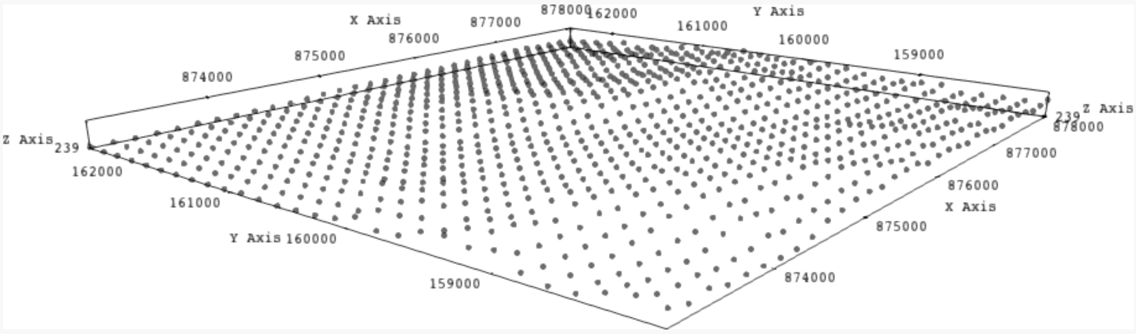
In this tutorial let us use `topIIvol_DistMesher` to create a volume mesh from a point cloud cluster `./xyz/point-cloud-coarse.xyz` which contains $(x \times y) = 32 \times 29 = 928$ points. `topIIvol_DistMesher` is a parallel computing tool, it will takes in a point-cloud as an input (`.xyz`) and generate volumetric meshes (partitioned) that can be extracted in medit's `*.mesh` format. Simply, `topIIvol_DistMesher` is tool to created distributed mesh from a point cloud.



Initial point cloud with 928 data points

Let us say we would like to create the volumeteric mesh `top-ii-vol-mesh`, with volume stretching upto a depth (z) of -1000 and z direction should be meshed with 50 layers. Let us accomplish this task using 24 parallel processes (24 MPI ranks).

- Let us highlight 3D partitioning of distributed mesher producing `*.mesh` mesh with 24 MPI ranks (with 24 subdomains divided between x, y and z directions). This can be achieved by:

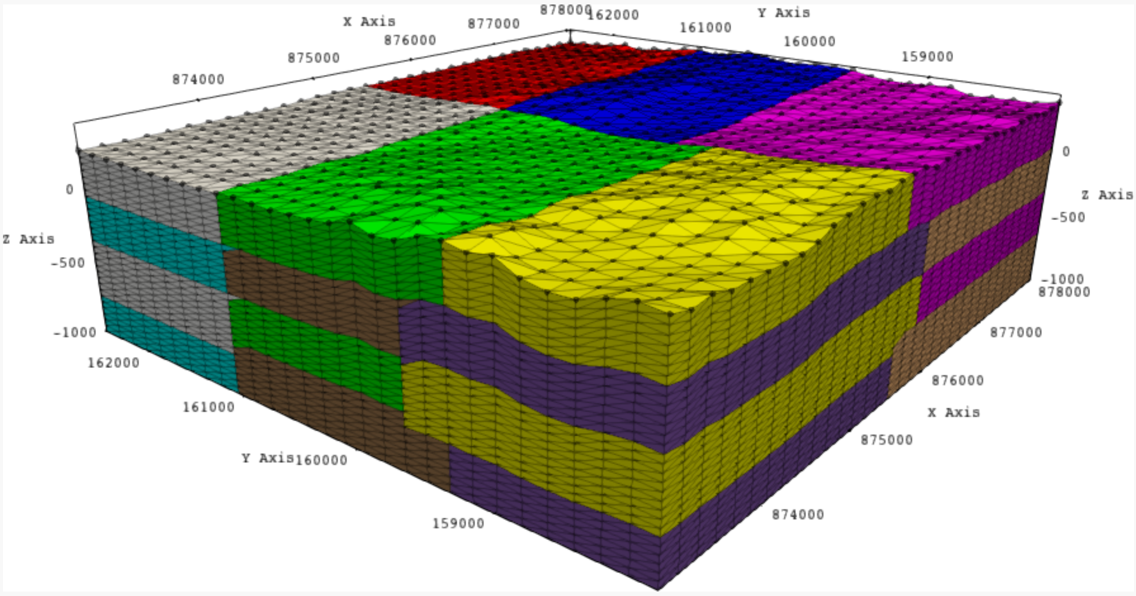
```
mpirun -n 24 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 2 --partition_y 3 --partition_z 4 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

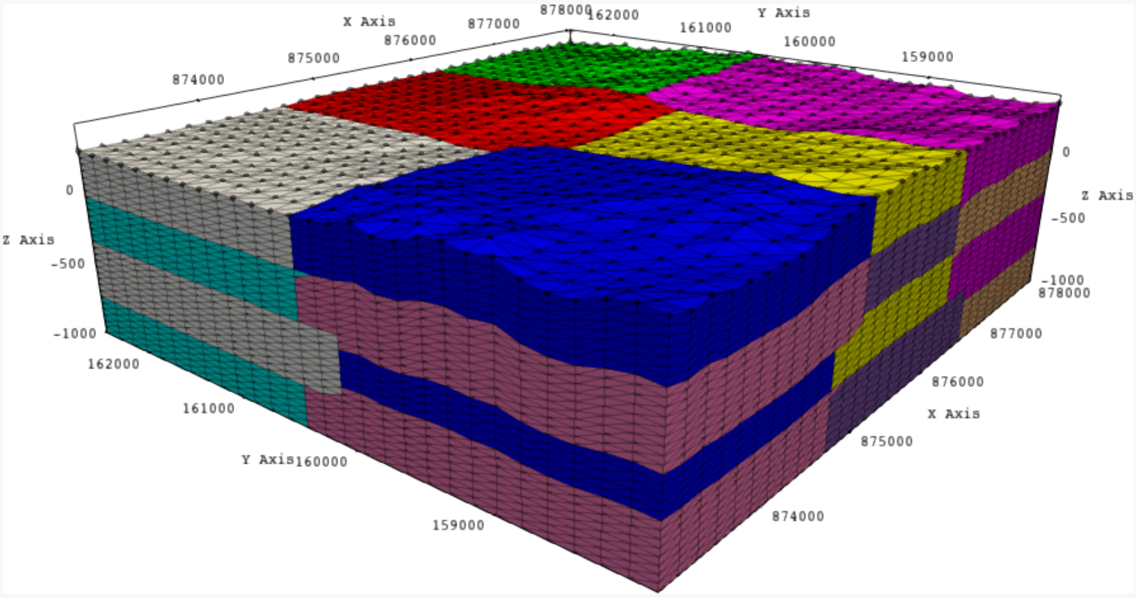
```
mpirun -n 24 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 3 --partition_y 2 --partition_z 4 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

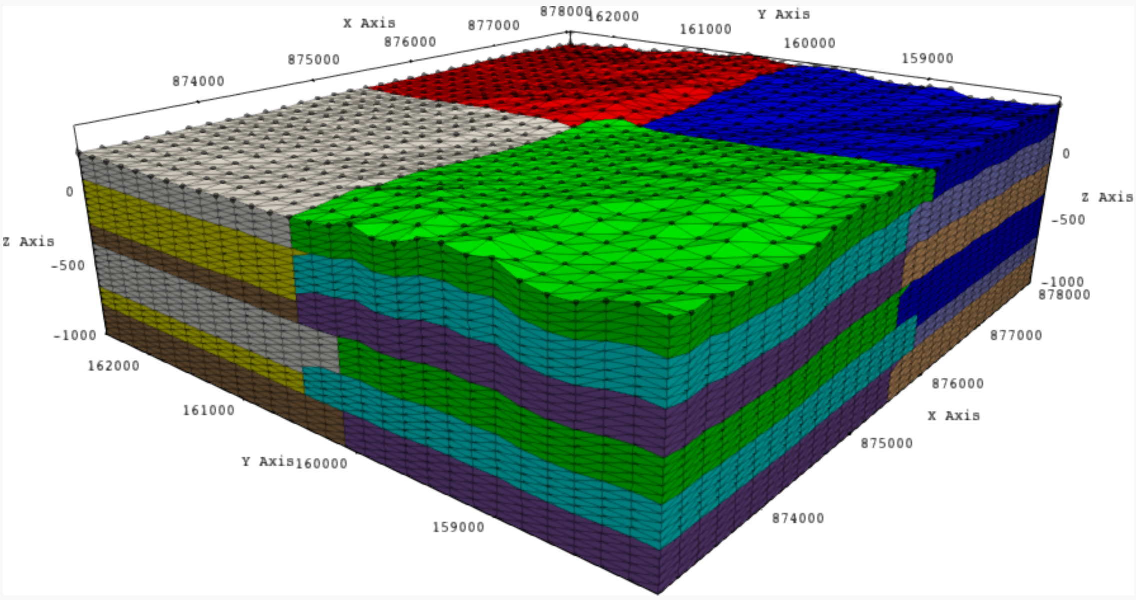
```
mpirun -n 24 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 2 --partition_y 2 --partition_z 6 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```



3D partitioning: Mesh with 24 subdomains using (2,3,4) partitions in (x, y, z).



3D partitioning: Mesh with 24 subdomains using (3,2,4) partitions in (x, y, z).



3D partitioning: Mesh with 24 subdomains using (2,2,6) partitions in (x, y, z).

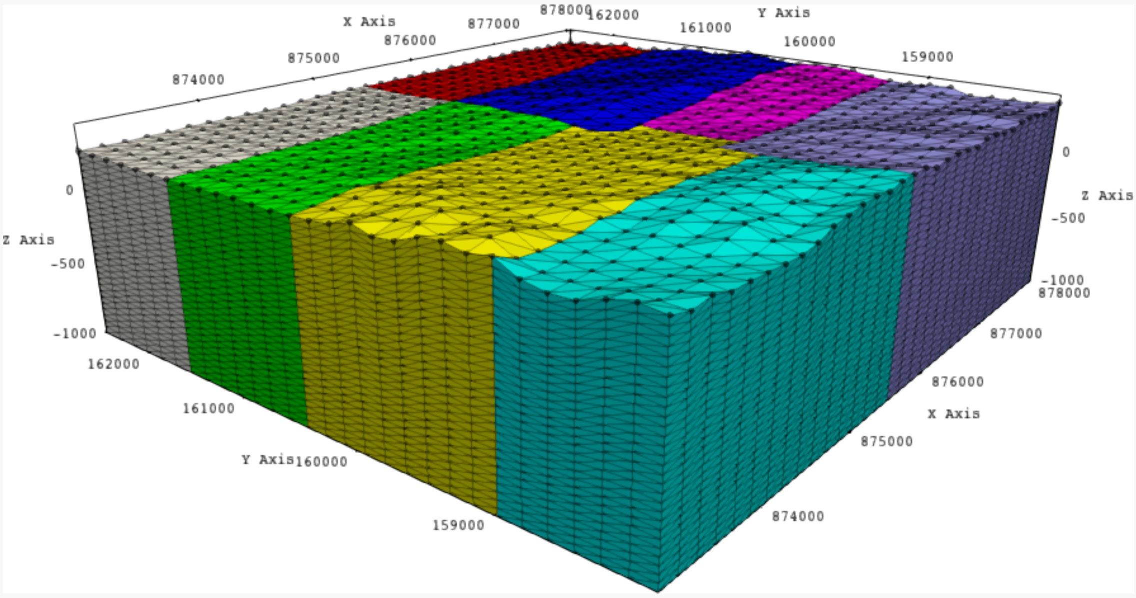
Notice that in all the examples `--partition_x` times `--partition_y` times `--partition_z` is equal to 24. In other words we are setting work load distribution between 24 MPI processes.

- Let us now highlight 2D partitioning of distributed mesher producing `*.mesh` mesh with 8 MPI ranks (with the 8 subdomains divided between x and y directions):

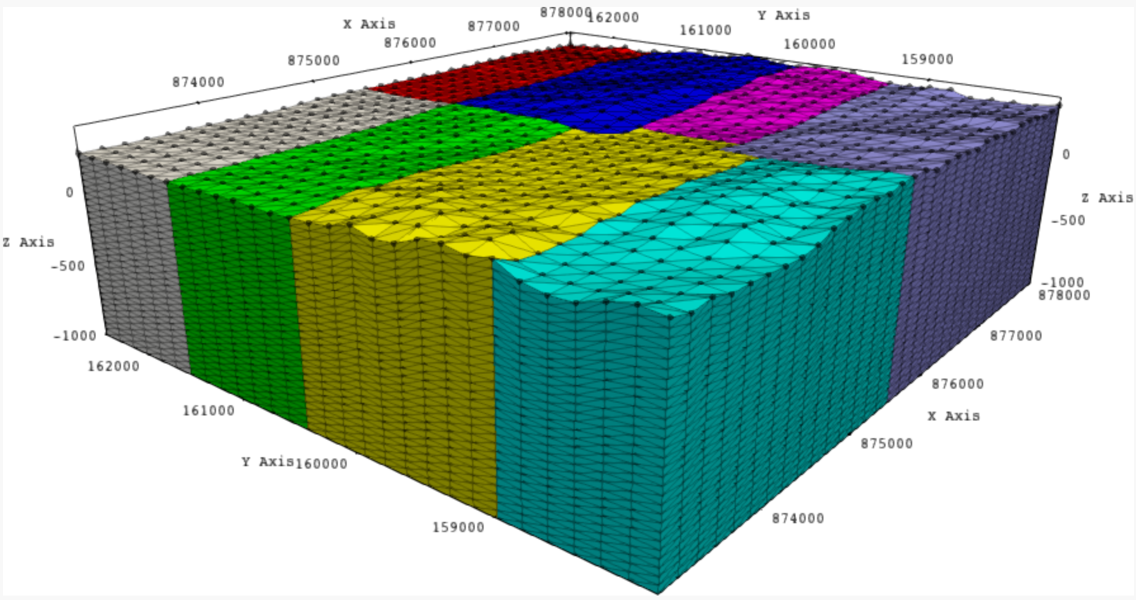
```
mpirun -n 8 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 2 --partition_y 4 --partition_z 1 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

```
mpirun -n 8 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 2 --partition_y 1 --partition_z 4 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```



2D partitioning: Mesh with 8 subdomains using (2,4,1) partitions in (x, y, z).



2D partitioning: Mesh with 8 subdomains using (2,1,4) partitions in (x, y, z).

- Let us now highlight 2D partitioning of distributed mesher producing `*.mesh` mesh with 6 MPI ranks (with the 6 subdomains divided between x and z directions):

```
mpirun -n 6 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 2 --partition_y 1 --partition_z 3 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

```
mpirun -n 6 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 3 --partition_y 1 --partition_z 2 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

- Let us now highlight 2D partitioning of distributed mesher producing `*.mesh` mesh with 16 MPI ranks (with the 16 subdomains divided between y and z directions):

```
mpirun -n 16 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 8 --partition_z 2 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

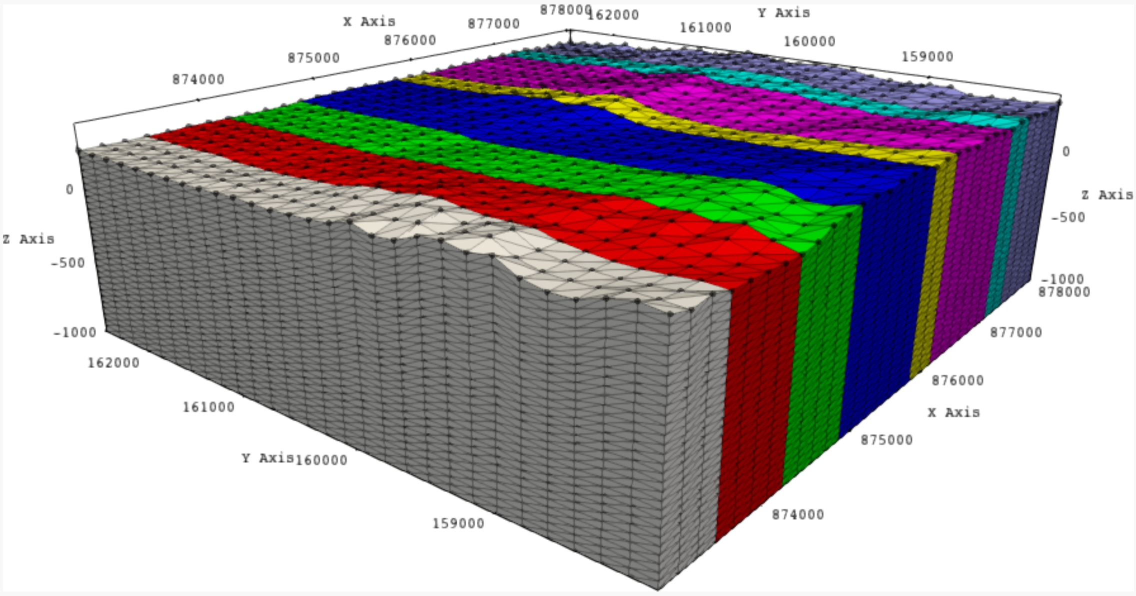
```
mpirun -n 16 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 2 --partition_z 8 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

or

```
mpirun -n 16 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 4 --partition_z 4 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

- Let us now highlight 1D partitioning of distributed mesher producing `*.mesh` mesh with 4 MPI ranks (letting the algorithm decide the partition direction):

```
mpirun -n 4 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

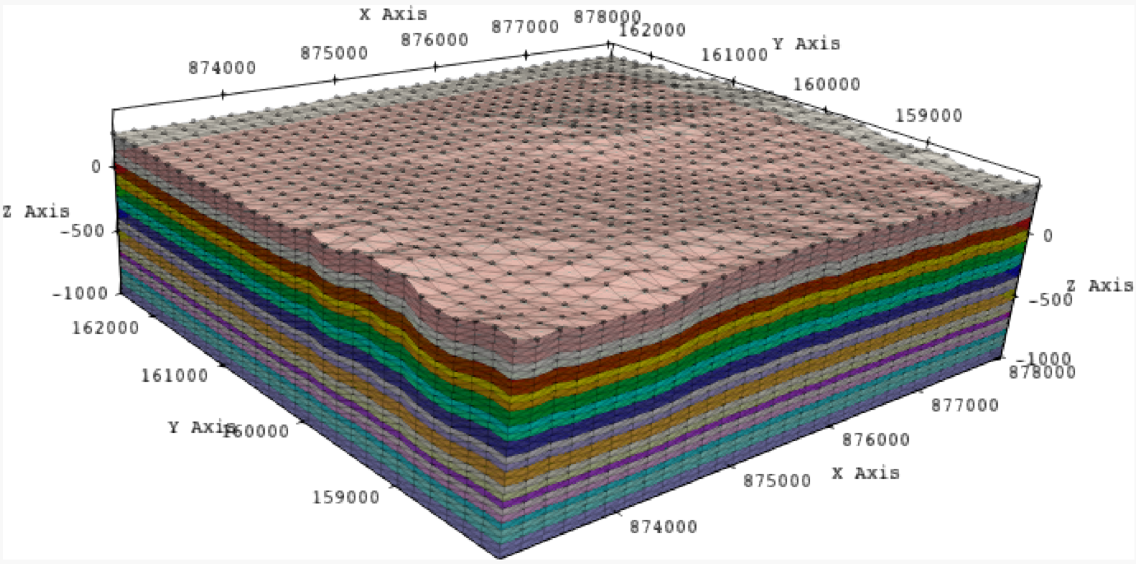


1D partitioning: Mesh with 8 subdomains using 1D partitioning.

Note that we did not provide `--partition_x` , `--partition_y` or `--partition_z` flags to the mesher, it automatically determines that there are more points in x direction ($32 > 30 > 29$)and partitioning is performed in x.

- Let us now highlight 1D of distributed mesher producing `*.mesh` mesh with 8 MPI ranks (enforced partitioning in x direction):

```
mpirun -n 8 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 1 --partition_z 8 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```



1D partitioning: Mesh with 8 subdomains using forced 1D partitioning.

- Let us now highlight 1D partitioning of distributed mesher producing `*.mesh` mesh with 8 MPI ranks (enforced partitioning in y direction):

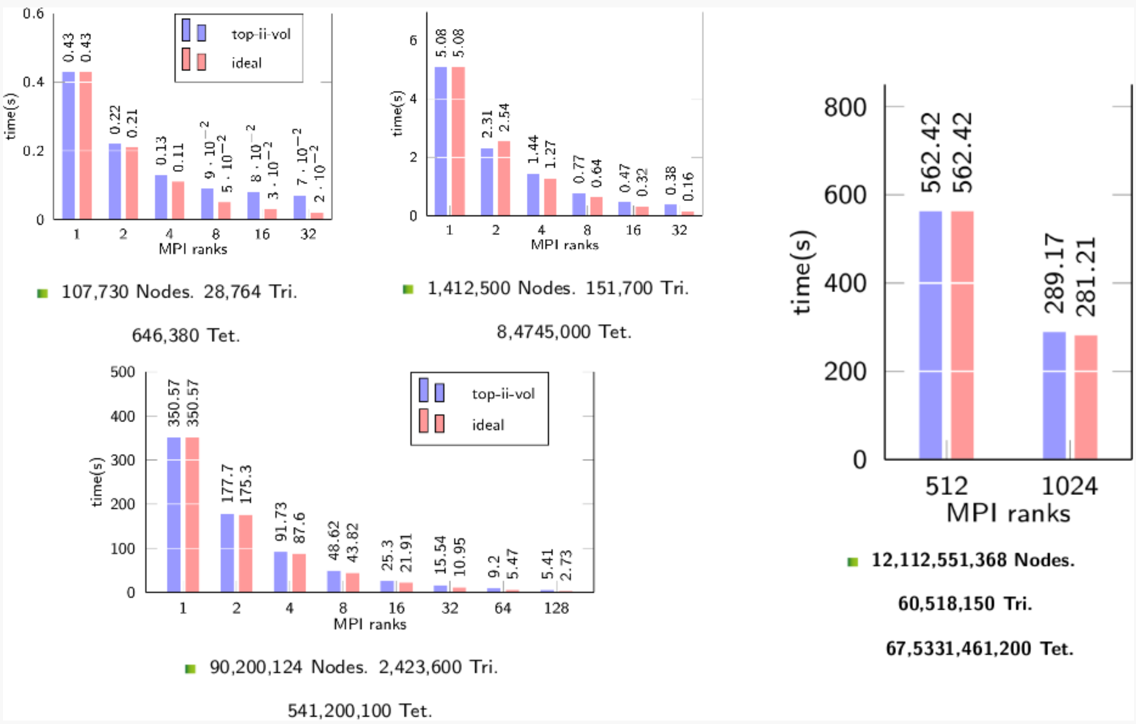
```
mpirun -n 8 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 8 --partition_z 1 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

- Let us now highlight 1D partitioning of distributed mesher producing `*.mesh` mesh with 3 MPI ranks (enforced partitioning in z direction):

```
mpirun -n 3 topIIvol_DistMesher --zpoints 30 --xpoints 32 --ypoints 29 \
--depth -1000 --partition_x 1 --partition_y 1 --partition_z 3 \
--out top-ii-vol-mesh --in ./xyz/point-cloud-coarse.xyz
```

What else is there to try

The 3D distributed mesher is a tool suitable for exascale computing, it has been tested to produce meshes with over 12 Billion nodes and 67 Billion tetrahedra in less than 5 minutes. Scaling of this tool Intel Skylake nodes on Inti supercomputer, hosted at TGCC is shown below.



Benchmarking scaling of topIIvol_DistMesher on Skylake CPU architecture on Inti

Try reproducing such large meshes on a supercomputer of choice. And try confirm the quasi optimal scaling characteristics of `topIIvol_DistMesher` on your supercomputer.

To report bugs, issues, feature-requests contact:*

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