Secondary Beam Pattern Measurement for Broadband Feeds

Internal Technical Report

March 2012

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Abstract:
This report describes a new technique to measure Secondary Beam Shape for Broadband feeds at GMRT observatory and the usage of

a) Spectrum Dump Code: To record the RF data into a file using LabVIEW code.
b) Curve Fitting Algorithm: To fit the raw data with Gaussian fit and to get FWHM.

1. Introduction:

The Giant Metrewave Radio Telescope (GMRT) consists of an array of 30 antennas. Each antenna is 45 m in diameter, and has been designed to operate at a range of frequencies from 50 MHz to 1450 MHz. The antennas have been constructed using a novel technique (nicknamed SMART) and their reflecting surface consists of panels of wire mesh. This panel is attached to rope trusses, and by appropriate tensioning of the wires used for attachment the desired parabolic shape is achieved. This design has very low wind loading, as well as a very low total weight for each antenna. Consequently it was possible to build the entire array very economically.

2. Procedure for Secondary Beam Pattern Measurement:

Let us consider an example, Cone-Dipole Feed 250-500MHz @ C06 Antenna.

1) Switch ON the Spectrum Analyzer and set the Spectrum Analyzer for

a) Center Frequency: 400MHz

b) Span: 400MHz

c) Resolution BW: 300 KHz

d) Video BW: 3KHz

2) Place markers as required

3) Switch ON the Laptop, which is loaded with Labview 8.0 and 8.2 version.

Note: Both the versions are necessary to run the application “Spectrum_Dump.vi”.

4) Connect the National Instruments Interface unit “GPIB-USB-HS” to the Laptop and Spectrum Analyser and Open the application “G:Hanuman/labviewprg/Spectrum_Dump.vi”. And set

    a) Delay Time (S): 3 sec (We can set upto 1 sec)

    b) Name or Relative path: SPD_C06_ch1.txt (Name of the file)

    c) Base Path: G:/Hanuman/Labviewprg (Location of the file)

5) Focus the Cone-Dipole Feed 250-500MHz to the parabolic dish and set default setting to activate and select RF 327MHz since Cone-Dipole Feed 250-500MHz is sitting on the turret at the same phase of 327MHz Kildal Feed. See **Appendix-A** for the settings of Narrow Band Beam Shape Measurement.

6) Slew the Antenna across the strong source (CASA) for 16 minutes with 50 arc-min/min (slew rate) either elevation or azimuth direction and get the raw data (SPD_C06_ch1.txt file) from the Spectrum Dump's Labview Program (Fig:1 & Fig:2). See **Appendix-B**.

   Note: Max of 1.2MB data can be recorded thereafter needs to change the file name.

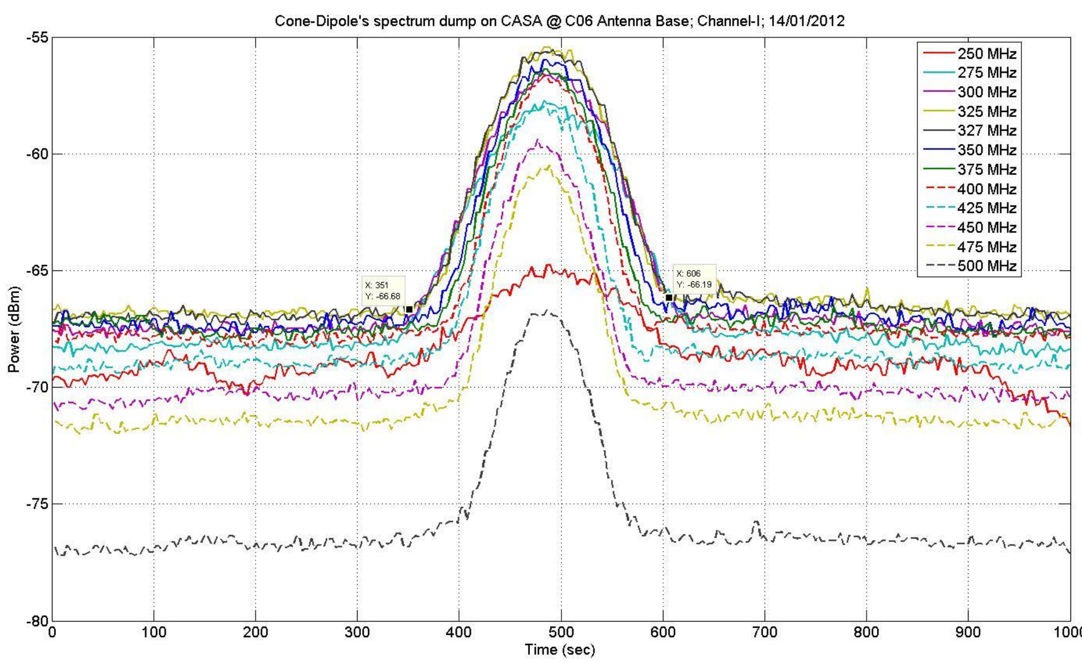

Fig 1: Raw data of RF channel-I of Cone-Dipole Feed @ C06 Antenna.

7) Repeat 5, to get the raw data for RF Channel-II (SPD_C06_ch2.txt) (fig-spd2).

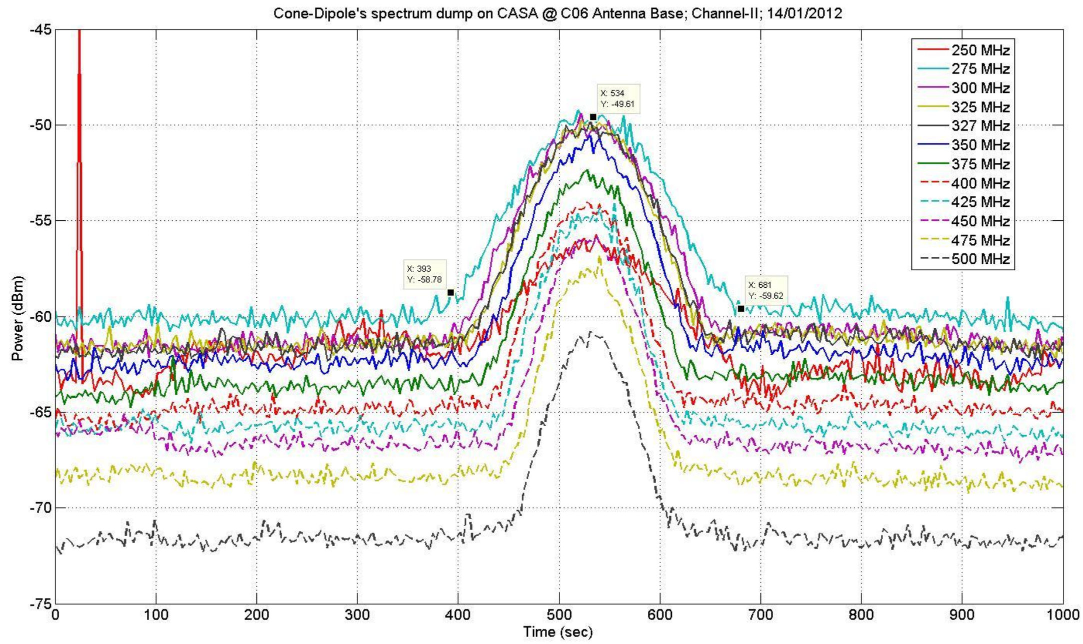

Fig 2: Raw data of RF channel-II of Cone-Dipole Feed @ C06 Antenna.

8) After getting the raw data from both the channels, one can get the plots for sensitivity/Source Deflection. As shown in the fig

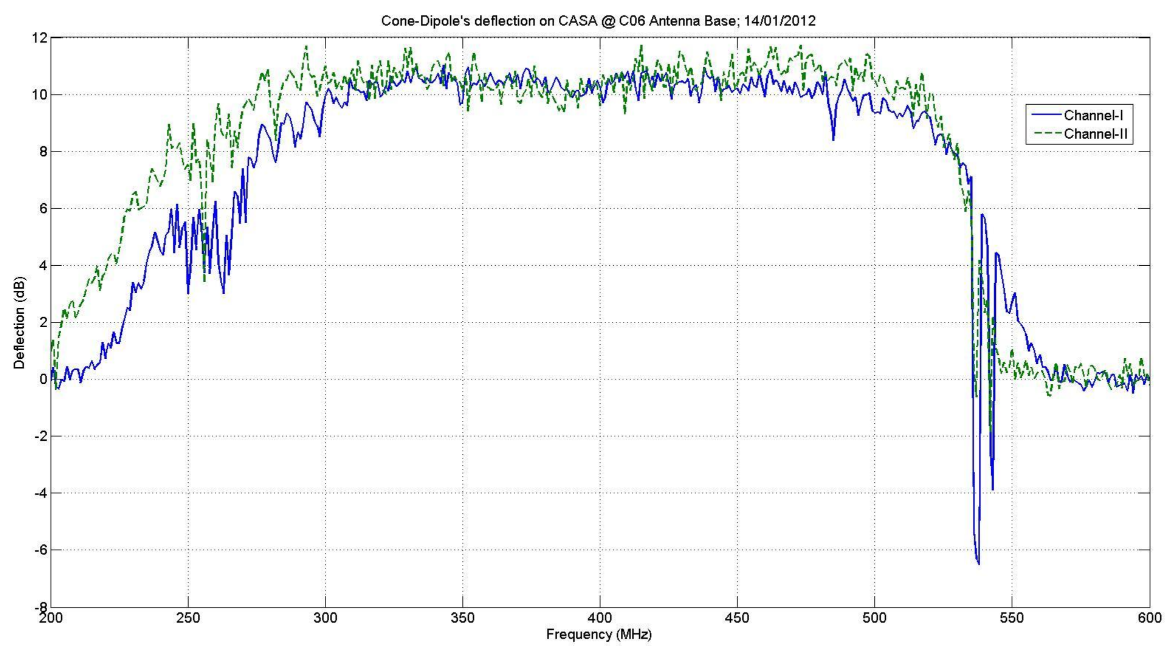

Fig 3: Sensitivity/Source Deflection of Cone-Dipole Feed 250-500 on CASA @ C06 Antenna.

9) Fed the raw data to the MATLAB software and get the FWHM plots after fitting the raw curves to Gaussian fit. See **Appendix-C**

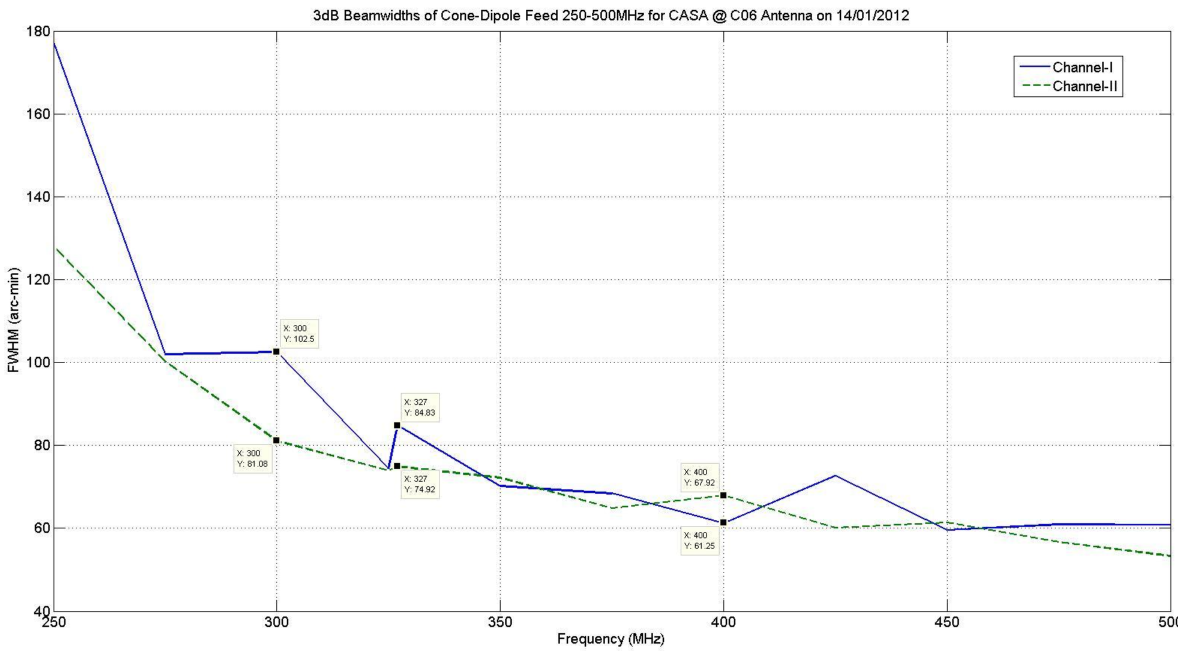

Fig 4: Secondary Beam Pattern of Cone-Dipole Feed 250-500 MHz

4. Conclusion

Variation of Secondary Beam Pattern of Cone-Dipole Feed 250-500MHz is as expected (see Fig 4). Spectrum Dump code using LabVIEW is more rigorous and It can be used independently i.e., irrespective of Antenna or Feeds concerned. More rigorous code of curve fitting will be detailed in a forthcoming ITR.

5. Acknowledgement

I would like to thank **Prof.Y.Gupta**, Dean GMRT. and **Shri.A.Praveen Kumar**, for their constant motivations. I would like to thank my guide **Shri.G.Sankar**. And I also thank **Mr.Atul Ganla** for providing a labVIEW code for data acquisition. Finally, I would like to thank the staff at NCRA workshop, Control Room operators and Colleagues at FE lab, for making the experiment successful.

References:

1. GMRT antenna power pattern in L band Data from 27-28 December 2000 by Nimisha G. Kantharia & A.Pramesh Rao, July 20,2001.
2. G. Sankar, GMRT Antennas and Feeds (chapter-19), “Low Frequency Radio Astronomy“, 3rd Edition.
3. Kolundzija, B., et. al., “WILP-D Pro v7.0, 3D Electromagnetic Solver Professional Edition User‟s Manual”, *WIPL-D Ltd.* 11070 Belgrade, Serbia, Europe.

Appendix-A (Settings for Narrow Band Beam Shape Measurement):

The standard grid-pointing (in self) in elevation on Source (Virgo or Hydra or CASA) at the frequencies listed below.

The final bandwidth and IF bandwidth will each be 32 MHz. The other settings are LO-4 = 51 MHz, LO-5 = 149, 167 MHz (default values), and 2 second integrations (lta=1). Also, do power equalization at the first setting and will stay with this equalization for all later settings.

The settings are:

(1) LO-1 : 275 MHz
TPA 326 326 275 275 51 51

(2) LO-1 : 210 MHz
TPA 261 261 210 210 51 51

(3) LO-1 : 475 MHz
TPA 424 424 475 475 51 51

(4) LO-1 : 545 MHz
TPA 494 494 545 545 51 51

(5) LO-1 : 510 MHz
TPA 459 459 510 510 51 51

(6) LO-1 : 315 MHz
TPA 366 366 315 315 51 51

At each frequency, have to run getoffsets, and save the output plots, and also save a log file with all the details (scan rate, peak time, etc....).

Appendix-B (Spectrum Dump code):

Spectrum Dump: It is an Labview Application programmed by **Mr.Atul Ganla**, colleague at GMRT observatory, consists of an algorithm connecting all the blocks (see Fig 5, Fig 6)

a) Instrument Descriptor: A string that uniquely identifies the instrument to open or initialize. Parameters (default value):
   i) bd-GPIB board (0)
   ii) prim addr-GPIB primary address (1)
   iii) sec addr-GPIB secondary address (none)
   iv) logical addr- VXI logical address
   Example: A GPIB instrument on GPIB board o, at primary address 5, and no secondary addressing.

b) hp859x Initialize.vi: This block connects to the spectrum analyser (hp859x) and calls the protocols/drivers related to the spectrum analyzer.

c) hp859x Read Wvfm to Array Ascii.vi: This block coverts the waveform details into ASCII format and writes to the file as mentioned in Name or Relative path.

d) Delay time (s): Specifies how many seconds to wait. The value you wire to this input overrides the value you set in the configuration dialog box, which stores the data (400 points) per every 3 seconds from Spectrum Analyzer to a text/excel file.

e) Spreadsheet file.vi: This block describes the type of the file to be stored.

f) Name or Relative path: This is the name of the file, where data gets stored.

g) Base path: This string tells us about the Location of the file to write the spectrum values.

h) Waveform: This block shows the spectrum (Like window on spectrum analyzer).

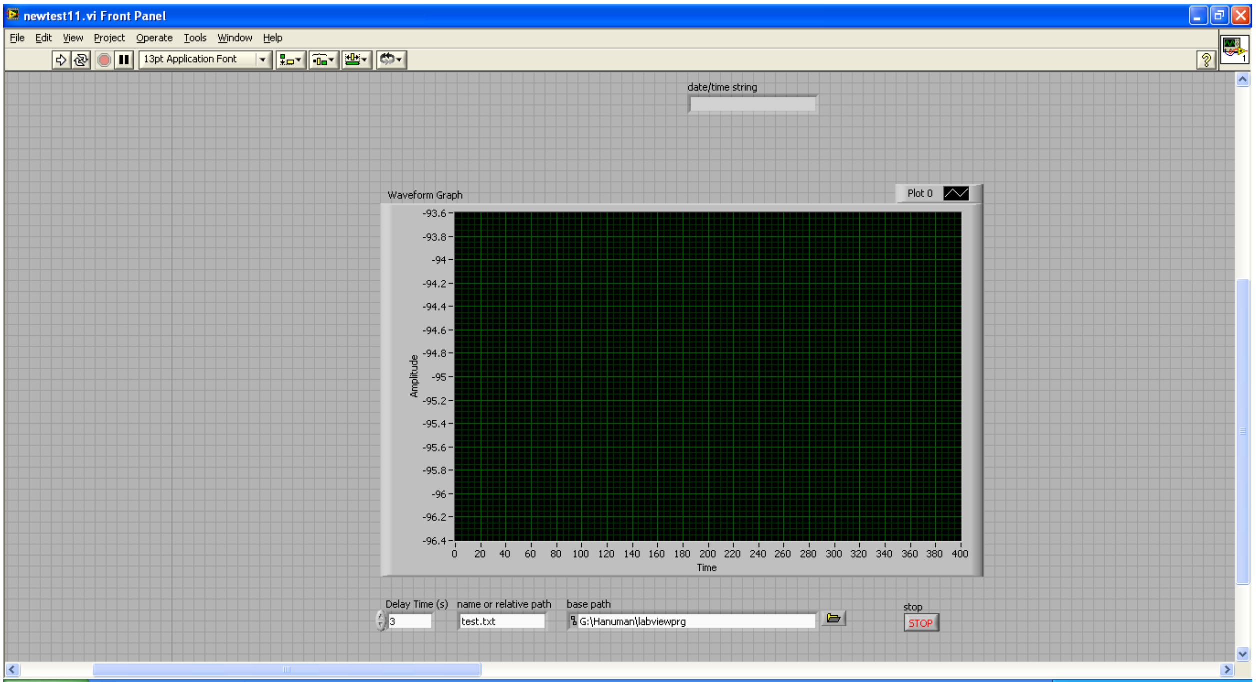

Fig 5: Front Panel of Spectrum Dump LabVIEW code

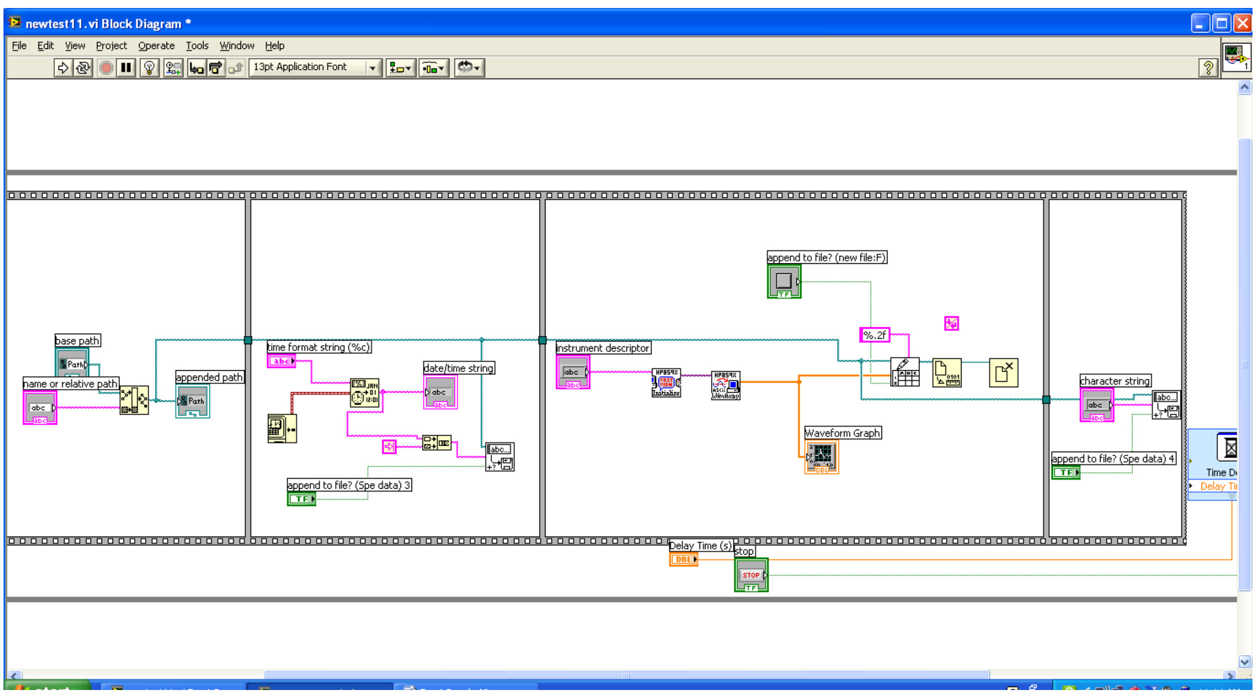

Fig 6: Block Diagram of Spectrum Dump LabVIEW code

Appendix-C (Curve Fitting Algorithm)

Curve fitting, also known as regression analysis, is used to find the "best fit" line or curve for a series of data points. Most of the time, the curve fit will produce an equation that can be used to find points anywhere along the curve. In some cases, you may not be concerned about finding an equation. Instead, you may just want to use a curve fit to smooth the data and improve the appearance of your plot.

We have used MATLAB technical programming language for the curve fitting, code as follows

1) Load the files, SPD_C06_ch1.txt and SPD_C06_ch2.txt

2) Assign each column (Amplitude data for each frequency) to different variables. i.e.,

   a=SPD_C06_ch1(:,1) [First column consists of Time (sec)

   b=SPD_C06_ch1(:,2) [Second column consists of Power (dB) of corresponding freq]
   . .
   . .
   n=SPD_C06_ch1(:,14) [14th column………………………………………………]

   and So on… upto last column

3) Use curve fitting tool to get, Gaussian fit for as shown in Fig 8.

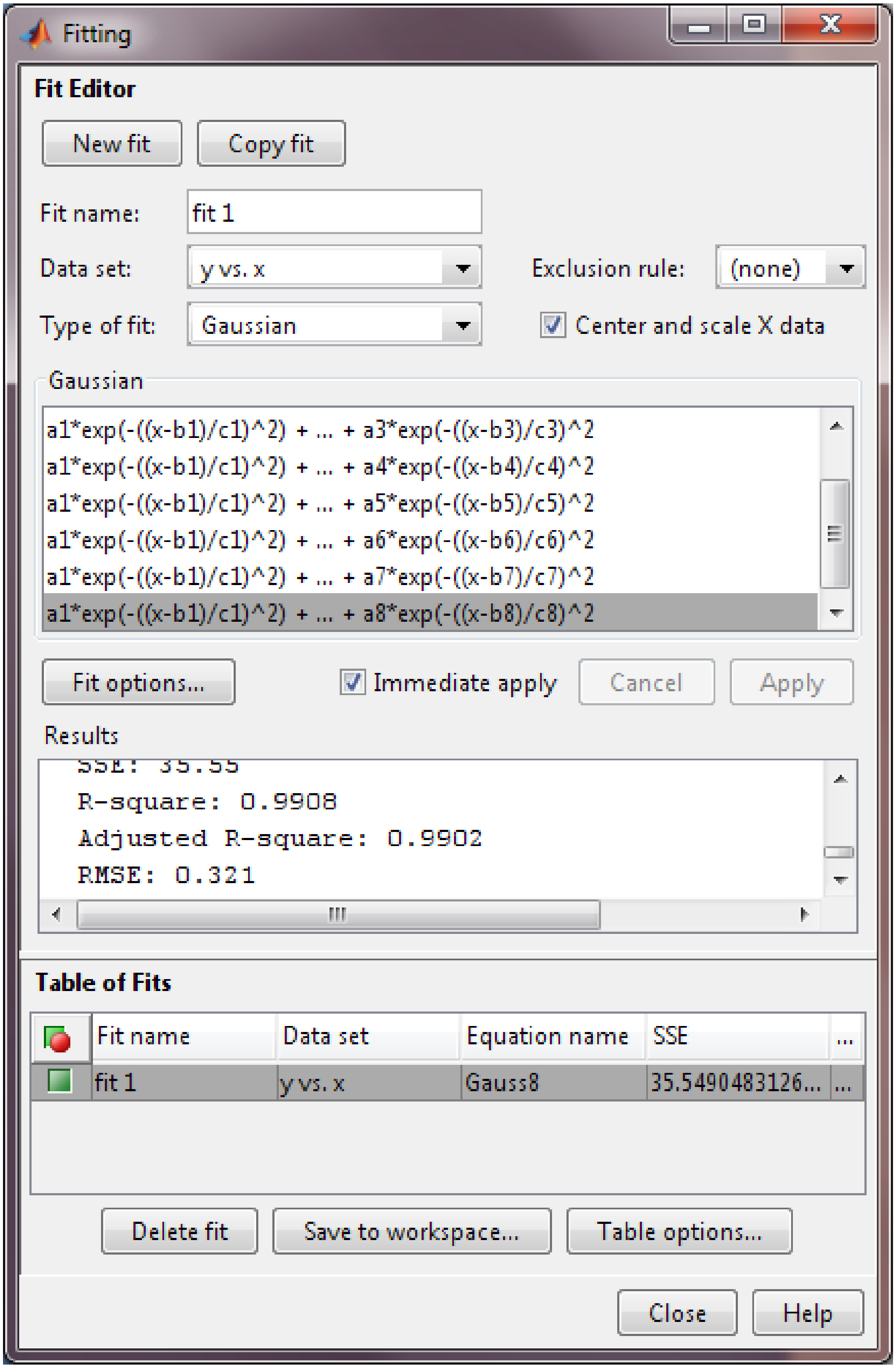

Fig 7: Curve fitting Editor

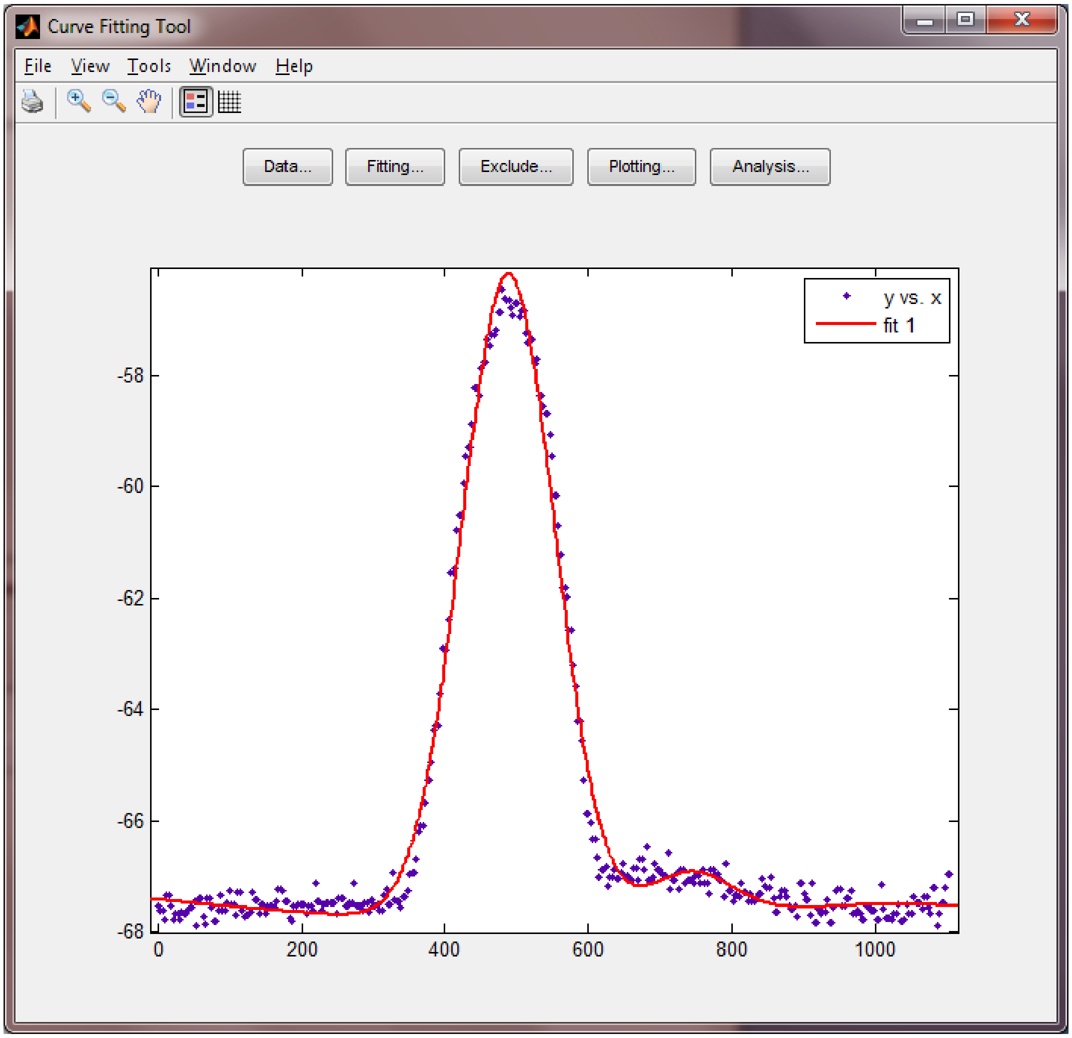

Fig 8: Curve Fitting Tool