Case Study 5.3: Compression low V.1.0

In section 5 of the FCL e-book
(https://github.com/bernie4375/FCL-potential-autoISF)
principal approaches were discussed how to deal with situations that lie outside outside of meal-time windows, where the **autoISF loop might over-react** to a glucose jump.

One such incidence that frequently can happen at night is a **compression** low from lying on the sensor, followed by a jump in sensor bg value when the body is turning and pressure is relieved.

This case study shows such an incidence in detail, and how it was fully automatically dealt with.

Measures in place to deal with potential compression low

- **Odd nighttime profile target to exclude SMBs**

Following suggestions as in section 5.1.2, I set for my sleep time an **odd profile target** at which no SMBs can be given by the loop.

- **Automation for still allowing SMBs when needed**

However, this can conflict with nights where, after a fatty late dinner, I might need a SMB or two to get bg down that seems “stuck high”. To also capture this case, I have Automations running as shown in section 5.1.2. These are for times when I do need insulin, and they are only running for a very brief period of a few minutes. So this will not “ruin” my automatic vigilance against compression lows at any point during my bedtime.

- **Checking *all* (!) Automations**: **None should end the odd profile target at night**

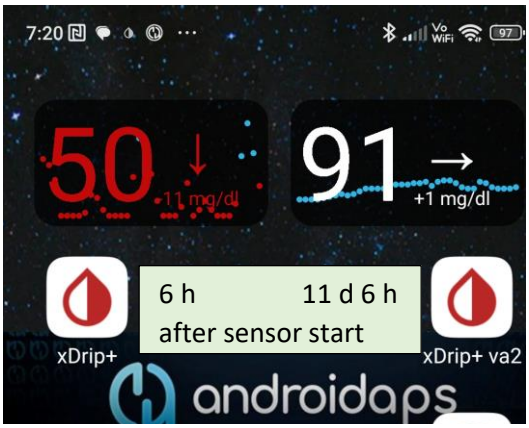
As the following example shows, bg deltas after a compression low can be quite high. Any Automation that makes the loop more aggressive after e.g. a delta >10 could fully ruin my concept to prevent SMBs for the night!

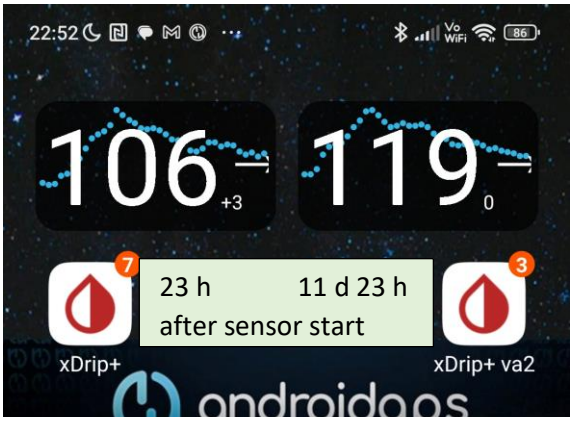
In fact I do have an Automation (shown below) that sets a TT of 74 mg/dl to magnify SMBs whenever bg jumps up strongly. This Automation was meant to “replace” EatingSoonTT (see section 2.5). Only by restricting such Automations strictly to daytime, the nighttime odd profile target will remain in place and prevent SMB (see the following case report).

Fully automated successful dealing with a compression low (example)

This case is especially nice to report as it is from a night in which both my G6 sensors (see [Case study 1.5] on permanent reliable CGM values via 2 x G6) were basically in good shape.

Remark: *In the first 24 hours*, the values on the left arm (new sensor on day-1) were, after warm-up, 40 to 50 too low and very jittery (dots behind red 50); at 23 h, still 13 mg/dl too low:

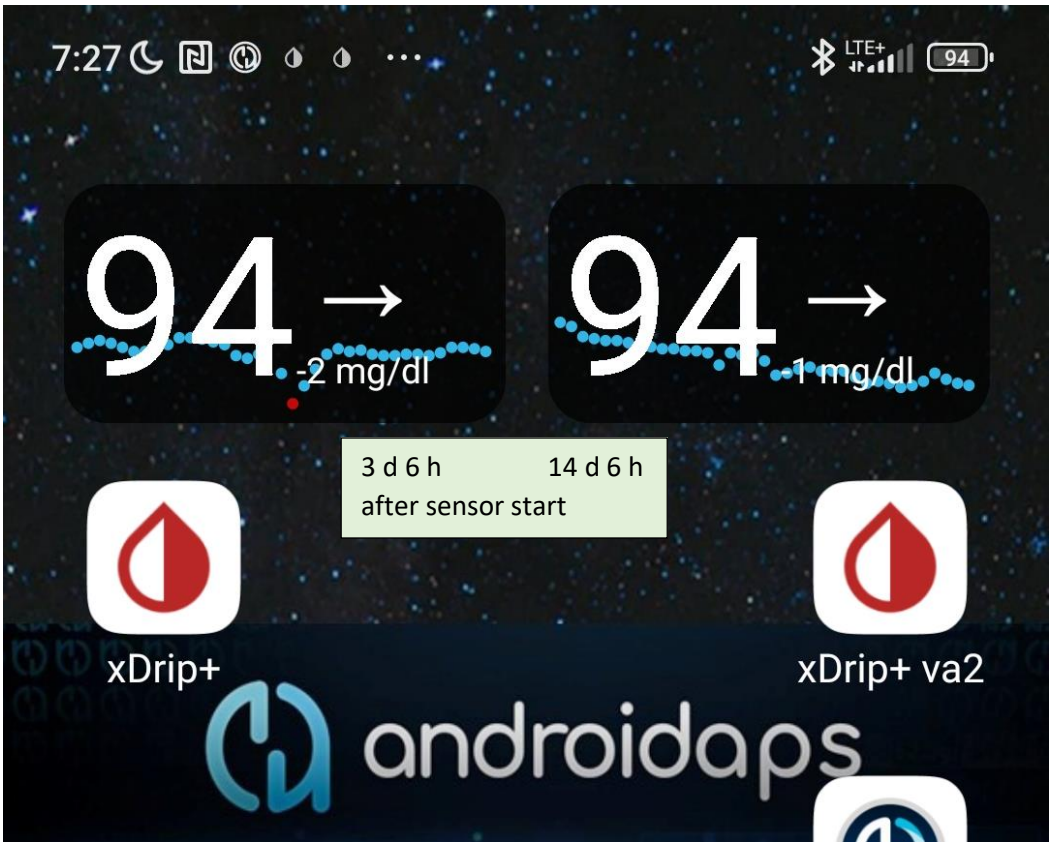




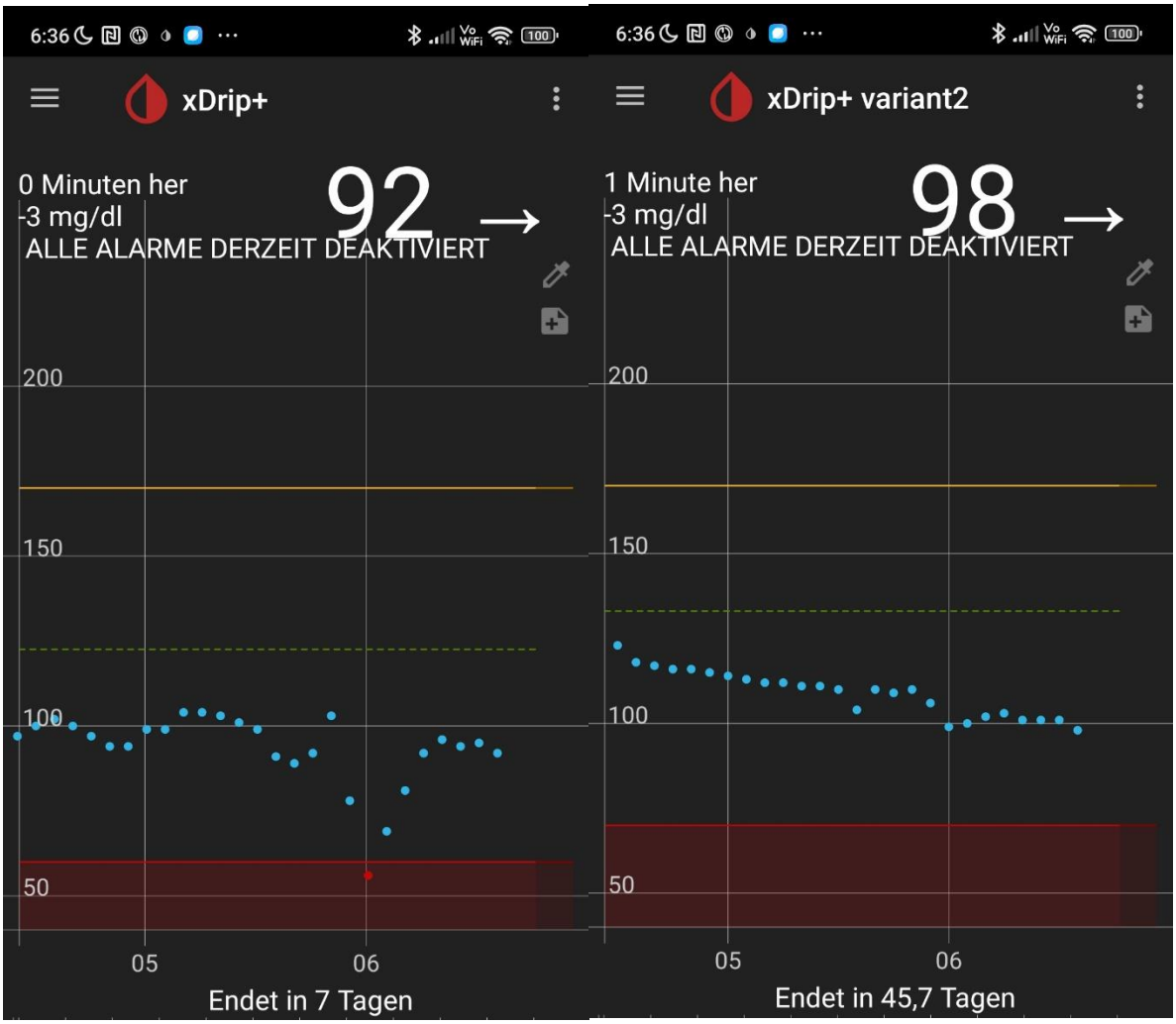
But *without doing any calibration* eventually data got in line with reality, and with the other one:

Below left, the sensor is 3 day old and (since day-2) reports into AAPS via xDrip. On the right, data from the already 14 day old sensor (Anubis, xDripVariant2.still looking good.

During that night, my loop regulated my bg well to target.
However, the left arm curve shows a red dot in the otherwise blue curve:



Directly in xDrip resp. xDripVariant2 app, we can see better what exactly happened:

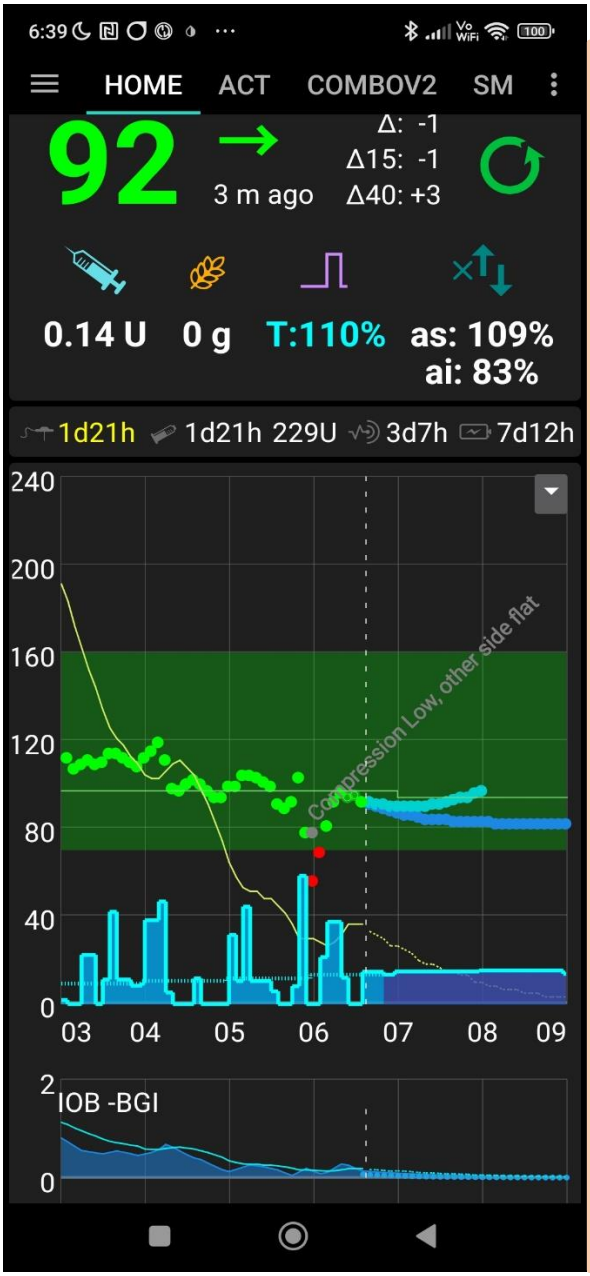


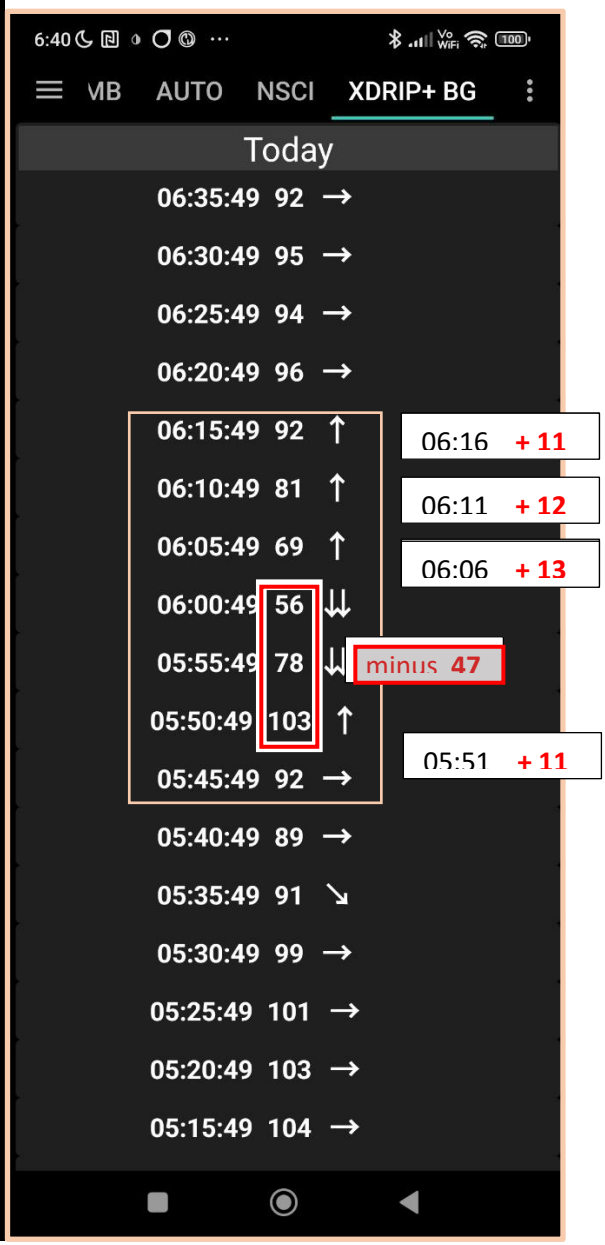
The sensor on the left side is 3 d 6 h old, so we should assume it works actually *better* than the 14 d 6 h old sensor operating with Anubis on the right.

So it is logical to make a compression on the left arm responsible for the significantly more jittery glucose curve there.

> Note that the extra sensor on my right arm does not interfere (“help”) in any way in the loop’s workings. It only happened to be there in parallel, and incidentally can provide proof that the values from the left arm (that my loop was operating with) were actually having a problem.
> It could have become highly clinically significant - a nightly hypoglycemia would have resulted - *without* the implemented automated safeguarding measures.

Here the AAPS screen, and the log of recent bg values:

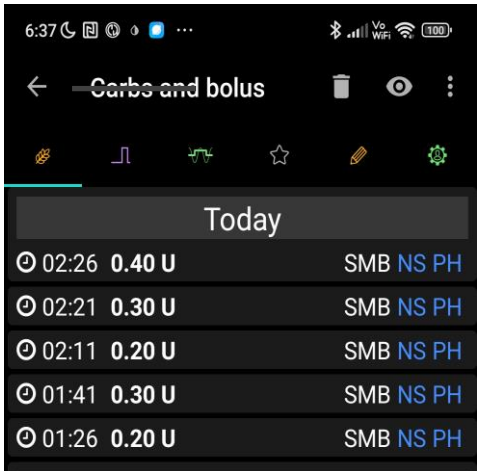




05.50 – 6:00 the compression low went from 103 all the way down to 56 (minus 47 !)

The resulting bg deltas up by **> +10** are marked red (adding up to + 47)

As no SMBs can be given in the night (due to odd TT after 02:30 am) …

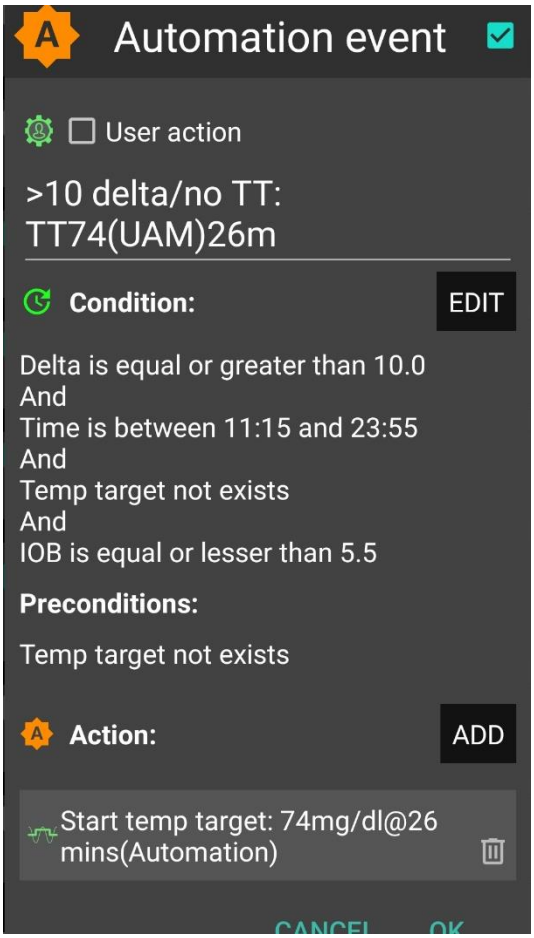


.. 500%, 160%, 280% and 90% TBR are issued for 5 minutes each ---------- >

At 0.6 U/h = 0.05 U/5min basal this is..

TBR	U	U above basal	min	U * min/5 cumulated
500%	0.25	0.20	5	
160%	0.08	0.03	5	0.23
280%	0.14	0.09	9	0,38
90%	0.045	-0.005	4	0.38

…*in total* like a small 0.38 U SMB., which, if an error in hindsight, the loop can balance out by reducing basal (0.6 U/h in profile)



So, (previous page), the four bg jumps did not lead to strong iob growth.

The autoISF triggered strengthened ISFs were leading only to three, each 5 – 9 minutes long, segments with strongly elevated %TBR

The **Automation** shown on the left…

- which is helpful to boost SMBs after a meal start (see section)

…would, however, set a low and even TT at bg deltas above 10, and would allow SMBs in all 4 instances!

This Automation was restriced though to potential times of major meals (11:15 - 23:55 h), so, luckily, it did not become activated.

My autoISF still did strengthen ISF significantly at the detected acceleration and rise (see section with logfile

Logfile analysis using the emulator

Note: The AAPS logfiles are generally using universal time (Greenwich standard time) which in summer is minus 02:00 hours to central European summer time as on my phone and AAPS.

The table on the following page is an extraction of key info from the “noChange-csv” Emulator results (obtained following FCL e-book section 10.2.3 and 10.2.4).

The yellow fields in column E mark instances of jumps that should be connected with a detected acceleration (then, or in the preceding 5-10 minutes) and elevated bgAccel_ISF impact.

Indeed this is what we see in lines 26 and 42, but not in lines 29-31 where the recovery from the low in line 28 took place.

It looks like the “fit” is a problem in these instances. Does that mean that autoISF detected that something is wrong, untypical, with this bg curve shape from a compression?

	B	C	E	F	G	L	U	V	W	X	Y	AA	AB	AC	AE	AF	AH	AI	AK	AQ
1			bg	bg	targe			parab	parab	parab	parab	acce	bg	pp	dura	final			Ins.	
2	UTC	AAPS	accel	brake	low		lin.fit	fit	fit	fit	fit	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	TBR
3	time	time			orig	iob	delta	correl	durat	last-Î″	next-Î″	emul	emul	emu	emul	emul	prof	emul	emul	emul
23	3:36	5:36	91		97	0,17	-5	0	0	0	0	1	0,82	1	1	0,82	38	46,5	0	0
24	3:41	5:41	89		97	0,11	-4,4	0	0	0	0	1	0,8	1	1	0,8	38	47,3	0	0
25	3:46	5:46	92		97	0,05	-2,6	0	0	0	0	1	0,82	1	1	0,82	38	46,1	0	0,37
26	3:51	5:51	103		97	0,03	7	0,999	20	10,1	16,3	2,34	0,94	1	1	2,21	38	17,2	1,92	4,39
27	3:56	5:56	78		97	0,2	-2,2	0,8566	20	-9,3	-14,8	1	0,73	1	1	0,73	38	52,3	0	0
28	4:01	6:01	56		97	0,15	-23,7	0	0	0	0	1	0,65	1	1	0,65	36	55,4	0	0
29	4:06	6:06	69		97	0,08	-12,4	0	0	0	0	1	0,66	1	1	0,66	36	54,2	0,18	0,99
30	4:11	6:11	81		97	0,11	12,5	0	0	0	0	1	0,75	1	1	0,75	36	48,1	0,58	1,79
31	4:16	6:16	92		97	0,19	12	0	0	0	0	1	0,82	1	1	0,82	36	43,6	0,62	1,764
32	4:21	6:21	96	96	97	0,28	10,3	0,9984	20	6,2	3,5	0,41	0,85	1	1	0,41	36	87,1	0	0,63
33	4:26	6:26	94	94	97	0,26	8,1	0,9972	20	-1	-6	-0,07	0,84	1	1	0,4	36	90	0	0
34	4:31	6:31	95		97	0,2	6,5	0	0	0	0	1	0,85	1	1	0,85	36	42,6	0	0
35	4:36	6:36	92		97	0,14	5,1	0	0	0	0	1	0,82	1	1	0,82	36	43,6	0	0,63
36	4:41	6:41	91	91	97	0,13	-2	0,9989	20	-1,6	-1,9	0,94	0,82	1	1	0,82	36	44	0	0,63
37	4:46	6:46	91		97	0,13	-1,1	0,9728	25	-0,9	-0,8	1,01	0,82	1	1	0,82	36	43,7	0	0
38	4:51	6:51	92		97	0,07	0,5	0	0	0	0	1	0,82	1	1	0,82	36	43,6	0	0,63
39	4:56	6:56	92		97	0,06	0,4	0,9977	35	0,4	0,8	1,04	0,82	1	1	0,86	36	41,9	0	0,05
40	5:01	7:01	91		94	0,01	-0,5	0	0	0	0	1	0,84	1	1	0,84	38	45,3	0	0,07
41	5:06	7:06	93		94	-0,05	0,3	0	0	0	0	1	0,85	1	1	0,85	38	44,5	0,18	1,06
42	5:11	7:11	97		94	0,07	3	0,9967	20	3,5	5	1,33	0,9	1	1	1,2	38	31,6	0,35	1,4
43	5:16	7:16	97		94	0,32	2,2	0,9857	40	2,1	2,5	1,08	0,9	1	1	0,8	38	47,8	0	0
44	5:21	7:21	96	96	94	0,25	-0,5	0,9942	20	-0,7	-2,2	0,84	0,89	1	1	0,54	38	70,8	0	0
45	5:26	7:26	94	94	94	0,18	-1,5	1	25	-2,2	-3,6	0,83	0,86	1	1	0,53	38	71,7	0	0
46	5:31	7:31	92	92	94	0,12	-2	0,9987	20	-2,4	-3,1	0,85	0,85	1	1	0,54	38	70,2	0	0

Searching in another results file specifically for these time slots of lines 29-31 we find the following:

Line 26: created at= 2024-06-30T03:51:07.214Z

---------- Script Debug ----------

Activity monitor disabled: Phone seems not to be carried for the last 15m

Autosens ratio: 1; Basal unchanged: 0.55; ISF unchanged: 38; CR: 6.2

---

start autoISF 3.0.1

User setting iobTH=60% not modulated

SMB disabled; current target 97 is odd number; Loop allows minimal power

acce_ISF adaptation is 2.34

bg_ISF adaptation is 0.94

bg_ISF adaptation lifted to 2.21 as bg accelerates already

final ISF factor is 2.21

---

end autoISF

---

currenttemp: 0.39 lastTempAge: 0 m tempModulus: 25 m

profile.sens: 38 sens: 17.2 CSF: 2.77

Limiting carb impact from 7.5 to 6.9 mg/dL/5m (30 g/h)

Carb Impact: 6.9 mg/dL per 5m; CI Duration: 0 hours; remaining CI (~2h peak): 0 mg/dL per 5m

UAM Impact: 7.5 mg/dL per 5m; UAM Duration: 0.5 hours

minPredBG: 130 minIOBPredBG: 140 minZTGuardBG: 103

minUAMPredBG: 120 avgPredBG: 130 COB: 0 / 0

BG projected to remain above 97 for 240 minutes

naive_eventualBG: 103 bgUndershoot: -35 zeroTempDuration: 240 zeroTempEffect: 38 carbsReq: -26

---------- Reason ----------

COB: 0, Dev: 45, BGI: 0, ISF: 17, CR: 6.2, Target: 97, minPredBG 130, minGuardBG 109, IOBpredBG 140, UAMpredBG 120; Eventual BG 148 >= 97, temp 0.39 < 4.39U/hr.

Line 29 created at= 2024-06-30T04:06:09.680Z

---------- Script Debug ----------

Activity monitor disabled: Phone seems not to be carried for the last 15m

Autosens ratio: 1; Basal unchanged: 0.63; ISF unchanged: 36; CR: 6

---

start autoISF 3.0.1

User setting iobTH=60% not modulated

SMB disabled; current target 97 is odd number; Loop allows minimal power

acce_ISF adaptation by-passed as correlation 0 is too low

bg_ISF adaptation is 0.66

final ISF factor is 0.66

---

end autoISF

---

currenttemp: 0 lastTempAge: 0 m tempModulus: 20 m

profile.sens: 36 sens: 54.2 CSF: 9.03

Carb Impact: 13.5 mg/dL per 5m; CI Duration: 0 hours; remaining CI (~2h peak): 0 mg/dL per 5m

UAM Impact: 13.5 mg/dL per 5m; UAM Duration: 0.2 hours

minPredBG: 107 minIOBPredBG: 139 minZTGuardBG: 67

minUAMPredBG: 76 avgPredBG: 107 COB: 0 / 0

BG projected to remain above 97 for 0 minutes

BG projected to remain above 68 for 240 minutes

naive_eventualBG: 64 bgUndershoot: 4 zeroTempDuration: 240 zeroTempEffect: 137 carbsReq: -15

---------- Reason ----------

COB: 0, Dev: 81, BGI: 0, ISF: 54, CR: 6, Target: 97, minPredBG 107, minGuardBG 76, IOBpredBG 139, UAMpredBG 76; Eventual BG 145 >= 97, temp 0.00 < 0.99U/hr.

Line 30 created at= 2024-06-30T04:11:14.448Z

---------- Script Debug ----------

Activity monitor disabled: Phone seems not to be carried for the last 15m

Autosens ratio: 1;; Basal unchanged: 0.63;; ISF unchanged: 36; CR: 6

---

start autoISF 3.0.1

User setting iobTH=60% not modulated

SMB disabled; current target 97 is odd number; Loop allows minimal power

acce_ISF adaptation by-passed as correlation 0 is too low

bg_ISF adaptation is 0.75

final ISF factor is 0.75

---

end autoISF

---

currenttemp: 1.01 lastTempAge: 0 m tempModulus: 25 m

profile.sens: 36 sens: 48.1 CSF: 8.02

Carb Impact: 12.4 mg/dL per 5m; CI Duration: 0 hours; remaining CI (~2h peak): 0 mg/dL per 5m

UAM Impact: 12.4 mg/dL per 5m; UAM Duration: 0.5 hours

minPredBG: 125 minIOBPredBG: 144 minZTGuardBG: 80

minUAMPredBG: 105 avgPredBG: 125 COB: 0 / 0

BG projected to remain above 97 for 0 minutes

BG projected to remain above 68 for 240 minutes

naive_eventualBG: 76 bgUndershoot: -8 zeroTempDuration: 240 zeroTempEffect: 121 carbsReq: -16

---------- Reason ----------

COB: 0, Dev: 74, BGI: 0, ISF: 48, CR: 6, Target: 97, minPredBG 125, minGuardBG 91, IOBpredBG 144, UAMpredBG 105; Eventual BG 150 >= 97, temp 1.01 < 1.79U/hr.

Line 31 created at= 2024-06-30T04:16:13.829Z

---------- Script Debug ----------

Activity monitor disabled: Phone seems not to be carried for the last 15m

Autosens ratio: 1; Basal unchanged: 0.63; ISF unchanged: 36; CR: 6

---

start autoISF 3.0.1

User setting iobTH=60% not modulated

SMB disabled; current target 97 is odd number Loop allows minimal power

acce_ISF adaptation by-passed as correlation 0 is too low

bg_ISF adaptation is 0.82

final ISF factor is 0.82

---

end autoISF

---

currenttemp: 1.76 lastTempAge: 0 m tempModulus: 25 m

profile.sens: 36 sens: 43.6 CSF: 7.27

Carb Impact: 11.3 mg/dL per 5m; CI Duration: 0 hours; remaining CI (~2h peak): 0 mg/dL per 5m

UAM Impact: 11.3 mg/dL per 5m; UAM Duration: 0.4 hours

minPredBG: 124 minIOBPredBG: 146 minZTGuardBG: 90

minUAMPredBG: 102 avgPredBG: 124 COB: 0 / 0

BG projected to remain above 97 for 0 minutes

BG projected to remain above 68 for 240 minutes

naive_eventualBG: 84 bgUndershoot: -16 zeroTempDuration: 240 zeroTempEffect: 110 carbsReq: -17

---------- Reason ----------

COB: 0, Dev: 68, BGI: 0, ISF: 44, CR: 6, Target: 97, minPredBG 124, minGuardBG 100, IOBpredBG 146, UAMpredBG 102; Eventual BG 152 >= 97, temp 1.76 < 1.87U/hr.
25m left and 1.764 ~ req 1.87U/hr: no temp required

Indeed, bgAccel_ISF was not applied in the time around the big deltas that resulted when the compression low resolved: The parabola fit analysis revealed zero correlation in these cases.

Results

Suggested pre-cautions against getting SMBs after a compression low consist of

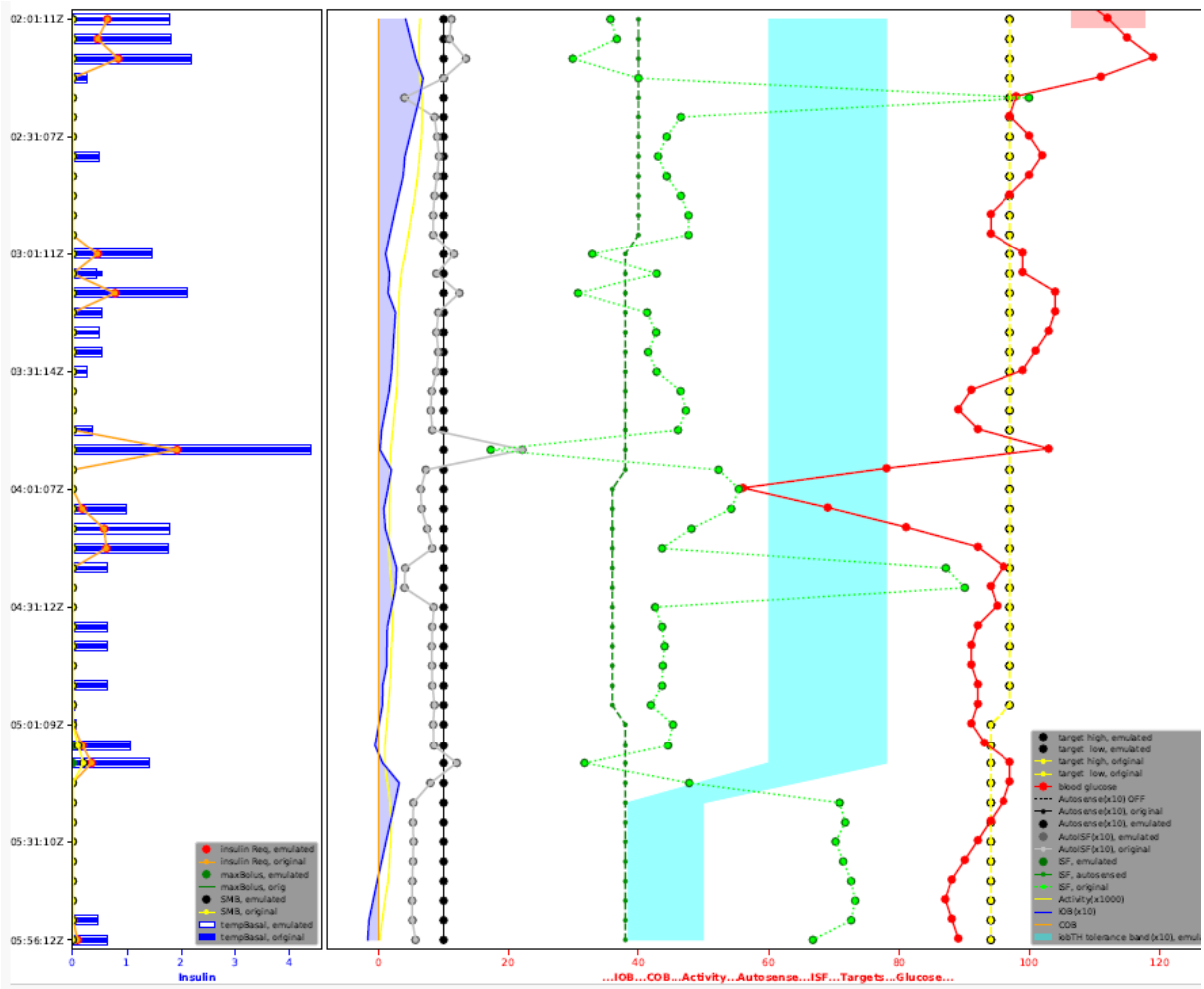
- setting a nighttime odd profile glucose target
- defining Automations for still allowing SMBs *when needed*
- Checking *all* (!) Automations: None should end the odd profile target at night

However, the emulator-based logfile analysis revealed that there is a lot of intelligent analysis and plausibility checks also built into the autoISF acceleration detection. In the presented compression problems case, this would largely have prevented the dreaded SMBs, even without employing any of the implemented pre-cautions.

Addendum:

The following is a chart produced by the emulator (refer to e-book section 10.2.4.4)-

Z + 2 hours = AAPS time (central EU summer); June 30, 2024 early morning



(Evtl. add in a later update, what insights we can draw from it.

Is it generally more useful in context with a What-if analysis?)