

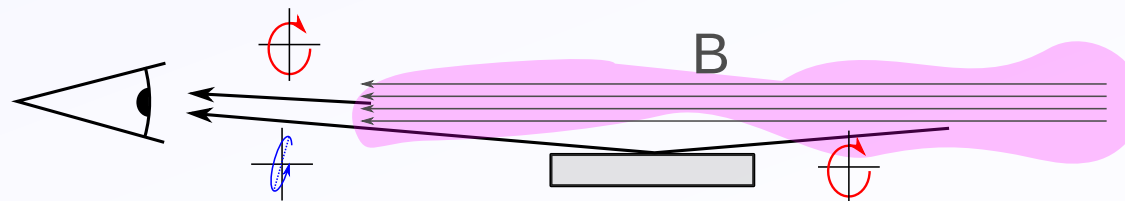
Polarisation reflection measurements

Preliminary Report, May 2021

O. P. Ford¹, D. Gradic¹, V Perseo¹

1: Max-Planck Institut für Plasmaphysik, Greifswald, Germany

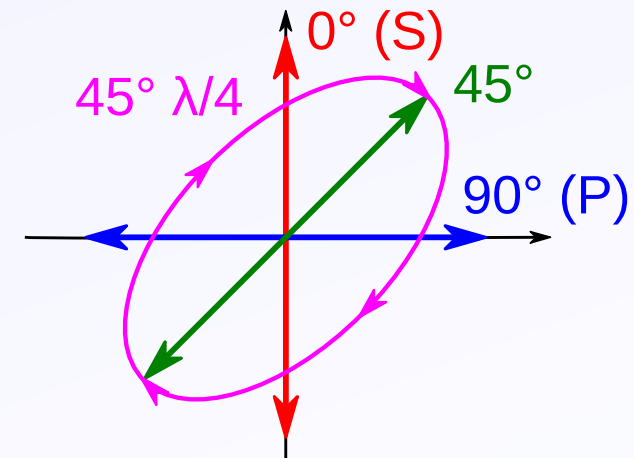
- ITER Flow monitor includes principle of isolating reflections from direct emission with polarisation change:



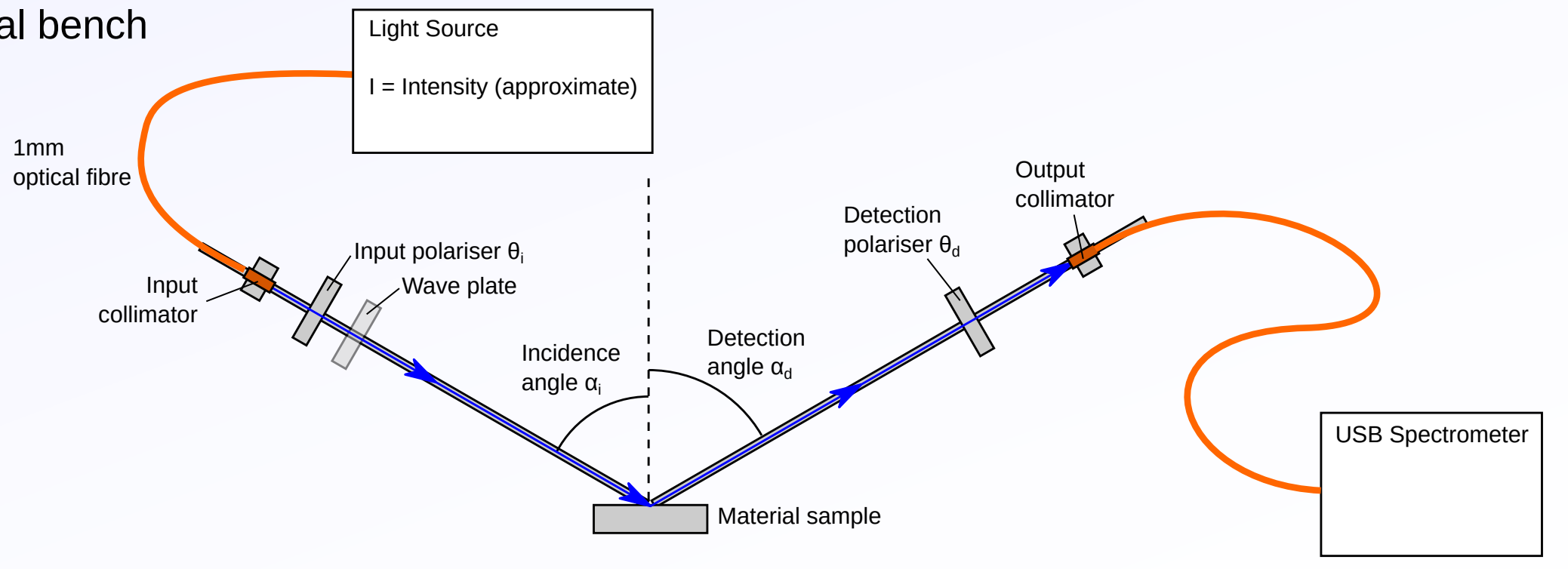
- Measurement of polarisation effect of reflection for relevant material surfaces to assess principle and inform the design

Measurement set up

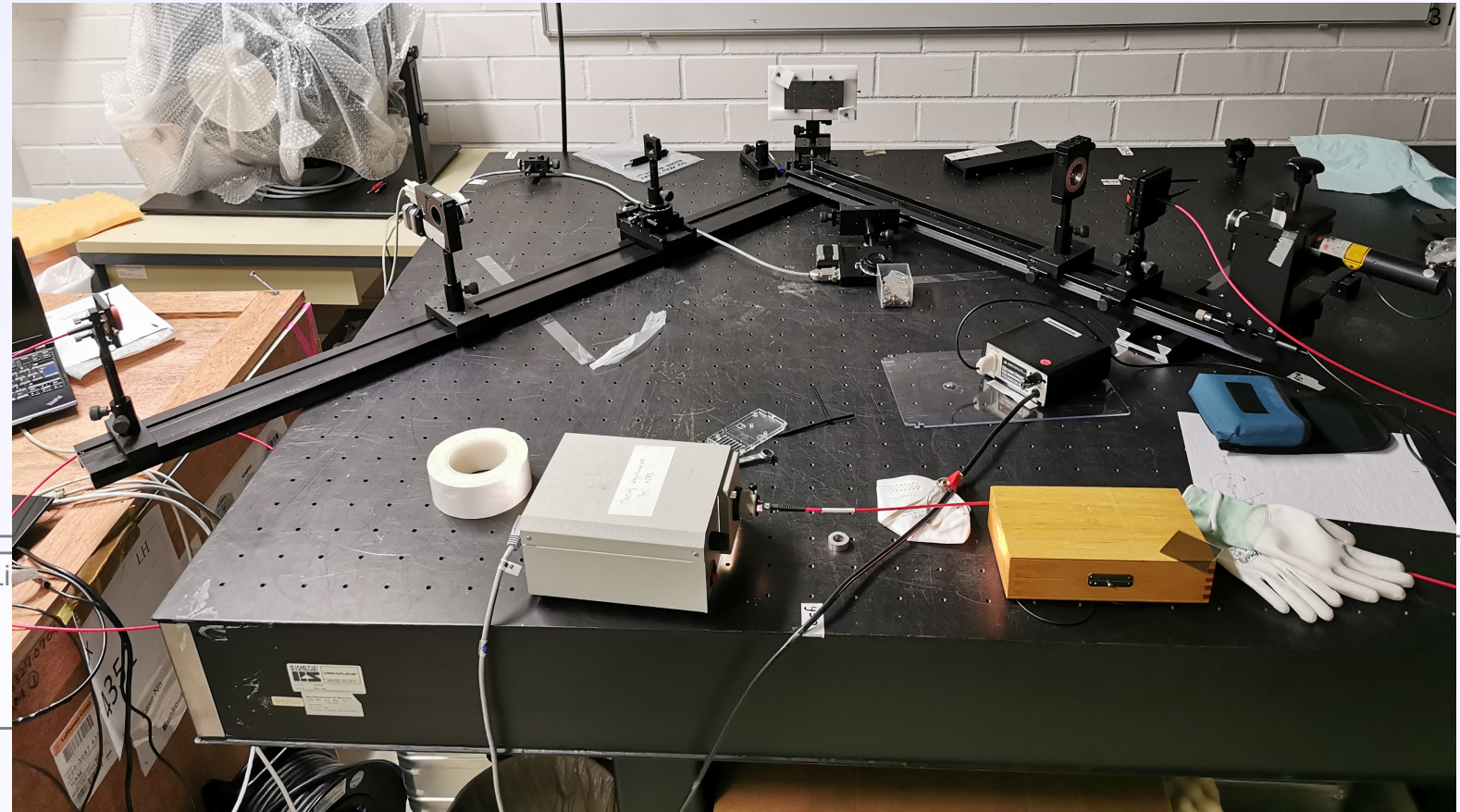
- Narrow beam projected reflected from mirror/material sample.
- 4 input polarisation states.
- Scan of output of polarisation.
- Measurement of:
 - Specular and diffuse reflection.
 - All visible wavelengths.
 - Absolute attenuation, full polarisation change and depolarisation.



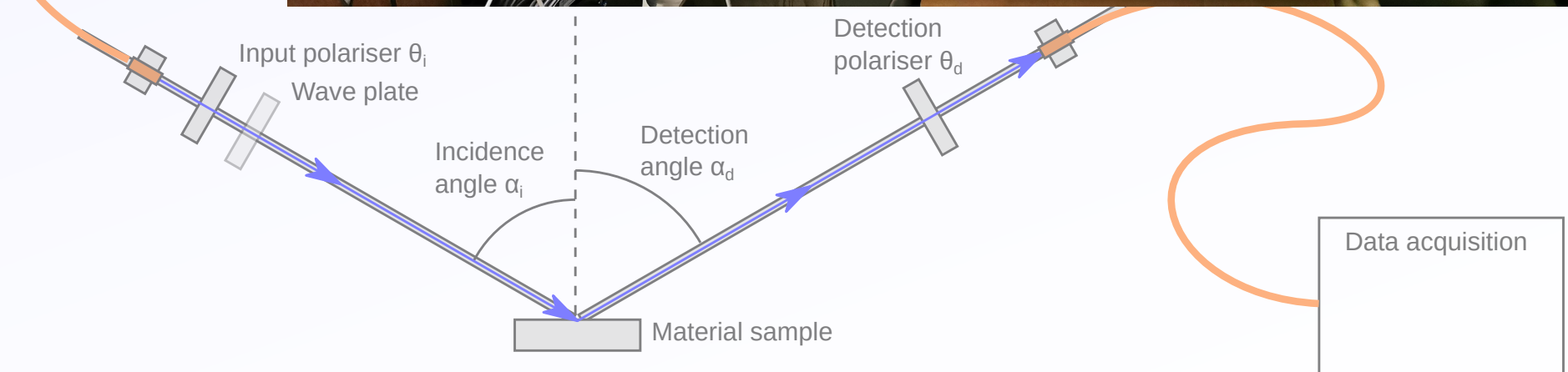
Optical bench



Real life is
somewhat messier:



Optical bench

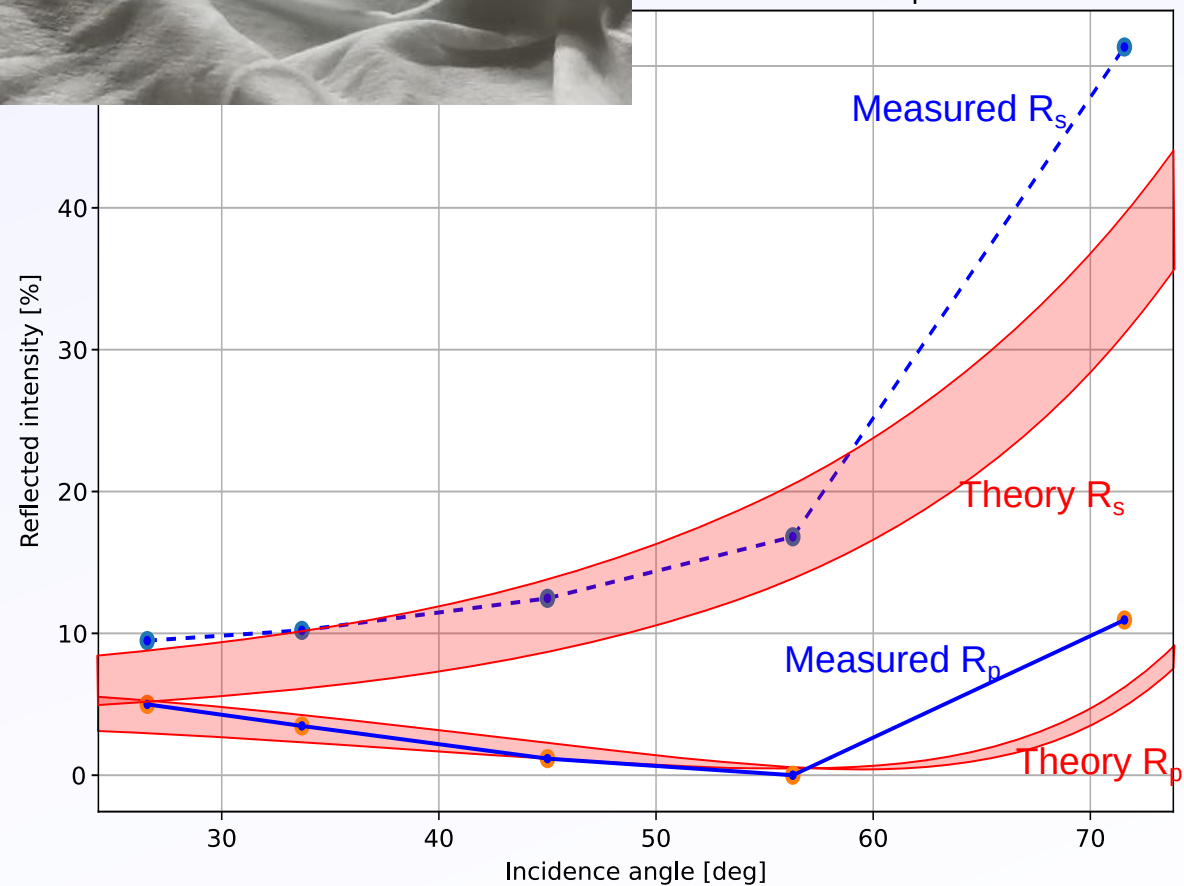


Glass

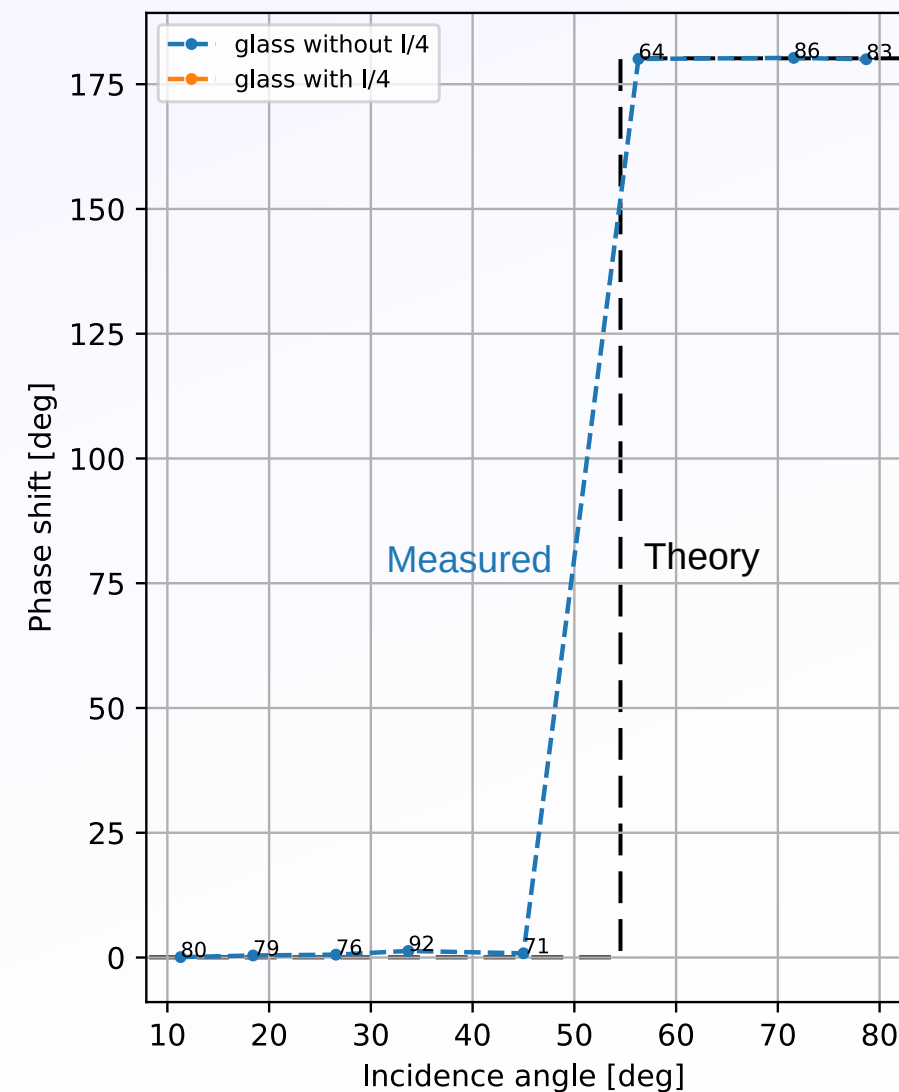
Reflection from glass surface as benchmark case:
simple known physics from Fresnel coefficients.



R_p , R_s from amplitude
relative to open arms



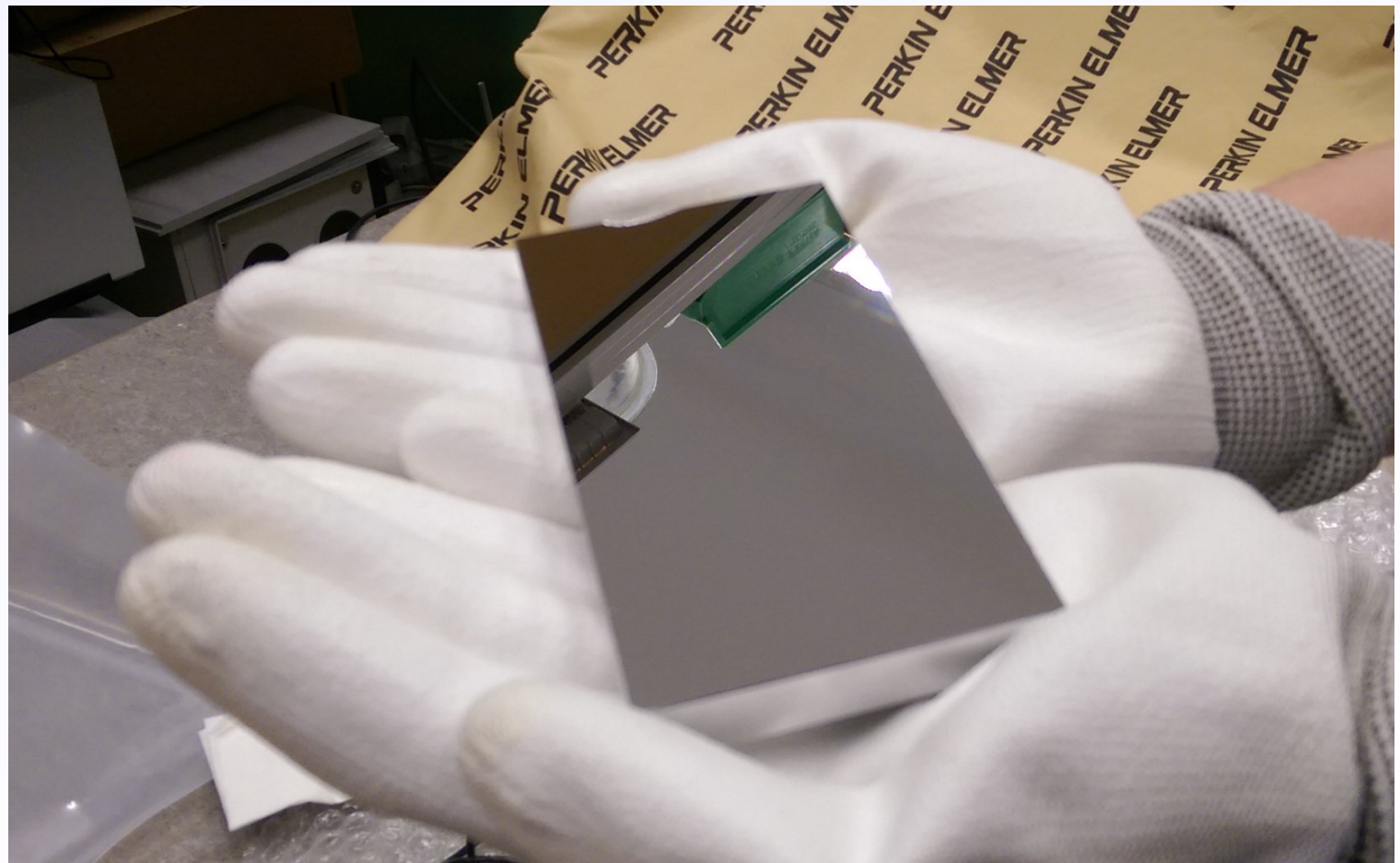
Fit contrast



Aluminium (specular)

Fine milled aluminium alloy RSA-905 (W7-X beam emission spectroscopy mirrors):

Benchmark for RaySect ray tracing software for pure specular reflection from ideal surface.

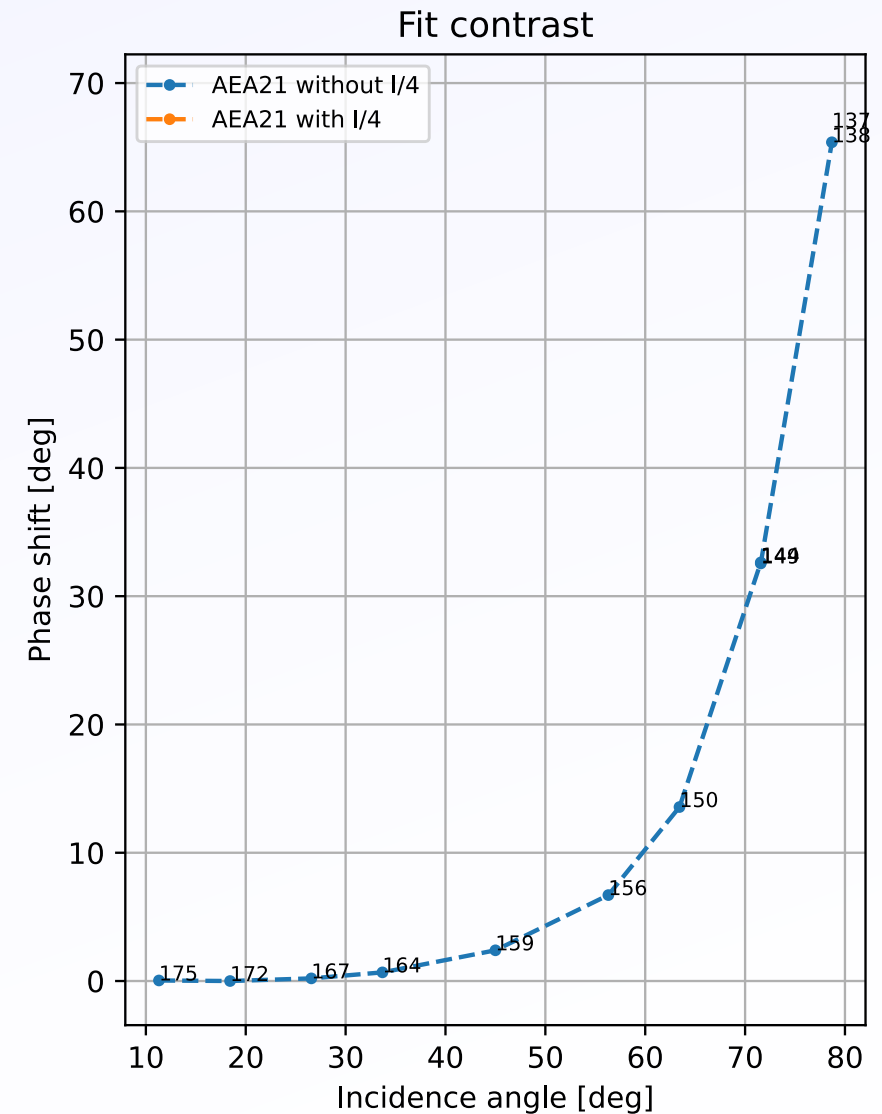
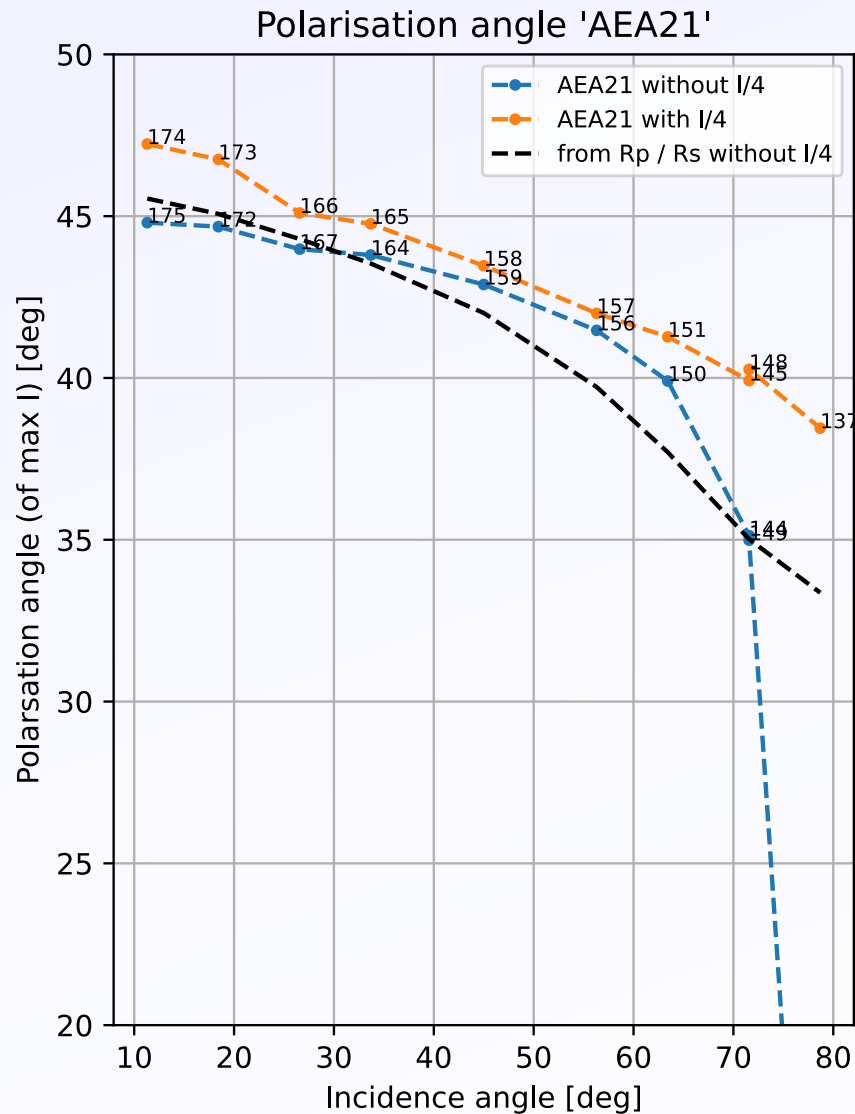


Aluminium

Near 'ideal' specular reflection

Normal incidence up to $\sim 45^\circ$ --> Almost **no effect on polarisation** except reference frame reversal

From 45° to oblique angles --> Small polarisation rotation due to P attenuation, **strong phase shift** between S and P.

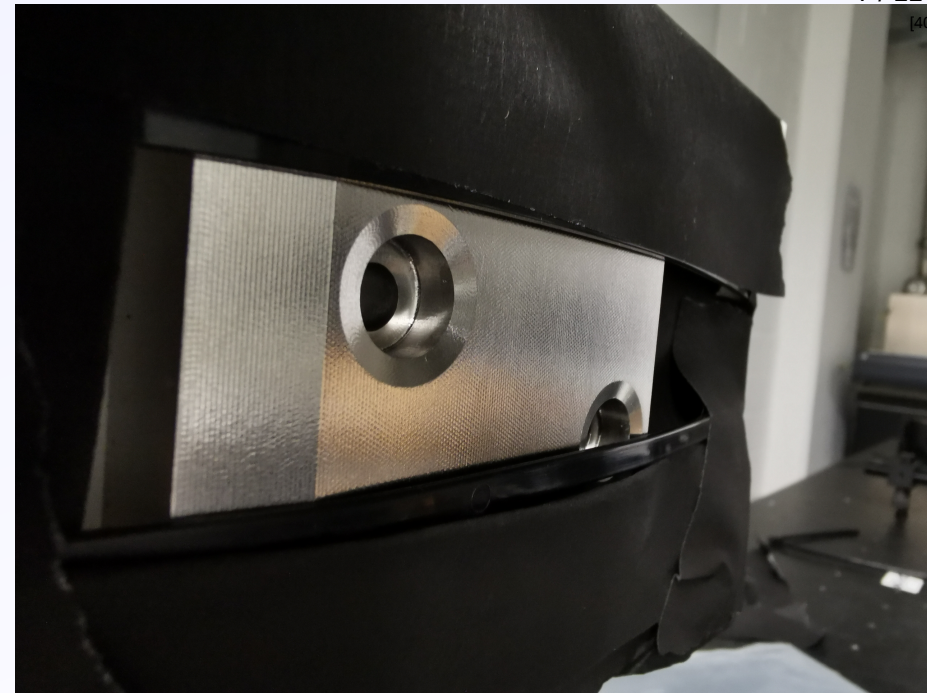
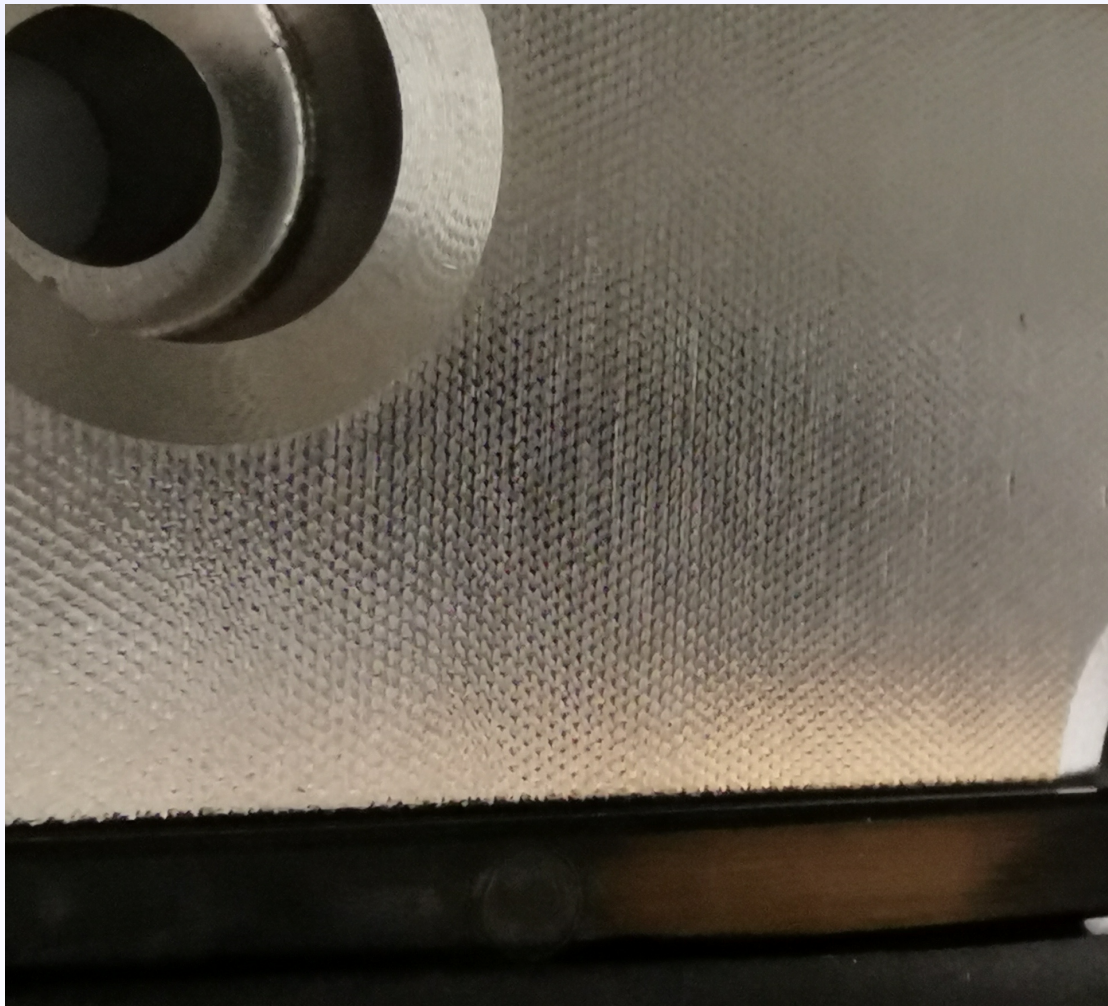


Tungsten

Tungsten alloy: W 97%, Fe 1%, Ni 2%

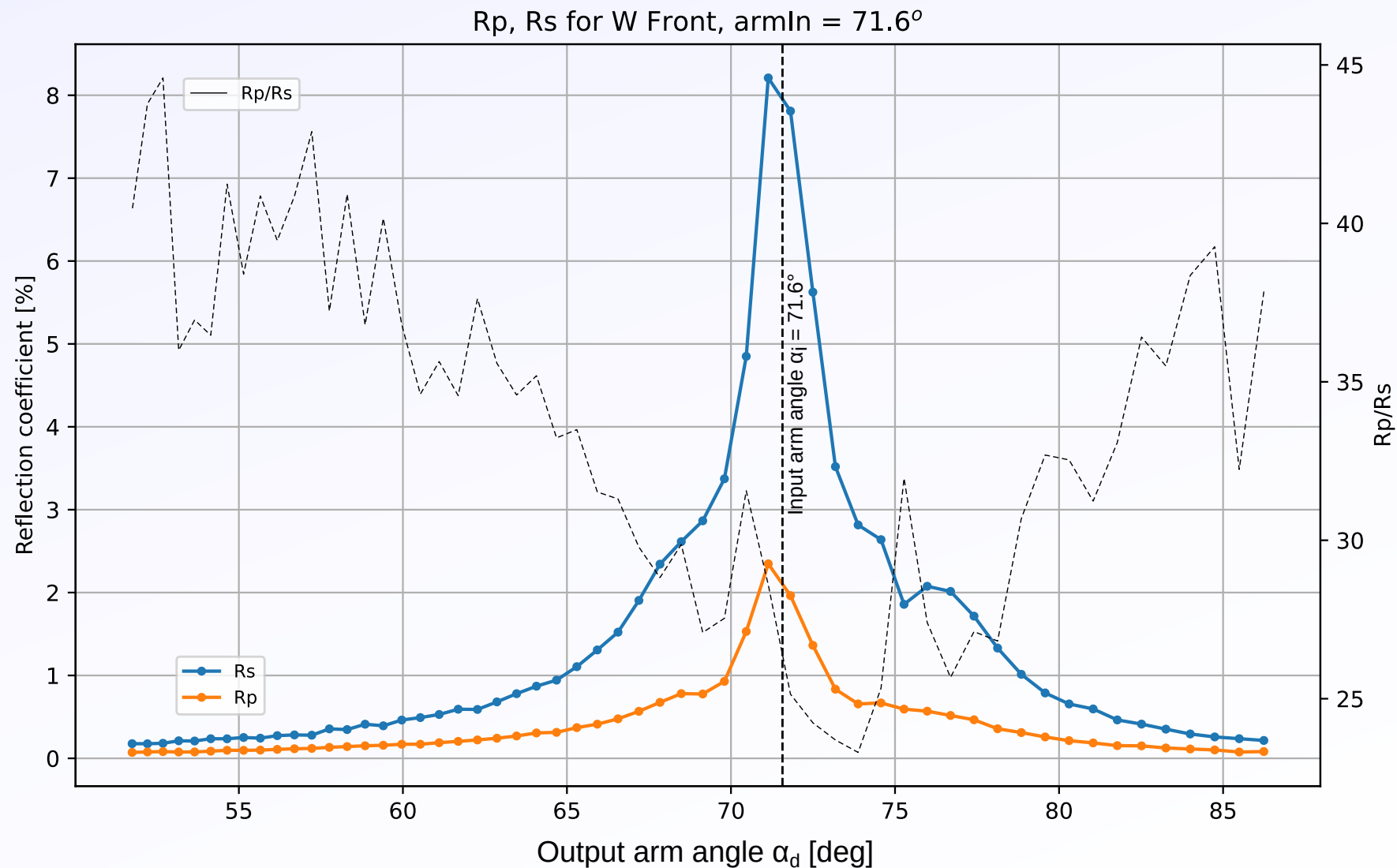
Wall tile from ASDEX Upgrade (not plasma exposed).

Visible surface structure without clear mirror effect:



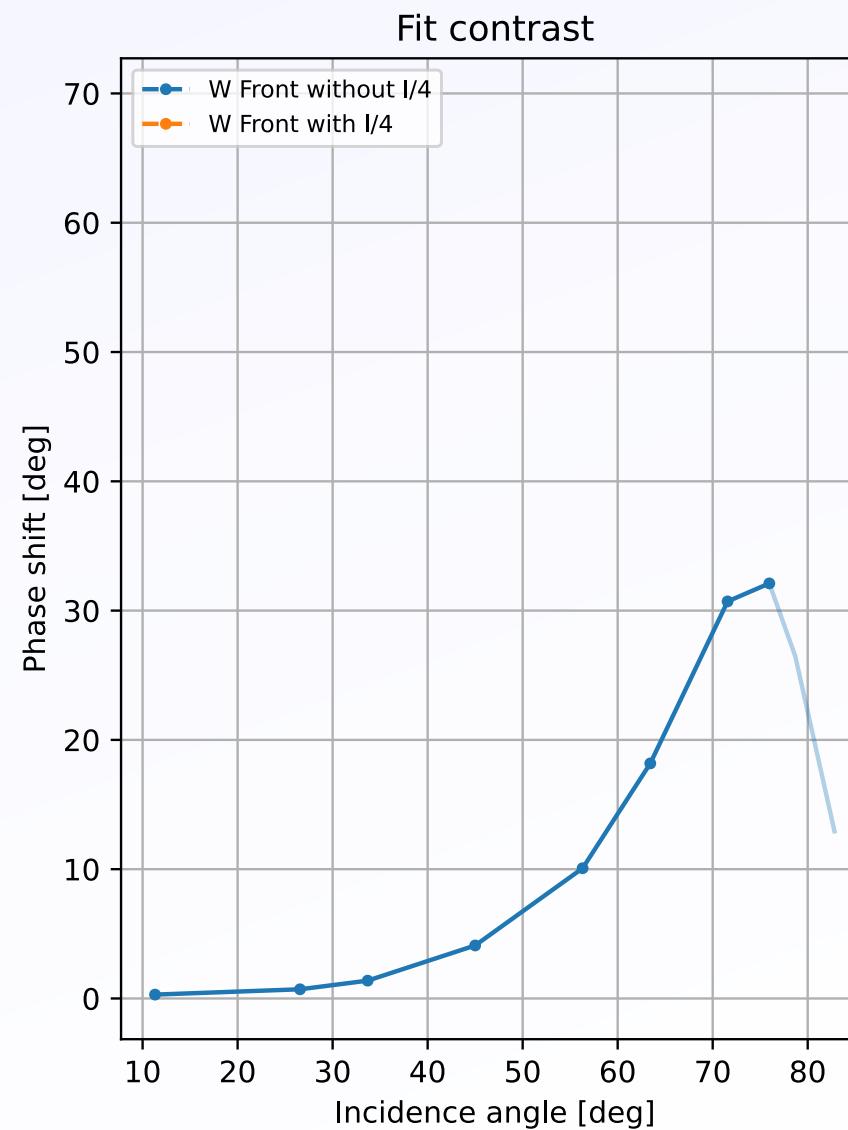
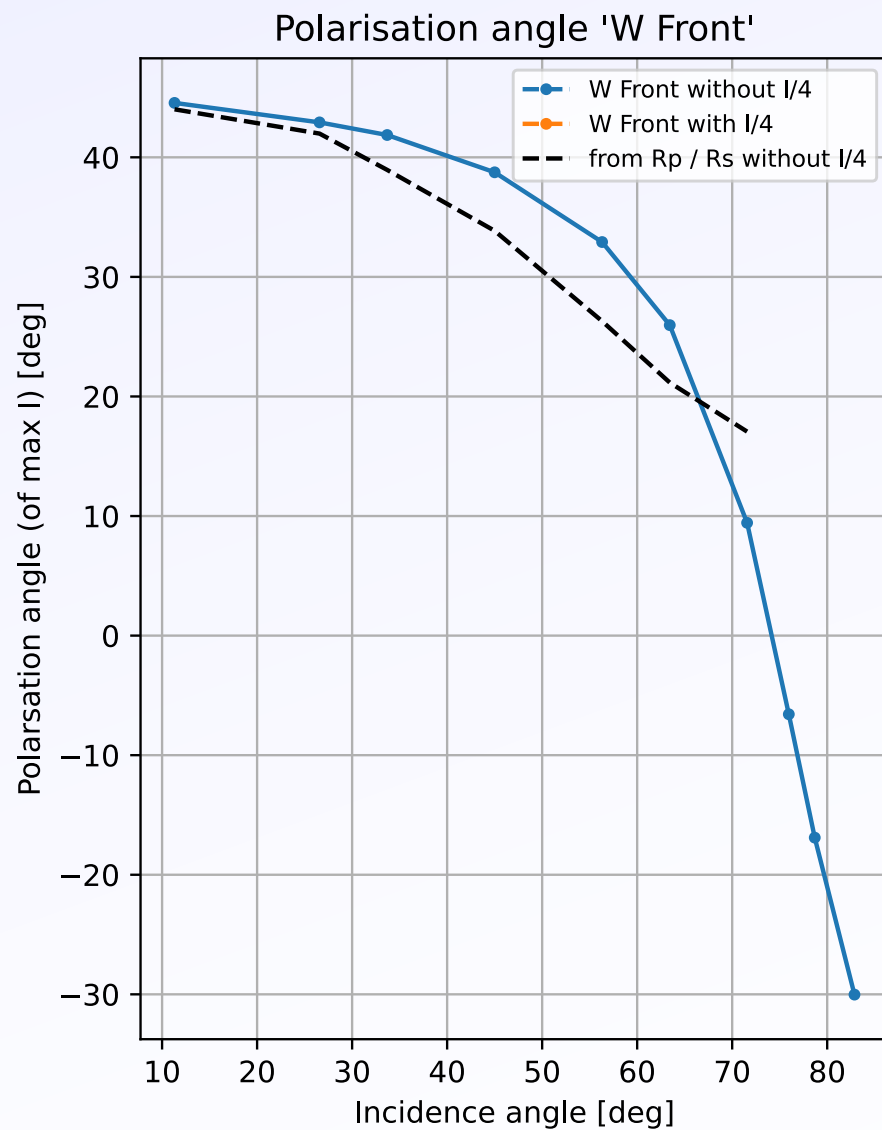
Tungsten

- Very significant diffuse reflection $> \sim 1\%$ up to $\pm 10^\circ$
- Weak specular reflection $\sim 5\%$
- Strong attenuation of P relative to S in both cases --> **tends toward linear polarisation.**



Tungsten

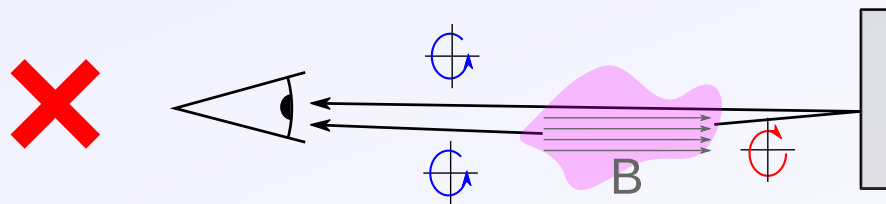
- Strong rotation toward S polarisation at oblique angles
- Similar phase shift to specular reflection.



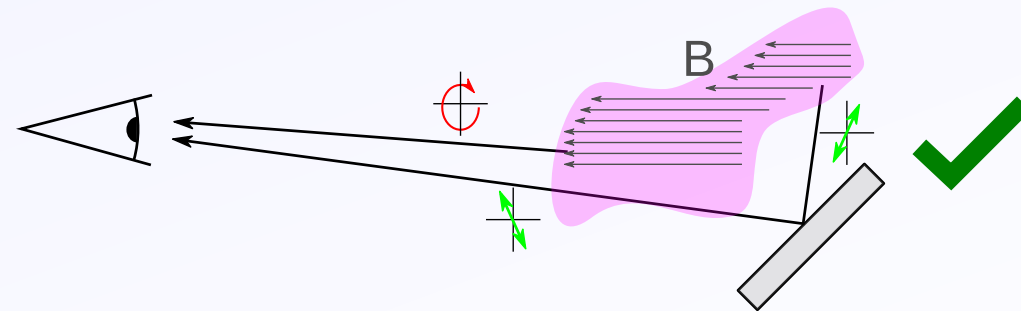
Simple cases

We can consider some simple relevant cases:

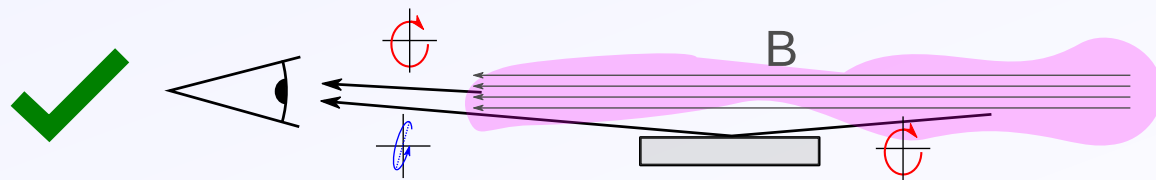
1) Specular reflector behind emitter



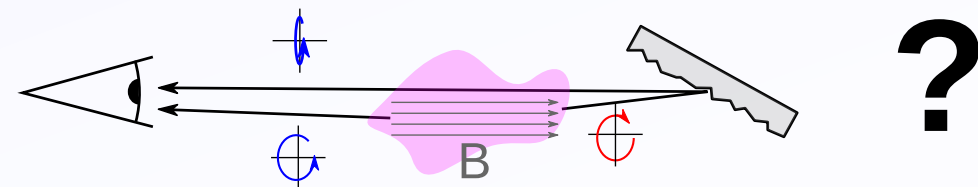
2) Mid range specular reflection



3) Oblique specular reflection



4) Diffuse reflection behind emitter



- Situation is complex - depends on precise geometry, emission and reflection properties.
- Many cases will be separable, some not.
- In most cases, disturbance from reflections will be possible to identify.

Summary

Main indications so far:

- Preliminary measurements completed and validated with glass reflection (Brewster angle)
- Reflection properties strongly dependant on material surface (machining, coating, finish etc)
--> We should measure an actual ITER wall tile if possible.
- No simple behaviour (e.g. *"Reflections tend to give linear polarisation"*)
--> **Assumption not generally valid (chit #12).**
- Strong phase shift and R_p attenuation at oblique angles, $\Delta\phi=180^\circ$ at small angles.
--> Significant transform of polarisation on reflection.
- **Should be possible to at least detect and avoid reflection contamination** using polarisation change.
- Isolate possible in some cases but this will require the Luffy simulation to tell us where it can trusted.

Future work:

- Use data set to validate Luffy reflection model for measured samples:
 - 1) Basic model for polarisation and phase change for ideal specular reflection.
 - 2) More realistic model for an arbitrary rough surface. Is this like the measured tungsten tile?
- Repeat measurements with more relevant materials - ITER wall tungsten tile?