Linux Suspend/Resume…
…at the Speed of Light

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Intel OpenSource TECHNOLOGY CENTER

Acknowledgements

Todd Brandt – analyze_suspend.py maintainer
Rafael Wysocki – suspend/resume maintainer

Agenda

Concepts

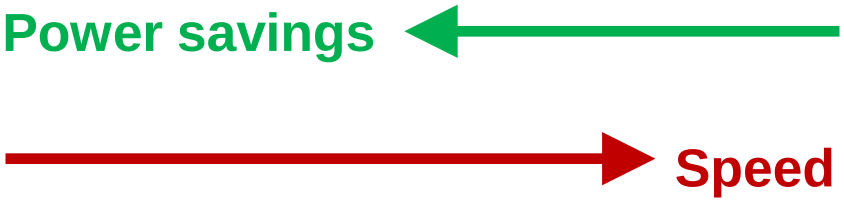
Tools

Results

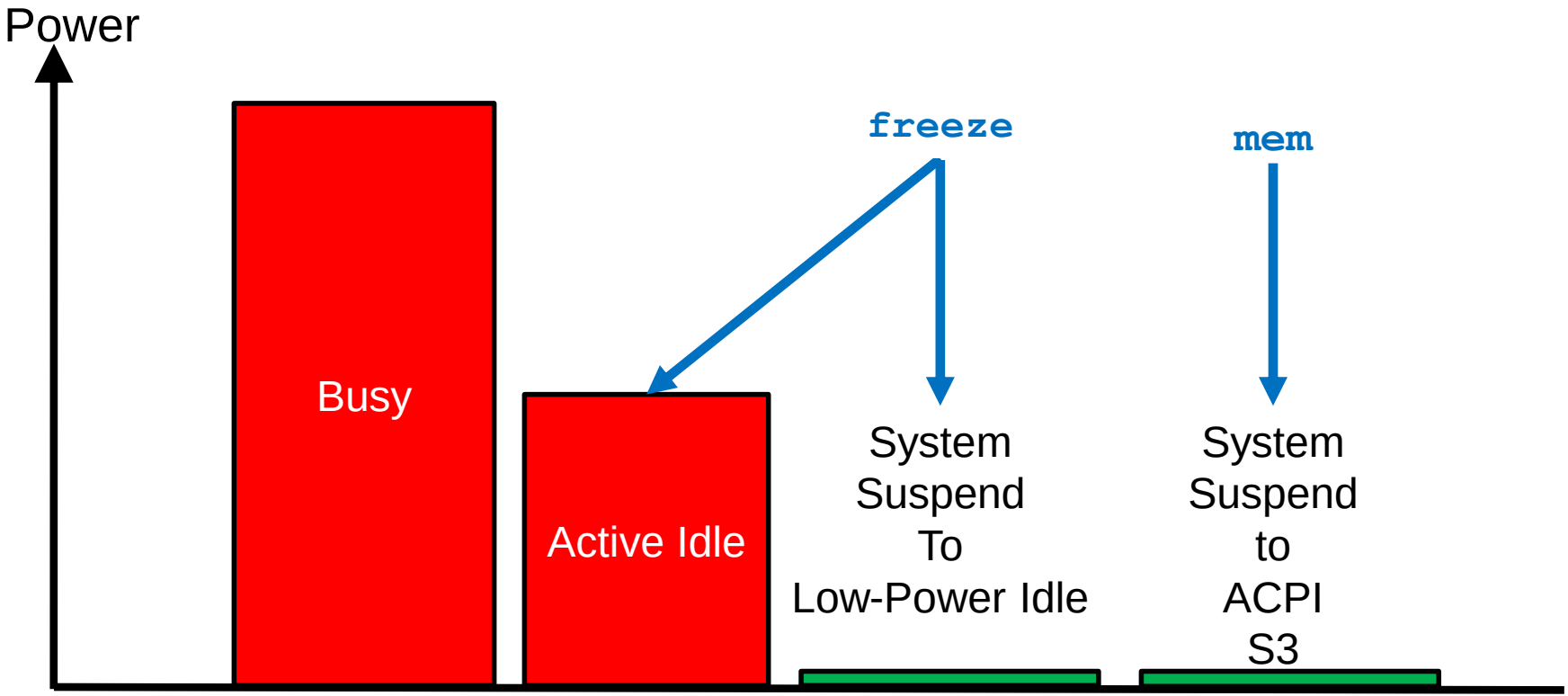
Future

Linux Suspend Types

```
$ cat /sys/power/state
disk mem standby freeze
```



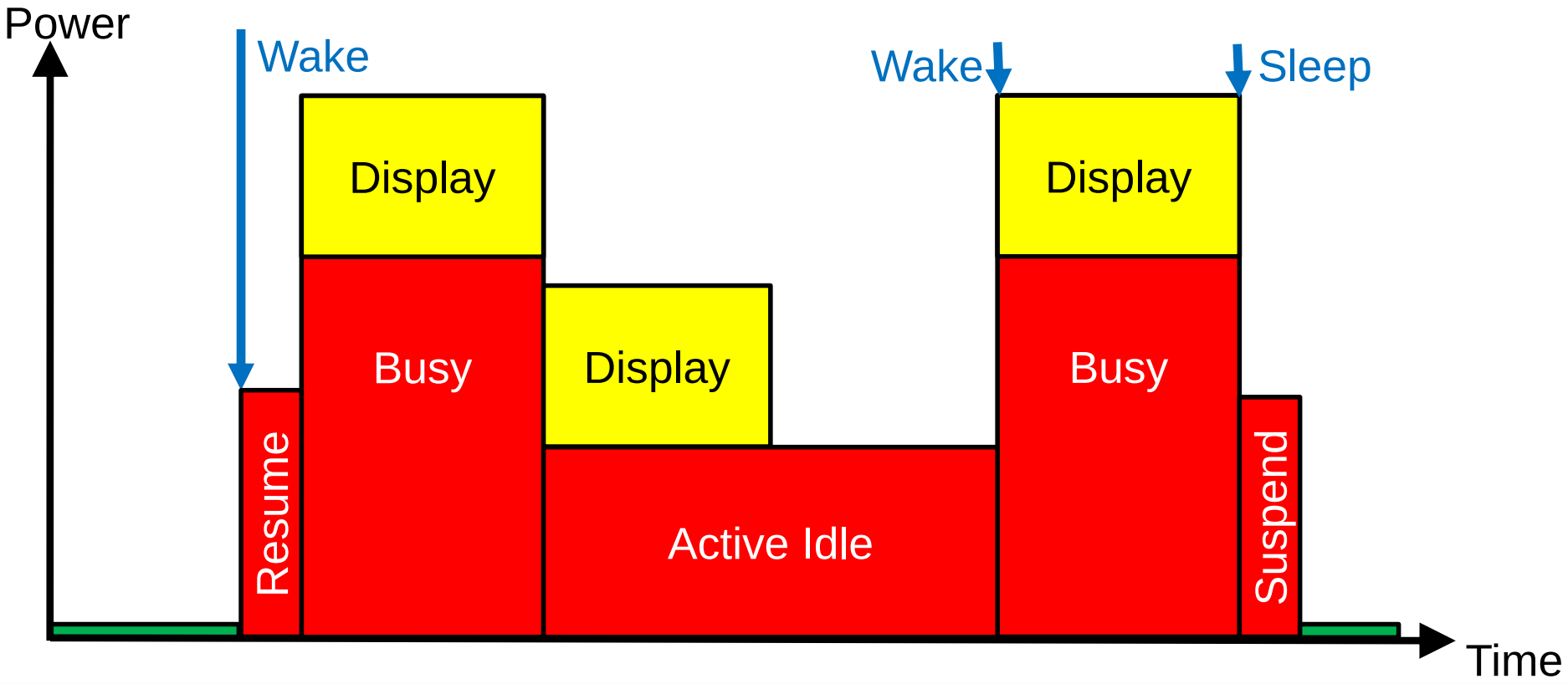
Saving Power with System Suspend



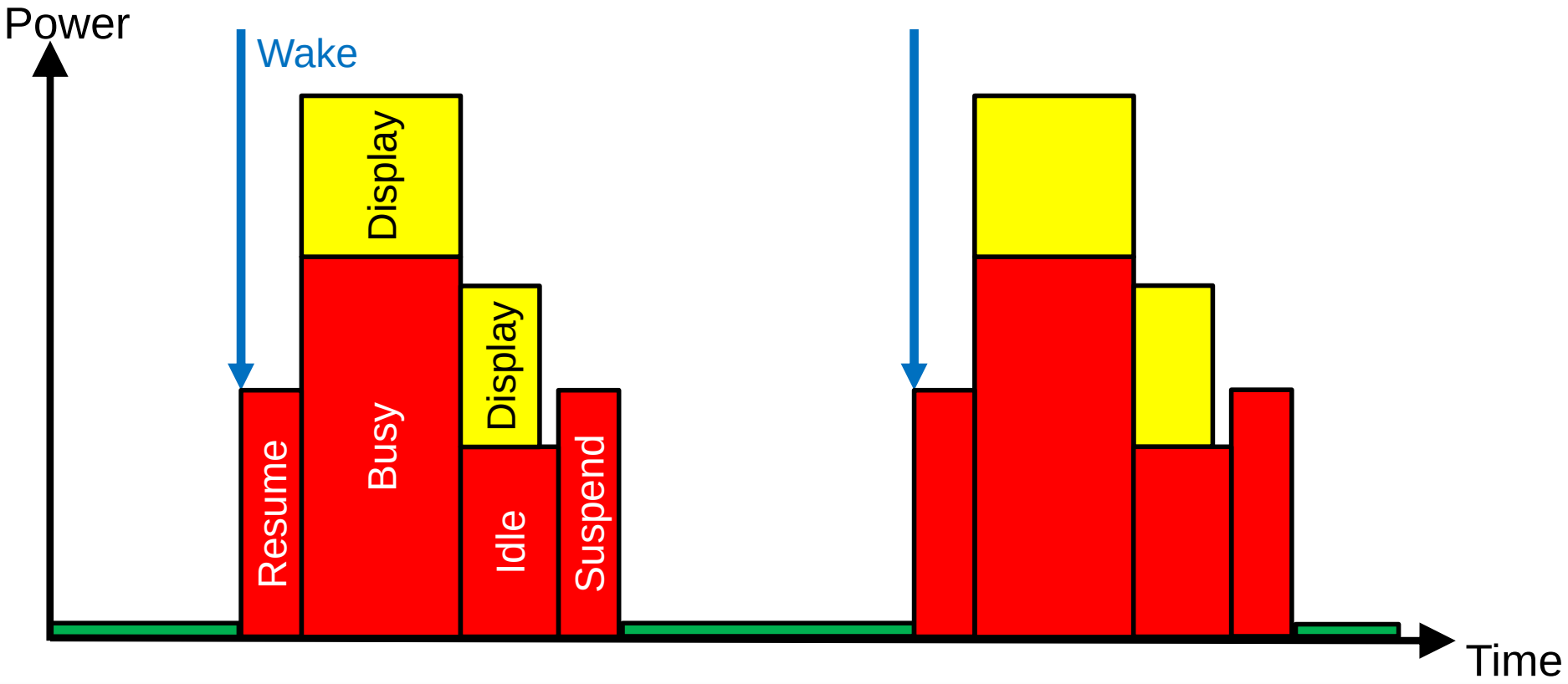
Suspend Trade-Offs

	Busy	Active Idle	Suspend to Low-Power Idle	Suspend to ACPI S3
Power				
Latency				
Driver API	Run-Time Suspend	Run-Time Suspend	System Suspend	System Suspend
Display				
Network				

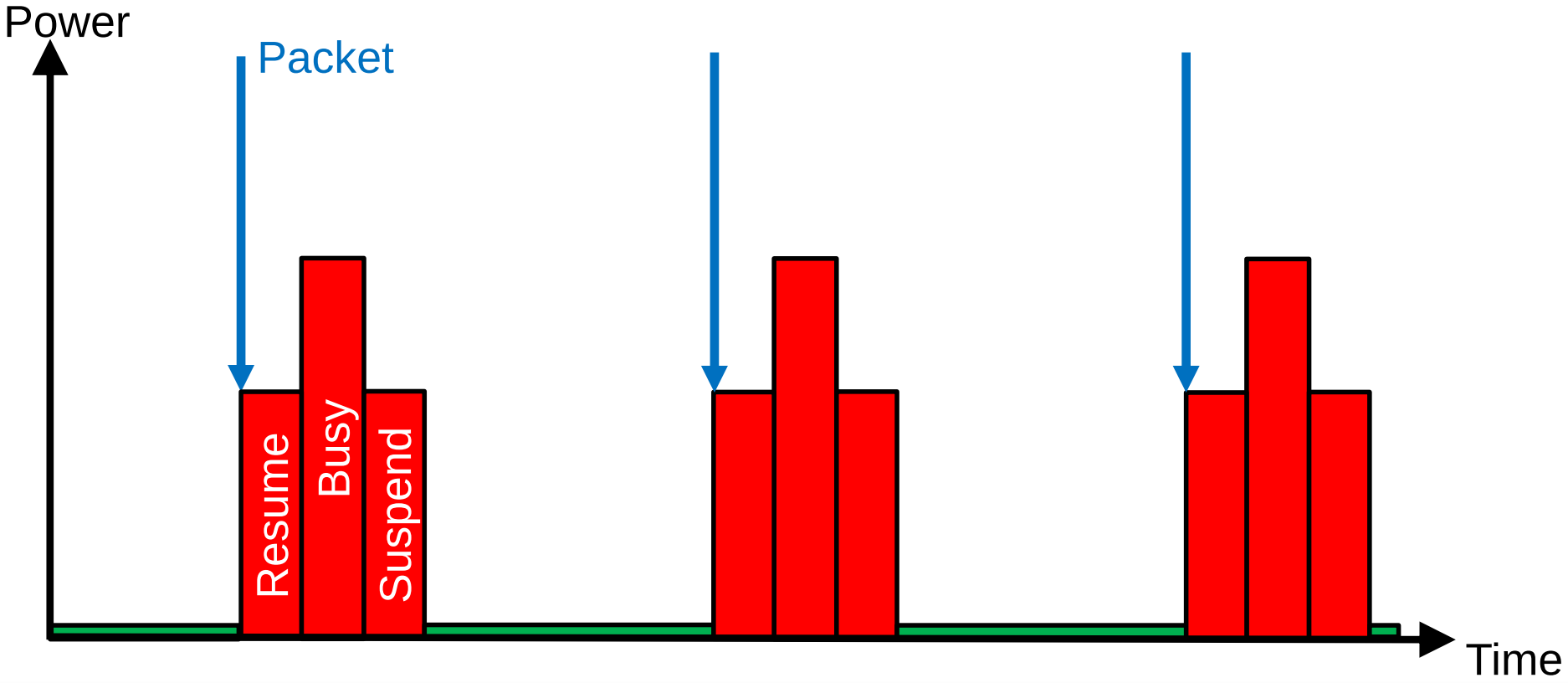
Interactive Laptop Scenario



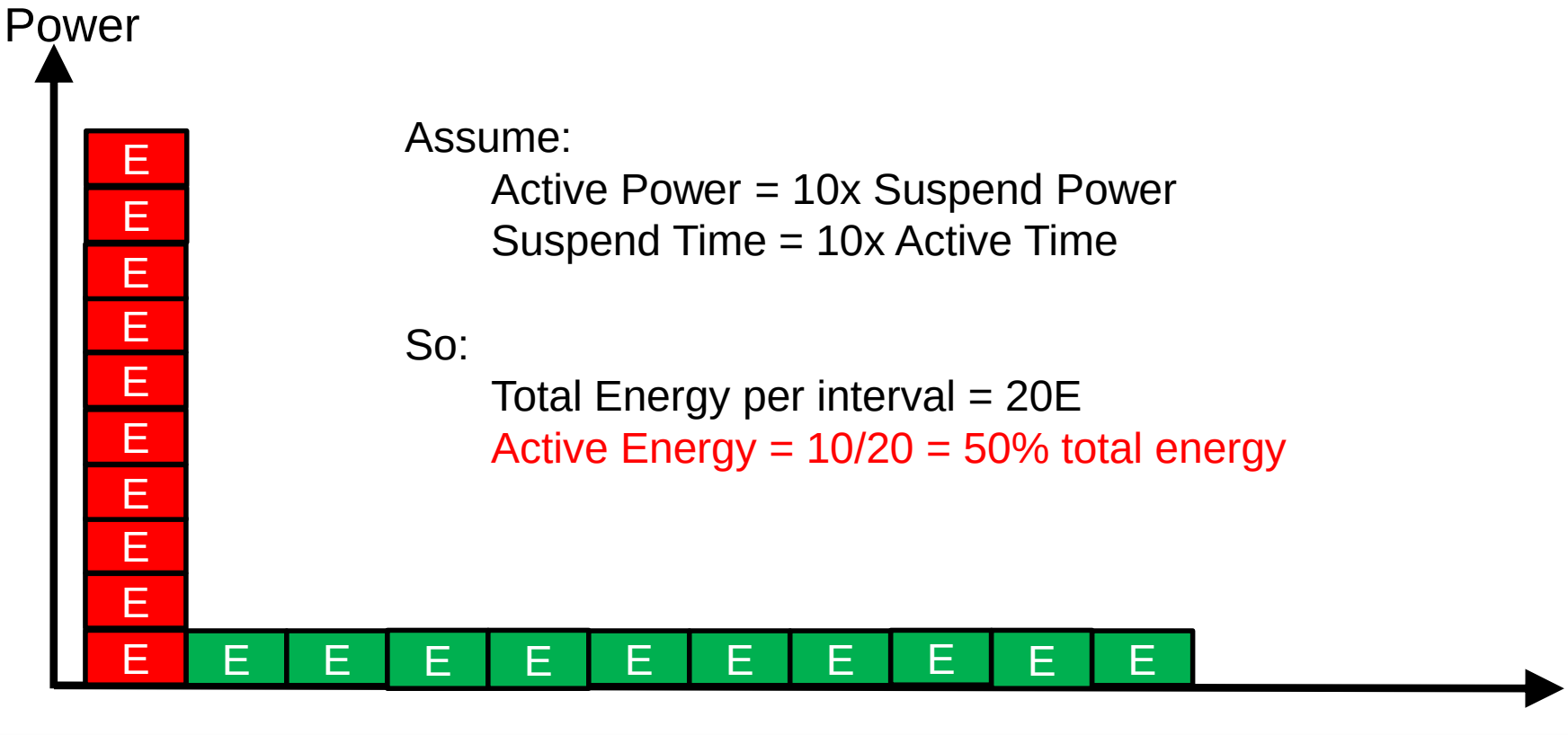
Interactive Handheld Scenario



Dark Resume Scenario



Dark Resume Power vs Time



Assume:

Active Power = 10x Suspend Power

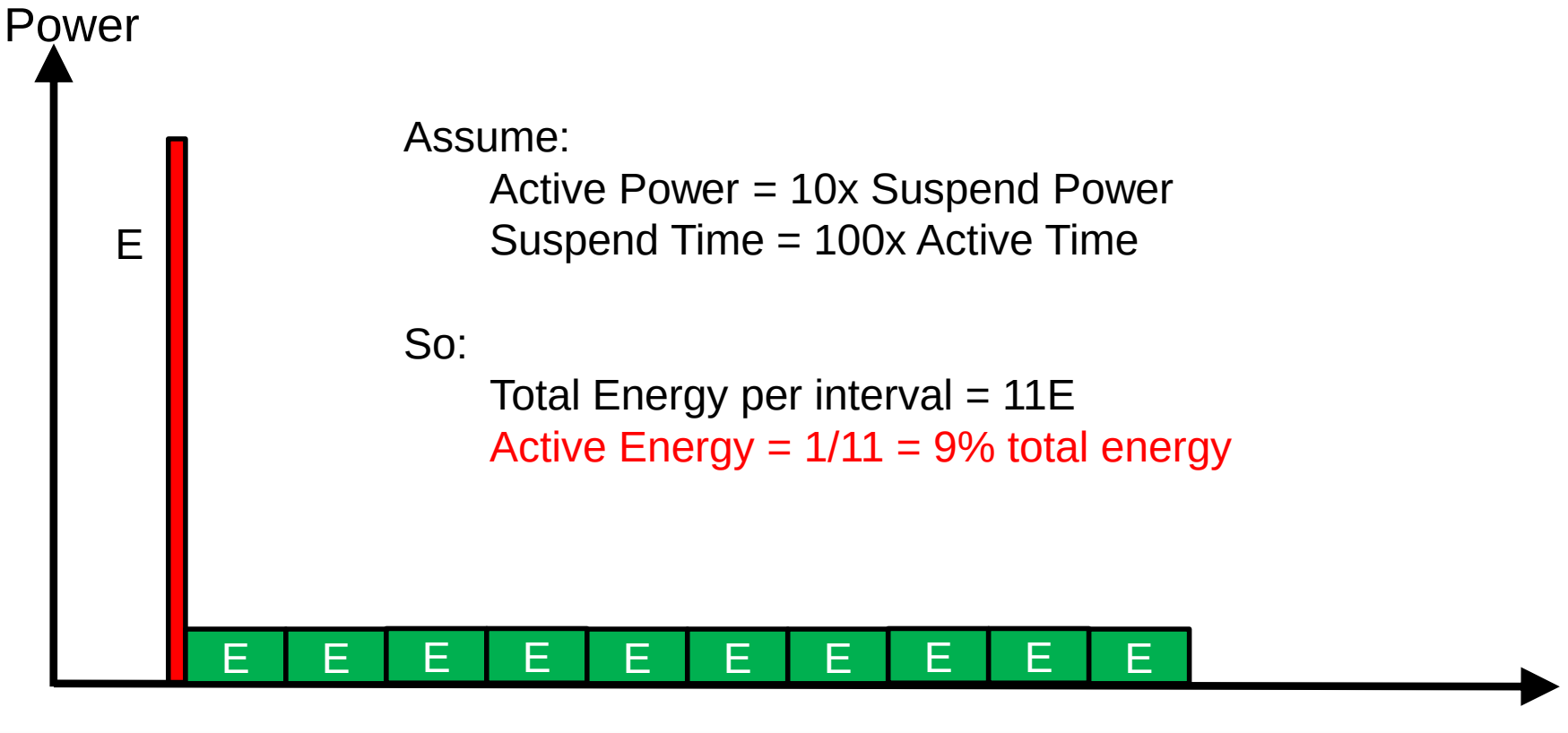
Suspend Time = 10x Active Time

So:

Total Energy per interval = 20E

Active Energy = 10/20 = 50% total energy

Dark Resume Power vs Time, 10x faster



Assume:

Active Power = 10x Suspend Power

Suspend Time = 100x Active Time

So:

Total Energy per interval = 11E

Active Energy = 1/11 = 9% total energy

Dark Resume Challenge

Suspend + Resume time may exceed Active time

Suspended battery life depends directly on suspend & resume performance

Resume Latency = packet latency

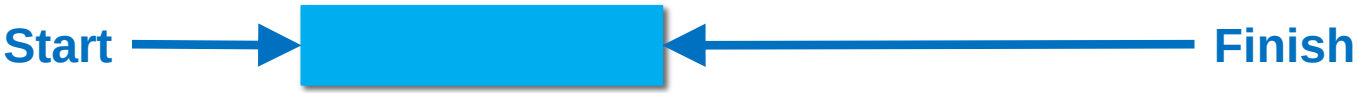
Going Faster

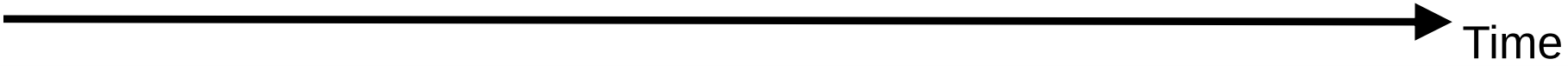
Going Faster (strategy 1)

Less work, or less waiting

Before:

After:



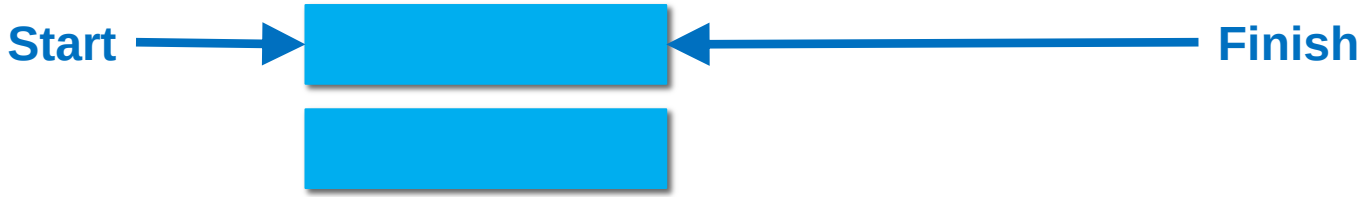


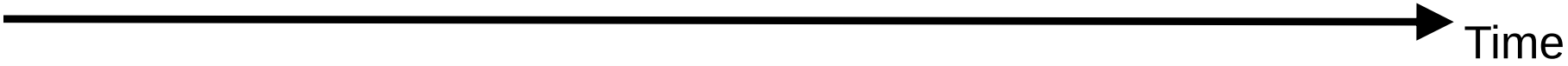
Going Faster (strategy 2)

Same work, in parallel, but still synchronous

Before:

After:





Going Faster (strategy 3)

Same work, asynchronous

Before:

After:

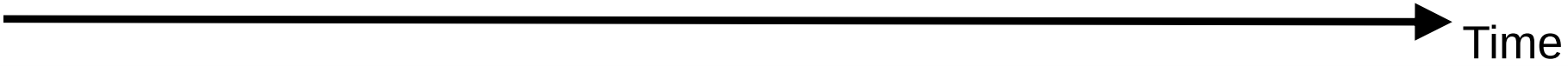
Time

Going Faster (strategy 4)

Avoid work entirely

Before:

After:



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Measuring Suspend Speed

Method 1: Use external measuring device

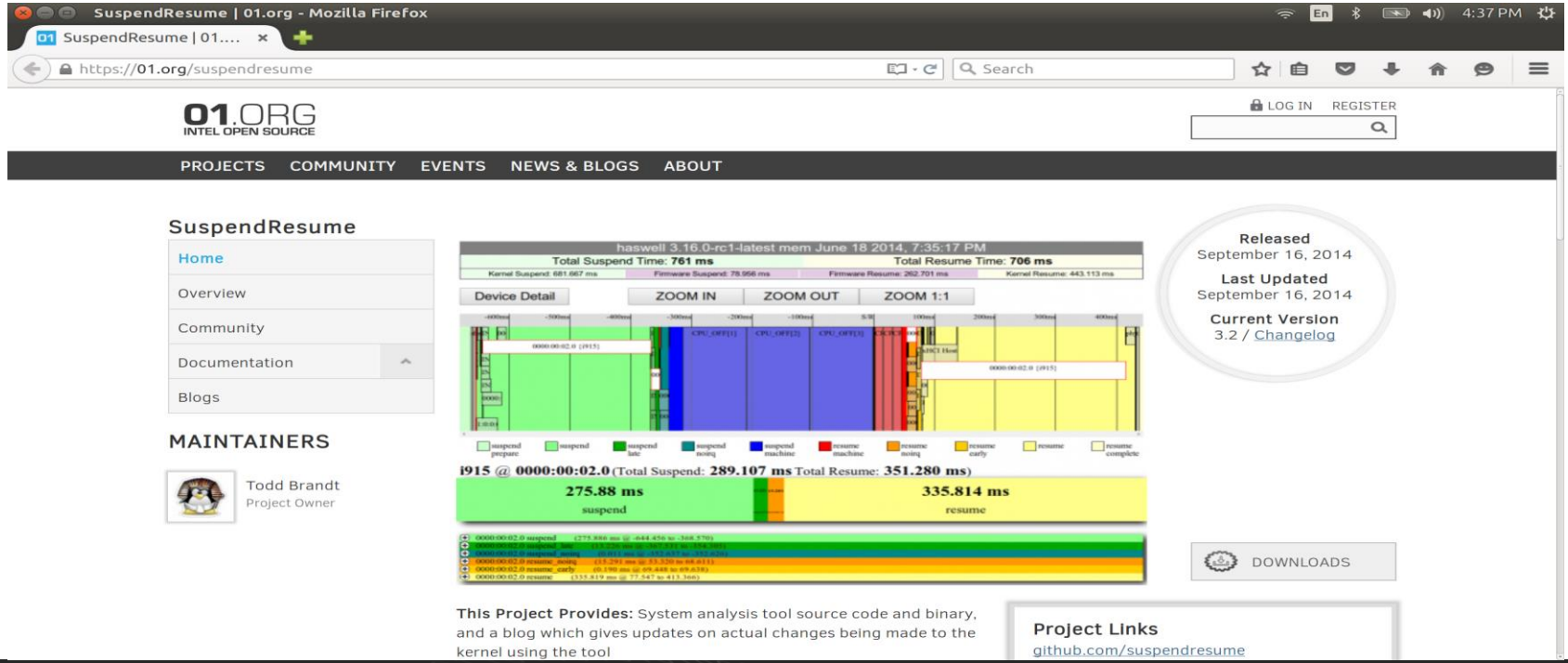
Measuring Suspend Speed

Method 2: Boot with “initcall_debug”, examine msgbuf

```
$ dmesg | grep call
…
[  661.392498] calling  phy0+ @ 2367, parent: 0000:07:00.0
[  661.417798] call phy0+ returned 0 after 24721 usecs
```

Measuring Suspend Speed

Method 3: Run analyze_suspend



Download and run analyze_suspend.py

```
$ git clone https://github.com/01org/suspendresume.git
$ cd suspendresume
$ sudo ./analyze_suspend.py
```

Generates output files in subdirectory: suspend-yymmdd-HHMMSS

HTML output:	<hostname>_<mode>.html
raw dmesg output:	<hostname>_<mode>_dmesg.txt
raw ftrace output:	<hostname>_<mode>_ftrace.txt

```
$ firefox suspend*/*.html
```

analyze_suspend.py -h

New script can re-analyze output of previous measurement

“initcall_debug” and dmesg used up through Linux 3.15, ftrace there-after

```
[general]
   …
   -m mode      Mode to initiate for suspend ['freeze', 'mem', 'disk'] (default: mem)
   -rtcwake t   Use rtcwake to autoresume after <t> seconds (default: disabled)
   …
   -addlogs     Add the dmesg and ftrace logs to the html output
 [advanced]
   …
   -f           Use ftrace to create device callgraphs (default: disabled)
   …
 [utilities]
   …
 [re-analyze data from previous runs]
   -ftrace ftracefile  Create HTML output using ftrace input
   -dmesg dmesgfile    Create HTML output using dmesg (not needed for kernel >= 3.15)
   -summary directory  Create a summary of all test in this dir
```

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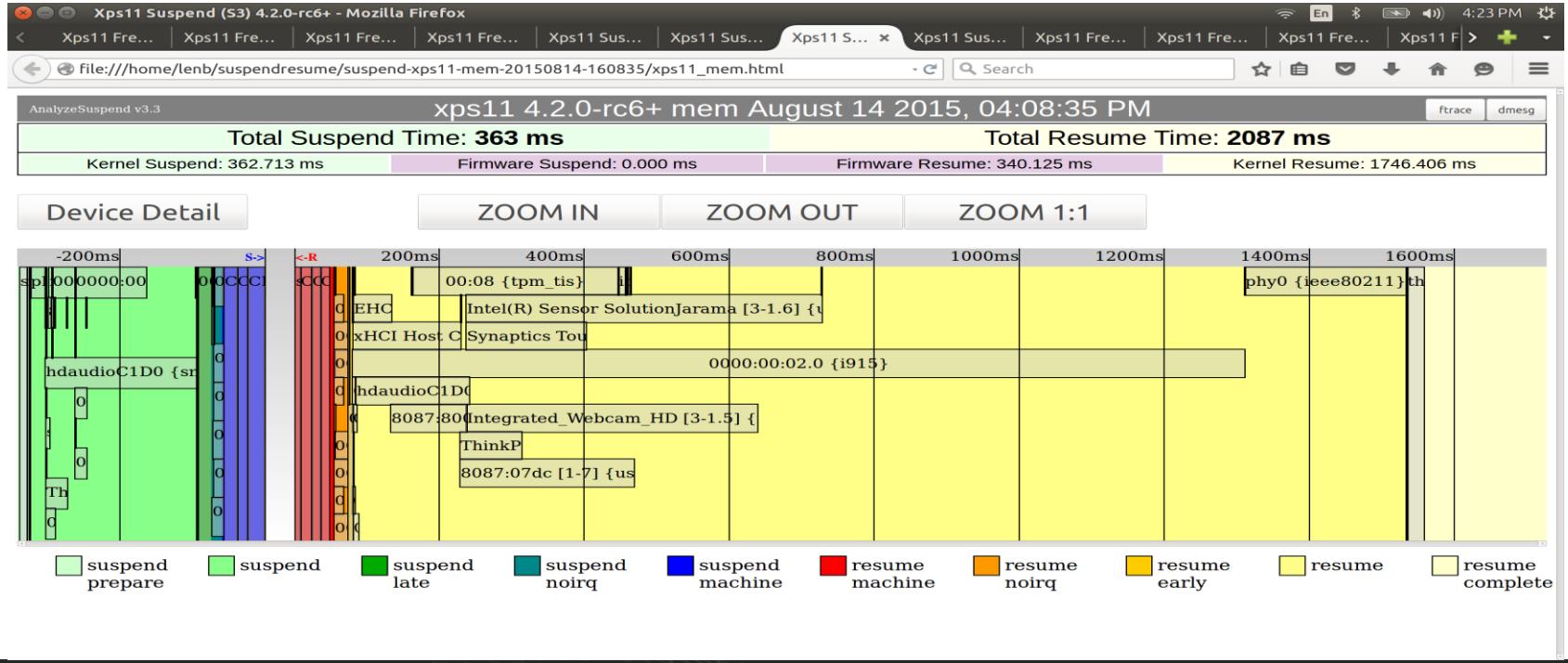
Suspend/Resume (mem)

ACPI S3: Firmware resume = 340ms
Display on: i915 resume > 1200ms



How to force Dark Suspend/Resume

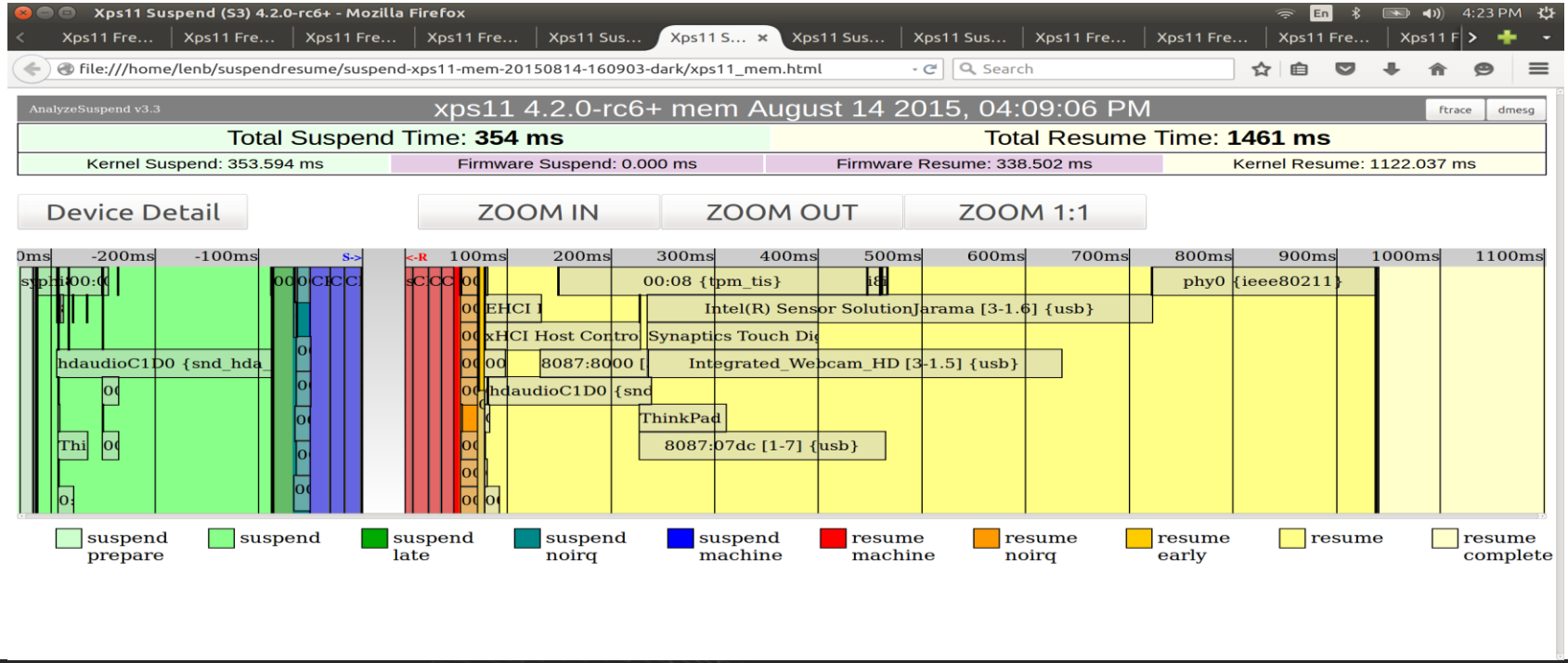
Run-time suspend display before system-suspend:

```
$ xset -display :0 dpms force off
$ sleep 2
$ sudo analyze_suspend.py
```

Display will not be resumed upon system-resume,
but availability is platform dependent…

Dark Suspend/Resume (mem)

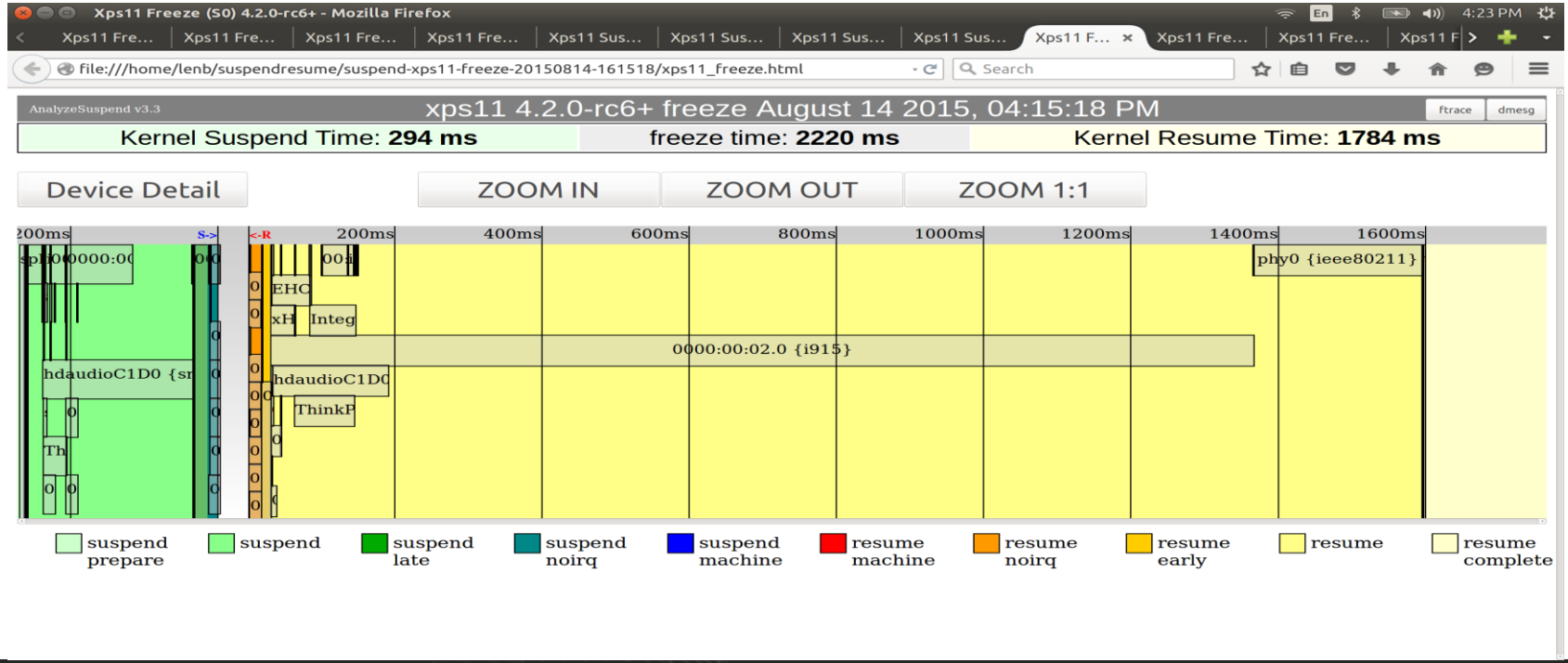
ACPI S3: Firmware resume = 340ms
Display OFF



Suspend/Resume (freeze)

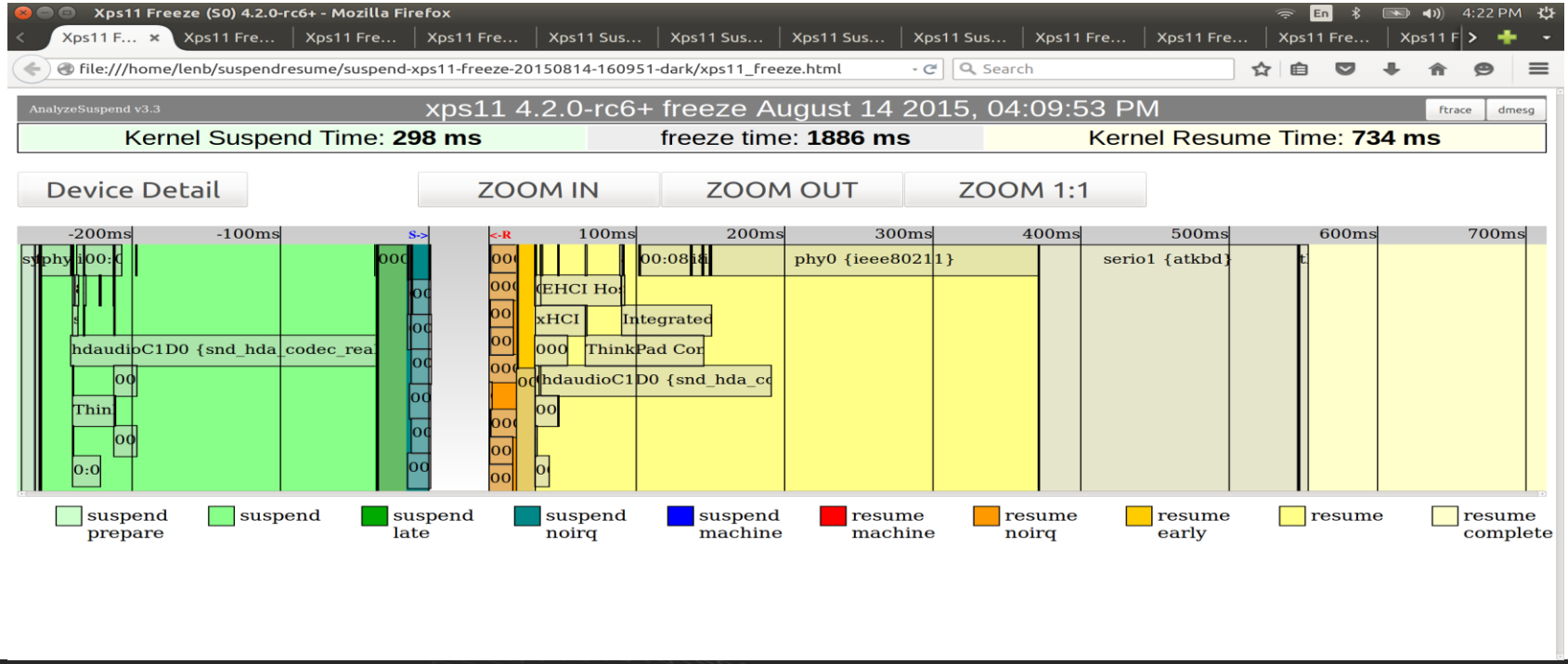
Firmware resume = 0

Display on: i915 resume > 1200ms



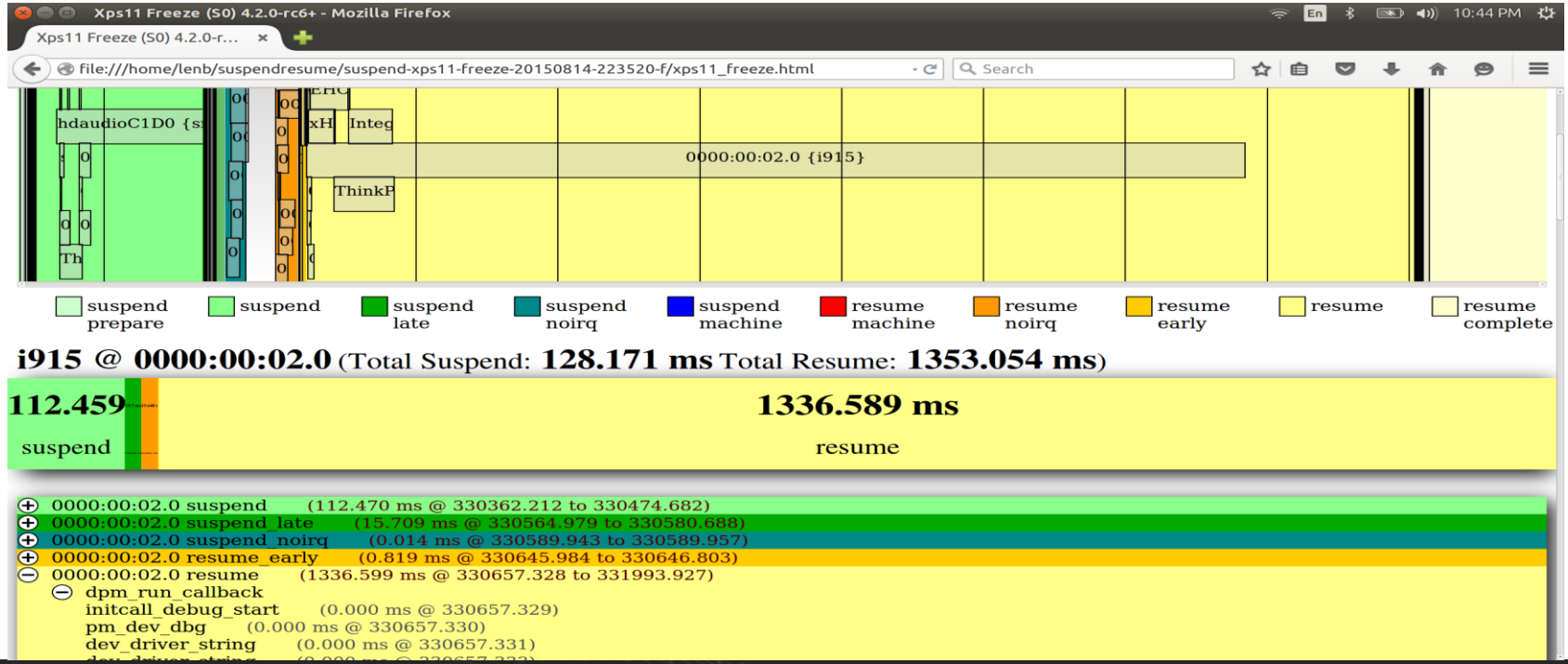
Dark Suspend/Resume (freeze)

Firmware resume = 0
Display OFF



analyze_suspend -f

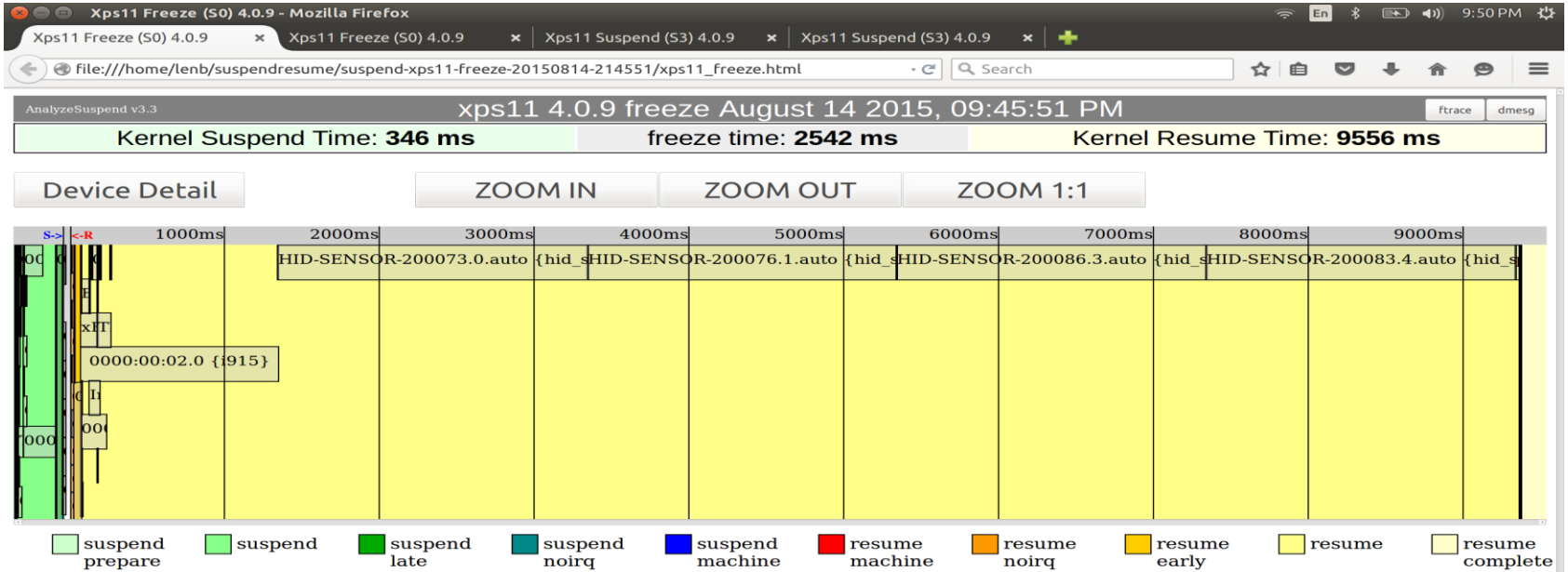
Captures full ftrace call graph, parses in HTML GUI
{HTML file size ~ 64MB}



Things can go very wrong

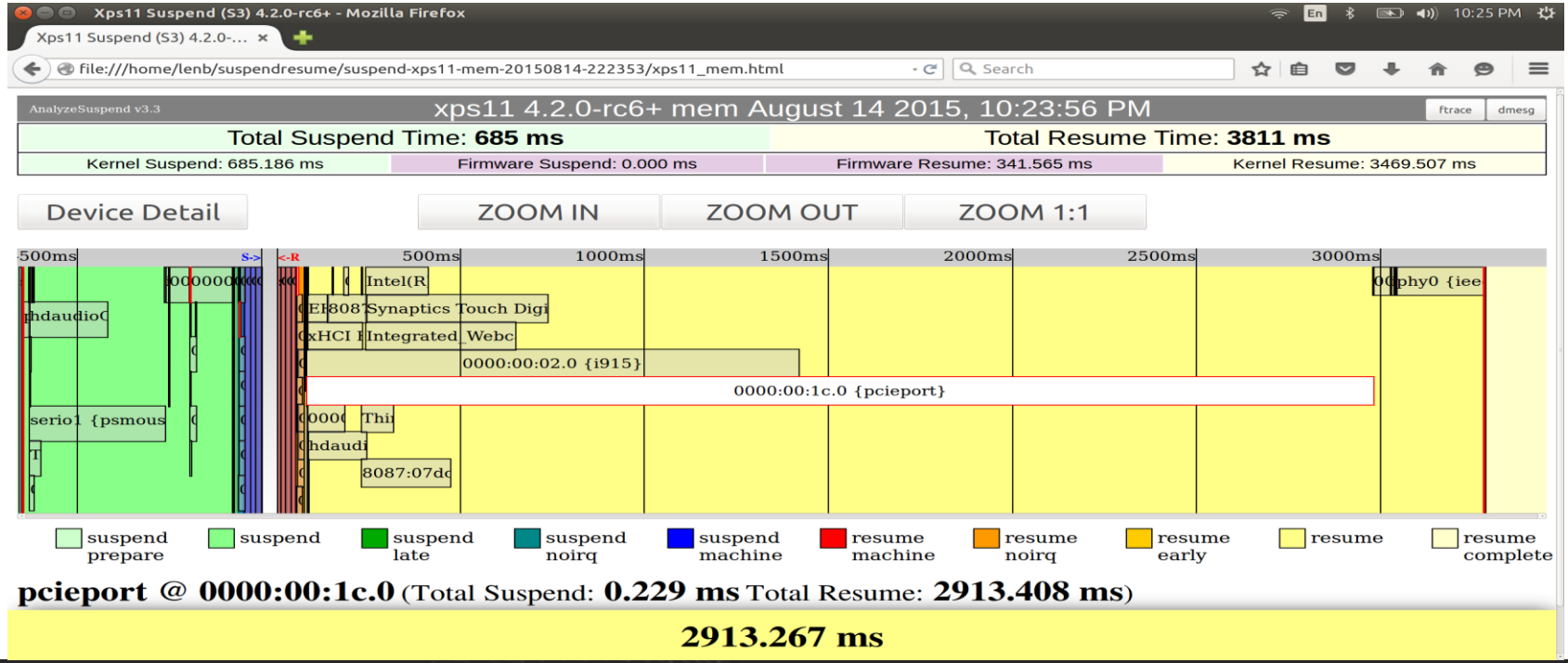
Linux-4.0 sensors regression – no workaround

Fixed in Linux-4.2, Linux-4.1-stable. Not fixed in Linux-4.0-stable.



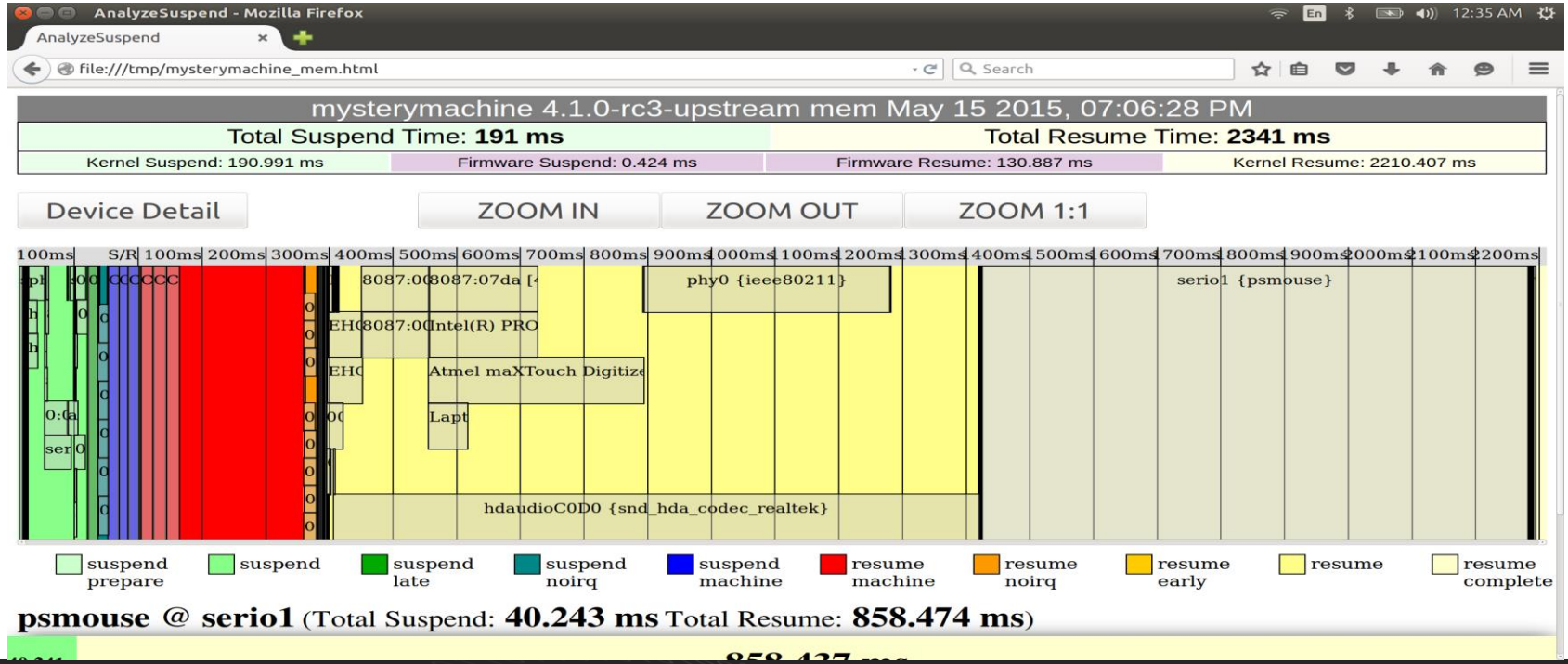
Things can go very wrong

pcieport resume 2900ms (https://bugzilla.kernel.org/show_bug.cgi?id=99751)
Workaround: boot with “pcie_ports=compat”



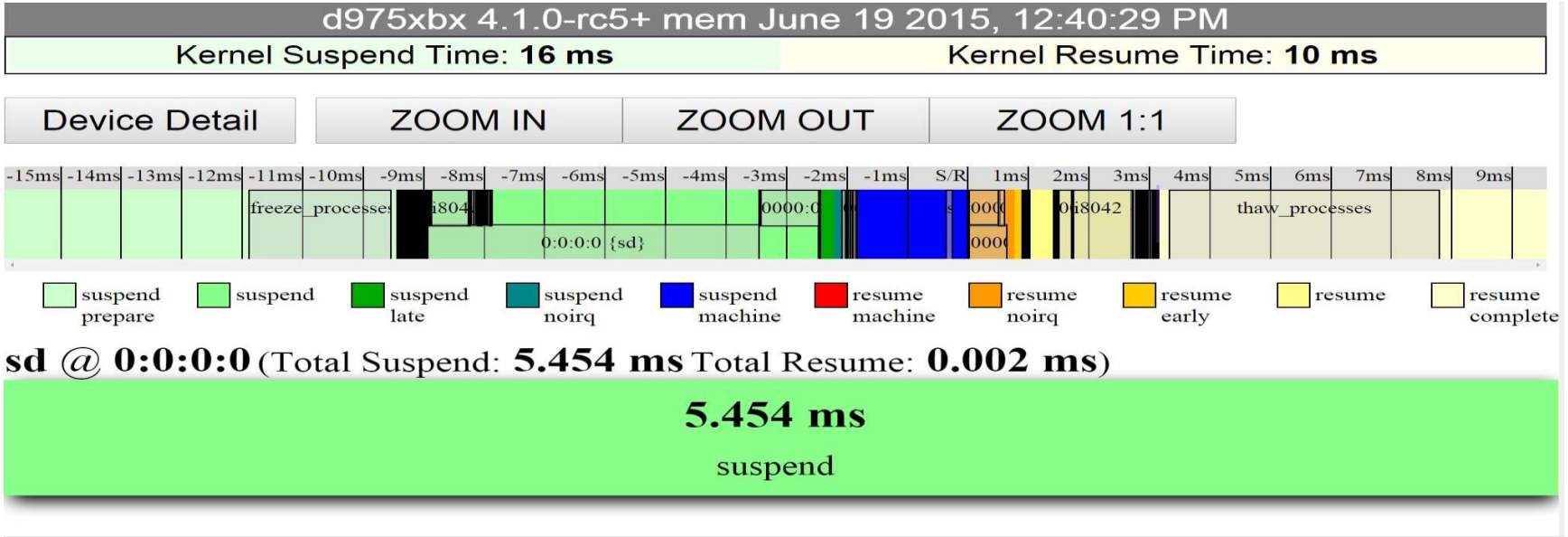
Things can go very wrong

850ms Serio1/psmouse due to lock contention in resume_complete. Fixed in Linux 4.2-rc1.
Workaround: boot with “no_console_suspend”



regarding the “speed of light”

O(25ms) to suspend and wake on this stripped-down Core2 desktop
UP, no sync, no GFX, serial console, no network, no USB, SSD drive, yes ACPI, but not FPDT



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What needs to be done?

Run analyze_suspend on more systems – help us!

- Prevent regressions
- Discover, report, fix more issues

Display, USB, Network, Audio

- When run-time suspended, stay suspended
- When must resume, go asynchronous
- Optimize actual resume latency

Wireless network re-association speed

Q & A

Linux “freeze” History

Linux-3.18:

functional for 1st time, including wakeup

Linux-4.0:

freeze timers, improves deep idle-state residency

Key Patches

ATA drives can take multiple SECONDS to resume

This patch makes that ASYNCHRONOUS, not blocking the resume path to user-space

In Linux v3.15-rc1:

```
commit 200421a80f6e0a9e39d698944cc35cba103eb6ce
Author: Todd Brandt <todd.e.brandt@linux.intel.com>
Date:   Fri Mar 14 13:52:54 2014 -0700

libata: async resume
```

Key Patches

Fix race condition in resume_complete

(boot with “no_console_suspend” may workaround)

In Linux v4.2-rc1:

```
commit 32e8d689dc12e29fcb6ba9c65a33473d0cbdfec8
Author: Todd E Brandt <todd.e.brandt@linux.intel.com>
Date:   Thu May 28 12:55:53 2015 -0700

PM / sleep: trace_device_pm_callback coverage in dpm_prepare/complete
```

Key Patches

Sensors regression – run-time vs system-suspend conflict

No workaround

Linux 4.0 regression

Fixed in Linux v4.2, v4.1.4; NOT fixed in Linux 4.0-stable

```
4.2-rc3 commit 1e25aa9641e8f3fa39cd5e46b4afcafd7f12a44b
4.2-rc4 commit 88cc7b4eee1e7b9bca1a64dae5adaa044cf72312
4.1.4 commit be43d21df90d10f5f10252c114f5fb024b7ba5ae

Author: Srinivas Pandruvada <srinivas.pandruvada@linux.intel.com>
Date:   Mon Jun 1 16:36:27 2015 -0700

hid-sensor: Fix suspend/resume delay

https://bugzilla.kernel.org/show_bug.cgi?id=102891
```