



Diffraction studies with gas detectors

Powder diffraction with 2D detector

Spherical
GEMs

Serge
Duarte Pinto

Motivation

Parallax error

Single
spherical
GEM

Heat forming

First results

Vacuum box

First success

Deposits

Current state

Field cage

Design

Spacers

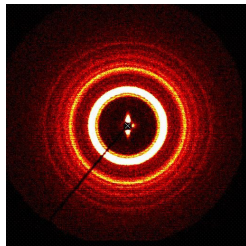
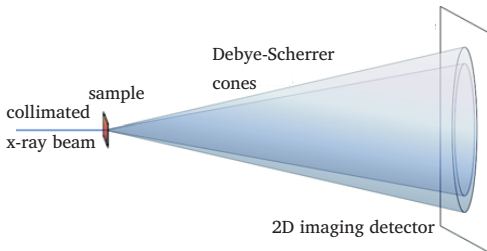
Multiple
GEM

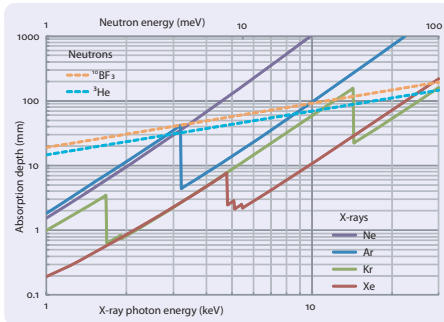
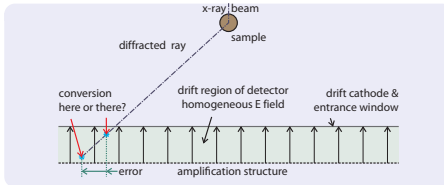
Readout board

Conclusions

Powder diffraction and detector requirements

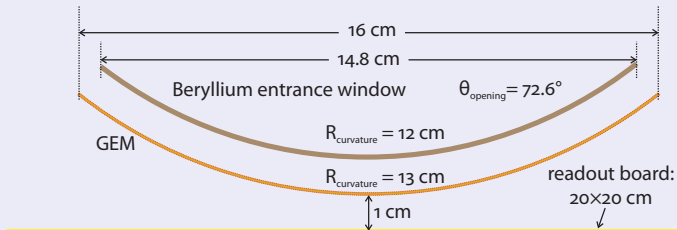
- Circular patterns if sample is powder of randomly oriented crystals.
- Need a large area detector (large for solid state standards)
- Gas detector seems natural solution, but introduces parallax error





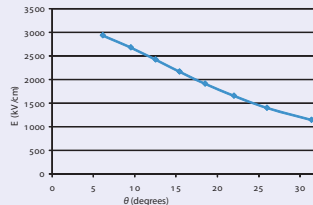
Methods to suppress parallax error

- 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)

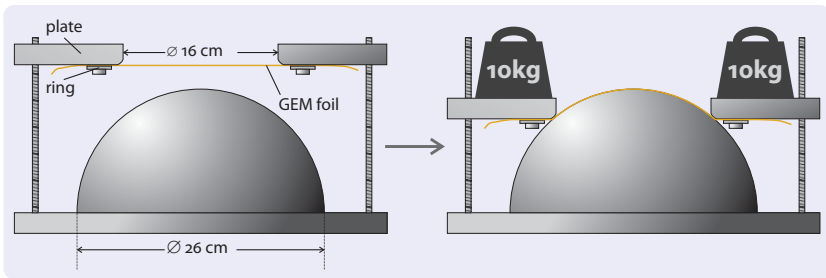


Single spherical GEM

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



Work done in collaboration with a commercial partner. An agreement is under negotiation with the knowledge and technology transfer division (KTT).



- 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 350°C for about 24 hours
- Weight of $\sim 20\text{kg}$ applied



Forming spherical GEMs

First tests: mapping a multi-parameter space

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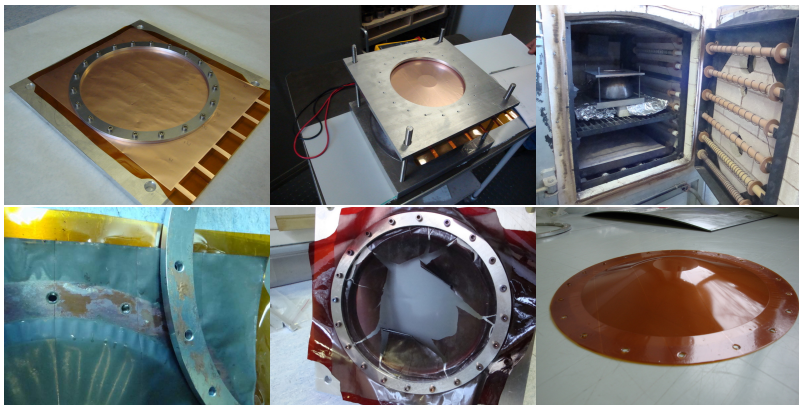
Field cage
Design

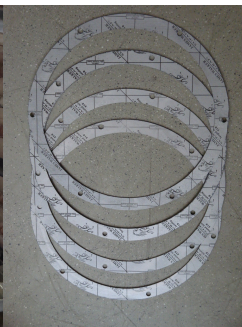
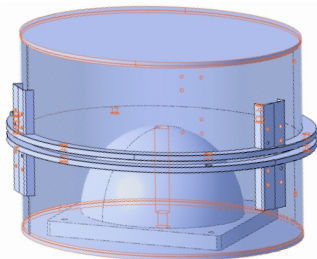
Spacers

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Conclusions





- Stainless steel box encloses the setup completely
- Fits entirely in the oven, and can still be opened easily
- Flow of argon to prevent oxidation
- Upgrade to work in a vacuum

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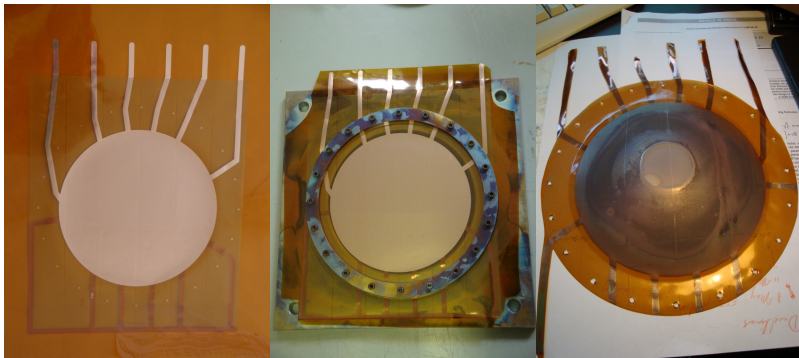
Design

Spacers

Multiple GEM

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Conclusions



- GEM bends properly if temp. cycle is ~ 24 hrs, at ~ 20 kg of pressure
- It holds high voltage! 650 V in air, few nA leakage



Forming spherical GEMs

Deposits

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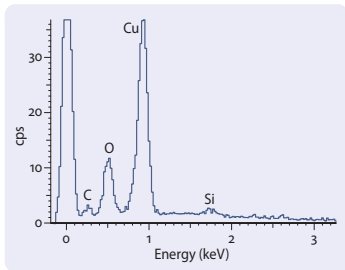
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Conclusions



Thin film growth

- ↑ Apart from some oxidation, a thin film deposits on the electrodes
- ← Elemental analysis indicates it consists mainly of copper oxide
- ... Improving the vacuum further helps a lot to eliminate this phenomenon



Forming spherical GEMs

In a vacuum

Spherical GEMs

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Conclusions



We can still improve

- Looks better than ever before
- Holds high voltage
- Still needs to be cleaned after forming, will improve vacuum to eliminate that step
- Outgassing pre-treatment to prevent polymer deposition during forming



Conical field cage

For a well-defined field in the conversion region

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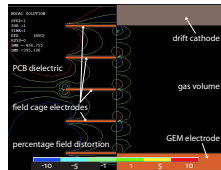
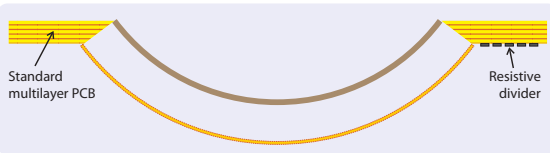
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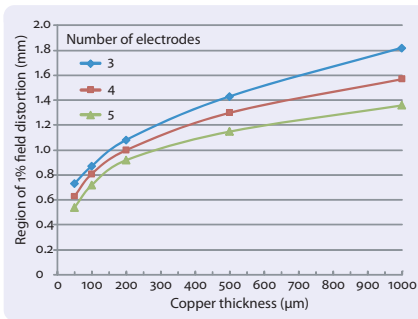
Multiple GEM

Readout board

Conclusions



- Lateral extension 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





Conical field cage

Made from multilayer PCB

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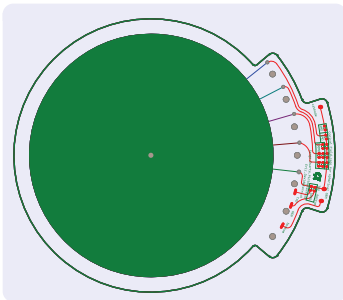
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Conclusions

Design of conical field cage for first prototype

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





Spacers

Curved structure to keep accurate spacing

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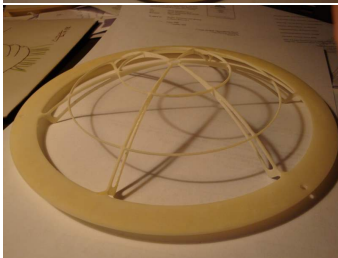
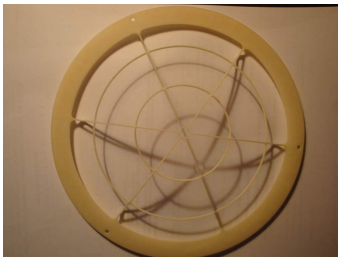
Spacers

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Conclusions



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





Plan for prototype

Multiple spherical GEM with spherical readout

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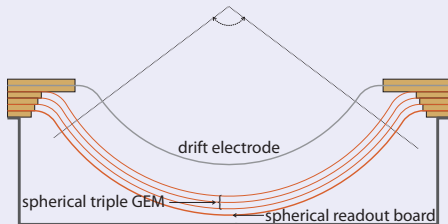
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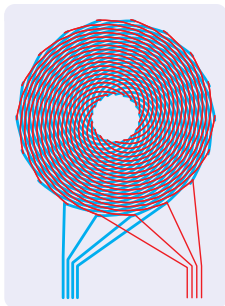
Multiple spherical GEM

- Thin foil entrance window (x-ray) or aluminum spherical cathode/window (neutrons)
- Xe or Kr, or high pressure ^3He
- High sensitivity due to thin window, rather than high absorption efficiency
- No charge transfer issues
- Mechanical tolerances between GEMs are tight: need spacers
- Spherical readout board

Sketch of a spherical triple GEM detector

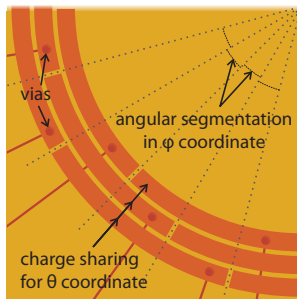


For the final applications, pure noble gases are foreseen (no quencher). Purity is maintained by getters.



Constraints on spherical readout board

- Vias are less reliable, would need extensive tests
- No traditional 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



- It was a long way to the first satisfactory spherical GEM
- Processes are now understood, and we can make spacers and field cage
- First implementation in a detector will be within weeks
- Results in operation will guide the way for further improvement
- Preparing spherical double GEM with spherical readout for the summer

