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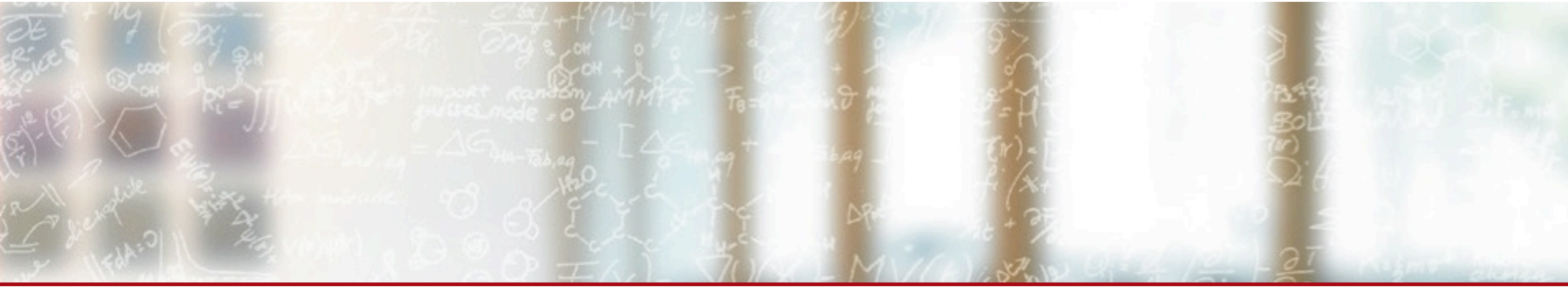

ReFrame: A Regression Testing and Continuous Integration Framework for HPC systems

FOSDEM'19

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https://eth-cscs.github.io/reframe

https://github.com/eth-cscs/reframe

https://reframe-slack.herokuapp.com

Background

- CSCS had a shell-script based regression suite
  - Tests very tightly coupled to system details
  - Lots of code replication across tests
  - 15K lines of test code

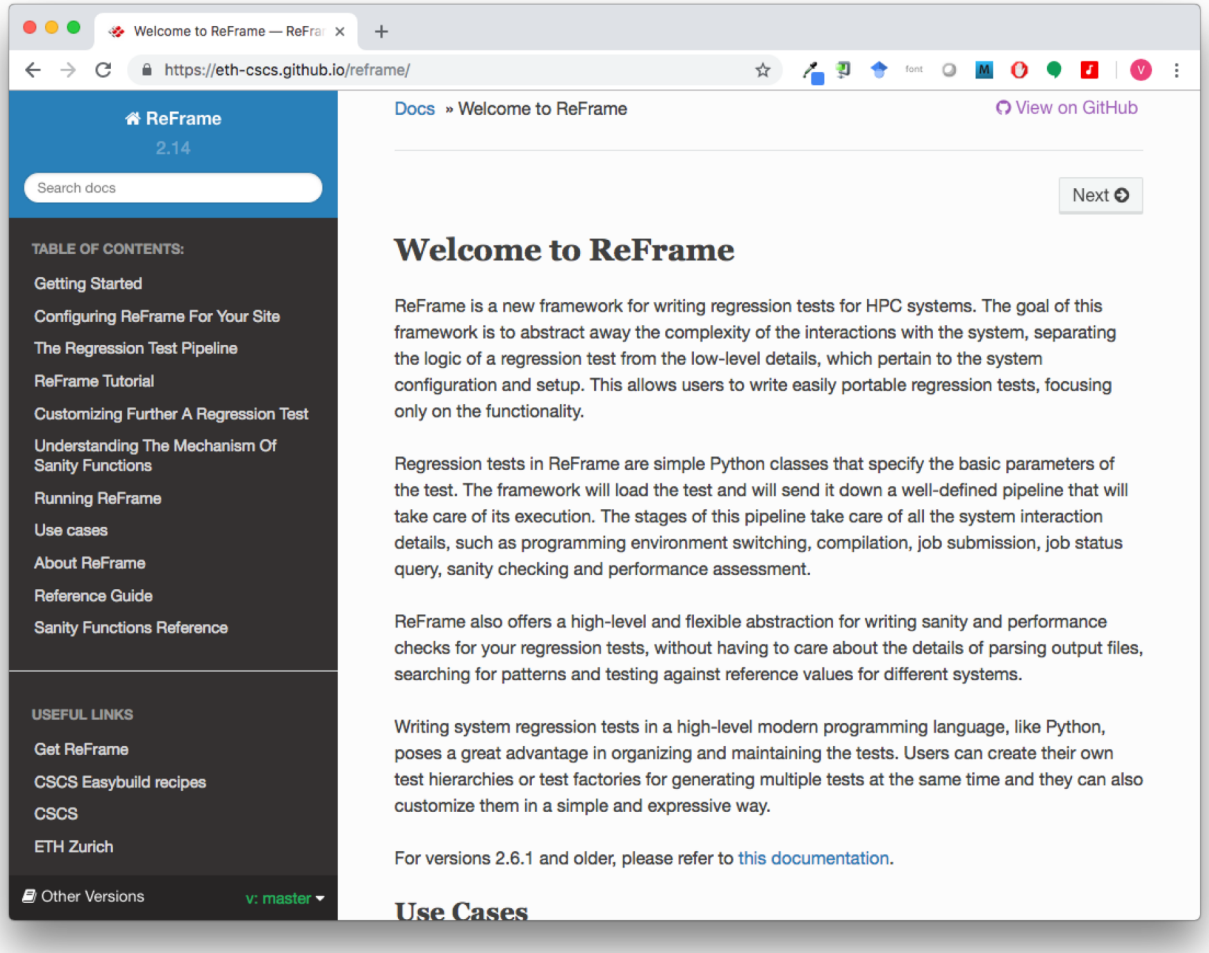
- Simple changes required significant team effort
  - Porting all tests to native SLURM took several weeks

- Fixing even simple bugs was a tedious task
  - Tens of regression test files had to be fixed

What is ReFrame?

A new regression testing framework that

- allows writing **portable HPC** regression tests in Python,
- **abstracts away** the system interaction details,
- lets users focus solely on the **logic** of their test.



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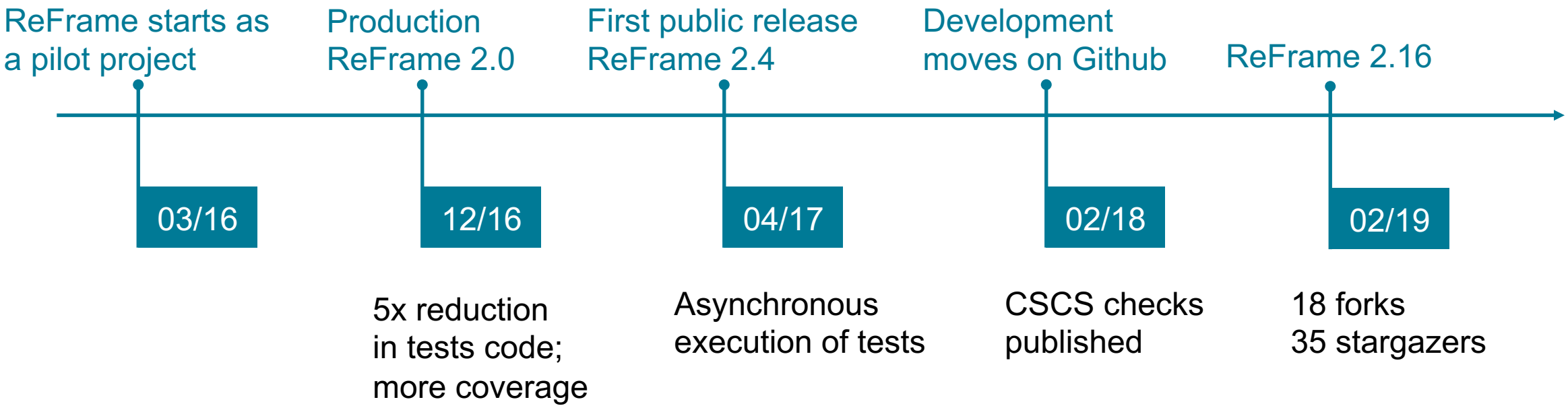
Timeline / ReFrame Evolution



Design Goals

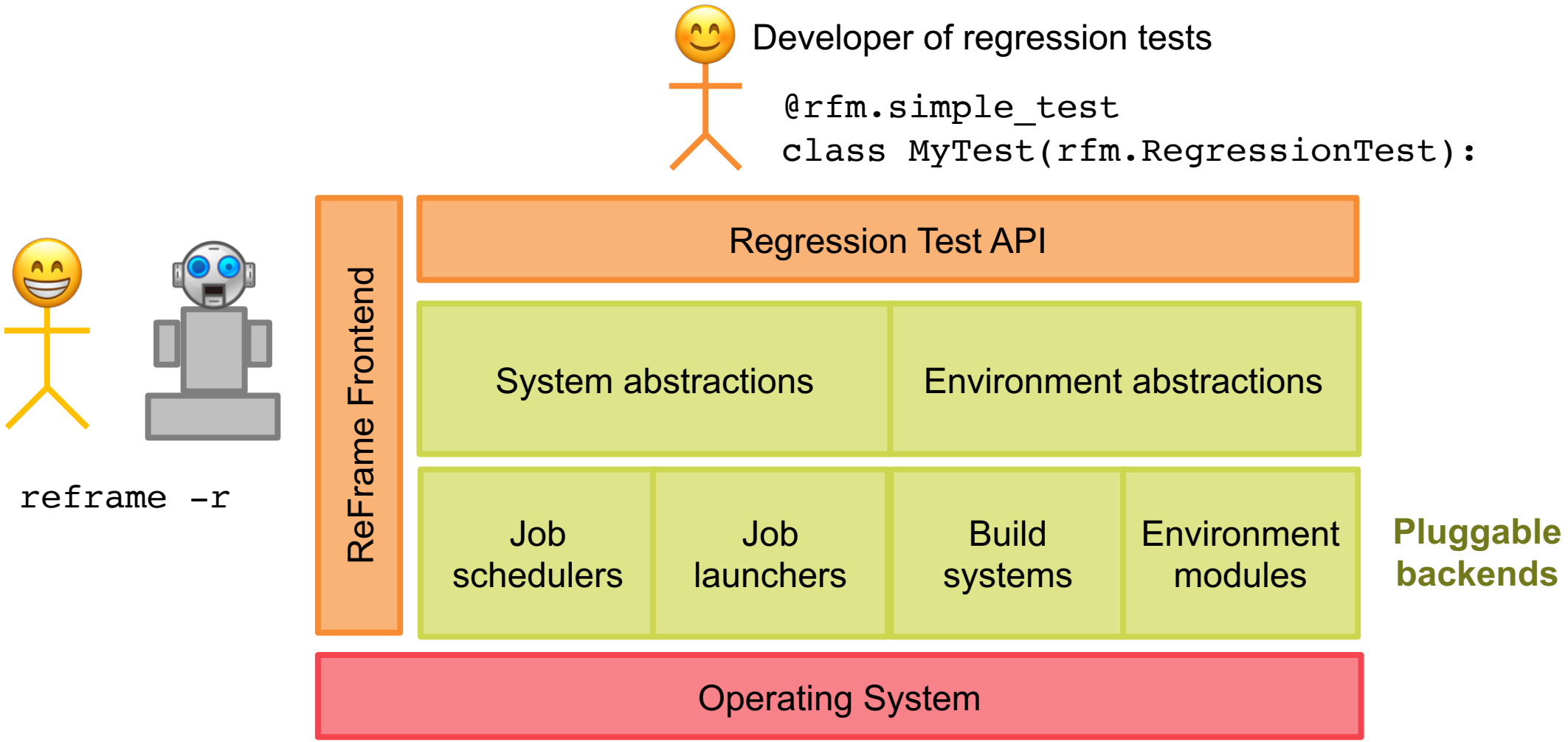
- Productivity
- Portability
- Speed and Ease of Use
- Robustness

Write once, test everywhere!

Key Features

- Separation of system and prog. environment configuration from test's logic
- Support for cycling through prog. environments and system partitions
- Regression tests written in Python
  - Easy customization of tests
  - Flexibility in organizing the tests
- Support for sanity and performance tests
  - Allows complex and custom analysis of the output through an embedded mini-language for sanity and performance checking.
- Progress and result reports
- Performance logging with support for Graylog
- Clean internal APIs that allow the easy extension of the framework's functionality
- Complete documentation (tutorials, reference guide)
- ... and more (*https://github.com/eth-cscs/reframe*)

ReFrame's architecture



Writing a Regression Test in ReFrame

ReFrame tests are specially decorated classes

Valid systems and prog. environments

Compile and run setup

Sanity checking

Extract performance values from output

Reference values and performance thresholds

Tags for easy lookup

```python
import reframe as rfm
import reframe.utility.sanity as sn


@rfm.simple_test
class Example7Test(rfm.RegressionTest):
    def __init__(self):
        super().__init__()
        self.descr = 'Matrix-vector multiplication (CUDA performance test)'
        self.valid_systems = ['daint:gpu']
        self.valid_prog_environs = ['PrgEnv-gnu', 'PrgEnv-cray', 'PrgEnv-pgi']
        self.sourcepath = 'example_matrix_vector_multiplication_cuda.cu'
        self.build_system = 'SingleSource'
        self.build_system.cxxflags = ['-O3']
        self.executable_opts = ['4096', '1000']
        self.modules = ['cudatoolkit']
        self.num_gpus_per_node = 1
        self.sanity_patterns = sn.assert_found(
            r'time for single matrix vector multiplication', self.stdout)
        self.perf_patterns = {
            'perf': sn.extractsingle(r'Performance:\s+(?P<Gflops>\S+) Gflop/s',
                                     self.stdout, 'Gflops', float)
        }
        self.reference = {
            'daint:gpu': {
                'perf': (50.0, -0.1, 0.1),
            }
        }
        self.maintainers = ['you-can-type-your-email-here']
        self.tags = {'tutorial'}
```

Writing a Regression Test in ReFrame

```
@rfm.simple_test
class ArborBaseTest(rfm.RegressionTest):
    def __init__(self):
```

```
47  @rfm.parameterized_test(['haswell'], ['broadwell'], ['native'])
48  class ArborSIMDTest(ArborBaseTest):
49      def __init__(self, arch_kind):
50          super().__init__()
51          if arch_kind == 'haswell':
52              self.valid_systems = ['daint:gpu']
53          elif arch_kind == 'broadwell':
54              self.valid_systems = ['daint:mc', 'tresa']
55          elif arch_kind == 'native':
56              self.valid_systems = ['tresa']
57
58          self.arch_kind = arch_kind
59          self.build_system.config_opts += ['-DARB_VECTORIZE=ON',
                                              '-DARB_ARCH=%s' % self.arch_kind]
```

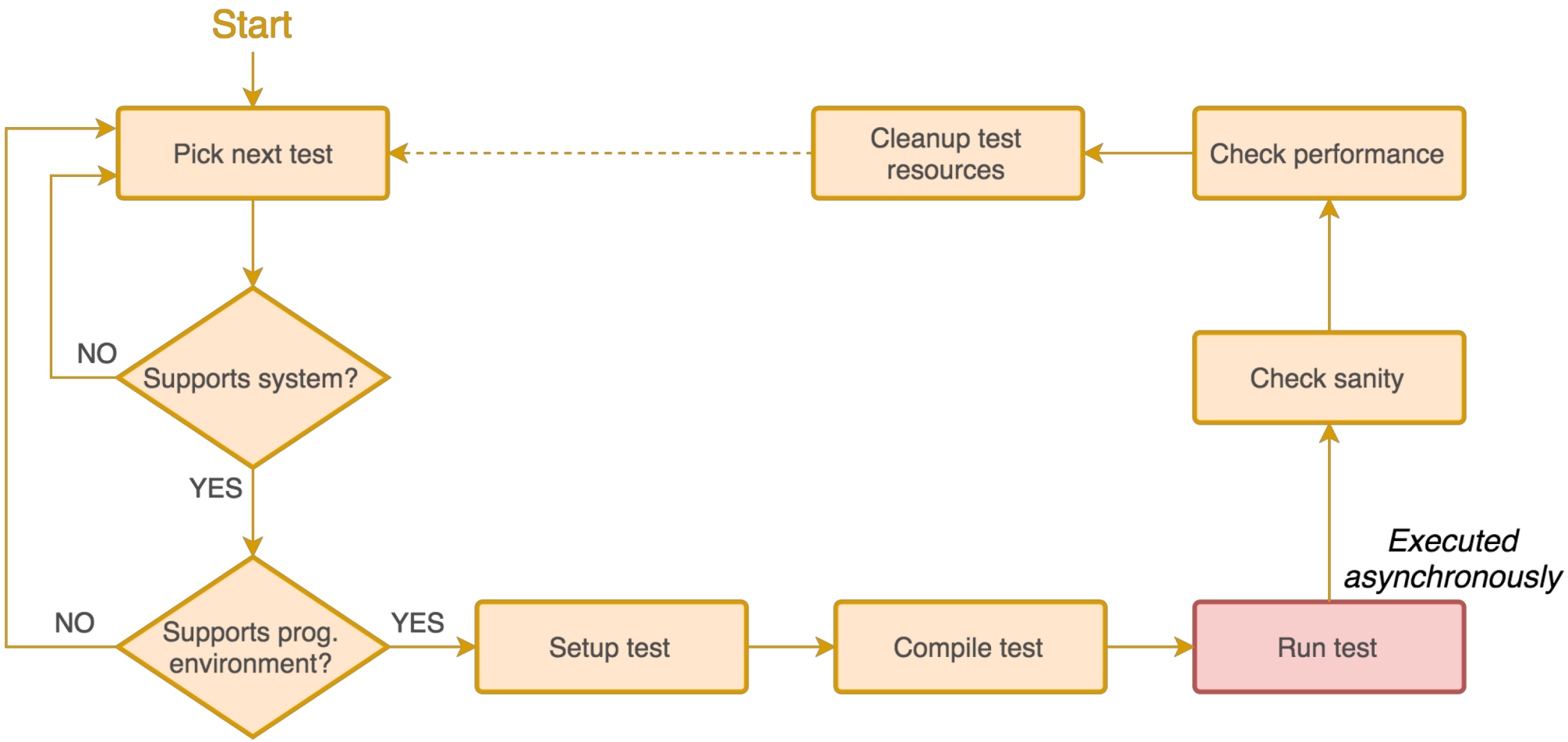
Use parameterized tests to create test factories!

n use inheritance to avoid ning common functionality!

```
nt:gpu', 'daint:mc']
 ['PrgEnv-gnu']
pts += ['-DARB_WITH_MPI=ON']
']
```

The Regression Test Pipeline / How ReFrame Executes Tests

A series of well defined phases that each regression test goes through



The Regression Test Pipeline / How ReFrame Executes Tests

- Tests may skip some pipeline stages
  - Compile-only tests
  - Run-only tests
- Users may define additional actions before or after every pipeline stage by overriding the corresponding methods of the regression test API.
  - E.g., override the setup stage for customizing the behavior of the test per programming environment and/or system partition.

- Frontend passes through three phases and drives the execution of the tests
  1. Regression test discovery and loading
  2. Regression test selection (by name, tag, prog. environment support etc.)
  3. Regression test listing or execution

Running ReFrame

```
reframe -C /path/to/config.py -c /path/to/checks -r
```

- ReFrame uses three directories when running:
  1. Stage directory: Stores temporarily all the resources (static and generated) of the tests
     - Source code, input files, generated build script, generated job script, output etc.
     - This directory is removed if the test finishes successfully.
  2. Output directory: Keeps important files from the run for later reference
     - Job and build scripts, outputs and any user-specified files.
  3. Performance log directory: Keeps performance logs for the performance tests

- ReFrame generates a summary report at the end with detailed failure information.

Running ReFrame (sample output)

```
[==========] Running 1 check(s)
[==========] Started on Fri Sep  7 15:32:50 2018

[----------] started processing Example7Test (Matrix-vector multiplication using CUDA)
[ RUN      ] Example7Test on daint:gpu using PrgEnv-cray
[       OK ] Example7Test on daint:gpu using PrgEnv-cray
[ RUN      ] Example7Test on daint:gpu using PrgEnv-gnu
[       OK ] Example7Test on daint:gpu using PrgEnv-gnu
[ RUN      ] Example7Test on daint:gpu using PrgEnv-pgi
[       OK ] Example7Test on daint:gpu using PrgEnv-pgi
[----------] finished processing Example7Test (Matrix-vector multiplication using CUDA)

[  PASSED  ] Ran 3 test case(s) from 1 check(s) (0 failure(s))
[==========] Finished on Fri Sep  7 15:33:42 2018
```

Running ReFrame (sample failure)

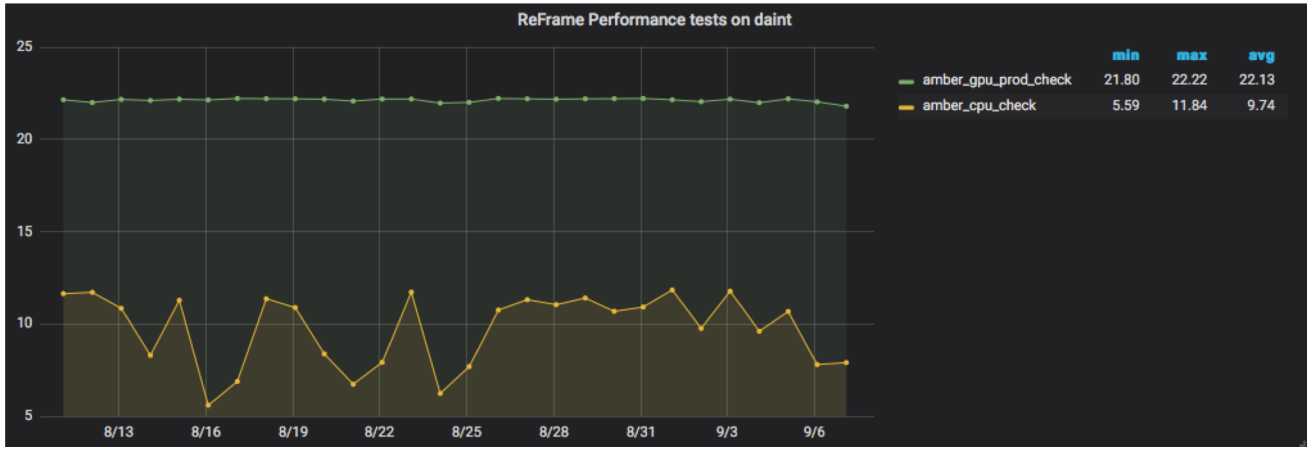
```
[==========] Running 1 check(s)
[==========] Started on Fri Sep  7 16:40:12 2018

[----------] started processing Example7Test (Matrix-vector multiplication using CUDA)
[ RUN      ] Example7Test on daint:gpu using PrgEnv-gnu
[     FAIL ] Example7Test on daint:gpu using PrgEnv-gnu
[----------] finished processing Example7Test (Matrix-vector multiplication using CUDA)

[  FAILED  ] Ran 1 test case(s) from 1 check(s) (1 failure(s))
[==========] Finished on Fri Sep  7 16:40:22 2018

==============================================================================
SUMMARY OF FAILURES
------------------------------------------------------------------------------
FAILURE INFO for Example7Test
  * System partition: daint:gpu
  * Environment: PrgEnv-gnu
  * Stage directory: /path/to/stage/daint/gpu/PrgEnv-gnu/Example7Test
  * Job type: batch job (id=823427)
  * Maintainers: ['you-can-type-your-email-here']
  * Failing phase: performance
  * Reason: sanity error: 50.363125 is beyond reference value 70.0 (l=63.0, u=77.0)
------------------------------------------------------------------------------
```

Running ReFrame (examining performance logs)

- `/path/to/reframe/prefix/perflogs/<testname>.log`
  - A single file named after the test's name is updated every time the test is run
  - Log record output is fully configurable

```
2018-09-07T15:32:59|reframe 2.14-dev2|Example7Test on daint:gpu using PrgEnv-cray|jobid=823394|perf=49.71432|ref=50.0 (l=-0.1, u=0.1)
2018-09-07T15:33:11|reframe 2.14-dev2|Example7Test on daint:gpu using PrgEnv-gnu|jobid=823395|perf=50.1609|ref=50.0 (l=-0.1, u=0.1)
2018-09-07T15:33:42|reframe 2.14-dev2|Example7Test on daint:gpu using PrgEnv-pgi|jobid=823396|perf=51.078648|ref=50.0 (l=-0.1, u=0.1)
2018-09-07T16:40:22|reframe 2.14-dev2|Example7Test on daint:gpu using PrgEnv-gnu|jobid=823427|perf=50.363125|ref=70.0 (l=-0.1, u=0.1)
```

- ReFrame can also send logs to a Graylog server, where you can plot them with web tools.



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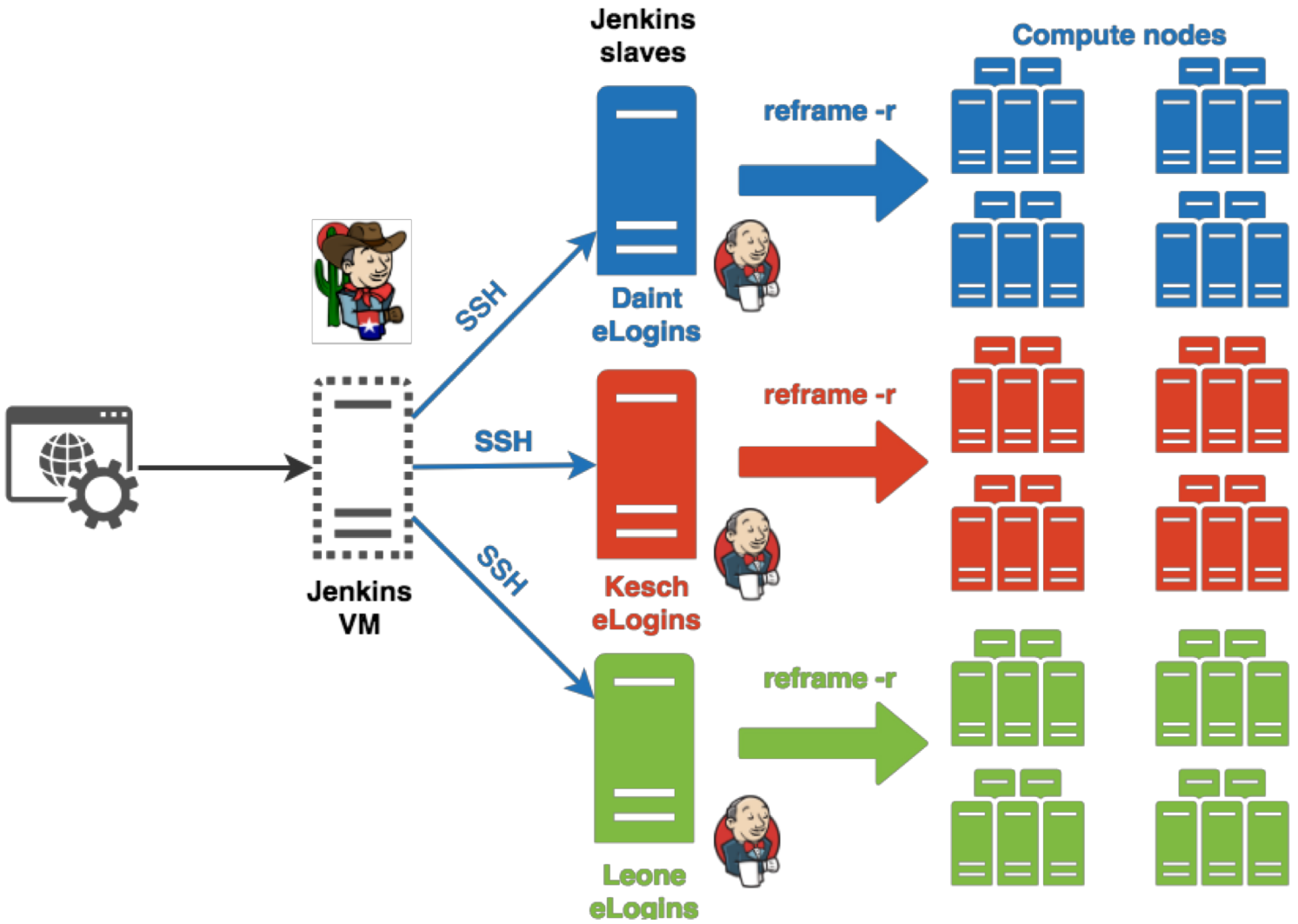
Using ReFrame at CSCS

ReFrame @ CSCS / Tests

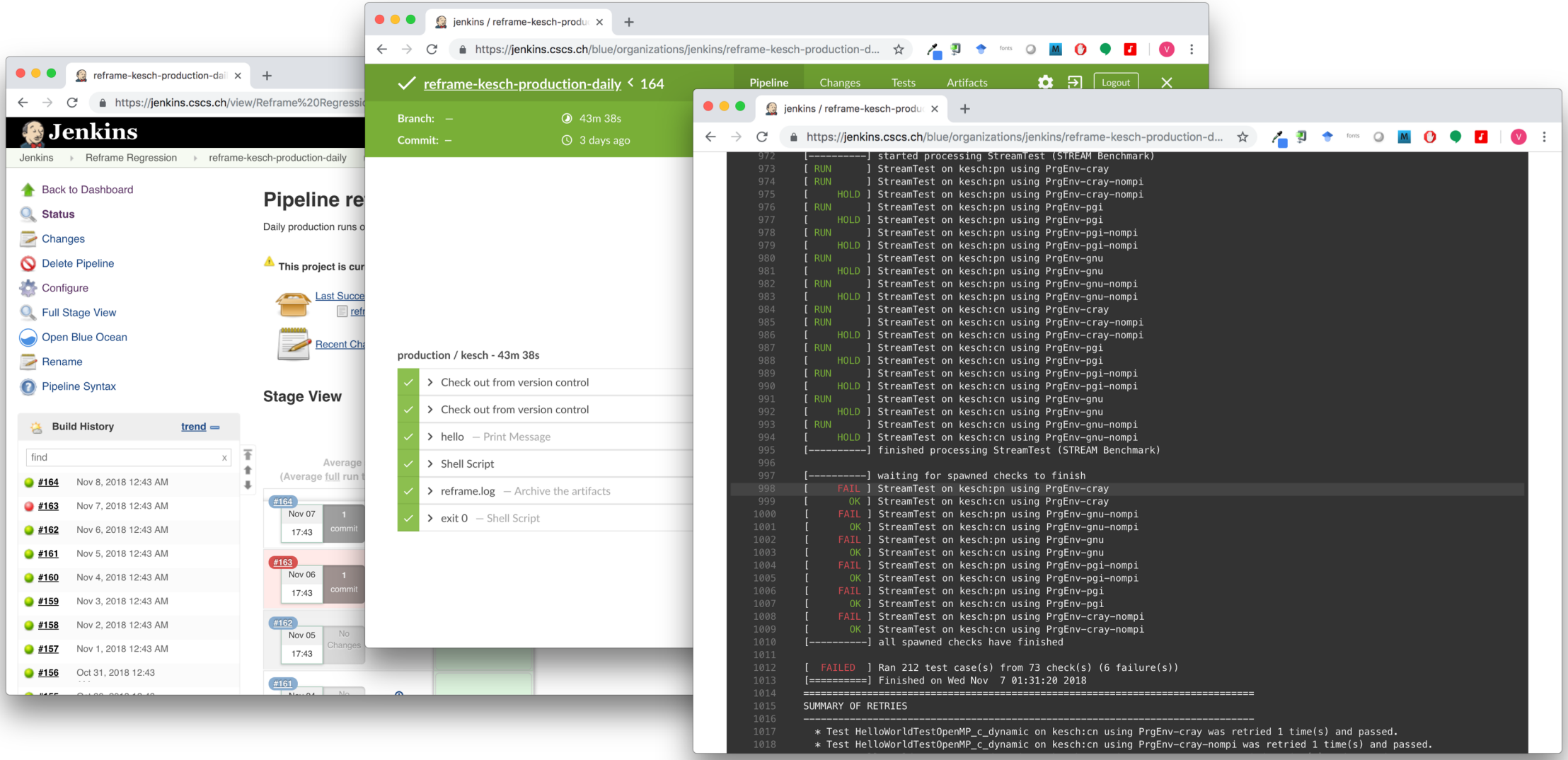
- Used for continuously testing systems in production
  - Piz Daint: 179 tests
  - Piz Kesch: 75 tests
  - Leone: 45 tests
  - **Total: 241 different tests (reused across systems)**

- Three categories of tests
  1. Production (90min)
     - Applications, libraries, programming environments, profiling tools, debuggers, microbenchmarks
     - Sanity and performance
     - Run nightly by Jenkins
  2. Maintenance (10min)
     - Programming environment sanity and key user applications performance
     - Before/after maintenance sessions
  3. Diagnostics

ReFrame @ CSCS / Production set-up



ReFrame @ CSCS / Production set-up



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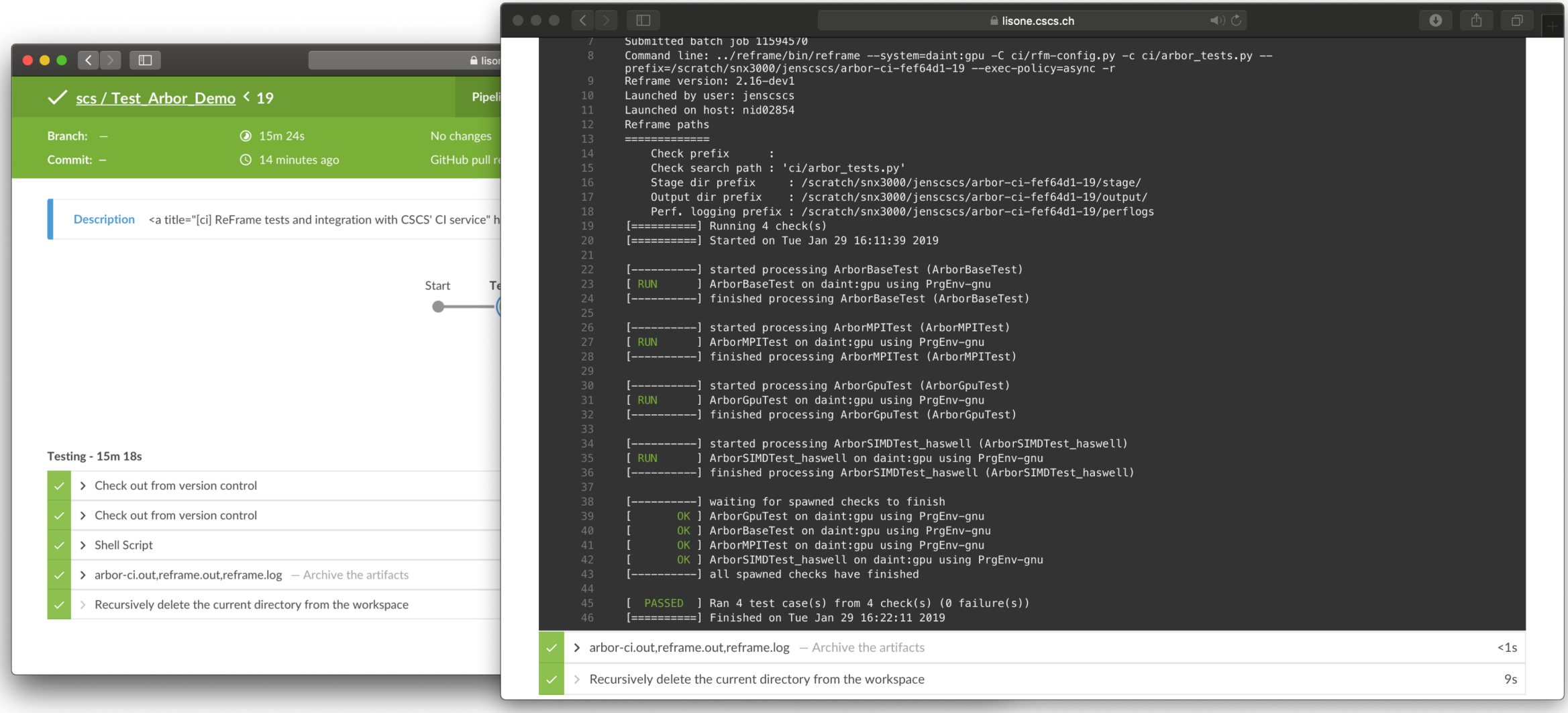
Using ReFrame with a CI service

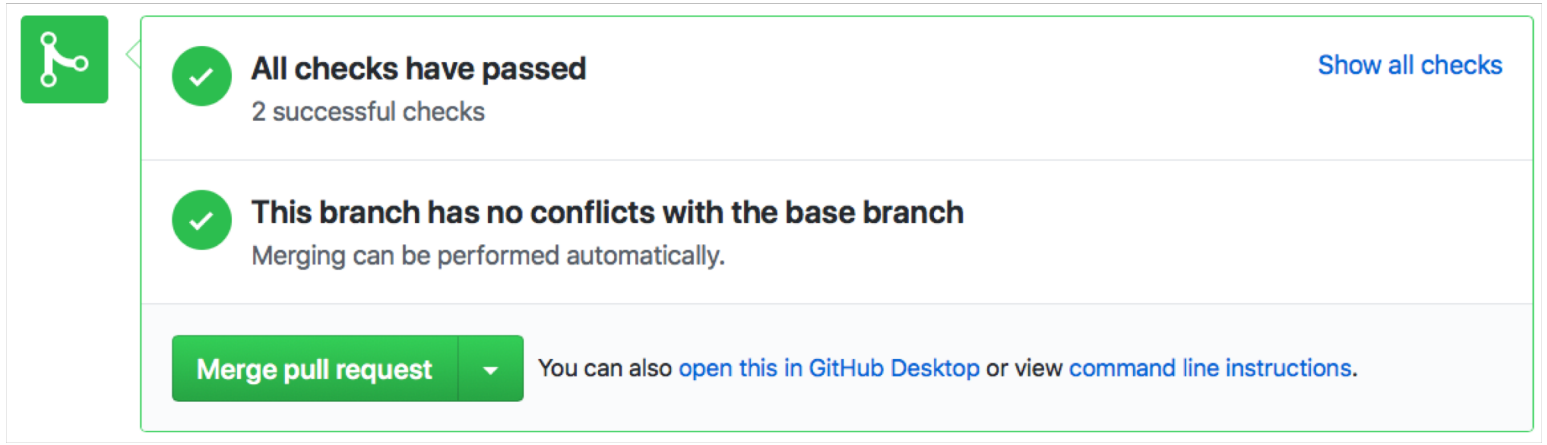
ReFrame integration with CI service

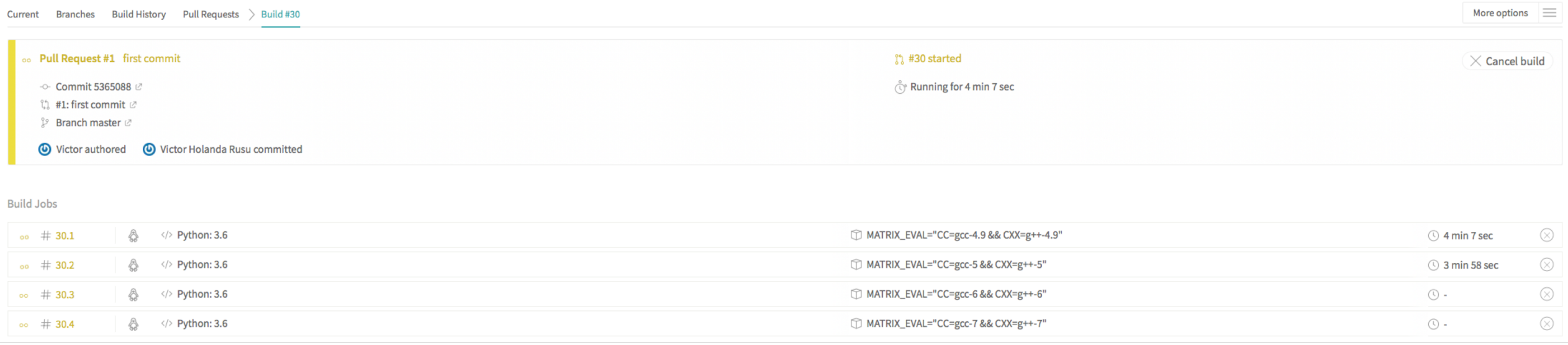
- CSCS CI service
  - Based on Jenkins
  - Run on CSCS HPC systems
  - On the remote side there is a Jenkins VM that can only run sbatch to the compute nodes
  - Integration steps
    1. Add a Jenkinsfile to project
    2. Add a batch script for running ReFrame on the compute nodes
    3. Add configuration entry for the target systems
    4. Add ReFrame tests
- Travis – Github
  - Runs a VM on the cloud
  - Integration steps
    1. Add .travis.yml file
    2. Add configuration entry for the Travis VM
    3. Add ReFrame tests

ReFrame with CSCS CI service



ReFrame with Travis





Conclusions and Future Directions

ReFrame is a powerful tool that allows you to continuously test an HPC environment without having to deal with the low-level system interaction details.

- High-level tests written in Python
- Portability across HPC system platforms
- Comprehensive reports and reproducible methods

- ReFrame is being actively developed with a regular release cycle.
- Future directions
  - Test dependencies
  - Seamless support for containers
  - Benchmarking mode

- Bug reports, feature requests, help @ https://github.com/eth-cscs/reframe

Who is running ReFrame

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Swiss National Supercomputing Centre

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Ohio Supercomputer Center
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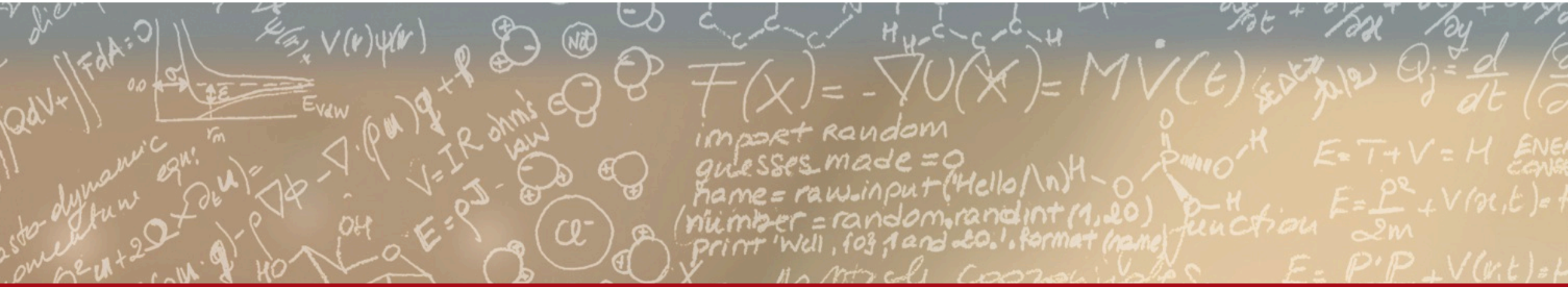
  - Rafael Sarmiento
  - Samuel Omlin
  - Theofilos Manitaras
  - Vasileios Karakasis
  - Victor Holanda
- Regression tests
  - SCS and OPS team



Thank you for your attention.

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