SER–SAG
in-kind proposal

Serbian AGN (SER-SAG) Team

LSST AGN Science Collaboration

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SER-SAG Team

- Proposal Lead: Luka Popović (AOB)
- Core Team: Anđelka Kovačević (MatF), Maša Lakičević (AOB), Dragana Ilić (MatF)
- Other members:
  Saša Simić (FSUK), Marko Stalevski (AOB), Oliver Vince (AOB), Edi Bon (AOB), Djordje Savić (AOB), Jelena Kovačević-Dojčinović (AOB), Nataša Bon (AOB), Nemanja Rakić (PhD Student, MatF), Isidora Jankov (PhD student, MatF), Sladjana Mandić-Marčeta (PhD student, AOB), Iva Čvorović Hajdinjak (PhD Student, MatF)

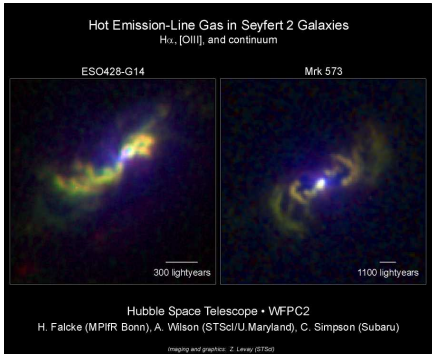
- Currently Serbian science facing huge challenges:
  - complete change in financing: institutional + limited projects
  - advices from the region most welcomed

Research: AGN & microlensing

- Long experience of AGN research and microlensing
- Time-domain: special focus on AGN variability
  - Peridicity (oscilation in light curves; time-delays in light curves)
- Monitoring-campaigns (spectroscopy & photometry)

SMBH, EHT Collaboration, 2019

Broad line region, dusty torus



Narrow line region

Vidojevica 1.4m

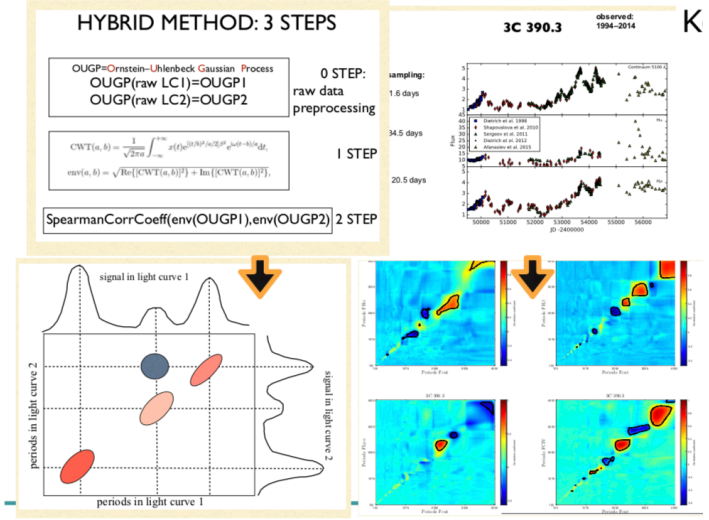
BTA 6m

Rozhen 2m

OAN SPM 2m

GHO 2m

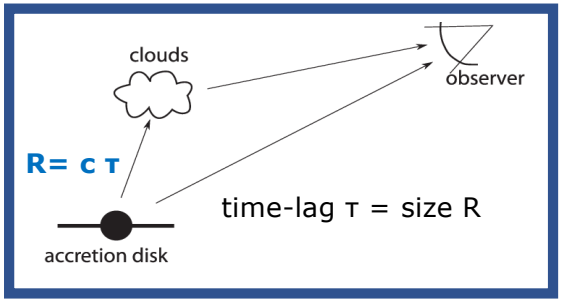
Calar Alto 2m



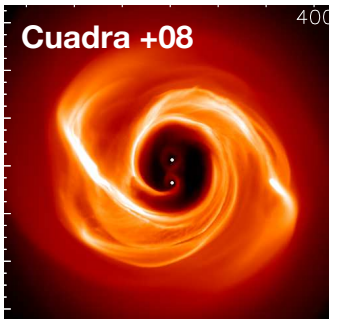
AGN variability hot topics

- AGN core difficult to resolve with current optical telescopes (except w/interferometry, e.g. GRAVITY Sturm+2018, EHT Collaboration, 2019)

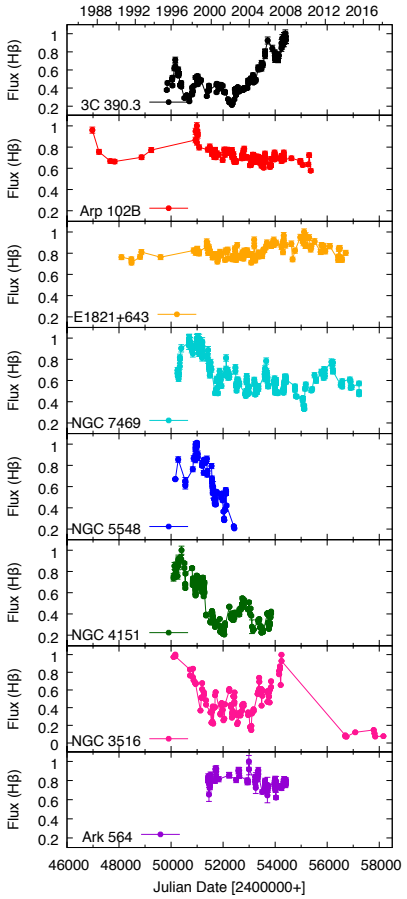
  → we can resolve it in time-domain



- study AGN accretion disk and BLR through **reverberation mapping**:
  → one of the priorities of LSST AGN SC
  (e.g. Brandt et al. 2018)
- detect oscillation in AGN light curves, **searching for periodicities**
  → important for detection of close binary SMBHs, and possible GW sources
  (for a recent review see De Rosa et al. 2020)



AGN long-term (decades) monitoring campaign



our RM campaign features:

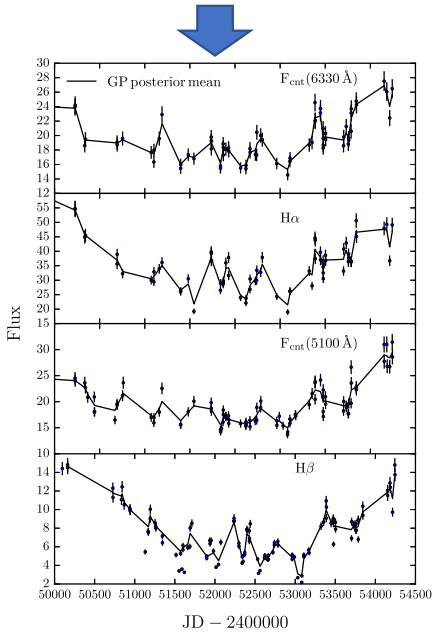
- long (10+ years) uniform dataset
- different sub-types of type 1 AGN of different variability and optical spectra behavior

- spectral campaign → some problems in light curves such as e.g. **gaps, nonuniform cadence**, etc.
- applied machine learning, i.e. Gaussian processes to model light curves → extract time lags

Gaussian PROcesses for TIme-Delays Estimates in AGN
GPro-TIDE

- a complementary tool for time-delays measurements
- utilizes generalized Gaussian processes to model the observed light curves used for extraction of time-delays (e.g. Kovačević et al. 2015, 2018)

GP modeled light curves of a changing look AGN: NGC 3516



e.g. Shapovalova et al. 2016, 2017, 2019
Ilic et al. 2020

In-kind contributions of SER-SAG

- Software for analysis of variability of celestial sources
  - Feedback: medium
  - Non-directable software contribution
- Optical follow-up of bright LSST transients
  - Feedback: medium
  - Join via AEON
- Access to data on long-term variability of AGN
  - Feedback: low
  - Discouraged from including

In-kind telescope time

- Astronomical Station Vidojevica, Southern Serbia
  - Average seeing ~1.5”
- 1.4m telescope
- possibility of fast response (telescope moving speed is 4-6 degree/sec)
- Photometer:
  - Andor iKon-L, pixel scale 0.244 arcsec/pixel, Field of view 8.3x8.3 arcmin
  - Filters: BVRI broad bands (+L very broad filter) + Halpha, SII, red continuum narrow bands
- 6-year long experience in the Gaia-FUN-TO
- In process of joining AEON

Andjelka Kovačević

Rubin Observatory

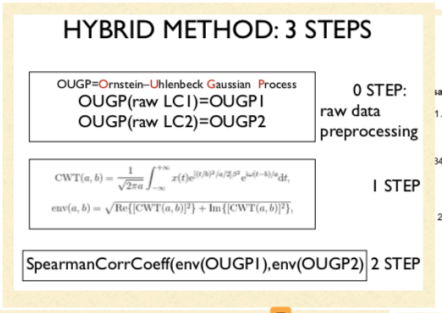
METHODOLOGICAL STRATEGY TO CATCH VARIABLE SIGNAL IN LSST LIGHT CURVES

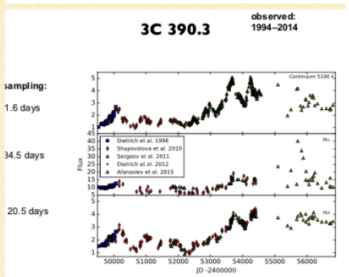
the observng strategy will affect LSST efficiency to detect CB-SMBBH candidates:
-the "rolling cadence" will prohibit LSST to build the long base-lines that are necessary for the search of CB-SMBBH
-a nominal cadence of 3 days will produce, due to the filters successively alternation, the light curves in each band with just a dozen points every year

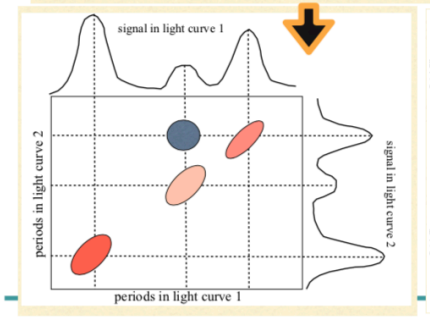
MUST INCLUDE NOVEL MACHINE LEARNING BASED PERIODICITY DETECTION METHODS INTO LSST PERIODICITY SEARCH FLOW:

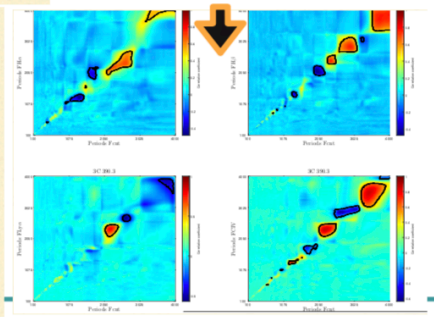
2DHYBRID METHOD BASED ON GAUSSIAN PROCESS MODELING

Successfull on decadal AGN LC with cadences of > 80days!



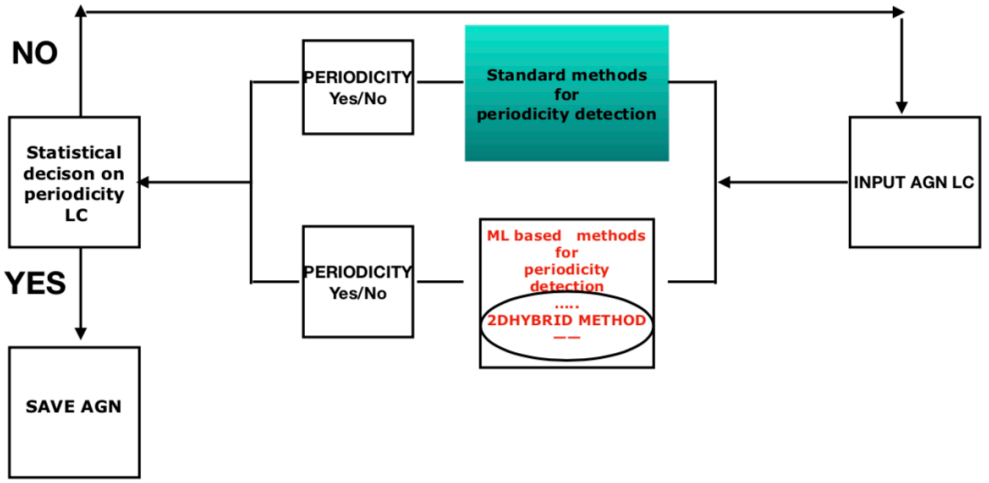






Kovačević et al. 18,19,20 Gaussian processes: Kovačević et al. 17

2DHYBRID METHOD IN POSSIBLE LSST PERIODICTiY SEARCH FLOW



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#rubin 2020