

DIY Astronomy



Raspberry Pi Telescope Control Phase I

Why Raspberry Pi?

Option 1 – Laptop Control:

- Expensive
- Long durations in the 'elements'
 - Dew
 - Possible rain
 - Cold / hot
- Have to sit outside to operate & monitor



Option 2 – Raspberry Pi:

- Low Cost: \$35
- Not worried about it being in the elements
- Can operate & monitor from remote location (in the house)

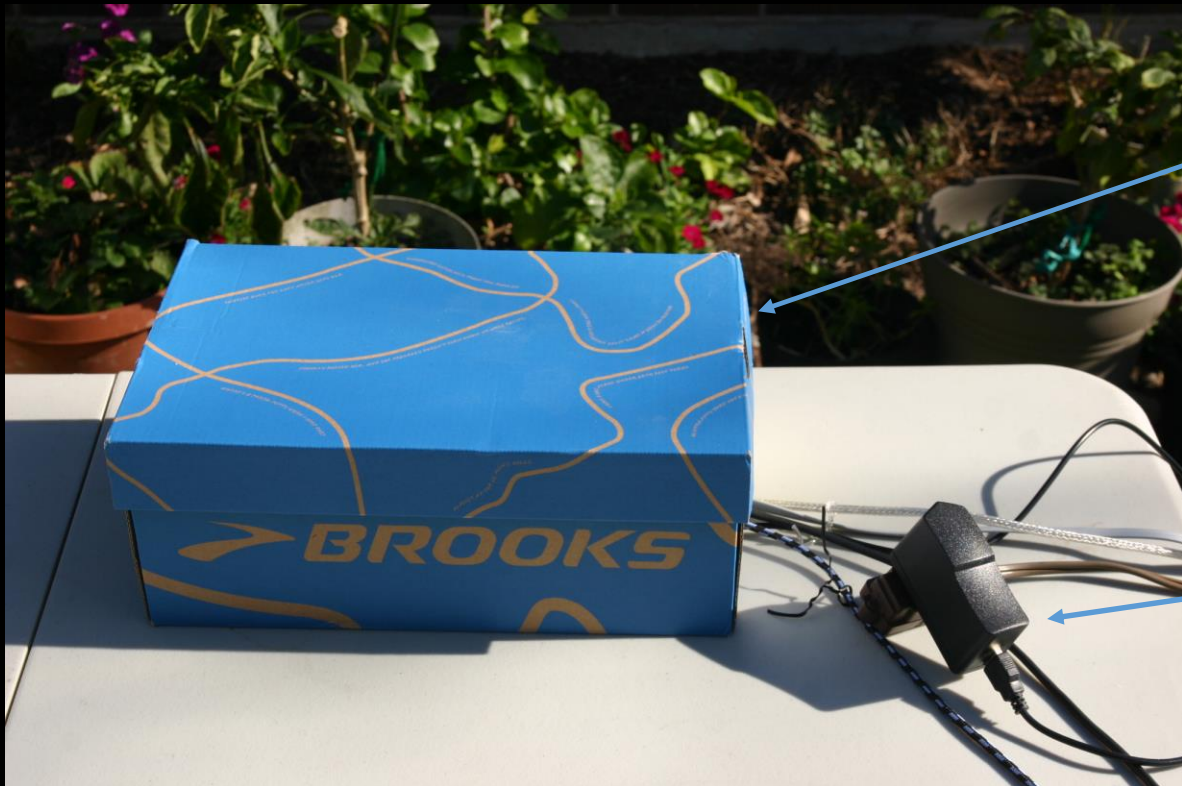


Initial concerns:

1. Too slow? Nope
2. Too little storage for imaging? Nope

What does the configuration look like?





Shoe box –

- Able to open & close
- Run cables through hole in bottom

Power Supply –

- USB output Cell Phone type
- Requires 2A version



Raspberry Pi 3B+
(and case)

GPUSB – for guiding
[Shoestring Astronomy]

What does it look like when it is operating?

Raspberry Pi Outside ↔ Laptop Inside

Connect your equipment

The screenshot displays the KStars software interface with the INDI Control Panel for a Losmandy Gemini telescope. The main window is titled "Ekos - INDI Control Panel - KStars" and features several tabs: Main Control, Connection, Options, Motion Control, Site Management, and Guide. The "Main Control" tab is active, showing various control options:

- Connection: **Connect** (green), **Disconnect** (grey)
- Startup Mode: **Cold** (green), **Warm** (grey), **Restart** (grey)
- On Set: **Track** (green), **Slew** (grey), **Sync** (grey)
- Eq. Coordinates: RA (hh:mm:ss) 10:48:32, 0:00:00; DEC (dd:mm:ss) 90:00:00, 0:00:00. **Set** button.
- Abort Motion: **Abort** (grey)
- Track Mode: **Sidereal** (green), **King** (grey), **Lunar** (grey), **Solar** (grey)
- Tracking: **On** (green), **Off** (grey)
- Parking: **Park** (green), **UnPark** (grey)
- Pier Side: **West (pointing east)** (green), **East (pointing west)** (grey)
- Use Pulse Cmd: **Off** (green), **On** (grey)
- Park Settings: **Home** (green), **Startup** (grey), **Zenith** (grey)

At the bottom of the window, a log shows the following messages:

```
2020-02-02T02:21:51: [INFO] Site location updated to Lat 29:36:14 - Long 264:53:24
2020-02-02T02:21:51: [INFO] Time updated, updating planetary data...
2020-02-02T02:21:50: [INFO] Device configuration saved.
2020-02-02T02:21:50: [INFO] Saving device configuration...
2020-02-02T02:21:50: [INFO] Device configuration saved.
2020-02-01
2020-02-01T20:21:51 Re-disabling debug logging for SC285 CCD Model 1...
2020-02-01T20:21:51 Guider port from Losmandy Gemini is ready.
```

On the right side of the interface, there is a "Connect & Disconnect Devices" panel with **Connect** and **Disconnect** buttons. Below it, a "Target:" section shows coordinates: DE: 90° 00' 00", AL: 29° 36' 14". There are also fields for HFR, σRA, and σDEC.

The background of the software is a star field with labels for NGC 2247, NGC 2245, and NGC 2251. The system tray at the bottom left shows the time and date: "LT: 8:22:22 PM Saturday, February 1, 2020".

GO TO your target

Deep Sky Survey (DSS) overlay of images

The screenshot displays the KStars software interface. The main window shows a star field with a red crosshair and a large red circle representing the field of view. A yellow box highlights a region of interest, labeled "C285 CCD Model" and "25.8'x19.2'". A blue box highlights a specific star, labeled "127mm R SC286" and "25.8'x19.2'". The star "Monocerotis" is also labeled. The interface includes a menu bar (File, Time, Pointing, View, Tools, Data, Observation, Settings, Help), a toolbar, and a status bar (LT: 12:24:01 AM Sunday, February 2, 2020). Several control panels are visible: "INDI Control Panel - KStars", "Ekos - SC285_127mm_SC2M034_50mmGS_GPUSB_G11_Remote Profile - KStars", and two "KStars FITS Viewer - KStars" windows. The "Ekos" panel shows a "Sequence Queue" table with the following data:

Status	Filter	Type	Bin	Exp	ISO/Gain	Count
In Progress	--	Light	1x1	900.000	--	0/12

Astrometry / Plate Solving

➤ For image framing and refining GO TOs

The screenshot displays the KStars software interface. The main window shows a star field with a red crosshair and a white rectangular box indicating the solved area. A vertical label next to the box reads "C2 solved FOV: 26.1x19.5". The interface includes a menu bar (File, Time, Pointing, View, Tools, Data, Observation, Settings, Help) and a toolbar with various icons. A status bar at the top left shows "LT: 2:39:33 AM Sunday, February 2, 2020".

A secondary window titled "Ekos - SC285_127mm_SC2M034_50mmGS_GPUSB_G11_Remote Profile - KStars" is open, displaying the Solver Control panel. This panel includes buttons for "Capture & Solve", "Load & Slgw...", and "Stop". It also features "Solver Action" options: "Sync", "Slew to Target", and "Nothing".

The "Telescope Coordinates (Now)" section shows RA: 08:52:26, Accuracy: 30, DE: 11:45:12, and Settle: 1500. The "Solution Coordinates (Now)" section shows RA: 08:52:24, DE: 11:44:10, Err: 9 arcsec, RA: 7, DE: 5, Pix: 1.12, Rot: 86.729, and FOV: 26.1' x 19.5'. The "Solver Options" section includes "CCD: SC285 CCD Model 1", "Exp: 15.00", "Bin: Dark", "FW: Filter:", and "Options: +u aw -3 133.1 -4 11.7336 -5 30". The "Solver" section has radio buttons for "ASTAP", "Astro.net", and "Online".

The "Solution Results" table is displayed below the Solver Control panel. It contains the following data:

	RA	DEC	Obj Name	~	dRA
1	07:28:14	08:14:48	Gomeisa (β Canis Minoris)	✕	
2	07:28:14	08:14:48	Gomeisa (β Canis Minoris)	✕	
3	07:34:44	09:11:42	star	✕	
4	07:34:44	09:11:42	star	▲	83.266"
5	07:34:44	09:11:42	star	✕	

Below the table, a "Mount Model" button is visible. At the bottom of the Ekos window, a status bar displays the following messages:

2020-02-02T02:35:14 Target is within acceptable range. Astrometric solver is successful.
2020-02-02T02:35:14 Target is within 00° 00' 08" degrees of solution coordinates.
2020-02-02T02:35:14 Solution coordinates: RA (08h 52m 24s) DEC (11° 44' 10") Telescope Coordinates: RA (08h 52m 25s) DEC (11° 44' 10")

At the bottom of the KStars window, the "INDI Control Panel - KStars" is visible, showing tabs for "Losmandy Gemini", "GPUSB", "SC285 CCD Model 1", and "SC2M034 CCD Model 1". The "Main Control" tab is active, showing "General Info", "Options", "Image Settings", "Image Info", and "WCS". A status bar at the very bottom right shows the coordinates: "+249° 30' 20", +53° 35' 26" 08h 48m 15s, +12° 3'".

Autoguiding

- Internal Guider or PHD2 or Linguider

The screenshot displays the KStars software interface for autoguiding. The main window is titled "Ekos - SC285_127mm_SC2M034_50mmGS_GPUSB_G11_Remote Profile - KStars". The interface is divided into several sections:

- Control Panel:** Includes buttons for "Capture", "Loop", "Guide", "Subframe", "Auto Star", "Stop", and "Dark". It also features a "Main Control" section with "Connect", "Expose", and "Gain" indicators.
- Guide Info:** Shows the "Scope: Guide Scope" and "Guiding rate" set to 0.500. It lists various parameters: Focal (162.0), Aperture (50.0), F/D (3.2), FOV (101.9x76.4), Guiding Delta (0.47, 0.41), Pulse Length (0), RA RMS (0.81), DE RMS (0.65), and Total RMS (1.04).
- Drift Graphics:** A line graph showing "drift (arcsec)" over time (00:45 to 01:30) for RA and DE. A "Control parameters" window shows a "Drift Plot" with dRA and dDE axes.
- Log Window:** Displays a series of status messages, including "Autoguiding started", "Calibration completed", and "Download complete".
- Image Viewer:** A window titled "Viewer - KStars" showing a star field image with a red circle highlighting a specific star.

At the bottom of the interface, there are sliders for "Shadows" (0.0650), "Midtones" (0.0124), and "Highlights" (1.0000). The status bar at the bottom right shows coordinates: "+142° 10' 43\", +66° 29' 09\" 06h 45m 13s, +10° 18' 33\" (J2020.1)".

Imaging Sequence Generation –

- Includes dithering between images
- Can set entire imaging run of: Lights, Darks, Flat Lights, Bias

The screenshot displays the KStars software interface. The main window is titled "Ekos - SC285_127mm_SC2M034_50mmGS_GPU5B_G11_Remote Profile - KStars". The interface is divided into several panels:

- Left Panel:** "INDI Control Panel" for "Losmandy Gemini" telescope, showing status for Connection, Startup Mode, On Set, Eq. Coordinates, Abort Motion, Track Mode, Tracking, Parking, Pier Side, Use Pulse Cmd, and Park Settings.
- Top Panel:** "CCD & Filter Wheel" and "Sequence Queue". The CCD is set to "SC285 CCD Model 1" with a filter of "--". The Sequence Queue table shows one entry: "In Progress" with Filter "--", Type "Light", Bin "1x1", Exp "900.000", ISO/Gain "--", and Count "1/8".
- Middle Panel:** "Capture Settings" with Exposure: 900.000, Filter: --, Count: 8, Delay: 0, Format: FITS, Type: Light. "File Settings" include Prefix: Cone_Nebula_, Directory: C:/Users/sdh/Pictures/Ekos, and Upload: Both. "Limit Settings" include Guiding Deviation: 2.00, Autofocus if HFR: 0.500, and Refocus every: 60.
- Bottom Panel:** "FITS Viewer" showing a progress bar for "Expose: 822.00 seconds left" and "Progress: 1 of 8 completed" (12%).
- Right Panel:** "KStars FITS Viewer - KStars" displaying a grayscale image of a nebula. The image title is "Cone_Nebula_Light_900_secs_2020-02-01T21-10-03_001.fits". The viewer includes sliders for Shadows (0.0650), Midtones (0.0124), and Highlights (1.0000). The image coordinates are 4,088 X:28 Y:154 46% 1396x1040.

Log messages at the bottom of the Ekos window show: "2020-02-01T21:10:29 Capturing 900.000-second image...", "2020-02-01T21:10:29 Dither complete.", and "2020-02-01T21:10:03 Received image 1 out of 8." A system tray at the bottom right shows coordinates: "+136° 44' 38", +64° 54' 14" 06h 47m 10s, +10° 17' 57" (J2020.1)".

How does this configuration work?

OUTSIDE (40°)

Raspberry Pi 3B+

- Ubuntu Operating System (OS) [Linux type OS]
- Operates as INDI device driver server – connects to devices (telescope, cameras), communicates through WiFi to laptop
 - INDI = Instrument Neutral Distributed Interface (like ASCOM but for Linux type OS)

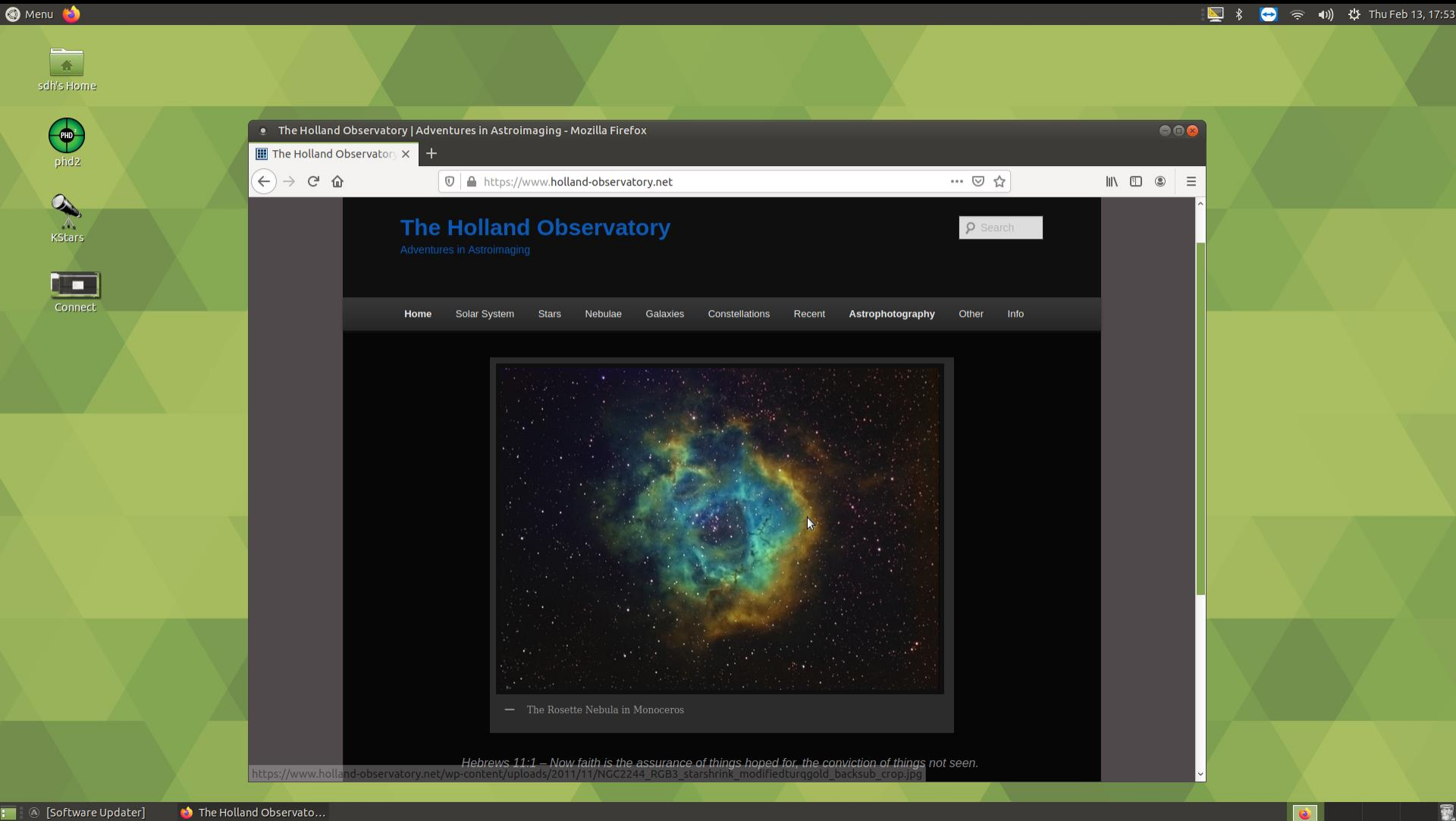
INSIDE (70°)

Laptop

- Windows 10 OS
- Operates as Client
- Uses *free* KStars Planetarium Program & Ekos imaging control
- Communicates via WiFi

Info about Ubuntu OS

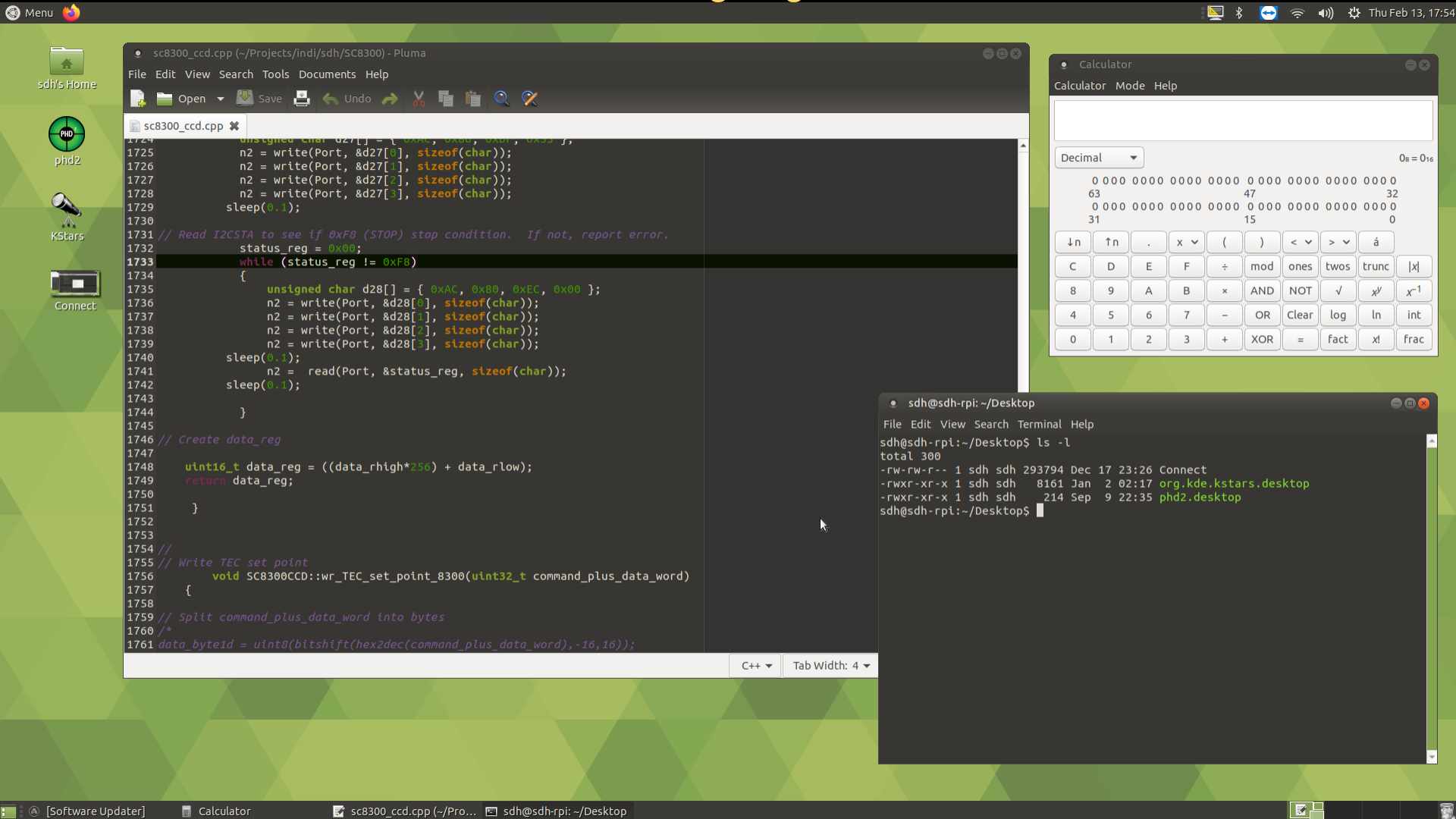
Very similar to windows with similar capabilities
Comes with: Web browser (Firefox)



Programming Editor
Calculator
Command Window (Terminal)

Word Processor
Presentation Creator
Spreadsheet Program
Drawing Program

Image Viewer
Audio & Video Player
Etc., Etc.



All Free – Why am I paying for Windows?

How well does work?

- INDI Drivers available for most common astronomy equipment
- All free
 - Online user & developer community
 - Borderline support available
- Fairly complicated to figure out
- Once figured out, works well

- Storage – Raspberry Pi supports up to 128GB SD card (I think)
 - Had 32GB SD card – Still plenty of space left (Efficient OS)

- Speed – OS is very efficient and primary storage is SD card (SSD)
 - Download speed and communications to laptop is fast
 - 0.5 Sec to download astroimage
 - No perceivable lag in autoguiding monitoring

- KStars Planetarium Program – very capable and free
 - Can download and use for other purposes

One more thing – Off topic: Length of subs



12x10min = 2 hours

Shorter subs:

1. More read noise (more images)
2. Less signal per image
3. Decreased risk of tracking errors

8x15min = 2 hours



Longer subs:

1. Less read noise (less images)
2. More signal per image
3. Increased risk of tracking errors



The End