RAG Eval BDD Framework

A production-grade Python framework for evaluating RAG systems using:

- `pytest`
- `pytest-bdd` (Cucumber-style Given/When/Then)
- `deepeval` metrics
- `allure-pytest` reporting
- persistent run history + trend comparison (last N runs)

This framework is isolated under `rag_eval_bdd/` and **does not modify notebooks**.

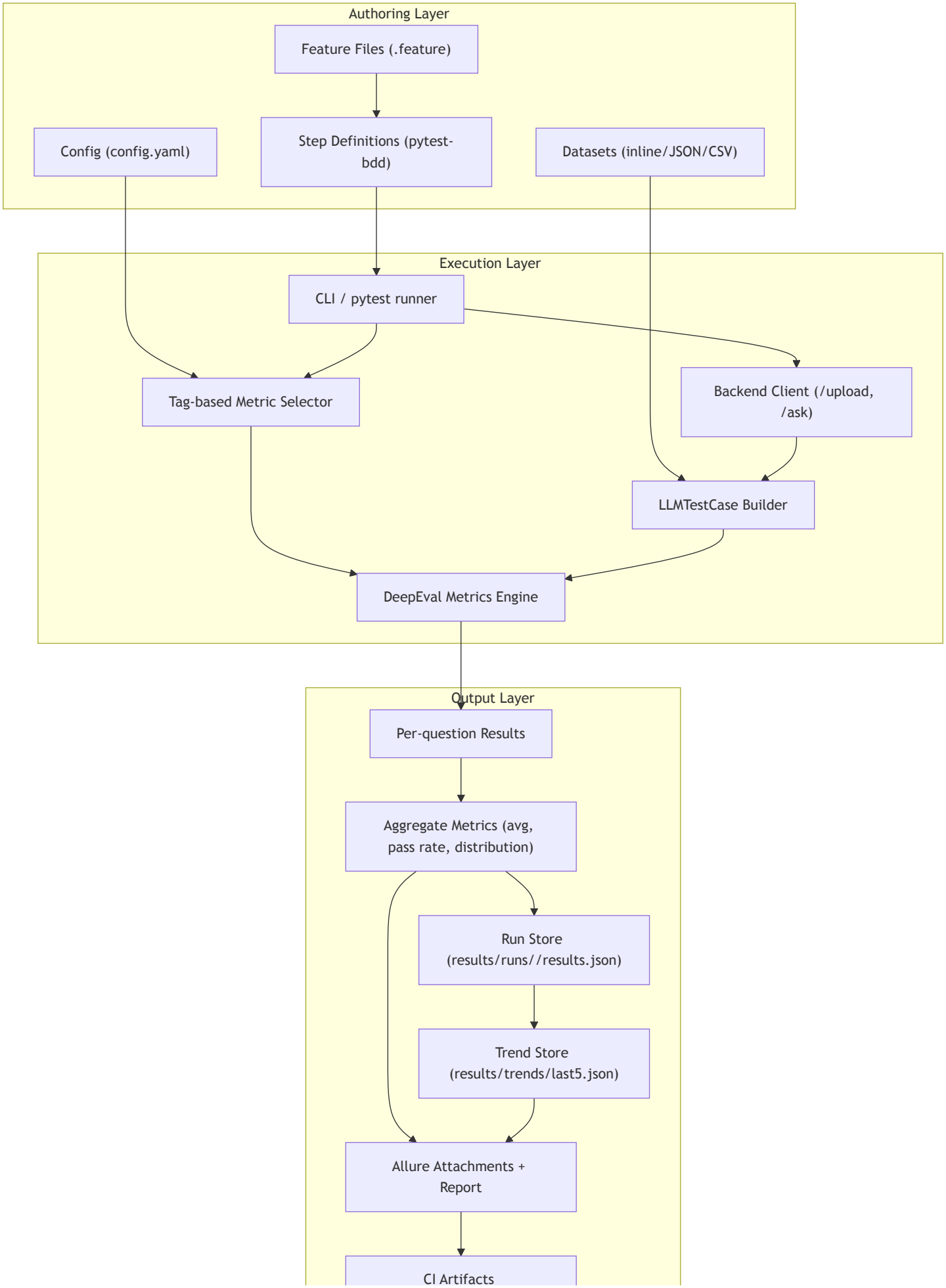
Quick Start (60 seconds)

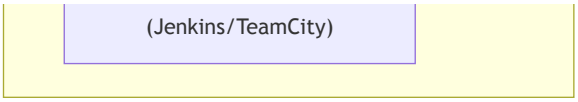
```
git clone <your-repo-url>
cd rag-session-qa-eval
source .venv/bin/activate   # reuse existing repo venv if available
cd rag_eval_bdd
python -m pip install -r requirements.txt
export BASE_URL="http://localhost:8000"
export OPENAI_API_KEY="your_openai_key"
make smoke
make live
make live-notebook-parity
```

Use `make ci` for a stable pipeline flow (`smoke` gate + non-blocking `live`).

BDD Framework Architecture (Quick Access)

If your IDE does not render Mermaid, use the ASCII architecture right below the Mermaid diagram.


Authoring Layer
Feature Files (.feature)
Config (config.yaml)
Step Definitions (pytest-bdd)
Datasets (inline/JSON/CSV)
Execution Layer
CLI / pytest runner
Tag-based Metric Selector
Backend Client (/upload, /ask)
LLMTestCase Builder
DeepEval Metrics Engine
Output Layer
Per-question Results
Aggregate Metrics (avg, pass rate, distribution)
Run Store (results/runs//results.json)
Trend Store (results/trends/last5.json)
Allure Attachments + Report
CI Artifacts




```
AUTHORING LAYER
  Feature Files + Step Definitions + Config + Datasets
                    |
                    v
EXECUTION LAYER
  pytest/CLI -> tag-based metric selection -> backend (/upload,/ask)
                           -> LLMTestCase -> DeepEval metric execution
                    |
                    v
OUTPUT LAYER
  per-question results -> aggregates -> run store -> trend store
                                     -> Allure report -> CI artifacts
```

1) Repository Setup

1.1 Clone the repository

```
git clone <your-repo-url>
cd rag-session-qa-eval
```

1.2 Required tools

- Python `3.11+`
- `pip`
- `venv`
- Java (required by Allure CLI)
- Allure CLI (optional but recommended for local report generation)
- OpenAI API key for live DeepEval metric runs (`OPENAI_API_KEY`)

Check versions:

```
python3 --version
pip --version
java -version
```

1.3 Install framework dependencies

Preferred (reuse existing repo-level virtual environment):

```
cd rag_eval_bdd
source ../.venv/bin/activate
python -m pip install --upgrade pip
python -m pip install -r requirements.txt
```

If `../.venv` does not exist, create a local environment:

```
cd rag_eval_bdd
python3 -m venv .venv
source .venv/bin/activate
python -m pip install --upgrade pip
python -m pip install -r requirements.txt
```

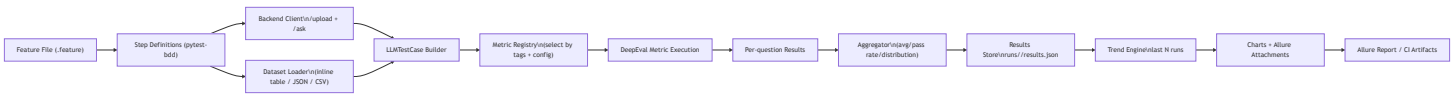
1.4 Configure environment

Set the backend URL and optional runtime settings:

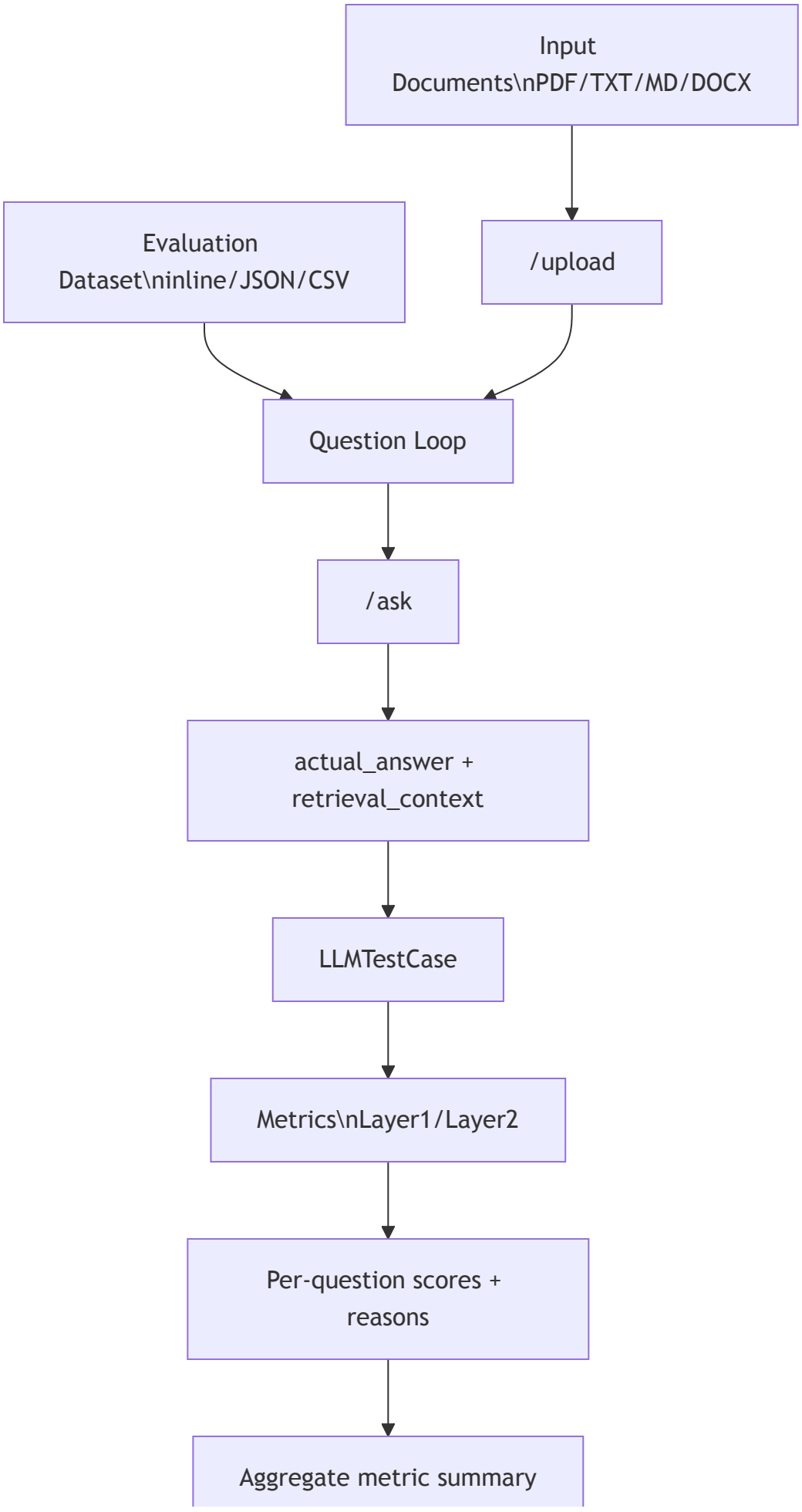
```
export BASE_URL="http://localhost:8000"
export OPENAI_API_KEY="your_openai_key"  # required for live metric evaluation
export API_KEY=""                         # optional backend auth header
export MODEL="gpt-4.1-mini"              # optional
export EMBED_MODEL=""                    # optional
export RAG_EVAL_CONFIG="rag_eval_bdd/config/config.yaml"  # optional override
```

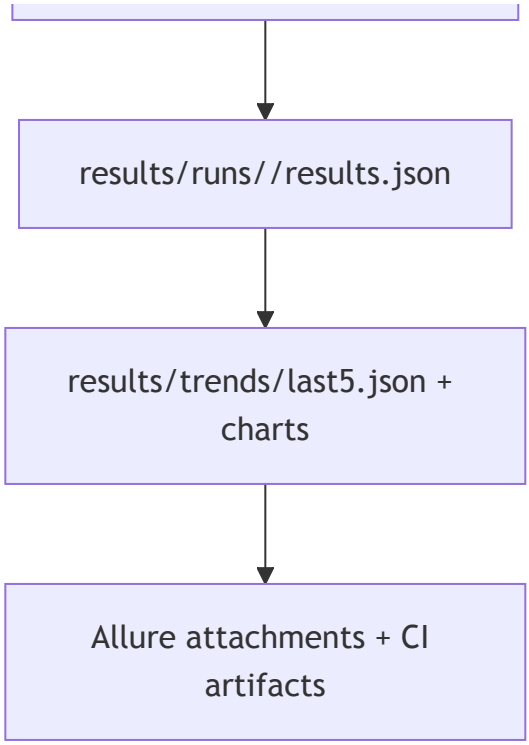
You can set these in repo-level `.env` or `rag_eval_bdd/.env` ; the framework auto-loads both.

2) Workflow Diagram (End-to-End)



3) Data Flow Diagram (Input → Processing → Output)


Input Documents\nPDF/TXT/MD/DOCX
Evaluation Dataset\ninline/JSON/CSV
/upload
Question Loop
/ask
actual_answer + retrieval_context
LLMTestCase
Metrics\nLayer1/Layer2
Per-question scores + reasons
Aggregate metric summary


results/runs//results.json
results/trends/last5.json + charts
Allure attachments + CI artifacts

4) Project Structure Overview

```
rag_eval_bdd/
├── config/
│   └── config.yaml
├── features/
│   ├── layer1_context_metrics.feature
│   └── layer2_answer_metrics.feature
├── steps/
│   └── test_eval_steps.py
├── src/rag_eval_bdd/
│   ├── __main__.py
│   ├── backend_client.py
│   ├── cli.py
│   ├── config_loader.py
│   ├── dataset_loader.py
│   ├── evaluator.py
│   ├── metric_registry.py
│   ├── models.py
│   ├── reporting.py
│   ├── results_store.py
│   └── synthesize.py
├── data/
│   ├── datasets/
│   ├── generated/
│   └── source/
├── results/
│   ├── index.json
│   ├── runs/
│   └── trends/
├── tests/
│   ├── test_config_loader.py
│   ├── test_dataset_loader.py
│   ├── test_evaluator_modes.py
│   ├── test_reporting.py
│   └── test_results_store.py
├── jenkins/
│   └── Jenkinsfile
├── teamcity/
│   ├── README.md
│   └── settings.kts
├── Makefile
```

```
├── pytest.ini
└── requirements.txt
```

What goes where

- `features/` : business-readable BDD scenarios.
- `steps/` : step implementation code (Given/When/Then bindings).
- `data/datasets/` : reusable static test datasets.
- `data/generated/` : synthesized datasets (generated by CLI).
- `results/runs/` : immutable run snapshots.
- `results/trends/` : computed trend artifacts/charts.
- `tests/` : unit tests for framework internals (non-network).

5) Configuration

Primary config file:

- `rag_eval_bdd/config/config.yaml`

Important sections:

- `backend` : base URL, endpoints, retries, timeout.
- `thresholds` : pass/fail criteria by metric.
- `reporting` : run retention and trend chart toggles.
- `synthesize` : default generation settings.
- `evaluation` : token/cost controls for metric execution.

Cost-optimized defaults

The framework is now cost-optimized by default:

- default eval model: `gpt-4.1-mini`
- metric `reason` generation disabled unless enabled
- retrieval context trimmed before metric evaluation
- document upload/session reuse across scenarios for same document
- `/ask` response cache reuse for repeated `(session_id, question)` pairs
- DeepEval retry attempts reduced to `1` (no extra retry call)

Useful overrides:

- `MODEL=gpt-4.1` (or any supported model)
- `RAG_EVAL_INCLUDE_REASON=1`
- `RAG_EVAL_MAX_CONTEXT_CHUNKS=3`
- `RAG_EVAL_MAX_CONTEXT_CHARS_PER_CHUNK=1200`
- `RAG_EVAL_DEEPEVAL_RETRY_MAX_ATTEMPTS=2`
- `RAG_EVAL_CACHE_UPLOADED_DOCUMENTS=0`
- `RAG_EVAL_CACHE_ASK_RESPONSES=0`
- `RAG_EVAL_FRESH_SESSION_PER_QUESTION=1`
- `RAG_EVAL_DISABLE_CONTEXT_TRIMMING=1`
- `RAG_EVAL_METRIC_QUESTION_MAPPING_MODE=all|positional|row`

Notebook parity mode

Use this mode when you want live BDD behavior to be close to the notebooks:

- thresholds auto-set to `0.50`
- fresh upload/session per question
- context trimming disabled
- reason text enabled
- cost optimization disabled
- positional metric-question mapping (row1->metric1, row2->metric2, row3->metric3 when counts match)

Enable with:

- `RAG_EVAL_NOTEBOOK_PARITY_MODE=1`
- or `make live-notebook-parity`

Threshold policy

Thresholds are **only** in config, not in feature files. This keeps business scenarios clean and allows centralized quality control.

6) Test Case Guidelines

6.1 Writing new test cases

Use either:

1. Inline dataset tables in feature files.
2. External dataset files (`JSON/CSV`) loaded by a step.

6.2 Naming conventions

- Feature file: `<layer>_<intent>.feature`
  - Example: `layer2_answer_metrics.feature`
- Scenario names: explicit business intent
  - Example: `Evaluate layer2 answer metrics from external dataset file`
- Dataset ids: stable and traceable
  - Example: `L2_EXT_001`

6.3 Best practices

- Keep one scenario focused on one evaluation objective.
- Reuse dataset files for stable regression coverage.
- Add category/topic fields to slice failures quickly.
- Keep expected answers concise and factual.
- Avoid overfitting thresholds to one run.

7) Feature File Creation (Gherkin)

7.1 Minimal template

```
@layer2 @answer_relevancy @faithfulness
Feature: Layer 2 answer quality

  Scenario: Evaluate answer metrics
    Given backend is reachable
    And documents are uploaded from "eval/sample_docs/Match_Summary.pdf"
    And I load dataset "rag_eval_bdd/data/datasets/layer2_questions.json"
    When I evaluate all questions
    Then metric "answer_relevancy" should be >= configured threshold
    And metric "faithfulness" should be >= configured threshold
    And save results for reporting
```

7.2 Inline table example

```
And I use inline dataset:
  """
  | id   | question                              | expected_answer                  |
  | Q001 | How many sixes did Tilak Varma hit? | Tilak Varma hit 3 sixes.          | ba
  | Q002 | Who dismissed Suryakumar Yadav?     | Kwena Maphaka dismissed Surya.    | wi
  """
```

7.3 Readability and reuse tips

- Keep Given steps generic and reusable.
- Put large datasets in files, not inline.
- Use tags to control metric scope.
- Keep scenarios short; move heavy details to data files.

8) Step Definitions

Step bindings are in:

- `rag_eval_bdd/steps/test_eval_steps.py`

8.1 Binding pattern

- `@given(...)` prepares backend/session/data.
- `@when(...)` executes evaluation loop.
- `@then(...)` asserts aggregate thresholds and persists artifacts.

8.2 Typical organization pattern

- Input setup steps
- Execution step(s)
- Assertion steps
- Persistence/reporting step

8.3 New step template

```
from pytest_bdd import given, when, then, parsers

@given(parsers.parse('I set category "{category}" filter'))
def set_category_filter(category, scenario_state):
    scenario_state.category_filter = category

@when("I evaluate filtered questions")
def evaluate_filtered(...):
    ...

@then(parsers.parse('metric "{metric_name}" pass rate should be >= {min_rate:f}%'))
def assert_pass_rate(metric_name, min_rate, scenario_state):
    ...
```

9) Dataset Creation and Management

9.1 Supported formats

- JSON (`.json`)
- CSV (`.csv`)
- text lines (`.txt` , `.md`) for basic loading/synthesis context extraction

9.2 Recommended dataset schema

```
[
  {
    "id": "L2_EXT_001",
    "question": "How many sixes did Tilak Varma hit?",
    "expected_answer": "Tilak Varma hit 3 sixes.",
    "category": "batting",
    "source_reference": "Match_Summary.pdf"
  }
]
```

9.3 CSV schema

```
id,question,expected_answer,category,source_reference
L2_EXT_001,How many sixes did Tilak Varma hit?,Tilak Varma hit 3 sixes.,batting,Match_S
```

9.4 Data reuse guidelines

- Keep canonical datasets under `data/datasets/` .
- Keep generated datasets under `data/generated/` .
- Use stable IDs for trend comparison and triage.
- Version control curated datasets.

10) Synthetic Dataset Generation (DeepEval Synthesizer)

Generate from folder/file/dataset:

```
cd rag_eval_bdd
python -m rag_eval_bdd synthesize \
  --input data/source/ \
  --output data/generated/questions.json \
  --num-questions 50
```

Generated output fields:

- `id`
- `question`
- `expected_answer` (optional)
- `category` (optional)
- `source_reference` (optional)

11) Execution and Reports

11.1 Test execution

Note: run `pytest` against `steps/` (not `features/`) because `pytest-bdd` scenarios are materialized from Python step modules.

Recommended (via Makefile):

```
cd rag_eval_bdd
make smoke              # deterministic and stable
make live               # live backend + LLM metrics
make live-notebook-parity  # notebook-like behavior for live demo parity
make ci                 # smoke gate + live non-blocking
```

Deterministic smoke suite (stable CI gate, no live LLM/backend dependency):

```
cd rag_eval_bdd
python -m pytest -c pytest.ini tests -m "smoke" -q
```

Live BDD evaluation suite:

```
python -m pytest -c pytest.ini steps -m "live" --alluredir=allure-results
```

Notebook-parity live run:

```
RAG_EVAL_NOTEBOOK_PARITY_MODE=1 python -m pytest -c pytest.ini steps -m "live" --allure
```

Run all live features:

```
python -m pytest -c pytest.ini steps --alluredir=allure-results
```

Live suite as non-blocking quality signal:

```
python -m pytest -c pytest.ini steps -m "live" --alluredir=allure-results || true
```

By default, the framework now does this automatically for every run (when `--alluredir` is present):

- clears old `allure-results/` and `allure-report/`
- generates a fresh `allure-report/`
- opens the report in browser via `allure open` (local HTTP server)

Run layer-specific:

```
python -m pytest -c pytest.ini steps -m "layer1" --alluredir=allure-results
python -m pytest -c pytest.ini steps -m "layer2" --alluredir=allure-results
```

Run metric subset:

```
python -m pytest -c pytest.ini steps -m "faithfulness or completeness" --alluredir=allu
```

Run via CLI wrapper:

```
python -m rag_eval_bdd run --suite smoke
python -m rag_eval_bdd run --suite live --tags "layer1"
python -m rag_eval_bdd run --suite live --feature features/layer2_answer_metrics.featur
```

`--feature` currently derives layer filter (`layer1` / `layer2`) from the feature file name.

11.2 Allure report generation

Auto-generation happens at the end of each pytest run. Manual command is still available:

```
allure generate allure-results --clean -o allure-report
```

11.3 Output meaning

- `results/runs/<run_id>/results.json`

    - full run payload (question-level + aggregate)
- `results/index.json`
    - pointers to recent runs
- `results/trends/last5.json`
    - trend summary across recent runs
- Allure attachments
    - per-question metrics
    - raw request/response
    - trend charts and trend HTML summary

12) CI/CD Integration

12.1 Jenkins

Use provided pipeline:

- `rag_eval_bdd/jenkins/Jenkinsfile`

It performs:

1. Checkout
2. Create virtualenv
3. Install dependencies
4. Run deterministic smoke gate
5. Run live eval as non-blocking stage
6. Publish Allure results
7. Archive `results/` artifacts

12.2 GitHub Actions (example)

Create `.github/workflows/rag-eval-bdd.yml`:

```yaml
name: rag-eval-bdd

on:
  workflow_dispatch:
  push:
    paths:
      - "rag_eval_bdd/**"

jobs:
  test:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v4
      - uses: actions/setup-python@v5
        with:
          python-version: "3.11"
      - name: Install
        run: |
          cd rag_eval_bdd
          python -m venv .venv-ci
          . .venv-ci/bin/activate
          pip install --upgrade pip
          pip install -r requirements.txt
      - name: Run tests
        env:
          BASE_URL: ${{ secrets.BASE_URL }}
          OPENAI_API_KEY: ${{ secrets.OPENAI_API_KEY }}
          API_KEY: ${{ secrets.API_KEY }}
        run: |
          cd rag_eval_bdd
          . .venv-ci/bin/activate
          pytest -c pytest.ini tests -m "smoke" -q
          pytest -c pytest.ini steps -m "live and (layer1 or layer2)" --alluredir=allur
      - name: Upload artifacts
        uses: actions/upload-artifact@v4
        with:
          name: rag-eval-artifacts
          path: |
            rag_eval_bdd/allure-results
            rag_eval_bdd/results
```

12.3 TeamCity

See:

- `rag_eval_bdd/teamcity/README.md`
- `rag_eval_bdd/teamcity/settings.kts`

13) Troubleshooting

Error: `ModuleNotFoundError: No module named 'pytest_bdd'`

Fix:

```
cd rag_eval_bdd
source ../.venv/bin/activate
python -m pip install -r requirements.txt
```

Error: `no tests ran` when using `pytest ... features`

Cause:

- `pytest-bdd` scenarios are materialized from Python step modules, so collecting only `features/` does not execute scenarios.

Fix:

```
python -m pytest -c pytest.ini steps --alluredir=allure-results
```

Error: `pytest: error: unrecognized arguments: --alluredir=...`

Cause:

- `allure-pytest` plugin is not installed in the active virtual environment.

Fix:

```
cd rag_eval_bdd
source ../.venv/bin/activate
python -m pip install -r requirements.txt
python -m pytest -c pytest.ini steps --alluredir=allure-results
```

Error: Backend not reachable

Symptoms:

- `RuntimeError: Backend is not reachable`

Checks:

- Backend process is running
- `BASE_URL` is correct
- network/firewall allows access

Error: `/upload` or `/ask` failures

Checks:

- endpoint paths in `config/config.yaml`
- request payload compatibility with backend
- API auth (`API_KEY`) if required

Error: No metrics selected

Cause:

- tag selection does not map to layer/metric tags

Fix:

- include `@layer1` or `@layer2`
- or include explicit metric tags (`@faithfulness` , etc.)

Error: Completeness/Context relevance class unavailable

Behavior:

- framework falls back to `GEval` for unsupported metric classes

Flaky score movements across runs

Mitigation:

- evaluate using distributions and pass rate, not only single score
- compare against trend (`last5.json`)
- tune thresholds conservatively in config

Allure report empty or not rendering

Checks:

- tests executed with `--alluredir=allure-results`
- allure CLI installed and Java available
- do not open `allure-report/index.html` directly with `file://` in browser; use `allure open allure-report`
- if browser shows endless "Loading...", rerun tests and let auto-open handle it (served over HTTP)

Auto-report controls:

- `RAG_EVAL_AUTO_ALLURE_CLEAN=0` to keep previous `allure-results`
- `RAG_EVAL_AUTO_ALLURE_GENERATE=0` to disable auto generation
- `RAG_EVAL_AUTO_ALLURE_OPEN=0` to disable browser popup

14) Quick Start (Minimal)

```
cd rag_eval_bdd
source ../.venv/bin/activate
python -m pip install -r requirements.txt
export BASE_URL="http://localhost:8000"
export OPENAI_API_KEY="your_openai_key"
make live
```

15) Contributor Checklist

Before pushing changes:

1. Add/update tests in `rag_eval_bdd/tests/` for non-network logic.
2. Keep feature files business-readable.
3. Do not hardcode thresholds in feature files.
4. Ensure new steps are reusable and generic.
5. Verify outputs are persisted and trend-compatible.
6. Keep notebooks untouched.