The 4MOST Facility Simulator (4FS)

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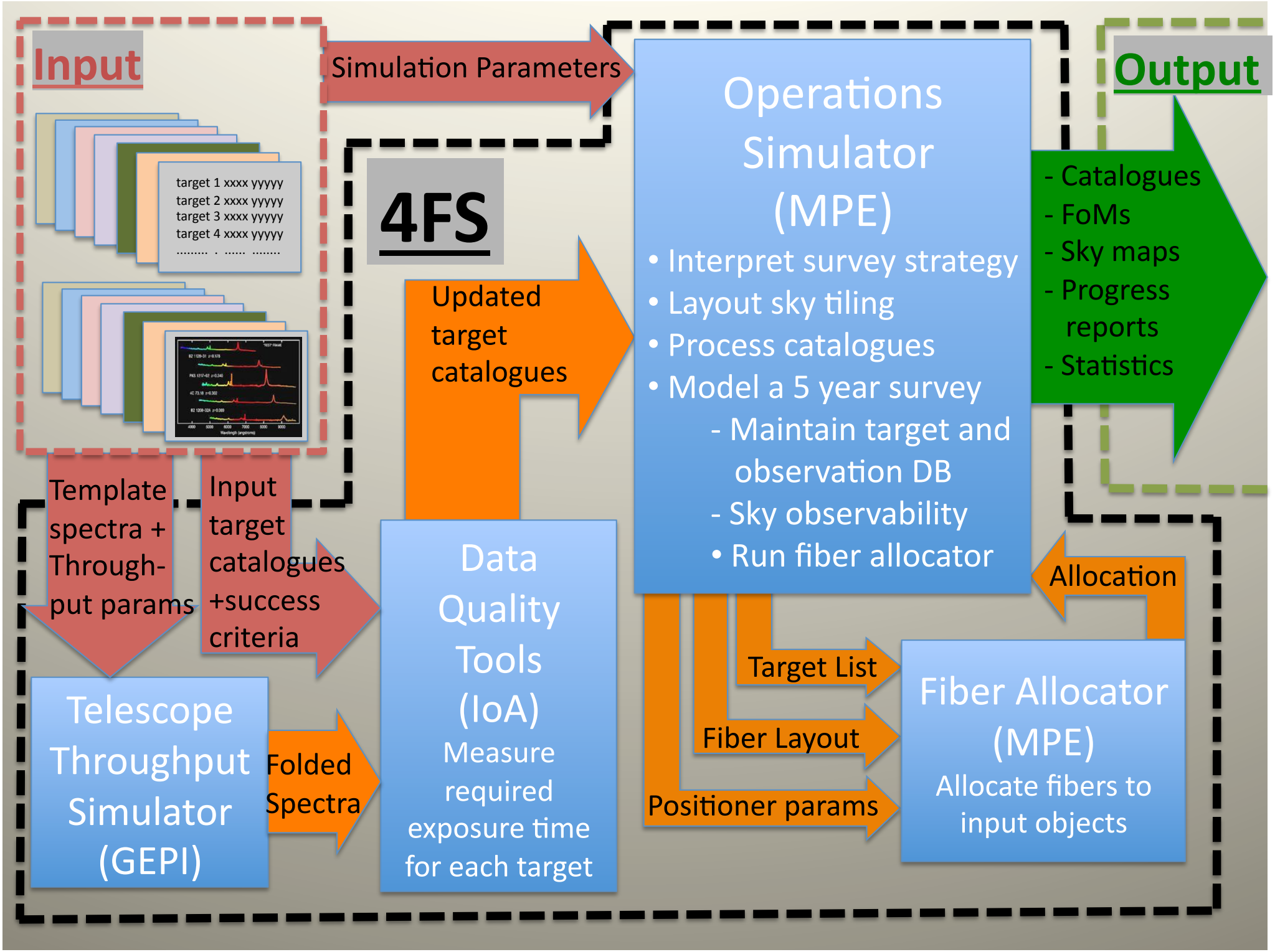
and the 4MOST Facility Simulator team

Large Area Optical Spectroscopic Surveys: Science with 4MOST
Potsdam, 13th Nov 2012

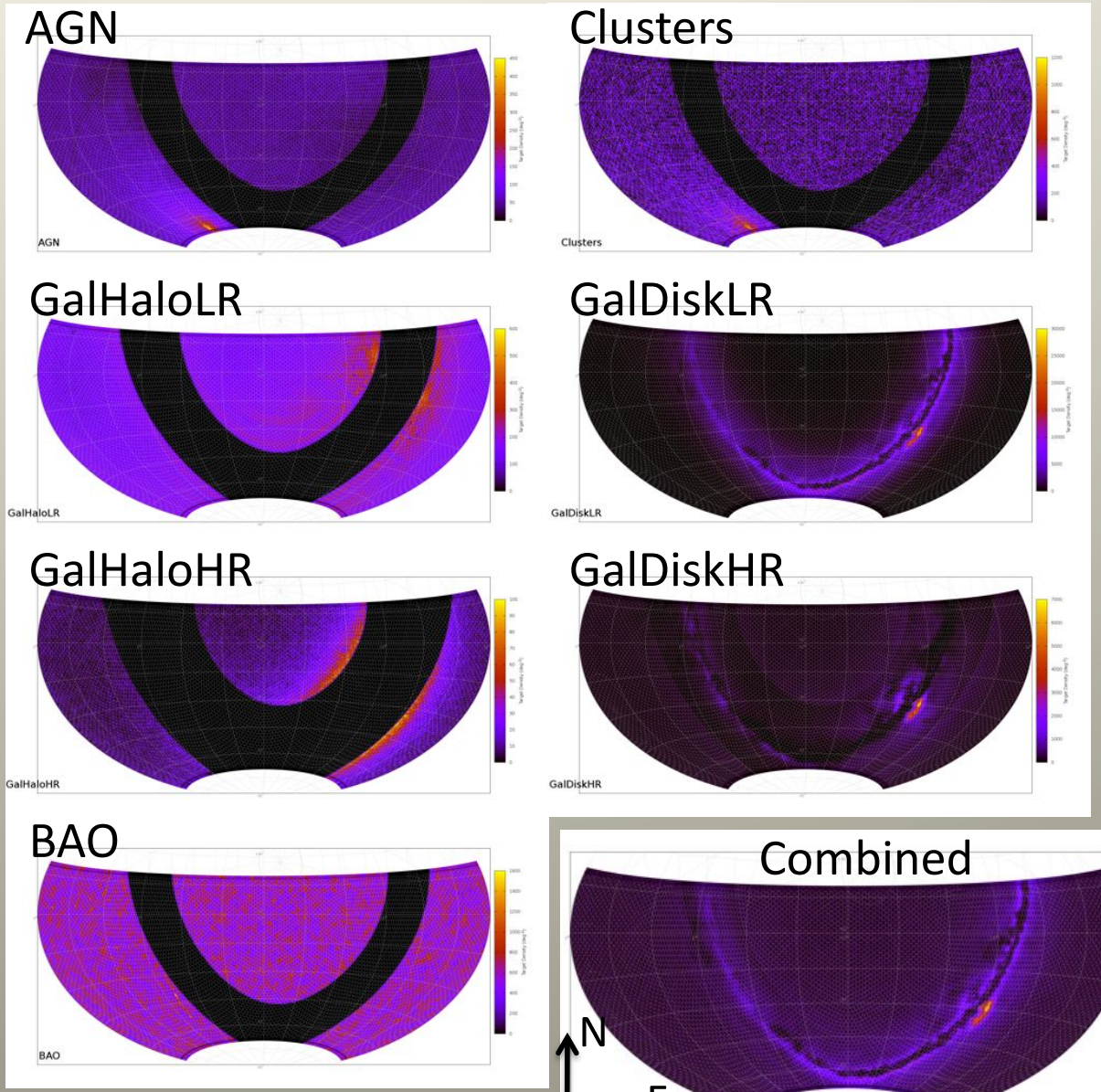
The 4FS philosophy

- Model all relevant 4MOST sub-systems and interactions between them, including:
  - focal plane layout/positioner geometry
  - targeting (fiber -> target assignments)
  - scheduling algorithms (optimal field selection)
  - observing constraints and survey strategy
- Parameterize (more or less) everything
- Survey operations are dynamic
  - night-by-night simulation of survey
  - respond to conditions and survey progress
- Simulator outputs must be user friendly
- Efficient coding (1 simulation runs in ~1 hour)


Input
target 1 xxxx yyyyy
target 2 xxxx yyyyy
target 3 xxxx yyyyy
target 4 xxxx yyyyy
Simulation Parameters
4FS
Operations Simulator (MPE)
• Interpret survey strategy
• Layout sky tiling
• Process catalogues
• Model a 5 year survey
- Maintain target and observation DB
- Sky observability
• Run fiber allocator
Output
- Catalogues
- FoMs
- Sky maps
- Progress reports
- Statistics
Updated target catalogues
Template spectra + Through-put params
Input target catalogues +success criteria
Data Quality Tools (IoA)
Measure required exposure time for each target
Telescope Throughput Simulator (GEPI)
Folded Spectra
Allocation
Target List
Fiber Layout
Positioner params
Fiber Allocator (MPE)
Allocate fibers to input objects

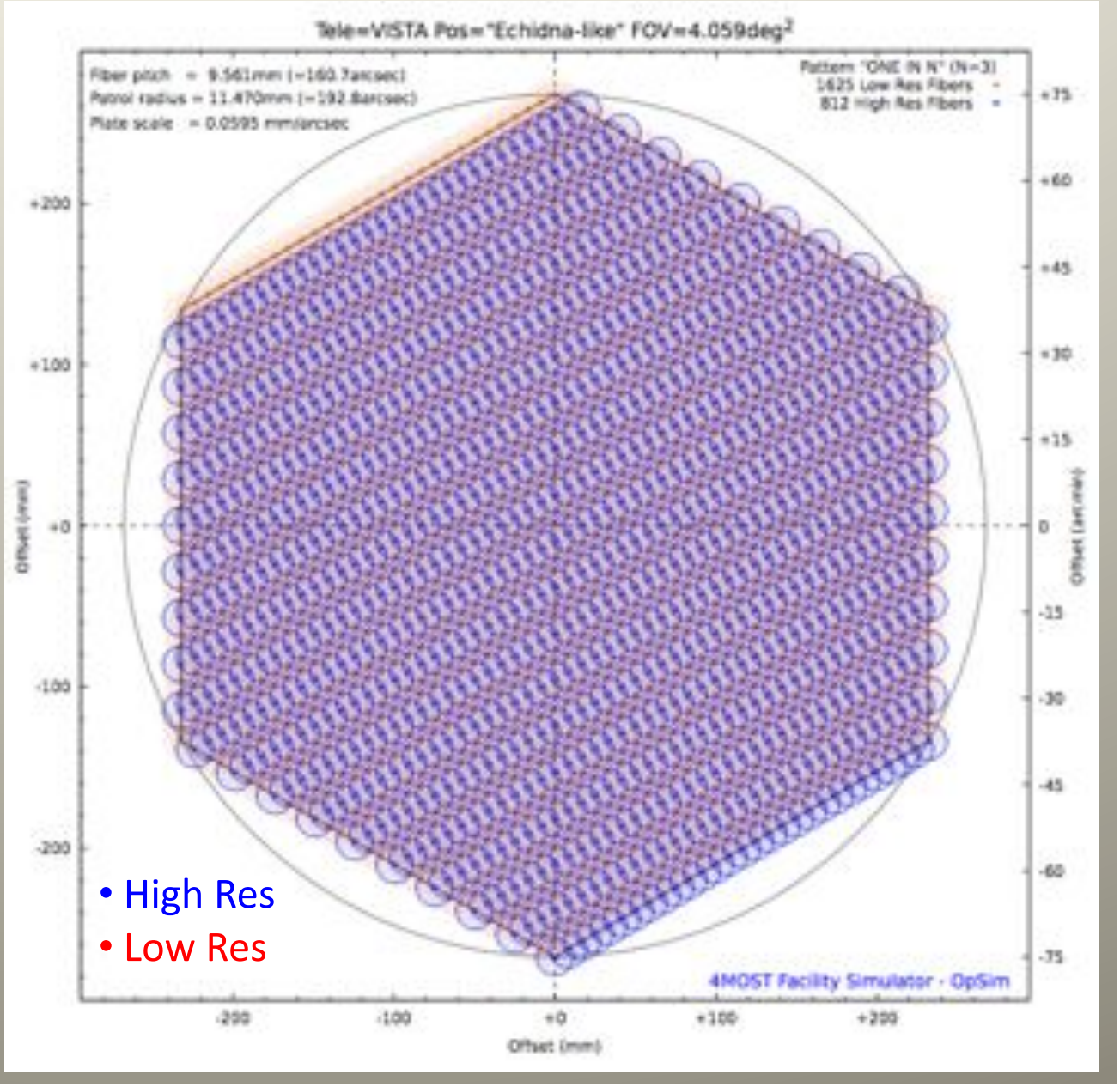
Baseline Input Catalogues

- Design Reference Surveys:
  - eRosita AGN
  - eRosita Clusters
  - Gal. Halo LoRes
  - Gal. Halo HiRes
  - Gal. Disk LoRes
  - Gal. Disk HiRes
  - Galaxy redshift survey (BAO)



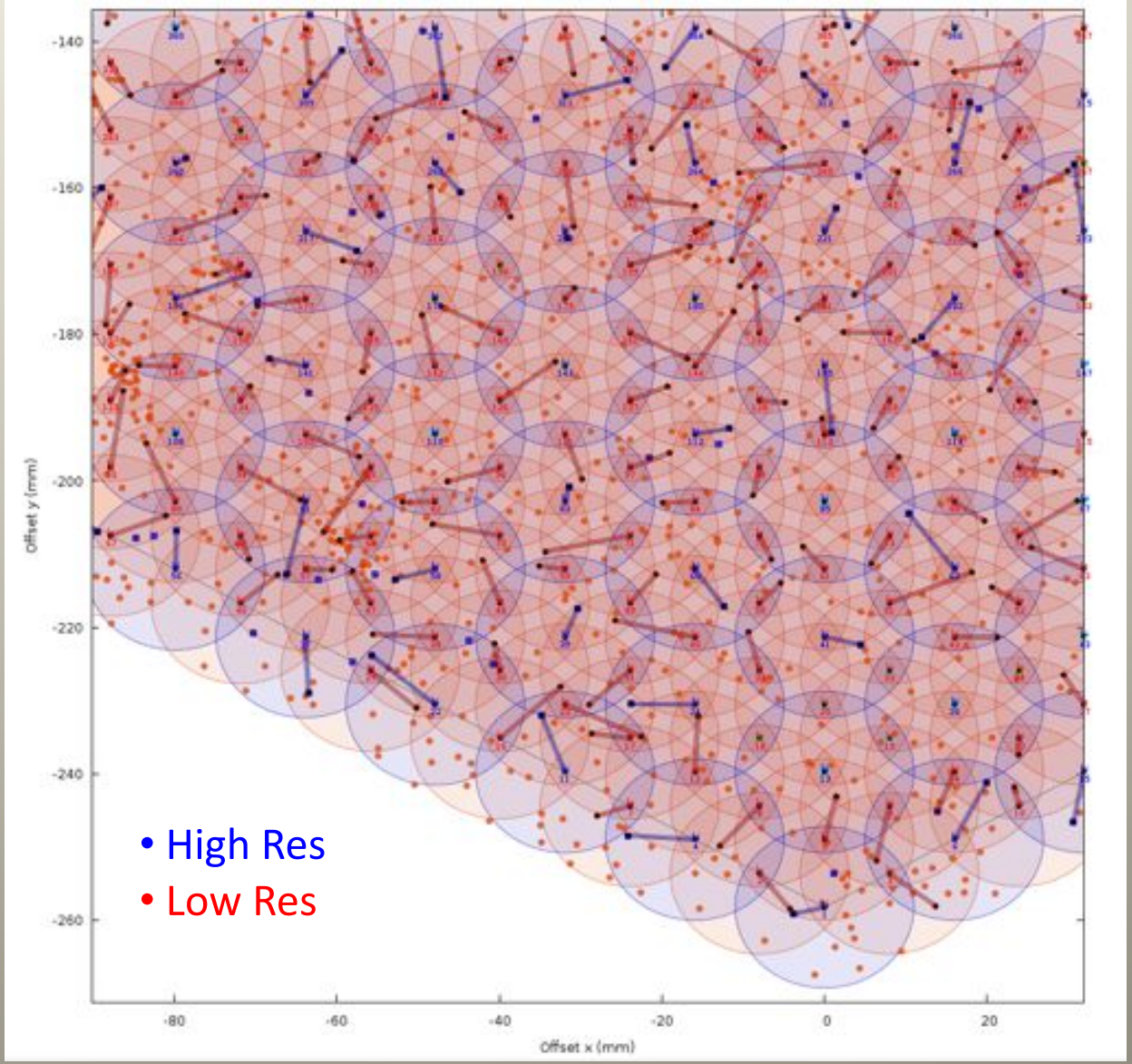
Instrument Configuration

- FOV = 4.06deg^2 (2.5^o diameter)
- Echidna-style positioner
- 2437 positioners (filled hexagon with 28 per side)
  - 812 hi-res fibers
  - 1625 lo-res fibers
- Pitch = 9.6mm
- Patrol radius = 11.5mm
- Plate scale = 59.5µm/arcsec

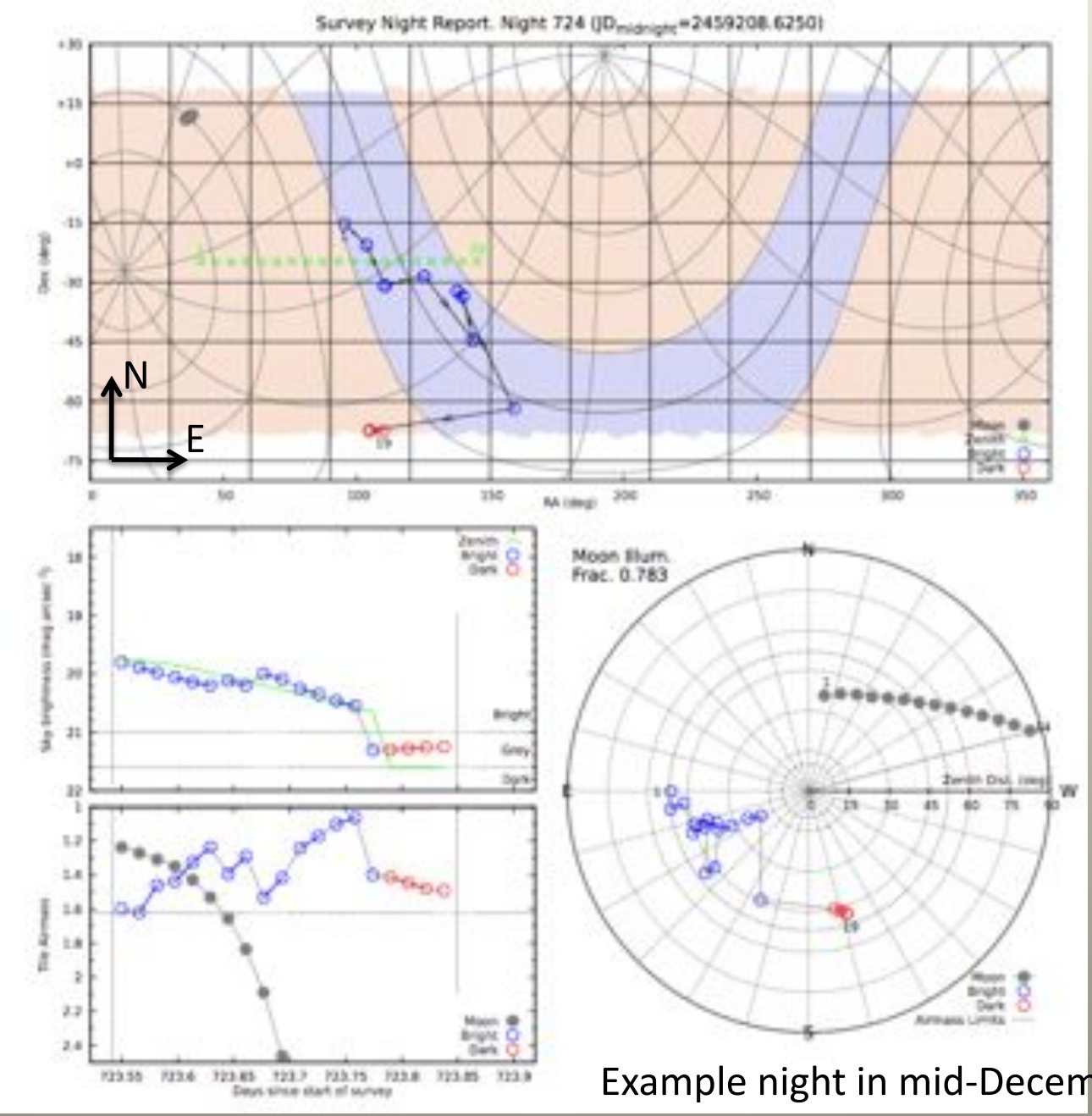


Fiber ←→ Target Allocation

- Reconfigure for each Tile
- Assign high priority targets first
- Avoid fiber collisions
  - Positioner geometry (Echidna, PotzPos ...)
- Assign sky fibers
- Collision mitigation routine
  - to be added



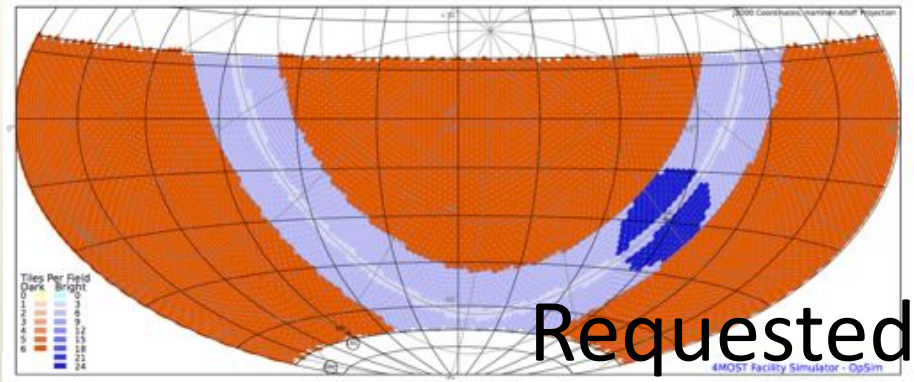
Night-by-night operations

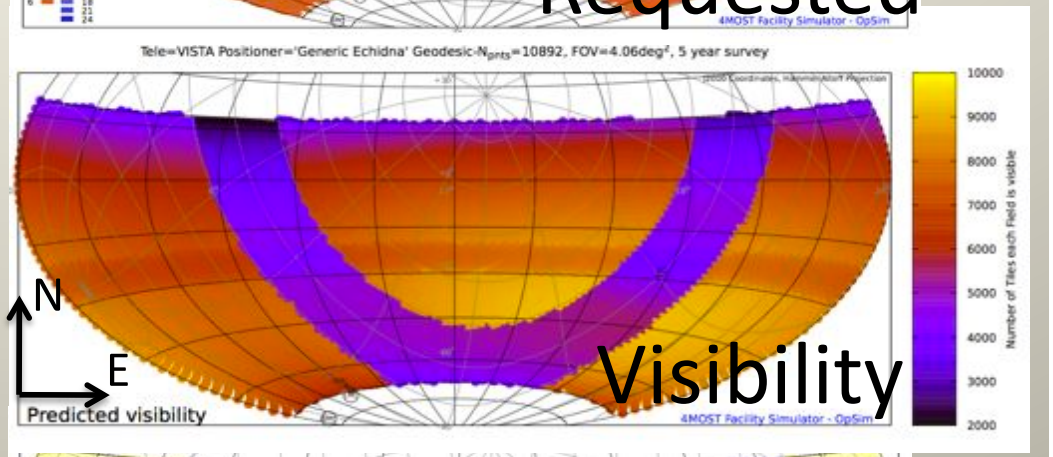


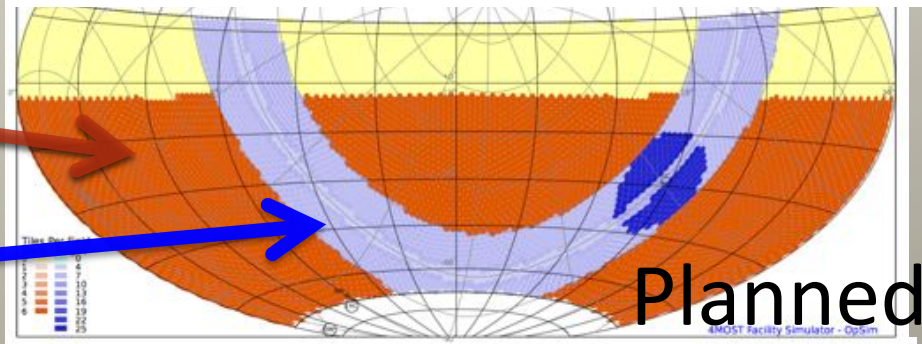
Example night in mid-December 2020

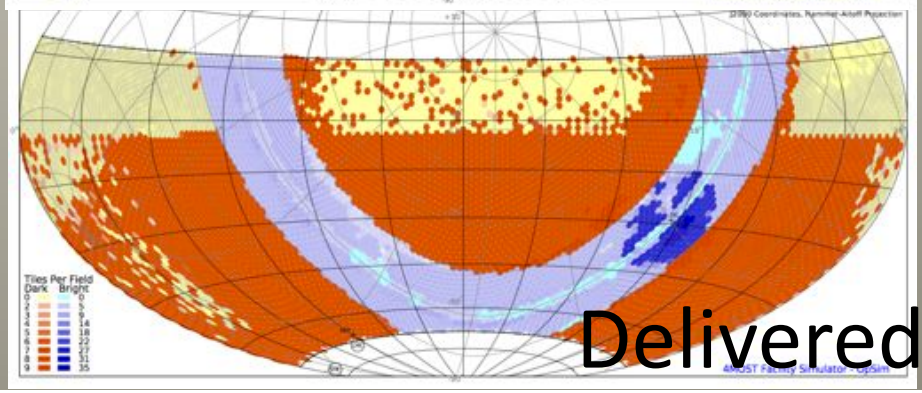
Survey Strategy

- Constraints:
  - Airmass limit (<1.624)
  - Moon avoidance (>15°)
  - Time lost to poor weather
  - Consider -70°<Dec<+20°
    - Total ~ 26 000 deg^2
  - 12k Bright, 20k Dark+Grey Tiles
  - + LMC/SMC observations?
- Segregate sky about b=±15°
  - **Dark/grey moon:**
  - **$|b| > 15°$**
  - **goal: n_{dg}×20min per field**
  - Bright moon:
  - $|b| < 15°$
  - goal: n_b×20min per field
  - + extra on Gal. Bulge
  - - fewer v. near Gal. Plane
- Geodesic tiling pattern





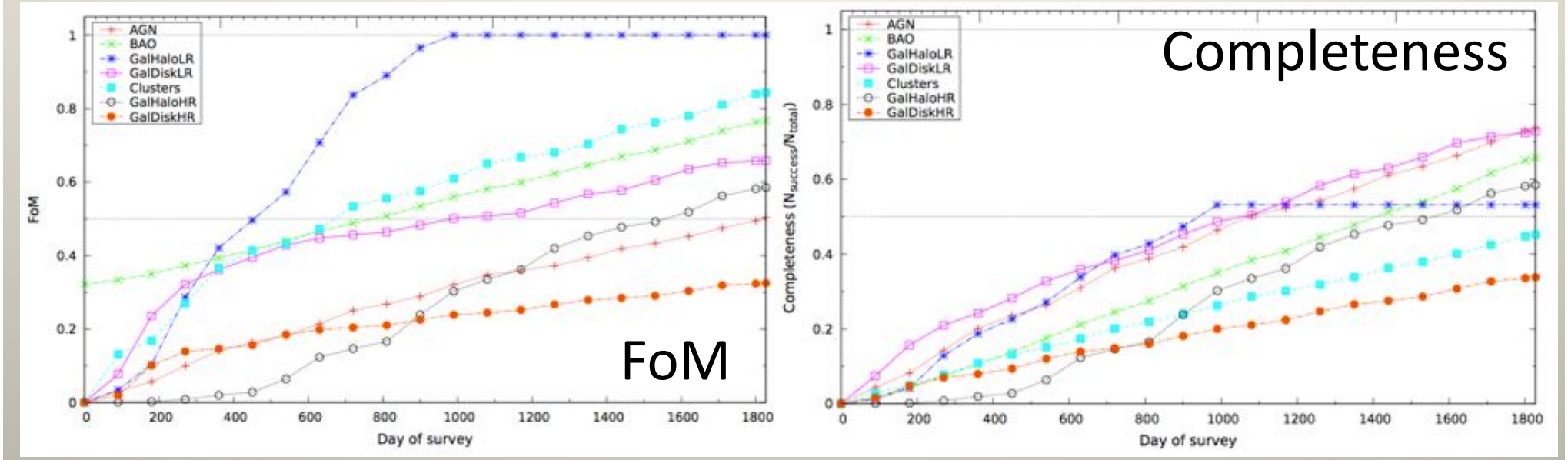


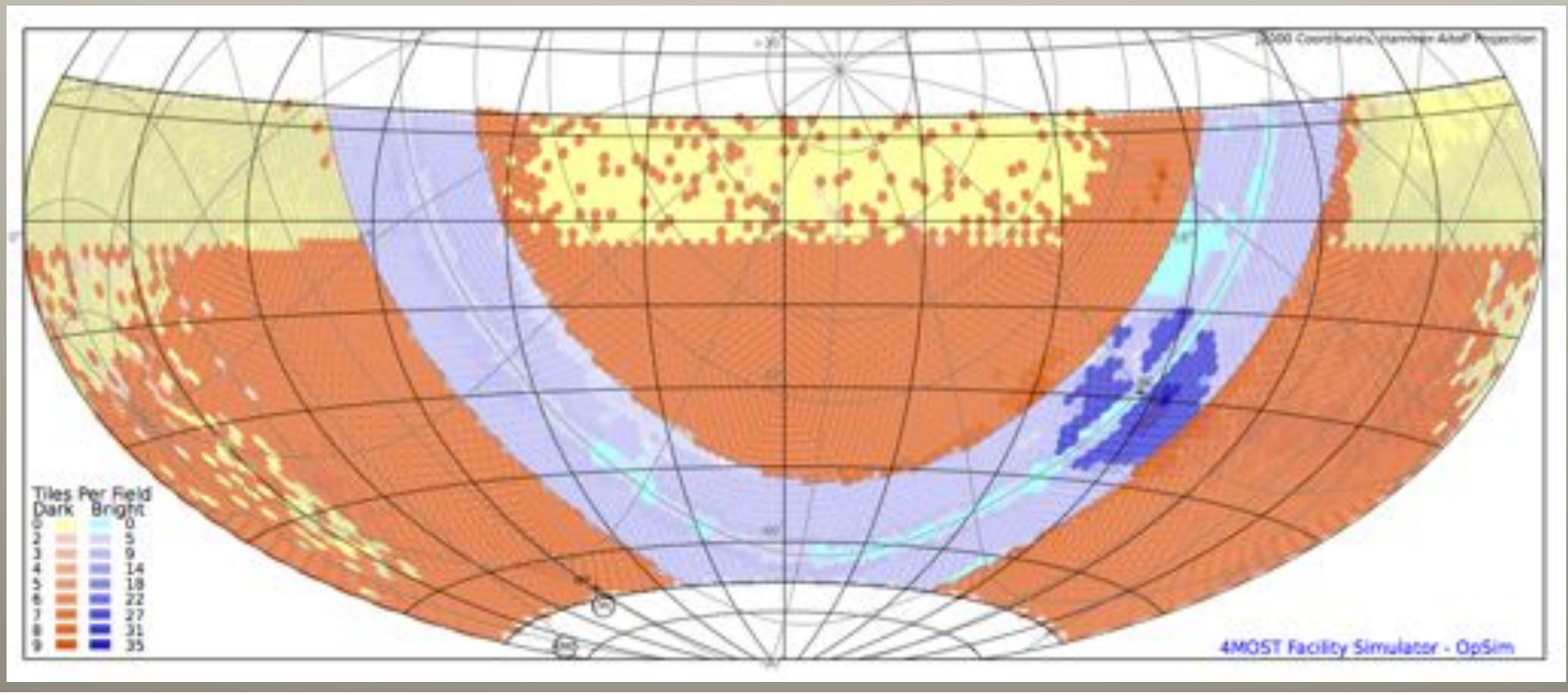


Impact of changing Survey Strategy

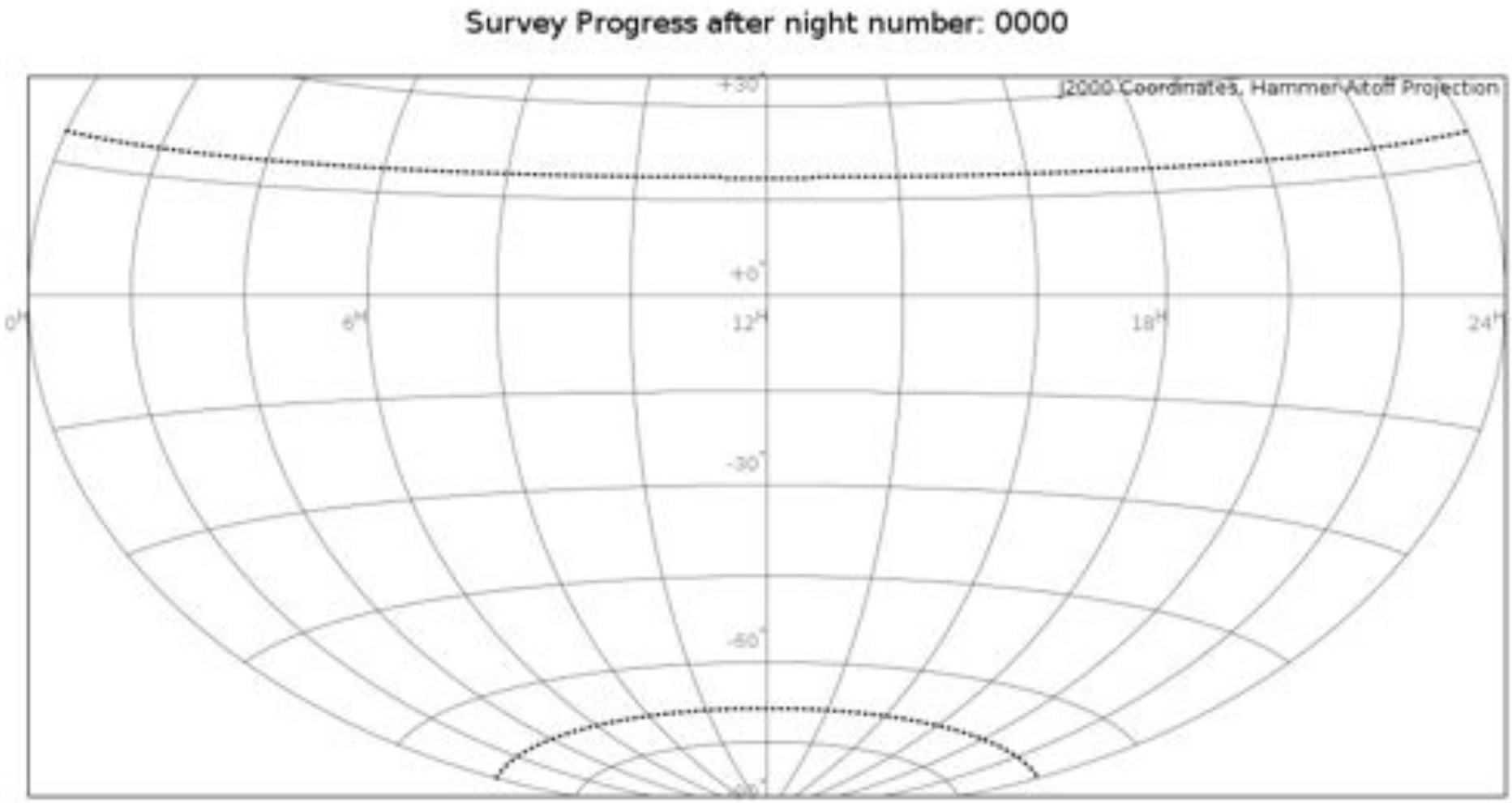
- Option 1: Cover sky to minimum depth
  - require at least 6x20mins/pointing
  - cover -70°<Dec<-10° of extragalactic sky
  - cover full visible Galactic Disk
    - + extra tiles on Galactic Bulge
- Option 2: Go as wide as possible
  - cover full -70°<Dec<+20° sky
  - 4-5×20min/pointing on extragalactic sky
  - 6×20mins/pointing on Galactic Disk
    - + extra tiles on Galactic Bulge

Option 1: Depth over Area

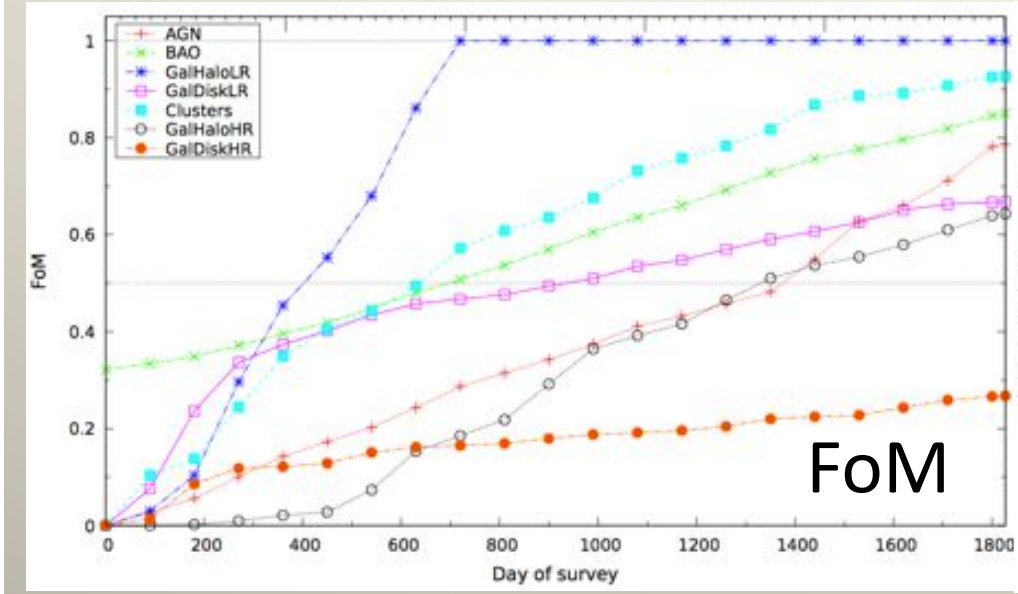


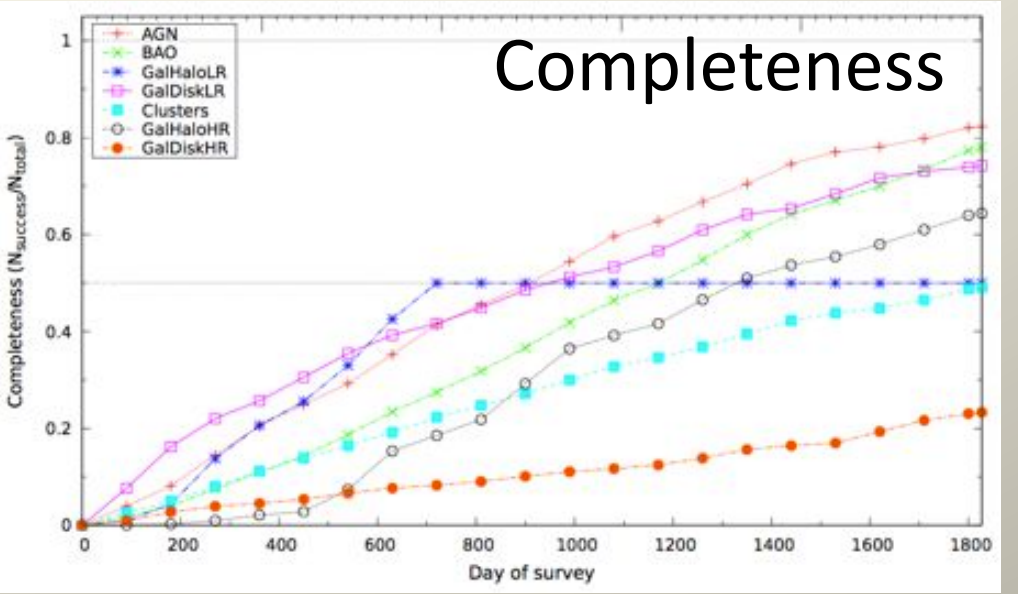


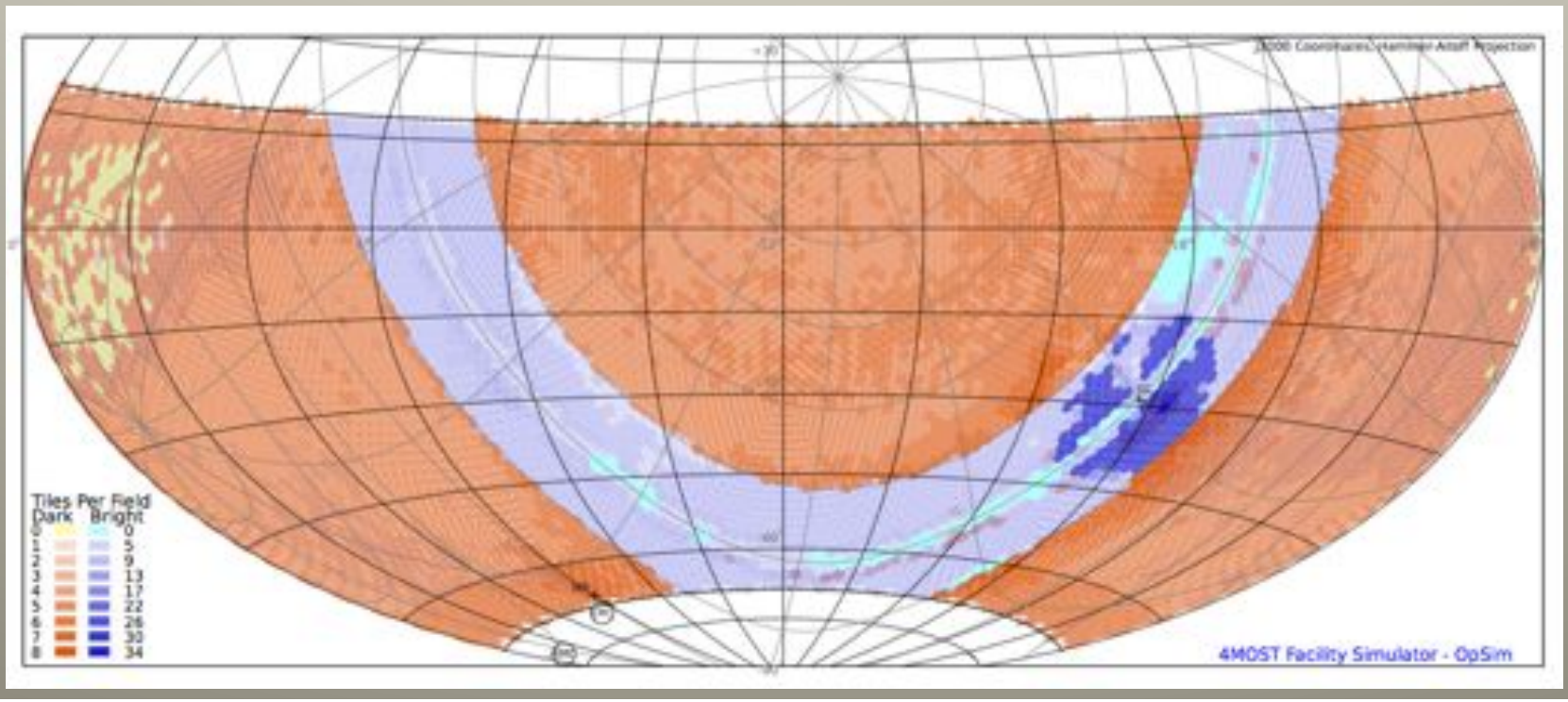
Option 1: Depth over Area



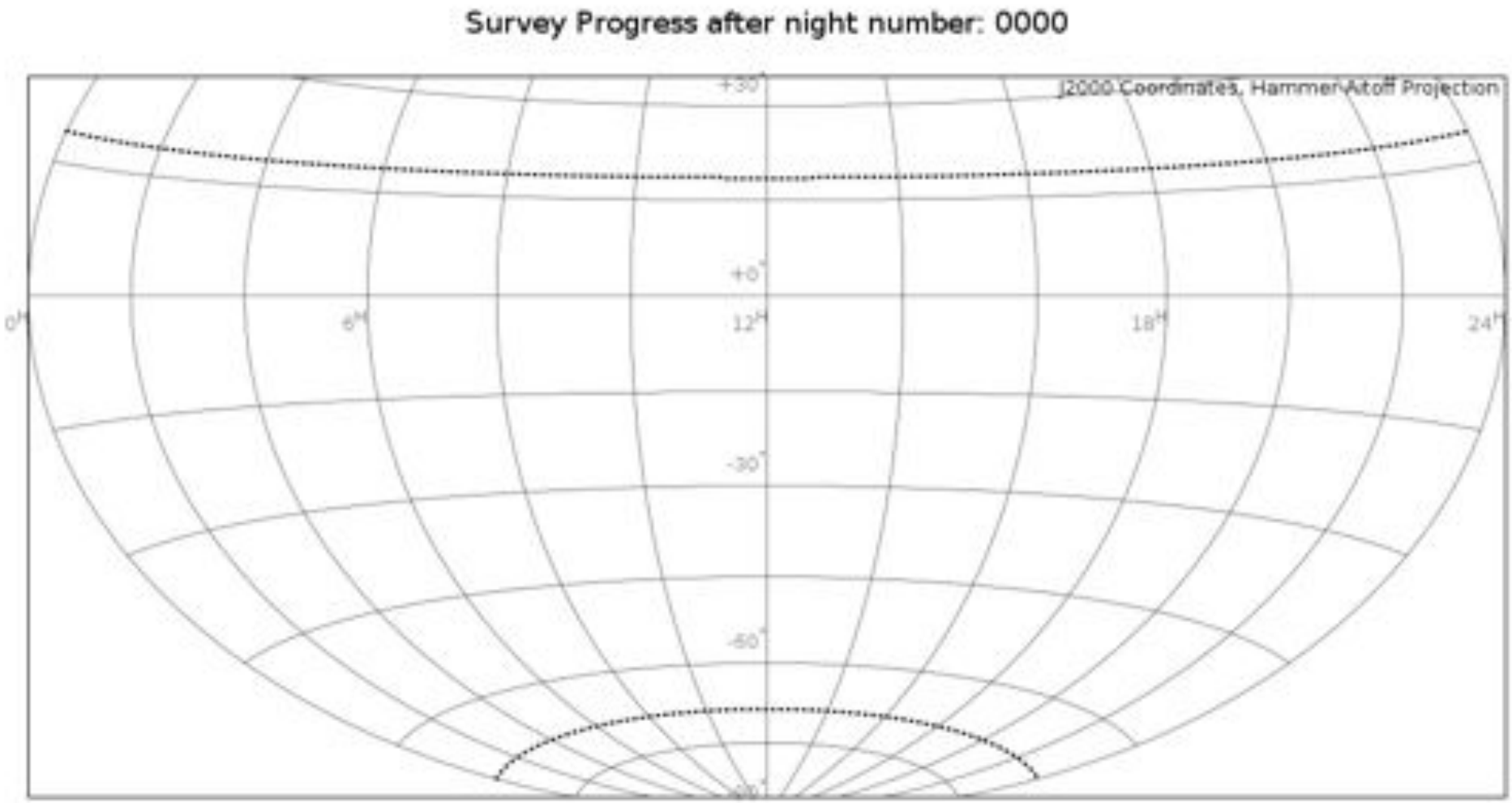
Option 2: Area over Depth







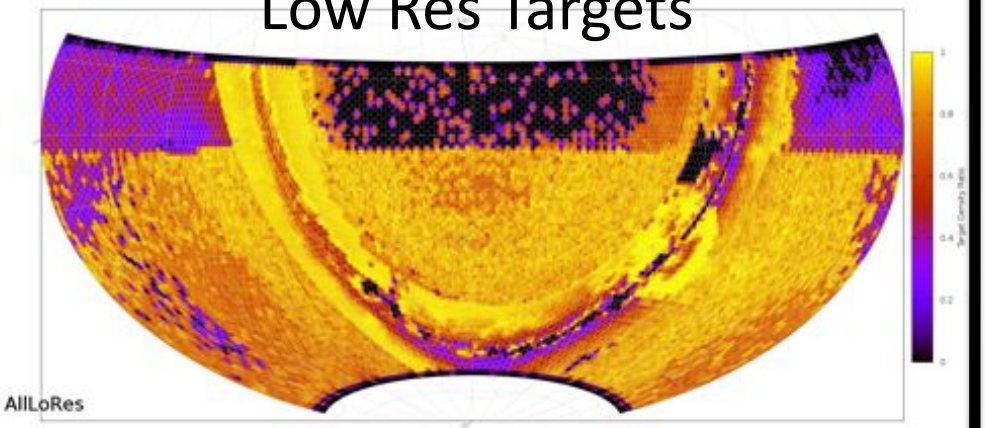
Option 2: Area over Depth



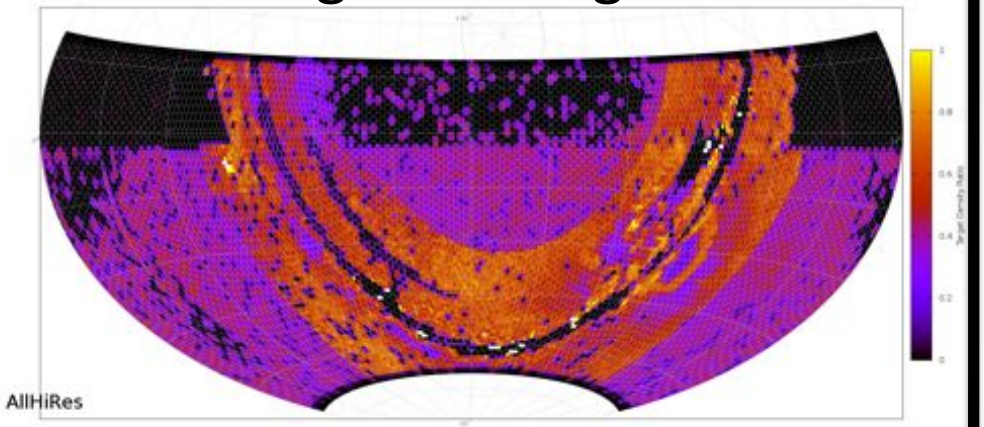
Comparison: Completeness

Option 1: Deeper

Low Res Targets

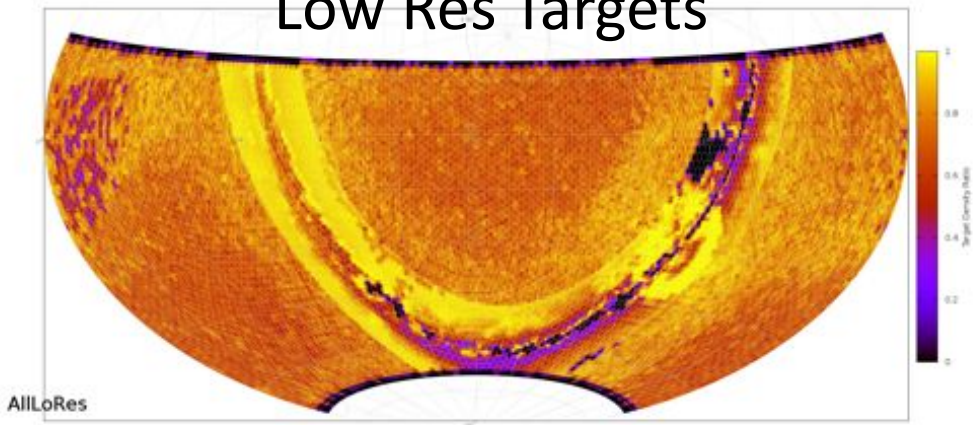


High Res Targets

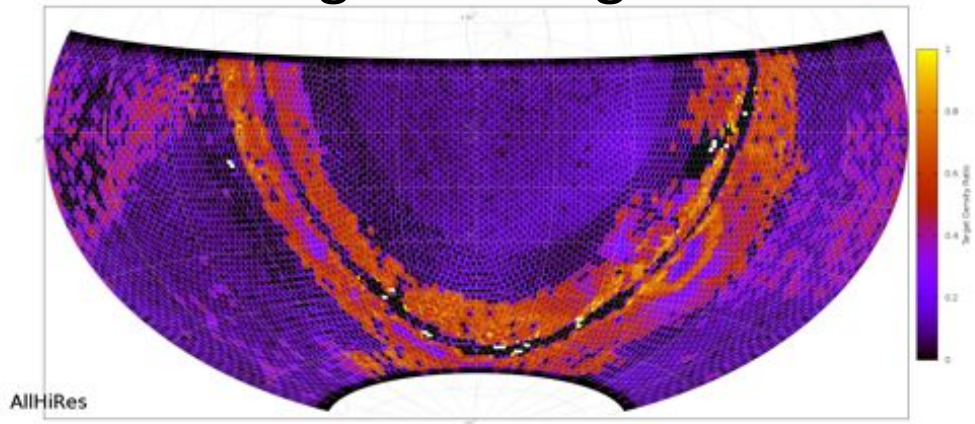


Option 2: Wider

Low Res Targets

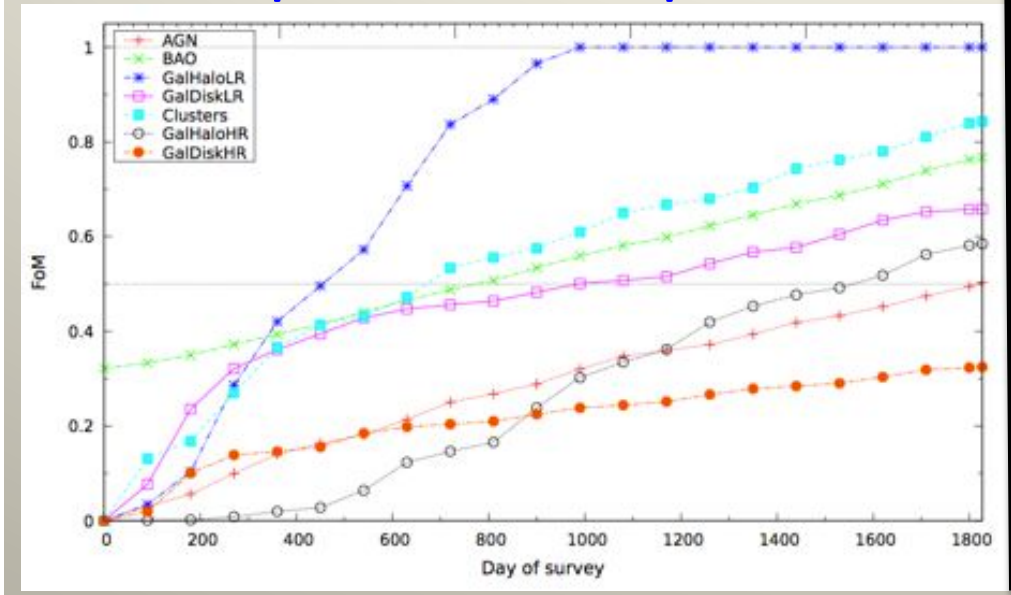


High Res Targets

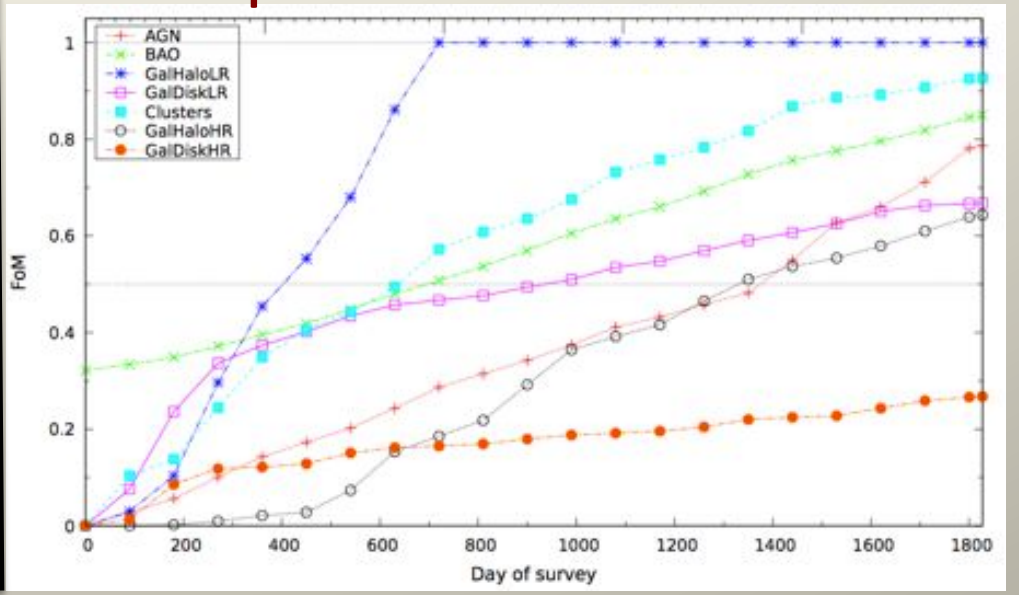


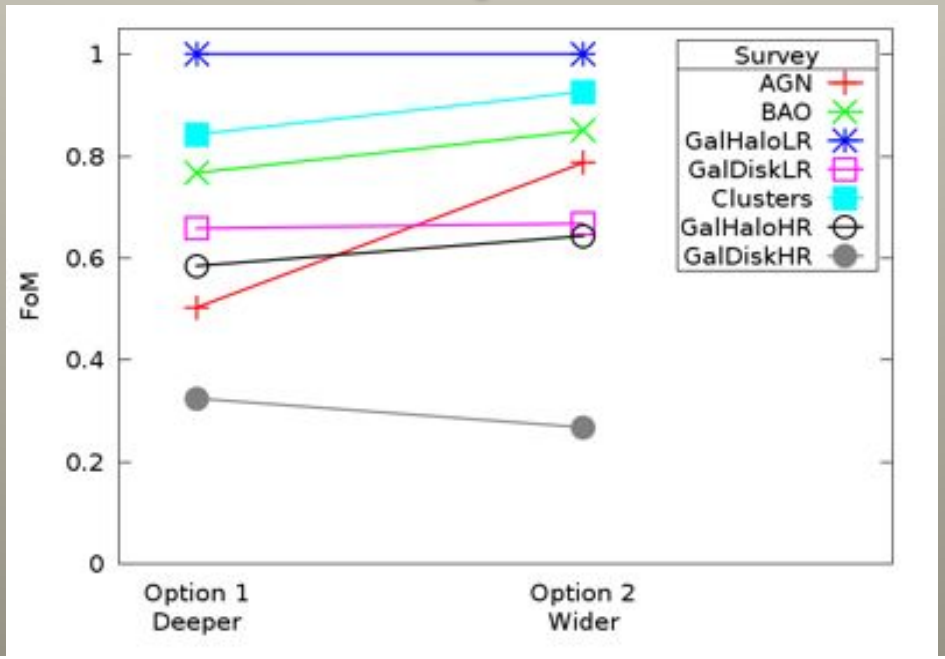
Comparison: Survey Figure of Merit

Option 1: Deeper



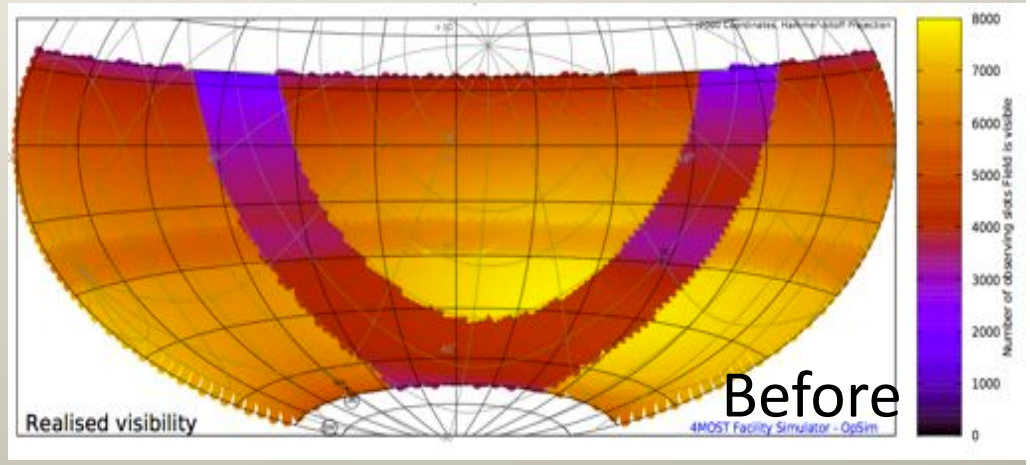
Option 2: Wider

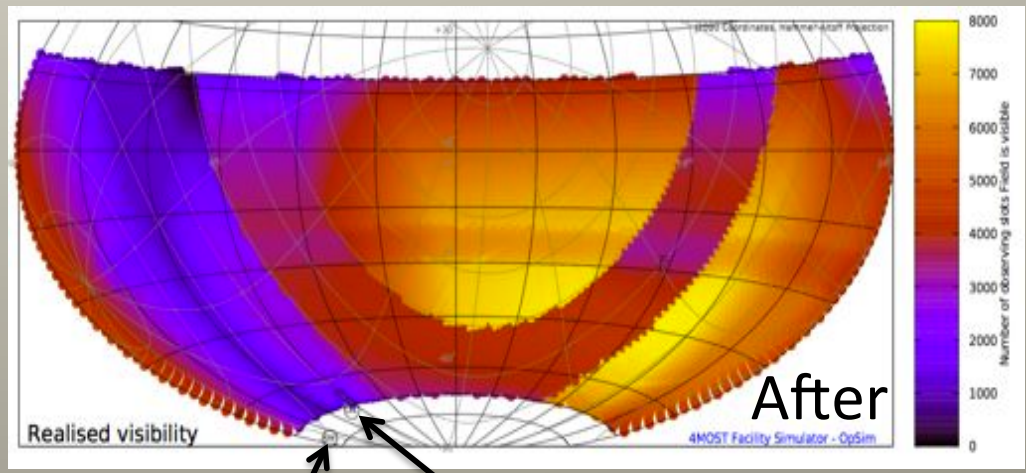




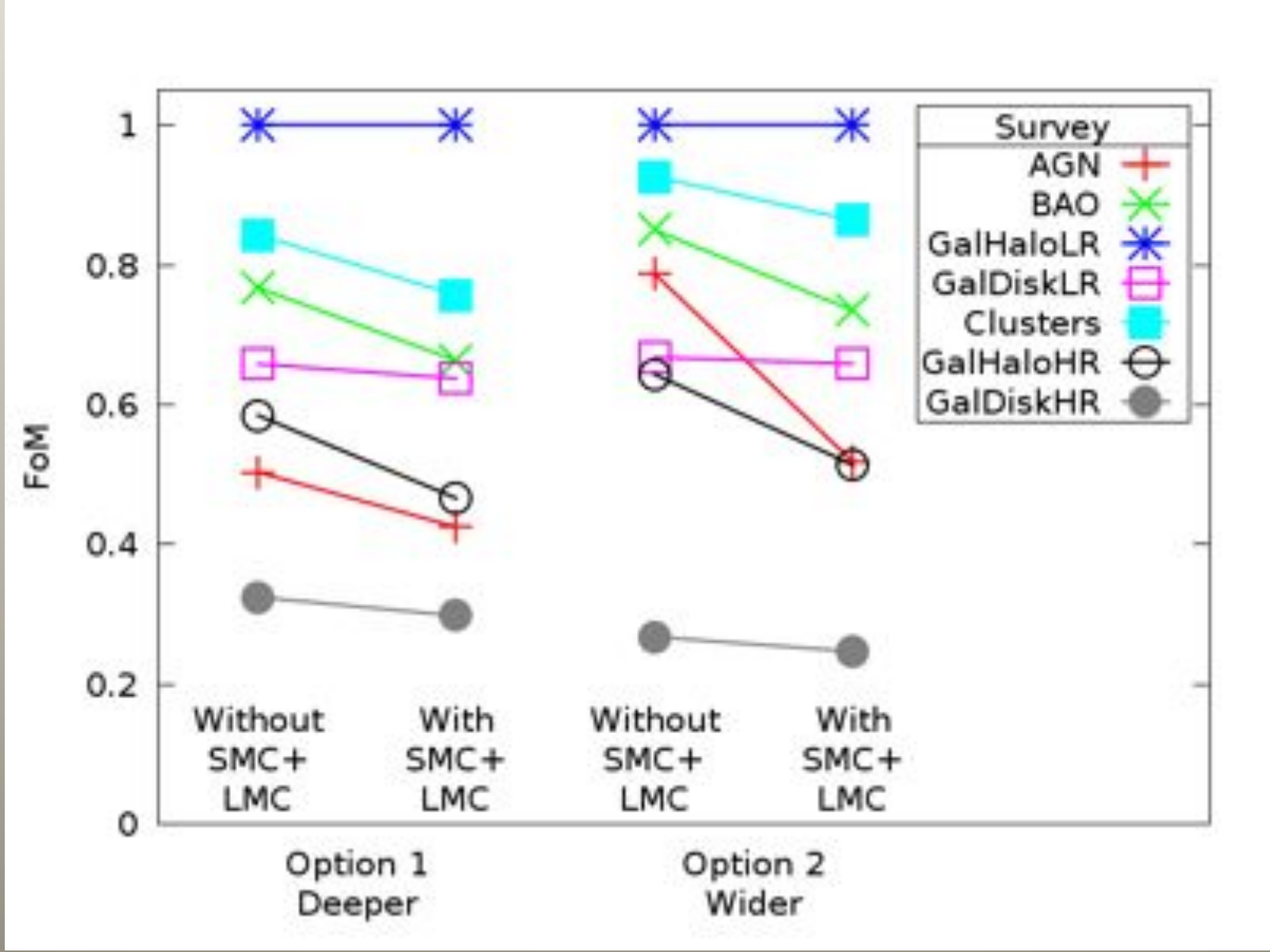
Impact of adding SMC/LMC survey

- Repeated observations spanning 5 years
- SMC
  - 6 pointings, each with 6x20mins/epoch
  - with 40 epochs
  - 480hrs + overheads
  - ~3 million spectra
- LMC
  - 16 pointings, each with 6x20mins/epoch
  - with 40 epochs
  - 1280hrs + overheads
  - ~9 million spectra





Effect of adding SMC/LMC surveys



4MOST Facility Simulator: Summary

- The 4FS is a versatile tool for instrument design verification and survey planning
- First results suggest 4MOST will be a very powerful tool for a wide range of science projects
  - Balancing interests of competing surveys is possible, but complex
  - Realistic simulations of survey outcomes are vital to make most efficient use of 4MOST time
  - Surveys must clearly define their success criteria
- Additional surveys can be examined with the 4FS
  - estimate success of additional surveys
  - quantify adverse impact (if any) on reference surveys

Positioner statistics