ITOKAWA
A Global Shaked and Fractured Asteroid with Brasilian Nut Effect

COSPAR 2007 - Montevideo Uruguay

S. Bruzzone, S. Roland

Facts I

- Impacts in small bodies produce global shaking and they can easily fracture the asteroid
- Global shaking produce the Brazilian nut effect
- Collisions that produce global shaking in Itokawa require projectiles d>2cm
- Collisions that produce catastrophic disruption in Itokawa require projectiles d>12m
- There are > 10^7 shaking collisions before a catastrophic one

The Brazilian Nut effect:

Shake a can of mixed nuts long enough and the biggest nuts end up on top. Studied since the 1930s but still poorly understood, this phenomenon--called the Brazil nut effect--also occurs in batches of particles ranging from stones to powders.

Shaking Nuts? What about Itokawa

- Itokawa's surface is covered, as a first view, by gravels of different sizes distributed in roughly two apreciable regions.

- By looking on the slopes models and the relative gravity-potential maps it is clear that boulder-size distributions can by linked with Itokawa's geometry.

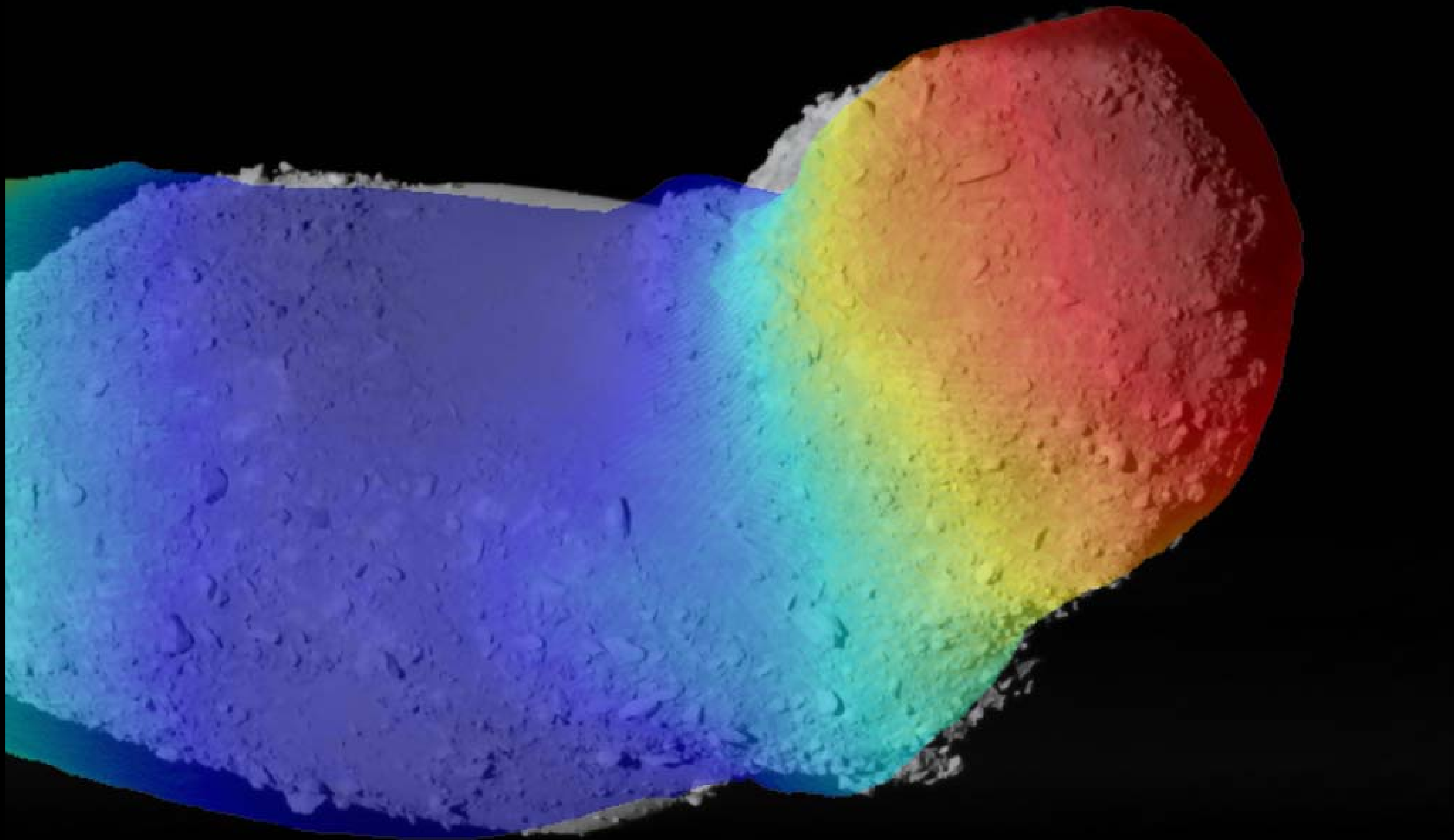
- With a high collision frecuency in the past, it is suggested that global vibration or “shaking” could be a major agent modeling the actual gravel distribution.

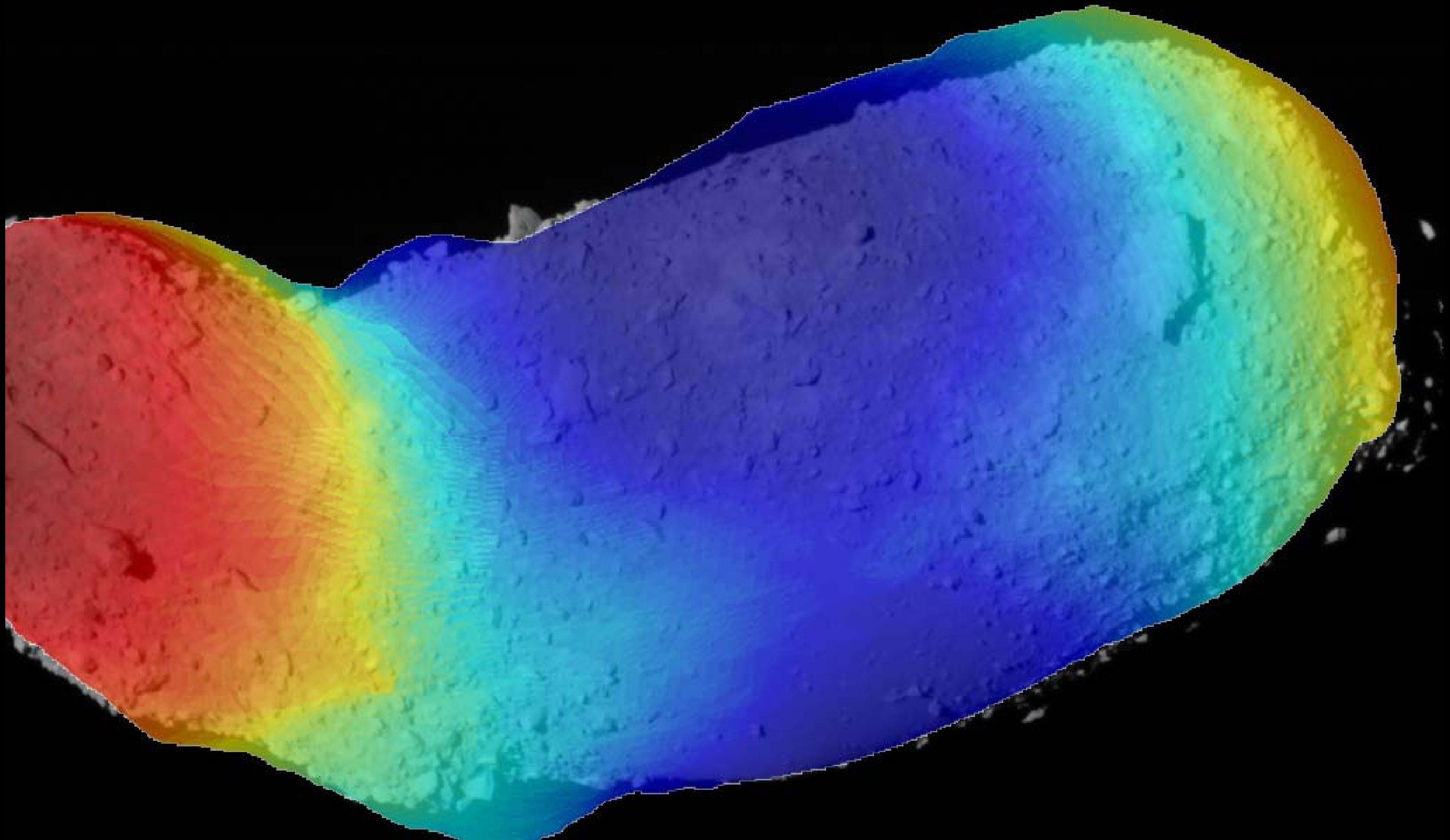
Facts II

- Itokawa has a low inclination orbit ($i=1.6°$), that implies a heavily and frequently collisioned object
- Itokawa comes from the inner belt (Michel & Yoshikawa 2006), a region with an even higher collisional rate

Hypothesis

- The distribution of boulders is due to the Brazilian nut effect on a heavyly fractured asteroids that suffers very frequent shaking impacts
- The distribution of boulders is correlated with the Gravitational+Rotational potential: large boulders in the Head&Bottom and small ones in the Muses Sea





Before Measurements

- For adequate selection of Bottom Region and Muses Sea images, we used SPICE.
- The SPICE output were the 3D Ellipsoid angle between major asteroid axis (x) and hayabusa spacecraft vector.
- Also SPICE determined the distance between Hayabusa Spacecraft and the Itokawa surface, in order to determine the footprint scale needed for the boulder size determination.
- SPICE also told us the date that the images were taken.
- Finally we selected global and close up images of both images of Bottom Region and Muses Sea.

Measurements

- In order to show unequal boulder distribution, we had to count for boulders in both Bottom region and Muses Sea region
- The boulder counting must record the pixel size of boulders. This was obtained by measuring the pixel area of each boulder considered as an ellipsoidal shape.
- Dpix=2*sqrt(Apix/pi)

Global Bottom Region Image

- Image (ST_2498167622_v.fits)
- R= 4.736 km
- theta= 175.6º (Ellipsoid)
- Date= 28/10/2005 (Home Position)
- Apix=40000 px2
- Plate Scale = 0.47 m/px
- Am2= 8800 m2

Close Up Bottom Region Image

- Image (ST_2498167622_v.fits)
- R= 4.736 km
- theta= 175.6º (Ellipsoid)
- Date= 28/10/2005 (Home Position)
- Apix=40000 px2
- Plate Scale = 0.47 m/px
- Am2= 8800 m2

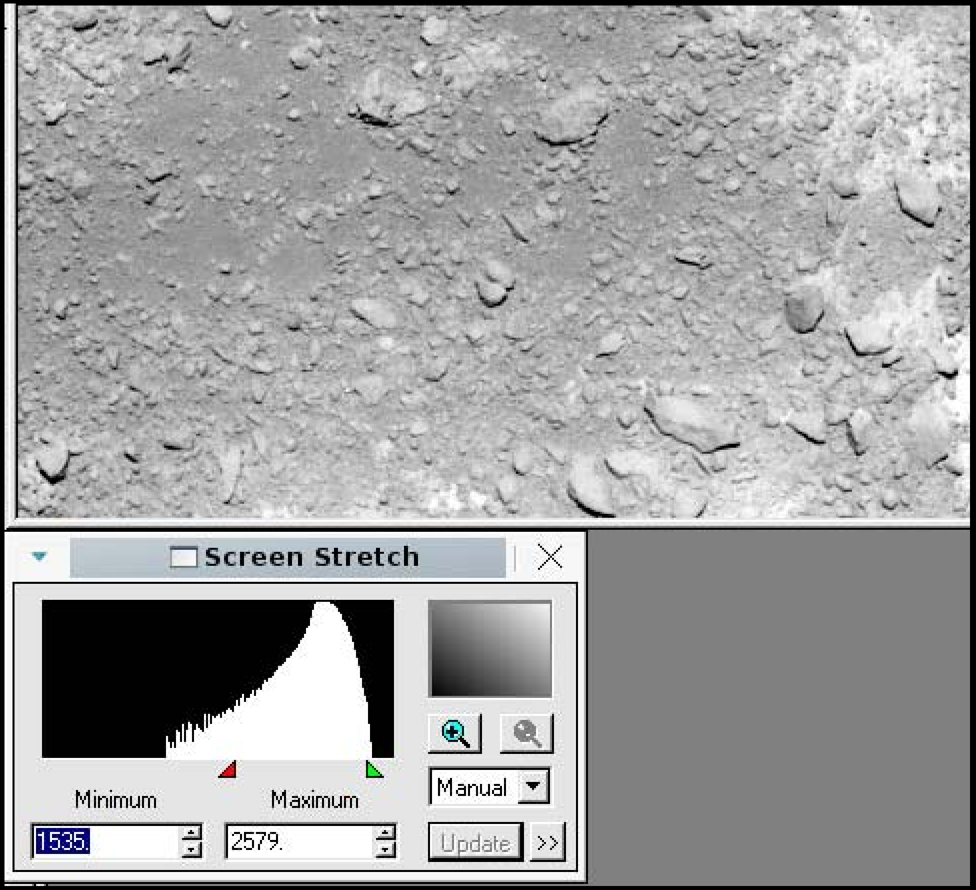
Global Muses Sea Region Image

- Image (ST_2498647696_v.fits)
- R=4.93 km
- theta=51.98º (Ellipsoid)
- Date= 28/10/2005 (Home Position)
- Apix=30000 px2
- Plate Scale= 0.489 m/px
- Am2 = 7173 m2

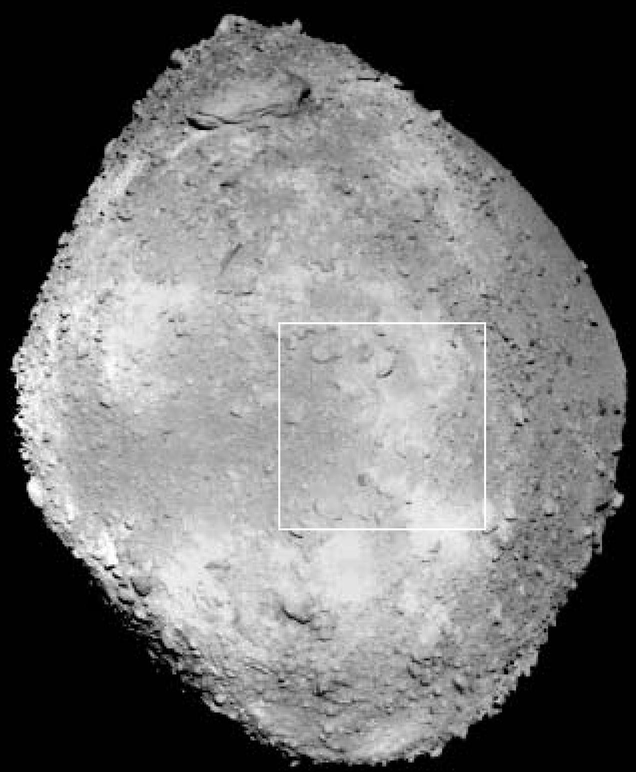
Global Muses Sea Region Image

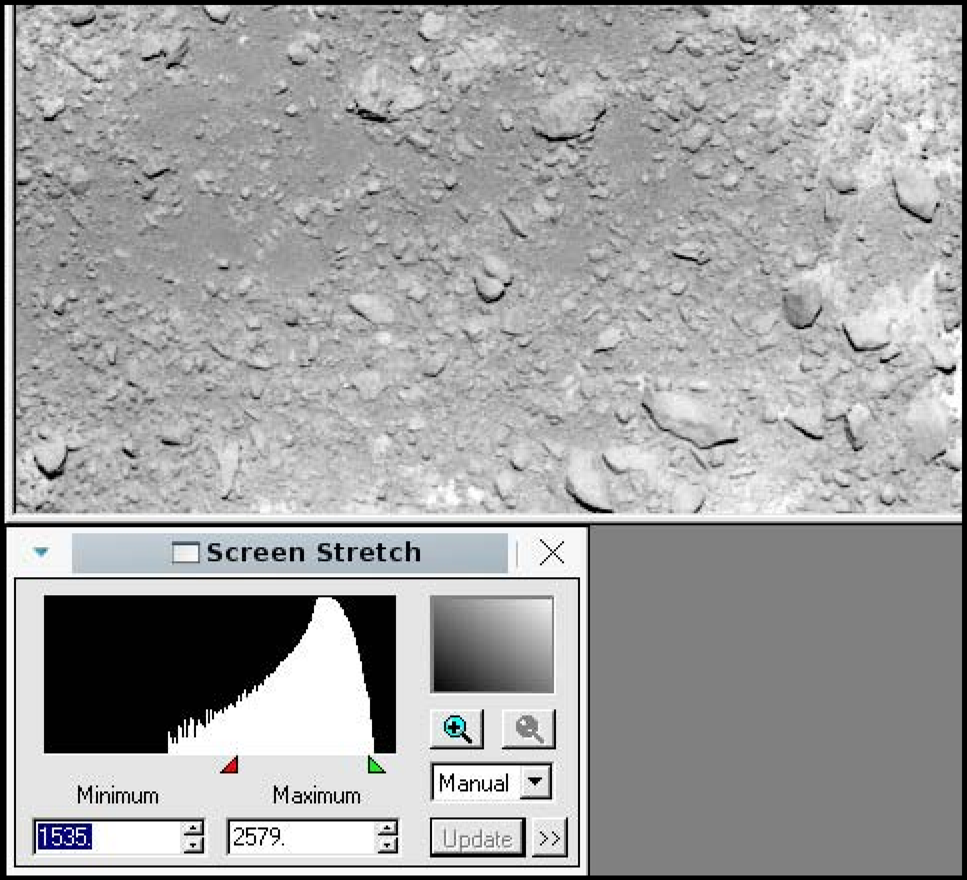
- Image (ST_2563511720_v.fits)
- R=0.19 km
- theta=73.09º
- Date=19/11/2005 (Descent & Touching Down)
- Apix=819200 px2
- Plate Scale= 0.0188 m/px
- Am2= 289.5 m2

Bottom Region Counting

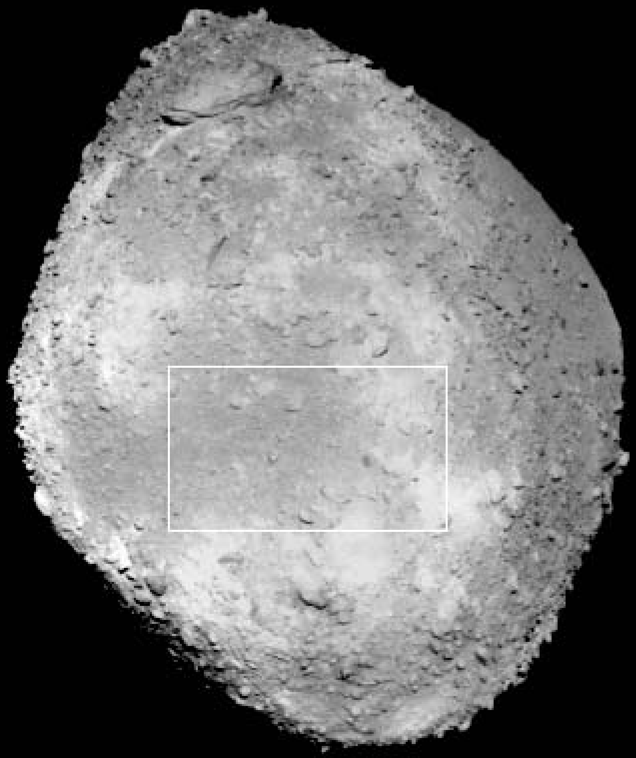


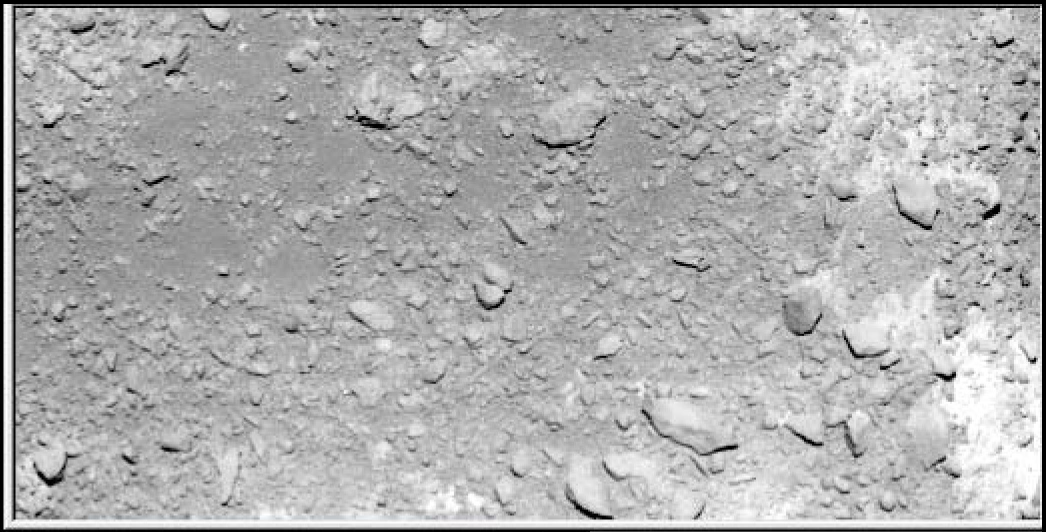
Bottom Region Counting

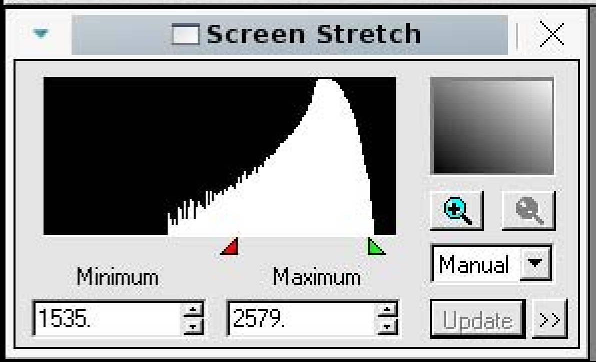




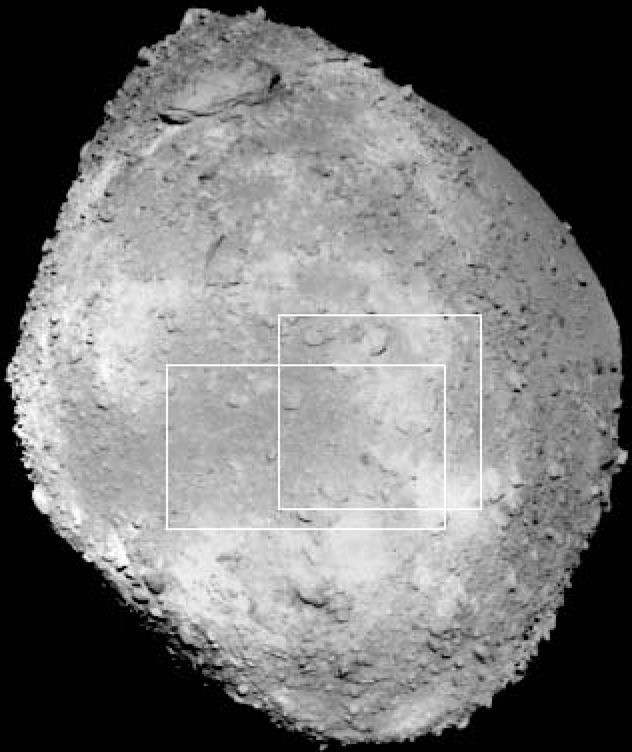
Bottom Region Counting

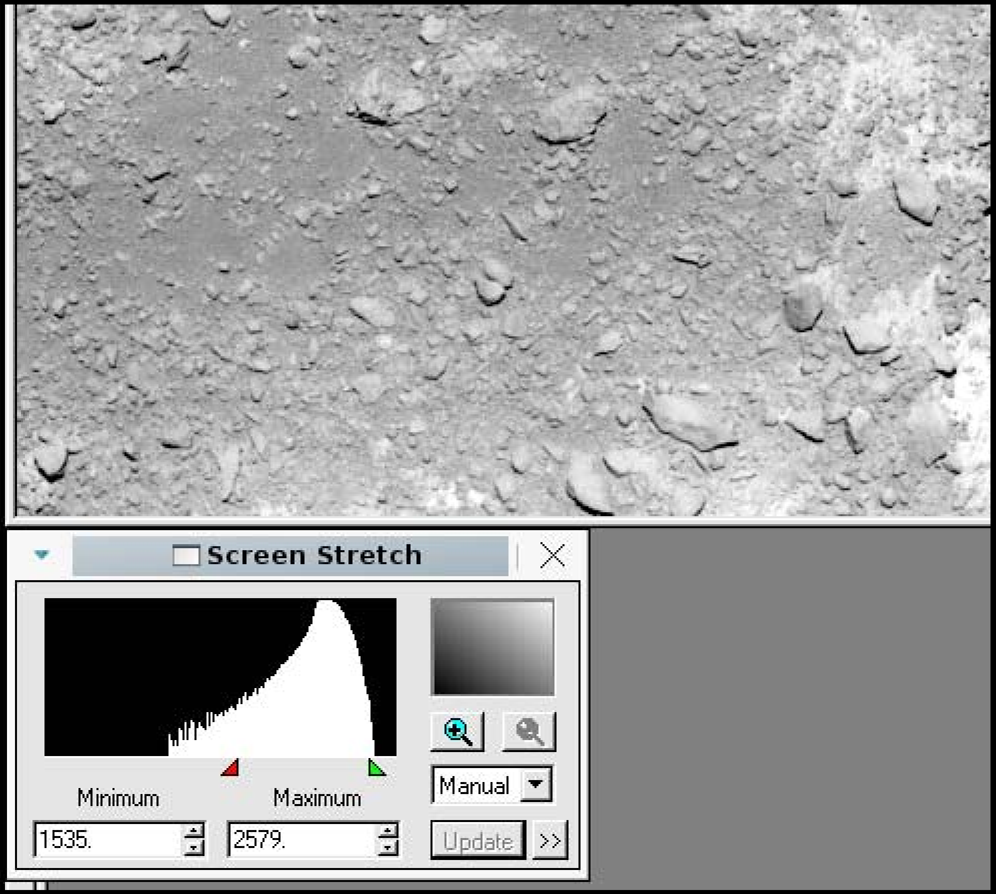




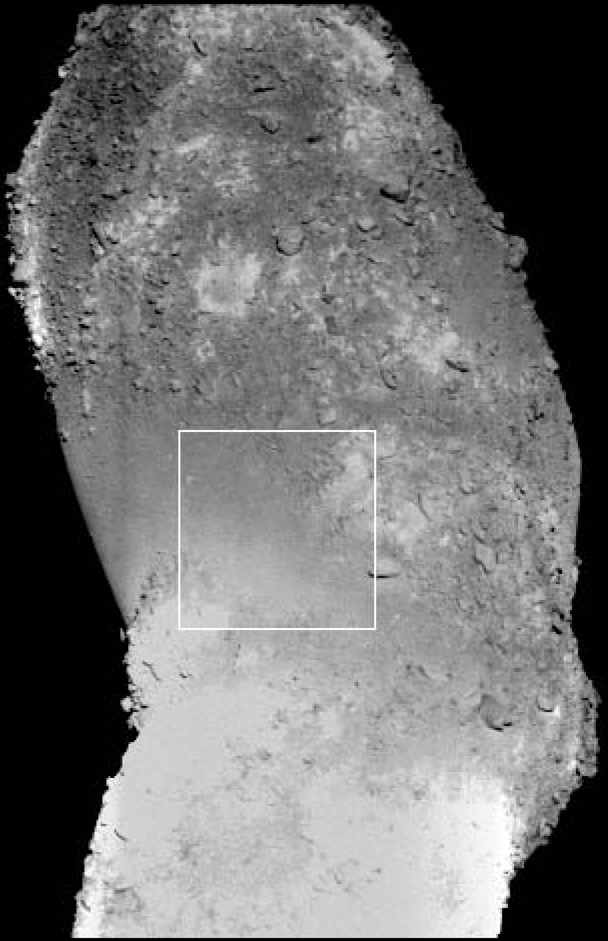


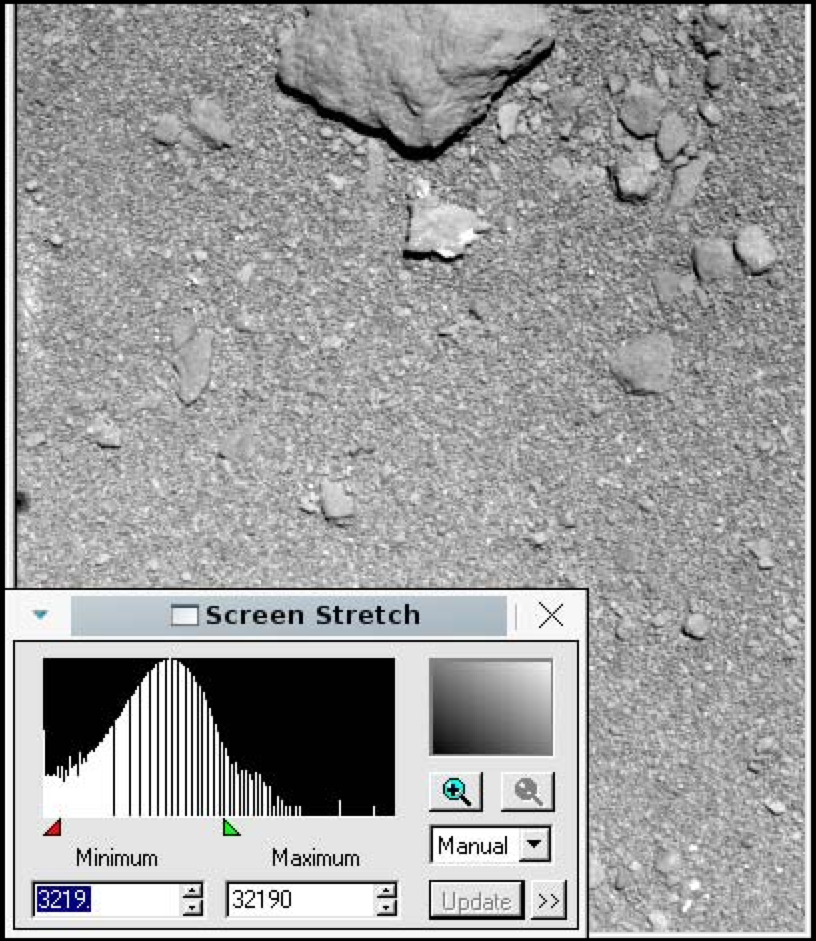
Bottom Region Counting



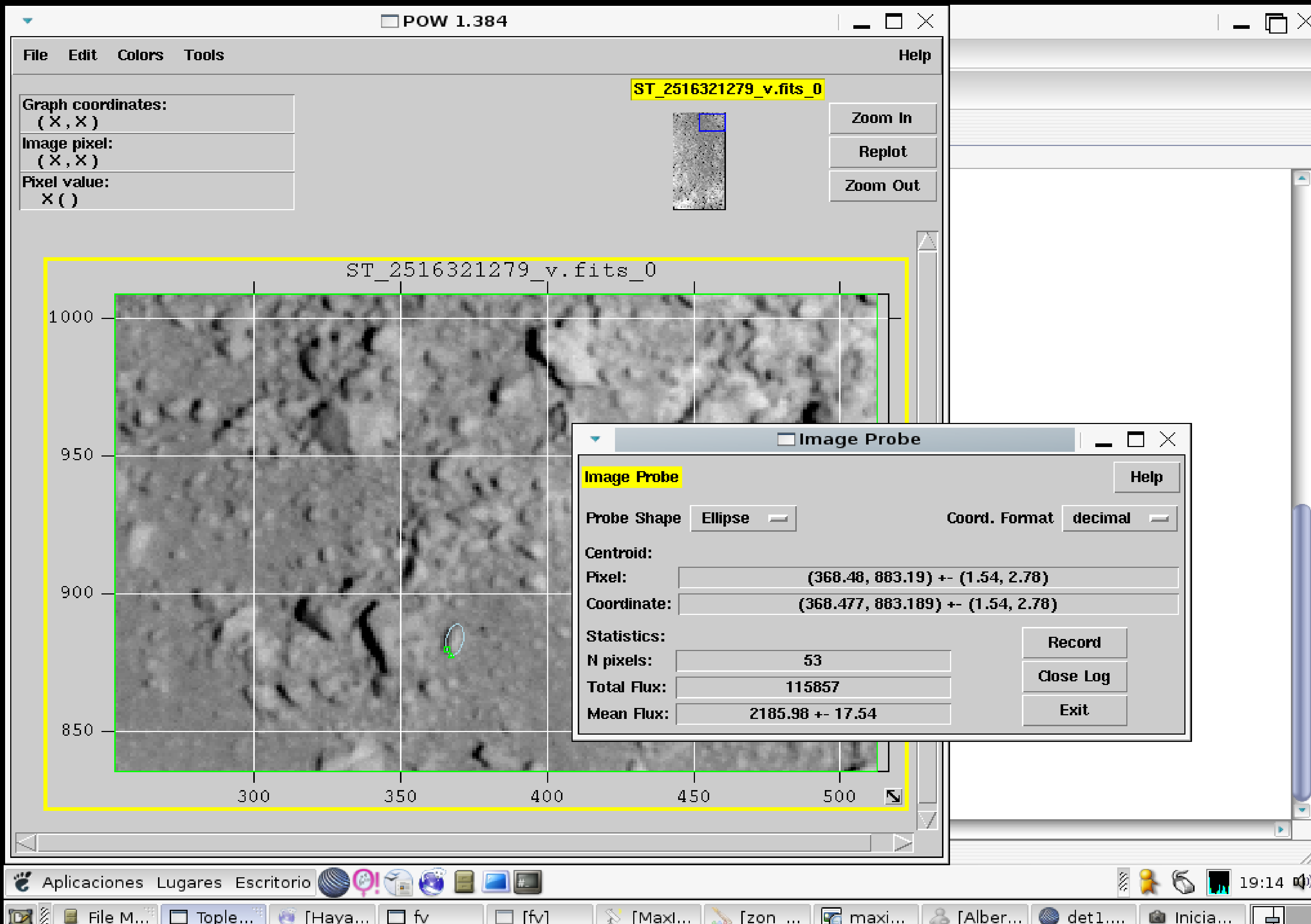


Muses Sea Region Counting

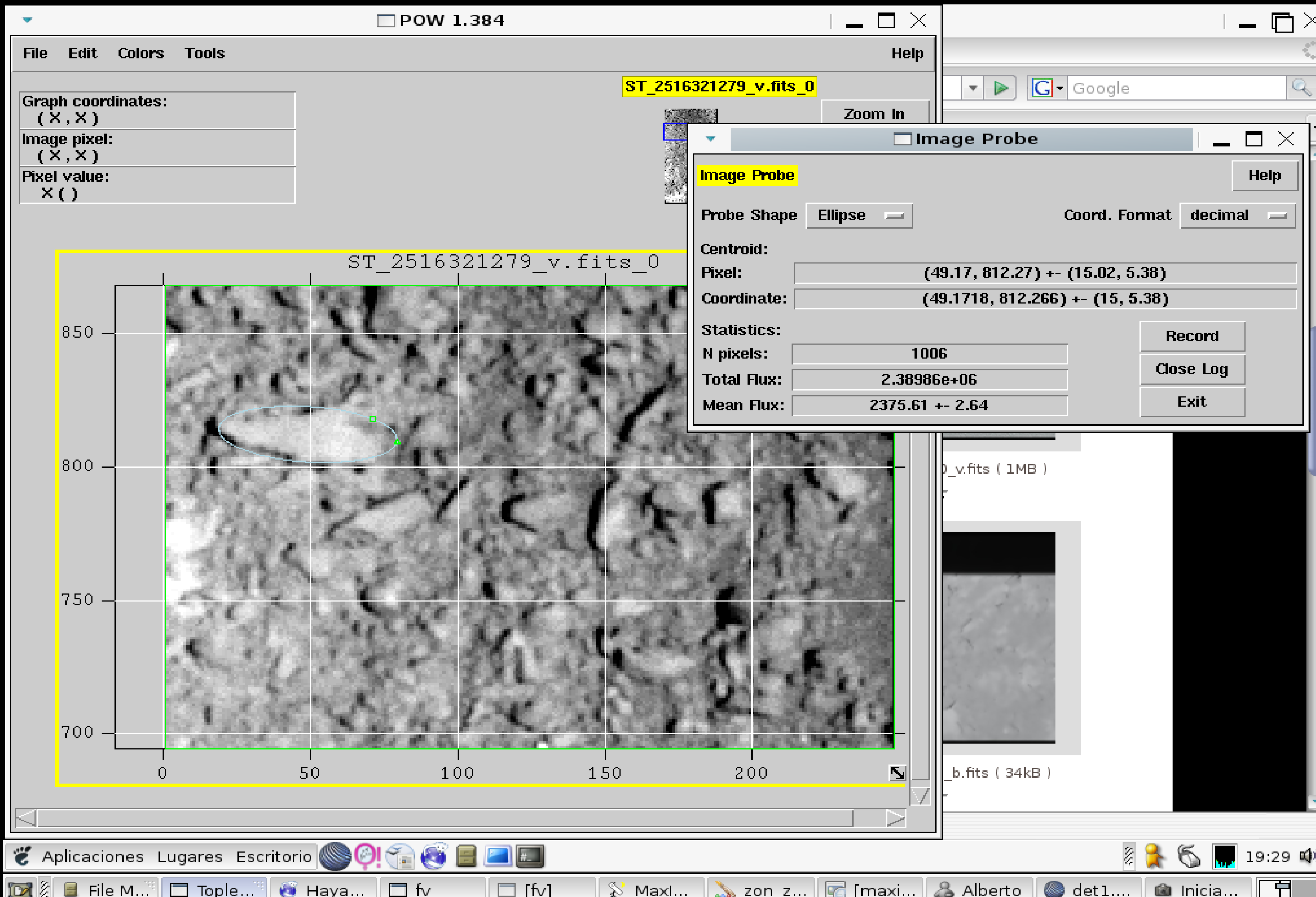




Counting...

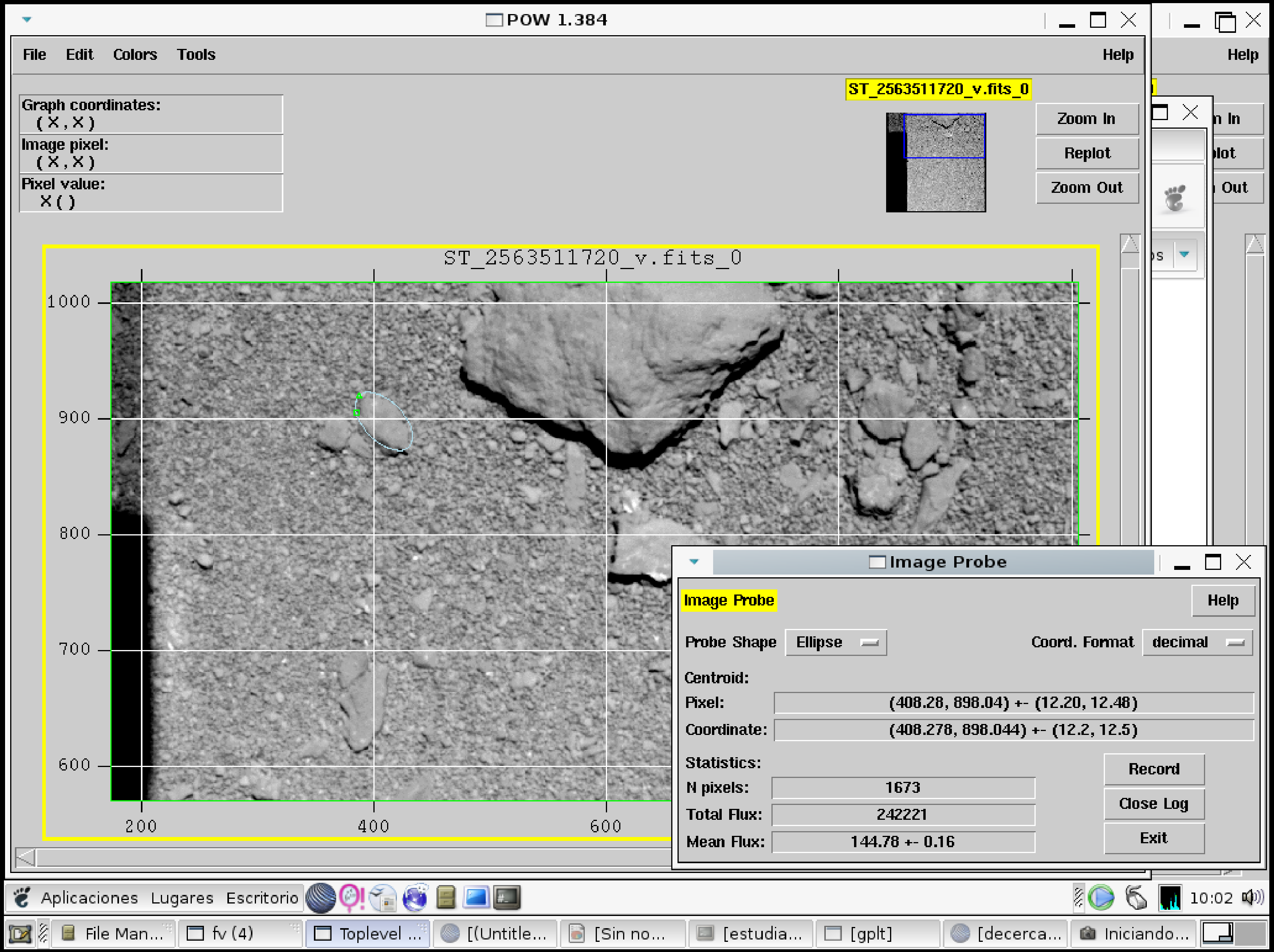

POW 1.384
File
Edit
Colors
Tools
Help
Graph coordinates:
(X , X)
Image pixel:
(X , X)
Pixel value:
X ( )
ST_2516321279_v.fits_0
Zoom In
Replot
Zoom Out
ST_2516321279_v.fits_0
1000
950
900
850
300
350
400
450
500
Image Probe
Image Probe
Help
Probe Shape
Ellipse
Coord. Format
decimal
Centroid:
Pixel:
(368.48, 883.19) +- (1.54, 2.78)
Coordinate:
(368.477, 883.189) +- (1.54, 2.78)
Statistics:
N pixels:
53
Total Flux:
115857
Mean Flux:
2185.98 +- 17.54
Record
Close Log
Exit
Aplicaciones
Lugares
Escritorio
19:14
File M...
Tople...
[Haya...
fv
[fv]
[Maxl...
[zon_...
maxi...
[Alber...
det1....
Inicia...

Counting...



POW 1.384
File
Edit
Colors
Tools
Help
Graph coordinates:
(X , X)
Image pixel:
(X , X)
Pixel value:
X ( )
ST_2516321279_v.fits_0
Zoom In
ST_2516321279_v.fits_0
850
800
750
700
0
50
100
150
200
Image Probe
Image Probe
Help
Probe Shape
Ellipse
Coord. Format
decimal
Centroid:
Pixel:
(49.17, 812.27) +- (15.02, 5.38)
Coordinate:
(49.1718, 812.266) +- (15, 5.38)
Statistics:
N pixels:
1006
Total Flux:
2.38986e+06
Mean Flux:
2375.61 +- 2.64
Record
Close Log
Exit
Google
_v.fits (1MB)
_b.fits (34kB)
Aplicaciones
Lugares
Escritorio
19:29
File M...
Tople...
Haya...
fv
[fv]
MaxI...
zon_z...
[maxi...
Alberto
det1....
Inicia...

Counting...

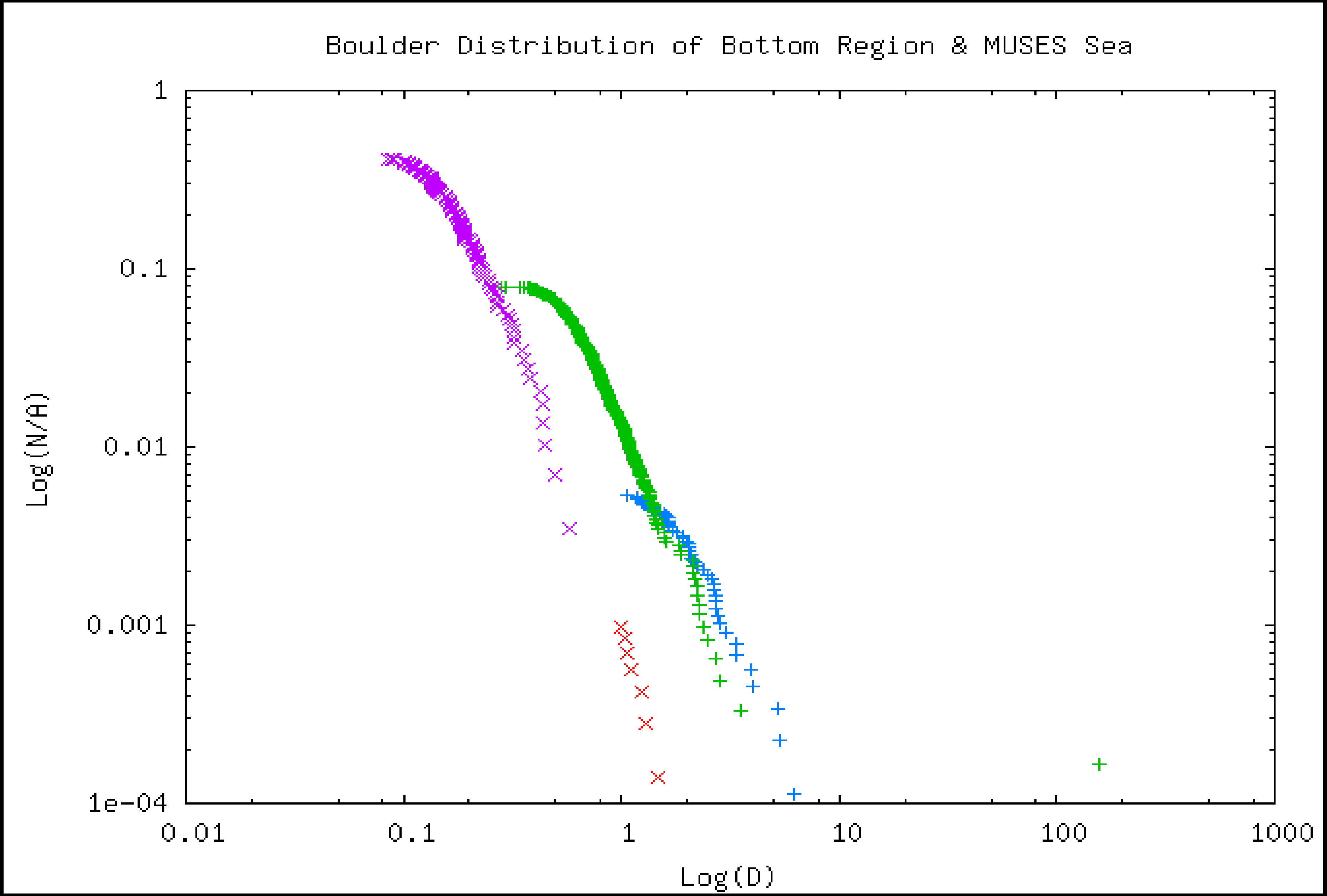


POW 1.384
File Edit Colors Tools Help
Graph coordinates:
Image pixel:
Pixel value:
ST_2563511720_v.fits_0
Zoom In
Replot
Zoom Out
1000
900
800
700
600
200
400
600
Image Probe
Help
Probe Shape Ellipse
Coord. Format decimal
Centroid:
Pixel: (408.28, 898.04) +- (12.20, 12.48)
Coordinate: (408.278, 898.044) +- (12.2, 12.5)
Statistics:
N pixels: 1673
Total Flux: 242221
Mean Flux: 144.78 +- 0.16
Record
Close Log
Exit
Aplicaciones Lugares Escritorio
10:02
File Man...
fv (4)
Toplevel ...
[(Untitle...
[Sin no...
[estudia...
[gplt]
[decerca...
Iniciando...

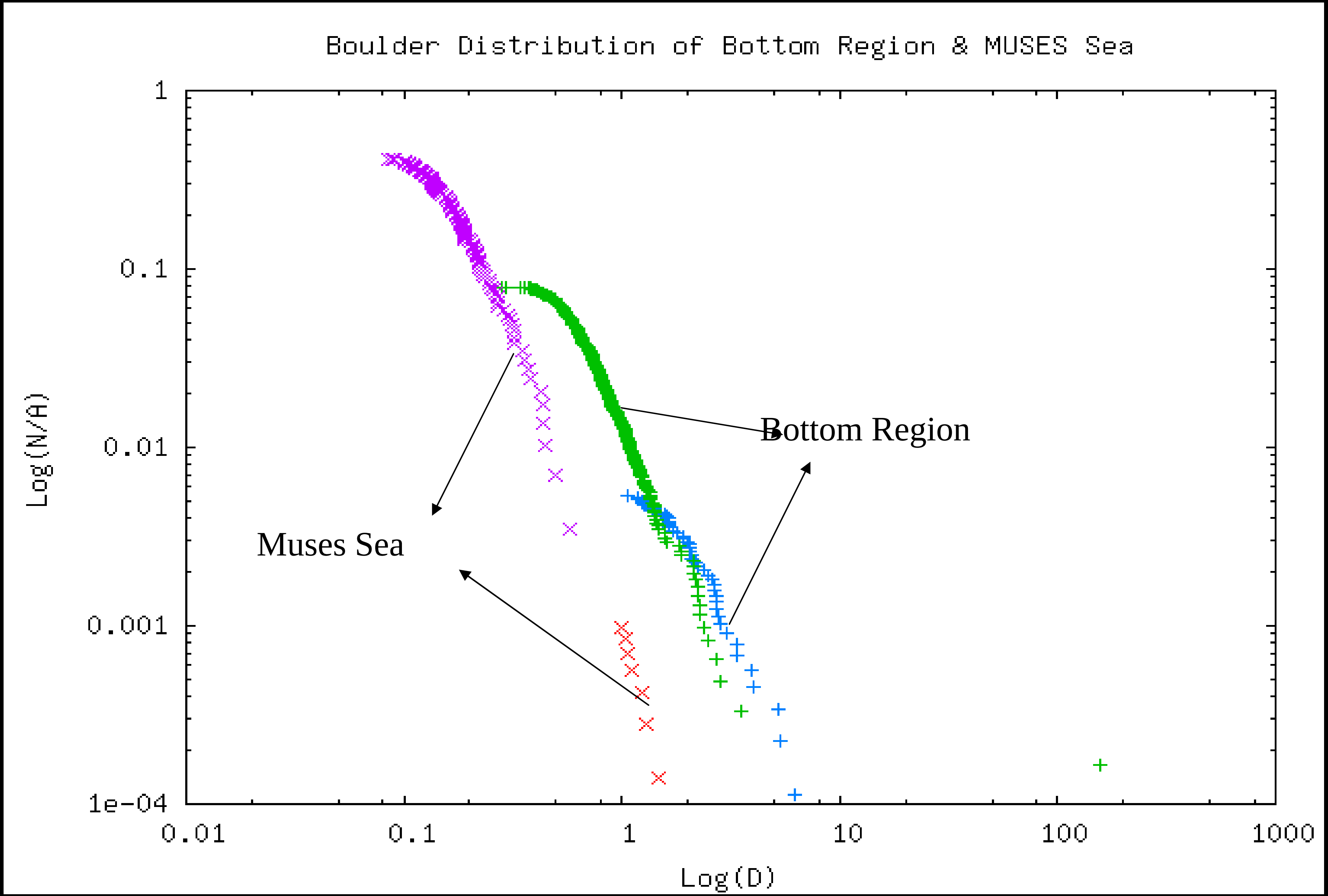
Software used

- Counting – Fits Viewer (NASA)
- Image display – Fits Viewer (NASA)
- Data reduction - Octave
- Graphics – Matlab & GNUPlot
- Image Processing – None (we didn't process images at this time, because we don't have much time)

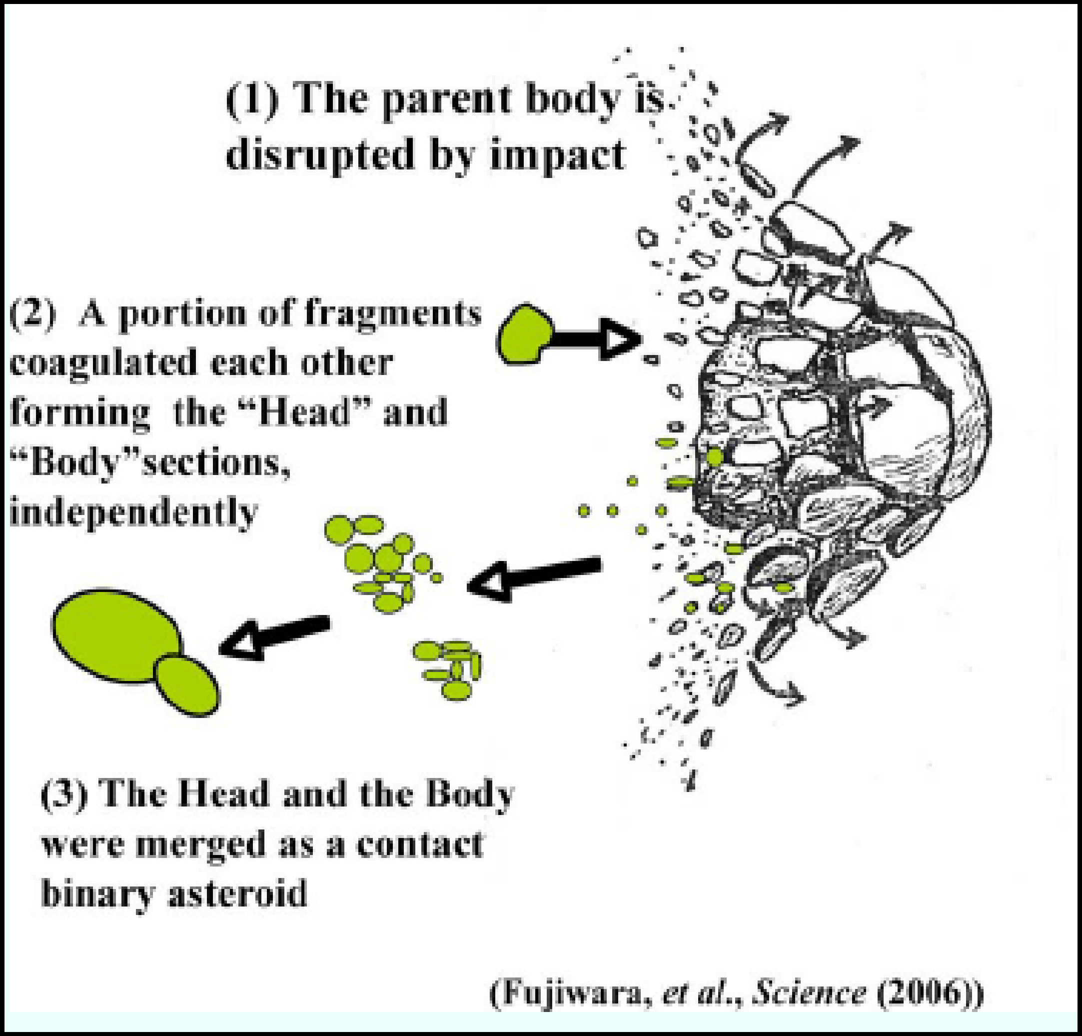
Boulder Distribution



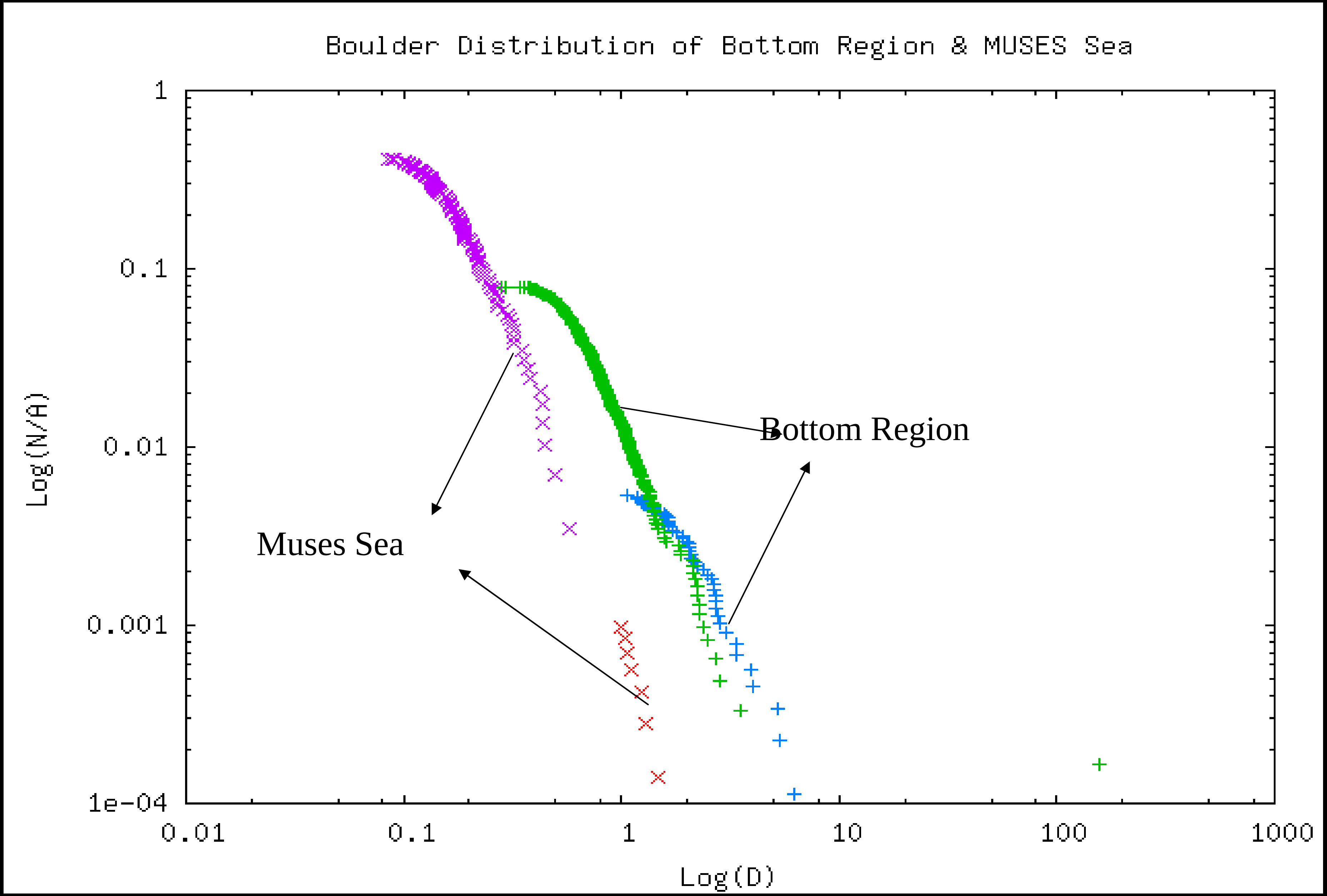
Boulder Distribution



Two pieces or a single rubble pile with bazilian nut effect?



Boulder Distribution



- Thanks...