



MSA Planning Tool Development

- ❖ We created a suite of IDL software programs for planning NIRSpec MSA science.
- ❖ Based MSA Optimization Tool on a “Basic” Algorithm implementation
- ❖ We know this basic algorithm isn’t “final” yet, but it is a first step...
- ❖ STScI Developers are incorporating the optimization into the Astronomer’s Proposal Tool (APT) and the NIRSpec MSA Template.

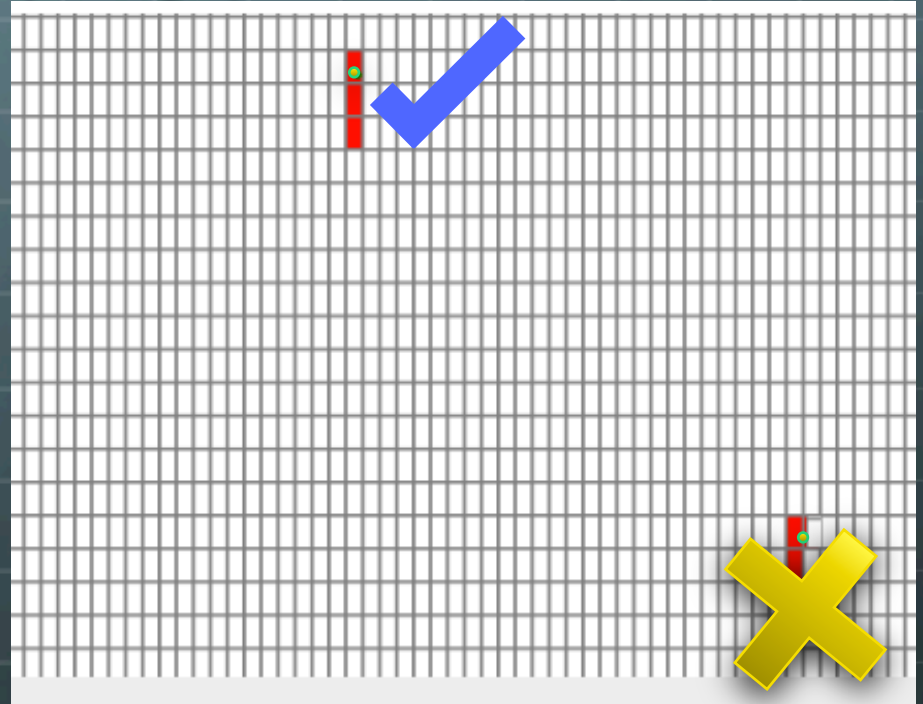
Tracy Beck, STScI

27 September 2012, NIRSpec ELIXIR Science School

MSA Tool Development

🌐 Why is Observation Planning with the NIRSpec MSA so complicated?

➤ NIRSpec is unlike nearly all MOS spectrographs in existence because it has a *FIXED GRID* of MSA shutters...



➤ Choosing targets one-by-one...
by hand?

➤ Fixing a pointing based on one target position could automatically rule out observing many other targets, we need an optimized way to maximize observations of as many targets as possible!

MSA Tool Development

- 🌐 In Spring 2012, The STScI proposal team defined an algorithm for the MSA tool to optimize MSA pointings and configurations for an entire *Observation*.
 - This includes many targets observed over multiple *visits* – so many different pointing positions with different guide stars...
- 🌐 A **prototype** algorithm was developed using the *Hubble UDF* case, using a modular suite of IDL procedures to optimize the pointings.
- 🌐 **The *Hubble UDF* Science Case:**
 - Based on the UDF catalog of faint, high z galaxies
 - In this scenario, as an example we have 22 “ultra-high” priority galaxies that are candidate extremely high z targets
 - Science case: We *MUST* observe all 22 galaxies in (6) exposures, MSA Tool should iterate over pointings/visits until all galaxies are observed.
 - Lower priority galaxies are used as “Fillers”

Elements of the Basic Algorithm



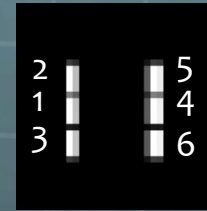
IDL Procedures:



Construct Hi-priority candidate list (and optionally, a Fillers List).



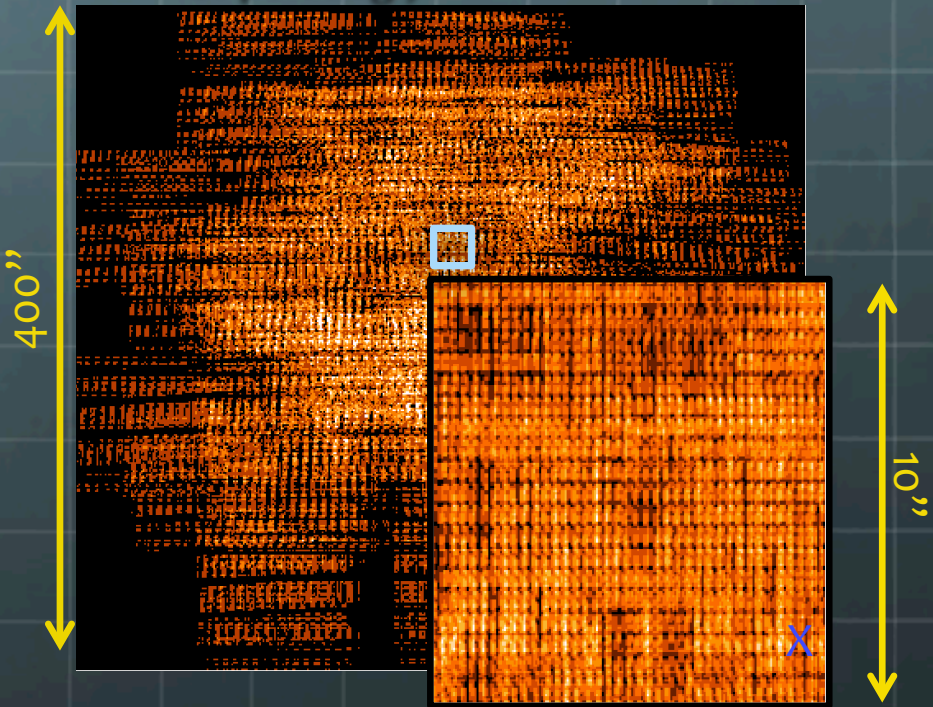
Operates by reserving a “slitlet pattern” up front, to ensure all targets will be present in all dithers. A good *starting point*.



1. On a coarse search grid, find an optimal pointing:

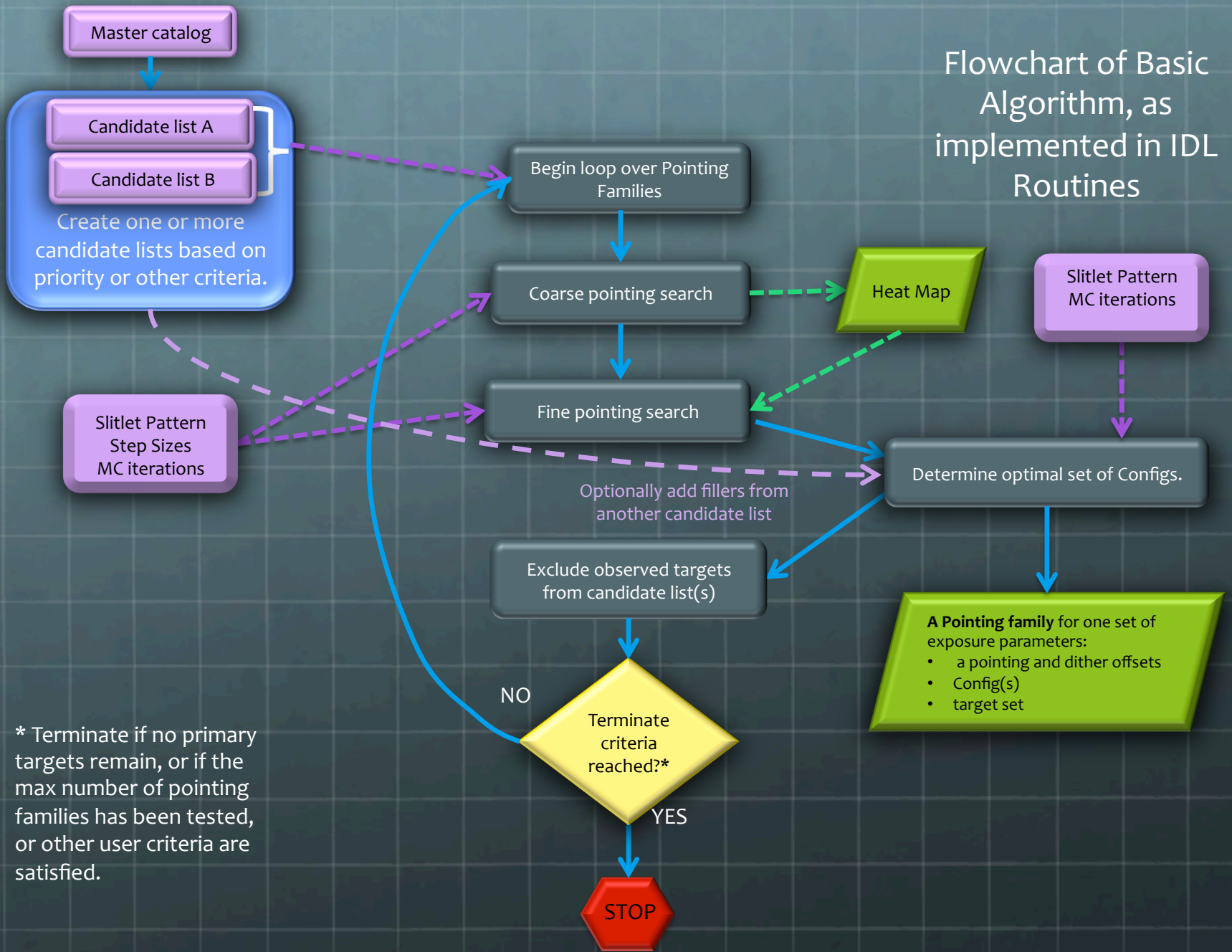
- At each grid point, generate a config by assigning targets to available shutters. All dithers are taken into account at once.
- Count targets. Produce a ‘heatmap’ (=number of targets as function of pointing.)

Two 3-shutter slitlets,
2 MSA Configs
6 exposures



2. At best pointing in heatmap, do a local fine search.
3. Determine an optimal config.
4. Refine the candidate list to exclude sources observed in the config.
5. Repeat steps until all sources are observed, or other termination criterion.

Flowchart of Basic Algorithm, as implemented in IDL Routines



* Terminate if no primary targets remain, or if the max number of pointing families has been tested, or other user criteria are satisfied.

Results for HUDF case

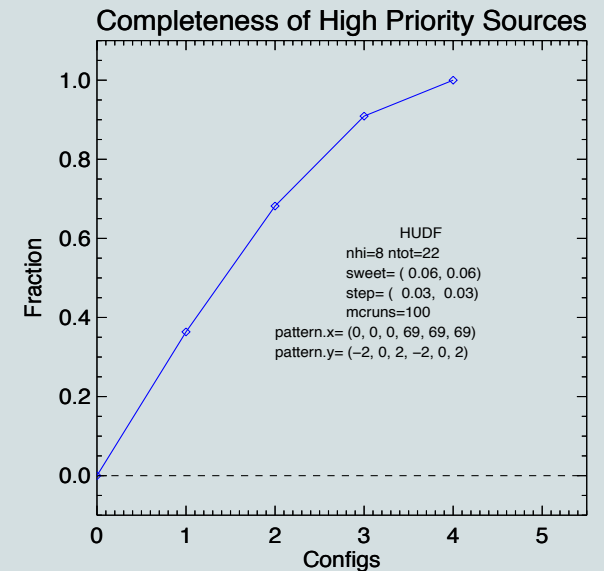
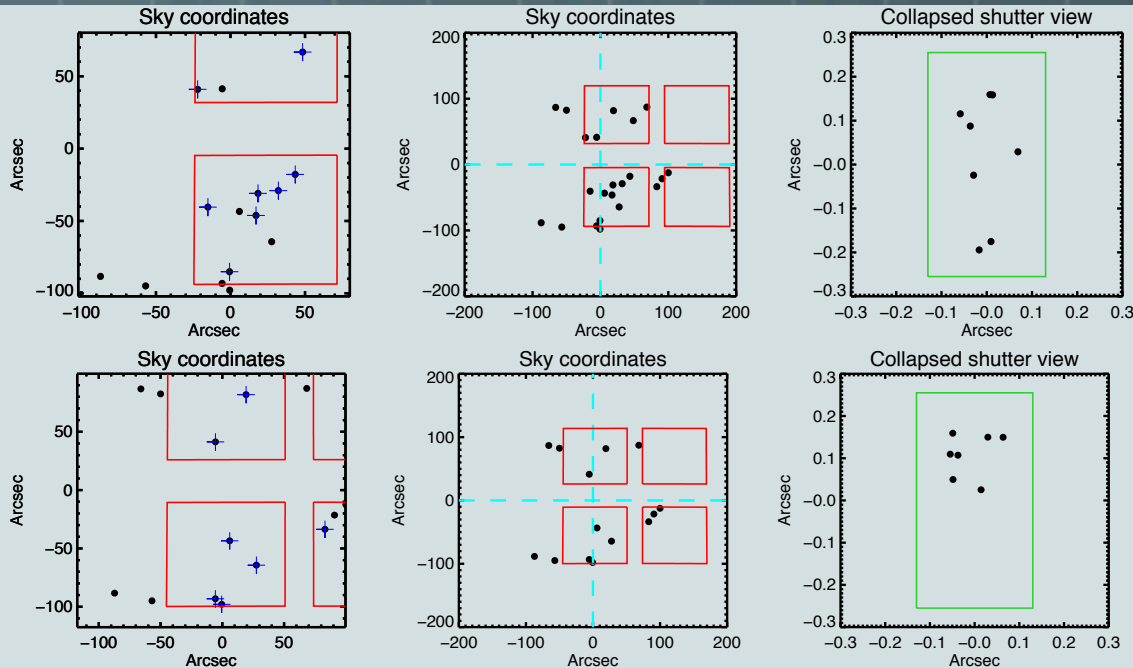
Metrics:

- How long does it take?
- How many configs are required to get most or all hi-priority sources?
- How many secondary sources observed?

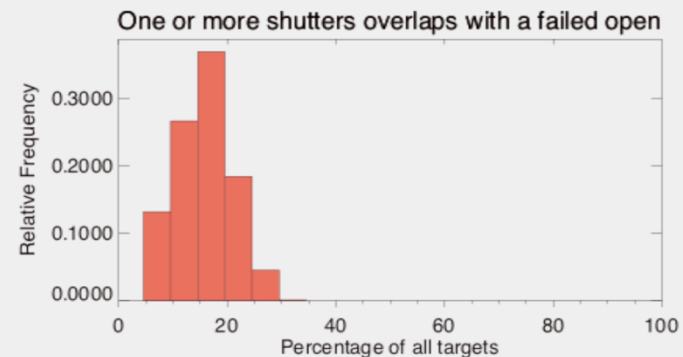
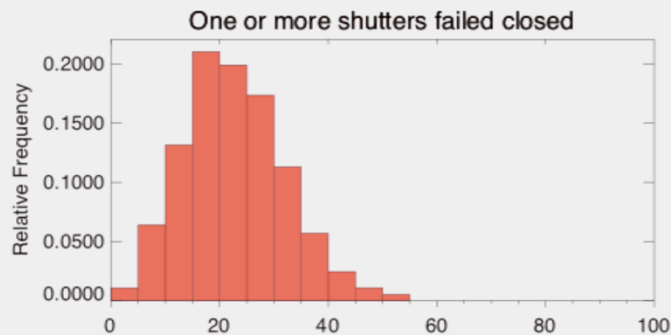
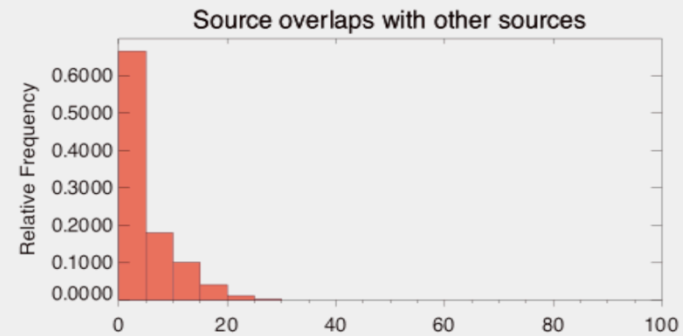
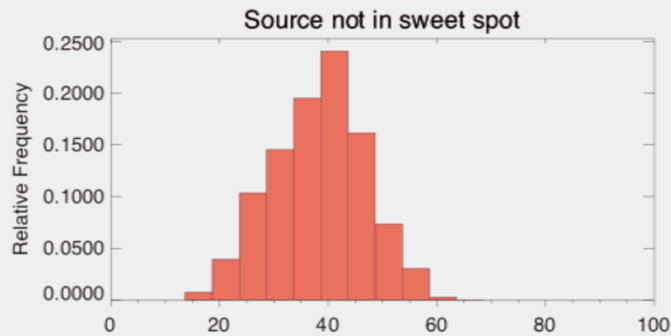
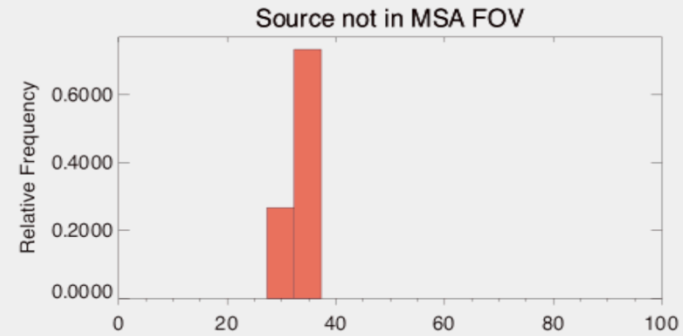
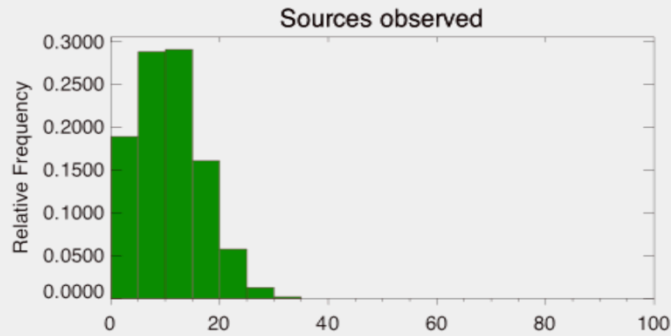
Timing results:

Pointing Family	# High priority targets	# Fillers	Execution time
1	8	80	101.35
2	7	79	99.34
3	5	70	98.93
4	2	44	61.63
Total	22	273	361.3 (6.0min)

Optimal Configs 1 and 2 (of 4)



Exclusion Rates – Why targets fail



Relative Frequencies are tabulated over all pointings in heatmap.

MSA Tool Development

- Previous slides present flow and diagnostics from the *IDL Suite* of modular procedures used to create the MSA Algorithm planning prototype.
- STScI Developers have now incorporated the back-bone of this planning methodology into the *Astronomers Planning Tool*, APT, to test the creation of a full NIRSPEC MSA Observation in the user interface.
- MSA Tool Demo in APT...

MSA Tool Development

- 🌐 MSA Tool Demo in APT...
- 🌐 Some Key Limitations of Current MSA Algorithm implementation in APT:
 - 1 – We know MSA Tool in APT presently does NOT generate the optimal set of configurations (Monte Carlo optimization search over target catalog incorporated in IDL procedures, not yet in APT).
 - 2 – MSA Plans are not currently overplotted in an image window.
 - 3 - Presently, there's no specification of how many times to observe filler candidates (i.e., we can envision having a field asking how many exposures to include fillers in).
 - 4 – Currently, Plan setups include just one instrument configuration. Of course, multi-grating NIRSpec observations should be observed together within MSA configurations (this will affect your “sweet spot”).
 - 5 - MSA Tool can't currently move targets to new regions of the field by very extended distances (>10”) where distortion affects are important. (This capability is coming in a future algorithm).

MSA Tool Development

- 🌐 MSA Tool Demo in APT...
- 🌐 Further Work on MSA Tool – Continue to look for ways to make the algorithms more efficient and improve usability.
- 🌐 Incorporate new and better algorithms, some may need tailored to science use case.
- 🌐 Expect to define ~2 to 4 algorithms for implementation that offer different observing strategies...
- 🌐 An alternate example...

Alternate Case – galactic stellar cluster

- Candidate list constructed from Orion dataset moved to distance of 2 kpc
- Two brightness categories to avoid saturation
- Dither to cover wavelength gap

“Bright” targets 987 candidates

Pointing Family	# targets	Execution time (s)
1	63	93.4
2	62	90.3
3	57	82.9
4	53	79.9
5	52	78.5
6	50	71.7
Total	337	496.7

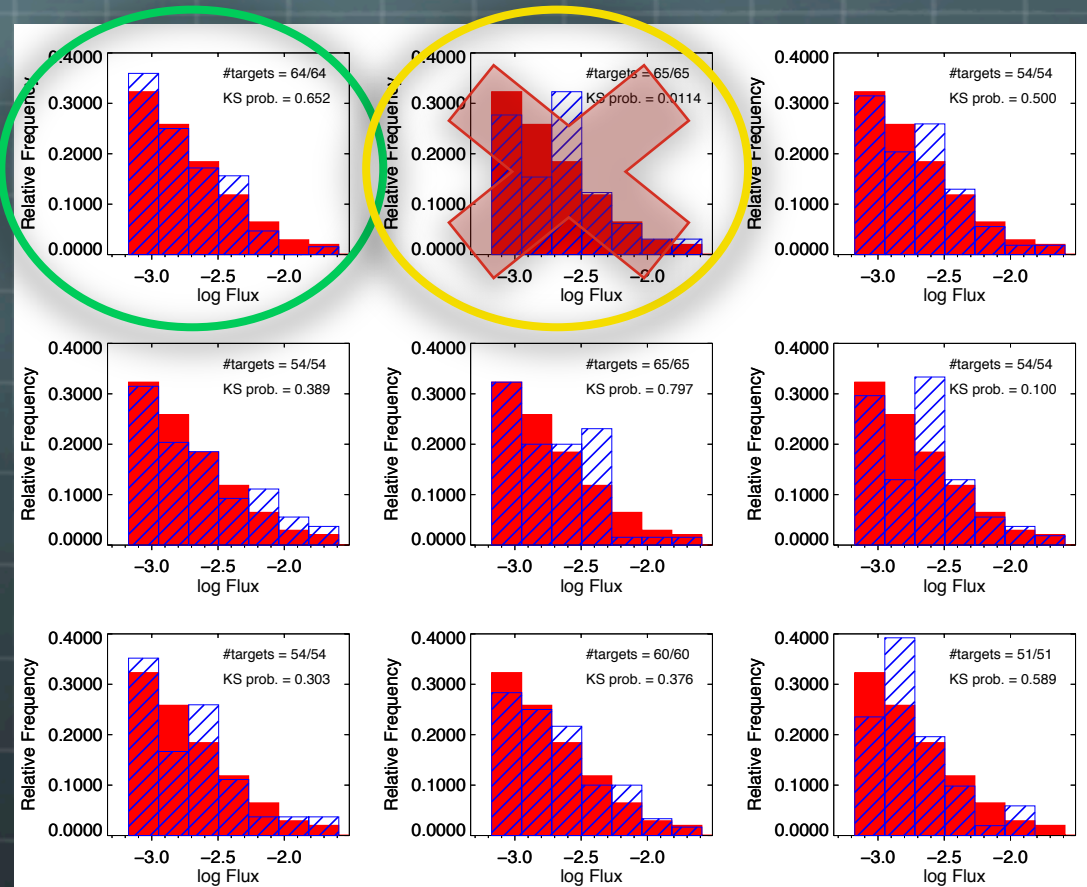
- Completeness is not required (or feasible), no priorities, so heat map grid can be coarser than in HUDF case
- Goal is to observe a statistically significant sample with a reasonable number of configurations

Alternate Case – galactic stellar cluster

- Default does not guarantee statistical sampling: use a new optimization planning criteria to balance target properties?

Example: flux distribution

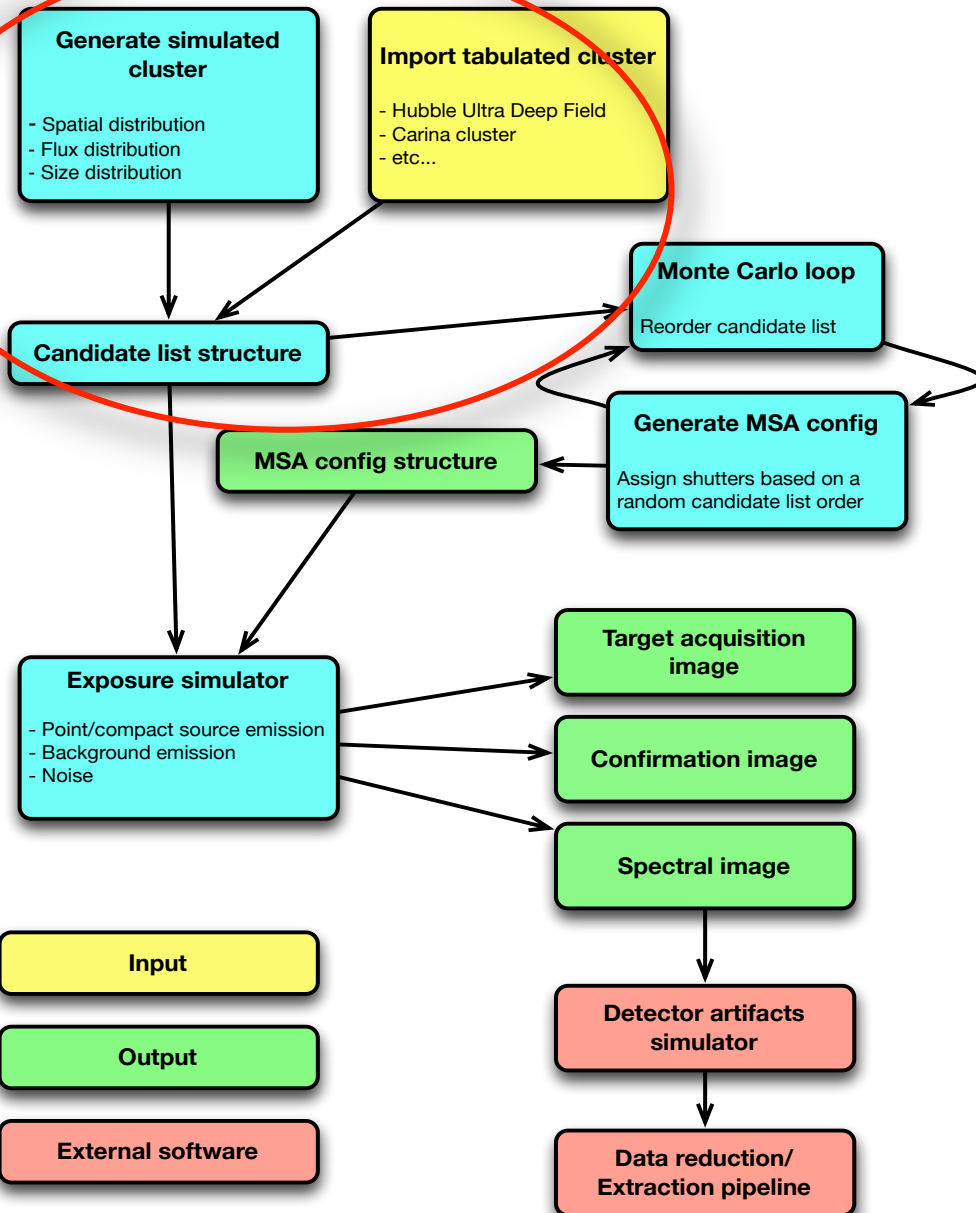
- Pick grid point with flux distribution that best matches the input candidate catalog
- End up with 30% of candidates in 6 pointing families (12 configurations).



Future Work

- 🌐 APT developers will release the MSA Tool in the next version of APT: Release Date: Oct. 2012!
- 🌐 NIRSpec team at STScI will:
 - **Continue evaluating alternate algorithms.** Test algorithms with alternate MSA Observing scenarios. Identify ~2-4 **algorithms** that can handle many different science cases.
 - **Future new functionality, improve efficiency :**
 - Orient analysis?
 - Avoid spoilers in background and “print-through” of bright objects in low-contrast shutters?
 - Add extra background shutters?
- 🌐 **YOU CAN HELP!**
 - Try MSA Planning in APT. Provide feedback while in development phase.
 - E.g., explore catalog options, fillers, sweet spot sizes – examine results.

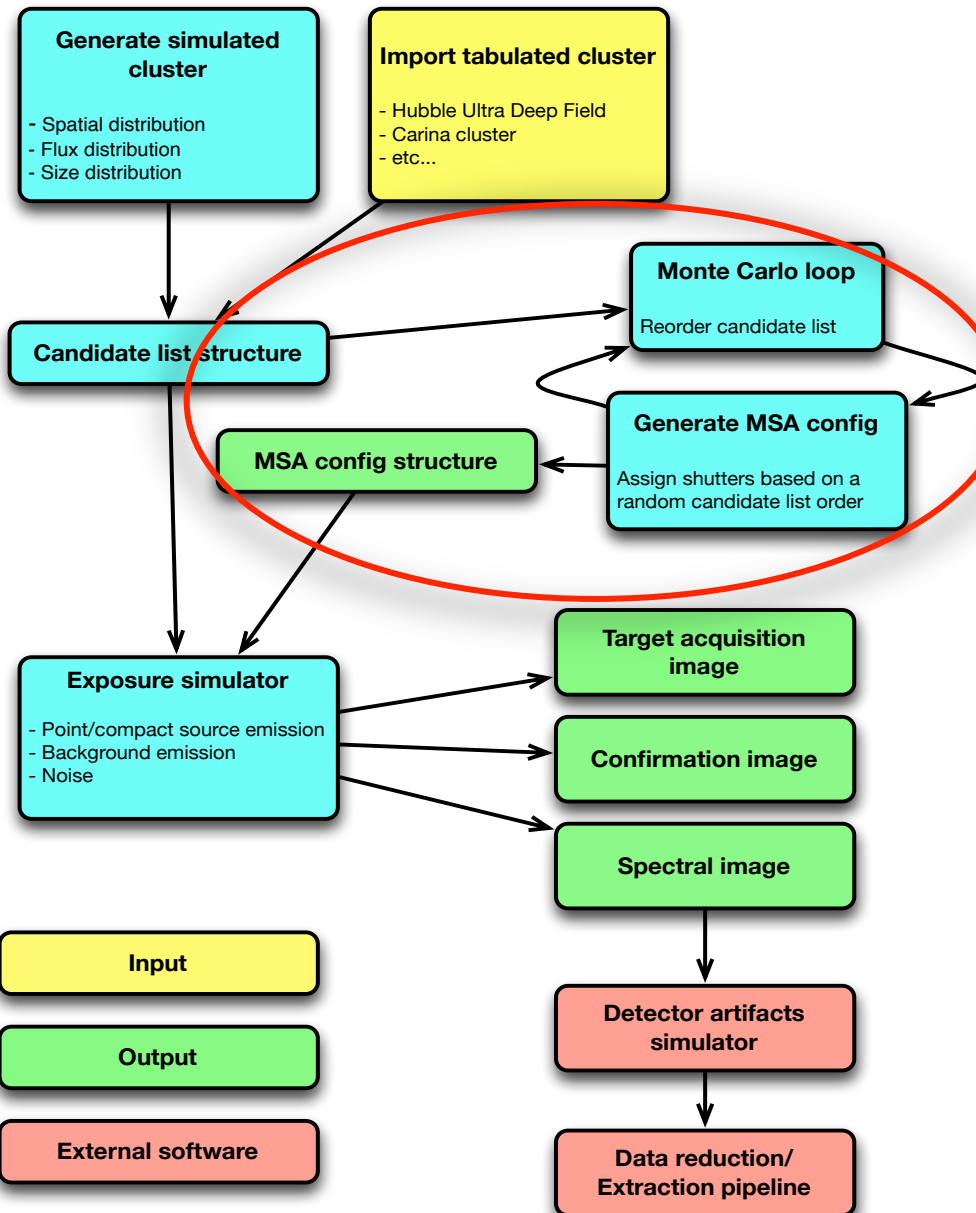
MC Select – developed by Klaus Pontoppidan



Features

- Monte Carlo shuffling of catalog for maximizing optimization scores
- Scriptable operations
- Modular and extensible code structure
- Simulated and real cluster catalogs
- Optical distortion
- Arbitrary slitlet patterns
- Realistic shutter mask (failed open/ closed)
- WebbPSFs
- 2D Extended sources
- FM1 wavecals
- Blaze functions
- Filter curves
- Optical train efficiency
- MultiAccum noise model
- Spectral and MIRROR TA/confirmation images
- Realistic backgrounds
- Model spectra including continuum and emission lines

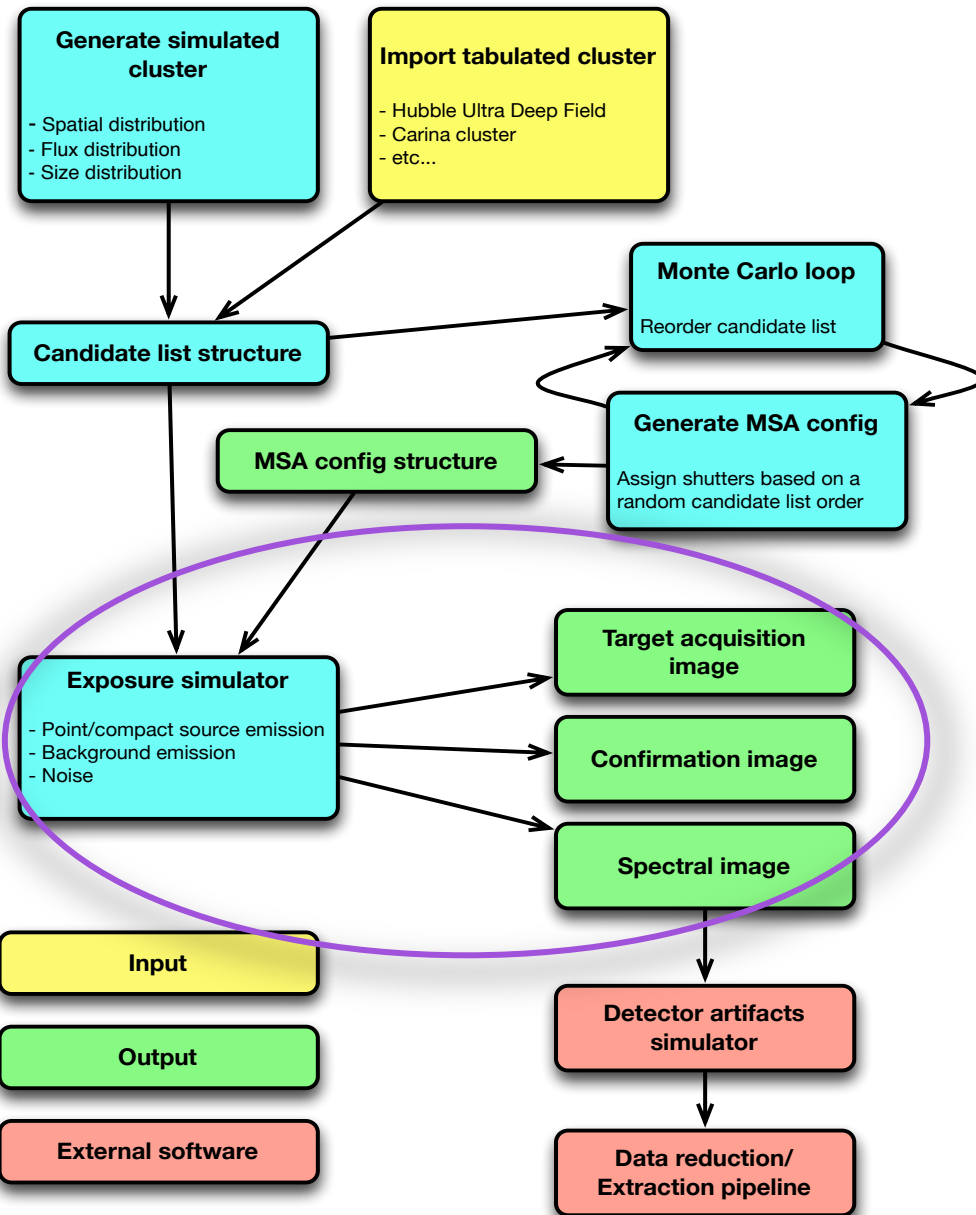
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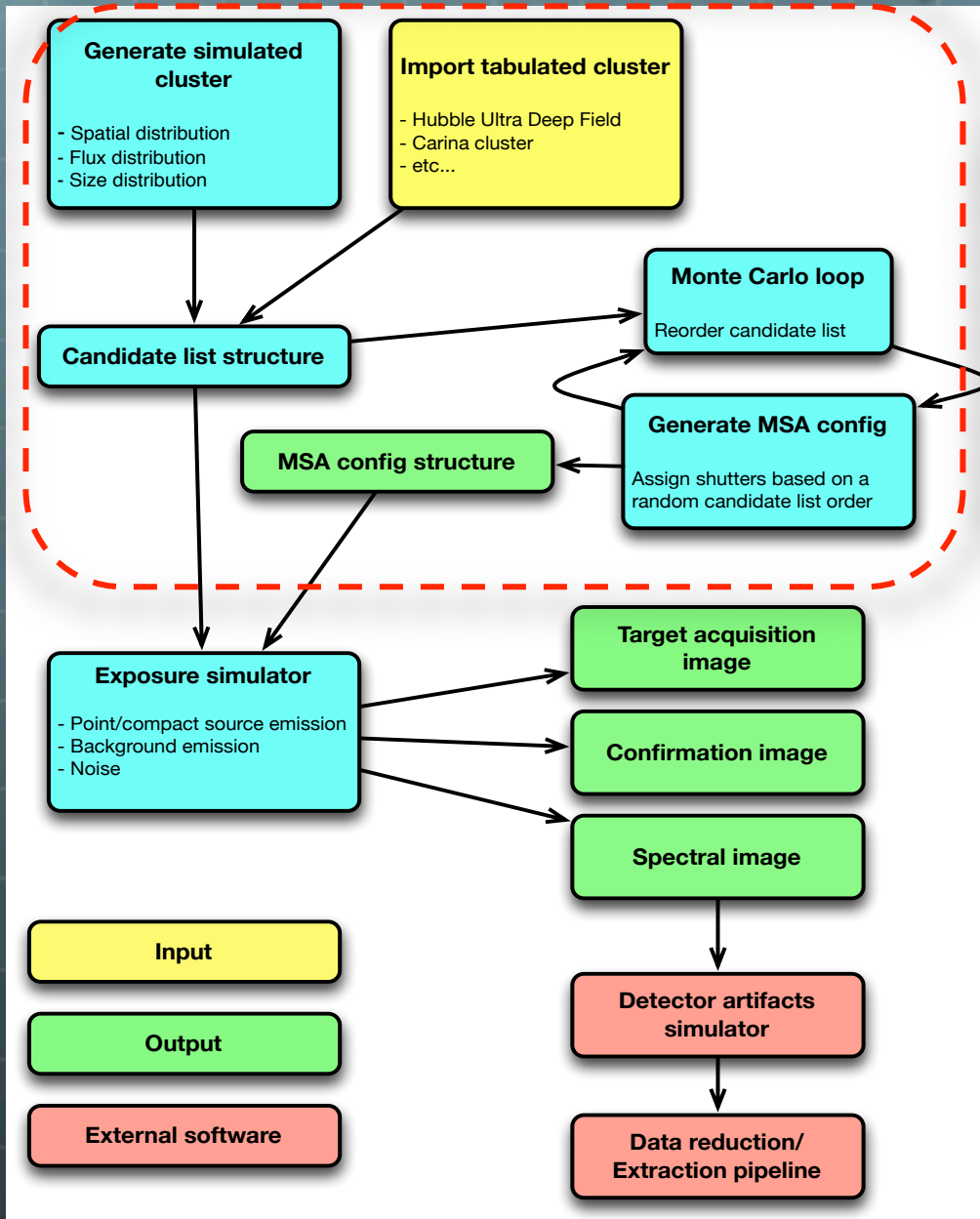
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Global Algorithm

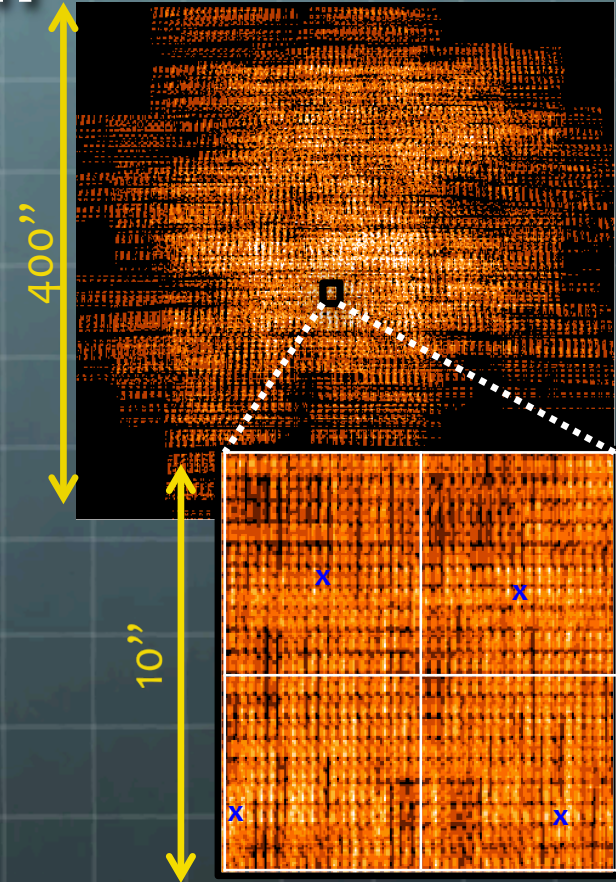
Does global optimization, not sequential, as in the Basic Algorithm.

Saves different potential combinations of configurations, scores them, and selects best ones.

➤ Scoring may depend on various criteria:
E.g. User may wish to ensure final target sets are drawn from a wide distribution of fluxes.

How is it done?

- Divide heatmap into cells (5x5)
- Do fine pointing search at optimal spot in each cell
- Generate a best config.
- Save all combinations of N potential configs.
Choose a limited number of configs (e.g. 4/25) that maximize the number of high-priority sources.

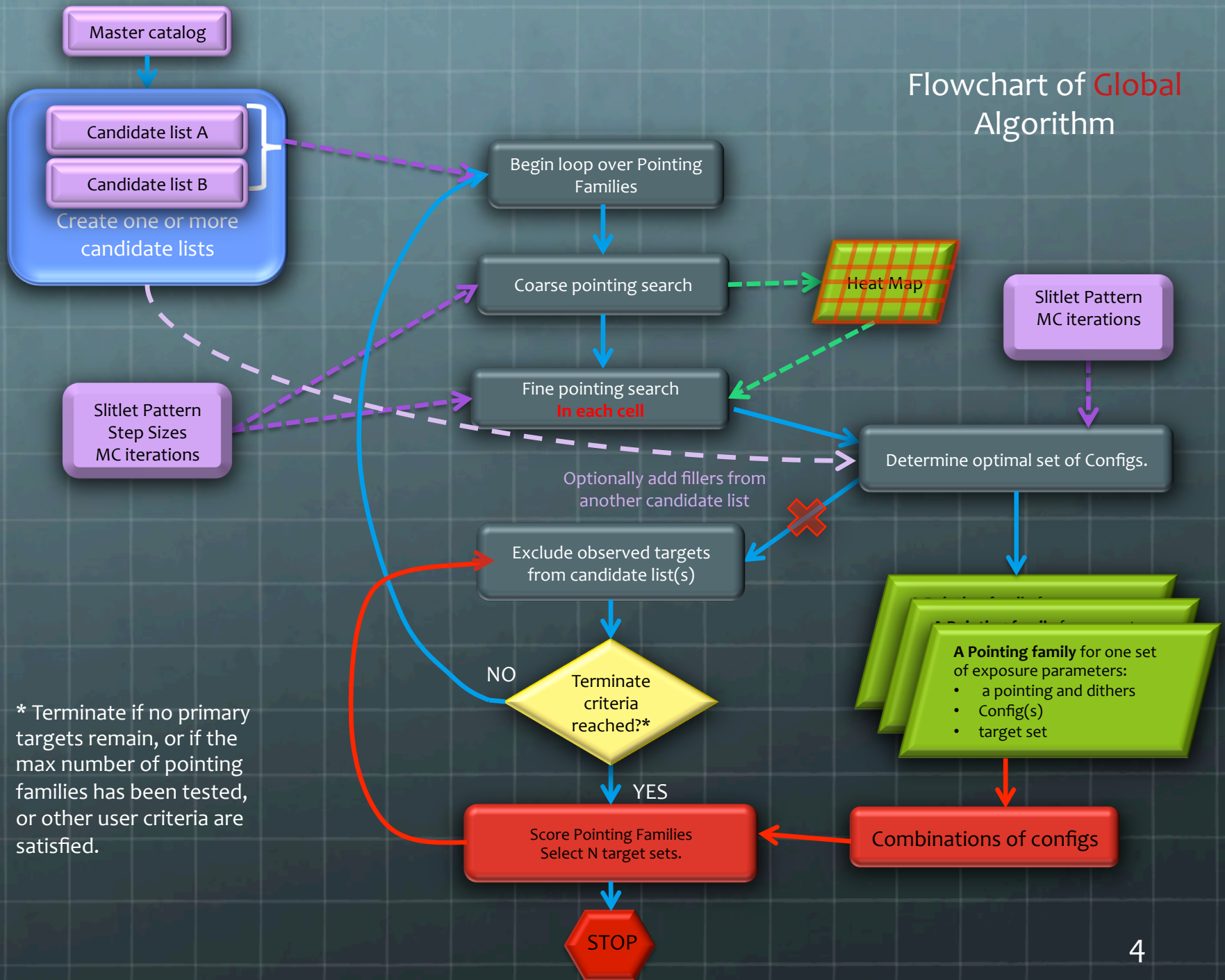


Targets

	1	2	3	4	5	6	7	...
1	1	1	0	0	1	0	0	0
2	0	1	1	0	0	1	1	0
3	0	0	1	1	1	0	0	1
...	1	1	1	0	0	0	1	0

- In practice, we must limit the combination of # cells and # configs chosen.
- Then, **exclude observed candidates** from hi-priority list.
- Repeat the above steps to derive next target set.

Flowchart of Global Algorithm



* Terminate if no primary targets remain, or if the max number of pointing families has been tested, or other user criteria are satisfied.

A Pointing family for one set of exposure parameters:

- a pointing and dithers
- Config(s)
- target set