



# Enriched query-server response: DataLinks and Column Groups

Judith Silverman

Northern Fall Virtual IVOA Interop 2020



## The team

**Gregory Dubois-Felsmann** proposed this project, brainstormed with **Serge Monkewitz** to outline a plan of action, consulted throughout, and tested the finished product.

**Serge Monkewitz** oversaw the Jira epic and provided detailed and insightful code reviews at every stage.

**Angela Zhang** ingested many versions of new TAP\_Schema tables.



The query-server is a standalone web-server for servicing IVOA's TAP, SCS, SSA, and SIA queries as well as our in-house Firefly, Gator, Sofia, Radar, and IBE queries.

Sample TAP query:

```
https://irsa.ipac.caltech.edu/TAP/sync?QUERY=SELECT TOP 100 mjd, ra, dec, w1mpro, w2mpro, w1snr, w2snr FROM neowiser_p1bs_psd WHERE 1=CONTAINS(POINT( 'ICRS ', 269.1469808, 66.739237), CIRCLE( 'ICRS ', 269.1469808, 66.739237, 0.005 )) AND (w1snr >3 AND (w2snr >3)) &format=votable
```

Response-table columns as determined by SELECT clause don't necessarily correspond directly to columns of database tables, but this talk concerns those that do.



# Simple query-server response in VOTable format

```
<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"
  xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/STC/v1.30
http://www.ivoa.net/xml/STC/v1.30">
```

```
<RESOURCE type="results">
```

```
<INFO name="QUERY_STATUS" value="OK"/>
```

```
<TABLE>
```

```
<FIELD name="w4sigmpro" datatype="double" ID="col_0" precision="3" unit="mag" width="5">
```

```
<DESCRIPTION>instrumental profile-fit photometry flux uncertainty in mag units, band 4</DESCRIPTION>
```

```
</FIELD>
```

```
<FIELD name="w4snr" datatype="double" ID="col_1" precision="1" width="8">
```

```
<DESCRIPTION>instrumental profile-fit photometry S/N ratio, band 4</DESCRIPTION>
```

```
</FIELD>
```

```
<FIELD name="w4rchi2" datatype="double" ID="col_2" precision="3" width="9">
```

```
<DESCRIPTION>instrumental profile-fit photometry reduced chi2, band 4</DESCRIPTION>
```

```
</FIELD>
```

```
<FIELD name="rchi2" datatype="double" ID="col_3" precision="3" width="9">
```

```
<DESCRIPTION>instrumental profile-fit photometry reduced chi squared, total</DESCRIPTION>
```

```
</FIELD>
```

```
<FIELD name="x" datatype="double" ID="col_4" precision="16" ucd="pos.cartesian.x" width="19">
```

```
</FIELD>
```

```
<DATA>
```

```
<TABLEDATA>
```

```
<TR>
```

```
<TD></TD>
```

```
<TD>0.40000000000000002</TD>
```

```
<TD>1.0110000400000001</TD>
```

```
<TD>1.2669999599999999</TD>
```

```
<TD>-0.66630988326023799</TD>
```

```
</TR>
```

```
</TABLEDATA>
```

```
</DATA>
```

```
</TABLE>
```

```
</RESOURCE>
```

```
</VOTABLE>
```



# Column Groups, DataLinks, Service Descriptors

**Column Groups** and **Service Descriptors**, described in IVOA specs, are optional elements in the VOTable format which call attention to or add information about groups of columns in the query-server response.

If one column contains error estimates for another column, or if several columns contain related data, we can indicate that connection using a **Column Group** element.

Perhaps a column or group of columns corresponds to input for some other service. In that case, we can add a **Service Descriptor** element to point the user to that service, describing it briefly and indicating how to call it. (A **Service Descriptor** is a kind of **DataLink**, a mechanism to link resources found via one service to resources provided by other services [3], [4].)

[1] <http://www.ivoa.net/documents/VOTable/20130920/REC-VOTable-1.3-20130920.html>

[2] <http://www.ivoa.net/documents/VOTable/20191021/REC-VOTable-1.4-20191021.html>

[3] <http://www.ivoa.net/documents/DataLink/20150617/REC-DataLink-1.0-20150617.pdf>

[4] [https://wiki.ivoa.net/internal/IVOA/DataLink-1\\_0-Next/DataLink.pdf](https://wiki.ivoa.net/internal/IVOA/DataLink-1_0-Next/DataLink.pdf) (work in progress)

[5] <https://sites.google.com/site/nasanavo/datalink-wg>



## What's coming

- What do VOTable elements corresponding to Column Groups and Service Descriptors look like?
- How do we introduce a new Column Group or Service Descriptor to the query-server's repertoire?
- How does the query-server decide whether and with what content to add elements corresponding to Column Groups or Service Descriptors to a given VOTable response?



# Response with Column Group (GROUP element within TABLE)

<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" xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30" />

<RESOURCE type="results">

<INFO name="QUERY\_STATUS" value="OK"/>

<TABLE>

<GROUP id="group\_allwise\_p3as\_psd\_pos" name="pos" ucd="pos.eq" utype="">

<DESCRIPTION>Position, determined using a profile-fitting measurement model that does not include motion</DESCRIPTION>

<FIELDref ref="col\_0"/>

<FIELDref ref="col\_1"/>

<FIELDref ref="col\_2"/>

<FIELDref ref="col\_4"/>

<FIELDref ref="col\_5"/>

</GROUP>

<FIELD name="ra" datatype="double" ID="col\_0" precision="7" ucd="pos.eq.ra;meta.main" unit="deg" width="11">  
<DESCRIPTION>right ascension (J2000)</DESCRIPTION>

</FIELD>

<FIELD name="dec" datatype="double" ID="col\_1" precision="7" ucd="pos.eq.dec;meta.main" unit="deg" width="11">  
<DESCRIPTION>declination (J2000)</DESCRIPTION>

</FIELD>

<FIELD name="sigma" datatype="double" ID="col\_2" precision="4" unit="arcsec" width="8">  
<DESCRIPTION>uncertainty in RA</DESCRIPTION>

</FIELD>

<FIELD name="w4sigmpro" datatype="double" ID="col\_3" precision="3" unit="mag" width="5">  
<DESCRIPTION>instrumental profile-fit photometry flux uncertainty in mag units, band 4</DESCRIPTION>

</FIELD>

<FIELD name="sigdec" datatype="double" ID="col\_4" precision="4" unit="arcsec" width="8">  
<DESCRIPTION>uncertainty in DEC</DESCRIPTION>

</FIELD>

<FIELD name="sigradec" datatype="double" ID="col\_5" precision="4" unit="arcsec" width="9">  
<DESCRIPTION>cross-term of RA and Dec uncertainties</DESCRIPTION>

</FIELD>

<DATA>

<TABLEDATA>

<TR>

<TD>224.3159972</TD>

<TD>-21.368905699999999</TD>

<TD>0.053400000000000003</TD>

<TD>0.40000000000000002</TD>

<TD>0.054100000000000002</TD>

<TD>-0.006100000000000004</TD>

</TR>

</TABLEDATA>

</DATA>

</TABLE>

</RESOURCE>

</VOTABLE>

# Response with Service Descriptor (RESOURCE element of type "meta")



```
<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"
xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30">
```

```
<RESOURCE type="meta" utype="ad hoc:service">
  <DESCRIPTION>Link to ZTF light curve for default ztf collection</DESCRIPTION>
  <GROUP name="inputParams">
    <PARAM name="id" datatype="char" arraysize="*" ref="col_0" value="">
      <DESCRIPTION>Identifier of a ZTF object.</DESCRIPTION>
    </PARAM>
    <PARAM name="bad_catflags_mask" datatype="int" value="0">
      <DESCRIPTION>Bitmask used to exclude lightcurve points with at least one of the indicated catflag bits set. Default is 0.</DESCRIPTION>
    </PARAM>
    <PARAM name="time" datatype="char" arraysize="*" value="">
      <DESCRIPTION>Date-time range for which lightcurve data is to be retrieved, unlimited by default. Space-separated endpoint(s) are interpreted as Modified Julian Date MJD.</DESCRIPTION>
    </PARAM>
  </GROUP>
  <PARAM name="standardID" datatype="char" arraysize="*" value="ivo://ivoa.net/std/DataLink#links-1.0"/>
  <PARAM name="accessURL" datatype="char" arraysize="*" value="https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph_light_curves?collection=ztf"/>
</RESOURCE>
```

```
<RESOURCE type="results">
  <INFO name="QUERY_STATUS" value="OK"/>
  <TABLE>
    <FIELD name="oid" datatype="long" ID="col_0" ucd="meta.id;src;meta.main">
      <DESCRIPTION>Unique object identifier</DESCRIPTION>
    </FIELD>
    <DATA>
      <TABLEDATA>
        <TR>
          <TD>686203400167748</TD>
        </TR>
      </TABLEDATA>
    </DATA>
  </TABLE>
</RESOURCE>
```

[https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph\\_light\\_curves?collection=ztf&id=68203400167748...](https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph_light_curves?collection=ztf&id=68203400167748...)

```
</VOTABLE>
```





## What's coming

- What do VOTable elements corresponding to Column Groups and Service Descriptors look like?
- How do we introduce a new Column Group or Service Descriptor to the query-server's repertoire?
- How does the query-server decide whether and with what content to add elements corresponding to Column Groups or Service Descriptors to a given VOTable response?



## Adding new Column Group

To introduce a **Column Group**, we update the (new) tables **irsa\_groups** and **irsa\_group\_columns** in TAP\_Schema.

**irsa\_groups**, whose columns are ID, name, ucd, utype, description, params\_xml:

**ID:** group\_allwise\_p3as\_psd\_pos

**name:** pos

**ucd:** pos.eq

**utype:** null

**description:** Position, determined using a profile-fitting measurement model that does not include motion

**params\_xml:** null

**irsa\_group\_columns**, whose columns are table\_name, column\_name, group\_id:

**table\_name:** allwise\_p3as\_psd

**column\_name:** ra

**group\_id:** group\_allwise\_p3as\_psd\_pos

**table\_name:** allwise\_p3as\_psd

**column\_name:** dec

**group\_id:** group\_allwise\_p3as\_psd\_pos

...



# GROUP element up close, in context

```
<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"
xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3
http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30">
```

```
<RESOURCE type="results">
```

```
<INFO name="QUERY_STATUS" value="OK"/>
```

```
<TABLE>
```

```
<GROUP id="group_allwise_p3as_psd_pos" name="pos" ucd="pos.eq" utype="">
```

```
<DESCRIPTION>Position, determined using a profile-fitting measurement model that does not
include motion</DESCRIPTION>
```

```
<FIELDref ref="col_0"/>
```

```
<FIELDref ref="col_1"/>
```

```
<FIELDref ref="col_2"/>
```

```
<FIELDref ref="col_4"/>
```

```
<FIELDref ref="col_5"/>
```

```
</GROUP>
```

```
<FIELD name="ra" datatype="double" ID="col_0" precision="7" ucd="pos.eq.ra;meta.main" unit="deg" width="11">
```

```
<DESCRIPTION>right ascension (J2000)</DESCRIPTION>
```

```
</FIELD>
```

...



## Adding new Service Descriptor

To introduce a **Service Descriptor**, we update new tables **irsa\_serv\_descriptors ...**

**columns are ID, description, xml\_fragment, access\_url:**

**ID:** ztf

**description:** Link to ZTF light curve for default ztf collection

**xml\_fragment:** <PARAM arraysize="1" datatype="int" name="bad\_catflags\_mask" value="0">

<DESCRIPTION>

Bitmask used to exclude lightcurve points with at least one of the indicated catflag bits set. Default is 0.

</DESCRIPTION>

</PARAM>

<PARAM arraysize="\*" datatype="char" name="time" value="">

<DESCRIPTION>

Date-time range for which lightcurve data is to be retrieved, unlimited by default. Space-

separated range endpoint(s) are interpreted as Modified Julian Dates (MJD).

</DESCRIPTION>

</PARAM>

**access\_url:** [https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph\\_light\\_curves?collection=ztf](https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph_light_curves?collection=ztf)



... and `irsa_serv_descriptor_cols`.

**Columns are `table_name`, `column_name`, `serv_descriptor_id`, `param_name`, `param_description`:**

**`table_name`:** ztf\_objects

**`column_name`:** oid

**`serv_descriptor_id`:** ztf

**`param_name`:** id

**`param_description`:** Identifier of a ZTF object.



# Service Descriptor RESOURCE up close, in context

```
<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" xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/
v1.3 http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30">
```

```
<RESOURCE type="meta" utype="ad hoc:service">
```

```
<DESCRIPTION>Link to ZTF light curve for default ztf collection</DESCRIPTION>
```

```
<GROUP name="inputParams">
```

```
<PARAM name="id" datatype="char" arraysize="*" ref="col_0" value="">
```

```
<DESCRIPTION>Identifier of a ZTF object.</DESCRIPTION>
```

```
</PARAM>
```

```
<PARAM name="bad_catflags_mask" datatype="int" value="0">
```

```
<DESCRIPTION>Bitmask used to exclude lightcurve points with at least one of the indicated catflag bits set. Default is 0.
```

```
</DESCRIPTION>
```

```
</PARAM>
```

```
<PARAM name="time" datatype="char" arraysize="*" value="">
```

```
<DESCRIPTION>Date-time range for which lightcurve data is to be retrieved, unlimited by default. Space-separated endpoint(s) are
interpreted as Modified Julian Date (MJD).
```

```
</DESCRIPTION>
```

```
</PARAM>
```

```
</GROUP>
```

```
<PARAM name="standardID" datatype="char" arraysize="*" value="ivo://ivoa.net/std/DataLink#links-1.0"/>
```

```
<PARAM name="accessURL" datatype="char" arraysize="*" value="https://irsa.ipac.caltech.edu/cgi-
bin/ZTF/nph_light_curves?collection=ztf"/>
```

```
</RESOURCE>
```

```
<RESOURCE type="results">
```



## What's coming

- What do VOTable elements corresponding to Column Groups and Service Descriptors look like?
- How do we introduce a new Column Group or Service Descriptor to the query-server's repertoire?
- How does the query-server decide whether and with what content to add elements corresponding to Column Groups or Service Descriptors to a given VOTable response?



## From TAP\_Schema tables to query-server response

- TAP\_Schema: metadata and **enrichment** tables  
tables, columns  
`irsa_groups`, `irsa_group_columns`  
`irsa_serv_descriptors`, `irsa_serv_descriptor_cols`
- query-server at start-up  
queries database for metadata and **enrichment** tables and caches the contents
- query-server at runtime
  - constructs database call (SQL) from incoming query (ADQL) using cached metadata
  - determines which **enrichment elements** are called for using cached **enrichment data** and column info
  - makes database call
  - builds RESOURCE of type “results” around database response using cached metadata and column info
  - adds **enrichment elements** using cached **enrichment data** and column info
  - assembles final VOTable






## Loading cache at **start-up** (columns and tables)

At start-up, query-server retrieves and caches contents of TAP\_Schema tables.

- Lookup from fully qualified table name (FQTN) to table-level metadata

FQTN  { Description, Permission/access level, DBMS (Oracle, Postgres),  
Data source (spitzer, allwise), Technical information (spatial index level), ... }

- Lookup from fully qualified column name (FQCN) to column-level metadata

FQCN  { Description, Data type (char, int double), Format (width, precision),  
Unit, Utype, UCD, Principal...}



# Loading cache at **start-up** (irsa\_groups and irsa\_service\_descriptors)

- Lookup from group\_id to struct of associated values:

```
group_allwise_p3as_psd_pos ✉ {desc: "Position, determined using a profile-fitting...",  
    name: "pos",  
    ...},
```

```
group_allwise_p3as_psd_pos_pm ✉ {desc: "Position, determined using a profile-fitting...",  
    name: "pos_pm",  
    ...},  
...
```

- Lookup from serv\_descriptor\_id to struct of associated values:

```
ztf_dr1 ✉ {desc: "Link to ZTF light curve for ztf_dr1 collection",  
    access_url: " https://irsa.ipac.caltech.edu/cgi-bin...",  
    ...},
```

```
ztf_dr2 ✉ {desc: "Link to ZTF light curve for ztf_dr2 collection",  
    access_url: " https://irsa.ipac.caltech.edu/cgi-bin...",  
    ...},  
...
```



## Loading cache at **start-up** (irsa\_group\_columns and irsa\_service\_descriptor\_cols)

Add **lists** of associated Column Groups and Service Descriptors to column-level metadata:

allwise\_p3as\_psd.ra    ✉    {desc: “right ascension (J2000), data\_type: “double”, ...,  
group\_IDs: [“group\_allwise\_p3as\_psd\_pos”],  
service\_descriptor\_ids: []},

...

Add **counts** of associated columns to Column Group and Service Descriptor lookup entries:

group\_allwise\_p3as\_psd\_pos    ✉    {desc: “Position, determined using a profile-fitting...”,  
ucd: “pos.eq”, ...,  
column\_count: 5},

group\_allwise\_p3as\_psd\_phot\_w4    ✉    {desc: “Instrumental photometry parameters...”,  
ucd: “phot;em.IR.15-30um”, ...,  
column\_count: 4},

...



# Metadata prep at runtime (columns and tables)

```
https://irsadev.ipac.caltech.edu/TAP/sync?QUERY=SELECT w4sigmpro, w4snr, ra, dec, x, y, z, sigra, sigdec, sigradec
FROM allwise_p3as_psd WHERE (cntr>=2243021301351018444 and cntr<=2243021301351018445)
```

Extract lists of database tables and columns from FROM and SELECT clauses respectively of incoming query.

allwise\_p3as\_psd, w4sigmpro, w4snr, ra, dec, x, y, z, sigra, sigdec, sigradec

Retrieve table- and column-level metadata from TAP\_Schema cache for tables and columns in those lists in the form of mappings from fully qualified table/column names to metadata:

allwise_p3as_psd		{desc: "ALLWISE source catalog", dbms: "oracle", datasource: "allwise",...}
w4sigmpro		{desc: "instrumental profile-fit photometry flux..", data_type: "double",...}
w4snr		{desc: "instrumental profile-fit photometry S/N ratio...", data_type: "double"...
ra		{desc: "right ascension (J2000), data_type: "double", ...}
...		

Create mapping between FQCN in expanded SELECT clause and index of corresponding column in that clause.

w4sigmpro	<input type="checkbox"/>		0
w4snr	<input type="checkbox"/>		1
ra	<input type="checkbox"/>		2
dec	<input type="checkbox"/>		3
x	<input type="checkbox"/>		4
...			...



# Enrichment data prep at runtime (Column Groups)

```
https://irsadev.ipac.caltech.edu/TAP/sync?QUERY=SELECT w4sigmpro, w4snr, ra, dec, x, y, z, sigra, sigdec, sigradec  
FROM allwise_p3as_psd WHERE (cntr>=2243021301351018444 and cntr<=2243021301351018445)
```

Examine metadata for FQCNs in SELECT statement...

allwise_p3as_psd.ra	✉	{...,group_IDs: ["group_allwise_p3as_psd_pos"], service_descriptor_ids: []},
allwise_p3as_psd.dec	✉	{...,group_IDs: ["group_allwise_p3as_psd_pos"], service_descriptor_ids: []},
allwise_p3as_psd.w4snr	✉	{...,group_IDs: ["group_allwise_p3as_psd_phot_w4"], service_descriptor_ids: []},

...

...and note which Column Groups those FQCNs are associated to:

group\_allwise\_p3as\_psd\_pos ✉ ["ra", "dec", "sigra", "sigdec", "sigradec"]

group\_allwise\_p3as\_psd\_phot\_w4 ✉ ["w4sigmpro", "w4snr"]



## Enrichment data prep at runtime (Column Groups)

From previous slide:

```
group_allwise_p3as_psd_pos [ "ra", "dec", "sigra", "sigdec", "sigradec" ]
```

```
group_allwise_p3as_psd_phot_w4 [ "w4sigmpro", "w4snr" ]
```

Compare number of elements in each list of columns with the Column Group's cached 'column\_count' value. If the numbers are equal, then all columns associated to the Column Group will be present in the result table and we will want to add a corresponding enrichment element to the final response. If not, not.

```
group_allwise_p3as_psd_pos { desc: "Position, determined using a profile-fitting...",  
  ucd: "pos.eq", ...,  
  column_count: 5 }, YES
```

```
group_allwise_p3as_psd_phot_w4 { desc: "Instrumental photometry parameters...",  
  ucd: "phot;em.IR.15-30um", ...,  
  column_count: 4 }, NO
```



## Database call and final response

With metadata and enrichment prep out of the way, query-server makes the database call as usual.

When creating the final response, it proceeds as usual except that it adds

- a VOTABLE.RESOURCE.GROUP element for each surviving **Column Group**
- a VOTABLE.RESOURCE element of type “meta” for each surviving **Service Descriptor**

Most of the ingredients for these additional elements come from the cache. The only values that depend on the query are the FIELDRef values which point to the columns associated to the **Column Group** or **Service Descriptor**.



## Assemble final response (Column Groups)

```
https://irsadev.ipac.caltech.edu/TAP/sync?QUERY=SELECT w4sigmpro, w4snr, ra, dec, x, y, z, sigra, sigdec, sigradec  
FROM allwise_p3as_psd WHERE (cntr>=2243021301351018444 and cntr<=2243021301351018445)
```

From cache:

```
group_allwise_p3as_psd_pos {desc: "Position, determined using a profile-fitting...",  
ucd: "pos.eq", ...,  
column_count: 5},
```

From runtime:

Group's list of associated columns:

```
group_allwise_p3as_psd_pos ["ra", "dec", "sigra", "sigdec", "sigradec"]
```

Mapping of column name to index in result table:

w4sigmpro	<input type="checkbox"/>	<input checked="" type="checkbox"/>	0
w4snr	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1
ra	<input type="checkbox"/>	<input checked="" type="checkbox"/>	2
dec	<input type="checkbox"/>	<input checked="" type="checkbox"/>	3
x	<input type="checkbox"/>	<input checked="" type="checkbox"/>	4

...





Put it all together:

```
<GROUP id="group_allwise_p3as_psd_pos" name="pos" ucd="pos.eq"
utype="">
  <DESCRIPTION>Position, determined using a profile-fitting measurement
  model that does not include motion</DESCRIPTION>
  <FIELDref ref="col_2"/>
  <FIELDref ref="col_3"/>
  <FIELDref ref="col_7"/>
  <FIELDref ref="col_8"/>
  <FIELDref ref="col_9"/>
</GROUP>
```



# Response with Column Group (GROUP element within TABLE)

<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" xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30">

<RESOURCE type="results">

<INFO name="QUERY\_STATUS" value="OK"/>

<TABLE>

<GROUP id="group\_allwise\_p3as\_psd\_pos" name="pos" ucd="pos.eq" utype="">

<DESCRIPTION>Position, determined using a profile-fitting measurement model that does not include motion</DESCRIPTION>

<FIELDref ref="col\_2"/>

<FIELDref ref="col\_3"/>

<FIELDref ref="col\_7"/>

<FIELDref ref="col\_8"/>

<FIELDref ref="col\_9"/>

</GROUP>

<FIELD name="ra" datatype="double" ID="col\_0" precision="7" ucd="pos.eq.ra;meta.main" unit="deg" width="11">  
<DESCRIPTION>right ascension (J2000)</DESCRIPTION>

</FIELD>  
<FIELD name="dec" datatype="double" ID="col\_1" precision="7" ucd="pos.eq.dec;meta.main" unit="deg" width="11">  
<DESCRIPTION>declination (J2000)</DESCRIPTION>

</FIELD>  
<FIELD name="sigma" datatype="double" ID="col\_2" precision="4" unit="arcsec" width="8">  
<DESCRIPTION>uncertainty in RA</DESCRIPTION>

</FIELD>  
<FIELD name="w4sigmpro" datatype="double" ID="col\_3" precision="3" unit="mag" width="5">  
<DESCRIPTION>instrumental profile-fit photometry flux uncertainty in mag units, band 4</DESCRIPTION>

</FIELD>  
<FIELD name="sigdec" datatype="double" ID="col\_4" precision="4" unit="arcsec" width="8">  
<DESCRIPTION>uncertainty in DEC</DESCRIPTION>

</FIELD>  
<FIELD name="sigradec" datatype="double" ID="col\_5" precision="4" unit="arcsec" width="9">  
<DESCRIPTION>cross-term of RA and Dec uncertainties</DESCRIPTION>

</FIELD>

<DATA>

<TABLEDATA>

<TR>

<TD>224.3159972</TD>

<TD>-21.368905699999999</TD>

<TD>0.053400000000000003</TD>

<TD>0.40000000000000002</TD>

<TD>0.054100000000000002</TD>

<TD>-0.0061000000000000004</TD>

</TR>

</TABLEDATA>

</DATA>

</RESOURCE>

</VOTABLE>



# Assemble final response (Service Descriptors)

```
https://irsa.ipac.caltech.edu/TAP/sync?QUERY=SELECT oid FROM ztf_objects WHERE INTERSECTS(pt,CIRCLE(298.0,29.87,0.001)) AND ((nobs>=5) AND (fid IN (1,2)))
```

From cache:

```
ztf ✉ {desc: "Link to ZTF lightcurve for default collection...",
  access_url: "https://irsa.ipac.caltech.edu/cgi-bin/ZTF/...",
  xml_fragment: "<PARAM>... name=\"bad_catflags_mask\"..."
  ...,
  column_count: 1},
```

From runtime:

Service Descriptor's list of associated columns:

```
ztf ✉ ["ztf_objects.oid"]
```

Mapping of column name to index in result table:

```
ztf_objects.oid ☐ ✉ 0
```



## Put it all together:

```
<RESOURCE type="meta" utype="adhoc:service">
  <DESCRIPTION>Link to ZTF light curve for default ztf collection</DESCRIPTION>
  <GROUP name="inputParams">
    <PARAM name="id" datatype="char" arraysize="*" ref="col_0" value="">
      <DESCRIPTION>Identifier of a ZTF object.</DESCRIPTION>
    </PARAM>
    <PARAM name="bad_catflags_mask" datatype="int" value="0">
      <DESCRIPTION>Bitmask used to exclude lightcurve points with at least one of the indicated catflag bits set. Default is 0.
    </DESCRIPTION>
    </PARAM>
    <PARAM name="time" datatype="char" arraysize="*" value="">
      <DESCRIPTION>Date-time range for which lightcurve data is to be retrieved, unlimited by default. Space-separated endpoint(s) are
        interpreted as Modified Julian Date MJD).
      </DESCRIPTION>
    </PARAM>
  </GROUP>
  <PARAM name="standardID" datatype="char" arraysize="*" value="ivo://ivoa.net/std/DataLink#links-1.0"/>
  <PARAM name="accessURL" datatype="char" arraysize="*" value="https://irsa.ipac.caltech.edu/cgi-
    bin/ZTF/nph_light_curves?collection=ztf_dr3"/>
</RESOURCE>
```

# Response with Service Descriptor (RESOURCE element of type "meta")



```
<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"
xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/VOTable/v1.3 http://www.ivoa.net/xml/STC/v1.30 http://www.ivoa.net/xml/STC/v1.30">
```

```
<RESOURCE type="meta" utype="ad hoc:service">
  <DESCRIPTION>Link to ZTF light curve for default ztf collection</DESCRIPTION>
  <GROUP name="inputParams">
    <PARAM name="id" datatype="char" arraysize="*" ref="col_0" value="">
      <DESCRIPTION>Identifier of a ZTF object.</DESCRIPTION>
    </PARAM>
    <PARAM name="bad_catflags_mask" datatype="int" value="0">
      <DESCRIPTION>Bitmask used to exclude lightcurve points with at least one of the indicated catflag bits set. Default is 0.</DESCRIPTION>
    </PARAM>
    <PARAM name="time" datatype="char" arraysize="*" value="">
      <DESCRIPTION>Date-time range for which lightcurve data is to be retrieved, unlimited by default. Space-separated endpoint(s) are interpreted as Modified Julian Date MJD.</DESCRIPTION>
    </PARAM>
  </GROUP>
  <PARAM name="standardID" datatype="char" arraysize="*" value="ivo://ivoa.net/std/DataLink#links-1.0"/>
  <PARAM name="accessURL" datatype="char" arraysize="*" value="https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph_light_curves?collection=ztf"/>
</RESOURCE>
```

```
<RESOURCE type="results">
  <INFO name="QUERY_STATUS" value="OK"/>
```

```
<TABLE>
  <FIELD name="oid" datatype="long" ID="col_0" ucd="meta.id;src;meta.main">
    <DESCRIPTION>Unique object identifier</DESCRIPTION>
  </FIELD>
  <DATA>
    <TABLEDATA>
      <TR>
        <TD>686203400167748</TD>
      </TR>
    </TABLEDATA>
  </DATA>
</TABLE>
```

[https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph\\_light\\_curves?collection=ztf&id=68203400167748...](https://irsa.ipac.caltech.edu/cgi-bin/ZTF/nph_light_curves?collection=ztf&id=68203400167748...)

```
</RESOURCE>
</VOTABLE>
```



# Questions?