In [1]:
```
import numpy as np
import argparse

filename   = str("bin_files/002_00000001.bin")
pointcloud = np.fromfile(filename, dtype=np.float32)
pointcloud = pointcloud.reshape([-1,4])

print('LiDAR data loaded as a variable pointcloud')

str1= str('\nLidar data file : ') + str(filename) + str('\nSize of pointcloud
print(str1)
```

```
LiDAR data loaded as a variable pointcloud

Lidar data file : bin_files/002_00000001.bin
Size of pointcloud data = (92246, 4)
```

In [11]:
```
def cart2Spherical_np(xyz):
    ptsnew = np.zeros((xyz.shape[0],4))
    xy = xyz[:,0]**2 + xyz[:,1]**2
    ptsnew[:,1] = np.sqrt(xy + xyz[:,2]**2)          # theta for elevation ang
    ptsnew[:,2] = np.arctan2(np.sqrt(xy), xyz[:,2]) # phi
    ptsnew[:,0] = np.arctan2(xyz[:,1], xyz[:,0])    # r
    ptsnew[:,3] = xyz[:,3]
    return ptsnew
```

In [12]:
```
polar_pointcloud = cart2Spherical_np(pointcloud)
```

Visualize in polar co-ordinate space

In [25]:
```
def visualize_3d(pointcloud,cloud_color,Point_size):
    import pptk
    import numpy as np

    # Extract first three points as x y z inputs and 4th for reflectivity val
    P = pointcloud[:,0:3]

    a = pointcloud.shape[0]
    R = np.ones((a))*20

    if pointcloud.shape[1]==4:
        R   = pointcloud[:,3]

    # define color channels
    rgb = np.ones((P.shape))*cloud_color # for grayish effect [200,200,200]

    if len(cloud_color)<3:
        rgb = cloud_color

    # Visualize point cloud
    v = pptk.viewer(P)
    v.set(lookat = [0,0,0])            # set zero /ego vehicle coordinate
    v.attributes(rgb/255, R)
    v.set(floor_color = [0,0,0,0])
    v.set(show_grid=0)
    v.set(point_size=Point_size)        # for better visualization point size
```

In [62]:
```
#scale for better visualization
polar_pointcloud_scaled = polar_pointcloud*[19,1,23,1]

visualize_3d(polar_pointcloud_scaled,[190,190,190],0.001)
```

Visulaize pointcloud with RGB color proportional to r, theta and phi

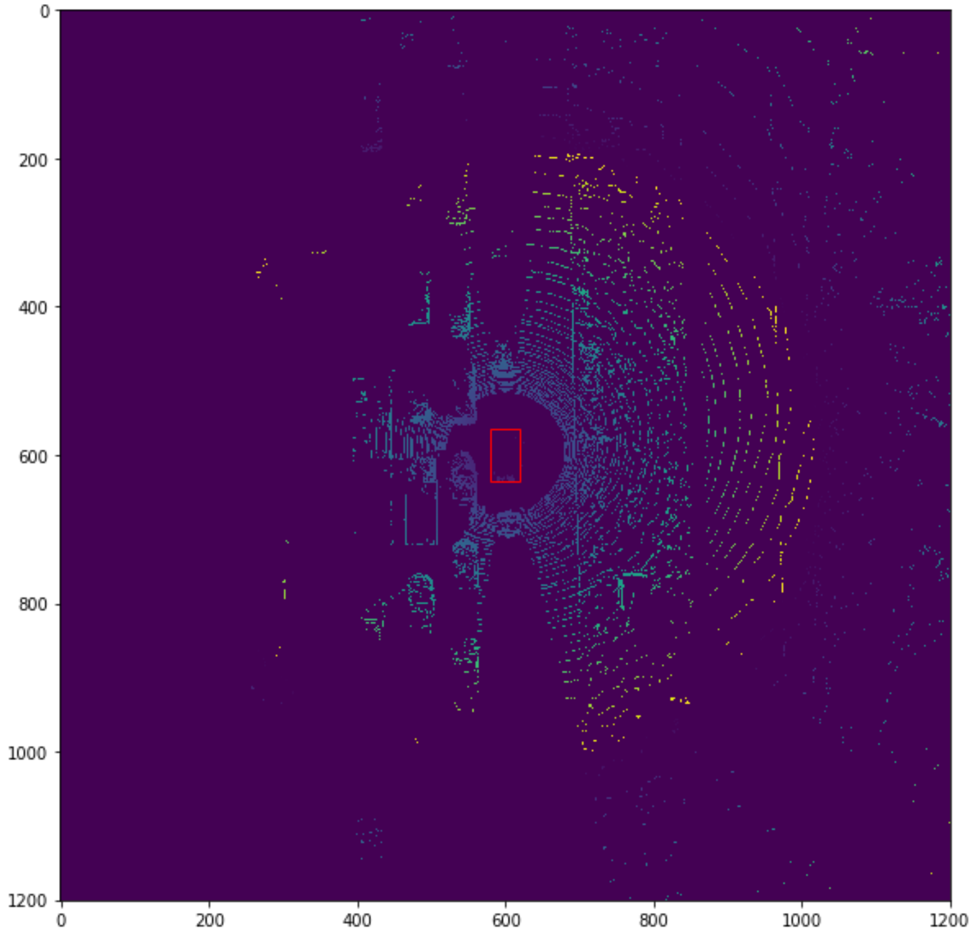
In [107]:
```
r_max     = np.max(polar_pointcloud[:,2])*3/3
theta_max = np.max(polar_pointcloud[:,0])*3/3
phi_max   = np.max(polar_pointcloud[:,1])/3

print('max of r, theta, phi = ',str(r_max),' ',str(theta_max),' ',str(phi_max

rgb_from_polar_pointcloud = polar_pointcloud[:,0:3]*[1/theta_max,1/phi_max,1/

import pptk
v = pptk.viewer(pointcloud[:,0:3],rgb_from_polar_pointcloud)
v.set(floor_color = [0,0,0,0.5])
v.set(show_grid=0)
v.set(lookat = [0,0,0])
```

```
('max of r, theta, phi = ', '1.9541178941726685', ' ', '3.1415767669677734',
' ', '23.324966430664062')
```

Generate the projected 2D depth image w.r.t horizontal and vertical angels, with intensity value using the distance. Visualize the 2D depth image

In [108]:
```
def point_cloud_top_view_distance_intensity(velo,fwd_range,side_range,height_

    import matplotlib.pyplot as plt
    from matplotlib.patches import Rectangle
    from PIL import Image
    import numpy as np

    x_points = velo[:, 0]
    y_points = velo[:, 1]
    z_points = velo[:, 2]
    r        = velo[:, 3]

    f_filt   = np.logical_and((x_points > fwd_range[0]), (x_points < fwd_rang
    s_filt   = np.logical_and((y_points > -side_range[1]), (y_points < -side_
    filter   = np.logical_and(f_filt, s_filt)
    indices  = np.argwhere(filter).flatten()

    # KEEPERS
    x_points = x_points[indices]
    y_points = y_points[indices]
    z_points = z_points[indices]
    r_points = r[indices]

    res      = 0.05
    # CONVERT TO PIXEL POSITION VALUES - Based on resolution
    x_img    = (-y_points / res).astype(np.int32)  # x axis is -y in LIDAR
    y_img    = (-x_points / res).astype(np.int32)  # y axis is -x in LIDAR

    # SHIFT PIXELS TO HAVE MINIMUM BE (0,0)
    # floor and ceil used to prevent anything being rounded to below 0 after
    x_img   -= int(np.floor(side_range[0] / res))
    y_img   += int(np.ceil(fwd_range[1] / res))

    # CLIP HEIGHT VALUES - to between min and max heights
    pixel_values = np.clip(a     = z_points,
                           a_min = height_range[0],
                           a_max = height_range[1])

    def scale_to_255(a, min, max, dtype = np.uint8):
        return (((a - min) / float(max - min)) * 255).astype(dtype)

    # RESCALE THE HEIGHT VALUES - to be between the range 0-255
    pixel_values  = scale_to_255(pixel_values, min = height_range[0], max = h

    # INITIALIZE EMPTY ARRAY - of the dimensions we want
    x_max = 1+int((side_range[1] - side_range[0])/res)
    y_max = 1+int((fwd_range[1] - fwd_range[0])/res)
    im    = np.zeros([y_max, x_max], dtype=np.uint8)

    # pixel value based on distance
    D_points = np.sqrt(x_points*x_points + y_points*y_points + z_points*z_poi
    D_points = D_points*255/D_points.max()

    # FILL PIXEL VALUES IN IMAGE ARRAY
    im[y_img, x_img]   =D_points*2 # pixel_values

    plt.figure(figsize = (10,10))
    a = plt.imshow(im,vmin = 0, vmax=255)

    ax = plt.gca()
    rect = Rectangle((580,565),40,70,linewidth=1,edgecolor='r',facecolor='non
    ax.add_patch(rect)
    #plt.text(600,575, "Ego Vehicle",horizontalalignment='center',rotation='v
```

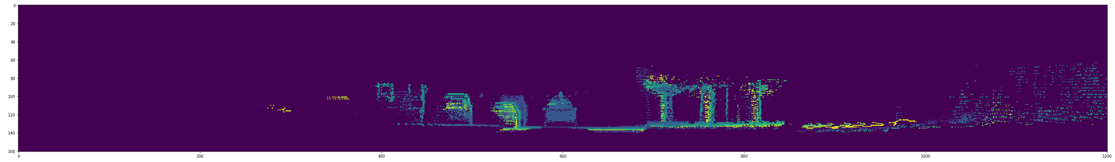
In [110]:
```
b = point_cloud_top_view_distance_intensity(pointcloud,(-30,30),(-30,30),(-3,
```



Front view

In [121]:
```
def point_cloud_front_view_distance_intensity(velo,fwd_range,side_range,heigh

    import matplotlib.pyplot as plt
    from matplotlib.patches import Rectangle
    from PIL import Image
    import numpy as np

    x_points = velo[:, 0]
    y_points = velo[:, 1]
    z_points = velo[:, 2]
    r        = velo[:, 3]

    f_filt   = np.logical_and((x_points > fwd_range[0]), (x_points < fwd_rang
    s_filt   = np.logical_and((y_points > -side_range[1]), (y_points < -side_
    filter   = np.logical_and(f_filt, s_filt)
    indices  = np.argwhere(filter).flatten()

    # KEEPERS
    x_points = x_points[indices]
    y_points = y_points[indices]
    z_points = z_points[indices]
    r_points = r[indices]

    res      = 0.05
    # CONVERT TO PIXEL POSITION VALUES - Based on resolution
    x_img    = (-y_points / res).astype(np.int32)  # x axis is -y in LIDAR
    y_img    = (-z_points / res).astype(np.int32)  # y axis is -x in LIDAR

    # SHIFT PIXELS TO HAVE MINIMUM BE (0,0)
    # floor and ceil used to prevent anything being rounded to below 0 after
    x_img   -= int(np.floor(side_range[0] / res))
    y_img   += int(np.ceil(height_range[1] / res))


    # INITIALIZE EMPTY ARRAY - of the dimensions we want
    x_max = 1+int((side_range[1] - side_range[0])/res)
    y_max = 1+int((height_range[1] - height_range[0])/res)
    im    = np.zeros([y_max, x_max], dtype=np.uint8)

    # pixel value based on distance
    D_points = np.sqrt(x_points*x_points + y_points*y_points + z_points*z_poi
    D_points = D_points*255/D_points.max()

    # FILL PIXEL VALUES IN IMAGE ARRAY
    im[y_img, x_img]   =D_points*2 # pixel_values

    plt.figure(figsize = (50,50))
    a = plt.imshow(im,vmin = 0, vmax=255)

    ax = plt.gca()
    rect = Rectangle((580,565),40,70,linewidth=1,edgecolor='r',facecolor='non
    ax.add_patch(rect)
    #plt.text(600,575, "Ego Vehicle",horizontalalignment='center',rotation='v

    return a
```

In [122]:
```
positive_x_pointcloud = pointcloud[pointcloud[:,0]>0]

c = point_cloud_front_view_distance_intensity(positive_x_pointcloud,(-30,30),
```



In [ ]:
```
```