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MOTIVATION

Aim:

Intraperitoneal (IP) glucose sensing

- Promising location for an artificial pancreas (AP) [1]
- Understand dynamics and distribution of IP glucose
- Verify performance of prototypes
- Map IP glucose dynamics

Particular challenges

- No off-the shelf system available
- Adapt a commercially available continuous glucose sensor for IP use
- Achieve sufficiently high sampling rate ($\geq 1/\text{min}$)
- Automate sampling as far as possible
- Prove and monitor function of set-up

GLUCOSE SENSING

Approach 1

- Continuous, enzyme-based amperometric sensors (Abbott Freestyle Libre Flash (FLF))

Approach 2

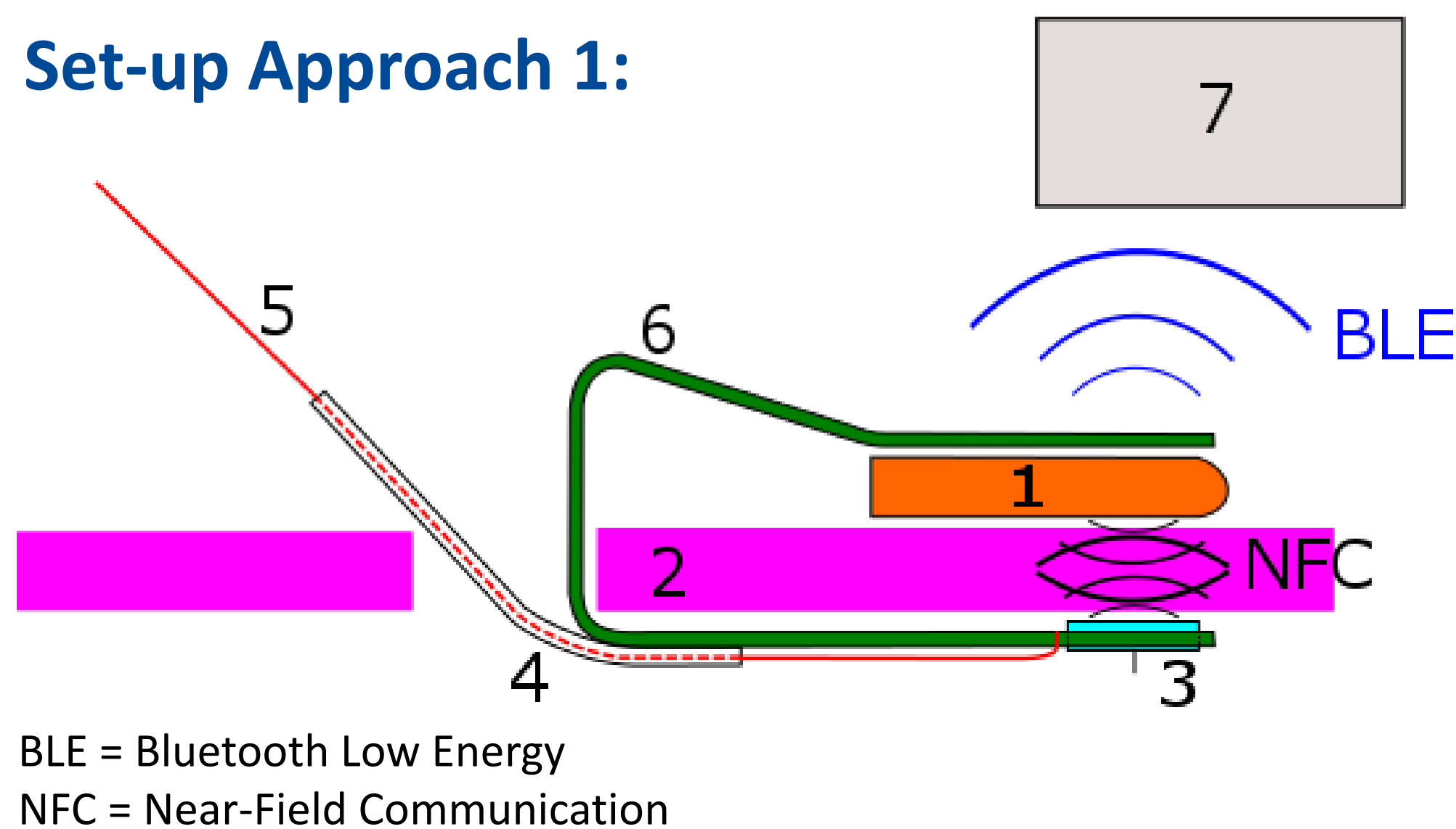
- Manual, discrete sampling of IP fluid
- Analysis with blood gas analyzer (Radiometer ABL 725)

METHOD

Approach 1 (for continuous IP glucose data)

- FLF acquires glucose value in peritoneum (1 new value per minute)
- LimiTter[2] (DIY automated read-out system) with modified software reads data from FLF 3 times per minute via NFC
- LimiTter transmits data via BLE to xDrip[3] (app to log and display glucose value)
- Inserter aligns FLF with LimiTter

Set-up Approach 1:



BLE = Bluetooth Low Energy
NFC = Near-Field Communication

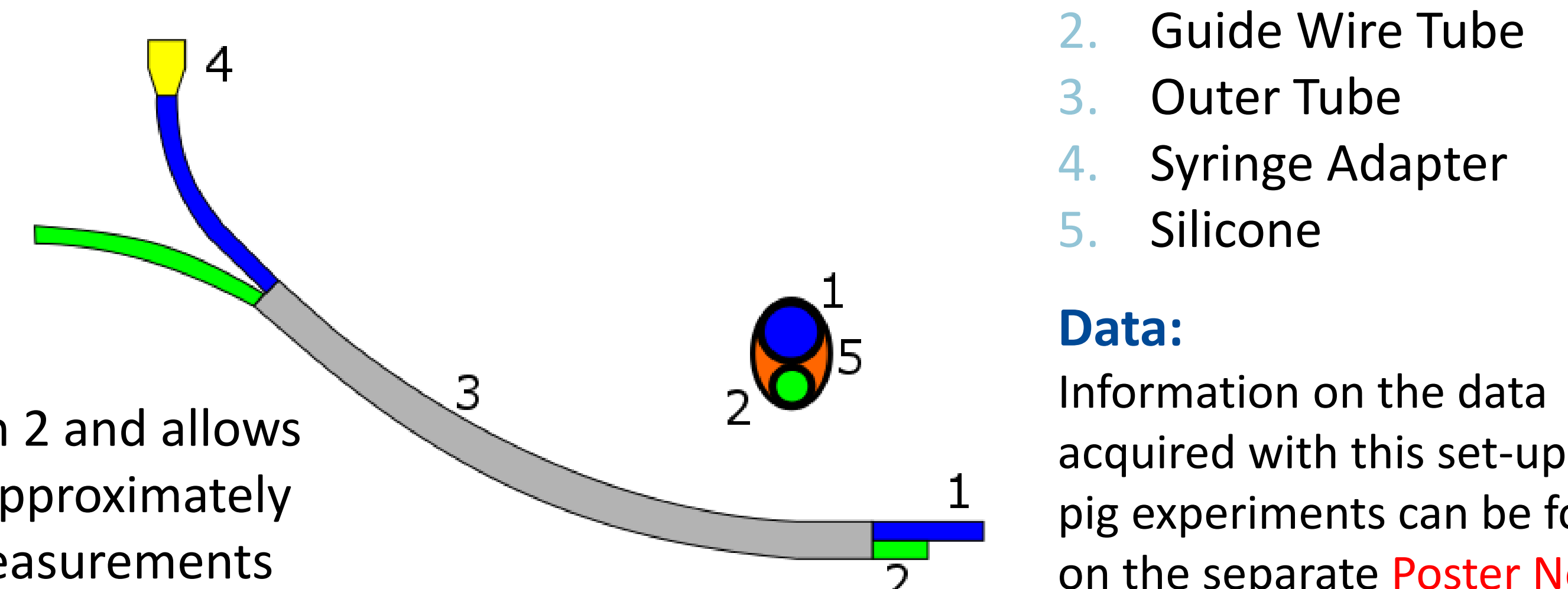
1. LimiTter
2. Abdominal Wall
3. FLF
4. Guide Tube*
5. Guide Wire*
6. Inserter
7. Tablet with xDrip

*Only needed for Approach 2 and allows for IP fluid sampling from approximately the same site as the FLF measurements

Approach 2 (to verify and possibly calibrate FLF data)

- Sampling tube is manually inserted along the guide wire
- Syringe is used to cause a vacuum in the sampling tube
- Sampling tube is removed and sample analyzed with blood gas analyser (BGA)
- Guide tube ensures easy insertion through the abdominal wall

Sampling Tube Approach 2:



1. Sampling Tube
2. Guide Wire Tube
3. Outer Tube
4. Syringe Adapter
5. Silicone

Data:

Information on the data acquired with this set-up in pig experiments can be found on the separate [Poster No. 46](#)

RESULTS

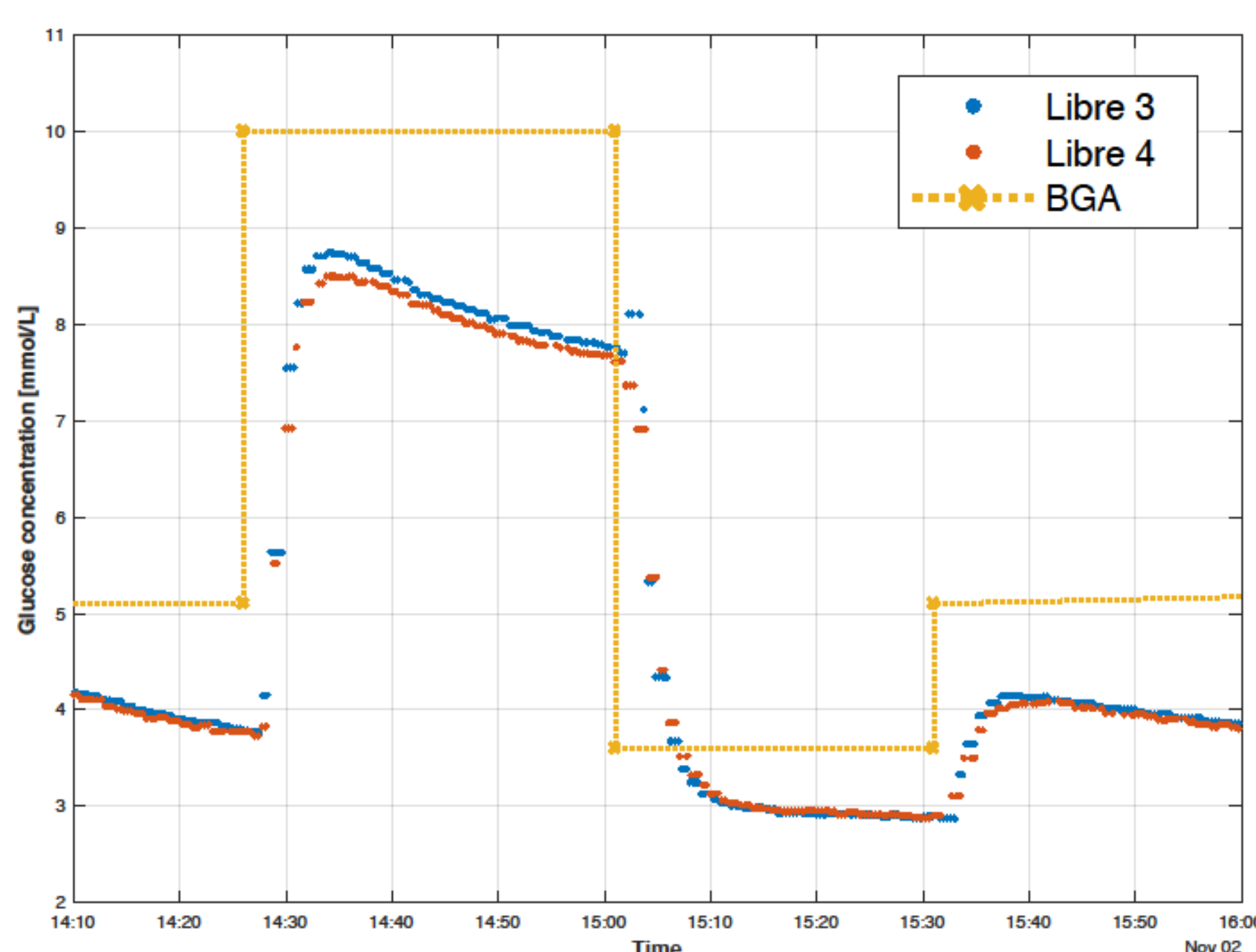


Fig. A: Two Libre sensors in Phosphate Buffered Solution (PBS) with glucose during an in Vitro experiment with a step profile

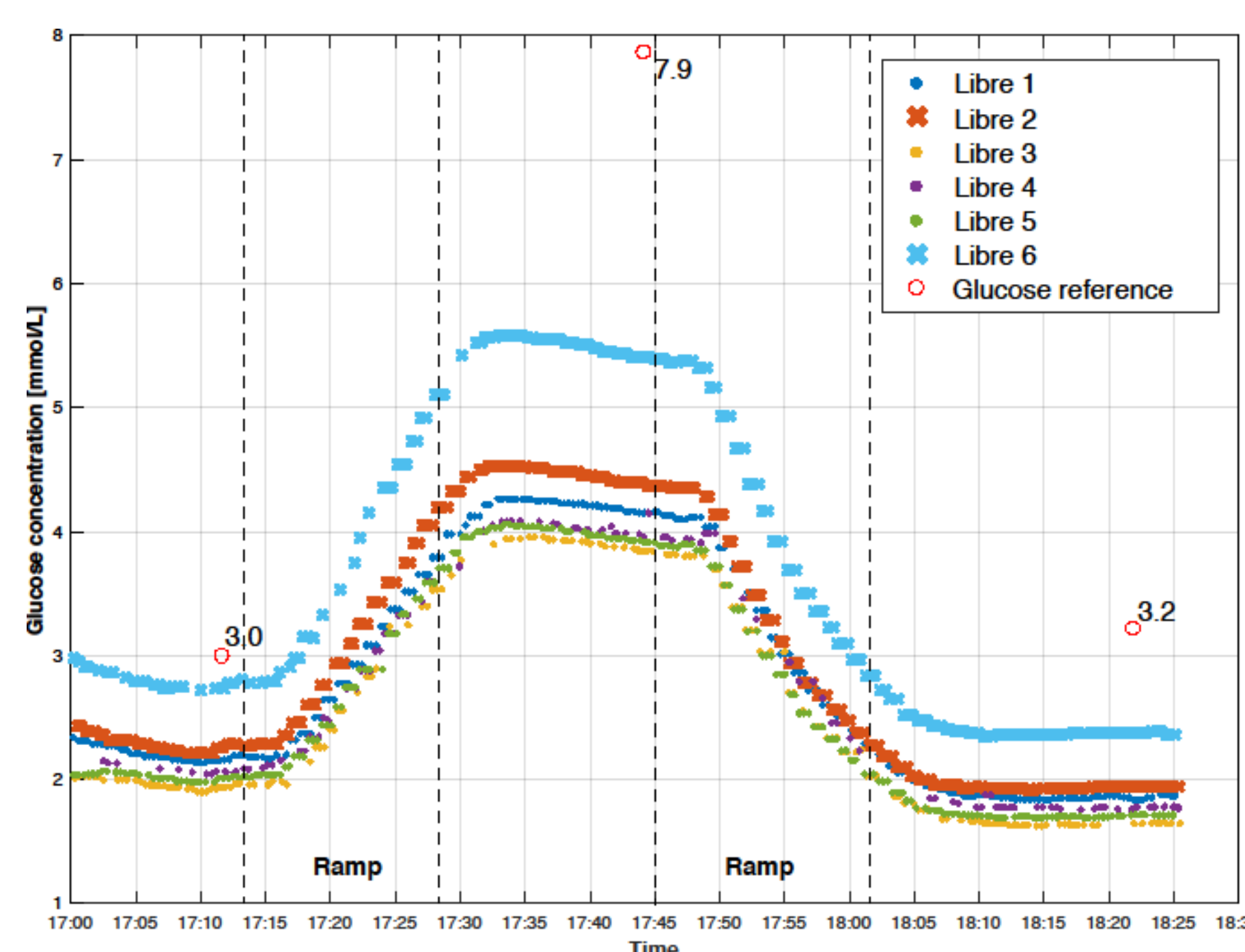


Fig. B: 6 Libre sensors PBS with glucose during a performance test with a ramp profile after a pig experiment, glucose reference on BGA. Vertical dashed lines mark start and end of ramps.

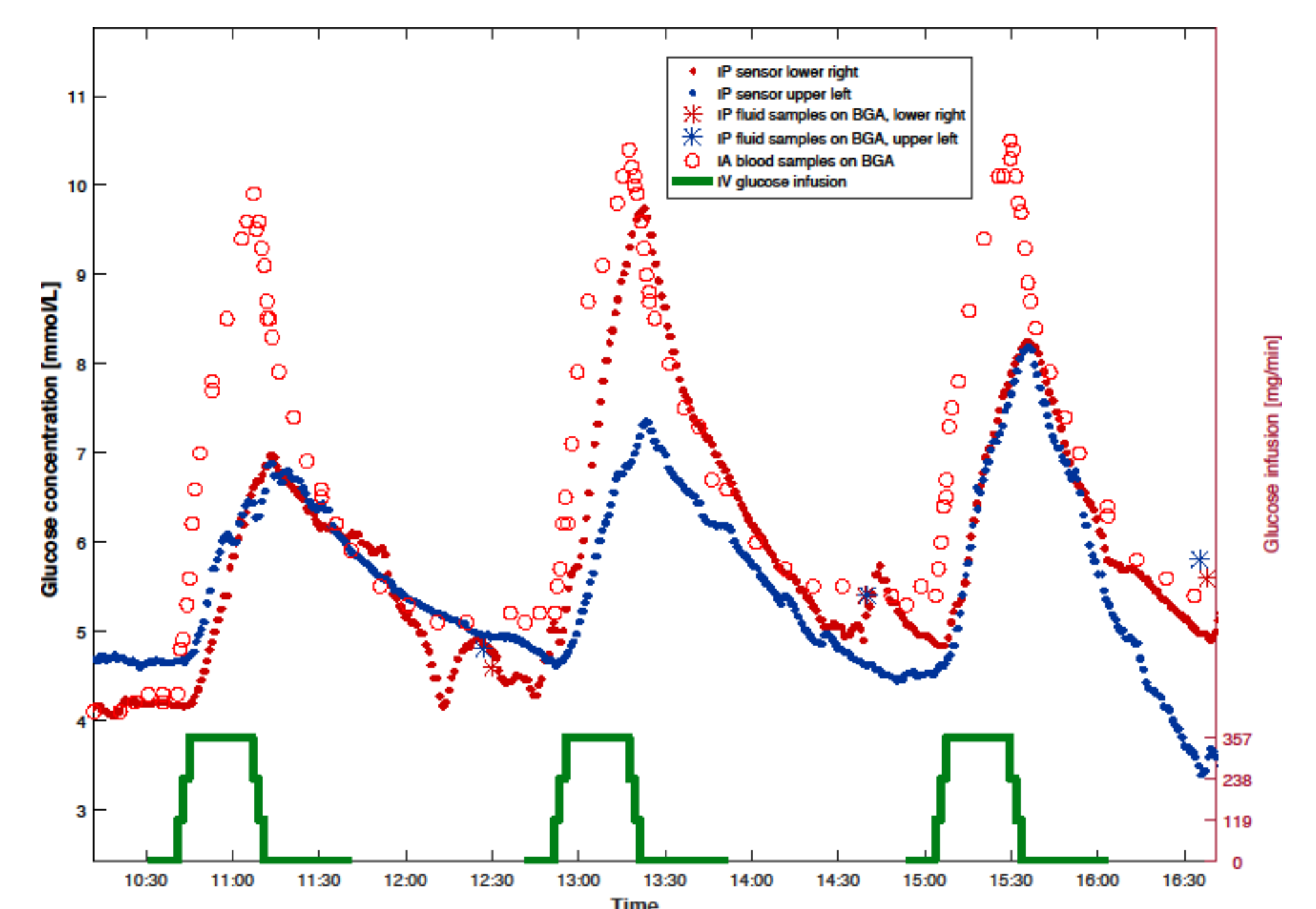


Fig. C: Two IP sensors compared to IA and IP fluid samples on BGA taken at corresponding site from one of the pig experiments

Summary of FLF for IP glucose sensing

- When the FLF is exposed to a step, an overshoot followed by a declining output results (Fig. A). This is *believed* to be a response of an internal FLF calibration algorithm
- A sensor dependent offset can be detected when testing the FLF *in vitro* in Phosphate Buffered Solution (PBS) with glucose (Figs. A and B)
- There is a visible delay between the change of glucose and the detection by the Libre sensor (Fig. B)
- One can observe variations in offset and gain under identical, controlled conditions (Fig. B)
- The FLF adapted for IP use performs well during experiments with anaesthetised pigs, when comparing the uncalibrated data to the IA and IP samples analysed on the BGA (Fig. C)

DISCUSSION

- The use of the IP FLF (Approach1) offers a simple and inexpensive tool to continuously measure IP glucose
- The manual sampling of IP fluid (Approach 2) allows to compare the FLF data to a gold standard, BGA
- If glucose levels change too rapidly, apparent correction algorithms of the FLF make data temporarily unusable (changes of up to 0,675mmol/min tested and approved, further testing to find maximum needed)
- It is necessary to calibrate the data for offset and gain, due to intra-sensor and environmental variations

REFERENCES

- [1] Nelson, J. A. et al. *Intraperitoneal insulin administration produces a positive portal-systemic blood insulin gradient in unanesthetized, unrestrained swine, Metabolism*, 31(10), pp. 969-72, 1982.
- [2] LimiTter by JoernL @ GitHub
- [3] xDrip by stephenblackwasalreadytaken @ GitHub