

Diffraction studies with gas detectors

Powder diffraction with 2D detector

Spheric GEMs

Motivation

Parallax e

Heat formin First results Vacuum bo First succes

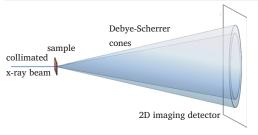
Field cag

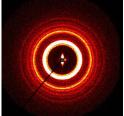
Spacers Multiple GEM

Conclusio

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 studies with gas detectors

Parallax error & how it degrades resolution



Serge Duarte Pi

Motivation Parallax error

Single spherica GEM

Heat forming First results Vacuum box First success Deposits Current state

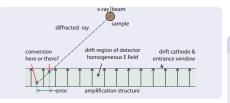
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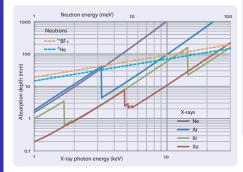
Design

Spacers

Multiple GEM Readout board







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)

Plan for prototype Single spherical GEM with flat readout

Spheric GEMs

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Motivation Parallax er

Single spherical GEM

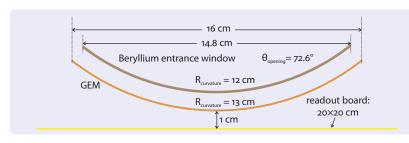
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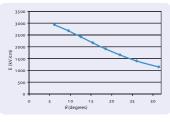
Readout boar

Conclusio



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).





Forming spherical GEMs The tooling

Spheric GEMs

Duarte Pir

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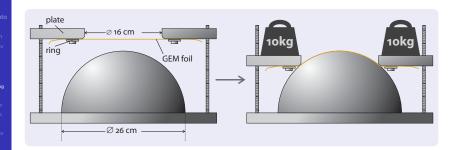
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Conclusio

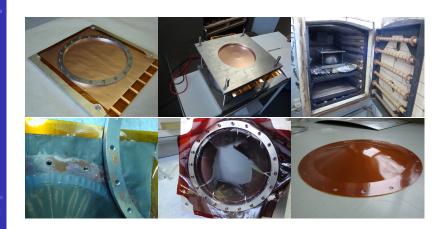


- Minimal amount of custom tooling
- The flat GEM is mounted on the plate without possibility to slip
- Opening diameters and radii of curvature can be individually tuned
- Temperature 350°C for about 24 hours
- ullet Weight of \sim 20kg applied



Forming spherical GEMs First tests: mapping a multi-parameter space

First results





Forming spherical GEMs Gas tight enclosure

Spheric GEMs

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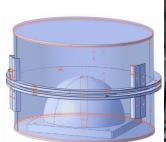
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Conclusio





- 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



Forming spherical GEMs Using a GEM with modified electrodes

Spheric GEMs

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Motivation

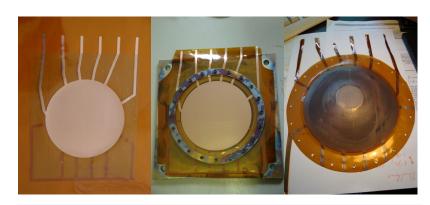
Single spheric GEM

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Multiple GEM

Conclusio



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

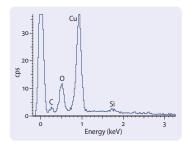


Forming spherical GEMs Deposits

Deposits







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

Spherica GEMs

Serge Duarte Pint

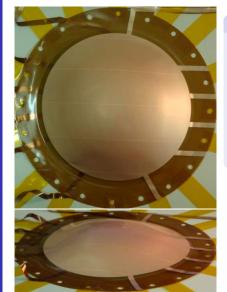
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Pield cage
Design
Spacers
Multiple

GEM Readout boar

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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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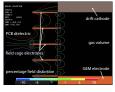
Field cage

Space

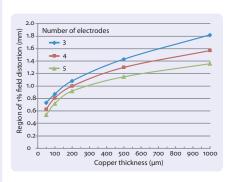
GEM Readout boar

Conclusion





- 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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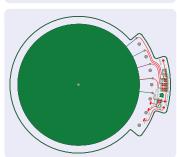
Field cag Design Spacers

Multiple GEM Readout boar

Conclusi

Design of conical field cage for first prototype

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





SpacersCurved structure to keep accurate spacing

Spherical GEMs

Serge

Single spheric

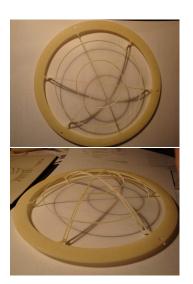
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GEM Readout boar

Conclus



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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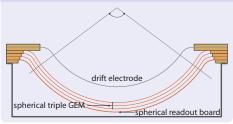
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Conclusio

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.



Spherical triple GEM Considerations for a readout board

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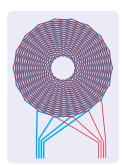
GEM Readout board

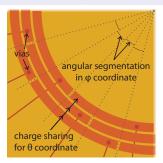
Conclusi



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





Conclusions & outlook Moving closer to implementation

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Conclusions

• 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







