Introducing cling

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cling?

C++

cling?

LHC++

cling?

cling$ LHC++

cling?

cling$ LHC++
(int const) 42

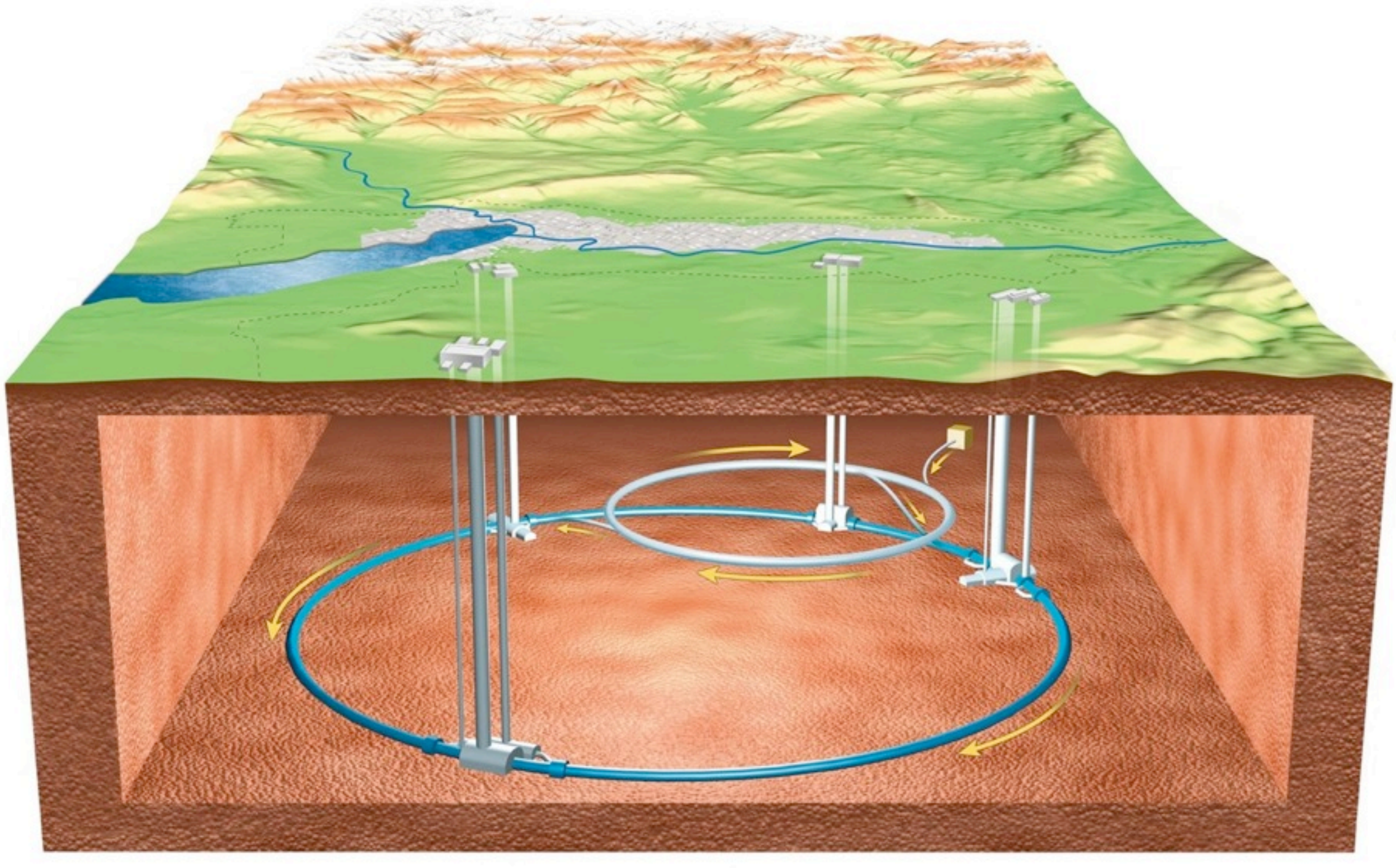
CERN, LHC

- fundamental research: high energy physics
- international organization in Geneva, CH
- main tool: Large Hadron Collider
  - proton smasher's measurements: 8TeV, 2K, 27km
  - several experiments, 10'000 users

Postcard From CERN

Postcard From CERN

Underground Science



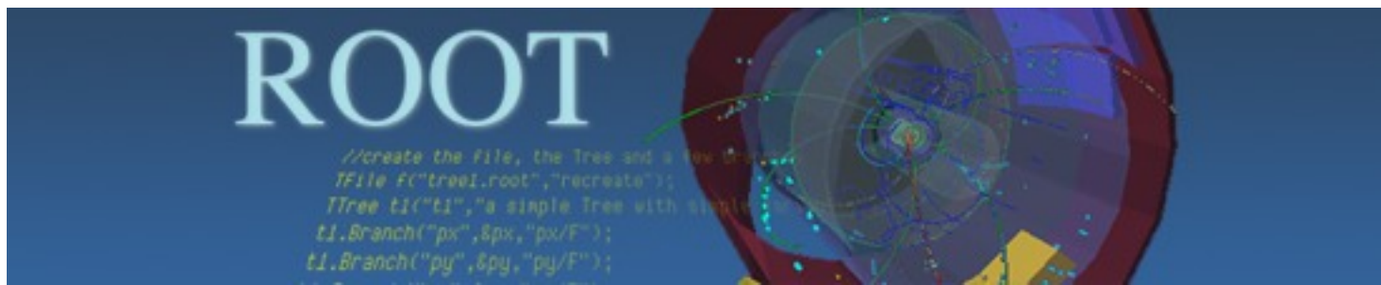
Big Questions, Big Tools

The C++ in CERN

- data analysis = interfacing with experiments' code
- several GB of libraries, hundreds of thousands of types / templates, 50MLOC C++ code
- physics is the goal, computing the tool

http:// ROOT .cern.ch

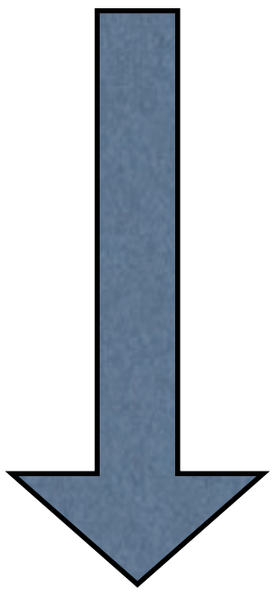
- data analysis (math), persistency (I/O), visualization (graphics),...
- about 20’000 users, also outside science
- core software element for experiments
- interface point for experiment’s code
- C++ interpreter CINT almost 20 years old



Use of Interpreters

1970

access data



today

Use of Interpreters

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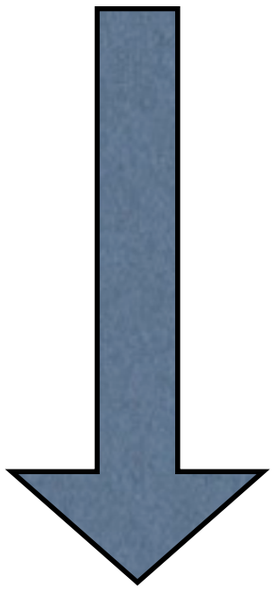

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simple expressions

Use of Interpreters

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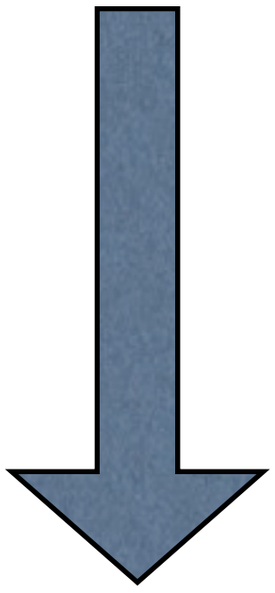

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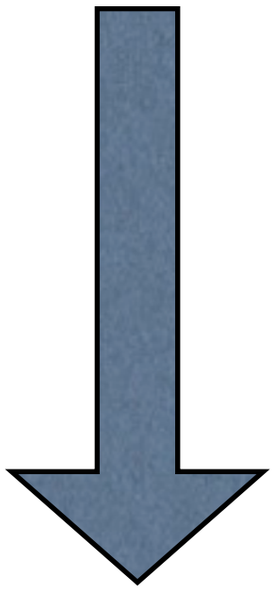

today

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prototype algorithm

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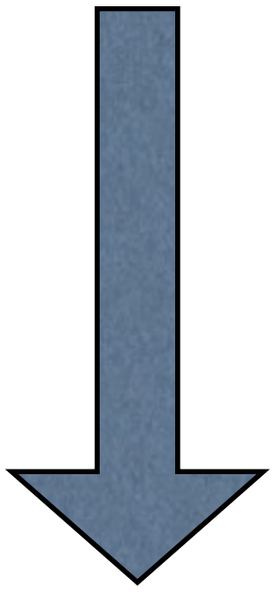

today

access data

simple expressions

simple algorithms

prototype algorithm

develop code

Setup

Experiment's code

Third-party libraries

Persistent data

User code

Interpreter

Current Use

- IDE-on-the-prompt
- interpreter = not linking + state
- rapid edit / “compile” / run cycles
- exploration-driven development
- matches physics analysis approach with its gradual optimizations

cling: interpreting C++

- http://cern.ch/cling
- based on LLVM http://llvm.org
  + clang http://clang.llvm.org
- developed by team @ CERN and Fermilab
- maps interpreter to compiler concept
- not an interpreter: JIT!

cling's Translation Unit

- AST keeps growing as input comes
- incremental parsing, codegen, evaluation
  - action at end of translation unit now at end of input transaction
    - pending template instantiation
    - codegen

Expr vs Decl

```
cling$ int i = 1; sin(i++)
```

- decls must stay visible across input lines
- expressions must be evaluated
- ...and is it decl or expr or both?

Expr vs Decl (2)

```
cling$ int i = 1; sin(i++)
```

1. determine whether decl or expr:
   manipulation of input string

```
void wrap_0() {
  int i = 1; sin(i++); }
```

Expr vs Decl (3)

```
cling$ int i = 1; sin(i++)
```

```
void wrap_0() {
  int i = 1; sin(i++); }
```

2. extend decl lifetime: move onto global scope (AST editing)

```
int i = 1;
void wrap_0() { sin(i++); }
```

Expressions

```
int i = 1;
void wrap_0() { sin(i++); }
```

3. call wrap_0() to evaluate expressions
4. print value if no trailing ';'
   uses template magic on AST level:

```
cling$ int i = 1; sin(i++)
(double const) 8.414710e-01
```

Details, details

- global initialization after each input - but not re-initialization
- collect global destructors to run at ~cling()
- error recovery reverting whole input transaction and its AST nodes

Dynamic Scopes

```
if (date % 2) {
  TFile f(getFilename());
  objInFile->Draw();
}
```

- inject serialized C++ objects into scope
- delay expression evaluation until runtime
- compiler as a service - sort of like DLR

JIT

- optimized code
- ABI-compatible:
  in-memory layout vs serialization
- calls into native libraries

```
$ echo 'const char* zlibVersion();
zlibVersion()' | cling -x c -lz
(const char * const) "1.2.3.4"
```

Reflection

- weak point in C++
- can tap clang's AST!
  + target info!
  + ABI!
- dynamic, two ways: query + edit AST

Growing cling

- clang vs. Windows C++ ABI!
- clang as front-end, thus C++11
- ObjC[++] can be extended (not by CERN)
- OpenCL could be done
- or new front-ends? LINQ, anyone?

Where?

- available in subversion:
  http://root.cern.ch/svn/root/trunk/cint/cling
- stable: few interface changes, only 10k LOC
- works on anything with clang + LLVM-JIT
  (thus not native Windows ABI)
- stand-alone binary plus modular C++
  libraries like LLVM + clang

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Interpreter Language

- C++: complex syntax, verbose, precise; improvements from C++11
- Current #1 alternative python: simple syntax, casual code

PyROOT

- bi-directional

```
TPython::Exec("print \'PyROOT!\'");
```

```
from ROOT import TLorentzVector
b = TLorentzVector()
b.SetX(1.0)
```

- map concepts (iterators, dictionary)

PyROOT Internals

- reflection-, not stub-based: highly dynamic
- injects C++ methods into python
- objects traverse language boundary
- performant: caches, annotates python objects with PyROOT metadata

iC++ vs iPython

- migrating python code to C++: difficult
- interfacing C++ though python: difficult
- writing 1 MLOC python: easy
- python is slow ("thanks to python, we are not I/O bound anymore!")

Conclusion: Interpreter

- interpreters enable dynamic access to huge binary worlds
- different approach to programming
- reflection is the key: interpreter binding, serialization, dynamic behavior

Conclusion: Language

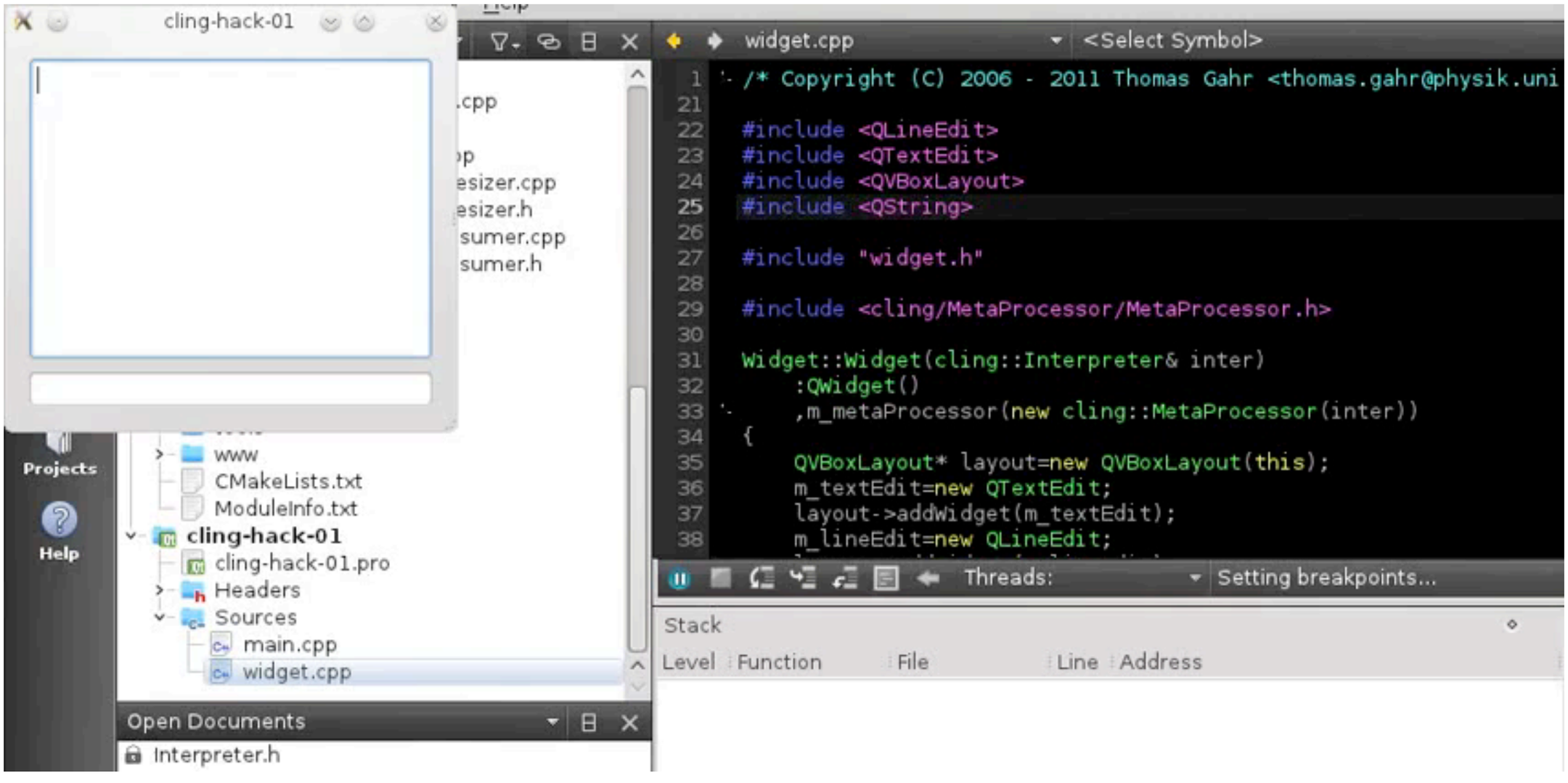
- choice of languages still limits us
- python is simple but slow; interface with C++ difficult but possible
- C++ easily too complex for novices
- either language dead-end: no interfaces from other languages (extern “C++”)

Conclusion: cling

- based on decades of experience with novices, code development, large libraries - and CINT
- clang + llvm make miracles happen
- it's stable and fun: enjoy it!

Offline Demo

- demo by “arbitrary (smart) user” Thomas Gahr showing powers of Qt + cling
- http://youtu.be/BrjV1ZgYbbA
- recursive youtube!



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