7. Advanced HCL: Meal Announcement (MA) via a pre-bolus… V.3.8nxt

Please note that with autoISF you are in an early-dev. environment, where the user interface is **not optimized for safety** of users who stray away from intended ways to use. Good safety features exist, but these are only as good as the development-oriented user understands and implements them. This is not a medical product, refer to disclaimer in section 0

Available related case studies:

Case study 7.1: MA_Adv.HCL_5 year old

See also Case study 13.3 from a user of Boost

Originally it was planned to provide an extra section on FCL **for kids** here.

To establish and maintain *any loop* for kids brings about some extra challenges if:

- Going through marked changes of insulin sensitivity or of circadian pattern makes it difficult to keep the FCL appropriately tuned.

  This problem is about the same in all loops. However, Autotune, dynamicISF, and some commercial systems with elementary “self-learning” might provide rough (and time.delayed) solutions to this that could prove good-enough.

  When facing such challenges, you should try to set appropriate (temp.?) changed profiles, that serve also as a basis for your autoISF loop.

- Between kid and supervising parent it must be guaranteed, especially in the initial weeks, that an eye is kept on whether the “Meal Announcement” (MA) advanced hybrid closed loop” is working about as to be expected.

- Extra caution is needed re. the SMB delivery ratio**.** The fixed 0.5 value in AAPS was installed also with a consideration on user/follower (parent) set up and limiting potential problems from a bolus being initiated from both phones in parallel. Recommendation is to stay with 0.5.

However, we came to realize that the approach is no different for kids than already laid out. It just seems some implementation hurdles are significantly higher for implementing a safe FCL for minors.
Also adults may face special challenges, or just lack the time to do a sophisticated FCL set-up project.
For that reason, we like to focus this section 7. on how a **hybrid closed loop without carb inputs, using autoISF**, might get you to a **solution that removes most of the everyday burden** associated with having to co-manage meals.
This ”Meal Announcement” could - not only for kids - also be an **intermediary step, from which to progress into FCL as soon as a currently missing pre-requisite resolves** for you in the future.

7.1 Hurdles for FCL

Deficit making FCL difficult or unsafe	Bridging solution with Meal Announcement (MA) via pre-bolussing for meals
Lyumjev or Fiasp (also in 50% mix w.slower insulin) not tolerated/too many occlusions; poor discipline re. scheduled **infusion site changes**	Different insertion (site, depth, angle, cannula material), injection speed, site exchange frequency might help, but difficult w/ pod pumps. Low carb diet would help, but not consistently used by many. => Pre-bolussing (possible also with pen + AAPS data entry)
Poor discipline regarding keeping 100% **BlueTooth** connectivity (keeping phone 24/7 at body, and well charged)	Giving meal boli (+ pump providing profile basal in case of problems) will reduce potential problems significantly. Install alarm on (parent) phone. Libre3 (1 minute) might aggravate problems
Leaking pods	(still a “no go; pre-bolussing w/pen would help)
Jumpy CGM	Use strong smoothing, and weak bgAccel_ISF (MA and HCL do not rely on early aggressive action, upon first signs of rising bg)
CGM does not allow **SMBs always** (also at cob=0, which we always have in FCL)	Use Dexcom or Libre3. For others you probably will find work-arounds described
Very **low hourly basal**	No problem as MA (HCL) does not require super boosted SMBs
Erratic patterns of **sweet drinks and snacks**	Much less of a problem when a bolus is given with it, and bgAccel_ISF is dialed-in much softer, SMBs come smaller and delayed (compared to FCL)

7.2 Getting ready to advance from your Hybrid Closed Loop

7.2.1 Optimize your Hybrid Closed Loop

Switch off dynamicISF, forget what Autotune tries to tell you, and make sure your profile parameters are set right. Refer to guidance given in the HCL repo (https://github.com/bernie4375/HCL-Meal-Mgt.-ISF-and-IC-settings).

Optimize meal management, notably watch that your ISFs are set right to deal with rising bg once your given meal bolus loses power.

With properly set ISFs, you should be able to expand allowed SMB sizes to 120 minutes worth of basal.

Next, introduce a method that allows your loop take care of temp. insulin resistance from fats. (In the past, dynamicISF might have helped you for that.)
For this, you have two options:

- Temporary increase of %profile via an Automation at signs of post-meal fatty acid resistance. See: https://androidaps.readthedocs.io/en/latest/Usage/FullClosedLoop.html#stagnation-at-high-bg-values
- *Or:* Step into using the AAPS dev variant with autoISF, but make exclusively use of the dura_ISF component there.

Make sure your HCL now works at satisfying performance.

7.2.2 Develop your Advanced HCL: Meal Announcement (MA) w/o carb counting

In the next steps, you try to get same performance, but with only a very rough idea, what you will eat (and **no** carb inputs)

Go through section 2 – 4 for setting up your autoISF,
Caution: If you do not fully establish a FCL, make sure to use significantly less aggressive (**lower** than suggested there for FCL) **settings** for SMB_range_extention (section 2.1), for autoISF_max (section 2.2) and for bgAccel_ISF_weight (section 4.2).
If you and your child operate with remote bolusses via a NSClient caregiver set-up, it is important to **not** extend the SMB delivery ratio above 0.5 in the MA mode (This is for safety, in case issuing a bolus by the remote parent overlaps with autoISF driven SMB)(section 2.3)
Do not forget to install your iob threshold above which your autoISF loop will no longer issue any SMBs (section 2.4).

7.3 Pre-bolussing

Operating in the SMB+UAM mode, you do no longer need to count any carbs. (If you wonder why, section 4.5.9 attempts to explain why this can work just fine) .

However, going for a Full Closed Loop comes with difficult issues, how to automatically get iob up to control carb absorption and bg level after meal start.

“Meal Announcement” via giving a bolus

A “Meal Announcement” mode based on autoISF must deal with the fact that giving a **user bolus** severely distorts the glucose curve.
You need a different look (than we did in section 4.1-4.7 for FCL) on the contributions we expect from bgAccel_, pp_, bgBrake, bg_ and dura_ISF.
The proper settings will vary between

- no-bolus (FCL),
- substantial bolus
- or very small pre-bolus..

This topic is currently not well investigated. Inconsistent daily patterns of bolus size, time, and ratio of %coverage for the carbs consumed could complicate the matter further.

> Maybe we are too cautious here, and in fact the autoISF adaptation to glucose behavior is tolerant enough of disturbances by **user boli**. Please report your findings in case you collect data of “mixed use” (FCL / Meal Announcement / HCL use with meal bolus).
>
> A n=1 finding, and guide how to evaluate, is reported here: https://github.com/ga-zelle/autoISF/blob/A3.2.0.2_ai3.0/To%20prebolus%20or%20not%20to%20prebolus.pdf).
>
> Once we have a body of data, including from those who moved from *HCL with autoISF* to FCL, we may need to re-define what the bi-directional transitions FCL < - > HCL in detail shall mean, and whether or not this has implications for needing different autoISF settings in /preferences for FCL and for HCL. .

To “help” your advanced hybrid closed loop not bear the full burden of quickly getting iob up (like in FCL) you have two options: Giving a substantial meal bolus, or just giving a little pre-bolus:

7.3.1 Meal bolus in Meal Announcement (advanced HCL)

Based on a very rough idea on how *in HCL* a bolus *in the past* looked for the meal you are about to start, issue nearly that bolus size.

Note that timing is very critical: You should **bolus** (and AAPS must have the related iob info to work with) **before any** meal-related **acceleration** and first pos. delta bg **happen.**

> This is important, because - even with Lyumjev given at meal start -, carb absorption and bg rise happen earlier than the insulin activity kicks in "against it". So, autoISF would issue SMBs if it had no info about the big bolus you already gave, or you are about to give. (The latter case can get really dangerous, especially if you operate with FCL-suitable autoISF_weights and SMB sizes!, You must look at your screen and ***deduct*** the **iob that the FCL *already issued*** from your intended bolus in that case!)

Most eaters will have **over 60 g carbs** in each of their meals. This means that the amount that gets digested while their fast insulin is active in a major way (without many extra SMBs already complementing), is always the same, and hence just define your personal meal bolus for your advanced HCL (~ 60 g / IC. At an IC = 8 g/U this would for instance mean to **always** bolus 60/8 = 7.5 U, or maybe 1 unit less to play it safer) . This should immediately put you above iobTH, and from there, your loop will not differ from FCL, and should work with the same settings.

- In Meal Announcement mode, you need not pay so much attention to setting an aggressive bgAccel_weight (section 4.2). Also, you generally operate with higher safety because you require no super big SMB sizes as you would in FCL (section 2). This also helps keeping your autoISF loop from over-reacting to small snacks, or any "bumps" in your maybe sub-optimal CGM.

- FCL users should be able to occasionally just give a meal bolus, too, without worrying how that works out with their FCL settings. (The author does not know of much experience with this, but used it a few times as a quick fix when, in a critical time period around meal start, the FCL was without BT connectivity).

Low carb eaters should of course bolus for an estimated lower amount of carbs (as they estimate gets digested in the first 2 hours). In this case iob remains under iobTH. autoISF tuning should focus on bgBrake_ISF (section 4.4) and dura_ISF (section 4.5). Consistent low carb eaters in MA mode might set their bgAccel_ISF_weight (section 4.2) to zero, or very low.

Users coming from (positive experience with) dynamicISF might look deeper into tuning bg_ISF, as well.

7.3.2 Small pre bolus in Meal Announcement (advanced HCL)

Giving a **small bolus before or at meal start** can be helpful in several respects:

- It provides some iob to cover for the first grams of carbs that will be absorbed faster than a subcutaneous insulin could become active
- It relieves the FCL algorithm from the job (difficulty depends on your CGM performance) to recognisze a meal start
- Allows to keep max. possible SMB size within safer limits, and probably does not require quite the strong amplification of ISF via high bgAccel_ or pp_ISF_weights (as for FCL, see sections 4.2 and 4.3):

The challenge then is, how the loop can take over, notably, as your bolus severely distorts the bg curve upon which you must "train" your autoISF loop to reasonably respond (via tuning your …_ISF_weights):

- Fortunately, the loop always has the iob and insulin activity data (stemming also from your bolus), and can factor this in when determining the insulinRequired. Also, your set iobTH (section 2.4) remains valid.
- But, **problem** is, that size of the pre-bolus, relative timing (minutes) vs. meal start, and kind of meal, all strongly would impact the bg curve, and tuning the four …_ISF_weights might become a mission impossible on such shaky grounds. The key author of this e-book did not even experiment with this, and just looks forward to eventual case studies that can give insights into the workings of autoISF in Meal Announcement mode, with **small** pre-boli.

Tuning example autoISF in HCL (after a reduced bolus that needed complimentary SMBs)

Starting point: Bolus of 7.7 U and announcing 55 g carbs

With the chart next page we show a dinner that had received a pre-bolus of 7.7 U for announced 55g of carbs.

> Little problem: The screenshot was taken before the iob and insulin activity info for the time before 19 h was backfilled.

We (and also the loop, see first SMBs coming very soon) realize that **this pre-bolus was not enough to cover these carbs**.

> The 55g could also not be grossly misjudged, because 60g is about the max that could be bolussed for with Lyumjev. (At 30g/h absorption, carbs above 60g are coming to absorption when Lyumjev lost already 75% of its power, and SMBs took center stage anyways).

So, we can conclude that

- the IC is too weak (if the user meant to do classic Hybrid Closed Loop)

- or: the user meant to only **partially bolus**, to get her/his loop trained **towards** eventually **doing MA or FCL** successfully. This is what we like to consider and discuss further here.

The good thing we see in the chart is that SMBs were nearly permanently fired, up to the time point when the bg curve finally turned downwards.
But, for over two hours the loop struggles to get the rising bg under control (see the middle graph: IOB maxes only two full hours after meal start). As a consequence, the thin yellow insulin activity curve in the glucose chart does not display the needed power before 21 h.

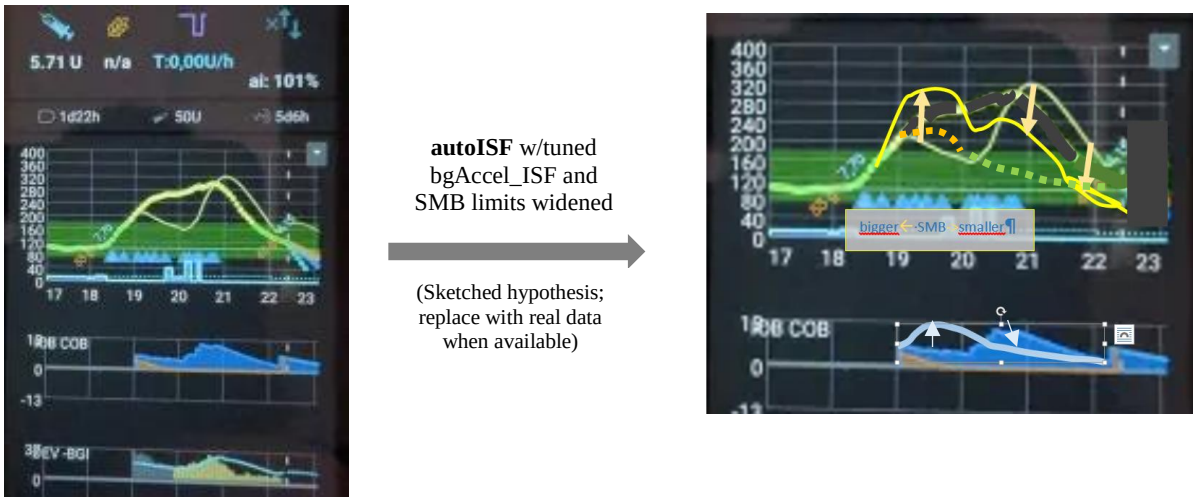
It took from 18 to 21 h to produce the max level of insulin activity. This produces two serious problems:

1. bg is rising for too long, and is getting higher than would be if applying more of the needed iob earlier
2. The strongest power is coming so late that then, the period of strong carb absorption (and insulin need) is over. This led to a need for rescue carbs around 22 h to prevent a serious hypo incident.

Suggestion what to improve

The easy remedy is to make the first SMBs much bigger.

This would produce a different shape of insulin activity and IOB curves as sketched below



Clearly, the bg curve would not go as high as we had seen (see dotted curve in the hypothetical right side graph). And around 22h there would be much less insulin activity left, with sharply reduced hypo danger.

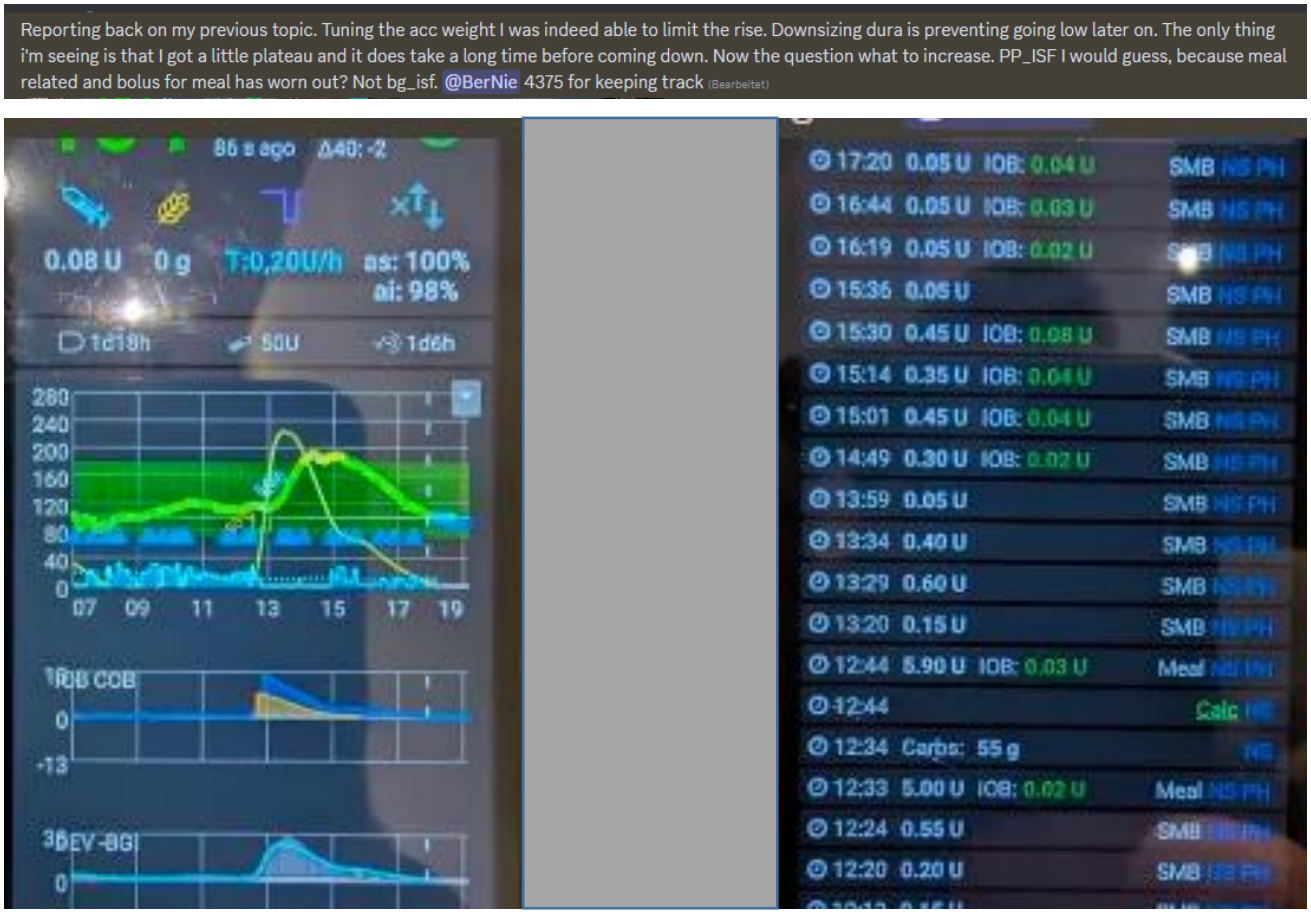
How can we get bigger SMBs, early in the bg rise?

Best way to accomplish this is autoISF, specifically setting a high bgAccel_ISF_weight.

> At the same time, you must allow substantially expanded SMB sizes (like 5 hours worth of basal per one SMB). And also the factor (autoISFmax) by which profile ISFs can be modulated, must be high. Refer to section 2 of FCL book, but note that the author has no experience with autoISF in HCL or MA application. You might need lower amplification factors.

Tuning the bgAccel_ISF is easy and safe to do for just (any) one type of meal, if complying with the instructions about setting an iobTH (iob level above which further SMBs are blocked).

Second try: No upfront bolus; still 55g announced; bgAccel_weight sharpened; dura_weight decreased



Interpretation and suggestions:

That meal picture strongly improved, and looks pretty good now! Two things:

1) I doubt your adding carb inputs makes any difference. ((Unless, maybe, if you use Autosens also; and even in that case, for that meal it would not make a difference))

2) I would not make any parameters like pp*ISFweight stronger now "to shave off that bit of yellow". Reason: Overall, you get nicely exactly the insulin you need ((because you have a great landing in the end, ...that would lean towards hypo again then, if you make your loop more aggressive late on the way up, or at peak)).*

Suggestions

What I would try is shift the received iob towards a bit earlier ((that would eliminate "the yellow" in your picture)). So, how could you do that?

3.1) One way to try would be to set a low (even) TT around meal start. You can do that manually, or via an Automation ((Automation around certain fixed meal times, or upon first seeing a glucose delta of > ??? at iob < ???))

3.2) Another way is to increase bgAccel_weight (or pp) a bit further. Always: Provided SMB sizes and autoISFmax don't hold you back. –

Third try: Same without carb inputs, and using …. (TT) …

insert 3rd iteration without carb inputs, and with a TT

Need to move forward incorporating very different meals

It makes **no** sense to optimize everything for what you see/saw **in one meal.** Test some other meals, and then decide where you "lean", - or whether it actually is good-enough, as-is. - - -

> Especially balancing how much iob build up is via acce vs via pp depends, in my experience, very strongly on the kind of meal. As my meals vary strongly between high and lower carb, I need a careful balance there. (See also ~ 1 page lower).

The complicated part of tuning autoISF is to find your personal “good-enough” value for all “_weights”, that will work well

- with all kinds of your meals

  See also discussion in FCL part, section 04, and related case studies!
- with what (and when, relative to meal start) you might give as pre-bolus.

In HCL application of autoISF, both aspects together determine the bg curve form that autoISF acts on, and determine also the level of insulin activity required over the hours of the respective meal.

In the discussed example of a meal with 55g of “early” carbs, bgAccel_ISF was helping us control the situation.

However, if your diet also contains low carb meals, you may, in a next step, have to “tame” your bgAccel_ISF, so not invariably, for any acceleration and beginning-to-rise bg (as also observed in low carb meals), it would shoot insulin rapidly to exceed iobTH.

The material put together for FCL (see especially section 4.2.5) shows that

- passing some of the “duty” of bgAccel_ISF over to pp_ISF for high carb meal management
- tuning dura_ISF for low carb

may be a (somewhat complicated) additional task, after you mastered the kind of meal we discussed here as an example.

7.3.3 Conclusions

- Setting Meal Announcement with small or large pre-boli might be easier or better than going all the way for a FCL, in case:
    - key pre-requisites for a FCL are missing (extremely reliable bg data, and leak-/occlusion-free insulin supply)
    - time is missing for a sophisticated FCL set-up project
    - user appreciates to gradually move from HCL towards FCL.
- The Meal Announcement mode (**MA**) **can be the best solution** for many kids. Especially for small kids (but probably also for teenagers in a negligent phase), the much **more reactive FCL** mode **could too often backfire** (and in effect ruin the principally possible high %TIR) because it:
    - strongly elevates the need to have a technically super working system, to carry phone 24/7 on the body etc
    - may be less forgiving of spontaneous bursts of activity, a small sweet snack etc (anything that distorts the bg curve, and could be misinterpreted by the FCL, which is (always?<- that can be restricted) looking out for meal starts…).
    - comes with extra challenges if the real user of the FCL is not aware of, and “mindful” about, what limitations of the system to watch out for, to avoid, or to actually very easy deal with (See next section 7.4. Available methods are the same in FCL and in MA).
- Overall, giving a bolus in MA mode is no guarantee for improved meal management, compared to Full Closed Loop:

    Overall comparable performance in MA and in FCL mode was for instance demonstrated in this study: https://androidaps.readthedocs.io/en/latest/Usage/FullClosedLoop.html#what-to-expect

    True, MA gives you a handle at limiting the first bg rise. However, earlier delivered insulin is also earlier gone, while additionally creating a gap in insulin supply by induced zero-temping after the user bolus. So what is gained by giving an early bolus is eventually lost by the difficulties associated

with the “hand-over phase” towards having the loop handle your meal. These difficulties increase to the extent your meals vary, and depend also on consistency of your pre-bolussing.

Further investigations (by “MA loopers”) might lead to insights how the performance loss in the “hand-over phase” can be minimized.

See also “To pre-bolus or not to pre-bolus” here: https://github.com/ga-zelle/autoISF/blob/A3.2.0.2_ai3.0/To%20prebolus%20or%20not%20to%20prebolus.pdf

7.4 Dealing with special situations / insulin sensitivity / disturbances in MA mode

7.4.1 Manual nudging of loop aggressiveness

Whenever you see a need, you can temporarily “micromanage” your loops aggressiveness by:

- temp, switching between **even / odd bg target**, to allow / block SMBs
- setting a **temp. profile%**
- significantly elevating or lowering the (even) **bg target** temporarily

More see in sections 5.1.3 and 5.2.2.1

7.4.2 Automations to adjust loop aggressiveness

To set up suitable Automations, you first must **analyze patterns** you find **in *your* data**, at times (or geo-locationa, or bg and iob patterns that point to a problem …) **where you want your loop act differently**, to carve out Conditions that describe the respective situations (and either for how long it typically lasts, or at which *other* Conditions you want your loop get back to default FCL operation).

Under Actions, make use of any (combination of) measures that adapt aggressiveness (see above, under 7.4.1). Also, setting a different iobTH%, or temporarily shutting off ISF modulation by autoISF are selectable Actions.

More see in section 5.1.4

7.4.3 Automations triggered via custom buttons

Via defining “User action” Automations, you can install customized buttons for your “DIY cockpit” on your AAPS main screen (section 5.2.2.3).

Recurring special situations can be addressed via a DIY cockpit button, and **receive automatically** (whenever the conditions that describe the special situation are indeed given) **treatment with adjusted aggressiveness** (up to a suitable iobTH level).

This should be very helpful to custom program buttons, e.g. for kids in kindergarten, and you can even custom-define the hours of day when they show up, and disappear again from, the AAPS main screen!!

Over time you can have a big number of User action Automations, and keep them “shelved” rather invisibly (clicked inactive via top left box in the Automation description) in your long list of potential Automations. Even when active, they only show in your cockpit (bottom grey field of your AAPS home screen) in the time slot you assigned as potentially relevant

7.5 Exercise management and Activity Monitor

In MA mode:

- you are giving a meal bolus that you can simply reduce in an exercise context (just as customary in hybrid Closed Looping)
- your bolus choice is completely independent from any exercise settings that reduce further insulin supply With small pre-bolus (7.3.2), focus should be on setting a TT and exercise mode, right after giving that bolus, that would limit iob from rising more than desirable during exercise.

More see section 6.

(But in MA you need not worry about the extra challenge in FCL as discussed in section 6.5)

7.6 Remote control:_Implications of looping in MA or FCL mode for small children

(The main author is unfamiliar with that area, and happy to include contribution from a co-author)

7.7 Other methods w/ Meal Announcement (MA)

See section 13.3

Off-topic remark, to complete the picture about looping options:

There are also advocates of doing “the opposite”, precise carb inputs, but no (or reduced) boli. See section 13.4.

7.8 Closing remarks

The author is sceptical about effort / benefit of setting up your MA loop vs just working with very sloppy carb inputs in a well-tuned “vanilla AAPS” SMB+UAM HCL.

The author is also not sure about effort / benefit of setting up your MA loop vs going for FCL. I guess there is a higher safety level in MA, especially when the pre-requisites (section 1, and 7.1) are **not** permanently given. Not having to watch out for this so much, may also relief of some extra vigilance (and frustration?). See Case study 7.1

Regarding a journey towards FCL for/with your kid, there are a couple of parents and kids pioneering this area,

Unfortunately, many need to work on eliminating any deficits (as listed in section 7.1) that stand in the way of establishing a FCL.

This may not be possible within their next year or so. Advancing your HCL into one or another form of Meal Announcement (MA) mode involving pre-boli then might be an intermediary step that is worth developing.

Section 13.3 points to a couple of other options, besides autoISF, that do well with Meal Announcement. See also Case study 13.3 .

We highlighted areas that would require some minimum compliance.

In the end it comes down to compare the achieved ease in daily use and achieved %TIR to how it was in prior hybrid closed looping.

Generalizations of conclusions will always be difficult in this area.

Note that while you may be able to conclude an improvement in *your* looping, this does not necessarily say anything about superiority or inferiority of the involved methods…

- …not even for you, as you probably did not put the same effort, at same knowledge level, into “getting the best out of” both methods…
- …plus there is always that “YDMV” (your diabetes may vary) …