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# Characterization of Dobson Instruments within EMRP ATMOZ Project

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Agencia Estatal de Meteorología

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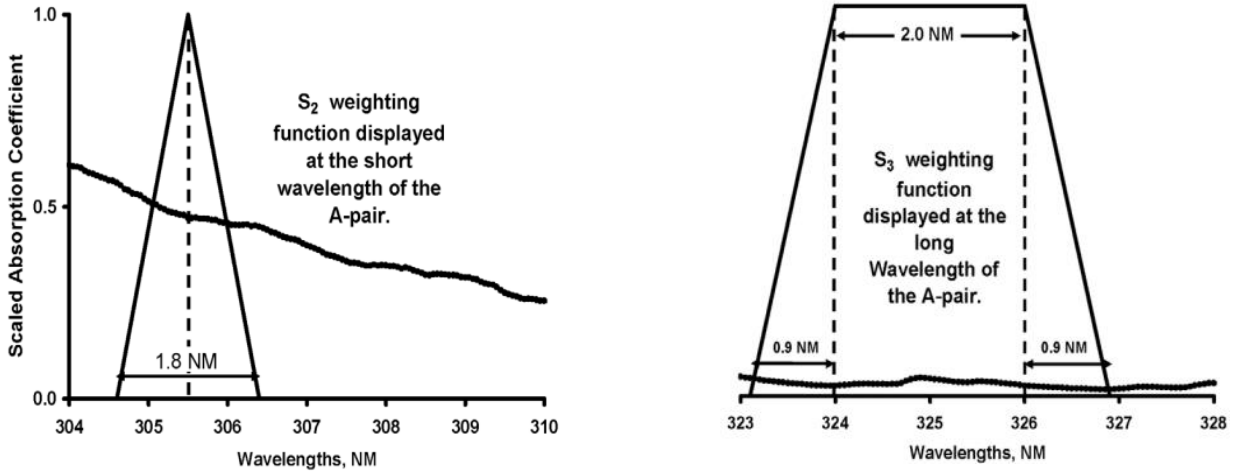
# Outline

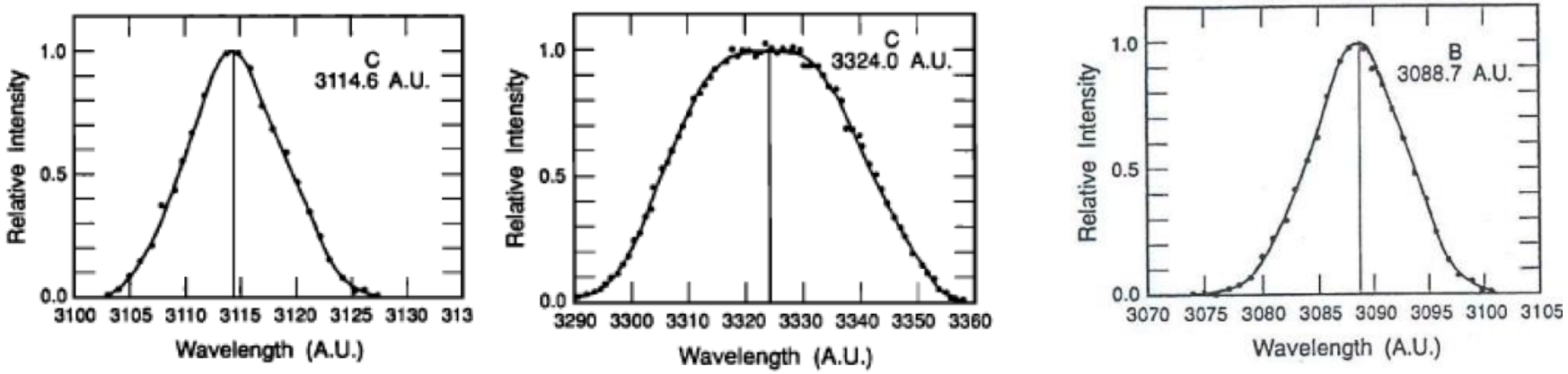
- A short history of Dobson characterisations
- Aims and work within the EMRP ENV59 project ATMOZ
- Measurement setups
- Summary of results for D013, D064, D074, D083 and D101
- Estimated impact on TOC retrieval
- Conclusions and outlook

# A short history

- Nominal slit functions



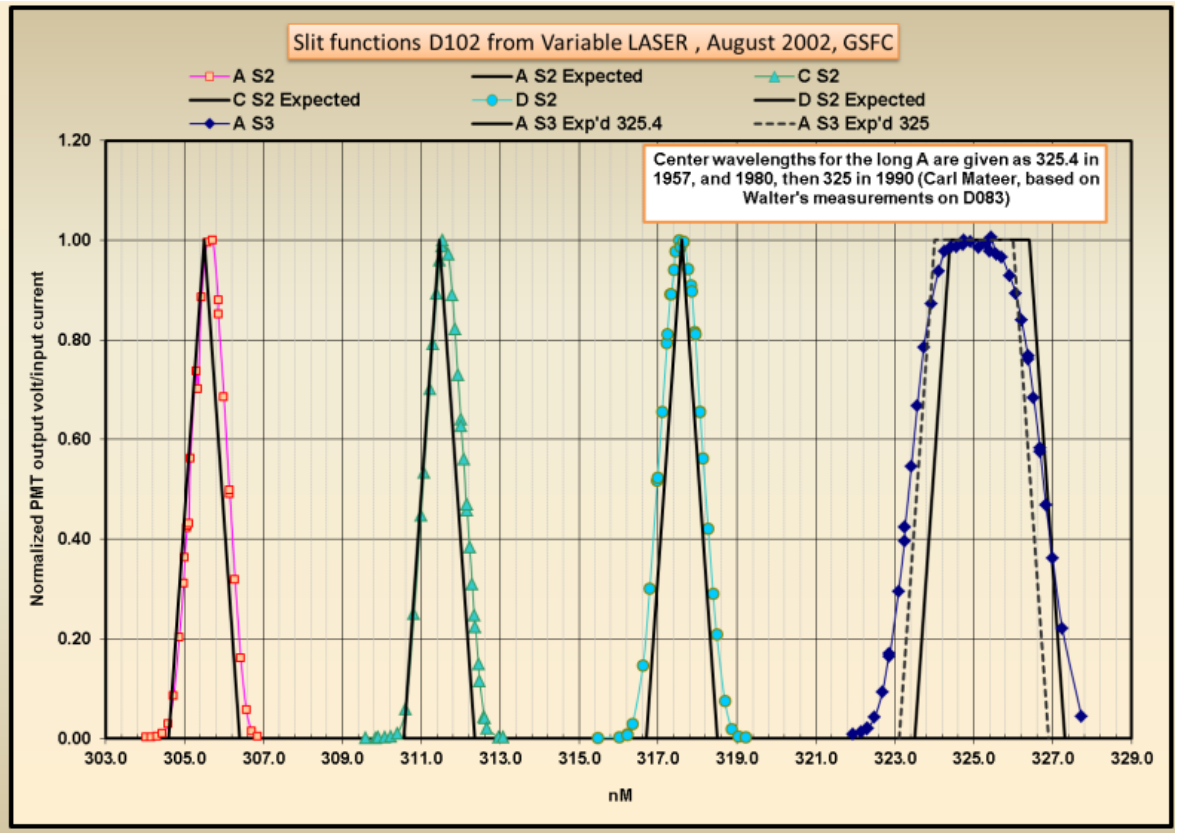

- Slit functions for Dobson instrument Nr. 83 were determined using a model 783 McPherson spectrometer in 1992



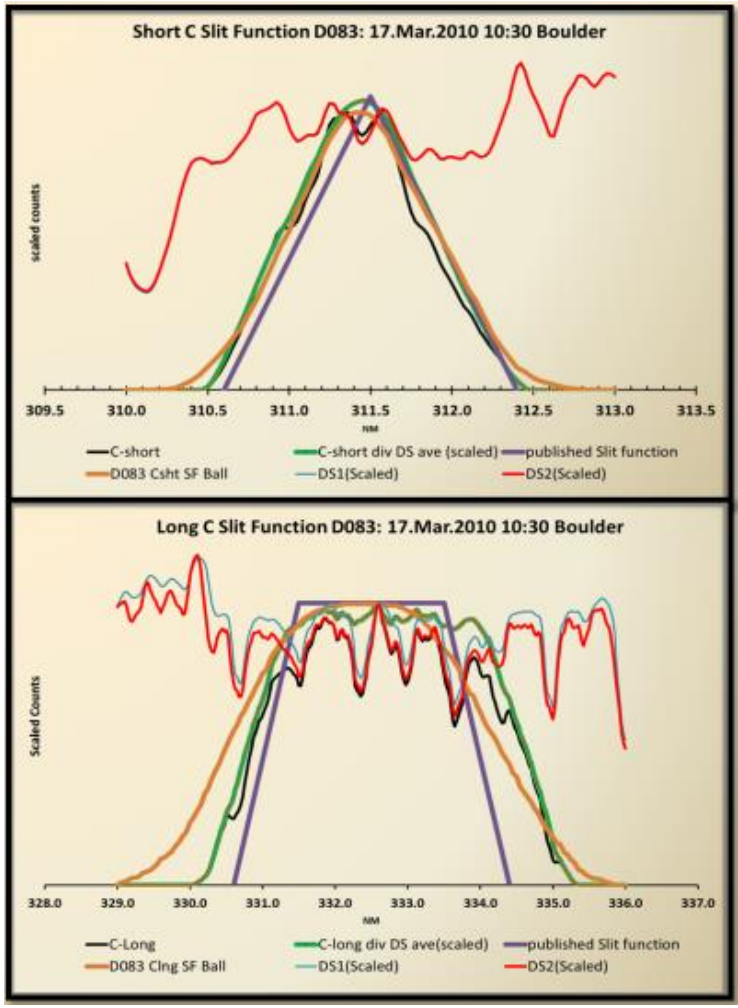

Effective Bass-Paur 1985 Ozone Absorption Coefficients for Use With Dobson Ozone Spectrophotometer JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 98, NO. Dll, PAGES 20,451-20,465, NOVEMBER 20, 1993 - Komhyr, Mateer and Hudson

# A short history

- Slit functions of D102 measured by Robert D. Evans and Gordon Labow with a tunable Laser at Goddard in August 2002




- Poster at 2012 QOS on Avantes-based measurements of D083



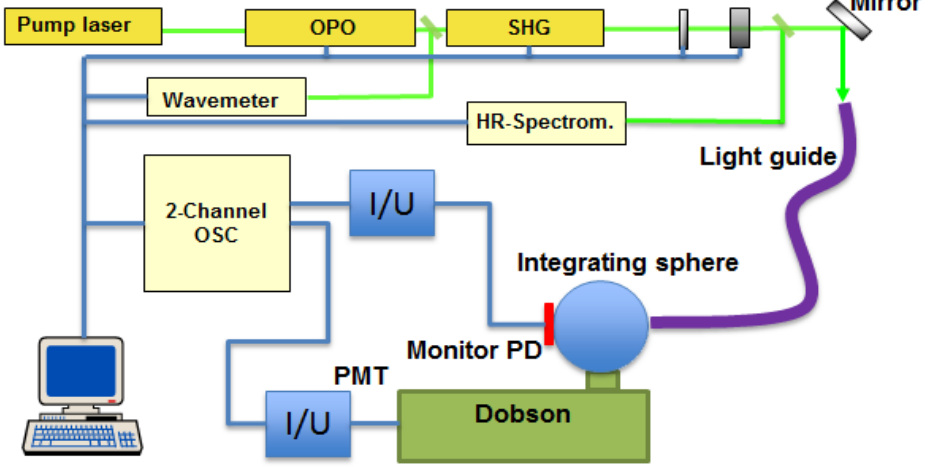
# Aims and work within ATMOZ

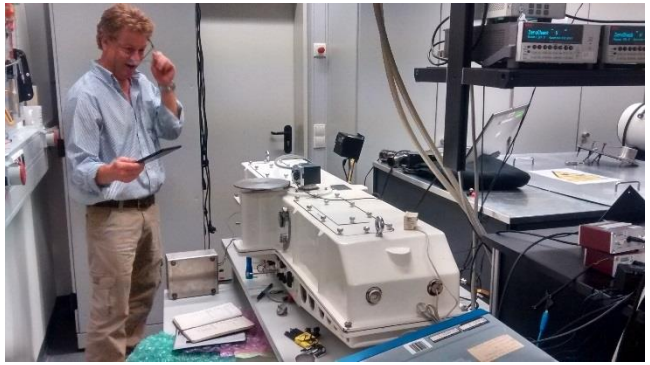
- EMRP ATMOZ project: wavelength and bandpass characterisation of Dobson instruments
- The measurements carried out by PTB (tuneable laser source)
  - Regional standard Dobson Nr. D064 (DWD) in 2015
  - World reference Dobson Nr. D083 (NOAA) in 2015
- and by CMI (lamp-monochromator setup)
  - Second European reference Nr. D074 (CHMI) in 2016
- Characterisation of further Dobsons at PTB as selected by the stakeholder committe:
  - Dobson Nr. D101 (Swiss) in 2017
  - Dobson Nr. D013 (Portuguese) in 2017

# Setups: PTB

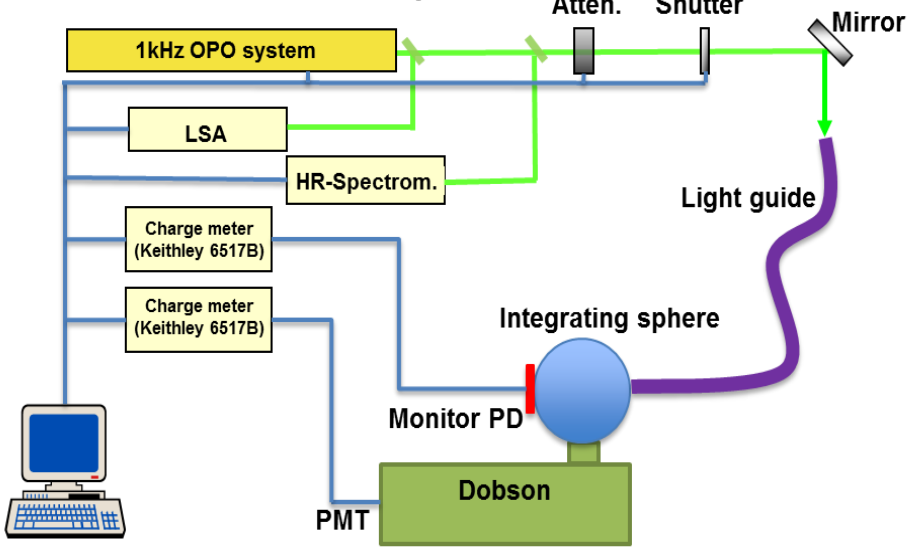
- Pulsed optical parametric oscilator (OPO)
  - 5 ns - 7 ns pulses, FWHM < 0.05 nm, $u_{wl}$ = 0.01 nm
- PMT-anode and monitor photodiode photocurrents measured either by an osciloscope or electrometers

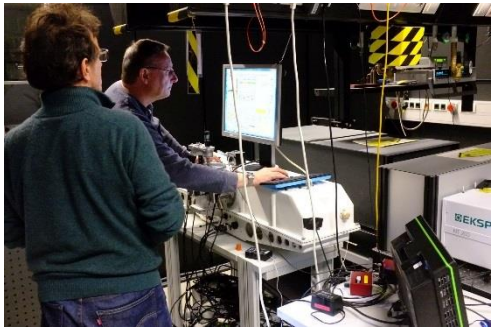
2015



2017

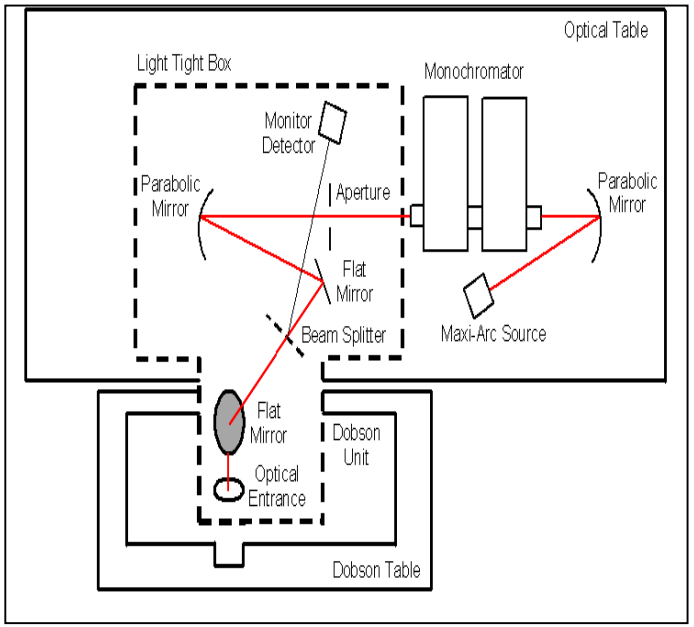


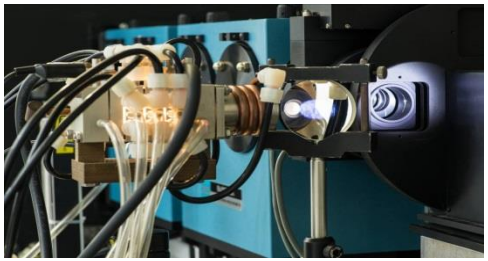
# Setups: CMI

- Reference monochromator-based facility

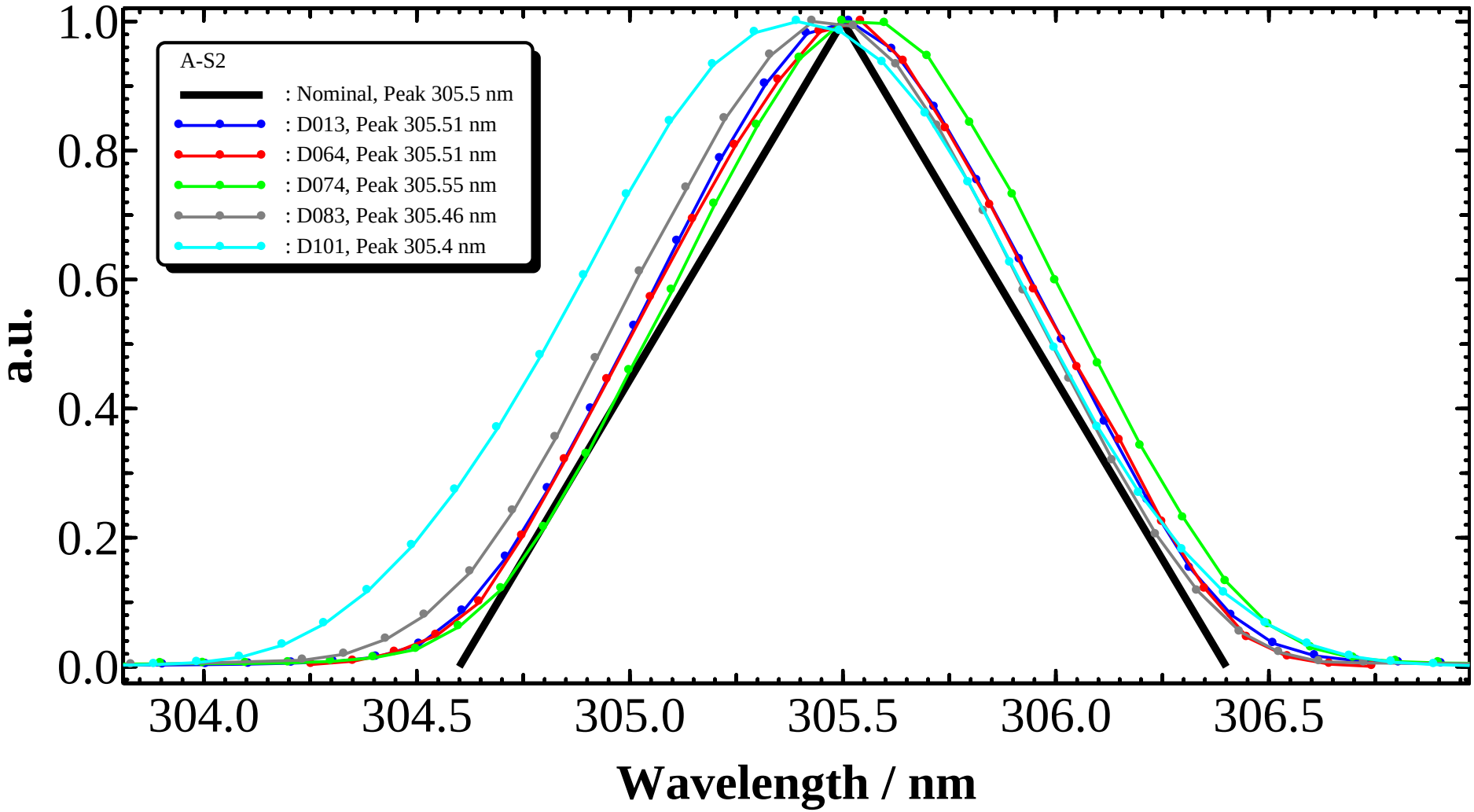
CZECH METROLOGY INSTITUTE



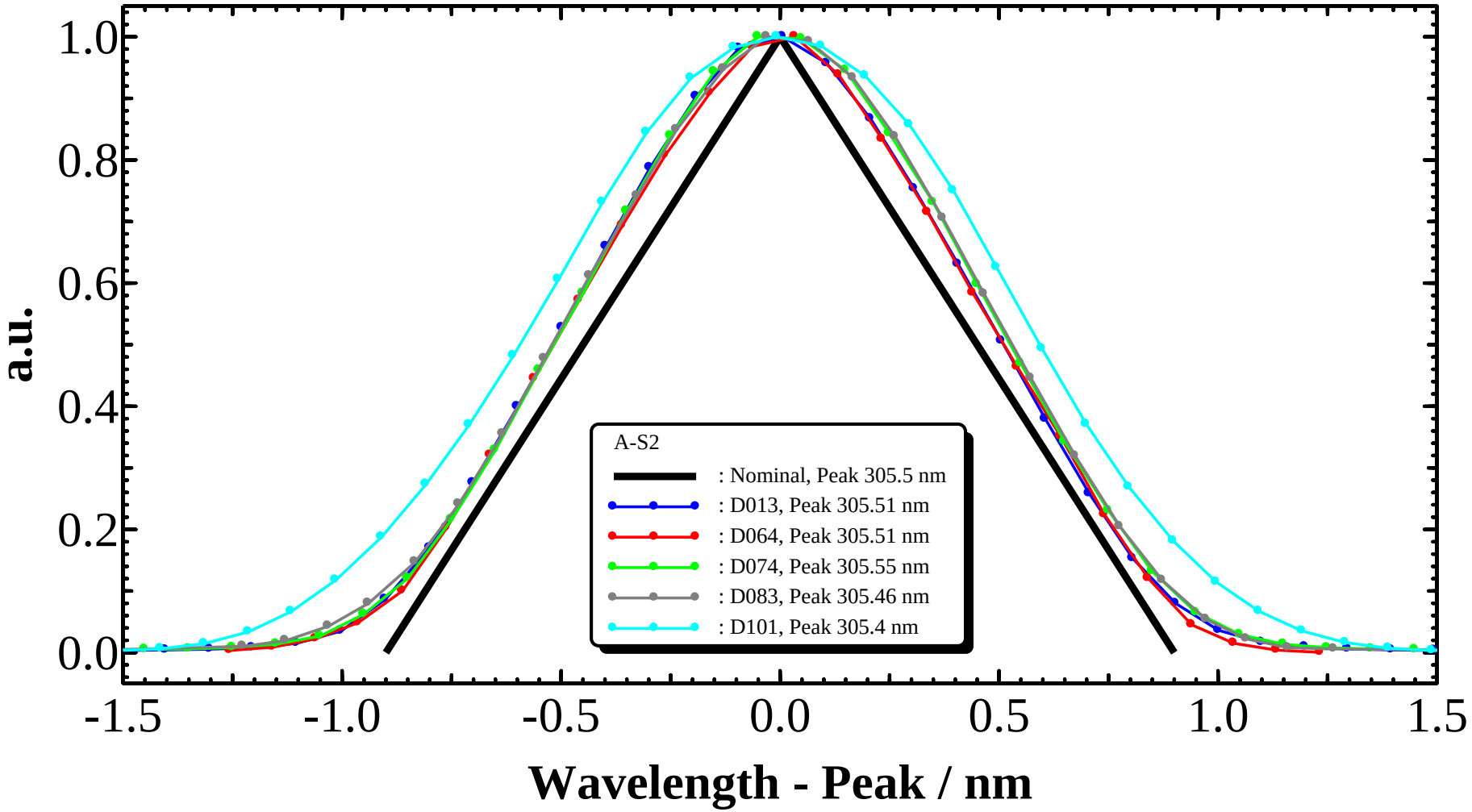

- Argon plasma source Maxi-Arc
- McPherson 2035D double grating monochromator
- Wavelength scale u = 0.015 nm
- FWHM of measuring beam 0.1 nm
- Output beam at F= #/10
- Low photon flux reference SSDS detector system used as a monitor detector
- Custom made light tight box
- Flipping mirror used to align the beam with the #074 Dobson spectrophotometer



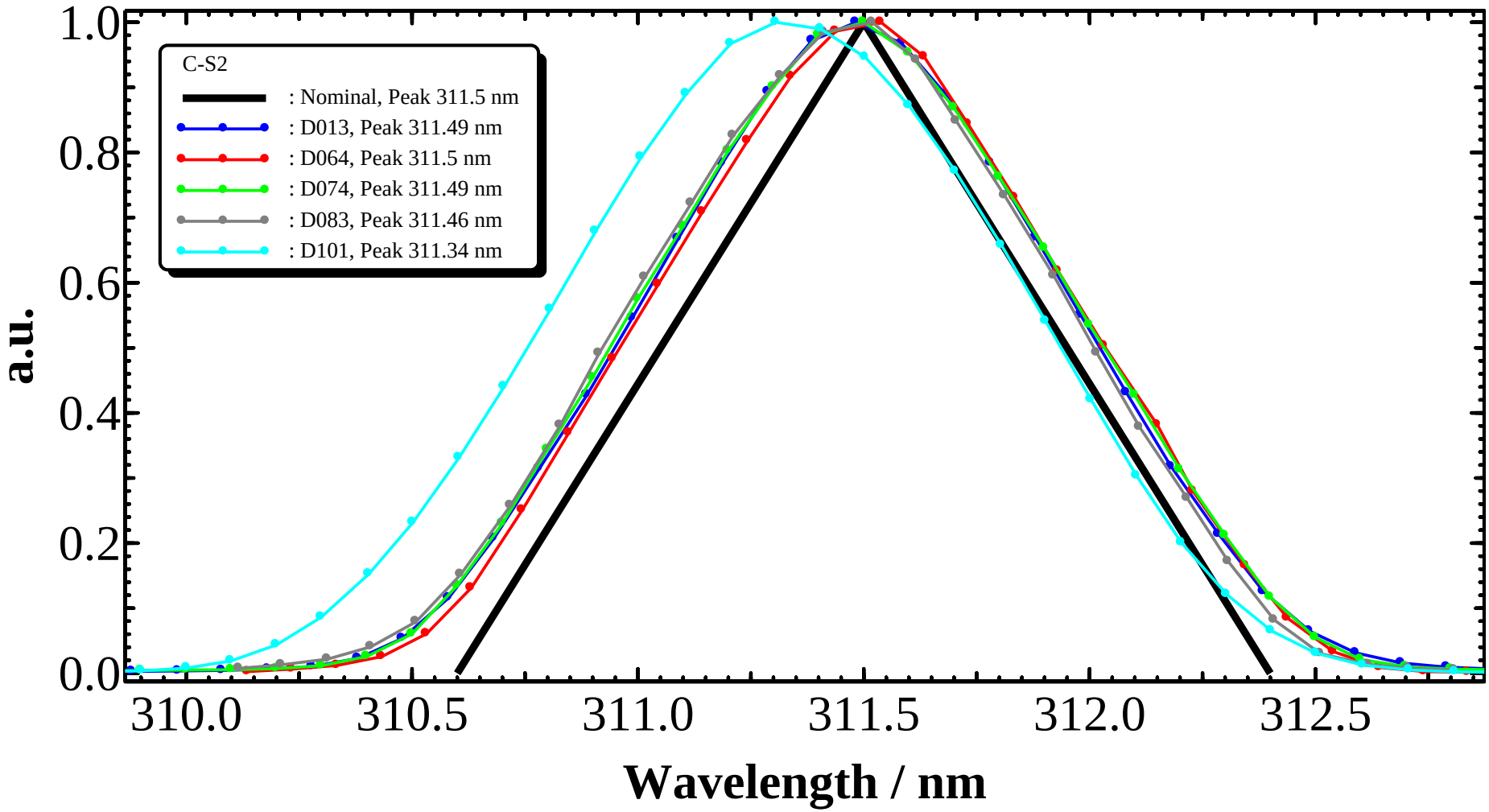
# Results


A-S2
: Nominal, Peak 305.5 nm
: D013, Peak 305.51 nm
: D064, Peak 305.51 nm
: D074, Peak 305.55 nm
: D083, Peak 305.46 nm
: D101, Peak 305.4 nm
a.u.
1.0
0.8
0.6
0.4
0.2
0.0
304.0
304.5
305.0
305.5
306.0
306.5
Wavelength / nm

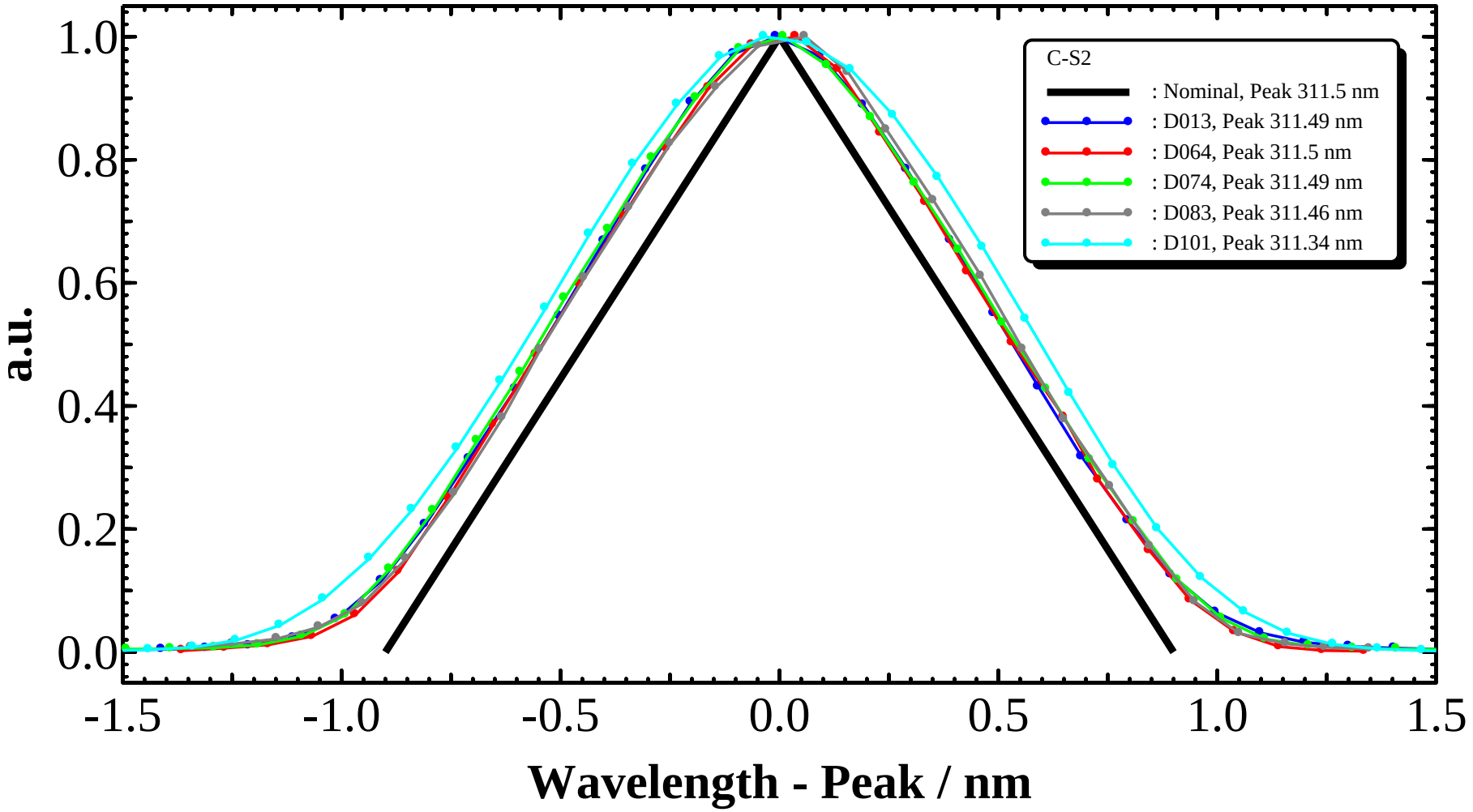
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Wavelength - Peak / nm
A-S2
: Nominal, Peak 305.5 nm
: D013, Peak 305.51 nm
: D064, Peak 305.51 nm
: D074, Peak 305.55 nm
: D083, Peak 305.46 nm
: D101, Peak 305.4 nm

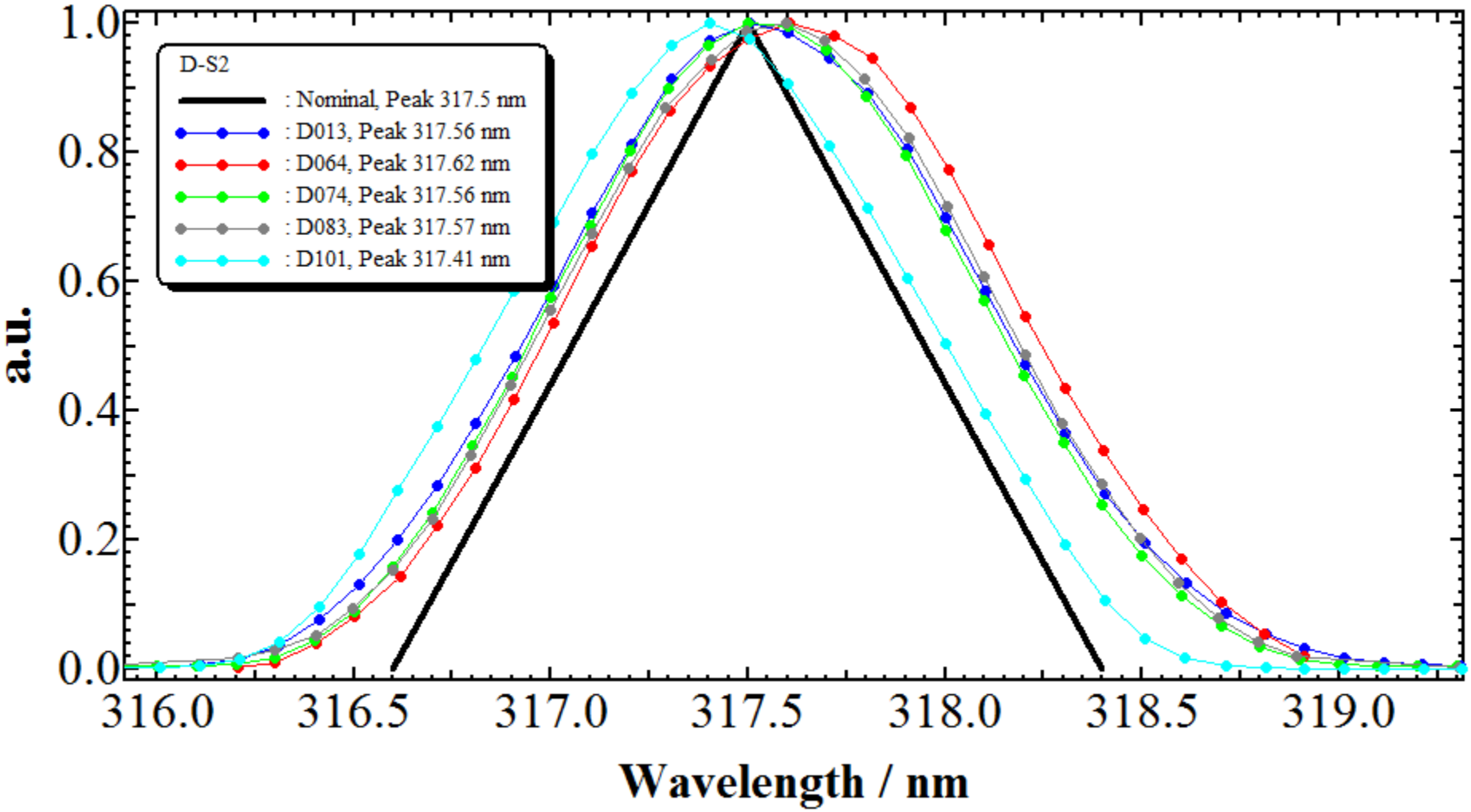
# Results


C-S2
: Nominal, Peak 311.5 nm
: D013, Peak 311.49 nm
: D064, Peak 311.5 nm
: D074, Peak 311.49 nm
: D083, Peak 311.46 nm
: D101, Peak 311.34 nm
a.u.
1.0
0.8
0.6
0.4
0.2
0.0
310.0
310.5
311.0
311.5
312.0
312.5
Wavelength / nm

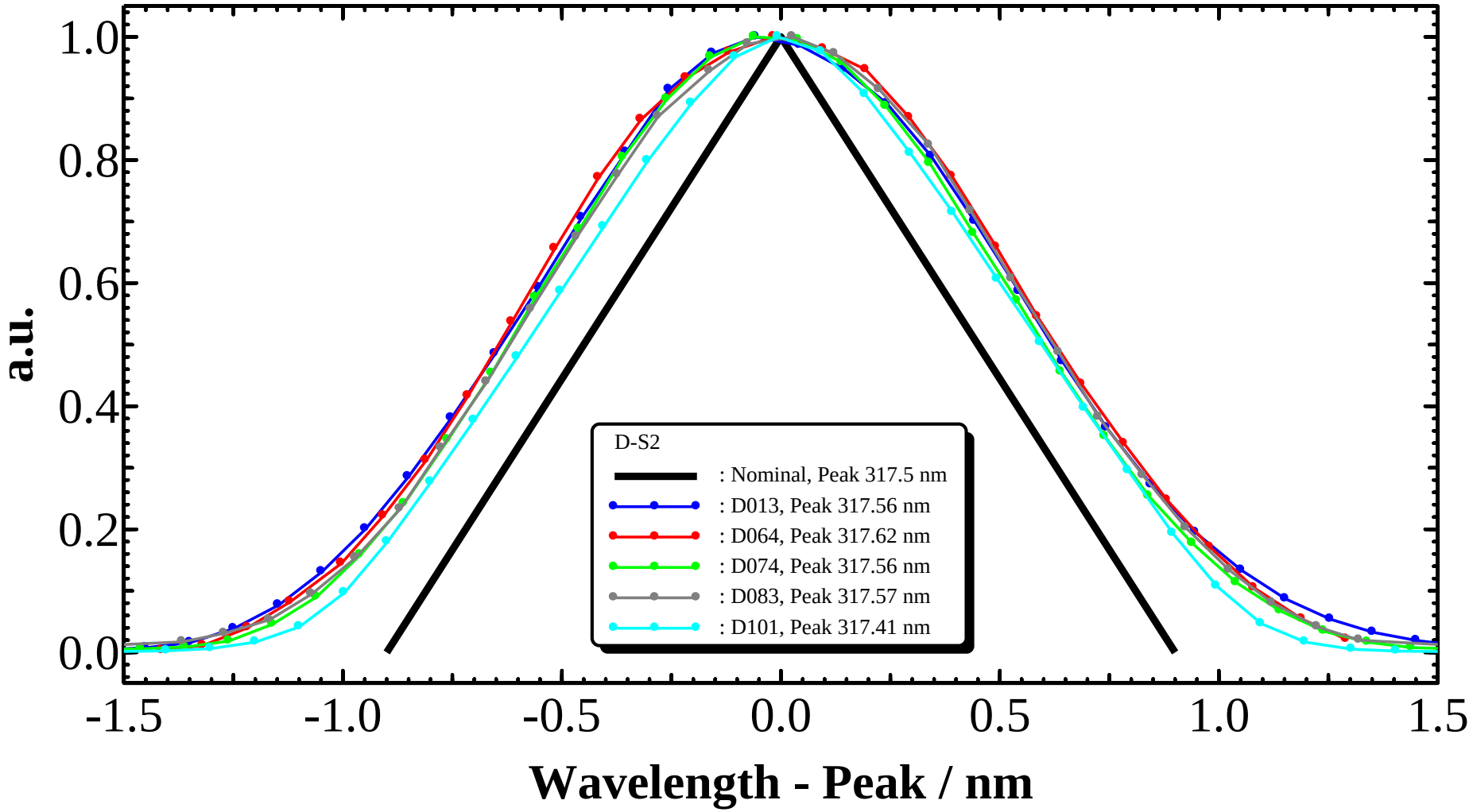
# Results


C-S2
: Nominal, Peak 311.5 nm
: D013, Peak 311.49 nm
: D064, Peak 311.5 nm
: D074, Peak 311.49 nm
: D083, Peak 311.46 nm
: D101, Peak 311.34 nm
a.u.
1.0
0.8
0.6
0.4
0.2
0.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Wavelength - Peak / nm

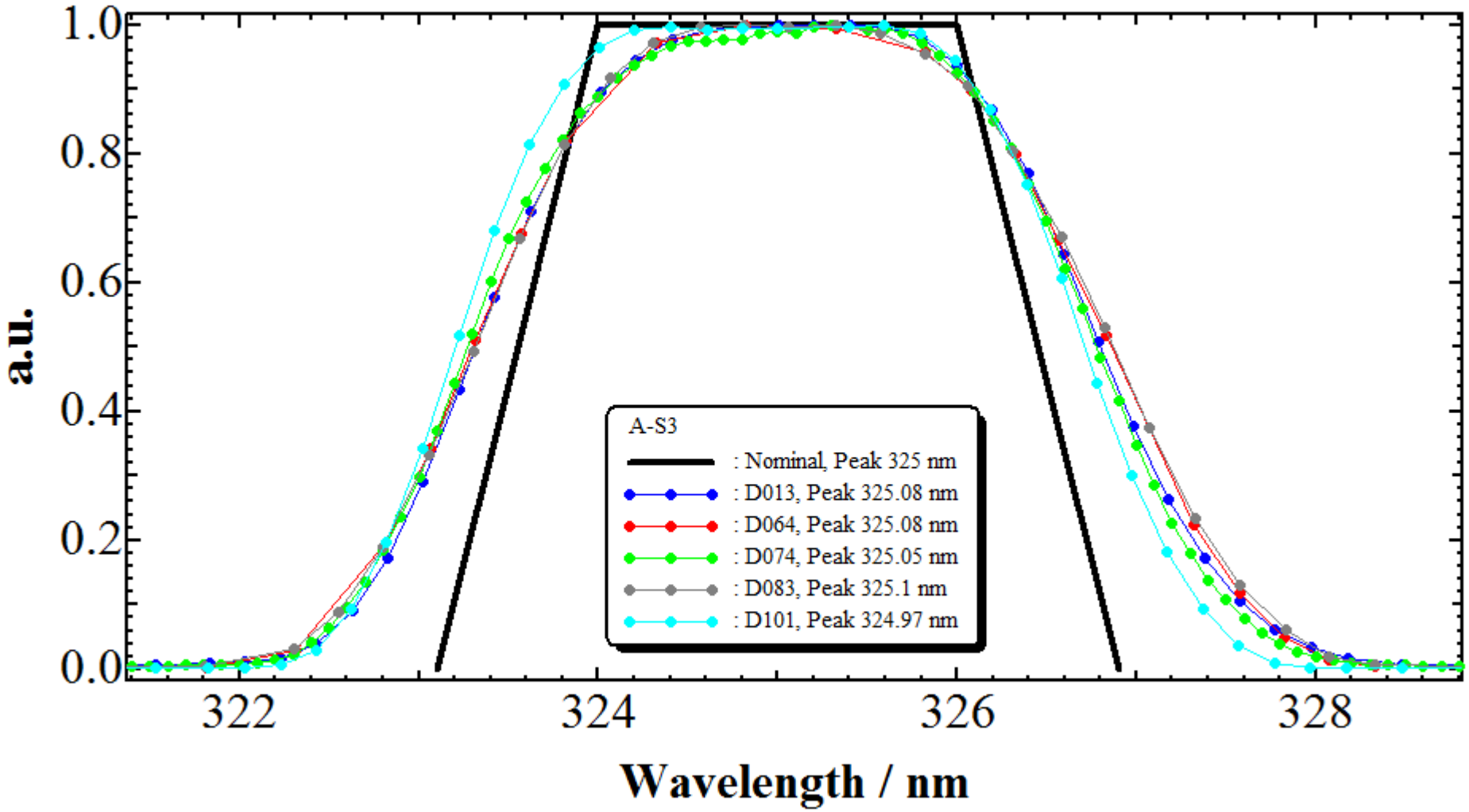
# Results


D-S2
: Nominal, Peak 317.5 nm
: D013, Peak 317.56 nm
: D064, Peak 317.62 nm
: D074, Peak 317.56 nm
: D083, Peak 317.57 nm
: D101, Peak 317.41 nm
a.u.
1.0
0.8
0.6
0.4
0.2
0.0
316.0
316.5
317.0
317.5
318.0
318.5
319.0
Wavelength / nm

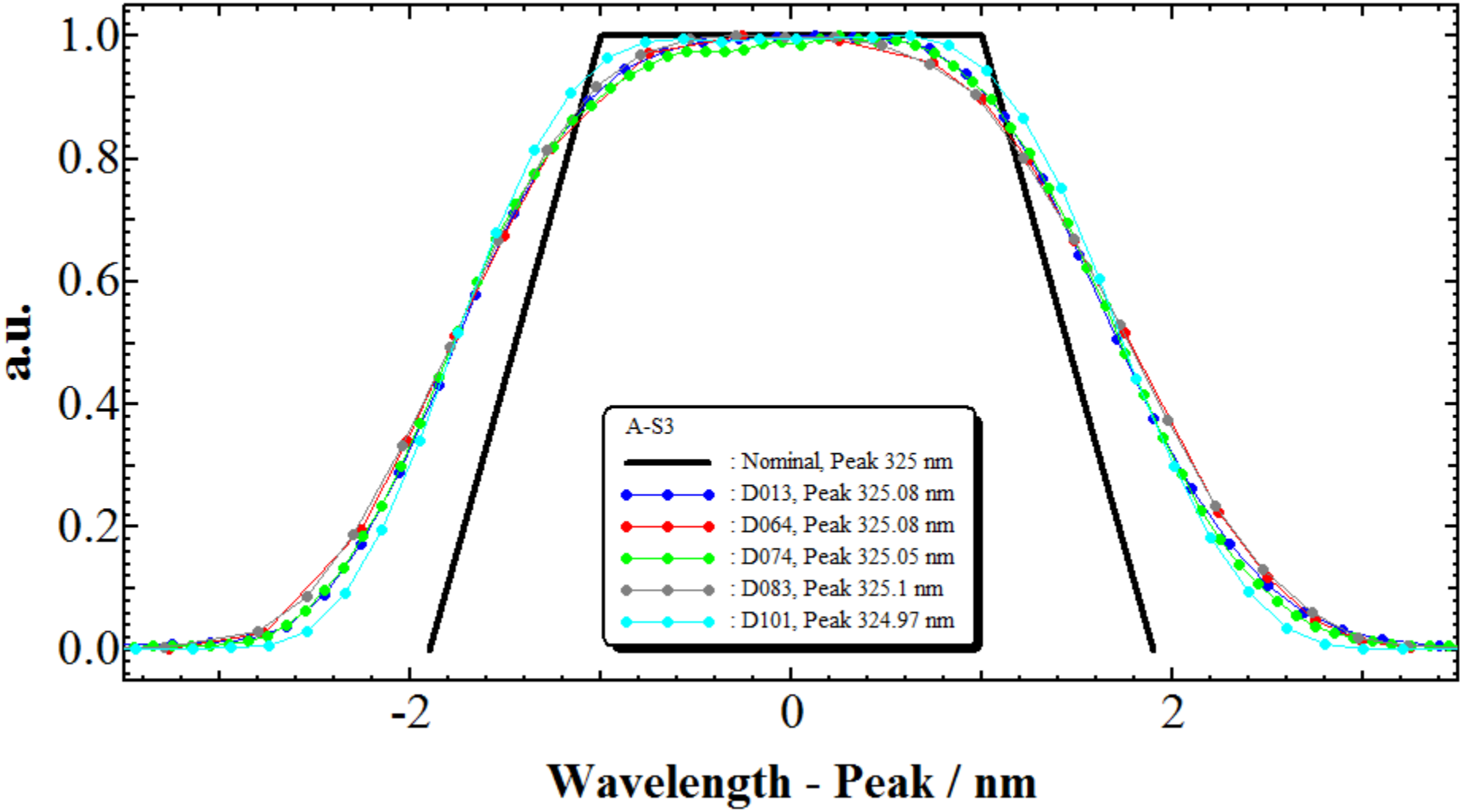
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Wavelength - Peak / nm
D-S2
: Nominal, Peak 317.5 nm
: D013, Peak 317.56 nm
: D064, Peak 317.62 nm
: D074, Peak 317.56 nm
: D083, Peak 317.57 nm
: D101, Peak 317.41 nm

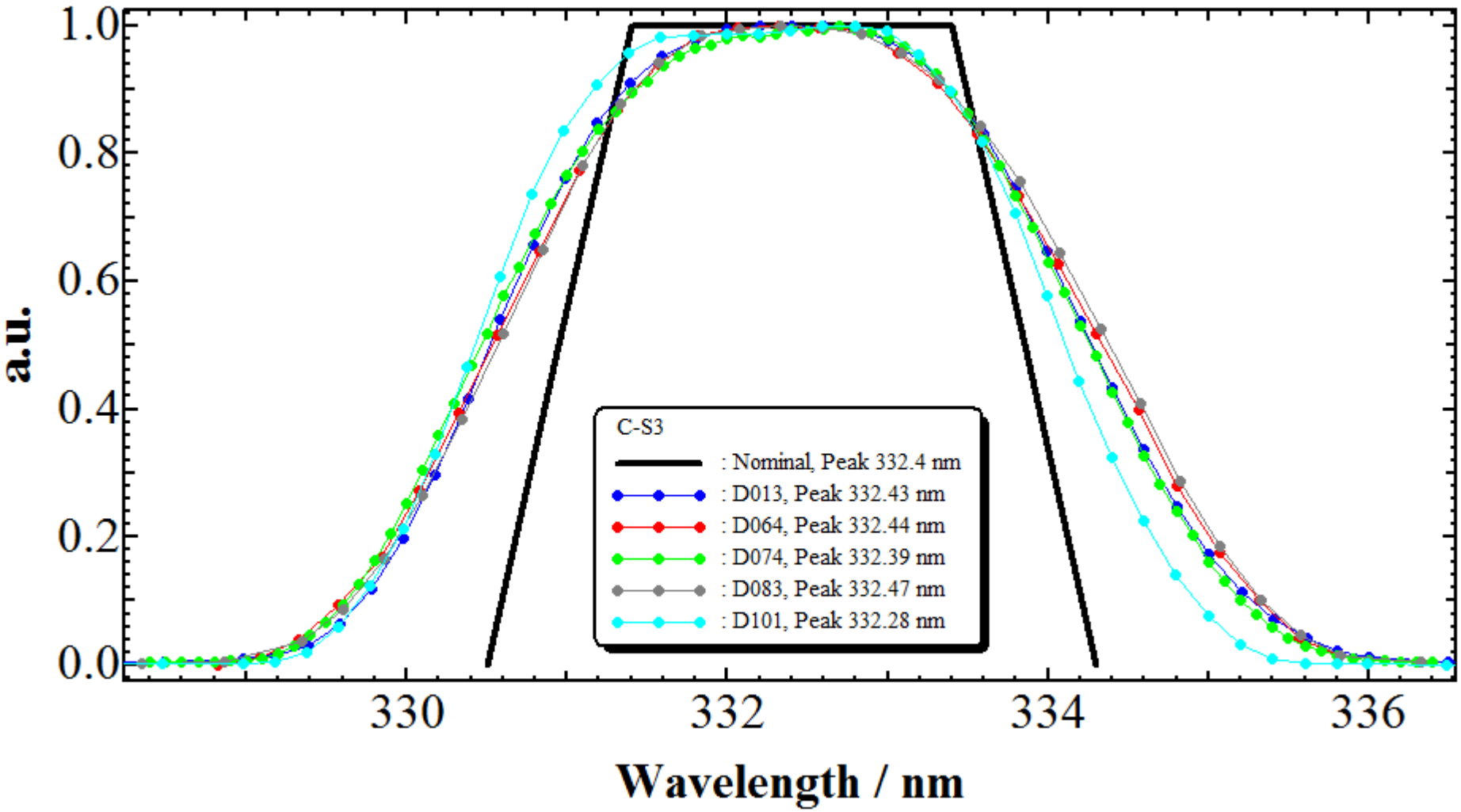
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
322
324
326
328
Wavelength / nm
A-S3
: Nominal, Peak 325 nm
: D013, Peak 325.08 nm
: D064, Peak 325.08 nm
: D074, Peak 325.05 nm
: D083, Peak 325.1 nm
: D101, Peak 324.97 nm

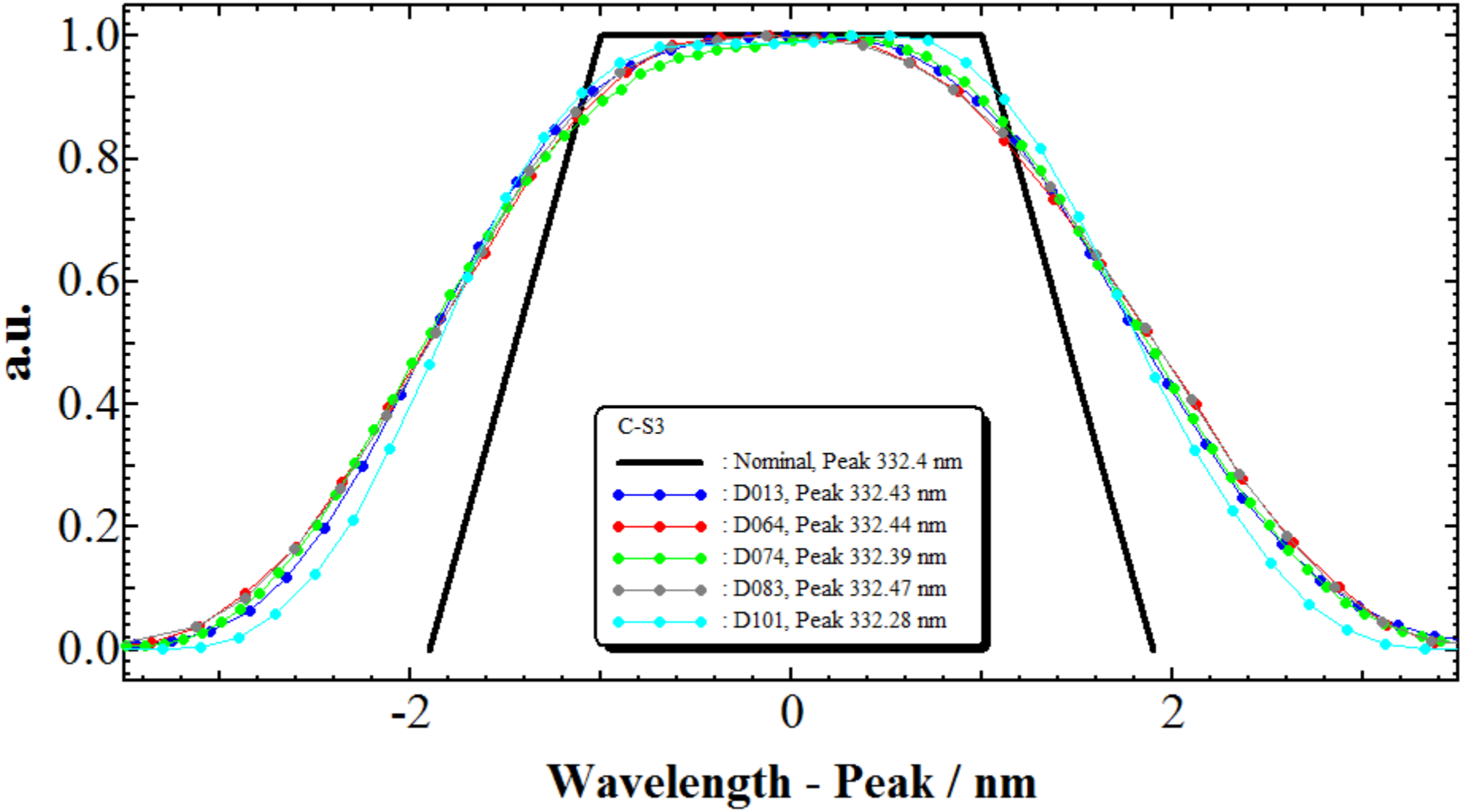
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
-2
0
2
Wavelength - Peak / nm
A-S3
: Nominal, Peak 325 nm
: D013, Peak 325.08 nm
: D064, Peak 325.08 nm
: D074, Peak 325.05 nm
: D083, Peak 325.1 nm
: D101, Peak 324.97 nm

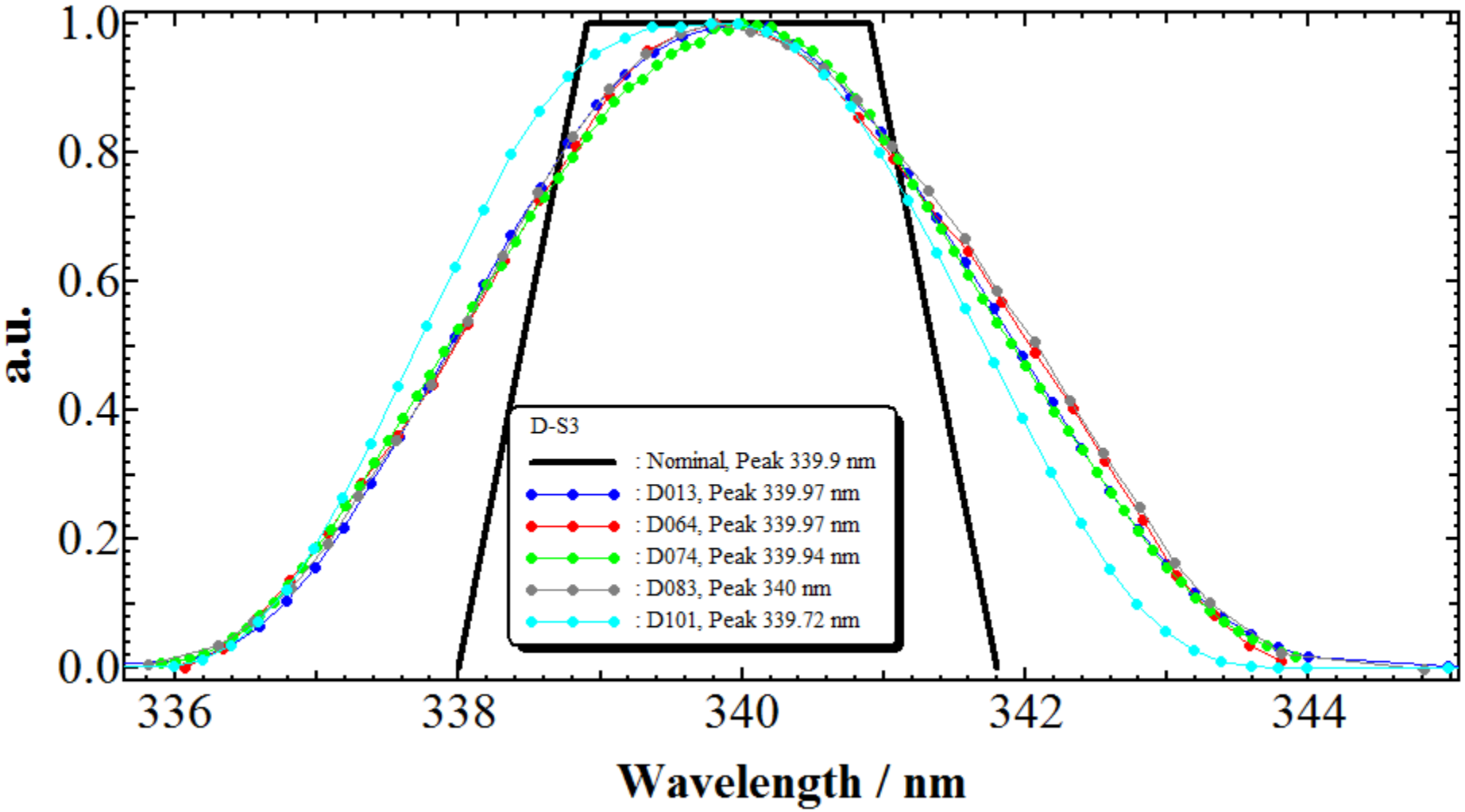
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
330
332
334
336
Wavelength / nm
C-S3
: Nominal, Peak 332.4 nm
: D013, Peak 332.43 nm
: D064, Peak 332.44 nm
: D074, Peak 332.39 nm
: D083, Peak 332.47 nm
: D101, Peak 332.28 nm

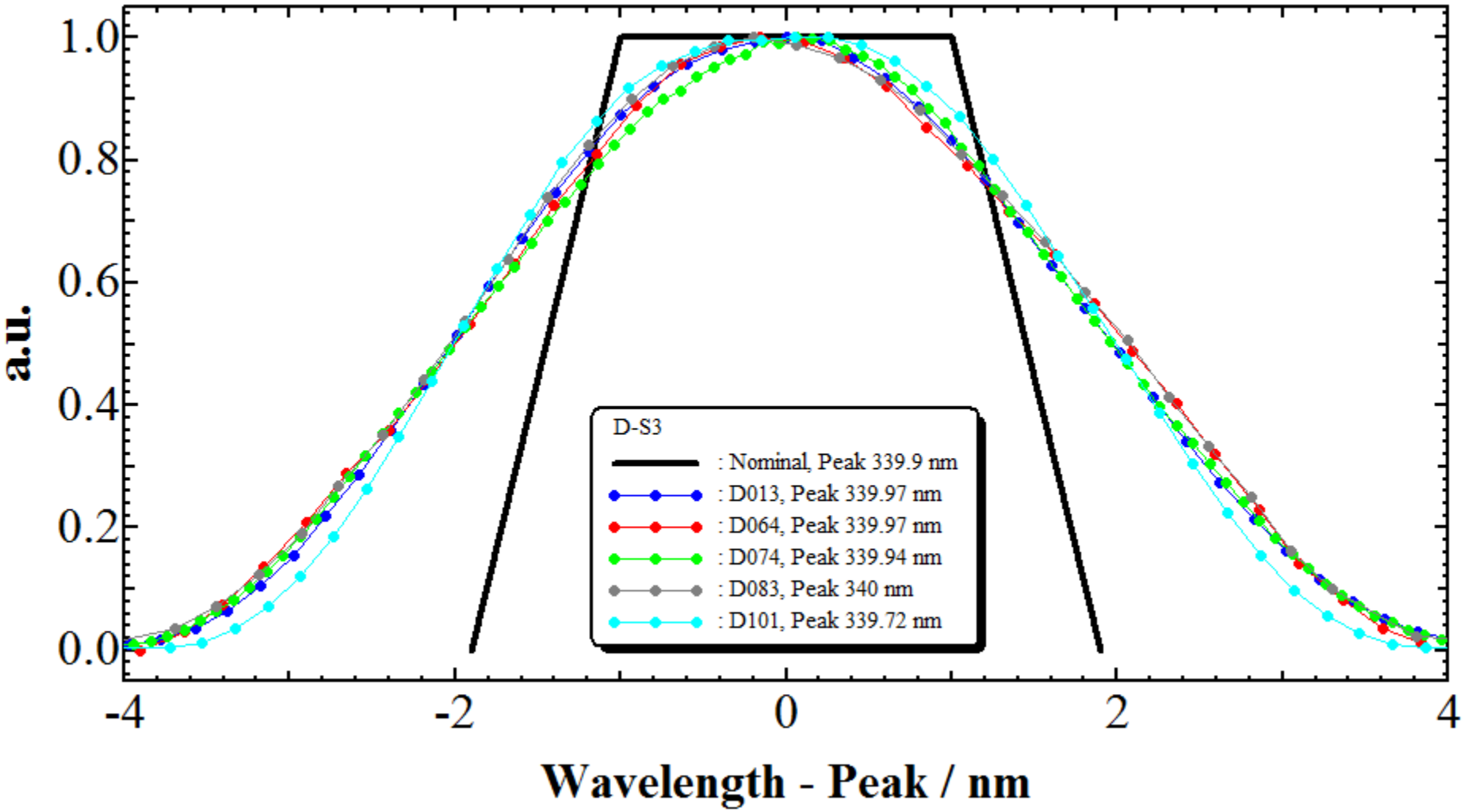
# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
-2
0
2
Wavelength - Peak / nm
C-S3
: Nominal, Peak 332.4 nm
: D013, Peak 332.43 nm
: D064, Peak 332.44 nm
: D074, Peak 332.39 nm
: D083, Peak 332.47 nm
: D101, Peak 332.28 nm

# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
336
338
340
342
344
Wavelength / nm
D-S3
: Nominal, Peak 339.9 nm
: D013, Peak 339.97 nm
: D064, Peak 339.97 nm
: D074, Peak 339.94 nm
: D083, Peak 340 nm
: D101, Peak 339.72 nm

# Results


1.0
0.8
0.6
0.4
0.2
0.0
a.u.
-4
-2
0
2
4
Wavelength - Peak / nm
D-S3
: Nominal, Peak 339.9 nm
: D013, Peak 339.97 nm
: D064, Peak 339.97 nm
: D074, Peak 339.94 nm
: D083, Peak 340 nm
: D101, Peak 339.72 nm

# Effective absorption coefficients

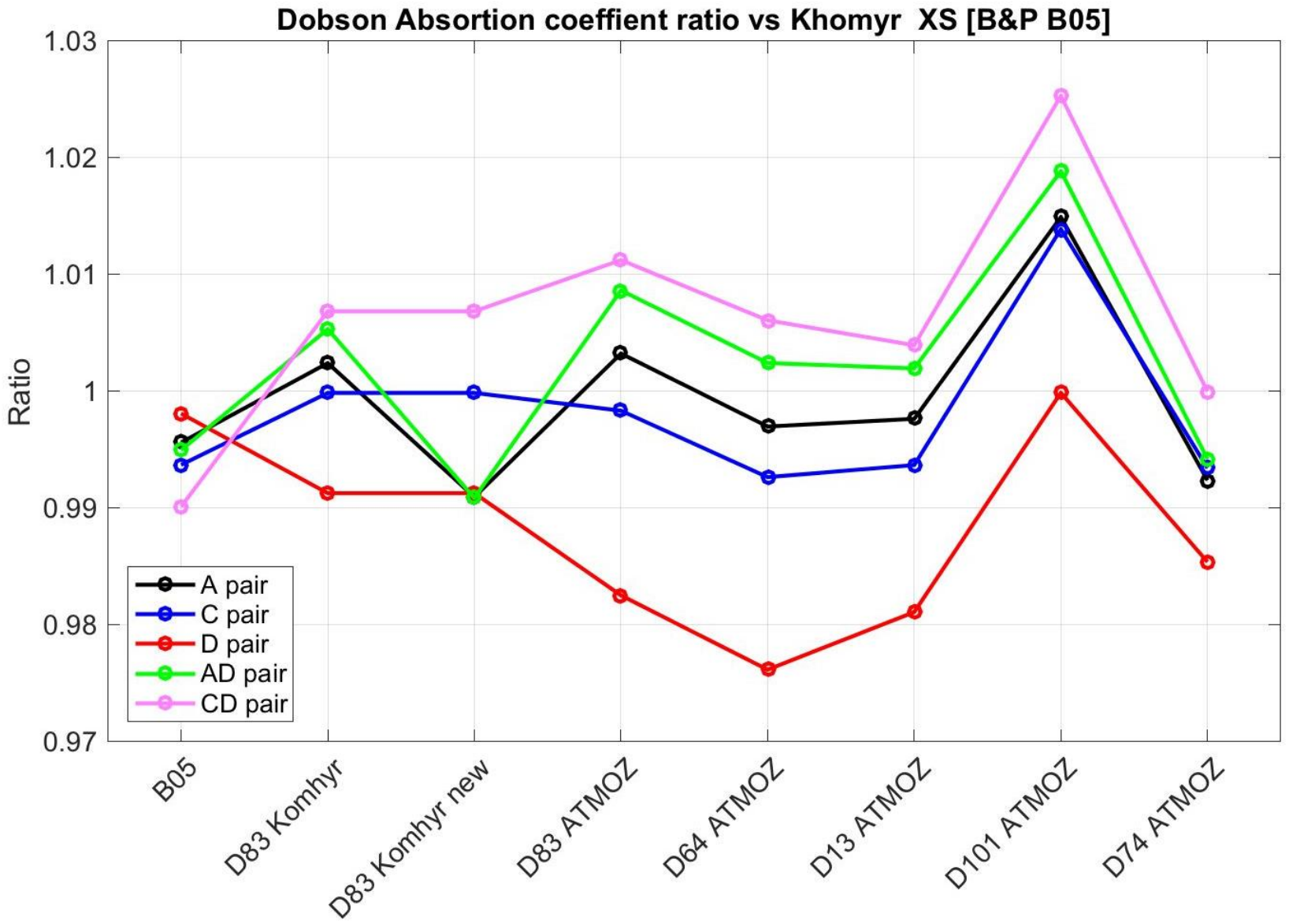
## Measured parameters of Dobson slit functions

| Slit | D083 (NOAA) | | D074 (CHMI) | | D064 (DWD) | | D013 (Portugal) | | D101 (Arosa) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Peak/FWHM (nm) | Peak (nm) | FWHM (nm) | Peak (nm) | FWHM (nm) | Peak (nm) | FWHM (nm) | Peak (nm) | FWHM (nm) | Peak (nm) | FWHM (nm) |
| A-S2 (305.5/0.90) | 305.46 | 1.05 | 305.55 | 1.04 | 305.51 | 1.03 | 305.51 | 1.03 | 305.40 | 1.19 |
| C-S2 (311.5/0.90) | 311.47 | 1.09 | 311.49 | 1.09 | 311.50 | 1.08 | 311.49 | 1.07 | 311.34 | 1.18 |
| D-S2 (317.5/0.90) | 317.58 | 1.24 | 317.56 | 1.22 | 317.62 | 1.27 | 317.56 | 1.26 | 317.42 | 1.18 |
| A-S3 (325.0/2.90) | 325.10 | 3.56 | 325.05 | 3.52 | 325.08 | 3.56 | 325.09 | 3.48 | 324.98 | 3.52 |
| C-S3 (332.4/2.90) | 332.47 | 3.81 | 332.39 | 3.80 | 332.44 | 3.81 | 332.43 | 3.75 | 332.29 | 3.68 |
| D-S3 (339.9/2.90) | 340.00 | 4.12 | 339.94 | 3.98 | 339.97 | 4.06 | 339.97 | 4.00 | 339.72 | 4.00 |

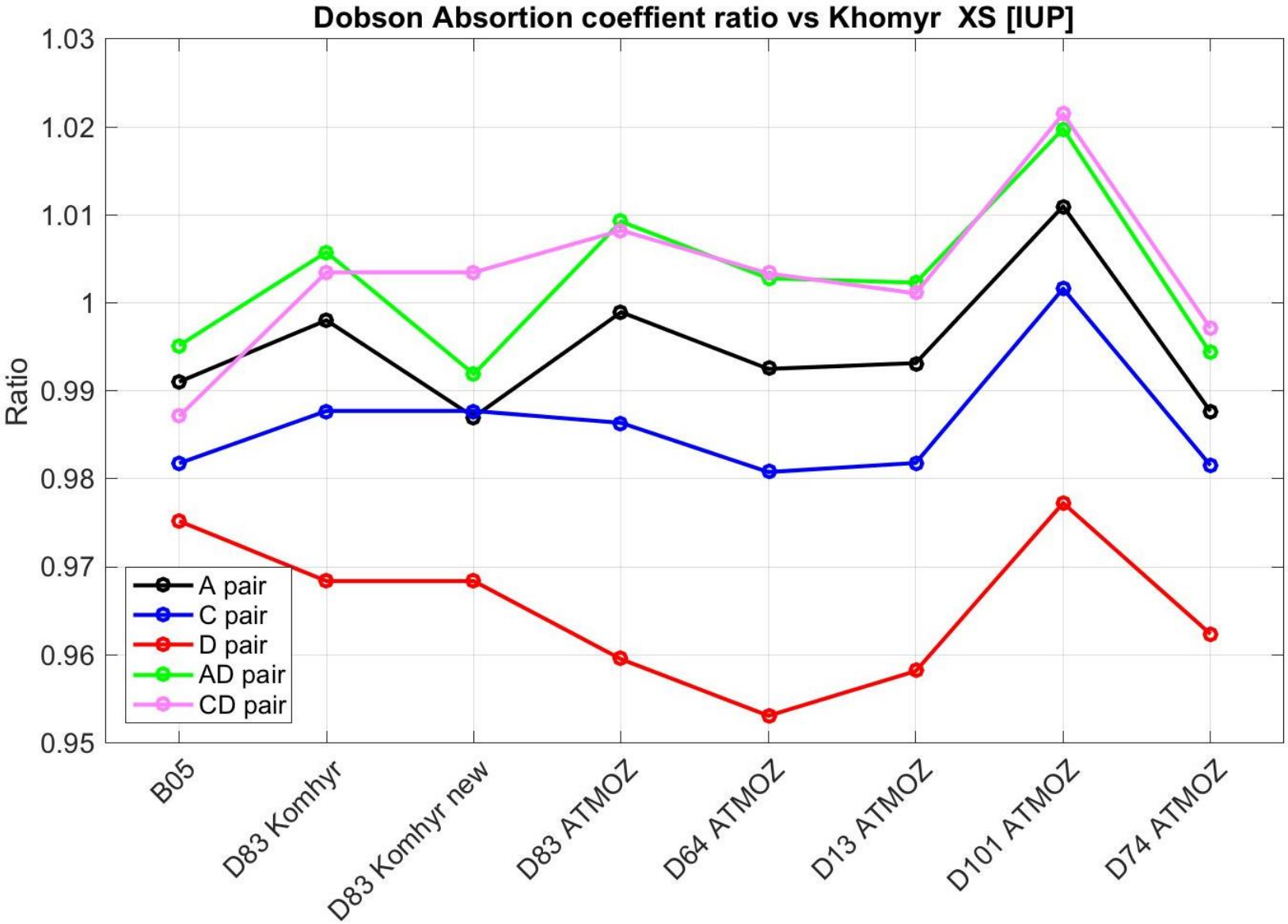
## Effective Absorption Coefficients (EAC) with IUP and relative difference to „old“ Bass/Paur (nominal)

| | D083 (NOAA) | | D074 (CHMI) | | D064 (DWD) | | D013 (Portugal) | | D101 (Arosa) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wavelength pair | EAC | Diff. % | EAC | Diff. % | EAC | Diff. % | EAC | Diff. % | EAC | Diff. % |
| A | 1.788 | 1.03 | 1.780 | 1.49 | 1.787 | 1.04 | 1.794 | 0.68 | 1.826 | -1.10 |
| C | 0.827 | 0.79 | 0.822 | 1.29 | 0.823 | 1.28 | 0.818 | 1.82 | 0.834 | -0.16 |
| D | 0.361 | 3.72 | 0.361 | 3.5 | 0.357 | 4.82 | 0.358 | 4.19 | 0.366 | 2.28 |
| AD | 1.427 | **0.35** | 1.418 | **0.98** | 1.431 | **0.1** | 1.435 | **-0.23** | 1.460 | **-1.98** |
| CD | 0.459 | **-1.48** | 0.461 | **-0.44** | 0.466 | **-1.5** | 0.460 | **-0.11** | 0.469 | **-2.15** |

# Effective absorption coefficients

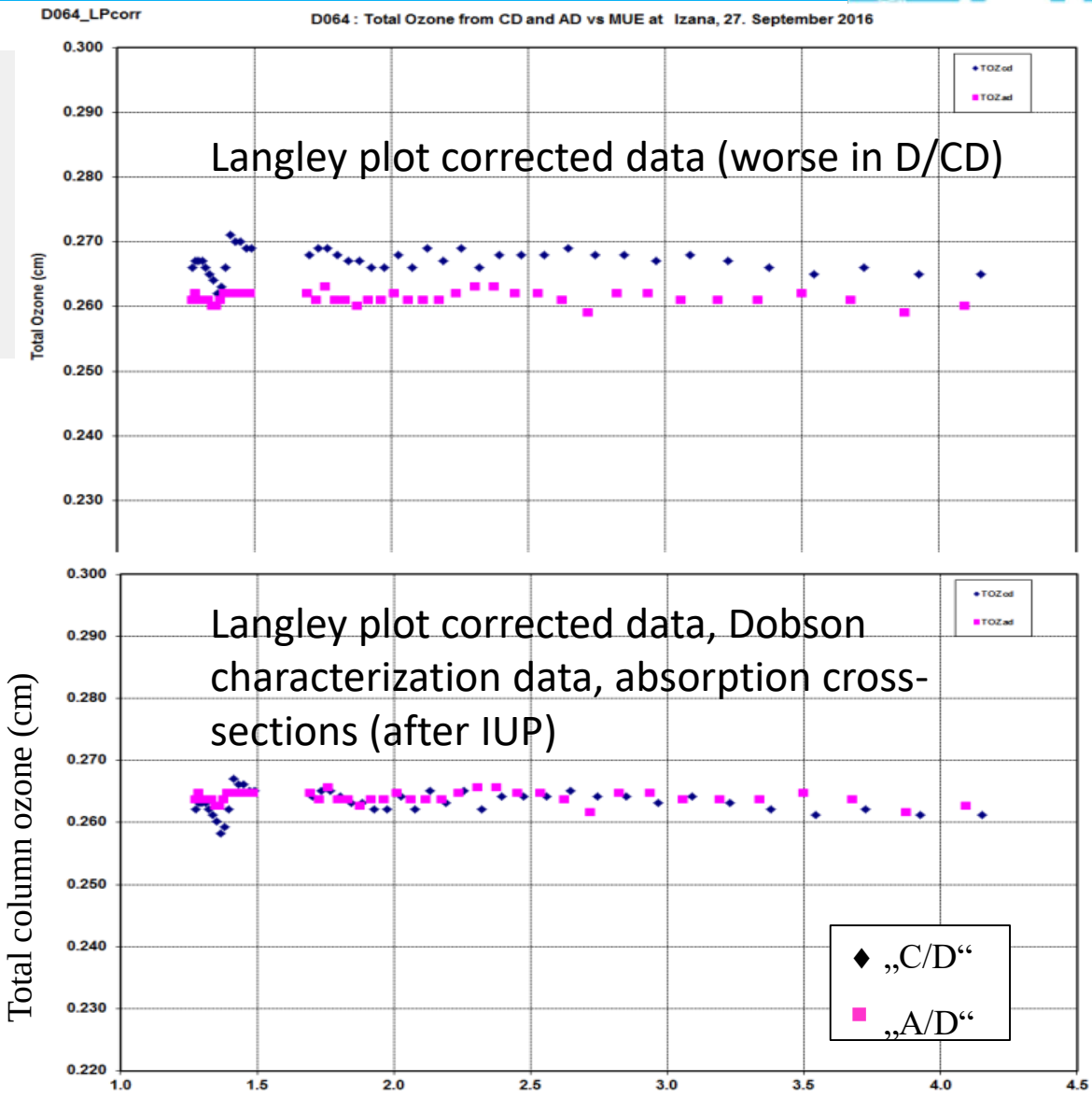


# Effective absorption coefficients



# Impact on TOC

Example of D064 data from Langley campaign in Tenerife



# Conclusions and outlook

- 5 Dobson spectrophotometers, including the World reference Nr. 083 and two European references Nr. 064 and Nr. 074, were characterised with respect to wavelengths and bandpass functions
- The measured Dobson bandpass functions do deviate from the nominal parametrised ones, the peak (centroid) wavelengths generally showed a good agreement
- The derived effective absorption coefficients have an effect on TOC within 1% for the AD- and up to 2% for the CD-wavelengths pairs
- The new data shall enable to reduce the observed differences among individual Dobsons and between Dobsons and Brewers instruments thus increasing the quality of the data needed for trend analyses and satellite validations
- Moreover, to facilitate characterisation of the instruments during Dobson campaigns, a Tuneable Portable Radiation Source (TuPS) was developed by CMI within the EMRP ATMOZ project