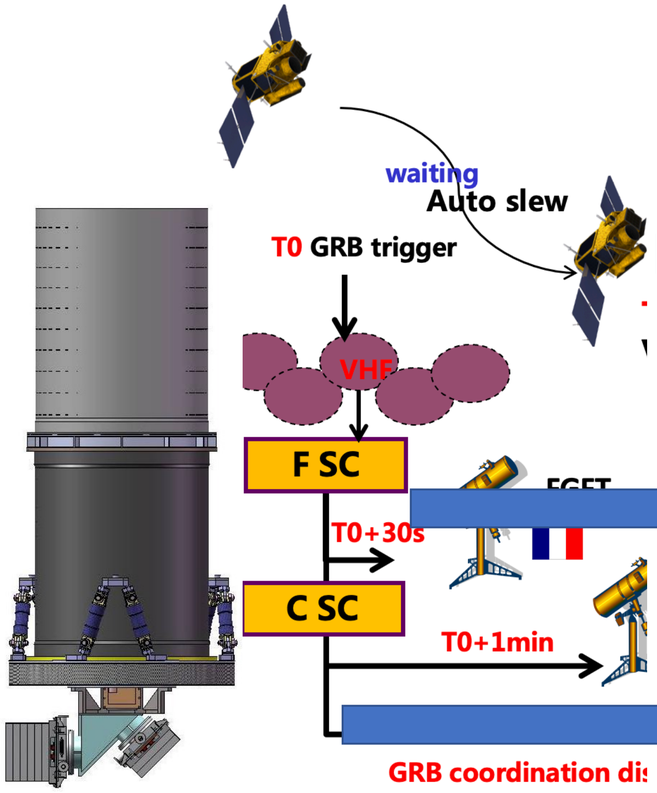
How to identify an optical counterpart of GRBs with SVOM data

VT and CGFT team

VT and CGFT

VT (first obs in typically 5 min after the burst)



VOPP (VT Onbarod Processing Pipeline)

CCD calibration,
image stack,
source exactor,
1 bit finding chart

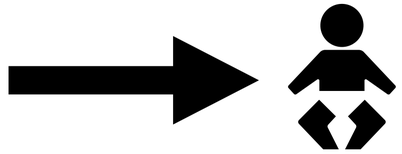
- Four sequences to be processed within the first two orbits
- Sources list are downlinked firstly
- 1 bit images with lower priority

VVPP (VT VHF data Processing Pipeline)

(a) Astrometry calibration, photometry calibration, 1 bit images

VTAC (VT Afterglow Candidate)

(a) Candidates with position, light curve, and others

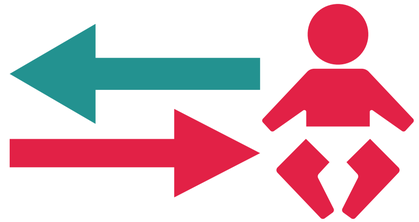


- Identify the candidates promptly
- To send the GCN
- To coordinate the follow-ups

VXPP(VT X-band data Processing Pipeline)

Precise photometry

Research for the counterpart for CP and ToO-MM



CGFT

Three channels
(g, r, i)

Photometries in one minutes if the burst is visible for CGFT

Real-time data processing

GRB search based on the trigger

Generate standard SVOM products
- Candidate list
- Light curve for each
- Finding chart for each
- Big image covering the whole error box of MXT with the sources marked

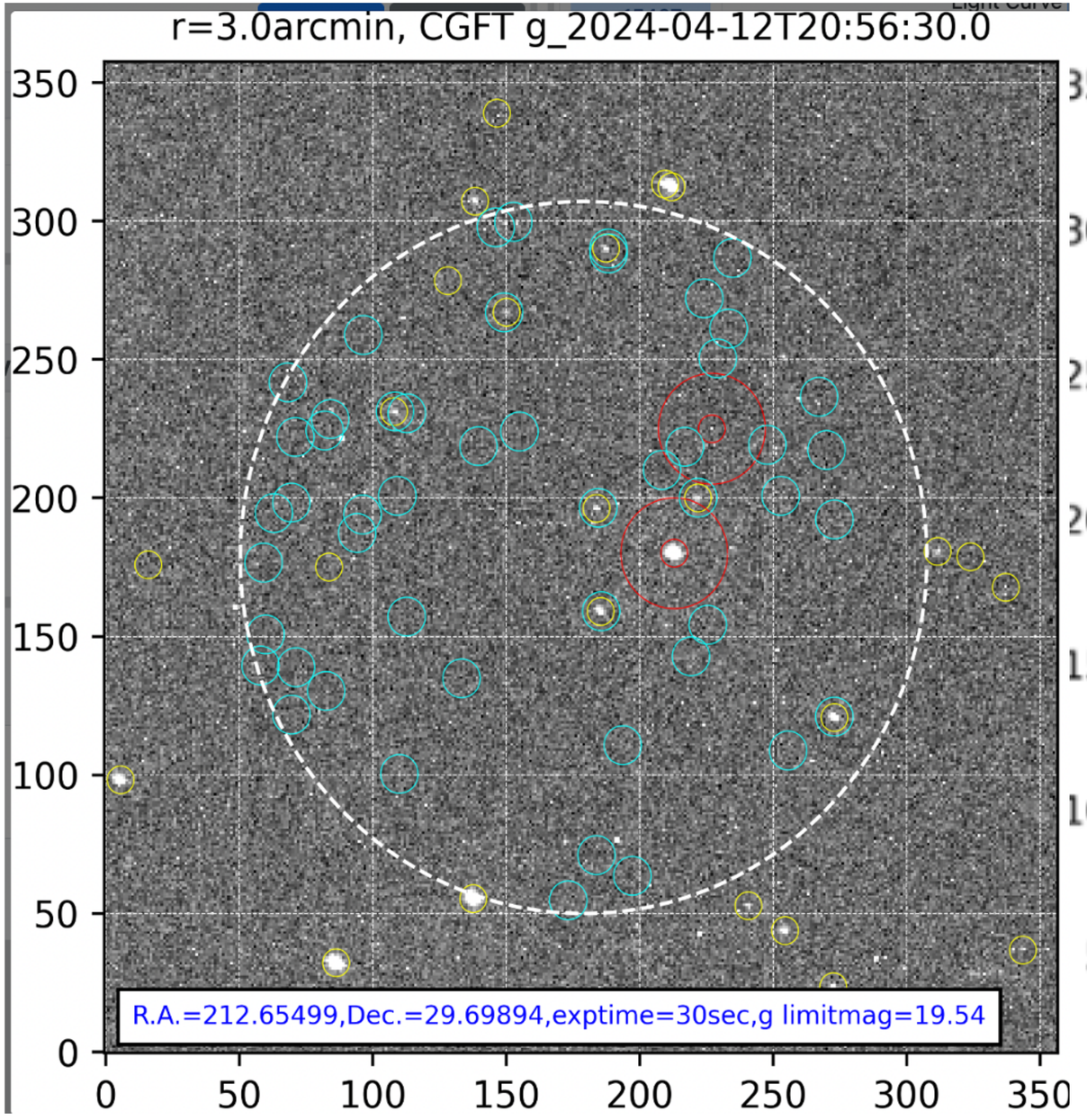
- Identify the candidates promptly
- To send the GCN
- To coordinate the follow-ups

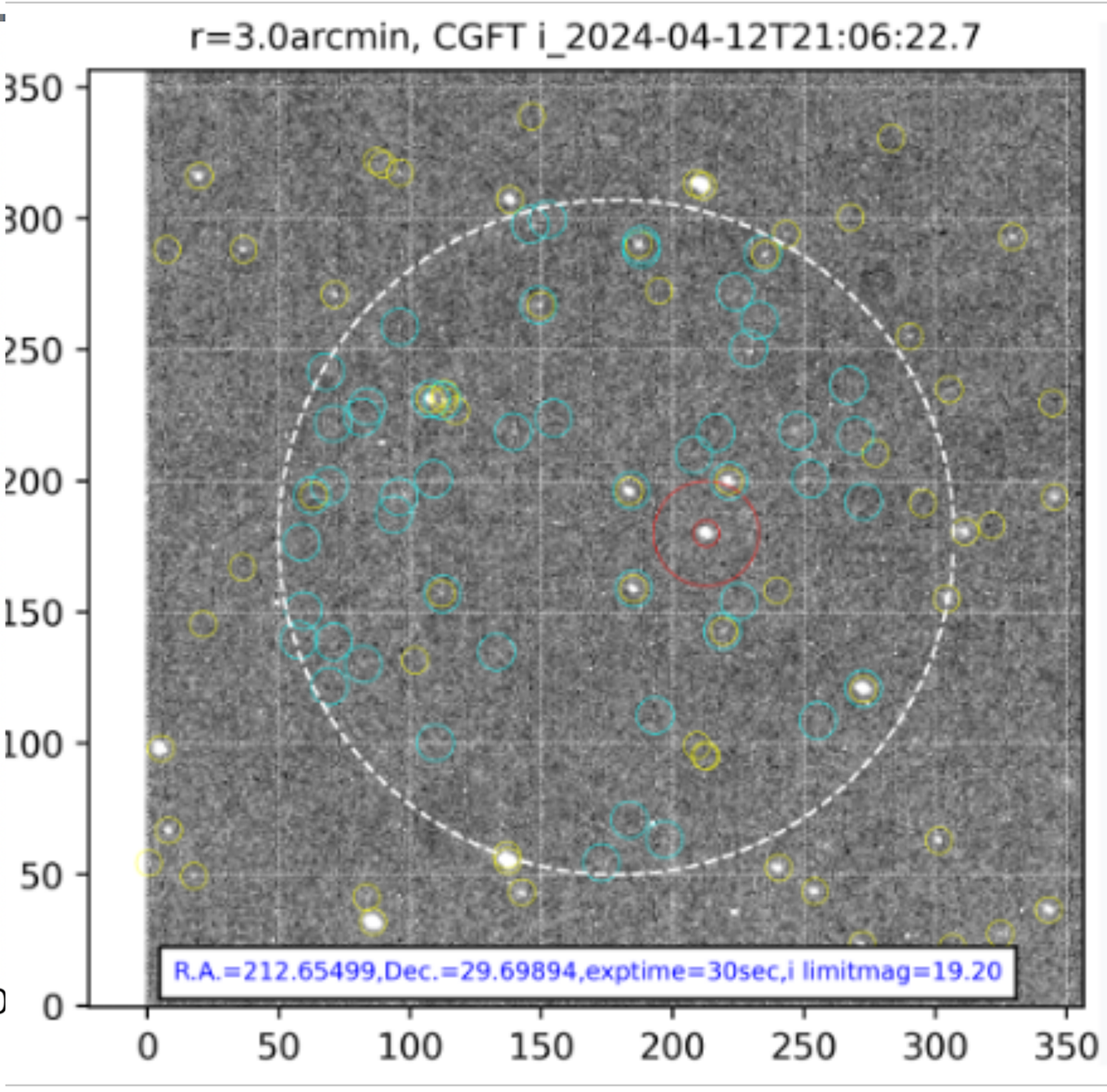
Burst localizations

- The complex of the identification is highly sensitive to the localization of the burst

- SVOM burst
  - Eclair: ~7-13 arcmin
  - GRM: Several degrees
  - MXT: < 2 arcmin for GRB afterglows (~80% bursts)

- Making the challenge to identify the optical counterpart


r=3.0arcmin, CGFT g_2024-04-12T20:56:30.0
R.A.=212.65499,Dec.=29.69894,exptime=30sec,g limitmag=19.54
0
50
100
150
200
250
300
350


r=3.0arcmin, CGFT i_2024-04-12T21:06:22.7
R.A.=212.65499,Dec.=29.69894,exptime=30sec,i limitmag=19.20
0
50
100
150
200
250
300
350

Types of fake candidates

- Hot pixel or cluster of hot pixels
- Slow moving artificial objects
- Minor planets or comets with bad localization
- Variables
- Cosmic rays
- Mis-match with catalogs
- Low S/N sources caused by the fluctuation of the sky backgound.
- Ghosts by the bright objects in our near the FoV
- Fake sources caused by the bright sources due to blooming
- ....

What is a good candidate for a GRB

in the idea scenario

- Position:
  - In or near the error box of high-E counterpart, if the astrometry calibration is good.
  - New source comparing any archived images, if the spatial resolution is good enough.
  - Variable with a large brightness change in short-term is also needed to be considered, if spatial resolution is not good enough.
- Profile
  - Stellar profile, rule out of cosmic ray, moving objects, or host
- Brightness
  - changing like a typical GRB afterglow
    - Fading in a long-term period
    - Complex at early phase (Several components).
- Spectral characteristics
  - Color by multi wavelength photometry
  - Spectrum
  - Note: Color is easily affected by the extinction and the redshift

Identification of optical counteract is a tough job

- BA has to correctly identify the real afterglow among these fake sources.
- There might be no real counterpart which shall be kept in mind all the time.
  - Optically faint brightness of a given GRB
  - Detection ability of a given telescope
  - Redshift makes the source to be more dimer in bluer filter
  - Bad data processing
- BA has to finish the identification as soon as possible
  - To distribute the GCN for GRB community to follow-ups
  - To coordinate the follow-ups with SVOM follow-up telescopes
  - The work is always carried out with limited data since the observations and downlink

How to select a good candidate

- For CGFT separately
  - To select the new sources with a stellar profile and with a brightness change, which is within or near the MXT localization.
  - BA could check the finding chart of each candidate by eye to confirm the correction of the data processing.
- For VT separately
  - Bvt and Rvt obs simultaneously. Candidates list is received firstly. 1 bit images for each sequence are downlinked later
    - New sources > variables
    - Bright > faint
    - Red color > blue color (\nv^-beta, beta~0.8)
  - Be careful for those only detected in Rvt band but no in Bvt band, which is a high-z or high-extinced GRB candidates.

How to increase the confident—-Joint-analysis

- If a new source is detected by both CGFT and VT, it would be a GRB candidate with a very confident of level
- To recognize the same object detected by different telescopes
  - Localization shall be no the fully same
  - crossmatching the positions after taking in to account of precise.

To do that:

OT1	New sources or variables by comparing the catalogs	Pipeline
OT2	Select any sources at any time when the objects are likely GRB candidates	BA
OT3	group the OT2 list with a best coordinate for the same source selected from different filters or telescopes.	BA
OT4	A good GRB counterpart/candidate	BA