

M13Rec001, signature 9b40a32d

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

339921d8-9255-4d78-9789-6816dd8b409c, 2026-10-28 18:40 UTC to 2026-10-28 18:48 UTC, status done. Protocol Mouse whole heart optical mapping (Luther lab), parameters v3 set by developer (not a domain scientist). Code 008c2dc076bcebf9e7fa01a05e8b7c4b5a713b37 (uncommitted changes), 9 workers.

Methods

For recording 55cb4aa3-6502-45a6-a14c-85cb676fe8c3 under protocol f65d786f-f194-4be2-88b8-10d3dd25d674, the provisional parameter set version 3 is used with baseline_frames=901, spatial_sigma=1.0, spatial_truncate=4.0, pad_frames=500, 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 is 1000 Hz from the publication, with DAQ consistency noted, and the pixel size is 133 µm from the publication. The recording has 9267 frames in a 64 by 55 npy movie; the analysed window is frames 500 to 8767. The provisional segment definitions are illuminated_arrhythmia from frames 0 to 3170, illuminated_after_termination from frames 3170 to 4977, and light_off from frames 4977 to 9267; the parameter set, the segment definitions and the criteria are provisional.

Verdict

Verdict: report only sensitivity-stable qualitative/algorithmic findings and do not report unstable metrics as single values; physiology_ok is null because the only cited range check, illuminated_arrhythmia.dominant_freq_hz, is unstable rather than physiology-validated. Stable observations include 0 persistent rotors and 0 maximum persistent-rotor count in light_off and illuminated_after_termination, dominant frequencies of 2.375 Hz in light_off and 2.214 Hz in illuminated_after_termination, and illuminated_arrhythmia singularity_frames_frac over 0.3816479400749064-0.48801498127340825, all without cited physiological ranges; unstable, not reportable as single values, are light_off.singularity_frames_frac over 0.0029023746701846965-0.02955145118733509, illuminated_arrhythmia.persistent_rotors over 4.0-15.0, illuminated_arrhythmia.persistent_rotor_count_max over 1.0-2.0, illuminated_arrhythmia.dominant_freq_hz over 15.356-19.85 Hz, illuminated_after_termination.singularity_frames_frac over 0.0005534034311012728-0.014941892639734366, and persistent_rotor_tracks over 4.0-15.0. The persistent-rotor rule holds using both the 52-frame measured-cycle threshold and the 50-frame cited 20 Hz rotation-period threshold, which agree; the relevant same-study context reports approximately 20 Hz before illumination and approximately 18.75 Hz during illumination (DOI 10.1371/journal.pcbi.1011660). Review required: pre-deposit processing/raw-data label, frame-3170 event interpretation, baseline/illumination artifact, provisional tool thresholds, and tracker sensitivity; the ranges, the stability threshold and the criteria are provisional. physiology_ok: None; send back: False. Reviewer sign-off: pending.

Parameters (as run)

```
% Mouse whole heart optical mapping (Luther lab), v3, read-only
% set by developer (not a domain scientist); provisional, REVIEW_NEEDED 16
baseline_frames = 901;      % >= 2 x slowest cycle (415, MAP): ok
pad_frames      = 500;      % 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 = 52
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	500-3,170	52 (n = 53)	present	LED on before frame 0 (DAQ) → termination step (image, ±17 frames)
Illumination after termination	3,170-4,977	3,170-4,977	415 (n = 4)	absent	termination step (image, ±17 frames) → illumination off (DAQ, ±11 frames)
Light off	4,977-9,267	4,977-8,767	411 (n = 10)	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	15.356-19.850 (unstable)	2.214	2.375	18.75-20 Hz, one recording provisional
Rotors					
Persistent rotors	count	4-15 (unstable)	0	0	none cited
Max concurrent persistent rotors	count	1-2 (unstable)	0	0	none cited
Frames with a singularity	fraction	0.479	0.001-0.015 (unstable)	0.003-0.030 (unstable)	none cited
Beats, where a global rhythm exists					
Beats	count	57	4	9	none cited
Global amplitude ratio	ratio	0.72	0.95	0.95	gate ≥ 0.30 provisional
APD50	ms	14	16	16	none cited
APD90	ms	25	76	75	none cited
Conduction velocity	cm/s	31.3	58.5	60.0	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 ≥ 52 frames (measured cycle) and ≥ 50 frames (cited agree (provisional) 20 Hz)	
persistent rotor tracks	all	4–15 count, unstable, not reportable
dominant freq (Hz)	light off	2.375 Hz, no cited range
persistent rotors	light off	0 count, no cited range
singularity frames fraction	light off	0.0029–0.0296 fraction of frames, unstable, not reportable
persistent rotor count max	light off	0 count, no cited range
dominant freq (Hz)	illuminated arrhythmia	15.4–19.9 Hz, unstable, not reportable
persistent rotors	illuminated arrhythmia	4–15 count, unstable, not reportable
dominant freq (Hz)	illuminated after termination	2.214 Hz, no cited range
singularity frames fraction	illuminated arrhythmia	0.479 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	0.000553–0.0149 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
baseline_window_rule worker/voltage/baseline_rule.py (FACTOR, evaluate)	A run proceeds only if the protocol's baseline window is $\geq 2 \times$ the slowest segment's cycle, the cycle from the MAP channel when a DAQ log exists, else from per-pixel dominant frequency on linearly detrended pixels; otherwise the run is held by code	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 = $ \text{winding} > \text{threshold turns}$, $\geq$ 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

Provisional rules behind this signature

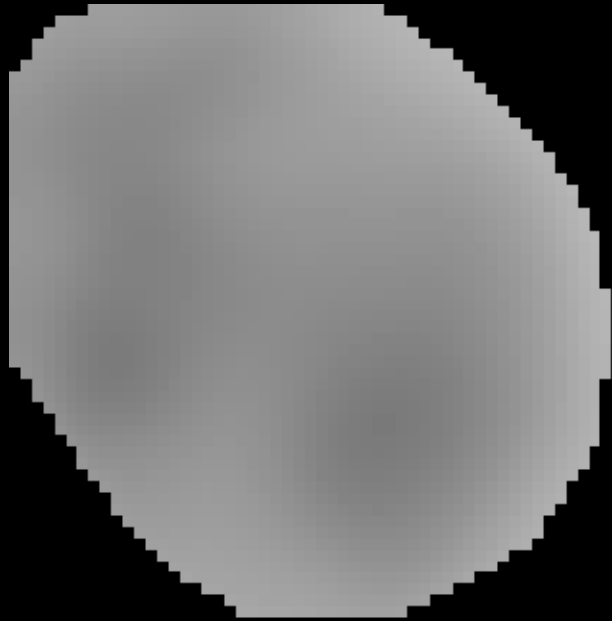
Rule	Description	Expert	Status
daq_interpretation worker/voltage/daq.py	DAQ channel names from depositor notebook; frames = first N triggers of closest burst; midpoint thresholds	experimentalist who recorded the data (or the depositor)	provisional
segment_definitions worker/voltage/annotations.py (MOUSE_SEGMENTS)	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

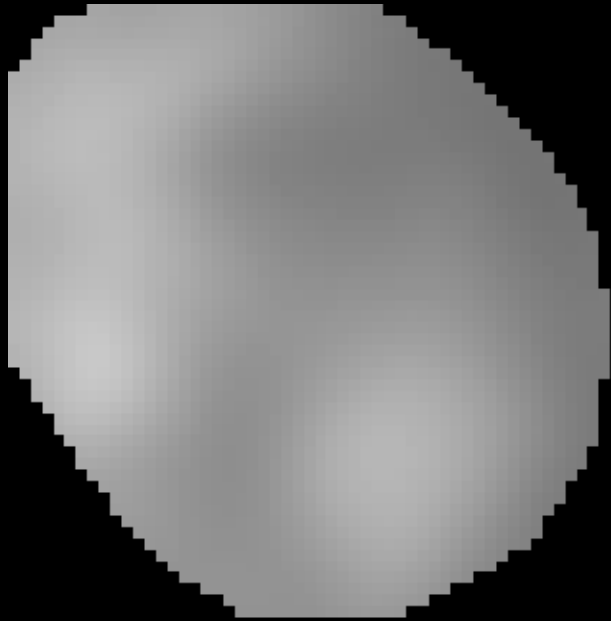
Topic	Detail	Severity
unstable:light_off.singularity_frames_frac	This metric varies over 0.0029023746701846965–0.02955145118733509 across the filter grid and should not be reported as a single value.	warn
unstable:illuminated_arrhythmia.persistent_rotors	This metric varies over 4.0–15.0 across filter and tracker settings and should not be reported as a single count.	warn
unstable:illuminated_arrhythmia.persistent_rotor_count_max	This metric varies over 1.0–2.0 across filter and tracker settings and should not be reported as a single maximum concurrent count.	warn
unstable:illuminated_arrhythmia.dominant_freq_hz	This metric varies over 15.356–19.85 Hz across baseline-window settings; frequency interpretation should be reviewed against the same-study cited rotation context.	warn
unstable:illuminated_after_termination.singularity_frames_frac	This metric varies over 0.0005534034311012728–0.014941892639734366 across the filter grid and should not be reported as a single value.	warn
unstable:persistent_rotor_tracks	This metric varies over 4.0–15.0 across filter and tracker settings and should not be reported as a single total track count.	warn
Pre-deposit processing / raw-data label	The recording is labeled as raw experimental data, but documentation and measurements indicate masking, spatial smoothing, temporal smoothing, and normalization; do not treat it as raw camera photon counts for analyses that require raw data or independent pixel noise.	warn
Event interpretation at frame 3170	Frame 3170 is a baseline_step only; illumination began before frame 0 and ended at frame 4977, so the stored spiral-termination interpretation is provisional and should not be treated as direct light onset evidence.	warn
Baseline and illumination artifact	The publication reports stimulation-light crosstalk and re-normalization; the recording also has a large slow baseline range and a baseline step, so absolute baseline or amplitude analyses need artifact review.	warn
Provisional tool thresholds	Event detection, processing flags, SNR, rhythm, reference-rate thresholds, stability threshold, and criteria are provisional and should be checked for critical uses.	info
tracker sensitivity of rotor counts	The persistent-rotor rule agrees across strict, default, and loose trackers, but the illuminated-arrhythmia counts differ across trackers, so report the qualitative rule result rather than a single count.	warn

Mouse heart, spiral wave and optogenetic termination (M13Rec001)

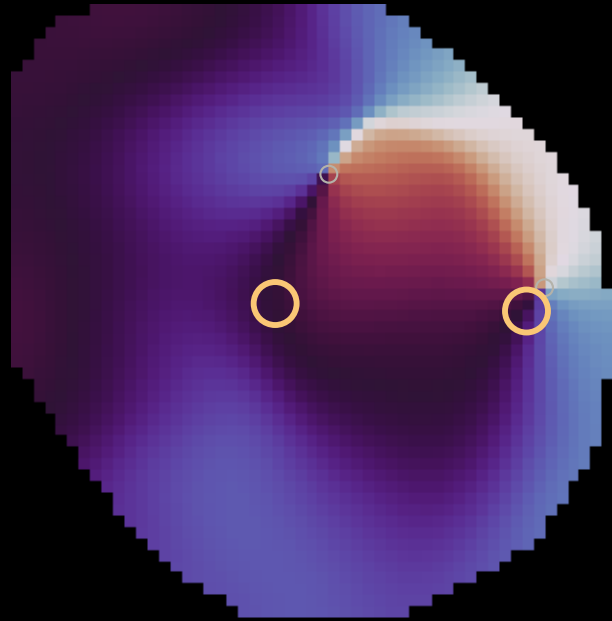
camera: frame as deposited



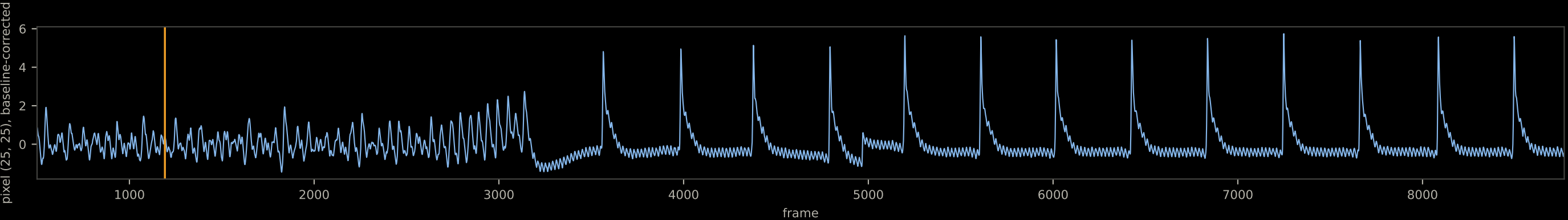
voltage: baseline-corrected only



phase: singularities (small), persistent rotors (ring)



frame 1192



Data: Public reference recording, Hussaini, Luther, Lädke (MPI Göttingen), CC-BY 4.0. doi:10.5281/zenodo.10228296. 64x55 px, 9267 frames; shown 500-8767 every 1. Frame rate: 1000 Hz.
Camera: values as deposited (may include the depositor's processing), linear gray -6.04 to 3.6, NaN black; nothing subtracted or filtered by us.
Voltage: baseline-corrected only (901-frame centered moving average subtracted), polarity x-1, no spatial filter, gray +/-2.93 (99th pct |V|).
Phase: Hilbert, on spatial Gaussian sigma=1.0 px (truncate 4.0) of the voltage signal, 500-frame pad. Singularity (small circle): |winding| > 0.9 turns, >= 3 px from tissue edge. Persistent rotor (large ring): tracked same-charge singularity lasting >= one cycle, not mostly in a close opposite-charge pair. Thresholds provisional.
Temporal low-pass: none. Display: native pixels, nearest-neighbour, no interpolation or boundary smoothing.
Opening frame 1192: display choice: frame with the most concurrent persistent rotors (2) in illumination with arrhythmia, midpoint of the longest such stretch.

Provenance

```
{
  "recording": {
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    "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",
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      "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,
```

```

    "height": 64,
    "width": 55,
    "inverted": true
  },
  "protocol": {
    "id": "f65d786f-f194-4be2-88b8-10d3dd25d674",
    "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": {
    "id": "339921d8-9255-4d78-9789-6816dd8b409c",
    "status": "done",
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    "finished_at": "2026-10-28T18:48:26.342209+00:00",
    "code": {
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    "track_and_pair",
    "beats_apd_cv",
    "sensitivity",
    "render"
  ],
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      "max_gap": 5,
      "min_cycles": 1.0,
      "pad_frames": 500,
      "paired_frac": 0.5,
      "render_step": 4,
      "pair_dist_px": 3.0,
      "spatial_sigma": 1.0,
      "rotor_erode_px": 3,
      "baseline_frames": 901,
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      "spatial_truncate": 4.0
    },
  },

```

```

"version": 3,
"protocol_id": "f65d786f-f194-4be2-88b8-10d3dd25d674"
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    },
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      "cycle_frames": 52,
      "n_activations": 53,
      "polarity_used": -1,
      "median_interval_ms": 52.25
    },
    "illuminated_after_termination": {
      "cycle_frames": 415,
      "n_activations": 4,
      "polarity_used": -1,
      "median_interval_ms": 415.0
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  },
  "factor": 2.0,
  "reason": null,
  "source": "MAP channel (DAQ log)",
  "status": "provisional",
  "daq_file": "0111210010.txt",
  "baseline_frames": 901,
  "slowest_segment": "illuminated_after_termination",
  "required_min_frames": 830,
  "slowest_cycle_frames": 415
},
"deposit_checks": {
  "flags": [
    {
      "flag": "negative_values",
      "value": 0.3231635934819897,
      "suggests": "baseline-subtracted or normalized; raw fluorescence counts are non-negative",
      "threshold": 0.01
    },
    {
      "flag": "non_integer",
      "value": 0.0,
      "suggests": "not raw camera counts (camera output is integer); weak alone",
      "threshold": 0.5
    },
    {
      "flag": "nan_mask_all_frames",
      "value": 1188,

```

```

    "suggests": "tissue masked by depositor; the mask is theirs"
  },
  {
    "flag": "temporal_smoothing",
    "value": 0.9120054707808141,
    "suggests": "temporally low-pass filtered (white shot noise gives dV lag-1 autocorr
near -0.5)",
    "threshold": 0.5
  },
  {
    "flag": "spatial_smoothing",
    "value": 0.9957938301611564,
    "suggests": "spatially filtered or binned (shot noise is independent between pixels)",
    "threshold": 0.8
  }
],
"status": "provisional",
"measures": {
  "max": 4.49806547164917,
  "min": -6.050762176513672,
  "frames_used": 2000,
  "integer_frac": 0.0,
  "negative_frac": 0.3231635934819897,
  "frames_with_nan": 9267,
  "dv_lag1_autocorr_median": 0.9120054707808141,
  "neighbour_dv_corr_median": 0.9957938301611564
},
"processed_before_deposit": true
},
"pipeline_check": {
  "model": "openai:gpt-5.5",
  "proceed": true,
  "anomalies": [
    {
      "topic": "Pre-deposit processing / raw-data label",
      "severity": "warn",
      "effect_on_analysis": "The deposited movie should not be treated as raw camera counts:
documented and measured masking, temporal smoothing, spatial smoothing, and normalization
mean that the protocol's Gaussian phase smoothing is added on top of prior filtering of
unknown total strength, and analyses depending on raw photon noise or independent pixel
noise would be misleading."
    },
    {
      "topic": "Event interpretation at frame 3170",
      "severity": "warn",
      "effect_on_analysis": "The segment boundary at frame 3170 is a provisional fluorescence
step/rhythm-change interpretation, not a directly measured light-on event. The fixed
segments can be analysed, but labels involving spiral termination should be read as
provisional and not as a direct measurement of illumination onset."
    },
    {
      "topic": "Baseline and illumination artifact",
      "severity": "info",
      "effect_on_analysis": "Blue-light crosstalk, re-normalization to the stimulation light

```

signal, and a large slow signal range/step can affect absolute fluorescence level and amplitude measures. The protocol's high-pass handling can be applied, but amplitude or fluorescence-level interpretations remain confounded by illumination/crosstalk/normalization effects."

```
    },
    {
      "topic": "Baseline-window rule",
      "severity": "info",
      "effect_on_analysis": "The coded rule passed: baseline_frames 901 is at least 2.0 times
the slowest segment cycle from the MAP channel, with slowest_segment
illuminated_after_termination, slowest_cycle_frames 415, required_min_frames 830, and ratio
2.171. This is reported as code status only and is not a separate reason to hold the run."
    }
  ],
  "rationale": "The recording may be analysed under the fixed Mouse whole heart optical
mapping protocol, parameter set version 3, because the available facts match the protocol
context: mouse whole heart optical mapping from the Luther-lab public reference recording,
with the recording frame rate established as 1000 Hz from the publication and DAQ
consistency, and pixel size 133 \u00b5m from the publication. No fact mismatch indicates
that the fixed frame-count or pixel-based parameters would be wrong for this recording.
However, the deposited data are processed rather than raw, the frame-3170 event and segment
labels are provisional, and illumination/crosstalk/normalization effects can confound
fluorescence-level and amplitude interpretation, so these warnings must accompany any
analysis.",
  "mismatches": [],
  "hold_reason": null,
  "protocol_id": "f65d786f-f194-4be2-88b8-10d3dd25d674",
  "methods_text": "For recording 55cb4aa3-6502-45a6-a14c-85cb676fe8c3 under protocol
f65d786f-f194-4be2-88b8-10d3dd25d674, the provisional parameter set version 3 is used with
baseline_frames=901, spatial_sigma=1.0, spatial_truncate=4.0, pad_frames=500,
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 is 1000 Hz from the
publication, with DAQ consistency noted, and the pixel size is 133 \u00b5m from the
publication. The recording has 9267 frames in a 64 by 55 npy movie; the analysed window is
frames 500 to 8767. The provisional segment definitions are illuminated_arrhythmia from
frames 0 to 3170, illuminated_after_termination from frames 3170 to 4977, and light_off from
frames 4977 to 9267; the parameter set, the segment definitions and the criteria are
provisional.",
  "recording_id": "55cb4aa3-6502-45a6-a14c-85cb676fe8c3",
  "params_version": 3,
  "prompt_version": "pipeline-v2"
},
"signature": {
  "id": "9b40a32d-d6e2-4d0d-9976-9137ed881bea",
  "created_at": "2026-10-28T18:47:37.807945+00:00",
  "movie_path": "runs/339921d8-9255-4d78-9789-6816dd8b409c/movie.mp4",
  "frames": {
    "f0": 500,
    "f1": 8767,
    "maps": "runs/339921d8-9255-4d78-9789-6816dd8b409c/frames/maps.npz",
    "dtype": "<f4",
    "phase": "runs/339921d8-9255-4d78-9789-6816dd8b409c/frames/phase.npy",
    "shape": [
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8267,
64,
55
],
"sha256": {
  "maps": "9982b72c2c9fd56f09a13d3db6a803e2b3c3eda5456cad070ea92dc38af675df",
  "phase": "7be44c8e09b68bd5a4ac810d79532c50cb8867226eb276ab970483c00839077c",
  "voltage": "5dabf0aed0a41315e6ecaaeeb78f0f5c252d12e6ae28aa55e9dc137ff561f8c3"
},
"voltage": "runs/339921d8-9255-4d78-9789-6816dd8b409c/frames/voltage.npy",
"map_keys": [
  "activation:illuminated_arrhythmia",
  "dominant_frequency:illuminated_arrhythmia",
  "activation:illuminated_after_termination",
  "dominant_frequency:illuminated_after_termination",
  "activation:light_off",
  "dominant_frequency:light_off",
  "dominant_frequency>window"
],
"map_units": {
  "activation:light_off": "ms",
  "dominant_frequency>window": "Hz",
  "dominant_frequency:light_off": "Hz",
  "activation:illuminated_arrhythmia": "ms",
  "activation:illuminated_after_termination": "ms",
  "dominant_frequency:illuminated_arrhythmia": "Hz",
  "dominant_frequency:illuminated_after_termination": "Hz"
}
},
"filter_params": {
  "mask": "not NaN in frame 0 and nonzero temporal std",
  "render": {
    "step": 4,
    "palettes": {
      "phase": "twilight",
      "camera": "gray",
      "voltage": "gray"
    },
    "interpolation": "nearest"
  },
  "window": {
    "f0": 500,
    "f1": 8767,
    "segments": [
      {
        "name": "illuminated_arrhythmia",
        "label": "illumination with arrhythmia",
        "defined": [
          0,
          3170
        ],
        "analysed": [
          500,
          3170
        ]
      }
    ]
  }
}

```

```

],
  "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",
  "end_event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
  "start_event_id": null,
  "expected_persistent_rotors": "present"
},
{
  "name": "illuminated_after_termination",
  "label": "illumination after termination",
  "defined": [
    3170,
    4977
  ],
  "analysed": [
    3170,
    4977
  ],
  "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": "c1444c59-1863-45aa-b6f3-2208392bf55a",
  "end_event_id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
  "start_event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
  "expected_persistent_rotors": "absent"
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{
  "name": "light_off",
  "label": "light off",
  "defined": [
    4977,
    9267
  ],
  "analysed": [
    4977,
    8767
  ],
  "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"

```
    },
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    "start_event_id": "db2ad5f3-9b96-4ec1-9ccd-9c82c3425609",
    "expected_persistent_rotors": "absent"
  }
],
  "illumination": "Acquisition log (LED trigger channel, provisional interpretation):
illumination on over frames 500-4977 of the analysed frames 500-8767.",
  "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 \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"
  },
  "segment_cycles_frames": {
    "light_off": 421,
    "illuminated_arrhythmia": 52,
    "illuminated_after_termination": 452
  }
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  "lowpass": null,
  "polarity": -1,
  "tracking": {
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    "max_gap": 5,
    "min_cycles": 1.0,
    "min_frames": 52,
    "paired_frac": 0.5,
    "pair_dist_px": 3.0
  },
  "pad_frames": 500,
  "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": 901,
  "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",
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```

    "rotor_threshold": 0.9,
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    "spatial_applies_to": "phase/activation only; displayed voltage is baseline-corrected
only"
  },
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        "status": "provisional",
        "values": {
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          "protocol": "Mouse whole heart optical mapping (Luther lab)",
          "protocol_id": "f65d786f-f194-4be2-88b8-10d3dd25d674",
          "params_version": 3
        },
        "decision": null,
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        "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
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      {
        "id": "baseline_window_rule",
        "expert": "optical mapping analyst",
        "status": "provisional",
        "values": {
          "ok": true,
          "factor": 2.0,
          "source": "MAP channel (DAQ log)",
          "required_min_frames": 830,
          "slowest_cycle_frames": 415
        },
        "decision": null,
        "location": "worker/voltage/baseline_rule.py (FACTOR, evaluate)",
        "reviewed": false,
        "reviewer": null,
        "description": "A run proceeds only if the protocol's baseline window is >= 2x the
slowest segment's cycle, the cycle from the MAP channel when a DAQ log exists, else from
per-pixel dominant frequency on linearly detrended pixels; otherwise the run is held by
code",
        "reviewed_at": null
      },
      {
        "id": "filter_defaults",
        "expert": "optical mapping analyst (cardiac electrophysiology)",
        "status": "provisional",
        "values": {
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    "baseline_frames": 901,
    "spatial_truncate": 4.0
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  "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
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{
  "id": "tissue_mask",
  "expert": "optical mapping analyst",
  "status": "provisional",
  "values": {
    "rule": "not NaN in frame 0 and nonzero std",
    "tissue_pixels": 2332
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  "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": {
    "method": "median skew of dV/dt",
    "result": -1
  },
  "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

```

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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": 52
    },
    "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,
    "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
},
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    "expert": "optical mapping analyst",
    "status": "provisional",
    "values": {
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            "light": 0.5,
            "default": 1.0,
            "heavier": 2.0
        },
        "trackers": {
            "loose": [
                6.0,
                10
            ],
            "strict": [
                2.0,

```

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    1
  ],
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    4.0,
    5
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},
"baselines": {
  "run": 901,
  "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
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{
  "id": "analysis_window",
  "expert": "cardiac electrophysiologist familiar with the dataset",
  "status": "provisional",
  "values": {
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    "f1": 8767
  },
  "decision": null,
  "location": "worker/voltage/runs.py (default_window)",
  "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": {
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      "non_integer",
      "nan_mask_all_frames",
      "temporal_smoothing",
      "spatial_smoothing"
    ],
    "thresholds": {
      "int_frac": 0.5,
      "neg_frac": 0.01,
      "dv_autocorr": 0.5,

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    "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",
  "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": {
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      4977,

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    9267
  ],
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    0,
    3170
  ],
  "illuminated_after_termination": [
    3170,
    4977
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},
"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,
  "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
},
{
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  "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": 52
  },
  "decision": null,
  "location": "worker/voltage/sensitivity.py (MIN_ROTORS_PRESENT, MAX_ROTORS_ABSENT)",
  "reviewed": false,

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    "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
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{
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    "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 rule"
        ],
        "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",
    "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": [

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    "light_off.singularity_frames_frac",
    "illuminated_arrhythmia.persistent_rotors",
    "illuminated_arrhythmia.persistent_rotor_count_max",
    "illuminated_arrhythmia.dominant_freq_hz",
    "illuminated_after_termination.singularity_frames_frac",
    "persistent_rotor_tracks"
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  "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": 52,
    "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,
disagreement flagged",
  "reviewed_at": null
}
],
"status": "provisional",
"all_reviewed": false,
"superseded_by_run": null
}
},
"segments": [
{
  "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 μ 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": {

"end": {

"kind": "baseline_step",

"frame": 3170,

"label": "spiral termination (interpreted; under illumination)",

"source": "image",

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"evidence": {

"step": 1.7134565711021423,

"per_window": [

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"z": 7.62002552466645,

"step": 1.6427573561668396,

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"window": 101

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{

"z": 7.940594943178843,

"step": 1.7134565711021423,

"frame": 3154,

"window": 151

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{

"z": 7.899171431654551,

"step": 1.732661247253418,

"frame": 3186,

"window": 201

}

],

"pre_window": [

2870,

3120

],

"post_window": [

3220,

3470

],

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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

},

"start": {

"illumination": {

"timing": "before_first_frame",

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    "daq_sample": 53144,
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    "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  $\mu\text{W}/\text{mm}^2$  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": "illumination_off",
      "frame": 4977,
      "label": null,
      "source": "acquisition_log",
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      "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
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  "start": {
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    "frame": 3170,
    "label": "spiral termination (interpreted; under illumination)",
    "source": "image",

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"event_id": "46c59a51-1a01-4aed-8021-db9a63720a1d",
"evidence": {
  "step": 1.7134565711021423,
  "per_window": [
    {
      "z": 7.62002552466645,
      "step": 1.6427573561668396,
      "frame": 3170,
      "window": 101
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      "step": 1.7134565711021423,
      "frame": 3154,
      "window": 151
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      "z": 7.899171431654551,
      "step": 1.732661247253418,
      "frame": 3186,
      "window": 201
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  "pre_window": [
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  "baseline_pre": -0.5335609912872314,
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  "interpretation": "mean fluorescence changed; cause not determined from the image",
  "beat_amplitude_p5_p95": 1.4402662966400377
},
"uncertainty_frames": 17
}
},
"provisional": true
},
{
  "id": "4eeedfd6-84c2-40d3-8a4a-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 \u003bcW/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"

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},
"evidence": {
  "end": {
    "recording_end_frame": 9267
  },
  "start": {
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    "frame": 4977,
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    "evidence": {
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      "daq_sample": 103145,
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      "led_level_before": 0.0784302,
      "photodiode_after": 0.015564,
      "photodiode_agrees": true,
      "photodiode_before": 0.0177002
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    "uncertainty_frames": 11
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    "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"
  },
  {

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    "status": "superseded",
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arrhythmic interval; mapped to frames via camera triggers"
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    "frame": 3153,
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    "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",
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    "uncertainty_frames": 17,
    "method": "consensus upward step in running-median baseline of tissue-mean raw signal"
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  {
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    "frame": 3170,
    "label": null,
    "source": "image",
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    "frame": 4977,
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    "uncertainty_frames": 11,
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triggers"
  }
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