Overview of Nikhef activities

Matteo Alfonsi

Martin Fransen

Harry van der Graaf

<u>Fred Hartjes</u>

Wilco Koppert

Gijs Hemink

Anatoli Romaniouk

Rolf Schön

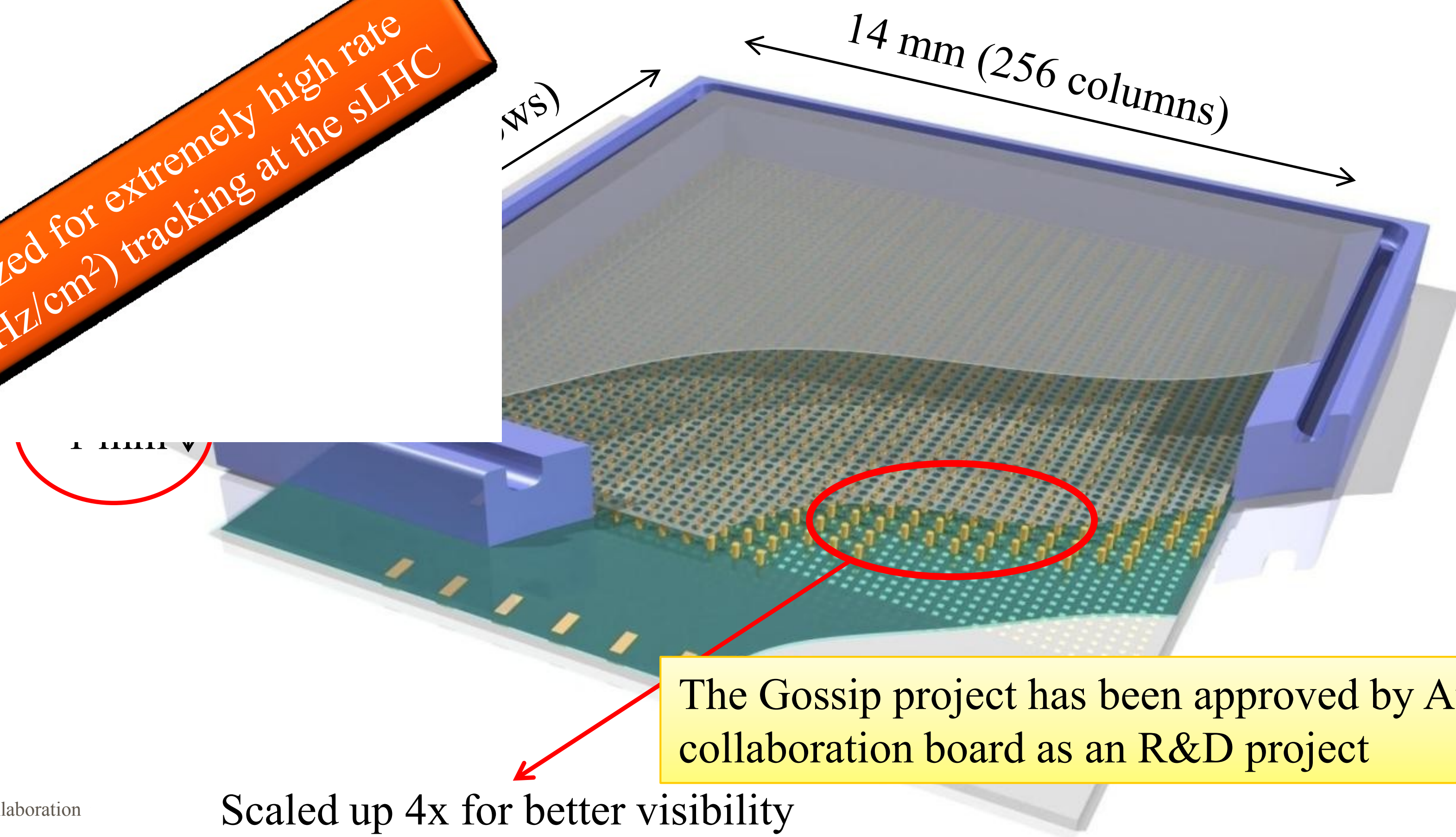
Rob Veenhof

- **Study on cross talk events at Gossip (Martin Fransen)**
  - **Partly responsible for excessive drift times**
- **Analysis August 2010 testbeam on Gossip (Wilco Koppert)**
  - **Local track fitting**
- **Nikhef's contribution to the DARWIN project**
  - **WIMP search**

Principle of Gossip

- **High granularity** pixel chip
  - Cell pitch 55 – 60 µm in X and Y
  - Thinned to 50 – 100 µm (not for this testbeam experiment)
- Detection medium: **drift gap ~ 1 mm high**
- Signal (~6 primary electrons) enhanced by **gas avalanche** from a grid
  - Gas gain 5000 - 10000

Optimized for extremely high rate (1 GHz/cm^2) tracking at the sLHC

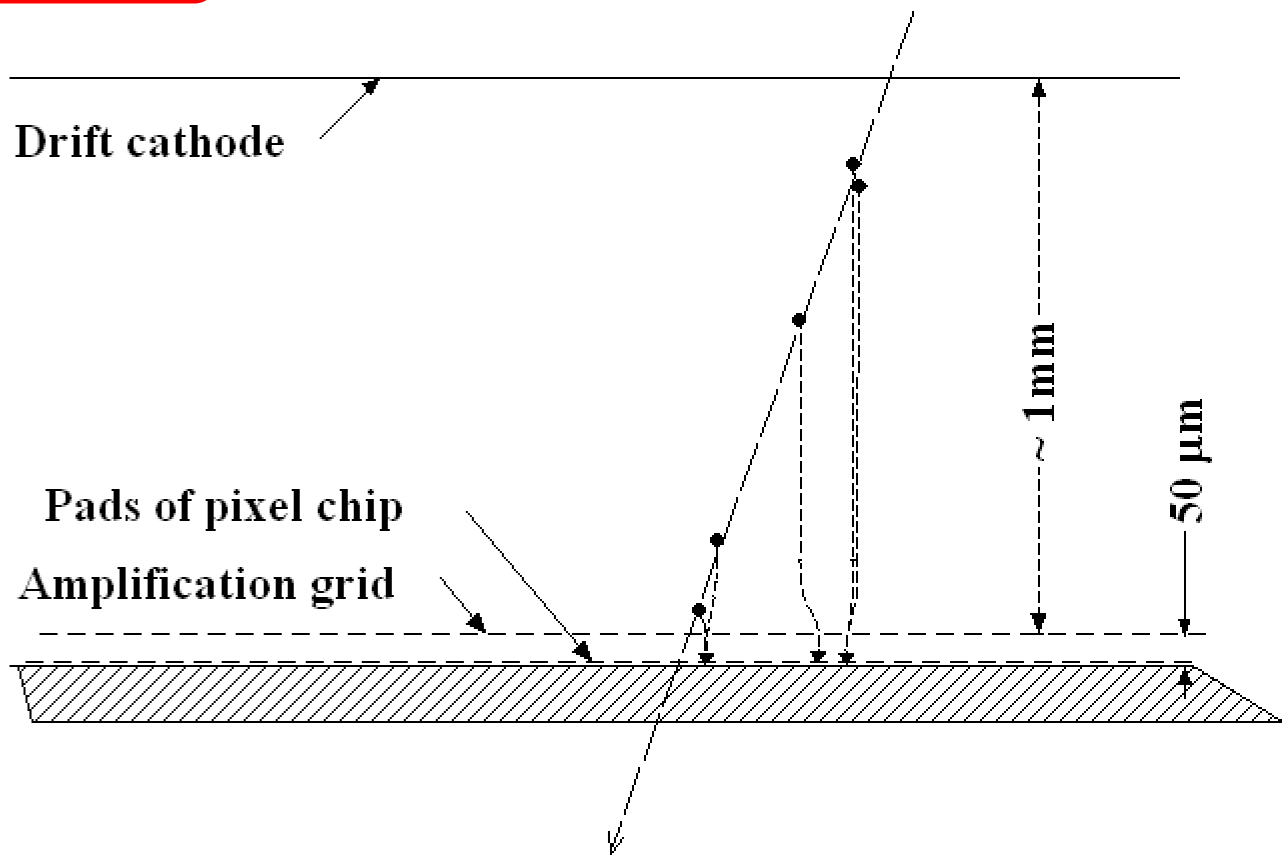


The Gossip project has been approved by Atlas collaboration board as an R&D project

Scaled up 4x for better visibility

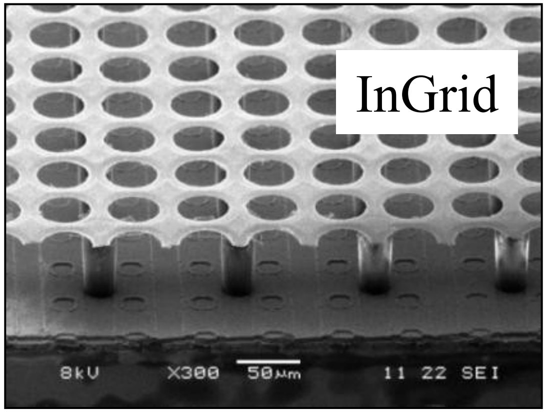
Gossip functioning

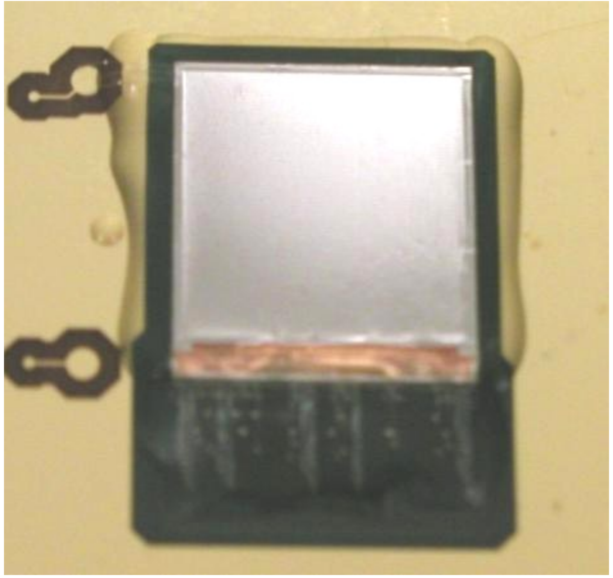
- Pixel chip with integrated Micromegas (InGrid)
- Drift gap height 1 mm
  - Getting > 98% track detection efficiency
- Often detecting **individual electrons**
- Reconstructing track segment characterized by
  - **Crossing point**
  - **Direction**



Timepix as a pixel chip

- TimePix
  - Derived from MediPix (X-ray detection)
  - Matrix of 256 x 256 pixels
  - 55 μm pitch
  - => 14.08 x 14.08 mm^2 sensitive area
  - Common clock (100 MHz) to measure drift time for each pixel
  - Also Time-over-Threshold (ToT) mode to measure charge signal spectrum
  - **Not optimized for accurate time measurements => much time walk**
  - Greatly improved TimePix-3 presently in development
- Postprocessing
  - 7 μm Si doped Si_3N_4 for **spark protection**
  - **Amplification grid** (InGrid) on TimePix

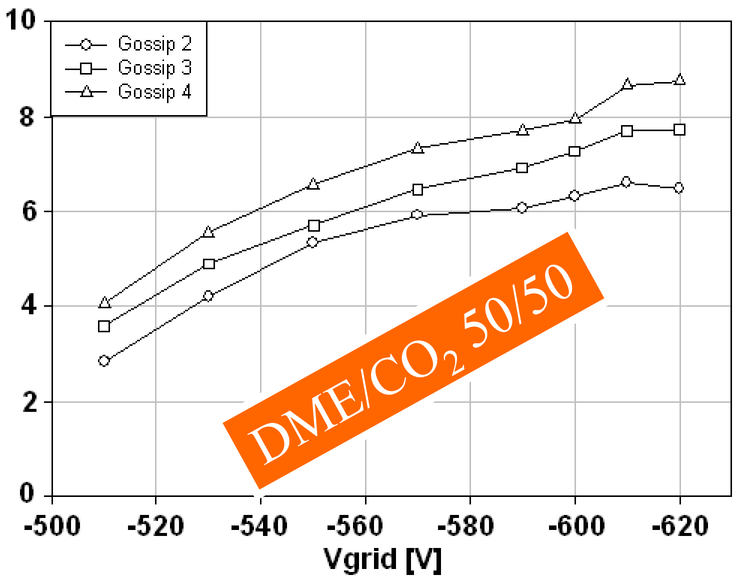




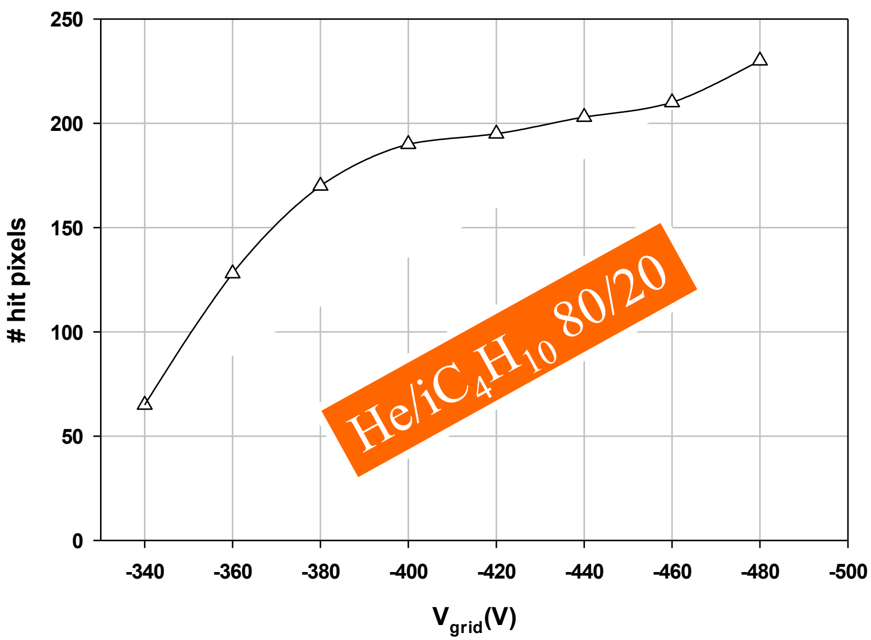
Test beam analysis: Plateau of hit pixels

- **Problem: No real plateau is formed**
- **Hypothesis** of Martin Fransen
  - Absence of a real plateau caused by **cross talk to neighbouring pixels**

Mips from August 2010 testbeam



γ conversions (^{55}Fe) drifting across 8 cm

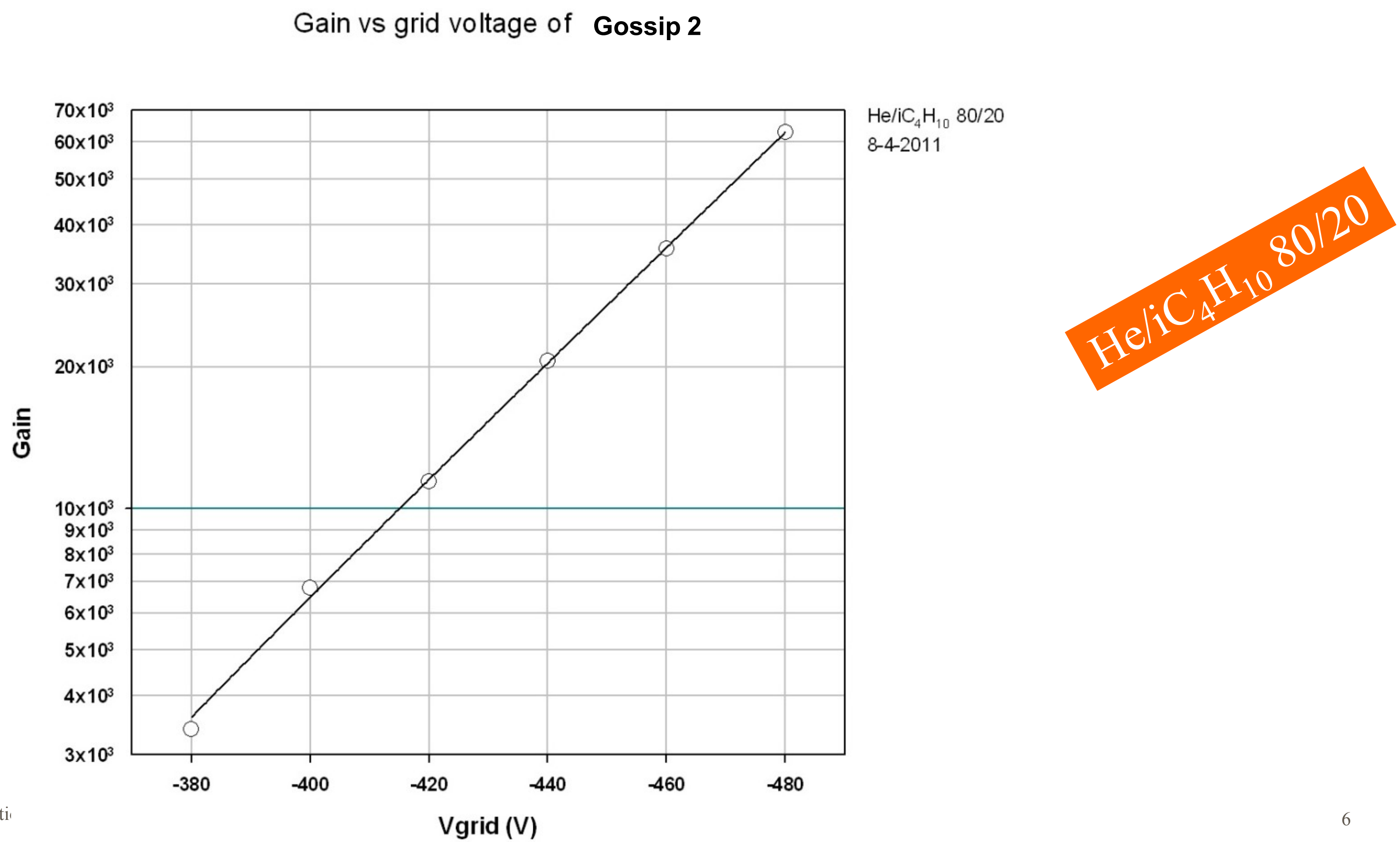


8 cm drift

Only central part of Timepix is considered to avoid events that have been cut by edges

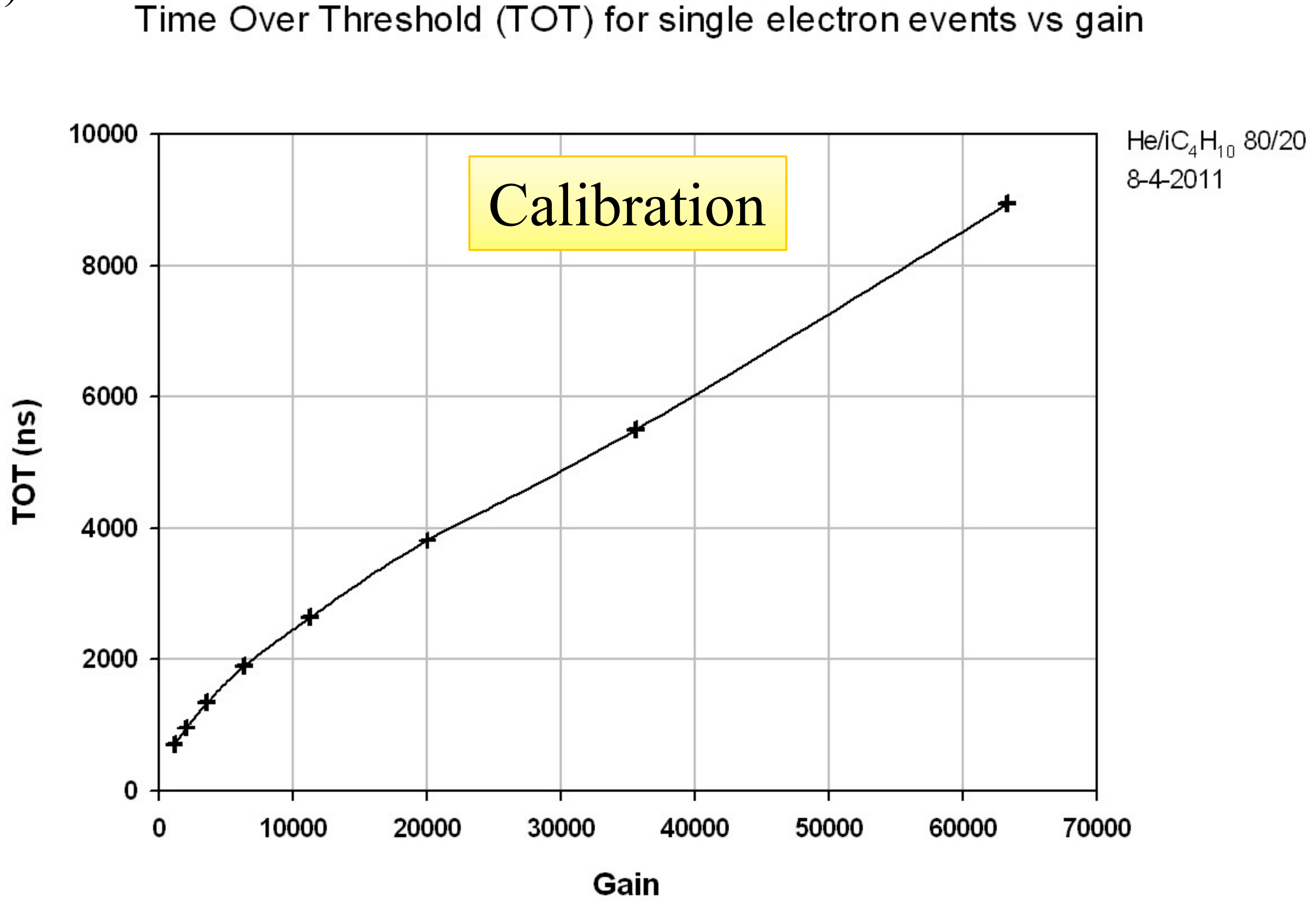
Study of Martin Fransen (Nikhef) to explain the absence of a good plateau

- Using a Gossip capable of having extremely high gain
  - **Up to 63k**
- Gain calculated from the induced charge signal on the amplification grid



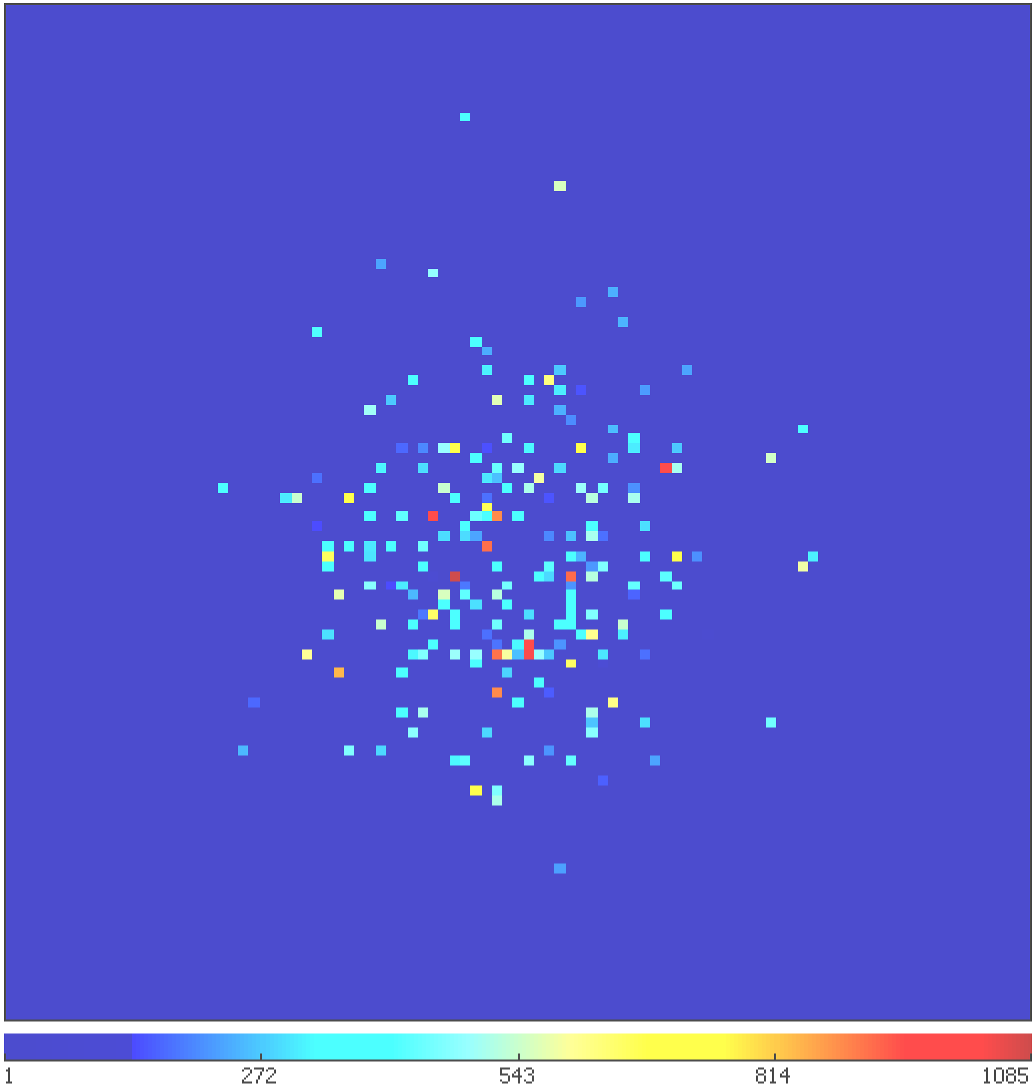
Charge signal calculated from measured Time over Threshold (ToT)

- No direct charge signal measurement on TimePix
- ToT: one op the operating modes of the TimePix (not simultaneous with drift time mode)



Using electron clouds from ^{55}Fe conversion

- **8 cm drift** to reduce pile-up (more than one electron to same pixel)
- Colour indicates collected pixel charge from **T**ime-**O**ver-**T**hreshold (ToT) measurement

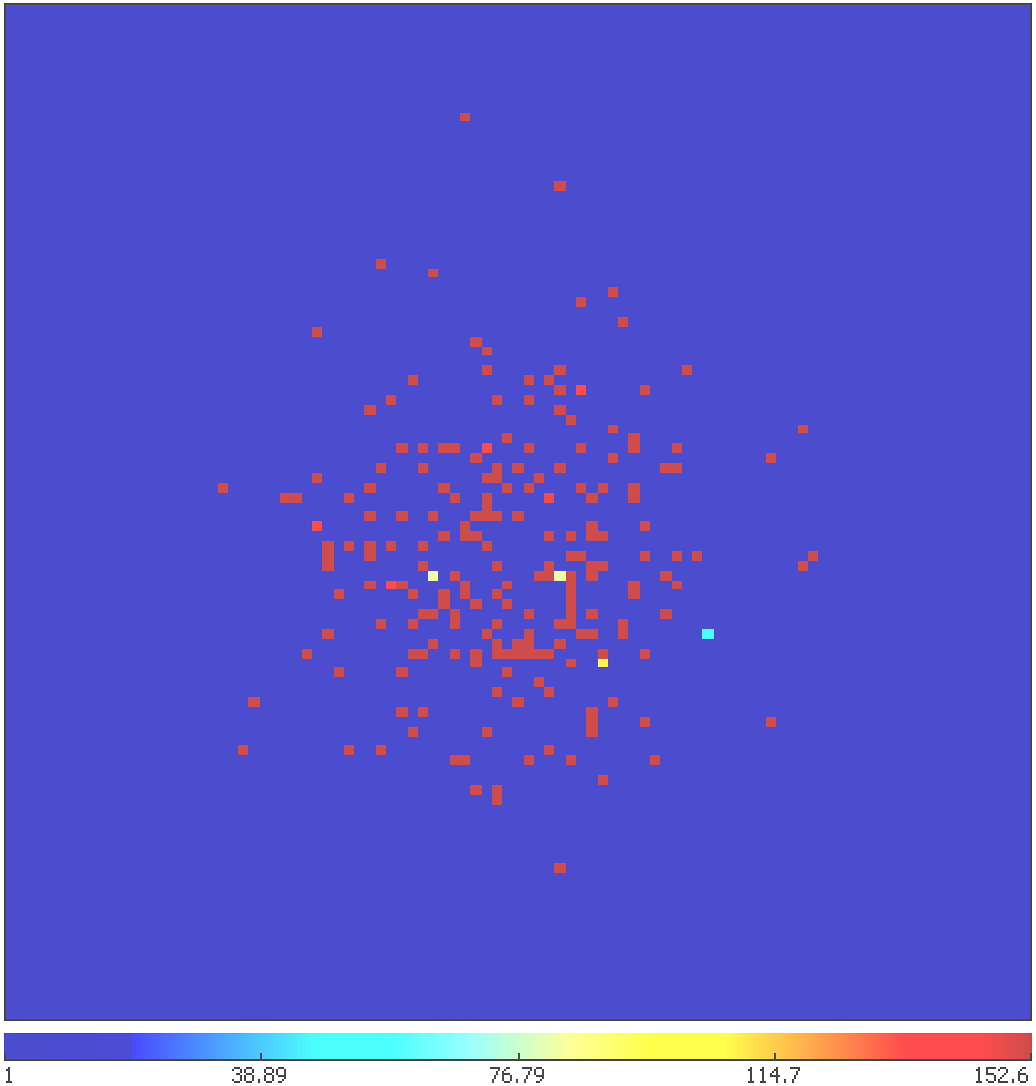


He/iC_4H_{10} 80/20

Same event

- **Colour scale reduced by 7.1**: most charge signals are dark red (overflow)
- Few small signal events, **often isolated**

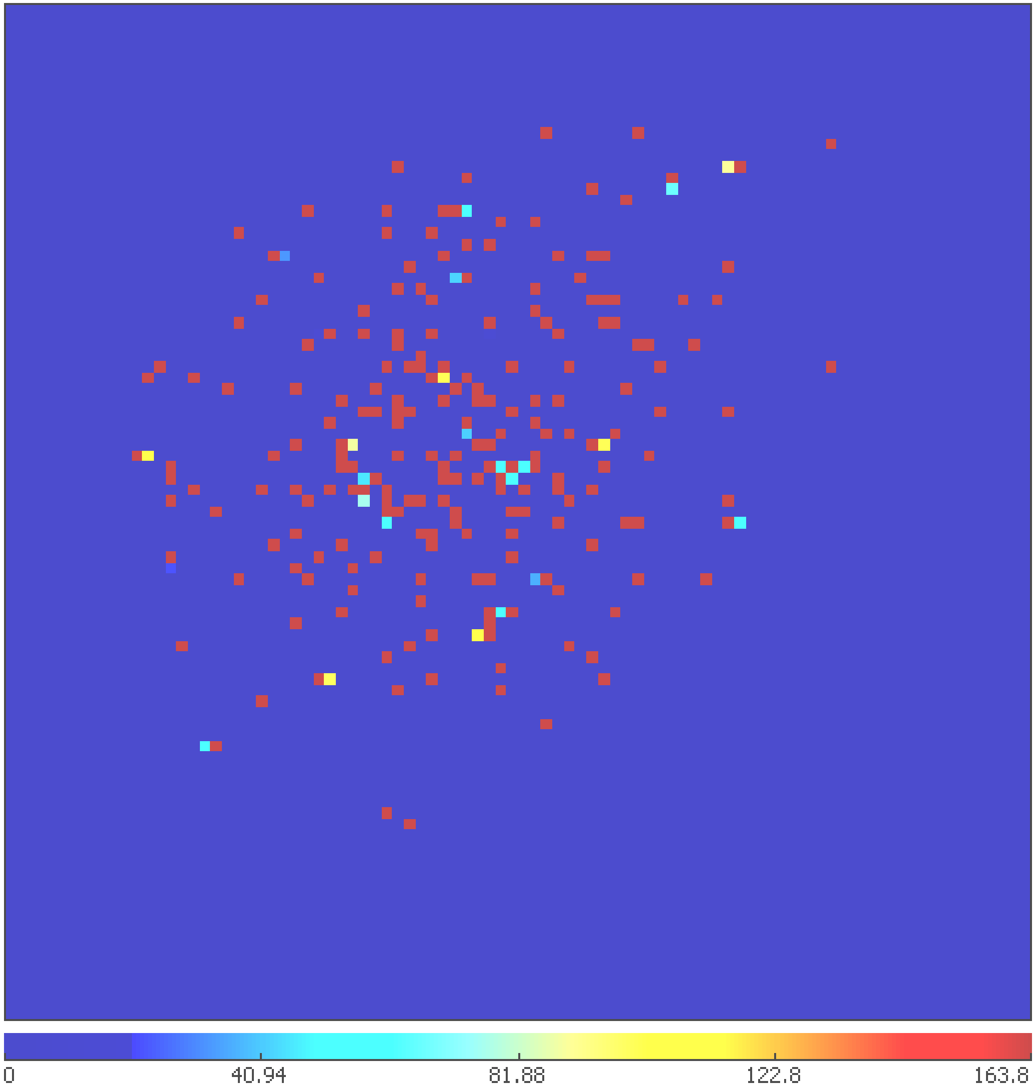
He/iC$_4$H$_{10}$ 80/20



Another event, but at a much higher gain

- Number of small signal events, **none is isolated**

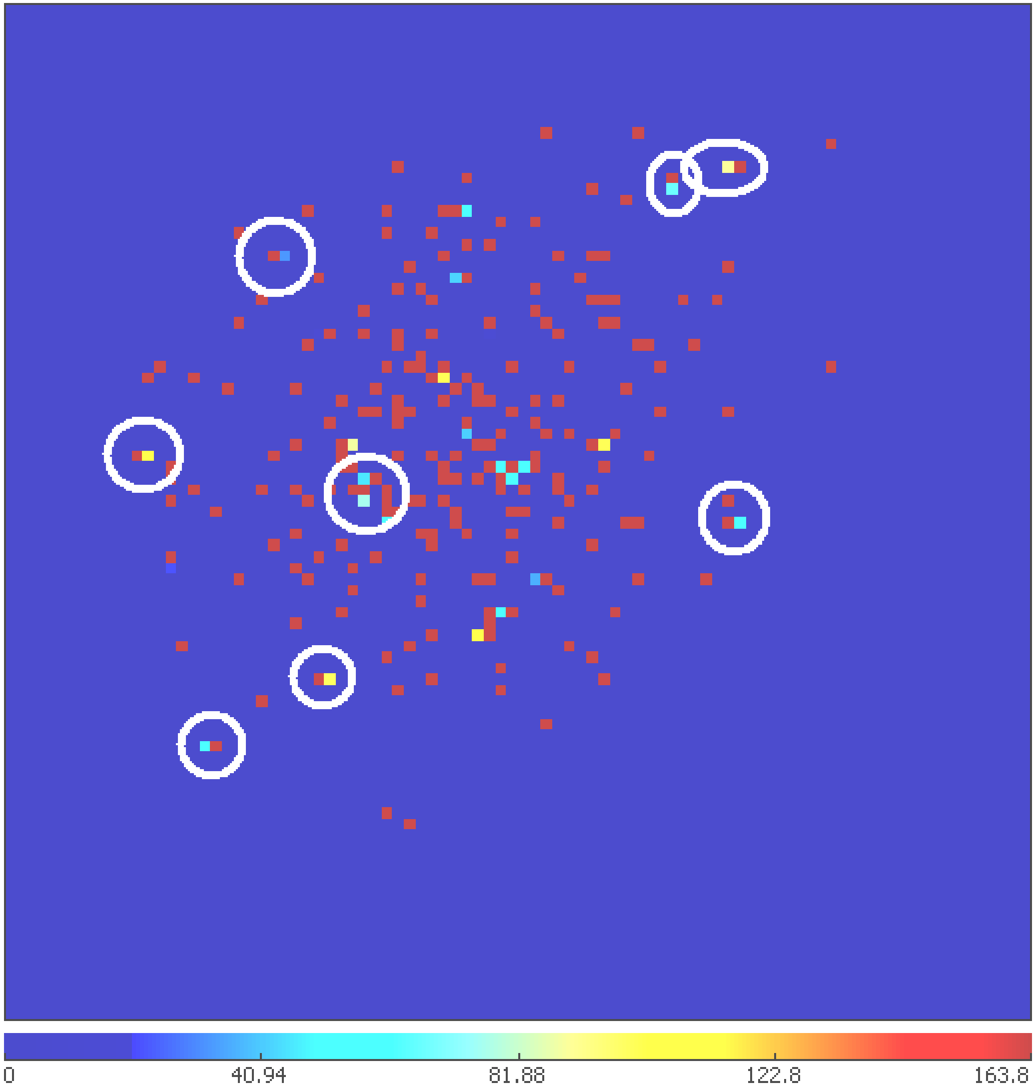
He/iC_4H_{10} 80/20



Higher gain

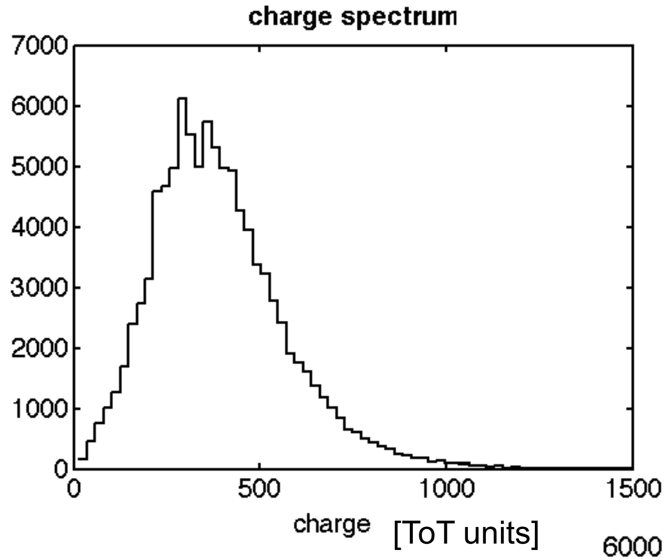
- Quite some small signal events, **none is isolated**

He/iC$_4$H$_{10}$ 80/20



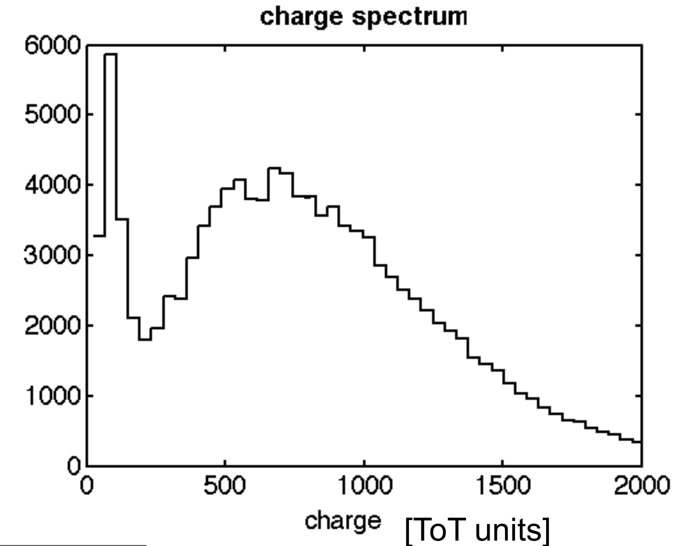
Cross talk effect is seen in charge signal spectrum per pixel

G = 20k

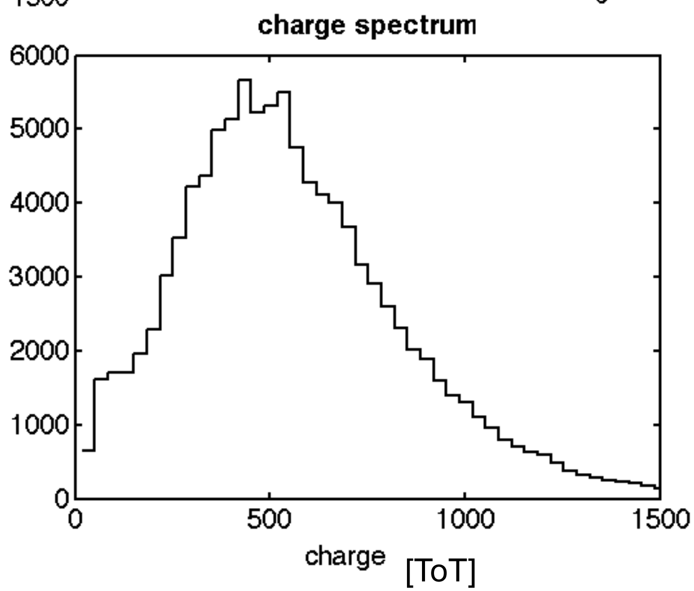


He/iC$_4$H$_{10}$ 80/20

G = 63k

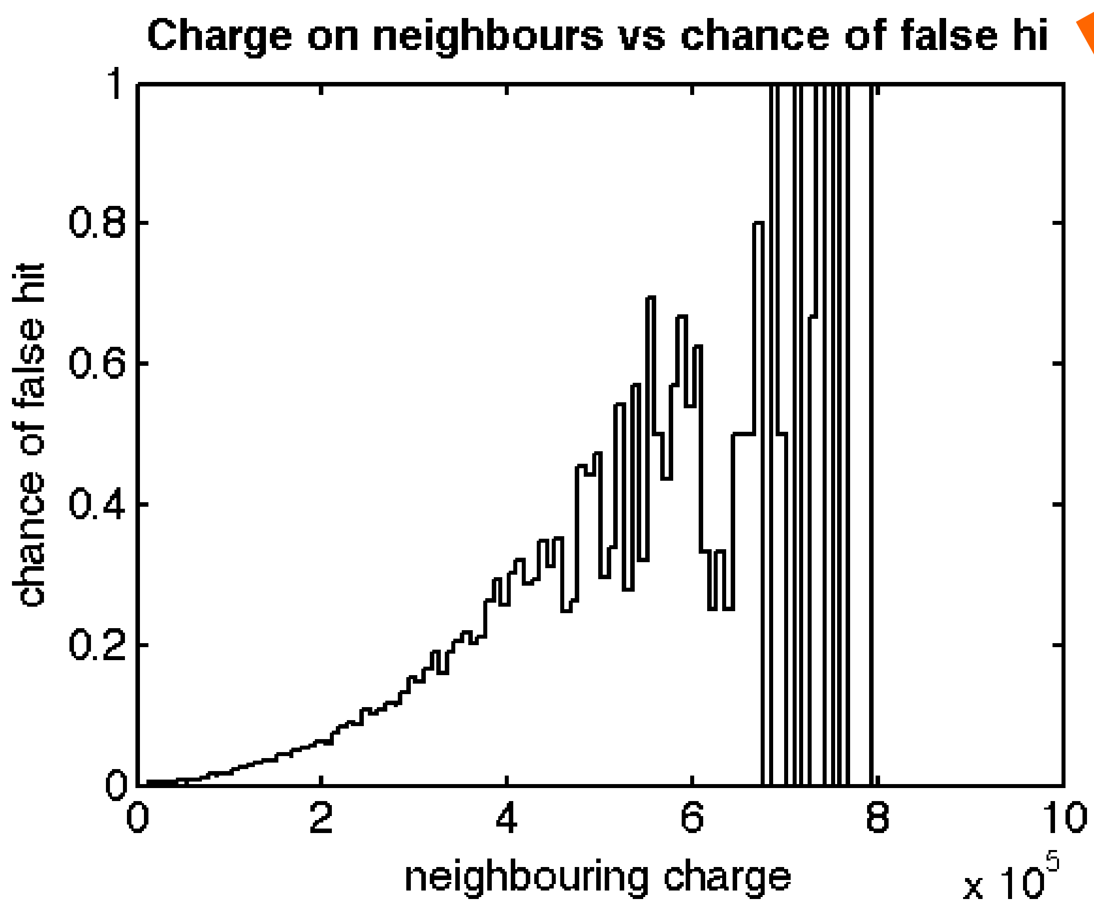


G = 35k



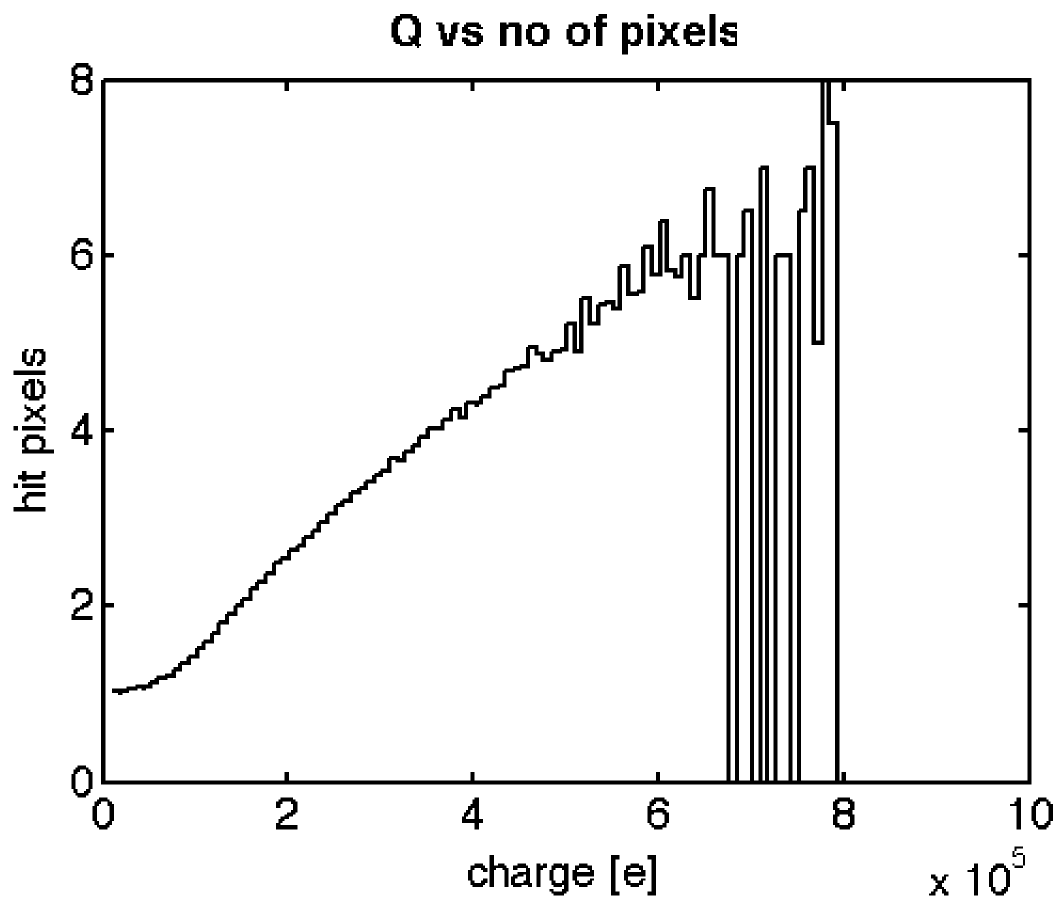
Dependence of false hits at neighbouring cells vs pixel charge

He/iC_4H_{10} 80/20



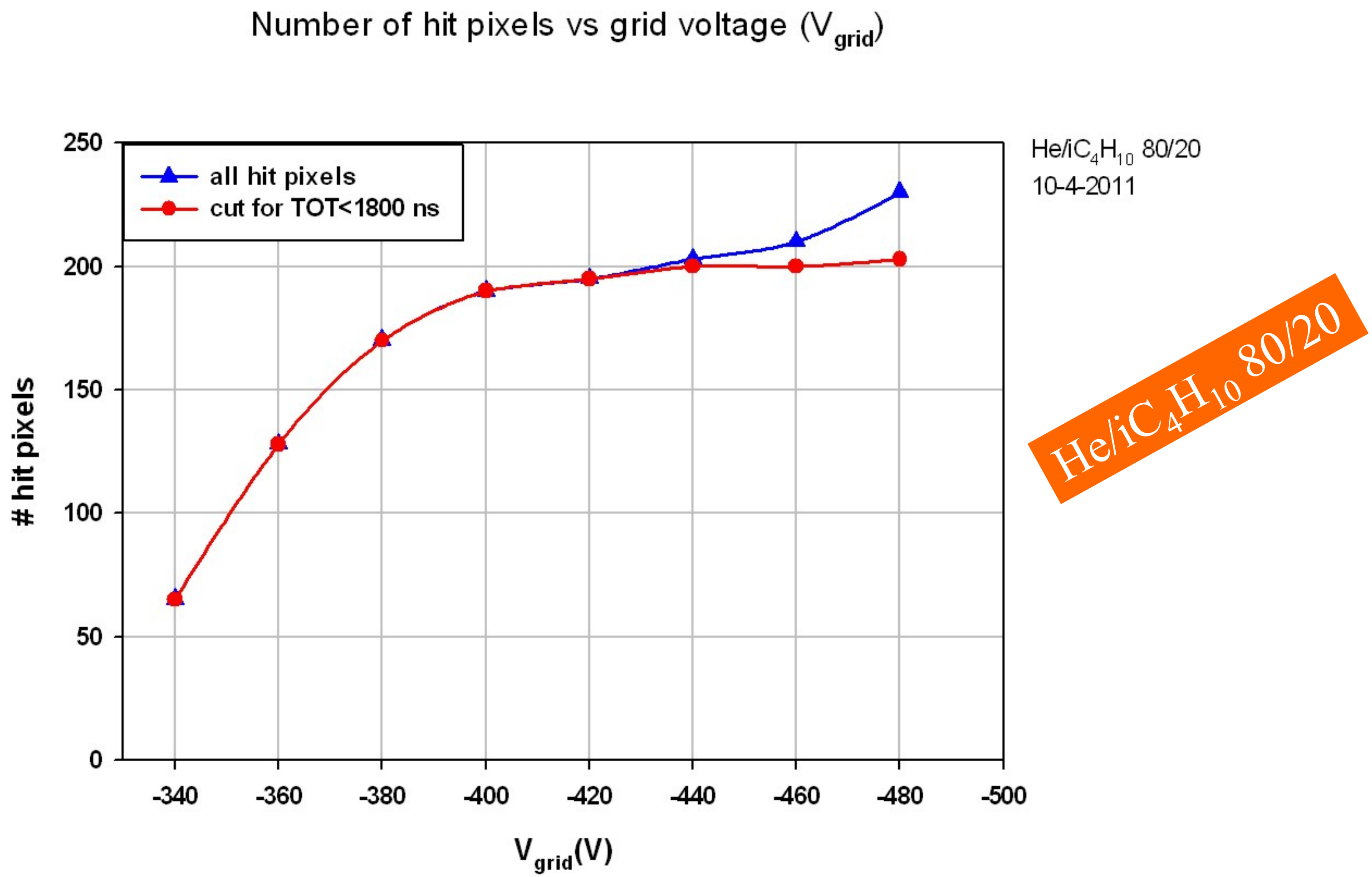
Number of hit pixels vs charge on single pixel

He/iC_4H_{10} 80/20



Hit histogram does have a plateau with proper cuts

- Cutting small signal hits with ToT < 1800 ns (≈ 5k electrons)

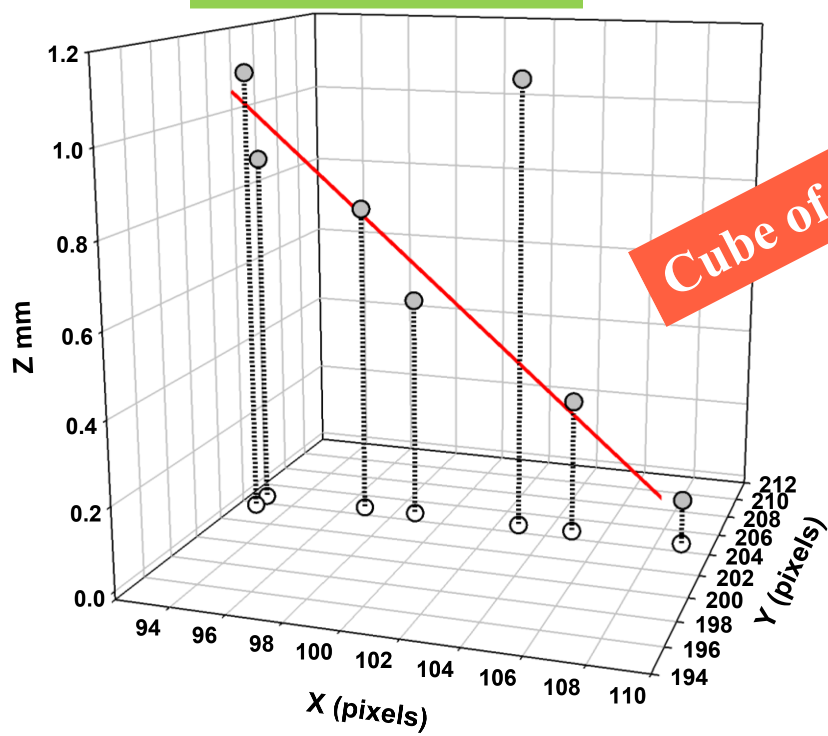


Local fitting of tracks under 45° at Gossip by Wilco Koppert

No global fitting yet

Event 124run32_4
detector 3

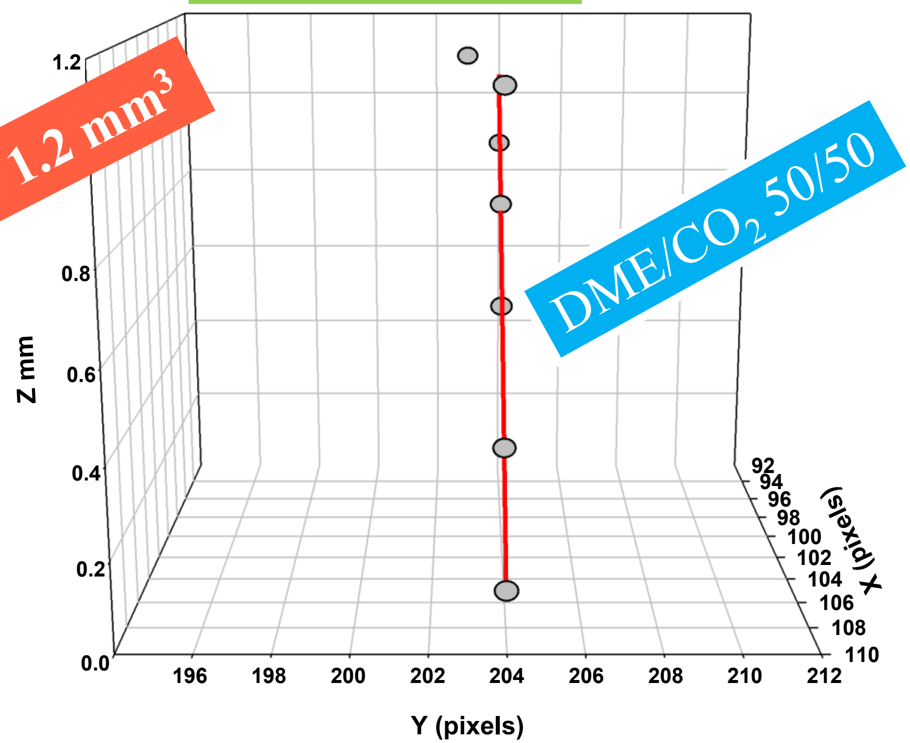
X-Z plane => 45°



Cube of ~ 1.2 mm³

Event 124run32_4
detector 3

Y-Z plane => 0°

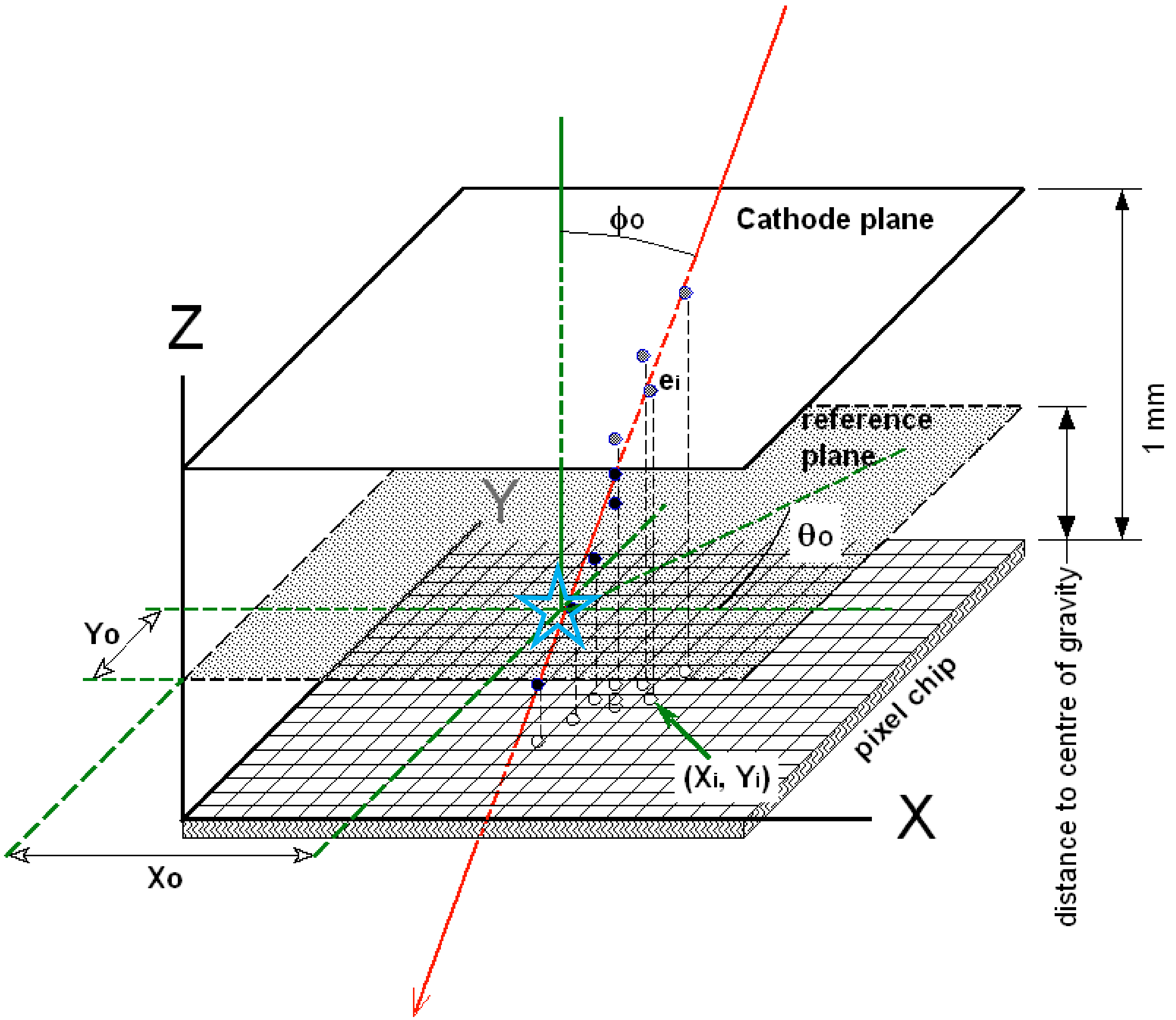


DME/CO_2 50/50

1 mm

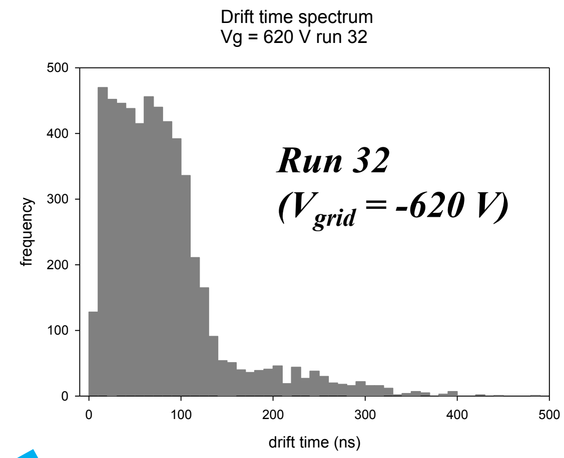
Reconstructing track segment

- Track characterized by φ, θ and the **crossing point** (X, Y) with the **reference plane**
- **Height** reference frame set at **centre of gravity** of reconstructed electrons
  - Taking into account the **weight factor** of the hit points (diffusion)

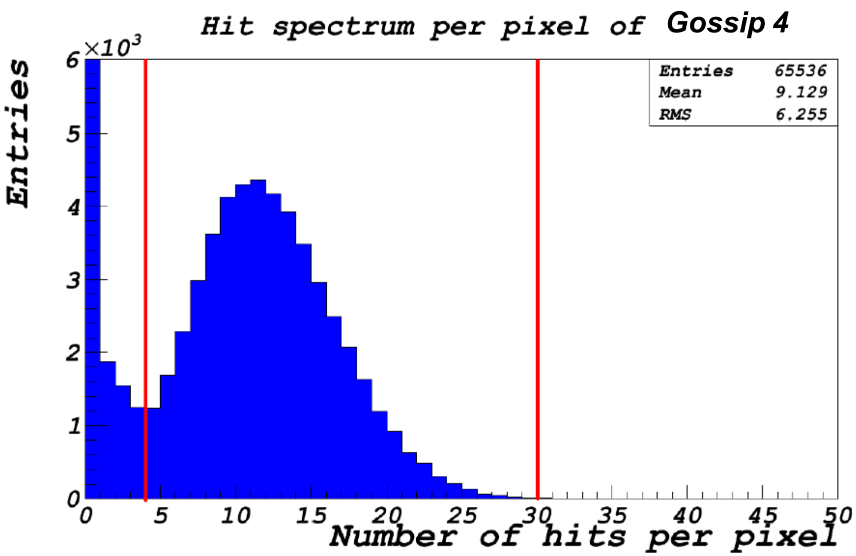


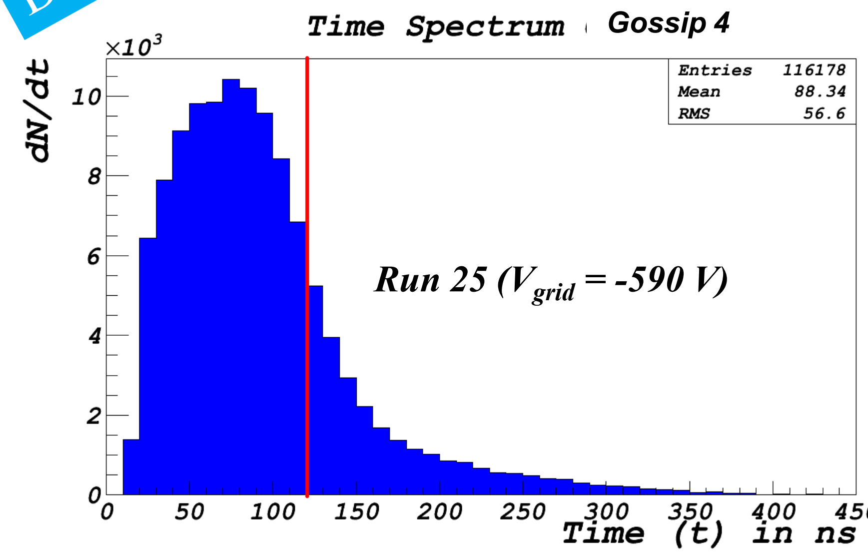
Data cuts for local track fitting

- Run of ~ 17k events
- Pixels < 4 hit pixels rejected
- Pixel hits with drift times > 100 ns rejected
- Events < 3 hit pixels rejected
  - Smaller does not make sense for this study
  - At later stage global fitting will use all events



DME/CO_2 50/50





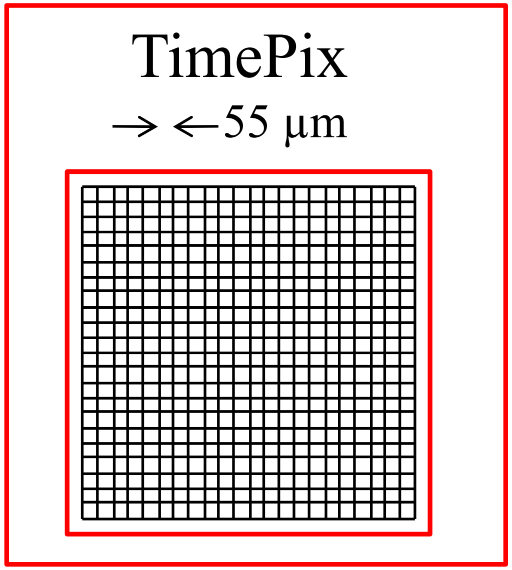
Run 25 (V_{grid} = -590 V) chosen because of high statistics (17k)

Error estimation

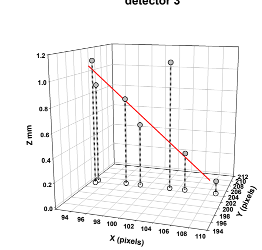
DME/CO_2 50/50

- If errors correct => fit correct
- XY errors
  - $\sigma_{pitch} = 0.055/\sqrt{12} = 0.0159$ mm
  - $\sigma_{DT} = 0.0200$ mm $/\sqrt{\text{mm}}$
- Z errors
  - $\sigma_{clock} = 0.01\ (\mu s) * V_{drift} /\sqrt{12} = 0.037$ mm
  - $\sigma_{DL} = 0.0231$ mm (GARFIELD)
  - $\sigma_{Timewalk} \approx 0.2$ mm (data)
- Requiring conf. level to be flat
  - => $\sigma_{Timewalk} \approx 0.13$ mm

Errors given by
- Finite pixel pitch
- Diffusion
- Clock frequency
- Timewalk effect
  - For small signals



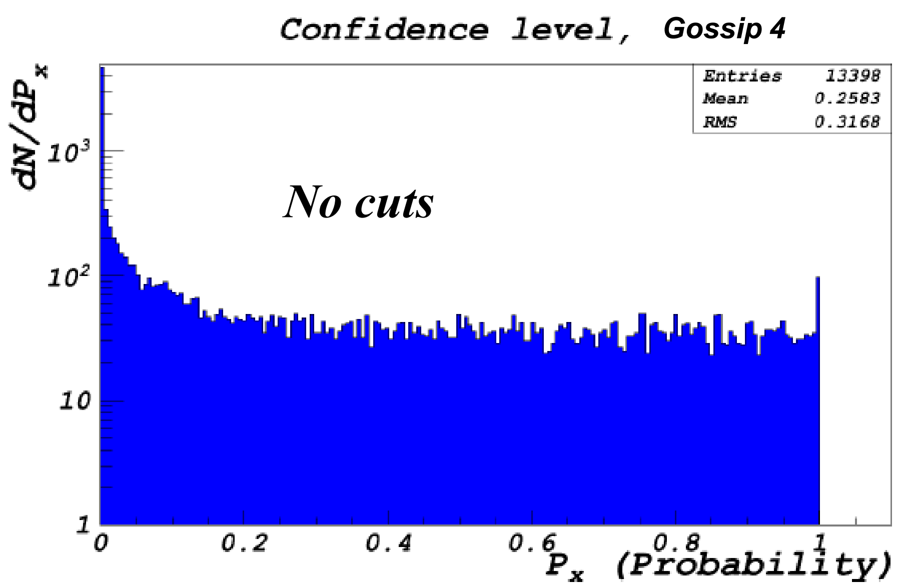
From testbeam measurement:
$V_{drift} = 11.7$ mm/µs
$\sigma_{DT} = 0.0200$ mm $/\sqrt{\text{mm}}$ (= 63.4 µm$/\sqrt{\text{mm}}$)

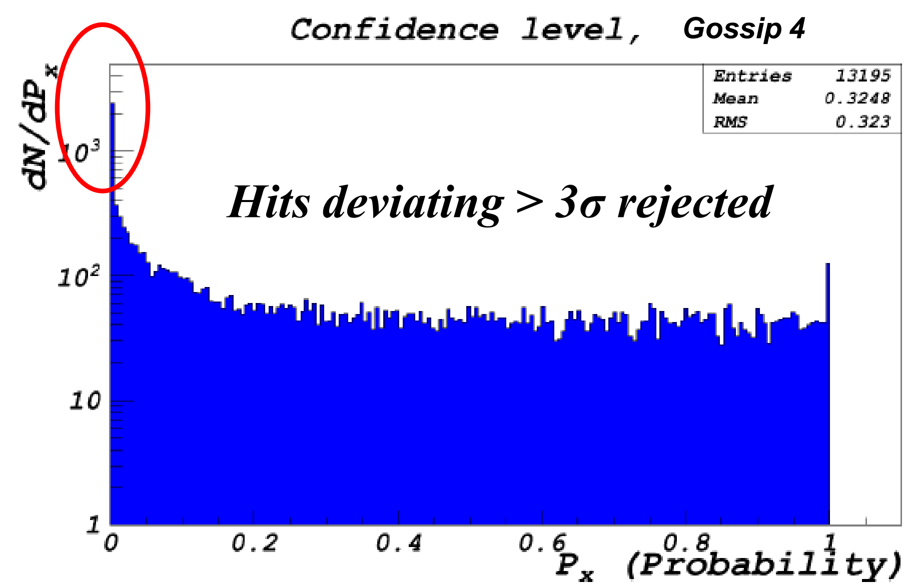


X-Z confidence level

- Should be as flat as possible
- May be tuned by **modifying** $\sigma_{Timewalk}$
  - **=> $\sigma_{Timewalk} \approx 0.13$ mm**
- Slight improvement if > 3 σ hits are rejected

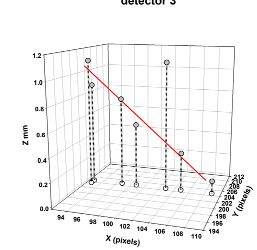
DME/CO_2 50/50

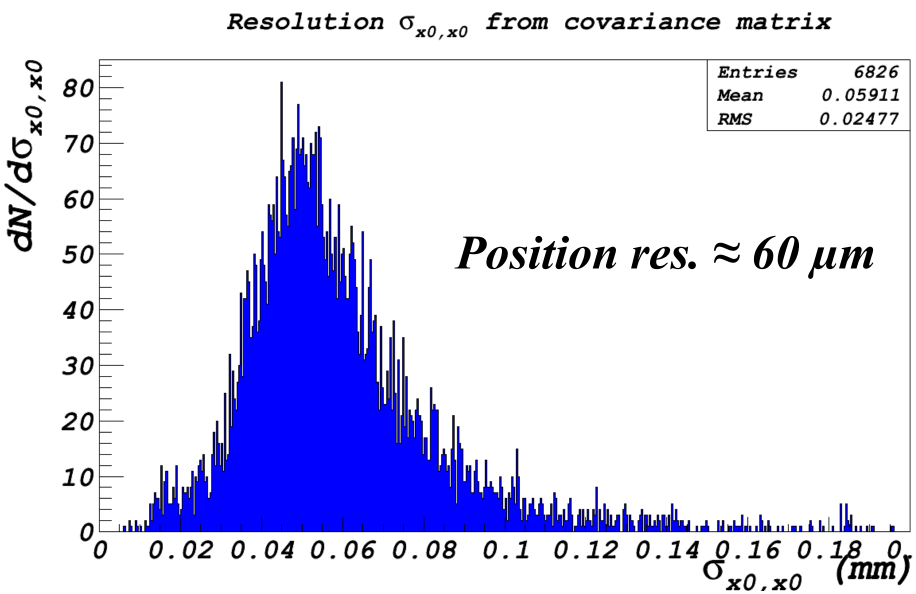


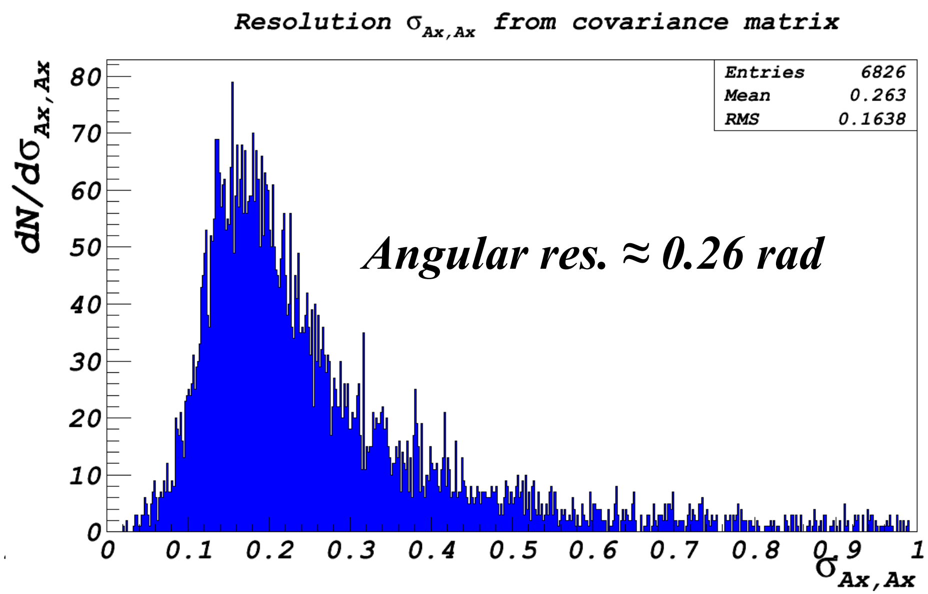


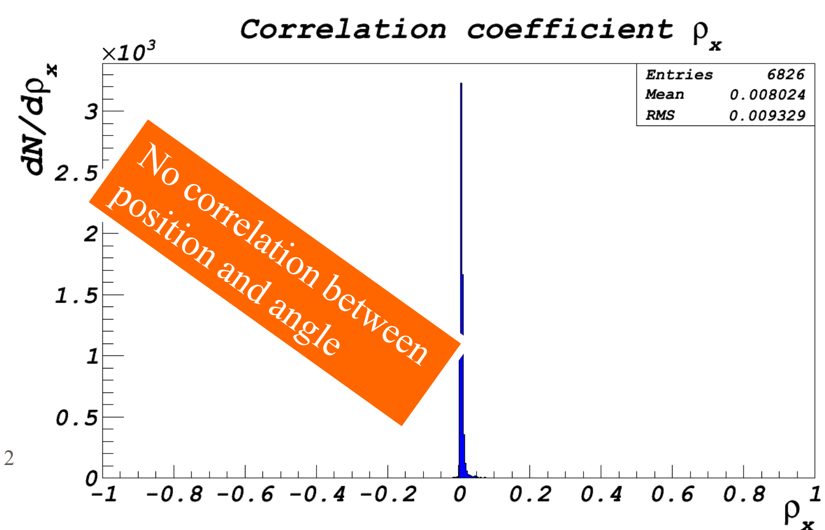
DME/CO_2 50/50

Fit in X-Z plane

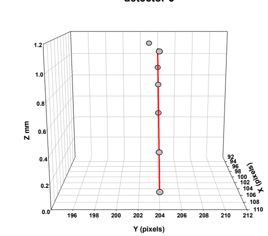






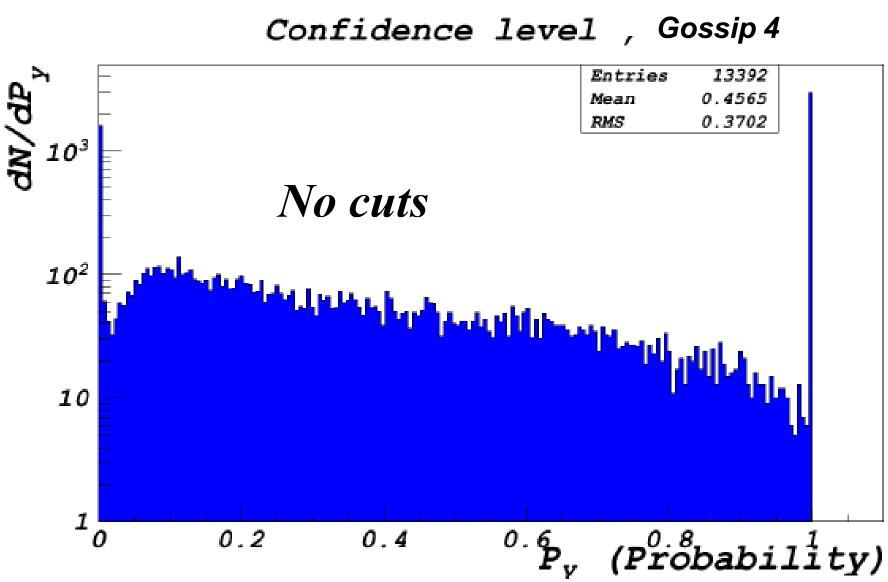


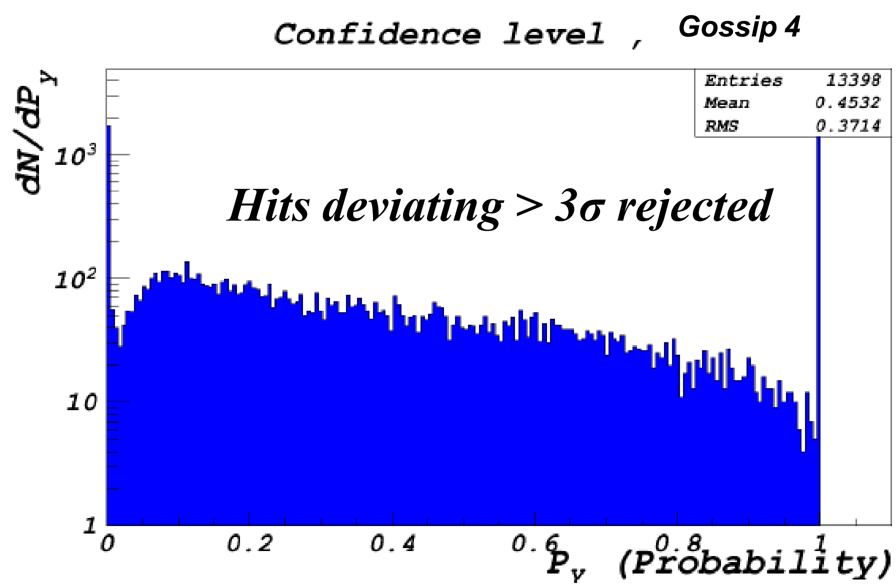
DME/CO_2 50/50



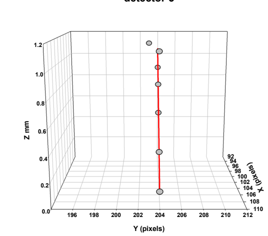
Y-Z confidence level

- Again using $\sigma_{Timewalk} \approx 0.13$ mm
- No significant effect using 3σ cuts
  - (Drift time hardly significant for this fit)

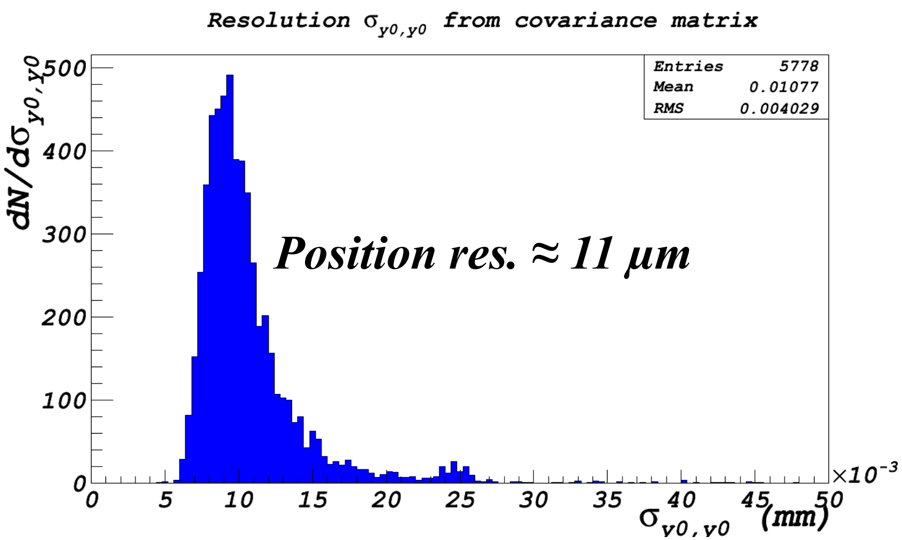


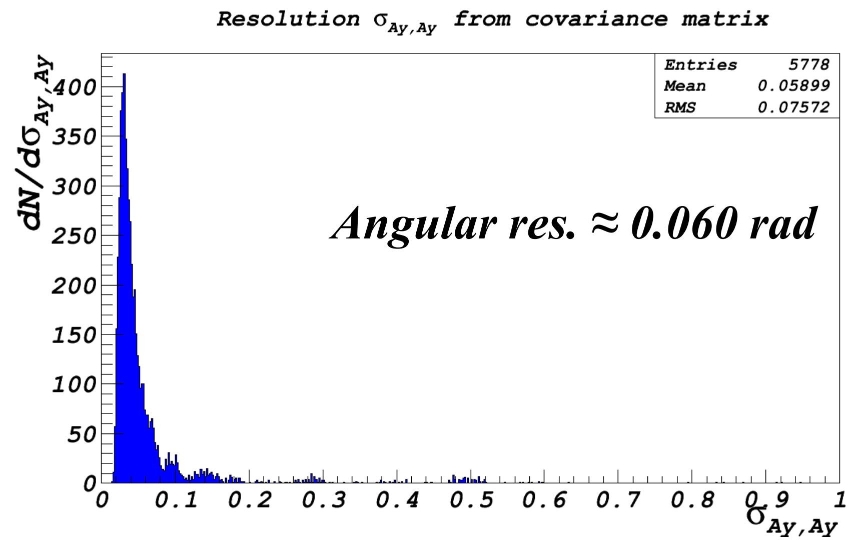


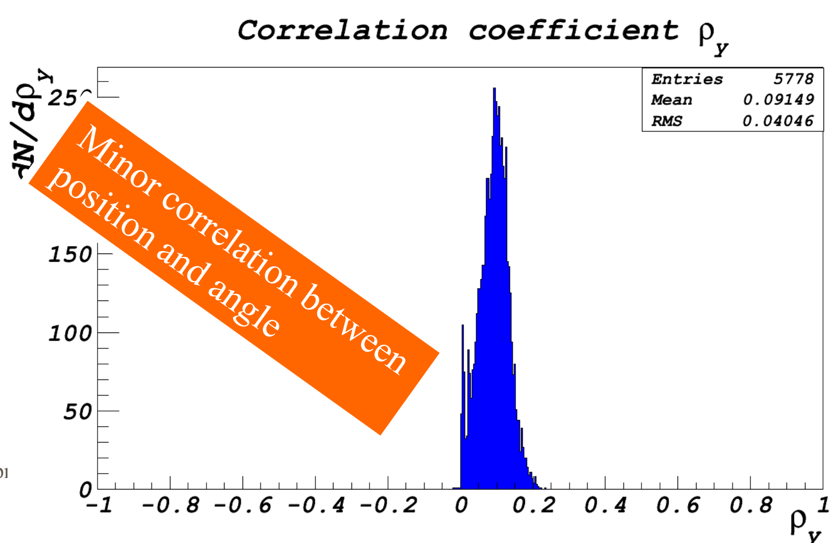
Fit in Y-Z plane



- Note that these values are deduced from **local fits**







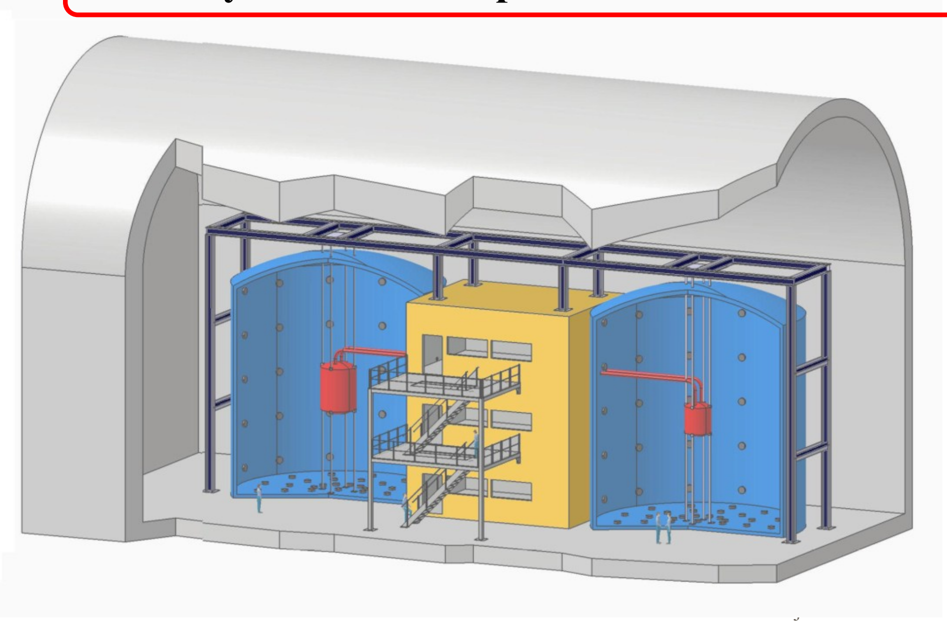
Minor correlation between position and angle

DME/CO_2 50/50

XENON and DARWIN: search for WIMPs

Matteo Alfonsi, Gijs Hemink, Rolf Schön

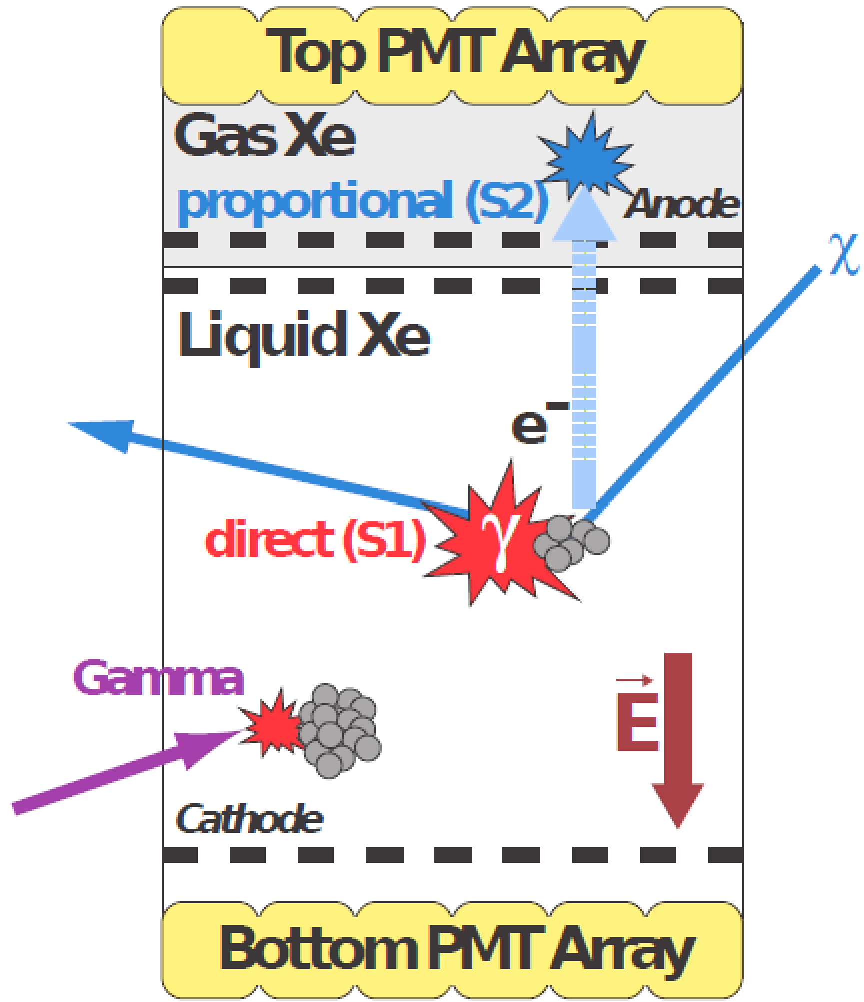
- **XENON**
  - XENON100: In Gran Sasso having 100 kg of LXe fiducial target mass
  - XENON1T : next upgrade to 1000 kg
- **DARWIN** is next generation experiment presently under study
  - Using target with LAr (left) and/or LXe (right) in water environment
  - **Presently Nikhef takes part in the studies for DARWIN**



Proposed setup of DARWIN

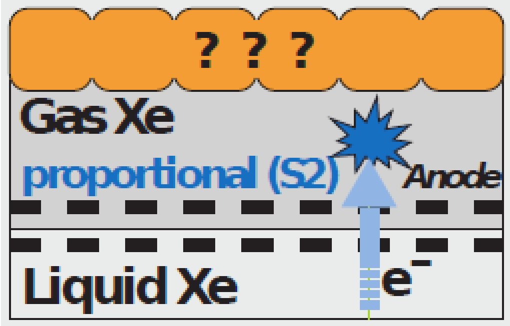
Present WIMP detection (XENON)

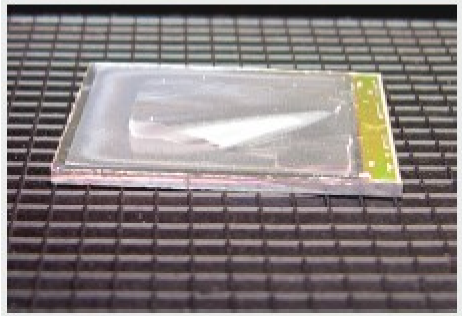
- Using PMTs to detect the scintillation light from interaction
  - Very high gas purity needed to avoid absorption of UV scintillation light
- Ionization electrons drifting across 0.5 m
- Avalanche in the proportional counter
  - **Avalanche light** detected as well
- No electrical signal from proportional counter used until now
- Problem: getting some gas gain in the very pure inert gas environment
  - Really NO quenching



Nikhef involvement in DARWIN

- **Using electrical signal** from the ionization electrons
- **GridPix detectors** to form a micro TPC for the ionization detection
  - (omitting upper PMTs)
- Problems to address
  - Thermal stress by low temperature
  - Operation of TimePix at -186°C (Ar) or -108°C (Xe)
  - Getting some gas gain in a very pure inert gas without any quencher



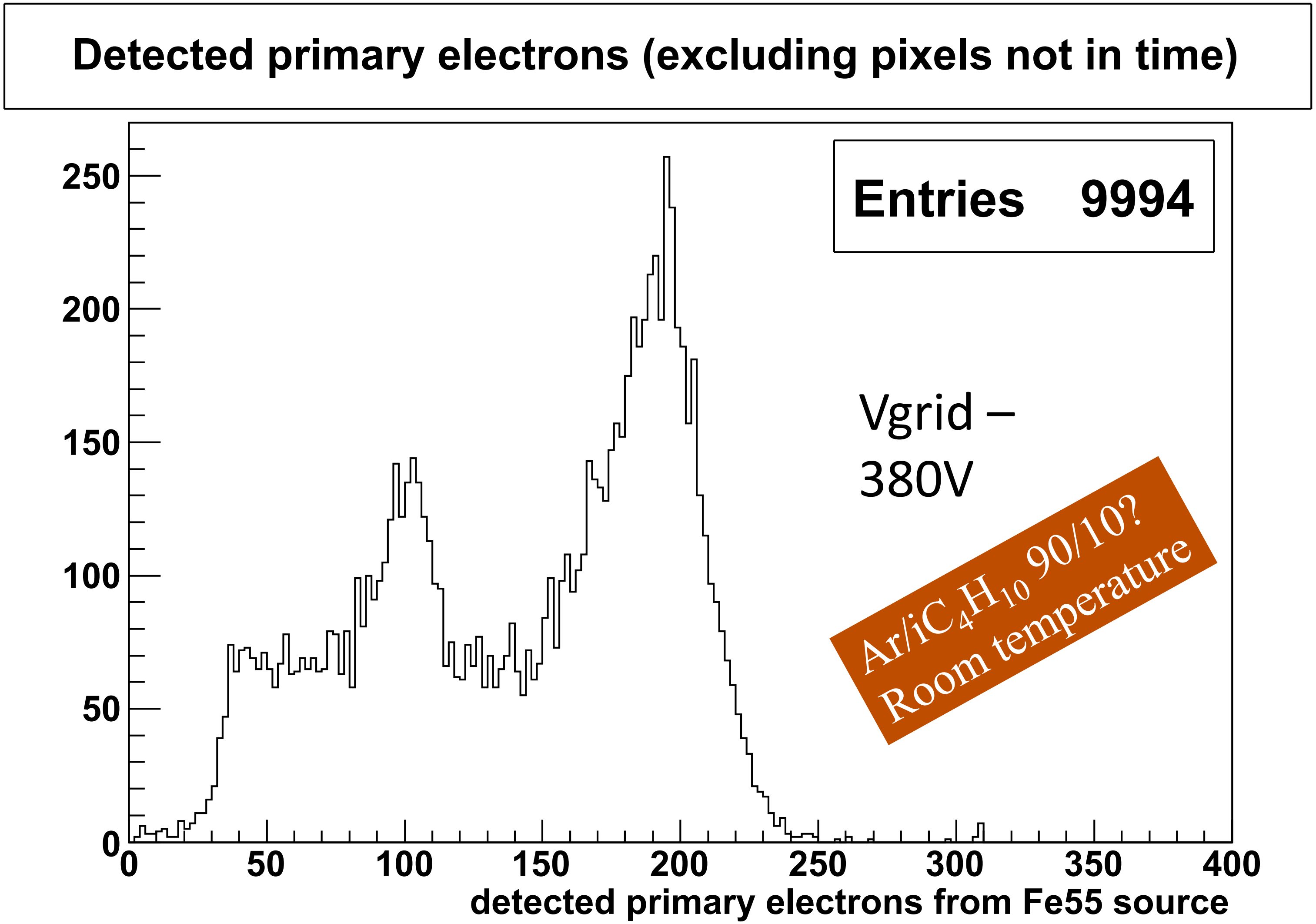


Present setup at Nikhef

Gain Setup

Cold setup in progress

First (pre-)results



Conclusions

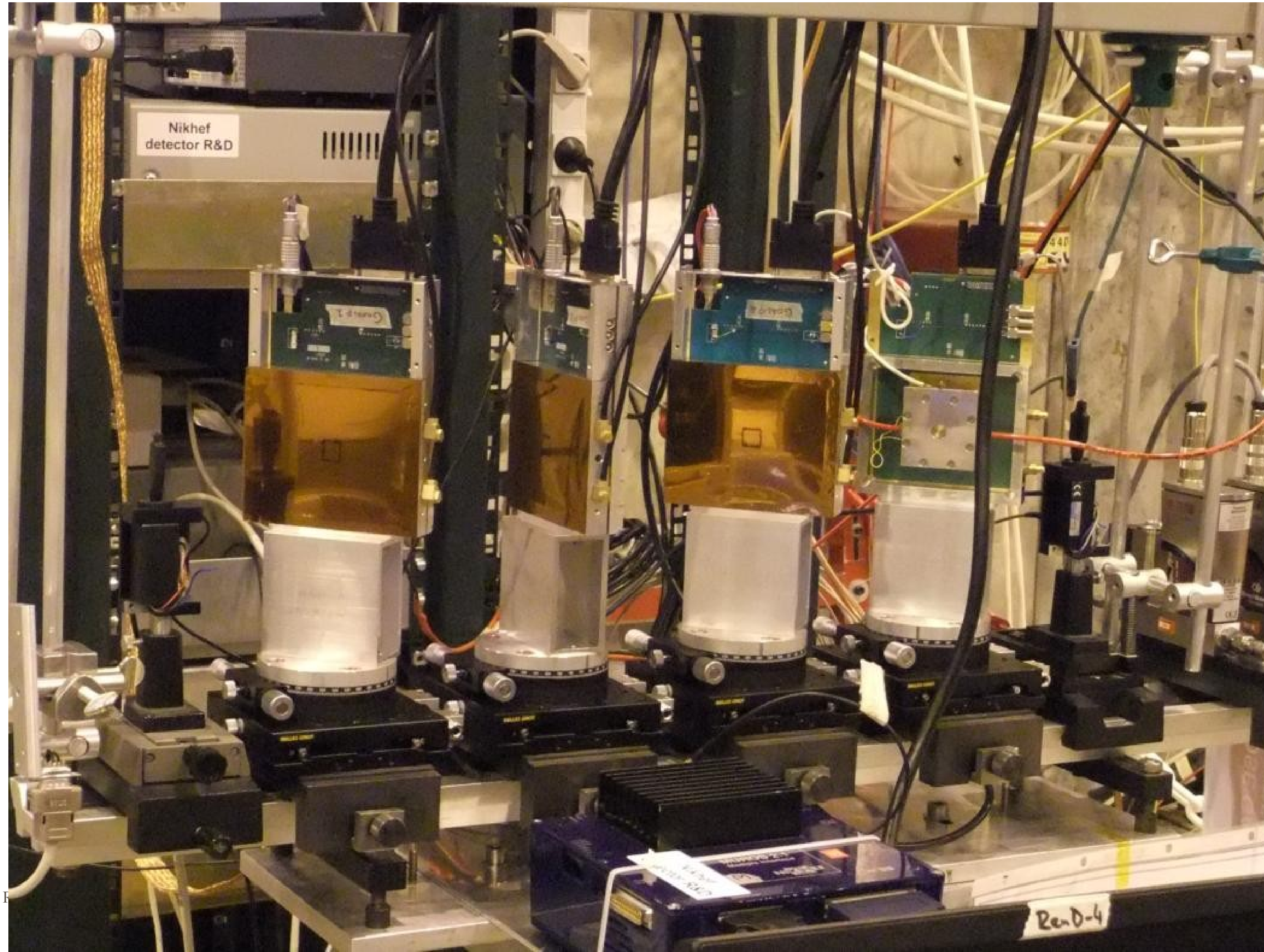
- For the TimePix-1 chip **cross talk** plays an important role at **high gas gains** (Martin Fransen)
  - Inducing small signals on neighbouring pixels
  - Deteriorating drift time resolution (timewalk)
- **Timewalk** problem can be overcome by more advanced front end: TimePix-3
  - Measuring ToT and drift time simultaneously

- **Local track fitting** in August 2010 testbeam data (Wilco Koppert) using 45° tracks
  - Tuning $\sigma_{\mathrm{Timewalk}}$ to 0.13 mm gives flat confidence level distribution
  - Position resolution
    - X: 60 μm (deteriorated by timewalk)
    - Y: 11 μm
  - Angular resolution
    - AX: 0.26 rad (deteriorated by timewalk)
    - AY: 0.06 rad

- DARWIN activities (Matteo Alfonsi, Patrick Decowski, Gijs Hemink)
  - Setup finishing, starting measurements

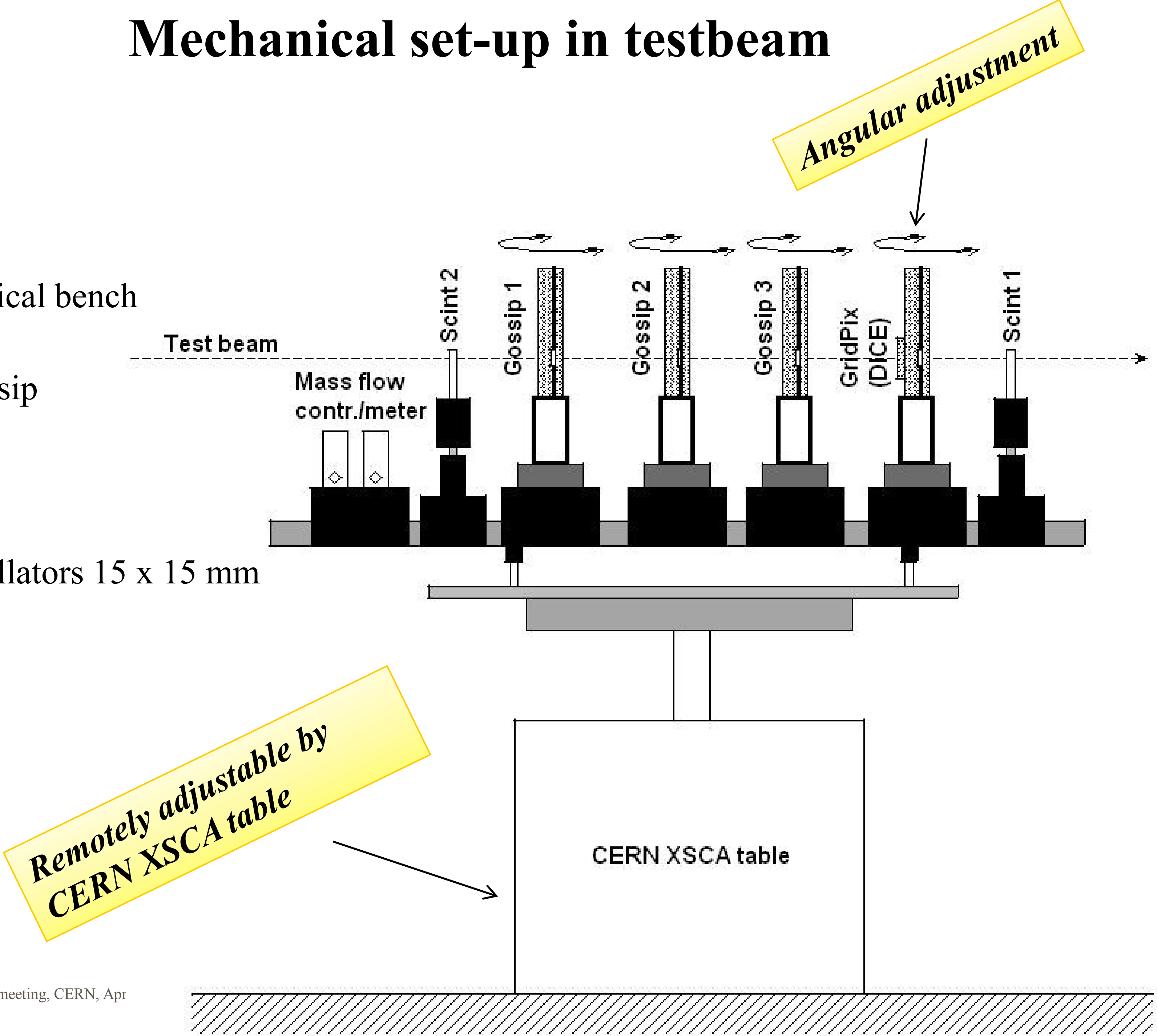
SPARE

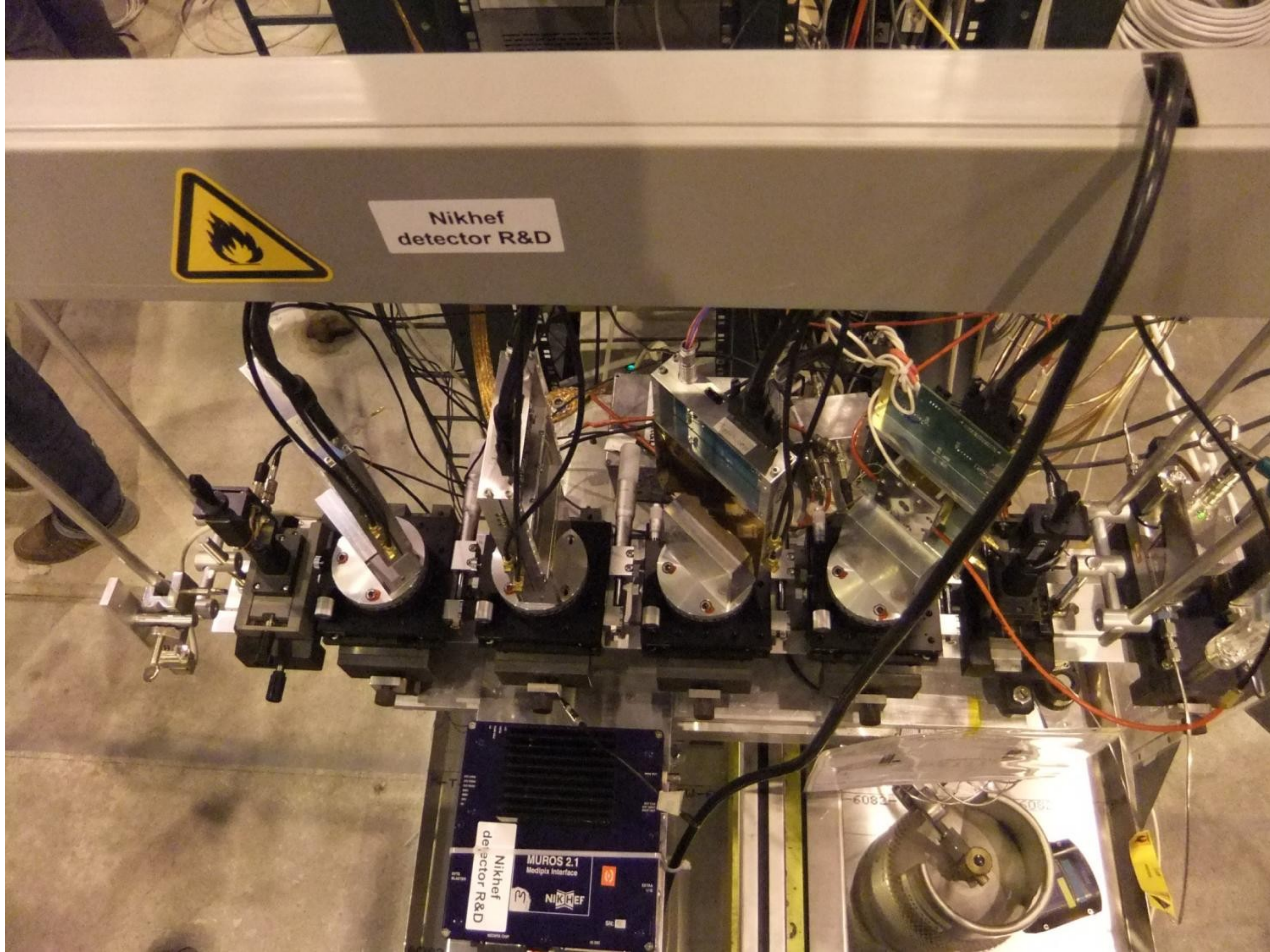
Gossip testbeam August 12 – 22 , 2010



Mechanical set-up in testbeam

- 1 m optical bench
- 3 x Gossip
- GridPix
- 2 Scintillators 15 x 15 mm

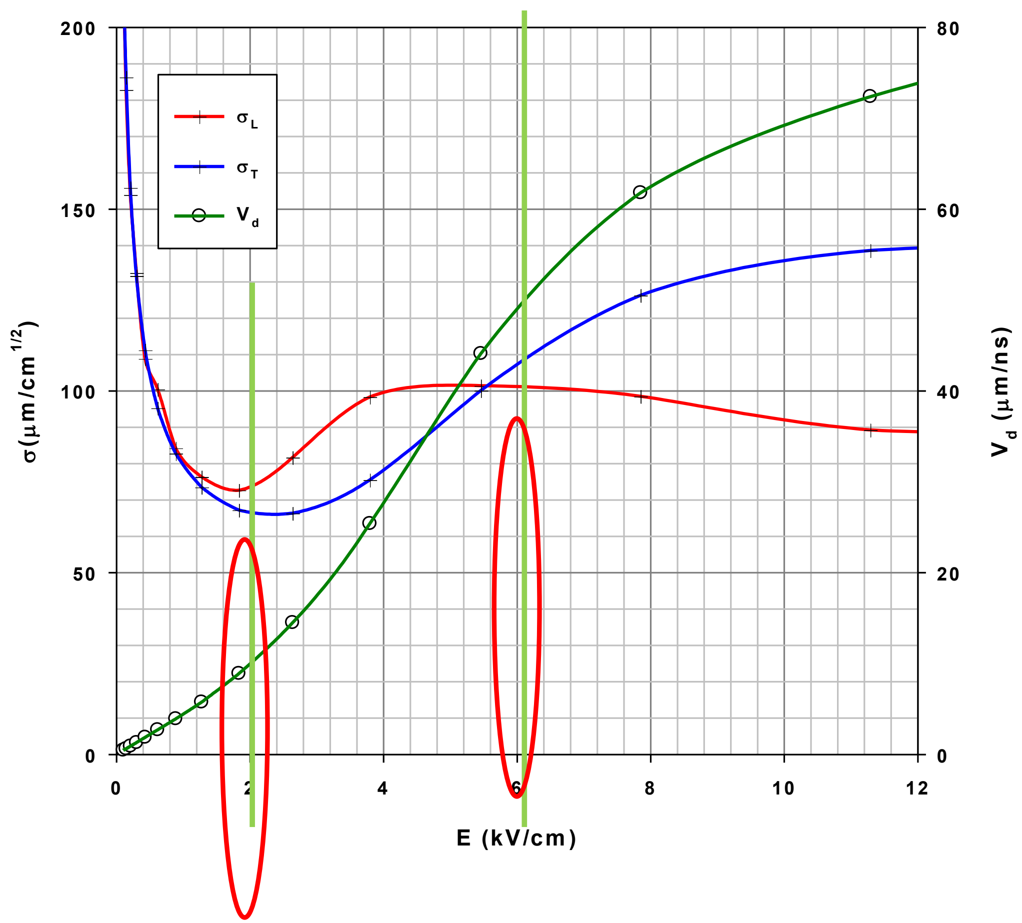



Nikhef
detector R&D
MUROS 2.1
Medipix Interface
NIKHEF

Chamber gas: DME/CO_2 50/50
Garfield simulations

- DME/CO_2 50/50
  - Very slow and "cool" gas
  - High drift field required
  - Very low diffusion
  - Suited for TPC
- Drift fields used in Gossips
  - **2 kV/cm** (lowest diffusion)
  - **6 kV/cm** (Vd = 50 µm/ns)
    - LHC tracking

Calculated diffusion (σ) and drift velocity (V_d)of DME/CO_2 50/50 vs electrical field (E)



- In total 60 runs containing ~250k events
- Almost all done with DME/CO_2 50/50 and 150 GeV muons
- Last 4 runs with Ar/iC_4H_{10} 80/20
  - 46k events
  - ~3k of them were hadrons

Run overview Gossip beam test August 2010

run#	start time	start date	# of event	Vg1	Vg2	Vg3	Vg4	Vf Gossip	Vguard	Vf DICE	α1	α2	α3	α4	gas	Analysed?	
1	19:41	12-8	273	580	580	580	500	780	540	2000	45	0	45	45	DME/CO2		
2		12-8	1696	580	580	580	500	780	540	2000	45	0	45	45	DME/CO2		
3		12-8	654	580	580	580	500	780	540	2000	0	0	0	0	DME/CO2		
4		13-8	1463	580	580	580	500	780	540	2000	0	0	0	0	DME/CO2		
5		13-8	1023	580	580	580	500	780	540	2000	0	0	0	0	DME/CO2		from ev 322 tests beam tuning
6		13-8	1024	600	600	600	530	800	630	4390	0	0	0	0	DME/CO2	X	
7		13-8	788	450	450	450	450	650	600	4310	45	45	45	45	DME/CO2		run in TOT mode
8		13-8	1340	450	450	450	450	650	600	4310	45	45	45	45	DME/CO2	X	
9		13-8	773	450	450	450	450	650	600	4310	45	45	45	45	DME/CO2		
10		13-8	714	470	470	470	470	670	620	4330	45	45	45	45	DME/CO2		run in TOT mode
11		13-8	1026	470	470	470	470	670	620	4330	45	45	45	45	DME/CO2	X	
12		13-8	4026	470	470	470	470	670	620	4330	45	45	45	45	DME/CO2		
13		14-8	770	490	490	490	490	690	640	4350	45	45	45	45	DME/CO2		repair timing + rot. DICE, TOT
14		14-8	1022	490	490	490	490	690	640	4350	45	45	45	45	DME/CO2	X	
15		14-8	1017	490	490	490	490	690	640	4350	45	45	45	45	DME/CO2		
16		14-8	741	510	510	510	510	710	660	4370	45	45	45	45	DME/CO2		run in TOT mode
17		14-8	1612	510	510	510	510	710	660	4370	45	45	45	45	DME/CO2	X	
18	14:19	14-8	1388	510	510	510	510	710	660	4370	45	45	45	45	DME/CO2		peak at 90 ns hopefully cured
19		14-8		530	530	530	520	730	670	4380	45	45	45	45	DME/CO2		run in TOT mode
20	17:40	14-8	4362	530	530	530	520	730	670	4380	45	45	45	45	DME/CO2	X	
21		14-8		550	550	550	530	750	680	4390	45	45	45	45	DME/CO2		run in TOT mode
22	20:28	14-8	2188	550	550	550	530	750	680	4390	45	45	45	45	DME/CO2	X	
23		14-8		570	570	570	530	770	680	4390	45	45	45	45	DME/CO2		run in TOT mode
24	22:12	14-8	2059	570	570	570	530	770	680	4390	45	45	45	45	DME/CO2	X	
25	23:27	14-8	17728	590	590	590	530	790	680	4390	45	45	45	45	DME/CO2	X	Run overnight until 8:06
26	10:32	15-8	339	590	590	590	530	790	680	4390	45	45	45	45	DME/CO2		run in TOT mode
27	10:55	15-8	348	600	600	600	540	800	690	4440	45	45	45	45	DME/CO2		run in TOT mode
28	12:19	15-8	2275	600	600	600	540	800	690	4440	45	45	45	45	DME/CO2	X	
29	14:52	15-8	2192	610	610	610	550	810	700	4450	45	45	45	45	DME/CO2	X	
30		15-8	824	610	610	610	550	810	700	4450	45	45	45	45	DME/CO2		run in TOT mode
31		15-8	694	620	620	620	560	820	710	4420	45	45	45	45	DME/CO2		run in TOT mode
32	19:40	15-8	2251	620	620	620	560	820	710	4420	45	45	45	45	DME/CO2	X	
33		15-8	2898	620	620	620	560	1220	710	4420	45	45	45	45	DME/CO2	X	
34		15-8	4270	620	620	620	560	1220	710	4420	10	45	10	10	DME/CO2		
35		16-8	5839	620	620	620	560	820	710	4420	10	45	10	10	DME/CO2		DICE trip
36		16-8	4015	620	620	620	560	820	710	4420	10	0	10	10	DME/CO2	X	
37		16-8	4596	620	620	620	560	1220	710	4420	10	0	10	10	DME/CO2	X	
38		16-8	4569	620	620	620	560	1220	710	4420	10	5.75	10	10	DME/CO2	X	
39		16-8	17919	620	620	620	560=> 550	820	710	4420	10	5.75	10	10	DME/CO2		DICE trip problems
40		16-8?	4084	620	620	620	520	1220	670	4380	10	11.5	10	10	DME/CO2		DICE reduced after trips
41		17-8	4306	620	620	620	530	820	680	4390	10	11.5	10	10	DME/CO2		broad beam, low intensity
42		17-8	5001	620	620	620	540	820	690	4390?	10	23	10	10	DME/CO2		~ 10x more particles
43		17-8	5307	620	620	620	540	1220	690	4440	10	23	10	10	DME/CO2		
44		17-8	30855	620	620	620	540	820	690	4440	0	0	0	90	DME/CO2	X	
45		18-8	6442	620	620	620	540	820	690	4440	0	0	0	90	DME/CO2	X	gasflow to 65 ml/min
46		18-8	7097	620	620	620	540	820	690	4440	0	0	0	90	DME/CO2	X	lower thresh. DICE
47		18-8	1940	620	620	620	540	820	690	4440	0	0	0	10	DME/CO2		Vf of pos2 at 0V
48		19-8	9854	620	620	620	540	820	690	4440	0	45	0	10	DME/CO2		Vf of pos2 at 0V
49		19-8	8358	620	620	620	540	820	690	4440	0	45	45	10	DME/CO2		Vf of pos2 at 0V
50	11:44	20-8	4440	620	620	620	540	820	690	4440	45	45	45	0	DME/CO2		Vf of pos2 at 0V
51	14:50	20-8	2410	620	0	620	540	820	690	4440	45	45	45	0	DME/CO2		PillarPix dead, P3 sparky
52	16:26	20-8	292	620	0	620	540	820	690	4440	45	45	45	0	DME/CO2		Hadr.;SCXA:106;306=>092;366
53	16:38	20-8	3832	620	0	620	540	820	690	4440	45	45	45	0	DME/CO2		Hadrons, no field on P3 and P2
54	18:07	20-8	2744	620	0	620	540	820	690	4440	45	45	45	0	DME/CO2		sheet missing
55	11:27	21-8	3381	620	620	620	540	820	690	4440	0	0	0	10	DME/CO2		
56	12:48	21-8	5314	620	620	620	540	570	450	3245	0	90	0	10	DME/CO2		SC2 5.5 to PC, SC1 2.5 oppos.
57	18:19	21-8	634	420	420	420	350	570	450	3245	0	0	0	10	Ar/iC4H10		150 GeV hadrons
58	18:32	21-8	4314	420	420	420	350	570	450	3245	0	0	0	10	Ar/iC4H10		Hadrons => muons
59	19:50	21-8	34348	420	420	420	350	570	450	3245	0	0	0	10	Ar/iC4H10		
60	9:30	22-8	11804	420	420	420	350	570	450	3245	0	11.5	0	10	Ar/iC4H10		

Time walk leading to excessive arrival times

- Rising edge effect: up to 50 ns delay
- Discriminator overdrive
  - Certain charge >0 is needed to let the discriminator fire

Hundreds of ns time walk possible