Diffraction applications

Development of spherical GEMs

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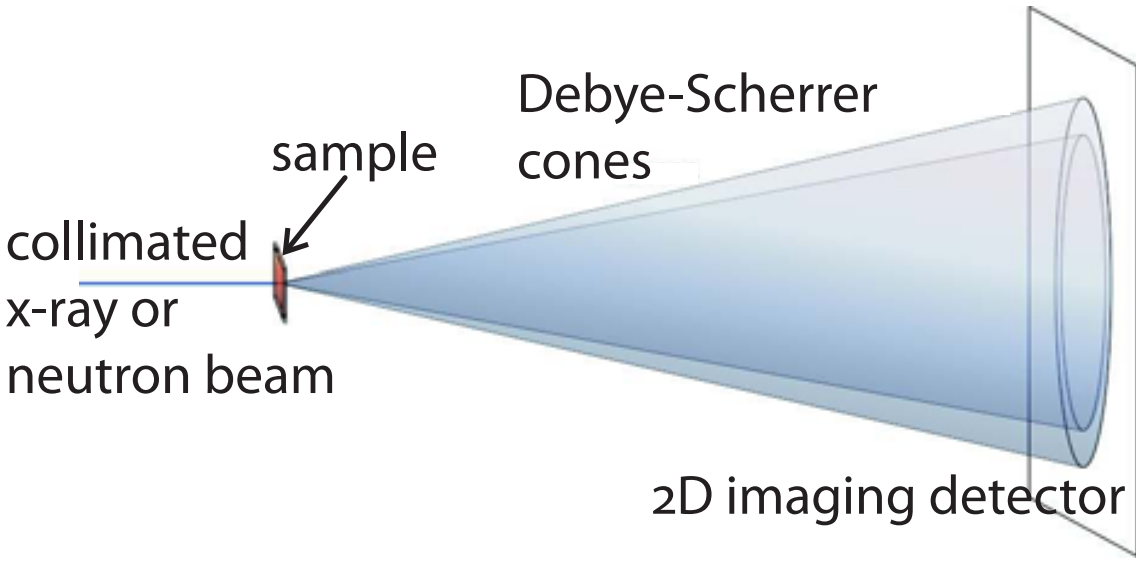
27 April 2012

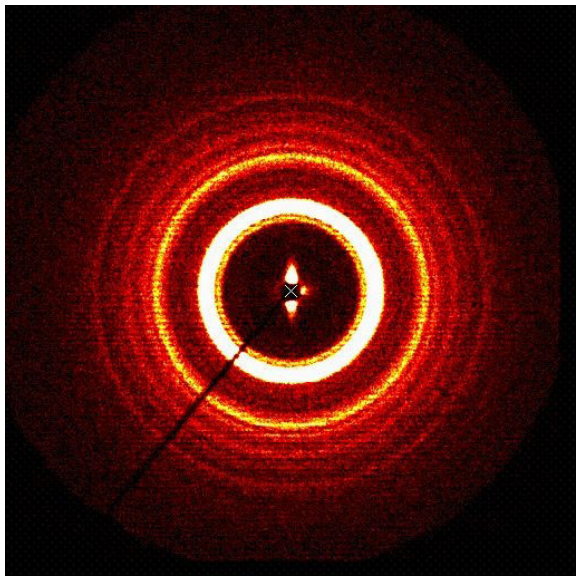
X-ray or neutron diffraction

Powder diffraction with 2D detector

Powder diffraction and detector requirements

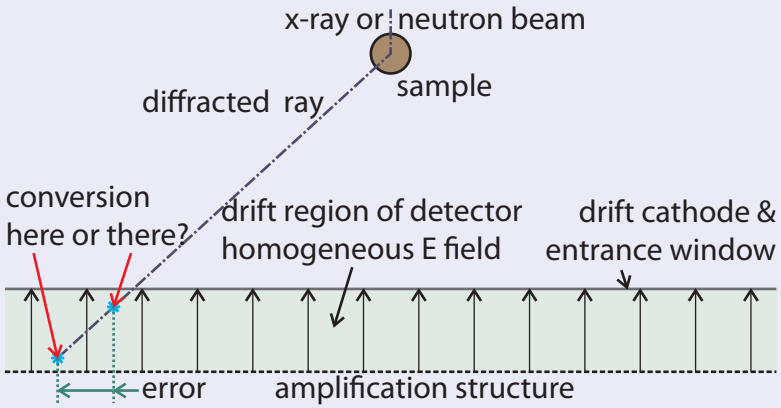
- Circular patterns if sample is powder of randomly oriented crystals.
- Need a large area detector (large for solid state standards)
- Gas detector seems natural solution, but introduces parallax error

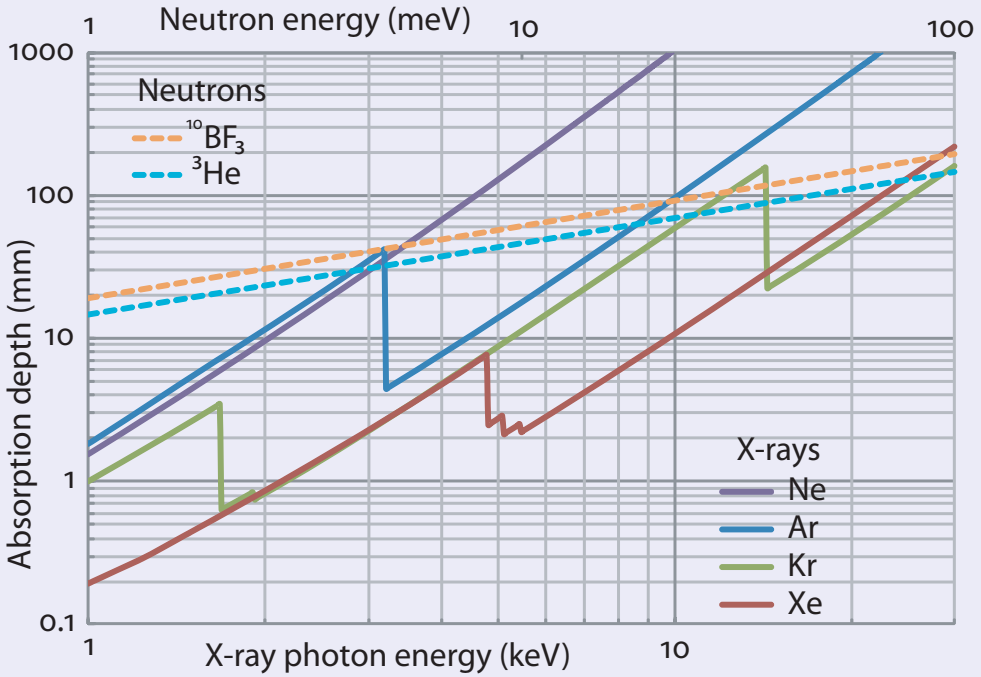




Diffraction with gas detectors

Parallax error & how it degrades resolution





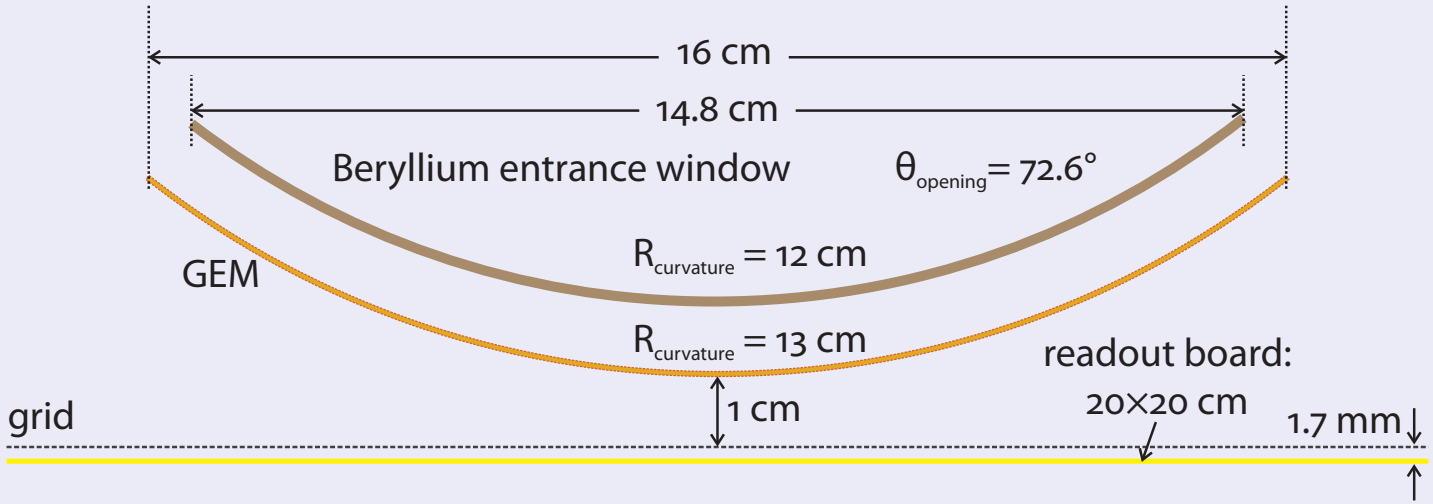
Methods to suppress parallax error

- Efficient conversion gas reduces the probable conversion depth
- Increase in pressure has same effect, but necessitates thicker window
- Spherical entrance window helps a lot, and allows higher pressure
- Truly spherical conversion gap would be optimal (zero parallax error)

Prototype

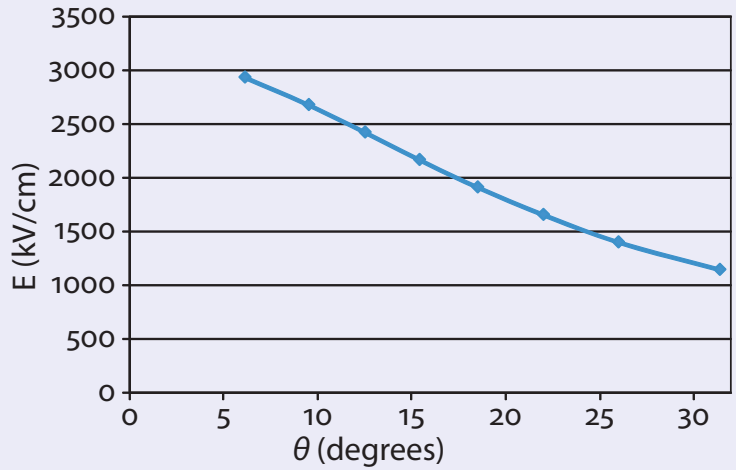
Single spherical GEM with flat readout

Enter a spherical GEM in an existing detector



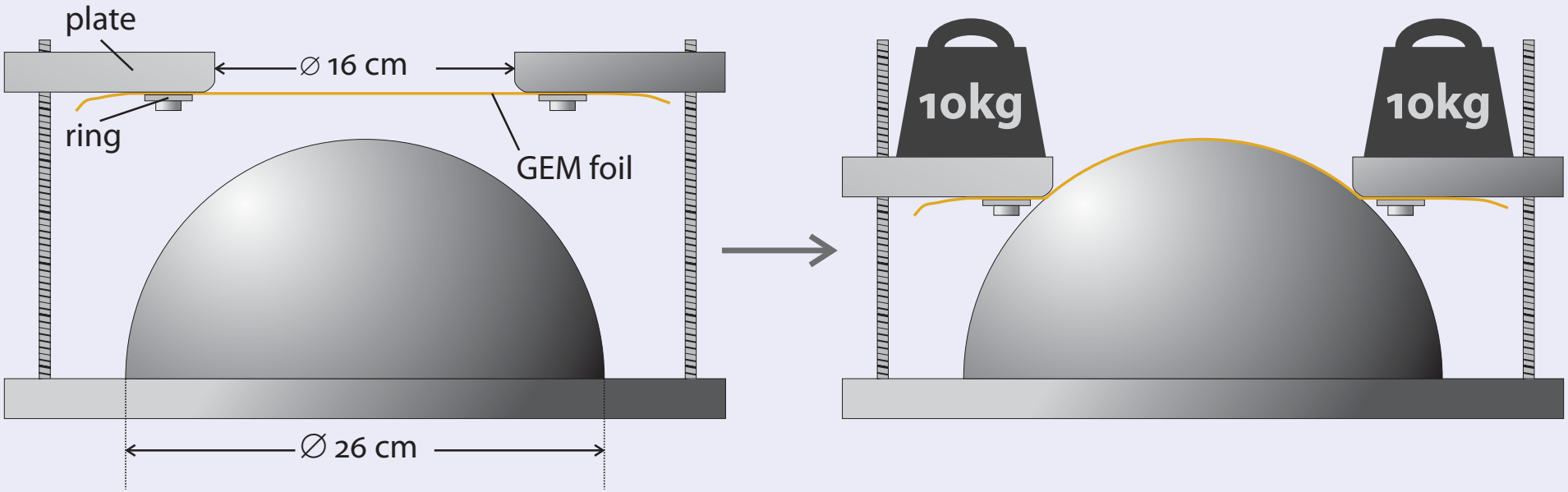
Single spherical GEM

- Spherical Be entrance window
- Can work with 3 bar of Xe
- Spherical GEM creates radial drift field
- Charge transfer issues in induction region



Forming spherical GEMs

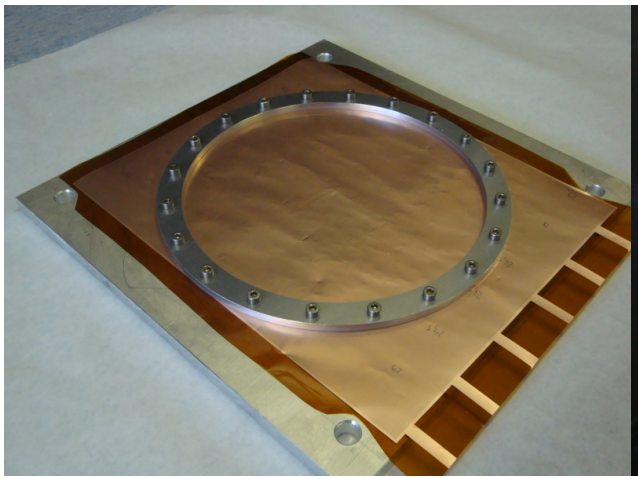
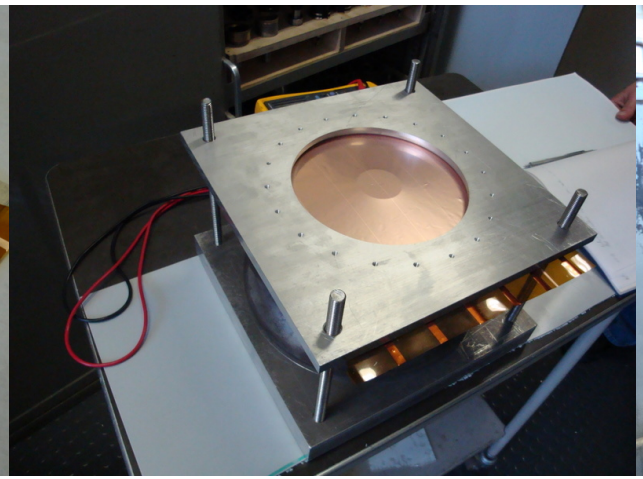
The tooling

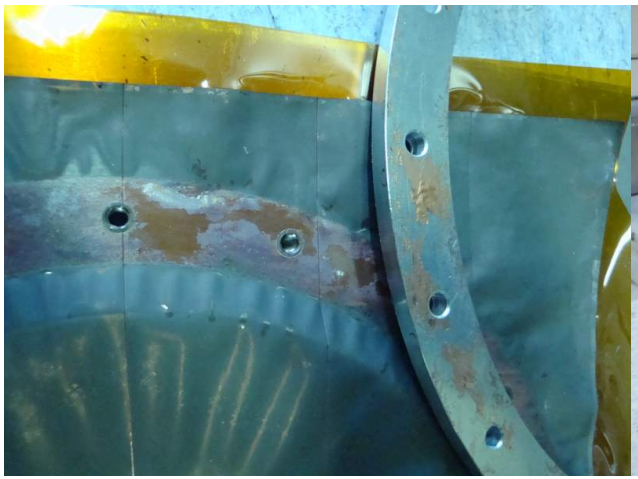
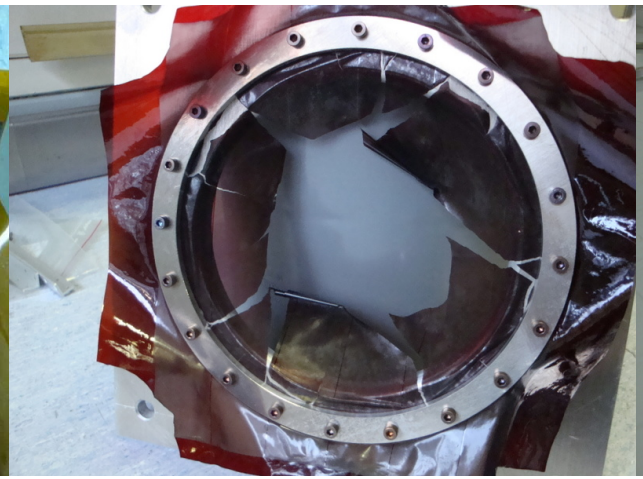
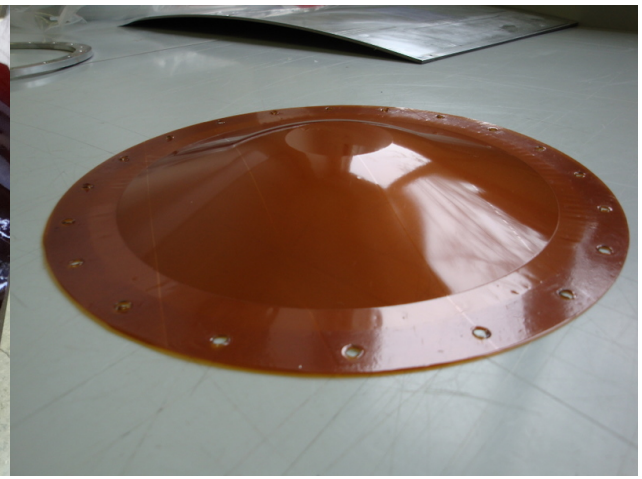


- Minimal amount of custom tooling
- The flat GEM is mounted on the plate without possibility to slip
- Opening diameters and radii of curvature can be individually tuned
- Temperature $\geq 350^{\circ}$C for about 24 hours
- Weight of $\sim$ 20kg applied

Forming spherical GEMs

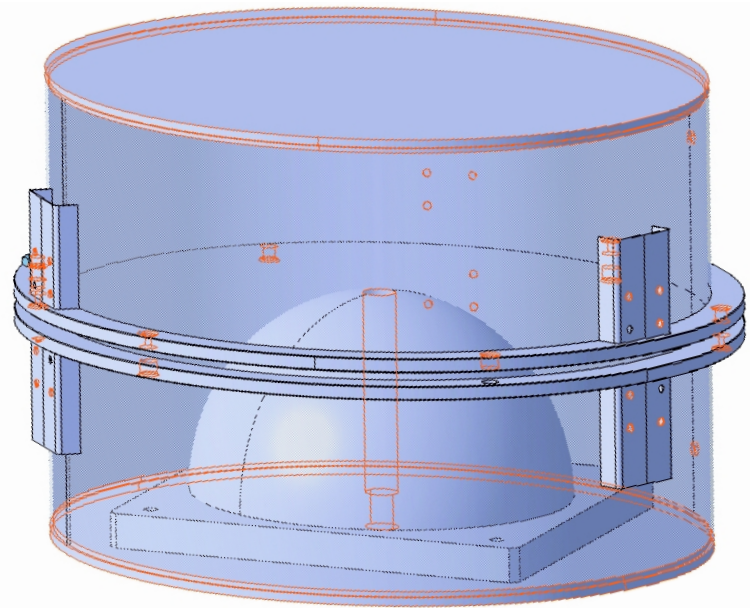
First tests: mapping a multi-parameter space

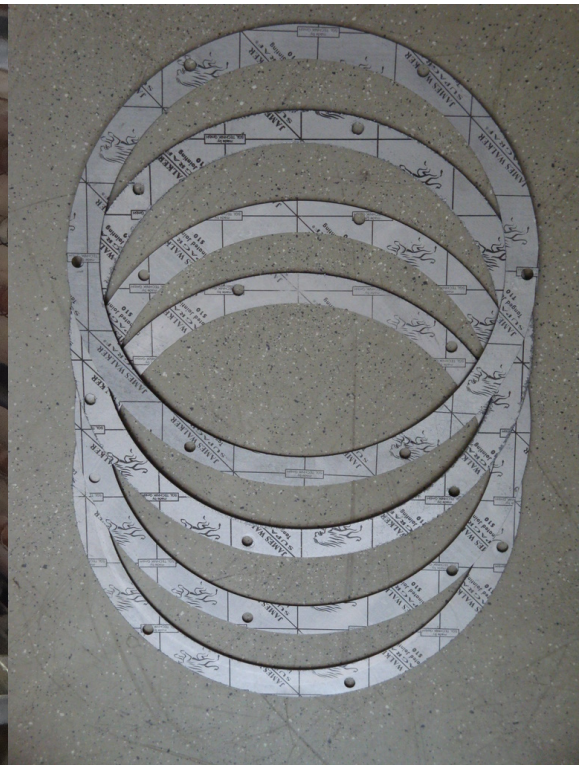



Forming spherical GEMs

Gas tight enclosure

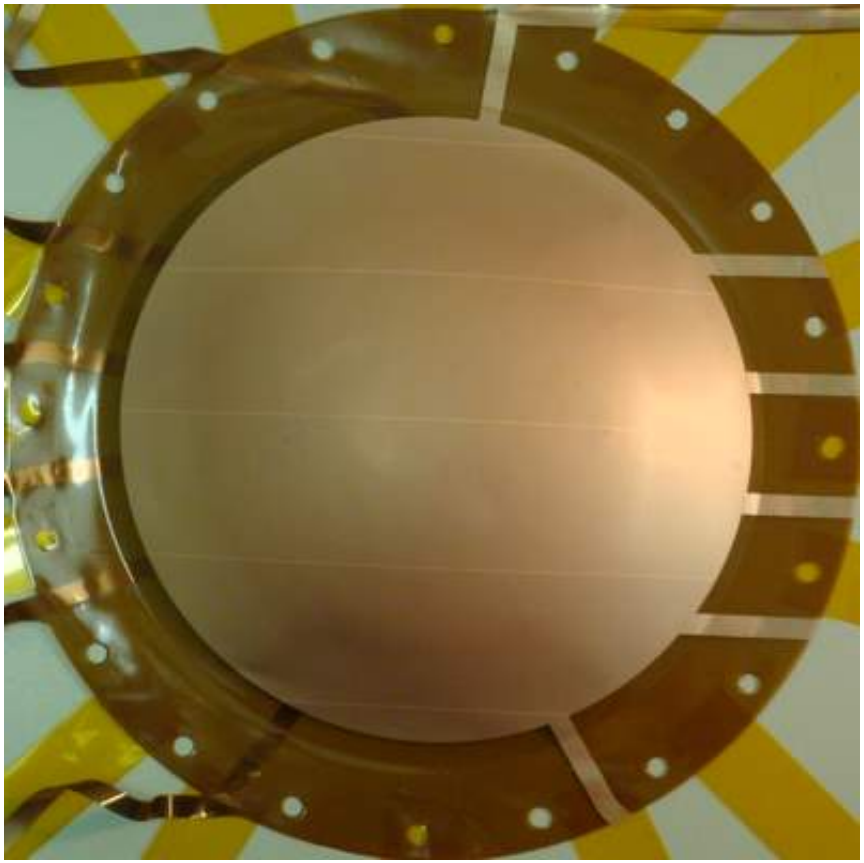


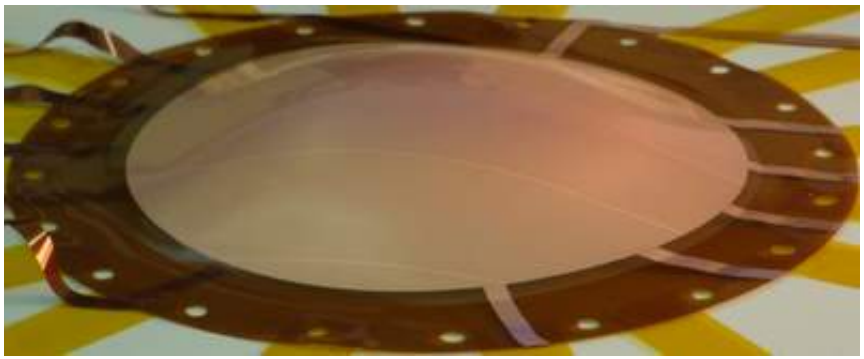


- Stainless steel box encloses the setup completely
- Fits entirely in the oven, and can still be opened easily
- Upgraded to work in a vacuum ($\sim 10^{-4}$ mbar)

Forming spherical GEMs

In a vacuum



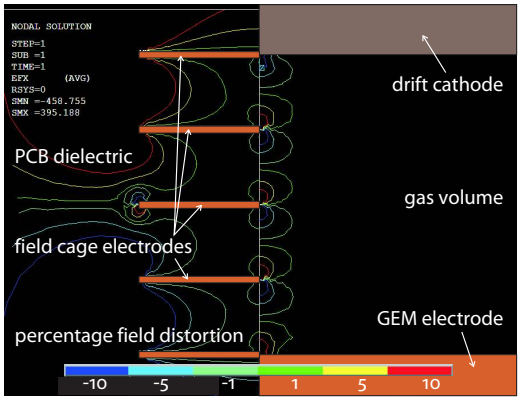


Great improvements

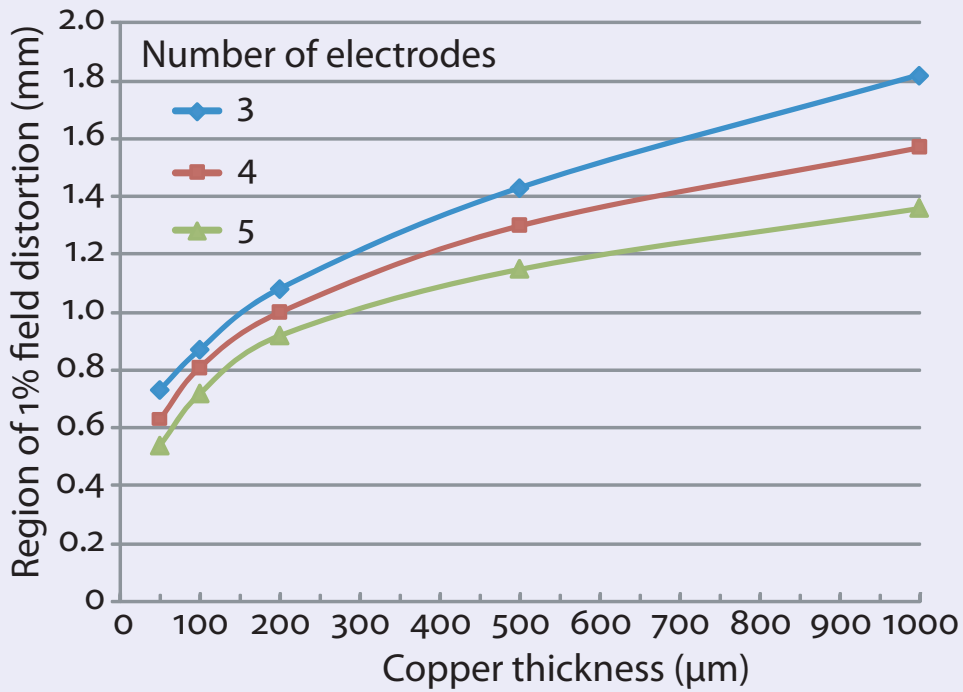
- Holds high voltage, 650 V in air, few nA leakage
- Still needs to be cleaned after forming, seems to be inevitable

Other components

Conical field cage



- Lateral extent of fringe field between the spherical planes is proportional to width of conversion gap
- Radial field quality is critical for parallax-free property
- A field cage can be made of a standard multilayer PCB
- Resistive divider distributes voltages over layers
- The cage can be the mechanical fixture for the GEM

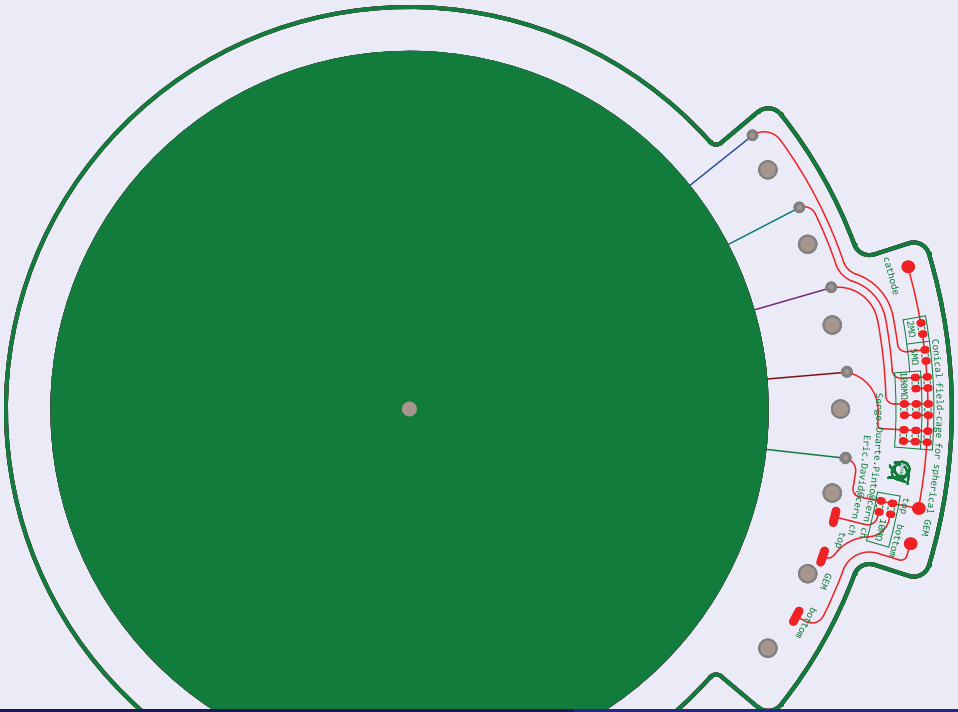


Other components

Conical field cage

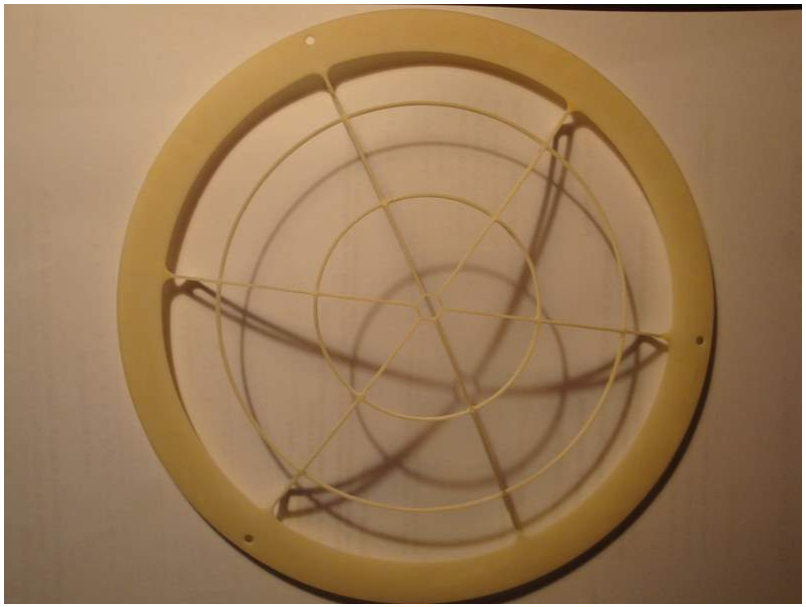
Design of conical field cage for first prototype

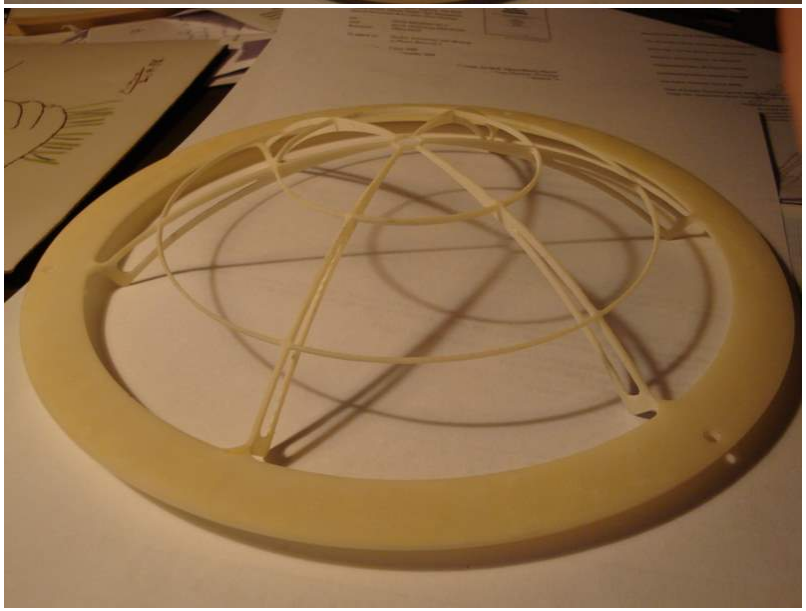
- 5 electrodes
- Also supplies GEM and fixes it mechanically
- Fabrication is fast and cheap



Other components

Curved spacers



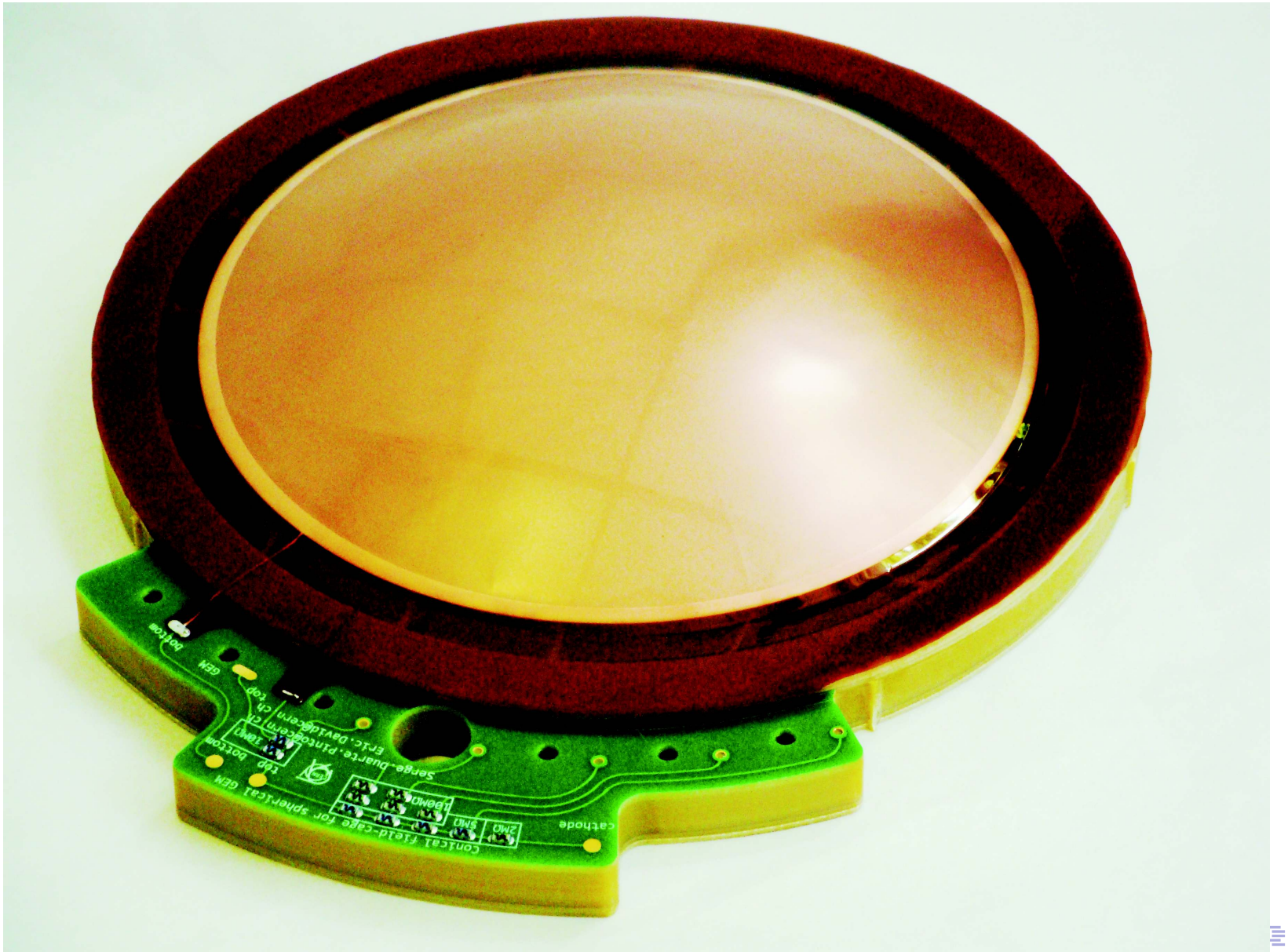


Curved spacer in drift gap

- Not certain if it is needed, spherical GEMs seem rather self-supporting
- Fabrication less straightforward than flat spacers
- Stereolithography is accurate, fast, and affordable
- Improved design solves minor flaws

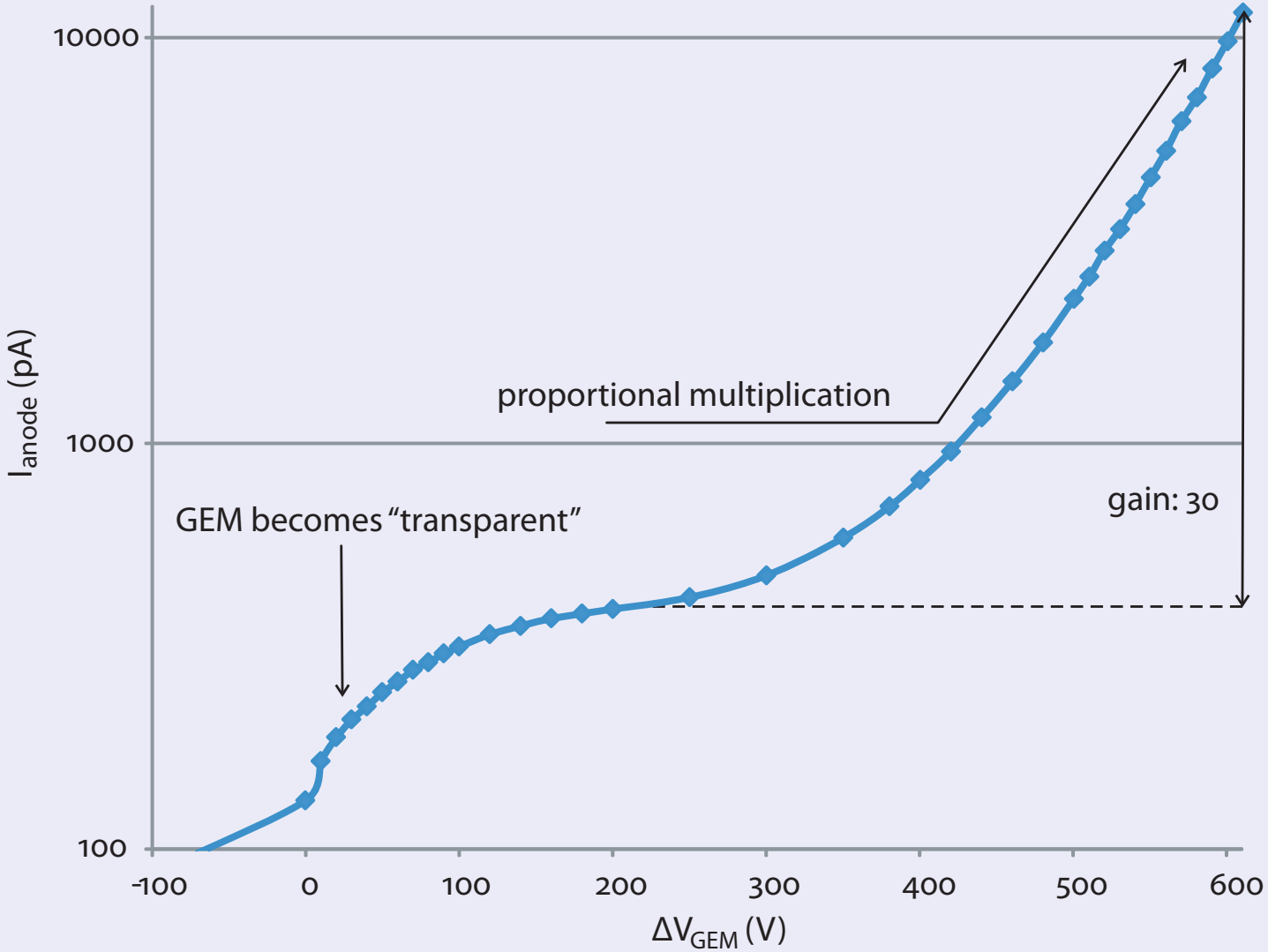
Final assembly

Before integration in detector



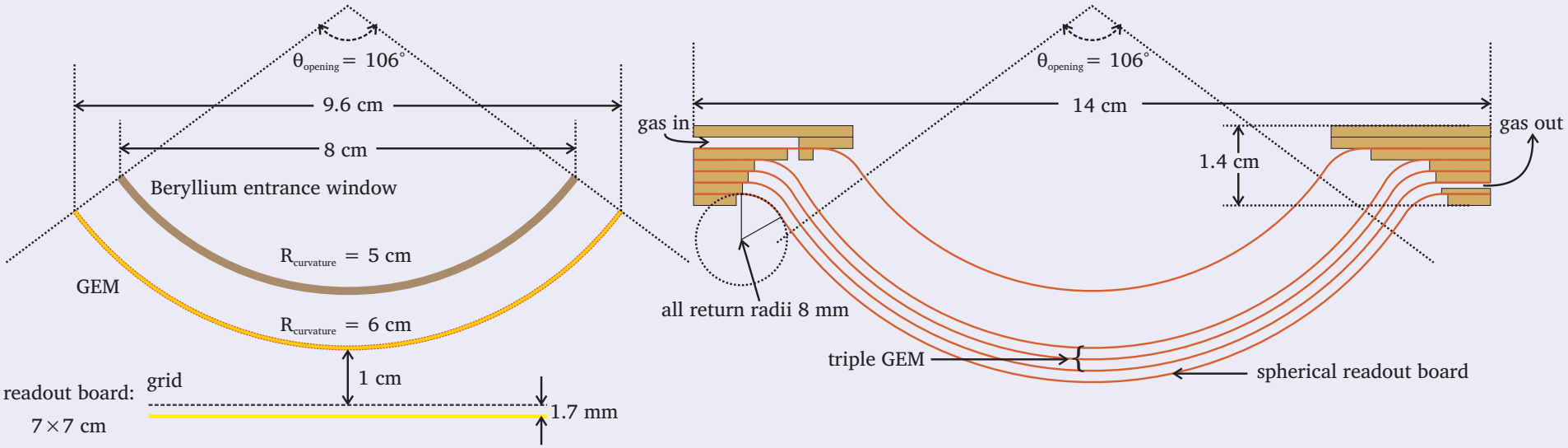
First results

At 2 bar pressure



Spherical multiple GEM

Solves transfer issues

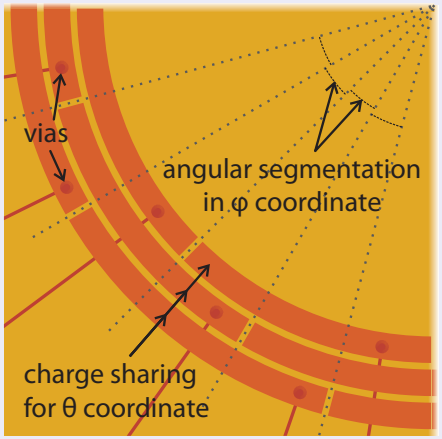


Multiple GEM with spherical readout

- We can recycle some tooling and films from existing design
- With 2D readout one can compensate gain variations with θ
- For mechanical tolerance, we may need to increase inter-GEM spacing
- Spherical readout board will be highly non-trivial

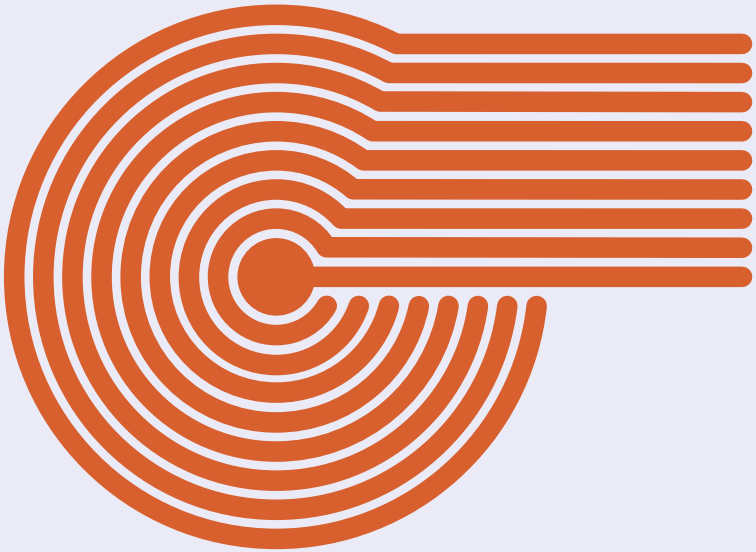
Spherical triple GEM

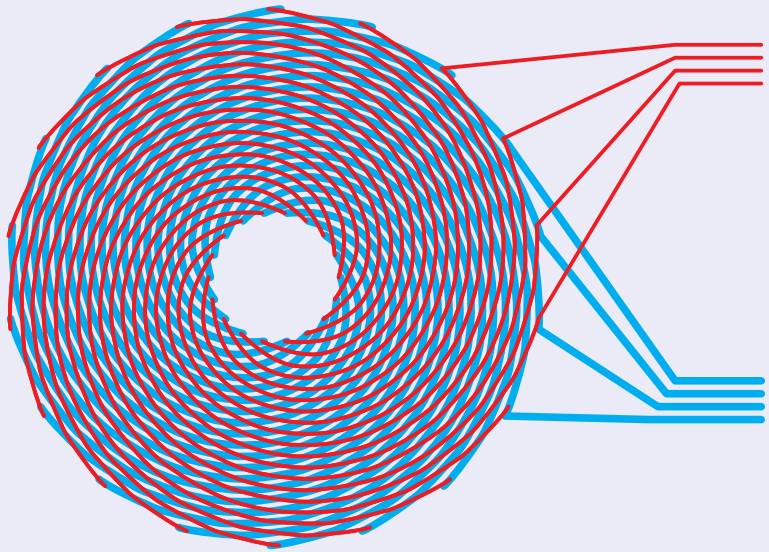
Considerations for a readout board



Constraints on spherical readout board

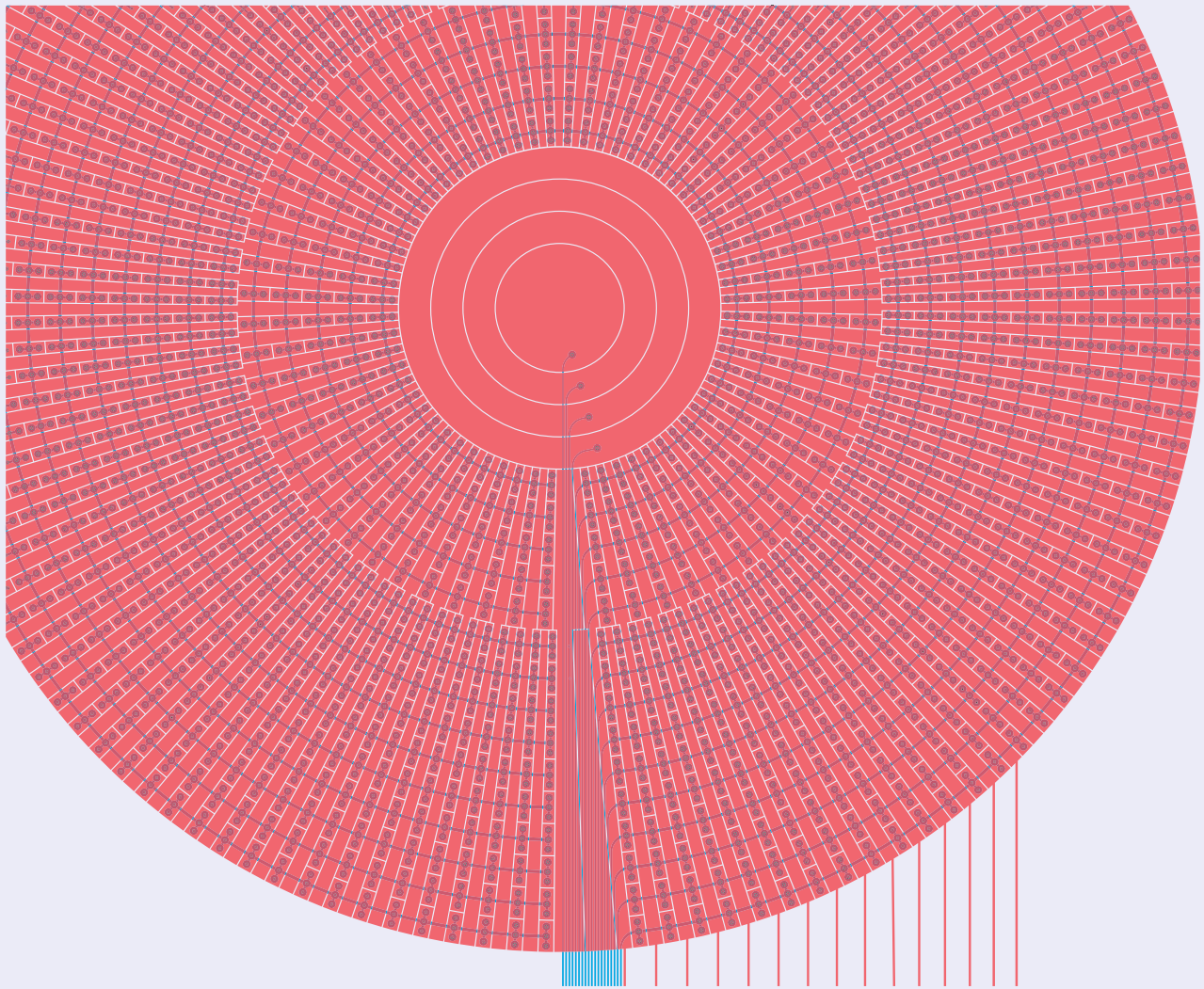
- Vias are less reliable, would need extensive tests
- No X-Y-strips, as adhesive is not compatible with 350°C
- One could pattern 2D strips on the faces of a GEM
- No rigid board. *Or invent spherical image transfer*
- Rigid board patterned by mechanical engraving





Spherical readout board

A feasible design



θ-coordinate readout channels φ-coordinate readout channels

Pads & strips

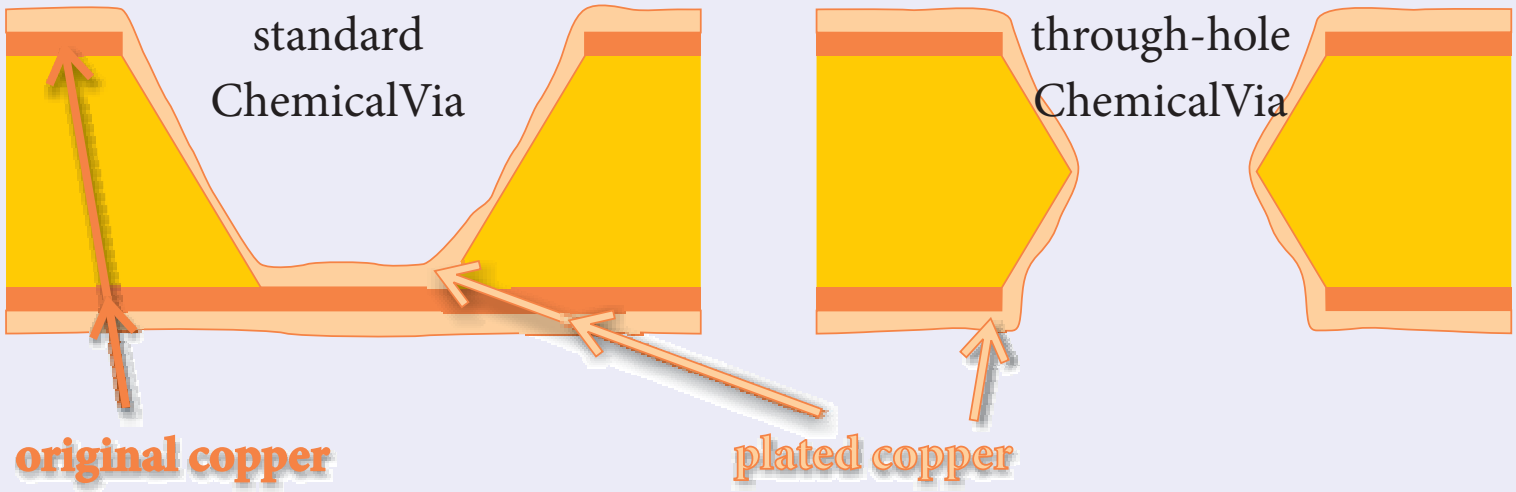
This readout (picture is symplified) appears compatible with spherical processing. If only the (triplicated) vias will hold . . .

Spherical readout board

An unbreakable via

A strain-resistant via technology

- Electrical contact should not depend critically on connection between two layers of copper.
- The solution: a metallized biconical GEM hole.



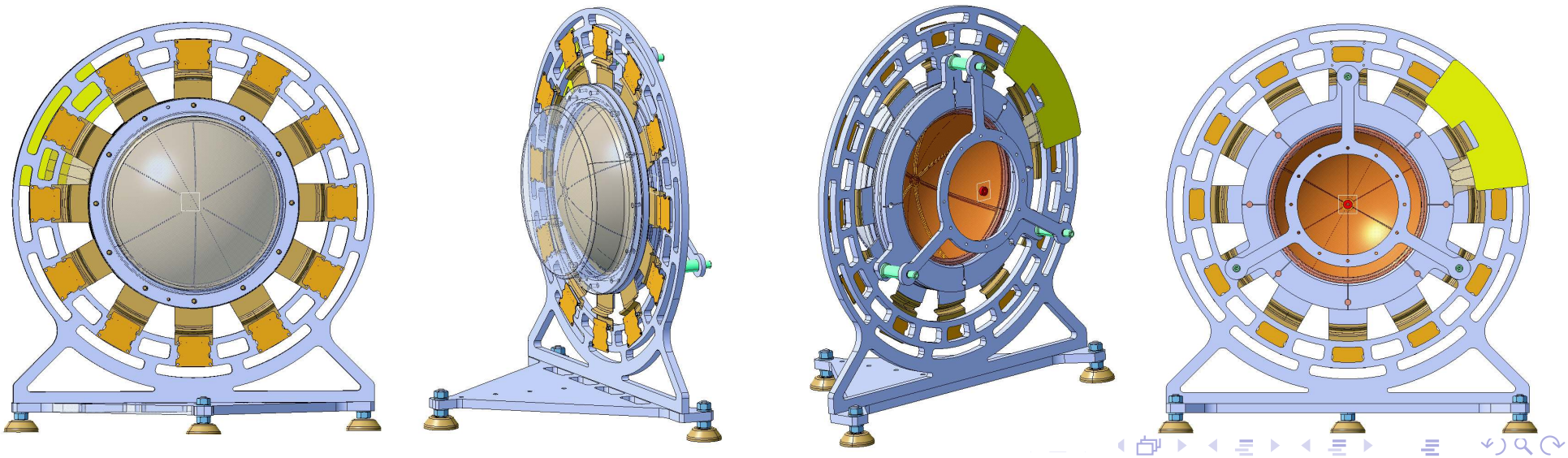
Conclusions & outlook

Moving closer to implementation

Spherical GEMs

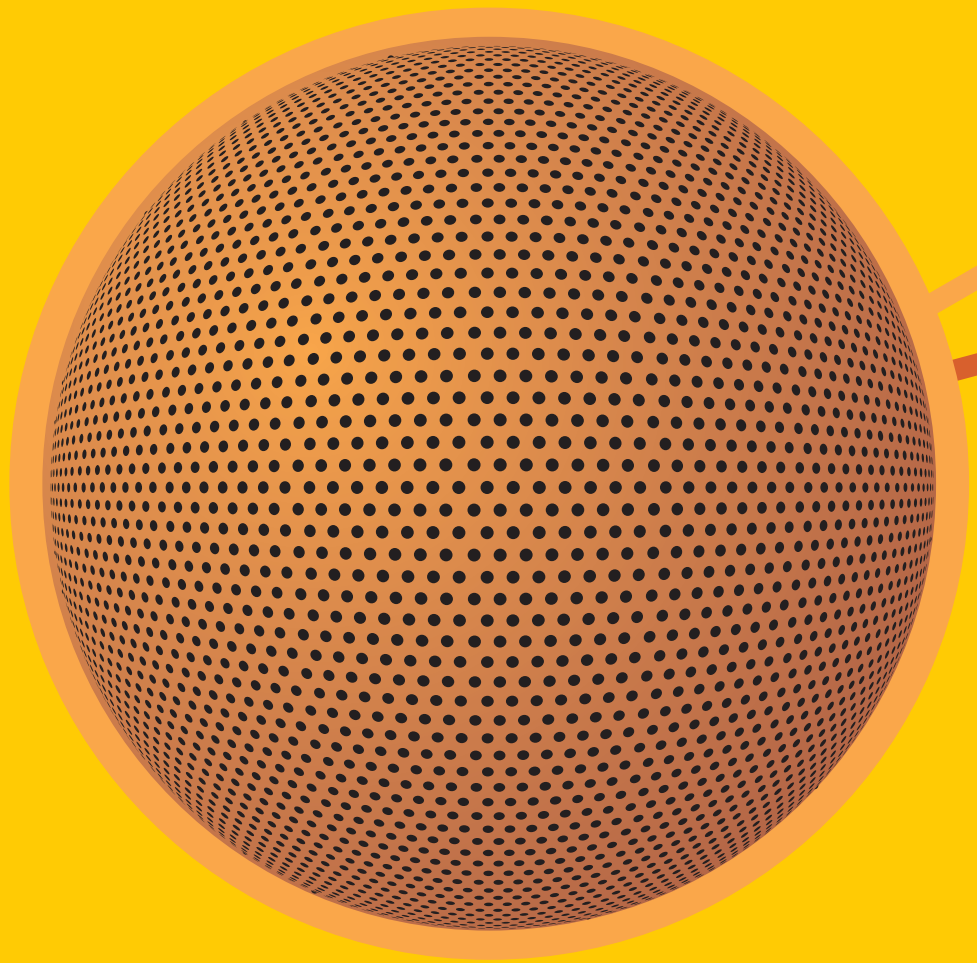
- It was a long way to the first satisfactory spherical GEM
- First assembly is now working
- Plenty of ideas for further improvement

S. Duarte Pinto et al., 2009 Jinst 4 p12006.
S. Duarte Pinto et al., IEEE-NSS 2009 conf. rec.
S. Duarte Pinto et al., IEEE-NSS 2010 conf. rec.



Industry-academia matching event on micropattern gaseous detectors

26 -- 27 April 2012, Annecy, France



Thank you!

Any questions?