Initial Results From a New AKARI/IRC Data Analysis Pipeline Optimised for Extragalactic Deep Field Images

IPMU talk

23rd July 2015

Introduction

- Which institute I have come from, and why I am visiting Japan
- 100 years of discoveries in Extragalactic Astronomy
- Out standing big Extragalactic questions
- How JAXA's satellite AKARI can help solve some of these questions
- Research work I have been doing with AKARI data
- My initial results
- Research I have been doing at ISAS/JAXA
- Future work

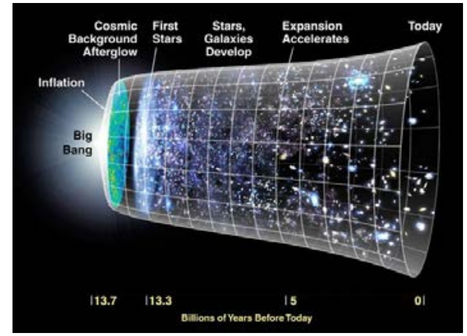
The Open University

The Open University
England

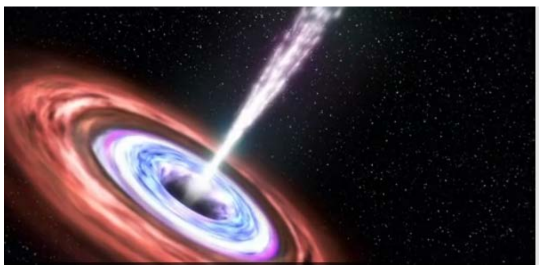
The Main Extragalctic Discoveries

1929

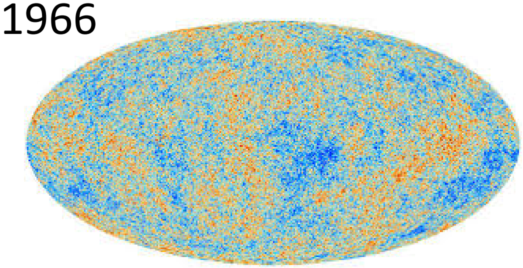
1931



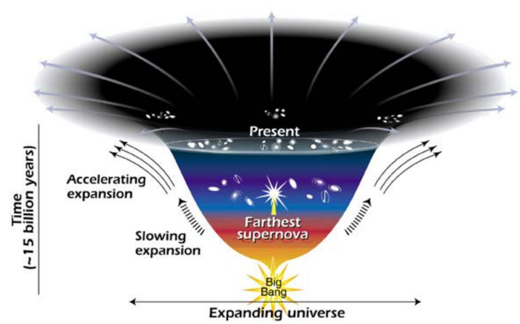
1963



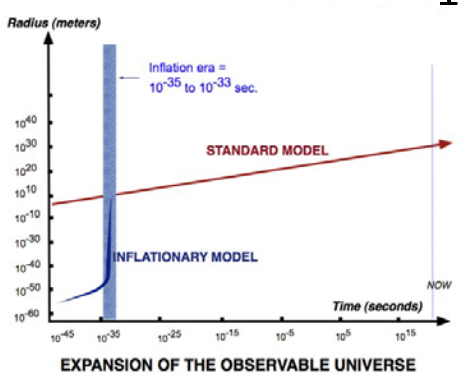
1966



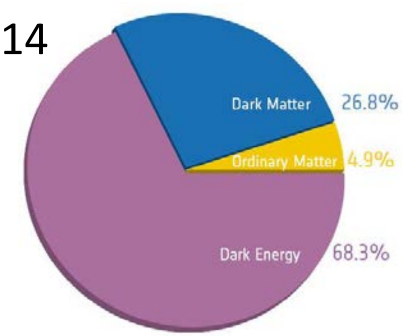
1998



1980

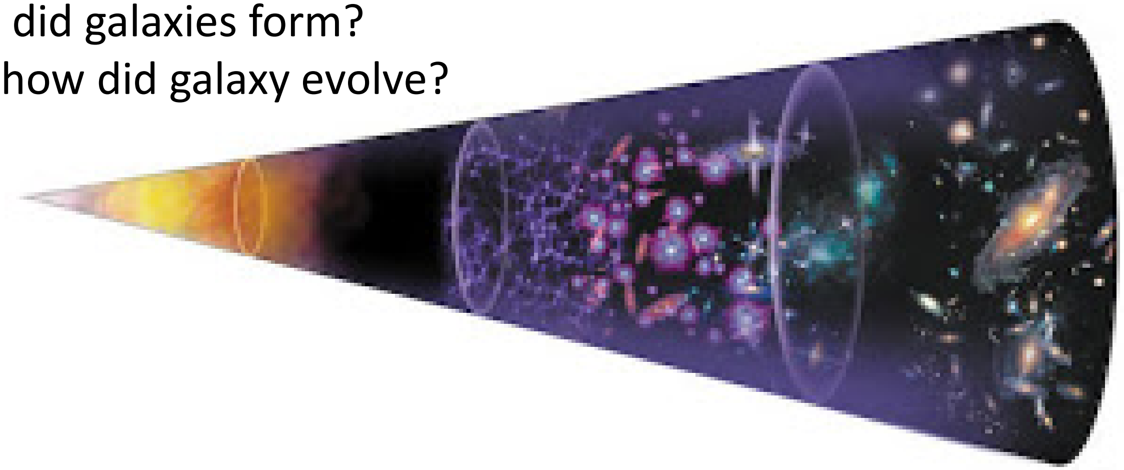


2014



There Are Still Many Big Extragalactic Questions

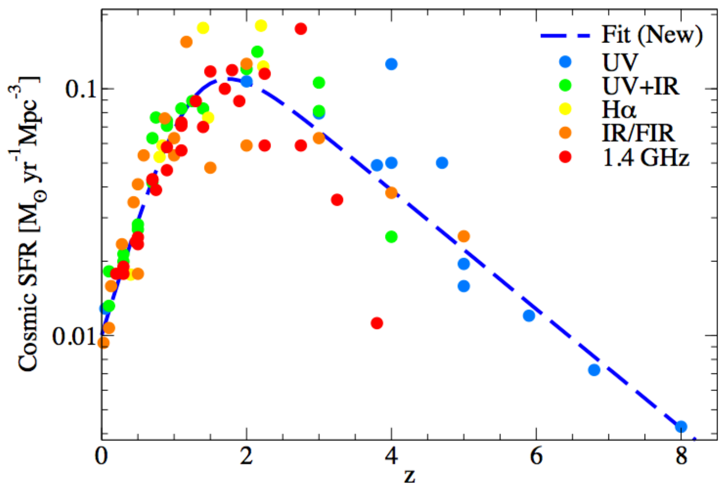
- What were the first stars in the Universe like?
- How did large scale structure evolution during cosmic dark ages?
- What caused reionisation - the first luminous objects after the big bang?
- What is causing the accelerated cosmic expansion
- How did galaxies form?
- And how did galaxy evolve?



Multi-wavelength data is required to answer these questions
And the mid-infrared is key to fully answer them!

Why AKARI is Important

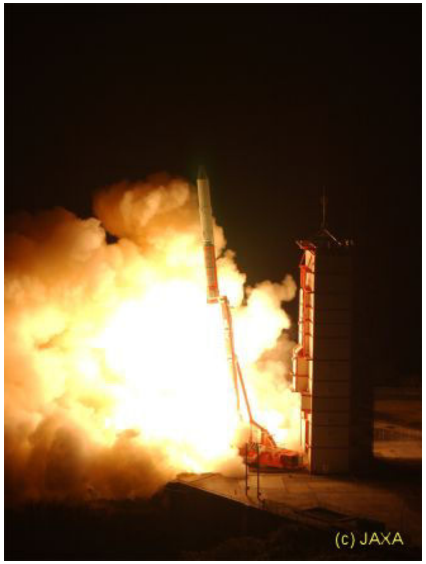
- Star formation peaks in galaxies between a
- redshift of 1 and 3
- AKARI/IRC deep fields can observe this redshift
- Using AKARI data with multi-wavelength data we can test galaxy evolution models



Behroozi et al. 2013

- AKARI observes in mid-infrared
- This is an important wavelength range
- AKARI covered the Spitzer/MIPS – Spitzer/IRAC band gap
- AKARI is able to observe deeply a wavelength range not covered by another other satellite
- There are over 5000 AKARI/IRC near/mid-infrared pointings in archive data at ISAS/JAXA

AKARI



AKARI – Japan's first dedicated Infrared satellite developed by ISAS/JAXA and collaborators

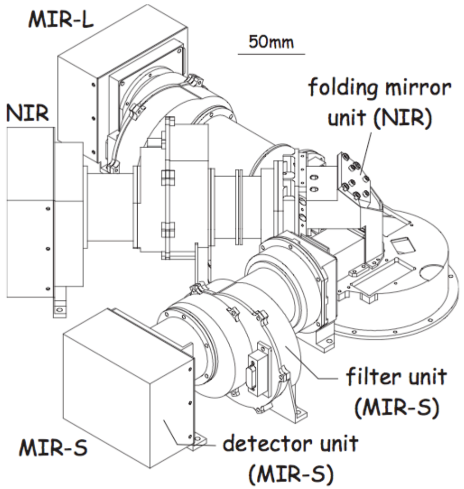
Operational April 2006 – November 2011

Instruments onboard:

InfraRed Camera – IRC

Far-Infrared Surveyor – FIS

The AKARI archive is maintained at ISAS/JAXA



The IRC

The IRC, contains 9 filters

2.4, 3.2, 4.1µm – near-infrared

7.0, 9.0, 11.0µm – short mid-infrared

15.0, 18.0 & 24.0µm – long mid-infrared

1 prism observing at: 1.8–5.2µm

4 grisms observing at: 2.5-5.0, 5.4-8.4, 7.5-12.9 & 17.5-25.7µm

AKARI/IRC Phase 2 data Pipeline optimised for processing extragalactic deep fields

Original pre-pipeline
Slicing the 3D data cubes

→ Wraparound correction
↓ Dark subtraction
↓ Normalisation
↓ Linearity
↓ Cosmic ray removal
↓ Mask anomalous pixels
↓ Flat fielding
↓ Create noise image
↓ Distortion correction
↓ Earth shine correction
↓ Scattered light correction
↓ Astrometry correction

→ Post-pipeline
Mosaicking

Original pre-pipeline
Slicing the 3D data cubes

→ Wraparound correction
↓
Dark subtraction
↓
Normalisation
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Linearity
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Cosmic ray removal
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Mask anomalous pixels
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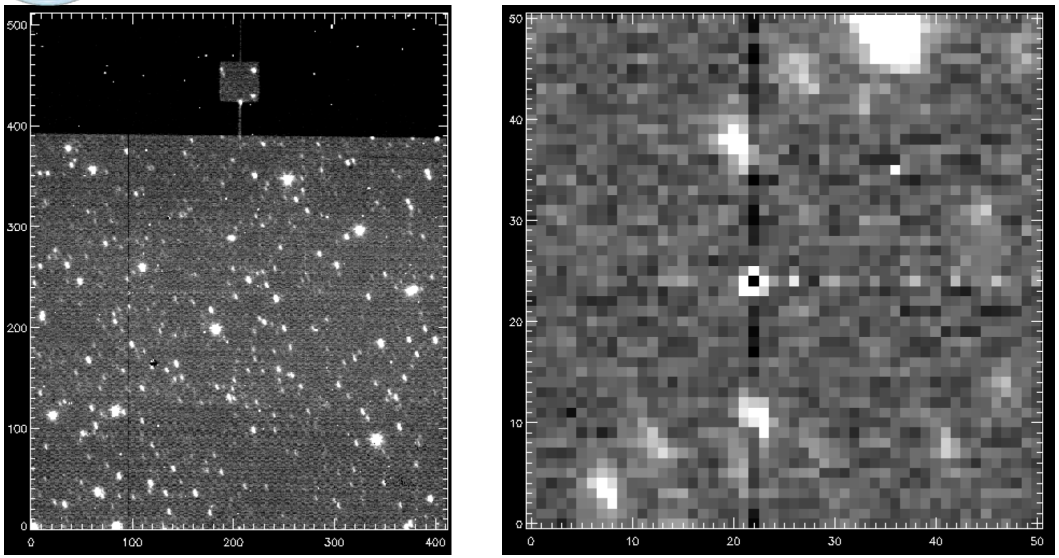
Flat fielding
↓
Create noise image
↓
Distortion correction
↓
Earth shine correction
↓
Scattered light correction
↓
Astrometry correction → Post-pipeline
Mosaicking

AKARI/IRC Phase 2 data Pipeline optimised for processing extragalactic deep fields

Saturated pixels affecting the row

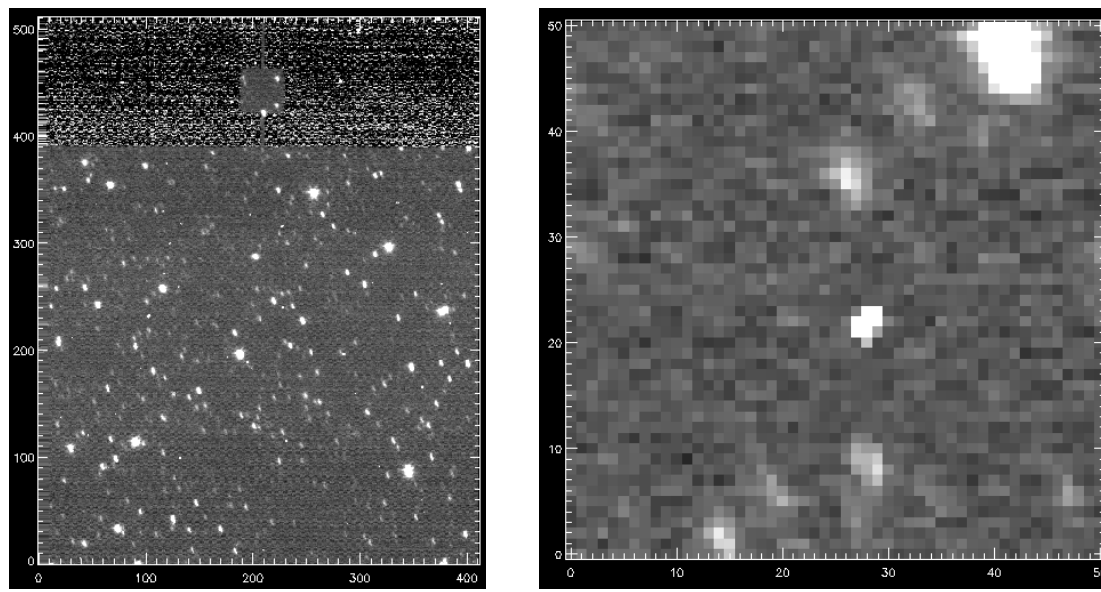


- After a saturated pixel in N detector image every 4th pixel's flux is overly bright
- This continues for a row or two
- It is every 4th pixel because there are 4 nodes
- After a saturated pixel in N detector image all pixels in the column above are overly dim

An N3 raw image

Processed image

- Every 4th pixel after a saturated pixel is masked for 2 rows
- All pixels in the same column as a saturated pixel are masked
- Currently we do not know why there is a vertical line beneath a saturated pixel



An N3 processed image

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AKARI/IRC Phase 2 data Pipeline optimised for processing extragalactic deep fields

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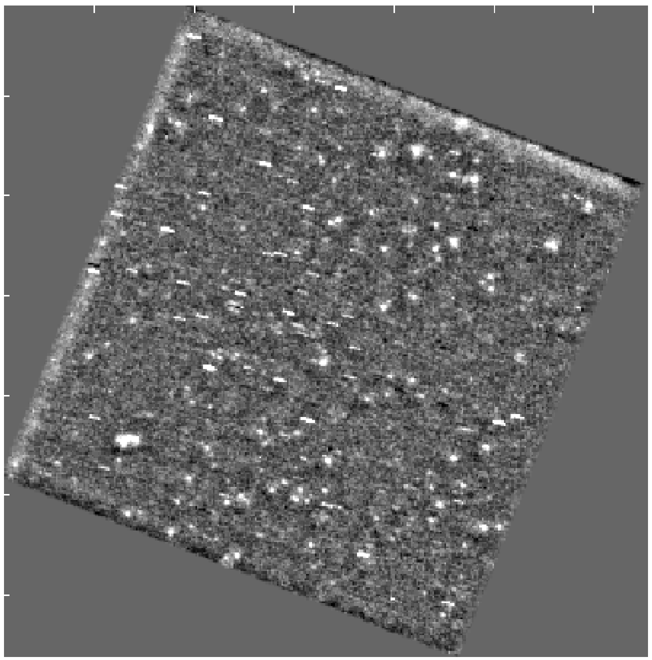
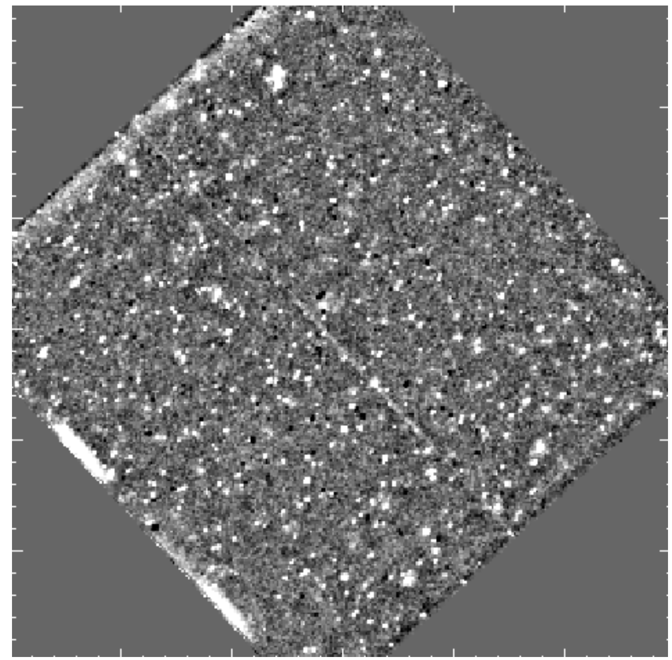
Bad pixels in later phase 2 data

All detectors have a lot more hot/bad/damaged pixels in later phase 2 data



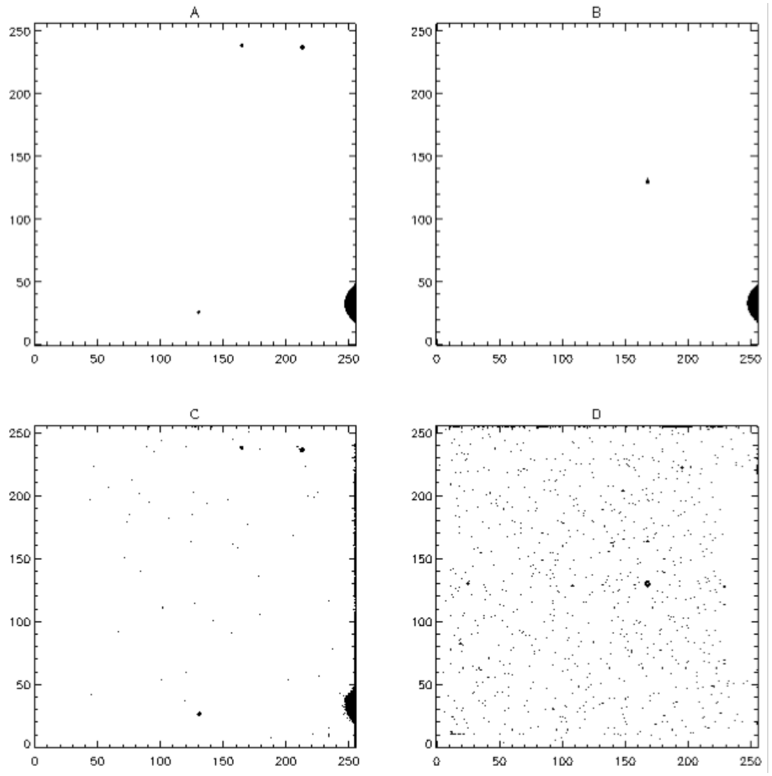
L15 October 2006



L15 April 2007

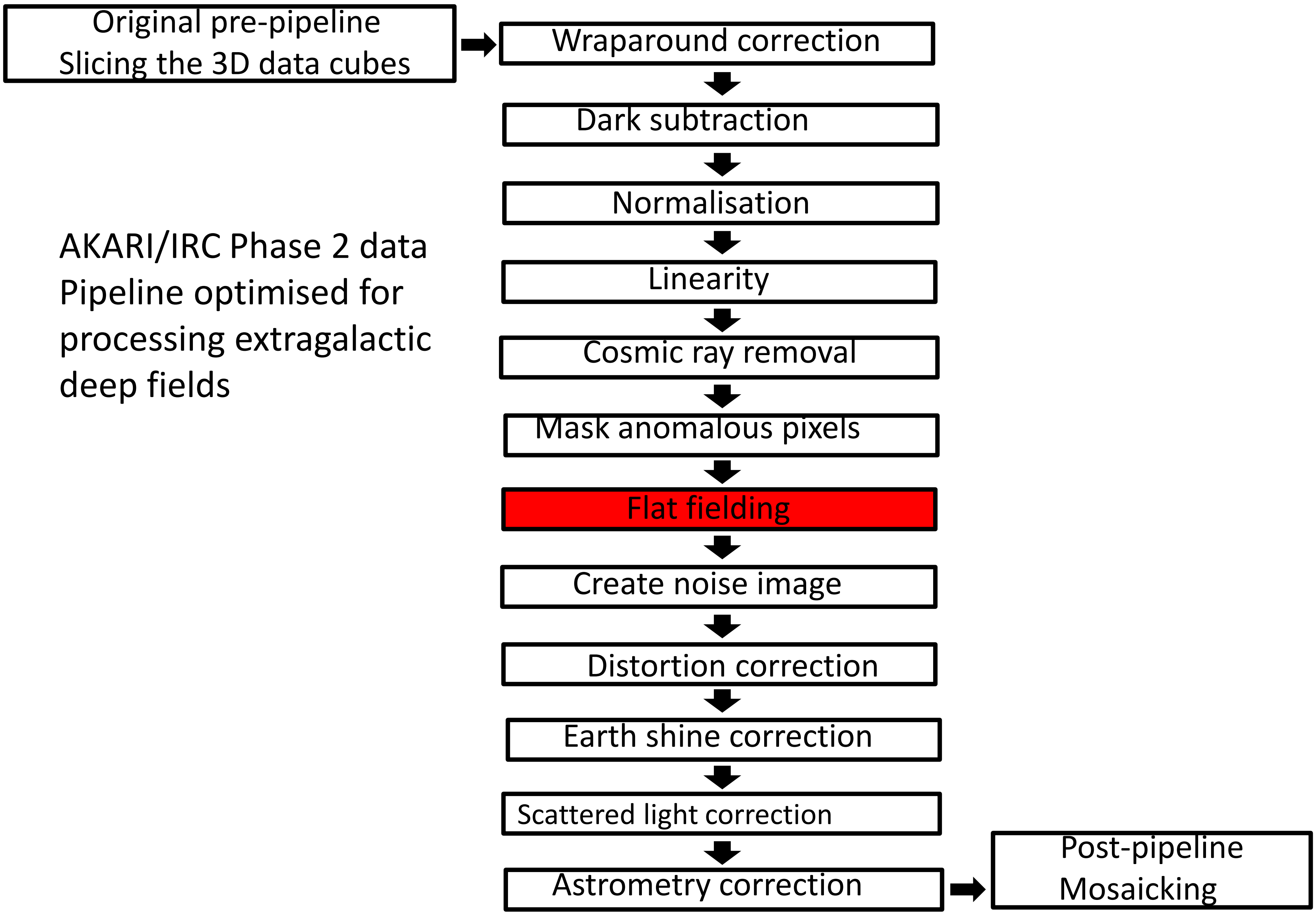
The same area of sky, just rotated

New bad pixel masks



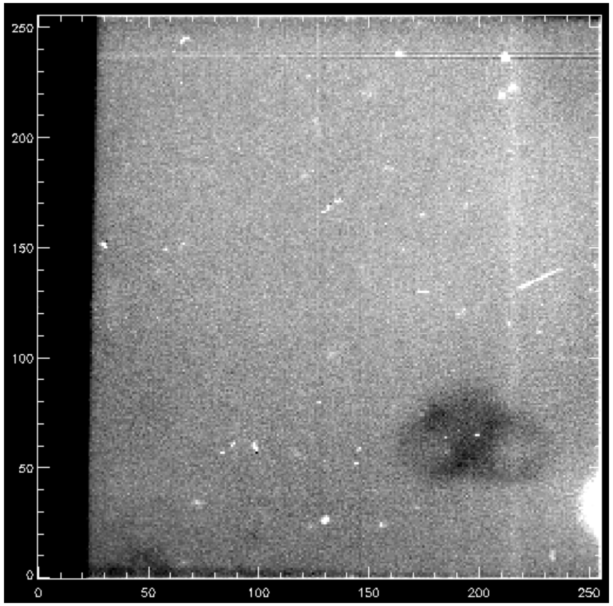
A – original S-band bad pixel mask
B – original L-band bad pixel mask
C – new S-band bad pixel mask
D - new S-band bad pixel mask

AKARI/IRC Phase 2 data Pipeline optimised for processing extragalactic deep fields

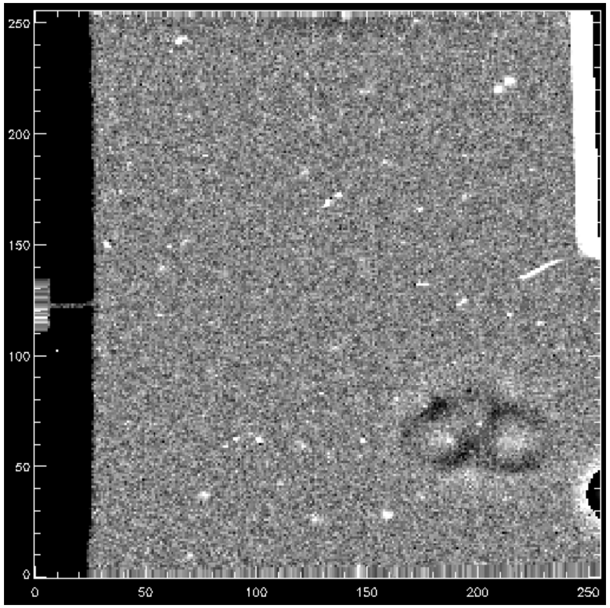


The Bean

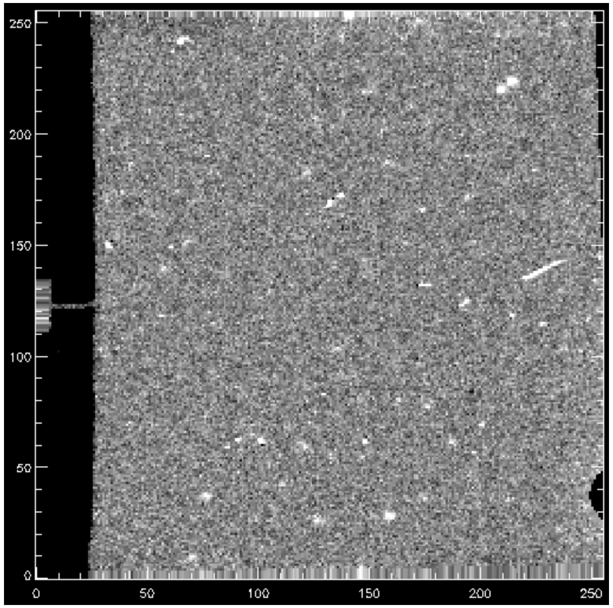
MIRS detector images taken before 07/01/2007 suffer from the Soramame (sky-Bean)
Creating a very time dependent flat (ie using images from no more than 2 days difference from the pointing) removes the Soramame



Raw frame



processed frame using generic phase 2 flat



Processed frame using time dependent flat

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Slicing the 3D data cubes

AKARI/IRC Phase 2 data Pipeline optimised for processing extragalactic deep fields

Wraparound correction

Dark subtraction

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Flat fielding

Create noise image

Distortion correction

Earth shine correction

Scattered light correction

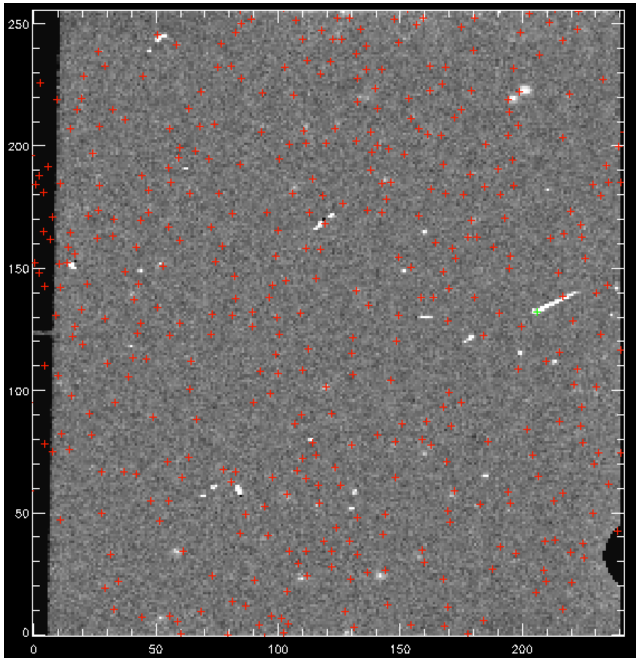
Astrometry correction

Post-pipeline
Mosaicking

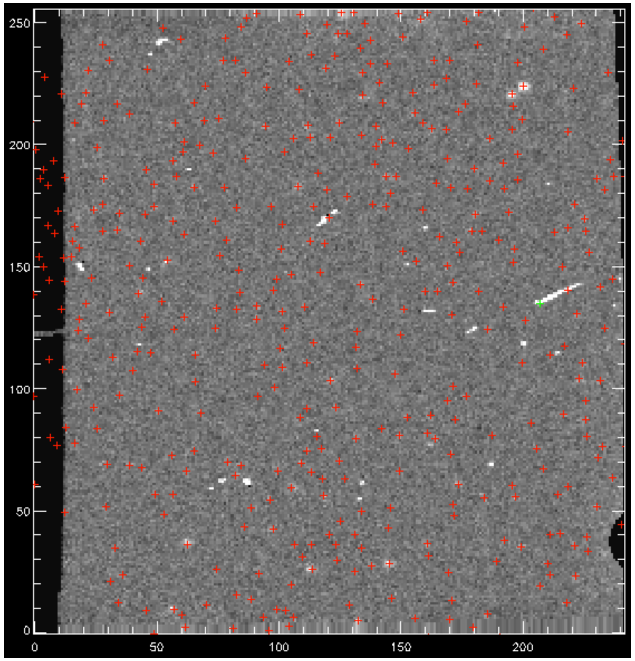
Distortion correction

AKARI/IRC MIR frames suffer from a distortion
The new pipeline corrects the aspect ratio and distortion using a second order polynomial

Below is a processed single S11 frame, over plotted is WISE



Jitter corrected in the centre but not distortion corrected



Jitter and distortion corrected

Original pre-pipeline
Slicing the 3D data cubes

AKARI/IRC Phase 2 data
Pipeline optimised for
processing extragalactic
deep fields

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Post-pipeline
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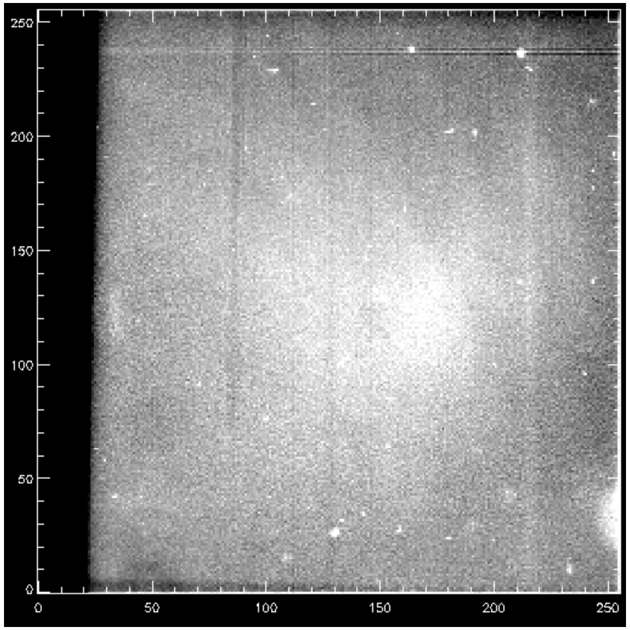
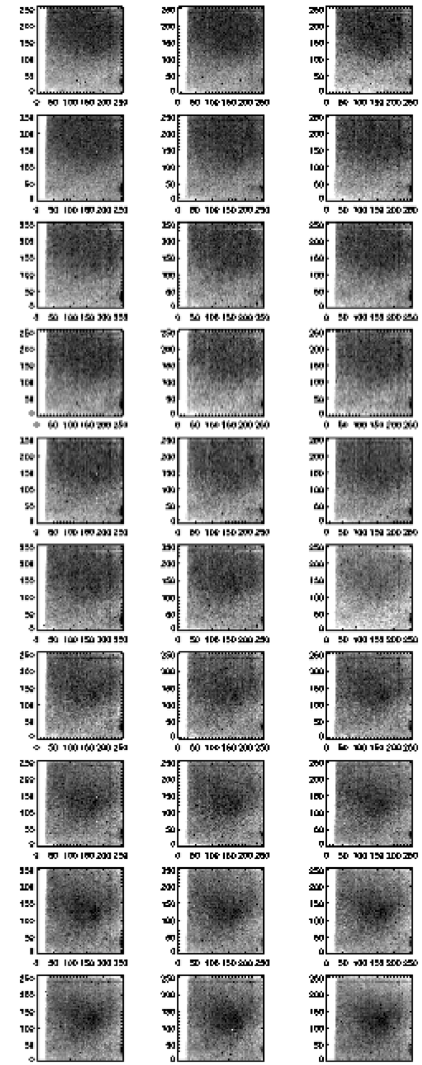
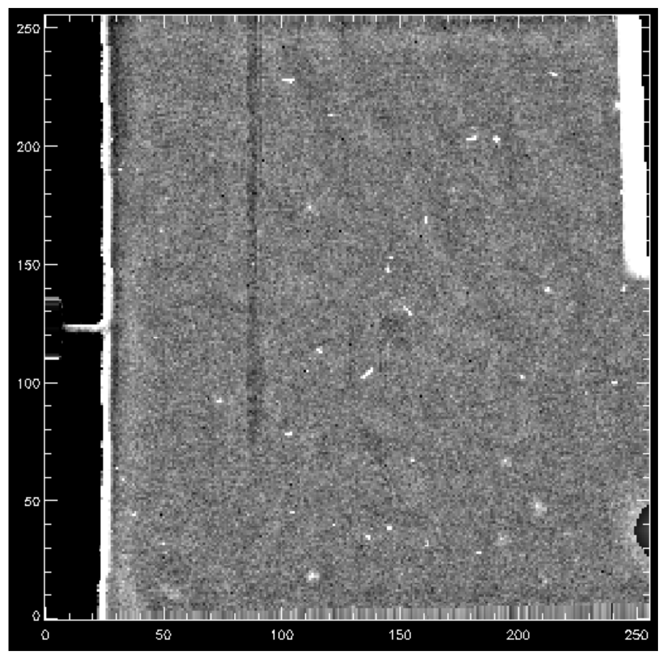
Removal of Earthshine Light



Reflected light from the Earth
Effects filters: N2, S7, S9, S11, L15, L18 & L24
This can vary position
on frames from the same pointing



The extragalactic pipeline removes this artefact individually on each image by creating a boxcar median filtered image, and subtracting that from the original image.



Original pre-pipeline
Slicing the 3D data cubes

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Post-pipeline
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AKARI/IRC Phase 2 data
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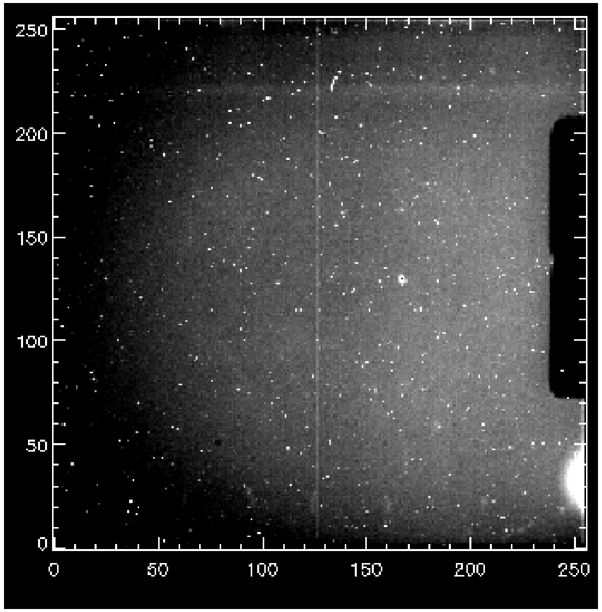
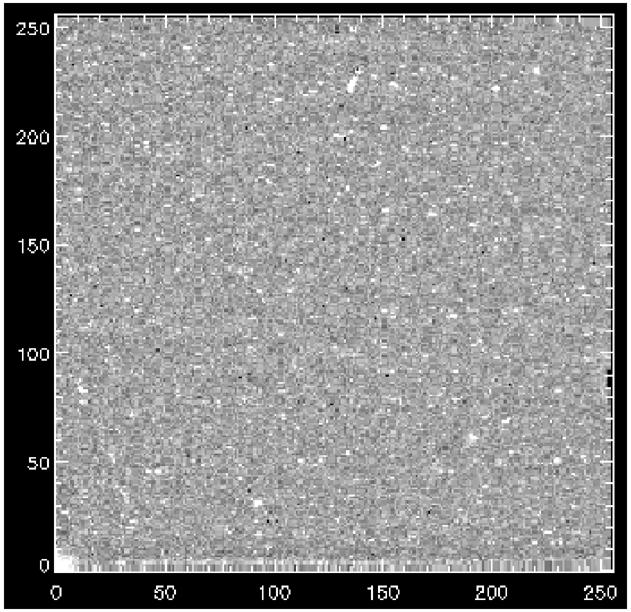
L15 gradient change of flux across a frame



L15 raw image

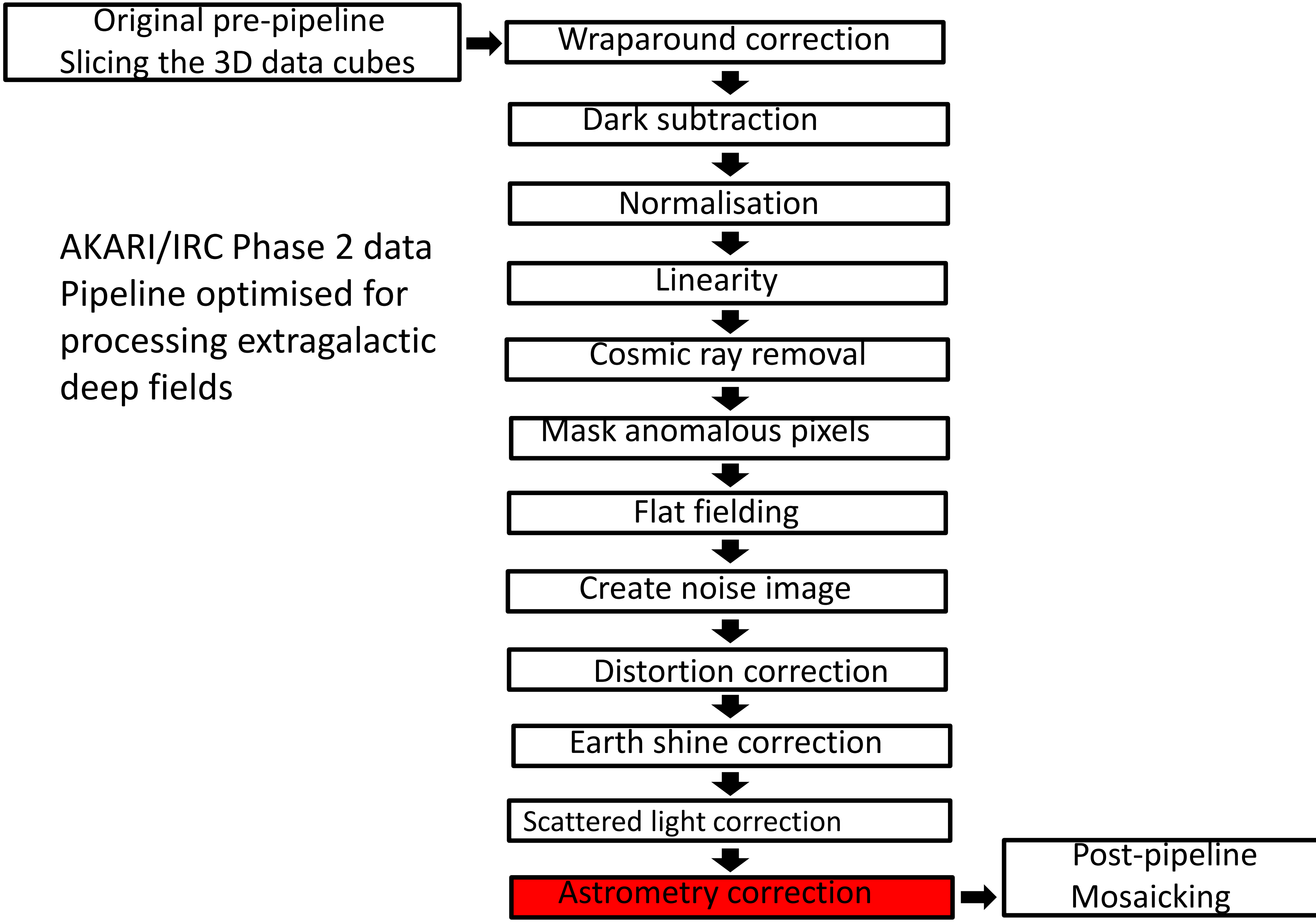
It is believed the gradient change of flux across the image is caused by light reflecting off the array or filter. It is not the light reflected off the detector – like scattered light in the S band

The extragalactic pipeline removes this artefact individually on each image by creating a boxcar median filtered image, and subtracting that from the original image.



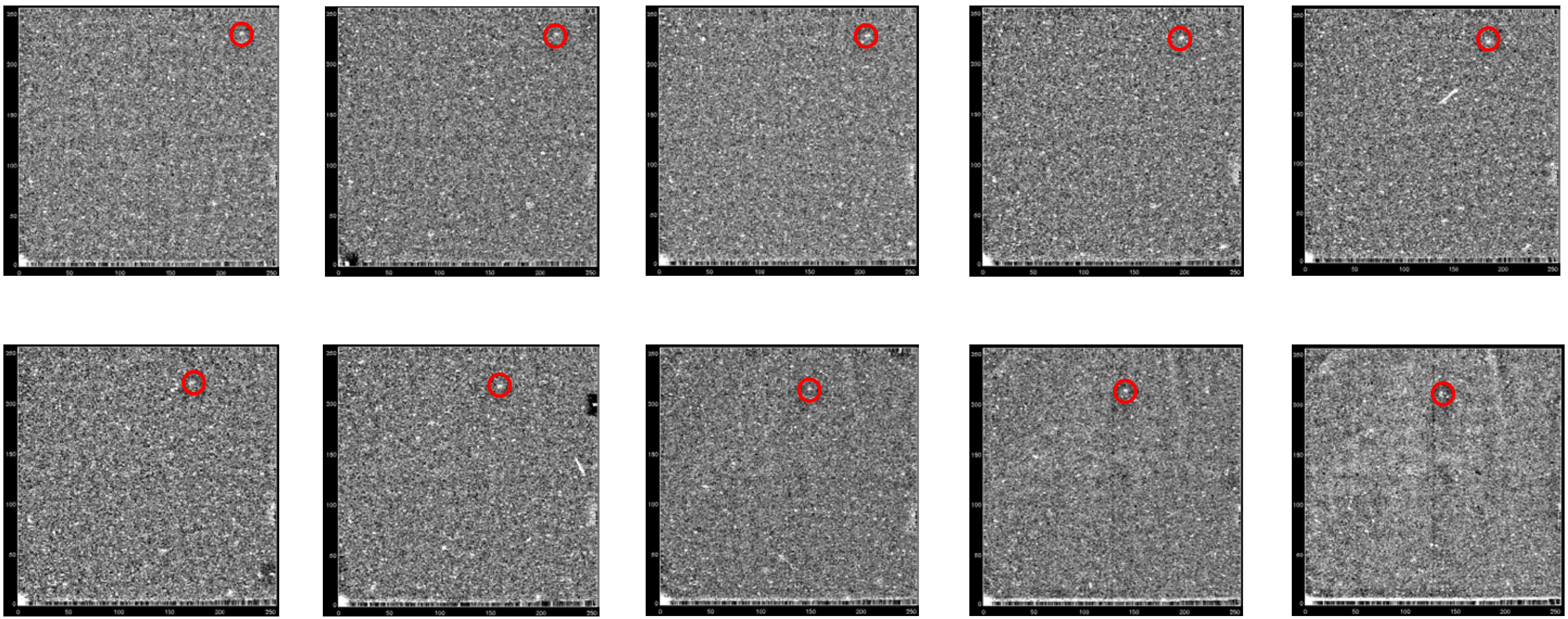
L15 processed image

AKARI/IRC Phase 2 data
Pipeline optimised for processing extragalactic deep fields

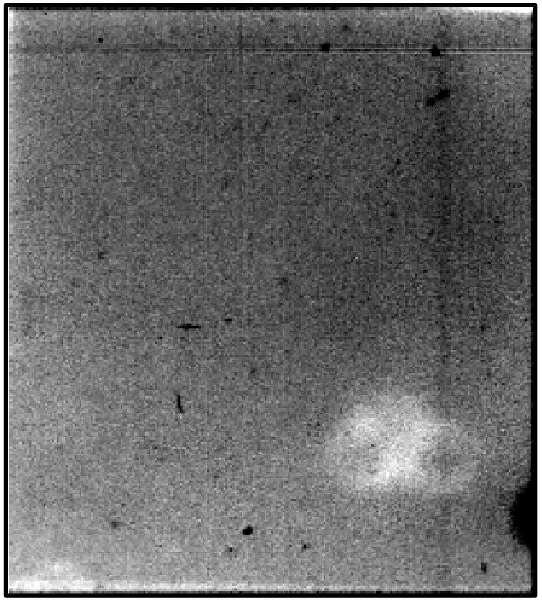


Large astrometry error

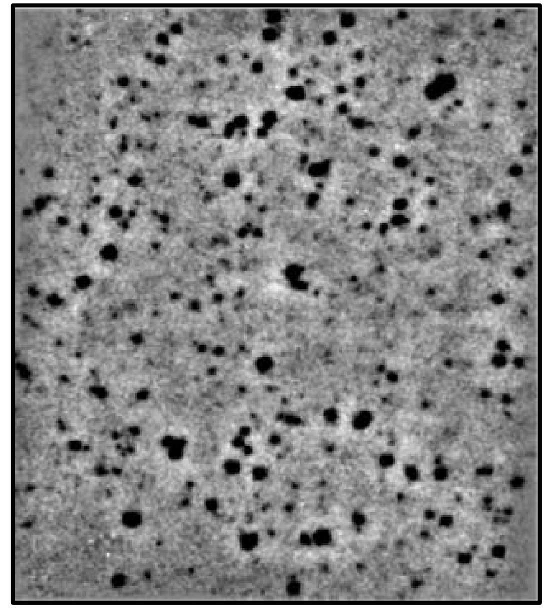
Example of a large amount of positional drift in L15 ELAIS N1
The Astrometry correction step corrects for this



Initial Results

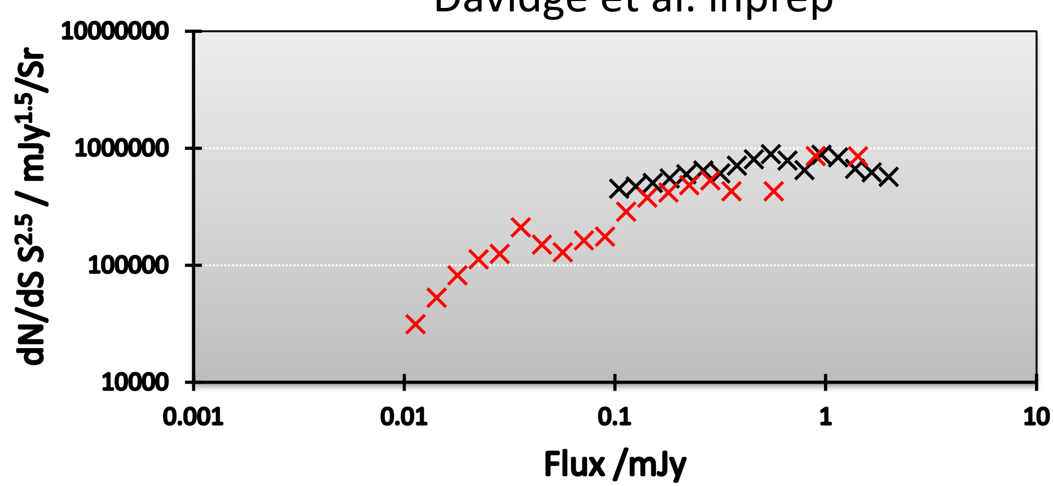


A raw AKARI/IRC image



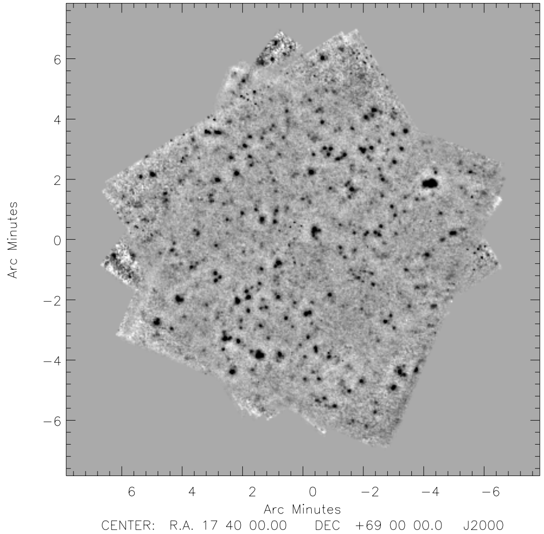
The 11 Micron IRAC Validation Deep Field
A process extragalactic deep field
Davidge et al. inprep

11 Micron Number Counts
Red crosses number counts from the new pipeline
Black crosses Murata et al. 2014 – AKARI/IRC NEP number counts

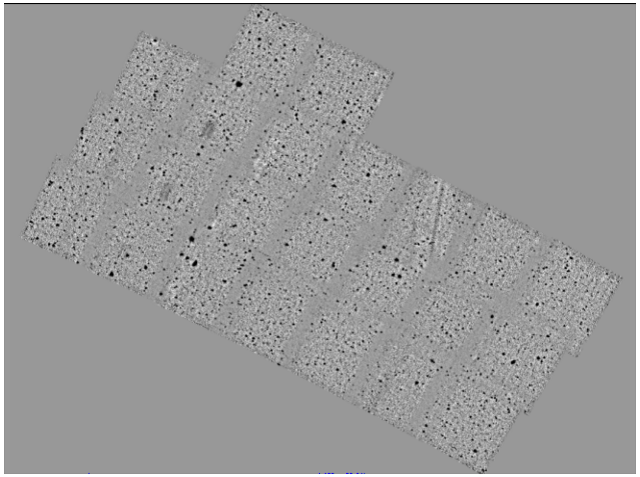


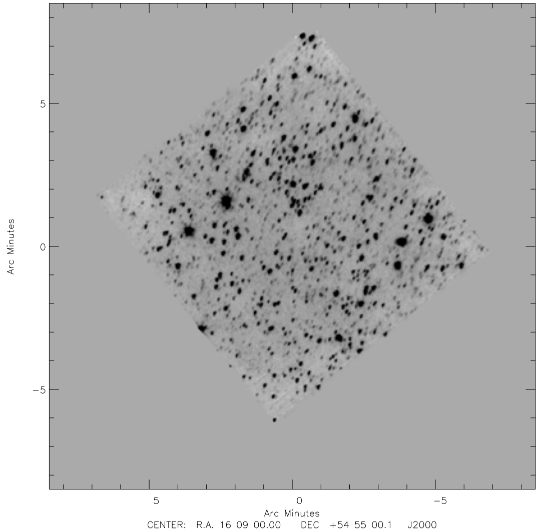
Research While at ISAS

- Collaborating with the AKARI/IRC team
- Improving the extragalactic pipeline
- Creating extragalactic deep field images
- Obtaining galaxy number counts
- Beginning Spectral Energy Distribution fitting



L15 filter IRAC Validation Field


S11 filter SEP – a shallow field



N4 filter ELAIS N1

Future Work

Work for Thesis

- To continue processing the three Extragalactic deep fields
- To perform Spectral Energy Distribution fitting on galaxies found in AKARI images
- Measure how much the Cosmic Infrared Background is resolved by the AKARI galaxies

Collaborative work

- Using L15 IRAC Validation Field images as a prior for detecting Herschel sources
- Further investigation of AGNs using the multi-wavelength AKARI images

Conclusions

- There are still many outstanding Extragalactic questions
- Multi-wavelength data, especially from the mid-infrared, is vital to answer these questions
- A new pipeline, optimised for extragalactic deep field images, has been presented
- The initial results from the new pipeline have been shown
- The galaxies in the newly processed images will be used to
    - Constrain galaxy evolution models
    - Perform Spectral Energy Distribution fitting
    - Find galaxies in Herschel Space Telescope images
    - Investigate specific types of galaxies, eg AGNs
    - Resolve part of the Cosmic Infrared Background