CCD UV QE improvement

by gas, radiative and thermal treatment

Sebastian Deiries, Mark Downing, Dietrich Baade

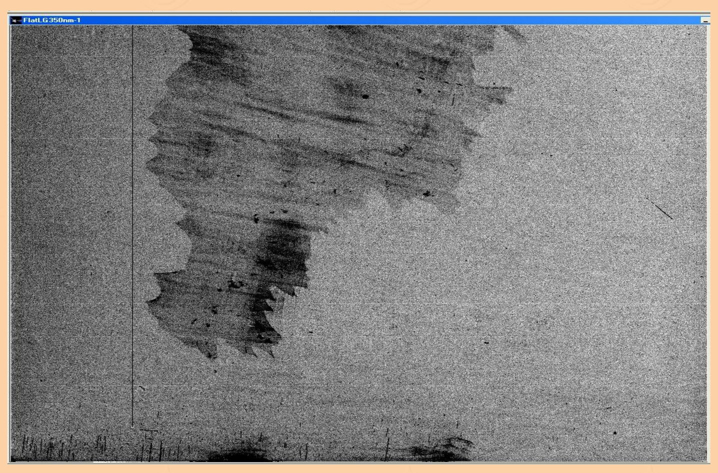
European Organisation for Astronomical Research in the Southern Hemisphere

Optical Detector Team

Ink stain removal

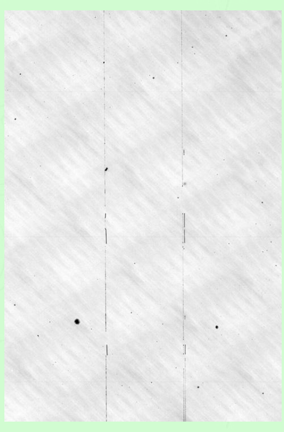
Before treatment

e2v-CCD44-82 broadband AR



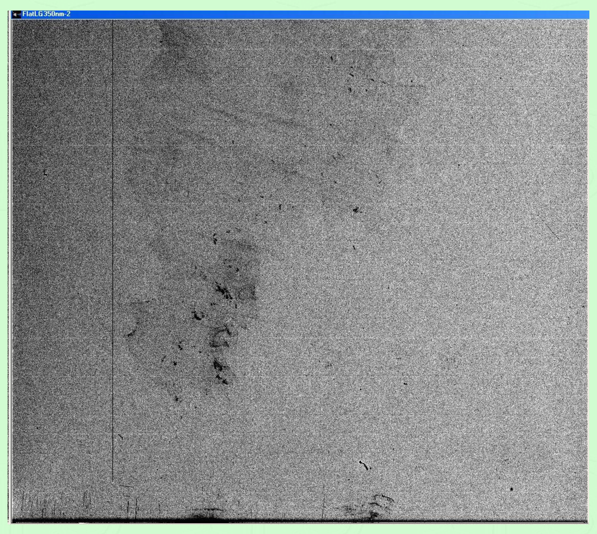
MIT/LL Phase4 CCD

After UV-/O2-treatment



e2v-CCD44-82 broadband AR

QE-level of positive ink stain reached



MIT/LL Phase4 CCD

Original recipe from Mingzhi Wei

„Soaking the CCDs in O2 at the same time heating them by a tungsten lamp and then quickly cool them. It works if the CCD is heated in the air: Maybe O2 from the air is sufficient.“

(Personal communication from April 10th, 2004)

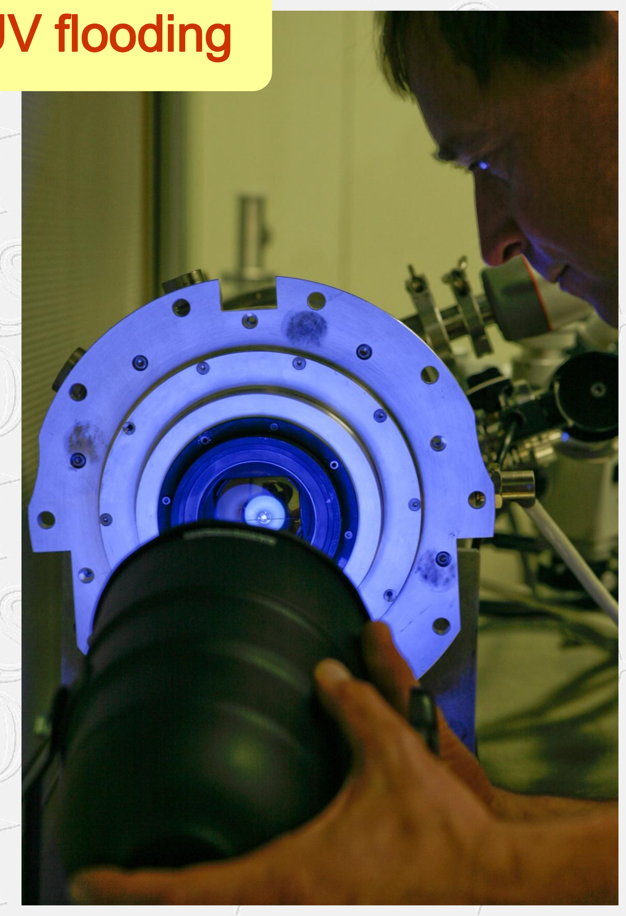
Further developed recipe from ODT

- Pumping the cryostat with regeneration of sorption pump
- Flushing of cryostat 2 - 3 times with dry synthetic air to 0.8 Bar: Over-pressure valve needed to prevent blowing out the window!
- Pumping of cryostat and heating of CCD to 60 degrees centigrade
- Filling of warm cryostat with synthetic air (or pure O2) to 0.8 Bar
- Flooding of CCD through quartz window with UV-lamp for 5 minutes
- Pumping and cooling of cryostat within 6 hours
- Precautions: The use of pure O2 is dangerous and may corrode bond wires of CCDs and the cryostat. Do not blow out the cryostat window.

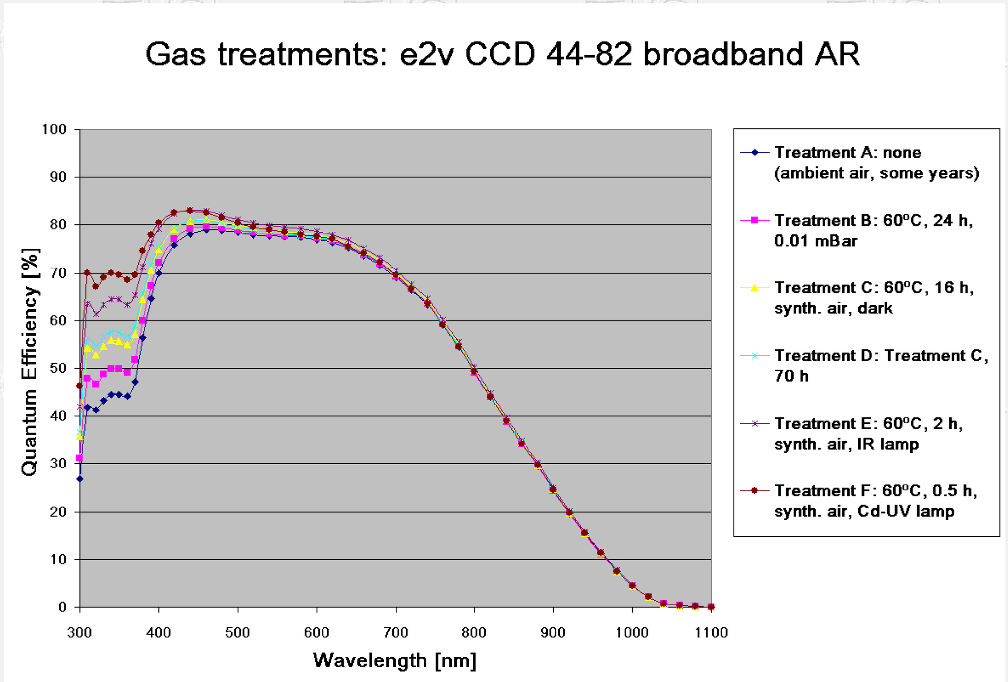
Summary:

A combination of oxygen (O2) soaking, UV flooding and baking permits the removal of "ink-stain" patterns of reduced UV and blue sensitivity observed in MIT/LL CCDs flat fields. With further optimization of the recipe, significantly improved quantum efficiency (QE) of e2v CCD44-82 CCDs was also achieved, especially at blue wavelengths. Examples of QE curves and CCD flat fields before and after the sensitization are shown, and crude estimates of the long-term stability of the results are given. A possible explanation is that water vapor contaminates the surface of the CCD and deteriorates the efficiency of the AR coating but is removed by the described procedure. An overview of the instrumental setup, the required materials, and precautionary measures is provided.

UV flooding

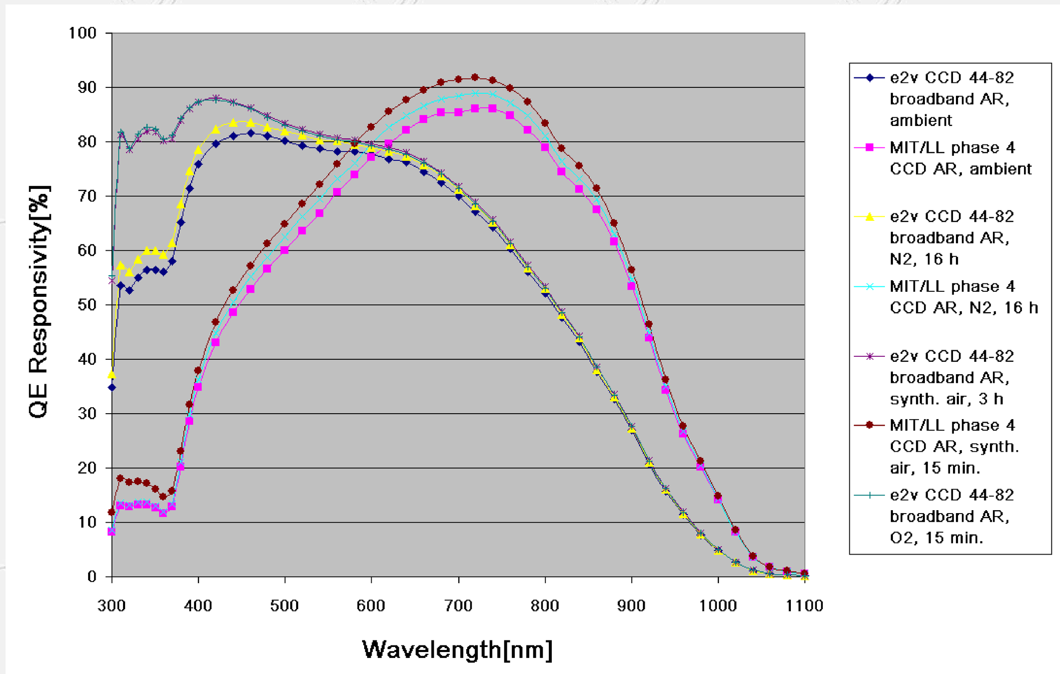


Results



UV treatment at ODT test bench with cadmium lamp

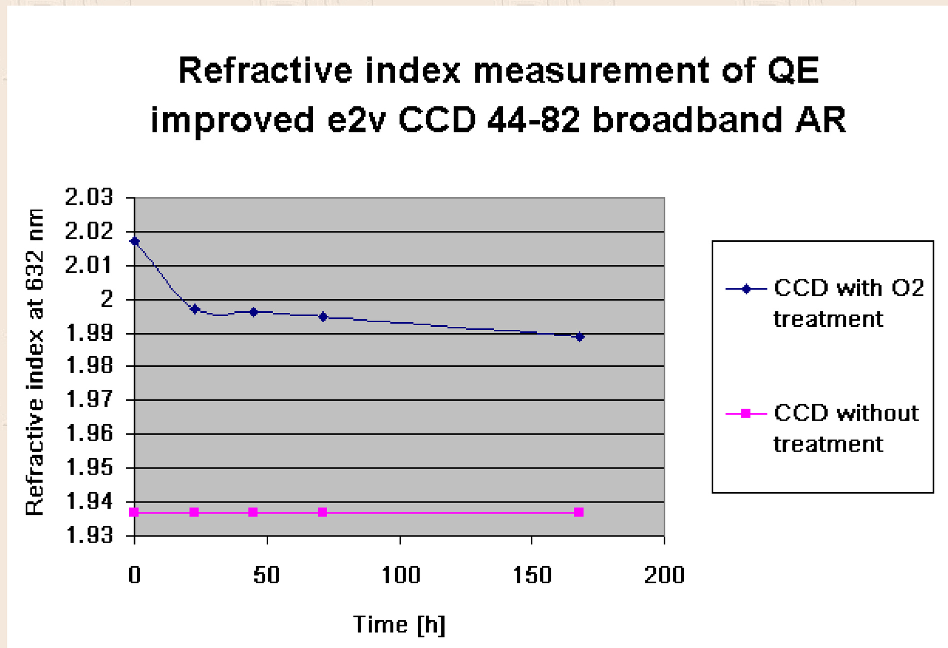
While the QE of e2v CCDs could be improved in the UV, blue and green, the QE improvement of MIT/LL CCD is only marginal:



A small QE improvement at e2v CCDs is reached by heating and soaking in pure N2 gas. An improvement of up to 60 % in the UV can only be achieved by means of soaking in synthetic air or pure O2.

Explanation:

Contamination by H_2O or H^+ molecules?



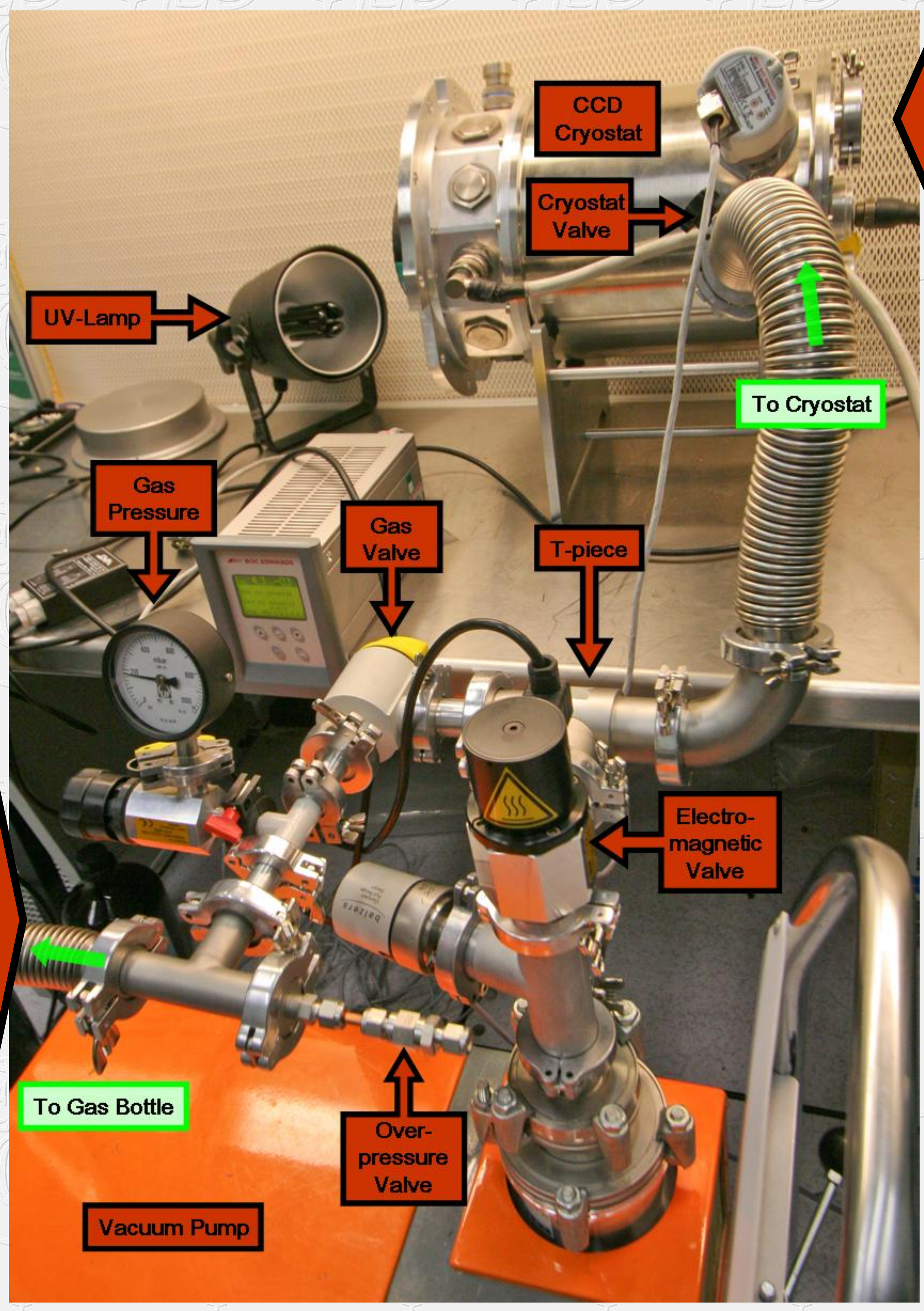
The refractive index of the AR coating of a CCD treated as described above is higher than the one of an untreated CCD but slowly decreases with time (measurements by SenTech, Berlin). One possible explanation is that, with time and under atmospheric conditions, the AR coating adsorbs H_2O and/or H^+ molecules, which change the refractive index. Since the AR coating is most important at UV and blue wavelength, the observed effect is strongest there. This would be consistent with occasional reports that the UV efficiency of CCDs improves after years of operation under high vacuum, when H_2O / H^+ might be desorbed.

Experimental setup

For the experimental set-up the following items are used and carefully assembled:

- Dry vacuum pump up to 10^{-5} mBar
- Safety over-pressure valve: 0.1 Bar
- Dry synth. air gas cylinder with pressure reducer 0-5 Bar
- Gas pressure manometer 0 - 1000 mBar
- Oil-free KF fittings, valves and flexible pipes
- UV-lamp (mercury discharge or cadmium spectral lamp)

Gas Bottle



Temperature Control

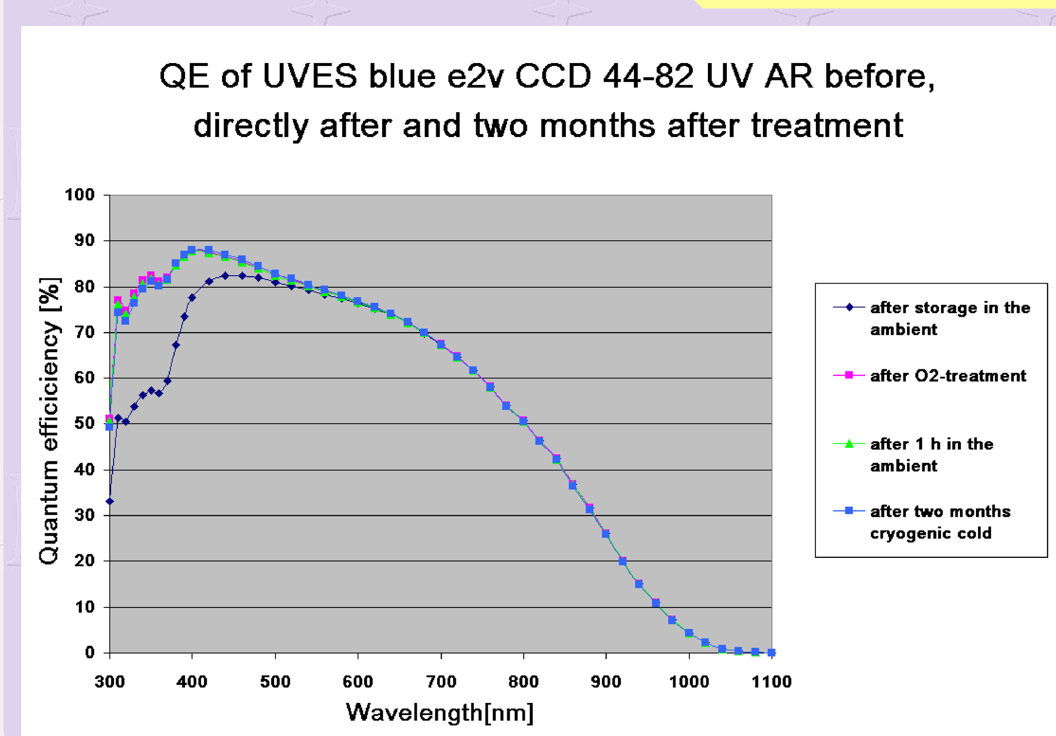
CCD detector warmed up to 60 degrees centigrade

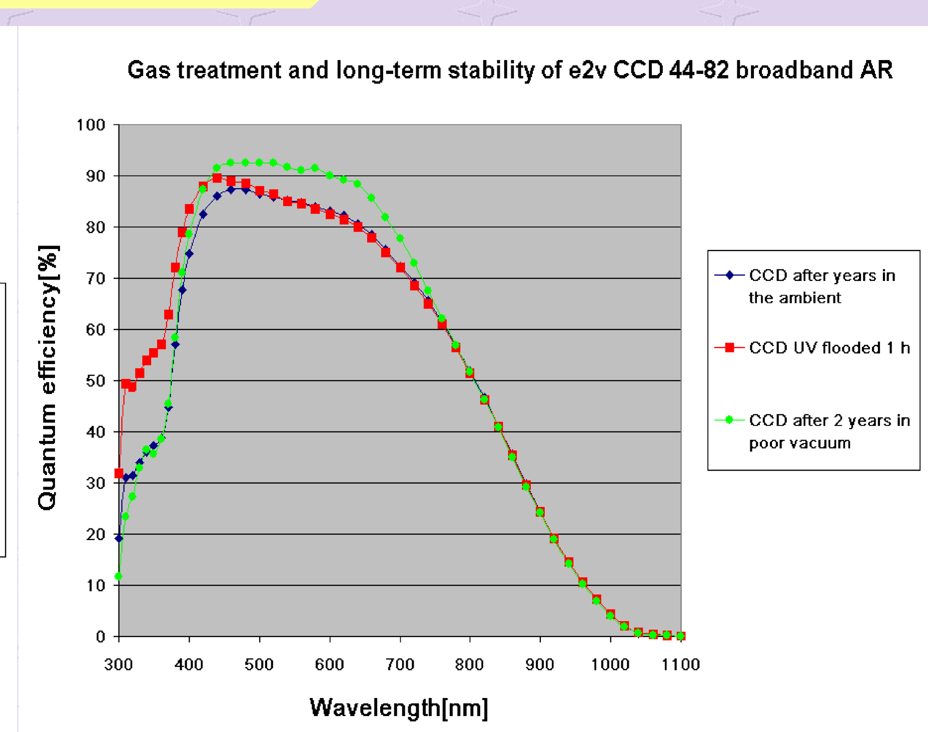
Long-term stability

Vacuum + cryo-temperature ⇨ ~ 1-2 years

1 mBar ⇨ ~ 2 months

Ambient air ⇨ ~ 1 week





Detectors for Astronomy, 12 - 16 October 2009, ESO Garching