

# MESA Batch Runs

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This directory contains tools to automate running multiple MESA models with different parameters. This README explains how to use these tools, their options, and the recommended workflow.

## Directory Structure

```
batch_runs/
├── bin/                                # Executable scripts for batch operations
│   ├── make_batch.py                  # Script to generate inlists from CSV
│   ├── make_batch.sh                  # Shell script version of make_batch.py
│   ├── run_batch.py                   # Script to run all inlists sequentially
│   ├── run_batch.sh                   # Shell script version of run_batch.py
│   ├── dependency_check.py            # Checks required dependencies
│   ├── verify_inlists.py              # Script to verify inlist parameters
│   ├── verify_outlists.py             # Script to verify run outputs
│   └── construct_output.py            # Script to extract results into CSV
├── batch_inlists/                     # Directory for generated inlist files
│   └── *.inp                          # Generated inlist files
├── runs/                              # Directory for run outputs
│   └── */                             # Subdirectories for each model run
├── analysis/                          # Analysis and visualization tools
│   ├── plot_hr.py                     # Script to generate HR diagram plots
│   ├── plot_ccore_mass.py             # Script to plot core mass evolution
│   ├── plot_composition.py            # Script to plot composition profiles
│   └── plot_timing.py                 # Analyze runtime performance
├── notebooks/                         # Interactive Jupyter notebooks
│   ├── run_batch.ipynb                # Notebook version for generating run script
│   └── make_batch.ipynb               # Notebook version for generating inlists
├── plots/                             # Output directory for generated plots
│   └── *.png                          # Plot image files
├── MESA_Lab.csv                       # Parameter combinations for batch runs
├── filled_MESA_Lab.csv                 # Results from completed runs
└── run_timings.csv                    # Performance data for each run
```

# Workflow Overview

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The typical workflow for batch runs is:

1. **Prepare a CSV** file with parameter combinations to explore
2. **Generate inlists** using `bin/make_batch.py` or `bin/make_batch.sh`
3. **Run the models** using `bin/run_batch.py` or `bin/run_batch.sh`
4. **Analyze the results** using the scripts in the `analysis/` directory or `bin/construct_output.py`

## Detailed Steps

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### 1. Use Provided CSV File

The online spreadsheet and the provided `MESA_Lab.csv` file contain the same parameter combinations.

You don't need to create your own CSV file. Use the provided `MESA_Lab.csv` file or access the [online spreadsheet](#)

This CSV file already contains the necessary columns:

- `YOUR NAME` (your name)
- `initial mass [Msol]` (stellar mass in solar masses)
- `initial metallicity` (Z value)
- `overshoot scheme` ("no overshooting", "exponential", or "step")
- `overshoot parameter (f_ov)` (overshooting parameter)
- `overshoot f0` (f0 parameter for overshooting)

### 2. Generate Inlists

Using Python Script:

```
python make_batch.py MESA_Lab.csv
```

Using Shell Script:

```
./make_batch.sh MESA_Lab.csv
```

This will:

1. Create the `batch_inlists` directory if it doesn't exist
2. Generate an inlist file for each parameter set in the CSV
3. Name each inlist file according to its parameters (e.g.,  
`inlist_M2_Z0.014_exponential_fov0.01_f00.001.inp` )

### Options during inlist generation:

You will be prompted to choose whether pgstar (visualization) should be enabled:

- Answer `yes` to enable visualization during runs (slower but you can see progress)
- Answer `no` to disable visualization (faster for batch processing)

### Alternative: Jupyter Notebook

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## 3. Run the Models

### Using Python Script:

```
python run_batch.py
```

### Using Shell Script:

```
./run_batch.sh
```

This will:

1. Process each inlist in `batch_inlists` directory
2. Create a subdirectory in `runs` for each model
3. Copy the model results to its respective subdirectory
4. Record timing information in `run_timings.csv`

## Alternative: Jupyter Notebook

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## 4. Analyze Results

### Extract Data to CSV:

```
python construct_output.py
```

This will create a CSV file ( `filled_MESA_Lab.csv` ) with the results from all runs, including:

- Input parameters
- $\log(\text{Teff})$
- $\log(L)$
- Core mass
- Core radius
- Age at TAMS
- Runtime

### Create Plots:

```
python plot_hr.py           # Create HR diagrams
python plot_ccore_mass.py   # Plot core mass evolution
python plot_composition.py  # Plot composition profiles
```

These scripts will:

1. Read data from all models in the `runs` directory
2. Create comparison plots for all models
3. Save plots to a `plots` directory

## Verification Tools

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To verify that your inlists were generated correctly:

```
python verify_inlists.py MESA_Lab.csv
```

To verify that your runs completed successfully and match the expected configurations:

```
python verify_outlists.py MESA_Lab.csv
```

## Compatibility Notes

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- The Python scripts require Python 3.6+ and the `mesa_reader` package for analysis scripts
- The shell scripts require a UNIX-like environment (Linux, macOS, or WSL on Windows)
- The Jupyter notebooks can be run in Google Colab for platform independence

## Troubleshooting

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- If a run fails, check the `run.log` file in the corresponding run directory
- Verify that the MESA installation is working with a single model before attempting batch runs
- Make sure paths are set correctly for `$MESA_DIR` and `$MESASDK_ROOT`
- Ensure all inlists have valid parameters (use `verify_inlists.py` to check)

## Running Individual Models

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To run a specific model rather than the entire batch:

1. Copy the desired inlist file from `batch_inlists` to the main MESA directory as `inlist_project`
2. Run MESA as normal with `./rn`

## Example Usage

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```
# Generate inlists from the provided CSV
python make_batch.py MESA_Lab.csv

# Run a subset of models for testing
cp batch_inlists/inlist_M2_Z0.014_noovs.inp ../inlist_project
cd ..
./rn

# Run all models in batch
cd batch_runs
./run_batch.sh

# Extract results to CSV
python construct_output.py

# Generate plots
python plot_hr.py
python plot_ccore_mass.py
```