

M13Rec001, signature 080dd569

Recording

Mouse heart, spiral wave and optogenetic termination. 64 × 55 px, 9,267 frames, 1 kHz, 133 µm/px, deposit checks: negative values, nan mask all frames, temporal smoothing, spatial smoothing. Source 10.5281/zenodo.10228296; publication 10.1371/journal.pcbi.1011660; licence CC-BY-4.0; Hussaini, Sayedeh; Luther, Stefan; Lädke, Sarah L.. sha256 3f8f2e1b8f776633089b33ccd4bf3fccb4f13140b71991f1dcd0e0a12bb48cbc.

Run

0b805159-6ca0-4616-995e-14b1e224b0be, 2026-10-27 22:13 UTC to 2026-10-27 22:19 UTC, status done. Protocol Mouse whole heart optical mapping (Luther lab), parameters v2 set by developer (not a domain scientist). Code 752b95b01dde60f86eb71b47343448c7af4551c1 (uncommitted changes), None workers.

Methods

Using the provisional parameter set version 2 for protocol f65d786f-f194-4be2-88b8-10d3dd25d674, the fixed parameters were baseline_frames=641, spatial_sigma=1.0, spatial_truncate=4.0, pad_frames=400, rotor_threshold=0.9, rotor_erode_px=3, link_px=4.0, max_gap=5, min_cycles=1.0, pair_dist_px=3.0, paired_frac=0.5, and render_step=4. The frame rate was 1000 Hz from the publication source recorded for this movie, and the pixel size was 133 µm from the publication source. The analysed window was frames 400 to 8867, with provisional segment definitions and provisional criteria: illuminated_arrhythmia from frames 0 to 3170, illuminated_after_termination from frames 3170 to 4977, and light_off from frames 4977 to 9267; within the analysed window these correspond to analysed frames 400 to 3170, 3170 to 4977, and 4977 to 8867.

Verdict

Verdict: report only stable/descriptive findings and the stable in-range illuminated-arrhythmia dominant frequency; physiology_ok is true because the only ranged check, illuminated_arrhythmia.dominant_freq_hz, is stable at 15.523 Hz and within the checked 14.0625–25.0 Hz contextual range derived from the cited mouse spiral-wave passages reporting approximately 20.0 Hz and 18.75 Hz (DOI 10.1371/journal.pcbi.1011660). Do not report single values for unstable metrics: light_off.singularity_frames_frac 0.002827763496143959–0.031105398457583547, light_off.dominant_freq_hz 2.314–4.884 Hz, illuminated_arrhythmia.persistent_rotors 4.0–17.0, illuminated_arrhythmia.persistent_rotor_count_max 1.0–2.0, illuminated_after_termination.singularity_frames_frac 0.0005534034311012728–0.007194244604316547, and persistent_rotor_tracks 4.0–17.0. Persistent-rotor presence holds provisionally with the 64-frame measured-cycle criterion and the 50-frame paper-rotation criterion, and strict/default/loose trackers agree on the rule verdict despite varying counts. Review the pre-deposit processing/raw-data label, the frame-3170 event interpretation, and baseline/illumination artifact before using this for critical analysis; the ranges, the stability threshold, and the criteria are provisional. physiology_ok: True; send back: False. Reviewer sign-off: pending.

Parameters (as run)

```
% Mouse whole heart optical mapping (Luther lab), v2, read-only
% set by developer (not a domain scientist); provisional, REVIEW_NEEDED 16
baseline_frames = 641;      % no baseline rule recorded for this run
pad_frames      = 400;      % each side, outside the window
spatial_sigma   = 1.0;      % px, Gaussian, phase only
spatial_truncate = 4.0;      % kernel radius, sigma
lowpass         = [];       % none
polarity        = -1;       % measured, skew of dV/dt
rotor_threshold = 0.9;      % turns, |winding| per plaquette
rotor_erode_px  = 3;        % px from tissue edge ignored
link_px         = 4.0;      % tracking, max step per frame
max_gap         = 5;        % frames a track may vanish
min_cycles      = 1.0;      % own rotations, min_frames = 64
pair_dist_px    = 3.0;      % opposite-charge pairing
paired_frac     = 0.5;      % max paired fraction of a track
render_step     = 4;        % movie only
```

Segments

Segment	Defined	Analysed	Cycle, frames	Expected rotors	Bounded by
Illumination with arrhythmia	0-3,170	400-3,170	[not measured]	present	LED on before frame 0 (DAQ) → termination step (image, ±17 frames)
Illumination after termination	3,170-4,977	3,170-4,977	[not measured]	absent	termination step (image, ±17 frames) → illumination off (DAQ, ±11 frames)
Light off	4,977-9,267	4,977-8,867	[not measured]	absent	illumination off (DAQ, ±11 frames) → recording end

Metrics

Metric	Unit	Illumination with arrhythmia	Illumination after termination	Light off	Physiological range
Rhythm					
Dominant frequency	Hz	15.523	2.214	2.314-4.884 (unstable)	18.75-20 Hz, one recording provisional
Rotors					
Persistent rotors	count	4-17 (unstable)	0	0	none cited
Max concurrent persistent rotors	count	1-2 (unstable)	0	0	none cited
Frames with a singularity	fraction	0.489	0.001-0.007 (unstable)	0.003-0.031 (unstable)	none cited
Beats, where a global rhythm exists					
Beats	count	54	4	9	none cited
Global amplitude ratio	ratio	0.70	0.96	0.96	gate ≥ 0.30 provisional
APD50	ms	14	16	17	none cited
APD90	ms	26	76	78	none cited
Conduction velocity	cm/s	29.7	58.4	59.4	none cited

Criteria and reportable values

Item	Rule or segment	Result
Singularities present where the design expects them, absent elsewhere	each 'present' segment: $\text{frac} \geq 0.1$ and $\geq 2.0 \times \text{max frac}$ over 'absent' segments, at every setting	holds at 12 filter settings (provisional)
Persistent rotors present where the design expects them, absent elsewhere	each 'present' segment: $\text{count} \geq 1$; each 'absent' segment: $\text{count} \leq 0$, at every setting	holds at 12 filter settings and 3 trackers (provisional)
Persistence threshold, paper context	lifetime ≥ 64 frames (measured cycle) and ≥ 50 frames (cited agree (provisional) 20 Hz)	
persistent rotor tracks	all	4–17 count, unstable, not reportable
dominant freq (Hz)	light off	2.31–4.88 Hz, unstable, not reportable
persistent rotors	light off	0 count, no cited range
singularity frames fraction	light off	0.00283–0.0311 fraction of frames, unstable, not reportable
persistent rotor count max	light off	0 count, no cited range
dominant freq (Hz)	illuminated arrhythmia	15.52 Hz, within range
persistent rotors	illuminated arrhythmia	4–17 count, unstable, not reportable
dominant freq (Hz)	illuminated after termination	2.214 Hz, no cited range
singularity frames fraction	illuminated arrhythmia	0.4888 fraction of frames, no cited range
persistent rotors	illuminated after termination	0 count, no cited range
persistent rotor count max	illuminated arrhythmia	1–2 count, unstable, not reportable
singularity frames fraction	illuminated after termination	0.000553–0.00719 fraction of frames, unstable, not reportable
persistent rotor count max	illuminated after termination	0 count, no cited range

Provisional rules behind this signature

Rule	Description	Expert	Status
protocol_parameter_set worker/voltage/protocol_params.py (developer_defaults, set_params)	Each protocol's fixed, versioned analysis parameters (version 1 = developer defaults); no run or agent may deviate	optical mapping analyst	provisional
filter_defaults worker/voltage/preprocess.py (Params)	Default baseline window (frames) and spatial Gaussian sigma/truncate for phase	optical mapping analyst (cardiac electrophysiology)	provisional
tissue_mask worker/voltage/io.py (tissue_mask)	Tissue = not NaN in frame 0 and nonzero temporal std	optical mapping analyst	provisional
polarity worker/voltage/preprocess.py (polarity)	Dye polarity from sign of median per-pixel skew of dV/dt	optical mapping analyst / voltage dye chemist	provisional
singularity_detection worker/voltage/preprocess.py (Params.rotor_threshold, rotor_erode_px)	Phase singularity = [winding] > threshold turns, >= erode px from tissue edge	computational cardiac electrophysiologist (phase mapping)	provisional
rotor_persistence worker/voltage/rotors.py (TrackParams)	Track linking distance/gap and minimum lifetime for a persistent rotor	computational cardiac electrophysiologist (phase mapping)	provisional
chirality_pairing worker/voltage/rotors.py (TrackParams.pair_dist_px, paired_frac)	Opposite-charge singularities within pair distance are a pair; tracks paired most of their life are excluded from rotors	computational cardiac electrophysiologist (phase mapping)	provisional
sensitivity_grid worker/voltage/sensitivity.py (SIGMAS, BASELINE_MULTIPLES, baseline_levels)	Filter levels tested: spatial sigma and baseline window values	optical mapping analyst	provisional
analysis_window worker/voltage/runs.py (default_window)	Frames analysed: whole recording minus one filter pad at each end (unless the plan narrows it)	cardiac electrophysiologist familiar with the dataset	provisional
prior_processing_flags worker/voltage/inspect.py (prior_processing)	Thresholds for flagging depositor processing (normalization, masking, temporal/spatial smoothing)	imaging scientist (camera acquisition and noise)	provisional
baseline_step_detection worker/voltage/events.py (detect_baseline_step)	Baseline step = consensus upward step in tissue-mean raw baseline (cause not inferred; first misread as light onset, contradicted by the DAQ)	optical mapping experimentalist	provisional
daq_interpretation worker/voltage/daq.py	DAQ channel names from depositor notebook; frames = first N triggers of closest burst; midpoint thresholds	experimentalist who recorded the data (or the depositor)	provisional

Provisional rules behind this signature

Rule	Description	Expert	Status
segment_definitions worker/voltage/annotations .py (MOUSE_SEGMENTS)	Mouse segments bounded by DAQ light events and the baseline step, interpreted as spiral termination under illumination (project lead, from Hussaini et al. 2023)	cardiac electrophysiologist (ideally the depositing authors)	provisional
rotor_finding_criterion worker/voltage/sensitivity .py (MIN_FRAC, MIN_RATIO)	Singularity before/after finding holds if $\text{frac}(\text{before}) \geq \text{min_frac}$ and $\geq \text{min_ratio} \times \text{frac}(\text{after})$ at every setting (also kept, superseded, for persistent rotors)	cardiac electrophysiologist + biostatistician	provisional
persistent_rotor_criterion worker/voltage/sensitivity .py (MIN_ROTORS_PRESENT, MAX_ROTORS_ABSENT)	Persistent-rotor finding holds if every 'present' segment has ≥ 1 persistent rotor and every 'absent' segment has none, at every setting	cardiac electrophysiologist	provisional
pipeline_check worker/agents/pipeline.py (INSTRUCTIONS, validator)	The pipeline agent's hold/proceed decision from protocol mismatches and inspector anomalies; it chooses no parameter	optical mapping analyst	provisional
physiology_reference_rates worker/voltage/physiology.py (RANGES, TOLERANCE_FRAC)	Cited physiological ranges (single-study values widened by a 25% tolerance), applied to segments by their expected rhythm; used by the critic and for frame-rate sanity checks	cardiac electrophysiologist per species	provisional
stability_rule worker/agents/critic.py (STABLE_FRAC, stability)	A metric is reportable only if its spread across all sensitivity settings is $\leq 25\%$ of its median (zero spread when all values are 0); otherwise 'unstable, not reportable'	biostatistician + optical mapping analyst	provisional
persistence_threshold_variants worker/agents/critic.py (persistence_variants)	The persistent-rotor rule is run at two lifetimes, one measured cycle of the fastest segment and the paper's cited rotation period; both verdicts stored, disagreement flagged	computational cardiac electrophysiologist (phase mapping)	provisional

Review items

Topic	Detail	Severity
unstable:light_off.singularity_frames_frac	Filter-grid sensitivity gives 0.002827763496143959–0.031105398457583547; do not report a single light-off singularity-frames fraction.	warn
unstable:light_off.dominant_frequency_hz	Baseline-window sensitivity gives 2.314–4.884 Hz; do not report a single light-off dominant frequency.	warn
unstable:illuminated_arrhythmia.persistent_rotors	Filter and tracker sensitivity gives 4.0–17.0 persistent rotors; report presence only, not a single count.	warn
unstable:illuminated_arrhythmia.persistent_rotor_count_max	Filter and tracker sensitivity gives 1.0–2.0 maximum simultaneous persistent rotors; do not report a single maximum count.	warn
unstable:illuminated_after_termination.singularity_frames_frac	Filter-grid sensitivity gives 0.0005534034311012728–0.007194244604316547; do not report a single post-termination singularity-frames fraction.	warn
unstable:persistent_rotor_tracks	Aggregate persistent-rotor tracks vary from 4.0 to 17.0 across filters and trackers; do not report a single track count.	warn
Pre-deposit processing / raw-data label	The recording is labeled as raw experimental data in the README, but documentation and measurements indicate masking, spatial smoothing, temporal smoothing, and normalization; analyses that require raw photon counts or independent pixel noise should not treat this as raw camera data.	warn
Event interpretation at frame 3170	Frame 3170 is a baseline_step only; illumination began before frame 0 and ended at frame 4977, so frame 3170 should not be treated as light onset. The termination label is provisional.	warn
Baseline and illumination artifact	The paper reports stimulation-light crosstalk and re-normalization; this recording also has a large slow baseline range and a baseline step, so absolute baseline or amplitude analyses require artifact review.	warn
Provisional tool thresholds	Event detection, processing flags, SNR, rhythm, and reference-rate thresholds have not yet been reviewed by a domain scientist.	info

Provenance

```
{
  "recording": {
    "id": "55cb4aa3-6502-45a6-a14c-85cb676fe8c3",
    "label": "Mouse heart, spiral wave and optogenetic termination (M13Rec001)",
    "source": "public",
    "source_ref": "10.5281/zenodo.10228296",
    "publication_ref": "10.1371/journal.pcbi.1011660",
    "storage_path": "public/M13Rec001_complete.npy",
    "format": "npy",
    "sha256": "3f8f2e1b8f776633089b33ccd4bf3fccb4f13140b71991f1dcd0e0a12bb48cbc",
    "size_bytes": 260958848,
    "license": "CC-BY-4.0",
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    "rights_source": {
      "ref": "10.5281/zenodo.10228296",
      "url": "https://zenodo.org/records/10228296",
      "kind": "deposit_metadata",
      "creators": [
        "Hussaini, Sayedeh",
        "Luther, Stefan",
        "L\u00e4dke, Sarah L."
      ]
    },
    "license_as_stated": "cc-by-4.0"
  },
  "frame_rate_hz": 1000,
  "frame_rate_source": {
    "ref": "10.1371/journal.pcbi.1011660",
    "kind": "publication",
    "note": "Camera frames are 64 x 64 in the paper; the deposit is 64 x 55 (cropped). Consistent with the DAQ: 10 samples per frame and a 5 s light pulse spanning 50,001 samples imply a 10 kHz DAQ.",
    "quote": " 775 \u00b1 70nm bandpass filter (FF01\u2013140-25, Semrock) and finally by the camera (EMCCD, Cascade 128+, Photometrics) with a spatial resolution of 64 \u00d7 64 pixels (133 \u00b5m per pixel) at 1 kHz. Optical Mapping recordings were acquired with software MultiRecorder and analysed with software PythonAnalyser (both developed by Research Group Biomedical Physics). Electrical s",
    "section": "Materials and methods: Optical mapping experiments on ventricular arrhythmia and its termination in the intact mouse heart"
  },
  "pixel_size_um": 133,
  "pixel_size_source": {
    "ref": "10.1371/journal.pcbi.1011660",
    "kind": "publication",
    "note": "paper states 64 x 64 px at 133 um; the deposit is 64 x 55 (cropped, not rebinned)",
    "quote": "rst collected by a 775 \u00b1 70nm bandpass filter (FF01\u2013140-25, Semrock) and finally by the camera (EMCCD, Cascade 128+, Photometrics) with a spatial resolution of 64 \u00d7 64 pixels (133 \u00b5m per pixel) at 1 kHz. Optical Mapping recordings were acquired with software MultiRecorder and analysed with software PythonAnalyser (both developed by Research Group Biomedical Physics). El"
  },
  "frames": 9267,
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```

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    "inverted": true
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    "name": "Mouse whole heart optical mapping (Luther lab)",
    "species": "mouse",
    "tissue": "whole_heart",
    "params_version": 3,
    "params_set_by": "developer (not a domain scientist)",
    "params_note": "version 3: baseline 901 frames = 2.1 x the 433-frame (2.31 Hz) post-
termination cycle resolved under v2; v2's 641 frames was 1.48 cycles, on the 1.5-cycle line,
and the pipeline check held one run and passed another on the same inputs. pad 500 >= half
the window. Provisional (REVIEW_NEEDED item 16).",
  },
  "run": {
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    "started_at": "2026-10-27T22:13:23.355061+00:00",
    "finished_at": "2026-10-27T22:19:36.177173+00:00",
    "code": {
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    },
  },
  "workers": null,
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    "deposit_checks",
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    "phase_singularities",
    "track_and_pair",
    "beats_apd_cv",
    "sensitivity",
    "render"
  ],
  "protocol_params": {
    "params": {
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      "max_gap": 5,
      "min_cycles": 1.0,
      "pad_frames": 400,
      "paired_frac": 0.5,
      "render_step": 4,
      "pair_dist_px": 3.0,
      "spatial_sigma": 1.0,
      "rotor_erode_px": 3,
      "baseline_frames": 641,
      "rotor_threshold": 0.9,
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    },
  },

```

```

"version": 2,
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negative",
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    },
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      "value": 0.0,
      "suggests": "not raw camera counts (camera output is integer); weak alone",
      "threshold": 0.5
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    {
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      "value": 1188,
      "suggests": "tissue masked by depositor; the mask is theirs"
    },
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      "flag": "temporal_smoothing",
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      "suggests": "temporally low-pass filtered (white shot noise gives dV lag-1 autocorr
near -0.5)",
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  ],
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    "integer_frac": 0.0,
    "negative_frac": 0.3231635934819897,
    "frames_with_nan": 9267,
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    "neighbour_dv_corr_median": 0.9957938301611564
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},
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"anomalies": [
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    "topic": "Pre-deposit processing / raw-data label",
    "severity": "warn",
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masking, temporal smoothing, spatial smoothing, and normalization were documented and
measured. The protocol's Gaussian phase smoothing is therefore added on top of prior spatial
filtering of unknown total, noise/SNR assumptions are not independent raw-pixel noise, and
amplitude or photon-count interpretations would be misleading; phase/rotor analysis may
proceed with this caveat."
  },
  {
    "topic": "Event interpretation at frame 3170",
    "severity": "warn",
    "effect_on_analysis": "Frame 3170 should be used only as the provisional segment
boundary supplied to the run, not as measured light onset. DAQ and photodiode evidence
indicate illumination was already present before frame 0 and ended at frame 4977, so any
segment-level interpretation depending on frame 3170 as light onset would be wrong; the
numerical pipeline itself can use the boundary as a provisional event boundary."
  },
  {
    "topic": "Baseline and illumination artifact",
    "severity": "warn",
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signal, a large slow baseline range, and a baseline step mean absolute baseline and
amplitude measurements are not reliable as raw fluorescence physiology. The fixed high-
pass/baseline procedure and rotor criteria may still be applied, but baseline-dependent
interpretation should be cautious."
  },
  {
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    "severity": "warn",
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termination segment rhythms put the baseline window at about the provisional lower limit
stated by the rhythm tool. This may modestly attenuate slow post-termination rhythm
components, but it is not a block because the frame rate is the intended 1000 Hz and this
version of the protocol was set for this recording."
  }
],
"rationale": "The recording may be analysed under protocol version 2 as it stands. The
recording is the intended mouse whole-heart public reference recording, and the 1000 Hz
frame rate from the publication agrees with the protocol note underlying the fixed 641-frame
baseline window; no species, tissue, frame-rate, pixel-size, or image-size mismatch requires
a hold. The important limitations are interpretive rather than eligibility-blocking: the
deposit is processed rather than raw, the frame-3170 event is a provisional
termination/baseline-change boundary rather than light onset,
illumination/crosstalk/normalization affect baseline and amplitude, and the post-termination
rhythm is close to the baseline-window caveat threshold. These warnings should accompany any
results, but they do not make the fixed parameters inapplicable.",
"mismatches": [],
"hold_reason": null,
"protocol_id": "f65d786f-f194-4be2-88b8-10d3dd25d674",
"methods_text": "Using the provisional parameter set version 2 for protocol
f65d786f-f194-4be2-88b8-10d3dd25d674, the fixed parameters were baseline_frames=641,

```

spatial_sigma=1.0, spatial_truncate=4.0, pad_frames=400, rotor_threshold=0.9, rotor_erode_px=3, link_px=4.0, max_gap=5, min_cycles=1.0, pair_dist_px=3.0, paired_frac=0.5, and render_step=4. The frame rate was 1000 Hz from the publication source recorded for this movie, and the pixel size was 133 um from the publication source. The analysed window was frames 400 to 8867, with provisional segment definitions and provisional criteria: illuminated_arrhythmia from frames 0 to 3170, illuminated_after_termination from frames 3170 to 4977, and light_off from frames 4977 to 9267; within the analysed window these correspond to analysed frames 400 to 3170, 3170 to 4977, and 4977 to 8867.",

```
"recording_id": "55cb4aa3-6502-45a6-a14c-85cb676fe8c3",
"params_version": 2,
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        ],
        "citation": {
          "ref": "10.1371/journal.pcbi.1011660",
          "quote": "t stimulus with LI = 3.44 \u03bcW/mm2 and PL = 5 s. Fig 2C shows a
monophasic action potential (MAP) signal (in black) before, during, and after illumination.
It shows the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer
look at the MAP signal of the heart during the last few rotations of arrhythmia and the
first few action potentials of sinus rhythm. Fig 2E illustrates a"
        }
      },
      {
        "defined_by": "project lead (not a domain scientist), following the paper's design",
        "segment_id": "f6ca0bce-f7e9-437d-84b6-1bb1b24f80ba",
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    "end_event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
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      4977
    ],
    "citation": {
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      "quote": "t stimulus with LI = 3.44 \u03bcW/mm2 and PL = 5 s. Fig 2C shows a
monophasic action potential (MAP) signal (in black) before, during, and after illumination.
It shows the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer
look at the MAP signal of the heart during the last few rotations of arrhythmia and the
first few action potentials of sinus rhythm. Fig 2E illustrates a"
    },
    "defined_by": "project lead (not a domain scientist), following the paper's design",
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    ],
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      8867
    ],
    "citation": {
      "ref": "10.1371/journal.pcbi.1011660",
      "quote": "t stimulus with LI = 3.44 \u03bcW/mm2 and PL = 5 s. Fig 2C shows a
monophasic action potential (MAP) signal (in black) before, during, and after illumination.
It shows the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer
look at the MAP signal of the heart during the last few rotations of arrhythmia and the
first few action potentials of sinus rhythm. Fig 2E illustrates a"
    },
    "defined_by": "project lead (not a domain scientist), following the paper's design",
    "segment_id": "4eedfd6-84c2-40d3-8a4a-8758716d02d9",
    "end_event_id": null,
    "start_event_id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
    "expected_persistent_rotors": "absent"
  }
}

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],
  "illumination": "Acquisition log (LED trigger channel, provisional interpretation):
illumination on over frames 400-4977 of the analysed frames 400-8867.",
  "frame_rate_hz": 1000.0,
  "frame_rate_source": {
    "ref": "10.1371/journal.pcbi.1011660",
    "kind": "publication",
    "note": "Camera frames are 64 x 64 in the paper; the deposit is 64 x 55 (cropped).
Consistent with the DAQ: 10 samples per frame and a 5 s light pulse spanning 50,001 samples
imply a 10 kHz DAQ.",
    "quote": " 775 \u00b1 70nm bandpass filter (FF01\u2013140-25, Semrock) and finally
by the camera (EMCCD, Cascade 128+, Photometrics) with a spatial resolution of 64 \u00d7 64
pixels (133 \u00b1cm per pixel) at 1 kHz. Optical Mapping recordings were acquired with
software MultiRecorder and analysed with software PythonAnalyser (both developed by Research
Group Biomedical Physics). Electrical s",
    "section": "Materials and methods: Optical mapping experiments on ventricular
arrhythmia and its termination in the intact mouse heart"
  },
  "segment_cycles_frames": {
    "light_off": 432,
    "illuminated_arrhythmia": 64,
    "illuminated_after_termination": 452
  }
},
"lowpass": null,
"polarity": -1,
"tracking": {
  "link_px": 4.0,
  "max_gap": 5,
  "min_cycles": 1.0,
  "min_frames": 64,
  "paired_frac": 0.5,
  "pair_dist_px": 3.0
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"pad_frames": 400,
"phase_method": "angle of scipy.signal.hilbert along time, on spatially filtered signal",
"spatial_sigma": 1.0,
"rotor_erode_px": 3,
"spatial_method": "scipy.ndimage.gaussian_filter per frame, mode=reflect; NaN set to 0
before filtering, non-tissue zeroed after",
"baseline_frames": 641,
"baseline_method": "scipy.ndimage.uniform_filter1d, mode=reflect, subtracted per pixel",
"polarity_method": "sign of median per-pixel skew of dV/dt on baseline-corrected signal",
"rotor_threshold": 0.9,
"spatial_truncate": 4.0,
"spatial_applies_to": "phase/activation only; displayed voltage is baseline-corrected
only"
},
"criteria_status": {
  "note": null,
  "rules": [
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      "id": "protocol_parameter_set",
      "expert": "optical mapping analyst",

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    "status": "provisional",
    "values": {
        "set_by": "developer (not a domain scientist)",
        "protocol": "Mouse whole heart optical mapping (Luther lab)",
        "protocol_id": "f65d786f-f194-4be2-88b8-10d3dd25d674",
        "params_version": 2
    },
    "decision": null,
    "location": "worker/voltage/protocol_params.py (developer_defaults, set_params)",
    "reviewed": false,
    "reviewer": null,
    "description": "Each protocol's fixed, versioned analysis parameters (version 1 =
developer defaults); no run or agent may deviate",
    "reviewed_at": null
},
{
    "id": "filter_defaults",
    "expert": "optical mapping analyst (cardiac electrophysiology)",
    "status": "provisional",
    "values": {
        "lowpass": null,
        "spatial_sigma": 1.0,
        "baseline_frames": 641,
        "spatial_truncate": 4.0
    },
    "decision": null,
    "location": "worker/voltage/preprocess.py (Params)",
    "reviewed": false,
    "reviewer": null,
    "description": "Default baseline window (frames) and spatial Gaussian sigma/truncate
for phase",
    "reviewed_at": null
},
{
    "id": "tissue_mask",
    "expert": "optical mapping analyst",
    "status": "provisional",
    "values": {
        "rule": "not NaN in frame 0 and nonzero std",
        "tissue_pixels": 2332
    },
    "decision": null,
    "location": "worker/voltage/io.py (tissue_mask)",
    "reviewed": false,
    "reviewer": null,
    "description": "Tissue = not NaN in frame 0 and nonzero temporal std",
    "reviewed_at": null
},
{
    "id": "polarity",
    "expert": "optical mapping analyst / voltage dye chemist",
    "status": "provisional",
    "values": {
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    "result": -1
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  "decision": null,
  "location": "worker/voltage/preprocess.py (polarity)",
  "reviewed": false,
  "reviewer": null,
  "description": "Dye polarity from sign of median per-pixel skew of dV/dt",
  "reviewed_at": null
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  "id": "singularity_detection",
  "expert": "computational cardiac electrophysiologist (phase mapping)",
  "status": "provisional",
  "values": {
    "rotor_erode_px": 3,
    "rotor_threshold": 0.9
  },
  "decision": null,
  "location": "worker/voltage/preprocess.py (Params.rotor_threshold, rotor_erode_px)",
  "reviewed": false,
  "reviewer": null,
  "description": "Phase singularity = |winding| > threshold turns, >= erode px from
tissue edge",
  "reviewed_at": null
},
{
  "id": "rotor_persistence",
  "expert": "computational cardiac electrophysiologist (phase mapping)",
  "status": "provisional",
  "values": {
    "link_px": 4.0,
    "max_gap": 5,
    "min_cycles": 1.0,
    "min_frames": 64
  },
  "decision": null,
  "location": "worker/voltage/rotors.py (TrackParams)",
  "reviewed": false,
  "reviewer": null,
  "description": "Track linking distance/gap and minimum lifetime for a persistent
rotor",
  "reviewed_at": null
},
{
  "id": "chirality_pairing",
  "expert": "computational cardiac electrophysiologist (phase mapping)",
  "status": "provisional",
  "values": {
    "paired_frac": 0.5,
    "pair_dist_px": 3.0
  },
  "decision": null,
  "location": "worker/voltage/rotors.py (TrackParams.pair_dist_px, paired_frac)",
  "reviewed": false,

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    "reviewer": null,
    "description": "Opposite-charge singularities within pair distance are a pair; tracks
paired most of their life are excluded from rotors",
    "reviewed_at": null
  },
  {
    "id": "sensitivity_grid",
    "expert": "optical mapping analyst",
    "status": "provisional",
    "values": {
      "sigmas": {
        "light": 0.5,
        "default": 1.0,
        "heavier": 2.0
      },
      "trackers": {
        "loose": [
          6.0,
          10
        ],
        "strict": [
          2.0,
          1
        ],
        "default": [
          4.0,
          5
        ]
      },
      "baselines": {
        "run": 641,
        "3x_cycle": 1356,
        "6x_cycle": 2712,
        "1.5x_cycle": 678
      }
    },
    "decision": null,
    "location": "worker/voltage/sensitivity.py (SIGMAS, BASELINE_MULTIPLES,
baseline_levels)",
    "reviewed": false,
    "reviewer": null,
    "description": "Filter levels tested: spatial sigma and baseline window values",
    "reviewed_at": null
  },
  {
    "id": "analysis_window",
    "expert": "cardiac electrophysiologist familiar with the dataset",
    "status": "provisional",
    "values": {
      "f0": 400,
      "f1": 8867
    },
    "decision": null,
    "location": "worker/voltage/runs.py (default_window)",

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    "reviewed": false,
    "reviewer": null,
    "description": "Frames analysed: whole recording minus one filter pad at each end
(unless the plan narrows it)",
    "reviewed_at": null
  },
  {
    "id": "prior_processing_flags",
    "expert": "imaging scientist (camera acquisition and noise)",
    "status": "provisional",
    "values": {
      "flags": [
        "negative_values",
        "non_integer",
        "nan_mask_all_frames",
        "temporal_smoothing",
        "spatial_smoothing"
      ],
      "thresholds": {
        "int_frac": 0.5,
        "neg_frac": 0.01,
        "dv_autocorr": 0.5,
        "neighbour_corr": 0.8
      }
    },
    "decision": null,
    "location": "worker/voltage/inspect.py (prior_processing)",
    "reviewed": false,
    "reviewer": null,
    "description": "Thresholds for flagging depositor processing (normalization, masking,
temporal/spatial smoothing)",
    "reviewed_at": null
  },
  {
    "id": "baseline_step_detection",
    "expert": "optical mapping experimentalist",
    "status": "provisional",
    "values": {
      "frames": [
        3170
      ]
    },
    "decision": null,
    "location": "worker/voltage/events.py (detect_baseline_step)",
    "reviewed": false,
    "reviewer": null,
    "description": "Baseline step = consensus upward step in tissue-mean raw baseline
(cause not inferred; first misread as light onset, contradicted by the DAQ)",
    "reviewed_at": null
  },
  {
    "id": "daq_interpretation",
    "expert": "experimentalist who recorded the data (or the depositor)",
    "status": "provisional",

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"values": {
  "events": [
    "illumination_on@0",
    "arrhythmia_termination@3153",
    "illumination_off@4977"
  ]
},
"decision": null,
"location": "worker/voltage/daq.py",
"reviewed": false,
"reviewer": null,
"description": "DAQ channel names from depositor notebook; frames = first N triggers of
closest burst; midpoint thresholds",
"reviewed_at": null
},
{
  "id": "segment_definitions",
  "expert": "cardiac electrophysiologist (ideally the depositing authors)",
  "status": "provisional",
  "values": {
    "light_off": [
      4977,
      9267
    ],
    "illuminated_arrhythmia": [
      0,
      3170
    ],
    "illuminated_after_termination": [
      3170,
      4977
    ]
  },
  "decision": null,
  "location": "worker/voltage/annotations.py (MOUSE_SEGMENTS)",
  "reviewed": false,
  "reviewer": null,
  "description": "Mouse segments bounded by DAQ light events and the baseline step,
interpreted as spiral termination under illumination (project lead, from Hussaini et al.
2023)",
  "reviewed_at": null
},
{
  "id": "rotor_finding_criterion",
  "expert": "cardiac electrophysiologist + biostatistician",
  "status": "provisional",
  "values": {
    "min_frac": 0.1,
    "min_ratio": 2.0
  },
  "decision": null,
  "location": "worker/voltage/sensitivity.py (MIN_FRAC, MIN_RATIO)",
  "reviewed": false,
  "reviewer": null,

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    "description": "Singularity before/after finding holds if frac(before) >= min_frac and
    >= min_ratio x frac(after) at every setting (also kept, superseded, for persistent rotors)",
    "reviewed_at": null
  },
  {
    "id": "persistent_rotor_criterion",
    "expert": "cardiac electrophysiologist",
    "status": "provisional",
    "values": {
      "expect": {
        "light_off": "absent",
        "illuminated_arrhythmia": "present",
        "illuminated_after_termination": "absent"
      },
      "max_absent": 0,
      "min_present": 1,
      "spanning_rotor": "counts in every segment it overlaps",
      "min_lifetime_frames": 64
    },
    "decision": null,
    "location": "worker/voltage/sensitivity.py (MIN_ROTORS_PRESENT, MAX_ROTORS_ABSENT)",
    "reviewed": false,
    "reviewer": null,
    "description": "Persistent-rotor finding holds if every 'present' segment has >= 1
    persistent rotor and every 'absent' segment has none, at every setting",
    "reviewed_at": null
  },
  {
    "id": "pipeline_check",
    "expert": "optical mapping analyst",
    "status": "provisional",
    "values": {
      "model": "openai:gpt-5.5",
      "proceed": true,
      "anomalies": [
        "Pre-deposit processing / raw-data label",
        "Event interpretation at frame 3170",
        "Baseline and illumination artifact",
        "Baseline window versus post-termination rhythm"
      ],
      "mismatches": []
    },
    "decision": null,
    "location": "worker/agents/pipeline.py (INSTRUCTIONS, validator)",
    "reviewed": false,
    "reviewer": null,
    "description": "The pipeline agent's hold/proceed decision from protocol mismatches and
    inspector anomalies; it chooses no parameter",
    "reviewed_at": null
  },
  {
    "id": "physiology_reference_rates",
    "expert": "cardiac electrophysiologist per species",
    "status": "provisional",

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"values": {
  "ranges": [
    "mouse_spiral_rotation_hz"
  ],
  "tolerance_frac": 0.25,
  "segment_rhythm_rule": "expected persistent rotors 'present' -> spiral arrhythmia"
},
"decision": null,
"location": "worker/voltage/physiology.py (RANGES, TOLERANCE_FRAC)",
"reviewed": false,
"reviewer": null,
"description": "Cited physiological ranges (single-study values widened by a 25%
tolerance), applied to segments by their expected rhythm; used by the critic and for frame-
rate sanity checks",
"reviewed_at": null
},
{
  "id": "stability_rule",
  "expert": "biostatistician + optical mapping analyst",
  "status": "provisional",
  "values": {
    "unstable": [
      "light_off.singularity_frames_frac",
      "light_off.dominant_freq_hz",
      "illuminated_arrhythmia.persistent_rotors",
      "illuminated_arrhythmia.persistent_rotor_count_max",
      "illuminated_after_termination.singularity_frames_frac",
      "persistent_rotor_tracks"
    ],
    "stable_frac": 0.25
  },
  "decision": null,
  "location": "worker/agents/critic.py (STABLE_FRAC, stability)",
  "reviewed": false,
  "reviewer": null,
  "description": "A metric is reportable only if its spread across all sensitivity
settings is <= 25% of its median (zero spread when all values are 0); otherwise 'unstable,
not reportable'",
  "reviewed_at": null
},
{
  "id": "persistence_threshold_variants",
  "expert": "computational cardiac electrophysiologist (phase mapping)",
  "status": "provisional",
  "values": {
    "measured_cycle": 64,
    "paper_rotation": 50
  },
  "decision": null,
  "location": "worker/agents/critic.py (persistence_variants)",
  "reviewed": false,
  "reviewer": null,
  "description": "The persistent-rotor rule is run at two lifetimes, one measured cycle
of the fastest segment and the paper's cited rotation period; both verdicts stored,

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disagreement flagged",
  "reviewed_at": null
}
],
"status": "provisional",
"all_reviewed": false,
"superseded_by_run": null
}
},
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{
  "id": "f6ca0bce-f7e9-437d-84b6-1bb1b24f80ba",
  "position": 1,
  "name": "illuminated_arrhythmia",
  "label": "illumination with arrhythmia",
  "start_frame": 0,
  "end_frame": 3170,
  "expected_persistent_rotors": "present",
  "definition": "from recording start to spiral termination (interpreted; under
illumination)",
  "defined_by": "project lead (not a domain scientist), following the paper's design",
  "citation": {
    "ref": "10.1371/journal.pcbi.1011660",
    "quote": "t stimulus with LI = 3.44  $\mu\text{W}/\text{mm}^2$  and PL = 5 s. Fig 2C shows a monophasic
action potential (MAP) signal (in black) before, during, and after illumination. It shows
the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer look at the
MAP signal of the heart during the last few rotations of arrhythmia and the first few action
potentials of sinus rhythm. Fig 2E illustrates a"
  },
  "evidence": {
    "end": {
      "kind": "baseline_step",
      "frame": 3170,
      "label": "spiral termination (interpreted; under illumination)",
      "source": "image",
      "event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
      "evidence": {
        "step": 1.7134565711021423,
        "per_window": [
          {
            "z": 7.62002552466645,
            "step": 1.6427573561668396,
            "frame": 3170,
            "window": 101
          },
          {
            "z": 7.940594943178843,
            "step": 1.7134565711021423,
            "frame": 3154,
            "window": 151
          },
          {
            "z": 7.899171431654551,
            "step": 1.732661247253418,

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    "frame": 3186,
    "window": 201
  }
],
"pre_window": [
  2870,
  3120
],
"post_window": [
  3220,
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],
"baseline_pre": -0.5335609912872314,
"baseline_post": 1.2153877019882202,
"interpretation": "mean fluorescence changed; cause not determined from the image",
"beat_amplitude_p5_p95": 1.4402662966400377
},
"uncertainty_frames": 17
},
"start": {
  "illumination": {
    "timing": "before_first_frame",
    "daq_sample": 53144,
    "led_level_after": 0.0784302,
    "led_level_before": -0.000305176,
    "photodiode_after": 0.0177002,
    "photodiode_agrees": true,
    "photodiode_before": 0.015564,
    "frames_before_first_frame": 23.0
  }
}
},
"provisional": true
},
{
  "id": "c1444c59-1863-45aa-b6f3-2208392bf55a",
  "position": 2,
  "name": "illuminated_after_termination",
  "label": "illumination after termination",
  "start_frame": 3170,
  "end_frame": 4977,
  "expected_persistent_rotors": "absent",
  "definition": "from spiral termination (interpreted; under illumination) to
illumination_off",
  "defined_by": "project lead (not a domain scientist), following the paper's design",
  "citation": {
    "ref": "10.1371/journal.pcbi.1011660",
    "quote": "t stimulus with LI = 3.44  $\mu$ W/mm2 and PL = 5 s. Fig 2C shows a monophasic
action potential (MAP) signal (in black) before, during, and after illumination. It shows
the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer look at the
MAP signal of the heart during the last few rotations of arrhythmia and the first few action
potentials of sinus rhythm. Fig 2E illustrates a"
  },
  "evidence": {

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"end": {
  "kind": "illumination_off",
  "frame": 4977,
  "label": null,
  "source": "acquisition_log",
  "event_id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
  "evidence": {
    "timing": "during_recording",
    "daq_sample": 103145,
    "led_level_after": -0.000610352,
    "led_level_before": 0.0784302,
    "photodiode_after": 0.015564,
    "photodiode_agrees": true,
    "photodiode_before": 0.0177002
  },
  "uncertainty_frames": 11
},
"start": {
  "kind": "baseline_step",
  "frame": 3170,
  "label": "spiral termination (interpreted; under illumination)",
  "source": "image",
  "event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
  "evidence": {
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    "per_window": [
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        "step": 1.6427573561668396,
        "frame": 3170,
        "window": 101
      },
      {
        "z": 7.940594943178843,
        "step": 1.7134565711021423,
        "frame": 3154,
        "window": 151
      },
      {
        "z": 7.899171431654551,
        "step": 1.732661247253418,
        "frame": 3186,
        "window": 201
      }
    ],
    "pre_window": [
      2870,
      3120
    ],
    "post_window": [
      3220,
      3470
    ],
    "baseline_pre": -0.5335609912872314,
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```

    "baseline_post": 1.2153877019882202,
    "interpretation": "mean fluorescence changed; cause not determined from the image",
    "beat_amplitude_p5_p95": 1.4402662966400377
  },
  "uncertainty_frames": 17
}
},
"provisional": true
},
{
  "id": "4eedfd6-84c2-40d3-8a4a-8758716d02d9",
  "position": 3,
  "name": "light_off",
  "label": "light off",
  "start_frame": 4977,
  "end_frame": 9267,
  "expected_persistent_rotors": "absent",
  "definition": "from illumination_off to recording end",
  "defined_by": "project lead (not a domain scientist), following the paper's design",
  "citation": {
    "ref": "10.1371/journal.pcbi.1011660",
    "quote": "t stimulus with LI = 3.44  $\mu\text{W}/\text{mm}^2$  and PL = 5 s. Fig 2C shows a monophasic action potential (MAP) signal (in black) before, during, and after illumination. It shows the sinus rhythm returns after 3190 ms of illumination. Fig 2D presents a closer look at the MAP signal of the heart during the last few rotations of arrhythmia and the first few action potentials of sinus rhythm. Fig 2E illustrates a"
  },
  "evidence": {
    "end": {
      "recording_end_frame": 9267
    },
    "start": {
      "kind": "illumination_off",
      "frame": 4977,
      "label": null,
      "source": "acquisition_log",
      "event_id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
      "evidence": {
        "timing": "during_recording",
        "daq_sample": 103145,
        "led_level_after": -0.000610352,
        "led_level_before": 0.0784302,
        "photodiode_after": 0.015564,
        "photodiode_agrees": true,
        "photodiode_before": 0.0177002
      },
      "uncertainty_frames": 11
    }
  },
  "provisional": true
}
],
"events": [
  {

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    "id": "e73142c8-f562-4714-9ace-dce759d293d9",
    "kind": "illumination_on",
    "frame": 0,
    "label": null,
    "source": "acquisition_log",
    "status": "detected",
    "uncertainty_frames": 11,
    "method": "midpoint threshold on DAQ channel 'led_trigger', mapped to frames via camera
triggers"
  },
  {
    "id": "bac2afbc-81b8-4d0e-9a26-7bee170f9239",
    "kind": "arrhythmia_termination",
    "frame": 24,
    "label": null,
    "source": "acquisition_log",
    "status": "superseded",
    "uncertainty_frames": 11,
    "method": "last activation on DAQ channel 'ecg' (MAP) followed by an interval > 2x the
arrhythmic interval; mapped to frames via camera triggers"
  },
  {
    "id": "d2476777-3e2a-4c5e-a20b-b858a7527678",
    "kind": "arrhythmia_termination",
    "frame": 3153,
    "label": null,
    "source": "acquisition_log",
    "status": "superseded",
    "uncertainty_frames": 11,
    "method": "last activation on DAQ channel 'ecg' (MAP) followed by an interval > 2x the
arrhythmic interval; mapped to frames via camera triggers"
  },
  {
    "id": "e39f76de-baaa-42c1-be7a-6852665b65a2",
    "kind": "arrhythmia_termination",
    "frame": 3153,
    "label": null,
    "source": "acquisition_log",
    "status": "detected",
    "uncertainty_frames": 11,
    "method": "last activation on DAQ channel 'ecg' (MAP) followed by an interval > 2x the
arrhythmic interval; mapped to frames via camera triggers"
  },
  {
    "id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
    "kind": "baseline_step",
    "frame": 3170,
    "label": "spiral termination (interpreted; under illumination)",
    "source": "image",
    "status": "detected",
    "uncertainty_frames": 17,
    "method": "consensus upward step in running-median baseline of tissue-mean raw signal"
  },
  {

```

```
    "id": "42ba71e2-c2c4-4833-abc2-467506ec90a1",
    "kind": "illumination_on",
    "frame": 3170,
    "label": null,
    "source": "image",
    "status": "contradicted",
    "uncertainty_frames": 17,
    "method": "consensus upward step in running-median baseline of tissue-mean raw signal"
  },
  {
    "id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
    "kind": "illumination_off",
    "frame": 4977,
    "label": null,
    "source": "acquisition_log",
    "status": "detected",
    "uncertainty_frames": 11,
    "method": "midpoint threshold on DAQ channel 'led_trigger', mapped to frames via camera
triggers"
  }
]
```