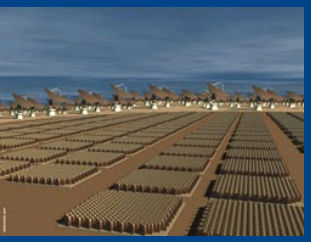

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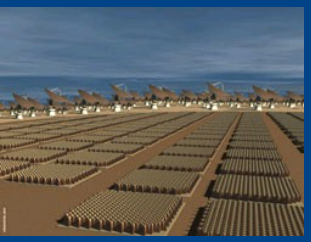
Classic AIPS

versus

AIPS++

Dharam Vir Lal



Classic AIPS *vs* aips++

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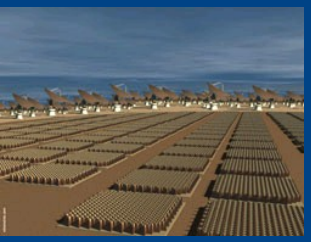
Plan

- Classic AIPS
  - Typical session
- aips++
- Similarities / Differences
- …

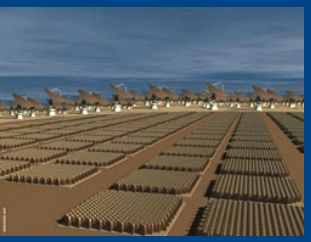


Classic AIPS

The NRAO AIPS is a software package for interactive (and, optionally, batch) calibration and editing of radio interferometric data and for the calibration, construction, display and analysis of astronomical images made from those data using Fourier synthesis methods.

- Development 1978
  - Over 4300 files containing 1.46 million lines of text.
  - Over 2300 Fortran and C source files
- 350 distinct application “tasks”.

Free Software foundation’s General Public Licence.



aips++

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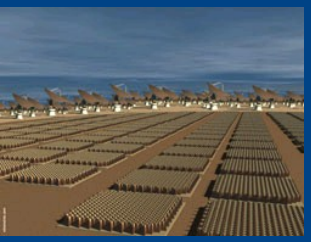
aips++ provides facilities for calibration, editing, image formation, image enhancement, and analysis of images and other astronomical data. A major focus is on reduction of data from both single-dish and aperture synthesis radio telescopes.

- Tool-based approach

  programmable by the user
- Mouse driven Graphical User Interfaces
- Programmed to be flexible and versatile to use.

Free Software Foundation's General Public License.



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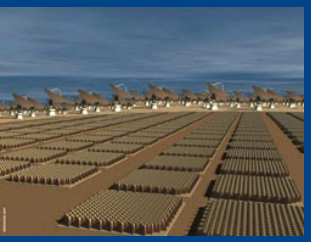
AIPS++

- C++
  - Bulk of code (> 1,700,000 lines)
  - C++ libraries have wide range of general utilities for data access, display, calibration and imaging.
  - Connected to IDL-like command language and GUI interface



aips++

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aips++ grand tour

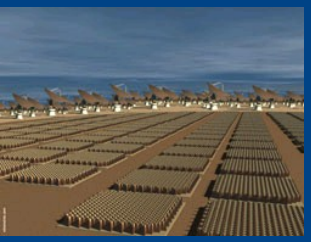
Glish

logger

Standard gui

viewer

http://aips2.nrao.edu/docs/presentations/presentations.html



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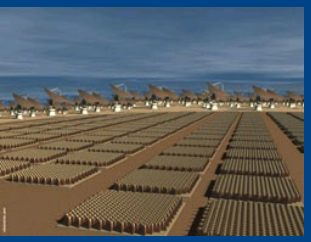
aips++

Tools: General purpose

- table:
  - access to all AIPS++ data
- tablebrowser:
  - edit, plot, query, and select data. Configurable.
- viewer:
  - display images, tables, measurementsets
- pgplotter:
  - plotting of Glish variables using the Caltech PGPLOT library
- quanta and measures:
  - measured quantities with units, coordinates, and reference frames; and their conversion
- catalog:
  - file manager

http://aips2.nrao.edu/docs/presentations/presentations.htm



Dictionary

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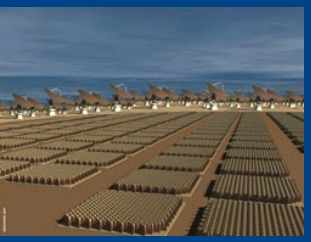
Software AIPS / aips++

AIPS Task/Verb	Description	AIPS++ tool/functic
APCLN	CLEAN deconvolution	imager.clean
BLCAL	Baseline-based (A,ϕ) calibration	calibrater.solve
BLING	Baseline-based fringe-fitter	*not yet available*
BPASS	Bandpass calibration	calibrater.solve
CCEDT	Edit CC tables	componentmodels
COMB	Image combination	image.calc
		imagepol
CPASS	Polynomial bandpass calibration	calibrater.solve
CALIB	(A,ϕ) self-calibration	calibrater.solve
DBCON	uv-data concatenation	*not yet available*
DTSIM	Simulator	simulator
DTSUM	uv-data summary	ms.summary
FILLM	VLA filler	vlafiller
FITLD	VLBA filler	*not yet available*
FITTP	UVFITS writer	ms.tofits
FRING	VLBI fringe-fitter	*not yet available*
GETJY	Set flux density scale	calibater.fluxscale
IBLED	Interactive VLBI editor	*not yet available*
IMAGR	Synthesis imaging	imager
IMFIT	Image-plane component fitter	imagefitter

IMLOD	FITS image filler	image.imagefromfits
IMH	File header summary	table.summary
IMSTAT	Image statistics	image.statistics
ISPEC	Plot image slice	*not yet available*
JMFIT	Image-plane component fitter	imagefitter
LISTR	List uv- and calibration data	tablebrowser
MCAT	List image catalog	catalog
MK3IN	MK3 VLBI filler	*not yet available*
MOVE	Move uv-data files	tablecopy
MSORT	Sort uv-data	tablecommand
MX	Synthesis imaging	imager
PBCOR	Primary beam correction	imager.setvp
		vpmanager
PCAL	Polarization calibration	calibrater.solve
PRTAB	List table data	tablebrowser
PRTAN	List AN table data	tablebrowser
PRTUV	List uv-data	tablebrowser
RENAME	Rename file name	tablerename
SETJY	Set source properties	imager.setjy
SNPLT	Plot calibration solutions	calibrater.plotcal
SUBIM	Extract sub-image	image.subimage
SPFLG	Interactive line data editing	*not yet available*

http://aips2.nrao.edu/docs/presentations.htm

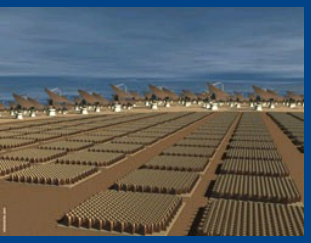


Dictionary

Software AIPS / aips++

AIPS Task/Verb	Description	AIPS++ tool/function
SPLIT	Apply calibration	calibrater.correct
		map.applycal
TAPLT	General table plotting	pgplotter
		table
TBIN	Read table from ASCII format	tablefromascii
TBOUT	Write table to ASCII format	table.toascii
TRANS	Transpose an image	*not required in AIPS++*
TVBOX	Set regions in an image	regionmanager
TVFID	Adjust TV display	viewer
TVFLG	Interactive TB data editing	msplot
TVLOD	Load image to TV display	viewer
UCAT	List uv-data catalog	catalog
UVCON	Simulator	simulator
UVFIT	uv-plane component fitter	*not yet available*
UVFLG	Command-based flagging	flagger
UVLOD	UV-FITS filler	ms.fitstoms
UVMOD	Simulator	simulator
UVPRT	List uv-data	tablebrowser
UVSRT	Sort uv-data	tablecommand
UVSUB	Source model computation	imager.ft
VBGLU	Concatenate VLBI data	*not yet available*
VBPLT	Baseline-based uv-data plotting	msplot
VMEM	MEM deconvolution	imager.mem
VPLOT	Baseline-based uv-data plotting	msplot

http://aips2.nrao.edu/docs/presentations/presentations.htm



Similarities 1

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Data Reduction Steps

Loading Visibility Data into AIPS++

AIPS FILLM	-	AIPS++ vla.vlafiller	- Loading Data from a VLA Filler Tape
AIPS FITLD	-	AIPS++ ms.fitstoms	- Loading Data from an AIPS FITS File

Viewing Visibility Data

AIPS UC,MC	-	AIPS++ File Catalog GUI	- File Management: List, Copy, Delete
AIPS IMHEAD	-	AIPS++ ms.summary	- Displays File Header Data
AIPS PRTAN	-	AIPS++ ms.summary	- Displays an Antennas List
AIPS PRTSU	-	AIPS++ ms.summary	- Displays a Sources List
AIPS PRTUV	-	AIPS++ tablebrowser	- Displays Complete Visibility Records
AIPS LISTR	-	AIPS++ (none)	- No LISTR functionality in AIPS++
AIPS PLOT	-	AIPS++ ms.msplot	- General Purpose Visibility Plotting

Flagging Visibility Data

AIPS UVFLG	-	AIPS++ flagger - tool	- Flagging Data Manually by Antenna, Source
AIPS QUACK	-	AIPS++ flagger.quack	- Running the Equivalence of the AIPS Task QUACK
AIPS TVFLG	-	AIPS++ ms.msplot	- Flagging with MSPLOT

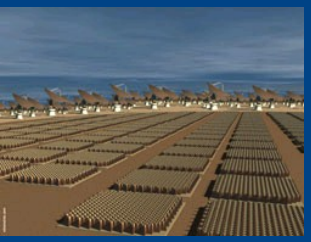
Bootstrapping Flux Scale Calibration

AIPS SETJY	-	AIPS++ imager.setjy	- Loading Calibrator Flux Densities
AIPS CALIB	-	AIPS++ calibrater - tool	- Solve for Calibrator Antenna Gains
AIPS GETJY	-	AIPS++ calibrater.fluxscale	- Get Flux Densities of Secondary Calibrators
AIPS SPLIT	-	AIPS++ calibrater.correct	- Apply Flux Density Scale to Visibility Data

Self-Calibration, Imaging a Strong Point Source

AIPS	-	AIPS++ componentlist - tool	- Construct a Model Image (Gaussian Comps.)
AIPS IMAGR	-	AIPS++ imager - tool	- Construct a Model Image (Clean Comps.)
AIPS CALIB	-	AIPS++ calibrater - tool	- A Self-Calibration Iteration

http://aips2.nrao.edu/docs/



Similarities 2

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Documentation

Adopted standard commercial model

aips++

- *Getting Results*

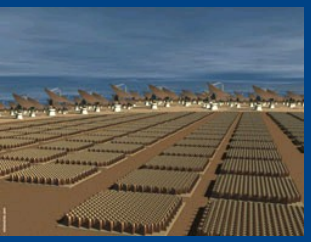
  cookbook

- *User Reference Manual*

  authoritative guide for each synthesis tool and function.

Classic AIPS

- cookbook



Differences 1

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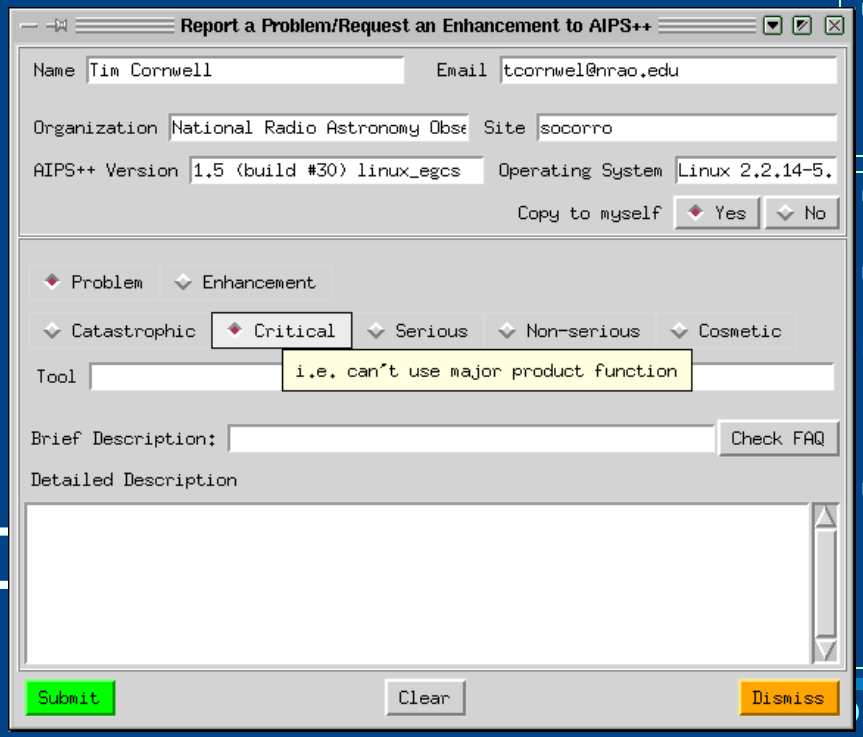
Newsletter

- aips++ Dec 2002
  - memo 17 Feb 1995
- Classic AIPS 31 dec 2007
  - memo AIPS pipeline for VLA data reduction 19 Mar 2007

Support

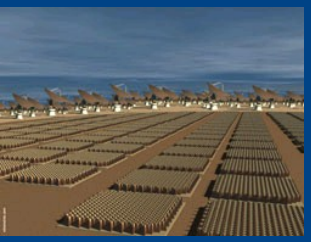


Classic AIPS

- FAQ online
- explain task to ask
- aipsmail@nrao.edu
  - Questions are harvested for the FAQ
- bug report
  - Searchable index of bug reports

aips++

- FAQ online
- ask() function to ask
- aips2-request@nrao.edu
  - Questions are harvested for the FAQ
- bug report
  - bug() function to submit a bug report
  - Searchable index of bug reports



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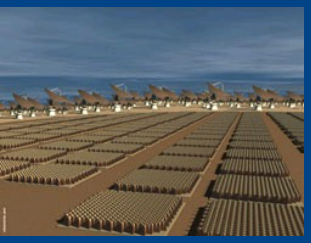
Differences 2

- **aips++**: Simulation of data from synthesis and single dish radio telescopes using the *simulator* tool.
- Complementary to *imager* and *calibrater*
- Two roles:
  - Provide synthetic data for testing AIPS++
  - Facility for telescope design *e.g.* SKA
- Can construct MeasurementSet from description of an observation
- Can add noise and corruptions of various types

- **Classic AIPS**: AIPS tasks UVSIM, UVMOD, UVCON
  - Limited features

Simulator



Differences 3

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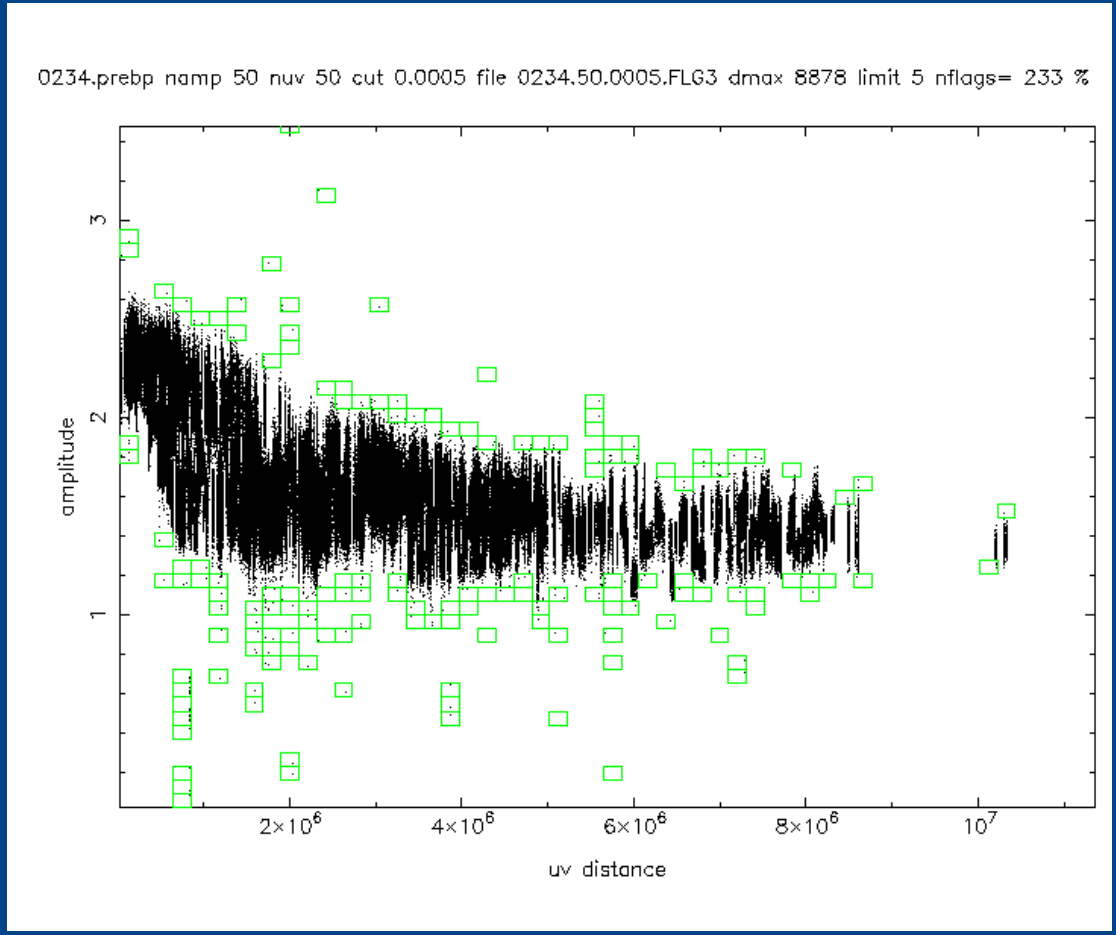
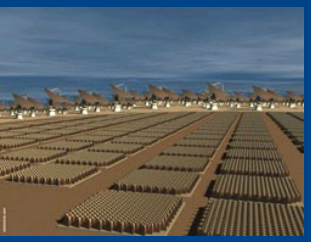
DATA Editing



Heuristics supported:

- UV-plane binning
- Median clip in time and frequency
- Spectral rejection (spectral line baseline fitting)
- Absolute clipping in a clip range
- View real / imaginary and clip.



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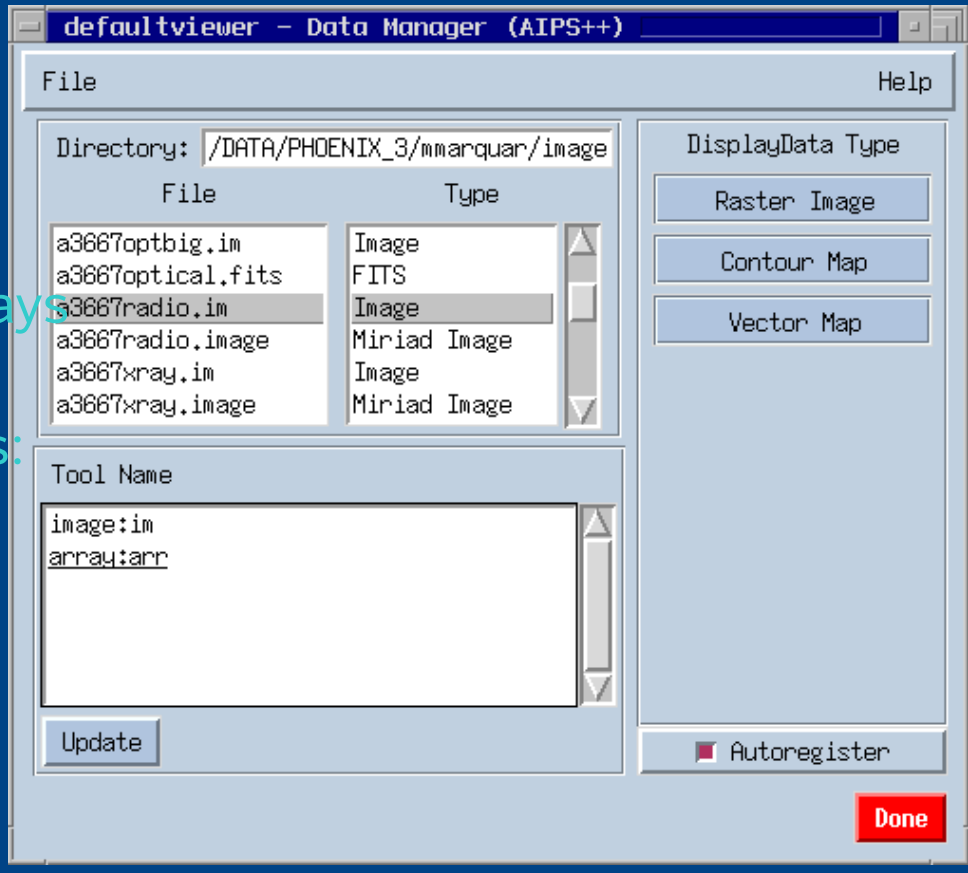
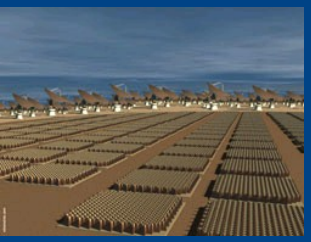
Differences 4

Viewer features

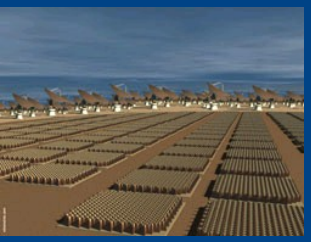
- Provides different drawing modes:
  - Raster Image
  - Contour Map
  - Vector Map
  - Catalog overlays
- Displays images and Glish arrays (simultaneously)
- Displays foreign image formats:
  - FITS
  - Miriad
  - Gipsy
- Displays complex images
  - e.g. Vector maps





Differences 5

- (A) Correcting direction dependent gains
  - Correcting direction-dependent gains in the deconvolution of radio interferometric images
    arXiv:0805.0834 (Bhatnagar et al.)
- (B) Scale sensitive deconvolution
  - Scale sensitive deconvolution of interferometric images I. Adaptive Scale Pixel (Asp) decomposition
    Bhatnagar & Cornwell (2004)
- (C) 3-D mapping for *w*-term correction
  Sault, Staveley-Smith, and Brouw (1994)



Differences (5c)

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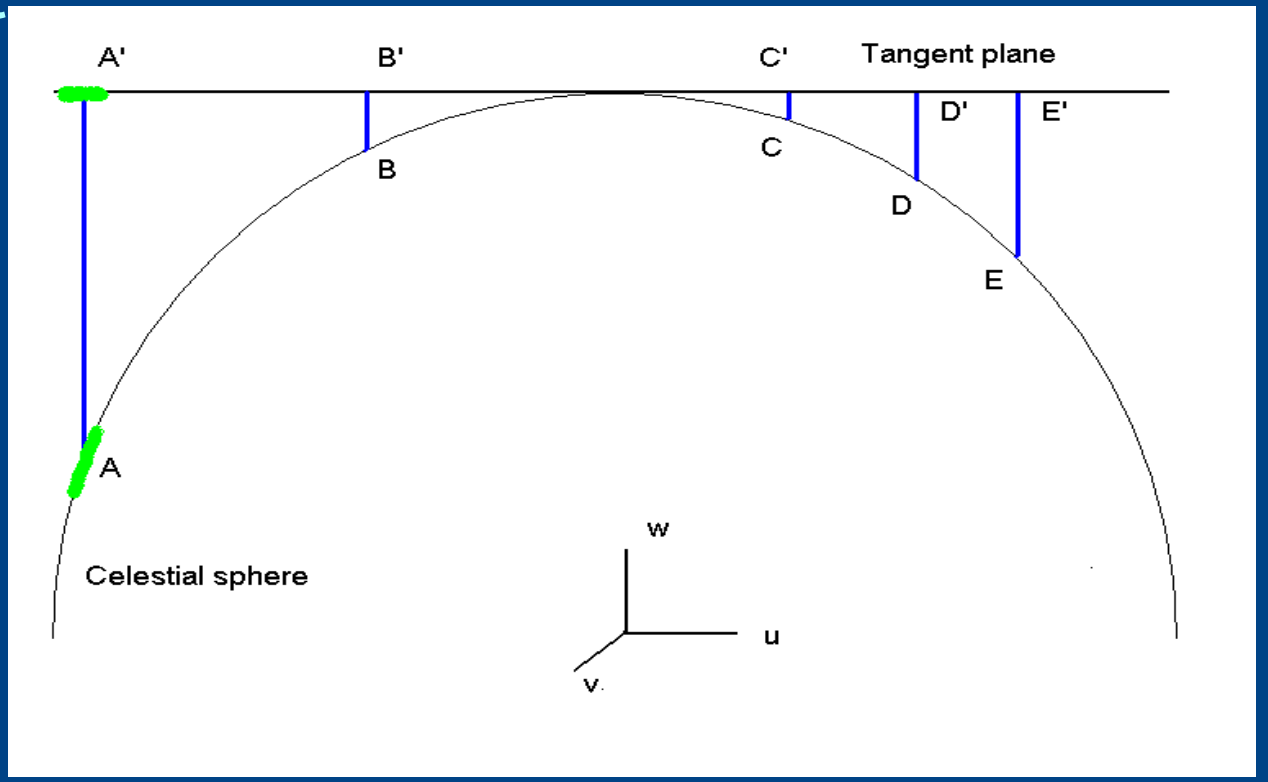
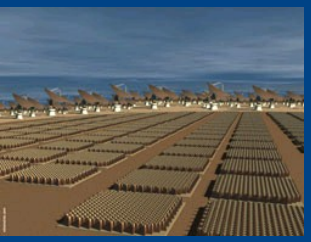
Must represent celestial sphere via a projection.



http://aips2.nrao.edu/docs/presentations/presentations.html



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Differences (5c)

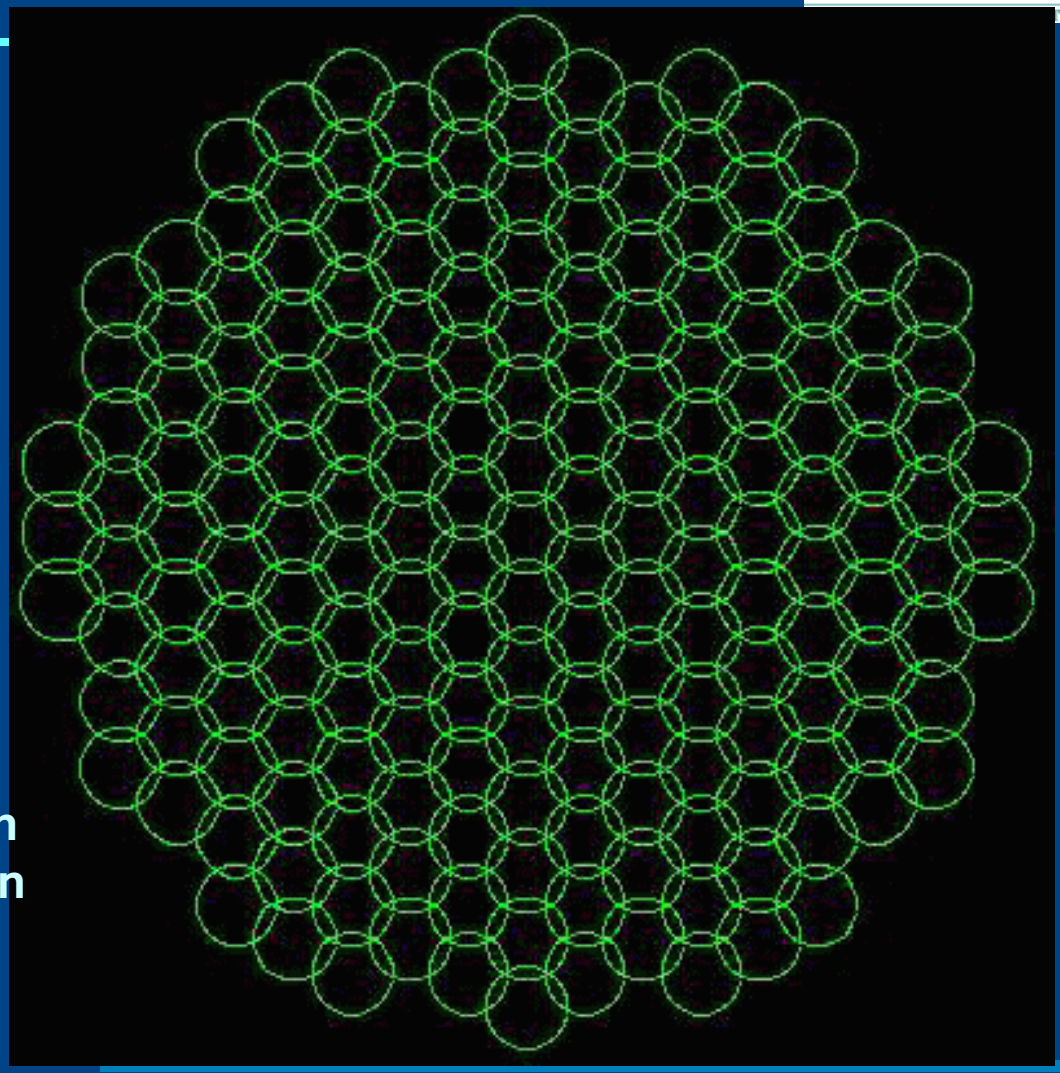
3D mapping Problem

Problem:-

- UV Coverage of synthesis data is non-coplanar
- A 3-D Fourier inversion of full FoV
- Current AIPS provide 2-D Fourier Inversion

Solution:-

- FoV is divided into many “facets”
- Each facet is small enough and is mapped with its own phase-centre
- The facets are combined into a single image



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Differences (5c)

Used in AIPS IMAGR task, AIPS++ imager, …

Iterative, multi-stage algorithm

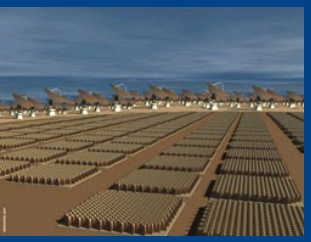
- Calculate residual images for all facets
- Partially deconvolve individual facets to update model for each facet
- Reconcile different facets

  either by cross-subtracting side-lobes

  or by subtracting visibility for all facet models
- Recalculate residual images and repeat

Project onto one tangent plane

- image-plane interpolation of final cleaned facets
- (u,v) plane re-projection when calculating residual images



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Differences (5c)

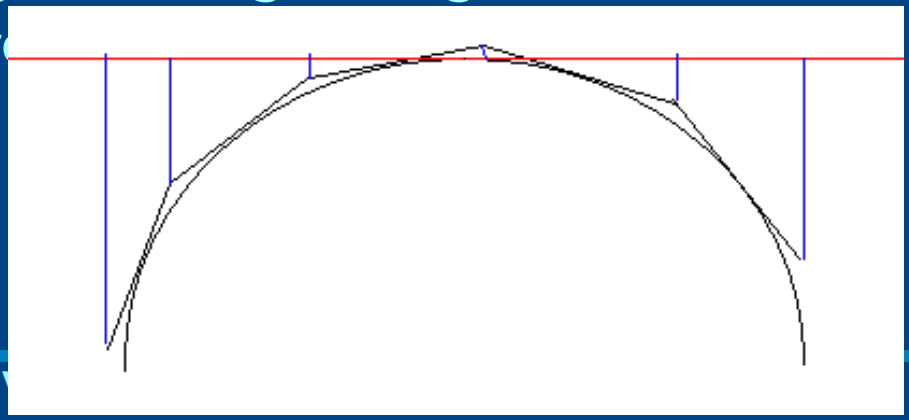
Reconciling Facets

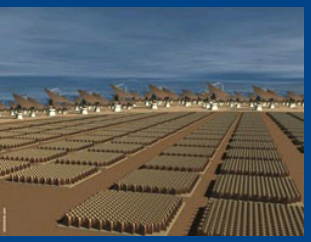
Facets are projected to a common plane. This can be done in image plane (in AIPS, FLATN).

- Re-interpolate facet image to new coordinate systems
  Cornwell and Perley (1992)

or in equivalently transforming the (*u,v*)'s of each facet to the one for the common tangent plane (in AIPS++)

- Re-project (*u,v,w*) coordinates to new coordinate systems during gridding and de-gridding
  Sault, Staveley-Smith & Br



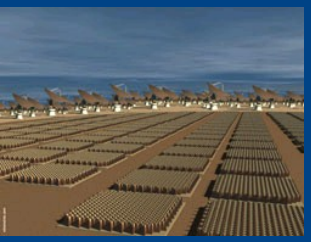


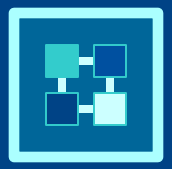
CASA

The Common Astronomy Software Applications (CASA) package is a set of C++ tools bundled together under an iPython interface as a set of data reduction tasks. CASA is being developed by a collaboration led by NRAO.

- The CASA tasks are oriented towards end-user data processing and analysis, while the toolkit is geared towards the support of pipeline processing, algorithm development, and the construction of tasks.
- Programmed to be flexible, but for ALMA and EVLA.

Free Software Foundation's General Public License.





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CASA

aips++ *versus* CASA

Similarities:

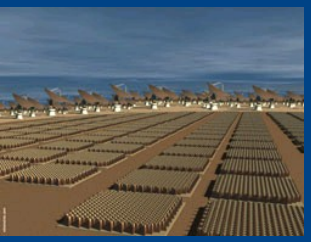
- **Support** (casa-request@nrao.edu)
- **Documentation**
  - **Cookbook**
  - **User Reference Manual**

Difference:

- **Language: glish / python**

All features of aips++

- **DD gains**
- **Scale-sensitive deconvolution**
- **3-D mapping**



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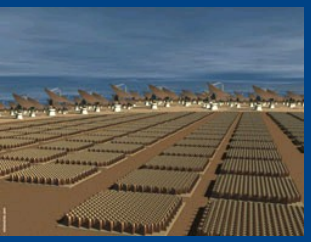
AIPS / aips++ / CASA

None of the these are parallelised,

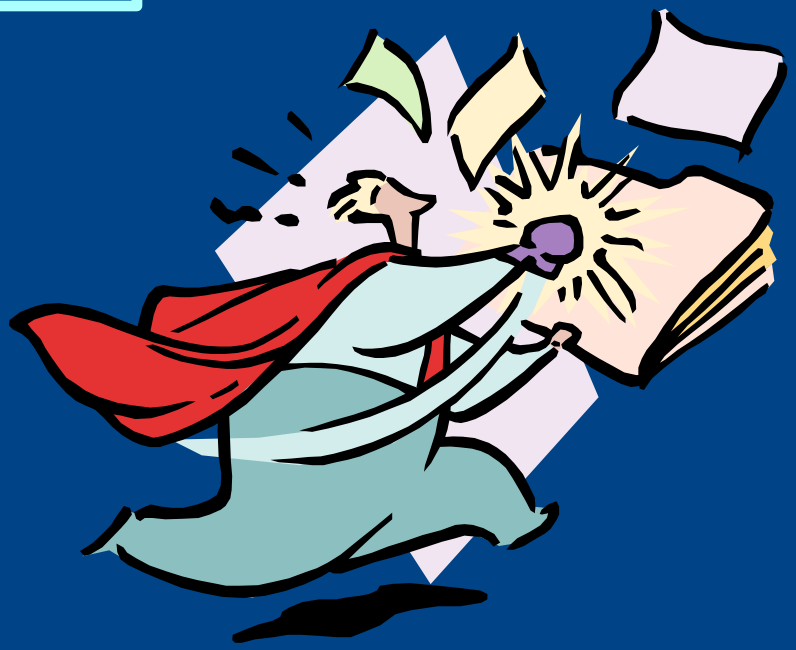
- Only Wide-field (3-D, faceted) imaging is parallelized! A feature in aips++ / CASA

  Decompose work per imaging facet

  Parallelised PSF formation, model prediction and residual computation per facet.

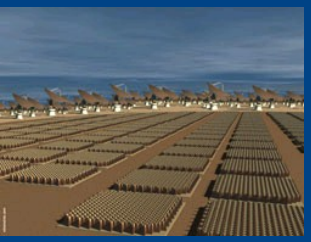


THANKS



Credits

- aips++
  - aips2.nrao.edu
- Classic AIPS
  - www.aips.nrao.edu
- CASA
  - casa.nrao.edu
- PPT presentations:
  - Grand tour aips++
  - Widefield imaging
- Pictures:
  - Purdue University Writing Lab



Max-Planck-Institut für Radioastronomie

MAX-PLANCK-GESELLSCHAFT

The *w*-term problem

3D mapping Problem

The relationship between visibility measured and Sky Brightness is given by the equation below.

It is not straight forward to invert and is NOT a Fourier transform

$V(u,v,w)$ is a 3-D function, while $I(l,m)$ is only a 2-D function

If we take the usual 2-D transform of the left side…the third variable manifests itself when the '*w*' becomes large.

$$V(u,v,w)=\int I(l,m)\cdot e^{j.2\pi.\left(ul+vm+w\sqrt{1-l^2-m^2}\right)}\frac{dl\,.\,dm}{\sqrt{1-l^2-m^2}}$$