

Twilight observations with MASS/DIMM

B. Safonov

Sternberg Astronomical Institute
Moscow State University

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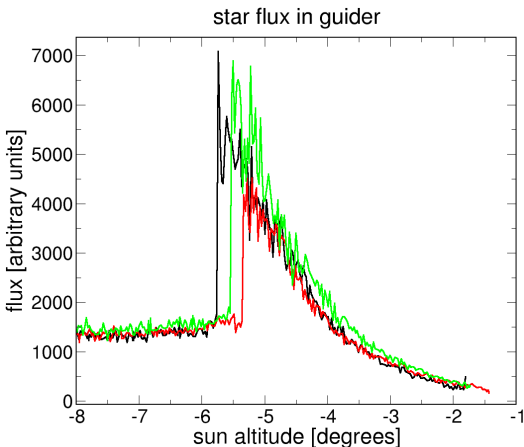
Why observe in twilight with MASS/DIMM?

- It's interesting how turbulence changes during transition from day to night.
- Evening twilight — to predict conditions of OT in forthcoming night.
- Morning twilight — to predict conditions of OT in forthcoming morning(for solar observations).

Our ability to observe in twilight is limited by the level of sky background. ASM includes 3 devices sensitive to background: guider, DIMM and MASS.

Background in guider.

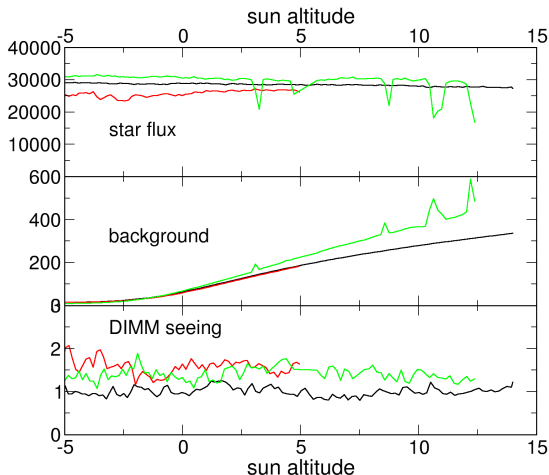
- CCD with angular scale $10''/\text{px}$ \rightarrow relatively sensitive to background.
- Serves for rough pointing to the star (proper pointing accuracy of telescope is quite poor).



Pointing is possible if $h_{\odot} < -1^{\circ}$.

Background in DIMM.

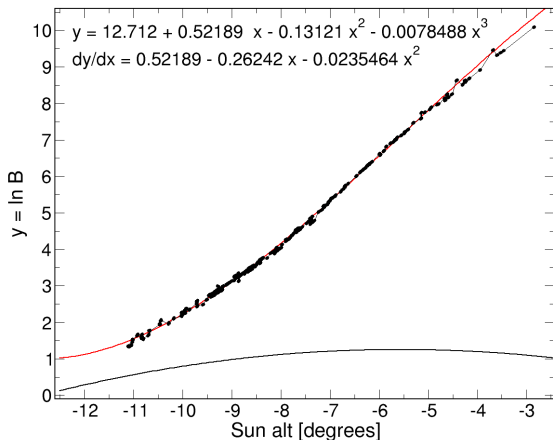
- CCD with scale $0.623''/\text{px}$ \rightarrow DIMM is less sensitive to background.
- Relatively large background doesn't affect measurements.



We can observe
up to $h_{\odot} = +13^{\circ}$

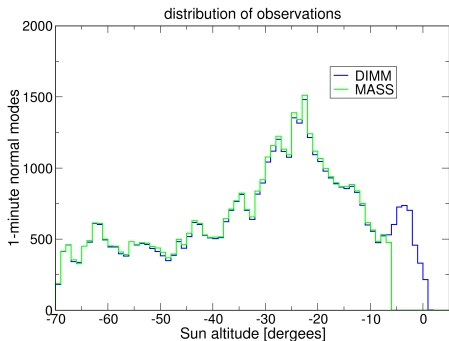
Background in MASS.

- Photometer with diaphragm $\varnothing = 220''$ \rightarrow MASS is very sensitive to background.



Approximation works
for $h_{\odot} < -6^{\circ}$

Statistics of MASS/DIMM twilight observations.



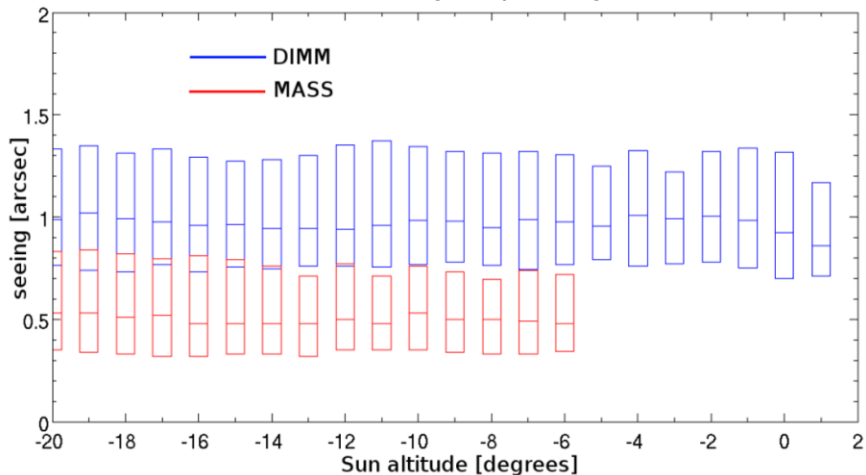
Regular automatic observations in twilight started in November'09. At the moment DIMM works at $h_{\odot} < 0^{\circ}$, MASS works at $h_{\odot} < -6^{\circ}$.

Table: Total duration of twilight measurement.

twilight	h_{\odot} limits	DIMM		MASS	
		evening	morning	evening	morning
total[days]		60	58		
civil[hours]	$(-6^{\circ}, 0^{\circ})$	24.9	38.0		
nautical[hours]	$(-12^{\circ}, -6^{\circ})$	24.8	32.1	24.4	32.5
astronomical[hours]	$(-18^{\circ}, -12^{\circ})$	39.1	48.3	39.5	48.9

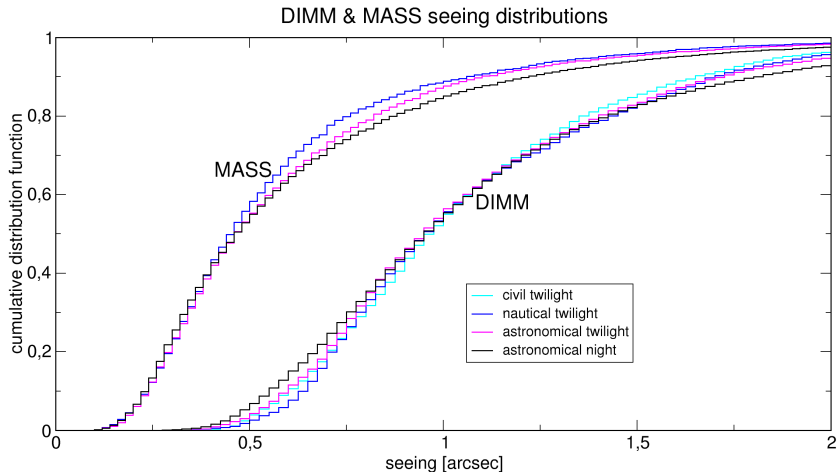
Variation of MASS & DIMM seeings: running quartiles.

Quartiles of MASS & DIMM seeings depending on sun altitude.



Variation of MASS & DIMM seeings: distributions.

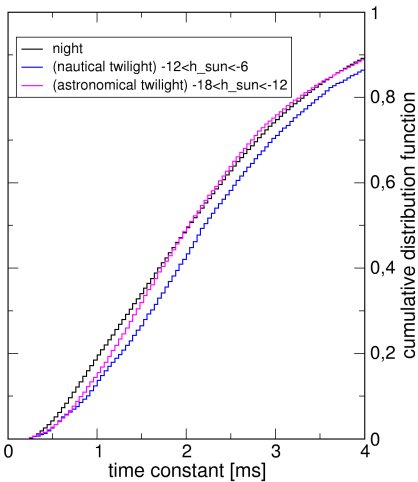
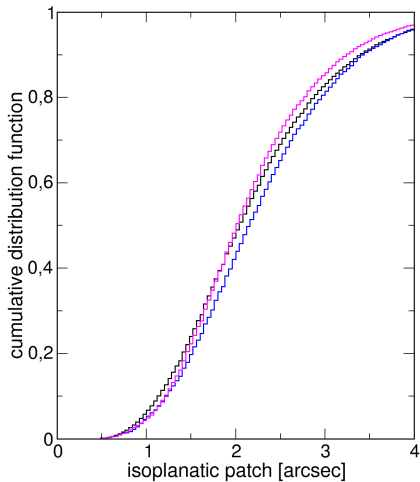
A closer look to distributions of seeings.



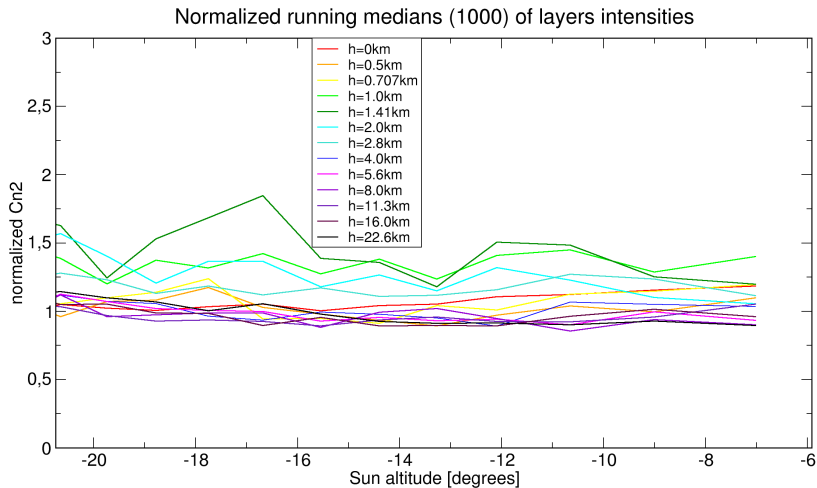
There is no significant dependence.

Variation of isoplanatic patch and time constant.

Cumulative distribution functions.



Variation of turbulent layers intensities.



Classification of nights.

- Take a parameter that we want to predict. Let's suppose this is DIMM seeing.
- Compute its mean β_T using twilight measurements
 $0^\circ > h_\odot > -12^\circ$
- Classify night using β_T .

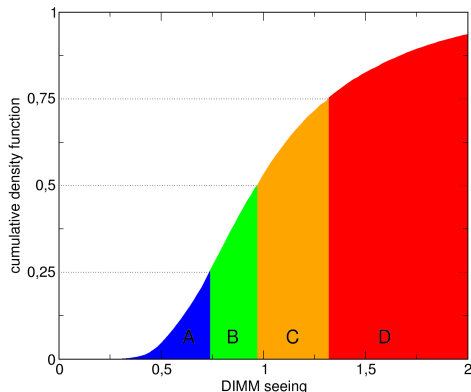


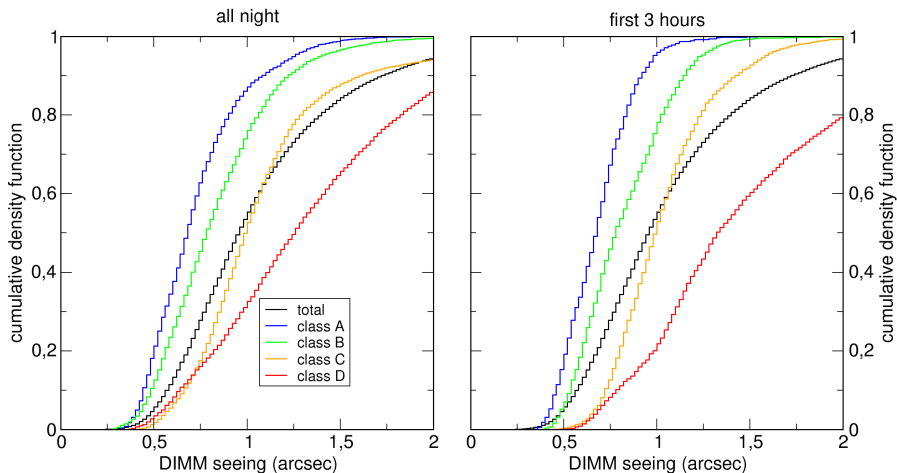
Table: Classes.

class	β_T
A	$(0, q_1]$
B	$(q_1, q_2]$
C	$(q_2, q_3]$
D	$(q_3, \infty]$

where q_i — quartiles of distribution of seeing.

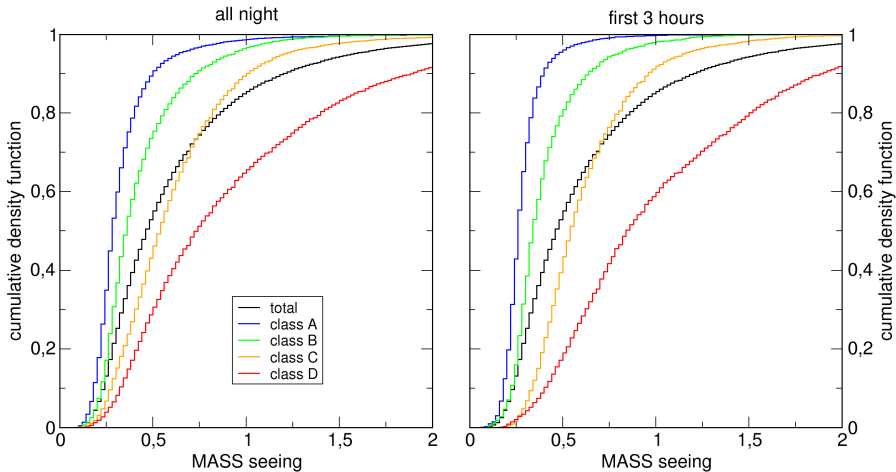
Prediction of DIMM seeing: distributions.

Distribution of DIMM seeing depending on night class.

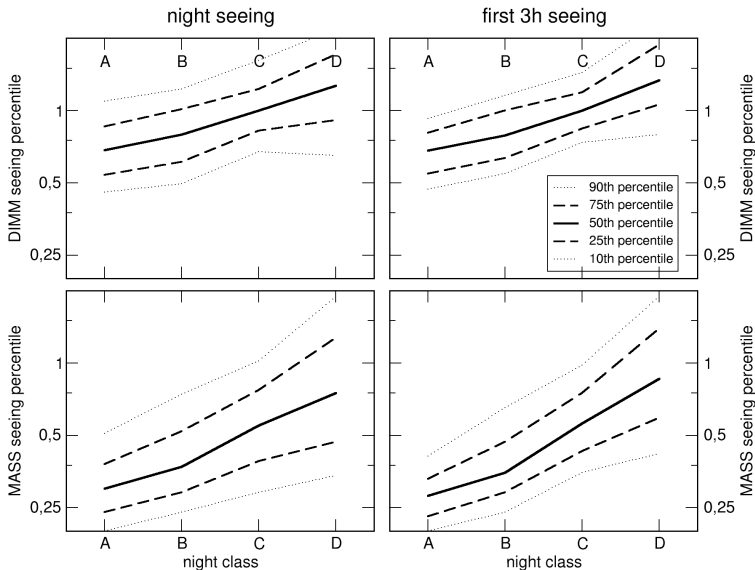


Prediction of MASS seeing: distributions.

Distribution of MASS seeing depending on night class.

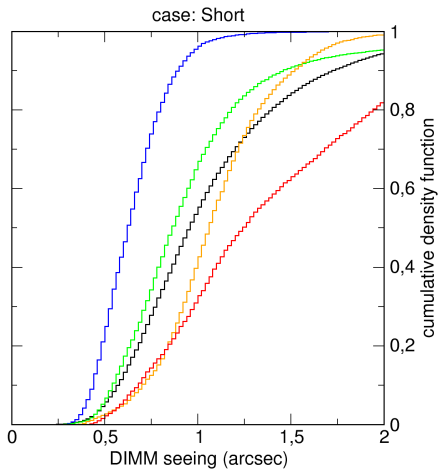
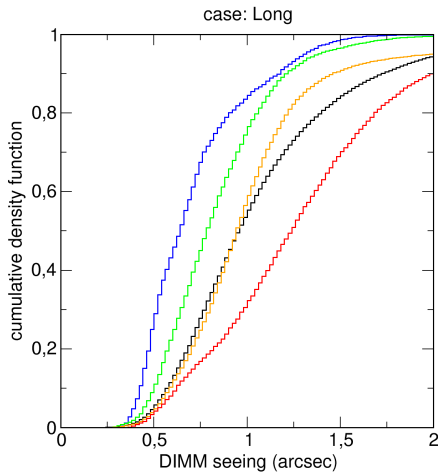


Prediction of MASS & DIMM seeings: percentiles.



Prediction of seeing.

Cases of long and short preparation time.



Conclusions

- Limiting sun altitudes for current configuration:
 - Guider $h_{\odot} < 0^{\circ}$
 - DIMM $h_{\odot} < +10^{\circ}$
 - MASS $h_{\odot} < -6^{\circ}$
- It appears that there were no significant changes in OT characteristics for investigated interval of sun altitudes ($h_{\odot} < 0$).
- Practical use — “prediction of seeing”.
 - If observational program switching takes more than 20-30 minutes.
 - If there is an observational program for twilight.

This is all valid for our particular summit — Mt. Shatdjatmaz!

Further upgrade

What we can do to reduce effect of background on:

- MASS
 - Reduce jitter of mount.
 - Shrink MASS diaphragm to 20".
- Guider
 - Improve mount pointing accuracy.
 - Remove guider.