n-XYTER for diamond detectors

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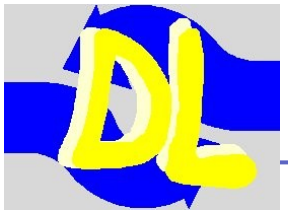


n-XYTER: The DETNI Neutron Detector Readout ASIC

GSI

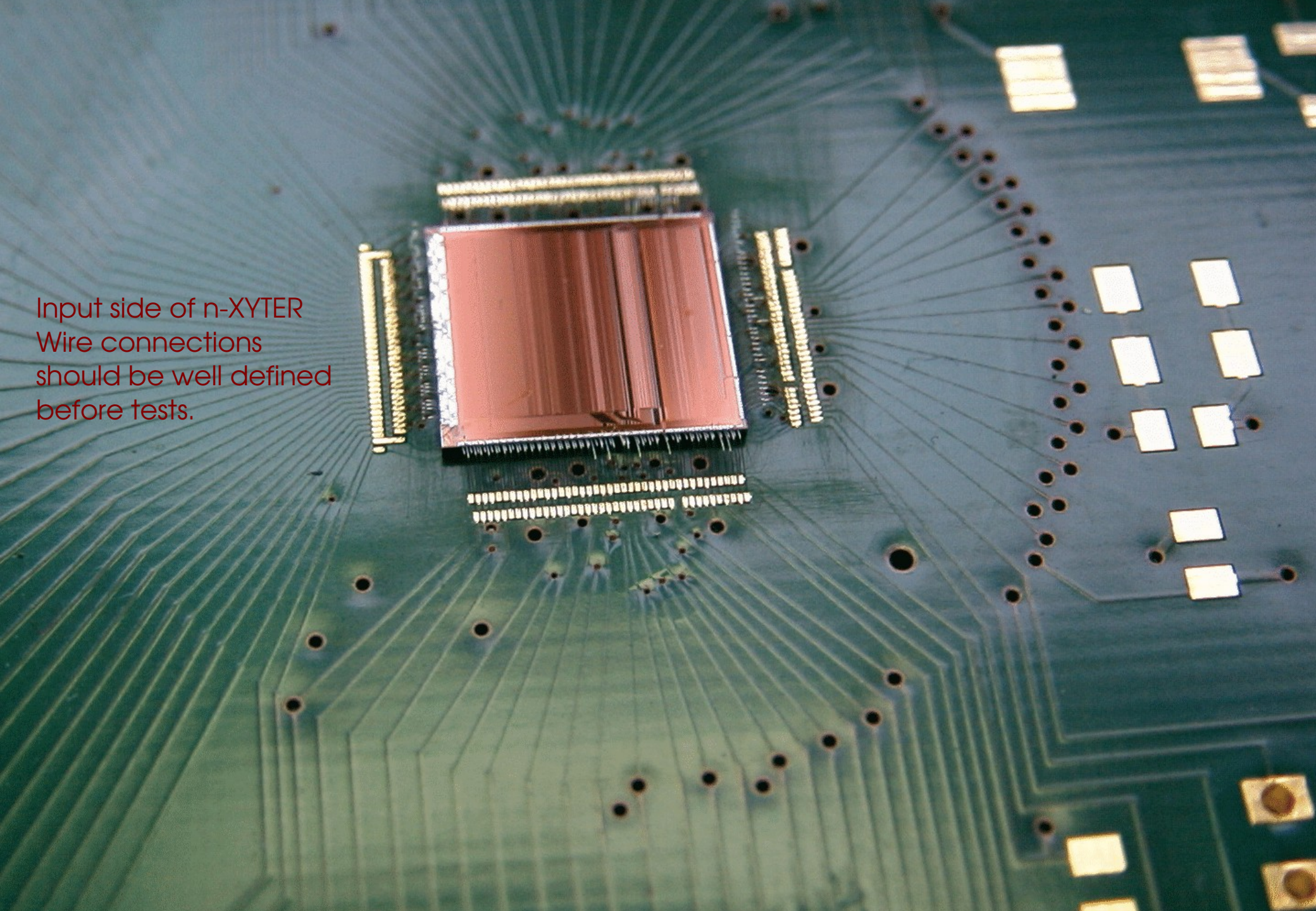
Neutron – X, Y, Time and Energy ... R

Front-End:

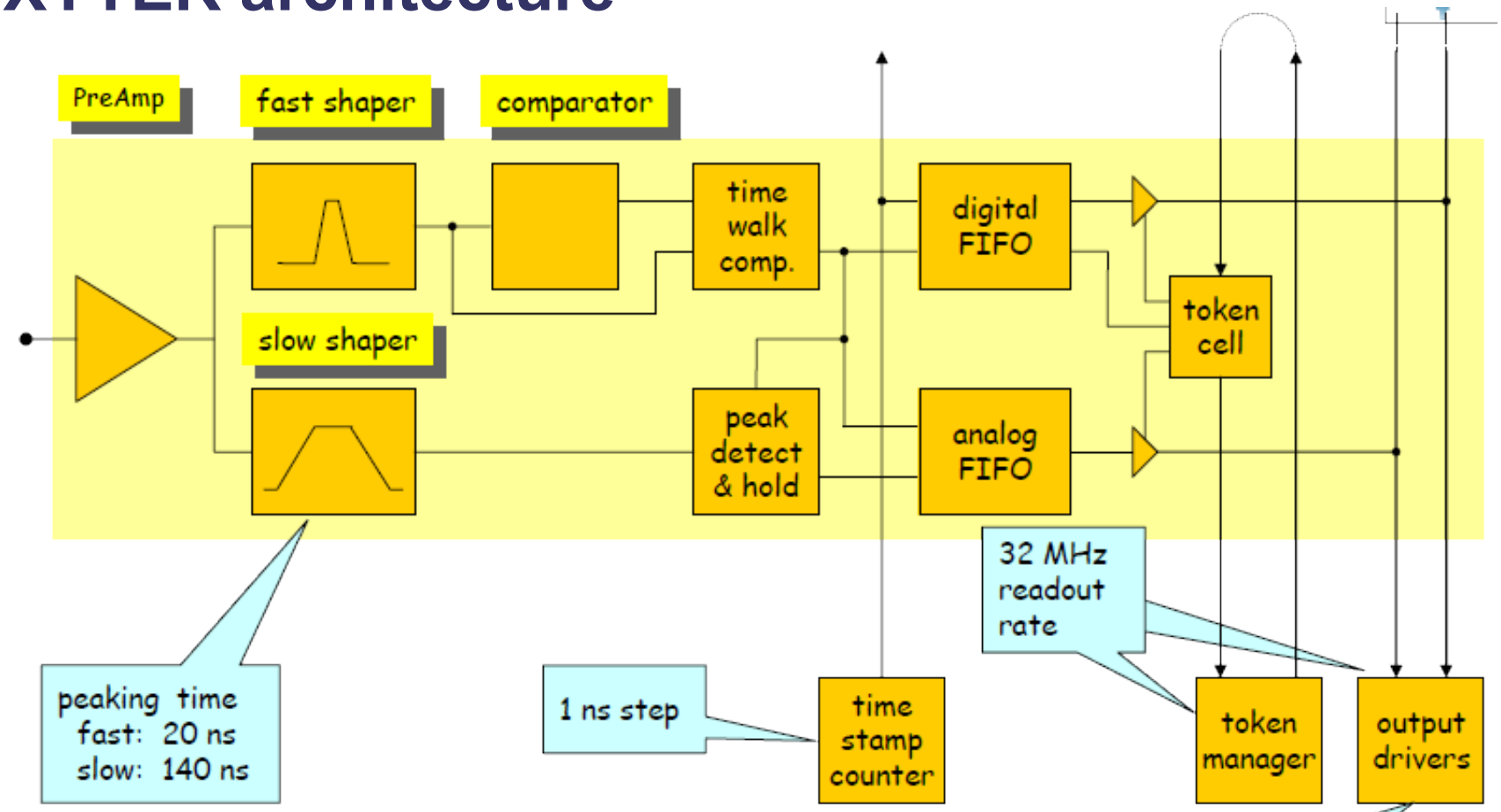
- 128 channels
- Ready for different popular input signals
- Charge sensitive pre-amp and peak detector
- Time stamping with 1ns LSB and 2ns resolution
- Peak detection and analogue storage (10 bit electronic storage)
- Purely data driven, autonomous hit detection (self triggered)
- Average per channel hit rate 160 kHz with 10% dead time
  (determined by pile up on slow channel)

Readout:

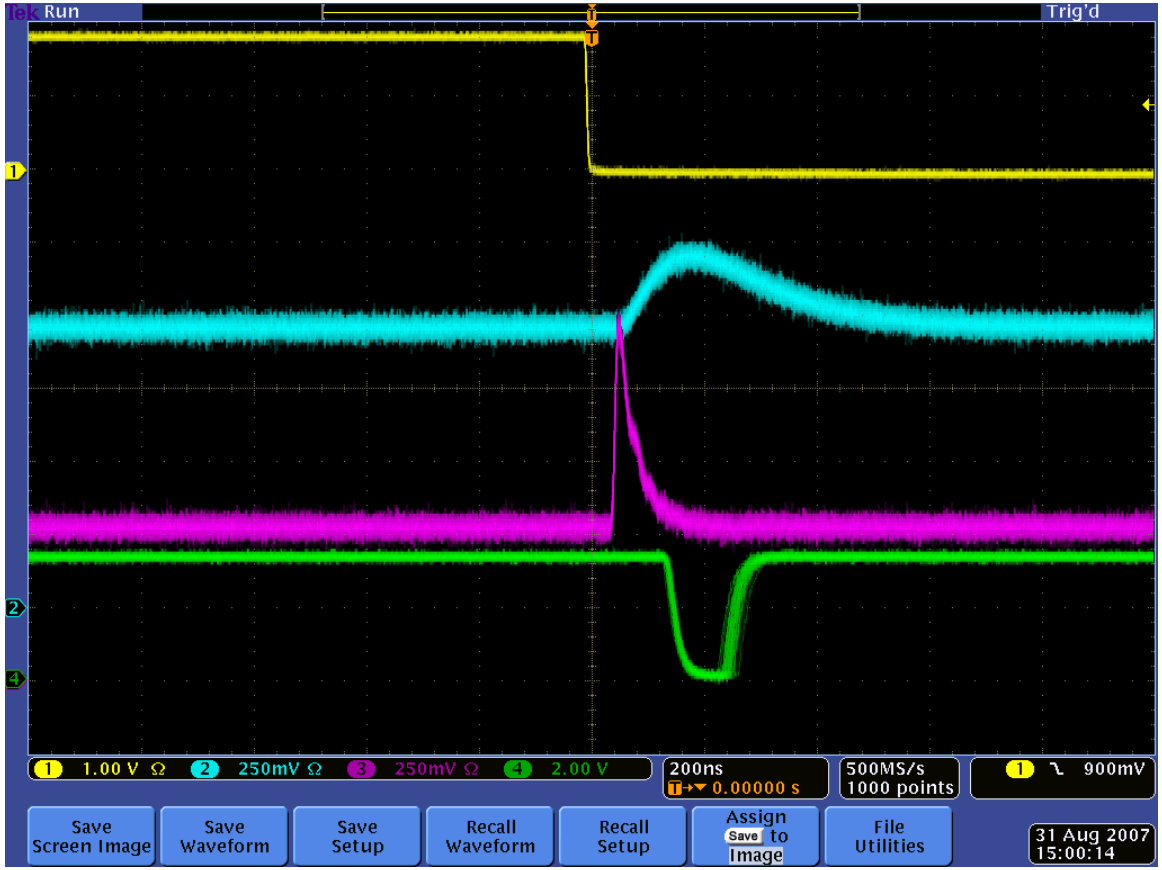
- Per channel analogue energy and digital timestamp FIFO (1ns res.)
- De-randomizing, specifying Token Ring readout at 32 MHz


Input side of n-XYTER
Wire connections
should be well defined
before tests.

n-XYTER architecture



Analogue Signal Sequence (Test channel)



Trigger pulse

Slow channel

Fast channel

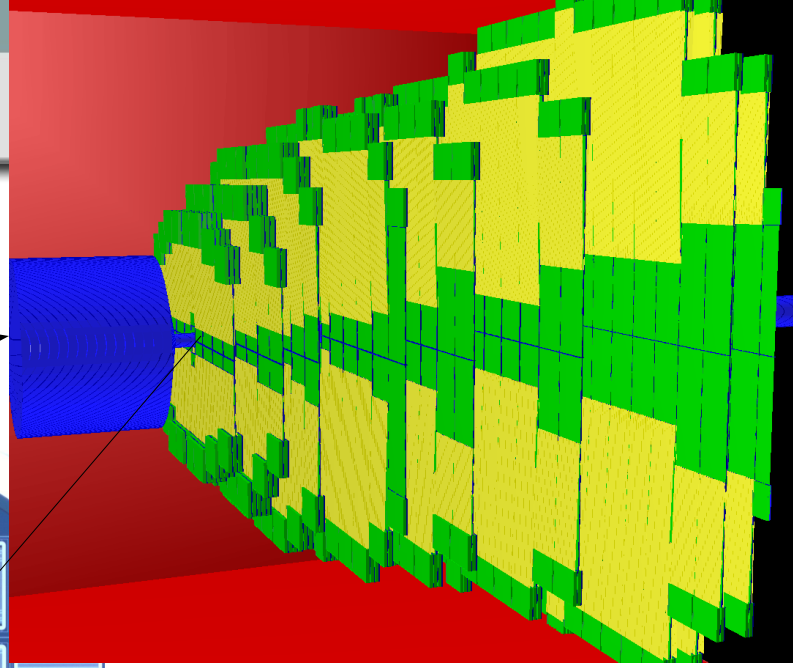
Comparator output

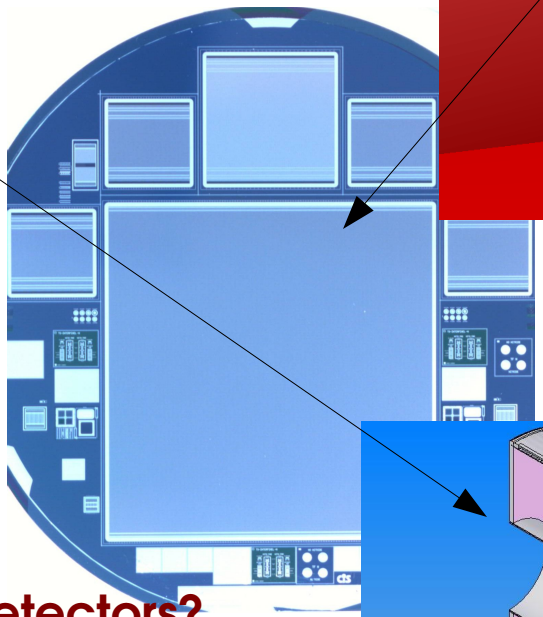
It really works!

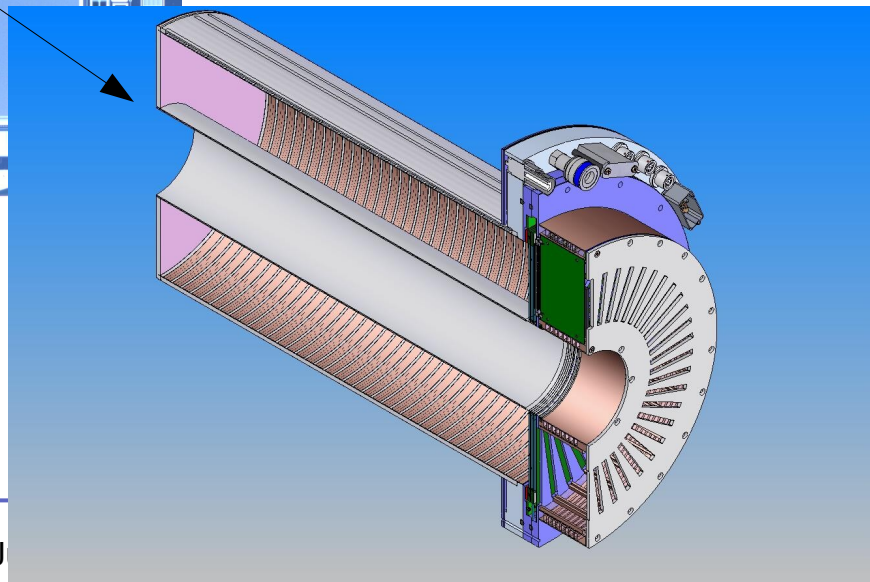
General Purpose

n-XYTER is designed to use for neutron measurements, but also can be used with:

- Silicon strip detectors (STS)
- Gas detectors (GEM-TPC)
- Other applications







Do we can use n-XYTER for Single- and PolyCrystal Diamond Detectors?

Lets investigate it!

Questions and input data

N-XYTER is designed for 30 pF input (detector) capacitance. DD give us the order of 1 pF.

Questions are:

- signal response for so low capacitance
- noise
- Discrimination Time and TimeWalk

Tested DD has pixel configuration and 5x5 mm of total area (3 pF):

- 9 pixels 1.67x1.67 mm, 0.33 pF each pixel
- 16 pixels 1.25x1.25 mm, 0.187 pF each pixel

Simulations

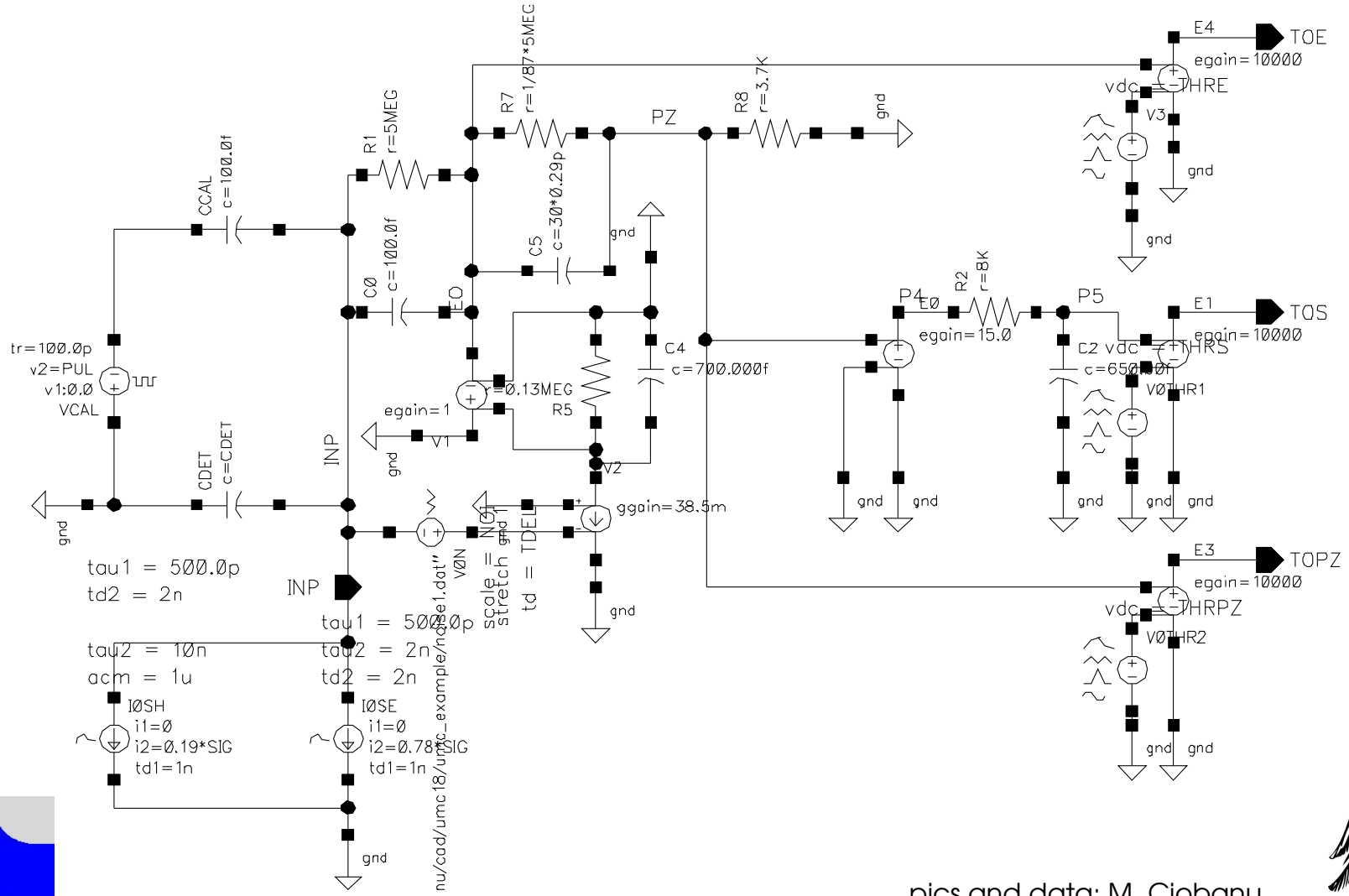
Simulation model of n-XYTER exist. It is very good approximation to real electrical model.

Simulations have been done by Mircea Ciobanu.

Simulations include:

- Simulation model of n-XYTER
- Noise source
- Simulation model of detector.

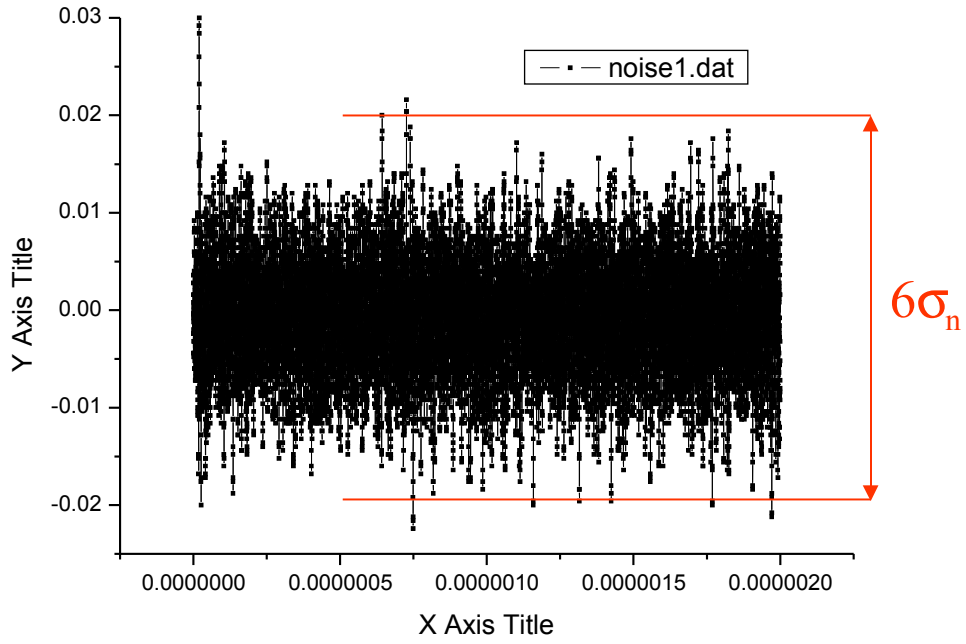
Simulation model od n-XYTER

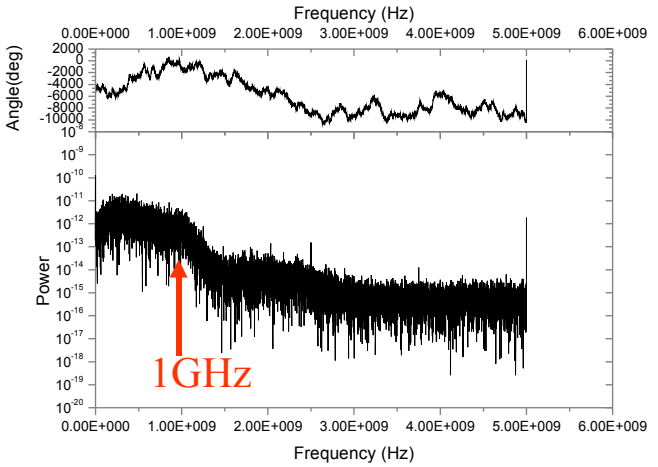


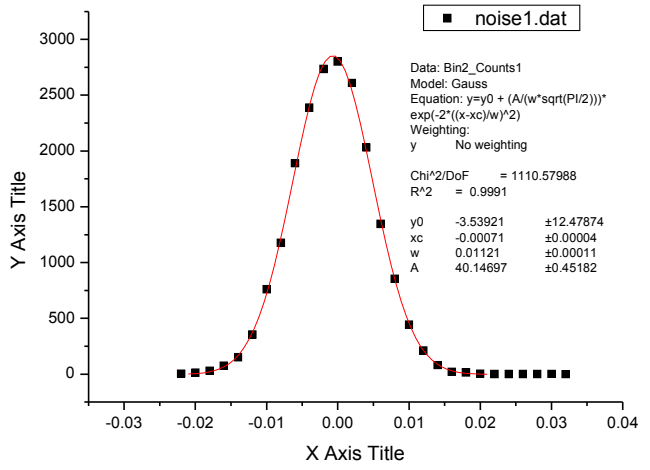
pics and data: M. Ciobanu

Noise parameters

Noise model used in simulations.







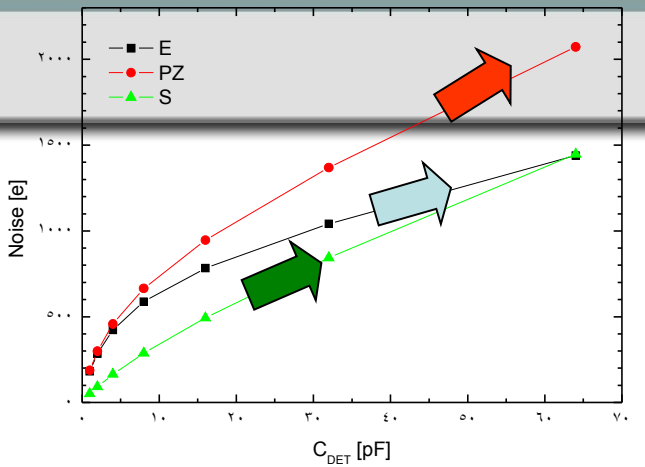
pics and data: M. Ciobanu

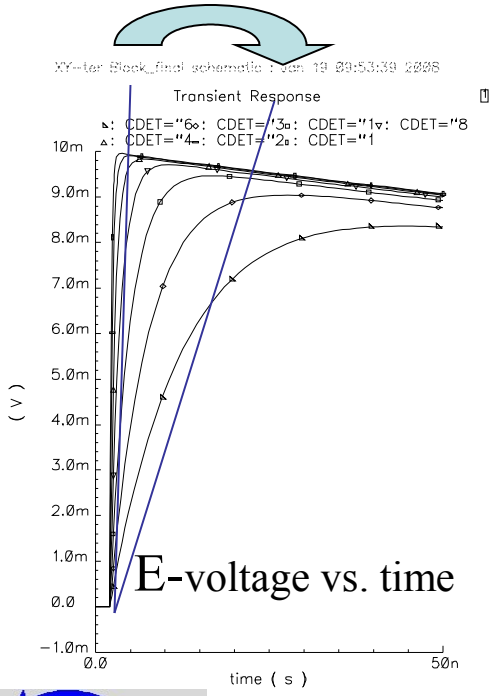
$\sigma_n = 5.65\ mV_{RMS}$

Step Pulse Response

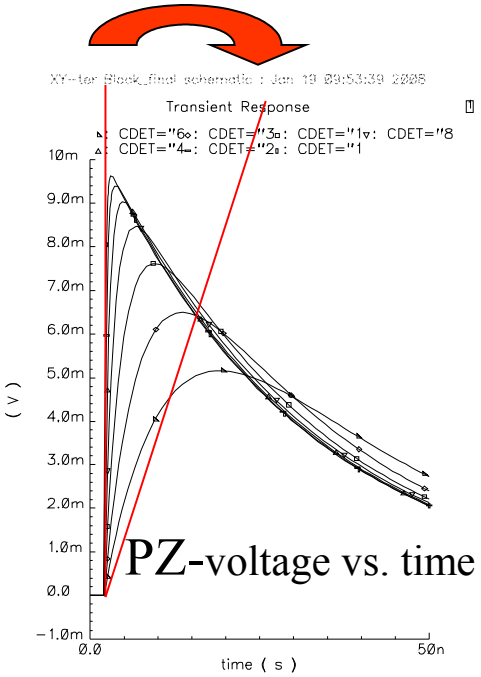
- 1 fC Step Pulse response
- C_{DET} = 1, 2, 4, 8, 16, 32, 64 pF

Noise

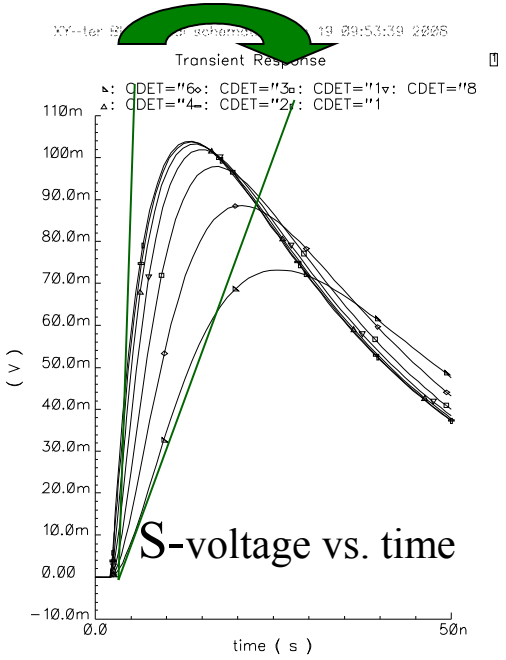




E-voltage vs. time



PZ-voltage vs. time

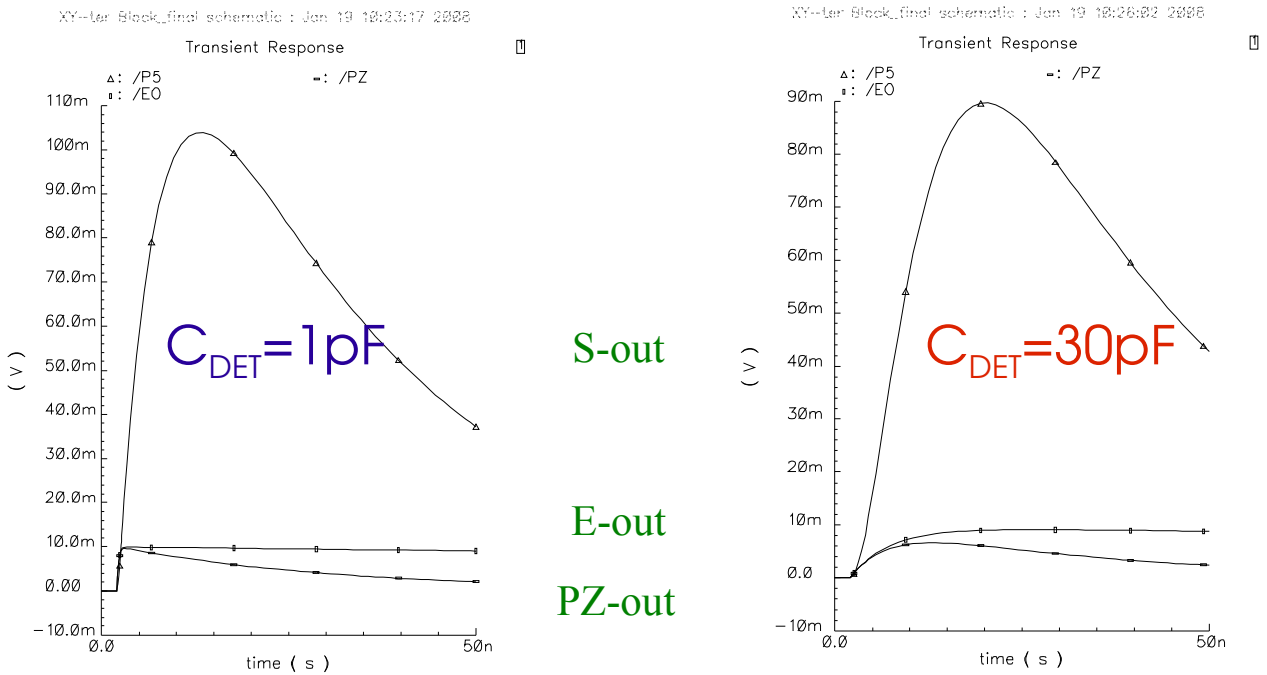


S-voltage vs. time

pics and data: M. Ciobanu

Step Pulse Response

	Sensitiv. (mV/fC)		t_{PK} (ns)		t_R (ns)		Slope (V/µs)	
E-out	9.95	9.09	1.49	24.5	0.5	10.2	16.3	0.71
PZ-out	9.63	6.61	1.03	11.4	0.44	6.2	17.6	0.88
S-out	103.9	89.67	11.6	18.3	6.1	10	13.8	7.4

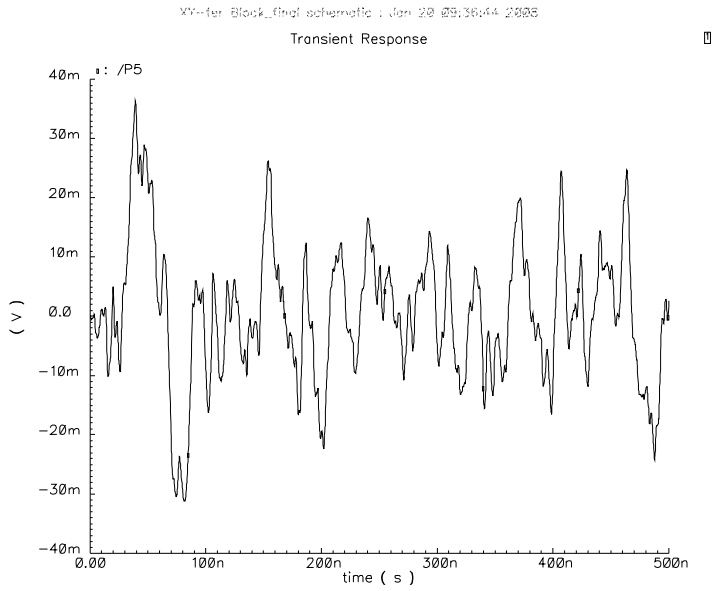


1 fC Step Pulse response

pics and data: M. Ciobanu

Electrical noise

Adjust input serial noise as to obtain shaper equivalent output noise of 800 ENC corresponding to n-XYTER performance.



1pF	Sensitiv. (mV/fC)	Noise (500ns) (mV_{RMS})	(e)	Slope (V/µs)	σ_T (ps)
E-out	9.95	0.290	**182**	16.3	**18**
PZ-out	9.63	0.289	**188**	17.6	**17**
S-out	103.9	0.856	**52**	13.8	**62**

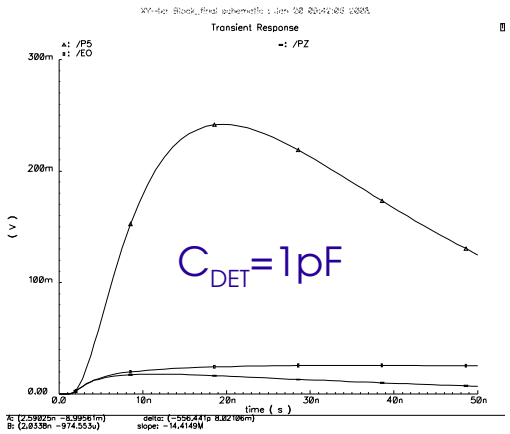
30pF	Sensitiv. (mV/fC)	Noise (500ns) (mV_{RMS})	(e)	Slope (V/µs)	σ_T (ps)
E-out	9.09	1.472	**1012**	0.711	**2070**
PZ-out	6.61	1.396	**1320**	876	**1590**
S-out	89.7	11.49	**800**	7.11	**1640**

1 fC Step Pulse response

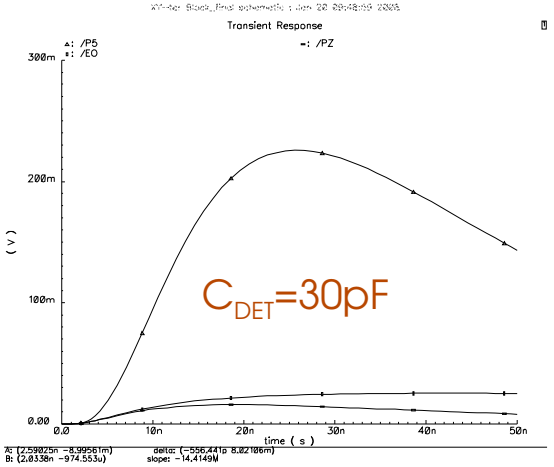
pics and data: M. Ciobanu

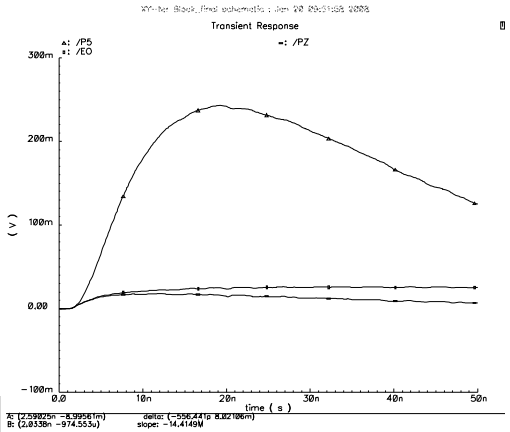
Electrical noise

The response to Si equivalent current generator (0.8 MIP)

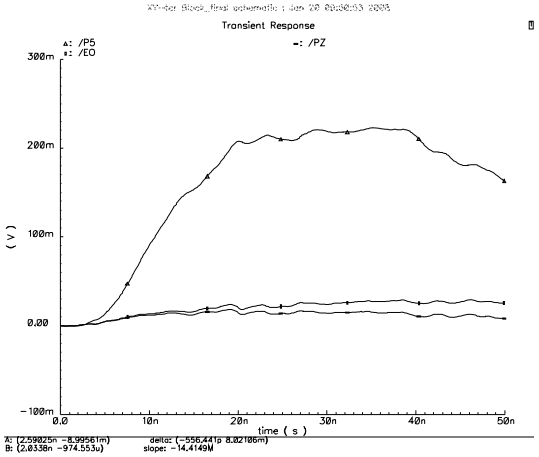


without noise





with noise



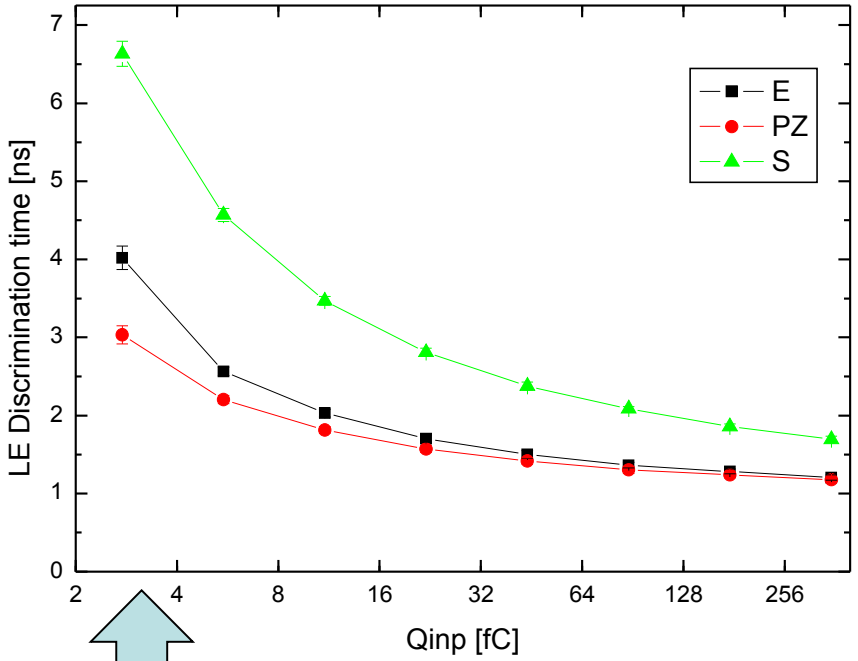
1 MIP = 22000 e (0.3mm Si) = ~ 3.5 fC

pics and data: M. Ciobanu

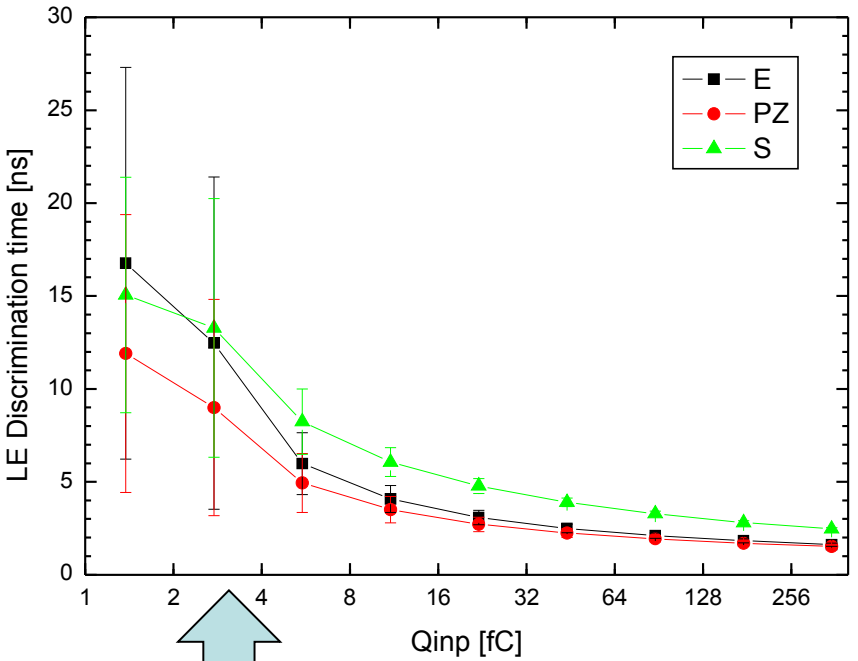
Discrimination Time

Discrimination time for two extreme cases: C_{det} = 1 pF and 30 pF

C_{det} = 1 pF



C_{det} = 30 pF



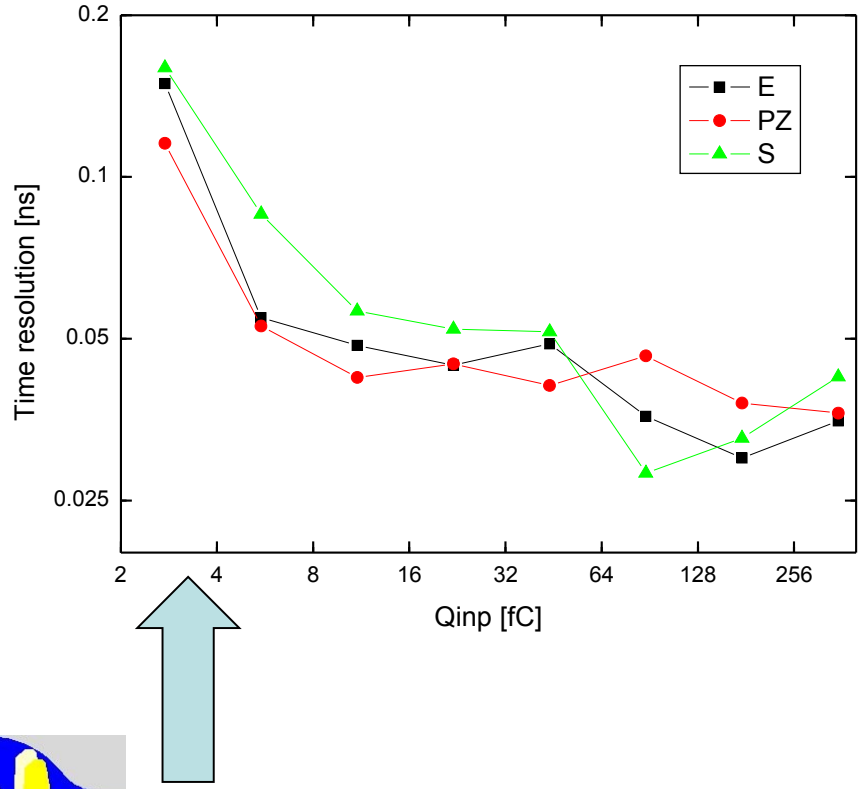
1 MIP = 22000 e (0.3mm Si) = ~ 3.5 fC

pics and data: M. Ciobanu

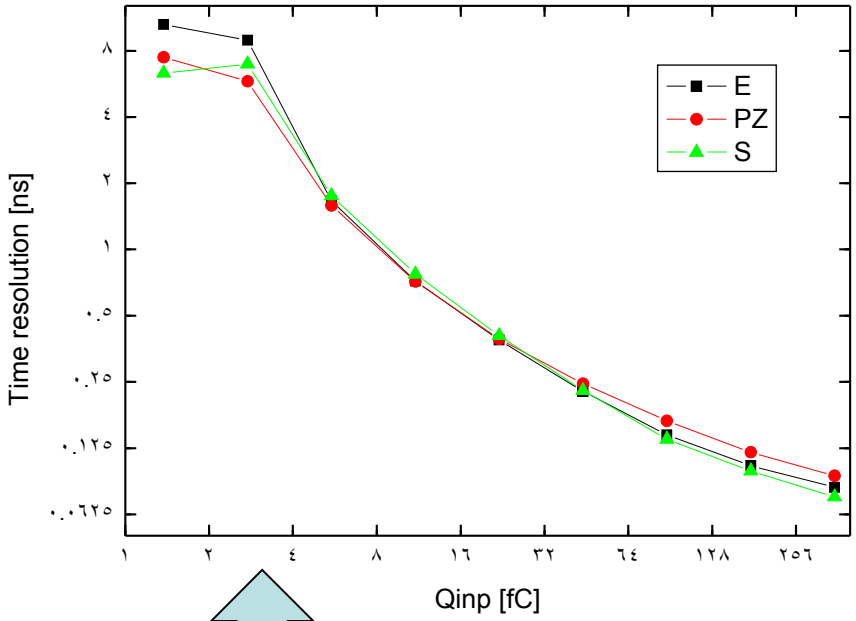
Time Walk

Time resolution for two extreme cases: C_{det} = 1pF and 30pF

C_{det} = 1 pF



C_{det} = 30 pF



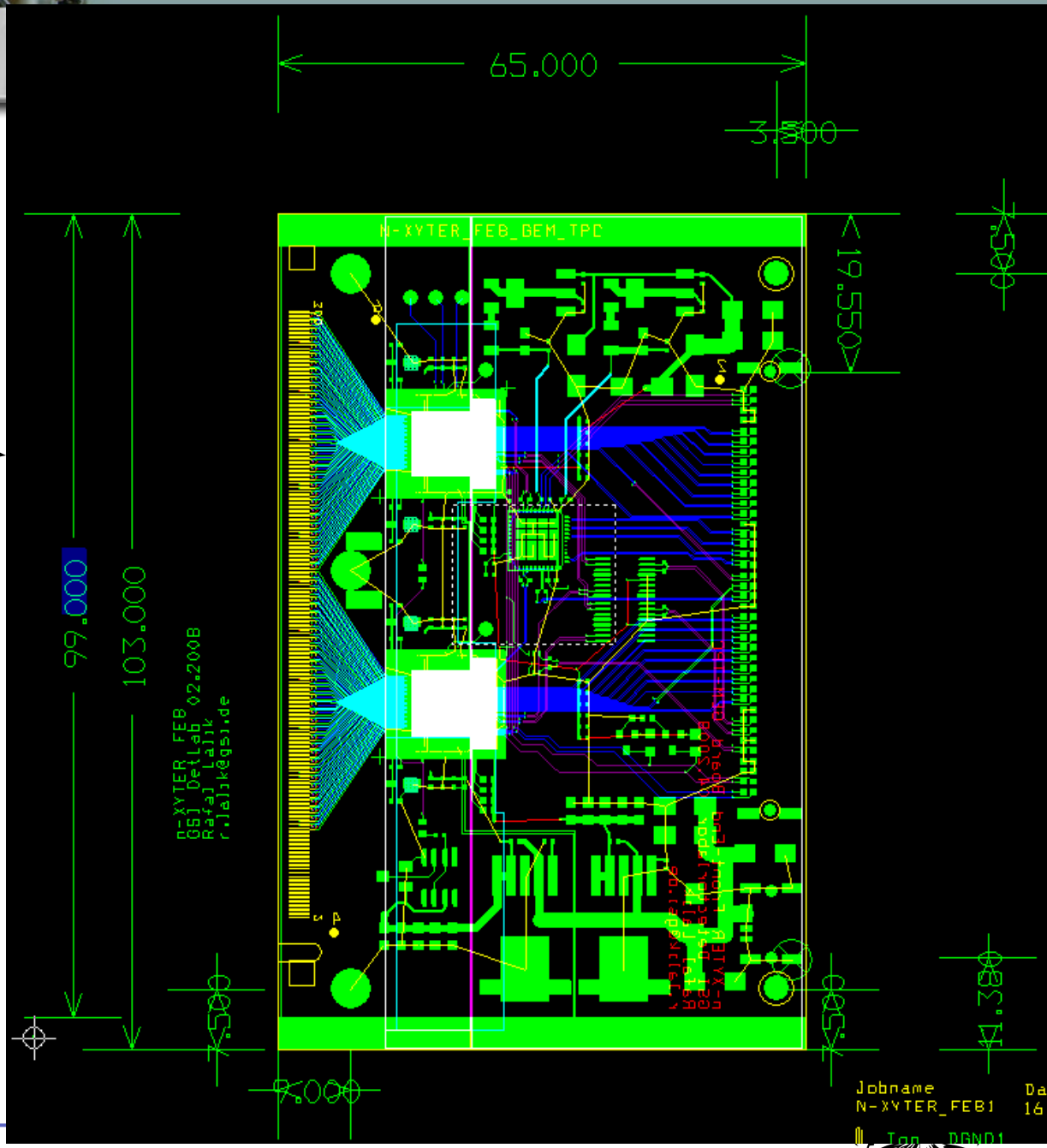
1 MIP = 22000 e (0.3mm Si) = ~ 3.5 fC

pics and data: M. Ciobanu

Future development

In next step we can start to do tests with existing/being developed n-XYTERs boards, ie.

n-XYTER GEM-TPC board.



Advantages:

- 2 n-XYTER chips on board.
- Very short connection (~10mm) on middle channels – low input capacitance!
- ADC (10 or 12-bits) on board.
- Existing ROC – we can automate the measurements process.

Conclusions

- Simulations works and gives us very interesting informations about data proceedings on the n-XYTER chip. Simulation model doesn't match exactly to n-XYTER electrical schematic – but is very good approximation.
- Simulated noise on fast shaper output is 52 EMC (for 1 MIPS input signal and 1 pF detector capacidance) – excelent S/N ratio!
- Signal processing is very fast – of the order of few ns.
- It looks like n-XYTER is very good readout chip for Diamond Detectors, maybe even better than for Silicon Detectors ;-)

- Beware! It is very important to keep total input capacitance (pixel+connection cables) lower than 1 pF – for 16 pixels detector (5x5 mm) suggested is 0.8 pF of total input capacidance.

Contact

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- Mircea Ciobanu
  GSI Darmstadt - Detectorlabor
  M.Ciobanu@gsi.de

References

- Mircea Ciobanu
  Is a Shaper Amplifier needed in the time branch after a CSA?

Questiontime

Thank you for your attention.