Automatic Identification of Bug-Introducing Changes

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Motivation

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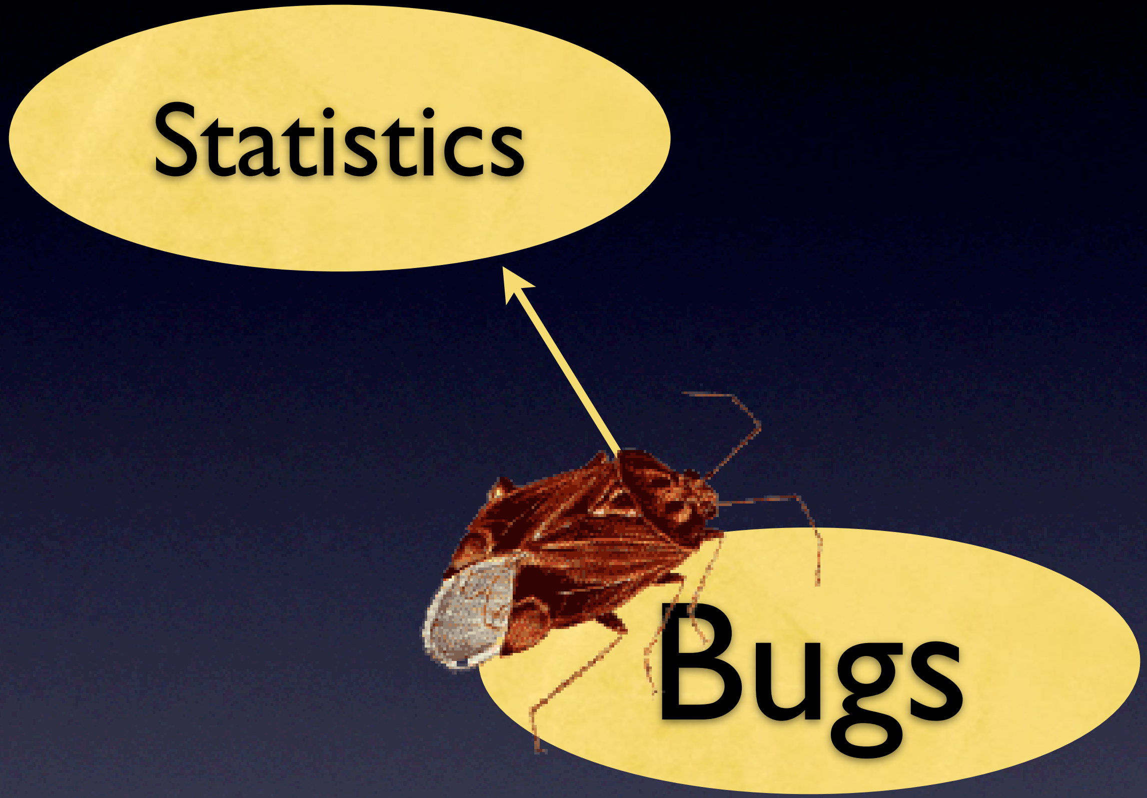

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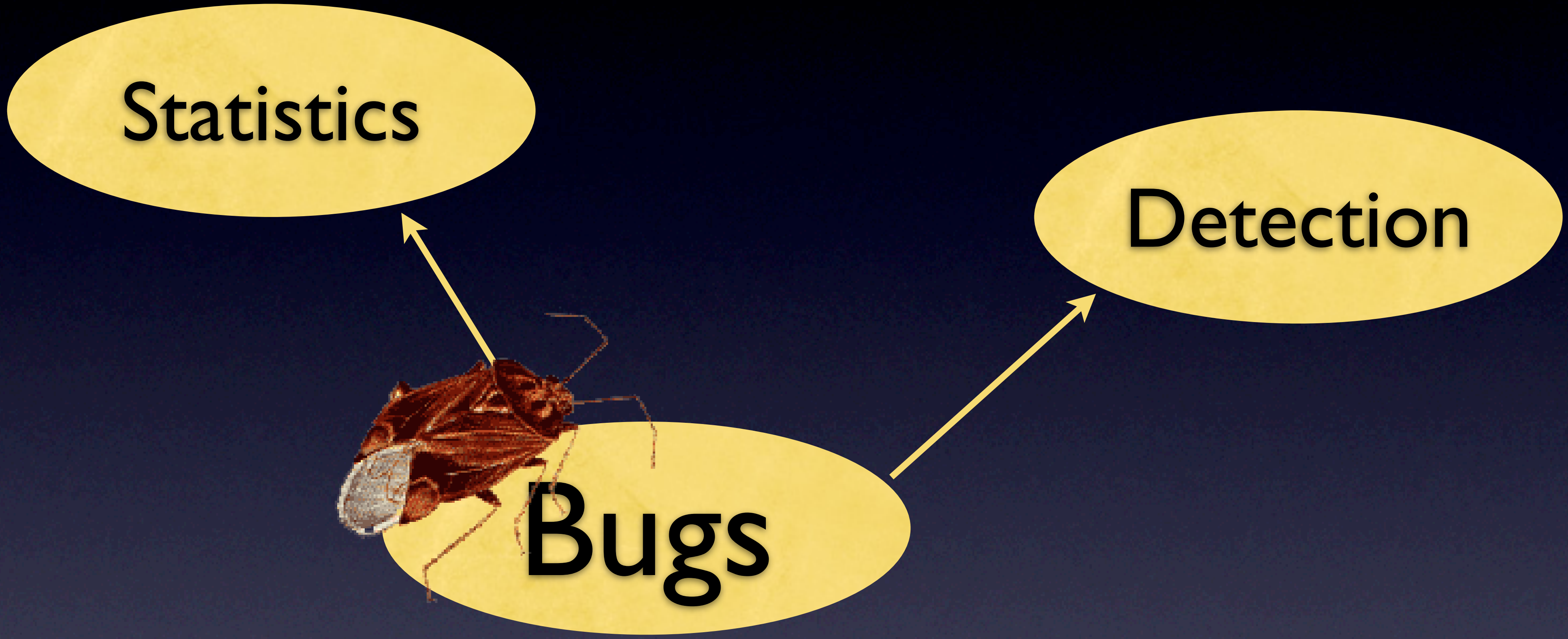

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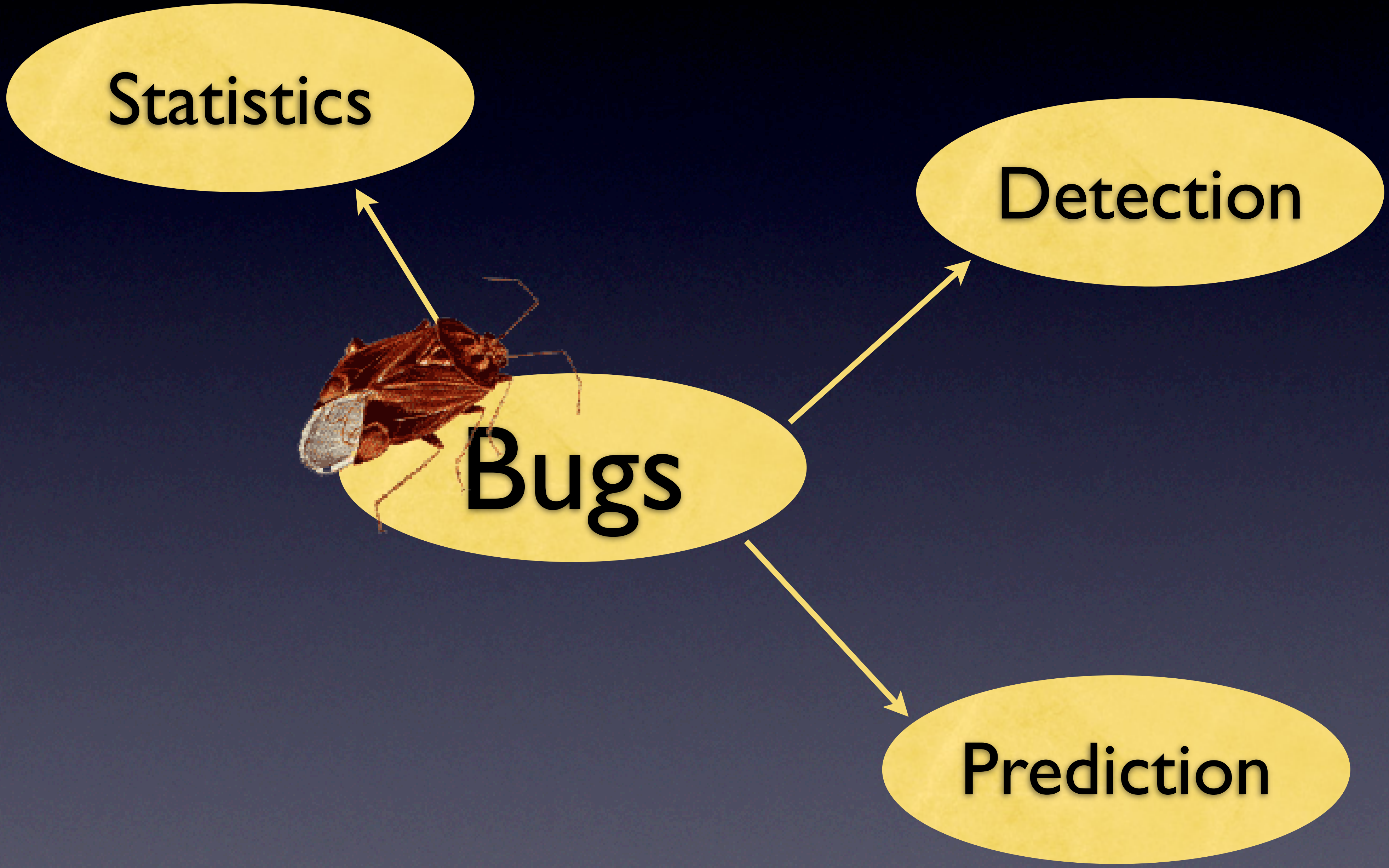

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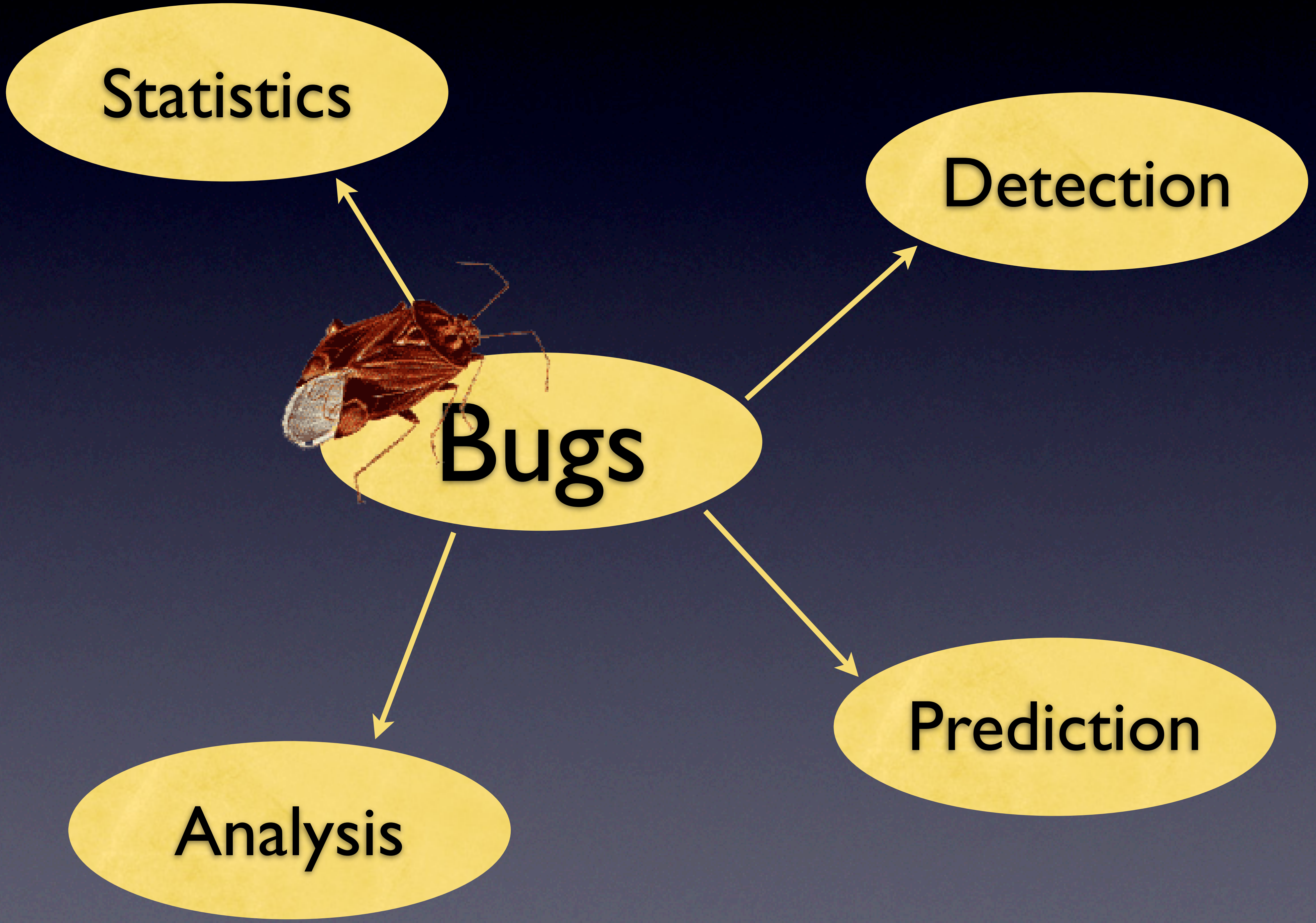

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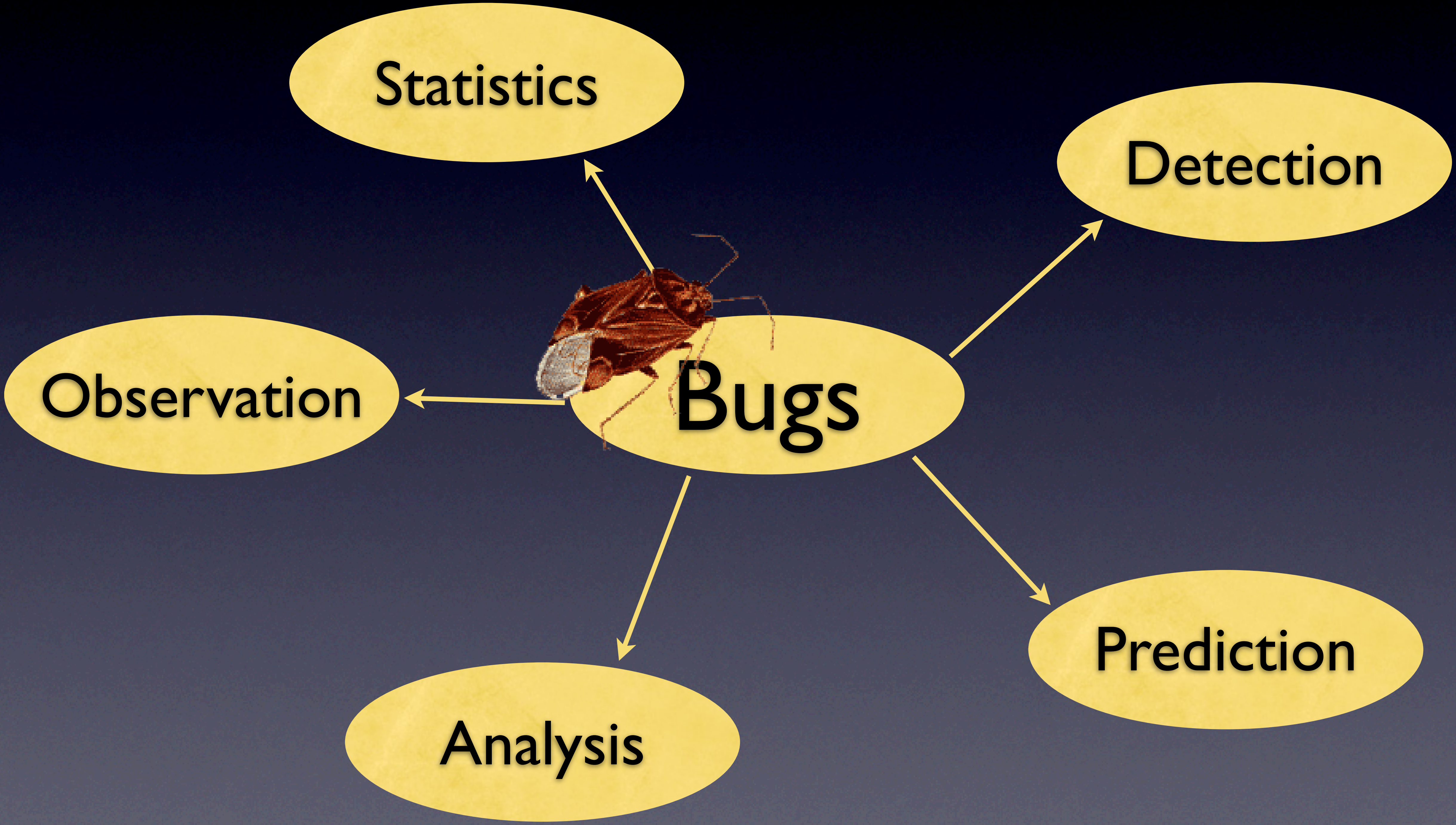
Statistics
Detection
Observation
Bugs
Analysis
Prediction

So far: Focus on fixes

```
teicher     2003-10-29 16:11:01
fixes issues mentioned in bug 45635: [hovering] rollover hovers
- mouse exit detection is safer and should not allow for
  loopholes any more, except for shell deactiviation
- hovers behave like normal ones:
        - tooltips pop up below the control
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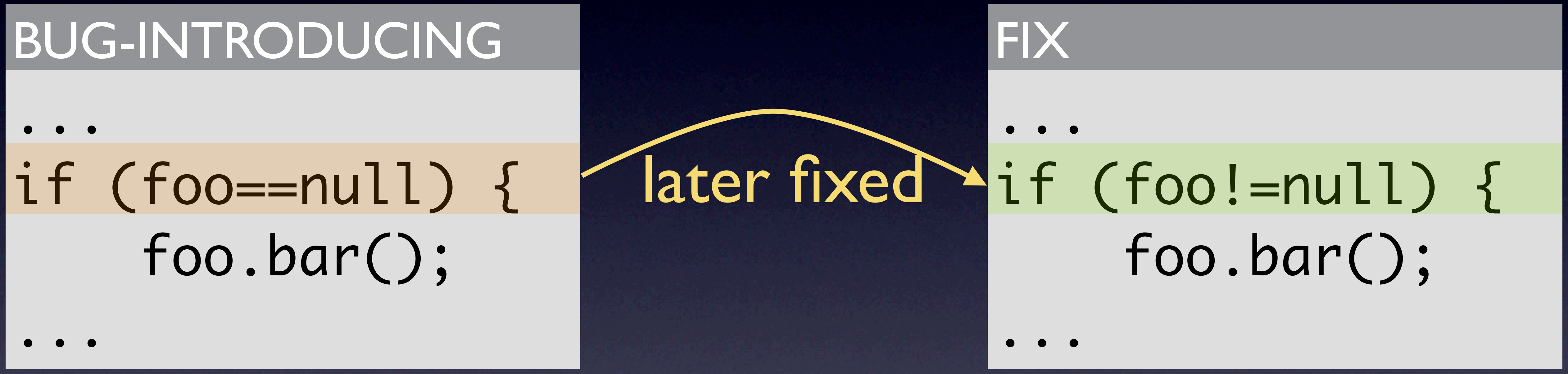
Fixes give only the location of a defect,
not when it was introduced.

Bug-introducing changes

BUG-INTRODUCING

```
...
if (foo==null) {
    foo.bar();
...
```

Bug-introducing changes



BUG-INTRODUCING

```
...
if (foo==null) {
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FIX

```
...
if (foo!=null) {
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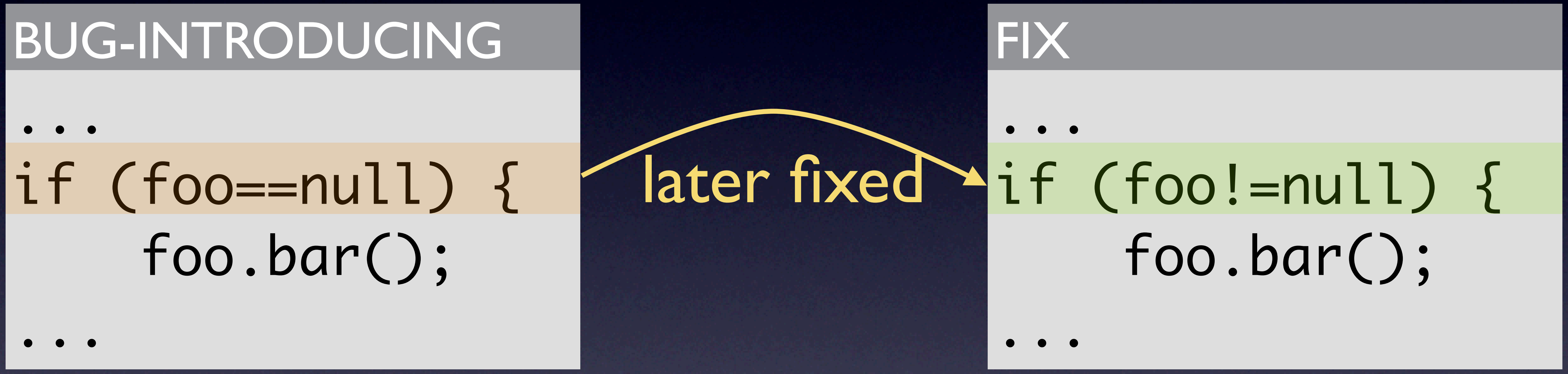
```

Bug-introducing changes



```
...
if (foo==null) {
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```

```
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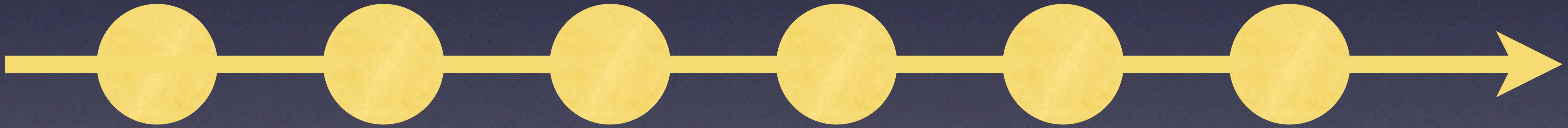
```

Bug-introducing changes are changes that lead to problems as indicated by later fixes.

Life-cycle of a “bug”



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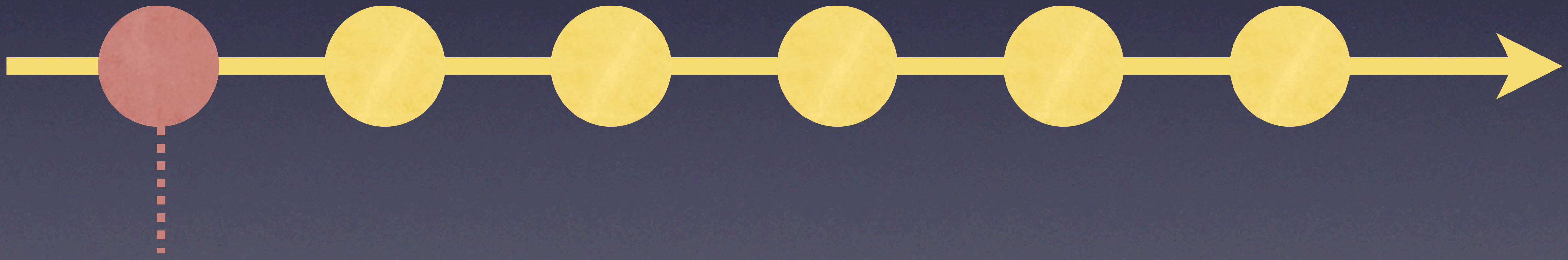
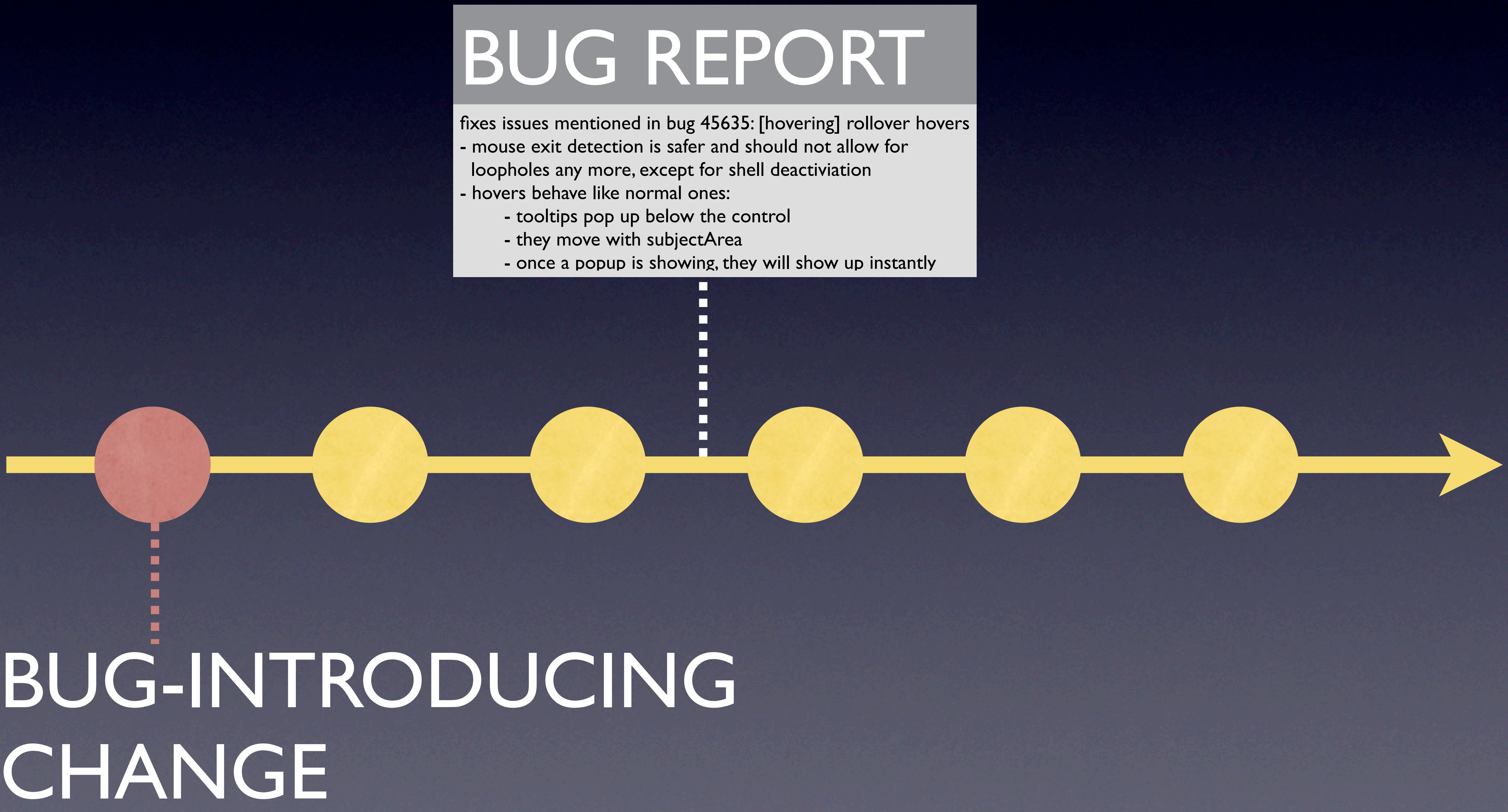


BUG-INTRODUCING CHANGE

Life-cycle of a "bug"



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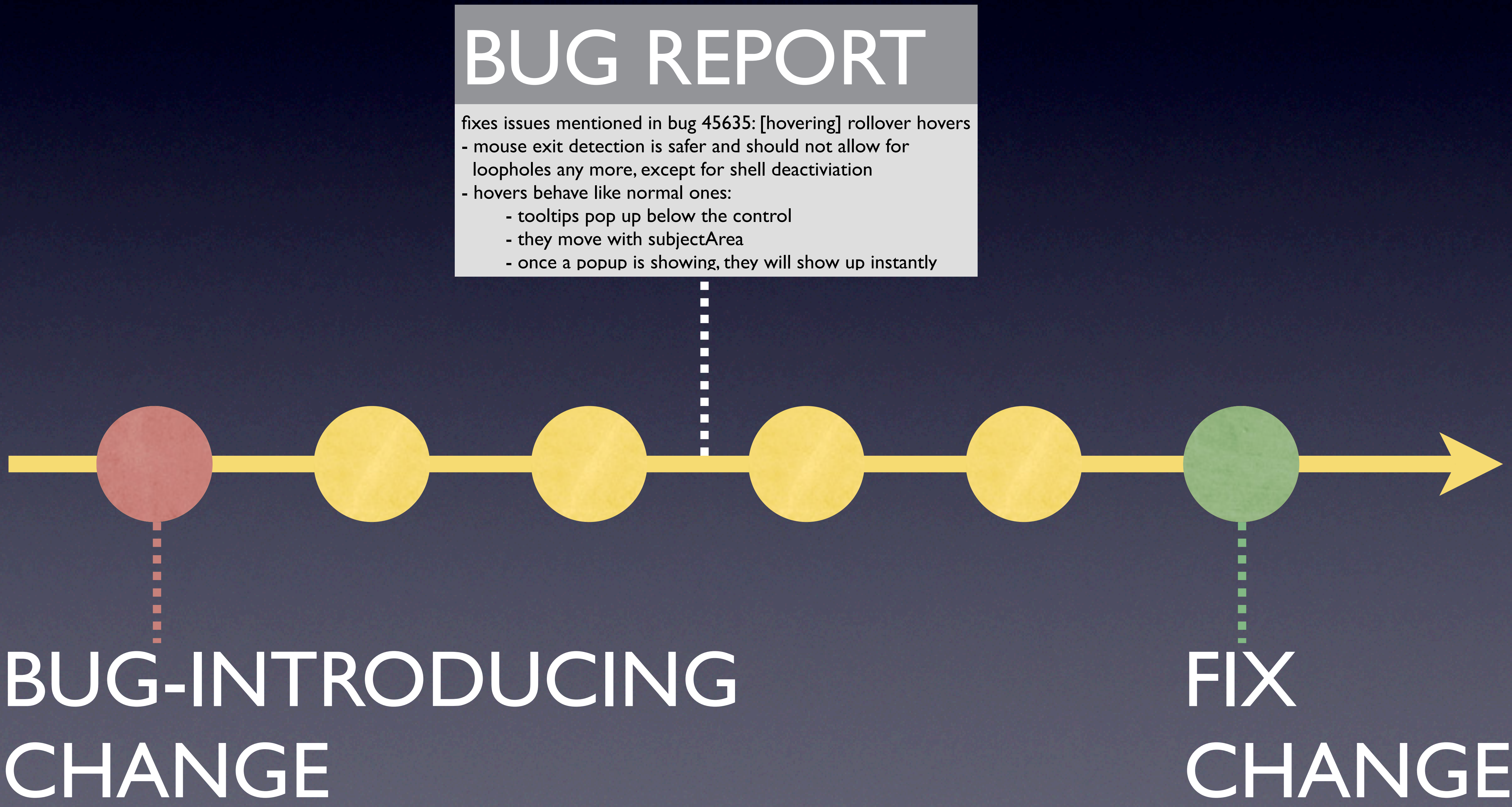

BUG REPORT

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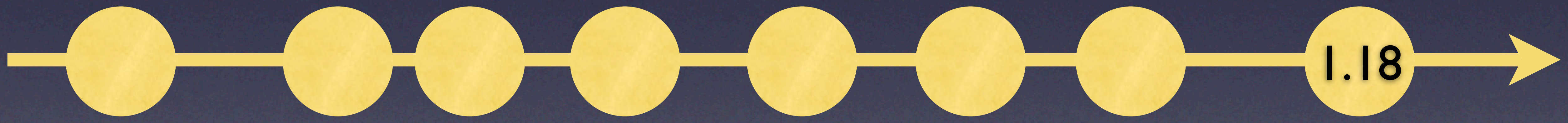
The SZZ algorithm



FIXED BUG
42233

The SZZ algorithm

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    $ cvs annotate -r 1.17 Foo.java
    ...
20: 1.11 (john 12-Feb-03):     return i/0;
    ...
40: 1.14 (kate 23-May-03):     return 42;
    ...
60: 1.16 (mary 10-Jun-03):     int i=0;
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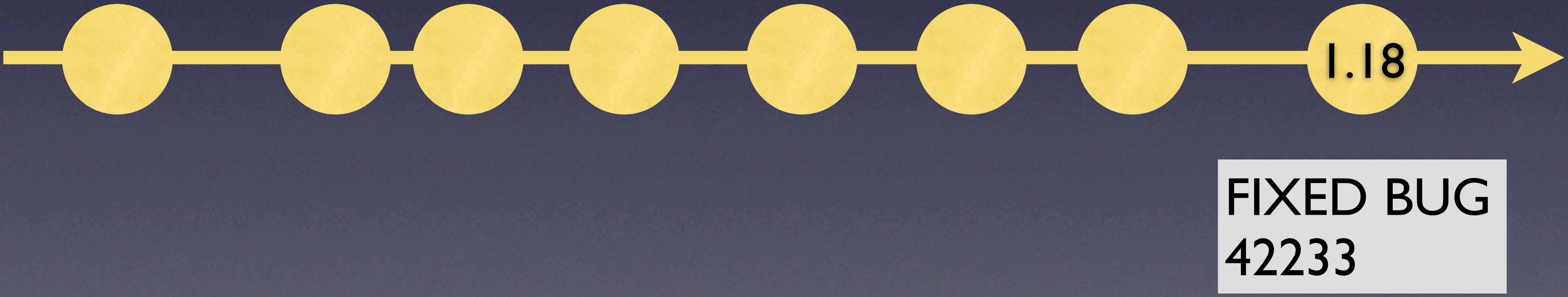

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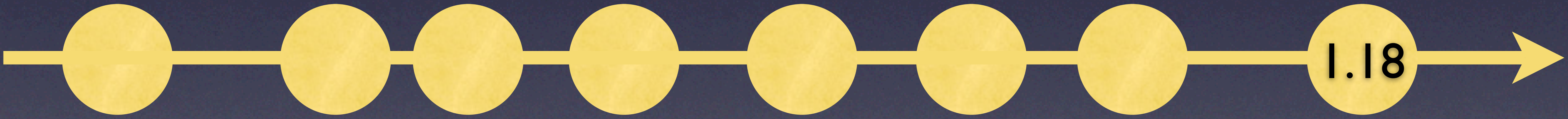

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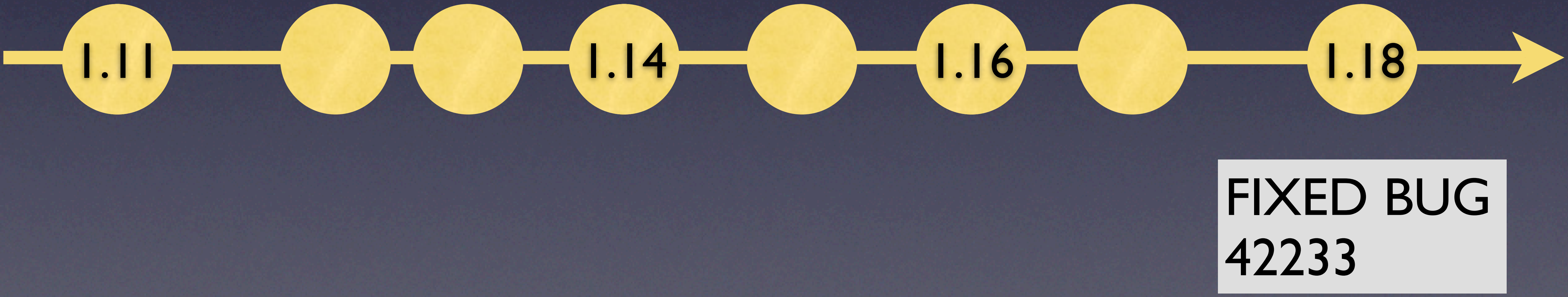

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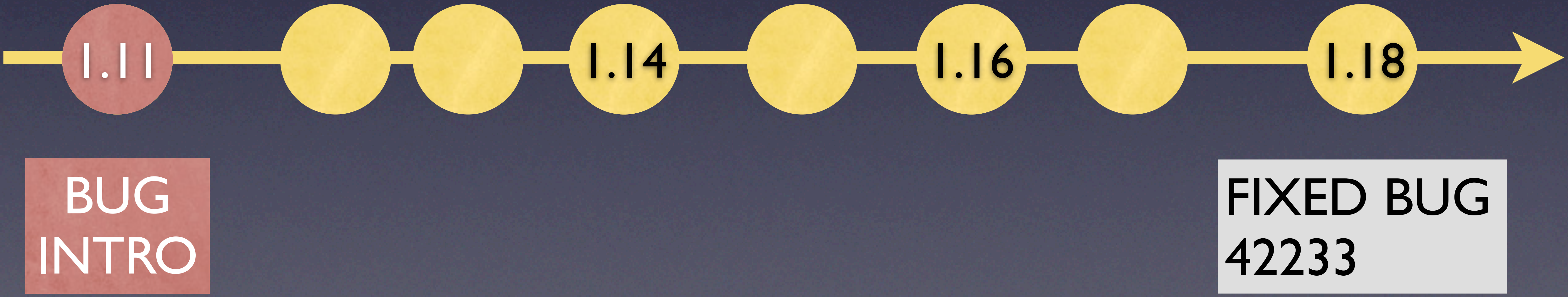

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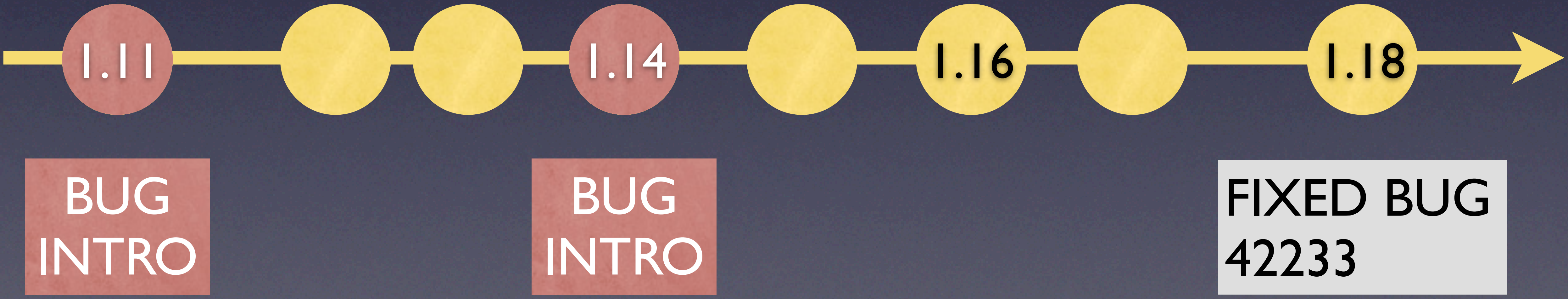

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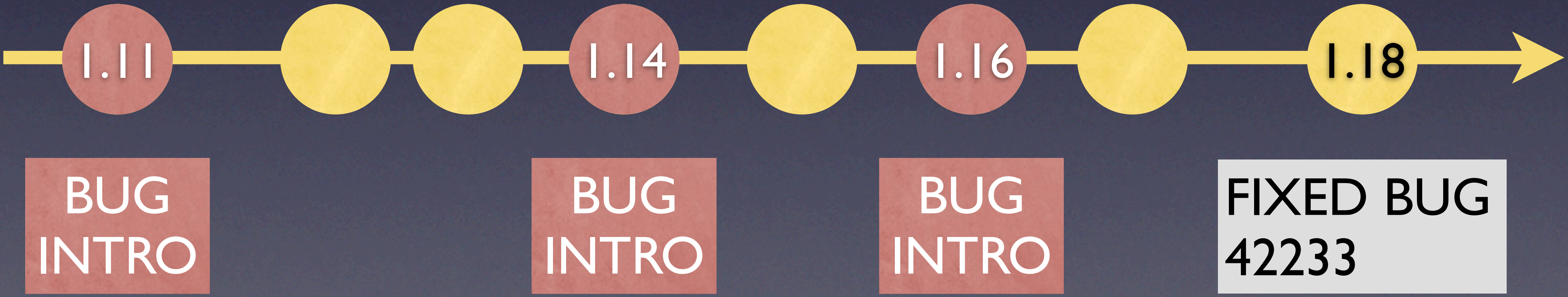

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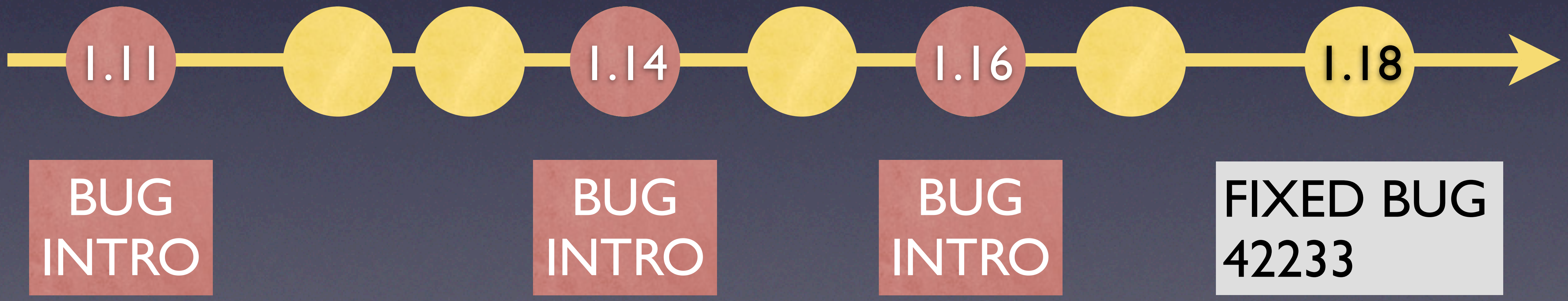

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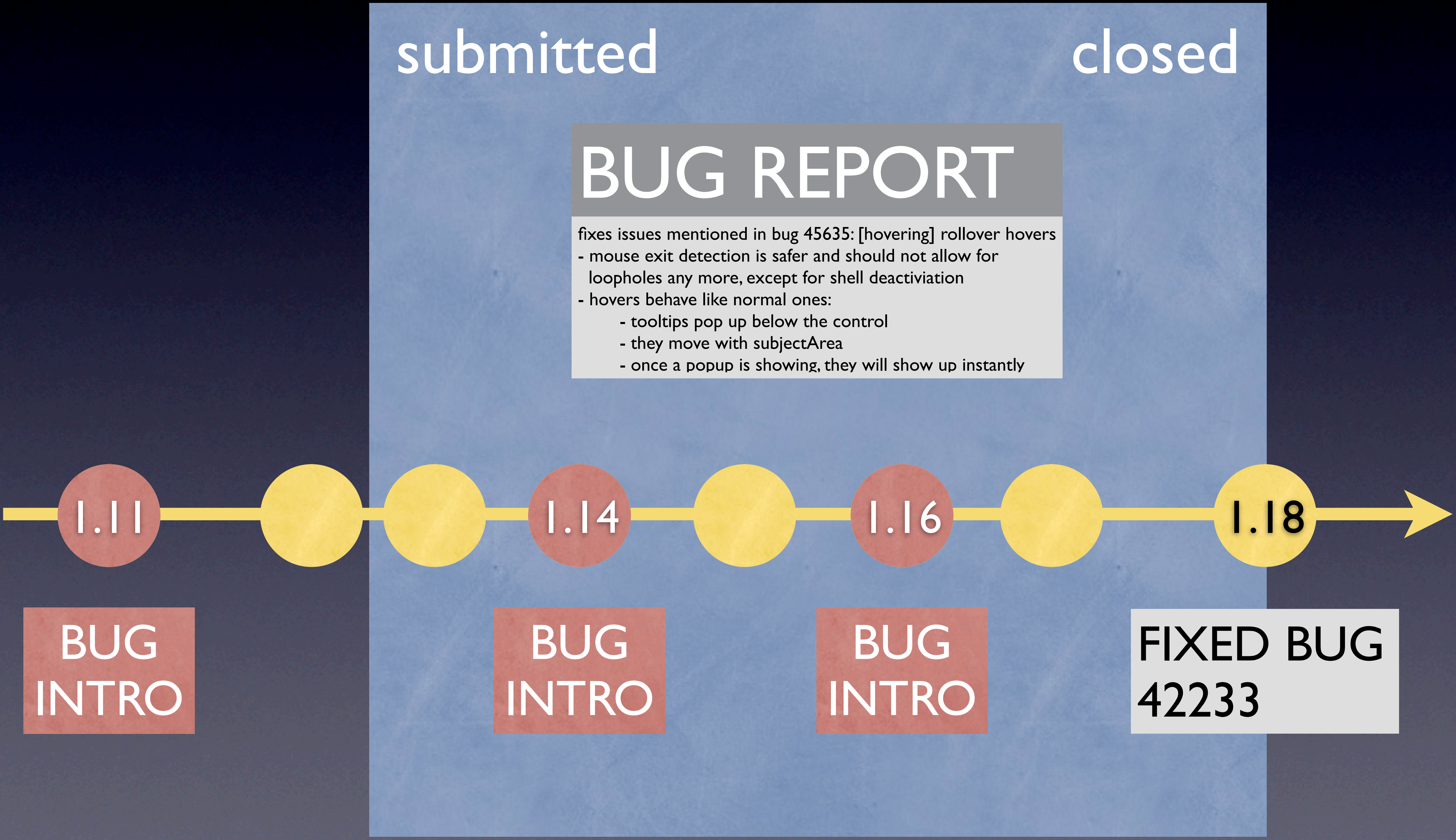

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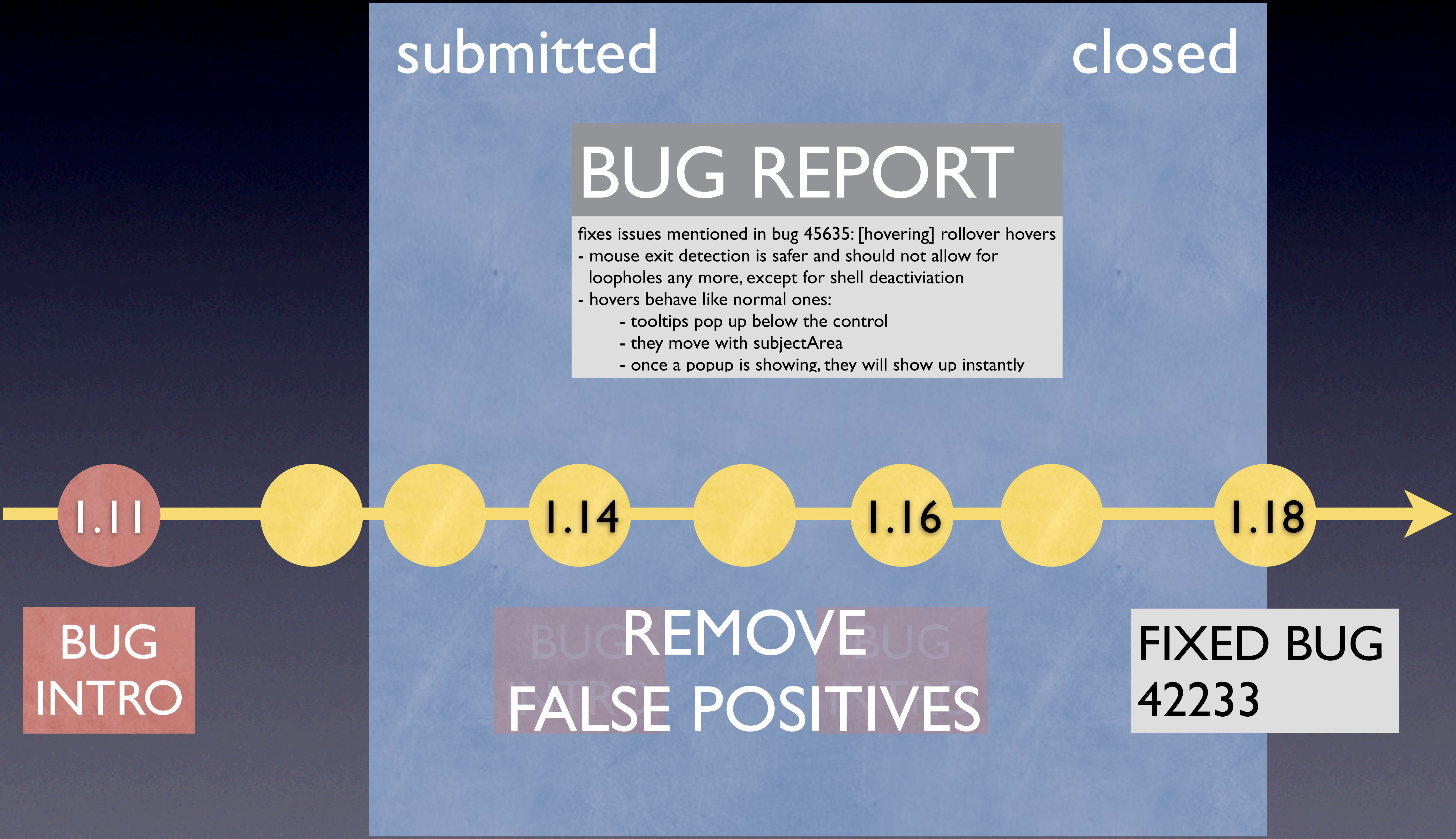

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Drawbacks of SZZ

Annotation by SCMs is insufficient.
(line number in bug-introducing revision is missing)

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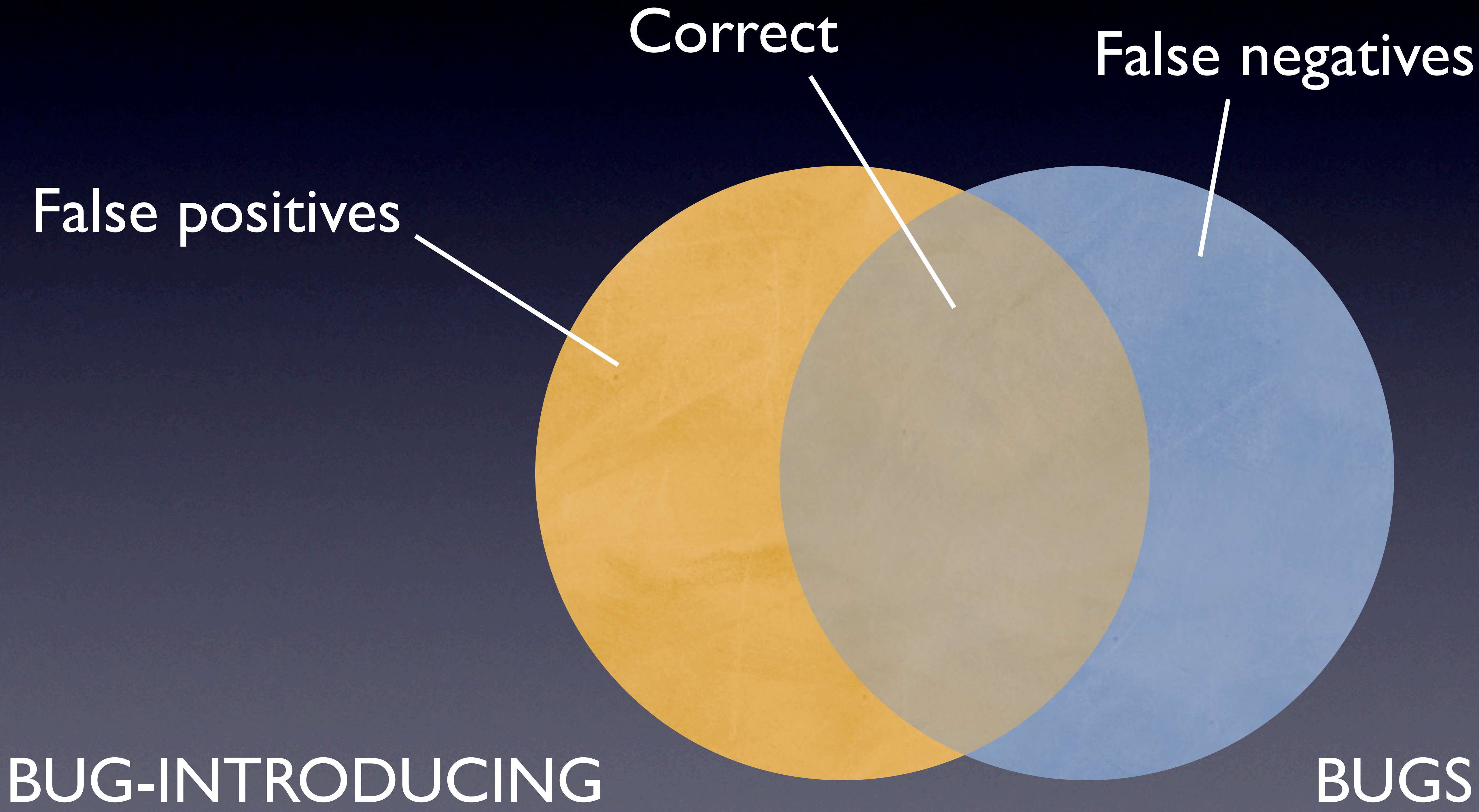
Not all modifications are fixes.
(blank lines, comments, etc.)

False negatives and positives



An example

BUG-INTRODUCING

```
void bar() {
  if (val==null) {
    println(val);
  }
...
```

Revision 7: tom
- introduces the defects

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Revision 23: jim
- inserts a comment
- reformats if statement

BUG FIX

```
void foo() {
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```

Revision 42: kim
- changes comment
- corrects defect

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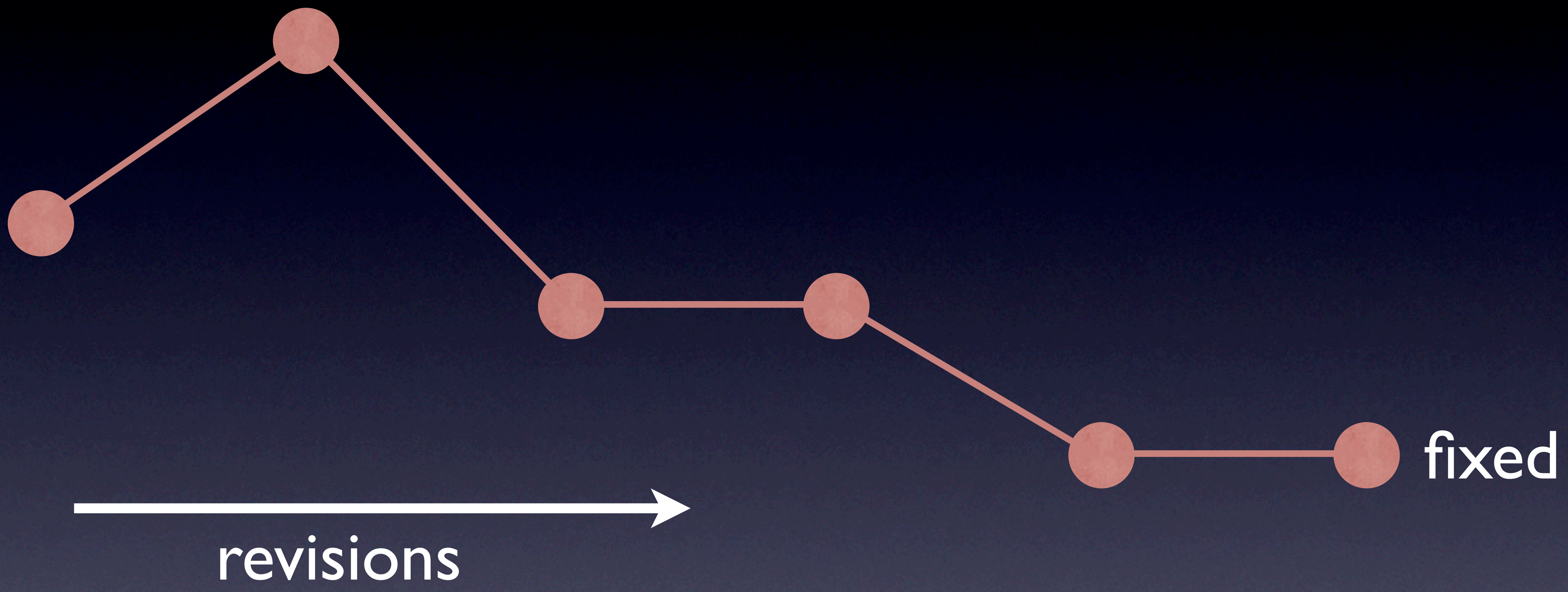
The originial SZZ algorithm has too many false positives (rev 23) and false negatives (rev 7).

Our study

Project	COLUMBA	ECLIPSE (jdt.core)
Software type	Email client	IDE
Investigated period	11/2002-06/2003	06/2001-03/2002
Number of revisions	500	1000
Number of fixes	143 (29%)	158 (16%)
Average LOC	48,135	111,059

Annotation graphs

Annotation graphs



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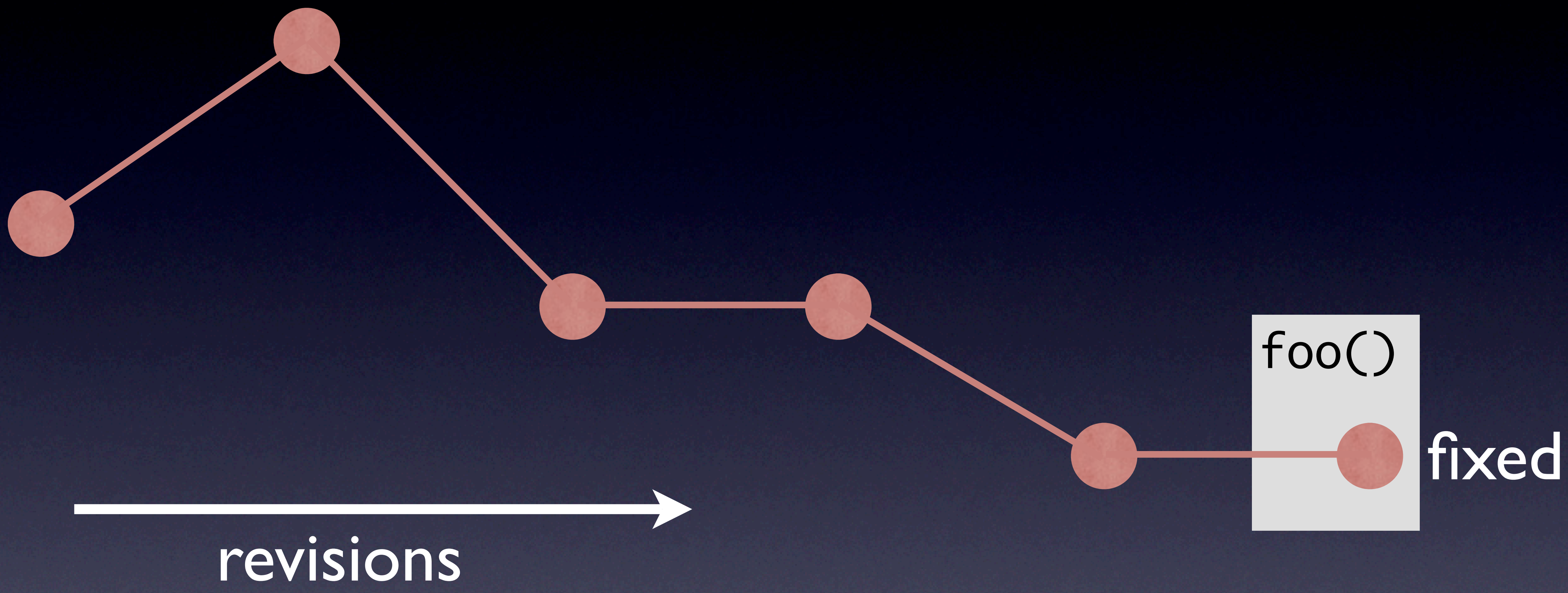

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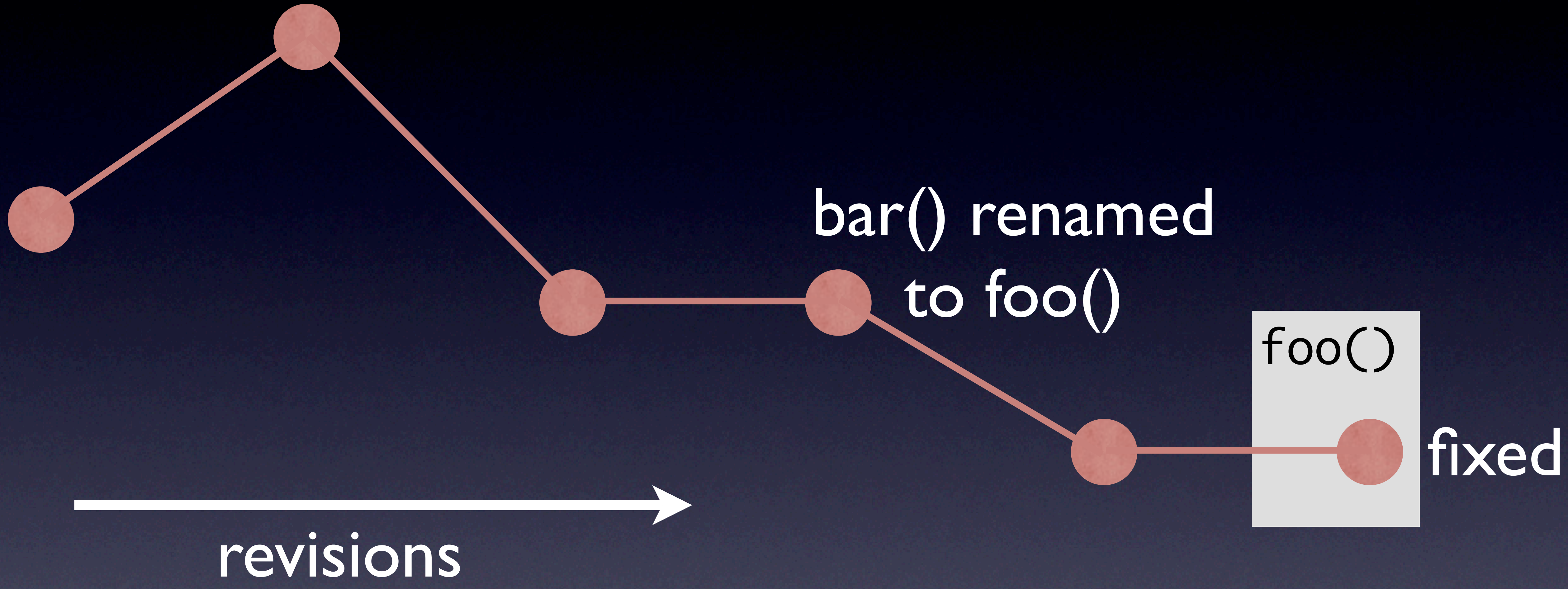

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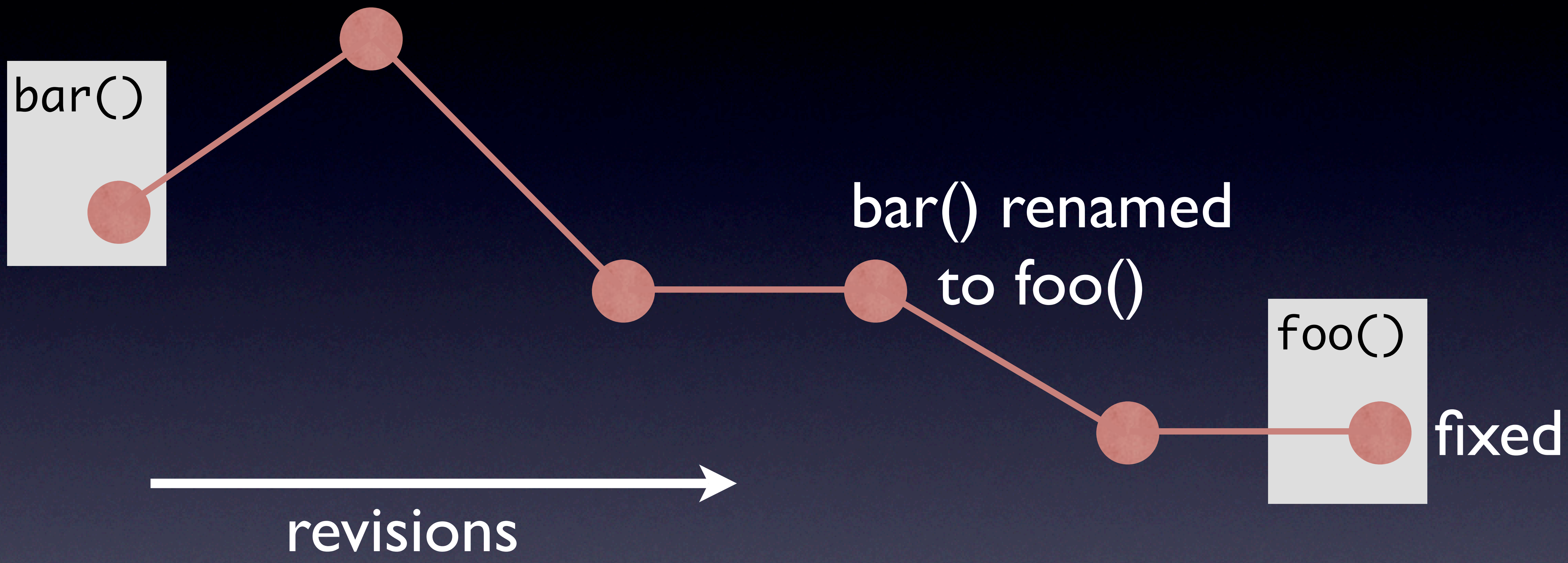

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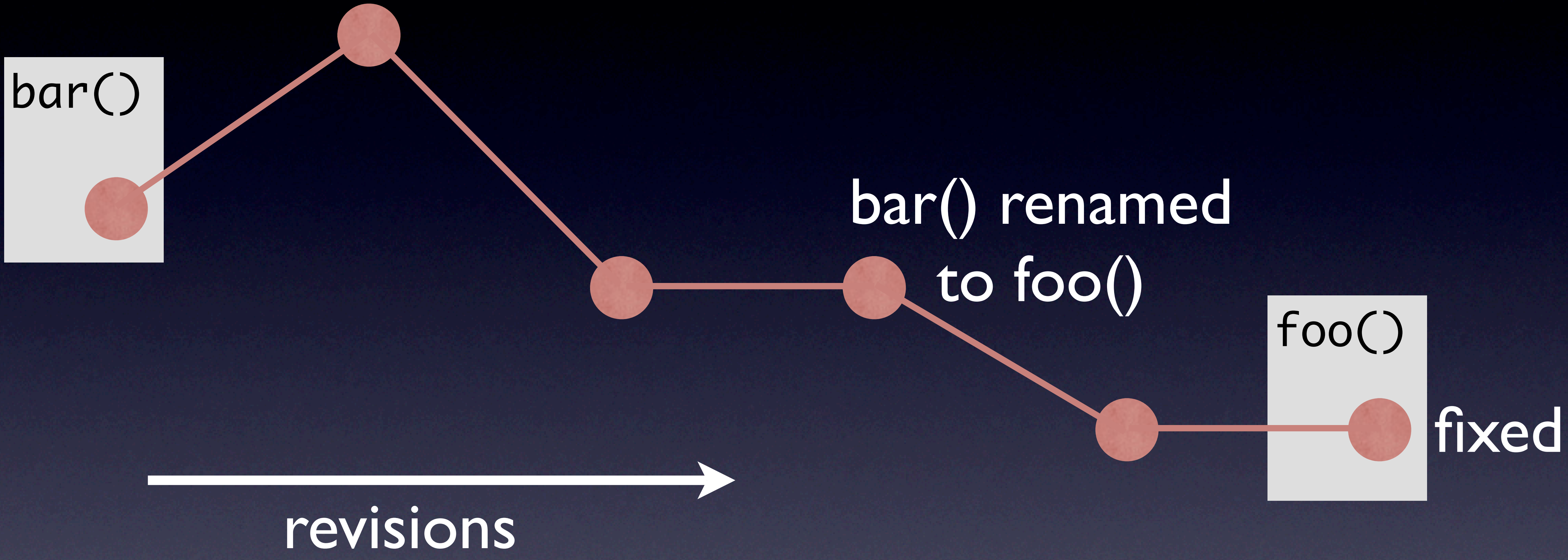
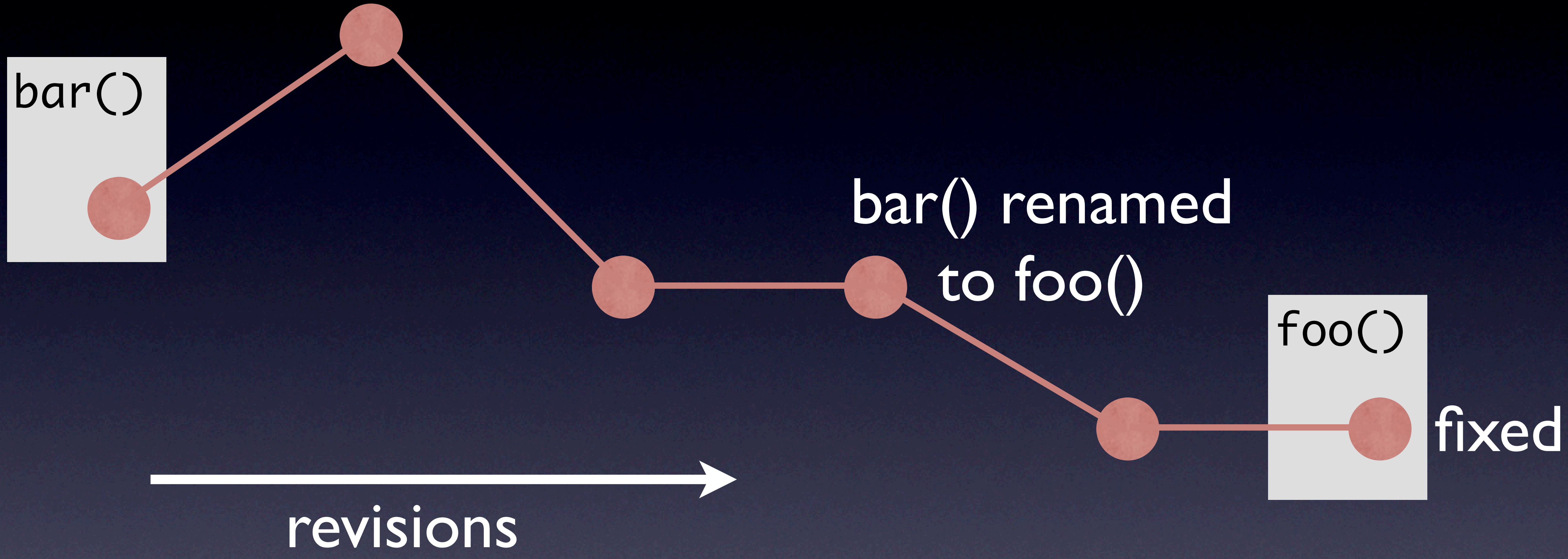


SZZ reports a bug-introducing change for `foo` (false positive) but not for `bar` (false negative).

Annotation graphs



Using annotation graphs we can remove 2% as false positives and identifies further 1%~4%.

Comments & blank lines

```
  public void notifySourceElementRequestor() {
-
+ if (reportReferenceInfo) {
+     notifyAllUnknownReferences();
+ }
  // collect the top level ast nodes
  int length = 0;
```

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Ignoring comments and blank lines removes 14%~20% as false positives.

Format changes

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```
if ( a==true ) return;
```

Format changes

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```
if ( a==true ) return;
```

```
if (a==true)
    return;
```

BUG FIX

```
if (a==false)
    return;
```

Format changes

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if ( a==true ) return;
```

```
if (a==true)
    return;
```

FALSE POSITIVE

BUG FIX

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if (a==true)
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FALSE POSITIVE

BUG FIX

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if (a==false)
     return;
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Ignoring format changes removes 18%~25% as false positives and identifies further 13%~14%.

Fixes that affect many files

Most large fixes are refactoring

```
- public boolean visit(TypeDeclaration
-   typeDeclaration, BlockScope scope){
+ public boolean visit(LocalTypeDeclaration
+  typeDeclaration, BlockScope scope){
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- public boolean visit(TypeDeclaration
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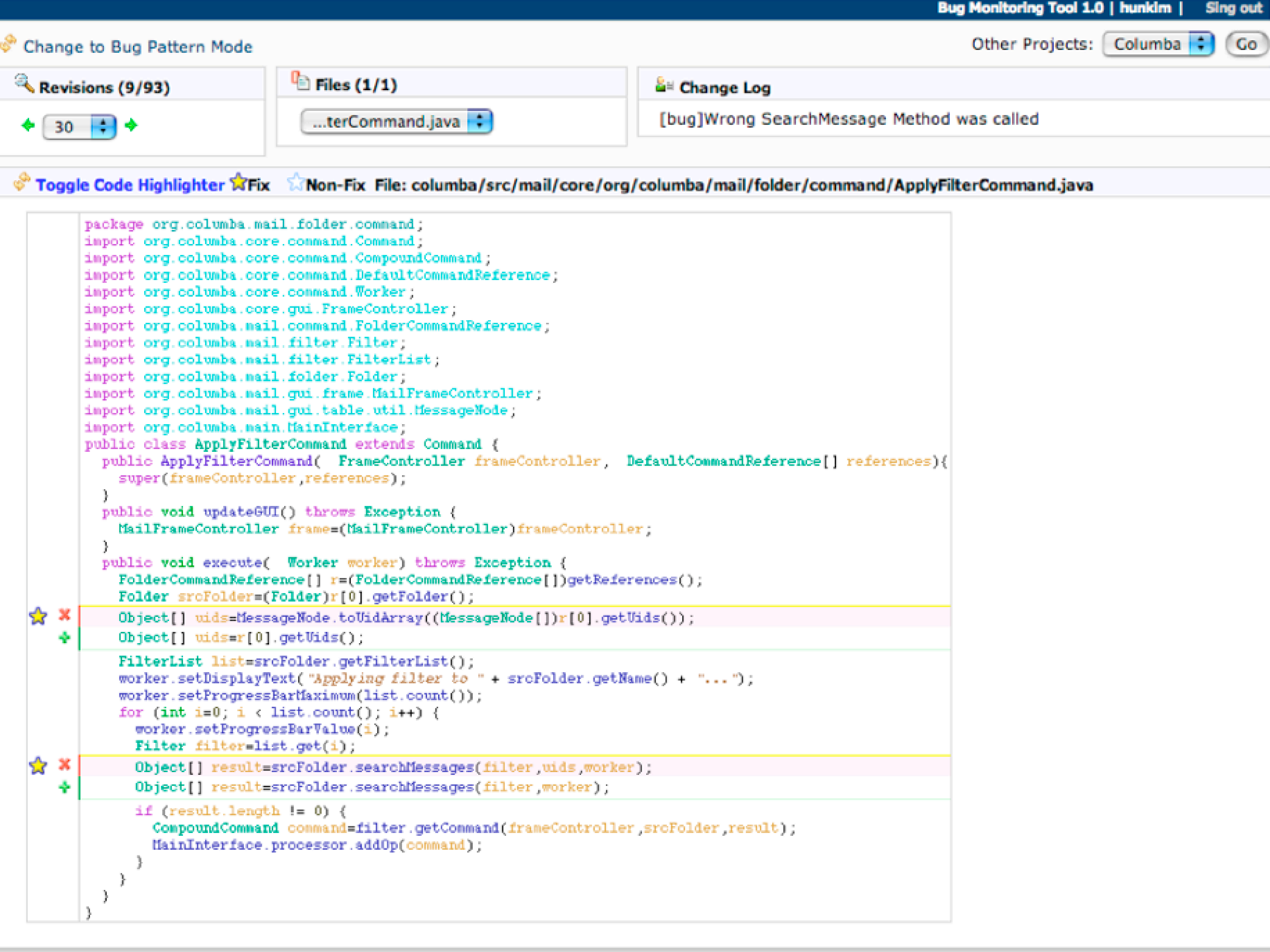
Ignoring fixes that affect many files
(=more than five times the median)
removes 7%~16% as false positives


Bug Monitoring Tool 1.0 | hunkim | Sing out
Change to Bug Pattern Mode
Other Projects: Columba Go
Revisions (9/93)
30
Files (1/1)
...terCommand.java
Change Log
Toggle Code Highlighter Fix Non-Fix

[bug]Wrong SearchMessage Method was called

File: columba/src/mail/core/org/columba/mail/folder/command/ApplyFilterCommand.java

```
package org.columba.mail.folder.command;
import org.columba.core.command.Command;
import org.columba.core.command.CompoundCommand;
import org.columba.core.command.DefaultCommandReference;
import org.columba.core.command.Worker;
import org.columba.core.gui.FrameController;
import org.columba.mail.command.FolderCommandReference;
import org.columba.mail.filter.Filter;
import org.columba.mail.filter.FilterList;
import org.columba.mail.folder.Folder;
import org.columba.mail.gui.frame.MailFrameController;
import org.columba.mail.gui.table.util.MessageNode;
import org.columba.main.MainInterface;
public class ApplyFilterCommand extends Command {
  public ApplyFilterCommand( FrameController frameController,  DefaultCommandReference[] references){
    super(frameController,references);
  }
  public void updateGUI() throws Exception {
    MailFrameController frame=(MailFrameController)frameController;
  }
  public void execute(  Worker worker) throws Exception {
    FolderCommandReference[] r=(FolderCommandReference[])getReferences();
    Folder srcFolder=(Folder)r[0].getFolder();
-   Object[] uids=MessageNode.toUidArray((MessageNode[])r[0].getUids());
+   Object[] uids=r[0].getUids();
    FilterList list=srcFolder.getFilterList();
    worker.setDisplayText("Applying filter to " + srcFolder.getName() + "...");
    worker.setProgressBarMaximum(list.count());
    for (int i=0; i < list.count(); i++) {
      worker.setProgressBarValue(i);
      Filter filter=list.get(i);
-     Object[] result=srcFolder.searchMessages(filter,uids,worker);
+     Object[] result=srcFolder.searchMessages(filter,worker);
      if (result.length != 0) {
        CompoundCommand command=filter.getCommand(frameController,srcFolder,result);
        MainInterface.processor.addOp(command);
      }
    }
  }
}
```

Manual inspection of fixes

Two judges check whether a fix is actually a fix.

```
  deleteResources(actualNonJavaResources,fForce);
- IResource[] remaingFiles;
+ IResource[] remainingFiles;
  try {
-      remaingFiles=((IFolder)res).members();
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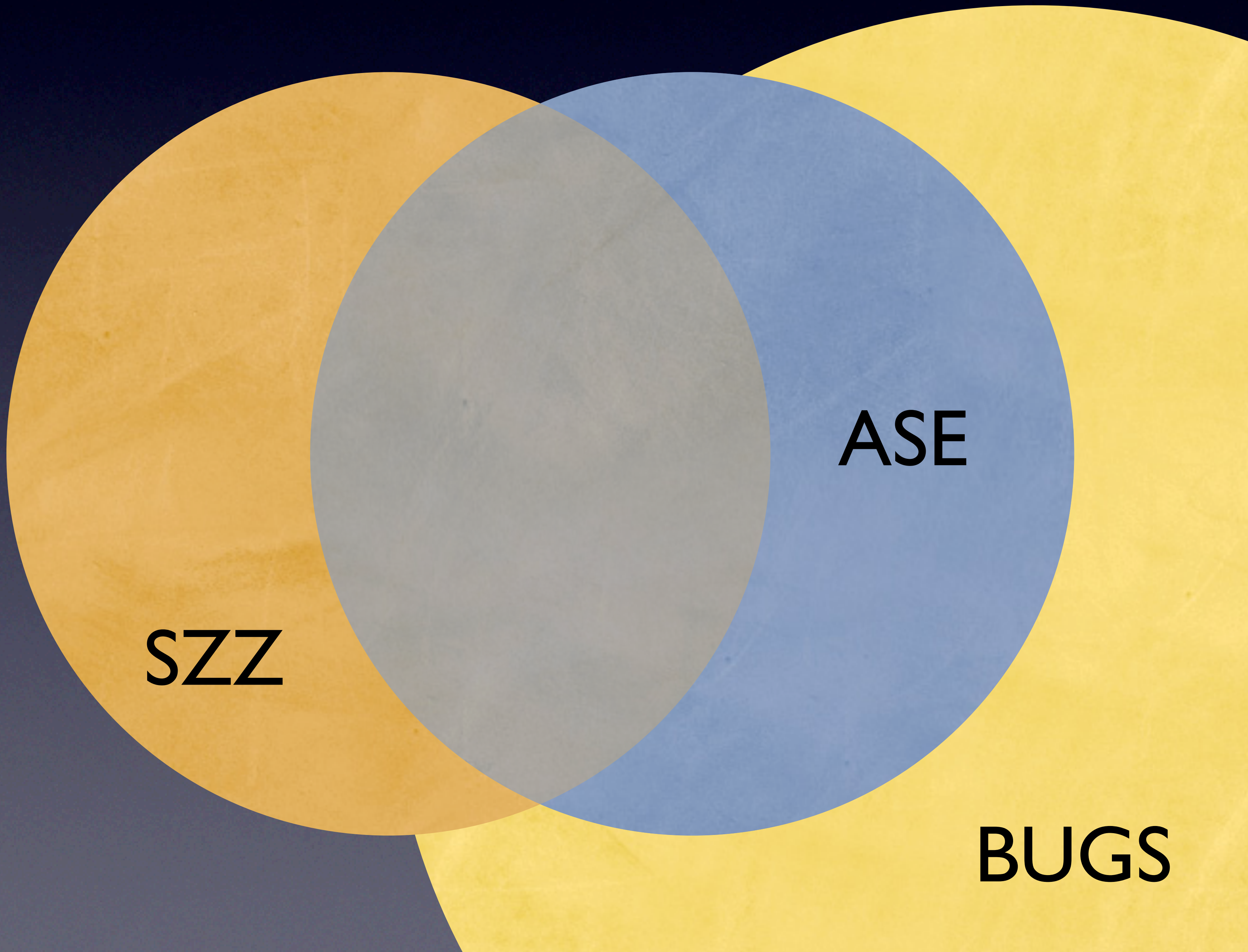
Manual inspection of fixes removes only 4%~5% as false positives.

Putting it together



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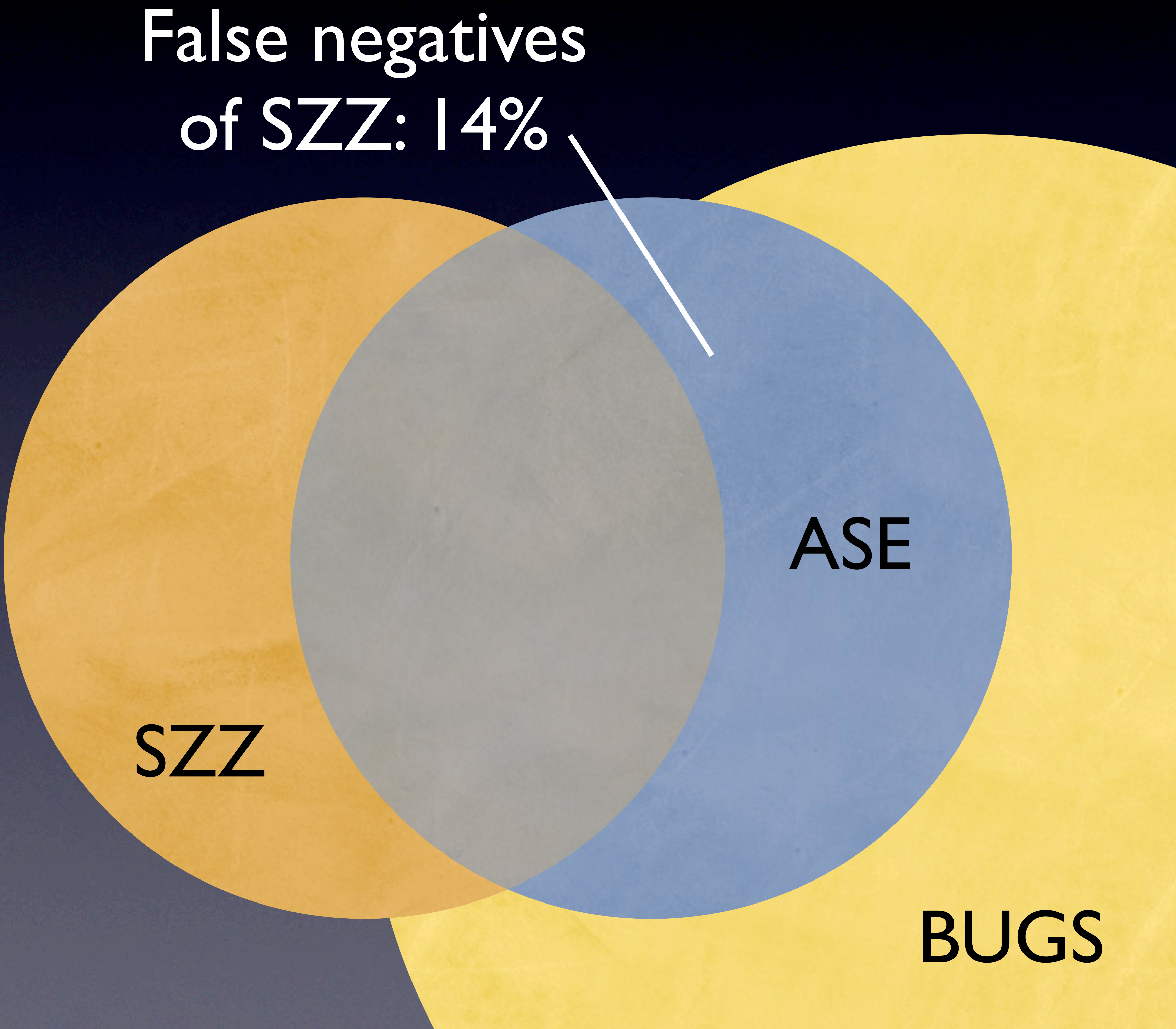

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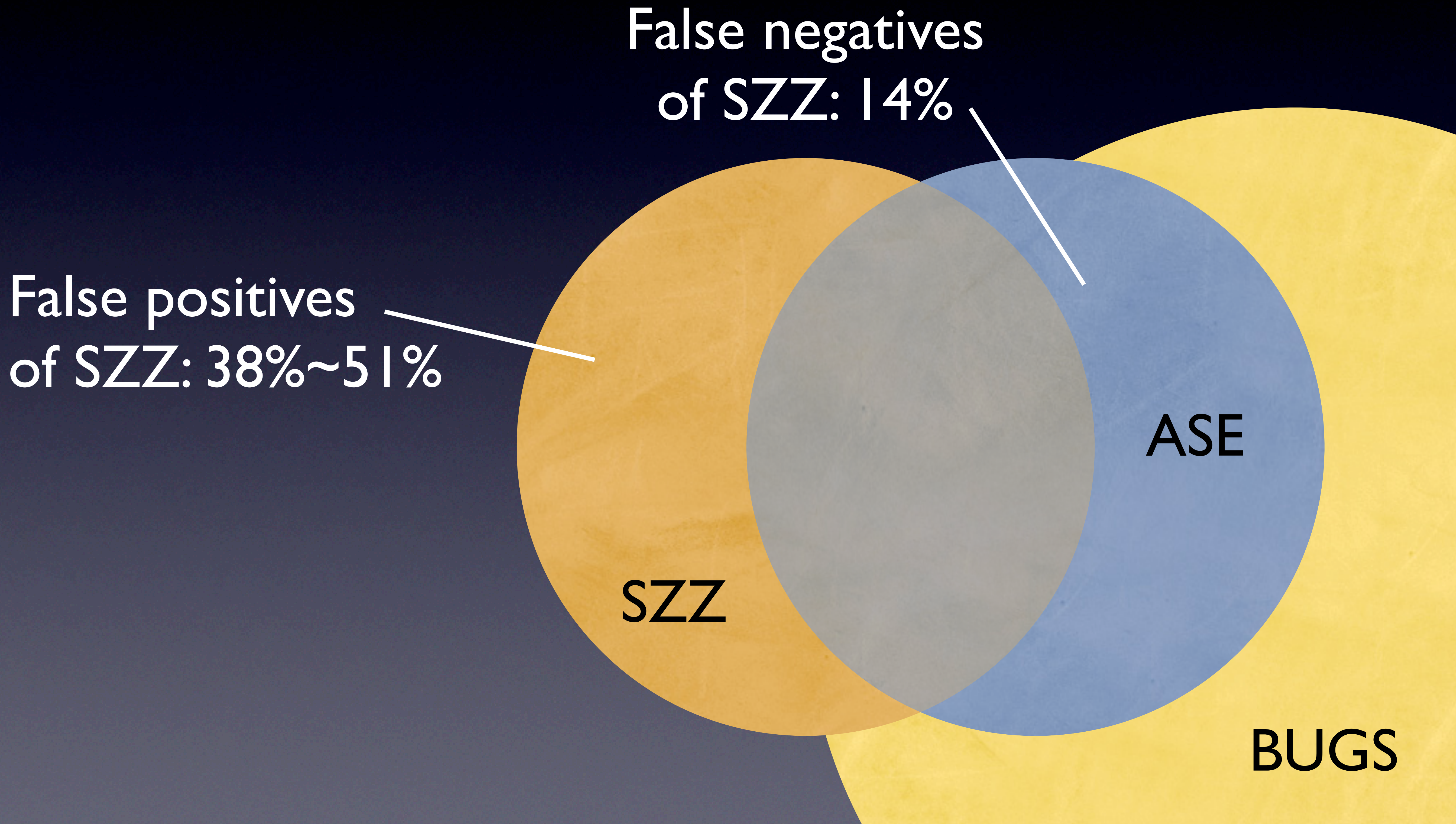

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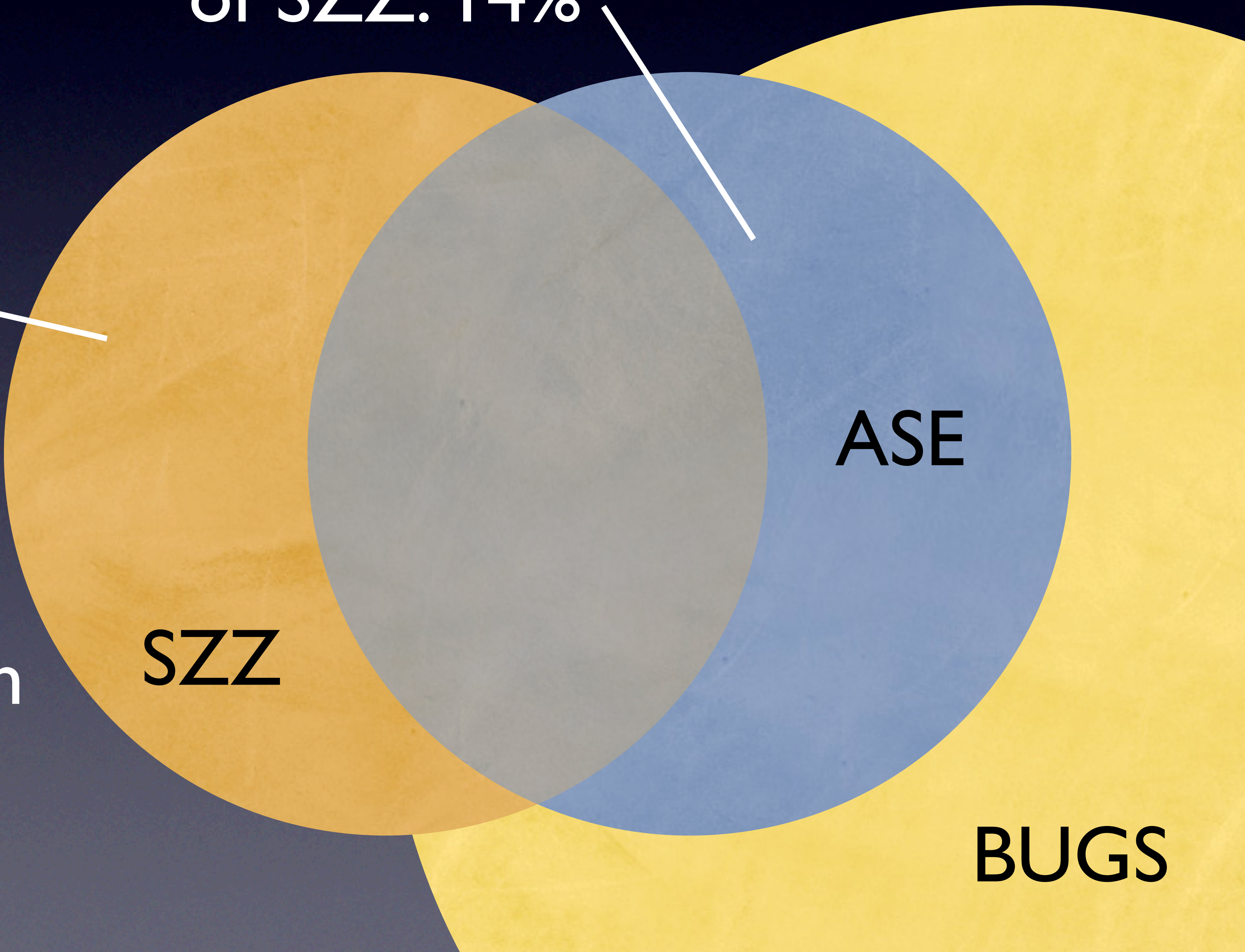
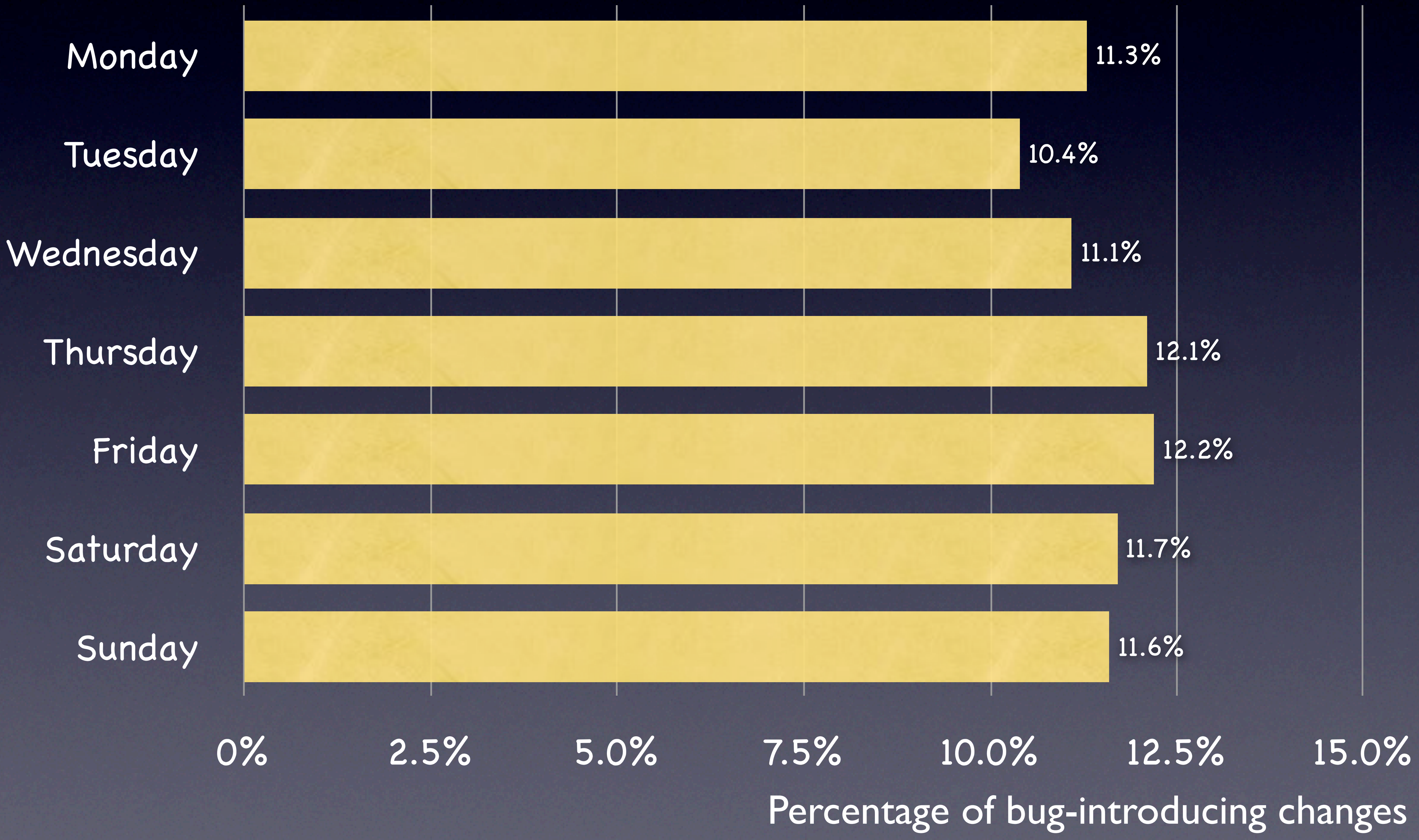


False negatives of SZZ: 14%

False positives of SZZ: 38%~51%

Automatically we can remove 36%~48% as false positive.

Don’t program on Fridays ;-)



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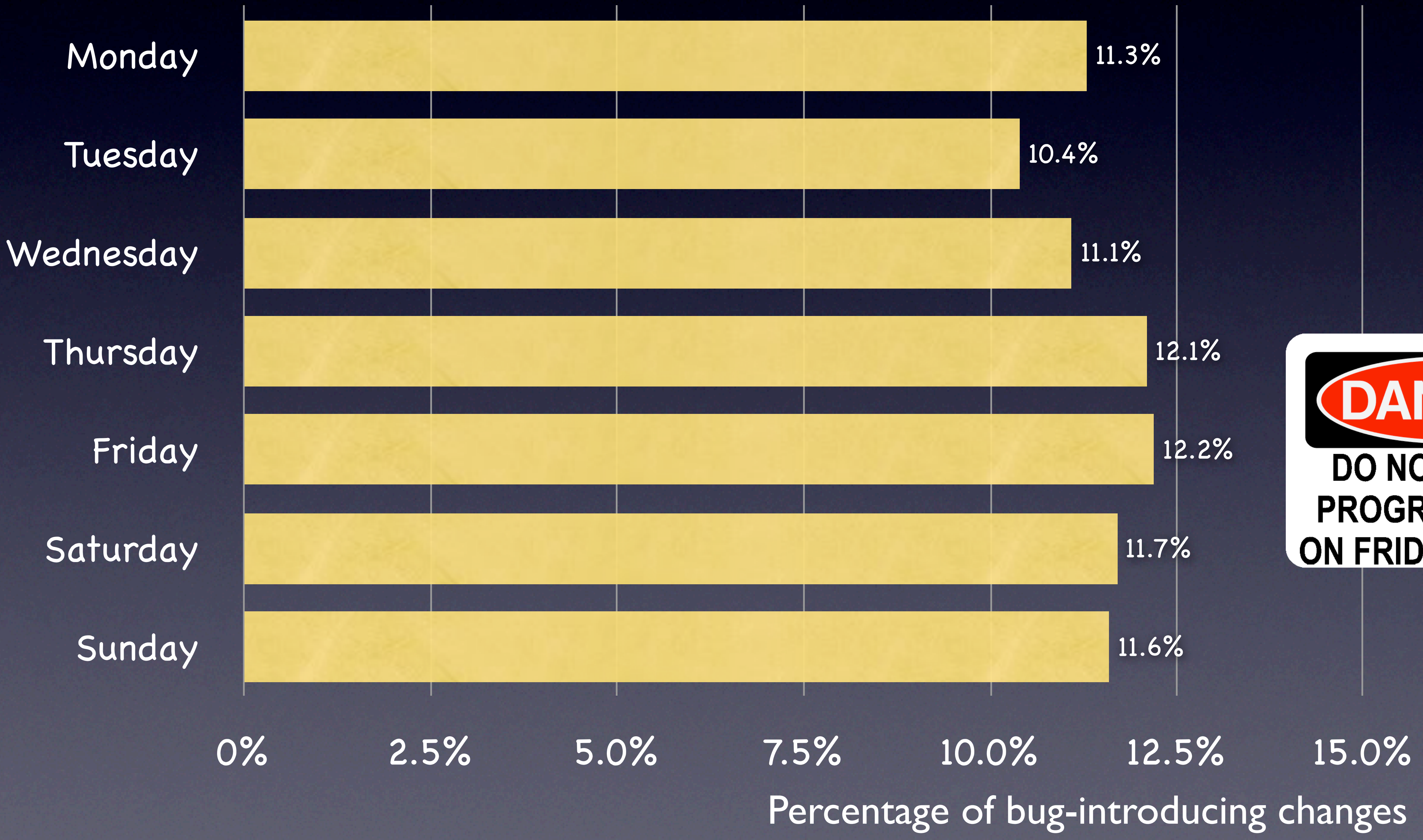
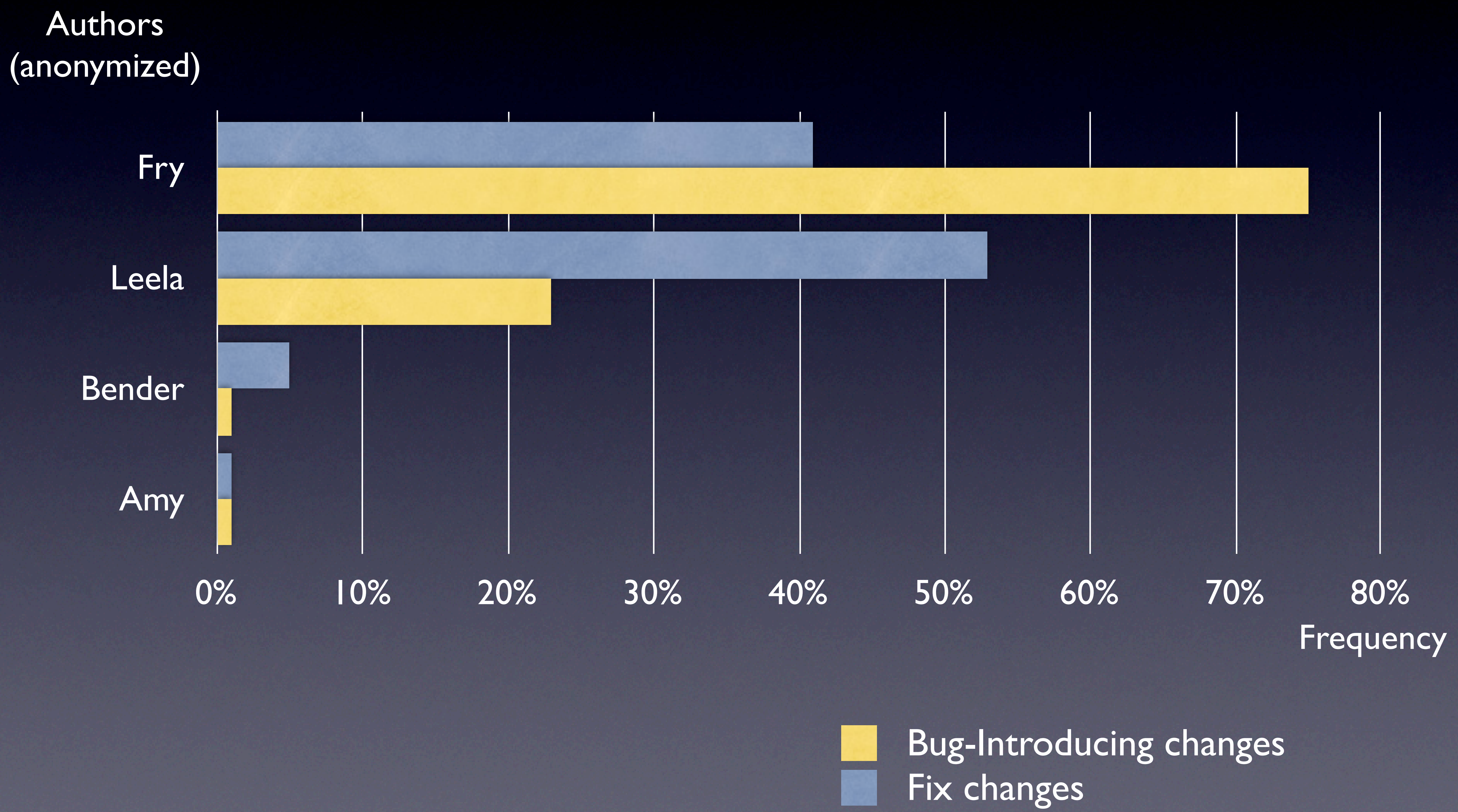


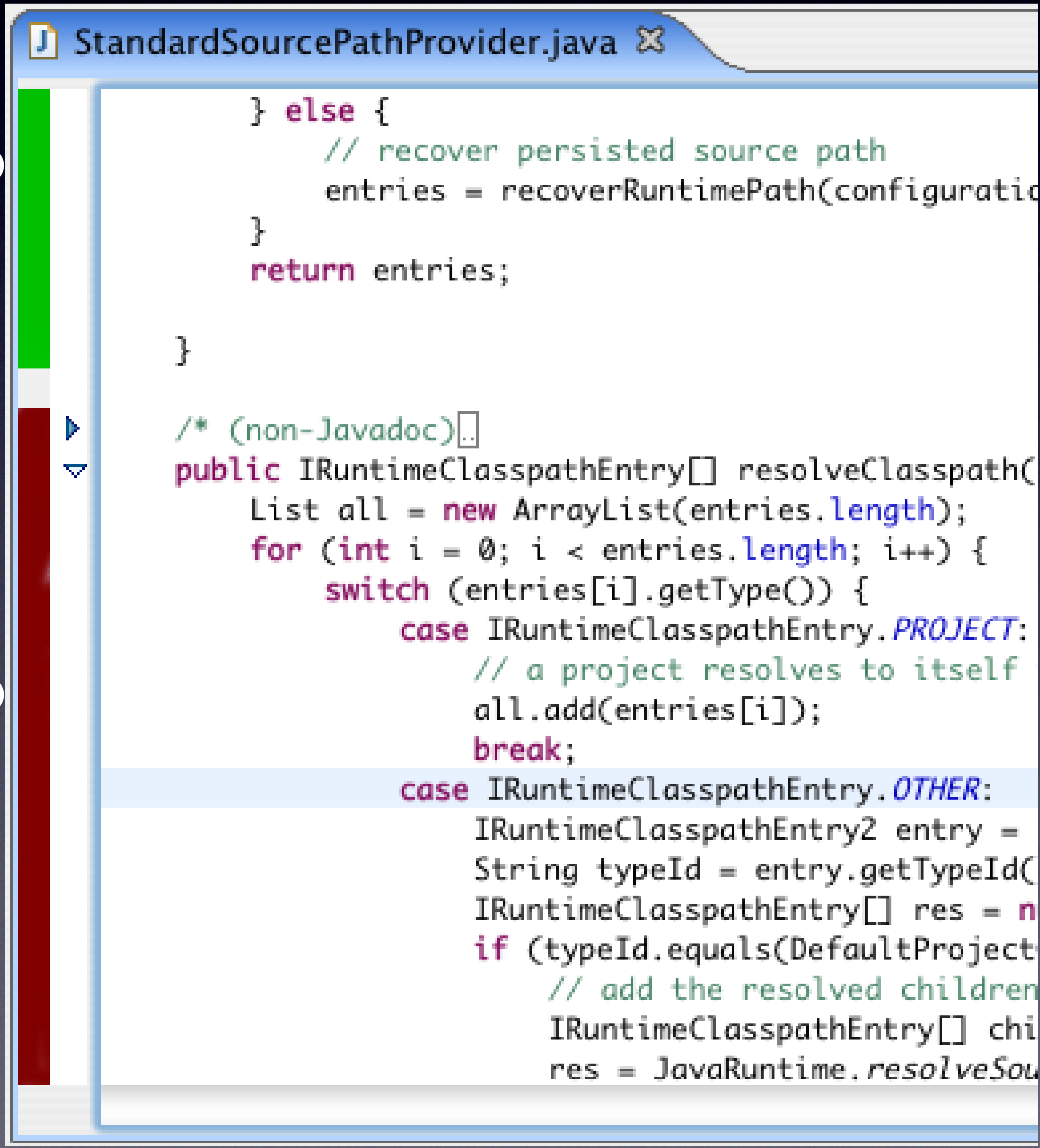
Defect-prone authors



Risk awareness

"Safe" Location (green)

Risky Location (dark red)



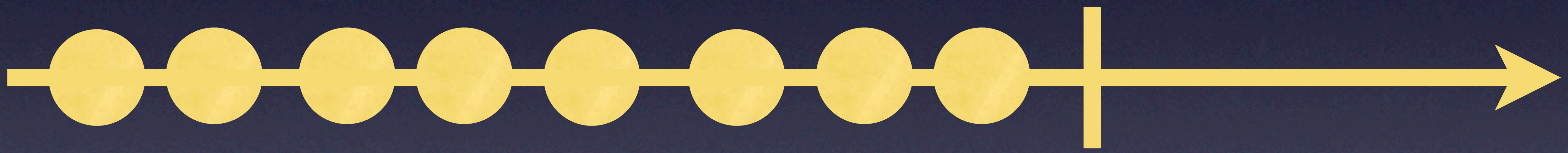
StandardSourcePathProvider.java

```
        } else {
            // recover persisted source path
            entries = recoverRuntimePath(configuratio
        }
        return entries;

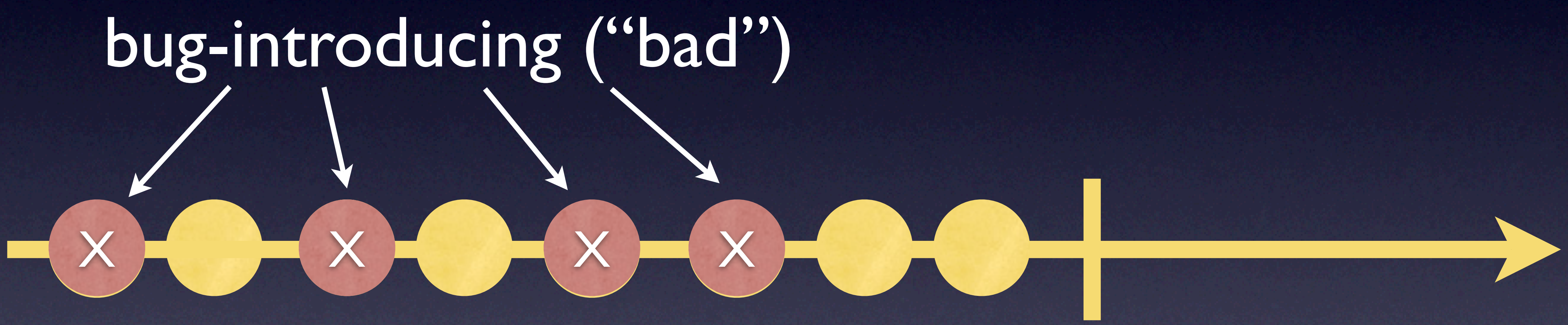
    }

    /* (non-Javadoc)
    public IRuntimeClasspathEntry[] resolveClasspath(
        List all = new ArrayList(entries.length);
        for (int i = 0; i < entries.length; i++) {
            switch (entries[i].getType()) {
                case IRuntimeClasspathEntry.PROJECT:
                    // a project resolves to itself
                    all.add(entries[i]);
                    break;
                case IRuntimeClasspathEntry.OTHER:
                    IRuntimeClasspathEntry2 entry =
                    String typeId = entry.getTypeId(
                    IRuntimeClasspathEntry[] res = n
                    if (typeId.equals(DefaultProject
                        // add the resolved children
                        IRuntimeClasspathEntry[] chi
                        res = JavaRuntime.resolveSou
```

Change classification

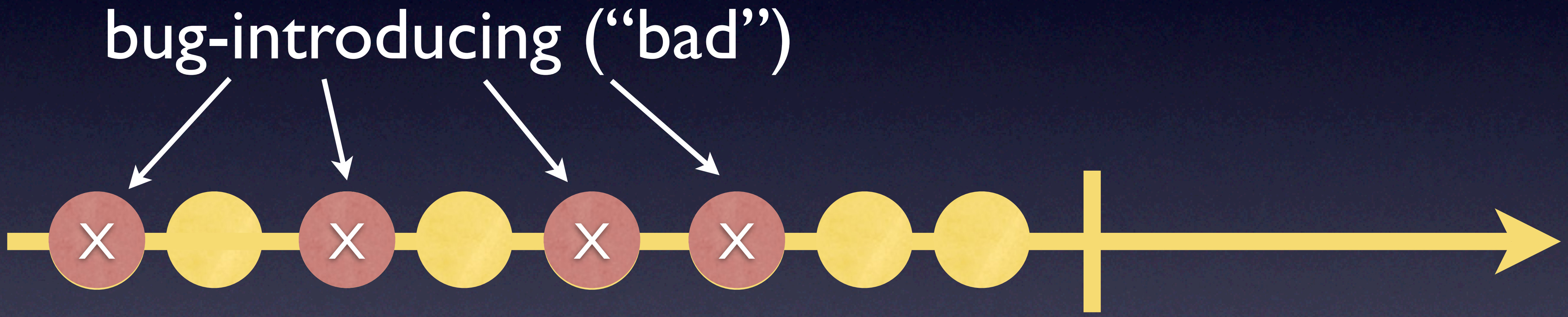


Change classification



Change classification

BUILD A CLASSIFIER



Change classification

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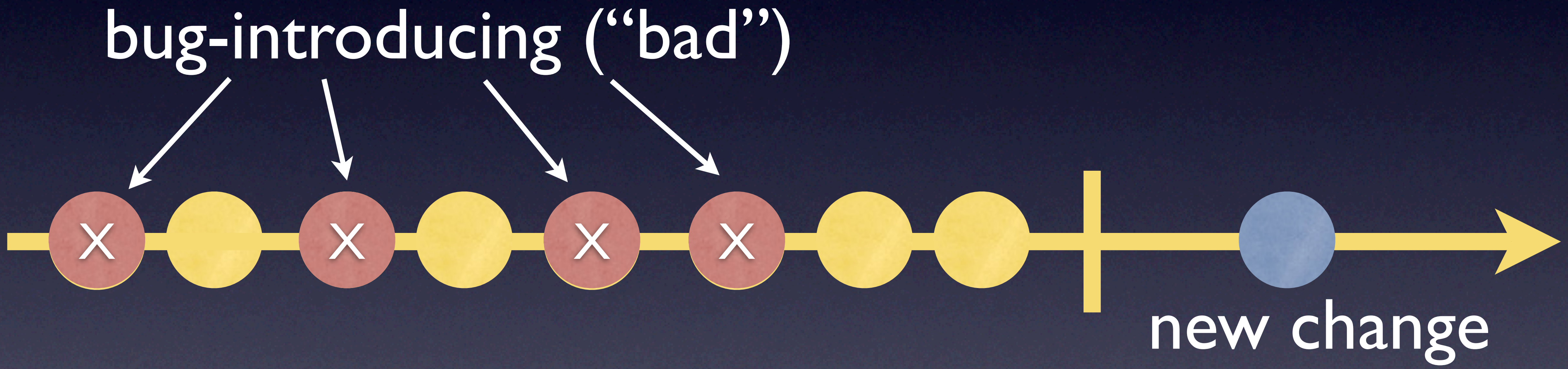

Change classification

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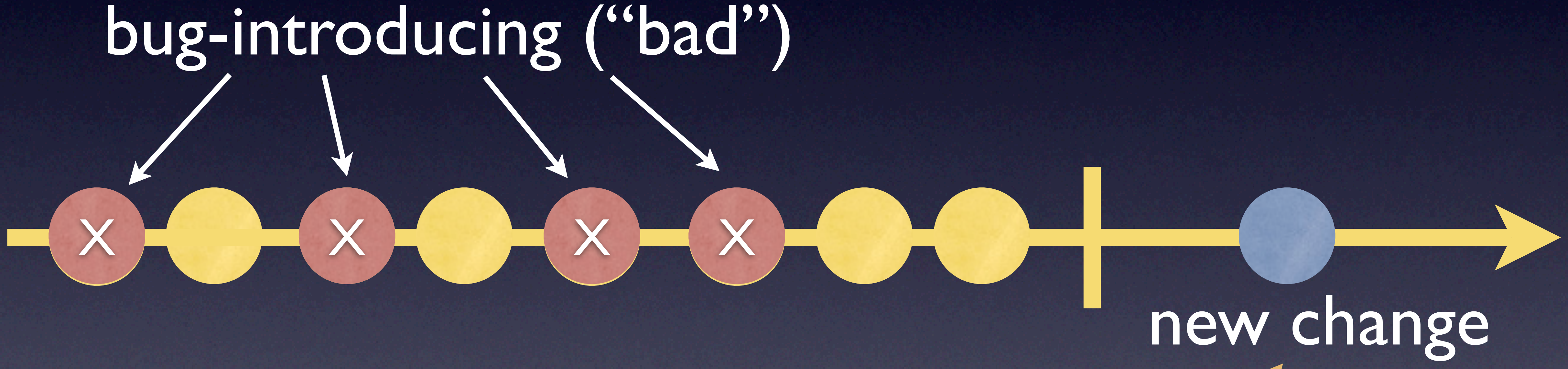

PREDICT QUALITY

Conclusions

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More mining @ ASE:
Friday morning.

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