TELESCOPE PARAMETERS

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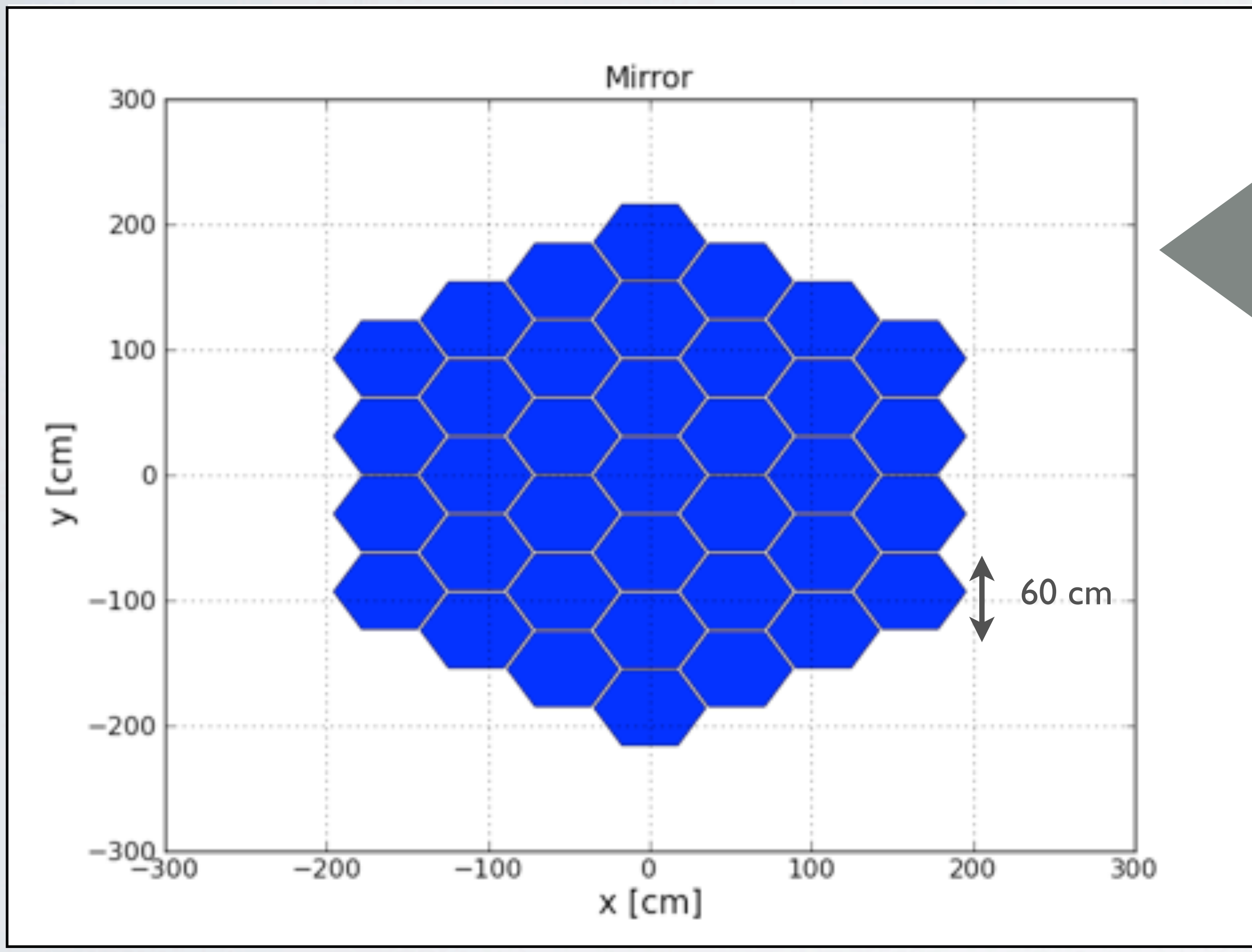
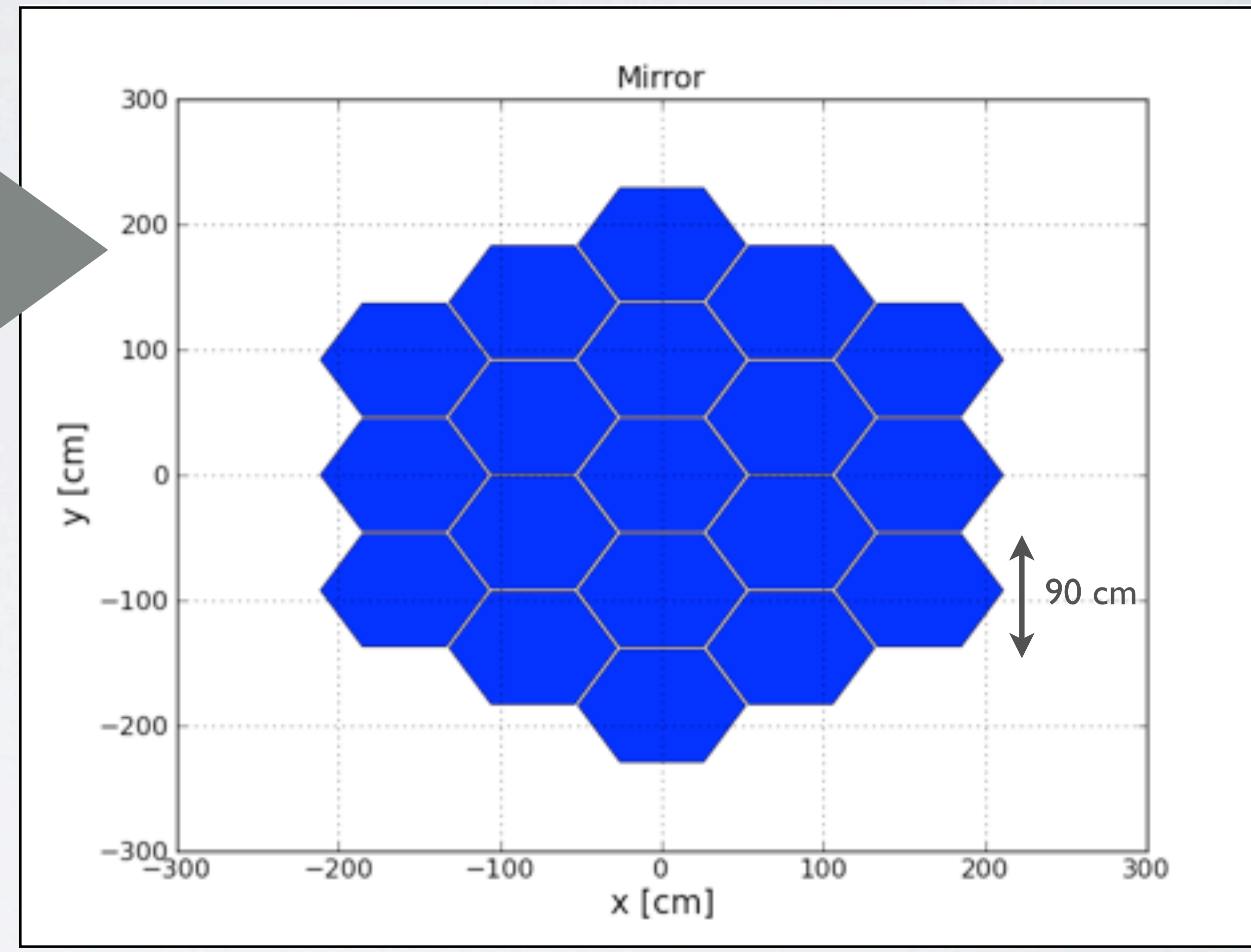
INTRODUCTION

- Define the necessary parameters of a small SST telescope and trigger parameters for a future next Prod 3.

MIRRORS

- Tested mirrors from 60cm (flat-to-flat) to 90cm with 2cm gap:

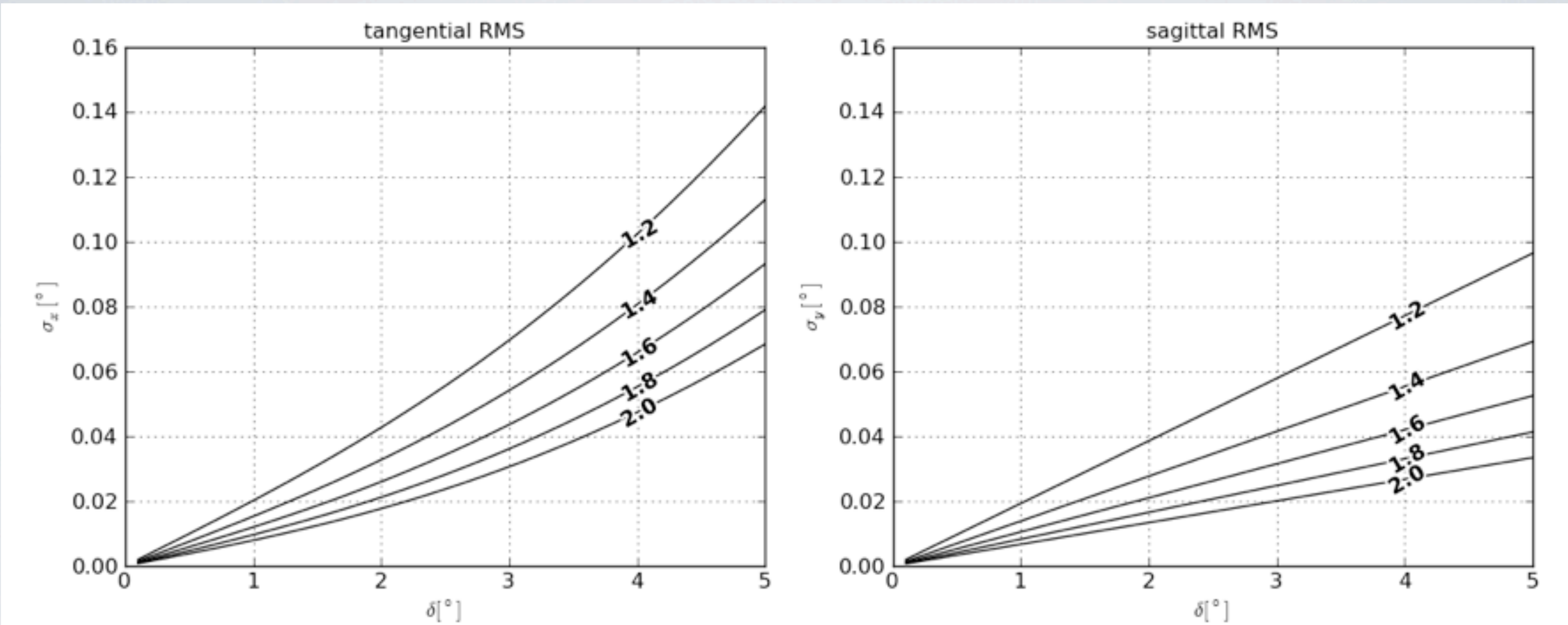




Maximum diameter = 4.32 m
Mirror surface area = 11.5 m^2

Maximum diameter = 4.58 m
Mirror surface area = 13.3 m^2

PSF ANALYTICAL

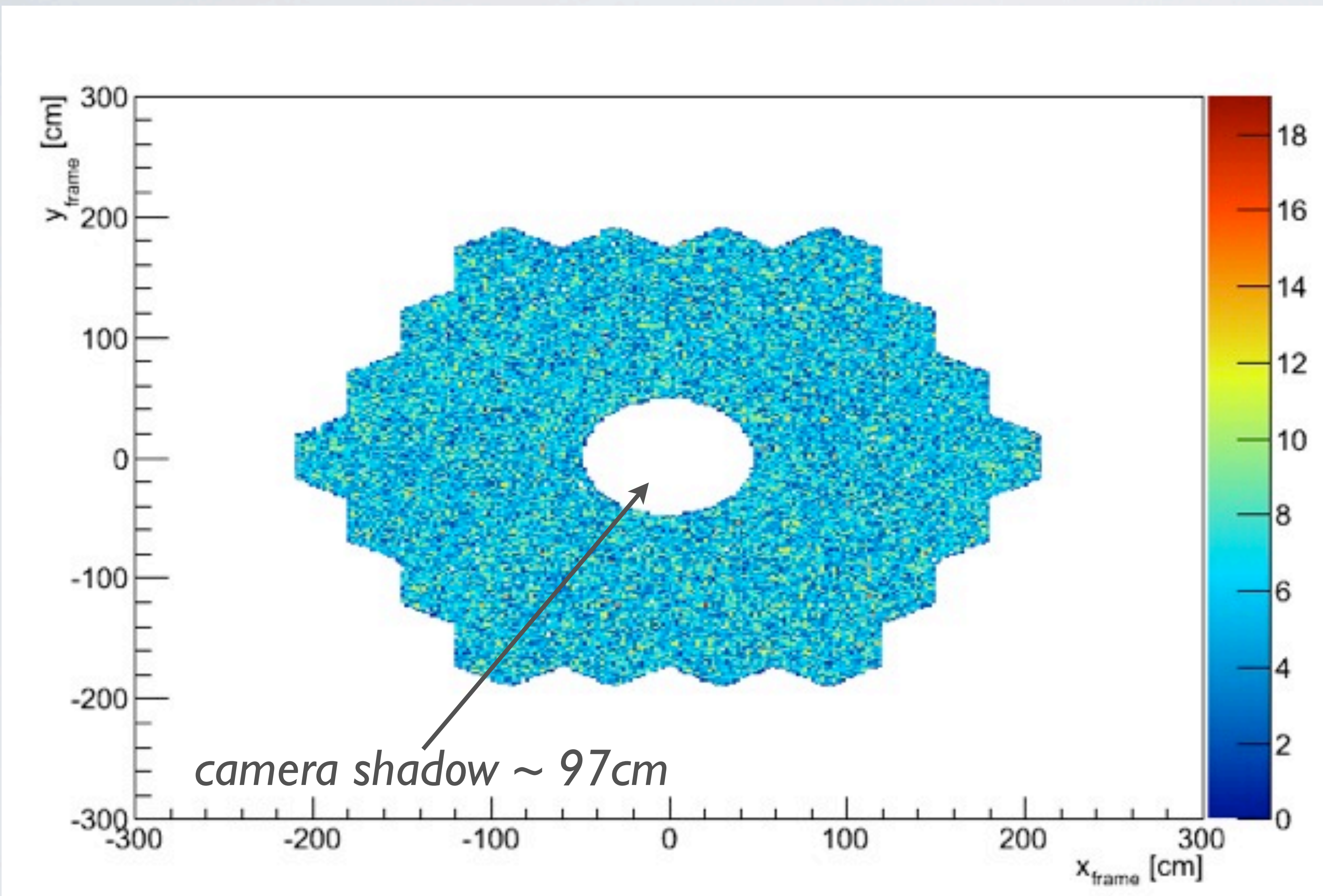


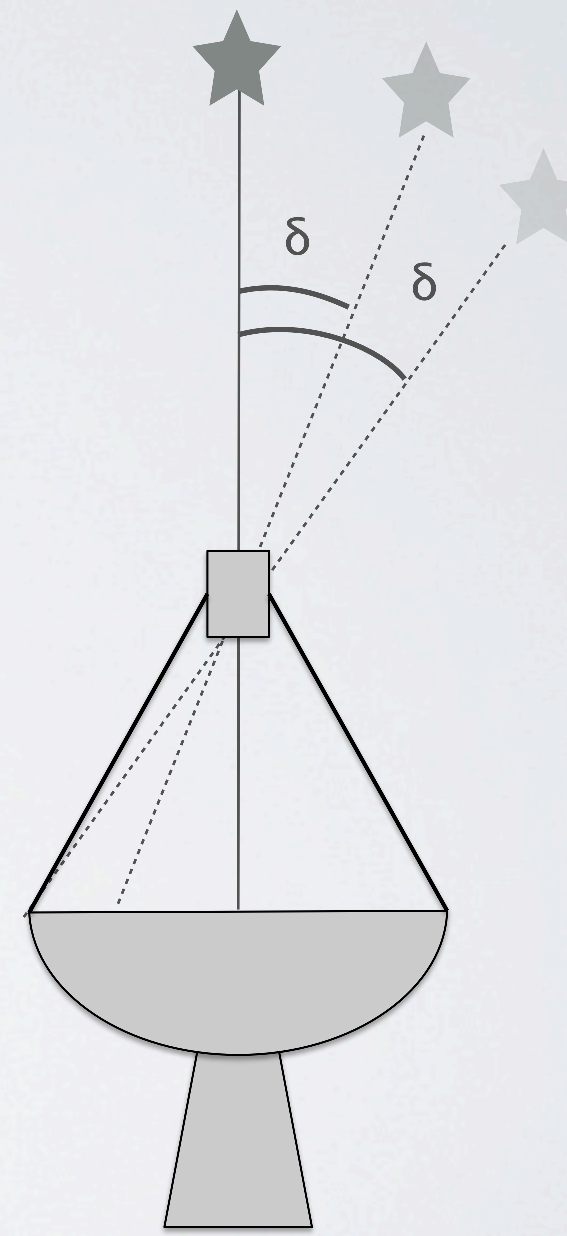
$$\sigma_x^2 = \frac{1}{1024}\frac{\delta^2}{F^4}\left(1 - \frac{1}{4F^2}\right) + \frac{1}{256}\frac{\delta^4}{F^2}\left(16 + \frac{35}{6F^2}\right) \qquad \sigma_y^2 = \frac{1}{1536}\frac{\delta^2}{F^4}\left(\frac{10}{9} + \frac{9}{32F^6}\right)$$

- Formulas taken from Vassiliev et al.

RAYTRACING IN SIMTELARRAY

Raytracing of a 4m mirror telescope:





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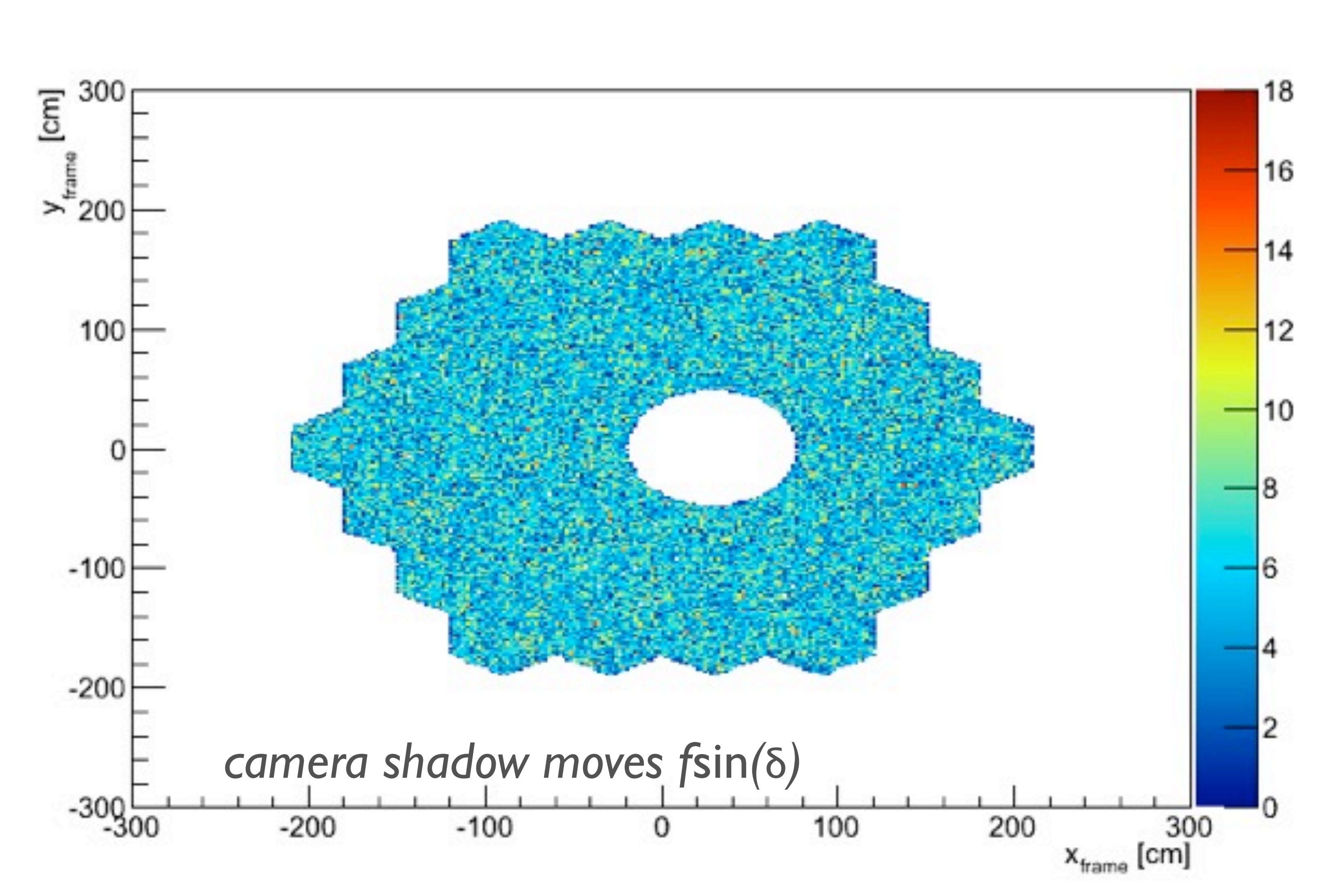

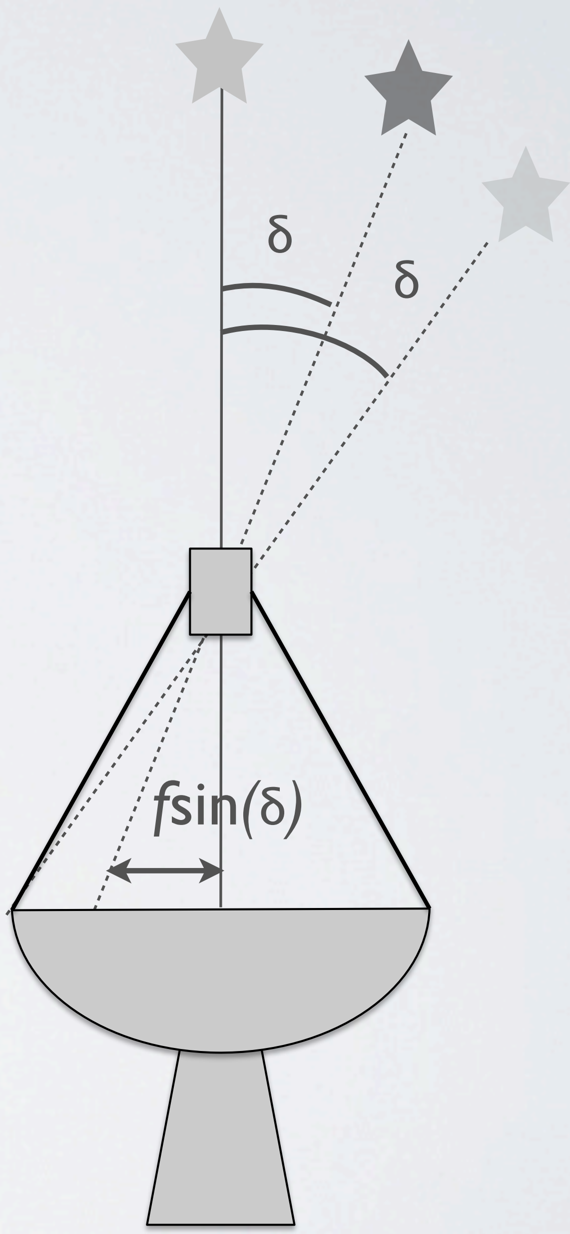

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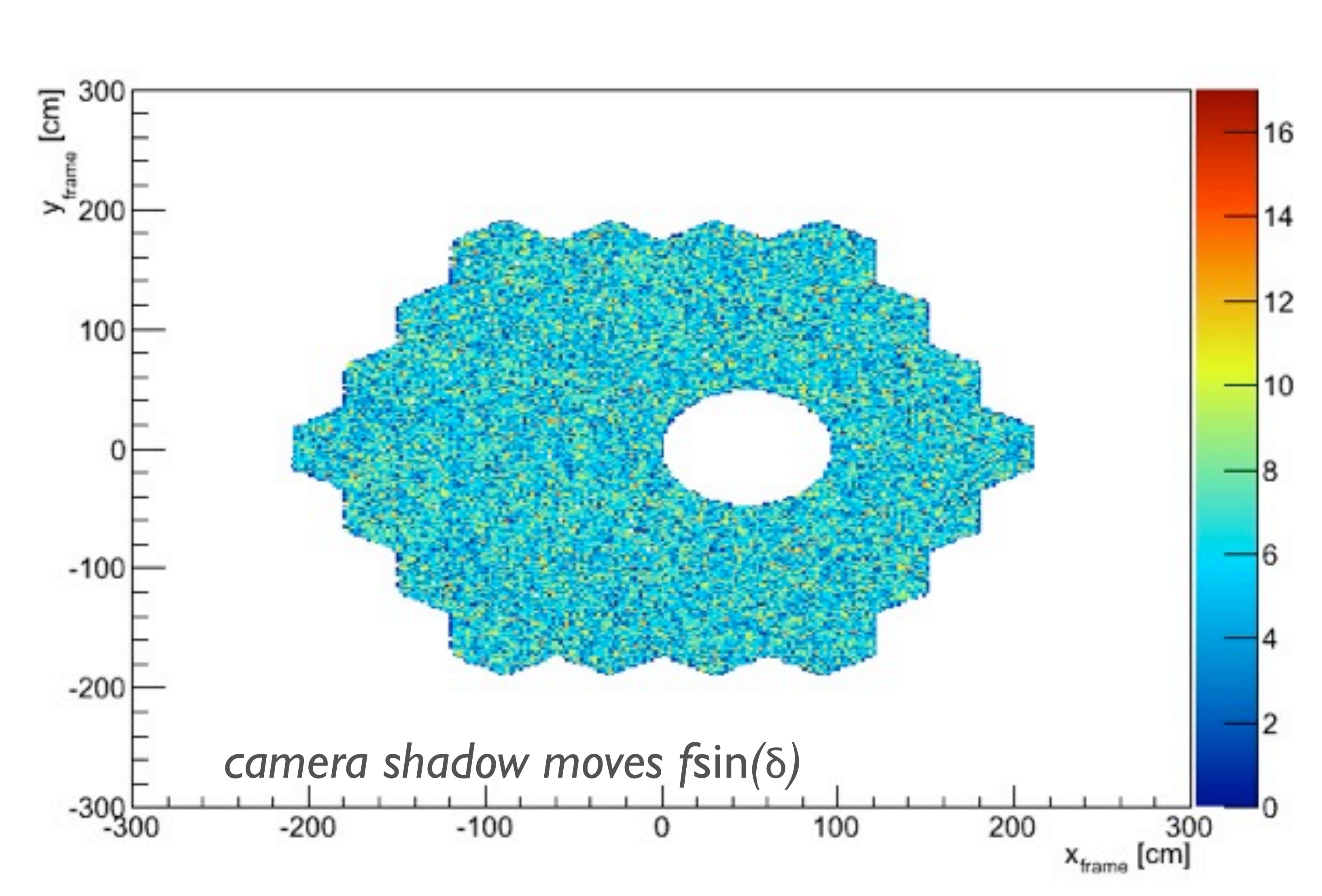
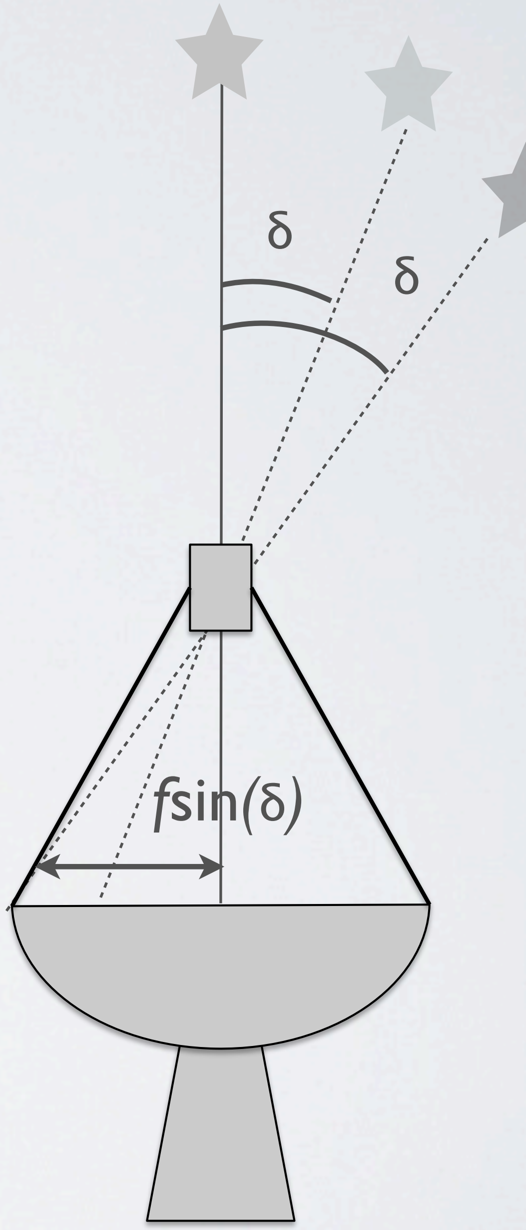
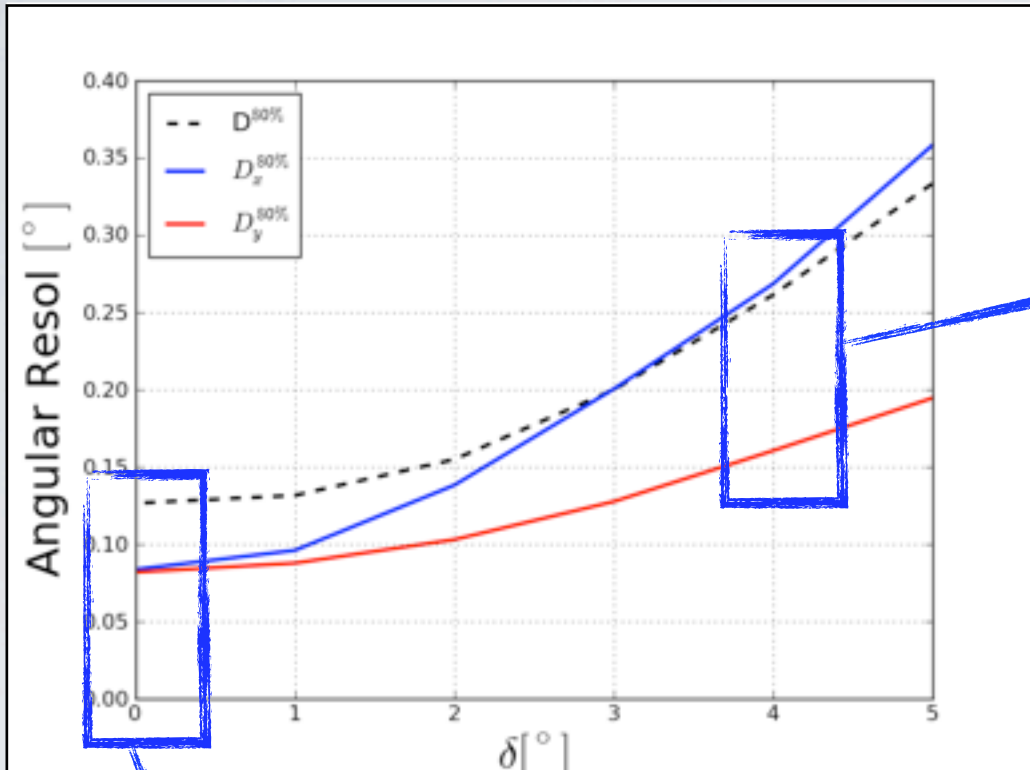
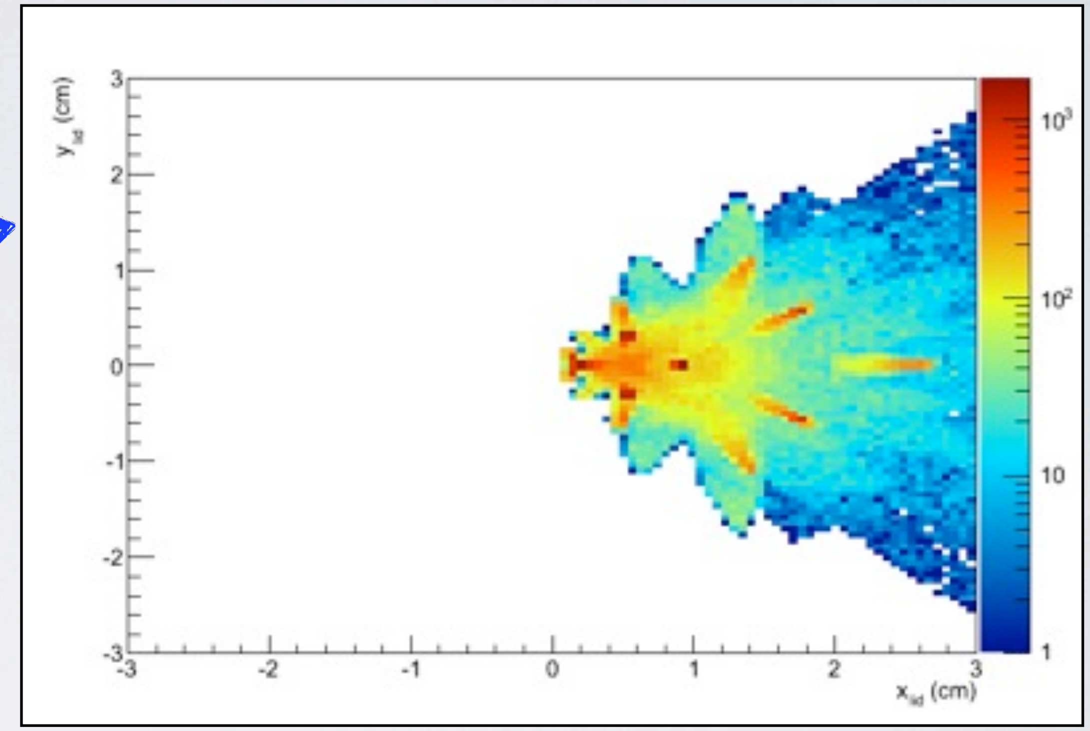
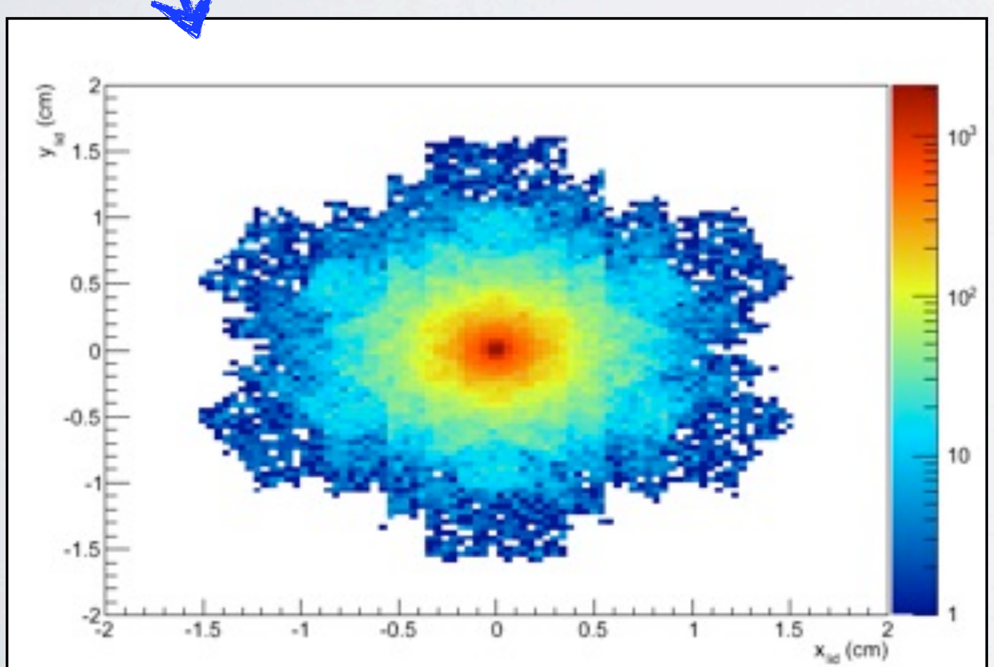




EXAMPLE FOR 60 CM

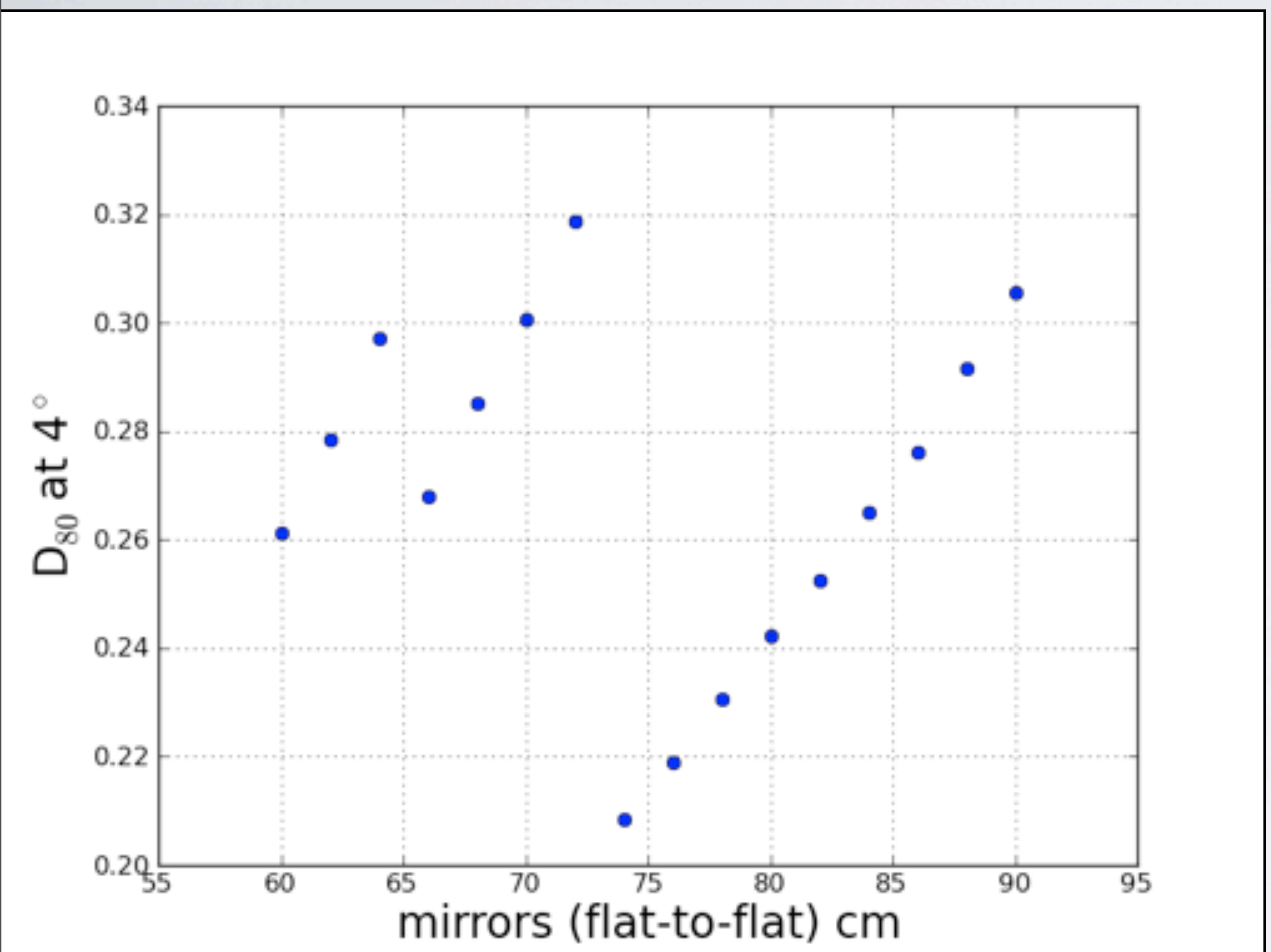


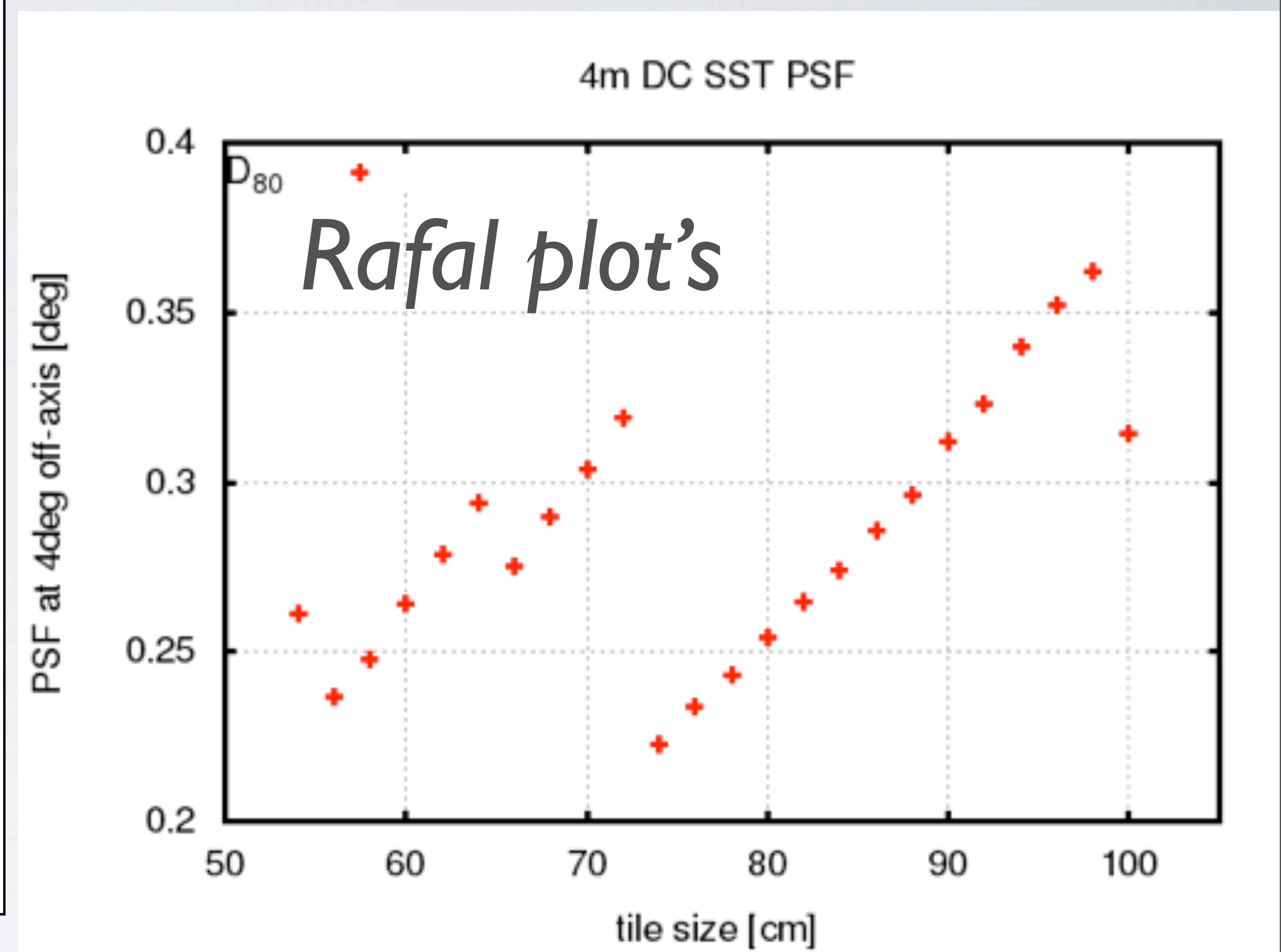




- Distributions of photons on the lid are very asymmetric when off-axis.
- D^{80} diameter that contains 80% of signal

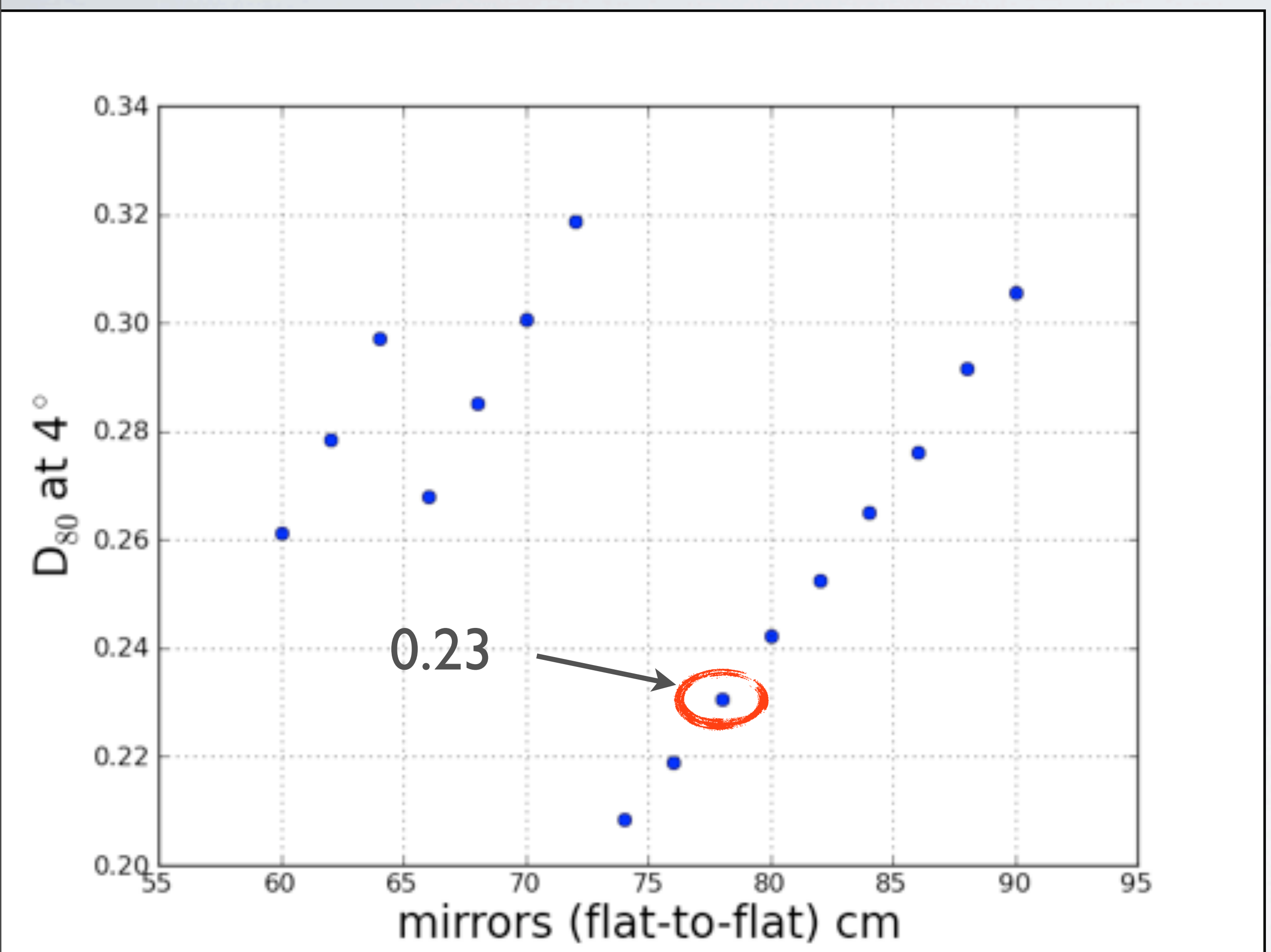
DIFFERENT MIRRORS

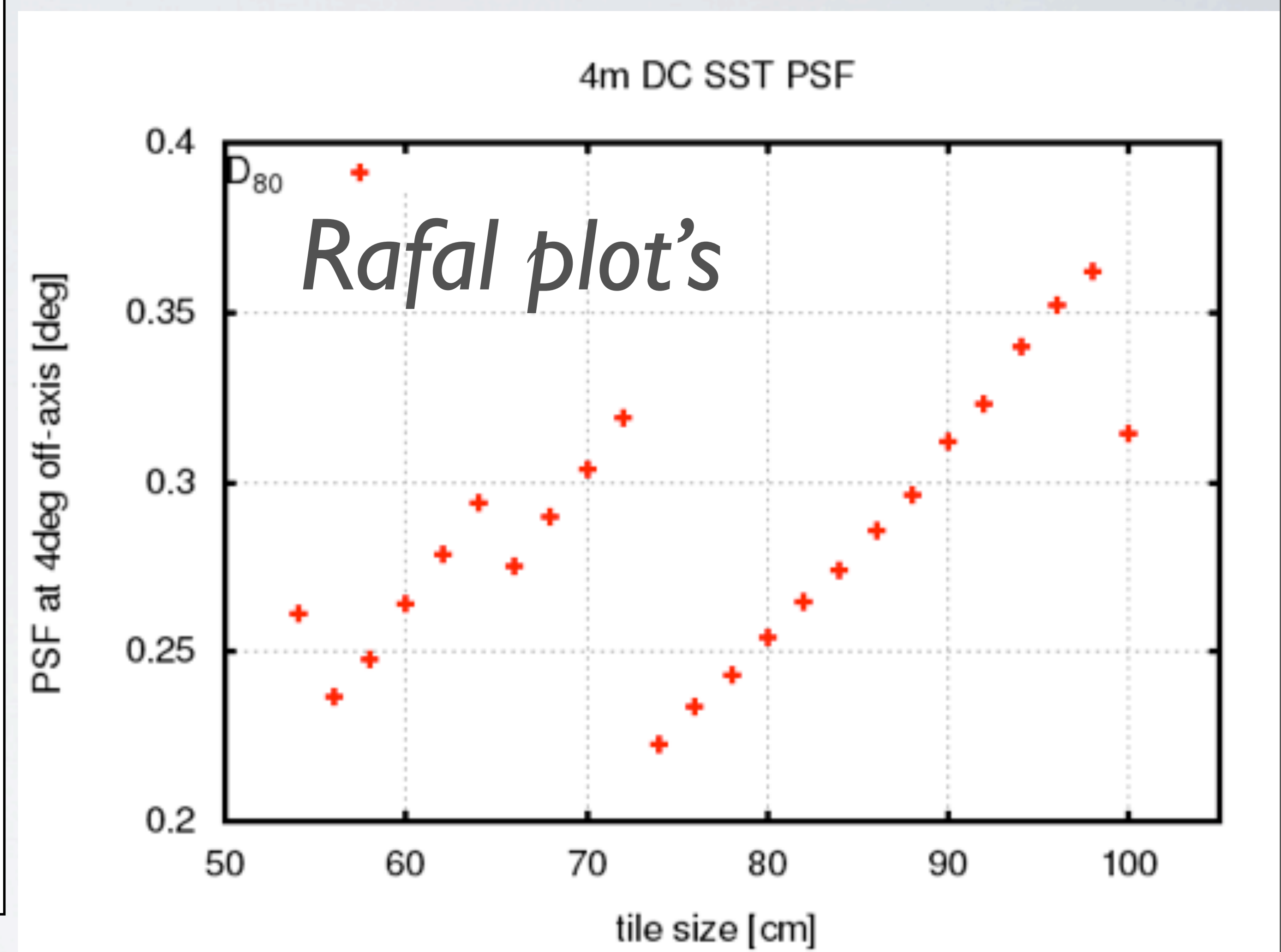




- Some differences in the D_{80} (different method calculation), but tendency is identical. Both using **simtel_array**.

DIFFERENT MIRRORS





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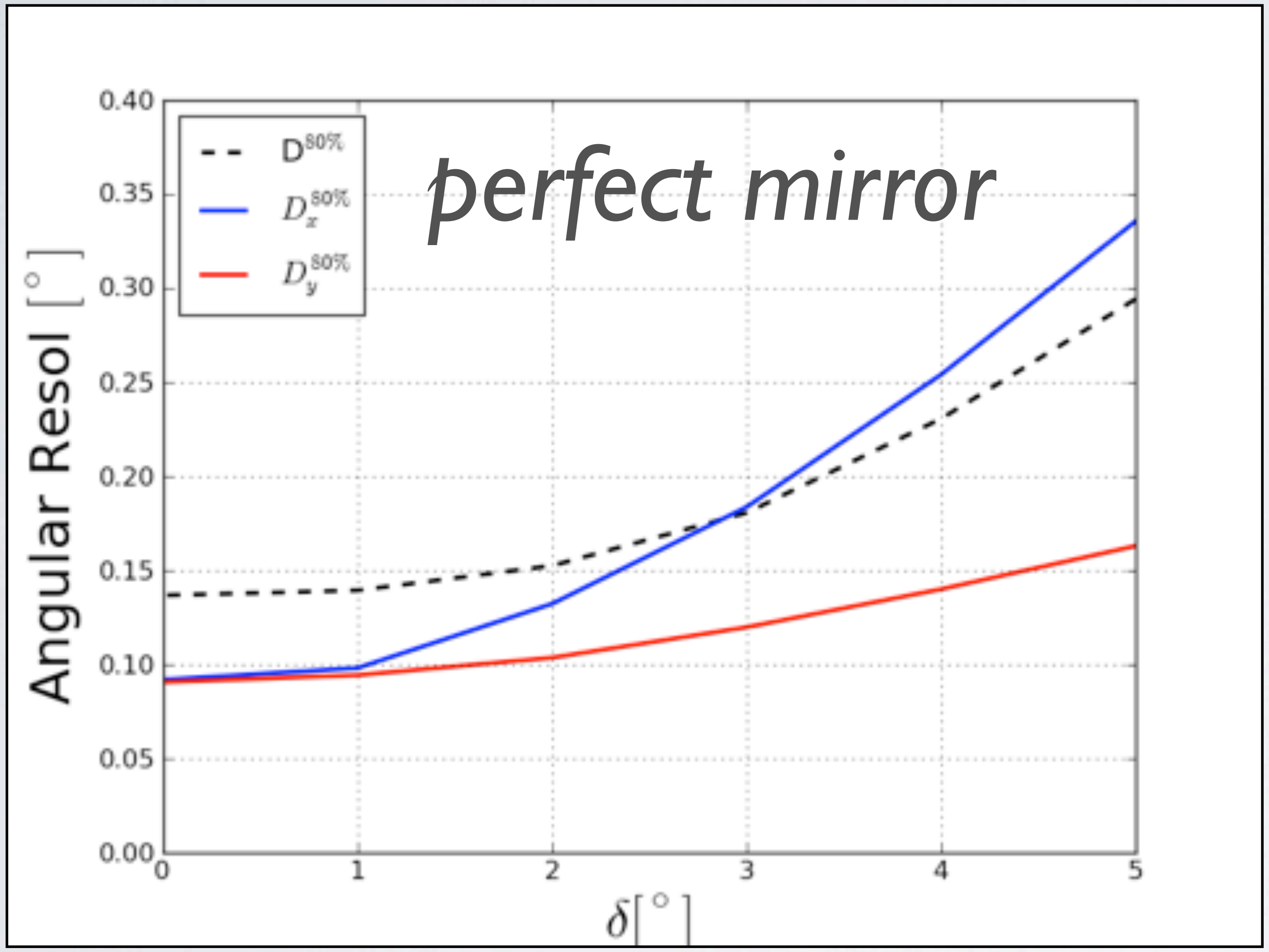
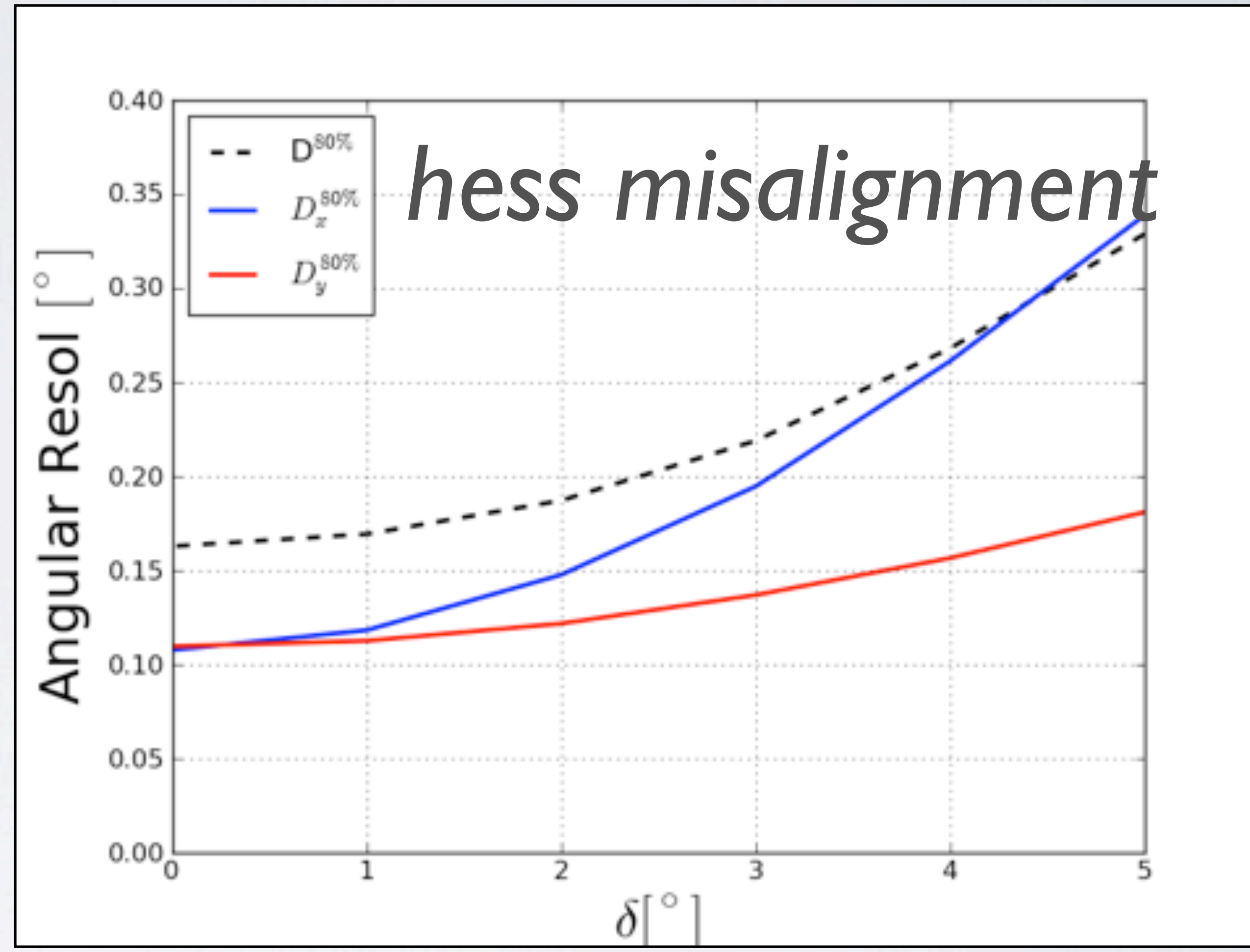
78 CM MIRRORS

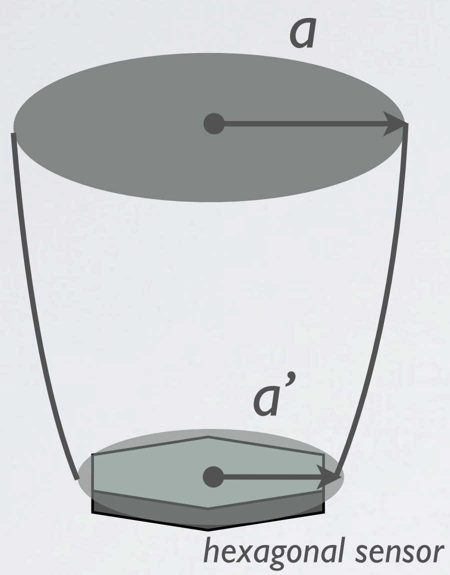


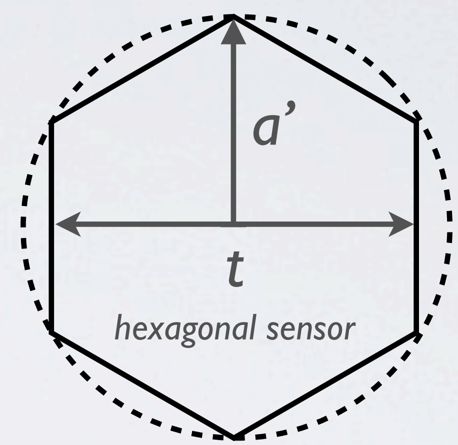


- Only taking hess misalignment (not realistic misalignment yet)

- The effect of misalignment is about ~ 12 %.

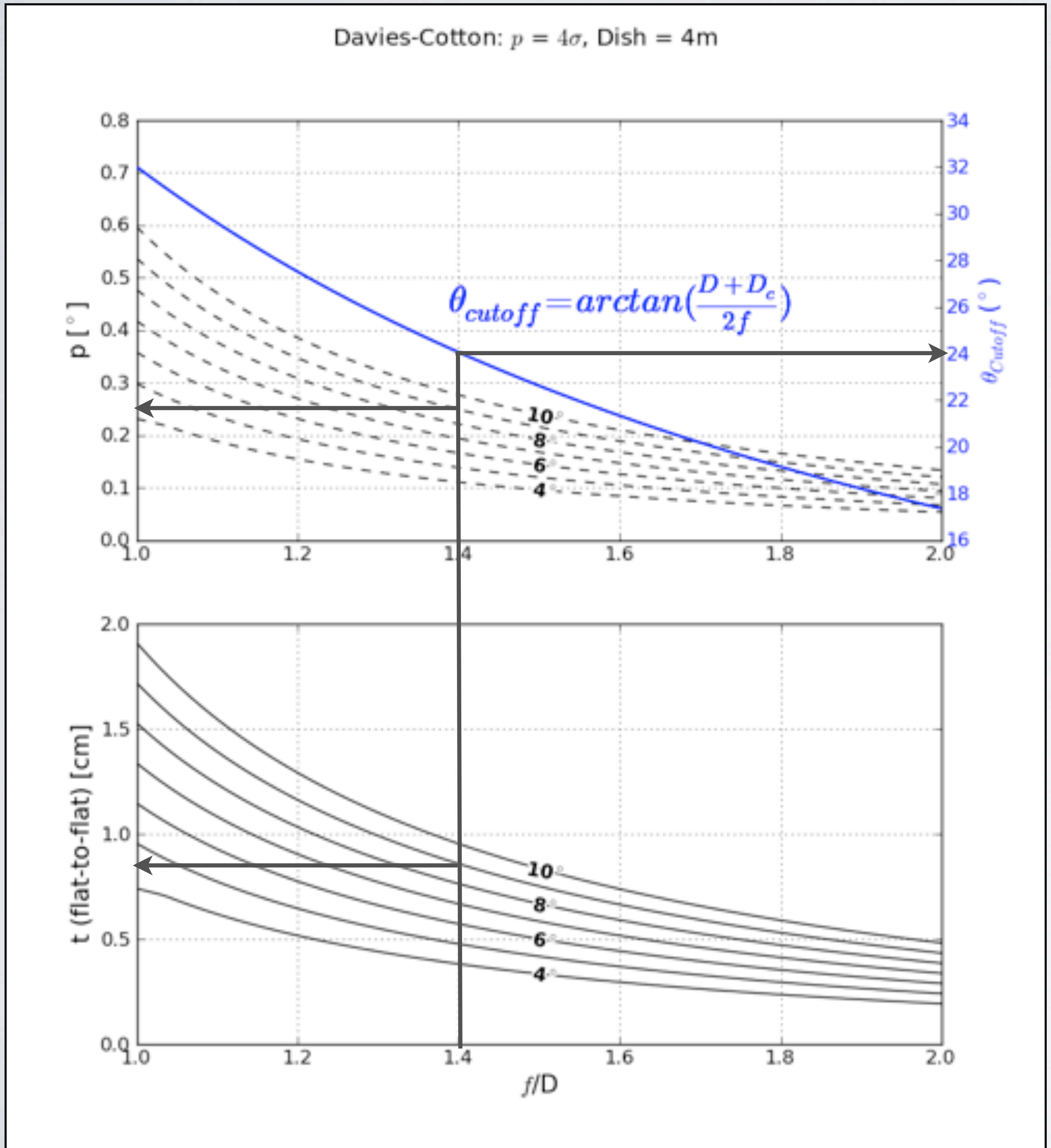
PIXEL SIZE: PARAMETERS & DEFINITIONS





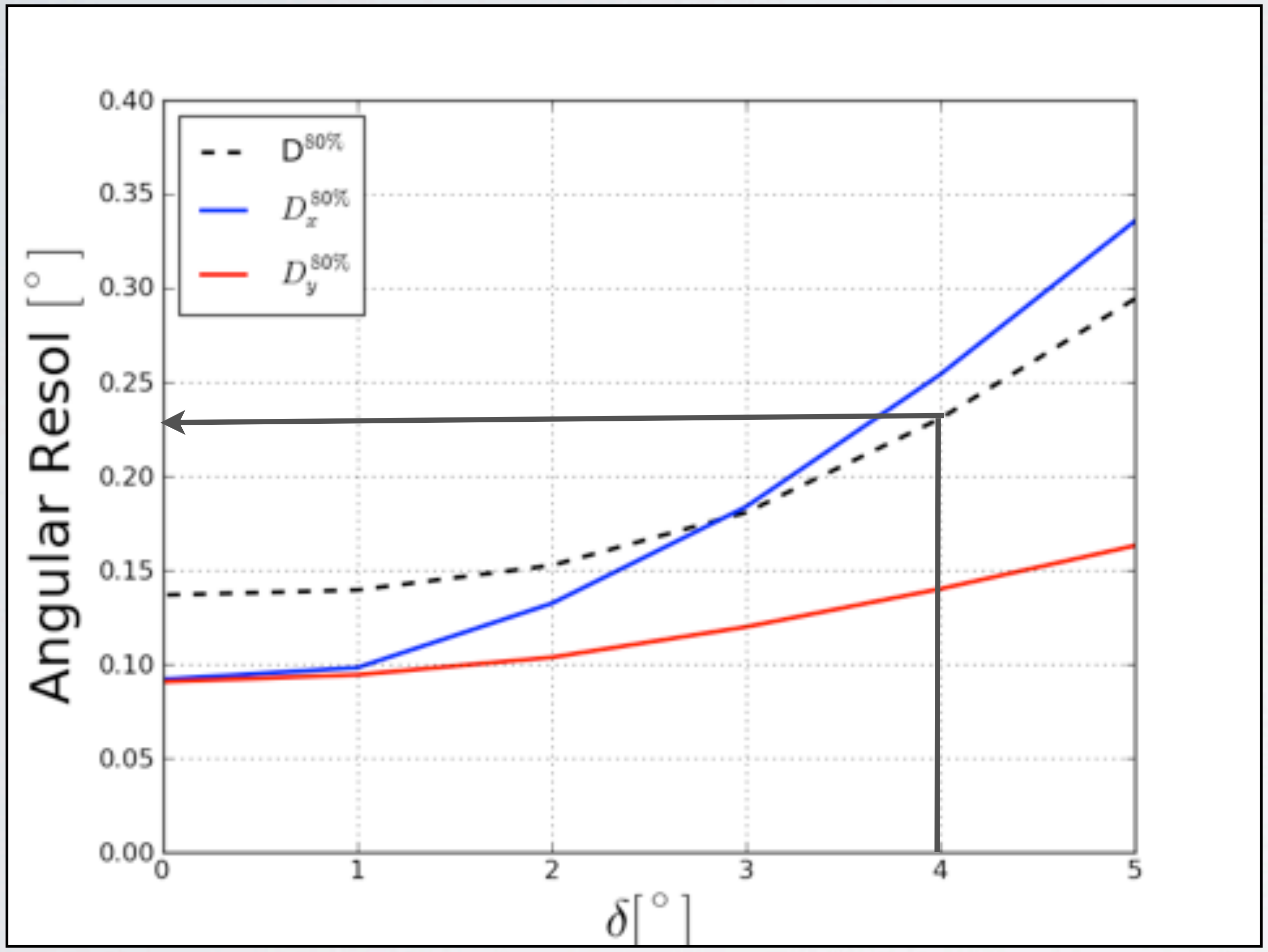
- **D** - dish diameter
- **FoV** - telescope field of view
- *f* - telescope focal length.
- **d** - physical pixel size (diameter). From figure above d = 2 * a.
- **p** - angular pixel size, 0.225°.
- **a’** - radius of the bottom of the funnel (Winston Cone)
- **t** - flat-to-flat distance of the hexagon sensor. From figure above t = sqrt(3)*a’
- θ_{cutoff} - Cutoff angle of the Winston Cone/Funnel
- n_p - number of camera pixels,
- D_c - camera diameter

PIXEL SIZE (ANALYTICAL)



- Conditions:
  - **Dish =** 4 m
  - **FoV =** 9 deg
  - Perfect Winston Cone (cutoff angle includes camera size).
  - **p** = 4min(sigma$_x$, sigma$_y$)
- Results for f/D = 1.4:
  - **p** = 0.25 deg
  - **d** = 2.44 cm
  - **n$_p$** = 1307
  - **D$_c$** = 88 cm
  - **a'** = 0.46 cm
  - **t** = 0.80 cm

PIXEL SIZE FROM PSF STUDIES

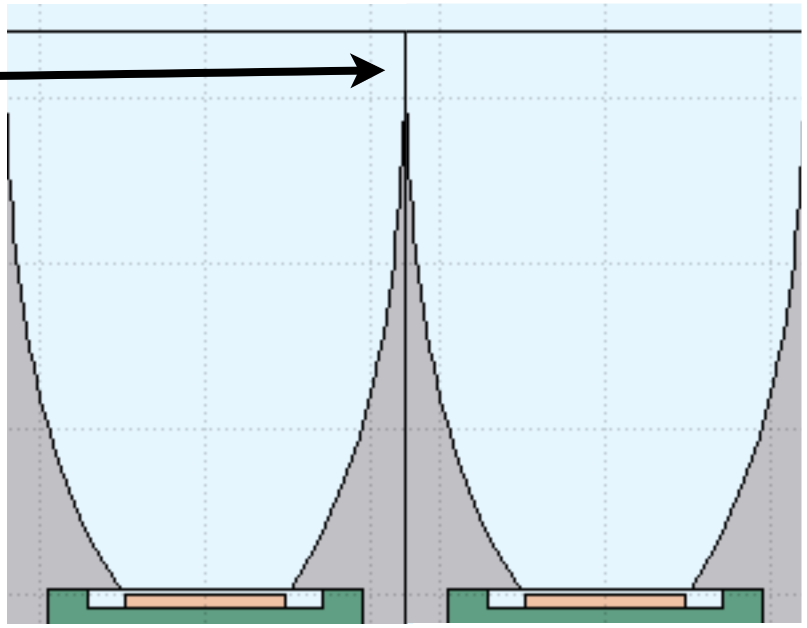


- Conditions:
  - **Dish =** 3.98 m (78 mirrors)
  - **FoV =** 9 deg
  - Perfect Winston Cone (cutoff angle includes camera size).
  - **p** = D_{80} at 4 deg
- Results for f/D = 1.4:
  - **p** = 0.232 deg
  - **d** = 2.24 cm
  - $\mathbf{n_p}$ = 1531
  - $\mathbf{D_c}$ = 88 cm
  - **a'** = 0.42 cm
  - **t** = 0.73 cm

Winston Cone Options

Open Cones:

- X Tangent surfaces in ideal winston cone, must be approximated and simulated
- ✓ Reduced weight the system;
- ✓ Compact;



Full Cones (alla FACT):

- X Absorption of light;
- X Weight.
- X Diffusion by impurities in the material
- X Degeneration of the materials (cone and glue) with thermal cycles;
- ✓ Rigidity of the system;
- ✓ Optical continuity (all same refractive index)

Simulation

Kick start the problem using FLUKA

- Flexible parametric geometry, can be updated with new sensor geometry easily;
- No simulation of interference and media with complex refractive indexes;
- Might be used to simulate the full chain, from HE-gamma to digitization of the signal;

Zemax license purchased:

- Need a short training before being productive with the simulations.

Pixel philosophy I

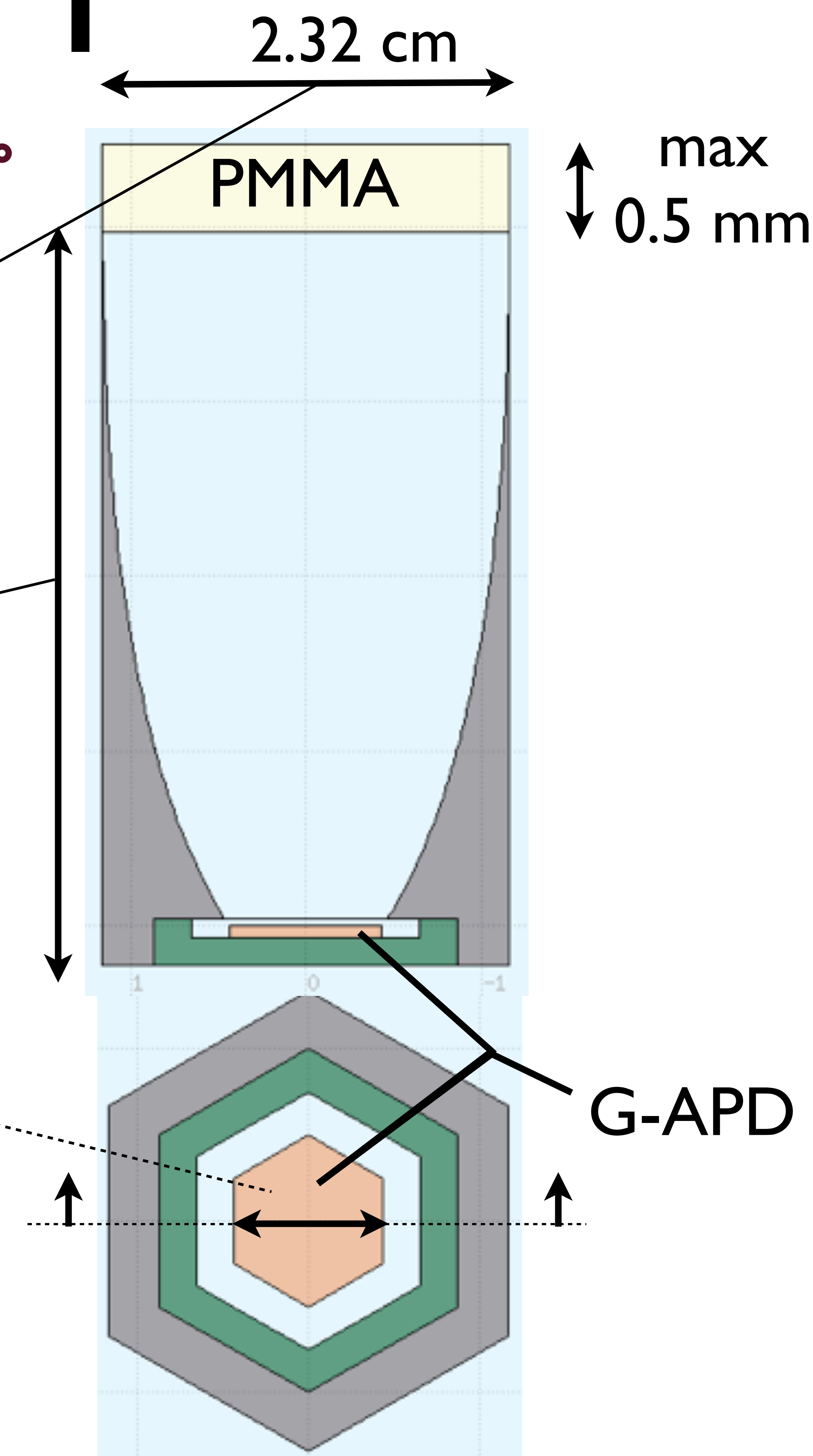
- Segmentation of the detector fixed to **0.25°** for f/D 1.4 and D=4 m d_{eqiv}= 2.44 cm;

- For a cut-off angle of 21.9° we have:
  - L_{side} = 1.34 cm
  - $L_{APEX-APEX}$= 2.68 cm
  - $L_{side-side}$ = 2.32 cm

  - L = 3.97 cm

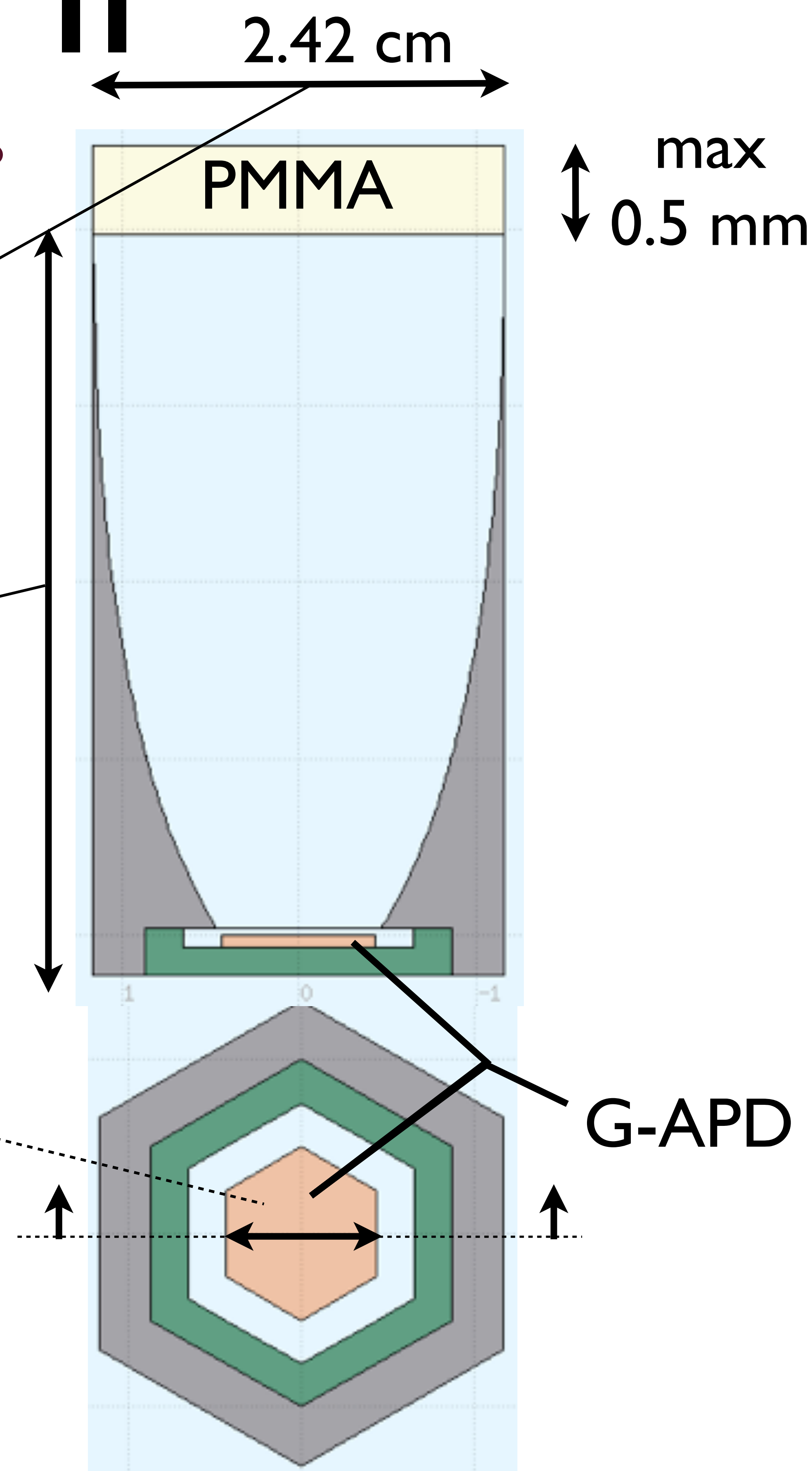
  - GAPD - L_{side}= 0.5 cm
  - GAPD - $L_{APEX-APEX}$= 1 cm
  - GAPD - $L_{side-side}$= 0.87 cm

  - Comp.Factor ~ 7.2



Pixel philosophy II

- Segmentation of the detector fixed to **0.30°** for f/D 1.4 and D=4 m d_{eqiv}= 2.93 cm;
- For a cut-off angle of 22.37° we have:
  - L_{side} = 1.395 cm
  - $L_{APEX\text{-}APEX}$= 2.79 cm
  - $L_{side\text{-}side}$ = 2.42 cm
  - L = 4.68 cm
  - GAPD - L_{side}= 0.53 cm
  - GAPD - $L_{APEX\text{-}APEX}$= 1.06 cm
  - GAPD - $L_{side\text{-}side}$= 0.92 cm
  - Comp.Factor ~ 6.9



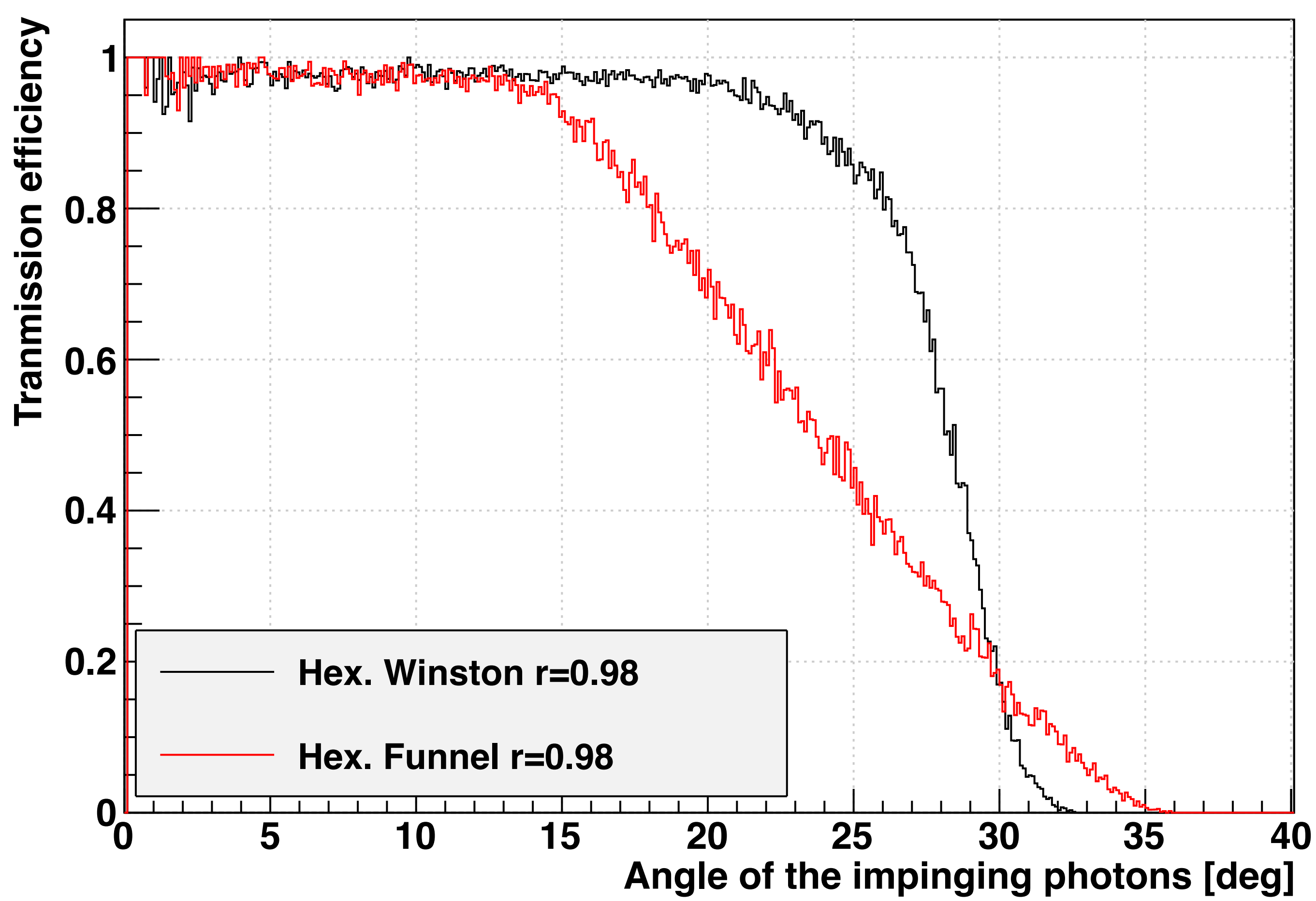
Status

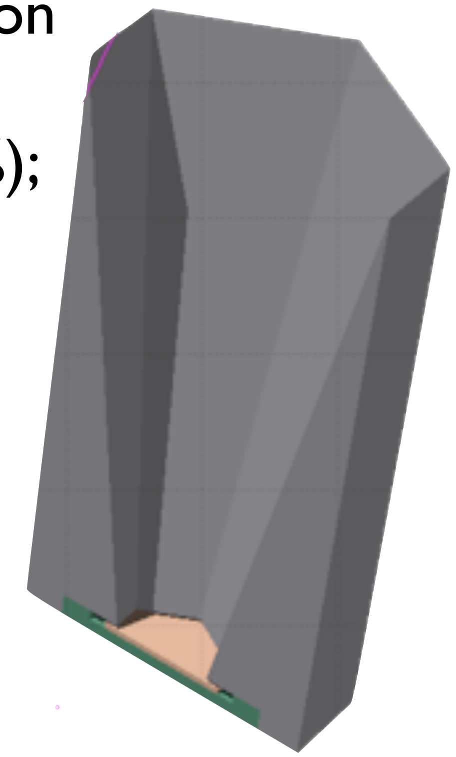
First results of FLUKA initial simulation (detailed ZEMAX simulation will follow):

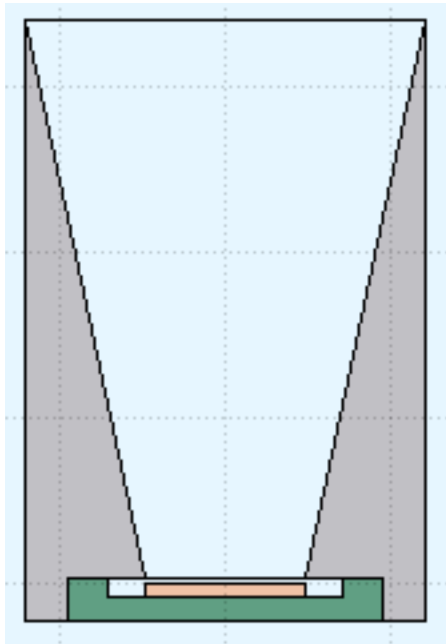
- Adding PMMA entrance window yet (double reflection loss ~8%);
- Light 400nm, no wavelength reflectivity dependence.

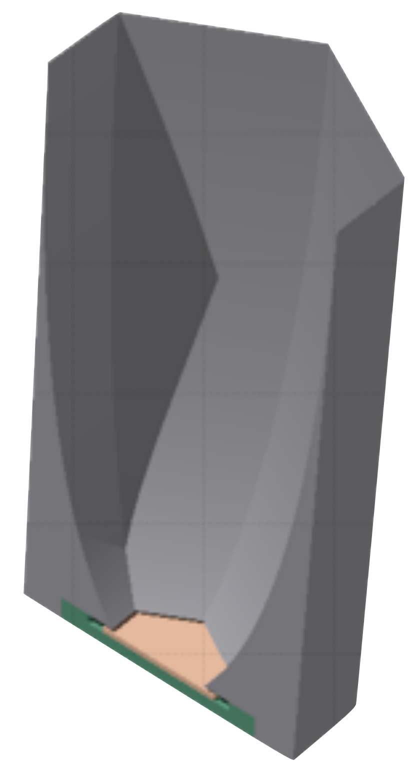
Comparison of parabolic (Winston -like) and flat reflectors;

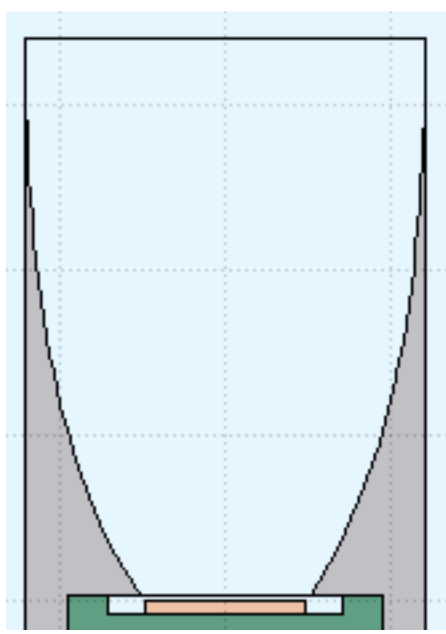
- 10M perfectly diffused photons on the top of the funnel,
- Hexagonal/Square pixel comparison;
- Real reflectivity of the 3M Vikuiti ESR foil 98%;
- Ideal reflector -> 100% reflectivity;



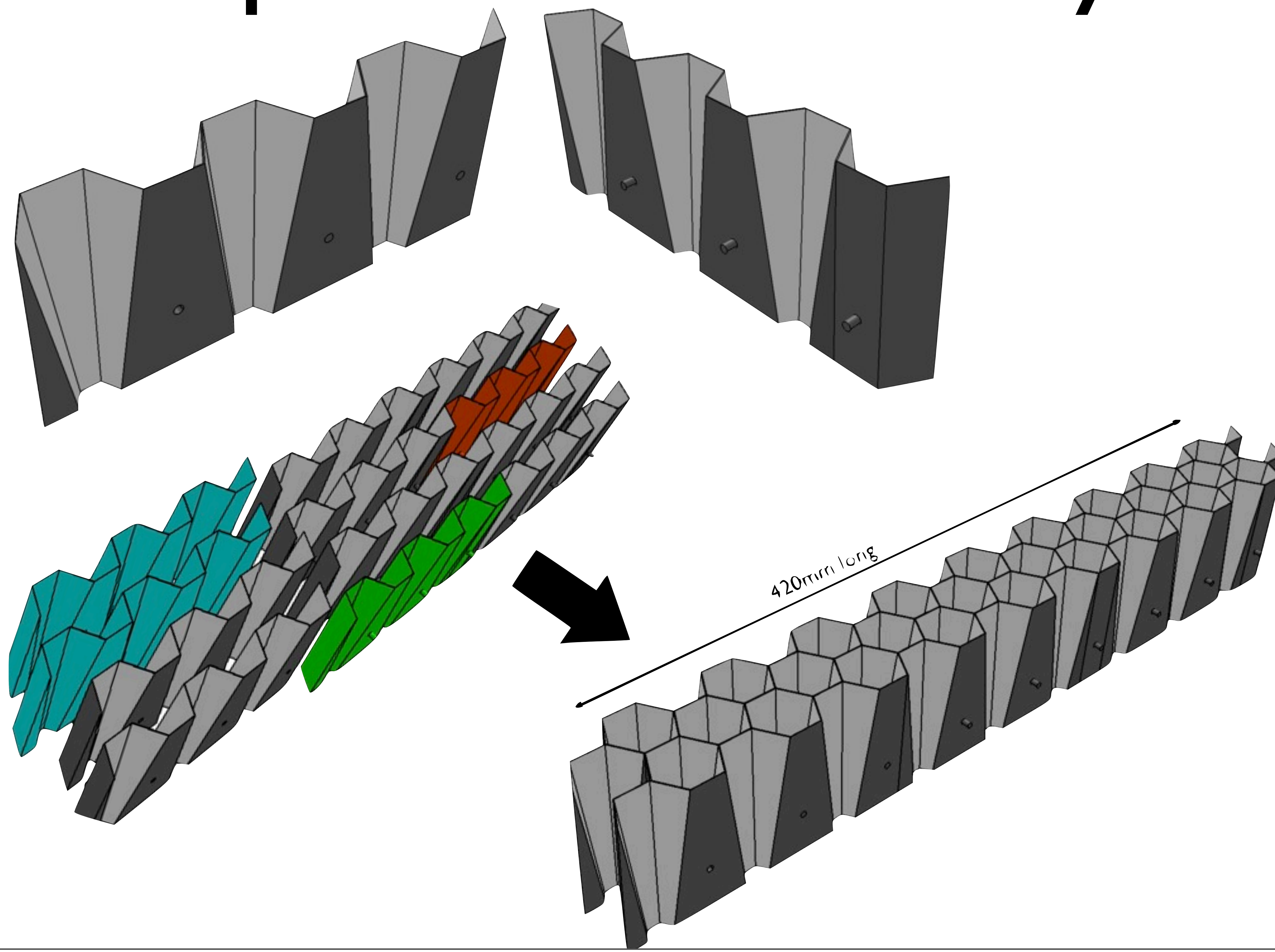




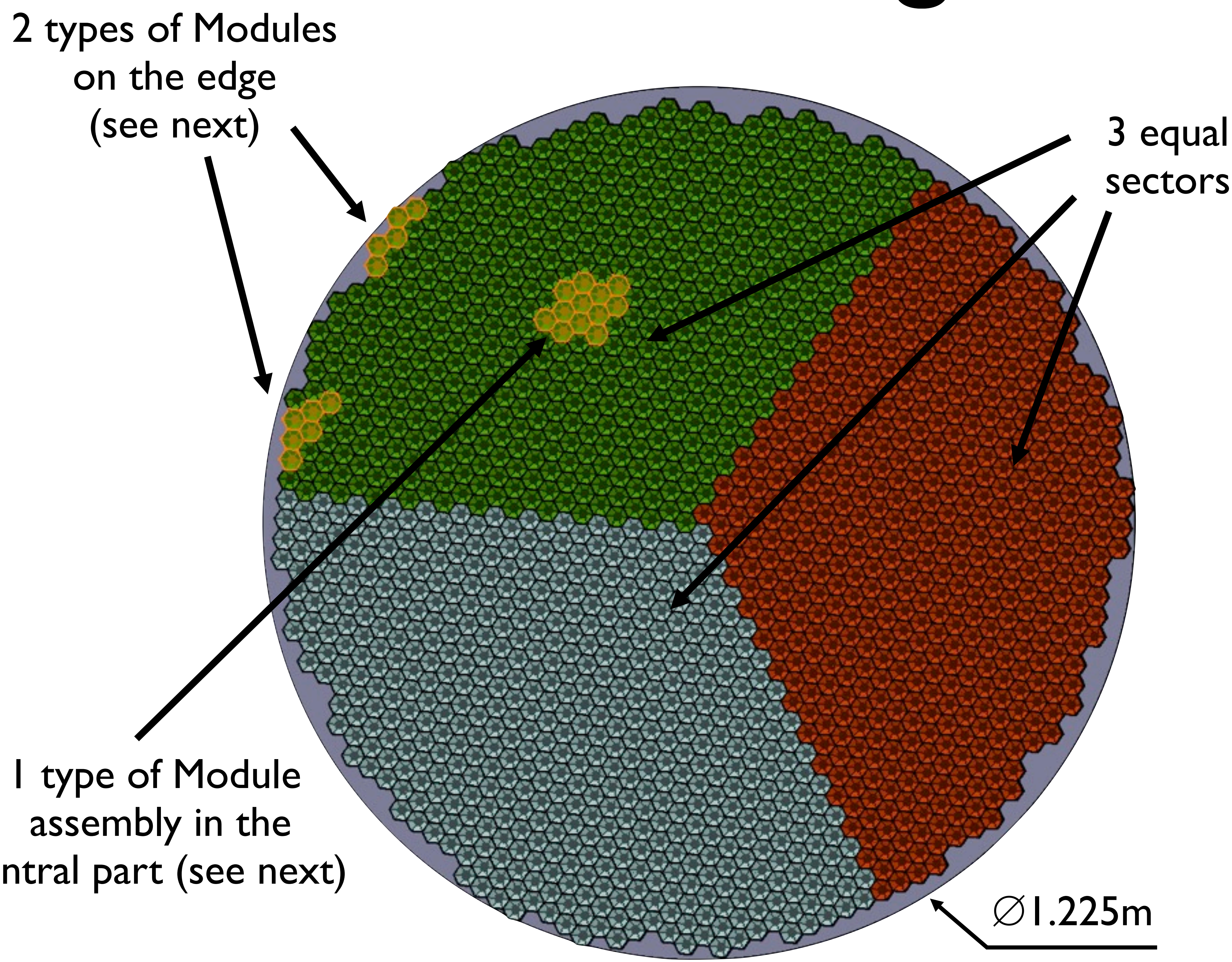




Simple cone assembly



Camera design



Cone evaporation tests

We are identifying possible local (d<50km) and mid range (d< 300 km) companies which can perform us quick test evaporation of different materials.

- CERN - Thin Film Glass Lab:
  thin films by means of vacuum evaporation and machining of glass and ceramic components. The thin film technologies are used to fabricate photocathodes (CsI, K2CsSb, Rb2Te), reflective mirror coatings and other functional layers or even organic wavelength shifters such as Tetra Phenyl Butadiene (TPB);
- SURCOTEC S.A. [Company in Geneva]:
  can perform CVD/PVC coating and SEM analysis;

Contacts/discussion are ongoing