THGEM production by Print Electronics

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Print Electronics

- Company was presented in RD51 meeting at CERN held in November 2011
- Produced many THGEMs for WIS with rim etched by standard photo-lithography
- Expressed high interest in producing large area THGEMs

- Current production technique adapted from Rui
  - http://indico.cern.ch/contributionDisplay.py?sessionId=5&contribId=39&confId=158402
  - Rims are made with chemical etching

Goals

- Produce high-quality large-area THGEMs
- Rim sizes from 5 μm to 100 μm
- Large scales
  - Present needs: COMPASS RICH, DHCAL for ILC
  - We started with 30×30 mm^2 electrodes
  - The first batch of 100×100 mm^2 electrodes is evaluated these days
  - The next step is segmented 300×300 mm^2 electrode

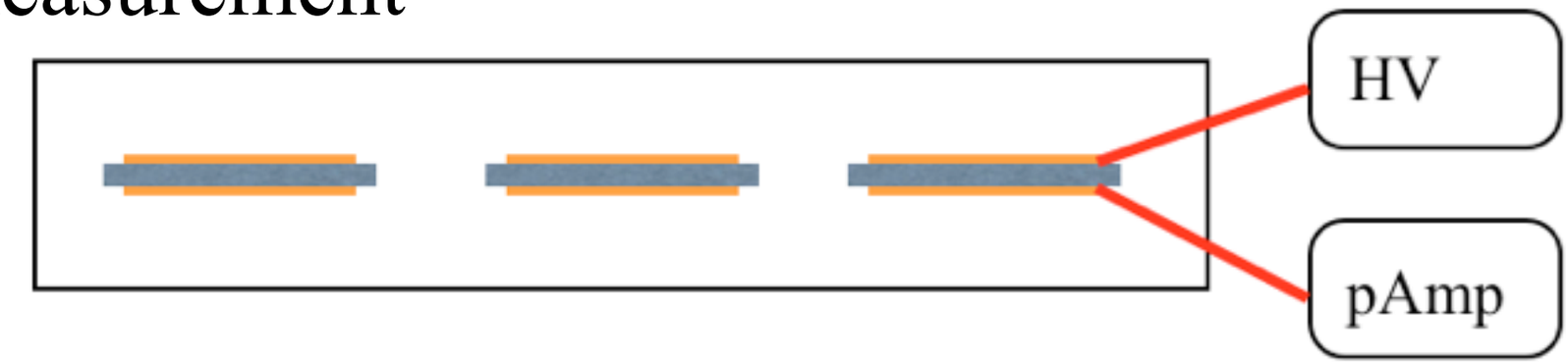
PE/WIS combined effort

- Production at PE according to WIS specs
- Quality control tests at WIS
- The following parameters are measured and compared
  - **Microscopy**: drilling and etching quality
  - **Dark current** under high voltage and controlled conditions
  - **Gain curve and maximal achievable gain**
    - measured in single THGEM structure using 8 KeV x-rays in pulse mode
  - Spark rate without source
    - work in progress

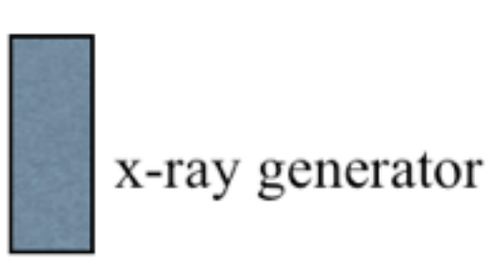
- WIS feedback improved production quality
- We plan a systematic comparison between PE production and Rui's

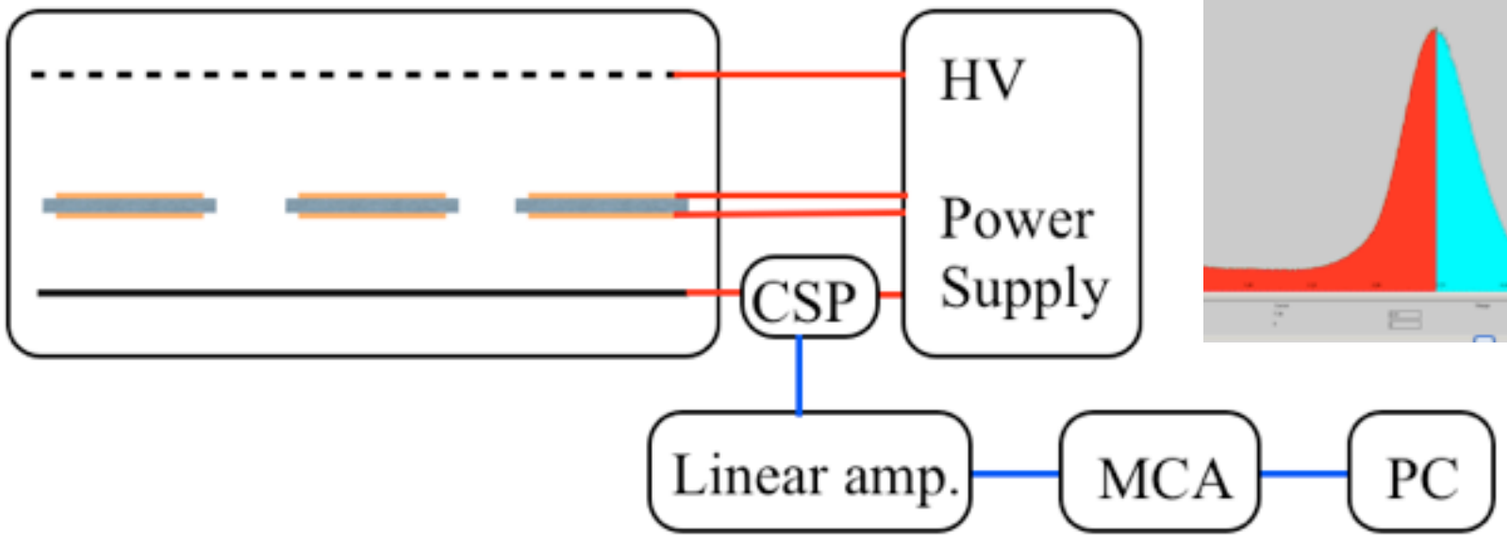
Test setups

- Dark current measurement



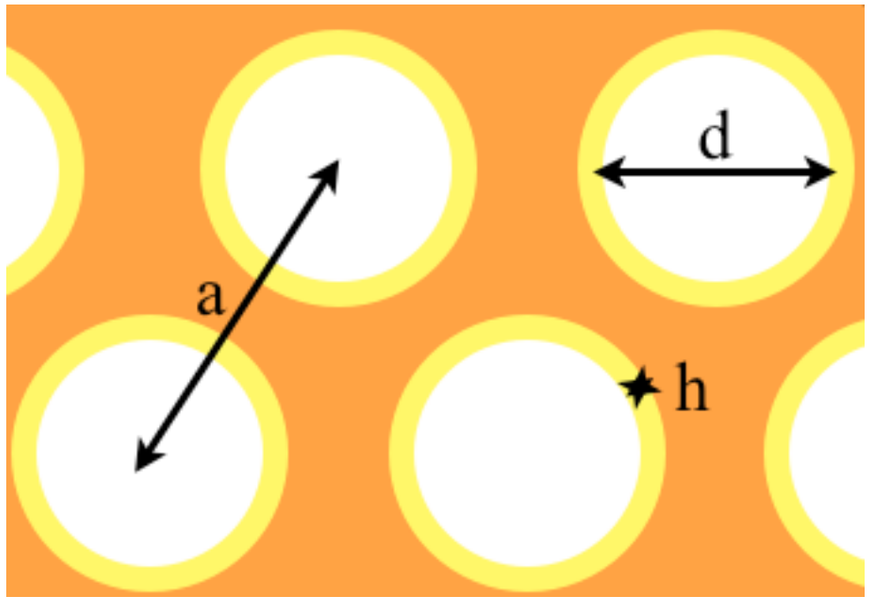
- Gain curve
- Gas NeCH4(5%)
- Source: 8KeV photons
- Drift gap: 6.5 mm
- Drift fields: 0.5 kV/cm
- Induction gap: 2mm
- Induction field: 1kV/cm

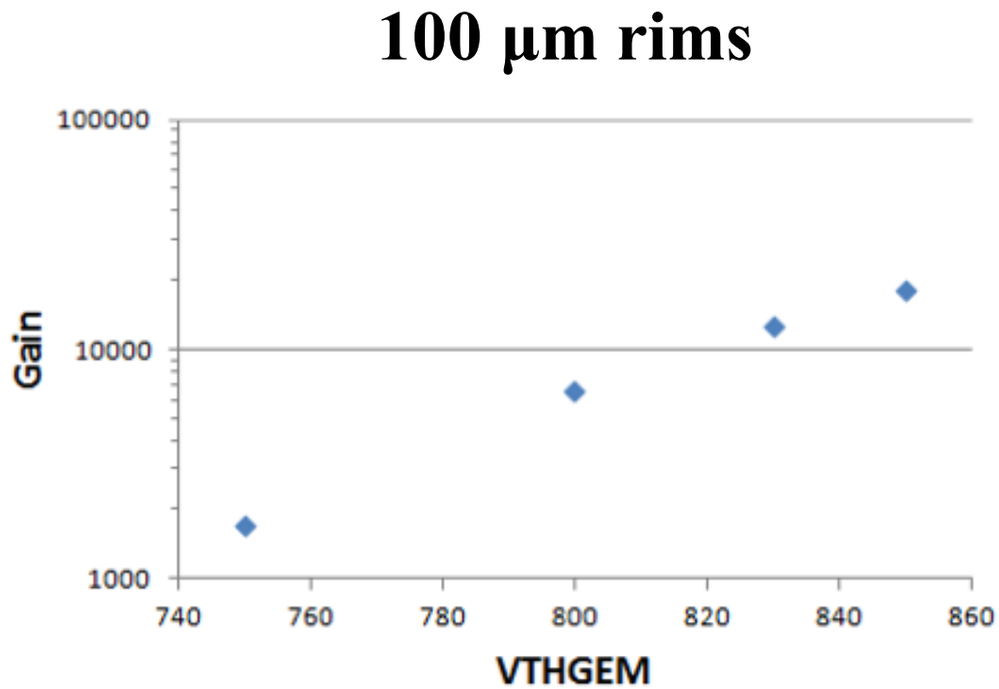




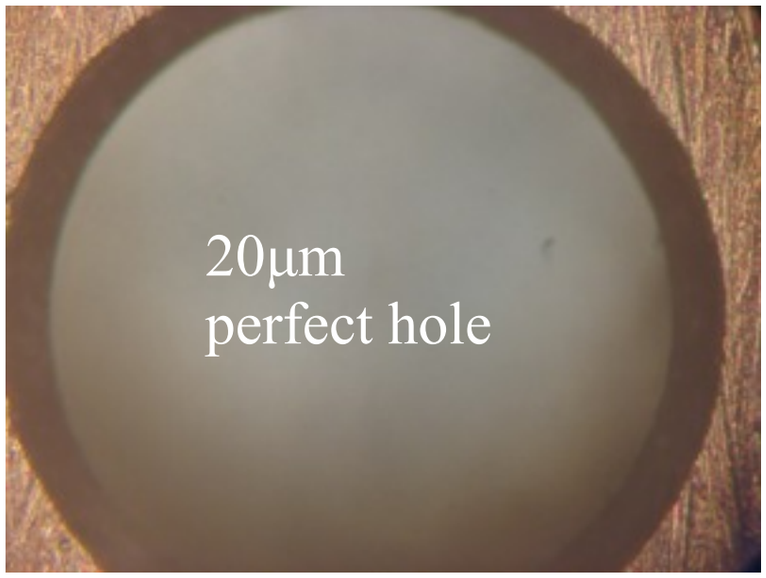
March 2012 batch - 30×30 mm^2 electrodes

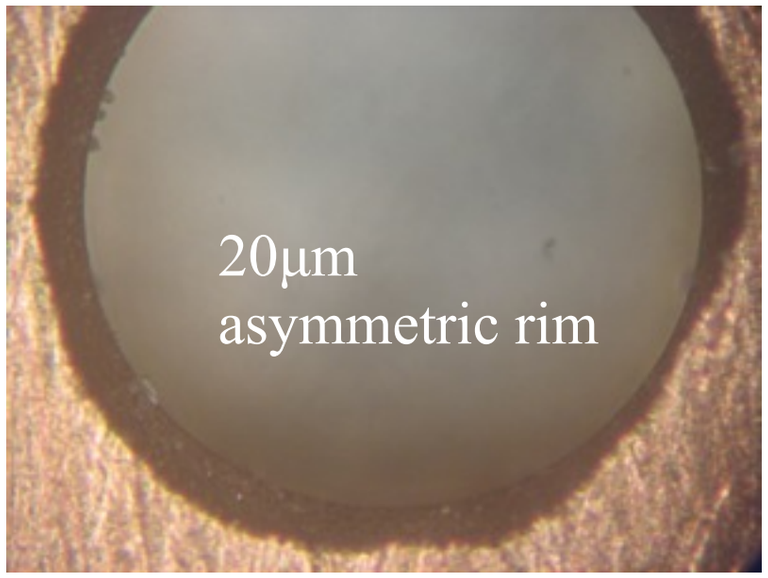
- Geometry:
- a = 1mm, d = 0.5 mm, t = 0.4 mm, h = 100 / 50 / 20 μm
- Dark currents:
  - h = 100 μm → 10pA - 2nA @ 1kV
  - h = 50 μm → < 1nA @ 1kV
  - h = 20 μm → < 1nA @ 1kV
- Maximal achievable gain @ NeCH4(5%):
  - h = 100 μm → 2×10^4
  - h = 50 μm → 6×10^3
- Sparks occur quite often

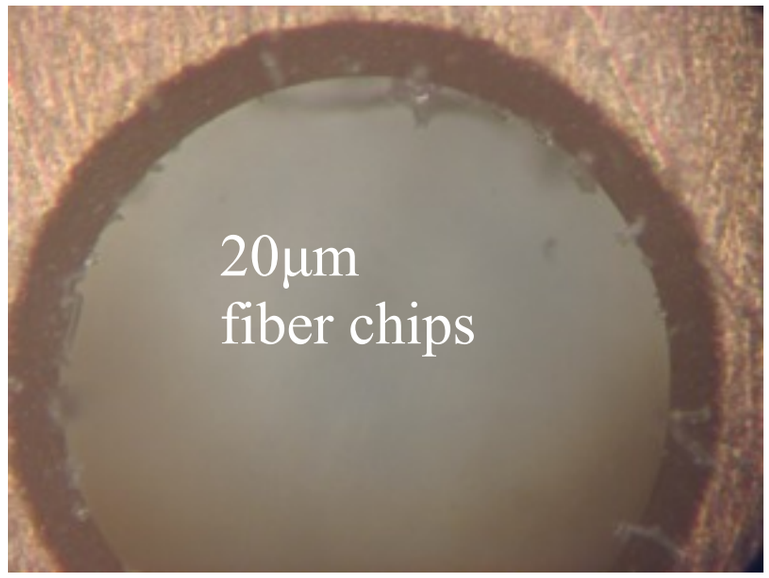




March 2012 batch - snapshots of defects





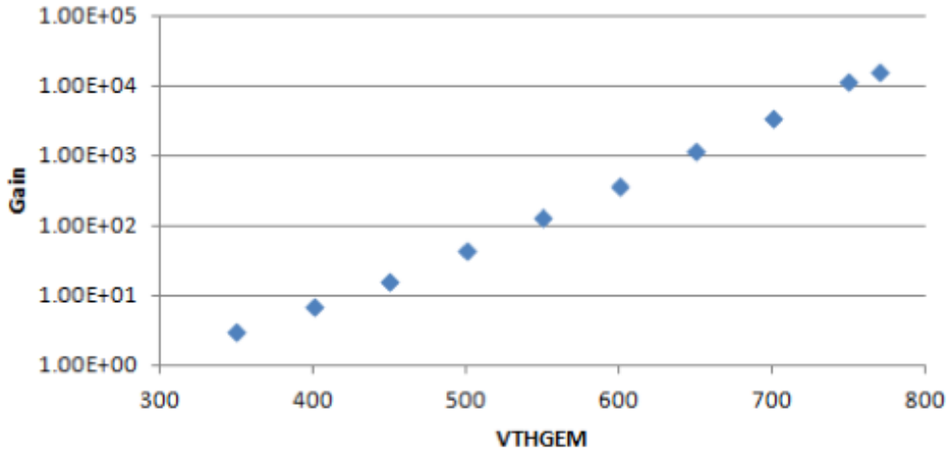


- We consulted with Rui who suggested the following
  - The asymmetric holes are due to remains of epoxy affecting the chemical etching → pointed at a problem in the de-smearing stage
  - The fiber chips can be removed with high pressure Nitrogen flush
- In addition, a problem in the baking step was found

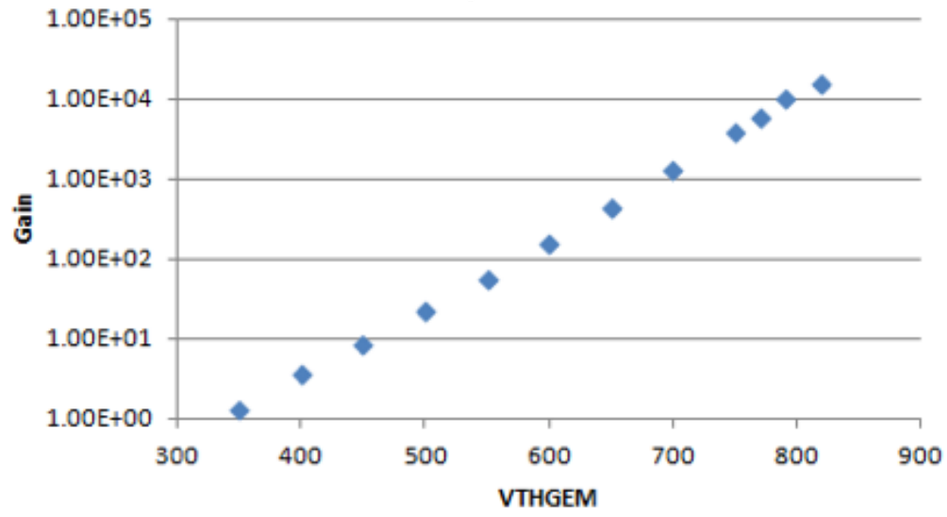
May 2012 batch - 30×30 mm^2 electrodes

- Geometry:
  - a = 1mm, d = 0.5 mm, t = 0.4 mm, h = 50 / 20 / 10 μm
- Dark currents:
  - h = 50 μm → 0.004 nA @ 1kV
    0.1nA @ 1.5kV
  - h = 20 μm → 0.2-0.4 nA @ 1kV
  - h = 10 μm → 0.1-1 nA @ 1kV
- Maximal achievable gain @ NeCH4(5%):
  - h = 50 μm → 2×10^4
  - h = 20 μm → 2×10^4
  - h = 10 μm → 8×10^3

20 μm rims

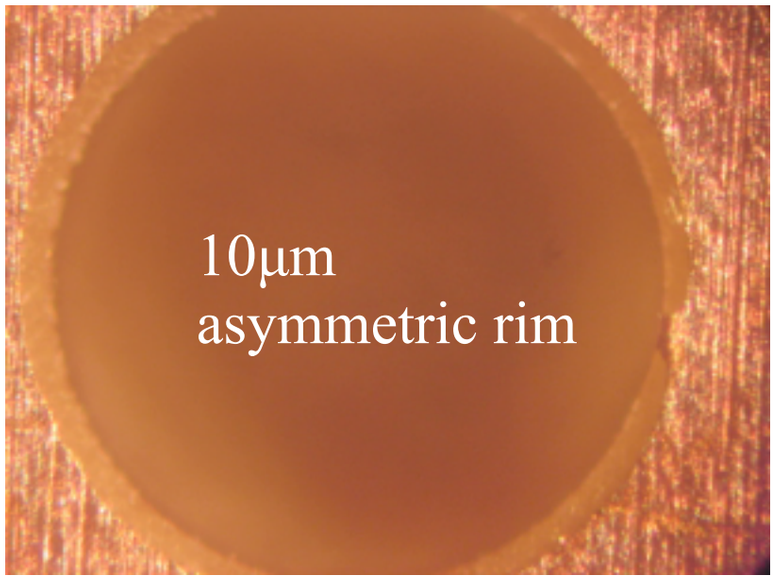


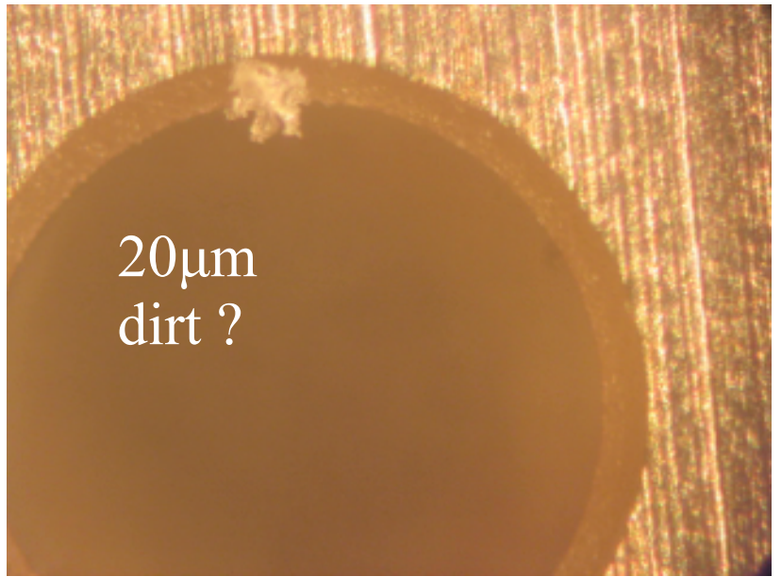
50 μm rims

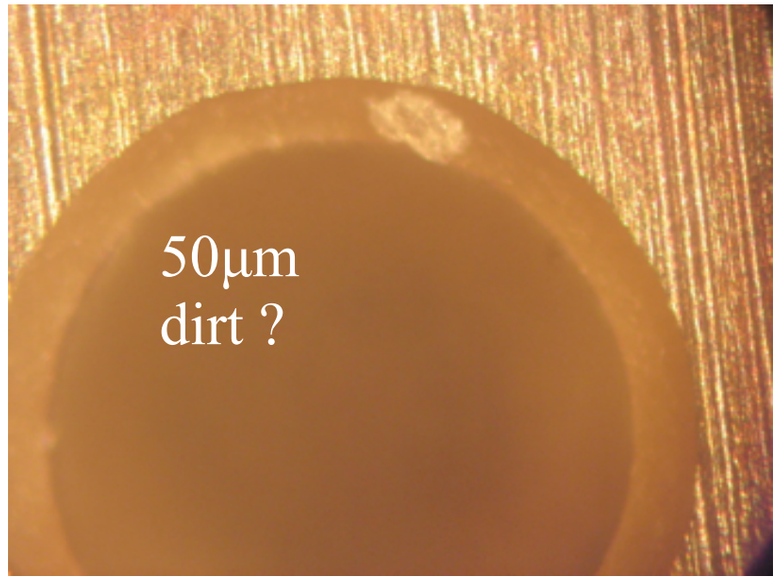


- Conclusions: lower dark current, higher gains (and less sparks) are observed compared to the previous batch

May 2012 batch - snapshots of defects





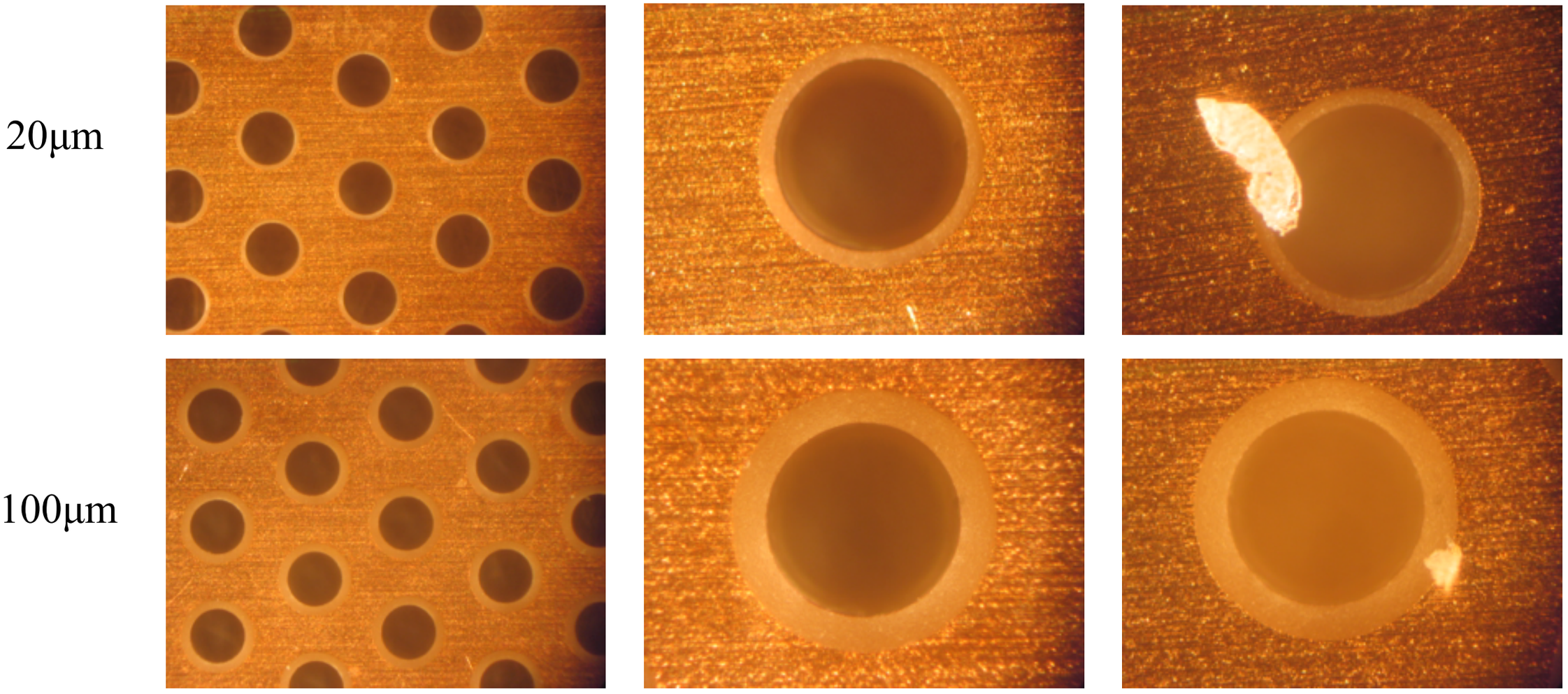


- Not all the holes are perfect but the defect frequency is much lower
- There is still room for improving the de-smearing
- Any additional recommendations are welcomed

- The 30x30 mm^2 detectors appear stable we continued to a 100×100 mm^2 production, instructing PE to pay more attention to the de-smearing stage and final washing

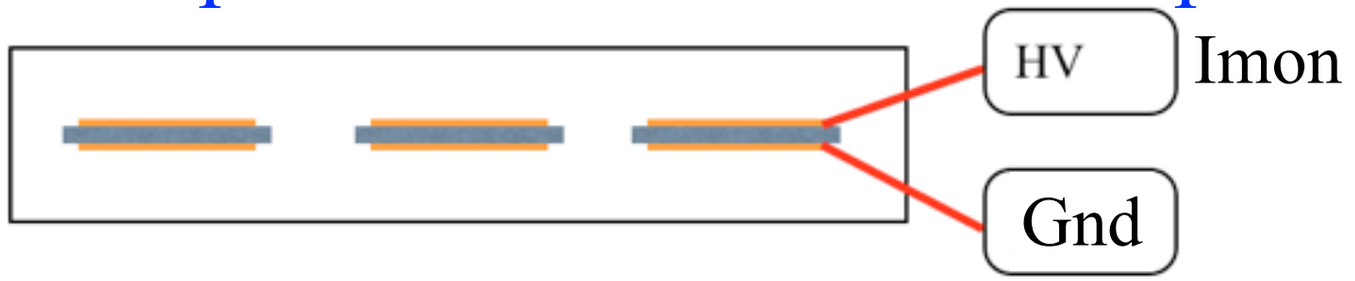
June 2012: 100×100 mm^2 electrodes

- Geometry:
  - a = 1mm, d = 0.5 mm, t = 0.4 mm,
    h = 100 / 50 / 20 / 10 μm



Comparison to CERN production

- After additional baking
  PE electrodes are compatible with the electrodes produced at CERN



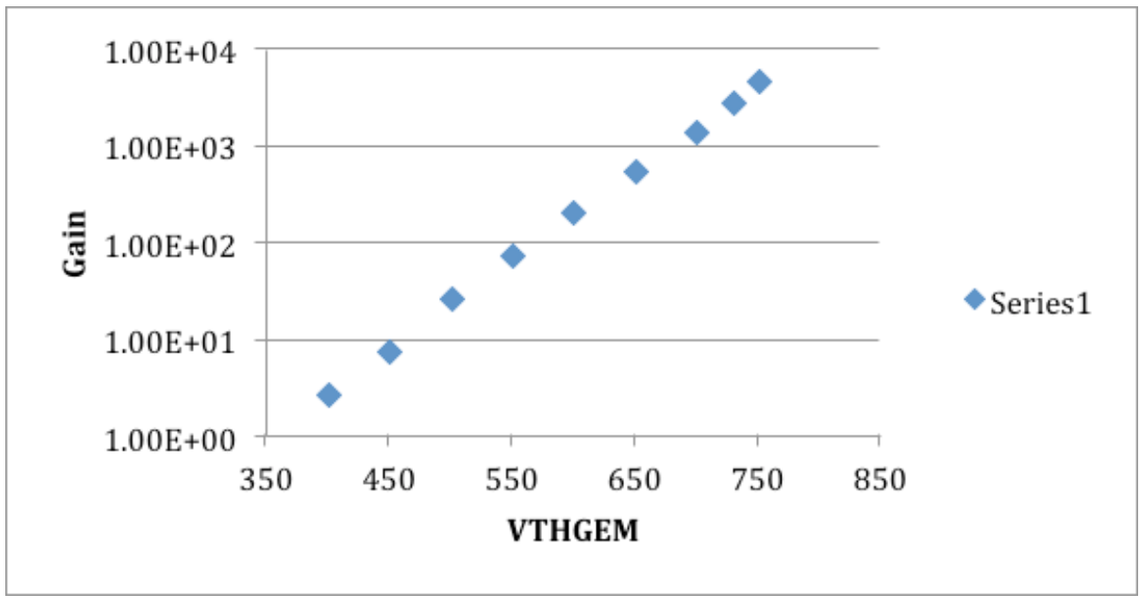
	CERN* 100 μm	PE 100 μm	PE 50 μm	PE 20 μm	PE 10 μm
I @ 1 kV	1 nA	< 1 nA	1 nA	< 1 nA	1 nA
I @ 1.5 kV	2 nA	< 1 nA	1 nA	1 nA	2 nA
I @ 2 kV	5 nA	2 nA	2 nA	2 nA	-
Sparks	2.3 kV	2.3 kV	2.4 kV	2.3 kV	2 kV

* Can be cleaned and probably improved

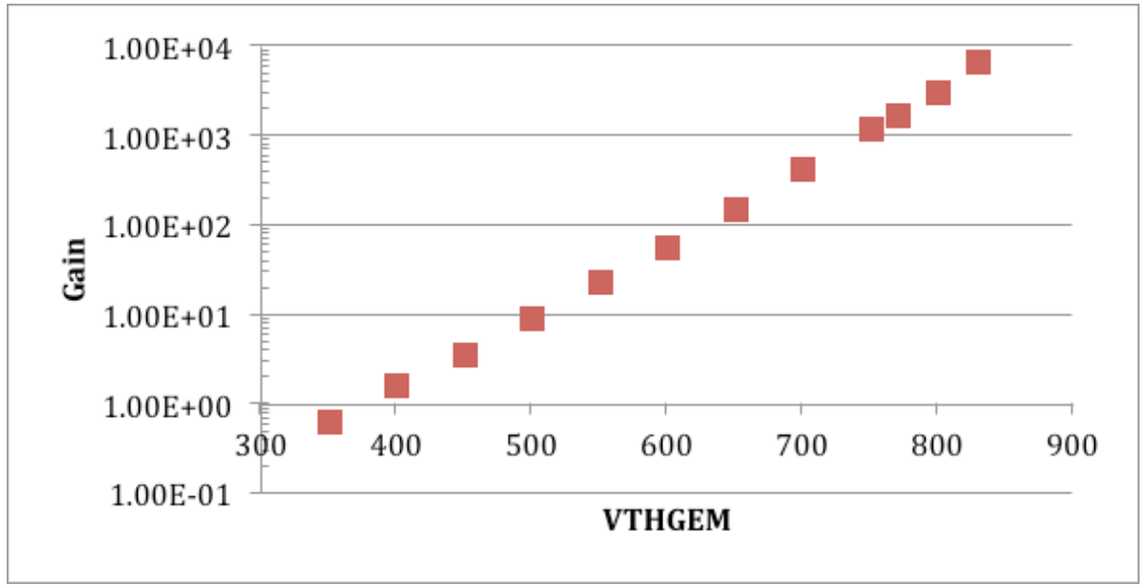
Comparison to CERN production

- Gain curves
- Measurements were taken before re-baking
  - An improvement is expected

20μm

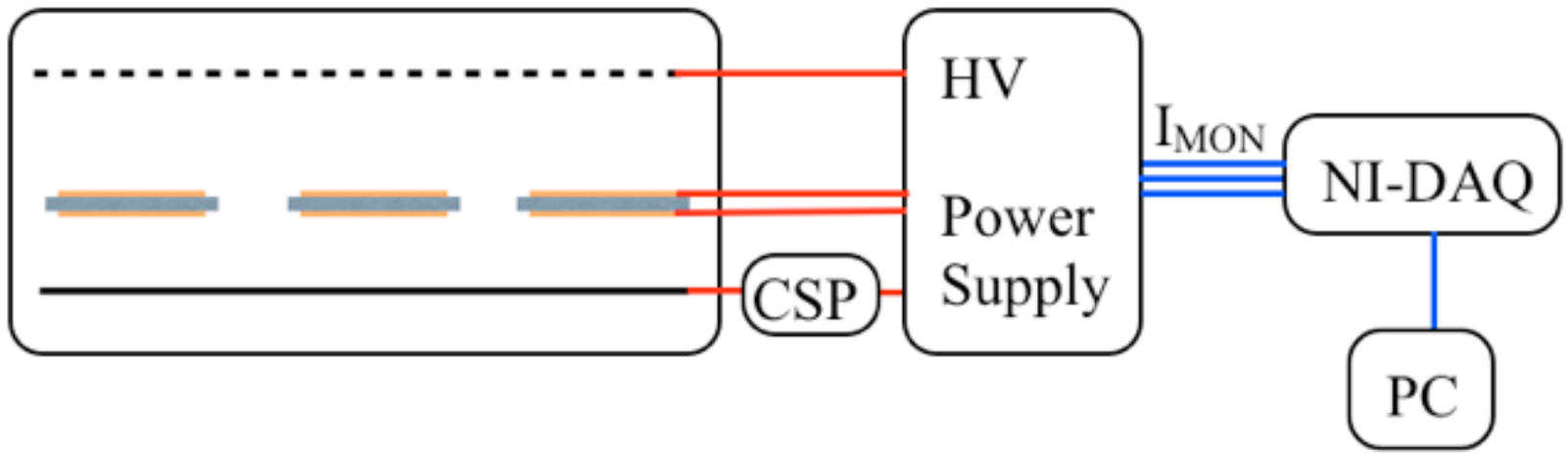


100μm



Prolonged spark rate measurement

- Two sources of discharge exist
  - Spontaneous (no radiation) due to defects
  - Radiation related
- In our QA evaluation we consider spontaneous discharges
- Setup scheme:



- We identified that some of the spark does not relate to the THGEM
- This effect is being studied

Future plan: 300×300 mm^2 electrodes

- Larger DHCAL prototype fully equipped with SRS electronics
- In collaboration with Aveiro and Coimbra
- Geometry:
  - a = 1mm, d = 0.5 mm, t = 0.4 mm, h = ## μm ?
- Segmentation:
  - Reducing detector segments capacitance
  - Any recommendations are welcomed
    - Strip width? number of segments? etc...

- Production date: as soon as the design is ready