# Fluorescence studies using low energy electron beam excitation

a very personal view by

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with real work done by:

Thomas Dandl, Thomas Heindl, and Andrei Morozov*

and a lot of help by

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**Optimare Analytik GmbH & Co KG

Air Fluorescence Workshop, Karlsruhe 2011

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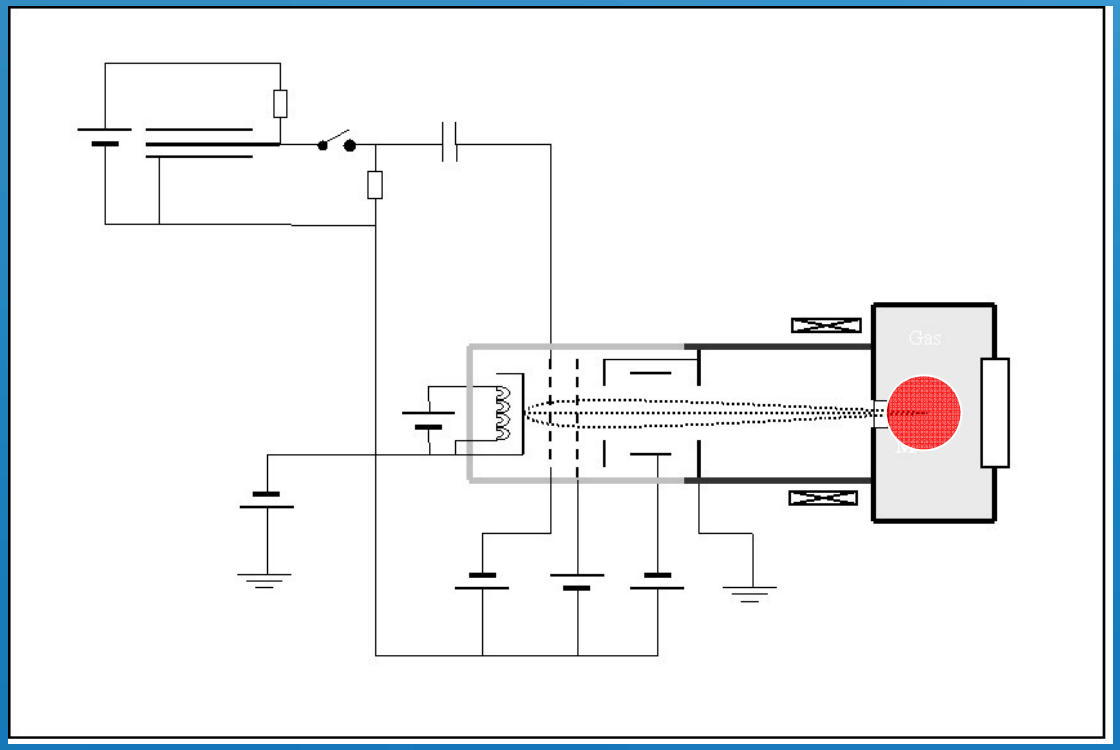
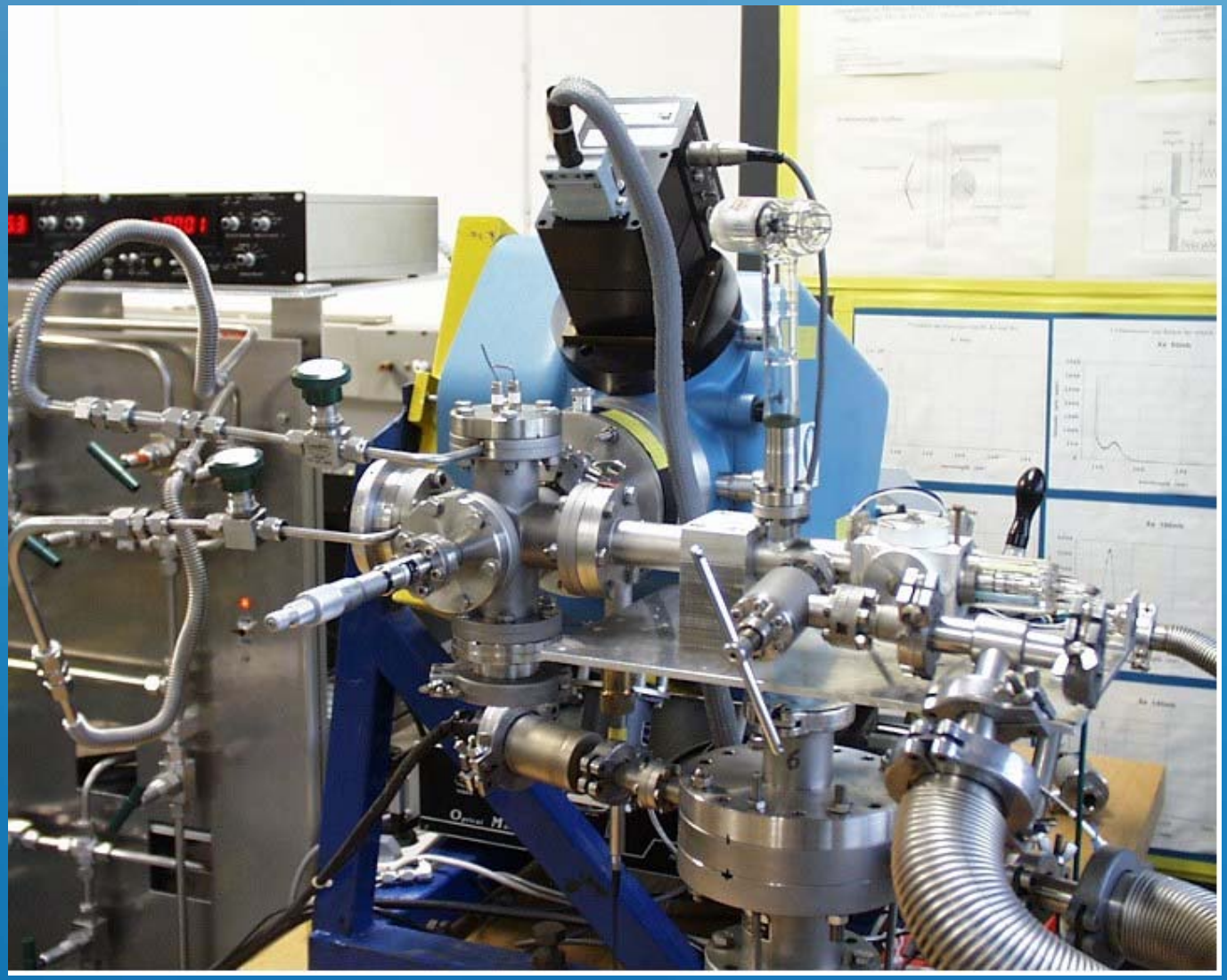
# Spectroscopy:

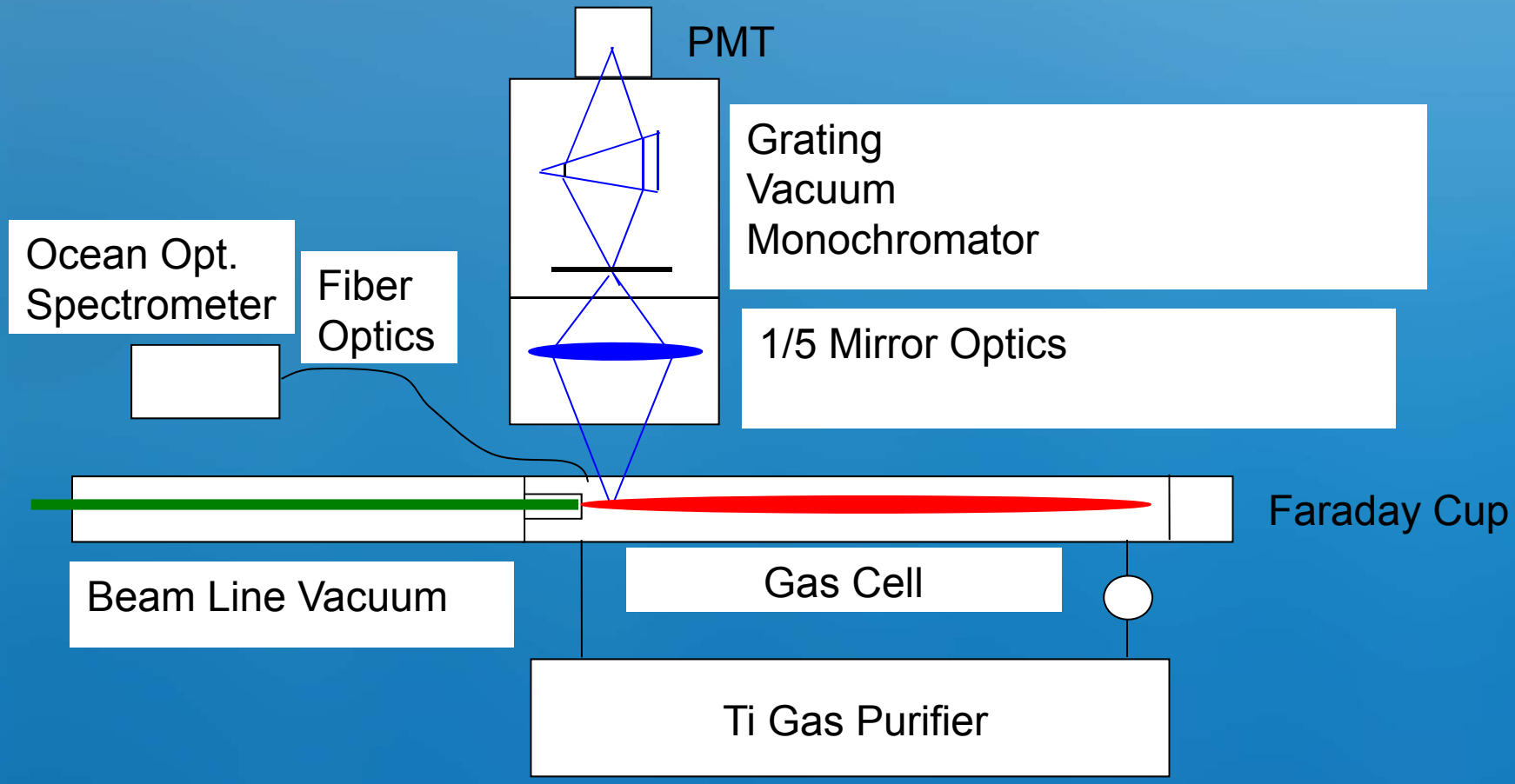
Provides information about the species involved

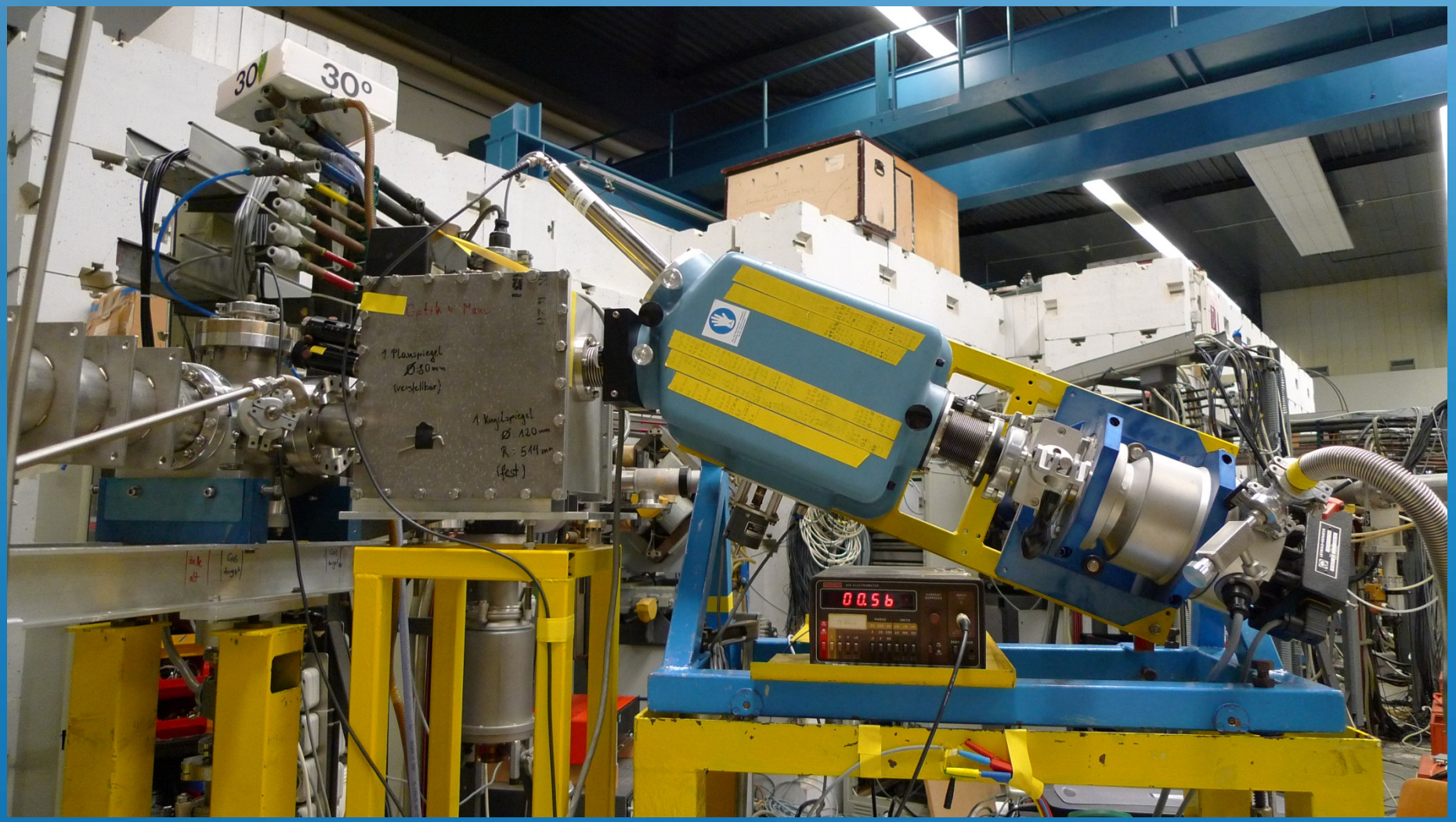
We work with beams in nitrogen and in air



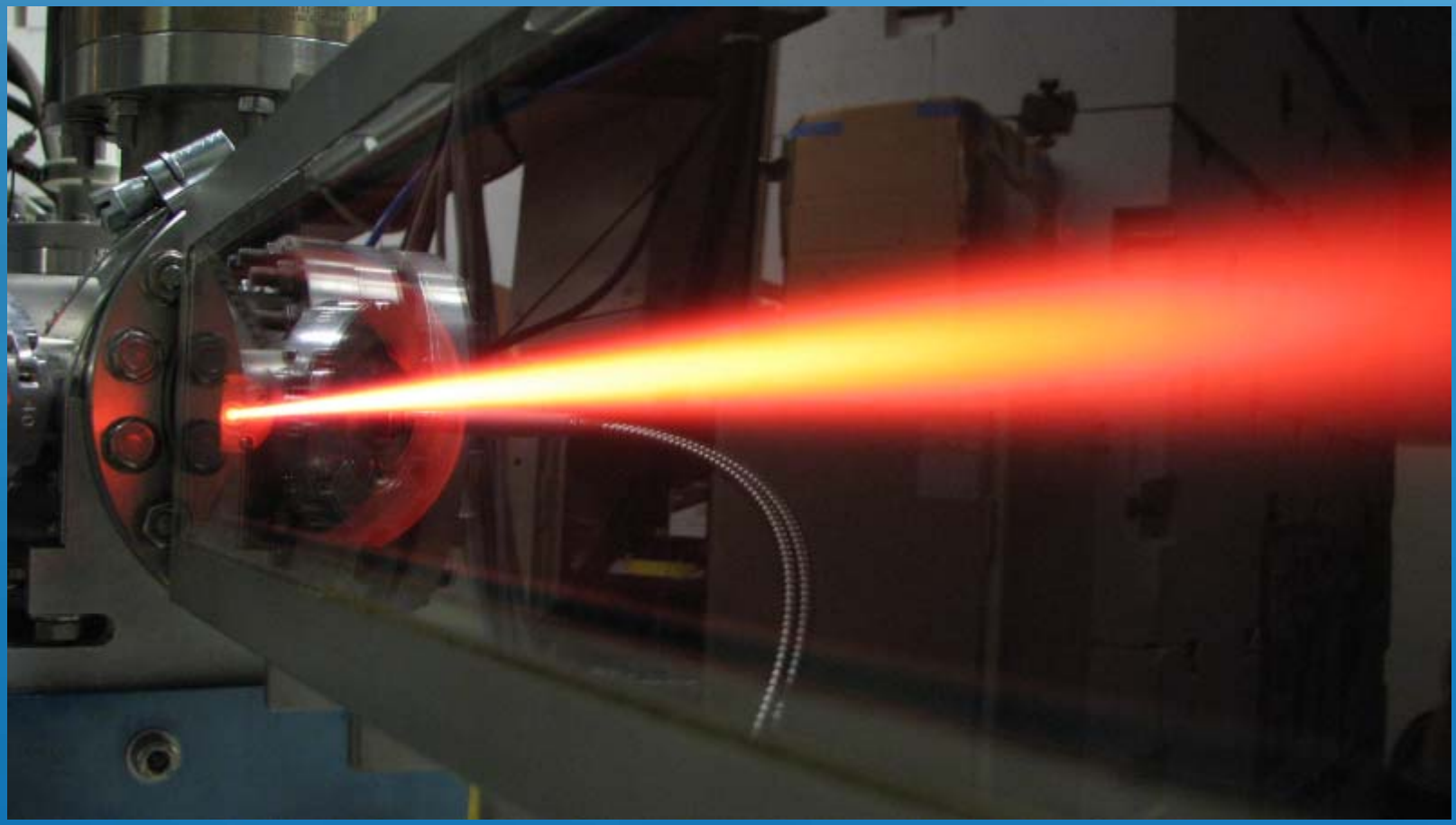


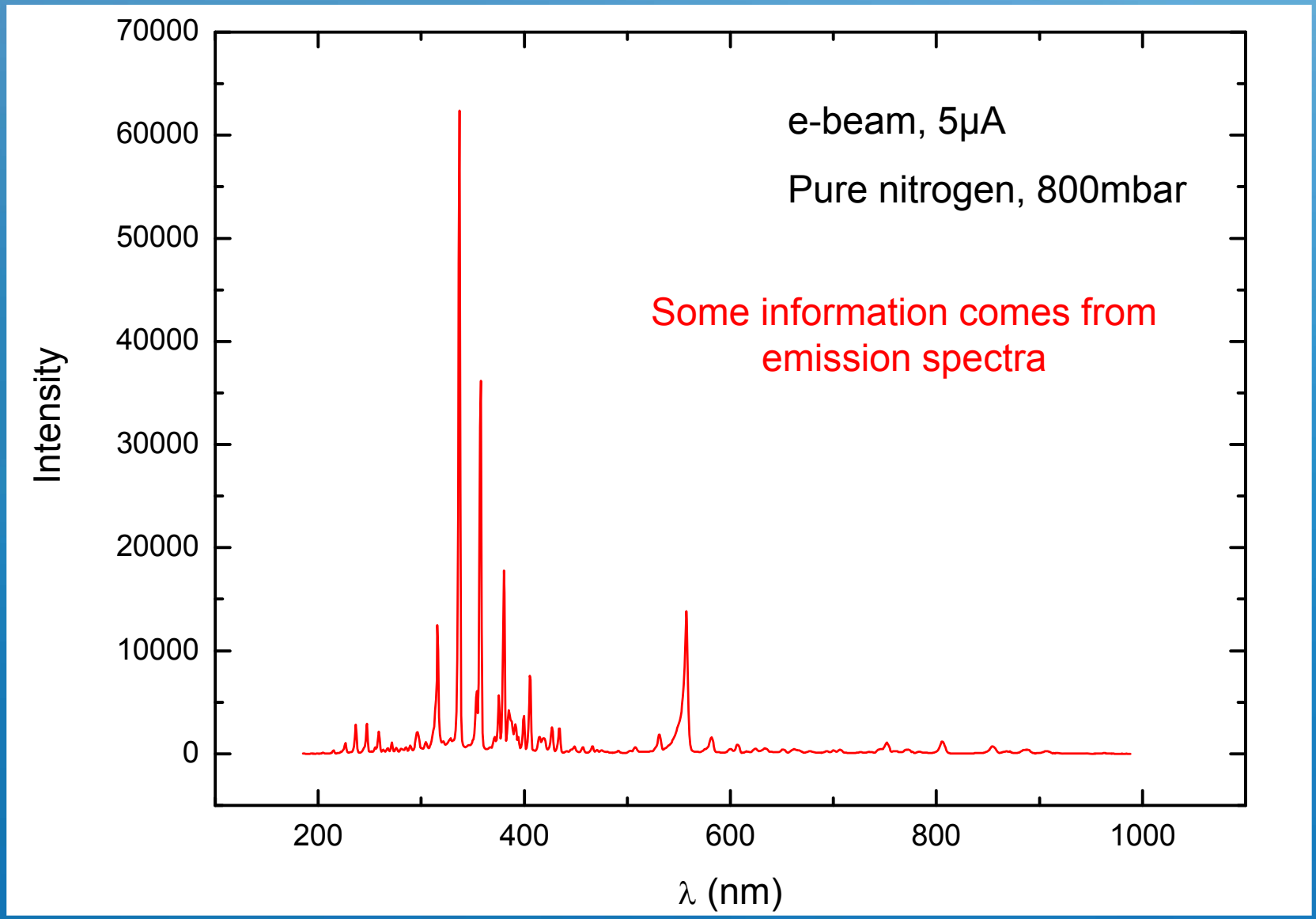
# Heavy ion beam experiments at the Munich 15 MV Tandem accelerator:

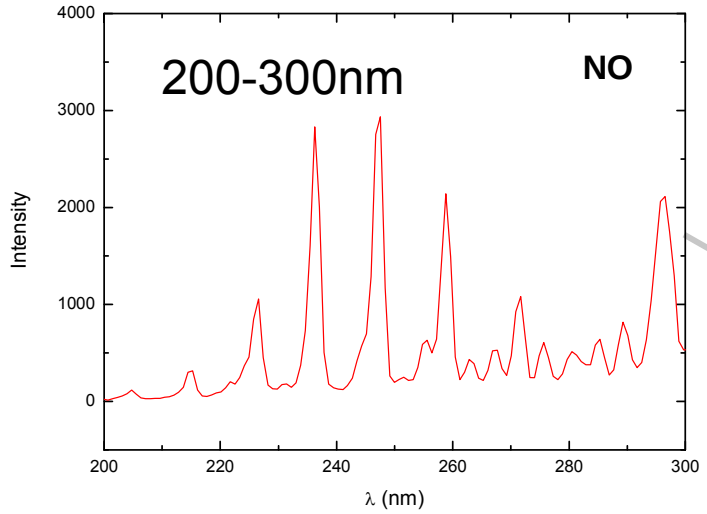


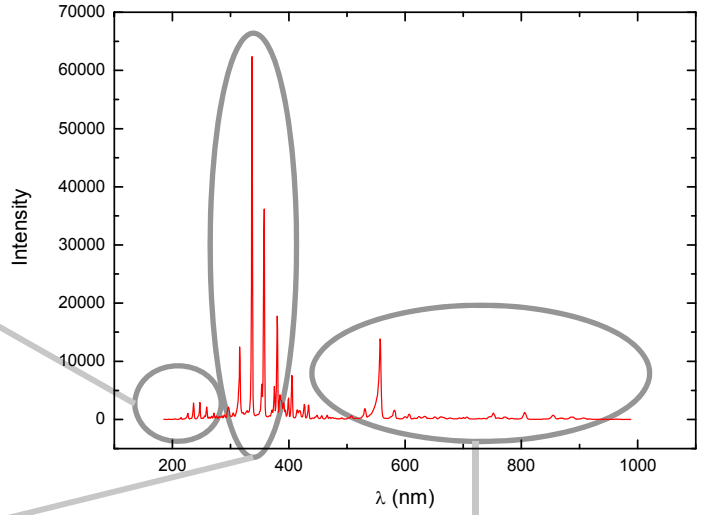

30°
30
1 Planspiegel
Ø 150 mm
(verstellbar)
1 Konkavspiegel
Ø 120 mm
R 514 mm
(fest)
0.5 b

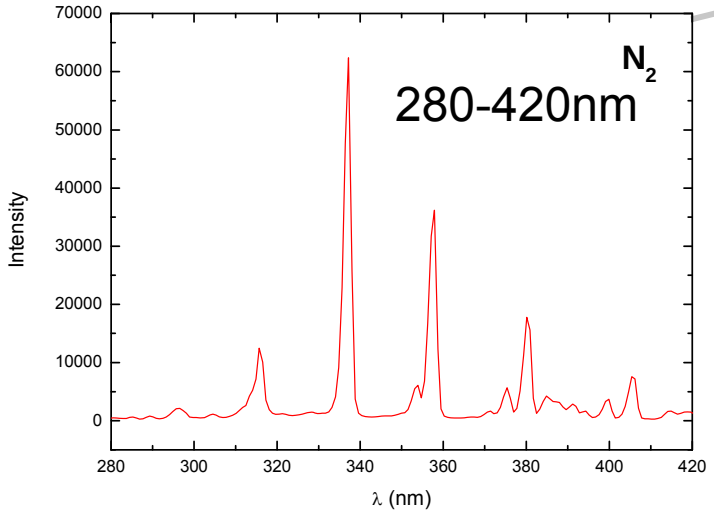
# 100 MeV $^{32}$S beam stopped in neon

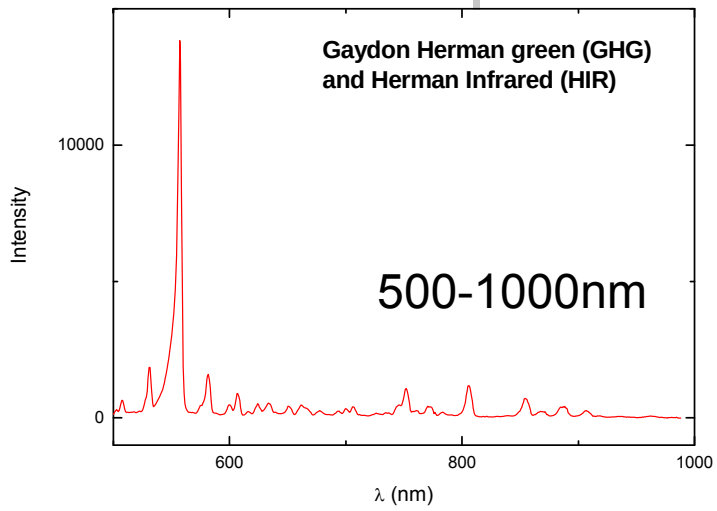



70000
60000
50000
40000
30000
20000
10000
0
Intensity
200
400
600
800
1000
λ (nm)
e-beam, 5μA
Pure nitrogen, 800mbar
Some information comes from
emission spectra

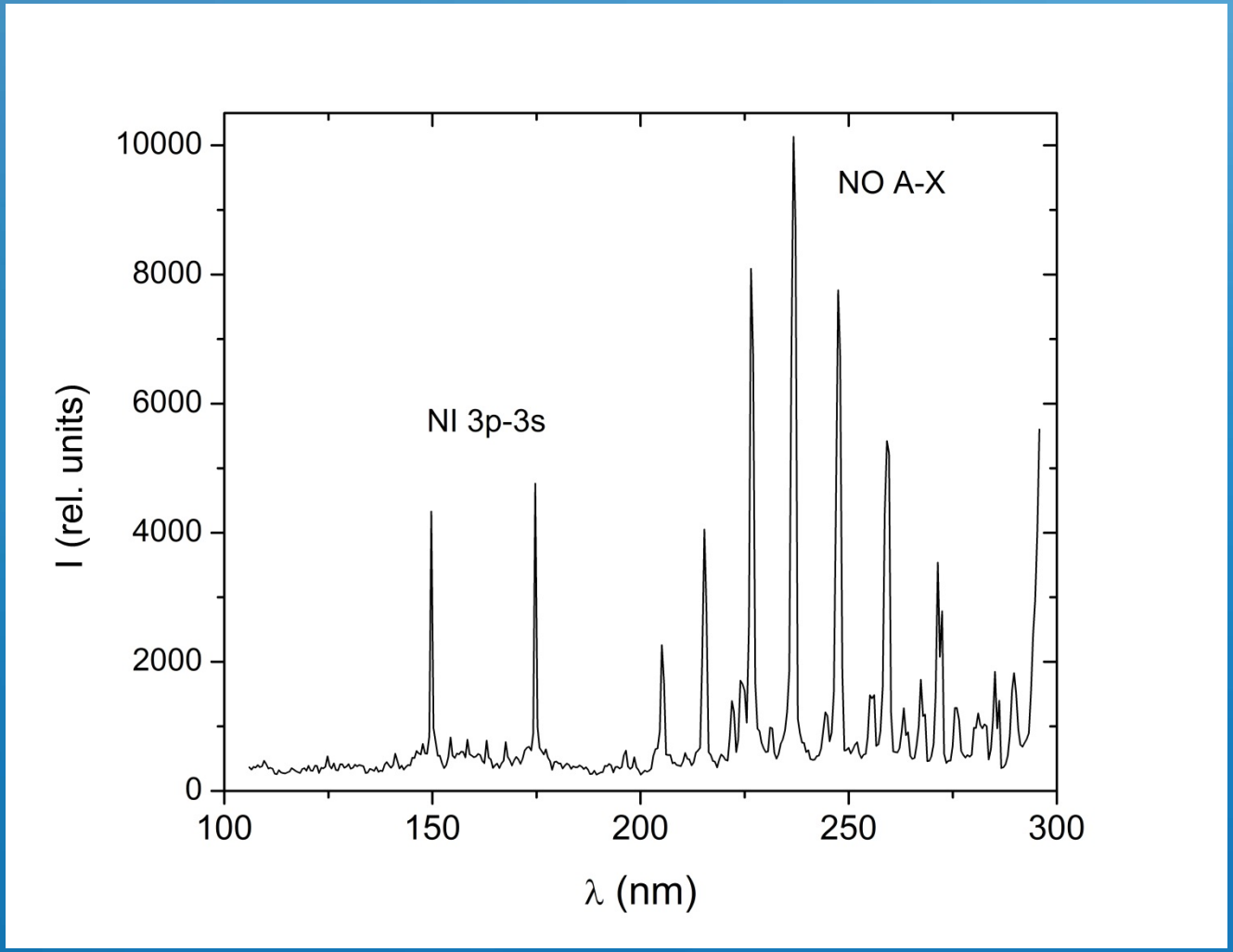

200-300nm
NO
Intensity
λ (nm)


Intensity
λ (nm)

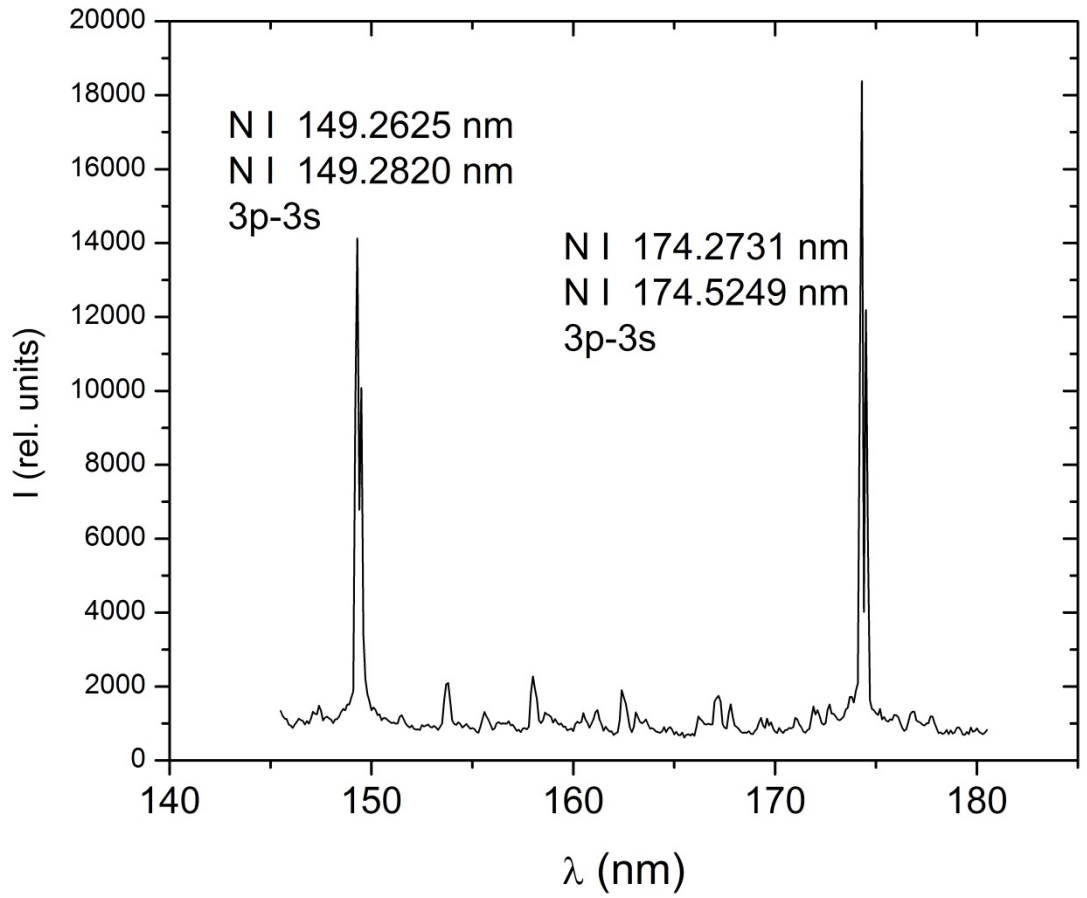

N2
280-420nm
Intensity
λ (nm)

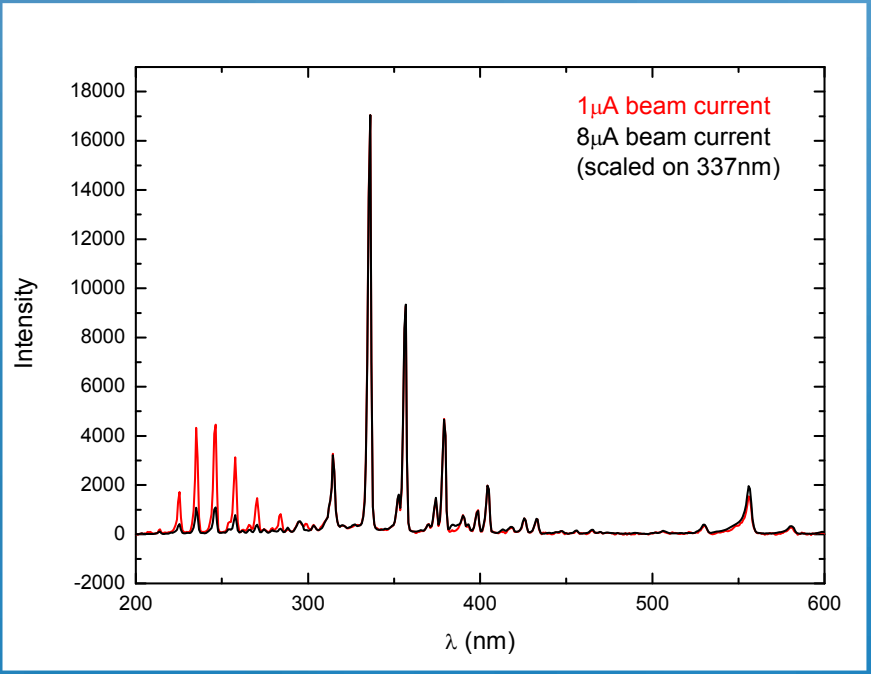

Gaydon Herman green (GHG)
and Herman Infrared (HIR)
500-1000nm
Intensity
λ (nm)

# Extension into the VUV shows N I lines ! (nitrogen spectrum)



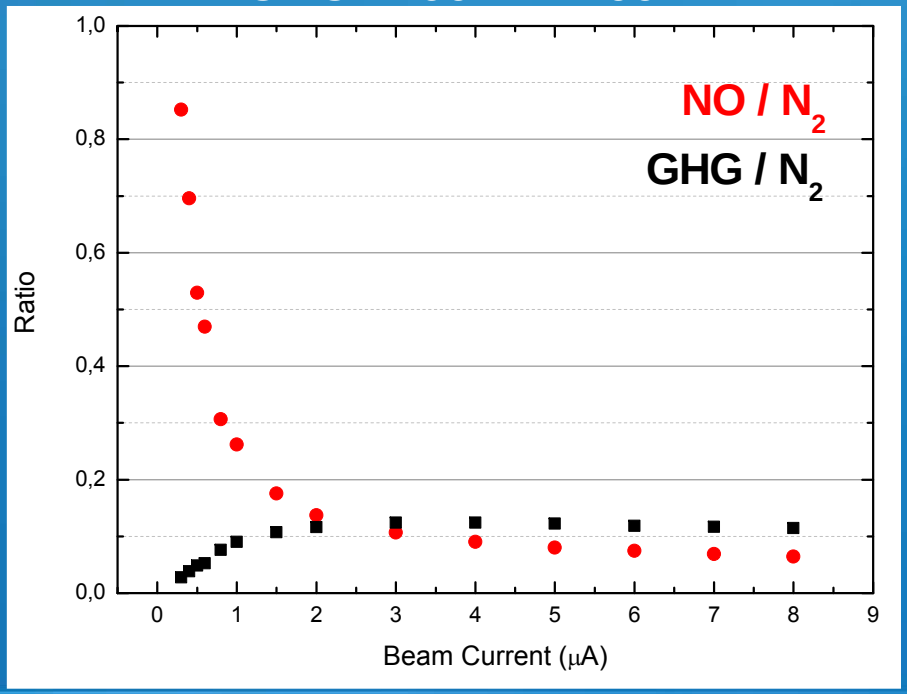
# Atomic nitrogen shows up in the VUV spectral range



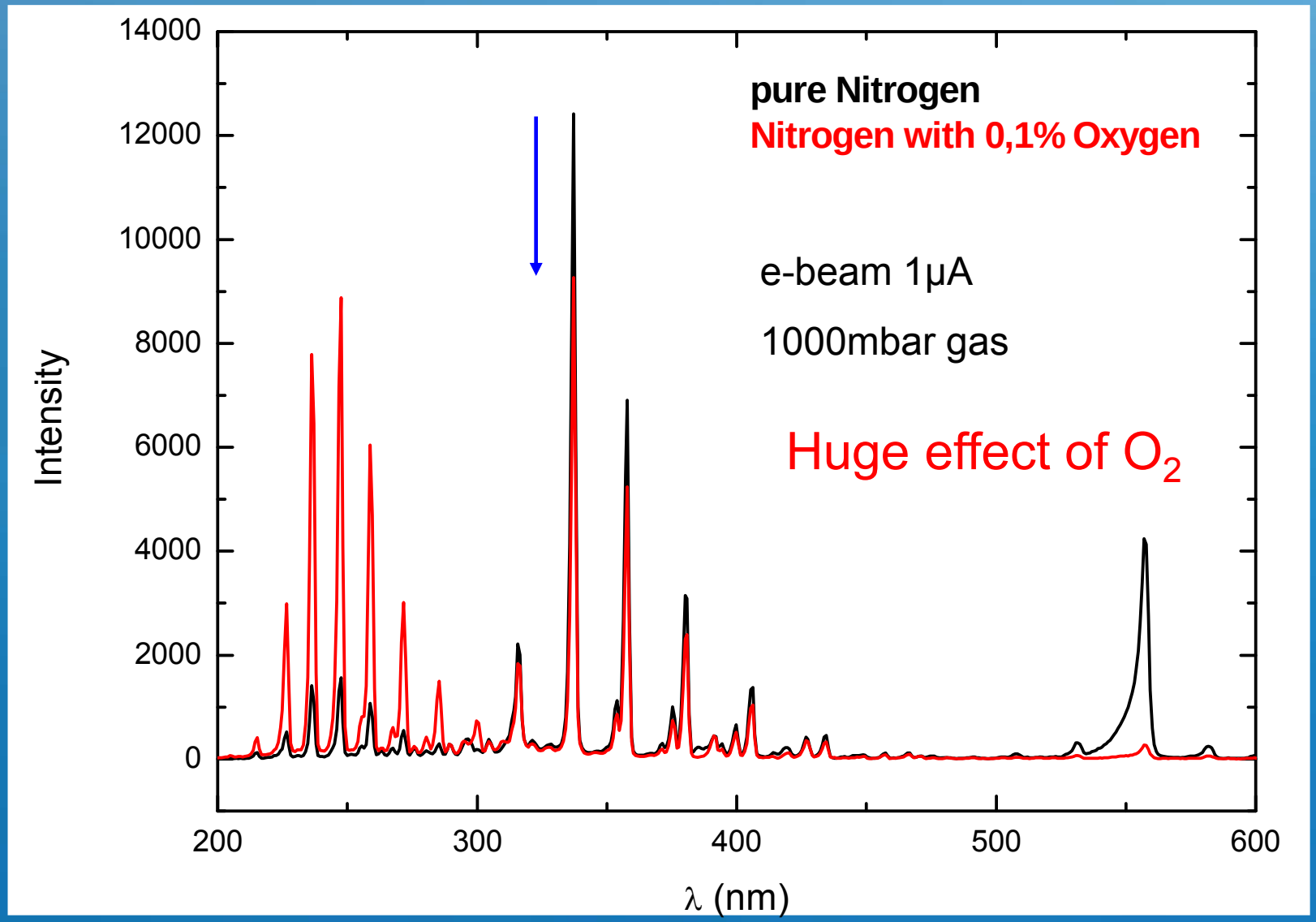


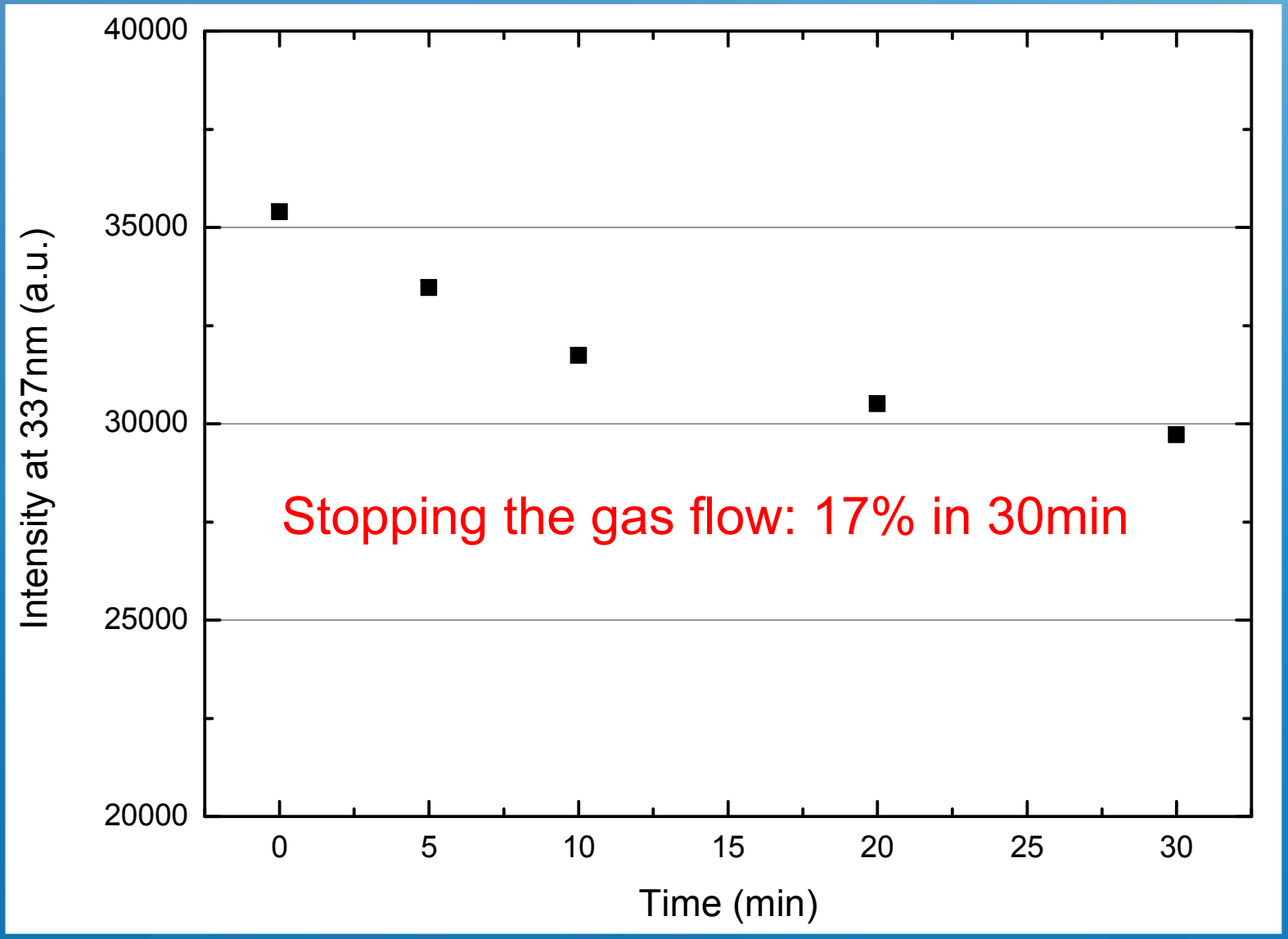

# The spectrum depends on beam current!

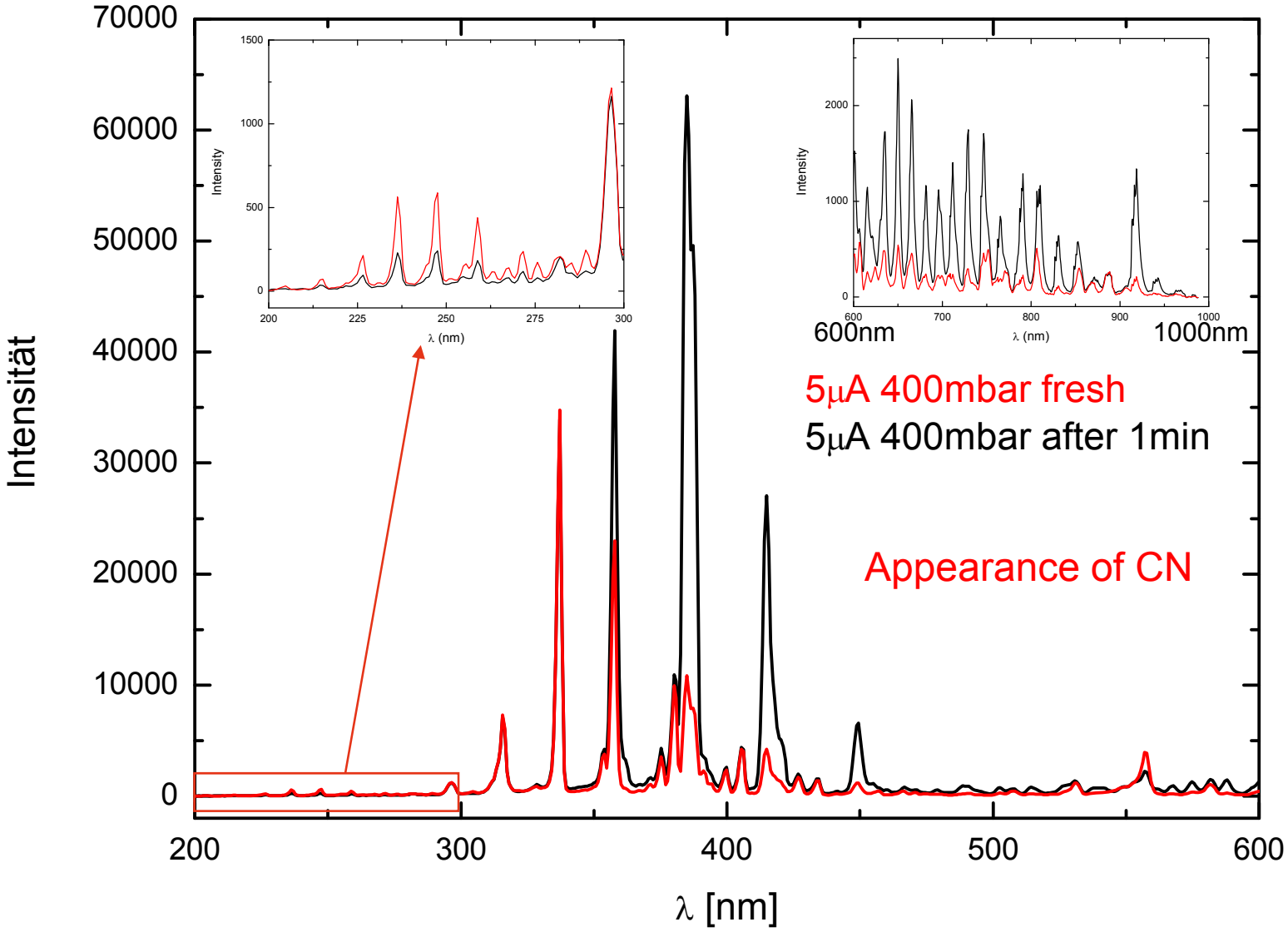
N2 / NO 337nm/247nm
N2 / GHG 337nm / 557nm

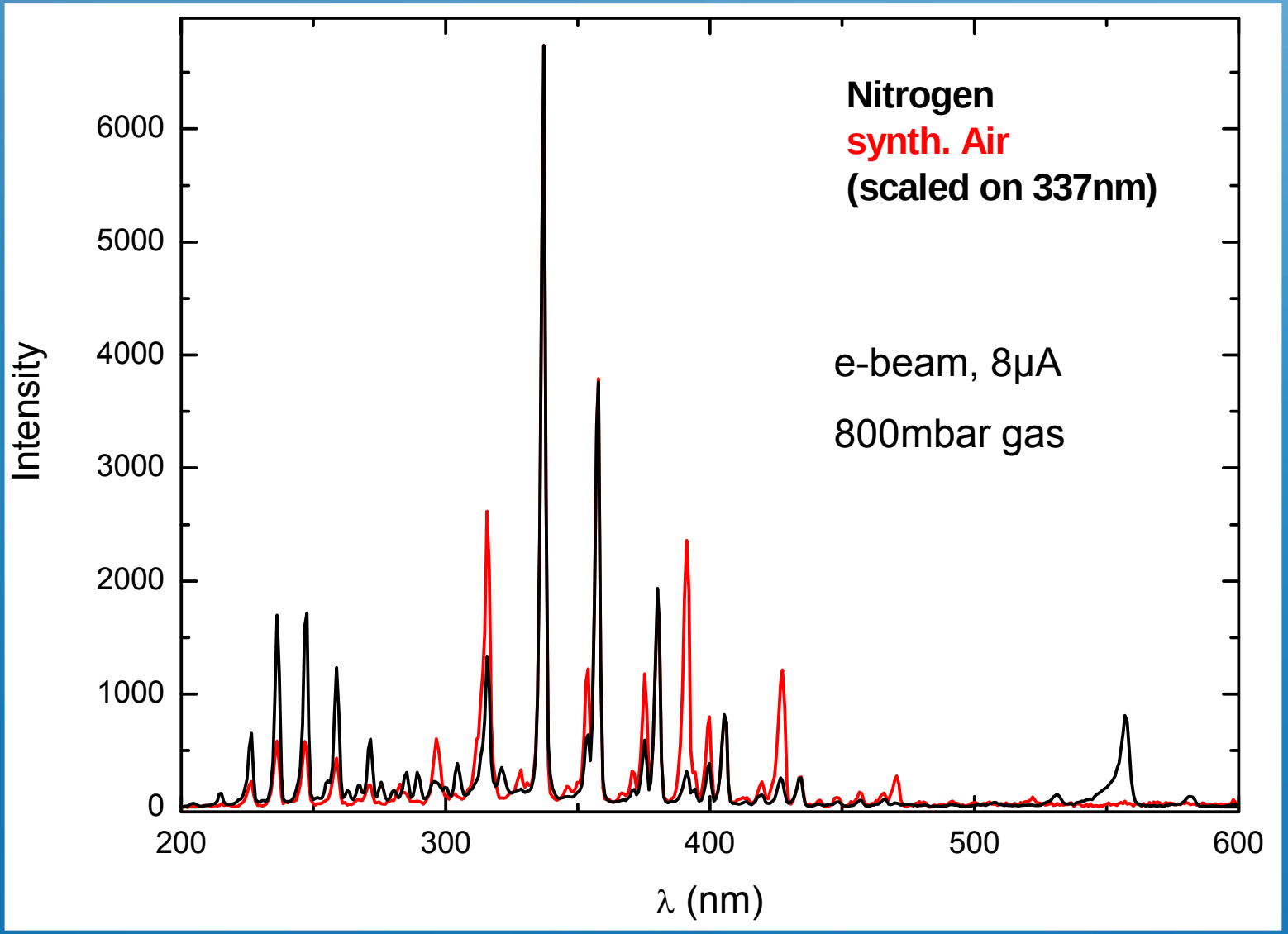


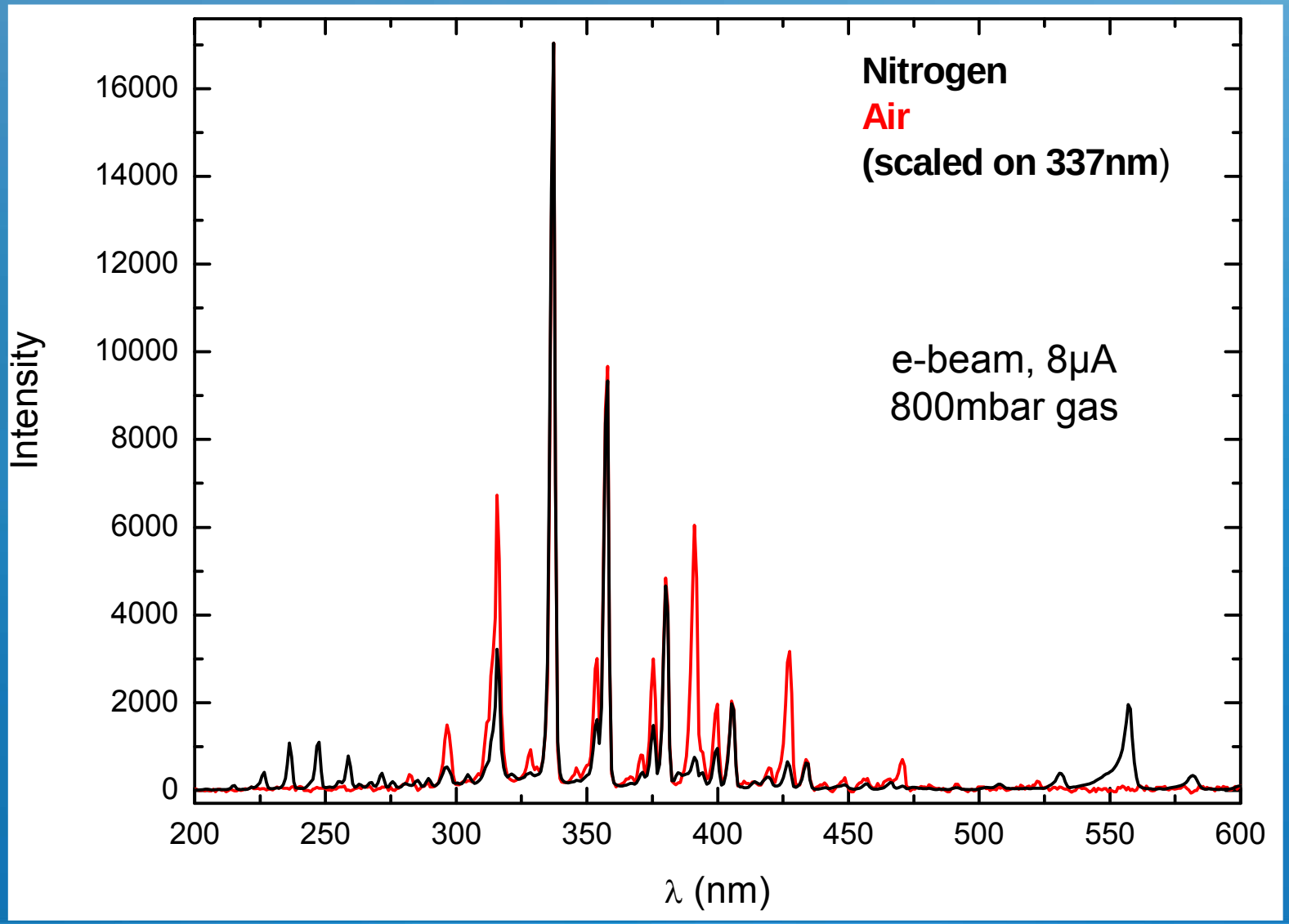

Plasma effects and radiation trapping


14000
12000
10000
8000
6000
4000
2000
0
Intensity
200
300
400
500
600
λ (nm)
pure Nitrogen
Nitrogen with 0,1% Oxygen
e-beam 1µA
1000mbar gas
Huge effect of $O_2$


40000
35000
30000
25000
20000
Intensity at 337nm (a.u.)
0
5
10
15
20
25
30
Time (min)
Stopping the gas flow: 17% in 30min


Intensität
λ [nm]
5μA 400mbar fresh
5μA 400mbar after 1min
Appearance of CN
600nm
1000nm
Intensity
λ (nm)


Nitrogen
synth. Air
(scaled on 337nm)
e-beam, 8µA
800mbar gas
Intensity
0
1000
2000
3000
4000
5000
6000
200
300
400
500
600
λ (nm)


Nitrogen
Air
(scaled on 337nm)
e-beam, 8µA
800mbar gas
Intensity
16000
14000
12000
10000
8000
6000
4000
2000
0
200
250
300
350
400
450
500
550
600
λ (nm)

## Qualitative results from spectroscopy:

Pure nitrogen is very sensitive to impurities

NO is often formed

Higher lying bands are populated (cascades ?)

Nitrogen is split to N atoms even excited N atoms

Regular air and synthetic air behave differently

## Next step:

## relative sensitivity calibration

Thomas Dandl has used 3 types calibration lamps:

Halogen Lamp (LOT)

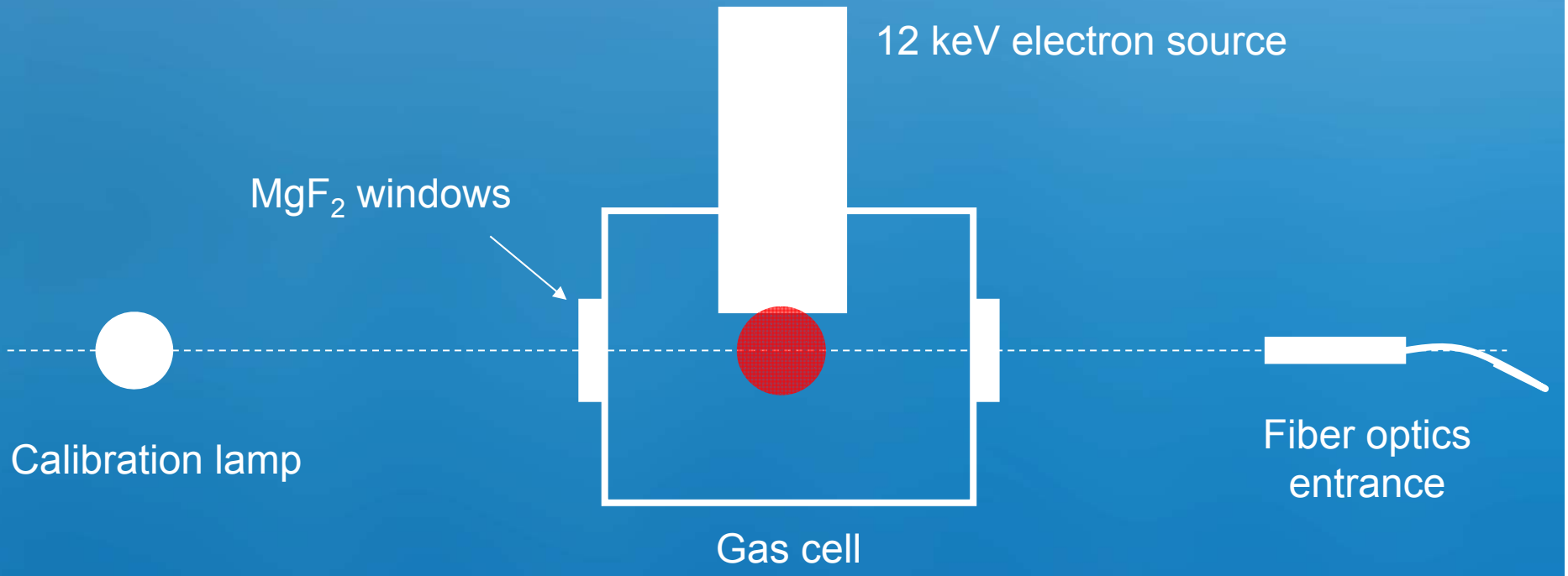
Wi 17G (Osram) 2x

Deuterium Lamp (LOT, Cathodeon) one lamp, 2 data sets

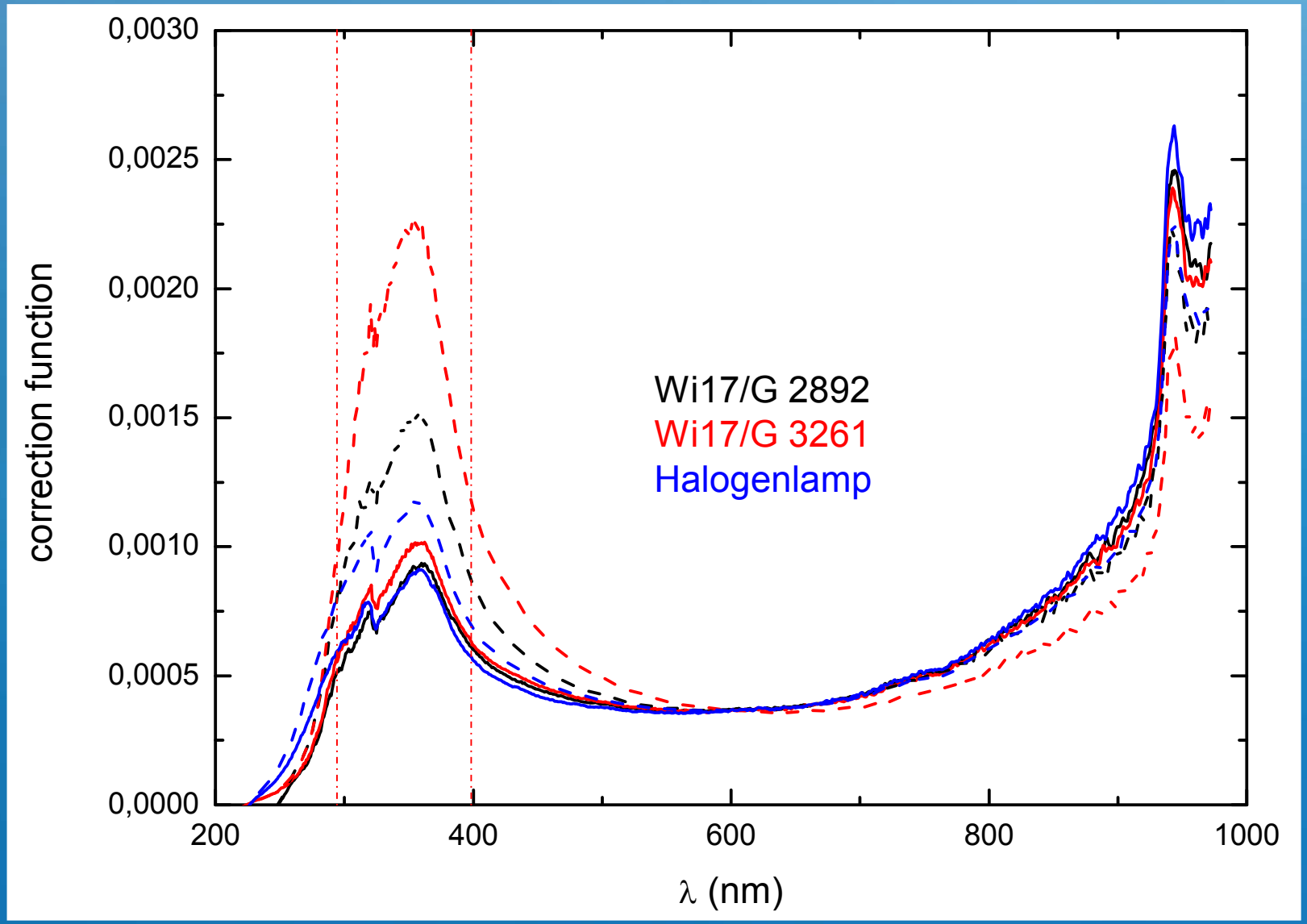
to measure the relative response of an Ocean Optics QE65000 between 280 and 420nm

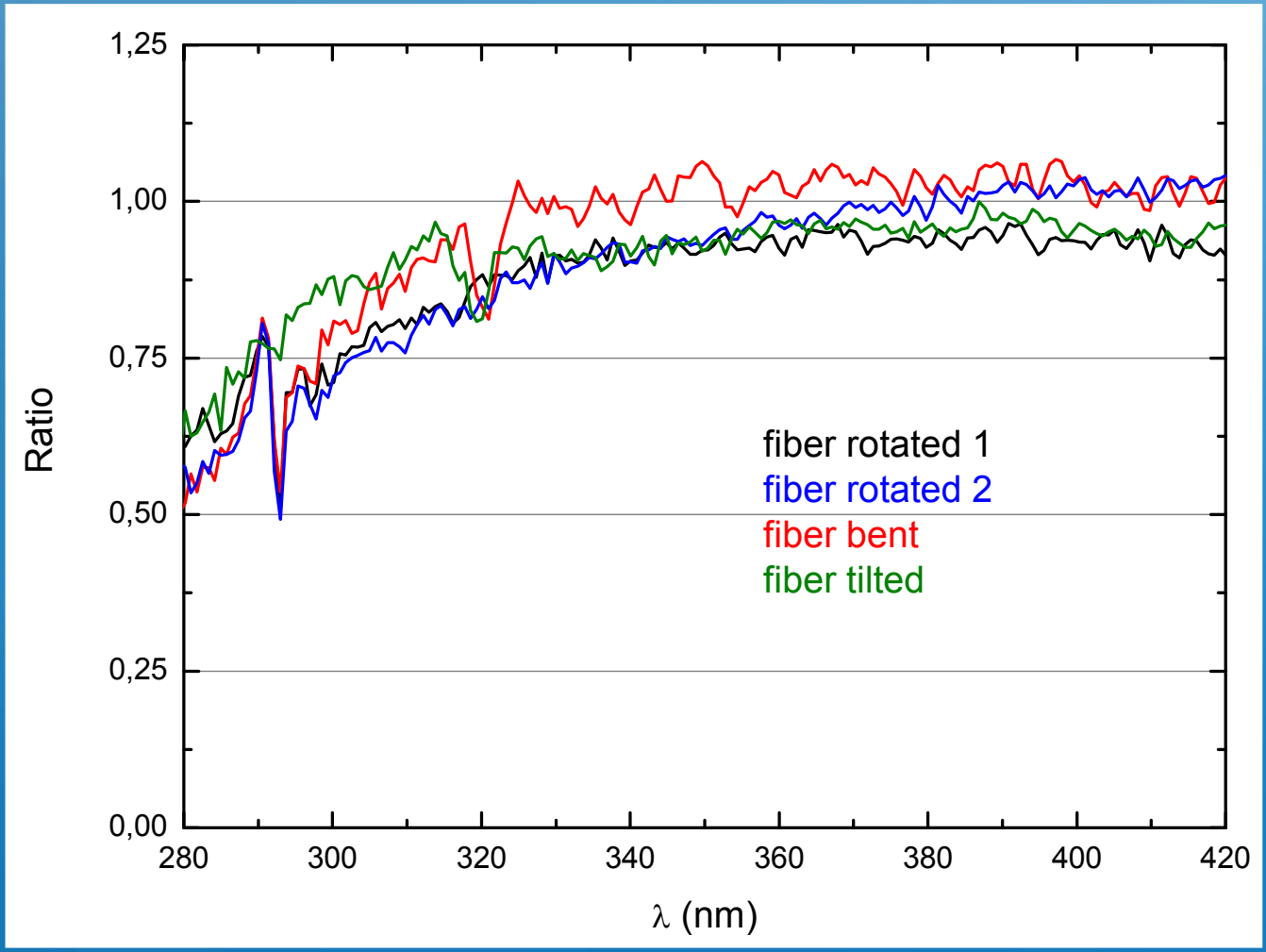
He used (in part) filters for the wavelength region to suppress stray light

# Setup for calibration

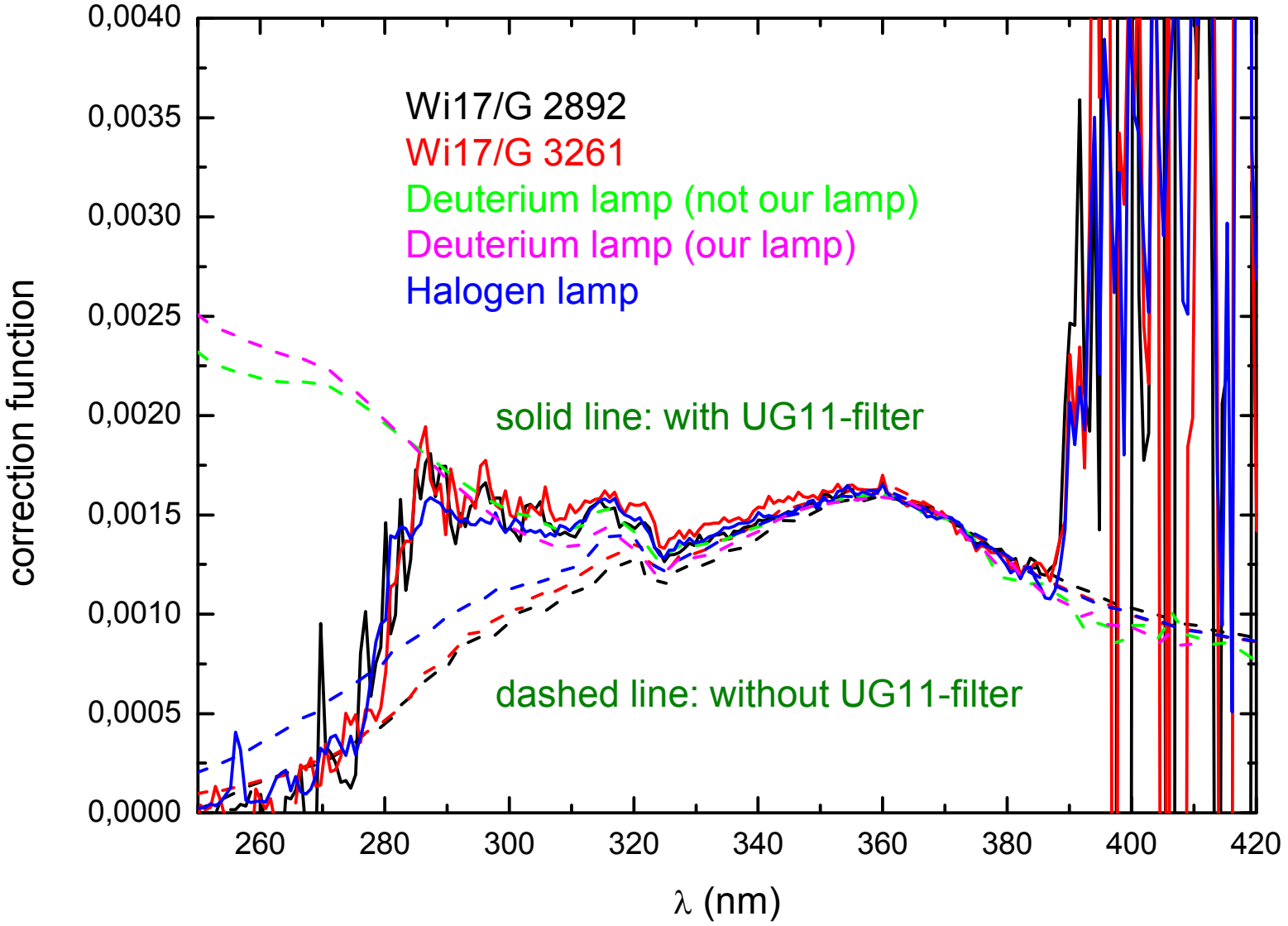


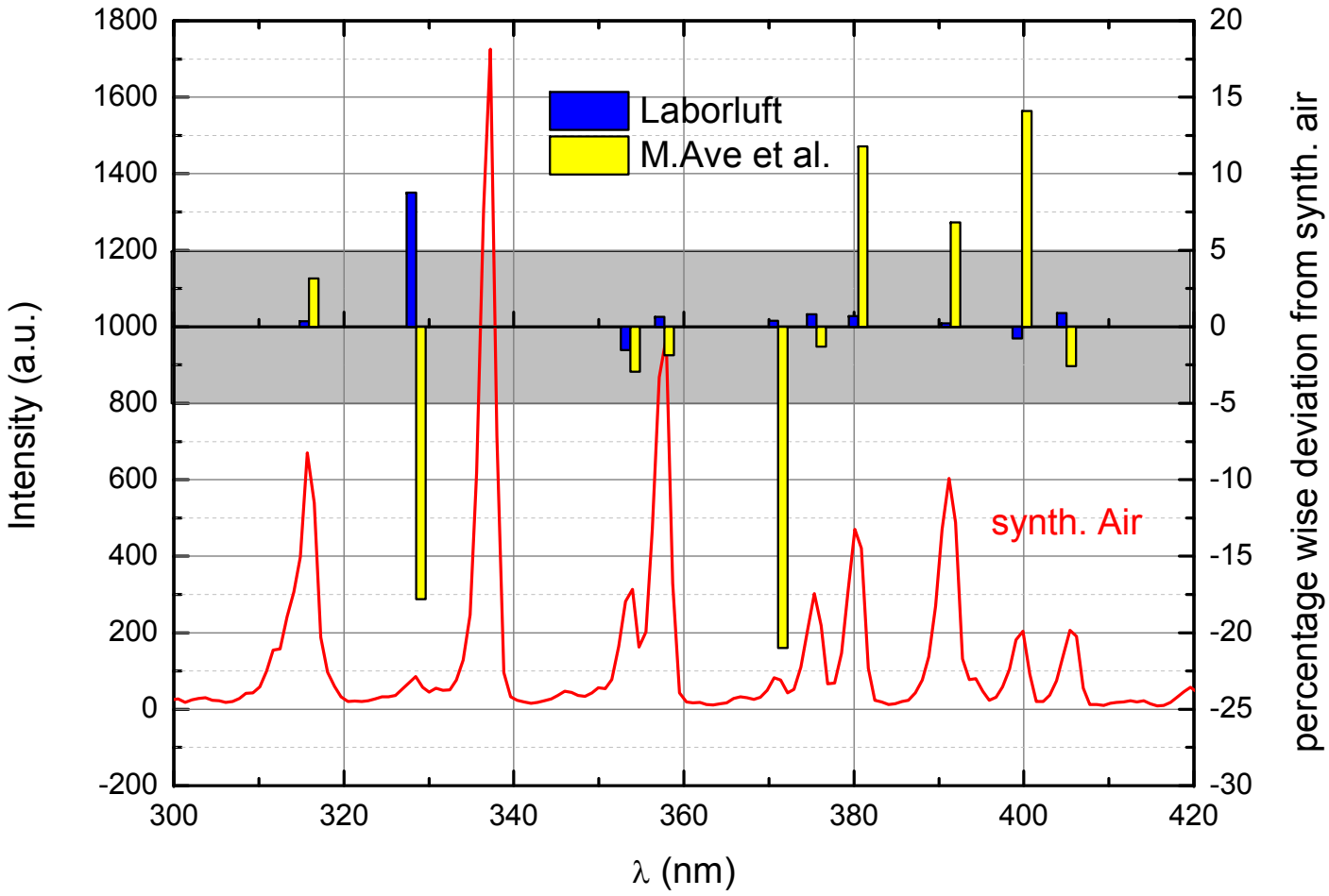

LTB


0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
correction function
200
400
600
800
1000
λ (nm)
Wi17/G 2892
Wi17/G 3261
Halogenlamp

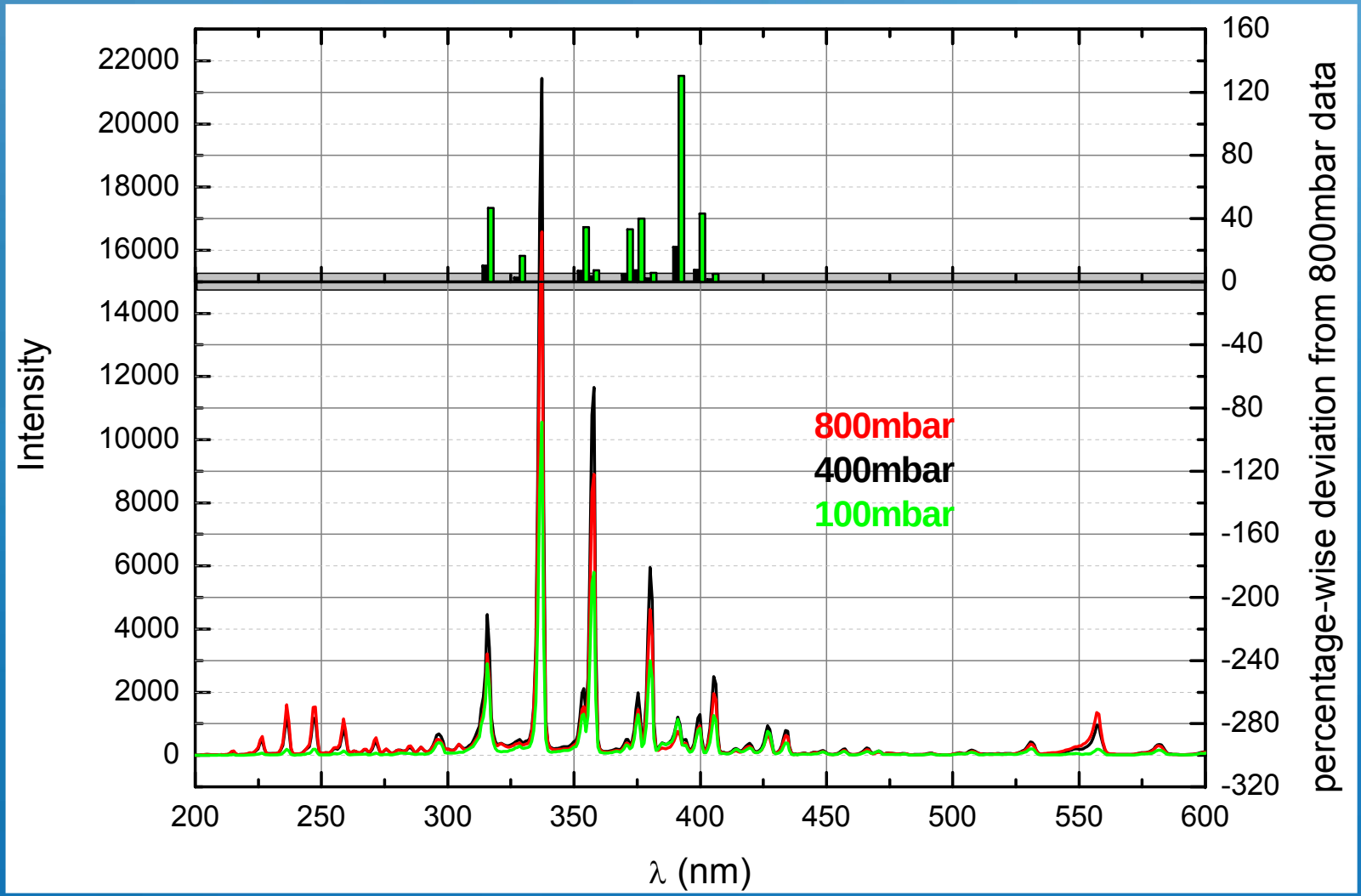



Important message: Do not touch the setup after calibration !


0,0040
0,0035
0,0030
0,0025
0,0020
0,0015
0,0010
0,0005
0,0000
correction function
260
280
300
320
340
360
380
400
420
λ (nm)
Wi17/G 2892
Wi17/G 3261
Deuterium lamp (not our lamp)
Deuterium lamp (our lamp)
Halogen lamp
solid line: with UG11-filter
dashed line: without UG11-filter

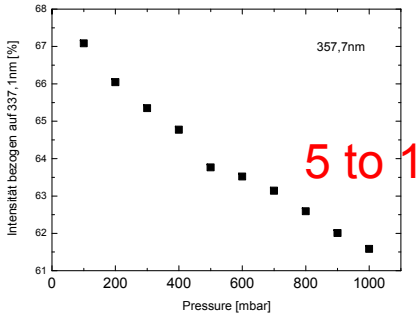

Laborluft
M.Ave et al.
synth. Air
Intensity (a.u.)
percentage wise deviation from synth. air
λ (nm)
1800
1600
1400
1200
1000
800
600
400
200
0
-200
20
15
10
5
0
-5
-10
-15
-20
-25
-30
300
320
340
360
380
400
420

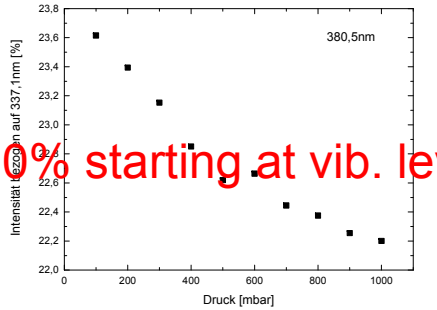
# Pure nitrogen, 8µA

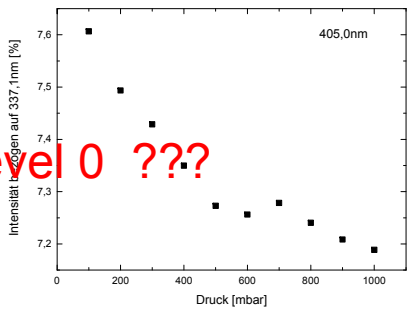


# Pressure dependence rel. to 337nm line



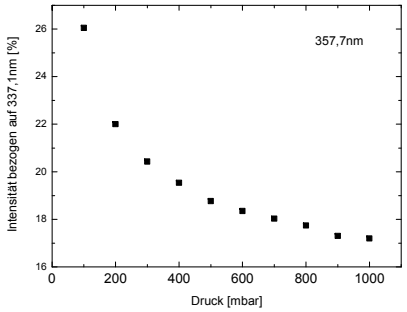


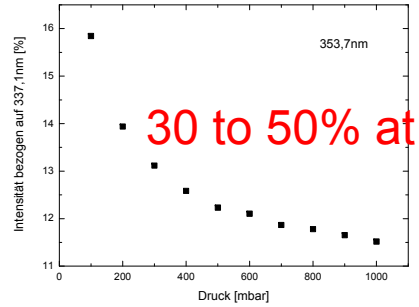



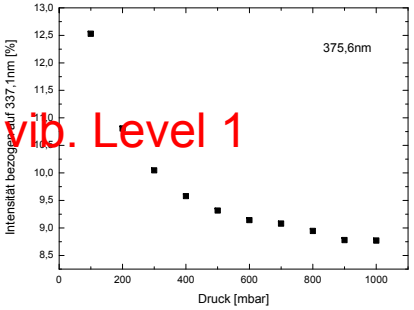

5 to 10% starting at vib. level 0 ???

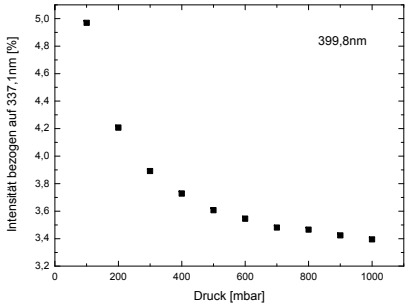
I (p) various lines relative to the 337nm line 100 to 1000mbar

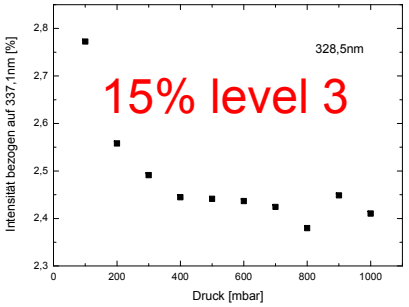


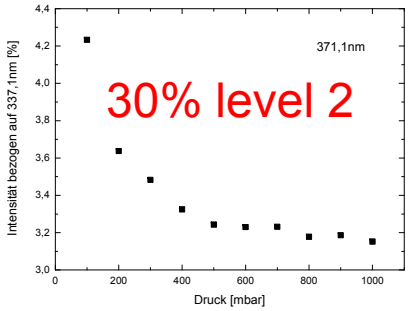

30 to 50% at vib. Level 1



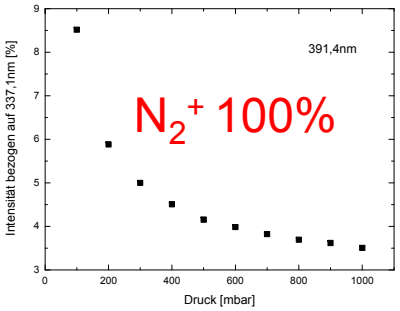



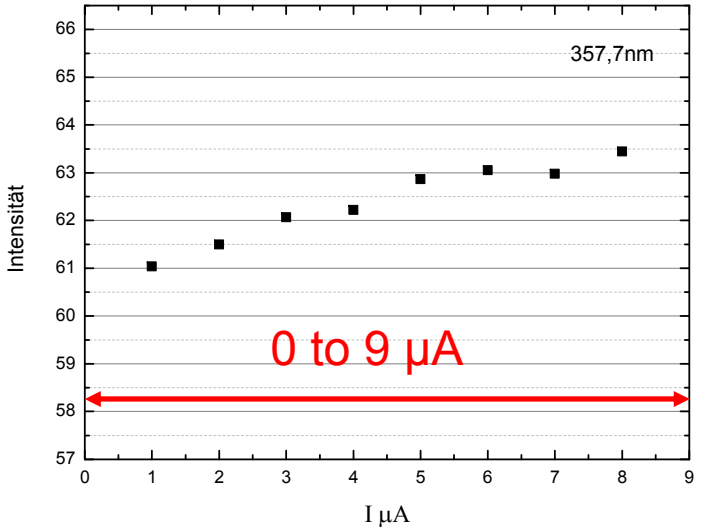

15% level 3

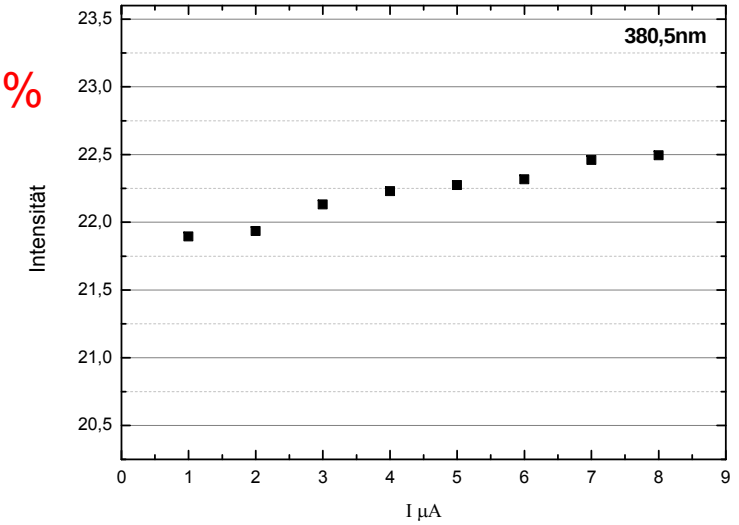


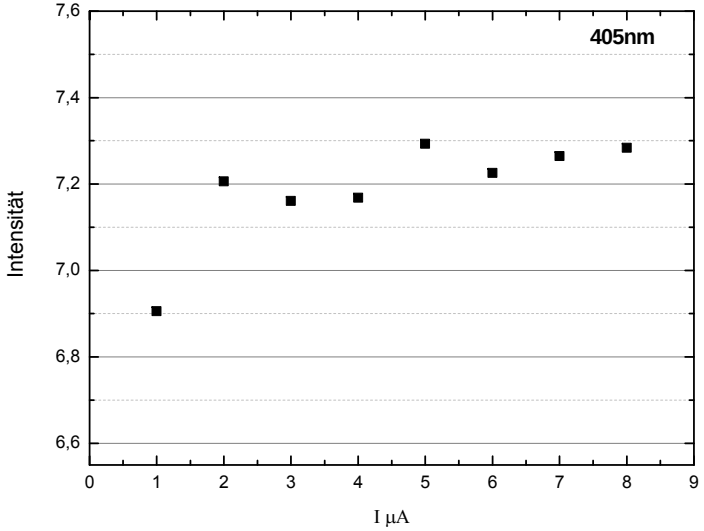

30% level 2




$N_2^+$ 100%

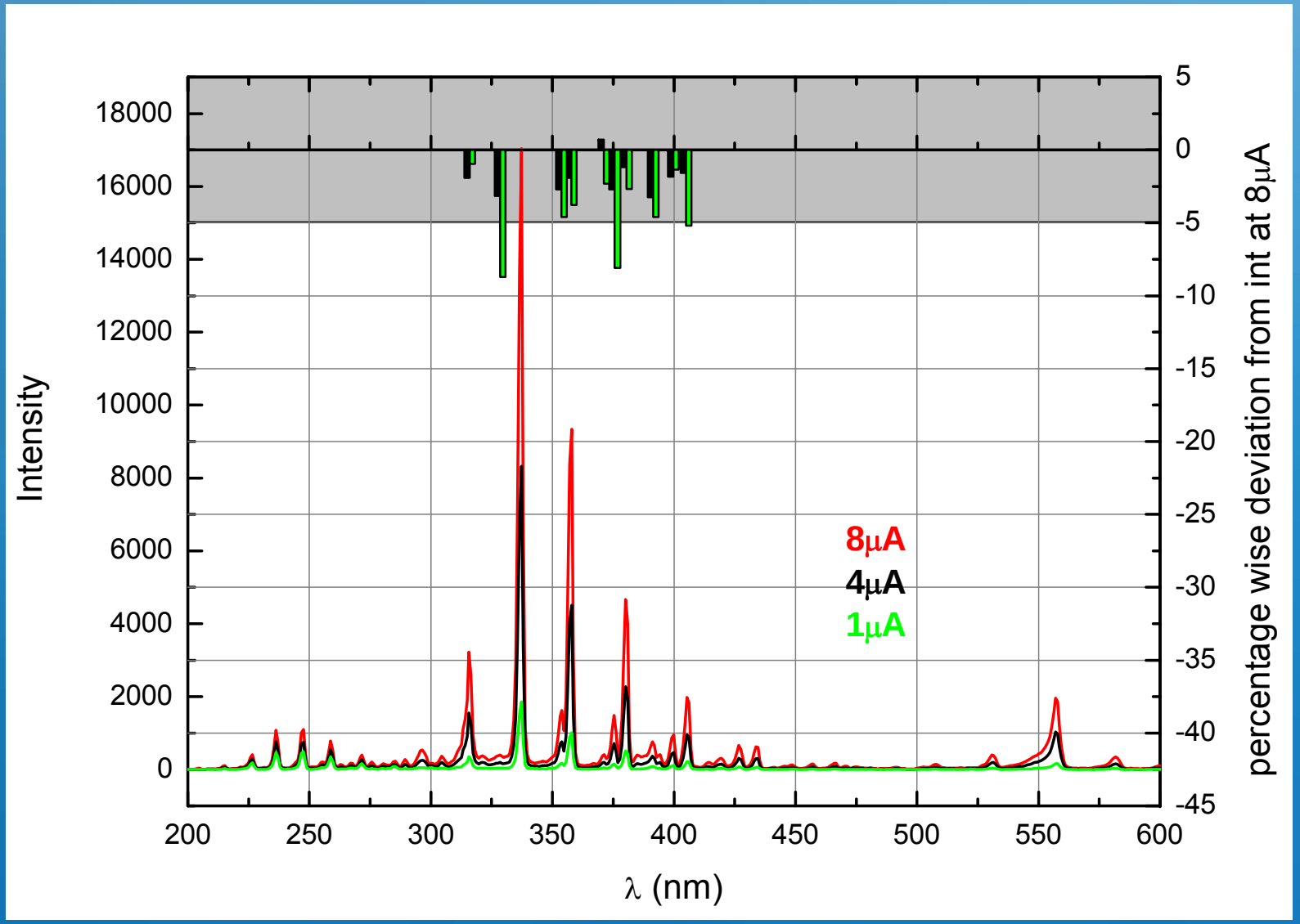



Beam current dependence of some lines in pure nitrogen normalized to the 337nm line

Quenching by free electrons?


Intensity
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
200
250
300
350
400
450
500
550
600
λ (nm)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
percentage wise deviation from int at 8μA
8μA
4μA
1μA

# Conclusion:

Spectroscopy provides a lot of information about the nitrogen fluorescence.

Calibration measurements have to be carefully prepared.

Relative intensity measurements of the emission bands would have to be repeated with better wavelength resolution.

# Thank you for your attention !