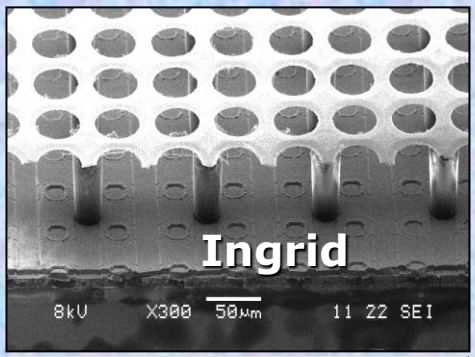
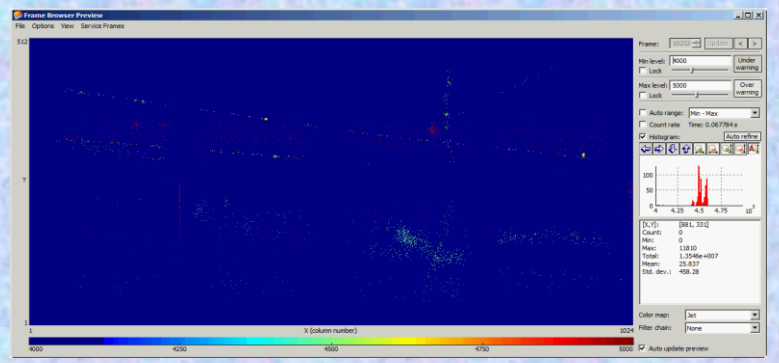
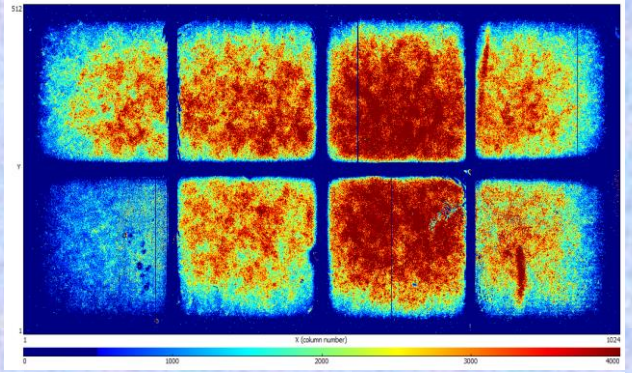
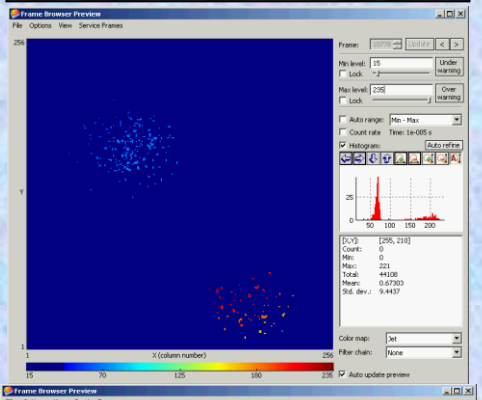
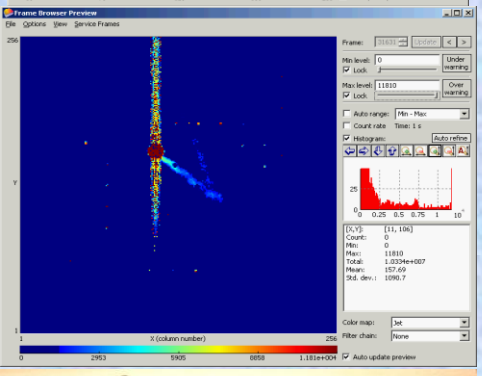










Pixel Readout for the ILC TPC in the Framework of the RD51

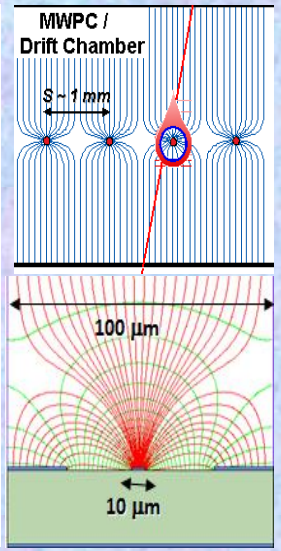
Maxim Titov
CEA Saclay, France

- University of Bonn: Y. Bilevych, C. Brezina, K. Desch, J. Kaminski, T. Krautscheid, C. Krieger, M. Lupberger
- NIKHEF: Jan Timmermann
- CEA Saclay: David Attie, Xavier Coppolani, Andrii Chaus, Paul Colas, Maxim Titov
- LAL Orsay (S. Barsuk)
- Kyiv University (O. Bezshyyko group)

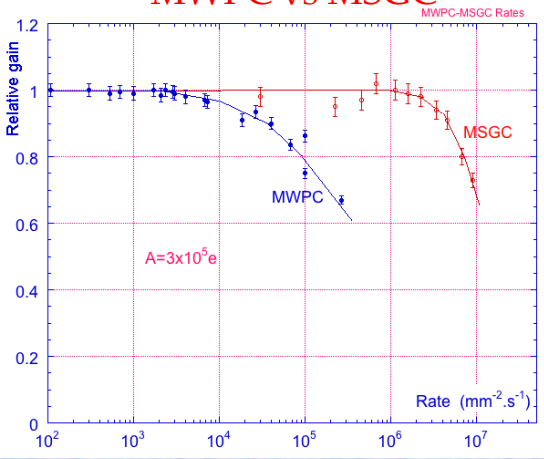
PICS Meeting (TESHEP School), Lvov, Ukraine, July 21, 2014

Micro-Pattern Gaseous Detector Technologies for Future Physics Projects

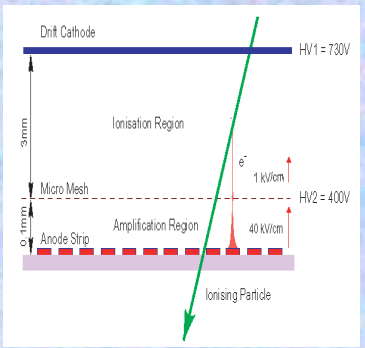
- Micromegas
- GEM
- Thick-GEM, Hole-Type and RETGEM
- MPDG with CMOS pixel ASICs ("InGrid")
- Micro-Pixel Chamber (µPIC)



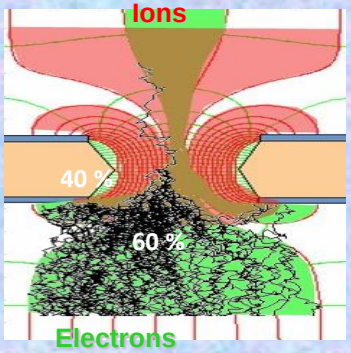
Rate Capability: MWPC vs MSGC



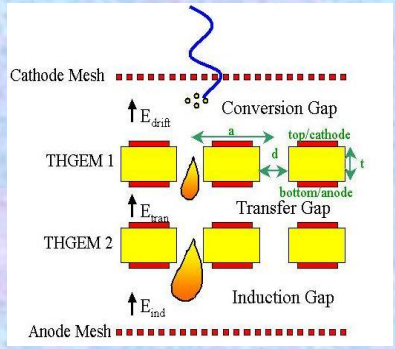
Micromegas



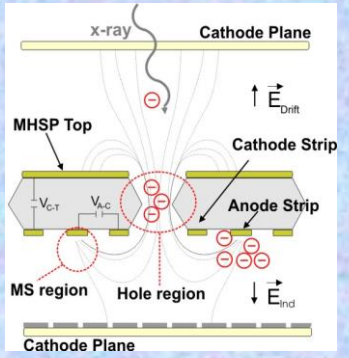
GEM



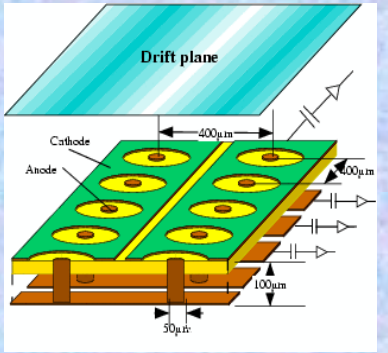
THGEM

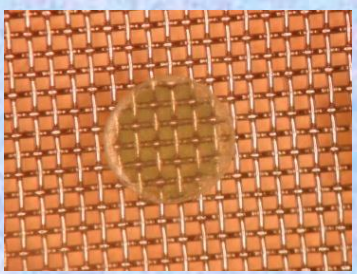


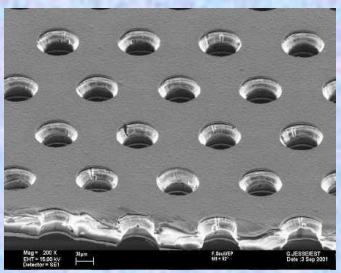
MHSP

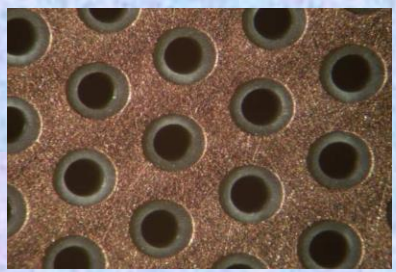


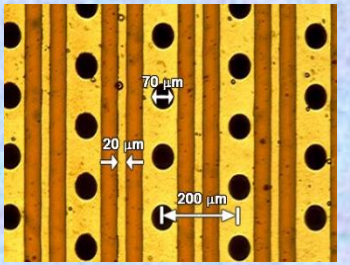
µPIC

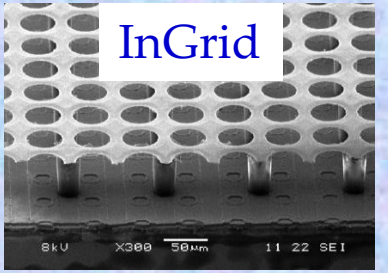






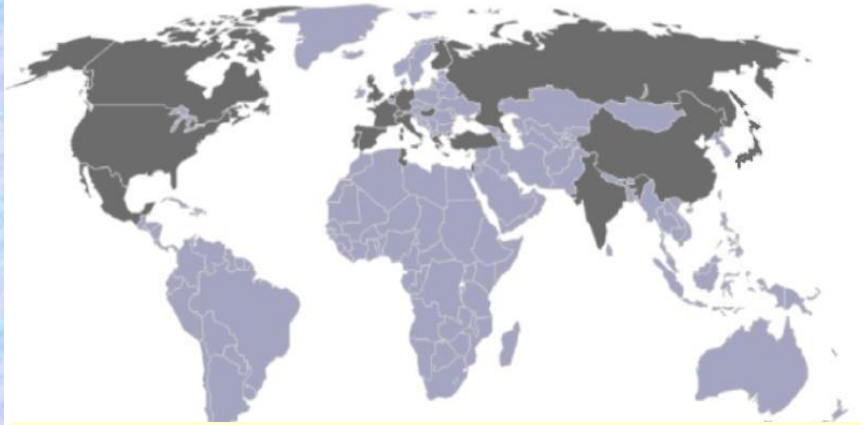






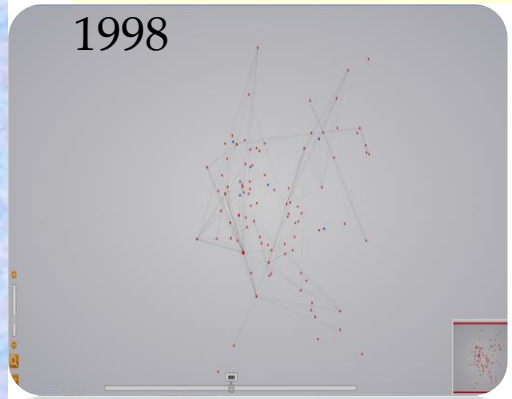
RD51 – Development of Micro-Pattern Gaseous Detector Technologies

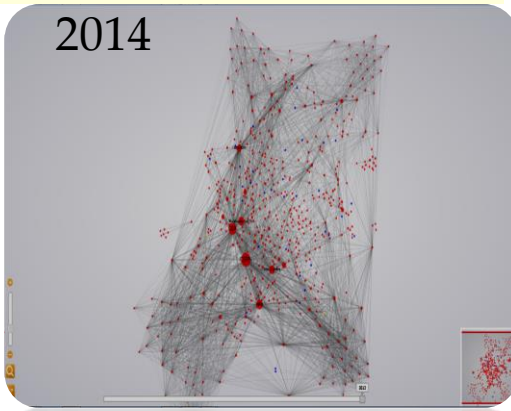
The main objective is to advance MPGD technological development and associated electronic-readout systems, for applications in basic and applied research"



http://rd51-public.web.cern.ch/rd51-public

A fundamental boost is offered by RD51: from isolate MPGD developers to a world-wide net

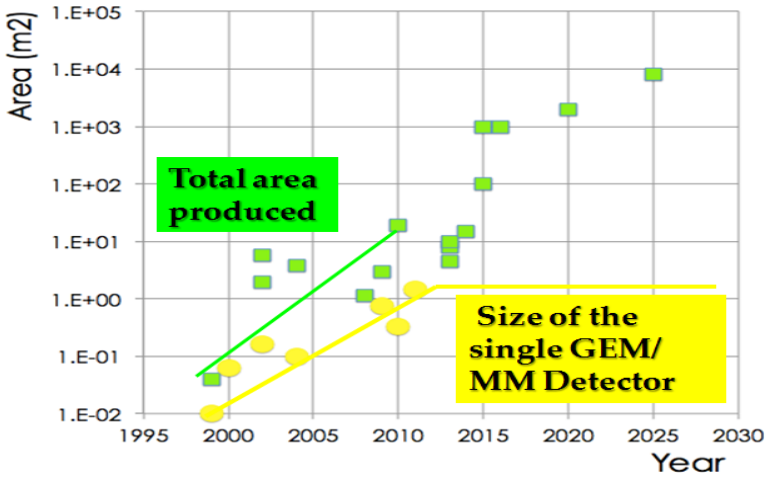




World-wide Collaboration for the MPGD Developments →
RD51 (91 institute, > 500 people):

- Large Scale R&D program to *advance MPGD Technologies*
- Access to *the MPGD "know- how"*
- Foster *Industrial Production*

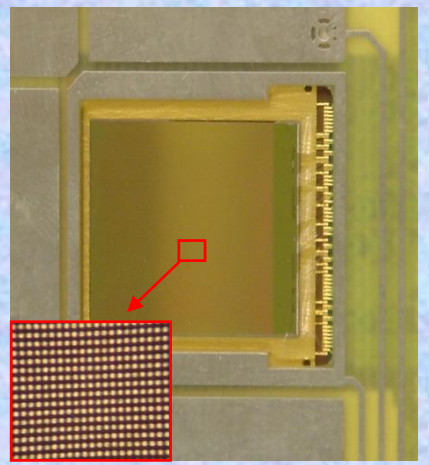
Advances in photolithography →
Large Area MPGDs (~ m^2 unit size)



Integrated Electronics: Pixel Readout of Micro-Pattern Gas Detectors

3D Gaseous Pixel Detector → 2D (CMOS pixel chip readout) x 1D (drift time)

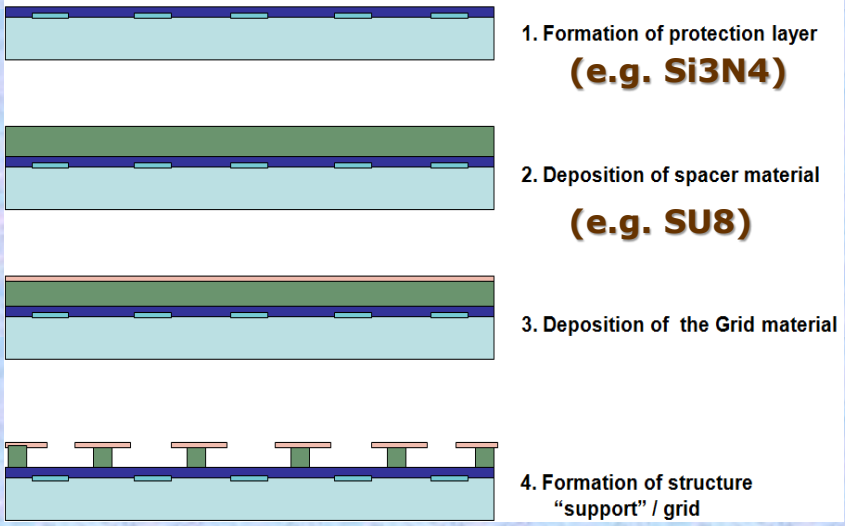
Bump bond pads for Si-pixel Detectors - Timepix or Medipix2 (256 × 256 pixels of size 55 × 55 μm2) serve as charge collection pads.

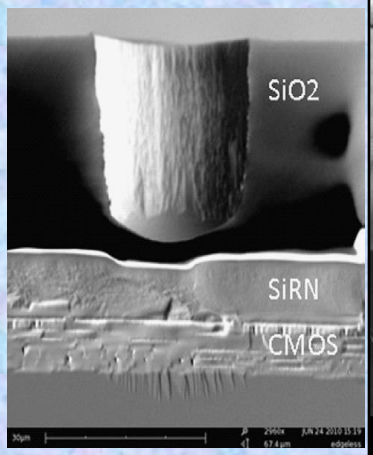


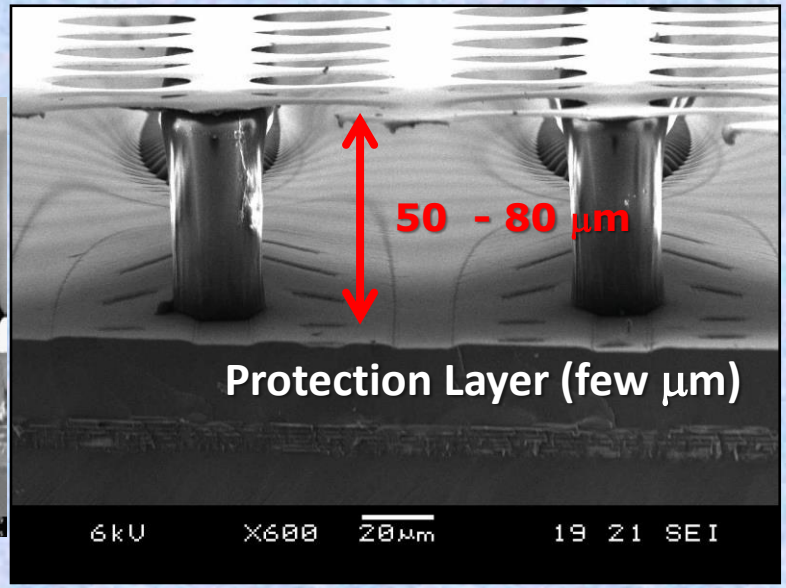
Each pixel can be set to:

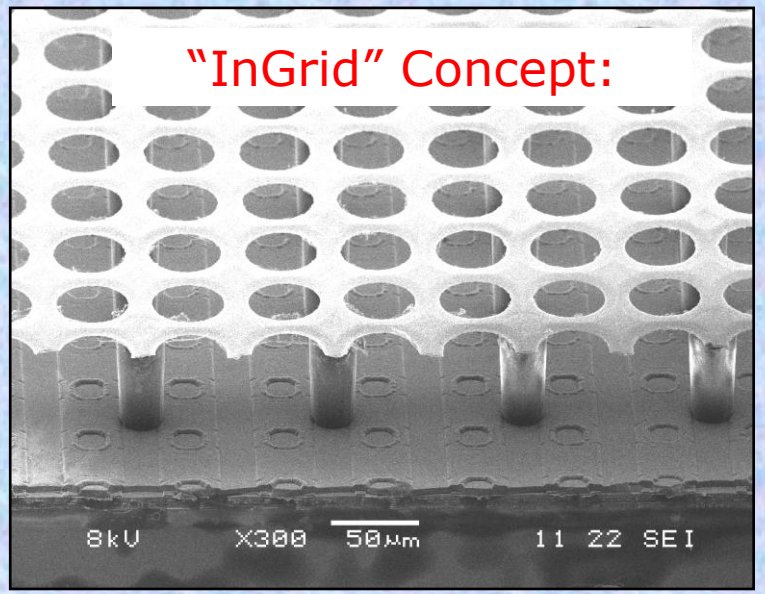
- TOT ≈ integrated charge
- TIME = Time between hit and shutter end

Through POST-PROCESSING INTEGRATE MICROMEGAS directly on top of CMOS chip

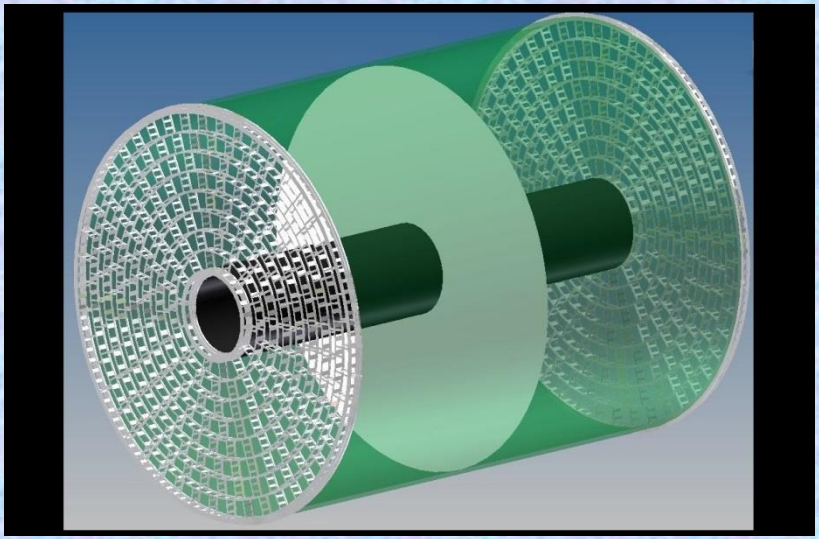








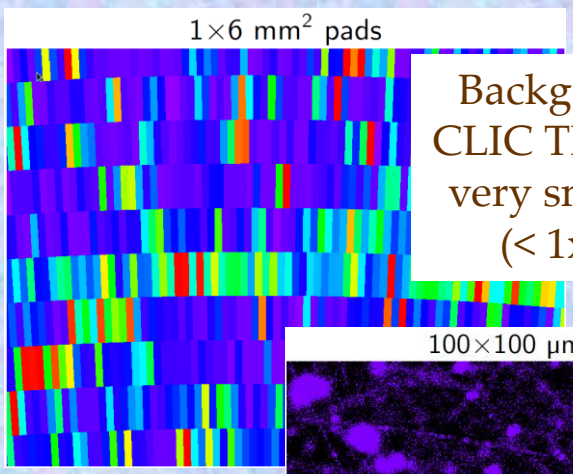
Pixel Readout for Time Projection Chamber at the ILC or CLIC



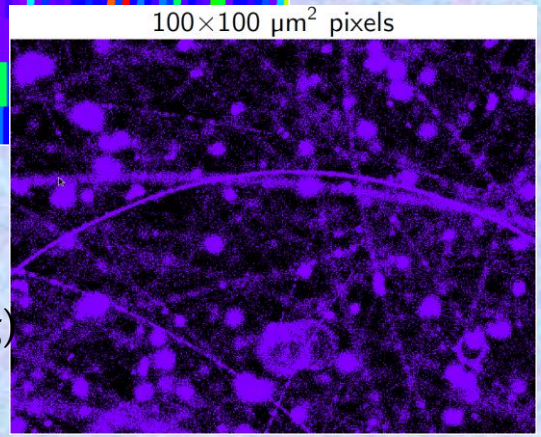
MPGDs are foreseen as TPC readout for ILC or CLIC (size of endcaps of ~ 10 m^2):

- Standard pads (1x 6 mm^2): 8 rows of detector modules (17×23 cm2); 240 modules per endcap
- Pixel (55x 55μm^2): ~100-120 chips per module

→ 25000-30000 per endcap



Backgrounds in CLIC TPC requires very small pixels (< 1x1 mm^2)



CLIC TPC Simulation (M. Killenberg)

Potential advantages of pixel TPC (55x 55μm^2):

→ very good point + momentum resolution

→ dE/dx via cluster counting

→ frontend electronics automatically integrated ('active endplate')

Potential concerns:

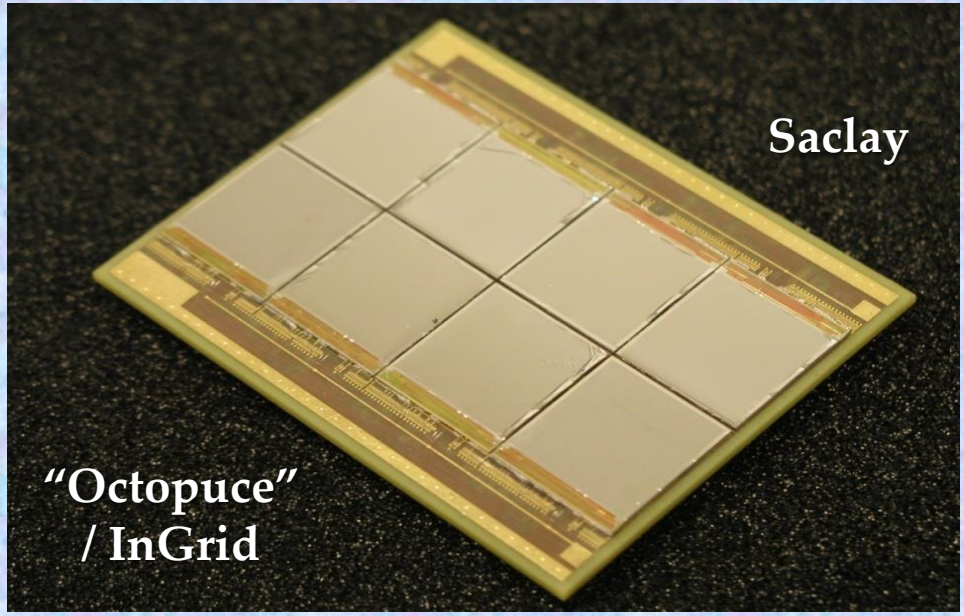
→ diffusion will limit resolution (gas!): how small is necessary?

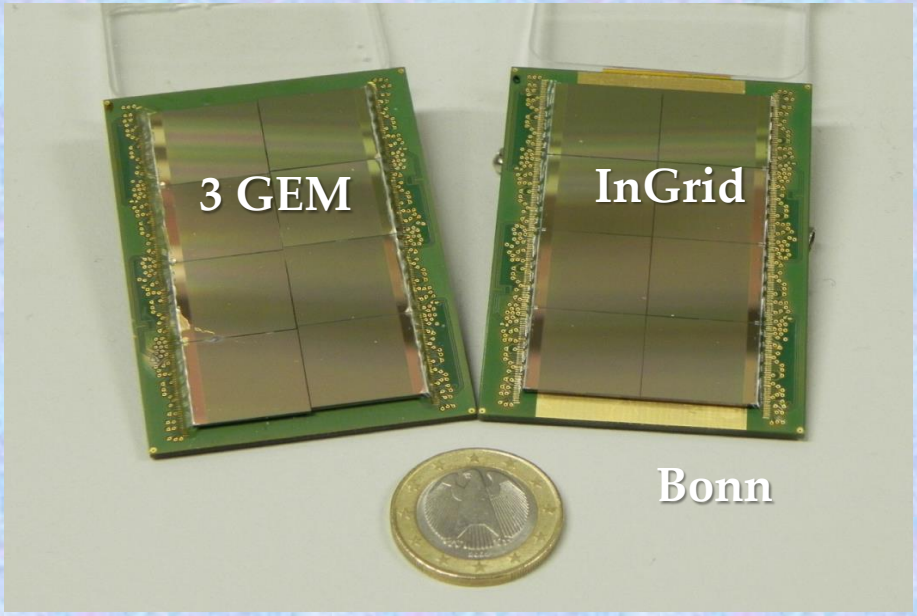
→ cost ?

→stable operation possible ?

- Demonstrate operability of the concept; Measure & understand (details of) charge cloud

Going to Larger Areas: "Octopuce" Modules based on the 2 x 4 Timepix ASICs





- 2010: Saclay / NIKHEF "Octopuce" (InGrid): studies with X-Rays and at DESY e- beam
- 2012-2013 : 2 Saclay / NIKHEF "Octopuce"(InGrid): 1 - some issues with readout; 2 - OK
- 2013: 2 Bonn "Octoboards" (InGrid & 3-GEM): studies with RD51 SRS at DESY e- beam

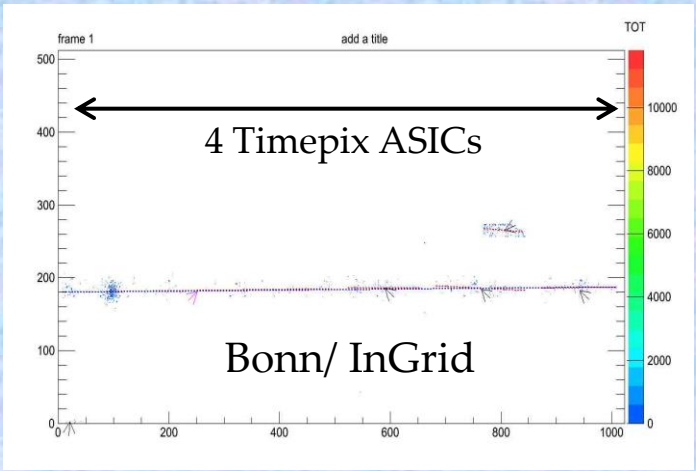
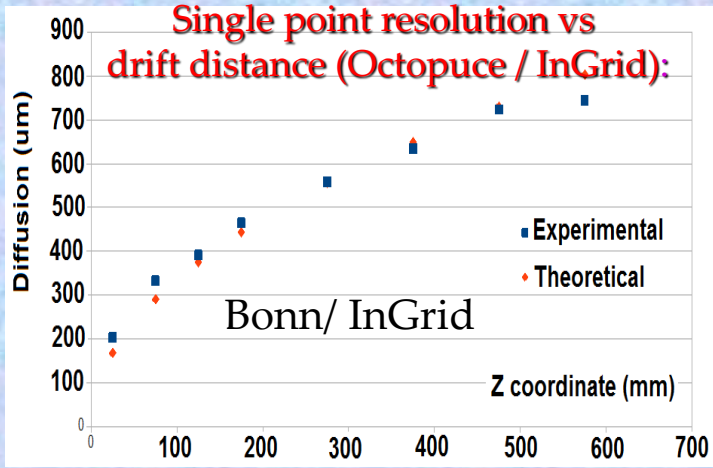
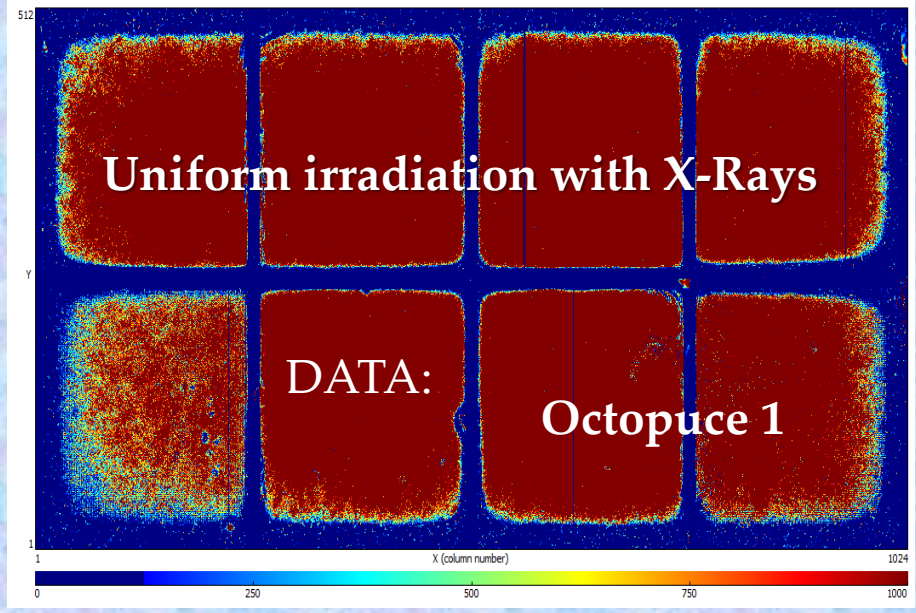


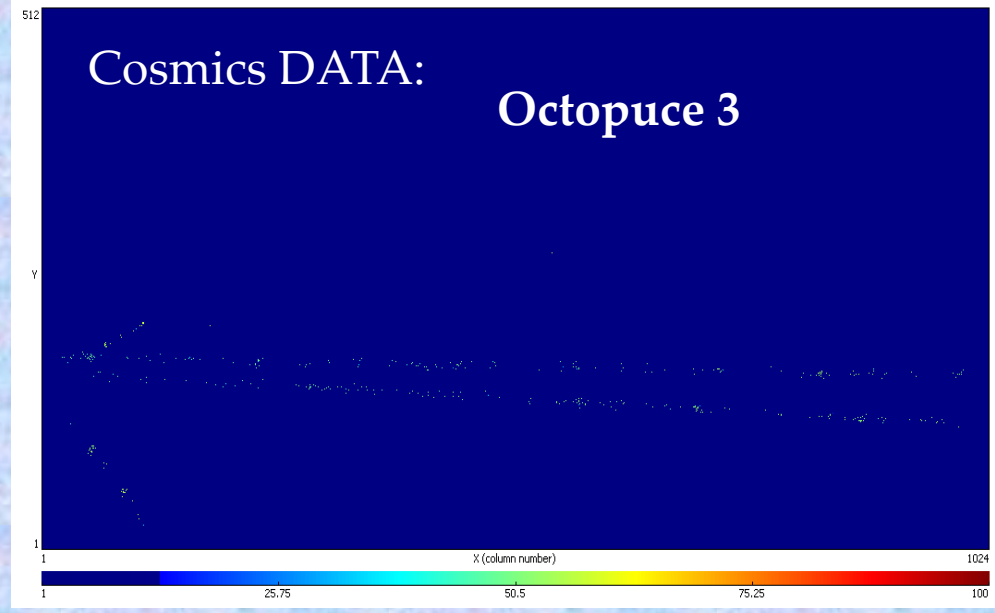
Image from Bonn/"Octoboard" (5 GeV e-):

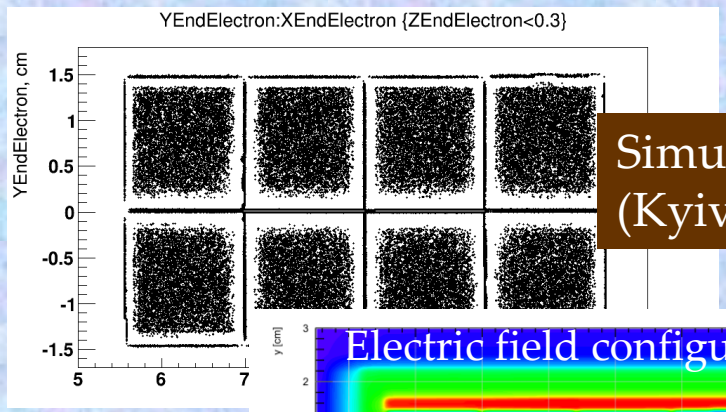
InGrid: each electron avalanche corresponds to single pixel hit



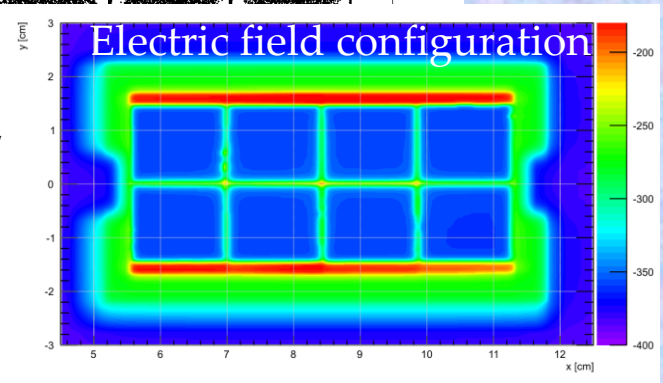
Saclay "Octopuce's": Study of Uniformity with X-Rays & Cosmics







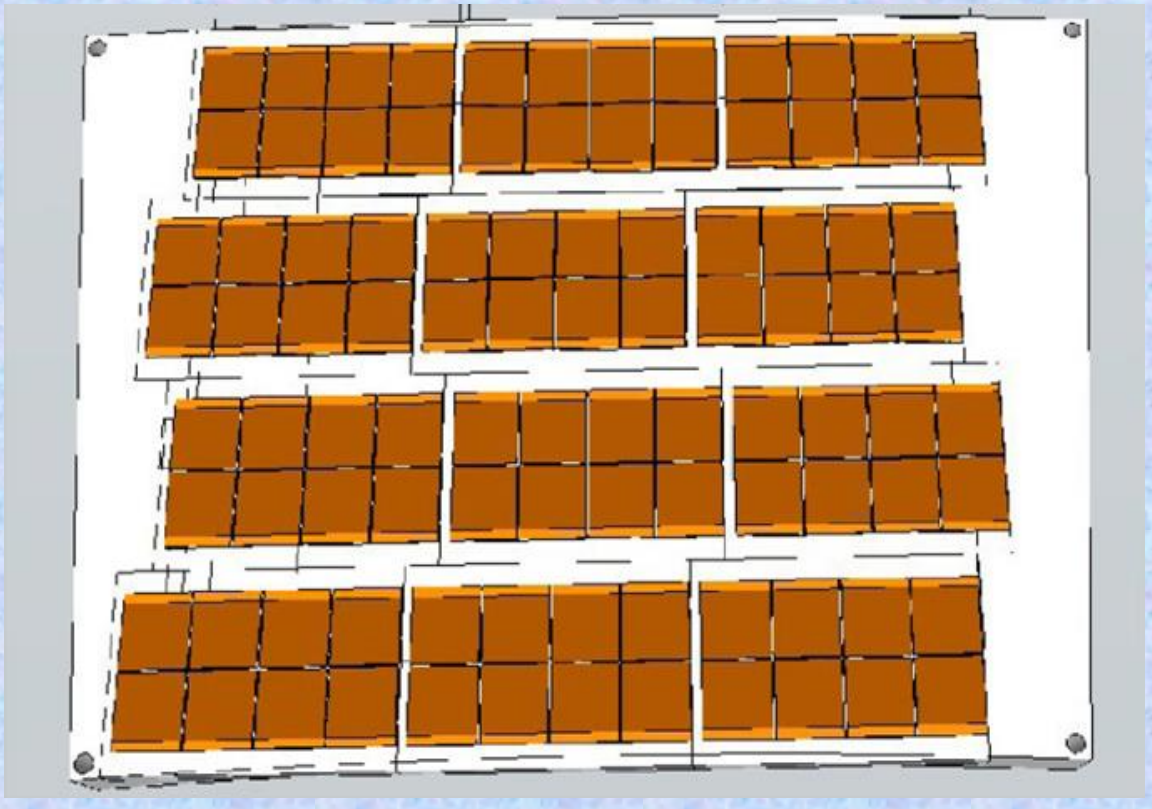
Simulation (Kyiv Univ.)



RD51-NOTE-2013-002

- Single electron sensitivity ~ 100 % (in the central areas of the chips)
- Work is ongoing to better understand & improve field distortions in-between and at the borders of "InGrid's (based on simulation)

Future Plans: Pixel Readout of MPGD - Proof-of-Principle of Si-TPC



Mid-term plan (3 years):

Develop and equip a full LCTPC module (~100 chips) with "InGrid"s, using "Octopuce" module as the basic building block

Pixel LC-TPC Consortium:
Bonn, Saclay, NIKHEF, DESY, LAL, Kyiv University

- Improved mass production of "InGrid"s (less dead area, higher yield, protection)
- Minimize field distortions in the « Octopuce » plane; work on more realisitic cooling and power pulsing
- Develop simulation chain to compare momentum resolution, double track resolution, dE/dx and pattern recognition to pad-based readout and to optimize the geometry
- Experimental dE/dx study by cluster counting using InGrid at the LAL/PHIL facility

Pixel Readout for LC TPC: Next Steps

Short-Term Plans:

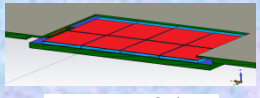
- Improve SU8-based « InGrid « structure (less dead area, higher yield, protection)
- Better understand and improve field distortion issues at the « InGrid » plane (in between chips and at the borders of the Octopuce);
- Develop simulation chain to compare momentum resolution, double track resolution, dE/dx and pattern recognition to pad-based readout and to optimize the geometry (e.g. minimize the needed chip coverage)

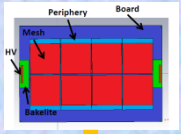
Long-Term Plans:

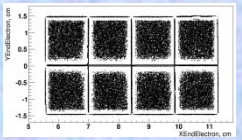
- Improved chip functionality → Timepix3 → transfer InGrid process to Timepix3
- Adapted readout system → high-speed SRS readout for Timepix(3)(8 &100 chips);
- Improved mass production of InGrids → in collaboration with IZM, Berlin
- Work on more realistic cooling and power pulsing;
- Develop a backside connection technology both for LV/data and for the HV;

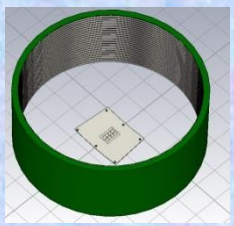
Irfu – LAL – Kyiv Cooperation: Present and Future

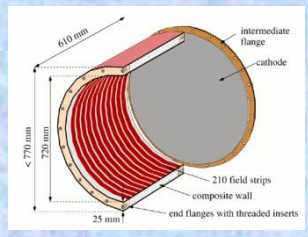
- Kyiv University made a major contributions towards optimization of geometry of large-area "InGrid" Detectors (Garfield ++ simulations) within the ILCTPC-Pixel Collaboration:



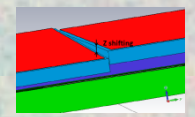


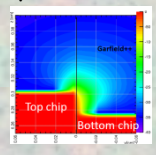


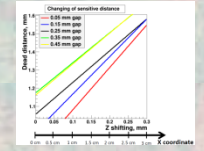


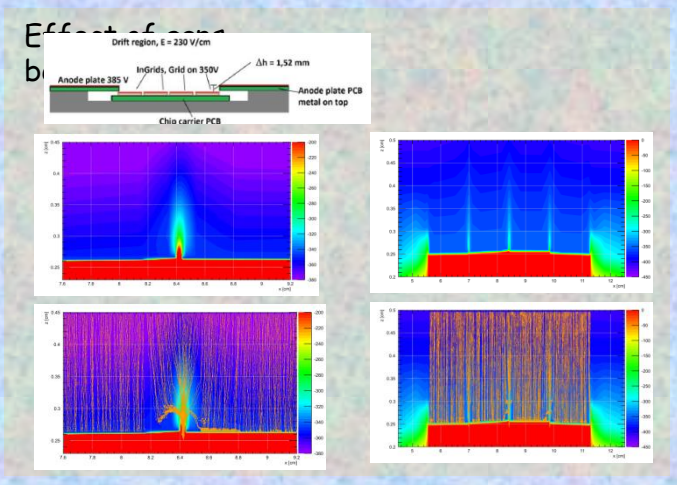


Effect of geometry deviations

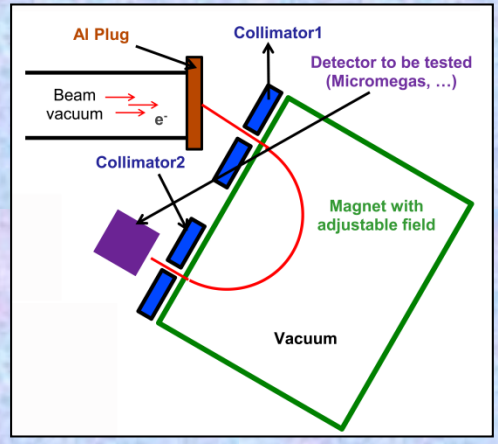








- LAL/Kyiv U/IRFU/CERN Cooperation on LEETECH Platform / PHIL @ LAL:
  Magnet (CERN) + Collimators (Kyiv University)



- Ultimate goal is to develop experimental setup with "InGrid" Detectors @ Kyiv university (optimization of detector characteristics and educational setup)