Optimal exposure time for detecting events with small dip depth (dip depth < 1,5 mag)

The following questions will be examined:

- **How many measuring points are needed for events with small signal to get a positive event calculated?**
- **What S/N ratio is required?**
- **Which integration time is needed ?**
- **Is observation feasible?**

Martin Gutekunst

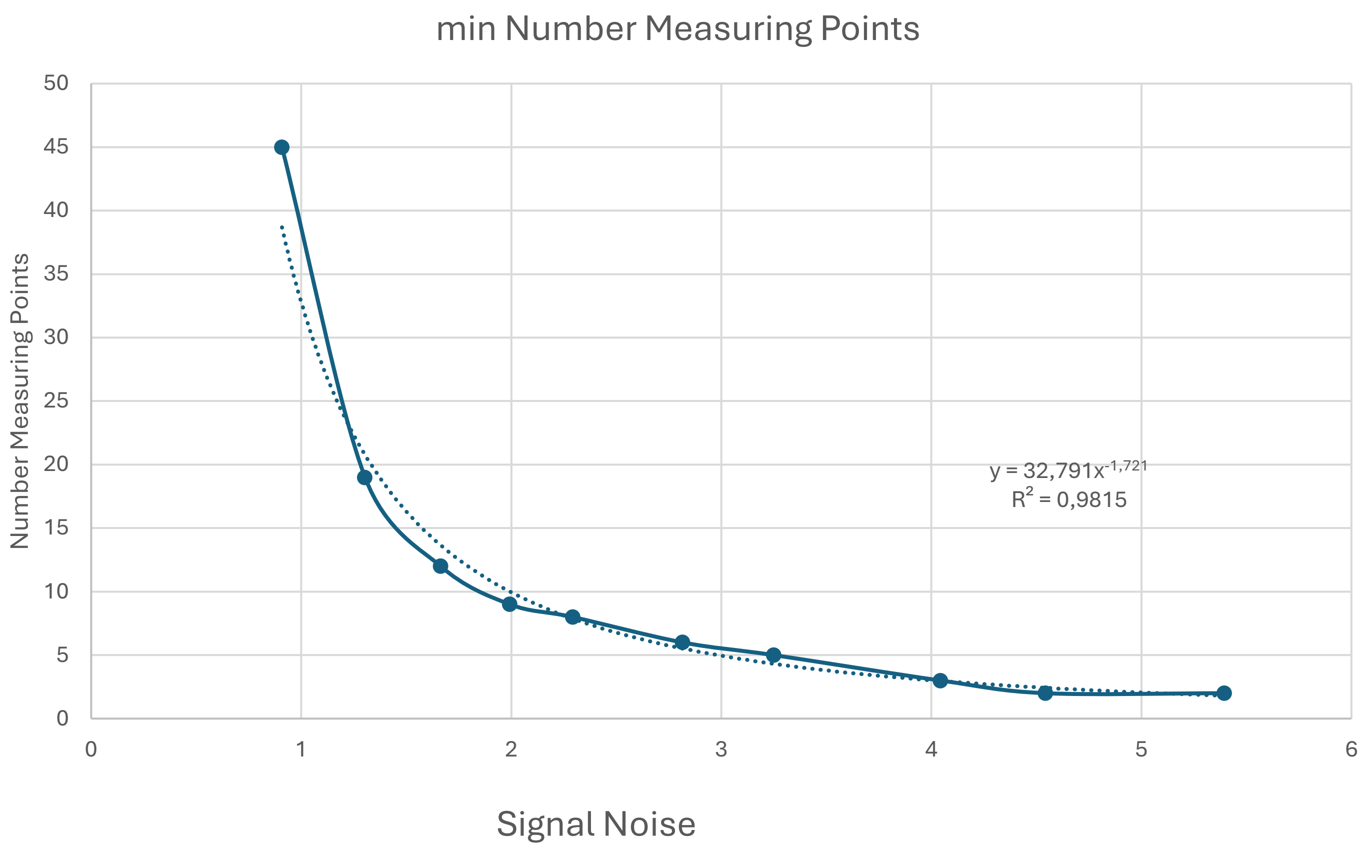
Optimal exposure time for detecting small DIPs

General procedure:

- Determine the necessary S/N based on the expected dip.
- Estimate the necessary exposure time based on experienced data
- Check whether the exposure time is compatible with the duration of the occultation

Martin Gutekunst

Optimal exposure time for detecting small DIPs



The diagram shows the minimum number of measurement points depending on the S/N of the dip for the event to be recognized as positive

(data was generated using Pyote)

This data can be represented using a negative power function.

Below an S/N of 2, the number of data points required increases dramatically.

Since time errors for SN <3 are greater than integration time

S/N should be > 3 for dip

Better S/N (Dip) < 4 to 5

Martin Gutekunst

Optimal exposure time for detecting small DIPs

An example:

Occultation of UCAC4 530-049269 by Misa on February 1, 2024 :

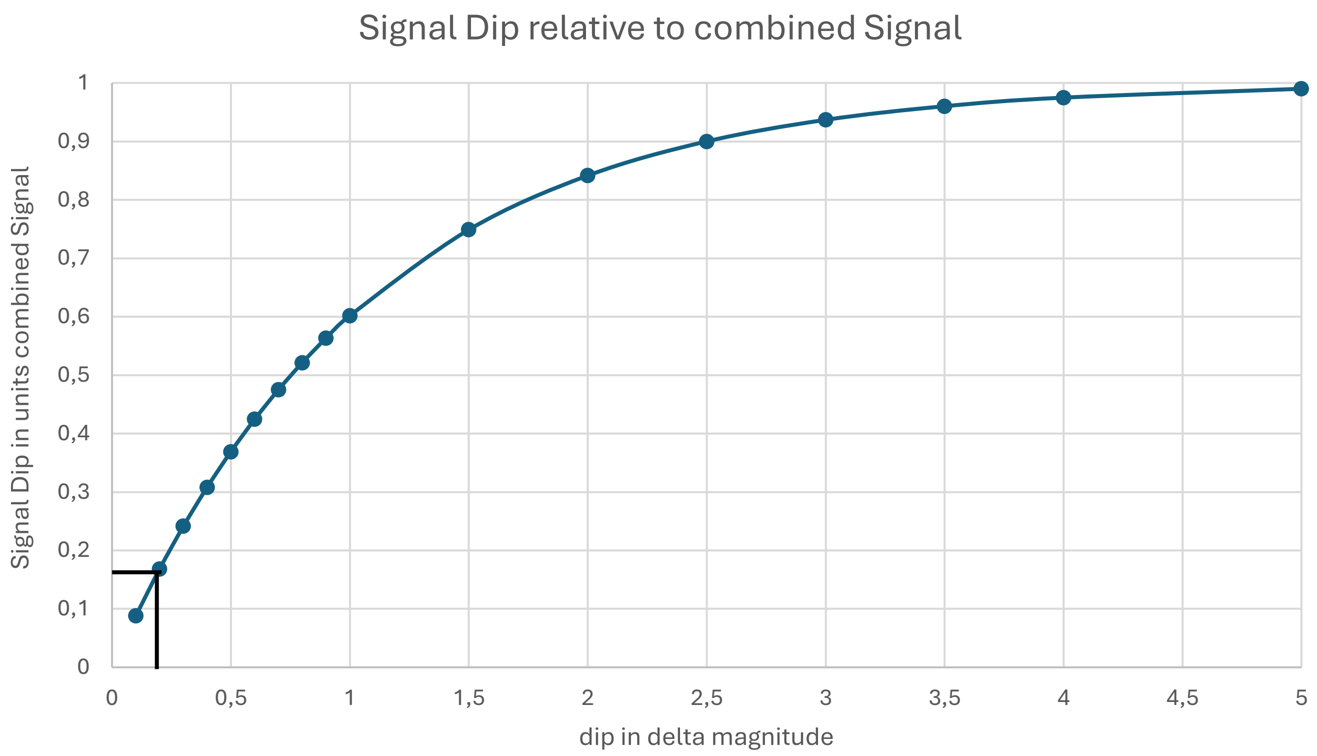
Data for planning the observation

Probability 100%
Mag*=12,9
Mag Asteroid = 14,4
Mag_Comb = 12,7
delta_mag_Dip = 0,2
Duration max 7,9s
Min Duration for planning 3,8s
Height of object 51° → expected good Seeing

Martin Gutekunst

Optimal exposure time for detecting small DIPs

1. Determine the ratio S/N(star) to achieve S/N(dip) 4.5 for a dip with 0,2mag



Read off the diagram at 0.2 mag -> dip approx. 17% star intensity

→ S/N Dip = 0,17*SN Stern

→ S/N > 4,5 for Dip:

→ **S/N Star > 4,5/0,17 = 26**

In case only SN 20 could be achieved
→ min SN(Dip) = 3,4

Martin Gutekunst

Optimal exposure time for detecting small DIPs

2. Step: Determine the exposure time required to achieve an S/N star of at least 20.

1			Stern	Planetoid	kombiniert	delta mag	Dauer	Belicht	S/N comb	S/N dip
26	**Lowell**	20.01.2024	13,8	16,7	**13,7**	**3**	**0,9**	150	4,4	4,1
27	**Lederle**	21.01.2024	14,2	15,4	**13,9**	**1,5**	**3**	200	6,9	--
28	**Misa**	01.02.2024	12,9	14,4	**12,7**	**0,2**	**5**	100	7,5	1,4
29	**Odysseus**	29.02.2024	15,4	15,8	**14**	**1**	**27,9**	500	7,6	4,2
30	**Tama**	02.03.2024	9,3	14,3	**9,3**	**5,1**	**1,6**	10	11,9	--
31	Theopolda	05.03.2024	12,2	13,9	**12**	**1,9**		**200**	**19,3**	**16**
32	**Clementina**	03.04.2024	15,4	15,7	**14,8**	**1**	**5,9**	500	7,38	3,33
33	**Leonteus**	30.04.2024	14	16,4	**13,9**	**2,5**	**4,8**	750	4	--
34	**Giza**	05.06.2024	12	18,5	**12**	**6,5**	**2,6**	100	4,1	--
35	**Isergina**	16.06.2024	15,3	15,4	**14,6**	**0,8**	**4,5**	500	5,7	2,5
36	Bronislawa	24.06.2024	14,7	14,4	**13,8**	**0,6**	**4,8**	300	5,66	2,63
37	**Bronislawa**	24.06.2024	14,7	14,4	**13,8**	**0,6**	**4,8**	500	5,66	2,63
38	**2003 YM9**	21.07.2024	12,8	20,5	**12,8**	**7,7**	**0,5**	40	4,11	4,11

From the experience table: At 100 ms, an S/N ratio of approximately 10 can be expected.

Theopolda SN ca 19,3 at 200ms

2003 YM9: SN=4,1 at 40ms

Martin Gutekunst

Optimal exposure time for detecting small DIPs

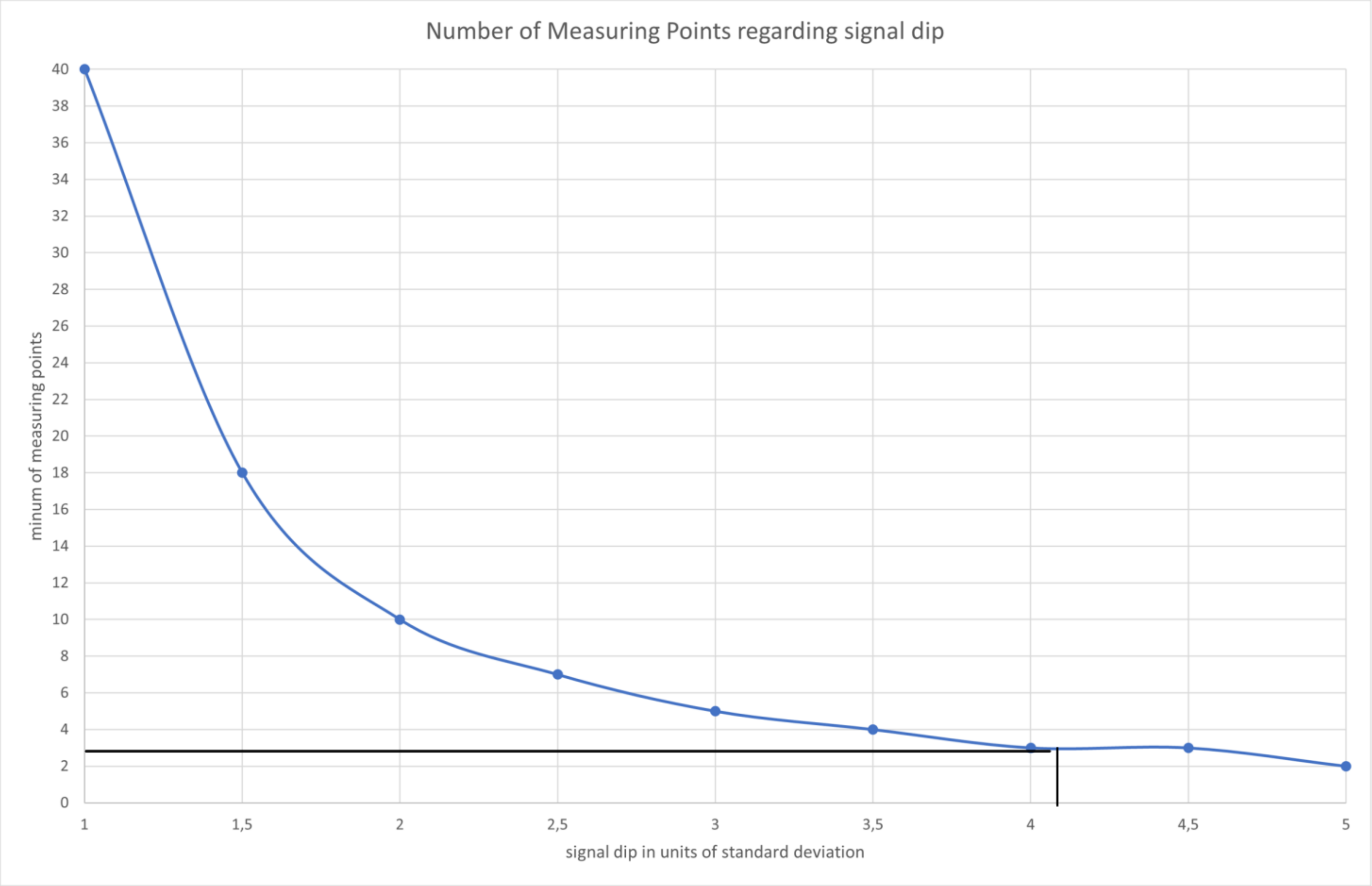
Table shows linearity S/N relative exposure time: SN 0,1/ms
Basis to calculate the expected integration time

Event	Mag Star	Integration Time	Achieved S/N	S/N / Integration Time
Theopolda 5.3.2024	12	200	SN Star 19,3	9,7/ms
2003 YM9 21.7.2924	12,8	40	SN Star 4,1	10,2/ms
Now to observe: Misa	**12,9**	**200**	**SN Star 20** **SN Dip 3,4**	**About 10/ms**
Option 2	**12,9**	**250**	**SN Star 25** **SN Dip 4,25**	**About 10/ms**

Martin Gutekunst

Optimal exposure time for detecting small DIPs

3. Check feasibility Measurement :



Max event duration 7.8s:
Safety factor 0.5 if
not on center line
→ Maximal Duration ca 4,0 s

Personal experience shows that
SN_Star=20 is the upper limit.

250ms SN_Star = 25

→ SN Dip = 25*0,17 = 4,25

Diagram:
SN 4,25 → min. 3 Measuring Points

Expected measurement points :
Tmin Duration/ 3* T_integr =
3800ms/750ms = Reserve Factor 5

→ ok!

Martin Gutekunst

Optimal exposure time for detecting small DIPs

Conclusion and hints:

- S/N of Dip should be at least 3 better 4 to 5

- Integration time is not always the limiting factor, but rather the maximum achievable S/N ratio

- My personal experience shows that, at best, an S/N of 20 to 25 can be expected from the star (my equipment and observation site)

- calculating needed integration time based in experience table

- Check feasibility with SN from star of max. 20 by using an experience table

Martin Gutekunst

Optimal exposure time for detecting small DIPs

→ **Gather empirical data by creating a table of results from the measurements taken in order to estimate integration times.**

The data table could contain following parameters

Object Parameter	Observation parameter	Measueremnts parameter
Asteorid Number	Datum event	Integration time
Mag star	Star height above horizon	Duration measured
Mag Asteorid	Sun height	Precision time achieved
Mag Comb	Moon height	Pos or negative
Duration theory	Moon distance	Camera type, Gain, Binning
Probability		

Martin Gutekunst

Thank you for your attention

Martin Gutekunst
Sternwarte Eberfing
Germany