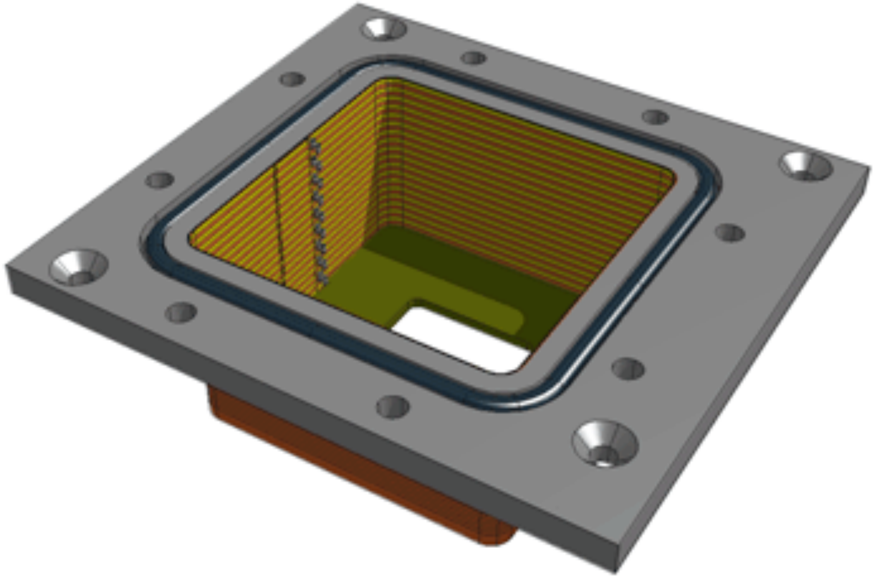
Reactor
Institute
Delft

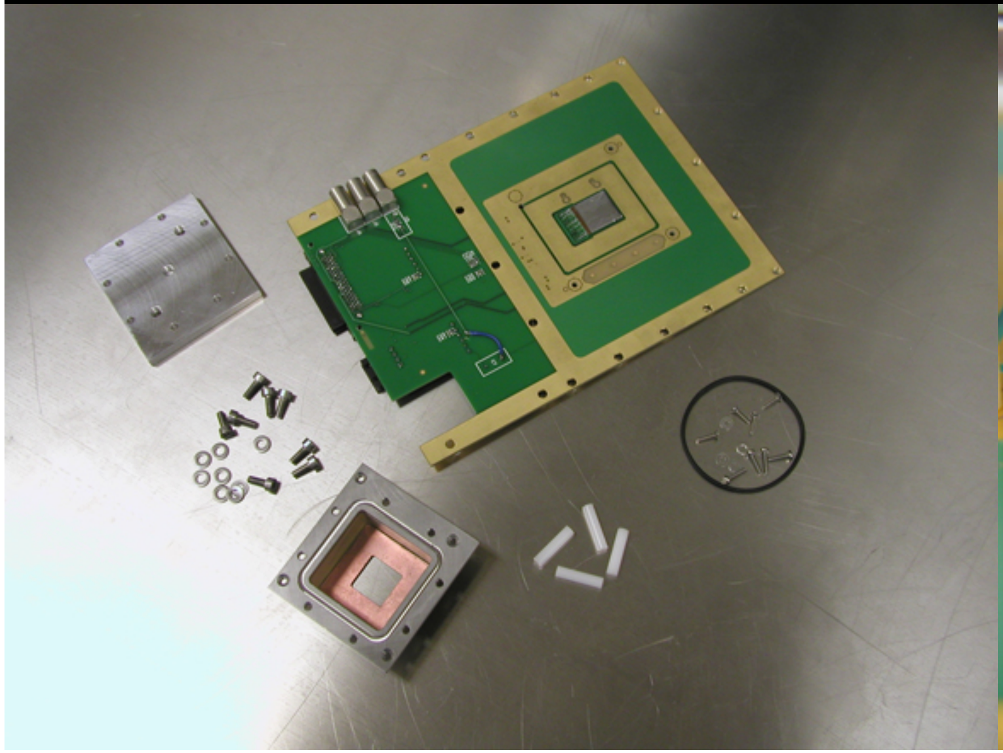


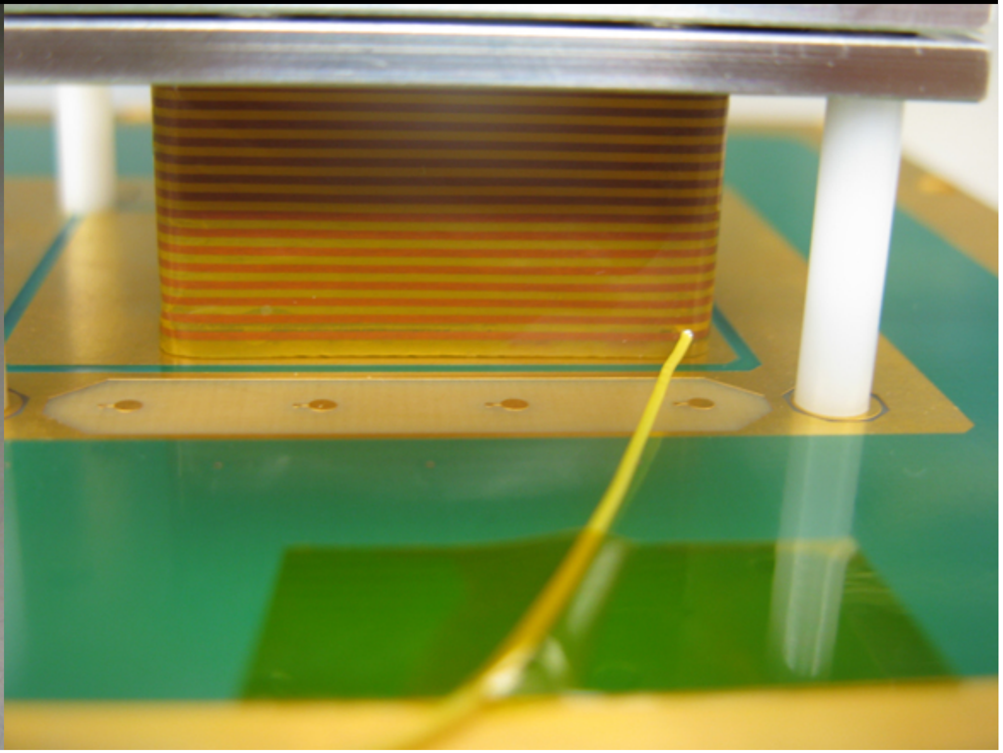
- practical application of GridPix
- Collaboration with RID / RD&M
- search for light boson
  ‘anomality in angular distribution of internal conversion e+e-’
- Student toy: complete experiment!

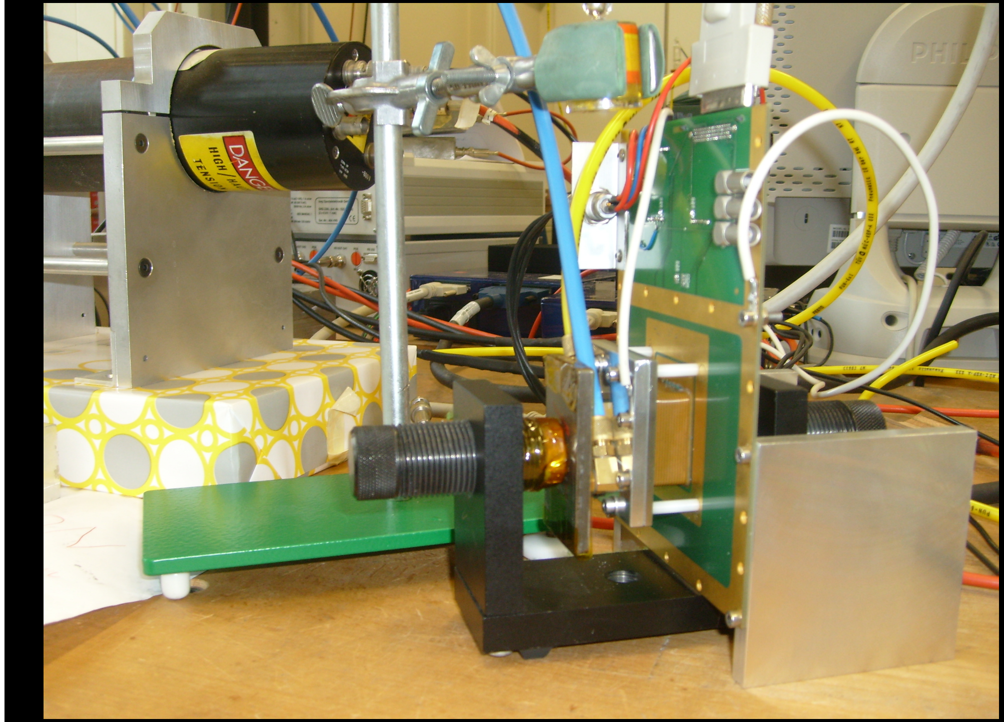
Mini high precision GridPix TPC



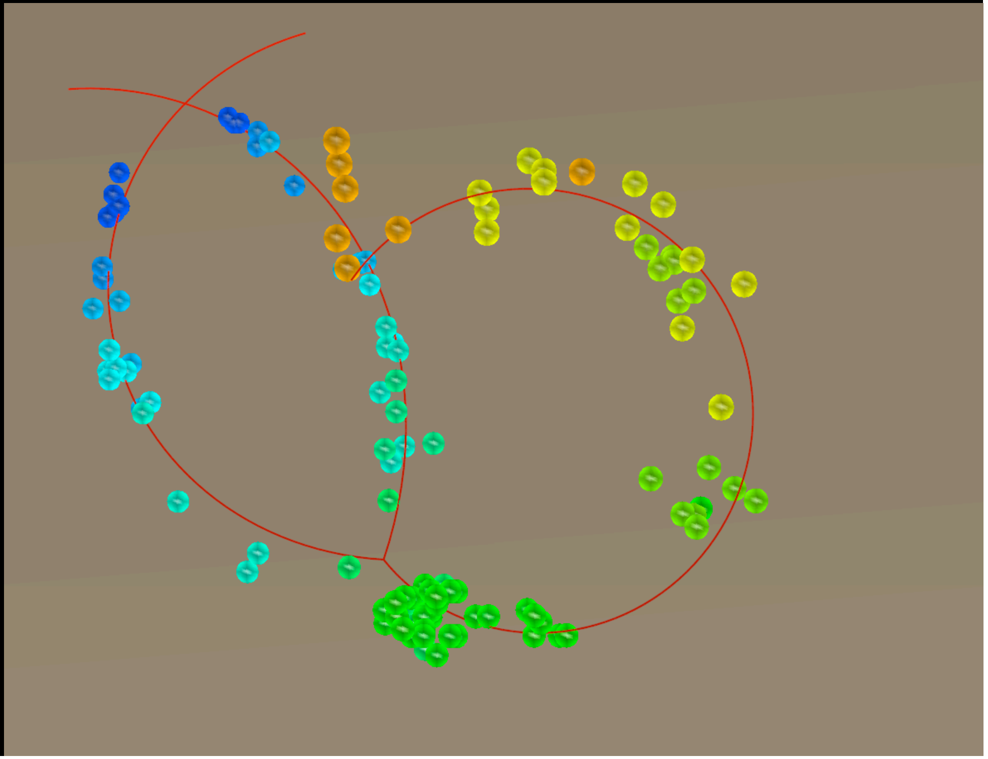








Internal Conversion decay of ^{24}Na

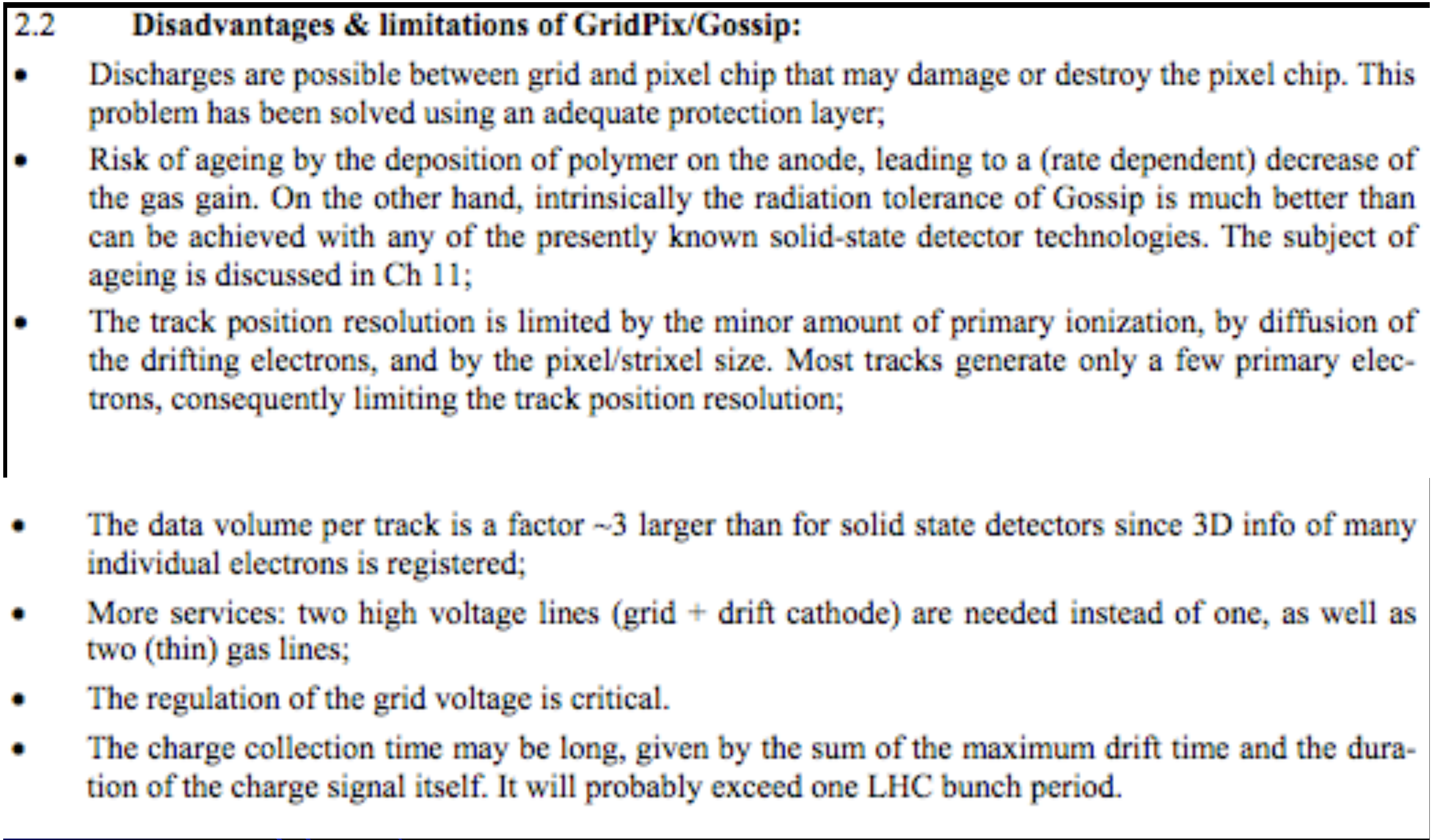


Fokke, Tjeerd, Jan T., Lucie, Wout, Martin,
Joop K.,
Aad vd Kooij
Arie Taal
Wim Lourens
Pieter Dorenbos

Constructed by Hans B., Joop R, Wim G.,
Berend M, Arnold R., Michiel J., Edward B.,

2.1 Advantages of GridPix/Gossip

- Gas is permanently exchanged or refreshed: therefore there is no radiation damage of sensor material; comparing the collected charge per unit of surface with ageing results for wire chambers, there is an outlook for extremely high radiation tolerance, exceeding the possibilities of solid state sensors [3];
- The magnitude of the (charge) signal is tuned by the grid voltage and may have the same magnitude of that of silicon or more;
- There is no bias or dark current through the detection medium;
- In gas $\varepsilon_r = 1$: therefore, and for geometrical reasons, the signal source capacity is as low as ~10 fF, allowing fast, low power and low noise preamps;
- Gossip measures in three dimensions the positions of all single electrons induced by a passing fast charged particle. A track segment is thus measured instead of hit point, and dE/dX information is obtained;
- The probability to generate confusing δ-rays is much smaller. In addition, δ-rays may be recognized, distinguished from primary track ionization, and rejected;
- Gossip has a low probability to detect (background) neutrons and X-rays;
- The technology to produce GridPix detectors is cheap. The detector consists of a CMOS chip on which SiNProt and InGrid are made using standard MEMS technology (no bump bonding). This results in a competitive price per cm^2;
- Gossip can operate in a wide temperature range from -100 to + 50 ^{o}C;
- The low electronic power dissipation, the absence of bias current, and the wide operational temperature range greatly reduce the demands on the cooling system. As a result the mass of the cooling system may be significantly diminished compared to a silicon tracker for high luminosity application, and integration of cooling and (stave) support is well possible.

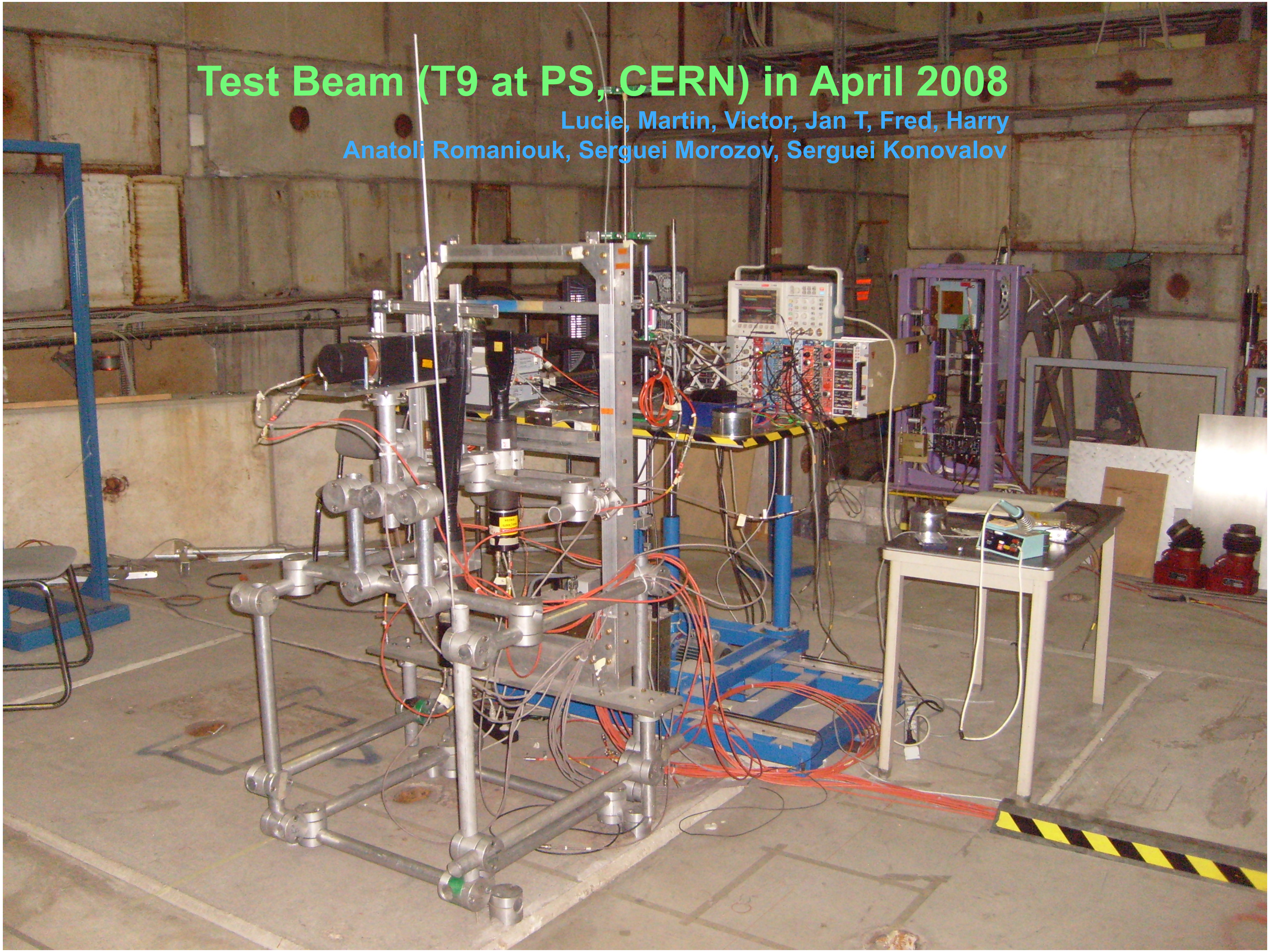


2.2 Disadvantages & limitations of GridPix/Gossip:

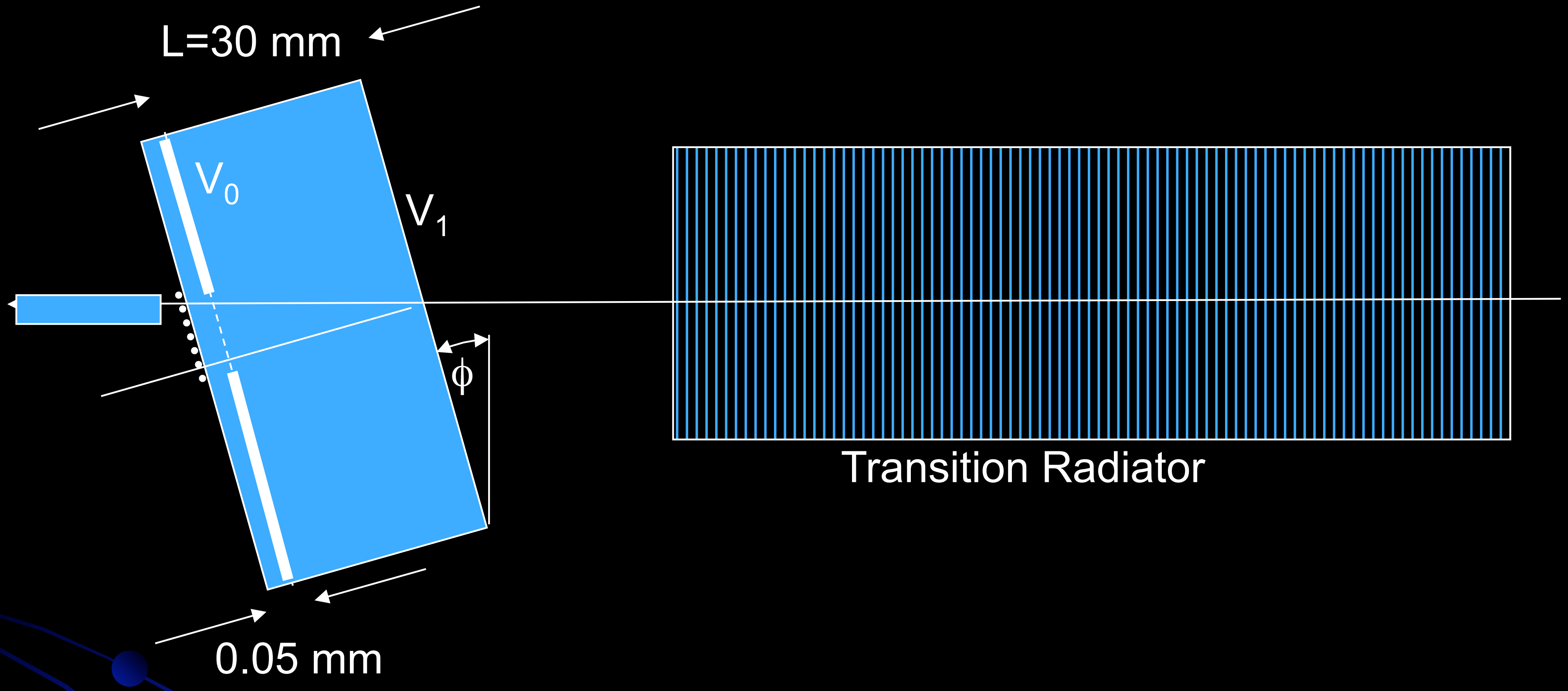
- Discharges are possible between grid and pixel chip that may damage or destroy the pixel chip. This problem has been solved using an adequate protection layer;
- Risk of ageing by the deposition of polymer on the anode, leading to a (rate dependent) decrease of the gas gain. On the other hand, intrinsically the radiation tolerance of Gossip is much better than can be achieved with any of the presently known solid-state detector technologies. The subject of ageing is discussed in Ch 11;
- The track position resolution is limited by the minor amount of primary ionization, by diffusion of the drifting electrons, and by the pixel/strixel size. Most tracks generate only a few primary electrons, consequently limiting the track position resolution;
- The data volume per track is a factor ~3 larger than for solid state detectors since 3D info of many individual electrons is registered;
- More services: two high voltage lines (grid + drift cathode) are needed instead of one, as well as two (thin) gas lines;
- The regulation of the grid voltage is critical.
- The charge collection time may be long, given by the sum of the maximum drift time and the duration of the charge signal itself. It will probably exceed one LHC bunch period.

Test Beam (T9 at PS, CERN) in April 2008

Lucie, Martin, Victor, Jan T, Fred, Harry
Anatoli Romaniouk, Serguei Morozov, Serguei Konovalov

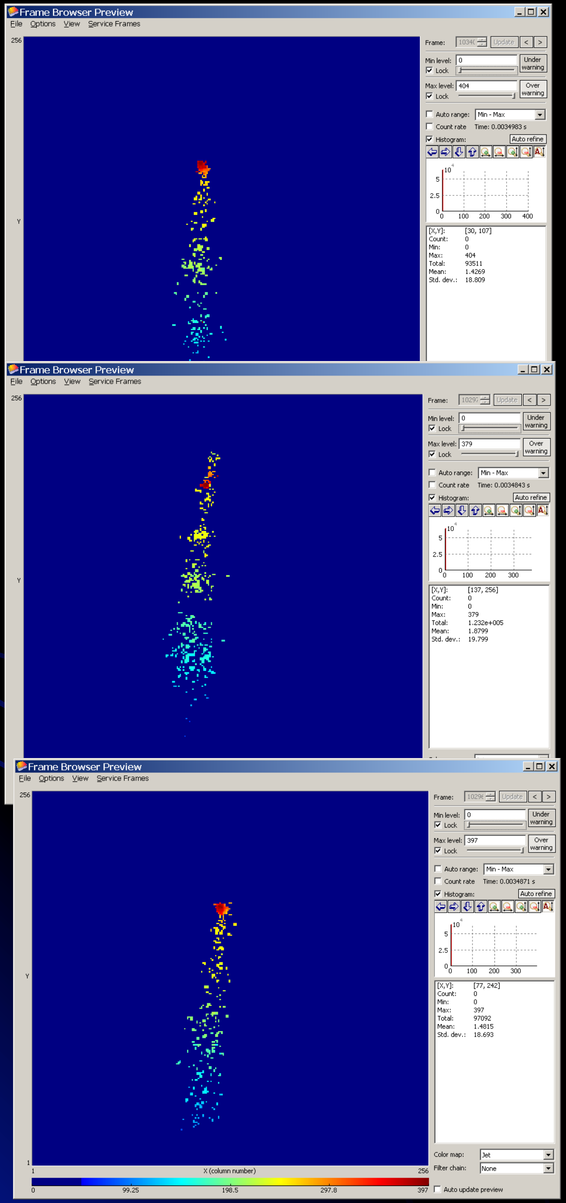


Testbeam April 2008
PS/T9: electrons and pions, 1 – 15 GeV/c



Particle Identification

Samples pions (left) and electrons (right)

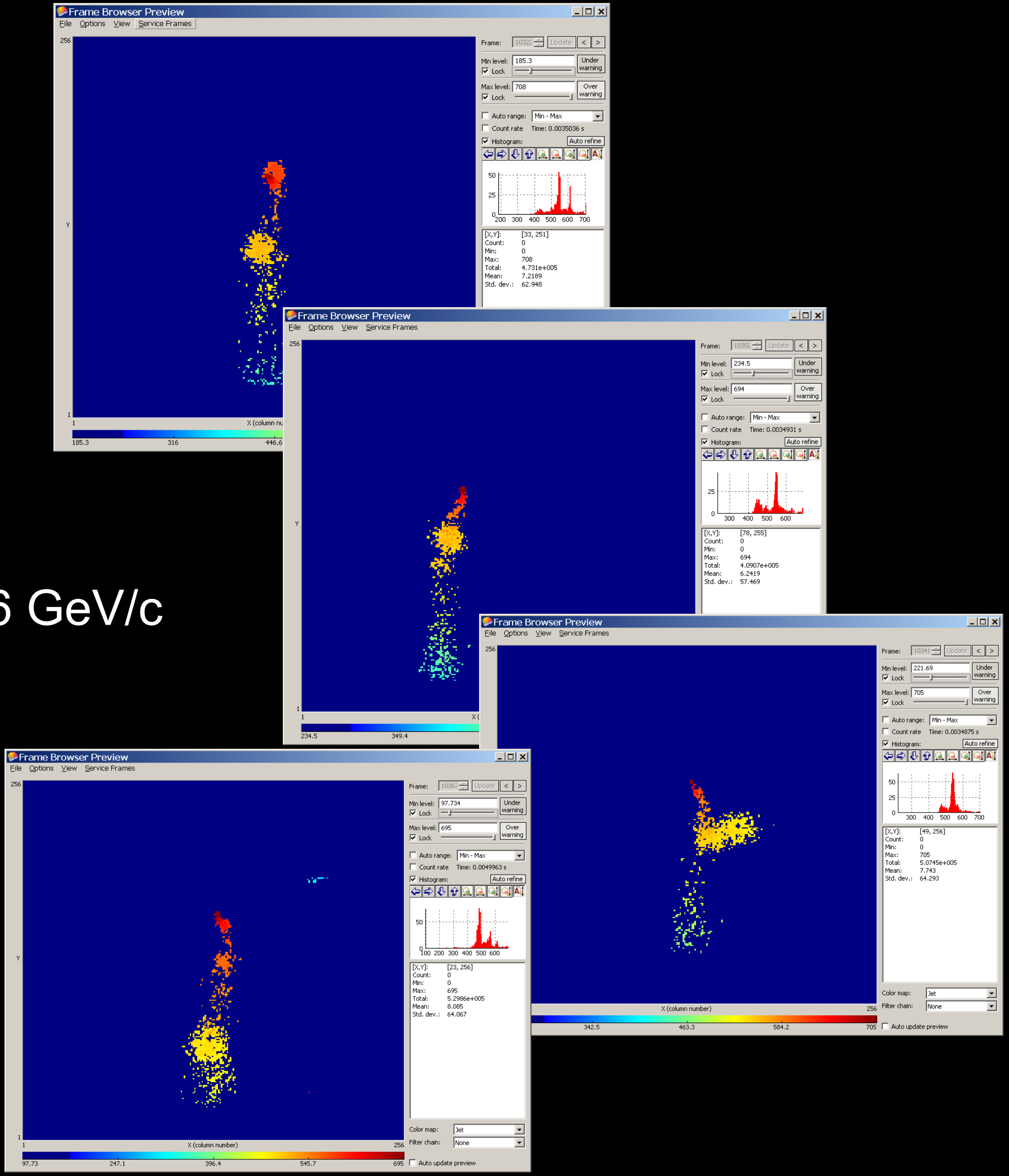


```
Frame: 10340
Min level: 0      ☑ Lock
Max level: 404    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0034983 s
☑ Histogram:
[X,Y]:      [30, 107]
Count:      0
Min:        0
Max:        404
Total:      93511
Mean:       1.4269
Std. dev.:  18.809
```

```
Frame: 10297
Min level: 0      ☑ Lock
Max level: 379    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0034843 s
☑ Histogram:
[X,Y]:      [137, 256]
Count:      0
Min:        0
Max:        379
Total:      1.232e+005
Mean:       1.8799
Std. dev.:  19.799
```

```
Frame: 10296
Min level: 0      ☑ Lock
Max level: 397    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0034871 s
☑ Histogram:
[X,Y]:      [77, 242]
Count:      0
Min:        0
Max:        397
Total:      97092
Mean:       1.4815
Std. dev.:  18.693
Color map: Jet
Filter chain: None
```

6 GeV/c



```
Frame: 10322
Min level: 185.3  ☑ Lock
Max level: 708    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0035036 s
☑ Histogram:
[X,Y]:      [33, 251]
Count:      0
Min:        0
Max:        708
Total:      4.731e+005
Mean:       7.2189
Std. dev.:  62.948
```

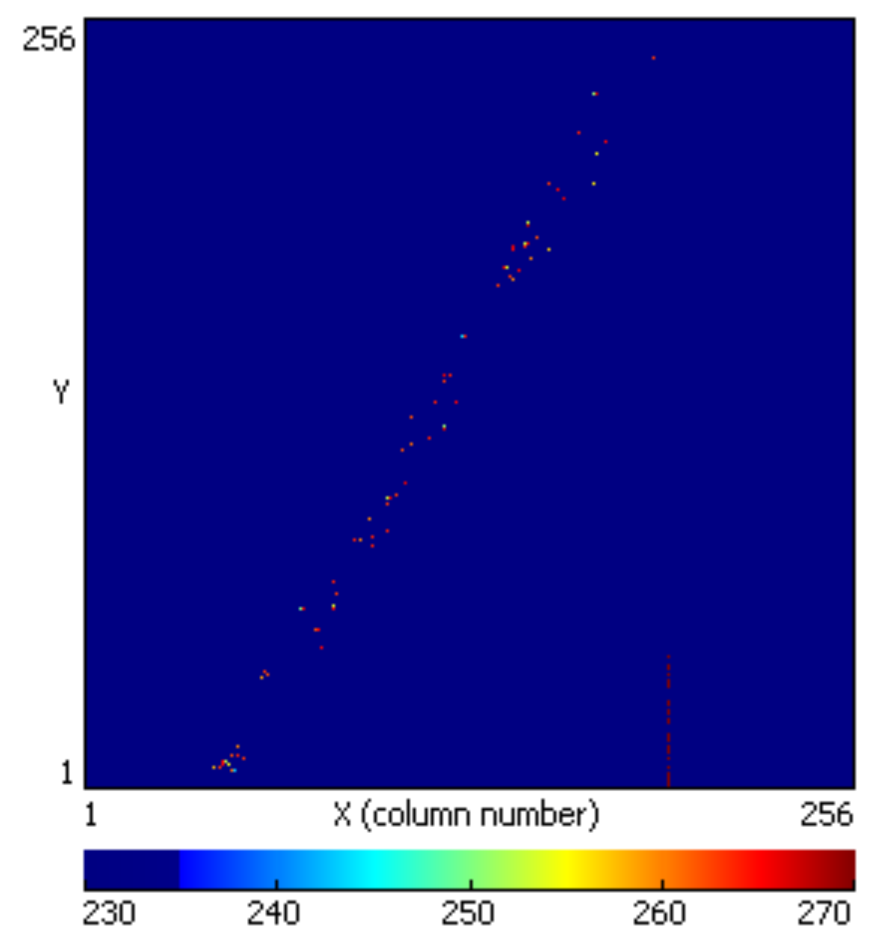
```
Frame: 10302
Min level: 234.5  ☑ Lock
Max level: 694    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0034931 s
☑ Histogram:
[X,Y]:      [78, 255]
Count:      0
Min:        0
Max:        694
Total:      4.0907e+005
Mean:       6.2419
Std. dev.:  57.469
```

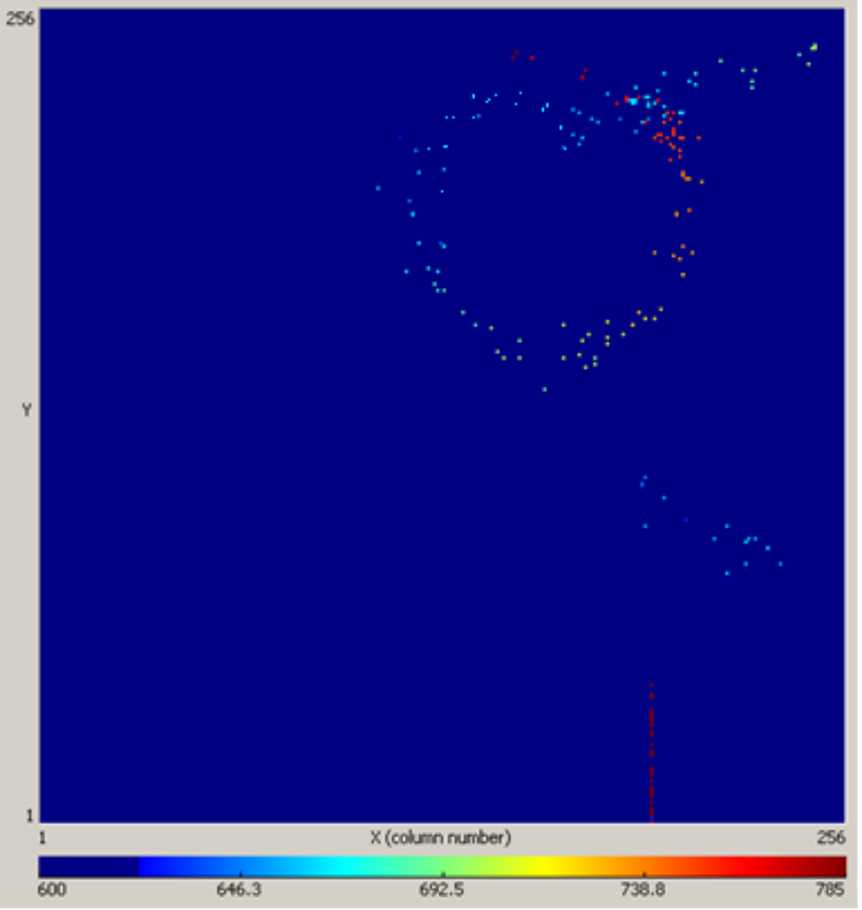
```
Frame: 10341
Min level: 221.69 ☑ Lock
Max level: 705    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0034875 s
☑ Histogram:
[X,Y]:      [49, 256]
Count:      0
Min:        0
Max:        705
Total:      5.0745e+005
Mean:       7.743
Std. dev.:  64.293
Color map: Jet
Filter chain: None
```

```
Frame: 10367
Min level: 97.734 ☑ Lock
Max level: 695    ☑ Lock
☐ Auto range: Min - Max
☐ Count rate   Time: 0.0049963 s
☑ Histogram:
[X,Y]:      [23, 256]
Count:      0
Min:        0
Max:        695
Total:      5.2986e+005
Mean:       8.085
Std. dev.:  64.067
Color map: Jet
Filter chain: None
```

…broke TimePix chip in Xe: 490 V on grid…

Analysis of test beam data and cosmic muon data with GridPix





Colloquium Lucie de Nooij, Tuesday 13 January, 15h, H331

Gridpix : assembly of

- CMOS pixel chip
- Protection layer
- InGrid
- gas-filled field cage

Micro Electronic Mechanical Structures MEMS- technology:

- output of MESA+ (Univ. of Twente) has dropped

- ongoing: technology transfer (SiNProt & InGrid) to IZM, SMC

- DIMES-Delft has shown strong interest:
  - InGrid made of Si_3N_4
  - Alternative for SU8: PerMX
  - EMGrid

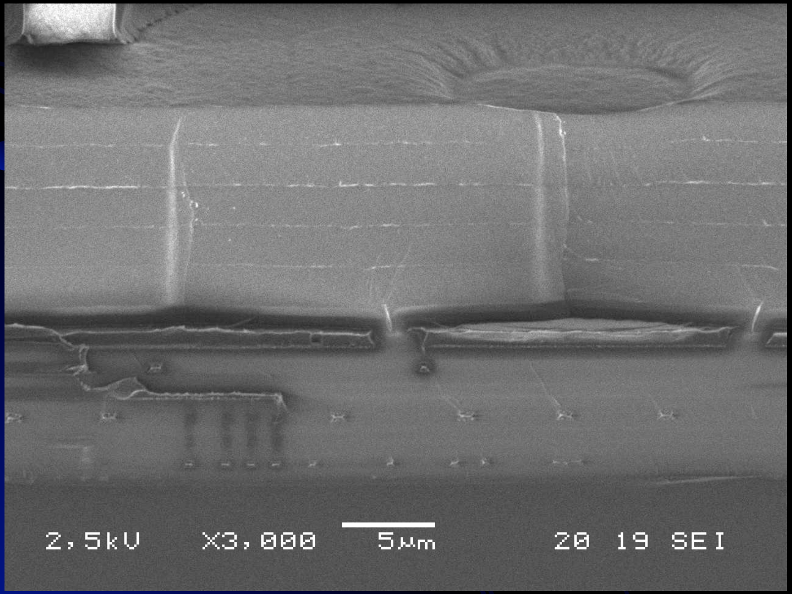
July 2008: protection layer made of Si_3N_4 (Silicon Nitride), only 7 μm thick

$3\ SiH_4 + 4\ NH_3 \rightarrow Si_3N_4 + 12\ H_2$

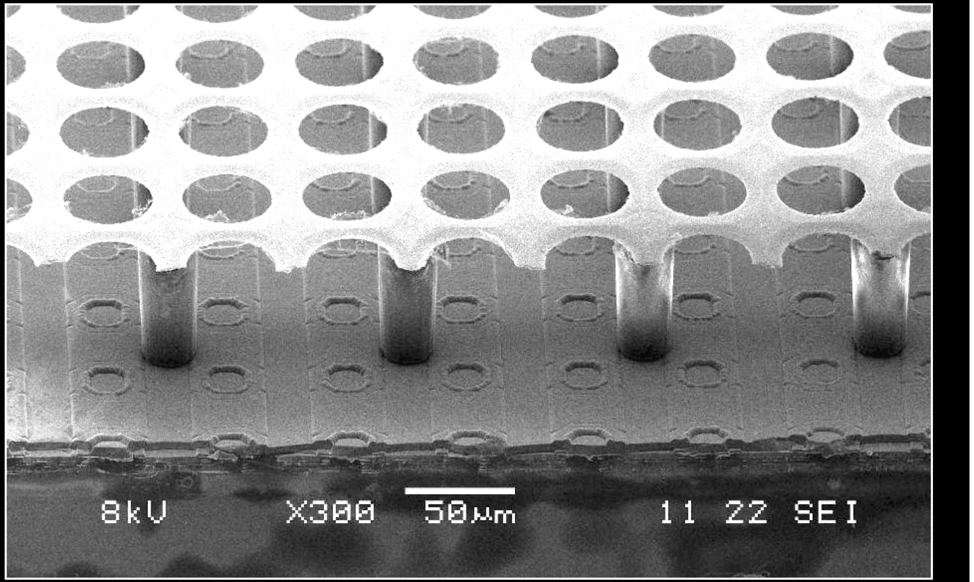
- Silicon Nitride is often applied as passivation layer: top finish of chips.

- With overdose of SiH_4:conductivity: high resistivity bulk material

- Favored material for bearings in turbo chargers, jet engines



5 layers of Si_3N_4



InGrid + a-Si:H

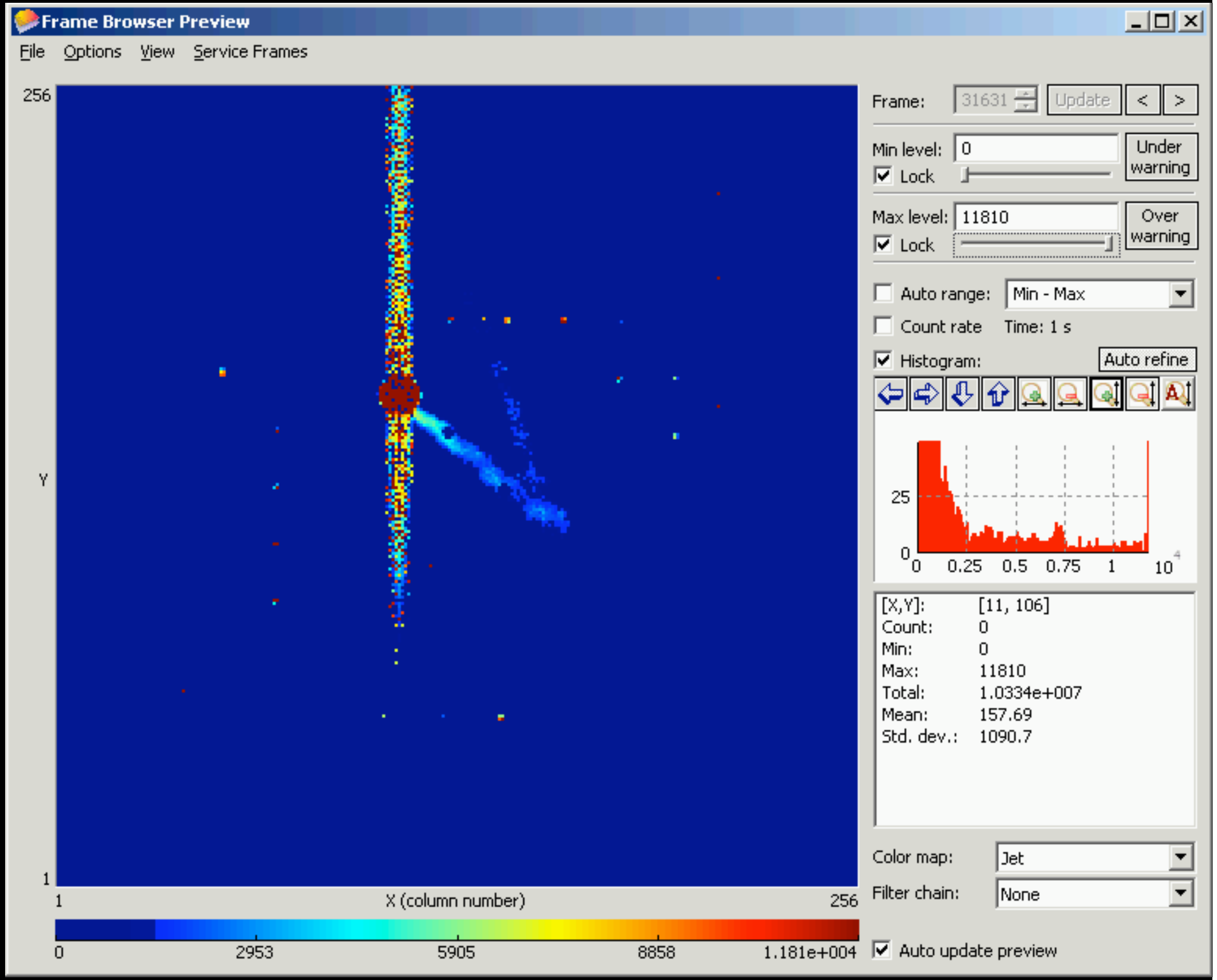
… discharges are observed !

For the 1st time: image of discharges are being recorded

Round-shaped pattern of some 100 overflow pixels

Perturbations in the concerned column pixels
- Threshold
- Power

Chip keeps working



Frame: 31631

Min level: 0

☑ Lock

Max level: 11810

☑ Lock

☐ Auto range: Min - Max

☐ Count rate Time: 1 s

☑ Histogram:

[X,Y]: [11, 106]
Count: 0
Min: 0
Max: 11810
Total: 1.0334e+007
Mean: 157.69
Std. dev.: 1090.7

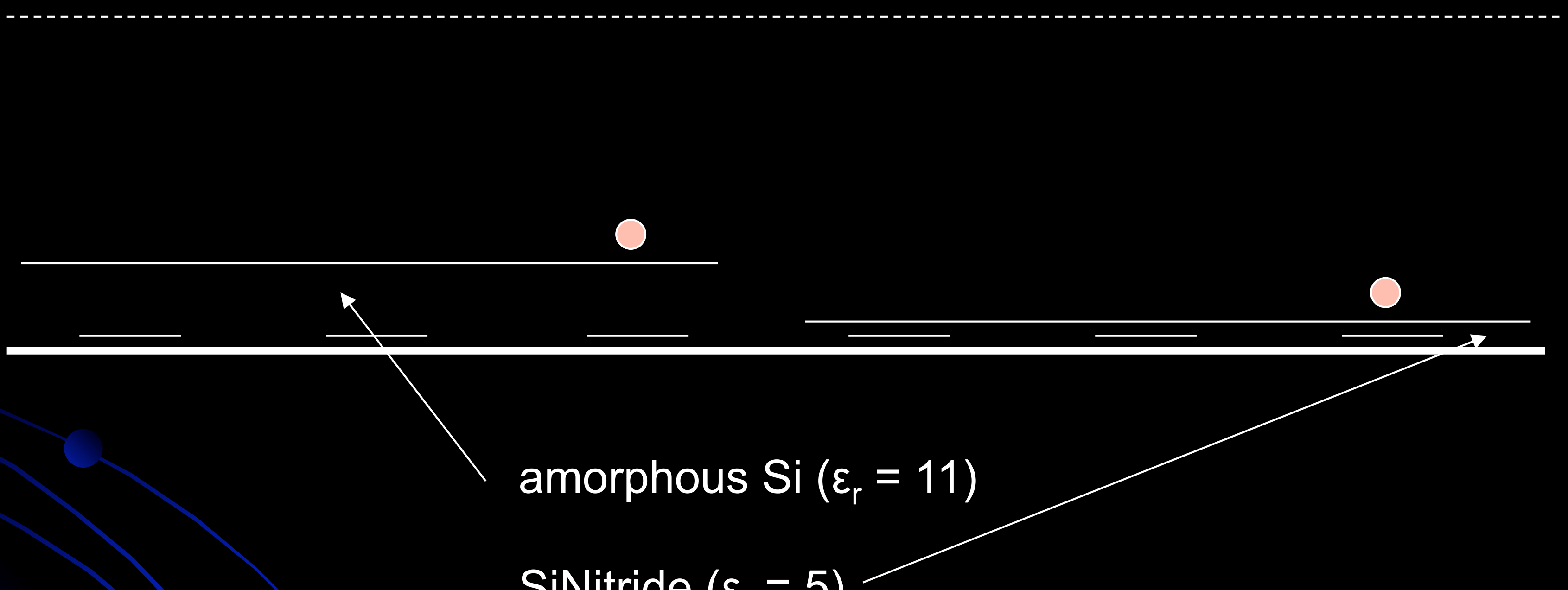
Color map: Jet

Filter chain: None

☑ Auto update preview

Protection layer of amorphous silicon: 2007

Now with Si_3N_4: lower dielectric constant

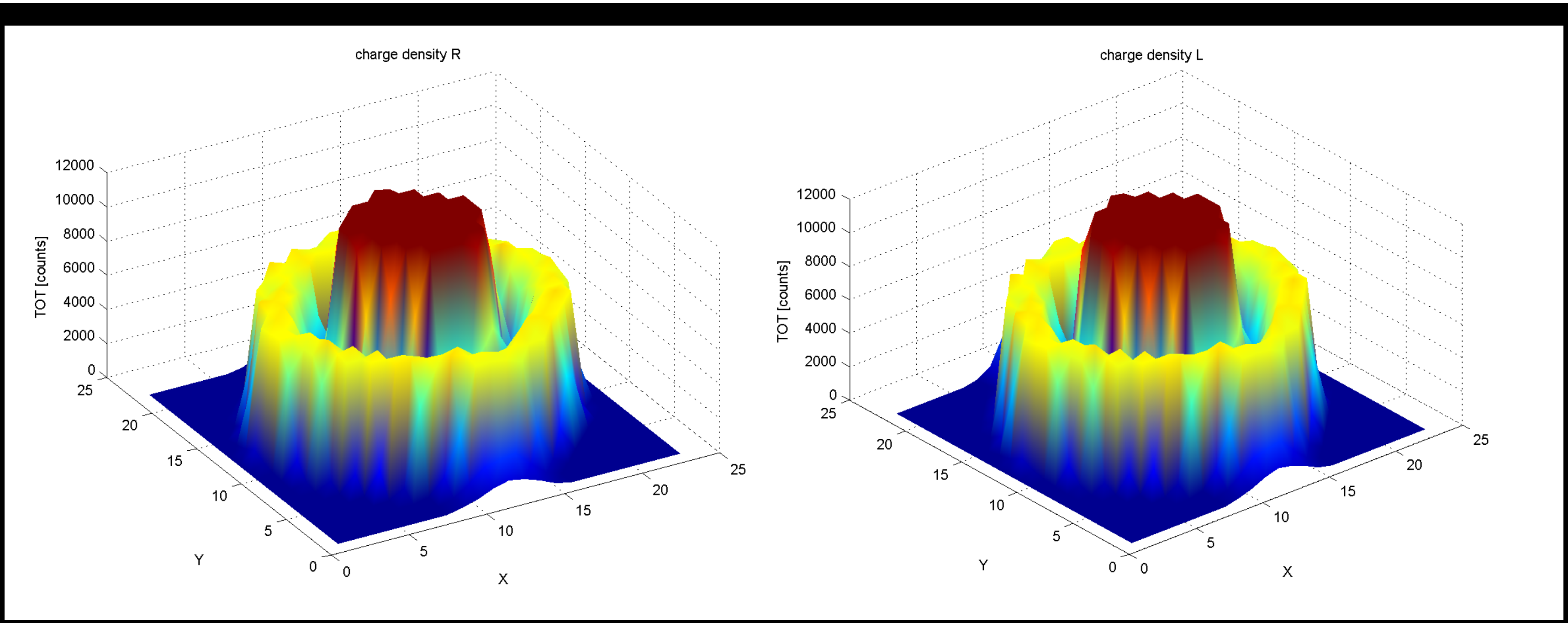


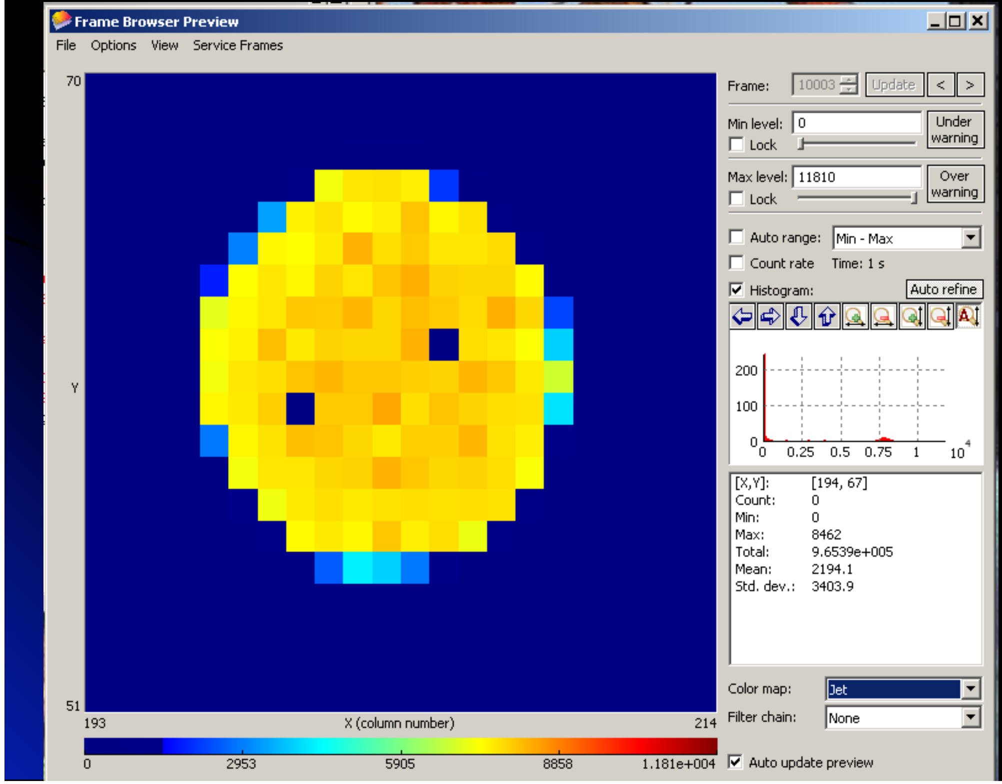
InGrid

amorphous Si (ε_r = 11)

SiNitride (ε_r = 5)

7 µm SiNitride:
Factor ~2 more charge on input pad
for normal (proportional) signals





Frame: 10003

Min level: 0
☐ Lock

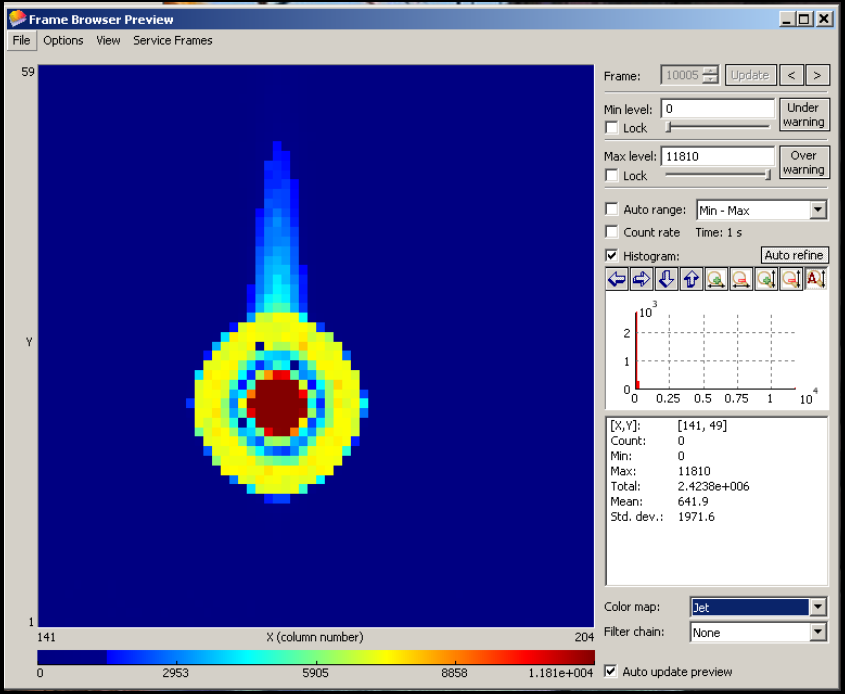
Max level: 11810
☐ Lock

☐ Auto range: Min - Max
☐ Count rate Time: 1 s
☑ Histogram:

[X,Y]: [194, 67]
Count: 0
Min: 0
Max: 8462
Total: 9.6539e+005
Mean: 2194.1
Std. dev.: 3403.9

Color map: Jet
Filter chain: None
☑ Auto update preview

Discharge (protection) studies:
Martin Fransen



Frame: 10005

Min level: 0

☐ Lock

Max level: 11810

☐ Lock

☐ Auto range: Min - Max

☐ Count rate Time: 1 s

☑ Histogram:

[X,Y]: [141, 49]
Count: 0
Min: 0
Max: 11810
Total: 2.4238e+006
Mean: 641.9
Std. dev.: 1971.6

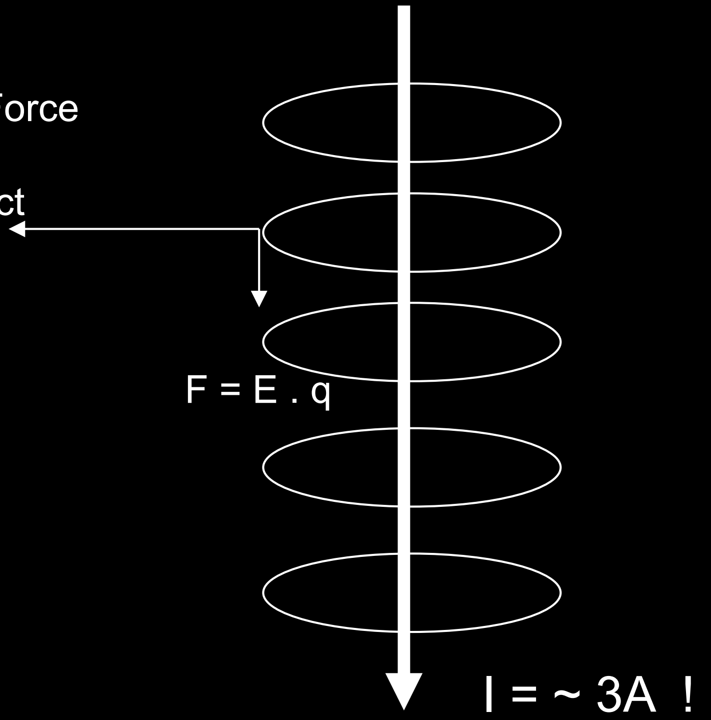
Color map: Jet

Filter chain: None

☑ Auto update preview

Lorentz Force

Skin Effect

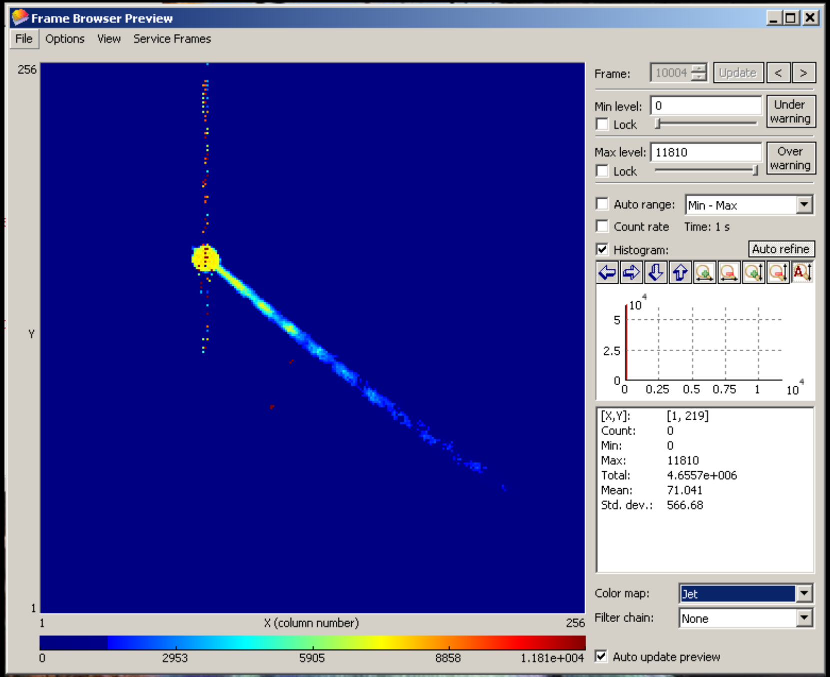


$F = E \, . \, q$

I = ~ 3A !

© Copyright 2004 Eric Nguyen

Improvement with Si Nitride



Frame: 10004

Min level: 0

☐ Lock

Max level: 11810

☐ Lock

☐ Auto range: Min - Max

☐ Count rate Time: 1 s

☑ Histogram:

[X,Y]: [1, 219]
Count: 0
Min: 0
Max: 11810
Total: 4.6557e+006
Mean: 71.041
Std. dev.: 566.68

Color map: Jet

Filter chain: None

☑ Auto update preview

4 years ago

Friday 13 (!) Feb 2004: signals from a ^{55}Fe source (220 e- per photon); 300 μm x 500 μm clouds as expected

The Medipix CMOS chip faces
an electric field of 350 V/50 μm

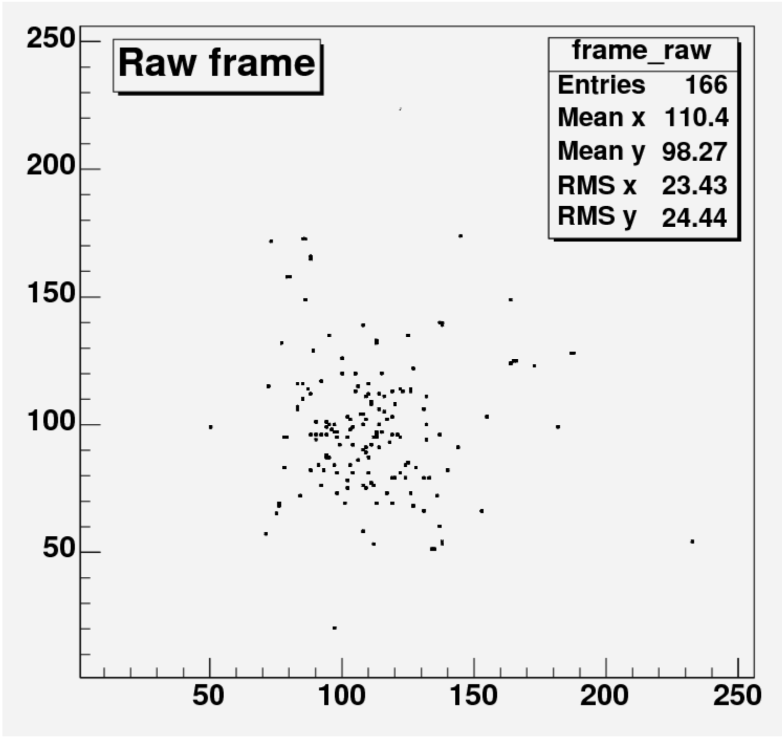
= 7 kV/mm !!

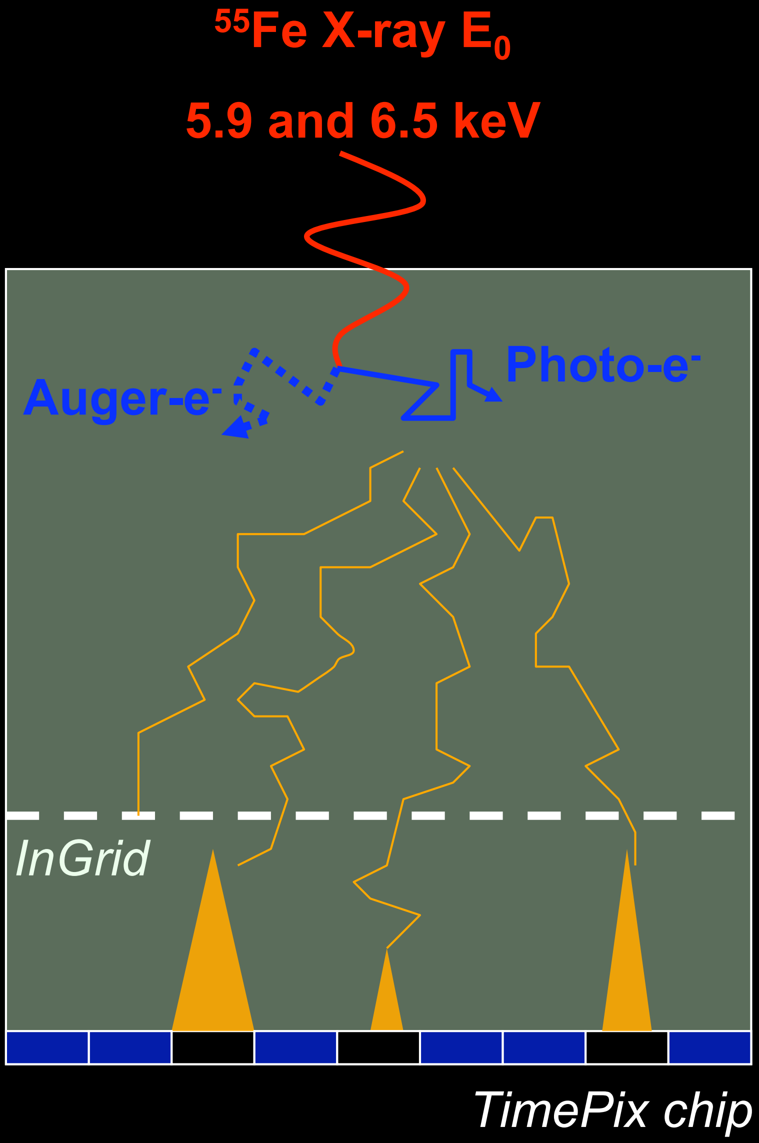
We always knew, but never saw: the conversion of ^{55}Fe quanta in Ar gas

^{55}Fe quanta conversions seen by GridPix: 'The digital TPC'

See Thesis Max Chefdeville: Jan 15, 2009

After large drift distance, primary e$^-$ separate and can be counted





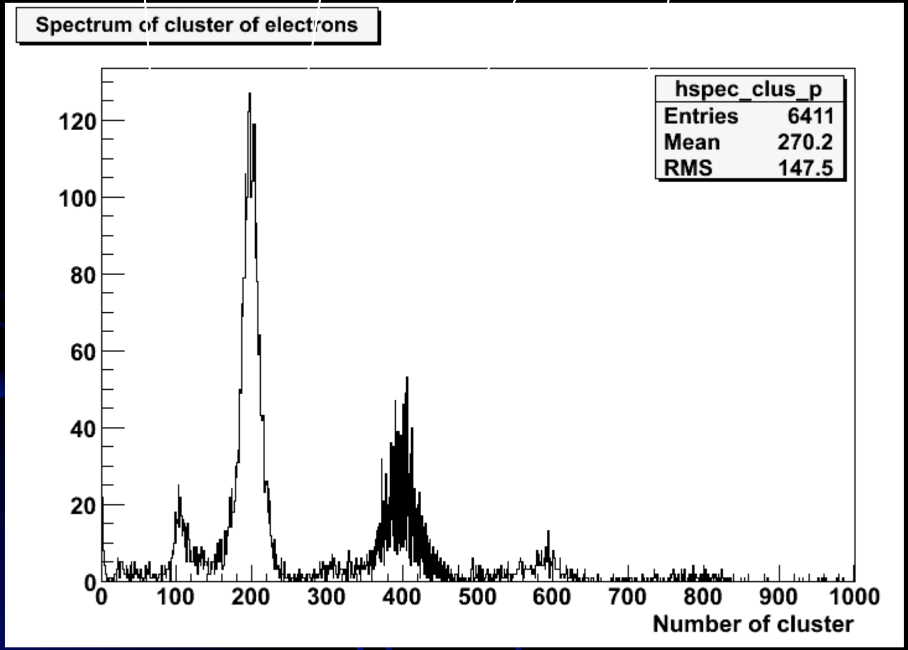
^{55}Fe quanta conversions seen by GridPix

Escape peak (only photo-e)

Photo-peak (photo-e and Auger-e)

2 conversions

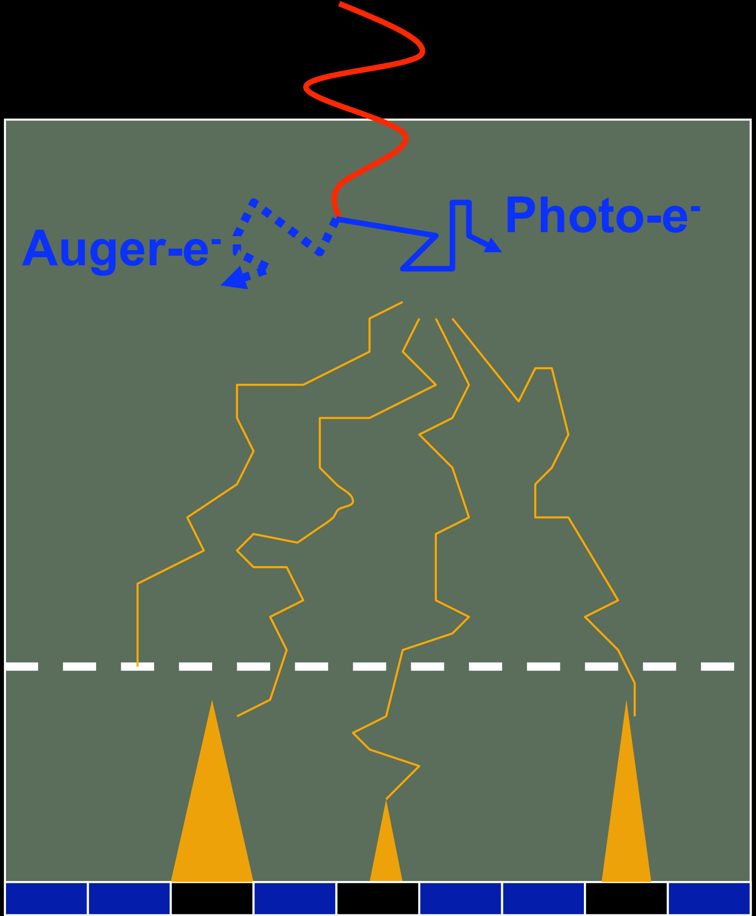
3 conversions



Raw spectrum

^{55}Fe X-ray E_0

5.9 and 6.5 keV



TimePix chip

Look at the escape peak only (smallest number of primary electrons)

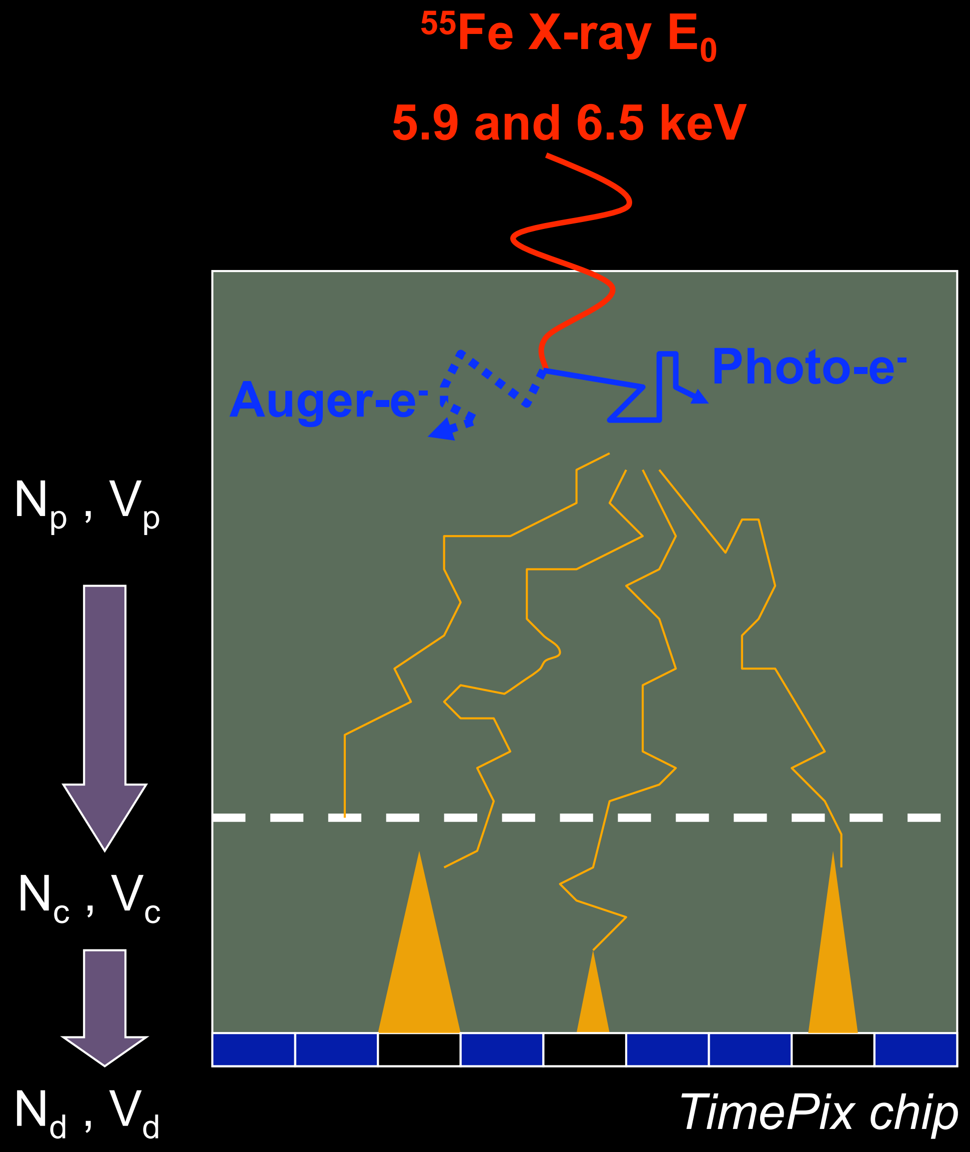
Measurements of W and F

What is measured is the mean and variance of the number of detected electrons (N_d, V_d)

Correction for limited collection and detection efficiencies yield N_p and V_p

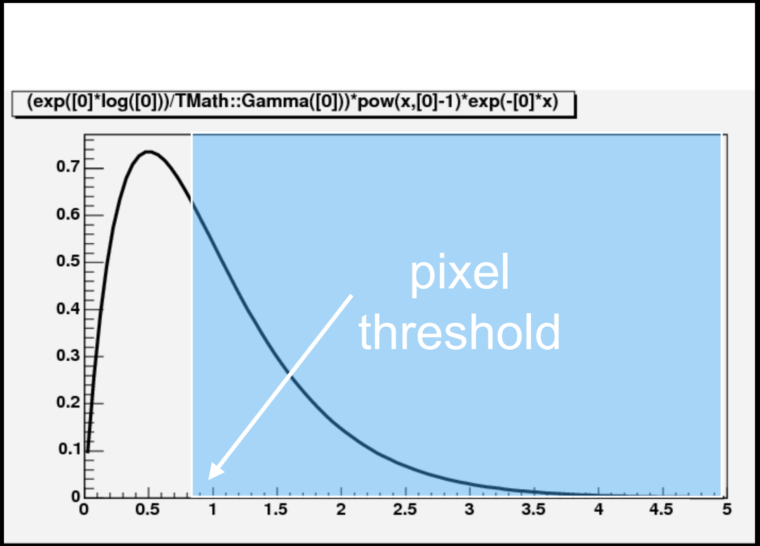
$W = E_0 / N_p$
$F = V_p / N_p$

Collection and detection eff. should be known



Detection efficiency

$\kappa = \int_t^\infty p(g).dg$



Exponential fluctuations:

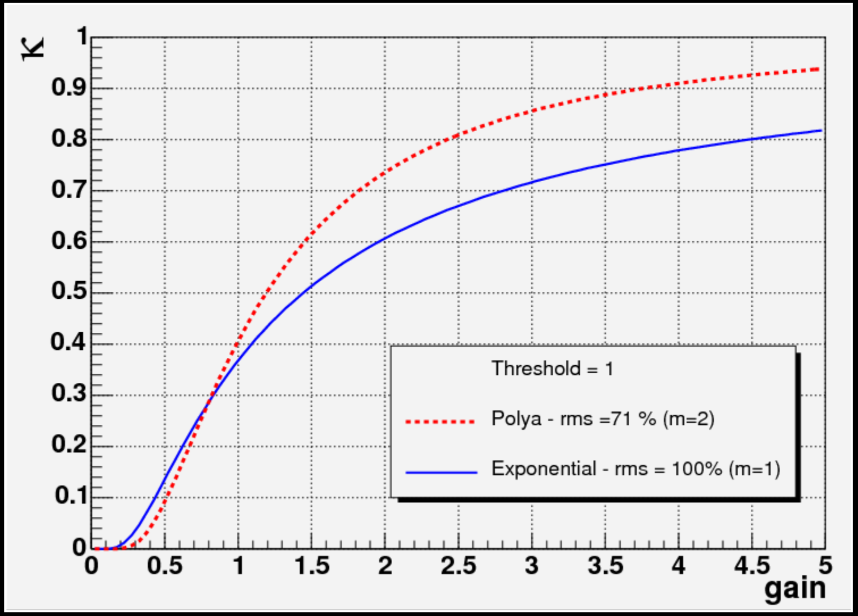
$\kappa(g) = \exp(-t/\langle g\rangle)$

Polya-like fluctuations:

parameter m=1/b ~ 2

with √b the relative rms

$\kappa(2,g) = (1+2.t/\langle g\rangle) . \exp(-2.t/\langle g\rangle)$



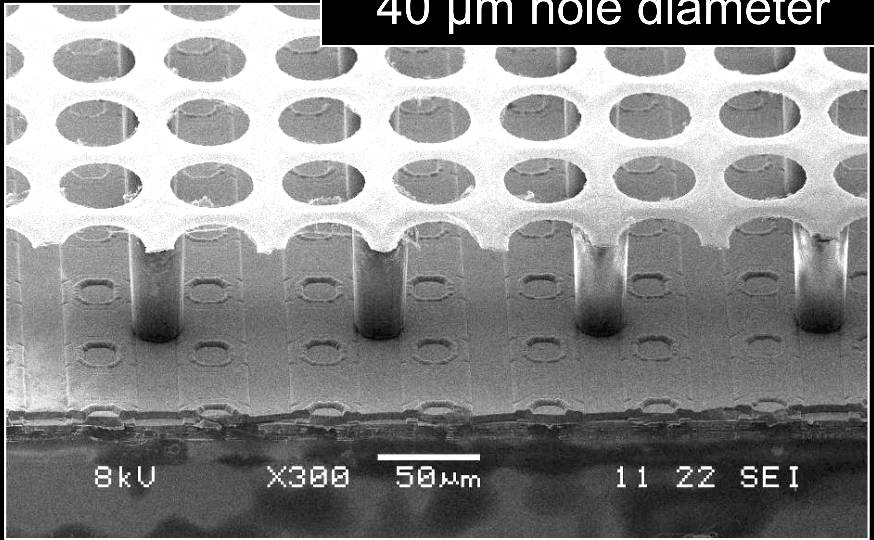
Detection efficiency will be determined by fitting κ(g) to (N_d, V_{grid}) data points

Detectors

Two measurement periods

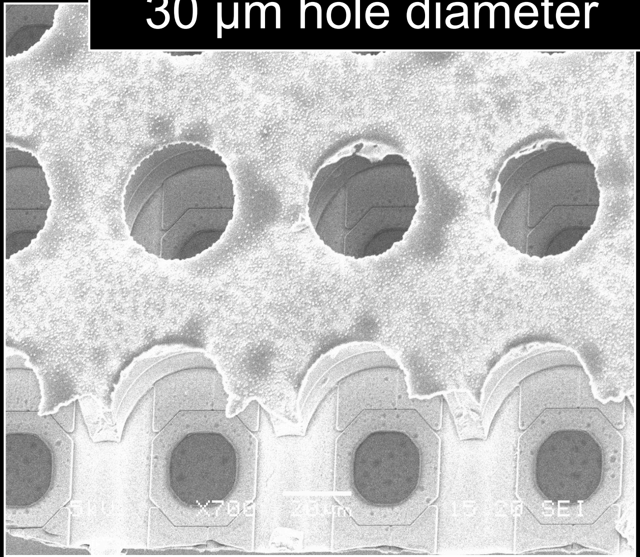
Timepix chip # 1:
Standard InGrid
Low event statistics

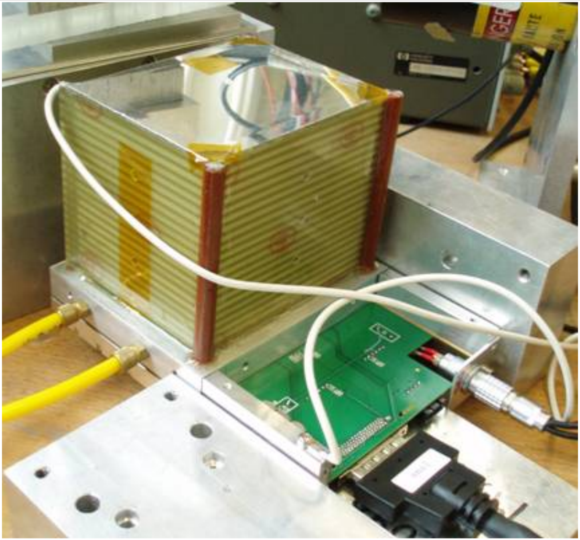
40 µm hole diameter

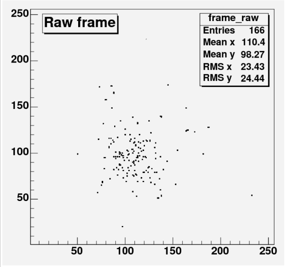


Timepix chip #2 :
Increased event statistics
New GEMGrid structure
Filter out 6.5 keV with Cr foil

30 µm hole diameter



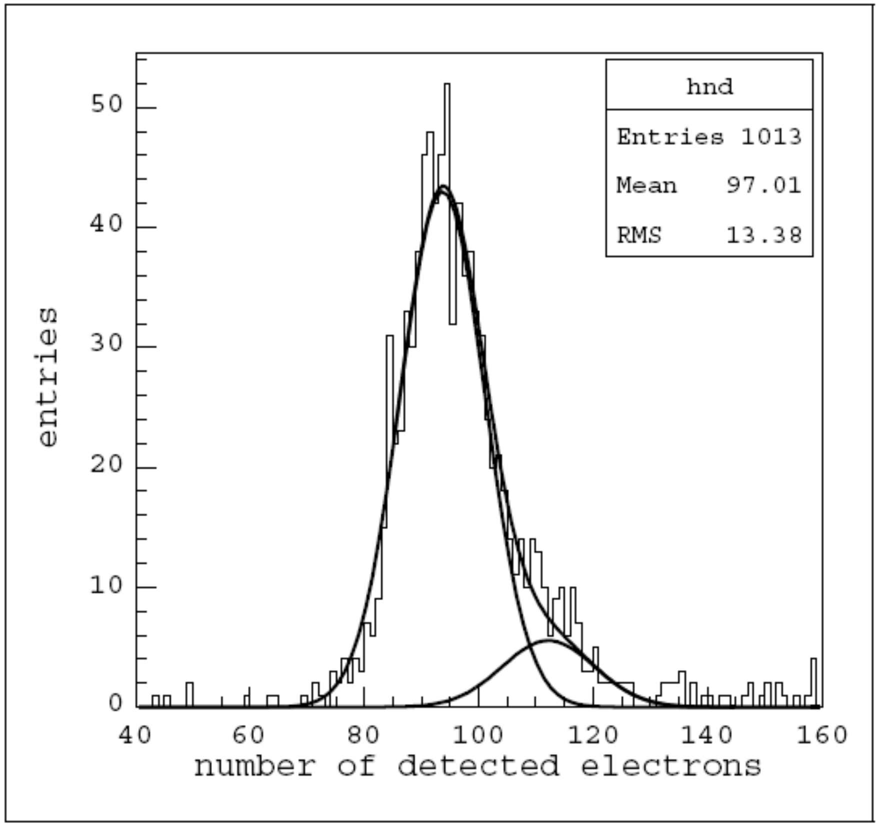




Chamber geometry:
10 cm field cage
Guard electrode surrounding the chip
(inside chamber)

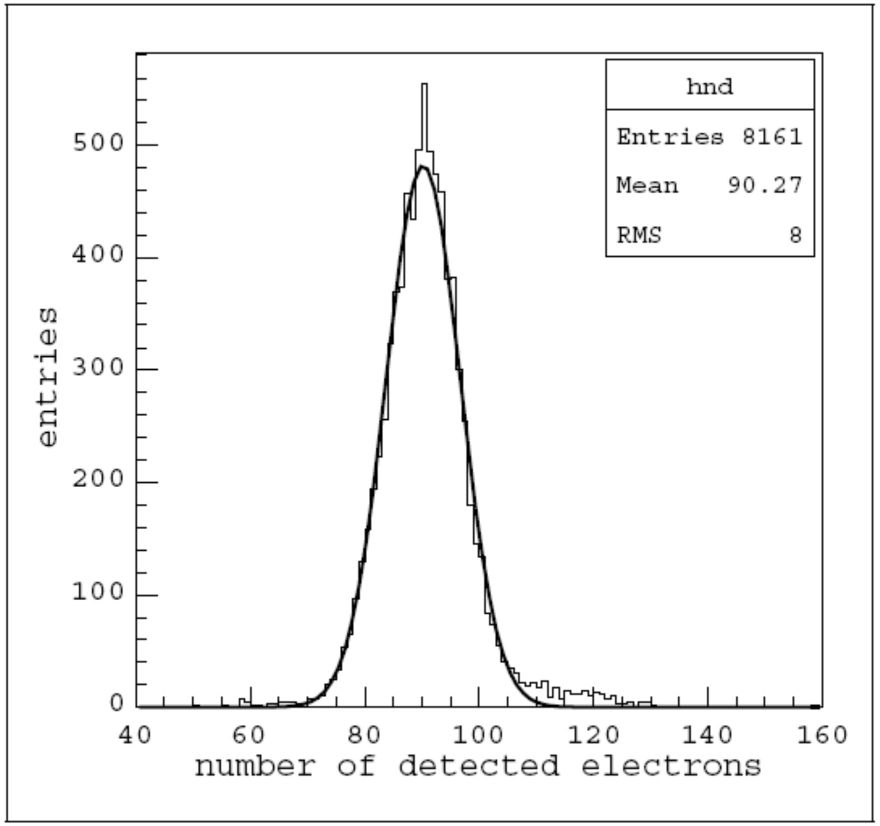
Measured spectra at -330 V

- Timepix #1



5.9 and 6.5 keV escape events
(event ratio ~ 7:1)

- Timepix #2

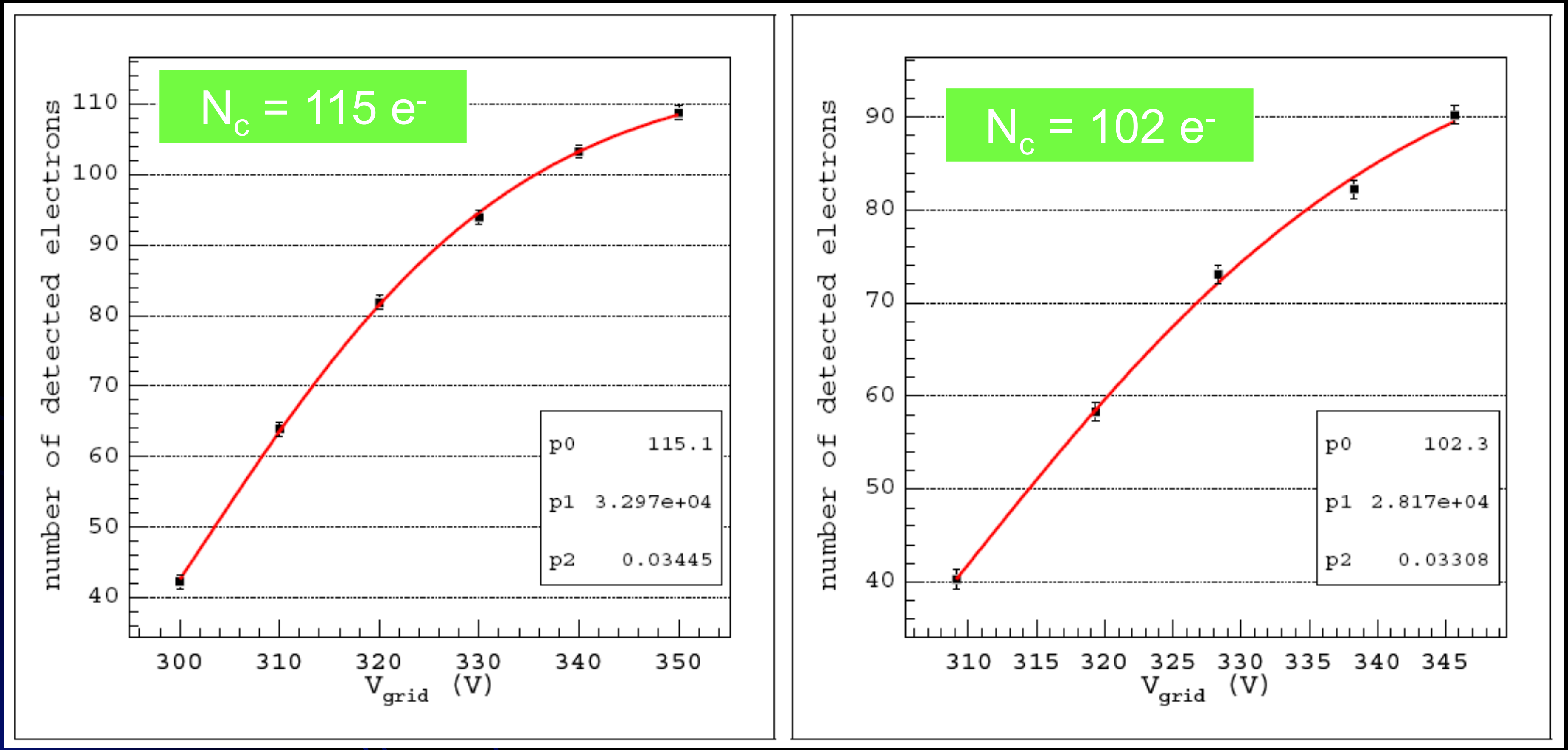


5.9 and 6.5 keV escape events
(event ratio ~ 50:1)

Peak position and grid voltage

Asymptotic value of N_d gives the number of collected electrons N_c

Polya fit works very well where exponential one (not shown) fails!



- Compatible with the smaller hole diameter of InGrid #2
- Contribution from collection efficiency to peak width now known

W and F in Ar/iso 95/5 at 2.9 keV

Assume full collection efficiency of detector #1

$N_p = N_c = 115 \pm 2$ e-

→ W = 25.2 ± 0.5 eV

Extrapolation to 5.9 keV photo-peak straightforward

$N_p = 230 \pm 4$ e-

Peak width measured with detector #2 corrected for detection and collection eff. (87 %)

$\mathrm{RMS}(N_p) \sim 4.3$ %

→ F = 0.21 ± 0.06

Compatible with literature

W = 25.0 ± 0.6 eV

F = 0.250 ± 0.010

Ar/iso 20/80 – 1253 eV X-rays

from Pansky. *et al.*

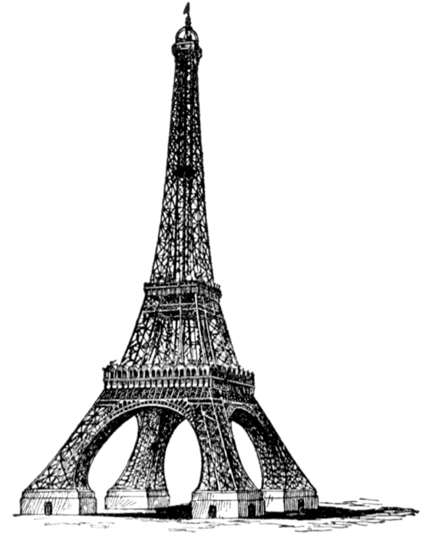
J. Appl. Phys. **79** (1996) 8892

GridPix in Double Beta Decay
Dark Matter/Energy experiments

FOURTH SYMPOSIUM ON LARGE TPCs
FOR LOW ENERGY RARE EVENT DETECTION

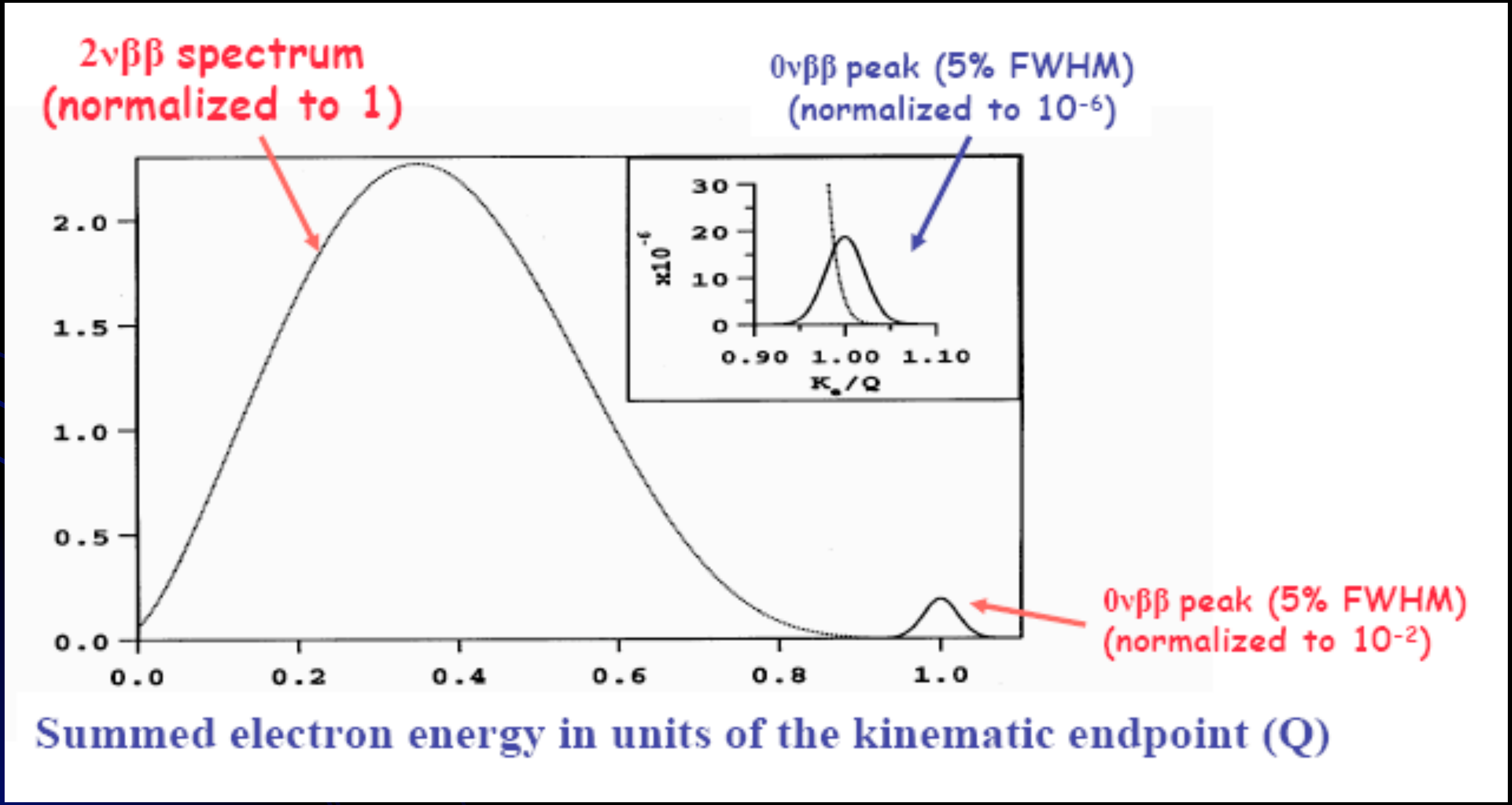
Institut Henri Poincaré
11 rue Pierre et Marie Curie
Hermite auditorium

PARIS 5ème, France
December 18-19, 2008



How to look for neutrino-less decay

- Measure the spectrum of the electrons



$2\nu\beta\beta$ spectrum (normalized to 1)

$0\nu\beta\beta$ peak (5% FWHM) (normalized to 10^{-6})

$0\nu\beta\beta$ peak (5% FWHM) (normalized to 10^{-2})

Summed electron energy in units of the kinematic endpoint (Q)

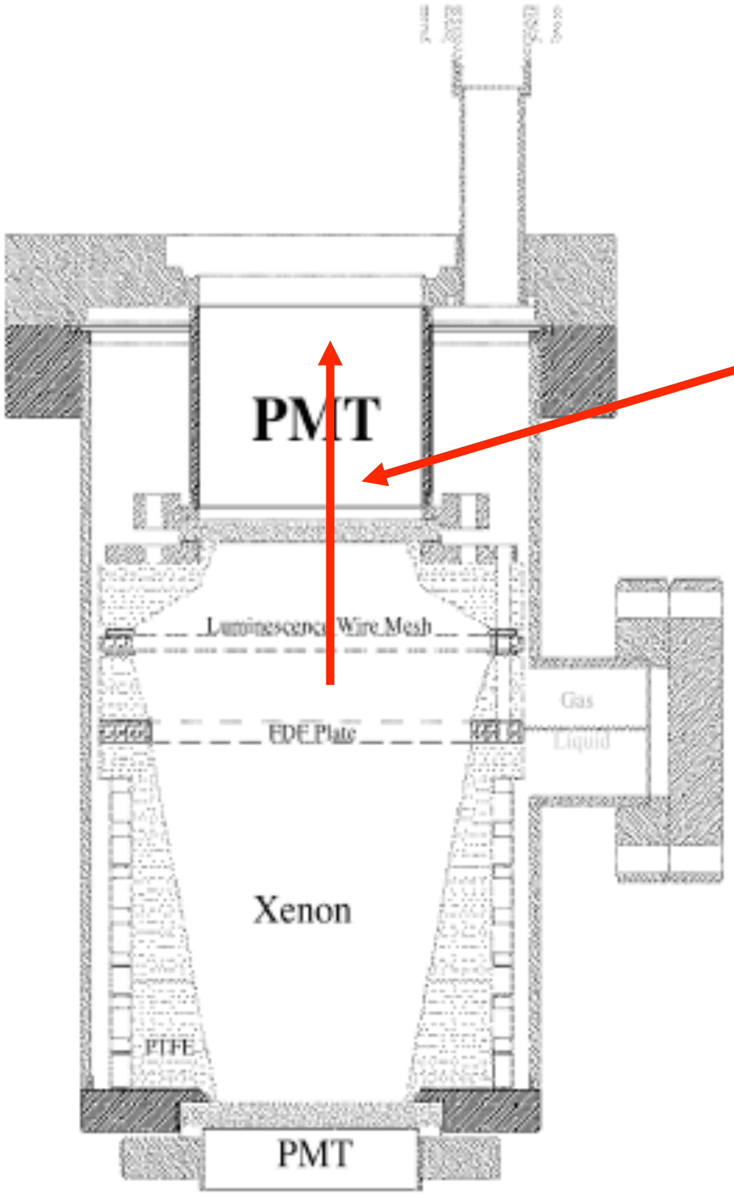


FIGURE 3. XEPLIN II: Electroluminescence in gas (principle of a two-phase, 1-kg detector, developed by UCLA–CERN–Torino).

photons

Drifting electrons in Xe gas

WIMP search in Xe:
Useful to get positional info of individual electrons?

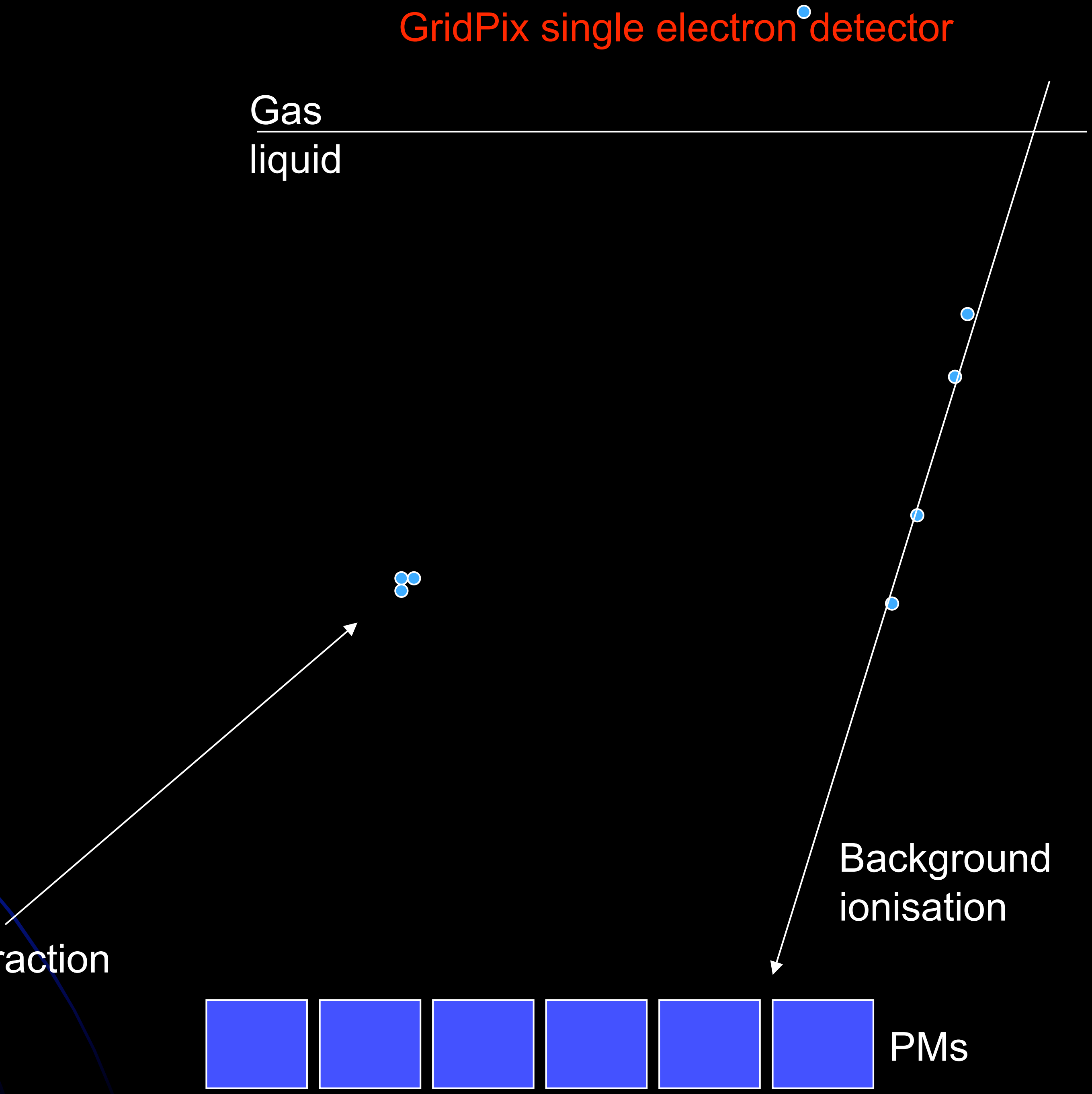
-Ionisation of recoil nucleon: small cluster ~ 10 e-
  σ (X,Y)min ~20 μm
  σ (Z) ~ 1 mm: Polya. Could be ~100 μm.

- zero-diffusion off-track electron positions

- Low (NO!) noise operation

- Background: contamination

- Background recognition & discrimination?



GridPix single electron detector

Gas

liquid

Background ionisation

WIMP interaction

PMs

Resent Results in the Study of High Pressure Xenon for WIMP Detection

James T. White

Texas A&M University

Collaborating with
D. Nygren – LBL
H. Wang - UCLA

4th Symposium – on Large TPCs for Low Energy Rare Event Detection
Institut Henri Poincare, Paris France Dec 18-19 2008

RD 51

R&D ‘experiment’, virtually based at CERN

Micro Pattern Gas Detectors

- Technology
- common tests
- electronics
- simulations
- ageing

- Kick off workshop at NIKHEF in April 2008

RD-51 WG2 meeting 10th Dec. 2008

Ageing tests and analysis of organic compounds released from various detector materials

Kari Kurvinen on behalf of

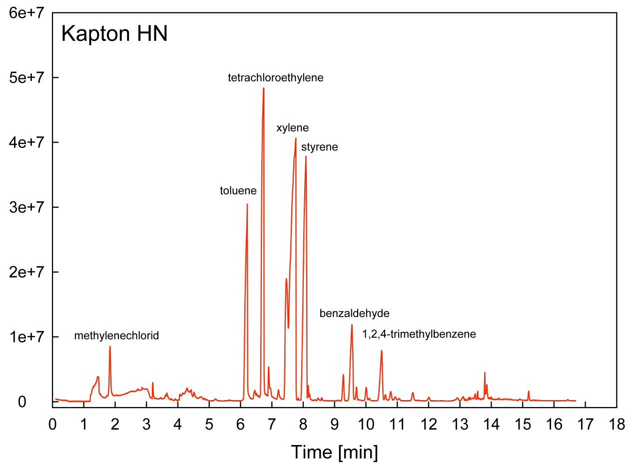
H.Andersson[d], T.Andersson[d], J.Heino[a], J.Huovelin[c], K.Kurvinen[a,], R.Lauhakangas[a],*

S.Nenonen[d], A.Numminen[a], J.Ojala[a], R.Orava[a,b], J.Schultz[c], H.Sipilä[d], O.Vilhu[c]

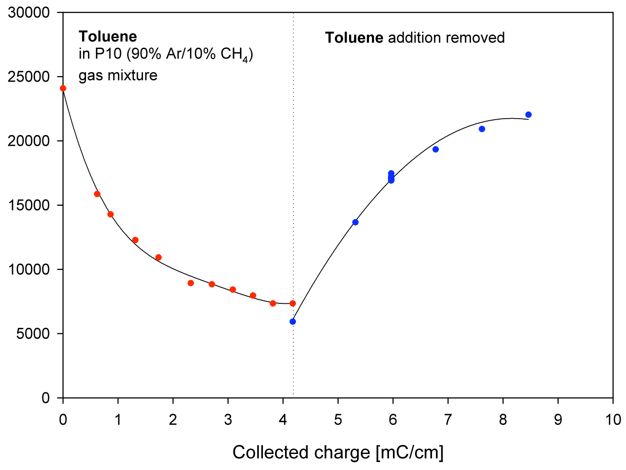
[a]Helsinki Institute of Physics, P.O.Box 64, FIN-00014 University of Helsinki, Finland
[b]Department of Physical Sciences / Division of High Energy Physics, P.O.Box 64, FIN-00014 University of Helsinki, Finland
[c]Observatory, P.O.Box 14, FIN-00014 University of Helsinki, Finland
[d]Metorex International Oy, P.O.Box 85, FIN-02631 Espoo, Finland

based on talks given in NSS 2003 and NSS2004 symposium
(see conf.CDs and IEEE Trans. on Nucl. Sci 51 No.5, 2004)

Results - Outgassing Analysis



Results - Accelerated Aging Test



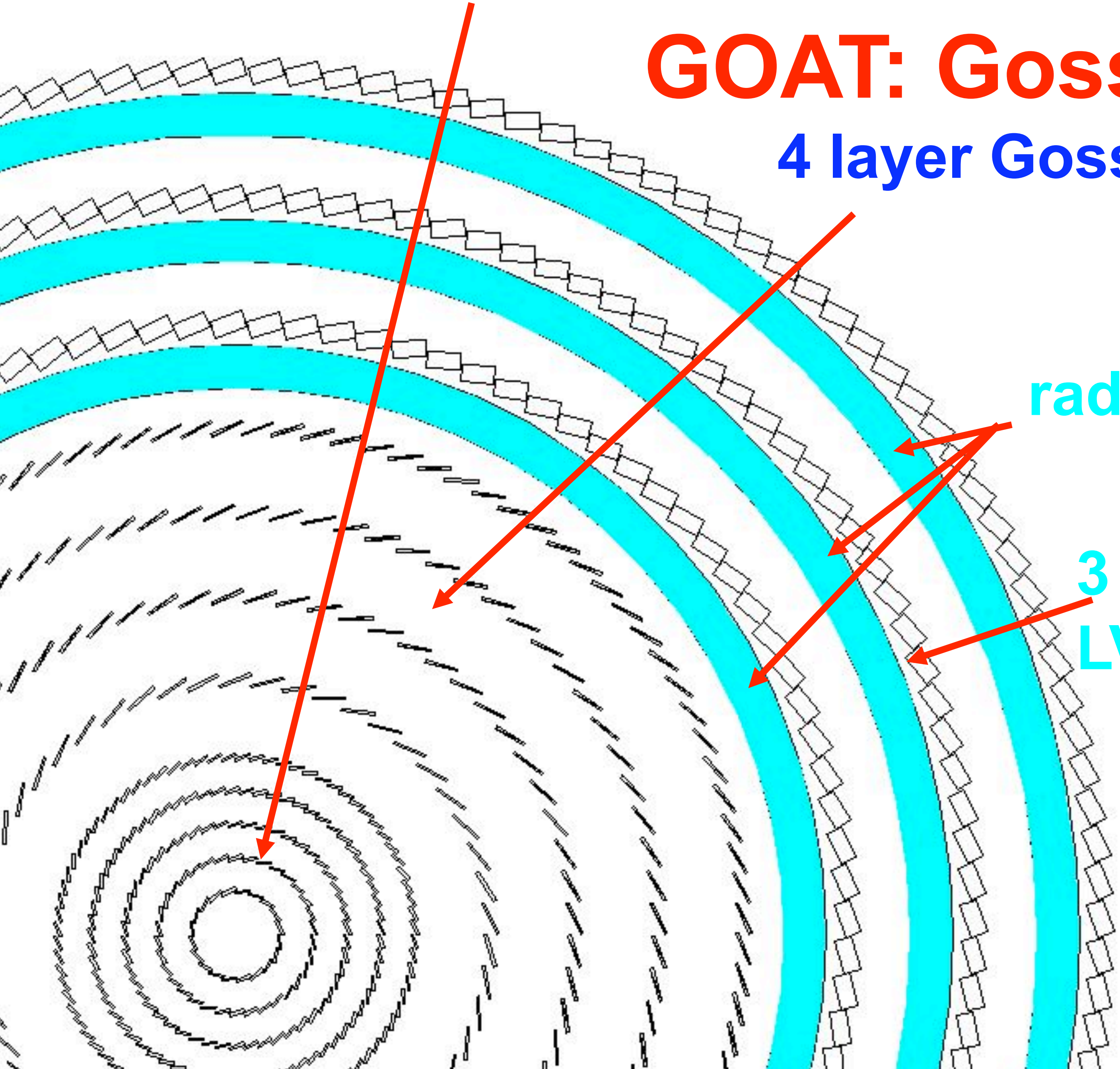
So: ageing are two effects in equilibrium!

Serious consequences for ongoing ageing studies @ Nikhef:

- LHCb problem
- Fred’s radiation facility
- UV ageing set-up @ Nikhef

RD-51 wide coordination: Helsinki/CERN/Nikhef

GOAT: Gossip in ATLAS



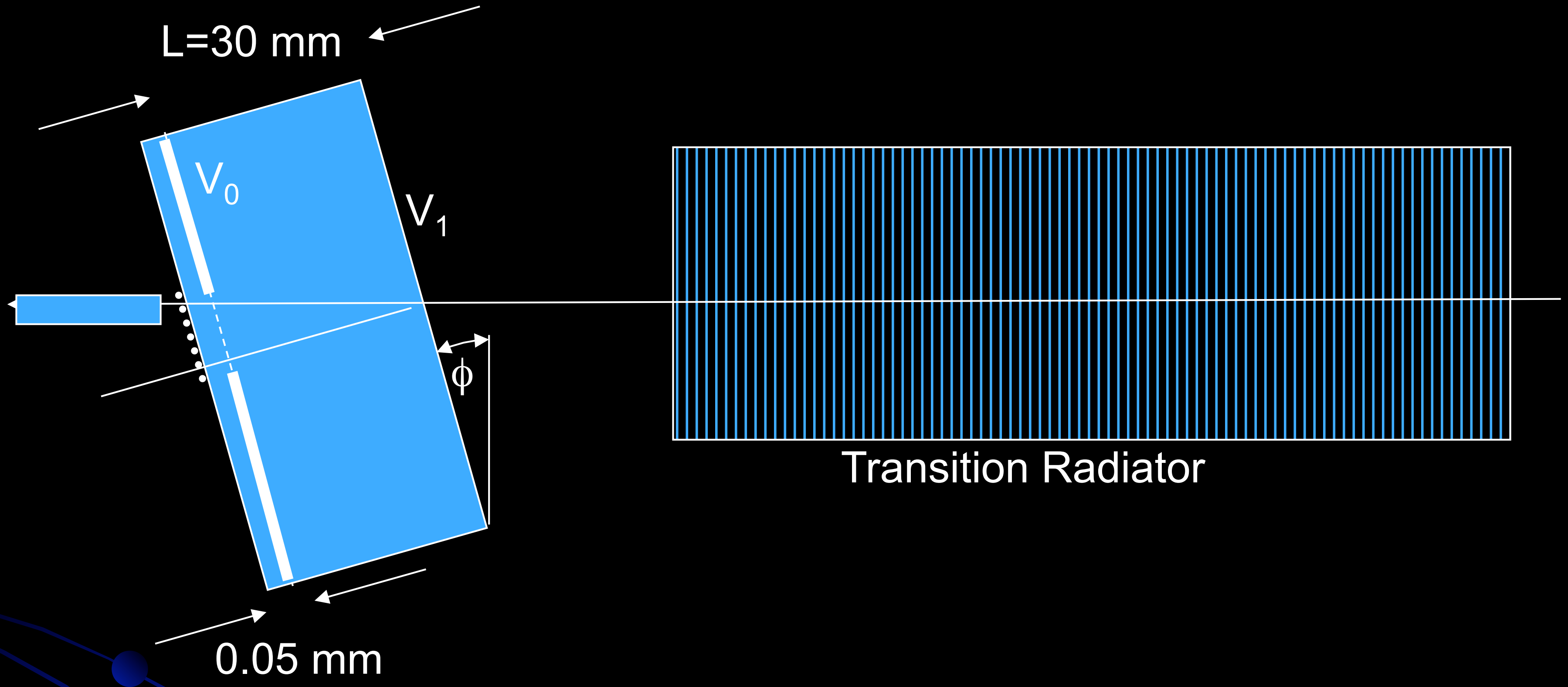
5 (double) layer Gossip Pixel

4 layer Gossip Strixel

radiator

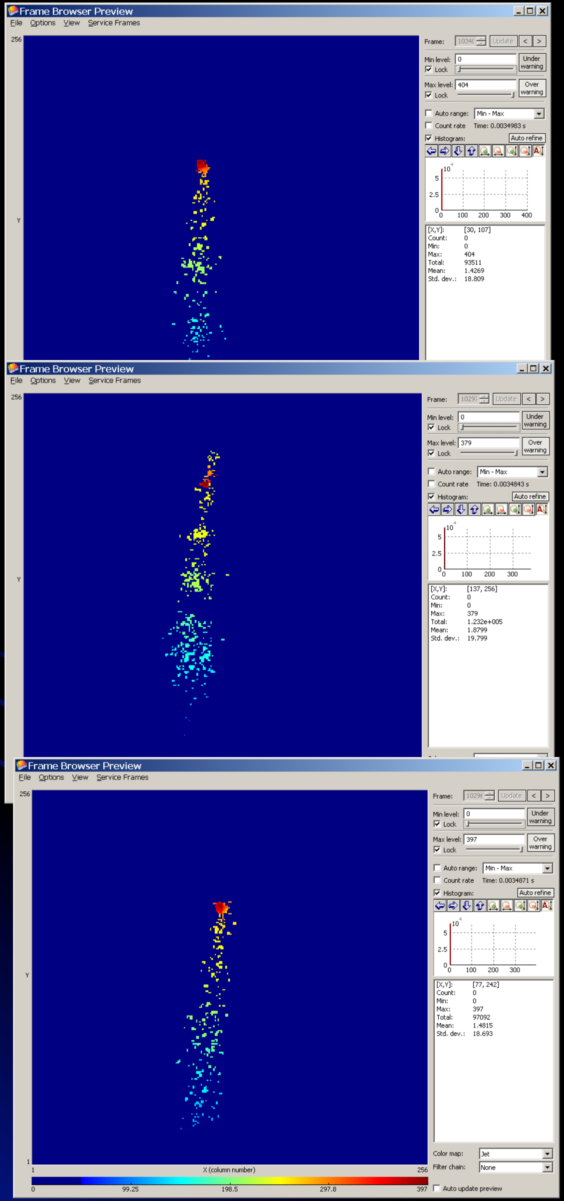
3 layers Gossip TRT
LVL-1 trigger

Testbeam April 2008
PS/T9: electrons and pions, 1 – 15 GeV/c



Particle Identification

Samples pions (left) and electrons (right)

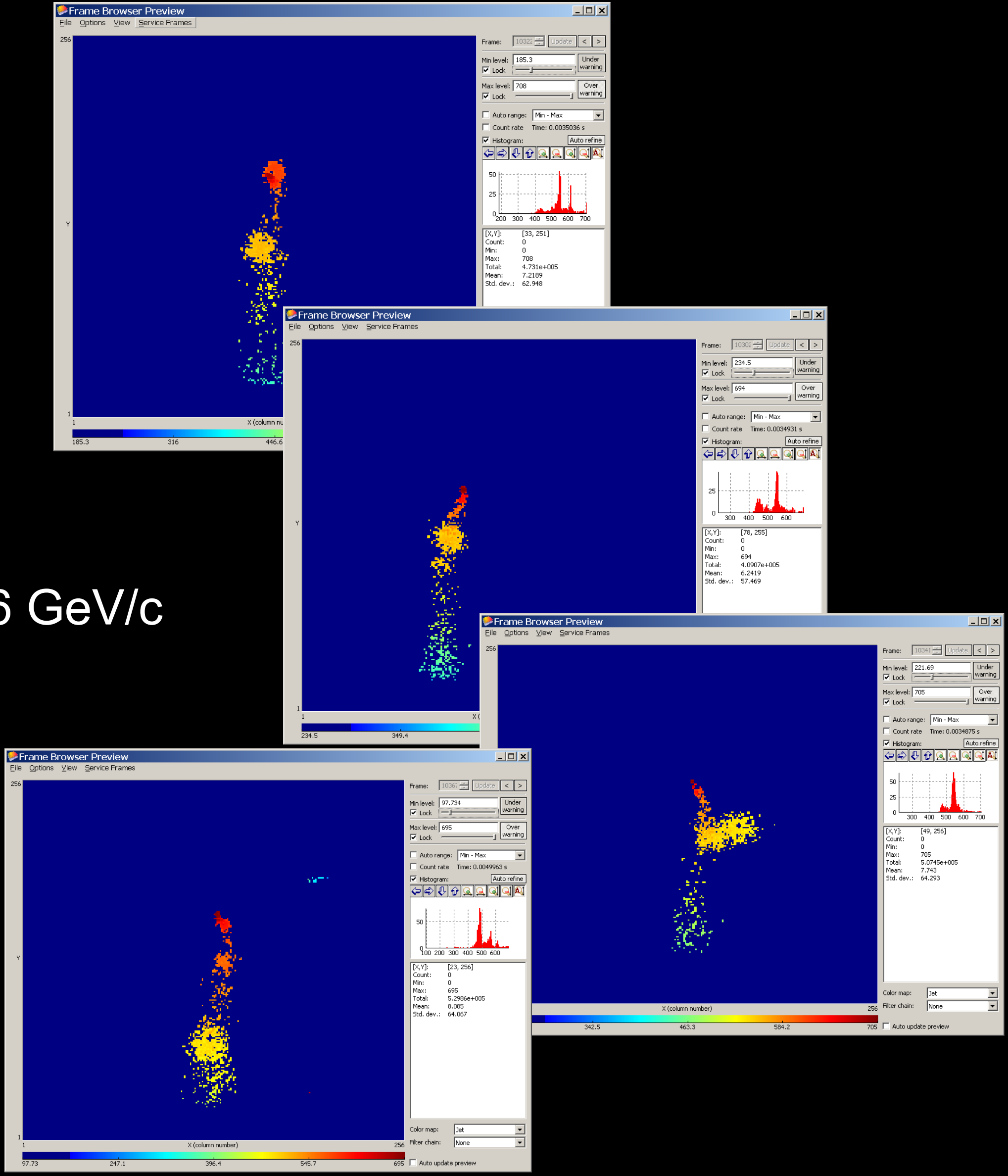


Frame: 10340
Min level: 0 ☑ Lock
Max level: 404 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0034983 s
☑ Histogram:
[X,Y]: [30, 107]
Count: 0
Min: 0
Max: 404
Total: 93511
Mean: 1.4269
Std. dev.: 18.809

Frame: 10297
Min level: 0 ☑ Lock
Max level: 379 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0034843 s
☑ Histogram:
[X,Y]: [137, 256]
Count: 0
Min: 0
Max: 379
Total: 1.232e+005
Mean: 1.8799
Std. dev.: 19.799

Frame: 10296
Min level: 0 ☑ Lock
Max level: 397 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0034871 s
☑ Histogram:
[X,Y]: [77, 242]
Count: 0
Min: 0
Max: 397
Total: 97092
Mean: 1.4815
Std. dev.: 18.693
Color map: Jet
Filter chain: None
☐ Auto update preview

6 GeV/c



Frame: 10322
Min level: 185.3 ☑ Lock
Max level: 708 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0035036 s
☑ Histogram:
[X,Y]: [33, 251]
Count: 0
Min: 0
Max: 708
Total: 4.731e+005
Mean: 7.2189
Std. dev.: 62.948

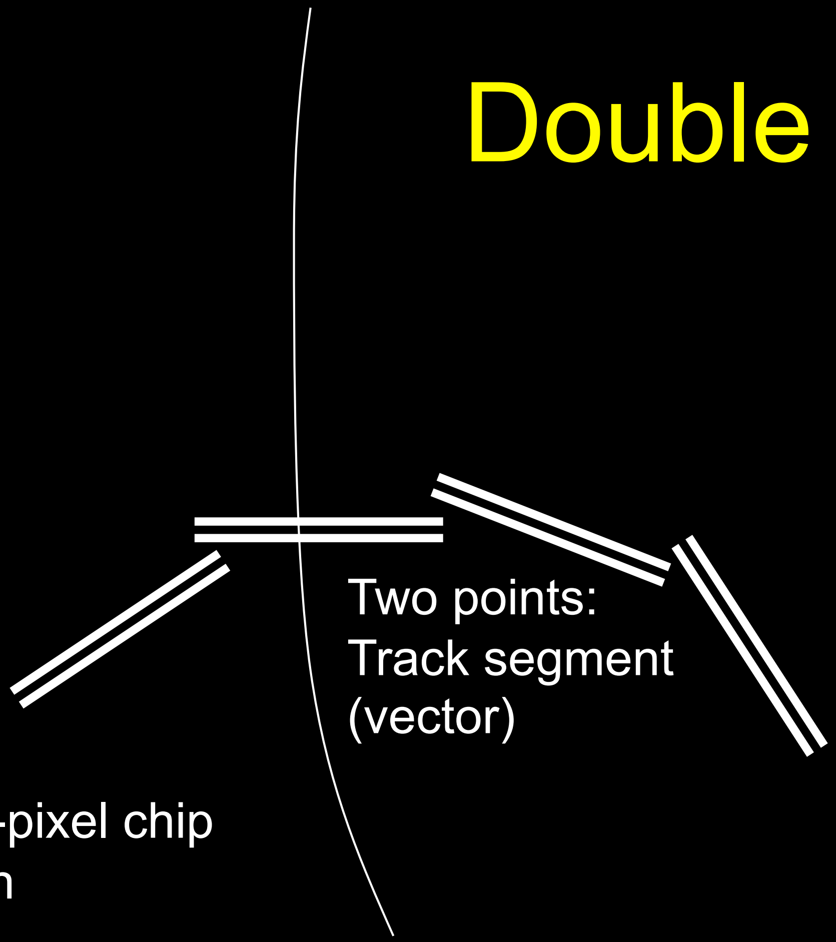
Frame: 10302
Min level: 234.5 ☑ Lock
Max level: 694 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0034931 s
☑ Histogram:
[X,Y]: [78, 255]
Count: 0
Min: 0
Max: 694
Total: 4.0907e+005
Mean: 6.2419
Std. dev.: 57.469

Frame: 10341
Min level: 221.69 ☑ Lock
Max level: 705 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0034875 s
☑ Histogram:
[X,Y]: [49, 256]
Count: 0
Min: 0
Max: 705
Total: 5.0745e+005
Mean: 7.743
Std. dev.: 64.293
Color map: Jet
Filter chain: None
☐ Auto update preview

Frame: 10367
Min level: 97.734 ☑ Lock
Max level: 695 ☑ Lock
☐ Auto range: Min - Max
☐ Count rate Time: 0.0049963 s
☑ Histogram:
[X,Y]: [23, 256]
Count: 0
Min: 0
Max: 695
Total: 5.2986e+005
Mean: 8.085
Std. dev.: 64.067
Color map: Jet
Filter chain: None
☐ Auto update preview

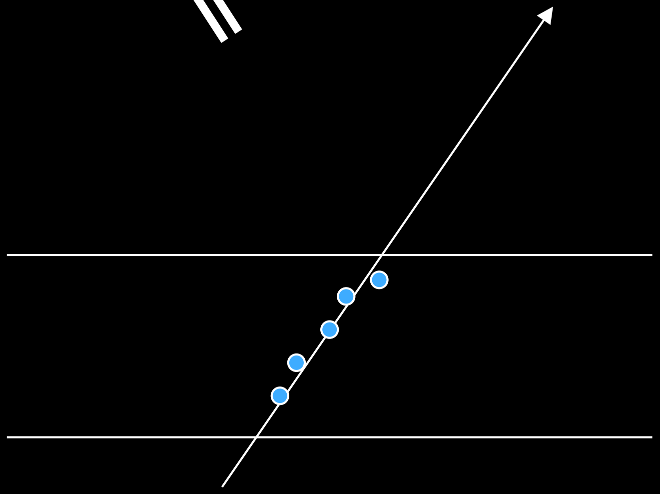
…broke TimePix chip in Xe: 490 V on grid…

Double (Si) layers



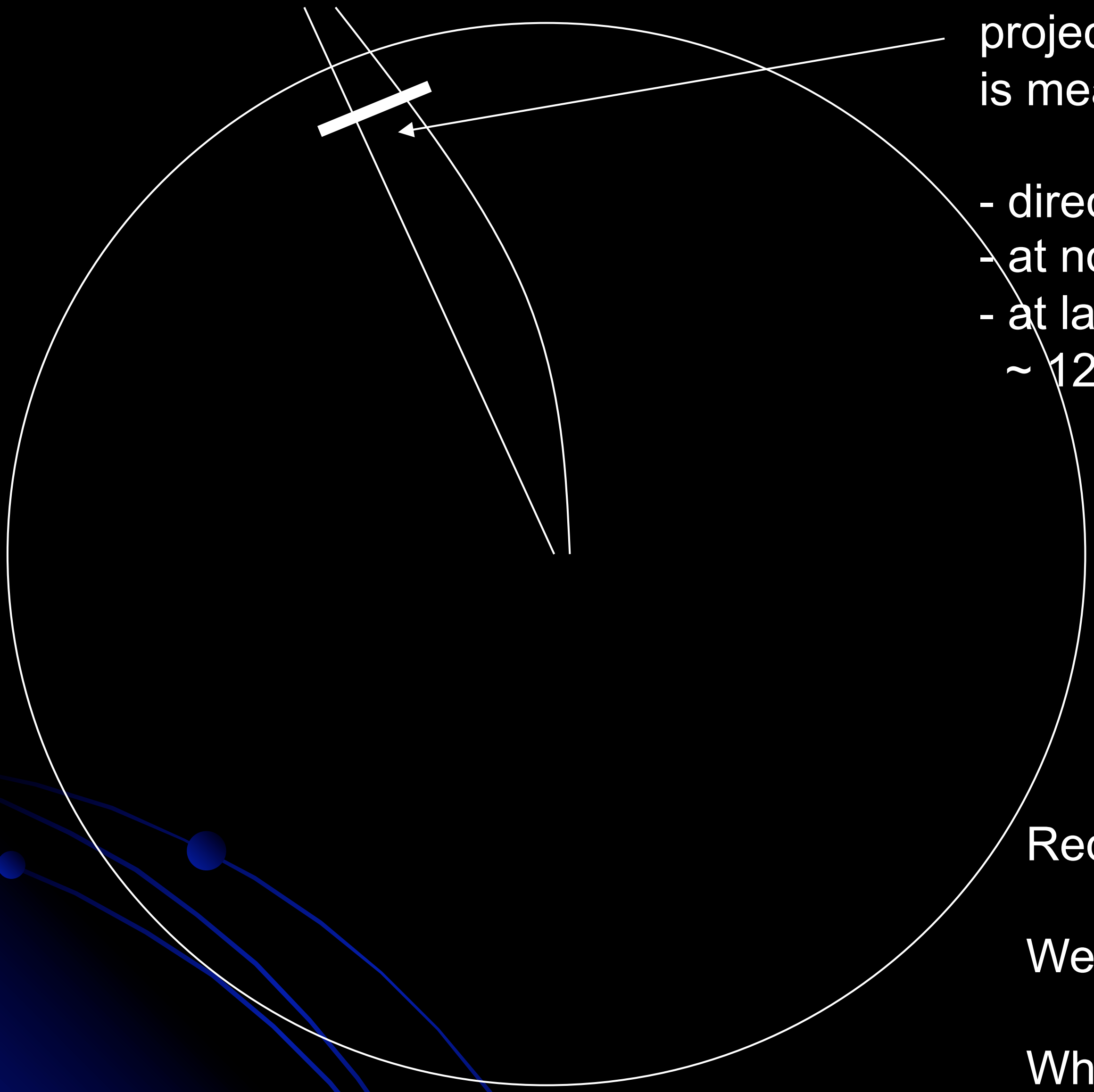
Two points:
Track segment
(vector)

Requires inter-pixel chip
communication



Gossip measures track segment
in single layer

LVL1 trigger from inner tracker



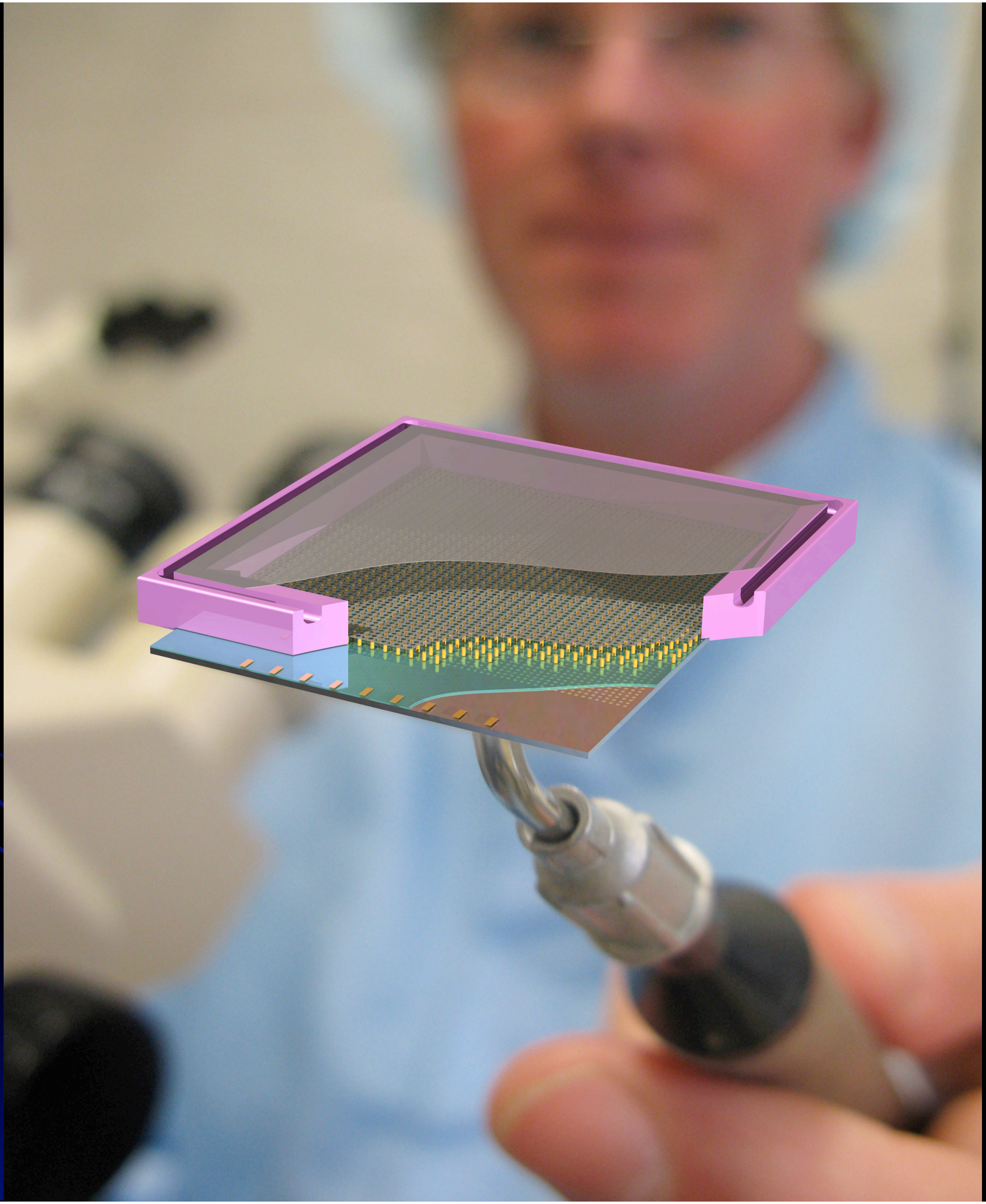
projected track length
is measure for momentum:

- directly available (LVL1)
- at no (extra) cost (mass, power)
- at larger R: gas drift gap ~20 mm
  ~ 12 BXs

Requires fast on-board processing

We are using 130 nm tech.

What about 45 nm tech?



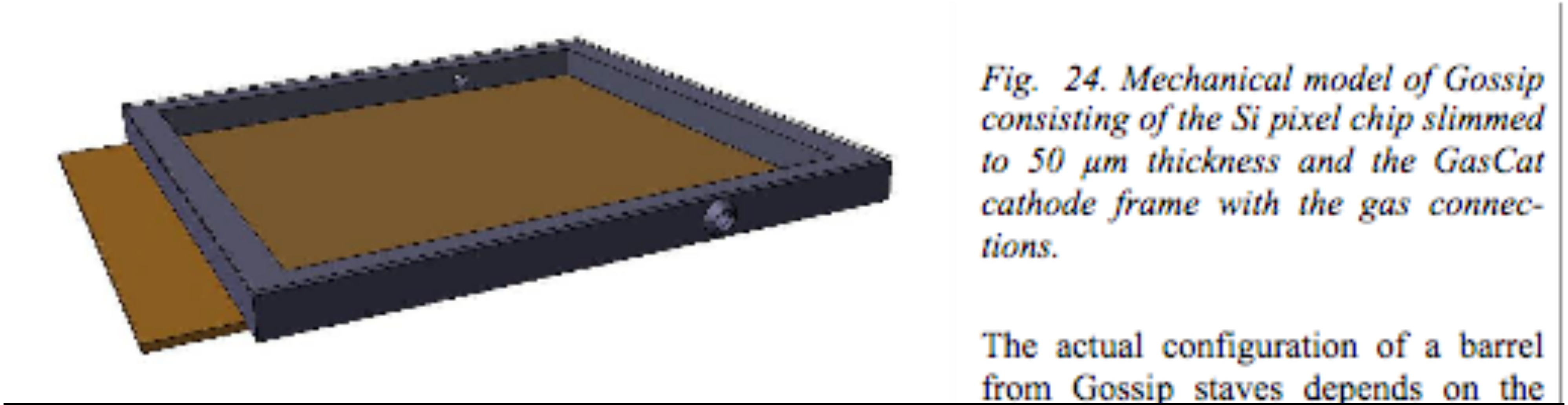


Fig. 24. Mechanical model of Gossip consisting of the Si pixel chip slimmed to 50 µm thickness and the GasCat cathode frame with the gas connections.

The actual configuration of a barrel from Gossip staves depends on the

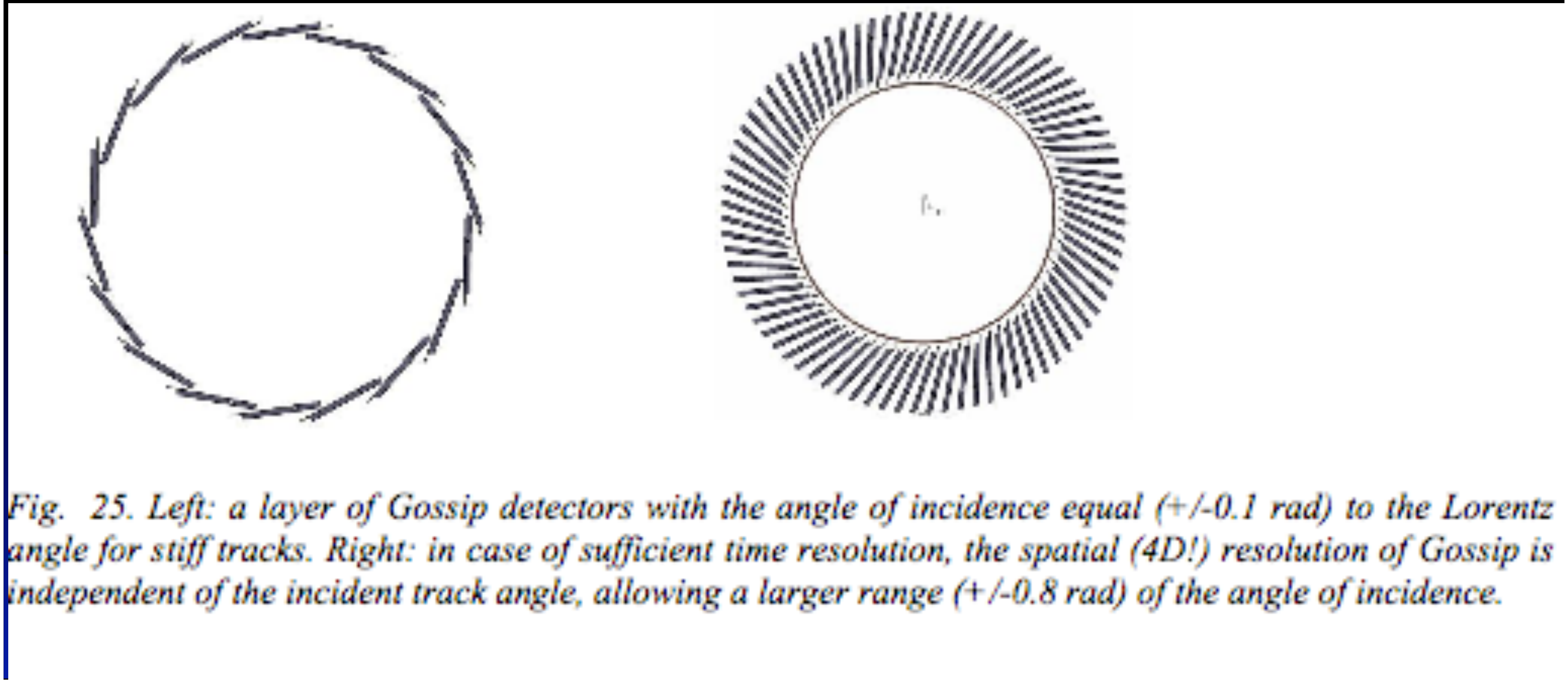


Fig. 25. Left: a layer of Gossip detectors with the angle of incidence equal (+/-0.1 rad) to the Lorentz angle for stiff tracks. Right: in case of sufficient time resolution, the spatial (4D!) resolution of Gossip is independent of the incident track angle, allowing a larger range (+/-0.8 rad) of the angle of incidence.

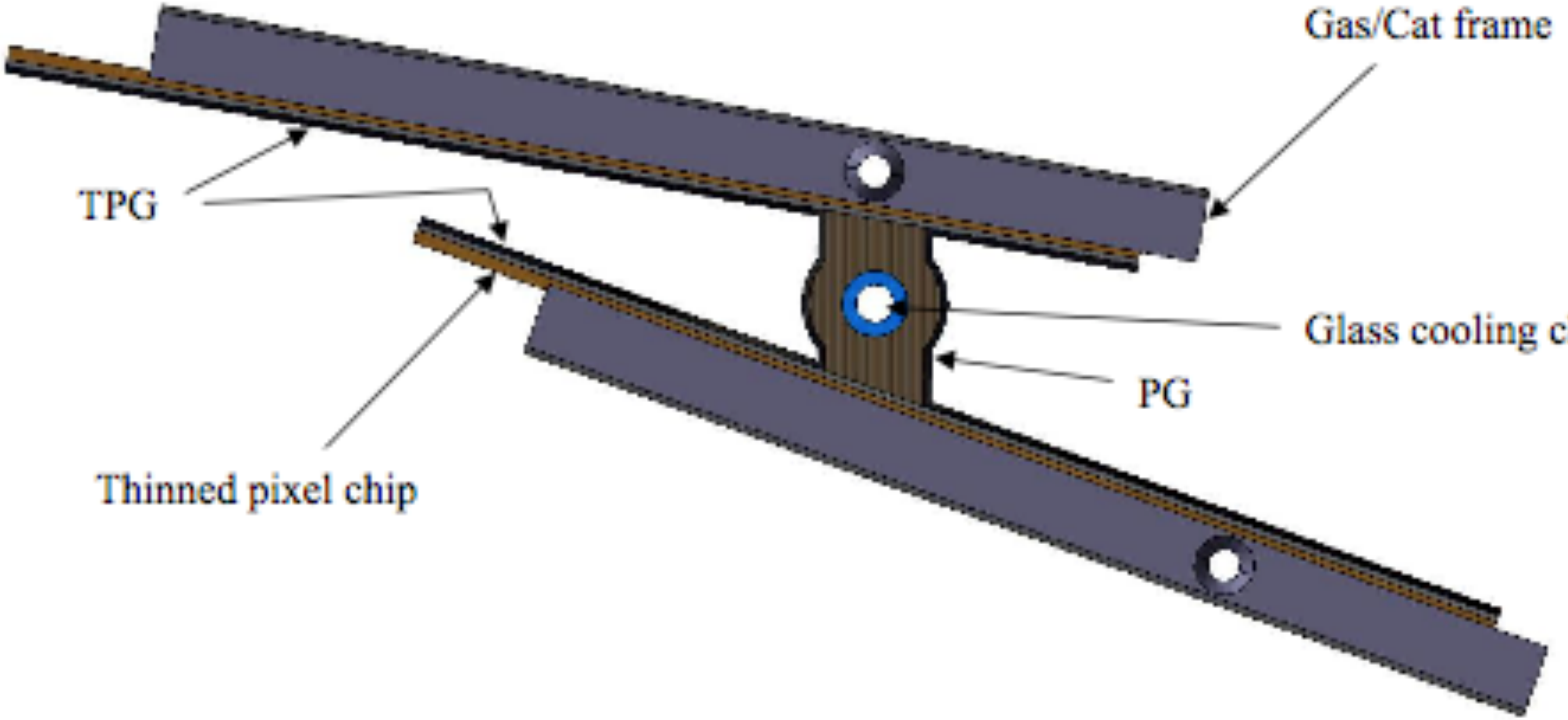
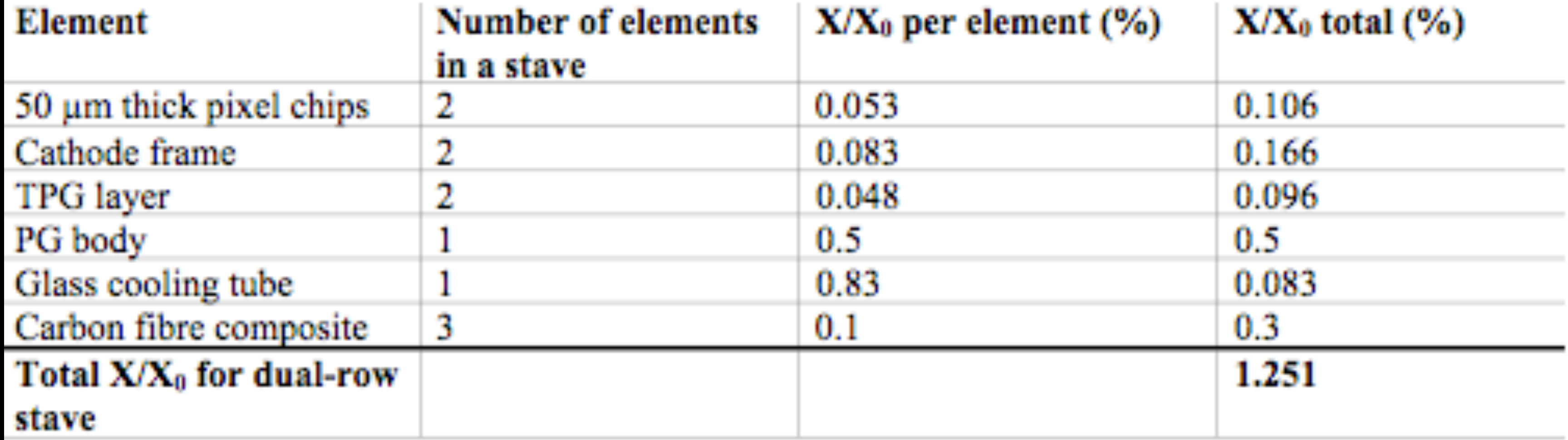


Fig. 26. Cross section of a 'dual-detector row' stave. The fibres of the PG are oriented from the cooling pipe to the detector plane for best heat conductivity.



Element	Number of elements in a stave	X/X_0 per element (%)	X/X_0 total (%)
50 µm thick pixel chips	2	0.053	0.106
Cathode frame	2	0.083	0.166
TPG layer	2	0.048	0.096
PG body	1	0.5	0.5
Glass cooling tube	1	0.83	0.083
Carbon fibre composite	3	0.1	0.3
Total X/X_0 for dual-row stave			**1.251**

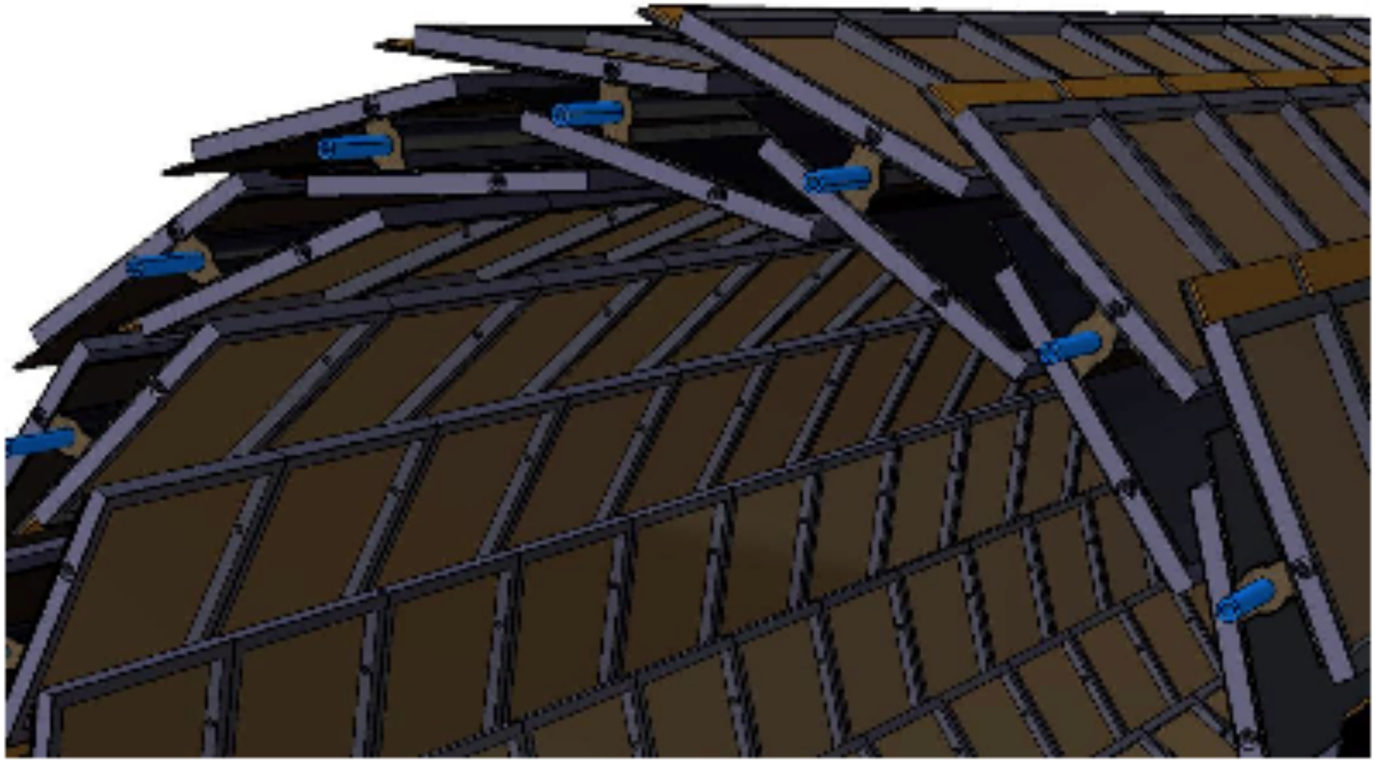


Fig. 28. Simplified 3D view of the B-layer barrel from dual-row staves.

Fig. 29. Dual-stave concept at a larger radius (strixel region). The spokes connecting the staves greatly enhance the stiffness of the assembly.

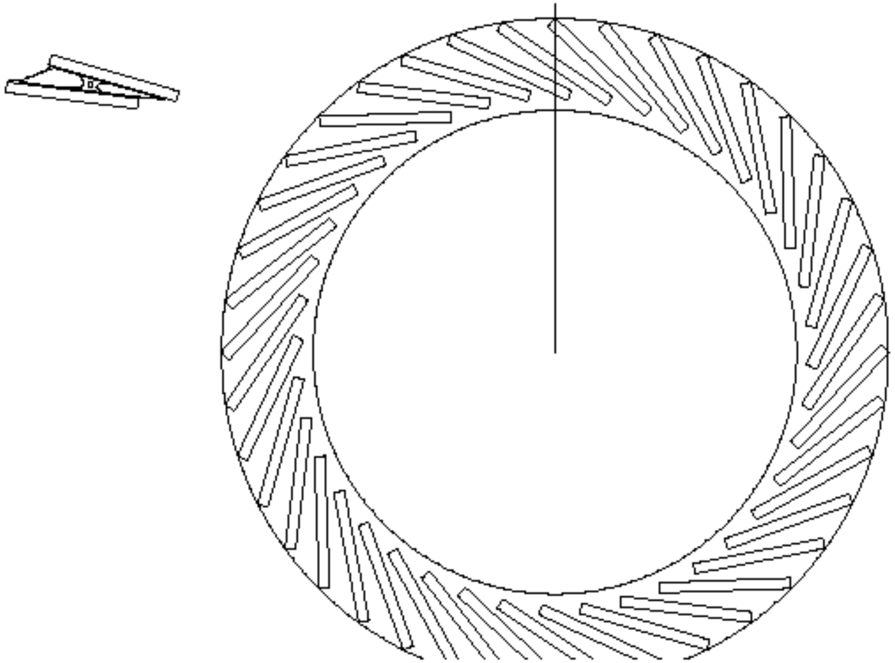
Policy:

- ASAP: submit Gossip in Atlas [GOAT] UpGrade Proposal
    - formal invitation other groups to participate
    - get defined, get funding, get other institutes to join

- define IBL as proto-project

- participate to IBL-related projects:
    - chip developments: FE-I4 , (Gossipo-3, TimePix-2)
    - FP420/FPA: common test beam work with 3D-Si
    - Stave engineering: CO$_2$ cooling !! Nikhef ATLAS/LHCb/ReLaXd/XFEL !!
      Composite tech: autoclave!
      Simulations, mech. dummy tests
      IfLink

Insertable B-Layer (IBL)



Detector mass much lighter:

- CO_2 cooling
- Serial powering
- stave composite design

New bottleneck:
Data bus Kapton/Cu/Al

IfLink:	low-mass rad hard

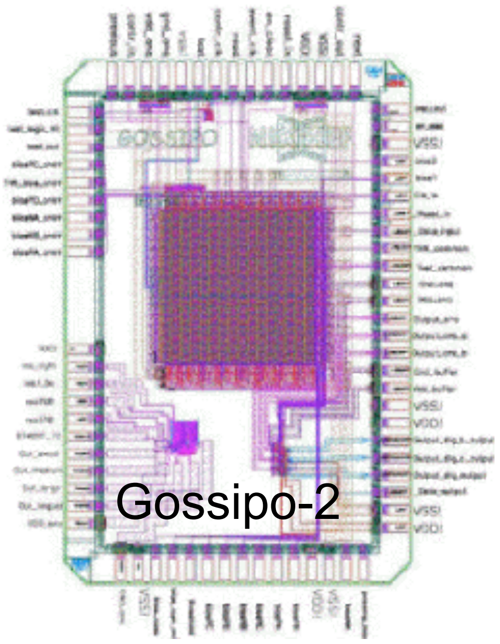
optical fiber link

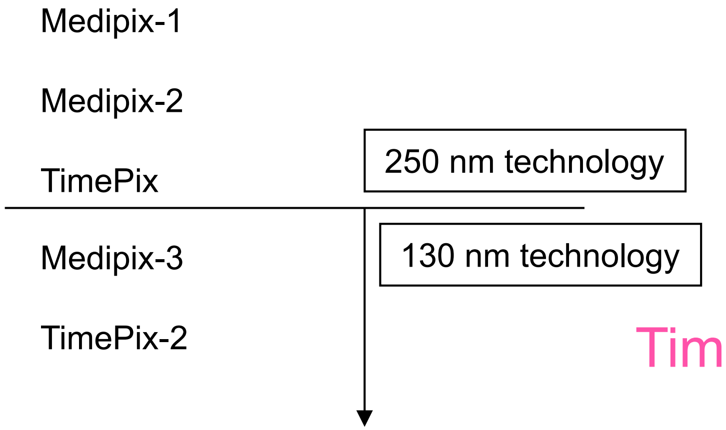
Chip Development

- FE-I4: new ATLAS Pixel chip
  - functionality: time resolution (FP420), Upgrade

-TimePix-2
  - Medipix Consortium
  - CERN TT: commercial interest (Panalytical)

- Gossipo-3
  - TDC per pixel: new DAQ structures
  - Joint Nikhef/Bonn project




Medipix-1

Medipix-2

TimePix

250 nm technology

Medipix-3

TimePix-2

130 nm technology

TimePix-2

simulations

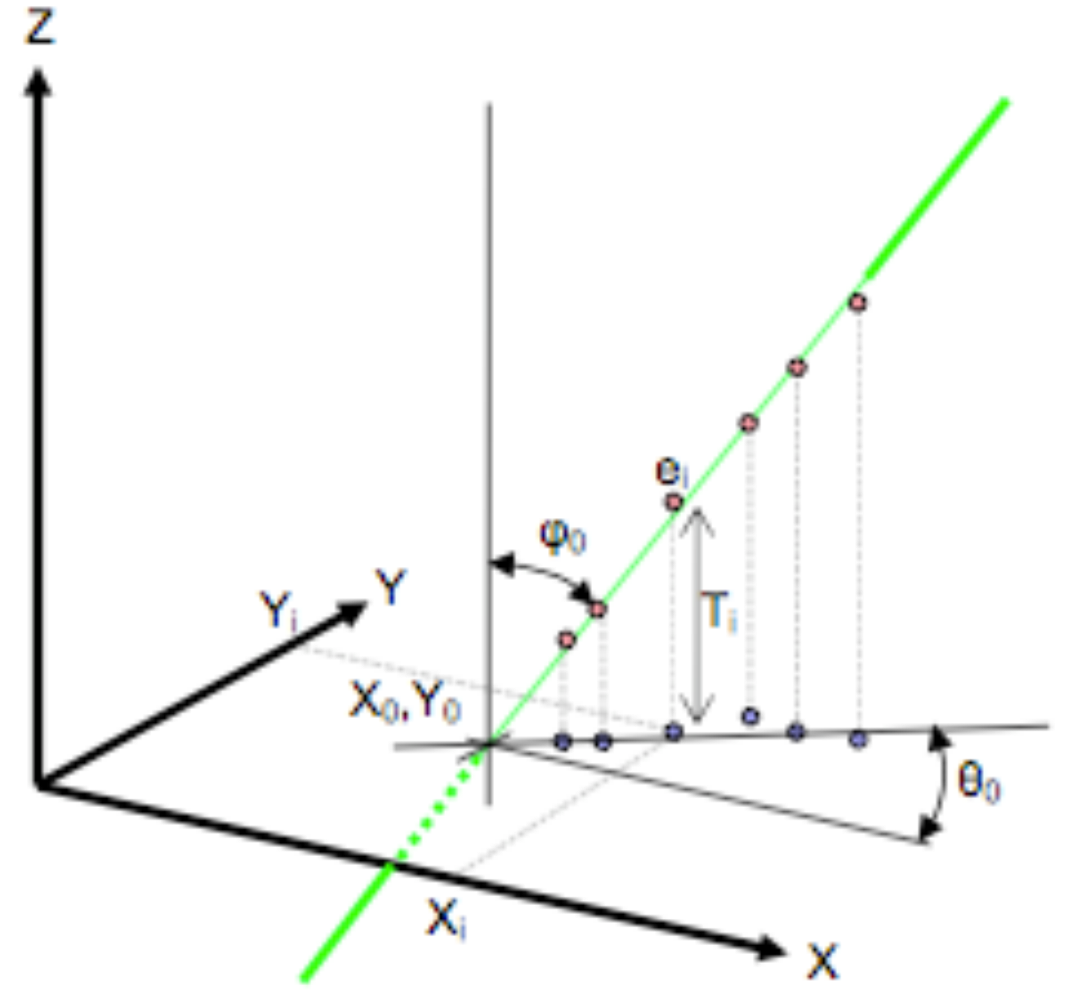
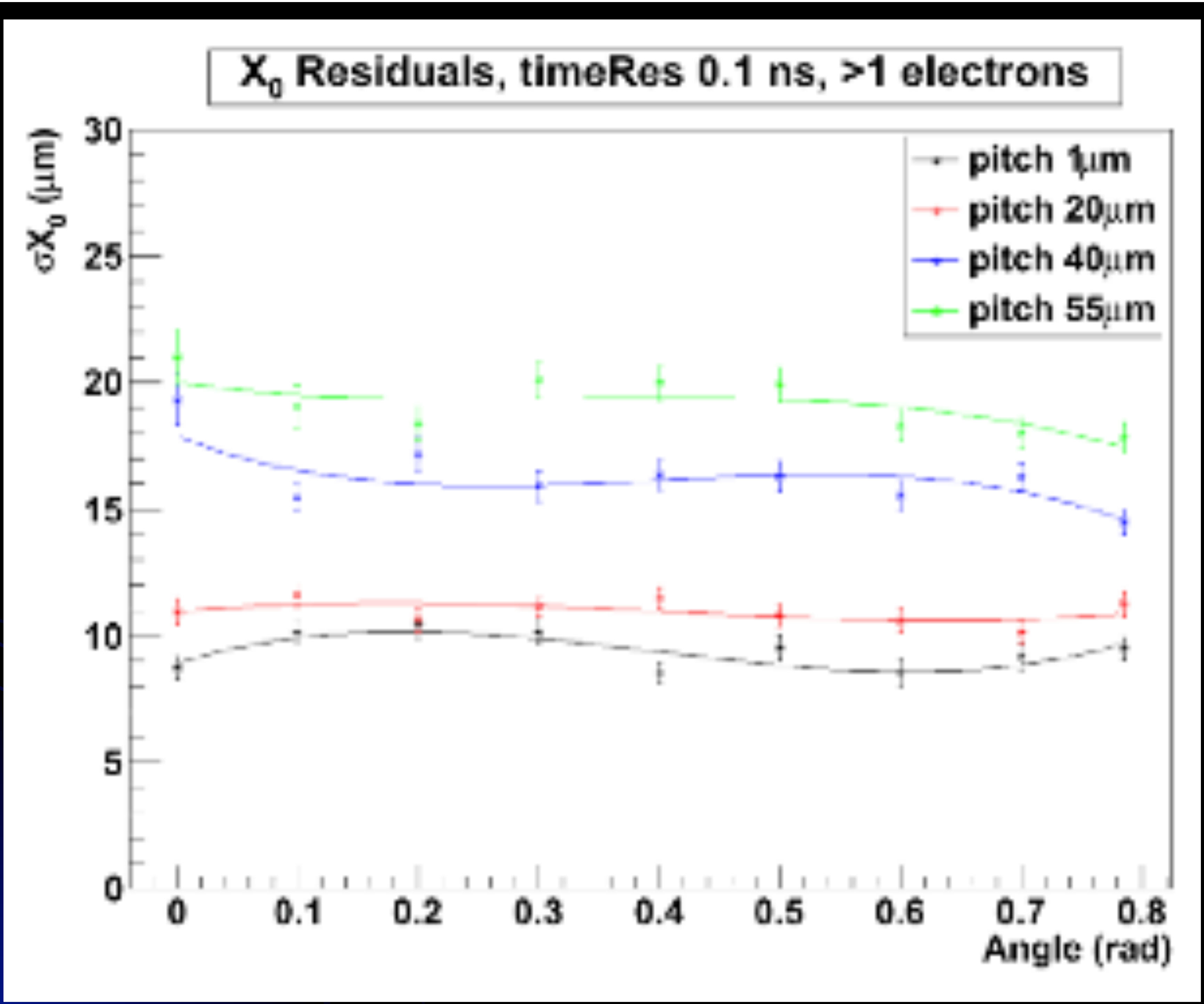
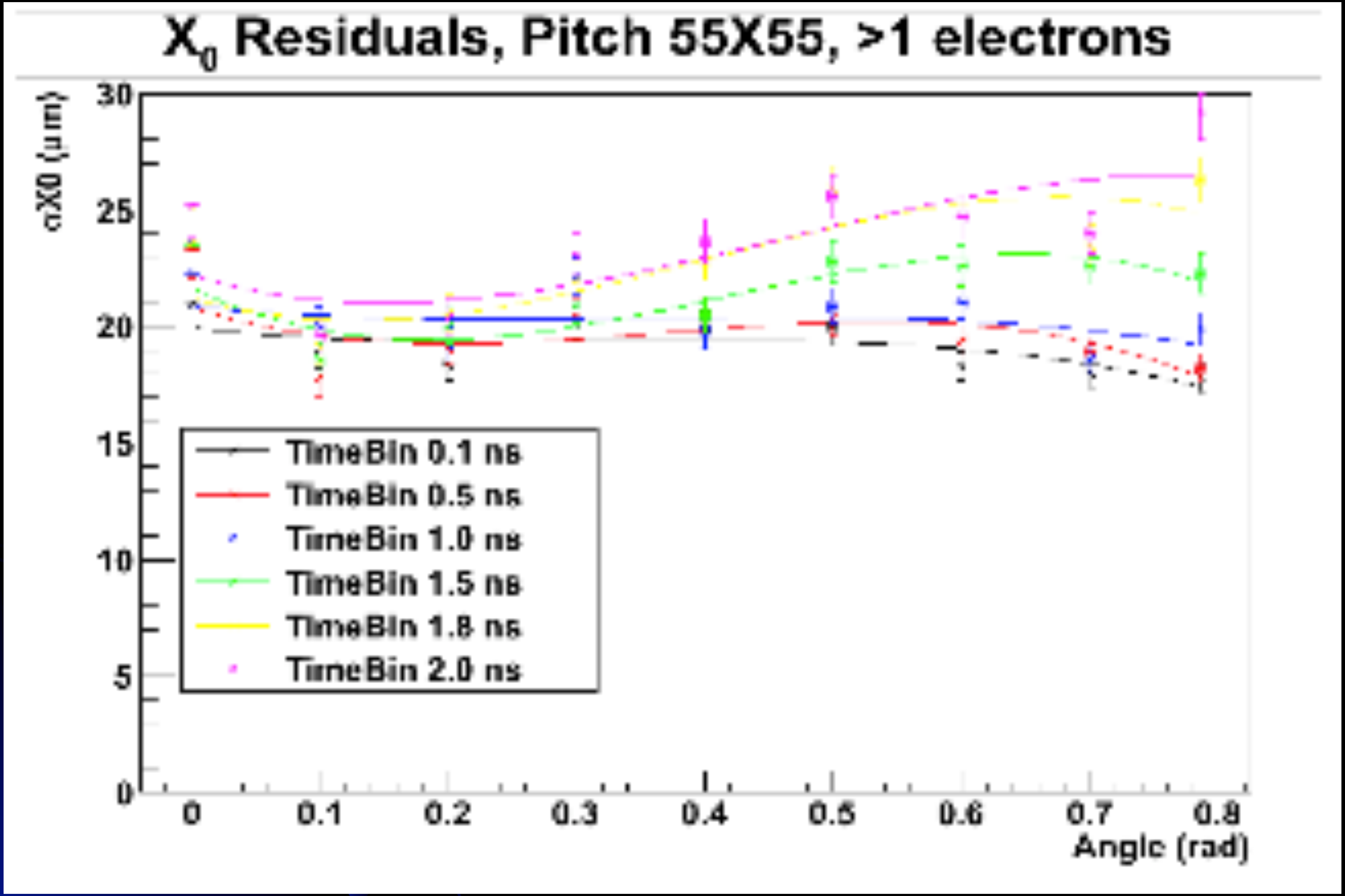
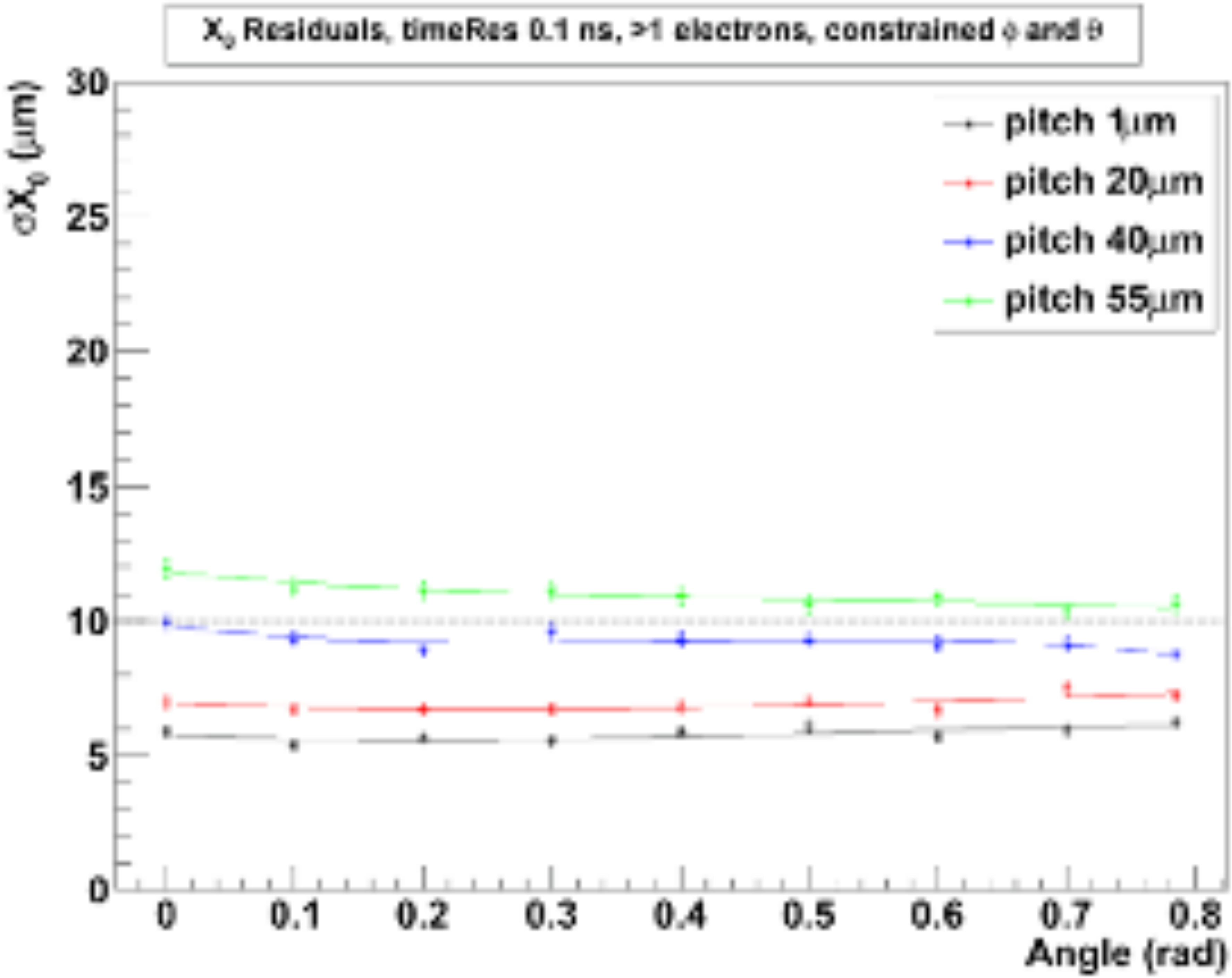


Fig. 14. Coordinate system and nomenclature of track parameters


X_0 Residuals, timeRes 0.1 ns, >1 electrons
σX_0 (μm)
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Angle (rad)
pitch 1μm
pitch 20μm
pitch 40μm
pitch 55μm


X_0 Residuals, Pitch 55X55, >1 electrons
σX0 (μm)
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Angle (rad)
TimeBin 0.1 ns
TimeBin 0.5 ns
TimeBin 1.0 ns
TimeBin 1.5 ns
TimeBin 1.8 ns
TimeBin 2.0 ns


X$_0$ Residuals, timeRes 0.1 ns, >1 electrons, constrained φ and θ
σX$_0$ (μm)
Angle (rad)
pitch 1μm
pitch 20μm
pitch 40μm
pitch 55μm
0
5
10
15
20
25
30
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

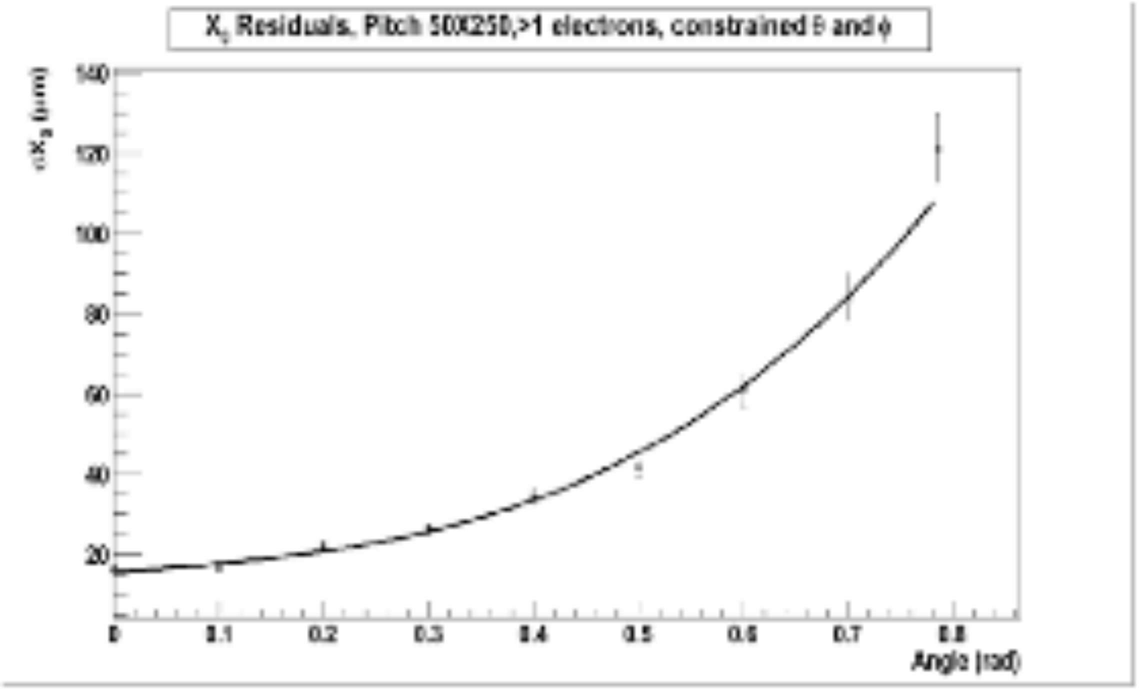
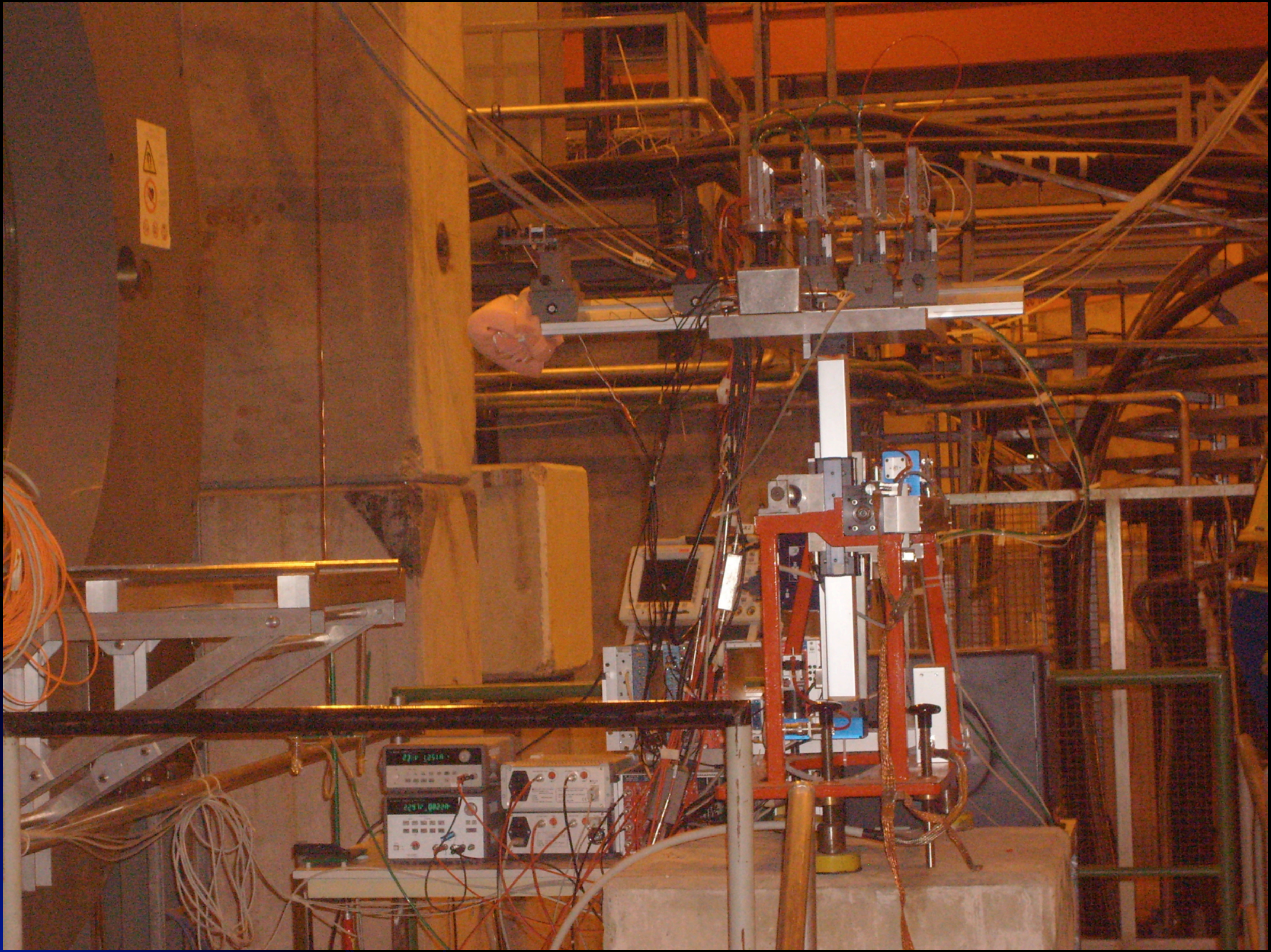


Fig. 20. The spatial resolution vs the gle of incidence φ using the FE-I4 chip that lacks time information.

Speed

Occupancy (pixels!)
space charge effects
currents

OK



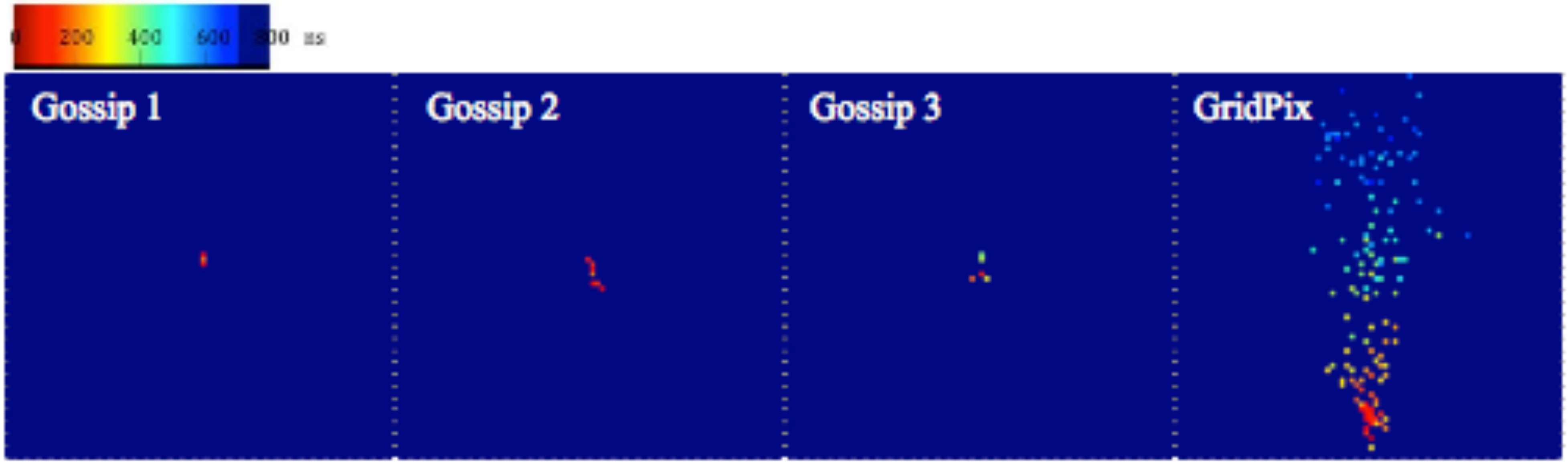


*Fig. 11. Drift time plots of a typical event from a 15 GeV π^- traversing three Gossip prototypes and a GridPix detector with 20 mm drift height. The drift times are indicated by colours. For better visibility only a rectangle of 80*80 pixels is displayed of each detector.*

Two new (risky) projects:

- electron emission & multiplication detectors

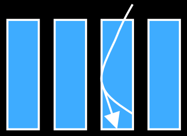
- light & light digital communication system

The future:

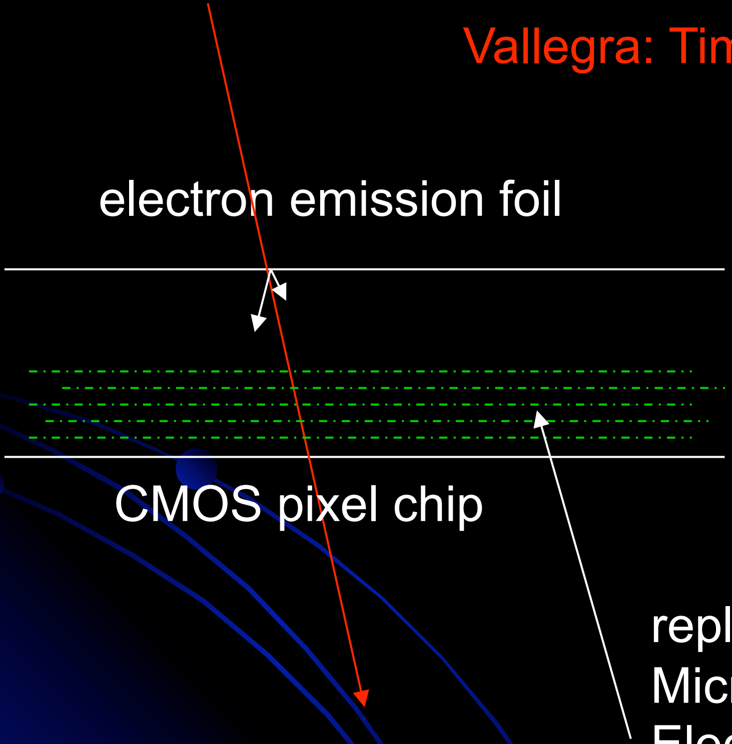
electron emission & avalanche detectors

Electron Emission Foil

MEMS made MicroChannelPlates: 200 ps time resolution: CLIC



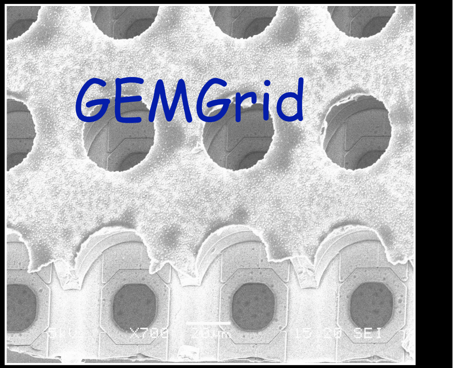
Vallegra: TimePix + MCPs

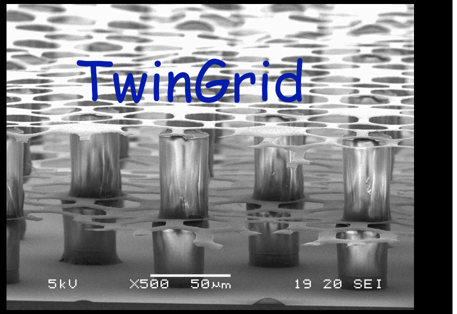


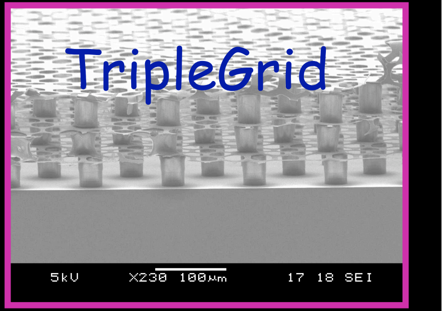
electron emission foil

CMOS pixel chip

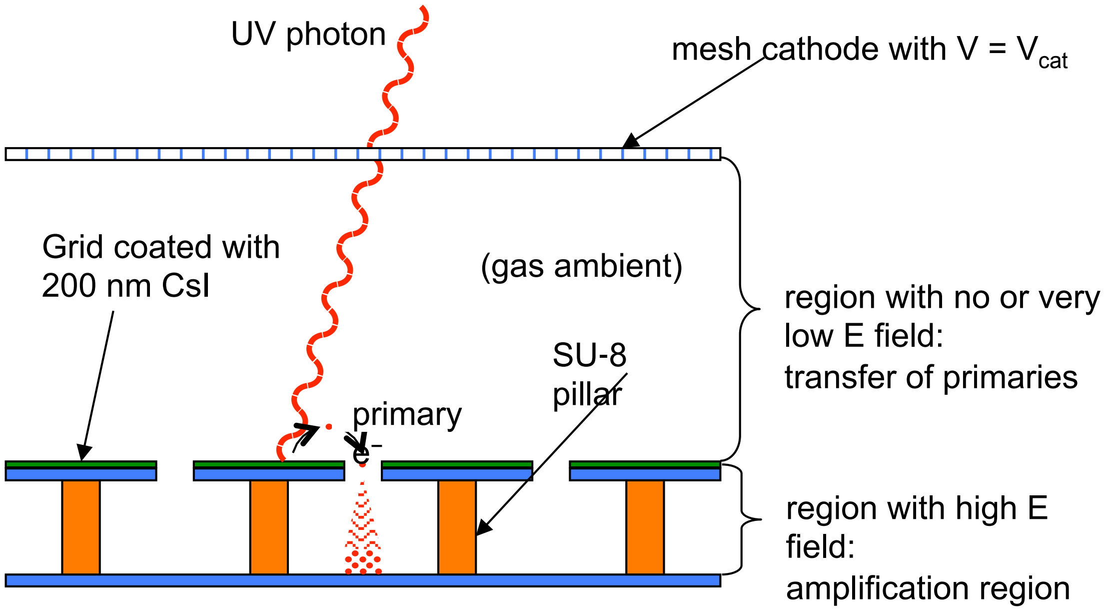
replace gas by vacuum
Micro Channel Plate (MCP)
ElectronMultiplyingGrid (EmGrid)
sub-ns time resolution
Note CLIC experiments, FP420







Now operational:

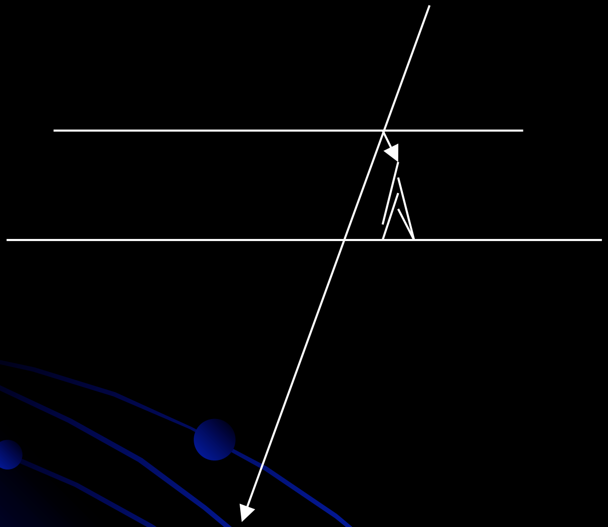


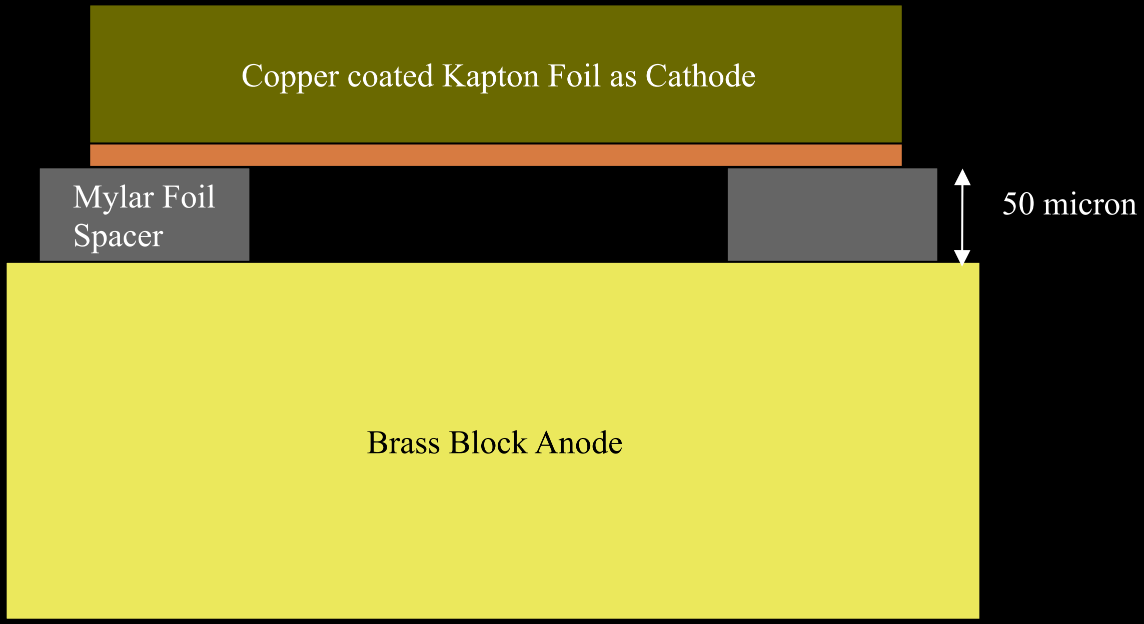
Joost Melay, Univ. Twente, MESA+
Jurriaan Schmitz' STW project 'There is plenty of room at the top'

With Amos Breskin, Weizmann Institute of Science in Rehovot, Israel ,

Parallel Plate Chamber

first EE foil tests with (gas filled) Parallel Plate Chamber





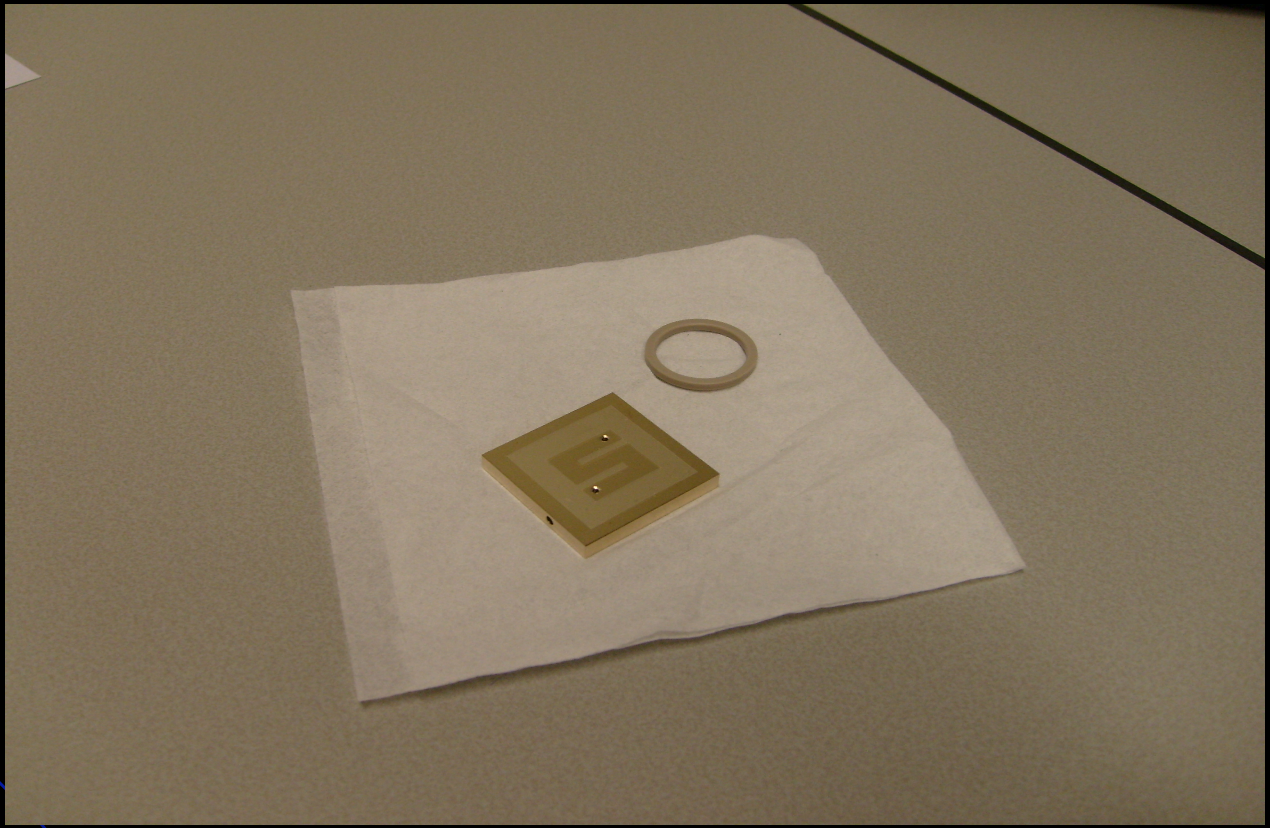
Copper coated Kapton Foil as Cathode

Mylar Foil Spacer

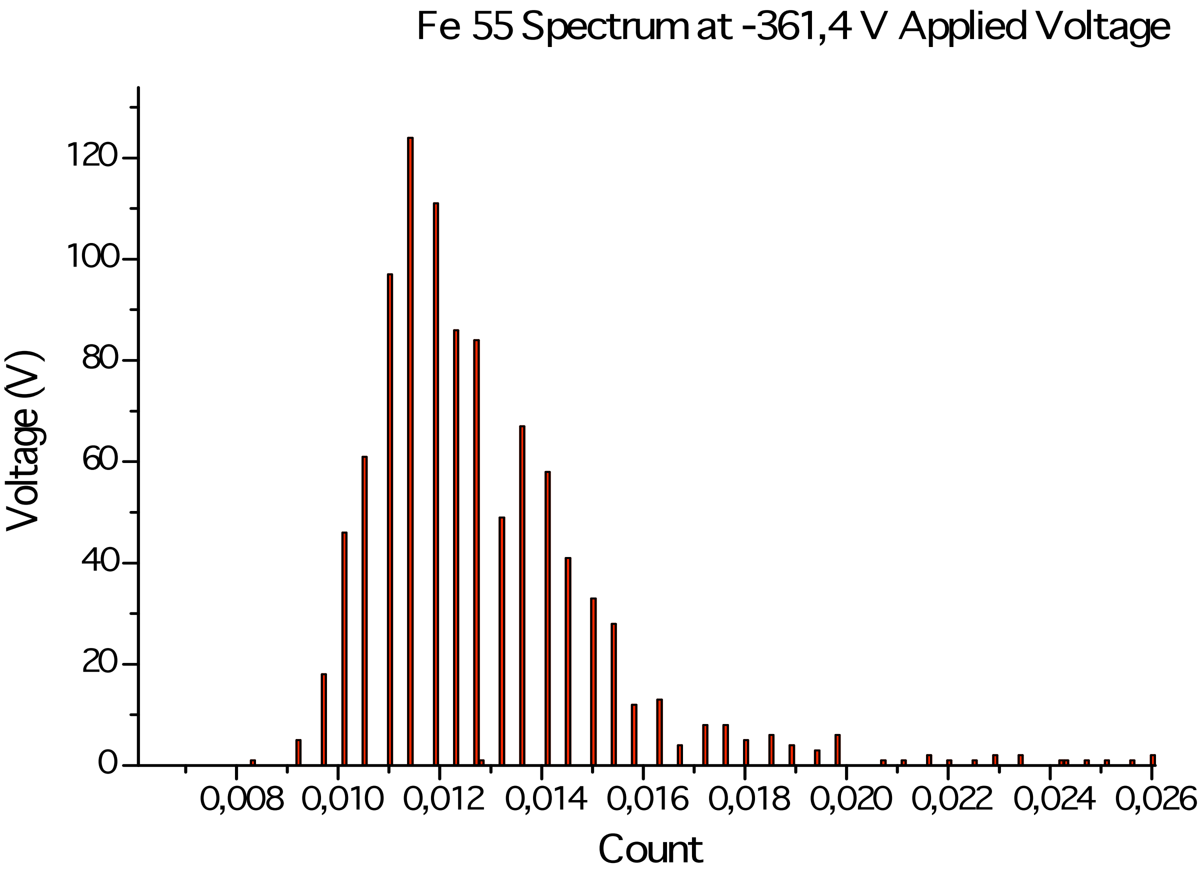
50 micron

Brass Block Anode

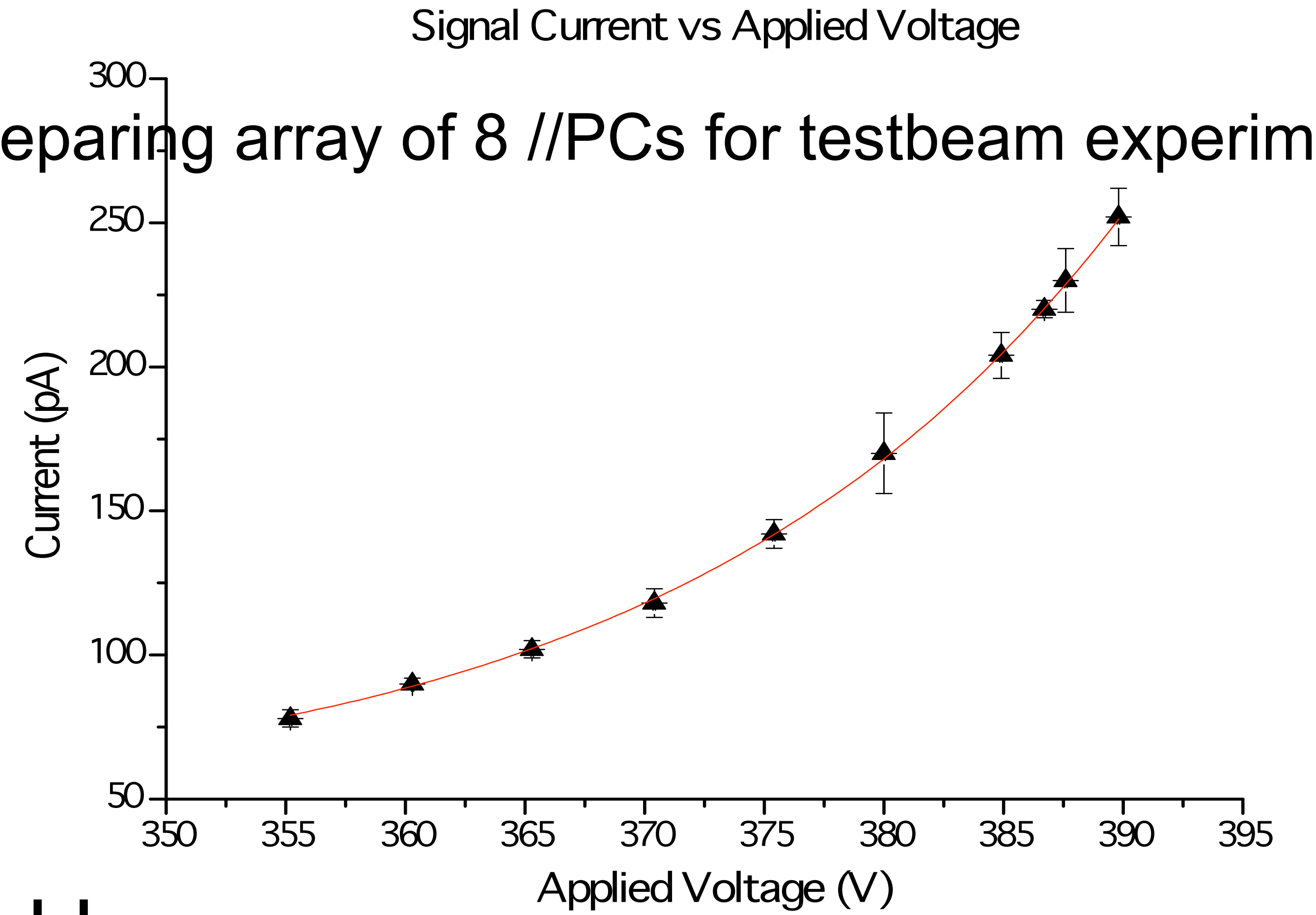
Parallel Plate Chamber



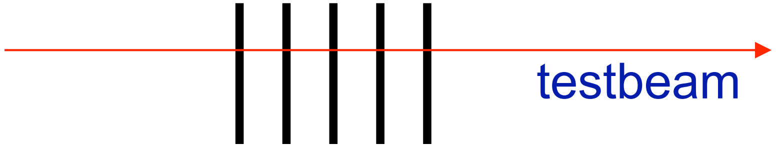
First Results



Preliminary Results



Preparing array of 8 //PCs for testbeam experiment



Wout Kremers, TU-Delft

Phase Modulator

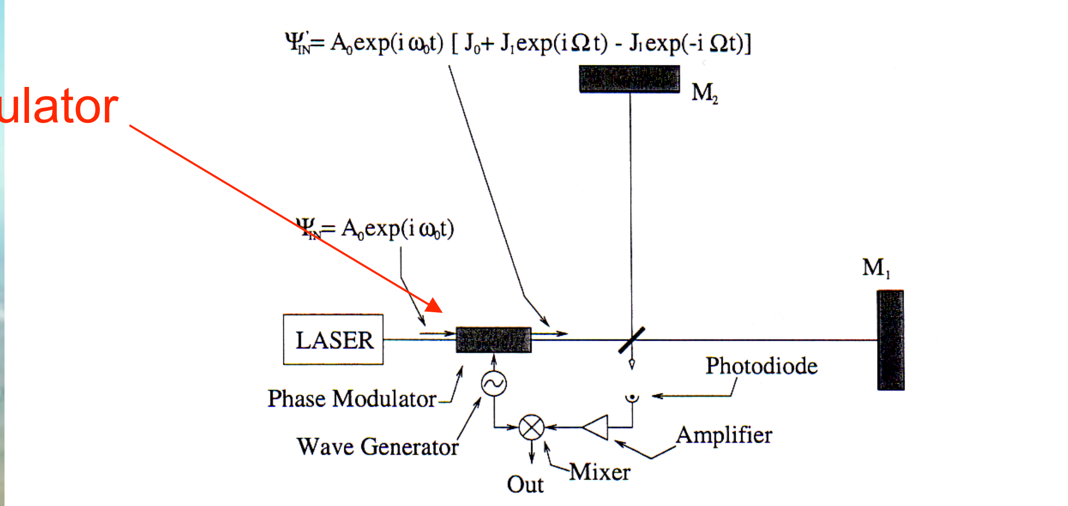


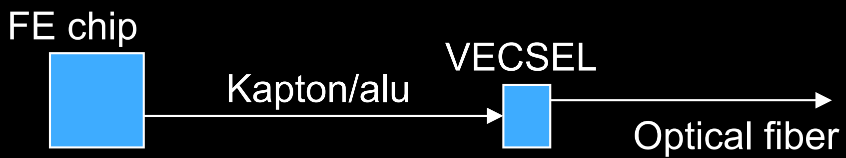
Figure 2.11: The Michelson interferometer in the frontal modulation scheme.

VIRGO

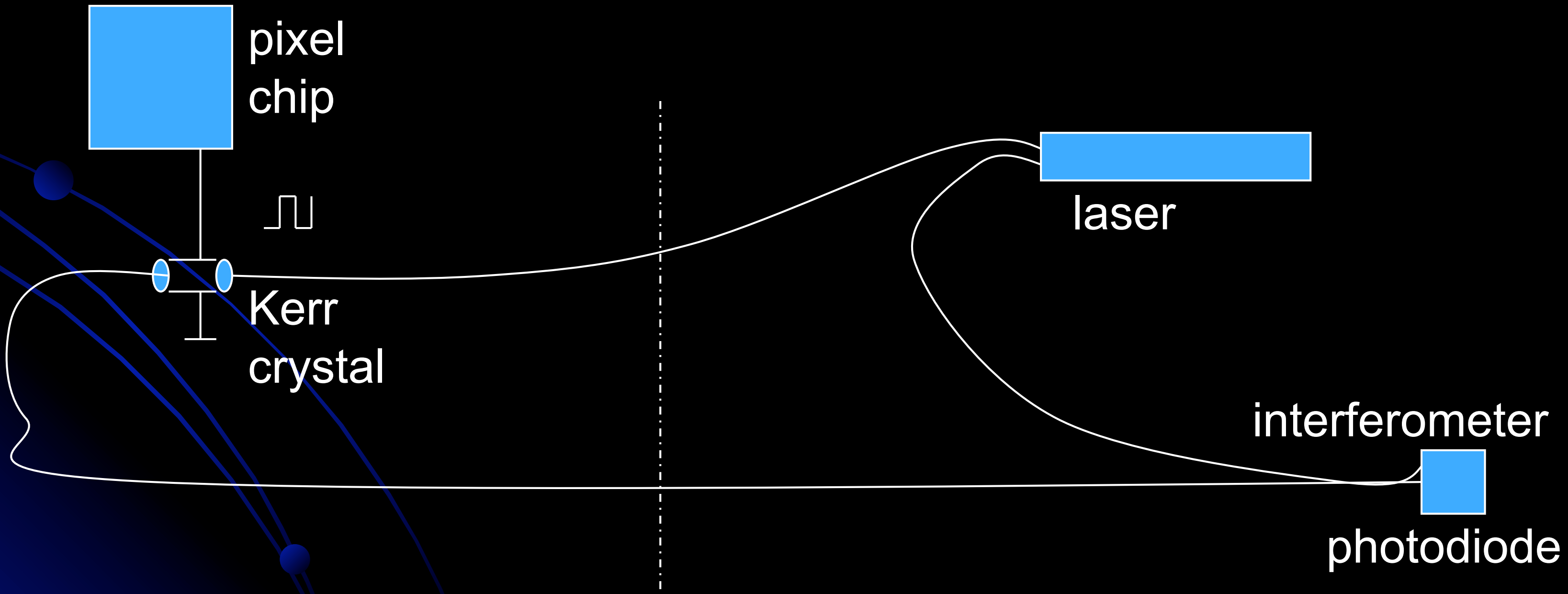
Data Transport

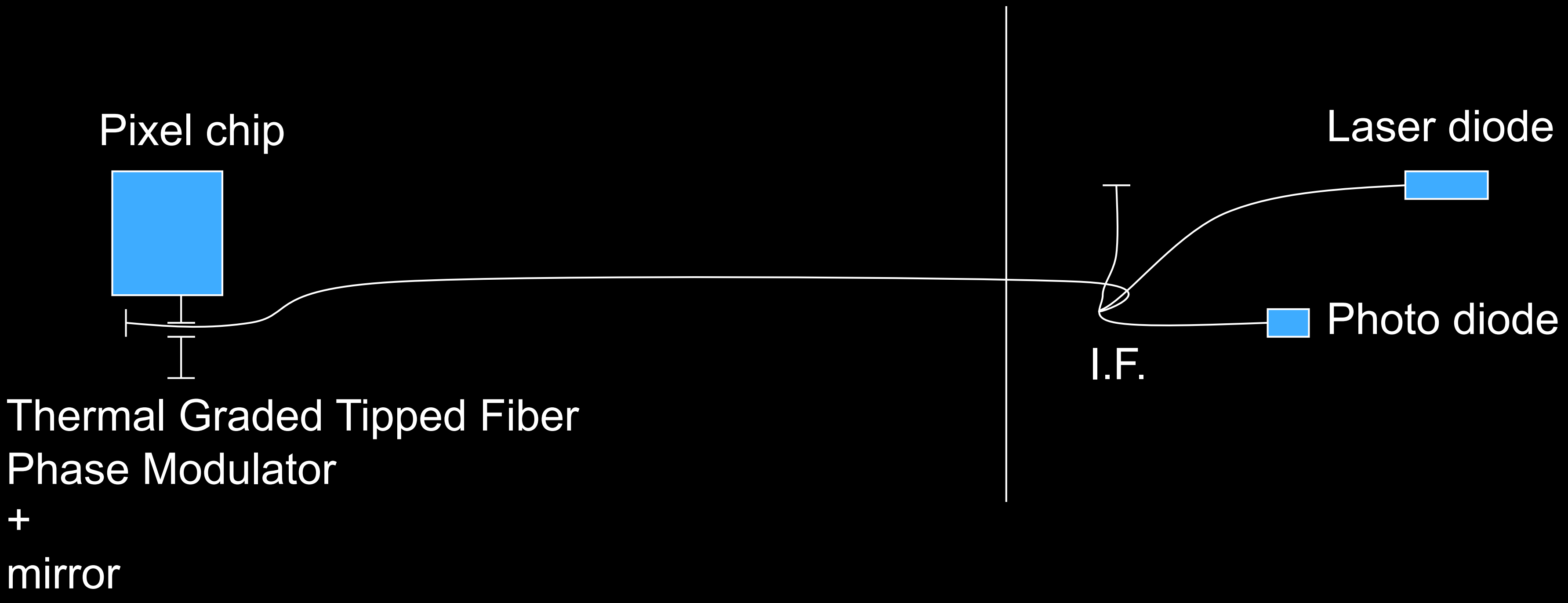
New bottleneck:
Data bus Kapton/Cu/Al

- data to outside world
- inter (pixel) chip communication
- Level 1 trigger



status: kapton/aluminium: dominant material for pixel detectors @ sLHC!
VECSELs + optical fiber: not rad hard, much material, much power required





Pixel chip

Laser diode

Photo diode

I.F.

Thermal Graded Tipped Fiber
Phase Modulator
+
mirror

- New rad-hard fiber with hole (tunnel) as core (only 5 m)
- new thermal-frozen gradedfiber phase modulator

Present activity: KM3NET data-to-shore connection
Experts: Mar v.d. Hoek, Jelle Hogenbirk
New joint project?

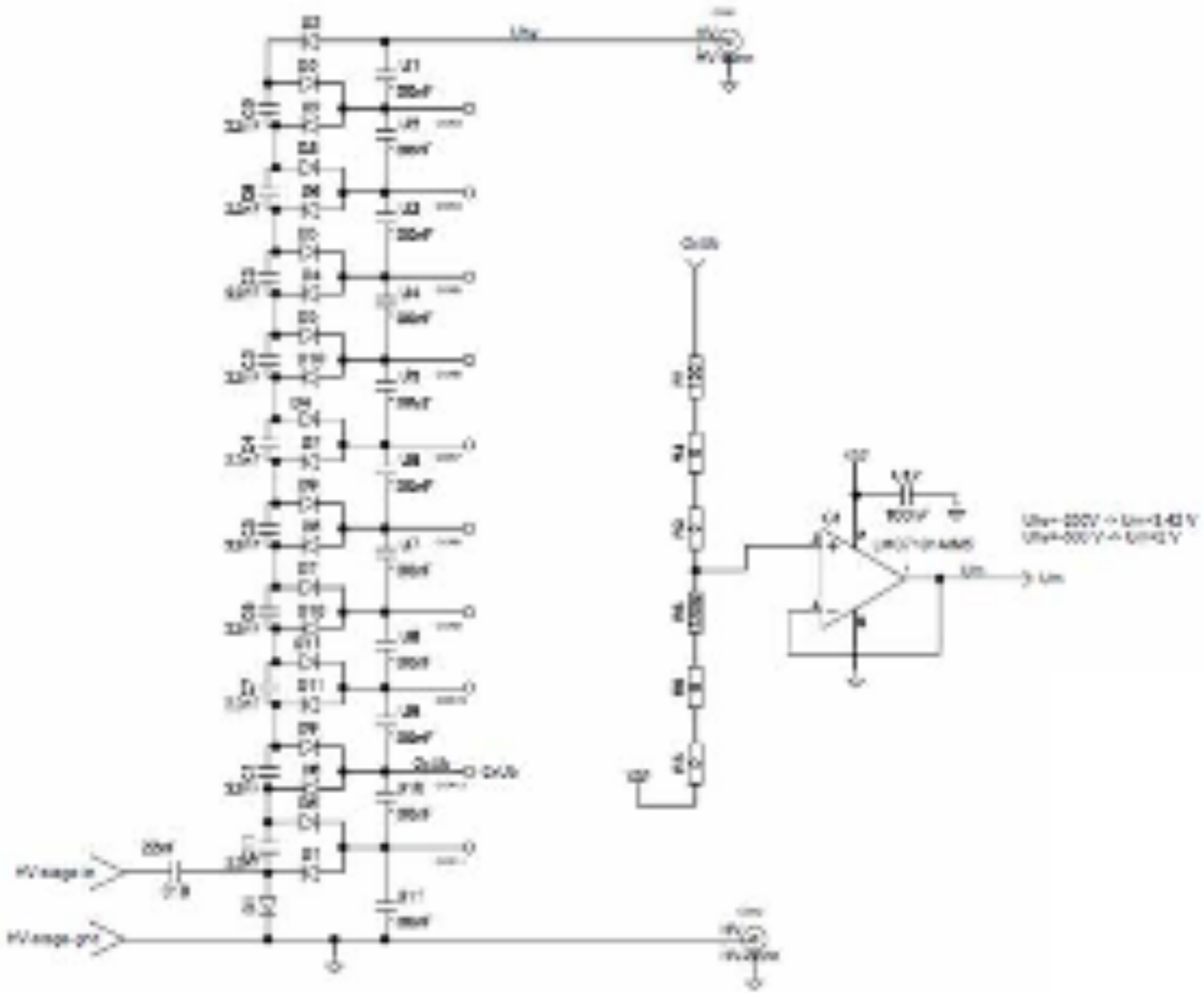
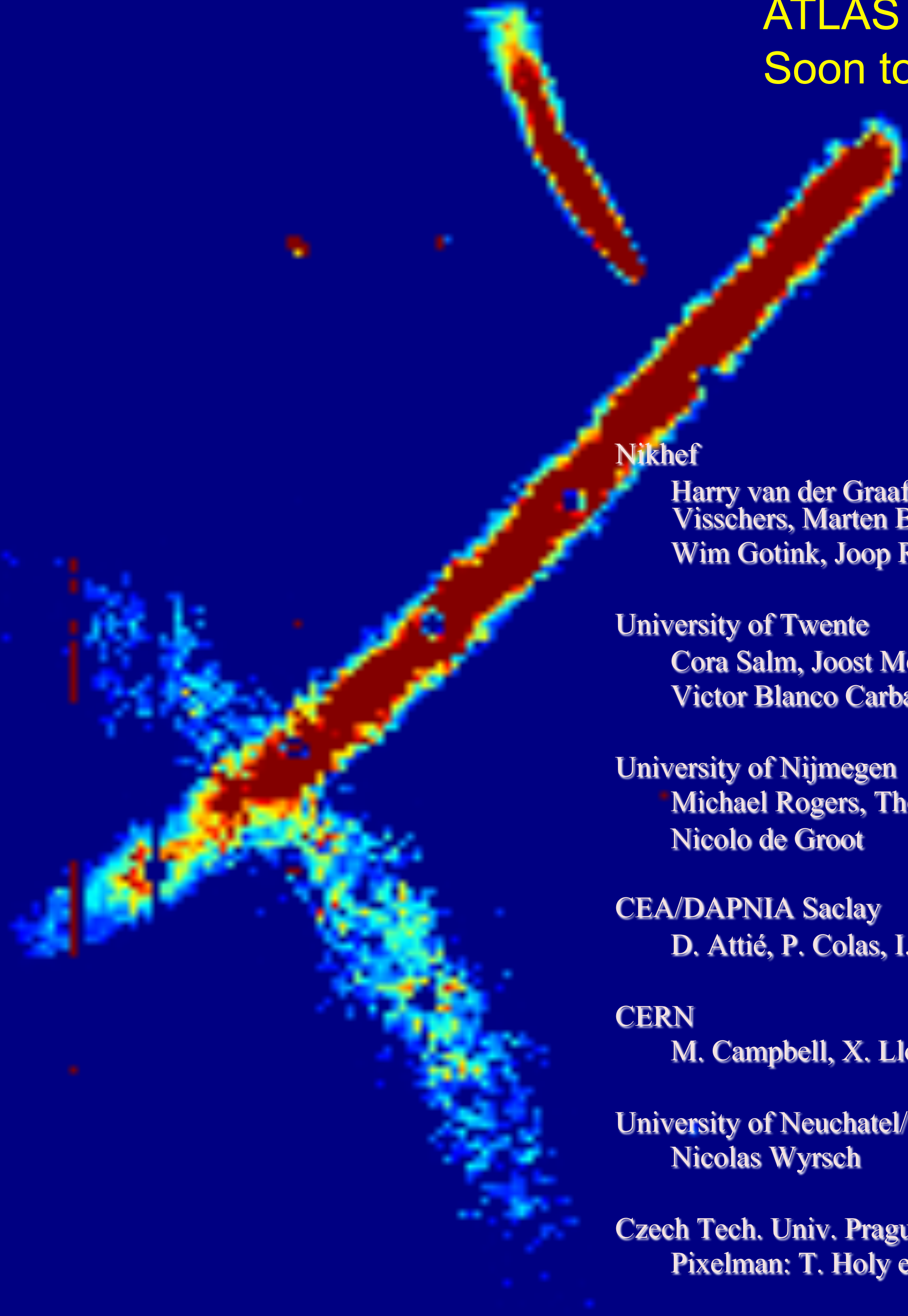


Fig. 31. Intended Cockroft-Walton circuit

ATLAS Note: GridPix/Gossip for the Upgrade
Soon to be submitted!



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