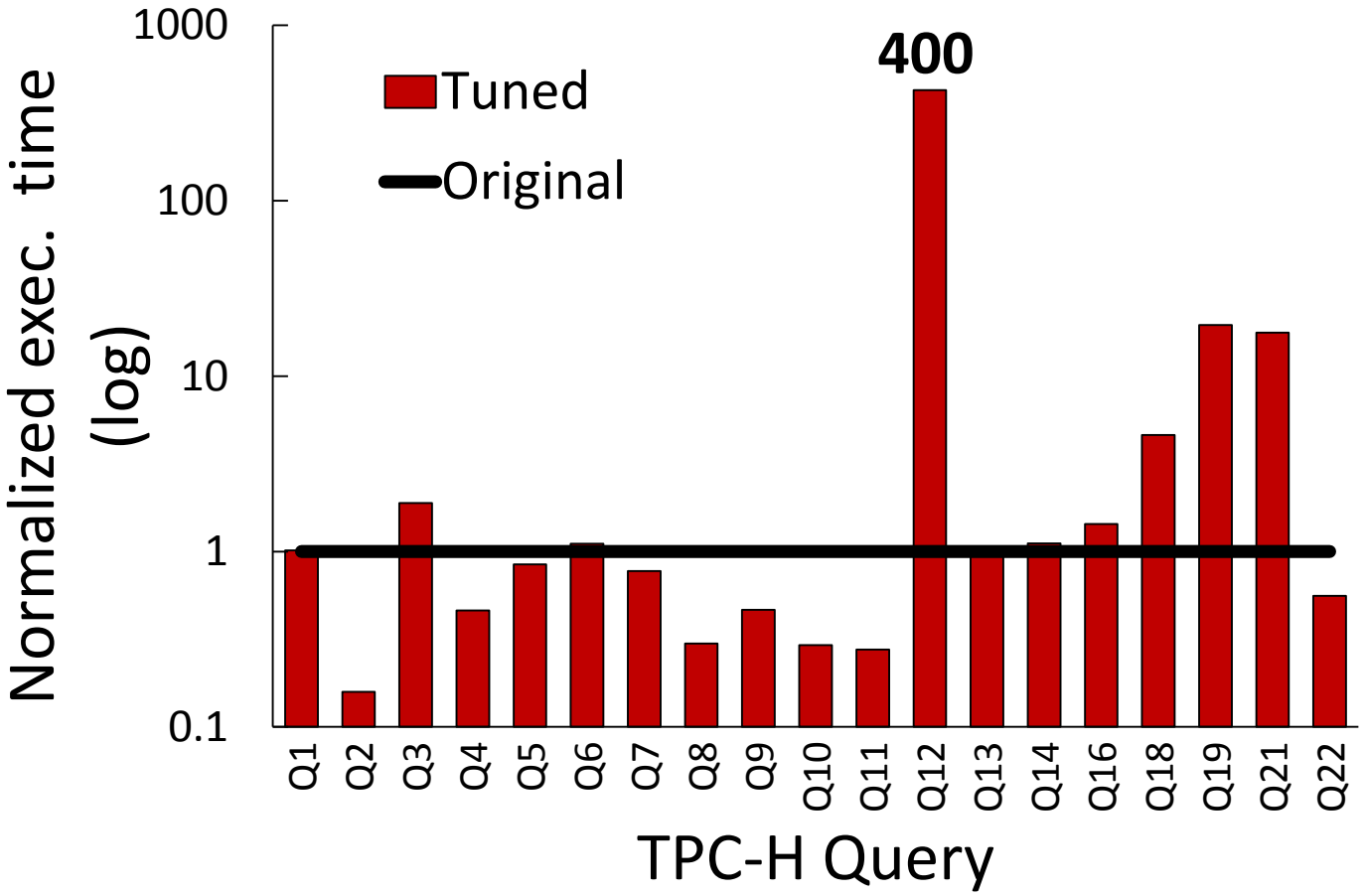
Smooth Scan: Statistics-Oblivious Access Paths

Renata Borovica-Gajic Stratos Idreos Anastasia Ailamaki
Marcin Zukowski Campbell Fraser

Inspired by Dagstuhl 2012 seminar on Robust Query Processing

Optimizers' sensitivity to statistics

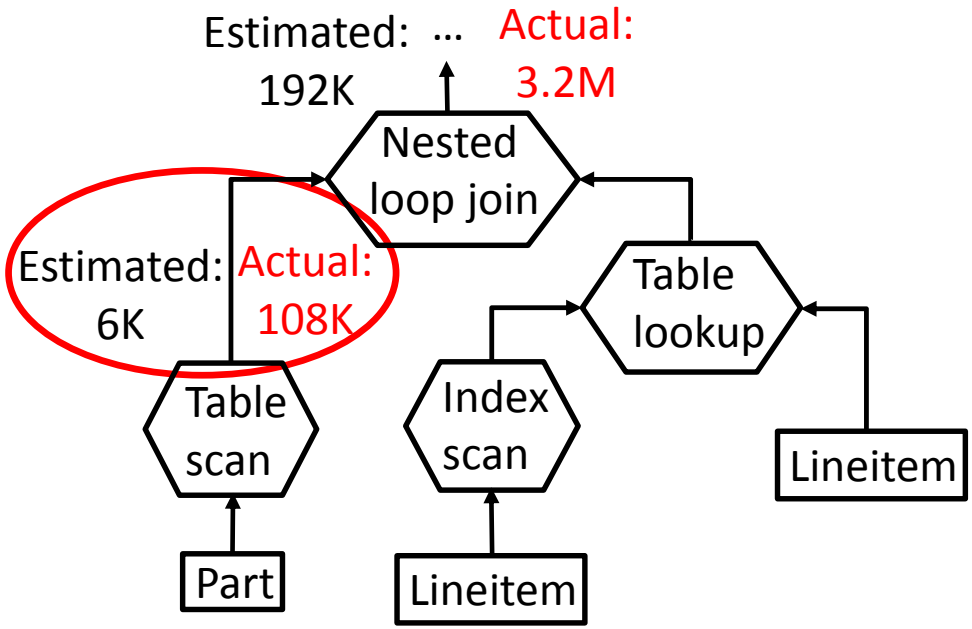
Setting: TPC-H, SF10, DBMS-X, Tuning tool 5GB space



Degradation due to sub-optimal access paths

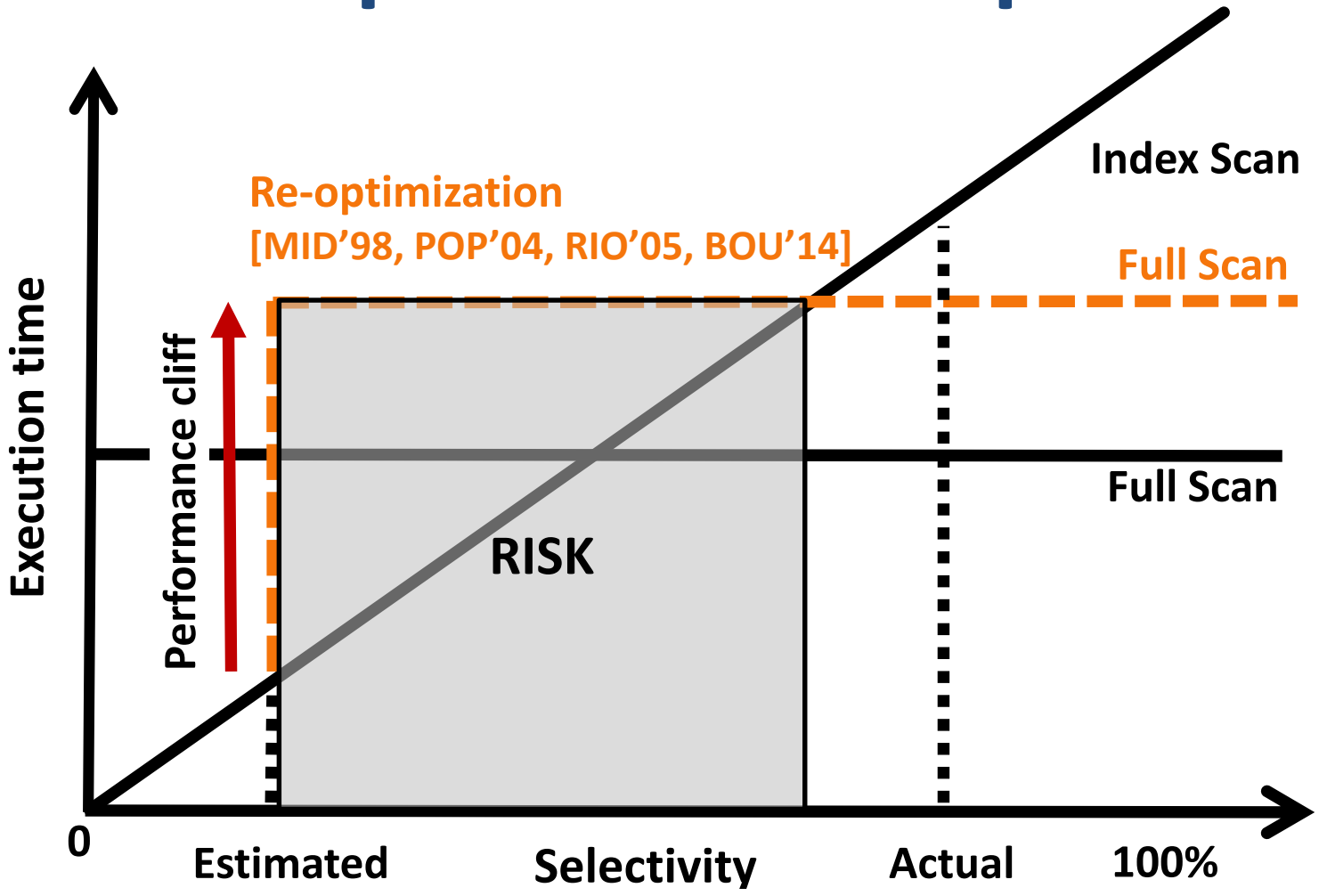
Cause for sub-optimal plans

CARDINALITY ERRORS



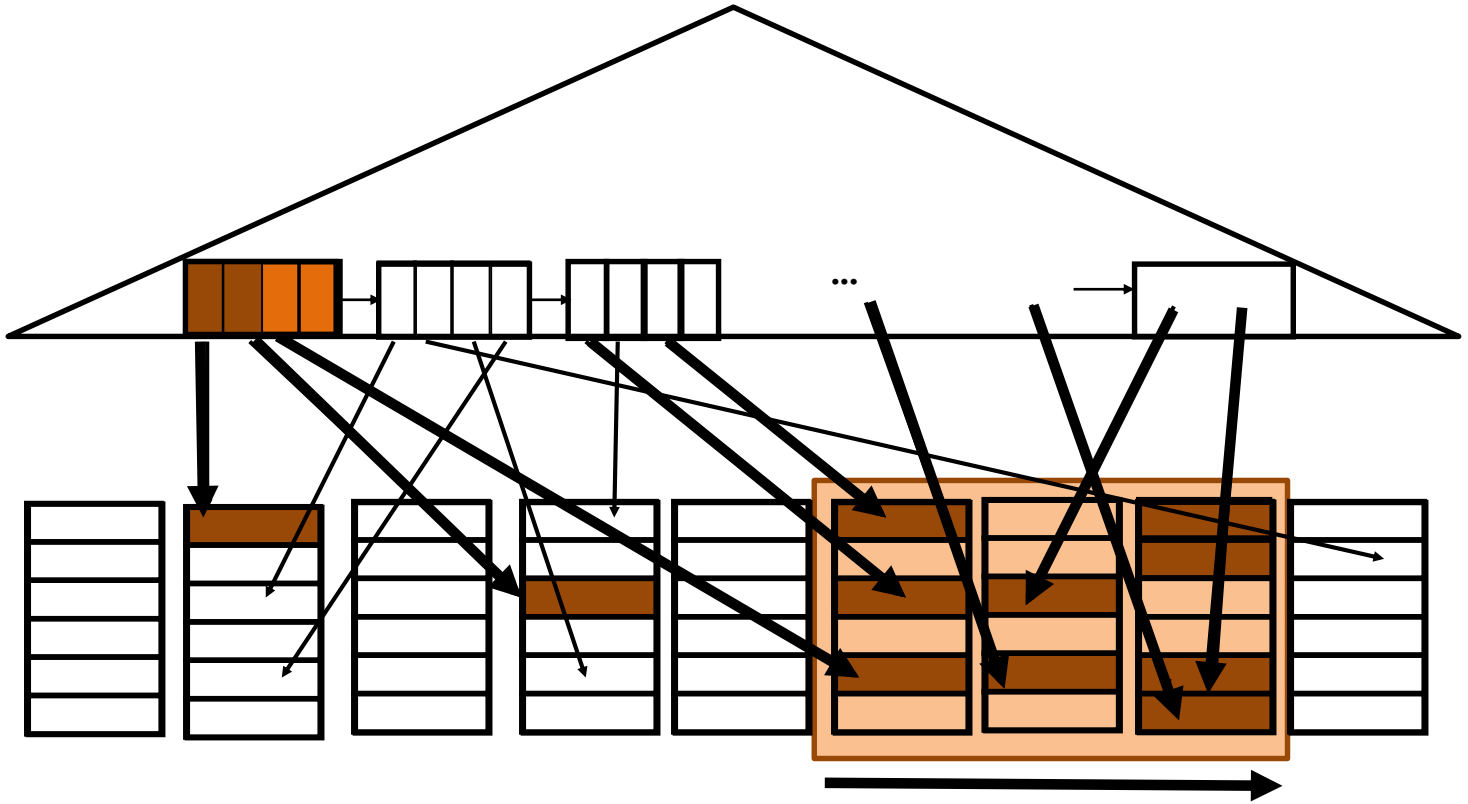
- Order of magnitude more tuples
- 75x longer execution time!

Access path selection problem



Statistics: unreliable advisor
Re-optimization: risky

Access paths under looking glass

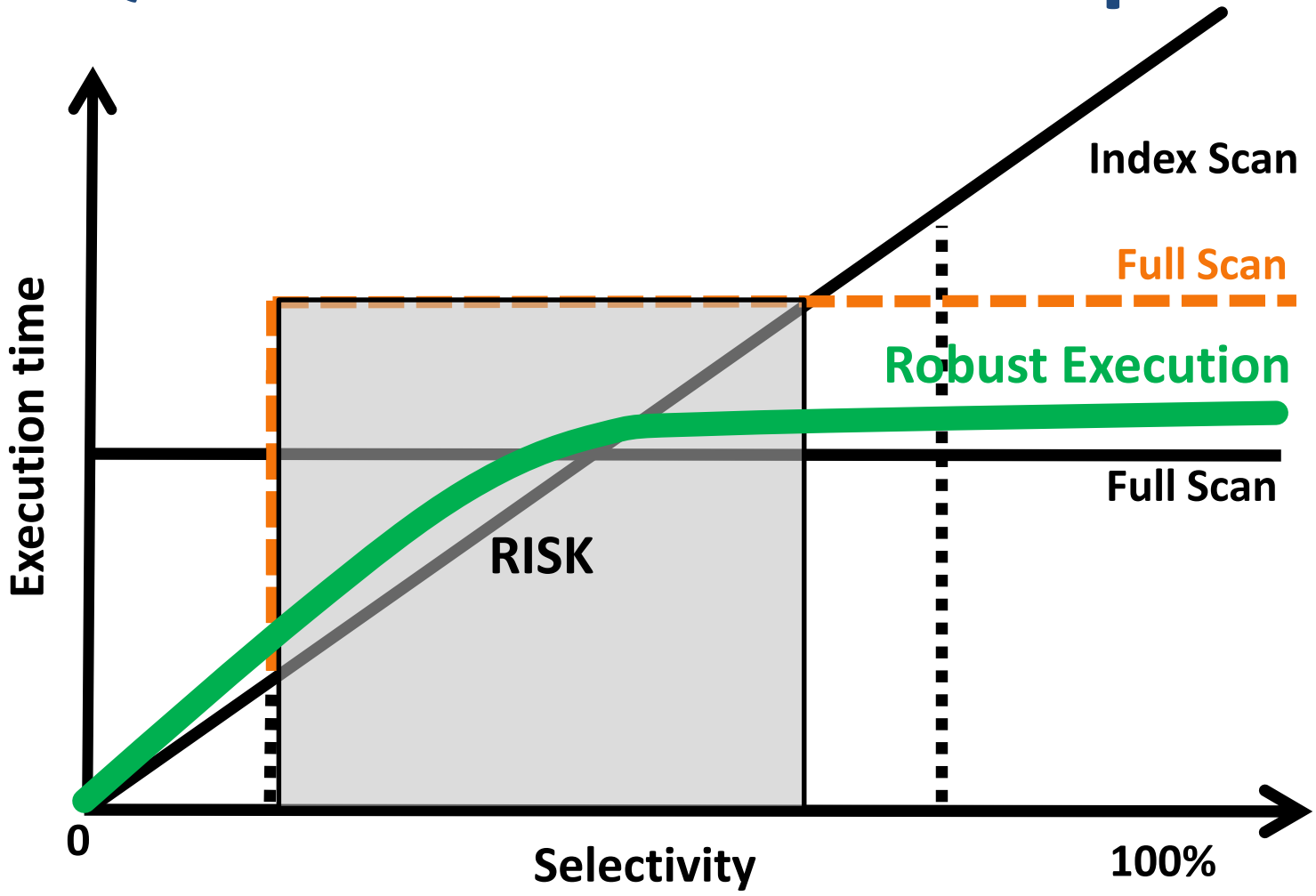


Index Access
+ read what you need
- random (& repeated) I/O

Sequential Access
+ (fast) sequential I/O
- read everything

No single path is optimal

Quest for robust access paths



Near-optimal throughout entire selectivity range

Smooth Scan in a nutshell

- Statistics-oblivious access path
- Learn result distribution at run-time
- **Adapt** as you go

DESIGN GOALS

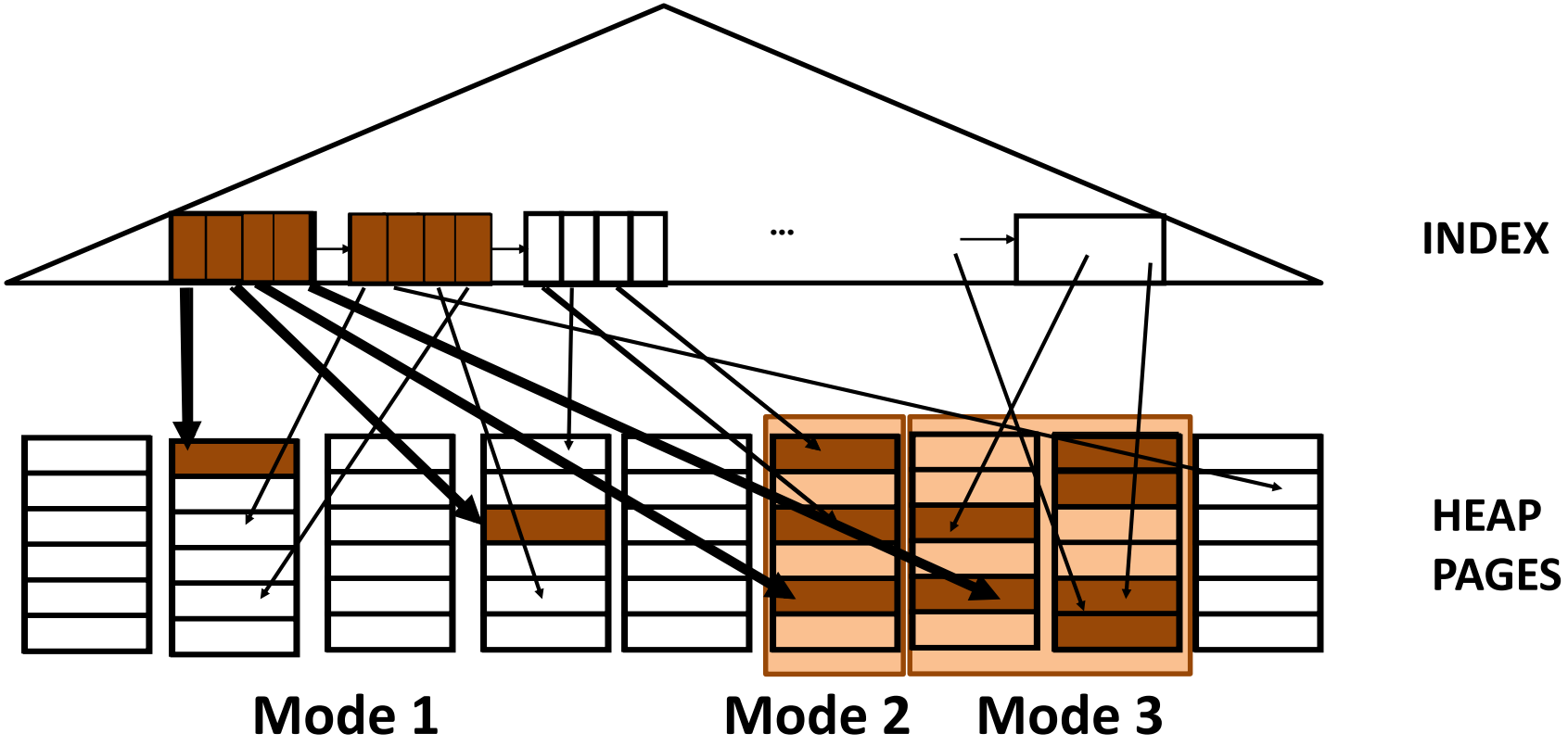
- Avoid **performance cliffs & risk**
- Continuous, gradual and **smooth adaptation**

Adaptivity with Smooth Scan

Morph between Index and Sequential Scan based on **observed result** distribution

Morphing mechanism

- Modes:
  1. **Index Access:** Traditional index access
  2. **Entire Page Probe:** Index access probes entire page
  3. **Gradual Flattening Access:** Probe adjacent region(s)

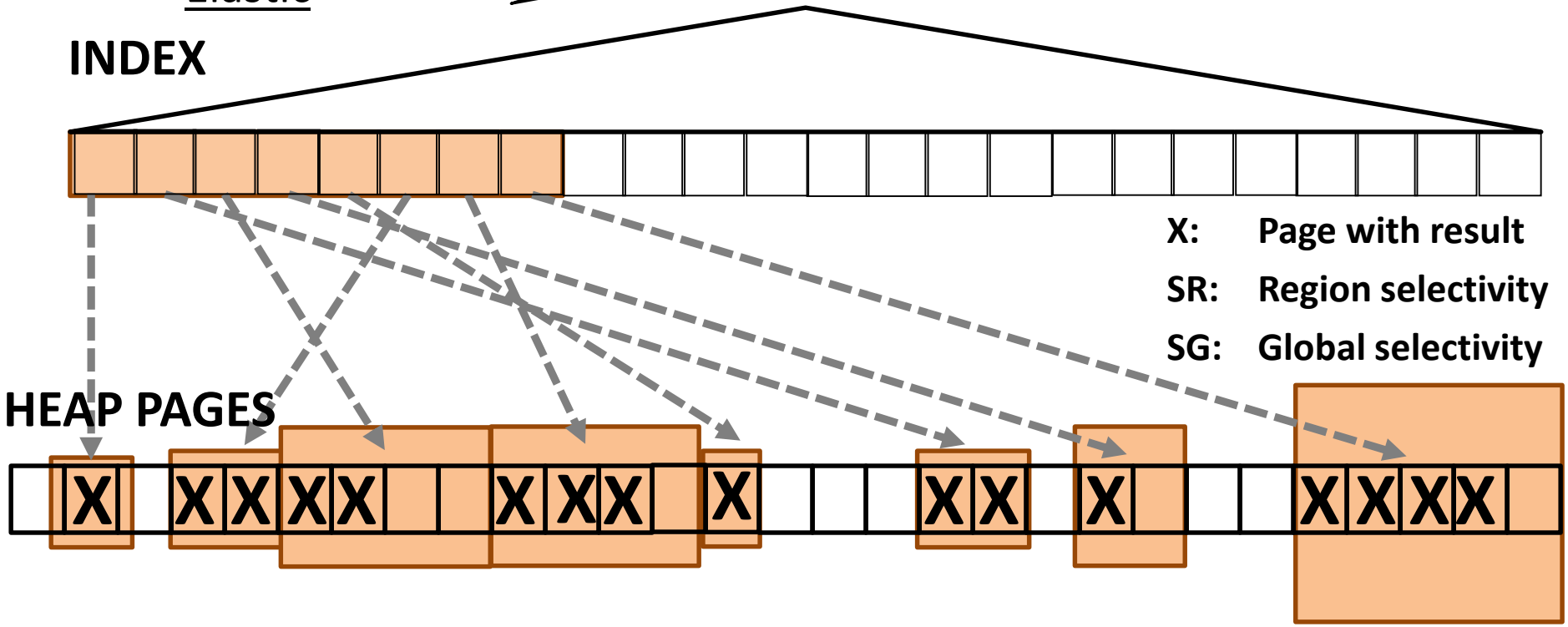


Morphing policies

- Policies:
  - Greedy
  - Selectivity Increase Driven
  - Elastic

Selectivity increase -> Mode Increase
SEL_region > SEL_global

Selectivity decrease -> Mode Decrease
SEL_region < SEL_global



Region snooping = Selectivity driven adaptation

Smooth Scan benefits

	Index Scan	Full Scan	Sort Scan	Smooth Scan
Avoid repeated accesses	✗	✓	✓	✓
Fast sequential I/O	✗	✓	✓	✓
Avoid full table read	✓	✗	✓	✓
Tuples pipelining	✓	✓	✗	✓

Experimental setup

Hardware:

2 Intel Xeon 6-core CPU @2.8 GHz, 48GB RAM

HDD: I/O transfer rate 120 MB/s, Random vs. Sequential ratio = 10

Software:

PostgreSQL 9.2.1: Index Scan, Full Scan, Sort (Bitmap) Scan, Smooth Scan

Workload:

TPC-H: SF 10

Micro-benchmark: 400M tuples, 10 columns random ($1 – 10^5$), 25GB

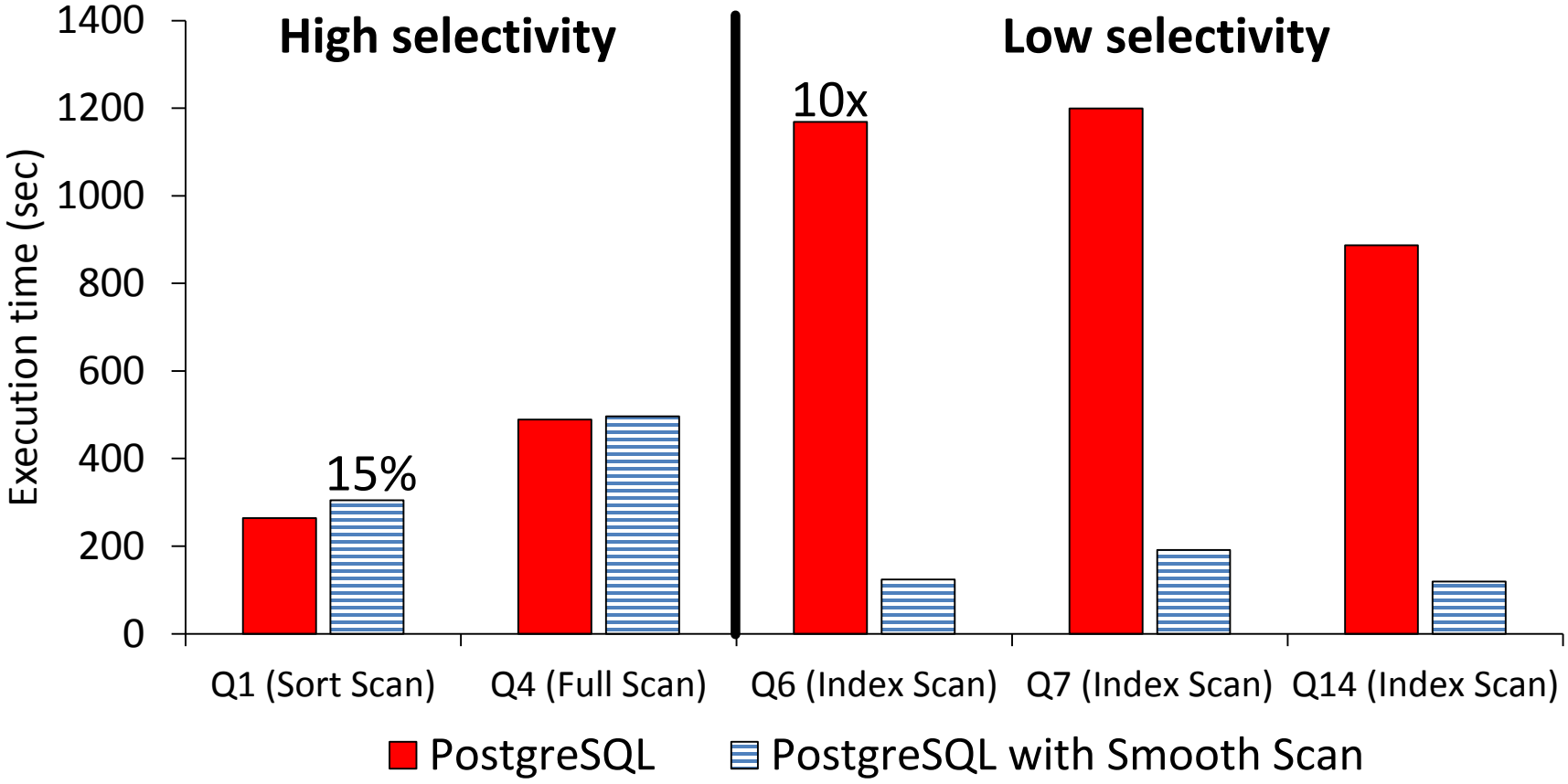
Q1: select * from relation where c2 >= 0 and c2< X% [order by c2];

Experimental Condition:

Cold file system cache

TPC-H with Smooth Scan

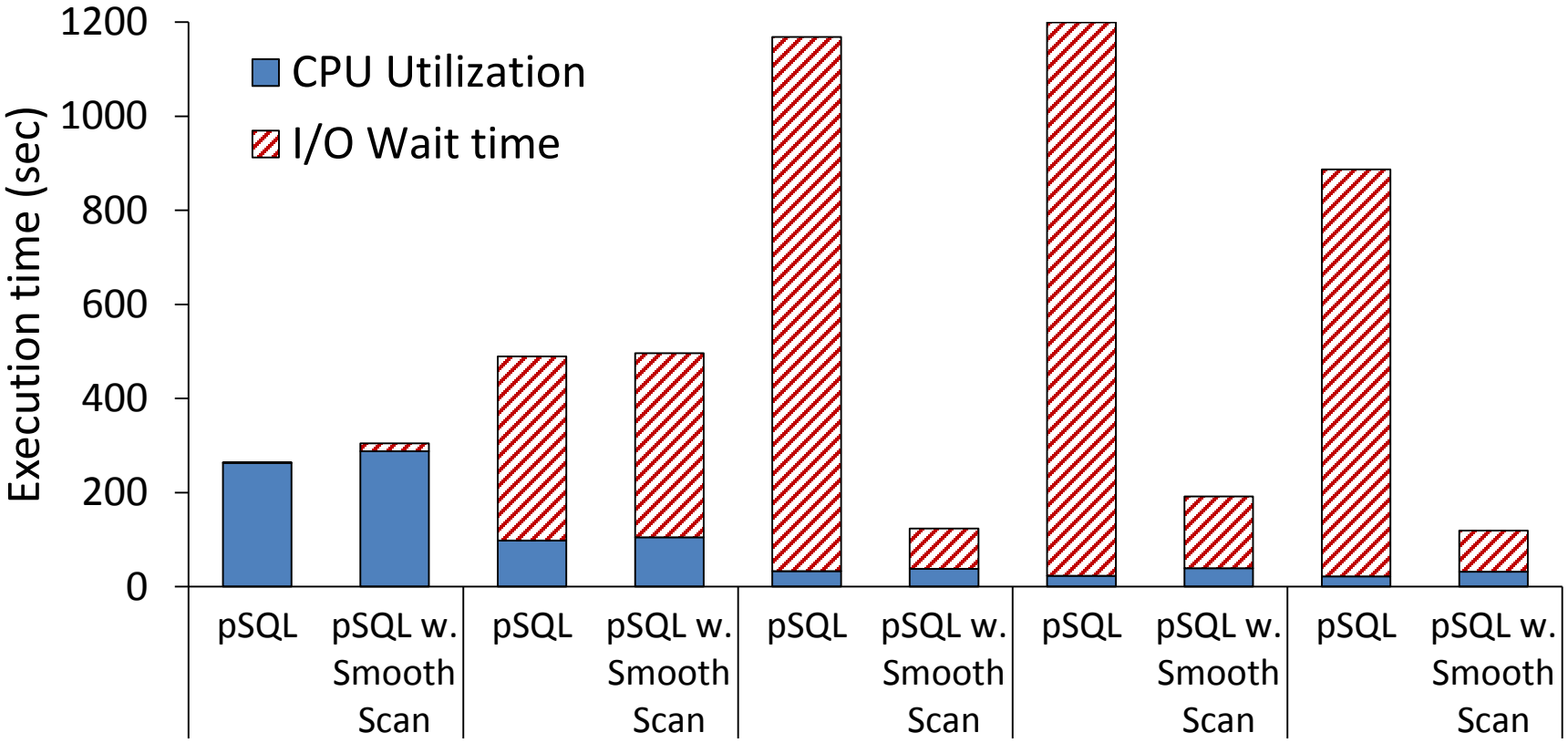
Setting: TPC-H, SF10, PostgreSQL with Smooth Scan



Robust execution for all queries

TPC-H breakdown

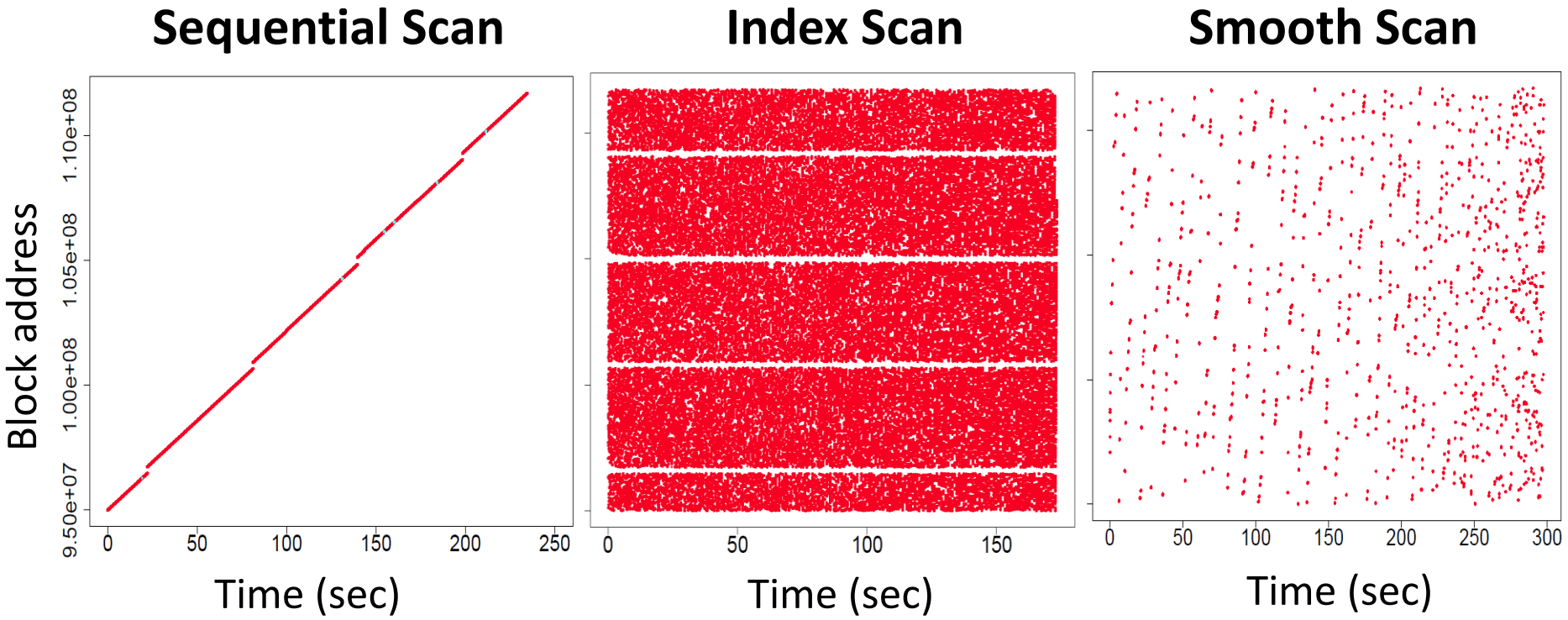
	Q1		Q4		Q6		Q7		Q14	
	pSQL	Smooth S.	pSQL	Smooth S.	pSQL	Smooth S.	pSQL	Smooth S.	pSQL	Smooth S.
# I/O Requests (K)	70	77	224	235	566	95	745	124	416	87



Smooth Scan significantly decreases I/O wait time

Snooping I/O access

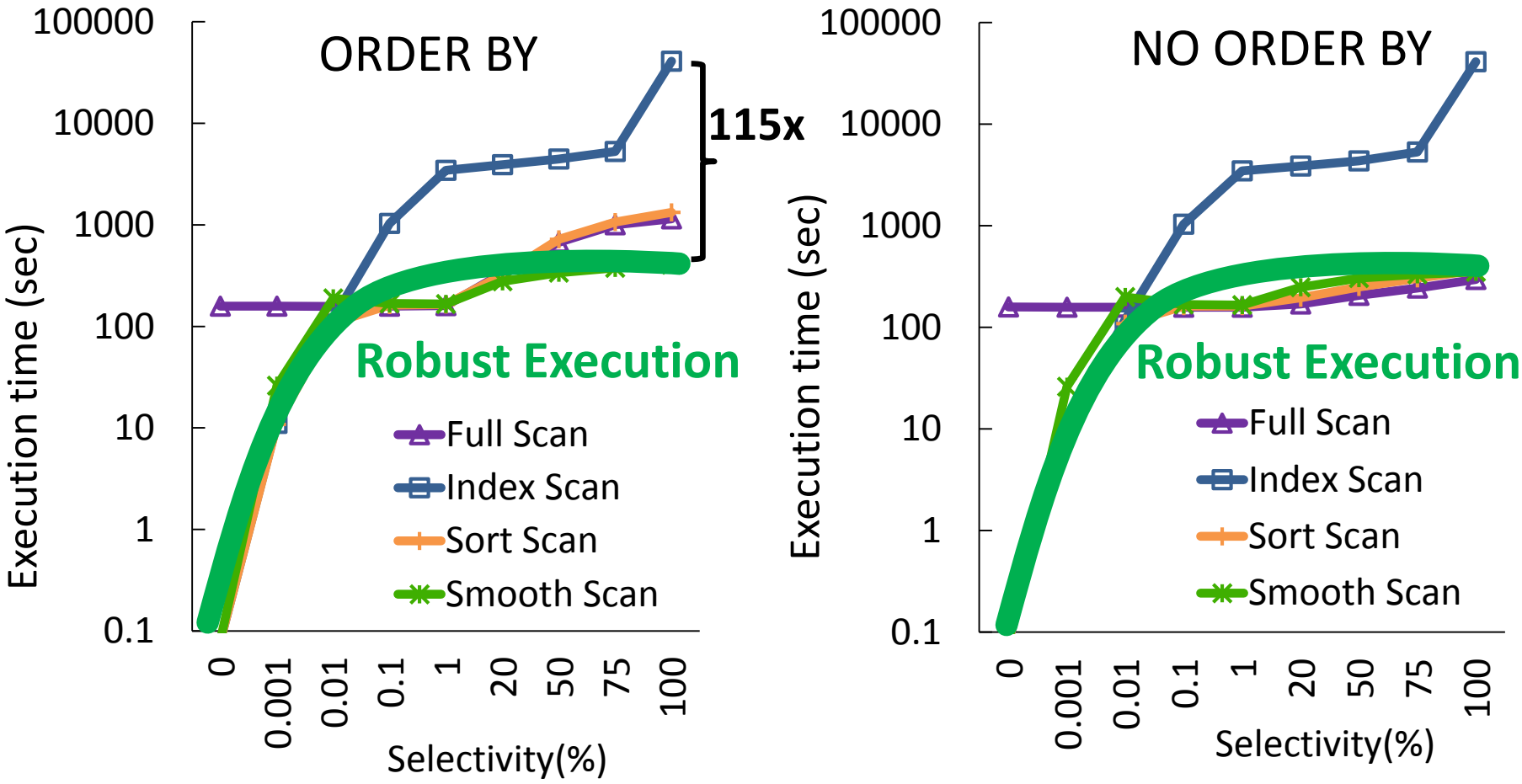
Setting: TPC-H, Q1, Lineitem table, iosnoop tool



Smooth Scan reduces random I/O requests

Adaptivity over selectivity range

Setting: Micro-benchmark, Q1 (w. and w/o. order), Selectivity 0-100%

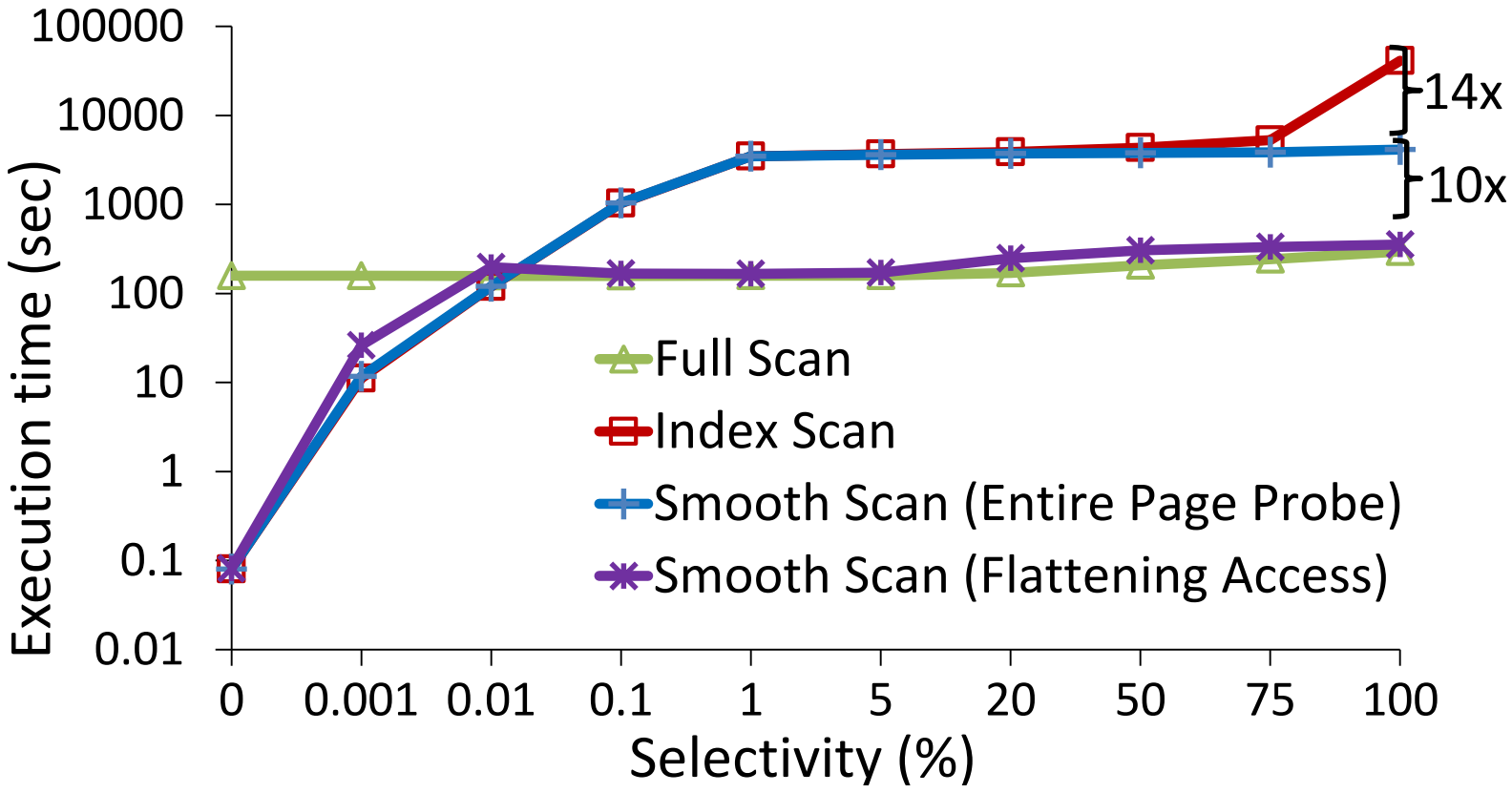


Near-optimal performance throughout entire range

Evaluation of Smooth Scan Modes

Setting: 400M tuples, 10 int. attributes, 25GB, Index(c2), cold runs

Query: select * from R where c2 < X%;

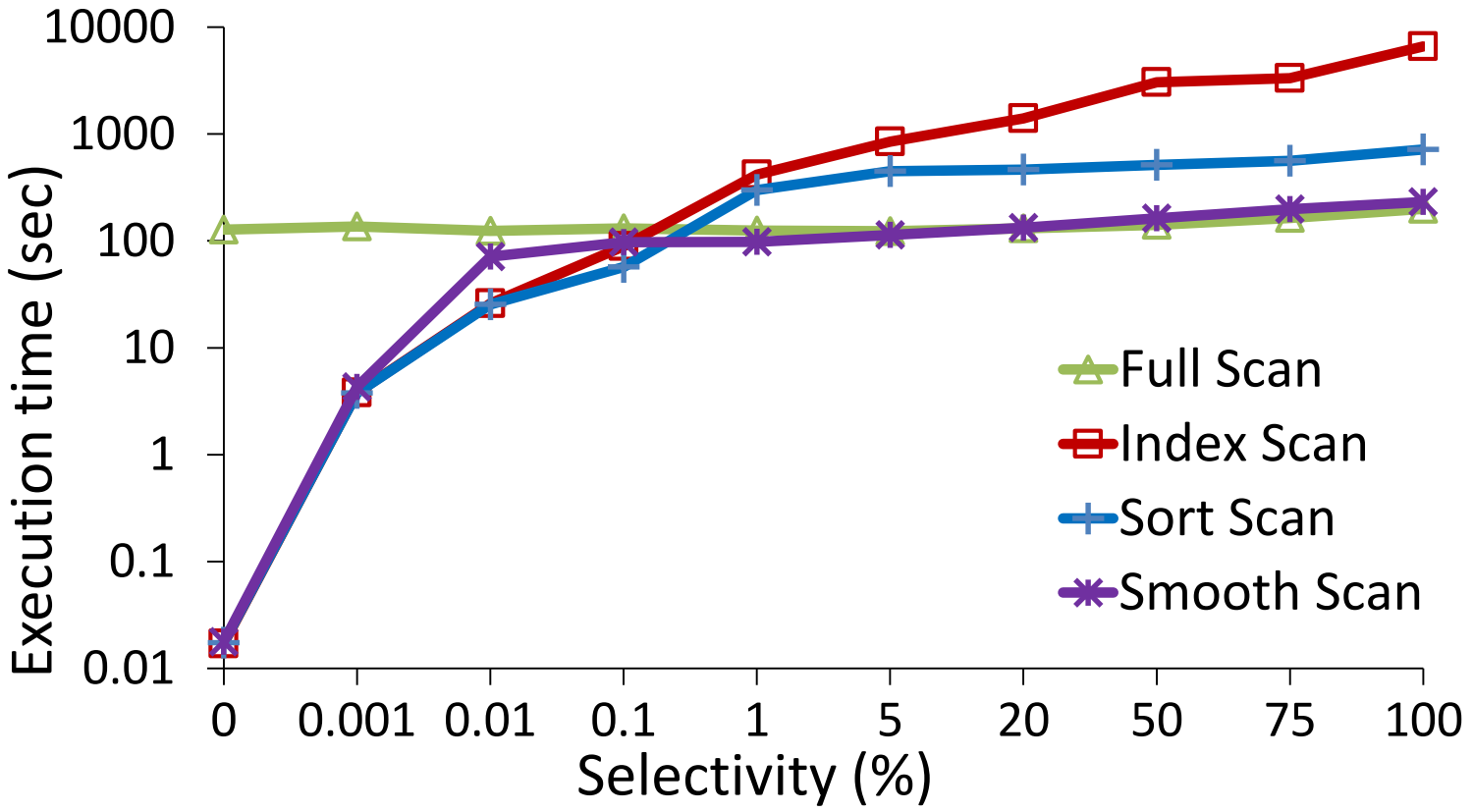


Full morphing prevents degradation of 115x compared to Index Scan and is 20% slower than Full Scan

Smooth Scan on SSD

SSD: Deneva 2C Series, transfer 550MB/s, 80kIO/s of random reads

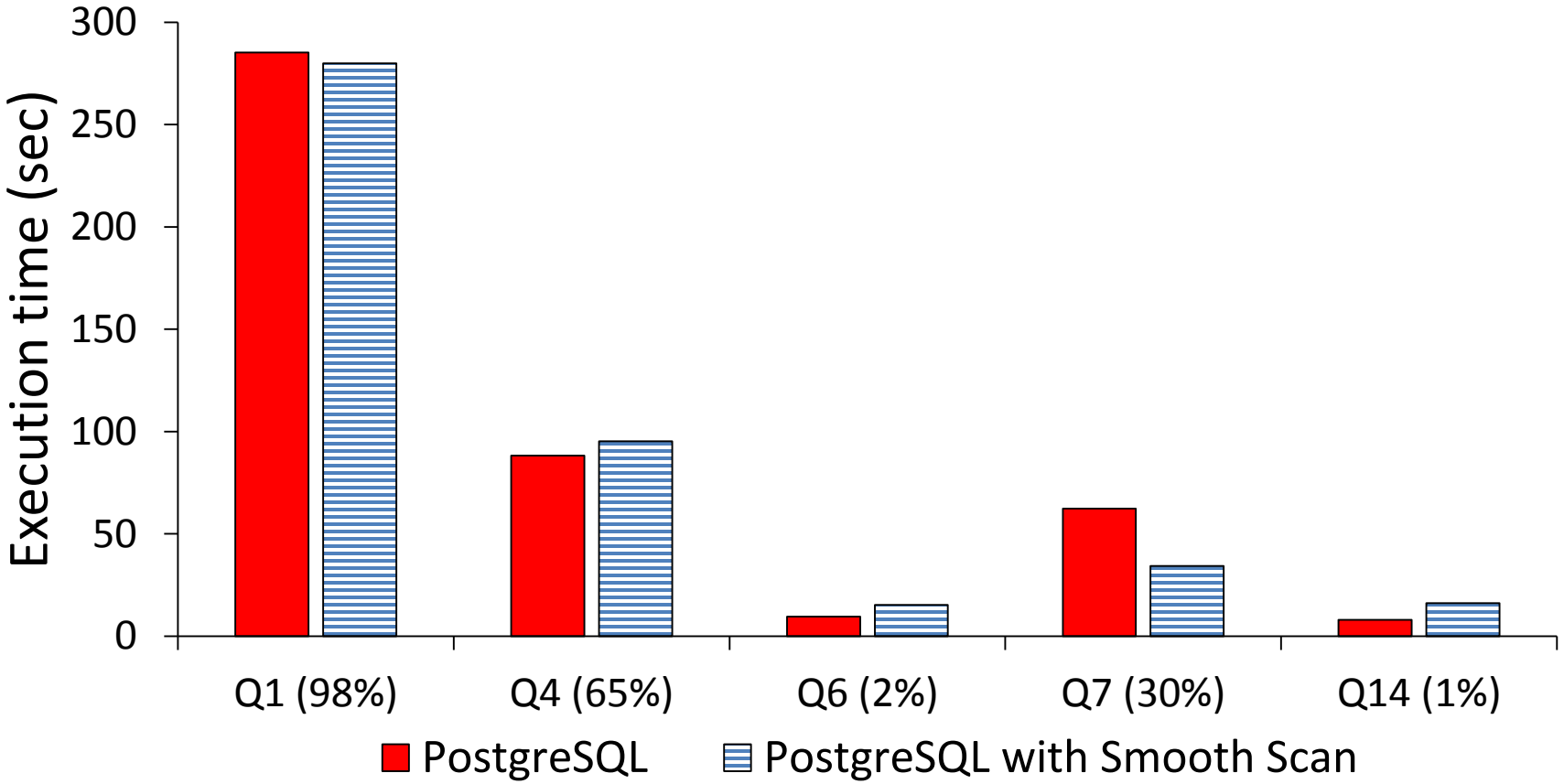
Query: select * from R where c2 < X%;



Higher benefit for Smooth Scan on SSD than on HDD

TPC-H in memory

Setting: TPC-H, SF10, Warm caches



CPU overhead cannot be fully masked

Conclusions

SMOOTH SCAN

- **Statistics-oblivious** access path
- Uses region snooping to **morph** between alternatives
- **Near-optimal performance** for all selectivities

IMPACT

- Removes access path selection decision
- Robust execution for all query inputs

Open questions

- In-memory implementation
- Handling concurrency
- Index intersection
- Column stores
- Sub-optimal join order
- Something else?

Thank you!

Q & A





renata.borovica@epfl.ch stratos@seas.harvard.edu natassa@epfl.ch marcin@snowflake.net campbellf@google.com

Thank you!

Bibliography

- **[MID'98]** N. Kabra and D. DeWitt. *Efficient Mid-Query Re-optimization of Sub-optimal Query Execution Plans.* SIGMOD, 1998.
- **[POP'04]** V. Markl et all. *Robust query processing through progressive optimization.* SIGMOD, 2004.
- **[RIO'05]** S. Babu, P. Bizarro, D. DeWitt. *Proactive Re-Optimization.* SIGMOD, 2005.
- **[BOU'14]** A. Dutt and J. Haritsa, *Plan Bouquets: Query Processing without Selectivity Estimation*, SIGMOD, 2014.