

CATCH Guide for SageHLS System

March, 2018

Overview of HLS-CATCH Process

- 1) Prior to day of extraction, schedule availability of cells. Check that cell preparation reagents are ready.
- 2) Prepare cells using Sage HLS cell prep kit instructions (kits/protocols for mammalian WBCs, tissue culture cells, and bacterial spheroplasts are available). Recommended cell load will contain ~2.5 ug genomic DNA per lane (for example, ~375,000 human diploid cells per lane) in a maximum loading volume of 70 ul. Higher cell loads will result in lower recovery of genomic CATCH targets.
- 3) Prepare HLS cassettes for run. (Dislodge bubbles, open cassettes, empty and refill elution modules, fill electrode reservoirs with electrophoresis buffer to top edge of cassette. Perform current test.)
- 4) Assemble wild-type SpCas9 enzyme with gRNAs. (Assembly can be done in advance.)
- 5) Set up desired workflow in software.
- 6) Load samples and carry out run, including user interventions for Treatment Stage using customized Cas9 cleavases.
- 7) After run, remove tape seals and remove samples from elution modules, preferably using wide-bore pipette tips.

HLS Software for CATCH

General description of HLS software

Users will use (and create) “Workflows” comprising up to three “Stages”.

The “Stages” fall into the following categories:

Stage 1 - Extraction

Cells are lysed by a brief period of DC electrophoresis (1 or 3 hrs). Released HMW genomic DNA enters the agarose wall of the sample well, and becomes immobilized there because of its large size (>10mb).

Stage 2 – Treatment

The user adds customized Cas9 cleavases to the sample well to release genomic region(s) of interest from immobilized genomic DNA in wall of sample well.

Stage 3 – Collection

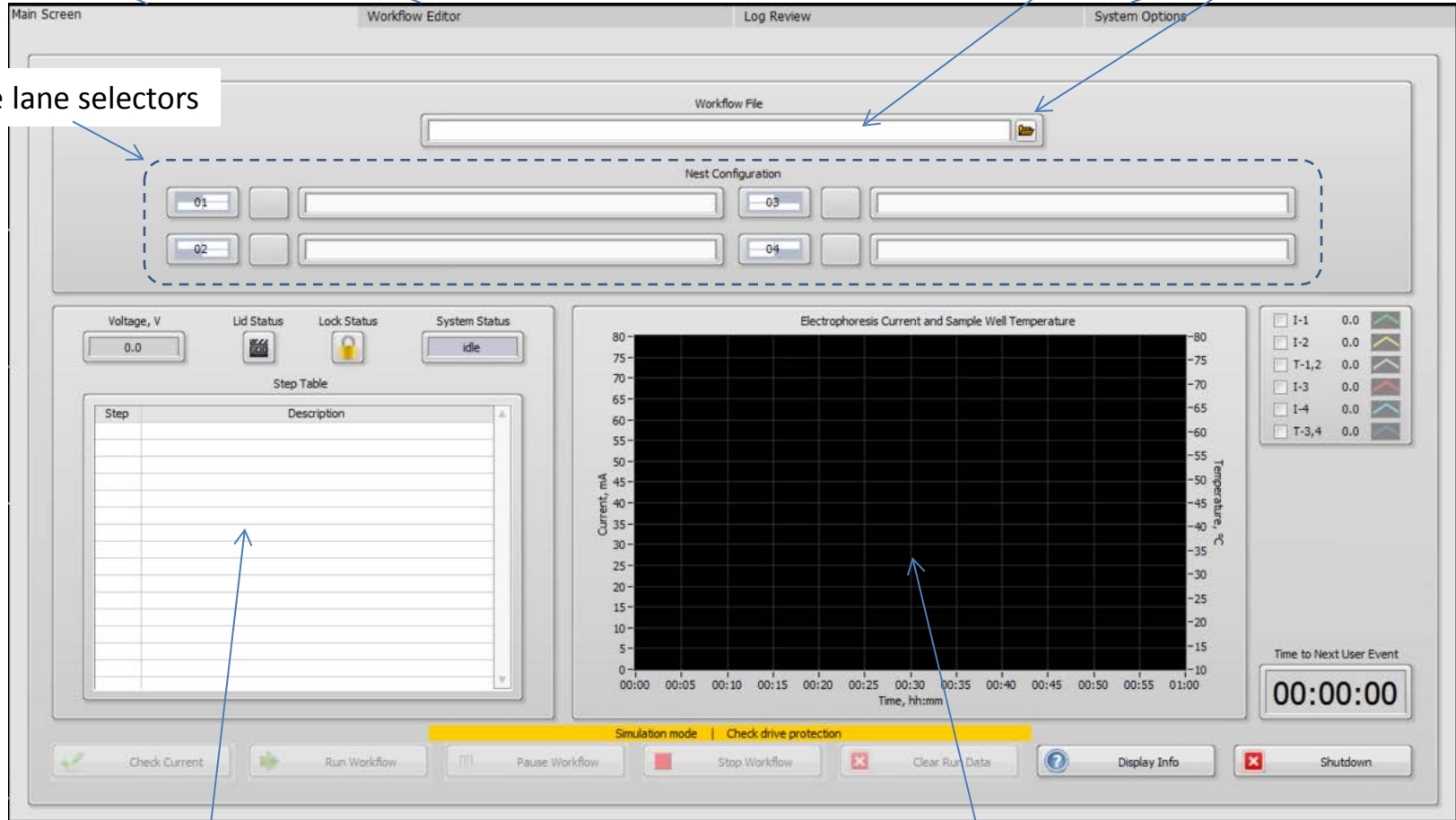
Electrophoretic size selection is carried out to remove enzymatic reagents, separate the targeted genomic fragments from non-specific digestion products, and electroelute the products into the elution modules.

Main screen on instrument startup

Workflow filename & selection menu

Workflow filename & selection menu

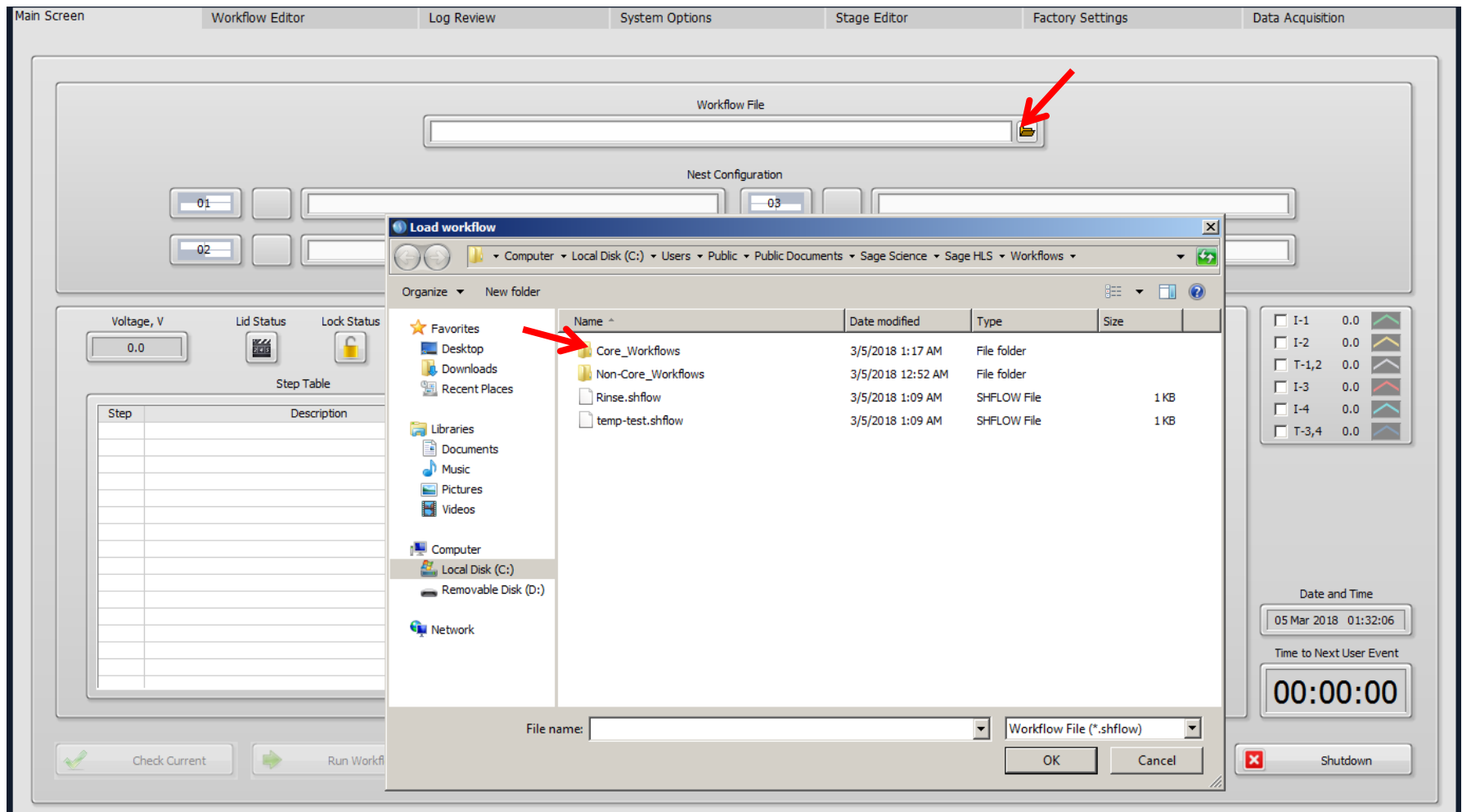
Cassette lane selectors



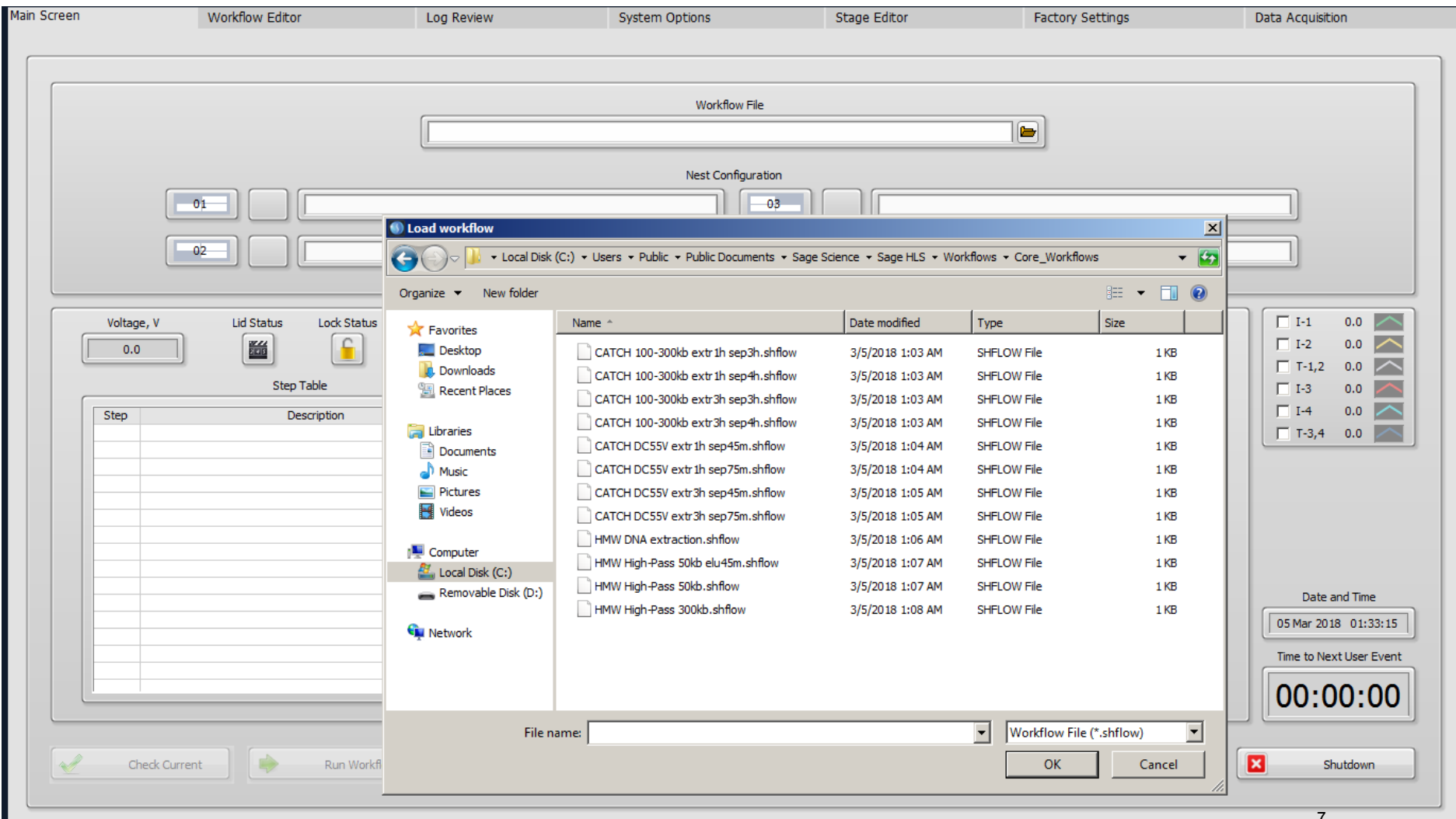
Window showing individual workflow steps.

Real time current and sample well temperature status.

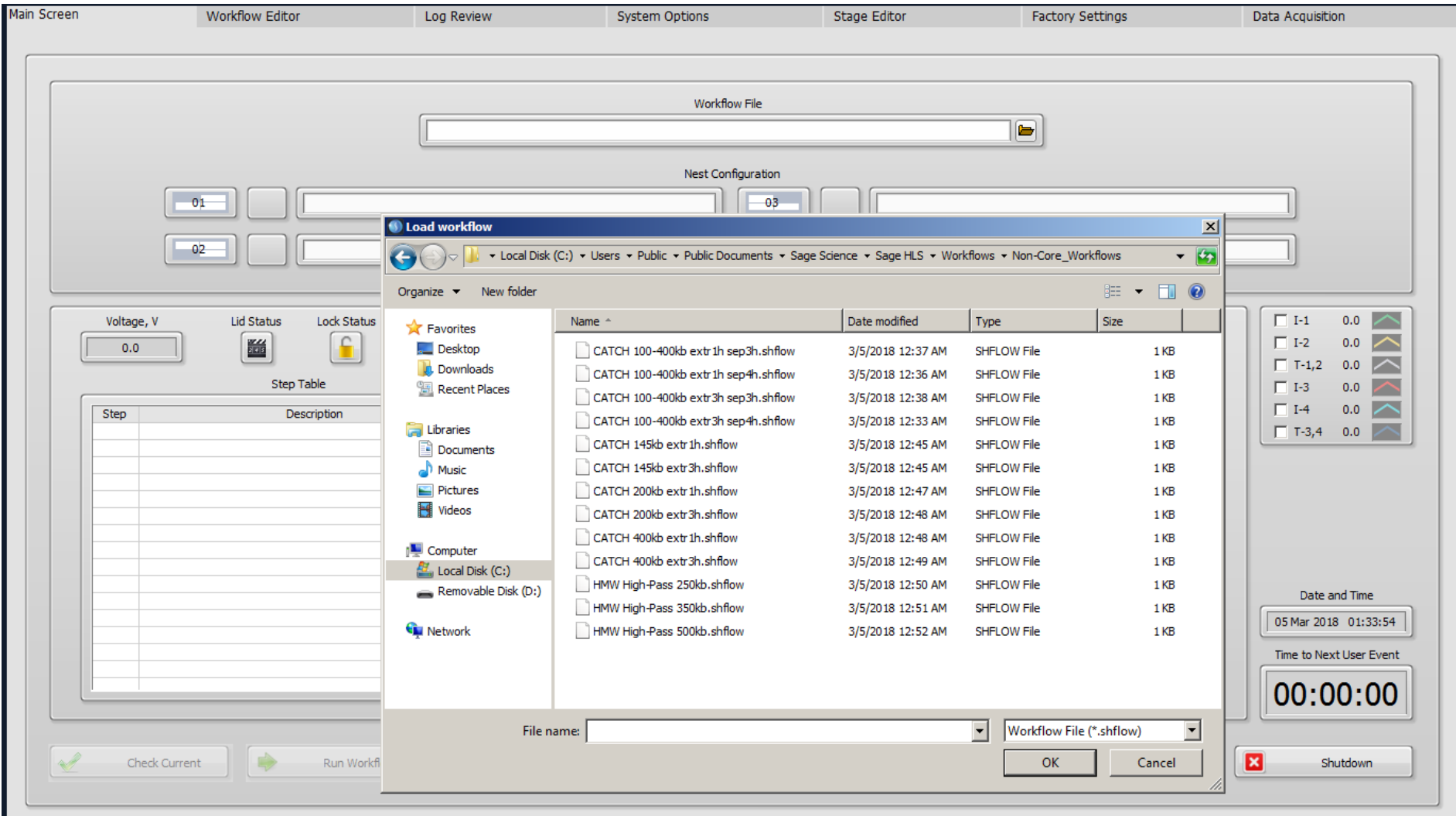
Workflows can be loaded from the “Main Screen” by clicking on the Workflow file directory icon, which will open a Workflow directory window. The Workflows are grouped into two categories, “Core” and “Non-core”, based on how much experience Sage has had with the workflow. Double-click on the folder to see the workflow files. Workflow files have a “.shflow” filetype.



Workflows designed for HLS-CATCH experiments include **“CATCH”** as the first term. Workflows designed for HMW DNA extraction include **“HMW”** as the first term. Some of the workflows share size-selection electrophoresis conditions, but differ in the duration of the extraction and/or collection stages. For instance the workflow **“CATCH 100-300kb extr1h sep3h”** uses a 1 hour extraction stage, and a 3 hour size-separation collection stage. The **“CATCH 100-300kb extr3h sep3h”** uses the same collection waveform (“100-300kb”), but uses a 3hr extraction stage, and a 4 hour collection stage.



Non-core workflows have been designed for special purposes. For instance, the **CATCH 100-400k** workflows are designed to have a broader collection range than the core 100-300kb workflows, whereas the “**CATCH <xxx>kb**” workflows are designed to have expanded resolution in a narrow window centered on <xxx>kb. In general, Sage has tested the non-core workflows with model samples, but doesn't yet have extensive test data from biological samples.



View of the main screen after selecting a CATCH workflow.

To view the stage structure of a particular HLS workflow, it is more convenient to load the workflow into the **Workflow Editor**, as shown on the next page.

The screenshot displays the main interface of the CATCH software. At the top, a navigation bar includes tabs for Main Screen, Workflow Editor (selected), Log Review, System Options, Stage Editor, Factory Settings, and Data Acquisition. The central area is divided into several sections:

- Workflow File:** A text box containing the path "Core_Workflows\CATCH 100-300kb extr1h sep3h".
- Nest Configuration:** Four input fields labeled 01, 02, 03, and 04, each with a dropdown menu and a checkbox.
- System Status:** A panel showing "Voltage, V" at 0.0, "Lid Status" with a lid icon, "Lock Status" with a lock icon, and "System Status" set to "idle".
- Step Table:** A table with two columns: "Step" and "Description".
- Electrophoresis Current and Sample Well Temperature:** A graph with "Current, mA" on the left y-axis (0 to 80) and "Temperature, °C" on the right y-axis (-10 to 80). The x-axis is "Time, hh:mm" from 00:00 to 06:02. The graph area is currently black.
- Monitoring and Controls:** A panel on the right showing checkboxes for I-1, I-2, T-1,2, I-3, I-4, and T-3,4, each with a value of 0.0 and a corresponding colored line icon. Below this is a "Date and Time" display showing "05 Mar 2018 02:40:25" and a "Time to Next User Event" display showing "00:00:00".

At the bottom, a yellow bar displays "Check drive protection". Below this is a row of control buttons: "Check Current" (green checkmark), "Run Workflow" (green play button), "Pause Workflow" (grey pause button), "Stop Workflow" (red stop button), "Clear Run Data" (red X button), "Display Info" (blue question mark button), and "Shutdown" (red X button).

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Repl
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 03:00:00 at 55.0 V with wave index 3-2
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

HLS Workflows can be viewed, created, and edited in the Workflow Editor.

Once an existing workflow is loaded into the Editor, each component stage used by the workflow is highlighted in yellow.

The screenshot shows the Workflow Editor interface with the following components:

- Workflow File:** Core_Workflows\CATCH 100-300kb extr 1h sep3h
- Extraction Stage:** Core_Stages\Extraction Method 1hr, Core_Stages\Extraction Method 3hr, Core_Stages\Rinse, Core_Stages\temp-test
- Treatment Stage:** Core_Stages\CATCH Method 1(HIT kit), Core_Stages\Fragmentase Method 1(HEX kit)
- Collection Stage:** Core_Stages\CATCH 100-300kb sep3h, Core_Stages\CATCH 100-300kb sep4h, Core_Stages\CATCH DC55V sep45m, Core_Stages\CATCH DC55V sep75m, Core_Stages\High-Pass 300kb, Core_Stages\HMW DC55V sep75m elu45m, Core_Stages\HMW DC55V sep75m, Core_Stages\HMW Method 1, Non-Core_Stages\CATCH 100-400kb sep3h, Non-Core_Stages\CATCH 100-400kb sep4h, Non-Core_Stages\CATCH 145kb, Non-Core_Stages\CATCH 200kb, Non-Core_Stages\CATCH 400kb, Non-Core Stages\High-Pass 250kb
- Step Table:**

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample well. Load 230ul of HLS Lysis reagent (A) in to reagent well, then load 70ul of prepared sample in to the sample well. Seal
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Replace sample well contents with 80ul of CATCH reaction mix. Replace reagent well contents with 230ul of enzyme buffer (C)
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enzyme buffer (C)
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents with 230ul HLS Lysis Reagent (A). Apply tape seal. Add running buffer to the cassette to refill.'
3-001	separate for 03:00:00 at 55.0 V with wave index 3-2
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Existing Workflows can be loaded into the Editor using this button.

Step numbering format is X-YYY, where X indicates stage number, and YYY indicates the step number in the X stage definition.

Notes on HLS-CATCH Extraction (Stage 1)

Extraction time considerations:

Sage has found that a variable amounts of non-specifically cleaved DNA (50kb to 200kb) is liberated from non-viable cells during the HLS extraction step. The 1 hour extraction time doesn't remove all of these non-specific fragments, and so they will contaminate the specific targets when using the 1 hr extraction time.

Current "Core" CATCH Workflows

```
CATCH 100-300kb extr1h sep3h.shflow
CATCH 100-300kb extr1h sep4h.shflow
CATCH 100-300kb extr3h sep3h.shflow
CATCH 100-300kb extr3h sep4h.shflow
CATCH DC55V extr1h sep45m.shflow
CATCH DC55V extr1h sep75m.shflow
CATCH DC55V extr3h sep45m.shflow
CATCH DC55V extr3h sep75m.shflow
```

This non-specific contamination is **actually beneficial** when library construction and sequencing is carried out with the 10x Genomics Chromium system. ***So the 1hr extraction workflows are recommended for 10x Genomics customers.***

For other sequencing platforms (PacBio and Oxford Nanopore), which employ less efficient library prep procedures, purer CATCH target products are needed, and the **3hr** extraction workflows are recommended.

Notes on HLS-CATCH Stage 3 Collection Stages

Sage R&D is actively developing new electrophoresis conditions for CATCH applications. Currently these efforts are focused on increasing the size range and resolution of the Stage 3 Collection electrophoresis step. Workflows that have been more thoroughly tested are released as “Core” workflows, while less tested workflows are released as “non-core”.

Current “Core” CATCH Workflows

```
CATCH 100-300kb extr1h sep3h.shflow
CATCH 100-300kb extr1h sep4h.shflow
CATCH 100-300kb extr3h sep3h.shflow
CATCH 100-300kb extr3h sep4h.shflow
CATCH DC55V extr1h sep45m.shflow
CATCH DC55V extr1h sep75m.shflow
CATCH DC55V extr3h sep45m.shflow
CATCH DC55V extr3h sep75m.shflow
```

Workflow names for HLS-CATCH follow the convention:

CATCH <collection electrophoresis waveform name> extrXX(h or m) sepYY(h or m).

where XX denotes extraction time, and YY indicates collection stage time, and “h”, “m” indicate time units of hours or minutes, respectively.

Notes on HLS-CATCH strategies for size selection and Stage 3 Collection Stages (cont.)

Target size considerations:

The “100-300kb” waveform has been successfully tested for 200kb CATCH targets with 3 and 4 hours separation times. It has also been used for 100kb CATCH targets with the 3 hour separation time.

The “DC55V” waveform has been used successfully for CATCH targets up to 16 kb in size with both 45 and 75 minute separation times. With the 75 minute separation time, the CATCH target range should extend up to 30kb.

Current “Core” CATCH Workflows

```
CATCH 100-300kb extr1h sep3h.shflow
CATCH 100-300kb extr1h sep4h.shflow
CATCH 100-300kb extr3h sep3h.shflow
CATCH 100-300kb extr3h sep4h.shflow
CATCH DC55V extr1h sep45m.shflow
CATCH DC55V extr1h sep75m.shflow
CATCH DC55V extr3h sep45m.shflow
CATCH DC55V extr3h sep75m.shflow
```

Cas9 enzyme assembly for HLS-CATCH

Overview of Cas9 enzyme assembly process

The following protocol assumes use of IDT ALT-R™ two-part synthetic guide RNAs, and *S. pyogenes* wild-type Cas9 enzyme from New England Biolabs. We have had consistently good results with these materials.

This protocol assembles the active Cas9 reaction mix in three steps.

- 1) The two-part guide RNAs are annealed by heating to 95C and cooling to room temperature.
- 2) The annealed guide RNAs are mixed with the Cas9 enzyme and incubated briefly at 37C.
- 3) The final assembled enzyme is diluted to the correct volume (80 ul) for loading into the HLS sample well.

Step 1. Annealing the two-part IDT ALT-R™ guide RNAs

Dissolve each of the crRNAs and tracrRNAs to be used at **100uM** concentration in IDT Duplexing Buffer. The correct volume for resuspension in microliters will be 10 times the number of nanomoles of RNA in the tube supplied by IDT.

To a 200 ul PCR tube add:

1) 15.4 ul IDT duplexing buffer.

2) 4 ul of a pooled mixture of all crRNAs used in the experiment. To make the pool, combine equal volumes of each stock crRNA solution. All crRNAs stock solutions should be at 100 uM, in IDT Duplexing Buffer.

(For instance, if two crRNAs are to be used, add 2 ul of each crRNA solution. If four crRNAs are to be used, add 1 ul of each crRNA solution. For more crRNAs, mix equal volumes of each crRNA (using some convenient volume), and then add 4 ul of the resulting crRNA mixture to the PCR tube. The goal here is to saturate the tracrRNA with a 1.5-fold molar excess of total crRNA.)

Mix the duplex buffer and crRNAs thoroughly by vortexing or pipetting, and spin down briefly.

3) Add 2.6 ul of tracrRNA (100 uM).

Mix thoroughly and spin down briefly. (Vol. =22 ul. Conc. after this step = 11.8 uM tracrRNA, 18 uM total pooled crRNA.)

4) Heat the 20 ul mixture for 5 minutes at 95C in a thermal cycler with a heated lid, then remove the tube from the cycler and allow to cool on the lab bench at room temp for 3-5 minutes. Centrifuge for 30-60 seconds to collect any condensation.

Total volume of the annealed RNA will be **approximately 22 ul**.

(We have found that annealed guide RNAs can be stored for at least 3 weeks at -20C with no loss of activity.)

Step 2. Assemble annealed guide RNAs and Cas9

Add in order:

- 1) 10 ul Sage HLS 4X Enzyme Buffer.
- 2) 22 ul annealed IDT guide RNAs (from Step 1). Mix thoroughly by vortexing or pipetting and spin down briefly.
- 3) 8 ul NEB wild-type *S. pyogenes* Cas9 enzyme (20 uM). Mix thoroughly by gentle pipetting of entire mixture (40ul). Conc. after this dilution step: 4 uM Cas9 enzyme, 6.5 uM annealed tracrRNA.
- 4) Incubate mixture at 37C for 10 minutes to assemble enzyme and gRNAs. Proceed to dilution (step 3), or store on ice until ready.

Step 3. Dilute to loading concentration with HLS Enzyme Buffer.

Dilute assembled Cas9 mixture from Step 2 (40ul), with 40 ul of HLS Enzyme Buffer. Mix thoroughly by gentle pipetting of the entire mixture (80 ul). (Final conc: 2 uM Cas9 assembled with 3.25 uM pool of annealed two-part gRNAs)

At this point the Cas9 mixture is ready to load in the HLS sample well. The mixture can be stored on ice, or at 4C, for several hours.

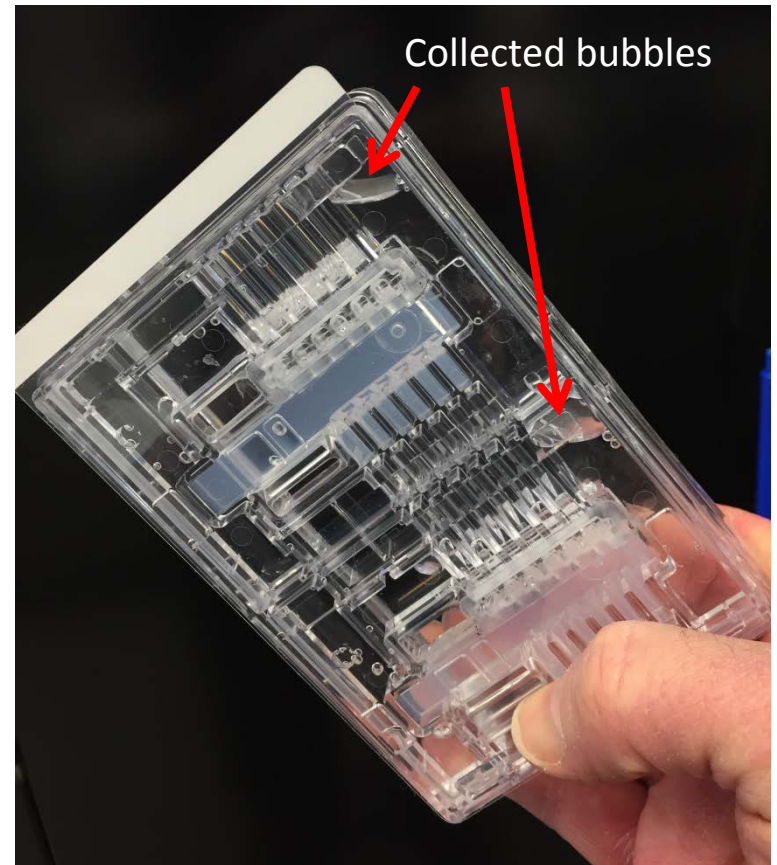
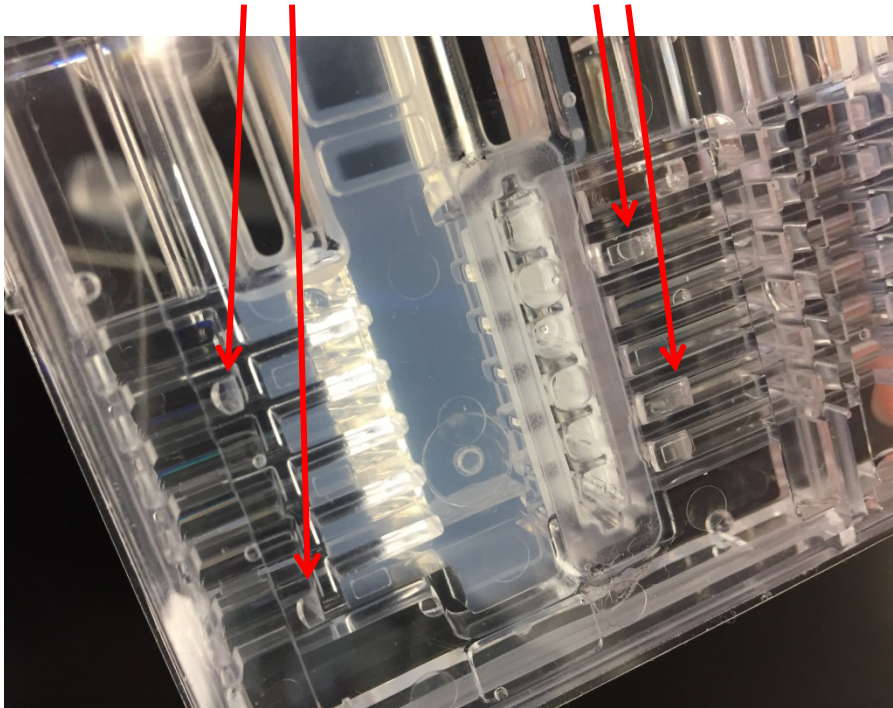
(According to some of our customers, the assembled ready-to-load Cas9 mixtures is stable for at least 48 hours at 4C. We will be testing 4C storage of assembled enzyme and will report when we have data.)

HLS Cassette Preparation

HLS Cassette Preparation- Collecting trapped bubbles.

Hold the sealed cassette with its surface plane vertical to the ground. Keeping the cassette surface vertical, slowly rotate the sealed cassette 360 degrees while tapping the top surface of cassette to remove all trapped air bubbles from the elution channels. Collect all the bubbles into one end of the reservoirs (either end is OK). The collected bubbles will escape after the cassette is opened and topped up with buffer before run.

Trapped air bubbles that interfere with elution



SageHLS – Cassette Preparation: Remove tape, Top-up buffer, Perform current check.

1. Grasp tabbed edge of sealing tape with one hand, hold cassette firmly in nest with other hand.
2. With a slow side-to-side movement, slowly peel off sealing tape. Go slow. Avoid contact with buffer in electrode port openings.
3. Completely empty and refill all the elution modules in each lane to ensure no bubbles are trapped inside. (Keep pipette tips vertical to avoid scraping membranes on each side of the elution module.) The elution modules hold approximately 80-85 ul of buffer. Refill each module with 80 ul of Running Buffer.
4. Top up the volume of the Reagent and Sample wells. These wells should have a slight concave meniscus when properly filled. The maximum volumes of the wells are approximately 270 and 85 ul, respectively.
5. Completely fill the electrode buffer chambers with Running Buffer. The electrode channels at the ends and sides of the cassette should be filled level with the top surface of the cassette.
6. Close lid, perform current check on lanes to be used for the experiment. (See next page for instructions on performing current check).

Current check procedure (brief version)

1. Select workflow file.
2. Choose lanes to be used.
3. Close lid. Click “Check Current”

The screenshot displays the SageHLS software interface with the following components:

- Workflow File:** A text box containing "Core_Workflows\CATCH DC55V extr 1h sep45m".
- Nest Configuration:** A grid of lane selection buttons (01-04) with checkboxes. Red dashed boxes and arrows highlight the checkboxes for lanes 01, 02, 03, and 04.
- System Status:** A green "ready" button.
- Step Table:** A table with columns "Step" and "Description".
- Electrophoresis Current and Sample Well Temperature:** A graph with "Current, mA" on the left y-axis (0-80) and "Temperature, °C" on the right y-axis (-10 to 80). The x-axis is "Time, hh:mm" (00:00 to 03:47).
- Check Current Button:** A green button with a checkmark icon, highlighted by a red arrow and the number "3".

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Current Check Procedure (cont.)

Pop-up “Current Check” window appears.

Click on “Start”.

Lid lock will click, and elevator will be heard.

The screenshot displays the SageHLS software interface. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow Editor' tab is active, showing a 'Workflow File' field with the path 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this is a 'Nest Configuration' section with four columns, each containing a cassette ID (01, 02, 03, 04) and a checked checkbox. The main area is divided into several panels: 'Voltage, V' (0.0), 'Lid Status' (represented by a lid icon), 'Lock Status' (represented by a lock icon), and 'System Status' (ready). A 'Step Table' is visible on the left, listing steps from 1-001 to 3-003. In the center, a 'Current Check' pop-up window is open, featuring a grid for selecting cassettes (01-04) and checkboxes for 'Separation' and 'Elution'. A red arrow points to the 'Start' button in this window. To the right of the pop-up is a 'Well Temperature' graph showing temperature in degrees Celsius over time. At the bottom right, there is a 'Date and Time' display (05 Mar 2018 16:02:30) and a 'Time to Next User Event' display (00:00:00). The bottom of the interface has a yellow bar with 'Simulation mode' and 'Check drive protection', and a row of control buttons: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Current Check Procedure (cont.)

Test takes a couple of minutes, first testing Separation electrodes, then Elution electrodes. After successful current test all boxes will be filled with green checkmarks. Hit "Return" in popup to get back to "Main".

The screenshot displays the 'Main Screen' of the CATCH software. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow File' field shows 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this is the 'Nest Configuration' section with four input fields (01, 02, 03, 04) and checkmarks. The 'Voltage, V' is set to 0.0, and the 'System Status' is 'ready'. A 'Step Table' is visible, listing steps from 1-001 to 3-003. A 'Temperature, °C' graph shows a rising trend. A 'Current Check' dialog box is open, showing a grid of checkboxes for Cassettes 01-04 and Separation/Elution steps. All checkboxes are checked with green checkmarks. A red arrow points to the 'Return' button. The 'Date and Time' is 05 Mar 2018 16:04:25, and the 'Time to Next User Event' is 00:00:00. At the bottom, there are buttons for 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Repl
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

HLS-CATCH Workflow and User Actions

Main screen: Ready to start Stage 1- Extraction

Click “Run Workflow” command.

(Command is only active after lid is closed.)

Main Screen Workflow Editor Log Review System Options

Workflow File
Core_Workflows\CATCH DC55V extr 1h sep45m

Nest Configuration

01 ✓ _____ 03 ✓ _____
02 ✓ _____ 04 ✓ _____

Voltage, V Lid Status Lock Status System Status
0.0 ready

Step Table

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Electrophoresis Current and Sample Well Temperature

Current, mA Temperature, °C

Time, hh:mm

I-1 0.0 I-2 0.0 T-1,2 0.0 I-3 0.0 I-4 0.0 T-3,4 0.0

Date and Time
05 Mar 2018 16:06:25

Time to Next User Event
00:00:00

Simulation mode | Check drive protection

Check Current Run Workflow Pause Workflow Stop Workflow Clear Run Data Display Info Shutdown



Popup window prompts user to replace sample and reagent well contents with sample and lysis reagent. See following slides for detailed instructions.

Main Screen Workflow Editor Log Review System Options

Workflow File
Core_Workflows\CATCH DC55V extr 1h sep45m

Nest Configuration

01 03
02 04

Voltage, V: 0.0 Lid Status: [Icon] Lock Status: [Icon] System Status: separate

Step Table

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Electrophoresis Current and Sample Well Temperature

Remove contents of reagent well and sample well. Load 230ul of HLS Lysis reagent (A) in to reagent well, then load 70ul of prepared sample in to the sample well. Seal with tape.

OK [Enter]

Temperature, °C

Time, hh:mm

Simulation mode | Check drive protection

Check Current Run Workflow Pause Workflow Stop Workflow Clear Run Data Display Info Shutdown

I-1 0.0 I-2 0.0 T-1,2 0.0 I-3 0.0 I-4 0.0 T-3,4 0.0

Date and Time: 05 Mar 2018 16:07:32

Time to Next User Event: 01:00:00

Initiating Stage 1- Extraction

User actions **after** current-check, at start-of-run pop-up prompt.

- 1) Empty all sample and reagent wells. Take caution not to pierce agarose at bottom of wells.
- 2) Load samples in all lanes. Always use 70ul sample loading volume. (Sample wells will not be completely full.)
- 3) Fill Reagent Wells with HLS Lysis Buffer. Fill, but do not overfill! Leave a concave meniscus to prevent contact with sealing tape in next step. Approximate volume needed will be 220-230 ul.
- 4) Seal reagent, sample, and elution ports with supplied tape. Press tape firmly around edges of ports (see next slides for taping details), and close lid.
- 5) Click on “OK”.

Placement of sealing tape after cassette loading

Be sure that all Reagent, Sample, and Elution ports are completely covered.

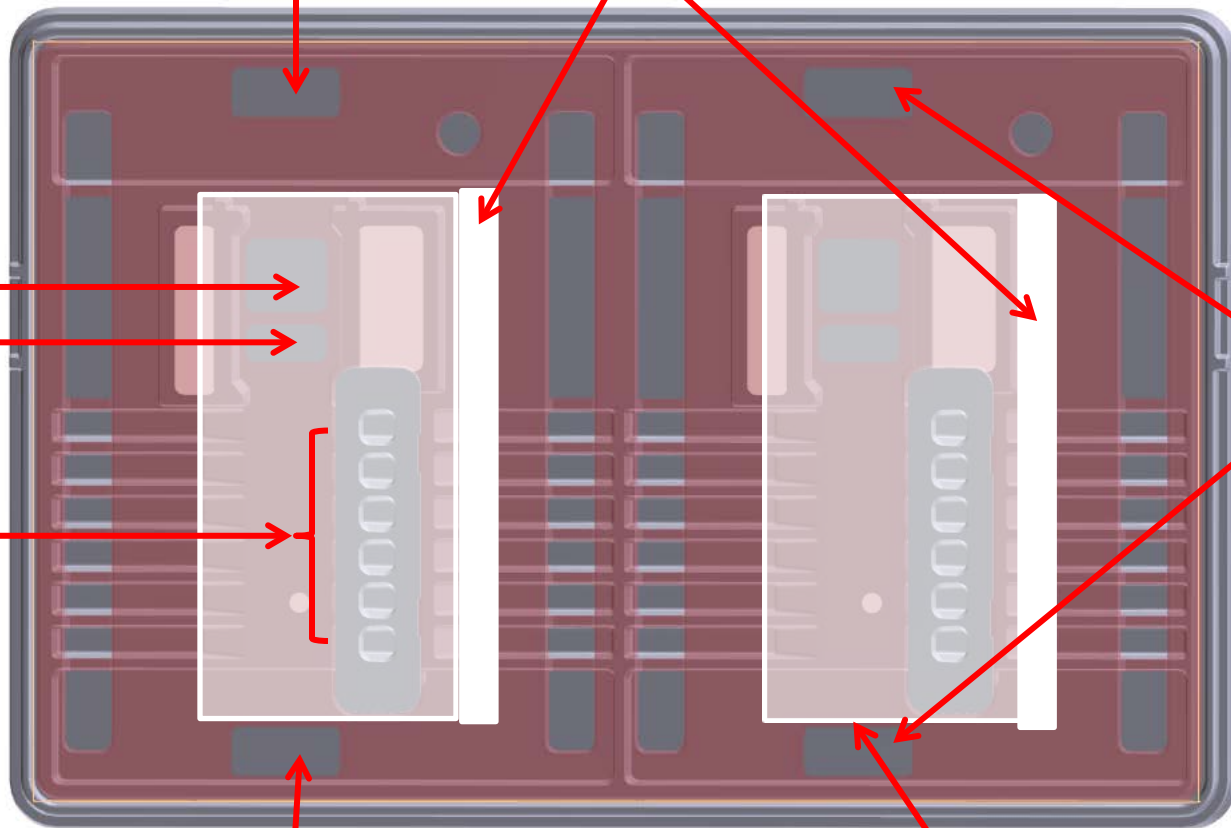
Upper electrode port

Tabs for removing tape seals should be on same side as elution modules.

Reagent
Sample

Elution
Ports

Be sure both electrode ports are not occluded by tape.

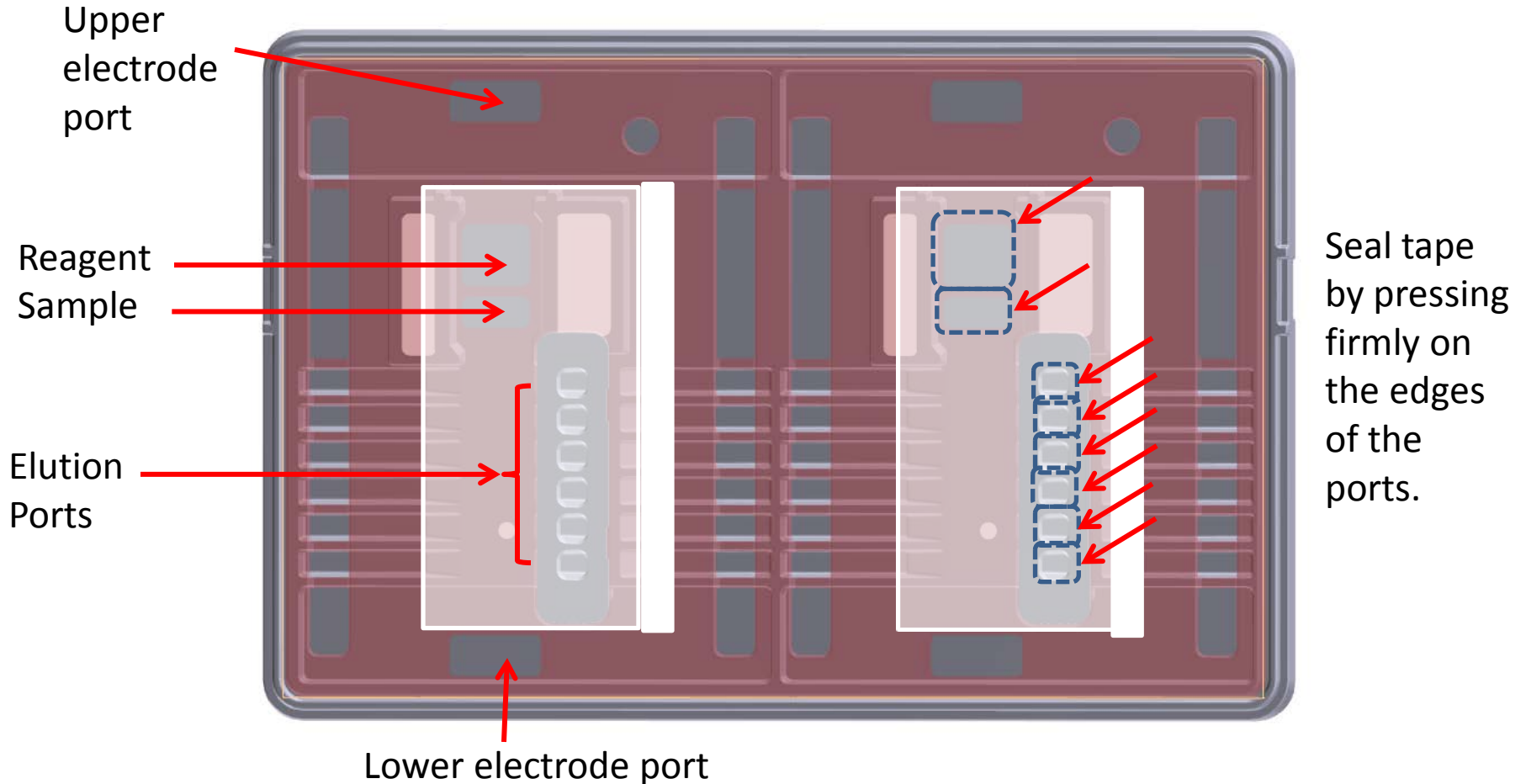


Lower electrode port

Lower edge of tape must not occlude lower electrode port

Seal tape securely around port borders

The tape is pressure-sensitive. After placing tape on cassette, **press tape tightly to the cassette surface at the edges of the reagent, sample, and elution ports** using a hard, smooth, round object like the back end of a lab marker, or the back side of a curved spatula. Take care **not to press on tape directly over open areas of the ports**, which could force liquid out under the tape.



Main screen during Stage 1 - Extraction (after 18 min)

Current should be similar for all lanes, and in the range of 10-15 mA.

Main Screen | Workflow Editor | Log Review | System Options

Workflow File: Core_Workflows\CATCH DC55V extr 1h sep45m

Nest Configuration

01 [✓] [] 03 [✓] []
 02 [✓] [] 04 [✓] []

Voltage, V: 54.2 | Lid Status: [] | Lock Status: [] | System Status: separate

Step Table

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Electrophoresis Current and Sample Well Temperature

Current, mA | Temperature, °C

Time, hh:mm

Simulation mode | Check drive protection

Check Current | Run Workflow | Pause Workflow | Stop Workflow | Clear Run Data | Display Info | Shutdown

I-1 14.9 []
 I-2 14.6 []
 T-1,2 0.0 []
 I-3 13.8 []
 I-4 14.2 []
 T-3,4 0.0 []

Date and Time: 05 Mar 2018 16:30:05

Time to Next User Event: 00:42:13

End of Stage I - Extraction

Prompts appear in popup window.

See next slide for details on completion of stage 1 and initiation of Stage 2.

The screenshot displays the SageHLS software interface. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow Editor' tab is active, showing a 'Workflow File' field with 'HLS_HMW DNA Extraction' and a 'Nest Configuration' section with four rows of controls (01-04) and checkboxes.

Below this, there are status indicators for 'Voltage, V' (0.0), 'Lid Status', 'Lock Status', and 'System Status' (with a 'pause' button). A 'Step Table' is visible, listing steps from 1-001 to 3-004. Step 2-001 is highlighted in yellow and contains the text: 'pause for user action 'Remove tape seal. Replace sample well conter...'. A blue popup window is overlaid on the graph, containing the text: 'Remove tape seal. Replace sample well contents with 80ul of reaction mix. Replace reagent well contents with 230ul Enzyme Buffer (2C). When done, close the lid and click OK to continue.' with an 'OK [Enter]' button.

The central graph is titled 'Electrophoresis Current and Sample Well Temperature'. The left y-axis is 'Current' (0-40) and the right y-axis is 'Temperature, °C' (-10 to -80). The x-axis is 'Time, hh:mm' (00:00 to 05:01). The graph shows a current of approximately 15 units and a temperature of approximately -20°C. To the right of the graph is a list of temperature setpoints for wells I-1 through T-3,4, each with a 0.0 value and a color-coded line graph icon.

At the bottom, there is a 'Simulation mode | Check drive protection' indicator and a row of control buttons: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'. A 'Time to Next User Event' display shows '00:00:00'.

Completion of Stage 1 Extraction

Open lid. Remove 2-5 ml of foamy, SDS-rich electrophoresis buffer from the lower separation electrode port of each cassette lane, and discard it.

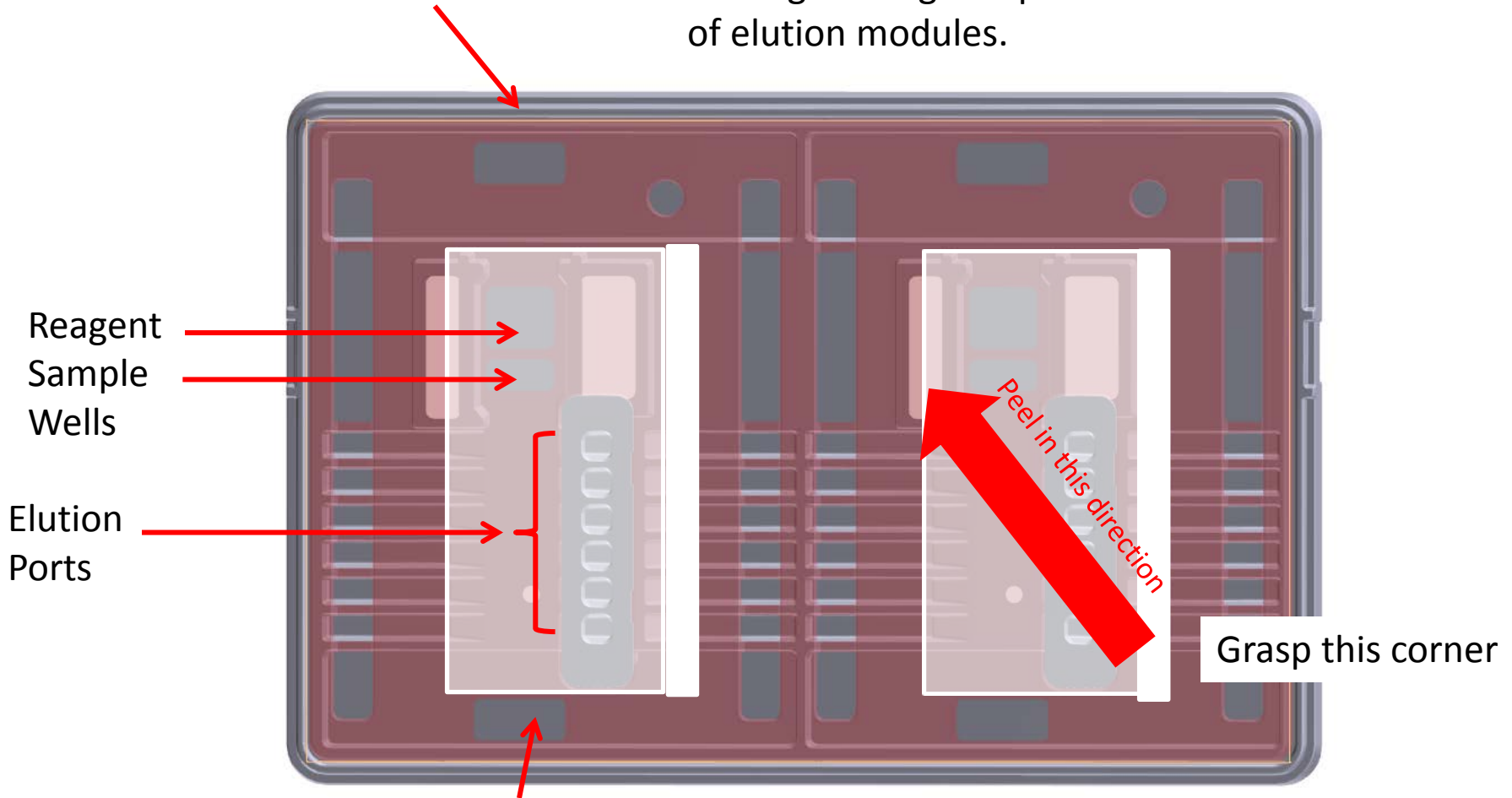
Remove port sealing tapes by pulling the tabs in a diagonal direction as illustrated on the next slide. (Removing the tape in this manner reduces the risk of introducing liquids from the Reagent or Sample well ports into the elution modules.)

Refill the electrode buffer chamber with fresh electrophoresis buffer so that the buffer level is even with the top surface of the cassette.

Completion of HLS Stage 1: Removing tape

Grasp tab on elution module side, peel slowly in diagonal direction, **away from elution modules**. Peeling on diagonal prevents cross-contamination of elution modules.

Upper electrode port



Lower electrode port, remove SDS-rich buffer here after Stage 1.

HLS-CATCH Stage 2 (treatment) Overview

After loading the Cas9 reaction mixture and clicking “OK” on the popup reagent addition prompt, the instrument performs a short electrophoresis pulse (1 minute) to “inject” the Cas9 complexes into the sample gel well where the DNA is immobilized.

Following the 1 minute injection, the user empties the sample well and refills with HLS Enzyme buffer (without Cas9) to ensure that the Mg^{++} concentration remains relatively constant.

HLS-CATCH Initiation of Stage 2: Cas9 digestion

Remove and discard contents of **Sample well** and **Reagent well**.

Add 80 ul of Cas9 reaction mixture to the **Sample well**.

Fill **Reagent well** with HLS Enzyme Buffer (without enzyme); approximately 230 ul.

Close lid (do **not** retape the sample/elution ports at this step).

Click “OK” on the popup user prompt to initiate the 1 minute electrophoretic injection.

After injection, replace sample well contents with 80 ul of fresh HLS Enzyme buffer (without Cas9 enzyme).

Close lid (do not retape cassette), and click OK on popup prompt to start Cas9 digestion timer.

Screen at end of Stage 1/Beginning Stage 2

Popup prompt shows request to replace Sample and Reagent well contents as discussed on previous slide. After these replacements, do not retape. Close lid. Click OK. (Lid lock will click.)

The screenshot displays the SageHLS software interface. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow Editor' tab is active, showing a 'Workflow File' field with the path 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this is a 'Nest Configuration' section with four input fields, each with a dropdown menu and a checkmark.

The main area is divided into several sections. On the left is a 'Step Table' with the following content:

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Repl
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

In the center, a 'Simulation mode' bar is visible. Below it is a 'Check drive protection' indicator. The main graph area is titled 'Electrophoresis Current and Sample Well Temperature'. It shows a plot of Current (0 to 40) and Temperature (°C, -10 to -80) over Time (hh:mm, 00:00 to 03:47). A blue popup window is overlaid on the graph, containing the following text:

Remove tape seal. Start Cas9 Reaction: Replace sample well contents with 80ul of CATCH reaction mix. Replace reagent well contents with 230ul of enzyme buffer (C).
When done, close the lid and click OK to continue.

Below the text is a green checkmark icon and the text 'OK [Enter]'. A red arrow points to the 'OK [Enter]' button.

On the right side of the interface, there is a 'Date and Time' section showing '05 Mar 2018 17:14:47' and a 'Time to Next User Event' section showing '00:00:00'. Below these are several control buttons: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Screen after reagent addition at start of Stage 2.

Instrument performs 1 minute of electrophoresis to inject Cas9 into the sample well where the HMW DNA is immobilized.

The screenshot displays the SageHLS software interface. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow Editor' tab is active, showing a 'Workflow File' field with the path 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this is a 'Nest Configuration' section with four rows of controls, each with a dropdown menu (01, 02, 03, 04) and a checkmark.

On the left side, there are status indicators for 'Voltage, V' (54.1), 'Lid Status', 'Lock Status', and 'System Status' (separate). Below these is a 'Step Table' with the following data:

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

In the center, a graph titled 'Electrophoresis Current and Sample Well Temperature' shows 'Current, mA' on the left y-axis (0 to 80) and 'Temperature, °C' on the right y-axis (-10 to 80) against 'Time, hh:mm' on the x-axis (00:00 to 03:47). The current is stable at approximately 15 mA, and the temperature is stable at approximately 20°C.

On the right side, there is a legend for temperature points: I-1 (14.9), I-2 (14.7), T-1,2 (0.0), I-3 (14.4), I-4 (13.2), and T-3,4 (0.0). Below the legend is a 'Date and Time' field showing '05 Mar 2018 17:18:24' and a 'Time to Next User Event' field showing '00:00:32'. Red arrows point to the 'separate' button and the 'Time to Next User Event' field.

At the bottom, there is a 'Simulation mode | Check drive protection' indicator and a row of control buttons: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Screen after electrophoretic injection of Cas9

User is prompted to refill **Sample well** with 80ul of HLS Enzyme buffer (without Cas9).
Do not retape cassette. Close lid. Click OK. (Lid lock will click.)

The screenshot displays the CATCH software interface during a workflow. At the top, the 'Workflow File' is set to 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this, the 'Nest Configuration' section shows four wells (01-04) with their respective configurations. The 'Voltage, V' is set to 0.0, and the 'System Status' is 'pause'. The 'Step Table' lists the following steps:

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

The 'Electrophoresis Current and Sample Well Temperature' graph shows a current of approximately 15 mA and a temperature of approximately 25°C. A modal dialog box is displayed in the center, prompting the user to 'Replace sample well contents with 80ul of enzyme buffer (C). When done, close the lid and click OK to continue.' The dialog box has an 'OK [Enter]' button. The 'Date and Time' is 05 Mar 2018 17:19:39, and the 'Time to Next User Event' is 00:00:00. The bottom status bar shows 'Simulation mode | Check drive protection' and several control buttons: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Screen after refilling Sample well with 80 ul of Enzyme buffer Cas9 digestion takes 30 minutes.

The screenshot displays the SageHLS software interface with the following components:

- Workflow File:** Core_Workflows\CATCH DC55V extr 1h sep45m
- Nest Configuration:** Four wells (01-04) are configured with checkboxes and empty text fields.
- System Status:** A yellow button labeled 'incubate' is highlighted with a red arrow.
- Step Table:** A table with columns 'Step' and 'Description'. Step 2-004 is highlighted in yellow and reads 'incubate for 00:30:00'.

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Repl
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1
- Graph:** 'Electrophoresis Current and Sample Well Temperature'. The x-axis is 'Time, hh:mm' (00:00 to 03:47). The left y-axis is 'Current, mA' (0 to 80). The right y-axis is 'Temperature, °C' (-10 to 80). The graph shows a constant current of approximately 15 mA and a temperature of approximately 25°C from 00:00 to 01:00.
- System Status Panel:** Includes checkboxes for I-1, I-2, T-1,2, I-3, I-4, T-3,4, each with a value of 0.0 and a corresponding color-coded arrow.
- Date and Time:** 05 Mar 2018 17:20:32
- Time to Next User Event:** 00:29:51 (highlighted with a red arrow)
- Simulation mode:** Check drive protection
- Control Buttons:** Check Current, Run Workflow, Pause Workflow, Stop Workflow, Clear Run Data, Display Info, Shutdown.

Screen after completion of Cas9 digestion.

Prompt will appear: “Stop reaction...”.

Empty Reagent well, and refill it with Lysis Buffer.

Carefully tape reagent, sample, and elution ports as for Stage 1. Close lid.

Click “OK” to start Stage 3 - Collection.

The screenshot displays the SageHLS software interface. At the top, there are tabs for 'Main Screen', 'Workflow Editor', 'Log Review', and 'System Options'. The 'Workflow Editor' tab is active, showing a 'Workflow File' field with the path 'Core_Workflows\CATCH DC55V extr 1h sep45m'. Below this is a 'Nest Configuration' section with four rows of controls, each consisting of a dropdown menu (showing '01', '02', '03', or '04'), a checkmark, and an empty text field.

The main dashboard is divided into several sections:

- System Status:** Includes 'Voltage, V' (0.0), 'Lid Status' (closed), 'Lock Status' (locked), and a 'pause' button.
- Step Table:** A table with columns 'Step' and 'Description'. The current step is 2-005: 'pause for user action 'Stop Reaction: Replace reagent well contents''. Other steps include 1-001, 1-002, 2-001, 2-002, 2-003, 2-004, 3-001, 3-002, and 3-003.
- Electrophoresis Current and Sample Well Temperature:** A graph with 'Current' on the left y-axis (0-40) and 'Temperature, °C' on the right y-axis (10-80). The x-axis is 'Time, hh:mm' (00:00-03:47). A blue dialog box is overlaid on the graph, containing the text: 'Stop Reaction: Replace reagent well contents with 230ul HLS Lysis Reagent (A). Apply tape seal. Add running buffer to the cassette. When done, close the lid and click OK to continue.' and an 'OK [Enter]' button.
- Channel Selection:** A list of channels on the right side, each with a checkbox and a color-coded arrow: I-1 (0.0, green), I-2 (0.0, yellow), T-1,2 (0.0, black), I-3 (0.0, red), I-4 (0.0, cyan), and T-3,4 (0.0, blue).
- Date and Time:** Shows '05 Mar 2018 17:52:15' and 'Time to Next User Event' as '00:00:00'.
- Simulation mode:** A yellow bar at the bottom indicates 'Simulation mode | Check drive protection'.
- Control Buttons:** A row of buttons at the bottom: 'Check Current', 'Run Workflow', 'Pause Workflow', 'Stop Workflow', 'Clear Run Data', 'Display Info', and 'Shutdown'.

Main Screen after initiation of Stage 3

In this example, a very short Stage 3 protocol is shown. Other Stage 3's may be as long as 9.5 hrs.

Main Screen | Workflow Editor | Log Review | System Options

Workflow File: Core_Workflows\CATCH DC55V extr 1h sep45m

Nest Configuration

01	✓		03	✓	
02	✓		04	✓	

Voltage, V: 54.2 | Lid Status: [Icon] | Lock Status: [Icon] | System Status: separate

Step Table

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Reple
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1

Electrophoresis Current and Sample Well Temperature

Legend:

I-1	13.5	[Green Arrow]
I-2	13.2	[Yellow Arrow]
T-1,2	0.0	[Red Arrow]
I-3	14.9	[Black Arrow]
I-4	14.7	[Blue Arrow]
T-3,4	0.0	[Light Blue Arrow]

Date and Time: 05 Mar 2018 17:56:47

Time to Next User Event: 02:11:22

Simulation mode | Check drive protection

Check Current | Run Workflow | Pause Workflow | Stop Workflow | Clear Run Data | Display Info | Shutdown

HLS-CATCH run completed

This run was simulated in software, so current traces may not be so smooth in a real run. Also, the separation stage used here was very short, other separations may be significantly longer.

IMPORTANT: To program next run, you must “Clear Run Data” from previous run.

The screenshot displays the SageHLS software interface with the following components:

- Workflow File:** Core_Workflows\CATCH DC55V extr 1h sep45m
- Nest Configuration:** Four rows of controls for nest configurations 01, 02, 03, and 04, each with a dropdown menu and a checkmark.
- System Status:** Voltage (0.0 V), Lid Status (closed), Lock Status (locked), and System Status (done).
- Step Table:**

Step	Description
1-001	pause for user action 'Remove contents of reagent well and sample
1-002	separate for 01:00:00 at 55.0 V with wave index 1-1
2-001	pause for user action 'Remove tape seal. Start Cas9 Reaction: Repl
2-002	separate for 00:01:00 at 55.0 V with wave index 2-1
2-003	pause for user action 'Replace sample well contents with 80ul of enz
2-004	incubate for 00:30:00
2-005	pause for user action 'Stop Reaction: Replace reagent well contents
3-001	separate for 00:45:00 at 55.0 V with wave index 3-1
3-002	elute for 01:30:00 at 50.0 V with wave index 3-1
3-003	reverse for 00:00:05 at 25.0 V with wave index 3-1
- Electrophoresis Current and Sample Well Temperature:** A dual-axis graph showing current (mA) on the left y-axis (0-80) and temperature (°C) on the right y-axis (-10 to 80) against time (hh:mm) on the x-axis (00:00 to 03:47). The current trace shows a step-wise increase from ~15 mA to ~35 mA. The temperature trace shows a step-wise increase from ~20°C to ~40°C.
- Temperature Legend:** A list of temperature points with checkboxes and color-coded arrows: I-1 (0.0, green), I-2 (0.0, yellow), T-1,2 (0.0, black), I-3 (0.0, red), I-4 (0.0, cyan), T-3,4 (0.0, blue).
- Date and Time:** 06 Mar 2018 08:52:46
- Time to Next User Event:** 00:00:00
- Simulation mode:** Check drive protection
- Control Buttons:** Check Current, Run Workflow, Pause Workflow, Stop Workflow, Clear Run Data (highlighted with a red arrow), Display Info, Shutdown.

Completion of HLS-CATCH Workflow

If possible, remove the eluted DNA within an hour of the end of the run to avoid contamination of the eluted DNA with SDS. The SDS is tightly localized around (+) separation electrode at end of run, but will slowly diffuse throughout the cassette over a period of several hours.

Remove port sealing tapes by pulling the sealing tape tabs in a diagonal direction as discussed previously. (Removing the tape in this manner reduces the risk of introducing liquids from the Reagent or Sample well ports into the elution modules.)

If targeting DNA >100kb, use a wide-bore pipette tip to remove the contents of the elution modules.

IMPORTANT: When working with DNA >100kb, pipette as slowly as possible to avoid shearing the HMW DNA. Use of an electronic pipettor at low speed settings may be helpful.

There should be 70-80 ul of liquid in each module.

Analysis of HLS-CATCH products

To identify the position of CATCH targets in the elution products, we recommend the following procedures:

- 1) Perform a Qubit HS assay to determine total DNA content. (Use 2-5 ul aliquots of elution product.)
- 2) Perform a qPCR assay on all 6 elution products for CATCH target and non-target (control) genomic sequences to obtain target copy numbers for each EM.

The Qubit assay will give a semi-quantitative evaluation of the quality of the CATCH procedure. When using the 3hr Stage 1 extraction, there is very little total DNA in elution modules 1-5, usually ~2 ng per 80ul, while there will be more in EM #6, sometimes 20-30 ng per 80ul. When using the 1 hr Stage 1 extraction, there will be at least 10 ng of DNA (range 10ng to 200ng) in all elution modules, with higher concentrations in EM #1-3 (up to 200ng).

Whenever possible we prefer to use the “custom” Taqman qPCR assays available from Thermo Life Technologies, but also use the SYBR green kits for regions outside of genes. When using the 1 hour Stage1 extraction we typically see single-plex CATCH target enrichment factors of 15-50x relative to a single copy reference gene like the human RNaseP RNA gene. When using the 3 hr Stage 1 extraction with an input of 300,000-400,000 diploid mammalian cells, we have gotten enrichment factors as high as 700-fold.

Examples of CATCH target analyses: qPCR and Qubit HS data

200kb and 400kb targets from mouse Brca1 locus
375,000 WBC input load

