Synthetic Source Injection for the DESC

Matthew Becker and Josh Meyers

Find us on slack: #desc-source-injection

What is it and what can you do with it?

Fake-source injection (FSI) is a technique where images of fake galaxies are added to real survey images.

One then re-analyzes the data to measure how well our data reduction pipelines recover the properties of the input source.

You can do a bunch of cool science with this idea:

- See this talk from Spencer Everett
- See these papers from the DES on the technique:
  - https://arxiv.org/abs/1507.08336
  - https://arxiv.org/abs/2012.12825
- Applications:
  - Photometric redshifts
  - Noise background for BFD shears
  - Magnification measurements
  - Cross-redshift shear calibration

FSI has been essential in DES analyses and we expect it to be essential for the DESC too!

What are we working on?

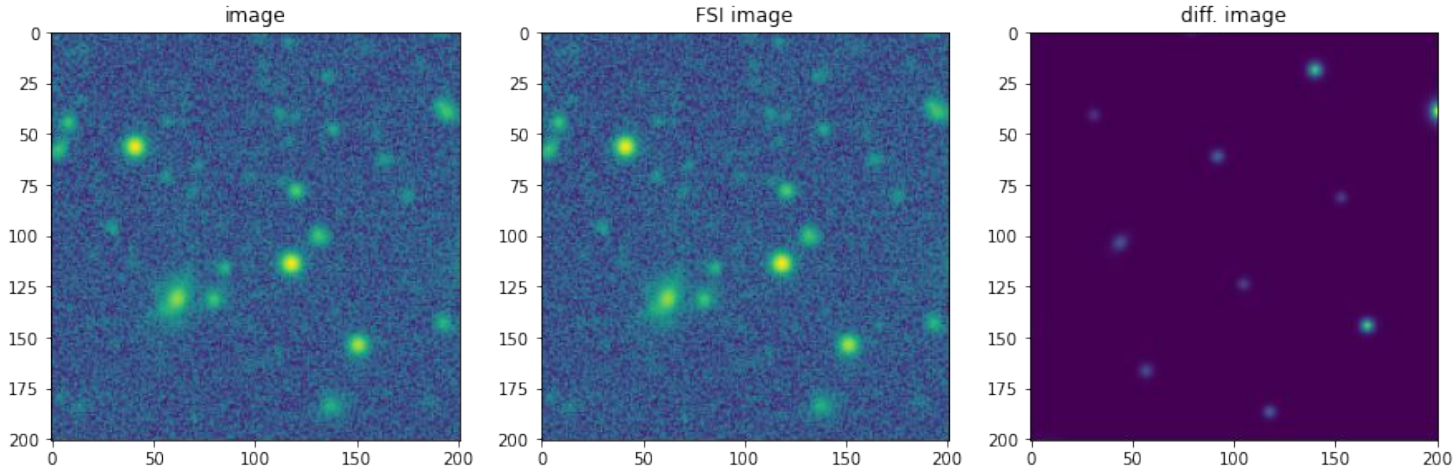
For Vera Rubin Observatory data, the DM team has developed a galsim-based pipeline task for injecting synthetic sources into Rubin Observatory data.

We've been trying out this tool on DC2 with a few goals:

- Get members of the DESC used to running this tool.
- Make sure it is meeting our needs (and supplying feedback when it is not).
- Provide extra code and/or scripts around this tool to make it easier to use for what we need.
- Produce some data for the collaboration by using DC2.

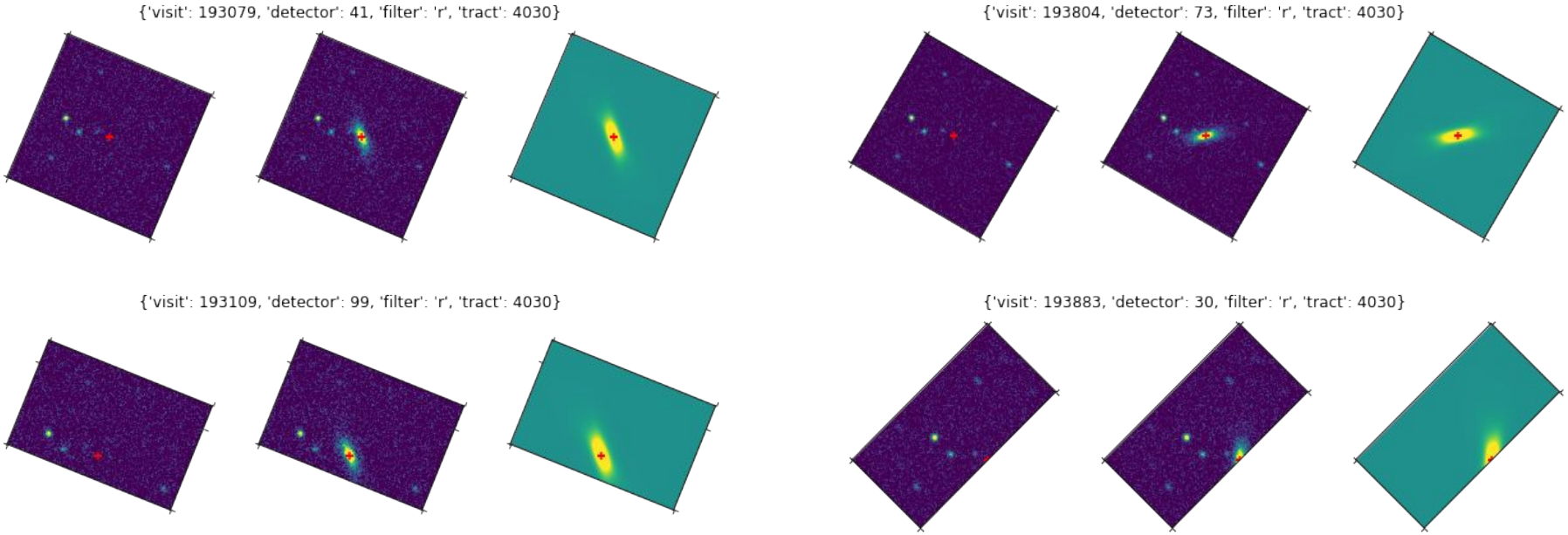
SSI with DC2 Coadds

Example using an hexagonal grid into a coadd DC2 image:



See the example notebook here:
https://nbviewer.jupyter.org/github/LSSTDESC/fsi-tools/blob/main/examples/cosmoDC2_galaxy_hexgrid_example.ipynb

SSI with Single-epoch (calexp) Images



(Some bugs regarding WCSs here that have been fixed!)

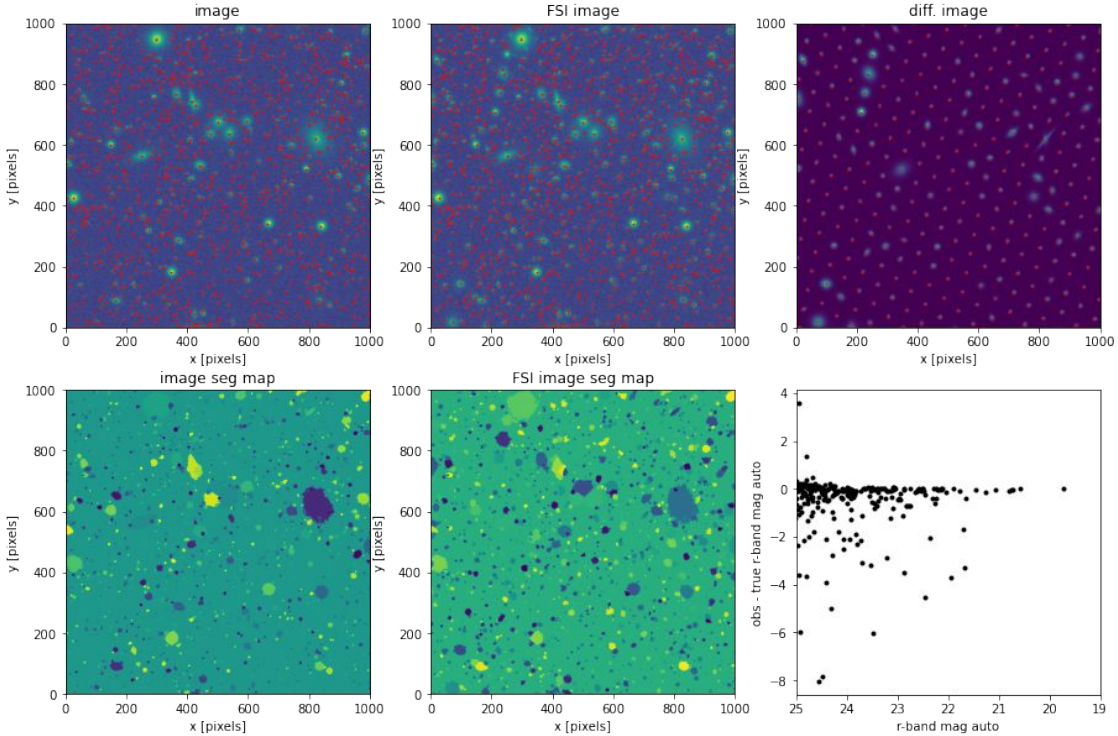
Notebook from Josh: https://github.com/LSSTDESC/fsi-tools/blob/main/examples/DC2_calexp_injection.ipynb

SSI analysis code exists!

Example using an hexagonal grid into a coadd DC2 image and detecting sources with `sep` (python port of source extractor).

See the example notebook here.

We are using the matching techniques from DES Y3.

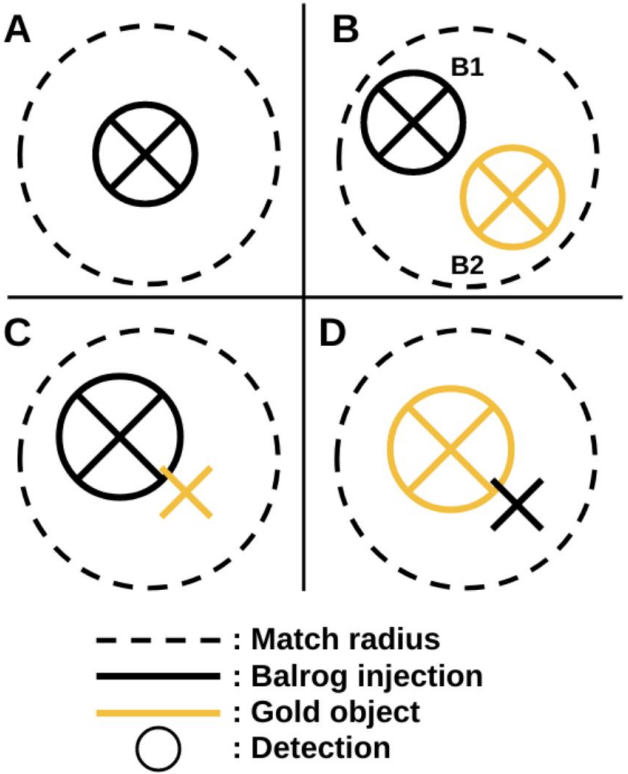


Matching injected sources back to the truth catalogs in non-trivial.

I have coded up the matching procedure from the DES Y3 Balrog results (Everett et al. 2000).

A: pure match of injected source to detection
B: blend of existing source and injection - keep the closer source
C: detect the injected source but not existing source - existing source is perturbing injection
D: detect existing source but not injected source - injected source is perturbing existing source

We remove case D and keep the rest.



What is next?

We plan to work on the follow items in the next few months:

- ~~Help DM fix the WCS issues. (Josh)~~
- Build easy to use Python APIs for running the task from a python script instead of the command line. (Josh)
- Produce a small amount of coadd DC2 images with the injected sources. (Matt)
- Get code running on shear simulations for testing the use of FSI for shear calibrations. (Matt)

If you have ideas, suggestions, or comments, get in touch with us!