# The ESO VO Polygons Tool

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Polygons in the interoperable VO context

1.- I'll show typical mistakes when serializing a polygon, impacting interoperability.

2.- I'll demo a tool to visualise and examine spherical polygons, circles, union of polygons and of circles.
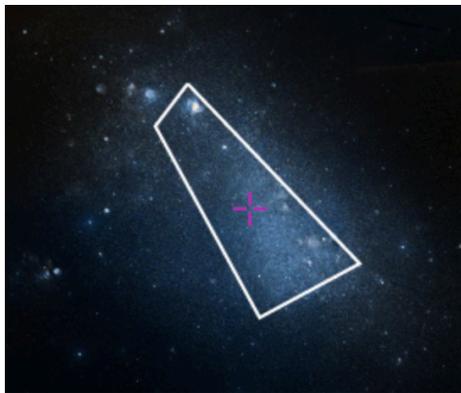
# Quiz
## Given image below,
## what's the DALI geometry of night/day boundary projected onto the sky?

# Typical polygon mistakes/issues Issue 1

**Wrongly ordered vertices => crossing segments => complex polygon**



Meant CCW



Mistaken

- Headedness: undefined (one part of a crossing segment is CCW, the other CW)
- In ADQL constraint:
  - **SQLServer throws error "polygon invalid"**
  - **ORACLE accepts it** (but I do not know how to interpret the query results)
    - e.g., a footprint entirely outside of the polygon (even outside of the repaired polygon)

# Polygon **provided** with the wrong headedness
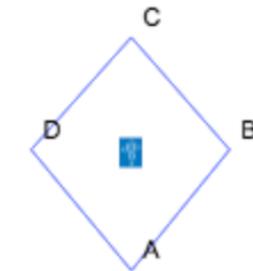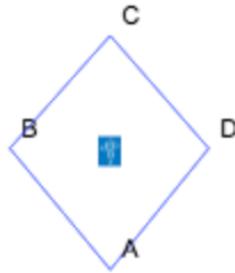


Meant CCW
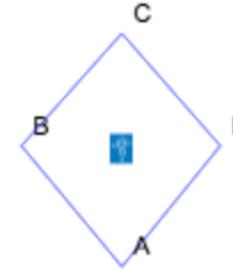


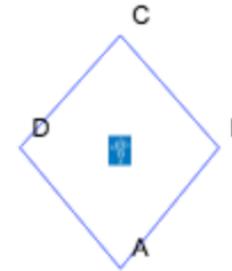Provided CW

## Why is that important?

- Any valid polygon defines two areas of the sky;

- Headedness defines which part is inside the polygon and which one outside (walk along AB, then BC, …: "inside" is at your left)

- In a constraint like: 1=CONTAINS( s_region, POLYGON(…) )
  **wrong polygon headedness means searching "outside" instead of "inside"**

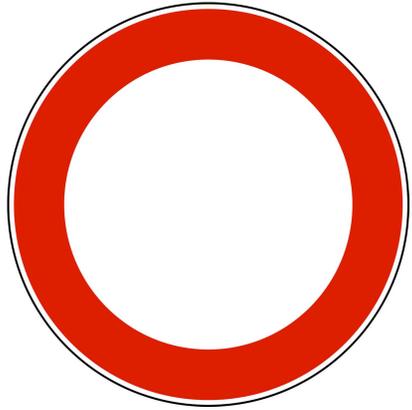# Polygon **interpreted** with the wrong headedness

Provided and meant CW



Interpreted by DBMS as CCW

- *The database returns whatever it considers "inside"*
- **Some DBMSes always consider "inside" the smaller part, however the polygon is provided (CW or CCW)**

# Interoperability at stake

Taking a polygon from one data centre
to place a query constraint onto another data centre
can only work if all implementations respect the same
definitions.

# Spherical Polygon defined in STC v1.33

| | |
|---|---|
| **1. Ordered list** | Ordered list of vertices. |
| **2. Implicit closure** | The last vertex in the list connects back to the first. |
| **3. Great circles** | Vertices are connected by the (shorter) great circle segment. |
| **4. Less than 180º** | Polygon sides must be shorter than 180 degrees to avoid ambiguities; add a vertex when necessary. |
| **5. Left of** | Internal part of the polygon is the one to the left of the lines connecting neighboring vertices (that is, in the ordered list), as seen from the centre of the sphere (left-handed celestial reference system). |
| **6. Closed region** | The boundaries are considered part of the region |
| **CCW** | The inside of the region is defined as that part of coordinate space that is encircled by the polygon in a counter-clockwise sense |
| **CW** | *The inside of the region is defined as that part of coordinate space that is encircled by the polygon in a clockwise sense* [not expressed this way, but see considerations in the area calculations (and errata)] |
| **NOT** | Negation operation is a simple matter of reversing the order of the vertex list |

# Spherical polygons across standards

**STC v1.33,** 2007: **the only standard with complete definition** (but do not use C/CW)

**ADQL v2.0**, 2008:                                    **Missing**: "Less than 180$^o$"

**TAP 1.0**, 2010: *section 6, xtype=adql:region,*

*<region> ::= <position> | <circle> | <box> | <polygon> | <union> | <intersection> | <not>*

**STC-S v1.0 Working Draft**, 2013:        **Missing: "**implicit closure"

**DALI v1.1**, 2017:                                    **Missing**: "Implicit closure","Less than 180$^o$"

**TAP v1.1,** 2019: *strongly recommends DALI syntax, accepting STC-S*

***ADQL v2.1****, 2023: refers to DALI 1.1, and to a future DALI version for regions*

***UNION are not (yet) supported by DALI, hence ESO still uses the STC-S convention***

# Note on polygon definition

"to the left of": always defined!

"CCW" and "CW": **not always defined**!

- Is a meridian CW or CCW? Observer in the centre of the sphere can't tell.
- Same for all great circles, onto which…
- …CW or CCW depends on the direction in which the observer looks.
  - Equator with increasing RAs: 0,0   90,0   180,0   270,0
    is CCW if the observer looks North, CW otherwise.
  - Equator with decreasing RAs: 0,0   270,0   180,0   90,0
    is CW if the observer looks North, CW otherwise.
- Notice that when posing an ADQL query, the direction in which the observer looks is not specified. Databases seem to use the "to the left" definition (*).

  (*) actually "to the right" (geography vs astronomy), but we reverse DB LONG=(180-RA)

# Footprints of ESO's immediate interest
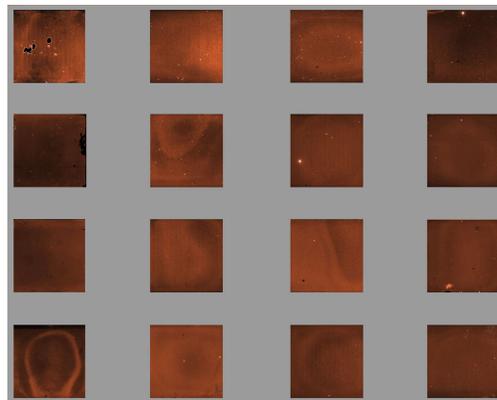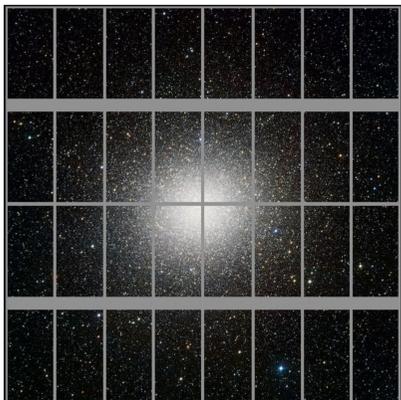


**POINT, CIRCLE, POLYGON,**

**UNION OF POLYGONS, UNION OF CIRCLES,**

**(POLYGONS WITH HOLES)**

| Observatory | Product type | Footprint type |
|---|---|---|
| La Silla, Paranal | spectrum, visibility | Point |
| La Silla, Paranal | image, image tile, cube, catalog tile | Polygon |
| La Silla, Paranal | image pawprint | Union of polygons |
| La Silla, Paranal | source table | None |
| ALMA | image, cube | Circle, Union of circles, Polygon, Union of polygons Polygons with holes |

# ESO VO Polygons Tool

while the emphasis is on polygons, other footprints are also supported

https://archive.eso.org/programmatic/vo_polygons/examples/examples.html

# Thanks!