COOL

Conditions Database for the LHC Experiments

Performance Optimization
Status and Outlook

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Distributed Database Operations Workshop,
11th November 2008

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Outline

- **Recent releases**
- **Performance tests and optimization**
  - Query optimization on small data samples
  - Scalability tests on large simulated samples
  - Support of actual deployment with real data
- **Work in progress**

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COOL releases: experiments

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- **COOL 2.4.0 (28 Feb 2008)**
  - Current Atlas production release (2008 DB tests)
- **COOL 2.5.0 (10 Jun 2008)**
  - Used in LHCb, while Atlas has not picked this up
    - Requires user code changes (removal of SEAL)
- ***COOL 2.6.0 (10 Nov 2008: yesterday!)***
  - *Will soon be integrated by both Atlas and LHCb*
- ***COOL 2.6.0a ? (Dec 2008 ?)***
  - *Rebuild: new externals (ROOT 5.22, Boost 1.36) and new platforms (gcc43/SLC5?, VC9) for 2009*

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COOL releases: performance

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- **COOL 2.4.0 (28 Feb 2008)**
- **COOL 2.5.0 (10 Jun 2008)**
  - Major internal cleanup of queries and hints: same SQL, C++ and hints for all use cases
    - *Faster and more stable queries for MV user tags*
      - *Using 240, Atlas had an issue fixed using SQL profiles*
    - Faster and more stable queries for MV HEAD
- **COOL 2.6.0 (10 Nov 2008: yesterday!)**
  - *Remove unnecessary COUNT(*) queries*
  - Faster IOV bulk insertion for MV closed IOVs
  - Complete internal cleanup of query use cases
  - *Payload queries: should monitor performance*

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Performance work in 3 areas

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- **Proactive optimization on small samples**
  - SQL query optimization of retrieval and insertion
- **Scalability tests: simulate large samples**
  - Atlas reference workload: store/read 10 years
- **React to requests from real deployment**
  - e.g. remove COUNT(*) queries in COOL 2.6.0
  - Test the system with simultaneous connections

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Performance optimization

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- **Main focus: performance for Oracle DBs**
  - Master T0 database for both Atlas and LHCb
- **Proactive performance test on small tables**
  - Test main use cases for retrieval and insertion
  - Query times should be flat as tables grow larger
    - e.g. avoid full table scans
- **Oracle performance optimization strategy**
  - Basic SQL optimization (fix indices and joins)
  - Use hints to stabilize execution plan for given SQL
    - Instability from unreliable statistics, bind variable peeking
    - Determine best hints from analysis of “10053 trace” files

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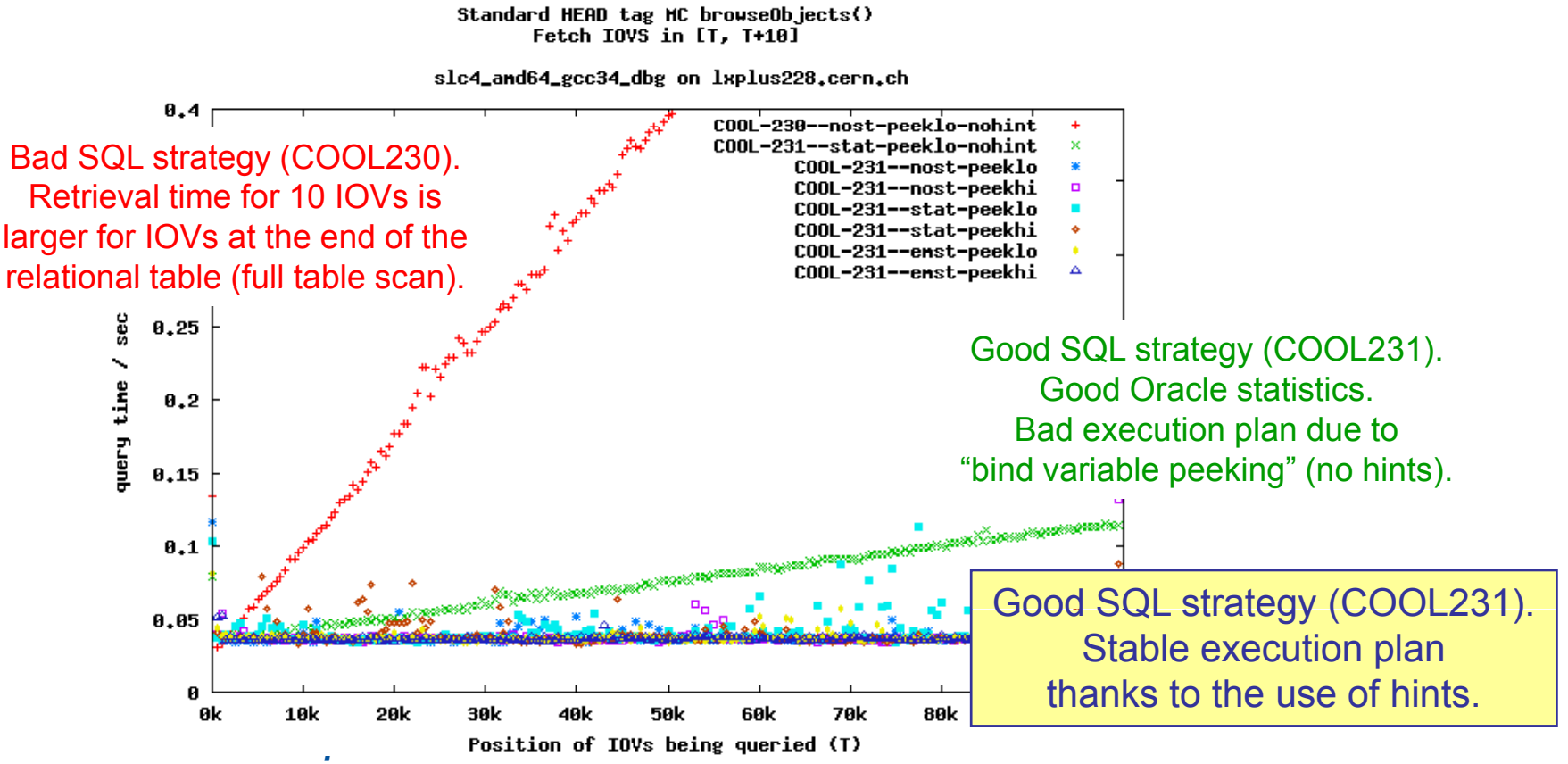
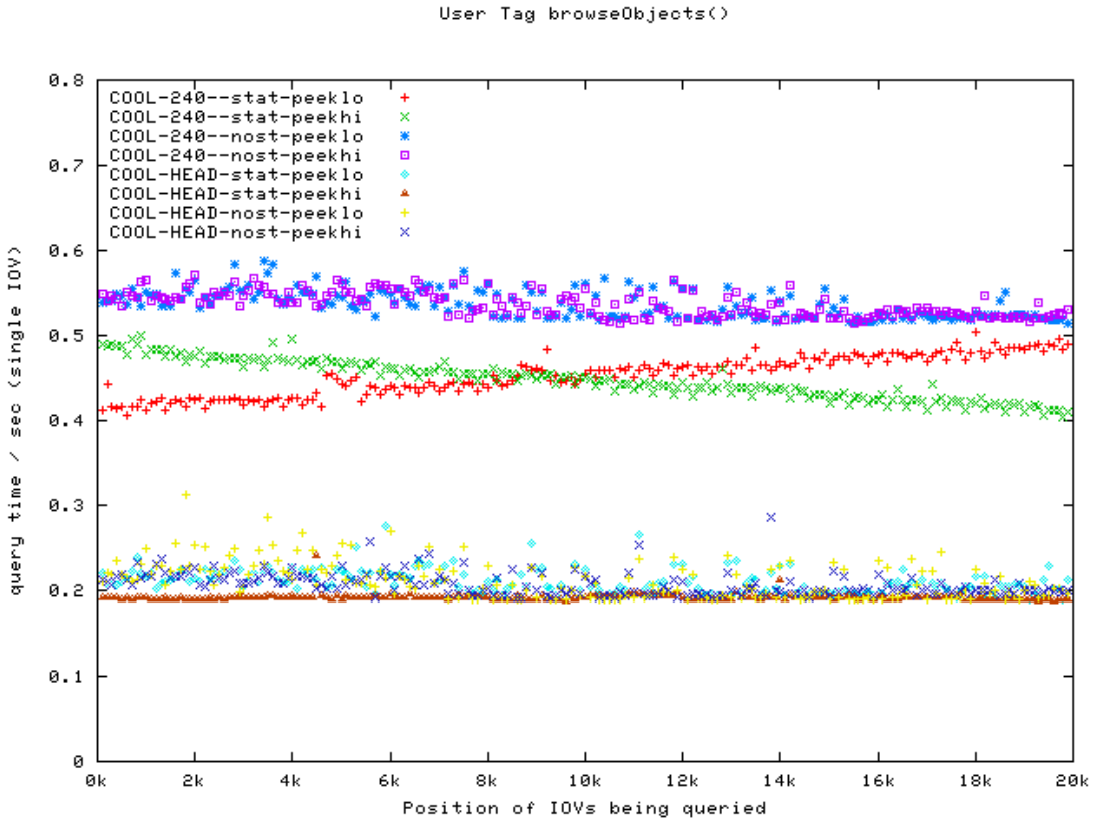
Performance optimization example

- **Systematic tests of known causes of instabilities**
  - Bind variable “peeking”, missing or stale “statistics”
    - Instabilities observed in the Atlas 2007 tests (e.g. CNAF vs. Lyon)
  - Stable performance after adding Oracle hints



COOL 2.5.0: MV user tags

- IOV retrieval from multi-version “user tags”
  - Used by Atlas for all MV data (e.g. calibrations)



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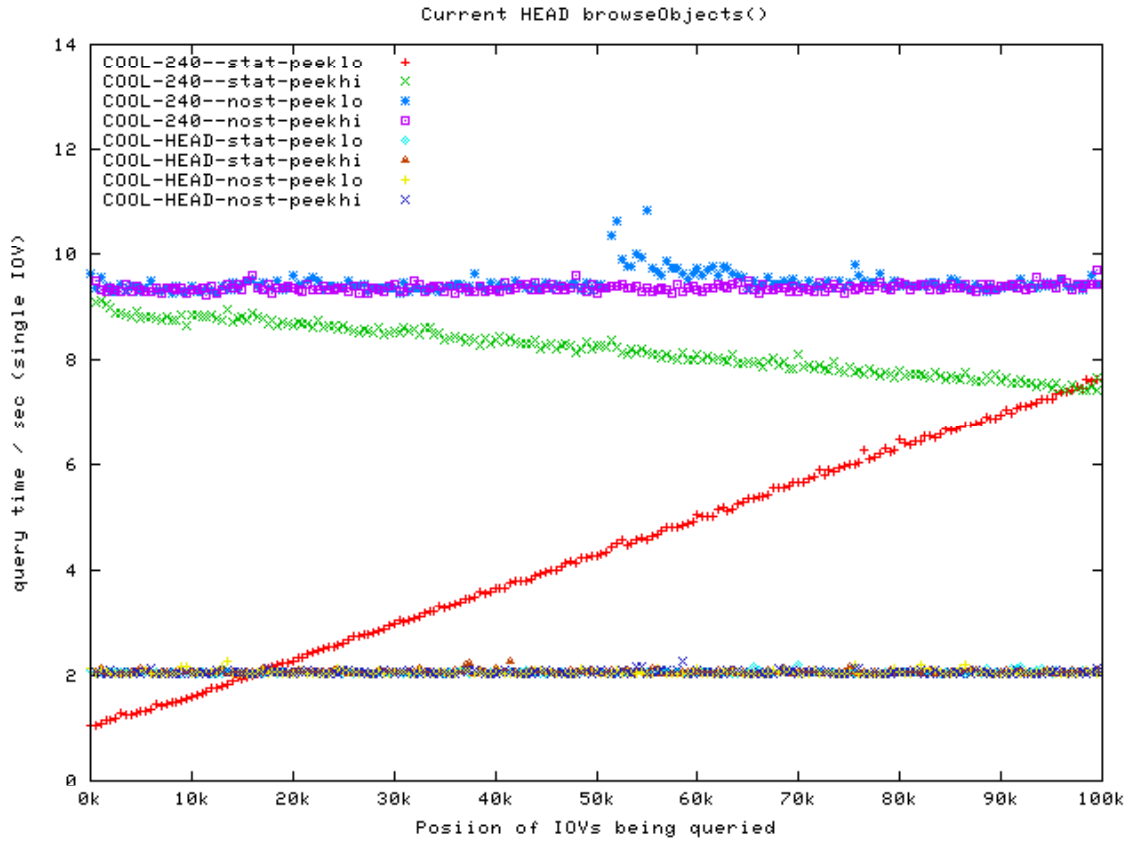
COOL 2.5.0: MV HEAD

- IOV retrieval from multi-version HEAD
  - Used by LHCb for tagging MV data



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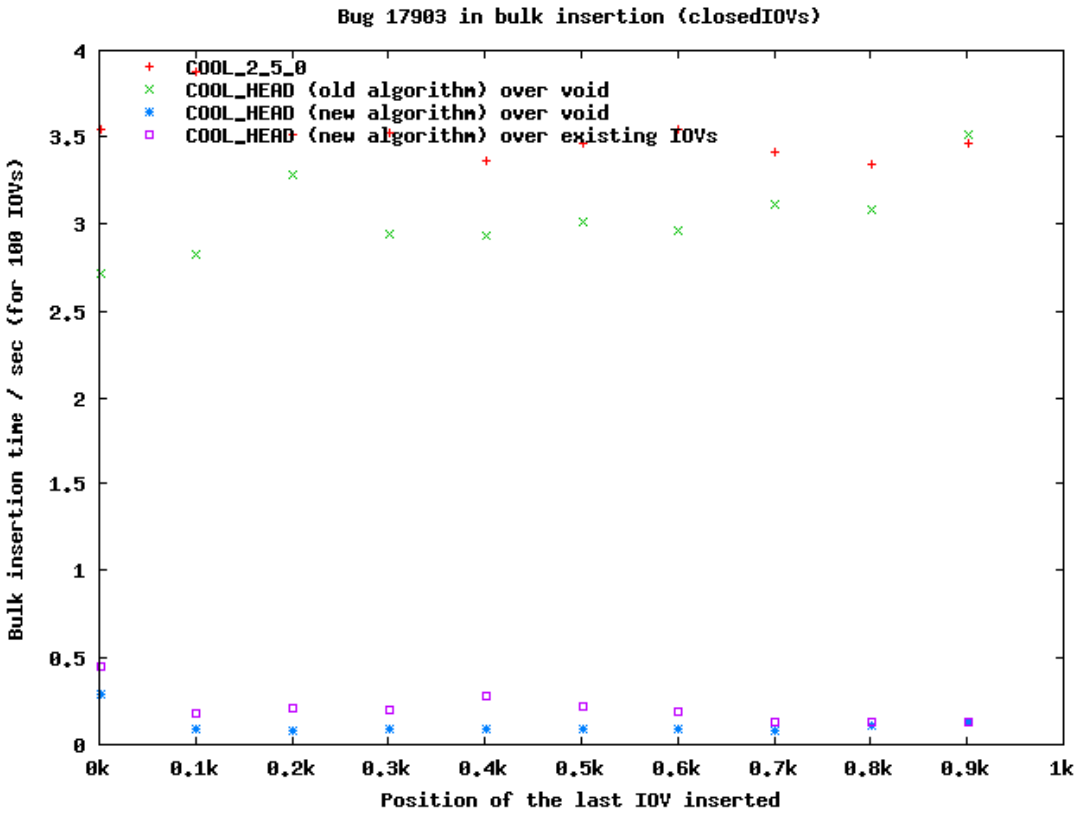
COOL 2.6.0: MV insertion

- IOV insertion in multi-version case
  - Problem was for [t1,t2], not for [t1,+inf]



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COOL 2.6.0: COUNT(*)

- **In COOL 2.5.0, IOVs were always counted before they were retrieved**
  - select count(*) from (select … from IOVS)
  - select … from IOVS
- **In COOL 2.6.0, this is done on demand**

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Scalability tests

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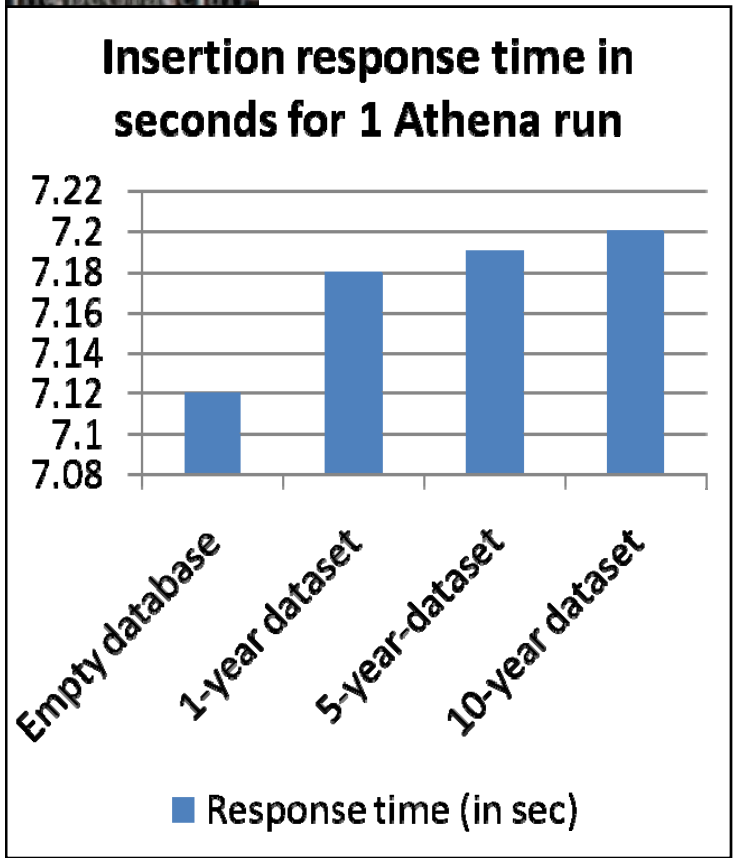
- **Proactive performance test on large tables**
  - Stable insertion and retrieval rates (>1k rows/s)
  - Simulate data sets for 10 year of LHC operation

Romain Basset



- **Test case: Atlas "DCS" data**
  - Measured voltages, currents...
  - Largest Atlas data set
    - 1.5 GB (2M IOVS) / day
- **To do next: data partitioning**
  - Goal: ease data management
  - Evaluating Oracle partitioning
    - Test possible performance impact

lassi

Work in progress

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- **Session sharing**
  - An Atlas job reads data from 10 COOL schemas
    - This now requires 10 sessions to the same DB
    - Will change COOL to use a single session
- **Schema improvements**
  - Store payload and metadata in 2 separate tables
    - Will reduce storage overhead (MV payload duplication)
- **Partitioning**
  - See next talk

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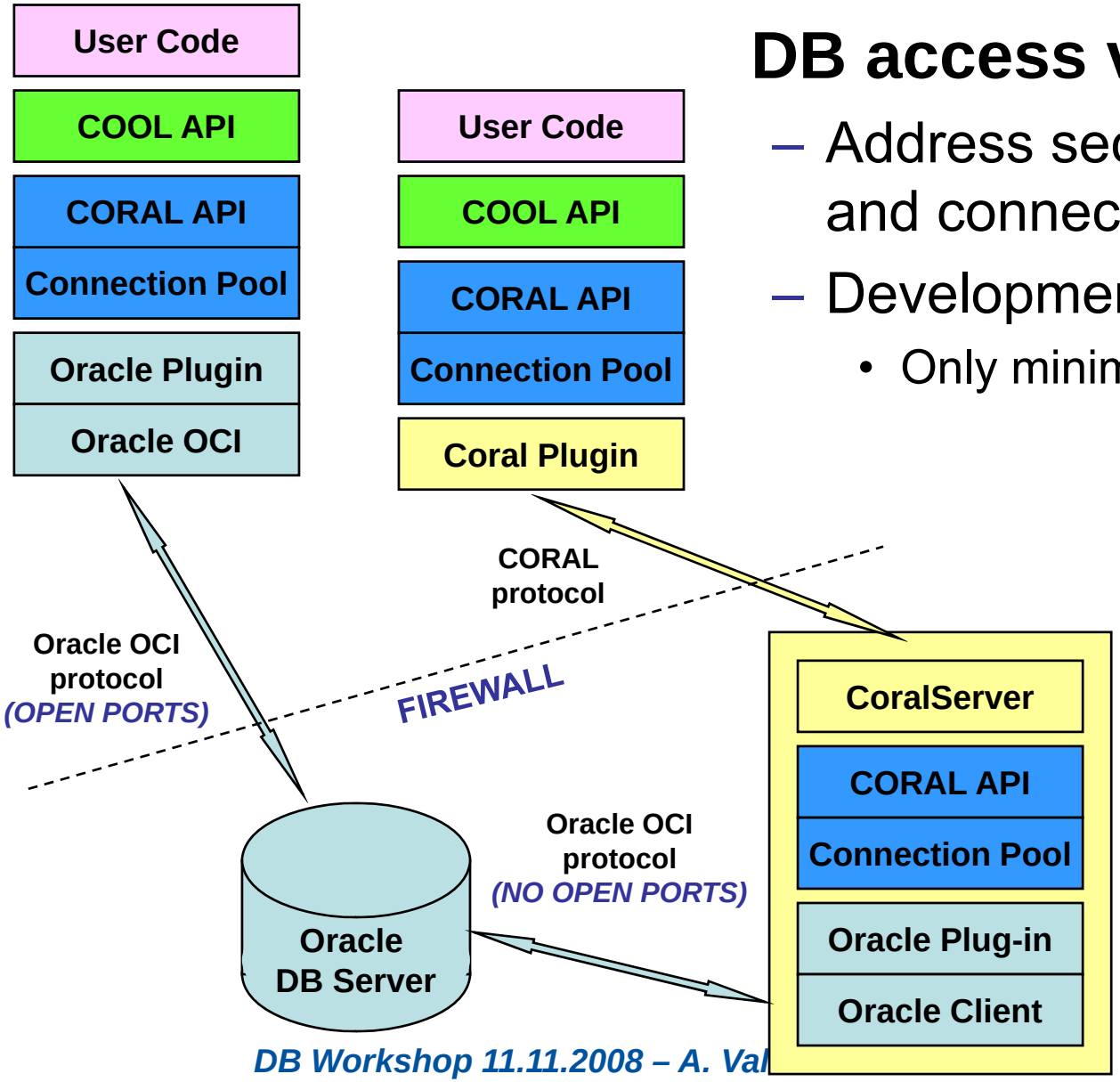
Future deployment model



DB access via CORAL server

- Address secure authentication and connection multiplexing
- Development still in progress
  - Only minimal changes in COOL

Reserve slides

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What is the COOL software?

- **Manage conditions data of Atlas and LHCb**
  - Time variation (validity) and versioning (tags)
    - e.g. calibration, alignment
  - Common project of Atlas, LHCb, CERN IT

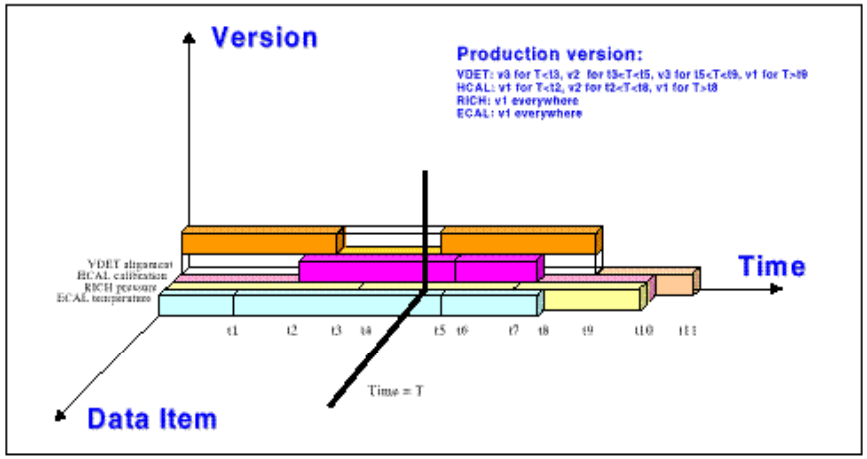

Figure 1 The three axes for identifying uniquely each data item in the condition database

- **Support for several relational databases**
  - Oracle, MySQL, SQLite, Frontier
  - Access to SQL from C++ via the CORAL libraries

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COOL data model

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- **Modeling of conditions data objects**
  - System-managed common **"metadata"**
    - Data items: many tables, each with many channels
    - *Interval of validity* - "IOV" [since, until]
    - *Versioning information* - with handling of interval overlaps
  - User-defined schema for **"data payload"**
    - Support for fields of simple C++ types
- ***Main use case: event reconstruction***
  - *Lookup data payload valid at a given event time*

objectID	channelID	since	until	pressure	temperature

Metadata
System-controlled
(versioning metadata not shown)

Data payload
User-defined schema
(different tables for different schemas)

COOL collaborators

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Core development team

- **Andrea Valassi (CERN IT-DM)**
  - 80% FTE (core development, project coordination, release mgmt)
- **Marco Clemencic (CERN LHCb)**
  - 20% FTE (core development, release mgmt)
- **Sven A. Schmidt (Mainz ATLAS)**
  - 20% FTE (core development)
- **Martin Wache (Mainz ATLAS)**
  - 80% FTE (core development)
- **Romain Basset (CERN IT-DM)**
  - 50% FTE (performance optimization) + 50% FTE (scalability tests)
- On average, around 2 FTE in total for development since 2004

Collaboration with users and other projects

- *Richard Hawkings* and other *Atlas users and DBAs*
- *The CORAL, ROOT, SPI and 3D teams*

Former collaborators

- *G. Pucciani, D. Front, K. Dahl, U. Moosbrugger*

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Outline *(DB WS July talk)*

- **COOL basics (only what is needed to understand the rest…)**
  - Data model basics
  - Use case for this talk: MV tags (relational schema and SQL query)
  - Performance plots (how we define 'good' performance)

- **Oracle performance optimization strategy**
  - Basic SQL optimization (fix indexes and joins)
  - Execution plan instabilities (same SQL, different plans)
    - Observe (causes: unreliable statistics, bind variable peeking)
    - Analyze (**10053 trace files** and the BEGIN_OUTLINE block)
    - Fix (rewrite queries to please the Optimizer; then add **hints**)

COOL – basics

- **Conditions data**
  - *Detector data that vary in time and may be versioned*
  - Several use cases (different schemas and SQL queries to optimize)
    - Temperatures, voltages (measured – single version, SV)
    - Calibration, alignment (computed – multiple versions, MV)

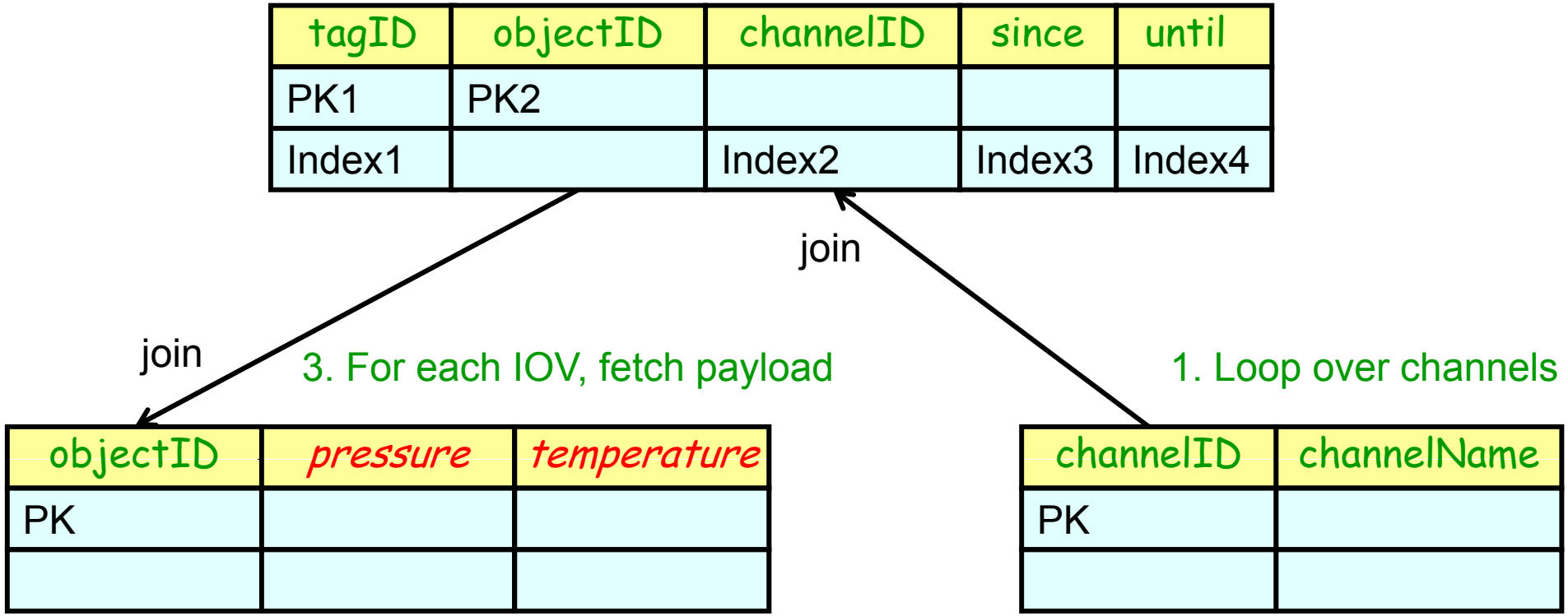
- **COOL conditions objects ("IOV"s – interval of validity)**
  - Metadata: channel (c), IOV (t_{since} ,t_{until}), version or tag (v)
  - Data: user-defined "payload" (x1,x2,…)
  - *Typical query: retrieve the condition data payload X that was valid at time T in channel C for tag V*

- **COOL relational implementation (based on CORAL)**
  - Several backends (Oracle, MySQL…); C++ only (no PL/SQL)

Test case: MV tag retrieval

Query: fetch all IOVs in [T1,T2] in tag PROD in all channels

2. For each channel C, select IOVs in tag PROD in [T1, T2]
(this is a *very large table* – and the most delicate part of the query to optimize)

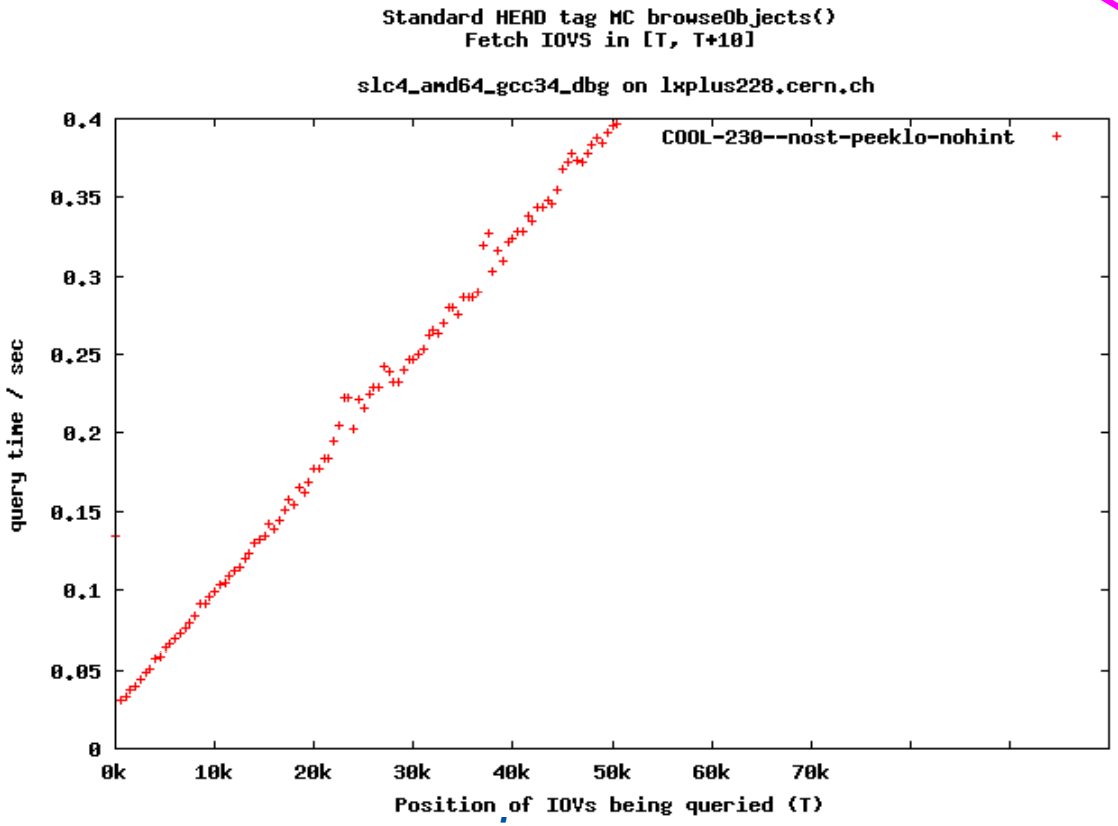


Measuring performance

Is query time the same for all values of parameters T1, T2?

- *It was not in the initial COOL releases (≤ COOL 2.3.0)*
  - *Query time is higher for more recent IOVs than for older IOVs*

"tagId=PROD AND chId=C AND ((since ≤ T1< until) OR (T1 < since ≤ T2))"

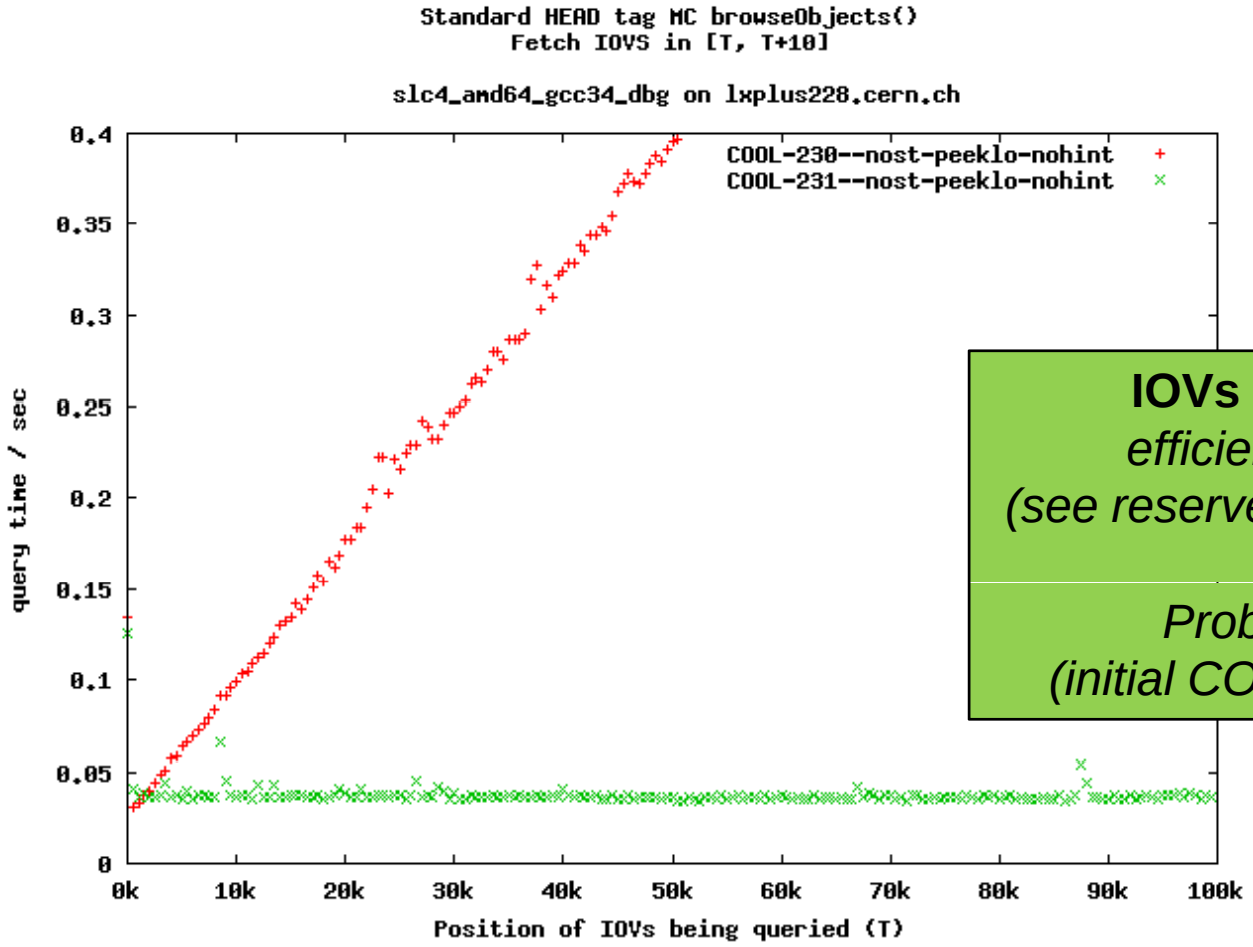


IOVs valid at t=T1 :
inefficient use of index for query on two columns since and until
(scan all IOVs with since ≤ T1, query time increases for high T1)

Basic optimization: better SQL

In tag PROD, in each channel at most one IOV is valid at T1

- Build a better SQL strategy from this constraint (unknown to Oracle)
  - The constraint is enforced in the C++ code, not in the database



IOVs valid at t=T1 :
efficient use of index
(see reserve slides for details...)

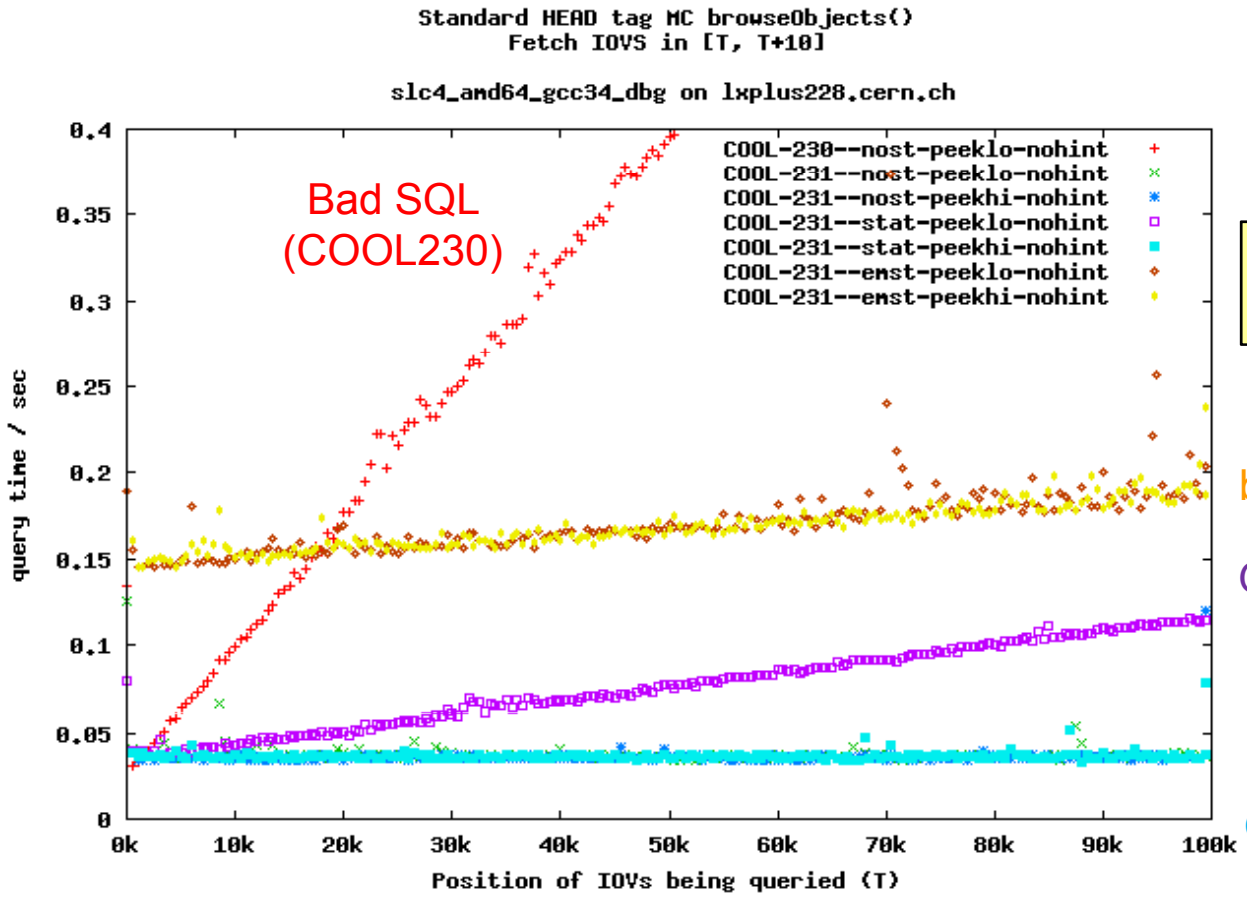
Problem fixed (?)
(initial COOL231 candidate)

Execution plan instabilities

- **So, we thought the job was done...**
  - Query time used to increase, we managed to make it flat
- **But... every now and then our tests or our users reported performance issues again (...?...)**
  - Example: different performance in ATLAS tests at CNAF and LYON
- **Symptoms: same SQL, different execution plan**
  - In time, we identified two possible causes for this:
    - *Bind variable peeking*
      - *Optimal exec plan for finding old IOVs and recent IOVs are different*
      - *Problem if optimal plan for old IOVs is used for finding recent IOVs*
    - *Missing or unreliable statistics*
      - *Optimal exec plan is computed starting from wrong assumptions*

Execution plan instabilities: plots

- **Systematic study of 6 (2x3) cases**
  - 2 cases for b.v. peeking: peek "low" (old IOVs) or "high" (recent IOVs)
  - 3 cases for statistics: none, full, unreliable (empty tables)



Same 'good' SQL (COOL231), three different exec plans!

Good SQL (COOL231), bad stats (empty tables).

Good SQL (COOL231) and stats, peek 'low' (bad plan for 'high').

Good SQL (COOL231) and stats, peek 'high' (plan OK for all).
Good SQL (COOL231), NO stats.

Analyze plans: 10053 trace

- **Look at the plan that was used for *your* query execution**
  - More reliable than 'explain plan', 'set autotrace' and other methods...
- **Look at how and why the Optimizer chose this plan**
  - Bind variable values
  - Alternative plans attempted
  - *Were user-supplied hints understood and used?*
    - *The "Dumping Hints" section at the end*
- **Look at the Optimizer's outline for the chosen plan**
  - *Get inspiration from the outline to prepare your user-supplied hints*
    - *The "BEGIN_OUTLINE_DATA" section towards the end*

Stabilize plans – add hints

- **This is an iterative process! In summary:**
  - 1. Execute your query for many cases (peek high/low...)
  - 2. Get plan and outline for a case with good performance
    - You want your plan to look like this in the end for *all* cases
  - 3. Do you need some query rewrite?
    - Are query blocks not named? Add QB_NAME and go to 1.
    - Is Oracle rewriting your query? Change SQL and go to 1.
    - Is Oracle using a different join order? Change SQL and go to 1.
  - 4. Is there a case with bad performance? Get its outline.
    - What is different in 'good' outline? Add as a hint and go to 1.
    - Was your hint not used or not useful? Try another and go to 1.
  - 5. Do all cases have good performance? You made it!

10053 technicalities

- ***Generate a 10053 trace file 'myfile.trc'***
  - From SQL*Plus
    - ALTER SESSION SET EVENTS
      '10053 TRACE NAME CONTEXT FOREVER, LEVEL 1';
    - ALTER SESSION SET tracefile_identifier='myfile'
  - From CORAL:
    - **export CORAL_ORA_SQL_TRACE_ON="10053"**
    - **export CORAL_ORA_SQL_TRACE_IDENTIFIER="myfile"**

- **Retrieve the trace file**
  - Ask your friendly DBA to get it from the server's udump...
  - *But please avoid generating (and asking for) trace files unless you need them... ;-)*

10053 – exec plan flush

- **You should invalidate existing exec plans between tests**
  - To remove the effect of bind variable peeking (e.g. when testing the effect of different bind variable values)
  - To make sure that execution plans are recomputed and ORA-10053 trace files are as complete as possible

- **To invalidate existing execution plans you may:**
  - Flush the shared pool (DBA only – affects the whole DB)
  - Simpler hack: alter a relevant table in a dummy way
    - e.g. **"ALTER TABLE mytable LOGGING;"**

Query rewrite – are *you* in control?

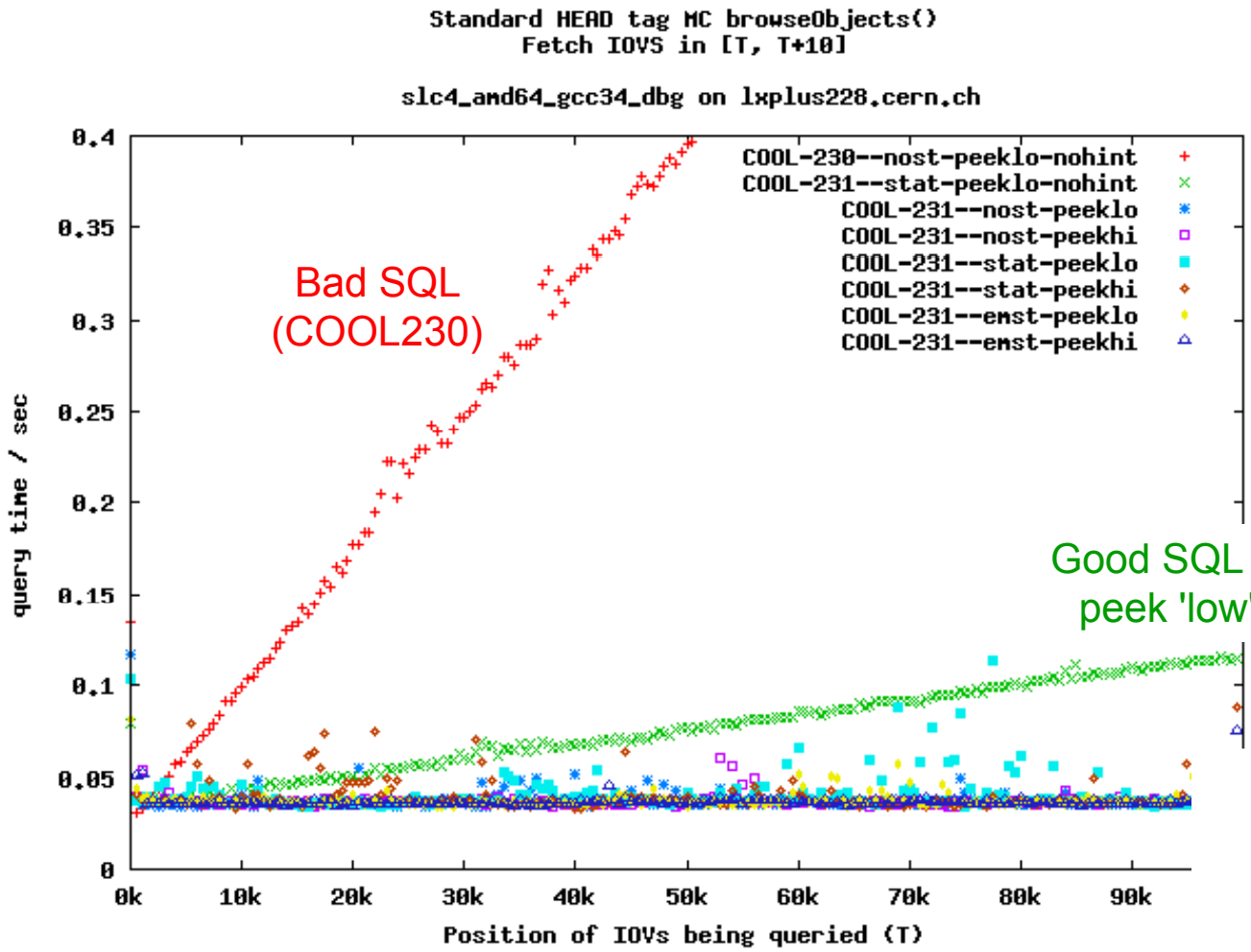
- **Master your query blocks**
  - *Name your query blocks – syntax is "/*+ QB_NAME(xxx) */"*
    - Else the Optimizer will name them for you (e.g. "SEL$1")
  - *The Optimizer rewrites your query blocks? Do it yourself!*
    - Symptoms: query block names like "SEL$3F979EFD", keywords like "MERGE" (remove inline views) or "CONCAT" (expand as union all)
    - Solution: do what the Optimizer would do (e.g. remove MERGE by expanding subqueries in WHERE clause into normal joins)

- **Master the order of your joins**
  - *The Optimizer reorders your joins? Do it yourself!*
    - Copy the Optimizer's favorite order from the "LEADING" keyword

Stabilized plan – results

Default hints added in COOL 2.3.1 release

– *Stable good plans in all 6 cases (2 bind var peeking x 3 statistics)*



Good SQL (COOL231) and stats, peek 'low' (bad plan for 'high').

Good SQL (COOL231), good/missing/bad stats, peek 'low' or ‘high’

Optimal query and hints

```
CORAL/RelationalPlugins/oracle    Debug Prepared statement : "SELECT /*+ QB_NAME
(MAIN) INDEX_RS_ASC(@MAIN COOL_I3@MAIN (TAG_ID "CHANNEL_ID" IOV_SINCE IOV_UNTIL)
) INDEX_RS_ASC(@MAIN COOL_I4@MAIN (OBJECT_ID)) LEADING(@MAIN COOL_C2@MAIN COOL_I
3@MAIN COOL_I4@MAIN) USE_NL(@MAIN COOL_I3@MAIN) USE_NL(@MAIN COOL_I4@MAIN) INDEX
(@MAX1 COOL_I1@MAX1 (TAG_ID "CHANNEL_ID" IOV_SINCE IOV_UNTIL))  */ COOL_I4."OBJE
CT_ID", COOL_I4."CHANNEL_ID", COOL_I4."IOV_SINCE", COOL_I4."IOV_UNTIL", COOL_I4.
"USER_TAG_ID", COOL_I4."SYS_INSTIME", COOL_I4."LASTMOD_DATE", COOL_I4."ORIGINAL_
ID", COOL_I4."NEW_HEAD_ID", COOL_I4."I" FROM LCG_COOL."S5820231_F0001_CHANNELS"
COOL_C2, LCG_COOL."S5820231_F0001_IOV2TAG" COOL_I3, LCG_COOL."S5820231_F0001_IOV
S" COOL_I4 WHERE COOL_I3."TAG_ID"=:"tagid3" AND COOL_I3."CHANNEL_ID"=COOL_C2."CH
ANNEL_ID" AND COOL_I3."IOV_SINCE">=COALESCE(( SELECT /*+ QB_NAME(MAX1)  */ MAX(C
OOL_I1."IOV_SINCE") FROM LCG_COOL.S5820231_F0001_IOV2TAG COOL_I1 WHERE COOL_I1."
TAG_ID"=:"tagid1" AND COOL_I1."CHANNEL_ID"=COOL_C2."CHANNEL_ID" AND COOL_I1."IOV
_SINCE"<=:"since1" ),:"sinc3s") AND COOL_I3."IOV_SINCE"<=:"until3" AND COOL_I3."
IOV_UNTIL">:"sinc3u" AND COOL_I4."OBJECT_ID"=COOL_I3."OBJECT_ID" ORDER BY COOL_I
3."CHANNEL_ID" ASC, COOL_I3."IOV_SINCE" ASC"
```

Good plan with hints (peek low)

```
| Id  | Operation                          | Name                          |
| 0   | SELECT STATEMENT                   |                               |
| 1   |  SORT ORDER BY                     |                               |
| 2   |   NESTED LOOPS                     |                               |
| 3   |    NESTED LOOPS                    |                               |
| 4   |     INDEX FULL SCAN                | S5820231_F0001_CHANNELS_PK    |
| 5   |     SORT AGGREGATE                 |                               |
| 6   |      FIRST ROW                     |                               |
| 7   |       INDEX RANGE SCAN (MIN/MAX)   | S5820231_F0001_IOV2TAG_4INDX  |
| 8   |    TABLE ACCESS BY INDEX ROWID     | S5820231_F0001_IOV2TAG        |
| 9   |     INDEX RANGE SCAN               | S5820231_F0001_IOV2TAG_4INDX  |
| 10  |      SORT AGGREGATE                |                               |
| 11  |       FIRST ROW                    |                               |
| 12  |        INDEX RANGE SCAN (MIN/MAX)  | S5820231_F0001_IOV2TAG_4INDX  |
| 13  |   TABLE ACCESS BY INDEX ROWID      | S5820231_F0001_IOVS           |
| 14  |    INDEX UNIQUE SCAN               | S5820231_F0001_IOVS_PK        |
```

Bad plan (peek low)

```
| Id  | Operation                          | Name                          |
| 0   | SELECT STATEMENT                   |                               |
| 1   |  NESTED LOOPS                      |                               |
| 2   |   NESTED LOOPS                     |                               |
| 3   |    TABLE ACCESS BY INDEX ROWID     | S5820231_F0001_IOV2TAG        |
| 4   |     INDEX SKIP SCAN                | S5820231_F0001_IOV2TAG_4INDX  |
| 5   |    INDEX UNIQUE SCAN               | S5820231_F0001_CHANNELS_PK    |
| 6   |     SORT AGGREGATE                 |                               |
| 7   |      FIRST ROW                     |                               |
| 8   |       INDEX RANGE SCAN (MIN/MAX)   | S5820231_F0001_IOV2TAG_4INDX  |
| 9   |   TABLE ACCESS BY INDEX ROWID      | S5820231_F0001_IOVS           |
| 10  |    INDEX UNIQUE SCAN               | S5820231_F0001_IOVS_PK        |
```

Good plan with hints (peek low)

```
  /*+
    BEGIN_OUTLINE_DATA
      IGNORE_OPTIM_EMBEDDED_HINTS
      OPTIMIZER_FEATURES_ENABLE('10.2.0.4')
      ALL_ROWS
      OUTLINE_LEAF(@"MAX1")
      OUTLINE_LEAF(@"MAIN")
      OUTLINE(@"MAX1")
      OUTLINE(@"MAIN")
      INDEX(@"MAIN" "COOL_C2"@"MAIN" ("S5820231_F0001_CHANNELS"."CHANNEL_ID"))
      INDEX_RS_ASC(@"MAIN" "COOL_I3"@"MAIN" ("S5820231_F0001_IOV2TAG"."TAG_ID" "S5
820231_F0001_IOV2TAG"."CHANNEL_ID" "S5820231_F0001_IOV2TAG"."IOV_SINCE" "S582023
1_F0001_IOV2TAG"."IOV_UNTIL"))
      INDEX_RS_ASC(@"MAIN" "COOL_I4"@"MAIN" ("S5820231_F0001_IOVS"."OBJECT_ID"))
      LEADING(@"MAIN" "COOL_C2"@"MAIN" "COOL_I3"@"MAIN" "COOL_I4"@"MAIN")
      USE_NL(@"MAIN" "COOL_I3"@"MAIN")
      USE_NL(@"MAIN" "COOL_I4"@"MAIN")
      INDEX(@"MAX1" "COOL_I1"@"MAX1" ("S5820231_F0001_IOV2TAG"."TAG_ID" "S5820231
_F0001_IOV2TAG"."CHANNEL_ID" "S5820231_F0001_IOV2TAG"."IOV_SINCE" "S5820231_F0001
_IOV2TAG"."IOV_UNTIL"))
    END_OUTLINE_DATA
  */
```

Bad plan (peek low)

```
  /*+
    BEGIN_OUTLINE_DATA
      IGNORE_OPTIM_EMBEDDED_HINTS
      OPTIMIZER_FEATURES_ENABLE('10.2.0.4')
      ALL_ROWS
      OUTLINE_LEAF(@"MAX1")
      OUTLINE_LEAF(@"MAIN")
      OUTLINE(@"MAX1")
      OUTLINE(@"MAIN")
      INDEX_SS(@"MAIN" "COOL_I3"@"MAIN" ("S5820231_F0001_IOV2TAG"."TAG_ID" "S5820
231_F0001_IOV2TAG"."CHANNEL_ID" "S5820231_F0001_IOV2TAG"."IOV_SINCE" "S5820231_F0
001_IOV2TAG"."IOV_UNTIL"))
      INDEX(@"MAIN" "COOL_C2"@"MAIN" ("S5820231_F0001_CHANNELS"."CHANNEL_ID"))
      INDEX_RS_ASC(@"MAIN" "COOL_I4"@"MAIN" ("S5820231_F0001_IOVS"."OBJECT_ID"))
      LEADING(@"MAIN" "COOL_I3"@"MAIN" "COOL_C2"@"MAIN" "COOL_I4"@"MAIN")
      USE_NL(@"MAIN" "COOL_C2"@"MAIN")
      USE_NL(@"MAIN" "COOL_I4"@"MAIN")
      INDEX(@"MAX1" "COOL_I1"@"MAX1" ("S5820231_F0001_IOV2TAG"."TAG_ID" "S5820231
_F0001_IOV2TAG"."CHANNEL_ID" "S5820231_F0001_IOV2TAG"."IOV_SINCE" "S5820231_F0001
_IOV2TAG"."IOV_UNTIL"))
    END_OUTLINE_DATA
  */
```

```
Dumping Hints
=============
  atom_hint=(@=0xb7185dd4 err=0 resol=1 used=0 token=1123 org=1 lvl=3 txt=INDEX_RS_ASC ("COOL_I3" "S5820231_F0001_IOV2TAG_4INDX") )
  atom_hint=(@=0xb7185bc0 err=0 resol=1 used=0 token=1123 org=1 lvl=3 txt=INDEX_RS_ASC ("COOL_I4" "S5820231_F0001_IOVS_PK") )
  atom_hint=(@=0xb71859e4 err=0 resol=1 used=0 token=501 org=1 lvl=4 txt=LEADING ("COOL_C2" "COOL_I3" "COOL_I4") )
  atom_hint=(@=0xb7185820 err=0 resol=1 used=0 token=924 org=1 lvl=3 txt=USE_NL ("COOL_I3") )
  atom_hint=(@=0xb7187748 err=0 resol=1 used=0 token=924 org=1 lvl=3 txt=USE_NL ("COOL_I4") )
  atom_hint=(@=0xb7185540 err=0 resol=1 used=0 token=83 org=1 lvl=3 txt=INDEX ("COOL_I1" "S5820231_F0001_IOV2TAG_4INDX") )
  atom_hint=(@=0xb71860c8 err=0 resol=1 used=1 token=1003 org=1 lvl=2 txt=QB_NAME ("MAIN") )
  atom_hint=(@=0xb718461c err=0 resol=1 used=1 token=924 org=1 lvl=3 txt=USE_NL ("COOL_I4") )
  atom_hint=(@=0xb7180668 err=0 resol=1 used=1 token=1123 org=1 lvl=3 txt=INDEX_RS_ASC ("COOL_I4" "S5820231_F0001_IOVS_PK") )
  atom_hint=(@=0xb718057c err=0 resol=1 used=1 token=924 org=1 lvl=3 txt=USE_NL ("COOL_I3") )
  atom_hint=(@=0xb71807cc err=0 resol=1 used=1 token=1123 org=1 lvl=3 txt=INDEX_RS_ASC ("COOL_I3" "S5820231_F0001_IOV2TAG_4INDX") )
  atom_hint=(@=0xb71802b0 err=0 resol=1 used=1 token=501 org=1 lvl=4 txt=LEADING ("COOL_C2" "COOL_I3" "COOL_I4") )
  atom_hint=(@=0xb7183918 err=0 resol=1 used=1 token=1003 org=1 lvl=2 txt=QB_NAME ("MAX1") )
  atom_hint=(@=0xb7180380 err=0 resol=1 used=1 token=83 org=1 lvl=3 txt=INDEX ("COOL_I1" "S5820231_F0001_IOV2TAG_4INDX") )
```

Good plan with hints (peek low)

CORAL workarounds

- **No support for hints**
  - Implemented in COOL queries using SQL injection
    - Prepend the hint "/*+...*/" to the 1st item in the SELECT list
  - *This hack does not work for UPDATE, INSERT, DELETE*
  - CORAL support request sr #103420

- **No support for subqueries in WHERE clause**
  - Implemented in COOL queries using SQL injection
    - CORAL receives a WHERE clause that explicitly contains a fully qualified "(SELECT ... FROM ...) " subquery
    - COOL needs to know if it is talking to Oracle or MySQL (quotes)
  - CORAL support request sr #103547

Performance – in progress

- **Handle all use cases consistently in C++ code**
  - SV, MV tags (~CVS tags) or 'user tags' (~CVS branches)
  - *Goal: same performance optimization in all use cases*
    - Share a single C++ method to define the general SQL strategy (with internal switches for use-case-dependent SQL fragments)
    - So far each use case was optimized separately
- **Evaluate Oracle partitioning**
  - Goal: ease data management (long-term archiving)
    - Partitioned tables with partitioned (local) indexes
  - *Evaluate impact (benefits?) for performance too*
- **Performance for non-Oracle backends**
  - Using the same SQL is not always possible
    - MySQL performance is bad with subqueries
  - Lower priority