The Roman IPAC/SSC MSOS Event pipeline: goals, implementation and early results

Etienne Bachelet and the MSOS team:

Rachel Akeson, Sebastiano Calchi Novati, Kyle Finner, Wanggi Lim, Alex Stukalov, Keto Zhang, Lijun Zhang

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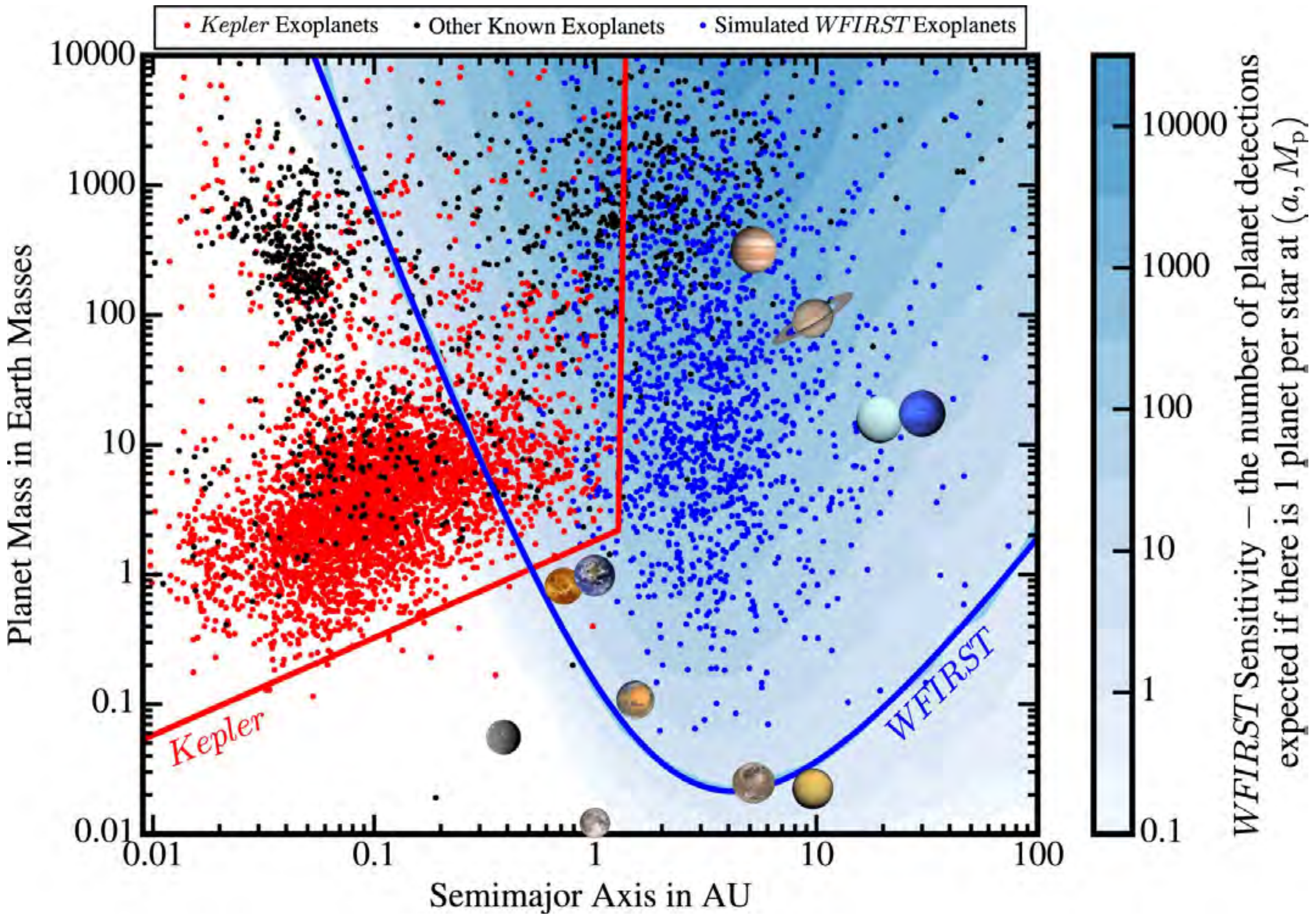
ipac

Summary

- Expectations
- Requirements
- Automation
- Event Pipeline
    - Classifier
    - Modeling
- Preliminary results

MSOS Event pipeline: expectations

- From Penny et al. 2019:
  - 200×10^6 stars monitoring (for 7 fields)
  - ~30 000 microlensing events
  - ~1500 planets
  - >100 Free-floating planets
  - >1 000 binary lenses
  - >100 of stellar remnants
  - many more cool things....



MSOS Event pipeline: requirements

- RST shall be capable of measuring the mass function of exoplanets with masses in the range 1 $M_{Earth} < m < 30\ M_{Jupiter}$ and orbital semi-major axes ≥ 1 AU to better than 15% per decade in mass.

- RST shall be capable of measuring the frequency of bound exoplanets with masses in the range 0.1 $M_{Earth} < m < 0.3 M_{Earth}$ to better than 25%.

- RST shall be capable of determining the masses of, and distances to, host stars of 40% of the detected planets with a precision of 20% or better.

- RST shall be capable of measuring the frequency of free floating planetary-mass objects in the Galaxy from Mars to 10 Jupiter masses. If there is one M_{Earth} free-floating planet per star, measure this frequency to better than 25%

- RST shall be capable of estimating η_{Earth} (defined as the frequency of planets orbiting FGK stars with mass ratio and estimated projected semimajor axis within 20% of the Earth-Sun system) to a precision of 0.2 dex via extrapolation from larger and longer-period planets.

- **The pipeline level 5 requirements are tied directly to these Level 1 science requirements**

MSOS Event pipeline: requirements

- Cloud requirements for MSOS Event
  - Processing will be done on NASA dedicated cloud
  - $1.8x10^6$ CPU-hours currently available
  - $1.8x10^6$ / 30000 = 60 CPU-hours/event
  - More CPU time can be requested if justified

- MSOS Event goals
  - 1 Classify lightcurves and identify microlensing events
  - 2 Find the "correct" microlensing model
  - 3 Estimate physical parameters (lens mass, distance etc...)

MSOS Event pipeline: requirements

- MSOS Event calendar
  - Requirements only on the completed survey
  - Will be run at the end of each season

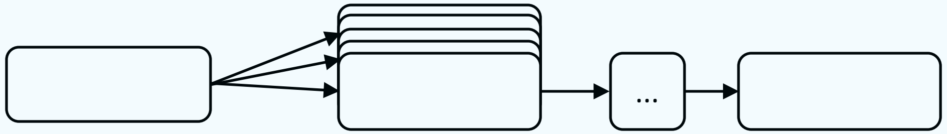
- MSOS Event data products to the public
  - Lightcurves classification+basic information from the pipeline
  - MCMC chains

- MSOS Event pipeline release
  - Fully open source at the mission launch
  - Documentation

MSOS Event pipeline: automation

Orchestrator

Apache Airflow



Cluster

kubernetes

Amazon EKS

Amazon EC2

Storage

AWS S3

AWS Aurora

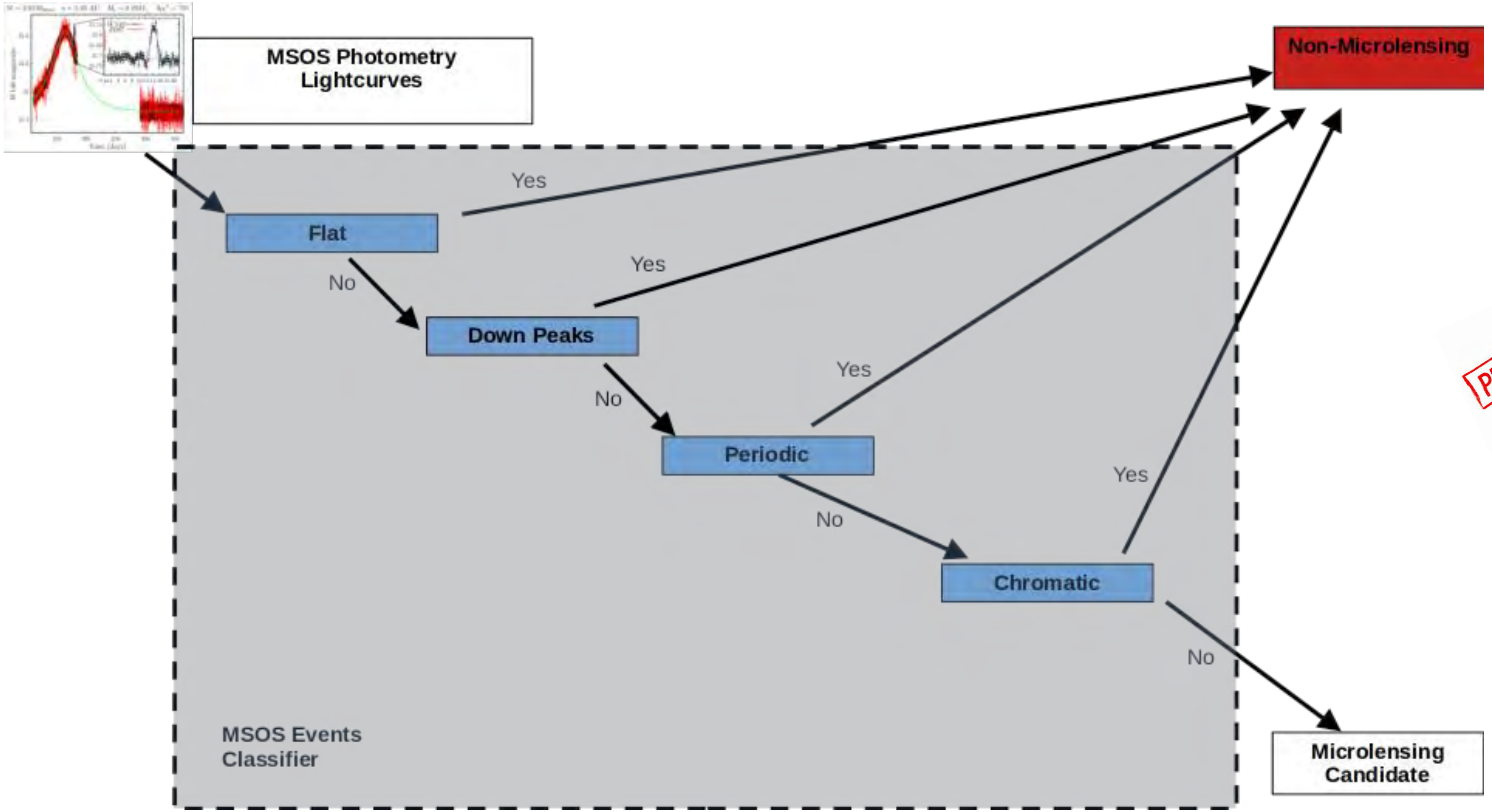
PostgreSQL

- Deploy on NASA-AWS cloud
- Apache Airflow automates the flow of the pipeline sending task to the cluster.
- Kubernetes cluster will scale to fit large batches of light curves in parallel.
- Data products send to ROMAN SOC (STSCI)

MSOS Event pipeline: classifier

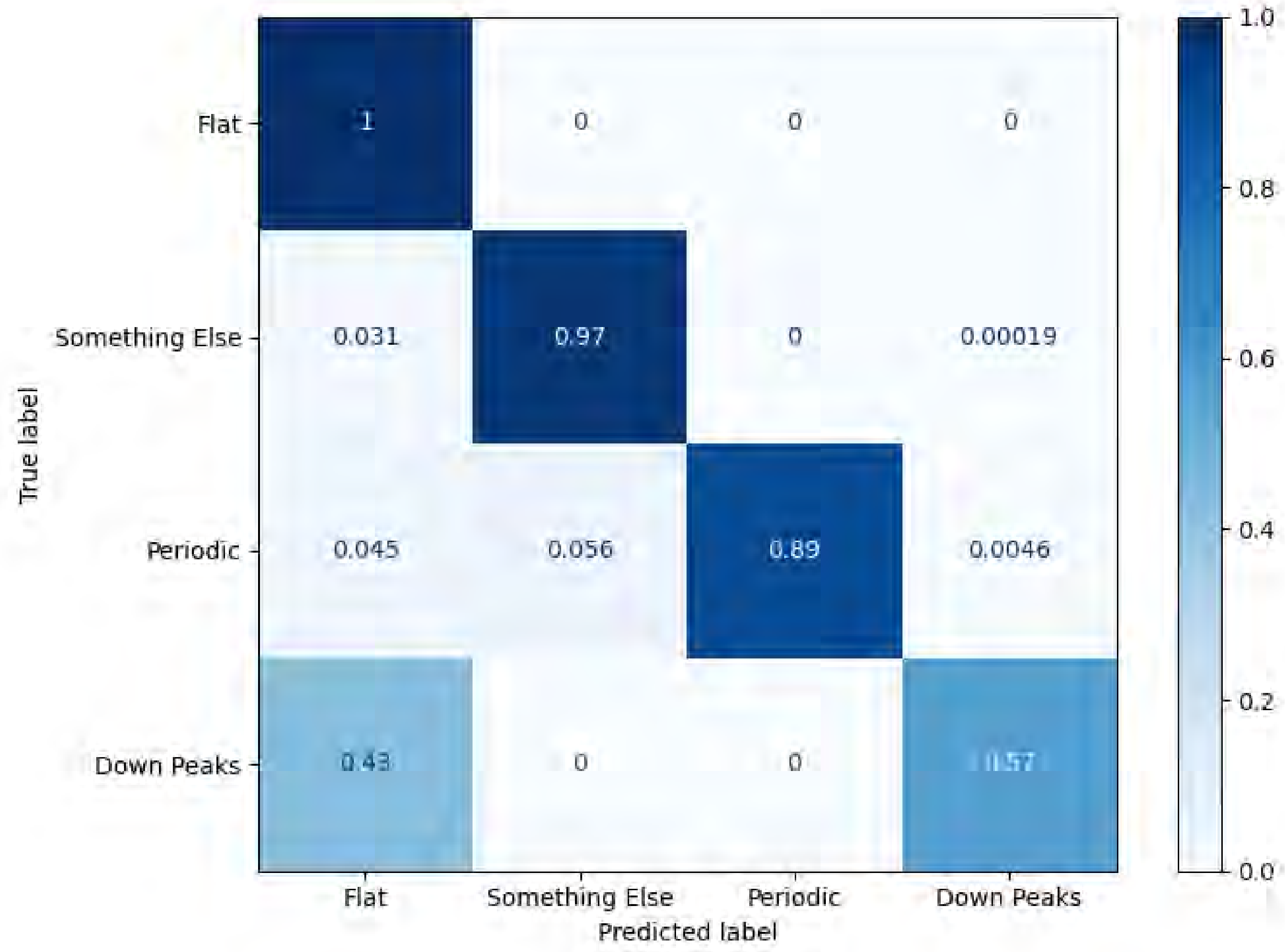
- MSOS Event Classifier early design
  1 Identify "flat" lightcurves
  2 Identify periodic signals (via Lomb-Scargle)
  3 Identify chromatic signal
  4 Everything else is considered as a microlensing candidate

MSOS Event pipeline: classifier



PRELIMINARY

MSOS Event pipeline: classifier



Early tests on the cloud :
2 s per lightcurve

MSOS Event pipeline: modeling

- MSOS Event Modeling early design

  1 PSPL using gradient like method

  2 PSPL+parallax using gradient like method

  3 FSPL using gradient like method

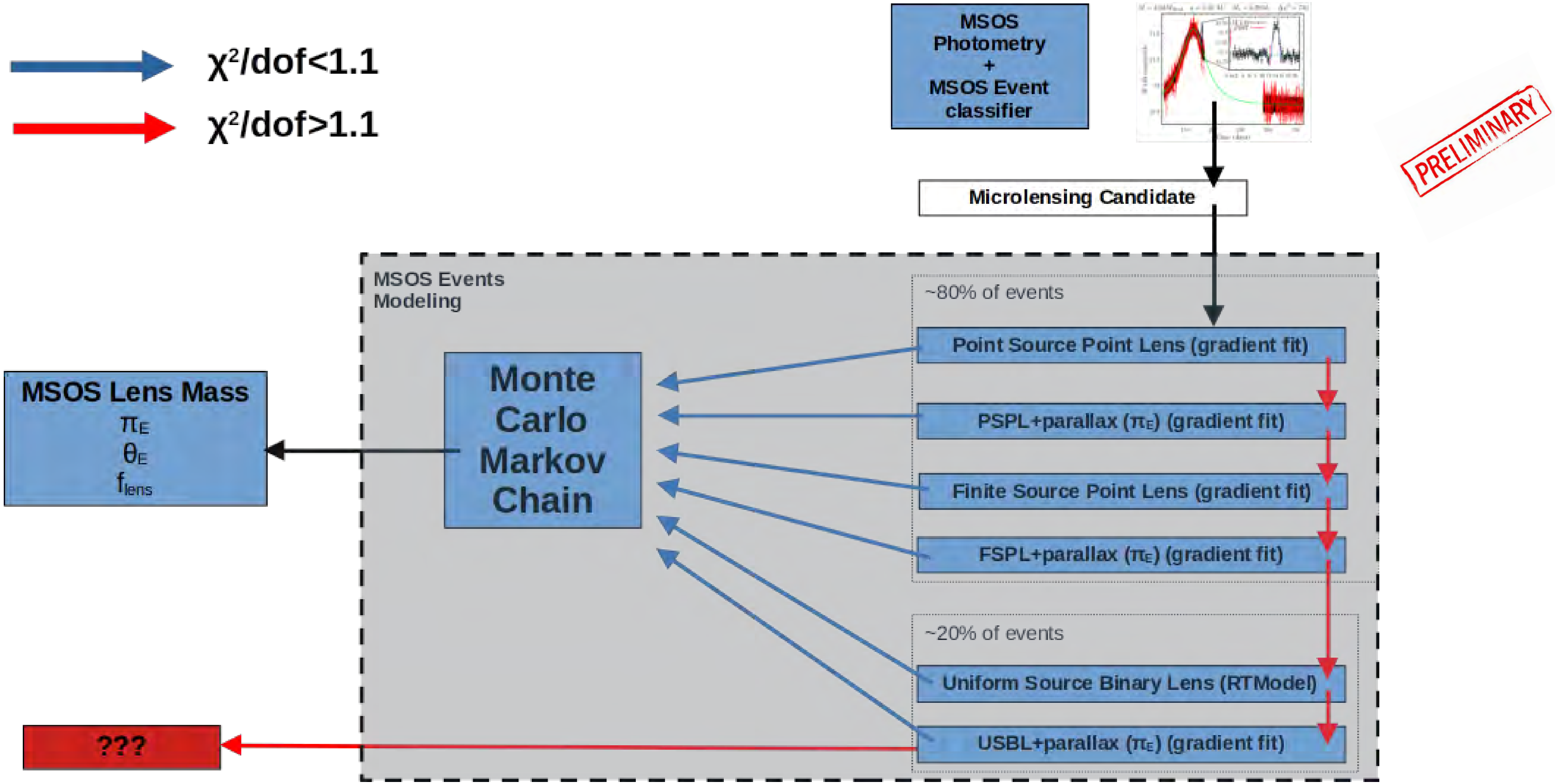
  4 FSPL+parallax using gradient like method

  5 USBL with RTModel algorithm

  6 USBL+parallax with gradient like method

  7 Explore posterior with MCMC around the best model (if any)

MSOS Event pipeline: modeling



MSOS Event pipeline: modeling

- Early results on the cloud

  - Single Lens

    Gradient fit: 45 s

    MCMC : 350 s

  - Binary
    - RTModel: 6h
    - MCMC : 2.5h

MSOS Event pipeline: mass estimation

- MSOS Event Mass estimation early design: multiple tools
  - Parallax vector (π_{EN} ,π_{EE})
  - Normalized source radius rho
  - Lens flux and lens/source separation
  - Galactic Models priors

MSOS Event pipeline: status

Module	Status	Calendar
Classifier	Implemented (but chromatic classifier to do)	
PSPL/FSPL	Implemented	
USBL (RTModel)	Implemented.	
MCMC (all models)	Implemented.	
Mass Estimation	To Do (some prototype).	2024/2025
Lens Flux (with MSOS photometry)	Under construction/testing	2024/2025

- Realistic tests first semester 2024 (ends of build 2.3)
  - ~20000 (simulated) lightcurves
  - ~1500 microlensing events including parallax
    - 1000 planets (from Penny et al. 19 catalog)
    - 250 binary (with q>0.03)
    - 100 PSPL
    - 150 FSPL (including 50 FFP)

How Roman Observations Will Confront Theory

July 9 - 12, 2024 • Caltech campus and online

The Nancy Grace Roman Space Telescope is a NASA observatory designed to settle essential questions in the areas of dark energy, exoplanets, and infrared astrophysics. The telescope has a 2.4-m primary mirror, the same size as the primary of the Hubble Space Telescope (HST). The Roman Space Telescope will have two instruments, the Wide Field Instrument, with a field of view that is 100 times greater than the HST WFC3/IR, and the Coronagraph Instrument technology demonstration, which will perform high contrast imaging and spectroscopy of individual nearby exoplanets. Roman will have a primary mission lifetime of 5 years, with a potential 5 year extended mission. Preparations are on track to target a launch in October 2026 and no later than May 2027.

The goal of this 4-day conference is to bring together inclusively members of the community to discuss how observations with the Nancy Grace Roman Space Telescope will confront and challenge theories, from exoplanets to the edge of the Universe. The conference will focus mainly on the Core Community Surveys -- the Galactic Bulge Time Domain Survey, High Latitude Wide Area Survey, and High Latitude Time Domain Survey, which will occupy the majority of the primary mission -- as well as the Coronagraph Instrument technology demonstration. However, there are boundless theories that will also be addressed and tested by the wide variety of General Astrophysics Surveys. This conference, to take place on the Caltech campus and online, will be an active and exciting confluence of both observers and theorists to outline the potential breakthroughs that could be made possible during the lifetime of the Roman Space Telescope.

If you have any questions, you can email us at romanssc AT ipac.caltech.edu.

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