4. Meals: Setting ISF_weights in /Preferences   V 2.2

Please note that with autoISF 3.0 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

Warning regarding importance of proper profile ISFs.

Starters on autoISF FCL who are coming from using HCL with **dynamic**ISF must be aware of the following: It is absolutely essential to build your FCL on properly set **profile** ISFs (likely a circadian pattern over 24 hrs). It may not apply to you, but many dynamicISF users did never bother to determine their ISFs that would maximize their HCL performance, but employ dynamicISF so to speak for going „dynamically" through a wide range of possible ISFs, until eventually hitting a sweet spot, and the whole thing works better than before with their profile ISF (often only one, e.g. coming from Autotune).

The following is important to understand, as it also leads straight into the core idea behind FCL with autoISF, too: It is a good idea to establish a well-running hybrid closed loop with set (non-dynamic) **ISF (as in profile each hour of the day).** That ISF must be **aggressive enough** that it gets you down from a high around 200 mg/dl to target. That is roughly also the way you experimentally determined it (I hope).

Using that value also at lower bg, on the way up (after meal start), is very positive, as it is probably **stronger** than you would use, if you had just that (lower) bg to correct. autoISF will also do just that, but in a much more pronounced and elegant way.

On the way down from peak to glucose target, a somewhat too strong ISF will not hurt because much of the time your loop (well supplied with insulin before, „on the way up") is zero temping or at least has only a small gap to correct from predicted bg to target bg.

You have no business to be much above 200 mg/dl where an even stronger ISF may or may not help. It sure does not help at an occlusion which is about the only reason to see super high values as an experienced looper.

Pegging ISF strength to bg level therefore does not make much sense for us. You will use the autoISF toolbox to get strongest ISF **at low** but beginning-to-rise bg,

> Disclaimer: There are very much refined versions of dynamicISF that can have beneficial applications. But going to autoISF FCL, you absolutely must anchor on the proper profile_ISF (which in times of illness etc. you can temp. change via profile switch, also when using autoISF in FCL).

40

41   When setting **your** parameters, **don't use any given numerical example**, but data from **your**

42   *successful* Hybrid Closed Loop!

43

44   Most *examples given in this paper* are from an adult diabetic (Lyumjev, G6) whose insulin

45   sensitivity can be characterized as follows: approximately 37 U TDD, thereof 13 U profile

46   basal, at about 200g daily carbs from mainly lunch and dinner; no couch snacks or sweet

47   drinks. The user also participates in multiple instances of daily moderate activity such as

48   dog walking, biking and gardening. In Hybrid Closed Loop, a typical meal bolus was 8 U

49   that was sometimes reduced such as when activity followed the meal.

50

51   After seeing some more inputs from a variety of users we might put together a profile helper

52   for some rough orientation and plausibility cross-checking in section 4.6

53

55

56   A **satisfying performance in Hybrid Closed Loop** mode is a pre-requisite. Expect to reproduce

57   about the same %TIR also in your FCL, but with less daily interaction, once established.

58   Note that this refers to prior use of „vanilla" software, without fancy „dynamic add-ons" (such as:

59   Autotune determined factors, dynamicISF etc). that probably will not be compatible with autoISF

60   use, and may have introduced bias into the profile settings you bring with you into FCL now.

61

62   To reach a satisfying performance you must start from a hybrid closed loop in which you did

63   **master your meal management well** using the oref(1) algo SMB+UAM**.**

64   This is a pre-requisite **to be able to forget it** … - because the initial tuning we now turn to

65   demands that you analyze your prior best practice, in an attempt to find appropriate settings and

66   „teach" your FCL to come up with the necessary iob.

67   .

68   This is the main subject of this section 4 (finding settings for automatic meal management) and

69   sections 5 and 6 (finding settings for highly automatic management also of other potential

70   disturbances).

71

72   ## 4.1 Getting started

73

74   Make sure you have studied the preceding sections 1-3 on the general pre-requisites for FCL and

75   on the workings of autoISF. Notably make sure you have set your default iobTH (refer to section

76   2.4 and if available 4.6)

77 In the early test phase, it is recommended to:

78 • run the system as dummy, not connected to your body (or, on own risk, connect only as
79   long as you watch closely)

80 • in AAPS preferences, switch your autoISF FCL (= **autoISF/"Enable adaptation of ISF to**
81   **glucose behaviour"**) ON only during daytime hours of a meal, *e.g. 11-18h*, for fully
82   automatic "full closed loop" management of lunches.

83   You can do this switching manually at 11 h and 18 h every day, *or* set up an
84   Automation that does that (see <u>section 3.4</u>).

85 • take typical but not extreme lunches. Omit sweet drinks, or drink only slowly

86 • do not use the Activity monitor (see <u>section 6.6</u>), unless it is already well calibrated.
87   In case you use an EatingSoonTT at meal start: Any active TT shuts activity monitor
88   automatically off.

89 It is then essentially a matter of your UAM Full Closed Loop recognizing a meal start from the
90 glucose trend, and ramping up iob.
91 When setting up your autoISF Full Closed Loop, you must set several ISF_weight parameters in
92 AAPS Preferences/OpenAPS SMB/autoISF settings. They relate to different stages of the typical
93 glucose curve after starting a meal:
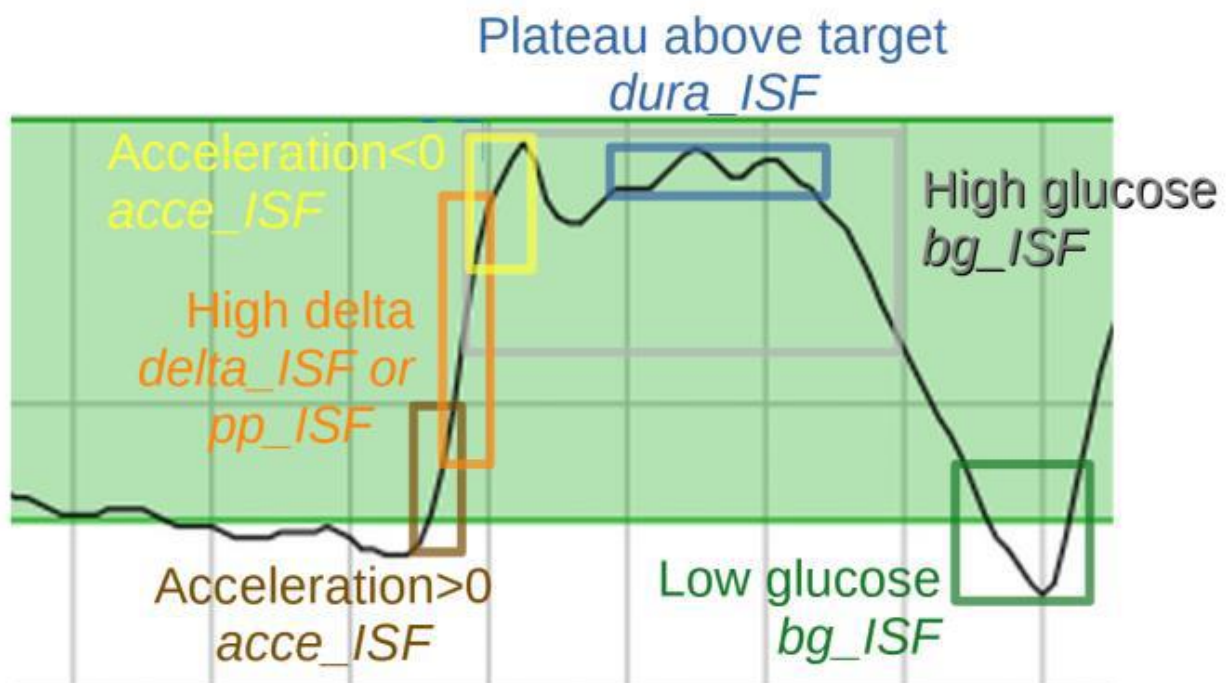
94
95 Make sure you studied the related flowcharts in <u>section 3.</u> before you proceed.
96

97 Warning: **Any bolus you „sneak in" will severely distort the glucose curve. That can render**

98 **your tuning of weights** (see below) **useless, and could make your loop act in unpredictable**

99 and potentially (see last bullet point below) dangerous **ways:**

100 - Your FCL ideally runs <u>without</u> an insulin button at the bottom of the AAPS home screen.

101 - Issuing a bolus should kick you out of the FCL mode, back into Hybrid Closed Loop. We are

102 working on improving the User Interface (see e.g. <u>section 5.3.1</u>) that would facilitate and

103 secure the bi-directional transitions.

104 - How proper autoISF settings would differ for your meal management, depending on no-

105 bolus, bolus like in HCL, or very small pre-bolus (Meal Announcement), is not well

106 investigated at this point.

107 Therefore it is best to remain consistent = use autoISF strictly for no-bolus FCL, and if you

108 want to bolus for a meal, switch ISF adaptation to glucose behavior (autoISF) temporarily

109 OFF.

110 - Maybe we are too cautious here, and in fact the autoISF adaptation to glucose behavior is

111 tolerant enough of disturbances by **user boli**. Please report your findings in case you

112 collect data of "mixed use" (FCL / Meal Announcement / HCL use with meal bolus). (A n=1

113 finding, and guide how to evaluate, is reported here: <u>https://github.com/ga-</u>

114 <u>zelle/autoISF/blob/A3.2.0.2_ai3.0/To%20prebolus%20or%20not%20to%20prebolus.pdf</u>).

115 Once we have a body of data, including from those who moved from *HCL with*

116 *autoISF* to FCL, we may need to re-define what the bi-directional transitions FCL <

117 - > HCL in detail shall mean, and whether or not this has implications for needing

118 different autoISF settings in /preferences for FCL and for HCL. .

119

120 After doing the prep work as outlined in <u>section 2</u> you now get to calibrate your FCL to your **normal**

121 **meal spectrum** by initially **setting and tuning the various _ISF_weights**, that dynamically

122 change with bg curve characteristics as sketched in the chart on the previous page.

123

124 Depending how satisfied you will be with the result, or which more extreme meals (smaller?

125 faster/slower carbs? totally different fat/protein content?) you would like to manage, as well,

126 you have a variety of options to deal with that, and this will be the topic in <u>sections 5</u> and,

127 focused on exercise, in <u>section 6</u>.

128

129 In a nutshell, this will be about manual *or* (aided by Automations you would set up) semi-

130 automatic (user triggered) *or* fully automatic **temporary modulation** of your FCL **to deal**

131   **with *different* disturbances than presented by the meal spectrum you were**

132   **calibrating for.** This "nudging" will often involve:

133   * the **%profile button** (top left on your AAPS home screen). Note that the set % multiplies

134   with both, the ISF resulting from autoISF and also with the default iobTH you have set, so

135   both are nicely modulated in a linear way with the % temporarily chosen

136   * the **TT button** (top right on your AAPS home screen). Note that a lowered (relative to

137   profile glucose target) TT signals lowered sensitivity (more insulin need), and an elevated

138   TT (as often used with exercise) increases sensitivity and hence works in the direction of a

139   lowered % profile to also reduce insulin given by the loop.

140   Moreover, the **exercise button** ((top center on your AAPS home screen) can be activated

141   (turns yellow, then). This will **further boost** how your set TT elevates the resulting ISF, and

142   sharply lowers iobTH, as often desired for sports. See section 6.1).

143

144   Taken together with a couple of more features (section 5.2 and 6.3), these functions make

145   the AAPS home screen your **FCL cockpit**.

146

147 So, yes, FCL is about fully automatic cruising. However, you have a cockpit to check how

148 everything is running, to sometimes "nudge" – and in exceptional situations also to temporarily

149 intervene, or even take over.

150 Also, like a pilot, you need to learn a bit, so everything will fly well.

151

152 But: You should do some fair weather stuff first *), which brings us back to our intended next step:

153

154 Researching your standard meal

155 patterns, and finding settings

156 for the various .._ISF_weights.

> *) If, to keep the motivation up for your project, you are itching to see what fancy stuff can all be done, you might peek for instance into case study 6.2 And if that looks like way too much, decide to be just a fair weather flyer for now - or, no offense taken, give up now before spending too much effort. Section 13 is about (maybe) "easier" alternatives.

157

158   ## 4.2 bgAccel_ISF_weight

159

160 When looping without carb inputs and without giving a bolus ourselves, the first crucial setting is to

161 set the **bgAccel_ISF_weight** so that large SMBs are requested immediately when the loop detects

162 an acceleration in your blood glucose (bg) that is starting to rise.

163

164 Ideally within about 20 minutes after acceleration detection, which woulkd be the first up to 4

165 SMBs, as much iob should automatically be supplied as we would have given with our bolus in

166 hybrid closed loop.

167 .

168 If you double the bgAccel_ISF_weight, the ISF strengthening is doubled.

169 Rule of thumb: Two of the first three SMBs each should be about ¼ (max 1/3) the size of a
170 previous meal bolus in your HCL „career".
171 Going over 1/3 can be problematic if your diet contains occasional low carb (or only
172 snacking), and generally of course if your CGM quality is sometimes unreliable, and might
173 produce an artefact that could be mistaken for a meal start. Be vigilant about this topic!
174
175 For hands-off FCL, your settings have to fit the whole **range of your meals**. In extreme cases you
176 will have to balance too high running iob with additional carbs (a late additional snack against
177 going too low), and in the opposite case, you will have to reckon with temporarily exceeding the
178 glucose target range and losses of the achieved %TIR for this day.
179
180 **If your meals vary very strongly**, there are avenues to ease your initial tuning job, or to optimize
181 overall resulting loop performance:
182 • Automations allow you to differentiate. For instance it is possible to apply different
183 iobTH_percent and/or different bgAccel_ISF_weights for meals in different **time windows**
184 or geo locations (details see sections 3.4 and 5.1)

185 In case you use autoISF 3.0 on the iAPS platform for i-phones, you need to use a third
186 party automation software (! call for a case study 4.X)

187 • You can pre-program **custom buttons for special** meal (or snack) **types**, with different
188 underlying FCL settings (see "cockpit", section 5.2.2.3)

189 • You can **modulate FCL aggressiveness manually** making use of temporary switches
190 of %profile and/or set glucose target (section 5.2.2.2)

191 • In an update, autoISF 3.x might provide the option to pre-program settings for 4 different
192 meal type clusters, accessible from the TT button (presented in section 5.3.3.1 (4) and 6.3).

193
194 In search of appropriate settings, you must keep (real-time) track of the **SMB tab** when tuning. This
195 can be impractical. You probably will end up making a lot of screenshots (quickly in the crucial
196 minutes where the SMBs were given, or when you thought they should be given), for later analysis.
197
198 The superior method is to just copy **logfiles** about once a day from your phone/internal
199 memory/AAPS/logs (all zip files there), and analyze them at your convenience later, using the
200 **emulator** (see section 10). Some emulator-based analysis is also possible within AAPS on your
201 phone (section-11).
202
203 Already when tuning the bgAccel_ISF_weight it can become evident that safety restrictions (as
204 discussed in section 2) must be widened further:

205   - Especially if your *profile basal* rate is very small, the **smb_delivery_ratio** and/or the
206   **smb_max_range_extention** "must" often be increased further.

207   - Furthermore, the **smb_delivery_ratio** provides more leeway to increase the
208   aggressiveness (e.g. 0.6 -> 0.72 results in another +20%).

209   In the end you should not set the limits too tight, so "nudging" aggressiveness by another
210   10 or 20% from your cockpit later will not bounce into your set limits.

211

212   In any case, it is worth the effort to tune the **bgAccel_ISF_weight** in such a way that high glucose
213   increases are already nipped in the bud, so to speak.

214

215   This also facilitates the tuning task for the subsequent phases of the meal, because there is then
216   largely zero-temping, as well known from HCL-times after YOUR administered bolus. Also, the
217   lower and shorter lasting the glucose peak, the lesser the hypo danger from the activity tail of
218   SMBs given when glucose was „stuck" high.

219

220   Default bgAccel_ISF_weight is set to zero in autoISF. **To start**, I would try 0.05 or **max 0.1**, and
221   keep trying in max 0.05 steps. Soon move to 0.02 steps (which still means 10-20% change). From
222   my (very limited) overview, many use around 0.2, but possibly higher if their hourly basal rate is
223   0.1U or lower. (Consult <u>section 4.6 </u>when available). Do not be tempted to rush this setting by using
224   large jumps in adjustments.

225

226   Ideally, one should set the bgAccel_ISF_weight so that for meals that are in the **lower** range of the
227   "fast **carb load**" of your cluster, the necessary insulin supply is already approximately provided
228   with 3 SMBs. The glucose curve, at such meals, begins to flatten early in this SMB phase, so a
229   deceleration follows very soon (-> section 4.4).

230

231   ## 4.3 pp_ISF_weight
232
233   With **higher carb load** meals, or meals that come with a sweet drink, the acceleration phase will
234   last longer, and BG will rise further, which will require a higher insulin supply.
235   Between acceleration and deceleration there is a more or less linear further increase of insulin
236   need in these cases.
237   Our autoISF should now "fight" this with the help of the post-prandial ISF, set via **pp_ISF_weight,**
238   after we have set a halfway suitable bgAccel_ISF_weight.

239

240   Select **pp_ISF_postprandial all day = ON**

241

242   In full closed loop mode, this parameter is preferred over deltaISF ((.. and highly beneficial
243   also for managing meals with gastroparesis)).

244

245 Tune your **pp_ISF_weight** after you have set a halfway suitable bgAccel_ISF_weight. You should
246 check meals in the upper spectrum of your g carb, and carefully start tuning with a weight of 0.01.

247

248 Normally the SMBs triggered by bgAccel_ISF_weight <u>and</u> pp_ISF_weight should be sufficient to
249 reach and slightly exceed the **iobTH** (see section 2.4) so all *the other* autoISF parameters are
250 relatively unimportant for now.

251

252   A reason why this can work at all, also for quite a variety of meals, lies in the fact that there
253   is an hourly carb absorption limit of about 30g/h (reference: Dana Lewis:
254   https://github.com/danamlewis/artificialpancreasbook/blob/master/8.-tips-and-tricks-for-real-
255   life-with-an-aps.md#heres-the-detailed-explanation-of-what-we-learned). So while meals
256   might wildly vary in composition and size, what is digested and needs insulin in the first <90
257   minutes (when FCL tries to catch up with insulin need and differs strongly from HCL, and
258   bgAccel_ISF and pp_ISF play the leading role) will be relatively close (…for meals with
259   similar *initial* glucose acceleration and rises, anyways, and *that* is information the loop does
260   have).

261

262 Depending on the type of meal and "aggressiveness" of your bgAccel_ISF_weight and
263 pp_ISF_weight tuning, the iob will already be so high that in the phase of decelerated glucose rise
264 towards the peak (the "last part of the rise") that no insulinReq is seen by the loop.

265

266 Therefore the **bgBrake_ISF_weight** is often unimportant (-> section 4.4)

267

268

269 Warning: Occasionally consult the SMB tab to see how your settings really work.

270

271 A setting that is actually set too aggressive might be masked. **Tuning only works if** the effects of
272 the settings being tuned are **not** unintentionally **limited by other** (e.g.„safety") **settings**.

273

274 Also, always look at two or three different meals before deciding whether a tuning "fits" („good
275 enough" for each of them)

276

277 Case Study 4.1 (Pizza Meal) contains, towards the end, an example how you can go about tuning
278 the _weights for various _ISF factors of autoISF.

279

4.4 bgBrake_ISF_weight

At a **low carb** meal, or an attempt at doing a **weight reduction diet**, 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 closed 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 eating/digestion speed). Also here, one should approach the tuning gradually, increasing the weight from small values.

Case Study 4.2 shows a user example of a low carb meal managed in FCL by autoISF.

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 Closed Loop must build up iob very quickly, but not too much, in the initial phase of a meal.

But high BG values (out of range, >180 mg/dl) can not always be avoided..

Note regarding acceleration happening in late part of dropping glucose:

> In version 2.2.8.2 there was a potential deficiency in situations where glucose was falling and the glucose acceleration was already positive. That meant a minimum glucose level can be extrapolated. If that happens to be less than target and expected in less than 15 minutes then there should be no strengthening of ISF as it would lower glucose even more. Therefore bgBrake_ISF_weight is used now instead of bgAccel_ISF_weight. But those situations were rare and less critical than might be expected at first sight. The reason is that in most cases the predictions ended up even below their threshold meaning SMB were disabled.

4.5 High Glucose Values and dura_ISF_weight

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.

314 High bg values and a plateaus in bg values are tuned using the **dura_ISF_weight** and associated
315 parameters. This feature is also very useful in Hybrid Closed Loop. It elegantly manages, fully
316 automatically, temporary fatty acid resistance. Please refer to other papers for details (for instance,
317 section „Late stage of meals" of:
318 https://www.facebook.com/download/649096606100188/MealMgt.Basics_09Dec21.pdf).
319

320 Since in Full Closed Loop we "turn up" our loop to give the maximum SMB size we can at the
321 beginning of a rise, it is crucial to **resist the temptation to continue with a particularly strong**
322 **ISF in the meal phase with the highest glucose values** .
323

324 This is a reason why in Full Closed Loop we do not make much use of the **bg_ISF** component of
325 autoISF.

326 • Wanting to get most of our insulin from SMBs delivered at fairly low (but beginning-to-rise)
327 bg implies that we do not make ISF weaker at low bg. Under preferences/OpenAPS
328 SMB/autoISF/bg_ISF settings we set lower_ISF_range_weight = 0.0

329 • The higher_ISFrange_weight should also be fairly irrelevant: Near glucose peak, zero-
330 temping usually prevails anyway, so the settings we try might often not be used really by
331 the loop. You probably can live with setting 0.0 there, too. Or you might set 0.1 or 0.2 to see
332 in the emulator tables where this effect, after inputting a much higher weight, could lead,
333 and whether that would be desirable (unlikely).

334 **Caution:** Investigating effects of set weights is not really possible in periods of zero-temping. Too
335 aggressive settings might not come into play most of the time. However, some other time they
336 might come into play, and produce a hypo 1-2 hours later.
337

338 Therefore, **carefully study the SMB tab** (or better yet, do an emulator based analysis, see
339 sections 10-11) **to see what the selected weights would do, if there was no zero-temping** at
340 the time. Also, try a completely different meal to see how your settings work there.
341

342 The UAM Full Closed Loop doesn't get any information from you as to how many grams of
343 carbs will be absorbed late. Not knowing when your steady-state max carb absorption
344 phase (the earlier mentioned 30g/h), and even sometimes a brief episode of insulin
345 resistance to fats, might end, the FCL will struggle to provide desired amounts of insulin,
346 facing potential hypo danger later because of the DIA of the insulin in use.
347

348 Actually, the UAM Full Closed Loop is *not completely clueless* regarding how carb
349 absorption will go on. It will work with a prediction of further carb absorption building on the
350 **carb deviation** (=hypothesis of how much got absorbed in the past 5 minute segments),

351   and phase out more carb decay in the course of the next 1 to max 3 hours. For more detail
352   see
353   https://openaps.readthedocs.io/en/latest/docs/While%20You%20Wait%20For%20Gear/Und
354   erstand-determine-basal.html#understanding-the-basic-logic-written-version (or study your
355   SMB tab info).
356

357   This UAM prediction about further carb absorption can be worse, but can also be better
358   than a prediction based on the user's „e-Carb" input in Hybrid Closed Loop.
359

360   In any case, and even when having perfect knowledge about how exactly the carbs fade
361   out in the next hours, there would still be a principal problem for the loop: Heavy insulin
362   „fire" against highs will not work immediately (depending on the insulin's time-to-peak), and
363   notably it comes with a significant hypo danger (from the „tail" of insulin activity.)
364   A big bolus, or also a series of boli, will rarely work exactly for several hours matching the
365   absorption of carbs (from what, how much and and how fast the user ate).
366

367   Once your BG sits high, neither you, nor a hybrid closed loop with all the carb info, nor your FCL
368   can work wonders. Resist the temptation to elevate the **dura_ISF_**weight very high.
369

370   The author is sceptical about using the **bg_ISF** (at least be careful, use small weight, or shut-off).
371   Highs will take time to resolve. Interestingly, an after-dinner walk can work wonders sometimes.
372

373   As often, the best solution is to be pro-active:
374

375   **The earlier large SMBs come** (driven by bgAccel_ISF and pp_ISF), the less high the
376   overall increase in BG will be, and (provided you set a proper iobTH) **the lesser the risk**
377   **will be for a hypo after the meal**.
378   Therefore, put most of your FCL tuning effort into determining suitable weights for
379   bgAccel_ and for pp_ISF, and a suitable iobTH.
380

381   Your FCL cockpit will give you access to modulate 2 of these 3 essential parameters (see
382   section 5.2.), providing you an opportunity for more research on the fly, so to speak.
383

384   The experience of the author is that it is possible to tune the above mentioned weights for very
385   different meals in such a way that the glucose almost always remains acceptably in range.
386

387   However, if you need **differentiated settings** for different meals or meal time clusters, you can

- manually modulate FCL aggressiveness via setting temp. %profile and/or TT (see section 5.2.2.2)

- define Automations that use different iobTH and/or different bgAccel_ISF-weights for different rough meal-time slots in your days (see section 5.1.4)

- or install and activate a user defined extra button in your cockpit for it (see section 5.2.2.3)

- or pre-program 4 different clusters in /preferences, and call them up within a second from the TT button in your AAPS home screen (*only after implementation of an improved cockpit, see* section 5.3.3.1 (4) and section 6.4.3))

4.6   Profile helper

xls based tool is still under development / needs more user data / chapter will follow later