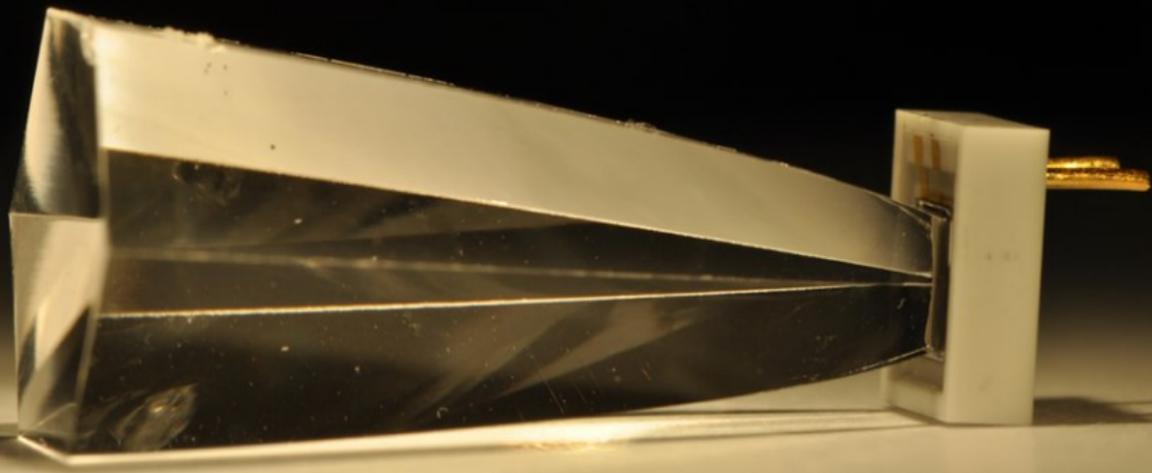


Solid light concentrators for a G-APD-based Cherenkov camera

Ben Huber, University of Zurich UZH
for the UZH CTA group and the FACT collaboration

Joint Annual Meeting of the SPS and APS, June 15th, 2011



Outline

- ▶ Light guides for Cherenkov cameras
- ▶ Design criteria of the FACT light concentrators
- ▶ Production iterations
- ▶ Frontplane assembly

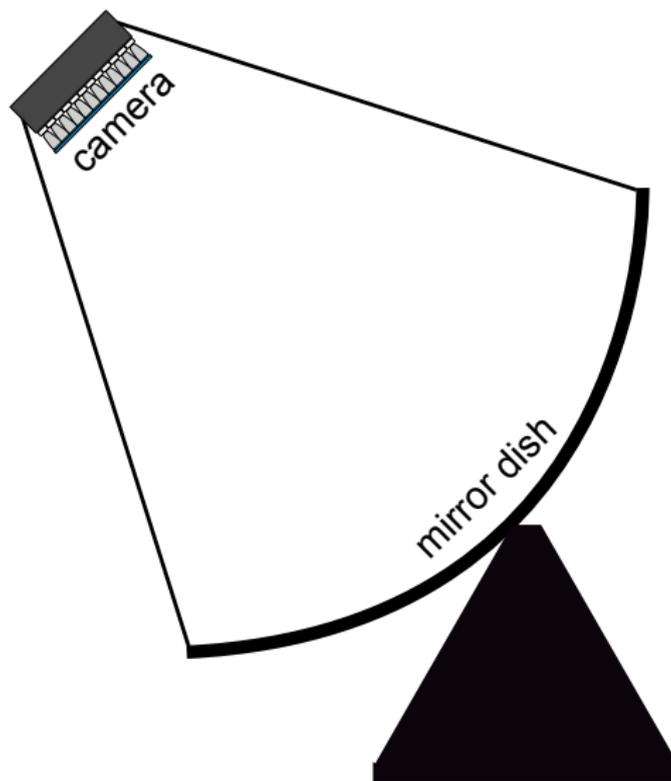
Light guides for Cherenkov cameras

Cherenkov telescopes



Light guides for Cherenkov cameras

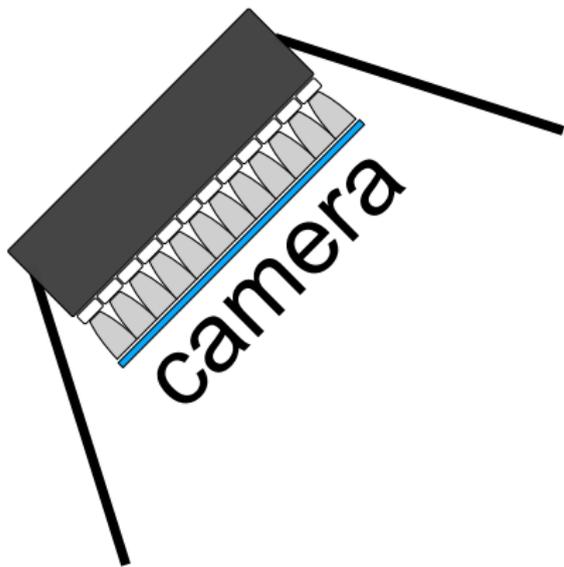
Cherenkov telescopes: a schematic sketch



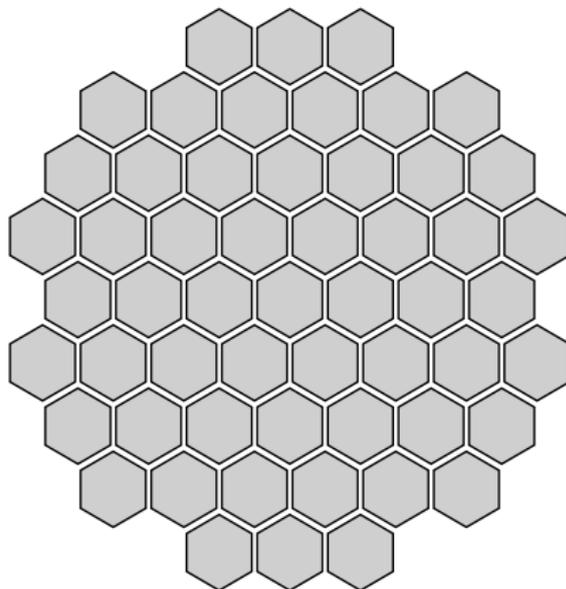
Light guides for Cherenkov cameras

Cherenkov telescopes: the camera

closer view on the camera:

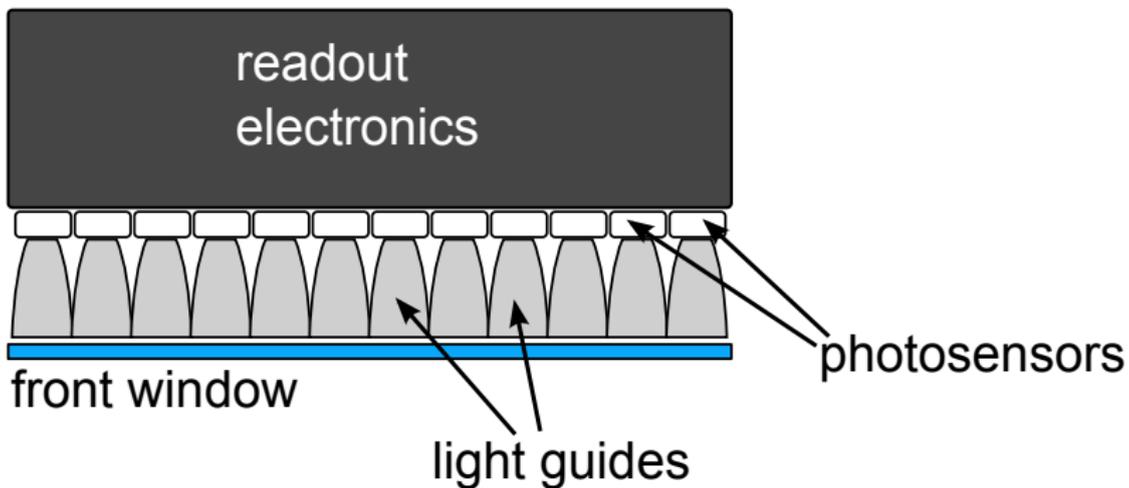


front view:



Light guides for Cherenkov cameras

Cherenkov telescopes: the camera



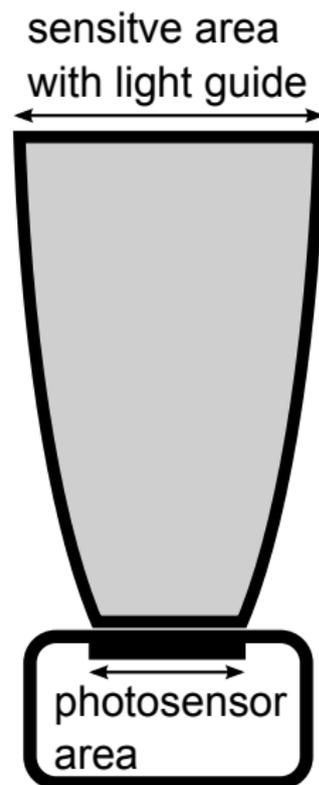
Light guides for Cherenkov cameras

Light guides are used to ...

- ▶ transform a small photosensor area to a large sensitive area
- ▶ and by that:
provide full camera coverage with
minimum amount of photosensor area

this is done by

- ▶ applying Liouville's theorem: decrease beam cross section by increasing the photon angular distribution



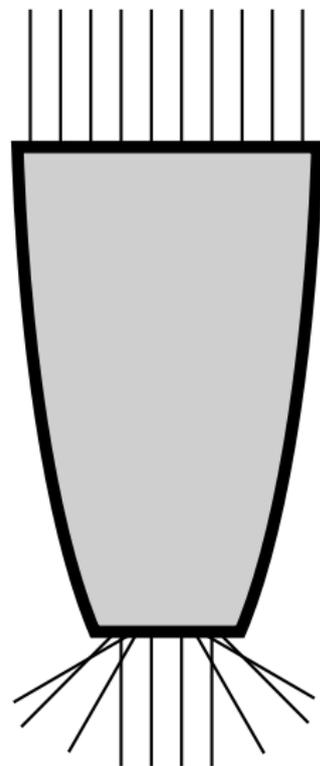
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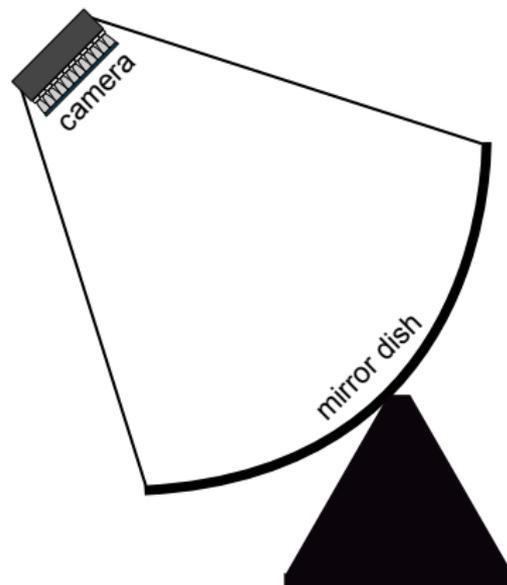
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Light guides for Cherenkov cameras

Additionally, the light guides are designed to ...

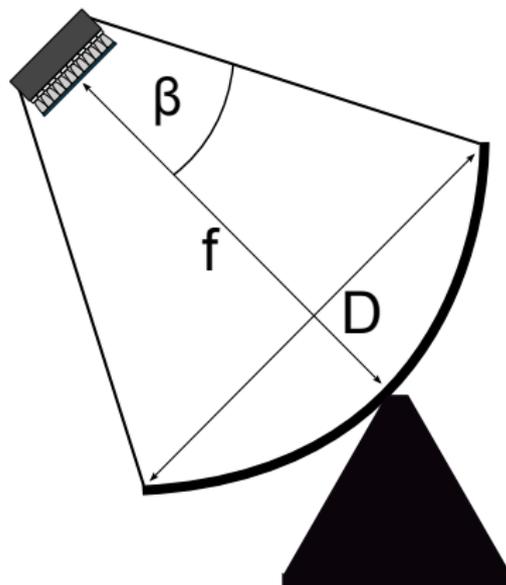
- ▶ **improve signal-to-noise ratio by cutting off environmental stray light (Night Sky Background).** Their angular response is limited by cutoff angle $\beta = \arctan\left(\frac{D}{2f}\right)$



Light guides for Cherenkov cameras

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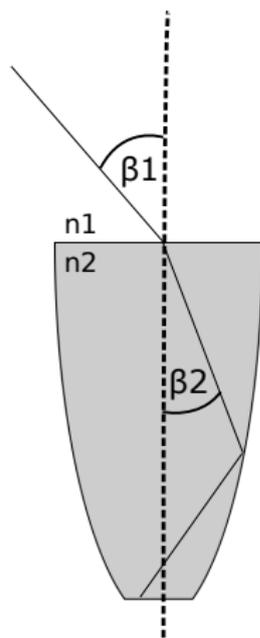
The motivation for solid material

solid cones provide ...

- ▶ **total internal reflection** with **nearly 100% reflectivity**
- ▶ a **larger area concentration** compared to hollow funnels **at the same cutoff angle**
- ▶ **minimum Fresnel losses** in case of a **camera front window**
- ▶ a possible production mechanism: **injection moulding**

solid cones require ...

- ▶ **minimum surface roughness**
- ▶ **good light transmittance**
(for FACT: 78% at 350 nm, 95% at 400 nm)
- ▶ an **excellent coupling** to the photosensor



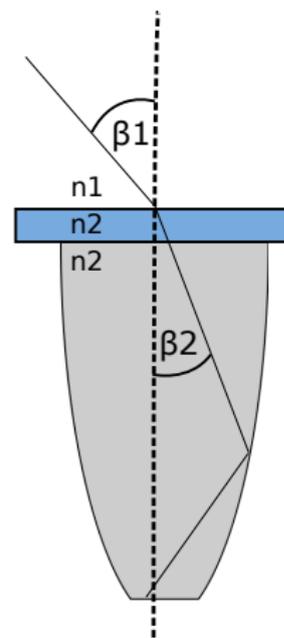
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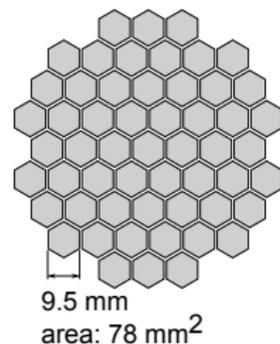
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Design criteria for the FACT light concentrators

The present light guides were designed ...

- ▶ to match a **G-APD** with **3x3 mm²** sensitive area and a top layer with **$n \approx 1.5$** (Hamamatsu MPPC S10362-33-100C)
 - ▶ **square-shaped output area**
- ▶ to allow for optimum fill factor and equal distances between pixel centers
 - ▶ **hexagonal entrance**
- ▶ for a telescope with $f/D=1.4$
 $\beta = \arctan\left(\frac{D}{2f}\right) \approx 20^\circ$

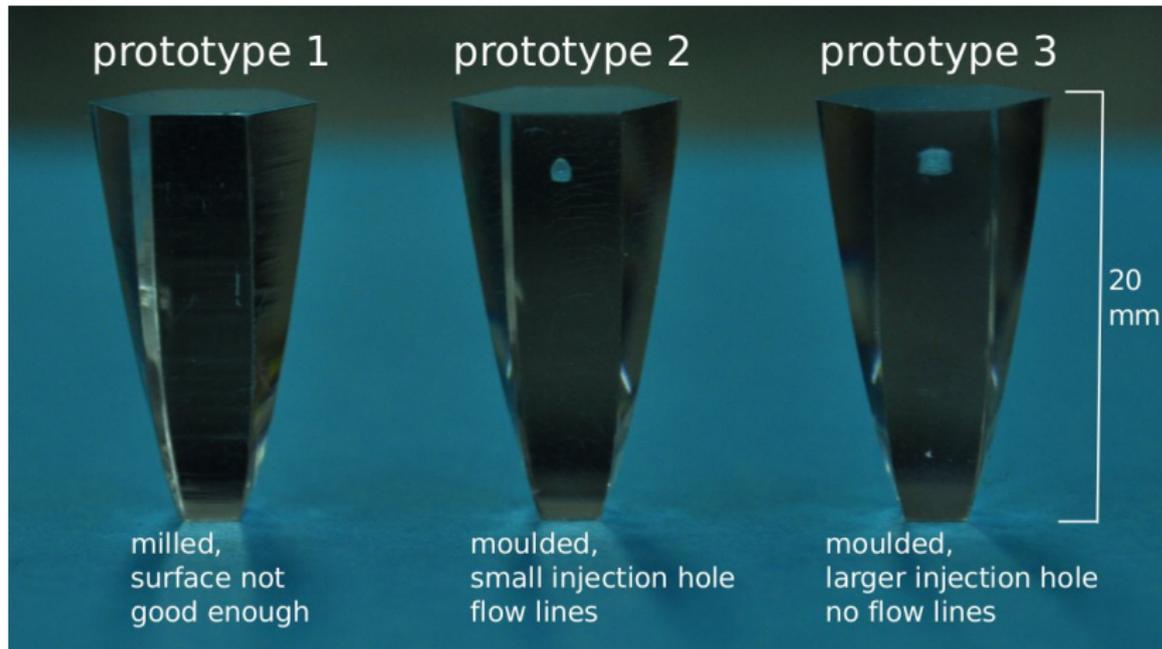


Ray-tracing simulations

Ray-tracing simulations were used to find an optimum shape and to optimize signal over noise. It resulted in a version with **non-tilted parabolic sidewalls**

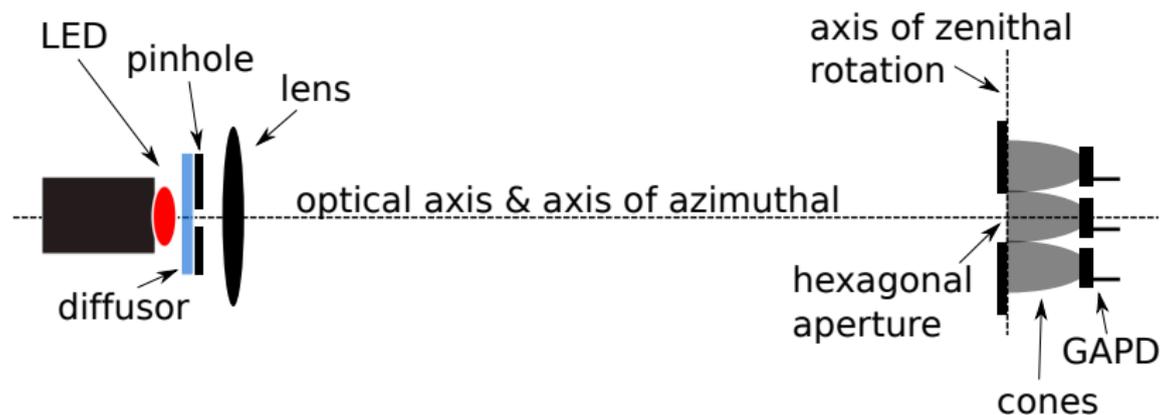
This version is produced out of **Plexiglas (PMMA)** by **injection moulding**

Production iterations



Comparison measurement - simulation

Goniometer setup



Comparison measurement - simulation

Goniometer setup



Comparison measurement - simulation

Goniometer setup



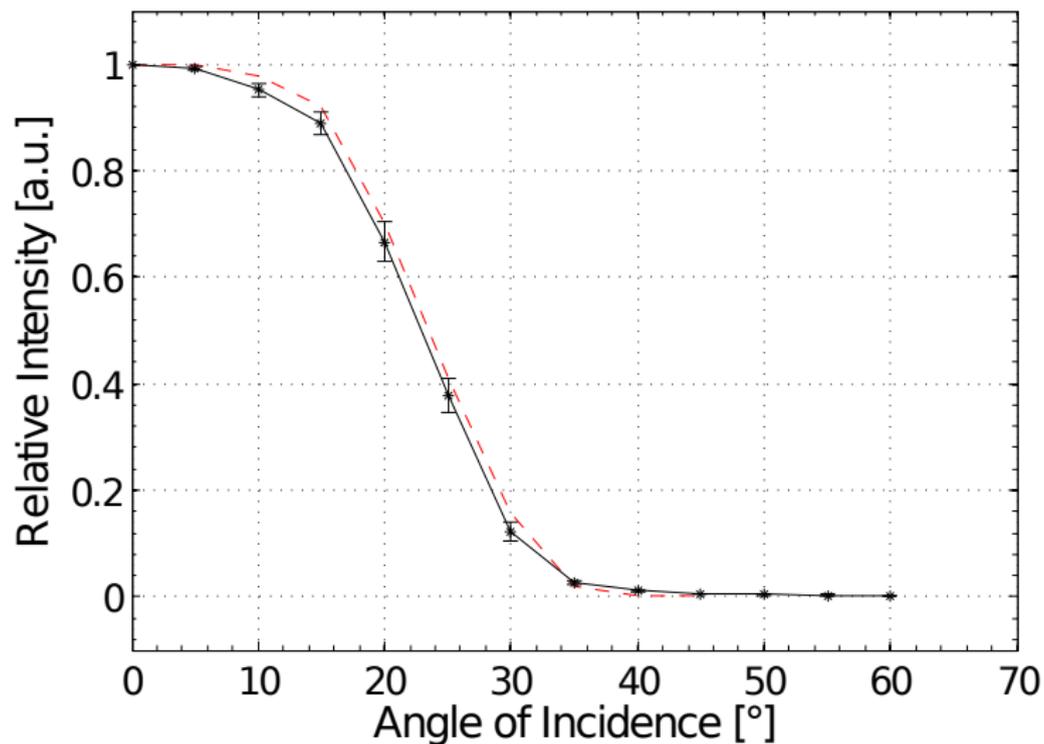
Comparison measurement - simulation

Goniometer setup



Comparison measurement - simulation

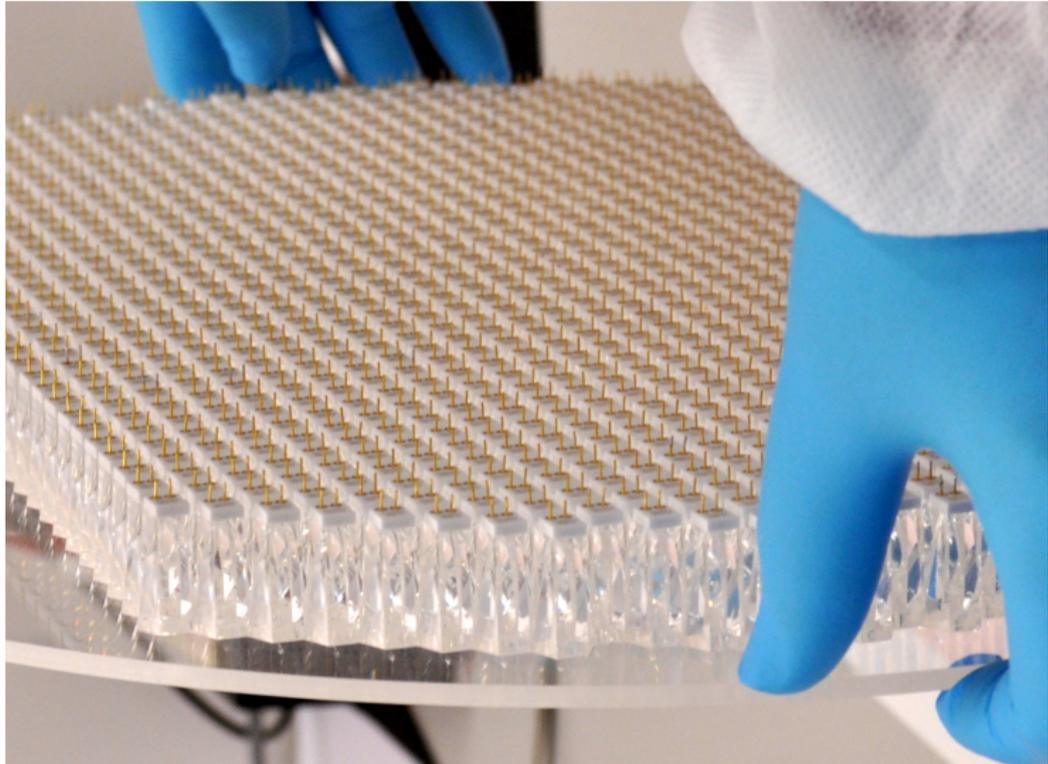
First results



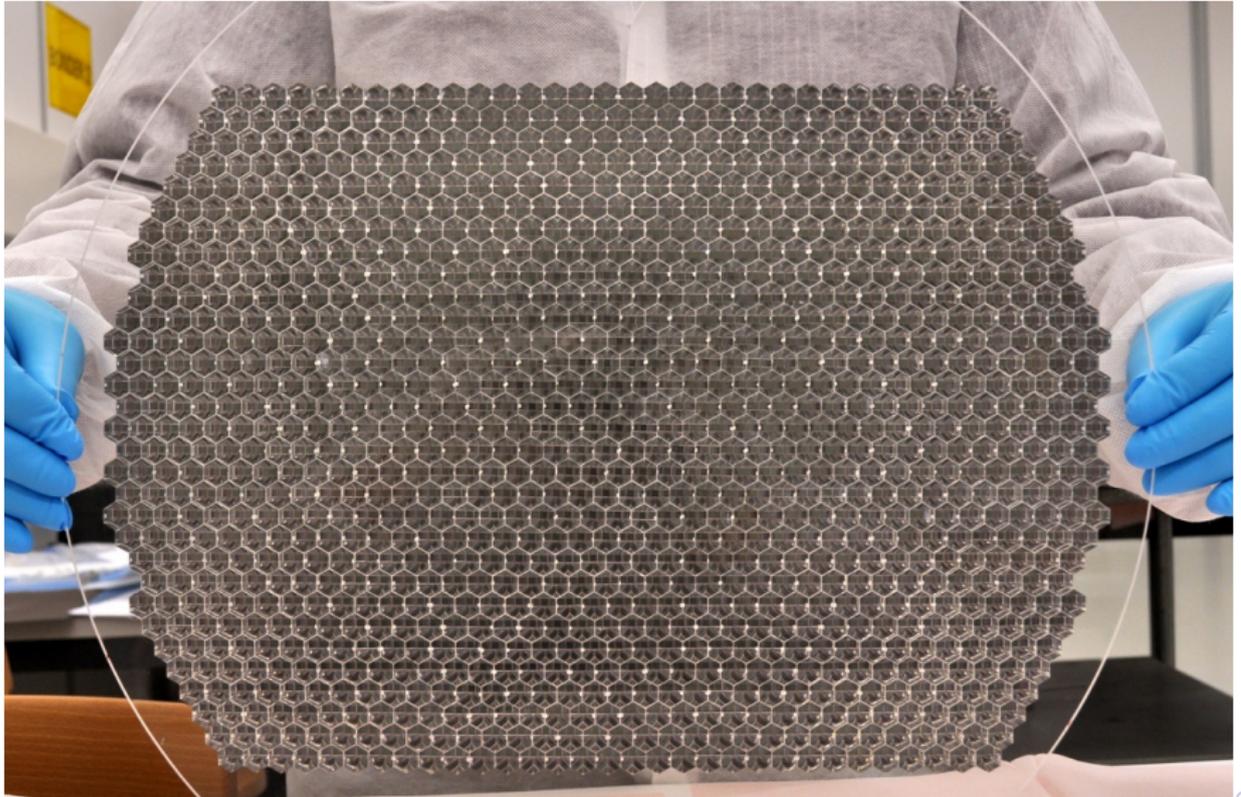
Frontplane assembly



Frontplane assembly



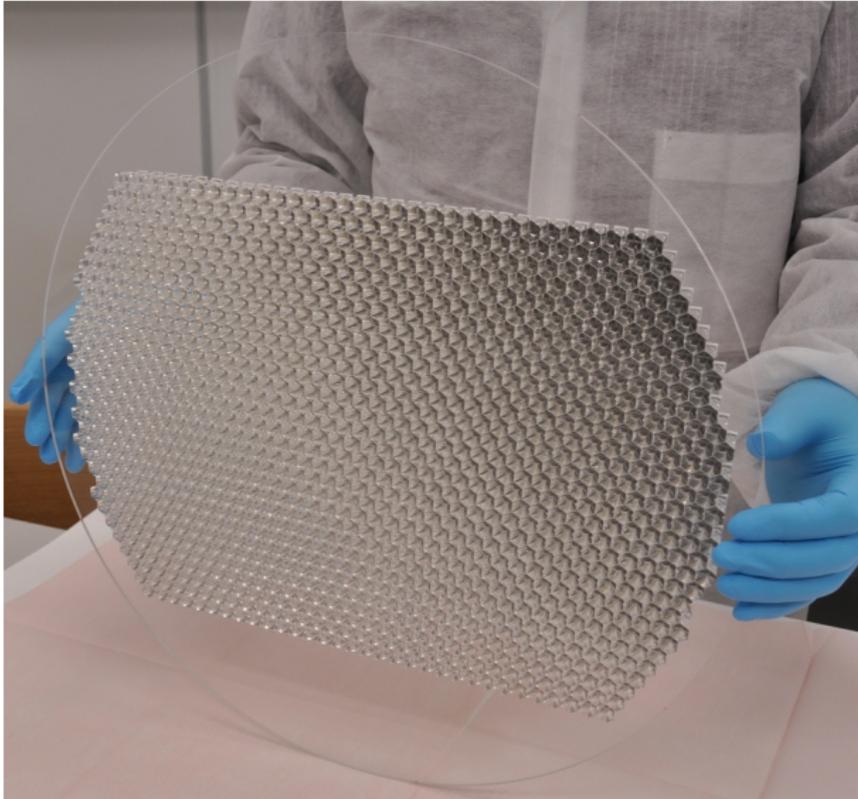
Frontplane assembly



Frontplane assembly



Frontplane assembly



Next steps

- ▶ finalize frontplane
- ▶ install in FACT camera
- ▶ perform remaining characterization