

## Simulation Interactions Diagram Report

## Simulation Details

Jobname: desmond\_md\_job\_ff\_PIK3CA\_5dxt\_5080804\_Iso  
Entry title: PIK3CA\_5080804\_complex\_ff - prepared

CPU #	Job Type	Ensemble	Temp. [K]	Sim. Time [ns]	# Atoms	# Waters	Charge
1	mdsim	NPT	310.0	250.252	97629	27682	0

## Protein Information

	Tot. Residues	Prot. Chain(s)	Res. in Chain(s)	# Atoms	# Heavy Atoms	Charge
	879	'A'	ict_values([879])	14369	7187	-7
- A	107	110 115 120 125 130 135 140 145 150 155 160 165 170	NREEKILNREIGFAIGMPVCEFDMDVKDPEVQDFRRNILLNVCKEAVDLRDLNSPHSRAMYVYPPNVESSE	176		
- SSA						
- A	177	180 185 190 195 205 210 215 220 225 230 250 255 260	LPKHIYNKLDKGOIIVVIWVIVDKQYTLKINHDCVPEQVIAEAIRKKTRSMGKYILKVCGCDEYFLEKY	265		
- SSA						
- A	266	270 275 280 285 290 295 300 305 310 325 330 335 340	PLSQYKYIRSCIMLGRMPNLMMAKESLYSQLPMDCTMPSYSRRTSTKSLWVINSALRIKILCATYVNV	346		
- SSA						
- A	347	355 360 365 370 375 380 385 390 395 400 405 420 425	NIYVRTGIYHGGEPLCDNVNTQRVPCSNPRNEWLNVDIYIPDLPRARLCLSLCSVEEHCPPLAWGNINL	429		
- SSA						
- A	430	430 435 440 445 455 460 465 470 475 480 485 490 495 500	FDYDTLTVSGKMAINLWVPDILLNPIGVGTGSNPNKETPCLELEFDWFSVVKFPDMSVIEEHANWSVSRE	503		
- SSA						
- A	504	505 510 515 520 525 530 535 540 545 550 555 560 565 570	AGFSYSHAGLSNRLARDNELRENDKEQLKAISTRDPLSEITEQEKFWSHRHYCVTIPEILPKLLLSVK	573		
- SSA						
- A	574	575 580 585 590 595 600 605 610 615 620 625 630 635 640	WNSRDEVAQMYCLVKDWPPKPEQAMELLDCNYPDPMPVRGFAVRCLEKYLTDDKLSQYLIQLVQVLKYEQ	643		
- SSA						
- A	644	645 650 655 660 665 670 675 680 685 690 695 700 705 710	YLDNLLVRFLKALTNQRIGHFFVHLLKSEMHNKTYSQRFGLLESYCRACGMYLKHLNRQVEAMEKLI	713		
- SSA						
- A	714	715 720 725 730 735 740 745 750 755 760 765 770 775 780	NLTDILKQEKDETKQVQMKFLVEQMRPDMALQGFSLPLNPAHQGLNLRLEECRIMSSAKRPLWLNW	783		
- SSA						
- A	784	785 790 795 800 805 810 815 820 825 830 835 840 845 850	ENPDIMSELLFQNNIEIFKNGDDLQDMLTLQIRIMENIWQNGQLDLRMLPYGCLSIGDCVGLIEVVRN	853		
- SSA						
- A	854	855 860 875 880 885 890 895 900 905 910 915 920 925 930	SHTIMOIQCNSTLHQWLKDKNKGIEYDAADLFTRSCAGYCVATFILGIGDRHNSNIMVKDDGOLFHD	933		
- SSA						
- A	934	935 940 955 960 965 970 975 980 985 990 995 1000 1005	FGHFLDHRERVPFVLTQDFLIVISKGAECTKTREFERFOEMCYKAYLAIRQHANLFINLFSMMLGSGMPE	1012		
- SSA						
- A	1013	1015 1020 1025 1030 1035 1040 1045	LOSFPDDIAYIRKTLALDKTEQEALEYFMKQMNDAHHGGW	1051		
- SSA						

## Ligand Information

SMILES

OC[C@@H]1[C@@H](O)[C@H](O)[C@@H](O)[C@@H](O1)Oc(=O)c(-c3cc(O)  
c(O)cc3)oc(c24)cc(O)cc4O

PDB Name 'UNK'

Num. of Atoms 53 (total) 33 (heavy)

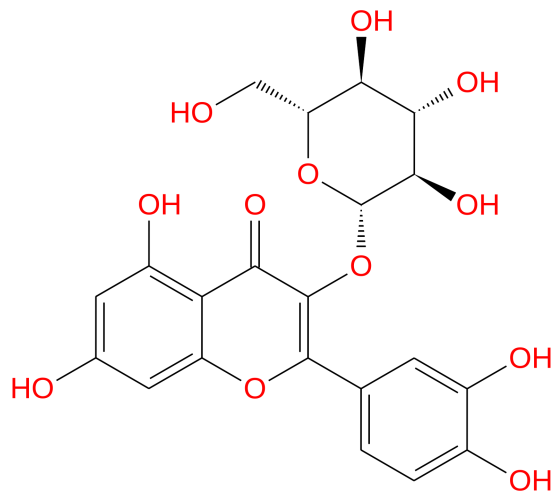
Atomic Mass 464.386 au

Charge 0

Mol. Formula C<sub>21</sub>H<sub>20</sub>O<sub>12</sub>

Num. of Fragments 4

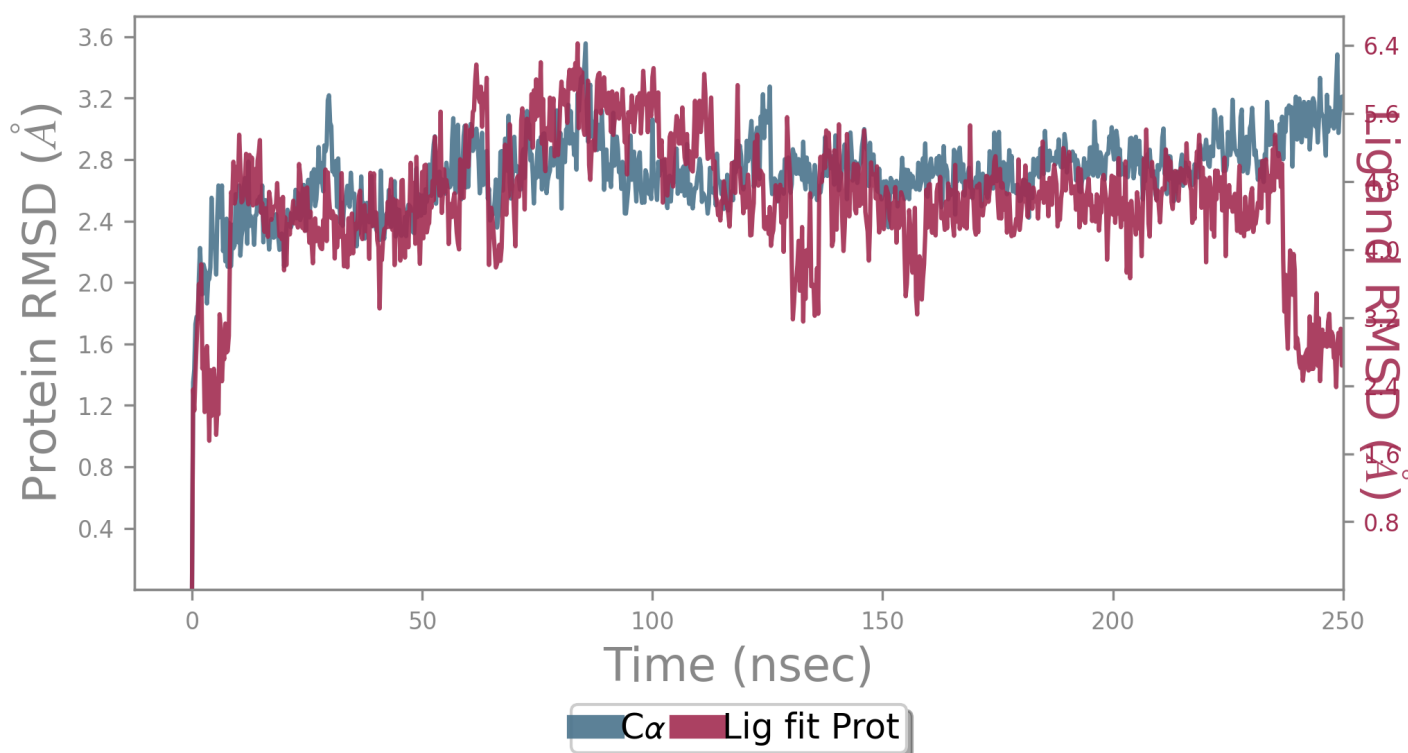
Num. of Rot. Bonds 12



#### Counter Ion/Salt Information

Type	Num.	Concentration [mM]	Total Charge
Na	84	55.172	+84
Cl	77	50.574	-77

## Protein-Ligand RMSD



The Root Mean Square Deviation (RMSD) is used to measure the average change in displacement of a selection of atoms for a particular frame with respect to a reference frame. It is calculated for all frames in the trajectory. The RMSD for frame  $x$  is:

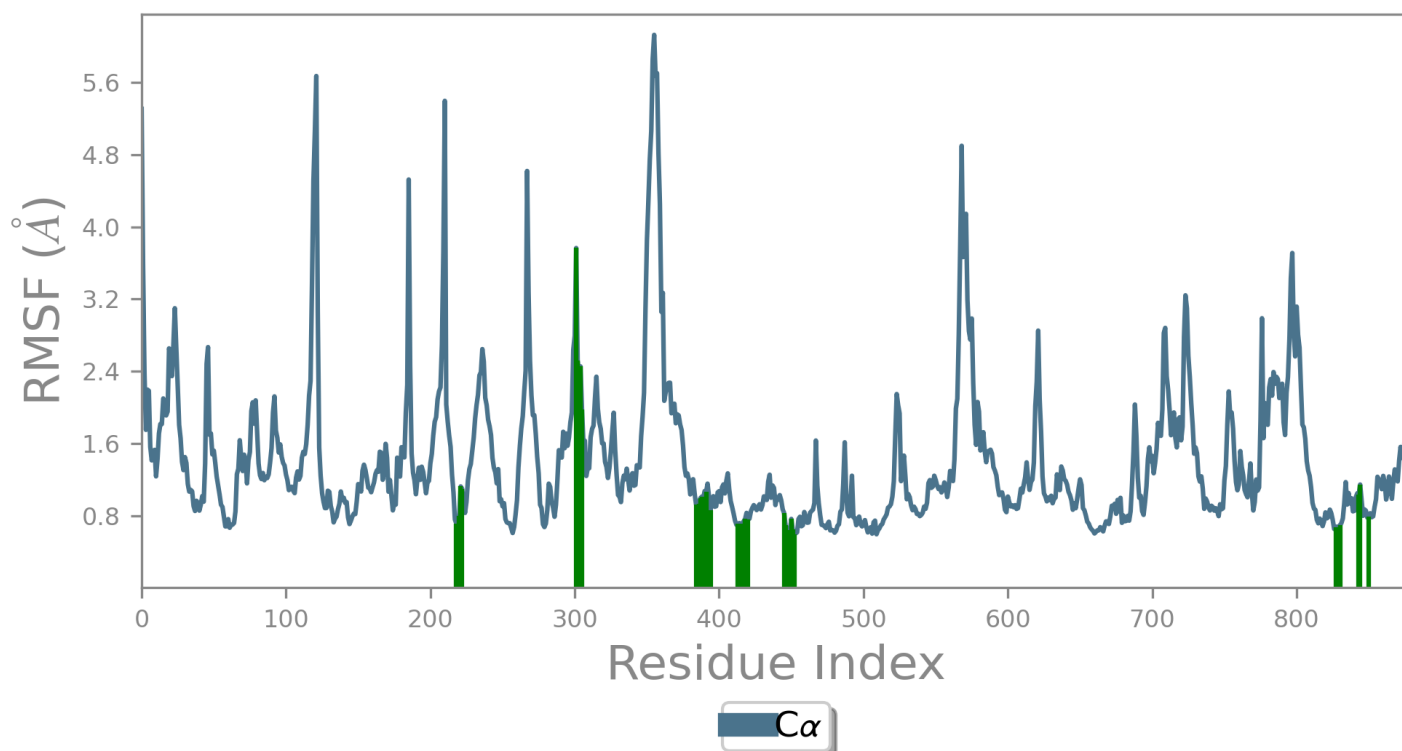
$$RMSD_x = \sqrt{\frac{1}{N} \sum_{i=1}^N (r'_i(t_x) - r_i(t_{ref}))^2}$$

where  $N$  is the number of atoms in the atom selection;  $t_{ref}$  is the reference time, (typically the first frame is used as the reference and it is regarded as time  $t=0$ ); and  $r'$  is the position of the selected atoms in frame  $x$  after superimposing on the reference frame, where frame  $x$  is recorded at time  $t_x$ . The procedure is repeated for every frame in the simulation trajectory.

**Protein RMSD:** The above plot shows the RMSD evolution of a protein (left Y-axis). All protein frames are first aligned on the reference frame backbone, and then the RMSD is calculated based on the atom selection. Monitoring the RMSD of the protein can give insights into its structural conformation throughout the simulation. RMSD analysis can indicate if the simulation has equilibrated — its fluctuations towards the end of the simulation are around some thermal average structure. Changes of the order of 1-3 Å are perfectly acceptable for small, globular proteins. Changes much larger than that, however, indicate that the protein is undergoing a large conformational change during the simulation. It is also important that your simulation converges — the RMSD values stabilize around a fixed value. If the RMSD of the protein is still increasing or decreasing on average at the end of the simulation, then your system has not equilibrated, and your simulation may not be long enough for rigorous analysis.

**Ligand RMSD:** Ligand RMSD (right Y-axis) indicates how stable the ligand is with respect to the protein and its binding pocket. In the above plot, 'Lig fit Prot' shows the RMSD of a ligand when the protein-ligand complex is first aligned on the protein backbone of the reference and then the RMSD of the ligand heavy atoms is measured. If the values observed are significantly larger than the RMSD of the protein, then it is likely that the ligand has diffused away from its initial binding site.

## Protein RMSF



The Root Mean Square Fluctuation (RMSF) is useful for characterizing local changes along the protein chain. The RMSF for residue  $i$  is:

$$RMSF_i = \sqrt{\frac{1}{T} \sum_{t=1}^T \langle (r'_i(t)) - r_i(t_{ref})^2 \rangle}$$

where  $T$  is the trajectory time over which the RMSF is calculated,  $t_{ref}$  is the reference time,  $r_i$  is the position of residue  $i$ ;  $r'$  is the position of atoms in residue  $i$  after superposition on the reference, and the angle brackets indicate that the average of the square distance is taken over the selection of atoms in the residue.

On this plot, peaks indicate areas of the protein that fluctuate the most during the simulation. Typically you will observe that the tails ( $N$ - and  $C$ -terminal) fluctuate more than any other part of the protein. Secondary structure elements like alpha helices and beta strands are usually more rigid than the unstructured part of the protein, and thus fluctuate less than the loop regions.

**Ligand Contacts:** Protein residues that interact with the ligand are marked with green-colored vertical bars.

## Protein Secondary Structure

% Helix

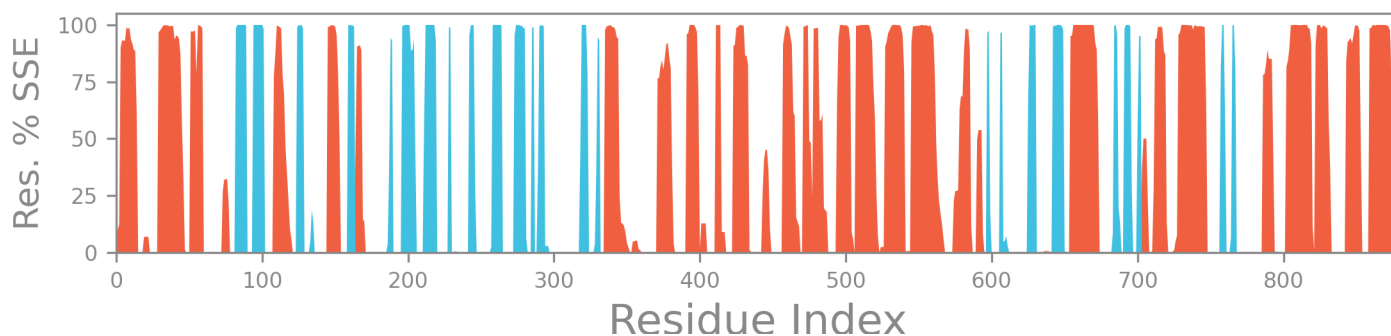
33.79

% Strand

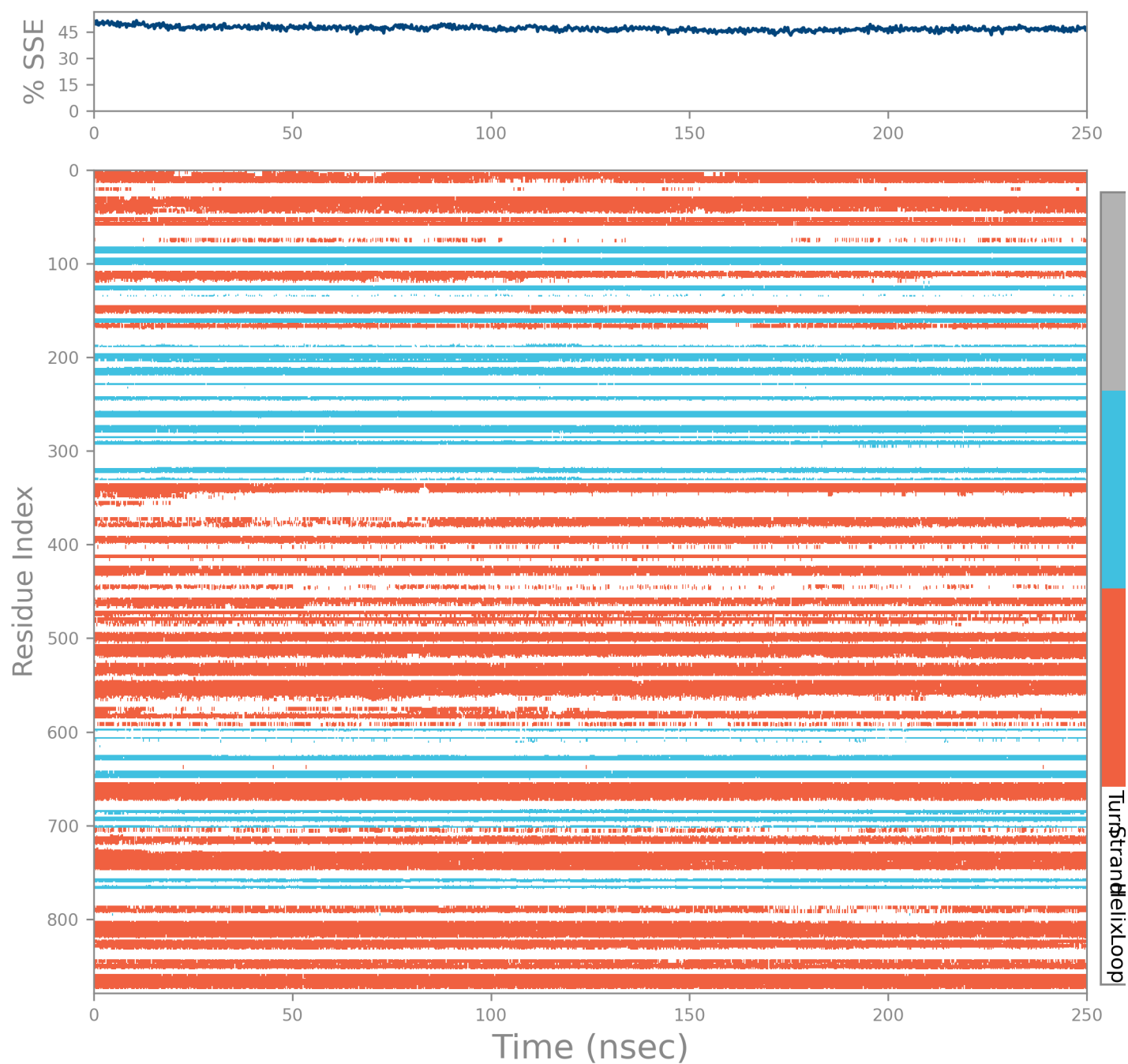
13.26

% Total SSE

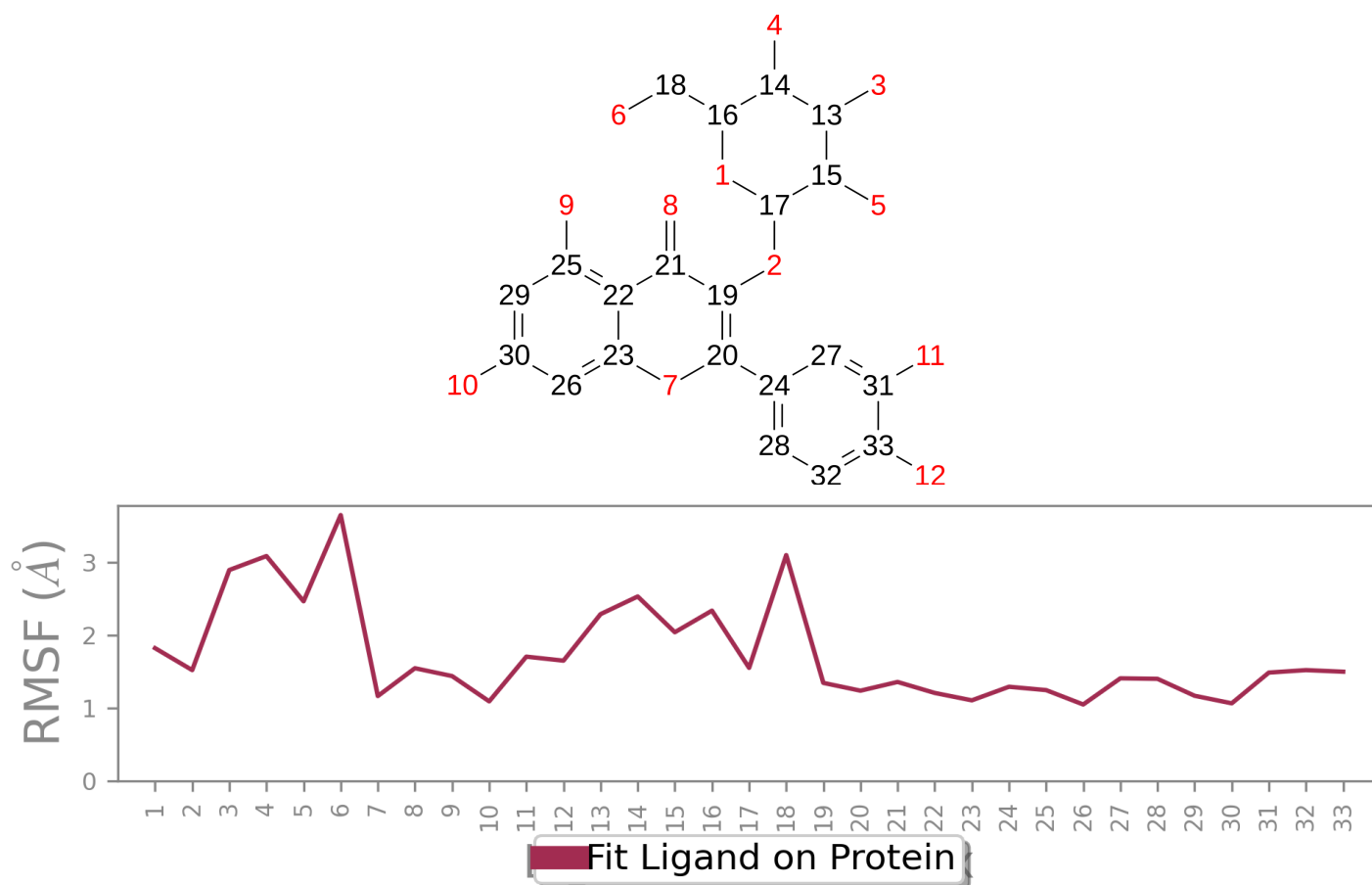
47.04



Protein secondary structure elements (SSE) like **alpha-helices** and **beta-strands** are monitored throughout the simulation. The plot above reports SSE distribution by residue index throughout the protein structure. The plot below summarizes the SSE composition for each trajectory frame over the course of the simulation, and the plot at the bottom monitors each residue and its SSE assignment over time.



## Ligand RMSF



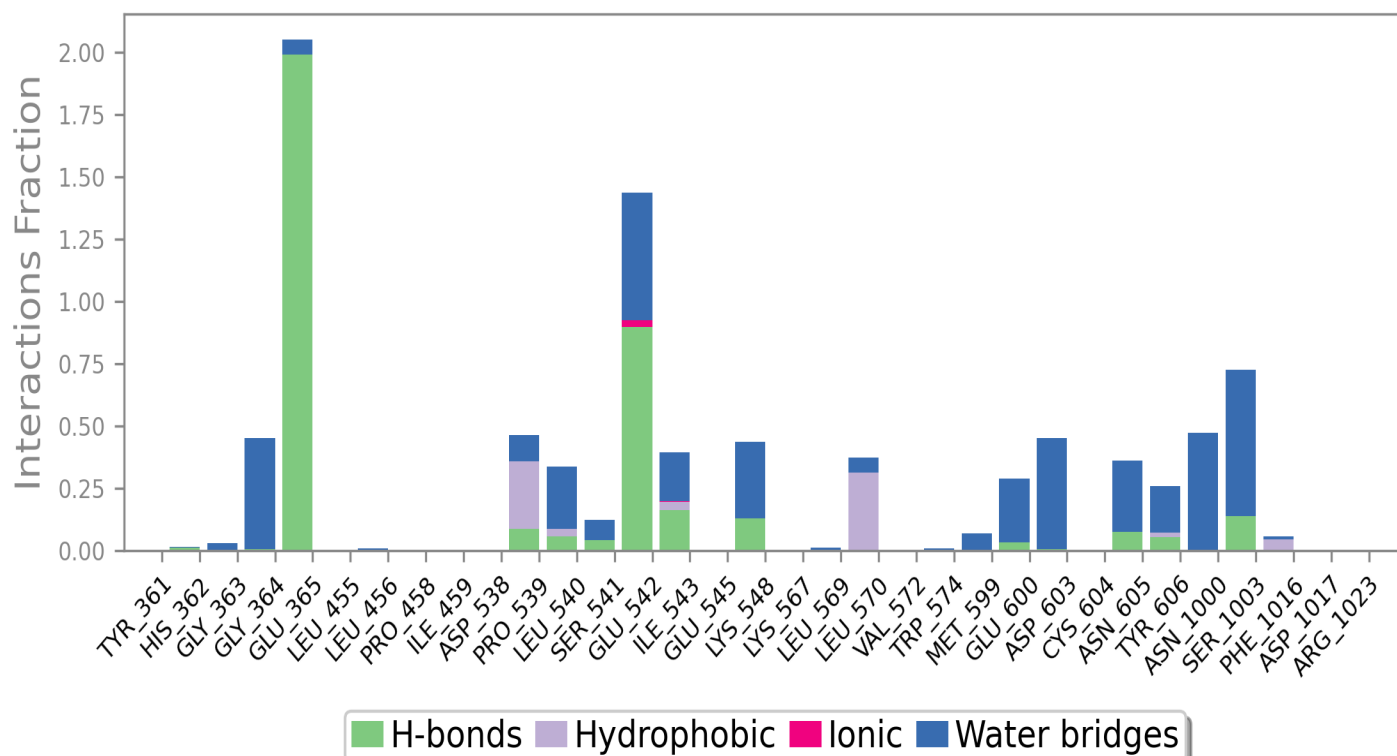
The Ligand Root Mean Square Fluctuation (L-RMSF) is useful for characterizing changes in the ligand atom positions. The RMSF for atom  $i$  is:

$$RMSF_i = \sqrt{\frac{1}{T} \sum_{t=1}^T (r'_i(t) - r_i(t_{ref}))^2}$$

where  $T$  is the trajectory time over which the RMSF is calculated,  $t_{ref}$  is the reference time (usually for the first frame, and is regarded as the zero of time);  $r$  is the position of atom  $i$  in the reference at time  $t_{ref}$  and  $r'$  is the position of atom  $i$  at time  $t$  after superposition on the reference frame.

Ligand RMSF shows the ligand's fluctuations broken down by atom, corresponding to the 2D structure in the top panel. The ligand RMSF may give you insights on how ligand fragments interact with the protein and their entropic role in the binding event. In the bottom panel, the 'Fit Ligand on Protein' line shows the ligand fluctuations, with respect to the protein. The protein-ligand complex is first aligned on the protein backbone and then the ligand RMSF is measured on the ligand heavy atoms.

## Protein-Ligand Contacts



Protein interactions with the ligand can be monitored throughout the simulation. These interactions can be categorized by type and summarized, as shown in the plot above. Protein-ligand interactions (or 'contacts') are categorized into four types: Hydrogen Bonds, Hydrophobic, Ionic and Water Bridges. Each interaction type contains more specific subtypes, which can be explored through the 'Simulation Interactions Diagram' panel. The stacked bar charts are normalized over the course of the trajectory: for example, a value of 0.7 suggests that 70% of the simulation time the specific interaction is maintained. Values over 1.0 are possible as some protein residue may make multiple contacts of same subtype with the ligand.

**Hydrogen Bonds:** (H-bonds) play a significant role in ligand binding. Consideration of hydrogen-bonding properties in drug design is important because of their strong influence on drug specificity, metabolism and adsorption. Hydrogen bonds between a protein and a ligand can be further broken down into four subtypes: backbone acceptor; backbone donor; side-chain acceptor; side-chain donor.

The current geometric criteria for protein-ligand H-bond is: distance of 2.5 Å between the donor and acceptor atoms (D—H...A); a donor angle of  $\geq 120^\circ$  between the donor-hydrogen-acceptor atoms (D—H...A); and an acceptor angle of  $\geq 90^\circ$  between the hydrogen-acceptor-bonded\_atom atoms (H...A—X).

**Hydrophobic contacts:** fall into three subtypes:  $\pi$ -Cation;  $\pi$ - $\pi$ ; and Other, non-specific interactions. Generally these type of interactions involve a hydrophobic amino acid and an aromatic or aliphatic group on the ligand, but we have extended this category to also include  $\pi$ -Cation interactions.

The current geometric criteria for hydrophobic interactions is as follows:  $\pi$ -Cation — Aromatic and charged groups within 4.5 Å;  $\pi$ - $\pi$  — Two aromatic groups stacked face-to-face or face-to-edge; Other — A non-specific hydrophobic sidechain within 3.6 Å of a ligand's aromatic or aliphatic carbons.

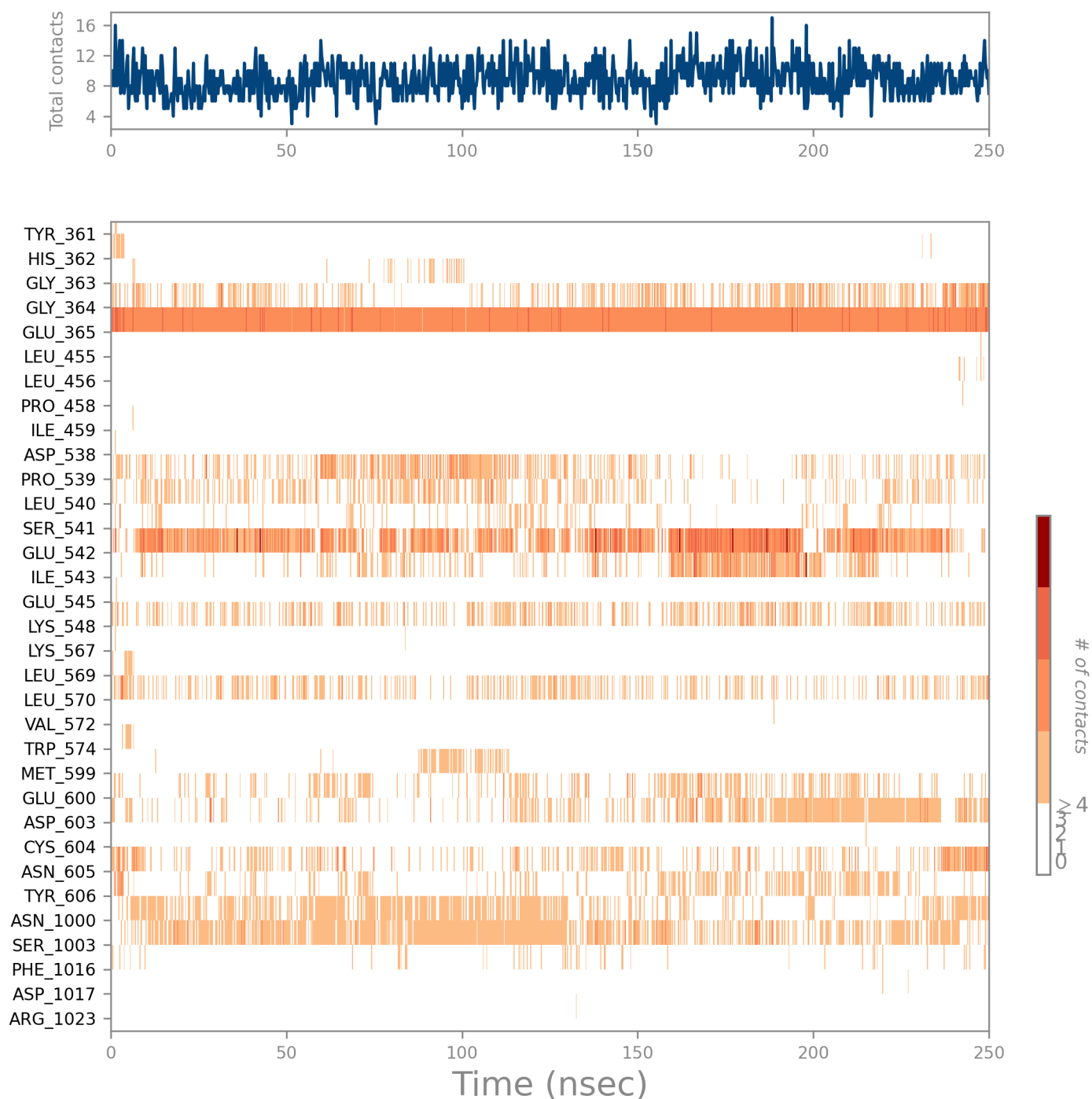
**Ionic interactions:** or polar interactions, are between two oppositely charged atoms that are within 3.7 Å of each other and do not involve a hydrogen bond. We also monitor Protein-Metal-Ligand interactions, which are defined by a metal ion coordinated within 3.4 Å of protein's and ligand's heavy atoms (except carbon). All ionic interactions are broken down into two subtypes: those mediated by a protein backbone or side chains.

**Water Bridges:** are hydrogen-bonded protein-ligand interactions mediated by a water molecule. The hydrogen-bond geometry is slightly relaxed from the standard H-bond definition.

The current geometric criteria for a protein-water or water-ligand H-bond are: a distance of 2.8 Å between the donor and acceptor atoms (D—H...A); a donor angle of  $\geq 110^\circ$  between the donor-hydrogen-acceptor atoms (D—H...A); and an acceptor angle of  $\geq 90^\circ$  between the hydrogen-acceptor-bonded\_atom atoms (H...A—X).

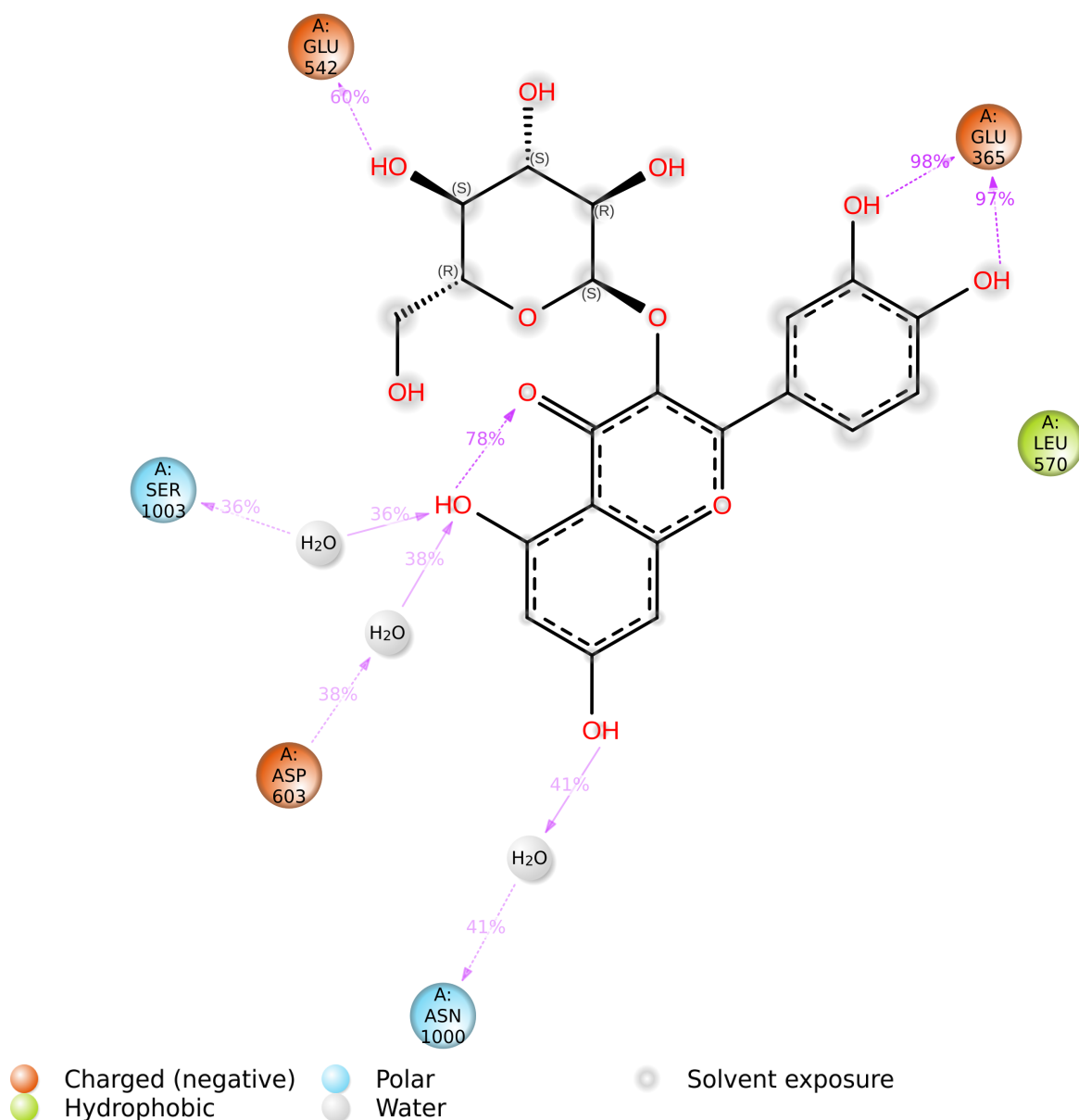


## Protein-Ligand Contacts (cont.)



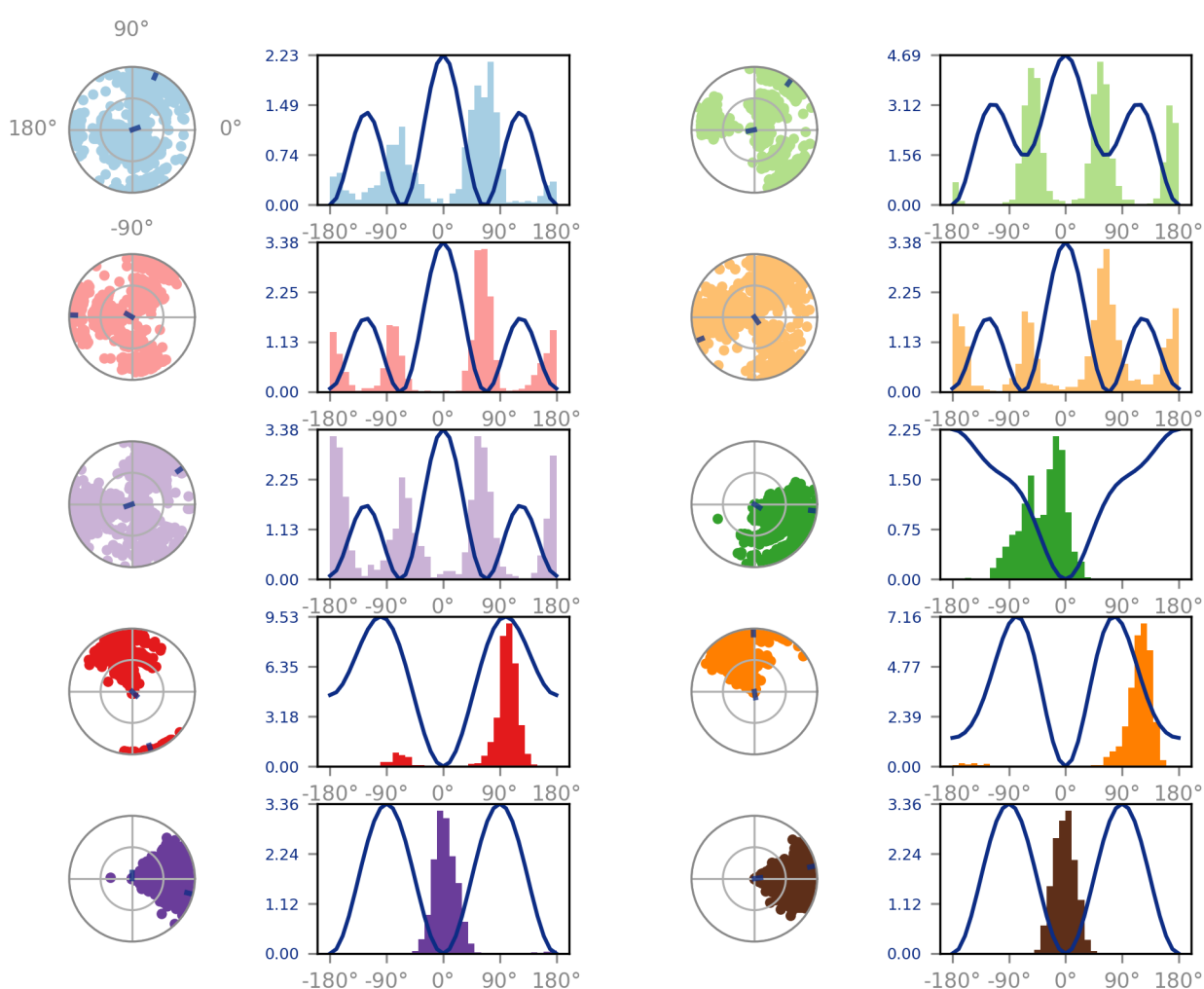
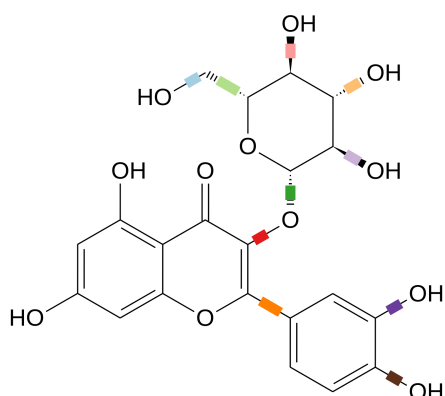
A timeline representation of the interactions and contacts (**H-bonds, Hydrophobic, Ionic, Water bridges**) summarized in the previous page. The top panel shows the total number of specific contacts the protein makes with the ligand over the course of the trajectory. The bottom panel shows which residues interact with the ligand in each trajectory frame. Some residues make more than one specific contact with the ligand, which is represented by a darker shade of orange, according to the scale to the right of the plot.

# Ligand-Protein Contacts

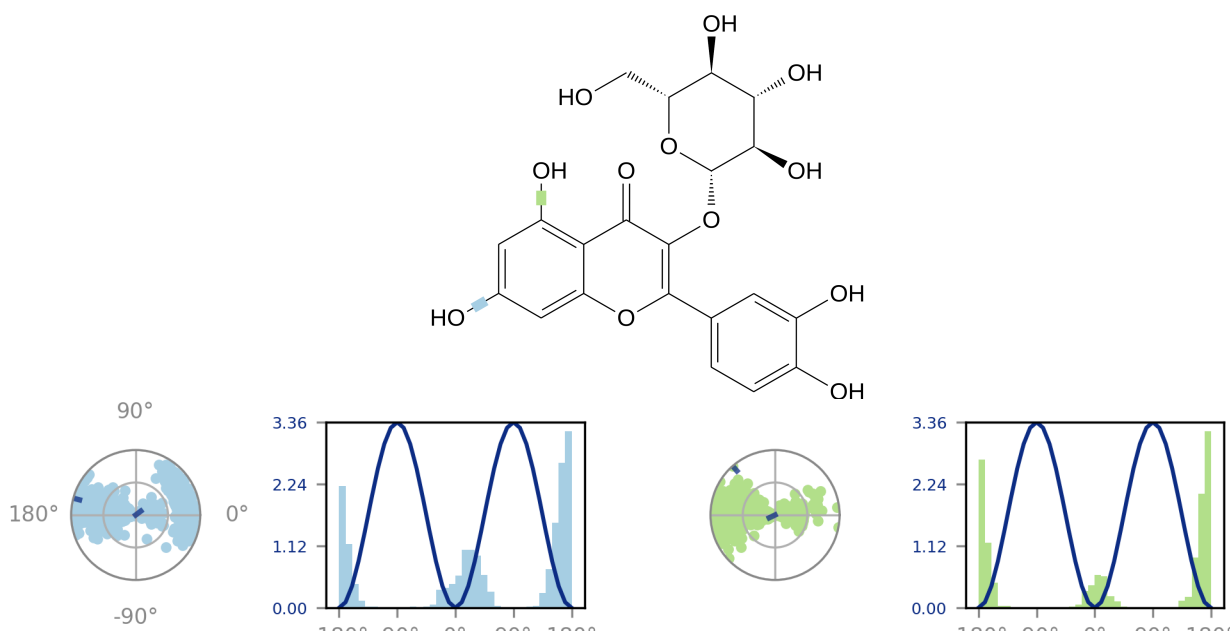


A schematic of detailed ligand atom interactions with the protein residues. Interactions that occur more than **30.0%** of the simulation time in the selected trajectory ( 0.00 through 250.00 nsec), are shown.  
 Note: it is possible to have interactions with >100% as some residues may have multiple interactions of a single type with the same ligand atom. For example, the ARG side chain has four H-bond donors that can all hydrogen-bond to a single H-bond acceptor.

# Ligand Torsion Profile



## Ligand Torsion Profile (cont.)

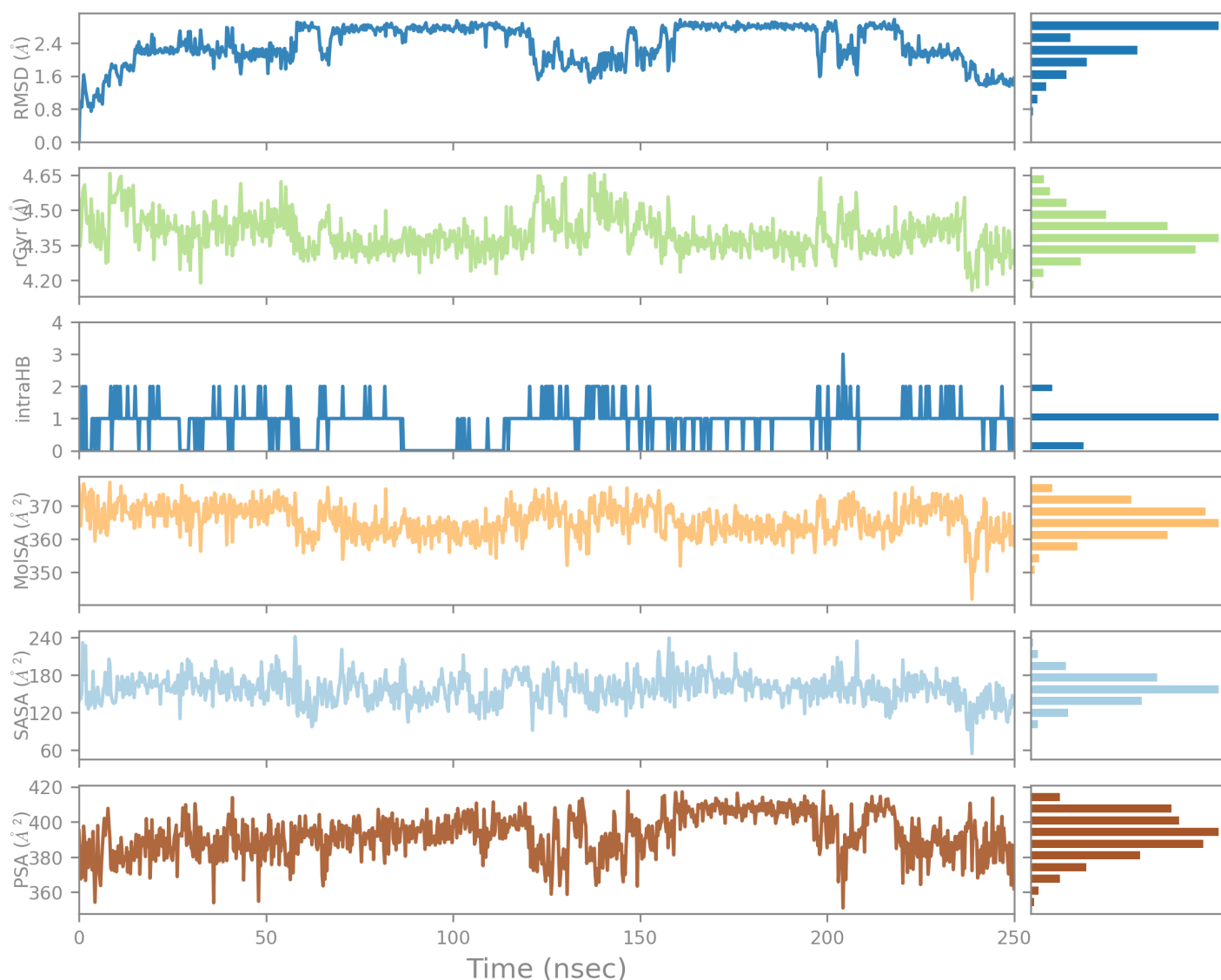


The ligand torsions plot summarizes the conformational evolution of every rotatable bond (RB) in the ligand throughout the simulation trajectory (0.00 through 250.00 nsec). The top panel shows the 2d schematic of a ligand with color-coded rotatable bonds. Each rotatable bond torsion is accompanied by a dial plot and bar plots of the same color.

Dial (or radial) plots describe the conformation of the torsion throughout the course of the simulation. The beginning of the simulation is in the center of the radial plot and the time evolution is plotted radially outwards.

The bar plots summarize the data on the dial plots, by showing the probability density of the torsion. If torsional potential information is available, the plot also shows the potential of the rotatable bond (by summing the potential of the related torsions). The values of the potential are on the left Y-axis of the chart, and are expressed in *kcal/mol*. Looking at the histogram and torsion potential relationships may give insights into the conformational strain the ligand undergoes to maintain a protein-bound conformation.

## Ligand Properties



**Ligand RMSD:** Root mean square deviation of a ligand with respect to the reference conformation (typically the first frame is used as the reference and it is regarded as time  $t=0$ ).

**Radius of Gyration (rGyr):** Measures the 'extendedness' of a ligand, and is equivalent to its principal moment of inertia.

**Intramolecular Hydrogen Bonds (intraHB):** Number of internal hydrogen bonds (HB) within a ligand molecule.

**Molecular Surface Area (MolSA):** Molecular surface calculation with 1.4 Å probe radius. This value is equivalent to a van der Waals surface area.

**Solvent Accessible Surface Area (SASA):** Surface area of a molecule accessible by a water molecule.

**Polar Surface Area (PSA):** Solvent accessible surface area in a molecule contributed only by oxygen and nitrogen atoms.