

# Ecole Centrale de Lyon – Car n°281

## B - Structural Design inc Suspension & Brakes

### Frame

### Objectives

- Enhance the **position of the driver**,
- Minimize the ratio between **weight** and **torsion stiffness**

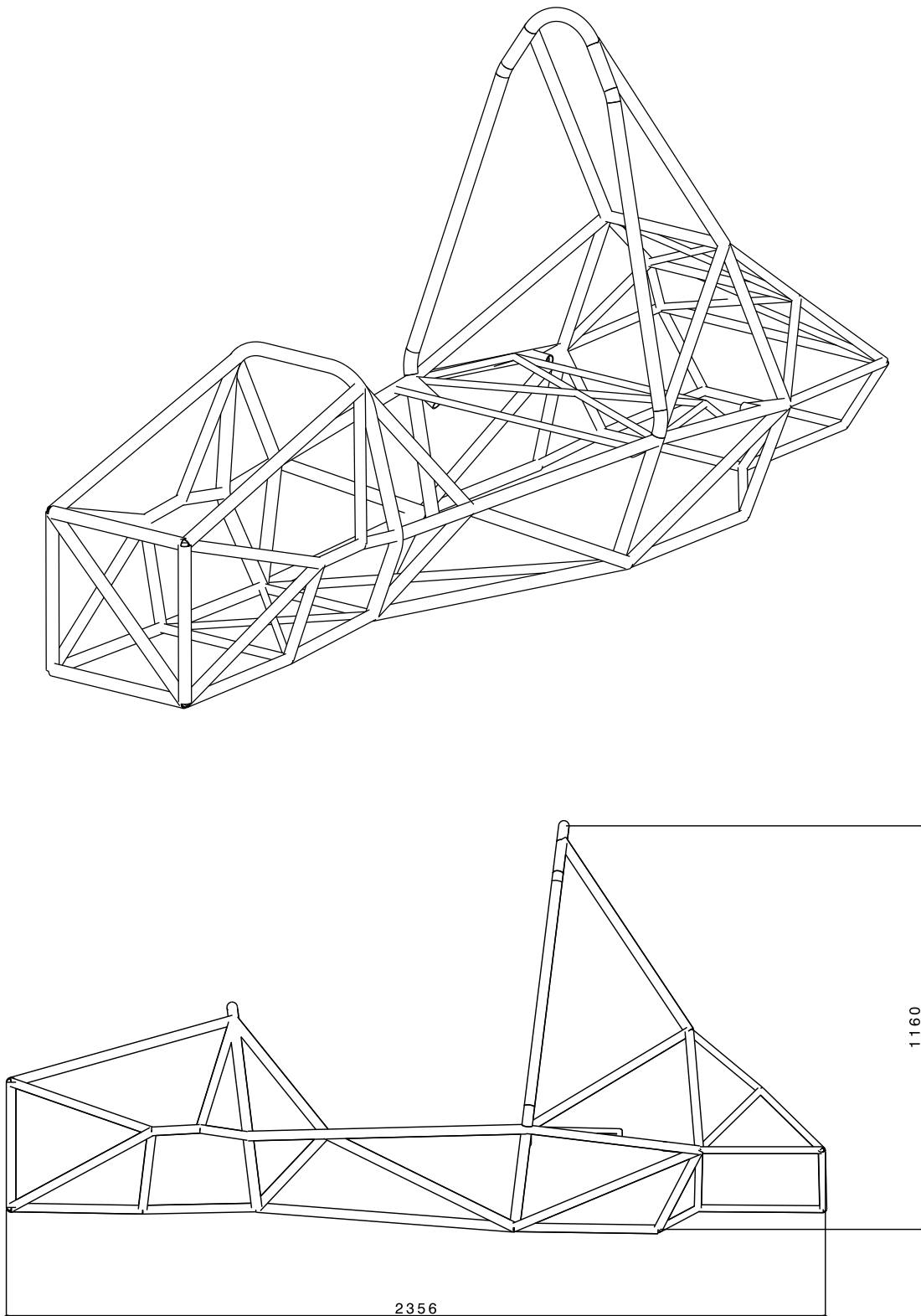
### Conception guidelines

	Target	Simulation
Stiffness (Nm/deg)	1600 - 2000	1865
Weight (kg)	35-40	35

### Load table

	Nom Meca Master	Nom	Type	Part 1	Part 2	Rx	Ry	Rz	F
Front Suspension	BJ_Front upper front inner BJ	Upper A-arm Front Ball Joint	BJ	frame	front upper f	522,735	1262,927	-68,583	1368,554
	BJ_Front upper rear inner BJ	Upper A-arm Rear Ball Joint	BJ	frame	front upper r	64,667	156,236	8,484	169,30294
	BJ_Front upper front outer BJ	N/A	BJ	front upright	front upper f	-522,735	1262,927	68,583	1368,554
	BJ_Front upper rear outer BJ	N/A	BJ	front upright	front upper r	-64,667	-156,236	-8,484	169,30294
	BJ_Front lower front inner BJ	Lower A-arm Rear Ball Joint	BJ	frame	front lower f	-574,995	1506,487	164,832	1620,8923
	BJ_Front lower rear inner BJ	Lower A-arm Front Ball Joint	BJ	frame	front lower r	-1082,543	2836,262	-310,329	3051,6529
	BJ_Front lower front outer BJ	N/A	BJ	front upright	front lower f	574,995	1506,487	-164,832	1620,8923
	BJ_Front lower rear outer BJ	N/A	BJ	front upright	front lower r	1082,543	2836,262	310,329	3051,6529
	BJ_front tie rod inboard	Inboard Tie-rod Ball Joint	BJ	frame	front tie rod	-58,87	518,871	50,688	524,65423
	BJ_front tie rod outboard	Outboard Tie-rod Ball Joint	BJ	front upright	front tie rod	58,87	-518,871	-50,688	524,65423
	BJ_front pullrod outboard	Outboard Push-Rod Ball joint	BJ	front upright	front pullrod	0	1119,053	974,098	1483,6261
	BJ_front pullrod inboard	Inboard Push-Rod Ball Joint	BJ	front rocker	front pullrod	0	1119,053	-974,098	1483,6261
	BJ_front absorber inboard	Inboard Shock Ball Joint	BJ	frame	front absorb	0	-259,085	-1135,99	1165,1602
	BJ_front absorber outboard	Outboard Shock Ball Joint	BJ	front rocker	front absorb	0	259,085	1135,99	1165,1602
	PI_front rocker	Rocker Pivot	PI	front rocker	frame	0	1378,139	-161,892	1387,6153
	SS-XZ_front outer bearing	Radial Force Outer Bearing	SS	front upright	front wheel	-1665,296	-16,773	-932,611	1908,7314
	SS-XZ_front inner bearing	Radial Force Inner Bearing	SS	front upright	front wheel	536,29	-50,329	-2798,42	2849,7885
	PO-Y_front wheel axis force	Axial Force Bearing	PO	front upright	front wheel	0	-777,983	13,992	778,10881
	PO-Z_front brake force	Brake Force	PO	front wheel	front upright	0	-46,543	-2588,033	2588,4515
	PO-Z_FL normal force	Normal Force on tire	PO	front wheel	ground	0	0	-1129,005	1129,005
	PO-Z_FR normal force	Normal Force on tire	PO	frame	ground	0	0	-826,157	826,157
Rear Suspension	BJ_rear upper rear inner BJ	Upper A-arm Front Ball Joint	BJ	frame	rear upper fr	-189,104	251,325	-21,228	315,23833
	BJ_rear upper rear inner BJ	Upper A-arm Rear Ball Joint	BJ	frame	rear upper re	924,468	1228,648	-103,779	1541,0993
	BJ_rear upper rear outer BJ	N/A	BJ	rear upright	rear upper fr	189,104	-251,325	21,228	315,23833
	BJ_rear upper rear outer BJ	N/A	BJ	rear upright	rear upper re	-924,468	1228,648	103,779	1541,0993
	BJ_rear lower rear inner BJ	Lower A-arm Rear Ball Joint	BJ	frame	rear lower fr	-507,226	1051,341	94,928	1171,1565
	BJ_rear lower rear inner BJ	Lower A-arm Front Ball Joint	BJ	frame	rear lower re	-1363,445	2826,051	-255,171	3148,1199
	BJ_rear lower rear outer BJ	N/A	BJ	rear upright	rear lower fr	507,226	1051,341	-94,928	1171,1565
	BJ_rear lower rear outer BJ	N/A	BJ	rear upright	rear lower re	1363,445	2826,051	255,171	3148,1199
	BJ_rear tie rod inboard	Inboard Tie-rod Ball Joint	BJ	frame	rear tie rod	-59,53	317,991	11,352	323,71433
	BJ_rear tie rod outboard	Outboard Tie-rod Ball Joint	BJ	rear upright	rear tie rod	59,53	-317,991	-11,352	323,71433
	BJ_rear pushrod outboard	Outboard Push-Rod Ball joint	BJ	rear upright	rear pushrod	0	1218,09	920,939	1527,0468
	BJ_rear pushrod inboard	Inboard Push-Rod Ball Joint	BJ	rear rocker	rear pushrod	0	1218,09	-920,939	1527,0468
	BJ_rear absorber inboard	Inboard Shock Ball Joint	BJ	frame	rear absorbe	0	1078,929	236,215	1104,4842
	BJ_rear absorber outboard	Outboard Shock Ball Joint	BJ	rear rocker	rear absorbe	0	1078,929	-236,215	1104,4842
	PI_rear rocker	Rocker Pivot	PI	rear rocker	frame	0	139,161	1157,154	1165,4918
	SS-XZ_rear outer bearing	Radial Force Outer Bearing	SS	rear upright	rear wheel	-1762,404	3,016	155,688	1769,2698
	SS-XZ_rear inner bearing	Radial Force Inner Bearing	SS	rear upright	rear wheel	567,567	-91,343	-4715,287	4750,2008
	PO-Y_rear wheel axis force	Axial Force Bearing	PO	rear upright	rear wheel	0	1171,245	22,689	1171,4647
	PO-Z_rear brake force	Brake Force	PO	rear upright	rear wheel	0	64,735	3342,073	3342,6999
	PO-Z_RL normal force	Normal Force on tire	PO	rear wheel	ground	0	0	-1194,837	1194,837
	PO-Z_RR normal force	Normal Force on tire	PO						

Fig 1. Load table for Right Turn 1G + braking 1G, given by the software MECAMaster.



*Fig 2. Frame of Valkyriz*

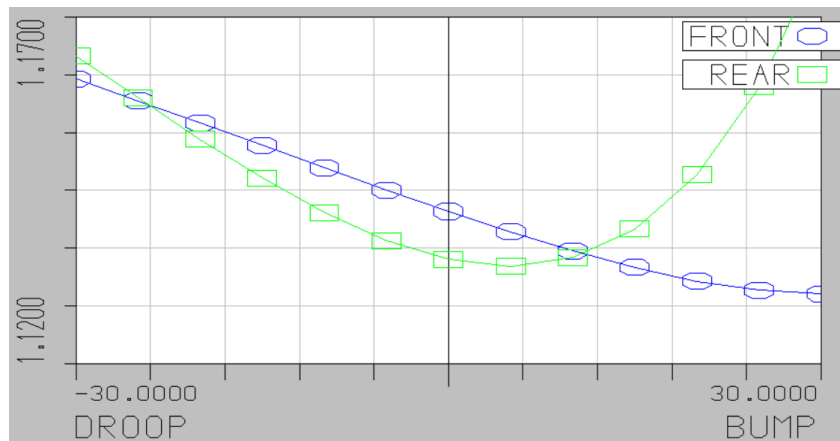
## Suspension design

### Objectives

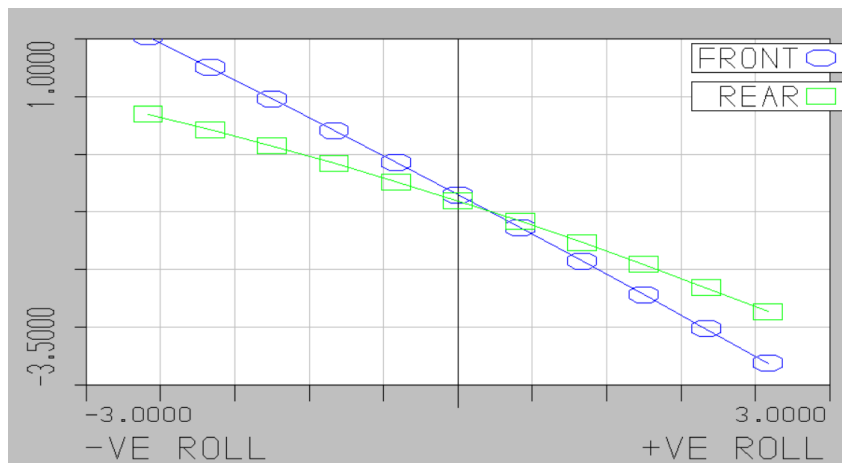
- Optimise the contact patch between the tire and the road surface in order to maximise the **grip**.
- Provide the best **driver control** of the vehicle.

### Conception guidelines

- Linear behaviour to **simplify calculations**
- Slow **camber** changes
- Minimized and coordinated **roll centers movements**
- Prevent from **compliances** and non-linear effects
- Move down the **gravity center** of the car

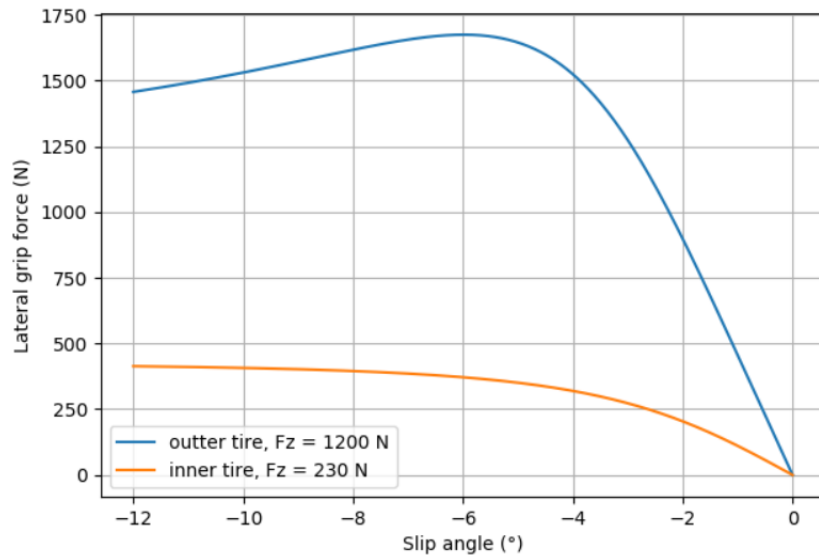


**Fig 3.** Motion Ratios of the Car during BUMP.



**Fig 4.** Camber variations during Roll.

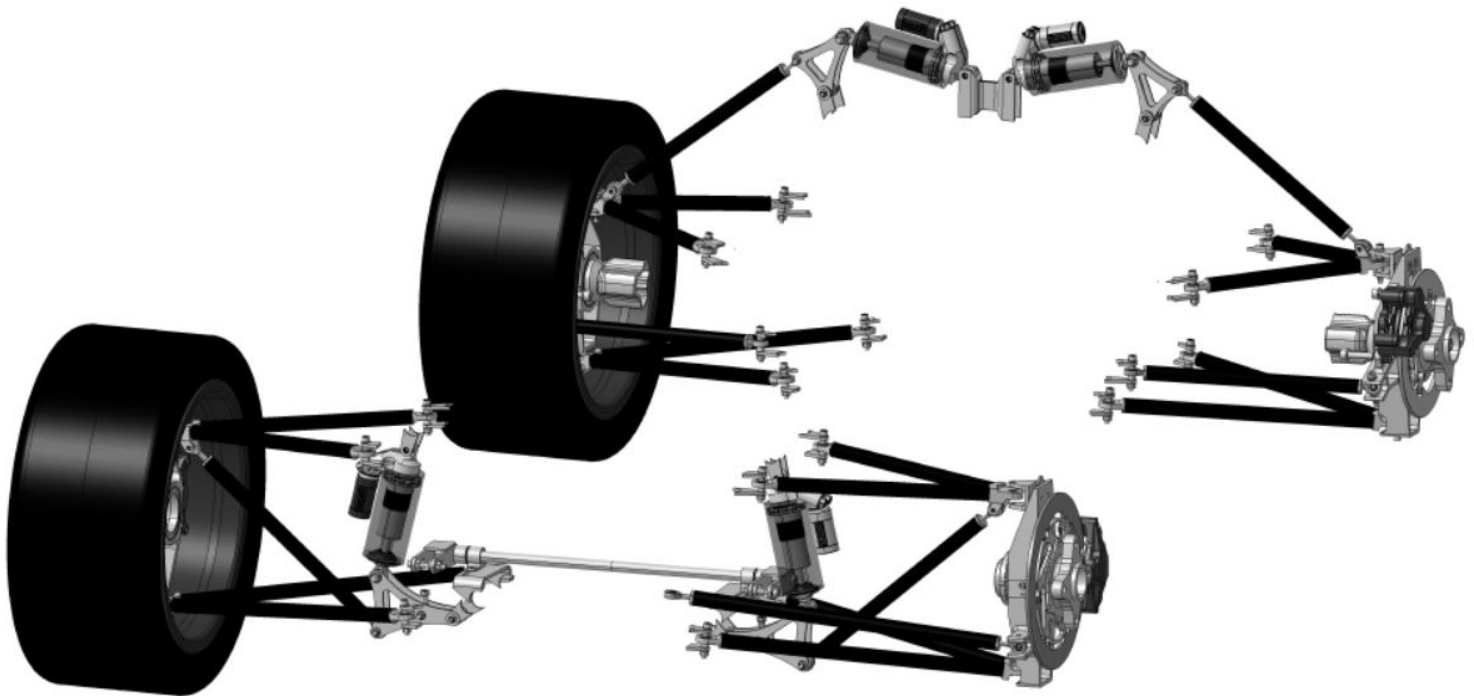
## Steering system



**Fig 5.** Lateral grip force we can get just before apparition of understeer

If we want to choose the **same slip angle** for the inner tyre, we see that the **loss of lateral grip is not significant** (approx. 50N). That's why we have chosen **parallel geometry** in order to have simple packaging and in the meantime, to keep having an efficient steering system.

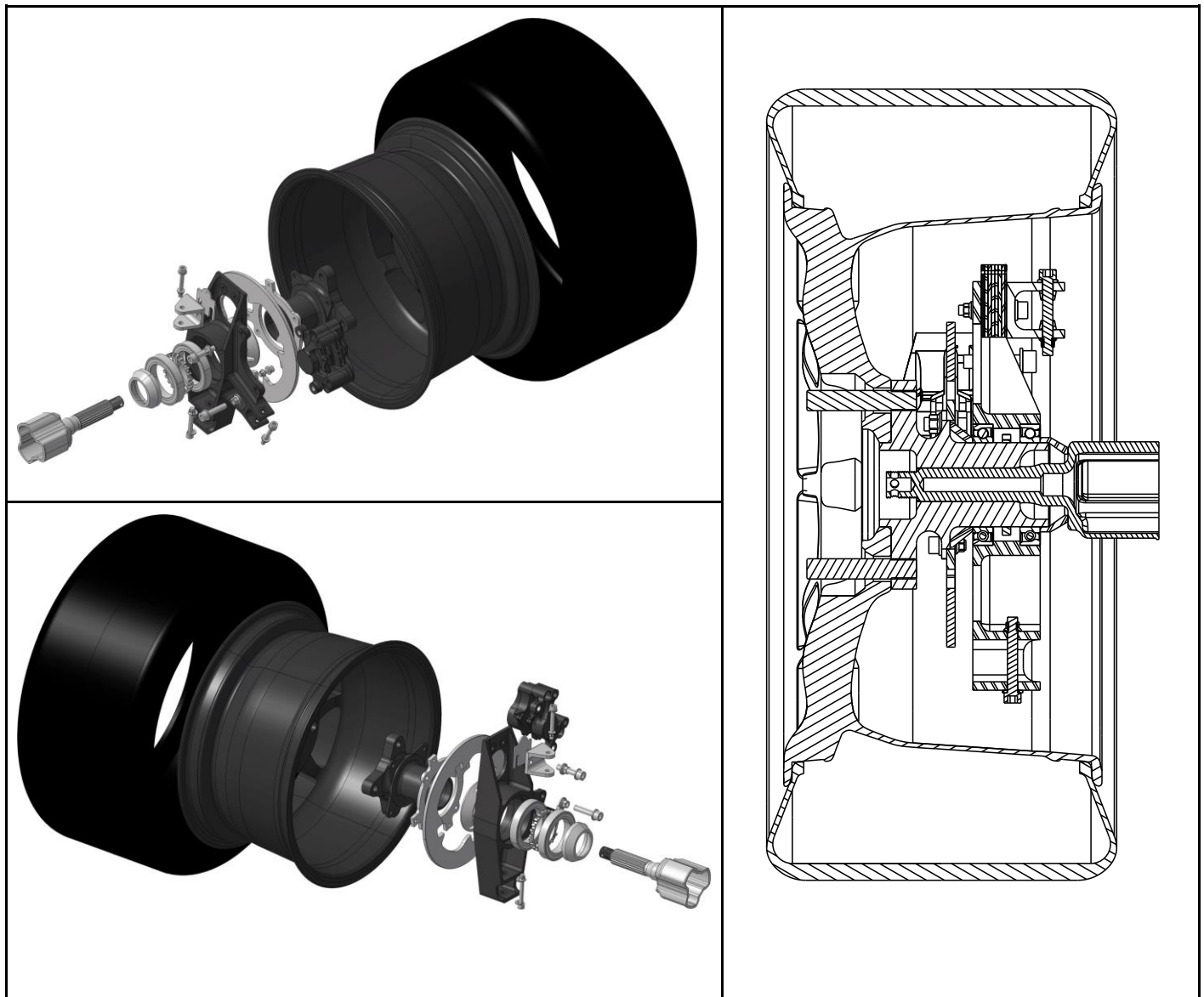
## Suspension Design summary



**Fig 6.** Suspension system of Valkyrie

	Front	Rear
Rim Size and tires	13" - Continental C19 R13	
Wheel rate (Nm/mm)	12.6	15.8
Roll rate (Nm/deg)	529	177
Sprung mass natural frequency (Hz)	1.92	1.87
Roll center height static (mm)	66.7	95.8

### *Wheels assembly*



*Fig 7. Rear Left Wheel Assembly*