

PROBA-V EXPERIMENTAL PHASE : LUNAR CALIBRATION

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CONTENT

- PROBA-V Lunar Calibration
- LIME Model
- Experiment
- Acquisitions
- Result : comparison with LIME
- Conclusion



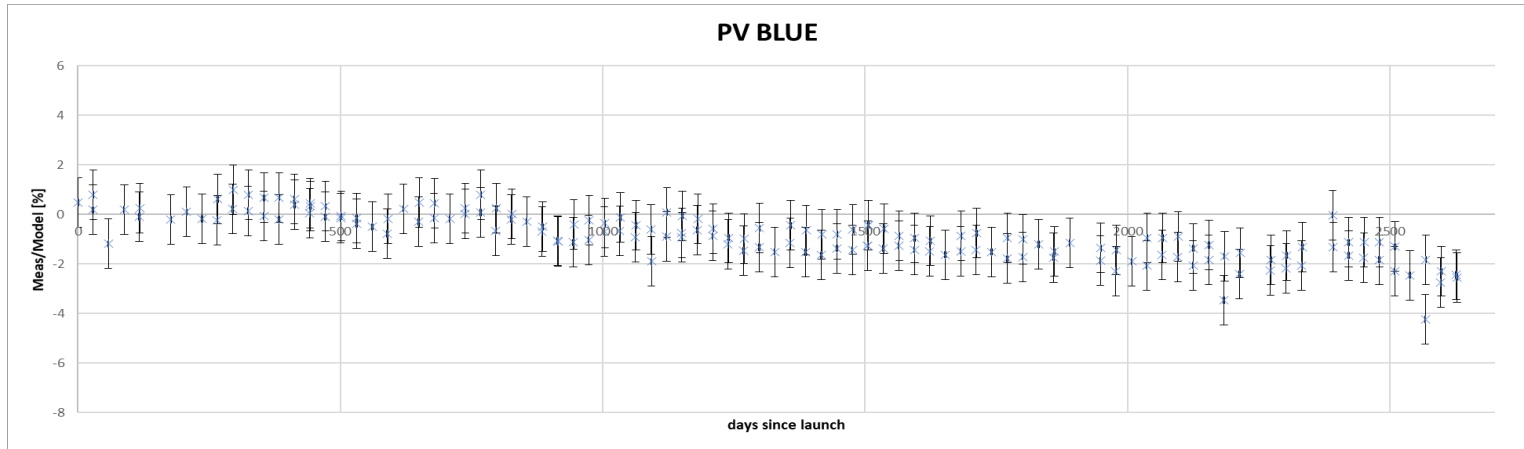
PROBA-V LUNAR CALIBRATION

- 'Nominal Lunar Acquisitions' : every month 2 lunar acquisitions are taken with CENTER CAM at +/- 7 degrees phase angle (based upon recommendation)
- Comparison with Lunar Irradiance Model ESA (LIME) for radiometric calibration
- Very good method to verify instrument degradation monitoring over time (<=1%/year degradation can be detected)
- Quite good agreement with the other methods



PROBA-V LUNAR CALIBRATION

- Example plot : Absolute comparison of the PV BLUE observations with LIME in % for the total lifetime





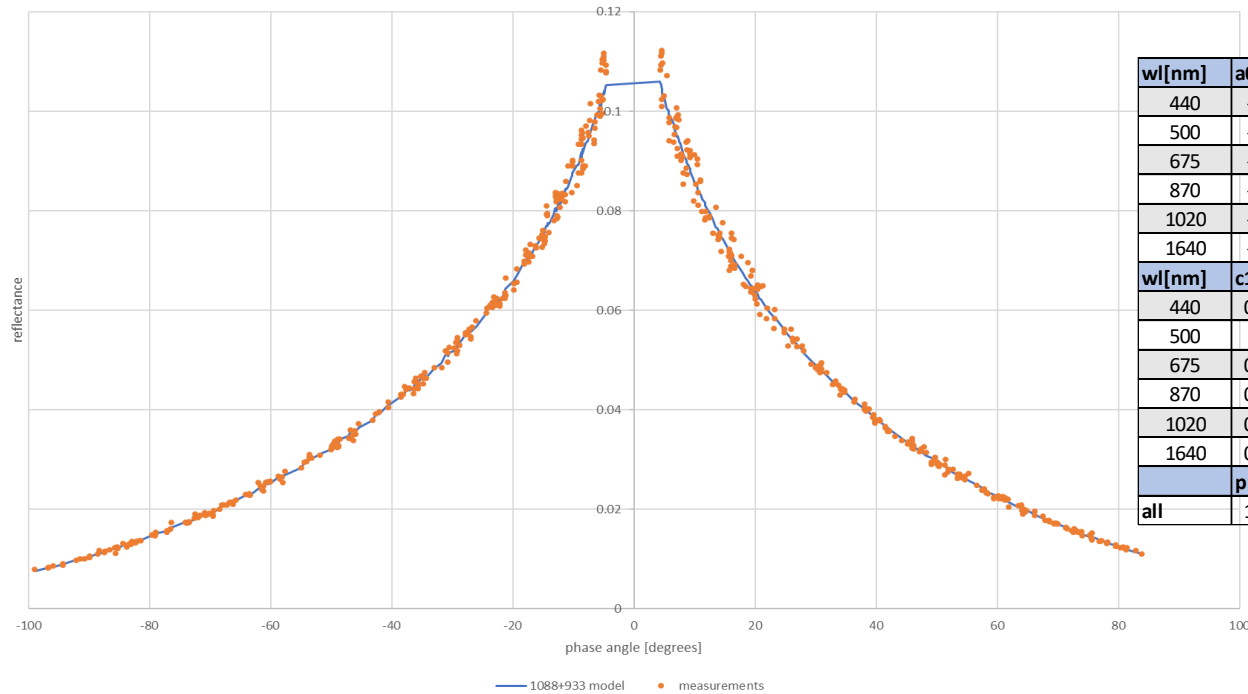
LIME MODEL

- The LIME model is (currently) derived from +/-300 irradiance measurements
 - NPL (UK), UVa (ES) and VITO(BE)
- CIMEL instrument at 6 different wavelengths at 440,500,675,870,1020,1640 [nm]
- The model simulates the observed exo-atmospheric total irradiance to be observed by any sensor within the 400nm – 2500nm wavelength range
 - Timestamp, location
 - Sensor spectral response
- Total Irradiance of the Moon is highly phase angle dependent

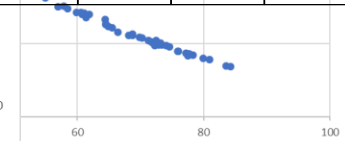


LIME MODEL

➤ Lunar Irradiance Measurements CIMEL 440nm (@Tenerife)



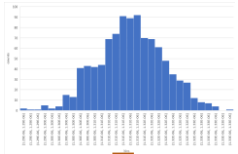
wl[nm]	a0	a1	a2	a3	b1	b2	b3
440	-2.82195	-0.67058	-0.35391	-0.01226	0.059246	0.005286	-0.00426
500	-2.51509	-1.01093	-0.06614	-0.09286	0.054643	0.009163	-0.00532
675	-2.38188	-0.67037	-0.28114	-0.0469	0.053769	0.006141	-0.00345
870	-2.26185	-0.60165	-0.31416	-0.03947	0.054968	0.010404	-0.00499
1020	-2.16789	-0.59006	-0.31791	-0.03482	0.057767	0.015604	-0.00728
1640	-1.75563	-0.60829	-0.27471	-0.04719	0.053116	0.006556	-0.00364
wl[nm]	c1	c2	c3	c4	d1	d2	d3
440	0.002143	0.000571	0.001373	0.000412	0.393375	0.590169	0.000999
500	0.00182	0.000218	0.001304	0.000555	0.840597	0.388049	-0.00117
675	0.001496	0.000229	0.001521	0.000706	0.328802	0.496161	-0.00061
870	0.001364	8.25E-05	0.001628	0.000624	0.376939	0.479259	-0.00021
1020	0.001457	-3.04E-05	0.001754	0.001015	0.456871	0.453514	-0.00094
1640	0.001473	5.62E-05	0.001497	0.00094	0.420775	0.315047	-0.00021
	p1	p2	p3	p4			
all	1.449524	19.68723	10.78809	8.994821			





LIME MODEL

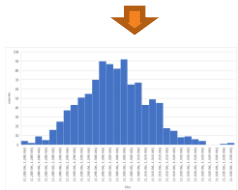
- The uncertainty at model wavelengths is derived using Monte Carlo analysis : every input measurement to the model has been perturbed 1000 times



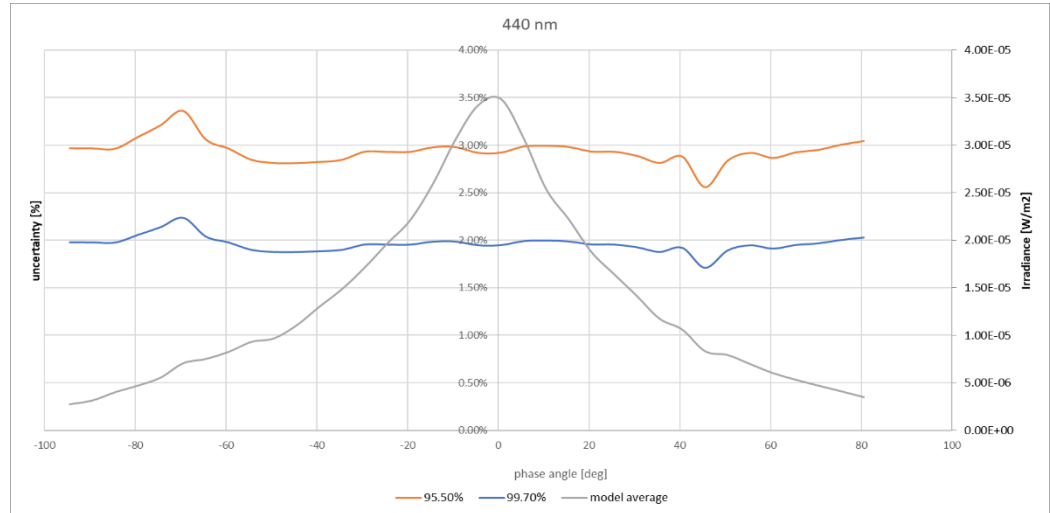
Input irradiance perturbed
1000x based upon
meas. uncertainty



Results : 1000 models



1000 model results per
observation



Uncertainty is established at 2% (2 sigma)



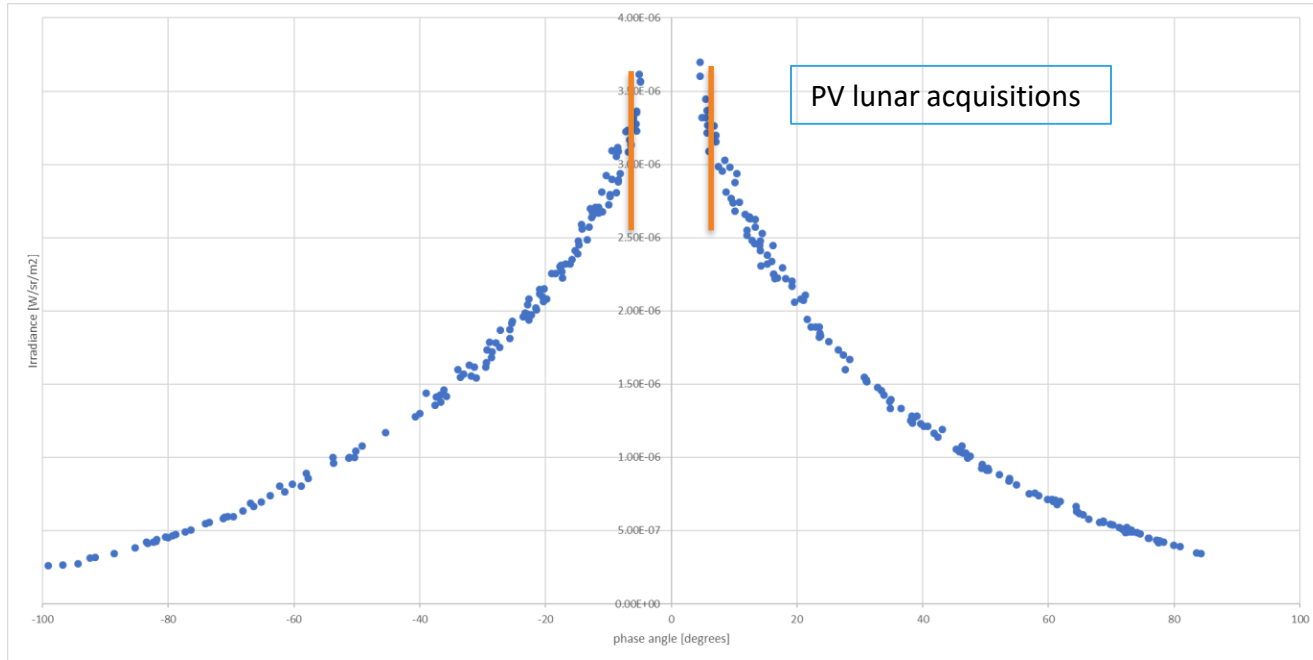
LIME MODEL

- The model development is ongoing
 - measurements
- The uncertainties defined do not cover the full model
 - Lunar reflectance spectrum interpolation
 - Application of spectral response function
- Possible phase angle dependency needs to be addressed
- To do this, we need (good) data



LIME MODEL

- PROBA-V only observes a limited set of the model phase angle range





EXPERIMENT

- PROBA-V operational phase ended in Mid 2020
 - **Lunar Calibration Workshop GSICS 2014** : (one) final recommendation to satellite operators : “capture the Moon as much as possible during satellite lifetime to improve lunar calibration in general”
 - VITO & ESA are involved in the development of a Lunar Irradiance Model (**LIME**). To support this activity, all measurements of the moon are welcome to better understand the model
 - PV lunar measurement uncertainties need to be addressed
 - Opportunities for experimental acquisitions due to ‘freed capacity’ after mid 2020

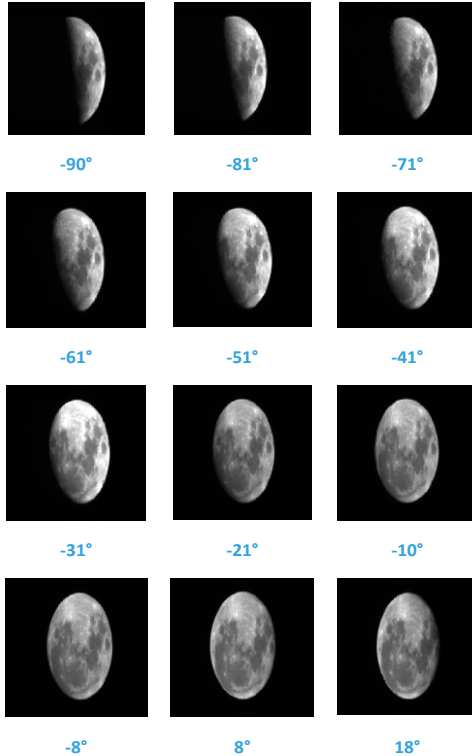


EXPERIMENT

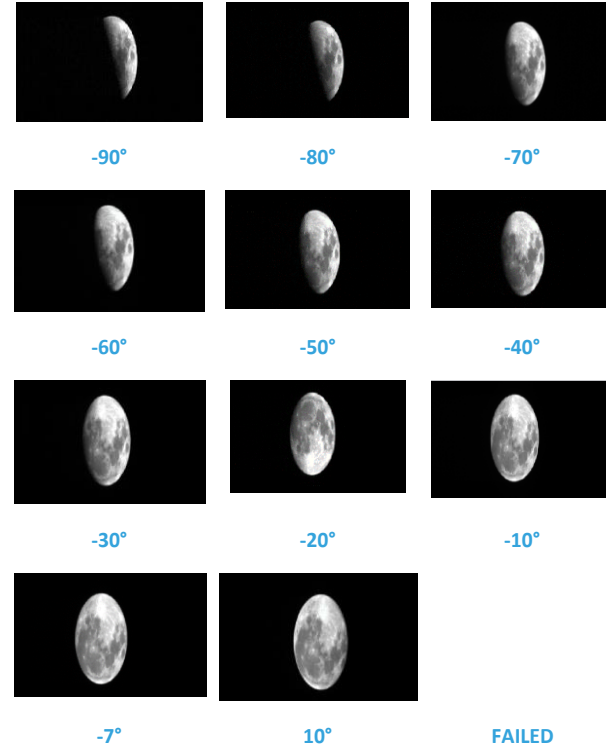
- The idea : to capture Moon full Lunar cycle(s) within the LIME valid model phase angle range : $[-90^\circ \rightarrow -2^\circ]$ and $[2^\circ \rightarrow 90^\circ]$ with approx. 10 degrees spacing
- QinetiQ - ESA-REDU – VITO agreed to capture between -90 and +30 degrees only, due to restrictions in the planning tool to avoid star-tracker blinding
- Currently 2 cycles have been recorded at November and December 2020



ACQUISITIONS



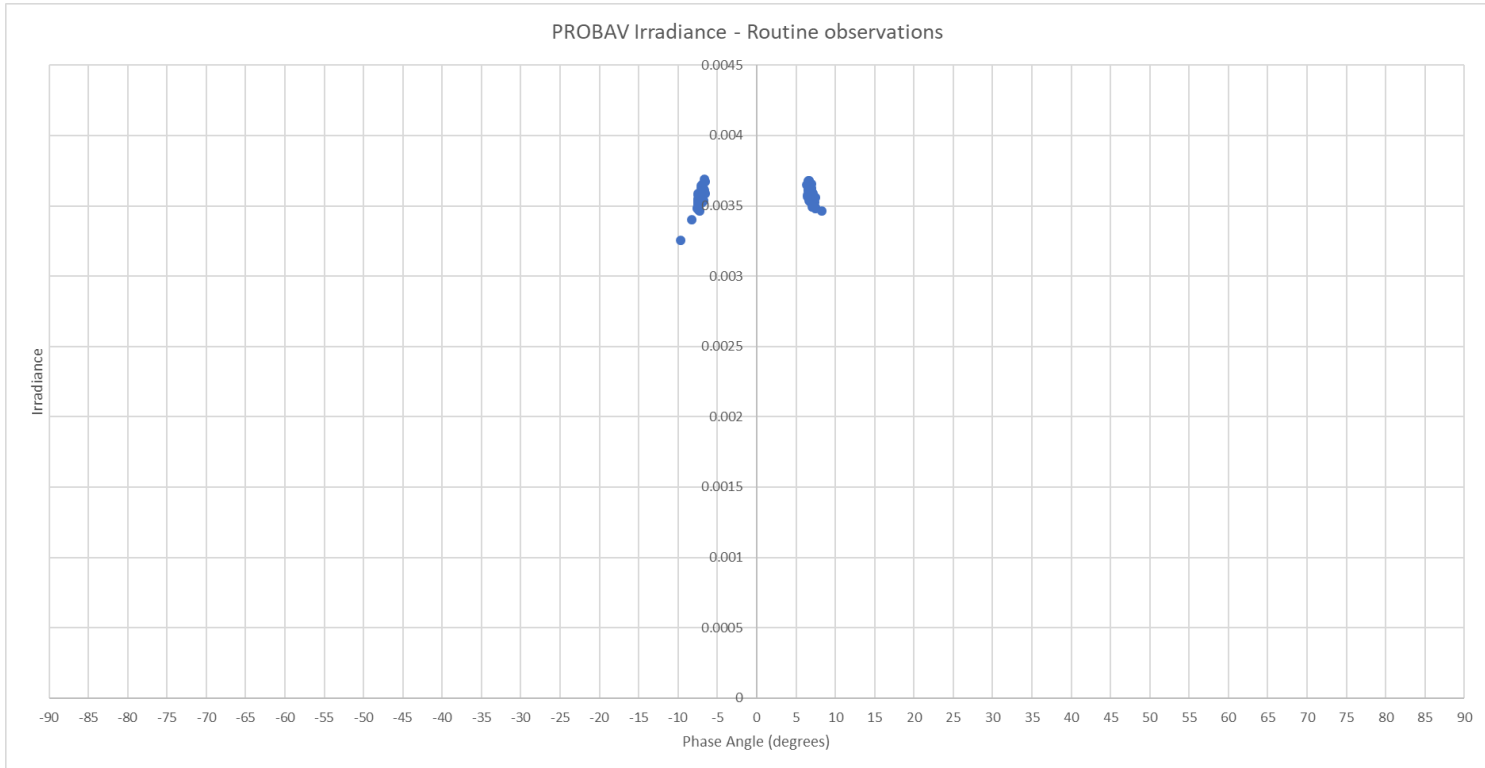
November 2020



December 2020

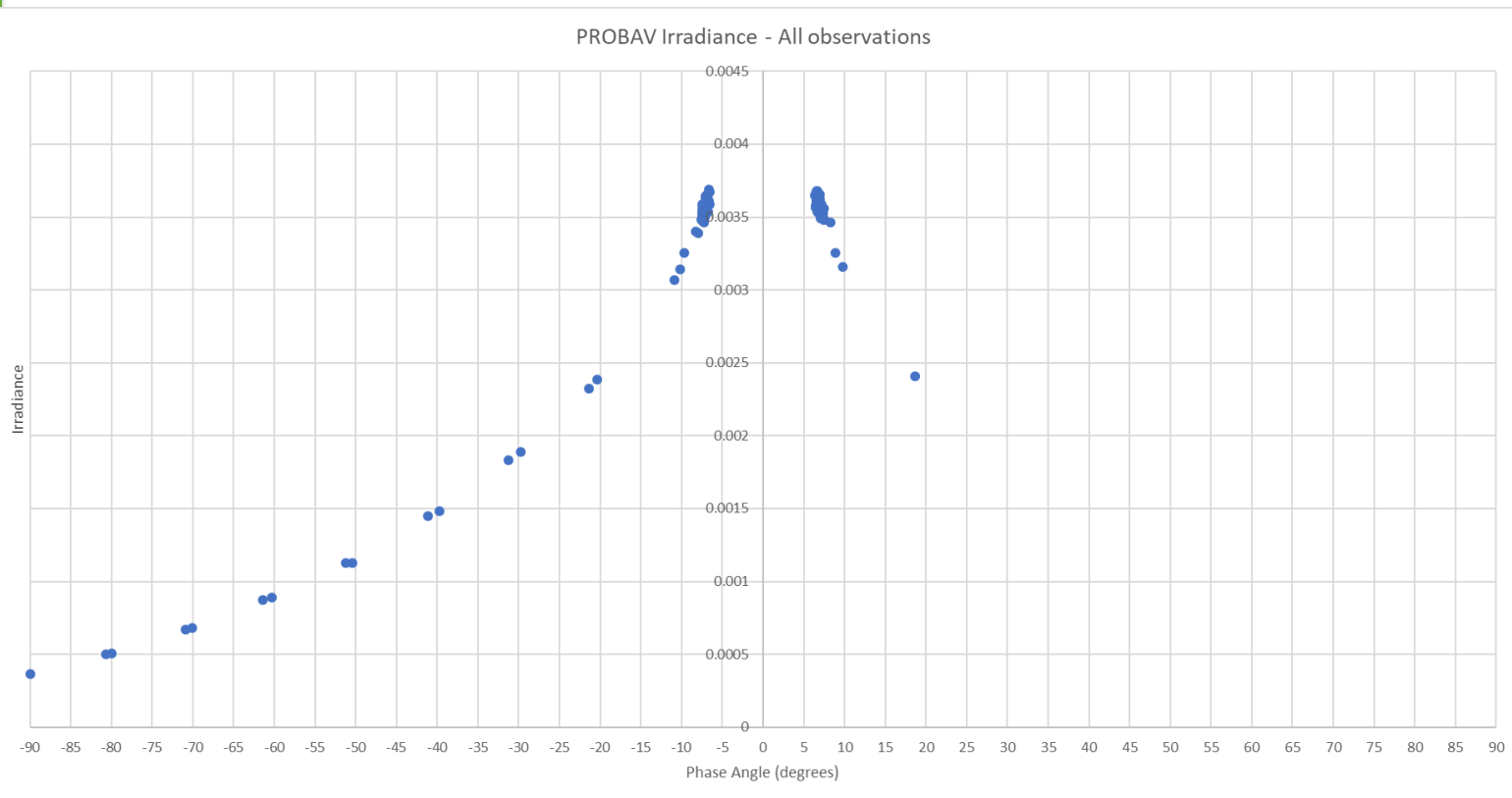


ACQUISITIONS



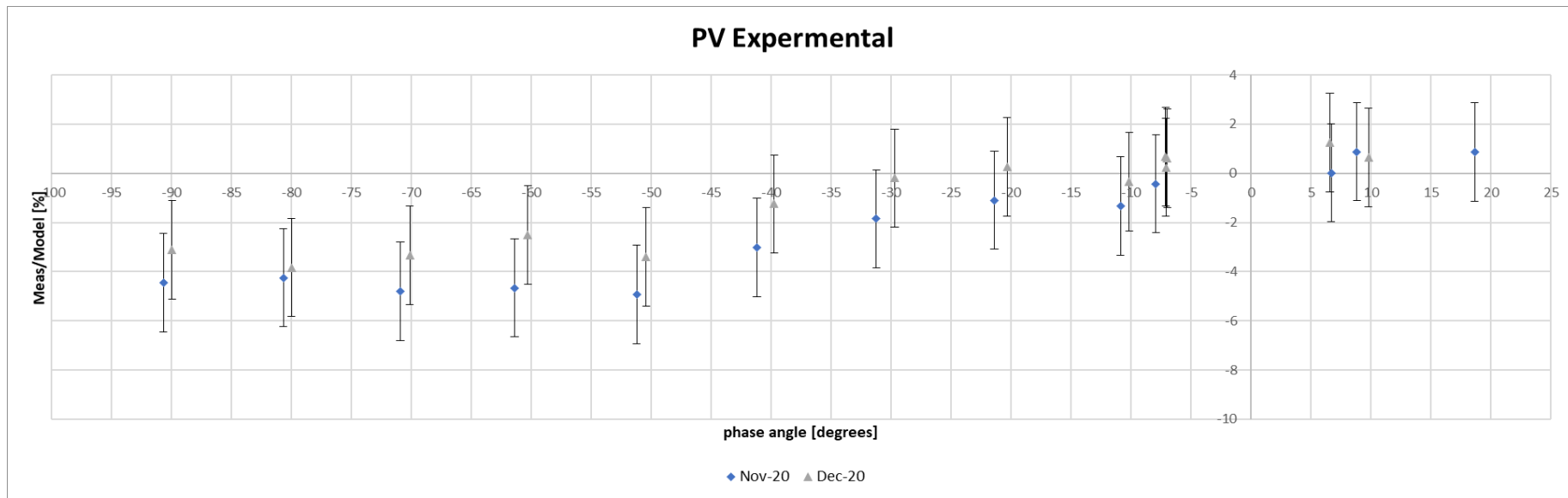


ACQUISITIONS





COMPARISON WITH LIME





CONCLUSIONS

- 2 partial lunar cycles have been acquired successfully (23 lunar observations in total)
- 2 acquisitions failed : one due to timing error (first cycle), one due to absence of telemetry (second cycle)
- Processing of the data went quite smooth
- Comparison with LIME
 - A phase dependency of 4% is detected (average over 2)
 - Contribution of the model yet to be defined with other measurements/sensors
 - The model will be improved in the near future (following 2/3 years)
- VITO would like to do 2 or 3 extra campaigns (with full cycle ?)



**THANKS FOR YOUR
ATTENTION**