AraSimQC
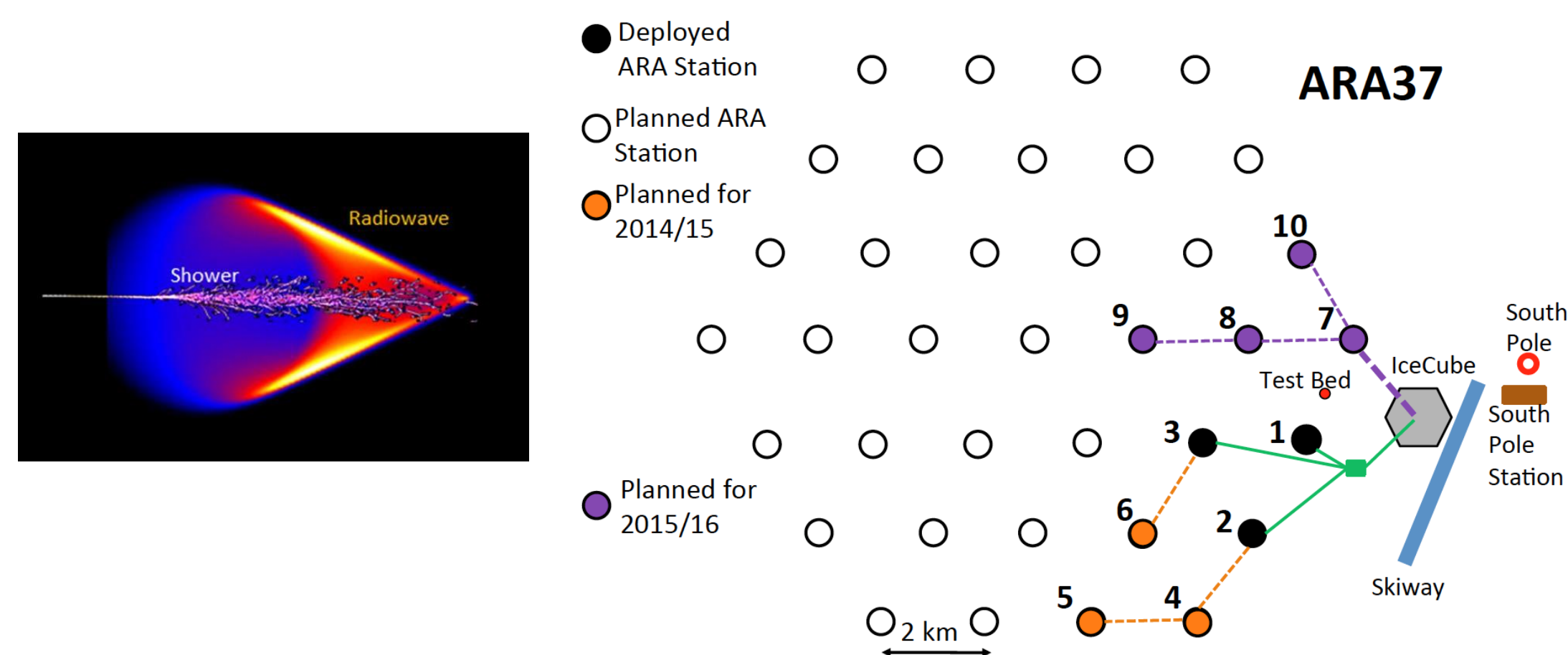
Simulation Quality and Control for the Askaryan Radio Array

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NSF

CCAPP ASKARYAN RADIO ARRAY

Introduction

- The Askaryan Radio Array (ARA) is a teraton *in-situ* ultra-high energy neutrino detector buried in the radio-clear ice at the South Pole
- Looks for the Askaryan signal: the bipolar impulsive radio signal produced when neutrinos interact with Antarctic Ice
- The simulation software for ARA, AraSim, is constantly being updated by various collaboration members, often 2-3 updates *per month*.
- Need a way to ensure basic functionality as the code evolved
- Track how *simulation changes* affected *physics outcomes* (fig 1)
- AraSimQC is a software automation package designed to fill this need

- Deployed ARA Station
- Planned ARA Station
- Planned for 2014/15
- Planned for 2015/16

ARA37

Radiowave
Shower

South Pole
IceCube
Test Bed
South Pole Station
Skiway

2 km

About AraSimQC

Purpose and Goals

- Quick visual comparisons between
  - Different versions of AraSim
  - Different detector configurations
  - Different neutrino energies and flux models
- Easily browse all plots/histograms of variables from a given simulation run
- Automatically generate general purpose simulation sets for each version of AraSim
- Create webpage for viewing of simulation output
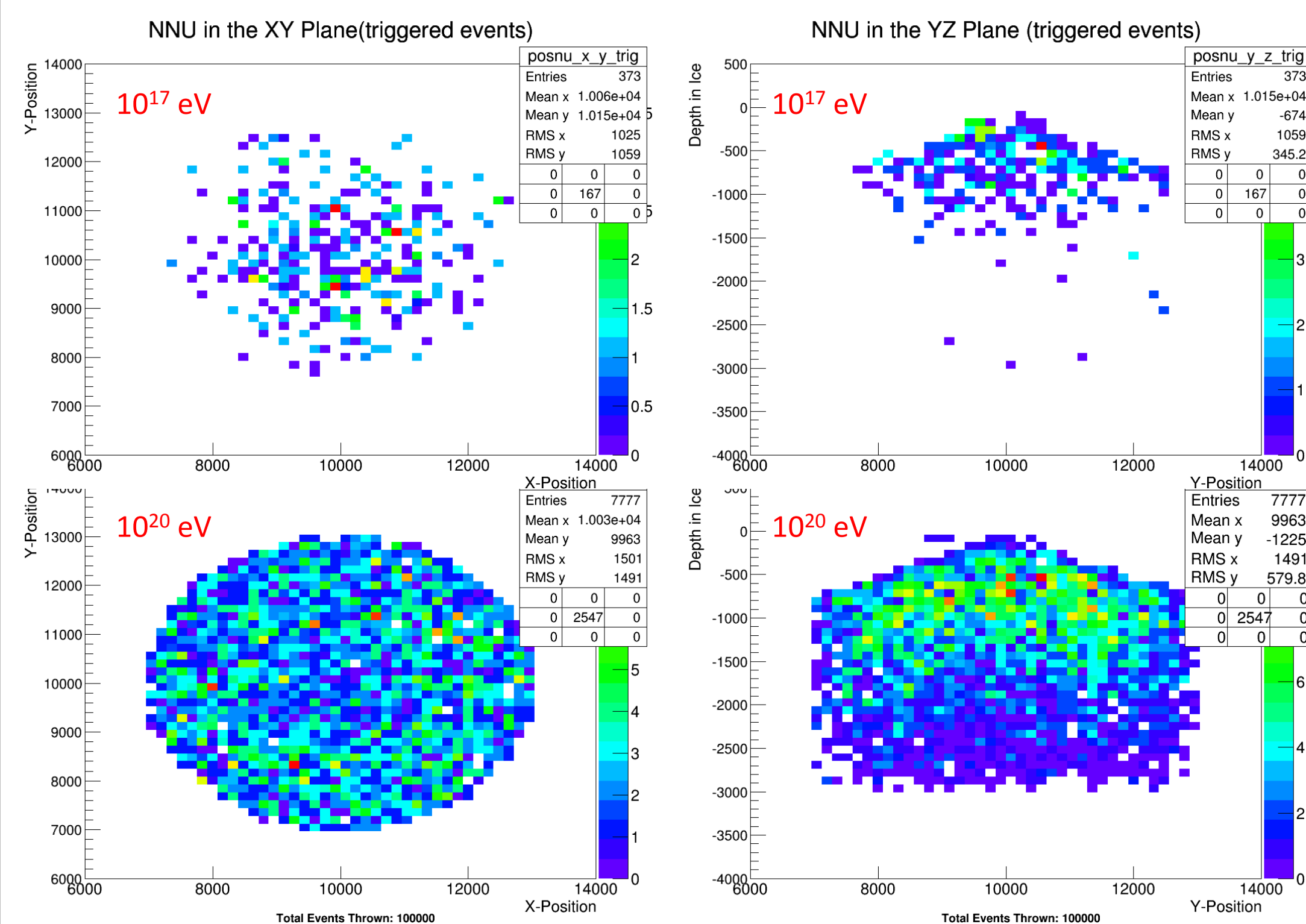
Design

- AraSimQC is a collection of shell scripts (fig 2)
- Checks for updates to AraSim code
- Generates a set of plots when changes are found
- Automatically posts plots to a website for viewing
- Saves simulation output so it can be repurposed

About AraSimQC (cont.)

Code Updating

- If AraSim code updates are found
  - AraSimQC downloads and runs the latest version of AraSim
  - Makes a standard set of plots
  - Uploads these plots to a website for viewing
- If AraSim code updates are *not* found
  - AraSimQC checks for new plotting programs
  - If new programs are found, new plots are made for all existing version of AraSim
  - Updates are appended to the website

Figure 1: Plot Comparison Example for Single Station

The simulated positon of the primary neutrino interaction in the ice for a single station, where the energy of the neutrinos are 10^{17} eV (top) and 10^{20} eV (bottom). The signal strength is much greater when the energy of the neutrino is 10^{20} eV, leading to a far higher number of triggered events.

Figure 2: Flow of AraSimQC Executables
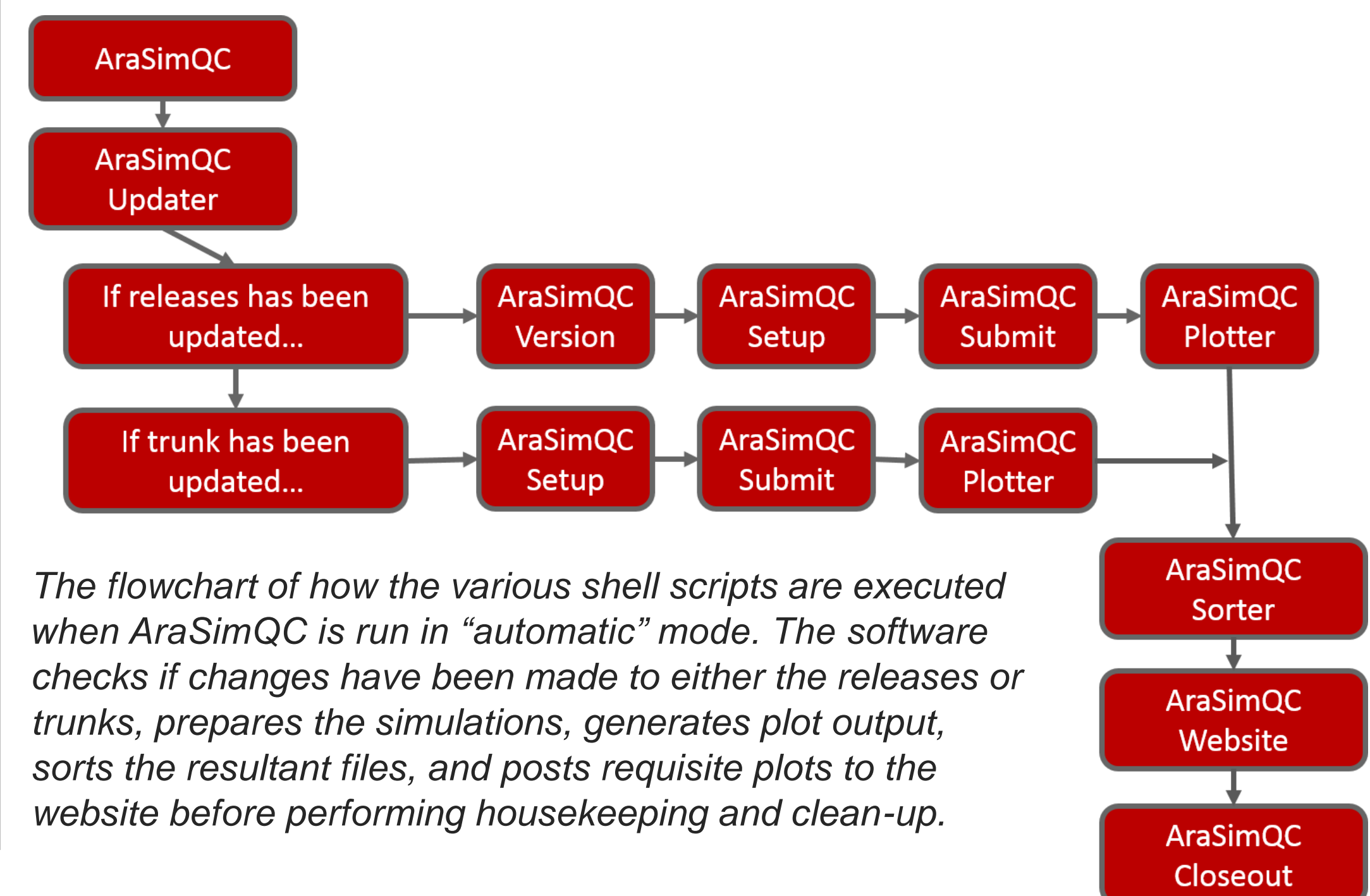
The flowchart of how the various shell scripts are executed when AraSimQC is run in "automatic" mode. The software checks if changes have been made to either the releases or trunks, prepares the simulations, generates plot output, sorts the resultant files, and posts requisite plots to the website before performing housekeeping and clean-up.

Website Features

Plot Comparison

- Easily compare plots across revisions, station configurations, and energies
- Useful "all plots" feature: shows all available plots for a single classification of variables (primary interaction variables, detector variables, etc.) (fig 3)
- Can easily download a PNG or PDF of each plot

Doxygen Comment Support

- Doxygen is a tool that generates documentation from annotated C++ sources
- Website displays a Doxygen comment, drawn from AraSim source code, for selected variables (fig 4)
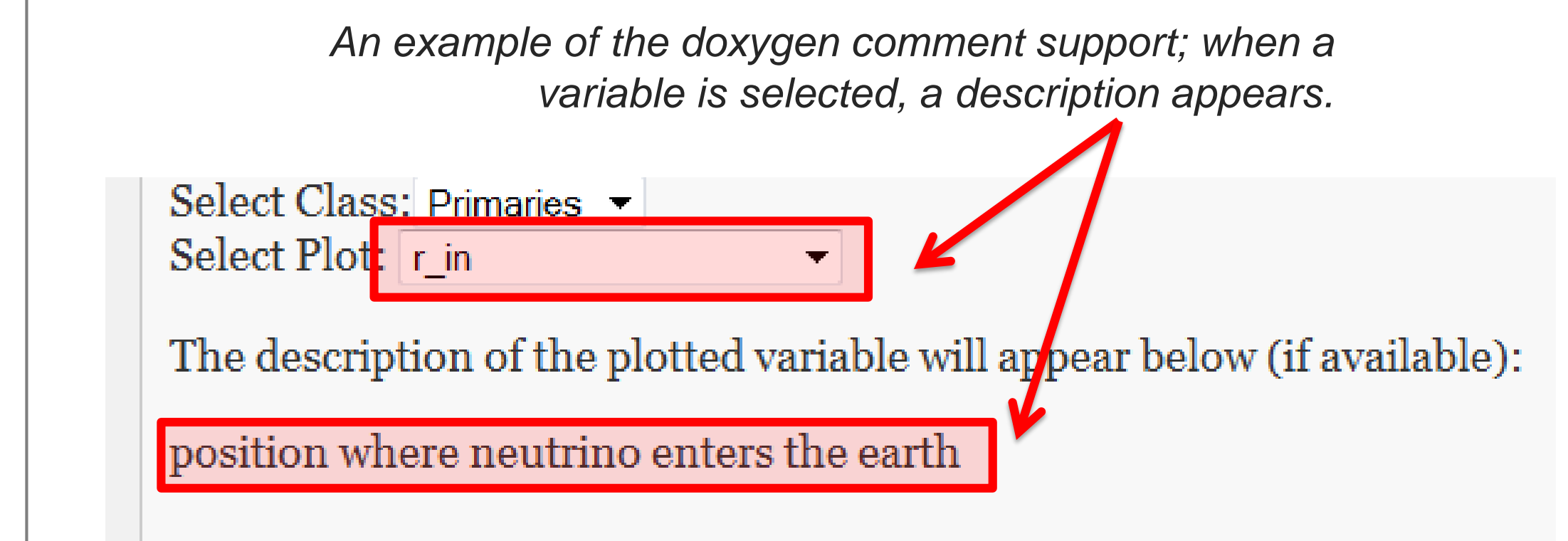
Doxygen

New Plots Submission

- Website supports submission of plots by the collaboration; makes AraSimQC more diverse
- Adding plots is straightforward
  - Collaboration member submits a .cc file and M. file through website
  - Super-user places both files in specified directory
  - AraSimQC handles the rest

Figure 3: All Plots Comparison
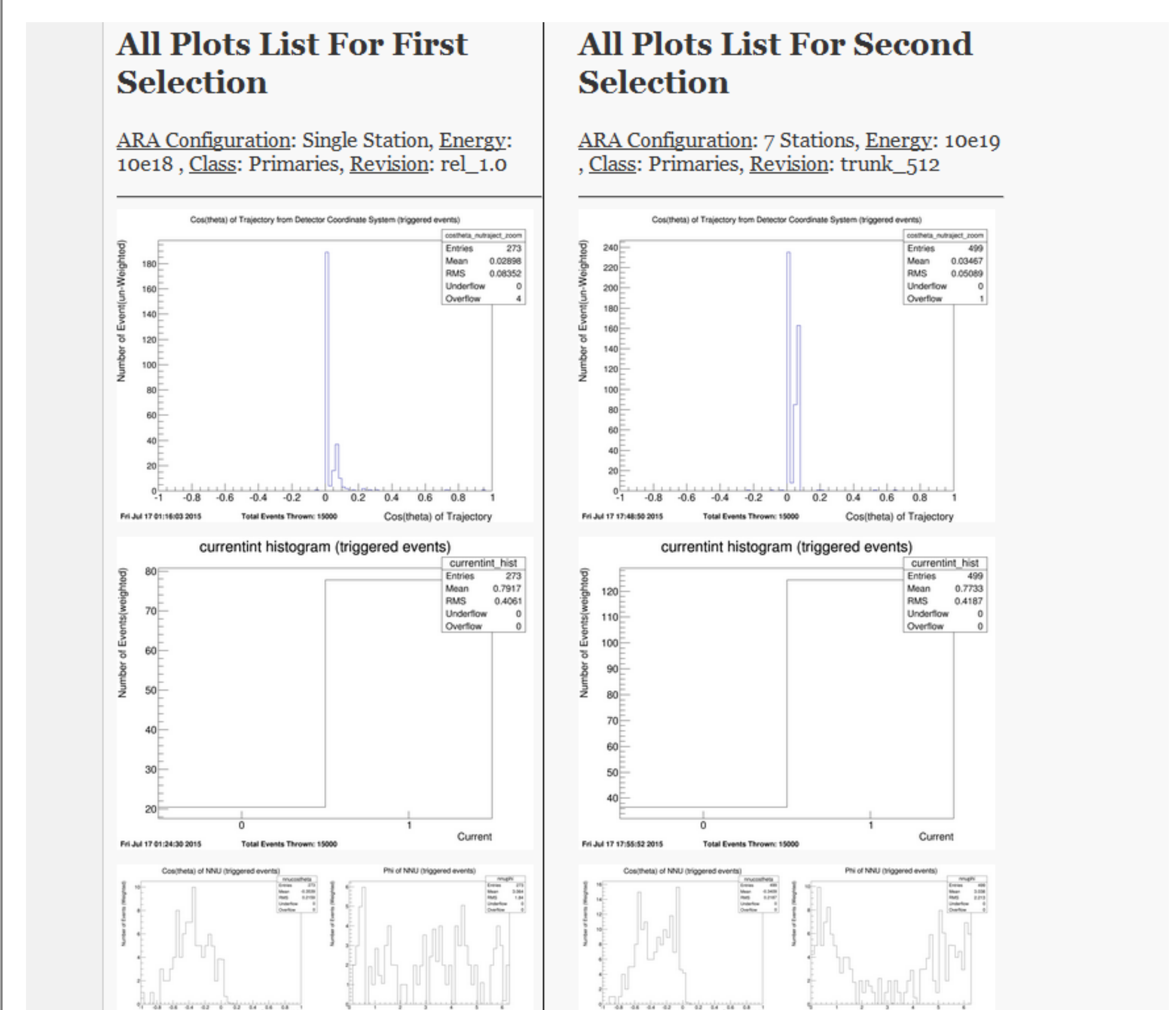
An example of the "All Plots" feature, which displays all of the plots available for a certain classification of variables. Here is a comparison of several plots between a single station detector set-up, and a seven-station detector set-up.

Figure 4: Doxygen Comments

An example of the doxygen comment support; when a variable is selected, a description appears.

Select Class: Primaries
Select Plot: r_in
The description of the plotted variable will appear below (if available):
position where neutrino enters the earth

Website Features (cont.)

Collaboration Simulation Sets

- Simulations are resource intensive (need lots of time and computing power)
- AraSimQC generates collaboration simulation sets
  - Several energies (10^{17} eV → 10^{21} eV), with option of injection spectrum
  - Several station configurations (Testbed prototype, one-station, seven-stations, etc.)

Acknowledgements

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- **A**chieving in **S**cience through **P**hysics **I**nstrumentation, **R**esearch, and **E**xploration Camp
- Led Mathematica workshop for 26 high school girls
- Campers practiced basic data analysis using various Mathematica applets