GRID

Purpose

The menu *Grid* contains classes that define regular output grids for field storage.

Field upon a surface in space:

Spherical Grid (includes far-field grids and uv-grids)

Planar Grid

Cylindrical Grid

Field at the surface of a scatterer:

Surface Grid

Links

Classes→*Electrical Objects*→*Field Storage*→*Grid*

SPHERICAL GRID (spherical_grid)

Purpose

The class *Spherical Grid* defines field points in a 2D grid on a sphere where the field shall be calculated. Both near fields and far fields may be calculated.

Links

Classes→*Electrical Objects*→*Field Storage*→*Grid*→*Spherical Grid*

Remarks

Syntax

```
<object name> spherical_grid
(
    coor_sys                      : ref(<n>),
    grid_type                     : <si>,
    x_range                       : struct(start:<r>, end:<r>, np:<i>),
    y_range                       : struct(start:<r>, end:<r>, np:<i>),
    truncation                    : <si>,
    e_h                           : <si>,
    polarisation                  : <si>,
    polarisation_modification     : struct(status:<si>, coor_sys:ref(<n>)),
    near_far                      : <si>,
    near_dist                     : <rl>,
    file_name                     : <f>,
    file_format                   : <si>,
    comment                       : <s>,
    beam_grid_file                : <f>,
    frequency                     : ref(<n>)
)
```

where

<i> = integer

<n> = name of an object

<r> = real number

<rl> = real number with unit of length

<s> = character string

<f> = file name

<si> = item from a list of character strings

Attributes

Coordinate System (*coor_sys*) [name of an object], default: **blank**.

Reference to an object of one of the *Coordinate Systems* classes defining the coordinate system (the output coordinate system) in which the field points will be calculated. Further, the origin serves as the phase reference for far fields. The field polarisation components will also be expressed in this coordinate system unless otherwise specified in the attribute `Polarisation Modification`.

Grid Type (*grid_type*) [item from a list of character strings], default: **uv**.

The field points are positioned in a 2D grid over the spherical surface. The 2D grid is defined by the variables X and Y (see `X-Range` and `Y-Range`) according to the following definitions (see also the figures in the remarks below).

uv

$(X, Y) = (u, v)$ where u and v are the two first coordinates of the unit vector to the field point. Hence,

$$\hat{r} = (u, v, \sqrt{1 - u^2 - v^2}) \tag{1}$$

u and v are related to the spherical angles by $u = \sin\theta\cos\phi, v = \sin\theta\sin\phi$. u and v have no units.

elevation_over_azimuth

$(X, Y) = (Az, El)$, where Az and El defines the direction to the field point by $\hat{r} = (-\sin Az\cos El,\ \sin El,\ \cos Az\cos El)$. Az and El are angles in degrees. Note that an antenna will be measured in such a grid (with respect to the antenna) applying an azimuth-over-elevation set-up.
Can only be used when `File Format` is specified to 'TICRA'.

elevation_and_azimuth

$(X, Y) = (Az, El)$, where Az and El defines the direction to the field point through the relations $Az = -\theta\cos\phi, El = \theta\sin\phi$ to the spherical angles θ and ϕ. Az and El are, as θ, angles in degrees.
Can only be used when `File Format` is specified to 'TICRA'.

azimuth_over_elevation

$(X, Y) = (Az, El)$, where Az and El defines the direction to the field point by $\hat{r} = (-\sin Az,\ \cos Az\sin El,\ \cos Az\cos El)$. Az and El are angles in degrees. Note that an antenna will be measured in such a grid (with respect to the antenna) applying an elevation-over-azimuth set-up.
Can only be used when `File Format` is specified to 'TICRA'.

theta_phi

$(X, Y) = (\phi, \theta)$, where θ and ϕ are the usual spherical angles of the direction to the field point. θ and ϕ are angles in degrees.

elevation_over_azimuth_EDX

$(X, Y) = (Az, El)$, where Az and El defines the direction to the field point by $\hat{r} = (\sin Az,\ \cos Az \sin El,\ \cos Az \cos El)$. Az and El are angles in degrees. Note that an antenna will be measured in such a standard grid (with respect to the antenna) applying a real elevation-over-azimuth set-up.
Can only be used when `File Format` is specified to 'EDX'.

azimuth_over_elevation_EDX

$(X, Y) = (Az, El)$, where Az and El defines the direction to the field point by $\hat{r} = (\sin Az \cos El,\ \sin El,\ \cos Az \cos El)$. Az and El are angles in degrees. Note that an antenna will be measured in such a standard grid (with respect to the antenna) applying a real azimuth-over-elevation set-up.
Can only be used when `File Format` is specified to 'EDX'.

X-Range (*x_range*) [struct].

Defines the range and number of points along the first grid coordinate, X, as specified by the attribute `Grid Type` above.

Start (*start*) [real number].

Start value of the first grid coordinate X.

End (*end*) [real number].

End value of the first grid coordinate X.

Np (*np*) [integer].

Number of field points along first grid coordinate X.

Y-Range (*y_range*) [struct].

Defines the range and number of points along the second grid coordinate, Y, as specified by the attribute `Grid Type` above.

Start (*start*) [real number].

Start value of the second grid coordinate Y.

End (*end*) [real number].

End value of the second grid coordinate Y.

Np (*np*) [integer].

Number of field points along second grid coordinate Y.

Truncation (*truncation*) [item from a list of character strings], default: **rectangular**.

Specifies the area in which the field is calculated.

rectangular

The field is calculated in all of the grid points within the rectangular area defined by `X-Range` and `Y-Range`.

elliptical

The field is only calculated at the grid points inside the elliptical area with the axes of the ellipse defined by `X-Range` and `Y-Range` (in a plane rectangular XY-coordinate system).

E/H-Field (*e_h*) [item from a list of character strings], default: **e_field**.

Specifies the field type to be calculated.

e_field

The complex E-field is calculated.

h_field

The complex H-field is calculated.

Polarisation (*polarisation*) [item from a list of character strings], default: **linear**.

Defines how the calculated field shall be decomposed. All components refer to the output coordinate system given in `Coordinate System` unless a polarisation coordinate system as defined under the attribute `Polarisation Modification`. In the near field the r-component of the field is calculated as a third component.

linear

Linear components are calculated according to Ludwig's 3rd definition, with the first component (E_{co}) along x and the second component (E_{cx}) along y (at $\theta = 0°$). The notation implies that for a field, which is mainly y-polarised then the second component (E_{cx}) represents the co-polar field component.

circular

Circular components are calculated based on the linear components defined above. The first component is the right hand circular (E_{rhc}) and the second is left hand circular component (E_{lhc}).

theta_phi

The field is decomposed along the θ- and ϕ-unit vectors with the θ-component (E_θ) being the first component and the ϕ-component being the second (E_ϕ).

major_minor

The field is decomposed along the major and minor axes of the polarisation ellipse. The first field component is parallel to the major axis (E_{maj}) and the second to the minor axis ($E_{\min}$).

linear_xpd

The ratios E_{co}/E_{cx} and E_{cx}/E_{co}, where E_{co} and E_{cx} are the first and second components as defined for the '*polarisation*: linear'. This is the linear cross-polar discrimination ratio.

circular_xpd

The ratios E_{rhc}/E_{lhc} and E_{lhc}/E_{rhc}, where E_{rhc} and E_{lhc} are the first and second components as defined for the '*polarisation*: circular' above. This is the circular cross-polar discrimination ratio.

theta_phi_xpd

The ratios E_θ/E_ϕ and E_ϕ/E_θ, where E_θ and E_ϕ are the first and second components as defined for the '*polarisation*: theta_phi' above.

major_minor_xpd

The ratios E_{maj}/E_{min} and E_{min}/E_{maj}, where E_{maj} and E_{min} are the first and second components as defined for the '*polarisation*: major_minor' above.

power

The first component is the amplitude of the field, $\left|\vec{E}\right|$, (i.e. the square root of the power) and the second component is the complex square root $\sqrt{E_{rhc}/E_{lhc}}$. The phase of the latter component is the rotation angle of the polarisation ellipse.
In the far field the square root of the power is determined from
$\left|\vec{E}\right| = \sqrt{|E_{co}|^2 + |E_{cx}|^2}$
and in the near field it is determined from all three field components: $\left|\vec{E}\right| = \sqrt{|E_{co}|^2 + |E_{cx}|^2 + |E_r|^2}$, E_r being the r-component of the field.

Polarisation Modification (*polarisation_modification*) [struct].

Defines a coordinate system in which the field polarisation components are determined (if different from the output coordinate system defined in attribute `Coordinate System` above).

Status (*status*) [item from a list of character strings], default: **off**.

Determines if the polarisation modification shall be performed:

off

No polarisation modification, the polarisation is defined in the above defined output coordinate system and the polarisation coordinate system is identical to the output coordinate system.

on

The polarisation is defined in the coordinate system defined next.

Coordinate System (*coor_sys*) [name of an object], default: **blank**.

Reference to an object of one of the classes in *Coordinate System* defining the coordinate system (the polarisation coordinate system) in which the polarisation components of the calculated field vectors will be expressed. Shall only be specified for *status*: on.

Near/Far (*near_far*) [item from a list of character strings], default: **far**.

The value specifies if a near or a far field is to be calculated.

far

A far field is calculated. In this case only two field components are calculated according to the specified `Polarisation`.

near

The three field components of a near field is calculated. These are the two components defined under the attribute `Polarisation` and the radial component.

Near-Field Distance (*near_dist*) [real number with unit of length], default: **0**.

Defines the radius of a near-field sphere. For a far field this attribute has no effect and needs not to be specified.

File Name (*file_name*) [file name].

Name of a file, to which the calculated field values shall be written.

File Format (*file_format*) [item from a list of character strings], default: **TICRA**.

The file format used to store the field data:

TICRA

The field is written in GRASP units and stored as an ASCII-file according to the TICRA-format described in *Field Data in Rectangular Grid*. The recommended file extension is *.grd*.

EDX

The field is written in SI units in a format according to the Electromagnetic Data Exchange (EDX) standard. The recommended file extension is *.grd*.
Files in this format cannot be read by the PostProcessor.

EDI

Obsolete file format name. The same as EDX.

Comment (*comment*) [character string].

A line of text which will be written as a header in the file specified by `File Name` above.

Beam Grid File (*beam_grid_file*) [file name].

Name of a file containing beam directions. The file is only used when the source generating the field is one of the array sources (see the listing of these under the menu point *Array*). When a file name is not specified, the field is determined at the XY-range given above without modifications. When the file is applied, each beam direction defines a translation of the above-specified grid such that the grid will become positioned relative to the beam direction specified in the file. The file shall for each direction contain an identification, which agrees with the element identification given in the relevant *Array* class. The beam directions in the file must be generated by the user. The format of the file is described in the section *Beam Grid Directions*.

Frequency (*frequency*) [name of an object], default: **blank**.

Reference to a *Frequency* object, defining the frequencies for which the field is calculated. The reference must be to the same object as specified in the *frequency* attribute of the source generating the field. A *frequency* needs not to be specified. In that case, the frequencies in the *frequency* object of the source generating the field will be applied.

Command Types

The *Spherical Grid* class is derived from the class *Field Storage*. See this class for available commands.

Remarks

The section introduces the grids specifying the positions of the field points and the definition of a polarisation coordinate system.

Field Points

The field points in a *Spherical Grid* are defined in usual spherical (θ, ϕ)-coordinates. For far fields, (θ, ϕ) defines a direction

$$\hat{r} = \hat{x} \sin\theta \cos\phi + \hat{y} \sin\theta \sin\phi + \hat{z} \cos\theta$$

and for near fields, (θ, ϕ) defines a point

$$\bar{R} = R(\hat{x} \sin\theta \cos\phi + \hat{y} \sin\theta \sin\phi + \hat{z} \cos\theta)$$

where $R = \left|\bar{R}\right|$ is the radius of the near-field sphere (as given by the attribute `Near-Field Distance`).

The unit vectors $\hat{x}$, $\hat{y}$ and $\hat{z}$ are the unit vectors along the axes of the output coordinate system as defined by the attribute *coor_sys*. In the following figures the axes are denoted x_o, y_o and z_o.

The field grid is defined by the ranges `X-Range` and `Y-Range` in a general XY-coordinate system where (X, Y) may take one of the definitions given by the attribute `Grid Type`. The field grid then consists of the points

$$X = X_s + \Delta X(i-1) + X_1$$
$$Y = Y_s + \Delta Y(j-1) + Y_1$$

where i and j takes on the values

$$i = 1, 2, \ldots, N_x$$
$$j = 1, 2, \ldots, N_y.$$

Moreover, X_s and Y_s are the `Start` values and N_x and N_y are the number of values, `Np`, of the attributes `X-Range` and `Y-Range`, respectively, and ΔX and ΔY are the spacings in the grid

$$\Delta X = (X_e - X_s)/(N_x - 1)$$
$$\Delta Y = (Y_e - Y_s)/(N_y - 1)$$

where X_e and Y_e are the `End` values of the attributes `X-Range` and `Y-Range`, respectively.

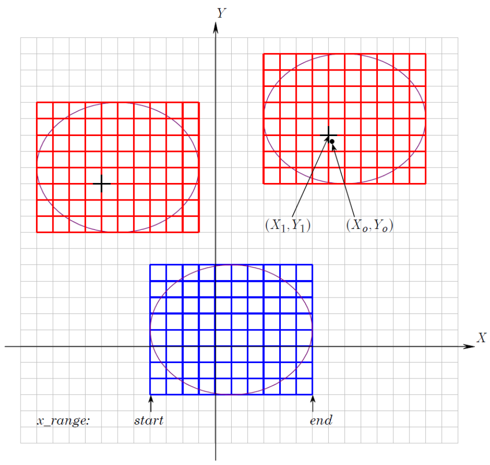

Figure 1 The XY coordinate system. A grid defined by `X-Range` and `Y-Range` is shown in blue. In the `Beam Grid File` two beams are defined, their grids, copies of the blue, are shown in red. For the right grid, the beam direction (X_0, Y_0) read from the file is shown along with the nearest grid point (X_1, Y_1). The ranges of the grid are measured from this point. When the `Truncation` is 'rectangular' the full grids in red are included, and when the `Truncation` is 'elliptical' only the grid points within the shown ellipses are included.

The numbers X_1 and Y_1 are zero if a `Beam Grid File` is not defined. If `Beam Grid File` is defined, beam directions (X_0, Y_0) are read from the file and X_1 and Y_1 are defined by

$$X_1 = \mathtt{NINT}(X_0/\Delta X) \cdot \Delta X,$$
$$Y_1 = \mathtt{NINT}(Y_0/\Delta Y) \cdot \Delta Y.$$

Herein, the function $\mathtt{NINT}(x)$ gives the integer number nearest to x. It is seen that a beam direction different from (0,0) has the effect that the field grid is translated by an integer number of grid spacings so that the new grid is centred as close as possible around (X_0, Y_0).

The Grids

The X and Y variables of the grid are related to the direction to the field points according to the selected value of the attribute `Grid Type`. The different possibilities are illustrated in the following figures. $x_0y_0z_0$ is the output coordinate system as defined by the attribute `Coordinate System`. Some grids are related to a scanning procedure, but for all grids the $x_0y_0z_0$-coordinate system is fixed with respect to the antenna and follows this during the scanning.

For all the grids, the central direction given by $(X, Y) = (0, 0)$ is along the z_0-axis, $\theta = 0$.

Note that many grid definitions involve the rotational angles azimuth and elevation. These grids are alike but have important differences which are explained in the following sections.

`Grid Type`: *uv*

The uv-grid constitutes a regular grid when projected to the x_0y_0-plane. The far-field directions of this grid are obtained by projecting the grid to a unit-sphere, see the following Figure 2. This grid is the only grid not given in angles.

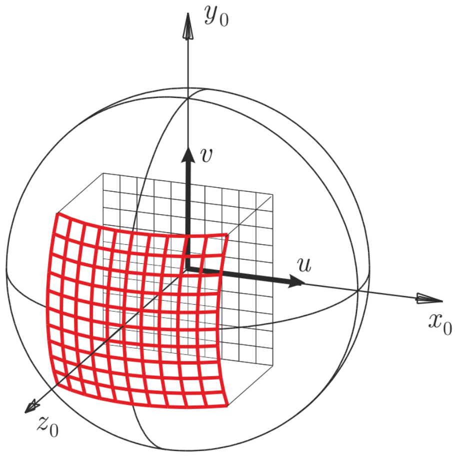

Figure 2 — `Grid Type`: *uv*.
The uv-grid is that drawn in the x_0y_0-plane, while the red grid upon the sphere (obtained by parallel projection) shows the far-field directions of the irregular angles corresponding to the regular uv-grid.
The grid is drawn for $-0.5 \leq u \leq 0.5$ and $-0.5 \leq v \leq 0.5$ with a spacing of 0.1 in both u and v.

`Grid Type`: *elevation_over_azimuth*

For the elevation-over-azimuth grid the direction to a field point can be visualized by a telescope mounted in an elevation-over-azimuth set-up at the origin of the $x_0y_0z_0$-coordinate system. When rotated the angles (Az, El), the telescope will point at the field point given by the angles (Az, El). The grid has poles on the y_0-axis, see Figure 3.

Apart from the positive direction of the azimuth rotation, the grid is the same as the *azimuth_over_elevation_EDX*-grid described below.

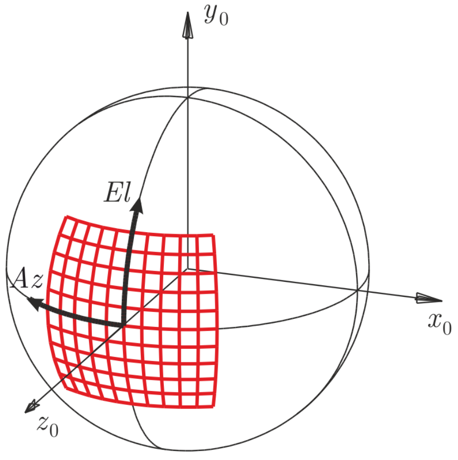

Figure 3 `Grid Type`: *elevation_over_azimuth*.
The grid is drawn for $-30° \leq Az \leq 30°$ and $-30° \leq El \leq 30°$ with a spacing of $6°$ in both Az (azimuth) and El (elevation).

`Grid Type`: *elevation_and_azimuth*

This grid treats azimuth and elevation symmetrically but is not related to physical rotations. The grid is shown in Figure 4.

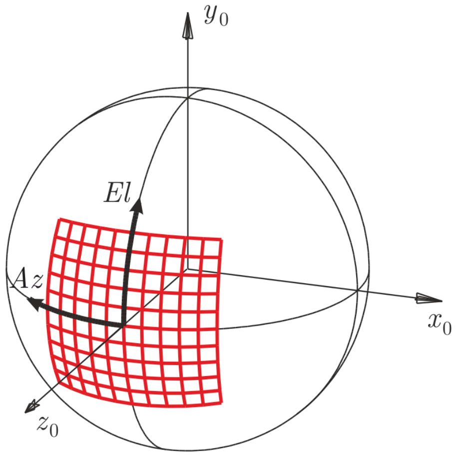

Figure 4 `Grid Type`: *elevation_and_azimuth*.
The grid is drawn for $-30° \leq Az \leq 30°$ and $0° \leq El \leq 30°$ with a spacing of $6°$ in both Az (azimuth) and El (elevation).

`Grid Type`: *azimuth_over_elevation*

Also for this grid the direction to a field point can be visualized by a telescope, now mounted in an azimuth-over-elevation set-up, placed at the origin of the $x_0y_0z_0$-coordinate system. When rotated the angles (Az, El), the telescope will point at the field point given by the angles (Az, El). The grid has poles on the x_0-axis, see Figure 5.

Apart from the positive direction of the azimuth rotation, the grid is the same as the *elevation_over_azimuth_EDX*-grid described below.

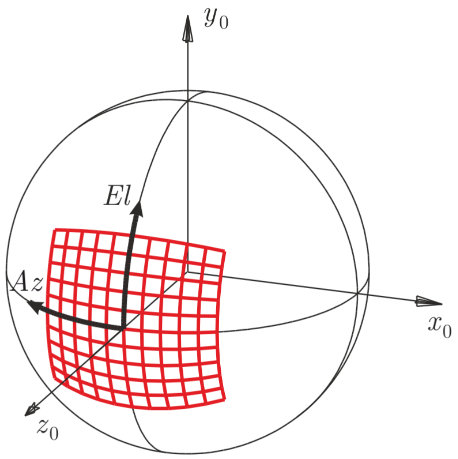

Figure 5 `Grid Type`: *azimuth_over_elevation*.
The grid is drawn for $-30° \leq Az \leq 30°$ and $-30° \leq El \leq 30°$ with a spacing of $6°$ in both Az (azimuth) and El (elevation).

`Grid Type`: *theta_phi*

This grid is a conventional grid in the spherical coordinates θ and ϕ with poles on the z_0-axis (for $\theta = 0°$ and $\theta = 180°$), Figure 6.

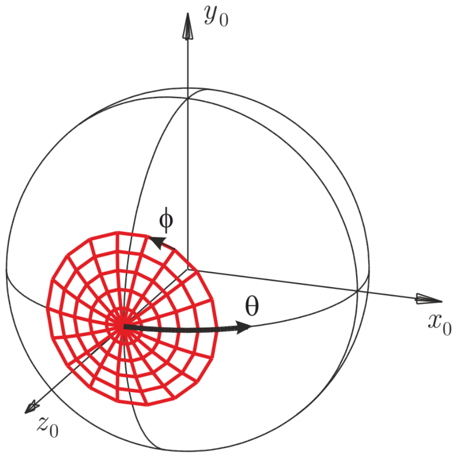

Figure 6 `Grid Type`: *theta_phi*.
The grid is drawn for $0° \leq \theta \leq 30°$ and $0° \leq \phi \leq 360°$ with a spacing of $6°$ in θ and $20°$ in ϕ.

`Grid Type`: *elevation_over_azimuth_EDX*

This grid is the grid in which an antenna will be sampled when it is mounted in a traditional elevation-over-azimuth (El/Az) scanner while the direction to the field point is kept constant as in a far-field range.

In order to illustrate the elevation-over-azimuth scanning, a reflector antenna is shown in the following figures. The scanner itself is not shown.

The grid type is one of the standard grid types in EDX[1]. The directions in the grid are given by azimuth, Az, and elevation, El, alternatively denoted α and ε, respectively, in order to distinguish from the azimuth and elevation angles in the azimuth-over-elevation grid (see following grid type). As for all other grids, the grid follows the antenna during rotations.

The grid has poles on the x_0-axis and is shown in Figure 7.

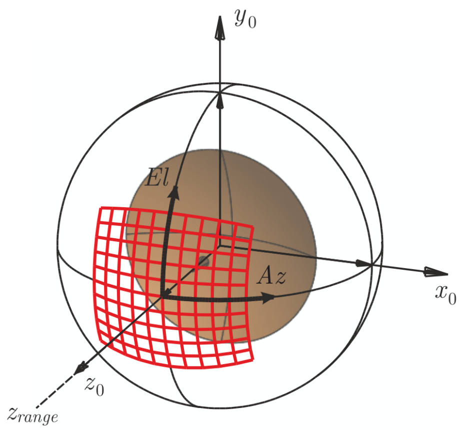

Figure 7 `Grid Type`: *elevation_over_azimuth_EDX* (El/Az or ε/α). To illustrate that this grid corresponds to rotation of the antenna in an elevation-over-azimuth positioner, this and the following figures shows the antenna rotations, here before rotation, i.e. $Az = \alpha = 0°$ and $El = \varepsilon = 0°$. z_{range} indicates the direction to the field probe (the far-field direction).
The grid is drawn for $-30° \leq Az\ (\alpha) \leq 30°$ and $-30° \leq El\ (\varepsilon) \leq 30°$ with a spacing of $6°$ in both Az (or α, azimuth) and El (or ε, elevation).

The rotation of an antenna mounted in an elevation-over-azimuth set-up is in the following figures illustrated step by step. The antenna is a front-fed reflector antenna which initially (i.e. for $Az = 0°$ and $El = 0°$) is pointing in the far-field direction of the measurement range which is along the z-axis of the range, z_{range}. The antenna is given in its output coordinate system (attribute `Coordinate System`) $x_0y_0z_0$ with the main beam along the z_0-axis. This initial situation is shown in Figure 7.

When this antenna is rotated in azimuth we get Figure 8. The antenna beam is rotated to the left in the figure as given by the angle Az which - in the grid fixed to the antenna - is positive to the right.

[1]EDX is a definition of how electromagnetic data may be exchanged between various software tools, see "Electromagnetic Data Exchange Field Data Dictionary definition", European Space Agency and Satimo S.A., 2008

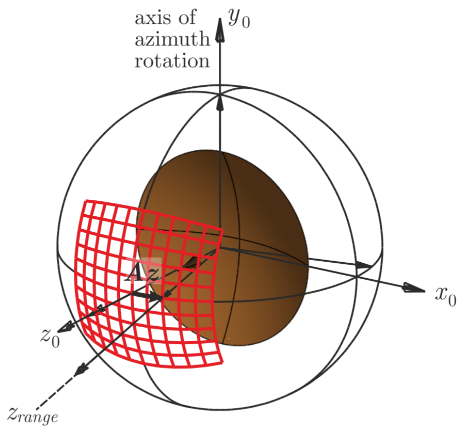

Figure 8 The reflector antenna is first rotated in azimuth. The grid spacing is $6°$, thus $Az = \alpha = 12°$.

The antenna is then tilted in elevation (upon the rotated azimuth platform), Figure 9. The antenna beam is hereby tilted down the angle El whereby the fixed far-field direction is moved the same angle El up with respect to the antenna.

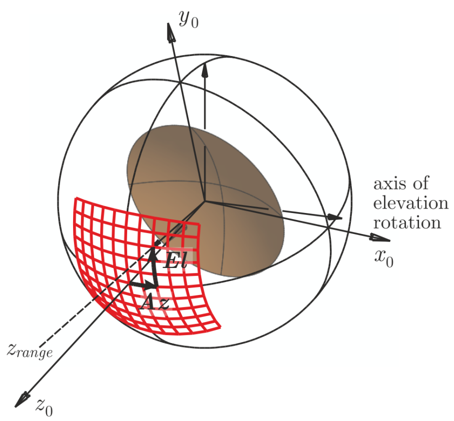

Figure 9 The reflector antenna is finally tilted in elevation. The grid spacing is $6°$ thus $El = \varepsilon = 18°$ (and $Az = \alpha = 12°$, unchanged).

In all the above figures, the range coordinate system is kept fixed (z_{range} points in the same direction) while the antenna is rotating as in a (imagined) physical scanner. If we instead show the antenna and the grid in a fixed antenna coordinate system, the $x_0y_0z_0$-coordinate system, and move the field direction (represented by z_{range}) to the grid point we obtain Figure 10. This figure is thus shown in the same antenna perspective as Figure 7 but with a field direction corresponding to the grid point at $(Az, El) = (18°, 12°)$.

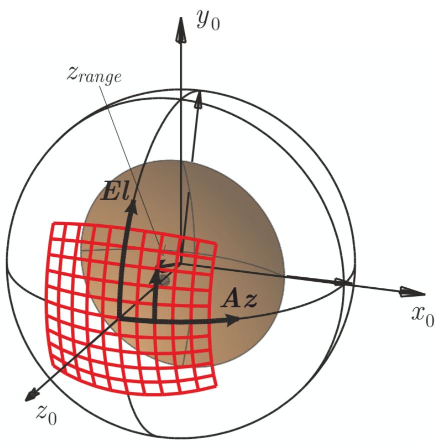

Figure 10 The grid is here shown with the field direction moved to $(Az, El) = (\alpha, \varepsilon) = (18°, 12°)$ but the antenna kept fixed, while in Figure 9 the antenna was moved. The antenna and the grid is therefore oriented in the same way as in Figure 7. The field direction is given by the z-axis of the range system, z_{range}, which here points near to directly out of the paper.

The *elevation_over_azimuth*-grid has poles on the x_0-axis and is thus the same as the *azimuth_over_elevation*-grid illustrated in Figure 5 apart from the positive direction of the azimuth rotation (Az or α) which for the EDX grid increases to the right.

`Grid Type`: *azimuth_over_elevation_EDX*

This grid is the grid in which an antenna will be sampled when it is mounted in a traditional azimuth-over-elevation (Az/El) scanner while the direction to the field point (Az, El) is kept constant as in a far-field range.

In order to illustrate the azimuth-over-elevation scanning, a reflector antenna is shown in the following figures. The scanner itself is not shown.

The grid type is one of the standard grid types in EDX[2]. As for all other grids, the grid follows the antenna when it is rotated. The grid has poles on the y_0-axis and is shown in Figure 11.

[2]EDX is a definition of how electromagnetic data may be exchanged between various software tools, see "Electromagnetic Data Exchange Field Data Dictionary definition", European Space Agency and Satimo S.A., 2008

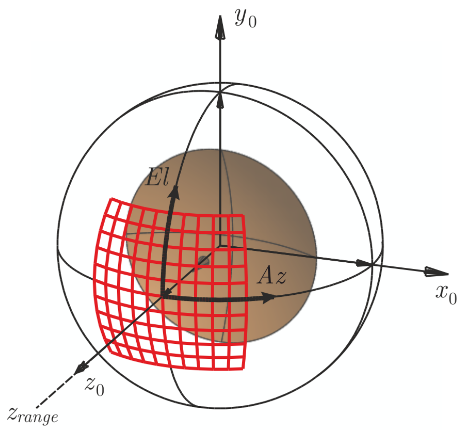

Figure 11 `Grid Type`: *azimuth_over_elevation_EDX* (Az/El).
To illustrate that this grid corresponds to rotation of the antenna in an azimuth-over-elevation positioner, this and the following figures shows the antenna rotations, here before rotation, i.e. $Az = 0°$ and $El = 0°$. z_{range} indicates the direction to the field probe.
The grid is drawn for $-30° \leq Az \leq 30°$ and $-30° \leq El \leq 30°$ with a spacing of $6°$ in both Az (azimuth) and El (elevation).

The rotation of an antenna mounted in an azimuth-over-elevation set-up is in the following figures illustrated step by step. The antenna is a front-fed reflector antenna which initially (i.e. for $Az = 0°$ and $El = 0°$) is pointing in the far-field direction of the measurement range which is along the z-axis of the range, z_{range}. The antenna is given in its output coordinate system (attribute `Coordinate System`) $x_0y_0z_0$ with the main beam along the z_0-axis. This initial situation is shown in Figure 11.

If this antenna is tilted in elevation we get Figure 12. The antenna beam is here tilted <u>down</u> the angle El whereby the fixed far-field direction is moved the same angle El <u>up</u> with respect to the antenna.

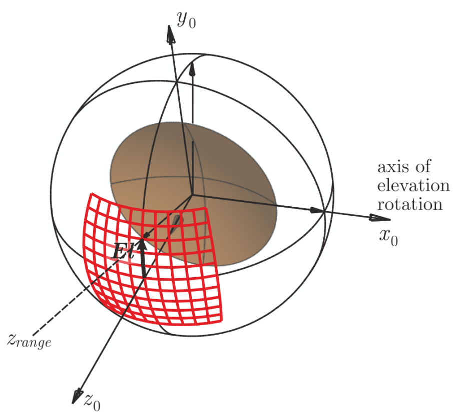

Figure 12 The reflector antenna is now tilted in elevation. The grid spacing is $6°$ thus $El = 18°$ (and $Az = 0°$).

Finally the antenna is rotated in azimuth upon the tilted elevation platform, Figure 13. The antenna beam is now rotated to the left as given by the angle Az which in the grid fixed to the antenna is positive to the right.

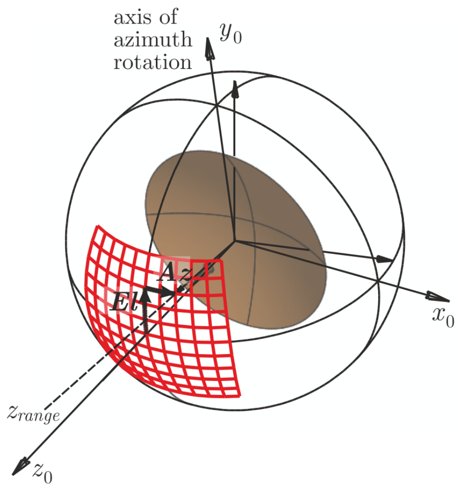

Figure 13 The reflector antenna is finally rotated in azimuth. The grid spacing is $6°$ thus $Az = 12°$ (and $El = 18°$, unchanged).

In all these figures, the range coordinate system is kept fixed (z_{range} points in the same direction) while the antenna is rotating as in a (imagined) physical scanner. If we instead show the antenna and the grid in a fixed antenna coordinate system, the $x_0y_0z_0$-coordinate system, and move the field direction (represented by z_{range}) to the grid point we obtain Figure 14. This figure is thus shown in the same antenna perspective as Figure 11 but with the grid point at $(Az, El) = (18°, 12°)$.

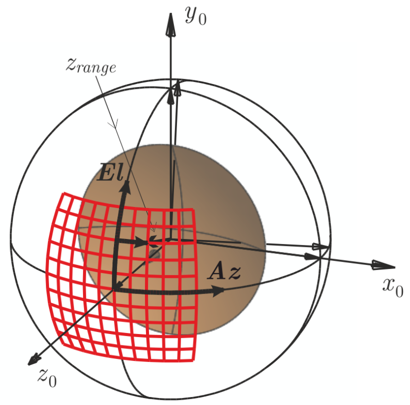

Figure 14 The grid is here shown with the field direction moved to $(Az, El) = (18°, 12°)$ and the antenna kept fixed, while in Figure 13 the antenna was moved. The antenna and the grid is therefore oriented in the same way as in Figure 11. The field direction is given by the z-axis of the range system, z_{range}, which here points out of the paper.

The *azimuth_over_elevation_EDX*-grid has poles on the y_0-axis and is thus the same as the *elevation_over_azimuth*-grid illustrated in Figure 3 apart from the positive direction of the azimuth rotation (Az) which for the EDX-grid increases to the right.

The Polarisation Coordinate System

When the field polarisation is requested in another coordinate system than the output coordinate system then the attribute *polarisation_modification* shall be applie d with '*status*: on' followed by a reference to the polarisation coordinate system.

The attribute *polarisation* may be specified as 'linear' (E_{co}- and E_{cx}-components), 'circular' (E_{rhc}- and E_{lhc}-components) or 'theta_phi' (E_θ- and E_ϕ-components). In the near field also an E_r-component will be present. In case of 'theta_phi' polarisation the electric field is given by

$$\bar{E} = E_r\widehat{r} + E_\theta\widehat{\theta} + E_\phi\widehat{\phi}$$

where $\widehat{r}$, $\widehat{\theta}$ and $\widehat{\phi}$ are the polarisation vectors in the polarisation coordinate system. The spherical grid in which the field is determined is always given in the output coordinate system.

An example is shown in Figure 15 in which only two perpendicular arcs of the grid are shown in red. The field is to be determined at the observation point P. The output coordinate system is denoted by $x_0y_0z_0$ and the polarisation coordinate system is $x_py_pz_p$. In the figure the latter is a simple rotation of the former around the y-axis but any coordinate system may be chosen as polarisation coordinate system.

Internally in GRASP the field is calculated in Cartesian components in the output coordinate system

$$\bar{E} = E_{ox}\widehat{x}_0 + E_{oy}\widehat{y}_0 + E_{oz}\widehat{z}_0.$$

The field is then converted to the new components

$$\bar{E} = E_{px}\widehat{x}_p + E_{py}\widehat{y}_p + E_{pz}\widehat{z}_p$$

before the Cartesian components are converted to (in this case) the polar components in the usual way.

The resulting θ_p-component (shown in blue) is pointing away from the z_p-axis in the same way as the standard θ_0-component will point away from the z_0-axis (along θ_0).

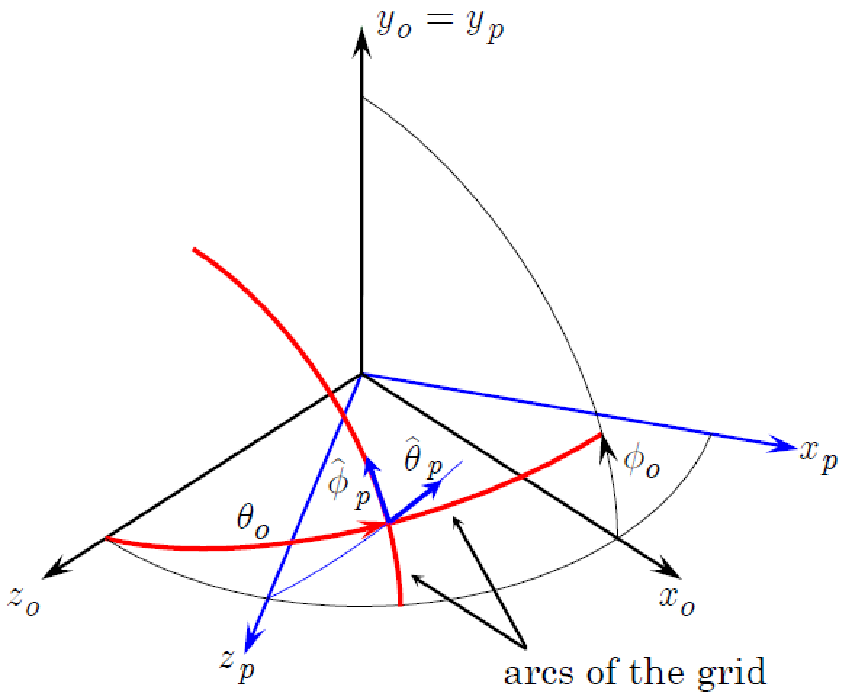

Figure 15 In red is shown two arcs of the spherical grid in the output coordinate system given by $x_0 y_0 z_0$. The observation point P is specified by the direction (θ_0, ϕ_0). The polarisation is expressed in theta_phi components along $\widehat{\theta}_p$ and $\widehat{\phi}_p$ in the polarisation coordinate system $x_p y_p z_p$.