Multilayer-coated EUV grating for the spectroscopic channel of METIS

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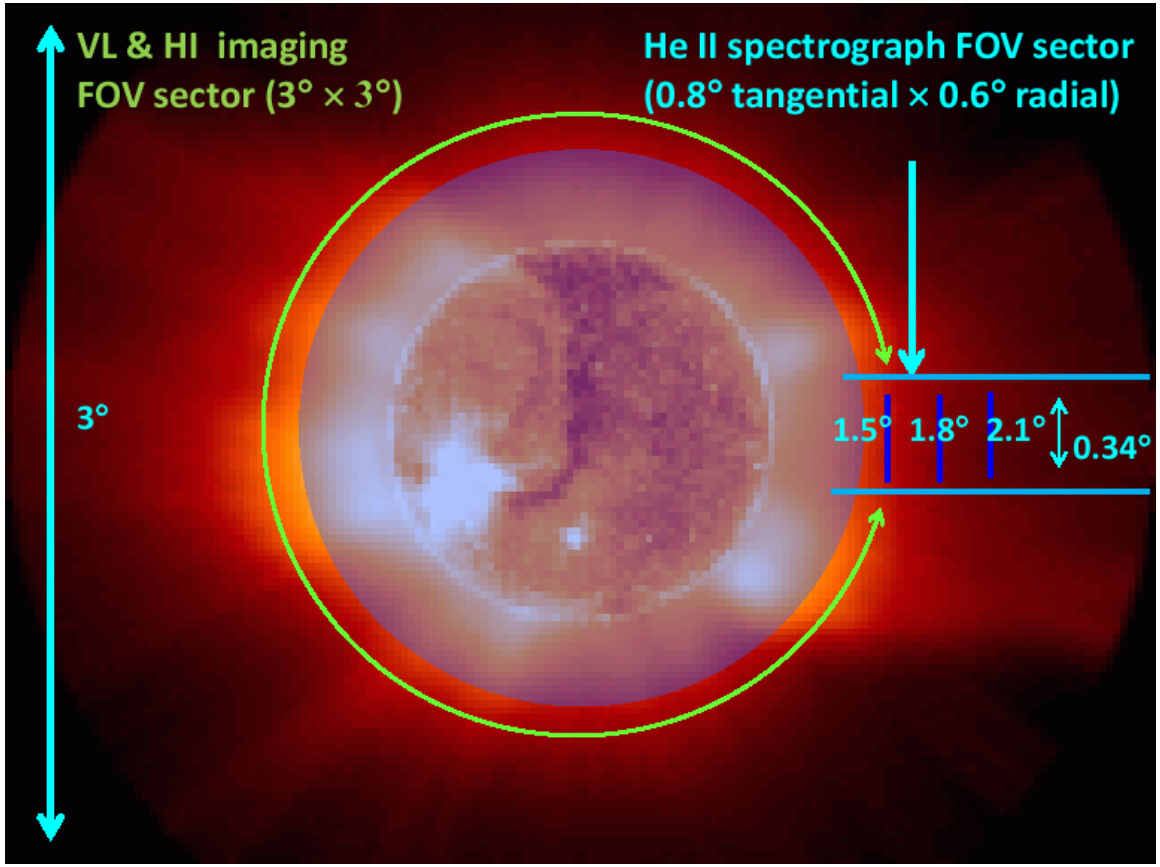
METIS: the spectroscopic channel (1/3)

The original METIS proposal included four optical paths:

1) linearly polarized visible-light ,590-650 nm
2) narrow-band ultraviolet HI Lyman-alpha,121.6 nm
3) narrow-band extreme-ultraviolet HeII Lyman-alpha, 30.4 nm
4) spectroscopic channel for the HI and He II Lyman-α in corona

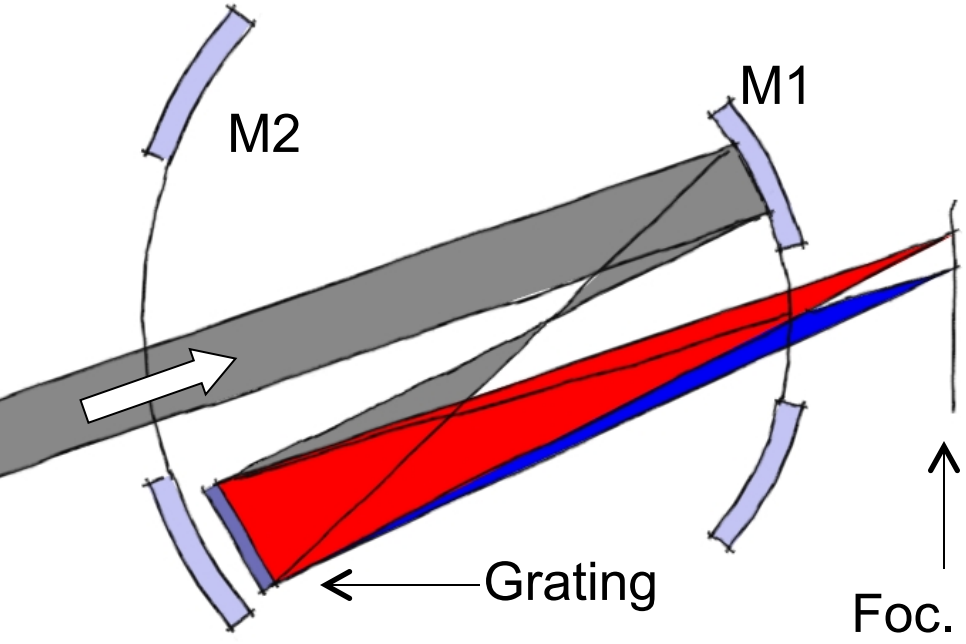
THE SPECTROSCOPIC CHANNEL WAS CANCELED BECAUSE OF DESCOPING

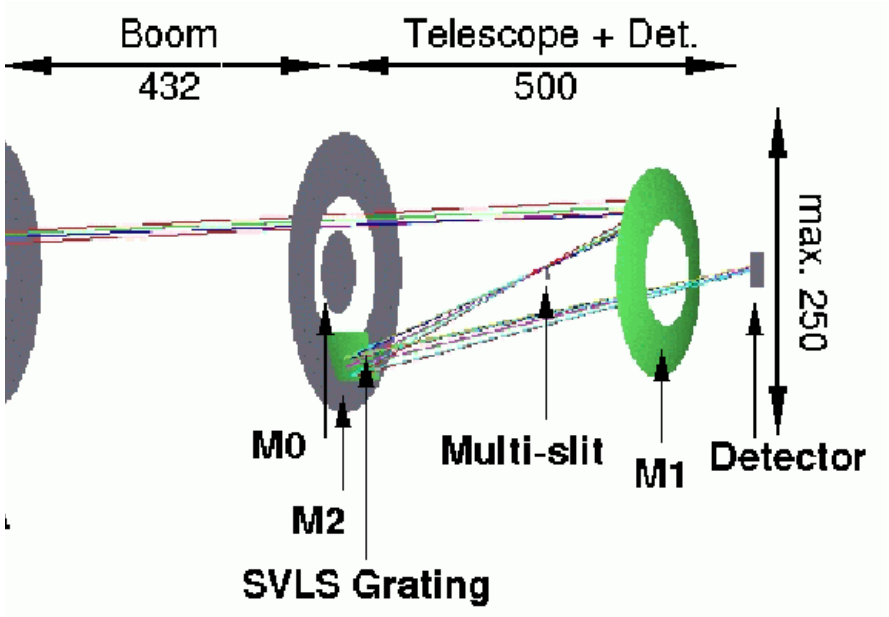
Imaging + multi slit spectroscopy



METIS: the spectroscopic channel (2/3)

A sector of the telescope primary mirror is used to feed a multi-slit spectrometer where the grating replaces a sector of the secondary mirror of the telescope and diffracts the spectrum on the portion of the detector that is not used for coronal imaging



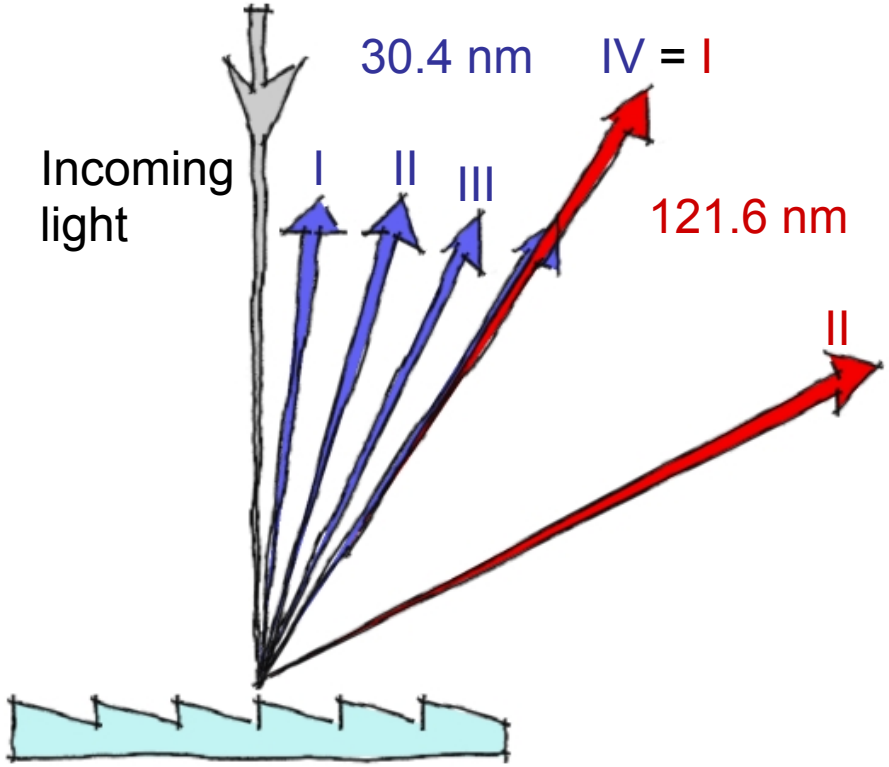


METIS: the spectroscopic channel (3/3)

He II H I

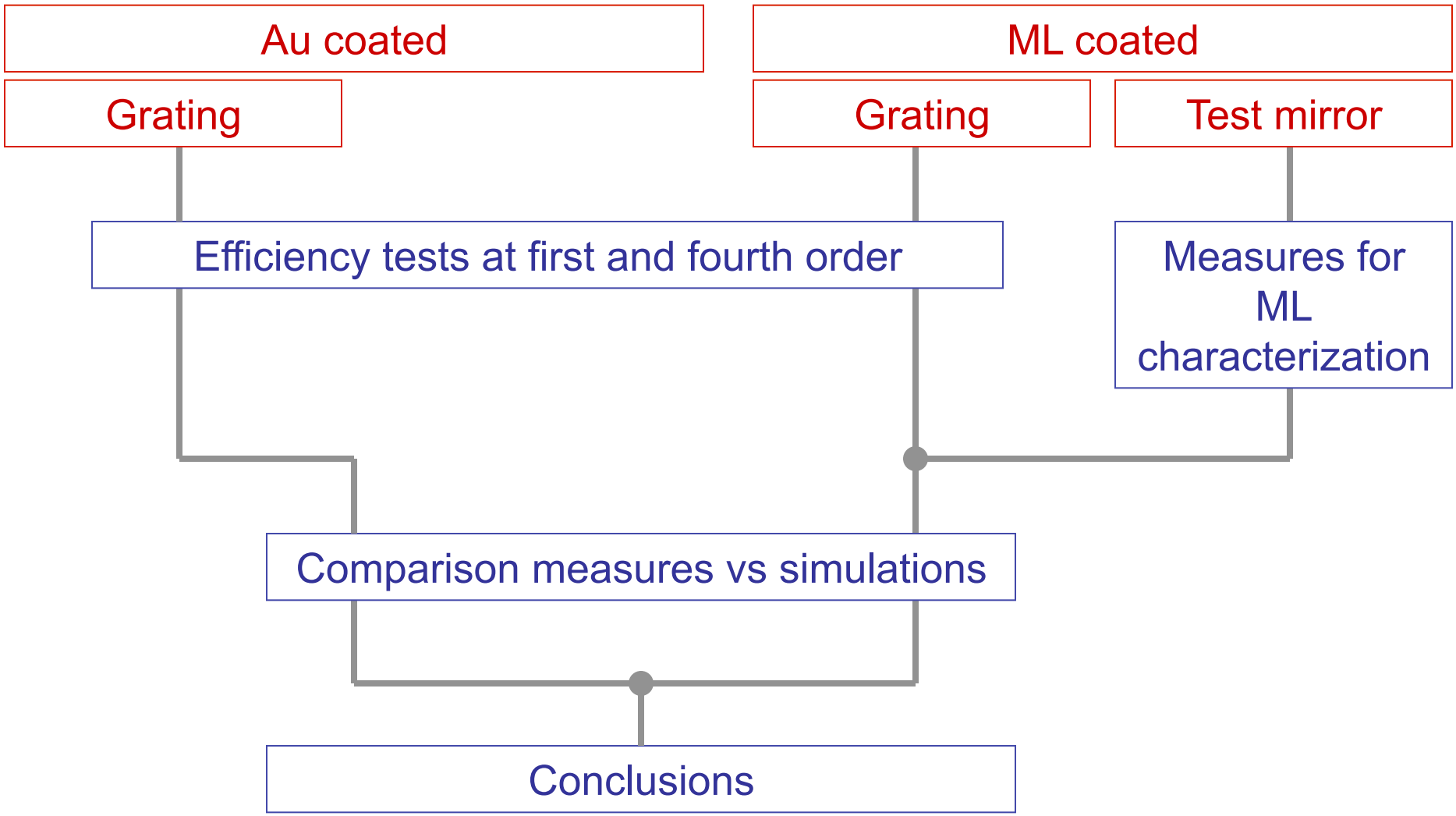
30.4 X 4 = 121.6

The two spectroscopic channels are overlapped on the focal plane.



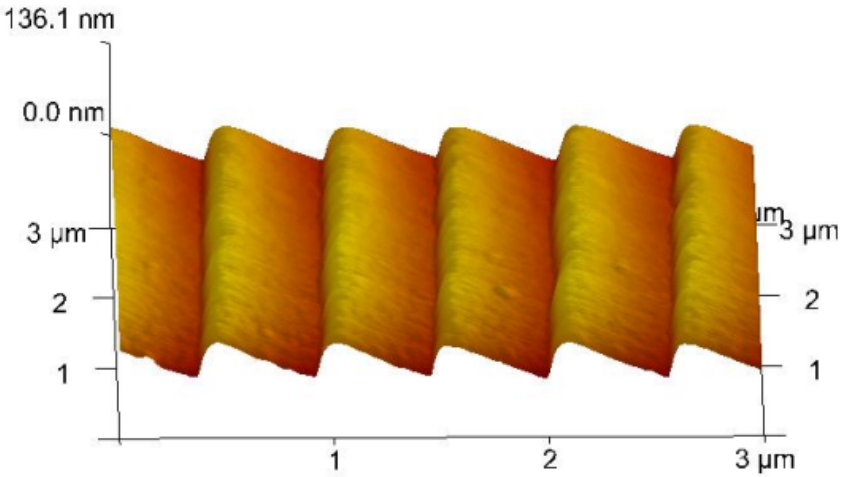
The spectroscopic path requires a grating with high efficiency both at the HI and HeII. This is achieved through an optimization of the saw-tooth groove profile for the first diffracted order at 121.6 nm and a multilayer (ML) coating optimized to enhance the diffraction efficiency both at the fourth order at 30.4 nm and at the first order at 121.6 nm.

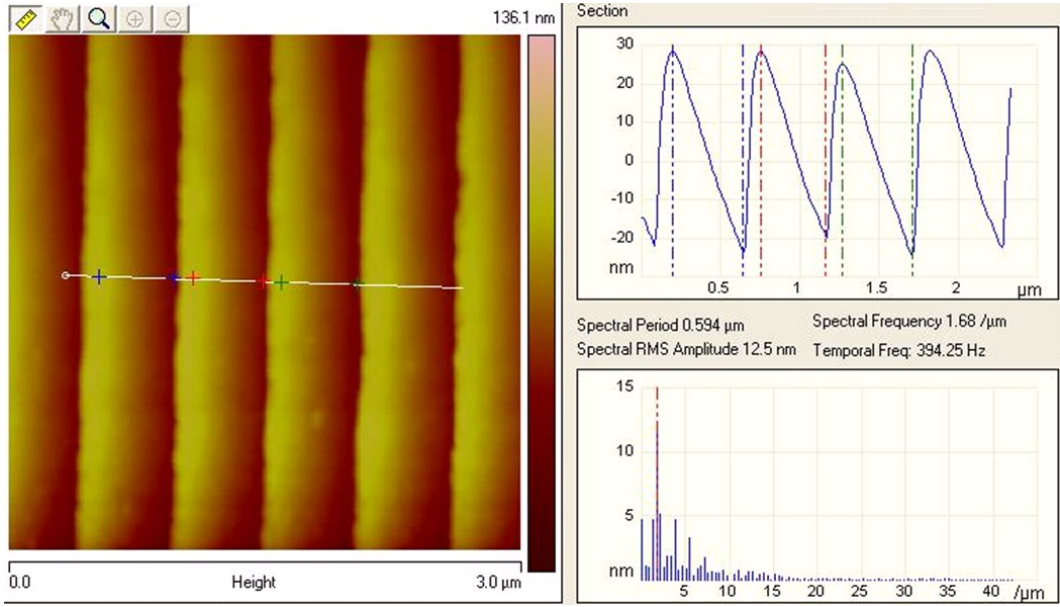
Work diagram



Grating: before ML deposition

The test grating has been mechanically ruled by Bach Research (USA)



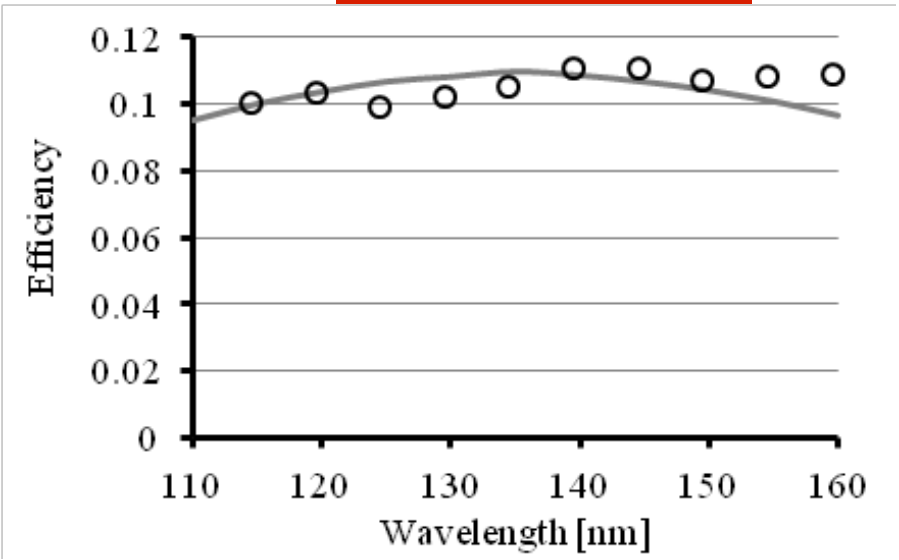


AFM measure of the grating surface with the gold coating. The measured groove parameters are:
density 1836 mm-1;
blaze angle 6.32 deg;
groove depth 48.5 nm.

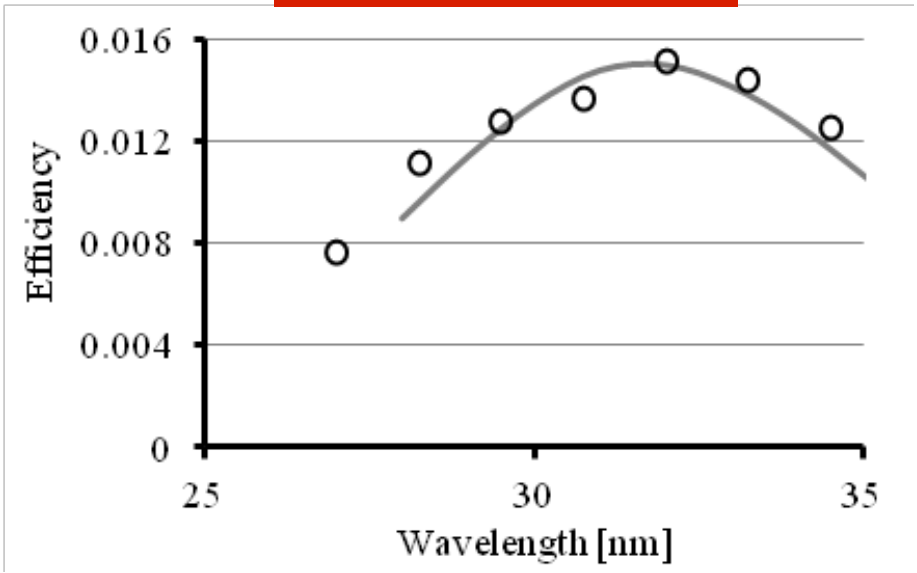
Coating: Gold
The inferred surface roughness is 2 nm.

Grating: before ML deposition

120 nm Ist Ord.



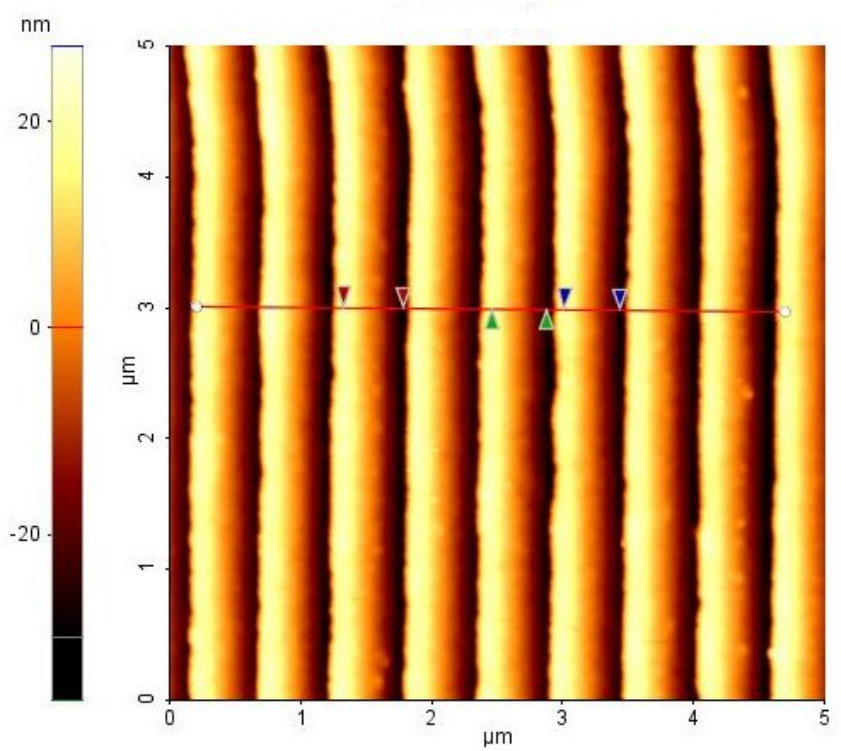
30.4 nm IVth Ord.

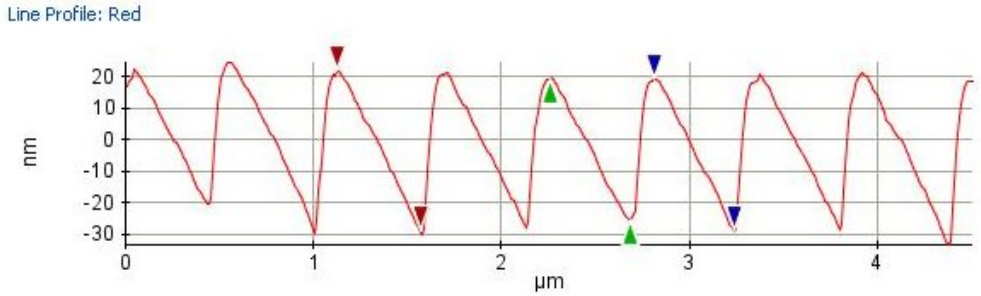


The circles are the experimental points; the continuous line is the simulated diffraction efficiency accounting for a surface roughness of 2 nm.

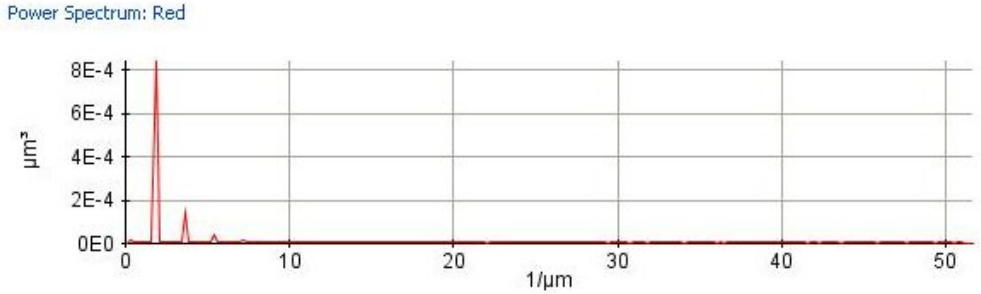
The measures have been carried out at CNR-IFN Padova and Sincrotrone ELETTRA (TS) Italy, BEAR beamline

Grating: after ML deposition





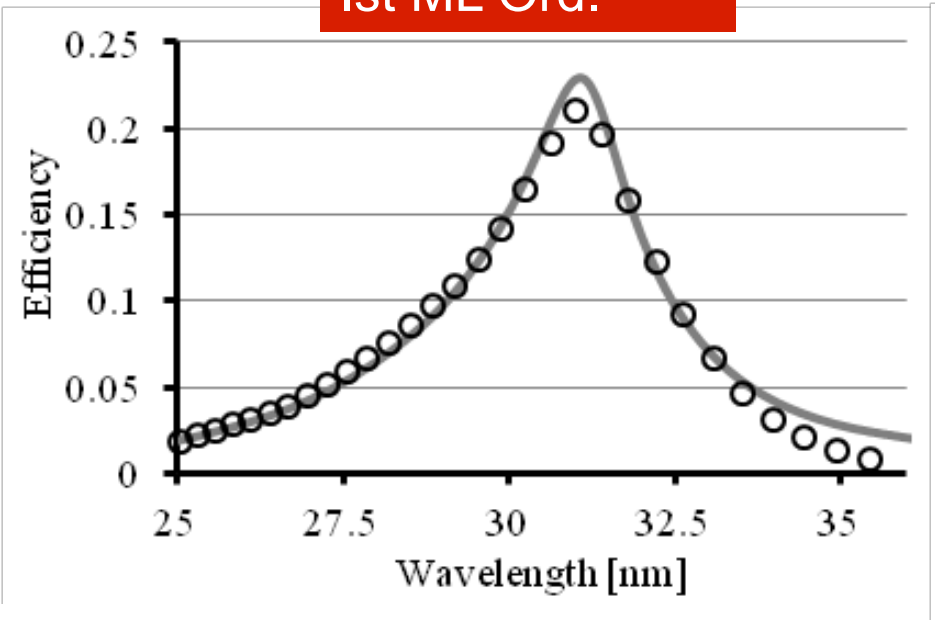
Cursor	ΔX(µm)	ΔY(nm)	Angle(deg)
Red	0.449	-50.572	-6.421
Green	0.422	-44.678	-6.042
Blue	0.422	-47.857	-6.470



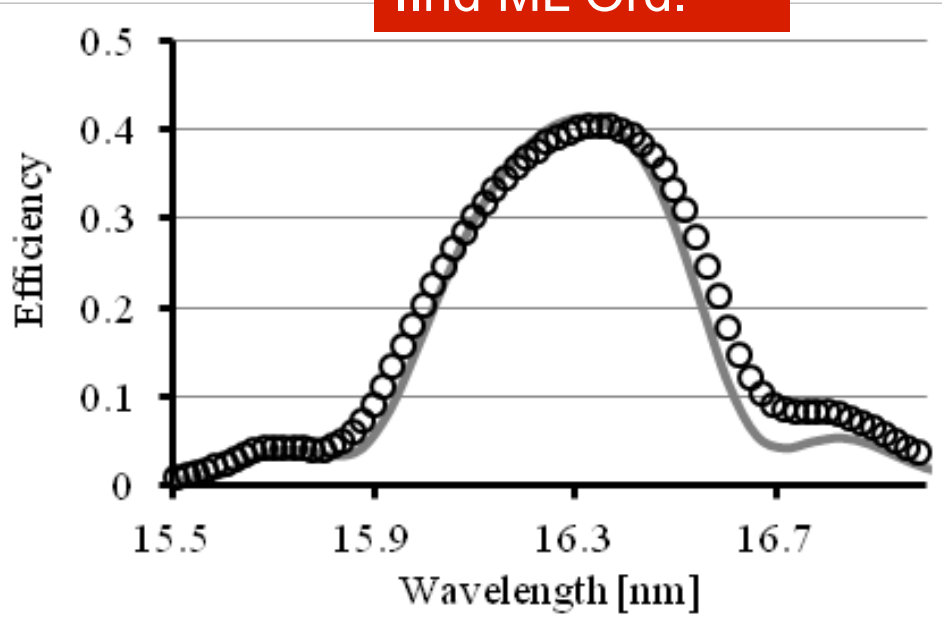
Deposition by DC magnetron sputtering on the top of the gold layer by Reflective X-Ray Optics (New York, NY, USA). The profile is very similar to the original one. Parameters:
mean blaze angle 6.58 deg;
groove depth 50.33 nm.
roughness 2 nm (measured with AFM)

ML characterization

Ist ML Ord.



IInd ML Ord.

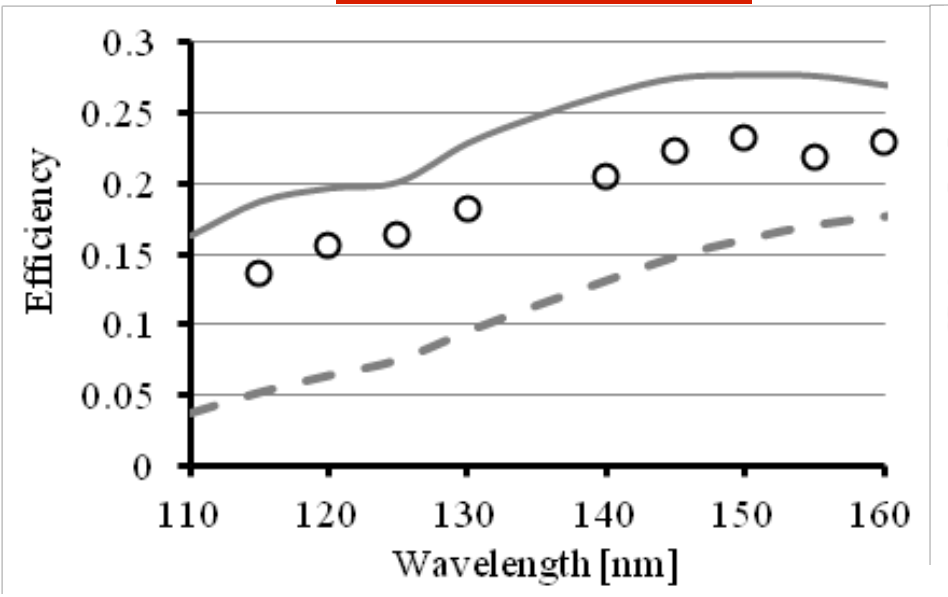


Reflectance measurements, that have been performed on a test silica wafer placed just nearby the grating during the same deposition run, are used to estimate the ML parameters.

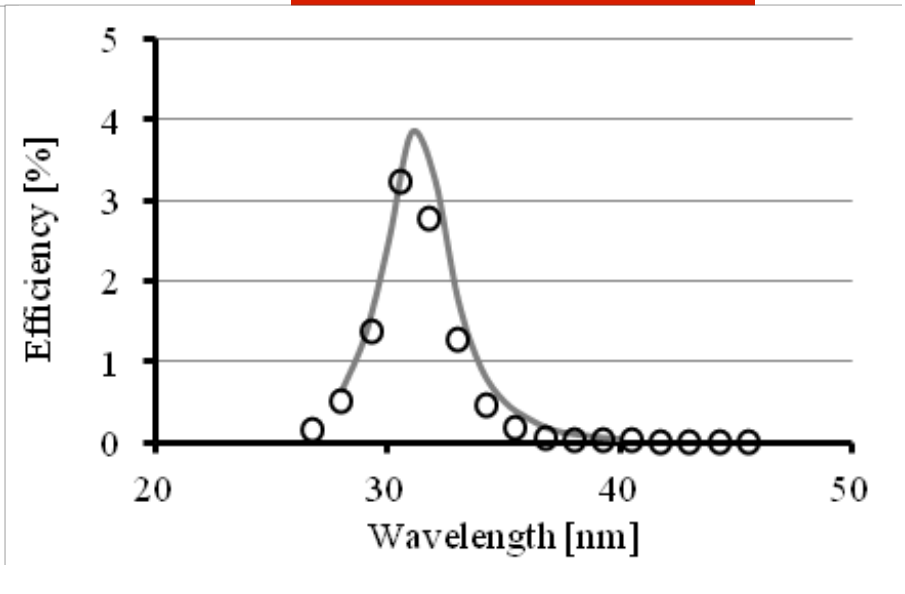
It has to be considered that the silica roughness is definitely lower that that of the grating (0.3 nm).

Grating: after ML deposition

120 nm Ist Ord.



30.4 nm IVth Ord.



The continuous lines are the simulated curves accounting for a saw-tooth profile. Circles are the experimental points. The error bars in the measurements are ±10% at 120 nm and ±20% at 30.4 nm.
The simulations are in good agreement with the measuremeents.

The grating efficiency is increased from 1.5% to 3.2%.

Conclusions 1/2

We have presented the results of the test measurements to evaluate the performances of a reflection grating designed to diffract the HI Ly-a (121.6 nm) at the first order and the HeII Ly-a (30.4 nm) at the fourth order.

The grating was originally coated by gold, and has been later coated by ML to improve the efficiency at the 30.4 nm.

Both the diffraction efficiency at first and fourth order are increased after the ML coating:

- from 10% to 15% at the first order,
- from 1.5% to 3.2% at the fourth order.

Both the first and the fourth order show a diffraction efficiency reduction with respect to the simulated behavior of an ideal profile.

The reduction in the efficiency is mainly due to the roughness of the grating surface