Composite Cryo-Detectors: Considerations on Thermo-Mechanical Stress

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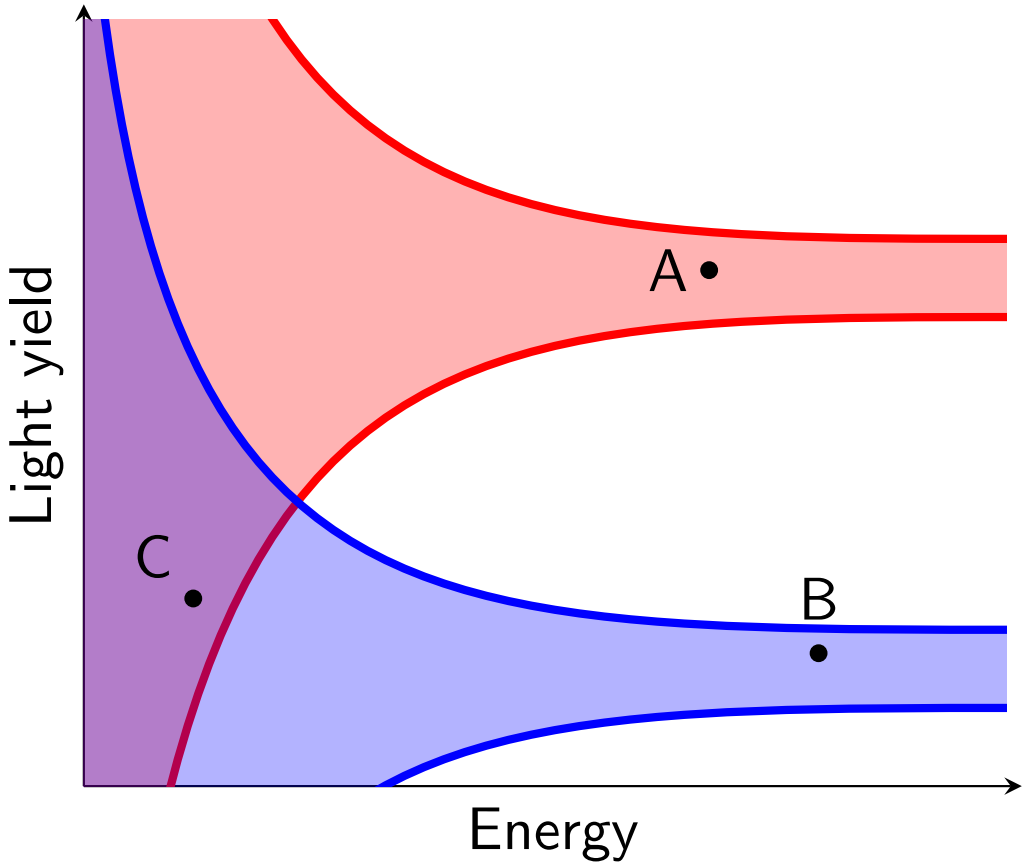
Ringberg, 26/07/2012

CRESST – Light Yield as a mean of Discrimination

Simple case

- 2 Particle types:
  - "Red"
  - "Blue"
- 3 Events:
  - A
  - B
  - C



Detector physics define width of bands

No clear identification possible for event "C"

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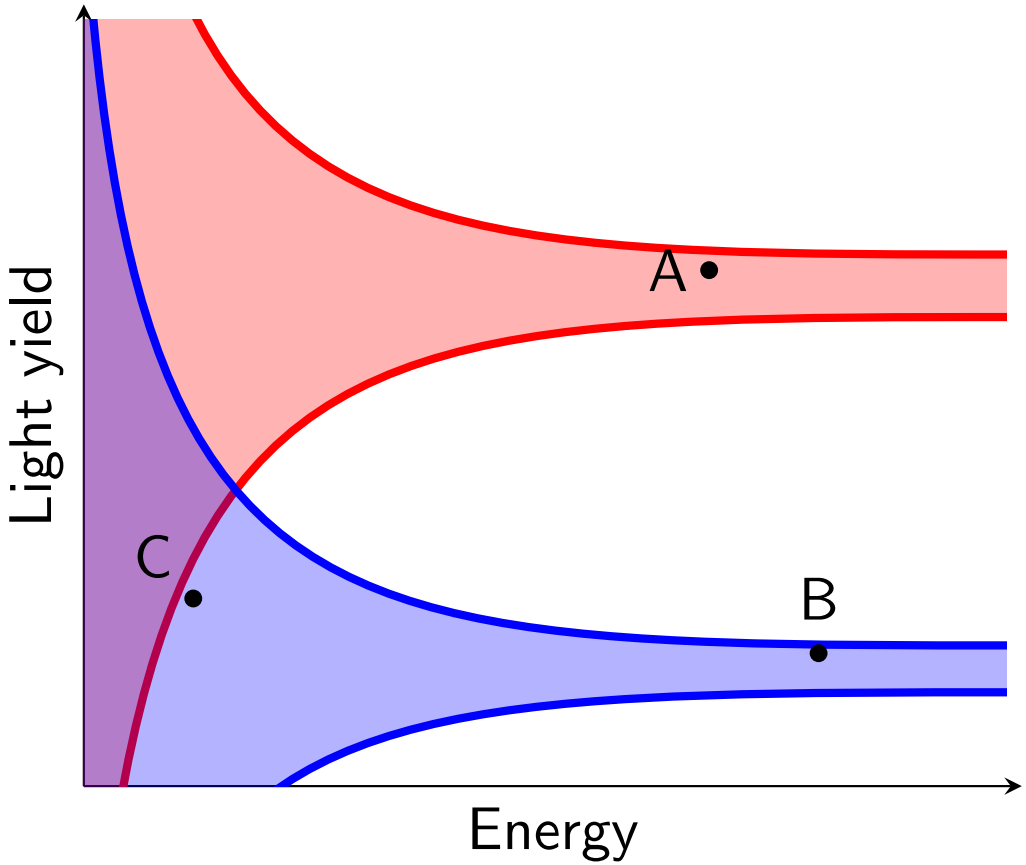
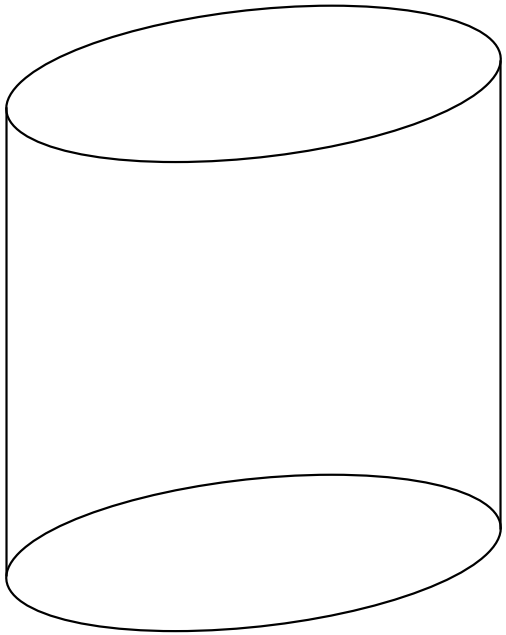


Narrower bands reduce overlap

Assignment more clear → better discrimination, especially for low energies

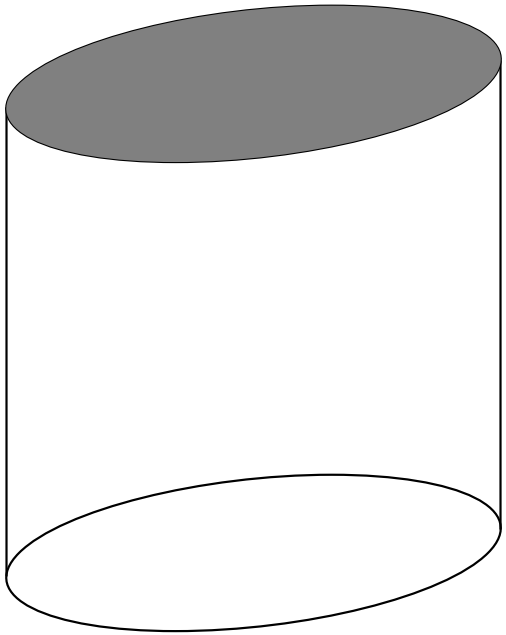
Crystal Degradation in Detector Production



Production Steps

- Scintillating crystal

Crystal Degradation in Detector Production



Production Steps

- Scintillating crystal
- Thin film evaporation

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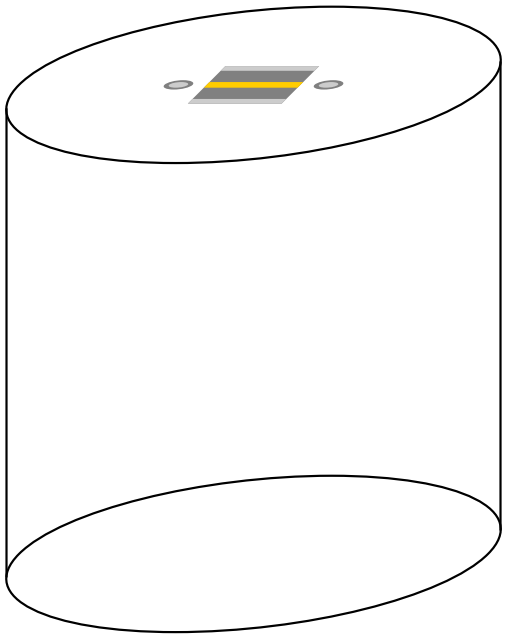

Production Steps

- Scintillating crystal
- Thin film evaporation
- Structuring

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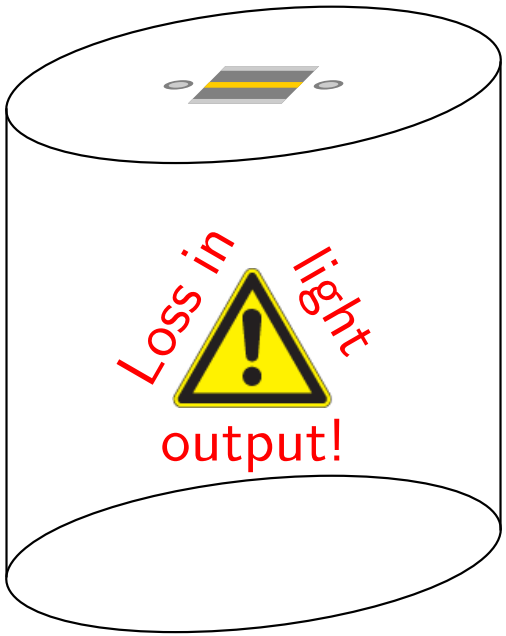

Production Steps

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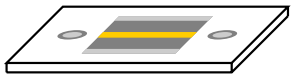
Problem

- High temperatures needed for evaporation
- Oxygen depletion
- Up to 50 % degradation of light output

Improving Light via Composite Technique

Glue a small thermometer carrier



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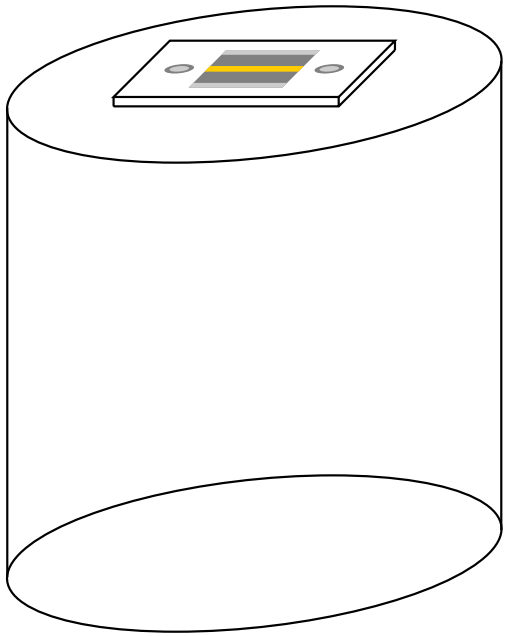
Glue a small thermometer carrier onto a big target crystal

- Improves the light output
- Simplifies production



Improving Light via Composite Technique

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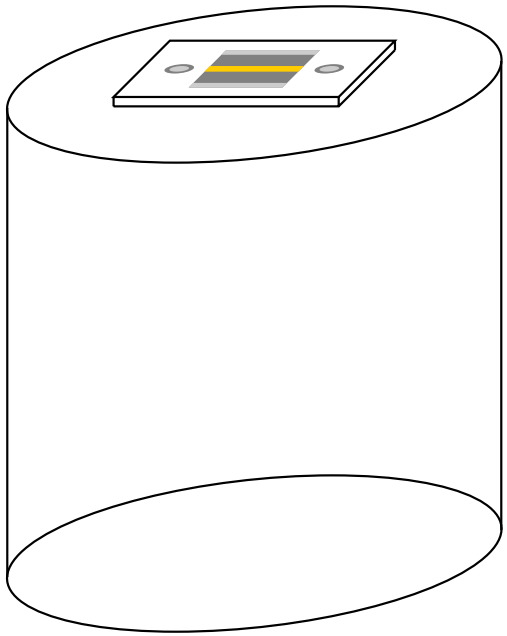
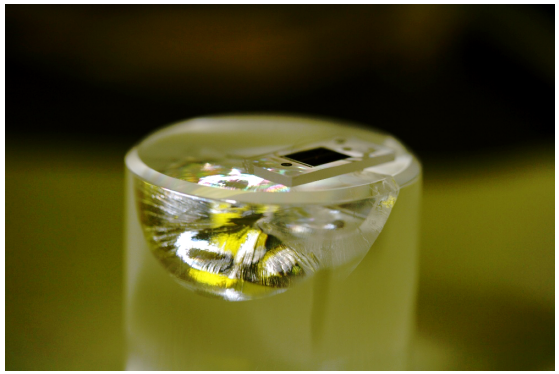
My work: Investigate gluing technique

- Does it improve the detector?
- Discrimination of carrier-events?
- Are there other unwanted effects?



Thermo-mechanical issue: Glue vs. Crystal



2 materials cooled down: $\Rightarrow$ thermo-mechanical stress

- Destruction of the detectors
- Might fake D.M. events

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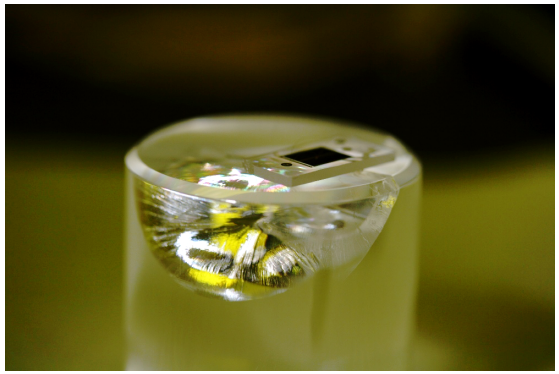

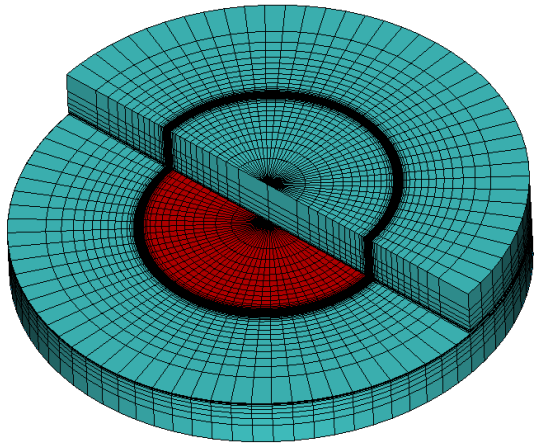

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FEM simulation

- Thickness of the glue layer
- Diameter of the glue layer
- Orientation of the two crystals

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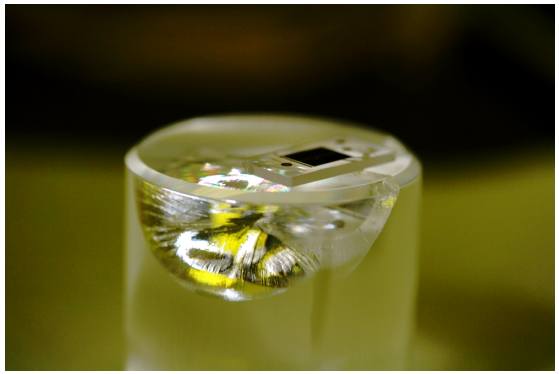

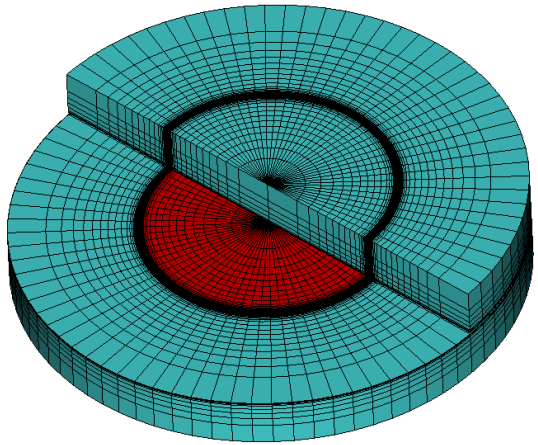

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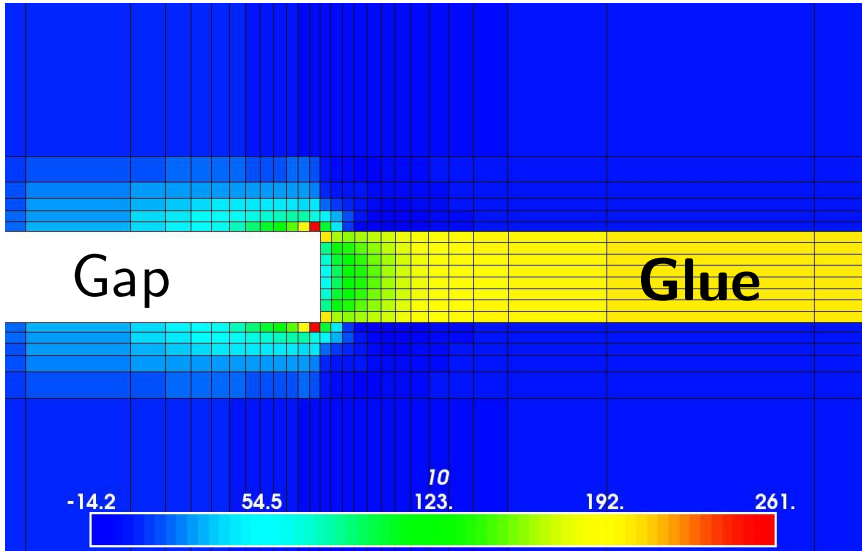
Results:

- Thin ($\leq 40\,\mu m$) layer is crucial
- Diameter and crystal orientation are not very important

Can Cracks Fake Dark Matter Events?



Compression Tension

- Main stress (possible cracks) occurring at the edge
- $\Rightarrow$ Significant part of the phonons headed towards carrier

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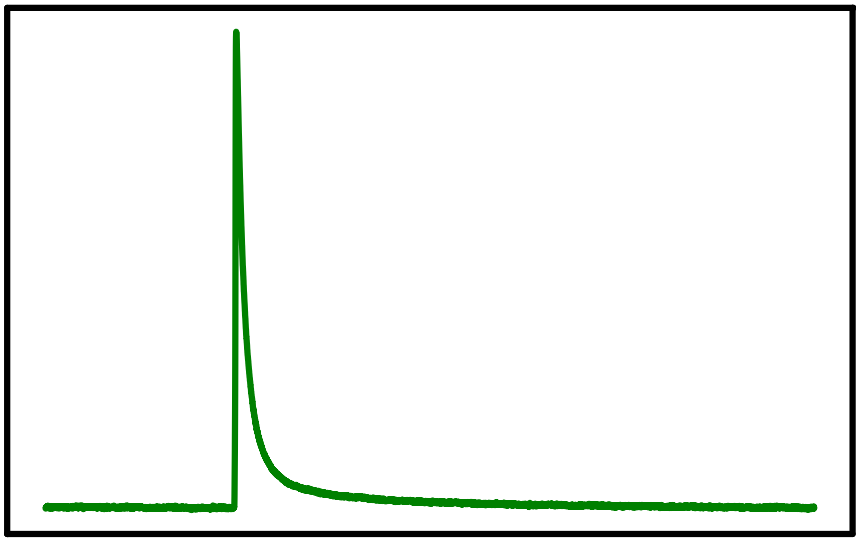
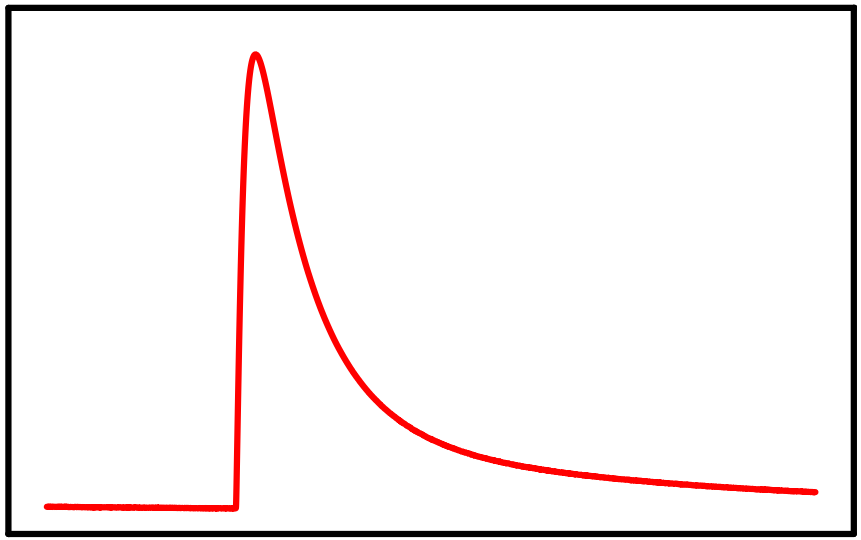


Carrier hit



Target hit

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- Events involving the carrier have a different signal shape
- All carrier like events in Dark Matter data have light

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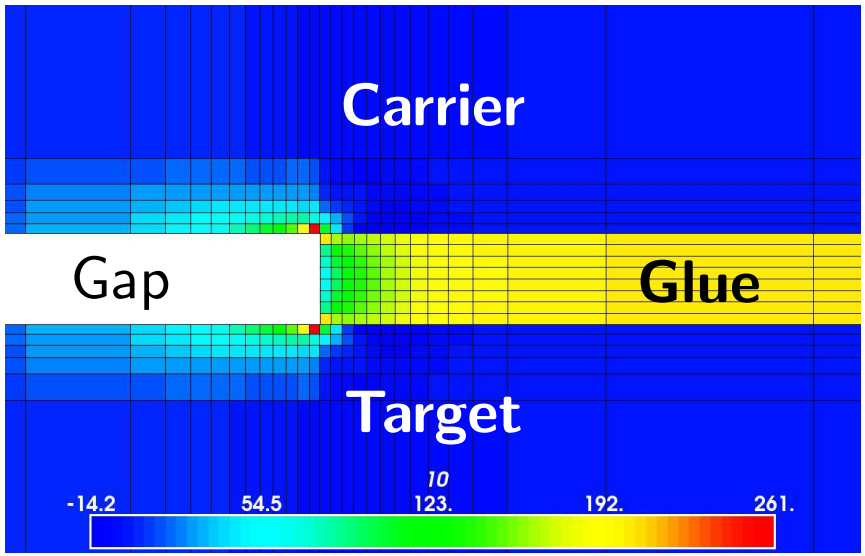

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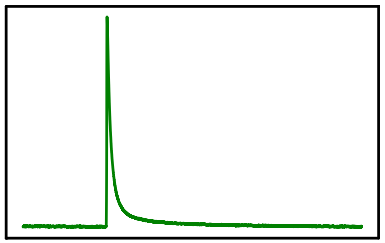

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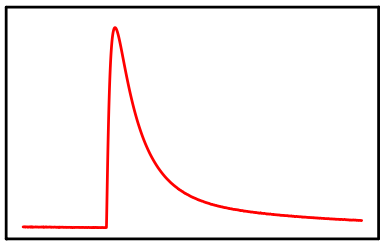

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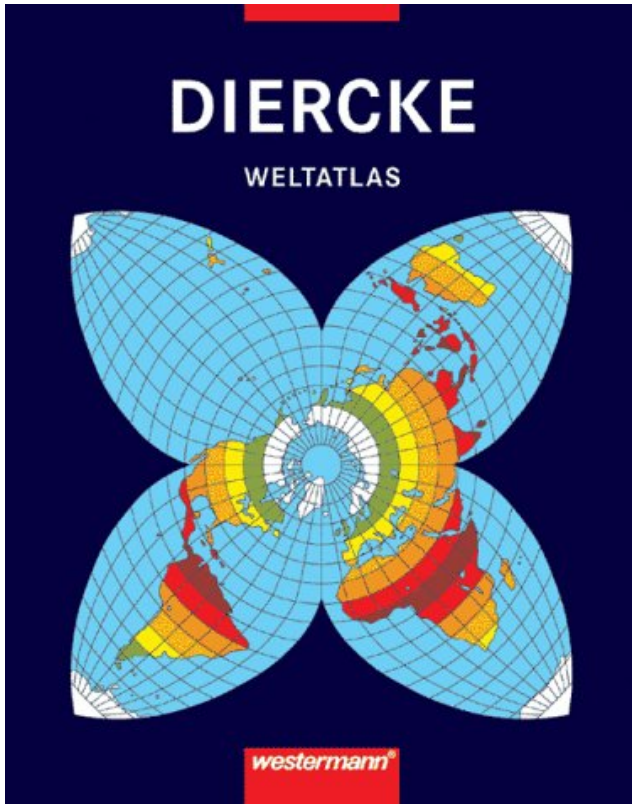
- $\Rightarrow$ Significant part of the phonons headed towards carrier
- Events involving the carrier have a different signal shape
- All carrier like events in Dark Matter data have light
- $\Rightarrow$ The glue does not fake Dark Matter signals

Conclusion

- Light signal crucial for event discrimination
- Composite technique improves light signal
- Thin glue layer avoids cracks
- Glue does not introduce fake Dark Matter signals

The mandatory ATLAS Picture



Thank you for your attention