An InGrid based Detector for CAST

49th CAST Collaboration Meeting
CERN

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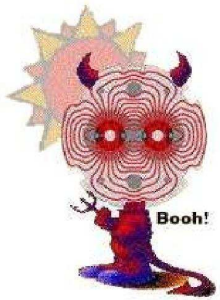

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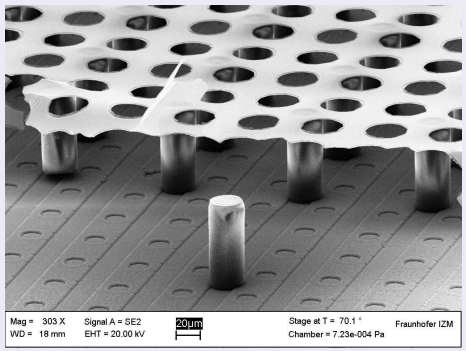
Outline

InGrid - What was it again?

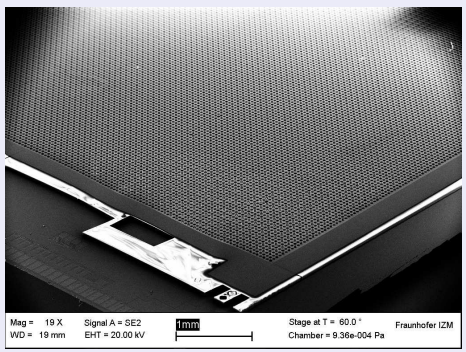
Micromegas on top of Timepix ASIC

- Fabrication by means of photolithographic postprocessing
- Very good alignment of grid and pixels
- Each avalanche is collected on one pixel
- Detection of single electrons possible

InGrid - SEM



Timepix + InGrid



Protection layer

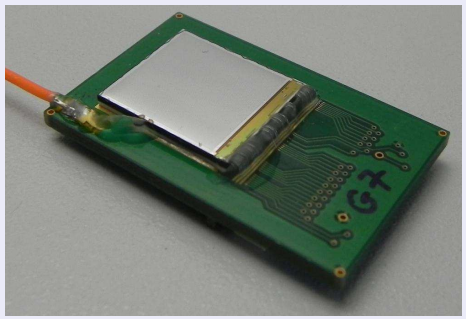
- Timepix was not designed to survive discharges: must protect electronics!
- Resistive layer (2-$8\,\mu\mathrm{m}$ silicon nitride) to spread charge in case of discharge

Timepix ASIC

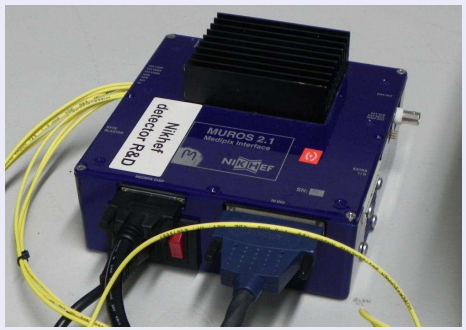
Timepix ASIC - Facts

- 256×256 pixels, $55 \times 55\,\mu\mathrm{m}^2$ pitch
- $1.4 \times 1.4\,\mathrm{cm}^2$ active area
- Charge sensitive amplifier and discriminator in each pixel, $90\,e$ ENC
- Two modes: **Charge** or **Time**

Carrier board



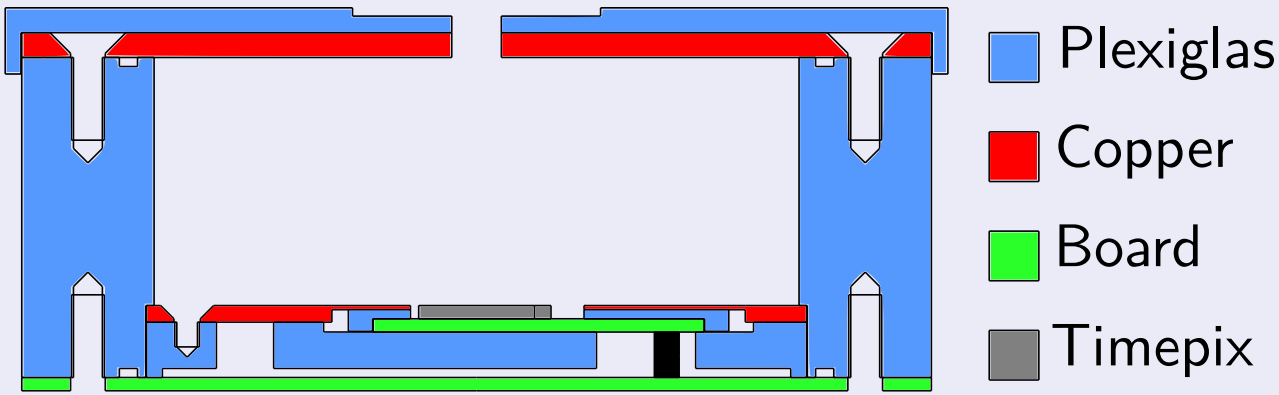
MUROS 2.1



Readout

- Readout with **MUROS 2.1**
  Medipix re**U**sable **R**ead**O**ut **S**ystem developed at NIKHEF
- Acquisition and control: `Pixelman`

New Detector Design



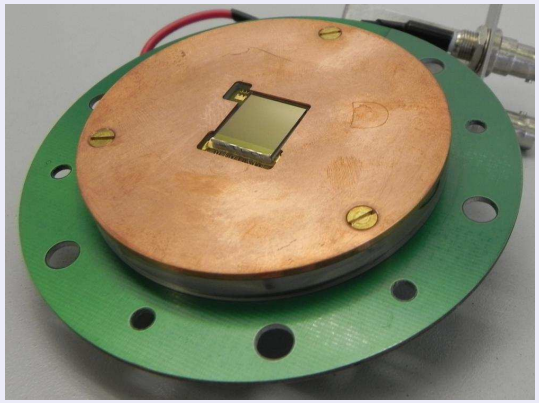
Changes in detector design

- New design based on the current CAST Micromegas
- Plexiglas instead of aluminium
- Metalized Mylar® film ($5\,\mu\mathrm{m}$) as cathode and window

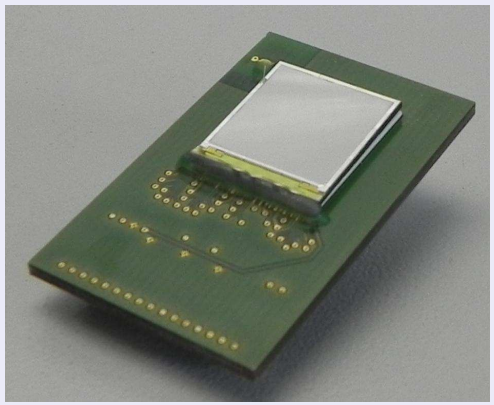
New Detector Design

Drift volume

Readout block



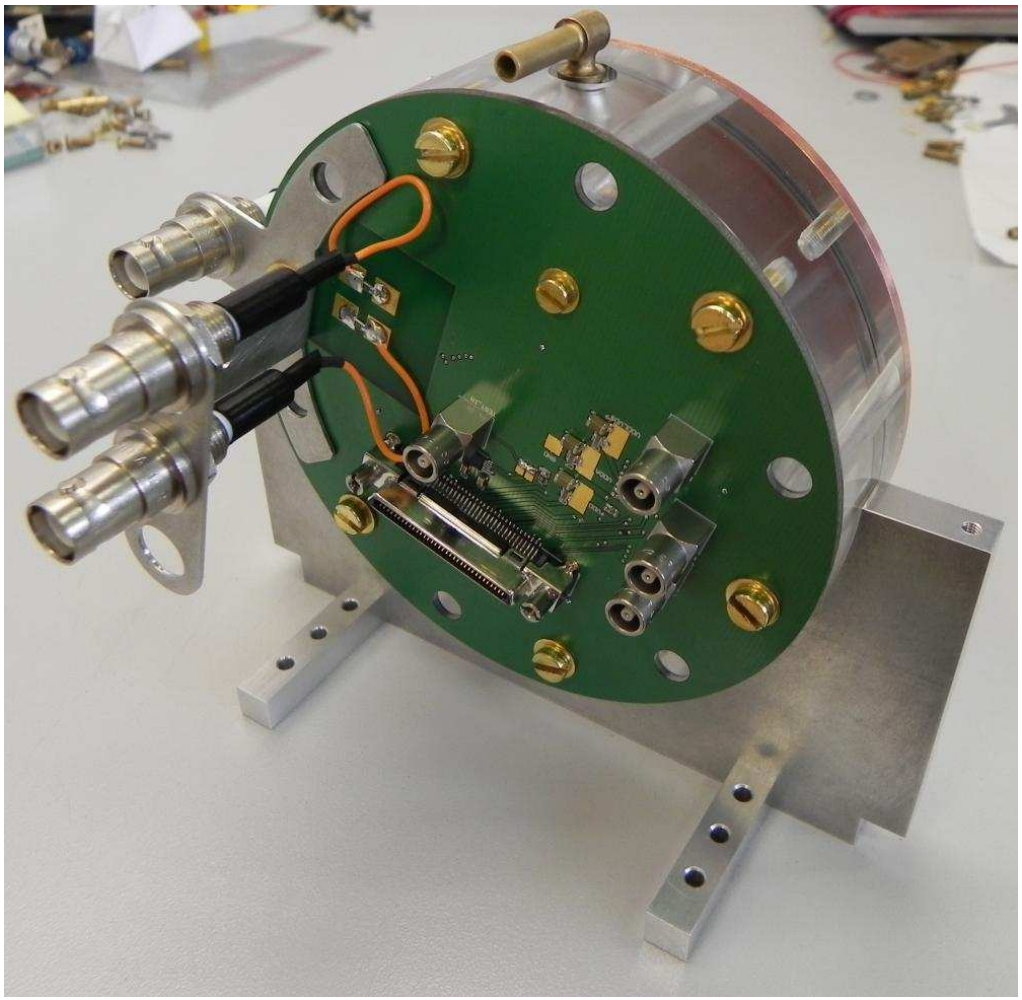
Carrier board

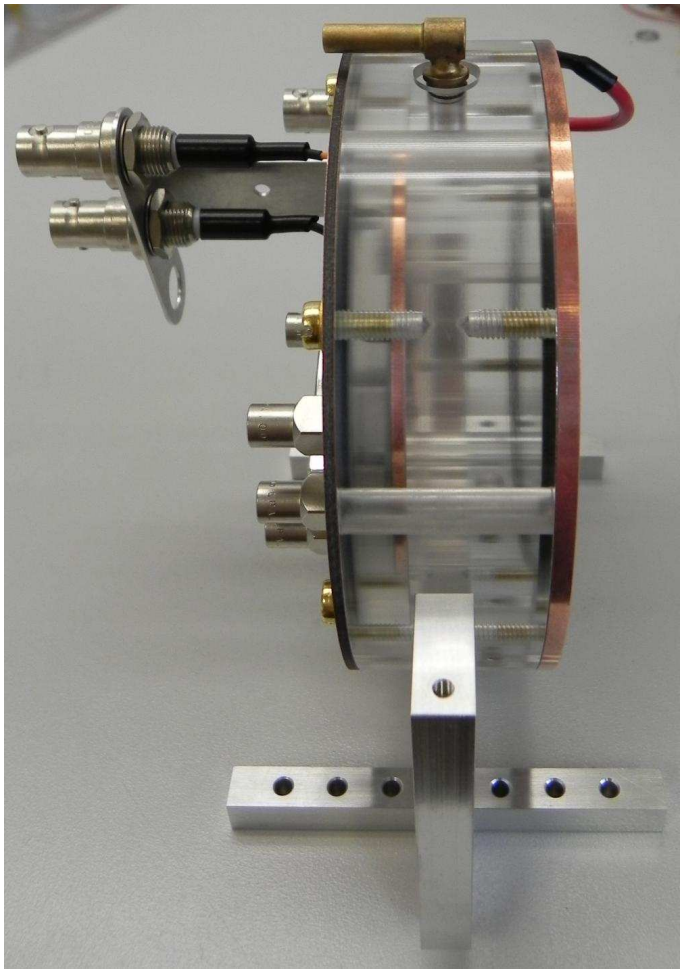


Changes in design

- New carrier and intermediate boards
- HV connection from downside
- HV feedthroughs implemented on intermediate board
- Plug and socket connection instead of flat ribbon cable

New Detector Design





Faraday Cage

Overall Detector Status

Detector status

- Detector works well
- Exchange of chip takes about $1\,\mathrm{h}$
- Grid signal could not be decoupled
- At the moment detector is occupied by colleague testing the new IZM-InGrids

Next steps

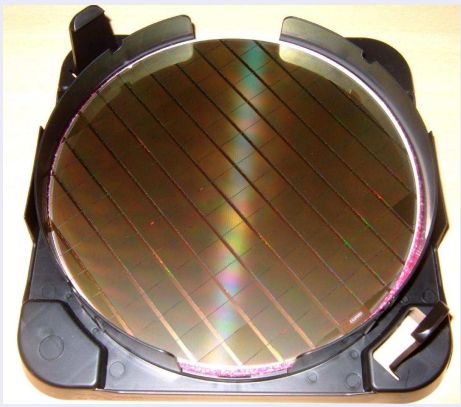
- Build clone of detector including minor improvements
- Mount detector inside Faraday cage
- Try to decouple grid signal with different preamplifiers
- Tests with different x-ray windows (with strongback)

Wafer Scale Ingrid Production

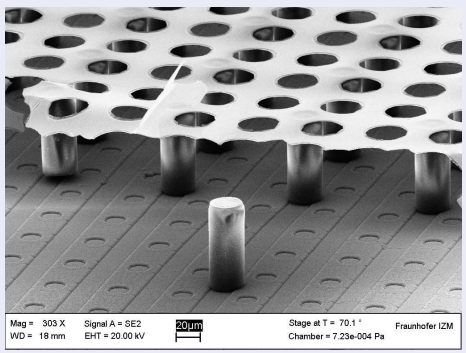
InGrid fabrication

- Fabrication steps take about one week
- Single and few chip processing: NIKHEF / Mesa+ (Twente)
- Wafer processing (~ 100 chips at once): in cooperation with IZM Berlin

Timepix wafer



IZM InGrid - SEM



Formation of the protection layer

- Vapor deposition process
- Very critical, high temperature ($> 200\,^{\circ}\mathrm{C}$)
- Bondpads have to be protected
- Achieved with photolithographic polyimide mask and a lift-off process

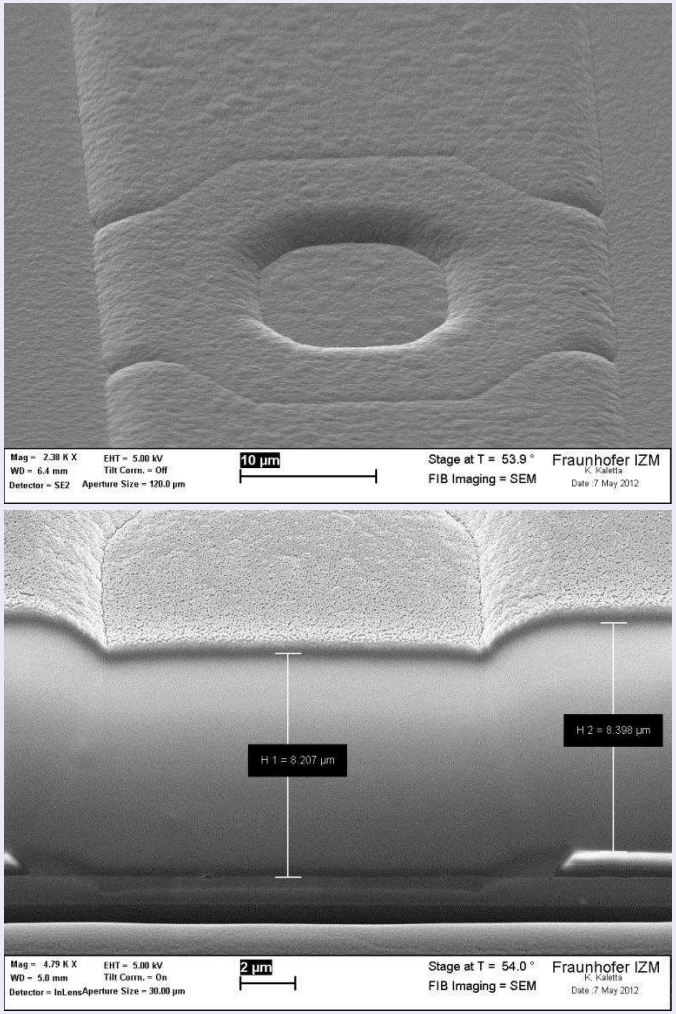
2nd batch of IZM InGrids

Problems

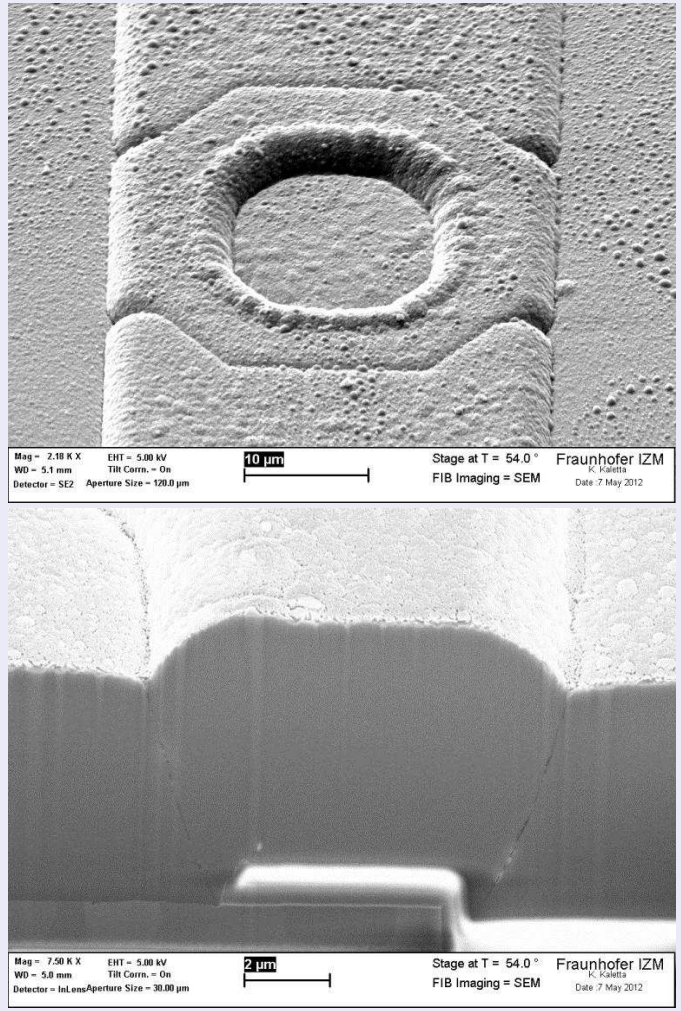
- Pillars are too high ($70\,\mu m$ instead of $50\,\mu m$)
- Inactive (less sensitive) areas, probably caused by residuals from cleaning process
- Chips die fast when operated above moderate grid voltages
- Pinholes/cracks in protection layer

Focused Ion Beam Imaging

Twente InGrids



IZM InGrids 2nd batch



3rd batch of IZM InGrids

Improvements

- New masks for the deposition of the protection layer: now larger area of chip is covered
- Pinholes in protection layer were caused by defect of machine
- Improved cleaning process to avoid residuals
- Fresh bottle of photoresist, old one was stored too long

First tests

- New InGrids withstand HV
- Less insensitive areas
- Up to now 2 chips were testes at Bonn: no one died!

Tests with Argon/iButane 97.7/2.3

General results

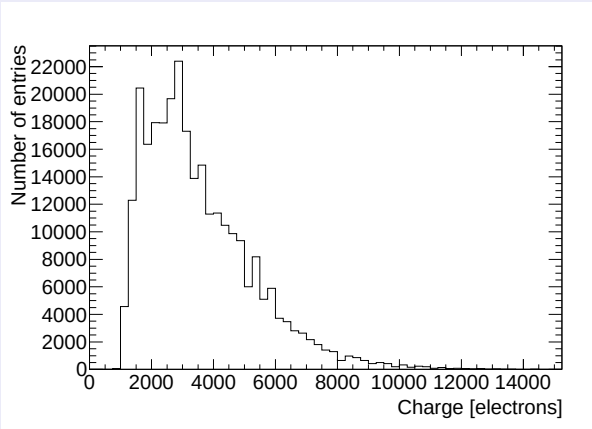
- Operation with Argon/iButane 97.7/2.3 is possible
- **BUT:** Already at low gas gains more pixels are observed than expected
- **AND:** Many isolated pixels with low charge

Possible causes

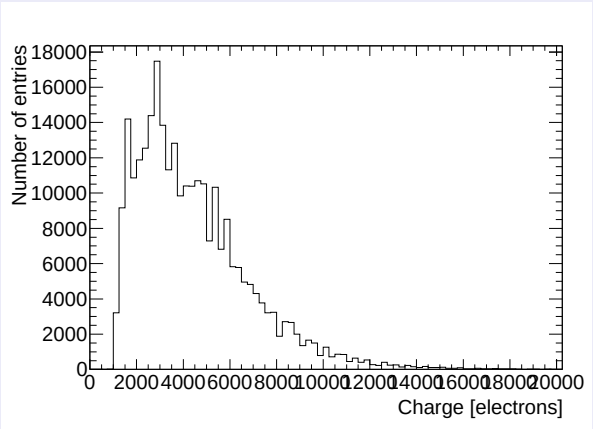
- Both effects were already seen for Argon/iButane 95/5, **BUT** only at very high gas gains
- Charge sharing between pixels? **NO**
  not at low gas gains; cannot explain isolated pixels
- Conversion of UV photons from the avalange? **MAYBE**
  could explain isolated pixels;
  less quencher $\rightarrow$ effect becomes stronger

Charge on isolated pixels

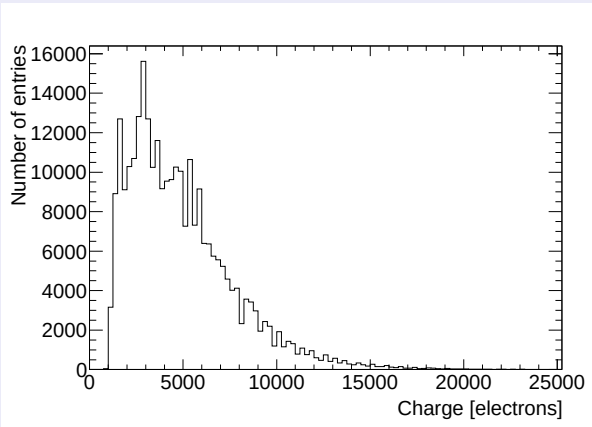
315 V



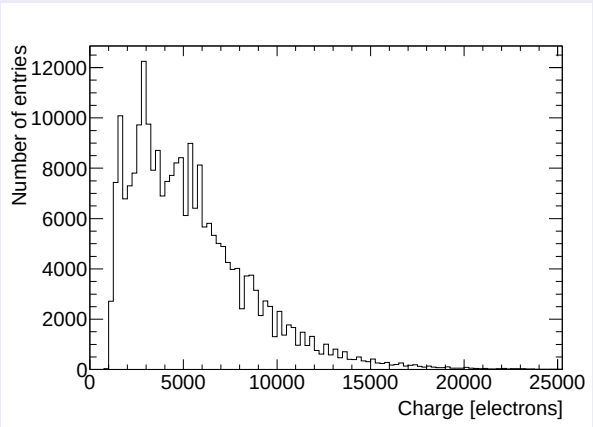
325 V



330 V



335 V



Operation with Argon/iButane 97.7/2.3

How to deal with these effects?

- Either operate at very low or very high gas gains
- Compensate in software: combine pixel clusters caused by charge sharing; correct number of pixels; ...
- Nevertheless these effects will affect energy resolution

What can we learn from it?

- Should be possible to do a (rough) measurement of the range of UV photons in the gas amplification stage
- Planning to do measurements with different quencher fractions

Tests in the CAST Detector Lab

Plans

- Do tests in CAST Detector Lab when X-ray beam line is able to produce low energy X-rays
- Optimistic planning: maybe begin of December?
- Maybe also test different drift windows
- Characterize detector at different energies (reference data sets)

To do...

- Drift windows with strongbacks have to be manufactured
- Clone of InGrid based detector has to be ready
- Build custom endplate for Faraday cage at X-ray beam line

Tests at CAST

Plans

- If tests in CAST Detector Lab are successful: install InGrid based detector at XRT
- Take data...

To do...

- Interconnection between XRT and detector has to be constructed and manufactured
- Question of shielding has to be discussed
- Windows transparent at low energies

Conclusion

- New InGrid based detector is ready
- 3rd batch of IZM InGrids is available and being tested
  They do not die that fast any more ☺
- Operation with Argon/iButane 97.7/2.3 is not optimal but should be possible
- Planning to do tests in the CAST Detector Lab
- Still many things to do and to consider towards an operation at CAST

Thanks for your attention!