Virtual Observatory Standards in Action

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Turning point into the VO era

- Essential for imminent data volumes and rates
- Multi-λ science requires
  - Data from different telescopes
  - Analysis tools
  - on-line services
  - archived information

  to be *readily compatible*
- VO = framework for interoperable systems
- VO Vision: *All Astronomy resources as if they were on your desktop*

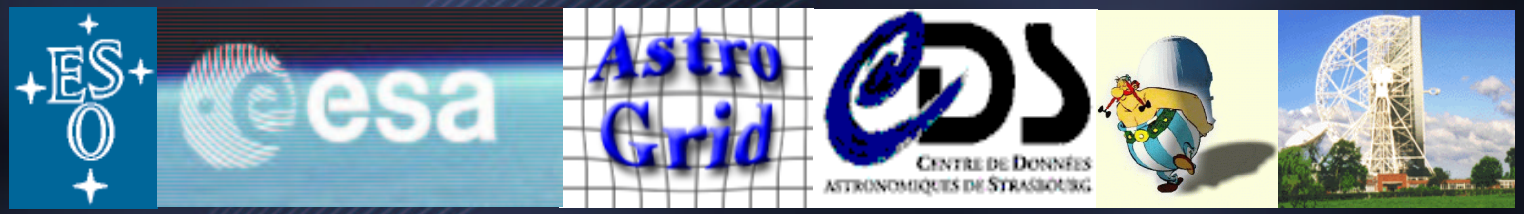
Standards – Key for Interoperability

- Formats and protocols -
  - Necessary links between VO components
- IVOA is rapidly moving towards v1.0 standards

- VOTable, SIA, SSA, UCD, Registry
- Coming: Data Model, VOQuery, GRID

AVO
ASTROPHYSICAL VIRTUAL OBSERVATORY

- R&D on scientific requirements and technology for building a VO



- Phase-A, 2001-2004/5
- Driven by strategy of scientific VO demonstrations
- Prototyping: Standards in Action
  - Implementing new and emerging standards

'First Science' (Jan 2004)

- Prototype VO tools for science
  - *Led to Discovery of Type 2 QSOs*
  - *Padovani, Allen, Rosati & Walton – A&A 2004*
- Enabled by real gains in standards for:
  - Data access
  - Manipulating image and catalogue data
  - Remote calculations

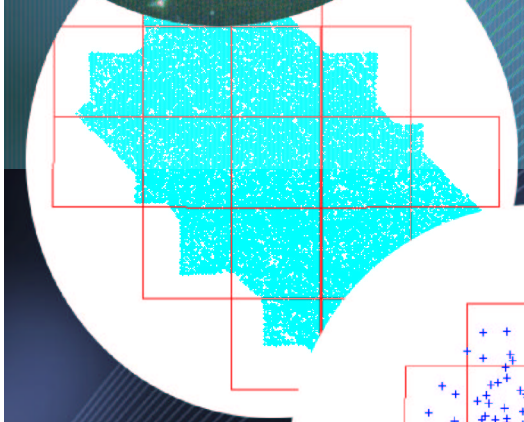
AVO prototype overview

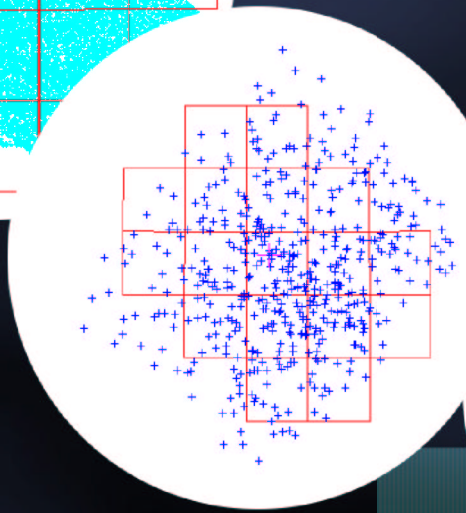
- Registry of services (GLU)
- CDS Aladin interface
  - Interactive manipulation of image and catalogue data
  - “Portal” for access to services/data
- Cross-matching service for catalogues
- Conventions for accessing remote data
- Remote calculations
- Interoperable with other VO tools

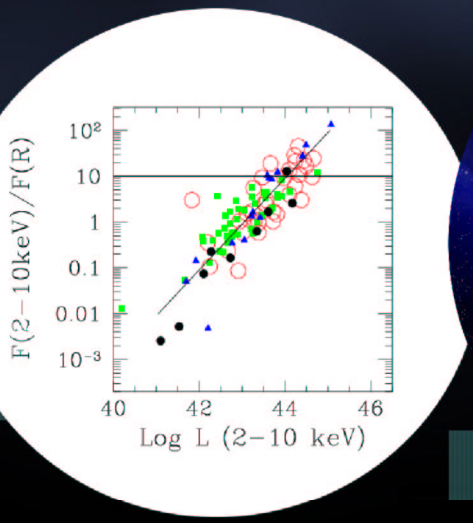
Discovery of QSO 2s with VO tools

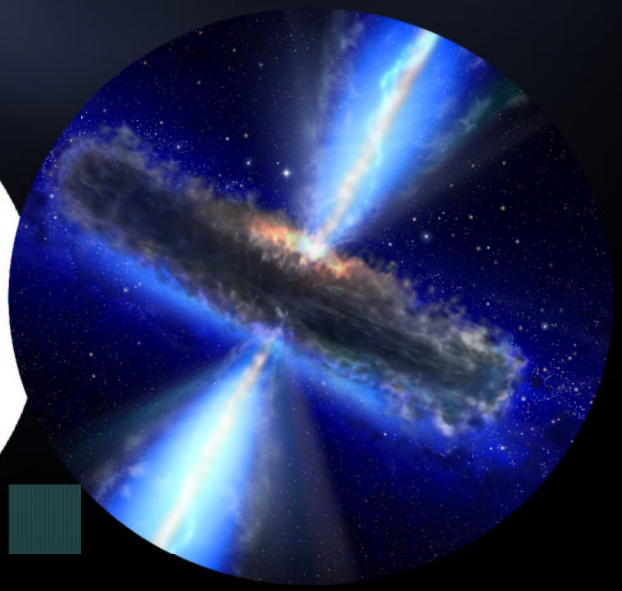
- GOODS Optical ACS data & catalogues
- Chandra X-ray catalogues
- Select absorbed X-ray sources
- Cross-match X-ray and optical
- Apply empirical estimator for Lx
- Check against spectroscopy

$Lx>10^{44}$: QSO 2









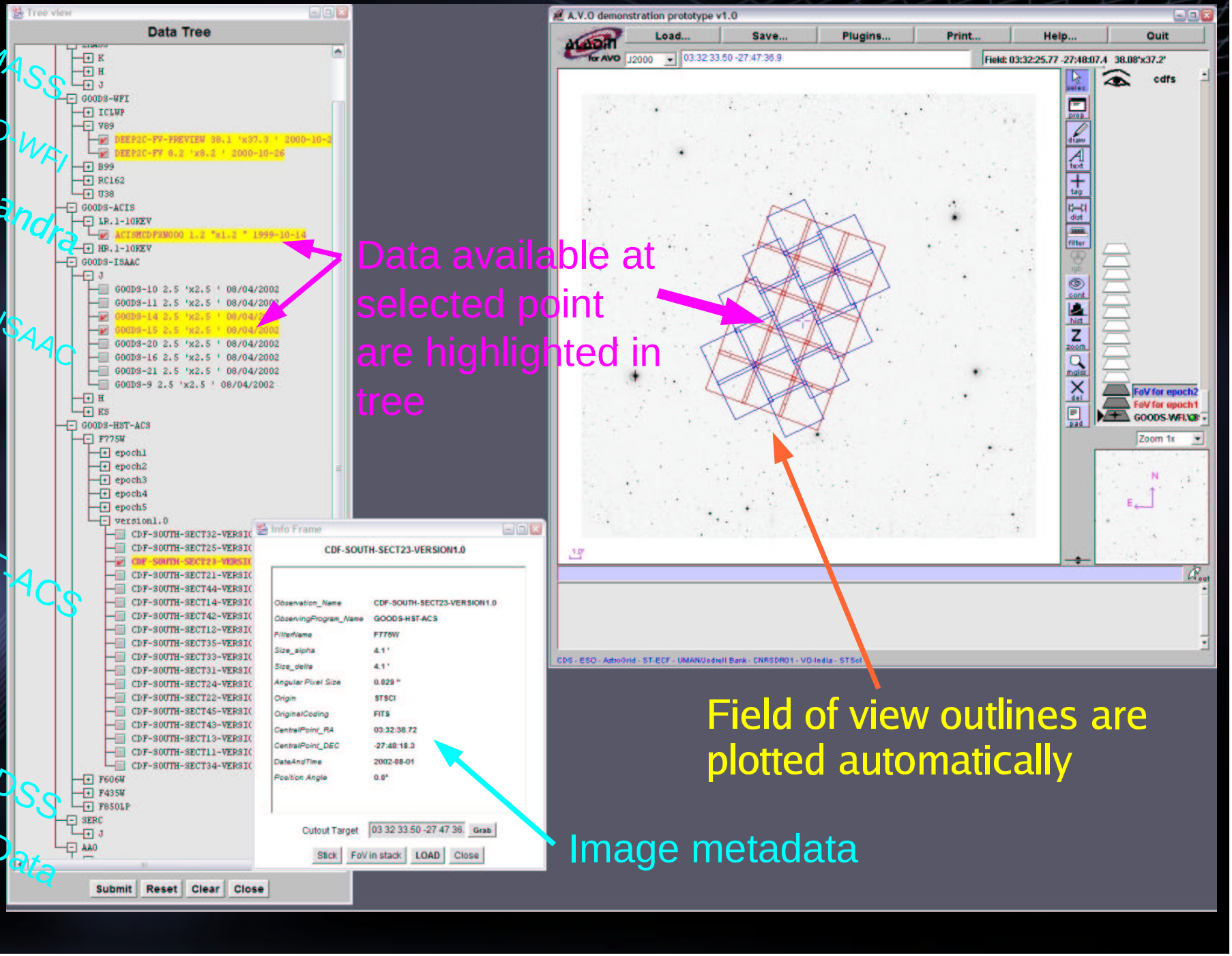
Results : NEW Type 2 AGN

- 68 new type 2 AGN candidates
- 31 have $L_X > 10^{44}$ erg s^{-2} : QSO 2
  - Only 9 previously known in GOODS fields

- Now 40 QSO 2s: Quadrupled the QSO 2s in the GOODS fields !

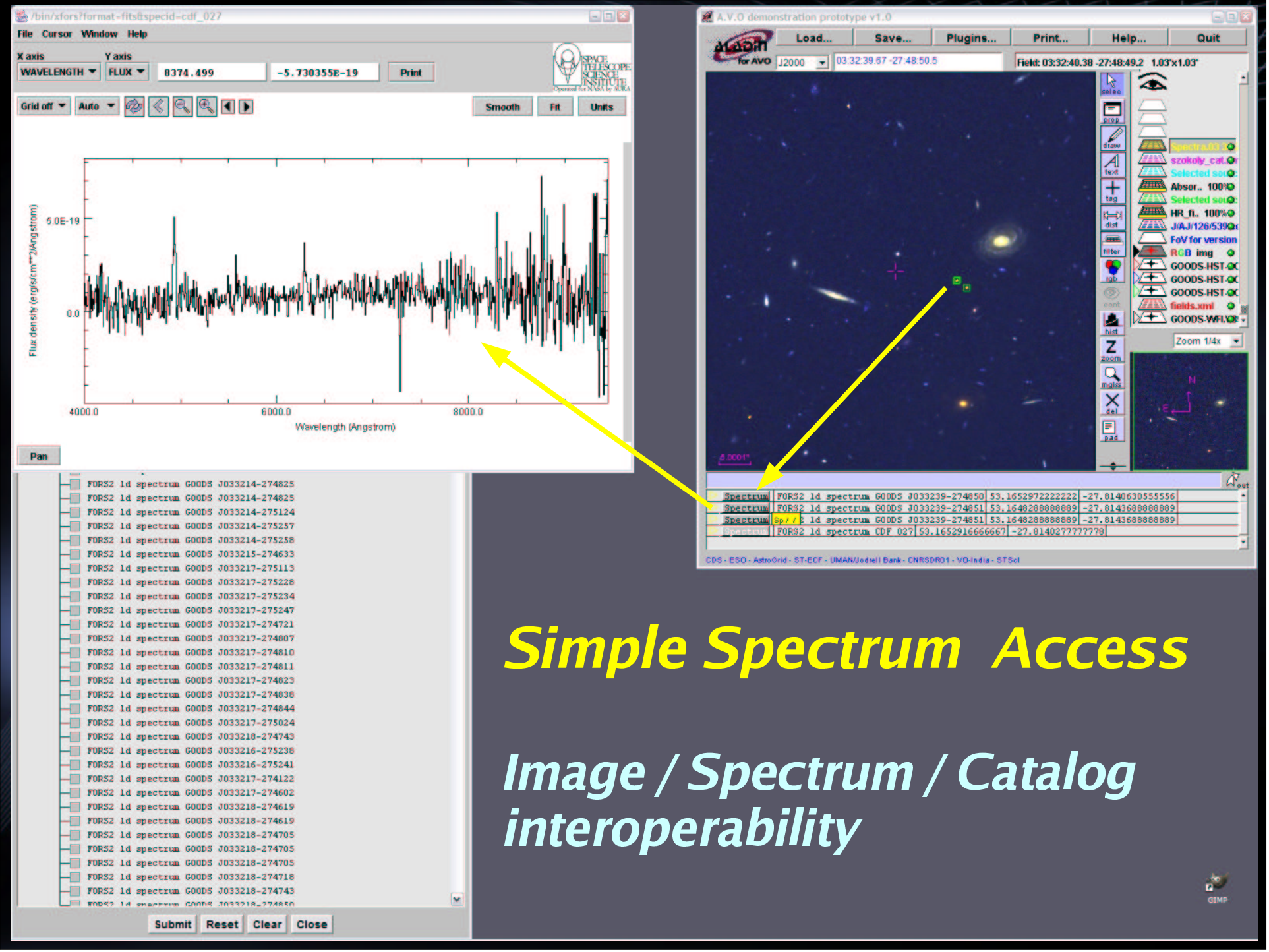
Standards/Protocols used

- Data and Information Discovery & Access
  - Registry – GLU
  - Data Model – IDHA
  - Data Tree + SIA, SSA
- Data and Catalogue Manipulation
  - VOTable
  - UCDs for filtering, and X-matching
  - WCS coordinates, FITS


2MASS
ESO-WFI
Chandra
VLT-ISAAC
HST-ACS
DSS
My Data
Data Tree
Data available at selected point are highlighted in tree
A.V.O demonstration prototype v1.0
Load...
Save...
Plugins...
Print...
Help...
Quit
Field: 03:32:25.77 -27:48:07.4 38.08'x37.2'
cdfs
FoV for epoch2
FoV for epoch1
Zoom 1x
Info Frame
CDF-SOUTH-SECT23-VERSION1.0
Observation_Name CDF-SOUTH-SECT23-VERSION1.0
ObservingProgram_Name GOODS-HST-ACS
FilterName F775W
Size_alpha 4.1 '
Size_delta 4.1 '
Angular Pixel Size 0.029 "
Origin STSCI
OriginalCoding FITS
CentralPoint_RA 03:32:38.72
CentralPoint_DEC -27:48:18.3
DateAndTime 2002-08-01
Position Angle 0.0°
Cutout Target
Grab
Stick
FoV in stack
LOAD
Close
Submit
Reset
Clear
Close
Field of view outlines are plotted automatically
Image metadata

Data Tree

- Scalable data access
  - Interoperability of large archives to small data sets
- Image metadata – FOV browsing
- Access to any image available by URL
  - Automatic generation of image data set description in XML
- Efficiently get to the relevant pixels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File Cursor Window Help
X axis
WAVELENGTH
Y axis
FLUX
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Flux density (ergs/cm**2/Angstrom)
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6000.0
8000.0
Wavelength (Angstrom)
Pan
FORS2 ld spectrum GOODS J033214-274825
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FORS2 ld spectrum GOODS J033218-274705
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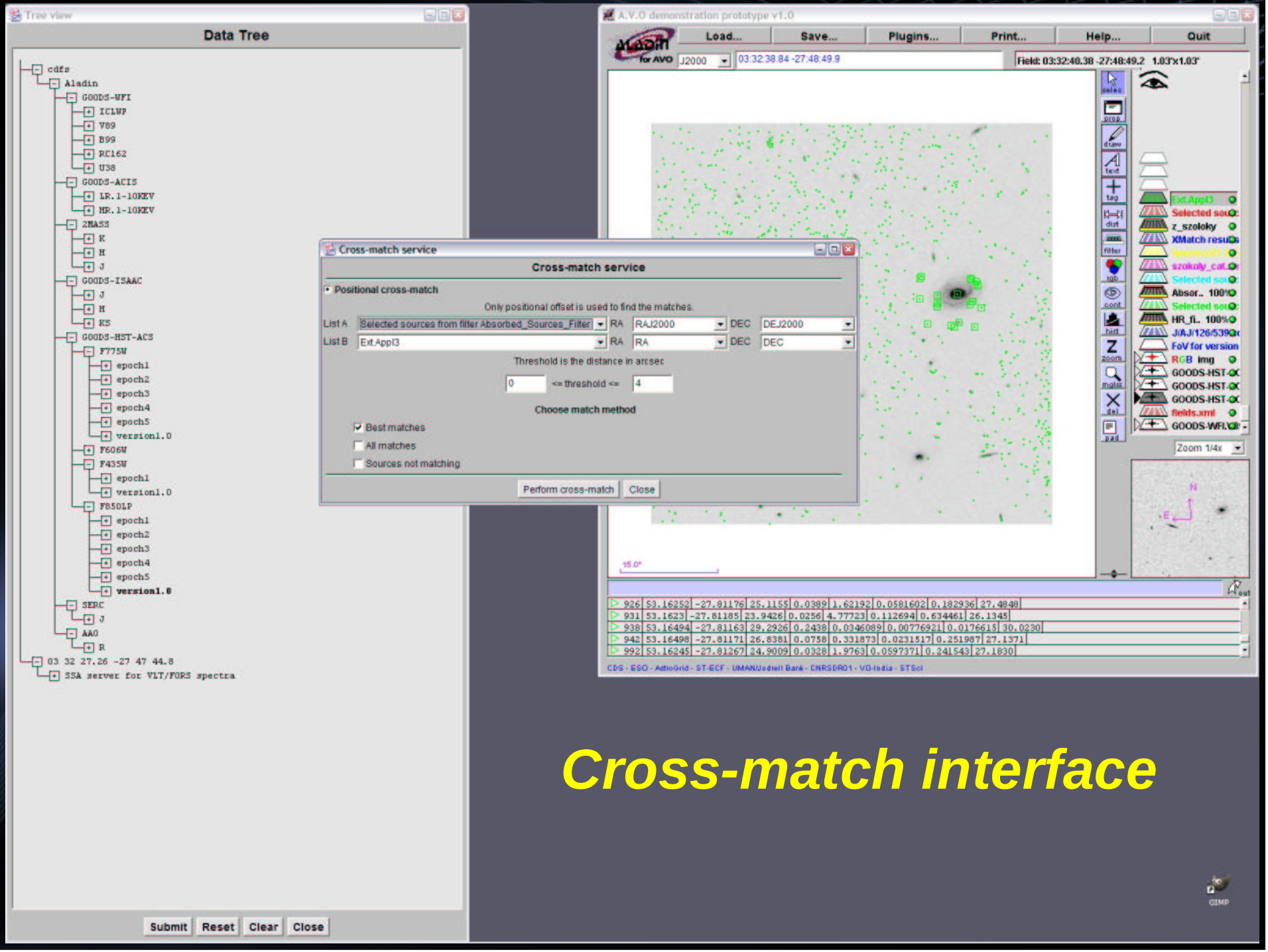
FORS2 ld spectrum GOODS J033218-274743
Submit
Reset
Clear
Close
A.V.O demonstration prototype v1.0
Load...
Save...
Plugins...
Print...
Help...
Quit
J2000
03:32:39.67 -27:48:50.5
Field: 03:32:40.38 -27:48:49.2 1.03'x1.03'
Zoom 1/4x
Spectrum FORS2 ld spectrum GOODS J033239-274850 53.1652972222222 -27.8140630555556
Spectrum FORS2 ld spectrum GOODS J033239-274851 53.1648288888889 -27.8143688888889
Spectrum FORS2 ld spectrum GOODS J033239-274851 53.1648288888889 -27.8143688888889
Spectrum FORS2 ld spectrum CDF_027 53.1652916666667 -27.8140277777778
CDS - ESO - AstroGrid - ST-ECF - UMAN/Jodrell Bank - CNRSDR01 - VO-India - STScI
Simple Spectrum Access
Image / Spectrum / Catalog interoperability
GIMP

Manipulating Data and Information

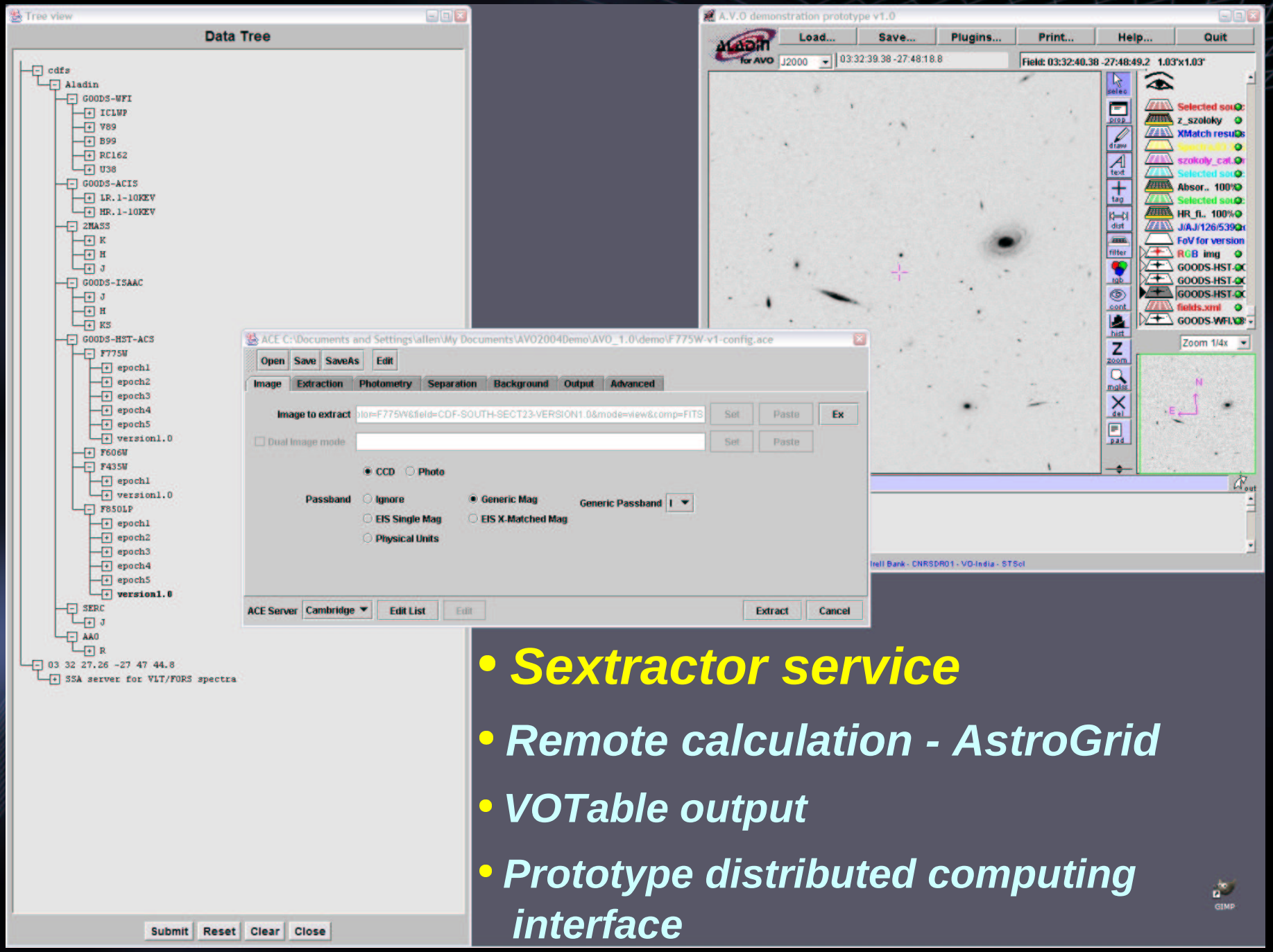
- VOTable: enables interoperability
  - As a rich interchange format
  - VOIndia VOPlot, Starlink TOPCAT
- UCDs: Uniform Content Descriptors
  - Enables identification of common information in many contexts
    - Data selection, X-matching, filtering, photometry

Cross-matching

- Simple positional cross-match implemented
  - Options: closest, multiple, or no-matches
  - Result: joined table
- Efficiency comes from interoperability with other tables and original image data
  - eg. X-match GOODS optical with X-ray sources taking positional error into account
- VOTable
- UCDs for identifying coordinate columns



Cross-match interface



- ***Sextractor service***
- ***Remote calculation - AstroGrid***
- ***VOTable output***
- ***Prototype distributed computing interface***

Summary

- VO milestone:
  Prototype VO tools ß Scientific Results
  Discovery of QSO 2s

- Standards in Action
  - Demos: Provide real tests of standards
  - Feedback into standards process

- This work enabled by the First VO interoperability gains
  - Scalable Data Access
  - Catalogue/image manipulation
    - X-match, filtering, link to original data
- Coming soon:
  - Distributed workflow
    - AVO move from *phase A* to build EURO-VO
  - IVOA: v1.0 Standards, working registries

VO tools

- Prototype tools available
  - www.euro-vo.org
  - www.ivoa.net
  - cdsweb.u-strasbg.fr
- Stabilised AVO prototype components migrate into the public version of CDS Aladin.