RECURVE ARCHERY

Adjusting the Bow Sight
Already after the 1st arrow?

Short Version

F. Wegrostek

June 2020

Adjusting the bow sight in a tournament - a subtle job

Most publications describe in which direction the bow sight should be adjusted in case of arrow deviation from the center (called offset or deviation) based on an arrow group.
Here a usually bigger problem for the archer should be discussed, namely **when** the archer should readjust the bow sight in a tournament, i.e. after **how many arrows**, and **by how much** should be readjusted.

The trivial answer to the question "when" is first of all when the archer is reasonably sure that the center of his arrow spread has moved from the center of the target face. To recognize this, however, it usually requires a few arrows, where a loss of score must be accepted. And how many arrows should be observed at least? Are there also situations where the bow sight should be readjusted after the first arrow? Because if the basic bow sight adjustment is changed too early, it is possible that the bow sight has been wrongly adjusted and the arrows following on it group outside the target face center.

The archer is therefore in a dilemma: the bow sight (grain, ring) should be adjusted as early as possible, especially in a tournament, but there is a risk of incorrect adjustment with subsequent loss of score points. But if the shooter only reacts after sighting a few arrows, he has already lost score points.

It is also common to consider whether changed circumstances, such as an approaching wind, could have caused the unexpected deviation from the center of the target face or whether the arrow strike is still compatible with the archer's skill level and it was just not such a clean shot. One must then decide to either shoot more arrows to clarify the issue or to readjust the bow sight immediately or to practice aiming off.

If the archer has already decided to readjust his bow sight after the first arrow, the next question arises, namely by how much the bow sight should be readjusted. He does not know the center of his new arrow grouping after the 1st arrow. Should he correct the bow sight adjustment by the full distance of the arrow deviation from the center of the target face or to only a part of it?

This article derives from a stochastic (probability-theoretical) point of view practical procedures for the archer, when at the earliest and by how much the bow sight should be reset or adjusted in an scored competition.

The basic bow sight setting

The starting point for every tournament and training in which performance scores are recorded is a well-adjusted bow sight. Usually at least 1-2 dozen arrows are shot in a row under good conditions (weather, archer) and the arrow grouping is considered. The lower the skill of the archer, the more arrows are necessary for a proper bow sight adjustment.

If the bow sight is not adjusted precisely, the scatter of hits is not in the center of the target face but, as shown in the example sketch below, away from it. One speaks of an arrow offset (German "Versatz") or deposit (German "Ablage" by Christian Nentwig).

In a group of several arrows shot, the optical mean or the so-called Median is the reference point of the offset of the arrow group.
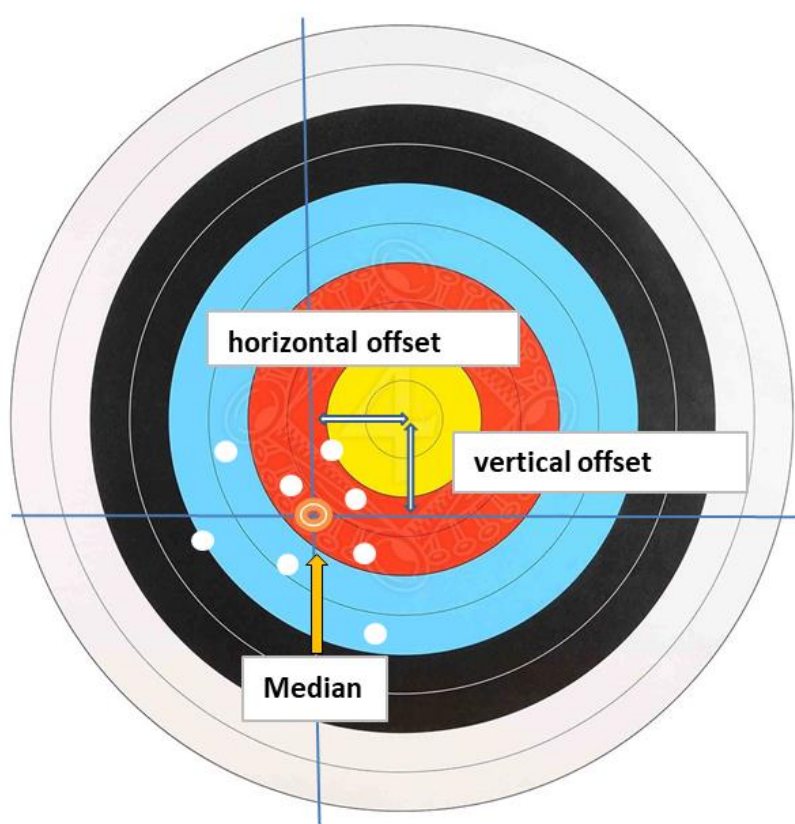
The **Median** of the arrow group is mathematically the mean value of the horizontal and vertical values ordered by size.

In archery practice, the median is the **optical center** of the arrow group. It divides the 8 arrow hits into 4 hits above, 4 hits below, 4 hits left, 4 hits right.

The **vertical and horizontal arrow offset** is then the vertical and horizontal distance of the median from the center of the target face.

In the given example, the median is at ring 7 (middle), approx. 8 o'clock.

The offset is the same vertically and horizontally and extends from the center of the target face to the middle of ring 8. After this offset, the bow sight is adjusted horizontally and vertically by **2.5 rings each.**

This brings the median of the arrow group to the centre of the target face.

Especially with a small number of arrows shot, the most clearly deviating arrow ("outlier") can be left out of consideration.

The adjustment on the bow sight itself is always made so that the knurled head screw is turned in the direction of the arrow deviation. Thus the bow window with the arrow rest moves against the arrow deviation and corrects it.

After only one single arrow, e.g. after the 1st arrow in a tournament and with a significant offset, the bow sight correction looks different! It is described in the following chapter!

Ring hit probabilities per arrow

Each archer has an individual spread of his arrows according to his shooting skills. This can be measured mathematically (standard deviation, variance) and the hit probability for each of the 10 rings (and miss) on all target face variants and distances can be calculated. In the same way, each archer can be assigned a value based on his hit scattering, according to J. L. Park and J. E. Larven, which describes his "Archery Skill Level" (ASL).

Table 1 shows the hit probabilities per arrow and ring on the 70m distance (122cm target face) for 15 skill levels. Ring touches with 0,5cm thick arrows were considered. Values for intermediate skill levels can be interpolated.
The display shows not only the individual hit probabilities corresponding to your own archery skills, but also the area with a very low hit probability, namely with **less than 5% in total** (highlighted in green).

Table 1

Achievement level			Strike probability for an arrow on the 70m-range (122cm target face)												5% Limit: 5% of the arrows are out of the ring-value …
Skill	WA 1440	WA 70	Ø Arrow-Score	10	9	8	7	6	5	4	3	2	1	Miss	Total	
120	1401	351	9,7	74%	25%	1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	9,5
115	1387	347	9,6	65%	34%	2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	9,3
110	1370	342	9,5	55%	40%	5%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	9,0
105	1349	337	9,4	45%	45%	9%	0,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	8,7
100	1325	331	9,2	37%	46%	15%	1,8%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	8,4
95	1298	323	9,0	30%	45%	21%	4,4%	0,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	8,0
90	1266	315	8,8	24%	41%	25%	8,3%	1,5%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	100%	7,6
85	1230	306	8,5	19%	36%	28%	13%	3,7%	0,7%	0,1%	0,0%	0,0%	0,0%	0,0%	100%	7,1
80	1187	296	8,2	15%	31%	28%	17%	6,9%	2,0%	0,4%	0,1%	0,0%	0,0%	0,0%	100%	6,5
75	1138	284	7,9	11%	26%	27%	20%	10%	4,2%	1,3%	0,3%	0,1%	0,0%	0,0%	100%	5,8
70	1079	270	7,5	9%	21%	25%	21%	13%	7,1%	3,1%	1,1%	0,3%	0,1%	0,0%	100%	5,1
65	1012	254	7,1	7%	17%	21%	20%	15%	9,9%	5,4%	2,5%	1,0%	0,4%	0,1%	100%	4,2
60	935	236	6,6	5%	13%	18%	19%	16%	12%	7,9%	4,6%	2,4%	1,1%	0,7%	100%	3,2
55	851	216	6,0	4%	11%	15%	17%	16%	13%	10%	7%	4%	2%	2,3%	100%	2,1
50	761	193	5,4	3%	8%	12%	14%	14%	13%	11%	8%	6%	4%	5,5%	100%	0,8

Attention:
The values for the 95%/5% limit correspond to the following rational scale:

Beginning of ring 10 = 10

Middle of ring 10 = 10.5

End of ring 10 = 10.999 (=the center of the target face)

and so on!

Beginning of ring 7 = 7

Middle of ring 7 = 7.5

End of ring 7 = 7.999

and so on!

Green marked is the hit area for which there is a probability of 5% and less. The column on the right shows t**he corresponding ring values for the 95%/5% limits. Since this area is hit on average only 5 times from 100 arrows, the following motto applies to the 1st arrow:**

> **If the 1st arrow hits outside this 95/5% limit, this should prompt the archer to rethink his shooting technique and consider possible additional external factors of influence.**

Adjusting the bow sight already after the 1st arrow
Yes or No?

Only 1 shot arrow normally provides too little information or clues for the archer to make an **immediate** bow sight correction at the start of the tournament. However, the situation is different if additional information is provided below:

Requirements for bow sight correction after only 1 shot:

> 1) **The arrow offset is - measured by the skill of the archer - very large and the expectation probability for this is very low, namely approx. 5% and lower (see Table 1).**
> 2) **From the point of view of the archer, the shot was done without any perceived major error.**
> 3) **In retrospect there is a recognizable (mostly external) cause for a directional deviation from the center (offset), e.g. wind, rain, shifted "string shadow", changed anchor point etc...**
> 4) **This cause will also be effective for all following arrows.**

If the above conditions are met, the archer should correct the basic setting of his bow sight already after the first arrow!

The 5% /95% limit was chosen so that an adjustment of the bow sight wrongly has a small chance (just a maximum of only 5%), but at the same time it is possible to react quickly to a large hit deviation in order to lose subsequently only few points. Of course the archer can also react with a slightly smaller deviation (10% limit; about 1 ring within the 5% limit); there the unpleasant risk of a wrongly bow sight adjustment increases rapidly.
(Note: Statistically the calculated probabilities for the 5% limit correspond to a two sided statistic check. If one expects a deviation in a certain directional plane, the probabilities are halved).

Ring value for the 95%/5% limit derived from the archer himself

The ring value for the 95%/5% limit is shown in Table 1. The ring value for the 5% limit can be easily derived by the archer from his average arrow score:

> **Empirical FORMULA for the ring value at the 5% limit:**
> **2 times average ring score per arrow minus 10**

Statistical background: The average arrow-ring score is 1.25 sigma from the center of the target face, the 5% limit is 2.45 sigma. This is about twice the distance.
RESTRICTION: When misses occur, the estimate of the ring value for the 5% limit from the average ring value becomes increasingly inaccurate!

Example for the decision to adjust the bow sight after the 1st arrow:

Achievement level				Strike probability for an arrow on the 70m-range (122cm target face)											5% Limit: 5% of the arrows are out of the ring-value …
Skill	WA 1440	WA 70	Ø Arrow-Score	10	9	8	7	6	5	4	3	2	1	Miss	Total	
85	1230	306	8,5	19%	36%	28%	13%	3,7%	0,7%	0,1%	0,0%	0,0%	0,0%	0,0%	100%	7,1

This archer with Skill level 85 starts a tournament at 70m with a **ring hit at 6**, which means for him an unexpectedly high deviation from the center!

His skill variation is for 95% of all arrows till ring 7.1 according to the table (according to the rule of thumb: Ring score of 306 divided by 36 times 2 minus 10 = 7). After the archer could not detect any serious shooting error, he can either judge this large arrow displacement as a rare "slip-up" (e.g. nervousness) or attribute it to a possible external cause (e.g. wind coming up). If he rather excludes a shooting error and decides for the upcoming wind as cause, which will also displace the future arrows, he should immediately adjust his bow sight or shoot with the next shot with the appropriate Aiming-off.

Guideline for hits outside the 95%/5% limit:

If the 1st arrow is outside the 95% hit probability when shot correctly (see ring limits according to table 1) and if there is an external reason for the deviation of the arrow from the center of the target face, which will also affect the next arrows, the bow sight correction should be made immediately (or aiming-off) in any case!

If the first arrow is just within the 95% limit, a second arrow should normally decide - unless there is an absolutely certain cause for the arrow offset.
In that case, a correction of the bow sight would also have to be made.

The bow sight correction after the 1st arrow
By how much? For what?

By how much to correct the arrow offset?

If the 1st arrow is outside the 5% probability limit and the archer has opted for a bow sight correction, the bow sight should be corrected by the ring amount that has been added to the personal skill variation. This could be the drift of the arrow by the wind, for example.

We have to keep in mind that a larger arrow offset can consist of 2 parts:

A) From the <u>hit variation</u> (dispersion), that <u>reflects the skill of the archer</u>.
B) From a possible <u>additional</u> arrow offset, caused by a mostly external factor like wind, rain, new string etc...

> **With a larger arrow offset, the basic setting of the bow sight is only corrected by this <u>additional</u> arrow offset!**

What is the arrow offset corrected for?

It is an important guideline:

> **<u>After a critical deviation of the 1st arrow</u> from the center, the bow sight should be readjusted to <u>that</u> ring of the FITA target face, which was highly likely to be expected for this 1st arrow (without an additional event). Statistically, this is the <u>median</u> of the skill-based hit spread of the archer. It represents the average skill of the archer.**
>
> **Thus the correction of the bow sight in rings is:**
> **Ring value of the 1st arrow minus median**

The **median** is the ring value that separates the 50% better hits from the 50% worse ones. It lies in the middle of the most common hit situation and represents a high probability of expectation.
The median is the center of gravity of the hits, but (unfortunately!) not identical to the target face center (except for the very few 1440 ring archers in a WA). Depending on the skill of the archer, it lies outside the center, close to the archer's Ø arrow score.
Since it can be assumed that the 1st arrow was in the median area rather than in the center of the target face, correction to the median is often sufficient to bring the wind drift into the basic setting of the bow sight.

It should also be mentioned here that there is a 2nd median point on opposite side to the 1st arrow target hit. If this were the skill-related reference point, this would result in an enormously large wind drift. It is rather unlikely to assume this. There is no need to discuss this further in this context.

The following sketch explains the theoretical background of the bow sight correction over the median using the example of an archer with skill 65 (WA 1440: 1012 rings)

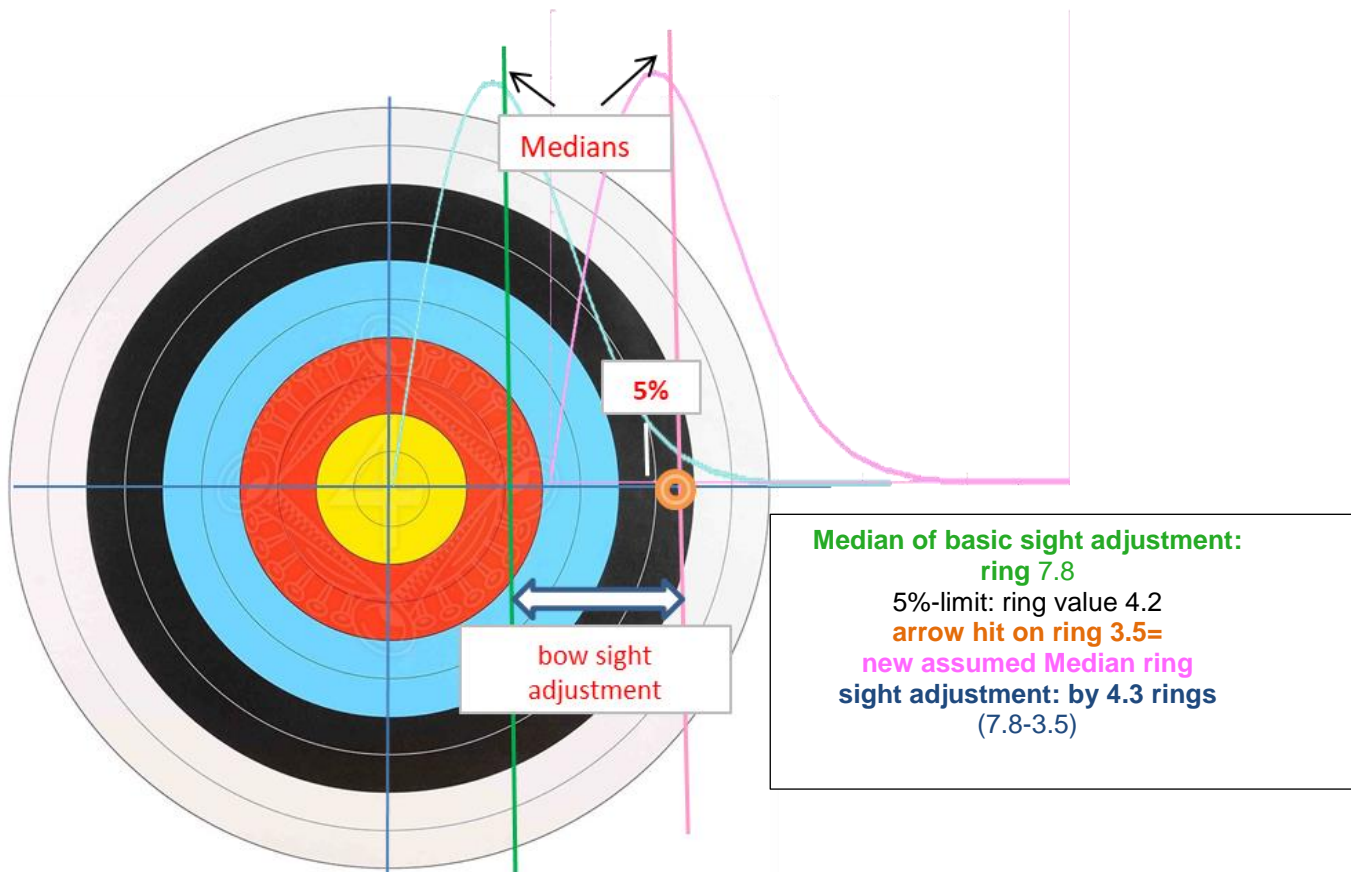| Achievement level				Strike probability for an arrow on the 70m-range (122cm target face)												5% Limit: 5% of the arrows are out of the ring-value …	Median: 50% of the arrows are within the ring-value …
Skill	WA 1440	WA 70	Ø Arrow-Score	10	9	8	7	6	5	4	3	2	1	Miss	Total		
65	1012	254	7,1	7%	17%	21%	20%	15%	9,9%	5,4%	2,5%	1,0%	0,4%	0,1%	100%	4,2	7,8

Following situation:

The 1st arrow is on ring 3.5 (ring 3, middle). That is outside the 95% / 5% limit!
The 5% limit is on ring 4.2.
The light-green curve corresponds to the basic bow sight setting on the center of the target face.
The median runs at the ring value of 7.8 around the center.

Medians

5%

bow sight adjustment

Median of basic sight adjustment: ring 7.8
5%-limit: ring value 4.2
arrow hit on ring 3.5=
new assumed Median ring
sight adjustment: by 4.3 rings
(7.8-3.5)

The wind has probably shifted the original hit distribution in the basic bow sight setting (green curve) further to the right (pink curve). This shift must be corrected with the bow sight pin/ring. You make the slightest mistake if you assume that this single 1st arrow roughly corresponded to the average skill of this archer, defined by the median of his (new) skill variation.
The bow sight setting is therefore corrected by the distance 1st arrow hit (3.5) to the median of the basic bow sight setting (7.8), i.e. by 4.3 rings.
The bow sight pin/ring is moved to the right by 4.3 rings.

The median and the 95% / 5% limit

can be read for every archer according to his level of performance from table 2! Intermediate values of the skill can be interpolated.

Table 2

Bow sight adjustment to the Median at an arrow offset of p<5%

Achievement level				95%/5% Limit: 5% of the arrows are out of the ring-value …	Median: 50% of the arrows are within the ring-value …	Description of the position of the median
Skill	WA 1440	WA 70	Ø Arrow-Score			
120	1401	351	9,7	9,5	10,3	Middle Ring 10
115	1387	347	9,6	9,3	10,2	Start-Middle Ring 10
110	1370	342	9,5	9,0	10,1	Start Ring 10
105	1349	337	9,4	8,7	9,9	Ende Ring 9
100	1325	331	9,2	8,4	9,8	Ende Ring 9
95	1298	323	9,0	8,0	9,6	Middle Ring 9
90	1266	315	8,8	7,6	9,4	Middle Ring 9
85	1230	306	8,5	7,1	9,1	Start Ring 9
80	1187	296	8,2	6,5	8,9	Ende Ring 8
75	1138	284	7,9	5,8	8,5	Middle Ring 8
70	1079	270	7,5	5,1	8,2	Start Ring 8
65	1012	254	7,1	4,2	7,8	Ende Ring 7
60	935	236	6,6	3,2	7,3	Start-Middle Ring 7
55	851	216	6,0	2,1	6,7	Middle Ring 6
50	761	193	5,4	0,8	6,1	Start Ring 6

Attention:
The values for the 95%/5% limit and for the median correspond to the following ring-divided rational scale:

Beginning of ring 10 = 10
Middle of ring 10 = 10.5
End of ring 10 = 10.999 (=the center of the target face)

Beginning of ring 7 = 7
Middle of ring 7 = 7.5
End of ring 7 = 7.999
and so on …

Formulas:
Median = 10-((Sigma*root (2*LN(2))-6,35)/6,1)
95%/5%-limit = 10-(Sigma*root (-2*LN(1-0,95))-6,35)/6,1)

= Median/Sigma in cm (acc. to skill, distance, size of target face)
= Ring width of the 10er-Ringes in cm
= Ring width of all other rings

Rough median estimate

A rough **estimate of the Median** is obtained by adding the **value 0.6** *) to the average arrow score.
Median and average arrow score are closely related with a distance of only ½ to 2/3 ring width.

<div style="border:1px solid black; text-align:center">

Empirical Formula for the Median:
Average score per arrow + 0.6

</div>

) Median ≈ average arrow score + 2$\sqrt{-2 * LN(1 - 0,04405)}$

RESTRICTION: If misses occur, the median calculated from the Ø Ring value becomes increasingly inaccurate!
This concerns especially archers with lower skills and the "difficult" distances like 50m, 90m and 18m indoor in the general class.
Table 2 shows the precisely determined medians for the 70m distance.

Bow sight correction with the halving method

The reader, who has followed the previous theoretical discussions with mixed feelings, asks himself: Is there not an easier method of correcting a significant offset of the 1st arrow? A method which also leads to an acceptable correction result without much thought and which can be easily applied by all archers?

Well, it exists, but with limitations!

It is the halving method (HM)! Either method A) or B)

Simply halve the distance of the strongly offset arrow to the center of the disc (11 or 10) to get close to the median. Then the bow sight is corrected by the difference between the ring values of 1st arrow hit and the HM value.

> **Rule of thumb for the halving method:**
> **A) HM/Median≈(target center [11] + subdivided ring value of the offset 1st arrow) / 2**
> **Bow sight correction = ring value of the 1st arrow minus HM/Median**

Or even simpler:

Often, especially at the greater distances of the target, the exact arrow position in the ring is not visible, for example at dazzling sun position or when no spotting scope is available. A ring-subdivided rational scale reading is then not possible. In these cases it is recommended

> **B) simply correct the bow sight**
> **by half the distance between ring 10 and the hit ring number.**

The halving method causes a rough approximation of the offset arrow to the median. It works best when the offset arrow is within the 5% -10% limits. Arrow median and arrow mean are then about halfway to the center of the target face.

If the offset arrow is further outside (<1% probability) or further inside (>10% probability), the method is less accurate. In the first case, it leads to too little correction, in the second case to too much correction. In spite of these limitations, the halving method for arrow offset is a proven method of correcting.

The following is an example of a bow sight correction. One time the bow sight correction is calculated according to the values in table 2 and another time simply according to the halving rule, A) as a ring-subdivided rational scale and B) as a simple ring-interval scale. There are no major differences in the results.

Example of a bow sight correction
via median and via the halving method

A highly skilled archer

Skill	WA 1440	WA 70	Ø Arrow-Score	10	9	8	7	6	5	4	3	2	1	Miss	Total
85	1230	306	8,5	19%	36%	28%	13%	3,7%	0,7%	0,1%	0,0%	0,0%	0,0%	0,0%	100%

ASSUMPTION: The **1st arrow is on ring 6 middle (=6.5),** so outside the 5% limit, as shown in the sketch!
95/5% limit: 306/36*2-10 = 7 (= beginning of ring 7; limit to ring 6).

CALCULATION-METHOD via median

Median: 306/36 + **0.6** = 9.1 (= beginning of ring 9, near ring 8).
Bow sight correction from ring 6.5 to ring 9/near ring 8, i.e. by about **2.5 rings** set the bow sight pin to the right.

HALVING METHOD

A) as a ring-subdivided rational scale:
   (**HM/Median≈(**11 [disc center] + 6.5 [arrow offset])/2=8.8.
   Bow sight correction from 6.5 to 8.8 (ring 8 near 9), i.e. by **about 2.3 rings**.

B) as a simple ring-interval scale:
   (10 - 6)/2= **2** , i.e. set pin of the bow sight **2 rings to the right**

Median

95% Grenze
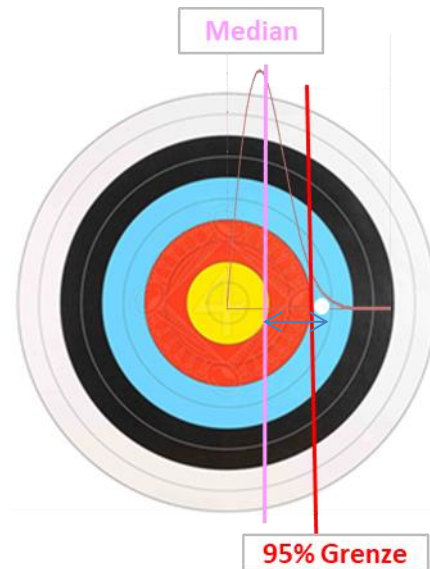
Practical tips

In the practice of archery, during training, but especially during a competition, there may only be max. 20 seconds for a change of the bow sight setting. A long thought or even arithmetic is not possible. However, once you have internalized the previously discussed basic principles and the **cornerstones such as Ø arrow score, your own median and the 5% limit**, a bow sight adjustment is possible in this short time. The most important points are summarized below.

➢ The starting point is always the <u>basic setting of the bow sight</u>, determined from the largest possible number of arrows shot (minimum 1-2 dozen) under optimal conditions. The optical center of the arrow group is the **Median**. It is brought to the center of the target face by an adjustment of the bow sight.

➢ <u>In a tournament, the bow sight should only be readjusted after the 1st arrow</u> if the shot was made without (heavy) mistake from the archer's point of view, but the arrow is still outside its "usual" hitting range (= approx. 95% of all hits) and also an external cause such as wind, rain, new string etc. could be present, which will also affect the future arrows.

➢ Therefore, get to know your ring area for each shooting distance, in which about <u>95% of your hits lie</u>! Take the value from table 1 or 2, which corresponds to your performance level! Or calculate it roughly yourself:

> Ring value for the **95%/5% limit** ≈ 2 times the average arrow score minus 10

➢ <u>The bow sight should be readjusted after critical deviation of the 1st arrow from the center to that ring of the target face, which was to be expected with average probability for this 1st shot</u>. This is statistically the **Median** (central value) of the skill-related hit dispersion of the archer. Therefore, determine your skill-related median (Table 2) or calculate it yourself:

> **Median** ≈ average arrow score plus the value 0.6

If the 1st arrow is critically offset, the bow sight is adjusted
by the difference: Ring value of 1st arrow minus median!

➢ The simplest method for an approximate correction of a heavily offset 1st arrow is <u>the halving method (HM)</u>:
Either:
A) **HM/median** ≈ (center of the target face [11] + exact ring value (ring-subdivided rational scale) of the offset 1st arrow) / 2

The archer corrects the bow sight by the
difference between the ring values of 1st arrow hit and the HM/median value.

Or even simpler:
B) **By half the distance between ring 10 and the hit ring number.**

➢ And one last piece of advice! Dealing with the probabilities and adjusting the bow sight needs to be practiced as often as archery itself.

All in Gold