ILD Phoenix Event Display

Creating an event display for ILD detectors, a way to add future detector designs and converting ILD geometry files to the right file format

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The ILD at the International Linear Collider (ILC)

ILC

- The ILC is the linear collider planned to be built in Japan which collides electrons with positrons.

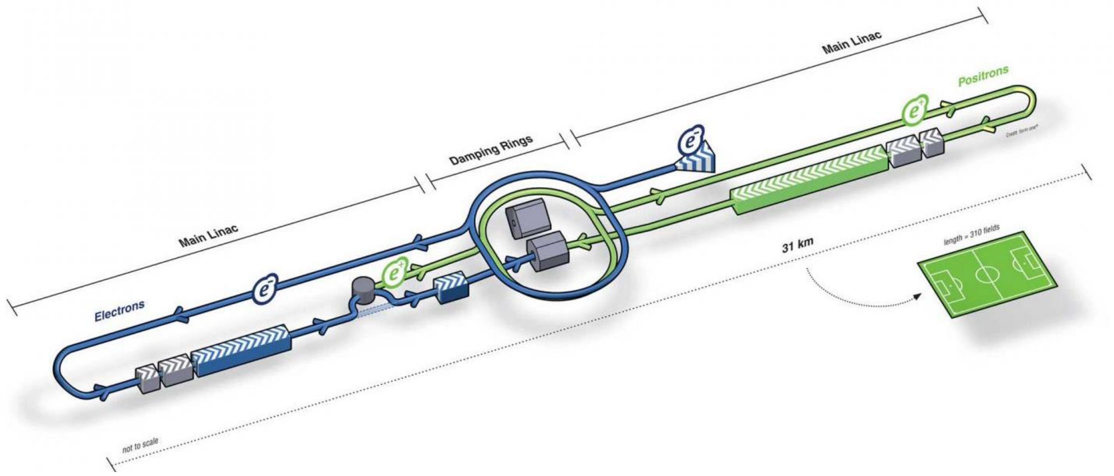


Figure 1: Diagram of the ILC.

ILD

- The ILD is a detector that will be used at the ILC.
- The ILD uses high granular calorimeters with excellent tracking which is needed for the particle flow reconstruction.

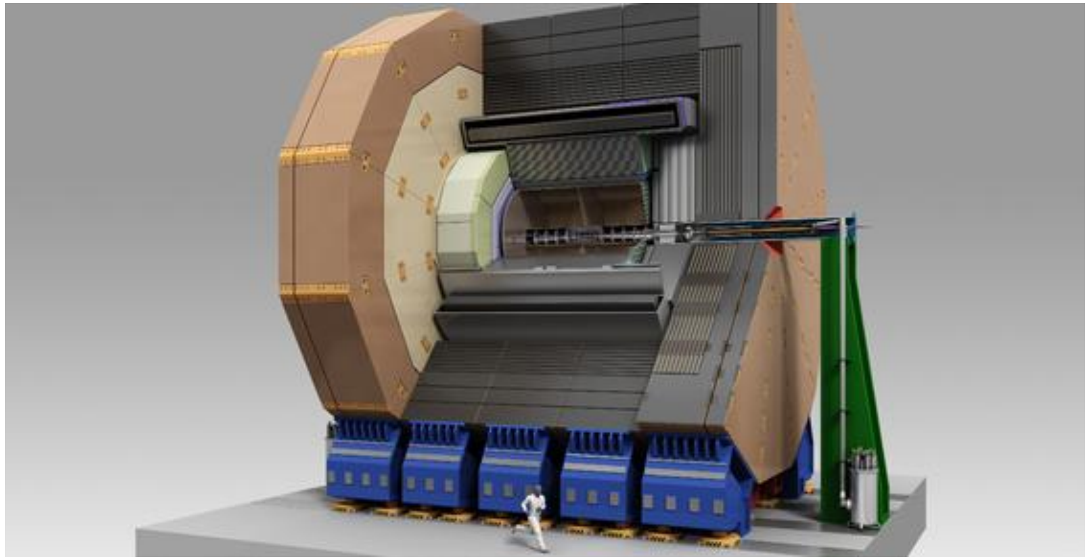


Figure 2: CAD Drawing of the ILD.

Event Displays

- Event displays allow for the visualization of subatomic particles propagation through matter.
- Some early examples of event displays include:
  - Cloud chambers
  - Bubble chambers
  - Spark chambers
- Modern event displays use digital data to display particle tracks and hits as well as the detector itself.

Figure 3: Spark Chamber.

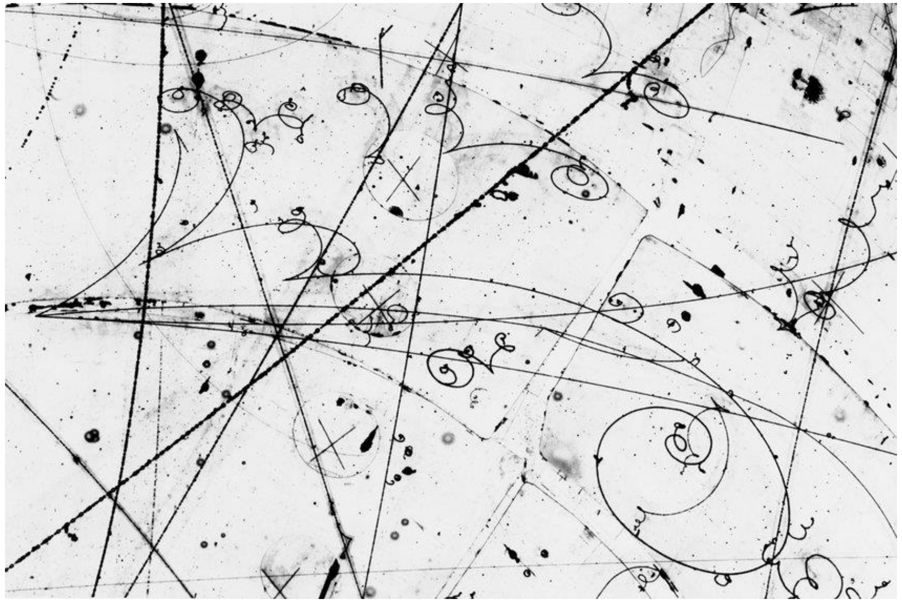


Figure 4: Bubble Chamber Tracks Image.

C Event Display (CED)

- One event display for the ILD, written in C that draws 3D images using OpenGL.
- The event display is still currently working but is quite old and therefore hard to maintain and not extendable.
- Using the CED also involves having the correct environment.

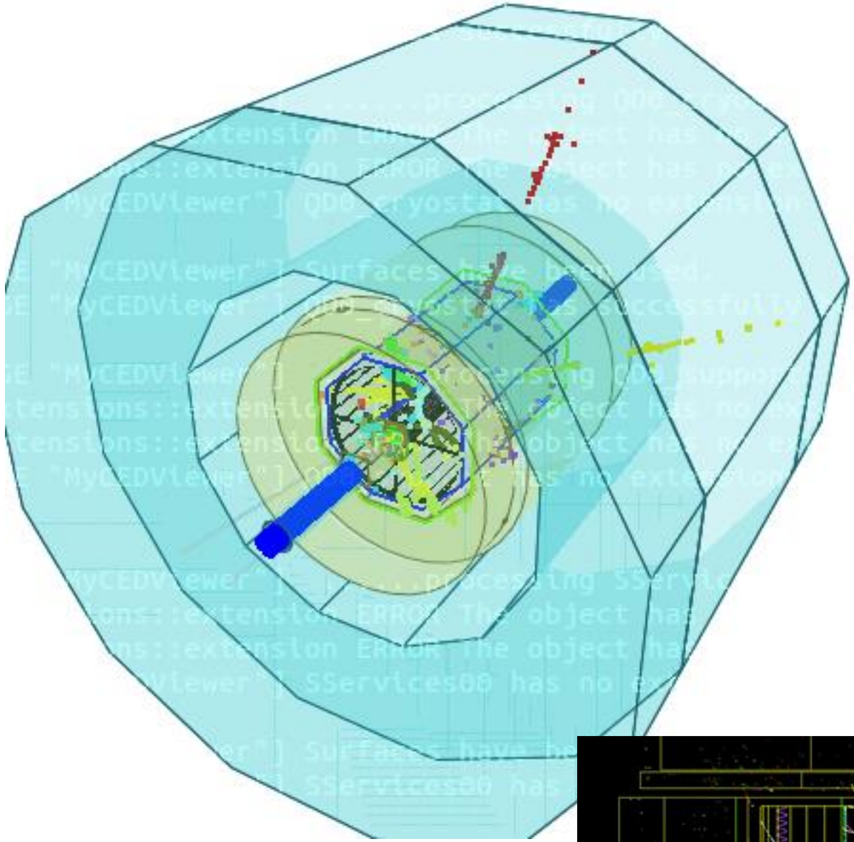


Figure 5: CED image of detector.

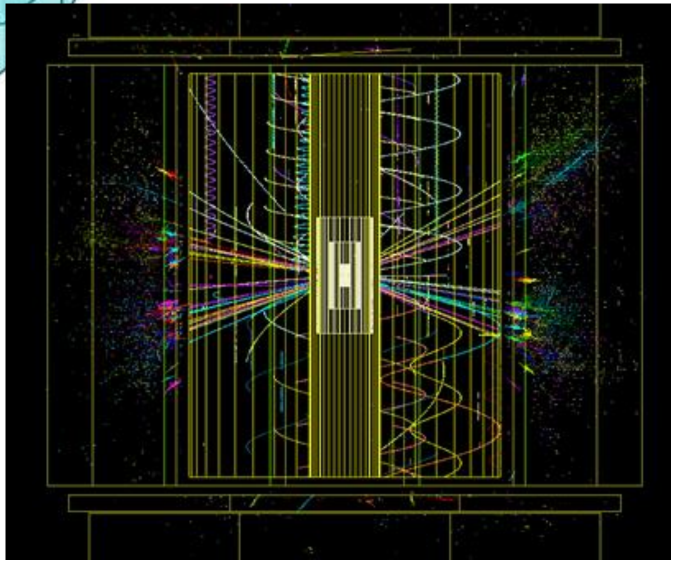


Figure 6: CED detector image with side view with wire mesh.

The Phoenix Event Display

Introduction

- The Phoenix Event Display was developed for ATLAS and there are also applications for the detectors at FCC and CMS.
- An event display using Typescript and three.js and Angular.
- The design principles for Phoenix state that the event display should:
  - Have good documentation.
  - Be easily accessible (available through a browser).
  - Avoid experiment-specific assumptions.

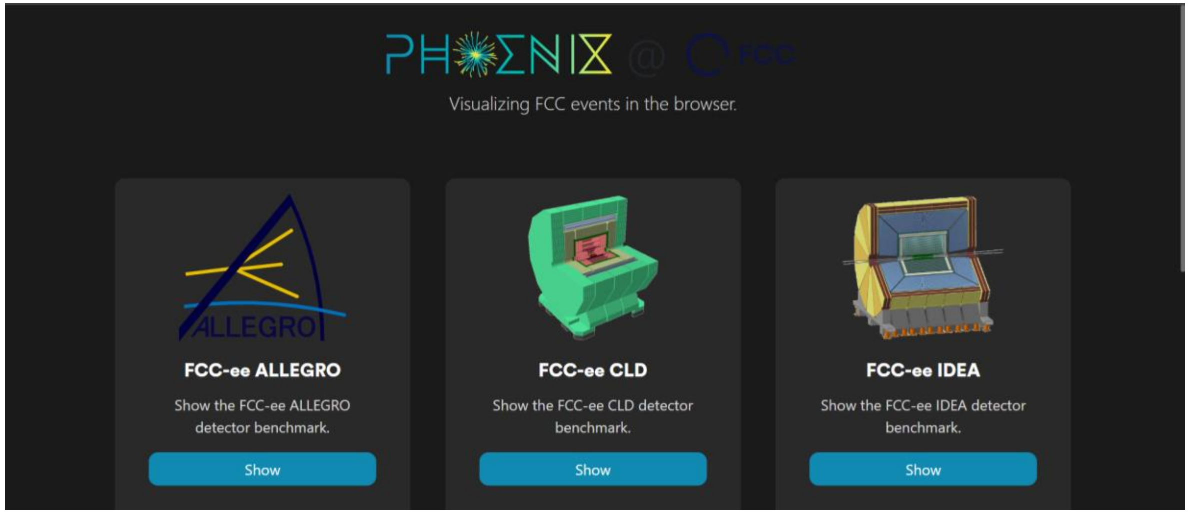


Figure 7: FCC Phoenix Event Display Main Page.

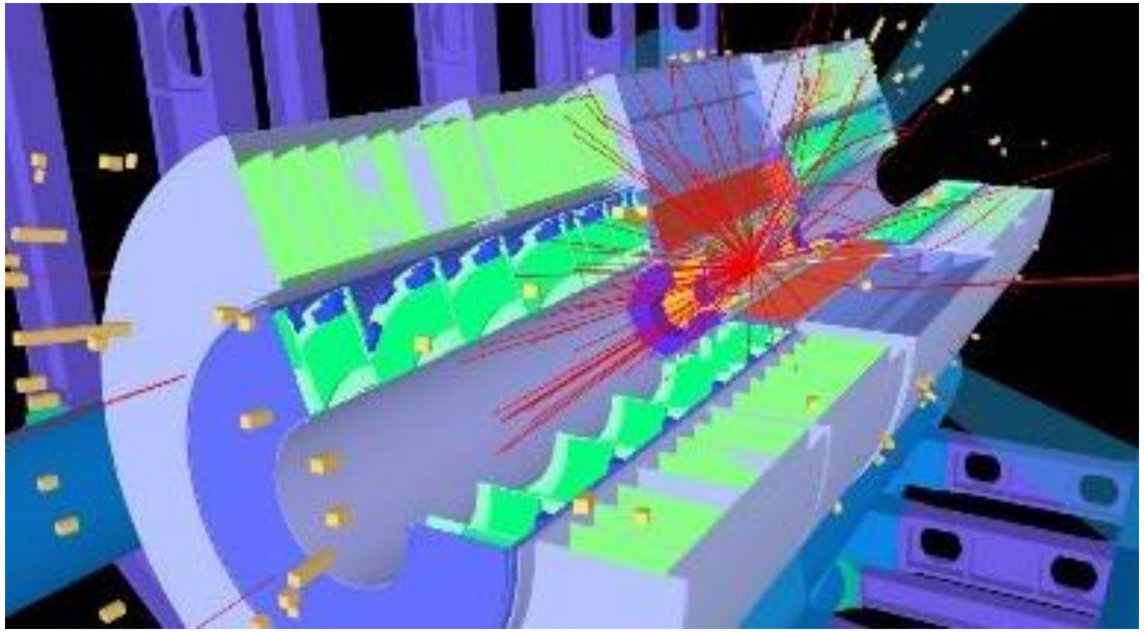


Figure 8: Example Image of a Detector using Phoenix.

The Phoenix Event Display

Features

- There are two menus in Phoenix: the Side Bar and the Bottom Menu.
- The Side bar allows users to:
  - Change appearance of the subdetector (colour, opacity).
  - Toggle subdetectors and event data.
  - Save different visualisation states.
- The bottom menu allows users to complete functions including:
  - Clip the detector (slice the detector at an angle to see the inside)
  - Add an event and look through the hits and tracks
  - Look at different views of the detector
  - Look at coordinates, lengths or object labelling

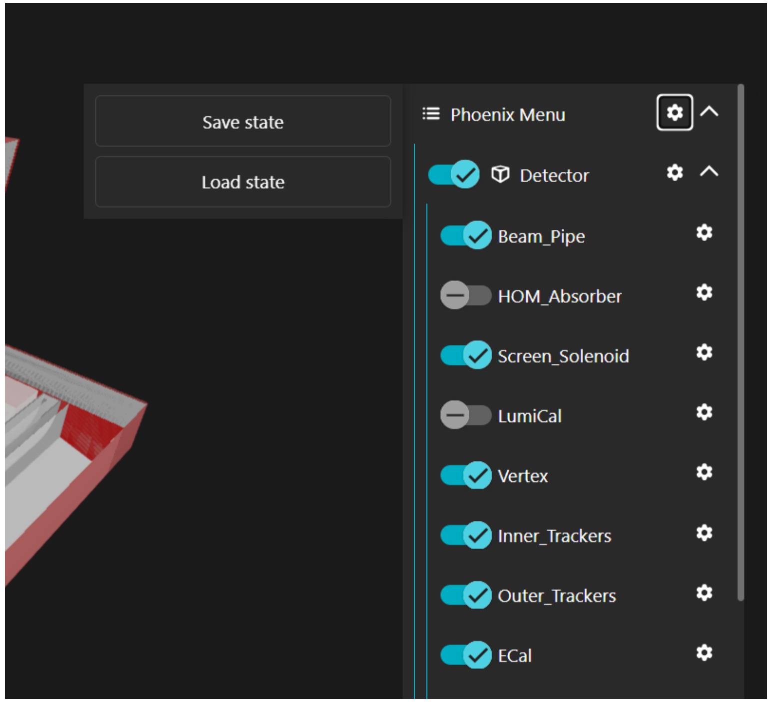
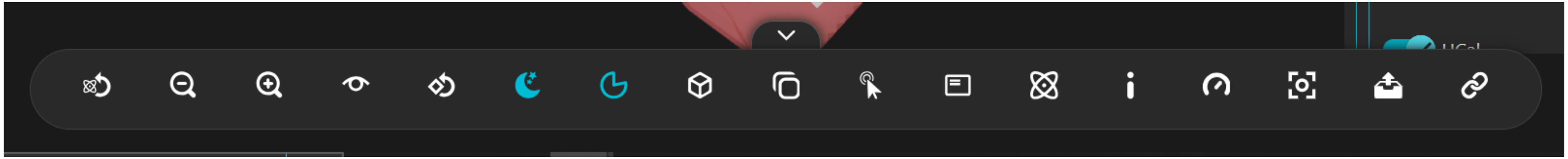


Figure 9: Phoenix Menu in Phoenix FCC.

Figure 10: Bottom Menu in Phoenix FCC.



Converting ILD Detector XML Files to GlTF

Introduction

- The ILD detector files are stored as XML files which are DD4hep geometries (they can be found at: https://github.com/key4hep/k4geo).
- For the Phoenix event display to read the detector files they need to be stored in the GlTF file which is a standard format for 3D scenes.

- This can be quite a lengthy procedure as it involves two steps (converting XML to ROOT and then ROOT to GlTF).
- Therefore, it was important to make a one-step automatic conversion script that would run each part of the conversion in sequence.
- An automatic configuration file generator was added to the one-step conversion, as the conversion of ROOT to GlTF requires a configuration file.

Converting ILD Detector XML Files to GlTF

Total Conversion

- This first conversion used DD4hep in the ROOT package in python to convert the DD4hep XML files into TGeo ROOT files.
- The user can set the number of layers that the ROOT file sees (‘visibility’).
- The second conversion from ROOT to GlTF, uses Javascript code from our FCCee colleagues (https://github.com/abbyxh/root2gltf.git).

```python
def root_convert(cfile, out_path, visibility):
    ## Converts an xml file to root file
    print('INFO: Converting following compact file(s):')
    print('       ' + cfile)

    ROOT.gSystem.Load('libDDCore')
    description = ROOT.dd4hep.Detector.getInstance()
    description.fromXML(cfile)

    ## Sets the number of layers visible in the root file
    ROOT.gGeoManager.SetVisLevel(visibility)
    ROOT.gGeoManager.SetVisOption(0)
    ## Sets an automatic root path if one isn't given
    root_path = determine_outpath(out_path, cfile, 'root')
    ROOT.gGeoManager.Export(root_path)

    return root_path
```

Figure 11: Code for converting file from xml to root.

My Contribution to the Conversion

Automatic Configuration File

- The conversion script provides an automatic configuration file that the user can either use or edit.
- The different variables that the user can determine in the configuration file:
  - What parts of the detector should be shown.
  - The opacity for each subdetector (set automatically at 0.8).
  - The colour (can either choose ‘ILD colouring’ or default colouring.

```
{
    "childrenToHide": ["SServices00"],
    "subParts": {
        "BeBeampipe": [
            [
                "BeBeampipe_(?!envelope)\\w+"
            ],
            0.6, [0,1,0]
        ],
        "BeamPipe": [
            [
                "BeamPipe_(?!envelope)\\w+"
            ],
            0.6, [0,1,0]
        ],
```

Figure 12: Example of edited configuration file.

```
"FTD": [
    ["(FTD_(?!envelope))\\w+|(FTD(?!_))\\w+",
    "FTDDisk_.*_negZ\\w+",
    "ftd_petal_negZ_.*_.*\\w+",
    "ftd_sensor_negZ_.*_.*_.*\\w+",
    "FTDDisk_.*_posZ\\w+",
    "ftd_petal_posZ_.*_.*\\w+",
    "ftd_sensor_posZ_.*_.*_.*\\w+",
    "FTD_support\\w+"],
    0.8,
    [0.39, 0.1, 0.57]
],
"HcalBarrel": [
    ["(HcalBarrel_(?!envelope))\\w+|(HcalBarrel(?!_))\\w+"],
    0.8,
    [0.76, 0.76, 0.19]
],
```

Figure 13: Example of automatic configuration file.

My Contribution to the Conversion

Adding ILD Colours

- Developed functionality to make colours configurable.
- User inputs ‘ild’ as a command line and the ILD colours are added.

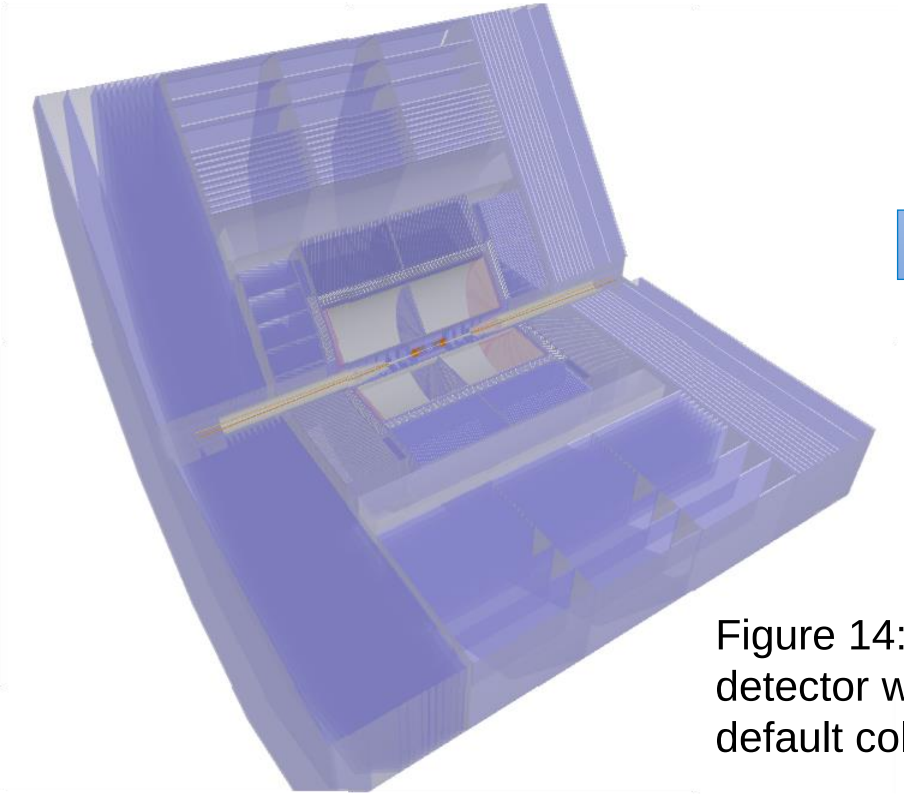


Figure 14: ILD detector with the default colouring.

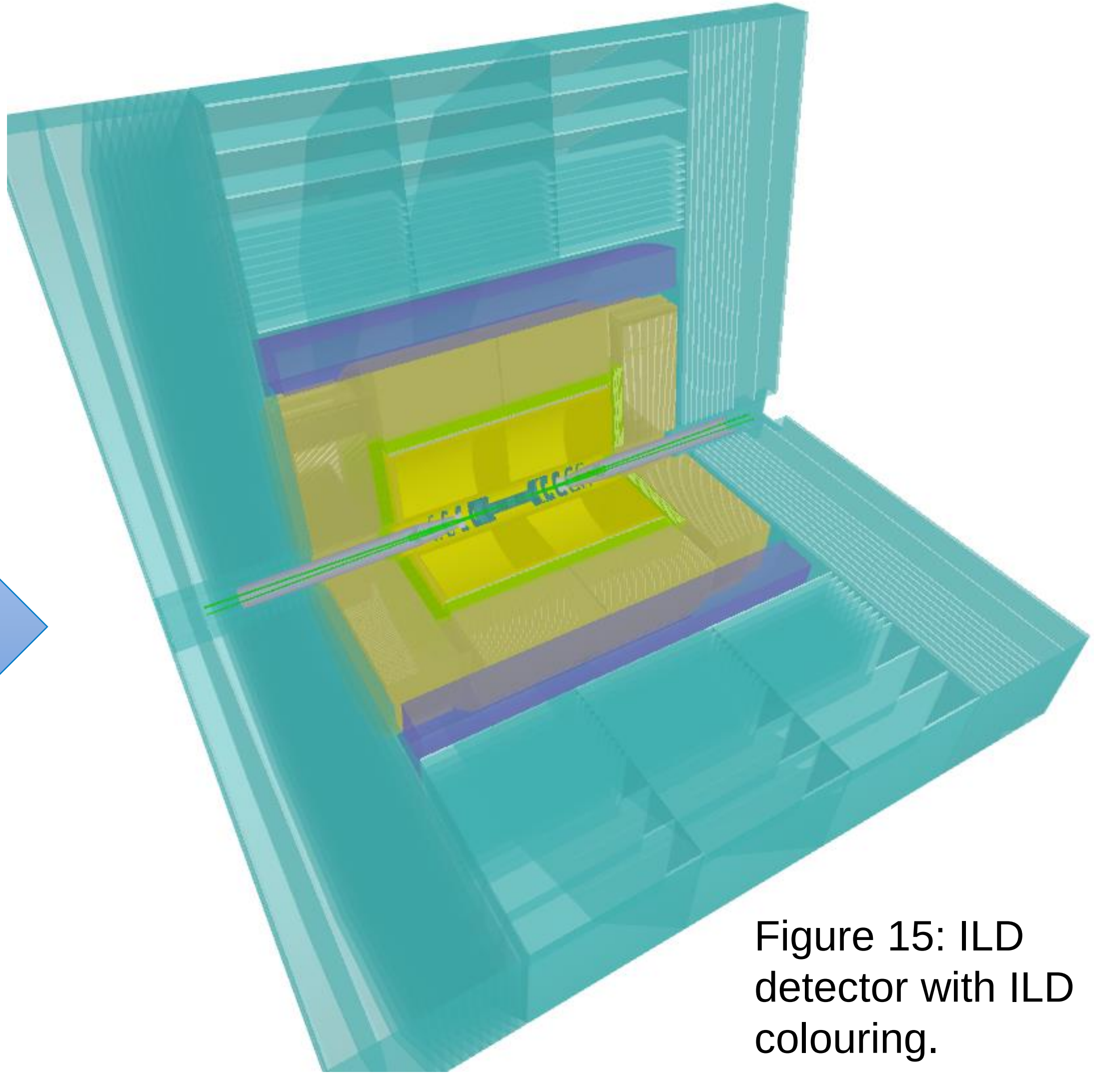


Figure 15: ILD detector with ILD colouring.

The ILD Phoenix Event Display

- The ILD Phoenix event display uses EDM4hep JSON files as input for event data.
- The ILD event display can be viewed on github pages using the link below:
  - https://ilcsoft.github.io/Phoenix-ILD/

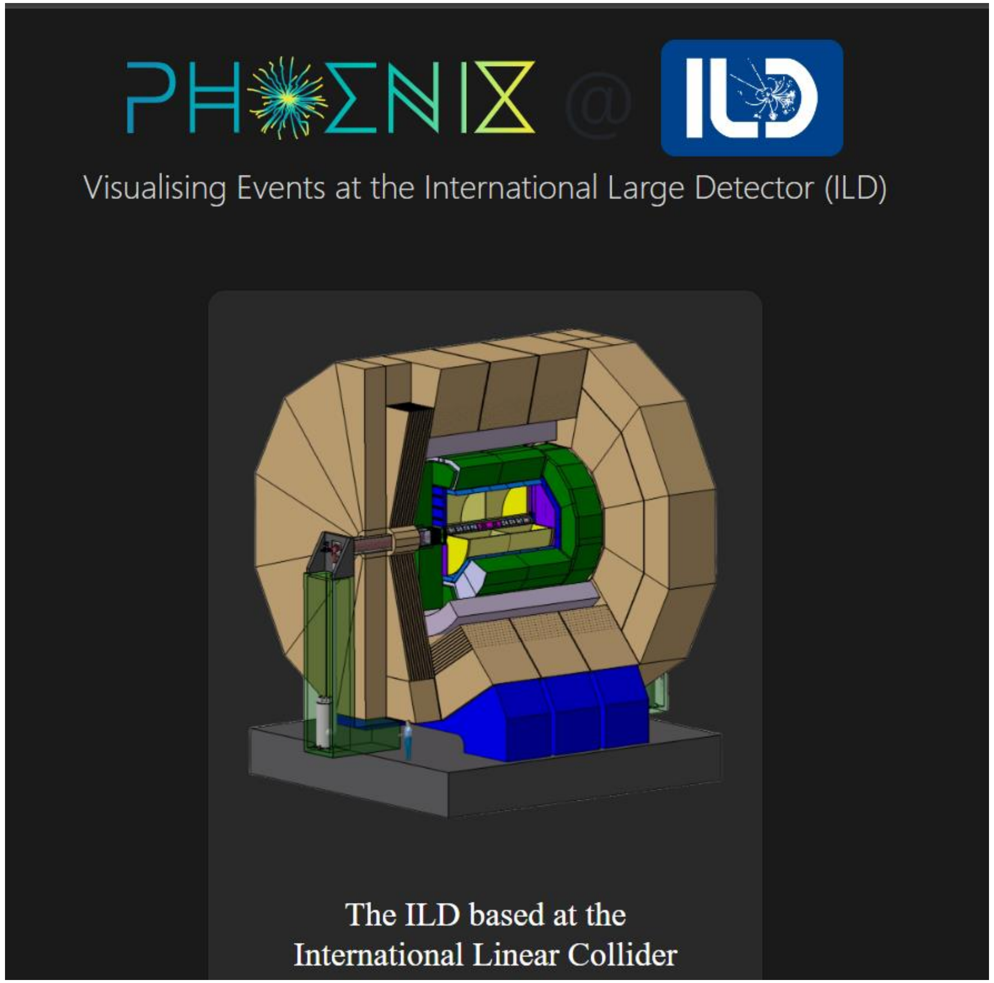


Figure 16: ILD Phoenix Event Display Main Page.

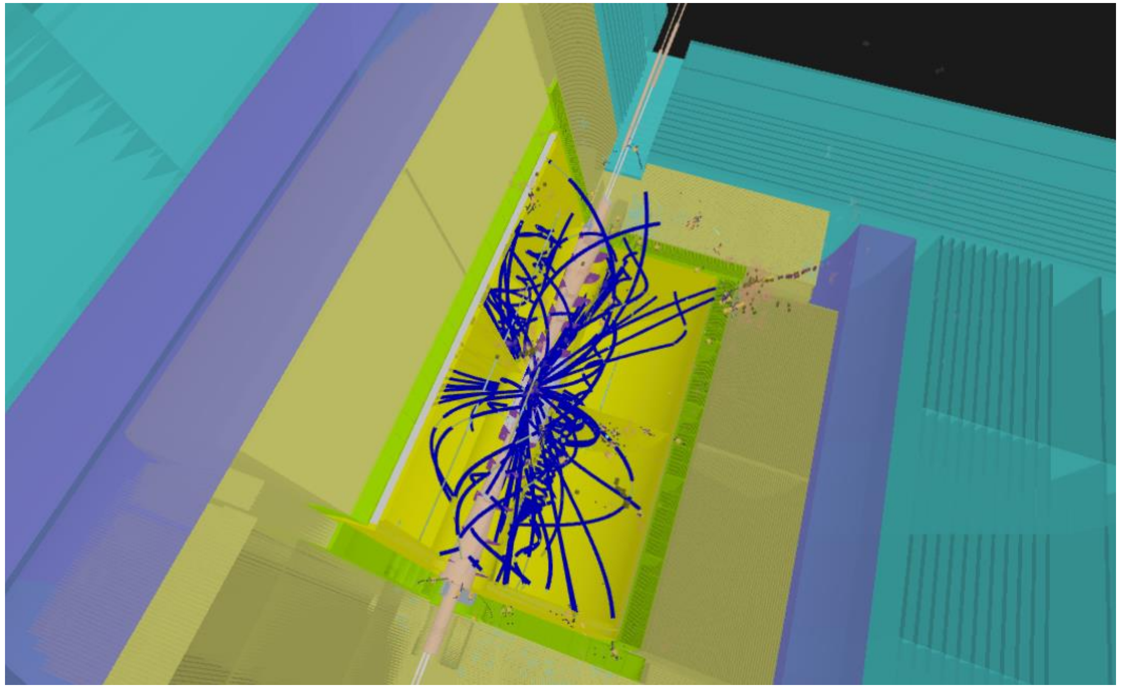


Figure 17: ILD Phoenix Event Display.

Adding a New Detector

- A new detector can be added using the command in the utils folder:

```
add_detector_component.py -d ... -n ...
```

- Where ‘d’ is the location of the GITF file and ‘n’ is the name of the detector.
- This method uses jinja templates to add a new detector Typescript, HTML and CSS file while adding a button to the drop-down menu.
- The app is then rebuilt and deployed again to github pages using a github action.

```
{%- for f in folders %}
import { {{ f }}Component } from './{{ f }}/{{ f }}.component';
{%- endfor %}

let routes: Routes = [
    {%- for f in folders %}
    { path: '{{ f }}', component: {{ f }}Component },
    {%- endfor %}
    { path: '', component: MainComponent }
]
```

Figure 18: Example of jinja template.

```
  - name: build app
    run: ng build --output-path ild-phoenix-app --base-href /Phoenix-ILD/

  - name: Upload artifact
    uses: actions/upload-pages-artifact@v3
    with:
      path: ild-phoenix-app
```

```
- name: update build file
  run: |
    tar -xvf doc_artifact/artifact.tar --directory ${GITHUB_WORKSPACE}
    rm -r doc_artifact

- name: commit and push
  env:
    GITHUB_TOKEN: ${{ secrets.PHOENIX_ILD }}
  run: |
    git config --global user.email ${GITHUB_ACTOR_ID}+${GITHUB_ACTOR}@users.noreply.github.com
    git config --global user.name ${GITHUB_ACTOR}
    git add .
    git diff-index --quiet HEAD 2>&1 > /dev/null || git commit -m "Update new detector files for Phoenix-ILD" && git push
```

Figure 19: Example of github action code.

Comparison Between CED and Phoenix- Images

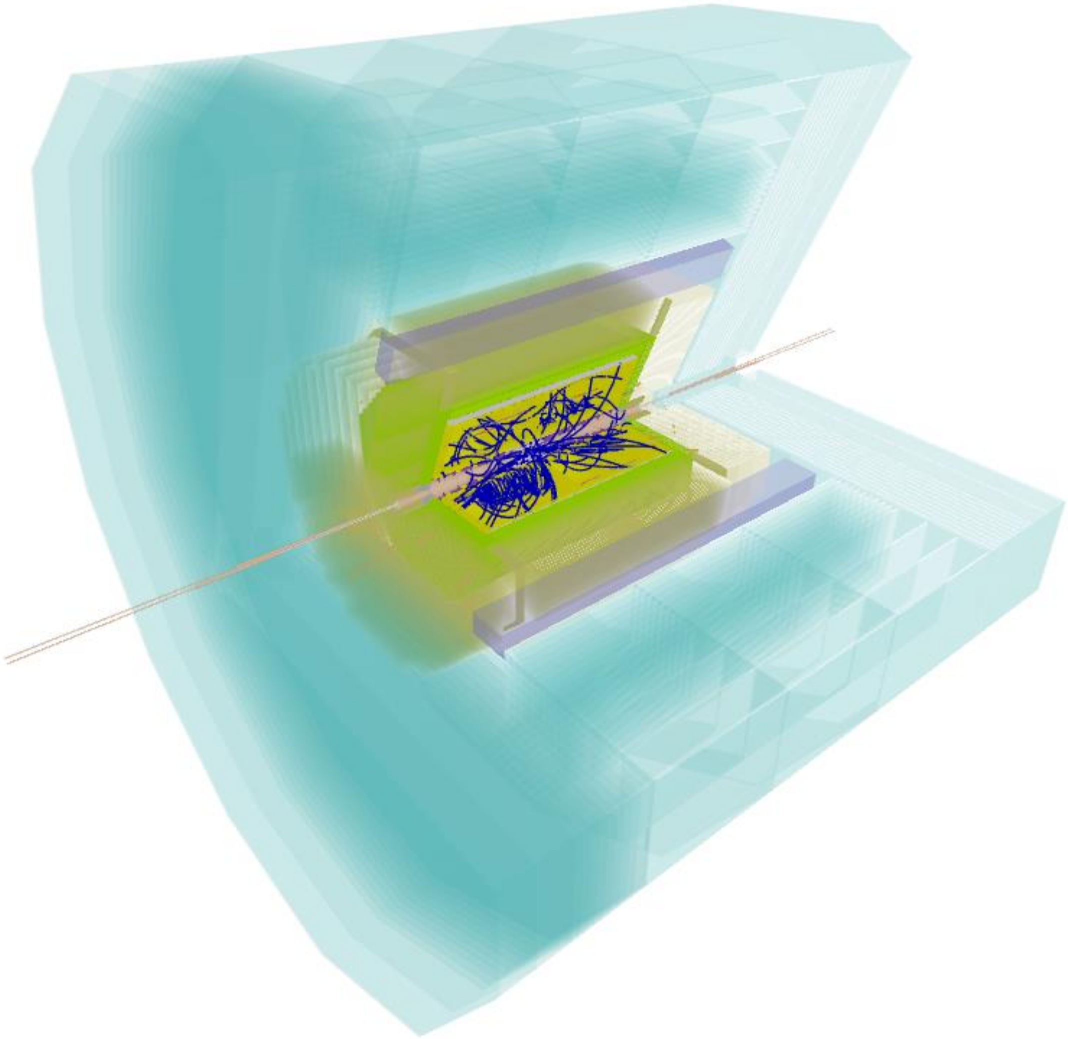


Figure 20: ILD in the Phoenix Event Display.

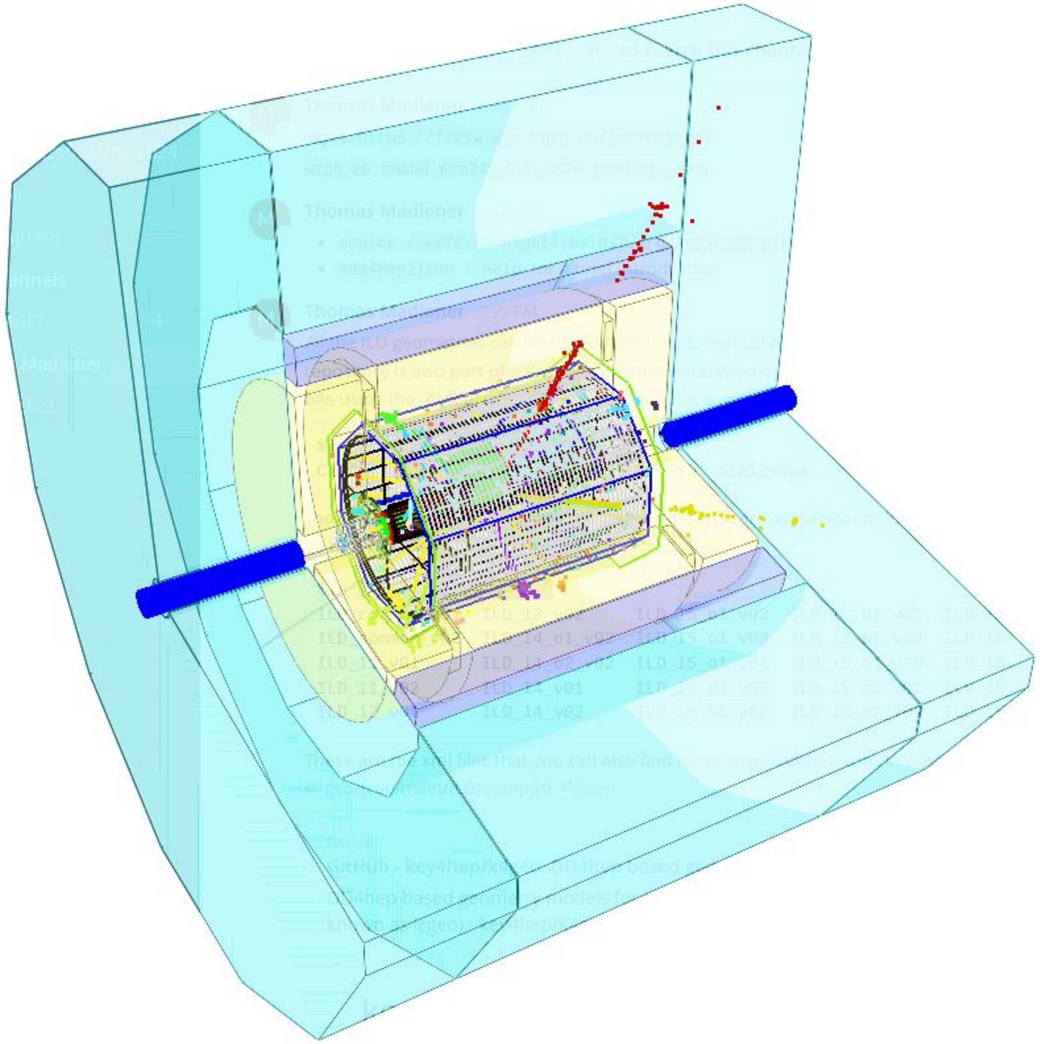


Figure 21: ILD in the CED.

Comparison Between CED and Phoenix

- Both Phoenix and the CED work very similarly.
- The CED event display however, had a few extra features compared to Phoenix:
  - Geometry fading at long distances.
  - Z-axis cuts.
  - Different views (side, front or fisheye view).
  - Background colours.
  - Keyboard shortcuts.
- The main difference was the way in which both could be used: Phoenix can be easily used in the browser whereas the CED needed more setting up time and the correct installations on the PC.

Conclusion

- Built the ILD Phoenix Event Display and deployed on github.
- Created extra scripts to help the usability of the Phoenix Event Display:
  - The XML to GlTF one-step conversion.
  - Automatic configuration file generator.
  - Adding a new detector and redeploying the app.

Thank you

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