ska-web-apps-documentation Documentation

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USER GUIDE

CHAPTER

ONE

USER GUIDE

Users control the Calculator via a web page interface, published at URL `http://example.com`.

The observing configuration is described by setting values in the web interface. 'Universal' inputs required for all observing modes, such as the target position, are displayed in the upper part of the web page as shown in Fig. 1.

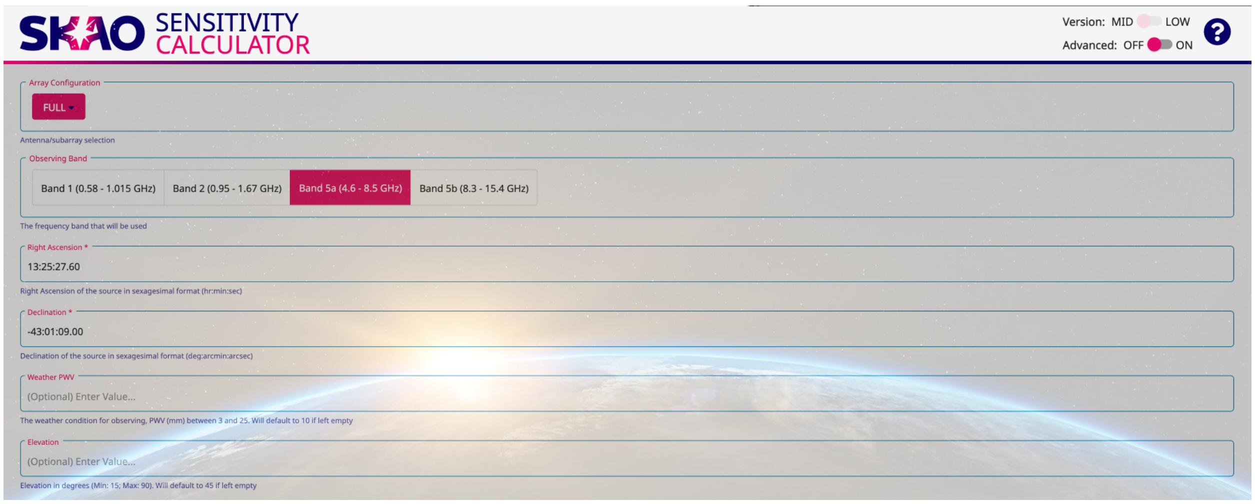

Figure 1 . Screenshot showing the 'universal' part of the Calculator page.

Configuration details that depend on observing mode are separated from the universal inputs by tabs. The User can switch between modes by selecting either the `Continuum` or `Line` tab, as shown in Fig. 2.

Figure 2 . Screenshot showing the tab for `Continuum` mode.

Once configured the Calculator can be used to either calculate the sensitivity for a given on-source integration time, by selecting 'Integration Time' under the `Supplied` drop down, entering the time and clicking `calculate`, or calculate the integration time required to reach a given sensitivity, by selecting 'Sensitivity' under the `Supplied` drop down, entering the sensitivity and clicking `calculate`. Fig. 3 shows an example report provided to the user when this is done.

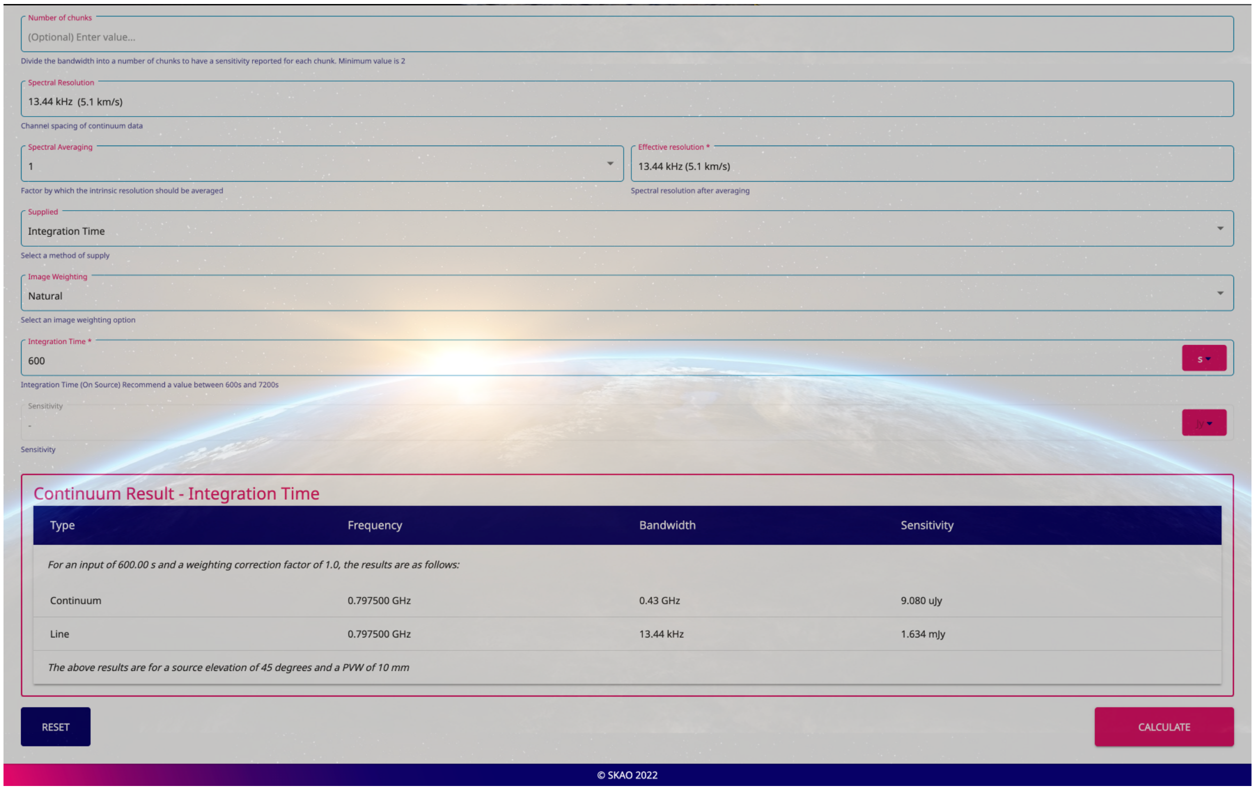

Figure 3 : Screenshot showing the report for the total continuum noise for a hypothetical observation. No PWV (Precipitable Water Vapour) or elevation angle were specified, and so the calculation is performed for default values.

1.1 Inputs

The calculator inputs can be categorised by the observing mode they fall under. **Universal** inputs are those that apply regardless of the selected observing mode.

1.1.1 Universal

- **Observing Band** The selected band to use for the observation. For the "SKA1" subarray the frequency ranges for the bands are:
  - Band 1: 0.58GHz - 1.015GHz
  - Band 2: 0.95GHz - 1.67GHz
  - Band 5a: 4.6GHz - 8.5GHz
  - Band 5b: 8.3GHz - 15.4GHz
- **Right Ascension** and **Declination** The equatorial coordinates of the observed source. The sensitivity is calculated for the time at which the target reaches its maximum elevation, crossing the meridian.
- **Array Configuration** Preset list of array configurations. Click on the tab to choose from:
  - SKA1 (133 x 15m): just the SKA1 antennas
  - Full (64 x 13.5m + 133 x 15m): all SKA1 and MeerKAT antennas
  - Meerkat (64 x 13.5m): just the MeerKAT antennas

Not currently available:

- Custom: activates the nSKA and nMeer fields where the user can enter the number of SKA and MeerKAT antennas directly.
- Core
- Extended

- **Weather PWV** If no value is set in the weather PWV (Precipitable Water Vapour) field then results will be given for the default value of 10mm, corresponding to "average" conditions. The PWV is used in the calculation of the atmospheric brightness temperature, T_{atm}. Since T_{sys} is dependent on T_{sky} and therefore T_{atm} and the weather conditions, if the user decides to manually edit T_{sys} in 'Advanced mode', or any of the variables it depends on, the option to set the PWV will be removed.
- **Elevation** The user can use this field to specify the elevation at which the target will be observed. If no value is set then a default of 45 degrees is assumed. If the given elevation is never reached by the target, then the target's zenith elevation will be used. The actual elevation assumed for the sensitivity calculation is reported in the result table.
- **'Advanced Mode' Inputs** By activating the 'Advanced' switch in the top right hand corner of the calculator, the user is given direct access to some of the parameters used in the sensitivity calculation, as shown in Fig. 4. The calculator front-end automatically enables/disables inputs to avoid conflicts as the user selects which one they want to edit. These are passed to the calculator back-end as hard-coded values which will override the calculated defaults.

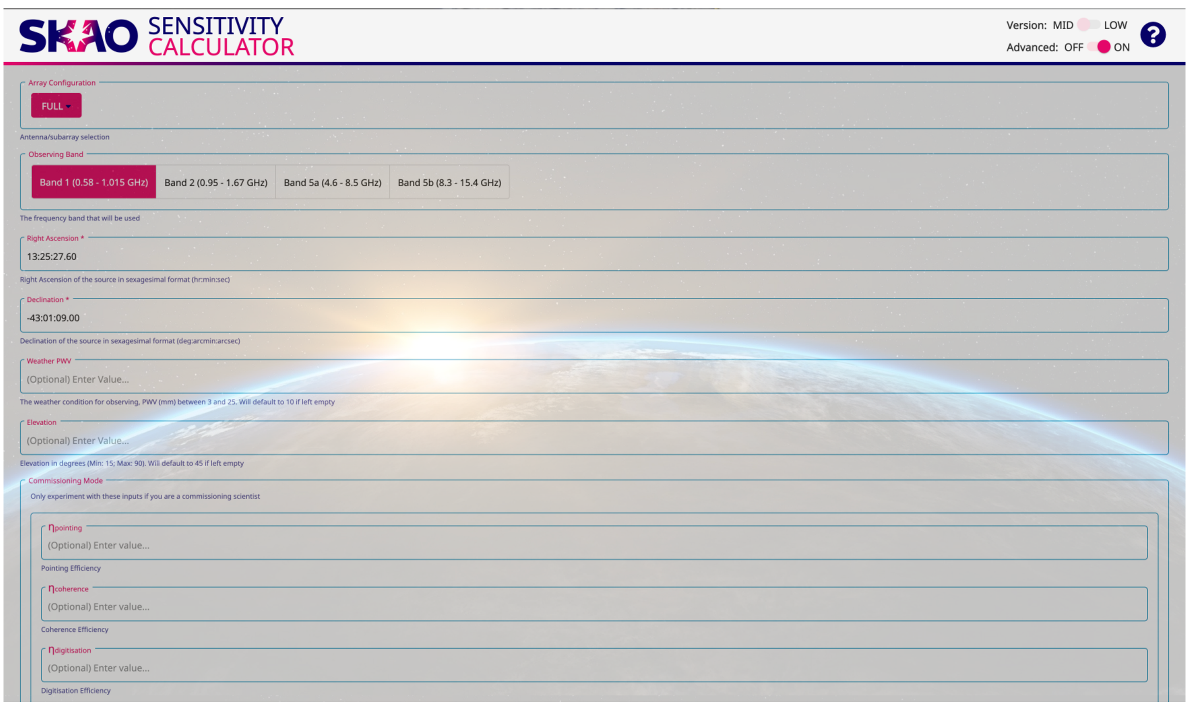

Figure 4 . Expanded view of an example use-case for the additional inputs on the 'Advanced mode' version of the calculator.

1.1.2 Continuum

- **Central Frequency** The central frequency for the observation. Must be within the selected band.
- **Bandwidth** The bandwidth for the observation. Must be fully contained within the selected band.
- **Number of chunks** The user can select an integer number of chunks to split the bandwidth up into. If they do, the output report will show the sensitivity (or integration time) for each chunk.
- **Spectral Averaging** The factor by which the intrinsic spectral resolution is averaged.
- **Supplied** Drop down allowing the user to swap between integration time and sensitivity as the input (giving the other as the output).
- **Image Weighting** The image weighting option to be used.
- **Integration Time** The integration time of the observation. Used when calculating the sensitivity that observing for this amount of time will achieve.
- **Sensitivity** The sensitivity for the observation. Used when calculating the integration time necessary to achieve this sensitivity.

1.1.3 Line

- **Zoom Frequency** For each zoom, the user can input a frequency for that zoom. When a value is entered, the next zoom becomes enabled, allowing a value to be entered. It can however be left blank, and the calculation will only be done for zooms which have a set frequency. This way, the user can select how many zooms they want (up to a maximum, currently 4).
- **Zoom Bandwidth and Resolution** For each zoom, the user can set a line resolution.
- **Supplied** Drop down allowing the user to swap between integration time and sensitivity as the input (giving the other as the output).
- **Image Weighting** The image weighting option to be used.
- **Integration Time** The integration time of the observation. Used when calculating the sensitivity that observing for this amount of time will achieve.
- **Sensitivity** The sensitivity for the observation. Used when calculating the integration time necessary to achieve this sensitivity.

CHAPTER

TWO

SENSITIVITY MODEL

The 'system equivalent flux density' (SEFD) for a single dish is given by:

$$SEFD_{dish} = \frac{2kT_{sys}}{\eta_A A}$$

where:

- k is the Boltzmann constant so that kT_{sys} measures the power received from background emission and all other sources of unwanted signal within the system, that is $T_{sys} = T_{spl} + T_{sky} + T_{rcv} + T_{cmb} + ...$
- η_A is the dish efficiency
- A is the geometric dish area.

The SEFD for an interferometer array made up of two types of dish is given by:

$$SEFD_{\text{array}} = \frac{1}{\sqrt{\frac{n_{\text{SKA}}(n_{\text{SKA}}-1)}{SEFD^2_{\text{SKA}}} + \frac{2n_{\text{SKA}}n_{\text{MeerKAT}}}{SEFD_{\text{SKA}}SEFD_{\text{MeerKAT}}} + \frac{n_{\text{MeerKAT}}(n_{\text{MeerKAT}}-1)}{SEFD^2_{\text{MeerKAT}}}}}$$

where n_{SKA} is the number of SKA antennas, n_{MeerKAT} is the number of MeerKAT antennas, $SEFD_{\text{SKA}}$ is the SEFD computed for an individual SKA antenna, and $SEFD_{\text{MeerKAT}}$ is the SEFD computed for an individual MeerKAT antenna.

We define the telescope sensitivity here as the minimum detectable Stokes I flux (1 σ). This is equal to the noise on the background power, obtained using the radiometer equation $\sigma = SEFD/\sqrt{2Bt}$, corrected for atmospheric absorption:

$$\Delta S_{min} \exp(-\tau_{atm}) = \frac{SEFD_{array}}{\eta_s\sqrt{2Bt}} Jy$$

where:

- ΔS_{min} is the source flux density above the atmosphere
- η_s is the efficiency factor of the interferometer
- B is bandwidth
- t is integration time
- τ_{atm} is the optical depth of the atmosphere towards the target

See implementation for more details.

CHAPTER

THREE

DESIGN

3.1 Public and 'Expert' Users

The calculator is intended for two types of user.

The first type is the ordinary observer who will use the calculator to simply calculate the performance of the telescope when looking at their target object.

The second type is the 'expert' user, who understands the telescope design and wants to test the effect of tweaking some aspect of it. This mode of use is intended for SKA staff. It allows the user to manually edit some of the values which are usually calculated automatically as part of the sensitivity calculation. Say a user wanted to test out how a different array configuration might affect the sensitivity of a given observation. They could manually edit the number of SKA1 and MeerKAT dishes in the array and these would override the numbers that the calculator uses and use the new values in the sensitivity calculation.

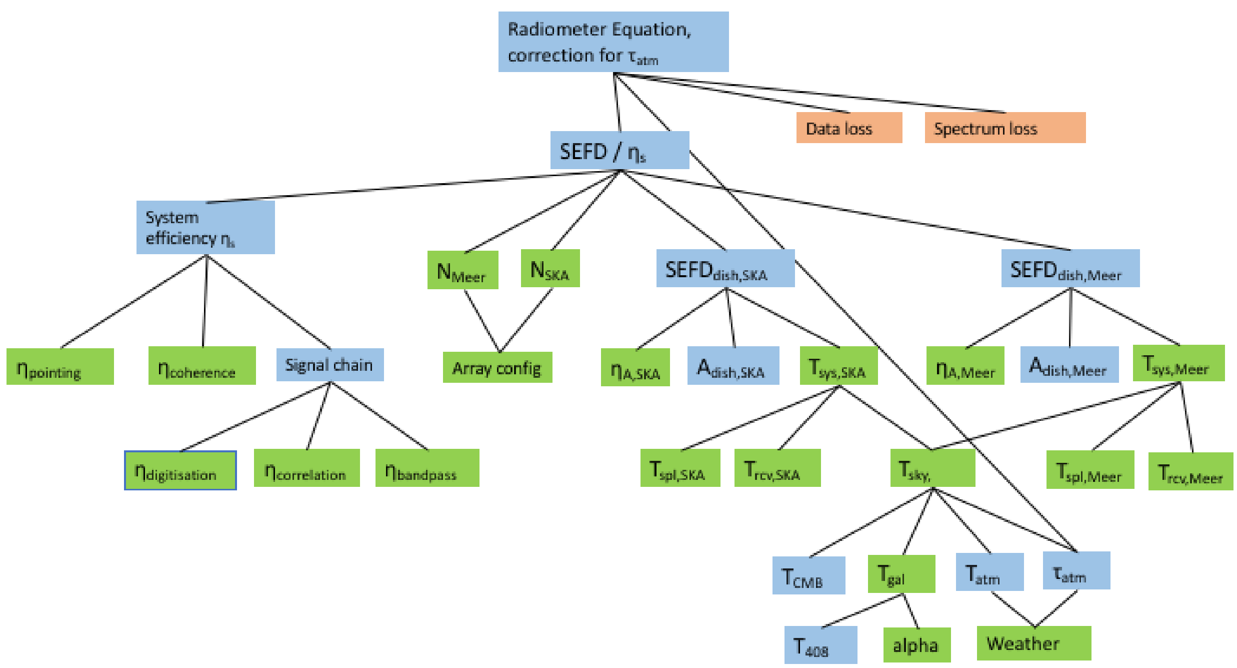

Figure 1 . Flowchart diagram showing the dependencies of the variables used in the sensitivity calculation.

3.2 Technologies

TODO

3.3 High Level Architecture

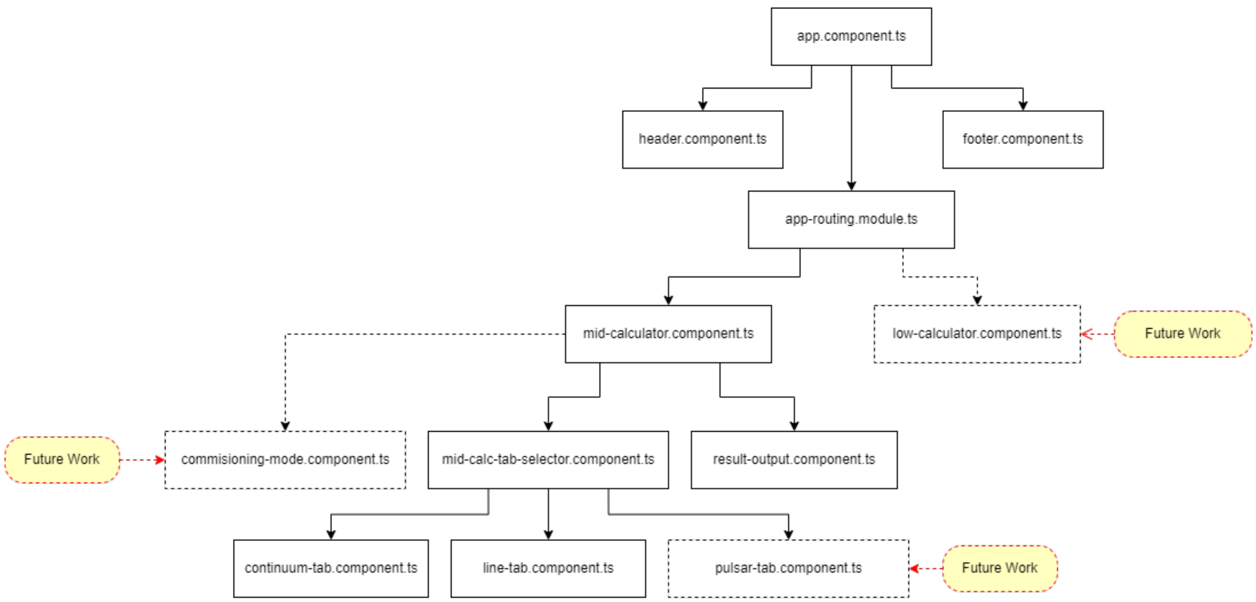

Figure 2 . Flowchart diagram showing the different parent and child angular components that make up the UI structure

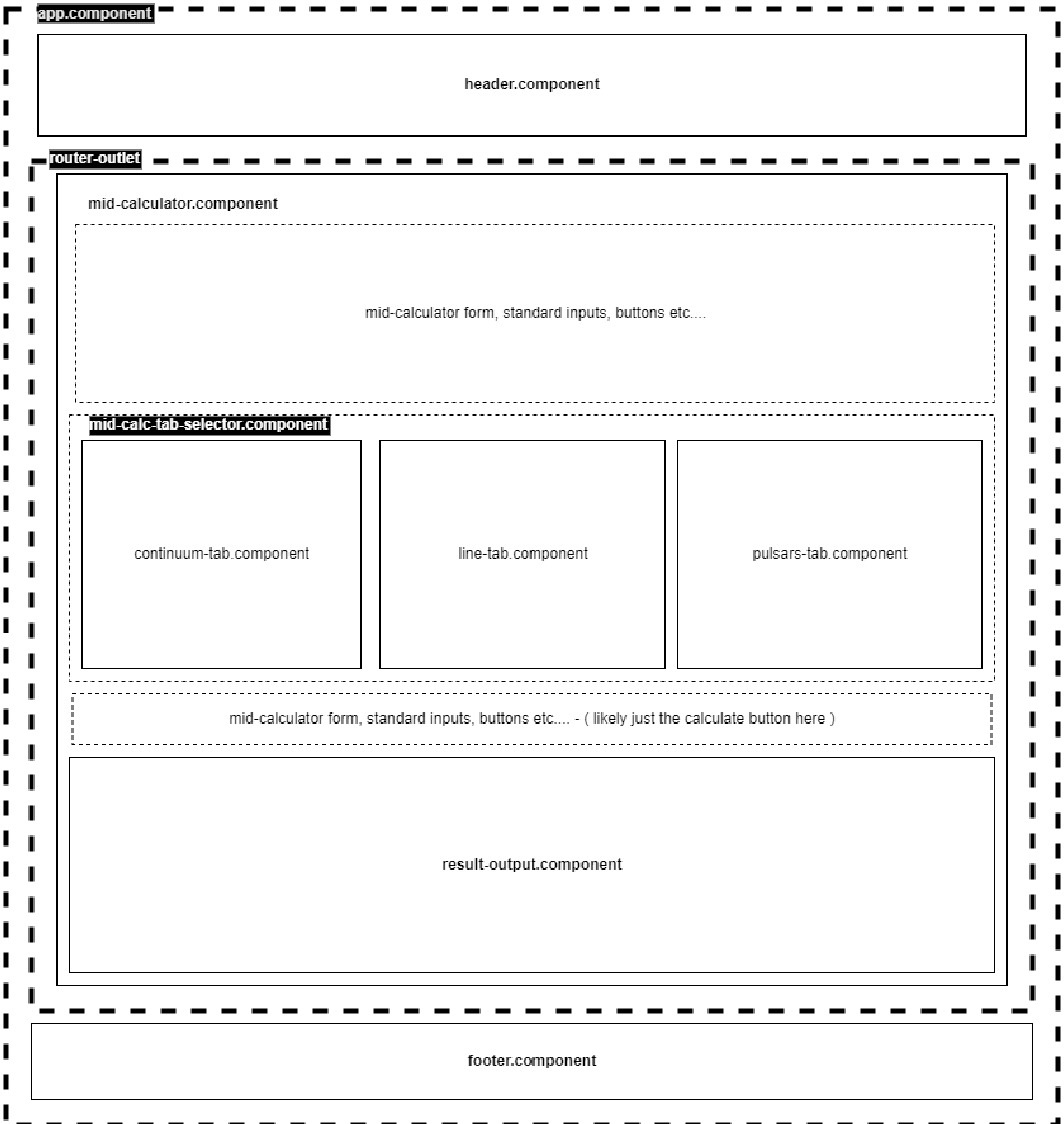

Figure 3 . High level diagram showing the different parent and child angular components that make up the UI structure in a nested format

3.4 Low Fidelity Prototype

Figure 4 . A Low Fidelity prototype that is built in InVision Studio. This is a screenshot from that prototype showing the design of how the UI could look pre-development.

CHAPTER

FOUR

DEVELOPMENT PLAN

4.1 PI13 Iteration 1

The suggested development plan for iteration 1 of the Angular Sensitivity Calculator is described in the plan diagram in Figure 1.

The main key point for development is to have two Angular developers working in parallel on the application to complete non blocking tasks.

The first 3 steps are core tasks that must be performed in order to get the large majority of the sensitivity calculator hanging together.

By specifying the tasks for each developer in step 1 to 3, it will prevent each developer waiting too long on something from the previous step being completed.

The first 6 tasks have been split out as fairly as possible in terms of size and complexity, so each developer will be busy and not overloaded.

For example, the Mid-Calculator Component and Mid-Calc-Tab-Selector Component depends on some sort of core SCSS styles/UX to be available for consistent look and feel for the componments so these must wait on step 2, but the Header Compomnent can probably be its own entity for the majority and tidy up with some parent level CSS at the end so it can be developed in parallel to the SCSS.

The final steps are not attached to either developer but are still in some sort of priority by steps to drive focus. When a developer reaches step 4 and beyond, they can pick up any task in that step (as long as its not been picked up already by the other dev). This also would allow a third developer to come onboard and pick up these later tasks if we need support for deadlines.

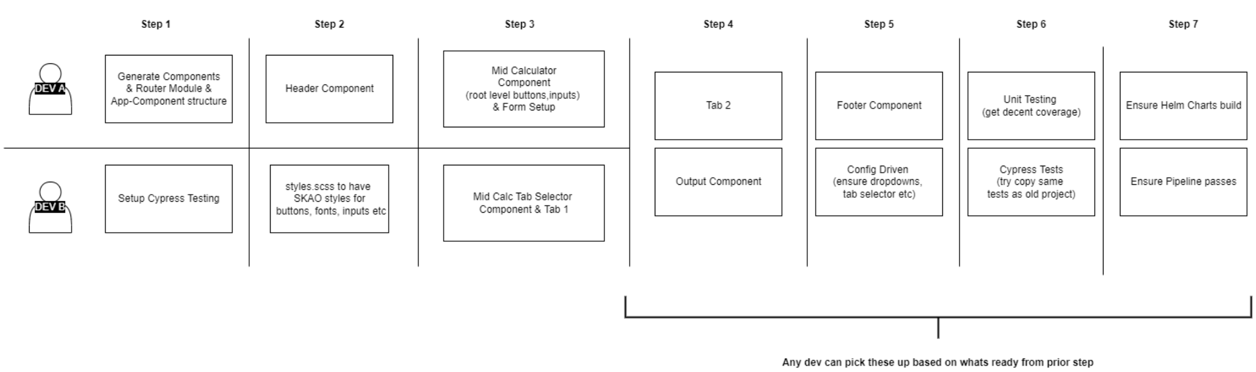

Figure 1 . Diagram shows the flow of work for two developers working in parallel.

Risks :

Availability in Sprint 4/5 is a risk, as these are already bloated sprints, so we have noted as a team we could descope Cypress testing to PI14 if required.

CHAPTER

FIVE

PROJECT DESCRIPTION

The SKA Sensitivity Calculator UI project is an Angular application which provides a graphical user interface for calculating sensitivity and integration time for SKA Mid telescope. The sensitivity and integration time calculation is done by ska-ost-senscalc project (see the backend project documentation for more details) which the UI connects to via a REST API.