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# Implementing SIAPv2 Interfaces at the Keck Observatory Archive (KOA): A Case Study.

<https://koa.ipac.caltech.edu>

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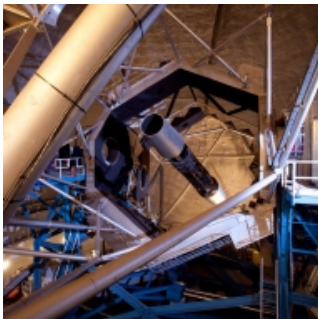
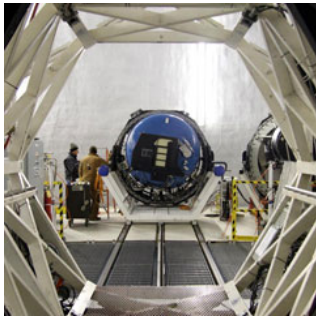
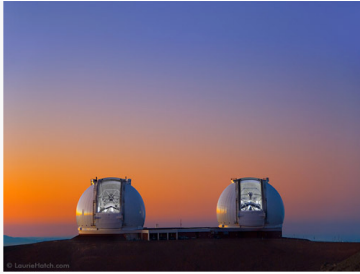
NASA Exoplanet Science Institute (NExSci), California Institute of Technology

Hien Tran

W. M. Keck Observatory

IVOA Meeting, Sesto, Italy. June 2015.

# The Keck Observatory Archive



- NASA-funded collaboration between WMKO and NExScI.
- KOA serves public data from 8 active instruments.
  - Operate in **imaging** and spectroscopic modes.
- WMKO is a classically scheduled telescope.
  - Observers have control over data.
  - Instruments built by different teams.
  - Heterogeneous metadata across instruments.
- Users now access raw science and calibration files, and (where available) calibrated data through a web interface.
- VO interfaces will enable access to **raw** data through a **common interface**.

# Keck Observatory Instruments

Instrument	Modes	Bandpass ( $\mu\text{m}$ )	Nights	Raw Data Vol (TB)
HIRES	Spectroscopic only	0.3-1.0	3,131	5.1
NIRSPEC	<b>Imaging</b> , spectroscopy	0.95-5.5	1,782	0.8
NIRC2	<b>Narrow-, medium, wide band imaging</b> ; spectroscopy	1-5	1,881	2.0
LRIS	<b>Imaging</b> , spectroscopy	0.3-10	3,649	7.2
MOSFIRE	<b>Imaging</b> , spectroscopy	1-2.4	538	2.4
DEIMOS	<b>Imaging</b> , spectroscopy	4-1.05	1,459	11.5
ESI	<b>Imaging</b> , spectroscopy	0.4-1.1	877	0.8
OSIRIS	<b>Imaging</b> , spectroscopy	1-2.5	941	3.0

... plus NIRC and LWS to be released Summer 2015

## Goals of this Case Study

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- Is the current specification of SIAPv2 adequate to mount a service that is valuable to science users?
- What does it take to prepare the data and build the service?
- Can we use a single code base that uses only open source components to serve data from heterogeneous instruments?
- How can we make it easy for end users to get started?

## The KOA SIAPv2 Service

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- Developed by a software engineer with no knowledge of the IVOA, or of the SIAPv2 standard.
- Implemented as a RESTful web service.
- The bulk of the work was in the creation of the VO-metadata.
  - WCS headers a nasty problem.
- Services implemented with adaptation and re-use of existing methods and components:
  - Spatial search uses R-tree indexing method developed by VAO (will be released as mQuickSearch as part of the Montage distribution).
  - Other parameters use relational constraints.

# Parameters

Name	Values
	Range of values: <lower>/<upper>, or a single value
POS <sup>+</sup>	CIRCLE (degrees) ra dec radius, POLYGON*: at least 3 vertices, RANGE*: band.
BAND	energy interval (m): scalar value or range of values.
TIME	Time interval in term of time stamps as <i>yyyy-mm-dd</i> , <i>yyyy-mm-ddThh:mm:ss.xxx</i> or numeric value for MJD.
POL	polarization state: I, Q, U, V, RR, LL, etc.
FOV	field of view (degree): scalar value or range of values.
SPATRES	Spatial resolution (arcsec/pixel): scalar value or range of values.
EXPTIME	Exposure time (second): scalar value or range of values.
ID	Identifier of dataset: string-valued, case-insensitive, substring match.
COLLECTION	Name of data collection: string-valued.
FACILITY	Name of facility usually telescope: string-valued.
INSTRUMENT <sup>+</sup>	Name of instrument: string-valued.

# Parameters

Name	Value
DPTYPE	Type of data product: string-valued, <i>image or cube</i> . For KOA, <i>image</i> only.
CALIB	Calibration level (no units): non-negative integer like 0, 1, or +1, or range of non-negative integer.
TARGET	Name of target: string-valued. Case insensitive and substring match.
TIMERES	temporal resolution (second) : scalar value or range of values.
SPECRP	Spectral resolving power (no units): scalar value or range of values.
FORMAT	Data format, string-valued, FITS, JPEG, etc. For KOA, FITS only .
UPLOAD	Upload a table of values to be referenced by one of above parameters.
resultformat~	Return data formats, votable, html, ipac, csv, tab, or json.

 : Parameter applied to KOA

- \*: CONE and POLYGON (4 sided - BOX) are implemented, no implementation for RANGE in the current version.
- †: required parameters in the release of VO services.
- ~: parameter not defined in SIA protocol.






## Columns of Metadata Table and Output Table of VO Service vs. KOA FITS Keywords

Metadata table columns	Output table columns	DE	ES	LR	LW	MF	N1	N2	NS	OS
NAXIS		X	X	X	X	X	X	X	X	X
NAXIS1	X	X	X	X	X	X	X	X	X	X
NAXIS2	X	X	X	X	X	X	X	X	X	X
RA	X	X	X	X	X	X	X	X	X	X
DEC	X	X	X	X	X	X	X	X	X	X
INSTRUME	X	X	X	X	X	X	X	X	X	X
ELAPTIME	X	X	X	X	X	X	X	X	X	X
TARGNAME	X	X	X	X	X	X	X	X	X	X
OBJECT	X							X	X	X
KO Aid	X	X	X	X	X	X	X	X	X	X
KOAIMTYP		X	X	X	X	X	X	X	X IMAGETYP	X
FILEHAND/ fname		X	X	X	X	X fname	X	X fname	X	X fname
TELESCOP		X	X	X	X	X	X OBSERVAT	X	X	X
UTC	X	X	X	X	X	X	X	X	X	X
DATE-OBS	X	X	X	X	X	X	X	X	X	X
MJD_OBS	X	X	X	X	X	X	X	X	X	X
SPECRES <sup>1</sup>								X	X	



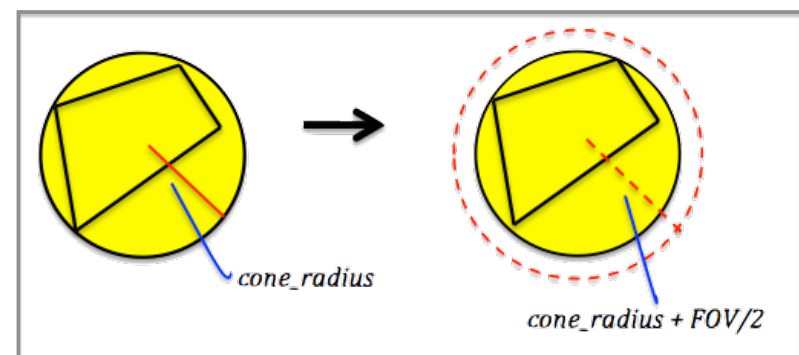
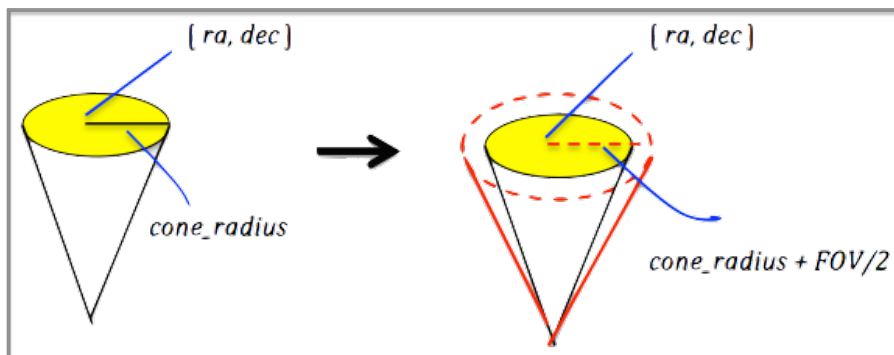
Metadata columns	Output columns	DE	ES	LR	LW	MF	N1	N2	NS	OS
WAVEBLUE	X							X	X	X
WAVED	X							X	X	X
FILTER	X	X DWFILNAM	X DWFILNAM	X REDFILT (LR.*) BLUFILT( LB.*)	X FILNAME	X	X	X	X FILNAME	X IFILTER
SLITNAME	X	X SLMSKNAM	X SLMSKNAM	X	X APNAME	X MASKNAME	X SLTNAME	X	X	
PROGID		X	X	X	X	X	X	X	X	X
PROGINST		X	X	X	X	X	X	X	X	X
PROGPI		X	X	X	X	X	X	X	X	X
PROGTITL		X	X	X	X	X	X	X	X	X
SEMID		X	X	X	X	X	X	X	X	X
cntr						X		X		X
cra						X		X		X
cdec						X		X		X
CTYPE1						X		X		X
CTYPE2						X		X		X
CRPIX1						X		X		X
CRPIX2						X		X		X
CRVAL1						X		X		X
CRVAL2						X		X		X
CDEL1+						X		X		X
CDEL2+						X		X		X

Metadata columns	Output columns	DE	ES	LR	LW	MF	N1	N2	NS	OS
CROTA2 <sup>+</sup>	X					X		X		X
EQUINOX						X		X		X
ra1						X		X		X
dec1						X		X		X
ra2						X		X		X
dec2						X		X		X
ra3						X		X		X
dec3						X		X		X
ra4						X		X		X
dec4						X		X		X
hdu						X		X		X
size	X	x	x	x	x	x	x	x	x	x
TIME		X	X	X	X	X	X	X	X	X
SPATRES	X	X	X	X	X	X PSCALE	X	X PIXSCALE	X SPATSCAL	X  CDEL1
FOV <sup>1</sup>		X	X	X	X	X	X	X	X	X
DPTYPE <sup>1</sup>		X	X	X	X	X	X	X	X	X
CALIB	X	X	X	X	X	X	X	X DATLEVEL	X DATLEVEL	X DATLEVEL
FACILITY	X	X	X	X	X	X	X	X	X	X

	: columns included in the output
	: columns included in metadata table
	: data from database
	: data from fits header
	: derived data

# Spatial Searches and WCS Headers

- Images with WCS: Use mQuickSearch to search image by the four corners derived from WCS data.
  - NIRC2, OSIRIS, MOSFIRE
- Images without WCS
  - Assume RA and Dec on the sky is the image center.
  - Pad the search area with the maximum field of view of the instrument.
    - R-tree index will accept point-like records.
    - Search not exact – we are padding the search area to a bounding circle around the location of the image.
    - Possibility of spurious results.

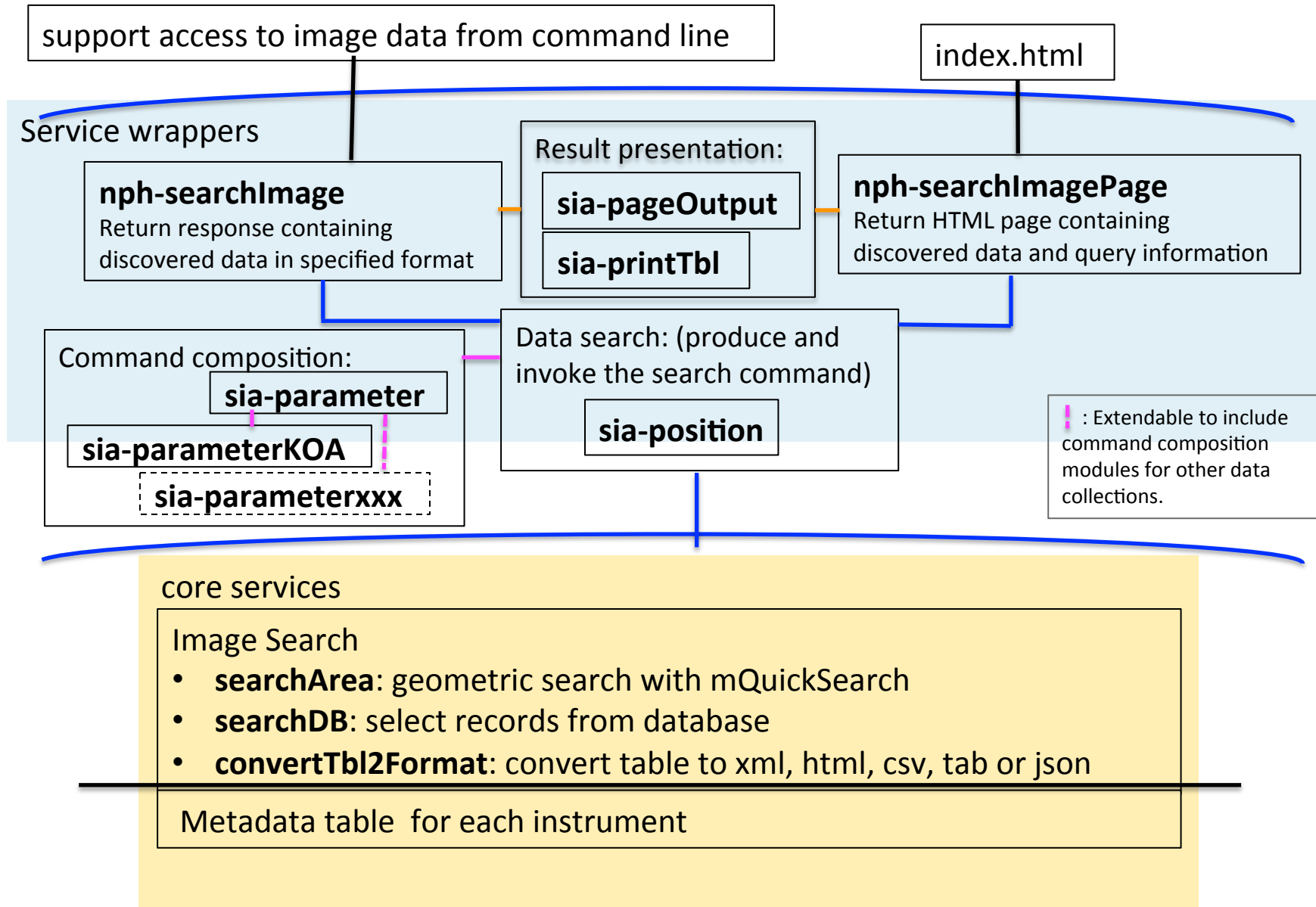


# Sample VO Service Output

Column Name	Description	unit	Corresponding FITS Keyword
ra	Right ascension (J2000) of the observed target	degree	RA
dec	Declination (J2000) of the observed target	degree	DEC
instrume	Instrument name		INSTRUME
elaptime	Total exposure time	second	ELAPTIME
utc	Coordinated universal time at the start of the exposure		UTC
targname	Target name		TARGNAME
koaid	Unique file identifier assigned by KOA		KO Aid
NAXIS1	Number of columns in image		NAXIS1
NAXIS2	Number of rows in image		NAXIS2
DATE_OBS	UT date of observation at the start of the exposure		DATE-OBS
MJD_OBS	Modified Julian Date of observation		MJD-OBS
FILTER	Filter name or position		DWFILNAM
SLITNAME	Slitmask name		SLMSKNAM
SPATRES	Spatial resolution	arcsec/pixel	
CALIB	Calibration level of data		
FACILITY	Name of the facility where the data were acquired		TELESCOP
size	Image file size	byte	
angleDistance	Angular distance between (ra, dec) and the center of the region (POS) specified in the query	degree	
url	Link to image files discovered in KOA (FITS)		
calibfiles	Link to associated calibration files (text file)		

Output formats: votable, ipac, tab, csv, html, json

# KOA SIA Service Architecture



# How Well Did It All Work?

- SIAPv2 works and is useful! We encourage its recommendation.
- Non-uniform metadata and absence of WCS information are likely to be serious issues for data providers from classical observatories.
- We have been able to implement the KOA service with substantial re-use of existing software.
- Examples, examples, examples. Make it easy to get started.

# Getting Started: VO Query Builder Interface

DEIMOS

Submit Reset

**Position** [POS], degree.  
*Format:* CIRCLE *ra*(degree) *dec*(degree) *radius*(degree) or POLYGON *ra*<sub>1</sub>(degree) *dec*<sub>1</sub>(degree) ... *ra*<sub>4</sub> *dec*<sub>4</sub>  
*Example:* CIRCLE 230.0 44.0 5.0, POLYGON 236.3840 38.8384 223.6159 38.8384 222.4534 48.7404 237.5465 48.7404

CIRCLE 150.0 45.0 5.0

**Instrument** [INSTRUMENT], no units.  
*Format:* *string* (*instrument name*)  
*Example:* DEIMOS, ESI, LRIS, LWS, MOSFIRE, NIRSPEC, NIRC, NIRC2, OSIRIS

DEIMOS       NIRC2  
 ESI             NIRSPEC  
 LRIS            OSIRIS  
 MOSFIRE

**Wavelength** [BAND], meter.  
*Format:* <*numeric value*>/<*numeric value*> or *numeric value*  
*Example:* 0.03, 0.20/0.22, 500e-9/, /550e-9, /, 3.1E-6/3.5E-6

<wavelength(m)> /<wavelength(m)> or wavelength(m)

**Time** [TIME], timestamp string.  
*Format:* <*time value*>/<*time value*> or *time value*  
*Example:* 2012-01-01/2012-02-03, /2012-01-05T01:02:03.33, 55123.456/, 2001-01-01 (same as 2001-01-01T00:00:00)

2002-06-14T00:00:00/2002-06-16T10:00:00

**Field of View** [FOV], degree.  
*Format:* <*numeric value*>/<*numeric value*> or *numeric value*  
*Example:* 2.0/3.0, 0.01/, /0.5, /, 1.2e-5

0.3/0.6

**Pixel Scale** [SPATRES], arcsec per pixel.  
*Format:* <*numeric value*>/<*numeric value*> or *numeric value*  
*Example:* 2.0/3.0, 0.01/, /0.5, /, 1.2e-5

0.1/0.15

**Exposure Time** [EXPTIME], second.  
*Format:* <*numeric value*>/<*numeric value*> or *numeric value*  
*Example:* 2/10, 2.0/10.0, /10, /, 2.0E2

# VO Query Builder Interface Return Page

[http://koatest.ipac.caltech.edu/cgi-bin/VOserv/nph-searchImage?POS=CIRCLE\\_150.0\\_45.0\\_5.0&INSTRUMENT=DEIMOS&TIME=2002-06-14T00:00:00/2002-06-16T10:00:00&FOV=0.3/0.6&SPATRES=0.1/0.15&EXPTIME=/200.0&COLLECTION=KOA&DPTYPE=image&CALIB=0&FORMAT=FITS&resultformat=votable](http://koatest.ipac.caltech.edu/cgi-bin/VOserv/nph-searchImage?POS=CIRCLE_150.0_45.0_5.0&INSTRUMENT=DEIMOS&TIME=2002-06-14T00:00:00/2002-06-16T10:00:00&FOV=0.3/0.6&SPATRES=0.1/0.15&EXPTIME=/200.0&COLLECTION=KOA&DPTYPE=image&CALIB=0&FORMAT=FITS&resultformat=votable)

The query encodes the following key/value pairs:

```
POS = CIRCLE 150.0 45.0 5.0
INSTRUMENT = DEIMOS
TIME = 2002-06-14T00:00:00/2002-06-16T10:00:00
FOV = 0.3/0.6
SPATRES = 0.1/0.15
EXPTIME = /200.0
COLLECTION = KOA
DPTYPE = image
CALIB = 0
FORMAT = FITS
resultformat = votable
```

**Keyword Values**

**Query**

**Sample Output**

Sample Query Results in selected output format. No more than 10 rows are shown; run the query above to return the complete query results.

DEIMOS: [/work/VOserv17372-iwiKhA/SearchDB/resultDBdeimos\\_17372.xml](http://work/VOserv17372-iwiKhA/SearchDB/resultDBdeimos_17372.xml)

```
<?xml version="1.0"?>
<VOTABLE version="1.3" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.ivoa.net/xml/VOTable/v1.3"
xmlns:stc="http://www.ivoa.net/xml/STC/v1.30">
<DEFINITIONS>
<COOSYS ID="J2000" equinox="J2000" system="eq_FK5" />
</DEFINITIONS>
<RESOURCE>
<PARAM name="nrows" datatype="char" arraysize="*" value="5" />
<TABLE>
<FIELD name="ra" ucd="POS_EQ_RA_MAIN" ref="J2000" datatype="double" unit="deg" precision="F3" width="7" />
<FIELD name="dec" ucd="POS_EQ_DEC_MAIN" ref="J2000" datatype="double" unit="deg" precision="F3" width="7" />
<FIELD name="instrume" datatype="char" arraysize="*" />
<FIELD name="elaptime" datatype="double" />
<FIELD name="utc" datatype="char" arraysize="*" />
<FIELD name="targname" datatype="char" arraysize="*" />
<FIELD name="koaid" datatype="char" arraysize="*" />
<FIELD name="NAXIS1" datatype="int" />
<FIELD name="NAXIS2" datatype="int" />
<FIELD name="DATE_OBS" datatype="char" arraysize="*" />
<FIELD name="MJD_OBS" datatype="char" arraysize="*" />
```

**Output  
Column  
Descriptions**



# Backup Material

---

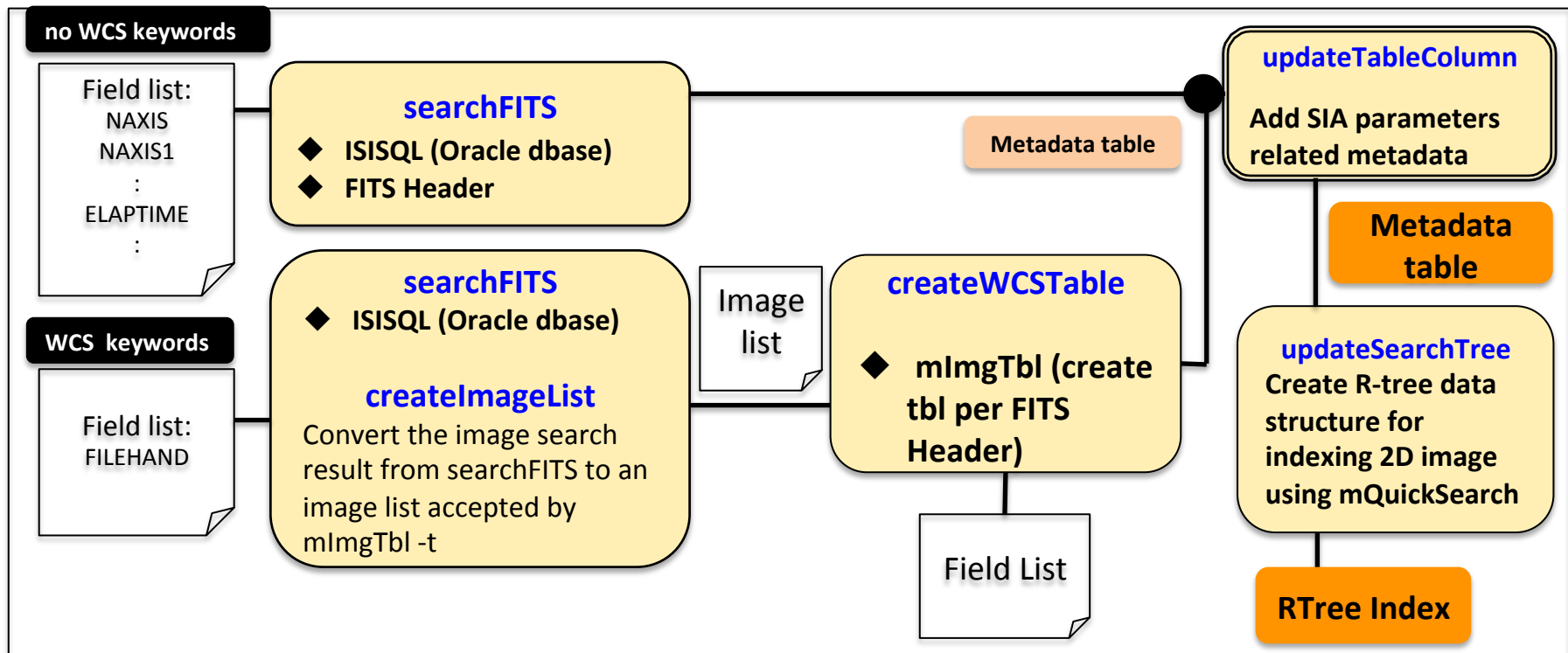
# SIA Service Configuration Files

- Use configuration files for different instruments inside KOA.
- The configuration file defines the dataset, its database, the instruments, the SIA parameter/FITS keyword dependency (for the creation of metadata table creation), and the SIA parameter/metadata dependency (for image discovery) of the dataset (in JSON format).

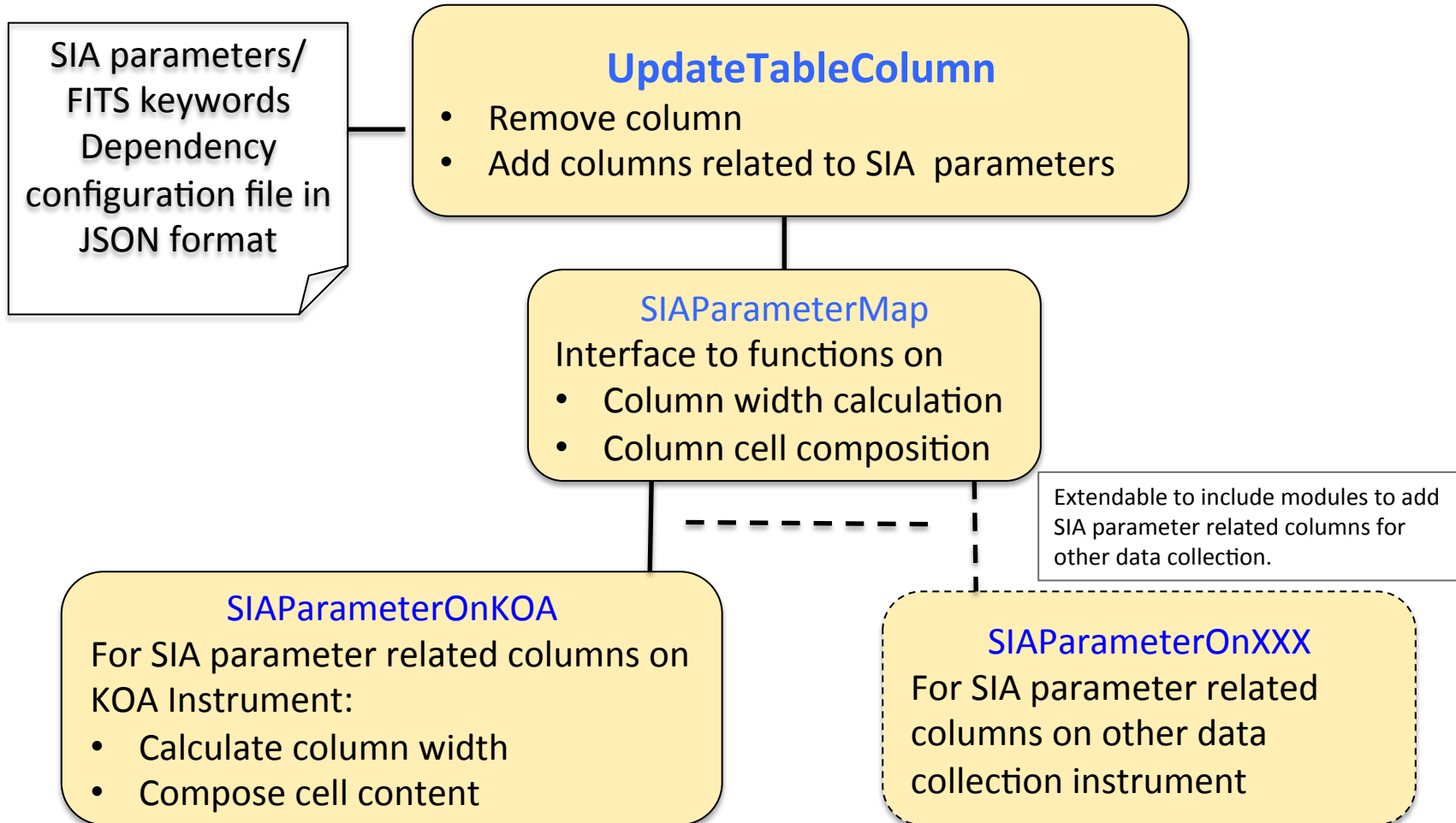
```
{
  "collections":[
    {
      "dataSet":"KOA",
      "database":"KOA_DB",
      "datapath":"KOA_DATAPATH",
      "dataformat":"FITS",
      "instrumentConfig":"KOAInstrumentMap.json",
      "SIAParameterConfig":"KOASIAParameters.json"
    },
    { ..... }
  ]
}
```

# Metadata Table Creation

- The metadata table includes columns related to
  - WCS
  - Common FITS keywords - TELESCOP, INSTRUME, ELAPTIME, UTC, ...
  - Instrument specific keywords
  - Metadata created related to SIA parameters



# updateTableColumn



# Service Wrapper and Modules

- **nph-searchImage**  
Generate result data in csv, tab, html, votable or json format.
- **nph-searchImagePage**
  - Generate response in html page including the query information, result data and result table column description.
  - Present the result in the format of csv, tab, ipac, json, html, or votable.
- **sia-position**  
Accept service request, compose search command and interact with service core.
- **sia-parameter**
  - Interface with dataset oriented DB select condition composition functions.
  - Extendable to interface with the DB select condition modules from multiple datasets.
- **sia-parameterKOA**  
DB select condition composition for KOA.
- **sia-pageOutput**  
Generate response heading or message for the query sent to nph-searchImage or nph-searchImagePage.
- **sia-printTbl**  
Data presentation in specified format for the query sent to nph-searchImage or nph-searchImagePage.