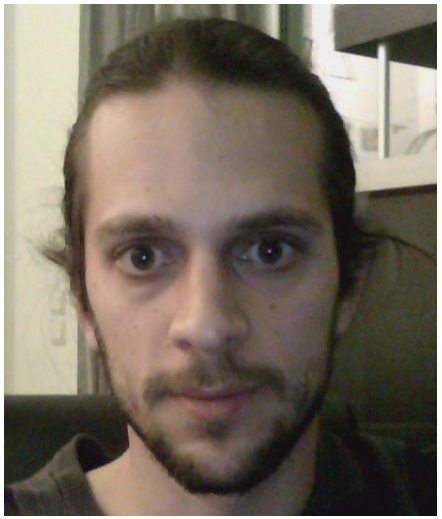
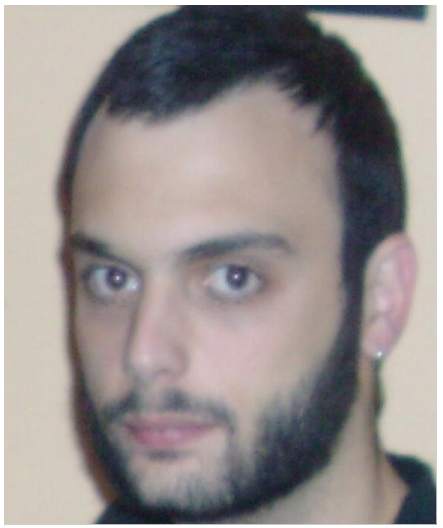
(e)rLLVM

Kostis Sagonas



joint work with

Chris Stavrakakis and **Yiannis Tsiouris**



What is ErLLVM?

- A project aiming to provide multiple back-ends for the **High Performance Erlang (HiPE)** native code compiler of Erlang/OTP ...
- … using the **Low Level Virtual Machine (LLVM)** compiler infrastructure …
- … in order to *improve the performance* of Erlang applications …
- … and *ease the maintenance* of its native code compiler.

This talk

- Overview and design
  - HiPE native code compiler
  - LLVM compiler infrastructure
- Architecture and implementation of ErLLVM
  - LLVM extensions
  - New HiPE component
- Performance evaluation
  - vs. BEAM
  - vs. HiPE
- Current status and future work

HiPE: High Performance Erlang

- Project at Uppsala University started in 1997
- Developed the native code compiler for Erlang
  - Integrated into Erlang/OTP since 2001
- A *mature* compiler that is *robust* and produces *reasonably efficient* code
- Back ends for
  - SPARC V8+
  - x86 and x86_64 (AMD64)
  - PowerPC and PowerPC64
  - ARM

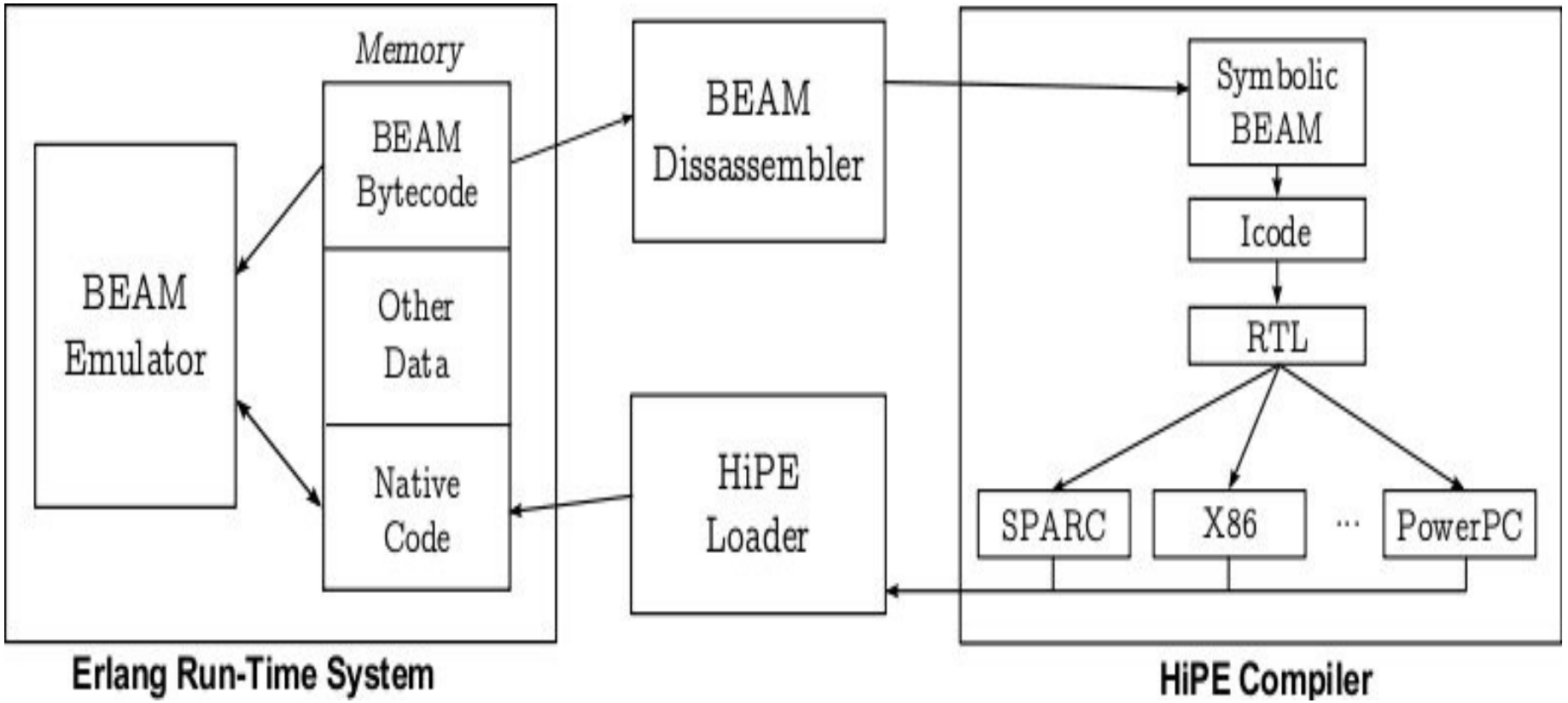
LLVM: Low Level Virtual Machine

- Collection of industrial strength compiler technology
  - Language-independent *optimizer* and *code generator*
    - Many optimizations, many targets, generates good code
  - Clang C/C++/Objective-C front end
    - Designed for speed, reusability, compatibility with GCC
  - Debuggers, “binutils”, standard libraries
    - Providing pieces of low-level tools, with many advantages
- High-level portable LLVM assembly
  - RISC-like instruction set; static type system; SSA form
  - Three forms: human-readable, on-disk, in-memory

Why LLVM?

- Used as a static or JiT compiler and for static analysis
- State-of-the-art software with very active community of developers
- A new compiler = glue code + any components not yet available. Allows choice of the right components for the job, e.g. register allocator, scheduler, optimization order.
- Supports many architectures: x86, x86_64, ARM, PowerPC, SPARC, Alpha, MIPS, Blackfin, CellSPU, Mblaze, MSP430, XCore, …
- Open source with a *BSD-like License* and many contributors: industry, research groups, individuals.

HiPE Architecture in Erlang/OTP



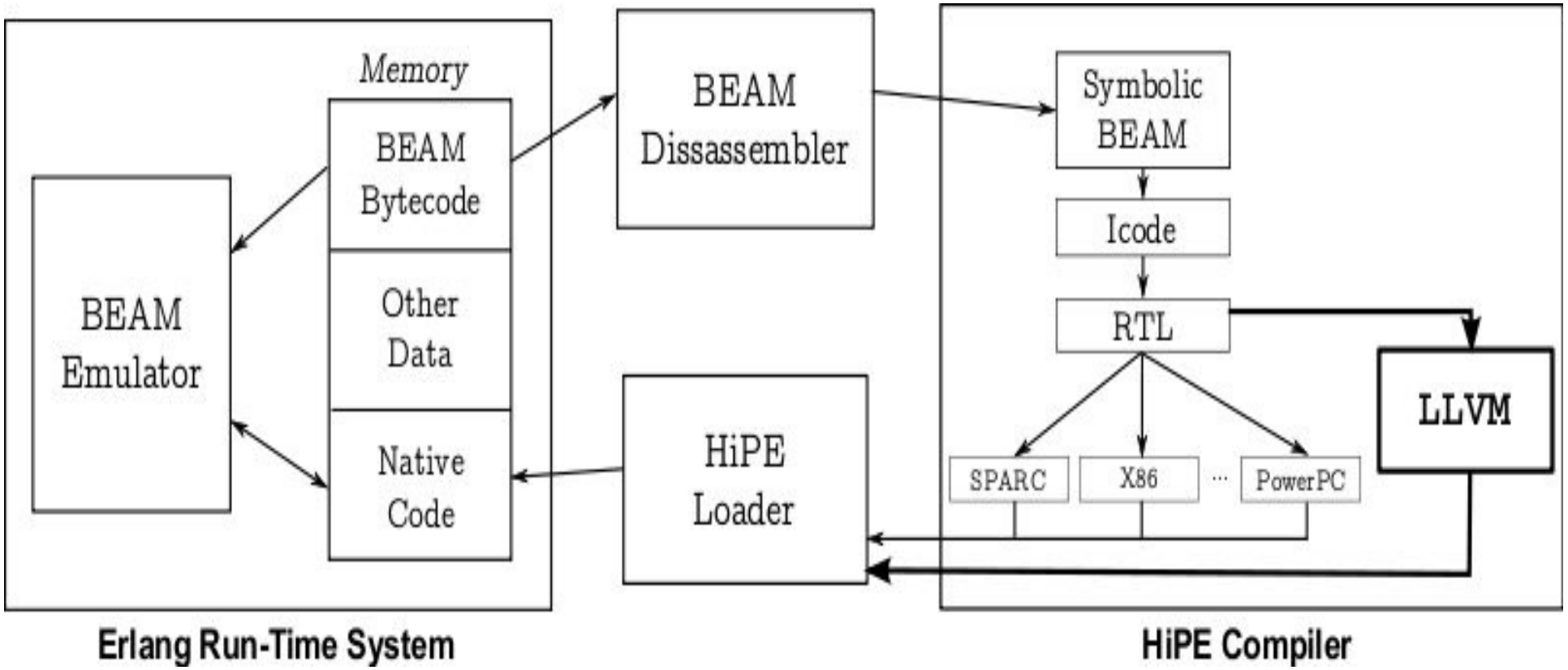
Structure of HiPE's Back-ends

- Register allocation
  - Many choices; default iterated register coalescing
- Frame management
  - Check for stack overflow
  - Set up frame
  - Create stack descriptors
  - Add “special” code for tailcalls
- Code linearization
- Assembly

Why use LLVM as a Back-end?

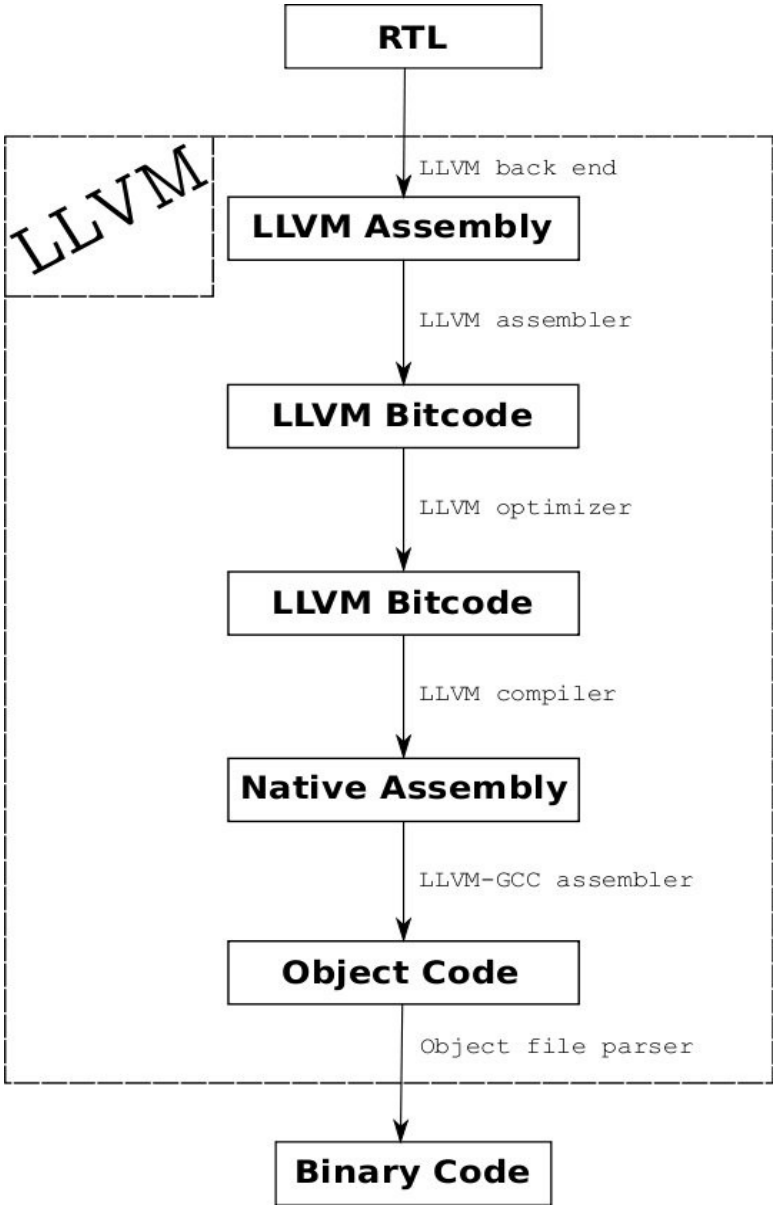
- Curiosity: perform a research experiment
- Easier maintenance of existing back-ends
  - One instead of six
  - Small-sized, straightforward code
  - Outsource implementation and further optimization
- Get more back-ends “for free” (well, almost...)
- Improve performance
  - Outsource target-related optimizations

HiPE Architecture in ErLLVM



- Use existing HiPE Loader and ERTS support
  - Be ABI compatible!

The LLVM Component



hipe_rtl2llvm	Create human-readable LLVM assembly (.ll)
llvm-as	Human-readable assembly (.ll) → LLVM bitcode (.bc)
opt	Optimization *Passes*, supports standard groups (-O1, -O2, -O3) (.bc → .bc)
llc	Bitcode (.bc) → Native assembly (.s), impose rules about memory model, stack alignment, etc.
llvm-gcc	Create object file (.s → .o)
elf64_format	Extract executable code and relocations

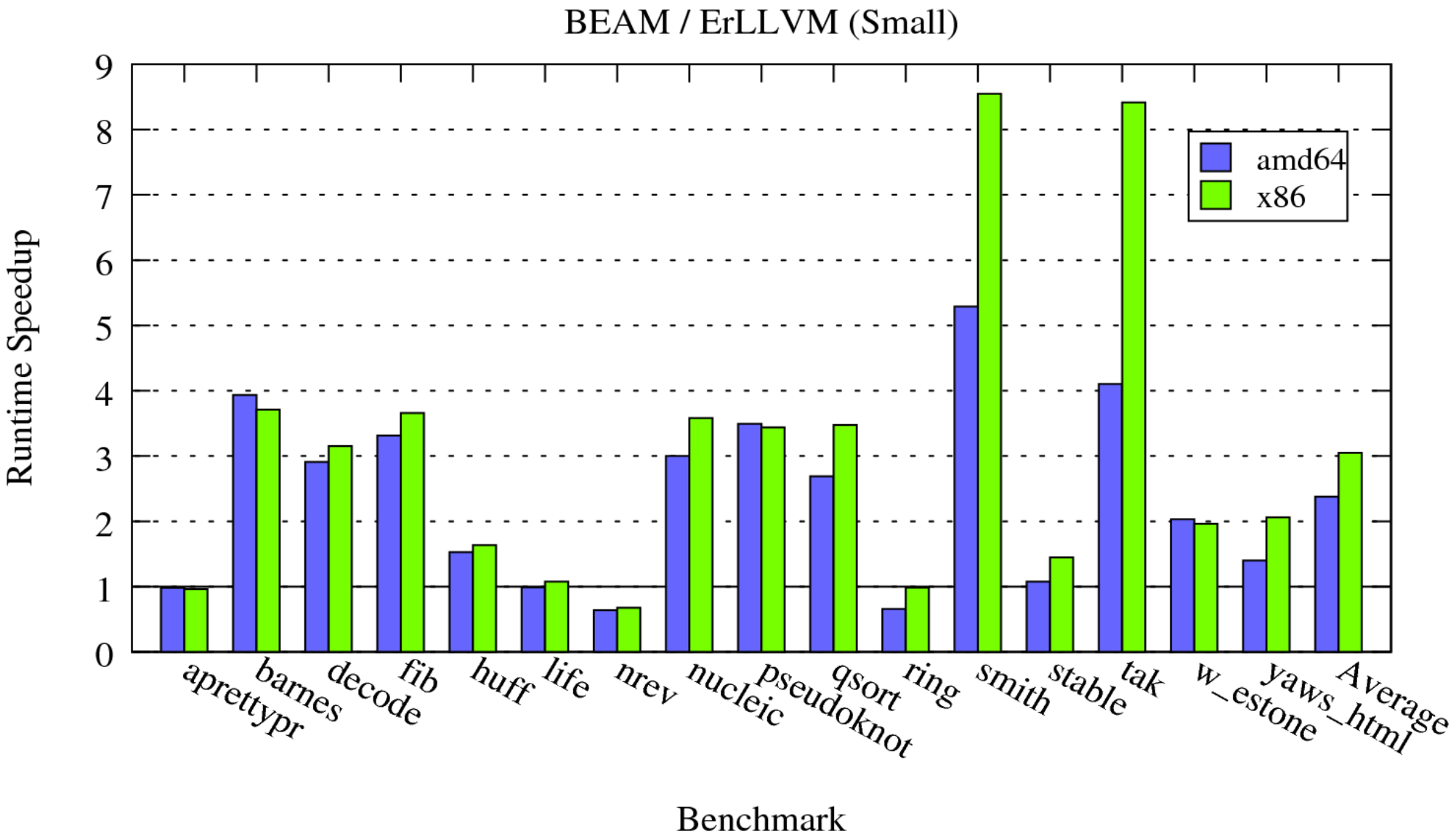
Subtle Points of Using LLVM

- Calling convention
  - VM “special” registers, args and return values
  - callee-/caller-save registers, callee pops args
- Explicit frame management
  - In-lined code for stack overflow checks in assembly prologue
- Stack descriptors
  - Exception handling
  - Precise garbage collection

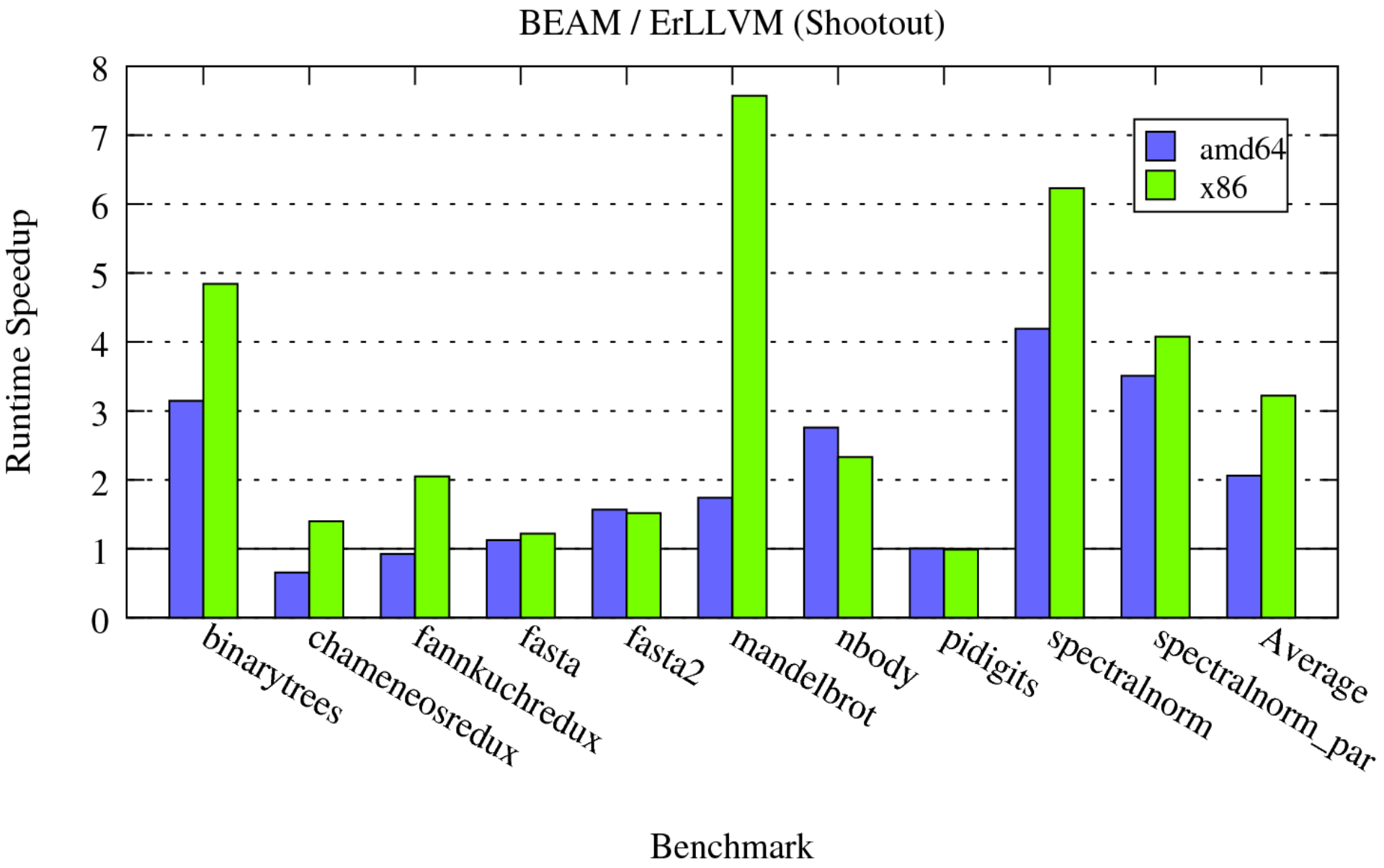
Current Status of ErLLVM

- Patches to LLVM
  - Custom calling convention & register pinning
  - GC plugin to write GC information in object file
    - Use **`elf_format`** to parse .o file and extract the info
  - Function pass to emit custom prologue
- New HiPE component on top of R15B “maint”
  - Support for x86 and x86_64
  - Support for *accurate GC:* mark stack slots not live when variables that “inhabit” them are no longer live
  - About 5000 LOC
- Very robust and ready to use in production!

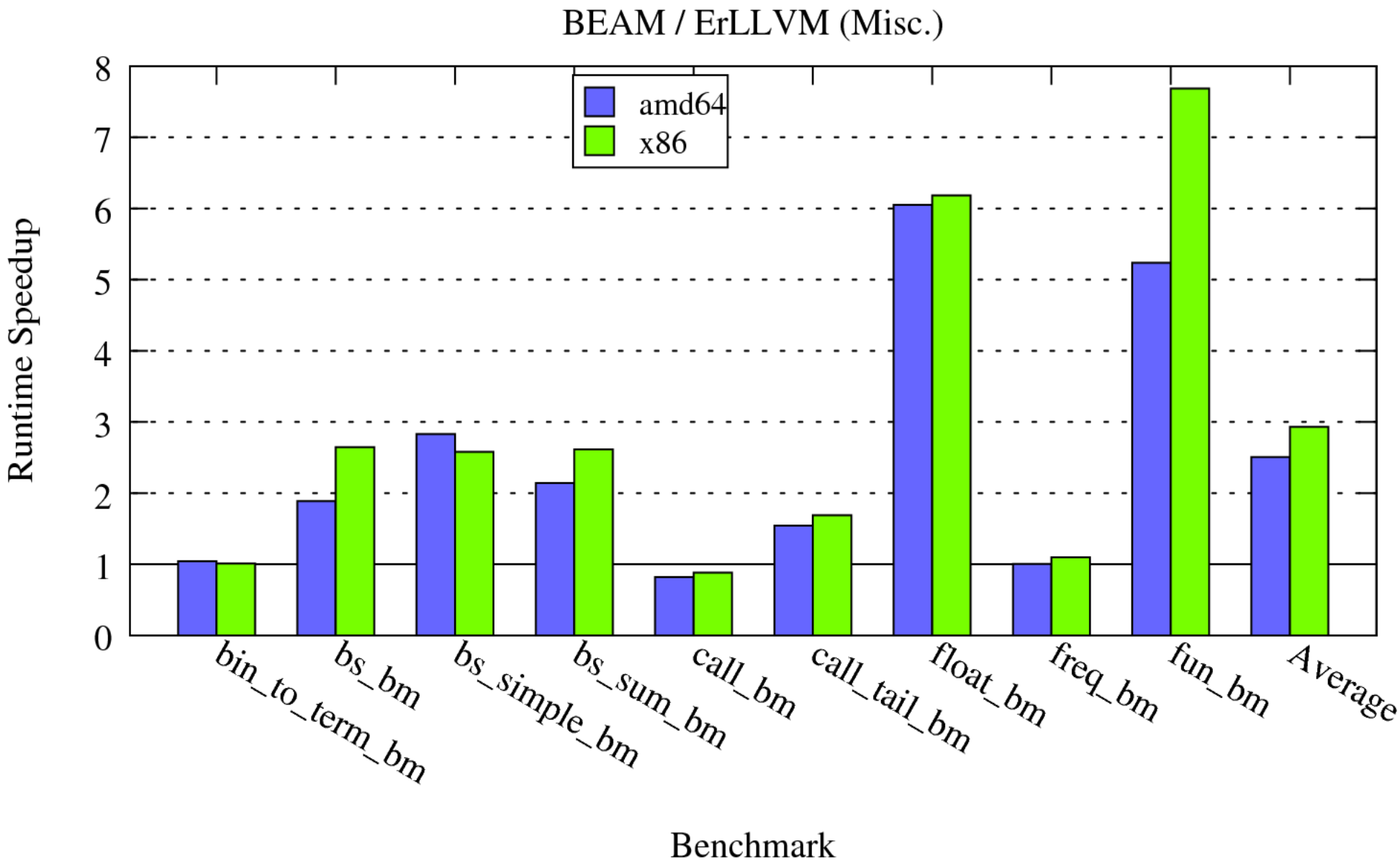
ErLLVM's Performance vs. BEAM



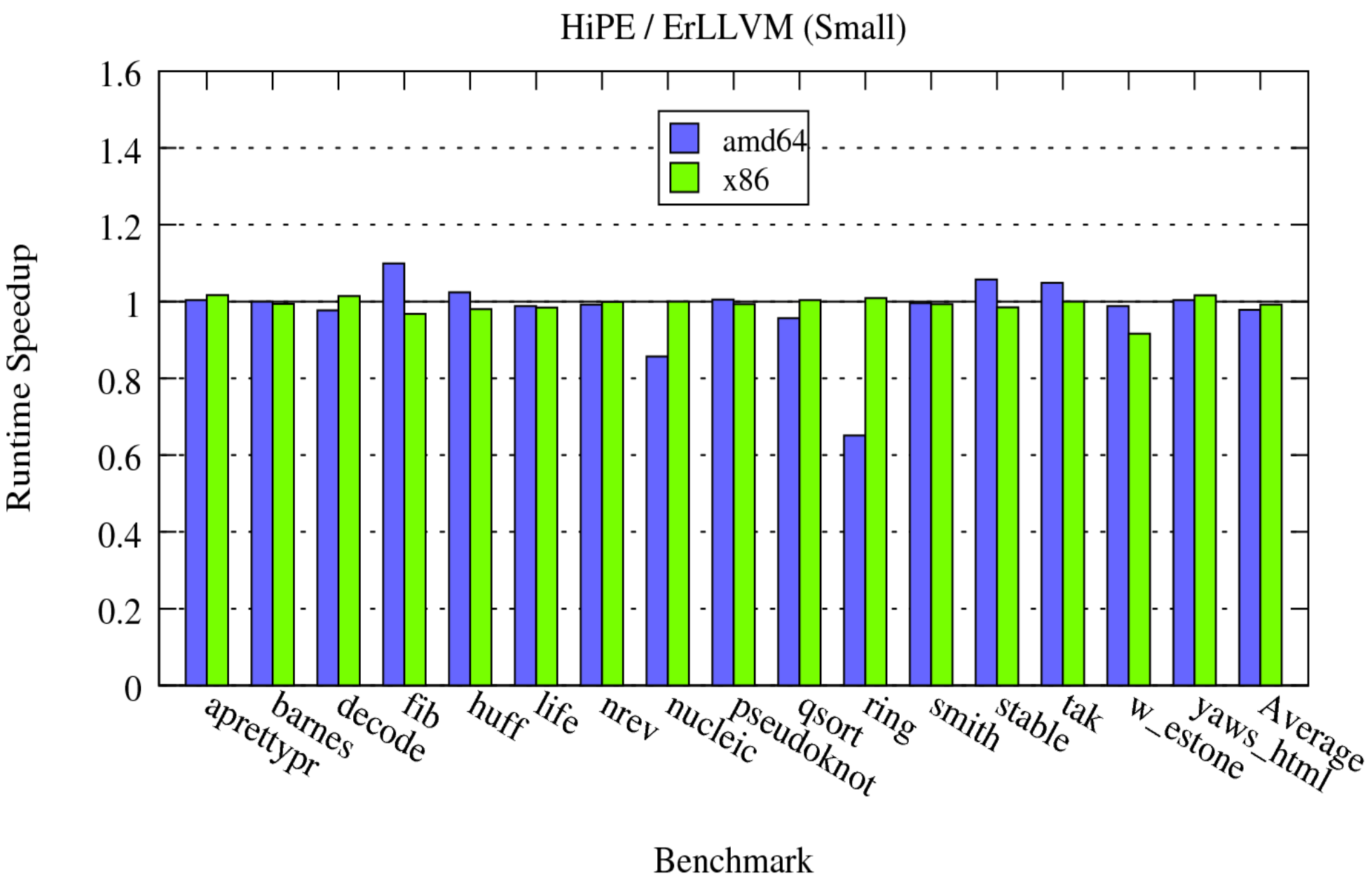
ErLLVM's Performance vs. BEAM



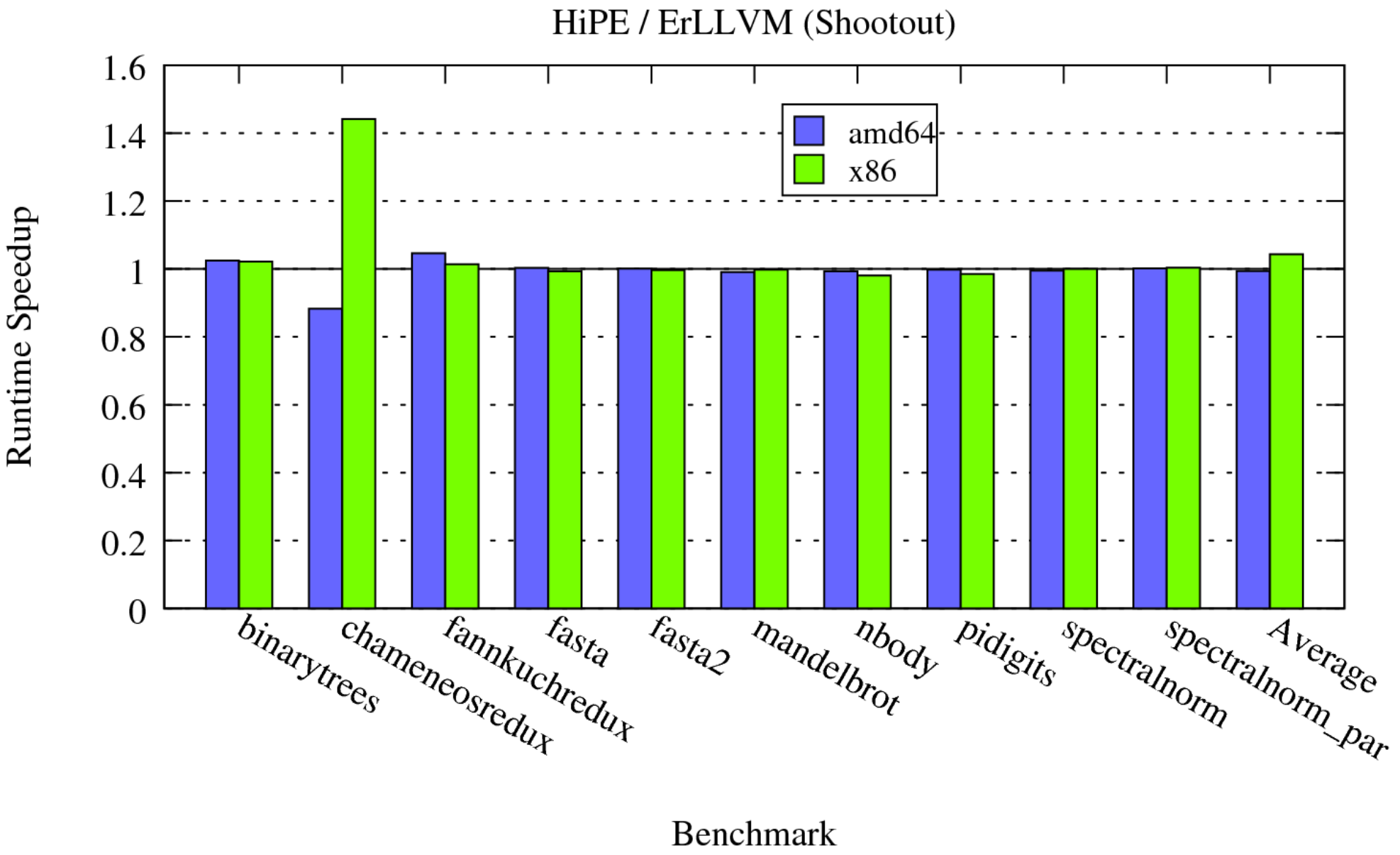
ErLLVM's Performance vs. BEAM



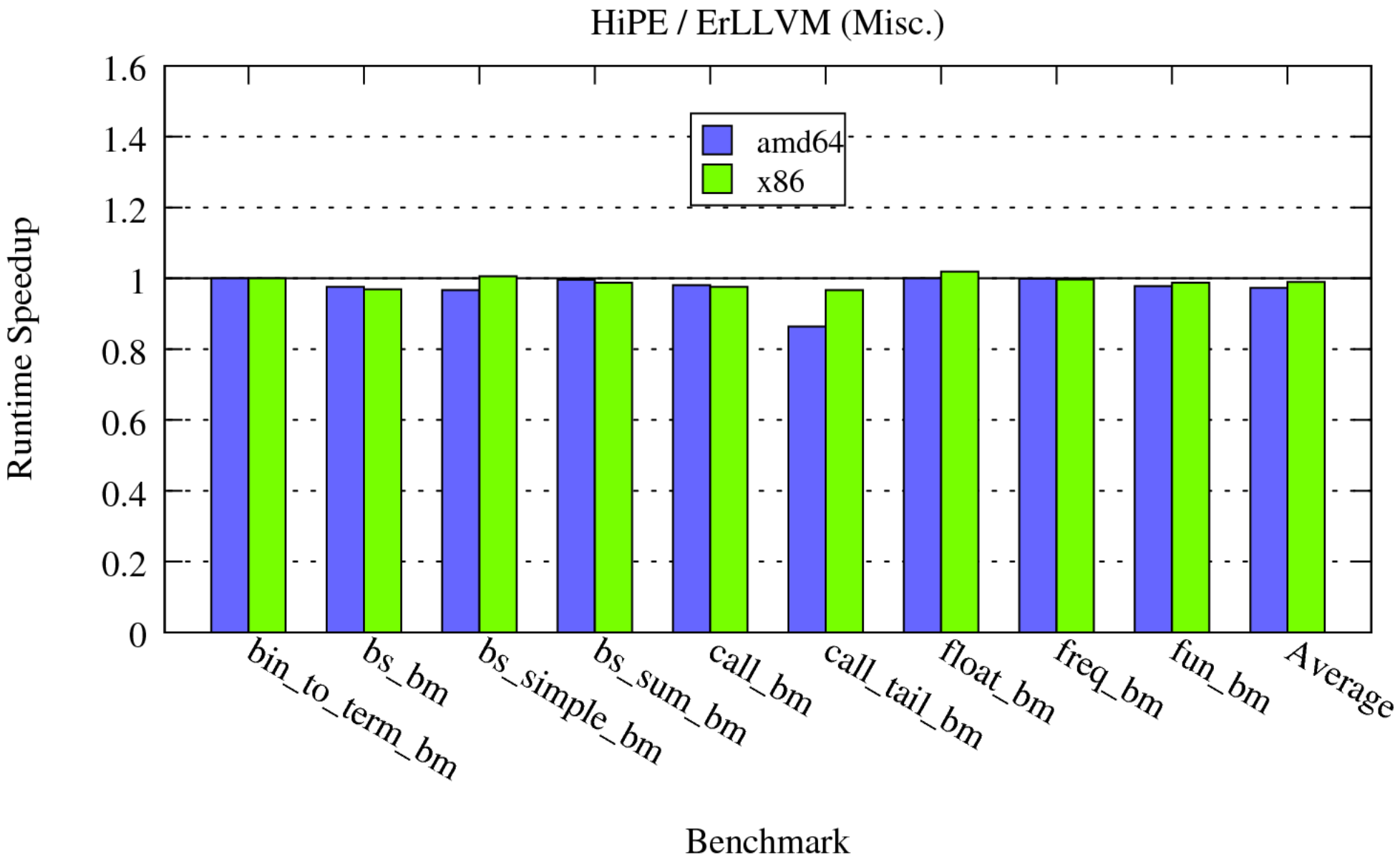
ErLLVM's Performance vs. HiPE



ErLLVM's Performance vs. HiPE



ErLLVM's Performance vs. HiPE



Now what?

Demo time!

Current Status: Pros

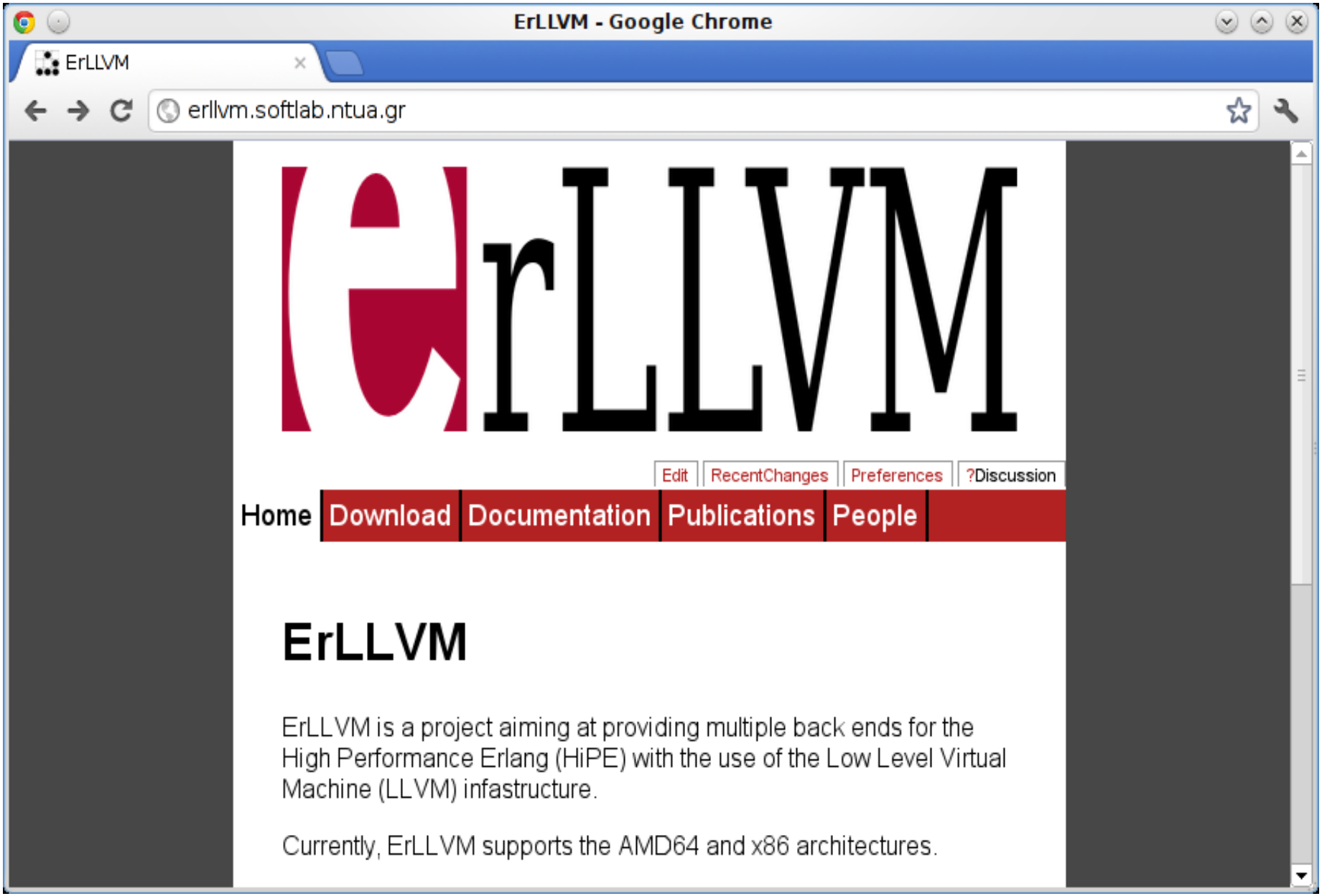
- Complete & robust: handles all Erlang programs
- ABI compatible:
  - smooth integration with BEAM and HiPE code
- Performance:
  - much better than BEAM
  - almost as good as HiPE
- Smaller and simpler code base for the back-ends
- Possibility to target more architectures
- LLVM back-end improvements now also improve performance of Erlang applications!

Current Status: Cons & Future Work

- Cons:
  - Need to download and install custom LLVM
  - Slightly longer compilation times
    - Erlang LLVM bindings to the rescue??

- Future Work
  - Push LLVM patches upstream
  - ARM
  - Improve GC support

Where can I find ErLLVM?



Users are now welcome!

- Install following the instructions at:

  `http://erllvm.softlab.ntua.gr`

- Grab code from `github`
- Test and measure!
- Report experiences
- Contribute to the project