ANDES-FIRE

The Argentina All-sky Video System

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Argentina on-site support: Jose Luis Hormaechea, Fernando Gini

***ANDES-FIRE** = **A**ll-sky **N**etwork and **DE**tection **S**oftware for **FIRE**balls*

Purpose & Phased Development since March 2018

Purpose:

– NASA/GSFC acquired 4 Fripon all-sky cameras for deployment around SAAMER in Argentina to obtain simultaneous radar/EO fireballs

Issue:

– Fripon's Freeture software was non-functional on deployed systems

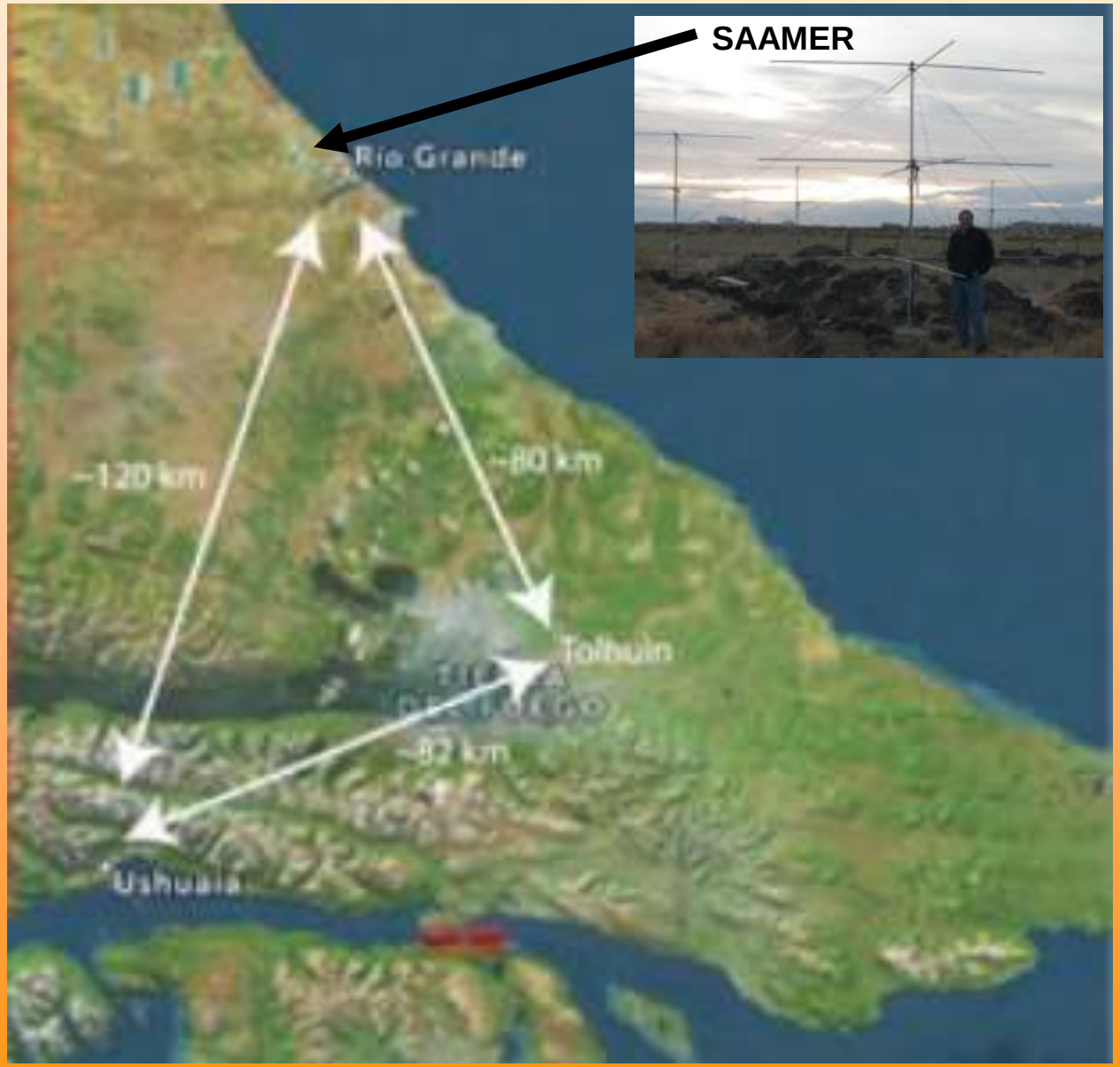
Mitigation:

– Develop a processing pipeline based on CAMS

- Phase 1 = Interface GigE via PYLON 5 SDK to a Windows capture app
- Phase 2 = Integrate CAMS capture and detection modules
- Phase 3 = Develop all-sky astrometry fitting capability
- Phase 4 = Support Argentina software deployment, setup, monitoring

– ***Supported by the NASA Solar System Observations (SSO) Program***

Argentina Radar / EO Deployment



FRIPON Cameras

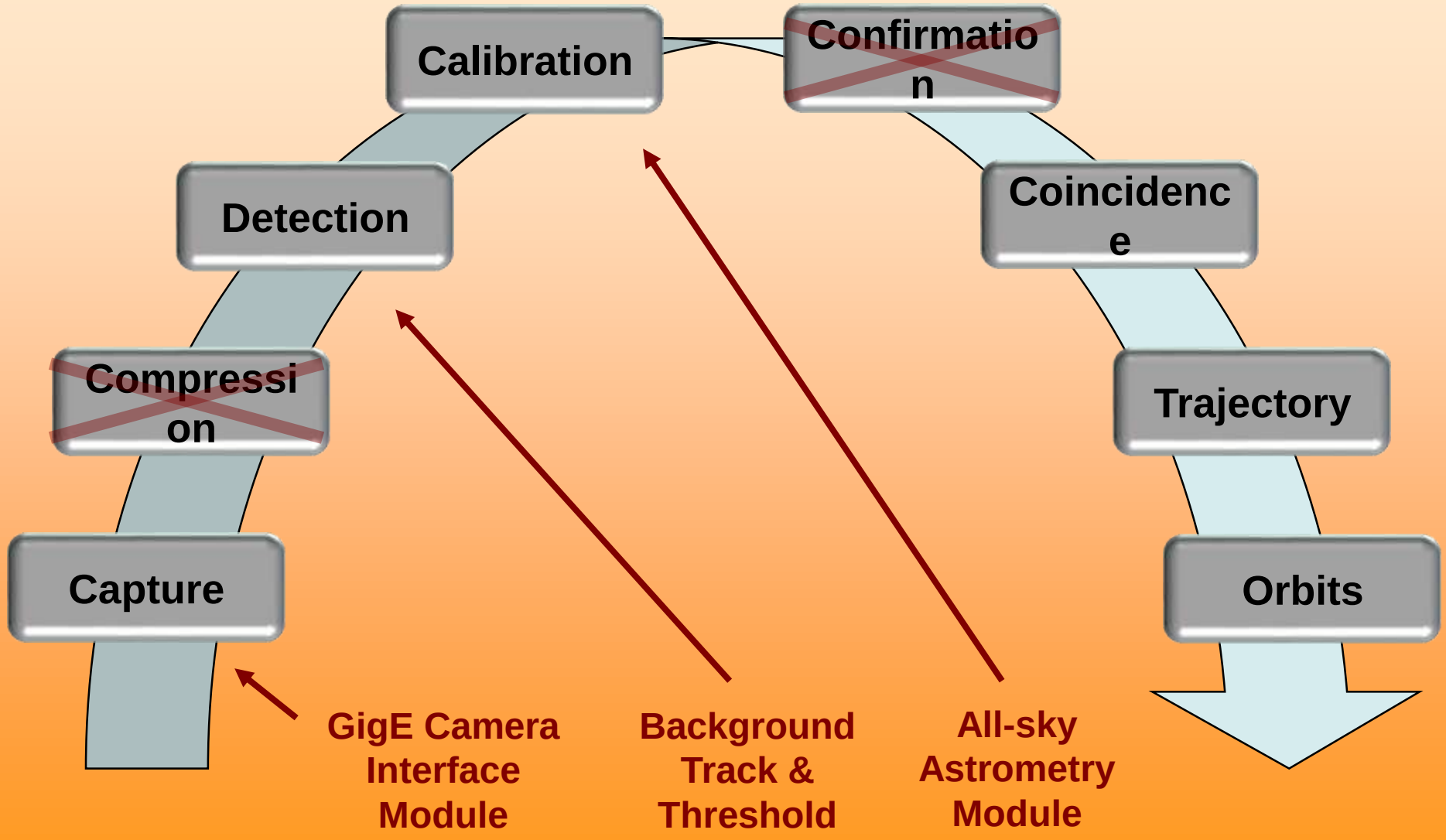
Sensor: Basler GigE acA1300-30gm, 12 bits, 1296 x 966

Optics: Rainbow 1.25mm f/2 → 10 to 13 arcmin/pixel

Sterling, Virginia USA
Development test site

← Ushuaia and Rio Grande →
Tierra del Fuego, Argentina

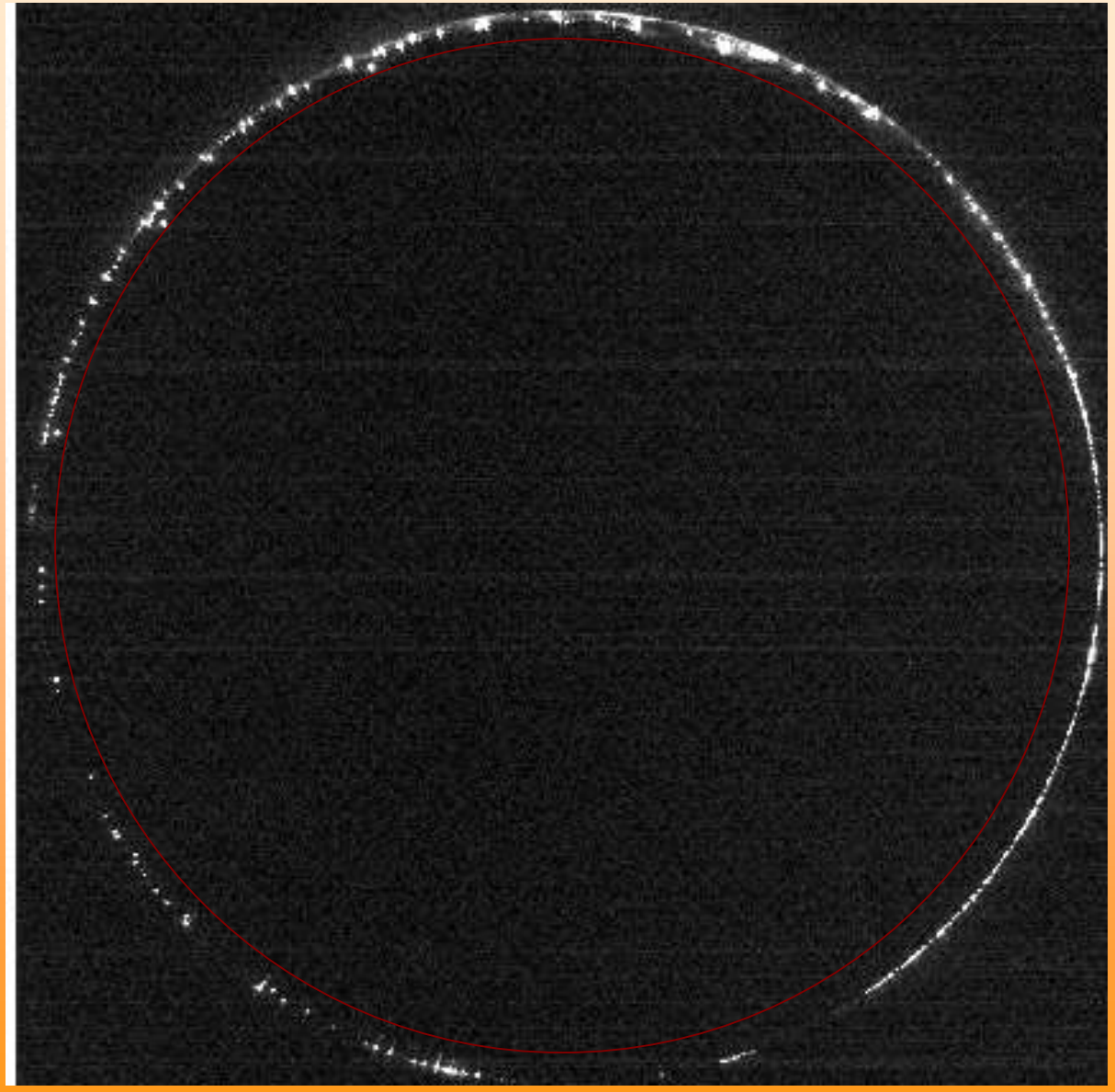
How Does ANDES-FIRE Fit into the CAMS Work Flow ?



Phase 1: Basler PYLON 5.0 SDK

- **Setup and live imaging with Pylon Configurator, Viewer**
  - *Compatible with GigE compliant sensors*
- **Quickly built settings control & capture interface module**
  - *Can adjust gain, fps, exposure, AOI, 8 or 12 bit depth*
  - *Operate and switch between **day**, **night**, & **astrometry** collect modes*
- **Issue with network card optimization**
  - *Required "jumbo" frames and inter-packet delay optimization*
  - *CAT 6 cabling and potential long distance limitations*
  - *Need C callable function to optimize packet size*

First Light in Rio Grande

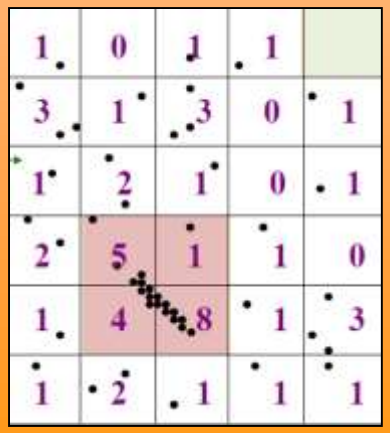


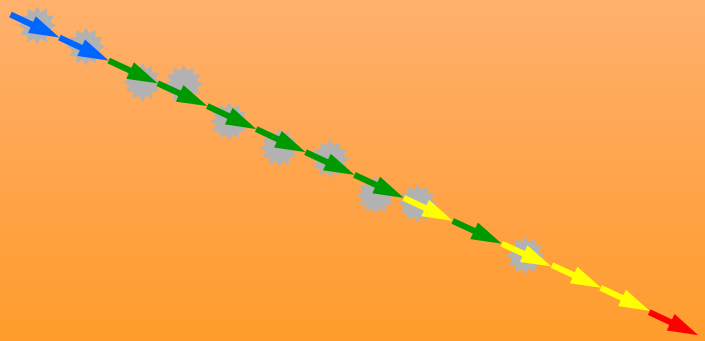
33 msec
Exposure

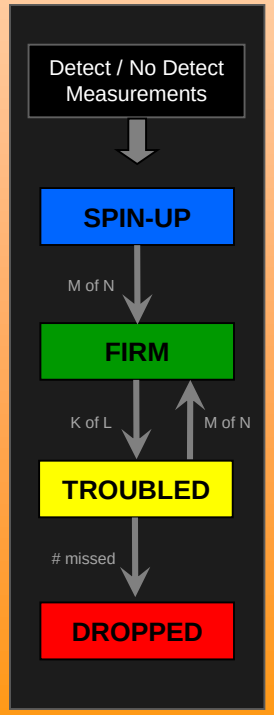
Red circle
defines mask

Phase 2: Capture and Detection Software

- **Live video feed confirmed with no dropped frames**
- **Developed clutter (background) tracking filter**
  - *Mean and σ estimation based on 8 frames earlier in time*
  - *Threshold binary map of exceedance pixels → cluster module*
- **Integrated CAMS cluster and tracking modules**
  - *Tested detection on laser sweep across ceiling*
  - *Output to CAMS "Detectinfo" file format*



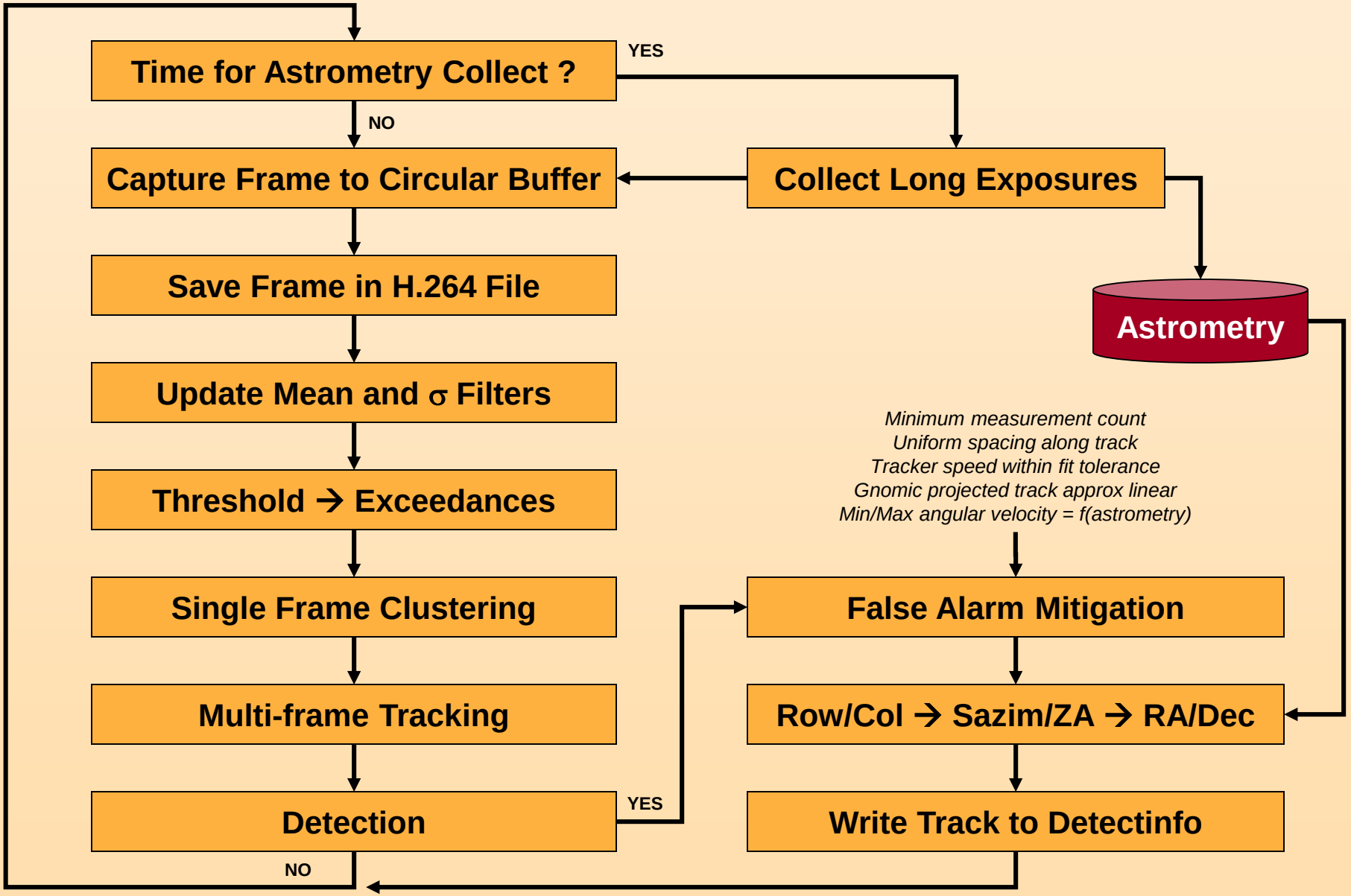




Archiving the Full Collection

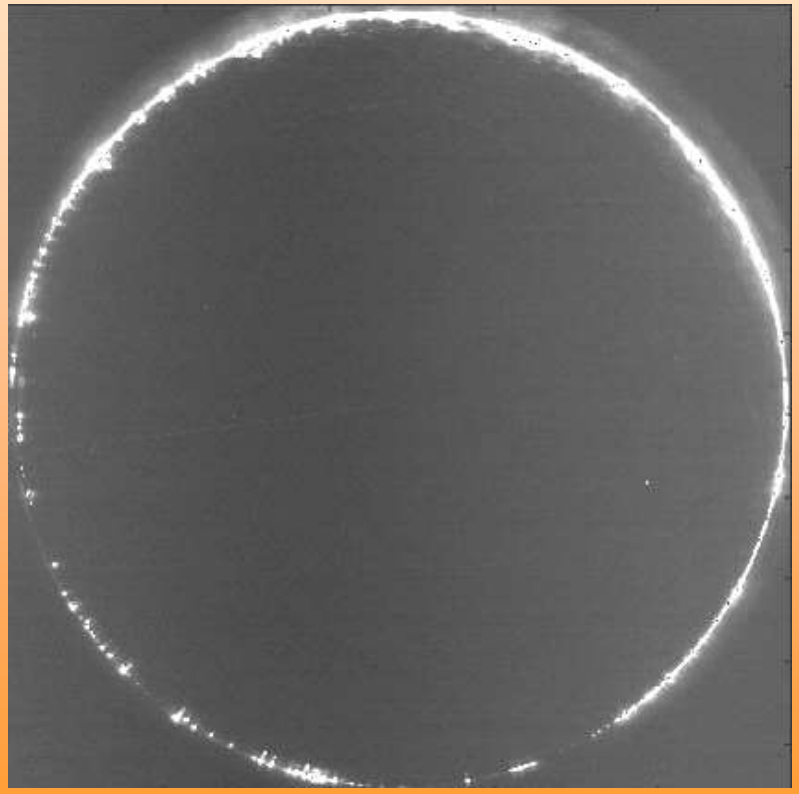
- **Issue: What if one or two cameras missed the fireball ?**
  - *Needed a means to go back and review the collection*
  - *Storing raw imagery would require 4.6 Tbytes / day / camera*
  - *Fripon plans to trigger neighboring cameras in real-time*
- **Current solution: Save 10 second H.264 video segments**
  - *Uses FFMPEG to place into a MP4 file container*
  - *Playable format on almost any PC*
  - *H.264 does not handle 12 bit grayscale, so truncate to 8 bit*
    - *8 bit gray → YUV420p → H.264*
  - *24 hours → 3 Gbytes*
  - *FFMPEG longest pole in the processing tent – Is there an alternative ?*

ANDES-FIRE Image Processing Flow



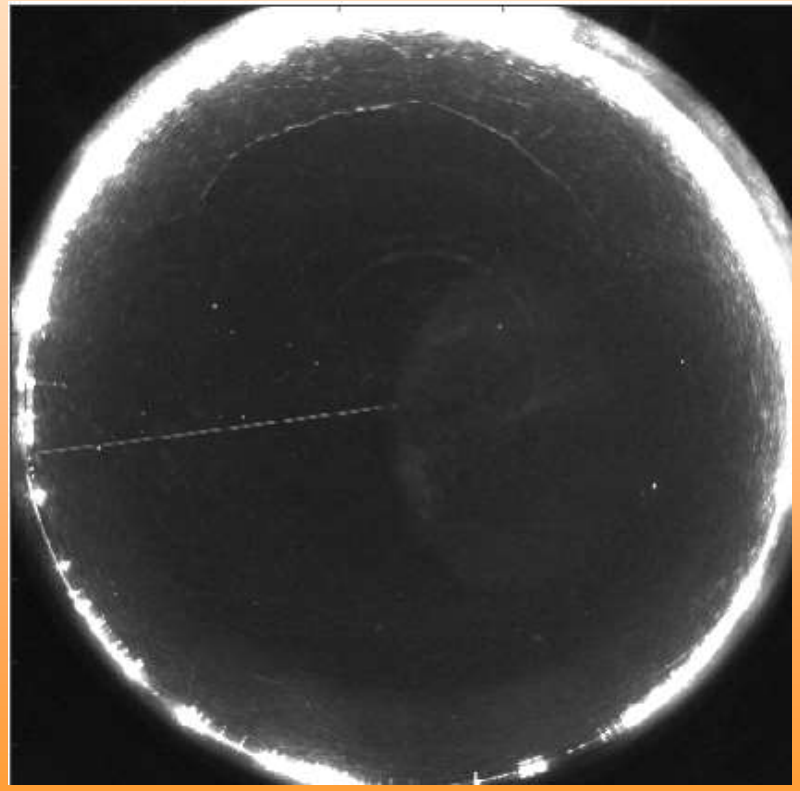
Phase 3: Astrometry and its Collection Challenge

- **Sum 30 fps imagery for N sec. *or* One long exposure ?**
  - *Can we avoid changing collection modes. Answer = NO*



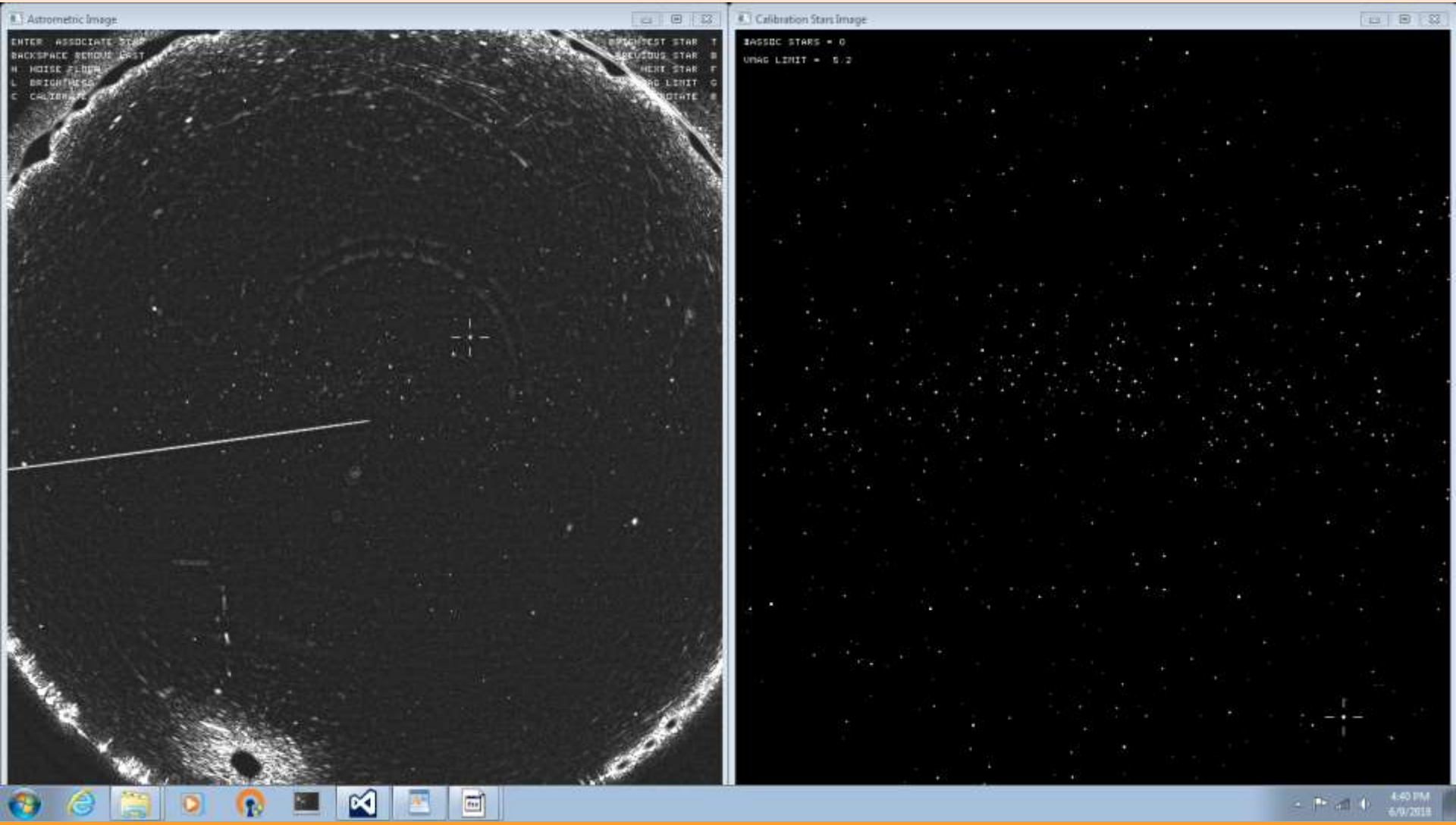
10 seconds = 300 frames @ 33 msec exposure

Read noise dominated



10 seconds = 1 frame @ 10 sec exposure

Manual and Semi-Auto Astrometry Apps



Spatial median filter to remove background

Point-and-click star association

Astrometry Fitting Options

- **Borovicka 1992 and 1995, Bannister 2013, Howell 2018**

The transformation of the plate coordinates x, y to the celestial coordinates a, z is done by means of five equations. The equation for r can be rewritten as

$$r = C\left[\sqrt{(x-x_0)^2+(y-y_0)^2} + \right. \quad (9)$$
$$\left. + A(y-y_0)\cos(F-a_0) - A(x-x_0)\sin(F-a_0)\right],$$

where we introduced the global scale factor C (see below). The other four equations are

$$u = Vr + S(e^{Dr}-1) + P(e^{Qr^2}-1) \quad (6)$$

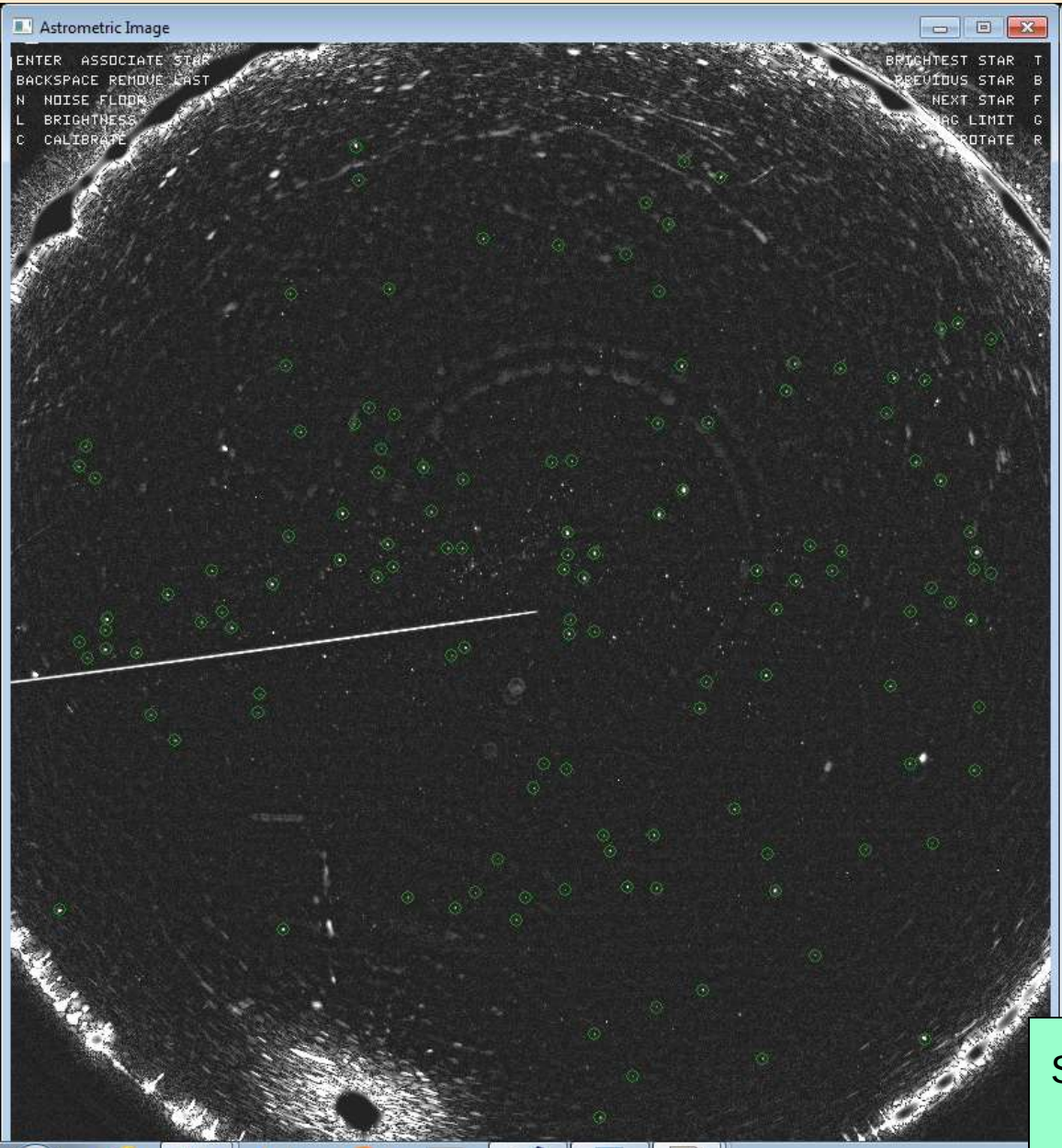
$$b = a_0 - E + \arctan\left(\frac{y-y_0}{x-x_0}\right) \quad (4)$$

$$\cos z = \cos u \cos\varepsilon - \sin u \sin\varepsilon \cos b \quad (1)$$

$$\sin(a-E) = \sin b \sin u / \sin z \quad (2)$$

The equations contain 13 (12 independent) reduction constants which must be determined or assumed for each

Astrometric Solution – Rio Grande



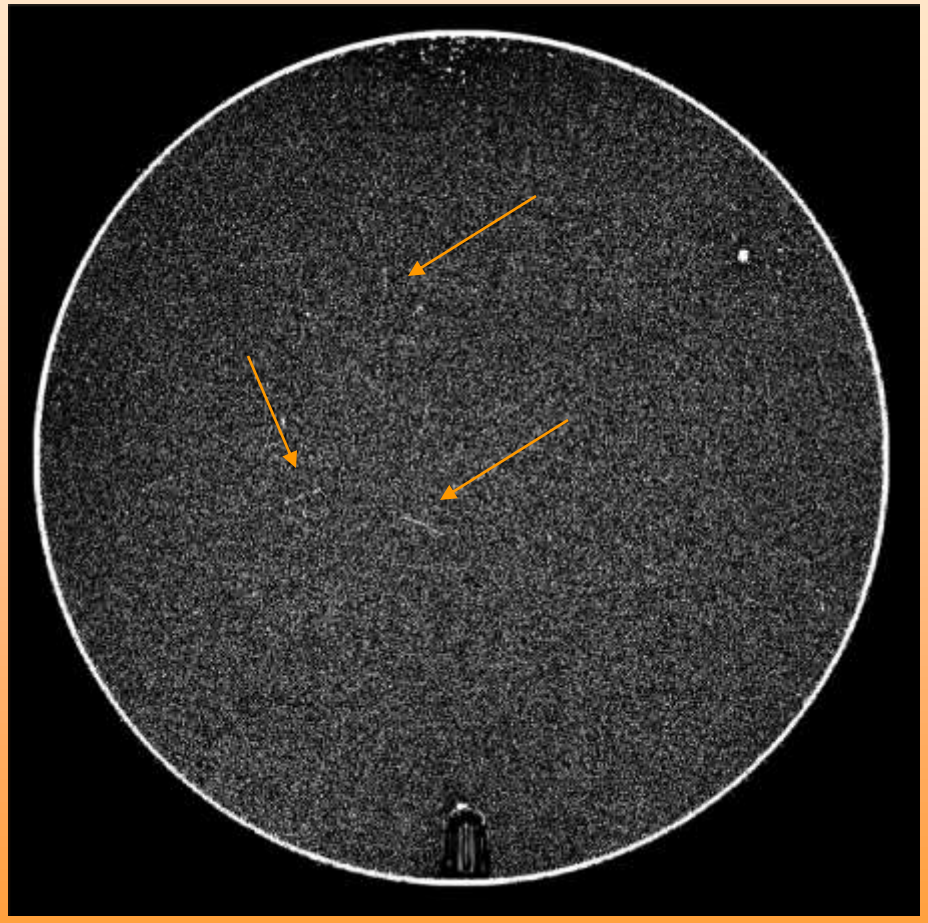
Console Window

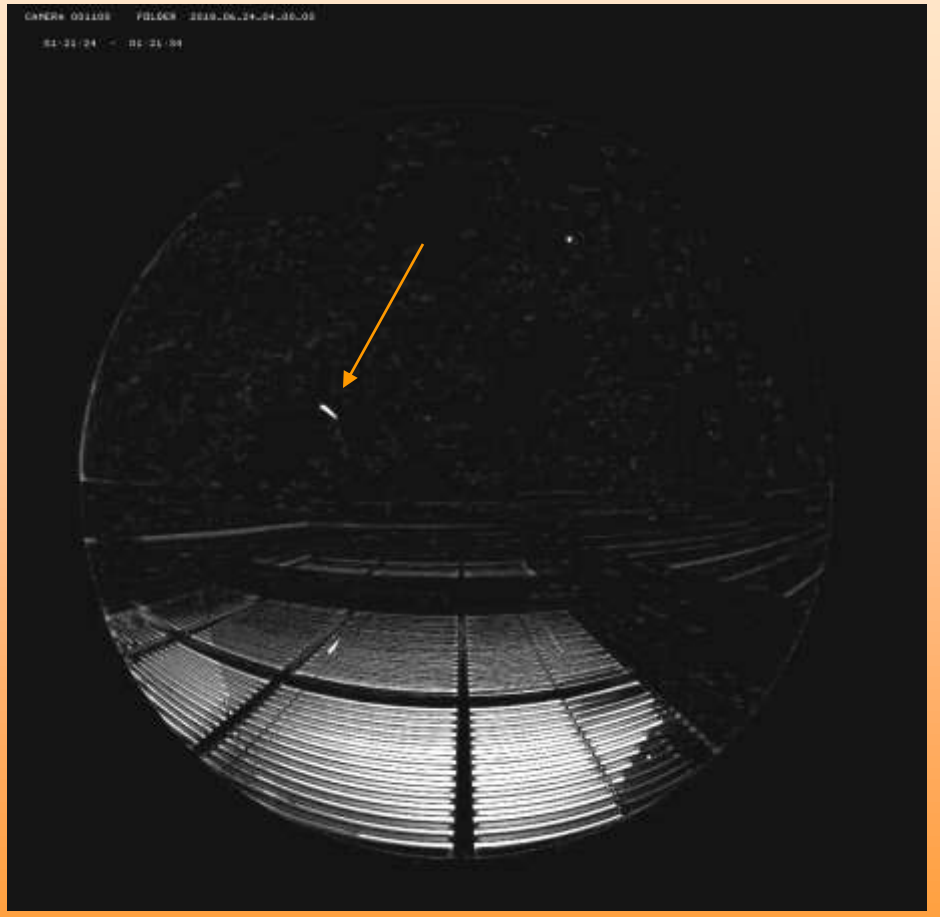
```
To add more stars to the solution      - A
To accept this as the final solution   - Y

 Peforming Fit with 129 stars

ao  = 84.132602
xo  = 476.641564
yo  = 479.069881
e   = 1.351014
E   = 321.051311
V   = 0.002877
S   = 0.000110
D   = 0.014732
P   = 0.047943
Q   = 0.000005
P1  = 0.000000
P3  = 0.000000
al  = 0.000000
di  = 1.000000
A   = -0.000136
F   = 269.182558
C   = 1.000000

RMSerror = 10.444817 arc-minutes

Worse O-C = 106.068597 arc-minutes

To cull the star with the worse O-C    - SPACEBAR
To retry the solution with latest fit  - ZERO
To add more stars to the solution      - A
To accept this as the final solution   - Y

 Peforming Fit with 128 stars

ao  = 84.136158
xo  = 477.343757
yo  = 479.060838
e   = 1.284974
E   = 326.917759
V   = 0.002874
S   = 0.000155
D   = 0.014075
P   = 0.042732
Q   = 0.000005
P1  = 0.000000
P3  = 0.000000
al  = 0.000000
di  = 1.000000
A   = -0.001209
F   = 316.970946
C   = 1.000000

RMSerror = 3.315374 arc-minutes

Worse O-C = 6.757063 arc-minutes

To cull the star with the worse O-C    - SPACEBAR
To retry the solution with latest fit  - ZERO
To add more stars to the solution      - A
To accept this as the final solution   - Y
```

O-C = 2.9’ ± 1.5’

Sufficient #stars using 60 sec exposure.
Shorter → combine multiple frames ?

First Detections: Birds and Meteor





Current Status and Plans

- **Running Rio Grande and Ushuaia daily with latest software release**
  - *i3 processor ~80% loaded at 25 fps (FFMPEG an issue in daylight)*
  - *Tolhuin to be deployed shortly*

- **Next steps**
  - *Optimize detection parameters*
  - *Monitor results daily - weather and detection thumbnails*
  - ***Process a multi-station detection via CAMS Coincidence***
  - *Photometric calibration*

- **Deploy 3 narrow FOV cameras for head echo studies with the radar**
  - *Watec 902H2 Ultimates with 17mm f/0.95 and CAMS capture → orbits software*
  - *First light expected December 2018*
  - ***Supported by the NASA Engineering and Safety Center (NESC)***

Code Module Availability – *See also CAMS Poster*

- **ANDES-FIRE Applications**
  - *ANDESFIRE_LiveViewer (can also use Pylon Viewer)*
  - *ANDESFIRE_Detection*
  - *ANDESFIRE_CalibrationManual (all-sky)*
  - *ANDESFIRE_CalibrationSemiAuto*
  - *ANDESFIRE_Quicklook (TIF thumbnails)*

- **“C” Function Module Files**
  - *Particle Swarm Optimization (non-linear minimizer)*
  - *Frame ingest for capture from Dongles, H.264 files, ZWO, GigE*
  - *Astrometry solvers for moderate, very wide, and all-sky FOVs*
  - *Trajectory and Orbit estimation*
  - *Utilities: Coordinates, Time, VSOP87, System, Image processing, I/O, …*

Any Questions ?

Fripon Tauxigny Astrometric Solution