Instruction <u>Full Loop</u> Using autoISF 2.2.8 Bernie/Steve V1

Introduction

Pre-requisites and the principal function of a Full Loop, <u>without the user ever giving a bolus</u> and without entering any carb info, are explained in „FullLoop…Feb21.pdf“ and available here: https://www.facebook.com/groups/AndroidAPSUsers/permalink/3229546620600066, or here, https://discord.gg/kTJeCShmGQ and also with supporting information in German here, (https://de.loopercommunity.org/t/uam-full-closed-loop-uebersicht-update-meal-mgt-iii/10146.

Currently Full Loop with autoISF is not represented in AAPS Master and related readthedocs. It is also not yet included in the official DEV version for the next master version. With autoISF, and especially with the intention to use it for Full Loop, you are in the early DEV area. It is therefore important to observe the warnings in the above paper, as well as the hints given by the developers in the manuals. autoISF has also been ported into an early DEV branch of FAX (oref(1) for i-Phone).

First of all, a tip: If the following looks too complicated for you - and it's not just about understanding, but also about time requirements and discipline during implementation - you would be well advised to first try the **Full Loop in a simpler form**, e.g. with Automations (Chapter 4.1 in the Full Loop paper). Depending on their expectations for %TIR or their rapid carb contents of „allowed“ meals, an increasing number of people succeed in making a respectable start the first time they try using AAPS in Full Loop mode. See also the first published medical study that included 16 patients using AAPS, who found, on average, comparable %TIR performance when using a basic Full Loop mode: https://pubmed.ncbi.nlm.nih.gov/36826996/

Alternatively, and this is also done by many people, you can use some techniques used in hybrid closed loop, such as **using a pre-bolus** with autoISF, or try other early DEV variants mentioned in the Full Loop Paper, which have also undergone further development (Boost, AIMI, EatingNow).

1. General Settings for Full Loop

Warning: This paper contains data from an adult diabetic (Lyumjev, G6) whose insulin sensitivity can be characterized as follows: approximately 13 U profile basal and 37 U TDD at about 200g daily carbs from mainly lunch and dinner; no couch snacks or sweet drinks. The user also participates in multiple instances of daily moderate activity such as gardening, dog walking and bikeing. In Hybrid Closed Loop, a typical meal bolus was 8 U that was sometimes reduced such as when activity followed the meal.

When setting **your** parameters, **don't use the given numerical example**, but data from **your** *successful* Hybrid Closed Loop!
A satisfying performance in Hybrid Closed Loop mode is therefore a pre-requisite. You have to master your meal management to be able to forget it. You can forget manual meal management after you have taught your meal management to the loop during tuning, which is the subject of the following.

1.1 SMB Range Extention

(preferences/OpenAPS SMB/autoISF settings/smb delivery settings/smb_max_range_extension)

Full Looping requires bigger SMB sizes, so it is suggested to go into AAPS Preferences/OpenAPS SMB/autoISF settings/smb delivery settings and set SMB/UAM max range extention (**smb_max_range_extension**) to 2.0 Even better, you could determine an estimate for your initial setting as follows:

In the following description, I will use the symbol, ….. , to denote where you would use your numbers. My numbers that I use for the same situation will be in parentheses ().

In full loop, you want to get at least half of our required meal bolus in 10 minutes, through 2 SMBs. To do that, you need ..... U (2 U) per SMB on average, and because the bolus sizes tend not to be equal when requested by the Loop, you should have at least **.....** U (3 U) as the allowable SMB size. Your hourly basal is around **.....** U (0.6 U), i.e. AAPS Master will allow a max. 2 times that hourly basal which = **.....** U (1.2 U) per SMB, because of the max min of basal setting's max 120 min. size limitation.

To get the required SMB size, you have to use the range extension feature in autoISF. You need at least a SMB range extention of:

Your needed SMB size/the 120 min max SMB size limit in master = .../.....= ..... (3/1.2 = 2.5).

You need to have the loop react aggressively to the first signs of a BG rise, since you have not given a meal bolus. To avoid the aggressive SMBs getting blocked, or reduced, by safety settings, you now need to make further setting adjustments in AAPS/ Preferences.

1.2 Max and Min autoISF Ratio

(preferences/OpenAPS SMB/autoISF settings/autoISF_min and autoISF_max)

Set **autoISF_max** = 2.0 (This allows up to doubling of ISF aggressiveness if "requested by the weights"; you can still sharpen later)

For situations of reduced insulin sensitivity, you must specify, in your settings (preferences) what your lower limit of weakening of ISF, compared to profile ISF, may be.
autoISF_min should be set to 0.5, or even lower.

1.3 SMB Delivery Ratio

(preferences/OpenAPS SMB/autoISF settings/smb delivery settings/smb_delivery_ratio)

Increase fixed **smb_delivery_ratio** from 0.5 to 0.6 (This generally results in 20% higher SMB "requirement"; it can be sharpened significantly later)

> *The* **smb_delivery_ratio** *can also be set dynamically (changing with glucose level). This seems a feature geared more towards hybrid closed loop applications.*

If you have an extremely low hourly basal rate, you may have to use a higher range extension along with adjusting settings such as **bgAccel_ISF_weight**, as discussed below.

1.4 Safety Against too Aggressive Settings: iobTH

Before you start tuning up your "weights" in autoISF, you should build in a safety measure against high accumulated iob from too many or too big SMBs.

The best way to do this in autoISF 2.2.8 is to define an automation, and keep it switched on, that defines an **iob threshold** beyond which our loop strongly decreases aggressiveness.

To define such a limit **for yourself**, take a look at your iob data of your "Hybrid Closed Loop career". As previously mentioned, during this early testing phase and using a typical lunch senario, determine how many units of iob your loop required at the meal time in question. 75 to 80% of this iob value is a good starting point. This is how much your loop is now allowed to shoot in, as fast as possible in full loop mode, without you wanting to slow it down with any further precautions.

If you eat very differently, such as only very low carb or a small snack at times and then other times you eat "the full program" of high carbs and such things as a sweet drink, it becomes somewhat difficult to determine the % for this automation and the values for „ISF_weights“, which will be selected soon.

It is best to avoid extreme meals during the first "getting to know" and calibration time, and leave eating as you wish to the later phase of testing the limits and fine-tuning.

Since the autoISF Full Loop is "trained" by you (!) to react strongly to characteristics of **your** glucose curves, it is absolutely essential that you have a well-functioning CGM where fluctuations in glucose rise are meaningful in terms of insulin demand. At the beginning of tuning autoISF, it is strongly recommended to switch on the autoISF Full Loop only for a couple of hours at a time to make "first walking tests" around an examined meal!

Ensure the even/odd logic in the settings is toggled on:

> Preferences> openAPS SMB> autoISF settings> smb delivery settings> Enable alternative activation...

iobTH is set in an Automation (not in Preferences!). Your automation should look like this:

Condition: iob > (your personal iobTH), and No TT is set

Action: Set TT = (an uneven #) for (~) 16 minutes

Warning regarding EatingSoonTT (which must be an even low number, like 74):
It is good if this setting is still active into the phase of the first glucose rise. However, the Automation with the iob threshold may not work **if a TT is still active**. This "risk" can be minimized by another automation (see e.g. # 2 in the picture p.10), and by putting the iobTH automation high up in your automations list, so other automations that might set a TT do not precede it.

> *Note for DEVELOPERS DEV#01: If the parameter iobTH should be included as a setting in Preferences in later autoISF versions, it would be very important to create an access for temp. modification at the same time (e.g. via sport button; and also as action and condition in automations).*

2. First Meals and Tuning of the ISF_weights

In the early test phase, it is recommended to:

- switch autoISF ON only during daytime hours of a meal, e.g. 11-18h, for fully automatic "full loop" management of lunch
- take typical but not extreme lunches. Omit sweet drinks, or drink only slowly

It is then essentially a matter of your UAM Full Loop recognizing a meal start from the glucose trend, and ramping up iob.

Besides the predictions (based on glucose value, trend of glucose value, insulin activity from past SMBs and TBRs, your entered profile), the glucose target value also plays a role if you want to enable your UAM Full Loop to give as large SMBs as possible.

- So it may be worthwhile to have a target or TT in the low (even) range around meal starts

- Most importantly, your profile ISF needs to be strengthened up to manage the situation.

2.1 EatingSoon TT

If you have relatively fixed meal time slots in the 24 hours of the day, you could set the target glucose values in your profile accordingly. So e.g. 11-15h target 76 if you almost always start a lunch between 10:45 and 14:30h. If you have rather irregular habits, it is more worthwhile to manually set an EatingSoonTT (which is quite time-uncritical) well before the start of a meal.
Preferred solution (especially if you usually have rather low glucose values before meals) is an Automation, which sets an EatingSoonTT automatically for a maximum time of half an hour at signs of a beginning meal (possibly also limited to a principal time slot). (Example# 1 in the list of automations, fig. p.10).

In the section on iobTH it was already mentioned that you need additionally #2 in fig. p.10.

The full loop works in principle also without setting an EatingSoonTT.

2.2 bgAccel_ISF_weight

When setting up your autoISF Full Loop, you must set a number of ISF_weight parameters in AAPS Preferences/OpenAPS SMB/autoISF settings.

When looping without carb inputs and without giving a bolus ourselves, the first crucial setting is to set the **bgAccel_ISF_weight** so that large SMBs are requested immediately when the loop detects an acceleration in your BG. Ideally within 15-20 minutes, after acceleration detection, as much iob is automatically supplied as we would have given with our bolus.

Rule of thumb: If we double the **bgAccel_ISF_weight**, the ISF to be applied is halved and, depending on how dominating of a role the bgAccel_ISF_weight plays, the SMB requested can be doubled.Two of the first three SMBs should be ¼ to 1/3 the size of a previous meal bolus.

> If you eat extremely little or low carb from time to time, however, you must not exaggerate with the initially triggered SMB sizes, or you would have to pause autoISF (temporarily switch off) in such cases.
> With an idea presented further below concerning further development of autoISF, a differentiation for strongly varying meals would also be conceivable, see *DEV#02* p.7

In the end, your settings have to fit the whole range of your meals. In the extreme case you will have to balance too high running iob with additional carbs, and in the opposite case, you will have to reckon with temporarily exceeding the glucose target range and losses of the achieved %TIR for this day.

Of course, as always, the devil is still in the details, and one should therefore keep (real-time) track of the SMB tab when tuning. This can be impractical, but at least screenshots of the SMB tab should be taken quickly in the crucial minutes where the SMBs were given, and evaluated later at leisure.

> Already when tuning the **bgAccel_ISF_weight** it can become evident that the **smb_delivery_ratio** and/or the **smb_max_range_extention** "must" be increased further especially if your profile basal rate is very small. Furthermore, the **smb_delivery_ratio** provides further leeway to increase the aggressiveness (e.g. 0.6 -> 0.72 results in another +20%).
>
> In any case, it is worth the effort to tune the **bgAccel_ISF_weight** in such a way that high glucose increases are already nipped in the bud, so to speak. (*This also facilitates the tuning task for the subsequent phases of the meal, because there is then largely zero-temping, as well known from times after YOUR administered bolus - and the ISF are then not so important)*.

Default **bgAccel_ISF_weight** is set to zero in autoISF. To start, I would try 0.05 or max 0.1, and keep trying in max 0.05 steps. Soon move to 0.02 steps (which still means 10-20% change). From my (very limited) overview, many use around 0.2, but possibly higher if their hourly basal rate is 0.1U or lower. Do not be tempted to rush this setting by using large jumps in adjustments.

Ideally, one should set the **bgAccel_ISF_weight** so that for meals that are in the middle and rather lower range of the "fast carb load", the necessary insulin supply is already approximately provided with 3 SMBs. The glucose curve, at such meals, begins to flatten early in this SMB phase, so a deceleration follows very soon.

2.3 pp_ISF_weight

With high Carb meals, or meals that have a sweet drink, the acceleration phase will last longer and BG will rise further, which will require a higher insulin supply. Between acceleration and deceleration there is also a more or less linear further increase of insulin need. Our autoISF should now "fight" this with the help of the post-prandial ISF, set via **pp_ISF_weight,** after we have set a halfway suitable **bgAccel_ISF_weight**.

> *In full loop mode, this parameter is preferred over deltaISF. DeltaISF is designed to make reduced insulin doses at low glucose values. However, this is not useful in the full loop, since we want to have particularly large SMBs available at rather low (but increasing) glucose values. Below you can see in an example in which phase of the postprandial glucose curve **pp_ISF_weight** gains the upper hand, and **delta_ISFrange_weight** never has an effect (11:43-11:58 h UTZ, columns AA and AB.in table on p17).*

In general, we choose the setting **pp_ISF_postprandial all day**: ON for full loop.

> *Only if this were OFF would the pp hours since the last COB matter (so this is only relevant in Hybrid Closed Loop, where one makes carb inputs). If **pp_ISF_always** is valid (e.g. for Full Loop), or if the pp hours since the last COB have not expired yet, **pp_ISF_weight** is always used. Otherwise only **delta_ISFrange_weight** is used..*

You tune your **pp_ISF_weight** after you have set a halfway suitable **bgAccel_ISF_weight**. You should check meals in the upper spectrum of your g carb, carefully starting with 0.01.

Normally the SMBs triggered by **bgAccel_ISF_weight** and **pp_ISF_weight** should be sufficient to reach and slightly exceed the iobTH, so all other autoISF parameters are relatively unimportant for now.

Depending on the type of meal and "aggressiveness" of your **bgAccel_ISF_weight** and **pp_ISF_weight** tuning, the iob will already be so high that in the phase of deceleration (i.e. the "last part of the rise to the peak") no insulinReq is seen by the loop. Therefore the **bgBrake_ISF_weight** is often unimportant.

> *But still, and therefore, be careful when tuning.**Consult the SMB tab!** A setting that is actually too aggressive might be masked. Tuning only works if the effects of the settings being tuned are not unintentionally limited or stopped by other settings.*

Therefore, here again is the general hint: Please always look at two or three different meals before deciding whether a tuning "fits". It can only ever be about "good enough".

2.4 bgBrake_ISF_weight

You may also have a low carb meal, or an attempt at doing a weight reduction diet, where the glucose goes up only sluggishly and iobTH should not be reached at all.

Acceleration and the phase of strong glucose rise are quickly over in these cases, and there is mainly a decelerating bulge of insulin action that projects over the next few hours. Now the importance of the **bgBrake_ISF_weight** comes in. In full loop, the **bgBrake_ISF_weight** is often only about half as large as the **bgAccel_ISF_weight** (but that would also depend on your personal diet pattern), and also here one should approach gradually, increasing the weight from small values.

What is very helpful for us in any case is that the loop calculates the situation every 5 minutes and corrects it. However, if there is too much insulin in the system, the loop can only correct to a very limited extent, namely only to the extent that it can set Basal to zero.

Therefore, the core problem is that the Full Loop must build up iob very quickly, but not too much, in the initial phase of a meal. The earlier large SMBs come, the less high the overall increase in BG will be.

But high BG values can temporarily occur.

2.5 High Glucose Values and dura_ISF_weight

After all, the UAM Full Loop doesn't even have any clues as to how many g CHO are added late, which means we're tuning, so far, in this description, as if it's just about managing a rise with a small to moderate amount of g CHO. With large or high fat/protein meals, a 2nd hill of glucose will form, or a long high plateau. For such situations there is in autoISF the modulation of ISF depending on BG level or duration of plateau formation.

High BG values and/or a plateau in BG values are tuned using the **dura_ISF_weight** and associated parameters. This feature is also very useful in Hybrid Closed Loop. It elegantly manages, fully automatically, temporary fatty acid resistance. Please refer to other papers on autoISF for details (e.g. the Full Loop paper, esp. p.33).

Since in Full Loop we "turn up" our loop to give the maximum SMB size we can at the beginning of a rise, it is crucial to resist the temptation to continue with a particularly strong ISF in the meal phase with the highest glucose values . This is a reason why in Full Loop we do not make much use of the bg_ISF component of autoISF. Near glucose peak, zero-temping usually prevails anyway, so the settings we try may not be used by the loop. This also means that too aggressive settings do not come into play most of the time. Sometimes they do come into play, and produce a hypo 1-2 hours later. Therefore, **study carefully the SMB tab to see what the selected weights would do, if there were no zero-temping at the time**. Also, try a completely different meal to see how your settings work there.

> The experience of the author is that it is possible to tune the above mentioned weights for very different meals in such a way that the glucose almost always remains acceptablly in range. However, if you need differentiated settings, please bring this into the debate of whether the following, or another similar *DEV proposals* should be followed:
>
> *DEV_#02: In autoISF settings (AAPS/Preferences) provided that next to each input (esp. weights) a milder, as well as a more aggressive variant, can be set. Each variant is also assigned a different even-numbered glucose target in the settings, with which the variant can be "called up".*
> *The respective setting can then be activated by setting the corresponding EatingSoonTT.*
> *Or this could happen fully automatically, with the help of automations. For example, if you want different "aggressivities" for breakfast / lunch / dinner, you can achieve this fully automatically by "installing" the respective EatingSoonTT in roughly suitable time blocks of the profile.*
> *Additionally, we would like to see on our AAPS main screen, which of the autoISF-settings is active, or would become active in case of a trigger (acceleration or delta in your current glucose curve) (see idea below at DEV_#03).*

3. Emulator

You can set up and tune the system for full loop as described above.

More elegant and precise tuning can be done with special evaluation software for the AAPS logfiles by using the Emulator.

In the Emulator, you can see in tabular and graphical form, which autoISF component contributed to SMB values that determined the glucose curve.

A detailed description and the program itself can be found here: https://github.com/ga-zelle/emulator

In section 7 of this guide, a detailed application example is given.

Another example, but not done with the latest version of the emulator, is given in the Full Loop paper (Feb.2022) p.38-39.

4. Time Blocks in which No Aggressive autoISF Should Run.

Once the initial tuning is done, you can turn autoISF on in the preferences.

Even with well fine-tuned parameters there may be time blocks where you prefer not to have the aggressively "brushed" autoISF running on full loop. One possible time could be overnight. An odd TT set for overnight would stop autoISF, if this logic has been selected as described on page 3.

> After a full year in autoISF Full Loop, the author finds managing meals rather the lesser challenge. Activity/sports need a bit more attention, but can then go quite well (and taking a snack is nice too). BUT:

Besides recognizing and managing partial occlusions, the lasting challenge has been dealing with times when the loop should be set "milder" as a precaution. How big this challenge is depends very much on your individual lifestyle.

4.1 Fully Automatic Full Loop with Time Blocks of Different Aggressiveness

In order to run the loop fully automatically around the clock, the times outside the meal blocks must also be precisely analyzed, and solutions to problems must be sought. This almost always requires **personalized Automations** that you make to tailor the loop exactly to **your** data so **fully automated handling** of time blocks with different aggressiveness of the loop can be made.

A relatively inflexible way to solve this problem would be to define **meal time windows** in which autoISF is turned on. Other early DEV variants make it so that there is either a time of day in the settings, or that e.g. by a small pre-bolus such a window is set. **Outside** of these time windows, the loop then runs with less aggressive SMBs like oref(1) SMB+UAM in AAPS Master.

> *Idea for further development of autoISF:*
>
> *DEV_#03: Something similar could be easily integrated in autoISF, if autoISF ON/OFF is embeded as Condition and as Action in Automations.*
> *Furthermore, it would be nice to extend the Full Closed Loop / Open Loop etc. button (circles in the main screen) with autoISF (FullLoop) ON/OFF. This would be manually switchable there,*

or could also be switched by automations in the background. The mode in which the loop is currently running would always be clearly visible in the main screen.

Another option is already implemented in autoISF 2.2.8: To achieve less aggressive SMBs, the new Sports button, situated on top of the AAPS main screeen between Profile and TT, can be utilized. *(See also section Sports after Meals, below).* Used together with an even temporary glucose target, one can significantly soften the "feared" meal response of the full loop for a defined period of time, for example, for the duration of an expected temporary glucose increase after a small snack. The ISF increases with higher TT being set. (See numerical representation in the AAPS main screen underAutosense%; example: ISF 39 -> 47 at TT 114 is about 20% weaker, and 39->59 at TT 134 about 50%). In addition, the SMBs are further reduced because the loop always calculates the required insulin for correction towards the increased target value. (See also the example. p.8 below/p.9).

Furthermore, in autoISF 2.2.8 we have for the first time the feature: SMB shutdown at odd glucose targets. This can be set in the profile for specified hours of each day, and/or it can be automated more "creatively" as TT in automations. With this feature, autoISF will continue to be used, but more aggressive ISF will only be implemented via elevated %TBR, which, compared to allowing SMBs, makes iob rise much slower and prevents overreactions of the loop to individual jumps.

Everyone must determine which time blocks or conditions they want to address nicely in automations; this is done on the basis of their **personal data**. So, in particular, one must look for "jumps" in the glucose curve, which our Full Loop could be misinterpreted as the start of a meal. A calibration of the CGM or a nightly compression-low could deform the glucose curve considerably and would be misinterpreted by autoISF!

If you have a time window in the morning, clearly before the first meal, where getting up from sleep the glucose rises violently, "foot to floor" syndrome, you could set an odd profile target around this typical time and then an even profile target for the following time period in which the first meal of the day falls and you want to have the SMBs back in play.

> The author has reservations when "exceptionally" a bolus is given in the full loop calibrated autoISF ON mode. A bolus influences the glucose curve atypically, and what the autoISF loop does with it has not been investigated. It should simply be unnecessary to "interfere" with your own bolus. If you absolutely don't want to leave the loop alone, you should maybe switch autoISF OFF for a few hours. *But, if anyone starts their own investigations: please share findings with the community!*

For an odd glucose target to trigger SMB deactivation, you need to set up your autoISF settings in the Preferences/SMB Setting/autoISF/SMB delivery settings: "Enable alternative activation of SMB depending on TempTarget" ON as well as "Enable...depending on profile target" ON.

Here is a case study: A rather complicated day, on which guests arrived very late and a second dinner, with many slices of baguette, was consumed around 23 h. This usually could be handled very well by the autoISF Full Loop. But:

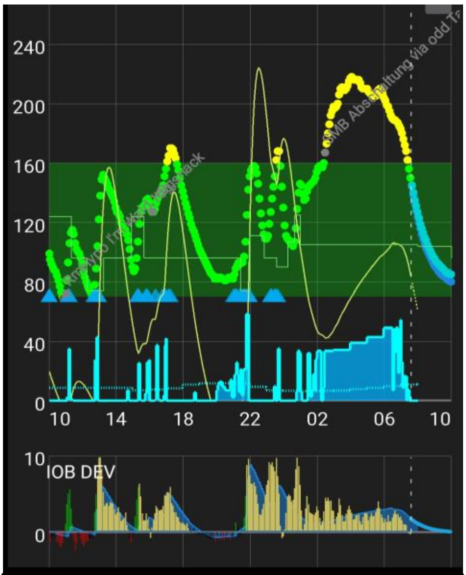
Around 01 h, the question arose, which setting to choose for the night?

A) Let autoISF continue to run unchanged?
With 140mg/dl, iob 3U and only few expected FPUs, I preferred option B when going to bed:

B) autoISF with SMBs off (odd glucose target for the night). Unfortunately, it turned out that the %TBR power was not enough to keep me in the target range during the night.

C) A third principle possibility would have been to switch autoISF entirely off during the night (and go with basic oref(1) SMB+UAM). This would have been better in this case. A disadvantage is, that you tend to forget to switch autoISF back on, the next day.

DEV_#04: A wish to the developers in this context: In order to integrate alternative C) - with which we almost always had quite nice night sequences (!) in our Hybrid Closed Loop times - you should be able to set autoISF ON/OFF via automations and/or (more for daytime) via a switch from the AAPS main screen. Additionally you should be able to see on your AAPS main screen in which mode the loop is currently operating.



B): SMB de-activation at night can „ruin“ %TIR for the entire day:

Based on B) two improved solutions could be built:

B*) If longer lasting digestion of fats etc. often occurs at night, one can set an even glucose profile (!) target for a part of the nights (02-04 h e.g.), and midnight to 02 h as well as 04 to 06 h a "no SMBs please" odd profile target. Users wanting more flexibility *would need either a (currently not offered) possibility to program an even TT in the future when going to bed (with odd profile targets for the nights). Or one* could choose the following problem solution:

B**) An odd glucose target is set for the night. To temporarily allow SMBs, an Automation is defined like: If BG> 140 mg/dl, then set TT=90 (even) for 15 minutes.

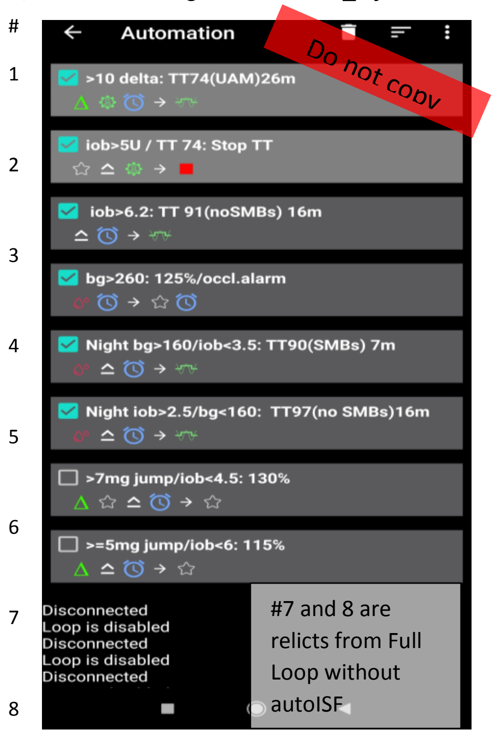
Finally, we refer again to section 1.4 - Safety Against too Aggressive Settings: iobTH, because, in the background, **iobTH** could contribute to another solution to a problem that would allow running autoISF around the clock and this could be "the silver bullet" (my preferred solution, *at least as long as other DEV_# features are lacking*). The solution is as follows

A*) Via **Automation** you can set **different iobTH for different time blocks** (@autoISF permanently ON).

For this purpose, we expand the Automation #3 as presented in the section "1.4 - Safety..." with a Condition; time block during the day. Then we "clone" a second Automation, and overwrite it with lower iobTH and Condition; night hours, see #6 in the list to the right.

Situations may occur, for example, when at the beginning of the night time period, fat-induced high glucose (e.g. bg>160) is present. We might still like SMBs under these conditions, so we can set - maybe only for a very short time duration - a TT that allows SMBs, but only as long as iob still seems too low, e.g. iob<3.5 (#5).

Additional note: This idea can be extended further. If someone needs an exceptional amount of iob for their sweet breakfast, they can set a higher iobTH, in an automation for this time slot, than in automation #3 for the other times of the day.



If you have many nested automations, please be aware that they are processed by the loop in exactly the order listed. So, one being triggered stops all others from being triggered, until the next loop decision. Conditions and actions within the automations need step-by-step tuning so that the loop really works well enough in different situations. For example, night progressions need to be analyzed to see if the bg and iob limits defined in #5 and #6 work sensibly, and if the TT duration is chosen appropriately. Swapping the sequence the automations appear in the automation list would also lead to different SMB impacts.

> Why had the author not applied A*) in the case study shown in the picture on the preceding page? Because only when a %TIR loss "hurts", one starts to look creatively for solutions. The author also had a little help from the autoISF DEV group. Since this is a brand new automation attempt, the automations in the above image are still in flux even for the author, and **you must create your own automations for exactly your observed problems**, possibly defining additional Automations to cover all observed cases, and then test them.

4.2 Simple User Interaction with the Loop for Temporarily Lowered Aggressiveness.

The above example shows that especially with a very restless lifestyle, as seen in the night example from above where the author ate very differently than normal with regard to timing of the meal, amount of food, and amount of fat, a lot of work can arise to equip one's own loop with Automations in such a way that almost all situations are managed FULLY AUTOMATICALLY.

One can always decide for oneself whether "it is really worth it" to have a 24/7 hands-off Full Loop at every moment, or which interaction one would like to make now and then, in special situations, and do so sufficiently reliably.

A method to temporarily reduce the aggressiveness of the loop we know well from hybrid closed looping is: Setting a temporarily increased glucose target, and lowering the profile to <100%. Both are easily accomplished with the buttons on the top right and left of the AAPS main screen, respectively.

In AAPS x autoISF 2.2.8 you will find between these two buttons another one, decorated with a sports icon.

This sport button is discussed in the general instructions for autoISF 2.2.8. Here, and in the following section, 5. Sports After Meals, only its relevance in Full Loop mode will be discussed.

The following two screenshots are intended to illustrate how the aggressiveness of the autoISF Full Loop can be significantly softened if desired.

- by pressing the Sport button (top center of the screen, between "DIA 7" and TT "124"; green = ON; grey = OFF)
- by over-typing the current profile glucose target with an increased, even-numbered target value. The higher TT, the lower the resulting ISF!

I would like to explain this further with an example:

Fig. 2 on the following page: Before a one-hour bike ride, about 11-12h, my glucose value is close to target at about 100 mg/dl, and I have less than 1 U iob, so a small snack before my ride should not hurt. Setting a <100% sports profile seems to me rather excessive for such a moderate activity.

In Hybrid Closed Loop, and especially with slower insulin than Lyumjev, I could probably proceed like just laid out, without any problems.

In Full Loop, however, I have the autoISF lurking for signs of a meal start, ready to fire substantial SMBs.

In all likelihood, my snack would lead to a glucose spike and, before cycling could produce any glucose-lowering effects, autoISF would be on the scene with some decent-sized SMBs. Whereupon I would be forced to hurriedly unpack my sports snack... and a roller coaster ride would begin, with CHO driving glucose into both the yellow and red areas of the chart.

So I took a different approach: No pre-snack. (It's generally a good idea to start sports near iob zero, by the way). Pressing the Sport button and entering TT 124 modifies the ISF from 43.0 to 63.6, as shown in fig. 1. This acts like a <100% profile lowering.

Fig. 1

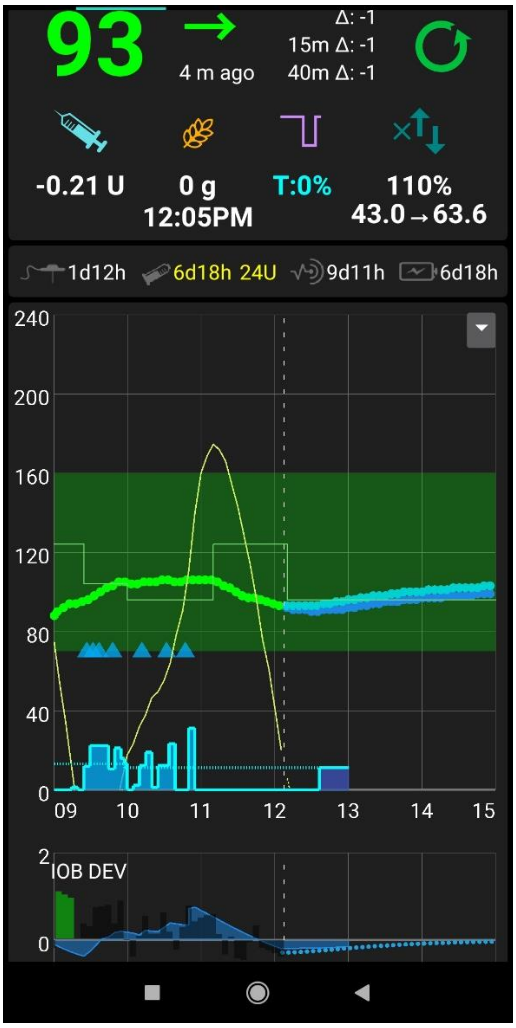


Fig. 2

A note about Autosens:
When using autoISF, it is generally better to switch off Autosens. As we can see in this example, Autosens would have sent my loop into the opposite direction, to 110% profile, because it relys on data of the past 8 or more hours.

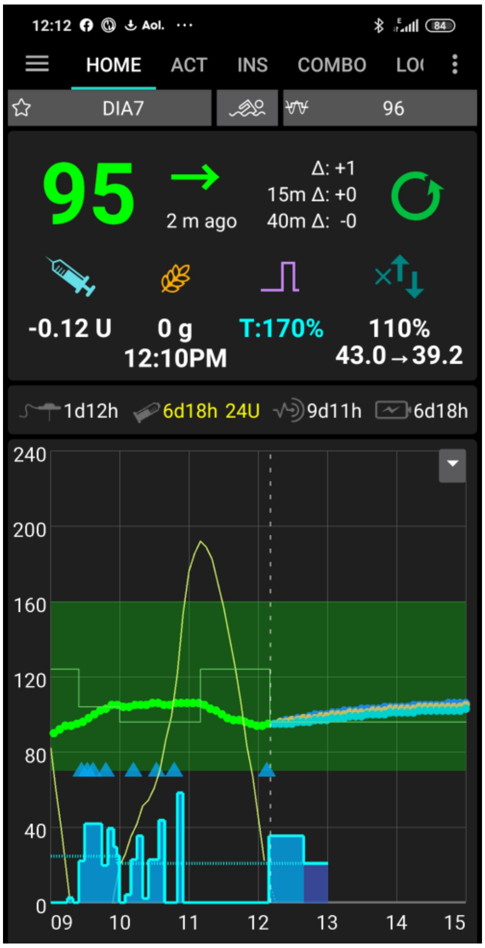


Fig. 3

Fig. 3: After finishing my bike ride, I switched back to my profile target of 96, which you can see in the upper right corner, and deactivated the sport button next to it. Now autoISF will work normally again. The slight rise to glucose values above 96 immediately lead to a small tightening of the ISF from 43.0 to 39.2, as well as to an SMB of 0.1U.

Even without a sports context, the procedure just shown can be used to temporarily „soften" our autoISF loop for a small snack.

Temporarily reducing iobTH:

Additionally, as a precautionary measure, you could temporarily reduce the iobTH in your automation. This can be done sometime before the meal, or at the latest when the first SMB was delivered.

> *Temporarily modify your set iobTH from the AAPS Main Screen/Burger top left/Automation, or if you have configured Automations as a tab, Automations tab/Automation(edit condition)*

> *DEV_#05: In future autoISF updates it would be desirable to integrate temp. modified iobTH at the sport button, especially if iobTH will be incorporated as another parameter in the SMB autoISF Settings in AAPS Preferences. See also DEV_#01 in section 1.4 and in the following section 5.*

5. Sports After Meal

In the Hybrid Closed Loop, we gave less insulin at meals before sport.

Since we now get our meal insulin automatically from the loop, we would have to at least somehow tell it that sport follows this time.

Simply setting a sport profile before the meal would make our full loop too weak in the "treatment" of the first glucose rise after a meal. What we want is our already delayed meal insulin delivered as fast as possible by SMBs... just a bit reduced or capped at the peak of acceleration.

This can be done quite painlessly if we simply **reduce** the **iobTH** in our automation by e.g. 25%. This can be done following the procedure mentioned on p12.

In this senario, our loop delivers SMB insulin as fast as always, only that when the last SMB has passed the iobTH, the loop only has elevated %TBR to work with, and cannot raise iob by much any longer.

As bg changes in this senario, after the iobTH is reached, and best still before the start of the sport, we can set an increased sport bg target, and press the new sport button in the AAPS main screen to elivate ISF and soften agressiveness. A more detailed description about using this feature will appear in the general description of autoISF 2.2.8.

> Don't forget to enter your default iobTH back into your automation a few hours later!

> DEV_#06: It would be nice to see the valid iobTH value next to the iob value above the glucose curve in the AAPS main screen. Maybe even with < or > sign in between and color change, if there is an overrun and temperary shut-off of SMBs.

6. Tips for Long-Term Use: **Performance Monitoring and Fine Tuning**

For good performance, how your glucose curve and iob develop **before** a meal is important.

Bad: Phase with neg.iob and glucose rise.
Good: Slightly decreasing glucose, and building up some positive iob.

Both decreasing glucose and pos.iob could be supported by setting an EatingSoonTT, which can also be automated.

Sometimes you might get into a rhythm, a bit like surfing. Having a small appetizer; an appetizer once in a while can also be surprisingly good. Even a late little dessert, such as dark chocolate or a cracker with fatty cheese, can work wonderfully, utilizing the insulin tail that is "lurking" to still take effect.
If you can develop a certain mindfulness, while remaining relaxed and positive-looking ahead, that may be the best recipe for good success ... not every time, but more and more often.

After the first tuning you have "earned" an opportunity to **let the loop run really easily**. That's what Full Loop is all about.

For example, it should be enough to **keep an eye on the weekly %TIR** on a rolling basis. Only if the danger of falling out of your desired range appears, it is time to consider what the reason could be. Just looking at the xDrip, or other uploader, and AAPS statistics pages often helps:

- What time of day/night are the outliers happening?
- Are certain meals or snack habits to blame?

If so, maybe just a behavioral correction might be indicated to avoid making things unnecessarily difficult for the loop, or maybe changing some Conditions and/or Actions in the list of Automations as mentioned on p10.

- Do sports or hormonal/disease-related sensitivity fluctuations interfere?

If so, as already known from the Hybrid Closed Loop, the profile, which also underlies the Full Loop and autoISF, would have to be temporarily adjusted on a percentage basis.

- Do the changes correlate with age of insulin delivery, CGM dropouts, etc.?

"Outliers" to very high TDD and high % in the hyper range are often a sign that there was a partial occlusion, and that has then zero to do with your Full Loop settings. You have to pay attention to the loop to ensure it always works **technically** well, and it has reliable iob and glucose data.

A time-consuming re-adjustment of the numerous autoISF parameters should only be necessary in exceptional cases if radical changes occur in the base profile, such as puberty perhaps. The author has no data to contribute there yet, sorry.

> In the following chapter, we will deliberately pick an example where a fine-tuning attempt based on data of an extreme day has led to deterioration of loop performance.

Finally, you can pause at any time by setting autoISF OFF, or still ON for dura_ISF, but all other weights set to zero, and continue in the oref(1) hybrid closed loop, as practiced before.

7. Fine-Tuning of autoISF Settings for Full Loop Aided by the Emulator

The following shows how to apply the Emulator to tune autoISF parameters in order to achieve better %TIR.

> Warning: It is not a good example in that a loop that had actually been well tuned for months was adjusted to better serve an extreme day. However, months before, the author had used an older Emulator version for his initial successful tuning, so images from that time do not match terminology and graphical presentation of the current Emulator.
> Hence this new application example ...and you do learn from mistakes :)

7.1 Glucose Data from a „bad day“ for Logfile Analysis

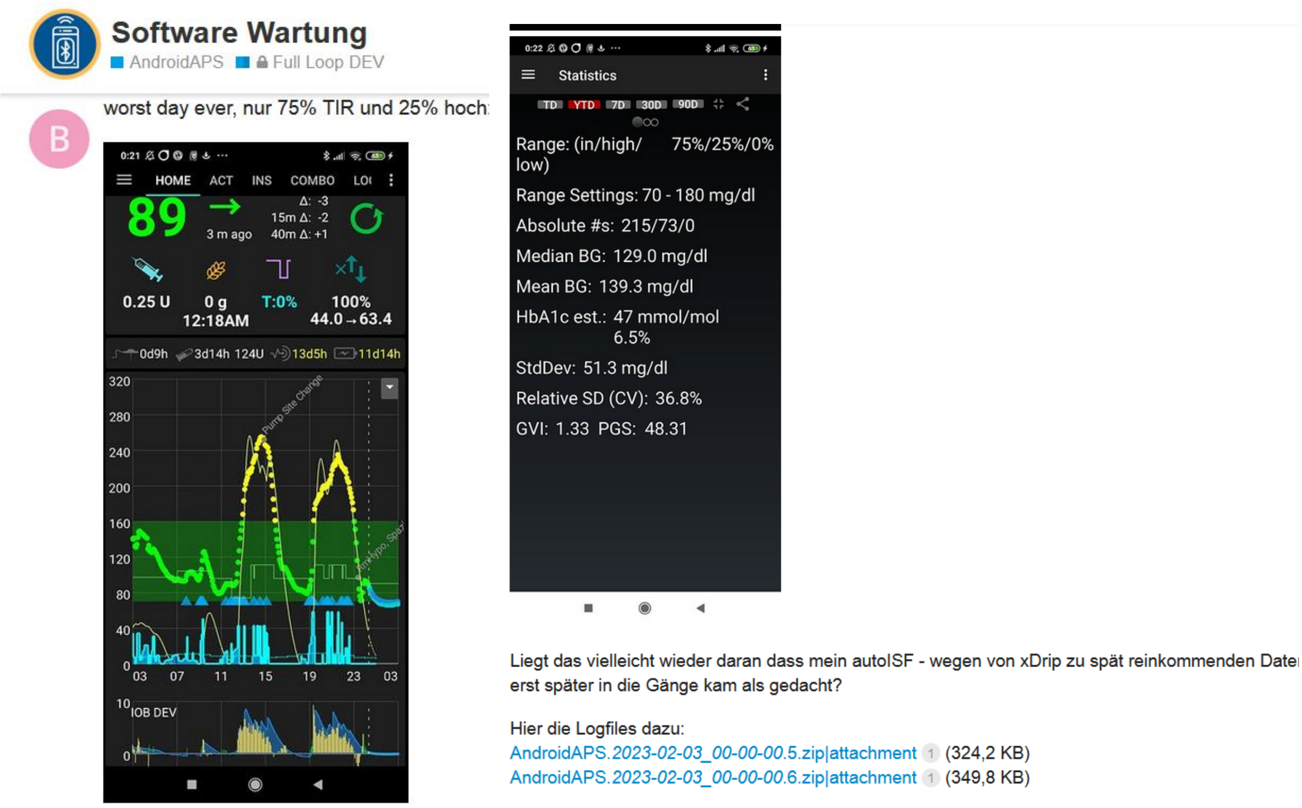
Frustrated about an extremely bad day, after a month with over 90% TIR, the logfiles of this day were analyzed.

> Attention: The number of logfiles in the archive of the smartphone (AAPS/Logs/info.nightsc..) is tightly limited. What you want to analyze can be gone forever after 2 days. Therefore in "important" times, pull these zip files to the PC before they are gone!

> DEV_#07: *It would be nice if we could automatically save the logfiles in the smartphone into a folder, which you then copy to the PC in larger time intervals.*

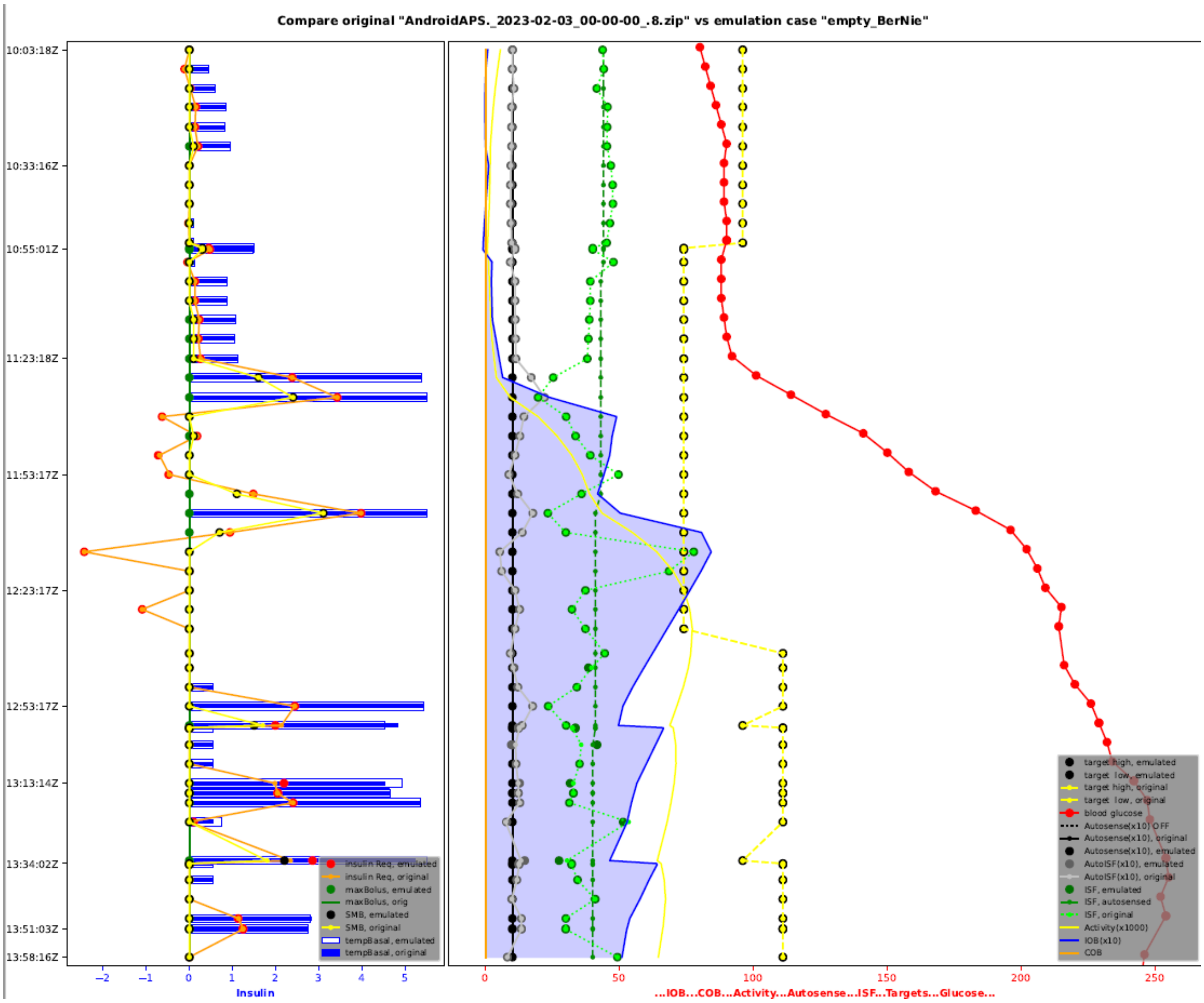
The first assumption was that higher peaks than usual resulted because perhaps CGM values arrived

late, or were released late by the built-in quality assurance. However, with one isolated exception (18.12 UTZ in table below), there was no problem that could be attributed to CGM "delays".



7.2 Emulator Analysis of the First Peak ~ 12:30 – 15:00 central EU winter time

= Greenwich UTZ 11:30 – 16:00 (the Emulator uses universial time zone)



References to columns (letters) are for the table on the following page.

Column (E) and the red curve in the top right graph show the glucose progression. There was an EatingSoonTT of 74 (G) set until UTZ 12:33. Column (L) shows the iob. Values above my iobTH, for SMB shut-down, are highlighted in orange. Column (AH) shows the insulin_required, which is multiplied by the delivery_ratio (0.5...1) to the SMB size column (AL).

The insulinReq is no longer defined by the profile_ISF shown in (AF), but by the ISF of column (AE), which results from a calculation of the five autoISF components (columns Y - AC).

A	B	C	E	G	L	O	P	Q	R	S	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
			bg	targ		final	dur		lin.fi		acce	bg	pp	delta	dura	final				Ins.	Ins.	ma	m				
	UTC		acce	low		ISF	mir	dura	min	lin.f	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	Req.	bol	bo	SMB	SMB	TBR	TBR
id	ime	Z		orig	iob	orig	ute	avg.	ute	delt	emul	emul	emul	emu	emul	emul	orig	pro	emu	orig	emul	ori	ei	orig	emu	orig	emul
16	11:13	Z	89	74	0,25	1,11	55	89	10	0,5	1	1	1,02	1	1,11	1,11	39	43	39	0,23	0,23	0	0	0,1	0,1	1,07	1,07
17	11:18	Z	90	74	0,38	1,12	60	89	10	1	1,1	1	1,02	1	1,12	1,12	38	43	38	0,21	0,21	0	0	0,1	0,1	1,05	1,05
18	11:23	Z	92	74	0,51	1,13	65	89	10	1,5	1,1	1	1,04	1	1,13	1,13	38	43	38	0,26	0,26	0	0	0,1	0,1	1,13	1,13
19	11:28	Z	101	74	0,64	1,7	0	101	10	5,5	1,7	1,01	1,18	1	1	1,7	25	43	25	2,38	2,38	0	0	1,6	1,6	5,37	5,37
20	11:33	Z	114	74	2,38	2,2	0	114	10	11	2,2	1,02	1,26	1	1	2,2	20	43	20	3,42	3,42	0	0	2,4	2,4	5,5	5,5
21	11:38	Z	127	74	4,89	1,43	0	127	10	13	1,4	1,04	1,26	1	1	1,43	30	43	30	-0,6	-0,6	0	0	0	0	0	0
22	11:43	Z	141	74	4,73	1,28	0	141	10	14	1,1	1,05	1,28	1	1	1,28	34	43	34	0,18	0,18	0	0	0,1	0,1	0	0
23	11:48	Z	150	74	4,63	1,1	0	150	25	12	0,9	1,06	1,18	1	1	1,1	39	43	39	-0,7	-0,7	0	0	0	0	0	0
24	11:53	Z	158	74	4,42	0,87	0	158	30	12	0,8	1,07	1,16	1	1	0,87	50	43	50	-0,5	-0,5	0	0	0	0	0	0
25	11:58	Z	168	74	4,18	1,2	0	168	10	9,2	1,1	1,07	1,2	1	1	1,2	36	43	36	1,48	1,48	0	0	1,1	1,1	0	0
26	12:03	Z	183	74	5,03	1,76	0	183	40	11	1,8	1,07	1,3	1	1	1,76	23	41	23	3,97	3,97	0	0	3,1	3,1	5,5	5,5
27	12:08	Z	196	74	8,06	1,37	0	196	15	13	1,4	1,07	1,26	1	1	1,37	30	41	30	0,94	0,94	0	0	0,7	0,7	0	0
28	12:13	Z	202	74	8,42	0,53	5	199	50	11	0,5	1,07	1,12	1	1	0,53	78	41	78	-2,4	-2,4	0	0	0	0	0	0
29	12:18	Z	206	74	8,04	0,6	10	201	55	11	0,5	1,07	1,08	1	1,17	0,6	69	41	69	0	0	0	0	0	0	0	0
30	12:23	Z	209	74	7,62	1,1	15	203	65	10	0,8	1,07	1,06	1	1,26	1,1	37	41	37	0	0	0	0	0	0	0	0
31	12:28	Z	215	74	7,21	1,27	15	208	20	4,5	1,2	1,07	1,12	1	1,27	1,27	32	41	32	-1,1	-1,1	0	0	0	0	0	0
32	12:33	Z	214	74	6,78	1,1	20	209	80	9,2	0,8	1,07	1	1	1,37	1,1	37	41	37	0	0	0	0	0	0	0	0
33	12:39	Z	214	111	6,23	0,92	20	210	5	-1	0,8	1,07	1	1	1,18	0,92	45	41	45	0	0	0	0	0	0	0	0
34	12:43	Z	216	111	5,91	1,03	30	211	10	1	0,8	1,07	1	1	1,27	1,07	40	41	38	0	0	0	0	0	0	0	0
35	12:48	Z	220	111	5,49	1,21	30	213	105	7,8	0,9	1,07	1,08	1	1,28	1,2	34	41	34	0	0	0	0	0	0	0,55	0,55
36	12:53	Z	226	111	5,13	1,76	35	215	10	5	1,8	1,07	1,12	1	1,33	1,76	23	41	23	2,44	2,44	0	0	0	0	5,43	5,43
37	12:58	Z	229	96	4,96	1,37	35	218	15	4,5	0,9	1,07	1,06	1	1,44	1,36	30	41	30	2,13	1,99	0	0	1,7	1,5	4,81	4,53
38	12:58	Z	229	111	6,62	1,26	30	220	15	4,4	0,9	1,07	1,06	1	1,3	1,22	32	41	34	0	0	0	0	0	0	0,55	0,55
39	12:59	Z	229	111	6,64	1,26	30	221	5	3	0,9	1,07	1,06	1	1,3	1,23	32	41	34	0	0	0	0	0	0	0	0
40	13:03	Z	232	111	6,35	1,12	15	228	5	3,1	0,8	1,07	1,06	1	1,16	0,96	36	40	42	0	0	0	0	0	0	0,55	0,55
41	13:08	Z	234	111	6	1,14	20	228	15	2,7	0,9	1,07	1,04	1	1,21	1,14	35	40	35	0	0	0	0	0	0	0,55	0,55
42	13:13	Z	242	111	5,65	1,22	25	230	30	4	1	1,07	1,16	1	1,27	1,27	33	40	32	1,98	2,19	0	0	0	0	4,51	4,93

A	B	C	E	G	L	O	P	Q	R	S	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
			bg	targ		final	dur		lin.fi		acce	bg	pp	delta	dura	final				Ins.	Ins.	ma	m				
	UTC		acce	low		ISF	mir	dura	min	lin.f	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	Req.	bol	bo	SMB	SMB	TBR	TBR
id	ime	Z		orig	iob	orig	ute	avg.	ute	delt	emul	emul	emul	emu	emul	emul	orig	pro	emu	orig	emul	ori	ei	orig	emu	orig	emul
43	13:15	Z	242	111	5,55	1,22	20	233	5	8	1	1,07	1,16	1	1,22	1,22	33	40	33	2,04	2,04	0	0	0	0	4,63	4,63
44	13:15	Z	242	111	5,54	1,22	20	234	5	8,2	1	1,07	1,16	1	1,22	1,22	33	40	33	2,04	2,05	0	0	0	0	4,63	4,65
45	13:18	Z	247	111	5,44	1,28	25	235	5	5	1,2	1,07	1,1	1	1,28	1,28	31	40	31	2,4	2,4	0	0	0	0	5,35	5,35
46	13:23	Z	248	111	5,29	0,75	30	236	40	4,2	0,6	1,07	1,02	1	1,34	0,78	53	40	51	0	0,1	0	0	0	0	0,55	0,75
47	13:33	Z	254	96	4,63	1,32	30	243	50	3,9	1,2	1,07	1,06	1	1,46	1,46	30	40	27	2,34	2,85	0	0	1,8	2,2	5,23	5,5
48	13:34	Z	254	111	6,38	1,25	20	247	10	3	1,2	1,07	1,06	1	1,25	1,25	32	40	32	0	0	0	0	0	0	0,55	0,55
49	13:34	Z	254	111	6,4	1,25	20	248	10	3	1,2	1,07	1,06	1	1,25	1,25	32	40	32	0	0	0	0	0	0	0	0
50	13:38	Z	255	111	6,1	1,17	25	249	5	1	0,9	1,07	1,02	1	1,31	1,17	34	40	34	0	0	0	0	0	0	0,55	0,55
51	13:43	Z	252	111	5,76	0,98	30	249	95	3,2	0,7	1,07	1	1	1,37	0,98	41	40	41	0	0	0	0	0	0	0	0
52	13:48	Z	254	111	5,38	1,34	35	250	100	3,1	0,9	1,07	1,04	1	1,44	1,34	30	40	30	1,14	1,13	0	0	0	0	2,83	2,81
53	13:50	Z	254	111	5,28	1,34	35	250	5	2	0,9	1,07	1,04	1	1,44	1,34	30	40	30	1,24	1,24	0	0	0	0	2,75	2,75
54	13:51	Z	254	111	5,27	1,34	35	250	100	3	0,9	1,07	1,04	1	1,44	1,34	30	40	30	1,24	1,24	0	0	0	0	2,75	2,75
55	13:58	Z	246	111	5,09	0,81	45	250	10	-4	0,5	1,07	1	1	1,56	0,81	49	40	49	0	0	0	0	0	0	0	0

The problem can be seen that at 12:53 and 13:13-13:33 as well as 13:48-13:51, that an odd TT 111 switched SMBs off too early. A too low iobTH triggered the TT, therefore, some measures should be taken:

- **M1)** Set **iobTH** from 5.7 to 6.5 in my Automation

To break the SMB blockade at TT 111 with high BG/high duraISF, the SMB shutdown, triggered by an odd TT, should not come so fast, and also dura_ISF is far from exhausted with weight=0.6. Tim Street had built the dura effect into OpenAps for an investigation and used it to run Scott Lybrand's backtest... and he thus found that 1.5 is the upper limit for dura_ISF_weight, above which hypos threaten. I don't quite trust this based on my experience so far, hence "only":

- **M2)** Increase **duraISF_weight** carefully from 0.6 -> 0.8

> Increases of weights can also be checked in the emulator. The only line for the VDF file for this would be e.g. to test M2): profile dura_ISF_weight 0.8 ### was 0.6.

In the table, the effects of each 5 minute calculation of SMBs * are then shown in column AM (i.vs. AL); the underlying insulinReq in column AI insulinReq (i.vs. AH); the ISF used in column AG (i.vs. AE).

> * *We can only ever see how ONE changed decision would affect the loop. However, this changed decision would alter the further course of the glucose curve, which is exactly the intention. You can not calculate, with the model, the overall resulting new glucose curve.*

At the points marked in yellow, in columns AH and AL, it can be seen that the SMB_delivery_ratio of 0.65 should be significantly increased, Therefore these actions could be taken:

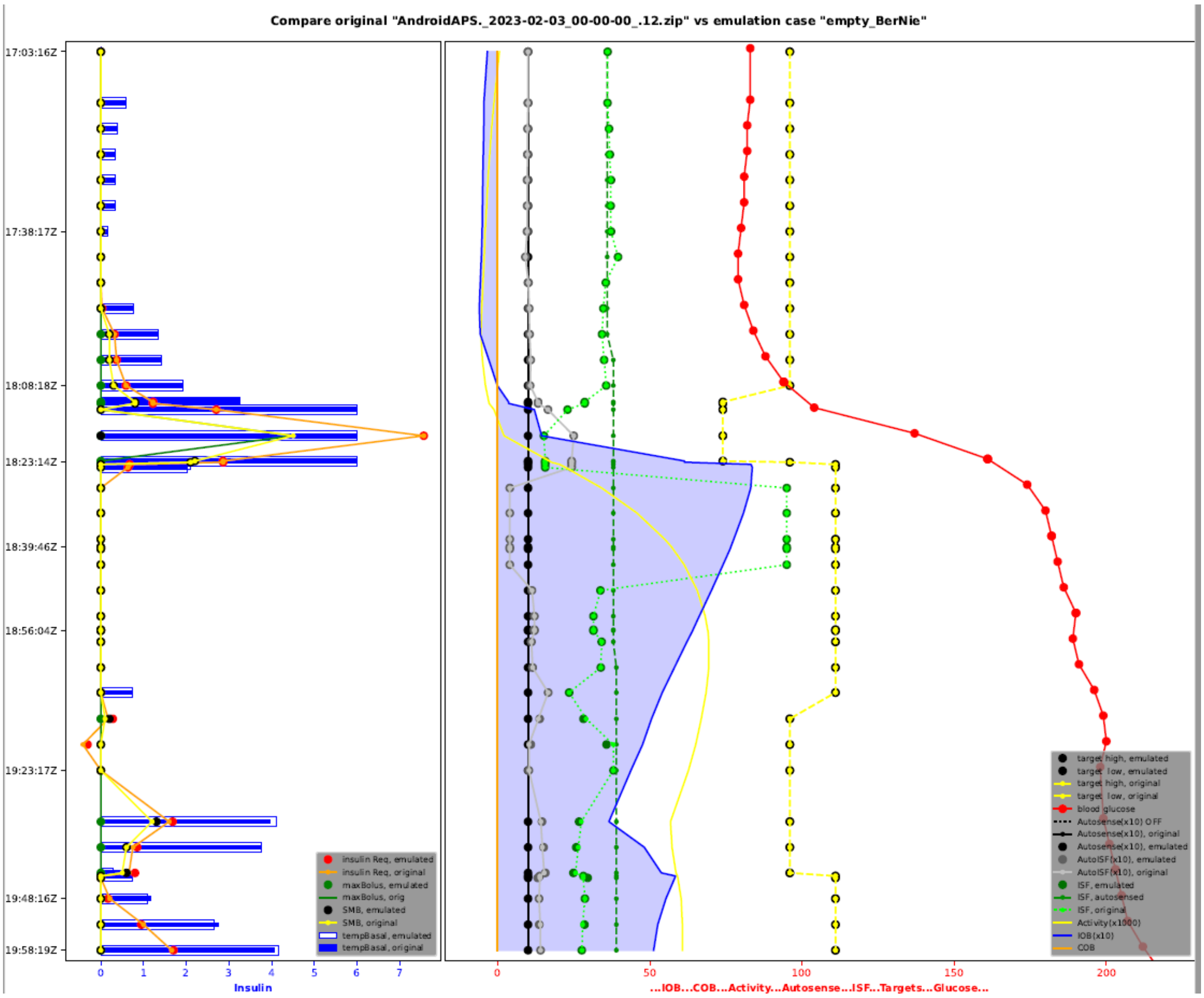
- **M3)** Set **SMB_delivery_ratio** from 0.65-0.75 to 0.8 to 0.9

In many cases, shown in the yellow highlighted entries in column Y, a higher insulinReq and thus higher SMB requested would be achievable with higher bgAcceI_ISF_weight.

- **M4) bgAccel_ISF_weight** is tuned from 0.22 to 0.26. This increases insulin required up to +18%*

7.3 Emulator Analysis of the Second Peak ~ 19:00 – 21:00 central EU winter time

= Greenwich UTZ 18:00 – 20:00



A	B	E	G	L	O	P	Q	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
		bg	targe		final	dura		acce	bg	pp	delta	dura	final				Ins.	Ins.	max	max				
	UTC	accel	low		ISF	min-	dura	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	Req.	bolus	bolus	SMB	SMB	TBR	TBR
id	ime		orig	iob	orig	utes	avg.	emul	emul	emul	emu	emul	emul	orig	pro	emul	orig	emul	orig	emul	orig	emul	orig	emul
8	17:48:15	79	96	-0,6	1,01	45	81,1	1,05	0,97	1	1	1	1,01	35,5	36	35,6	0	0	0	0	0	0	0	0
9	17:53:16	81	96	-0,6	1,04	50	81,1	1,07	0,97	1	1	1	1,04	34,7	36	34,7	0,03	0,03	0	0	0	0	0,76	0,76
10	17:58:18	84	96	-0,6	1,05	55	81,4	1,09	0,97	1	1	1	1,05	34,3	36	34,3	0,32	0,32	0	0	0,2	0,2	1,34	1,34
11	18:03:19	88	96	-0,3	1,09	5	86	1,12	0,97	1	1	1	1,09	35	38	35	0,37	0,37	0	0	0,2	0,2	1,425	1,425
12	18:08:18	94	96	-0	1,07	0	94	1,09	0,98	1	1	1	1,07	35,7	38	35,7	0,59	0,59	0	0	0,3	0,3	1,93	1,93
13	18:11:30	94	74	0,36	1,33	0	94	1,33	1	1,12	1	1	1,33	28,6	38	28,6	1,22	1,22	0	0	0,8	0,8	3,265	3,265
14	18:11:47	94	74	0,36	1,33	0	94	1,33	1	1,12	1	1	1,33	28,6	38	28,6	1,22	1,22	0	0	0,8	0,8	3,265	3,265
15	18:12:59	104	74	1,21	1,65	0	104	1,65	1,01	1,2	1	1	1,65	23	38	23	2,7	2,7	0	0	0	0	6	6
16	18:18:05	137	74	1,45	2,5	0	137	3,59	1,05	1,66	1	1	2,5	15,2	38	15,2	7,55	7,55	4,5	0	4,5	0	6	6
17	18:23:00	161	74	6,14	2,43	0	161	2,43	1,07	1,48	1	1	2,43	15,6	38	15,6	2,86	2,86	0	0	2,2	2,2	6	6
18	18:23:14	161	96	6,14	2,43	0	161	2,43	1,05	1,48	1	1	2,43	15,6	38	15,6	2,86	2,86	0	0	2,1	2,1	0	0
19	18:23:40	161	111	8,33	2,43	0	161	2,43	1,04	1,48	1	1	2,43	15,6	38	15,6	0,67	0,67	0	0	0	0	2,094	2,094
20	18:24:15	161	111	8,37	2,43	0	161	2,43	1,04	1,48	1	1	2,43	15,6	38	15,6	0,63	0,63	0	0	0	0	2,018	2,018
21	18:28:16	174	111	8,32	0,4	0	174	-0,2	1,05	1,26	1	1	0,4	95	38	95	0	0	0	0	0	0	0	0
22	18:33:09	180	111	8,08	0,4	5	177	-0,1	1,05	1,12	1	1	0,4	95	38	95	0	0	0	0	0	0	0	0
23	18:38:15	182	111	7,76	0,4	10	179	0,35	1,06	1,04	1	1,06	0,4	95	38	95	0	0	0	0	0	0	0	0
24	18:39:46	182	111	7,66	0,4	10	180	0,35	1,06	1,04	1	1,06	0,4	95	38	95	0	0	0	0	0	0	0	0
25	18:40:08	182	111	7,64	0,4	10	180	0,35	1,06	1,04	1	1,06	0,4	95	38	95	0	0	0	0	0	0	0	0
26	18:43:12	184	111	7,41	0,4	15	181	0,27	1,06	1,04	1	1,09	0,4	95	38	95	0	0	0	0	0	0	0	0
27	18:48:13	186	111	7,02	1,13	20	181	1	1,06	1,04	1	1,13	1,13	33,8	38	33,8	0	0	0	0	0	0	0	0
28	18:53:14	190	111	6,62	1,21	20	184	1,21	1,06	1,08	1	1,13	1,21	31,5	38	31,5	0	0	0	0	0	0	0	0
29	18:55:52	190	111	6,42	1,21	20	185	1,21	1,06	1,08	1	1,13	1,21	31,5	38	31,5	0	0	0	0	0	0	0	0
30	18:56:04	190	111	6,41	1,21	20	185	1,21	1,06	1,08	1	1,13	1,21	31,5	38	31,5	0	0	0	0	0	0	0	0
31	18:58:13	189	111	6,22	1,11	25	186	0,95	1,06	1	1	1,17	1,11	34,2	38	34,2	0	0	0	0	0	0	0	0
32	19:03:14	191	111	5,81	1,15	30	186	0,96	1,06	1,04	1	1,2	1,15	33,9	39	33,9	0	0	0	0	0	0	0	0
33	19:08:06	196	111	5,41	1,66	35	187	1,66	1,06	1,1	1	1,24	1,66	23,5	39	23,5	0	0	0	0	0	0	0,75	0,75
34	19:13:14	199	96	5,06	1,34	40	188	1,09	1,07	1,06	1	1,38	1,38	29,1	39	28,2	0,17	0,28	0	0	0,1	0,2	0	0
35	19:18:14	200	96	4,76	1,03	45	189	0,76	1,07	1,02	1	1,43	1,09	38	39	35,8	-0,4	-0,3	0	0	0	0	0	0
36	19:23:17	198	96	4,38	1,03	40	192	0,73	1,07	1	1	1,4	1,02	38	39	38,1	0	0	0	0	0	0	0	0

At 18:18, maxSMB size is 4.5 < insulin required; at 0.75 delivery ratio, as mentioned above in **M3)** 5.7 U (+1.2 U) would be asked for, but also ~ 25% bigger SMBs would have to be allowed, therefore some measures to take would be:

- **M5)** Allow 25%...33% larger SMB: change **SMB_range_extention from** 2.5 to 3.2
- **M6) autoISF_max** was already set quite high with 2.5, but to be able to ask for the "allowed" **M5)** SMB size, I increase **autoISF_max** by a similar percentage to 3.2

A	B	E	G	L	O	P	Q	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO
		bg	targe		final	dura		acce	bg	pp	delta	dura	final				Ins.	Ins.	max	max				
	UTC	accel	low		ISF	min-	dura	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	Req.	bolus	bolus	SMB	SMB	TBR	TBR
id	ime		orig	iob	orig	utes	avg.	emul	emul	emul	emu	emul	emul	orig	pro	emul	orig	emul	orig	emul	orig	emul	orig	emul
37	19:33:15	199	96	3,66	1,42	50	193	0,97	1,07	1	1	1,5	1,46	27,5	39	26,8	1,6	1,68	0	0	1,2	1,3	3,95	4,11
38	19:38:15	201	96	4,82	1,47	50	194	1,01	1,07	1,04	1	1,51	1,51	26,5	39	25,8	0,75	0,85	0	0	0,6	0,6	3,75	3,75
39	19:43:14	203	96	5,38	1,53	55	195	1,18	1,07	1,04	1	1,57	1,57	25,6	39	24,9	0,66	0,8	0	0	0,5	0,6	0,55	0,28
40	19:43:51	203	111	5,84	1,39	50	196	1,18	1,07	1,04	1	1,38	1,38	28,1	39	28,2	0	0	0	0	0	0	0,75	0,75
41	19:44:13	203	111	5,82	1,39	40	199	1,18	1,07	1,04	1	1,32	1,32	28,1	39	29,6	0	0	0	0	0	0	0	0
42	19:48:16	205	111	5,53	1,36	45	200	1	1,07	1,04	1	1,36	1,36	28,7	39	28,7	0,21	0,17	0	0	0	0	1,17	1,09
43	19:53:19	207	111	5,26	1,4	45	201	1	1,07	1,04	1	1,37	1,37	27,9	39	28,5	1	0,95	0	0	0	0	2,75	2,65
44	19:58:19	212	111	5,13	1,41	50	202	1,3	1,07	1,1	1	1,41	1,41	27,7	39	27,6	1,66	1,7	0	0	0	0	4,07	4,15

Also, in the evening, it shows in yellow fields in AH and AL columns, that a higher delivery ratio would bring improvements as described in **M3)**. Likewise, 19:53 shows again that stagnant high values at TT=111 produce the problem that no SMBs are allowed for correction and therefore the BG values remain elevated longer than necessary as described in **M2)**. On the other hand, at 18:58 - 19:08, the SMB blockade was harmless, because insulin required = 0. **M2)** would not have helped either.

At 18:12, we see a special case where a new CGM value received by the loop triggers a new loop run, however, the calculated **insulinReq**=2.7 did not trigger a SMB, because 3 minutes have not yet passed since the preceding SMB. Therefore some measures to be taken could be:

- **M7)** You could consider lowering the minimum 3 minutes between two SMBs in the source code

  I don't pursue this for now, because the incident 18:12 seems rather exotic, and a shortening of the time span between 2 SMBs could lead to "tangling" of the loop with complications in delivery speeds; "restlessness" with overlapping information and actions. This is just an assumption by the author.

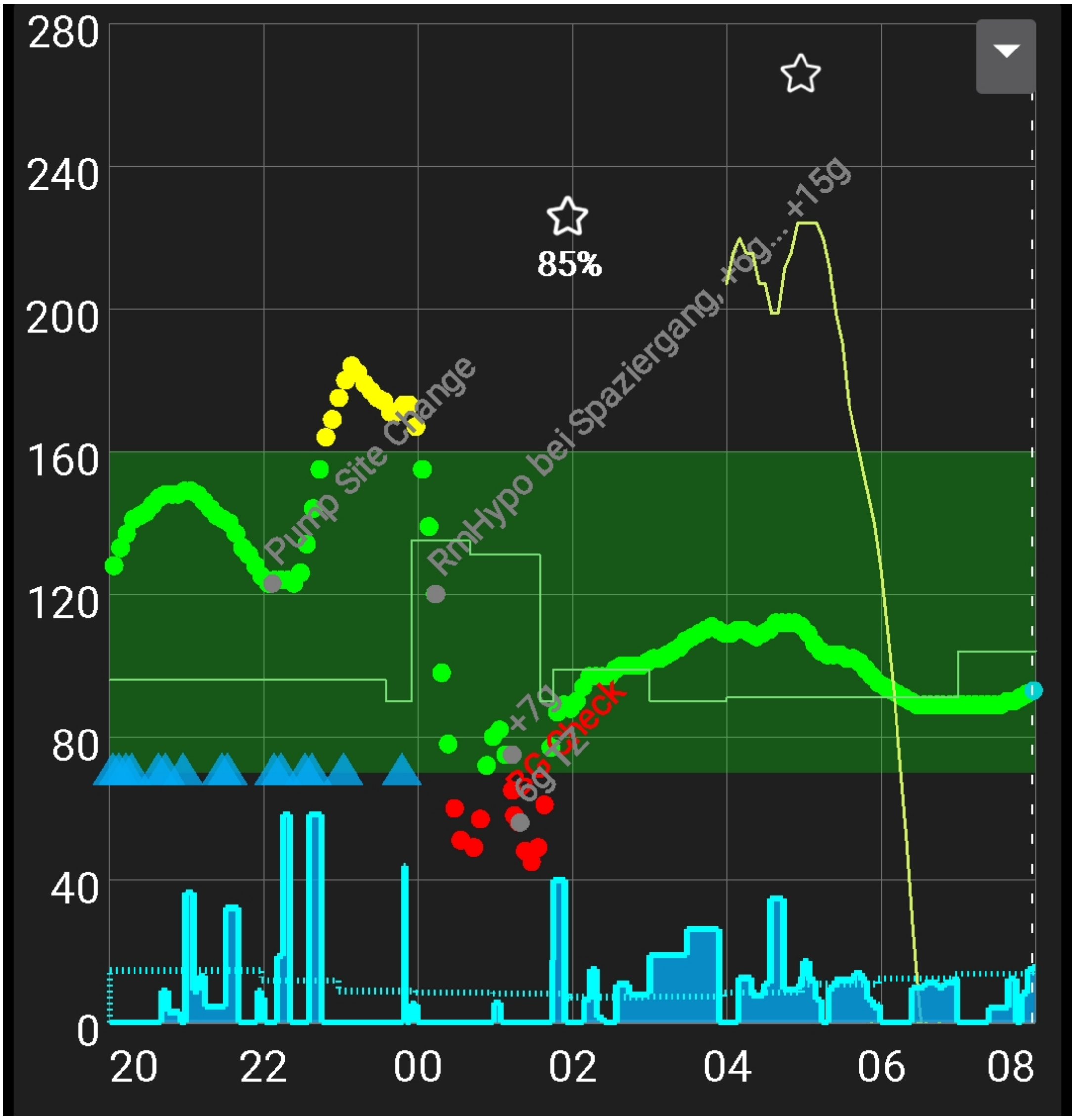
The actions **M1) - M6)** would definitely help to optimize the discussed day.

However, it's a bit daring to re-sharpen so many parameters at once.

7.4 Experience with the More Aggressive Settings

After 2-3 days with more aggressive settings, as described in **M1) - M6)** above, it was already clear that too often carbs must be eaten additionally to stay out of the hypo-zone. It just **didn't make sense to question everything** after a whole month at 94%TIR, just **because of one problem day** with 75% TIR!

The following dinner example shown in the screen shot on the next page shows the problems with the sharpened settings. It was initially well regulated until 22h. Then came influences of fat, some stress, and finally, "at an unfavorable moment" shortly after midnight, a dog walk.



It took a whopping 34 g of CHO, and over an hour of waiting before bedtime, to be feel reasonably safe to go to sleep. Annoying low alarms did not help. So I had received 3 - 4 U too much insulin from the loop, which equates to 34 g / my profile IC, of which 1 - 2 U could be owed to reduced need, because of activity.

So I had to "row back" to settings that result in about 2 U lower iob before zero temping, and/or lower my iobTH a bit.

Concerning 1-2 U reduction during activity, see section 5. Sport After Meal

Interim conclusion for me from tests described above:

The measures developed above are strongly attenuated for further testing as follows, respectively: By analyzing valid parameters in successful results obtained in previous months, I will decide on new settings, **N#)**, that are not as agressive as the ones described above in **M1) - M6)**

N1) set **iobTH** from 5.7 to 6.2 in my automation, rather than 6.5

Especially before activities, always pay attention to lowered iob threshold, as well as use sport button more often.

N2) increase **dura_ISF_weight** carefully 0.6 -> 0.8 (0.8)

N3) increase **SMB_delivery_ratio** from 0.65-0.75 to 0.8 (not 0.8 to 0.9, because I don't want to get much insulin, especially at high glucose levels)

N4) bgA**ccel_ISF_weight** becomes from 0.22 to 0.24 (not 0.26)

N5) SMB_range_extention increases from 2.5 -> 2.9 (not 3.2)

N6) autoISF_max increases from 2.5 -> 2.9 (not 3.2)

Do not copy these settings!

In the future, it must be observed:

- whether the new settings for different-type meals are good, which of the measures are really helpful and which are perhaps a bit problematic.
- It could also well be that in further steps I have to rebalance the "job distribution" between **bgAccel_ISF_weight** and **pp_ISF_weight**, with a view also to **bgBrake_ISF_weight**. Especially **bgAccel_ISF_weight** could trigger too large SMBs, but I do not want to over-provide iob, because a relatively flat glucose curve could follow after the first small rise, attributed to a low carb meal or a snack.

This job could possibly be simplified if the *DEV_#02* idea (p.7) is pursued.

- Setting even and odd targets could be improved, e.g. to roughly map time blocks of meals and to stop the "aggressiveness" of the autoISF loop whenever low CHO or small snacks could cause a complete meal response.
- If the *DEV_#03* idea (p.8) is followed, I could also switch fully automatically between autoISF full loop periods and normal oref(1) with SMB.
- Also a complete reset to the satisfactory settings that provided good results for months, before starting the analysis presented here, remains an option.

8. The best for the end: **Emulator on your AAPS Smartphone!**

The Emulator on the PC discussed above is very good for rough adjustment, when weighing different effects over the entire course of time after each meal considered.

The ultimate tool, however, is the Emulator running on the Loop smartphone, which can help clarify a "what if..." question.

In running the Emulator on the phone, one can define in the .vdf file of the Emulator, which setting one would like to be slightly more aggressive than in the active AAPS.

At times when this sharper setting would have resulted in greater SMB insulin delivery, the notification is reported via speech synthesis, and you can assess the situation yourself.
If this suggested extra bolus makes sense, you can add this portion manually* and in time observe whether this bolus was OK.

**In Full Loop, you don't need any buttons at the bottom of the AAPS main screen. But for such test phases it is practical to reinstall the insulin button at the bottom of the AAPS main screen (Preferences/Overview/Buttons/Insulin -> ON).*

DEV_#08: Instead of adding and removing the buttons via AAPS/Preferences as needed, the Full Loop user could remove them by default, and have the program automatically "offer" an insulin button at the bottom only when, and as long as, needed.

After a few iterations, you'll get a feel for whether you want to incorporate this tightening into the active AAPS.

Closing Remarks

With AAPS+autoISF, as well as the presented associated tools, those who do not mind the effort are enabled to create a **PERSONALIZED SYSTEM FOR FULL CLOSED LOOP** which is far ahead of others, especially of the available commercial systems.

Can we soon expect commercial systems that open a less tedious avenue to a Full Closed Loop?

After all, it is the basic idea of the OPEN SOURCE community to publish how automated insulin delivery systems can work... with a bit of an aftertaste for the industry, of course, that they then can't patent for themselves what others did already demonstrate.

It is in the nature of things that companies can rather throw a one size fits all, easy to use/easy to service variant on the market. It would be conceivable that Full Closed Looping could be equipped with a self-learning system for tuning with the help of appropriate peoplepower and financial power. A very large database will be required for this, and the usual "Clarity®" data will certainly not suffice. (We DIY developers, on the other hand, have complete access to all *our* relevant everyday data, can fine-tune algorithms and *personalized* settings in running test mode, etc.). Nevertheless, if you compromise a bit on expected %TIR or HbA1c performance, and/or on flexibility in lifestyles and their day-to-day variability, full closed looping can probably succeed sufficiently well at some point for the broad mass of diabetics, for whom it would still mean exciting progress.

Remember the completely clueless pigs of Stanford Univ.? They acieved 64% TIR in AAPS Full Loop, and that was without Lyumjev and without autoISF! (R.Lal et al, ADTT 2020, #246 abstract ID 474 "Comparing DIY full closed-loop performance in pigs..."). At the 2023 ADTT, a Czech group of 16 patients demonstrated comparable %TIR in hybrid and full closed loop with AAPS, 80-83% TIR, again, without autoISF. https://pubmed.ncbi.nlm.nih.gov/36826996/ Furthermore, in this context, reference is made to a study starting in 2023 in Australia, in which the AAPS full loop, in the simplest variant, without autoISF, is to be run in addition to CamAPS. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=384870&isReviwe=true
For a glimpse into the longer future e.g. with dual hormone systems and such see: https://www.diabettech.com/automated-insulin-delivery/how-far-are-we-from-fully-closed-loop-news-from-attd-2023/

So for now, we're doing this "DIY", each to his own, and that can work out quite well.

Also my big thanks go to the developer group (the author is not part of the core group).

And: The development is not finished. You can also contribute by sharing your experiences with all of us...

e.g. also by discussing DEV suggestions in the de.loopercommunity, or in English, in

https://discord.gg/kTJeCShmGQ).