# Debugging the Postgres Planner

Melanie Plageman

# Goals & Agenda

- Demystify PostgreSQL planner
- Query optimization concepts
- Case study: adding a planner improvement

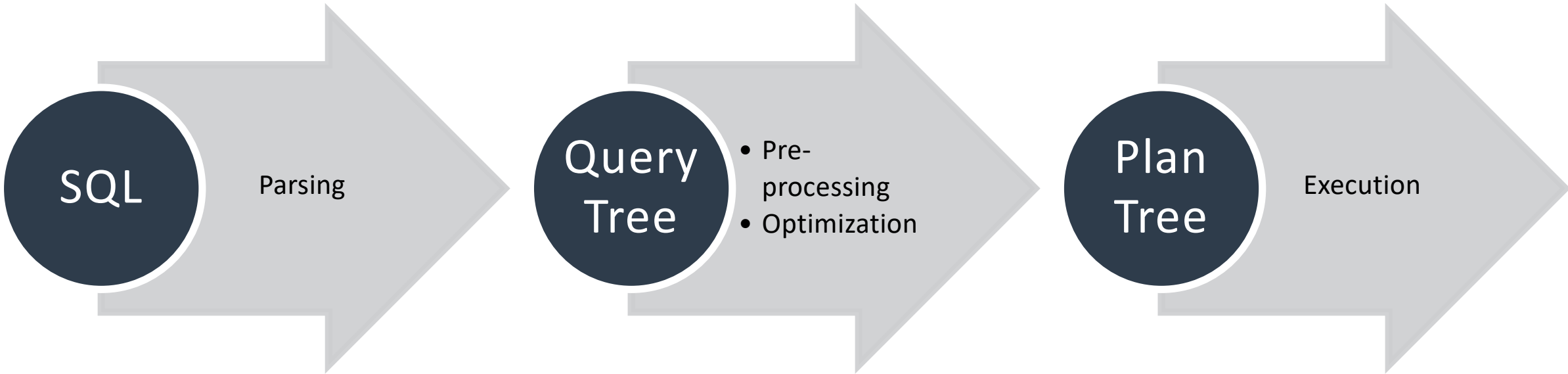
# Query Planning

SQL statement to plan tree

```
# SELECT a FROM foo;
```



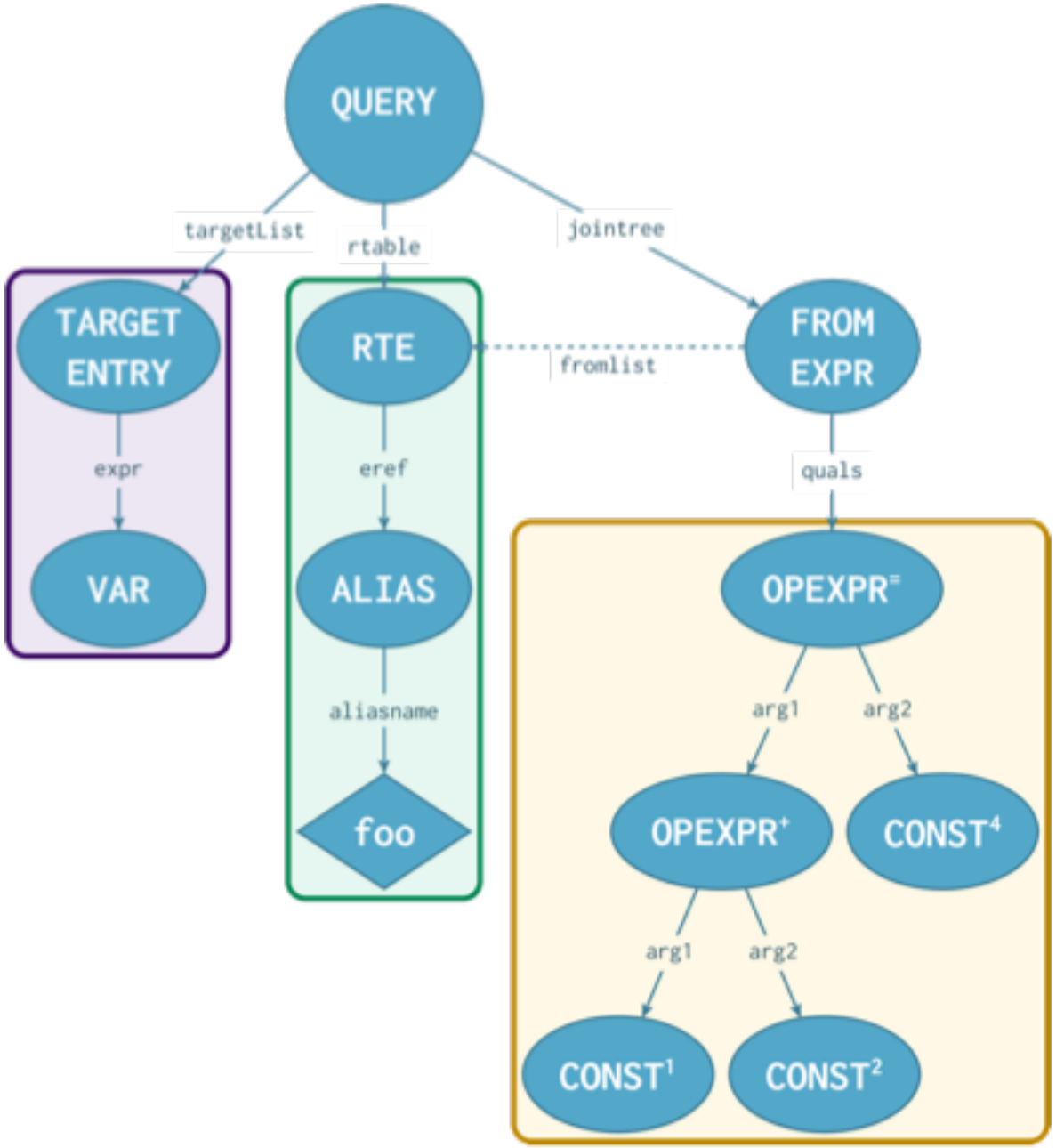
```
 a
---
 1
 2
 4
(3 rows)
```


SQL
Parsing
Query Tree
• Pre-processing
• Optimization
Plan Tree
Execution

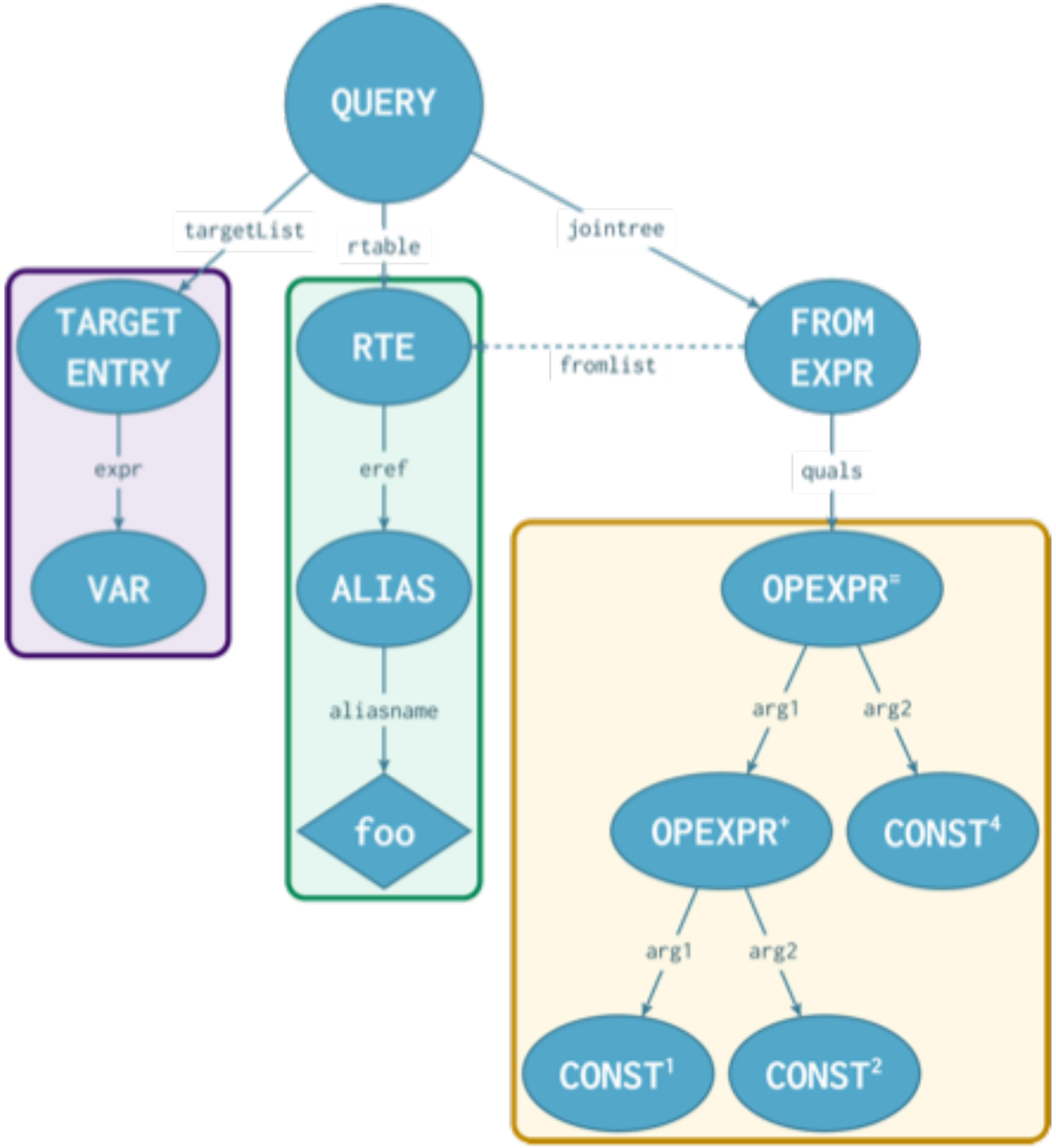
# Parsing

```
# SELECT a
  FROM foo
  WHERE 1 + 2 = 4;
```

```
{QUERY
   :rtable (
      {RTE
      :eref
         {ALIAS
         :aliasname foo
         :colnames ("a")
   :jointree
      {FROMEXPR
      :quals
         {OPEXPR
         :args (
            {OPEXPR
            :args (
               {CONST
               :constvalue 4 [ 1 0 0 0 0 0 0 0 ]
               {CONST
               :constvalue 4 [ 2 0 0 0 0 0 0 0 ]
            {CONST
            :constvalue 4 [ 4 0 0 0 0 0 0 0 ]
   :targetList (
      {TARGETENTRY
      :expr
         {VAR
      :resname a
```




```
{QUERY
   :rtable (
      {RTE
      :eref
         {ALIAS
         :aliasname foo
         :colnames ("a")
   :jointree
      {FROMEXPR
      :quals
         {OPEXPR
         :args (
            {OPEXPR
            :args (
               {CONST
               :constvalue 4 [ 1 0 0 0 0 0 0 0 ]
               {CONST
               :constvalue 4 [ 2 0 0 0 0 0 0 0 ]
            {CONST
            :constvalue 4 [ 4 0 0 0 0 0 0 0 ]
   :targetList (
      {TARGETENTRY
      :expr
         {VAR
      :resname a
```




```
# SELECT a
  FROM foo
  WHERE 1 + 2 = 4;
```

# Pre-processing

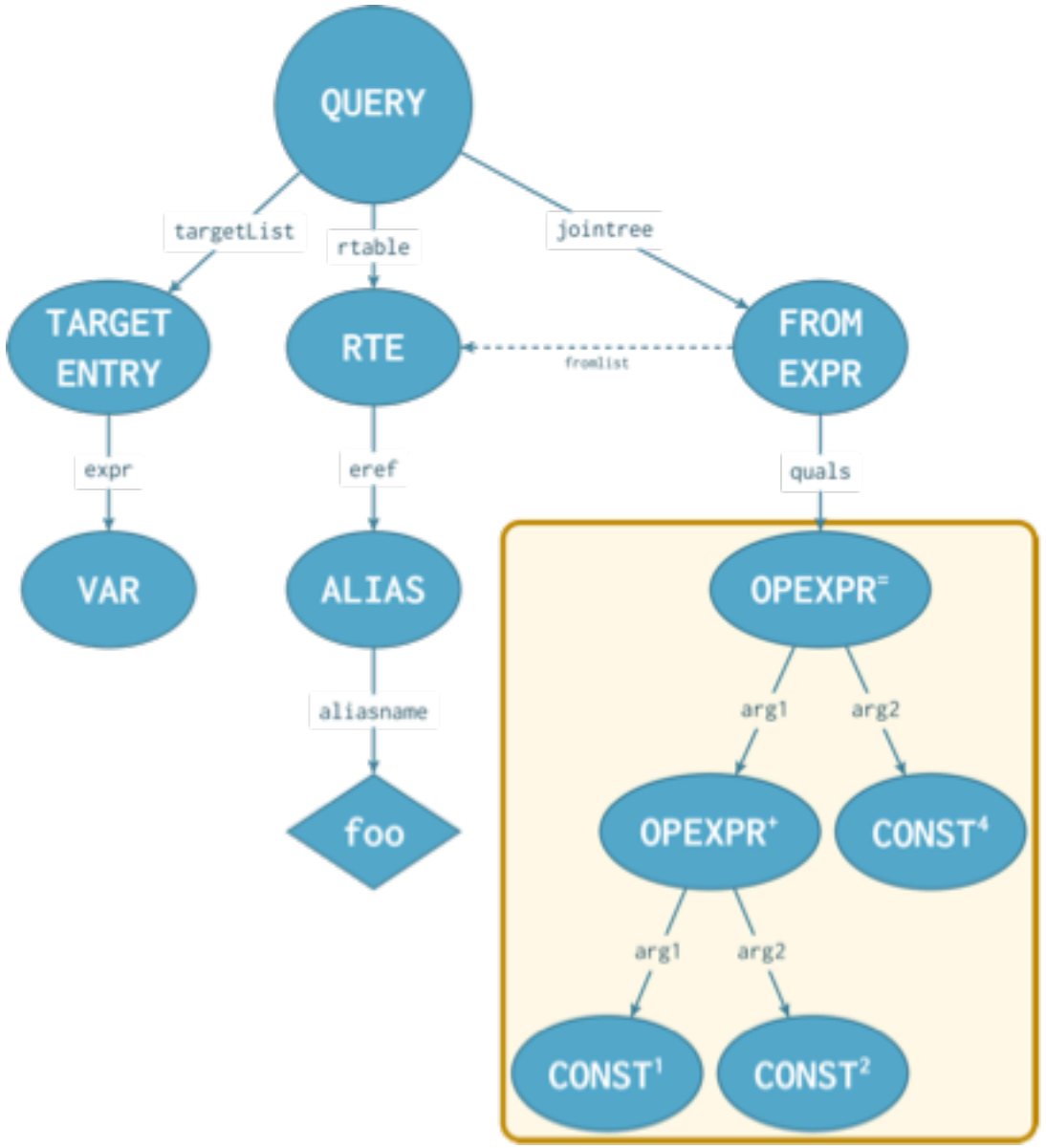
```
# SELECT a FROM foo WHERE 1 + 2 = 4;
```

```
1 + 2 = 4
```

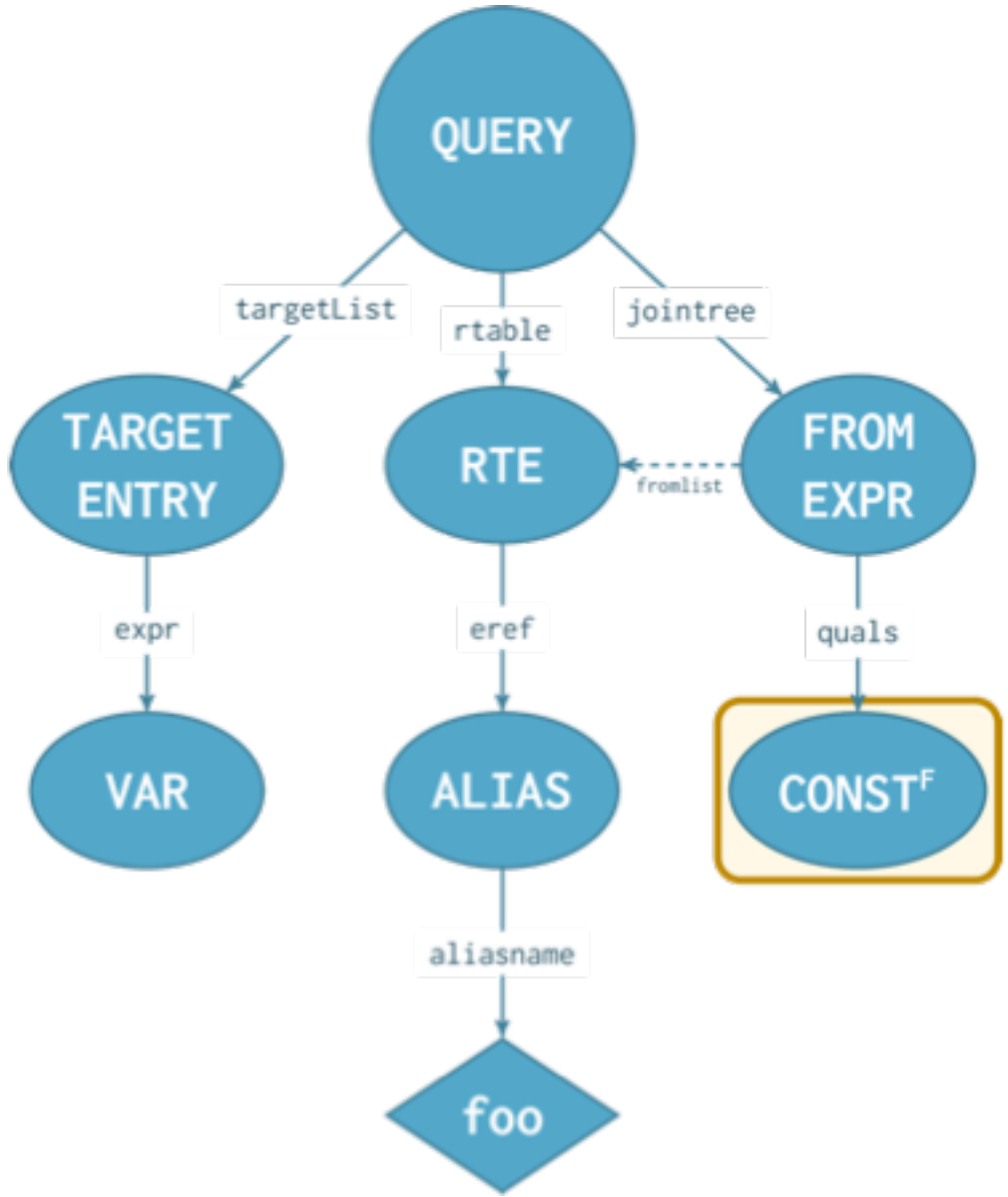
```
FALSE
```

```
# SELECT a FROM foo WHERE FALSE;
```

```
SELECT a FROM foo WHERE 1 + 2 = 4;
```

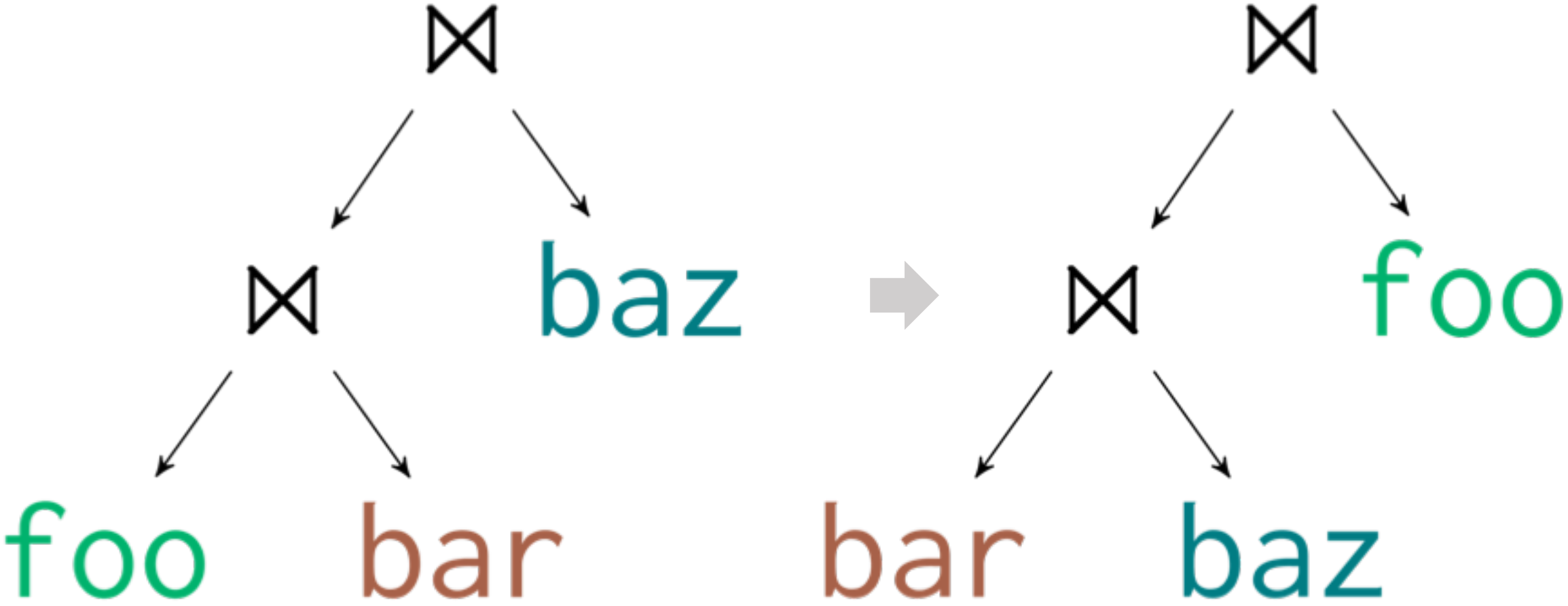



```
SELECT a FROM foo WHERE FALSE;
```

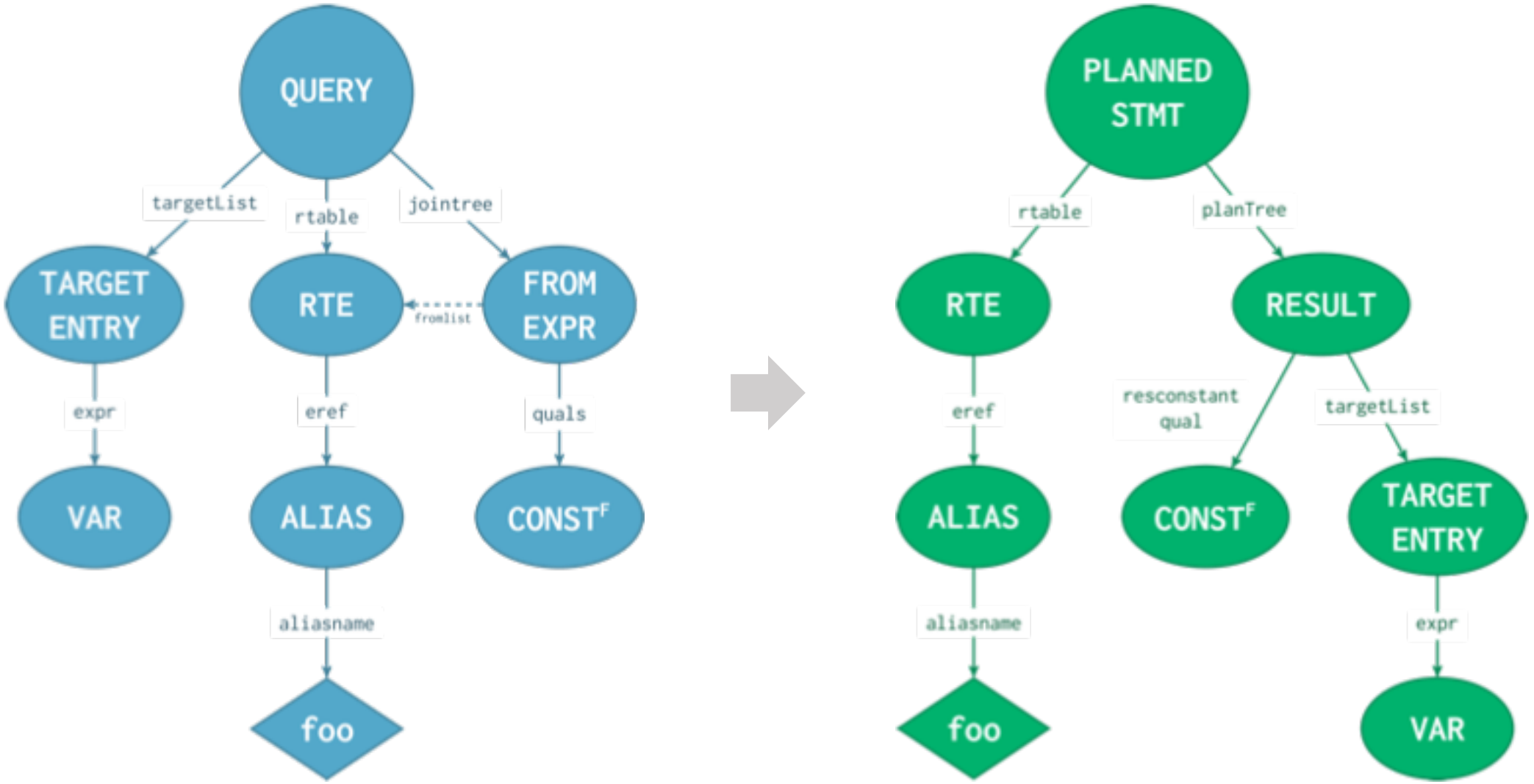


# Optimization

```
# SELECT a FROM foo ⋈ bar ⋈ baz;
```



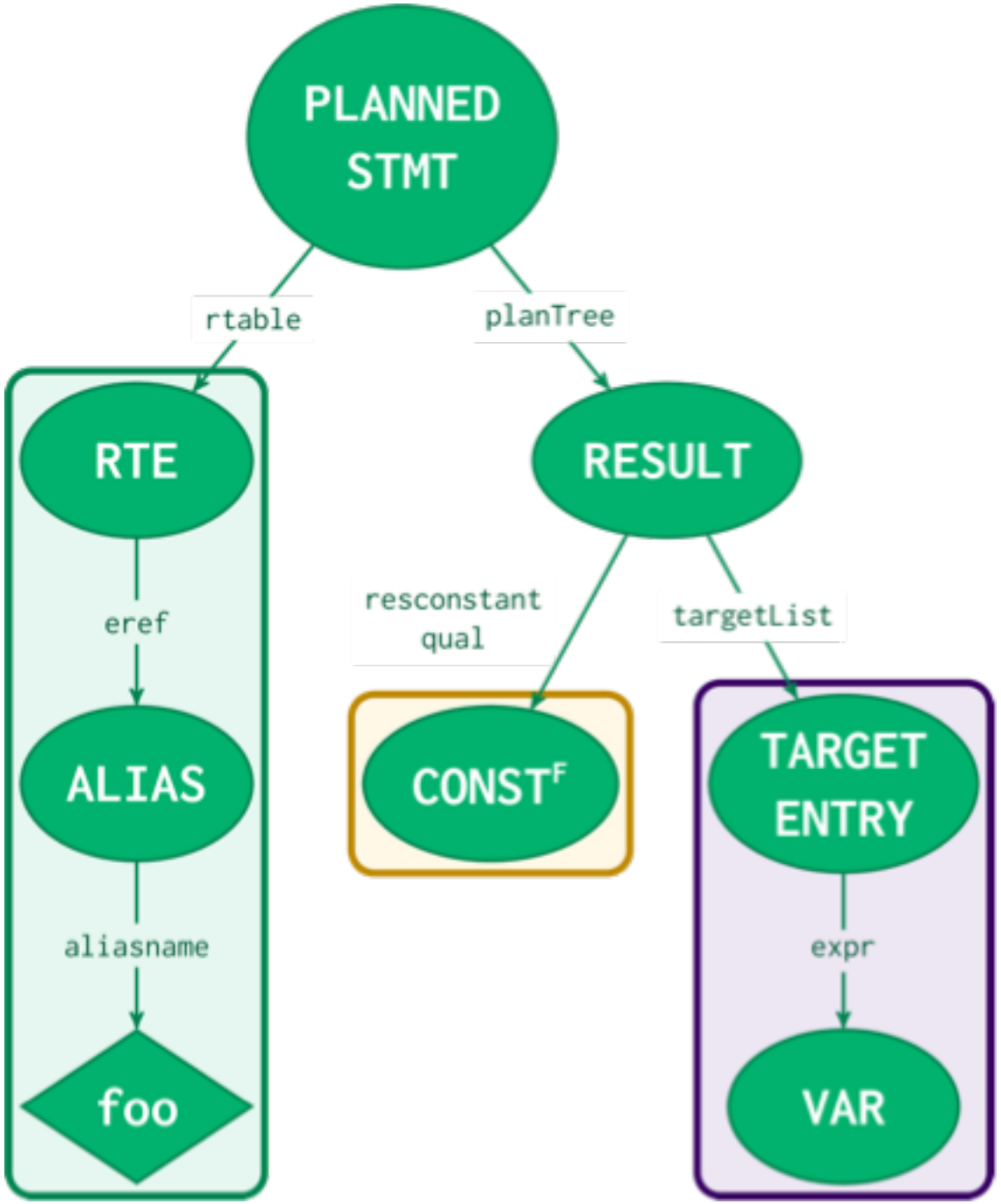
# SELECT a FROM foo WHERE FALSE;



# Plan Tree

```
# SELECT a
  FROM foo
  WHERE 1 + 2 = 4;
```

```
{PLANNEDSTMT
   :planTree
      {RESULT
      :targetlist (
         {TARGETENTRY
         :expr
            {VAR
         :resname a
      :resconstantqual (
         {CONST
         :constvalue 1 [ 0 0 0 0 0 0 0 0 ]
   :rtable (
      {RTE
      :eref
         {ALIAS
         :aliasname foo
         :colnames ("a")
```




```
{PLANNEDSTMT
   :planTree
      {RESULT
      :targetlist (
         {TARGETENTRY
         :expr
            {VAR
         :resname a
      :resconstantqual (
         {CONST
         :constvalue 1 [ 0 0 0 0 0 0 0 0 ]
   :rtable (
      {RTE
      :eref
         {ALIAS
         :aliasname foo
         :colnames ("a")
```

```
# EXPLAIN SELECT a FROM foo;
```

```
                        QUERY PLAN
-----------------------------------------------------------
Seq Scan on foo  (cost=0.00..1.03 rows=3 width=4)
```

```
# EXPLAIN SELECT a FROM foo WHERE a = 4;
```

```
                        QUERY PLAN
-----------------------------------------------------------
Seq Scan on foo  (cost=0.00..1.04 rows=1 width=4)
   Filter: (a = 4)
```

# Case Study

Adding a planner improvement

# Achieving Faster Execution

- Database tuning
- Change the query itself
- **Better plan**

Table "public.foo"

| Column | Type |
| --- | --- |
| a | integer |

Table "public.bar"

| Column | Type |
| --- | --- |
| b | integer |

```
# SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# EXPLAIN Output?

```
# EXPLAIN SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

```
                        QUERY PLAN
```

---

```
Result  (cost=… rows=0 width=…)
  One-Time Filter: (not true)
```

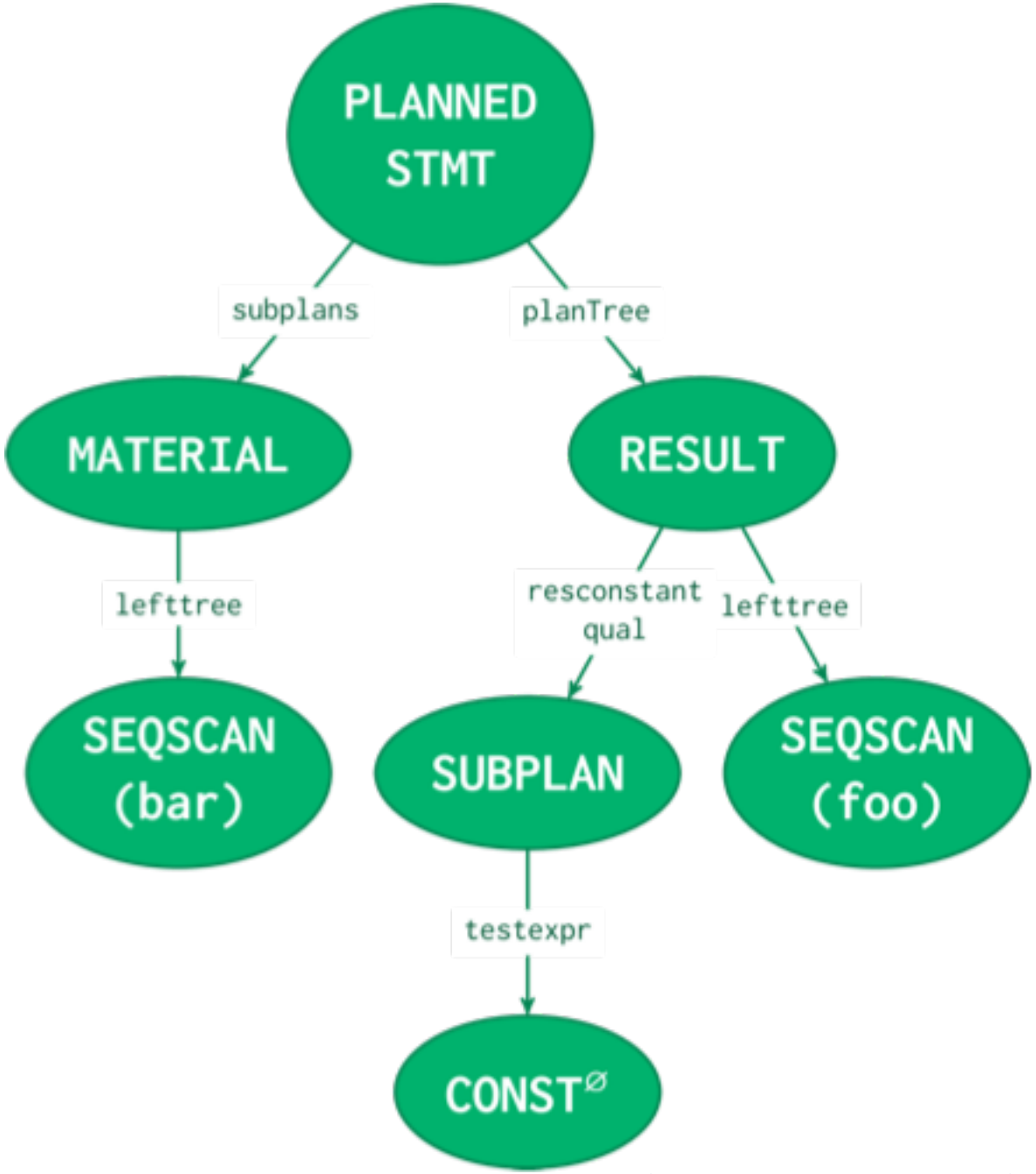
# EXPLAIN Output!

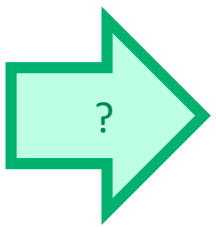
```
# EXPLAIN SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

```
                                QUERY PLAN
```

---

```
Result  (cost=… rows=3 width=…)
  One-Time Filter: (SubPlan 1)
  ->  Seq Scan on foo  (cost=… rows=3 width=…)
  SubPlan 1
    ->  Materialize  (cost=… rows=1000 width=…)
          ->  Seq Scan on bar  (cost=… rows=1000 width=…)
```



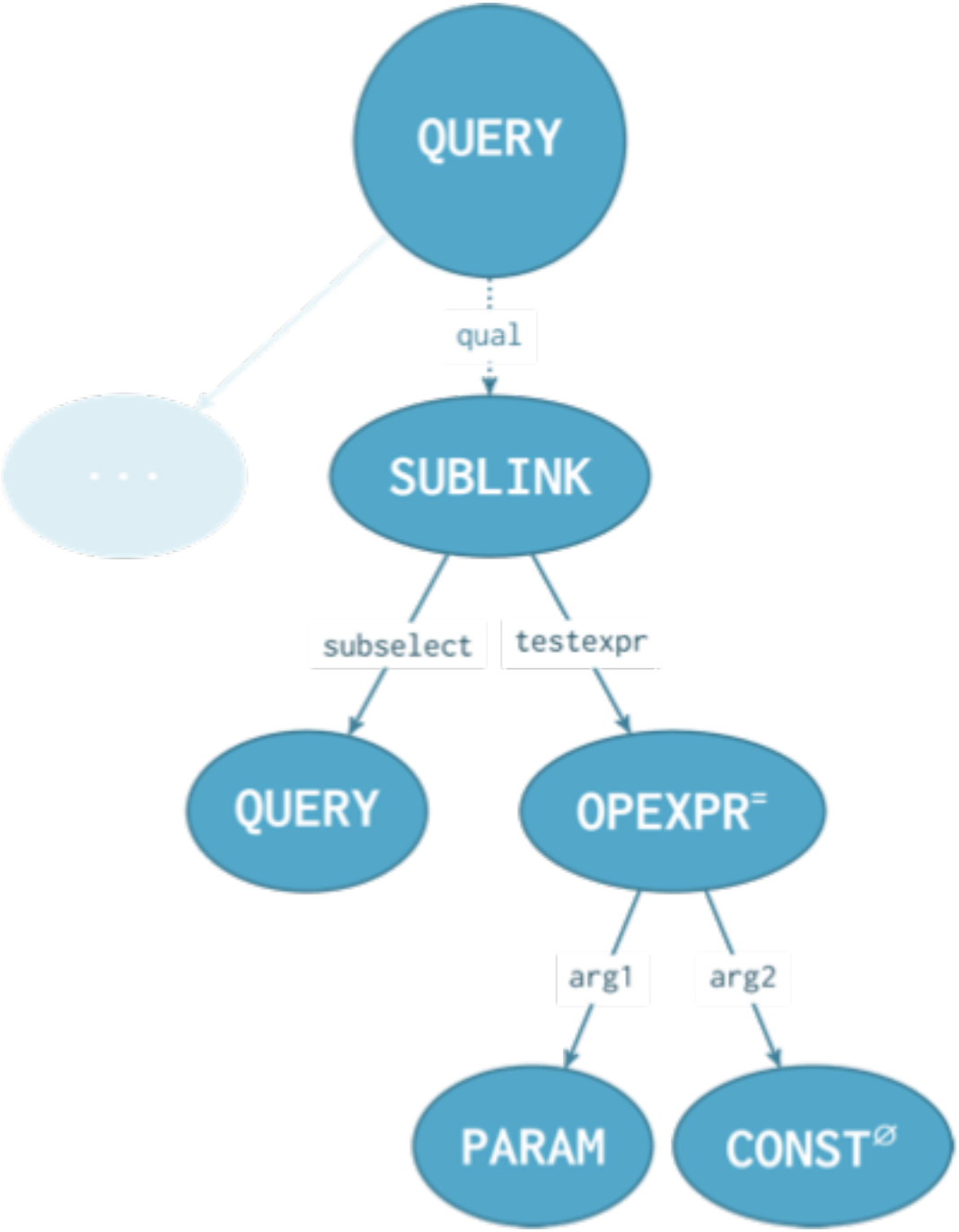





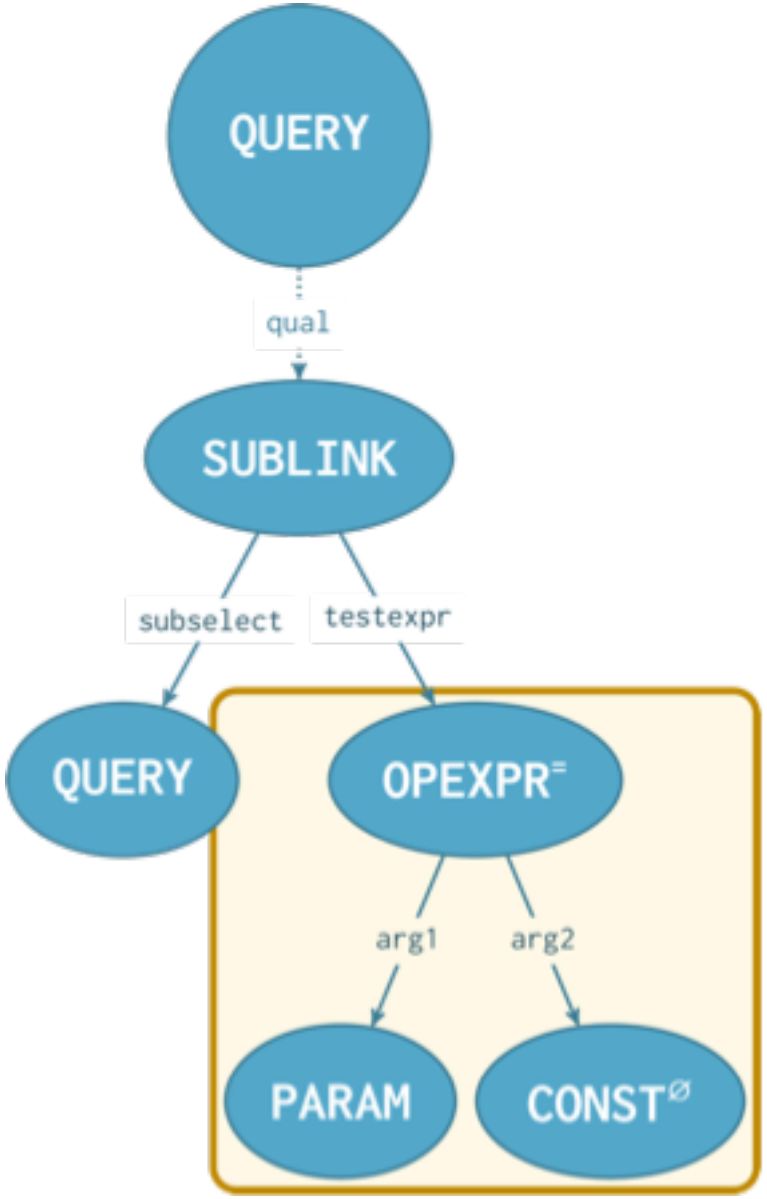
```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Parsing

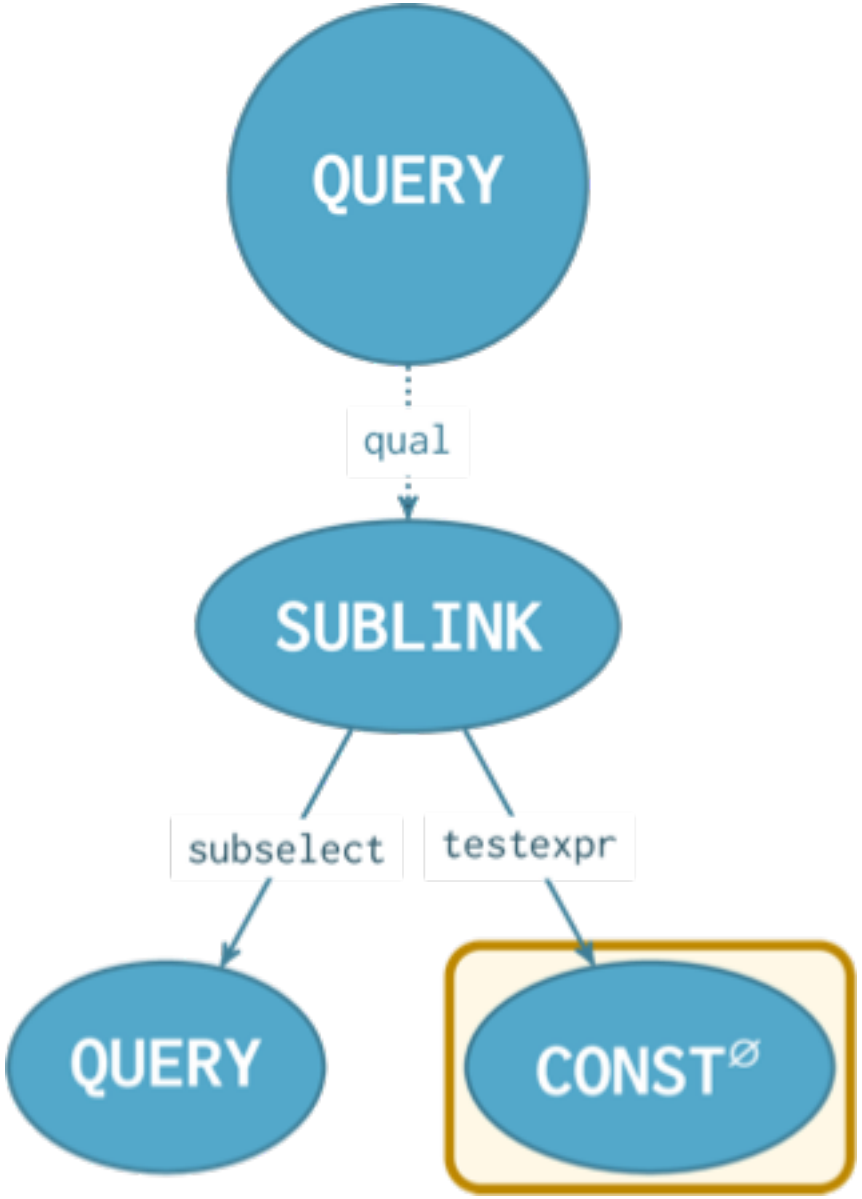
```
# SELECT a FROM foo
  WHERE NULL = ANY(
    SELECT b FROM bar
  );
```



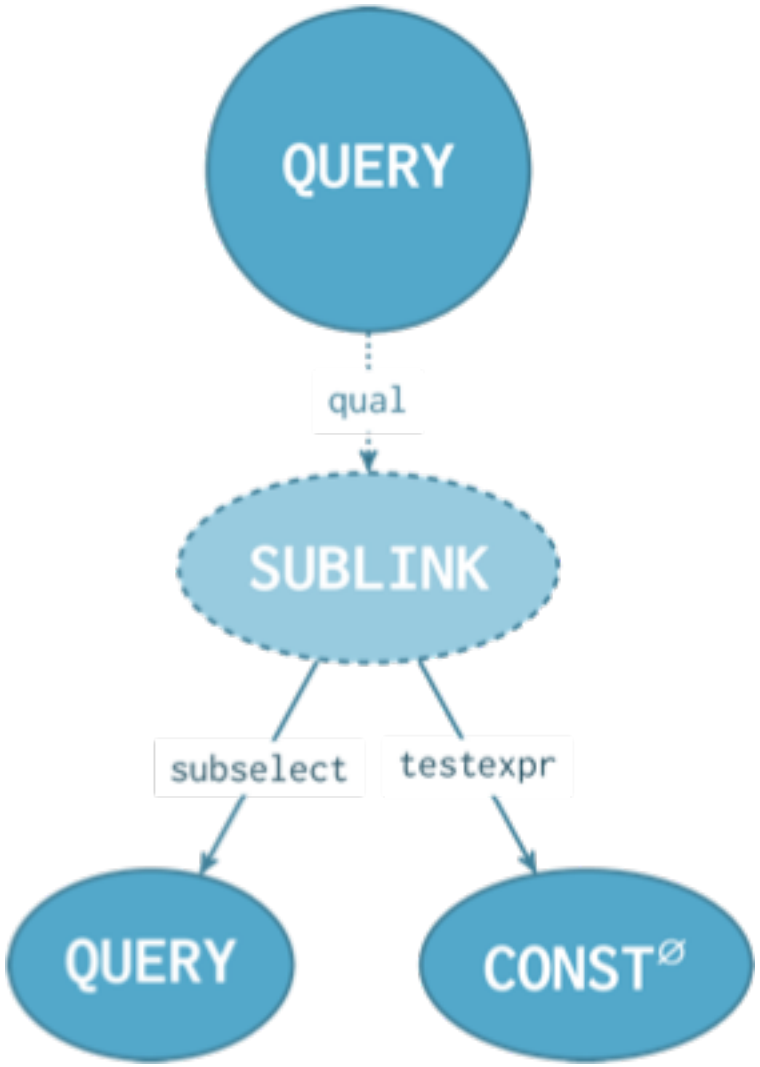
```
# SELECT a FROM foo WHERE
  NULL = ANY(SELECT b FROM bar);
```

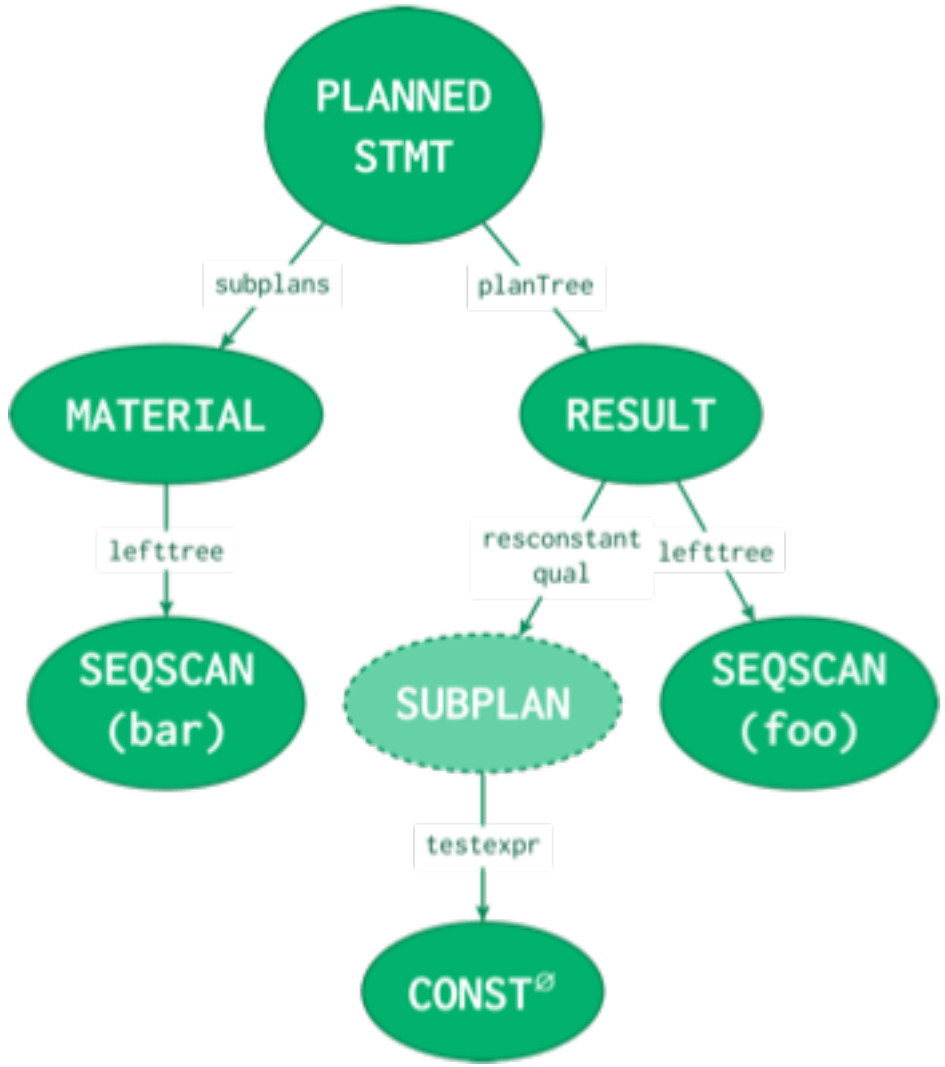



```
# SELECT a FROM foo WHERE
  (SELECT NULL FROM bar);
```

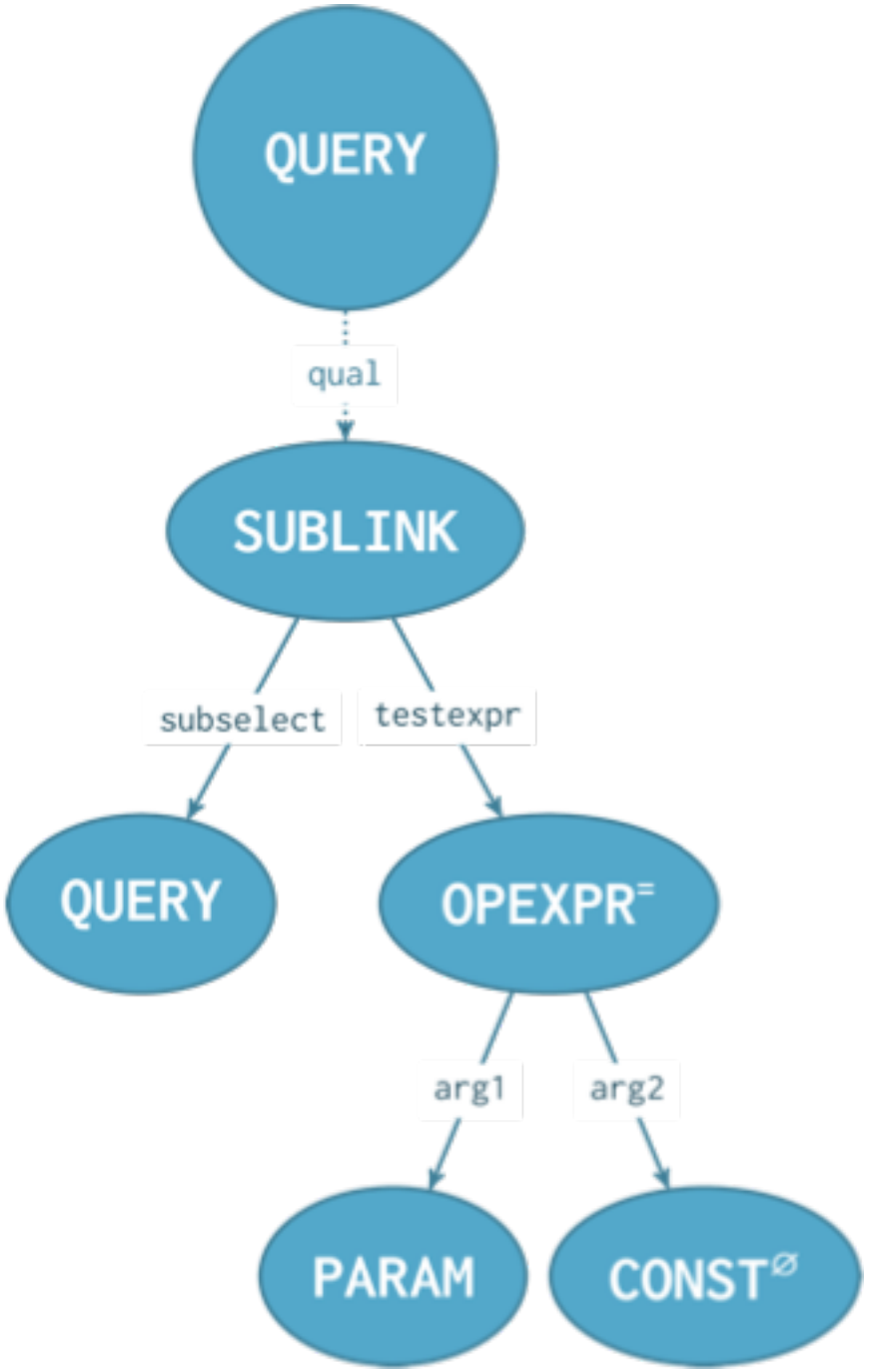


```
# SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

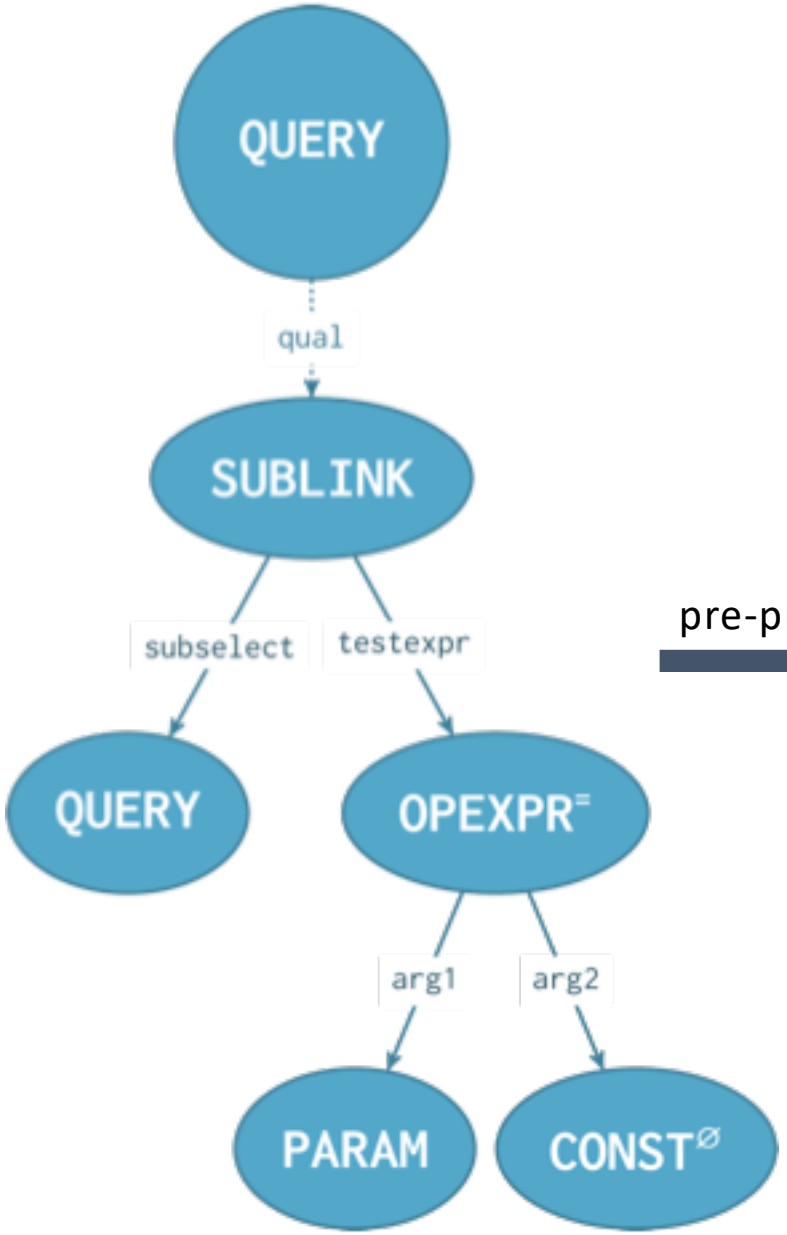


# Where should the change go?




```
# SELECT a FROM foo
  WHERE NULL = ANY(
    SELECT b FROM bar
  );
```




pre-process

?

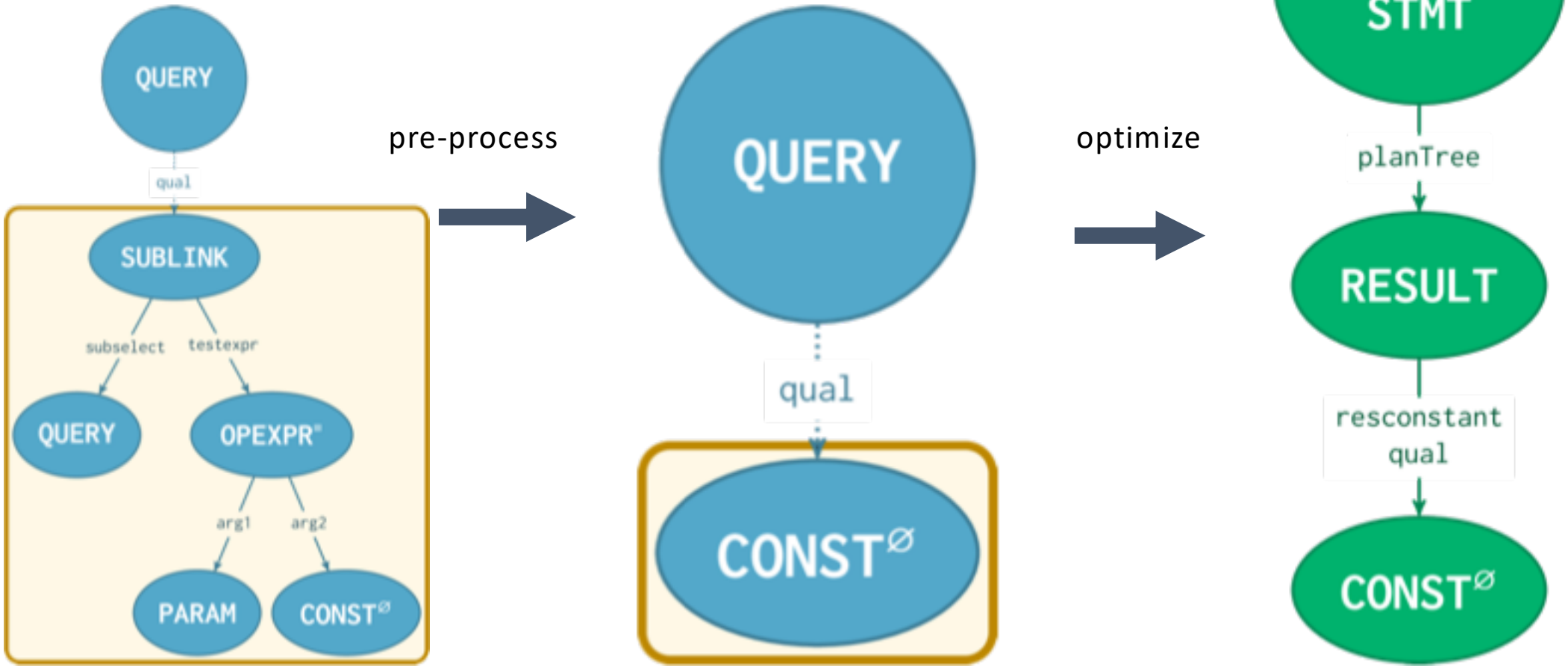
optimize


```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Proposed pre-processing transformation

```
# SELECT a FROM foo WHERE NULL
  = ANY(SELECT b FROM bar);
```

```
# SELECT a FROM foo WHERE NULL;
```



# Hacking Pre-processing

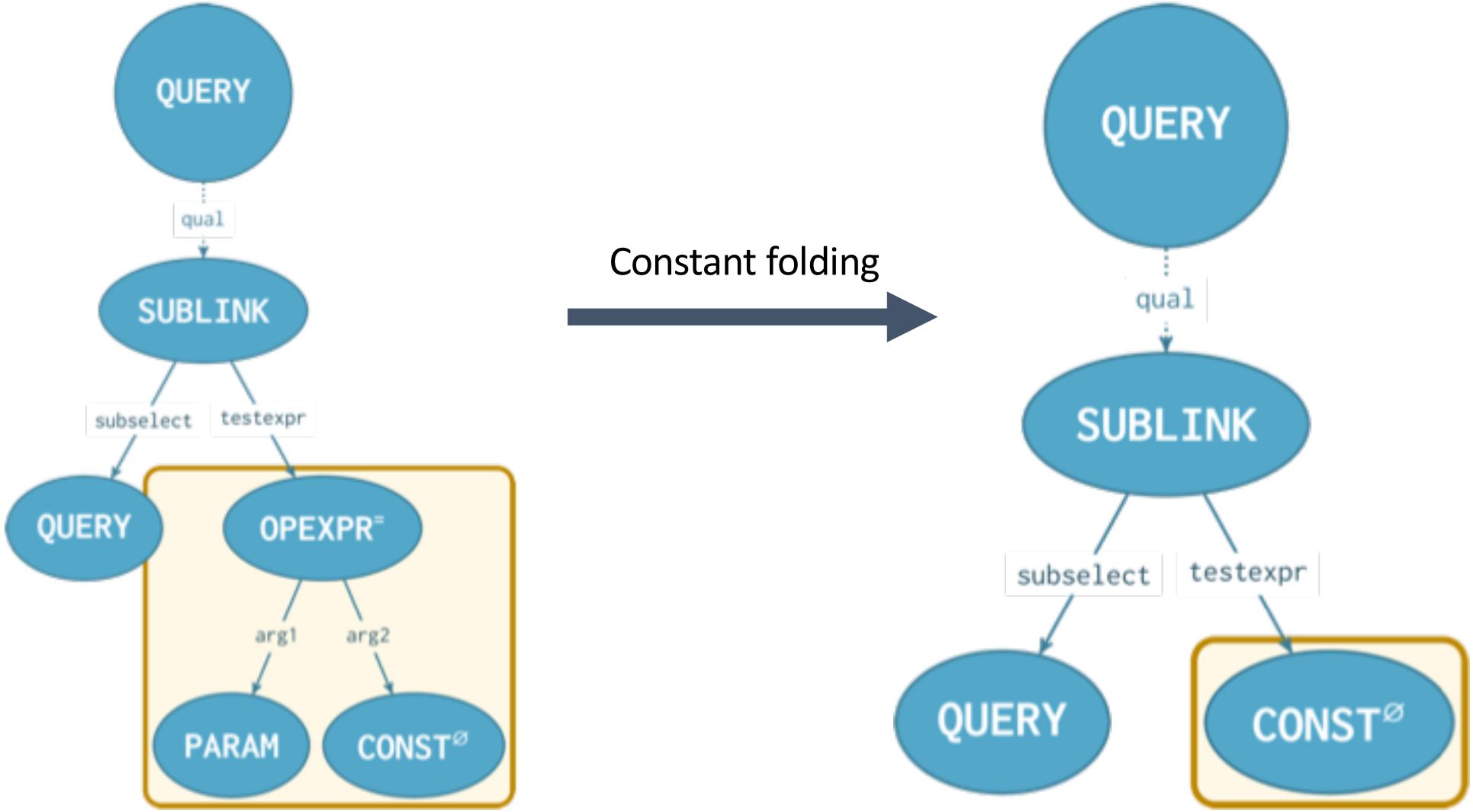
```
/*
 * Invokes the planner for a subquery and recursively
 * processes each sub-SELECT found in a plan
 */

Plan *
subquery_planner(PlannerGlobal *glob, Query *parse,
                 PlannerInfo *parent_root,
                 bool hasRecursion,
                 double tuple_fraction,
                 PlannerInfo **subroot,
                 PlannerConfig *config)
{
   ...
}
```

```
/*
 * Do subquery_planner's preprocessing work for an
 * expression, which can be a targetlist, a WHERE clause
 * (including JOIN/ON conditions), a HAVING clause, etc.
 */

static Node *
preprocess_expression(PlannerInfo *root,
                      Node *expr, int kind)
{
    …
    eval_const_expressions(…);
    …
}
```

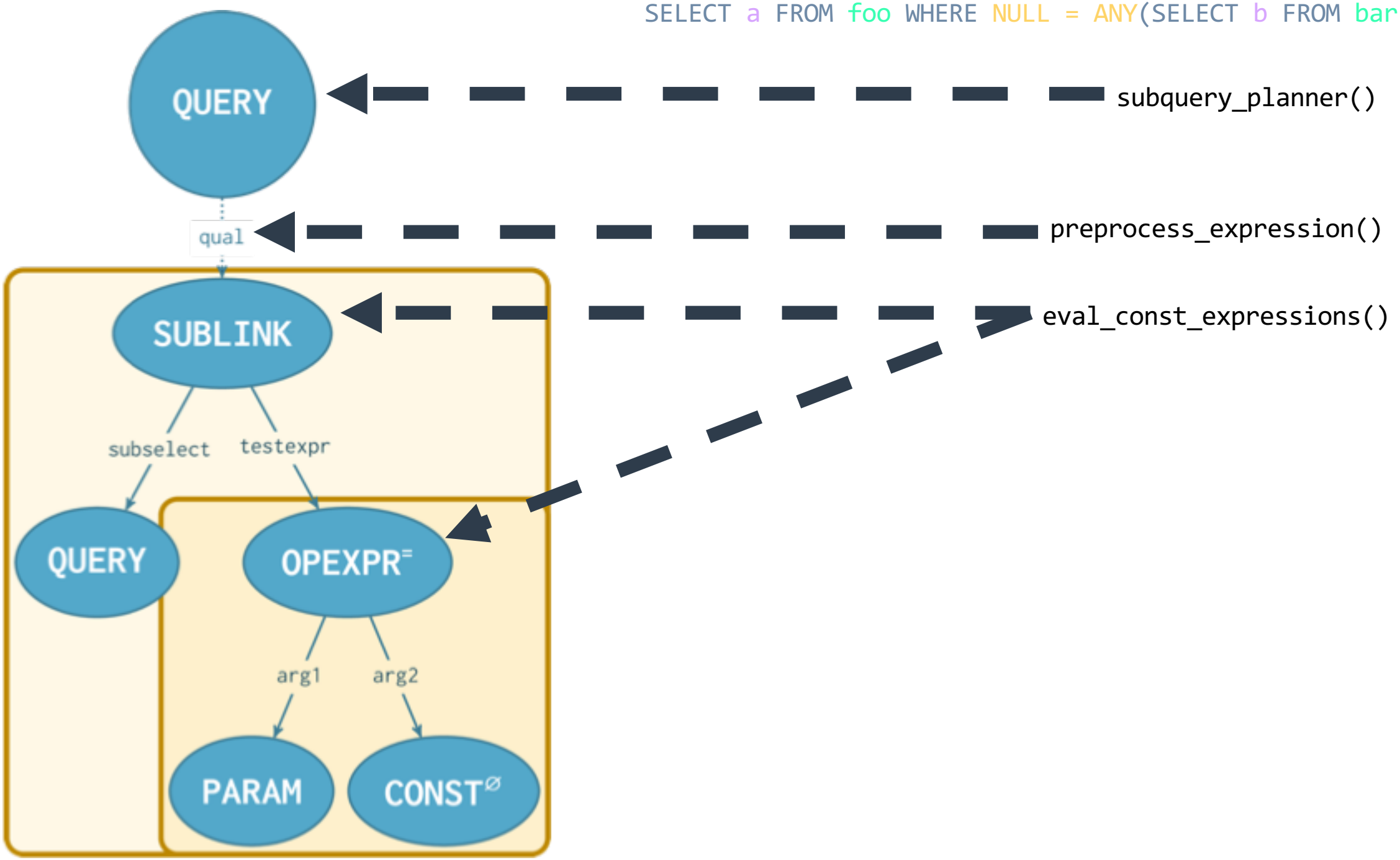
```
/*
 * Reduce any recognizably constant subexpressions of
 * the given expression tree, e.g.:
 *    "2 + 2" => "4”
 */

Node *
eval_const_expressions(PlannerInfo *root, Node *node)
{
   …
}
```

```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Current pre-processing

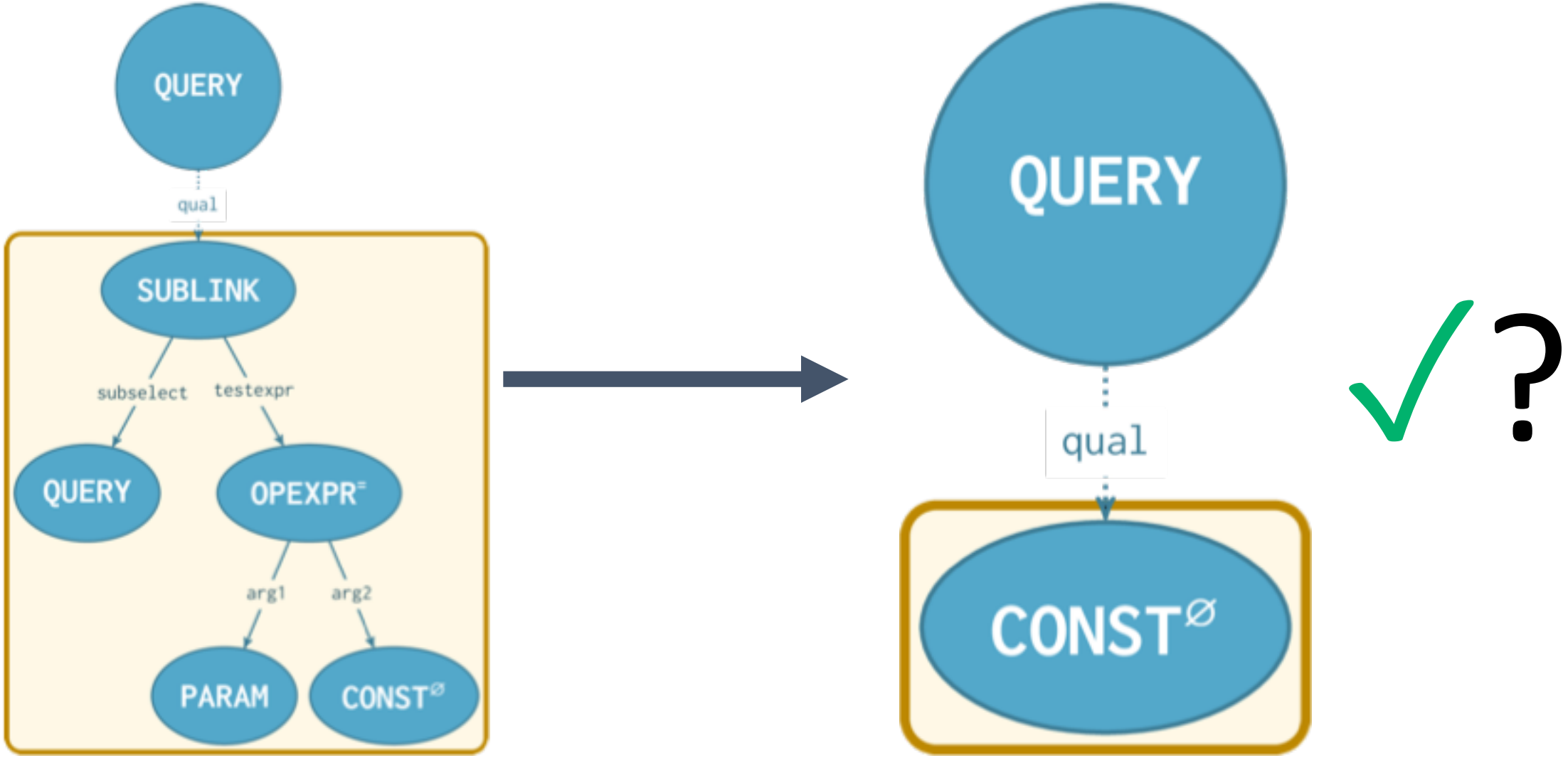


```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```



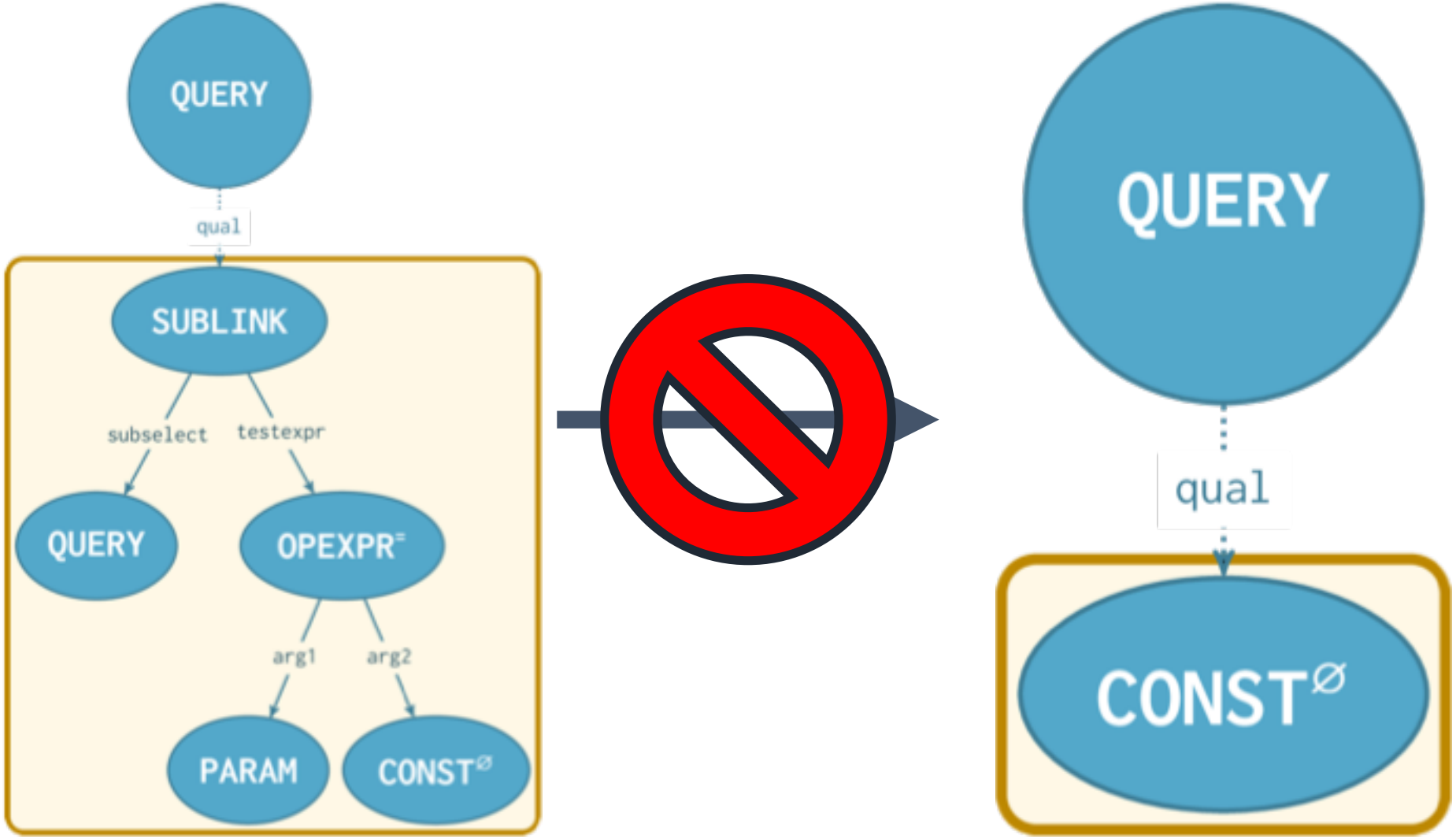
```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Add SUBLINK case to constant folding walker



```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Add SUBLINK case to constant folding walker



# NULL Semantics

# NULL ≈ Unknown

| p | q | p OR q | p AND q | p = q |
|---|---|---|---|---|

# NULL ≈ Unknown

| p | q | p OR q | p AND q | p = q |
|---|---|---|---|---|
| TRUE | TRUE | TRUE | TRUE | TRUE |
| TRUE | FALSE | TRUE | FALSE | FALSE |
| FALSE | FALSE | FALSE | FALSE | TRUE |

# NULL ≈ Unknown

| p | q | p OR q | p AND q | p = q |
|---|---|---|---|---|
| TRUE | TRUE | TRUE | TRUE | TRUE |
| TRUE | FALSE | TRUE | FALSE | FALSE |
| FALSE | FALSE | FALSE | FALSE | TRUE |
| TRUE | NULL | TRUE | NULL | NULL |
| FALSE | NULL | NULL | FALSE | NULL |
| NULL | NULL | NULL | NULL | NULL |

```
NULL ≟ ANY(SELECT b FROM bar)
```

Does any `b` in `bar` equal an unknown?

```
# SELECT NULL = ANY(SELECT b FROM bar);
```

Does any b in bar equal an unknown?

# Does any b in bar equal an unknown?

```
# SELECT NULL = ANY(SELECT
b FROM bar);

 ?column?
----------

(1 row)
```

# Does any b in bar equal an unknown?

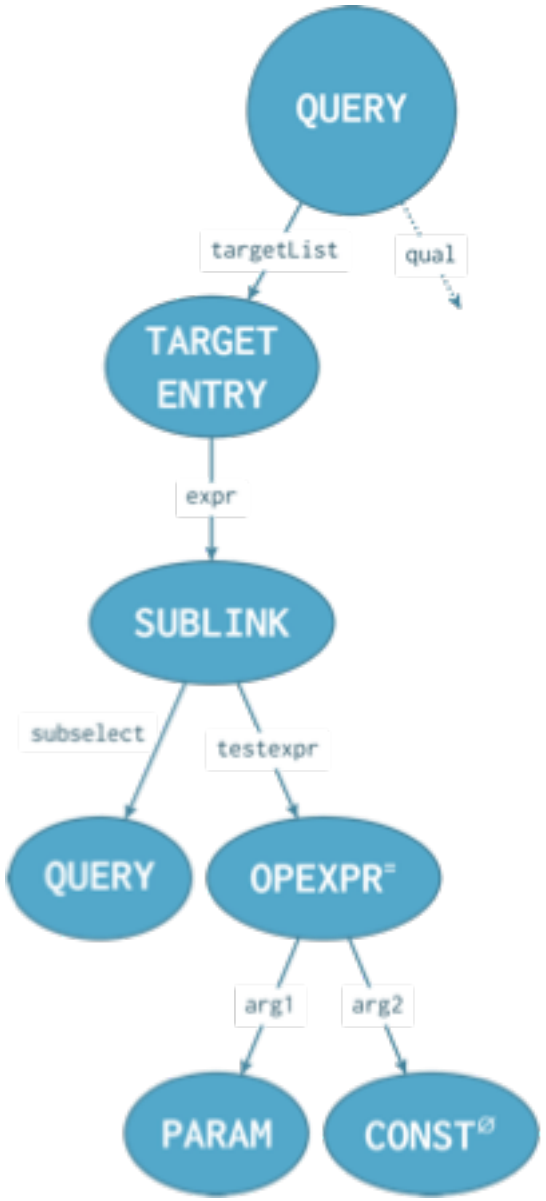
```
# SELECT NULL = ANY(SELECT
b FROM bar);

 ?column?
----------

(1 row)
```

```
# TRUNCATE bar;

# SELECT NULL = ANY(SELECT
b FROM bar);

 ?column?
----------
 f
(1 row)
```

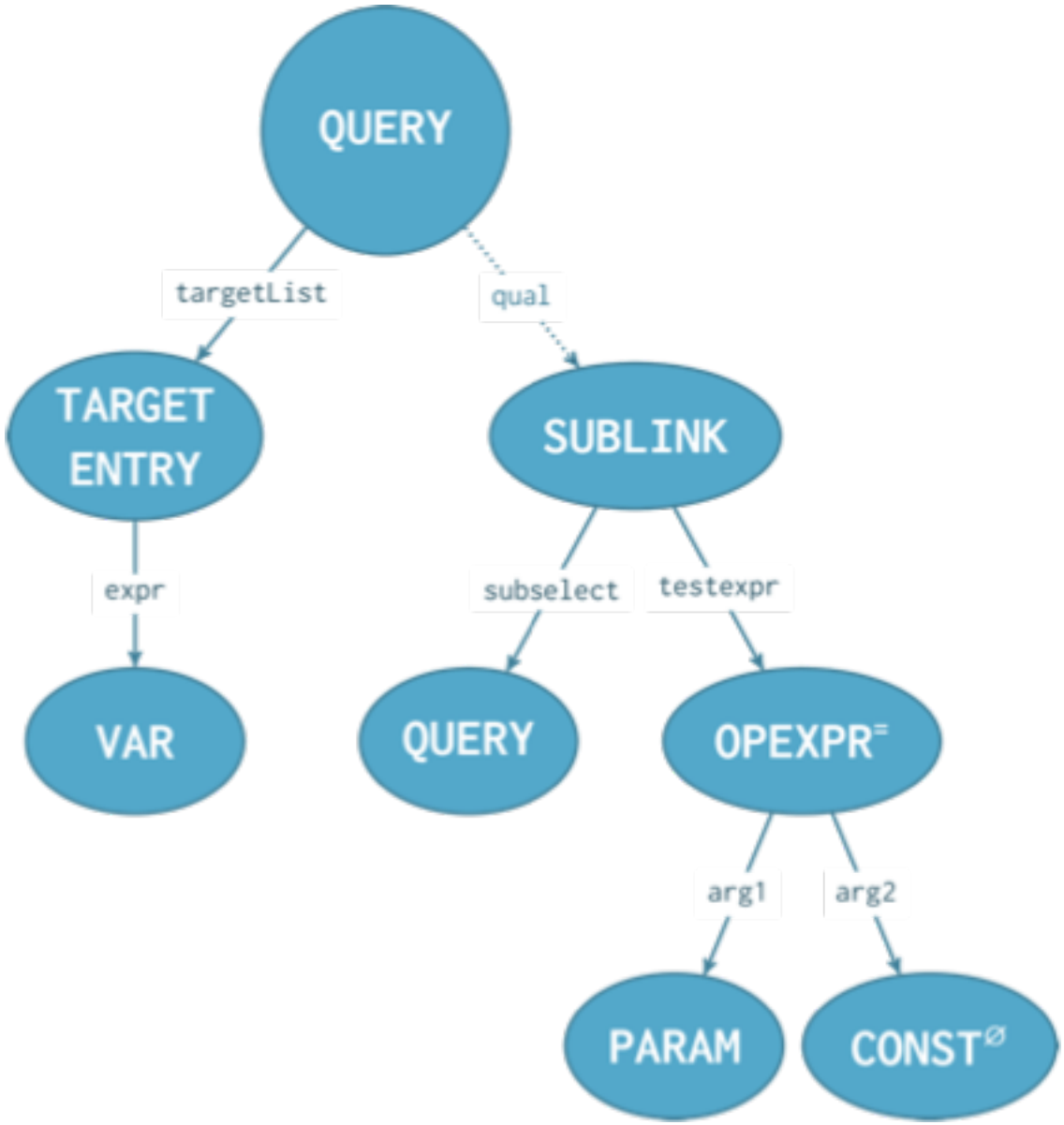
```
# SELECT a FROM foo
  WHERE NULL = ANY(
    SELECT b FROM bar
  );

 a
---

(0 rows)
```

```
# TRUNCATE bar;

# SELECT a FROM foo
  WHERE NULL = ANY(
    SELECT b FROM bar
  );

 a
---

(0 rows)
```

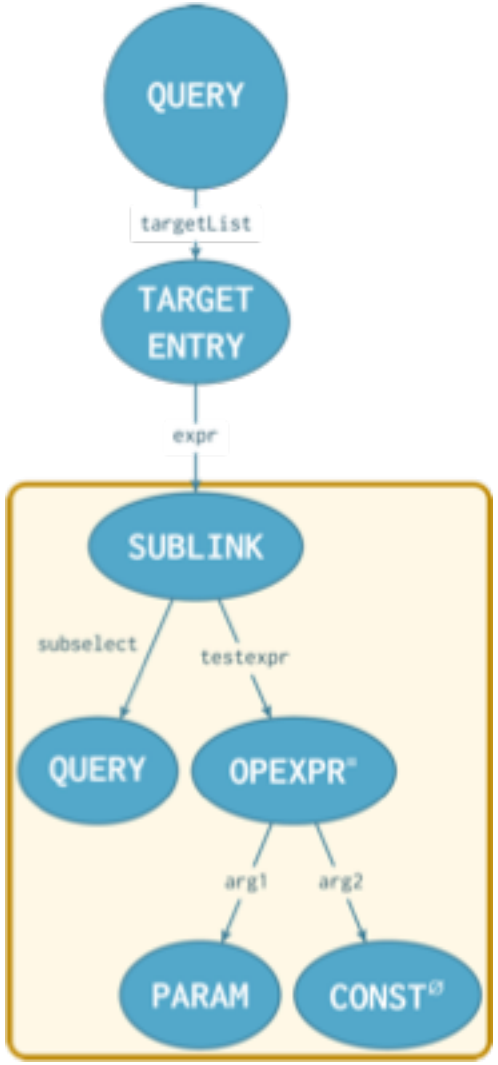
```
# SELECT NULL = ANY(SELECT b FROM bar);
```




```
# SELECT a FROM foo WHERE
  NULL = ANY(SELECT b FROM bar);
```



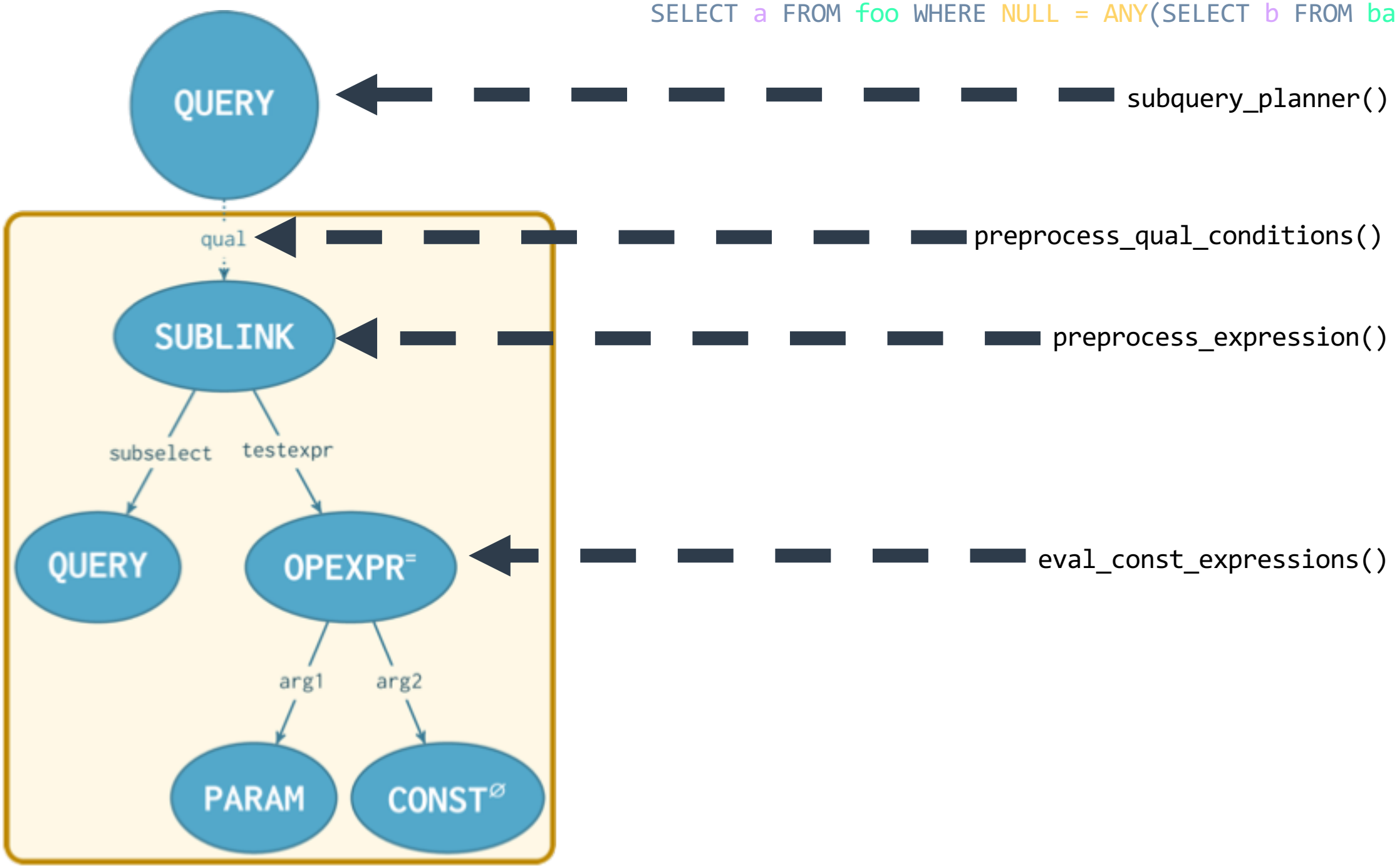
# FALSE if bar is an empty table and NULL otherwise



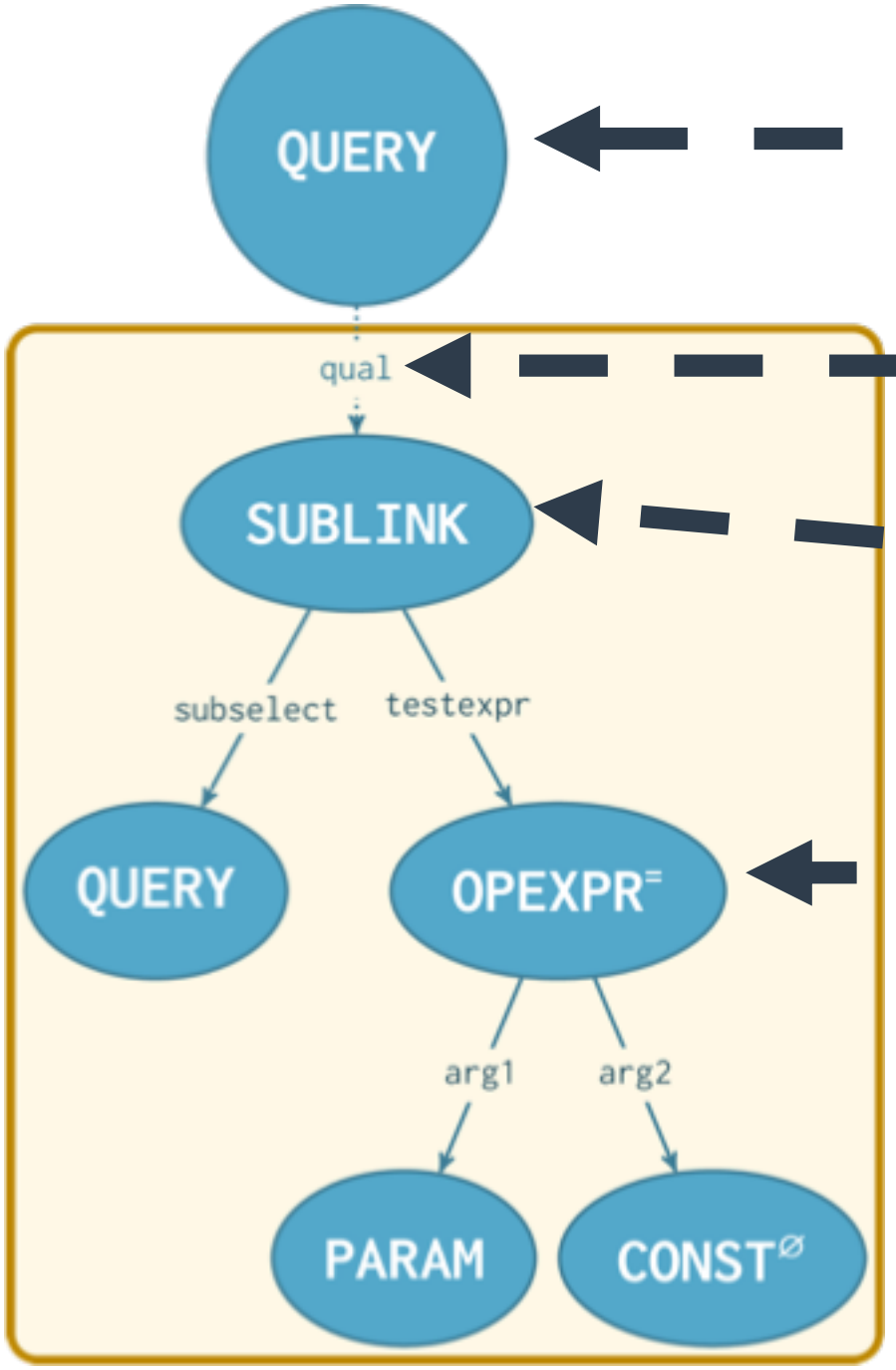

# Where else can we put a fix?

```
/*
 * Recursively scan the query's jointree and do
 * subquery_planner()’s preprocessing work on each qual
 * condition found therein.
 */

static void
preprocess_qual_conditions(PlannerInfo *root,
                           Node *jtnode)
{
    …
    preprocess_expressions(…);
    …
}
```

```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```



```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```




subquery_planner()

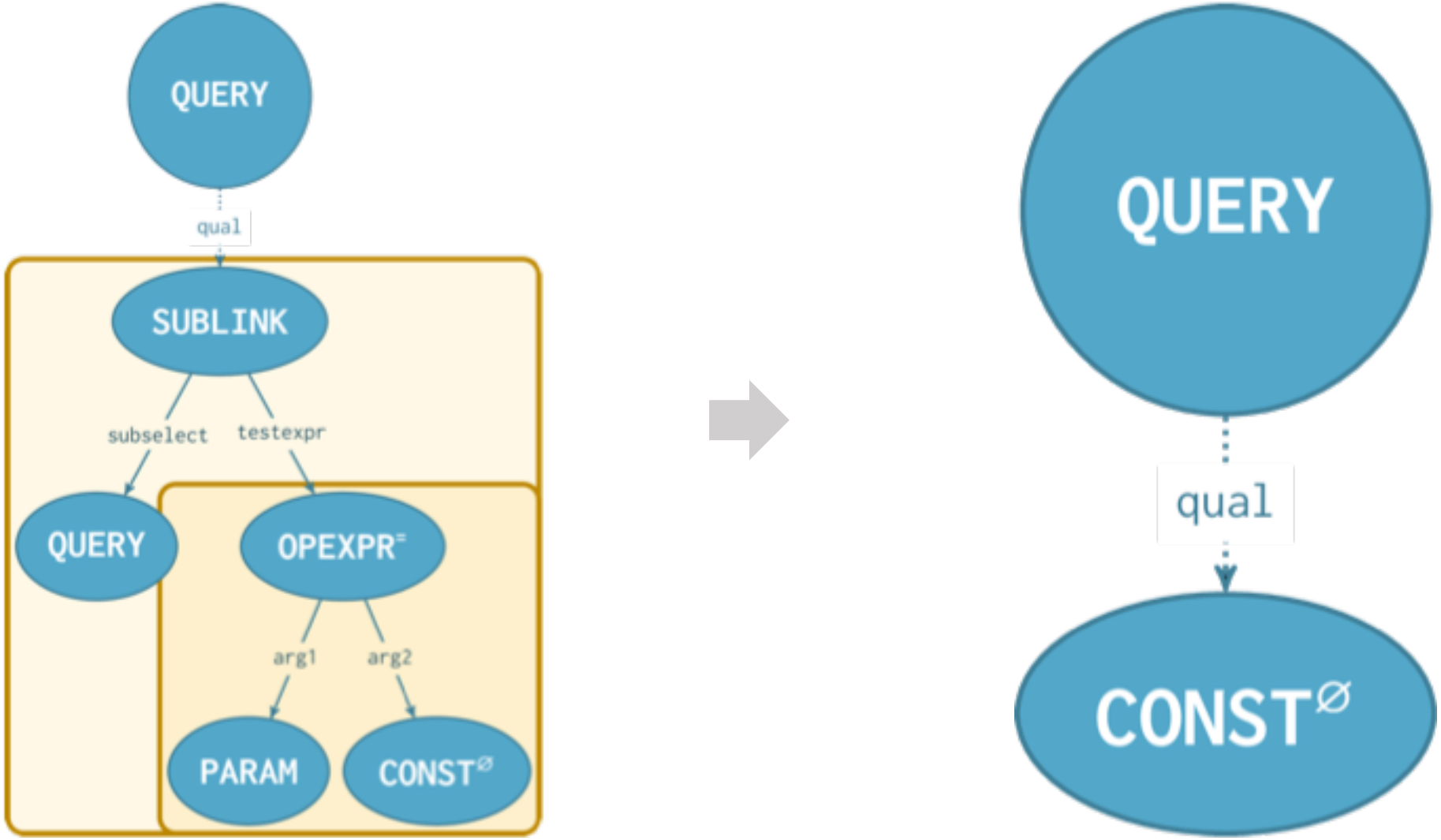
```
preprocess_qual_conditions()
{
if, after constant folding,
testexpr is a constant NULL,
replace SUBLINK with constant
NULL
}
```

preprocess_expression()

eval_const_expressions()

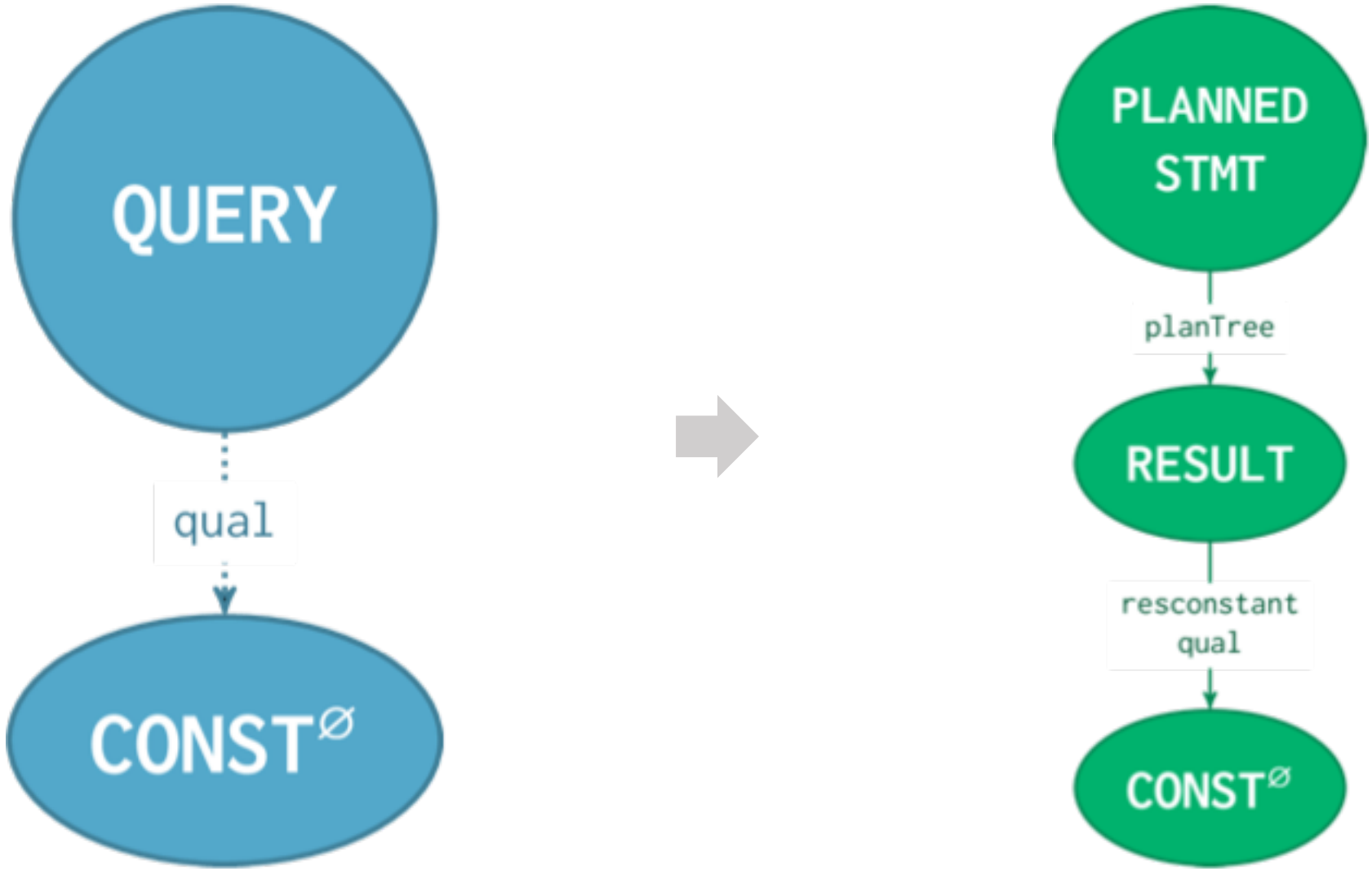
```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Replace **SUBLINK** when pre-processing **qual**s



```
SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

# Patched planning



# Patched plan

```
# EXPLAIN SELECT a FROM foo WHERE NULL = ANY(SELECT b FROM bar);
```

```
                                QUERY PLAN
```

---

```
Result  (cost=0.00..0.00 rows=0 width=4)
  One-Time Filter: false
```

github.com/melanieplageman