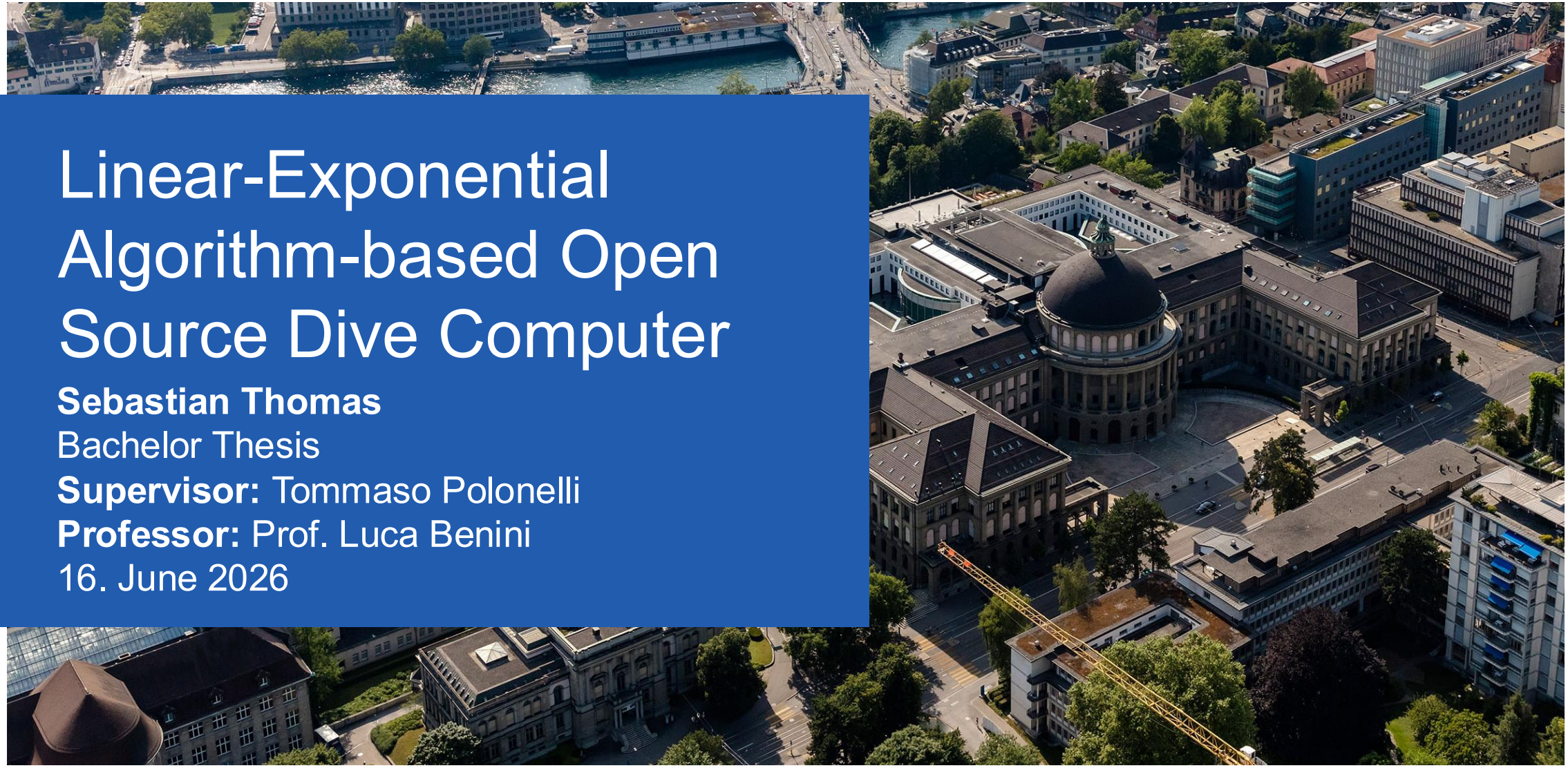
ETH zürich

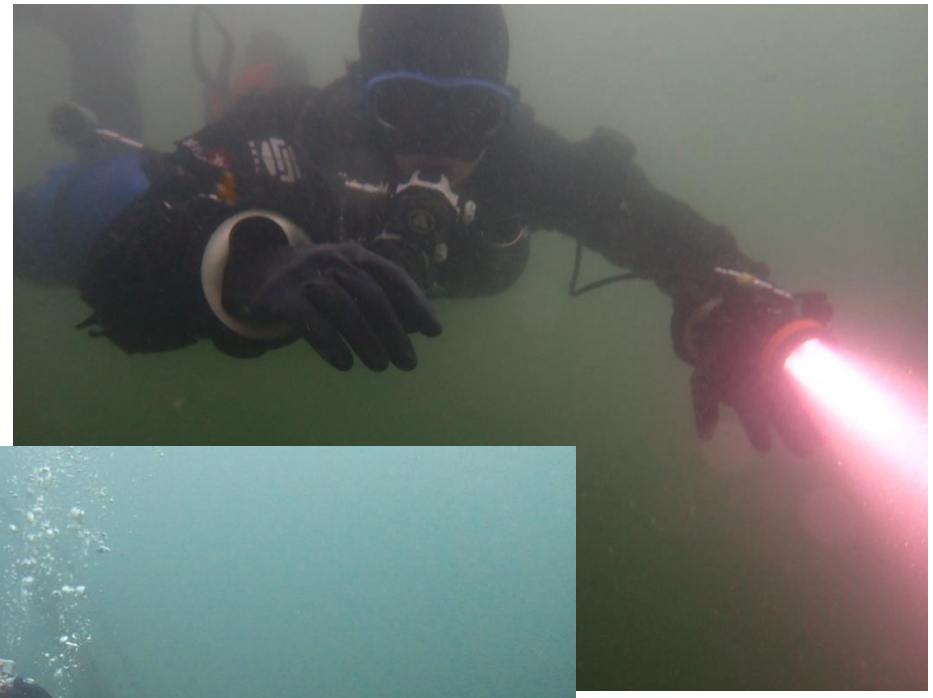
CENTER FOR PROJECT-BASED LEARNING

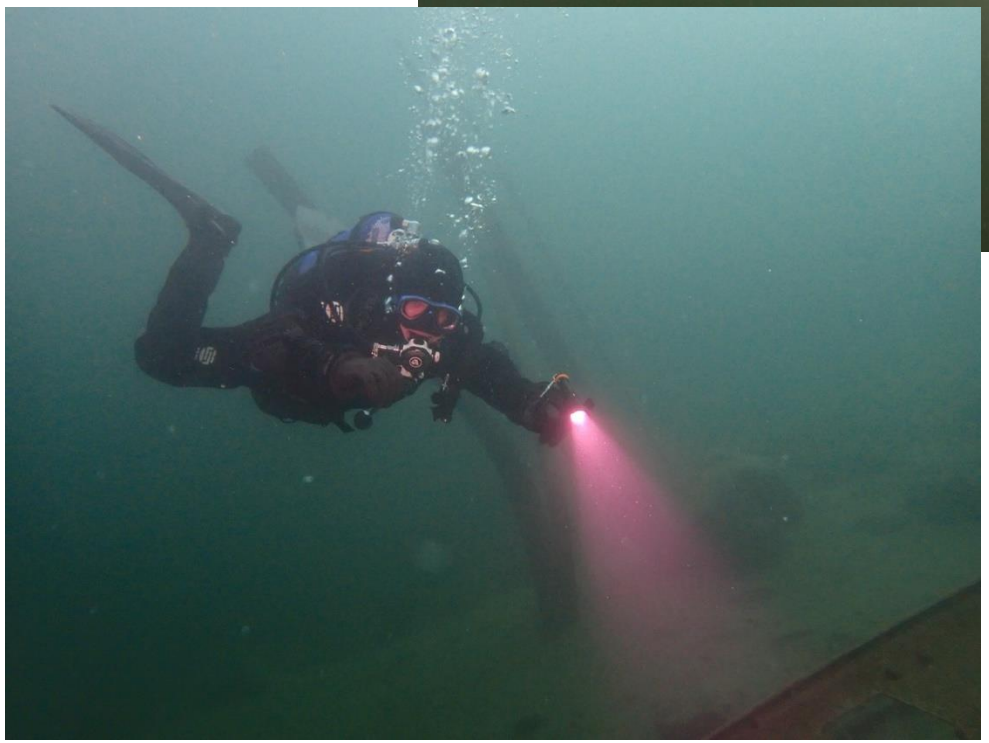


Linear-Exponential Algorithm-based Open Source Dive Computer

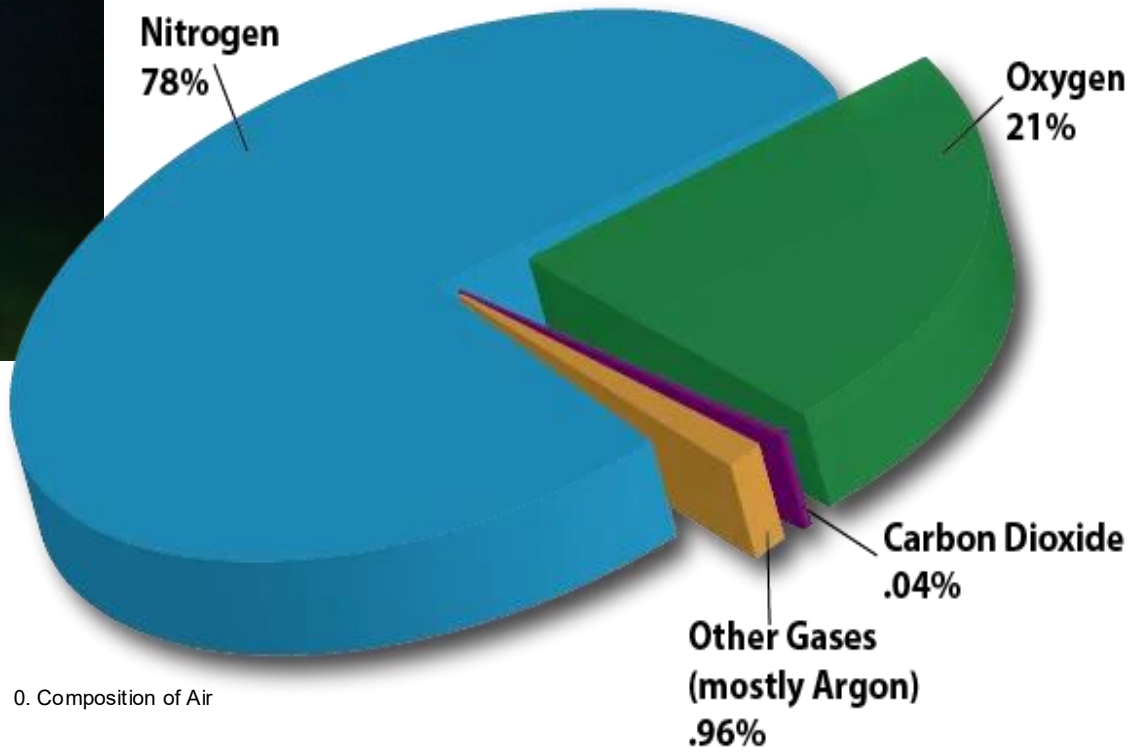
Sebastian Thomas
Bachelor Thesis
Supervisor: Tommaso Polonelli
Professor: Prof. Luca Benini
16. June 2026

Introduction: Diving & Hyperbaric Environments

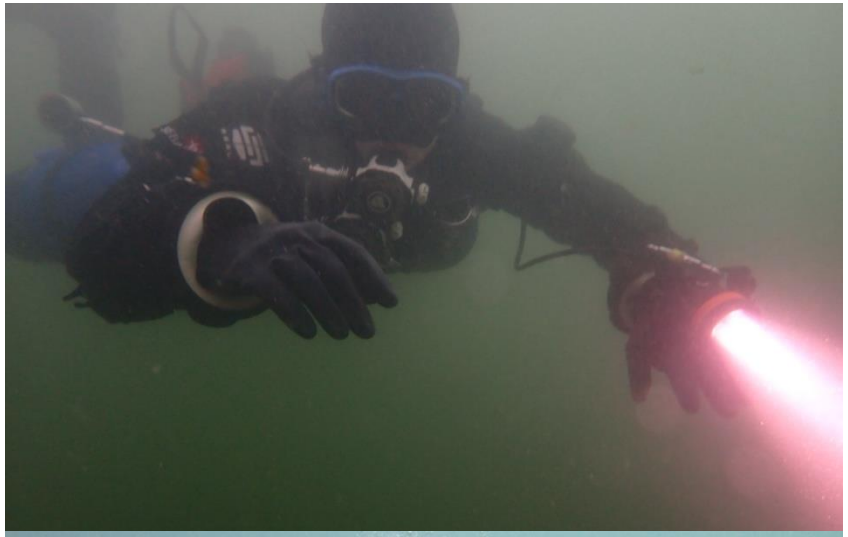


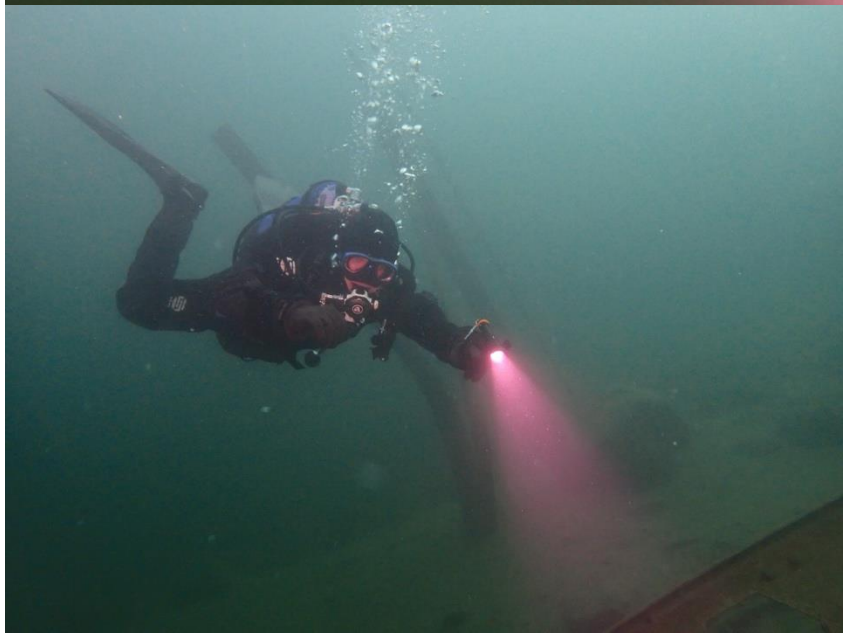


Introduction: Diving & Hyperbaric Environments



0. Composition of Air





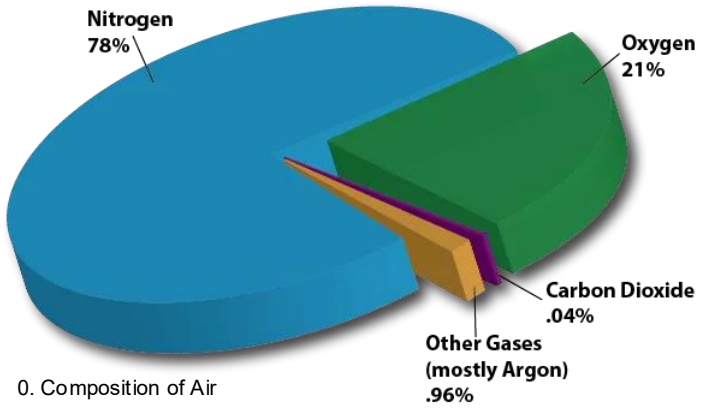
0. https://scied.ucar.edu/learning-zone/air-quality/whats-in-the-air

Introduction: Dive Computers

Hyperbaric Inert Gas
- Decompression

Hyperbaric O_2
- O_2 Toxicity

Bookkeeping
- Dive Log



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Introduction: Dive Computers

- **Hyperbaric Inert Gas**
  - Decompression
- **Hyperbaric O_2**
  - O_2 Toxicity
- **Bookkeeping**
  - Dive Log

1. Hans Hass DECO-BRAIN ® (1980s)

3. Shearwater Perdix 3 (2026)

2. Mares Sirius (2023)

1. https://www.divetable.info/img/helmet3.jpg
2. https://cdn-mdb.head.com/CDN3/D/414145_BKBK/1/1820x2428/sirius-black.webp
3. https://cdn.shopify.com/s/files/1/0711/0538/0397/files/ly_13501-01_perdix_3_black_left_angle_tec_bar_depth_22_9_1_german_1778708275.png

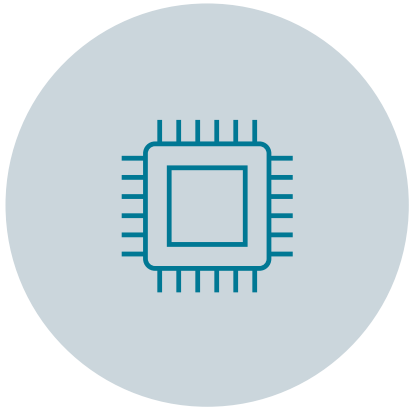
Problem Description

COMMERCIAL SETTING

FIXED DECOMPRESSION ALGORITHMS

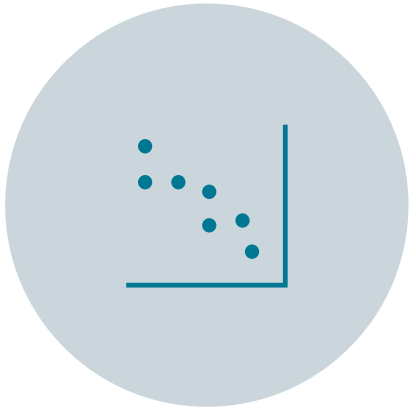
FIXED LOG RATE

Thesis Goals



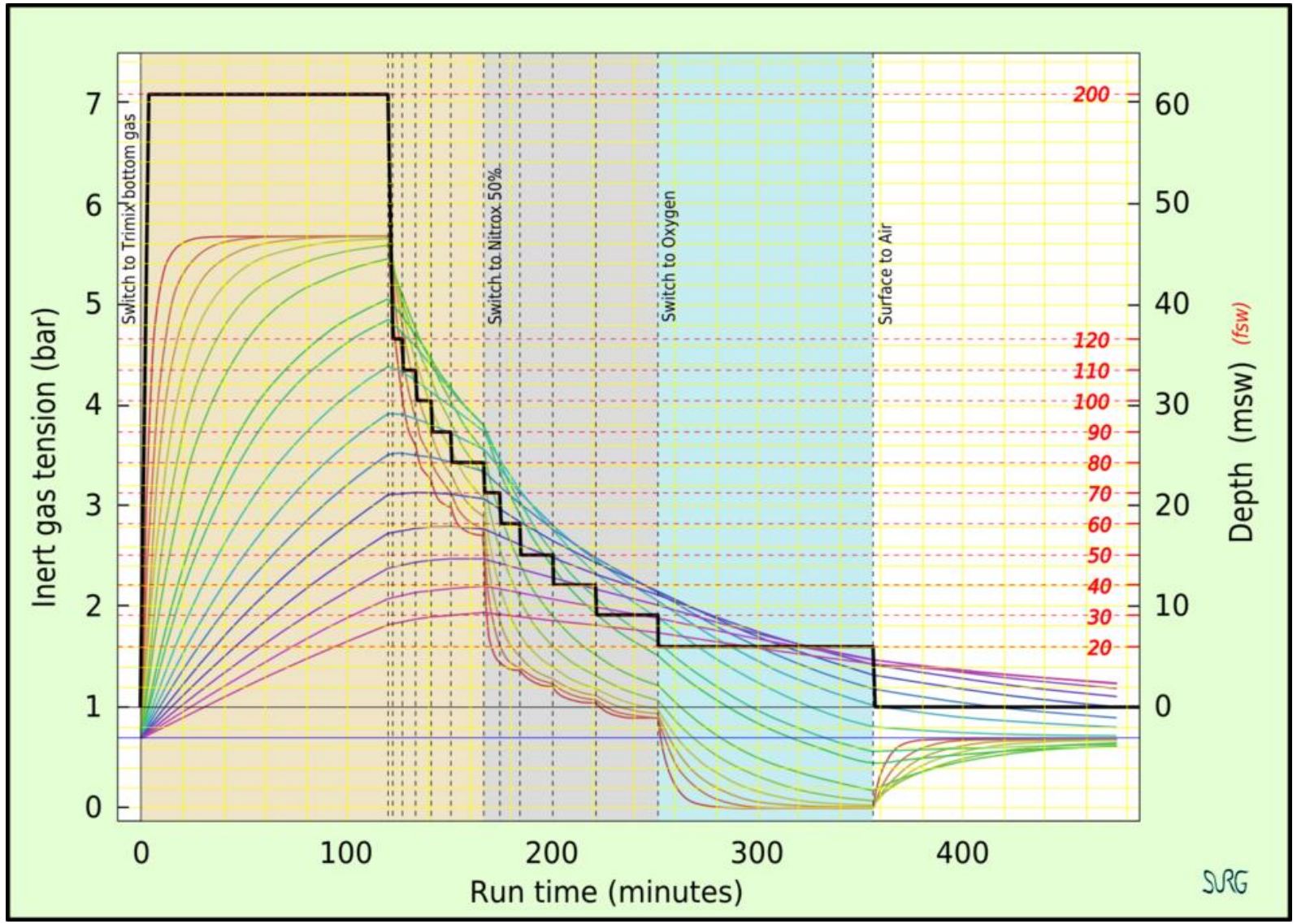
DESIGN & BUILD COMPACT PCB

IMPLEMENT & PROFILE LINEAR-EXPONENTIAL DECO-ALGORITHM



IMPLEMENT & PROFILE VARIABLE-RATE ALGORITHMS

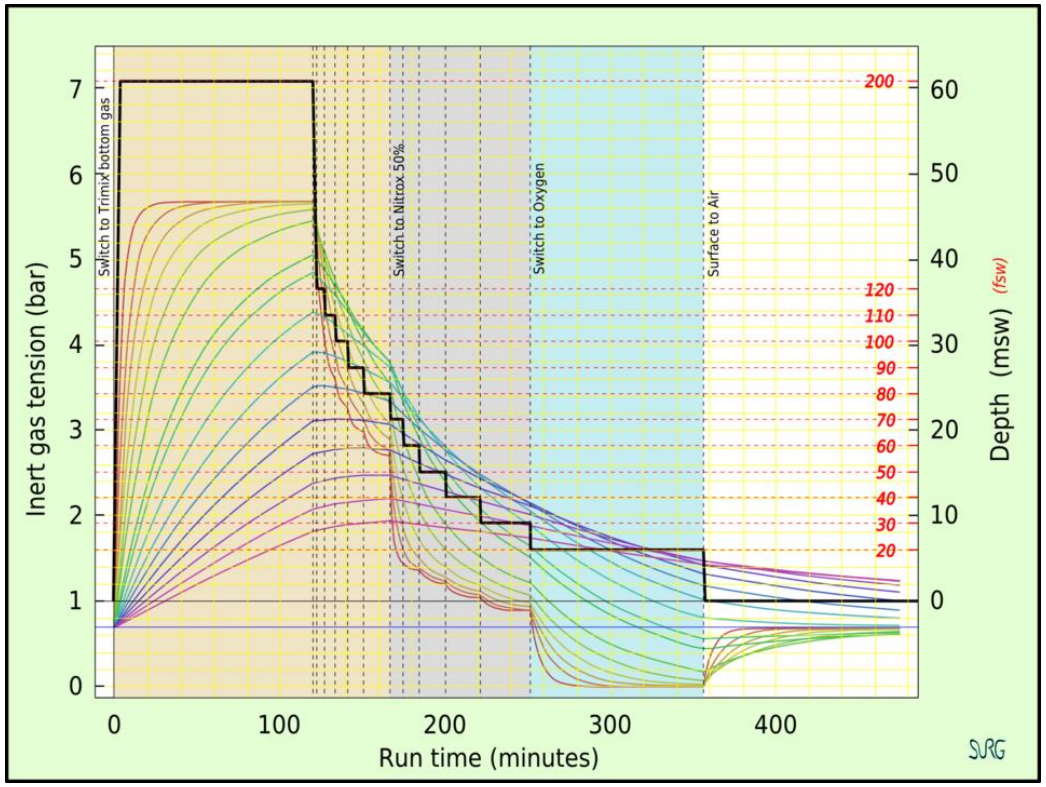
Background: Decompression Algorithms



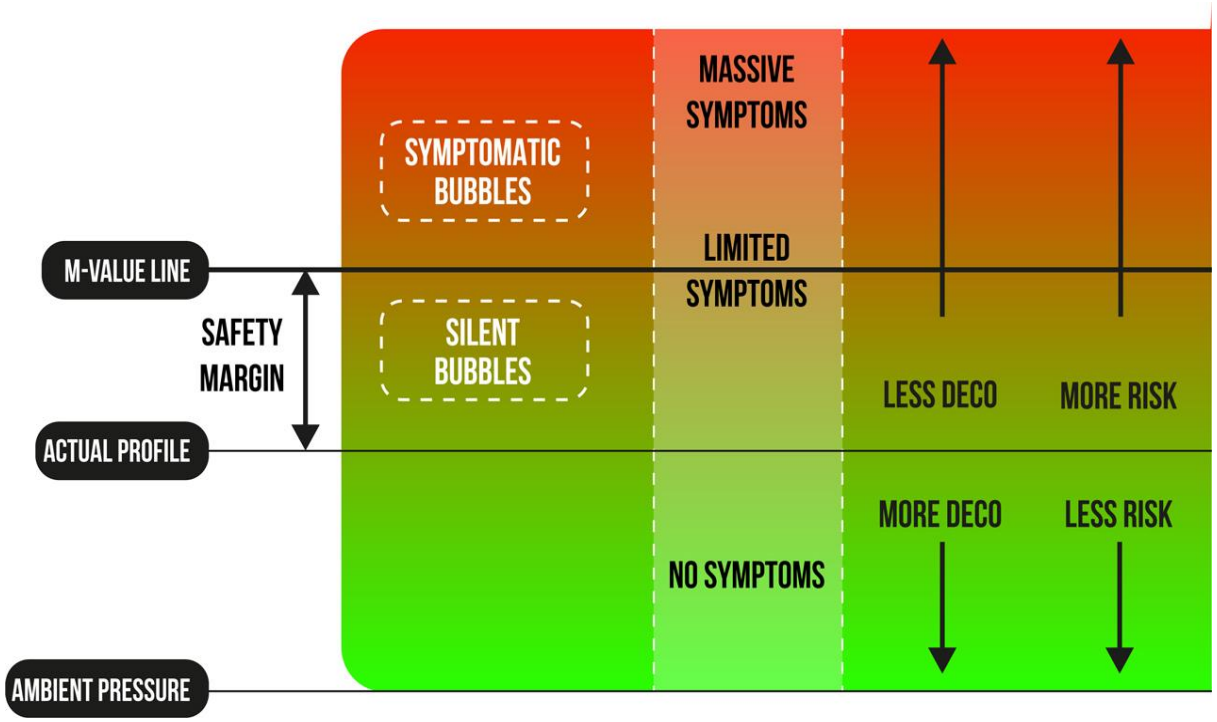
5. Example Decompression Model

5. https://en.wikipedia.org/wiki/File:Inert_gas_tensions_in_the_tissue_compartments_during_a_decompression_dive.png

Background: Hyperbaric Environments



5. Example Decompression Model

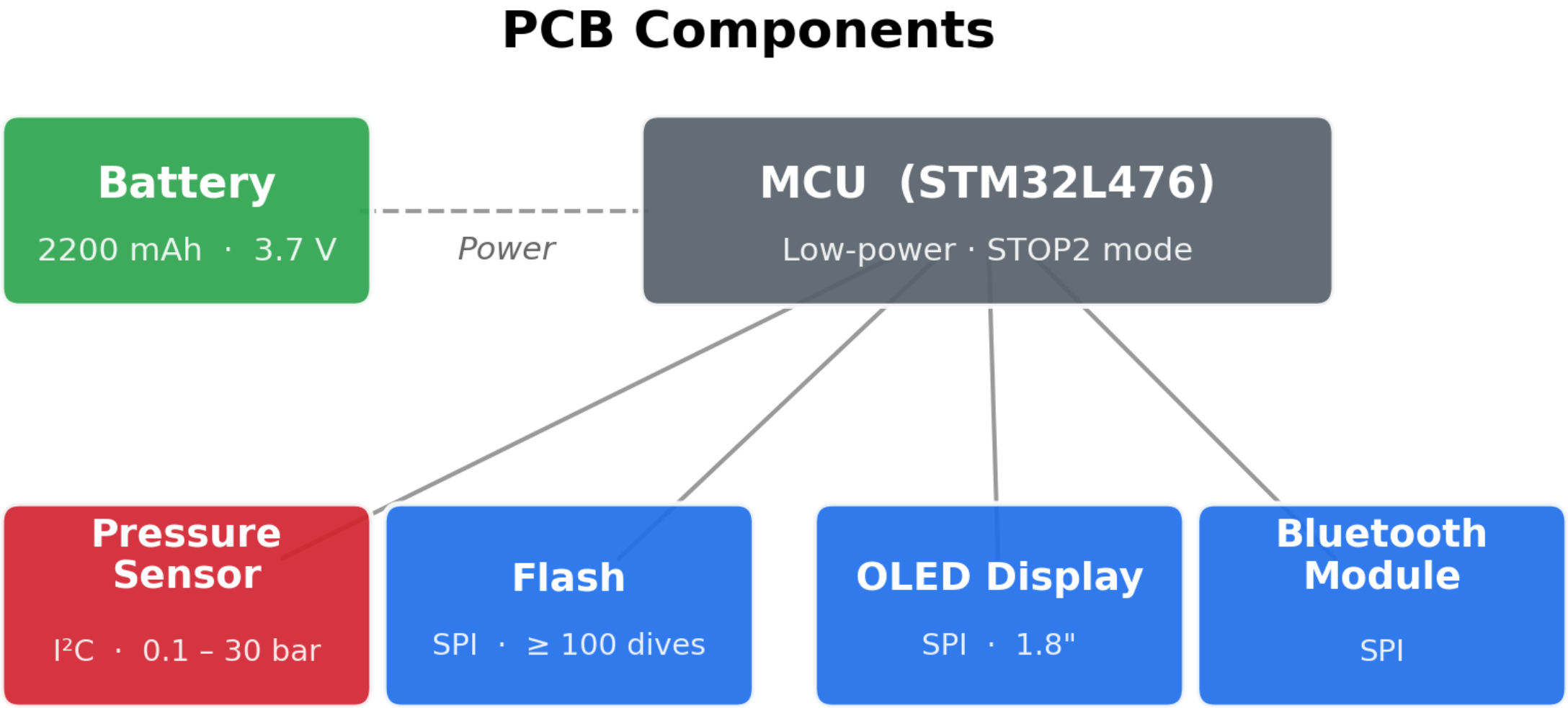


4. The M-Value

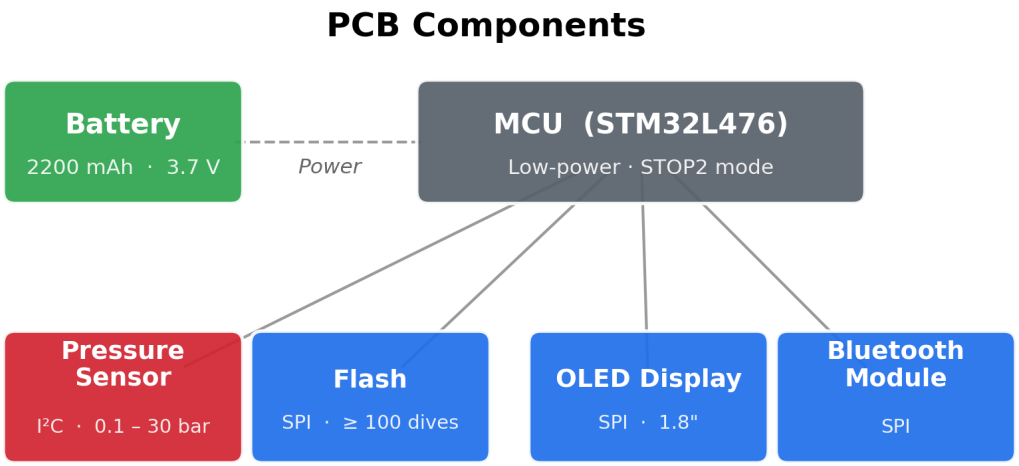
4. https://www.tdisdi.com/wp-content/uploads/2022/08/M_Value_Graph-1.jpg
5. https://en.wikipedia.org/wiki/File:Inert_gas_tensions_in_the_tissue_compartments_during_a_decompression_dive.png

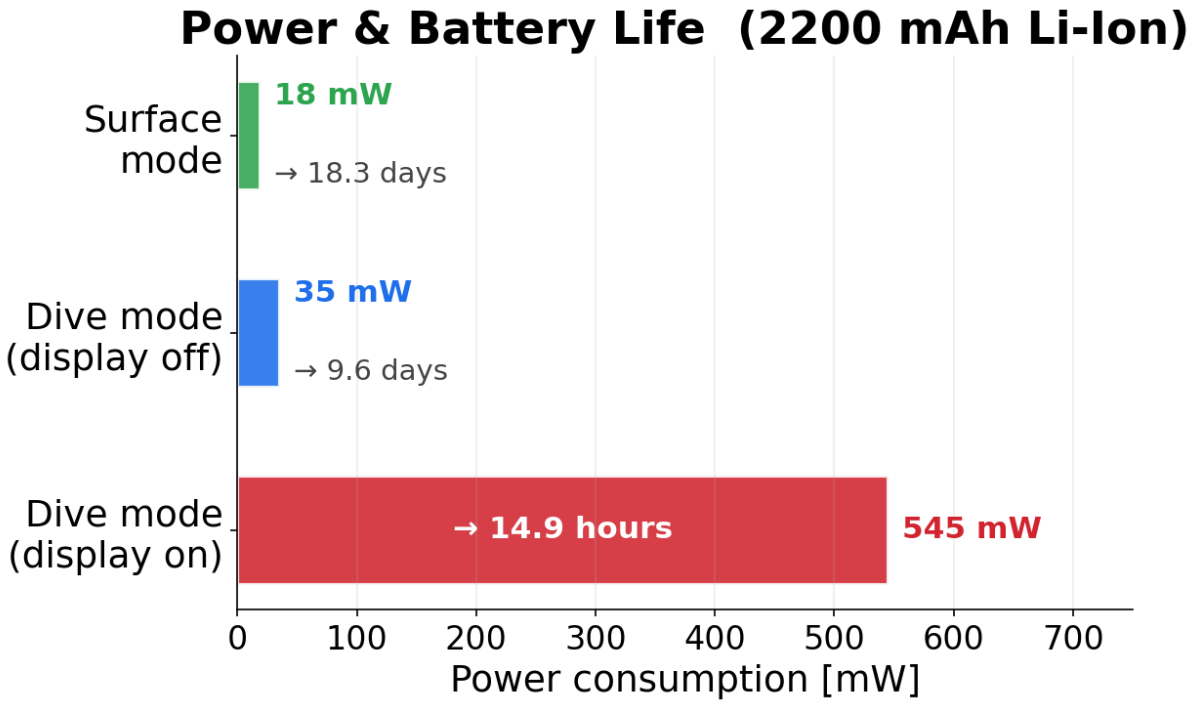
Implementation

Implementation: Hardware

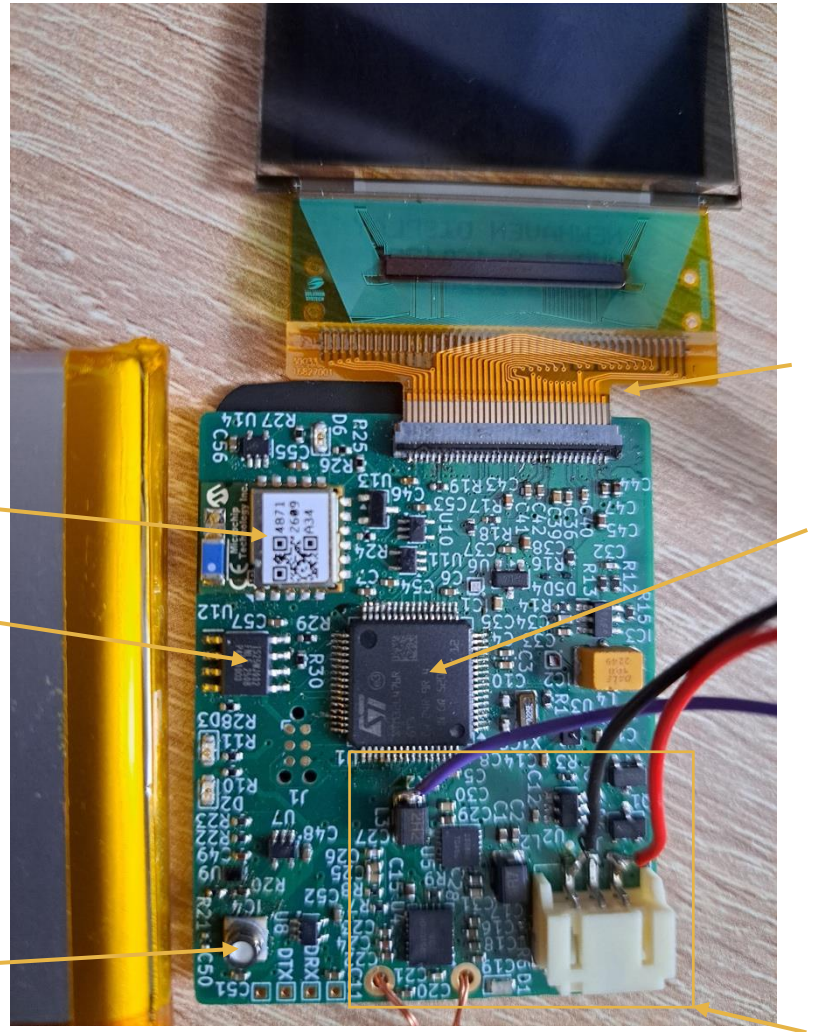


Implementation: Hardware



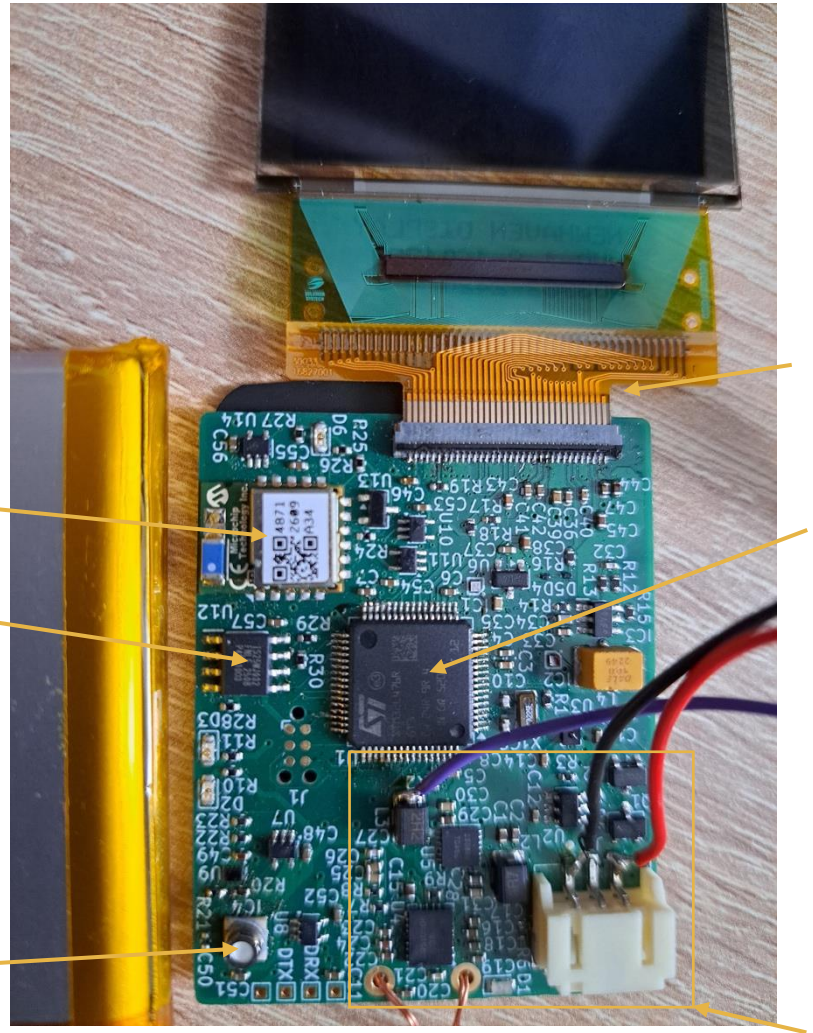


Implementation: Hardware



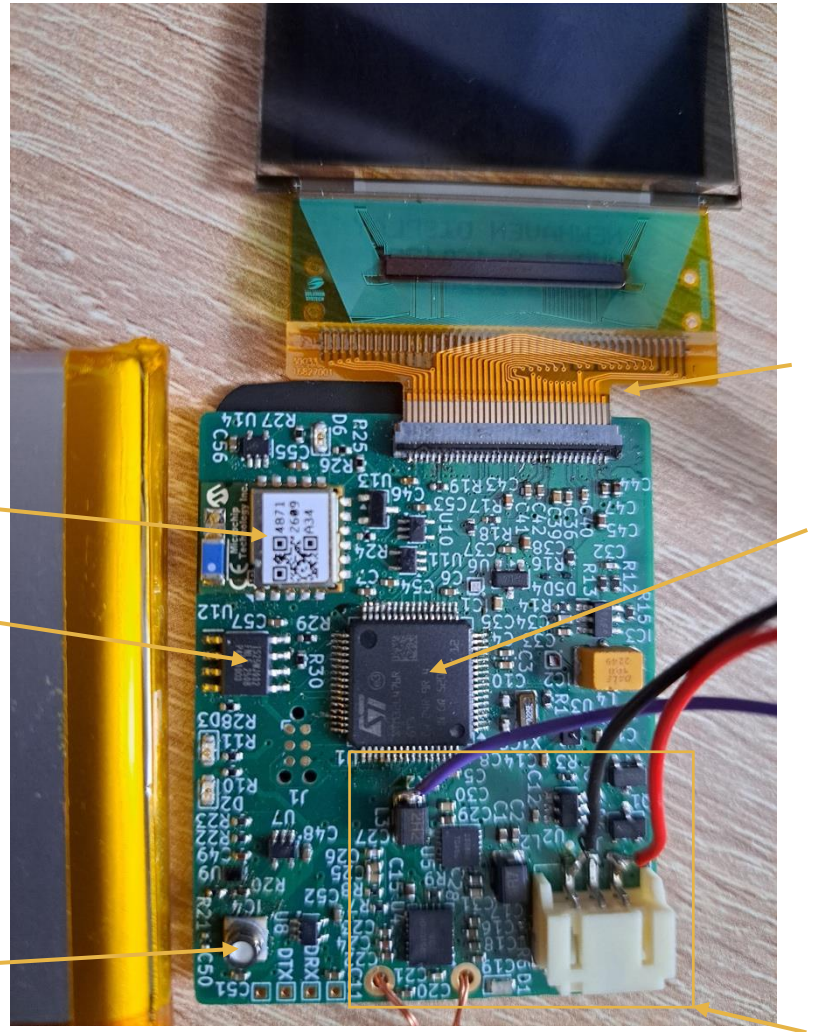
- MCU: Low-Power
- Battery: 18 days / 15 dive hours
- Pressure sensor: 0.1-30 bar
- External Bluetooth module
- Large, bright, OLED display
- Flash for >100 dives

Implementation: Hardware - Components



- MCU: STM32L476
- Connector for 3.7V Li-ion battery (2200mAh)
  - Wireless charging, battery protection
- MS5849-30BA pressure sensor
- RN-4871 BLE module
- 1.8” NHD OLED-Display
- 4MB Flash

Implementation: Hardware – Power Distribution



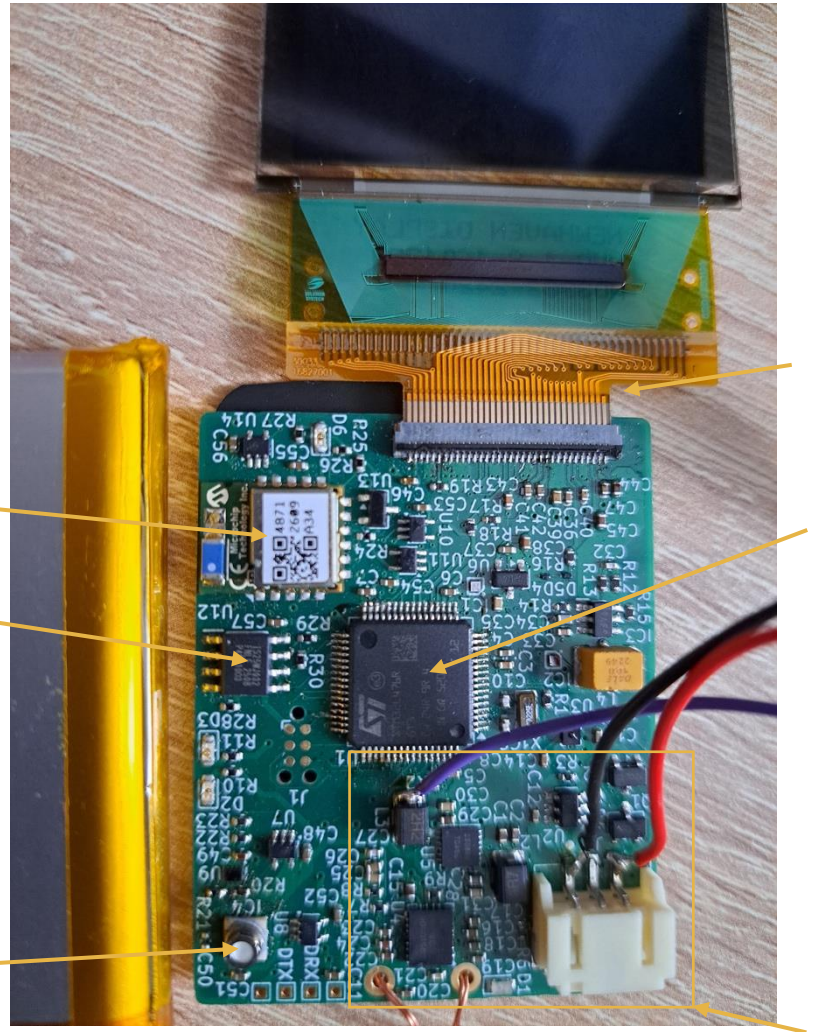
1.8V
- MCU
- Flash
- Display I/O

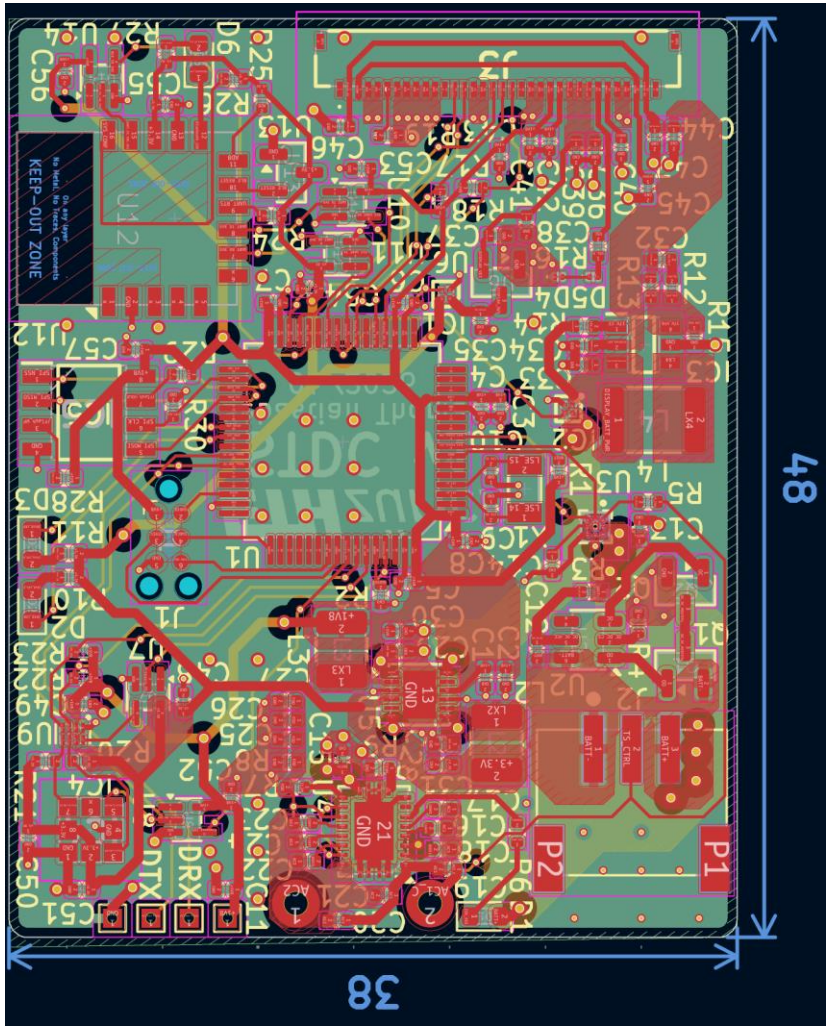
3.3V
- Pressure Sensor
- BLE Module
- LEDs

2.5V
- Display VCI

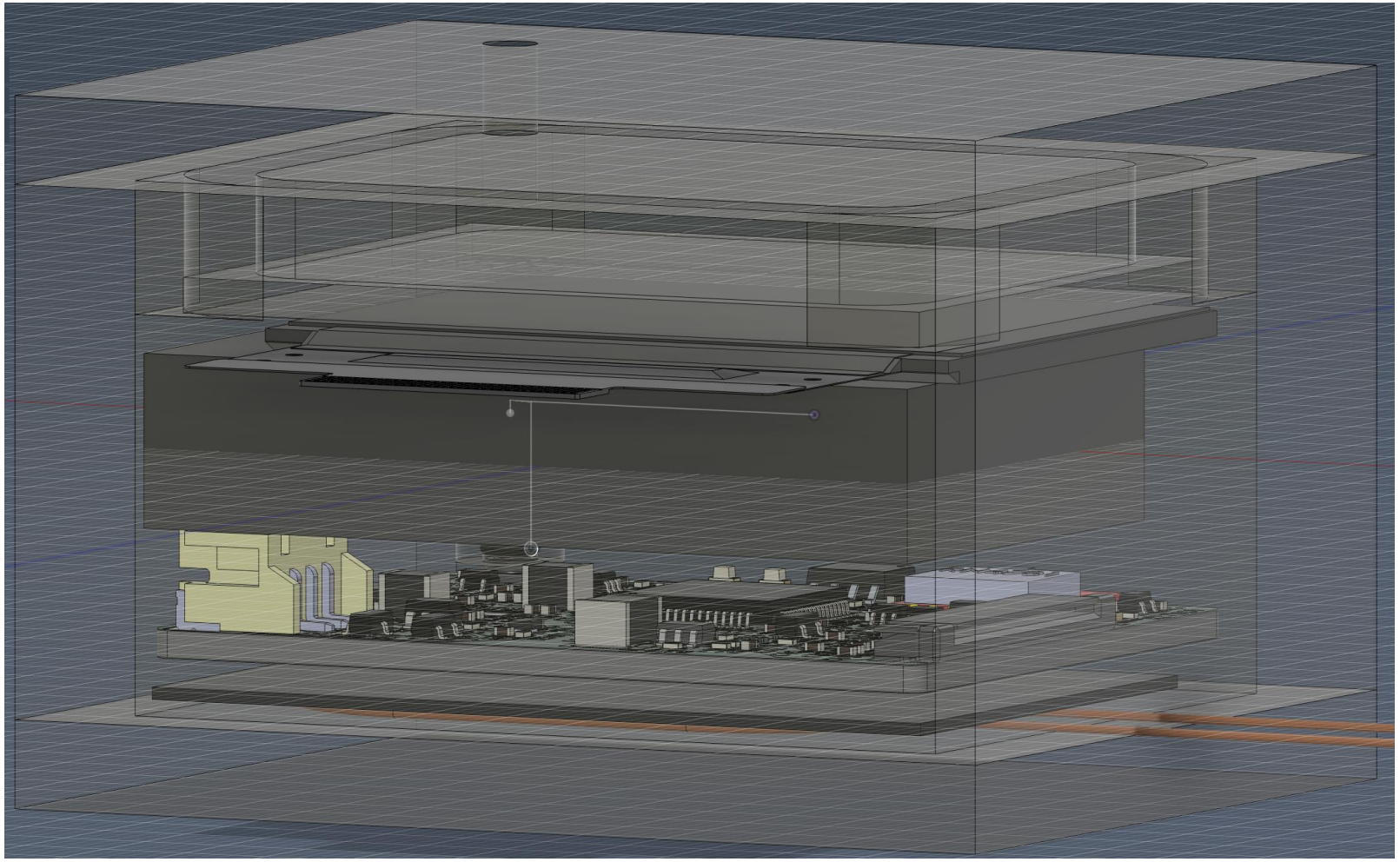
17V
- Display V_{CC}

Implementation: PCB Layout

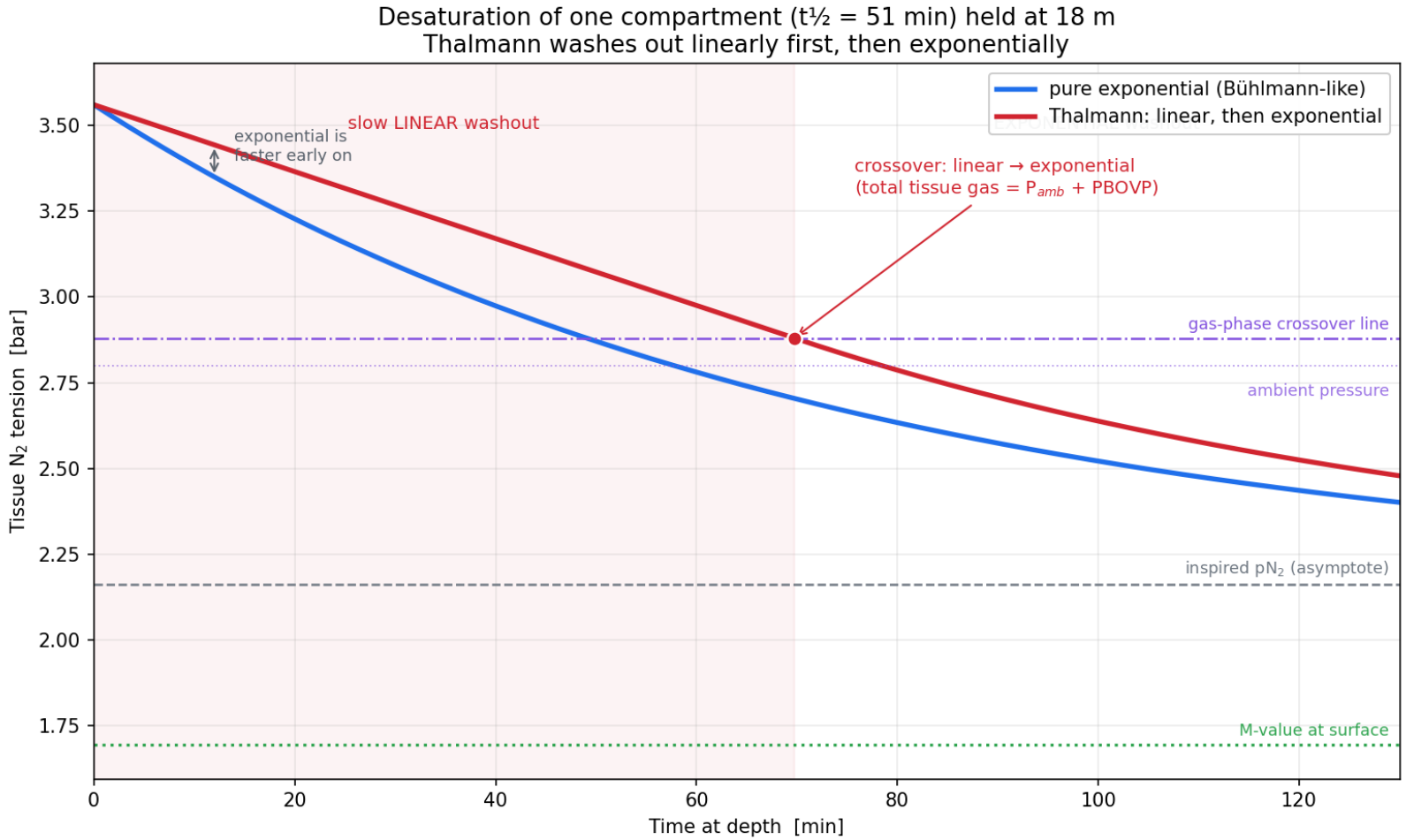




Example: Acrylic Enclosure



Implementation: Linear-Exponential decompression algorithm



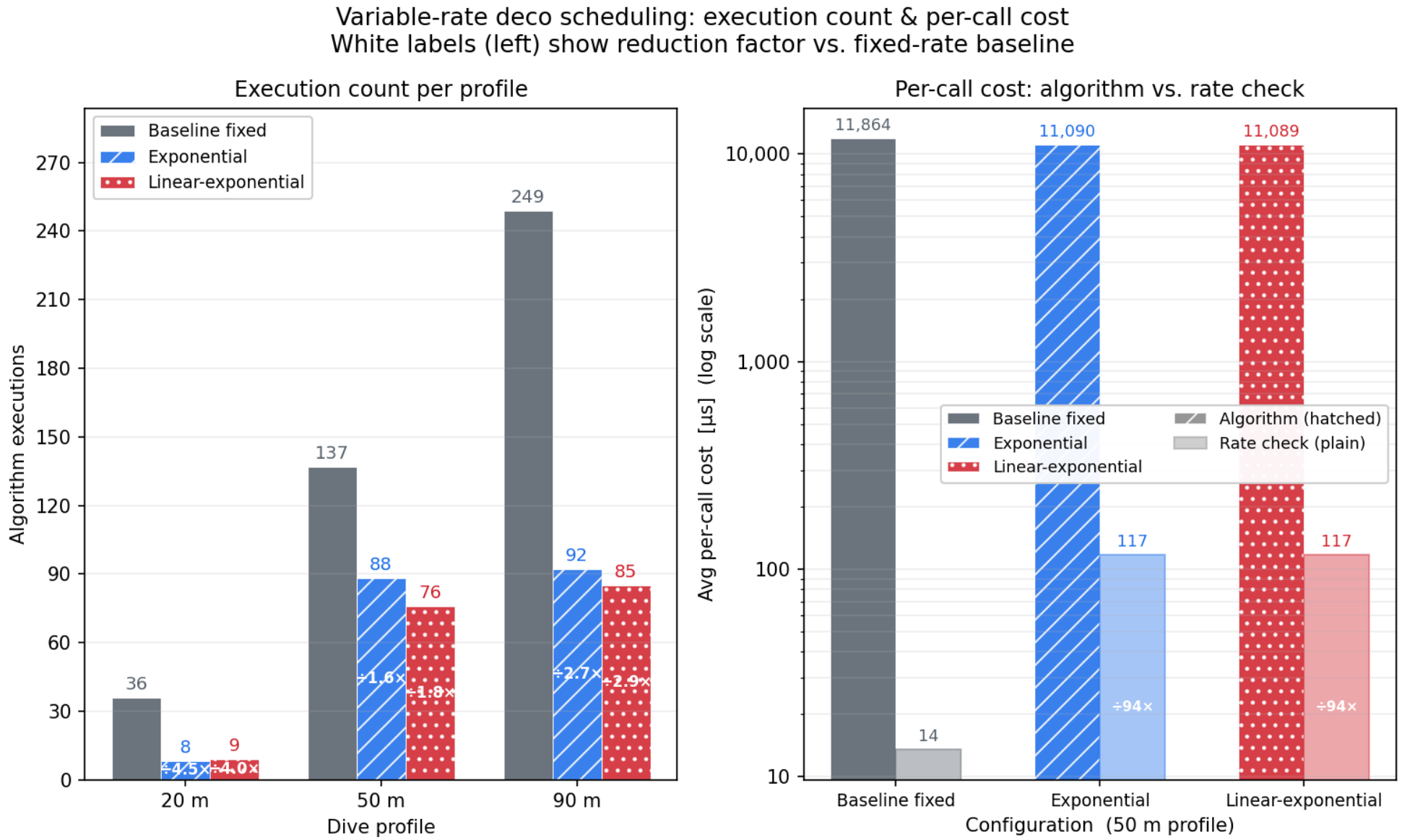
Implementation: Variable-rate algorithms

- Additive Increase (AI), Multiplicative Decrease (MD – **`change`**)

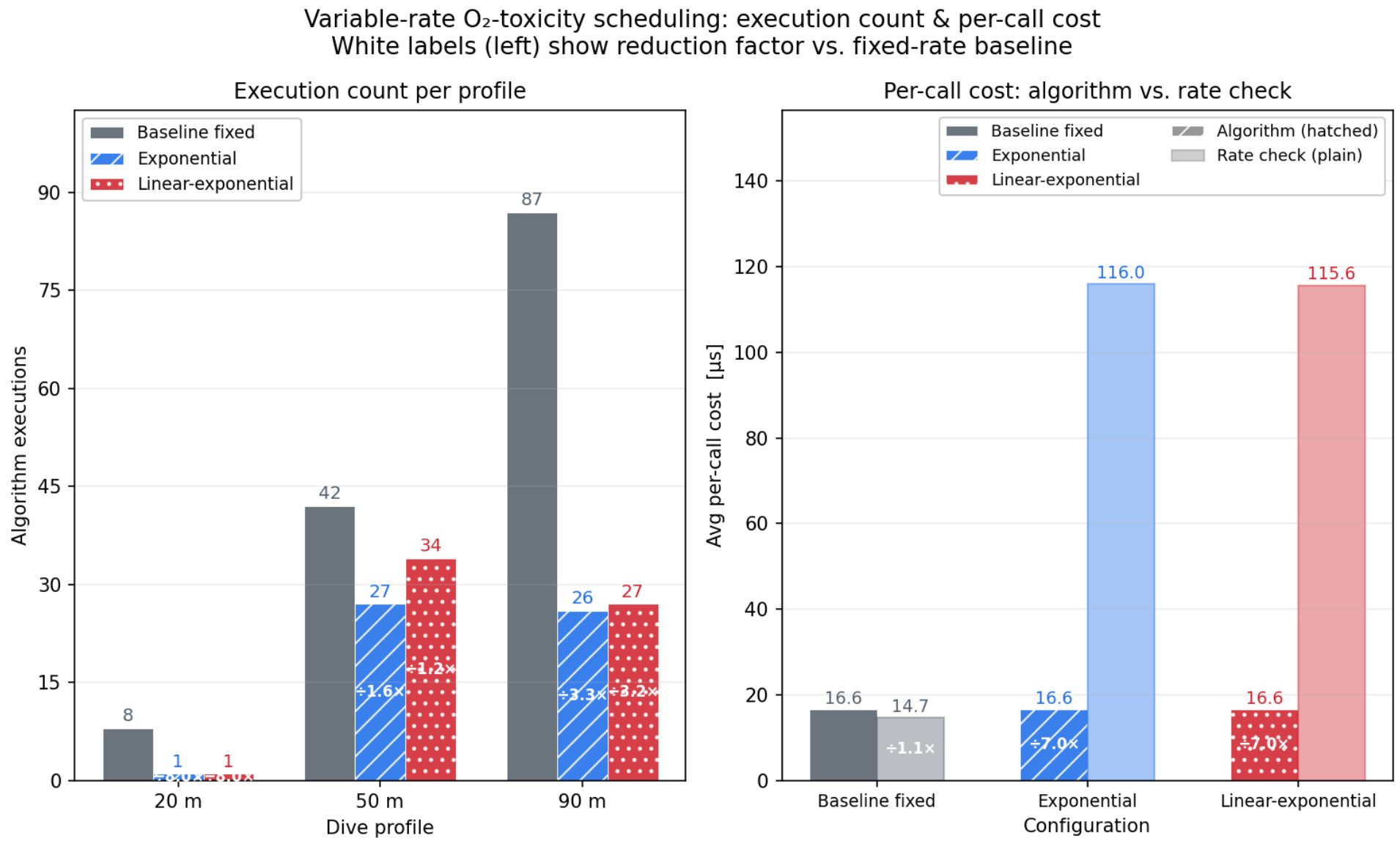
	`DiffAimdRateAlgorithm`	`DynamicDiffAimdRateAlgorithm`
`change`	$\frac{\delta v}{\delta t}$	$\frac{\delta v}{\delta t}$ or *fixed threshold*
Cycles	~ 1730	~ 1850

Results & Discussion

Results: Variable-rate algorithms – decompression models



Results: Variable-rate algorithms – O2Tox calculation

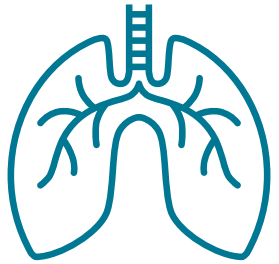


Discussion: Variable-rate for diving algorithms

Variable-rate Decompression Model

$1/3 \times$ energy required

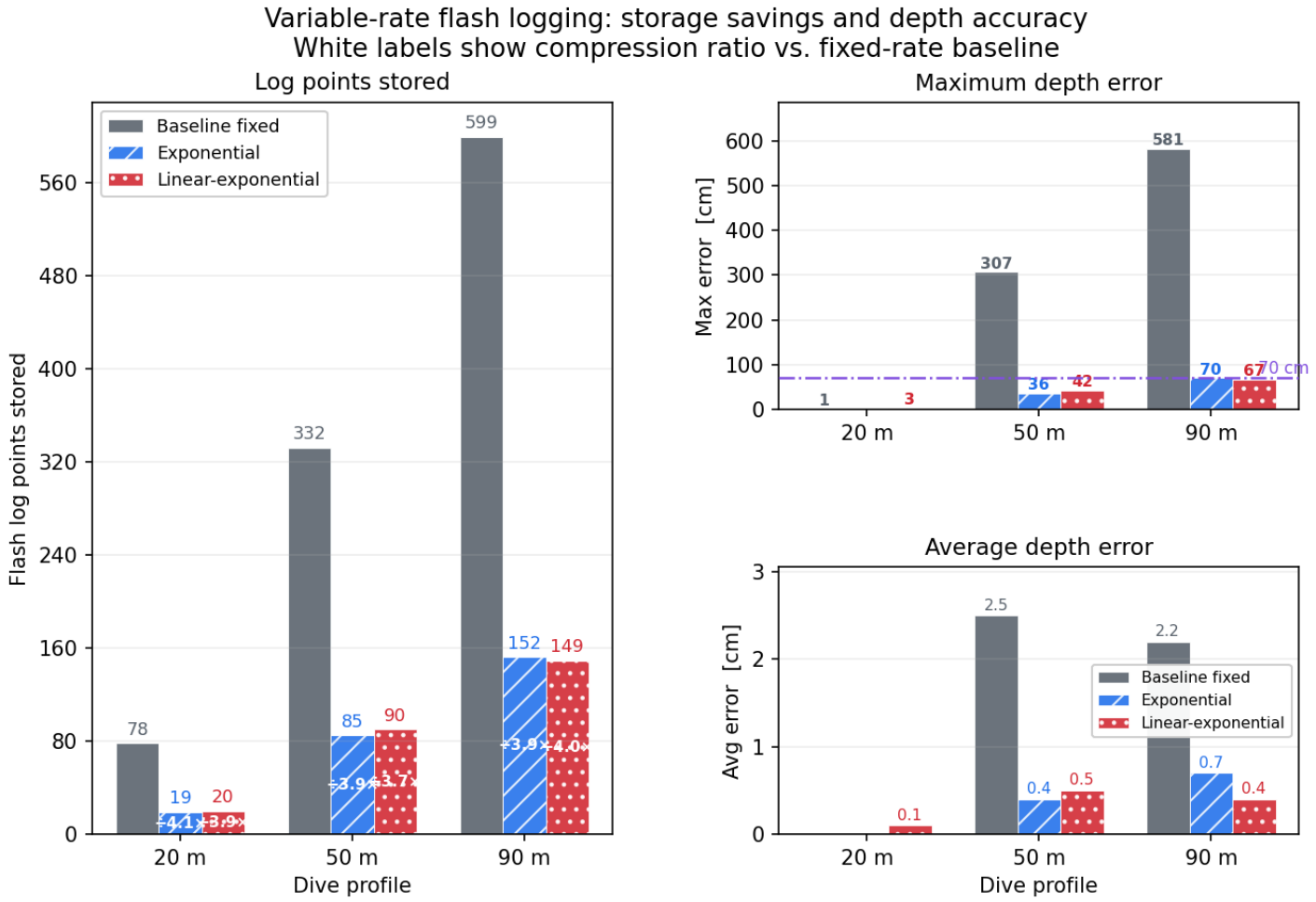
minor/short-term deviations



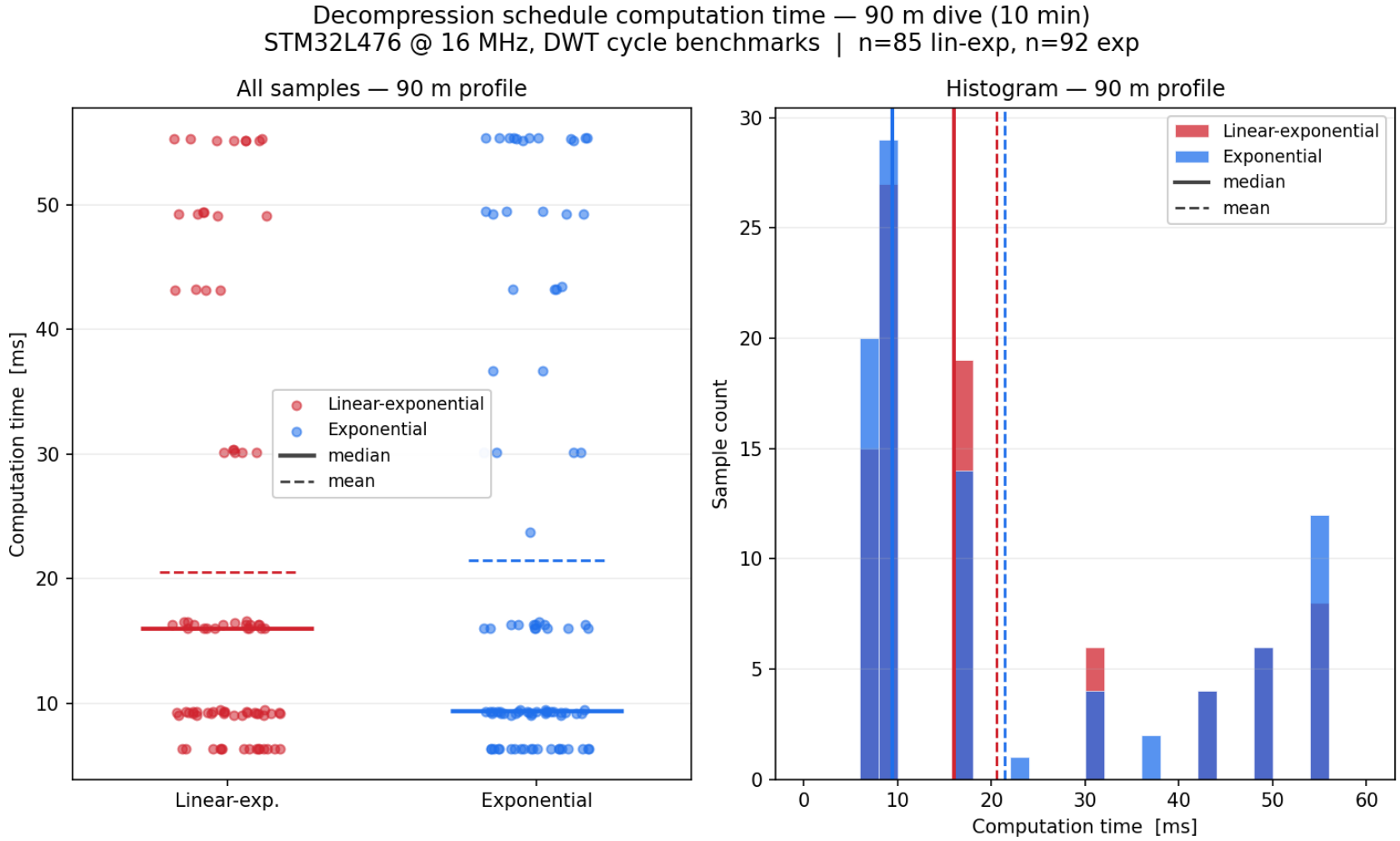
Variable-rate O2Tox

overhead too large

Results: Variable-rate algorithms – Dive Log to Flash



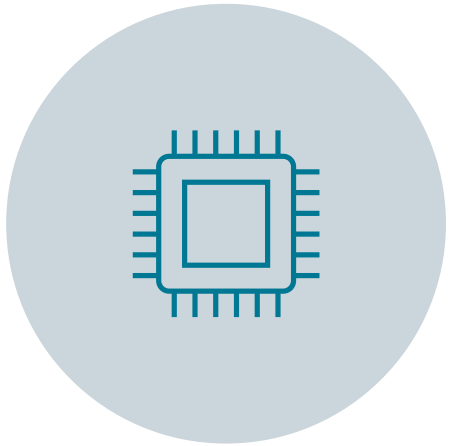
Results: Linear-exponential decompression algorithm



Discussion: Linear-exponential algorithms & Variable-rate Flash logging

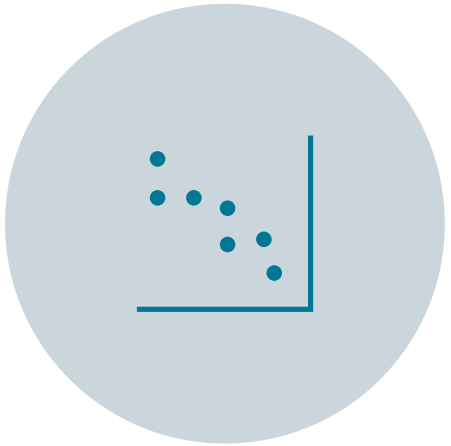
- Linear-exponential decompression algorithm
  - As expected, customizability
- Variable-rate Dive Log to Flash
  - Space Reduction: $3.6\times$-$4.1\times$

Conclusion



WEARABLE, COMPACT, OPEN SOURCE HARDWARE

LINEAR-EXPONENTIAL DECO:
$\leq$ 20% OVERHEAD

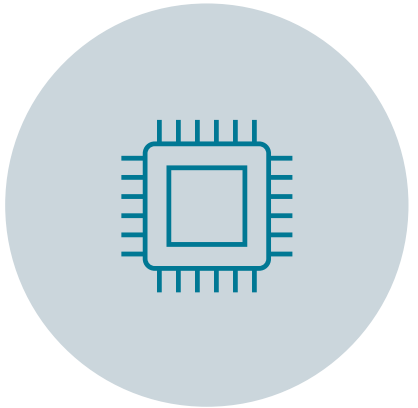


VARIABLE-RATE:
$\leq 0.28 \times$ FLASH SPACE
$\leq 0.32 \times$ DECO ENERGY

Future Work

REAL-WORLD TESTING

OPTIMIZE ALGORITHMS



FIX HARDWARE PROBLEMS

Figure References

Fig. 0. UCAR Center for Science Education, https://scied.ucar.edu/learning-zone/air-quality/whats-in-the-air, last accessed: 10.06.2026

Fig. 1. Tauch-Simulationssoftware und das D^3 Archiv, https://www.divetable.info/img/helmet3.jpg, last accessed: 09.06.2026

Fig. 2. Mares (Sirius Black), https://cdn-mdb.head.com/CDN3/D/414145_BKBK/1/1820x2428/sirius-black.webp, last accessed: 09.06.2026

Fig. 3. Shearwater Electronics, 2026, https://shearwater.com/en-sw/products/perdix-3, last accessed: 09.06.2026

Fig. 4. TDI/SDI: Decompression, 2024, https://www.tdisdi.com/wp-content/uploads/2022/08/M_Value_Graph-1.jpg, last accessed: 08.06.2026

Fig. 5. Wikimedia Foundation: Decompression theory (based on: Eric Maiken, 2004), https://en.wikipedia.org/wiki/File:Inert_gas_tensions_in_the_tissue_compartments_during_a_decompression_dive.png, last accessed: 09.06.2026

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