

Linux Suspend/Resume... ...at the Speed of Light

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Acknowledgements

Todd Brandt – analyze_suspend.py maintainer

Rafael Wysocki – suspend/resume maintainer

Agenda

Concepts

Tools

Results

Future

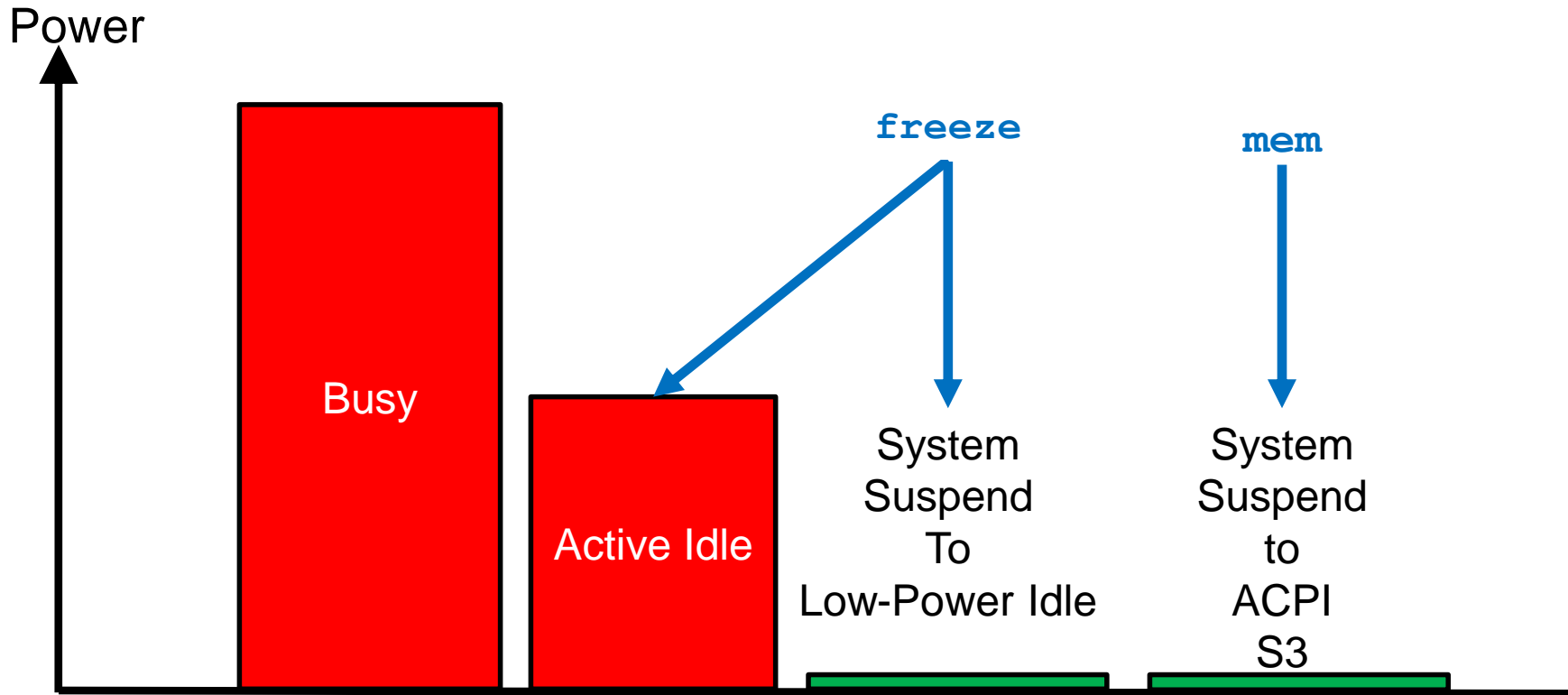
Linux Suspend Types

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

Power savings ←

→ Speed

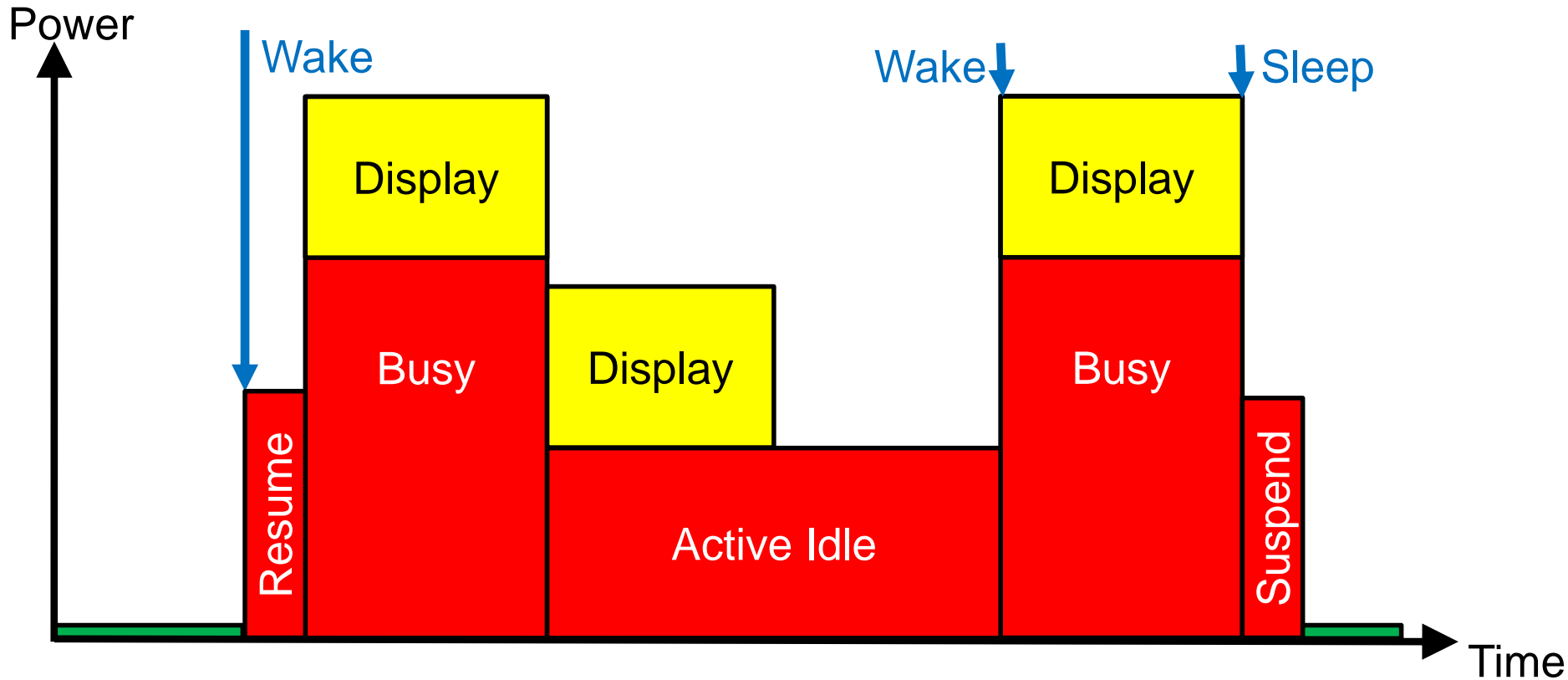
Saving Power with System Suspend



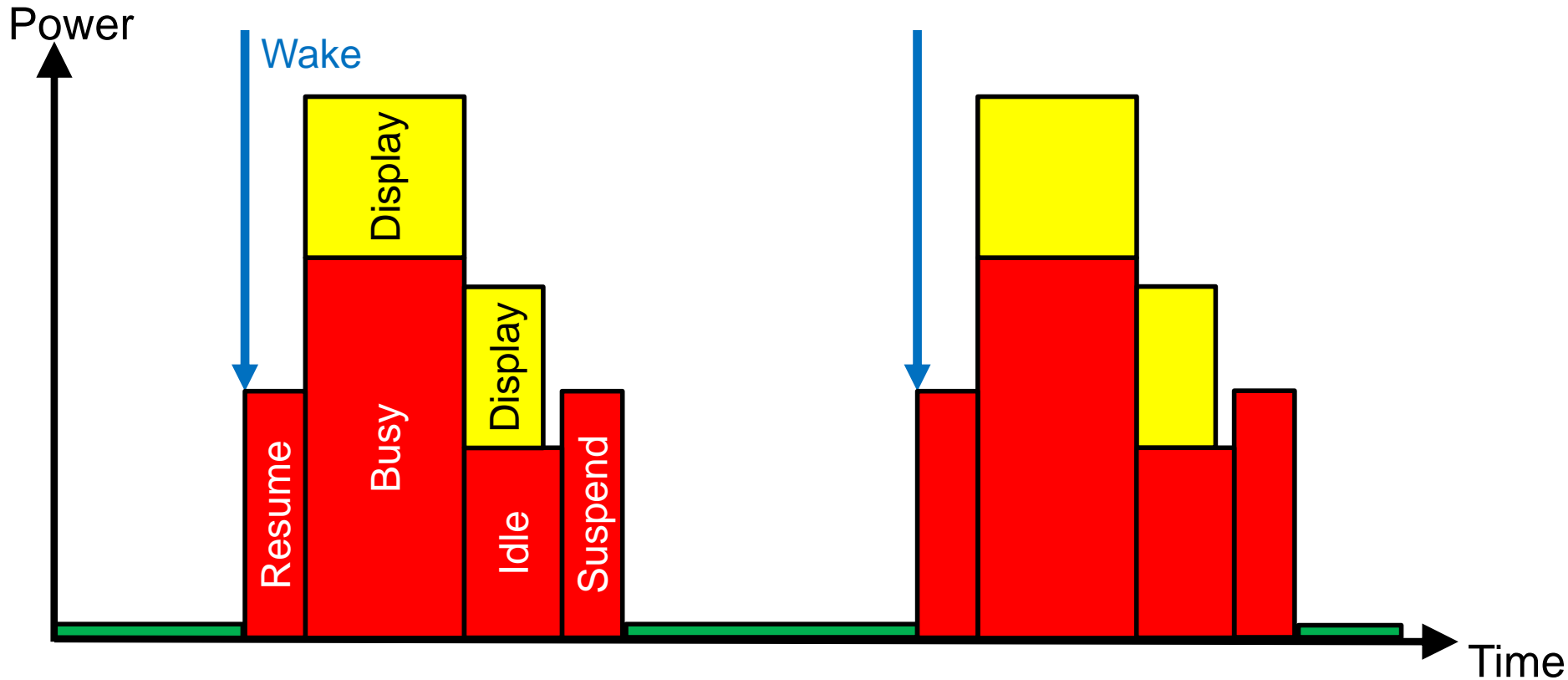
Suspend Trade-Offs

	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				

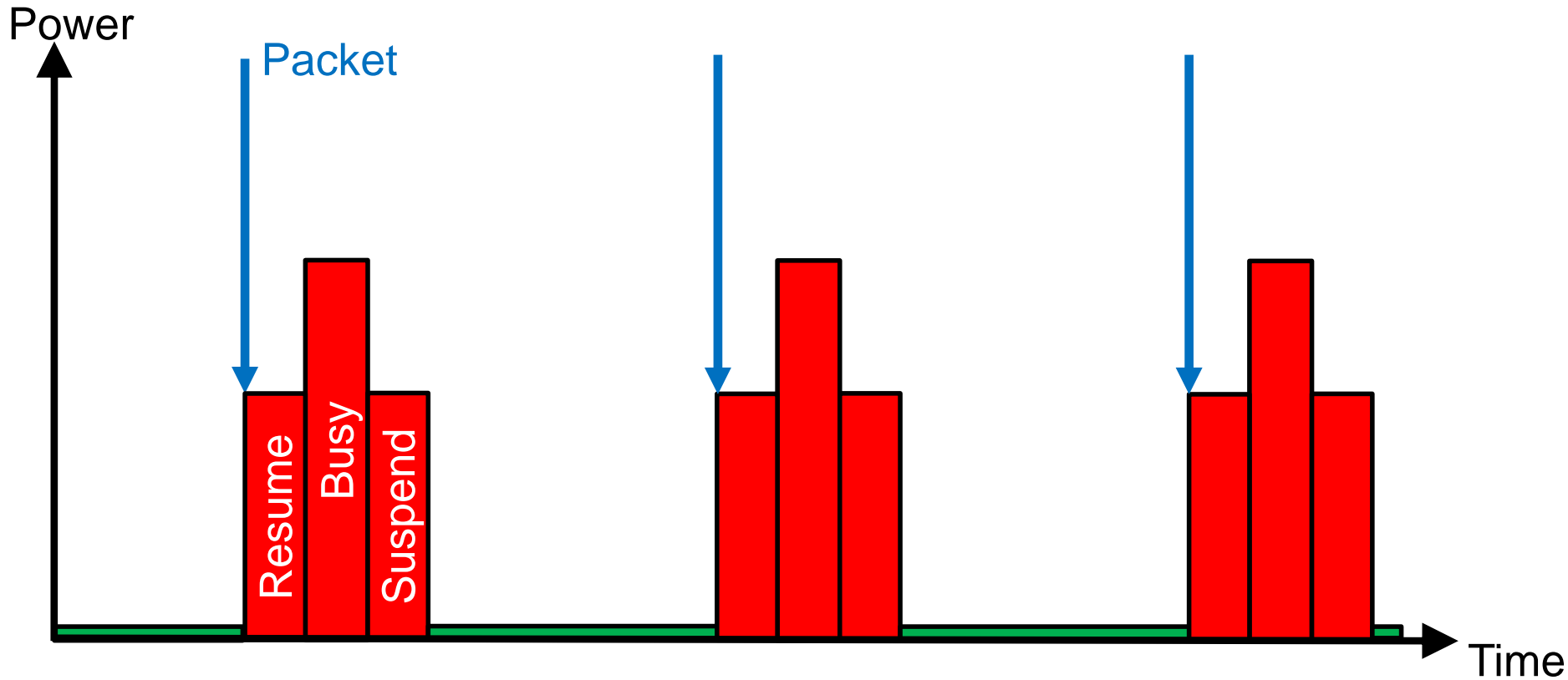
Interactive Laptop Scenario



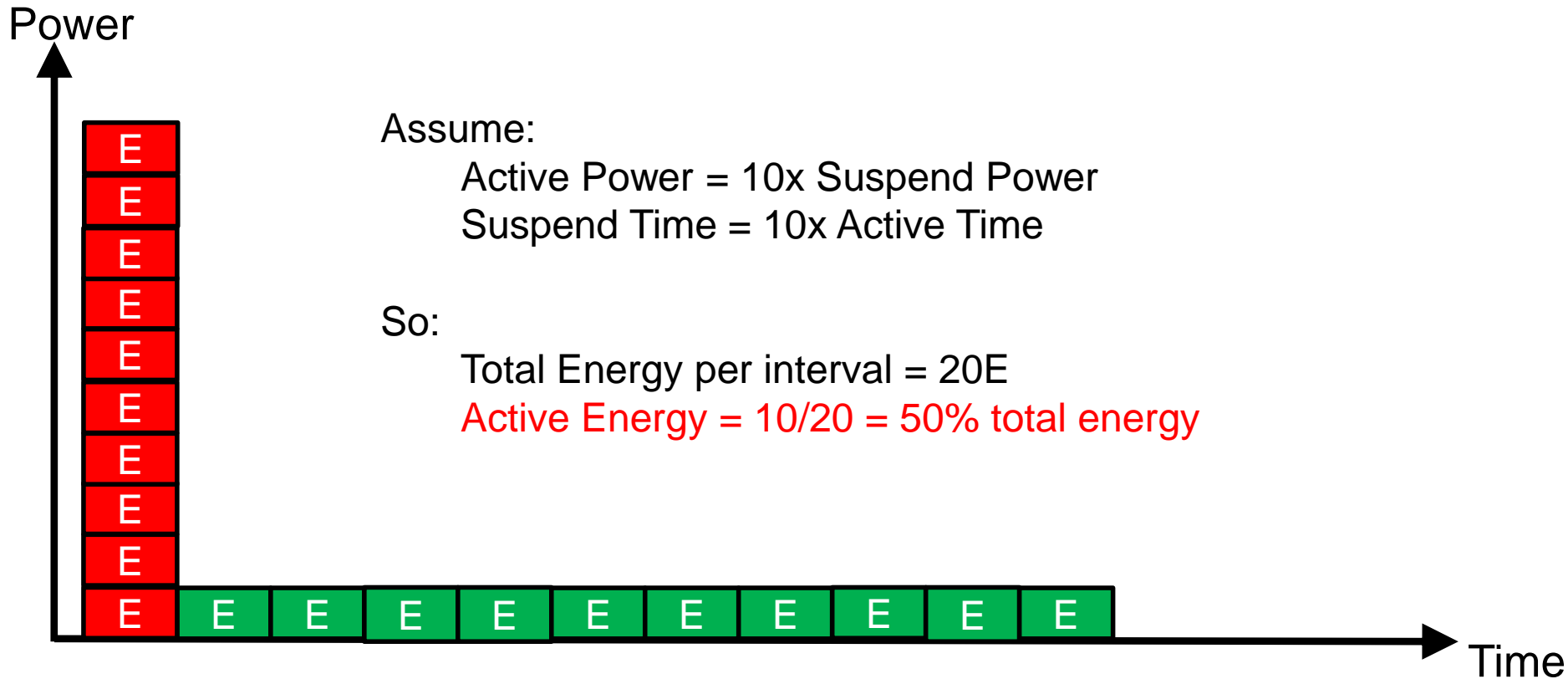
Interactive Handheld Scenario



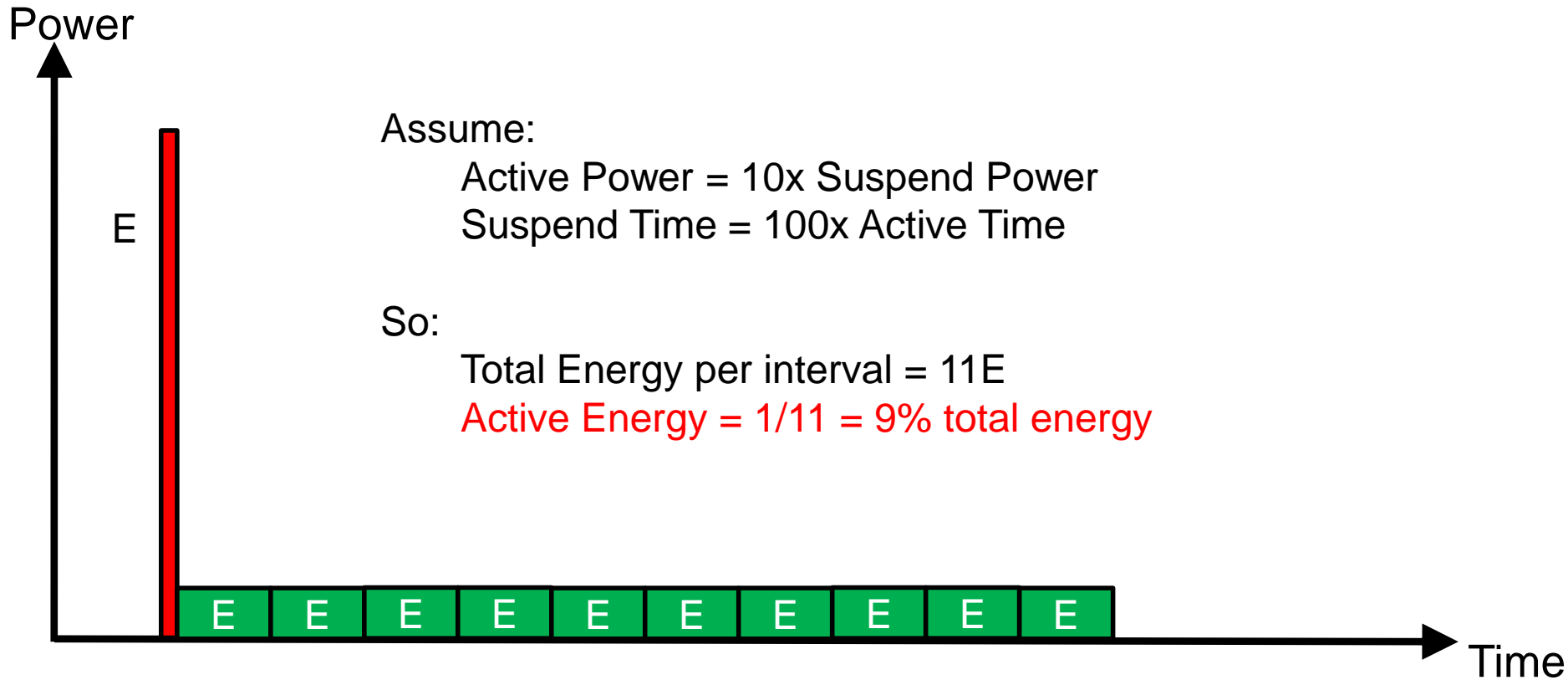
Dark Resume Scenario



Dark Resume Power vs Time



Dark Resume Power vs Time, 10x faster



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

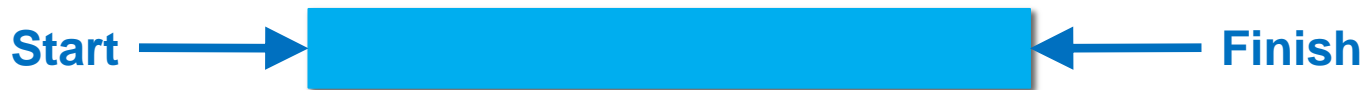
Before:



Going Faster (strategy 2)

Same work, in parallel, but still synchronous

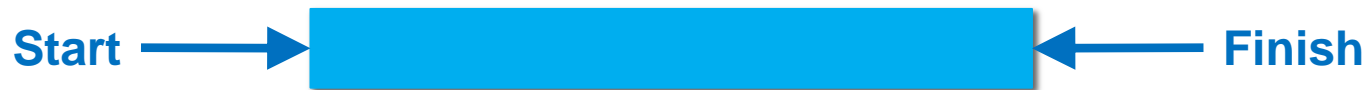
Before:



Going Faster (strategy 3)

Same work, asynchronous

Before:



Going Faster (strategy 4)

Avoid work entirely

Before:



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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

The screenshot shows the SuspendResume website interface. At the top, the browser address bar displays 'https://01.org/suspendresume'. The website header includes the '01.ORG INTEL OPEN SOURCE' logo, navigation links for 'PROJECTS', 'COMMUNITY', 'EVENTS', 'NEWS & BLOGS', and 'ABOUT', and buttons for 'LOG IN' and 'REGISTER'. A search bar is also present.

The main content area features a sidebar with navigation links for 'Home', 'Overview', 'Community', 'Documentation', and 'Blogs'. Below this is the 'MAINTAINERS' section, listing 'Todd Brandt' as the 'Project Owner' with a small profile picture.

The central focus is a performance analysis chart titled 'haswell 3.16.0-rc1-latest mem June 18 2014, 7:35:17 PM'. The chart displays 'Total Suspend Time: 761 ms' and 'Total Resume Time: 706 ms'. It breaks down the suspend and resume phases into kernel, firmware, and hardware components. A detailed bar chart shows the timing of various system events during the suspend and resume process, with a legend identifying different stages like 'suspend_prepare', 'suspend', 'suspend_daving', 'suspend_reachtime', 'suspend_finish', 'resume_prepare', 'resume_reachtime', 'resume_finish', 'resume_wakeup', and 'resume_completion'. A summary bar indicates a total suspend of 289.107 ms and a total resume of 351.280 ms. Below the chart, a list of kernel logs provides specific timing data for various suspend and resume events.

On the right side of the chart, a circular callout box contains the following information:
Released September 16, 2014
Last Updated September 16, 2014
Current Version 3.2 / Changelog

At the bottom right, there is a 'DOWNLOADS' button and a 'Project Links' section with the URL 'github.com/suspendresume'.

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)

-rtctime t Use rtctime 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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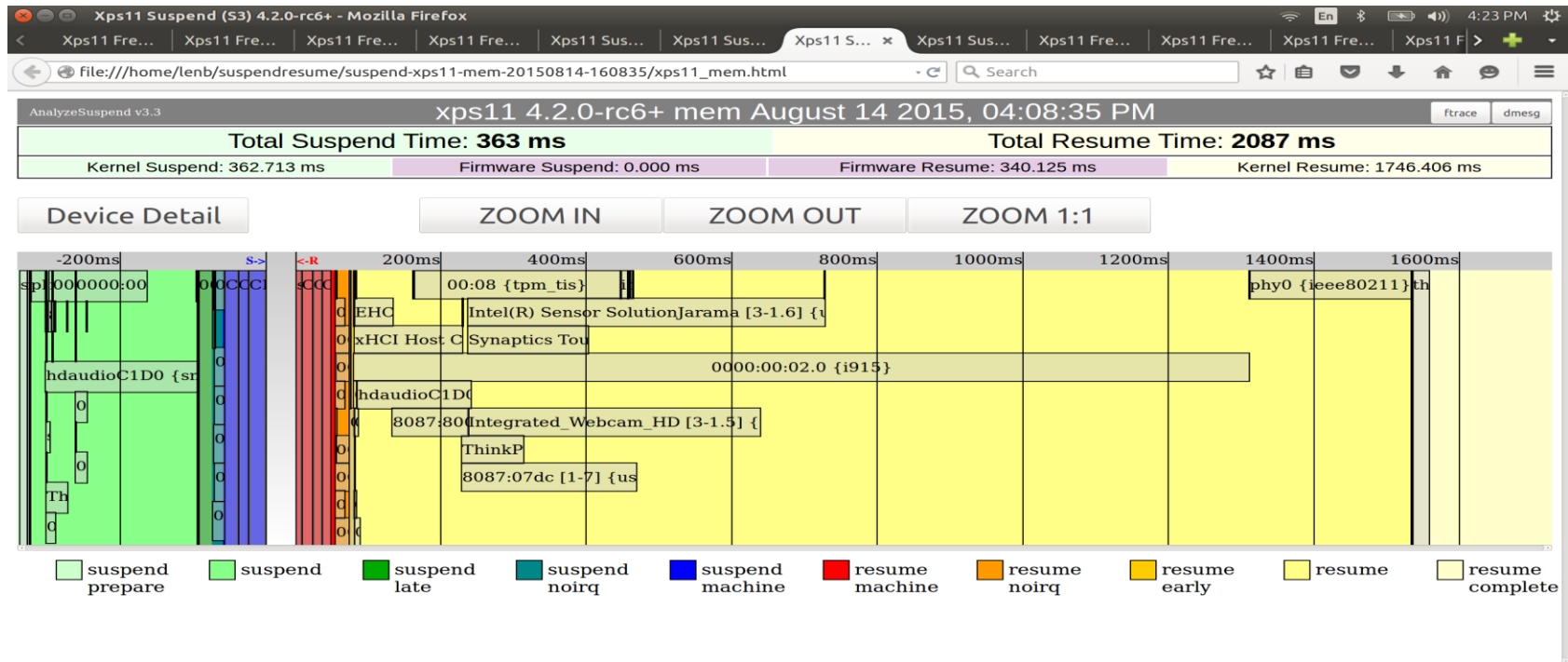
Results

Future

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:

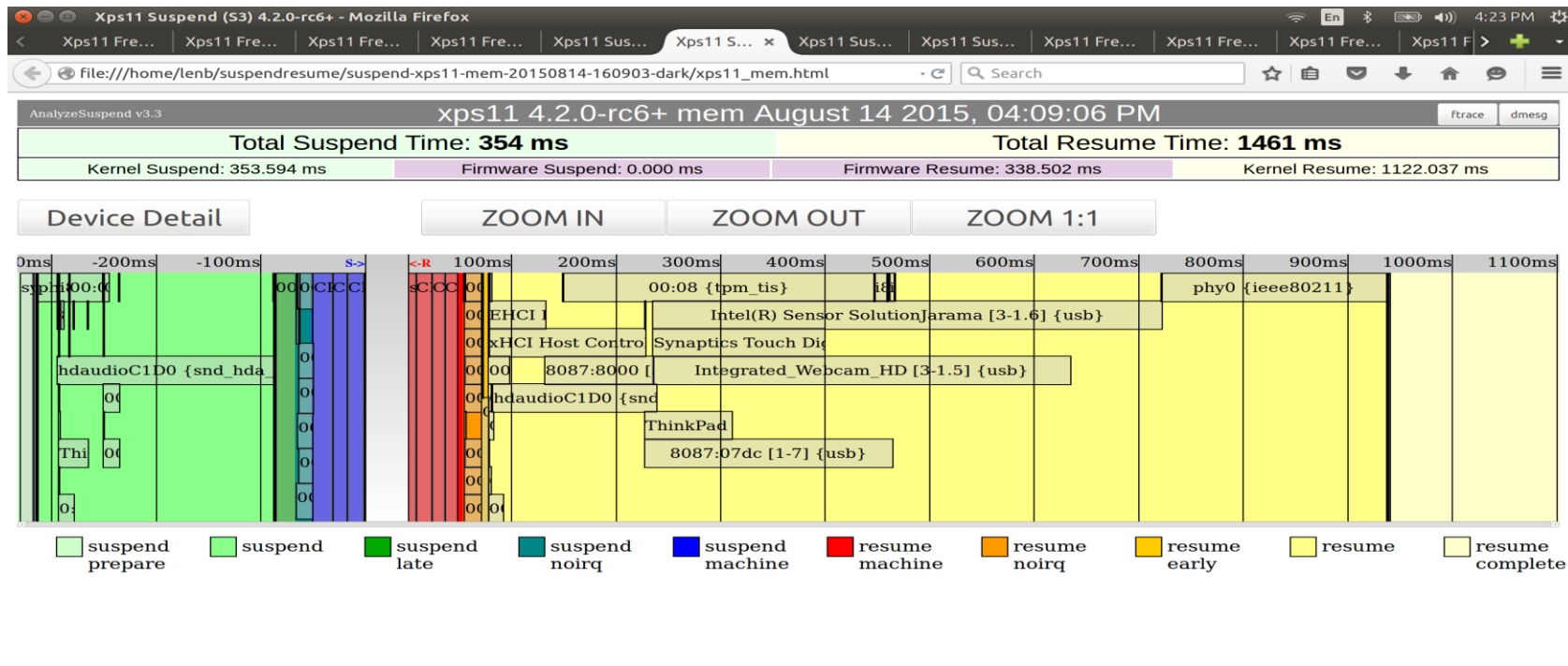
```
$ xset -display :0 dpms force off  
$ sleep 2  
$ sudo analyze_suspend.py
```

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

Dark Suspend/Resume (mem)

ACPI S3: Firmware resume = 340ms

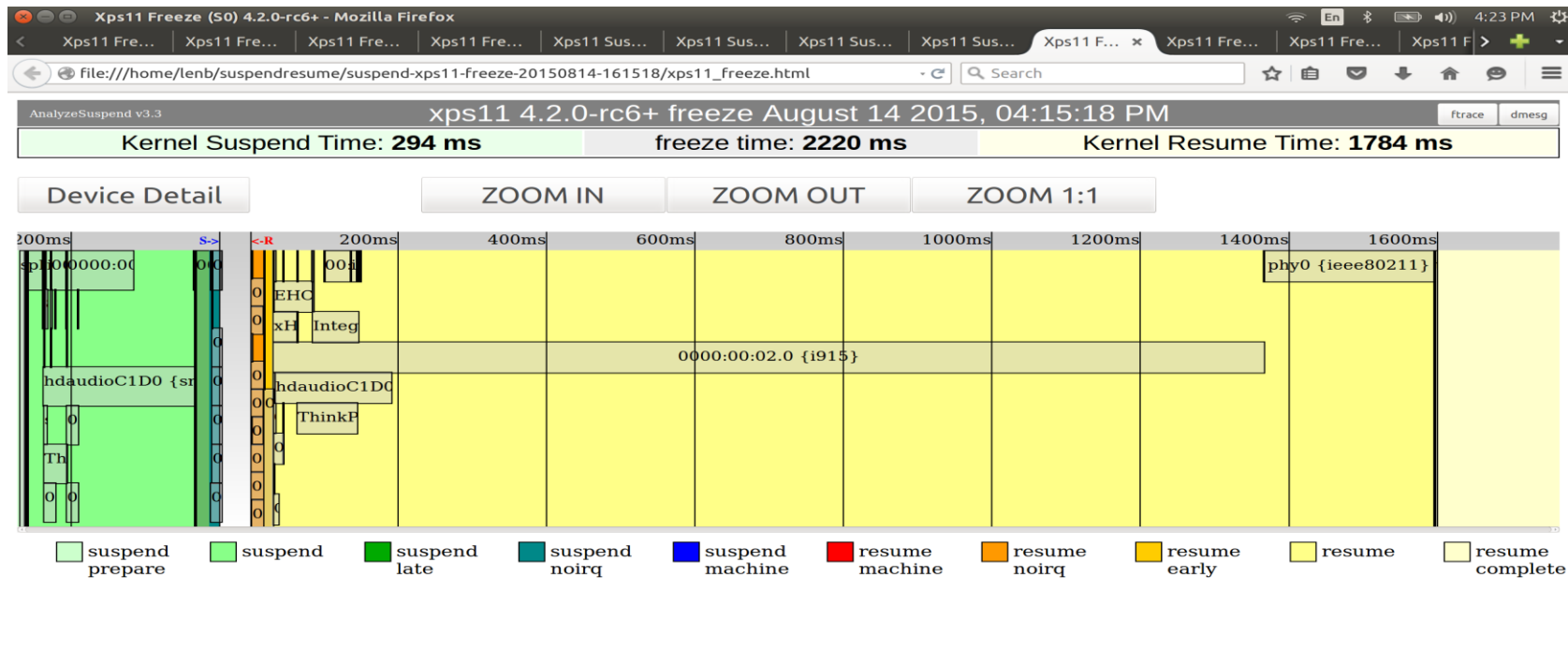
Display OFF



Suspend/Resume (freeze)

Firmware resume = 0

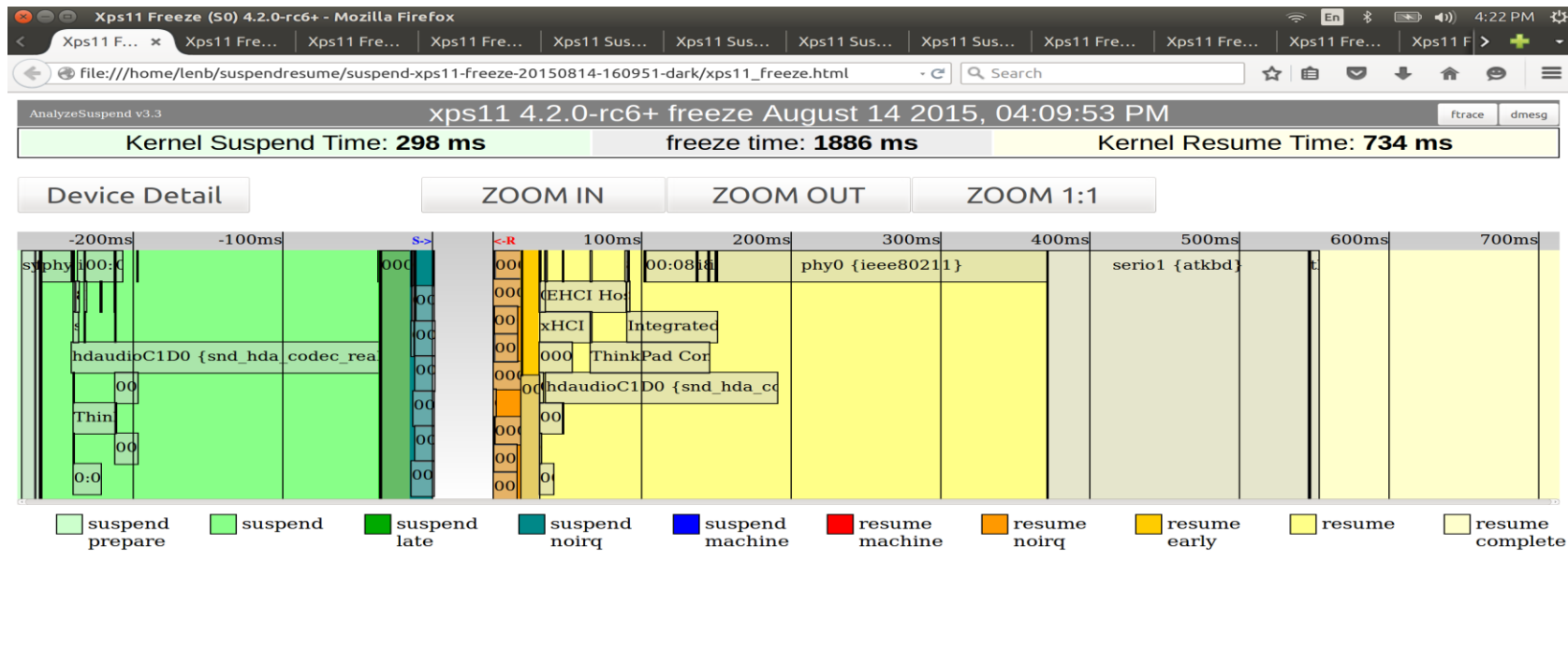
Display on: i915 resume > 1200ms



Dark Suspend/Resume (freeze)

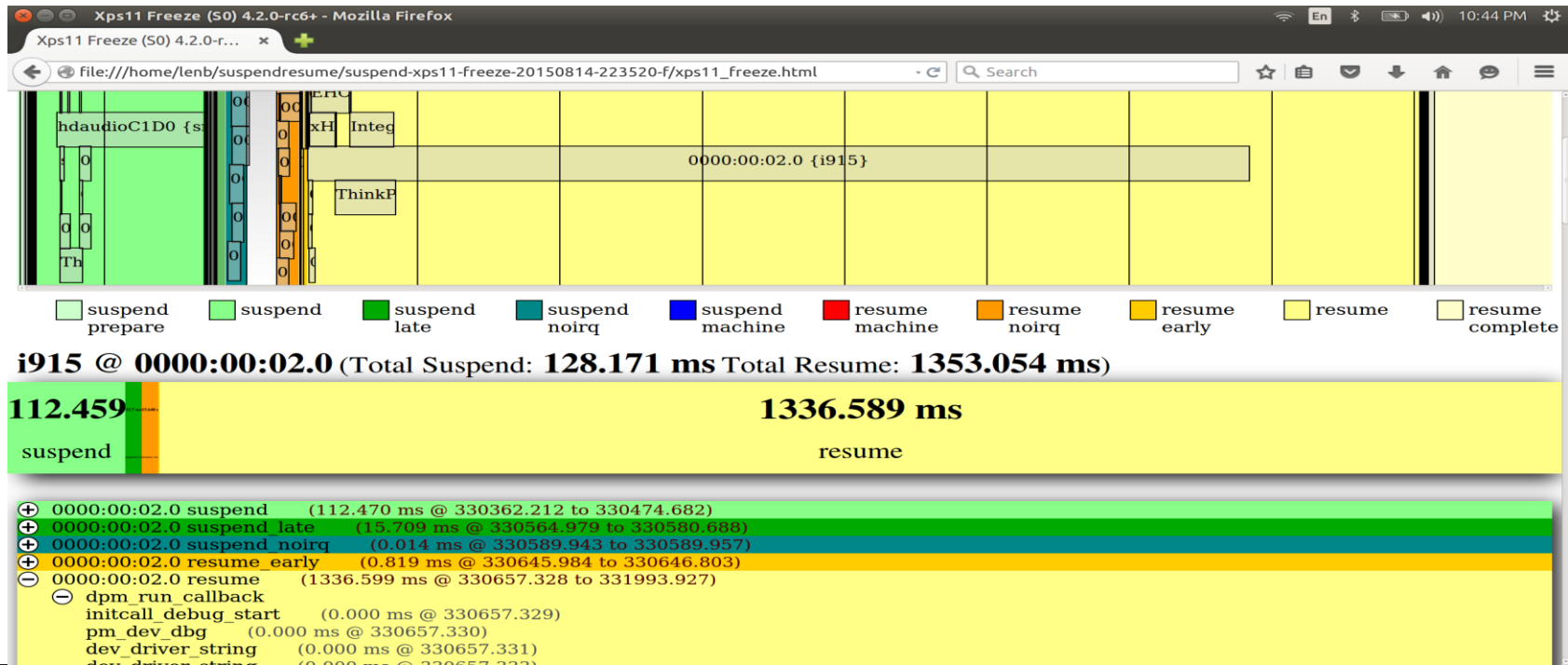
Firmware resume = 0

Display OFF



analyze_suspend -f

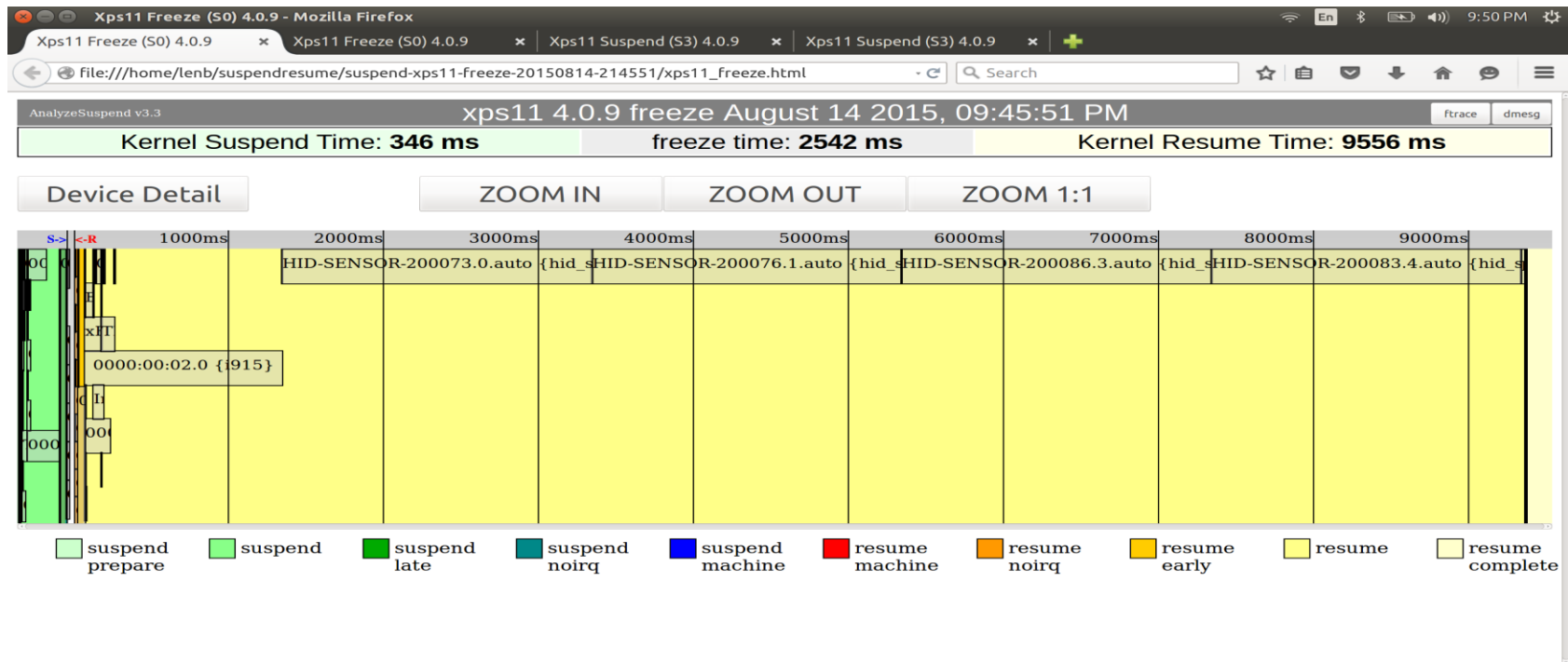
Captures full ftrace call graph, parses in HTML GUI
{HTML file size ~ 64MB}



Things can go very wrong

Linux-4.0 sensors regression – no workaround

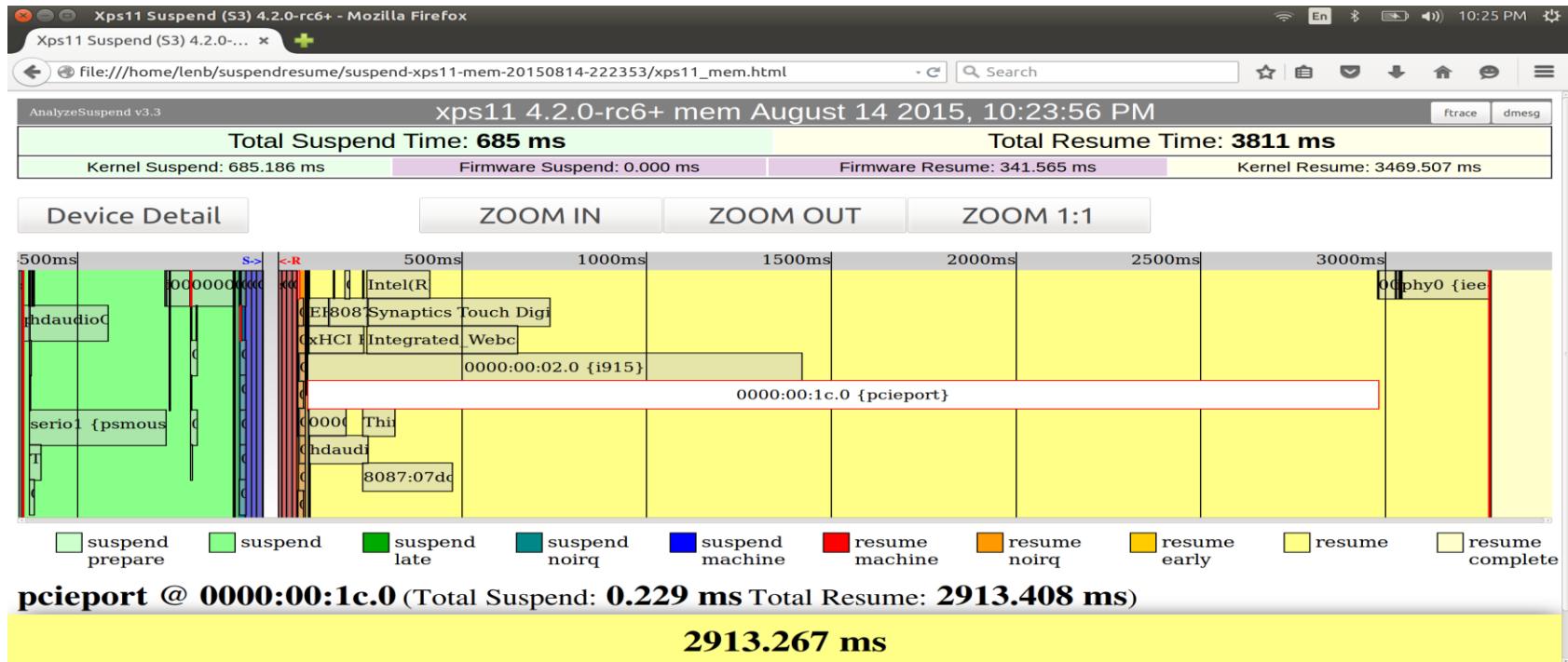
Fixed in Linux-4.2, Linux-4.1-stable. Not fixed in Linux-4.0-stable.



Things can go very wrong

pciport resume 2900ms (https://bugzilla.kernel.org/show_bug.cgi?id=99751)

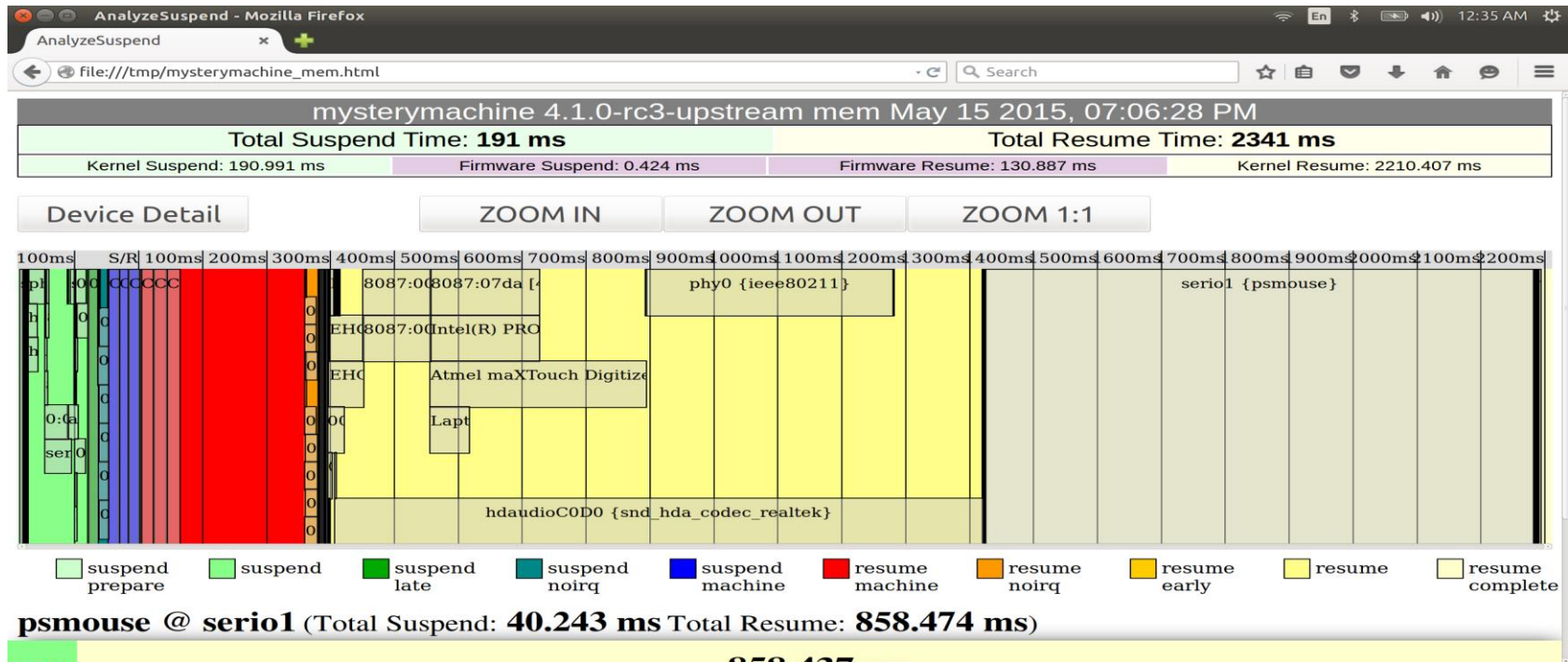
Workaround: boot with "pci_ports=compat"



Things can go very wrong

850ms Serio1/psmouse due to lock contention in resume_complete. Fixed in Linux 4.2-rc1.

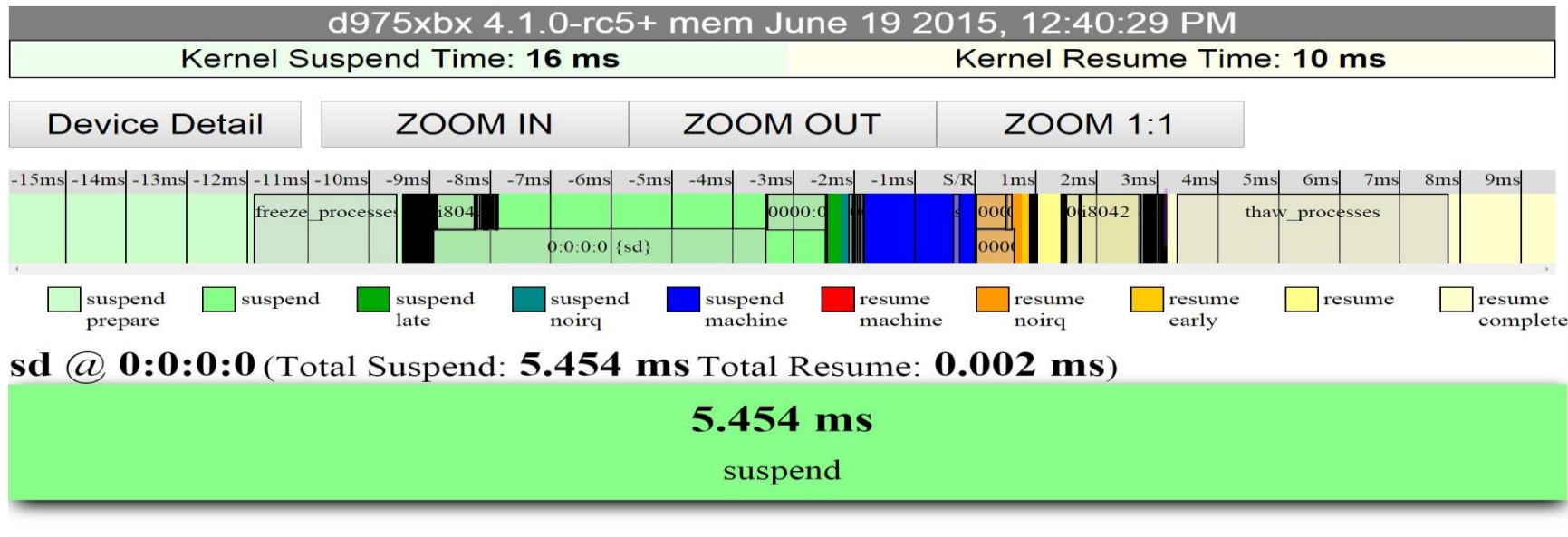
Workaround: boot with "no_console_suspend"



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
```