IntegrationTests.jl: a framework for the automatic generation of integration tests for Julia projects

Simeon Ehrig

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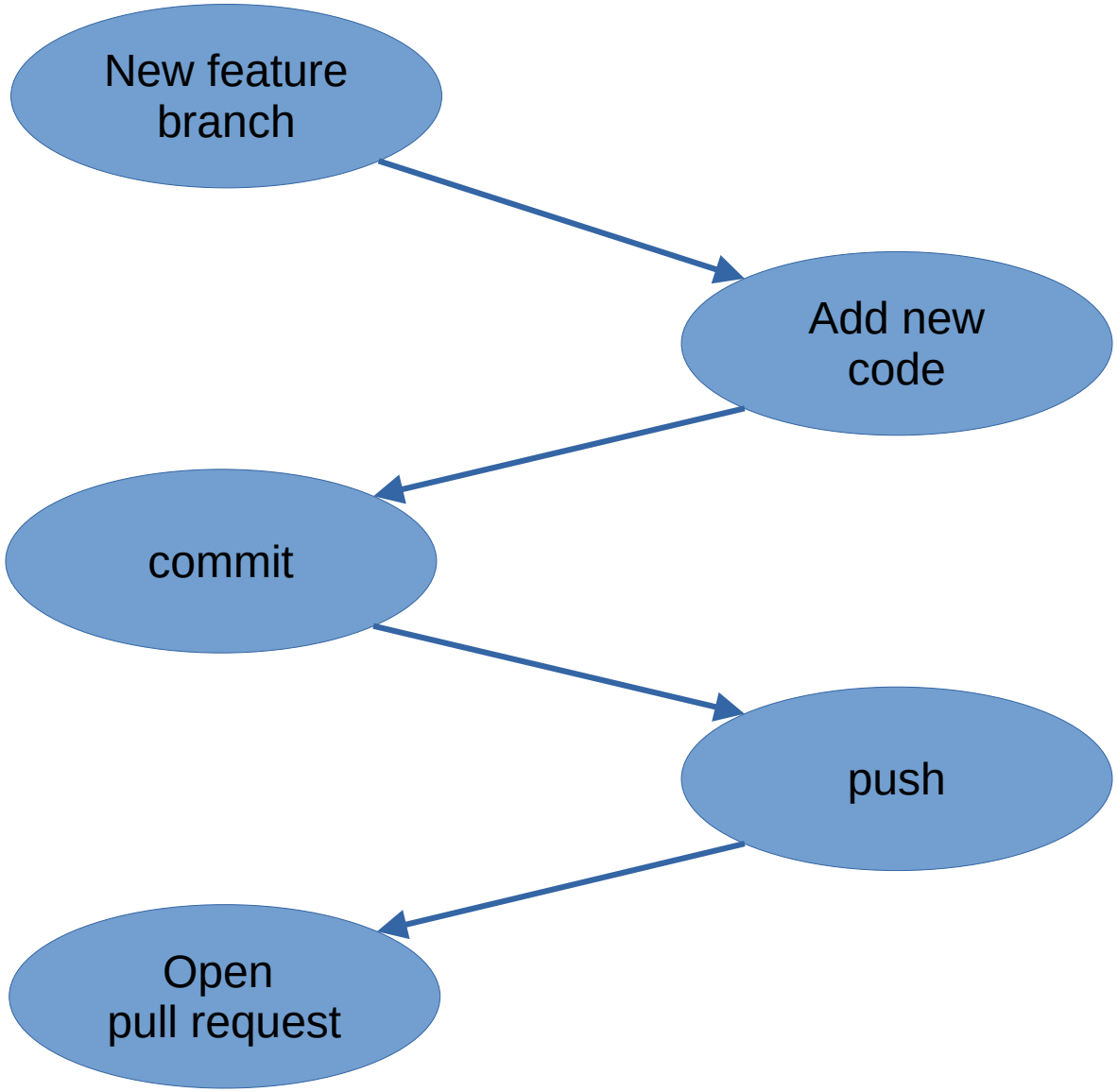
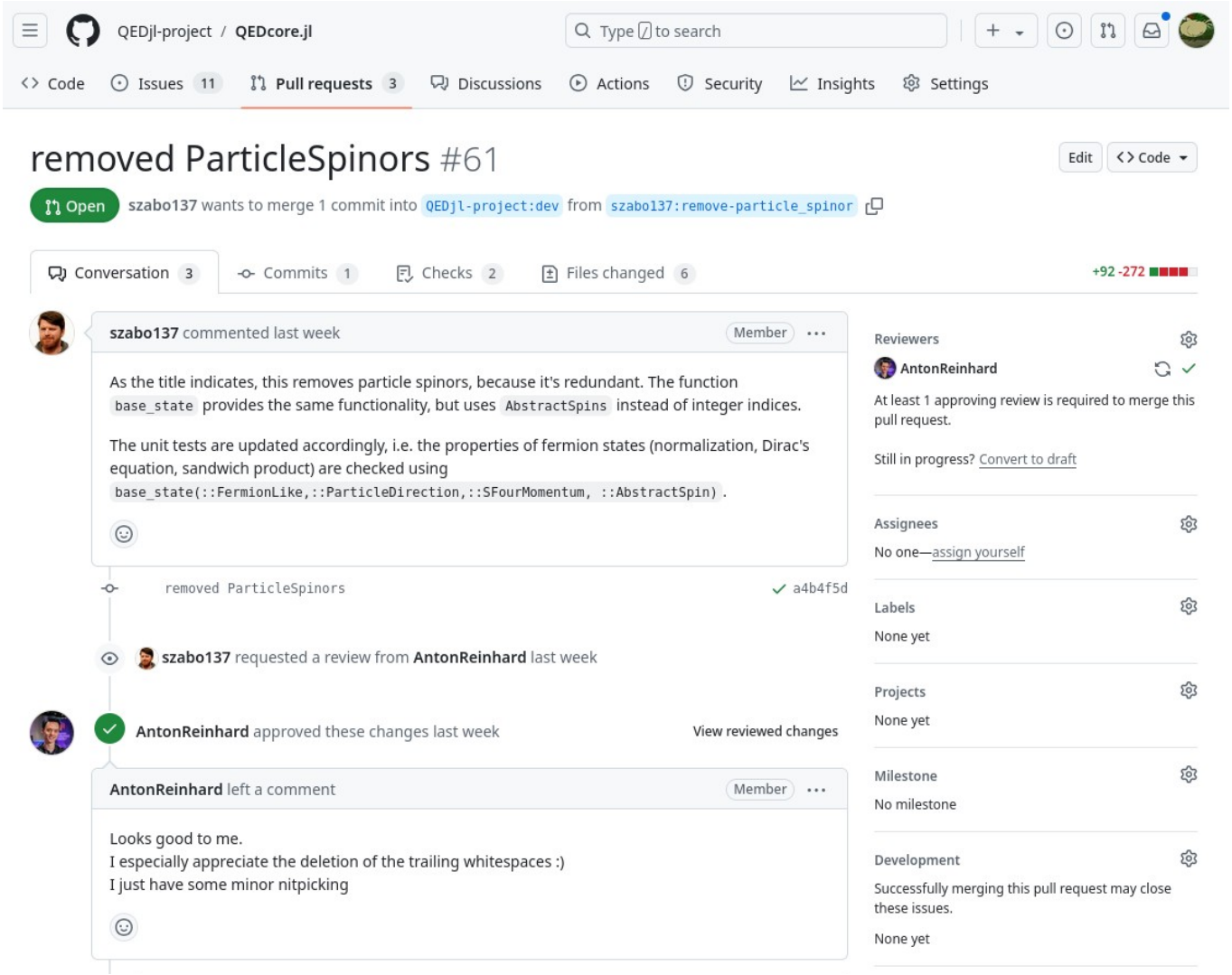
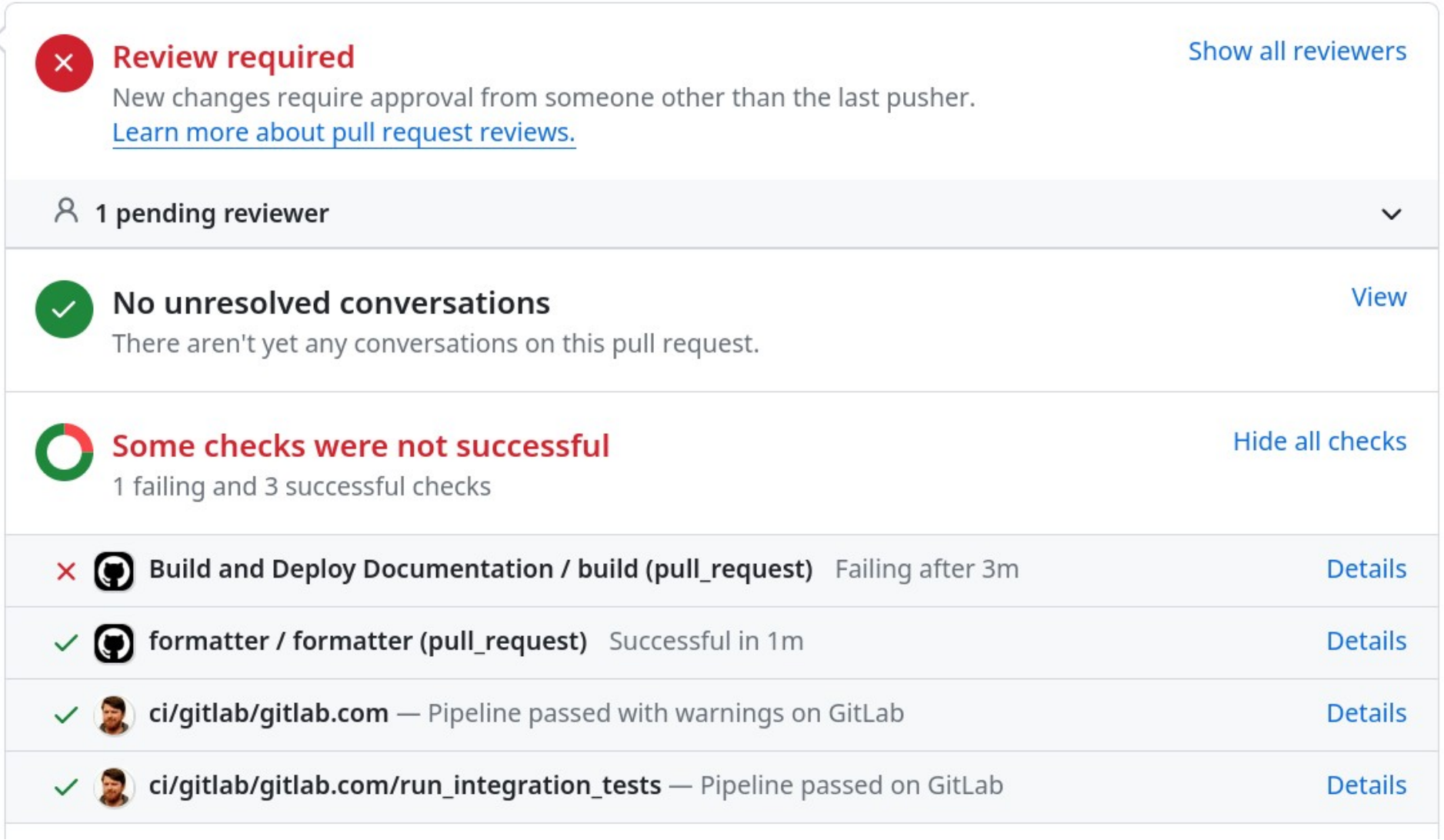
Git Workflow: new Code



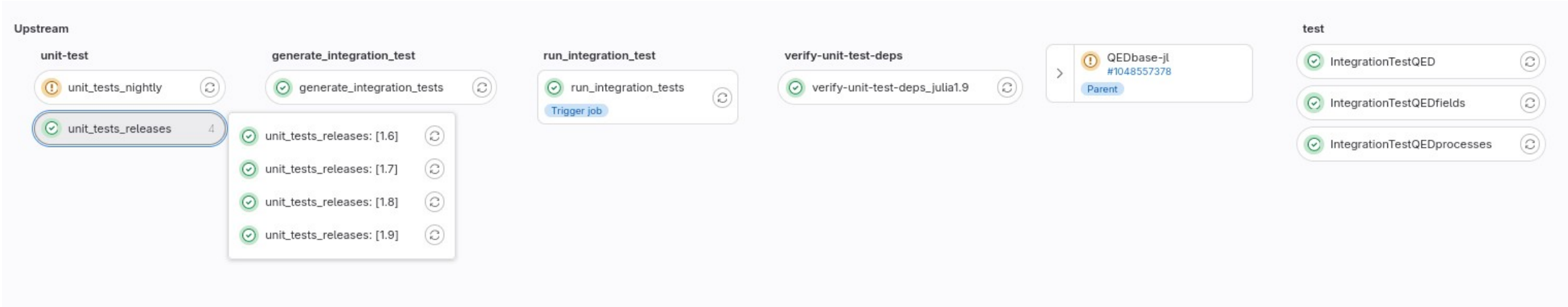
Open Pull Request



Pull Request triggers CI Tests



CI Pipeline


Upstream
unit-test
unit_tests_nightly
unit_tests_releases 4
generate_integration_test
generate_integration_tests
unit_tests_releases: [1.6]
unit_tests_releases: [1.7]
unit_tests_releases: [1.8]
unit_tests_releases: [1.9]
run_integration_test
run_integration_tests
Trigger job
verify-unit-test-deps
verify-unit-test-deps_julia1.9
QEDbase-jl
#1048557378
Parent
test
IntegrationTestQED
IntegrationTestQEDfields
IntegrationTestQEDprocesses

Defining Tests and execution

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Define the tests

```
using Test
using QEDcore

TESTPSDEF = TestImplementation.TestPhasespaceDef()

RNG = Random.MersenneTwister(727)
BUF = IOBuffer()

Anton Reinhard, 3 months ago | 1 author (Anton Reinhard)
@testset "broadcast" begin
    test_func(ps_def) = ps_def
    @test test_func.(TESTPSDEF) == TESTPSDEF
end
```

Defining Tests and execution

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Define the tests

```
using Test
using QEDcore

TESTPSDEF = TestImplementation.TestPhasespaceDef()

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Anton Reinhard, 3 months ago | 1 author (Anton Reinhard)
@testset "broadcast" begin
    test_func(ps_def) = ps_def
    @test test_func.(TESTPSDEF) == TESTPSDEF
end
```

Define the execution of the tests

```
.untit_test_template:
  stage: unit-test
  script:
    - julia --project=. -e 'import Pkg; Pkg.instantiate()'
    - julia --project=. -e 'import Pkg; Pkg.test(; coverage = true)'
  interruptible: true
  tags:
    - cpuonly

unit_tests_releases:
  extends: .untit_test_template
  parallel:
    matrix:
      - JULIA_VERSION: ["1.6", "1.7", "1.8", "1.9", "1.10", "rc"]
  image: julia:$JULIA_VERSION
```

Unit and Integration Tests

Unit vs. Integration Test

Unit vs. Integration Test: explanation

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Unit Test

- Does the function work in the context of your own package?

Integration Test

- Does the function work when used in other projects or packages?

Example Unit Test PkgA

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PkgA/src.jl

```
module PkgA

foo(i) = i + 3

end
```

PkgA/test/runtest.jl

```
using PkgA
using Test

@testset "PkgA.jl" begin
    @test PkgA.foo(4) == 7
end
```

Example Integration Test

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PkgA/src.jl

```
module PkgA

foo(i) = i + 3

end
```

PkgB/src.jl

```
module PkgB
using PkgA

bar() = PkgA.foo(3)

end
```

Integration Test in PkgB

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PkgB/src.jl

```
module PkgB
using PkgA

bar() = PkgA.foo(3)

end
```

PkgB/test/runtest.jl

```
using PkgB
using Test

@testset "PkgB.jl" begin
    @test PkgB.bar() == 6
end
```

Integration Test in PkgB

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PkgB/src.jl

```
module PkgB
using PkgA

bar() = PkgA.foo(3)

end
```

PkgB/test/runtest.jl

```
using PkgB
using Test

@testset "PkgB.jl" begin
    @test PkgB.bar() == 6
end
```

- Integration test for PkgA
- Unit test for PkgB

PkgA Interface Change

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PkgA/src.jl

```
module PkgA

foo(i, j) = i + j + 3

end
```

→ Change interface of PkgA

PkgA Interface Change

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PkgA/src.jl

```
module PkgA

foo(i, j) = i + j + 3

end
```

→ Change interface of PkgA

```
module PkgB
using PkgA

bar() = PkgA.foo(3)

end
```

```
using PkgB
using Test

@testset "PkgB.jl" begin
    @test PkgB.bar() == 6
end
```

PkgA Interface Change

PkgA/src.jl

```
module PkgA

foo(i, j) = i + j + 3

end
```

→ Change interface of PkgA

```
module PkgB
using PkgA

b

end
```

ERROR: MethodError

```
using PkgB
using Test

@tes

end
```

Test failes

Integration Tests: Followings

Find incompatibilities soon as possible to avoid stacking problems

Find dependencies between packages automatically

Define strategies to solve incompatibilies

https://www.youtube.com/watch?v=D-IP55-RTdk

Integration Tests: Followings

Find incompatibilities soon as possible to avoid stacking problems

→ automatic tests in the CI in each Pull Request

Find dependencies between packages automatically

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→ IntegrationTests.jl

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Integration Tests: Followings

Find incompatibilities soon as possible to avoid stacking problems

→ automatic tests in the CI in each Pull Request

Find dependencies between packages automatically

→ IntegrationTests.jl

Define strategies to solve incompatibilies

→ JuliaHEP 2023 talk: Unit and Integration testing in modularized Julia package eco-systems

https://www.youtube.com/watch?v=D-IP55-RTdk

IntegrationTests.jl

General Steps

1) Generate project graph
2) Find packages who uses modified package
3) Generate CI jobs for integration tests (project depend)

Step 1: Construct Dependency Graph

Use the dependency graph of the Project.toml

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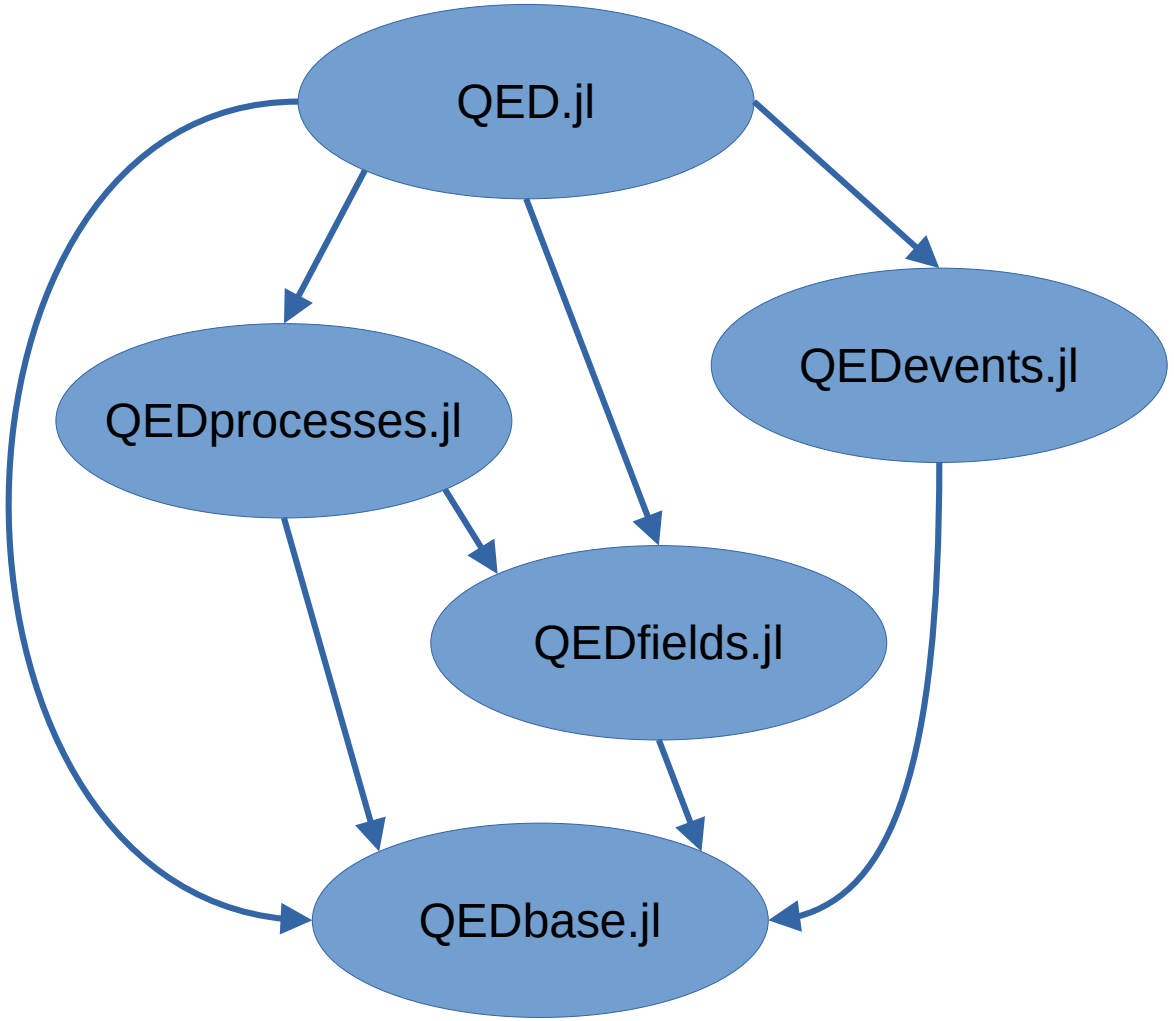
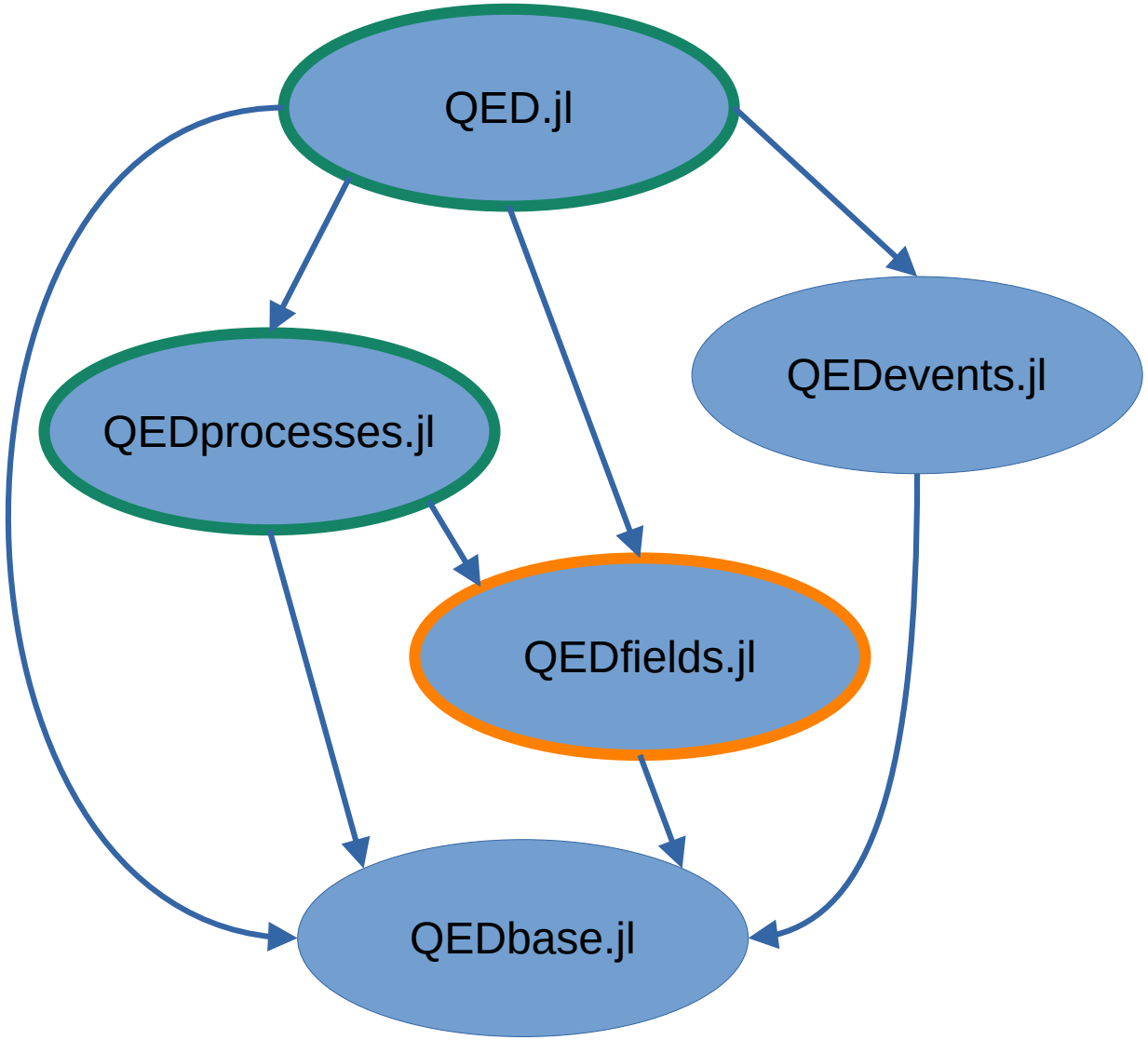
Use the dependency graph of the Project.toml



* graph is outdated

Step 2: Find using Packages



QEDfields.jl is modified

Dependent packages:

- QEDProcesses.jl
- QED.jl

Using IntegrationTests.jl

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```
using IntegrationTests
using Pkg

if !isinteractive()
    # search packages, which are dependent on QEDfields.jl
    # ignore all packages which does not start with QED
    depending_packages = IntegrationTests.depending_projects(
                                "QEDfields.jl", r"^QED*")

    println(depending_packages)
end
```

Using IntegrationTests.jl

```julia
using IntegrationTests
using Pkg

if !isinteractive()
    # search packages, which are dependent on QEDfields.jl
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    depending_packages = IntegrationTests.depending_projects(
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end
```
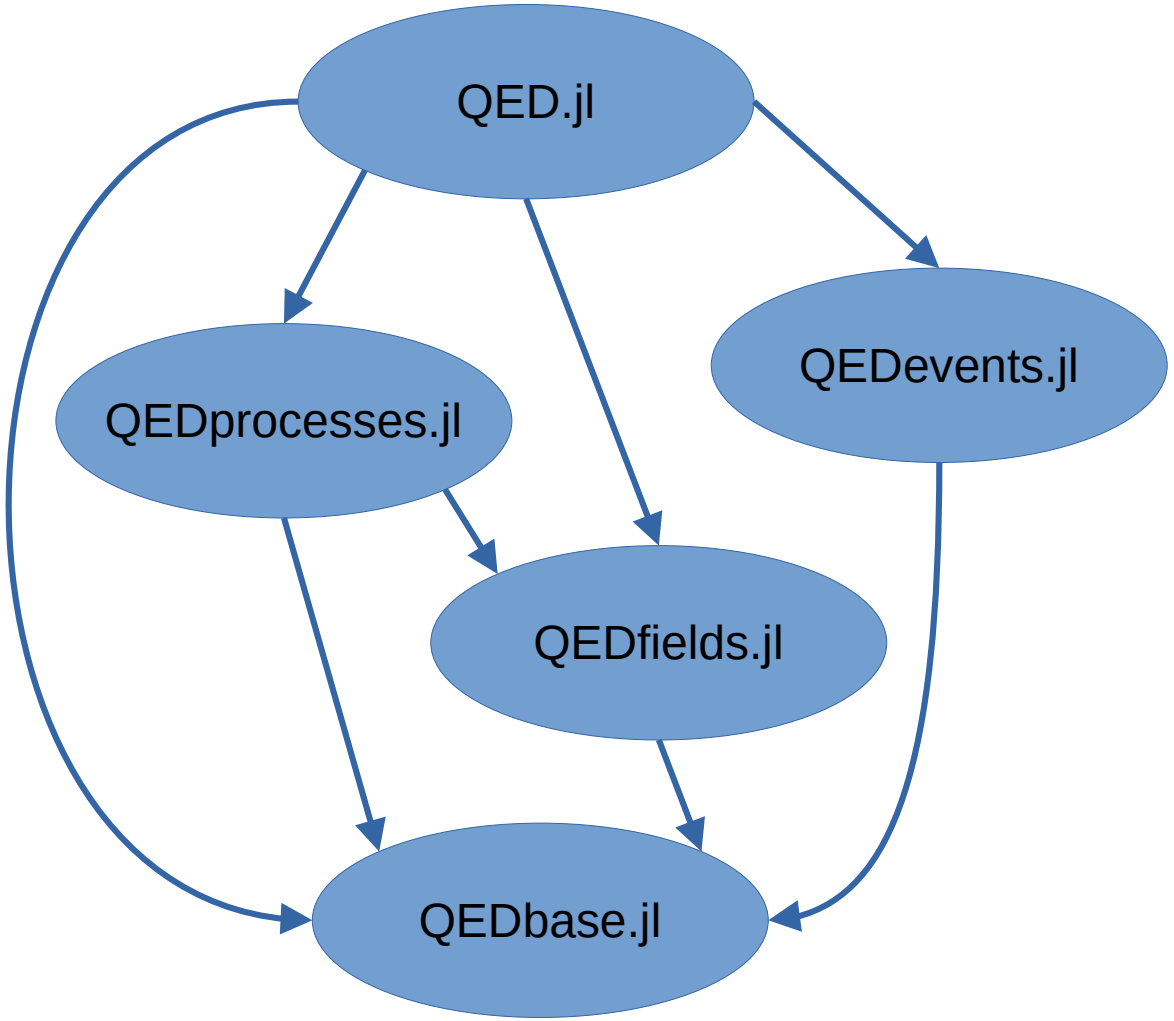

```
simeon@fwu066:~/projects/IntegrationTests.jl$ julia --project findIntegrationTests.jl
["QED.jl", "QEDprocess.jl"]
```

Old QED.jl Graph



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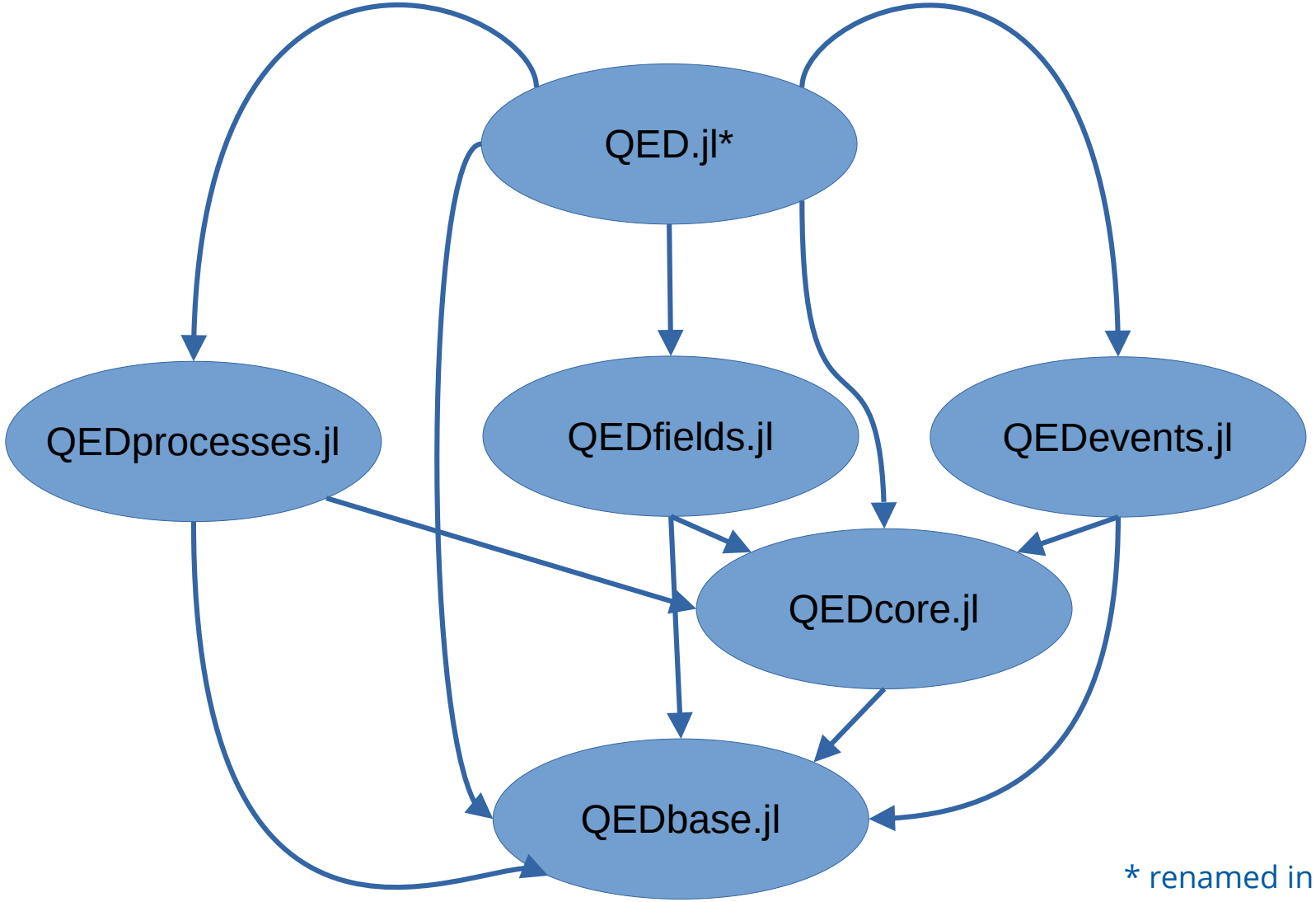
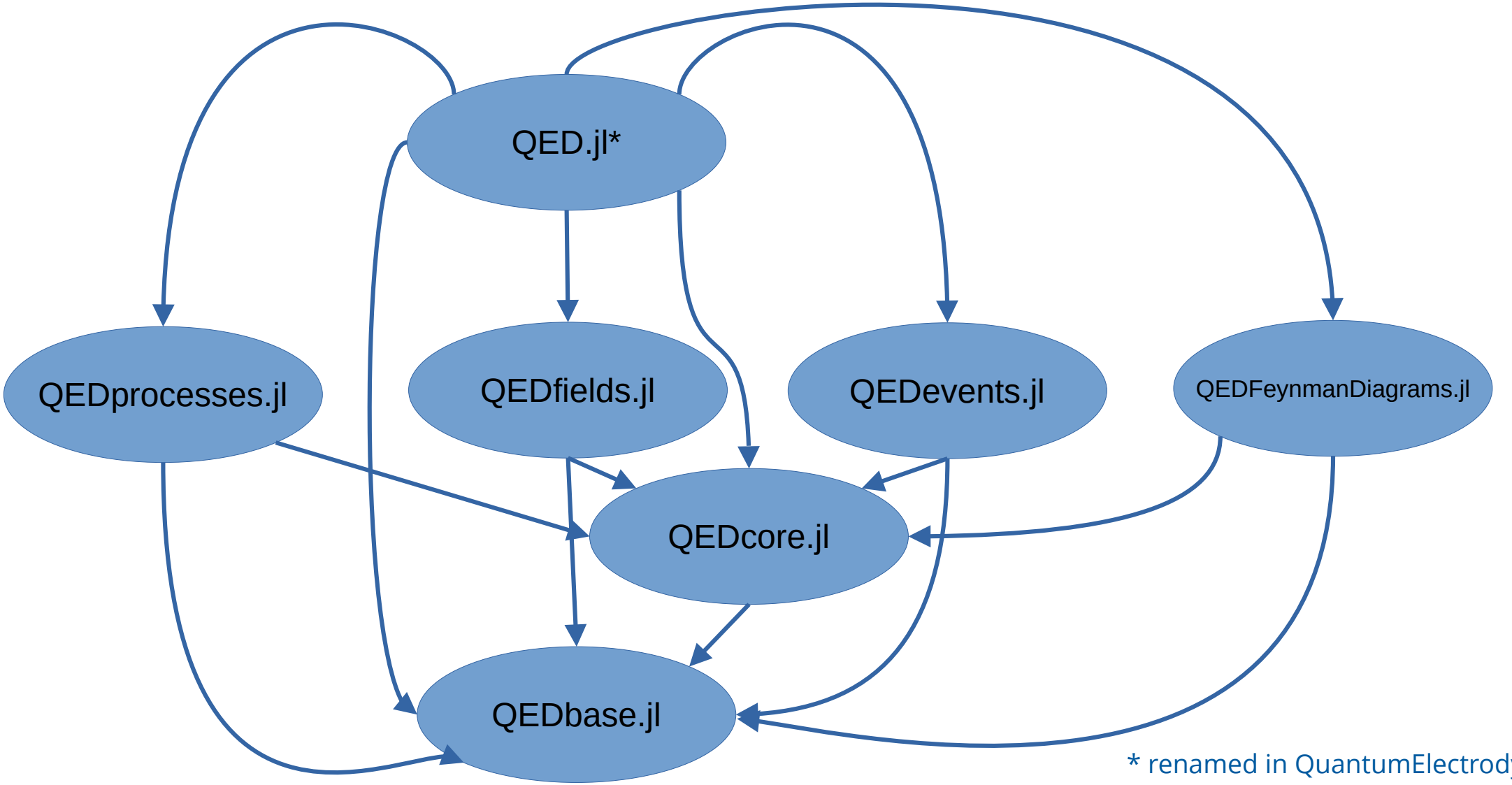
New QuantumElectrodynamics.jl Graph



* renamed in QuantumElectrodynamics.jl

Adding QEDFeynmanDiagrams.jl



* renamed in QuantumElectrodynamics.jl

IntegrationTests.jl with GitHub Actions

GitHub Actions

- GitHub Actions matrix mechanism
- Allows to create jobs with a given template and a range of parameters (e.g. Version numbers)
- Parameters can be hard coded or dynamically generated

https://qedjl-project.github.io/IntegrationTests.jl/stable/pipeline_tutorials/#GitHub-Actions

GitHub Actions: job yaml

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```yaml
jobs:
    generate:
        name: Github Action - Generator Integration Jobs
        runs-on: ubuntu-latest
        steps:
        - uses: actions/checkout@v3
        - uses: julia-actions/setup-julia@v1
            with:
            version: "1.10"
            arch: x64
        - uses: julia-actions/cache@v1
        - uses: julia-actions/julia-buildpkg@v1
        - id: set-matrix
            run: echo "matrix=$(julia --project=${GITHUB_WORKSPACE} generateIntegrationTests.jl 2> /dev/null)" >> $GITHUB_OUTPUT
        outputs:
            matrix: ${{ steps.set-matrix.outputs.matrix }}

    run-matrix:
        needs: generate
        runs-on: ubuntu-latest
        strategy:
            matrix:
                package: ${{ fromJson(needs.generate.outputs.matrix) }}
        steps:
            # define the job body of your integration test here depending on the `matrix.package` parameter
            - run: echo "run Integration Test for package ${{ matrix.package }}"
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    - id: set-matrix
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Job parameter generator

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Job parameter generator

Job template

https://qedjl-project.github.io/IntegrationTests.jl/stable/pipeline_tutorials/#GitHub-Actions

GitHub Actions: job yaml

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GitHub Actions: job yaml

```julia
using IntegrationTests
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if !isinteractive()
    # search packages, which are dependent on QEDfields.jl
    # ignore all packages which does not start with QED
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    println(depending_packages)
end
```

```yaml
      - id: set-matrix
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simeon@fwu066:~/projects/IntegrationTests.jl$ julia --project findIntegrationTests.jl
["QED.jl", "QEDprocess.jl"]
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GitHub Actions: job yaml

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GitHub Actions: job yaml

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    outputs:
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```



```yaml
  run-matrix:
    needs: generate
    runs-on: ubuntu-latest
    strategy:
      matrix:
        package: ${{ fromJson(needs.generate.outputs.matrix) }}
    steps:
      # define the job body of your integration test here depending on the `matrix.package` parameter
      - run: echo "run Integration Test for package ${{ matrix.package }}"
```

IntegrationTests.jl with GitLab CI

GitLab CI: parent-child pipeline

- GitLab CI parent-child pipelines
- Allows to run jobs from a (dynamically) generated job yaml
- Requires generator and trigger job

https://qedjl-project.github.io/IntegrationTests.jl/stable/pipeline_tutorials/#GitLab-CI

GitLab CI: job yaml

```yaml
stages:
  - generator
  - runTests

generateIntegrationTests:
  stage: generator
  image: "julia:1.10"
  script:
    - julia --project=. -e 'import Pkg; Pkg.instantiate()'
    - julia --project=. generateIntegrationTests.jl 2> /dev/null 1> jobs.yaml
    - cat jobs.yaml
  interruptible: true
  artifacts:
    paths:
      - jobs.yaml
    expire_in: 1 week

runIntegrationTests:
  stage: runTests
  trigger:
    include:
    - artifact: jobs.yaml
      job: generateIntegrationTests
    strategy: depend
```

https://qedjl-project.github.io/IntegrationTests.jl/stable/pipeline_tutorials/#GitLab-CI

GitLab CI: job yaml

```yaml
stages:
  - generator
  - runTests

generateIntegrationTests:
  stage: generator
  image: "julia:1.10"
  script:
    - julia --project=. -e 'import Pkg; Pkg.instantiate()'
    - julia --project=. generateIntegrationTests.jl 2> /dev/null 1> jobs.yaml
    - cat jobs.yaml
  interruptible: true
  artifacts:
    paths:
      - jobs.yaml
    expire_in: 1 week

runIntegrationTests:
  stage: runTests
  trigger:
    include:
    - artifact: jobs.yaml
      job: generateIntegrationTests
    strategy: depend
```

Job generator

Trigger Job

https://qedjl-project.github.io/IntegrationTests.jl/stable/pipeline_tutorials/#GitLab-CI

GitLab CI: job yaml

```
script:
  - julia --project=. -e 'import Pkg; Pkg.instantiate()'
  - julia --project=. generateIntegrationTests.jl 2> /dev/null 1> jobs.yaml
  - cat jobs.yaml
```

```
function print_job_yaml(package_name::AbstractString)
    job_yaml = """integrationTest$package_name:
          image: "alpine:latest"
          script:
              - echo "run Integration Test for package $package_name"

      """
    return print(job_yaml)
end

if !isinteractive()
    depending_packages = IntegrationTests.depending_projects(
                                "QEDfields.jl", r"^QED*")
    for dep in depending_packages
        print_job_yaml(dep)
    end
end
```

```
integrationTestQED.jl:
    image: "alpine:latest"
    script:
        - echo "run Integration Test for package QED.jl"

integrationTestQEDprocess.jl:
    image: "alpine:latest"
    script:
        - echo "run Integration Test for package QEDprocess.jl"
```

GitLab CI: job yaml

```yaml
stages:
  - generator
  - runTests

generateIntegrationTests:
  stage: generator
  image: "julia:1.10"
  script:
    - julia --project=. -e 'import Pkg; Pkg.instantiate()'
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runIntegrationTests:
  stage: runTests
  trigger:
    include:
    - artifact: jobs.yaml
      job: generateIntegrationTests
    strategy: depend
```

Lessons Learned

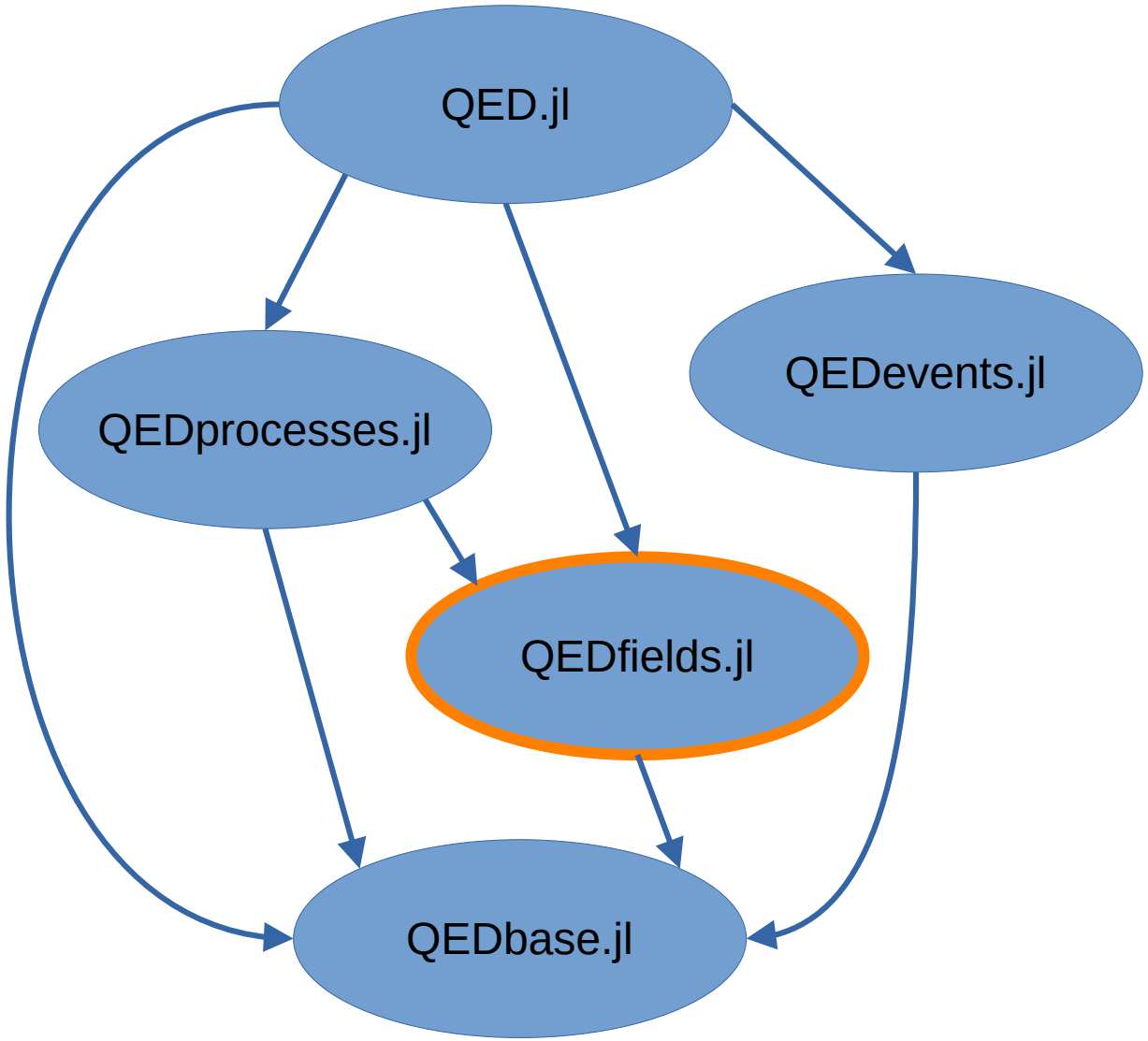
- Permanent integration testing avoids a lot of problems
- Automation is important for new developer

  → A new developer does not know that it's his code can break other codes
- Moving parts of helper code in extra packages improves quality and reliability

https://github.com/QEDjl-project/IntegrationTests.jl

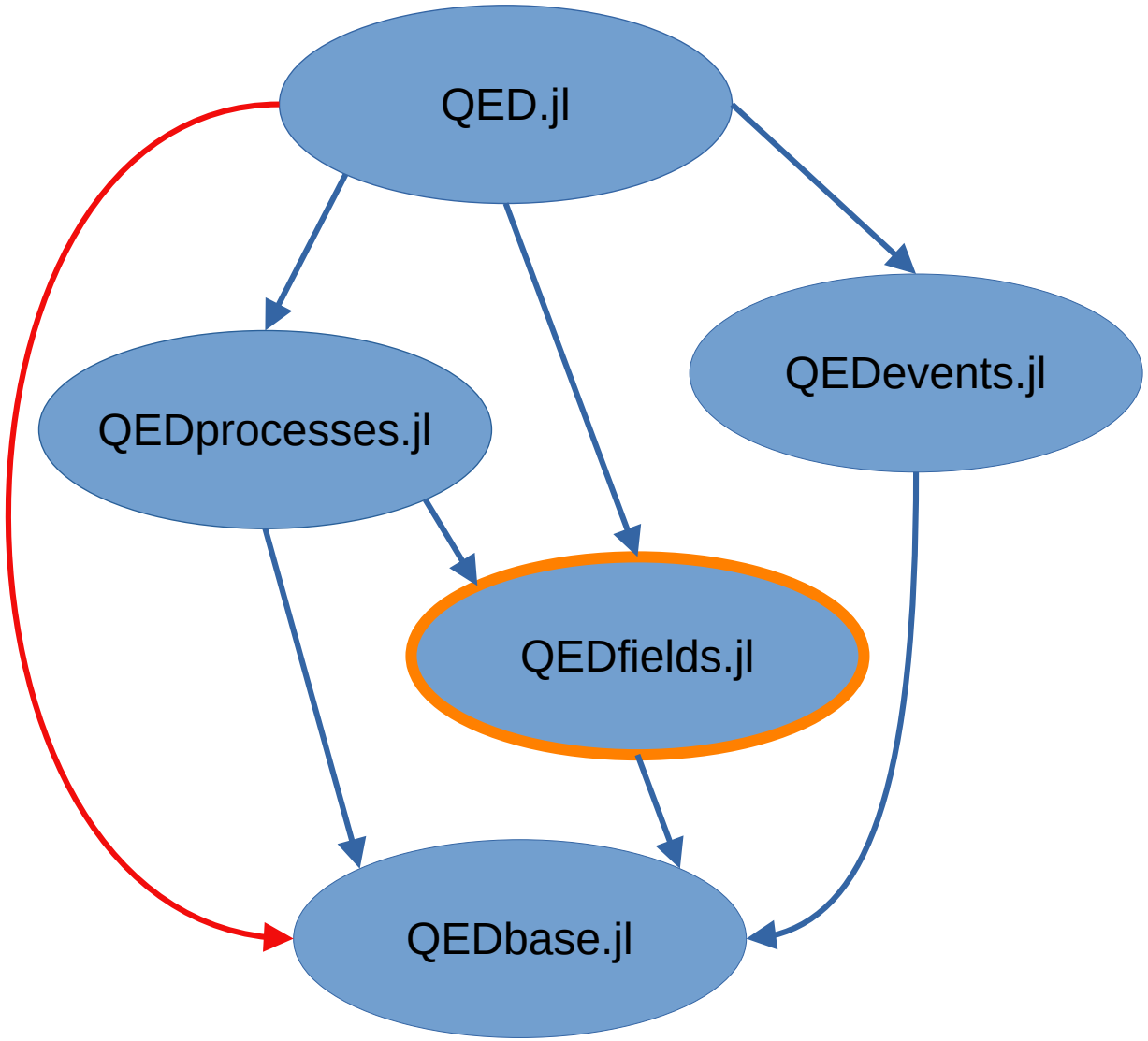
Backup

QED.jl Graph



QEDfields.jl modified

QED.jl Graph



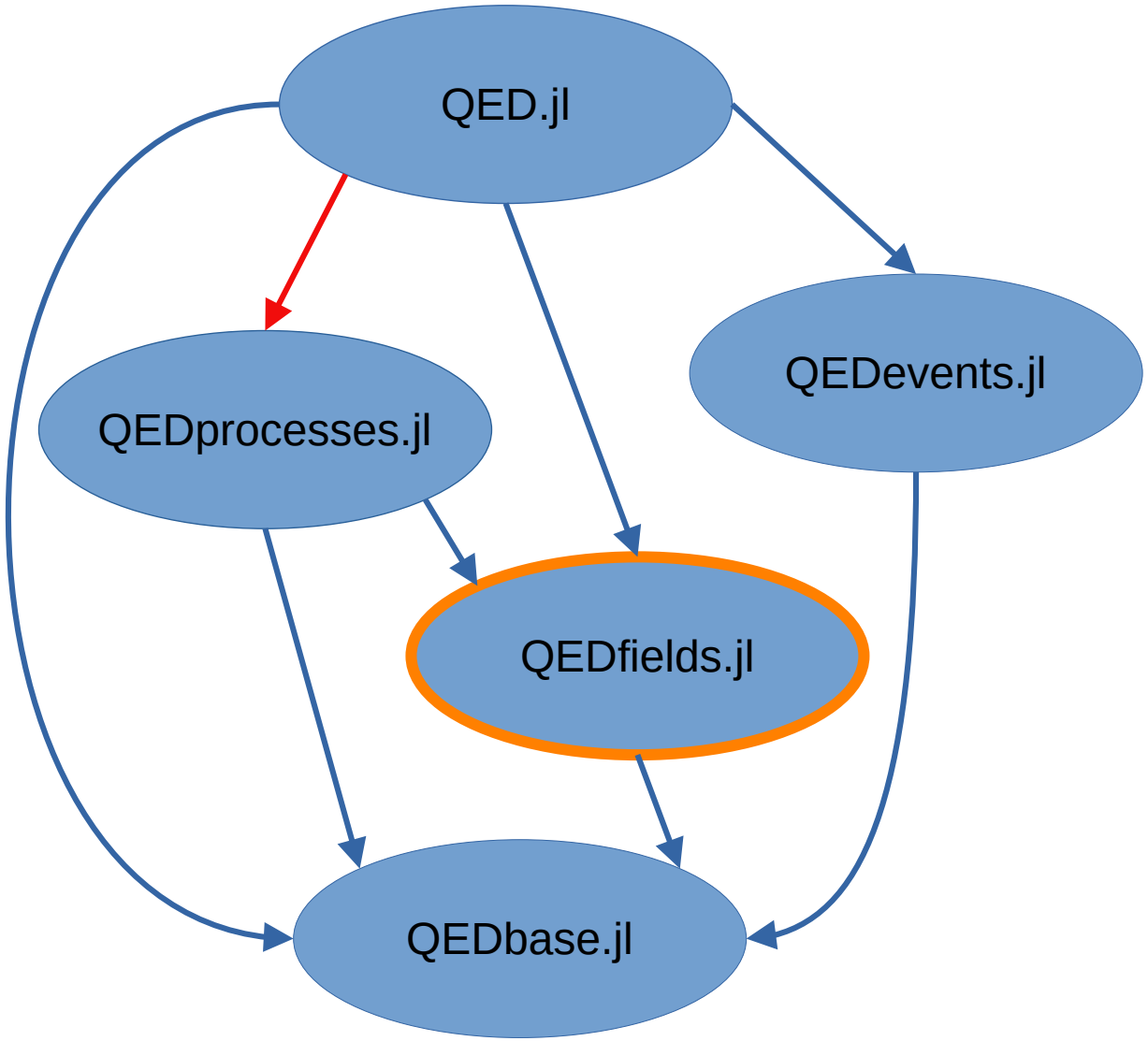
QEDfields.jl modified

Dependent packages:

Visited

- QEDbase.jl

QED.jl Graph



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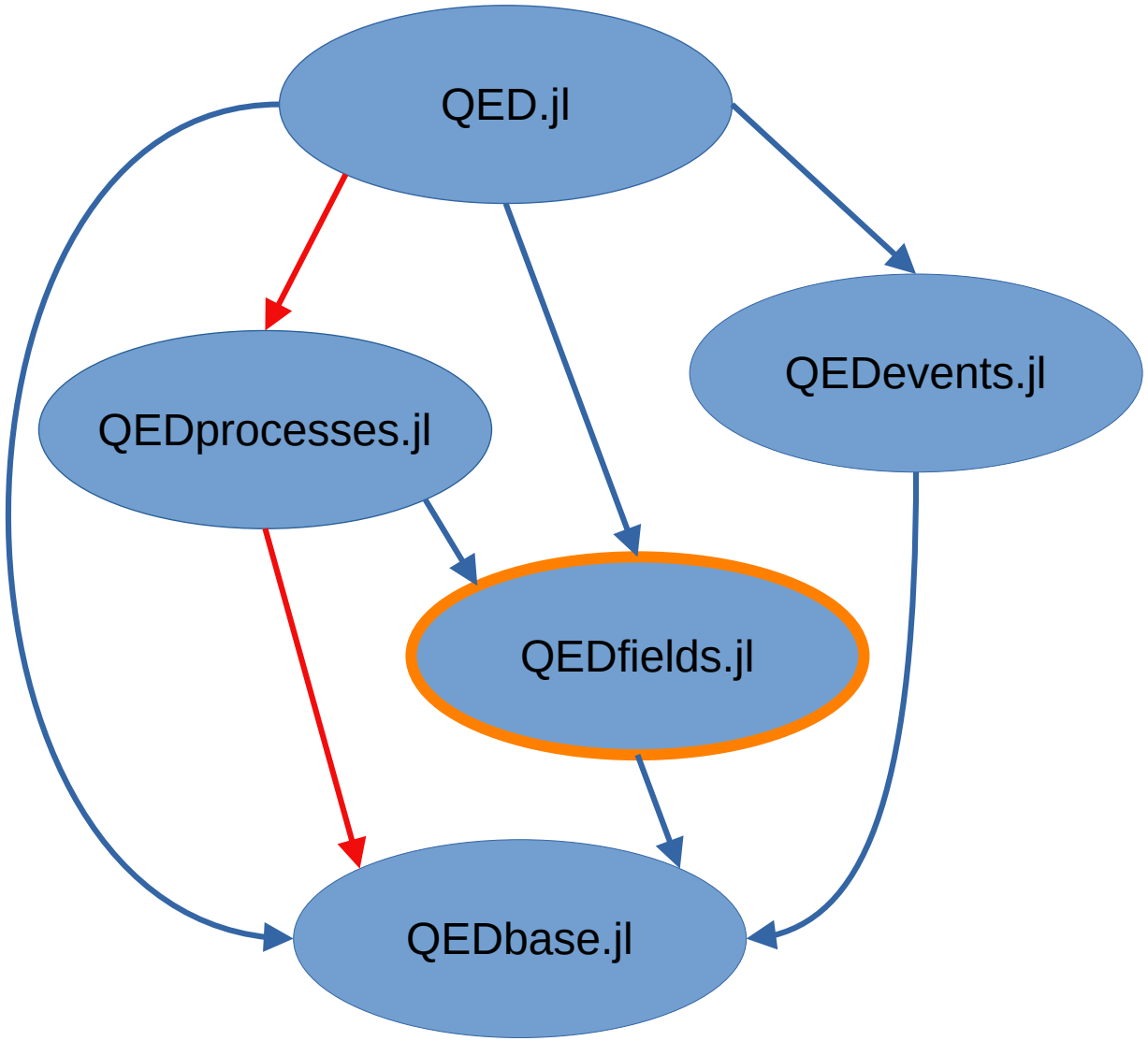
QED.jl Graph



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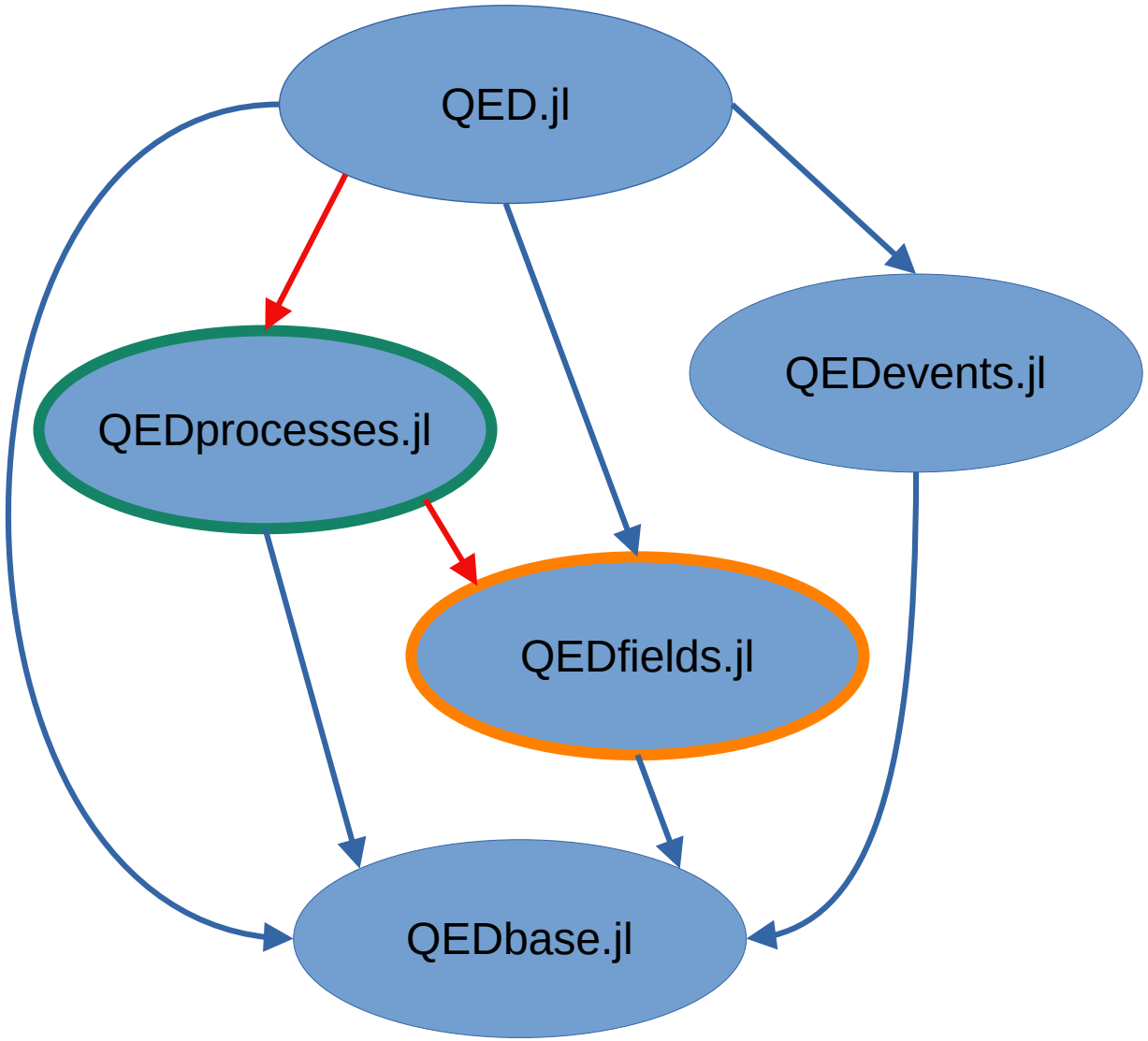

QEDfields.jl modified

Dependent packages:

- QEDProcesses.jl

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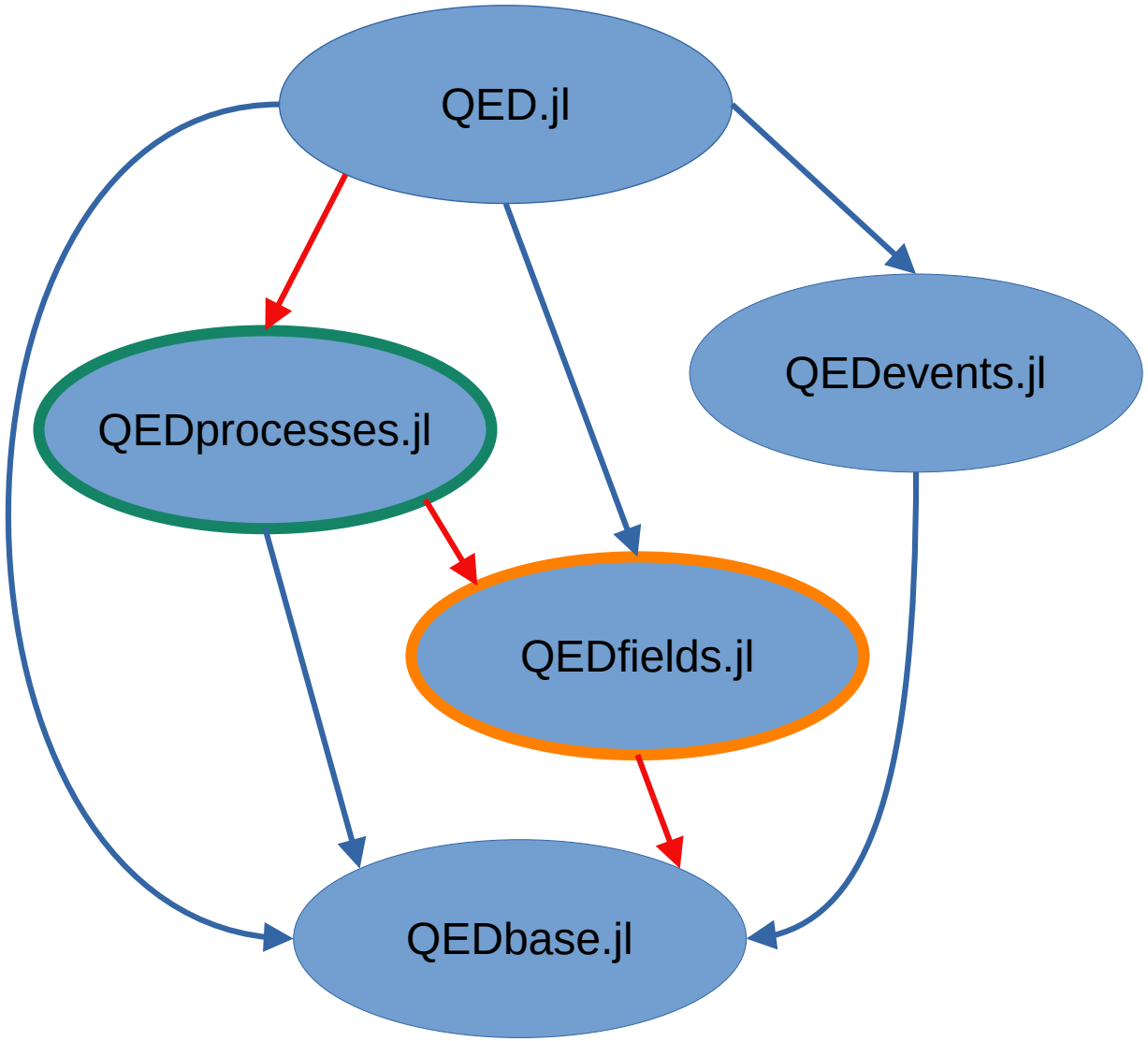
- QEDbase.jl
- QEDprocesses.jl
- QEDfields.jl

QED.jl Graph



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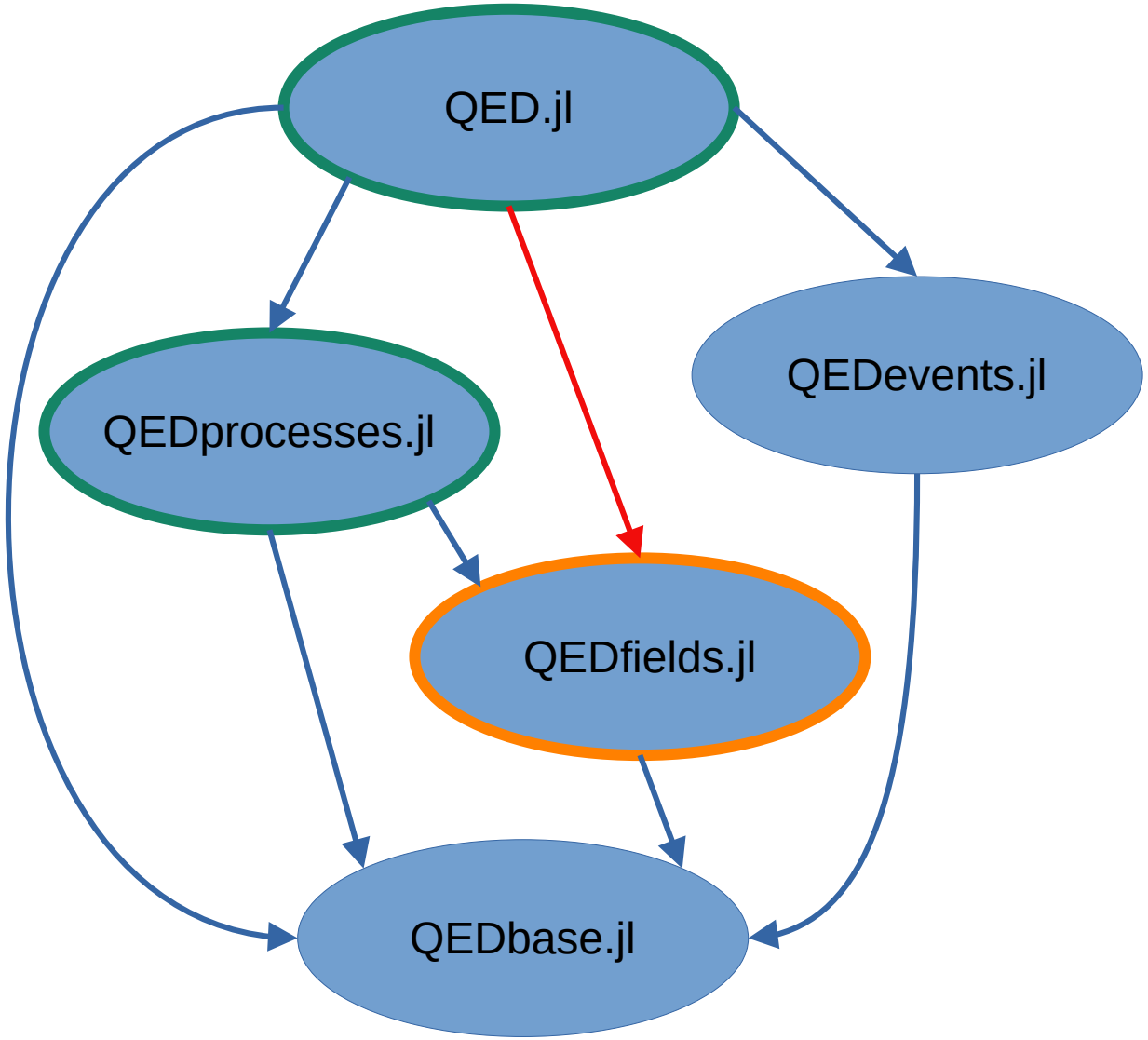
- QEDfields.jl

QED.jl Graph



QEDfields.jl modified

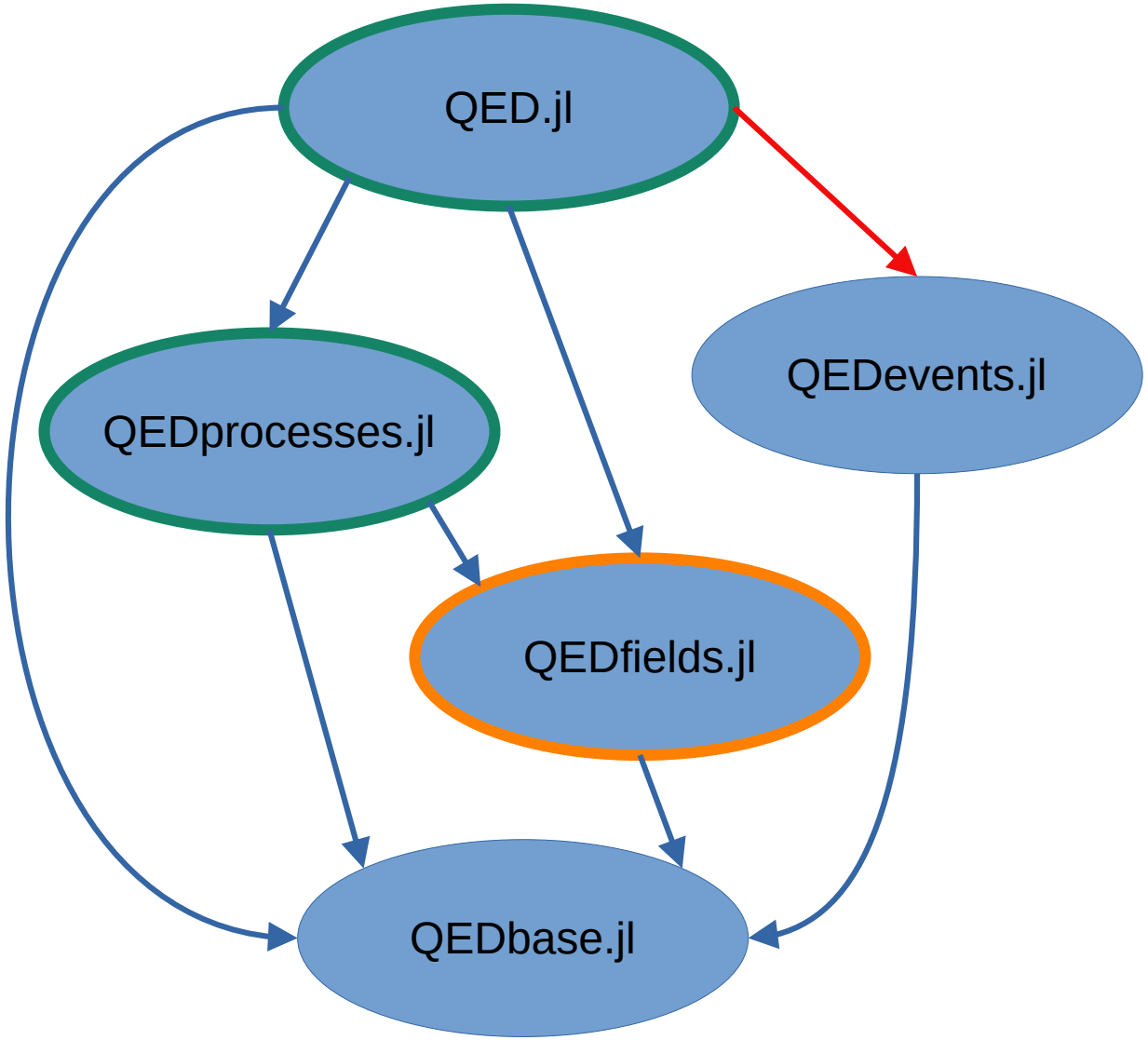
Dependent packages:

- QEDProcesses.jl
- QED.jl

Visited

- QEDbase.jl
- QEDprocesses.jl
- QEDfields.jl

QED.jl Graph



QEDfields.jl modified

Dependent packages:

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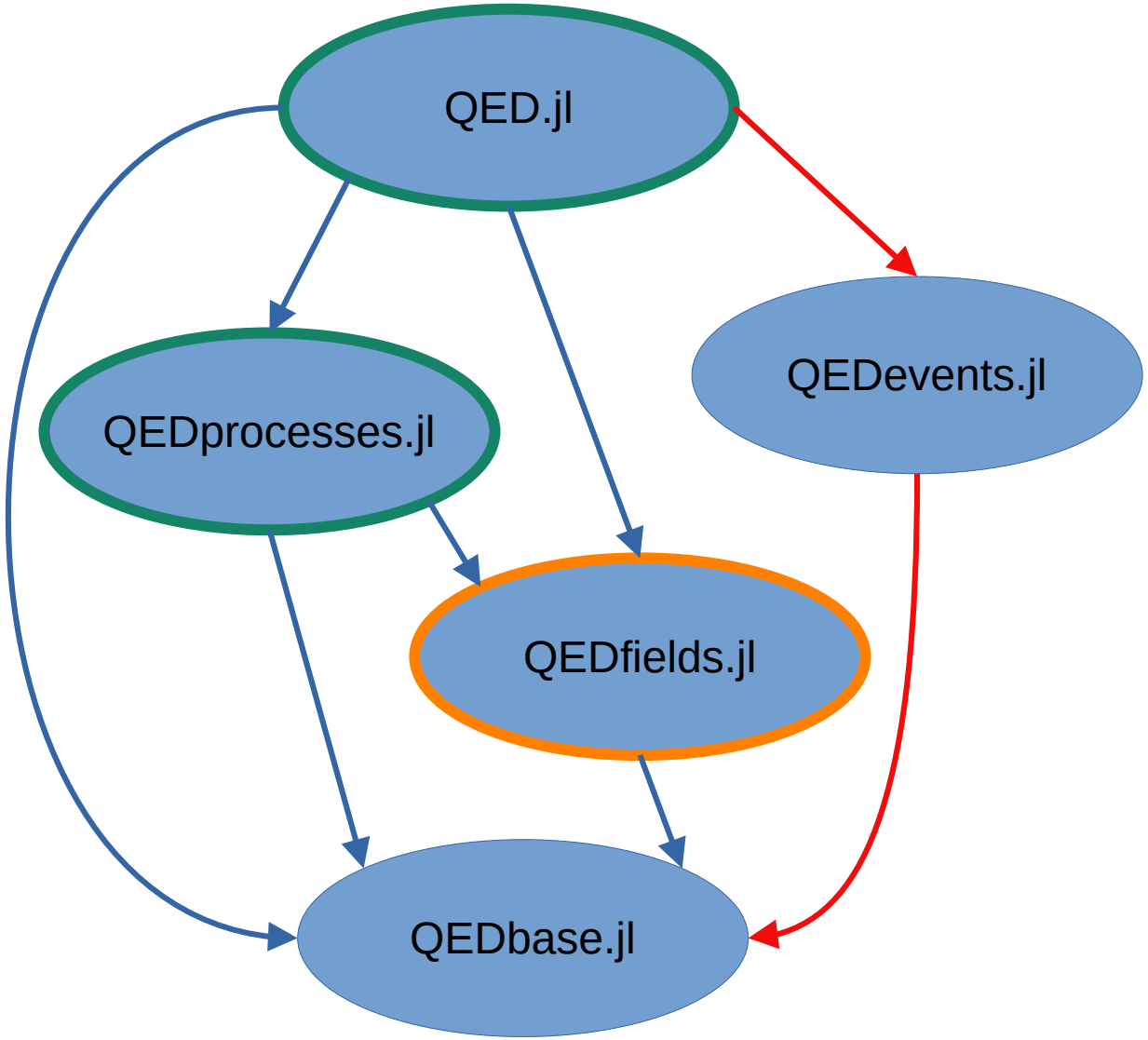
- QED.jl

Visited

- QEDbase.jl
- QEDprocesses.jl
- QEDfields.jl
- QEDevents.jl

QED.jl Graph



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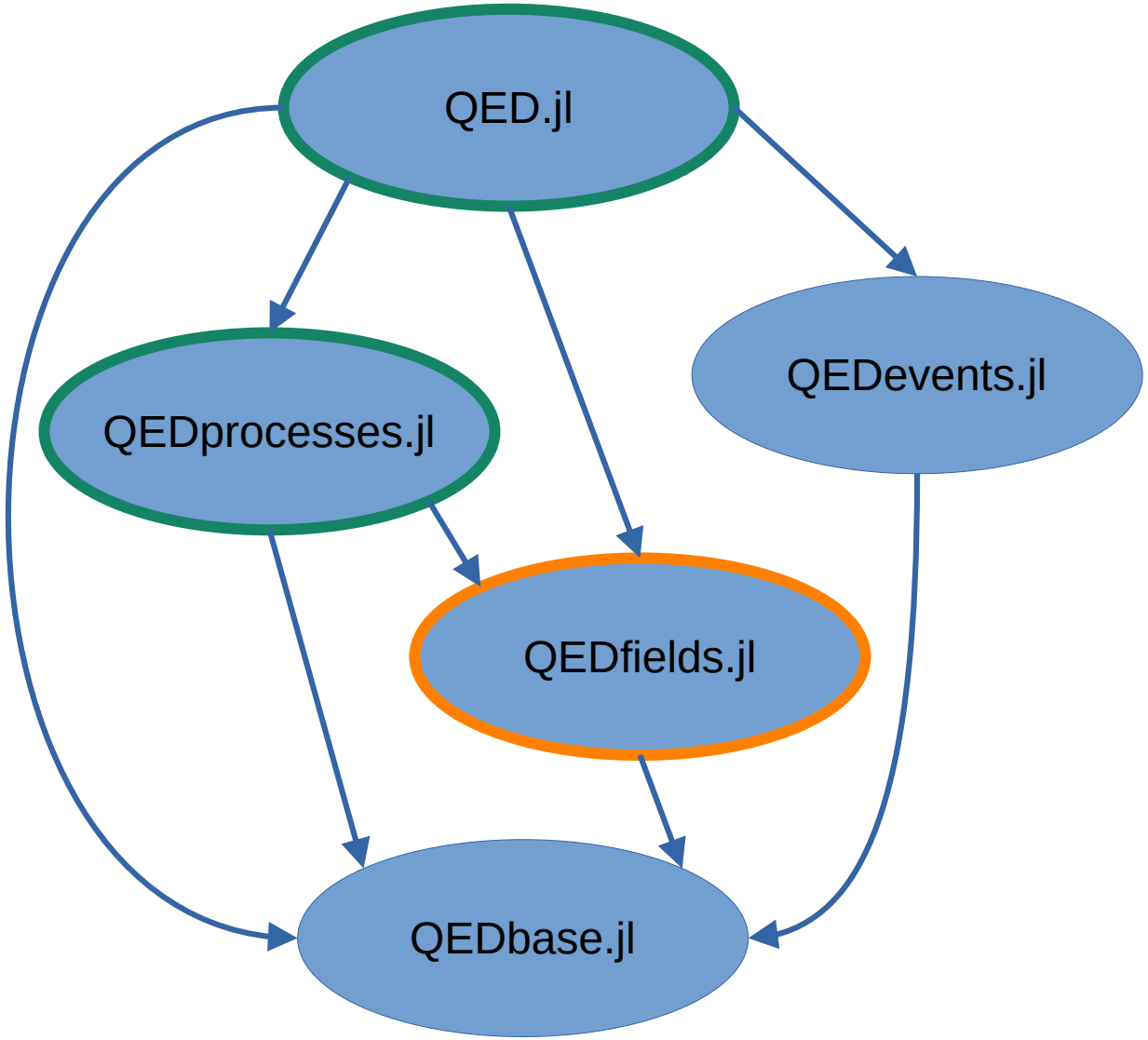
QED.jl Graph



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