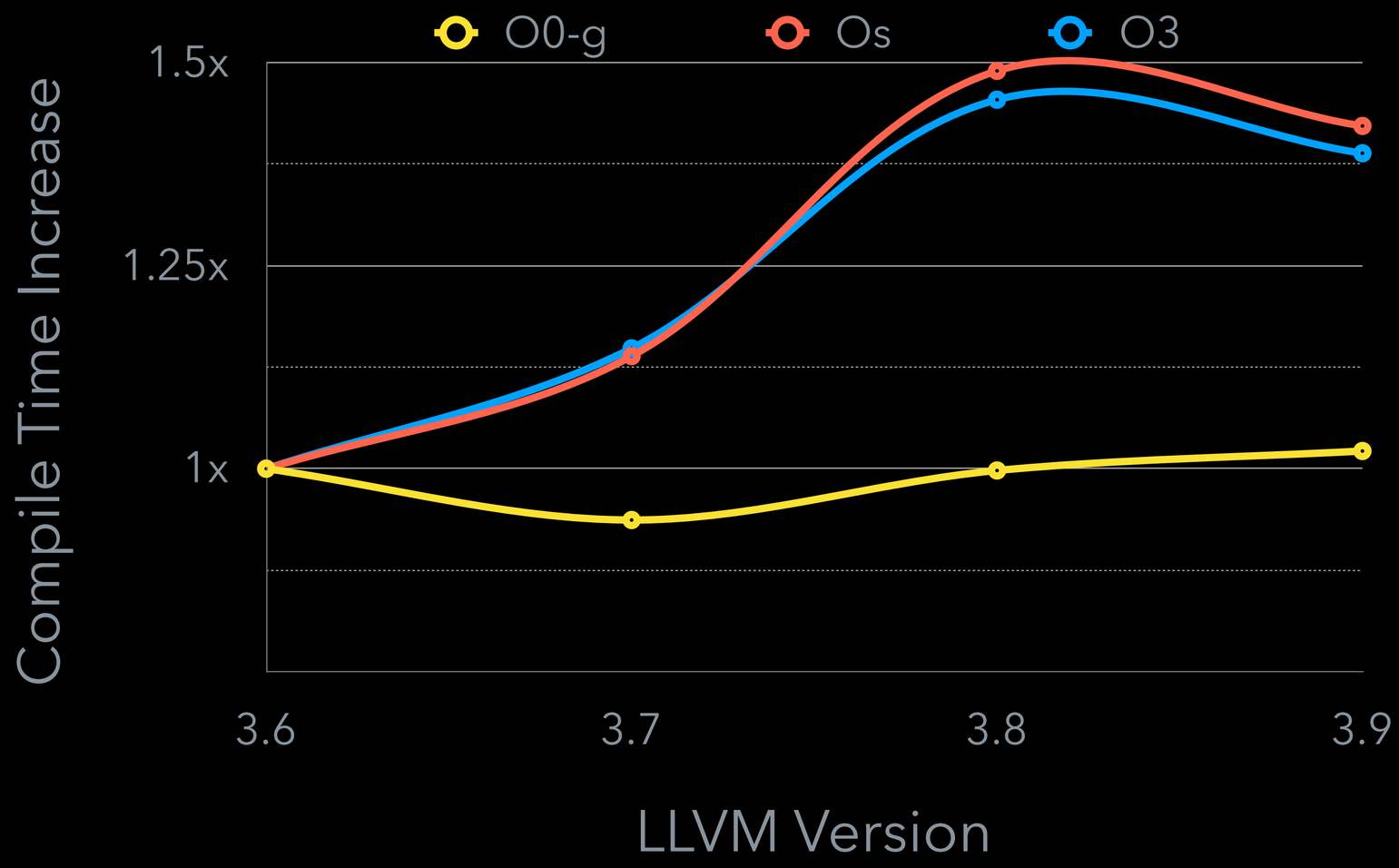
LLVM Compile Time.
Challenges. Improvements. Outlook.

Michael Zolotukhin, Apple

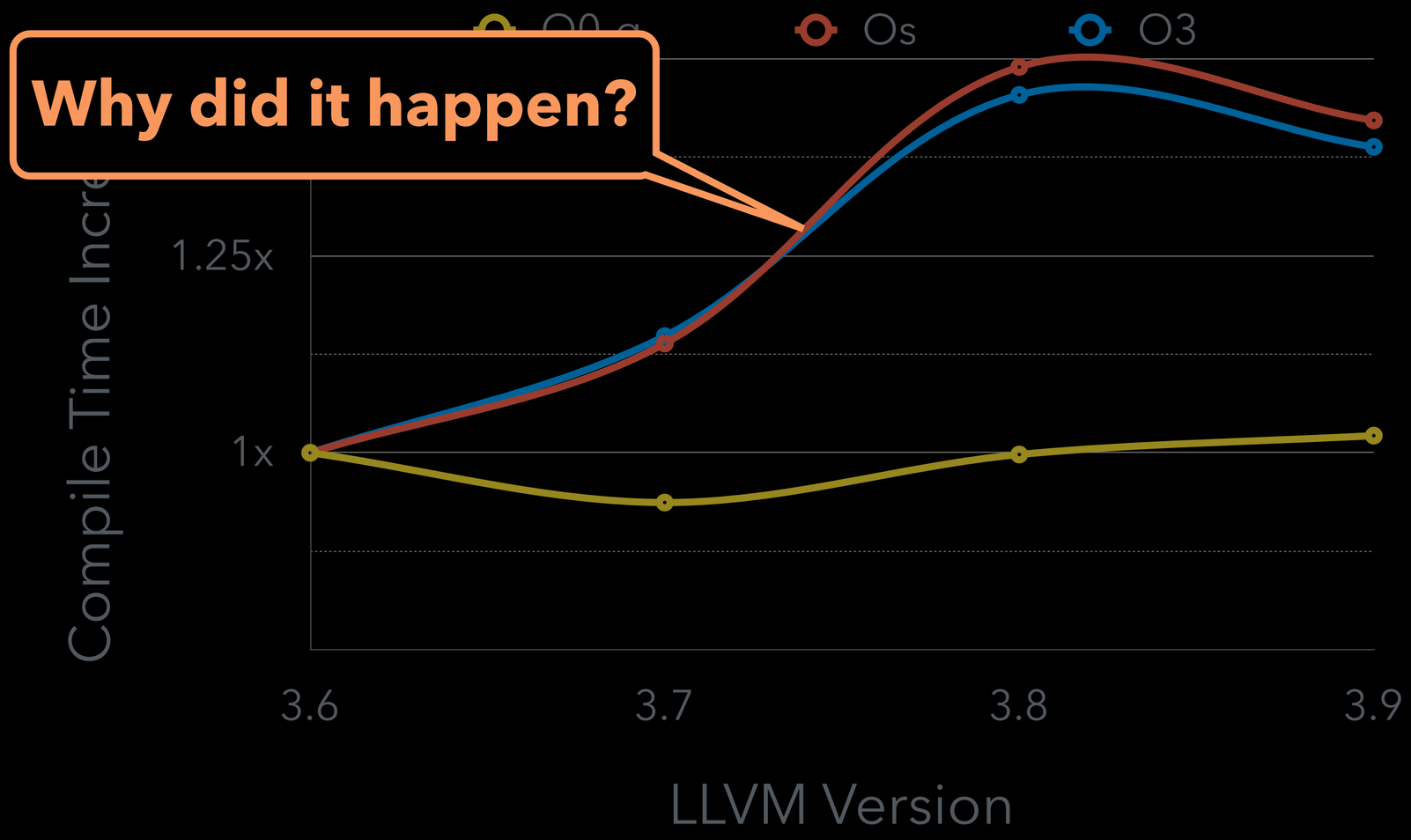
Agenda

- Benchmarking and tracking
- Historical findings
- Future work
- Tools and tricks

Compile Time Trend



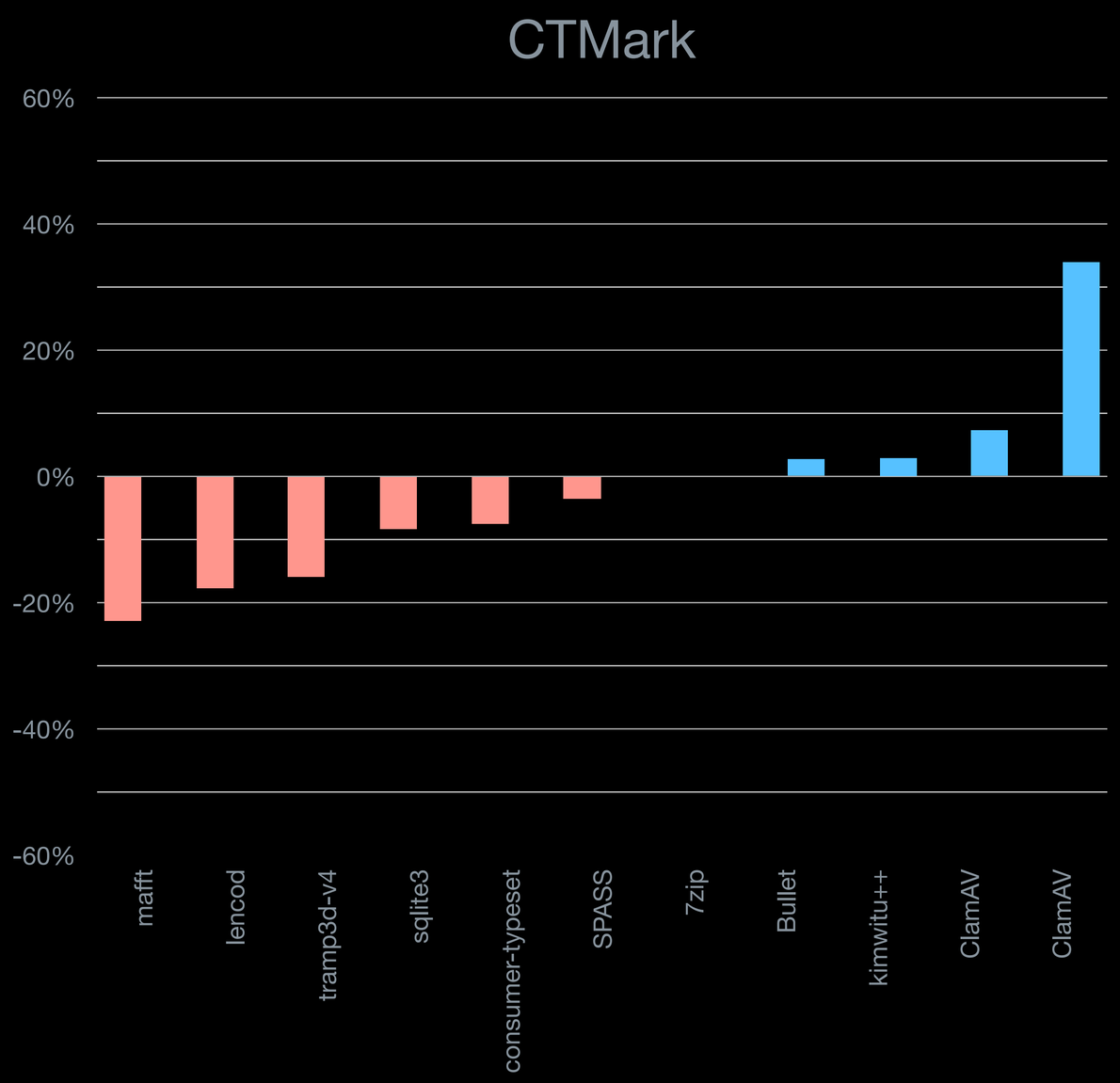
Compile Time Trend

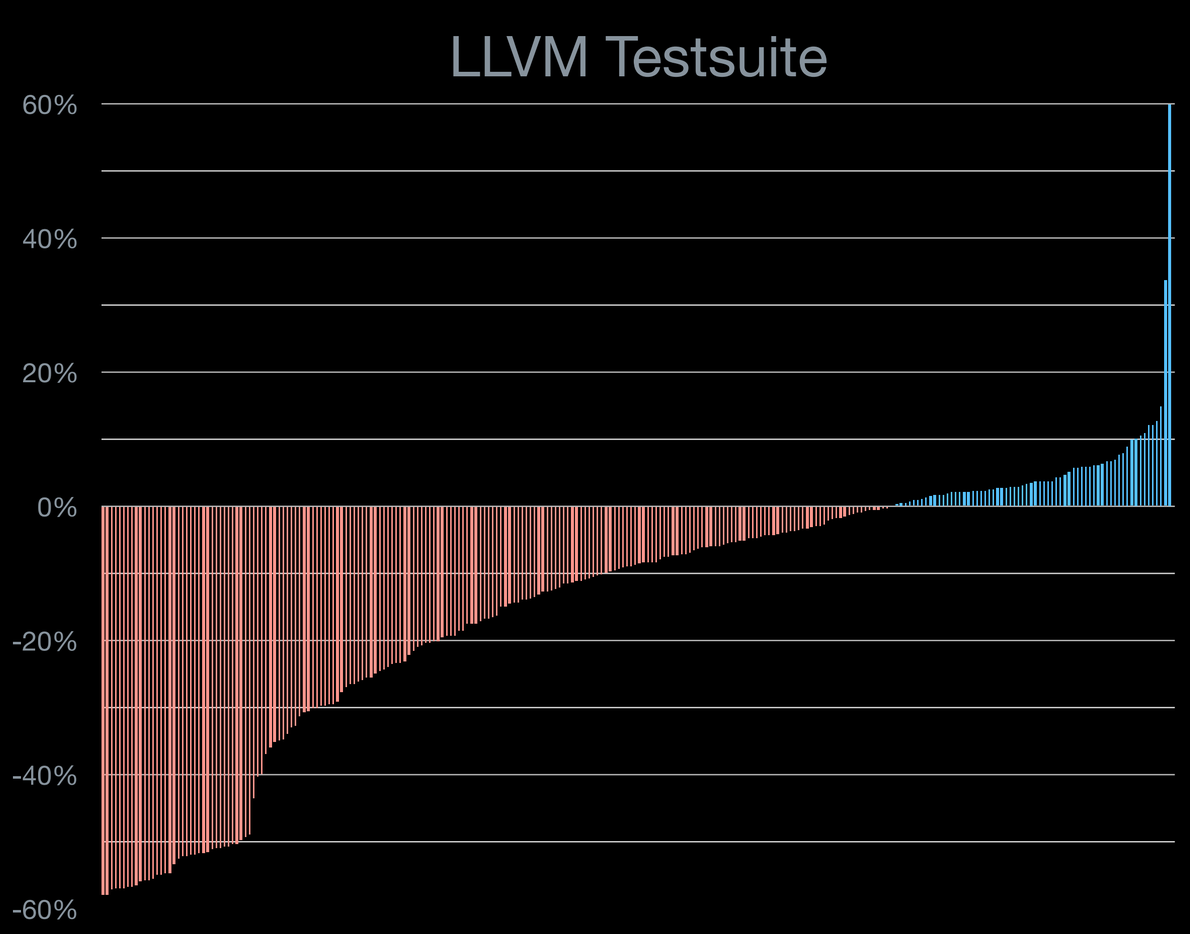


CTMark

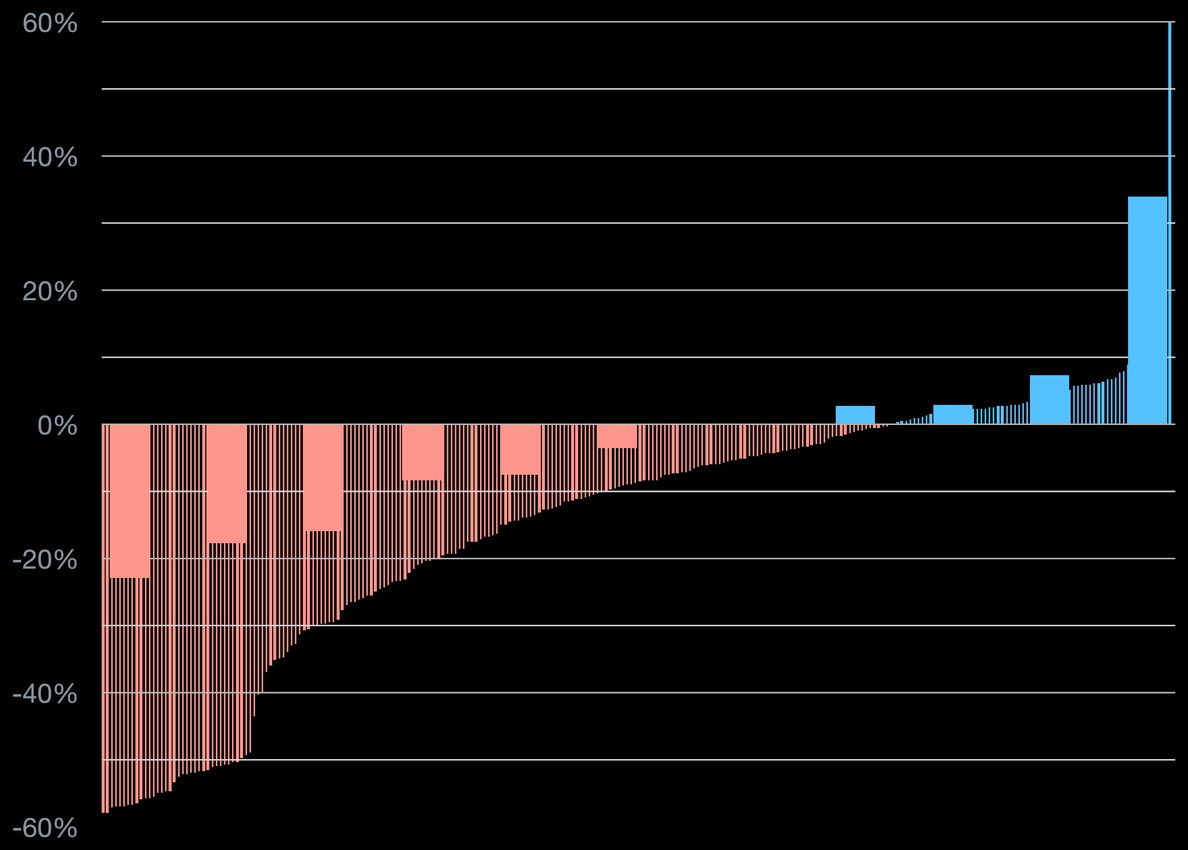
- Easy to use
- Reliable
- Fast
- Representative

CTMark


CTMark
60%
40%
20%
0%
-20%
-40%
-60%
mafft
lencod
tramp3d-v4
sqlite3
consumer-typeset
SPASS
7zip
Bullet
kimwitu++
ClamAV
ClamAV


LLVM Testsuite
60%
40%
20%
0%
-20%
-40%
-60%

CTMark

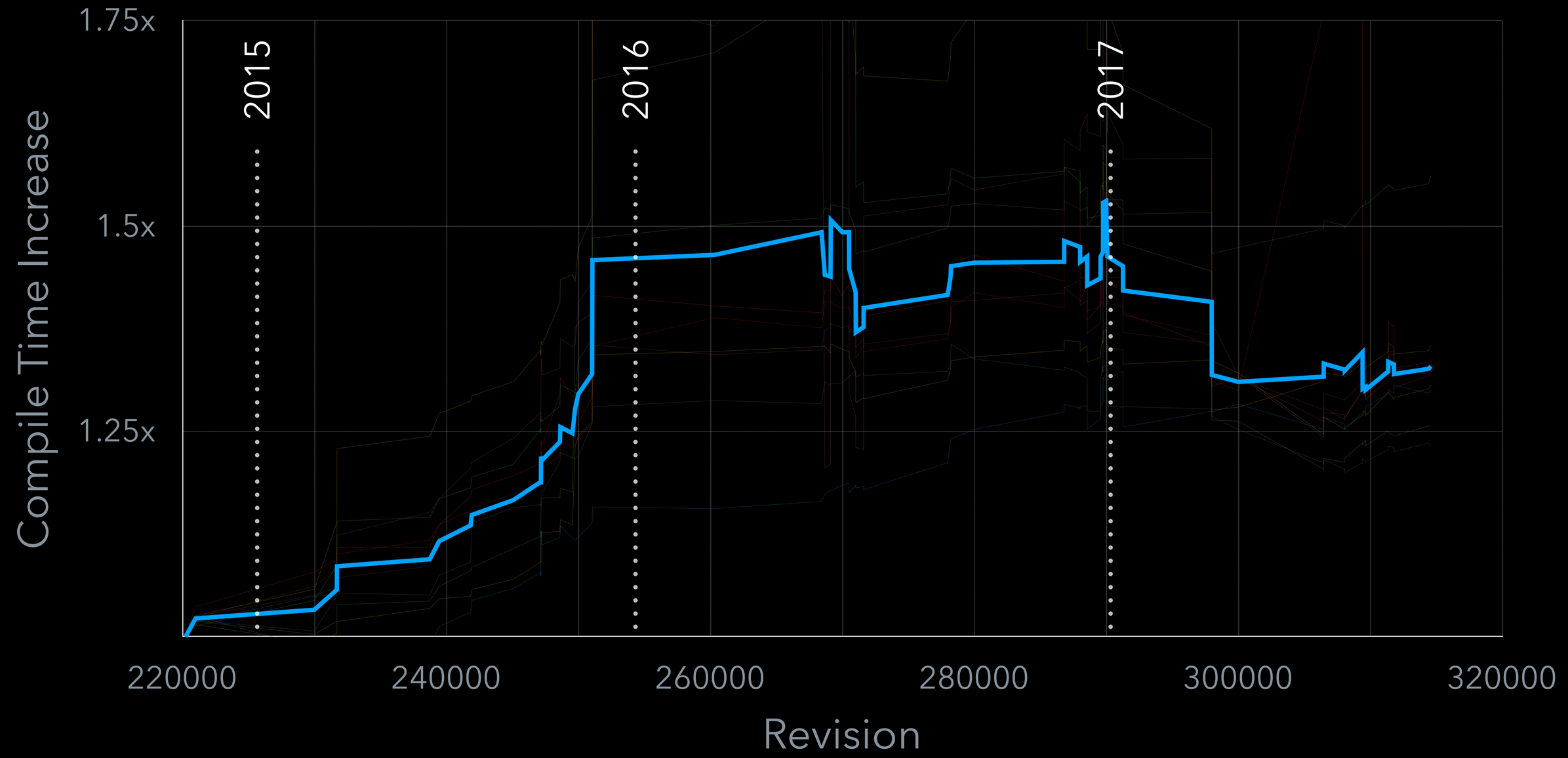


Regular Tracking

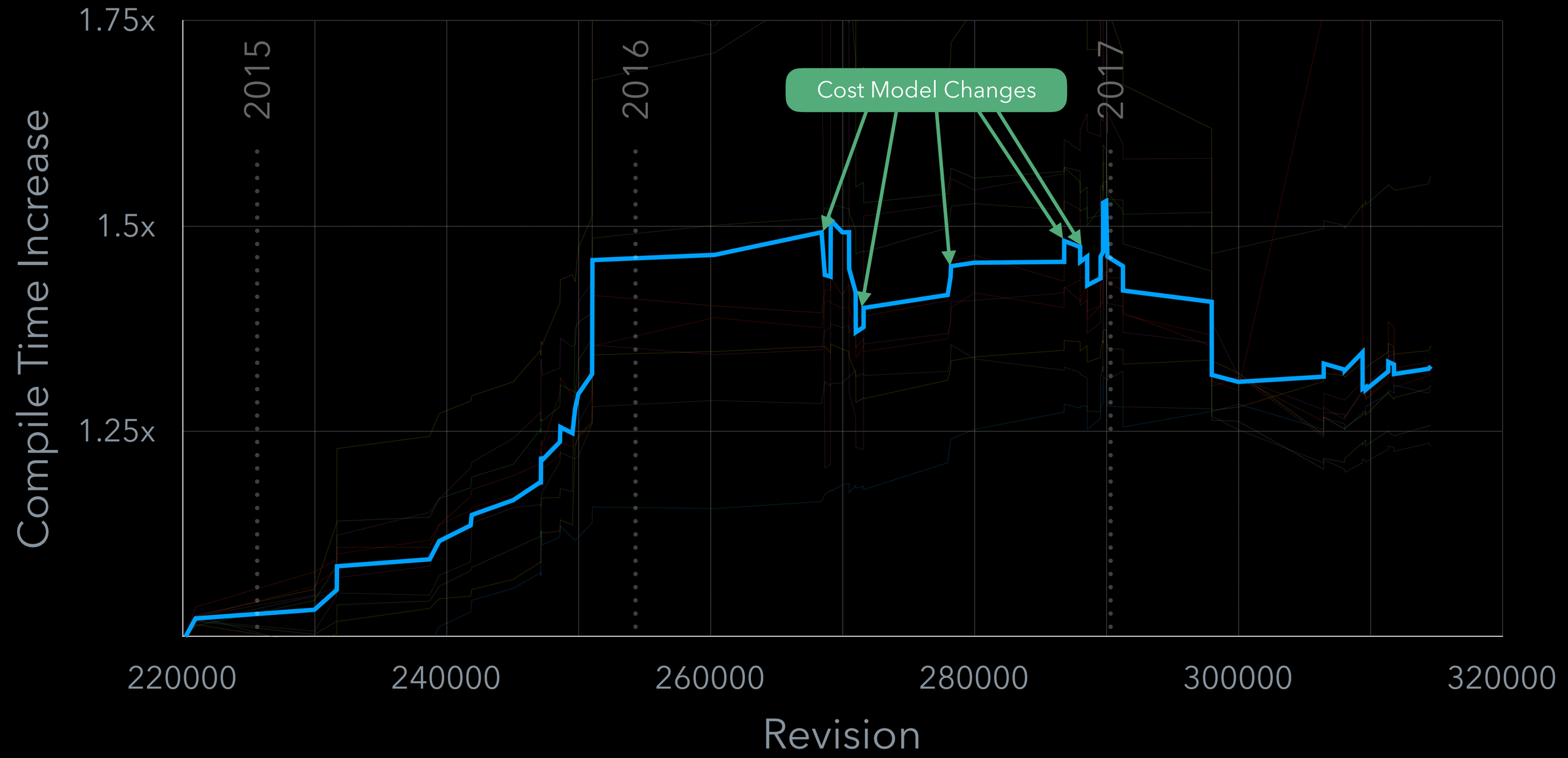
- Test every compiler build on several optlevels
- Detect and analyze incoming regressions
- Publish results on Green Dragon
- Raise awareness with reports

Historical Data

Historical Data



Historical Data



Historical Data

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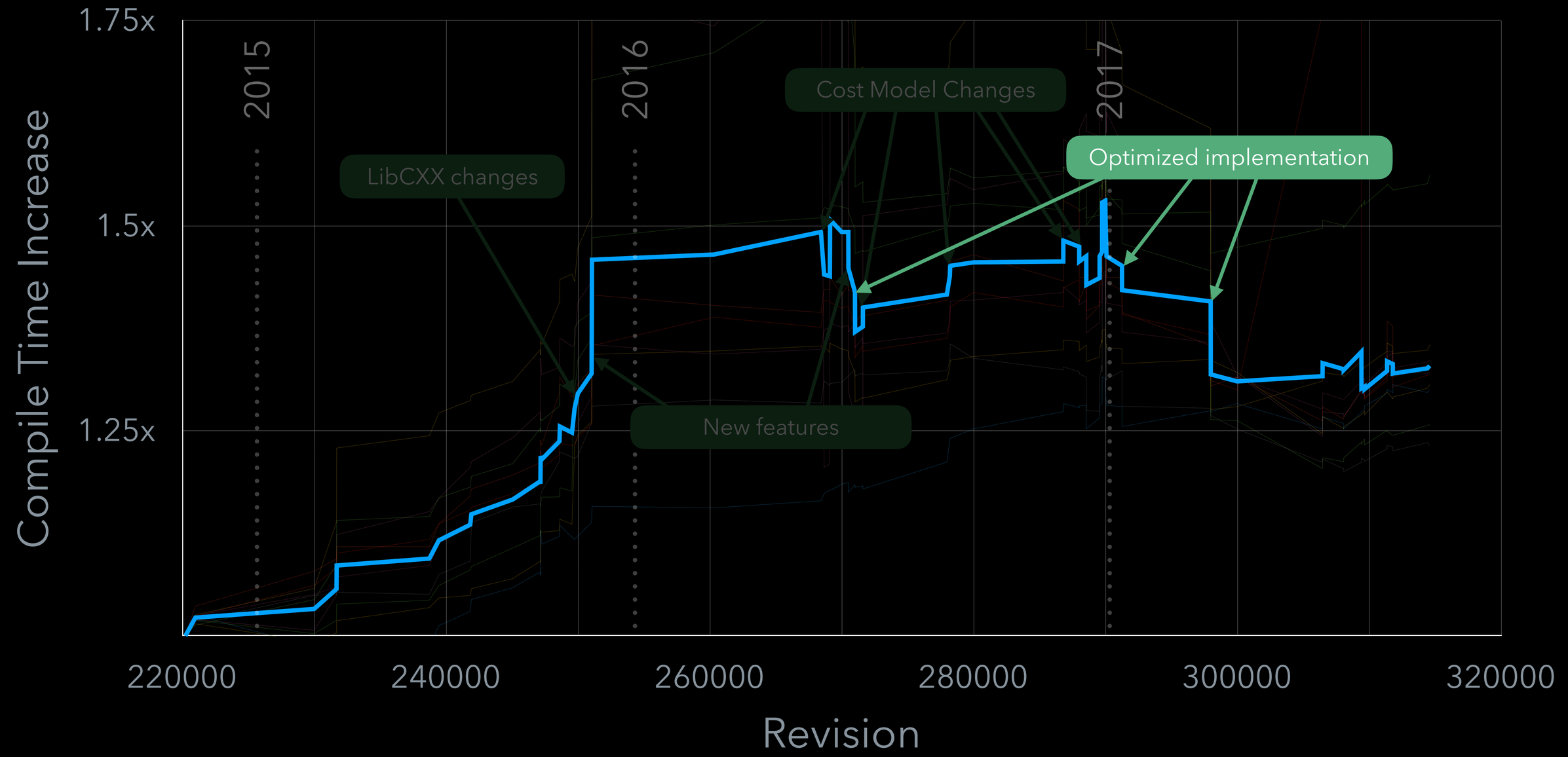
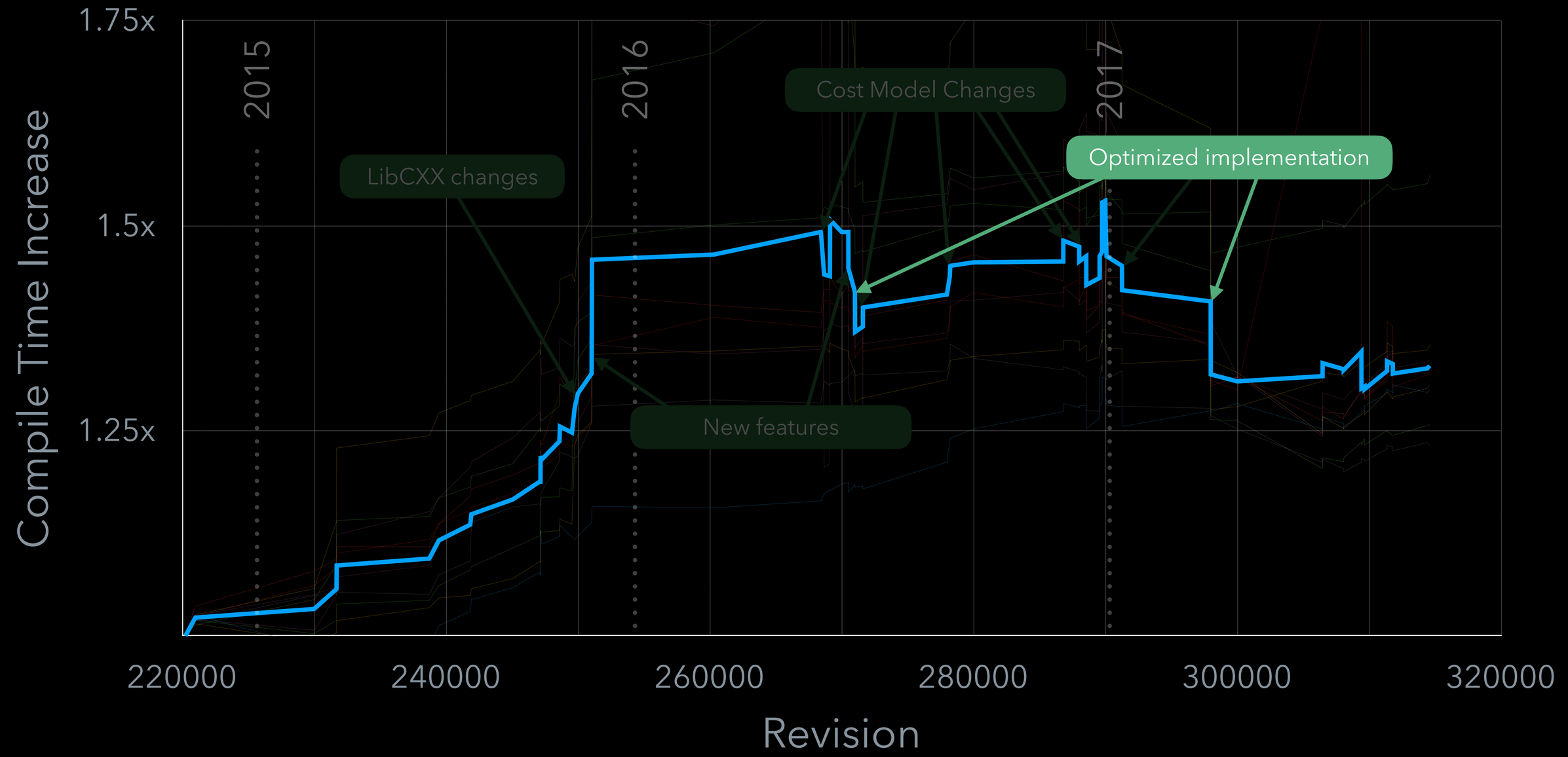


Historical Data

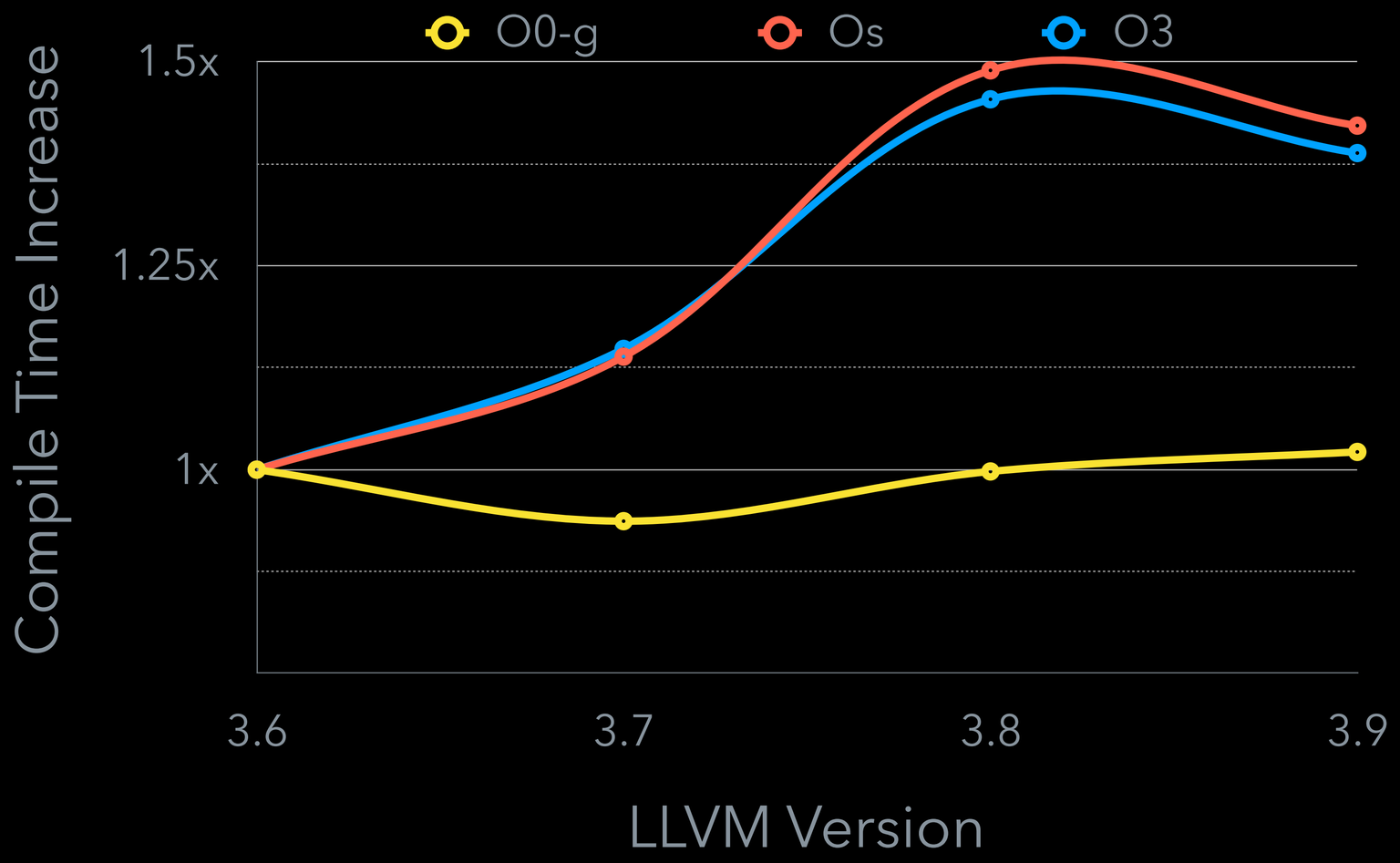


Historical Data

Historical Data

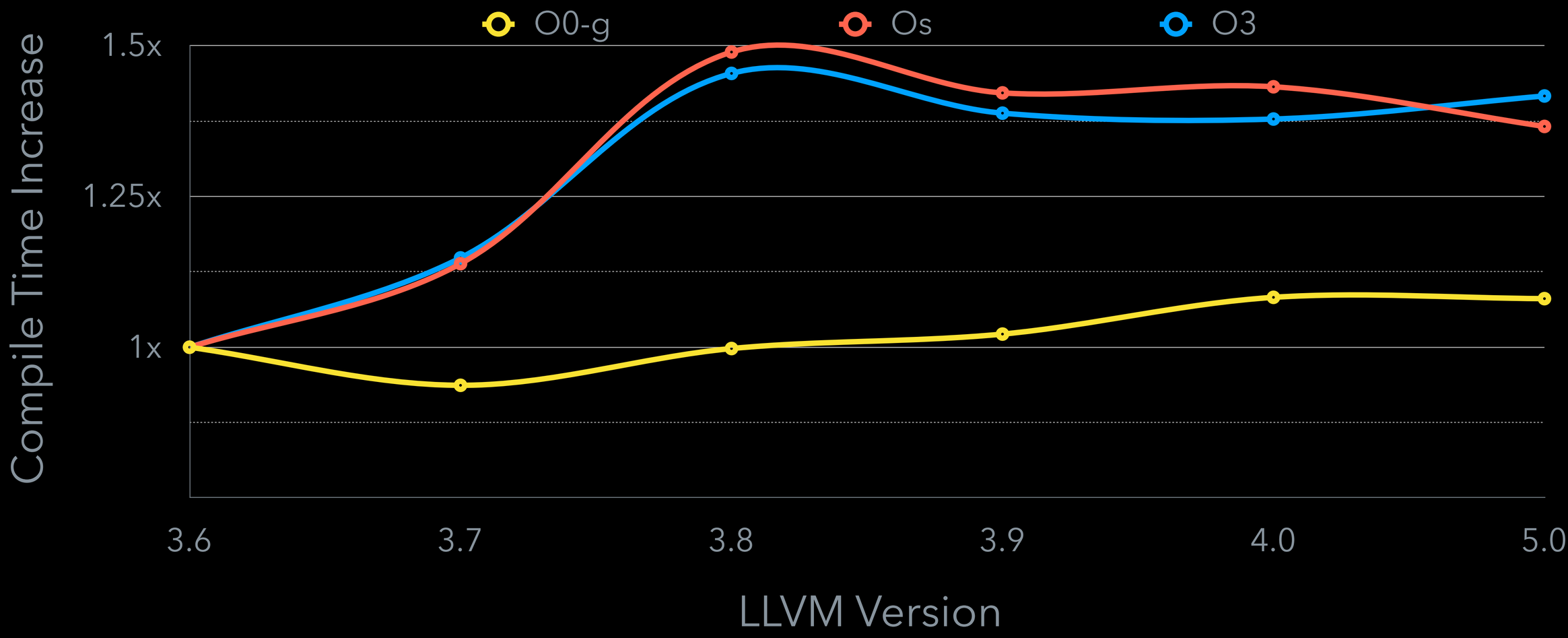
Historical Data

Compile Time Trend



Compile Time Trend

Compile Time Trend



Future Outlook

- Look at other components: front-end, libraries
- Find new ways to speed-up LLVM
- Add more benchmarks
- Speed-up your favorite pass

Tools and Tricks

Tools and Tricks

llvmlab

Tools and Tricks

llvmlab

Installation:

```
$ virtualenv venv && . venv/bin/activate
(venv)$ git clone http://llvm.org/git/zorg
(venv)$ pip install requests
(venv)$ python zorg/llvmbisect/setup.py install
(venv)$ which llvmlab
   /path/to/venv/bin/llvmlab
```

Tools and Tricks

llvmlab

Usage:

```
$ ### List available builders:
$ llvmlab ls
   clang-cmake-aarch64
   clang-cmake-armv7a
   clang-cmake-mips
   clang-cmake-mipsel
   clang-stage1-configure-RA
   clang-stage1-configure-RA_build
   clang-stage2-cmake-RgTSan
   clang-stage2-configure-Rlto
   clang-stage2-configure-Rlto_build
   clang-stage2-configure-Rthinlto_build
```

Tools and Tricks

llvmlab

Usage:

```
$ ### List available artifacts:
$ llvmlab ls clang-stage2-configure-Rlto
   clang-r314805-b21519
   clang-r314804-b21518
   clang-r314803-b21517
   clang-r314799-b21516
   clang-r314798-b21515
   clang-r314795-b21514
   clang-r314793-b21513
   ...
```

Tools and Tricks

llvmlab

Usage:

```
$ ### Download specified artifact:
$ llvmlab fetch clang-stage2-configure-Rlto clang-r314805-b21519
   downloaded root: clang-r314805-b21519.tar.gz
   extracted path : clang-r314805-b21519
$ clang-r314805-b21519/bin/clang -v
   Apple clang version 6.0.99 (master 314805) (based on LLVM 6.0.99)
   Target: x86_64-apple-darwin16.7.0
   Thread model: posix
   InstalledDir: /tmp/clang-r314805-b21519/bin
```

Tools and Tricks

Test-suite + LNT

Tools and Tricks

Test-suite + LNT

Installation:

```
$ virtualenv venv && . venv/bin/activate
(venv)$ git clone http://llvm.org/git/test-suite
(venv)$ git clone http://llvm.org/git/lnt
(venv)$ pip install -r lnt/requirements.client.txt
(venv)$ python lnt/setup.py install
(venv)$ pip install svn+http://llvm.org/svn/llvm-project/llvm/trunk/utils/lit
(venv)$ which lit
   /path/to/venv/bin/lit
(venv)$ which lnt
   /path/to/venv/bin/lnt
```

Tools and Tricks

Test-suite + LNT

Running CTMark:

```
$ lnt runtest test-suite --sandbox /Path/To/Sandbox                    \
                         --use-lit=lit                                 \
                         --cc  /Path/To/Compiler/bin/clang             \
                         --test-suite=/Path/To/test-suite              \
                         -C target-x86_64-macosx                       \
                         -C Os                                         \
                         --cmake-define TEST_SUITE_RUN_BENCHMARKS=Off  \
                         --cmake-define TEST_SUITE_SUBDIRS=CTMark
```

Tools and Tricks

Test-suite + LNT

Running full LLVM test-suite:

```
$ lnt runtest test-suite --sandbox /Path/To/Sandbox                    \
                         --use-lit=lit                                 \
                         --cc  /Path/To/Compiler/bin/clang             \
                         --test-suite=/Path/To/test-suite              \
                         -C target-x86_64-macosx                       \
                         -C Os                                         \
                         --cmake-define TEST_SUITE_BENCHMARKING_ONLY=On
```

Tools and Tricks

Test-suite + LNT

Running a subset of LLVM test-suite:

```
$ lnt runtest test-suite --sandbox /Path/To/Sandbox                    \
                         --use-lit=lit                                 \
                         --cc  /Path/To/Compiler/bin/clang             \
                         --test-suite=/Path/To/test-suite              \
                         -C target-x86_64-macosx                       \
                         -C Os                                         \
                         --cmake-define TEST_SUITE_BENCHMARKING_ONLY=On \
                         -only-test MultiSource/Applications
```

Tools and Tricks

Test-suite + LNT

Running a test-suite:

```
$ lnt runtest test-suite --sandbox /Path/To/Sandbox                    \
                         --use-lit=lit                                 \
                         --cc  /Path/To/Compiler/bin/clang             \
                         --test-suite=/Path/To/test-suite              \
                         -C target-x86_64-macosx                       \
                         -C Os                                         \
                         --cmake-define TEST_SUITE_BENCHMARKING_ONLY=On \
                         -only-test MultiSource/Applications

$ ### Results will be in /Path/To/Sandbox/test-DATETIME/output*.json
```

Tools and Tricks

Test-suite + LNT

Comparing results:

```
$ pip install pandas
$ /Path/To/test-suite/utils/compare.py -m compile_time output1.json output2.json
   Tests: 27
   Metric: compile_time

   Program                                 output1  output2 diff

   flops-3.test                            0.03     0.03   14.9%
   flops-2.test                            0.03     0.03   -13.7%
   himenobmtxpa.test                       0.10     0.12   11.6%
   ffbench.test                            0.06     0.07    9.3%
   …
$ ### The tool also has many useful options, see ‘--help’ for details
```

Tools and Tricks

Test-suite + cmake + lit

Tools and Tricks

Test-suite + cmake + lit

Building and running:

```
$ cd /Path/To/Sandbox

$ cmake   -DCMAKE_C_COMPILER=/Path/To/Compiler/bin/clang                  \
          -C /Path/To/test-suite/cmake/caches/target-x86_64-macosx.cmake \
          -C /Path/To/test-suite/cmake/caches/Os.cmake                   \
          -DTEST_SUITE_RUN_BENCHMARKS=Off                                \
          -DTEST_SUITE_SUBDIRS=CTMark                                    \
          /Path/To/test-suite
```

Tools and Tricks

Test-suite + cmake + lit

Building and running:

```
$ cd /Path/To/Sandbox

$ cmake   -DCMAKE_C_COMPILER=/Path/To/Compiler/bin/clang                \
          -C /Path/To/test-suite/cmake/caches/target-x86_64-macosx.cmake \
          -C /Path/To/test-suite/cmake/caches/Os.cmake                  \
          -DTEST_SUITE_RUN_BENCHMARKS=Off                               \
          -DTEST_SUITE_SUBDIRS=CTMark                                   \
          /Path/To/test-suite

$ ### Go to a subfolder if we don’t want to build all the tests:

$ cd CTMark/bullet

$ make -k -j 1 VERBOSE=1 all
```

Tools and Tricks

Test-suite + cmake + lit

Building and running:

```
$ cd /Path/To/Sandbox

$ cmake   -DCMAKE_C_COMPILER=/Path/To/Compiler/bin/clang                \
          -C /Path/To/test-suite/cmake/caches/target-x86_64-macosx.cmake \
          -C /Path/To/test-suite/cmake/caches/Os.cmake                  \
          -DTEST_SUITE_RUN_BENCHMARKS=Off                               \
          -DTEST_SUITE_SUBDIRS=CTMark                                   \
          /Path/To/test-suite

$ ### Go to a subfolder if we don’t want to build all the tests:

$ cd CTMark/bullet

$ make -k -j 1 VERBOSE=1 all

$ /Path/To/LLVM-Repo/utils/lit/lit.py -v -j 1 /Path/To/Sandbox/CTMark/bullet -o output.json
```

Tools and Tricks

Test-suite + cmake + lit

Per file stats:

```
$ find CTMark/Bullet -name “*.time"
   CTMark/Bullet/bullet.link.time
   CTMark/Bullet/CMakeFiles/bullet.dir/BenchmarkDemo.cpp.o.time
   …
   CTMark/Bullet/CMakeFiles/bullet.dir/SphereTriangleDetector.cpp.o.time
$ cat CTMark/Bullet/CMakeFiles/bullet.dir/SphereTriangleDetector.cpp.o.time
   exit 0
   real        0.1942
   user        0.1676
   sys         0.0172
$ size CTMark/Bullet/CMakeFiles/bullet.dir/SphereTriangleDetector.cpp.o
   __TEXT   __DATA   __OBJC   others   dec    hex
   3755     88       0        288      4131   1023
```

Tools and Tricks

Compiler Options

Tools and Tricks

Compiler Options

Collecting pass timings:

```
$ clang myfile.c -O3 -c -ftime-report
```

```
===-------------------------------------------------------------------------===
                         Miscellaneous Ungrouped Timers
===-------------------------------------------------------------------------===
  ---User Time---   --System Time--   --User+System--   ---Wall Time---  --- Name ---
   6.7877 ( 97.5%)   0.5060 ( 96.7%)   7.2938 ( 97.5%)   7.4313 ( 97.3%)  Code Generation Time
   0.1720 (  2.5%)   0.0172 (  3.3%)   0.1892 (  2.5%)   0.2075 (  2.7%)  LLVM IR Generation Time
   6.9598 (100.0%)   0.5232 (100.0%)   7.4830 (100.0%)   7.6388 (100.0%)  Total

===-------------------------------------------------------------------------===
                              Register Allocation
===-------------------------------------------------------------------------===
  Total Execution Time: 0.2353 seconds (0.2364 wall clock)
   ---User Time---   --System Time--   --User+System--   ---Wall Time---  --- Name ---
   0.1907 ( 83.5%)   0.0024 ( 34.6%)   0.1931 ( 82.1%)   0.1940 ( 82.0%)  Global Splitting
   0.0213 (  9.3%)   0.0010 ( 13.7%)   0.0222 (  9.4%)   0.0222 (  9.4%)  Spiller
    ...
```

Tools and Tricks

Compiler Options

Collecting pass timings:

```
$ clang myfile.c -O3 -c -ftime-report -save-stats=obj
$ cat myfile.stats
   {
          "time.regalloc.local_split.wall": 1.283169e-03,
          "time.regalloc.local_split.user": 1.176000e-03,
          "time.regalloc.local_split.sys": 9.700000e-05,
          "time.regalloc.spill.wall": 2.174950e-02,
          "time.regalloc.spill.user": 2.083200e-02,
          "time.regalloc.spill.sys": 8.420000e-04,
           ...
   }
```

Tools and Tricks

Compiler Options

Collecting pass timings:

```
$ clang myfile.c -O3 -c -disable-llvm-passes -emit-llvm
$ opt -O3 myfile.bc -o myfile.o -time-passes
```

```
   ===-------------------------------------------------------------------===
                         ... Pass execution timing report ...
   ===-------------------------------------------------------------------===
     Total Execution Time: 5.9781 seconds (6.0340 wall clock)
      ---User Time---   --System Time--   --User+System--   ---Wall Time---  --- Name ---
      0.5257 (  9.2%)   0.0044 (  1.7%)   0.5302 (  8.9%)   0.5351 (  8.9%)  Global Value Numbering
      0.3432 (  6.0%)   0.0035 (  1.3%)   0.3467 (  5.8%)   0.3494 (  5.8%)  Function Integration/Inlining
      0.2423 (  4.2%)   0.0019 (  0.7%)   0.2443 (  4.1%)   0.2458 (  4.1%)  Combine redundant instructions
       ...
```

Tools and Tricks

Compiler Options

Collecting optimization remarks:

```
$ clang myfile.c -O3 -c -fsave-optimization-record
$ cat myfile.opt.yaml
```

```
--- !Passed
Pass:            loop-unroll
Name:            FullyUnrolled
DebugLoc:        { File: myfile.c, Line: 3, Column: 3 }
Function:        foo
Args:
  - String:          'completely unrolled loop with '
  - UnrollCount:     '4'
  - String:          ' iterations'
...
```

Tools and Tricks

Compiler Options

Inspecting optimization remarks:

```
$ opt-viewer.py myfile.opt.yaml
$ open html/myfile.c.html
```

Line	Hotness	Optimization	Source	Inline Context
1			`int foo(int *a) {`	
		prologepilog	8 stack bytes in function	foo
		asm-printer	8 instructions in function	foo
2			`  int r = 0;`	
3			`  for (int i = 0; i < 4; i++)`	
		loop-unroll	completely unrolled loop with 4 iterations	foo
4			`    r += a[i];`	
5			`  return r;`	
6			`}`	

Tools and Tricks

Compiler Options

Inspecting optimization remarks:

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3			`  for (int i = 0; i < 4; i++)`	
		loop-unroll	completely unrolled loop with 4 iterations	foo
4			`    r += a[i];`	
5			`  return r;`	
6			`}`	

```
$ opt-diff.py myfile1.opt.yaml myfile2.opt.yaml
$ opt-viewer.py diff.opt.yaml
```

Tools and Tricks

Compiler Options

Inspecting optimization remarks:

```
$ opt-viewer.py myfile.opt.yaml
$ open html/myfile.c.html
```

Line	Hotness	Optimization	Source	Inline Context
1			`int foo(int *a) {`	
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		loop-unroll	completely unrolled loop with 4 iterations	foo
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6			`}`	

```
$ opt-diff.py myfile1.opt.yaml myfile2.opt.yaml
$ opt-viewer.py diff.opt.yaml
```

More details: LLVM Dev 2016 Talk: Compiler-assisted Performance Analysis

Summary

- Test your patches for compile time
- Use CTMark
- Know your tools
- Make LLVM faster!