

TO STUDY THE PROPERTIES OF PULSARS USING THE DATA AVAILABLE FROM RXTE

Uma Kamboj^{1*}, Kiranjot Kaur¹, Saqlain Bin Mushtaq¹, Neha Munjal¹

¹Department of Physics, Lovely Professional University, Punjab, India-144411

Abstract

A Neutron star is formed when an ordinary star dies and a rotating Neutron star is called a Pulsar. Study of pulsars have also been beneficial for time keeping as they are considered among the most accurate known natural time keepers. The current work is used to analyse the time period of a Pulsar using the secondary data from NASA data archive.

INTRODUCTION:

Pulsars are quickly rotating, extremely magnetised neutron stars that were first seen through pulsed radio emission at a very down radio observing frequency of 81 MHz.

A pulsar is a highly magnetized rotating neutron star or white dwarf that is emitting a beam of electromagnetic radiation.

There are different types of pulsars i.e. CRAB PULSAR and VELA PULSAR. The Crab Nebula is the supernova remnant in the constellation of Taurus. A neutron star that formed when a massive star collapsed. The Vela pulsar is about 1,000 light years away from Earth, spans about 12 miles in diameter, and makes over 11 complete rotations every second, faster than a helicopter rotor. As the pulsar whips around, it spit up out a jet of charged particles that race out along the pulsar's rotation axis at about 70% of the speed of light

MATERIALS AND METHODS:

Types of Data:

Data is used the secondary data in this study because it is quick and easy, and also it is short this data is in refined form and relatively takes less time.

Software used:

We have used the software program HEASOFT. The HEASOFT software environment was designed to make it effortless for external projects to add their own software package for a new instrument or mission. The guidelines provide an overview of the process of developing a new data analysis package. Projects are encouraged to contact the HEASARC early in the evolution process for further information and assistance. Most of the general FITS file handling tools that any project will need are already provided in HEASOFT. The only new tasks that typically need to be formed are the mission-specific calibration and analysis tools for the new mission. Several example programs (in C, Perl) are provided in the HEASOFT package and can be used as a templet for writing new software tasks. Simple process for compiling and linking the software are also provided, so the programmer can also concentrate on writing the specific data analysis algorithm and need not to spend much effort on the mechanics of how that task will be integrated within the HEASOFT environment. Each HEASOFT task that is formed should also consider a unit test suite, which includes a set of input data file(s) for the task and the expected output files or text output. This unit test is re-executed whenever any change is made up to the task or to the larger software environment (e.g., new versions of libraries or compilers) to assure that the new output is still identical to the previously generated output. The software modules must maintained within a suitable code to tracks all modifications to the code. The HEASARC presently uses the Git revision control system. The HEASOFT tasks must needs run on a wide range of computer platforms used by external scientists. HEASARC staff reconstruct the local "development" version of the entire HEASOFT package on several different level on a routine basis. These systems are then

accessible for testing by local scientists at GSFC. The process of writing a HEASOFT program is so simple enough, however, so that many of the existing HEASOFT tasks have been written by scientists without extensive scheduling experience.

Different Parts of HEASOFT:

1. FITSIO

2. FTOOLS

3. HERA The needs for using Hera are:

(a) the FV FITS file viewer and editing program must be installed on the local machine. FV is the local client portal to the Hera services.

(b) There must be broadband access to the Internet

(c) and also access to a standard web browser such as Firefox or Internet Explorer.

4. SAO Image DS9

5. PROFIT

6. XSTAR

Types of File Extensions:

1. FITS FILE

2. TAR FILE

3. GPS FILE

4. LC CURVE

Steps to Download Data:

1. Firstly open the link given below:

<https://heasarc.gsfc.nasa.gov/docs/cgro/db-perl/W3Browse/w3browse.pl>

2. In 1st dialog box, write Crab in the object name and in 2nd click RXTE in most requested missions and then click on search button.

(If you want to search on parameters other than object name or coordinates, see "Detailed Mission Catalog Search")

Object Name or Coordinates: and/or No file chosen

e.g. Crab X-1 or 10 36 30.4 12 6 or Crab X-2: 12 234.16 540 (note use of semi-colons (:) to associate multiple object names or coordinate pairs)

The plot(s) contain object and/or coordinate pairs (one per line or separated by semi-colons)

Coordinate System:

Search Radius:

Default uses the optimum radius for each catalog searched

... and/or search by date?

Observation Dates: YYYYMMDD (in view as of 142-2000 edit)

Not all dates have observation dates. For those that do, the time portion of the date is optional. Separate multiple dates/ranges with semicolons (;). Range operator is: (e.g. 1960-12-31; 40480.5; 1969-01-18 12:00:00; 1997-03-22; 2002-10-18)

2. What missions and catalogs do you want to search? (Bold text indicates mission is active)

Most Requested Missions

Chandra (CAC/CSC) **Fermi** **Hinode** **INTEGRAL**

Swift **ROSAT** **RXTE** **Suzaku**

Other X-Ray and EUV Missions

Swift **ASCA** **BEVIX (BeppoSAX)** **BeppoSAX**

Columbia **Euclid** **EUVE (MAS7)** **EUROSAT**

Ginga **HEAO 1** **Swift** **MAXI (GARTS)**

ORCA **RAS 1** **Ulysses** **Vela SR**

Other Gamma-Ray Missions

AGILE (ASDG) **COMPAG** **COMPAG** **HETE-2**

INTEGRAL (ISGA/ISDC) **RAS 2** **Gamma-Ray Burst** **BREXRT**

Missions and Facilities

3. It will take some time and then click query results.

Images generated by SkyView
Click on image to see full SkyView image



DSS Optical image, 2.83"



BASS X-ray image, 75 0"

Images centered on requested position

Search was based on:

Object/Coordinates:
resolved by SIMBAD (local cache) to | 05 34 31.94, +23 00 52.2 |

Using the coordinates from the SIMBAD resolver for crab

Coord System:

Maximum Rows:

Search Radius:

Rendering:

Browse Tip: Do you know how to get query results in a plain text table? [Learn more on this topic](#) or [See all tips](#)

Table Name/Row Count Summary: Querying table 1 out of 8

Click on table name to view search results

xteaster.XTE Master Catalog	276	xteindex.XTE Target Index Catalog
xtemicat.XTE Mission-Long Source Catalog		xteasscat.XTE All-Sky Slew Survey Catalog
xteasagc.XTE All-Sky Slew Survey AGN Catalog		xteao.XTE Proposal Info & Abstracts
xteasmong.XTE All-Sky Monitor Long-Term Observed Sources		xteslew.XTE Archived Public Slew Data

4. A table will pop up. Each row in the table is an observation with some exposure. Crab is a famous source, so there are a lot of observations and we can also search the same for Vela Pulsar.

[Home](#) | [About Us](#) | [Contact Us](#) | [Privacy Policy](#) | [Terms of Service](#)

Click mission tabs (middle tab level) to display table tabs. Move cursor over tabs to see more information.

Table Legend:

Display all parameters for a row
 Sort by a column in order: 1,2,3 Sort by column in reverse order: 3,2,1 Current table sort
 Services links: O: Digitized Sky Survey image, R: ROSAT All-Sky Survey image, N: NED objects near coordinates,
 S: SIMBAD objects near coordinates, D: get list of data products, B: ADS bibliography holdings, F: FGV plot for observation

Data Products: Click checkbox to add row to Data Product Retrieval List

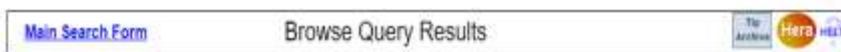
XTE Master Catalog (xtemaster)

Search radius used: 30.00'

Select	Related Links	Service	obsid	prob	status	pi name	pi name	target name	ra	dec	time	duration	exposure	Search Offset
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	10402-01-04-00	10402	archived	TOO	PUBLIC	CRAB	05 34 48.2	+22 04 52	1996-03-21 00:56:51.1	48567	25918	5.658 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	48095-01-05-00	48095	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1989-10-18 18:03:55.3	30140	27568	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	10402-01-05-00	10402	archived	TOO	PUBLIC	CRAB	05 34 48.2	+22 04 52	1996-04-11 04:30:57	48300	22324	5.838 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	29804-01-01-00	20804	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 31.9	+22 00 52	1997-03-22 22:16:07.1	44106	22195	0.012 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	29804-01-01-01	20804	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 31.9	+22 00 52	1997-03-22 11:28:57.2	36855	21366	0.012 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	29804-01-05-00	20804	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1997-12-10 08:33:20.4	36803	20587	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	48095-01-01-00	48095	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1989-03-24 02:47:18.4	35347	10075	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	58188-01-01-01	50188	archived	ZHANG	WILLIAM	CRAB_PULSAR/NEBULA	05 34 31.9	+22 00 50	2000-01-19 19:29:02.1	32244	19812	0.030 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	48095-01-01-00	40090	archived	RAJ	PAUL	CRAB_PULSAR	05 34 31.9	+22 00 50	1989-12-15 21:10:1	30214	15543	0.030 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	48095-01-04-00	40805	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1989-03-26 17:24:05.2	29934	13647	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	29804-01-06-00	20804	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1997-12-11 10:32:57.1	25700	15421	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	10402-01-01-00	10402	archived	TOO	PUBLIC	CRAB	05 34 48.2	+22 04 52	1996-02-10 09:48:24.8	22824	14830	5.658 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	29804-01-10-00	20804	archived	TOO	PUBLIC	CRAB_PULSAR	05 34 32.8	+22 00 52	1997-12-15 12:07:32.6	24578	14186	0.014 (crab)
<input type="checkbox"/>	Abstract Modes	<input type="checkbox"/>	10203-01-01-00	10203	archived	ZHANG	WILLIAM	CRAB_PULSAR/NEBULA	05 34 31.9	+22 00 52	1996-08-25 06:12:06.6	21800	13521	0.012 (crab)

5. To download a particular observation data, select it and click Retrieve Data Products for selected rows.

6. A new page will pop up. Click on retrieve and you will see a link to download the data.and from there the data can be downloaded.



[Query Information](#) | [Query Results](#) | [Data Products Retrieval](#) | [Help](#)

Data Products Download Options and Other Services

Data Products Download Options

Create Download Script for data products for selected rows

Preview and Retrieve data products for selected rows

Retrieve data products for selected rows

Save to Hera data products for selected rows

[What is Hera?](#)

Optionally, add a file name constraint to specify product types, e.g. "ftr" or "gr". Use a semicolon (;) for multiple constraints, e.g. "ftr;gr"

File name filter:

Other services for selected rows

Display all the columns for selected rows

Web-based services for selected rows

- NED
- SIMBAD
- Sky View ROSAT All-Sky
- Sky View DSS
- CoCo

[Web-based services help](#)

Data products that you have selected will appear below

Select all rows

XTE Master Catalog

obsid	prob	status	pi name	pi name	target name	ra	dec	time	duration	exposure	Search Offset
10402-01-04-00	10402	archived	TOO	PUBLIC	CRAB	05 34 48.2	+22 04 52	1996-03-21 00:56:51.1	48567	25918	5.658 (crab)

About the Software:

After downloading the data, we can have the different plotting of data (Histogram) using the FV software.

Data Interpretation:

To study the time period of the crab pulsar. This pulsar is observed by the suzaku observation satellite equipped Hard X-ray detector (HXD).

Tool and Data used: fv, Fits file.

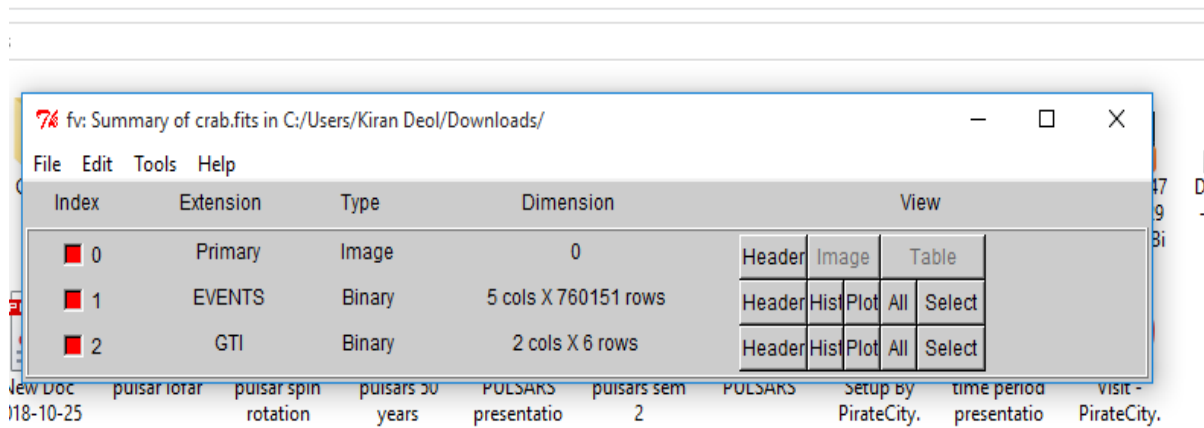
Pulsar and Neutron star: Crab.

Assignment Preparation: This assignment was prepared by Ken Ebisawa on 2008-12-25 and data was collected by the satellite on sep 15 2005.

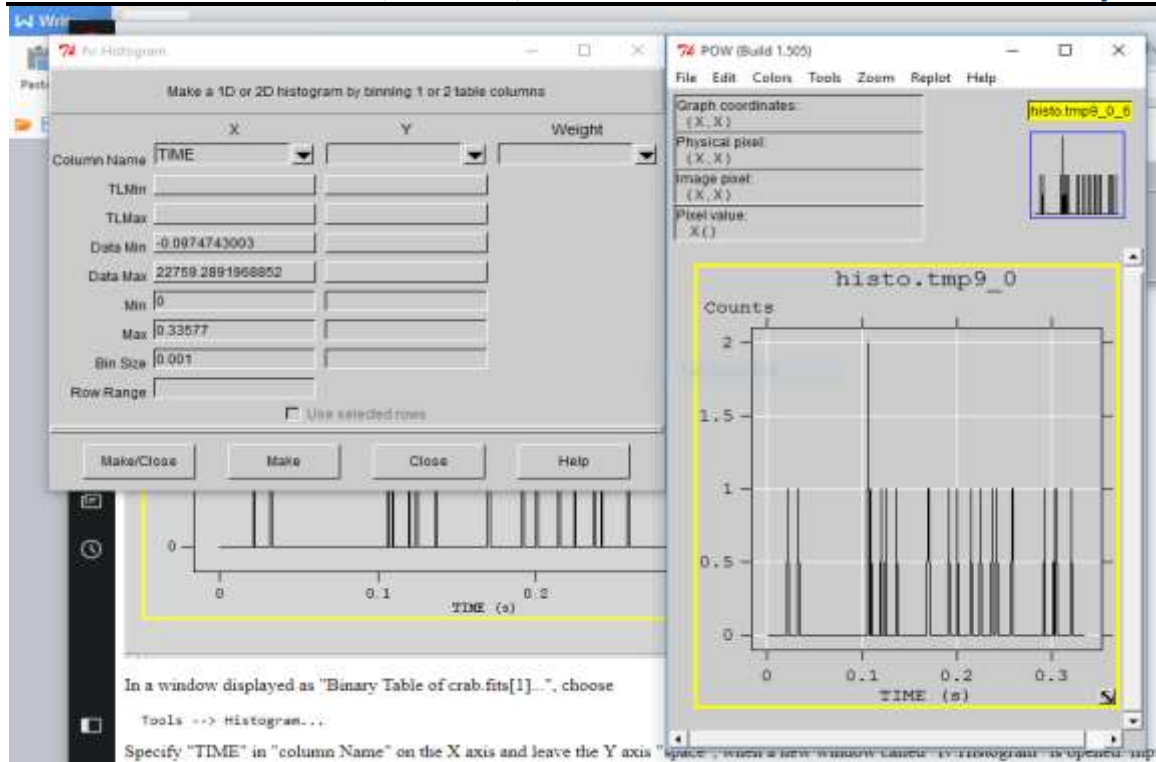
Time Analysis of Crab Pulsar:

Crab Nebula is a remnant of supernova explosion that was first occurred in 1054 AD. This pulsar is a revolving neutron star located at the centre of the crab nebula. The pulsar has magnetic poles as the earth has. pulsar has magnetic field strength about 1 trillion times as strong as that of earth. The pulsar is completely blinking like a beacon lamp, as two magnetic poles appear and disappear by turn. The revolving period of the pulsar is 0.03357701 sec precisely.

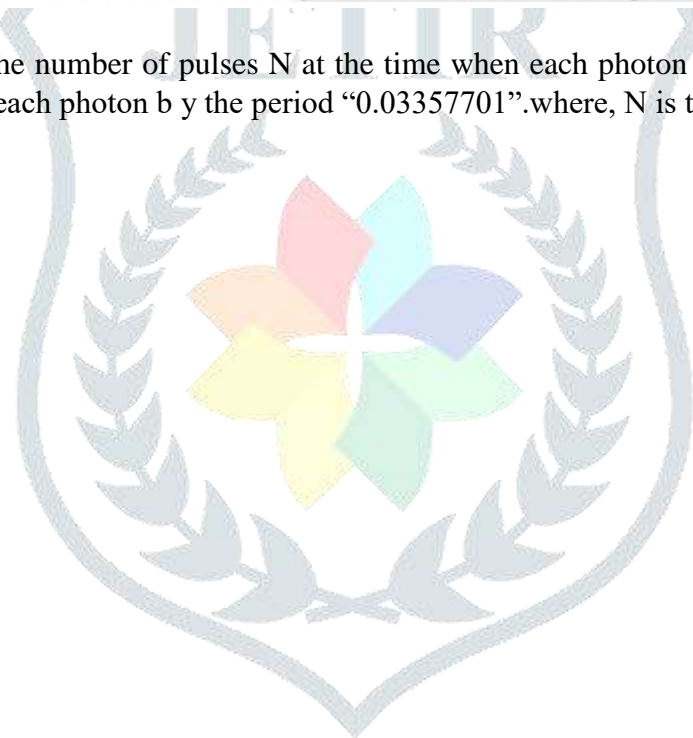
The data is in Fits file and it can be opened by using fv software. firstly, choose open file from the main menu of fv and select the file name. The file is divided into three extensions: in the "EVENTS" extension, the X-ray data is stored and from "ALL" all the contents of the "EVENTS" are shown. The detection time of the photon is written in the column called "TIME". the origin of the detection time is called the starting time of the observation.

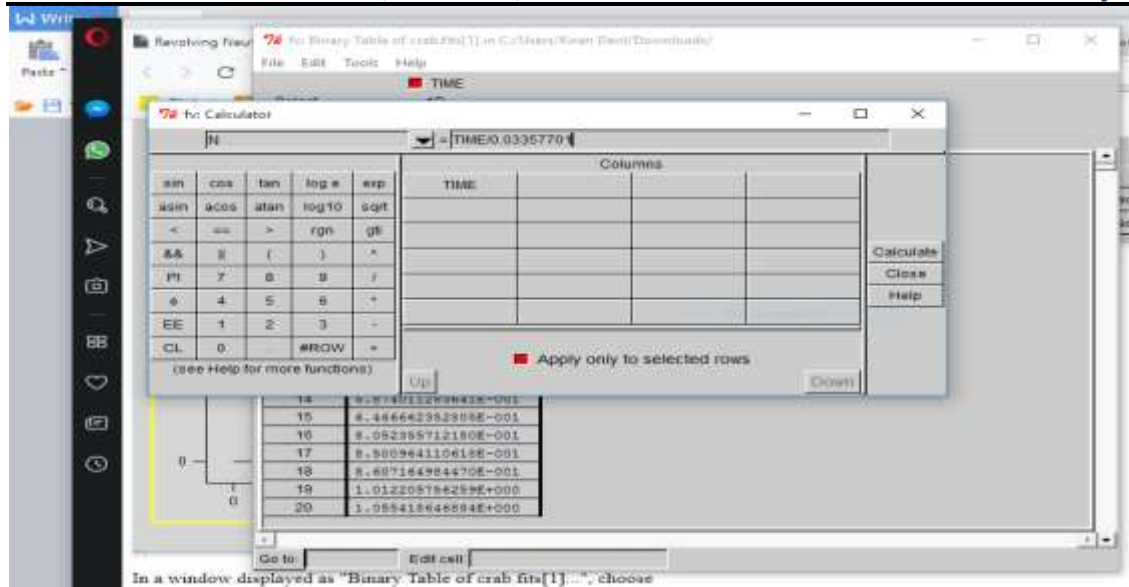


To see all data click on all, and to make histogram from tools click on Histogram. A table will be displayed, from there specify time in column name on the x-axis and leave the y-axis space. And enter the minimum value=0 and maximum value=0.3357701 for 10 periods. And also enter the bin size=0.001. then click Make. Bin is the one unit period which means each time interval on the evenly divided time axis.



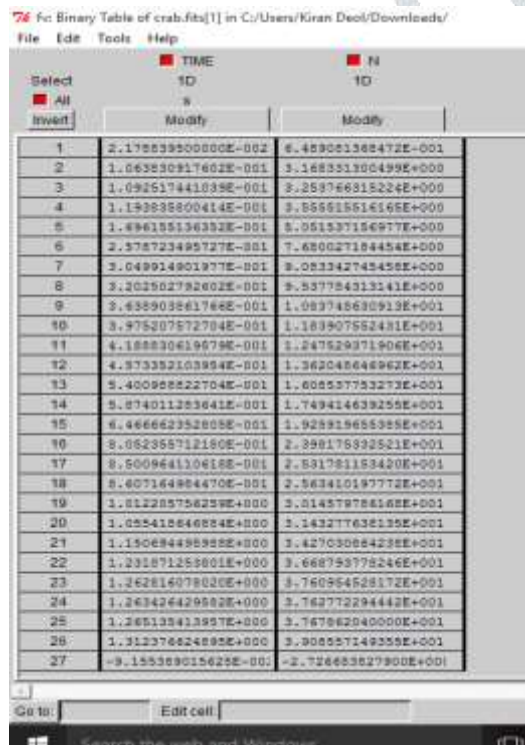
From the beginning, count the number of pulses N at the time when each photon reached. To find this divide the arrival time “TIME” of each photon by the period “0.03357701”. where, N is the real number.





In a window displayed as "Binary Table of crab fits[1]...", choose

From tools, open calculator and type $N = \text{TIME} / 0.03357701$ and click calculate. A new column named N will be added to the data, N is the real number.



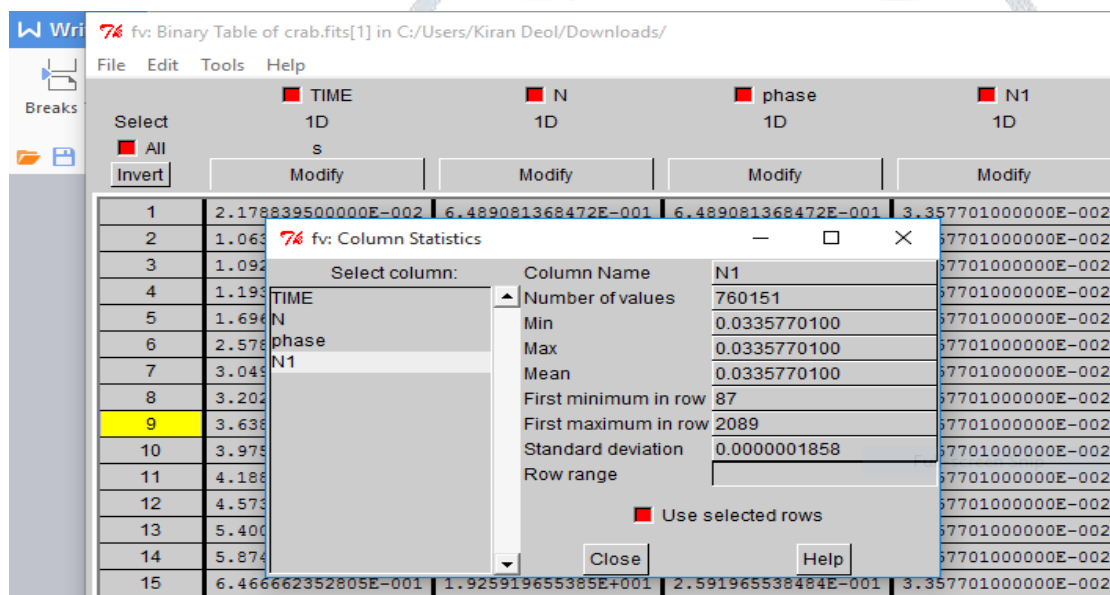
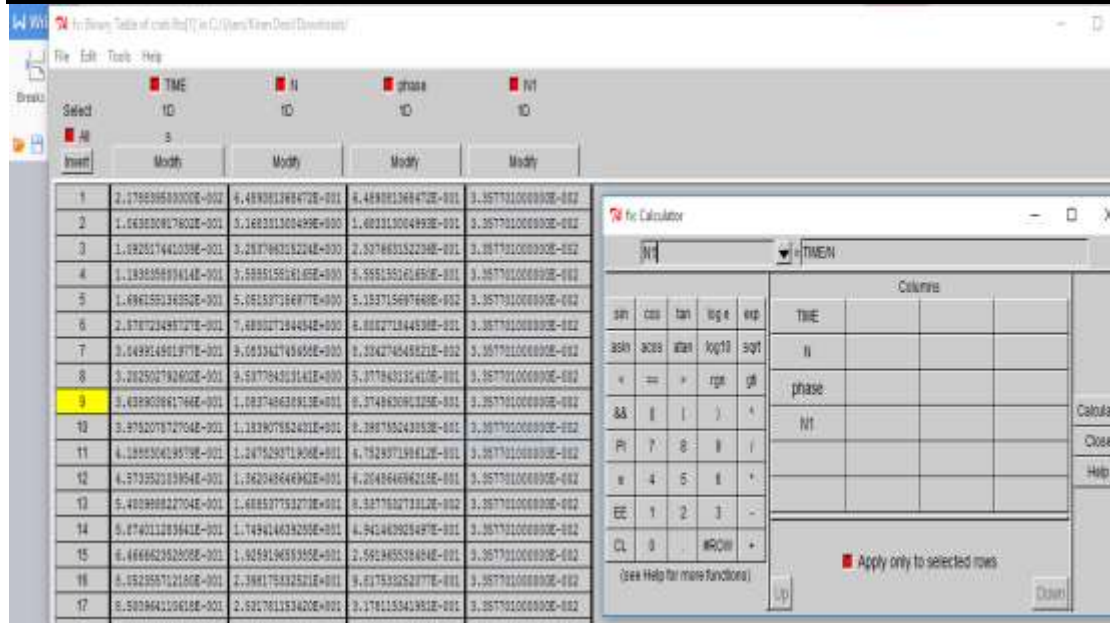
The decimal part of the N will only take values from 0 to 1, also mean the phase. The phase of each photon shows where the photon is detected in the pulse. And obtain the phase data onto a new column. In the calculator, type $\text{Phase} = N - \text{floor}(N)$ and click calculate, a new column will be added called "phase" to the window and it can also be seen that phase is having the decimal part of "N".

The screenshot shows a data table with three columns: TIME, N, and phase. Each column has a 'Select' dropdown and a 'Modify' button. A calculator window is open, showing the formula $phase = INT(Floor(N))$. The calculator interface includes a display, a keypad with mathematical functions (sin, cos, tan, log, exp, etc.), and buttons for 'Calculate', 'Close', and 'Help'. A red checkbox labeled 'Apply only to selected rows' is visible at the bottom of the calculator.

Now go back to the histogram again,specify “phase” to the x-axis and click make,after entering the values (Min=0,Max=1,and bin size=0.025).since 0.0335771 period is divided by 0.025 phase bin,and the length of one phase bin is 0.00084. it tells that 18000 to 21000 photons in one phase bin.as the pulsar revolves in one period,two magnetic poles appear and disappear turn by turn.it means there are two peaks.

The screenshot shows a 'Histogram' dialog box with the following settings: X-axis is 'phase', Y-axis is 'Counts', and Weight is '1'. The 'Data Min' is 0.000001438 and 'Data Max' is 0.999994210. The 'Bin Size' is 0.025. The 'Row Range' is set to 'Use selected rows'. Below the dialog box is a table of data. To the right, a 'POW (Build 1.505)' window displays a histogram plot titled 'histo.tmp12_0'. The plot shows 'Counts' on the y-axis (ranging from 18000 to 21000) and 'phase (pixels)' on the x-axis (ranging from 0 to 1). The plot shows two distinct peaks, one around phase 0.2 and another around phase 0.6.

Now,for time period enter $N1=TIME/N$ in the calculator from the tools of the fv . A column will be added to the data named N1.



CONCLUSION: The data was collected from the official website of the NASA for the crab pulsar. The time period is calculated by the formula $N1=Time/N$. putting this formula in the calculator tool makes the new column and gives the time period for the given pulsar and mean of the time period can also be seen through the statistics. From the time period the RATE for the crab pulsar is also calculated.

It is the required time period of the crab pulsar that is 0.03357701.

Rate or frequency = 1/Time Period

i.e. $1/0.03357701 = 29.7822$

REFERENCES:

[1] Lyne and Graham-Smith Pulsar Astronomy (3rd Edition)Cambridge University Press ISBN: 0521839548
 [2] Lorimer & Kramer Handbook of Pulsar Astronomy (Cambridge Observing Handbooks for Research Astronomers) Cambridge University Press ISBN: 0521828236

[3] Kramer, Wex and Wielebinski, eds. Pulsar Astronomy: 2000 and Beyond, ASP Conference Series, Vol. 202

[4] Pellizzoni et al. Discovery of new gamma-ray pulsars with AGILE 2009ApJ...695L.115P

[5] Pellizzoni et al. High-Resolution Timing Observations of Spin-Powered Pulsars with the AGILE Gamma-Ray Telescope 2009ApJ...691.1618P

[6] Scholten et al. Improved flux limits for neutrinos with energies above 10^{22} eV from observations with the Westerbork Synthesis Radio Telescope Submitted to Phys. Rev. Lett

[7] Scholten et al. Status report of the NuMoon experiment Contribution to the Arena 2008 conference, Rome, 25-27 June 2008

[8] Serylak et al. S2DFS: Analysis of temporal changes of drifting subpulses accepted for publication in A&A

[9] Slowikowska et al. Optical polarisation of the Crab pulsar: precision measurements and comparison to the radio emission submitted to MNRAS

