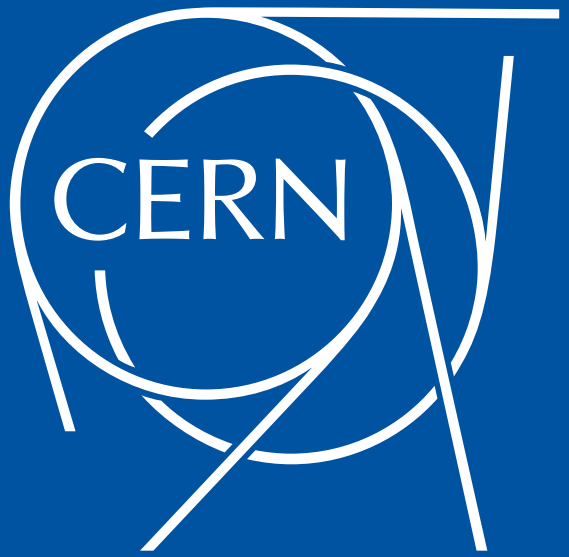
CERN

New Web Based Event Data and Geometry Visualization for LHCb

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Overview

Phoenix visualization framework

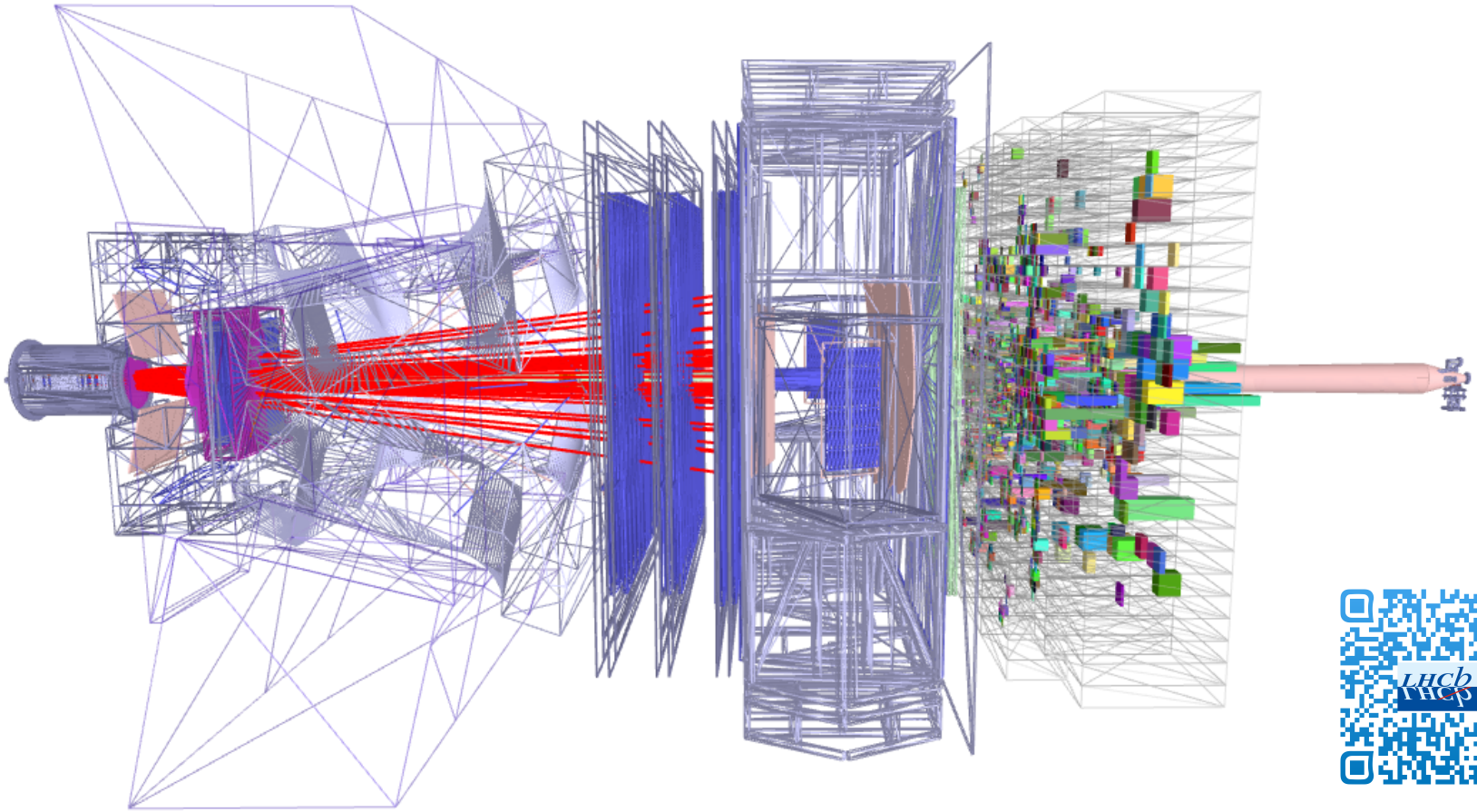
Import of GDML & ROOT geometry

LHCb usage of Phoenix & the data sink

PHOENIX visualization framework

Key Features:

- Ubiquitous web-based solution built on the Phoenix framework.
- Generic & reusable.
- Usability in outreach & data tracking.
- Collaboration between HEP experiments, Phoenix & ROOT.

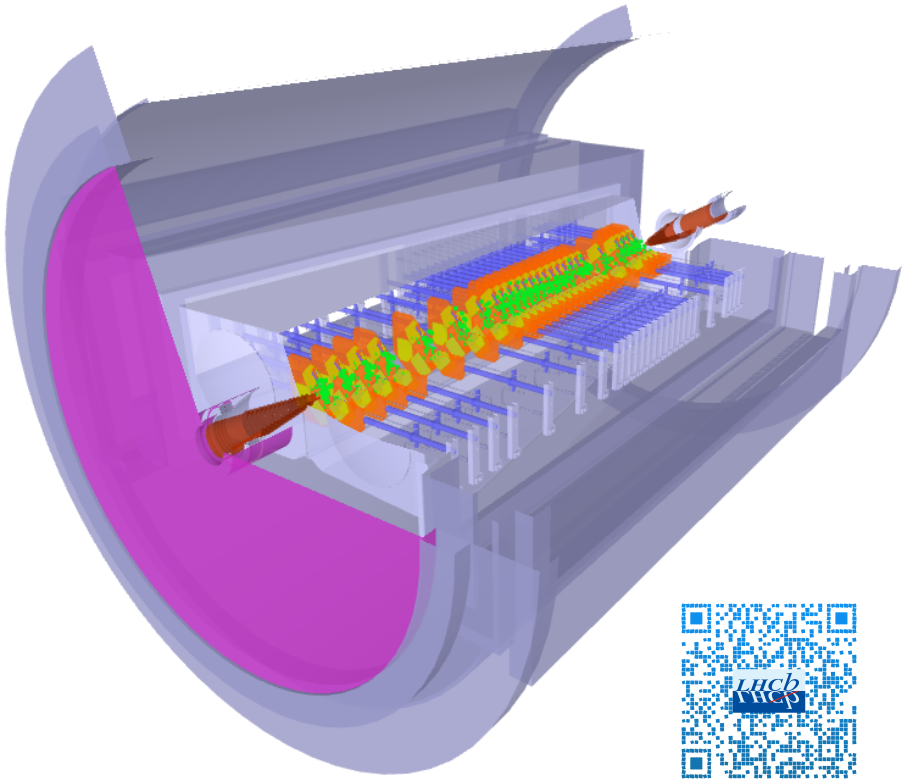


Phoenix, a generic framework

- Experiment agnostic, supported by HSF.
- Main visualization framework of ATLAS.
  - Now also used by LHCb, CMS, FCC...
- Easily extensible, allowing to add and visualize any event data & geometry with ease.
- Allows to visualize HEP experiments in Augmented Reality.
- **Kudos** to the Phoenix team for their amazing framework and support.

Integrating GDML & ROOT geometries

- GDML & ROOT are very common in HEP.
- Phoenix doesn't understand GDML & ROOT format.
- GDML & ROOT to GLTF conversion is needed.



Geometry converter tool

- Web based tool, no need to install locally.
- Import ROOT files via URLs or local ones.
- Display the imported ROOT files on the fly.
- Convert and download the imported ROOT file with a single button press.
- Display the converted file (GLTF) for validation purposes.
- Recently presented at ACAT2021
- Located at: Geometry converter tool

LHCb contributions onto Phoenix

- Extended the set of visualization primitives.
  - e.g. Calorimeter hits.
  - Already used by ATLAS to visualize their CaloCalTopoClusters.
- Improved performance of LHCb geometry visualization.
- Upgraded the geometry to be run 3 compatible.
- Made it relatively easy to visualize new LHCb event data.

Using functional algorithms to "spit out" data

- A new sink has been created.
- The sink receives "automatically" the small JSON data pieces, glues them & outputs into a proper single file.
- The outputted JSON file can be directly displayed into Phoenix.
- Complete working example can be found on the MRs, LHCb/!3241, Moore/!993, Rec/!2537.

Output the little piece of JSON for your own data

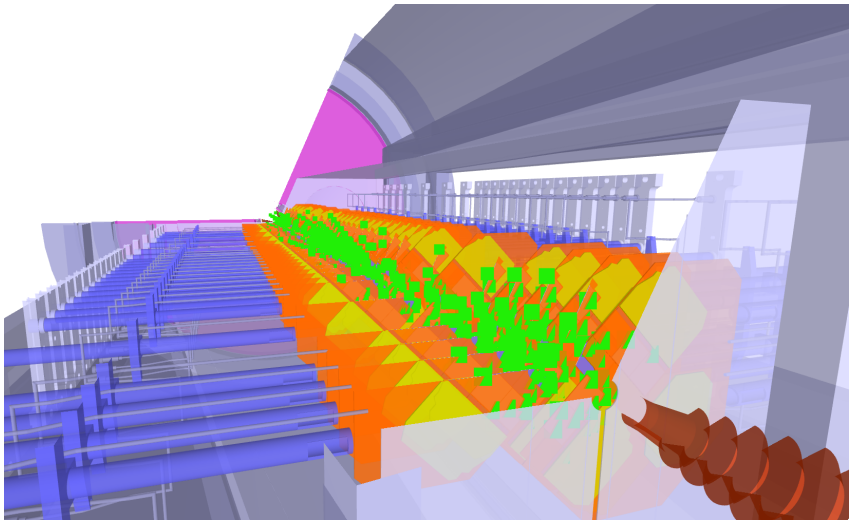
- Write your own 20 lines of C++ code for the desired data.
- Follow the boilerplate code located in Rec/Vis.
- The data should be converted to JSON format and nlohmann C++ framework is used for that purpose.
- Data format guidelines can be found in Phoenix
- Complete working LHCb event data JSON file.

Velo hits event data example

Data representation

```
"Hits": {
  "VPHits": [
  {
    "channelID": 52545260,
    "pos": [
        4.338100433349609,
        -13.067333221435547,
        736.9190063476563
    ]
}
```

Data visualization



Data extraction

```
nlohmann:json j = {};

for ( auto const hit : hits.scalar() ) {
  float x         = hit.template get<LHCb::Pr::Velo::VPHitsTag::pos>().x().cast();
  float y         = hit.template get<LHCb::Pr::Velo::VPHitsTag::pos>().y().cast();
  float z         = hit.template get<LHCb::Pr::Velo::VPHitsTag::pos>().z().cast();
  int   channelID = hit.template get<LHCb::Pr::Velo::VPHitsTag::ChannelId>().cast();

  j += {{"channelID", channelID}, {"pos", {x, y, z}}};
}
```

- Complete code in Rec.

Supported event data by Phoenix

- Phoenix already supports a # of physics objects.
- The new small piece of JSON data, might not be displayed directly.
  - e.g. Calorimeter hits.
- Some extra Javascript code might need to be implemented.
- Phoenix documentation, can be found useful.

Calorimeter data implementation in Phoenix

```
getPlanarCaloCell(caloCells: any): Object3D {
    const position = caloCells.pos;
    const length = caloCells.energy * 0.22;
    const size = caloCells.cellSize;
    const plane = caloCells.plane;

    const boxPosition = new Vector3(
      ...position.slice(0, 2),
      plane[3] + length / 2
    );

    box.position.copy(boxPosition);

    const qrot = new Quaternion();
    qrot.setFromUnitVectors(
      new Vector3(0, 0, 1),
      new Vector3(...plane.slice(0, 3))
    );
  [...]
}
```

- Complete code in Phoenix.

Conclusion

- Phoenix is a modern, ready to use event and geometry visualization.
- It is now used by LHCb and was extended on the way (e.g. new calorimeter visualization).
- It seamlessly integrates with GDML & ROOT geometry thanks to the new converter.
- Even more event data can be added and visualized easily.

Thank you!

References

vCHEP (2021)

The Phoenix Event Display Framework

https://indico.cern.ch/event/948465/contributions/4323946/

CERN-LHCC-2018-007 ; LHCB-TDR-017

Upgrade Software and Computing Technical Design Report

https://cds.cern.ch/record/2310827

ROOT Framework

https://root.cern/

The LHCb Web Event Data & Geometry Display

https://lhcb-web-display.app.cern.ch/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Complete References

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- The Phoenix Event Display Framework vCHEP 2021 (https://indico.cern.ch/event/948465/contributions/4323946/)
- HEP Software Foundation Community White Paper Working Group — Visualization (https://arxiv.org/abs/1811.10309)
- Framework TDR for the LHCb Upgrade, CERN-LHCC-2012-007 ; LHCb-TDR-12 (https://cds.cern.ch/record/1443882)
- Upgrade Software and Computing Technical Design Report, CERN-LHCC-2018-007 ; LHCB-TDR-017 (https://cds.cern.ch/record/2310827)
- HEP Software Foundation (https://hepsoftwarefoundation.org/)
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- ROOT (https://root.cern/)
- DD4hep (https://dd4hep.web.cern.ch/dd4hep/)
- Three.js (https://threejs.org/)
- WebGL (https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API)