CURVED DETECTORS: ASTRONOMICAL APPLICATIONS

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Northern skies Cosmic Flows, workshop, LAM, Marseille
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Wide field astronomy

Wide field optical system (typically Schmidt designs): observation of transients, planets, …

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Curved focal planes

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Additional field flatteners

Kepler focal plane, 42 flat CCDs

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WIDE FIELD ASTRONOMY

Wide field optical system (typically Schmidt designs):
observation of transients, planets, …

CURVED FOCAL PLANES

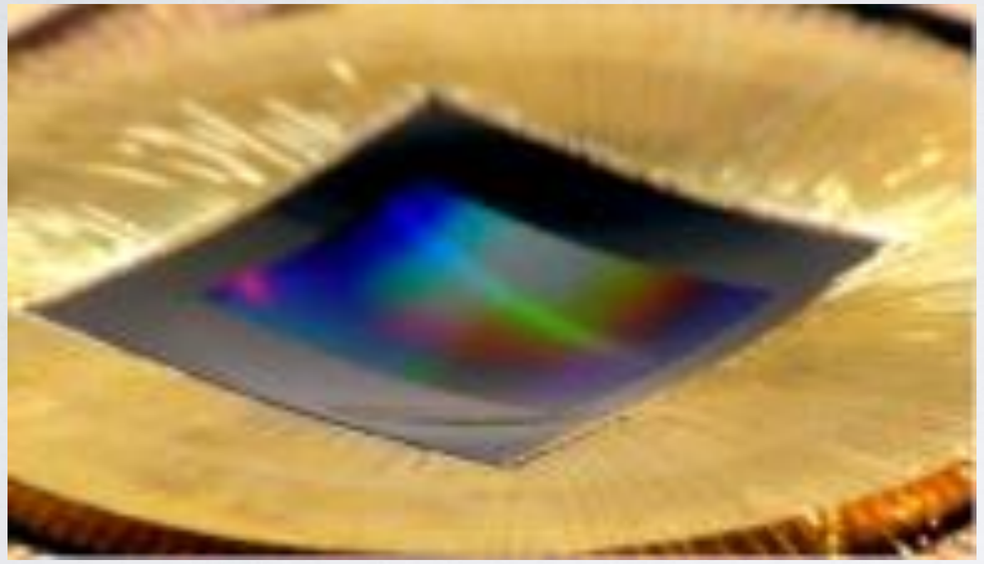
BUT NOW …

atteners

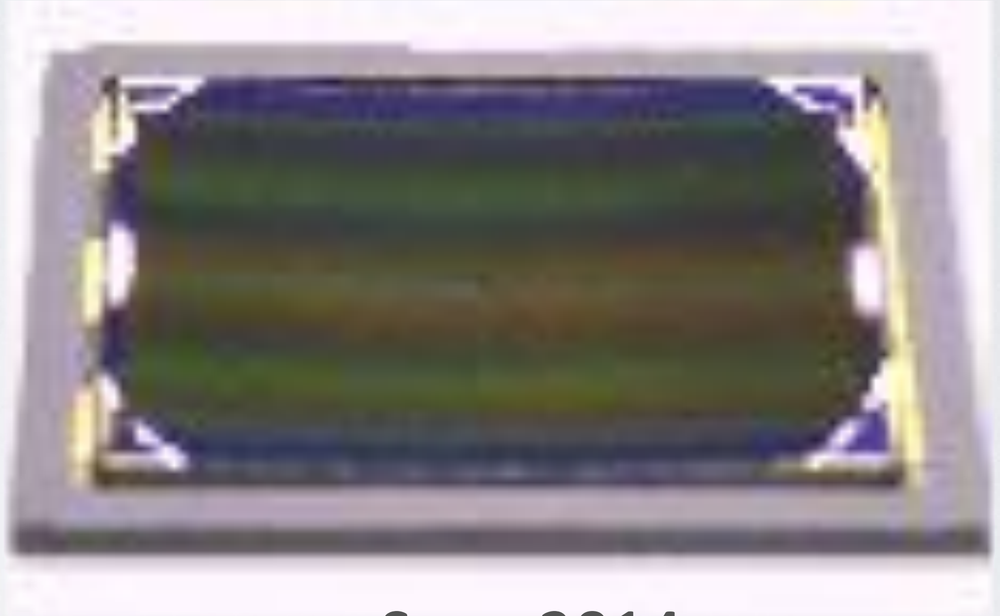
Kepler focal plane,
42 flat CCDs

CURVED DETECTORS DEVELOPMENT

A new way of solving the problem



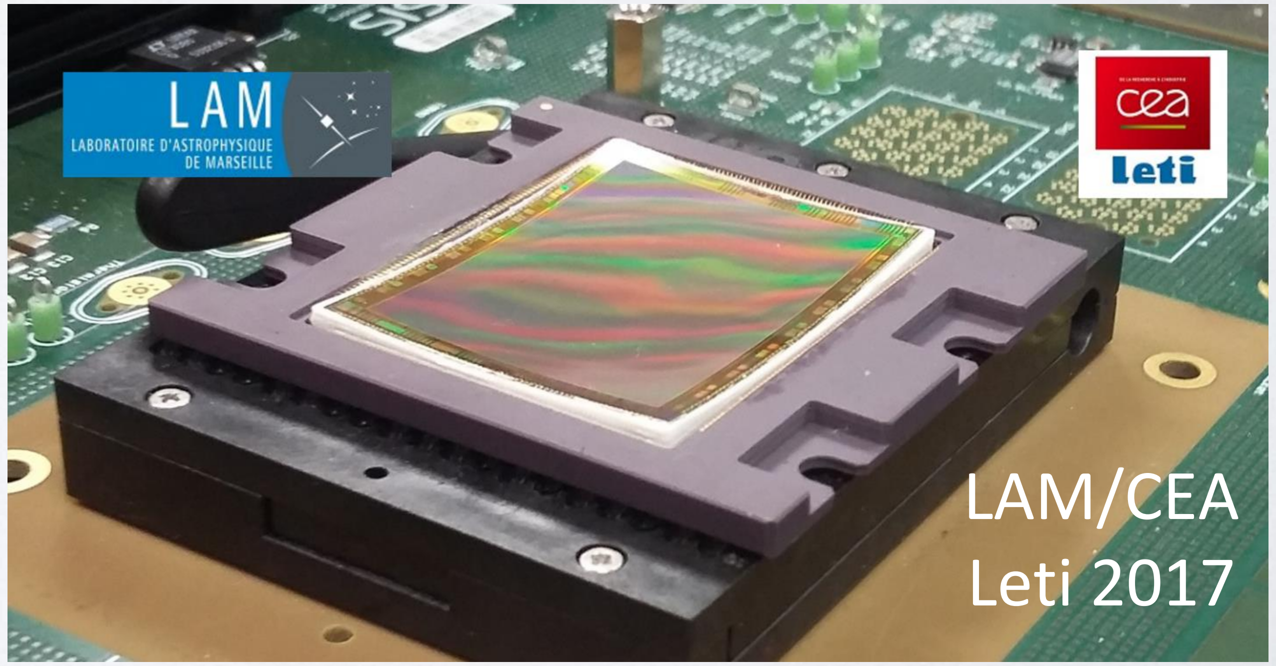
Microsoft 2017



Sony 2014

Many advantages:

- smaller and **more compact systems**
- **better throughput**



LAM/CEA Leti 2017

SCIENCE CASE I: MESSIER

Martinez-Delgado et al., 2008

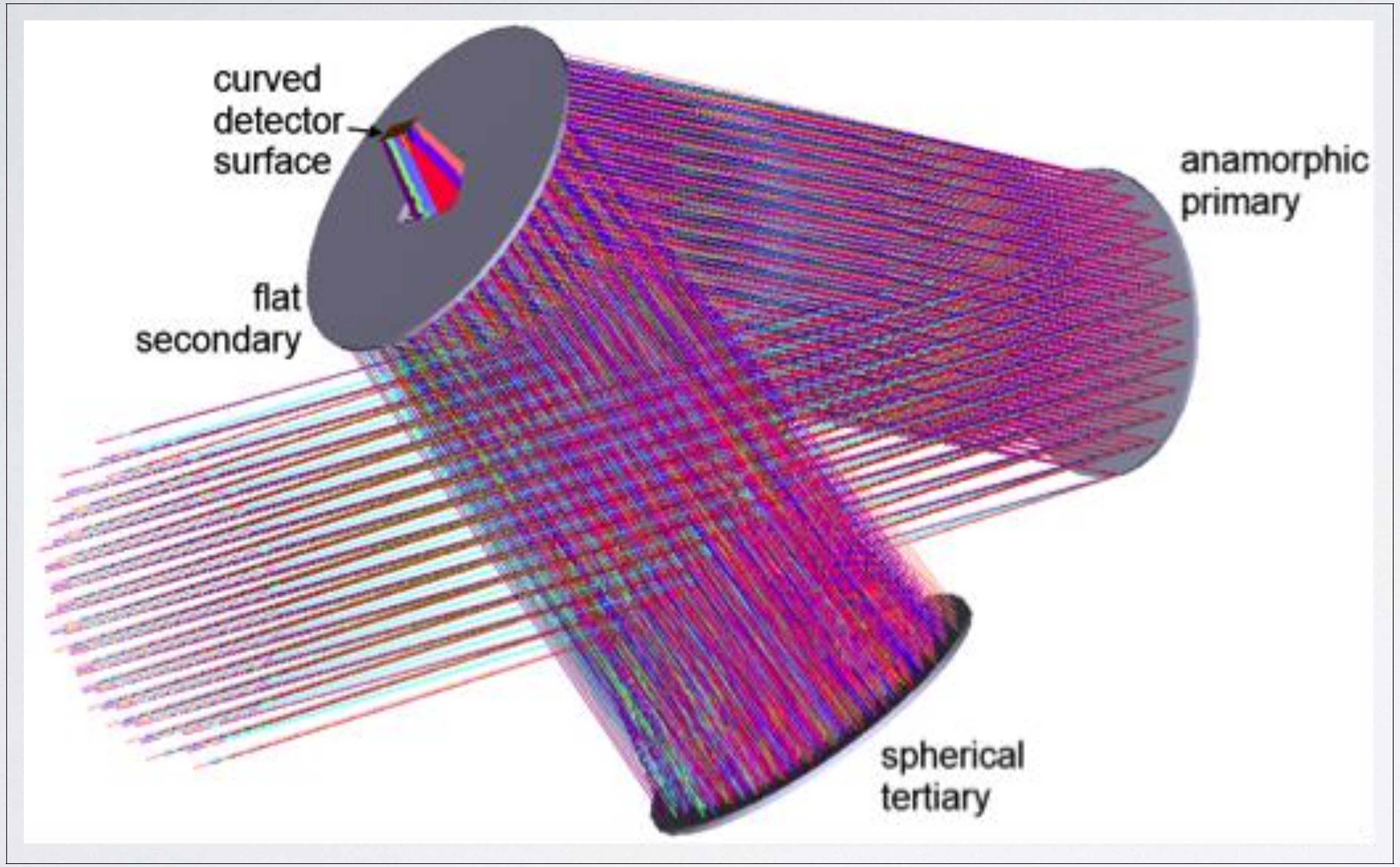
REQUIREMENTS:

- Low PSF wings
  (need to reach the faintest LSB levels)
- No refractive elements
  (no internal scattering, no Cerenkov)
- Observing from space
  (no molecular scattering)

Valls-Gabaud et al., 2017

MESSIER PATHFINDER DESIGN

Fully reflective Schmidt design to be installed in Tenerife/La Palma



- FoV: 1.6° x 2.6°
- F/# : 2.5
- Primary diameter: 356 mm

Muslimov et al., 2017,
Applied Optics, 56, 8639

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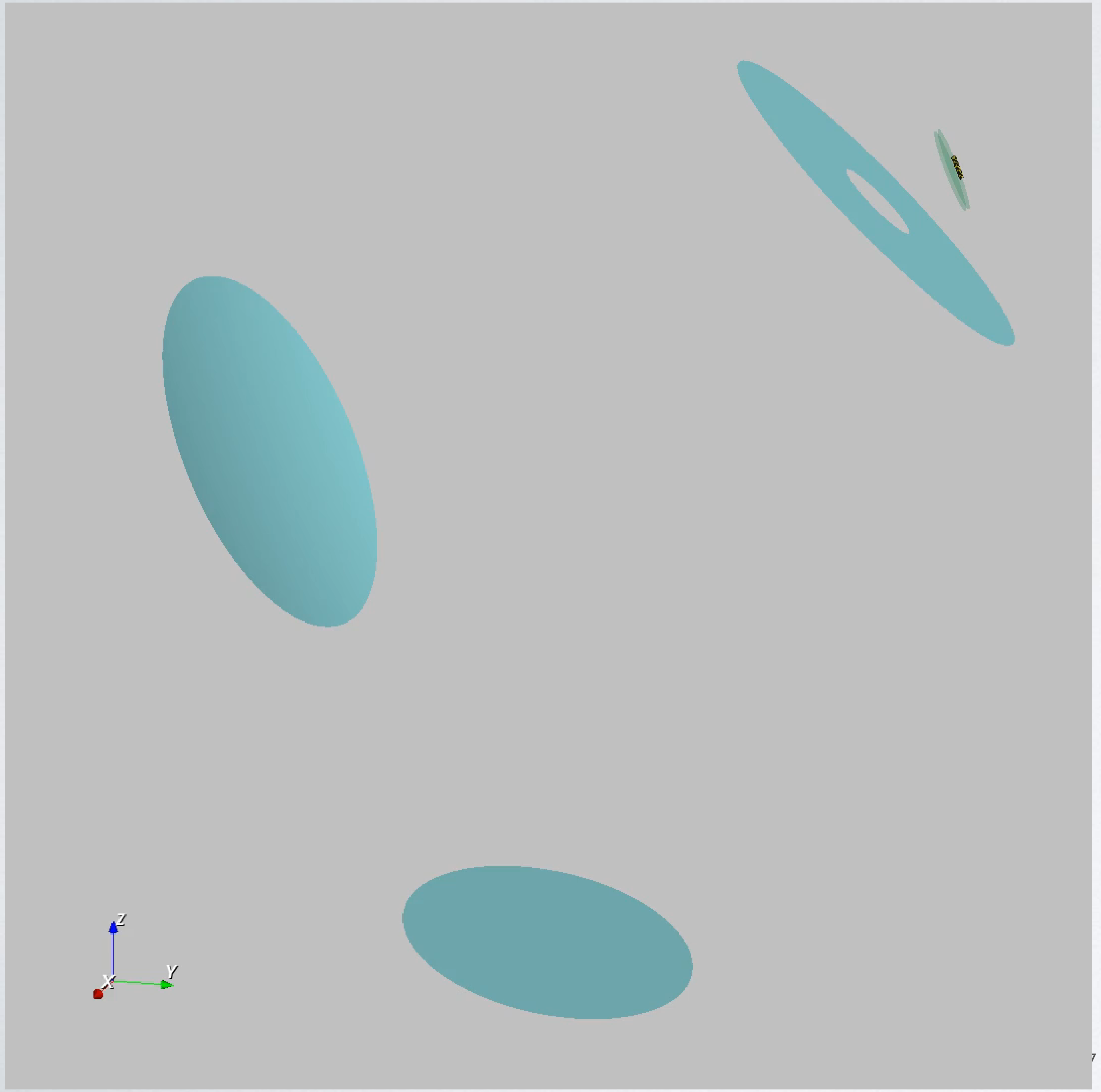
Photon Monte Carlo simulations



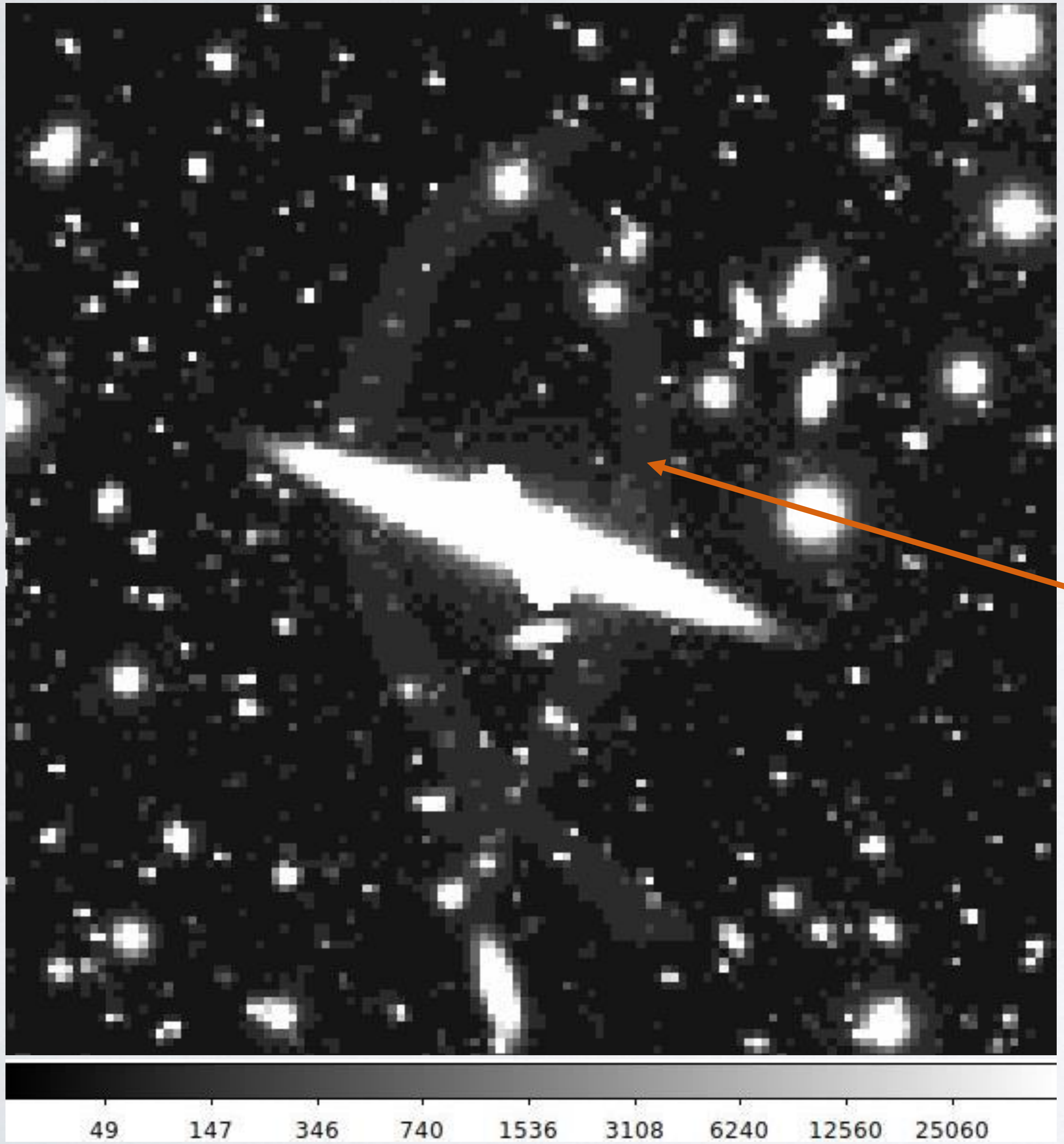
Pathfinder with one **necessary** refractive element:

g-band filter + cryostat window

Curved CCD detector

Peterson et al., 2015, PhoSim
https://www.lsst.org/scientists/simulations/phosim

U-LSB OBJECTS DRIFT SCAN SIMULATION

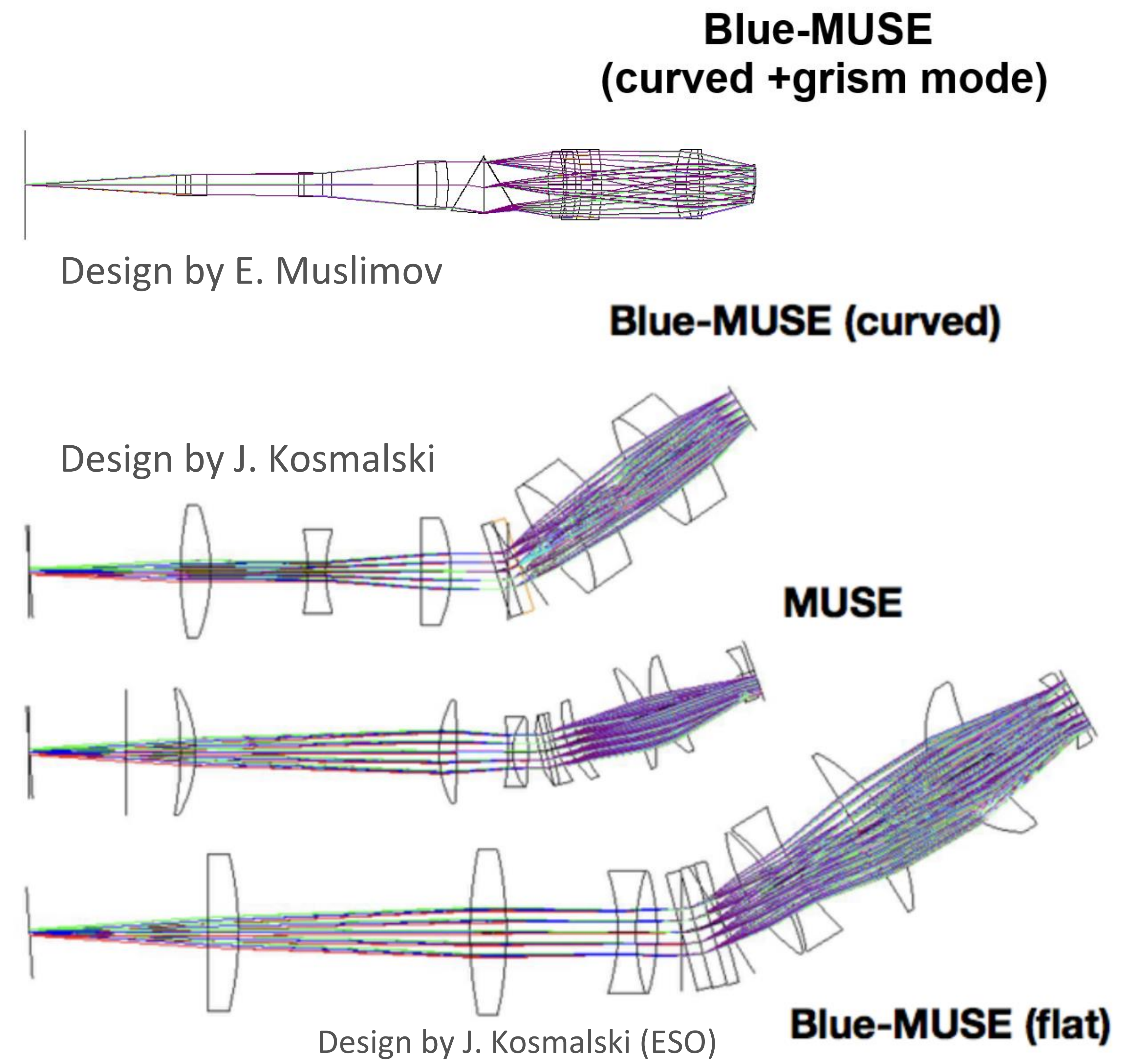


Total exp time: 6 hr

Dimension of field: 5’x5’

Brightness of arches: 29 mag/arcsec^2

Science case II: Blue MUSE



CCDs requirements:

- 24 CCDs
- 4kx4k, 15 µm pixels
- 200 mm curvature

Collaboration with Teledyne E2V

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Many detectors produced

We want to know their performances

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Characterization

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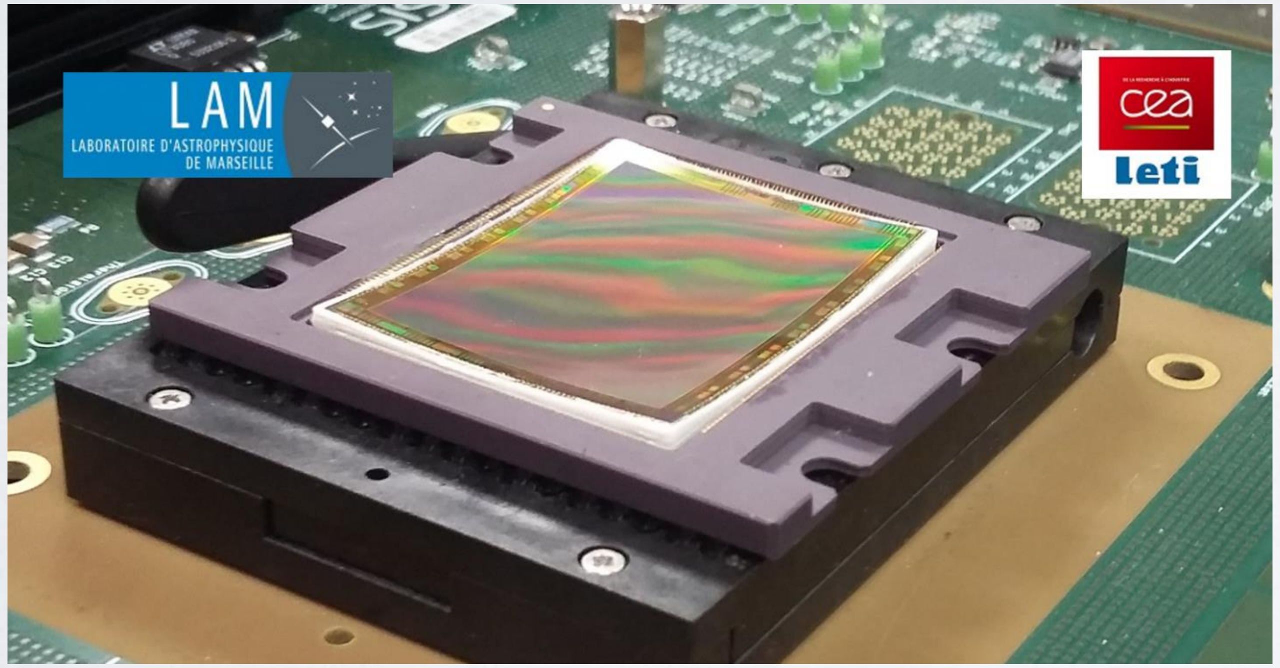
Comparing Curved Vs flat

CMV20000 CMOSIS sensors, 5120x3840 pixels of 6.4 µm

Concave with 150 mm radius of curvature



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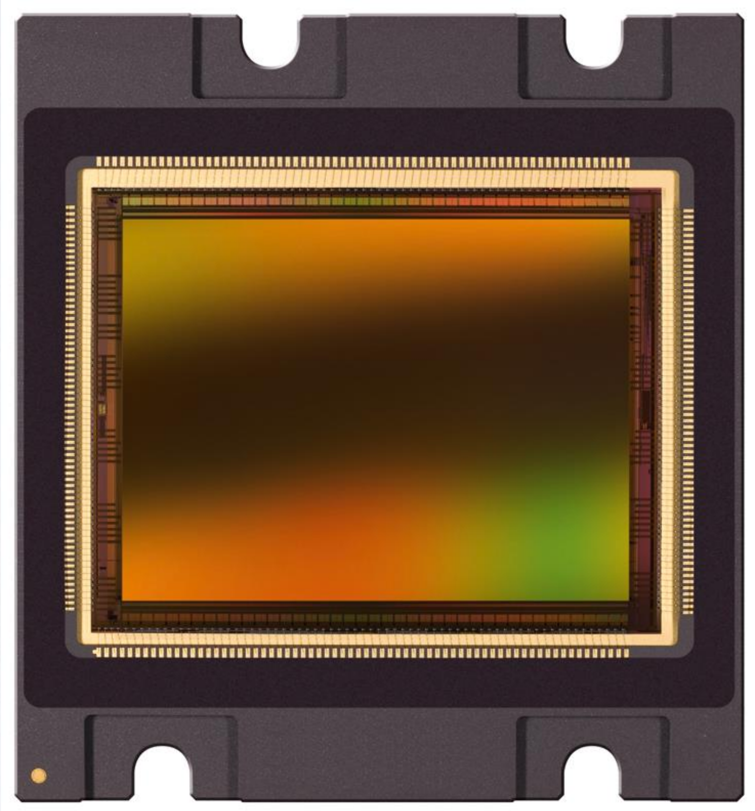
Flat



CMV20000 CMOSIS

Impact on performance?

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WHAT DOES CHARACTERIZATION MEAN?

- Noise components (readout noise, pixel-relative-non-uniformity, etc.).
- Dark current impact.
- Gain DN/e^- (conversion factor between digital number (DN) and number of electrons that originated it)

gain

Electrons generated due to light

$$S_{tot} = kN_e + S_{off}$$

offset/**bias** signal

Observed signal

RESULTS

Shape	Flat	Concave	Concave	Convex	Convex	Concave
R_c (mm)	∞	150	150	280	280	170
Bias (e^-)	595.9±24.2	604.0±23.9	588.4±21.7	637.9±24.5	603.5±24.8	574.2±22.7
Dark current (e^-/s) @ 35°C	431.4±2.7	403.4±3.5	293.8±2.9	770.6±2.3 @ 40°C	263.2±3.3	265.3±1.0
Gain (DN/e^-)	0.220±0.003	0.200±0.002	0.190±0.002	0.196±0.006	0.210±0.002	0.209±0.005
RON (e^-)	11	10	10	10	10	10
Saturation (DN)	4095	4095	3951	4095	4095	4095
Dynamic range (dB)	64.74	66.19	66.44	66.26	65.98	66.14
Full well (e^-)	18018	19871	20206	19331	18896	19019
PRNU factor	1.2%	2.0%	2.1%	1.9%	2.0%	1.9%

PRELIMINARY

Lower dark current!!

NEXT STEPS

Curved detectors have similar characteristics to the flat ones (noise, gain, dynamic range, …)

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NO CLEAR IMPACT ON PERFORMANCE IN THE CURVING PROCESS

We need to develop curved CCDs now
(collaboration with Teledyne E2V)

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Curved CCDs development plan

August/September 2018 - Funding request: **Done**

January 2019	- Beginning of production phase
Spring 2019	- First prototype
Fall 2019	- Full characterization

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CURVED CCDS DEVELOPMENT PLAN

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Many news in the next months!

THANK YOU!

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