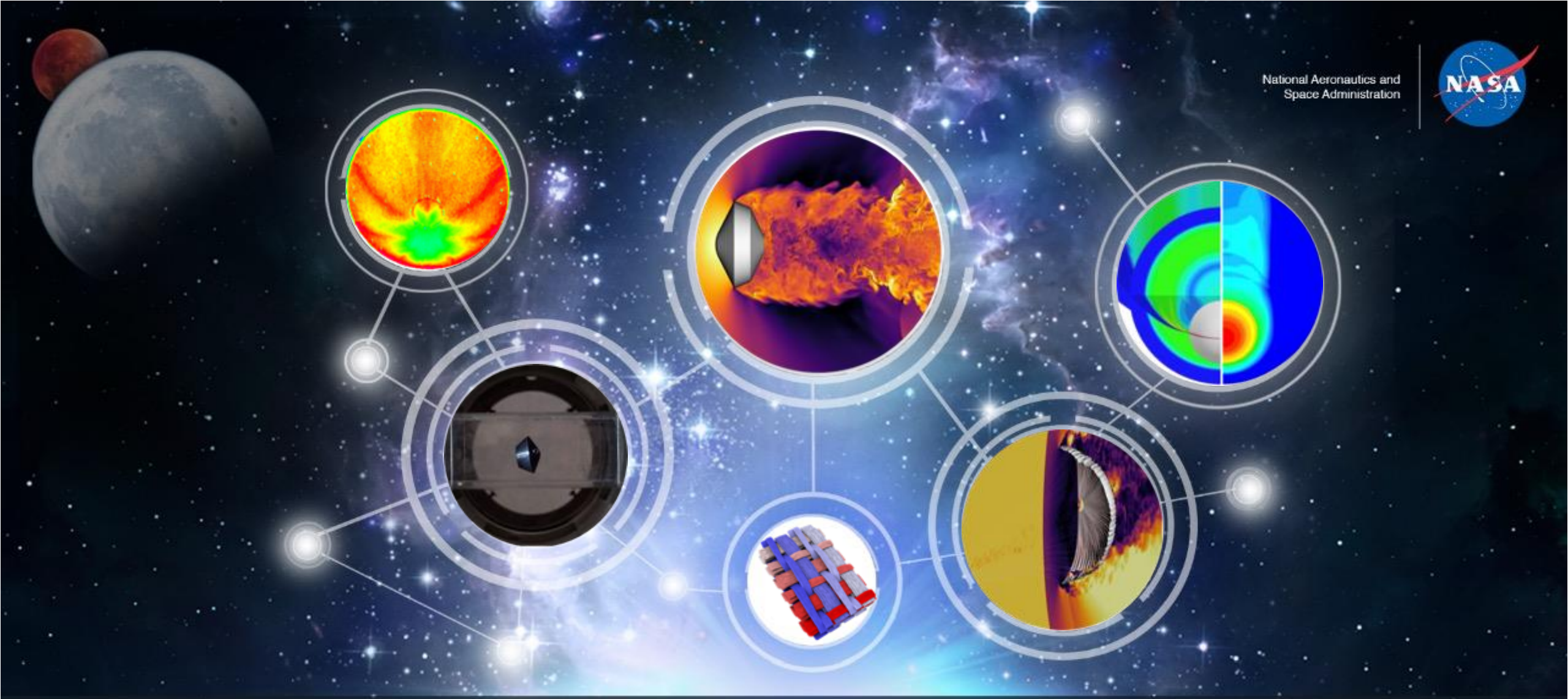

POST Explorer: A Design Space Exploration Tool for POST2

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Analytical Mechanics Associates

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AIAA SciTech Forum
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01/07/25

Background

- **Program to Optimize Simulated Trajectories II (POST2) is a widely used, flight validated trajectory simulation tool that has been used to solve a variety flight mechanics problems**

- **Development of POST2 began with POST in the 1970s, and has undergone continuous development and updates at NASA Langley Research Center (LaRC) since late 2000s**

- **Recent significant efforts funded by the Entry Systems Modeling (ESM) project to upgrade POST2**
  - Thread-safe computations, allowing multiple trajectories to be propagated simultaneously, enabling more rapid optimization solutions for example [AIAA 2023-0148]
  - Application Programming Interface (API) allowing for coupling with external tools and frameworks (such as MATLAB and Python) [AIAA 2024-0161]

- **POST2 is more widely available with v5.0 release, ~Q1 Cy25**
  - POST2 v5.0 now EAR, not ITAR
  - Two editions: Government and Commercial
  - API included in v5.0 release, POST Explorer will be part of future release

Motivation

- **POST2 is very powerful, but it can have a steep learning curve when simulating complex 6DOF flight systems, and can be difficult for non-expert users to become familiar with**

- **Often, project stakeholders are interested in understanding general trends and sensitivities of the flight system**
  - Typically POST2 expert completes analysis and conveys to project stakeholder
  - Scripts and data can be delivered to stakeholder, but require additional explanation

- **<u>Problem:</u> How can we facilitate POST2 usability by non-experts?**

- **<u>Solution:</u> POST Explorer**
  - Design space exploration tool for POST2
  - POST2 expert user defines base simulation inputs (**<u>not removing POST2 expert</u>**)
  - Non-expert user can tweak inputs from that starting point, inspect and visualize data

Outline

- **Design of POST Explorer**
- **Sample Use Cases**
- **Summary**

Design of POST Explorer - Framework

- **Programming language chosen for POST Explorer was Python**
  - Can leverage much of past work done to interface POST2 with Python via API, to couple POST2 with Copernicus
  - All data for trajectory simulation and graphical user interface (GUI) reside in one place

- **For GUI development, the Qt framework was selected**
  - Qt is widely used for GUI development, so it has good documentation and examples/tutorials
  - Pyside6 was utilized as it is the official module from Qt for Python project

- **PyQtGraph for visualizations**
  - Rich “out-of-the-box” features for plotting
  - Leverages numpy for computations, so is also efficient

- **Tool layout consists of multiple tabs**
  - Analyze, Explore, and Data

Design of POST Explorer – Analyze Tab

Base Inputs: Applied to All Runs

	Variable	Index	Event	Value
1	SPICE_EPOCH			24-SEP-2023 14:42:04.025 TDB
2	TIMEO			-5.347034740450686e+04
3	xi	1	1	-3.4214150208E+05
4	yi		1	5.4590052611E+06
5	zi		1	3.7609990438E+06
6	vxi	1	1	-1.0541537894E+04
7	vyi		1	-6.1209290444E+03
8	vzi		1	3.2071099153E+03

Index: 0 Event: 1.0

Varying Inputs: Run Definitions

	Variable	Index	Event	Values
1	dt		1	List: 0.1, 0.05

Index: 0 Event: 1.0

Outputs

- [x] time
- [x] gdalt
- [x] heatrt
- [x] asmg
- [x] gdlat
- [x] long

Output Cadence: 0.00

Run POST2

Base Inputs only (single run)

Run

Design of POST Explorer – Analyze Tab

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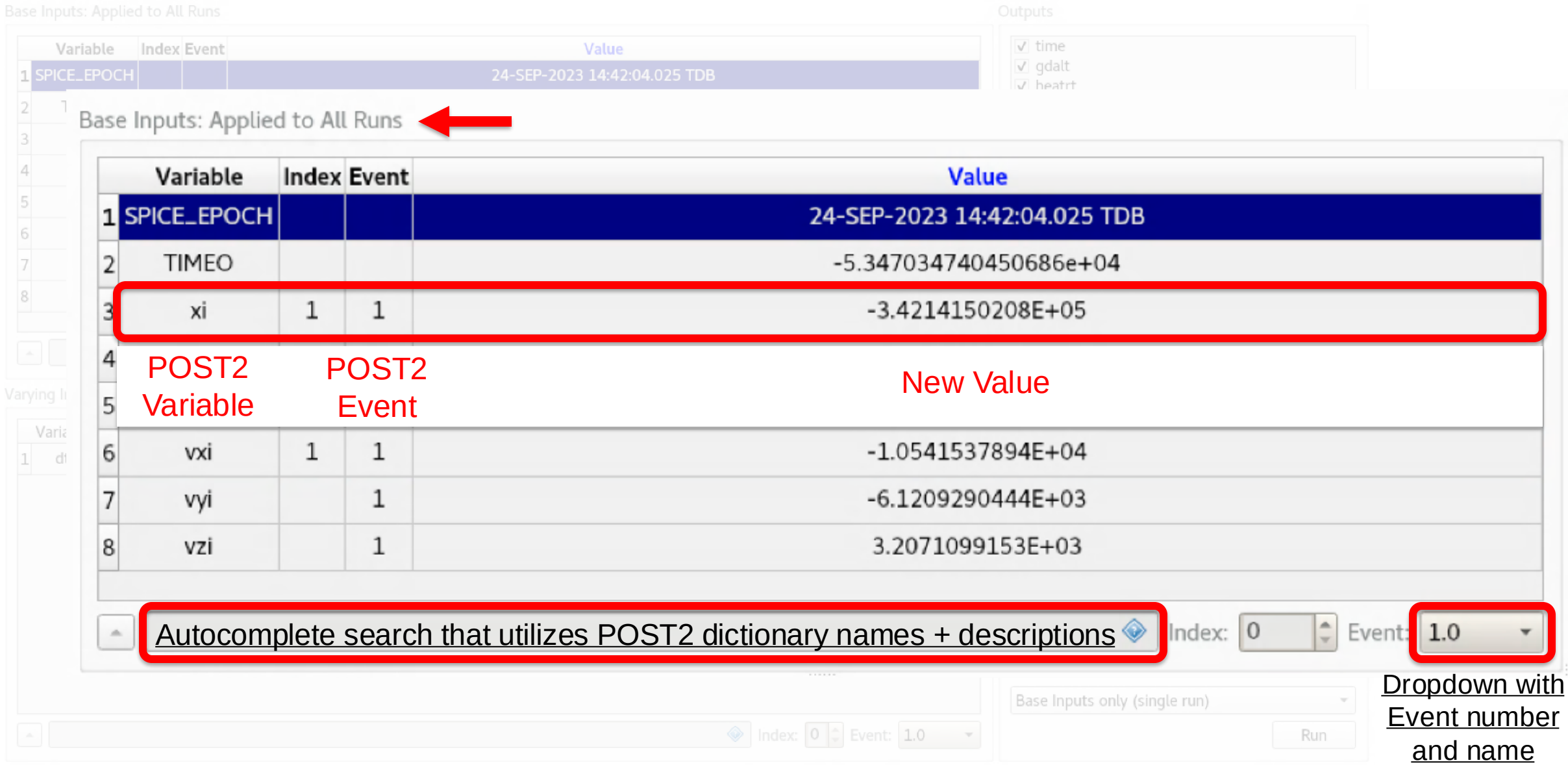

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Run

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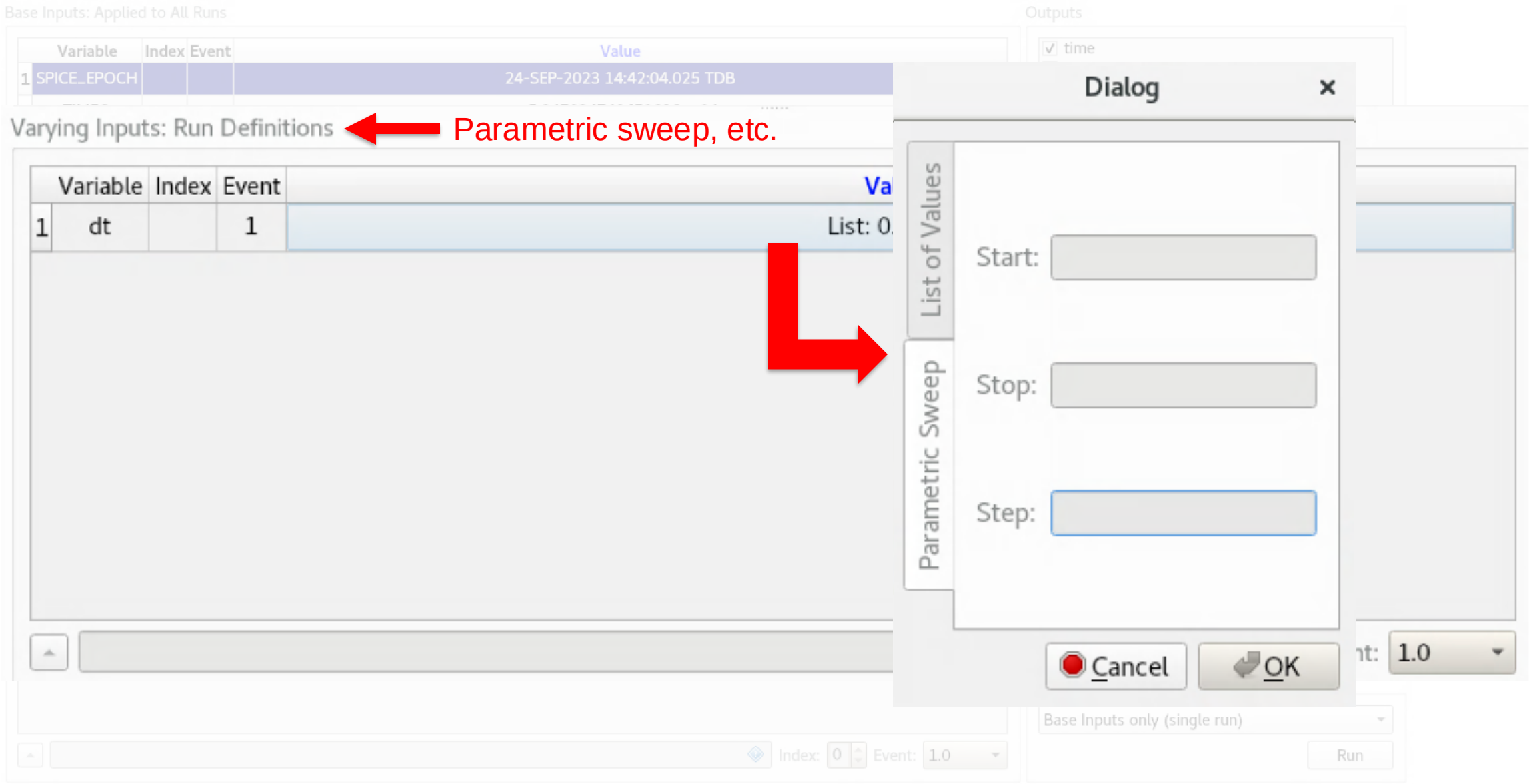

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Run POST2

Base Inputs only (single run)

Run

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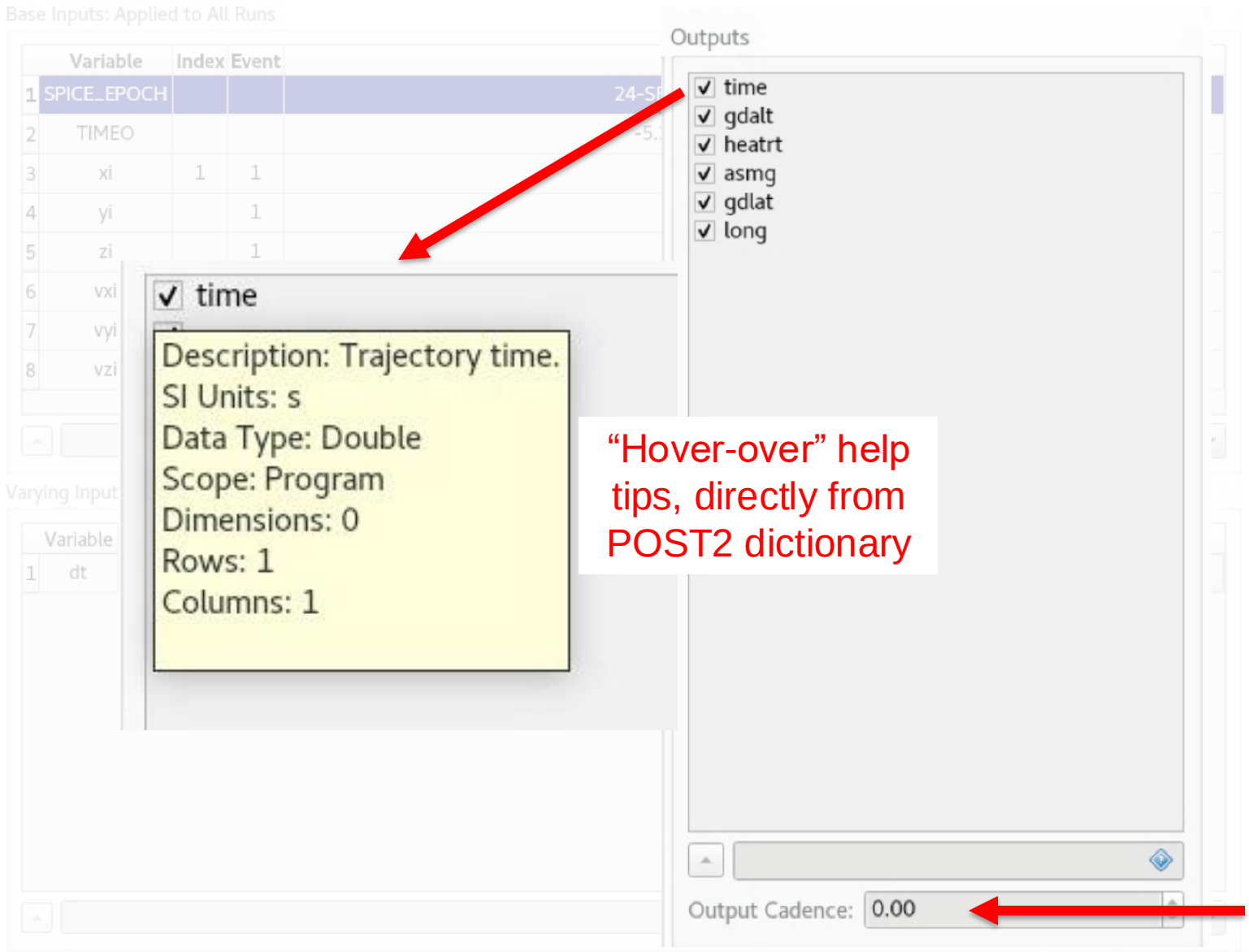

"Hover-over" help tips, directly from POST2 dictionary

POST Explorer only has time as default output

Meant to be lightweight to decrease how much data is stored

Can update how often data will be collected, no faster than simulation timestep

Design of POST Explorer – Analyze Tab

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Index: 0 Event: 1.0

Outputs

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- [x] gdalt
- [x] heatrt
- [x] asmg
- [x] gdlat
- [x] long

Output Cadence: 0.00

Run POST2

Base Inputs only (single run)

Run

Execute Analysis

Design of POST Explorer – Explore Tab

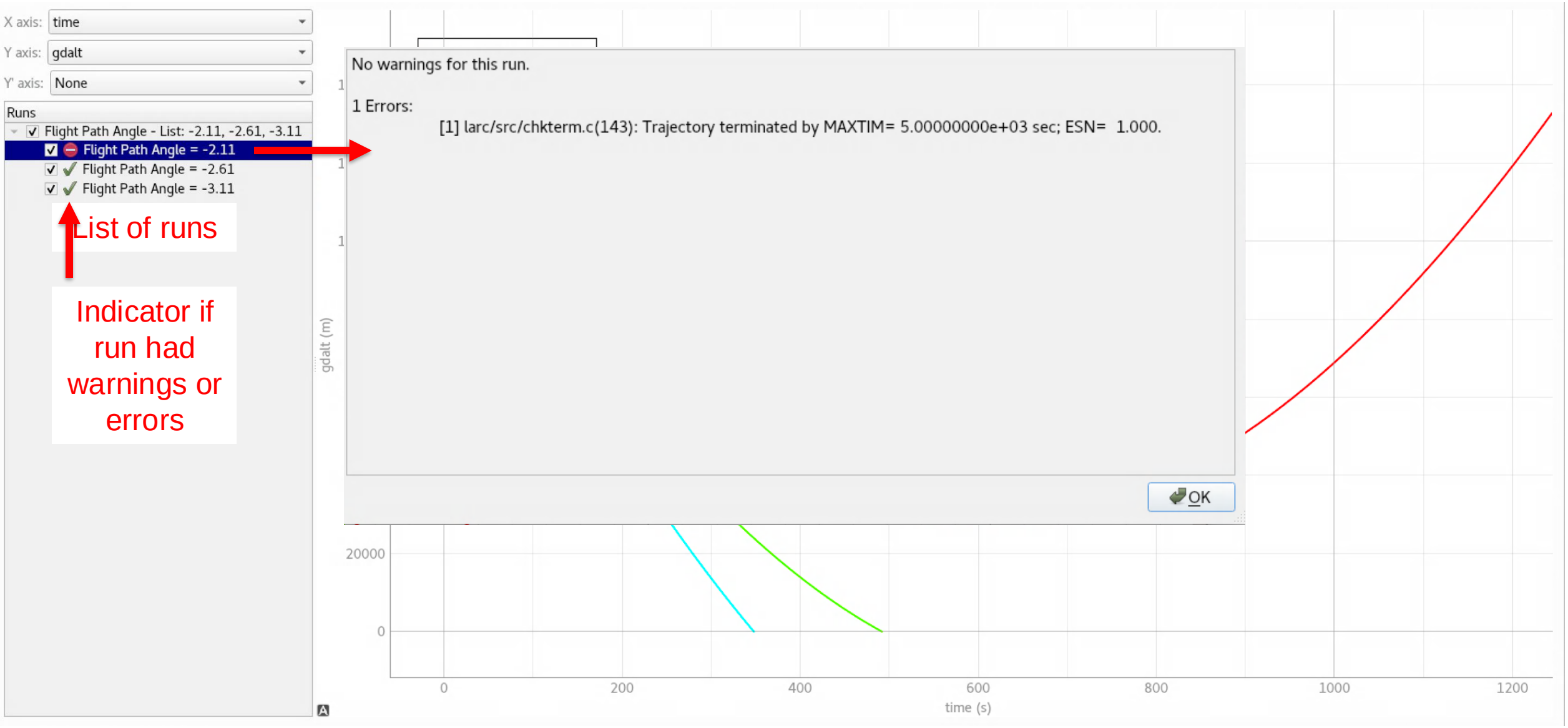
X axis: time
Y axis: gdalt
Y' axis: None

Left and right axis control

Runs
- Flight Path Angle - List: -2.11, -2.61, -3.11
  - Flight Path Angle = -2.11
  - Flight Path Angle = -2.61
  - Flight Path Angle = -3.11

Curves are plot as trajectory propagation finishes

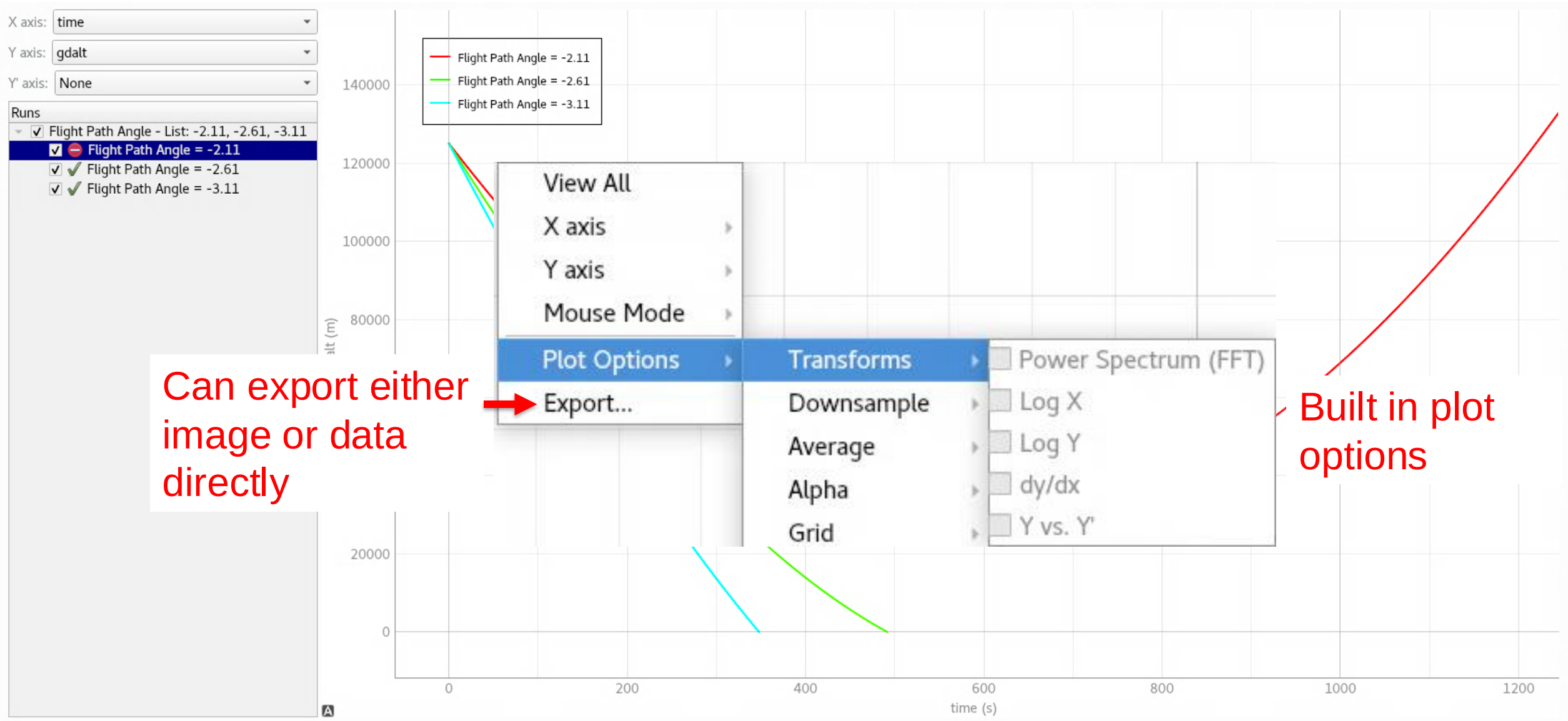
Design of POST Explorer – Explore Tab



List of runs

Indicator if run had warnings or errors

Design of POST Explorer – Explore Tab



Can export either image or data directly

Built in plot options

Design of POST Explorer – Data Tab

Runs

- gammar - Sweep: -13.5 to -12 step 0.25
  - gammar = -13.5
  - gammar = -13.25
  - gammar = -13
  - gammar = -12.75
  - gammar = -12.5
  - gammar = -12.25
  - gammar = -12

List of runs

	time (s)	gammar (degree)	azvelr (degree)	velr (m/s)
1	0.0	-13.500000000000004	61.3590752	12261.205899999999
2	0.01	-13.499321701073665	61.35975423352825	12261.22695312544
3	0.02	-13.498643397115222	61.36043328809637	12261.248005395846
4	0.03	-13.497965088124863	61.36111236370464	12261.269056811183
5	0.04	-13.497286774102763	61.3617914603533	12261.290107371418
6	0.05	-13.496608455049135	61.36247057804264	12261.31115707651
7	0.06000000000000005	-13.4	677292	12261.33220592643
8	0.07	-13.49525180184791	61.36382887654438	12261.353253921137
9	0.08	-13.494573467700704	61.36450805735732	12261.374301060601
10	0.09	-13.493895128522665	61.365187259212	12261.395347344791
11	0.09999999999999999	-13.493216784313999	61.36586648210866	12261.416392773655
12	0.10999999999999999	-13.49253843507486	61.36654572604758	12261.437437347171
13	0.11999999999999998	-13.491860080805454	61.36722499102905	12261.458481065305

Raw data

gammar = flight path angle

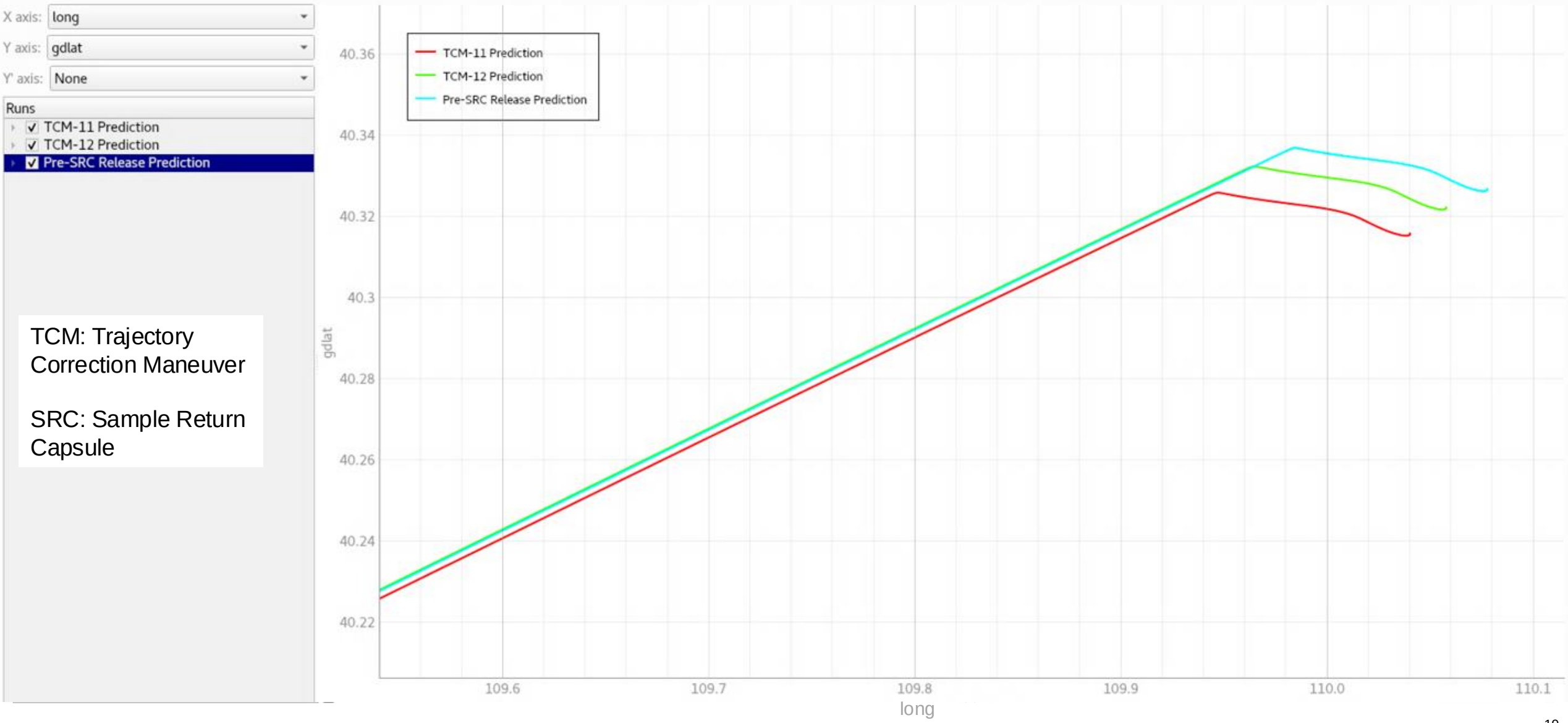
Design of POST Explorer – Explorer File

- **Explorer file (.exp) contains all information to setup initial POST2 trajectory and execute it, as well as any data generated from previous analyses completed**

- **Allows the expert POST2 user to deliver a ready made simulation setup that the non-expert user can run analysis with**

- **Expert user may also run analysis ahead of time to deliver to the non-expert user to interrogate**

Sample Use Cases



TCM: Trajectory Correction Maneuver

SRC: Sample Return Capsule

Summary

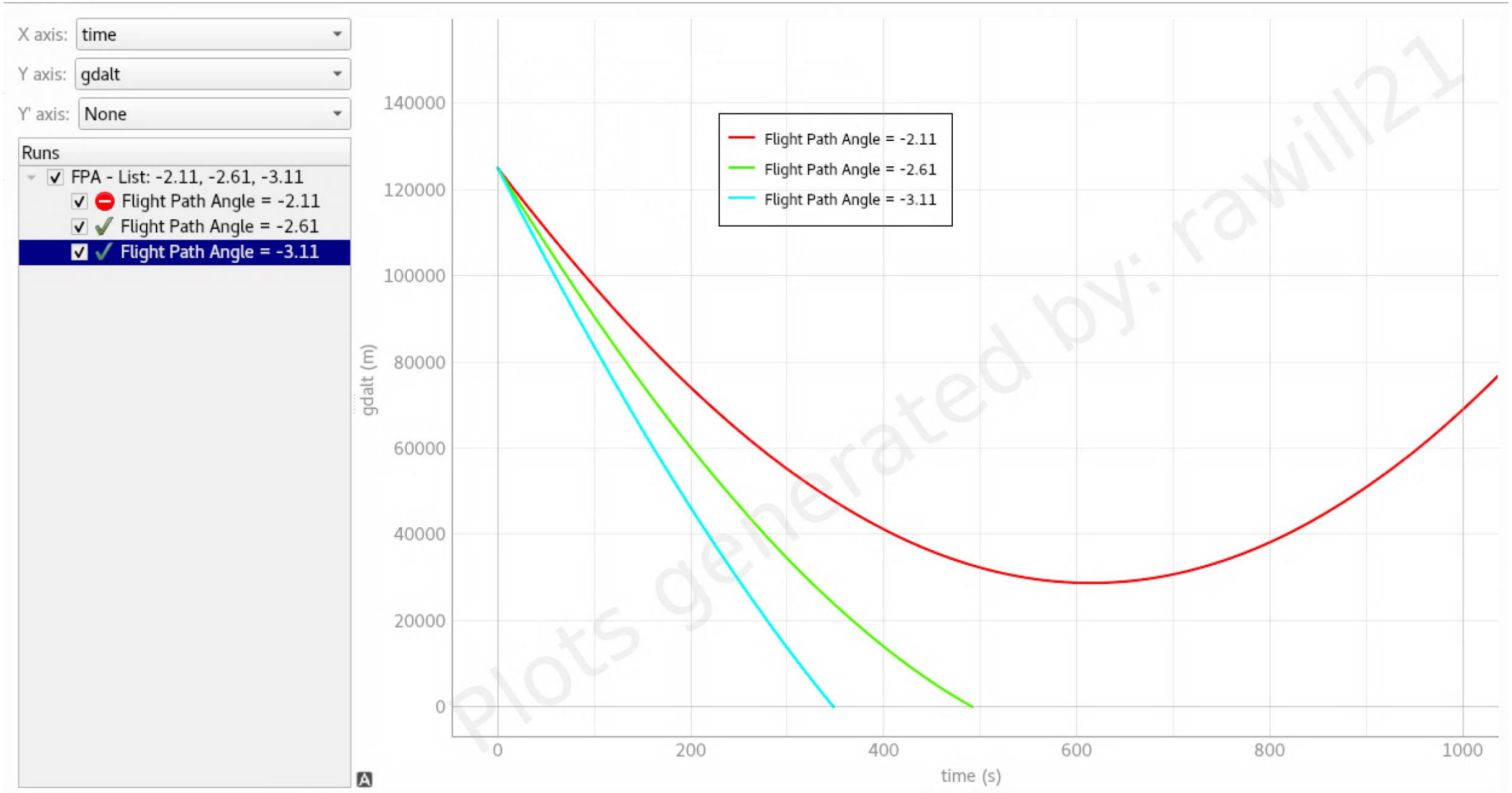
- **POST2 is more widely available with v5.0 release, ~Q1 Cy25**
  - POST2 v5.0 now EAR, not ITAR
  - Two editions: Government and Commercial
  - API included in v5.0 release, POST Explorer will be part of future release

- **POST Explorer was developed by leveraging the POST2 API, is a design space exploration tool for POST2**
  - Allows non-expert POST2 users to interface directly with POST2 simulation by modifying inputs and interrogating outputs
    - Does not remove the need to have expert POST2 user involved, but does decrease the day-to-day involvement
  - Demonstrates an example of how powerful the POST2 API can be when leveraged to solved specific problems

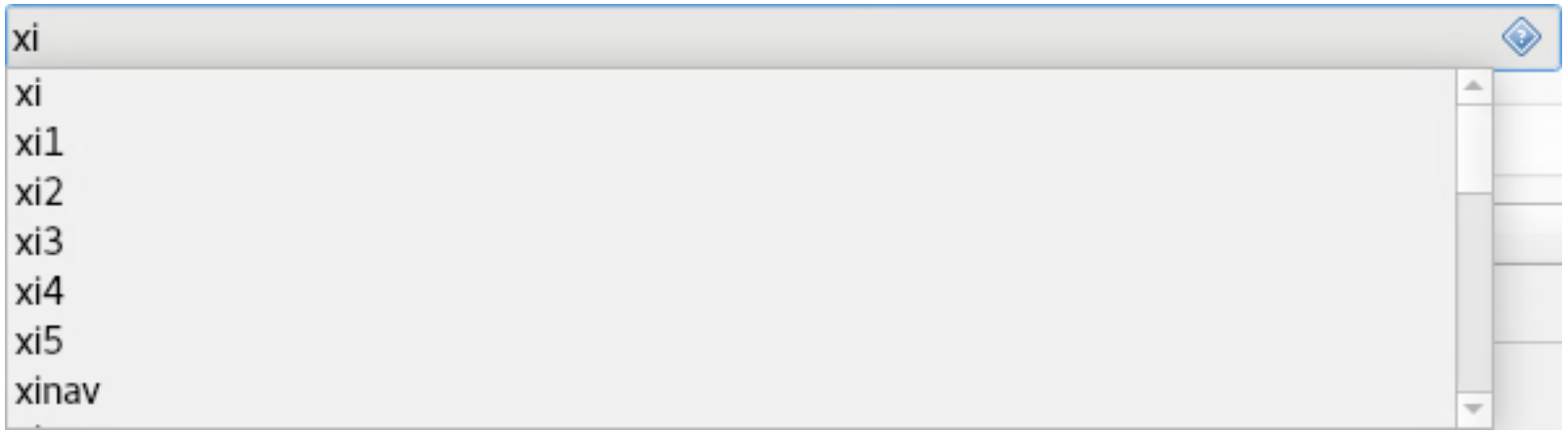
- **Non-exhaustive list of sample use cases was discussed**

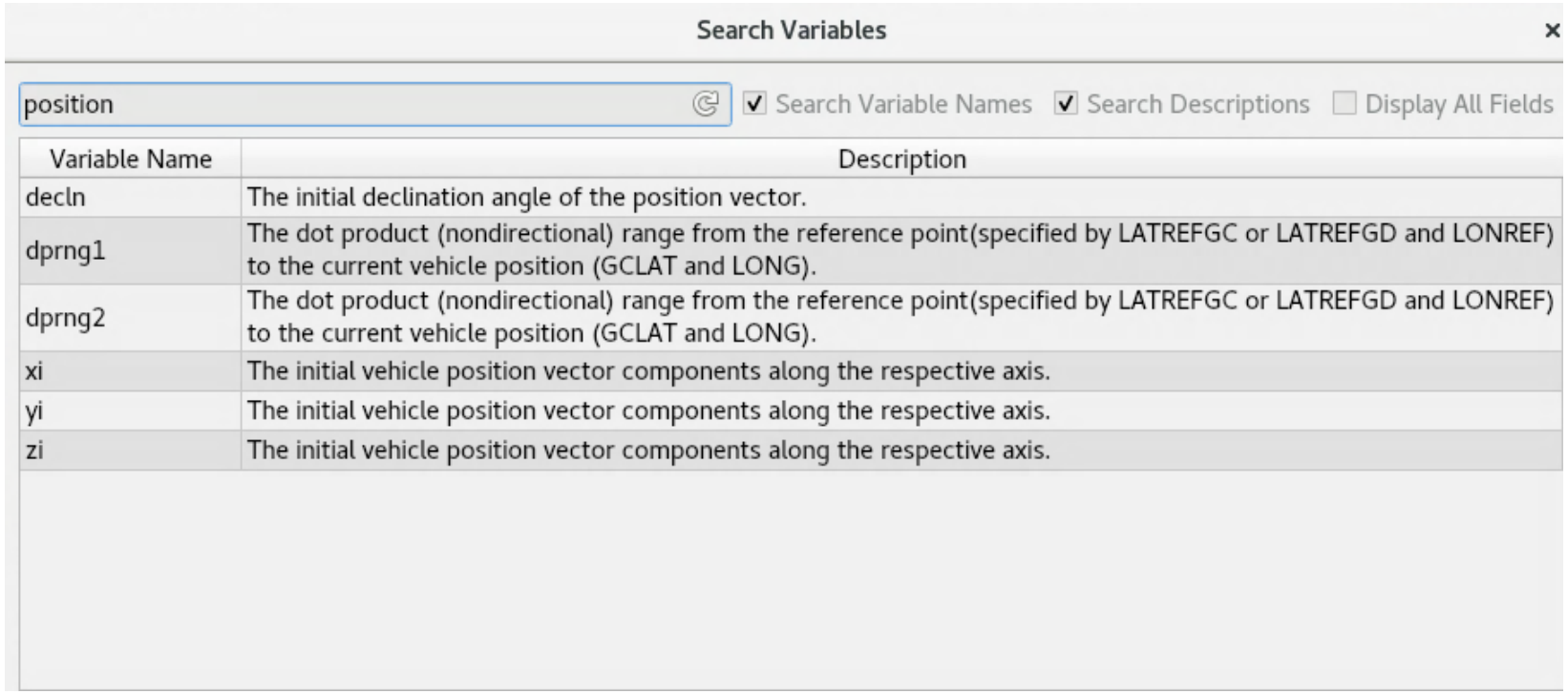
Backup

Design of POST Explorer – Explore Tab



Autocomplete/search Feature





Event Dropdown