baspl++ User Manual

CFD XY Plot Fluid Mechanics Synthesis Tools

SMR SA

Version 2.4

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1. Introduction

The *CFDxy Plot* suite of tools is an extension to baspl++ offering typical CFD typical visualization and post-processing functions, such as 'C_p profile' plots, one-dimensional probes along lines, and computation of aerodynamic coefficients by integrating CFD fields along a line, usually the x-axis. The *CFDxy Plot* suite of tools can handle structured multi-block finite volume grids and unstructured multi-block finite element grids, and it can be operated interactively or with scripts, which can be generated automatically from interactive sessions. The *CFDxy Plot* suite of tools works seamlessly with all other baspl++ viewing functions.

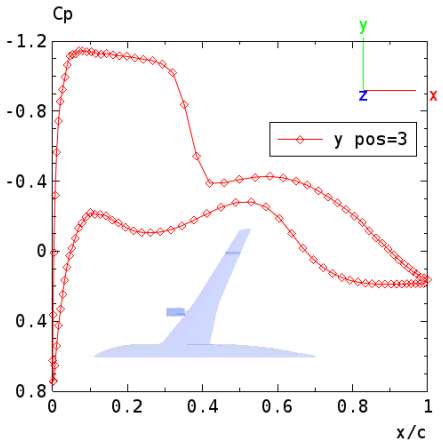


Figure 1. Example of wing profile C_p plot at position y=3.

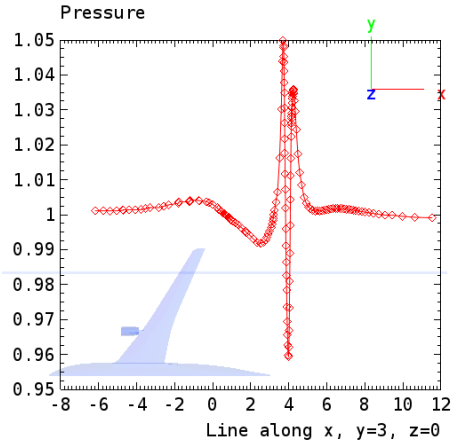


Figure 2. Example of pressure versus line plot along a line y=3, z=0 (blue line).

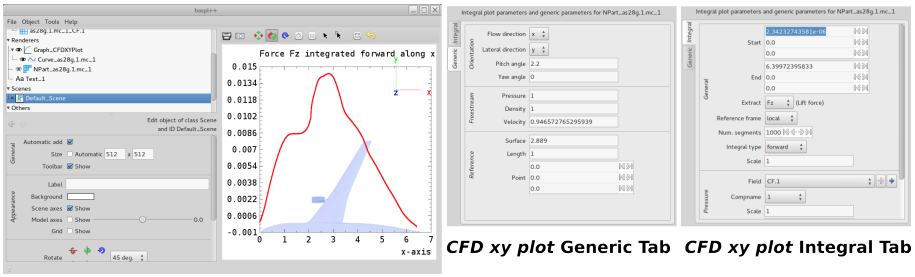
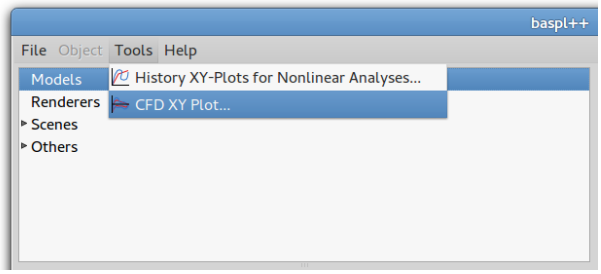


Figure 3. Example of integral plot: Lift force F_z integrated forward along x.

The *CFD xy plot* tools are started by selecting **CFD XY Plot...** from the **Tools** menu located in the baspl++ top menu bar:



The *CFD xy plot* tools require a surface to be worked with, usually the 'wet surface', i.e. the airplane surface extraction, which can be obtained in the following two ways:

- Start baspl++ from scratch, without any database: A database must be specified in the **Open Model and append NPart...** of the **File** menu (see example below). For NSMB models the surface (boundary condition codes 300-399) is extracted automatically and placed in a new *NPart*. For models originating from other CFD codes the surface must be extracted explicitly in a new *NPart*.

- Open the *CFD xy plot* tools within a running baspl++ session with a active model: The surface must be extracted explicitly in a new *NPart*. All defined NParts appear in the left column of the **CFDXYPlot Settings** widget (see example below).

The *CFD xy plot tools* assume that the CFD model is oriented such that the x-axis is pointing in the negative direction of flow, with pitch angle α and yaw angle β. Transforms always operate first over the pitch angle and the over the yaw angle.

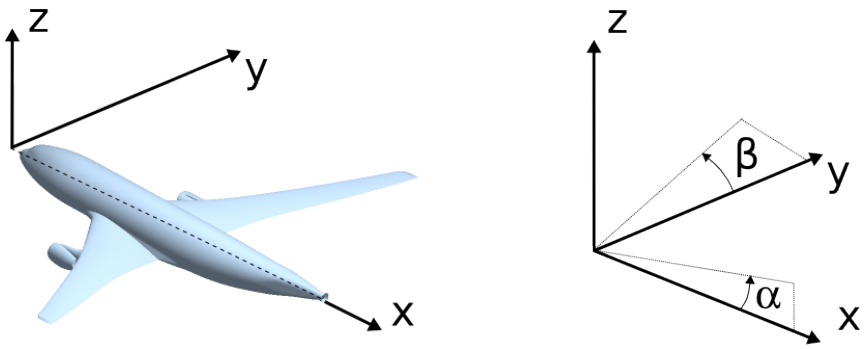


Figure 4. CFDxy plot model axes (left) and definition of pitch angle α and yaw angle β (right).

2. Profile Plots

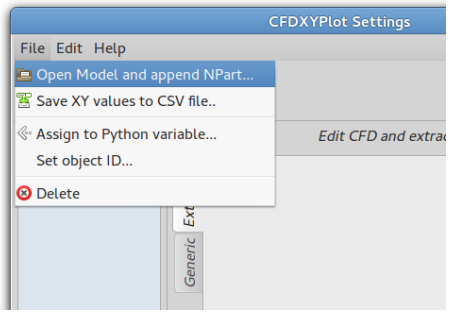
The profile plot tool generates various types of profile plots, ranging from generic field plots to C_p plots, with C_p defined as

$$C_p = \frac{p - p_\infty}{0.5 \rho_\infty v_\infty^2}$$

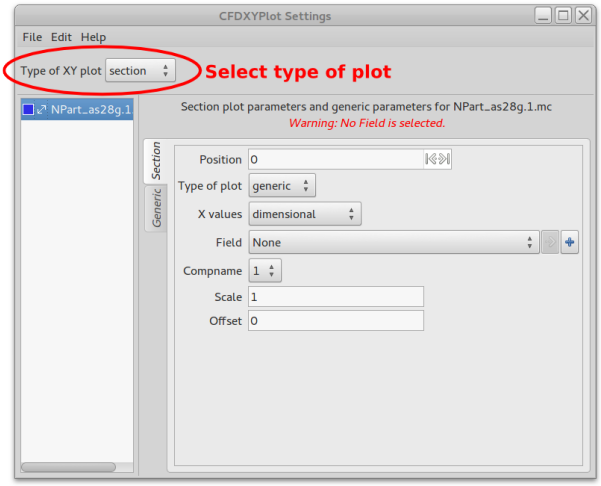
where p is the pressure (such as the PRES field), p_∞ the free-stream pressure, ρ_∞ the free-stream density, and v_∞^2 the free-stream velocity of the fluid.

The tool assumes that the model is oriented such that the x-axis is pointing in the negative direction of flow, with pitch angle α and yaw angle β, as shown in Figure 4. The wing can be oriented along the y- or the z-axis.

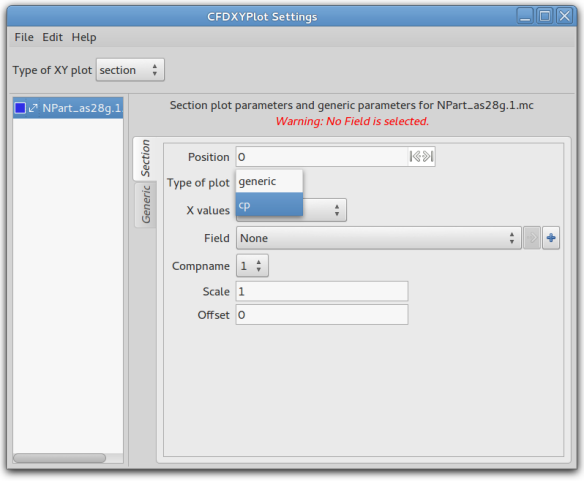
Start by opening a model database:



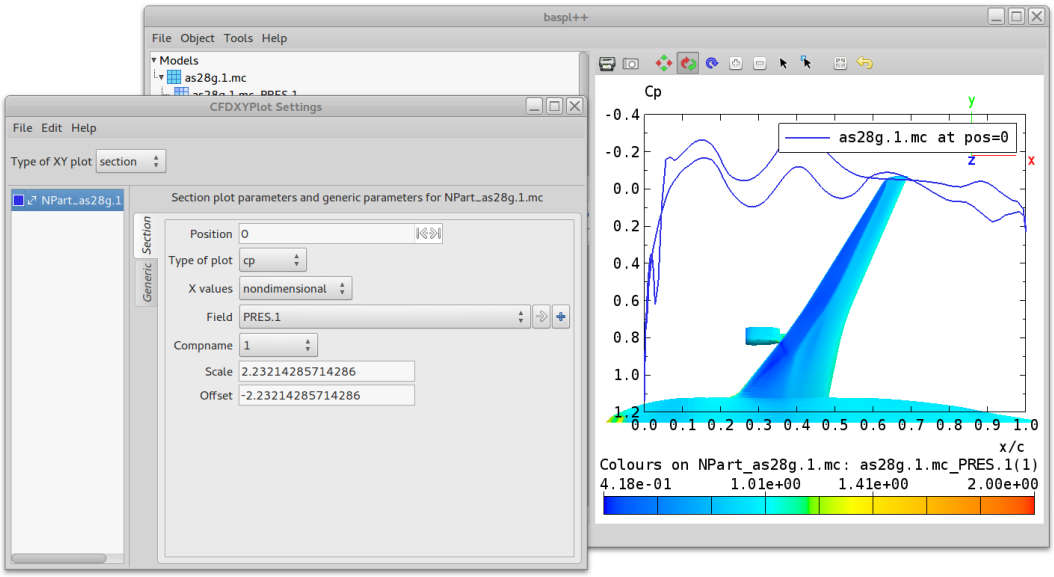
As already explained above, if baspl++ is launched from scratch, opening a NSMB model automatically extracts the surface and places it in a new *NPart*, activating the NPart and assigning a colour (left column below). For models originating from other CFD codes the surface must be extracted explicitly in a new *NPart*, and when the new *NPart* appears in the left column below it must be selected. When selected, it gets a blue background, as is the case with all selected items of baspl++.



Next, a field must be selected. In the example below, the *cp* (C_p) field is selected.



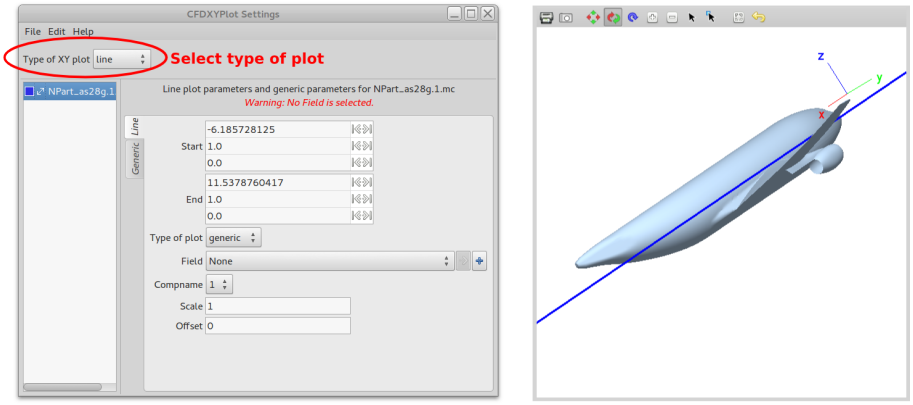
The *CFD xy plot* tool then automatically extracts the relevant fields (here: *PRES*), computes C_p, and plots the result in a graph. By default the profile is extracted by cutting the y axis in the x-z-plane for y=0 (**Position** menu item):



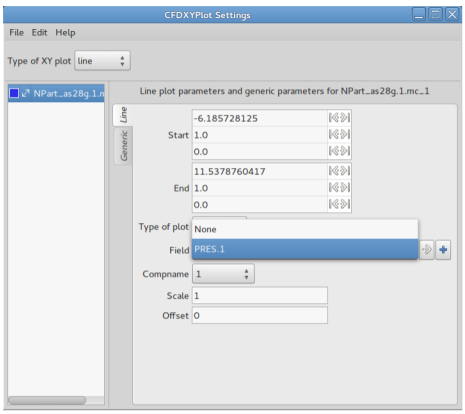
By default the surface will not appear as plotted in the figure above. To visualize the surface, activate it with the 'eye' icon of the relevant **Npart** entry in the **Renderers** menu. To obtain profiles for positions other than 0, simply specify the position in the **Position** menu item (see above).

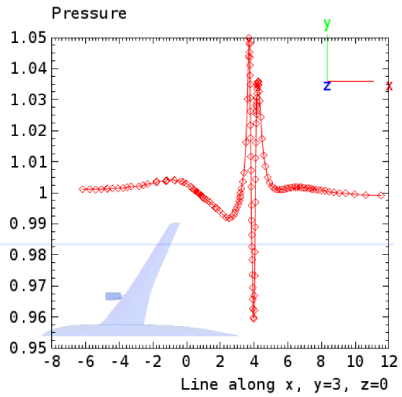
3. Line Plots

Line plots generate xy-plots by interpolating 3D field values along a line ('probe') and plotting them against the line. To generate line plots, select the **line** option of the **Type of XY plot** menu (top left in menu below). This plots the selected line in the baspl++ scene (right). Note that the surface and the line are not displayed by default - select the 'eye' icon of the relevant **Npart** entry in the **Renderers** menu.



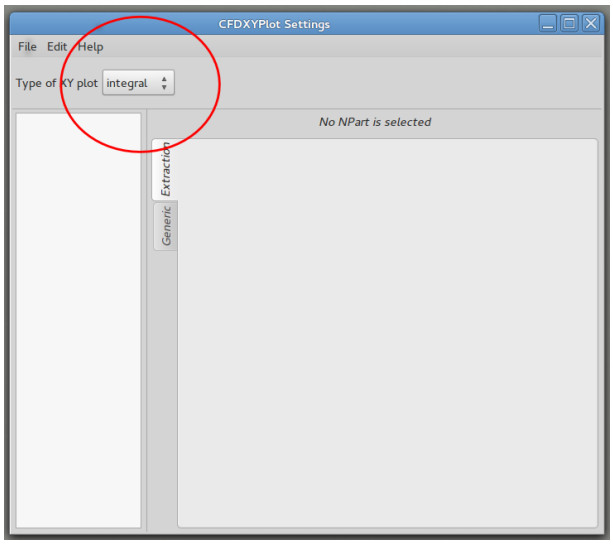
To obtain the xy plot, select a field from the **Fields** menu. This will automatically intersect the computational domain along a line from the **Start** to the **End** point of the line and create a graph:



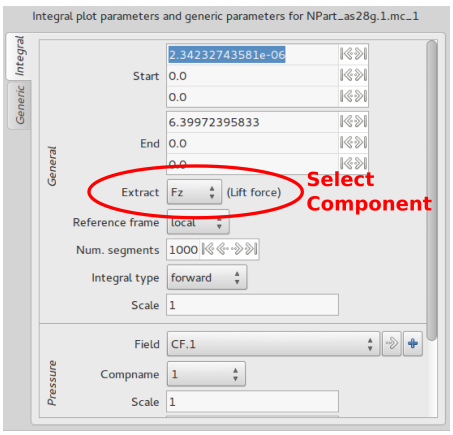


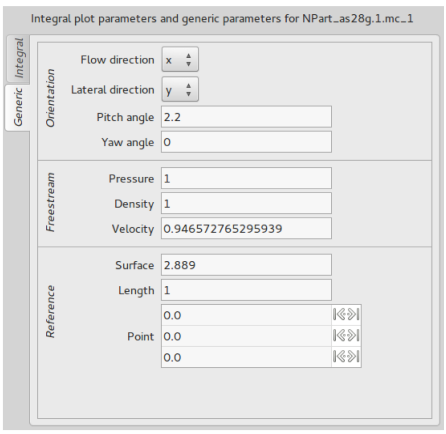
4. Integral Plots

Integral plots visualize functions defined by integrating coefficients, such as lift or drag, over the wetted surface along a line (usually the x-axis). Integral plots are started by selecting the **integral** menu item in the **Type of XY** plot menu.

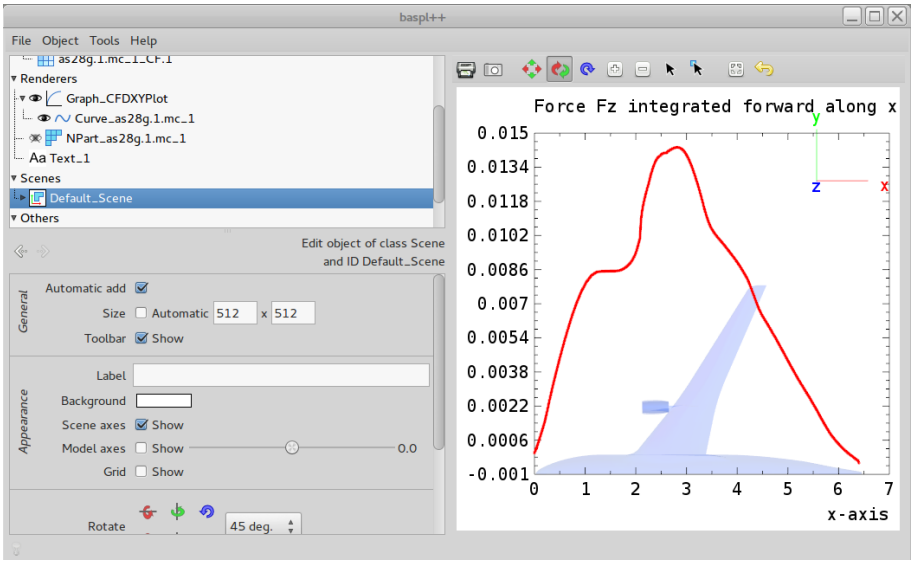


upon which the **Integral plot parameters and generic parameters** tabs appear. In this example, the lift force F_z is selected (left), integrating forward over the whole airplane along the x-axis. The generic parameters are found in the **Generic** tab (right).





Selecting the component to extracted and integrated triggers the integration and generates the xy plot in the default scene:



5. Detailed Description

5.1. C_p Profile Plots

The **Section** tab:

- **Position** specifies the distance from the x-axis for positioning the cut which generates the profile plot.
- **Type of plot** specifies if a C_p plot is to be generated or if a field without modification is to be viewed. If C_p is selected the tool will automatically extract all relevant fields and parameters to establish C_p.
- **Field** specifies the field to be viewed, such as PRES, CF, etc.
- **Compname** specifies the component of the field to be viewed. Default value is 1.
- **Scale** specifies the value by which the field is scaled. It is generated automatically and displayed in case C_p is selected.
- **Offset** specifies the offset by which the field is shifted. It is generated automatically and displayed in case C_p is selected.

The **Generic** tab:

- **Orientation** defines the reference frame and the orientation of the profile plot.
  - **Flow direction** specifies the flow direction. Valid are x (default), y, or z. For NSMB databases, this value is automatically detected.
  - **Lateral direction** specifies the lateral (wind) direction. Valid are x, y (default), or z. For NSMB databases, this value is automatically detected.
  - **Pitch angle** specifies the pitch angle α (see Figure 4).

    - **Yaw angle** specifies the yaw angle β (see Figure 4).

- **Freestream** defines the free-stream parameters (if any). For NSMB databases, these values are automatically detected.

    - **Pressure** specifies the free stream pressure. For NSMB databases, this value is automatically detected.

    - **Density** specifies the free stream density. For NSMB databases, this value is automatically detected.

    - **Velocity** specifies the free stream velocity. For NSMB databases, this value is automatically detected.

- **Reference** specifies the reference values for non-dimensional computations.

    - **Sref** specifies the reference surface. For NSMB databases, this value is automatically detected.

    - **Length** specifies the reference length. For NSMB databases, this value is automatically detected.

    - **Point** specifies the reference l??????????????????????????????????

5.2. Line Plots

The **Line** tab:

- **Start** defines the start point of the line cutting the domain. The start point can be plated outside or inside the domain. If placed inside the domain, the interpolation will start there. If placed outside the domain the interpolation will start where the line enters the domain.

- **End** defines the end point of the line cutting the domain. The end point can be placed outside or inside the domain. If placed inside the domain, the interpolation will end there. If placed outside the domain the interpolation will end where the line leaves the domain.

- **Type of plot** specifies if a C_p plot is to be generated or if a field without modification is to be viewed. If C_p is selected the tool will automatically extract all relevant fields and parameters to establish C_p.

- **Field** specifies the field to be viewed, such as PRES, CF, etc.

- **Compname** specifies the component of the field to be viewed. Default value is 1.

- **Scale** specifies the value by which the field is scaled. It is generated automatically and displayed in case C_p is selected.

- **Offset** specifies the offset by which the field is shifted. It is generated automatically and displayed in case C_p is selected.

The **Generic** tab:

- **Orientation** defines the reference frame and the orientation of the profile plot.

- **Flow direction** specifies the flow direction. Valid are x (default), y, or z. For NSMB databases, this value is automatically detected.
- **Lateral direction** specifies the lateral (wind) direction. Valid are x, y (default), or z. For NSMB databases, this value is automatically detected.
- **Pitch angle** specifies the pitch angle α (see Figure 4).
- **Yaw angle** specifies the yaw angle β (see Figure 4).

- **Freestream** defines the free-stream parameters (if any). For NSMB databases, these values are automatically detected.
  - **Pressure** specifies the free stream pressure. For NSMB databases, this value is automatically detected.
  - **Density** specifies the free stream density. For NSMB databases, this value is automatically detected.
  - **Velocity** specifies the free stream velocity. For NSMB databases, this value is automatically detected.
- **Reference** specifies the reference values for non-dimensional computations.
  - **Sref** specifies the reference surface. For NSMB databases, this value is automatically detected.
  - **Length** specifies the reference length. For NSMB databases, this value is automatically detected.
  - **Point** specifies the reference l??????????????????????????????????

5.3. Integral plots

The **Integral** tab:

- **Start** defines the start point of the line along which integration is performed on the wetted surface. The start point can be plated outside or inside the wetted surface. If placed inside the wetted surface, the integration will start there. If placed outside the domain the integration will start where the line enters the wetted surface.
- **End** defines the end point of the line integration the domain. The end point can be placed outside or inside the domain. If placed inside the domain, the integration will end there. If placed outside the domain the integration will end where the line leaves the domain.
- **Extract** specifies the integrand. Valid are CF_i, CM_i, F_i, MP_i, MA_i, A, with i=x,y,z.
- **Reference frame** specifies the reference frame with respect to which the integration is performed. Valid are local or global.
- **Num. segments** specifies the the number of integration segments. Default value is 1000.
- **Integral type** defines the type of integration to be performed. Valid are forward (default), backward, or segment.

- **Scale** specifies the value by which the field is scaled. Default is 1.

The **Generic** tab:

- **Orientation** defines the reference frame and the orientation of the profile plot.
  - **Flow direction** specifies the flow direction. Valid are x (default), y, or z. For NSMB databases, this value is automatically detected.
  - **Lateral direction** specifies the lateral (wind) direction. Valid are x, y (default), or z. For NSMB databases, this value is automatically detected.
  - **Pitch angle** specifies the pitch angle α (see Figure 4).
  - **Yaw angle** specifies the yaw angle β (see Figure 4).
- **Freestream** defines the free-stream parameters (if any). For NSMB databases, these values are automatically detected.
  - **Pressure** specifies the free stream pressure. For NSMB databases, this value is automatically detected.
  - **Density** specifies the free stream density. For NSMB databases, this value is automatically detected.
  - **Velocity** specifies the free stream velocity. For NSMB databases, this value is automatically detected.
- **Reference** specifies the reference values for non-dimensional computations.
  - **Sref** specifies the reference surface. For NSMB databases, this value is automatically detected.
  - **Length** specifies the reference length. For NSMB databases, this value is automatically detected.
  - **Point** specifies the reference l??????????????????????????????????