Java in space?

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Fiji Systems LLC

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Java is a *modern*, *portable*, *simple*, *safe*, and *widely-used* language.

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But, so far, Java has seen *limited use* in safety-critical applications.

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Fiji Systems LLC is trying to make Java flightworthy.

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Why even consider Java?

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- Top defects in existing embedded code: *
  - Buffer overflow and underflow
  - Null object dereference
  - Uninitialized variable
  - Inappropriate cast
  - Division by zero
  - Memory leaks

Source: “Diagnosing Medical Device Software Defects”
Medical DeviceLink, May 2009

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Why even consider Java?

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  - ~~Buffer overflow and underflow~~ *impossible in Java*
  - ~~Null object dereference~~ *checked in Java*
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  - ~~Inappropriate cast~~ *checked in Java*
  - ~~Division by zero~~ *checked in Java*
  - ~~Memory leaks~~ *GC*

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- Java supports safe dynamic loading.

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- *Java brings a plethora of modern language features that make software engineering more cost-effective.*

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Java for Real Time

- 1998 - NIST prepared a set of requirements for RT Java
- 1999 - JSR-001, first draft specification
- 2002 - Real Time Specification for Java (RTSJ) accepted
- 2005 - SUN and IBM release RTSJ implementations
- 2006 - JSR-302 Safety Critical Java started
- 2008 - development of Fiji VM SCJ begins.

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Fiji VM

High-performance Real-time Java

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Fiji VM

- Compiles Java to fast machine code
  - *no interpretation! competitive with C code!*
- Small footprint (~100KB)
- Strong real-time support
  - *Real Time Garbage Collection and scoped memory*
- Can write device drivers in Java
- Multi-core ready
- Portable (x86, PPC, SPARC, ARM, others)
- Runs on RTEMS, Linux, others

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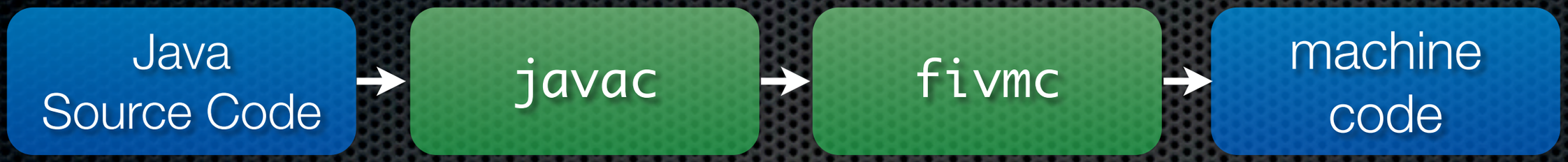
Fiji VM is a compiler



- Fiji VM uses Java byte code as input (*versions 1.0 through 7 supported*)
- Fiji VM produces executables.
- *Your code is never interpreted.*
- Result: small footprint, fast and predictable execution.

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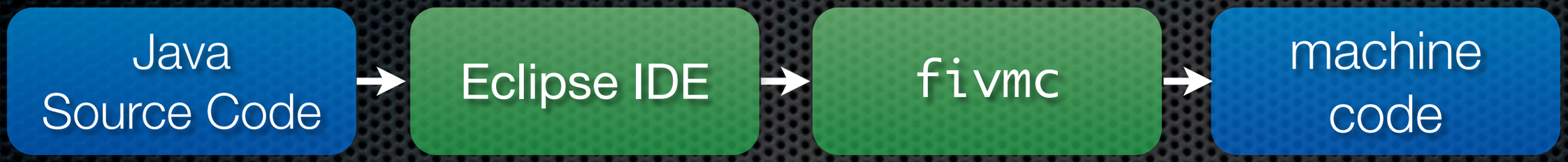

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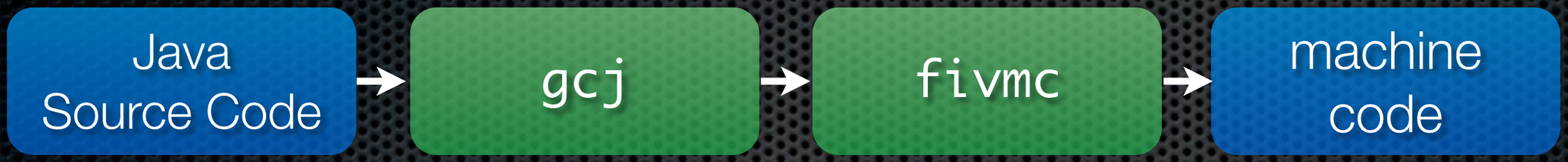

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Fiji VM real-time support

- Striving for Safety-critical Java (SCJ) compliance, targeting DO-178B and DO-178C level A certification.
- Every operation has predictable timing.
- Memory usage is predictable.
  - *both garbage collection and SCJ scoped memory*

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Fiji VM Garbage Collection

- Garbage collection allows *safe, fragmentation-free* dynamic memory allocation.
- Garbage collector runs as a separate thread.
- The scheduling of this thread can be programatically controlled.
- We provide WCET and schedulability formulas that describe how much CPU time this thread should get.
- *Application threads see no interference from the GC.*

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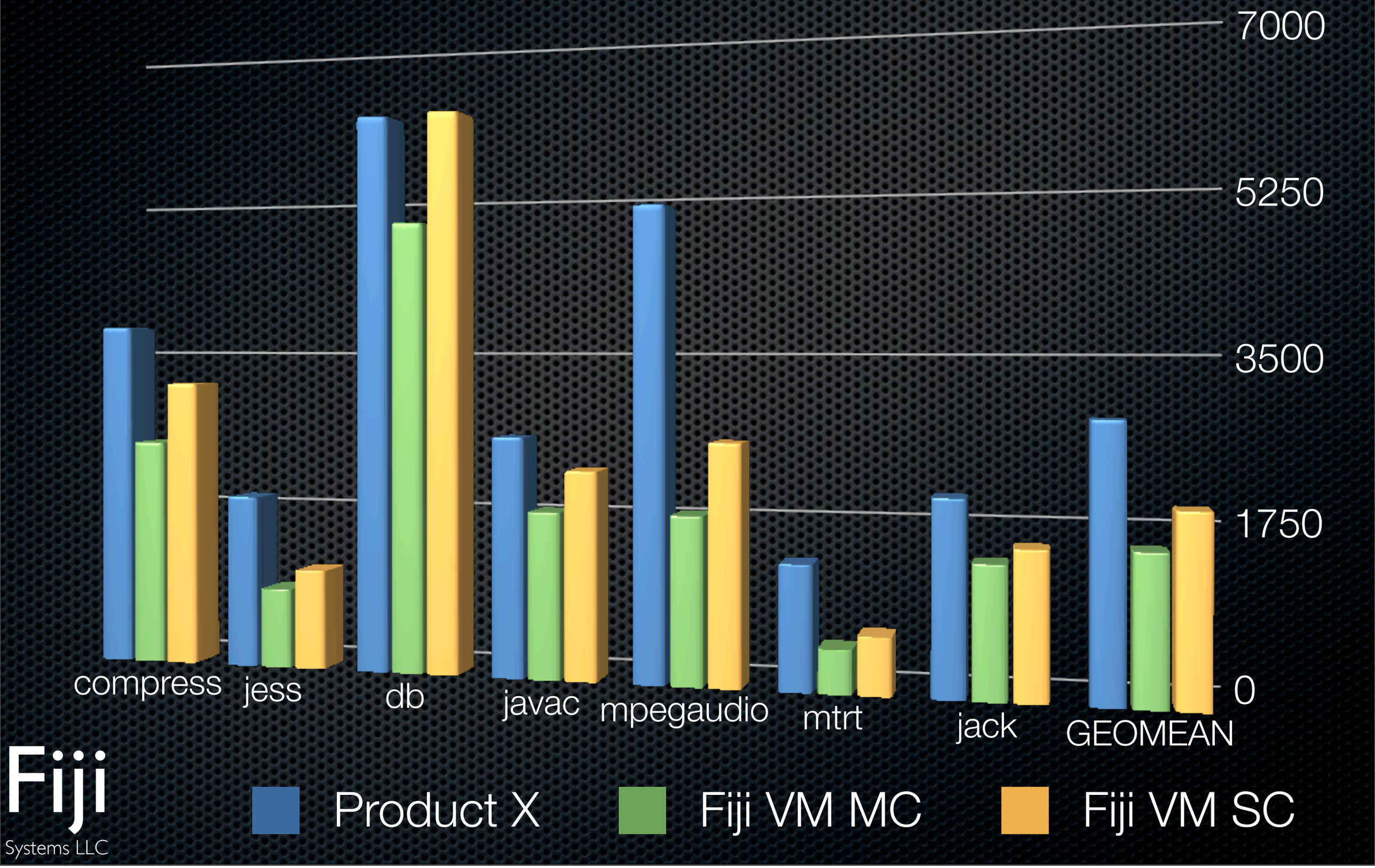
This isn't the Java you're used to.



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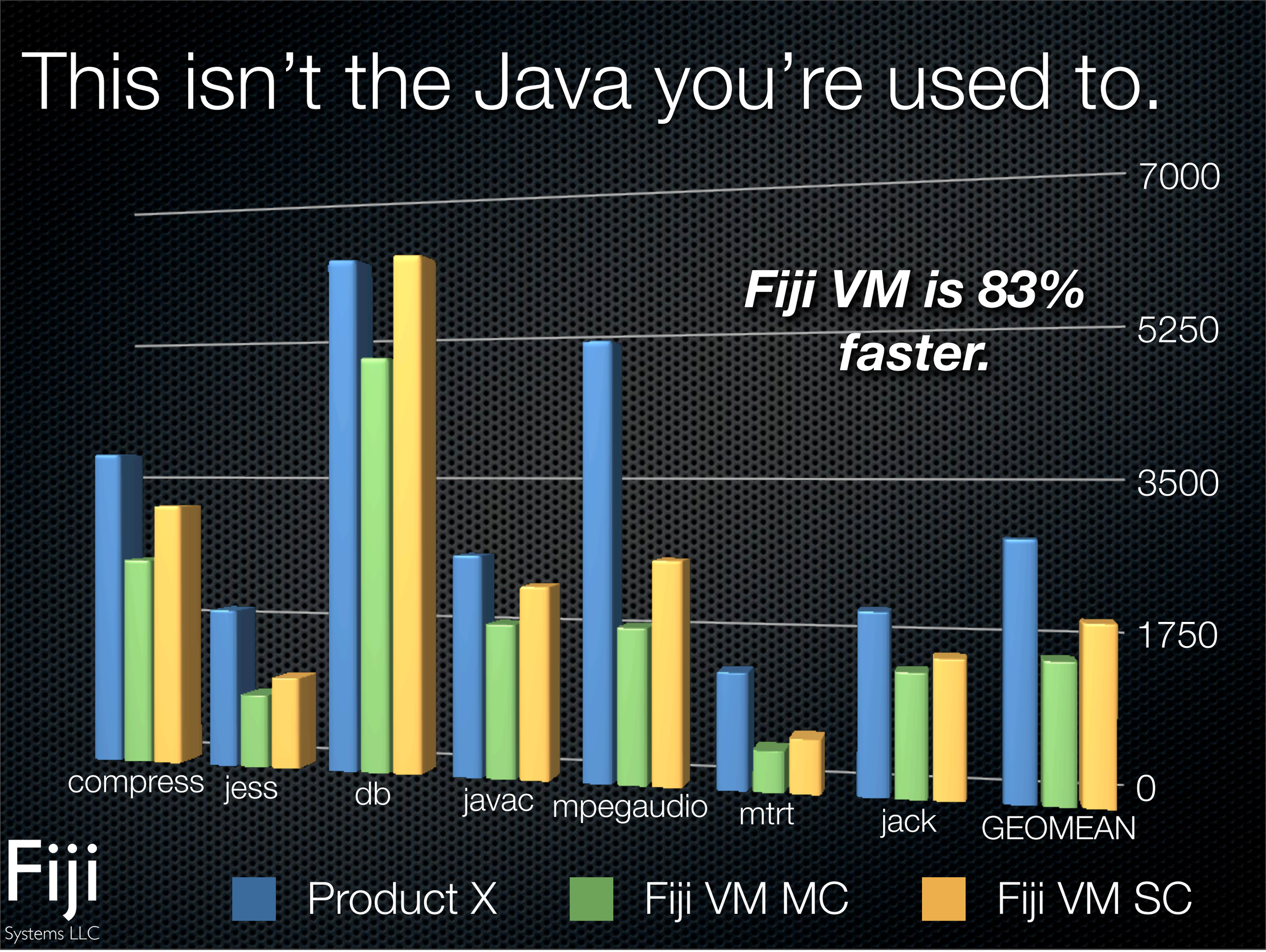

Fiji VM is 83% faster.

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Predictability Benchmark

- We use the CDx benchmark to measure performance and predictability of Fiji VM.
  - *see http://adam.lille.inria.fr/soleil/rcd/*
- CDx has a single periodic task that performs aircraft collision detections.
- *CDx includes both C and Java versions.*

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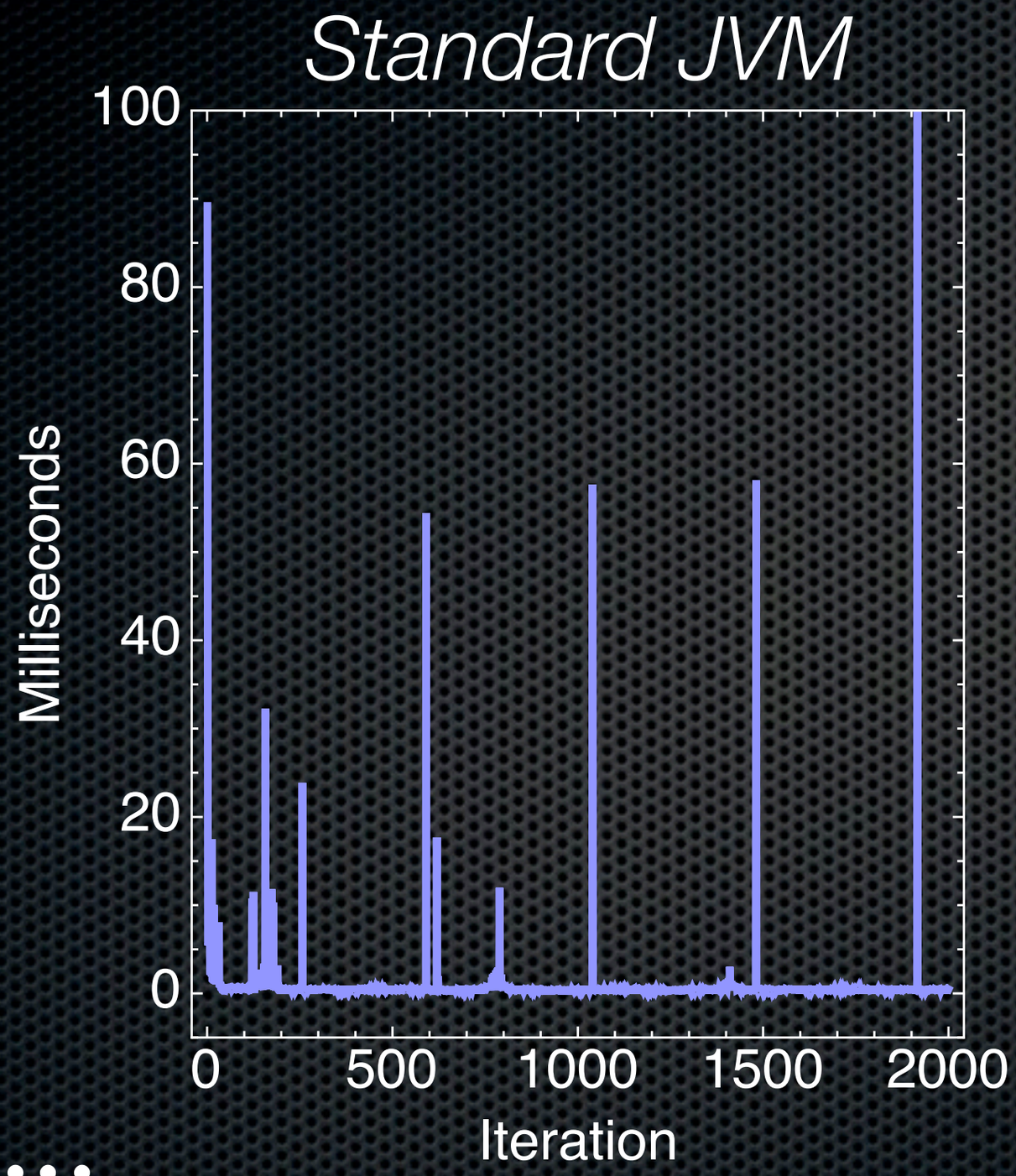
Predictability



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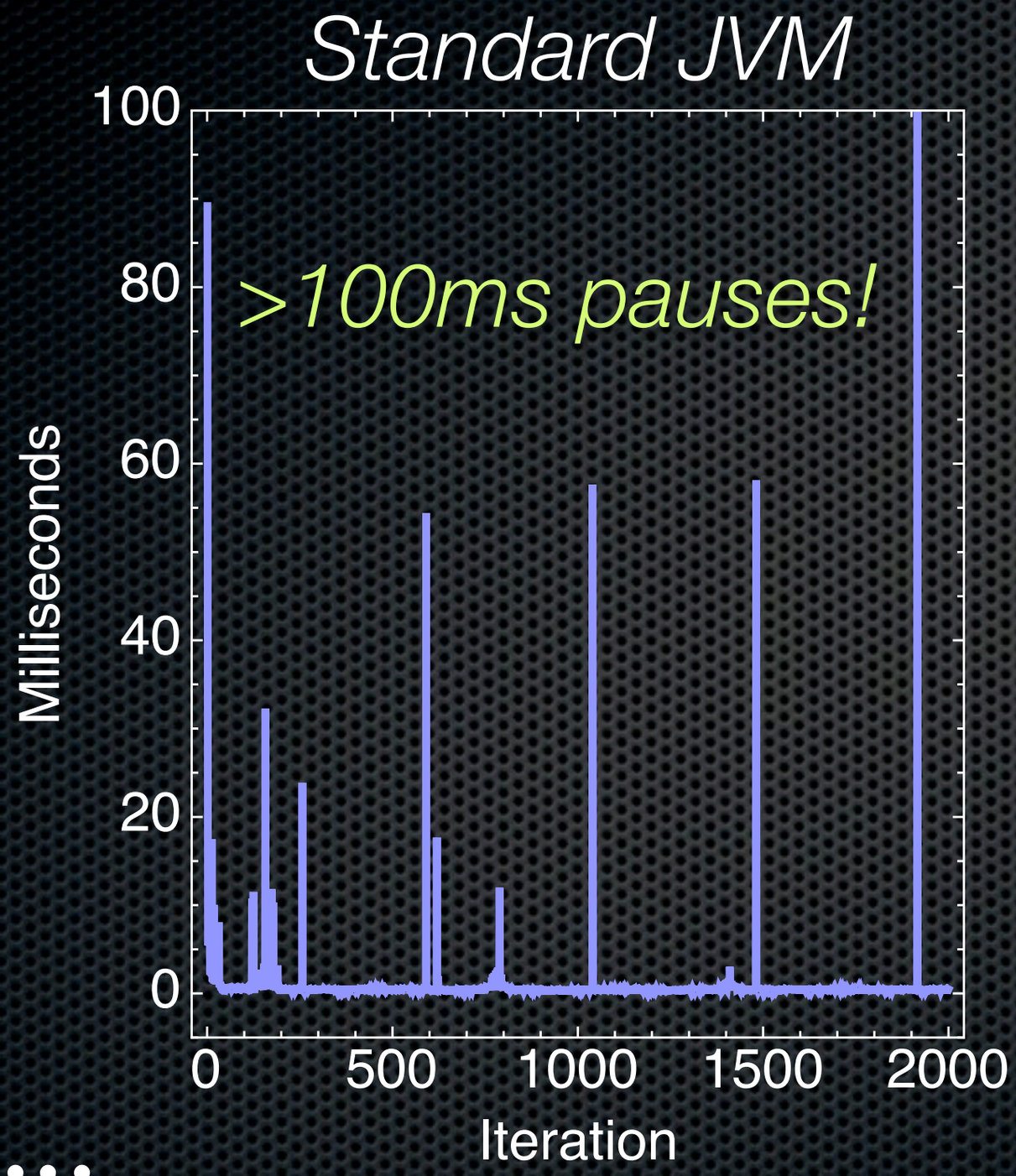
**CDx benchmark "HARD" configuration.*

Predictability



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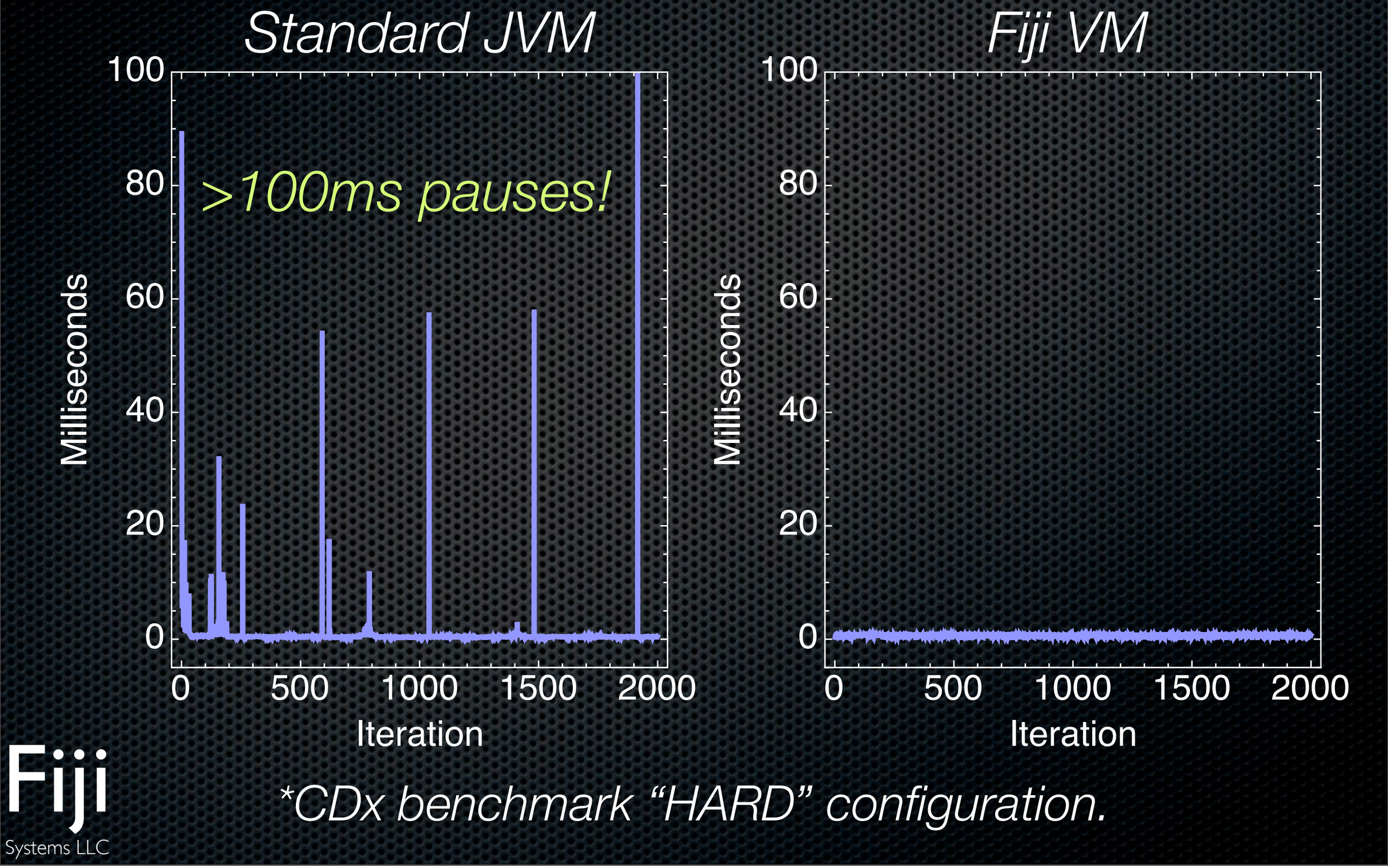

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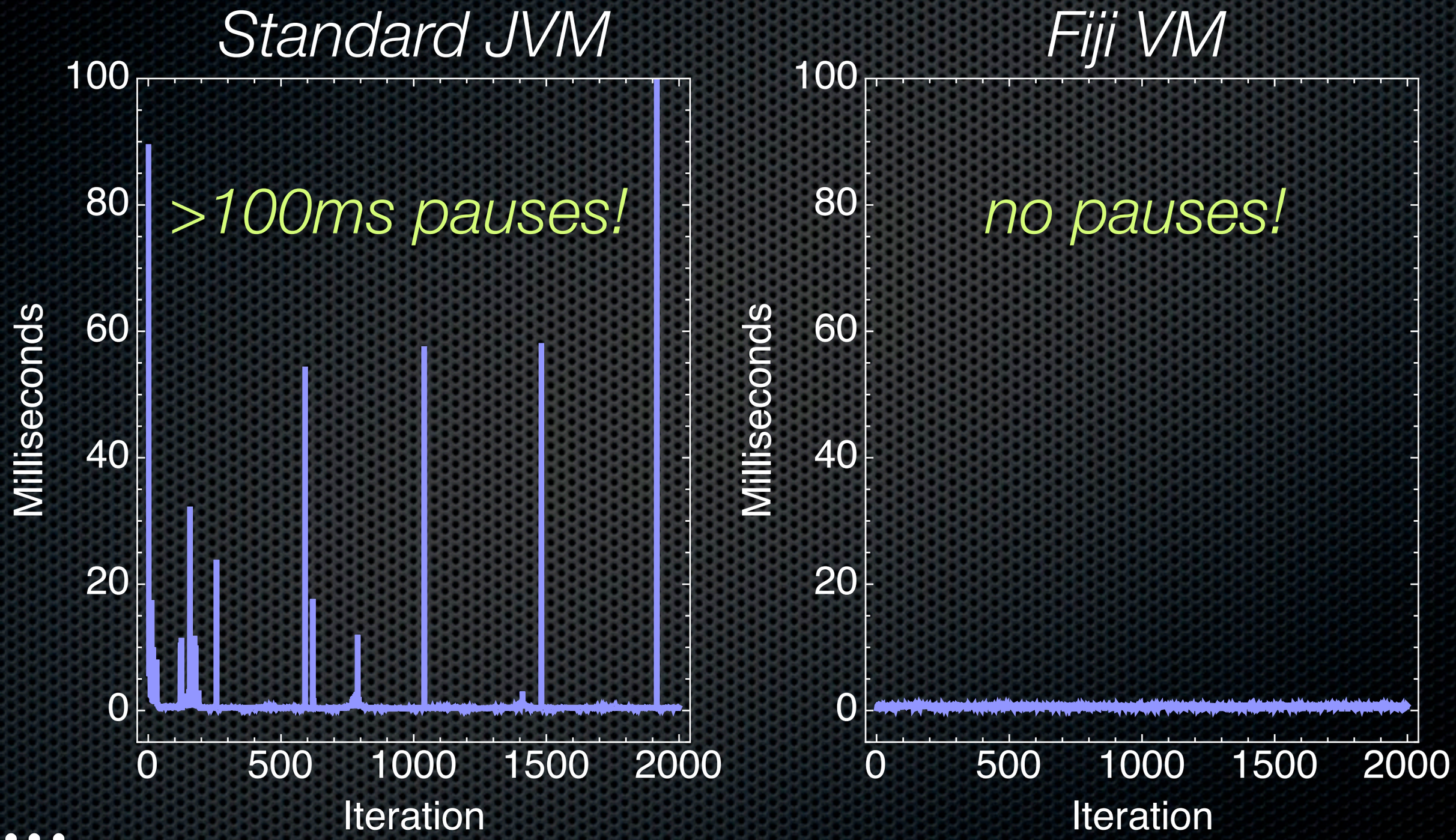

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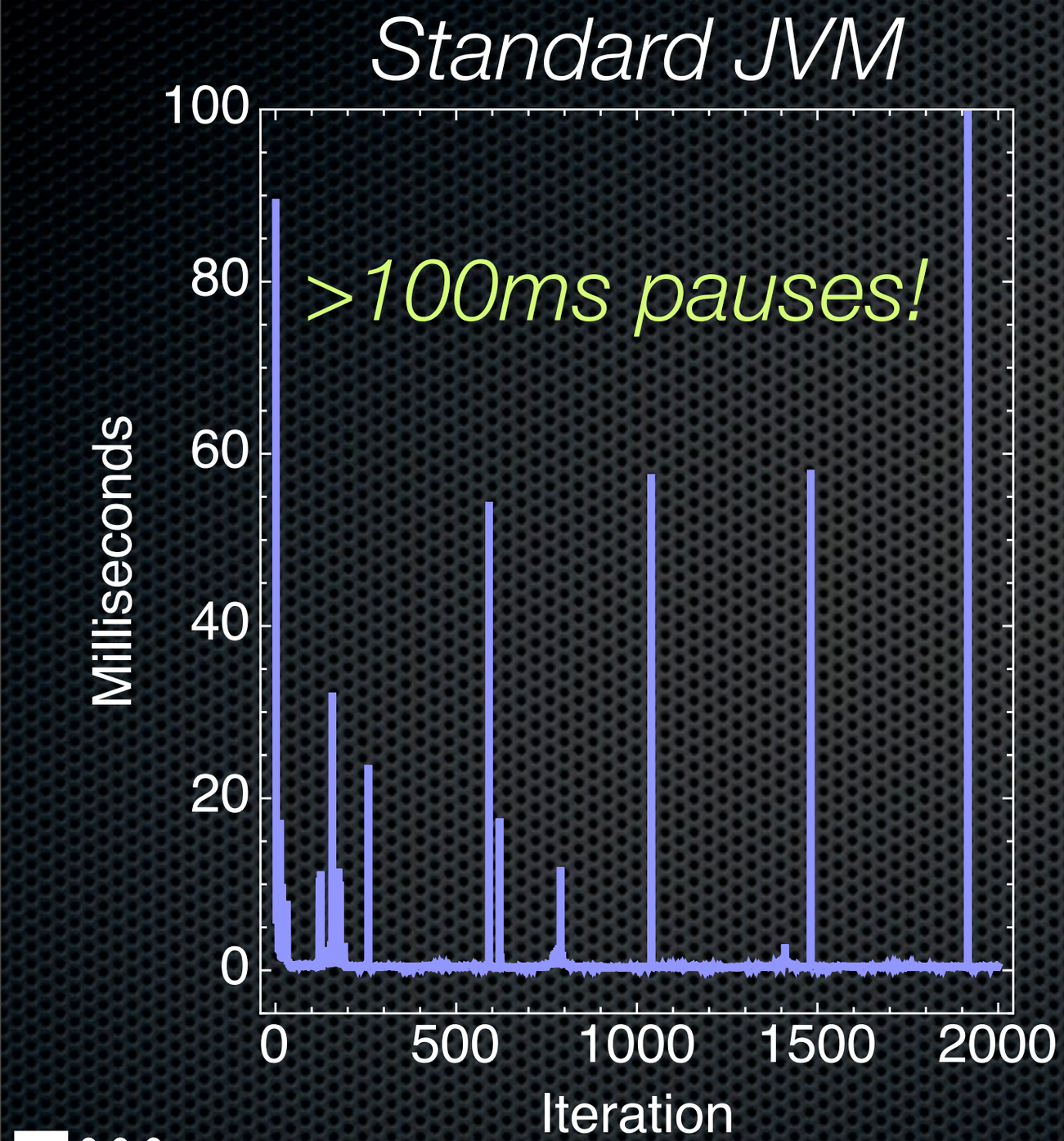

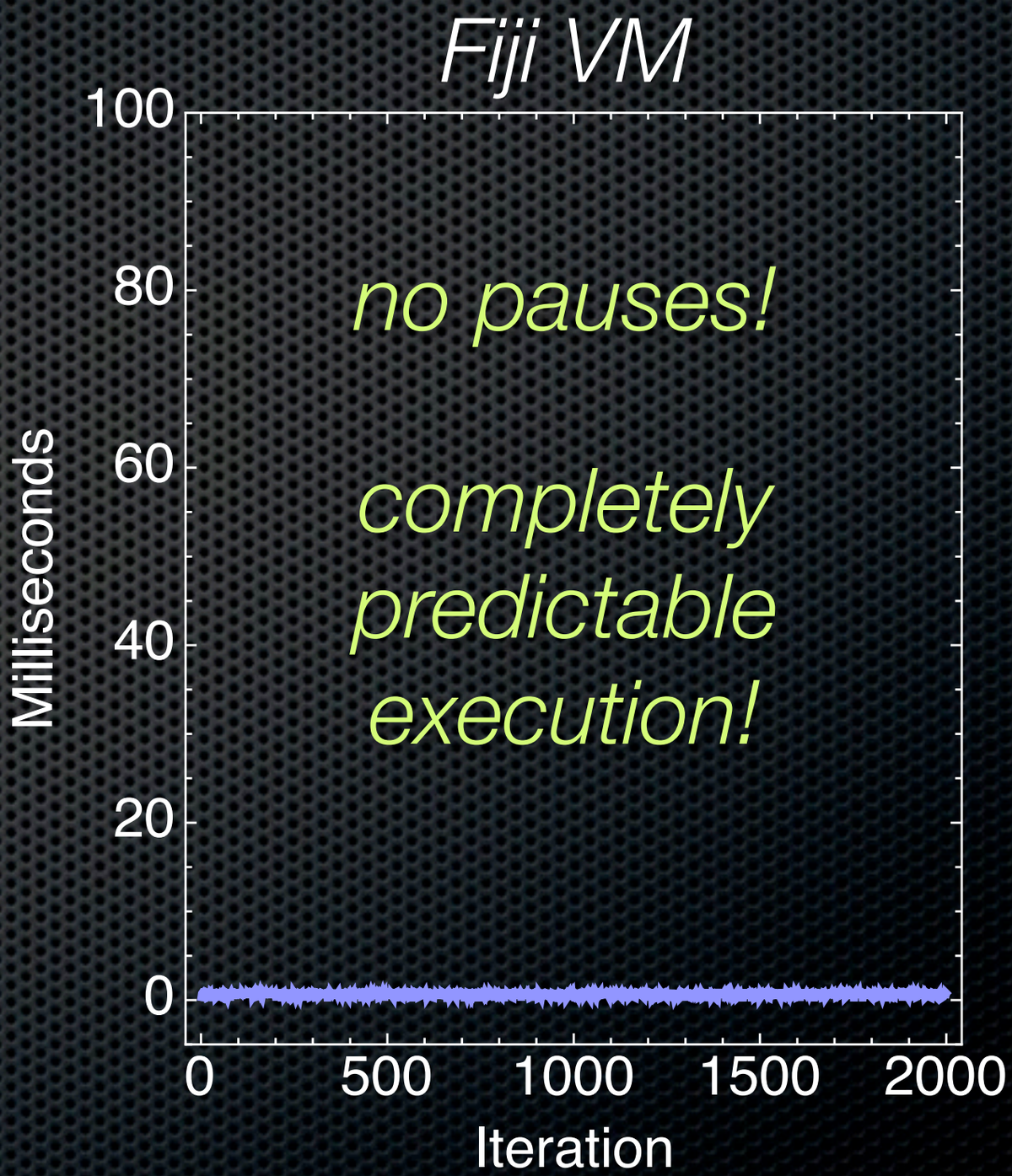

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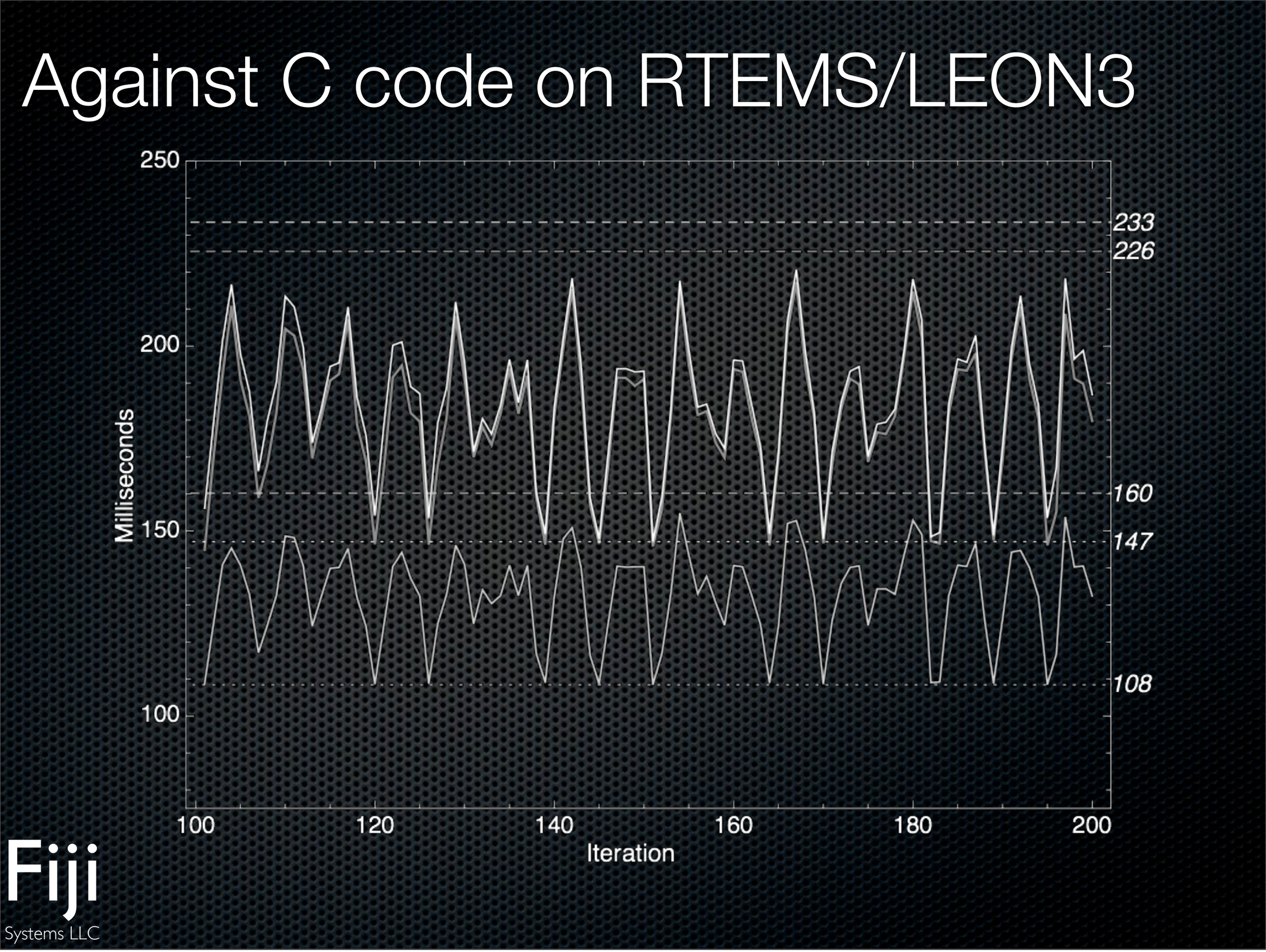
Against C code on RTEMS/LEON3



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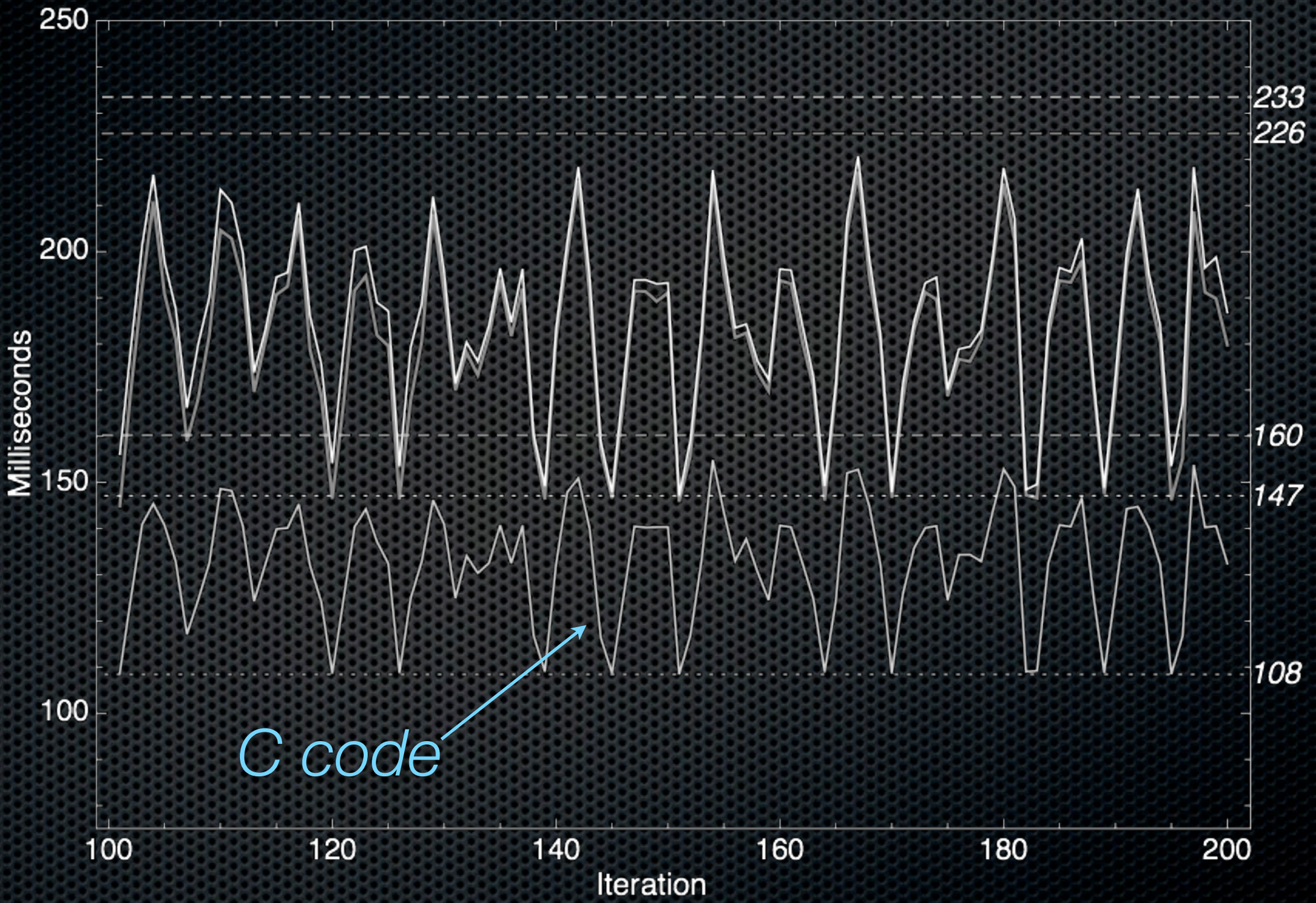

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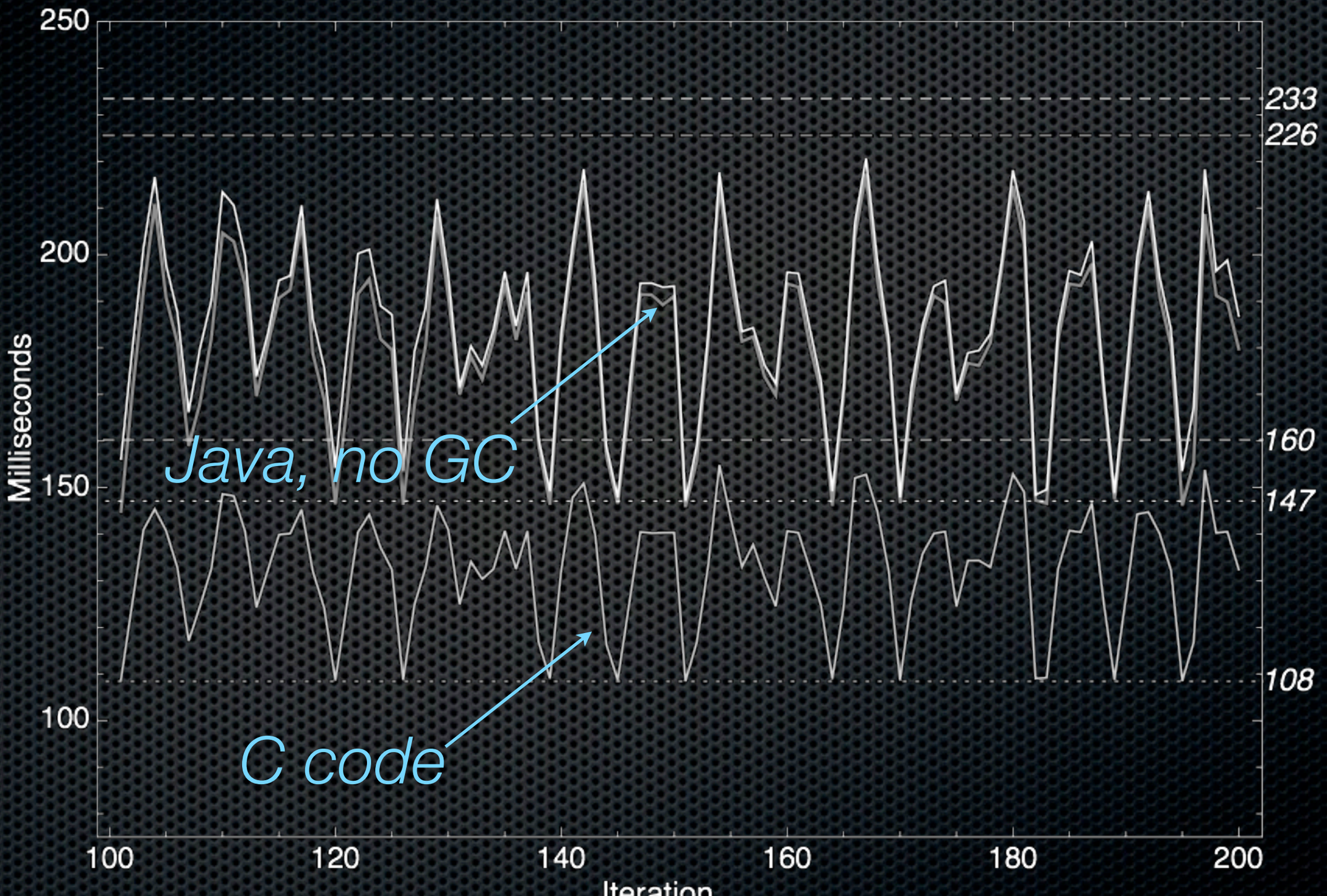

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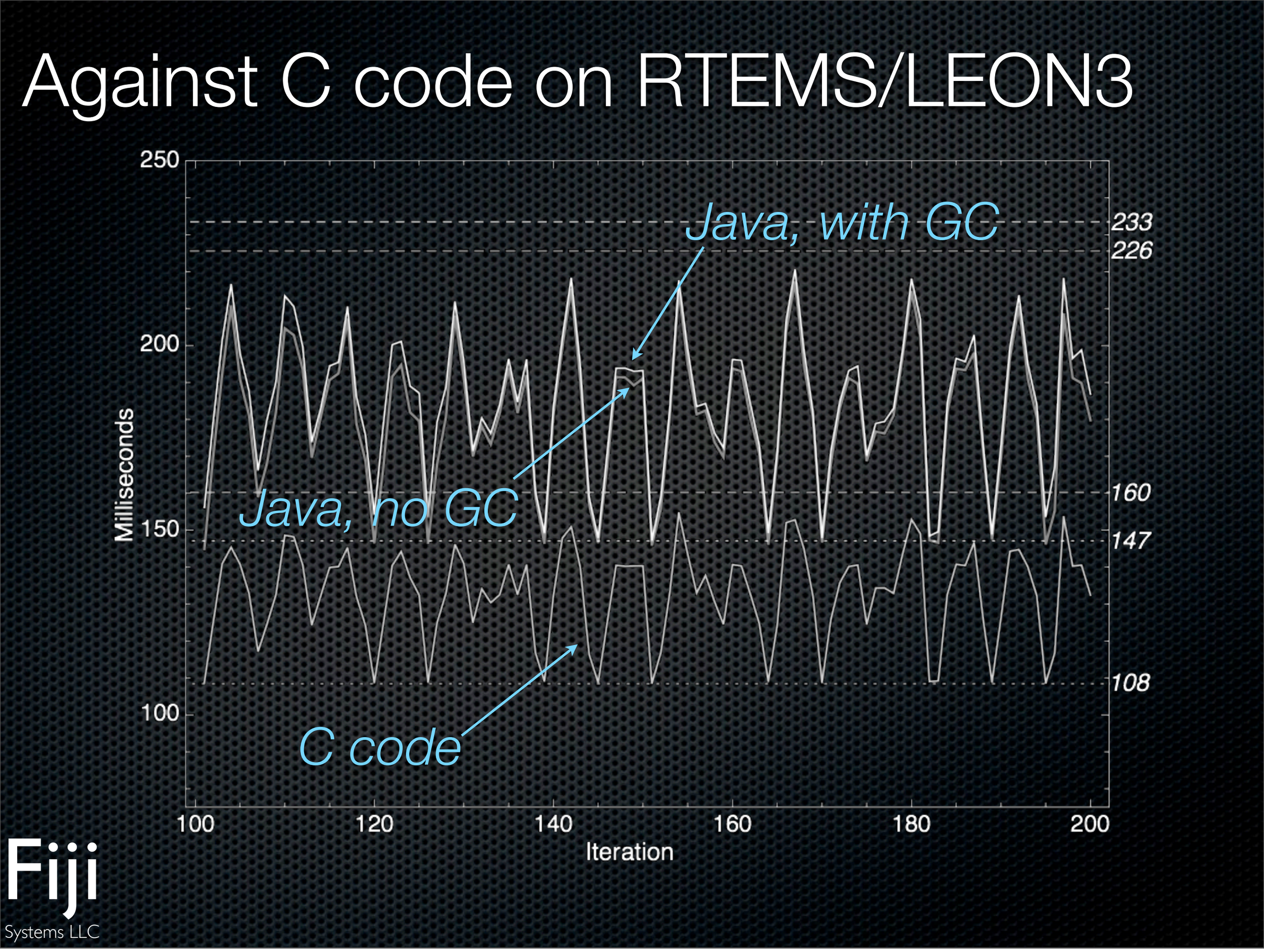

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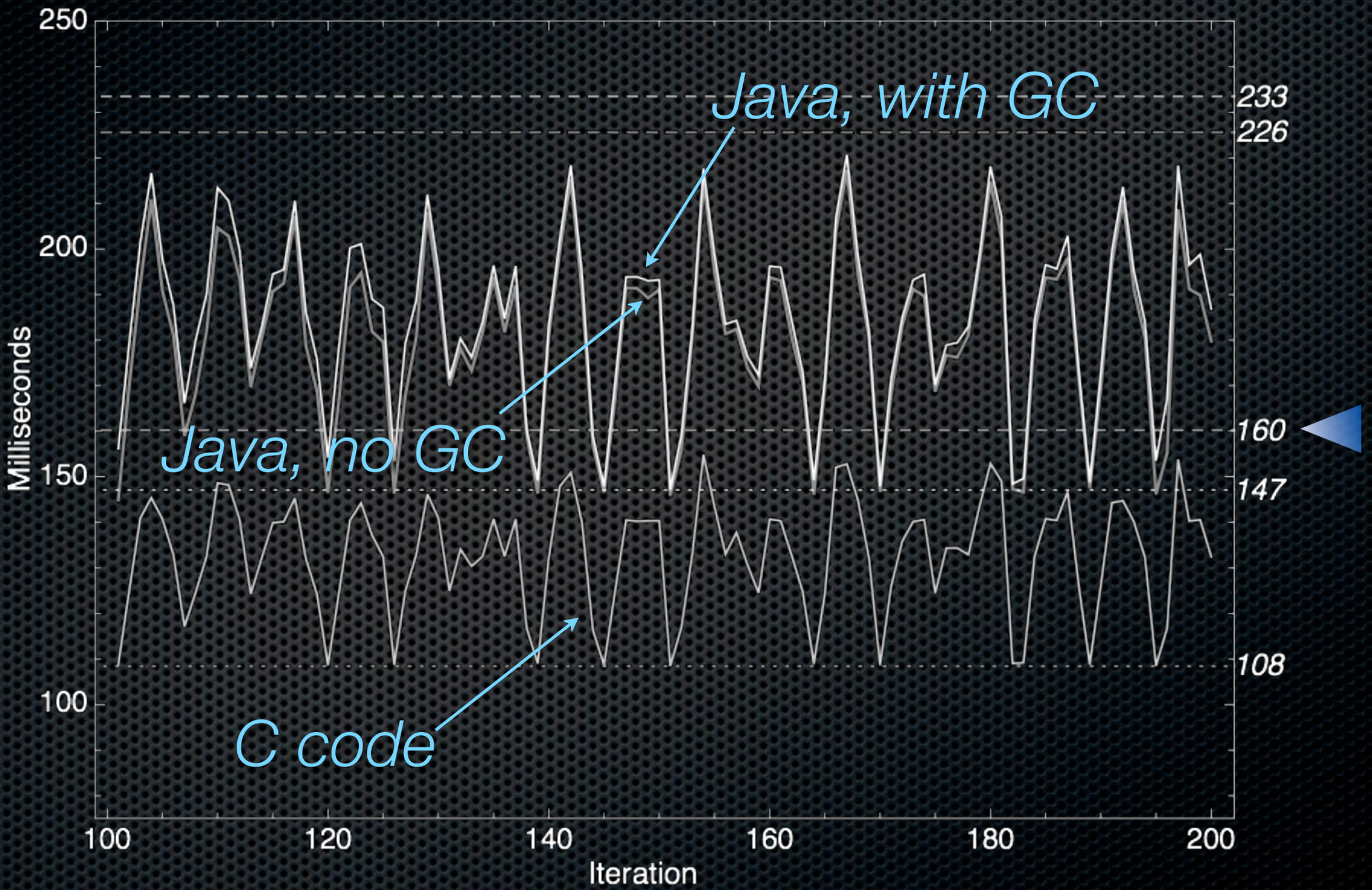

C worst case is 160 ms

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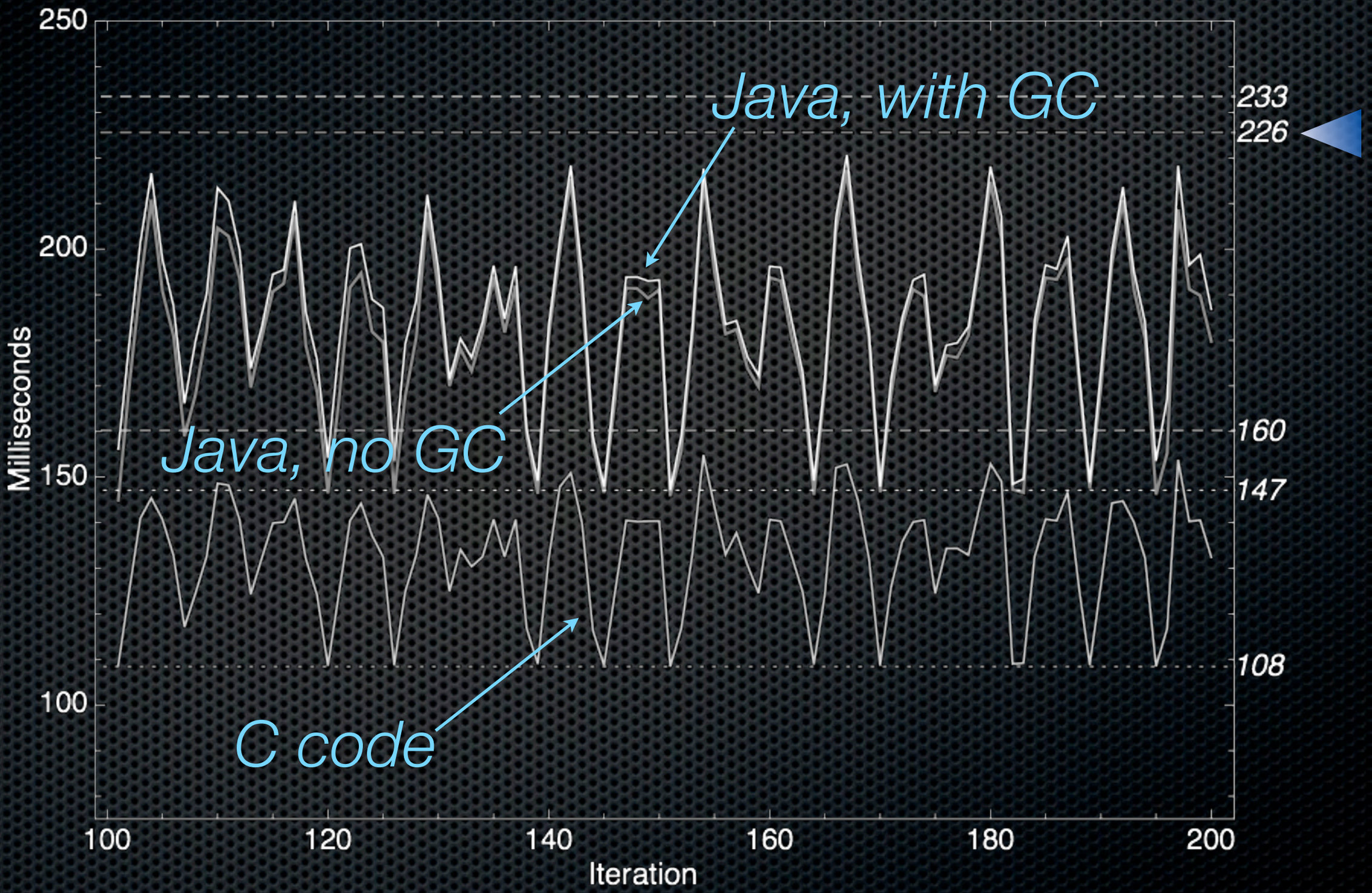

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Java no GC worst case is 226 ms

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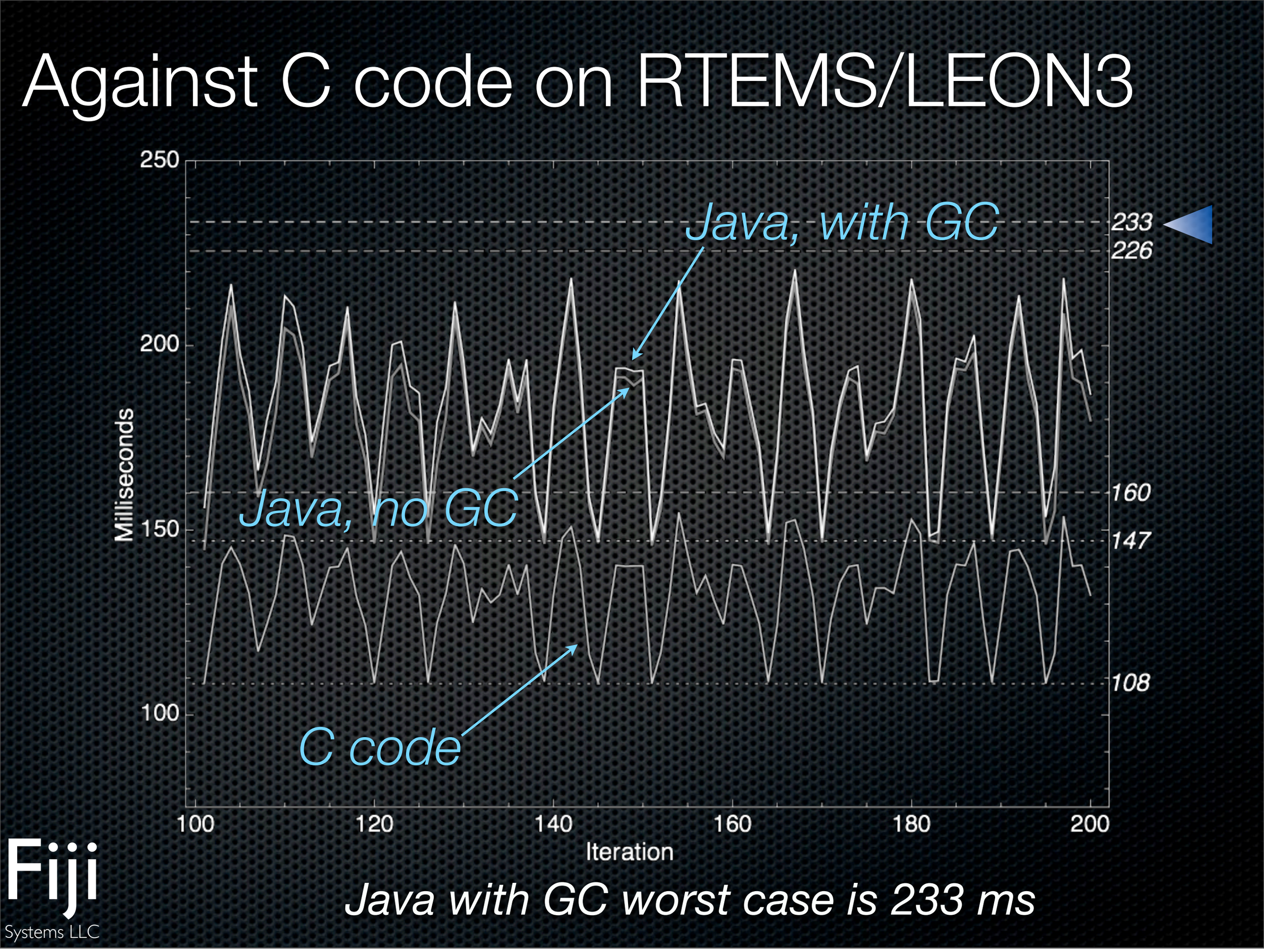

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Java with GC worst case is 233 ms

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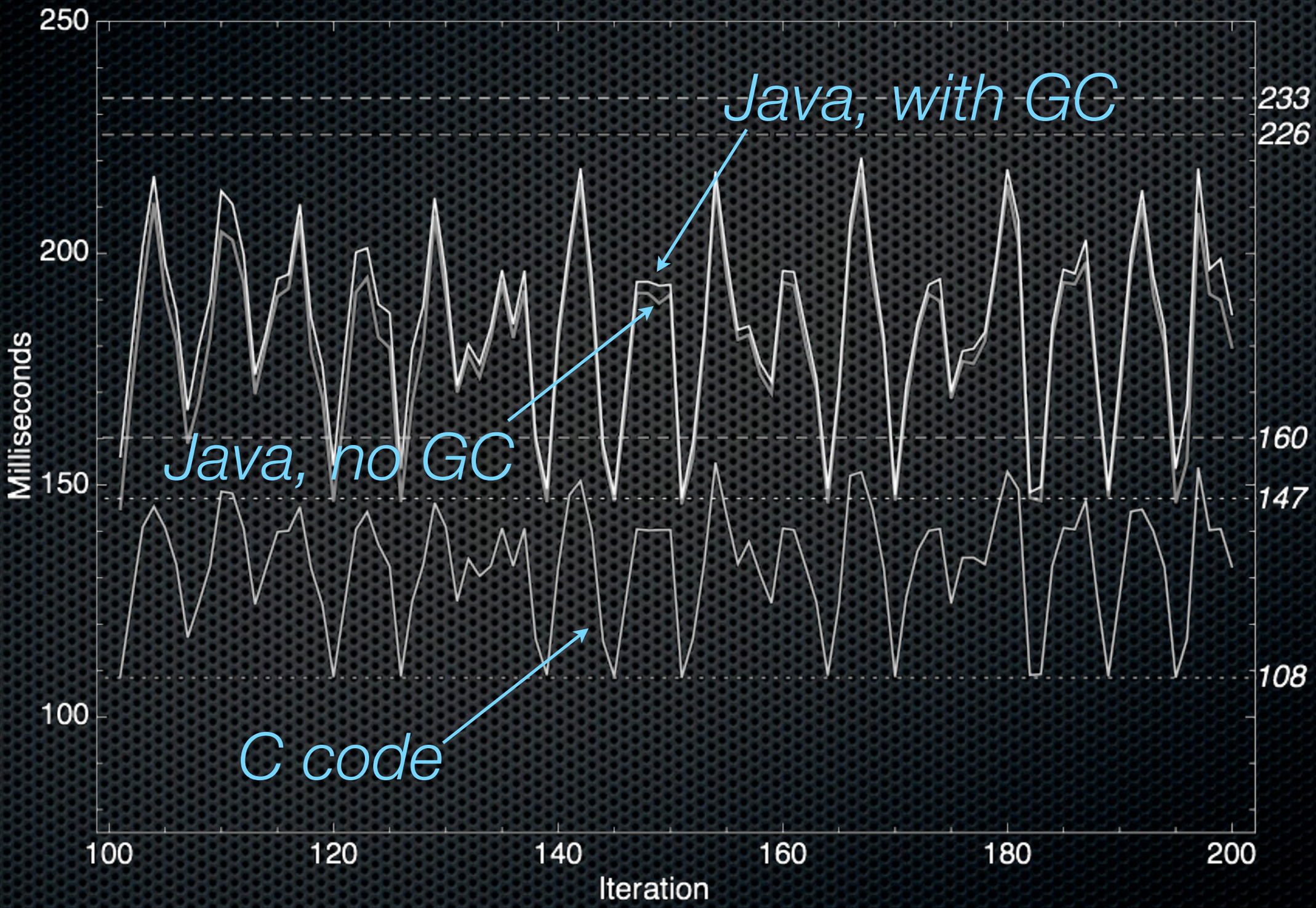

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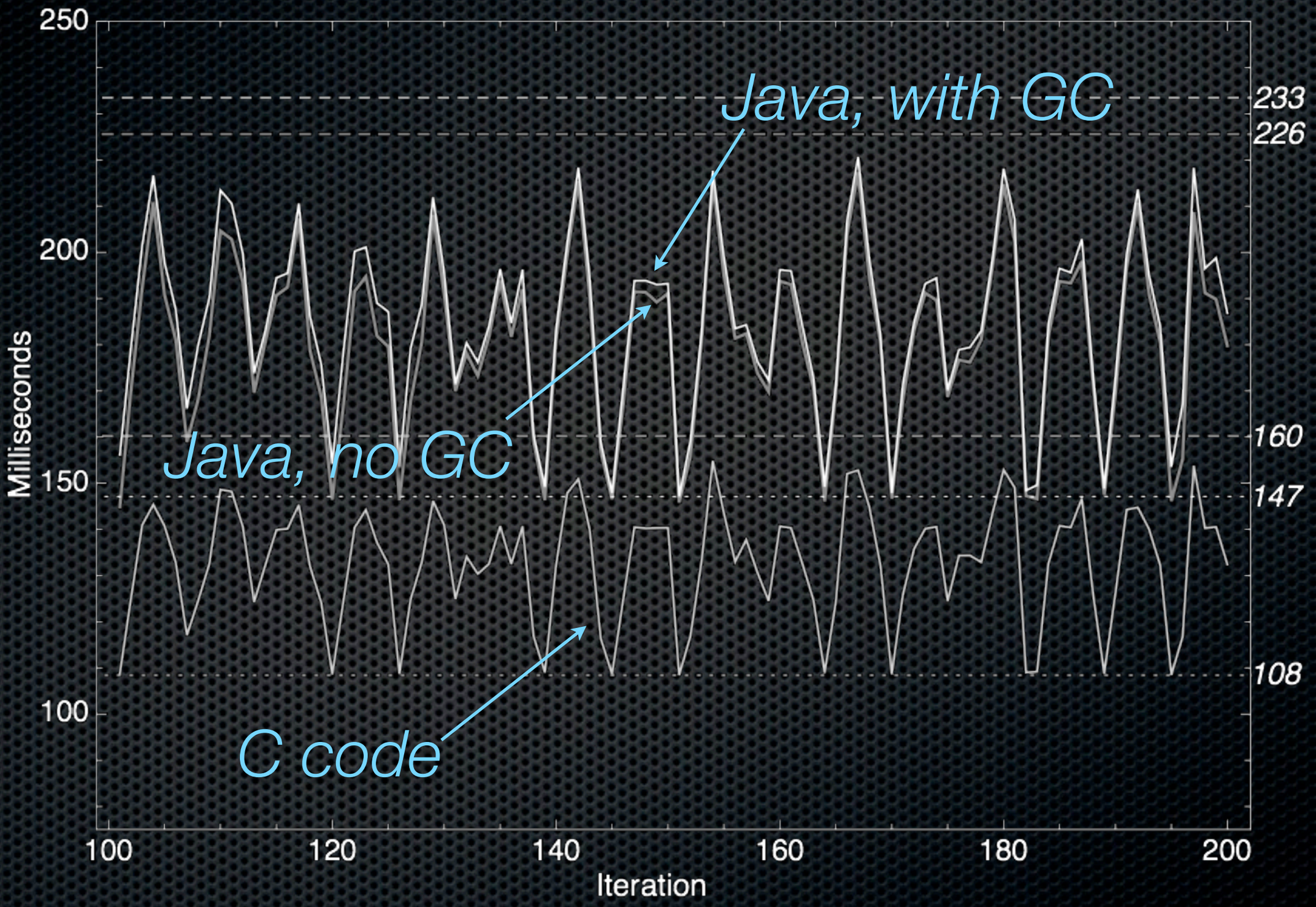
Java's worst-case is 45% worse than C's.

Against C code on RTEMS/LEON3



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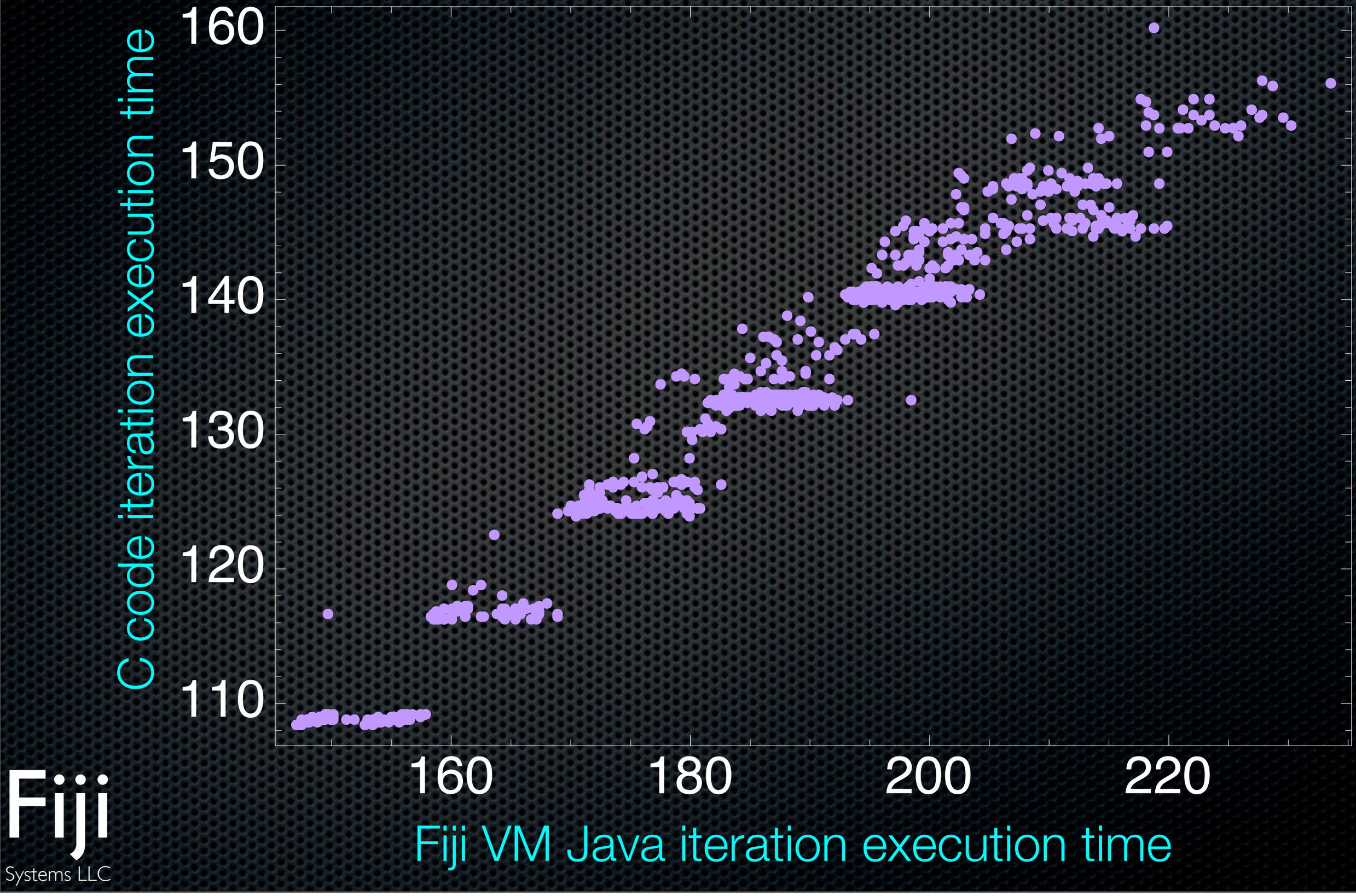
GC's effect on predictability: Worst-case goes up by 3%

Correlation: C vs. Java



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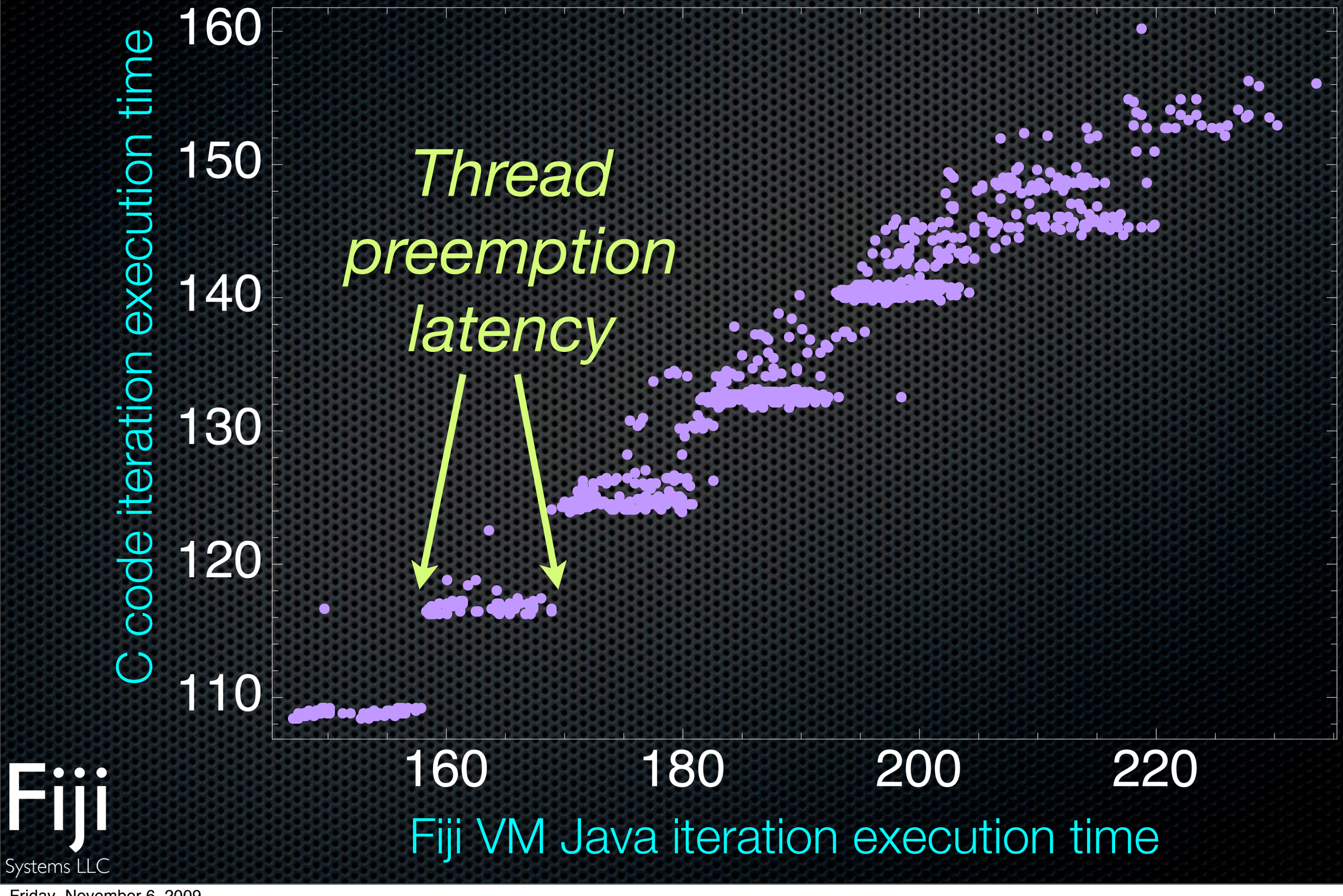

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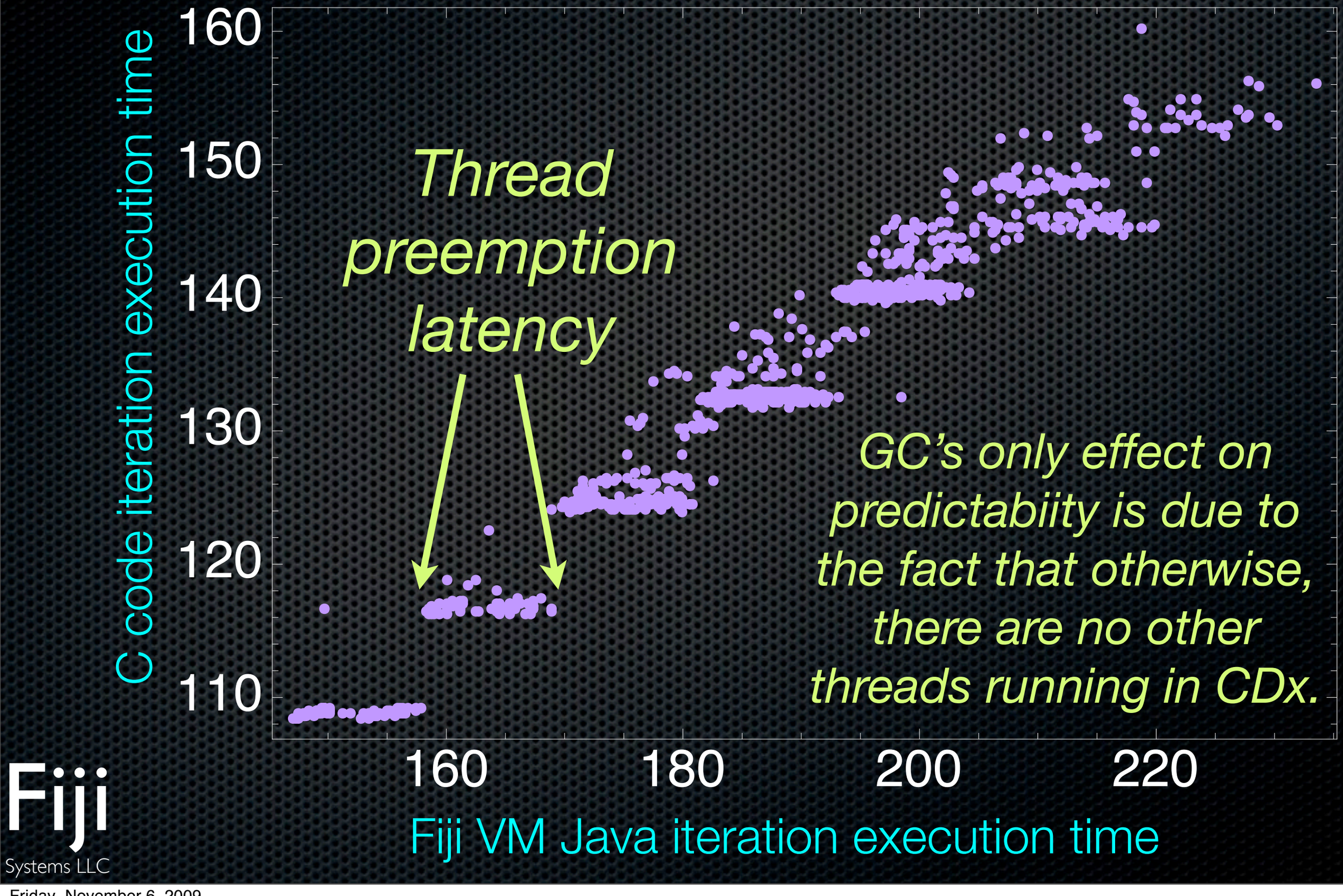

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Performance summary

- Fiji VM is currently the fastest Java implementation.
- Performance within 45% of C code.
- Garbage collection does not interfere with program execution.
  - *but GC does increase load on scheduler by introducing one additional thread.*

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Integration

Fiji VM

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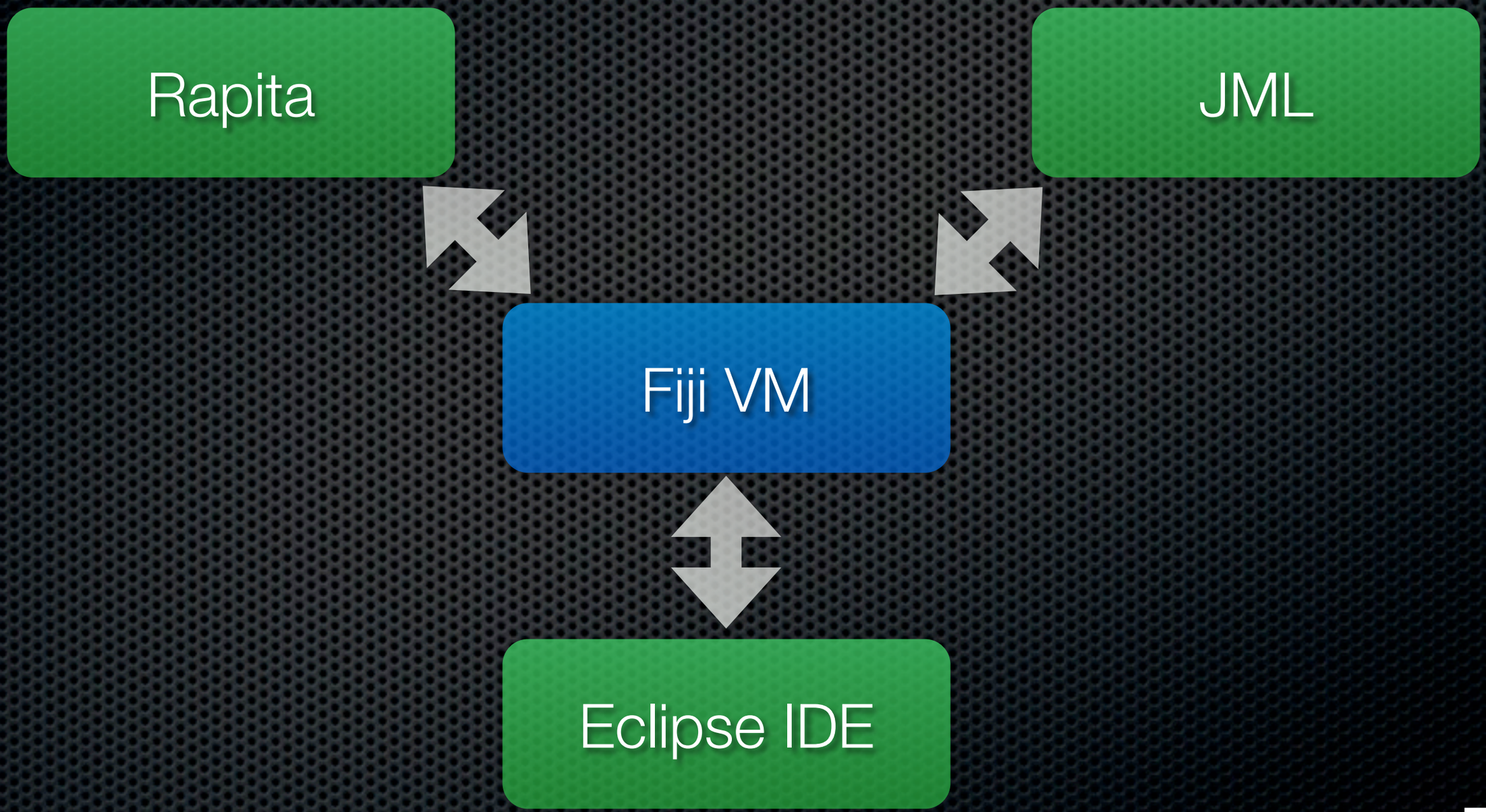

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Summary

- Fiji VM allows Java code to run *quickly* and *predictably*.
- Safety Critical Java promises a more *cost-effective* development process for safety-critical systems.

http://www.fiji-systems.com/

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Fiji VM Code Statistics

- Size of runtime:
  - 17,000 lines of C code
  - 11,000 lines of Java code
    - *this includes code for all configurations.*
- Size of compiler:
  - 3,000 lines of Ruby code
  - 44,000 lines of Java code

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