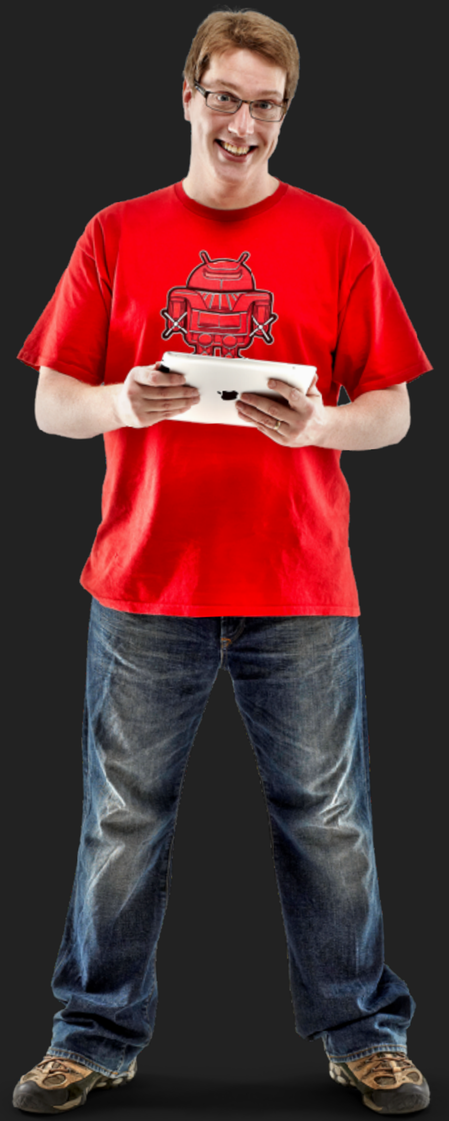
PAUL HUDSON – @twostraws

HOW TO INSTRUMENT YOUR CODE LIKE YOU MEAN IT



WHO AM I?


SAMSUNG
12:45
Sun, February 21
SAMSUNG
Galaxy S7


XBOX 360


iPad


Fender®


UBS


HACKING
WITH SWIFT
LEARN iOS DEVELOPMENT WITH REAL WORLD PROJECTS


HACKING WITH
macOS
LEARN macOS DEVELOPMENT WITH REAL WORLD PROJECTS


HACKING WITH
watchOS
LEARN TO BUILD WATCHOS APPS WITH REAL-WORLD PROJECTS


HACKING WITH
tvOS
LEARN TO BUILD tvOS APPS WITH REAL-WORLD PROJECTS


SERVER-SIDE
SWIFT
LEARN TO BUILD SWIFT WEBSITES WITH REAL-WORLD PROJECTS


PRO
SWIFT
BREAK OUT OF BEGINNER'S SWIFT WITH THIS HANDS-ON GUIDE


Practical
iOS 11
LEARN TO BUILD iOS 11 APPS WITH REAL-WORLD PROJECTS


SWIFT
CODING CHALLENGES
FROM THE AUTHOR OF HACKING WITH SWIFT AND PRO SWIFT


DIVE INTO
SPRITEKIT
CODE YOUR OWN GAMES BY CHOOSING WHAT SHOULD HAPPEN


2017
SWIFT COMMUNITY AWARDS
SWIFT
COMMUNITY
AWARDS


HACKING WITH
SWIFT: Live!

GET IN TOUCH!

- @twostraws on Twitter
- twostraws on GitHub
- twostraws on Reddit
- twostraws on StackOverflow
- paul@hackingwithswift.com

gum.co/proswift/pragma

INSTRUMENTS!

(aka Apple’s profiling power tools)

TODAY'S PLAN

- Why instrument
- What to instrument
- When to instrument
- **How to instrument**

WHY?


“But iOS is so fast – why bother?”


Settings
Battery
Low Power Mode
Battery Percentage
Last 24 Hours
Last 7 Days
Tweetbot
Home & Lock Screen
Facebook
Photos
Camera


CONE OF
SHAME


“Swift doesn’t have all that memory management pain of Objective-C.”


OBJECTION!

MEMORY MANAGEMENT

- Capture lists: `[unowned self]`
- `weak` keyword
- Implicit retains
- Reference types

ALL ABOARD THE FAILBOAT

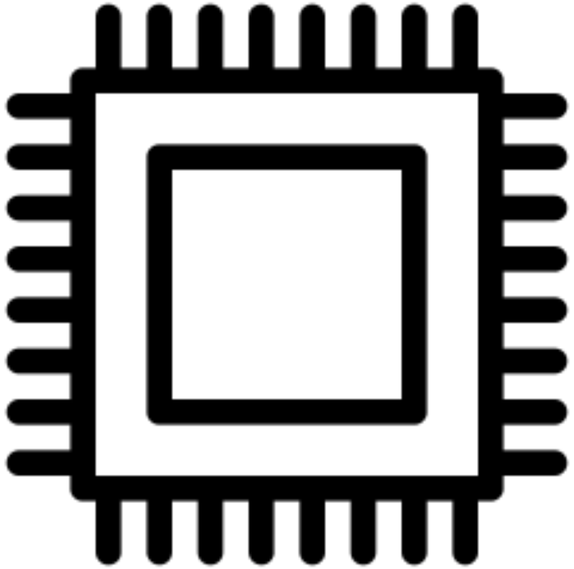
WHAT?

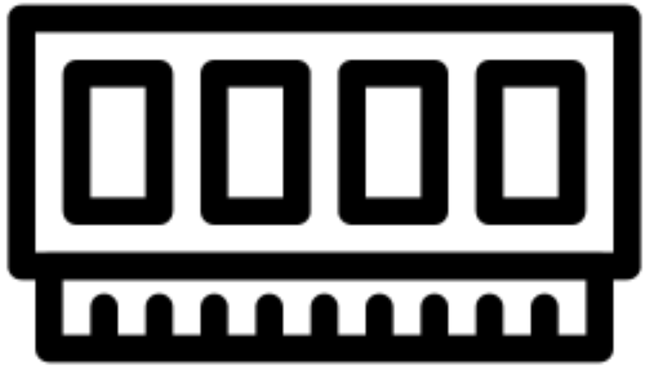
Q: Which methods should be instrumented?

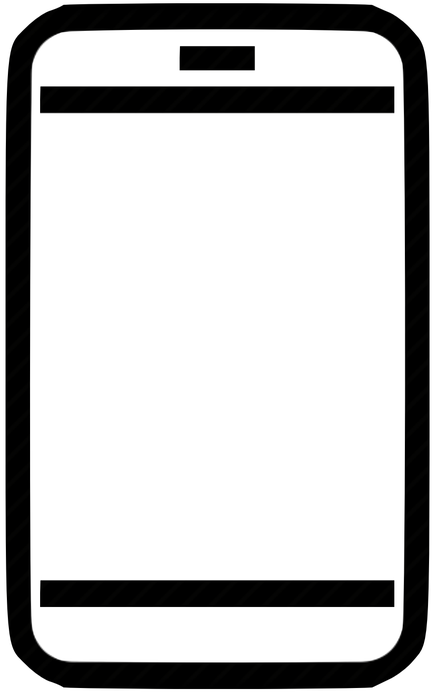
A: Only the ones you don’t want to leak.

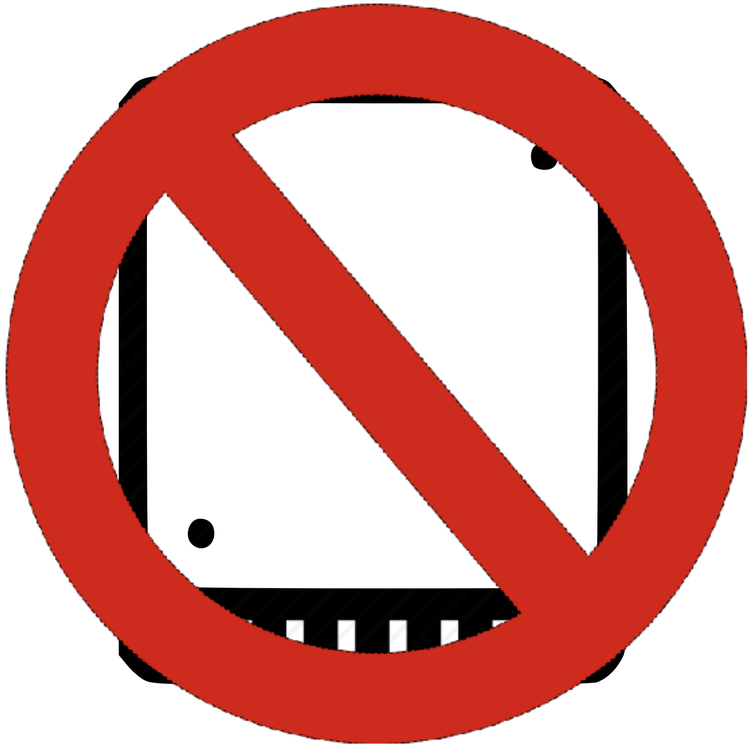
WHERE MEMORY GOES

- Abandoned memory
- Lost memory
- Caches







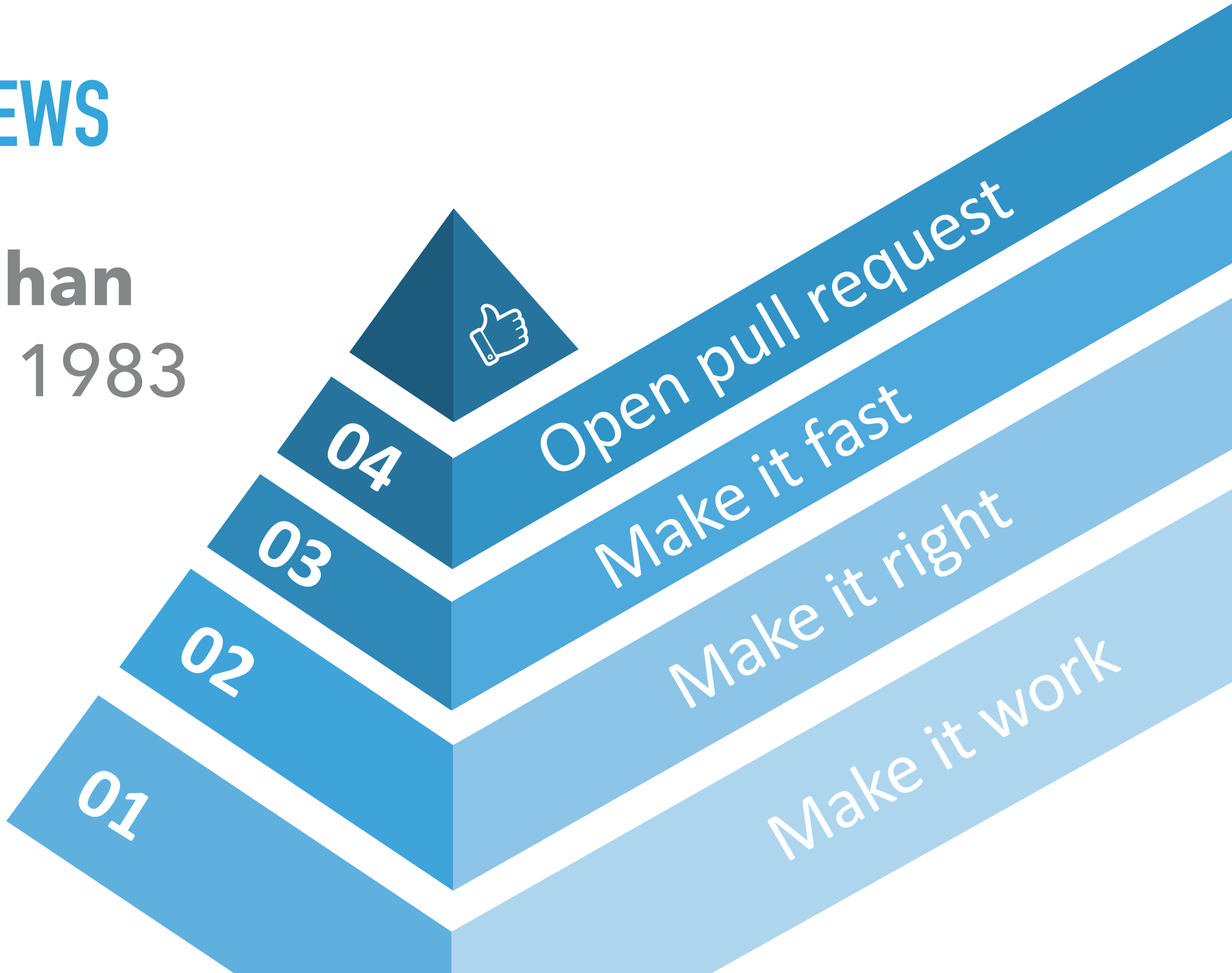


WHEN?


Cr ate Pu Requ st

THIS ISN'T NEWS

Brian Kernighan
Byte Journal, 1983



TAKES LESS TIME

PROFILE **EARLY**

PROFILE **OFTEN**

“I’m sorry, I can’t hear you over the sound how how awesome I am.”

TODAY'S PLAN

- ~~Why instrument~~
- ~~What to instrument~~
- ~~When to instrument~~
- How to instrument

HOW?

A SAMPLE APP

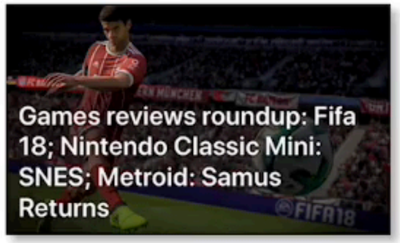
- Downloads* news stories from the internet.
- Renders titles onto images.
- Shown as UICollectionView.
- Tapping a story shows its content.
- Story content scrolls automatically.

09:41 100%

Technology News


Introducing the new celebrity accessory: bitcoin-style cryptocurrencies


Cuphead review: come for the 1930s visuals, stay for the hard-earned thrills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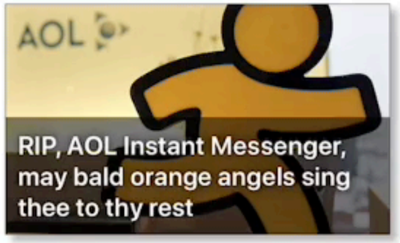

RIP, AOL Instant Messenger, may bald orange angels sing thee to thy rest


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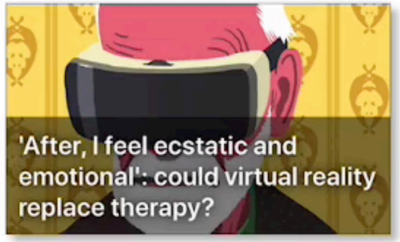
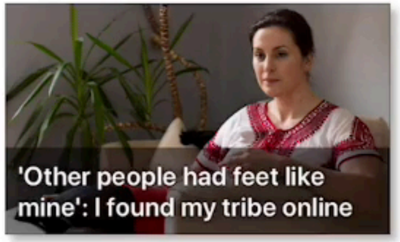
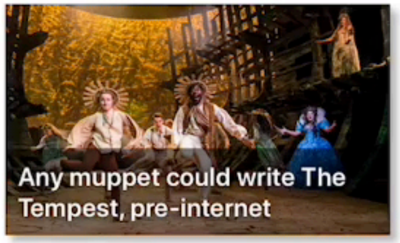
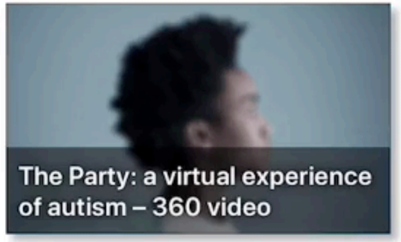
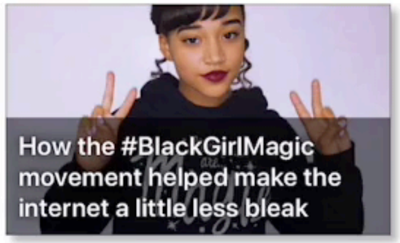

'After, I feel ecstatic and emotional': could virtual reality replace therapy?

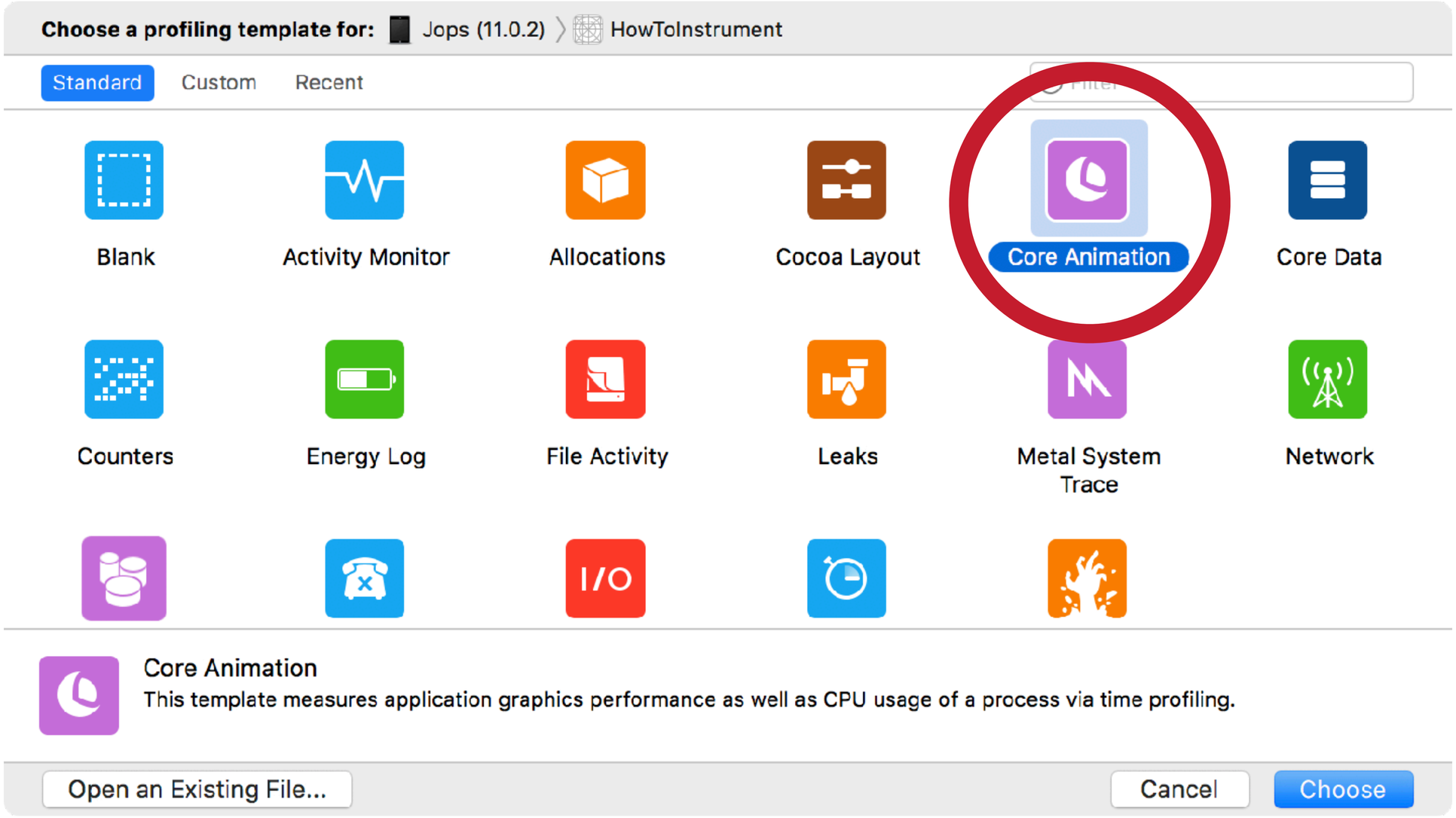

'Other people had feet like mine': I found my tribe online


Any muppet could write The Tempest, pre-internet


The Party: a virtual experience of autism – 360 video


How the #BlackGirlMagic movement helped make the internet a little less bleak


The road ahead for Uber and capitalism


Choose a profiling template for: Jops (11.0.2) HowToInstrument
Standard
Custom
Recent
Blank
Activity Monitor
Allocations
Cocoa Layout
Core Animation
Core Data
Counters
Energy Log
File Activity
Leaks
Metal System Trace
Network
I/O
Core Animation
This template measures application graphics performance as well as CPU usage of a process via time profiling.
Open an Existing File...
Cancel
Choose

Instruments5

Jops (11.0.2) 〉 HowToInstrument

Run 3 of 3 | 00:00:00

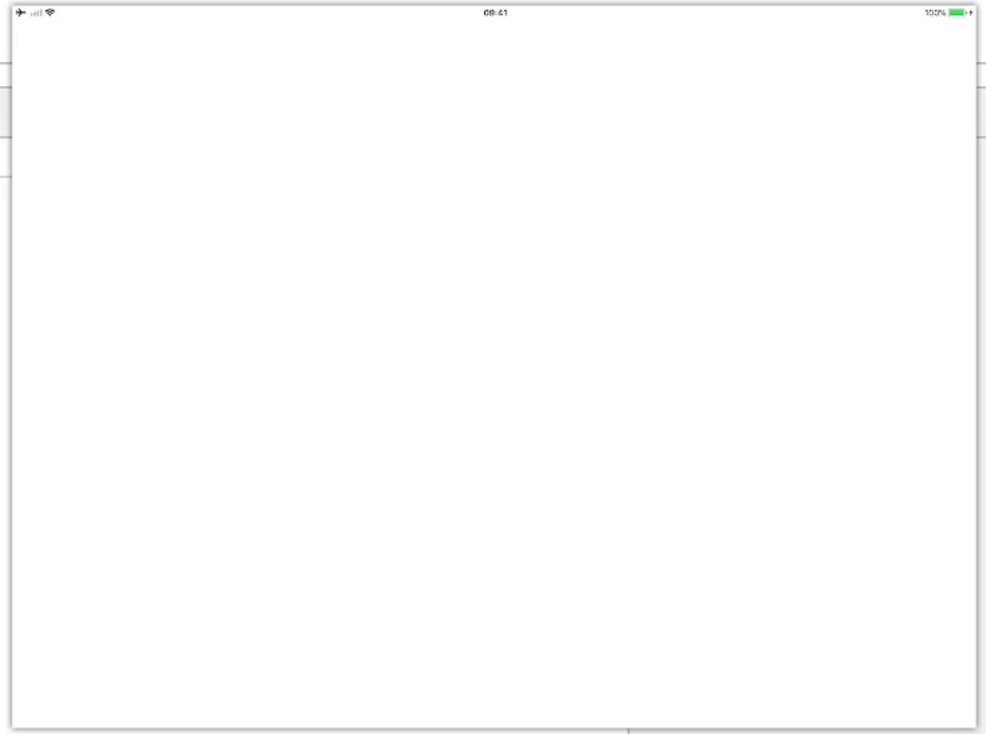
Track Filter

All | Instruments | Threads | CPUs

00:00.000 | 00:10.000 | 00:20.000 | 00:30.000 | 00:40.000 | 00:50.000 | 01:00.000 | 01:10.000 | 01:20.000 | 01:30.000 | 01:40

Frames Per Second

CPU Usage



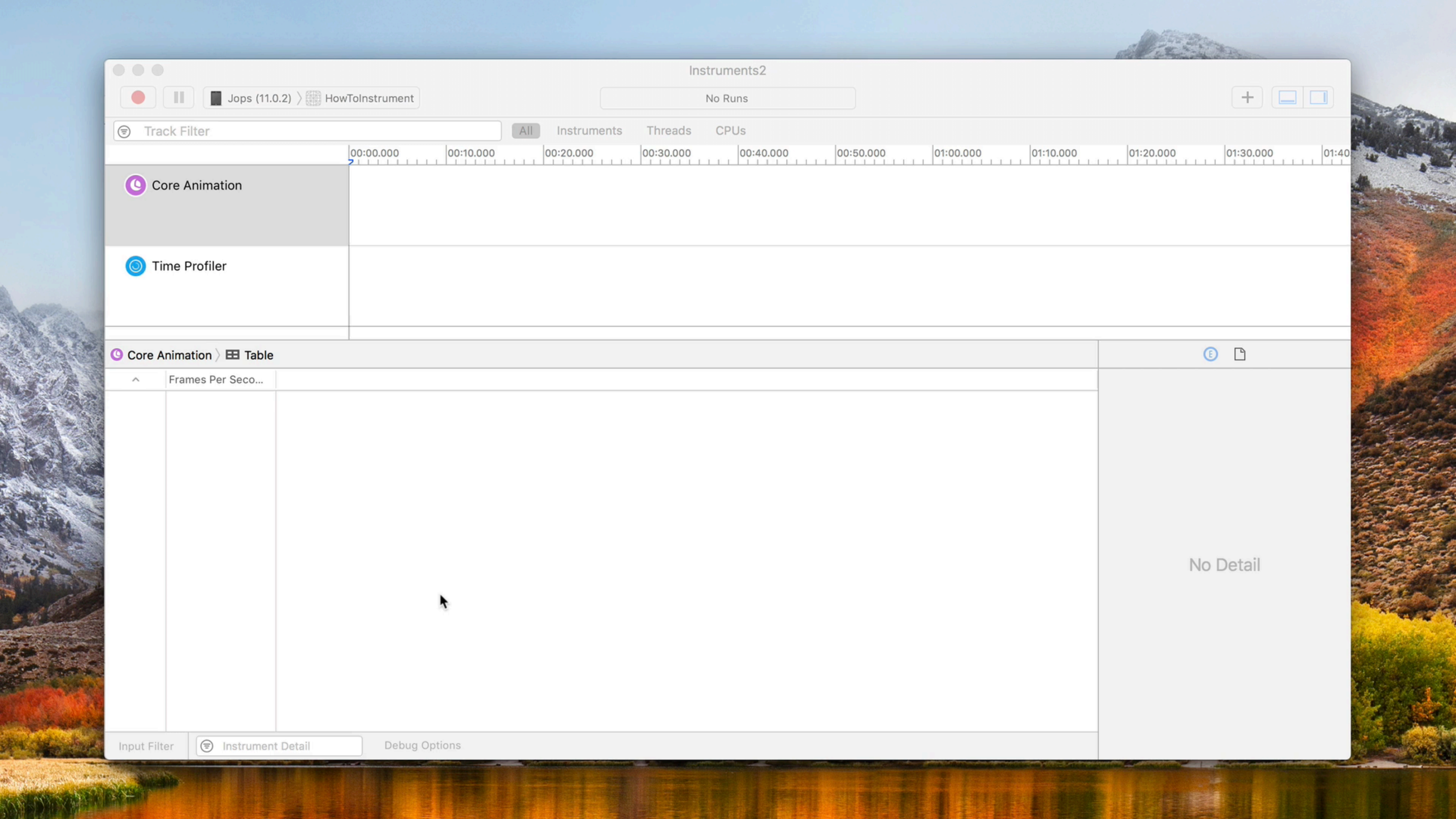
Core Animation 〉 Table

Frames Per Seco...

Input Filter | Instrument Detail | Debug Options

ProMotion

120Hz


Instruments2
Jops (11.0.2)
HowToInstrument
No Runs
Track Filter
All
Instruments
Threads
CPUs
00:00.000
00:10.000
00:20.000
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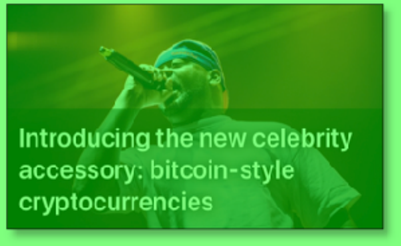
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
Core Animation
Time Profiler
Core Animation
Table
Frames Per Seco...
No Detail
Input Filter
Instrument Detail
Debug Options

```
let config = UIGraphicsImageRendererFormat()
config.opaque = true
let renderer = UIGraphicsImageRenderer(size: size, format: config)
```

Pad 11:04 100%

Technology News



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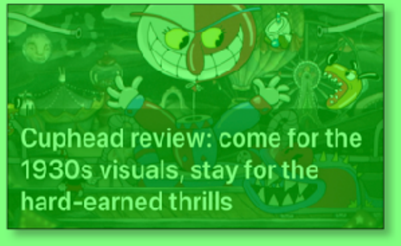

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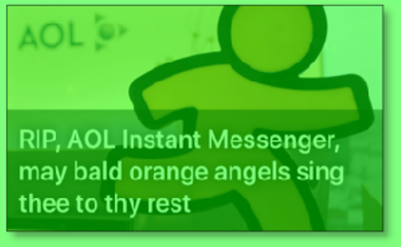

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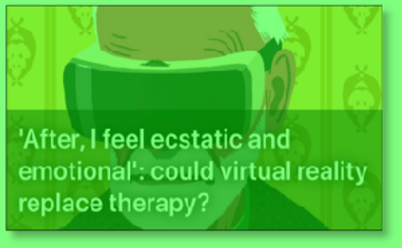

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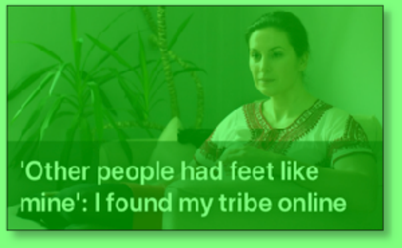

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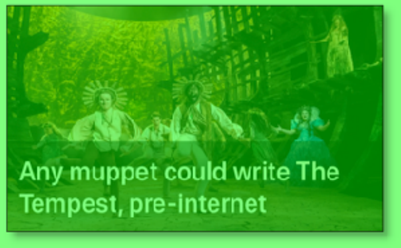

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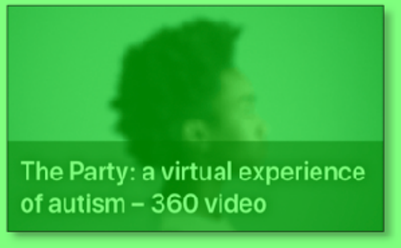

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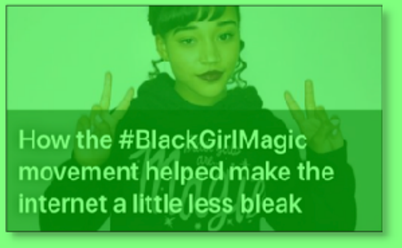

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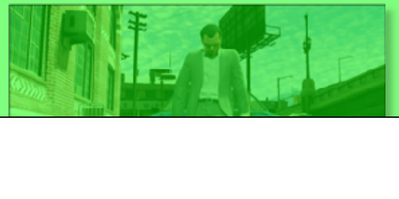

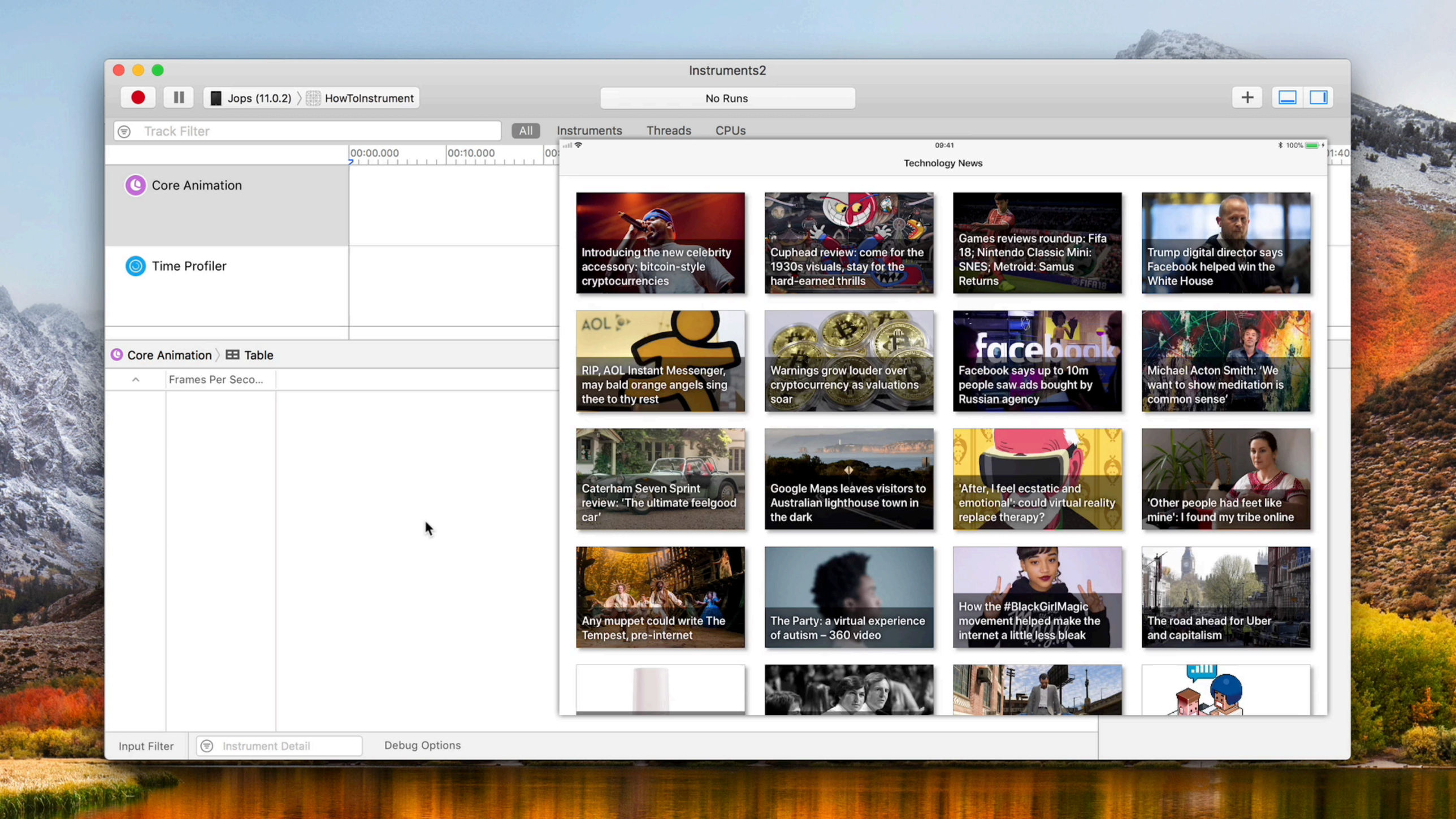
Instruments2
Jops (11.0.2)
HowToInstrument
No Runs
Track Filter
All
Instruments
Threads
CPUs
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Core Animation
Time Profiler
Core Animation
Table
Frames Per Seco...
Input Filter
Instrument Detail
Debug Options
09:41
100%
Technology News
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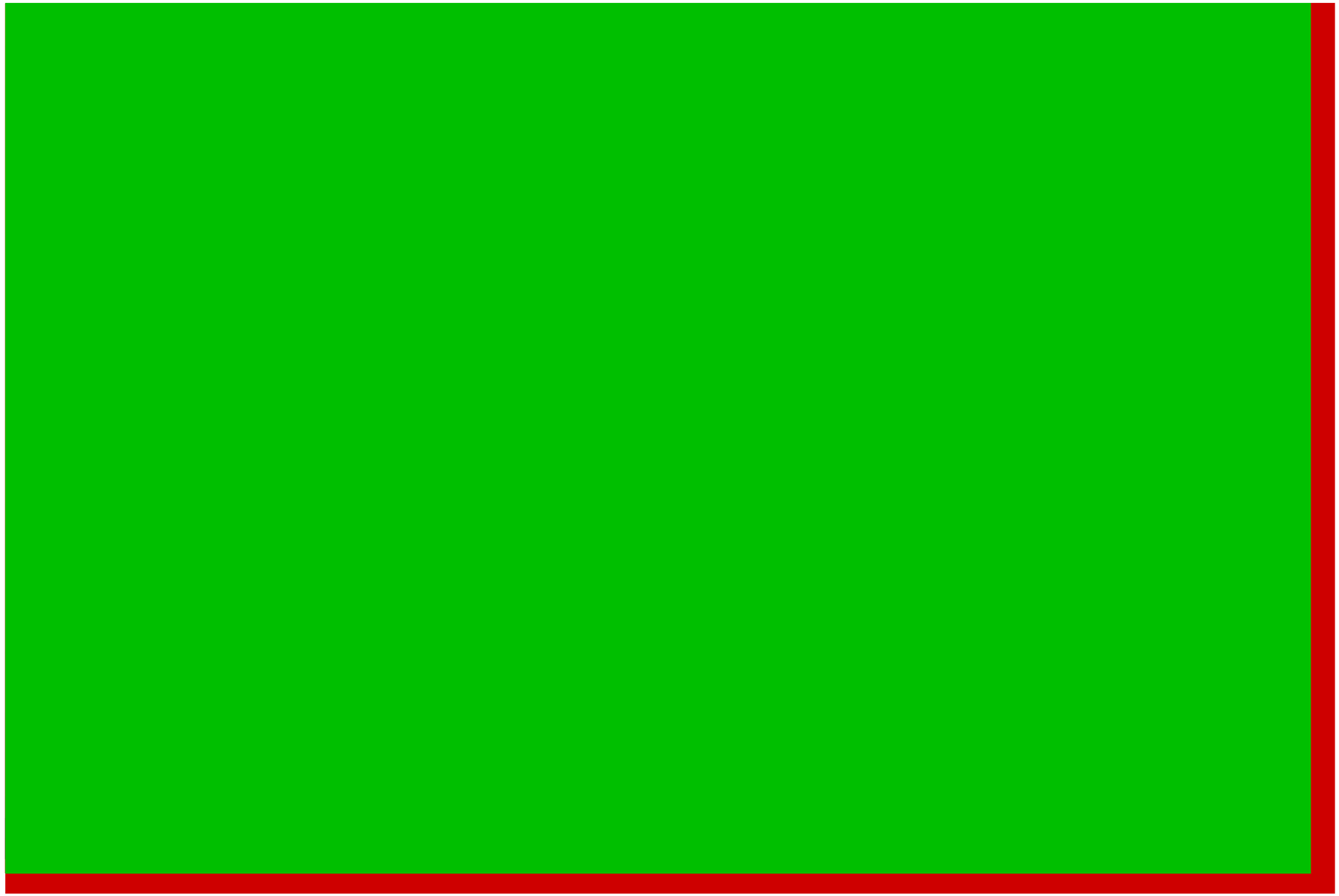
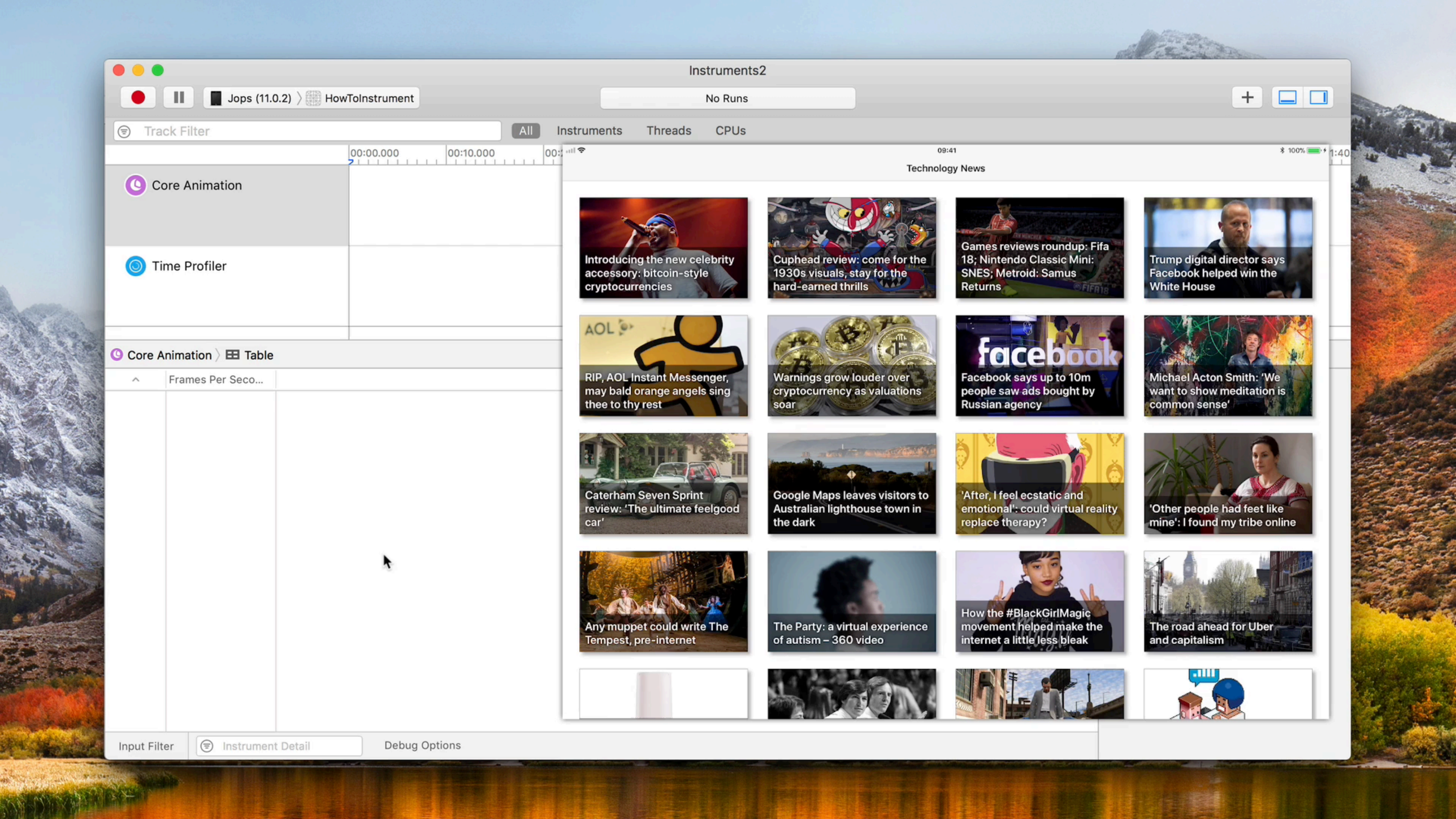


```
let drawRect = CGRect(x: 0, y: 0, width: 300, height: 170)
```

Bad: Generating an image based on hard-coded values

```
if let layout = collectionViewLayout as? UICollectionViewFlowLayout {
    let width = layout.itemSize.width
    let height = layout.itemSize.height
    let drawRect = CGRect(x: 0, y: 0, width: width, height: height)
    ...
}
```

Better: reading values from the view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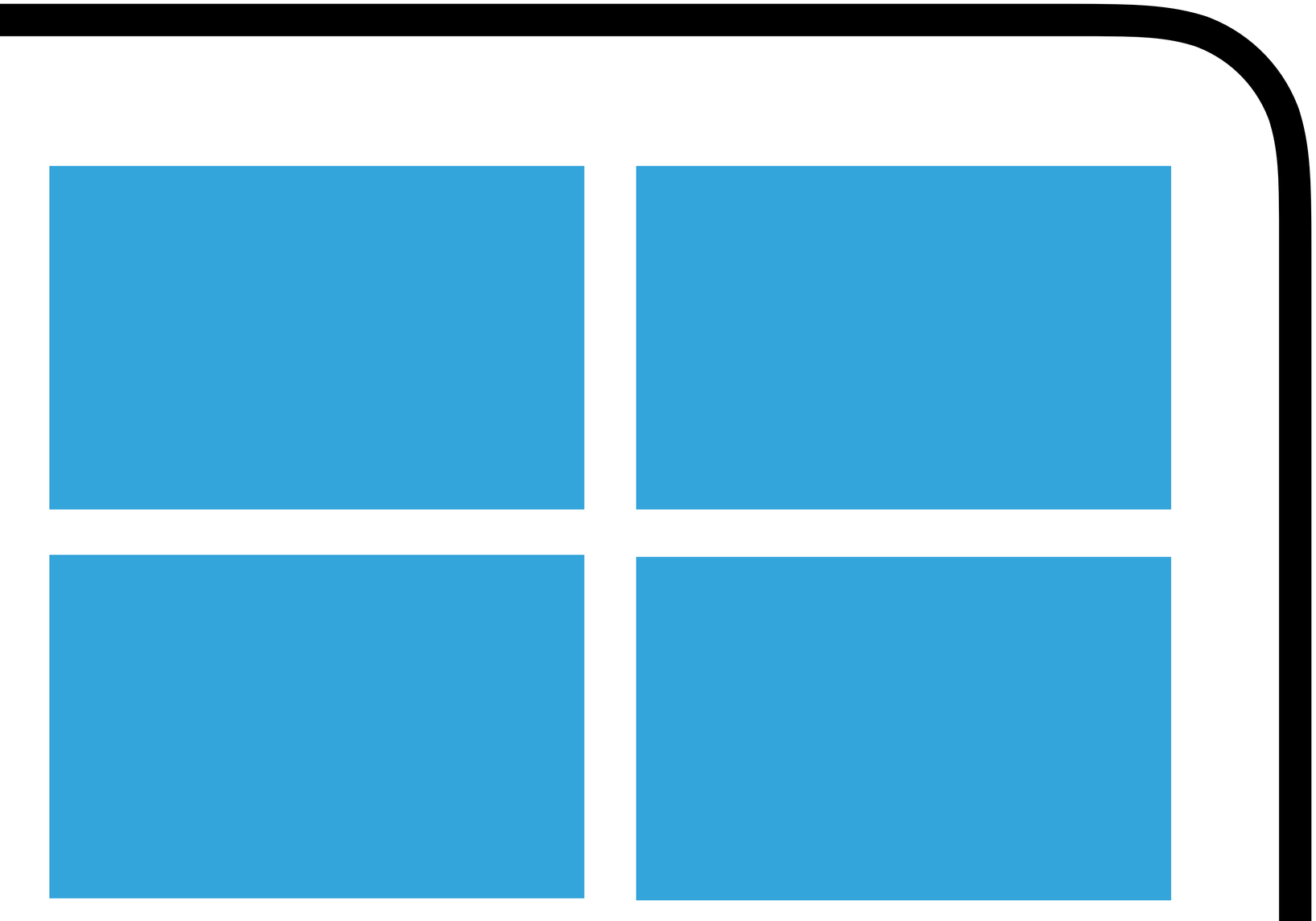
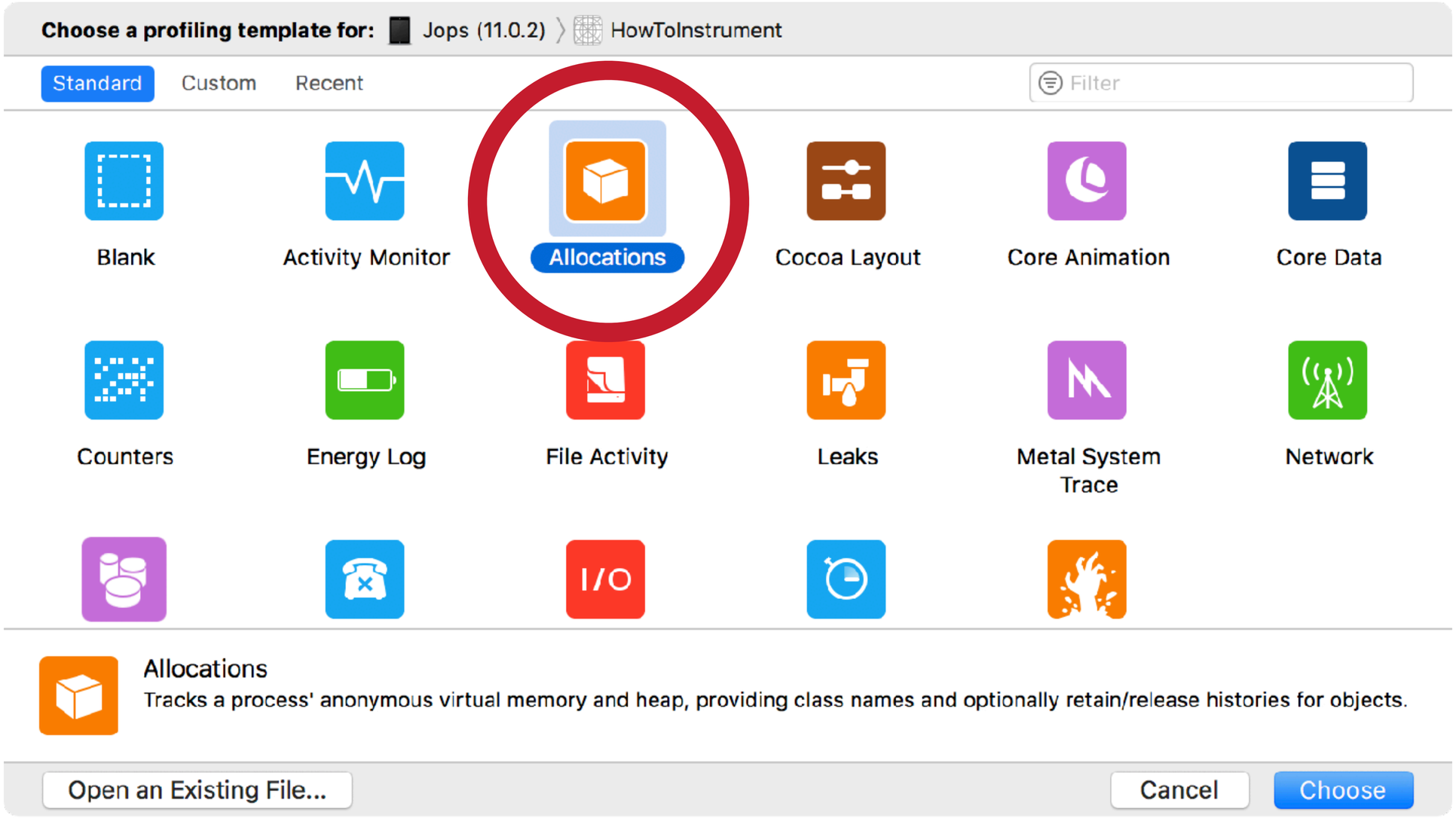


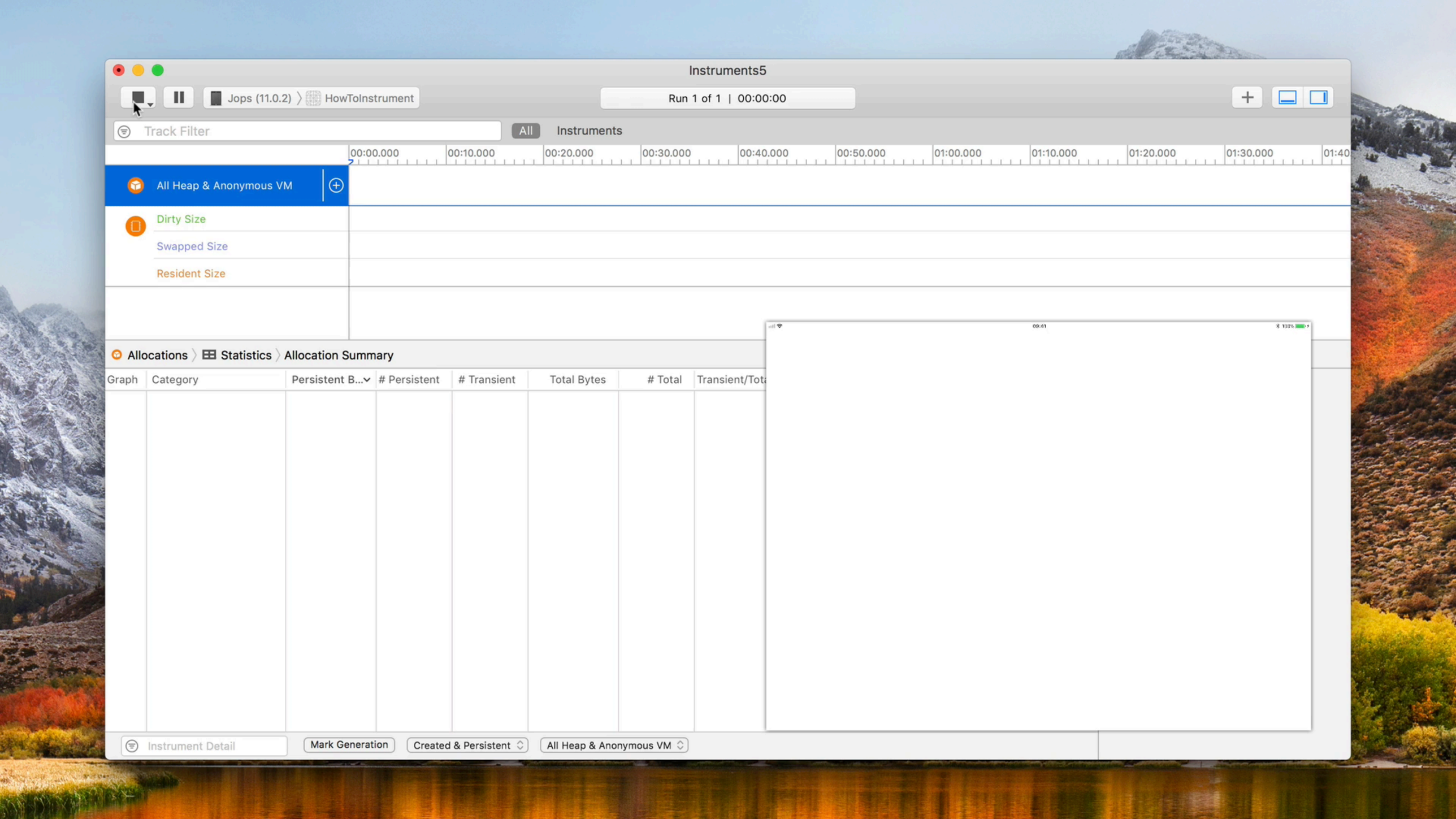
```
cell.layer.shadowOpacity = 0.3
cell.layer.shadowOffset = CGSize(width: 5, height: 5)

let rect = CGRect(x: 0, y: 0, width: item.width, height: item.height)
let path = UIBezierPath(rect:  rect).cgPath
cell.layer.shadowPath = path
```

DRAWING SPEEDBUMPS

- Avoid blending.
- Draw at natural size.
- Skip second draw pass.
- Combined: ~10fps in this project.
- From 56-77fps to 65-80fps


Meh


Choose a profiling template for: Jops (11.0.2) HowToInstrument
Standard
Custom
Recent
Filter
Blank
Activity Monitor
Allocations
Cocoa Layout
Core Animation
Core Data
Counters
Energy Log
File Activity
Leaks
Metal System Trace
Network
I/O
Allocations
Tracks a process' anonymous virtual memory and heap, providing class names and optionally retain/release histories for objects.
Open an Existing File...
Cancel
Choose


Instruments5
Jops (11.0.2)
HowToInstrument
Run 1 of 1 | 00:00:00
Track Filter
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Instruments
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00:10.000
00:20.000
00:30.000
00:40.000
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01:00.000
01:10.000
01:20.000
01:30.000
All Heap & Anonymous VM
Dirty Size
Swapped Size
Resident Size
Allocations
Statistics
Allocation Summary
Graph
Category
Persistent B...
Persistent
Transient
Total Bytes
Total
Transient/Tota
Instrument Detail
Mark Generation
Created & Persistent
All Heap & Anonymous VM


iPad
19:05
100%
Technology News
1
2
3
4
5
6
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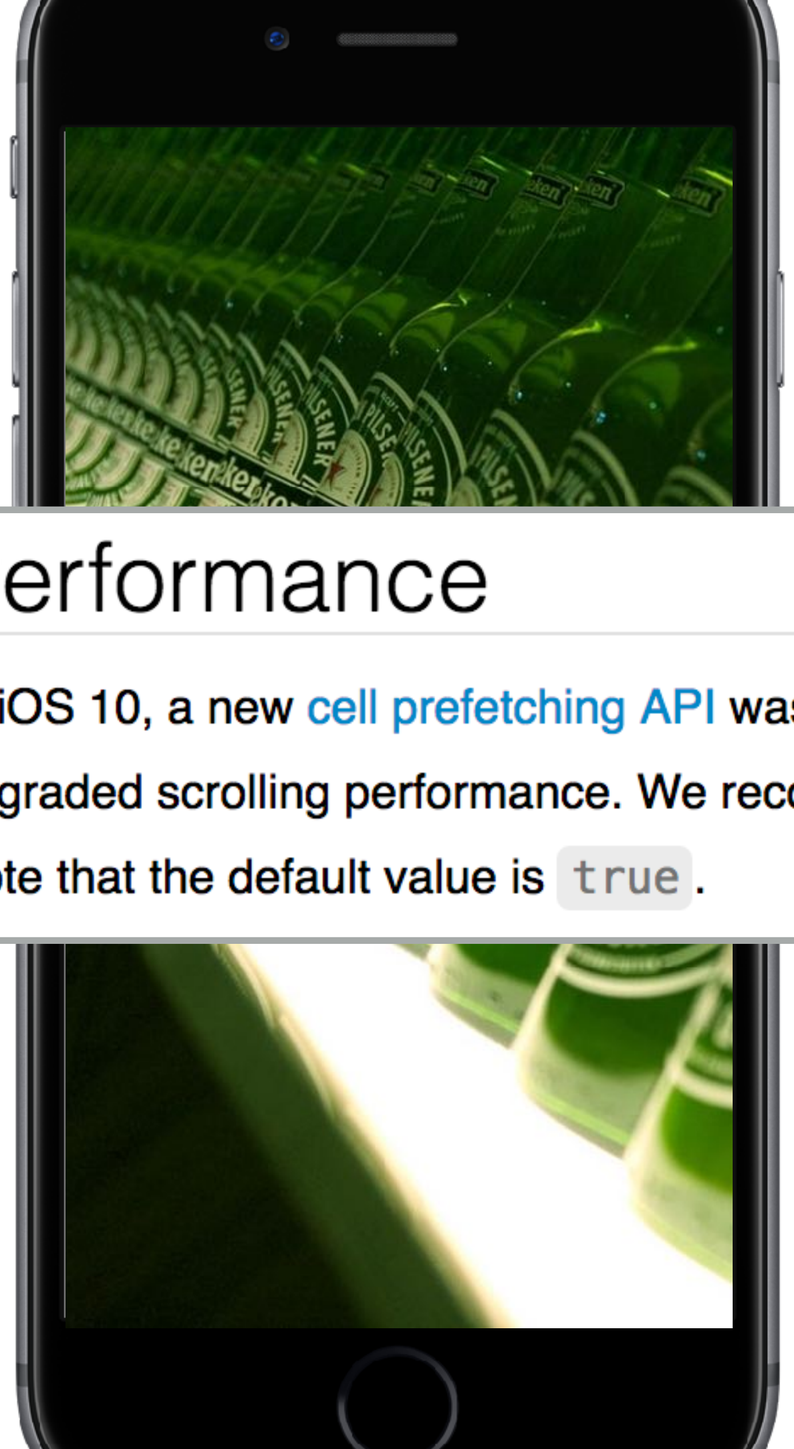
ProMotion

0.0083 120Hz



UICOLLECTIONVIEW PREFETCH

- Loads more collection view items

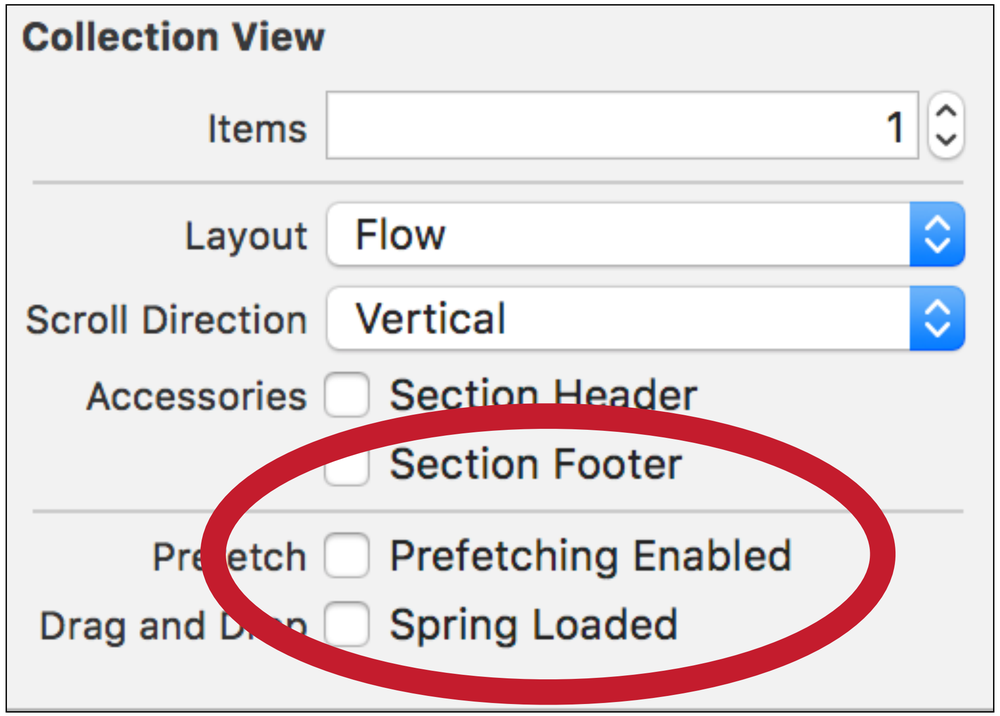
Performance

In iOS 10, a new cell prefetching API was introduced. At Instagram, enabling this feature substantially degraded scrolling performance. We recommend setting `isPrefetchingEnabled` to `NO` (`false` in Swift). Note that the default value is `true`.

people disable it.

- Test it for yourself.

```
collectionView?.isPrefetchingEnabled = true
```



Swapped Size

Resident Size

Allocations 〉 Statistics 〉 Allocation Summary

Graph	Category	Persistent B...	# Persistent	# Transient	Total Bytes	# Total	Transie
☐	UICollectionViewCell	26.12 KiB	44	0	26.12 KiB	44	

DRAWING SPEEDBUMPS

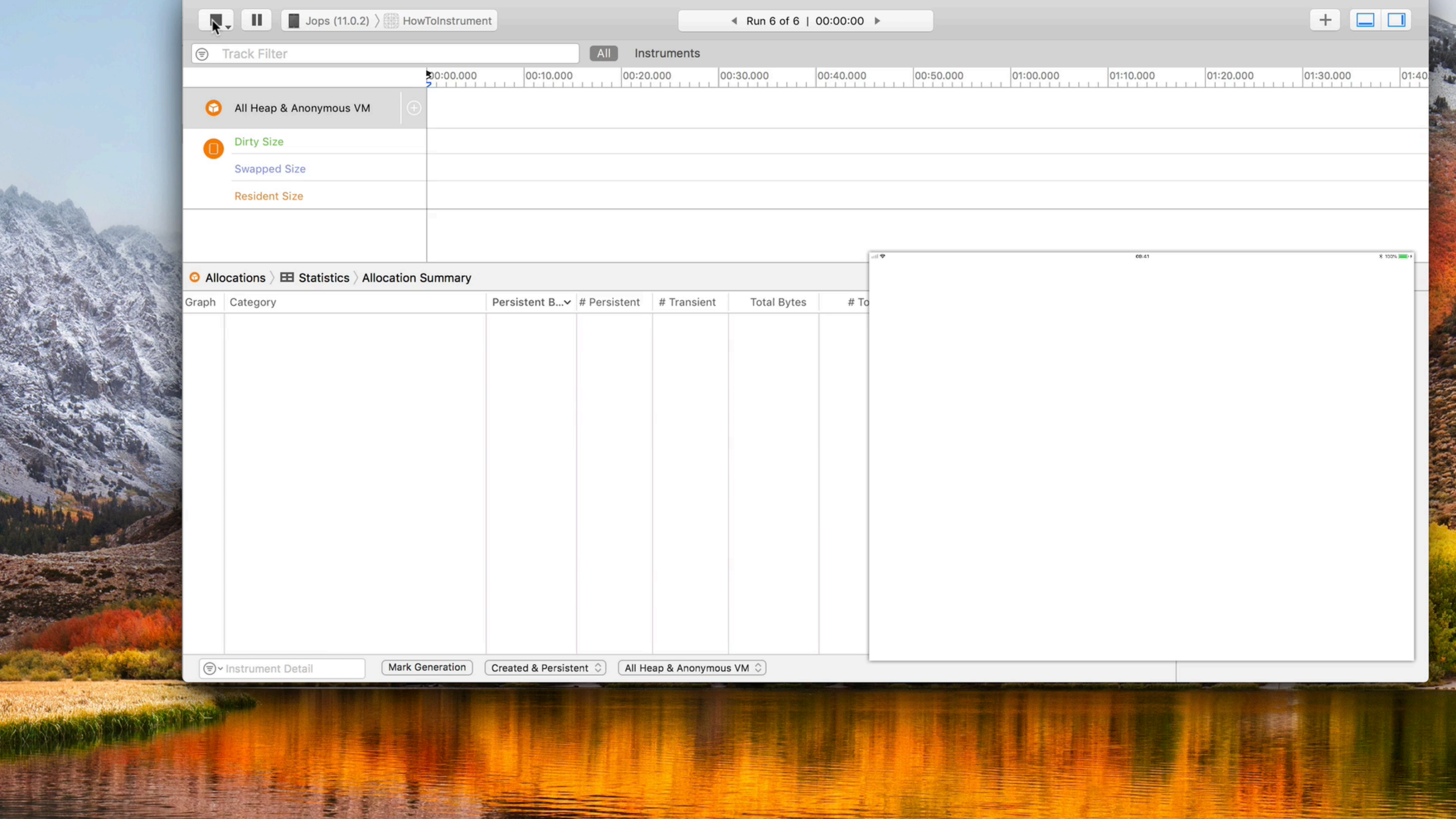
- Avoid blending.
- Draw at natural size.
- Skip second draw pass.
- Combined: ~10fps in this project.
- From 56-77fps to 65-80fps.
- Now at ~110fps.

WHERE MEMORY GOES

- Abandoned memory
- Lost memory
- Caches

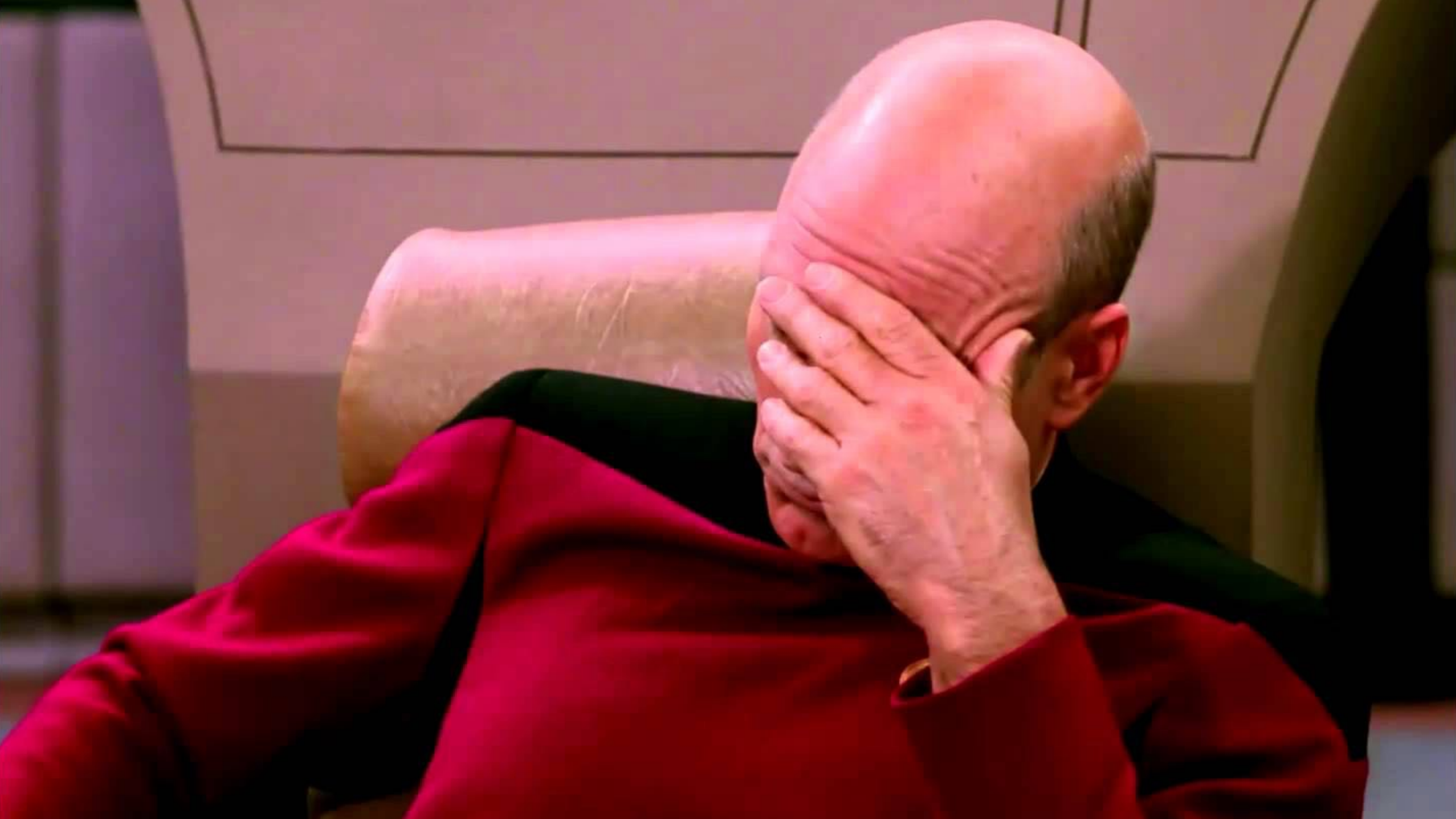
WHERE MEMORY GOES

- Abandoned memory
- Lost memory
- Caches


Jops (11.0.2)
HowToInstrument
Run 6 of 6 | 00:00:00
Track Filter
All
Instruments
00:00.000
00:10.000
00:20.000
00:30.000
00:40.000
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
All Heap & Anonymous VM
Dirty Size
Swapped Size
Resident Size
Allocations
Statistics
Allocation Summary
Graph
Category
Persistent B...
Persistent
Transient
Total Bytes
Instrument Detail
Mark Generation
Created & Persistent
All Heap & Anonymous VM

```
detail.delegate = self
present(detail, animated: true)
```

```
var delegate: ViewController?
```

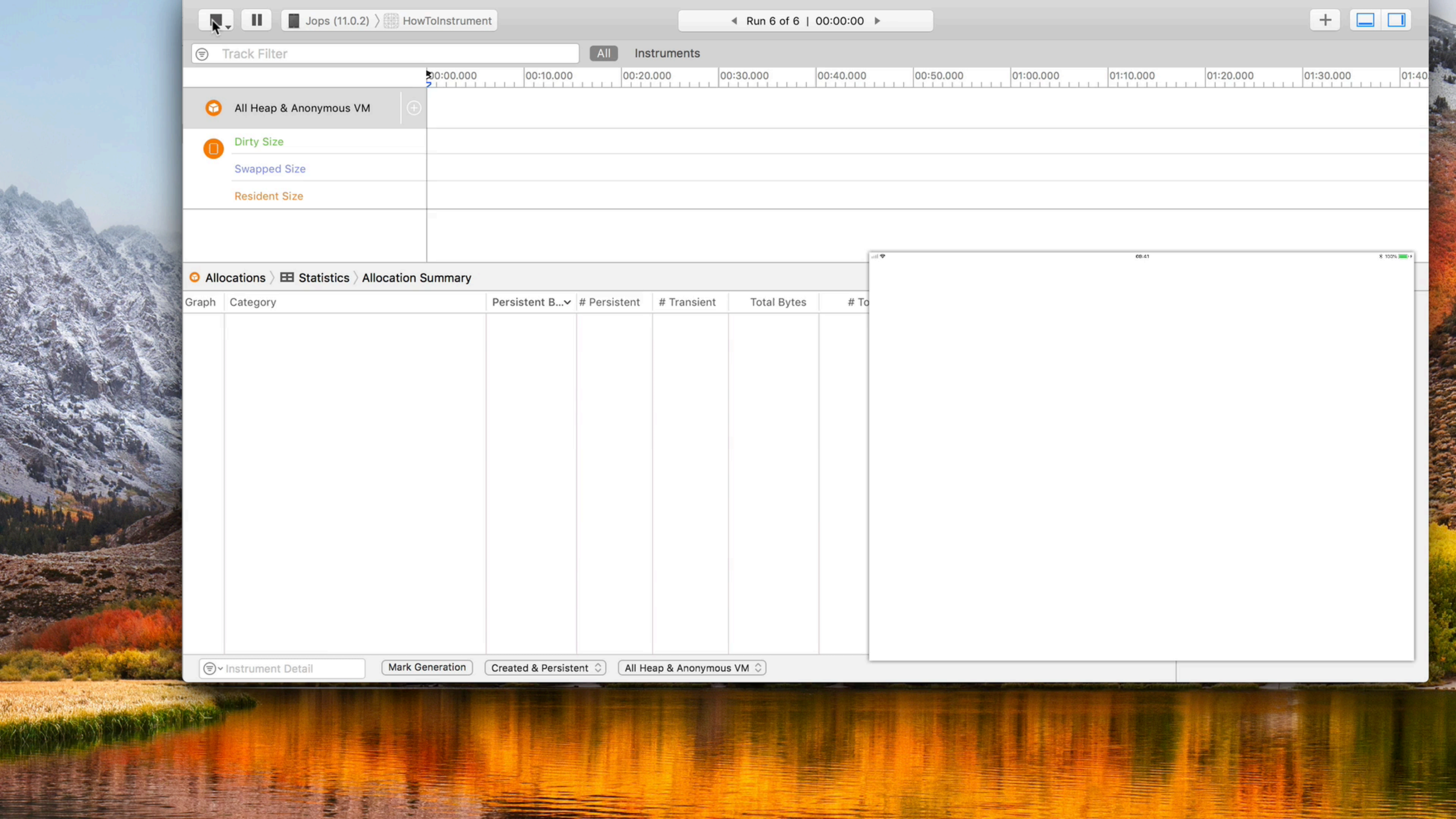


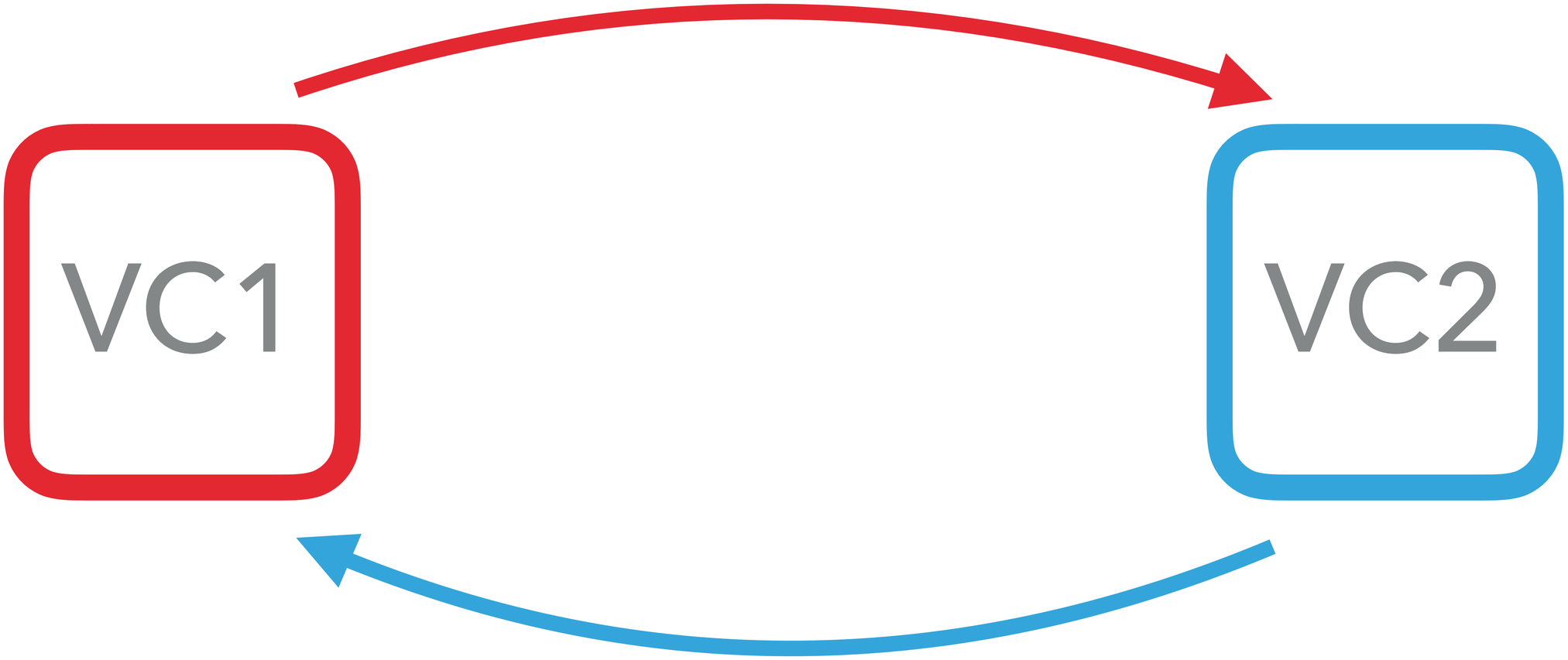
MEMORY MANAGEMENT

- Capture lists: `[unowned self]`
- **`weak`** keyword
- Implicit retains
- Reference types

```
detail.delegate = self
present(detail, animated: true)
```

```
var delegate: ViewController?
```


Jops (11.0.2)
HowToInstrument
Run 6 of 6 | 00:00:00
Track Filter
All
Instruments
00:00.000
00:10.000
00:20.000
00:30.000
00:40.000
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
All Heap & Anonymous VM
Dirty Size
Swapped Size
Resident Size
Allocations
Statistics
Allocation Summary
Graph
Category
Persistent B...
Persistent
Transient
Total Bytes
Instrument Detail
Mark Generation
Created & Persistent
All Heap & Anonymous VM


VC1
VC2

MEMORY MANAGEMENT

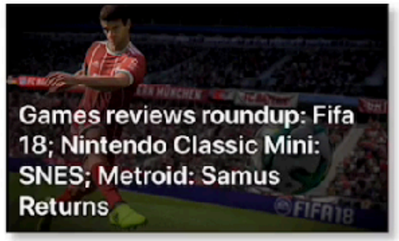
- Capture lists: `[unowned self]`
- **`weak`** keyword
- Implicit retains
- Reference types

09:41 100%

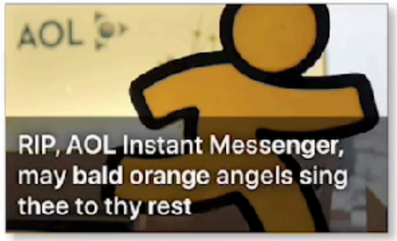
Technology News


Introducing the new celebrity accessory: bitcoin-style cryptocurrencies


Cuphead review: come for the 1930s visuals, stay for the hard-earned thrills


Games reviews roundup: Fifa 18; Nintendo Classic Mini: SNES; Metroid: Samus Returns


Trump digital director says Facebook helped win the White House



RIP, AOL Instant Messenger, may bald orange angels sing thee to thy rest

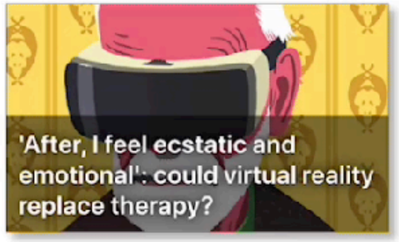

Warnings grow louder over cryptocurrency as valuations soar

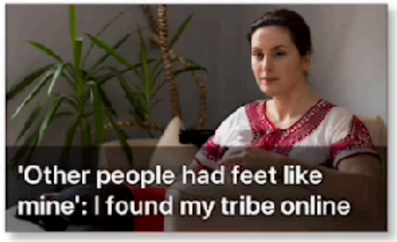
Facebook says up to 10m people saw ads bought by Russian agency

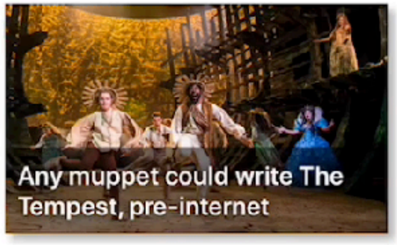

Michael Acton Smith: 'We want to show meditation is common sense'


Caterham Seven Sprint review: 'The ultimate feelgood car'

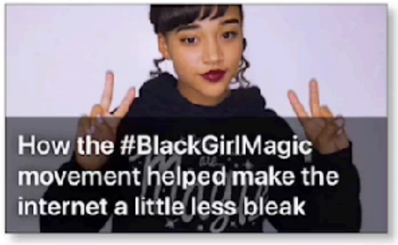

Google Maps leaves visitors to Australian lighthouse town in the dark


'After, I feel ecstatic and emotional': could virtual reality replace therapy?


'Other people had feet like mine': I found my tribe online


Any muppet could write The Tempest, pre-internet


The Party: a virtual experience of autism – 360 video


How the #BlackGirlMagic movement helped make the internet a little less bleak


The road ahead for Uber and capitalism

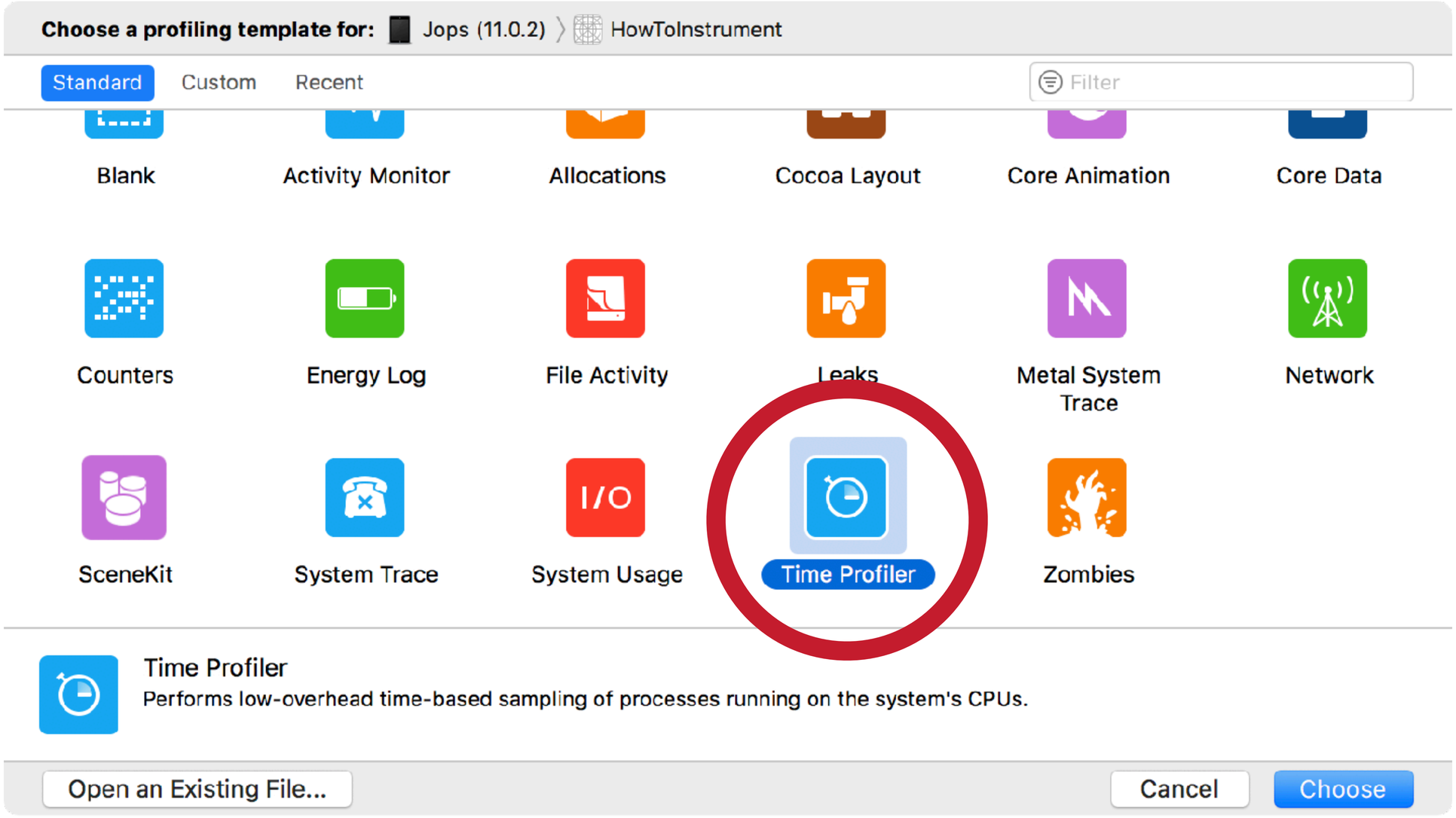
```
timer = Timer.scheduledTimer(timeInterval: 1,
                               target: self,
                             selector: #selector(scroll),
                             userInfo: nil,
                              repeats: true)
```

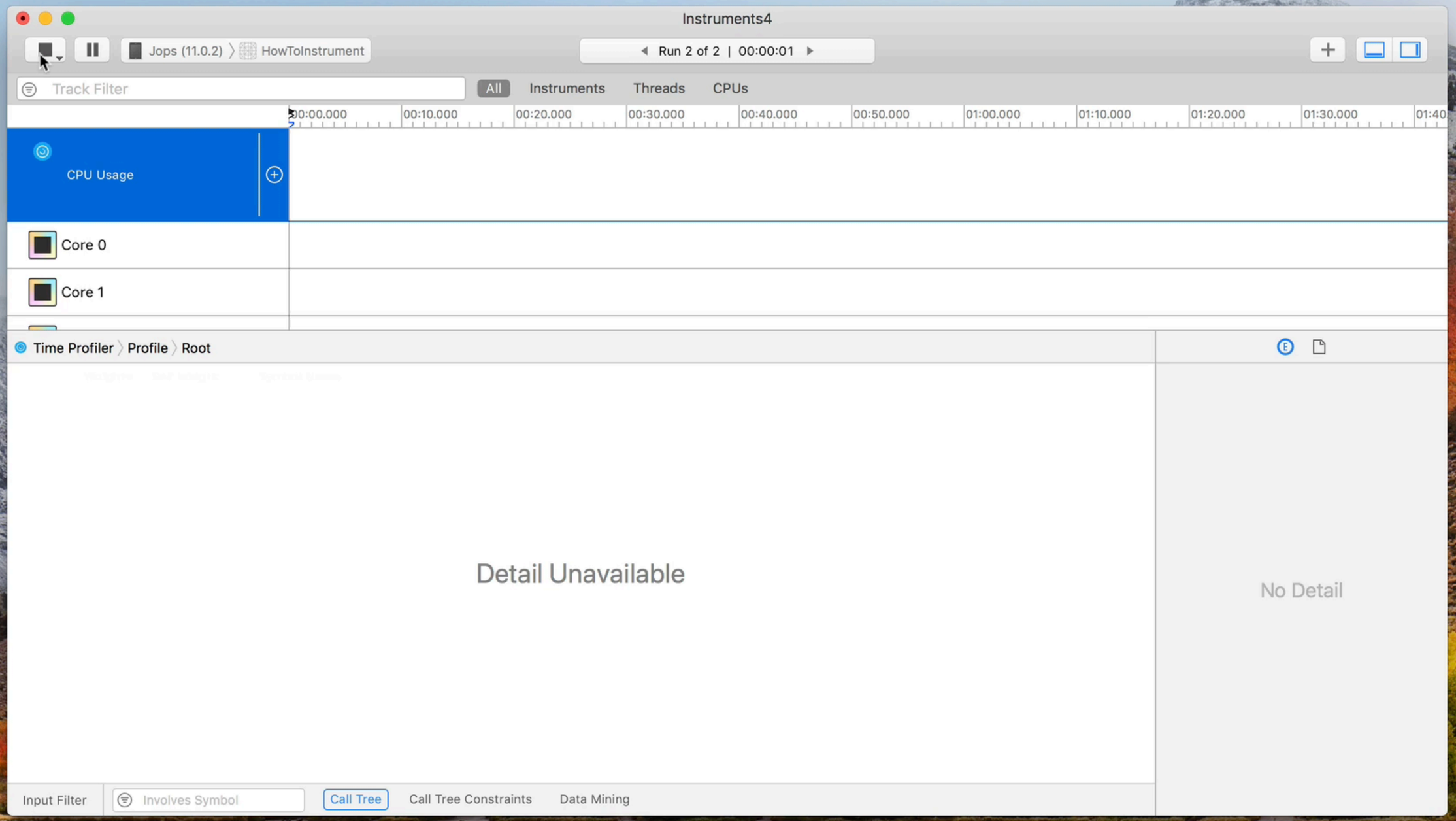
`target`

The object to which to send the message specified by a `Selector` when the timer fires. The timer maintains a strong reference to `target` until it (the timer) is invalidated.

```
override func viewWillDisappear(_ animated: Bool) {
    super.viewWillDisappear(animated)
    timer?.invalidate()
}
```

UNITED FEDERATION OF AWESOMENESS

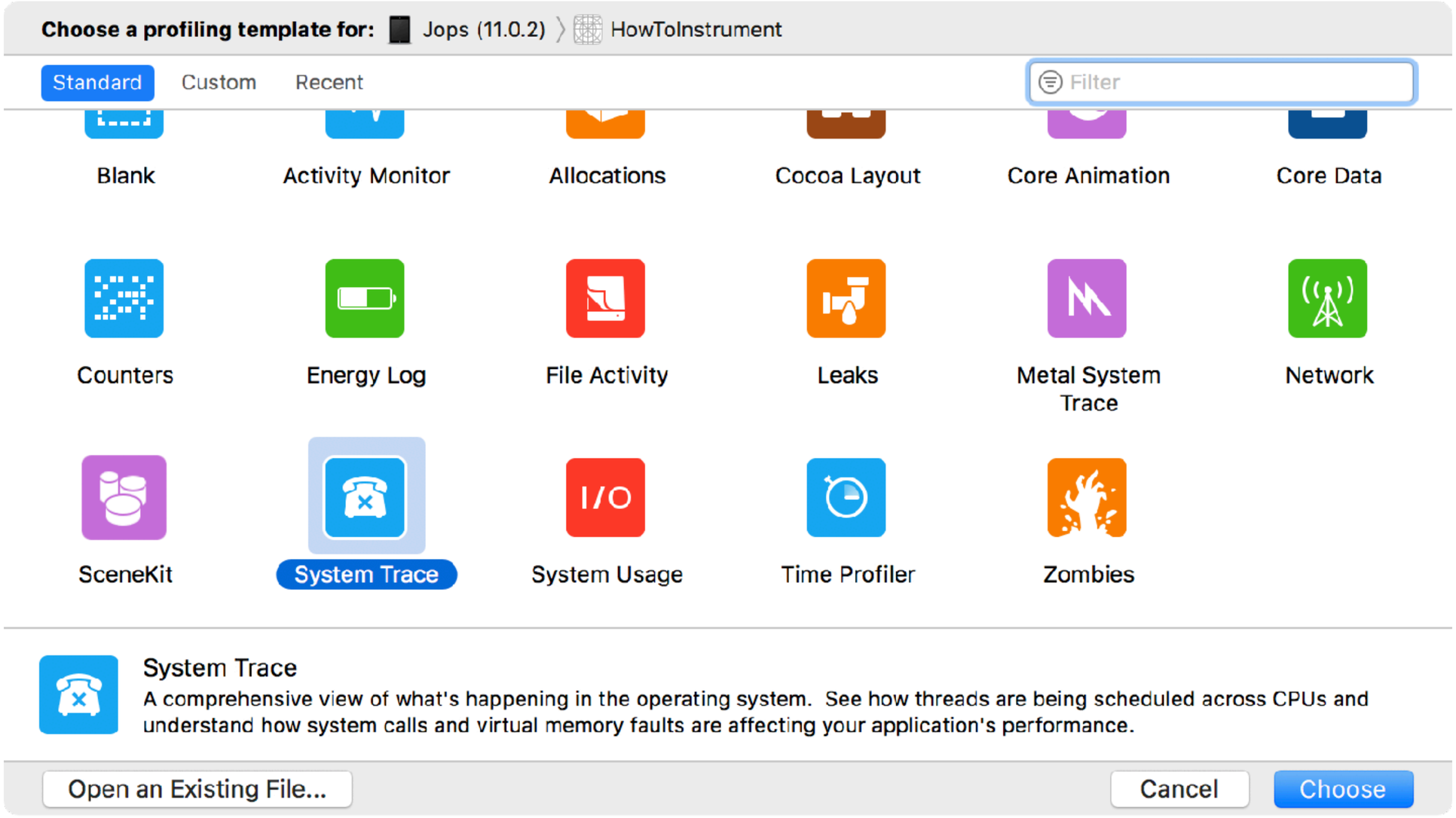

Choose a profiling template for: Jops (11.0.2) HowToInstrument
Standard
Custom
Recent
Filter
Blank
Activity Monitor
Allocations
Cocoa Layout
Core Animation
Core Data
Counters
Energy Log
File Activity
Leaks
Metal System Trace
Network
SceneKit
System Trace
System Usage
Time Profiler
Zombies
Time Profiler
Performs low-overhead time-based sampling of processes running on the system's CPUs.
Open an Existing File...
Cancel
Choose

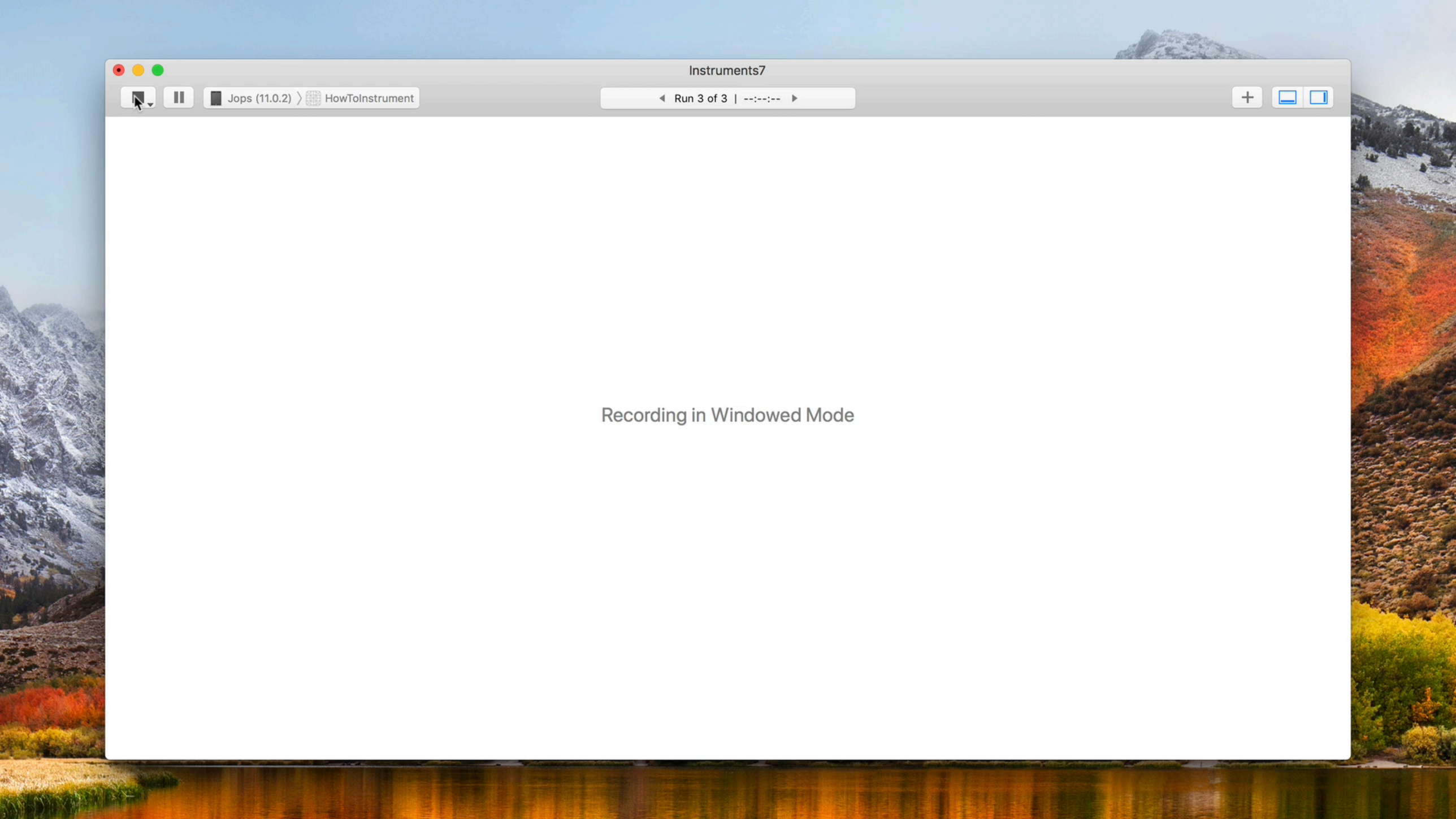

Instruments4
Jops (11.0.2)
HowToInstrument
Run 2 of 2 | 00:00:01
Track Filter
All
Instruments
Threads
CPUs
00:00.000
00:10.000
00:20.000
00:30.000
00:40.000
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
CPU Usage
Core 0
Core 1
Time Profiler
Profile
Root
Detail Unavailable
No Detail
Input Filter
Involves Symbol
Call Tree
Call Tree Constraints
Data Mining

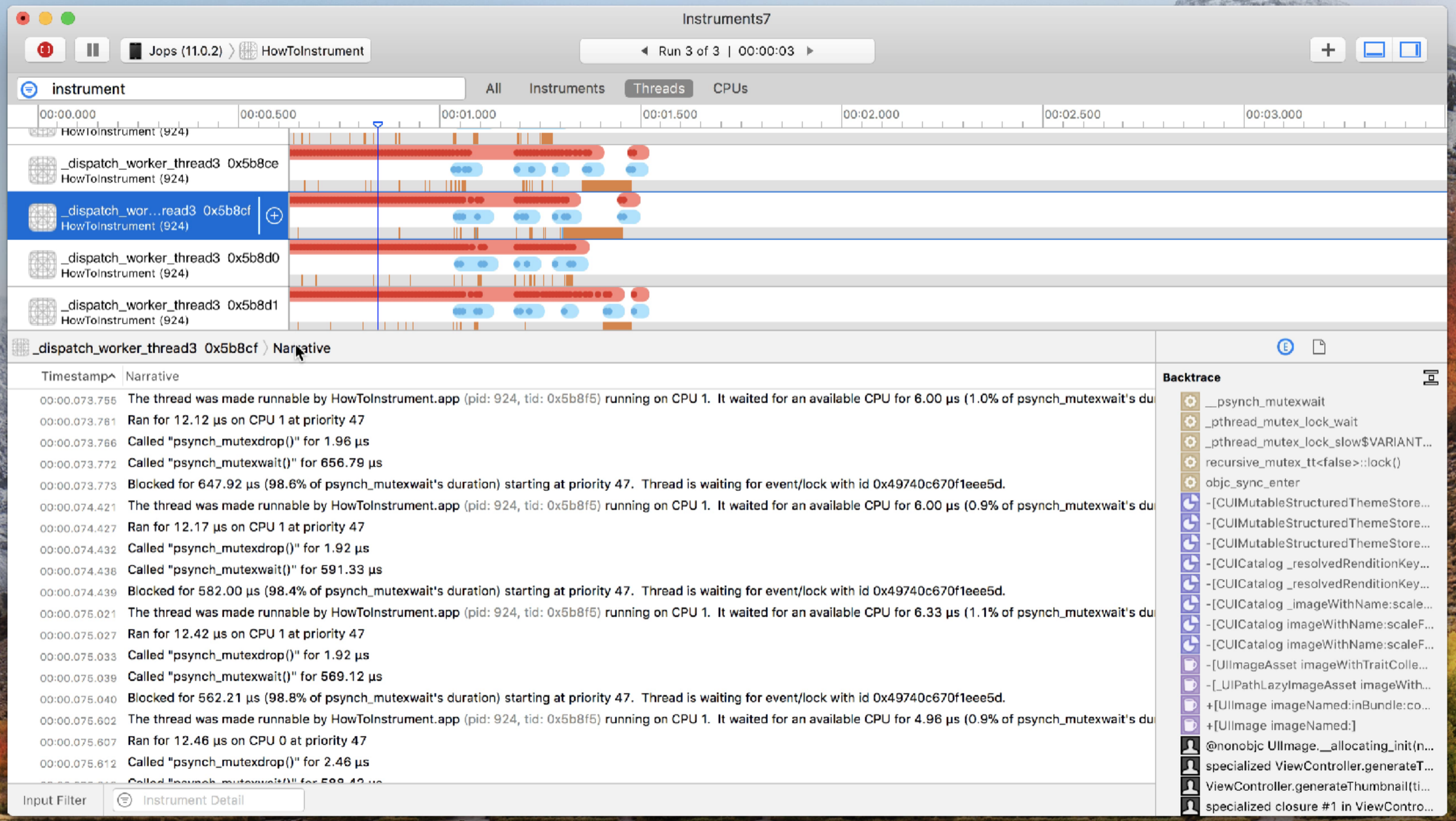
```
for headline in headlines {
        generateThumbnail(title: headline, image: thumb)
}
```

```
let queue = OperationQueue()

for headline in headlines {
    queue.addOperation {
        generateThumbnail(title: headline, image: thumb)
    }
}

queue.waitUntilAllOperationsAreFinished()
```


WTF?


Choose a profiling template for: Jops (11.0.2) HowToInstrument
Standard
Custom
Recent
Filter
Blank
Activity Monitor
Allocations
Cocoa Layout
Core Animation
Core Data
Counters
Energy Log
File Activity
Leaks
Metal System Trace
Network
SceneKit
System Trace
System Usage
Time Profiler
Zombies
I/O
System Trace
A comprehensive view of what's happening in the operating system. See how threads are being scheduled across CPUs and understand how system calls and virtual memory faults are affecting your application's performance.
Open an Existing File...
Cancel
Choose


Instruments7
Jops (11.0.2)
HowToInstrument
Run 3 of 3 | --:--:--
Recording in Windowed Mode


Instruments7
Jops (11.0.2) 〉 HowToInstrument
Run 3 of 3 | 00:00:03
instrument
All
Instruments
Threads
CPUs
00:00.000
00:00.500
00:01.000
00:01.500
00:02.000
00:02.500
00:03.000
HowToInstrument (924)
_dispatch_worker_thread3 0x5b8ce
HowToInstrument (924)
_dispatch_wor…read3 0x5b8cf
HowToInstrument (924)
_dispatch_worker_thread3 0x5b8d0
HowToInstrument (924)
_dispatch_worker_thread3 0x5b8d1
HowToInstrument (924)
_dispatch_worker_thread3 0x5b8cf 〉 Narrative
Timestamp
Narrative
00:00.073.755 The thread was made runnable by HowToInstrument.app (pid: 924, tid: 0x5b8f5) running on CPU 1. It waited for an available CPU for 6.00 µs (1.0% of psynch_mutexwait's du
00:00.073.761 Ran for 12.12 µs on CPU 1 at priority 47
00:00.073.766 Called "psynch_mutexdrop()" for 1.96 µs
00:00.073.772 Called "psynch_mutexwait()" for 656.79 µs
00:00.073.773 Blocked for 647.92 µs (98.6% of psynch_mutexwait's duration) starting at priority 47. Thread is waiting for event/lock with id 0x49740c670f1eee5d.
00:00.074.421 The thread was made runnable by HowToInstrument.app (pid: 924, tid: 0x5b8f5) running on CPU 1. It waited for an available CPU for 6.00 µs (0.9% of psynch_mutexwait's du
00:00.074.427 Ran for 12.17 µs on CPU 1 at priority 47
00:00.074.432 Called "psynch_mutexdrop()" for 1.92 µs
00:00.074.438 Called "psynch_mutexwait()" for 591.33 µs
00:00.074.439 Blocked for 582.00 µs (98.4% of psynch_mutexwait's duration) starting at priority 47. Thread is waiting for event/lock with id 0x49740c670f1eee5d.
00:00.075.021 The thread was made runnable by HowToInstrument.app (pid: 924, tid: 0x5b8f5) running on CPU 1. It waited for an available CPU for 6.33 µs (1.1% of psynch_mutexwait's du
00:00.075.027 Ran for 12.42 µs on CPU 1 at priority 47
00:00.075.033 Called "psynch_mutexdrop()" for 1.92 µs
00:00.075.039 Called "psynch_mutexwait()" for 569.12 µs
00:00.075.040 Blocked for 562.21 µs (98.8% of psynch_mutexwait's duration) starting at priority 47. Thread is waiting for event/lock with id 0x49740c670f1eee5d.
00:00.075.602 The thread was made runnable by HowToInstrument.app (pid: 924, tid: 0x5b8f5) running on CPU 1. It waited for an available CPU for 4.96 µs (0.9% of psynch_mutexwait's du
00:00.075.607 Ran for 12.46 µs on CPU 0 at priority 47
00:00.075.612 Called "psynch_mutexdrop()" for 2.46 µs
Backtrace
__psynch_mutexwait
_pthread_mutex_lock_wait
_pthread_mutex_lock_slow$VARIANT...
recursive_mutex_tt<false>::lock()
objc_sync_enter
-[CUIMutableStructuredThemeStore...
-[CUIMutableStructuredThemeStore...
-[CUIMutableStructuredThemeStore...
-[CUICatalog _resolvedRenditionKey...
-[CUICatalog _resolvedRenditionKey...
-[CUICatalog _imageWithName:scale...
-[CUICatalog imageWithName:scaleF...
-[CUICatalog imageWithName:scaleF...
-[UIImageAsset imageWithTraitColle...
-[_UIPathLazyImageAsset imageWith...
+[UIImage imageNamed:inBundle:co...
+[UIImage imageNamed:]
@nonobjc UIImage.__allocating_init(n...
specialized ViewController.generateT...
ViewController.generateThumbnail(ti...
specialized closure #1 in ViewContro...
Input Filter
Instrument Detail

on CPU 1. It waited for an available CPU for 6.00 µs (1.0% of psynch_mutexwait's du

hread is waiting for event/lock with id 0x49740c670f1eee5d.

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Backtrace

- __psynch_mutexwait
- _pthread_mutex_lock_wait
- _pthread_mutex_lock_slow$VARIANT...
- recursive_mutex_tt<false>::lock()
- -[CUIMutableStructuredThemeStore...
- -[CUIMutableStructuredThemeStore...
- -[CUICatalog _resolvedRenditionKey...
- -[CUICatalog _resolvedRenditionKey...
- -[CUICatalog _imageWithName:scale...
- -[CUICatalog imageWithName:scaleF...
- -[CUICatalog imageWithName:scaleF...
- -[UIImageAsset imageWithTraitColle...
- -[_UIPathLazyImageAsset imageWith...
- +[UIImage imageNamed:inBundle:co...
- +[UIImage imageNamed:]
- @nonobjc UIImage.__allocating_init(n...
- specialized ViewController.generateT...
- ViewController.generateThumbnail(ti...
- specialized closure #1 in ViewContro...

THREAD SAFE

- NSArray
- NSAttributedString
- NSCharacterSet
- NSData
- NSDictionary
- NSString

NOT THREAD SAFE

- NSMutableArray
- NSMutableAttributedString
- NSMutableCharacterSet
- NSMutableData
- NSMutableDictionary
- NSMutableString

```
guard let image = UIImage(named: thumb) else {
   fatalError("Unable to load thumbnail")
}
```

2.359 seconds
6.385 seconds
0.471 seconds

TODAY'S PLAN

- Why instrument
- What to instrument
- When to instrument
- How to instrument

SUMMARY


Stop your mediocre drawing before it **kills again!**

DRAWING CHECKS

- Check your CA frame rates.
- Make views opaque.
- Draw images at their natural size.
- Skip second draw pass.
- Prefetch cells.
- 250,000 frames during this talk!

CHECK FOR LEAKS

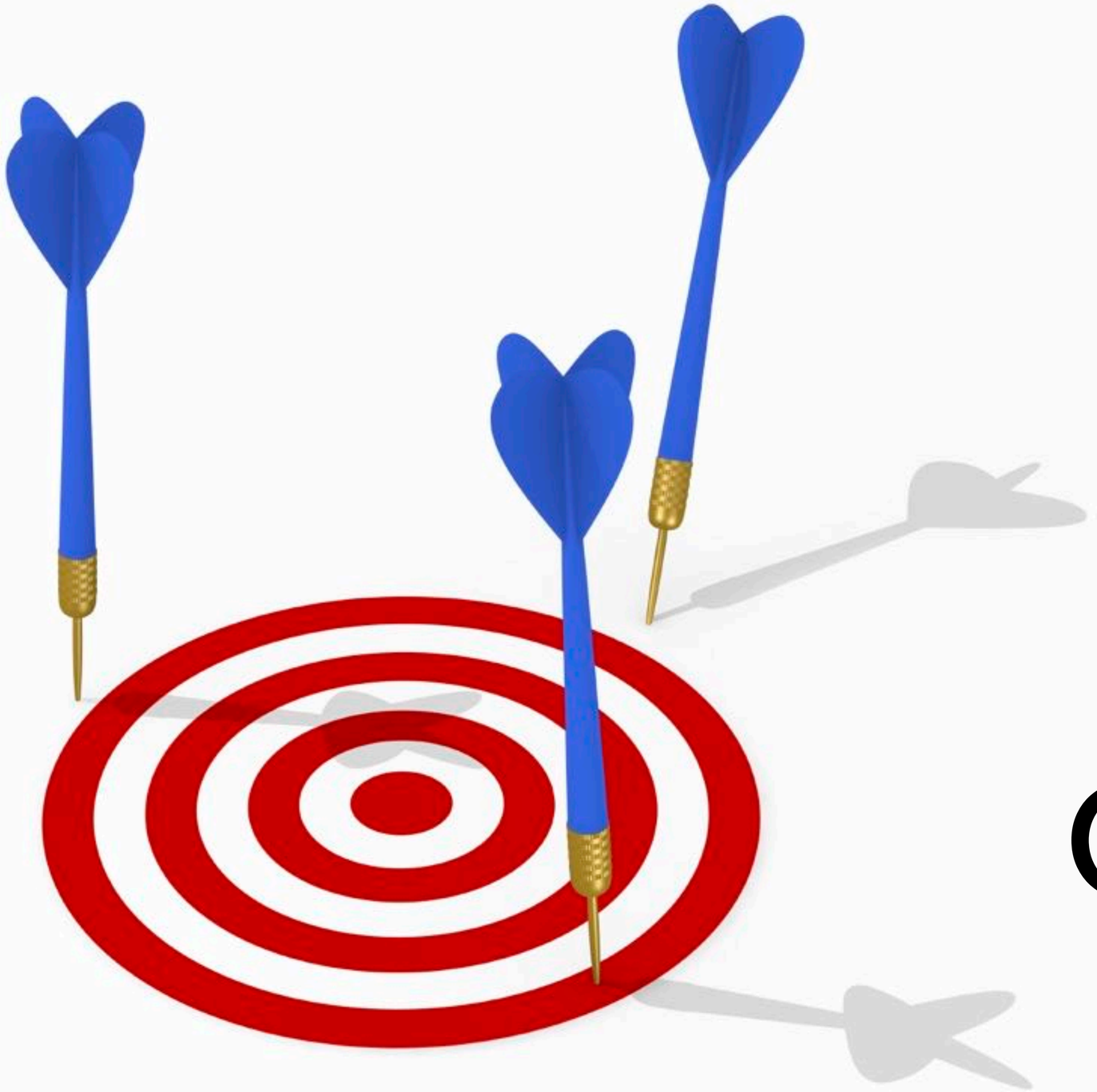
MEMORY CHECKS

- Abandoned memory.
- Cached memory.
  - Use **`NSCache`**.
- Leaked memory.
- Writing **`weak`** everywhere isn't enough: implicit retains!

Instruments is a contact sport

CPU CHECKS

- TMTOWTDI.
- Target #1: Time Profiler's heaviest stack trace.
- But: only measures *running* code.
- Check your thread states: are they interrupting each other?

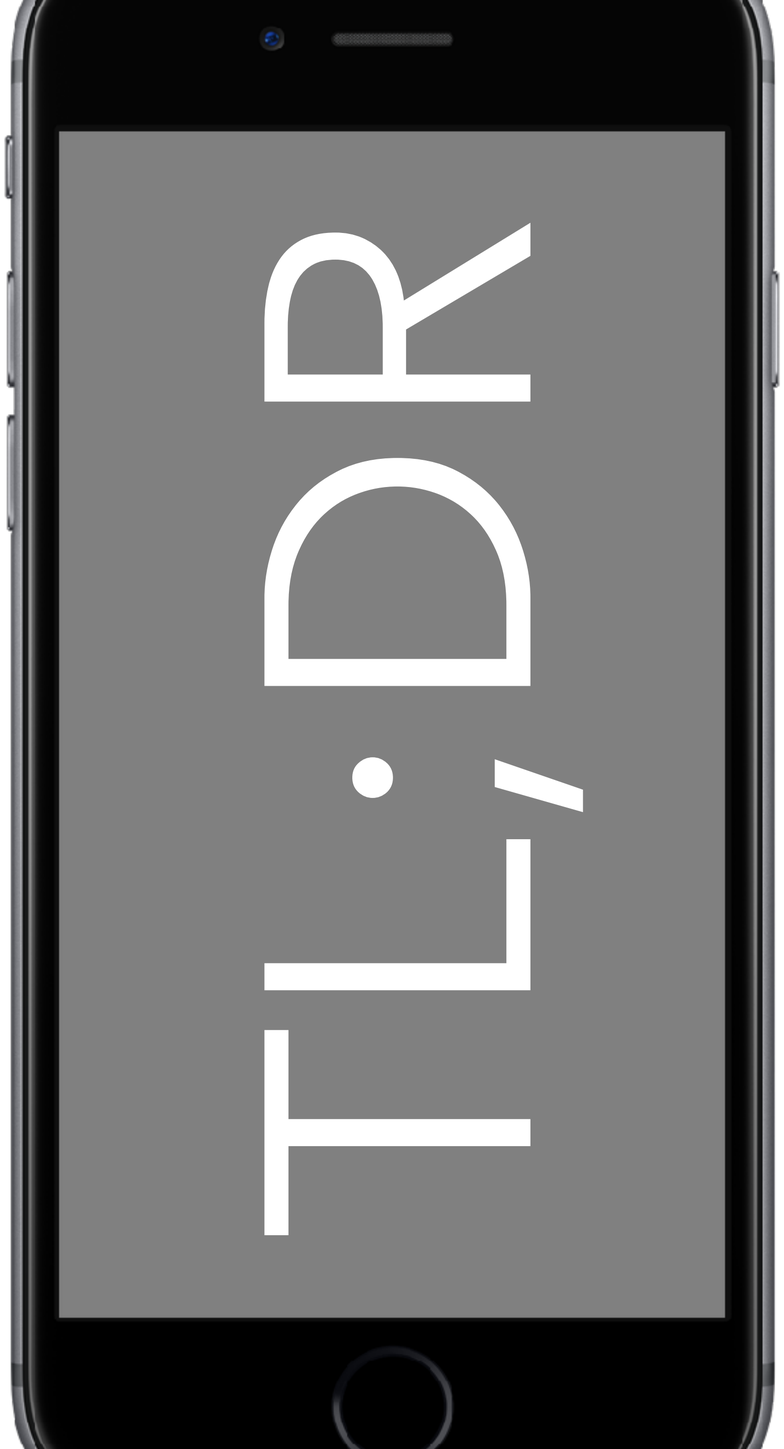


TEST ALL CHANGES

TEST ALL CHANGES

- My leak wasn't the result of a strong delegate.
- My performance got slower when using multi-threading.
- Instruments tells you what's going wrong – don't "trust your gut."

“You should use Instruments.”



LAST TIPS…

- Always profile on a real device.
- Always profile on the oldest device you support.
- **Make a small change then profile again.**

@twostraws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hackingwithswift.com/awards
COMMUNITY
AWARDS

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HOW TO INSTRUMENT YOUR CODE LIKE YOU MEAN IT