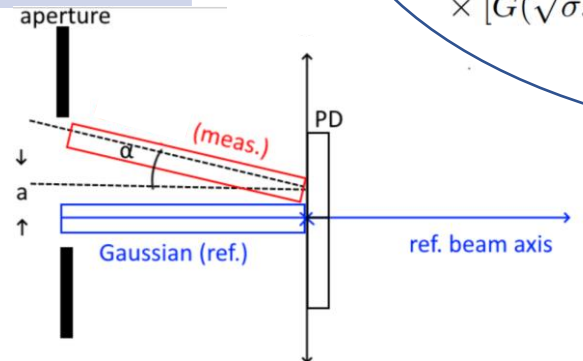


# First-order Tophat-Gaussian Signals

- 1<sup>st</sup> order series approximation in shift and in tilt
  - Apply scattering to modes before getting signals (scattering not timed)
- Time
  - Average execution time (1 LPS & DWS datapoint): ~0.84 s
  - ~42 s / 51 points (DWS and LPS)
  - ~O([max tophat mode]<sup>3</sup>): 100 POINT execution times

Tophat Mode (mode order/2)	Total Time (100 points) [s]
34	94.01
28	50.34
18	11.93

- Rotation about center of PD
  - 1mm radius tophat



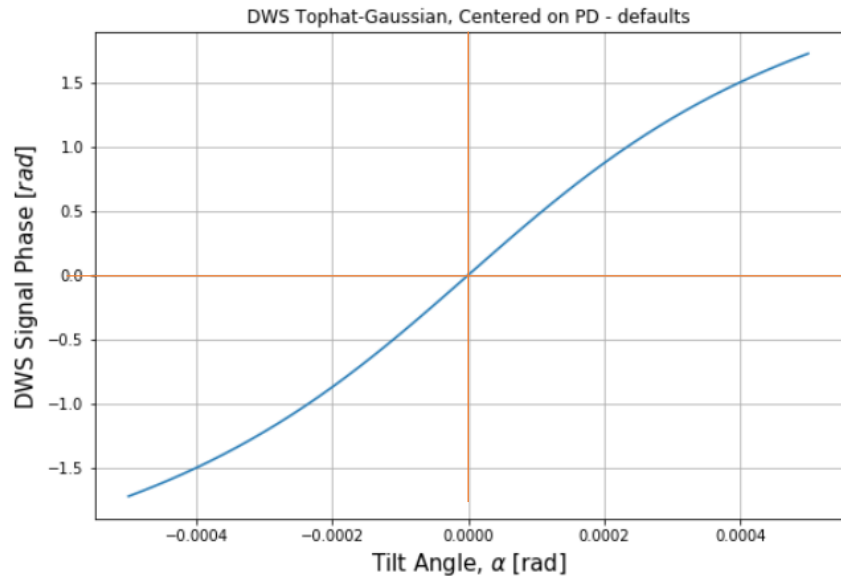
$$\begin{aligned}
 \langle 0, 0 | a, b \rangle = & \sum_{0}^N \sum_{0}^M \frac{2^{a+b+1} \sqrt{a!b!} e^{i(\Delta wt - (k_2 Z - k_1 d_1))}}{\pi \sqrt{\sigma^{2+a+b}} w_1 w_2^{1+a+b} (1 + i \frac{d_1}{z_{r1}}) (1 - i \frac{Z}{z_{r2}})^{1+a+b}} \\
 & \times \sum_{A=0}^{\lfloor \frac{a}{2} \rfloor} \sum_{B=0}^{\lfloor \frac{b}{2} \rfloor} \frac{(-\frac{\sigma}{8})^{A+B} W_2^{2(A+B)} \Gamma(\frac{b+1}{2} - B)}{A! B! (a - 2A)! (b - 2B)!} \\
 & \times [\text{erf}(\sqrt{\sigma} Y) - \frac{2e^{-\sigma Y^2}}{\sqrt{\pi}} \sum_{M=0}^{\lfloor \frac{b}{2} - (B+1) \rfloor} \frac{(M+1)!}{(2(M+1))!} (2\sqrt{\sigma} Y)^{2M+1}] \\
 & \times [G(\sqrt{\sigma} x_2; a - 2A) - G(\sqrt{\sigma} x_1; a - 2A)]
 \end{aligned}$$

# Parameters (center of rot. PD)

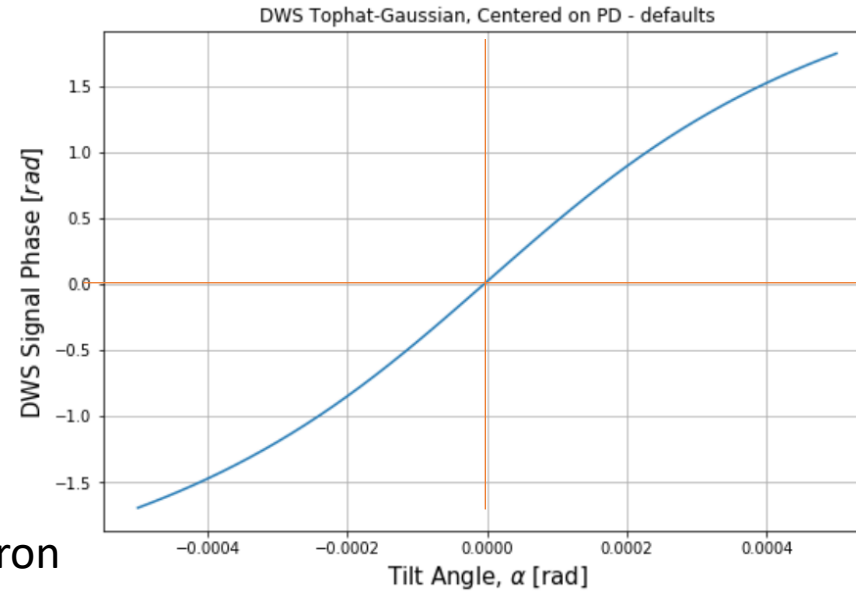
Param.	Default Value [mm]	Nomenclature
PD-ref. beam distance , PD-meas. beam distance	10	$Z = z_{PD} - z_m$ , $d_1 = z_{PD} - z_{LO}$
PD size	2x2	$x_{R2}, x_{L1}$
PD gap	0.02 (20 [micron] right & left)	$x_{R1}, x_{L2}$
Meas. Beam $w_0$	0.23067 (1mm-radius tophat)	$w_1$
Meas. Beam $z_0$	0 (at aperture)	$z_m$
Ref. Beam $w_0$ ( $w_2$ )	1	$w_2$
Ref. Beam $z_0$	0 (at aperture)	$z_{LO}$
Shift	0	$a$
Tilt	$\{-500, 500\}$ [microrad]	$\alpha_{arr}$

# Defaults DWS

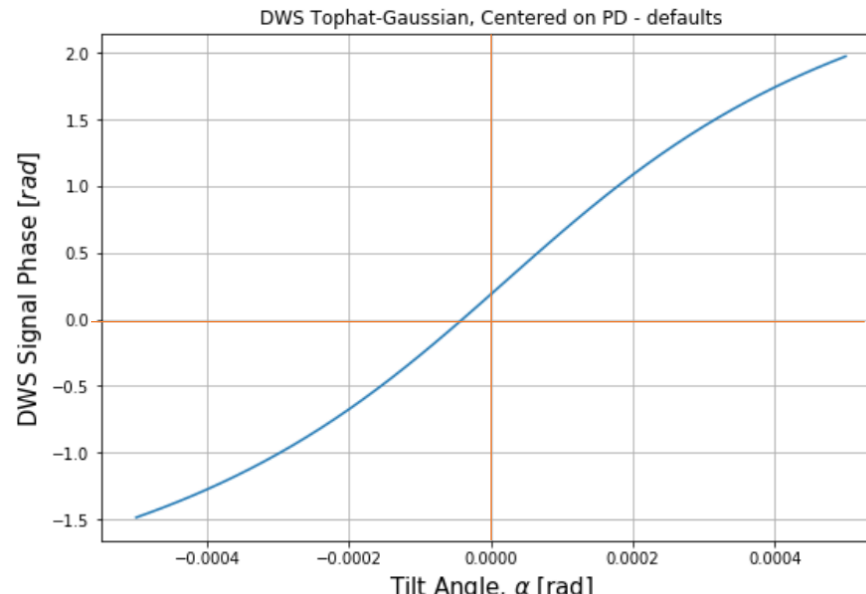
0



10 micron



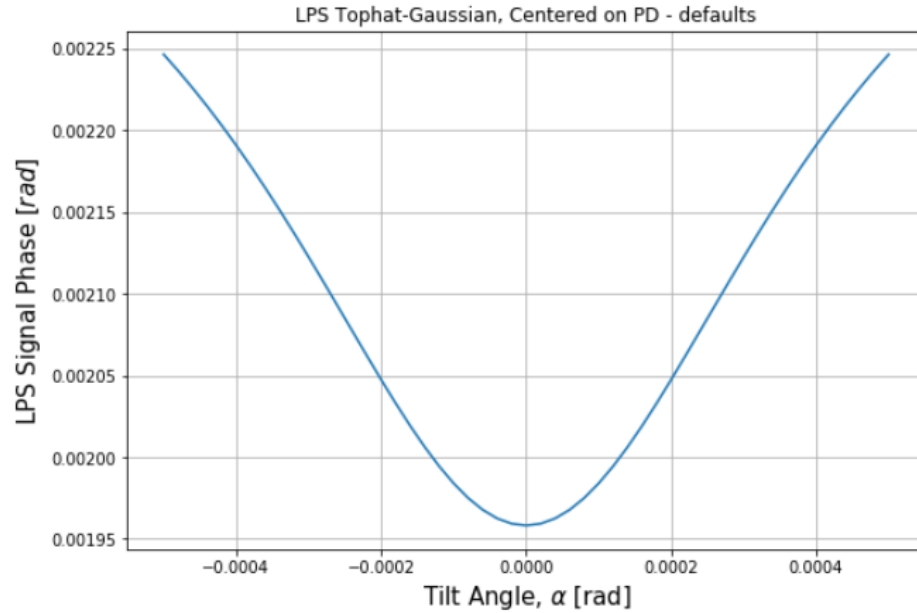
100 micron



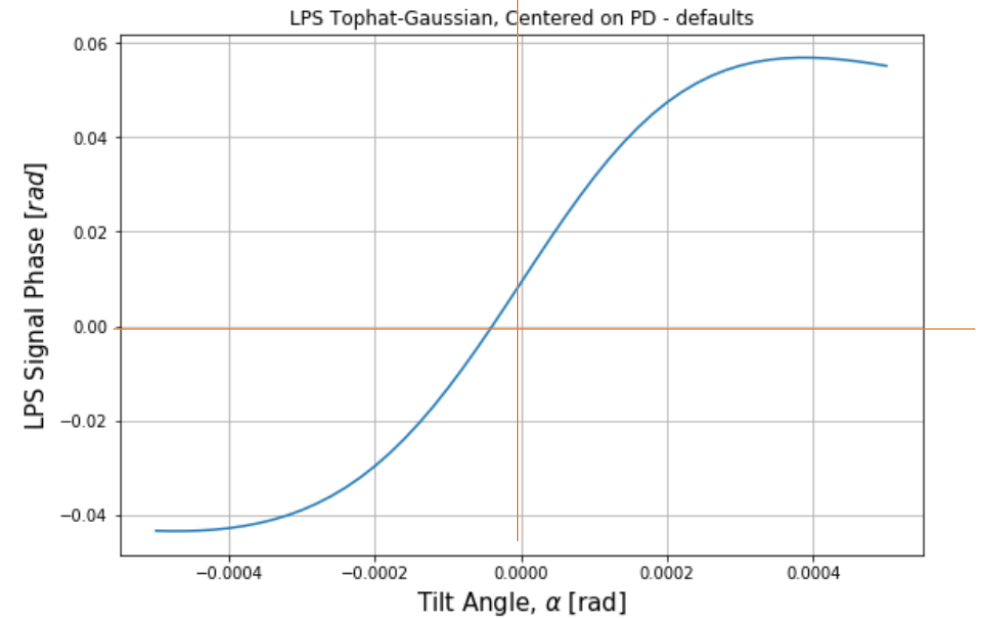
Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20 micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad

# Defaults LPS

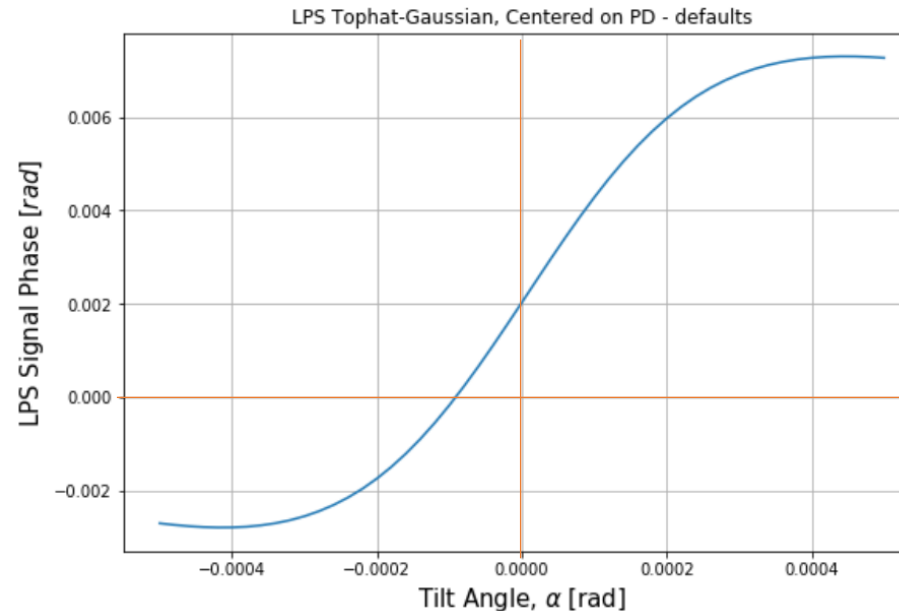
0



10 micron



100 micron



Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20 micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad

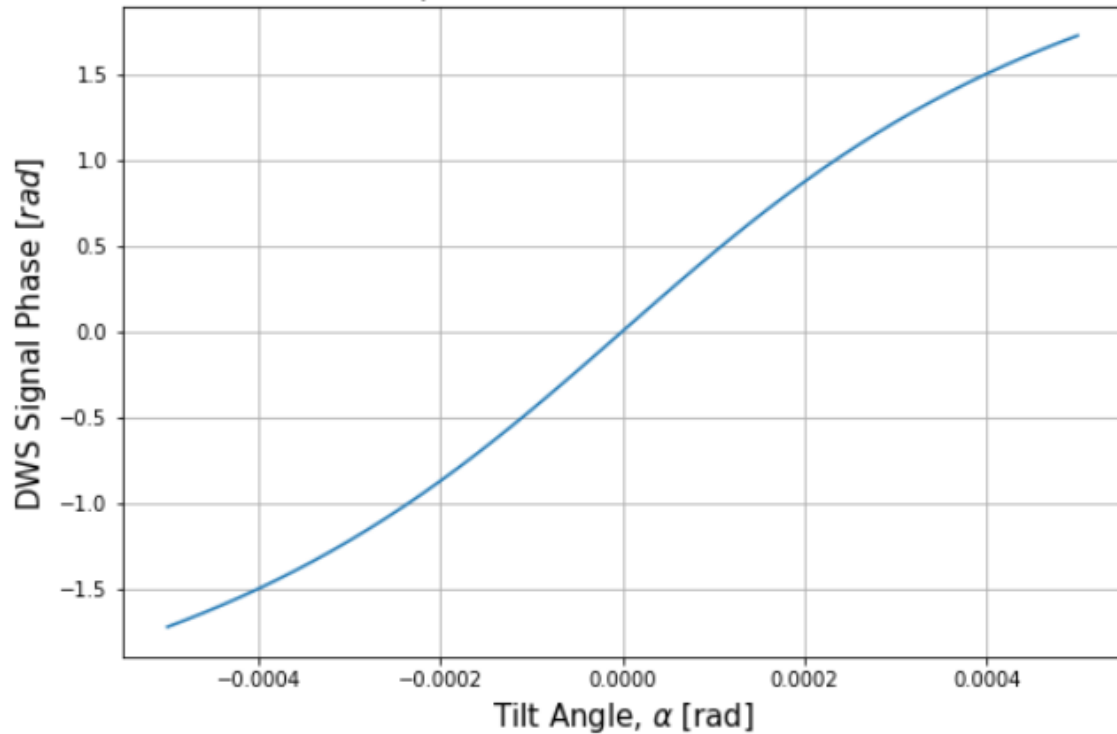
Shift = 0

- Default values
- Changing one parameter/slide

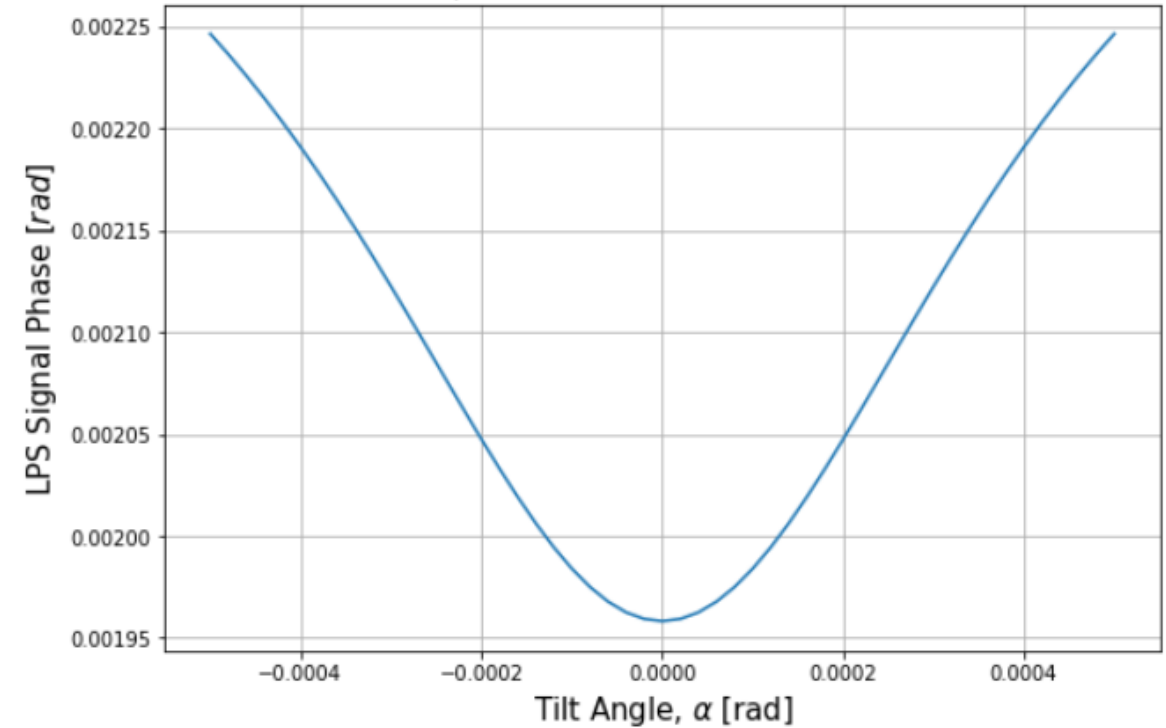
# Defaults

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad

DWS Tophat-Gaussian, Centered on PD - defaults

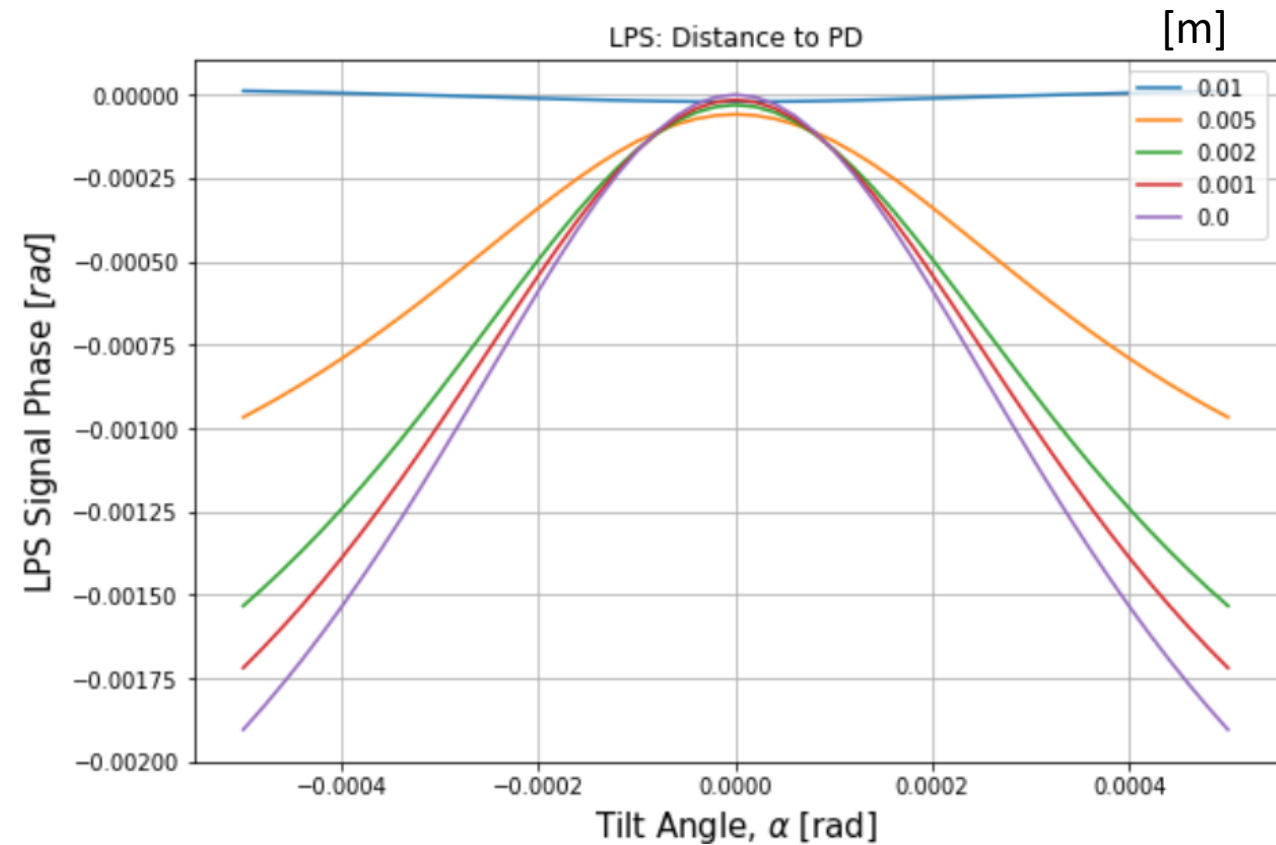
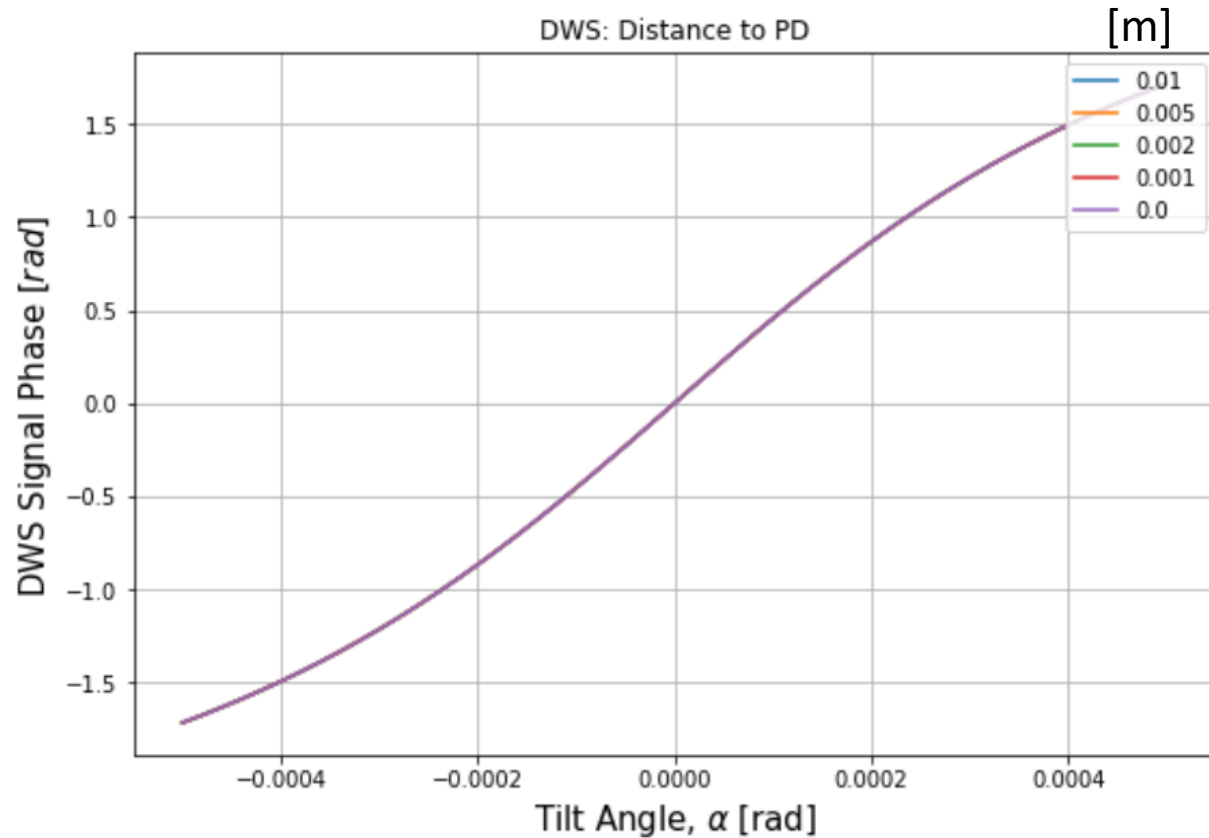


LPS Tophat-Gaussian, Centered on PD - defaults



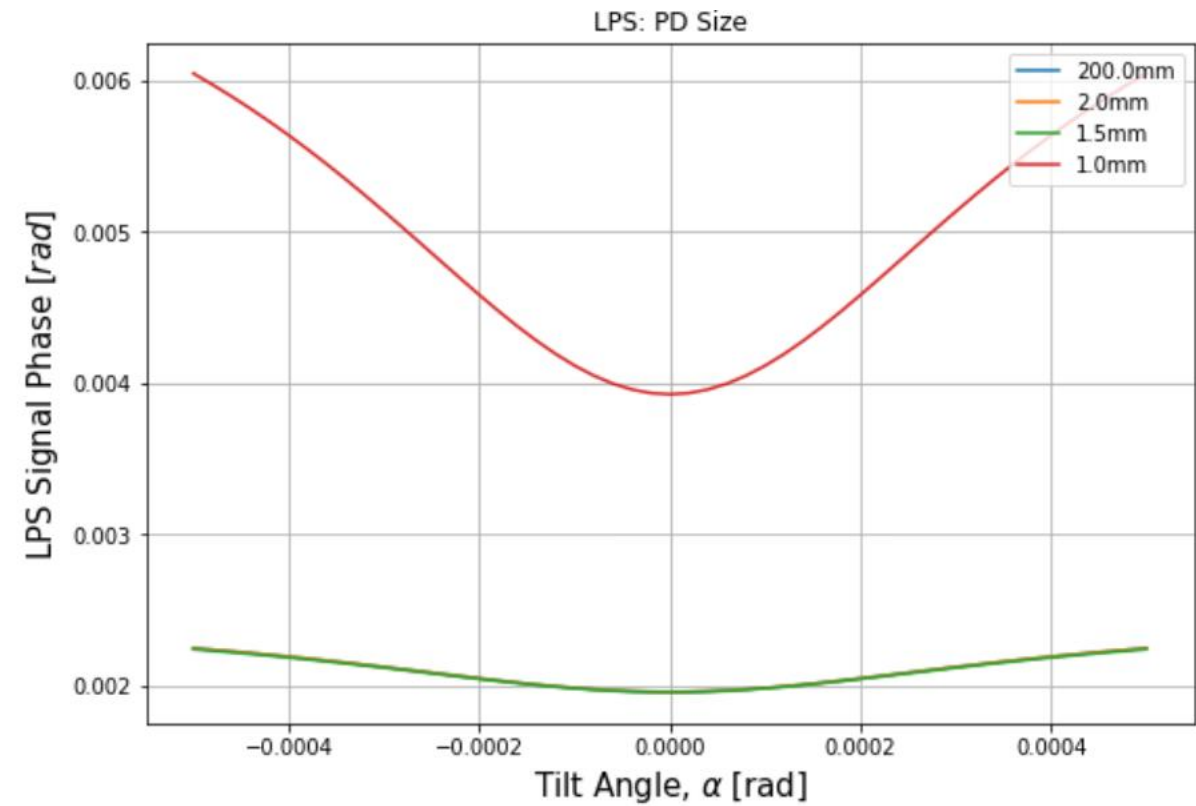
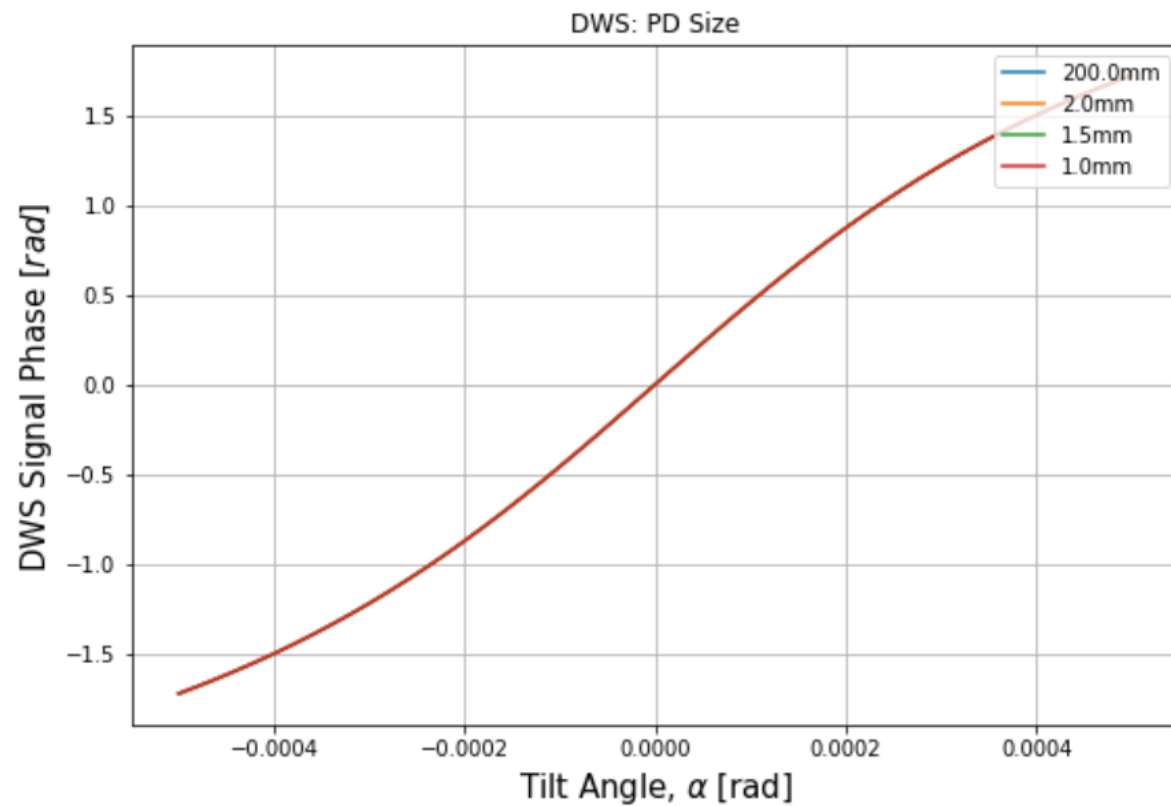
# Distance to PD[mm]

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad



# PD size [mm]

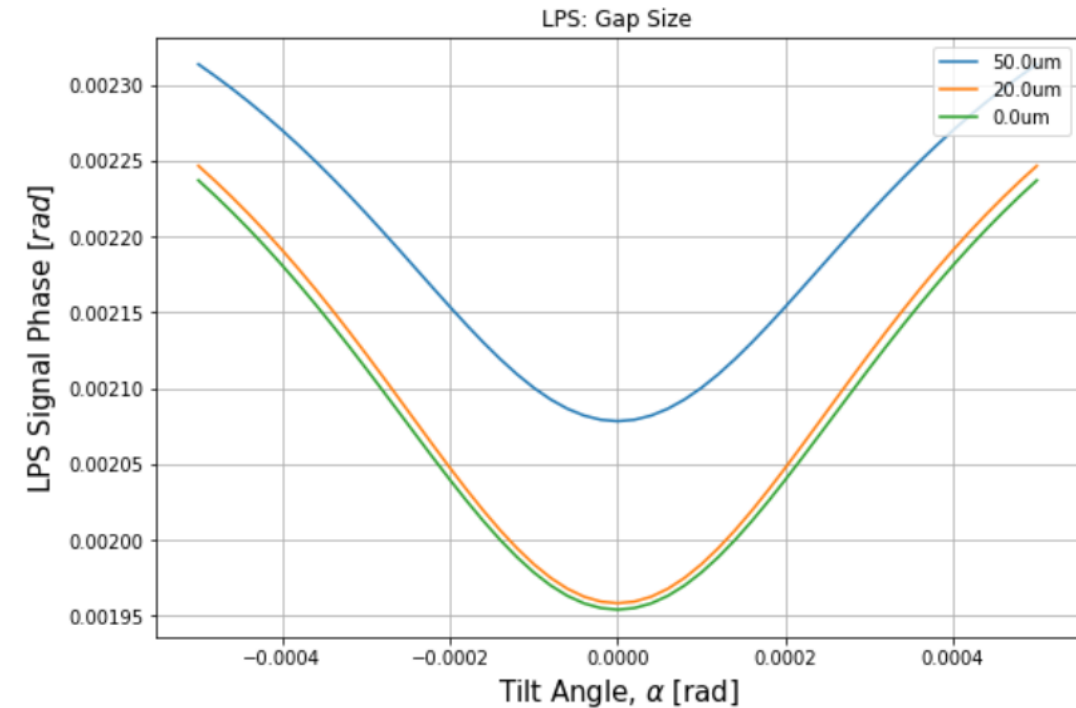
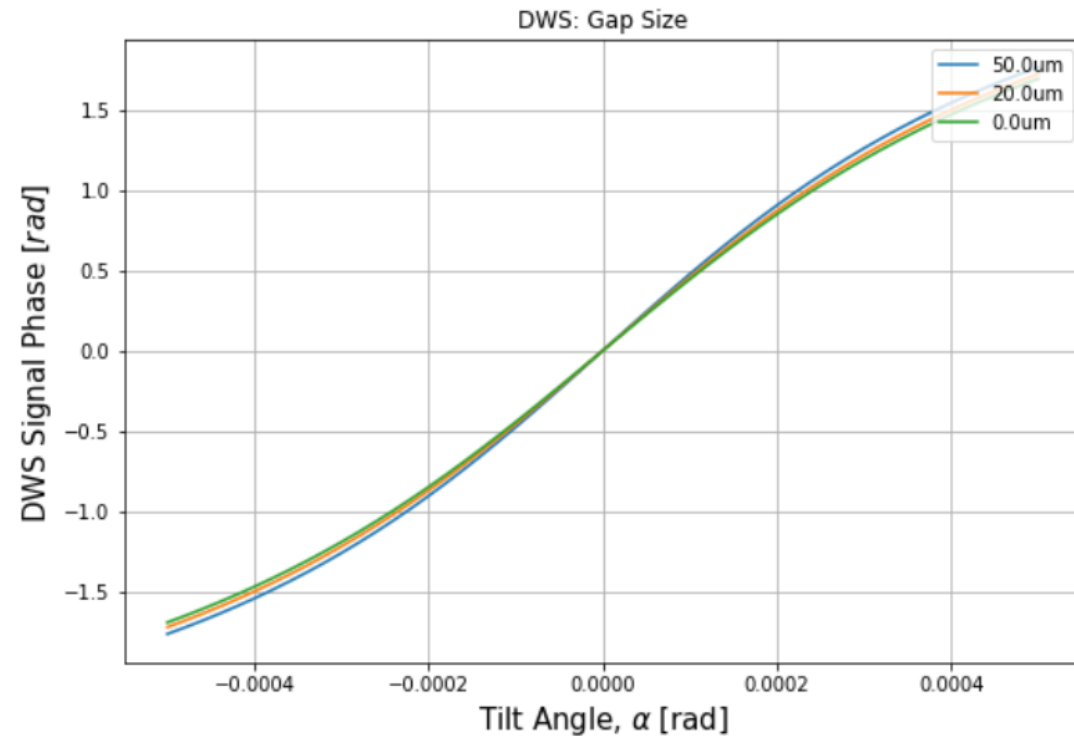
Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad





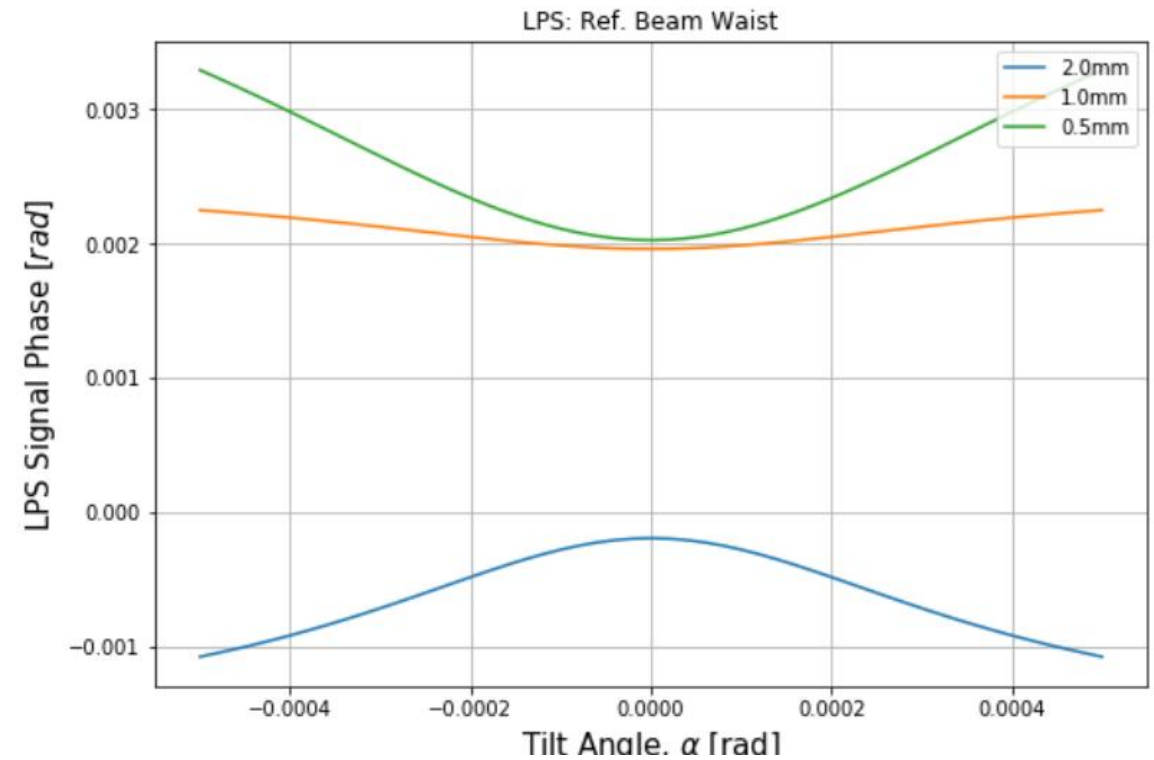
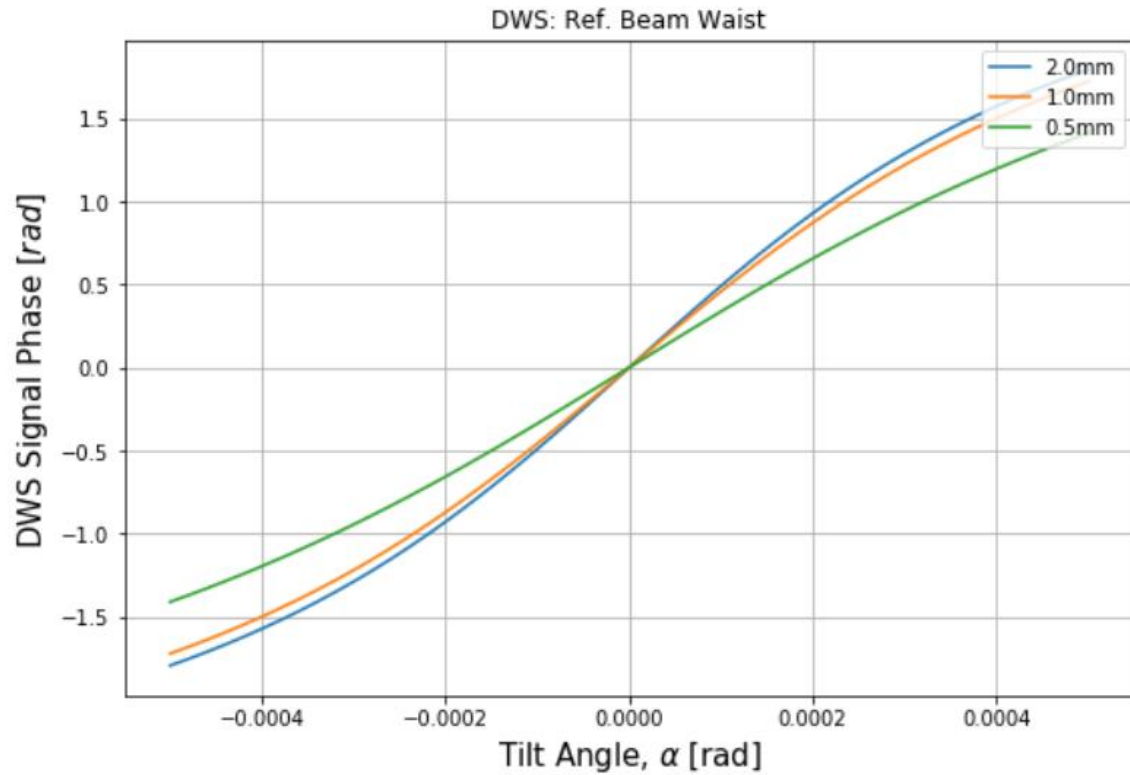
# Gap Size [mm] (half-gap)

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



# Ref. Beam Waist

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	0
Tilt	[-500,500] microrad



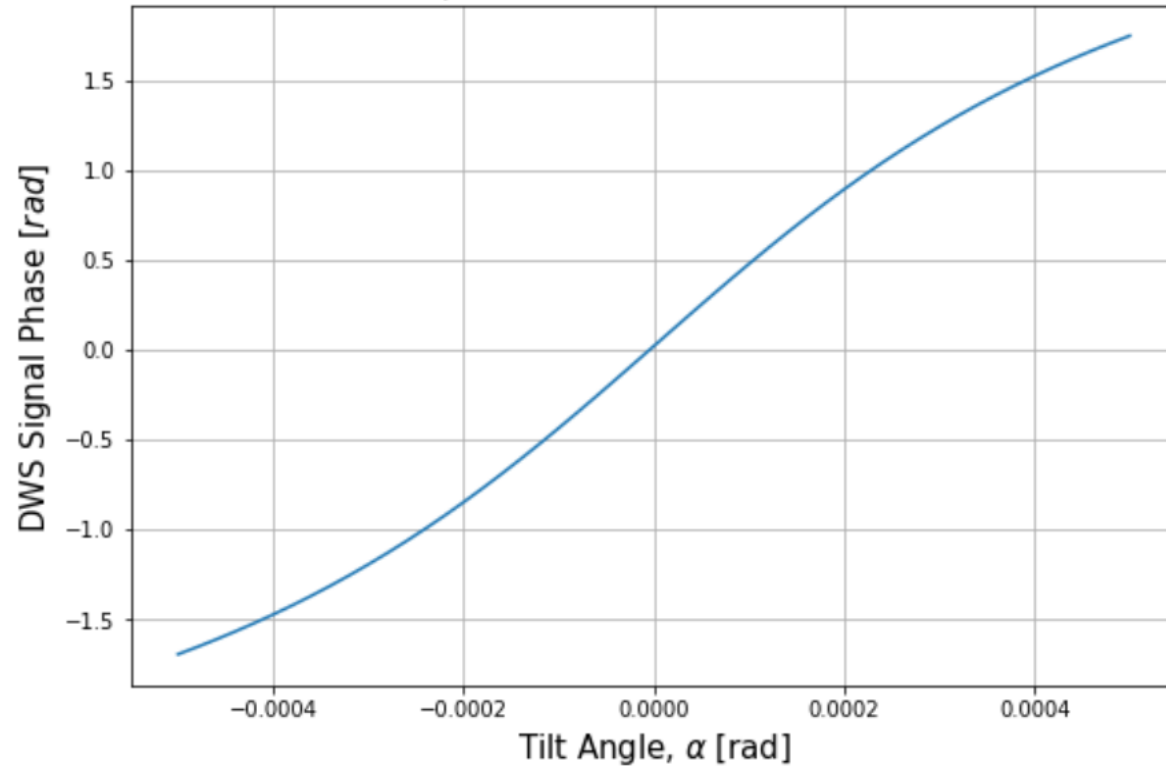
Shift = 10  $\mu\text{m}$

- Default values
- Changing one parameter/slide

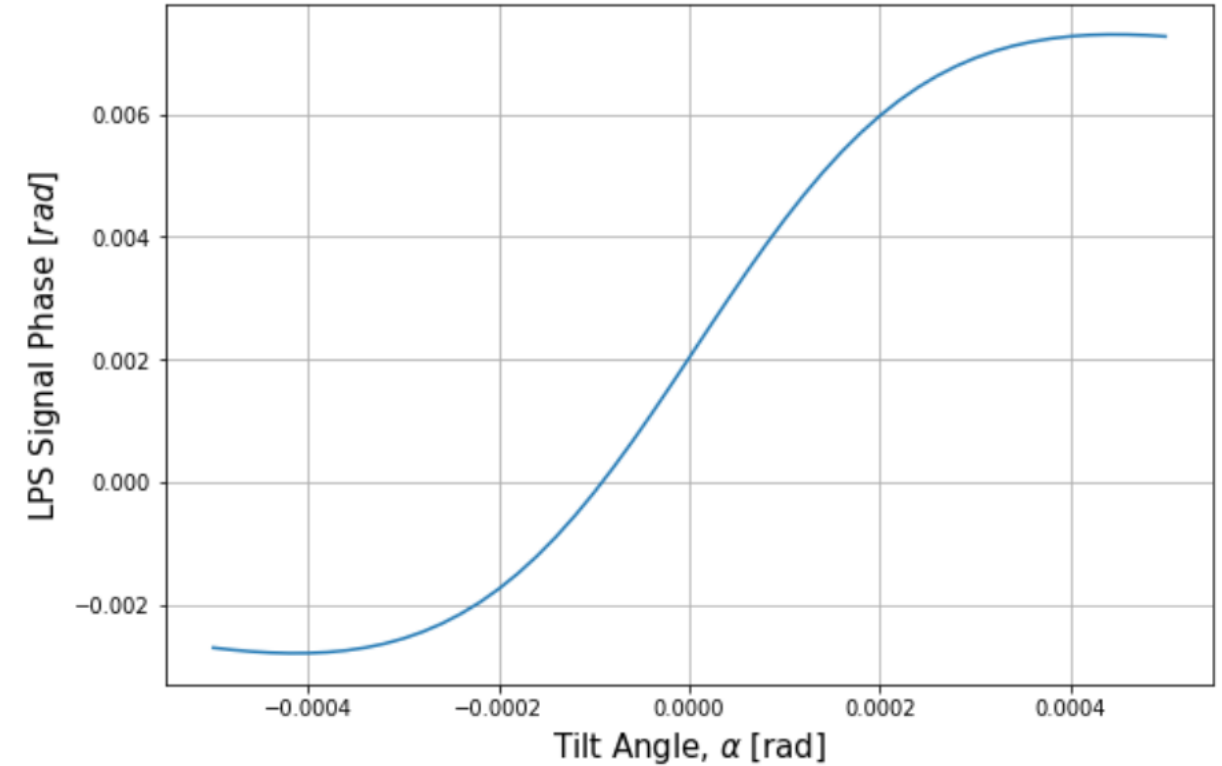
# Defaults

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad

DWS Tophat-Gaussian, Centered on PD - defaults

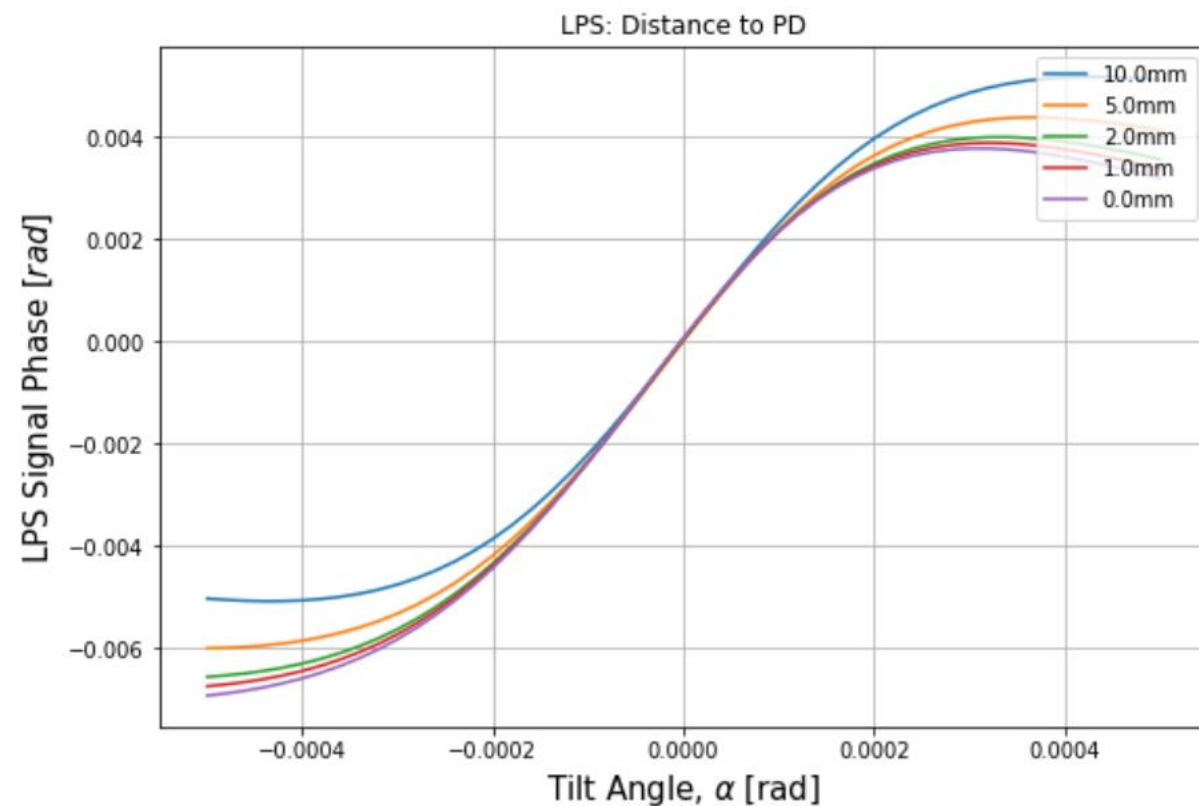
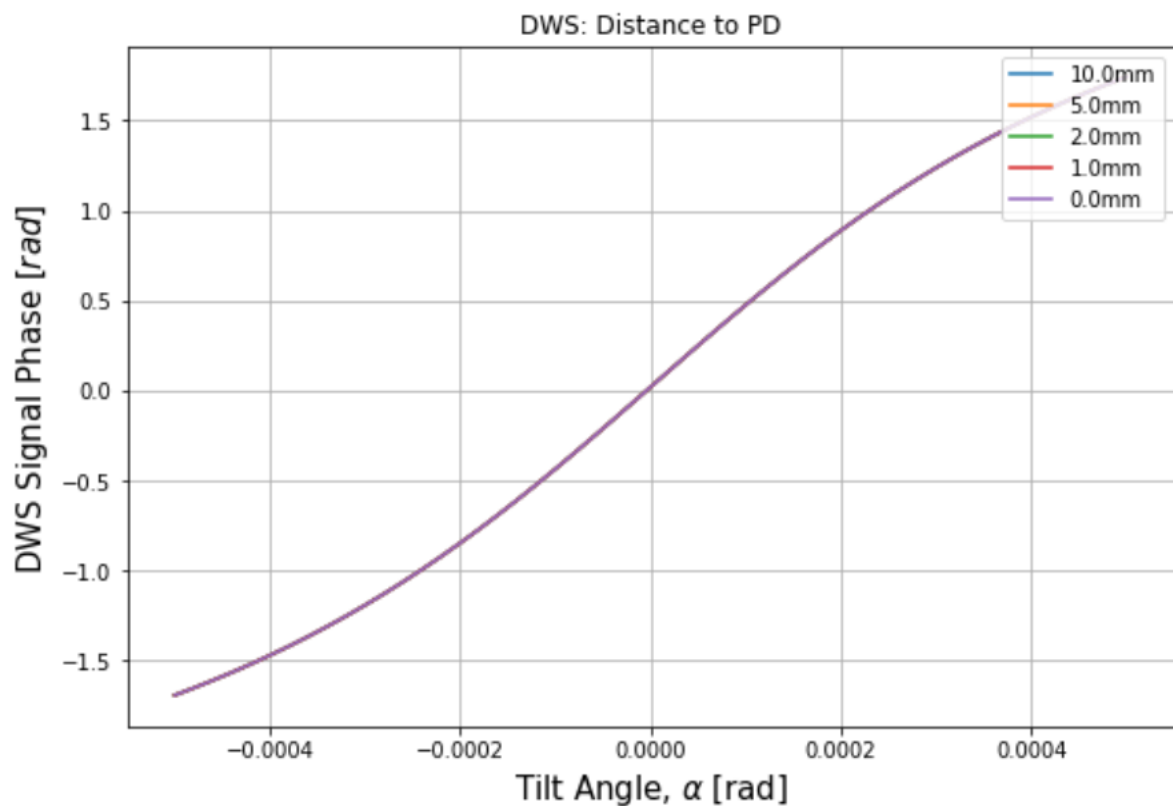


LPS Tophat-Gaussian, Centered on PD - defaults



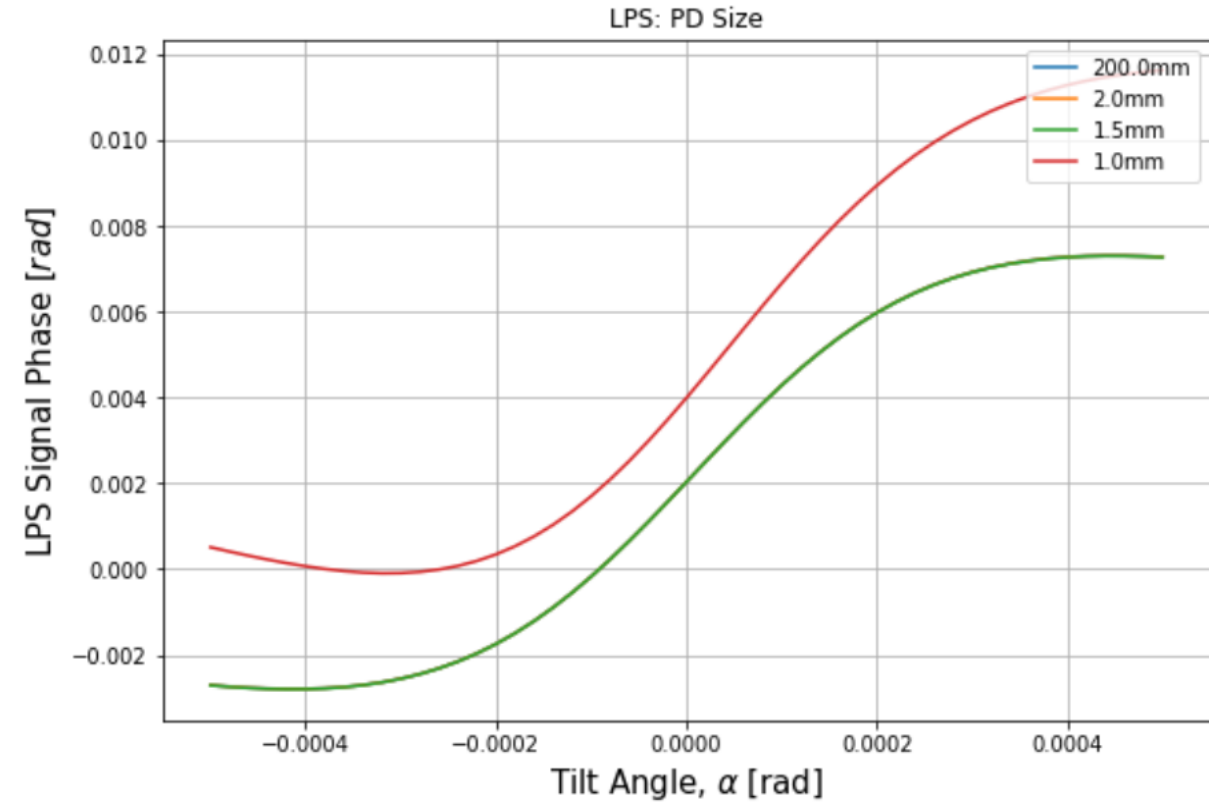
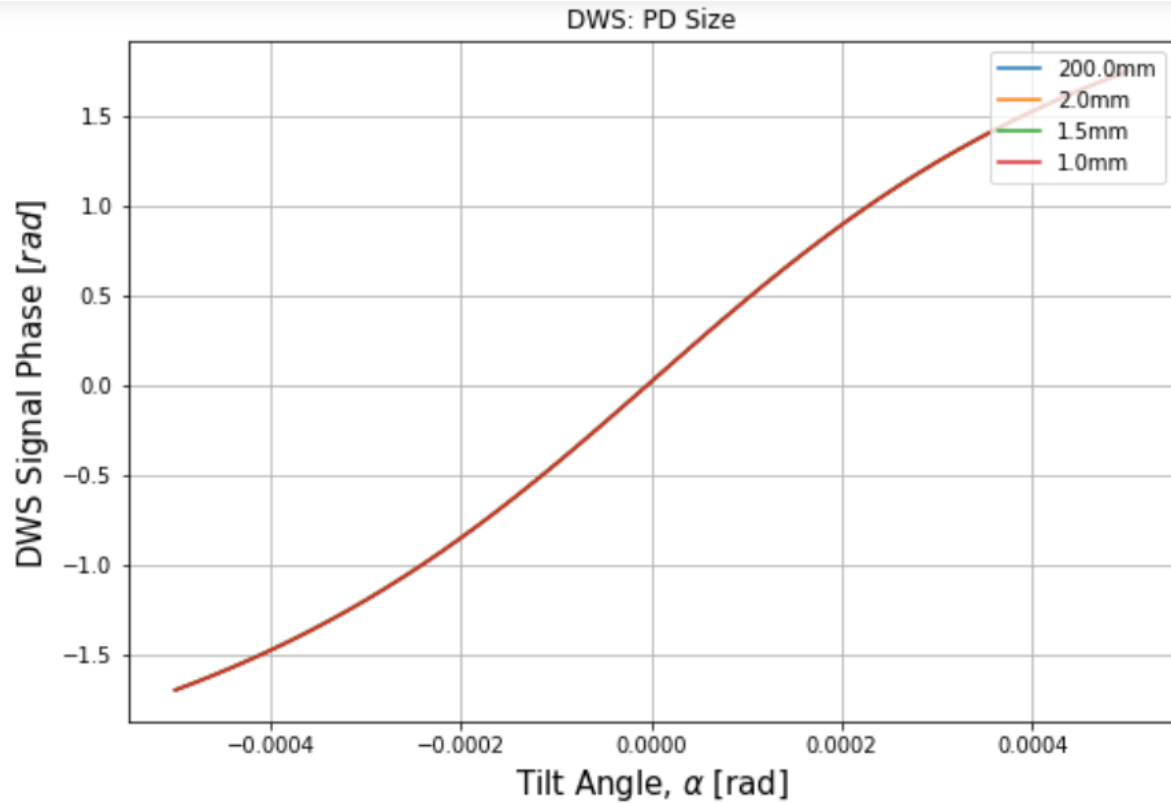
# Distance to PD[mm]

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



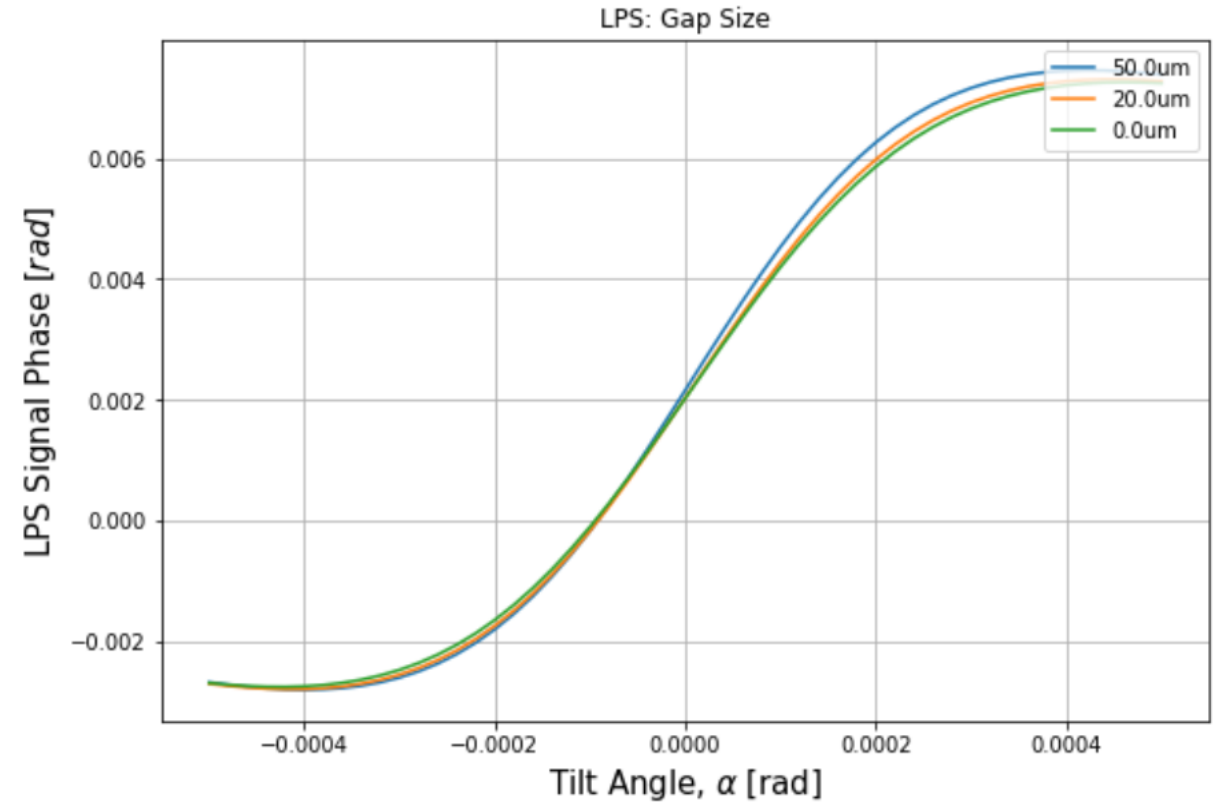
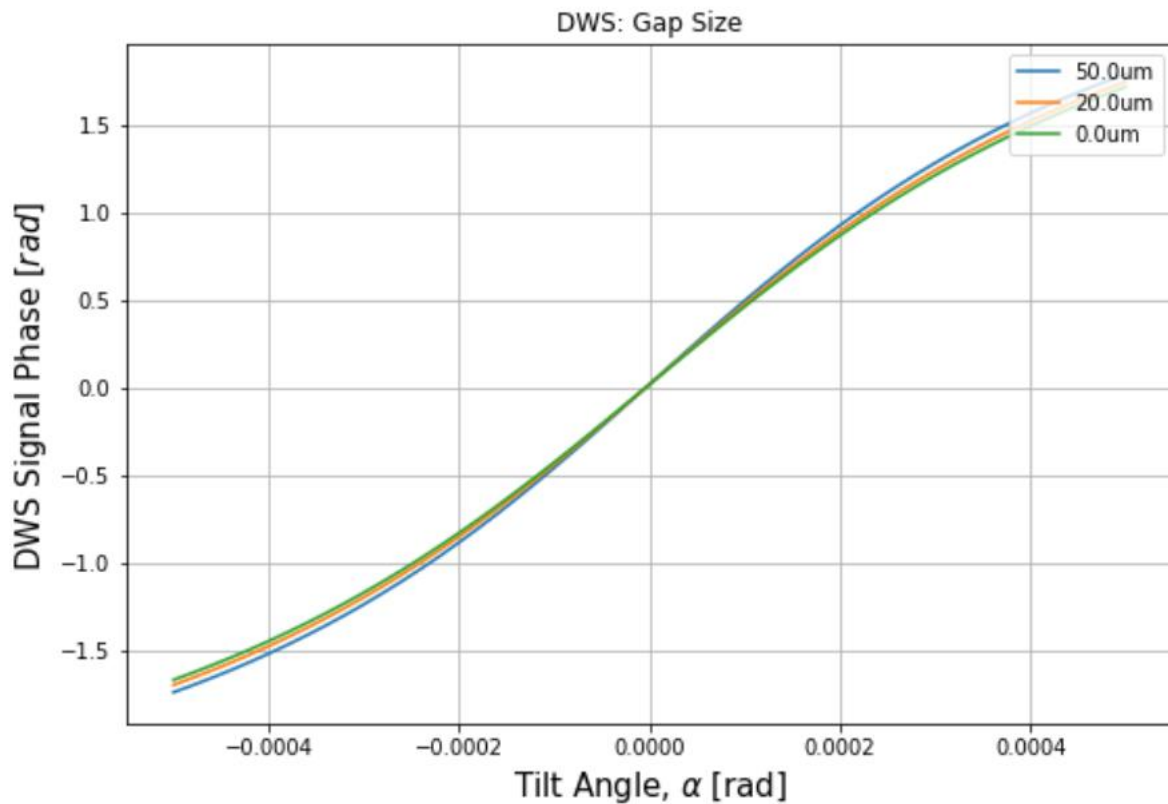
# PD size [mm]

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



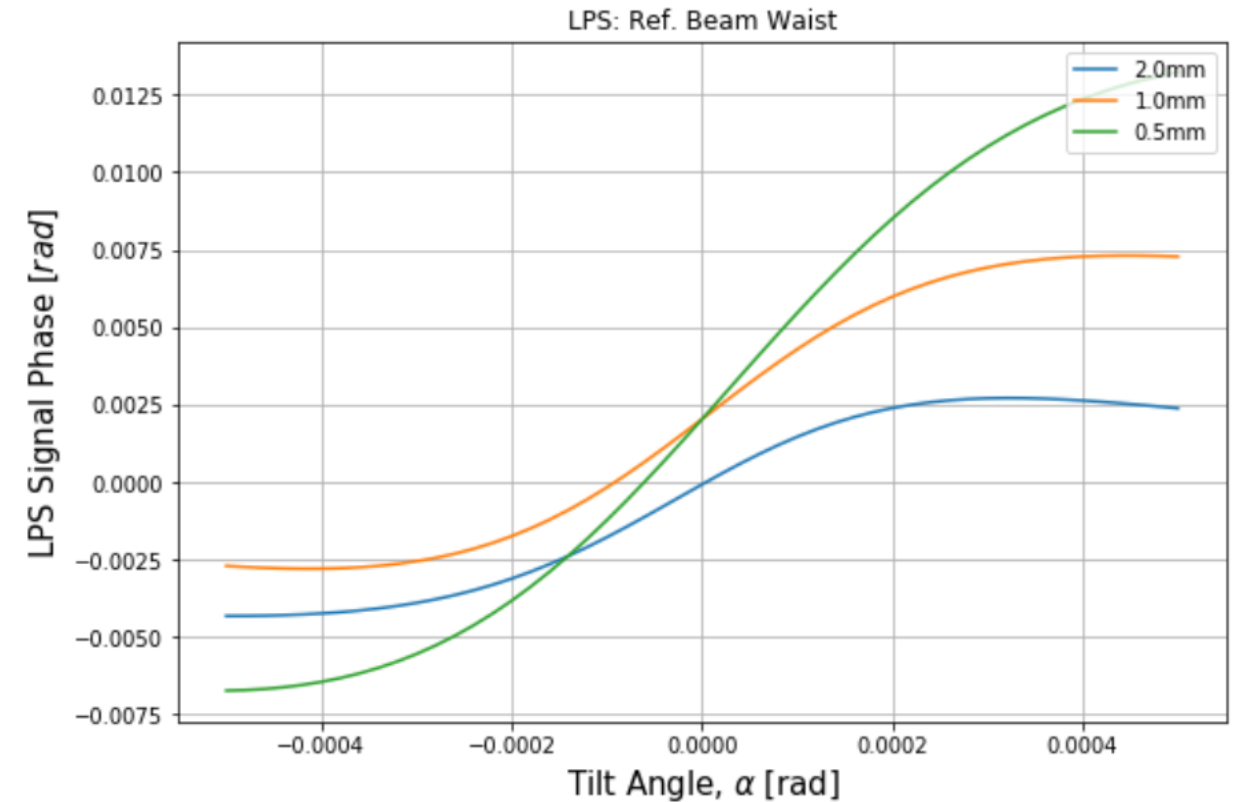
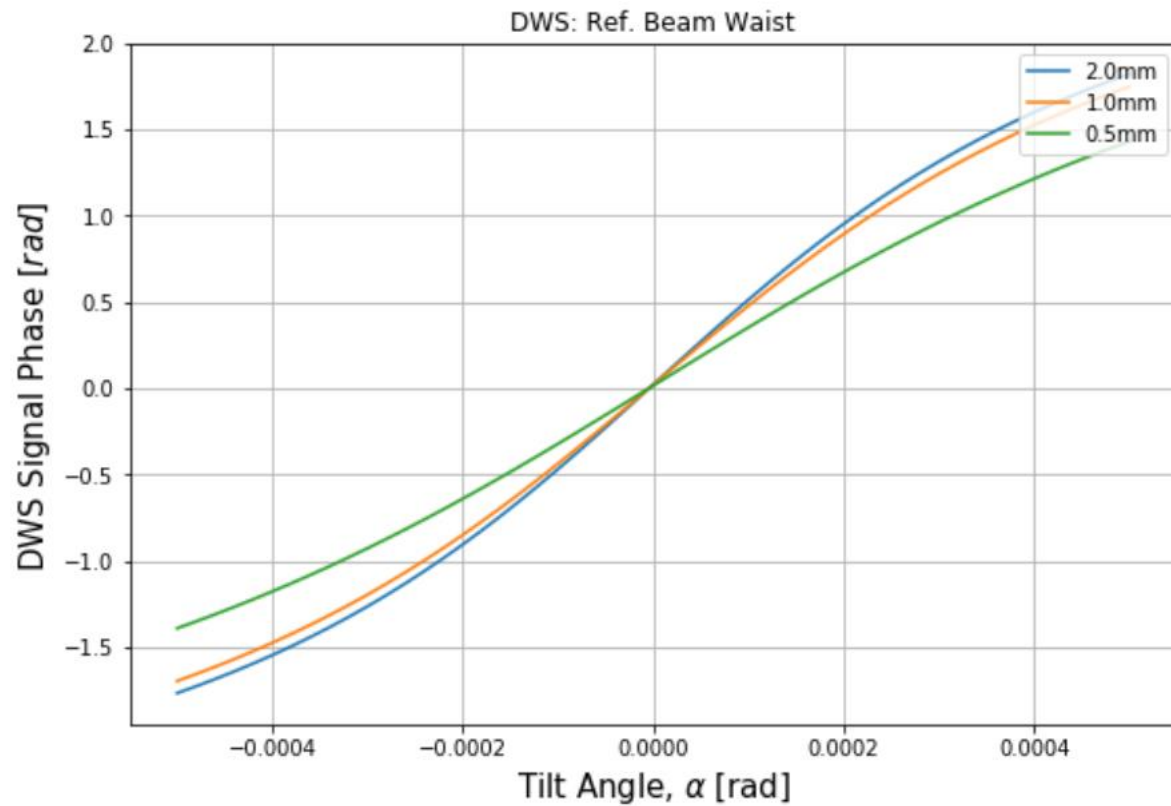
# Gap Size [mm] (half-gap)

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



# Ref. Beam Waist

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



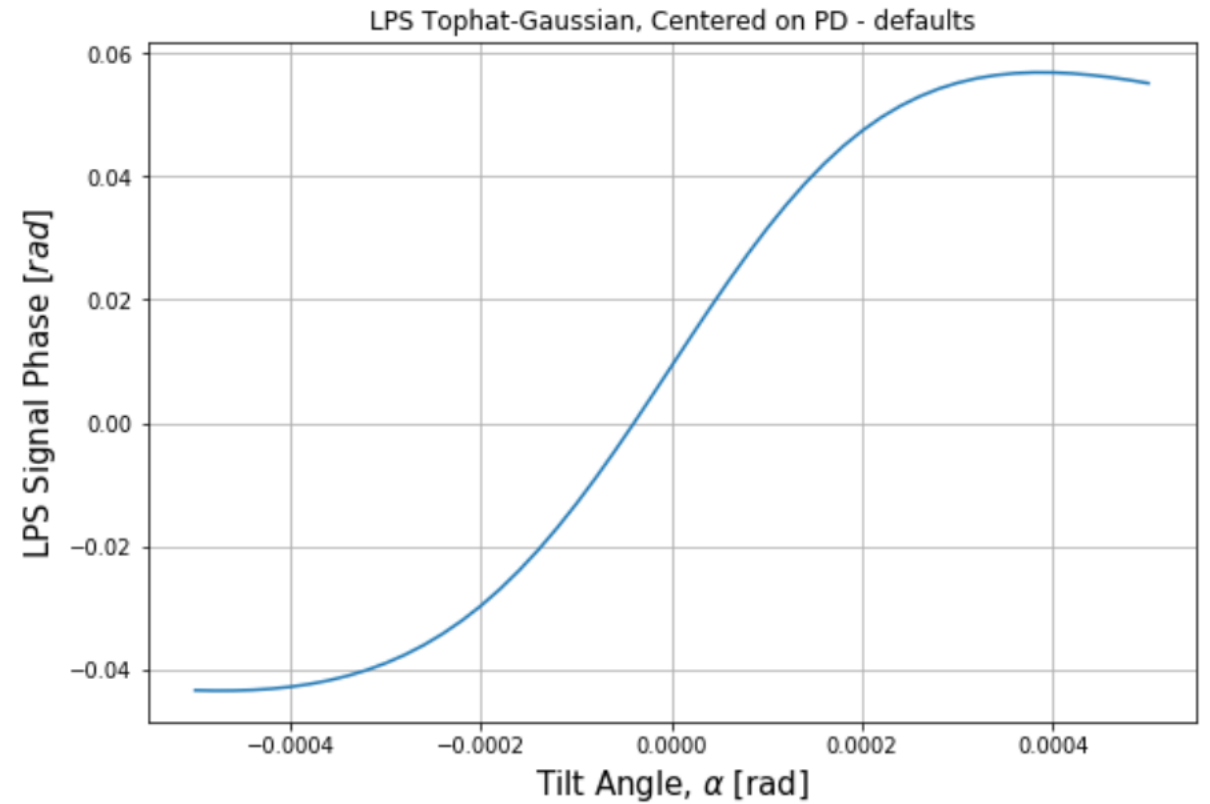
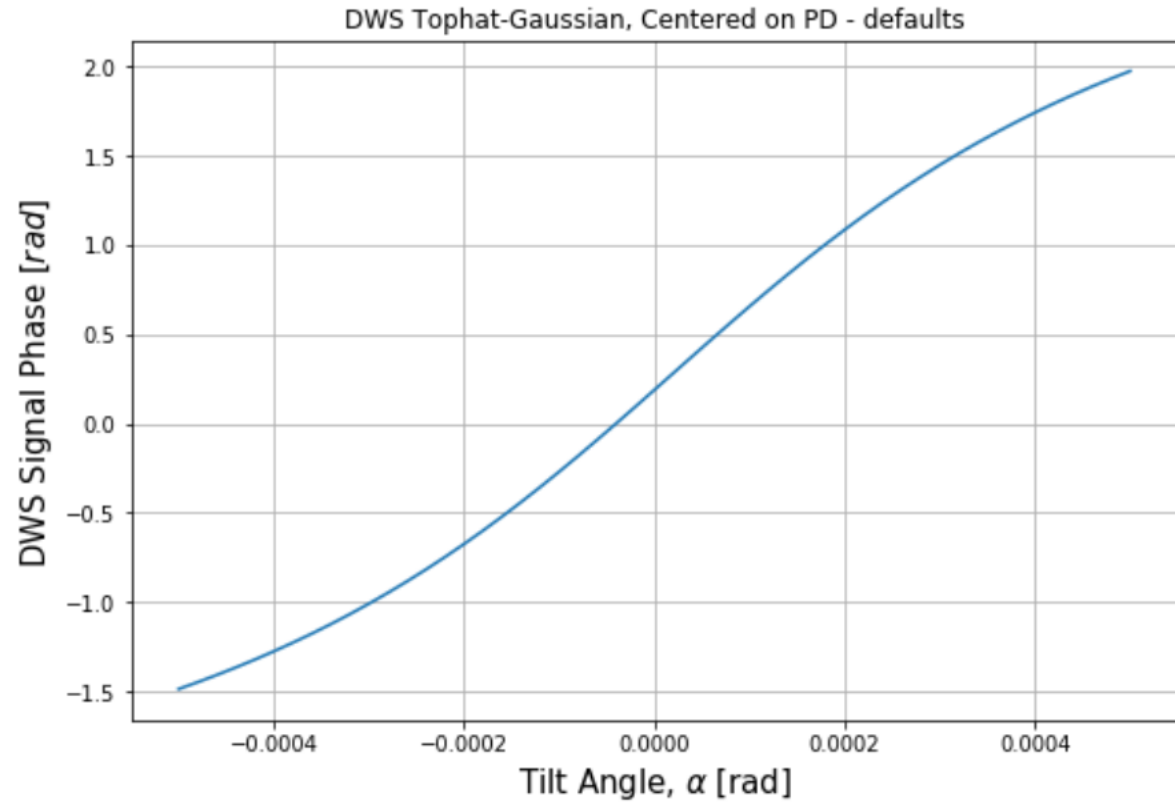


Shift = 100  $\mu\text{m}$

- Default values
- Changing one parameter/slide

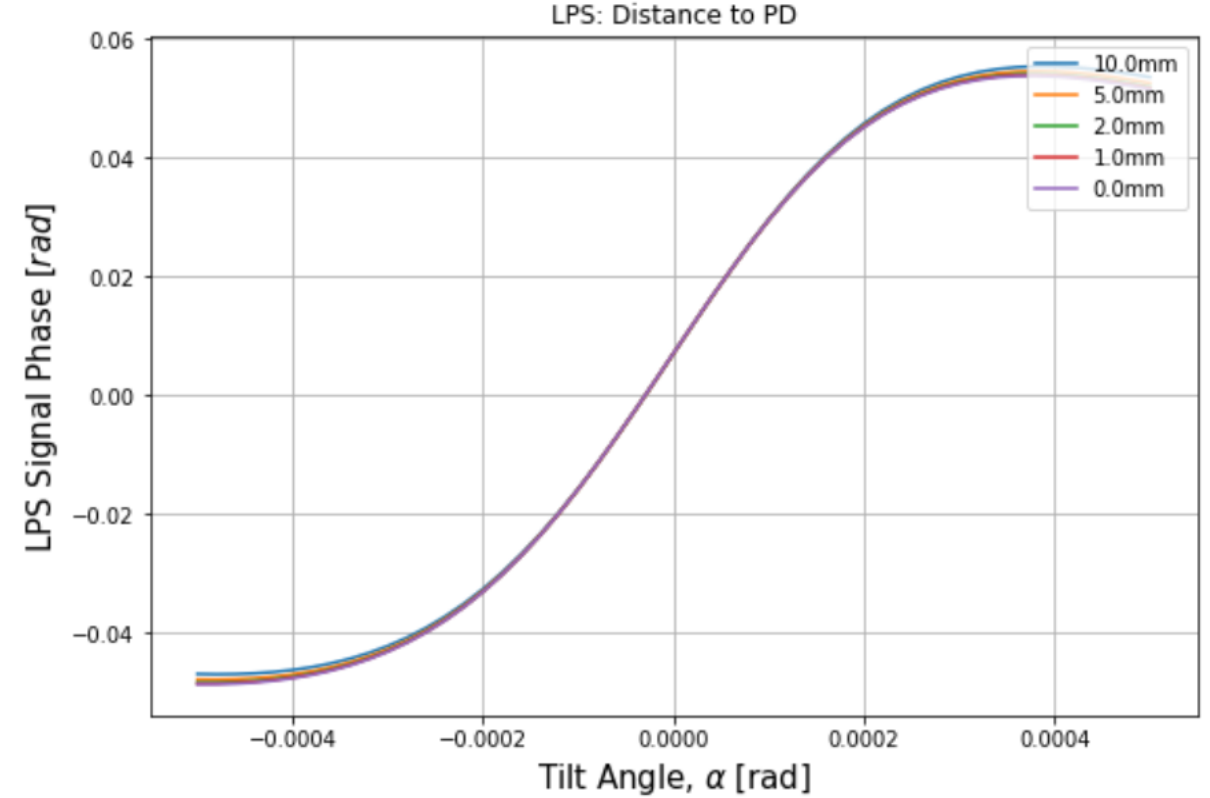
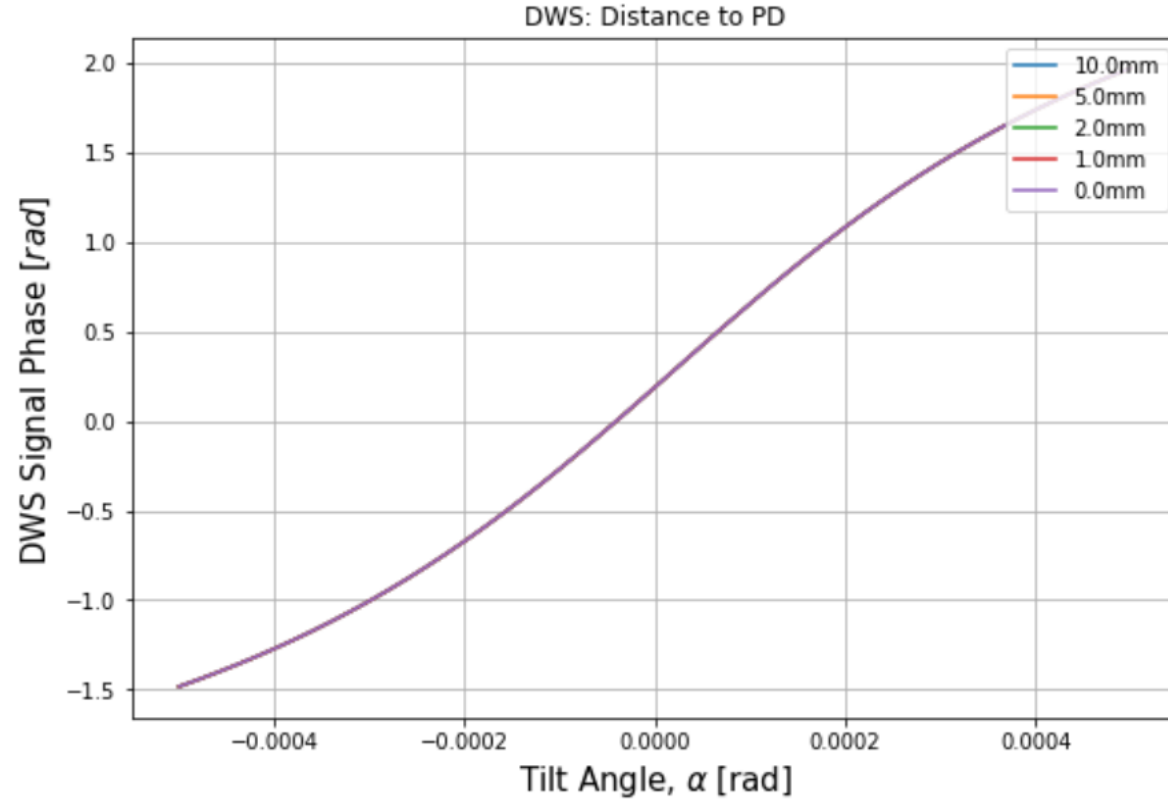
# Defaults

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20 micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	100 micron
Tilt	[-500,500] microrad



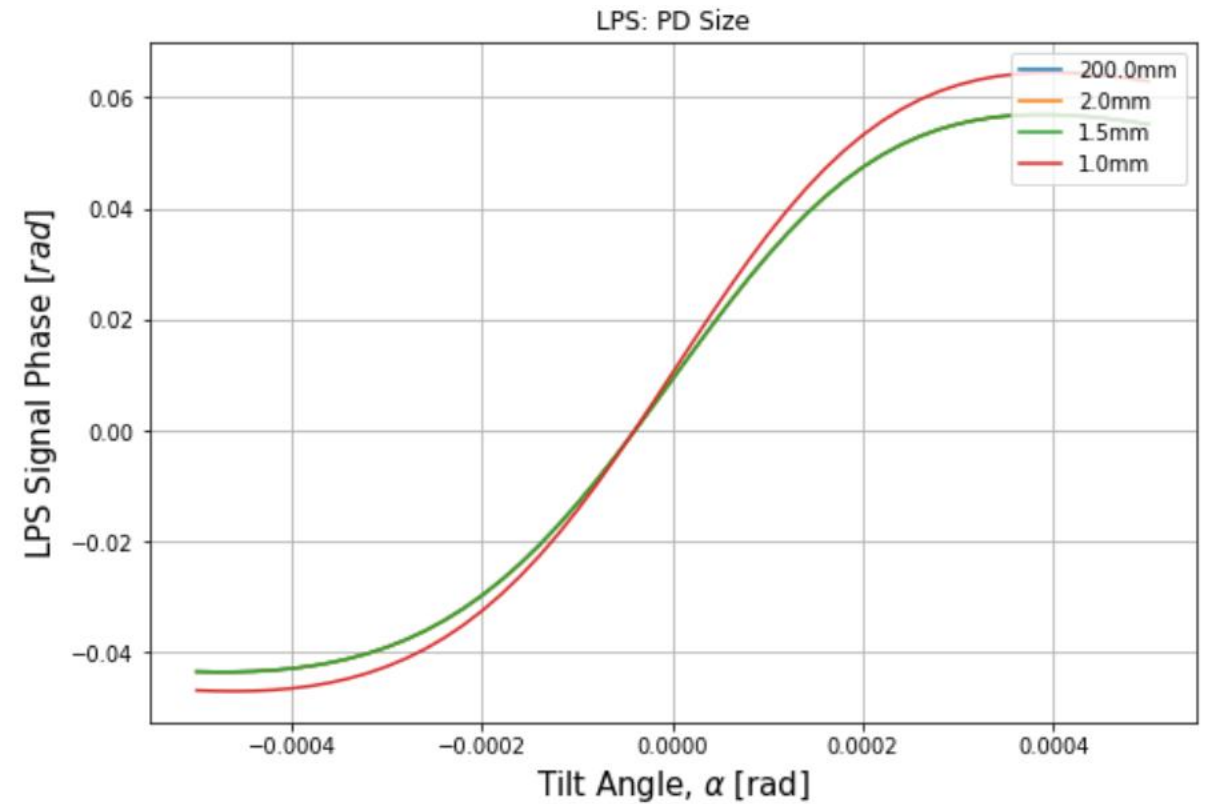
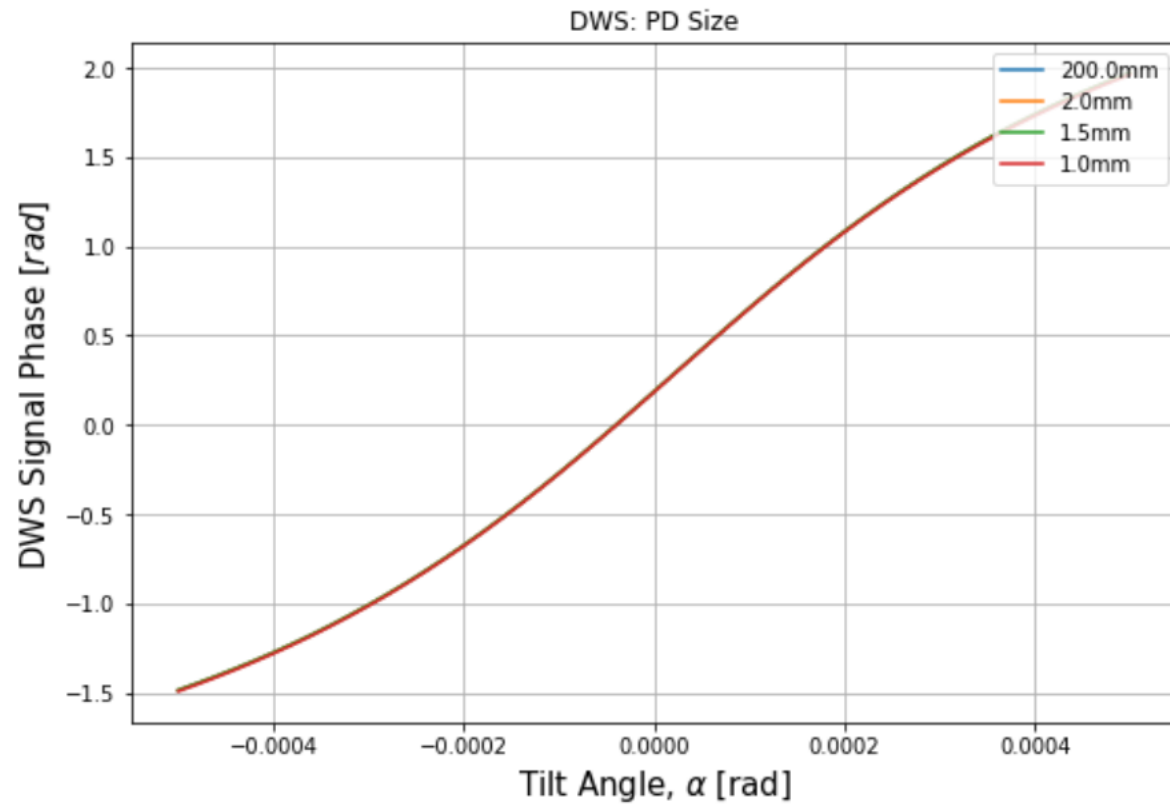
# Distance to PD[mm]

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	100 micron
Tilt	[-500,500] microrad



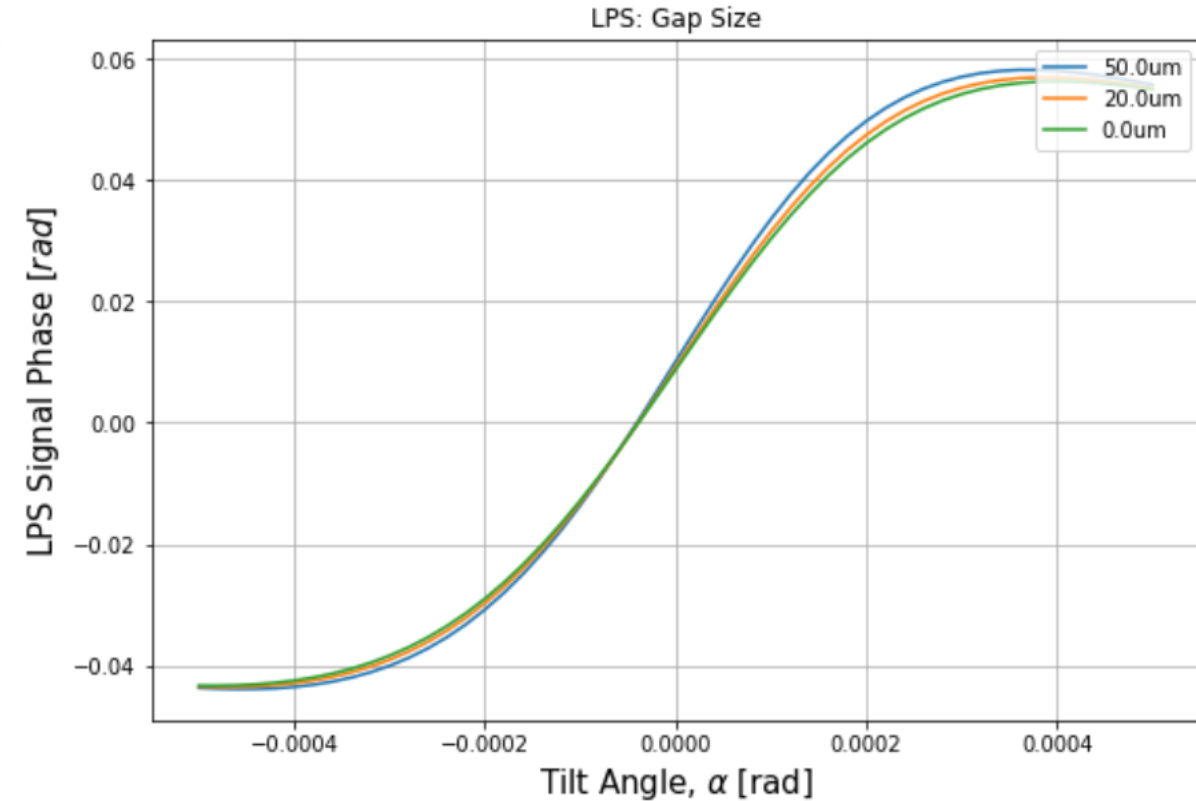
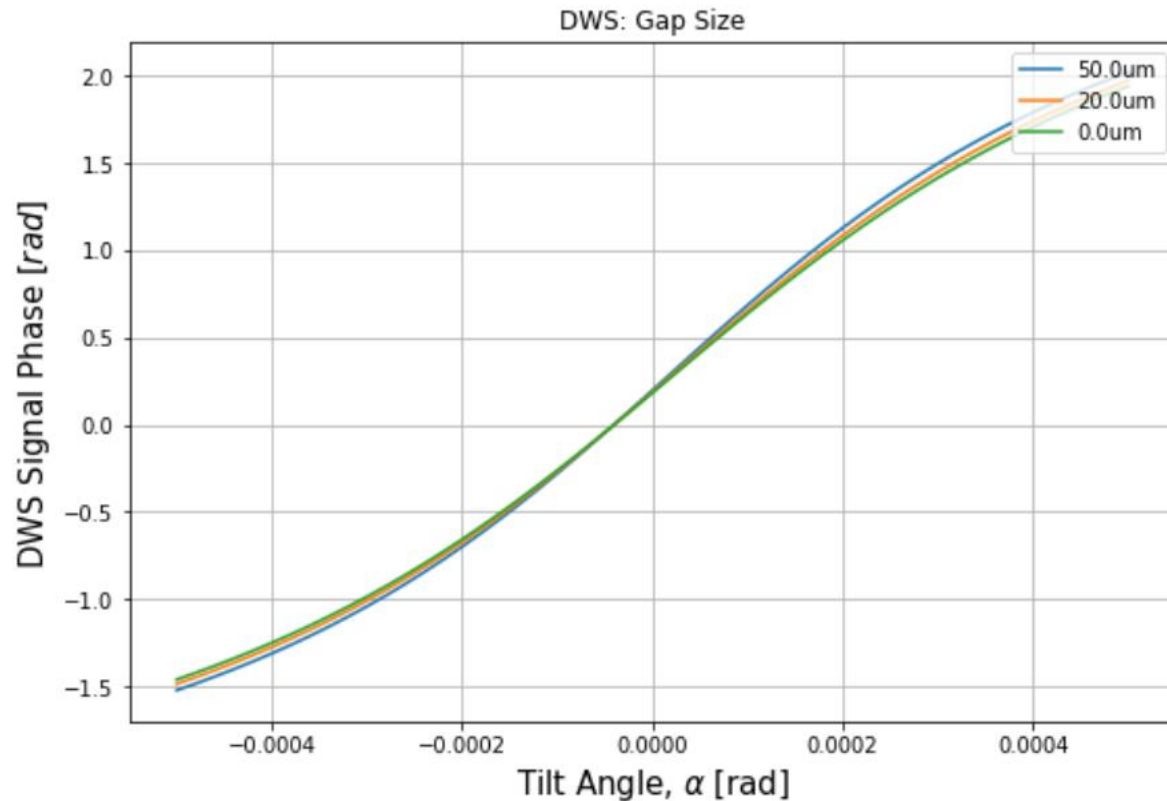
# PD size [mm]

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	100 micron
Tilt	[-500,500] microrad



# Gap Size [mm] (half-gap)

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	10 micron
Tilt	[-500,500] microrad



# Ref. Beam Waist

Param.	Default Value [mm]
PD-ref. , meas. beam distance	10
PD size	2x2
PD gap	0.02 (20micron right & left)
Meas. Beam waist	0.23067
Ref. Beam waist	1
Shift	100 micron
Tilt	[-500,500] microrad

