



The MIDAS Project

Moon Impacts Detection and Analysis System

JOSE M. MADIEDO

University of Huelva, Spain



- ☐ **Description of the project**

The Moon Impacts Detection and Analysis System (MIDAS)

- ☐ **Software tools**

The Impact flash detection and analysis software

Project description

INSTITUTIONS INVOLVED

- ☐ University of Huelva (UHU)
- ☐ Institute of Astrophysics of Andalusia,
Spanish National Research Council (IAA-CSIC)



Universidad
de Huelva



AIM

- ☐ Continue previous work started by Dr. Ortiz et al. (IAA-CSIC) in 1999
- ☐ Systematic monitoring of the night size of the Moon

SCIENCE

Focus on the analysis of parameters of interest for theoretical impact models:

- ☐ Luminous efficiency
- ☐ Crater size and location
- ☐ Impactor mass
- ☐ Impactor flux
- ☐ **Impactor source**

TECHNIQUES

- ☐ Monitoring of the night side of the Moon with small telescopes
- ☐ Input (synergy) from meteor observing stations operated by UHU and IAA-CSIC



Where?

OBSERVATORIES

❑ Sevilla (in operation since 2009)

❑ La Hita (in operation since 2013)

❑ La Sagra (testing phase)

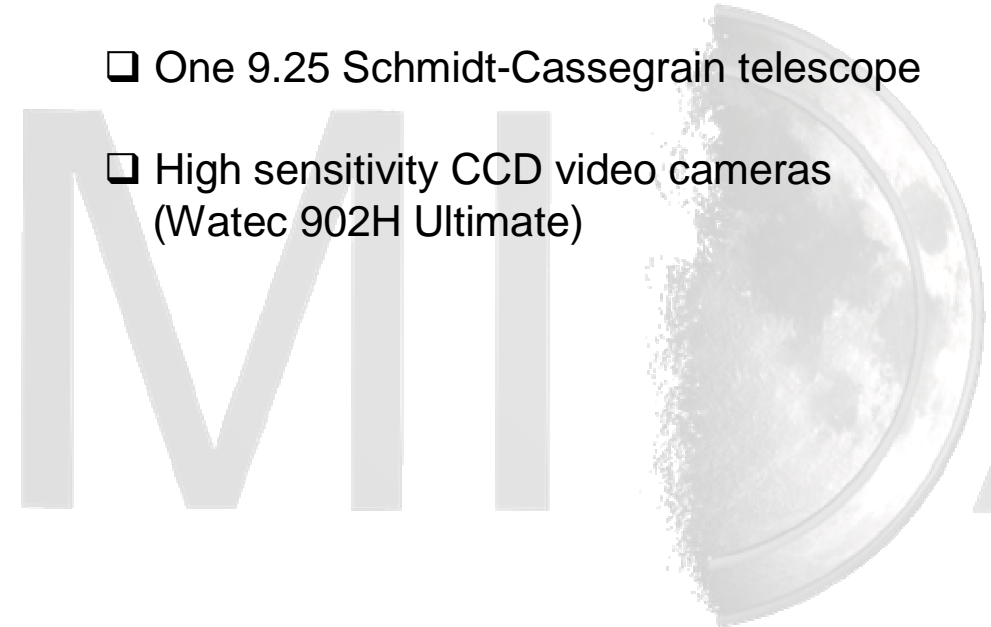
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Main equipment

Sevilla

- ❑ Two 14" Schmidt-Cassegrain telescopes
- ❑ Two 11" Schmidt-Cassegrain telescopes
- ❑ One 9.25 Schmidt-Cassegrain telescope
- ❑ High sensitivity CCD video cameras (Watec 902H Ultimate)



MIDAS-IR (monitoring in the infrared)

- ❑ Two 11" Schmidt-Cassegrain telescopes

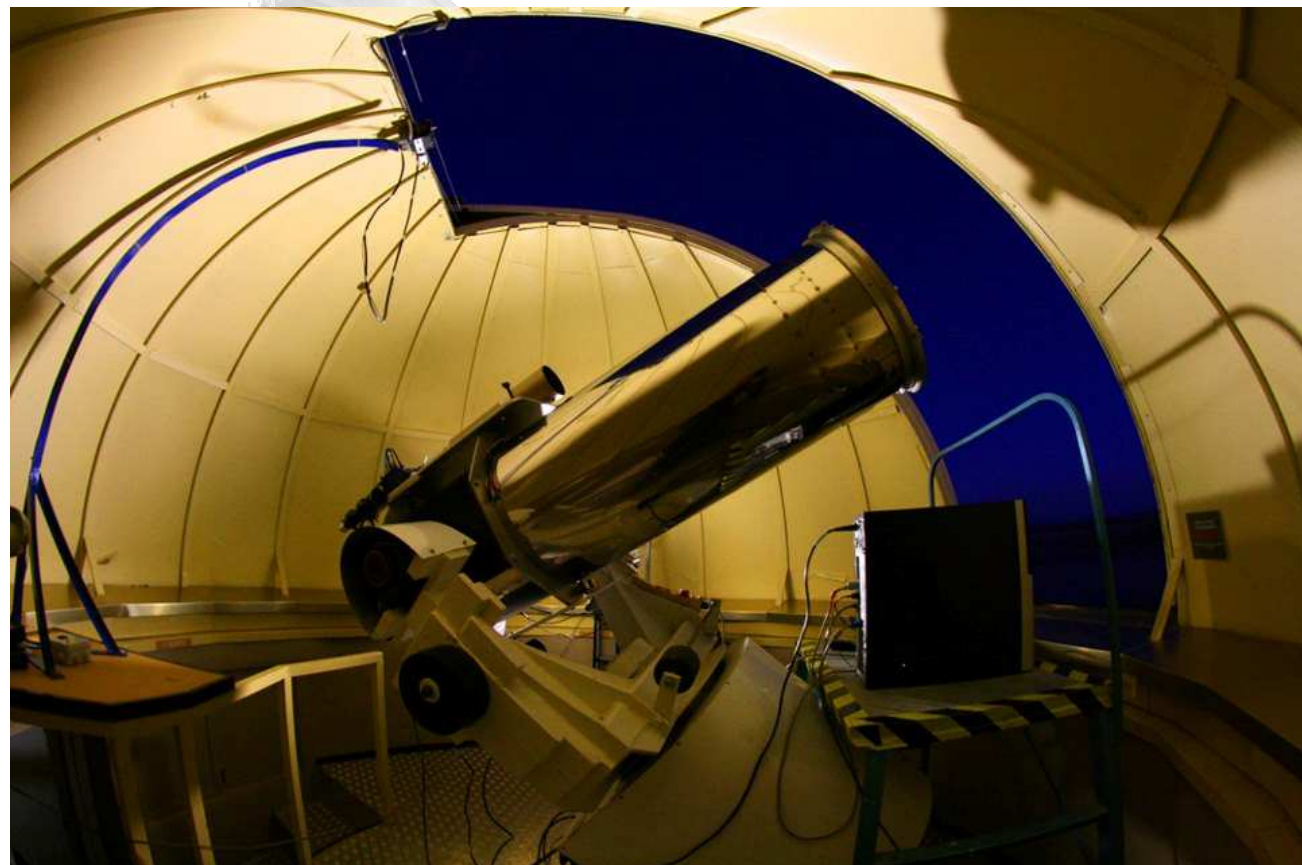


Main equipment

La Hita Astronomical Observatory (remotely operated)

- ❑ One 16" Schmidt-Newtonian telescope
- ❑ High sensitivity video camera (Watec 902H Ultimate)

M



Main equipment

La Sagra (Startup planned for September 2015)

- ☐ Four 14" Schmidt-Cassegrain telescopes
- ☐ High sensitivity CCD video cameras
- ☐ Phase 1: operation "in situ"
- ☐ Phase 2: remote operation
- ☐ **2nd node for MIDAS-IR**



Procedure

- ☐ Monitor the dark side of the Moon with at least two telescopes
- ☐ Limitations:
 - ☐ Illuminated area must be, at most, about 50-60%
 - ☐ Avoid terminator
- ☐ Observing period: about 2 weeks per month
 - ☐ New Moon-First Quarter
 - ☐ Last quarter-New Moon
- ☐ High sensitivity CCD video cameras
- ☐ Focal reducers are employed
- ☐ Earthshine allows identifying features on the lunar surface



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CONTRIBUTION FROM METEOR STATIONS

- ☐ Analyze the behavior of meteoroids in the atmosphere
- ☐ Fact: meteoroid streams impacting Earth also impact the Moon
(both bodies share a common meteoroid environment)
- ☐ Important to determine the source of meteoroids impacting the Moon
- ☐ Synergy with lunar impact monitoring



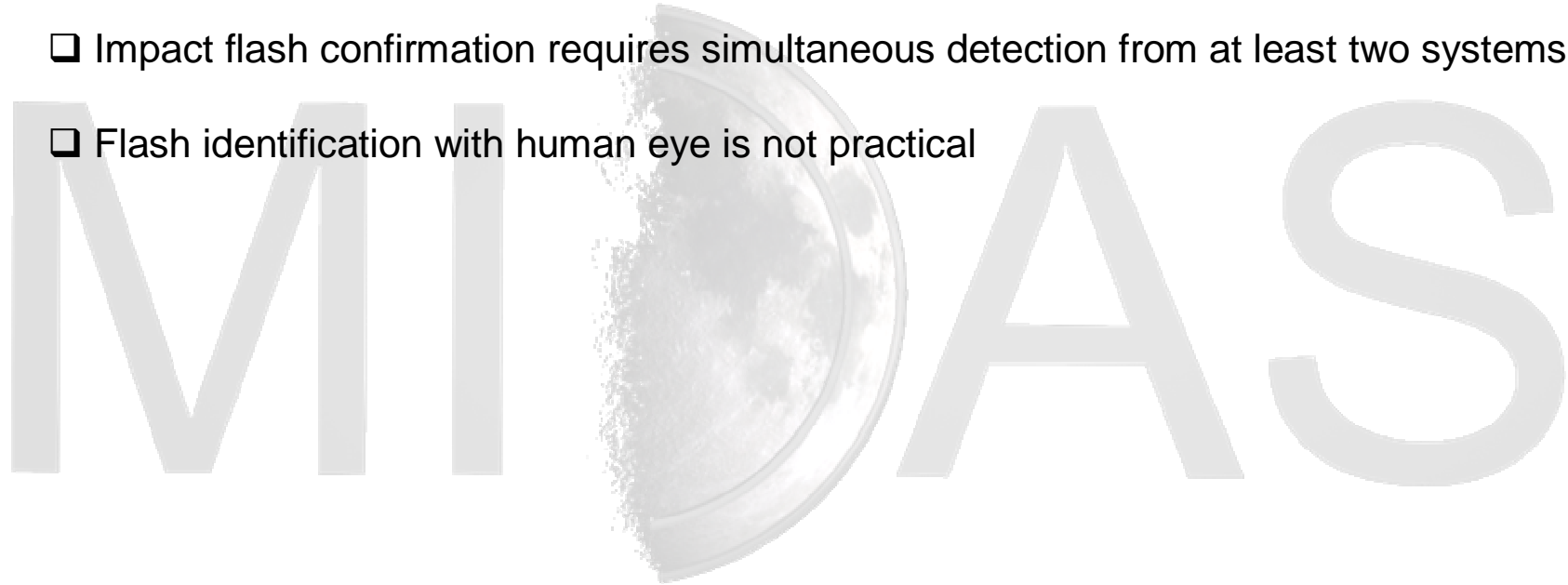
METEOR STATIONS OPERATED BY UNIVERSITY OF HUELVA

- ❑ 10 meteor stations
- ❑ Fully automated systems
- ❑ 50 CCD cameras
- ❑ Cover about 95% of the Iberian Peninsula and neighboring areas
- ❑ Collaboration with 15 extra stations operated by the Spanish Meteor Network

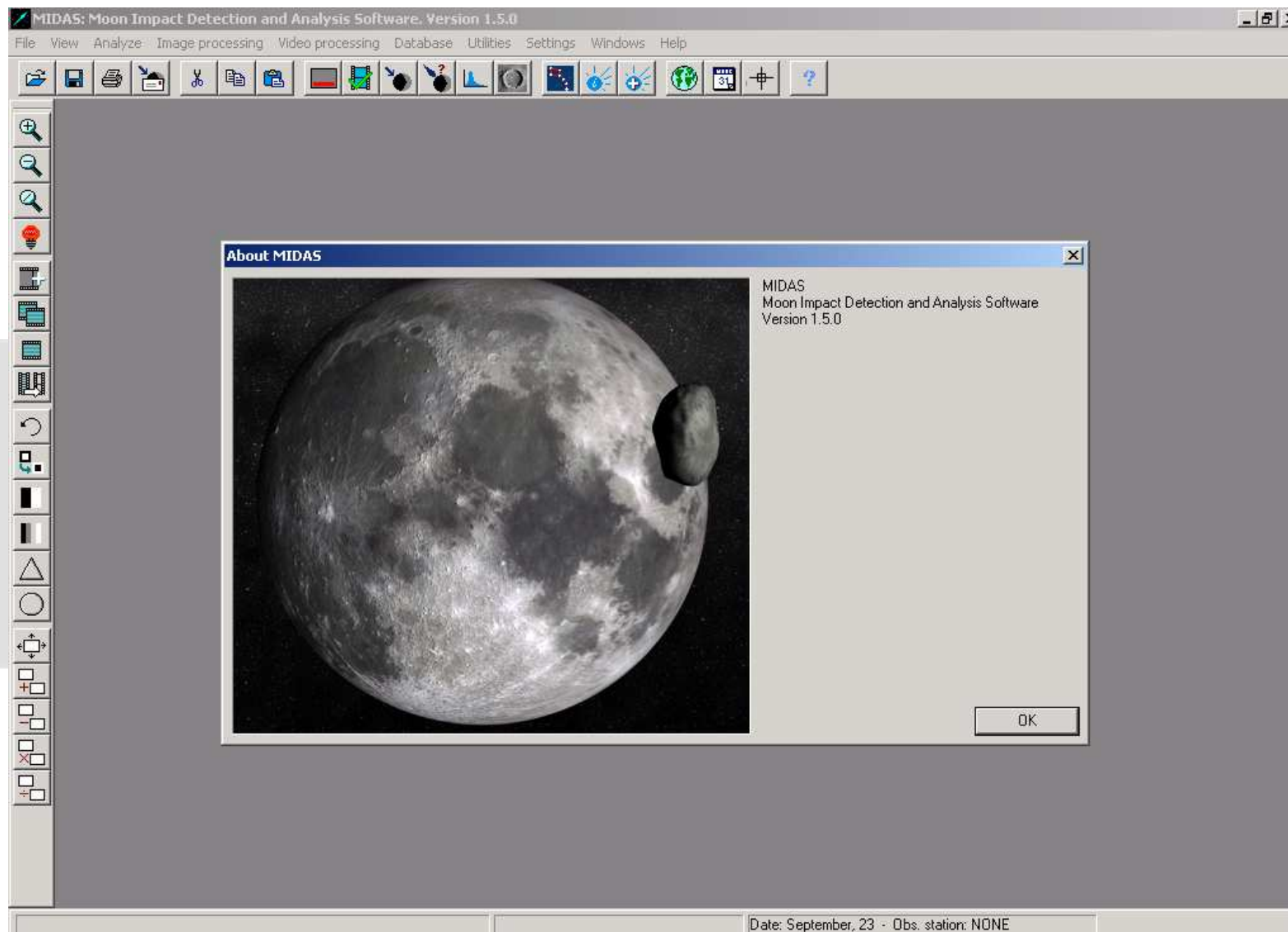


MAIN REASONS TO DEVELOP SOFTWARE

- ☐ Most impact flashes are dim and last a fraction of a second
- ☐ A large amount of video streaming is generated
- ☐ Impact flash confirmation requires simultaneous detection from at least two systems
- ☐ Flash identification with human eye is not practical



MIDAS: Moon Impacts Detection and Analysis Software



Moon impact flashes detection software. Developed by J.M. Madiedo.

- ☐ Developed under C/C++
- ☐ MS-Windows platforms (XP, Vista, 7, 8)
- ☐ Easily portable to other platforms (maybe in future)
- ☐ Requirements for specific or special features:
 - ☐ Intranet connection
 - ☐ Internet connection
- ☐ Fast real time processing: up to 100 fps with 720x576 pixels with Pentium 4 PC 2.4 GHz (depending on detection algorithm)

Main features

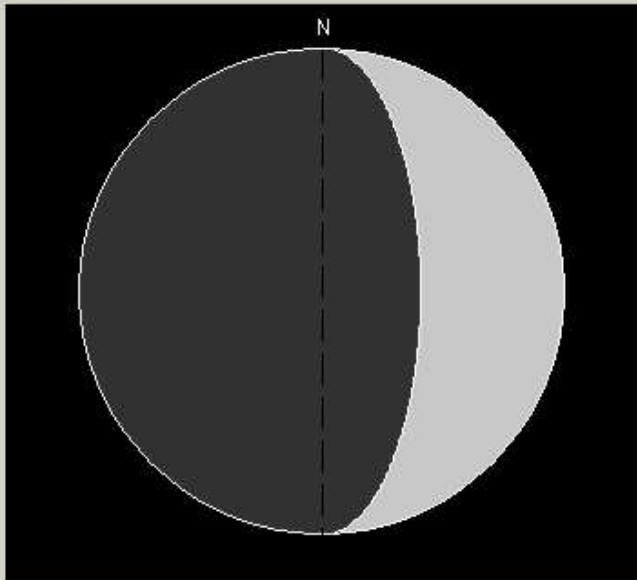
- ☐ Image capture (analogue and digital cameras)
- ☐ Image and video processing
- ☐ Moon Impact flashes identification
 - ☐ Method 1: **on the fly**
 - ☐ Method 2: **on previously recorded video streaming (preferred method)**
 - ☐ Very fast data reduction
- ☐ Moon impact flashes confirmation
- ☐ Photometry
- ☐ Calculation of impact parameters
- ☐ Determination of impactor source
- ☐ Adapted to indentify impacts on other bodies in the Solar System

Impact flash identification

Impacts detector (video file)

Icons: Folder, Save

Moon status



Moon data

RA (deg.): 264.91 DEC (deg.): -24.29 Phase (%): 29.77


Earth-Moon distance (km): 393110.65

Events detected

Total events detected: 2

Event identifier	Video size(Mb)	X-Pos	Y-Pos
20101012_19h39m24.199s	0.0	54	56
20101012_19h39m24.639s	0.0	50	52

Video stream



19:39:19 13/09/10
0325.6 0305.6

Current frame: 27 Total frames: 2312 Elapsed time: 0

Impact detection settings

Observing station:

Lat.(deg.): 0.0000 Lon.(deg.): 0.0000

Station:

Moon calibration

Is calibrated? No Load calibration

Image size: 640x480 Use image mask

Video rate (fps): 25 Show image mask

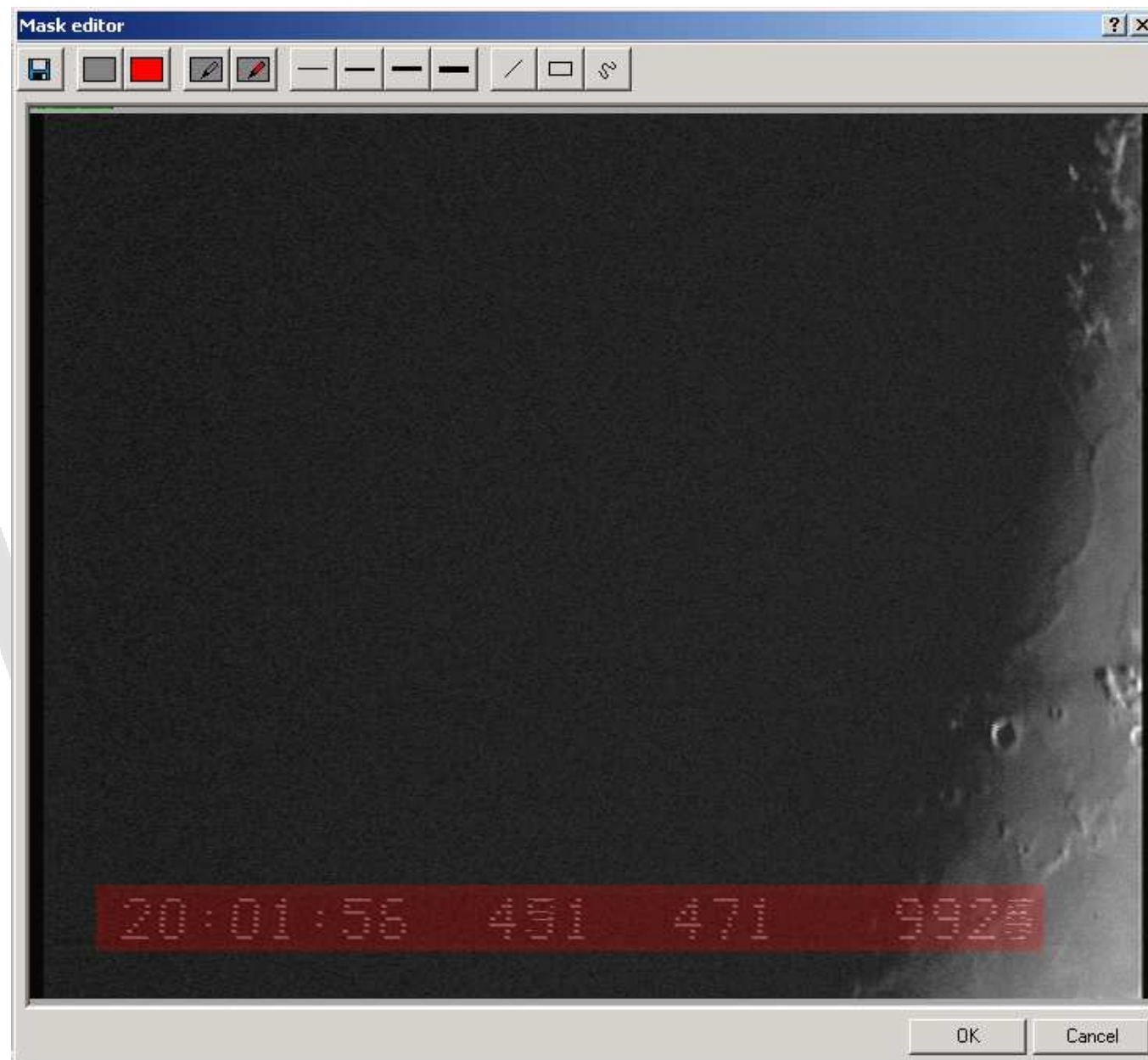
Insert time info Show video

Load mask

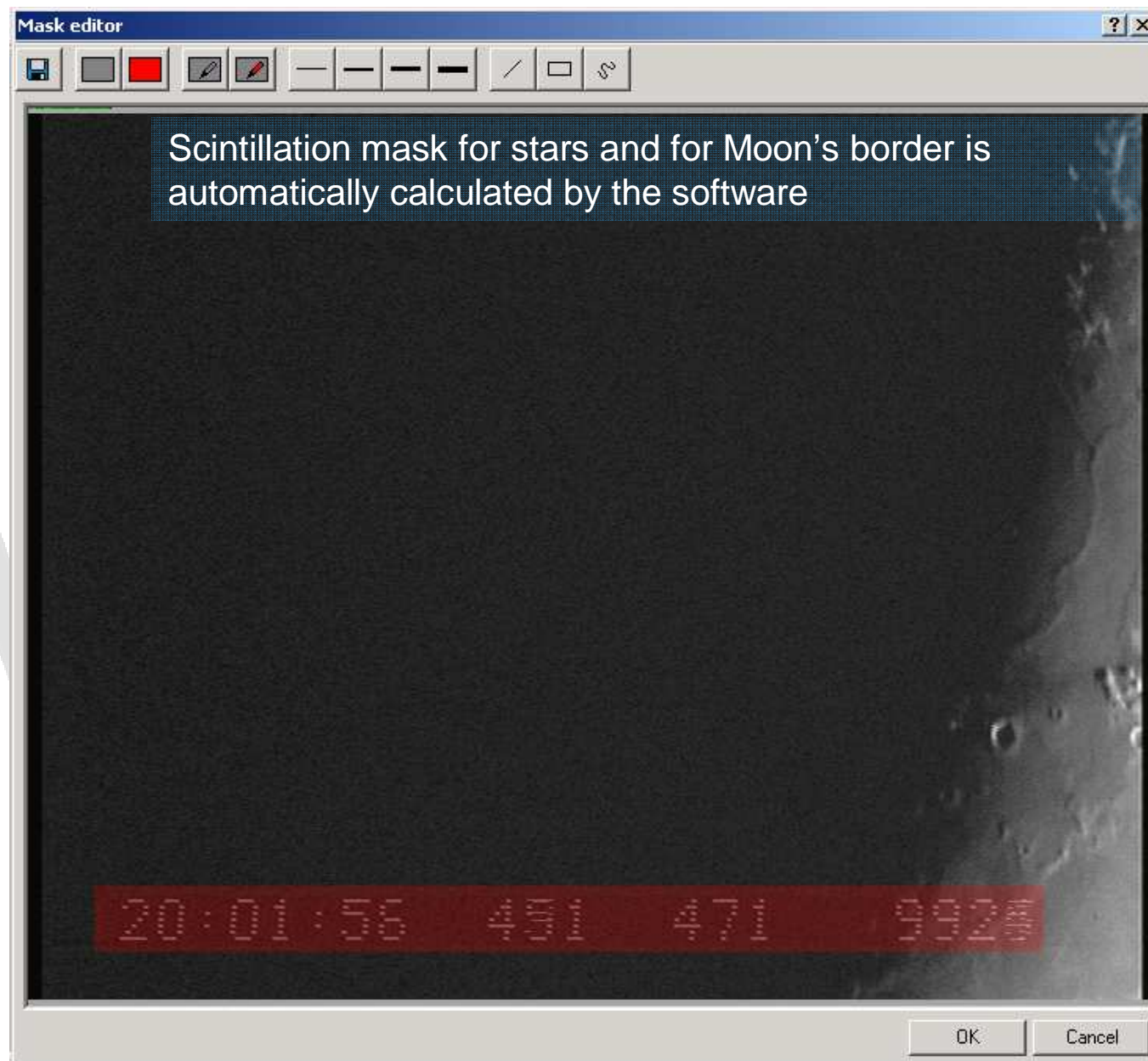
Start

Stop

Mask editor



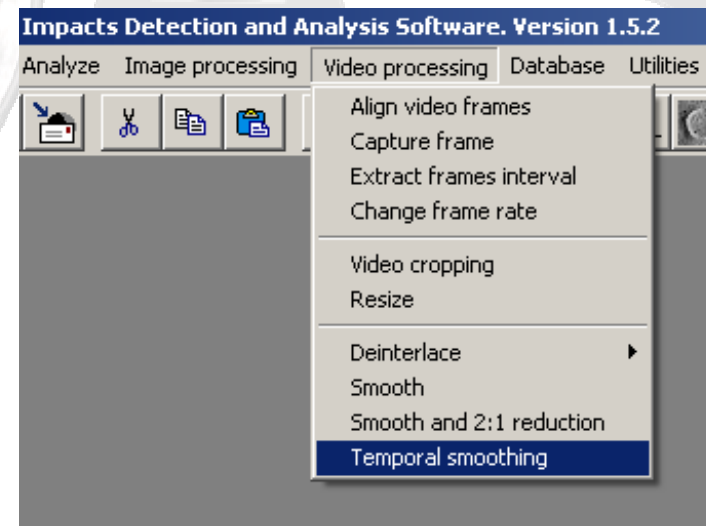
Mask editor



MIDAS: Moon Impacts Detection and Analysis Software

Image and video processing kernels

- ☐ Video files must be processed before the flashes identification
 - ☐ Watec cameras generate interlaced video
 - ☐ Improve the detectability of fainter flashes
- ☐ Main processing routines
 - ☐ Video deinterlacing
 - ☐ Noise reduction filters
- ☐ Increase data reduction time

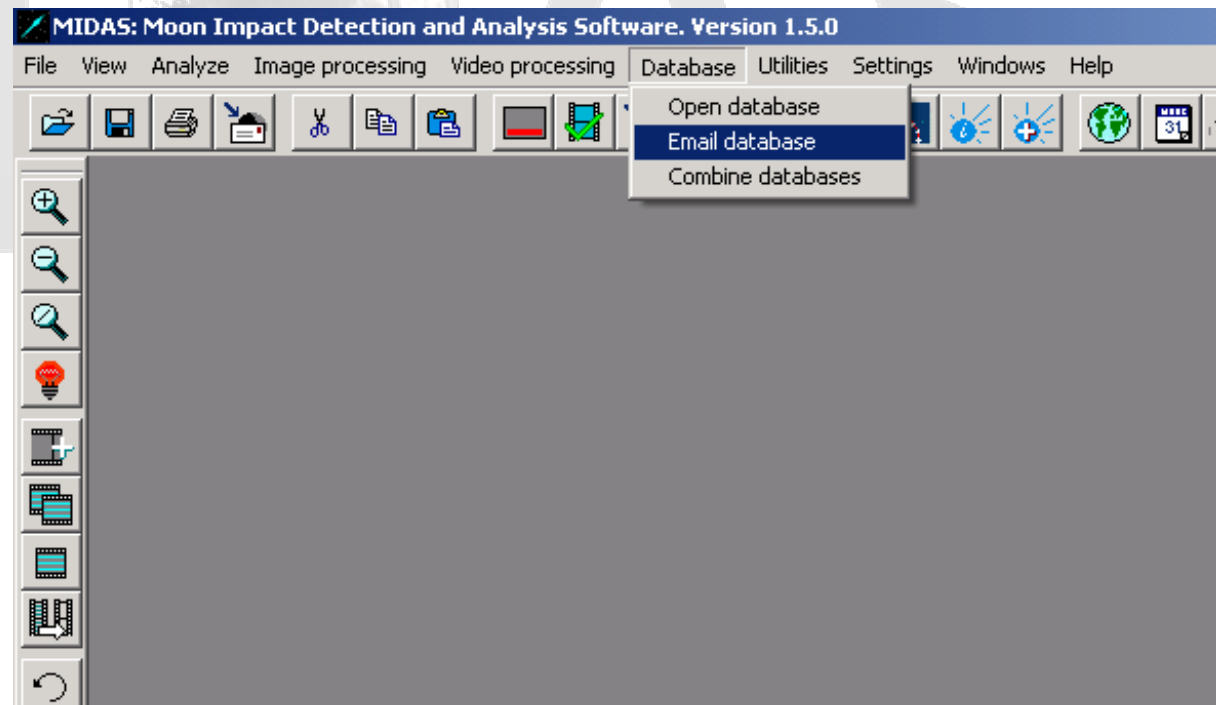


Impact flash confirmation on the fly

- ☐ When a telescope detects an event, it communicates with other telescopes in the system via TCP/IP network protocol
- ☐ The other telescopes may then confirm or not the detected event
- ☐ If the event is confirmed, it is automatically stored in a database
- ☐ If event is not confirmed, it will be ignored (but recorded for manual inspection if necessary)
- ☐ Intranet and/or Internet connections are requested to use this feature
- ☐ Selenographic or X,Y coordinates are provided for impact flashes
 - ☐ Method 1: Previous calibration of the lunar disk
 - ☐ Method 2: Superposition of a lunar map

Impact flash identification from previously recorded video

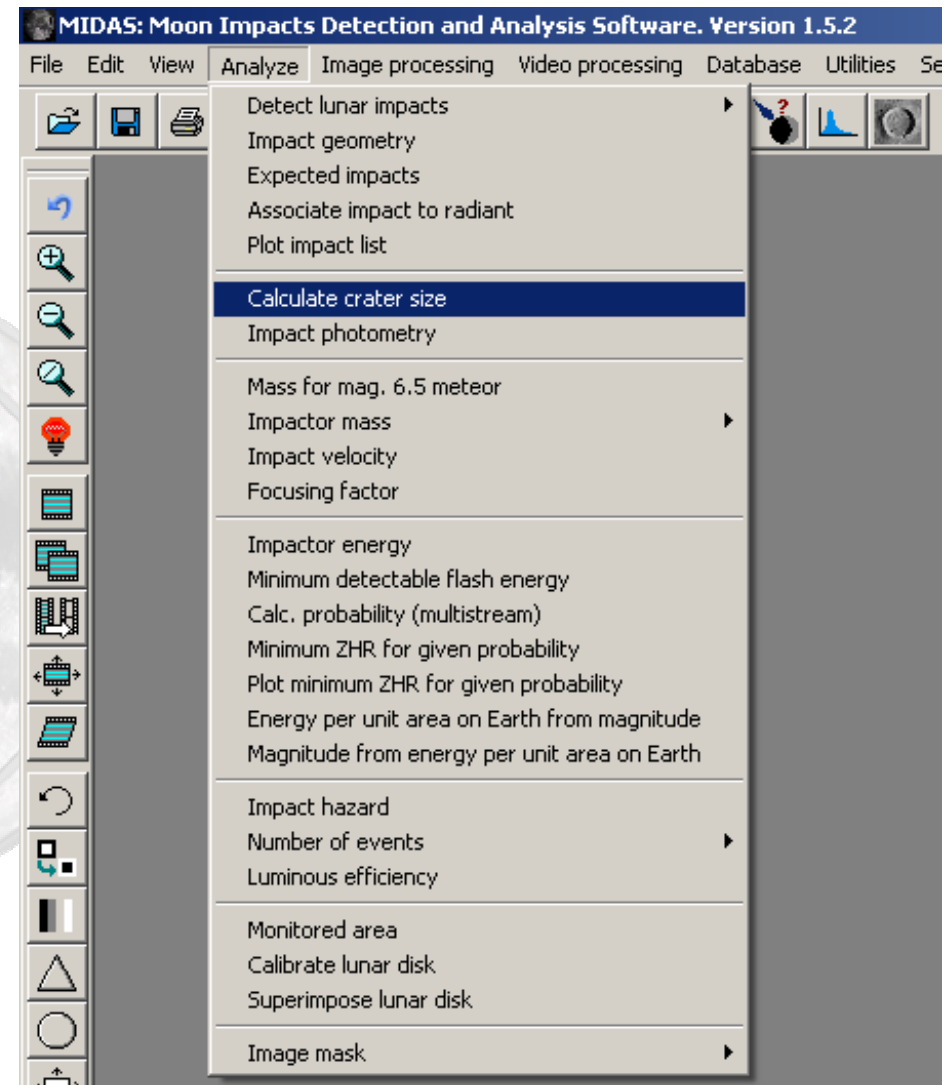
- ☐ A database with potential impact flashes is generated
- ☐ After the identification process is finished, the events database may be automatically emailed to the desired recipients
- ☐ Databases from different sources can be automatically compared by the software in order to search for common events



MIDAS: Moon Impacts Detection and Analysis Software

Data analysis kernel

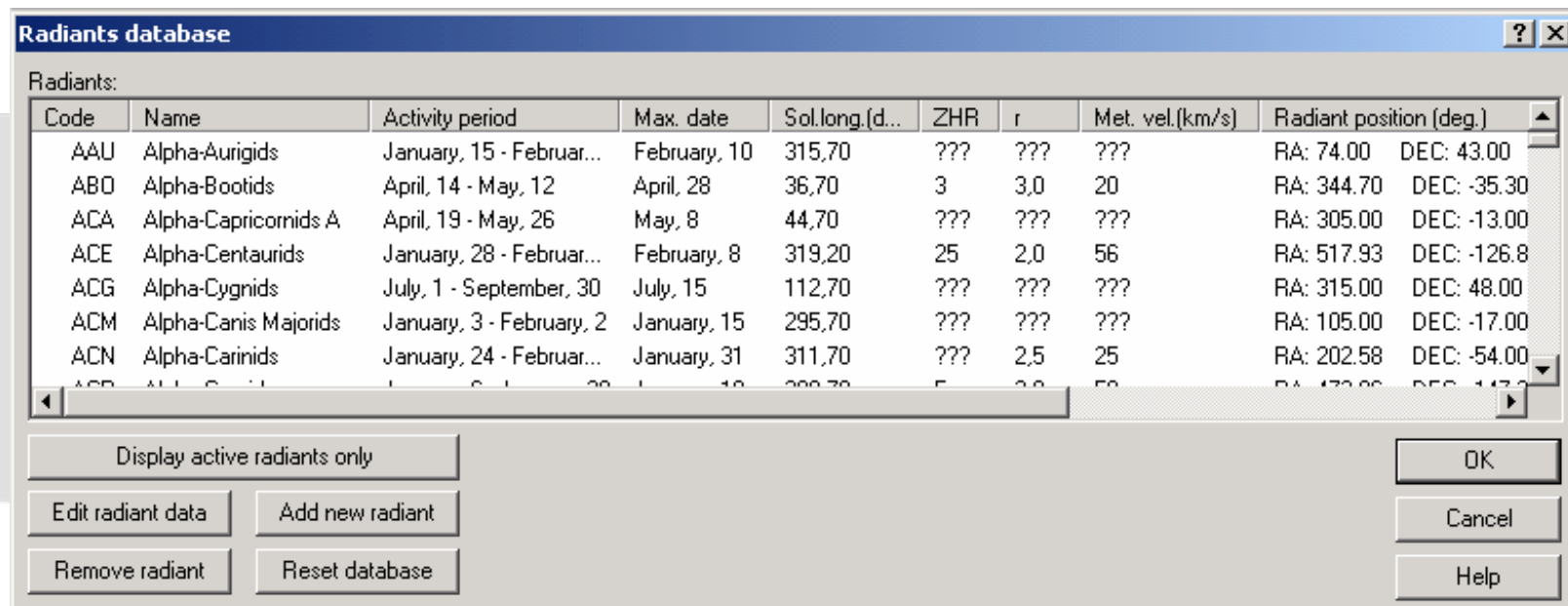
- ☐ Impactor source
- ☐ Photometry
- ☐ Impactor kinetic energy
- ☐ Impactor mass
- ☐ Crater size
- ☐ Luminous efficiency
- ☐ Other parameters



Impactor source identification

Meteoroid stream database (IAU Meteor Data Center)

- ❑ Aim: to check for compatible impact geometry



Radiants database

Radiants:

Code	Name	Activity period	Max. date	Sol. long.(d...	ZHR	r	Met. vel.(km/s)	Radiant position (deg.)
AAU	Alpha-Aurigids	January, 15 - Februar...	February, 10	315,70	???	???	???	RA: 74.00 DEC: 43.00
ABO	Alpha-Bootids	April, 14 - May, 12	April, 28	36,70	3	3,0	20	RA: 344.70 DEC: -35.30
ACA	Alpha-Capricornids A	April, 19 - May, 26	May, 8	44,70	???	???	???	RA: 305.00 DEC: -13.00
ACE	Alpha-Centaurids	January, 28 - Februar...	February, 8	319,20	25	2,0	56	RA: 517.93 DEC: -126.8
ACG	Alpha-Cygnids	July, 1 - September, 30	July, 15	112,70	???	???	???	RA: 315.00 DEC: 48.00
ACM	Alpha-Canis Majorids	January, 3 - February, 2	January, 15	295,70	???	???	???	RA: 105.00 DEC: -17.00
ACN	Alpha-Carinids	January, 24 - Februar...	January, 31	311,70	???	2,5	25	RA: 202.58 DEC: -54.00
ACD	Alpha-Centaurids	January, 28 - Februar...	February, 8	319,20	25	2,0	56	RA: 517.93 DEC: -126.8

Display active radiants only

Edit radiant data Add new radiant

Remove radiant Reset database

OK Cancel Help

Impactor source identification

Meteoroid stream database (IAU Meteor Data Center)

- ❑ Aim: to check for compatible impact geometry

Radiant data

*Radiant full name: *Radiant code:

Population index: Meteor velocity (km/s): ZHR:

*Activity period:

From: Month: Day:

To: Month: Day:

*Date of maximum activity:

Month: Day:

Radiant position at maximum:

Solar long. (deg.):

*RA (deg.):

*DEC (deg.):

Diameter:

RA (deg.):

DEC (deg.):

Drift velocity:

RA (deg./day):

DEC (deg./day):

☒ Show this radiant on the star chart

IMPORTANT: Fields marked with an asterisk must be filled in

Impactor source identification

Radiant identification [?] [X]

Selenographic coordinates of impact
Latitude (deg.): Longitude

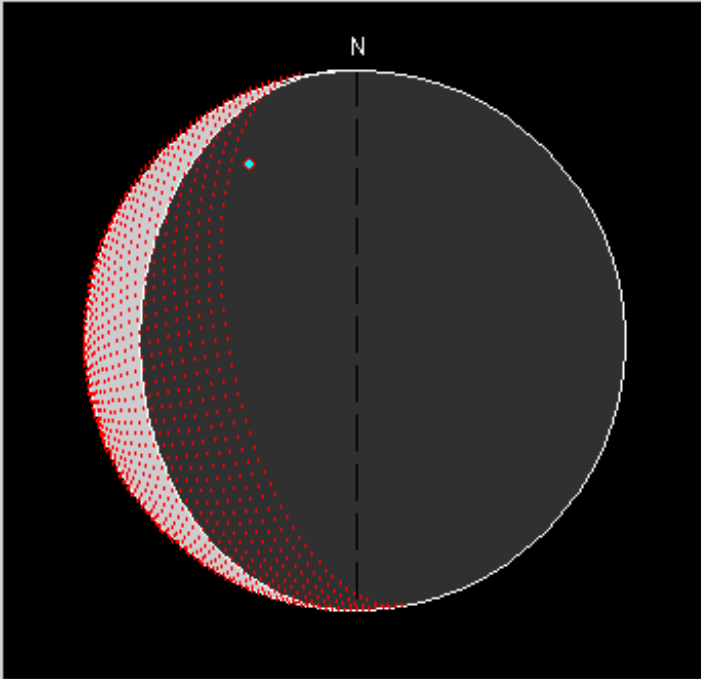
Date (UT):

Observing station:
Lat.(deg.): Lon.(deg.):
Station:

Active radiants

Andromedids (Annual) (AN)
Beta-Gruids (BCR)
Beta-Phoenicids (BPH)
Delta-Aurigids (DAU)
Kappa-Aquarids (KAQ)
Piscids N (NPI)
Capricornids (Oct) (OCC)

Impact area
% of near side area:
% of dark near side area:
RA (deg.):
DEC (deg.):



The diagram shows a circular representation of the Moon. A vertical dashed line runs through the center, with the letter 'N' at the top, representing the near side. The left half of the circle is filled with a pattern of red dots, representing the impact area. A small blue dot is visible on the left edge of the red dotted area.

Impactor source identification

Radiant identification [?] [X]

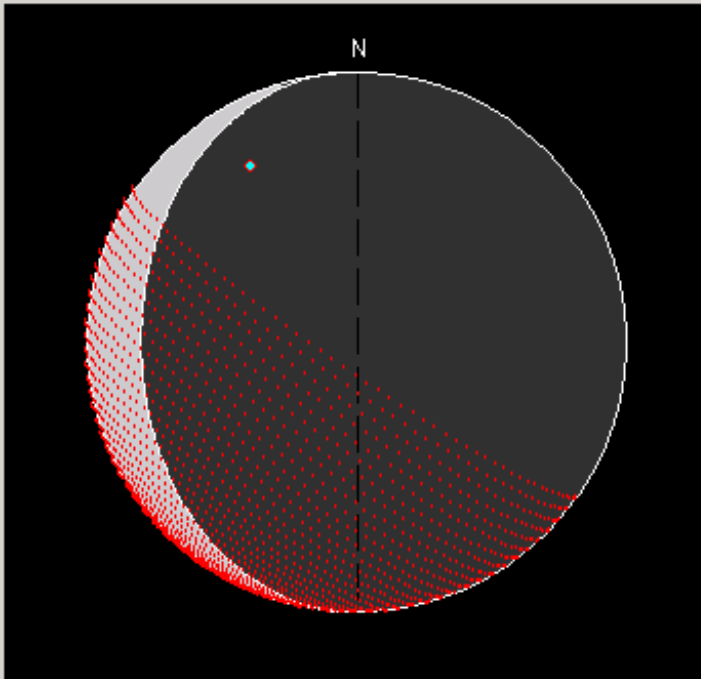
Selenographic coordinates of impact
Latitude (deg.): Longitude

Date (UT):

Observing station:
Lat.(deg.): Lon.(deg.):
Station:

Active radiants

Impact area
% of near side area:
% of dark near side area:
RA (deg.):
DEC (deg.):



Impactor source identification

Radiant identification [?] [X]

Selenographic coordinates of impact
Latitude (deg.): Longitude

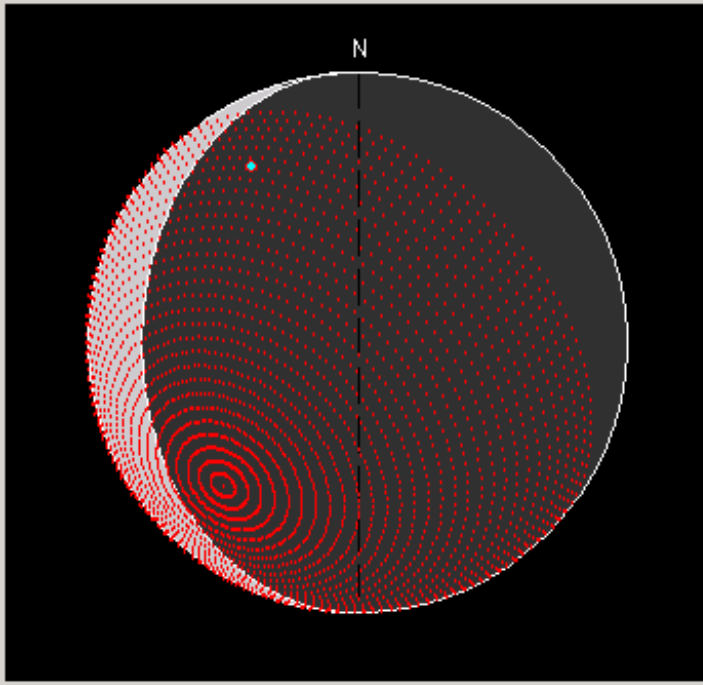
Date (UT):

Observing station:
Lat.(deg.): Lon.(deg.):
Station:

Active radiants

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RA (deg.):
DEC (deg.):



Impactor source identification

Radiant identification [?] [X]

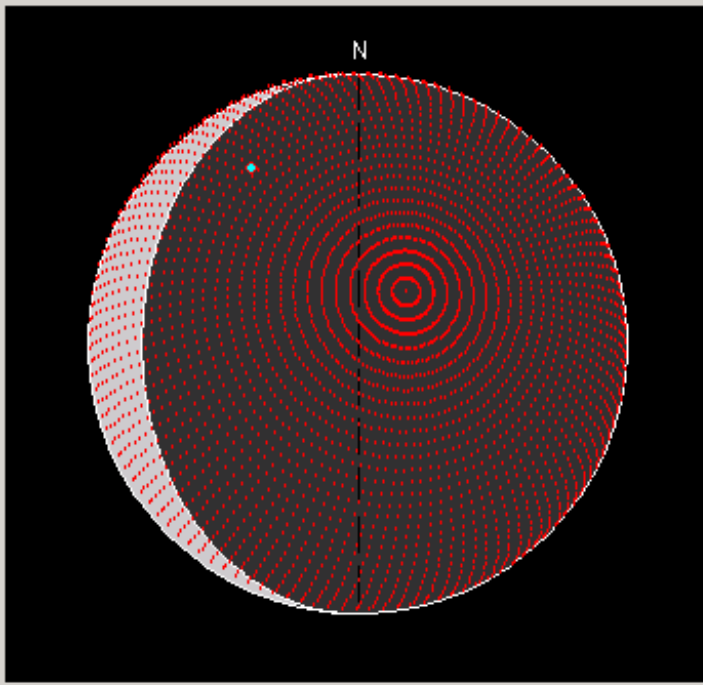
Selenographic coordinates of impact
Latitude (deg.): Longitude

Date (UT):

Observing station:
Lat.(deg.): Lon.(deg.):
Station:

Active radiants

Impact area
% of near side area:
% of dark near side area:
RA (deg.):
DEC (deg.):



Impactor source identification

- ☐ An impact flash is associated to a given meteoroid stream if
 - ☐ The impact geometry is compatible
 - ☐ The event takes place during or next to the activity period of the corresponding meteor shower
- ☐ If the conditions above are not fulfilled, the impact is associated to the sporadic background.

Problems

- ☐ This "classical" procedure does not quantify the link
- ☐ Can provide wrong results

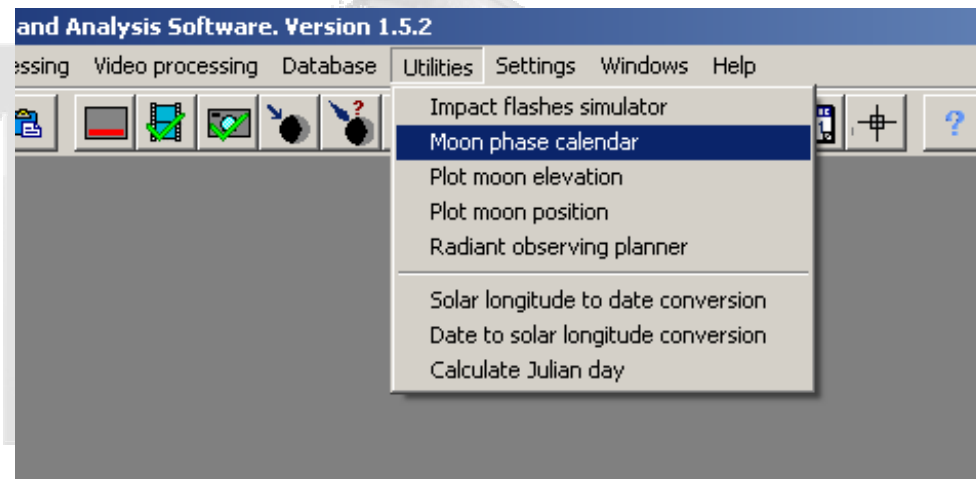
Solution

MIDAS employs a new method to quantify the link between an impact flash and a meteoroid source

MIDAS: Moon Impacts Detection and Analysis Software

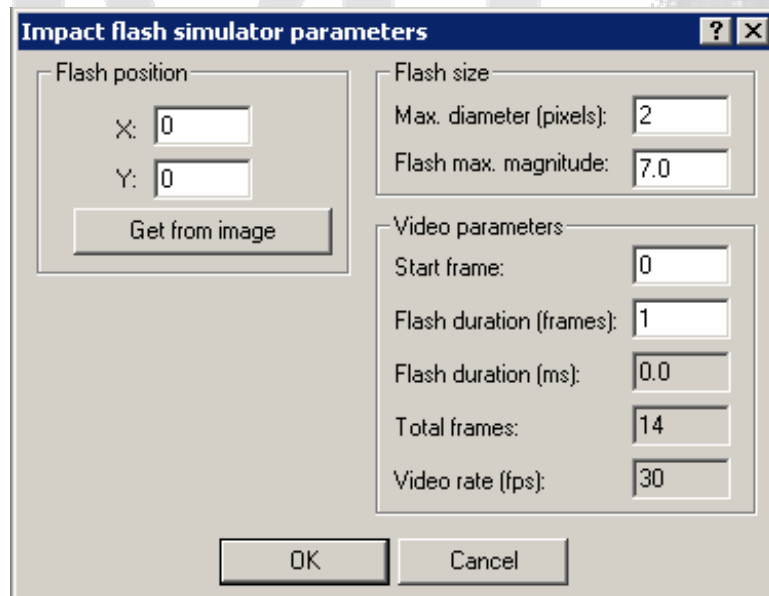
ADDITIONAL TOOLS

- ☐ Testing tools
- ☐ Monitoring planning tools

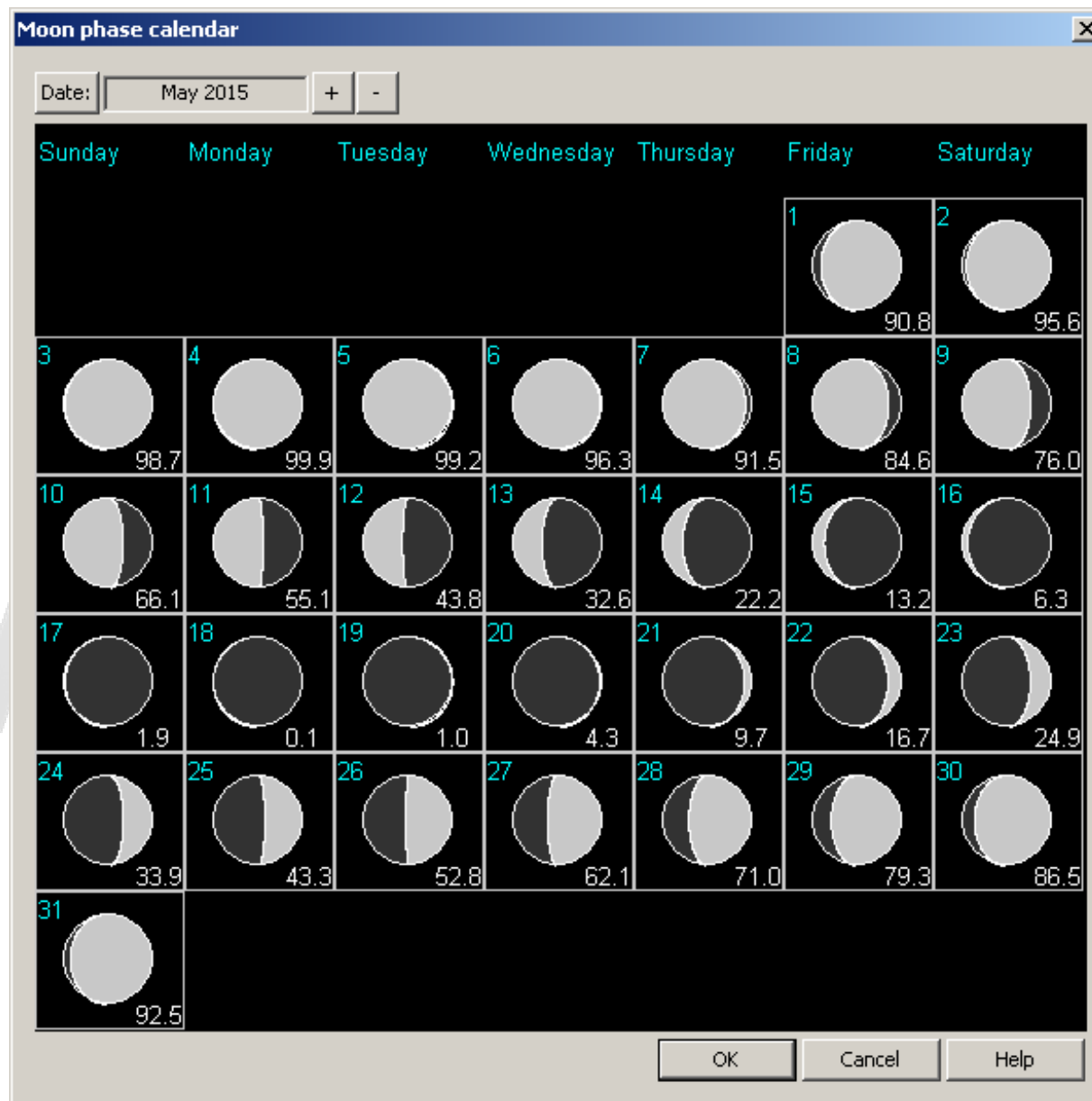


IMPACT FLASH SIMULATOR

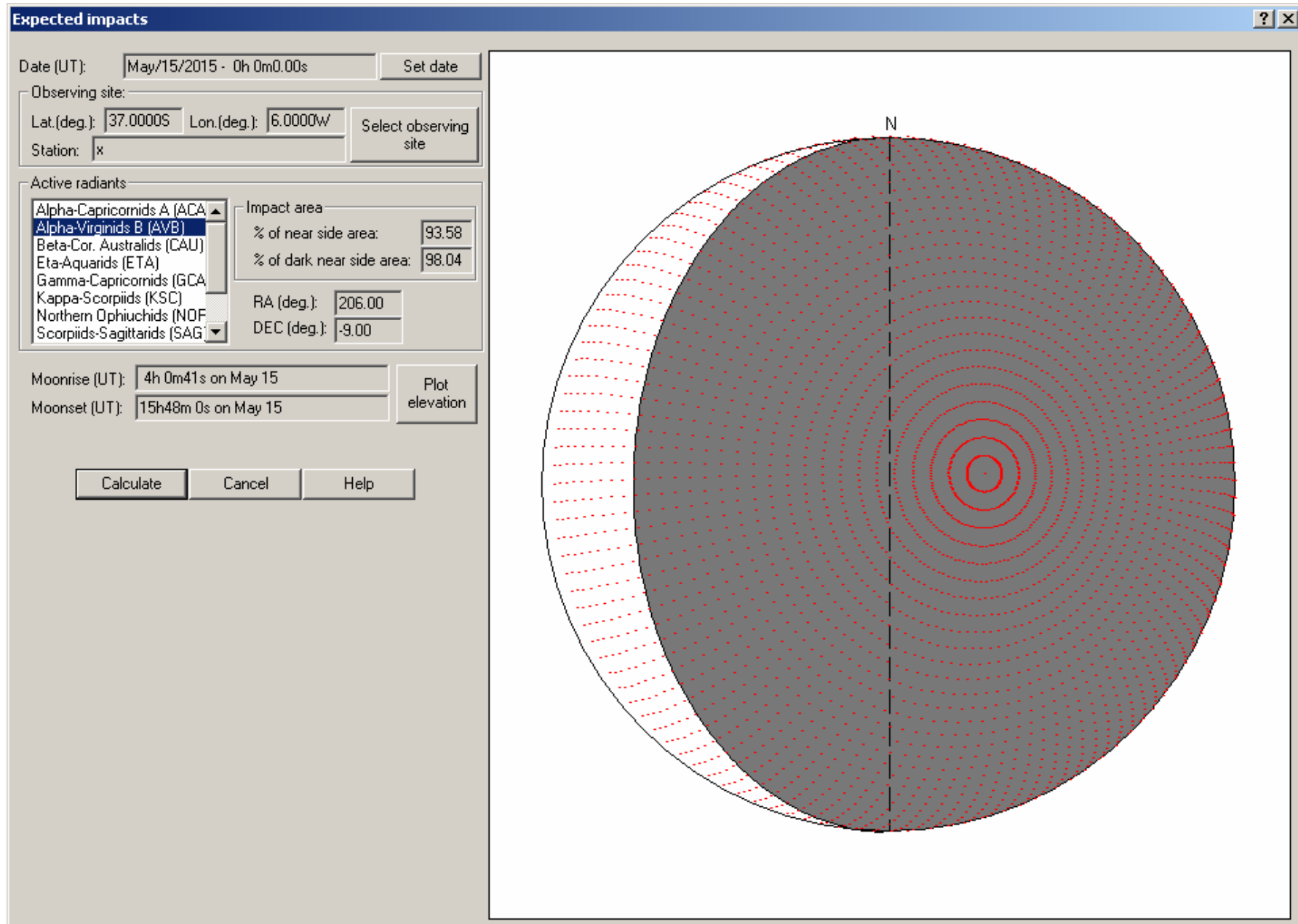
- ☐ Inserts a simulated flash on real footage
- ☐ Useful to...
 - ☐ Optimize impact flash identification parameters (noisy images, IR, etc.)
 - ☐ Know the limitations of a given experimental setup



Planning tools: Moon Phase Calendar



Planning tools: which area should be monitored?



Current status

- ☐ Systematic monitoring of impact flashes
 - ☐ V-band
 - ☐ IR band
- ☐ Setting up of new facilities at La Sagra Astronomical Observatory
- ☐ New version of the MIDAS software
- ☐ Analysis of data recorded before 2009
- ☐ Preparation of new publications

Future software developments

Software tool to establish the source of meteoroids impacting the lunar surface

- Web-based tool?
- Open for the impact flash monitoring community
- **Joint project with additional partners?**



Conclusions

- ☐ We have set up a system to monitor lunar impact flashes in Spain
 - ☐ Two stations in operation
 - ☐ Monitoring in V and IR bands
- ☐ We are setting up another system in Southwest Spain (La Sagra Astronomical Observatory)
 - ☐ Four 14" telescopes
 - ☐ Monitoring in V and IR bands
- ☐ Between 300 and 250 clear nights/year favor the observing tasks
- ☐ Software has been developed to identify and analyze impact flashes.
- ☐ Method to analyze the source of meteoroids impacting the Moon
 - ☐ Important synergy with meteor observing stations



Moon Impacts Detection and Analysis System