Lyman-Alpha Blobs Final Report

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## Abstract

In a attempt to research the creation of our universe, and of the individual galaxies in it, we have been analyzing a nonpareil astronomical feature, the Lyman-Alpha blob. In order to understand the Lyman-Alpha Blob, we need to understand specifically how the "blob" is energized. Observationally, we see that these Lyman-Alpha Blob clouds" have internal motion as well as some intrinsic luminosity. But, we do not quite see, visually, exactly what is providing the Lyman-Alpha Blobs their energy. In order to do so, we executed a form of spectral analysis on the blob. By separating the visible light by its wave length, we can analyze the quantities of the hydrogen and helium and the makeup of the various metalloids in the blob. With that data we can form ratios of the metals to either the hydrogen or helium present in the blob and then compare those determined ratios to known spectral diagnostics data. In comparing or data to that of the Sorbonne University we can determine whether the Lyman-Alpha Blob was energized by a Alpha Galactic Nucleus (AGN) or by star formation.

## Introduction

In Astronomy, there is an astronomical phenomena known as a Lyman-Alpha Blob. Simply put, it is a incredibly large concentration of gas emitting light at the Lyman-Alpha emission line. This phenomena is one of the largest individual entities in the known universe. The blobs can scale up to hundreds of thousands of light years in size.

As of now, all of the blobs that are registered are at an incredible distance away from Earth, in an area known as the "High-Redshift" Universe. The blobs may form closer to Earth but have not been seen near to us. This is possibly due the inherent visible qualities of the Lyman-Alpha Blobs, not because these blobs can only form in deep space. The Lyman-Alpha line is a spectral line of the element hydrogen. The "Alpha" jump is where an electron falls from the n=2 orbit into a orbit of n=1. The rest of the wavelength of the Lyman-Alpha line is at 1215 angstroms, which places it square in the ultraviolet section of the electromagnetic spectrum.

One of two things must take place in order for one to detect and locate a Lyman-Alpha Blob: (1) we must have a sensor above Earth's atmosphere looking at the right place, at the right time, or as happened in the case of the blob we are analyzing, (2) the Lyman-Alpha photons were redshifted to the point that they can not only penetrate the atmosphere but be visible to the human eye. It is worth noting that this level of redshift can only happen when the “z” value is decently high (greater than 2), and with the “blobs” which are visible for this study being at great distances from us in the universe..

Therefore, since the blobs that are in question are located incredibly far from us, at distances of the order of 11 billion light years, and with the age of the universe becoming increasingly older the further it retreats from our viewpoint (Earth), we are then looking at a feature of the universe that was formed when the universe was young; roughly 15% of the universes’ current age. This gives us an opportunity to research the universes’ distant past, and perhaps understand how galaxies are formed. With this research of the Lyman-Alpha Blobs, we will delve into and research the conditions of the universe which occurred close to the time of the “Big Bang”. By looking across the facing plane of the blob we can look even further back in time. When local stars and black holes age and fluctuate, disturbances will occur in the gas cloud. With the cloud having diameters of hundreds of thousands of light years in size, it will take time for these disturbances to travel across the cloud, and can thus be documented and recorded. This means that we get as close at 10% of the age of the universe and attempt to form a even better understand of the creation of our universe.

## Analytical Method

Our collected data was separated by one of two slits, one of three apertures styles and one of two colors, as well as by each individual emission line. In order to import the data and to parse it in such a way to be plotted, the code purposed a series of questions. These questions also asked the user which one of the three plots he/she wished as well.

Secondly the program compiled each of the user’s selections and ran a function program that grabbed each of the four files needed to create a plot and placed it in a numerical matrix that Matlab can work with. The program then went into each of the four files and separated the signal and noise columns for later use.

In order to guarantee useful data, we implemented two data cut-offs. Both were an option in the program. One would compare each individual emissions lines’ points’ signal to noise ratio and if that was greater then three it would then take that data line and place it in a new matrix for later use. The other cut off was a Lyman-Alpha cut off, which looked at the signal to noise ratios of Lyman-Alpha at any given point, and if that was above 3 it allowed all the other emission lines through into a new matrix.

As a last step before graphing the metal alloy ratios, we took each individual emission line position point, took the ratio of it and then calculated it’s logarithm.

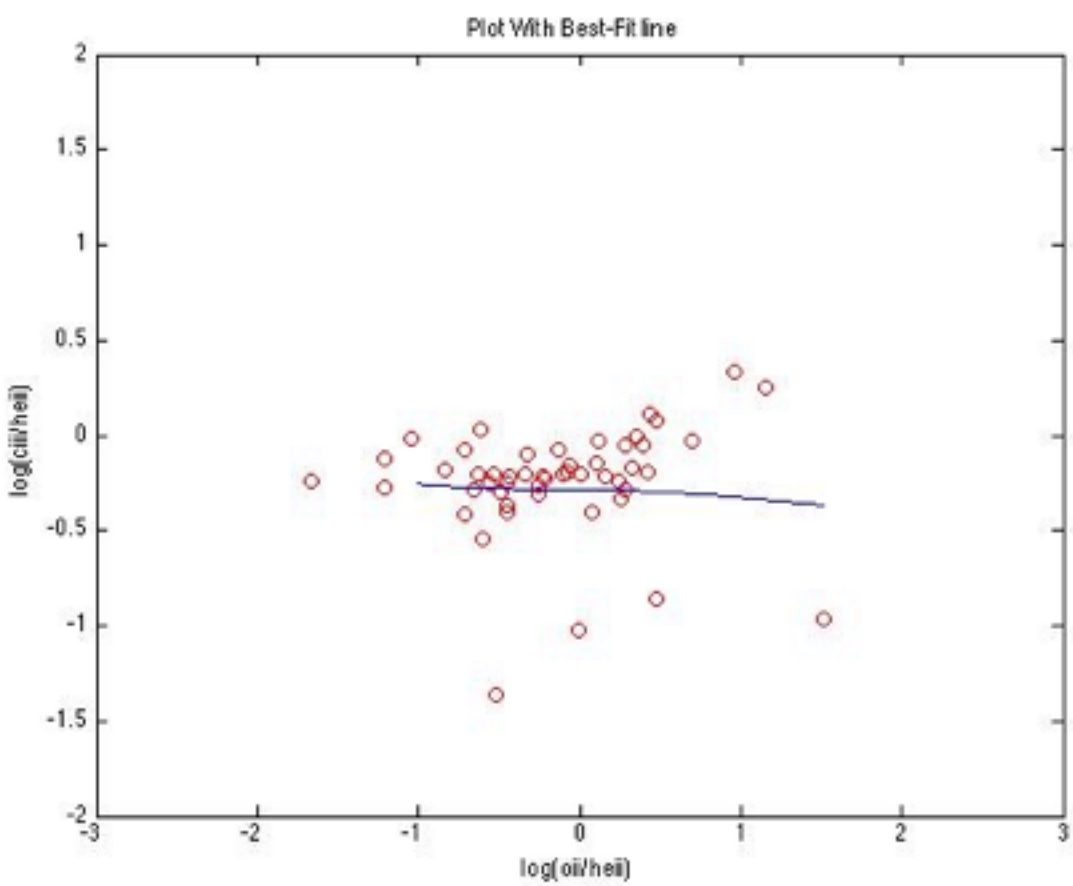
The program was able to produce three plots, one with a best fit line, one with horizontal and vertical error bars , and one with a color gradients based on physical position.

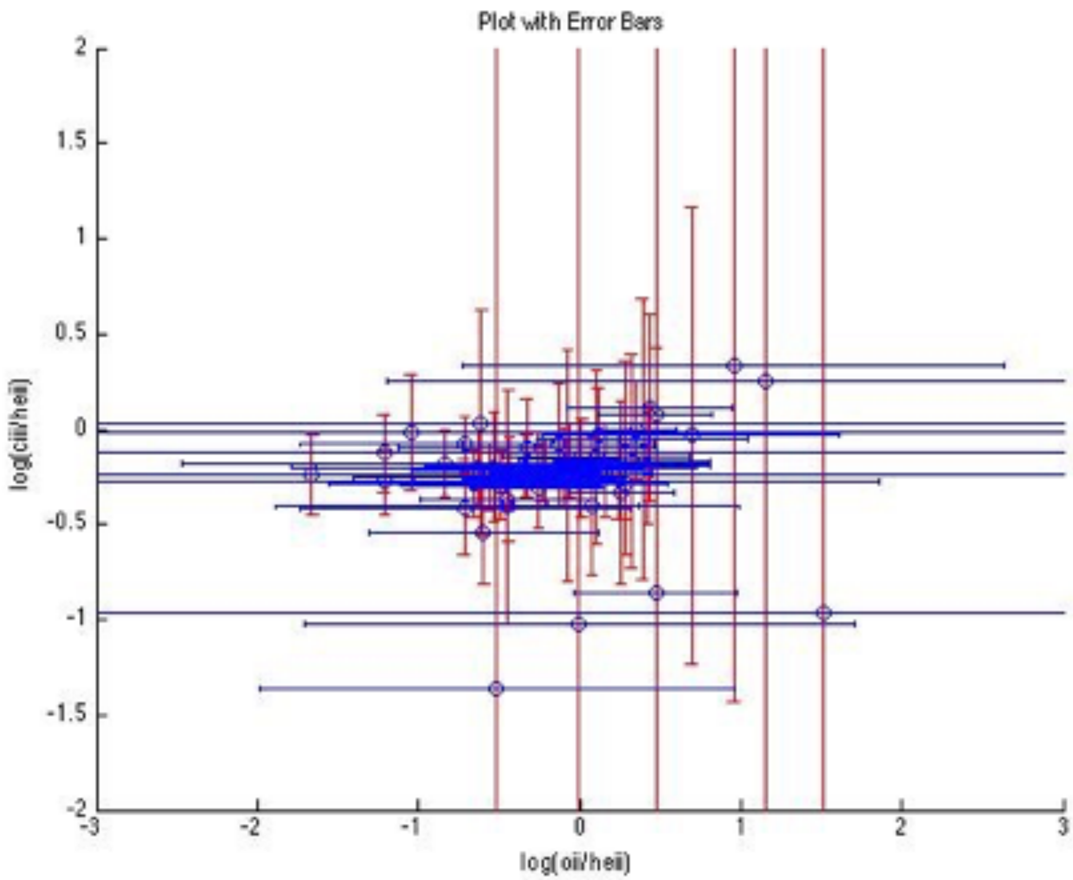
The best fit line was formed using a mixture of a exponential and linear functions. Using that we calculated two constants that were used for the line function that is the best fit line. The error bars were calculated by calculating the square root of each the two noise/signal ratios' squared. Then each error bound was calculated by dividing the above by the original signal to noise ratio and then multiplied by a constant, .434.

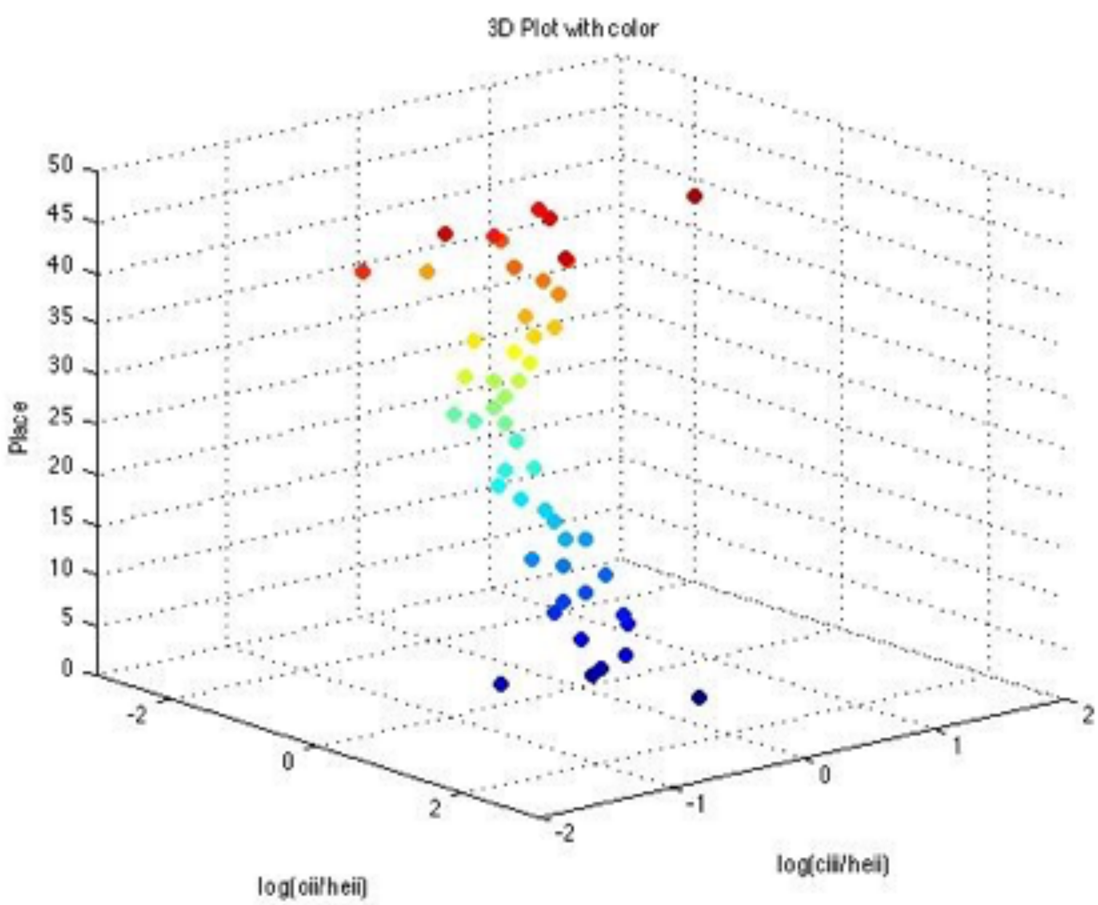
## Results

The plots below of the one pixel aperture style on 52.44 degrees slit using the Lyman-Alpha cut. The rest of the 96 plots are bellow in the appendices.

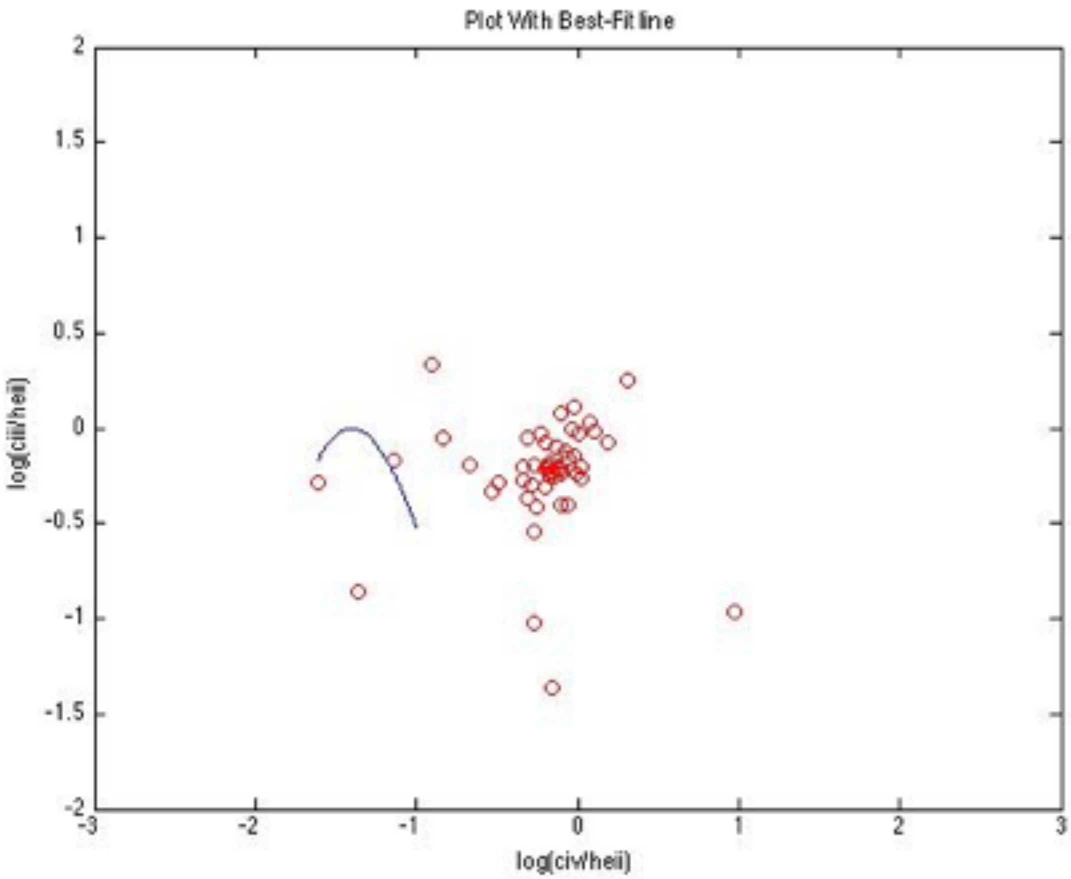
Carbon four vs Helium two compared to Carbon four vs Carbon three(Figure 5 in Sorbonne Universities paper):

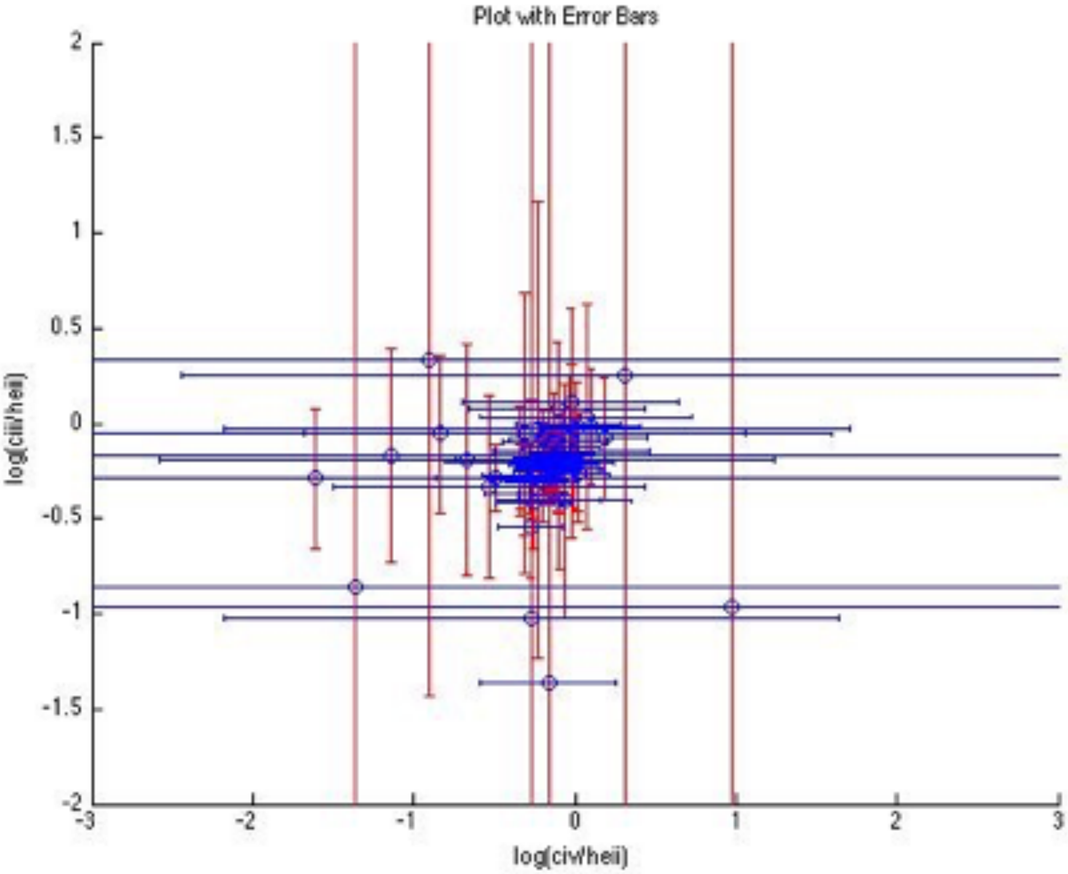



Plot with Error Bars
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-3
-2
-1
0
1
2
3
log(ciii/heii)
log(oii/heii)

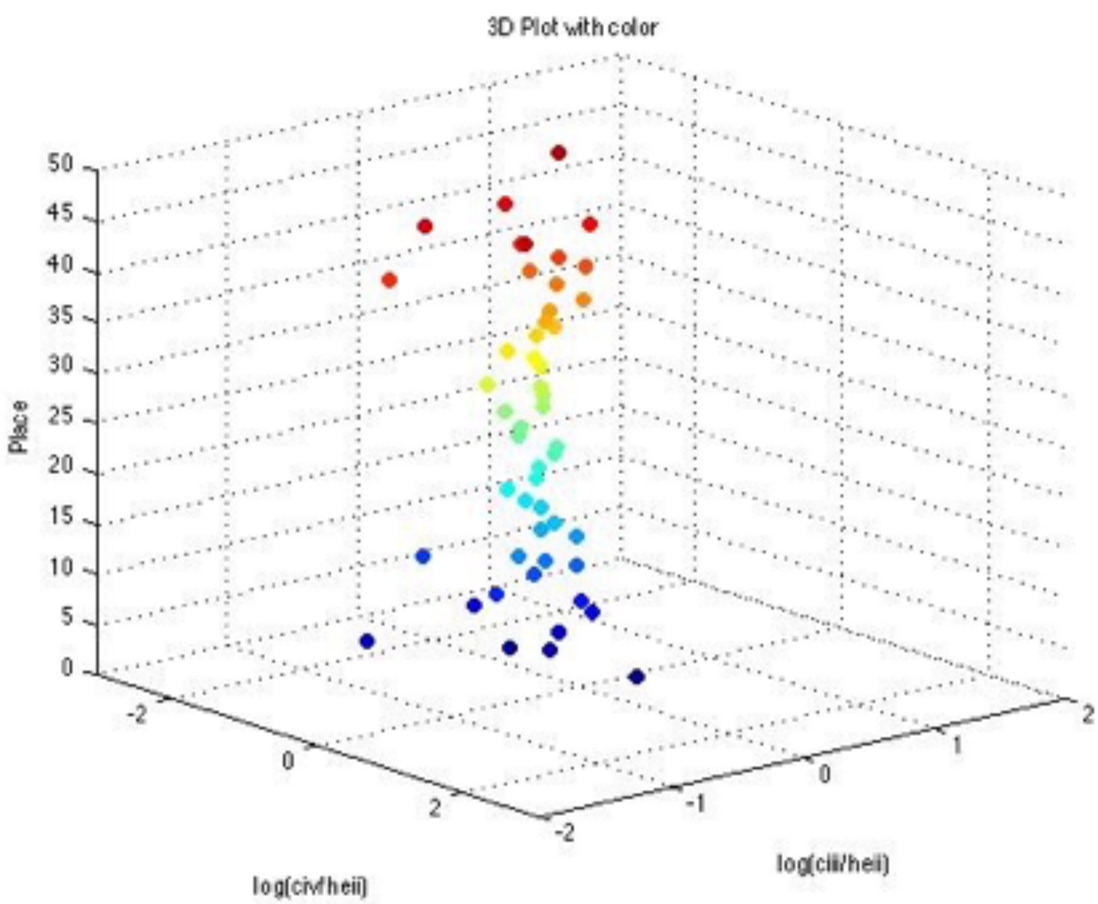

3D Plot with color
50
45
40
35
30
25
20
15
10
5
0
Place
-2
0
2
-2
-1
0
1
2
log(oii/heii)
log(ciii/heii)

Carbon four vs Helium two compared to Carbon three vs Helium two(Figure 6 and 14 in Sorbonne Universities paper):



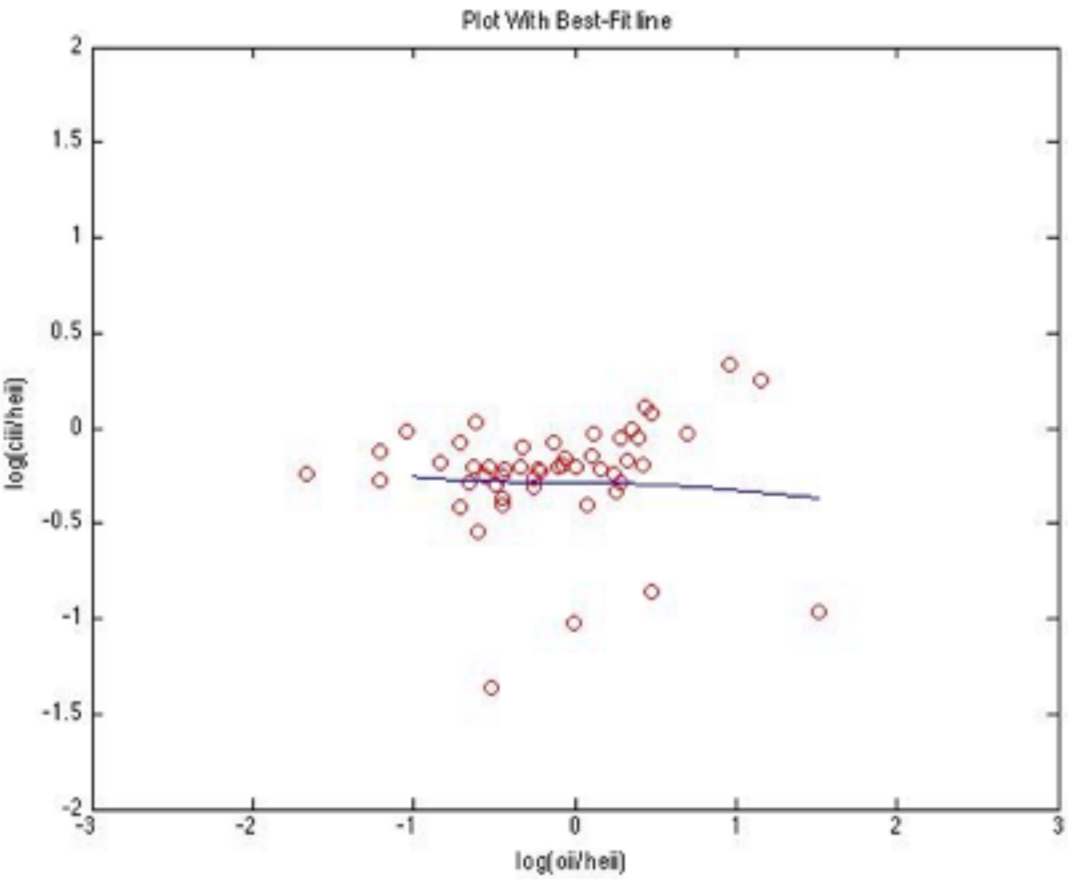


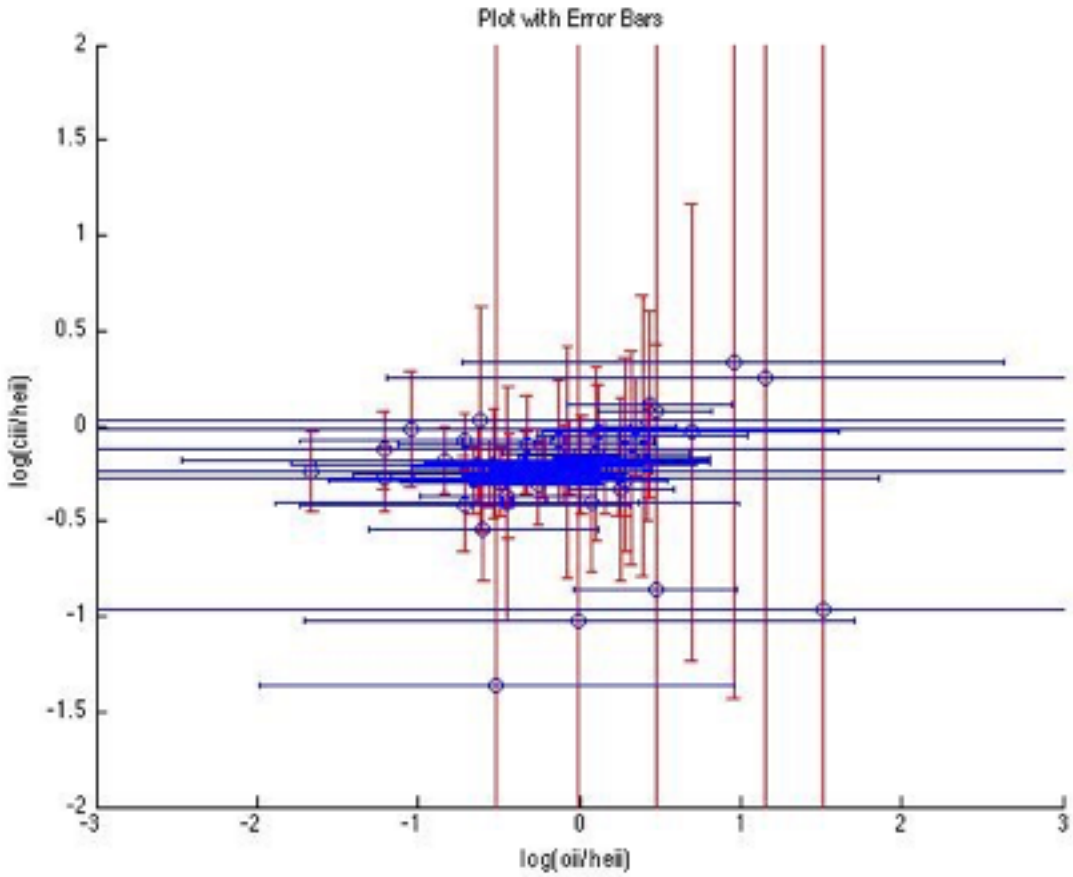
Plot with Error Bars
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-3
-2
-1
0
1
2
3
log(ciii/heii)
log(civ/heii)

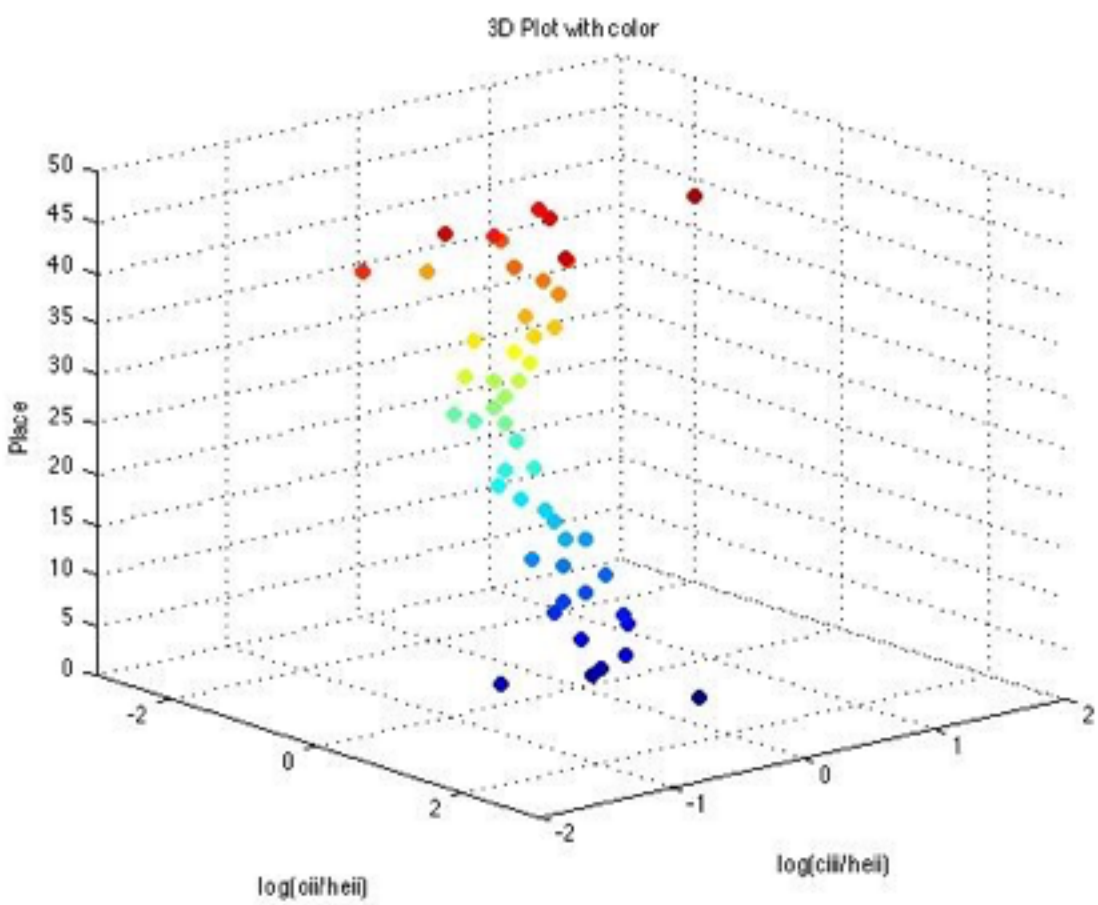



3D Plot with color
50
45
40
35
30
25
20
15
10
5
0
Place
-2
0
2
log(civ/heii)
-2
-1
0
1
2
log(ciii/heii)

Oxygen two vs Helium two compared to Carbon three vs Carbon Helium two(Figure 10 in Sorbonne Universities paper):




Plot with Error Bars
log(ciii/heii)
log(oii/heii)


3D Plot with color
Place
log(oii/heii)
log(ciii/heii)

## Discussion of Results

Looking at the groupings of the data points for all the three plots sets, we see the the points are ether centered just negative of the origin(0,0) or in quadrant three(Lower left) of the plot. The best fit line in most cases, but not all, has a upward-positive inclination. In the colored position plots we see a variety of shapes being formed as we vary the parameters. In some cases we see the ratios go to zero as we near the center of the blobs(Forming an hour glass shape), while in other cases we see the opposite were the ratios tend to infinity as we near the center(forming a zig-zag shape).

Comparing this to the figures in the data, we see a few things. One of which is our data lines up with the Ionization parameters' (Us) positive inclination and that our data seems to point to an Alpha Galactic Nucleus(AGN) as the Energetic device for the Lyman Alpha cloud.

As of now though, this is the only honest conclusion we have been able to draw. In order to truly determine what it energizing the Lyman-Alpha blob we must evolve the program to import the published models and run a comparison analysis. This well allow us to quantify the deviation our data has from true-known sources.

# Appendices

## A. References

a. 2016, “ Chandra X-Ray Obervatory”, from http://chandra.harvard.edu/photo/2009/labs

b. 2015 “Nuclear activity versus star formation: emission-line diagnostics at ultraviolet and optical wavelengths” form Sorbonne University by A. Feltrem S. Charlot and J. Nutkin.

## B. Code

Main program

```
%LYA BLOBS GRAPH PROGRAM
%ARTHUR COX
%ACOX20@NMSU.EDU

%NOTE, FOR THE TIME BEING THE LABLOBS FOLDER NEEDS TO BE ON YOUR DESKTOP
%TO WORK.
%2ND NOTE, THE IMPORTDATA FUNCTION IS DEISGNED FOR A MAC FILE STUCTURE.
%SOME MODIFACTIONS NEED TO BE MADE IN LINE 34 OF IMPORTDATA IF IT IS GOING TO
%BE USED ON WINDOWS.


%PROGRAMSTART
CLC
CLEAR
CLOSE ALL


%QUESTIONS
CHOICE = QUESTDLG('WHAT COLOR?', ...
                  'COLOR?', ...
                  'RED','BLUE','BOTH','BOTH');

SWITCH CHOICE
  CASE 'RED';
    DISP([CHOICE '--- RED CONFIMERD'])
    COLOR = 'RED';
  CASE 'BLUE';
    DISP([CHOICE '--- BLUE COMFIRED '])
    COLOR = 'BLUE';
  CASE 'BOTH';
    DISP([CHOICE '--- BOTH COMFIRED '])
    COLOR = 'BLUE';
END
CHOICE = QUESTDLG('HOW WIDE DO YOU WANT THE APERTURE?', ...
                  'APERTURE SIZE?', ...
                  '1 PIXEL','5 PIXELS','WIDE','WIDE');
SWITCH CHOICE
  CASE '1 PIXEL';
    DISP([CHOICE '--- 1 PIXEL WIDE CONFIMERD'])
    SIZE = 'VELO';
```

```
    CASE '5 PIXELS';
        DISP([CHOICE '--- 5 PIXELS WIDE COMFIRED '])
        SIZE = 'VELOBIN';
    CASE 'WIDE';
        DISP([CHOICE '--- MAX WIDTH COMFIRED '])
        SIZE = 'WIDE';
END

CHOICE = QUESTDLG('WHICH OF THE TWO ANGLES DO YOU WANT?', ...
                    'APERTURE SIZE?', ...
                    '52.44 DEGREES','146.0 DEGREES','146.0 DEGREES');
SWITCH CHOICE
    CASE '52.44 DEGREES';
        DISP([CHOICE '--- 52.44 DEGREES CONFIMERD'])
        ANGLE = 'MID_B';
    CASE '146.0 DEGREES';
        DISP([CHOICE '--- 146.0 DEGREES COMFIRED '])
        ANGLE = 'A_B';
END

PROMPTX = {SPRINTF('WHAT SHOULD BE ON THE X AXIS? \N ENTER ETHER LYA, HEII, CIV, CIII, NEIV, NV,
SIIV OR OII \N LEAVE AS 1 IF N/A \N\N LINE 1:'),'OVER'};
PROMPTY = {SPRINTF('WHAT SHOULD BE ON THE Y AXIS? \N ENTER ETHER LYA, HEII, CIV, CIII, NEIV, NV,
SIIV OR OII \N LEAVE AS 1 IF N/A \N\N LINE 1:'),'OVER'};
DEFAULTANSX = {'CIV', 'HEII'};
DEFAULTANSY = {'CIV', 'CIII'};
DLG_TITLE = 'WHAT SHOULD BE ON THE X AXES? ';
NUM_LINES = 1;
ANSWERX = INPUTDLG(PROMPTX,DLG_TITLE,NUM_LINES,DEFAULTANSX);

DLG_TITLE = 'WHAT SHOULD BE ON THE Y AXES? ';
ANSWERY = INPUTDLG(PROMPTY,DLG_TITLE,NUM_LINES,DEFAULTANSY);

CHOICE = QUESTDLG('WHAT YOU LIKE TO PLOT THE BEST FIT LINE?', ...
                    'CHOOSE', ...
                    'YES','NO','NO');
SWITCH CHOICE
    CASE 'YES';
        DISP([CHOICE '--- YES CONFIMERD'])
        PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:'};
        DEFAULTANS = {'1', '2'};
        FITONOFF = 1;
    CASE 'NO';
        DISP([CHOICE '--- NO COMFIRED '])
        PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:', 'LINE 3'};
        DEFAULTANS = {'1','2','3'};
        FITONOFF = 2;
END

CHOICE = QUESTDLG('WHAT YOU LIKE TO PLOT ERROR?', ...
                    'CHOOSE', ...
                    'YES','NO','NO');
SWITCH CHOICE
    CASE 'YES';
        DISP([CHOICE '--- YES CONFIMERD'])
        PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:'};
        DEFAULTANS = {'1', '2'};
        ERRORONOFF = 1;
```

```
   CASE 'NO';
      DISP([CHOICE '--- NO COMFIRED '])
      PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:', 'LINE 3'};
      DEFAULTANS = {'1','2','3'};
      ERRORONOFF = 2;
END
IF ERRORONOFF==1
CHOICE = QUESTDLG('WHAT YOU LIKE THE ERROR BARS TO BE LYA OR S/N', ...
                 'CHOOSE', ...
                 'LYA','S/N','S/N');
SWITCH CHOICE
   CASE 'LYA';
      DISP([CHOICE '--- LYA CONFIMERD'])
      PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:'};
      OPTIONONOFF = 1;
   CASE 'S/N';
      DISP([CHOICE '--- S/N COMFIRED '])
      PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:', 'LINE 3'};
      OPTIONONOFF = 2;
END
END

% PROMPT = {SPRINTF('WHAT SHOULD BE THE CUT?')};
% DEFAULTANS = {'3'};
% DLG_TITLE = 'WHAT SHOULD BE THE CUT OFF? ';
% NUM_LINES = 1;
% CUTS = INPUTDLG(PROMPT,DLG_TITLE,NUM_LINES,DEFAULTANS);



CHOICE = QUESTDLG('WHAT YOU LIKE TO PLOT COLOR?', ...
                 'CHOOSE', ...
                 'YES','NO','NO');
SWITCH CHOICE
   CASE 'YES';
      DISP([CHOICE '--- YES CONFIMERD'])
      PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:'};
      COLORONOFF = 1;
   CASE 'NO';
      DISP([CHOICE '--- NO COMFIRED '])
      PROMPT = {SPRINTF(' \N\N LINE 1:'),'LINE 2:', 'LINE 3'};
      COLORONOFF = 2;
END

Y1 = ANSWERY(1,1);
X1 = ANSWERX(1,1);
Y2 = ANSWERY(2,1);
X2 = ANSWERX(2,1);

OII = STRCMP(X1,'OII');
IF OII == 1;
     COLOR2 = 'RED';
ELSE
   COLOR2 = COLOR;
END


% IMPORT AND PARSE
```

```
[Y1I] = IMPORTDATA(COLOR,SIZE,ANGLE,Y1);
SIGNALY1=Y1I(:,10);
ERRORY1=Y1I(:,11);

[X1I] = IMPORTDATA(COLOR2,SIZE,ANGLE,X1);
SIGNALX1=X1I(:,10);
ERRORX1=X1I(:,11);

[Y2I] = IMPORTDATA(COLOR,SIZE,ANGLE,Y2);
SIGNALY2=Y2I(:,10);
ERRORY2=Y2I(:,11);

[X2I] = IMPORTDATA(COLOR,SIZE,ANGLE,X2);
SIGNALX2=X2I(:,10);
ERRORX2=X2I(:,11);

LYANAME = 'LYA';
[LYA] = IMPORTDATA(COLOR,SIZE,ANGLE,LYANAME);
SIGNALLYA=LYA(:,10);
NOISELYA=LYA(:,11);

[NSIGNALY1]=[];
[NSIGNALY2]=[];
[NSIGNALX1]=[];
[NSIGNALX2]=[];
[NERRORY1]=[];
[NERRORY2]=[];
[NERRORX1]=[];
[NERRORX2]=[];

%SIGNEL TO NOISE CUT OF 3

%CUT NUMBER
CUT = 2;


IF OPTIONONOFF==2
FOR I=1:LENGTH(SIGNALY1)
   IF SIGNALY1(I)/ERRORY1(I)>CUT && SIGNALY2(I)/ERRORY2(I)>CUT && SIGNALX1(I)/ERRORX1(I)>CUT &&
SIGNALX2(I)/ERRORX2(I)>CUT
       [NSIGNALY1]=[NSIGNALY1;SIGNALY1(I)];
       [NSIGNALY2]=[NSIGNALY2;SIGNALY2(I)];
       [NSIGNALX1]=[NSIGNALX1;SIGNALX1(I)];
       [NSIGNALX2]=[NSIGNALX2;SIGNALX2(I)];
       [NERRORY1]=[NERRORY1;ERRORY1(I)];
       [NERRORY2]=[NERRORY2;ERRORY2(I)];
       [NERRORX1]=[NERRORX1;ERRORX1(I)];
       [NERRORX2]=[NERRORX2;ERRORX2(I)];
   END
END
ELSEIF OPTIONONOFF==1
FOR I=1:LENGTH(SIGNALY1)
   IF SIGNALLYA(I)/NOISELYA(I)>CUT
       [NSIGNALY1]=[NSIGNALY1;SIGNALY1(I)];
       [NSIGNALY2]=[NSIGNALY2;SIGNALY2(I)];
       [NSIGNALX1]=[NSIGNALX1;SIGNALX1(I)];
       [NSIGNALX2]=[NSIGNALX2;SIGNALX2(I)];
       [NERRORY1]=[NERRORY1;ERRORY1(I)];
```

```
        [NERRORY2]=[NERRORY2;ERRORY2(I)];
        [NERRORX1]=[NERRORX1;ERRORX1(I)];
        [NERRORX2]=[NERRORX2;ERRORX2(I)];
    END
END
END
LOGSIGVALY=LOG10(NSIGNALY1./NSIGNALY2);
LOGSIGVALX=LOG10(NSIGNALX1./NSIGNALX2);


X=NSIGNALX1./NSIGNALX2;
Y=NSIGNALY1./NSIGNALY2;

ERR_X = X .* SQRT(((NERRORX1./NSIGNALX1).^2)+((NERRORX2./NSIGNALX2).^2));
ERR_Y = Y .* SQRT(((NERRORY1./NSIGNALY1).^2)+((NERRORY2./NSIGNALY2).^2));

ERRORPLUSX=.434 .* ERR_X./X;
ERRORNEGATIVEX=.434 .* ERR_X./X;
ERRORPLUSY=.434 .* ERR_Y./Y;
ERRORNEGATIVEY=.434 .* ERR_Y./Y;


%BEST FIT LINE


A=[LOGSIGVALX,ONES(LENGTH(LOGSIGVALX),1)];
Y=LOG(LOGSIGVALY);
C=(A'*A)\(A'*Y);
EC=C(1);
A=[EXP(EC*LOGSIGVALX),LOGSIGVALX.^2,LOGSIGVALX,ONES(LENGTH(LOGSIGVALX),1)];
Y=LOGSIGVALY;
C=(A'*A)\(A'*Y);
X=LINSPACE(MIN(LOGSIGVALX)-1,MAX(LOGSIGVALX),200);
Y=C(1)*EXP(EC*X)+C(2)*X.^2+C(3)*X+C(4);

%PLOT
XLAB = CHAR(STRCAT('LOG(',X1,'/',X2,')'));
YLAB = CHAR(STRCAT('LOG(',Y1,'/',Y2,')'));

IF FITONOFF==1
FIGURE
PLOT(LOGSIGVALX,LOGSIGVALY,'RO',X,Y,'B-')
TITLE('PLOT WITH BEST-FIT LINE')
AXIS([-3,3,-2,2])
XLABEL(XLAB)
YLABEL(YLAB)
END

IF ERRORONOFF==1
    FIGURE
    HOLD ON
    ERRORBAR(LOGSIGVALX,LOGSIGVALY,ERRORPLUSY,ERRORNEGATIVEY,'RO')
    HERRORBAR(LOGSIGVALX,LOGSIGVALY,ERRORNEGATIVEX,'BO')
    PLOT(LOGSIGVALX,LOGSIGVALY,'BO')
    AXIS([-3,3,-2,2])
    TITLE('PLOT WITH ERROR BARS')
    XLABEL(XLAB)
    YLABEL(YLAB)
```

```
   HOLD OFF
END

IF COLORONOFF==1
COLOR=JET(LENGTH(LOGSIGVALX));
FIGURE
HOLD ON
FOR I=1:LENGTH(LOGSIGVALX)

PLOT3(LOGSIGVALX(I),LOGSIGVALY(I),I,'MARKEREDGECOLOR',COLOR(I,:),'MARKERFACECOLOR',COLOR(I,:)
,'MARKER','O')
   AXIS([-3,3,-2,2])
   TITLE('3D PLOT WITH COLOR')
   XLABEL(XLAB)
   YLABEL(YLAB)
   ZLABEL('PLACE')
   GRID ON
END
HOLD OFF
END
```

## Function Program

```
%ARTHUR COX
%IMPORTING DATA FOR USE IN LYA.M


FUNCTION [A] = IMPORTDATA(COLOR,SIZE,ANGLE,LINE)
NAME = 'FAIL';
TB = STRCMP(COLOR,'BLUE');
TR = STRCMP(COLOR,'RED');
TV = STRCMP(SIZE,'VELO');
TVB = STRCMP(SIZE,'VELOBIN');
TW = STRCMP(SIZE,'WIDE');
%VAL=517;
IF TV == 1

   IF TB == 1
      NAME = '.SKYVELOCOMBO.';
   ELSEIF TR == 1
      NAME = '.SKYVELO.';
   END
ELSEIF TVB == 1
   IF TB == 1
      NAME = '.SKYVELOBINCOMBO.';
   ELSEIF TR == 1
      NAME = '.SKYVELOBIN.';
   END
ELSEIF TW == 1
   IF TB == 1
      NAME = '.SKYWIDECOMBO.';
   ELSEIF TR == 1
      NAME = '.SKYWIDE.';
   END
END
```

```
TESTFILEDIR = CHAR(STRCAT('~/DESKTOP/LABLOBS/DATAFILES/', COLOR,'/',SIZE,'/
CASDPRG1_',ANGLE,NAME,LINE,'.NOHEAD.DAT'));
FID=FOPEN(TESTFILEDIR);
[AF] = FSCANF(FID,'%C');
%A=A(VAL:END)
A=STR2NUM(AF);
% ROWS2REMOVE=[1 2];
% A(ROWS2REMOVE,:)=[];
```

## C. Plots