Grating Efficiency Analysis

REIXS Spectrometer, CLS

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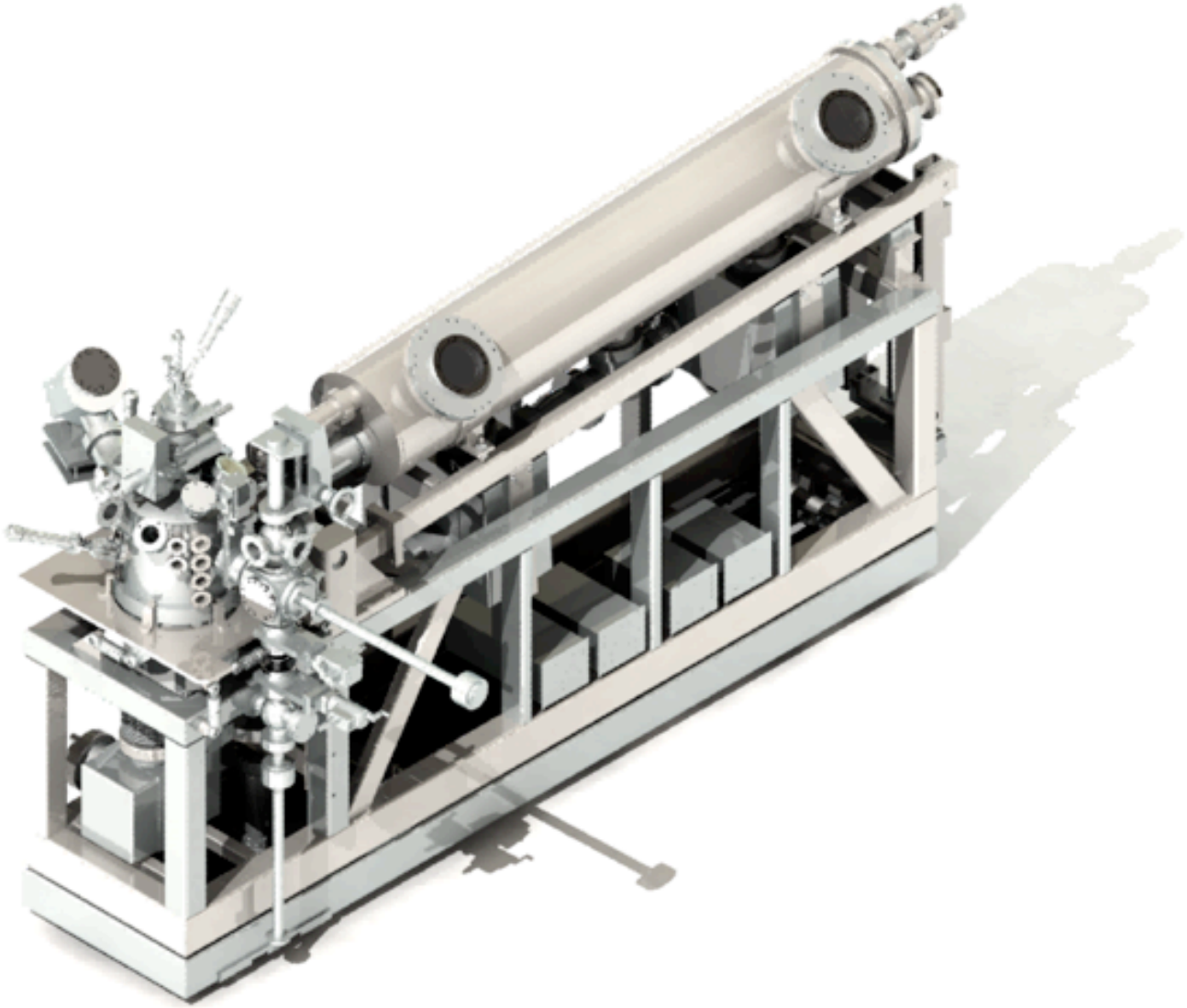
Background

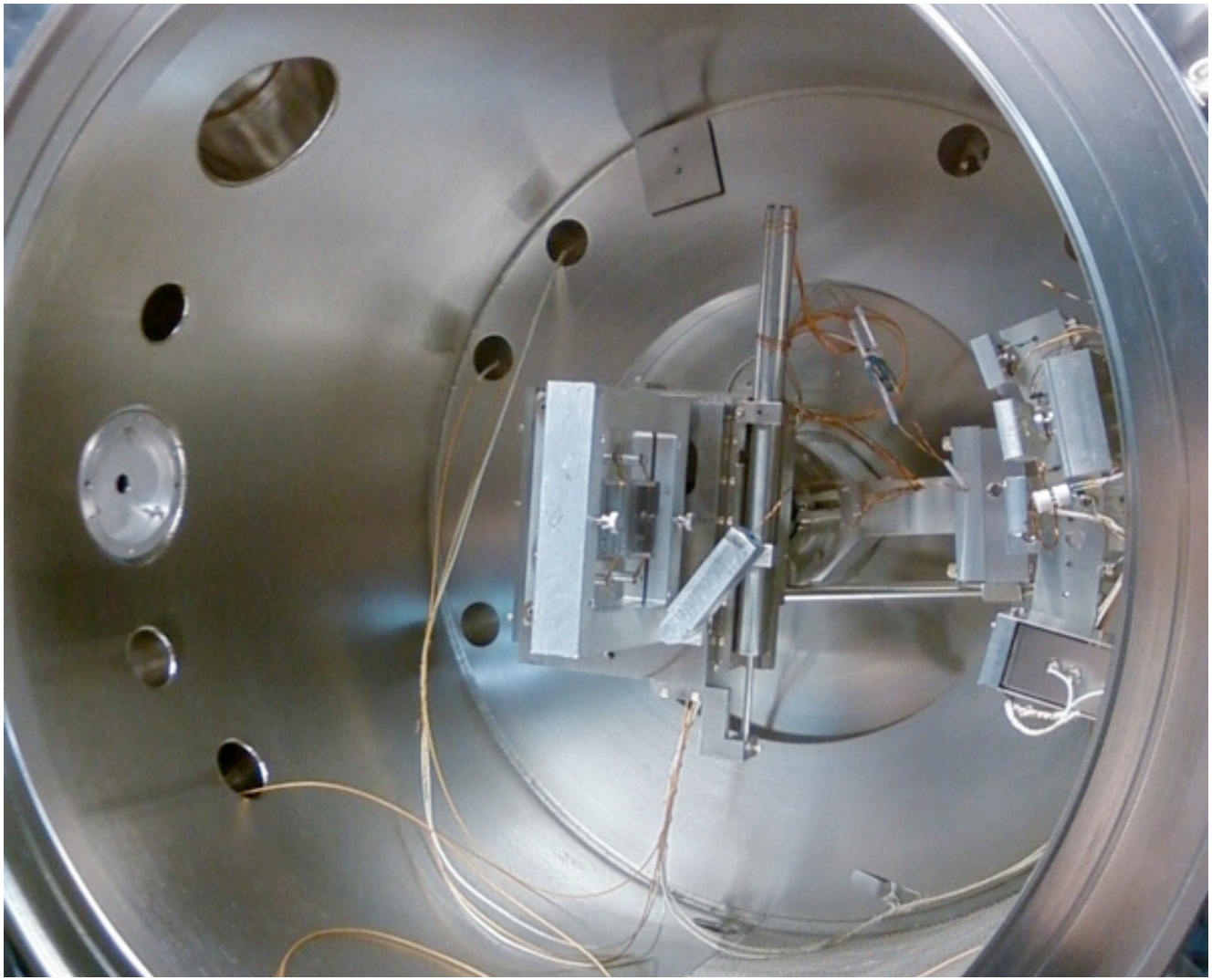
- Project 2005: optical design of REIXS spectrometer
  - David: resolving power
  - Mark: efficiency (photon out / photons in)
- Why concern with efficiency?
  - 2X increase in efficiency means twice as many experiments per shift
  - Allows measurement of low-concentration samples

Where are we now...



- Nov/Dec 2007: gratings delivered (Bach Research)
- Mechanical design... Looks beautiful on paper!

Grating efficiency



- Dec: Measured actual efficiency using diffractometer on BL 6 (ALS)

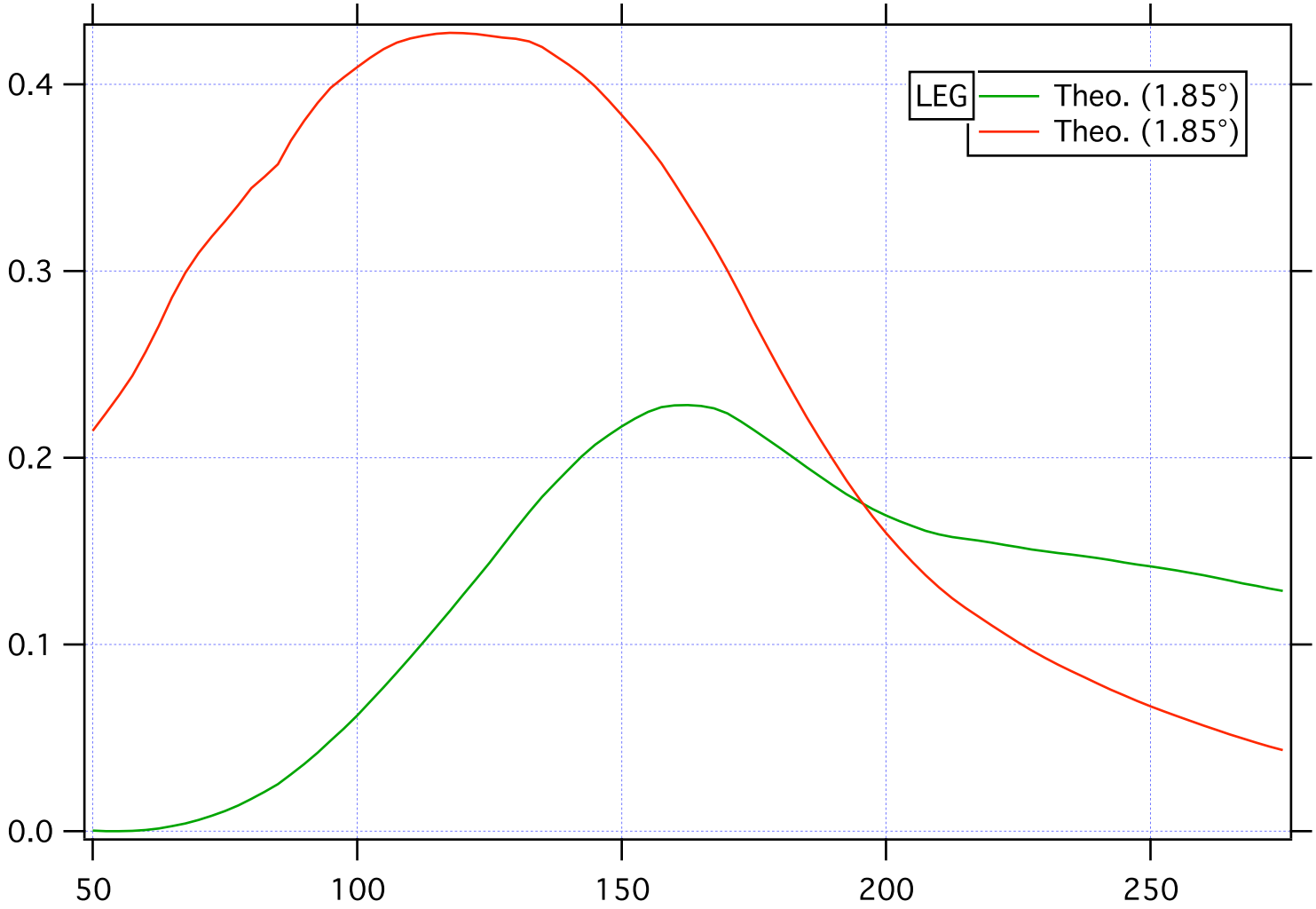
Design Summary: 6 gratings

- LEG: low energy use: 30-300eV
  (Au coating)
- IMP: high-efficiency over large range, up to 800eV
  (Ni coating)
- MEG: good resolution + efficiency up to 800eV
  (Ni coating)
- HEG: high energy use, high resolution (400eV+)
  (Pt coating)
- HRMEG, HRHEG: ultra-high resolution 3rd-order gratings

Results:

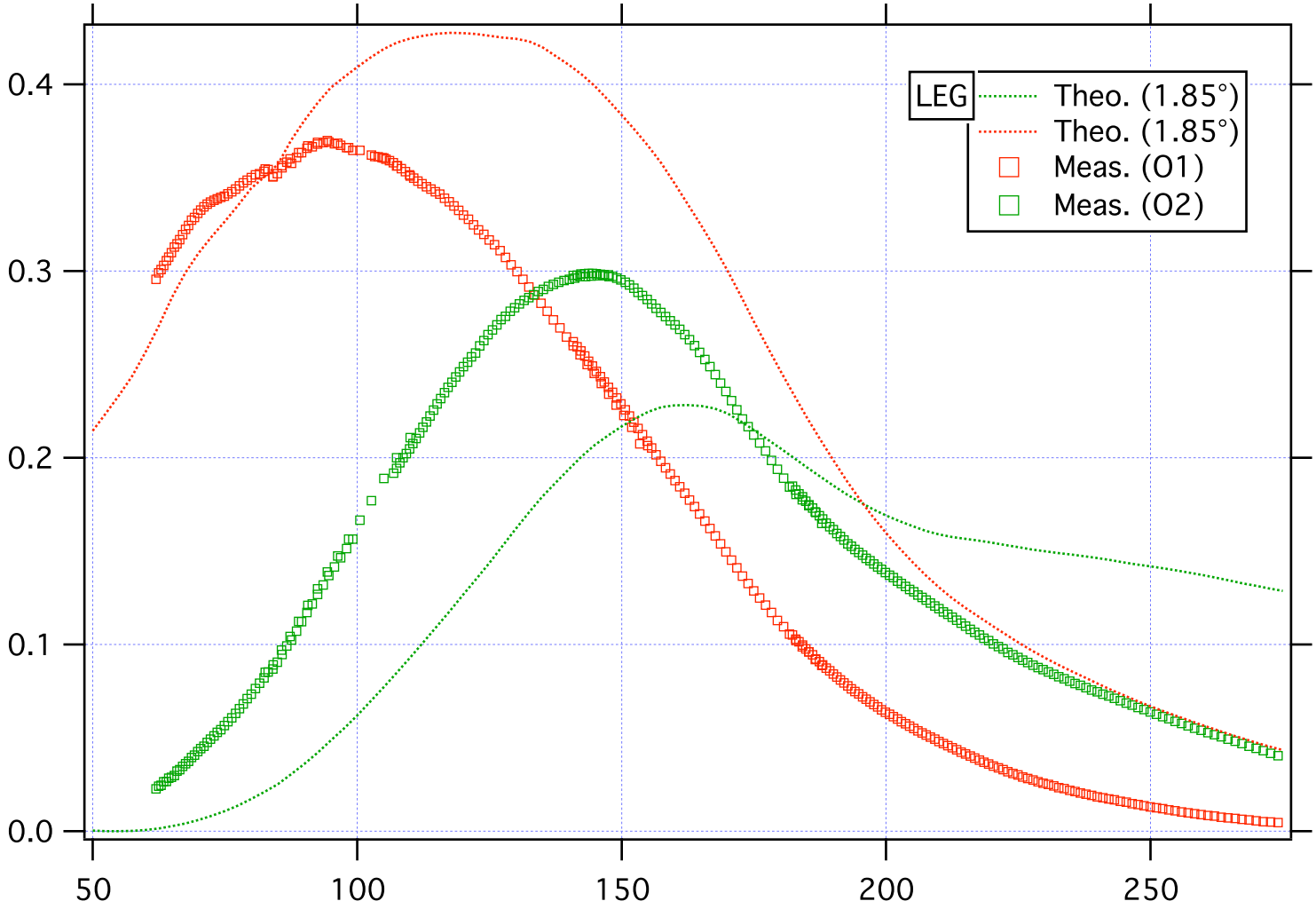
- All gratings measured lower efficiencies than the calculations predicted
- Some factor lower (0.9, 0.85, etc.) expected due to simple surface roughness
- Deeper analysis shows manufacturing problems...

LEG: Predicted



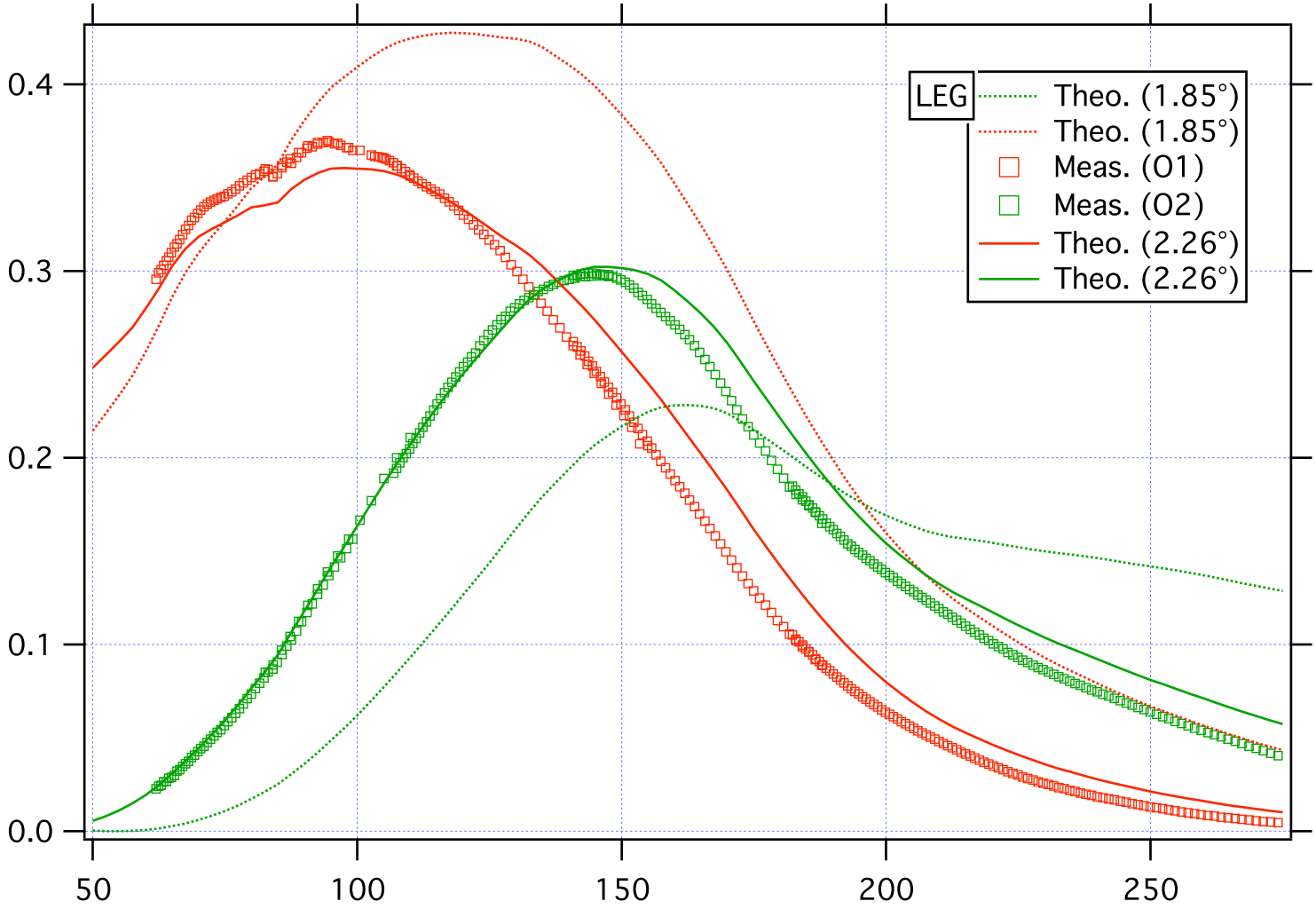
- Very efficient: up to 40% @ Si edge

LEG: Measured



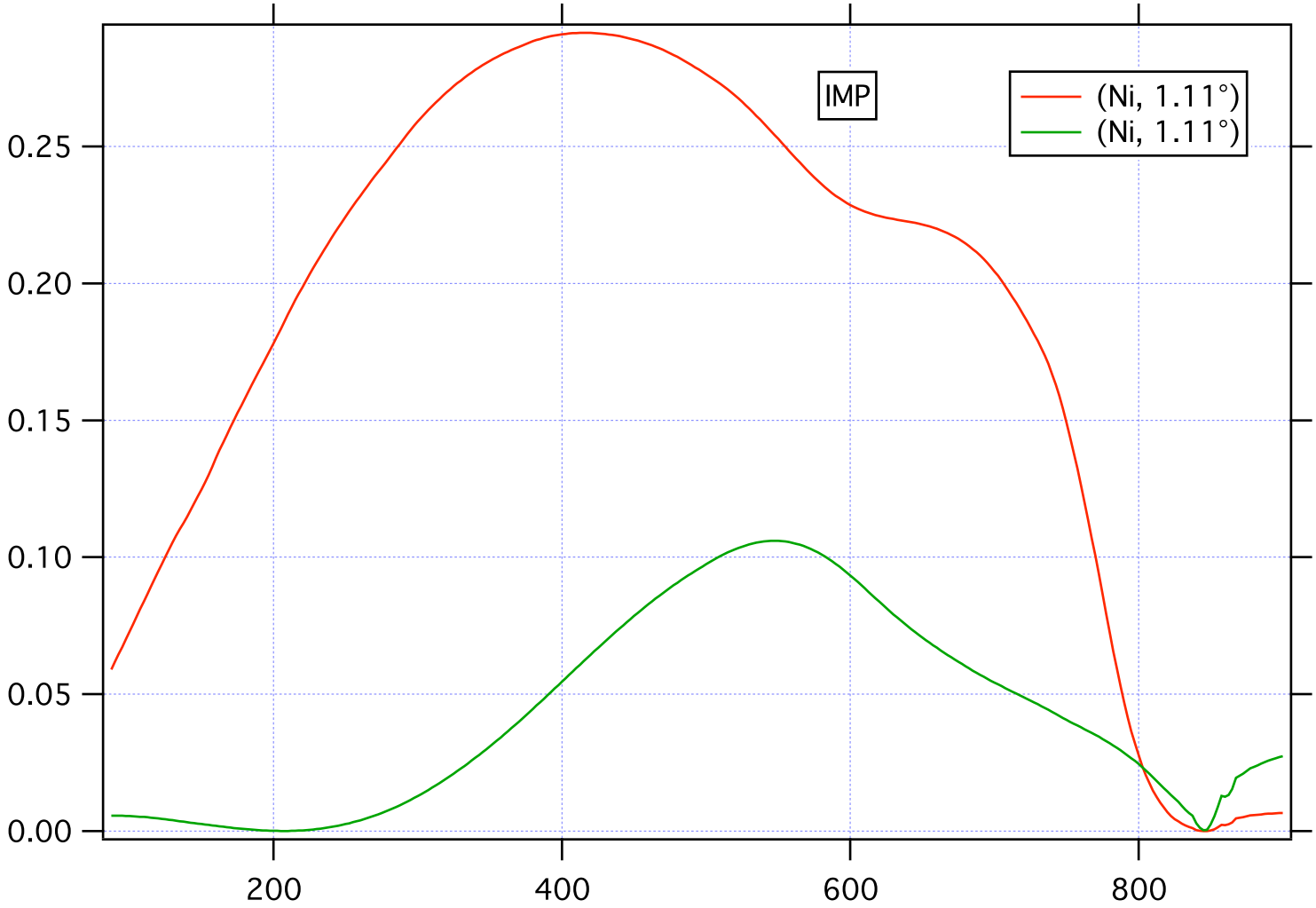
- What happened? Peaks shifted, 2nd order messed

LEG: Hypothesis



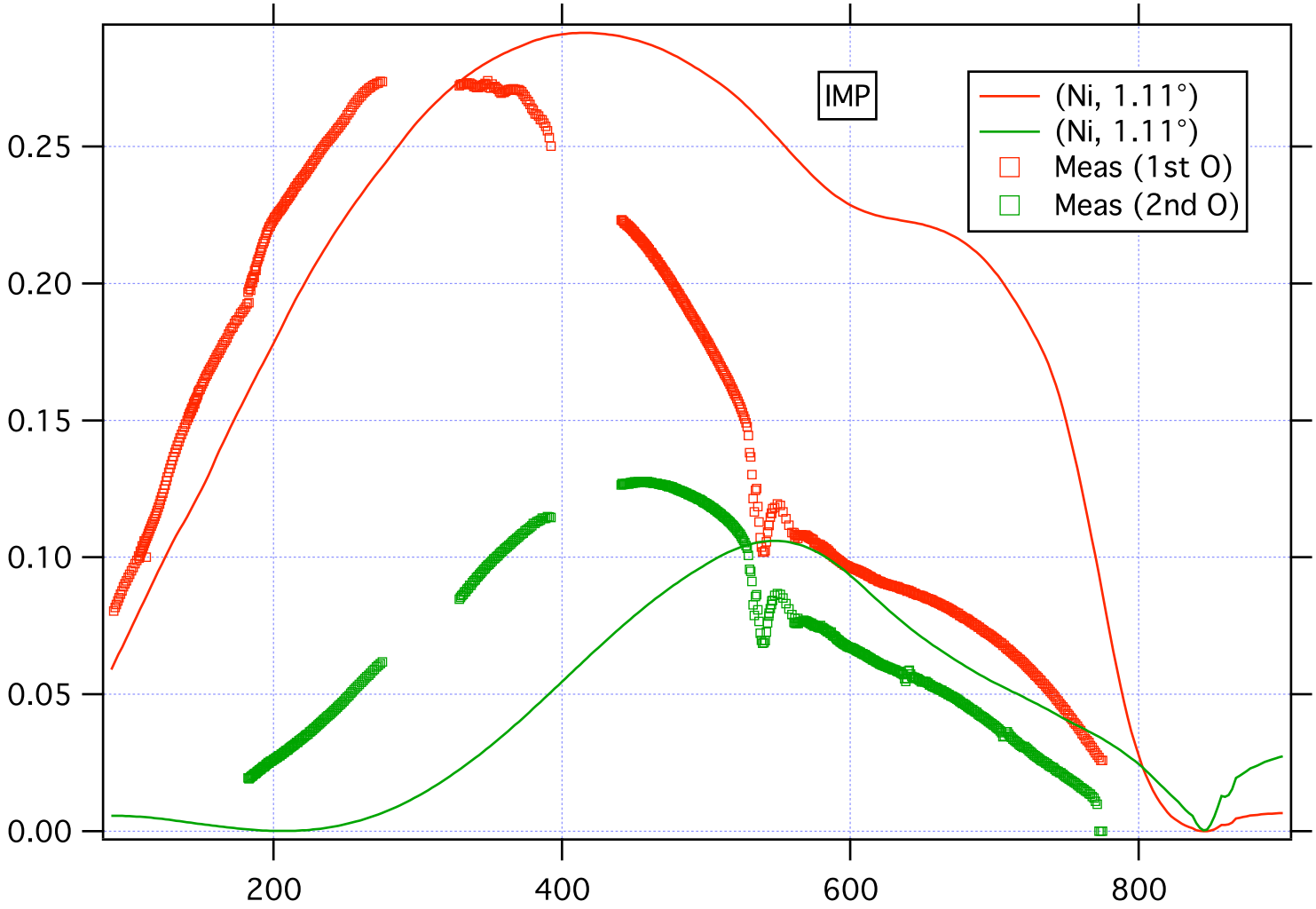
- Hypothesis: manufacturer missed blaze angle target of 1.85 degrees. Closer to 2.26 (estimated).

IMP: Predicted



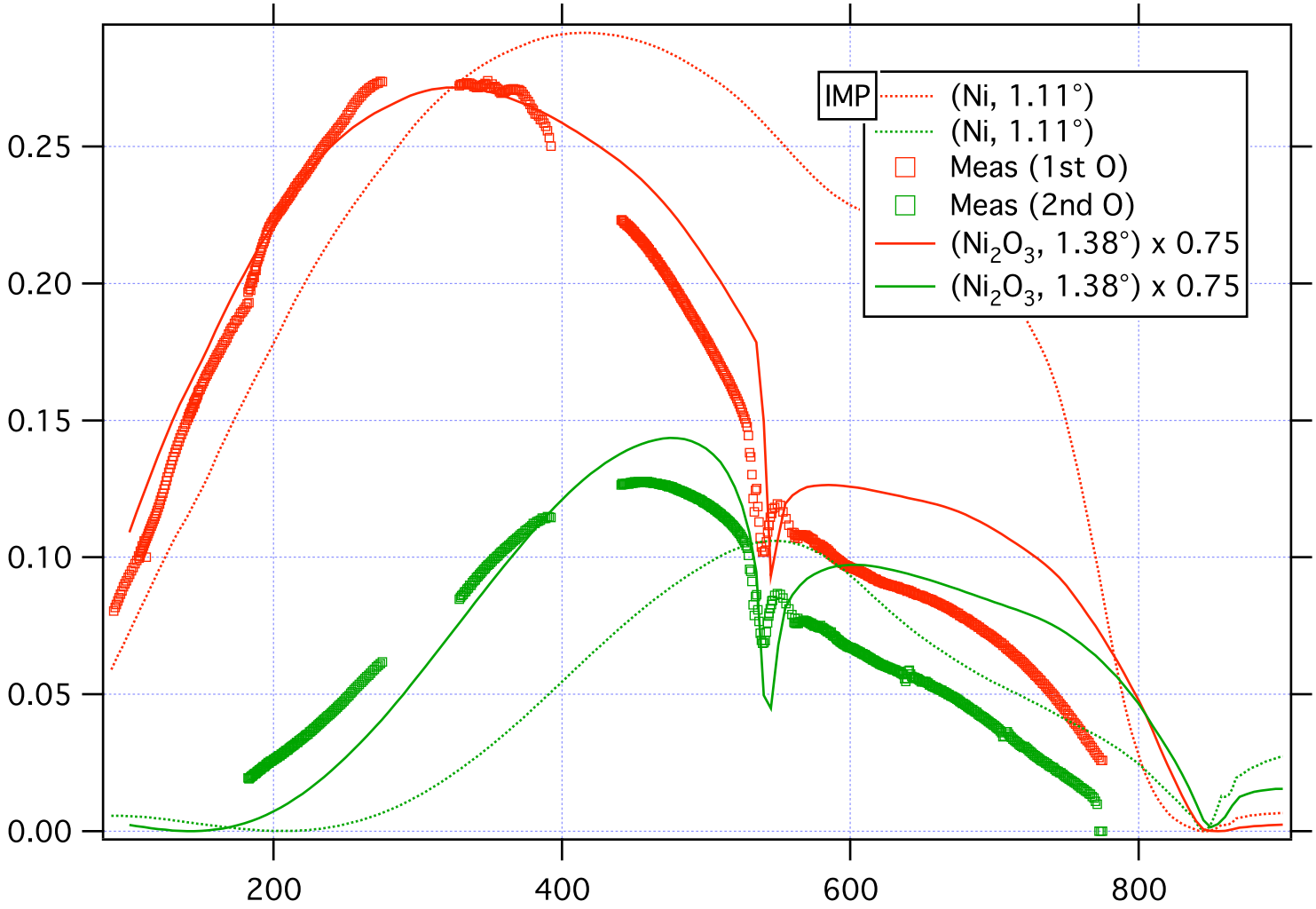
- Wide high-efficiency range

IMP: Measured



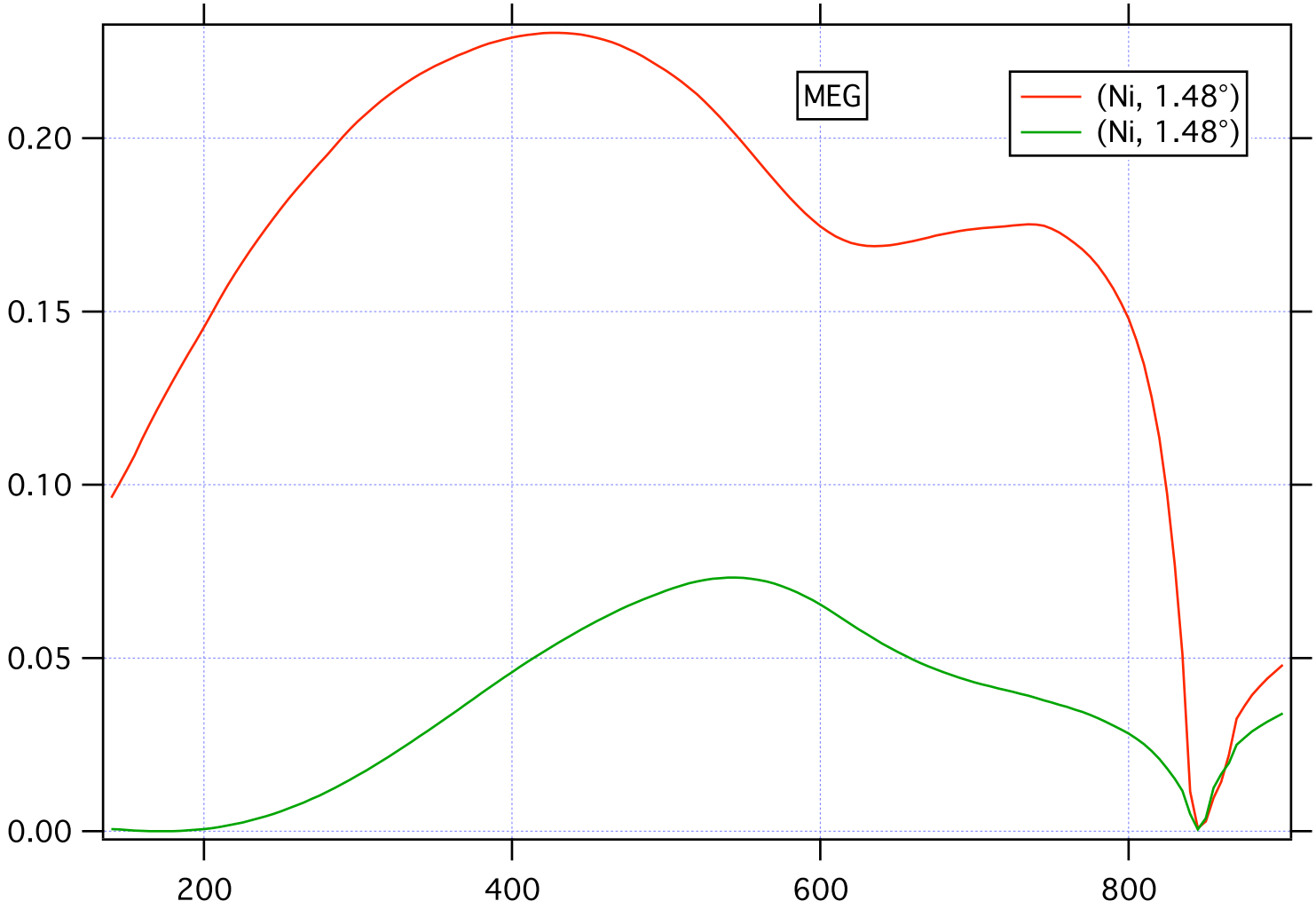
- What happened? Shifted again, but also... Drop-off near 520eV... Hmm... O-edge?

IMP: Hypothesis



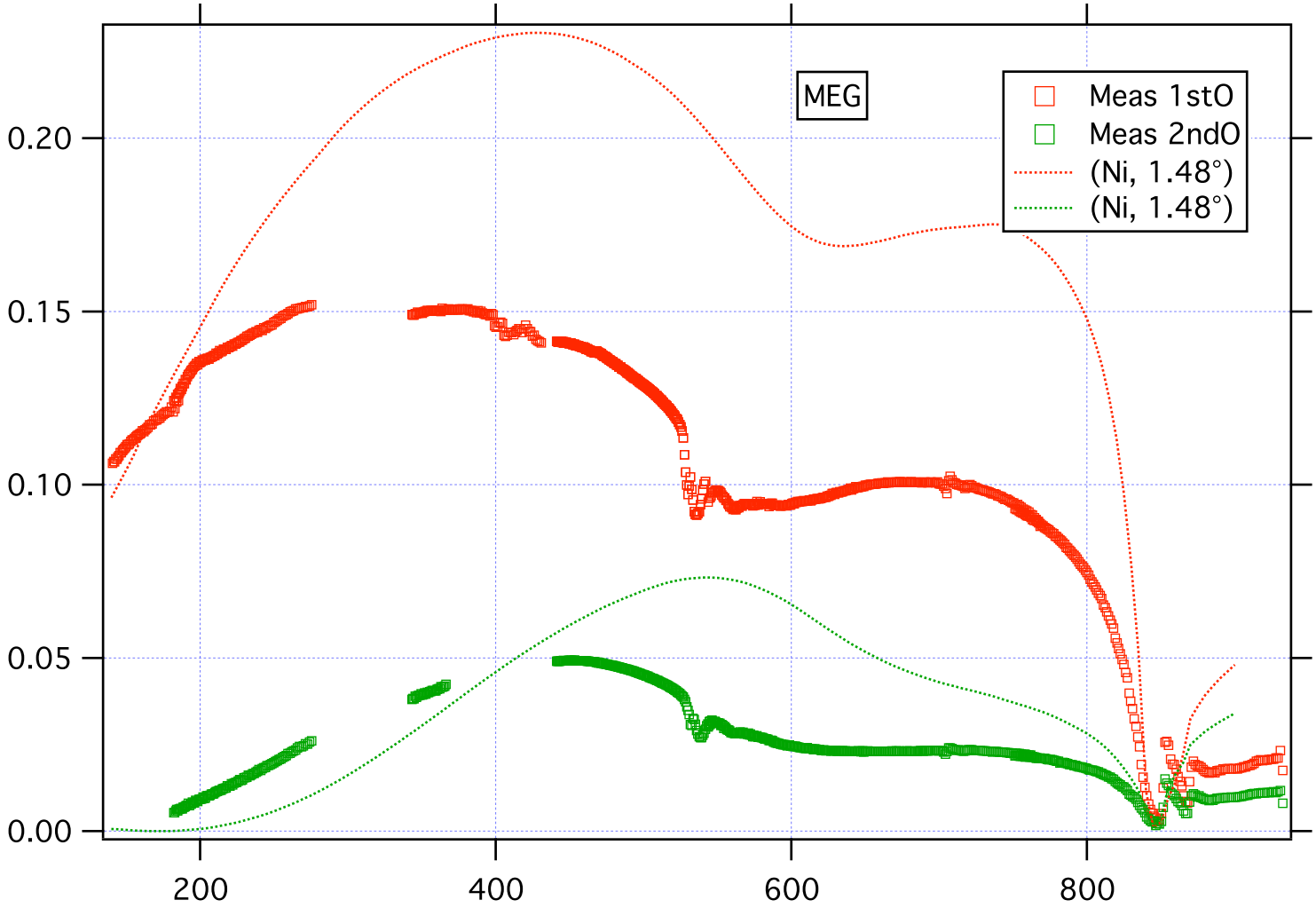
- Fitted: modeled as Nickel Oxide, 1.38deg blaze angle.
- Conclusion: Missed target blaze; Grating is oxidized.

MEG: Predicted



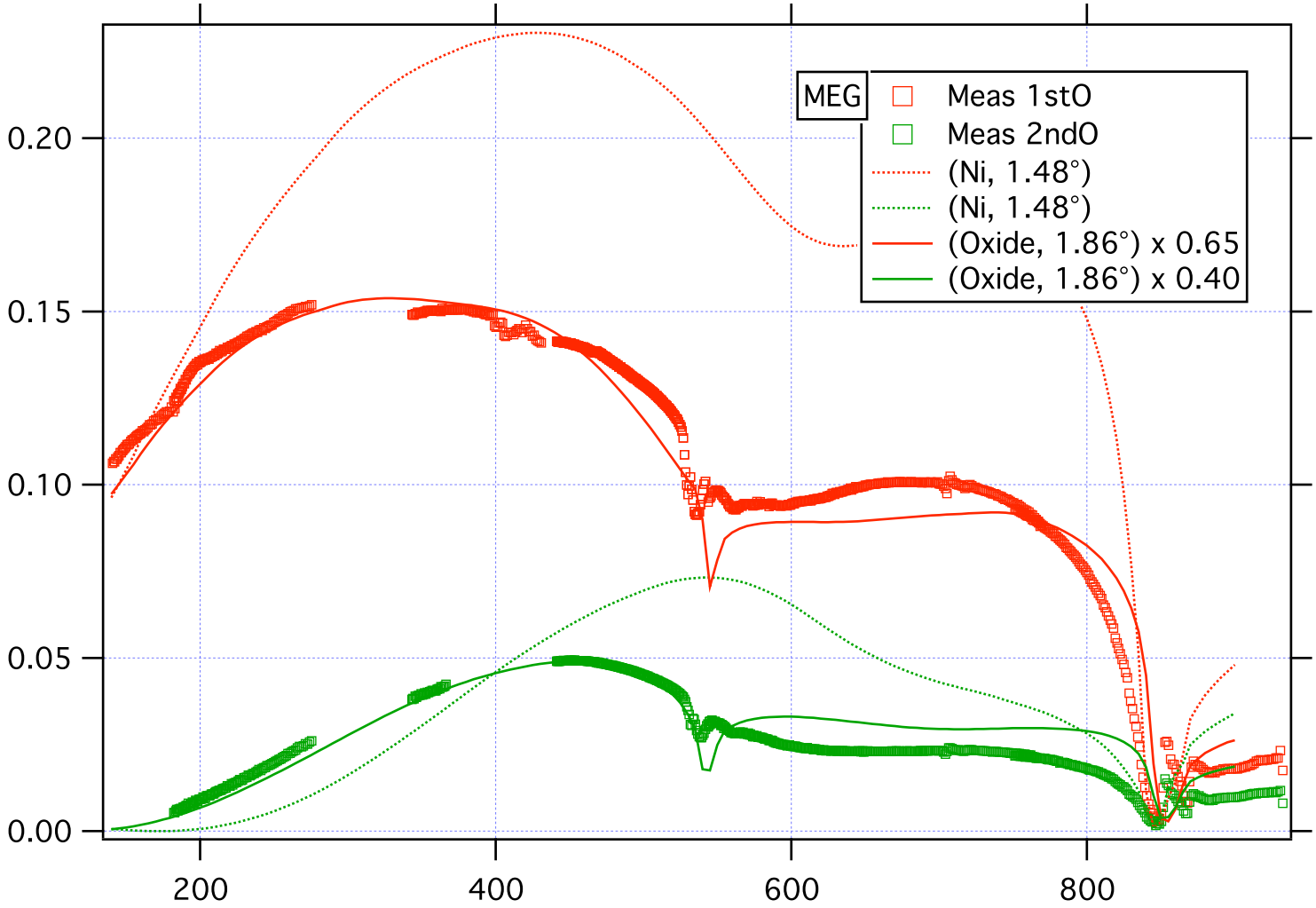
- Same story as IMP...

MEG: Measured



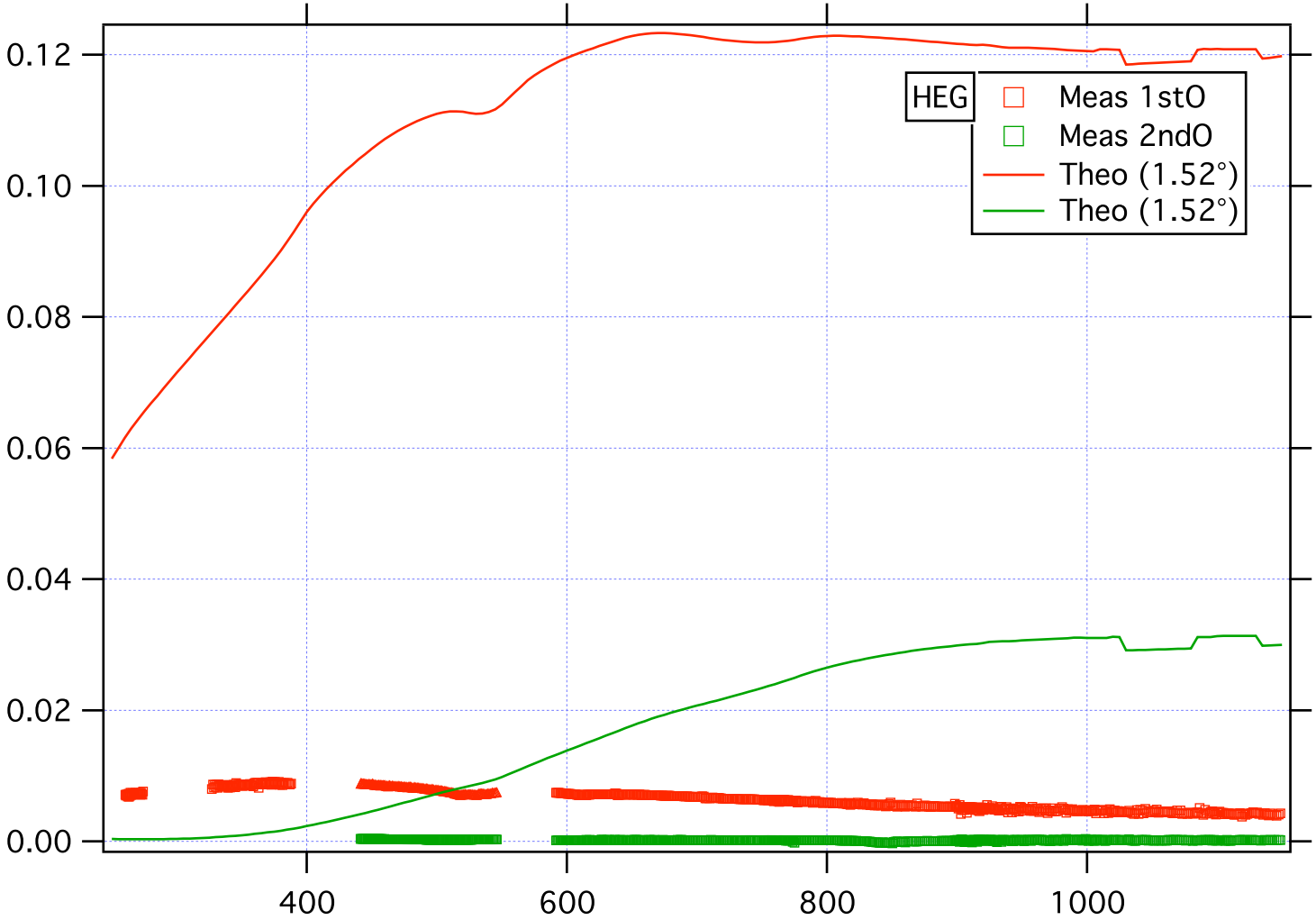
- What happened? Drop-off near 520eV... Hmm... O-edge?

MEG: Hypothesis



- Fitted: modeled as Nickel Oxide, 1.86deg blaze angle.
- Conclusion: Missed target blaze; Grating is oxidized.

HEG: a total dud...



- Hypothesis: ???
  (Did they mark the blaze direction backwards?
- Even high-res gratings in 3rd order get better efficiency

HEG: a total dud...

- Very disappointing; HEG is a critical grating.
  - Pt-coated: crucial for measuring above Ni-edge.
  - Covers entire range from 400 - 1300eV
- Even high-res gratings in 3rd order get better efficiency

- Best scenario: Direction of blaze was marked backwards, so simply rotating the grating 180deg. will fix it.
- If not... ???
  - AFM scan will reveal if this is the case.

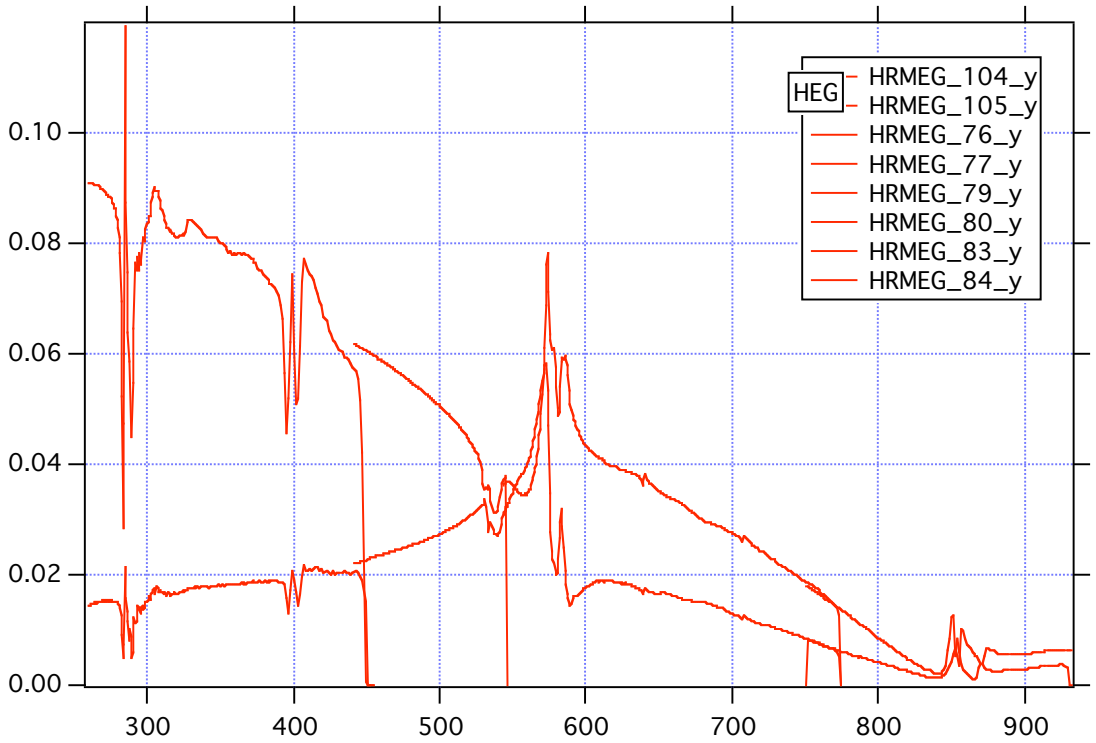
Next steps...

- Conduct AFM scans of all gratings to actually measure the groove profile / blaze angle
  - Fitting estimates show *all blaze angles* are 0.3deg to 0.4deg too large.
  - If so, gratings are off-spec (±10%) and should be fixed by Bernie and co.

- Find a chemical that will dissolve nickelous oxides but not nickel...
- Find out what happened with HEG.

HR gratings

- Still working on analyzing data from HR gratings.
  - Beamline 6 normalizing software had bug with offset points (apparent only near absorption edges)
  - Need to normalize manually, or fix software:



Conclusions:

- 2 problems with gratings apparent in measurements
  - Calculations can match measurements, only if:
    - Assume blaze angles too large (consistantly +0.35deg)
    - Nickel gratings are oxidized
- Todo:
  - Reverse oxidization? Is it possible?
  - Confirm blaze angles with AFM scan.