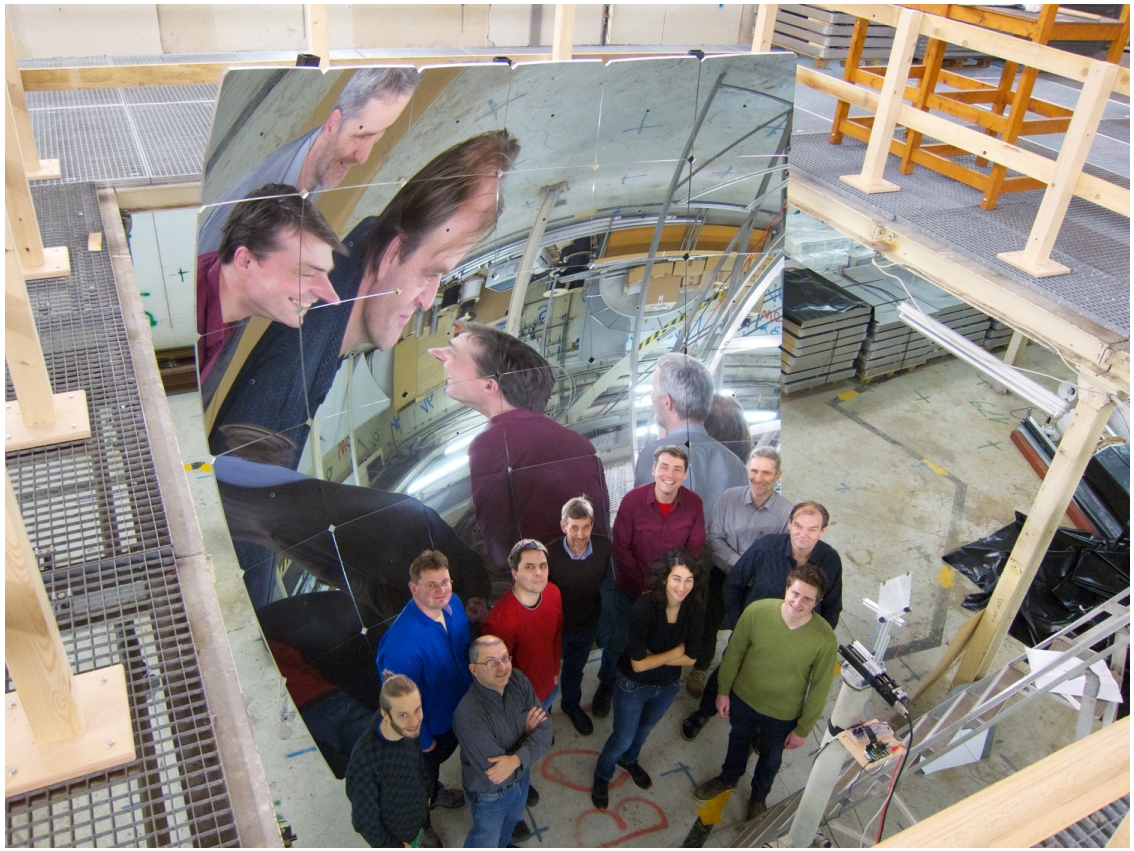


Search for Dark Matter in the Hidden-Photon Sector with a Large Spherical Mirror

The FUNK Experiment

Darko Veberic, K. Daumiller, B. Döbrich, R. Engel, J. Jaeckel, M. Kowalski, A. Lindner, H.-J. Mathes, J. Redondo, M. Roth, C. Schäfer, R. Ulrich

Hidden Photons

most prominent candidate DM are weakly interacting massive particles (WIMP)
ALP & HP are good alternative: weakly interacting slim particles (WISP)

HP as SM extension: light extra U(1) gauge bosons *X*, kinetic mixing with EM bosons *F*

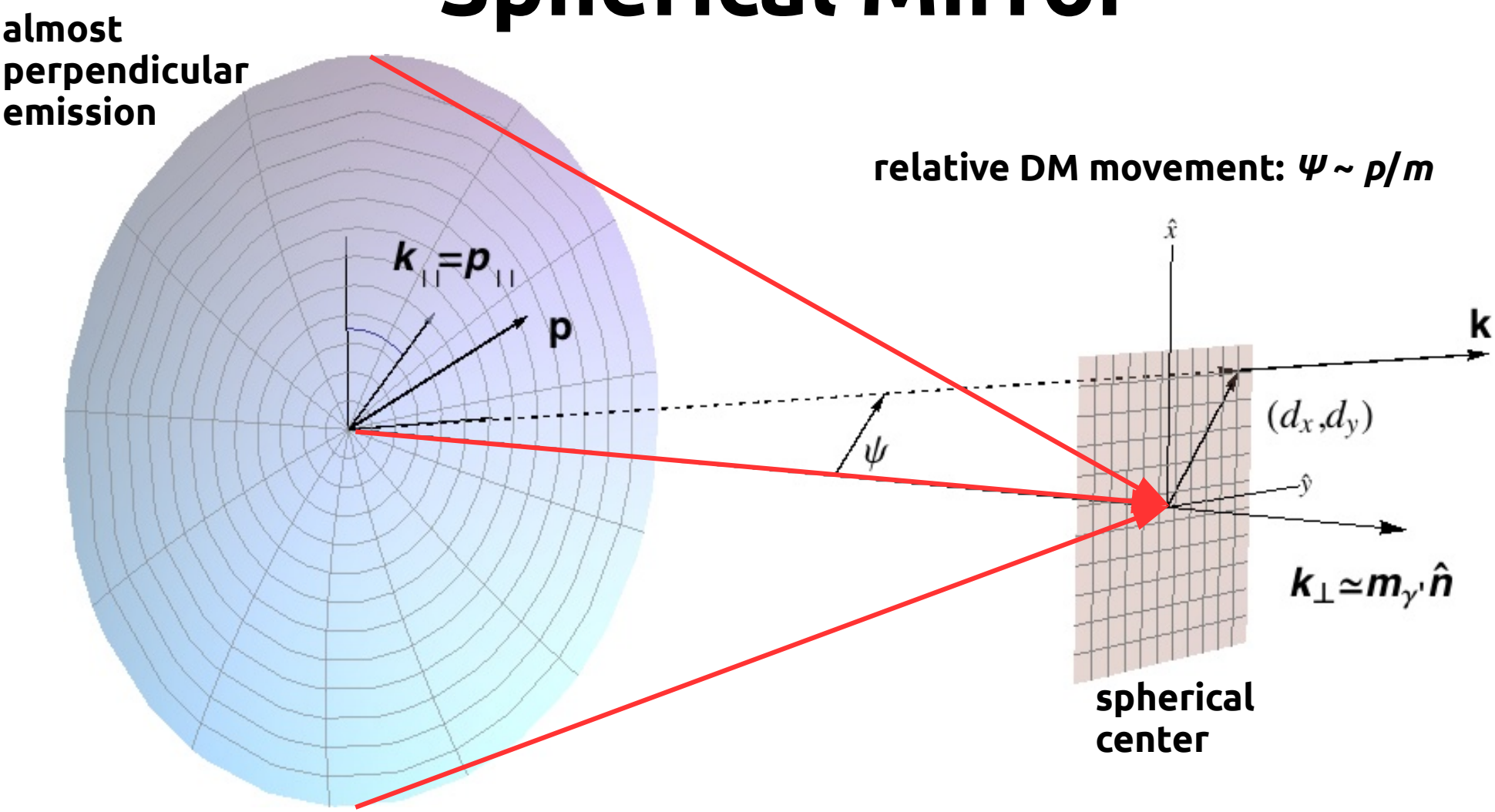
$$\mathcal{L} = -\frac{1}{4}\left(F_{\mu\nu}F^{\mu\nu} + X_{\mu\nu}X^{\mu\nu}\right) + J^{\mu}A_{\mu} + \frac{m^2}{2}X_{\mu}X^{\mu} - \frac{\chi}{2}F_{\mu\nu}X^{\mu\nu}$$

Arias *et al.*, JCAP 06 (2012) 013
Horns *et al.*, JCAP 04 (2013) 016

boundary condition for E-field on conducting surface
tiny EM component emitted almost perpendicularly, photon energy ~ *m*
reduce background: spherical mirror

Jaeckel & Redondo, JCAP 11 (2013) 016

Spherical Mirror

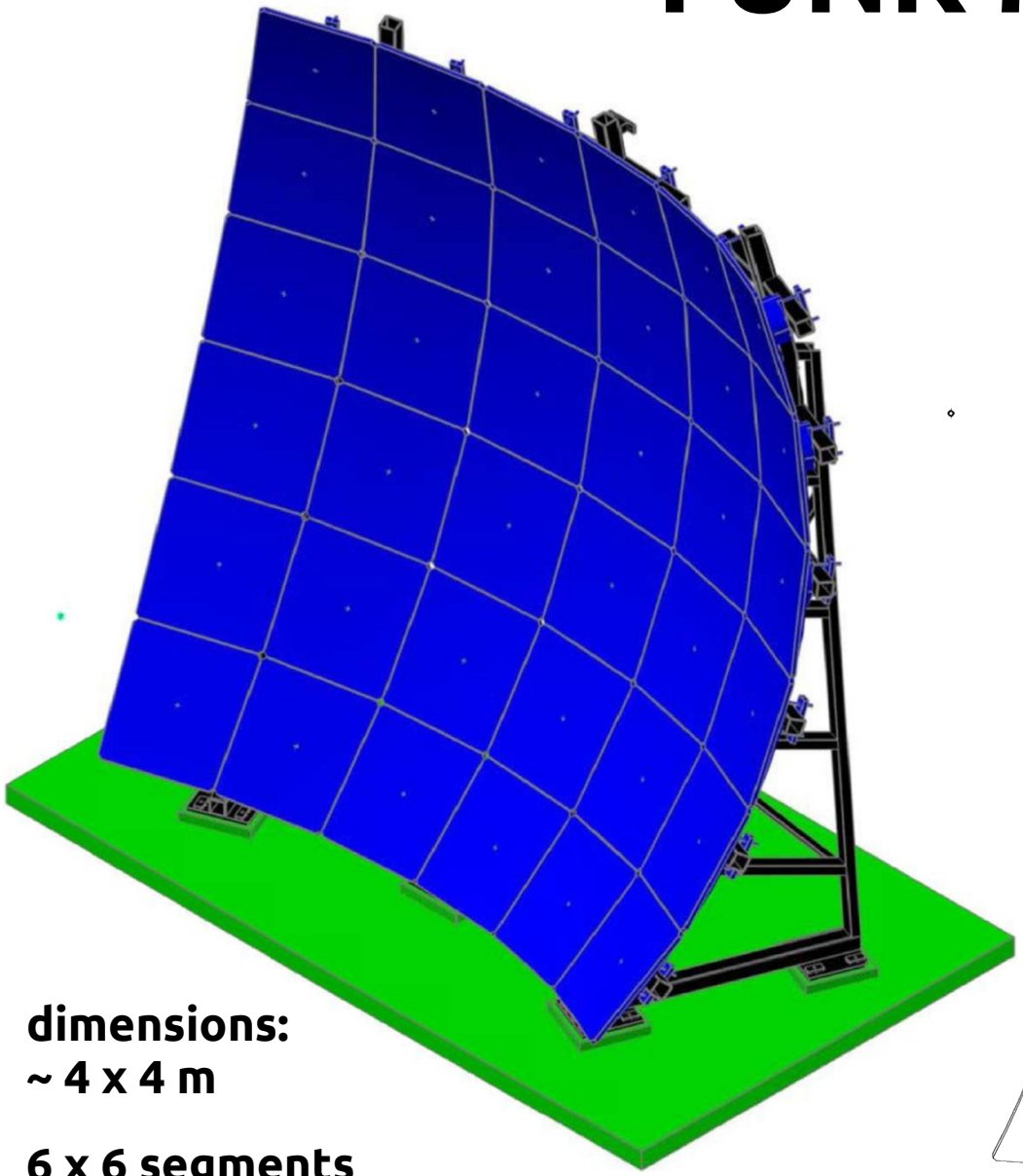


Jaeckel & Redondo, JCAP 11 (2013) 016

power from spherical mirror with area *A*

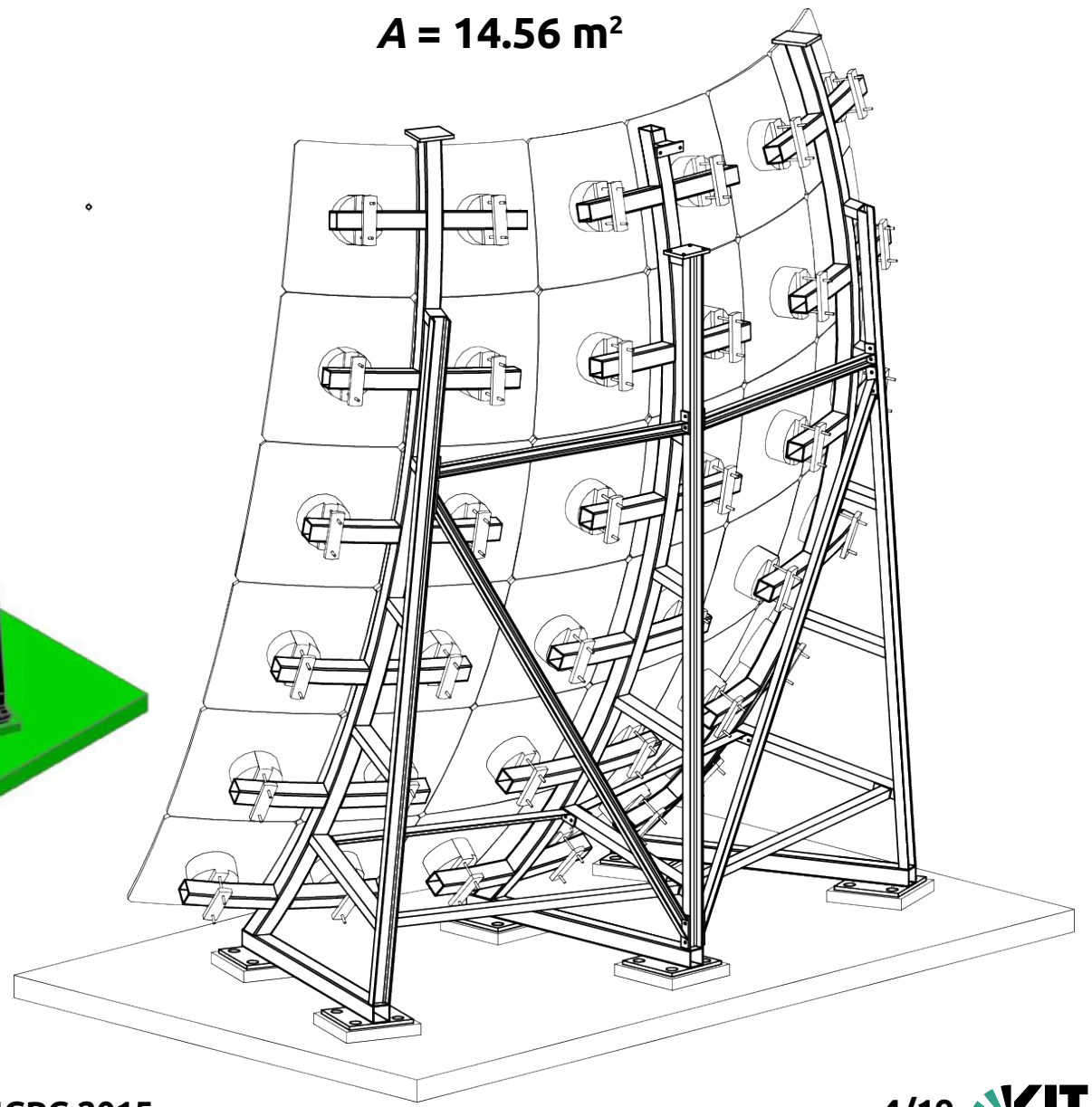
$$P = \langle \alpha^2 \rangle \chi^2 \rho_{\rm cdm} A \approx 2\times 10^5\,{\rm W}\,\chi^2$$

FUNK Mirror



R = 340 cm

A = 14.56 m²



dimensions:
~ 4 x 4 m

6 x 6 segments

only 3 unique shapes for simpler production

Pierre Auger Observatory

Abraham *et al.*, NIMA 620 (2010) 227

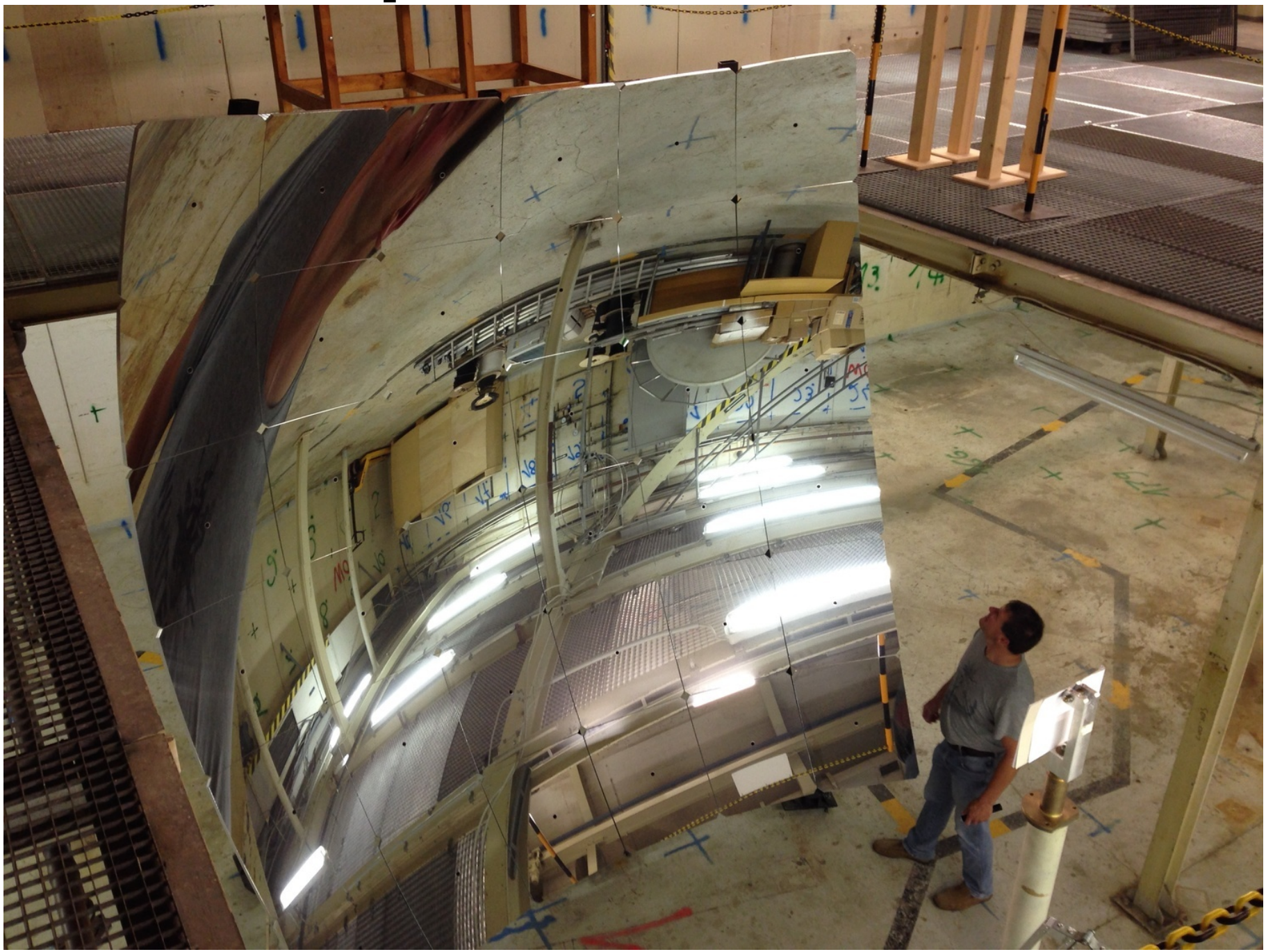
massively produced in early 2000
Observatory completed in 2008

four Fluorescence Detector sites;
6 telescopes each

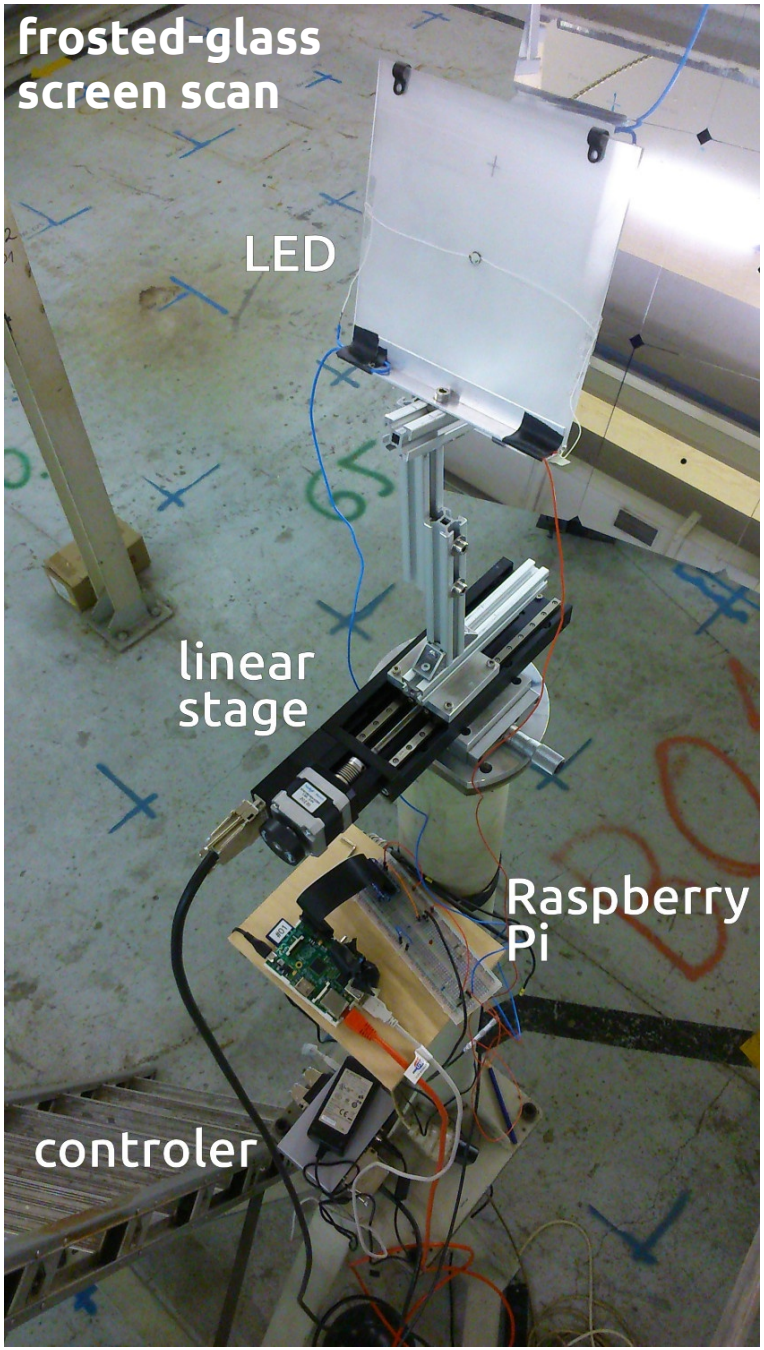
Schmidt telescope:
corrector ring, 440 PMT camera, mirror

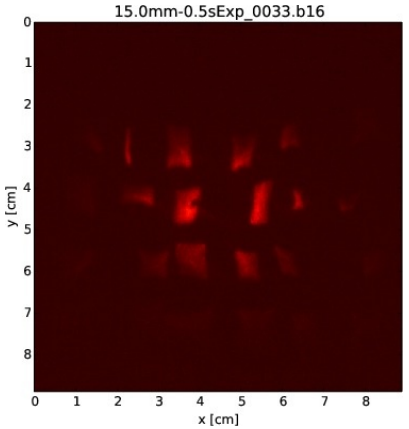
remaining spare segments
strict curvature quality controls <1 cm

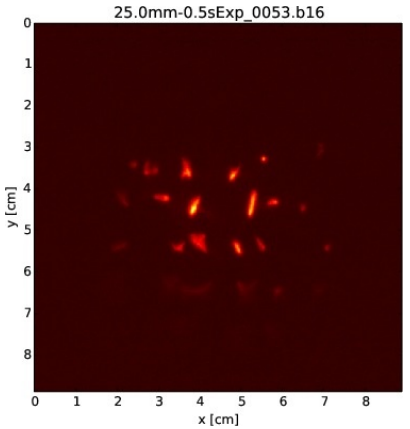
Experimental Hall

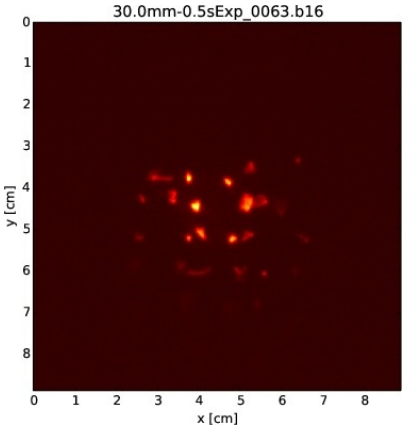


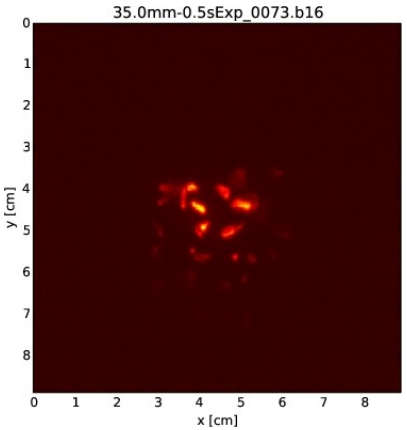
Optical Quality

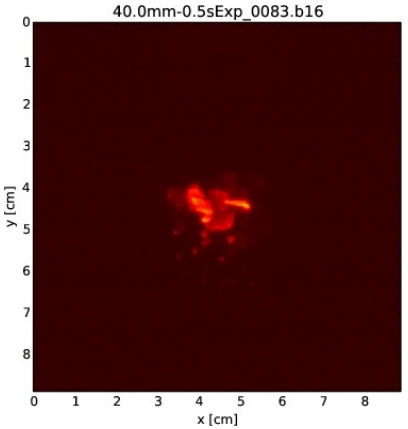


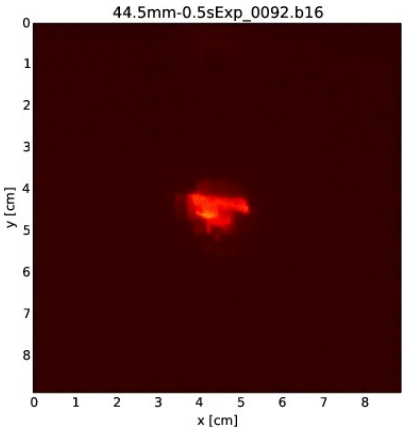


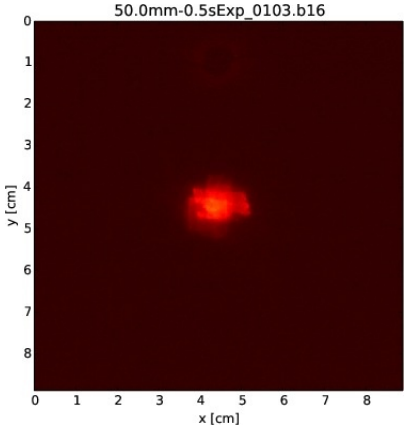


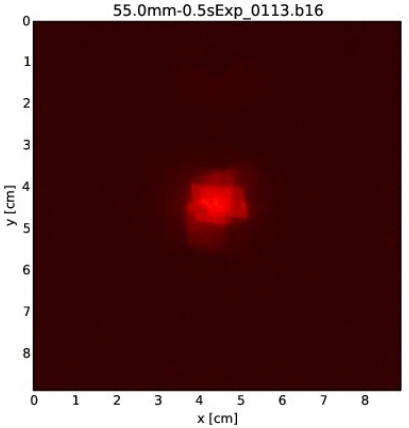






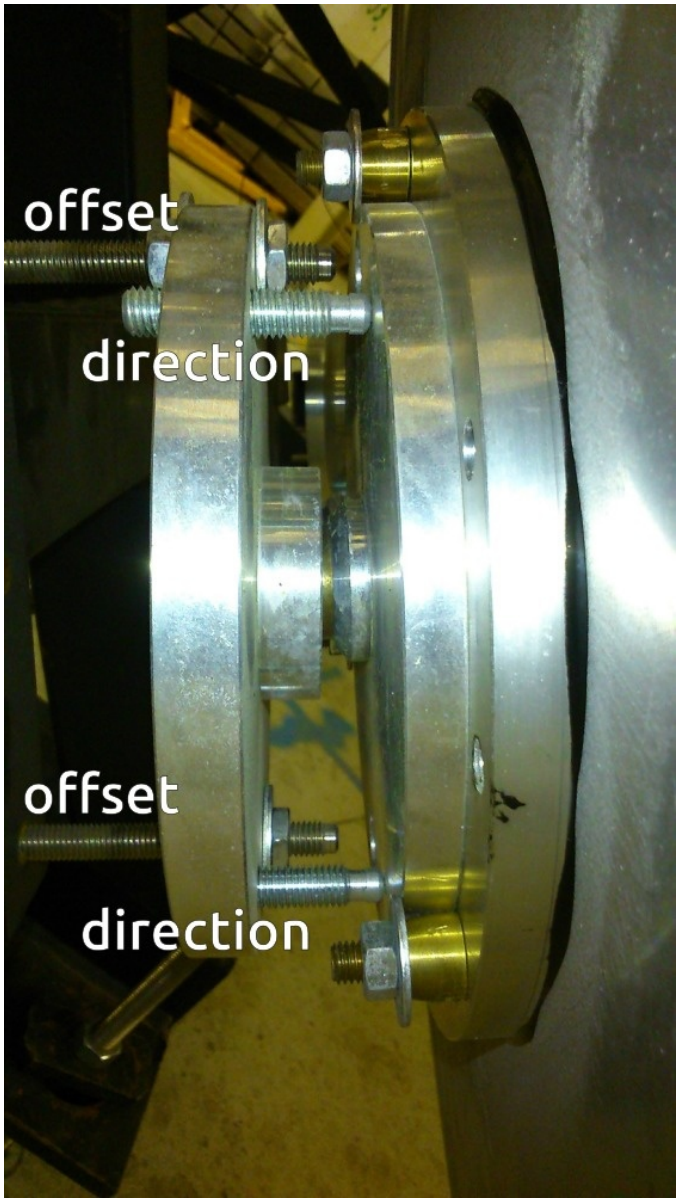






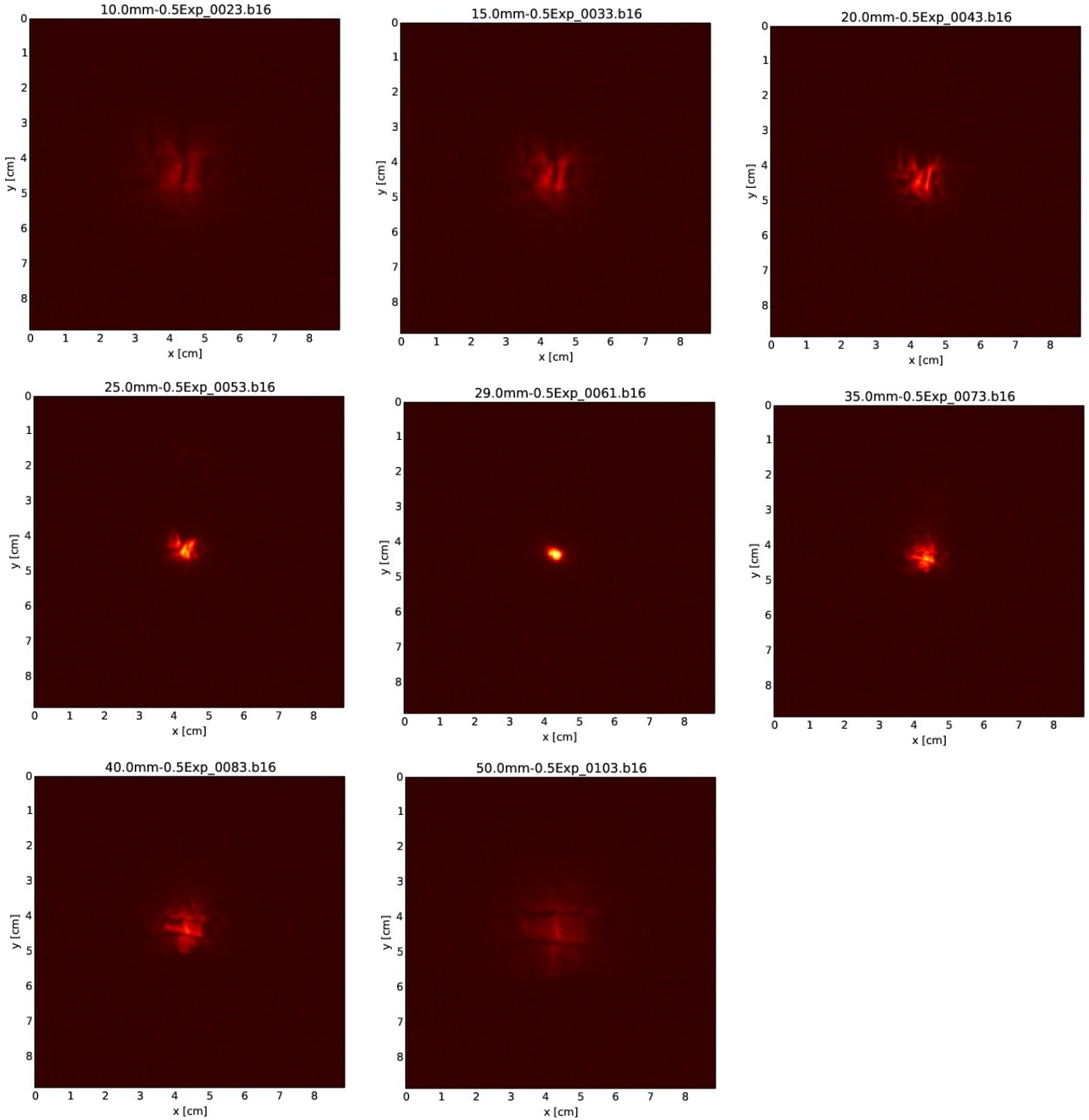
initial assembly

Fine Realignment

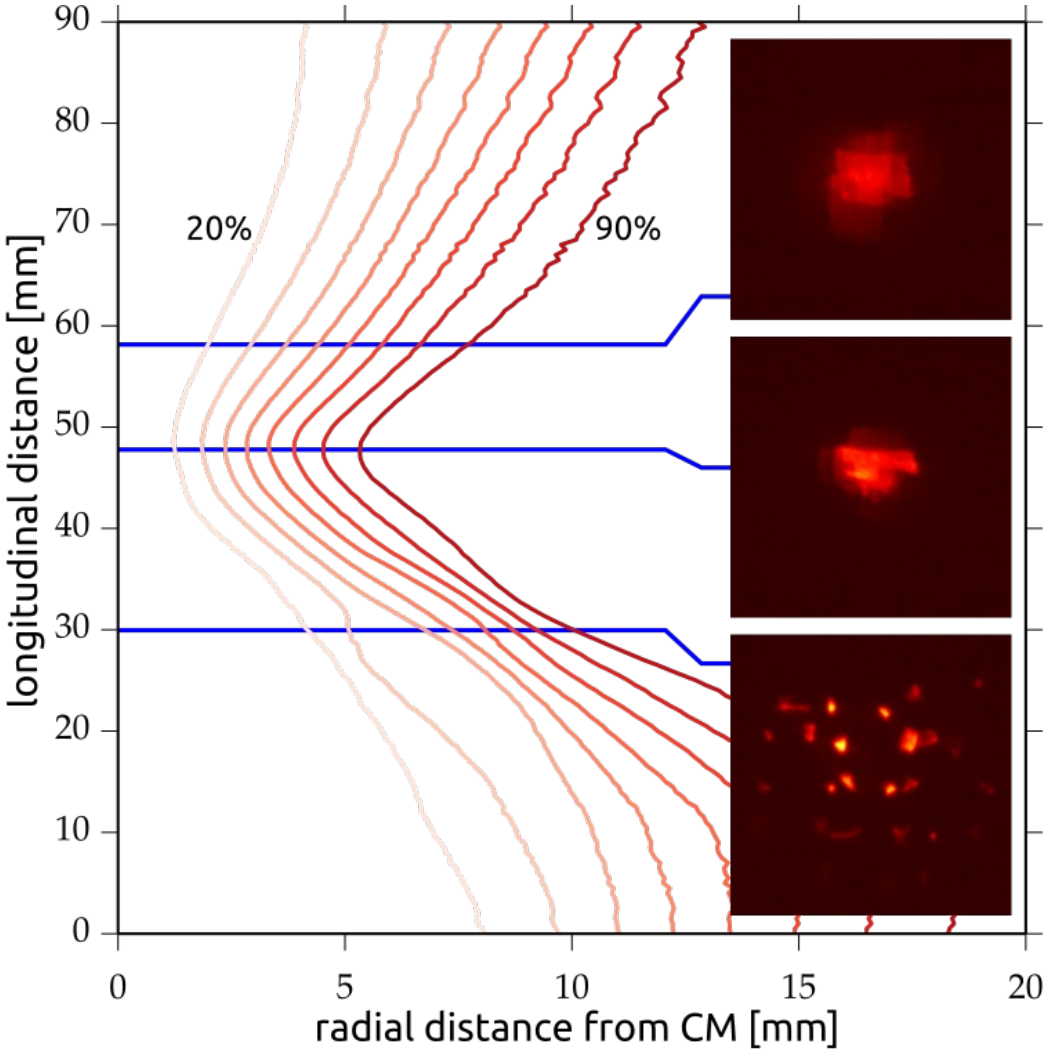


ball joint

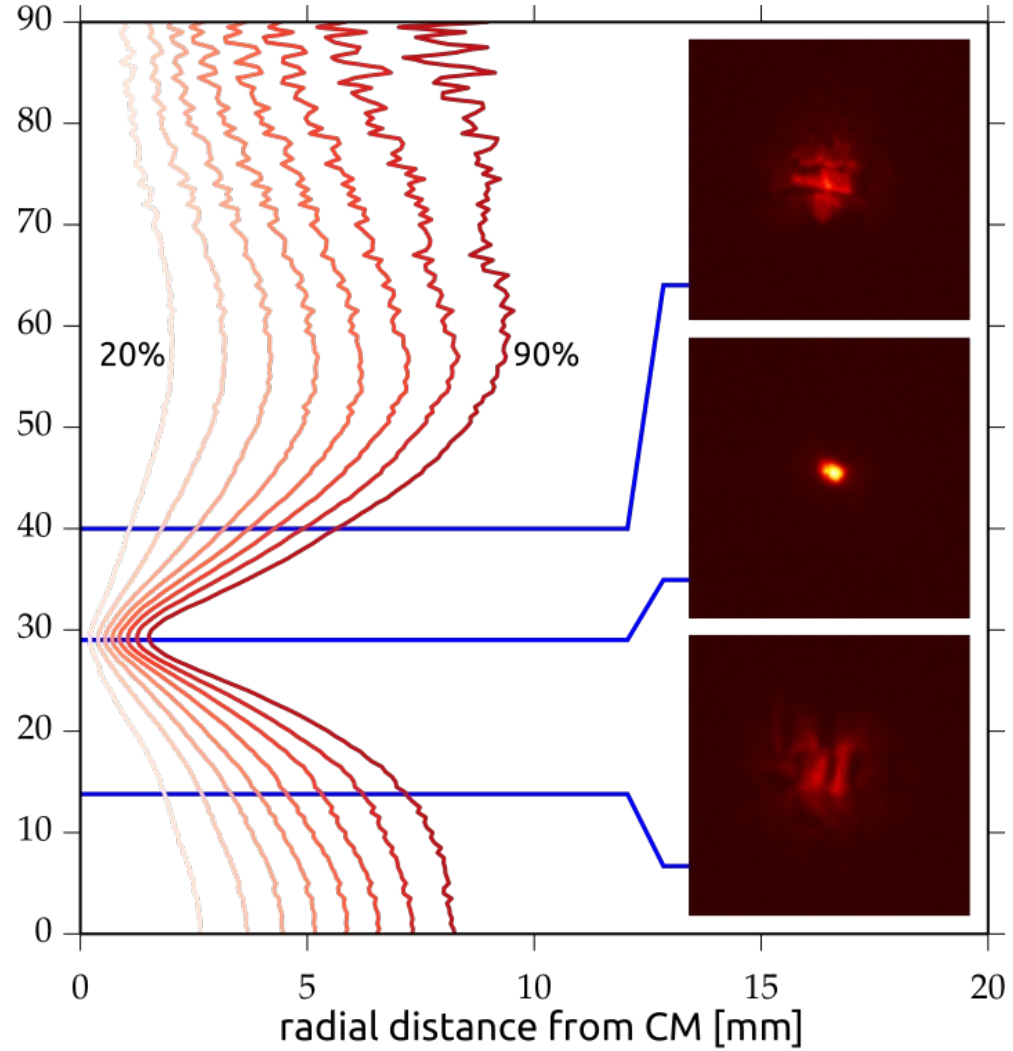
New alignment



New alignment

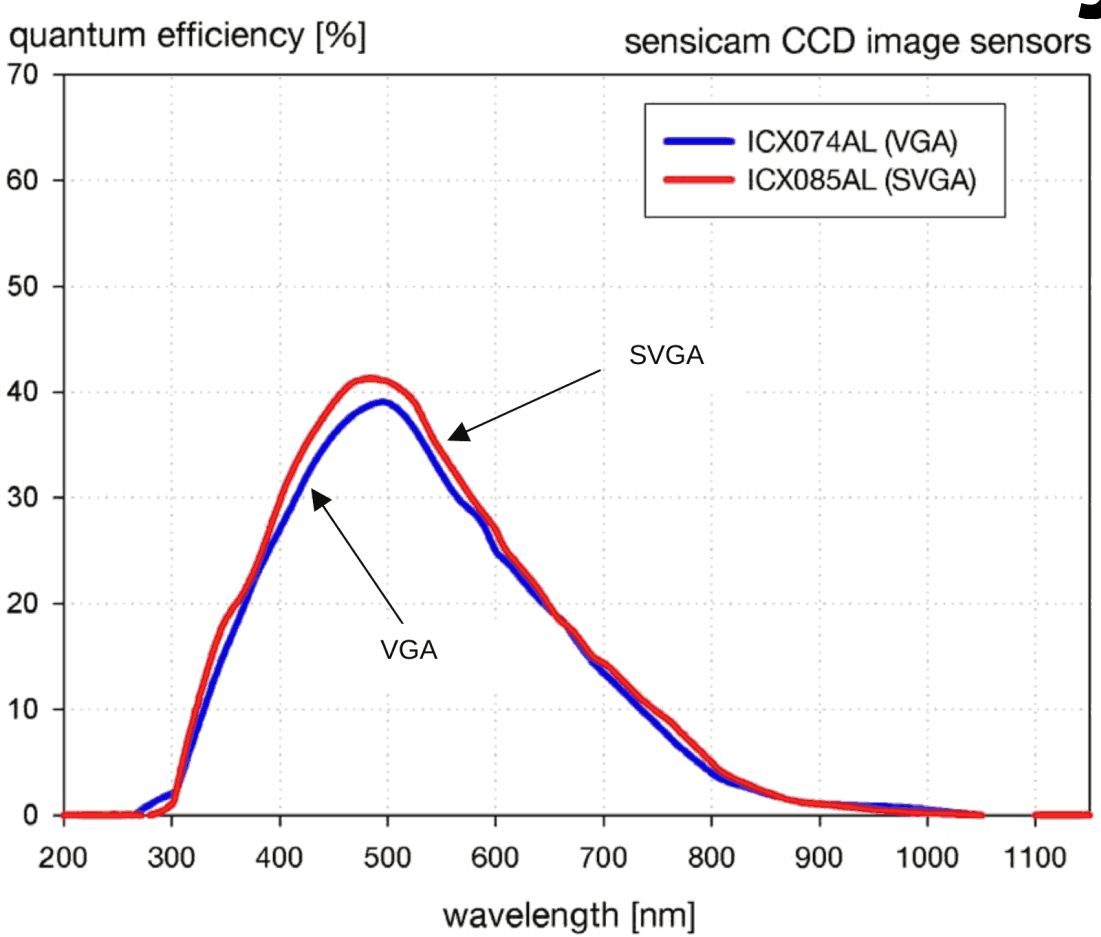


spot size ~6 mm



spot size ~2 mm

Preliminary Results

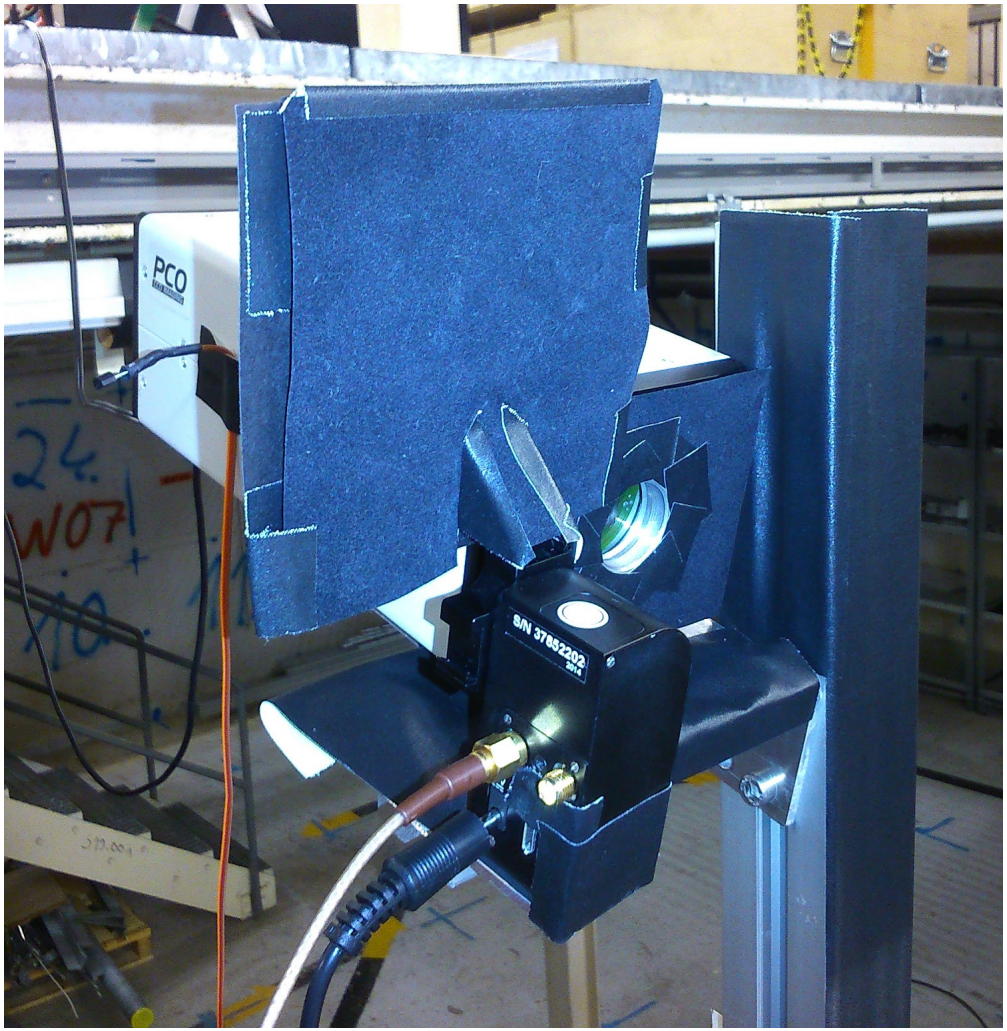


PCO Sensicam VGA
640x480 pixel CCD
internally Peltier-cooled –15°C

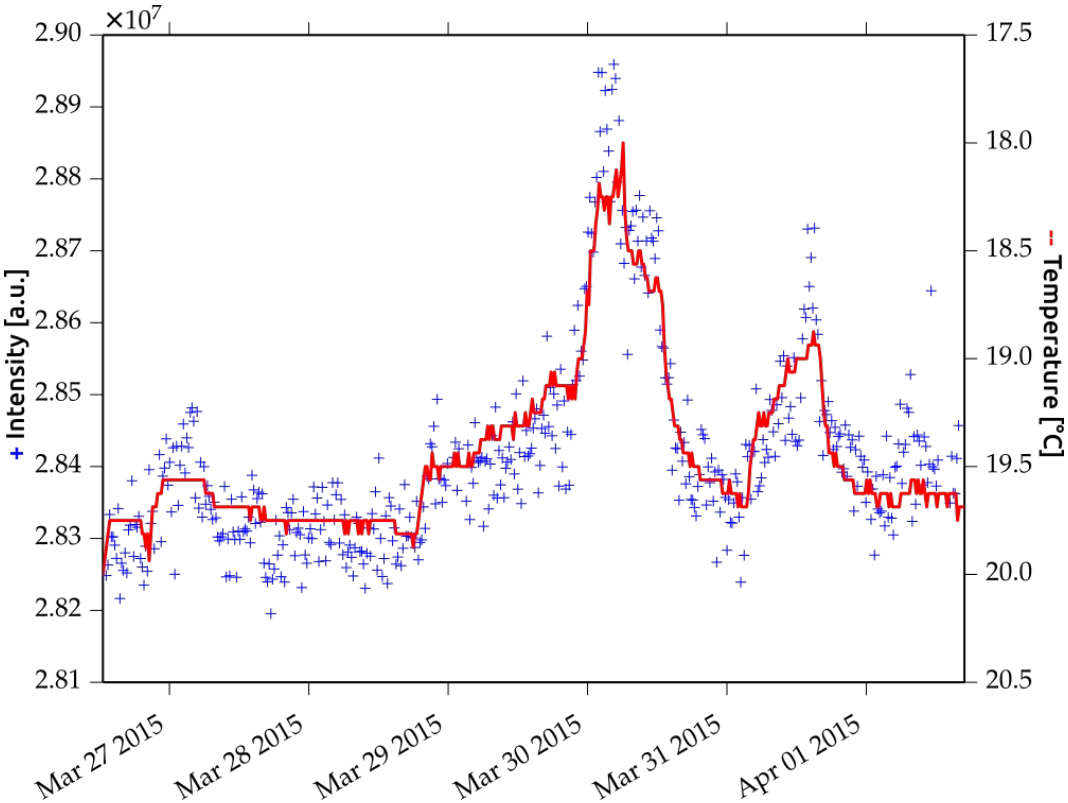
no lens, exposed CCD
total image intensity

Preliminary Results

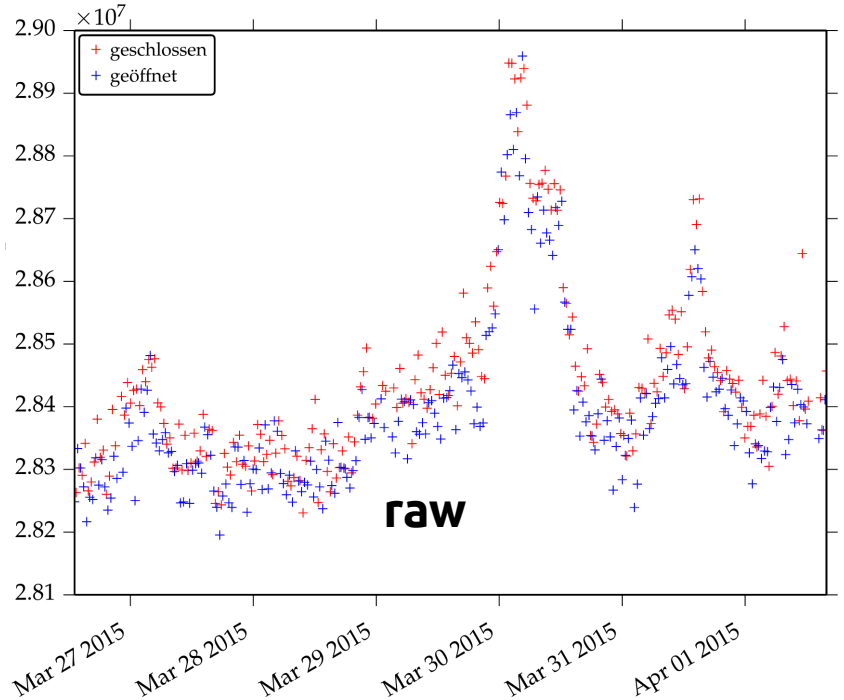
motorized flipper open/closed images



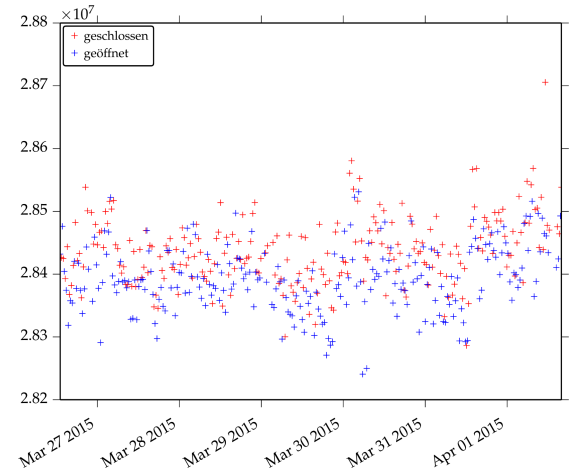
temperature dependence of image intensity



Preliminary Results

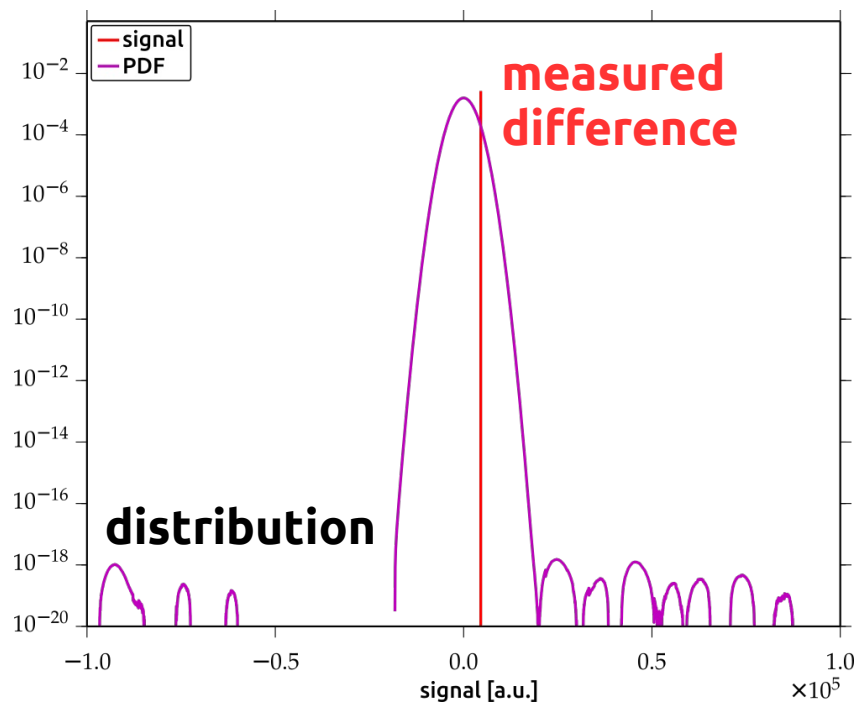


→ **temperature correction** →

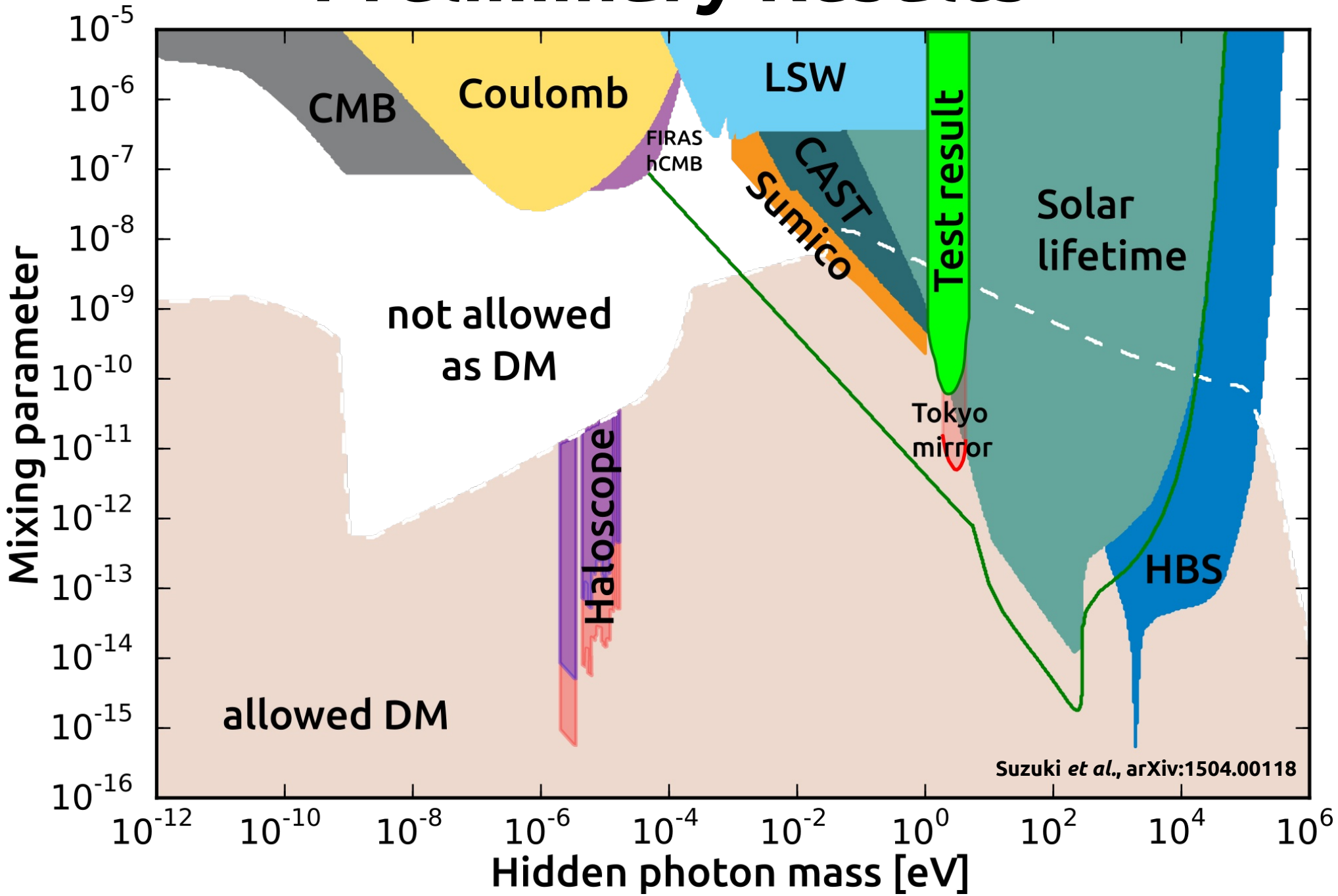


example 6 day run

1000 s exposure



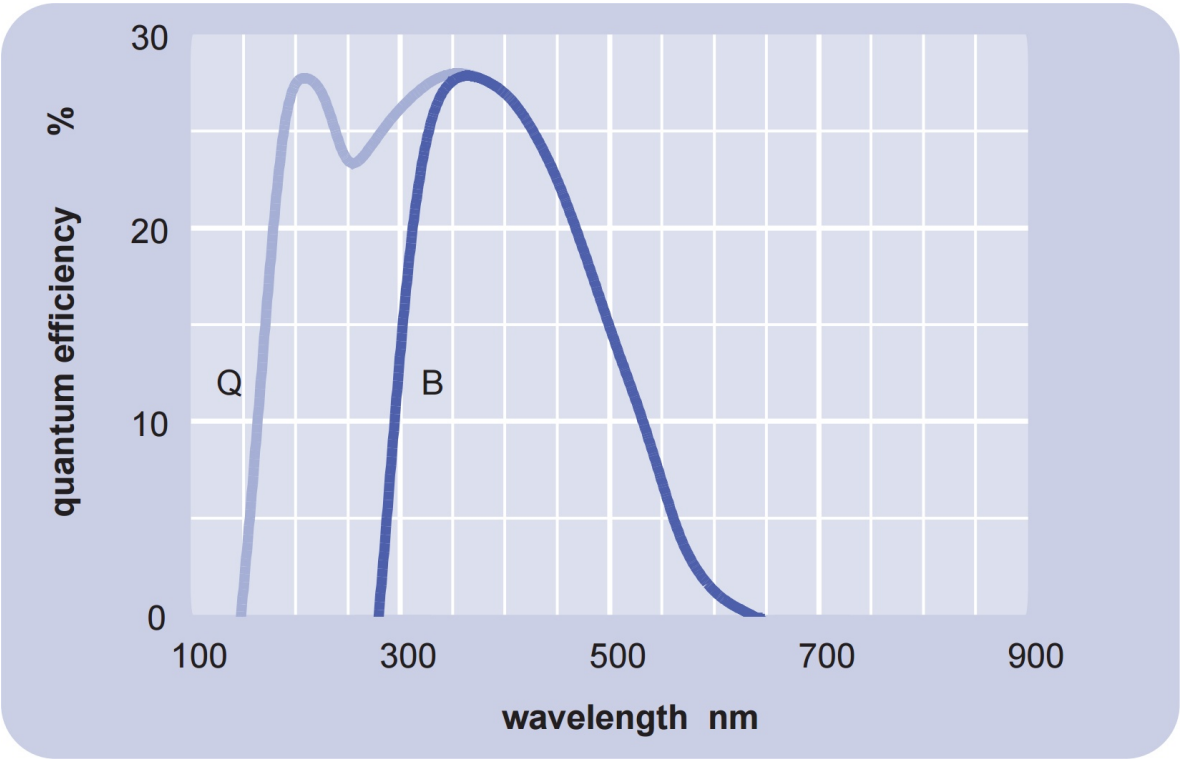
Preliminary Results



Outlook and Future Plans

Low-noise PMT

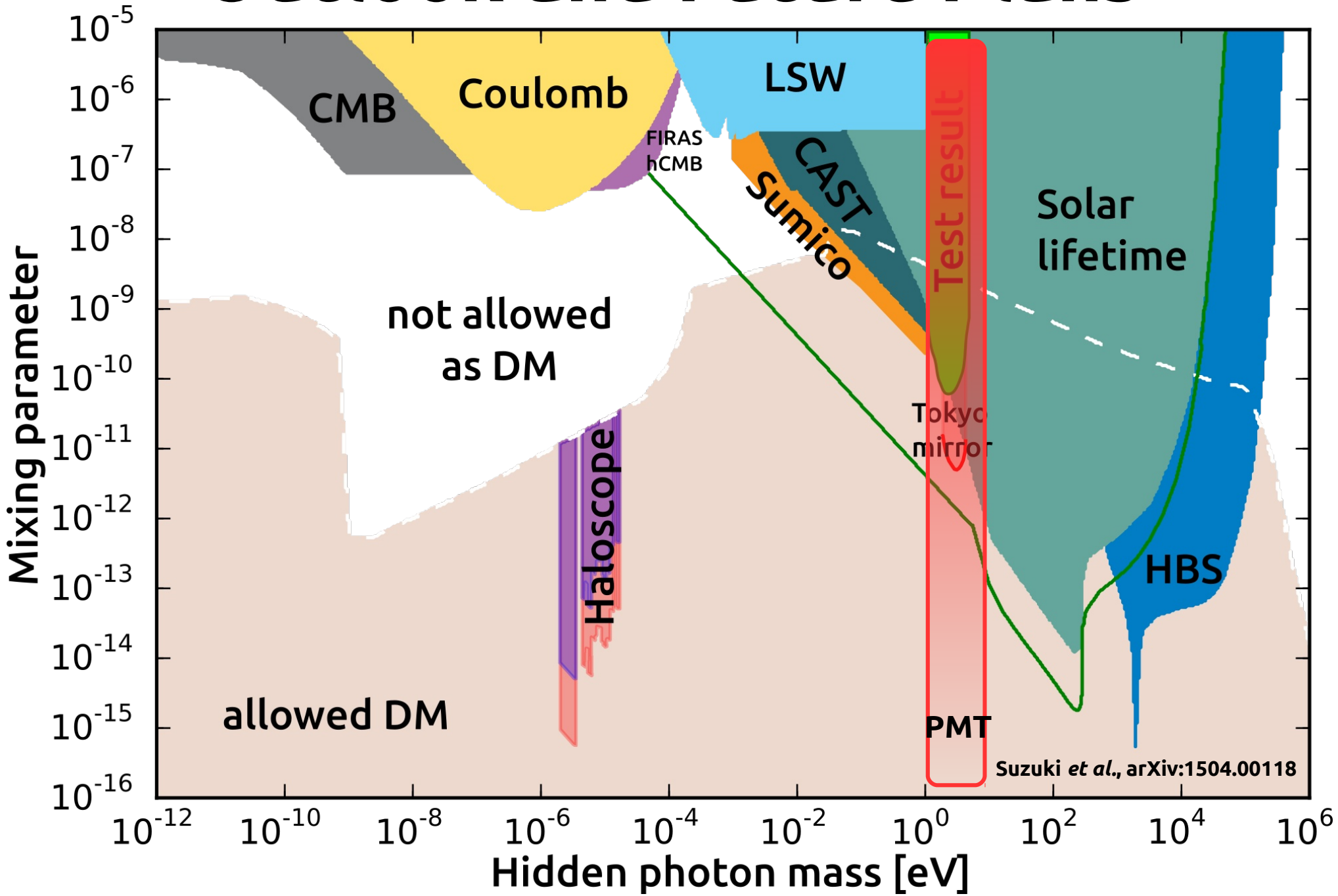
far-UV extended sensitivity (Q)



cooled encasing

T **= –50°C**

Outlook and Future Plans

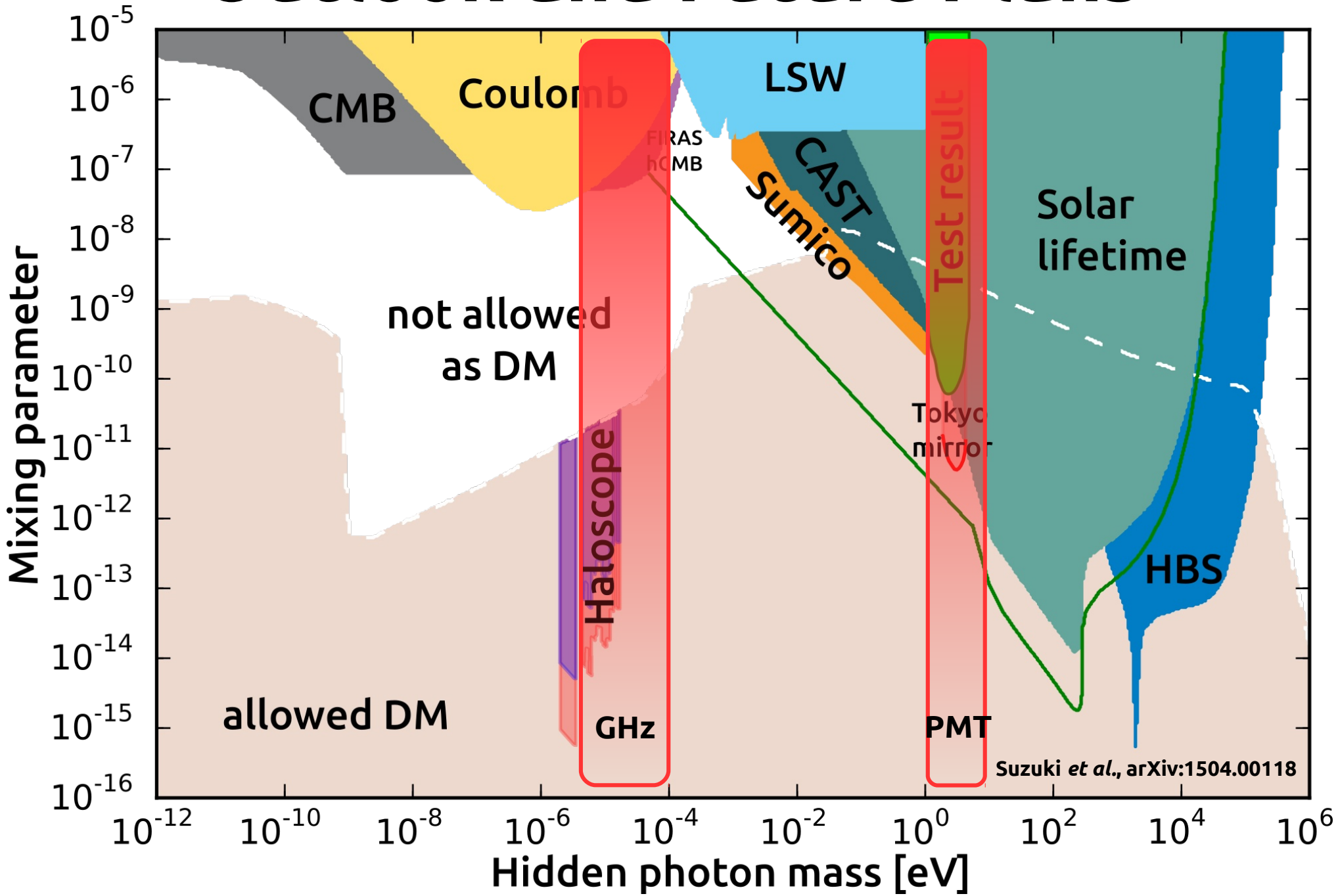


Outlook and Future Plans

1 – 20 GHz (UHF-SHF band)

CROME experiment
PRL **113** (2014) 221101

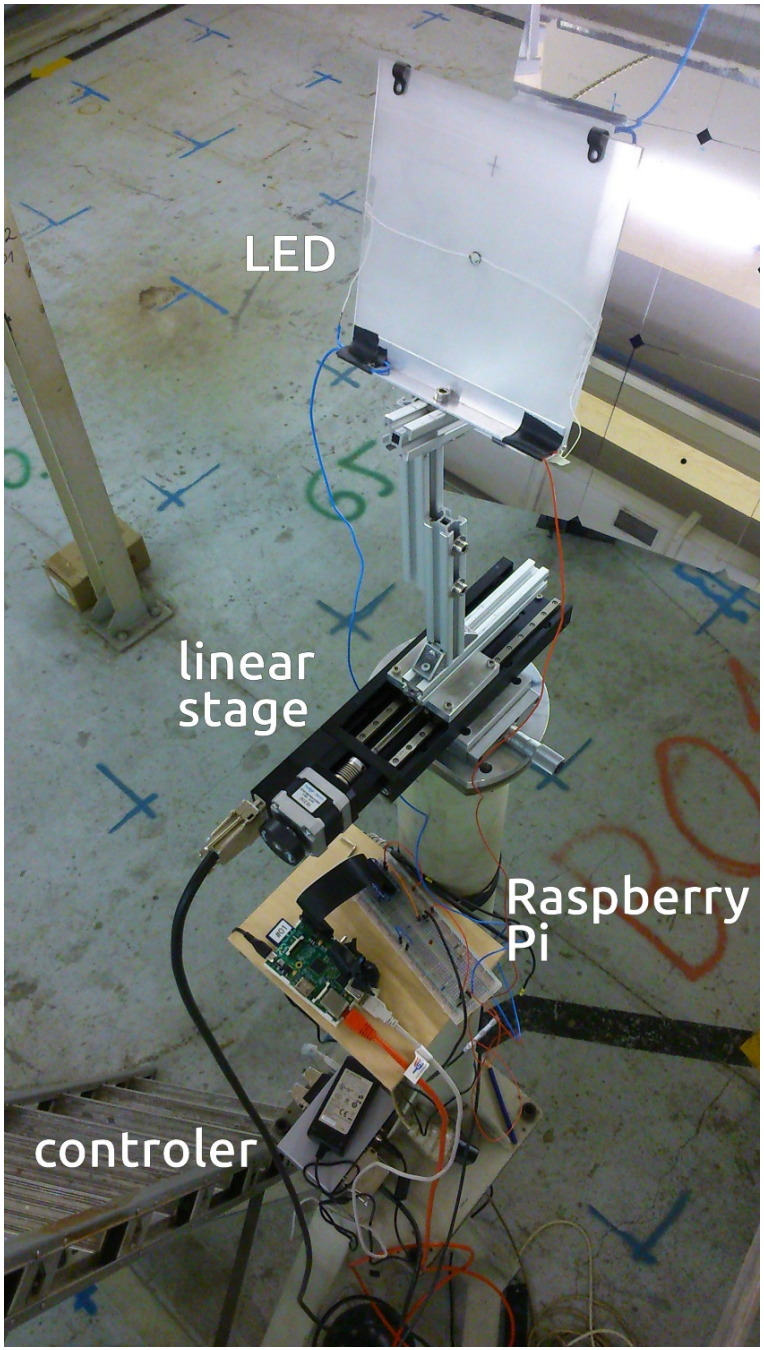
Outlook and Future Plans

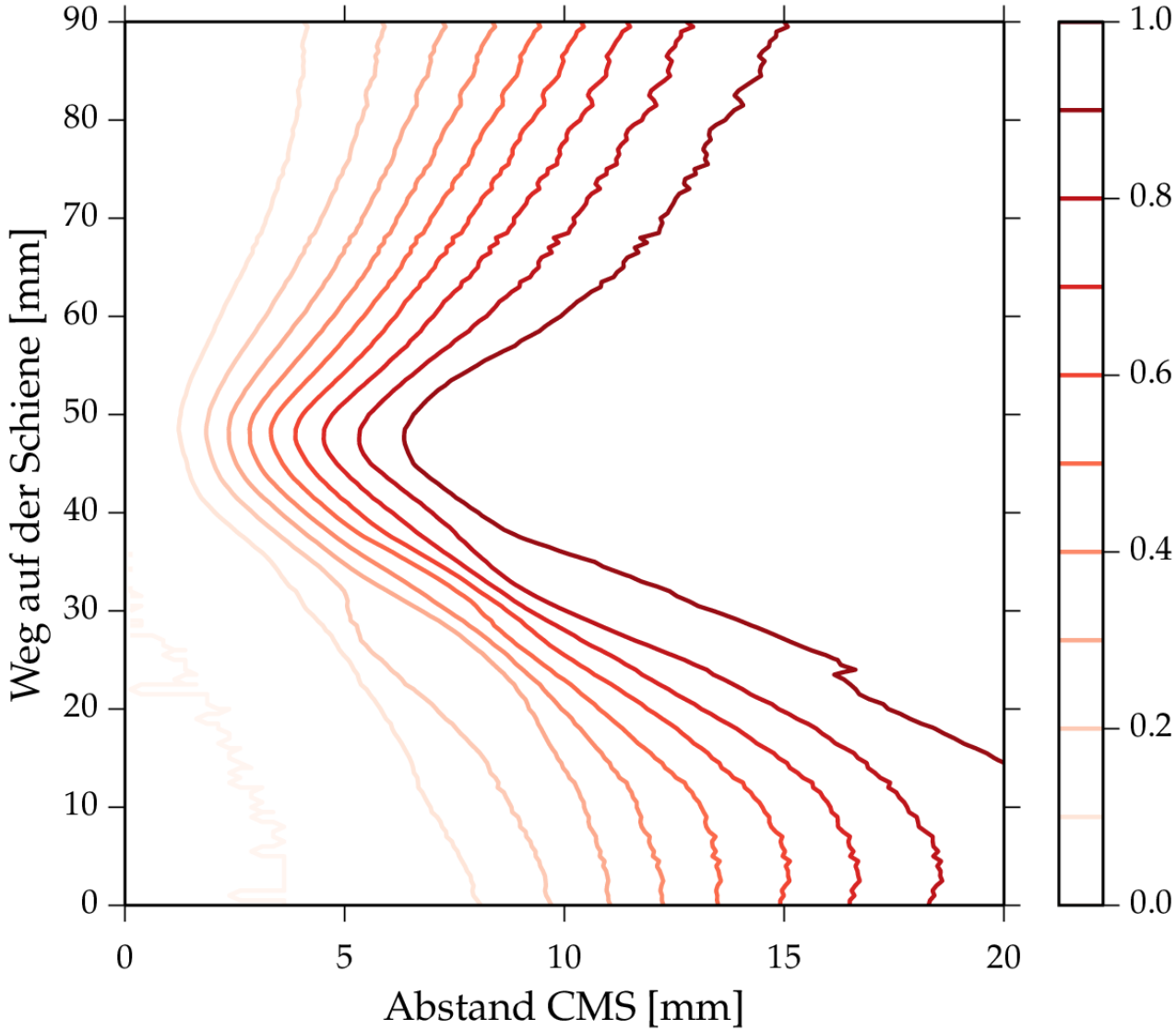


Thank you!

Backup Slides

Alignment Quality





New Center Point

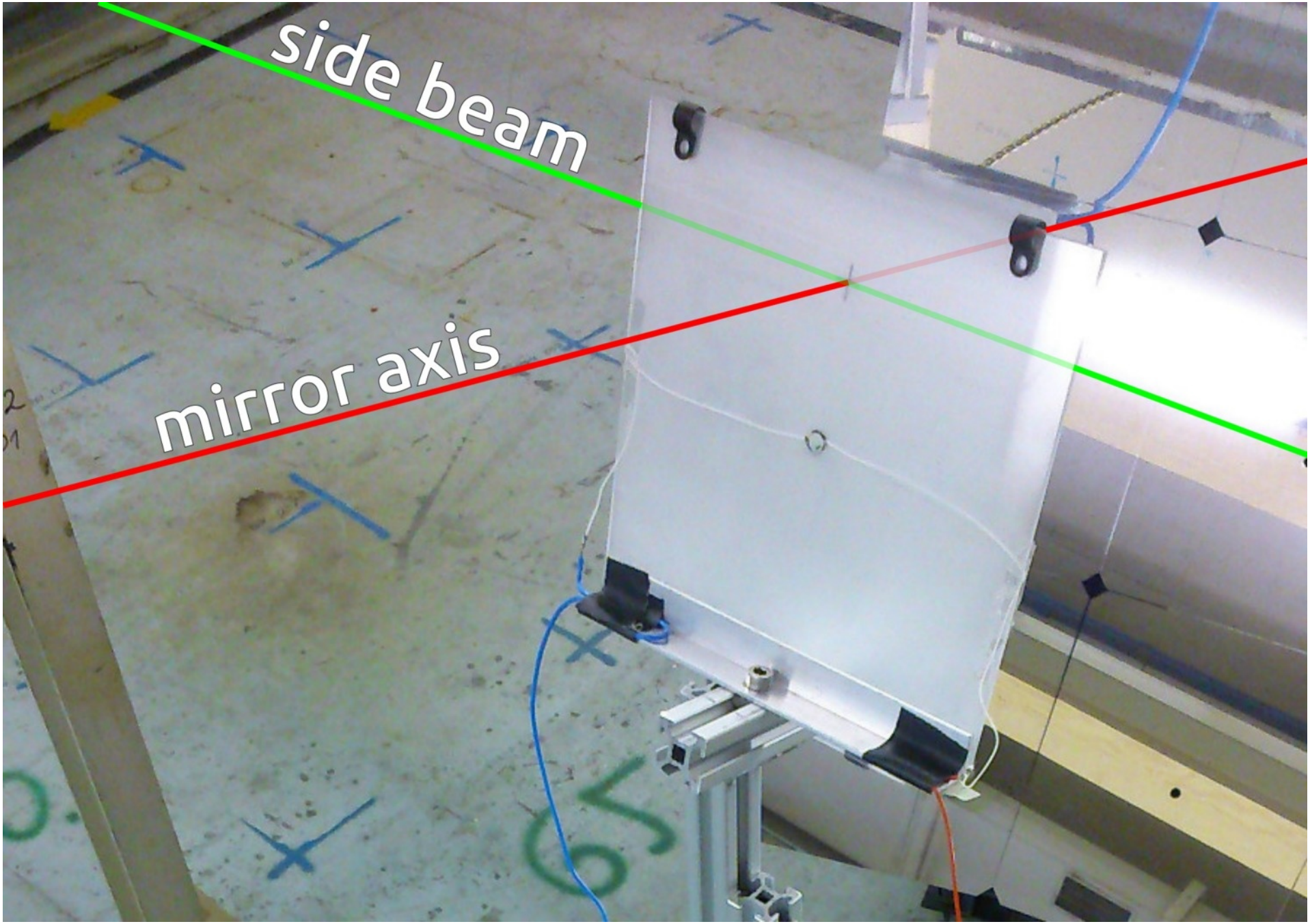
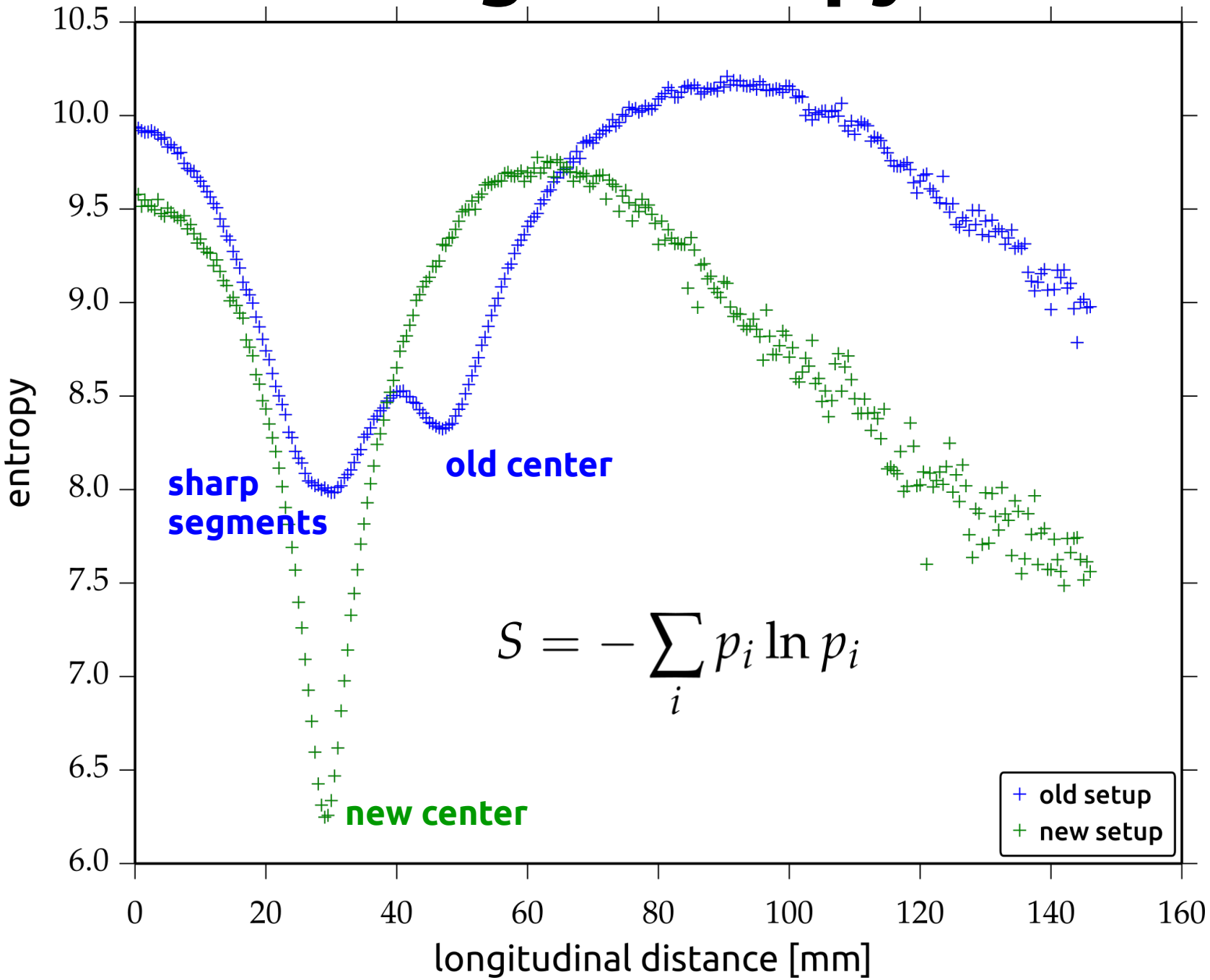
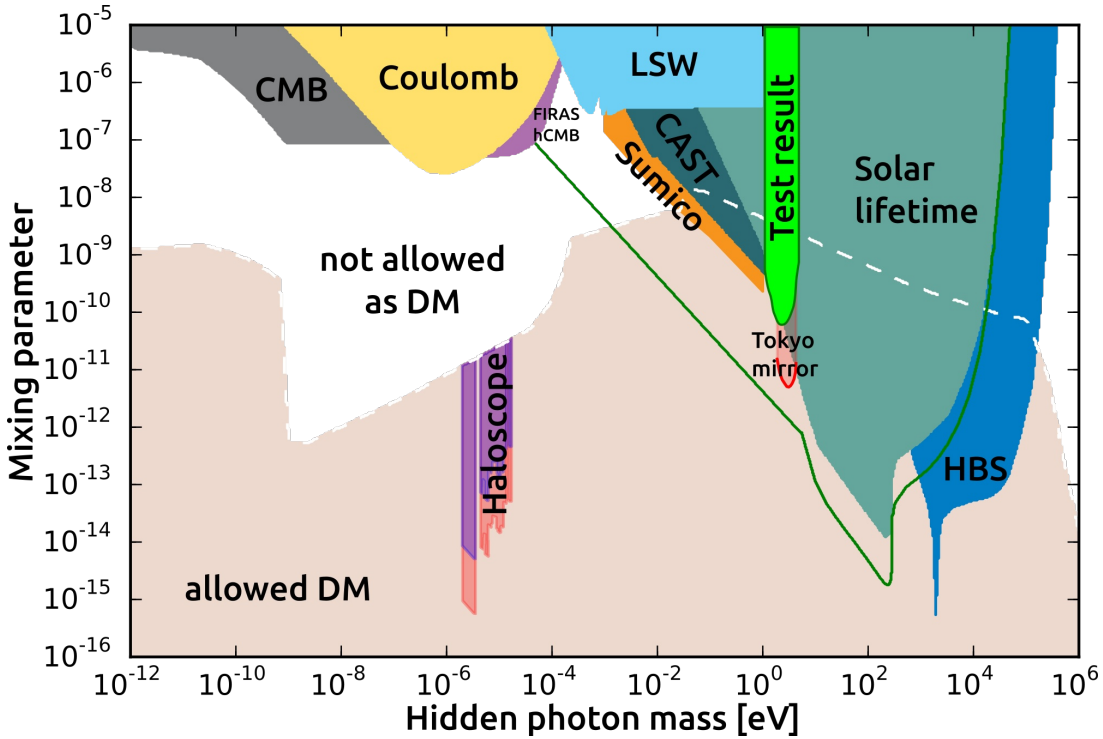
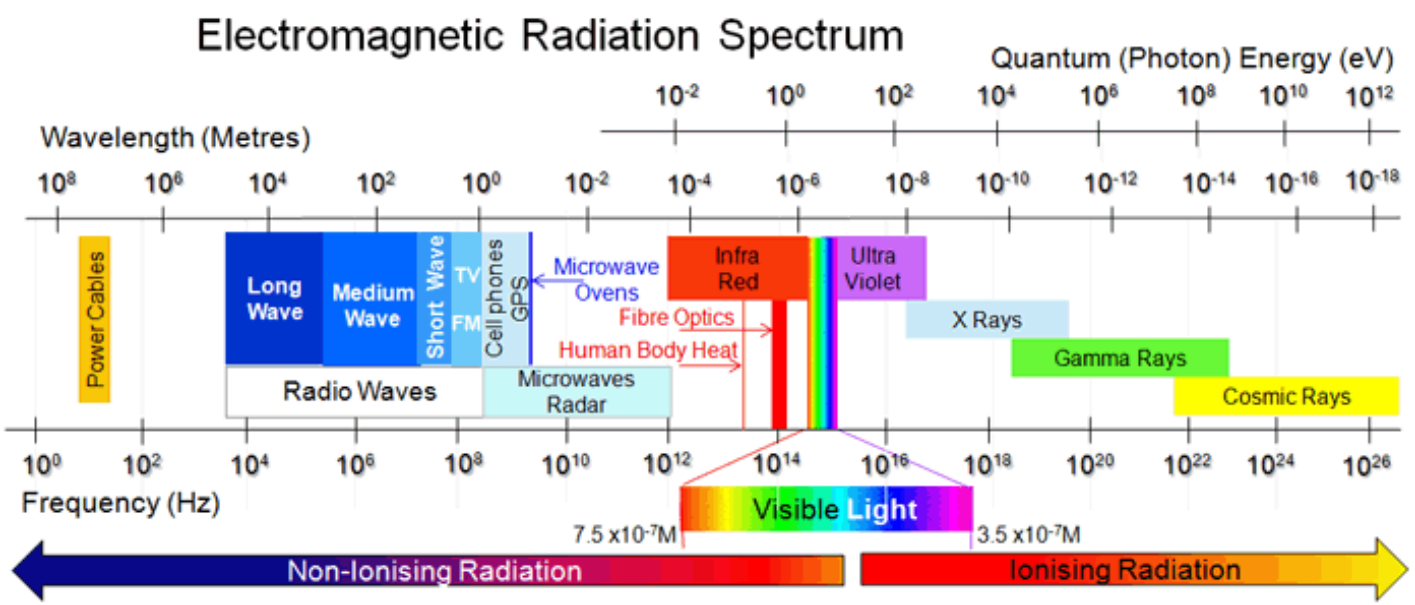


Image Entropy



$$S = -\sum_i p_i \ln p_i$$

Outlook and Future Plans