Speeding up Query Execution

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http://anarazel.de/talks/pgconf-us-2017-03-29/jit.pdf

Motivation

Scalability
Efficiency
Concurrency

OLTP
vs
OLAP
vs
HTAP

Online Transactional Processing
vs
Online Analytical Processing
vs
Hybrid Transactional / Analytical Processing

Amdahl's Law

Two independent parts **A** **B**

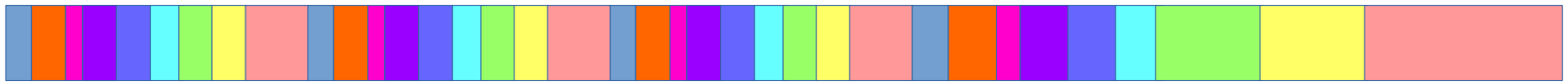
Original process

Make **B** 5x faster

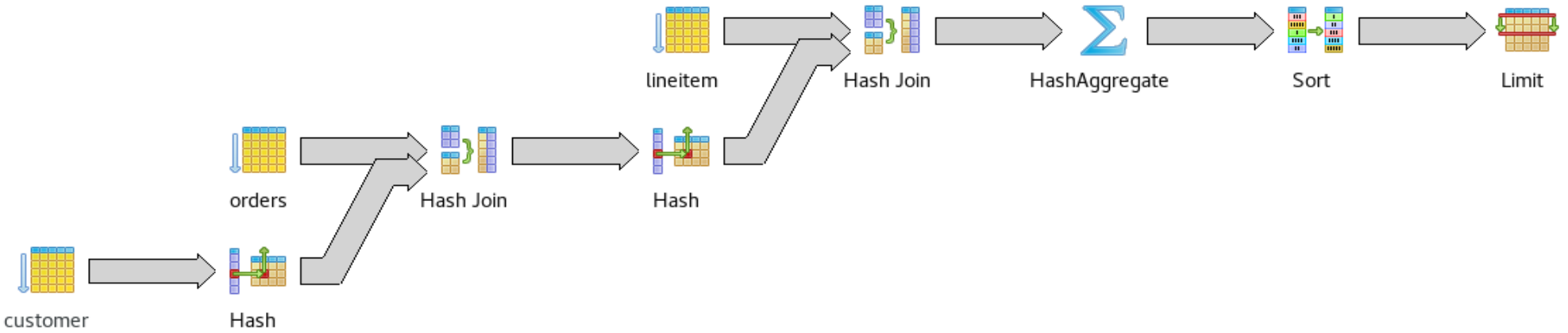
Make **A** 2x faster

https://commons.wikimedia.org/wiki/File:Optimizing-different-parts.svg

A
B
C
D
E
F
G
H
I

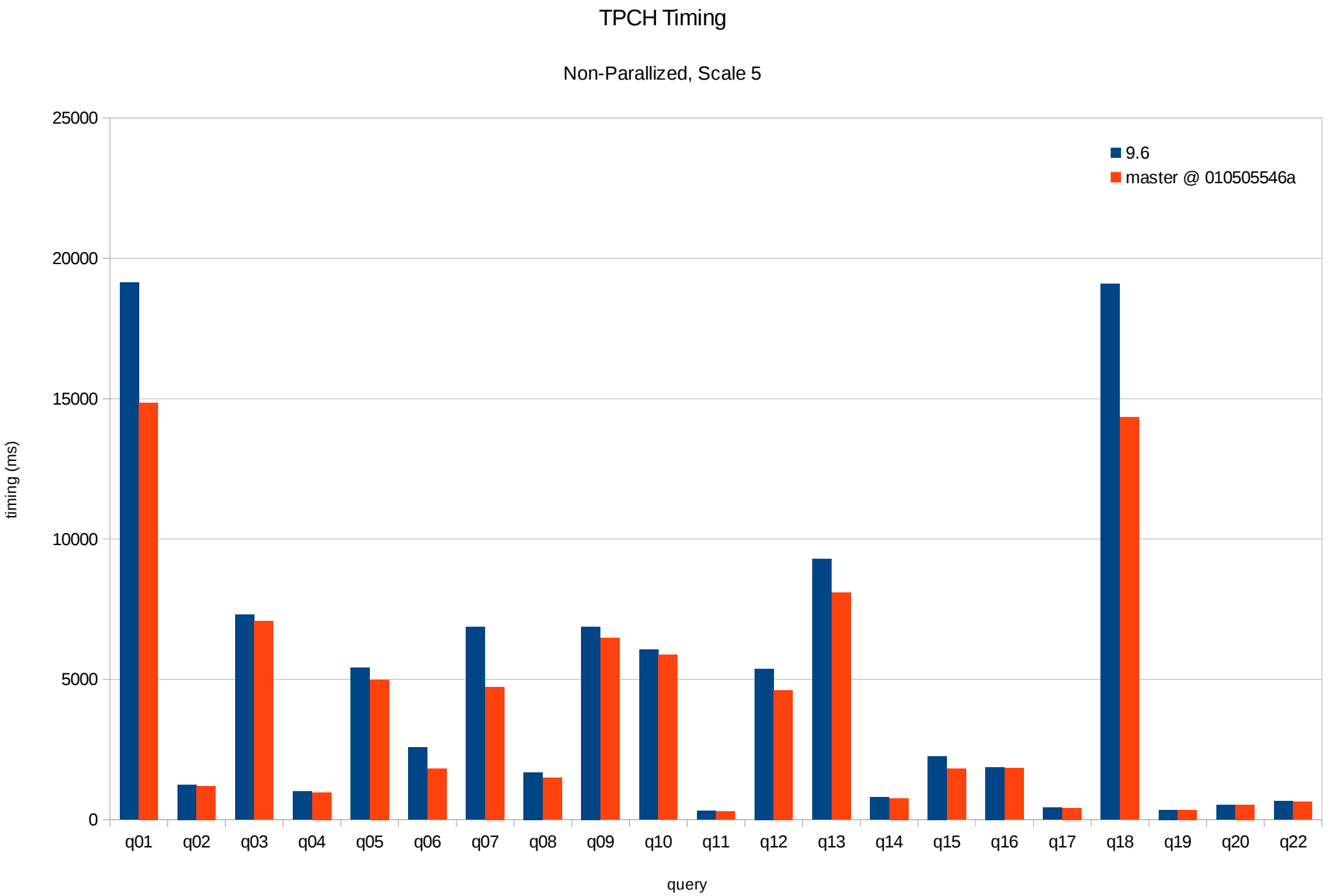


Batch Tuple Processing



```
SELECT
    l_returnflag,
    l_linestatus,
    sum(l_quantity) as sum_qty,
    sum(l_extendedprice) as sum_base_price,
    sum(l_extendedprice * (1 - l_discount)) as sum_disc_price,
    sum(l_extendedprice * (1 - l_discount) * (1 + l_tax)) as sum_charge,
    avg(l_quantity) as avg_qty,
    avg(l_extendedprice) as avg_price,
    avg(l_discount) as avg_disc,
    count(*) as count_order
FROM
    lineitem
WHERE
    l_shipdate <= date '1998-12-01' - interval '74 days'
GROUP BY
    l_returnflag,
    l_linestatus
ORDER BY
    l_returnflag,
    l_linestatus;
```

```
Sort  (cost=2153027.37..2153027.39 rows=6 width=68)
      (actual time=19742.591..19742.591 rows=4 loops=1)
 Sort Key: l_returnflag, l_linestatus
 Sort Method: quicksort  Memory: 25kB
 ->  HashAggregate  (cost=2153027.19..2153027.29 rows=6 width=68)
                    (actual time=19742.557..19742.559 rows=4 loops=1)
       Group Key: l_returnflag, l_linestatus
       ->  Seq Scan on lineitem  (cost= rows=29727516 width=36)
                                 (actual time=0.012..4514.186 rows=29713242 loops=1)
             Filter: (l_shipdate <= '1998-09-18 00:00:00'::timestamp without time zone)
             Rows Removed by Filter: 286553
Planning time: 0.326 ms
Execution time: 19742.705 ms
```


TPCH Timing
Non-Parallized, Scale 5
25000
20000
15000
10000
5000
0
timing (ms)
9.6
master @ 010505546a
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
query

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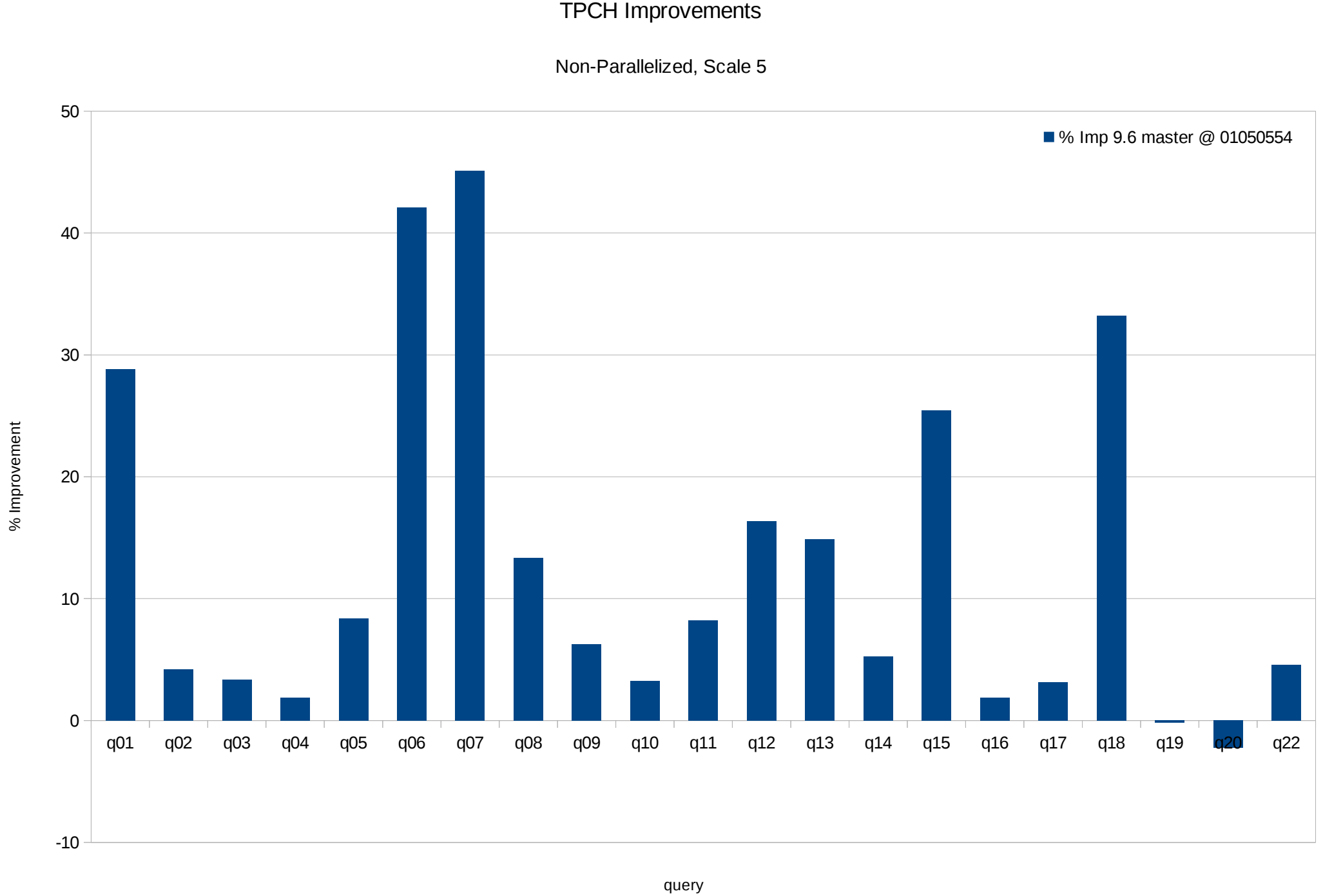
TPCH Improvements
Non-Parallelized, Scale 5
% Imp 9.6 master @ 01050554
% Improvement
query
50
40
30
20
10
0
-10
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22

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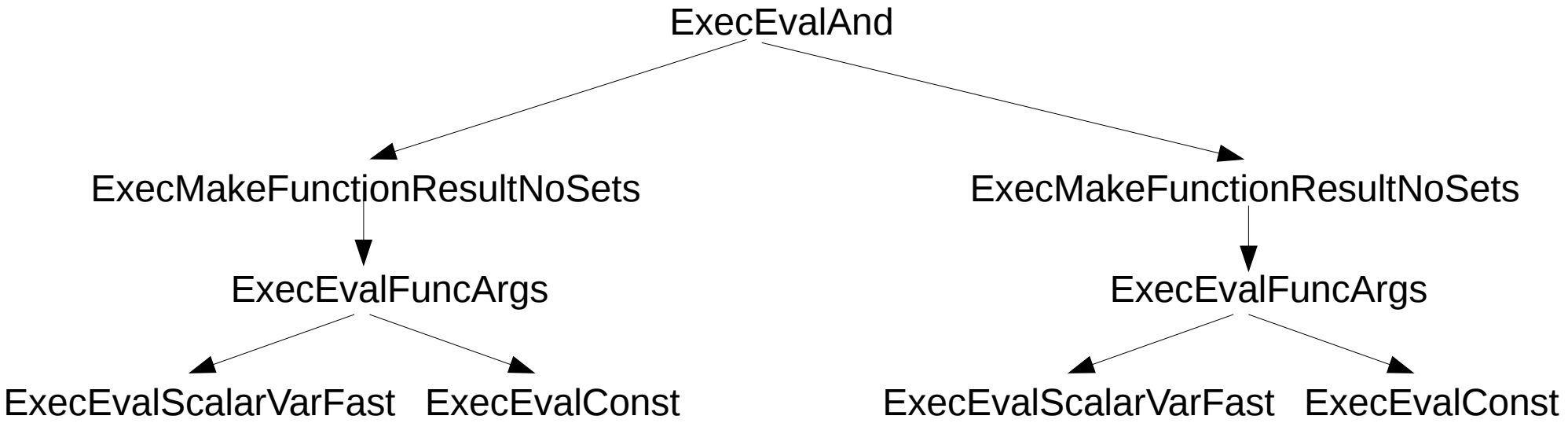
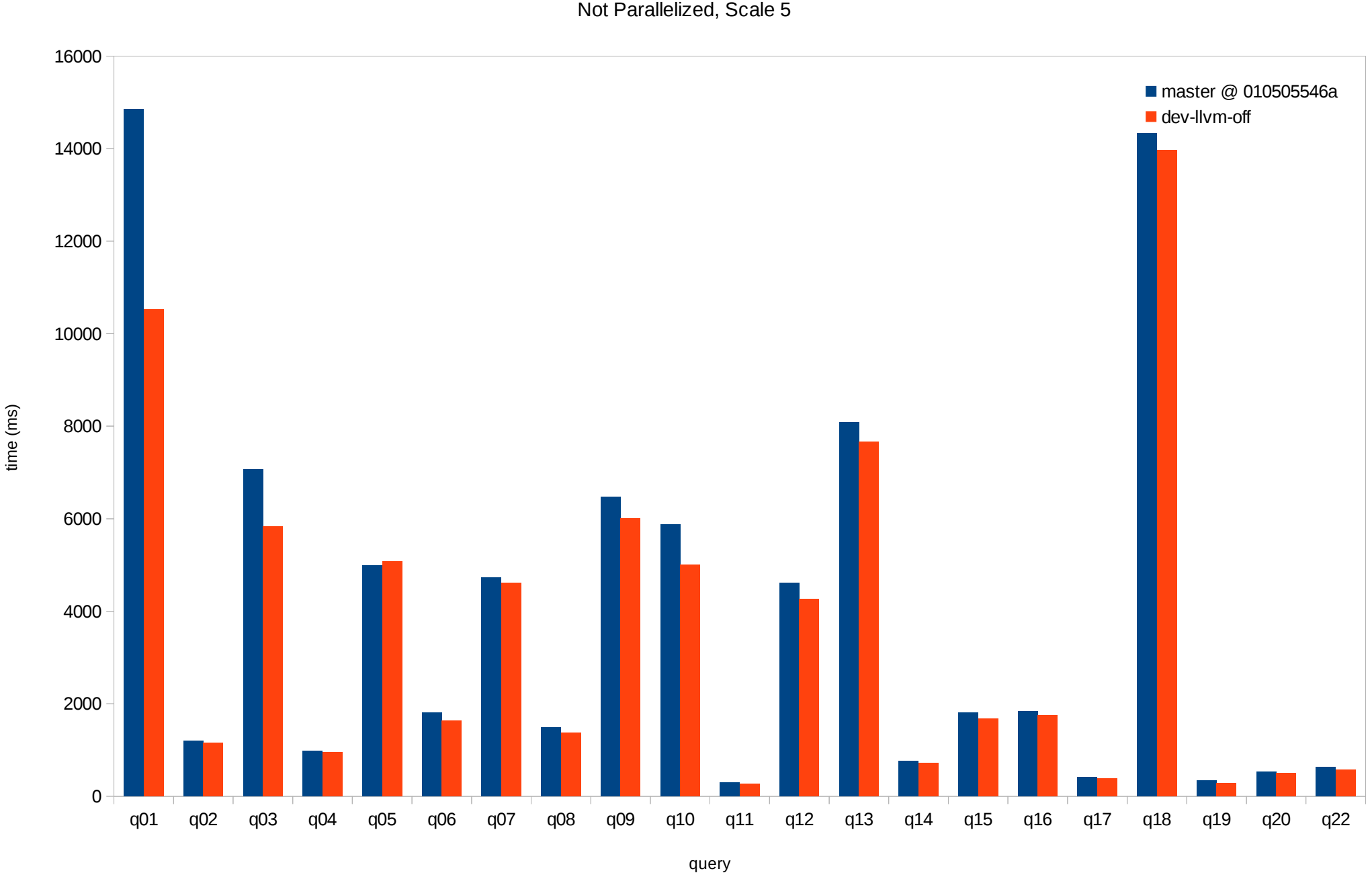
Expression Evaluation

- SELECT list, of, columns, a + b as expr
- WHERE clauses
- GROUP BY clauses
- ...


ExecEvalAnd
ExecMakeFunctionResultNoSets
ExecMakeFunctionResultNoSets
ExecEvalFuncArgs
ExecEvalFuncArgs
ExecEvalScalarVarFast
ExecEvalConst
ExecEvalScalarVarFast
ExecEvalConst

Expression Evaluation Methodology

- Old:
  - Tree Walk
  - Callback Based
  - Recursive
- New
  - “Byte code” generated internally
  - No / Fewer Callbacks
  - “Direct Threaded”
  - Non-Recursive


TPCH Timings
Not Parallelized, Scale 5
master @ 010505546a
dev-llvm-off
time (ms)
query
0
2000
4000
6000
8000
10000
12000
14000
16000
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
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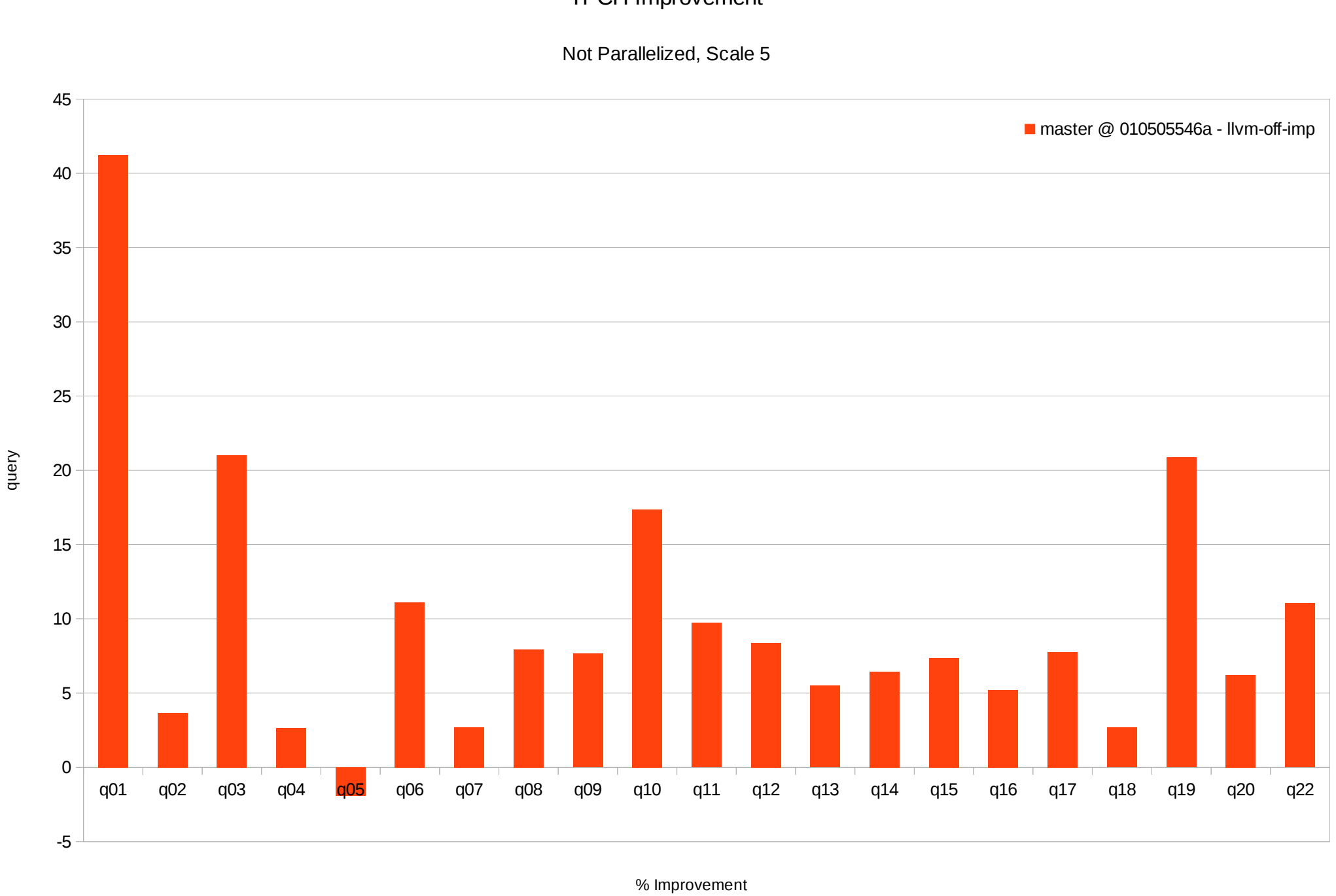
TPCH Improvement
Not Parallelized, Scale 5
master @ 010505546a - llvm-off-imp
45
40
35
30
25
20
15
10
5
0
-5
query
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
% Improvement

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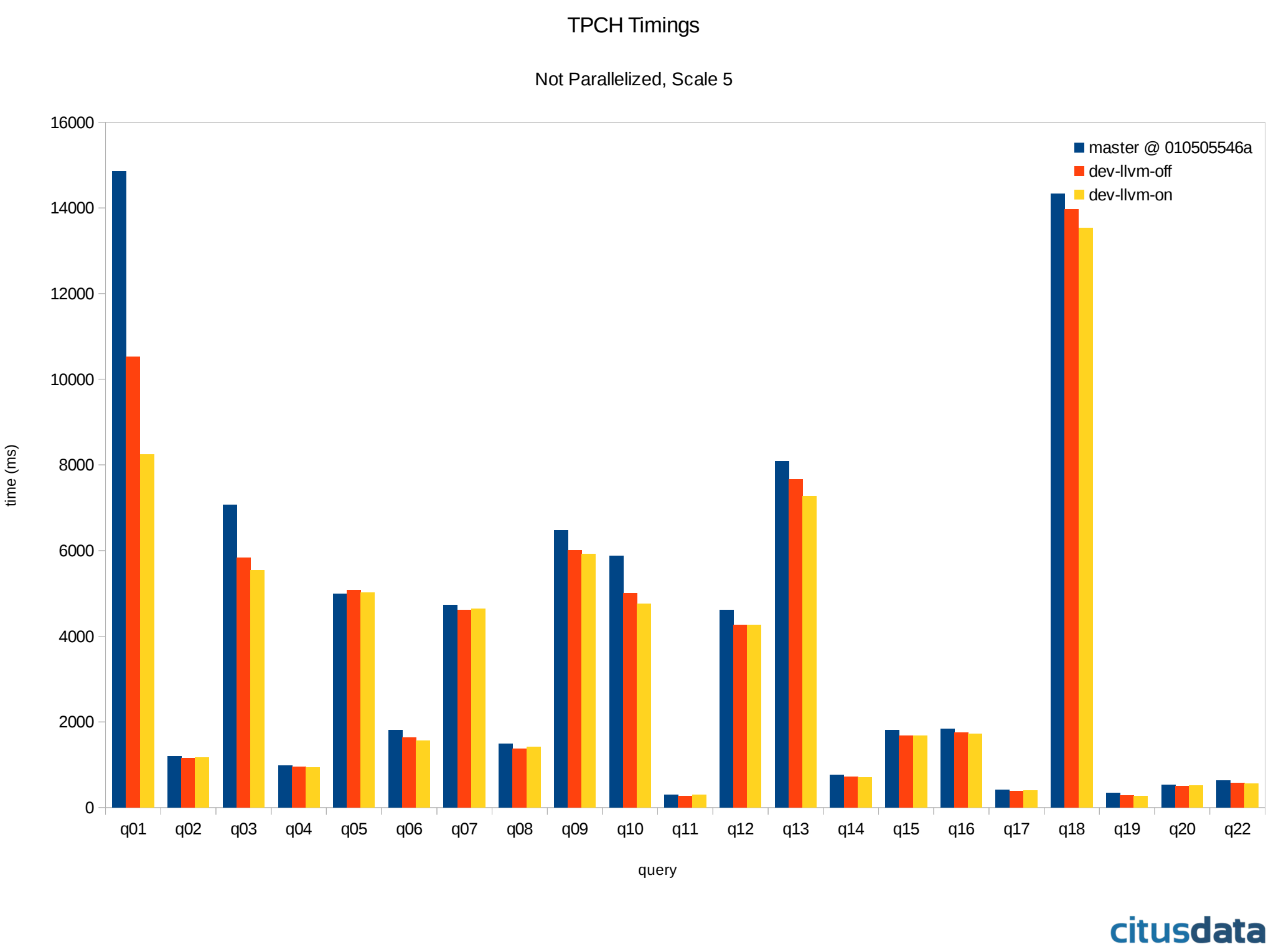
Just In Time Compilation

- Interpretation has a lot of “jumps”
- Interpretation calls a lot of “unknown functions”
- Native Code doesn’t have those Issues
- Only do so when beneficial
  - Generating a native function is expensive (~0.5-5ms)
- Can be used in a lot of places


TPCH Timings
Not Parallelized, Scale 5
master @ 010505546a
dev-llvm-off
dev-llvm-on
time (ms)
16000
14000
12000
10000
8000
6000
4000
2000
0
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
query
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TPCH Improvement
Not Parallelized, Scale 5
master v. llvm-off-imp
master v. llvm-on-imp
90
80
70
60
50
40
30
20
10
0
-10
query
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
% Improvement

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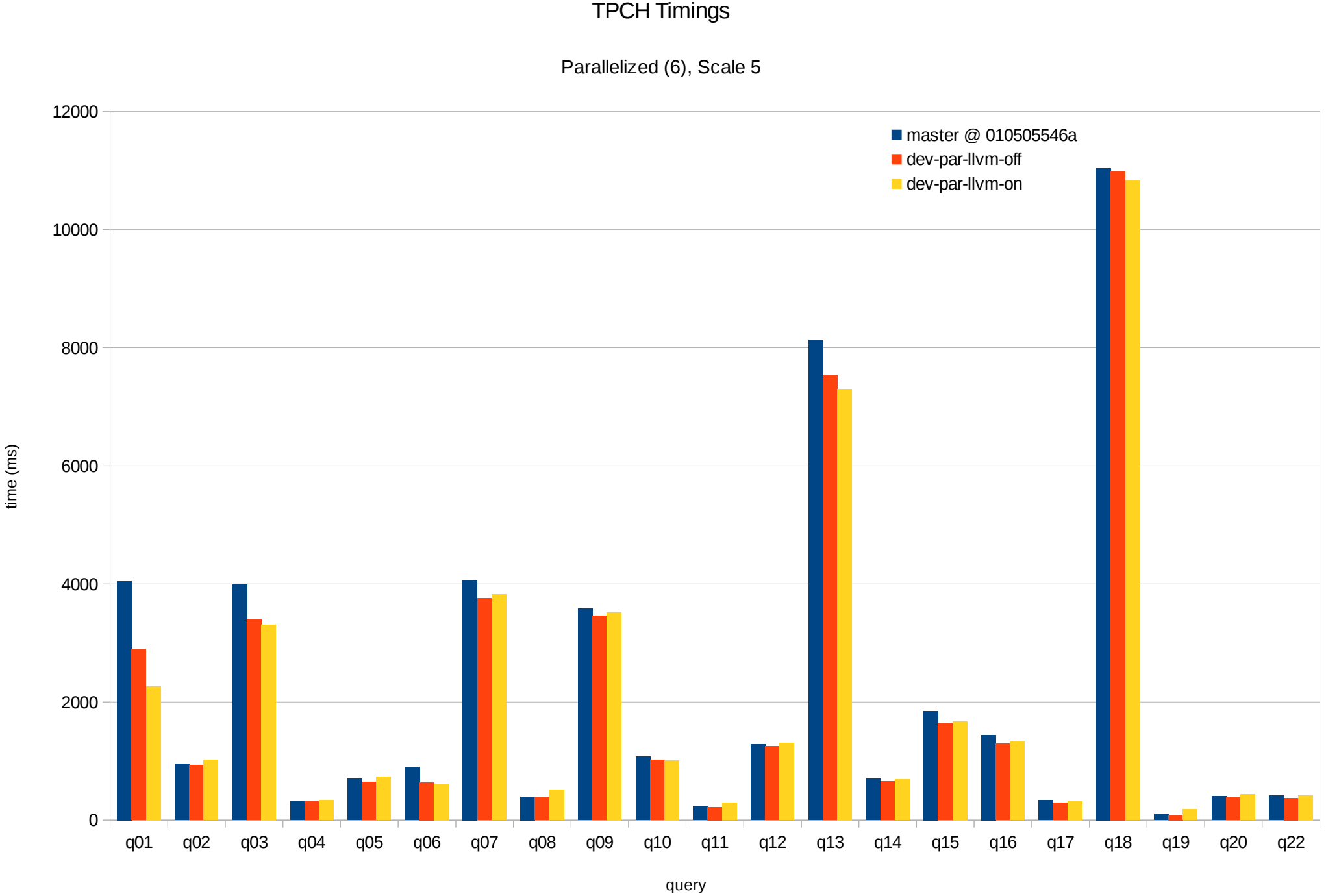
TPCH Timings
Parallelized (6), Scale 5
master @ 010505546a
dev-par-llvm-off
dev-par-llvm-on
time (ms)
query
0
2000
4000
6000
8000
10000
12000
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22

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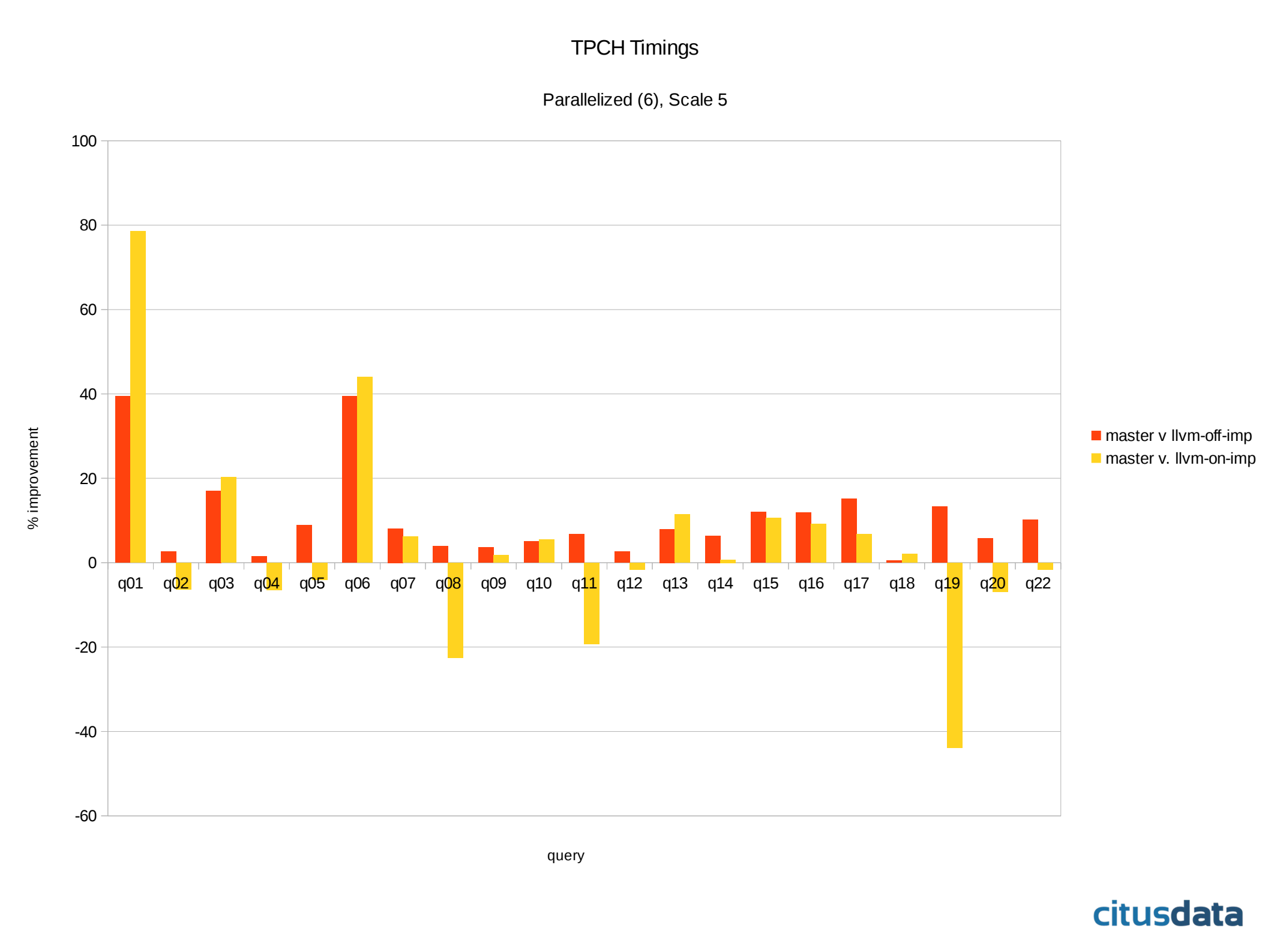
TPCH Timings
Parallelized (6), Scale 5
% improvement
100
80
60
40
20
0
-20
-40
-60
q01
q02
q03
q04
q05
q06
q07
q08
q09
q10
q11
q12
q13
q14
q15
q16
q17
q18
q19
q20
q22
query
master v llvm-off-imp
master v. llvm-on-imp
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Tuple Deforming

- On-Disk → Memory Representation
- Expensive, don’t know columns ahead
- Improving Code: 1 Month, up to 3%
- JIT: ~1 Month, up to 80 %

Better JIT

- Inline functions
  - WHERE (a + b) < c
    - float8pl / int4pl / *pl
    - float8lt / int4lt / *lt
  - AVG(a + b)
    - int8pl
    - int8_avg_accum
    - numeric_poly_avg
  - Function calls are expensive, content cheap to execute
- Better Code

Batch Tuple Processing #2

- Other Bottlenecks Are Gone
- Experiments show 0 - 40% in TPC-H queries

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