Detector geometry management system designed for Super Tau Charm Facility offline software

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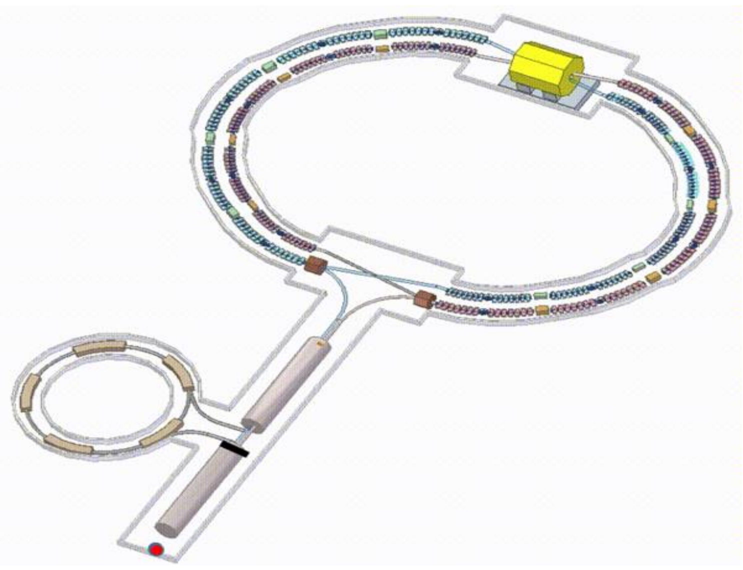
A geometry management system (GMS) is designed for the Offline Software of Super Tau Charm Facility (STCF) in China. Based on the eXtensible Markup Language (XML) and Detector Description Toolkit for High Energy Physics Experiments (DD4Hep), the system provides a consistent detector-geometry description for different offline applications, such as simulation, reconstruction and visualization. It is being used for detector optimization and performance evaluation with a customized full detector simulation package (FullSim). The paper presents the design, implementation, and performance of the GMS.

Introduction

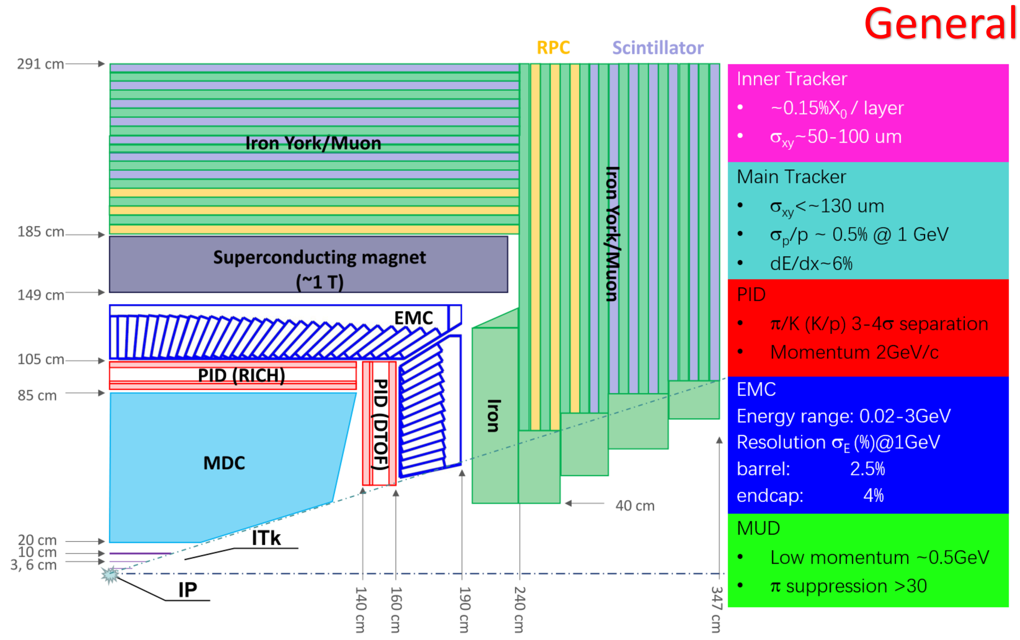


High Intensity Electron Positron Accelerator

Parameter	Value
E_{cm}	2-7 GeV
Luminosity	$(0.5\sim1.0)\times10^{35}cm^{-2}s^{-1}$
Circumference	~ 700m
Current	1.5A

- The Super Tau Charm Facility (STCF) [1] is a proposed high-luminosity electron-positron collider.
- It will operate in the transition interval between nonperturbative and perturbative quantum chromodynamics (QCD).
- The facility is currently in the conceptual design stage of its research and development in China.
- The experimental apparatus at STCF includes a general-purpose detector that probes the final
- state products of positron-electron collisions.

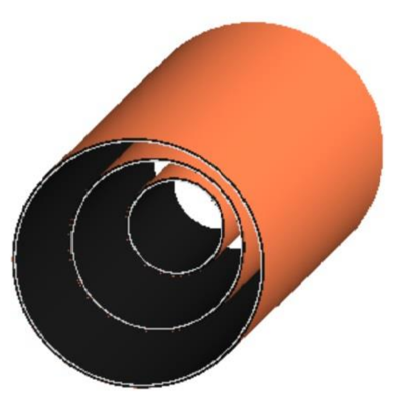
General purpose spectrometer



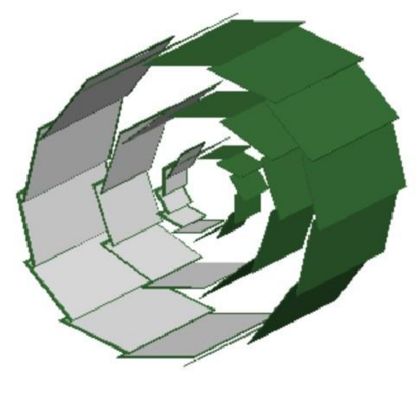
Sub-detector
Inner Tracker
Main Drift Chamber
Ring Image Cherenkov detector
DIRC-like Time Of Flight
Electro-Magnetic Calorimeter
Muon Chamber

Geometry management requirements

- Provide a consistent geometry description for offline applications.
- Provide a unified and user-friendly software environment for detector designers.
- Support flexible geometry combinations of sub-detectors and easy switching among different geometric designs.
- User friendly.



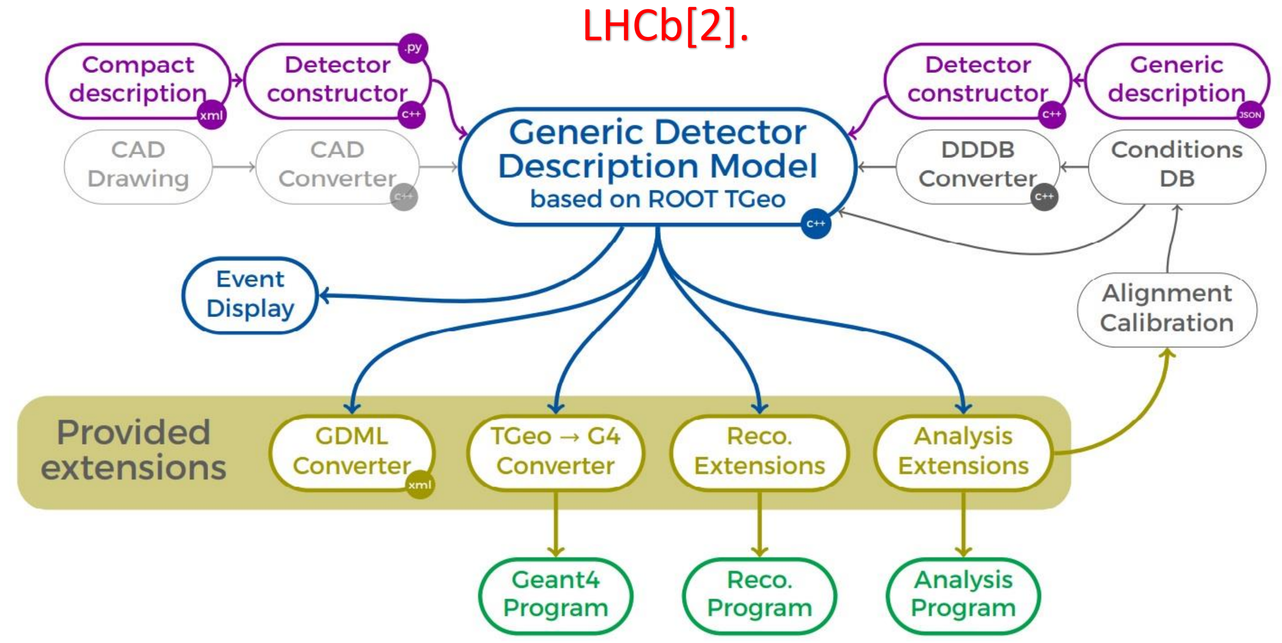
(a)µRWell design option



(b)µRWell design option

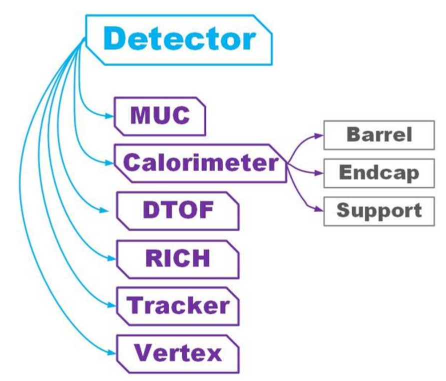
DD4hep

DD4hep: a general Detector Description tool for high energy physics, from LHCb[2].

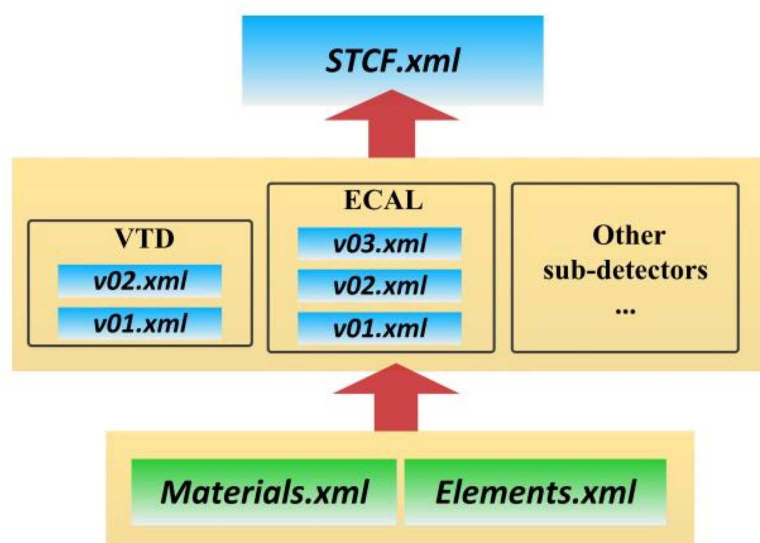


Geometry parameters Repository

Tree-like hierarchy structure

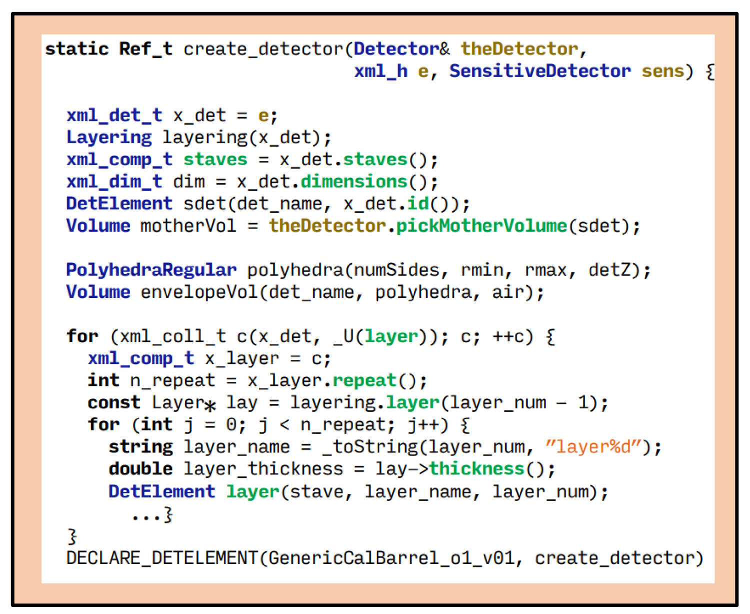


Design of the compact parameter repository

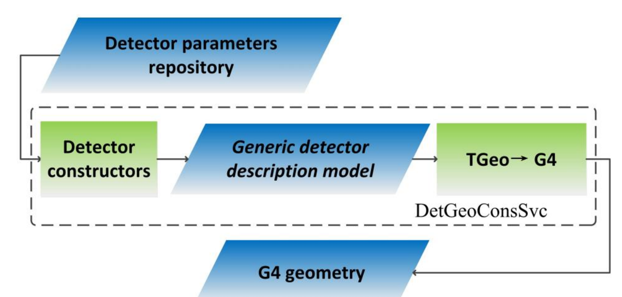


- Elements and materials.
- Volume parameters.
- Display, readout setups.
- Magnetic fields designs…

Design of geometry management system

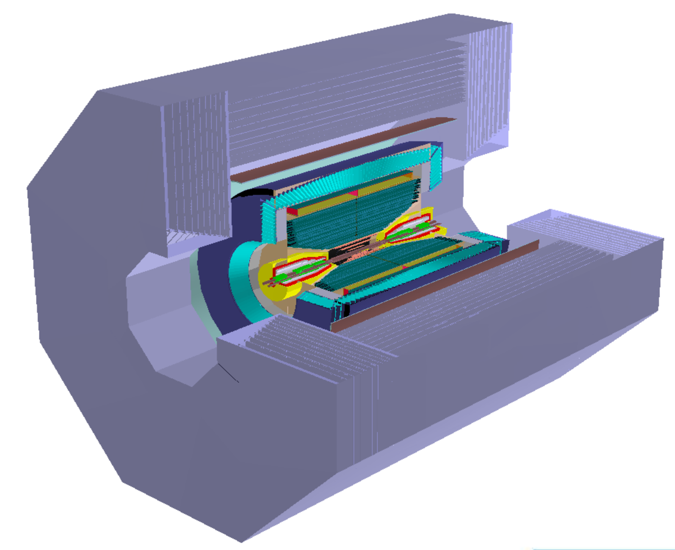


```
static Ref_t create_detector(Detector& theDetector,
                             xml_h e, SensitiveDetector sens) {

  xml_det_t x_det = e;
  Layering layering(x_det);
  xml_comp_t staves = x_det.staves();
  xml_dim_t dim = x_det.dimensions();
  DetElement sdet(det_name, x_det.id());
  Volume motherVol = theDetector.pickMotherVolume(sdet);

  PolyhedraRegular polyhedra(numSides, rmin, rmax, detZ);
  Volume envelopeVol(det_name, polyhedra, air);

  for (xml_coll_t c(x_det, _U(layer)); c; ++c) {
    xml_comp_t x_layer = c;
    int n_repeat = x_layer.repeat();
    const Layer* lay = layering.layer(layer_num - 1);
    for (int j = 0; j < n_repeat; j++) {
      string layer_name = _toString(layer_num, "layer%d");
      double layer_thickness = lay->thickness();
      DetElement layer(stave, layer_name, layer_num);
        ...}
  }
  DECLARE_DETELEMENT(GenericCalBarrel_o1_v01, create_detector)
```



- Detector constructors read and parse the geometry parameters.
- Construction of the generic detector description model.
- the generic detector description model is converted to G4 geometry.

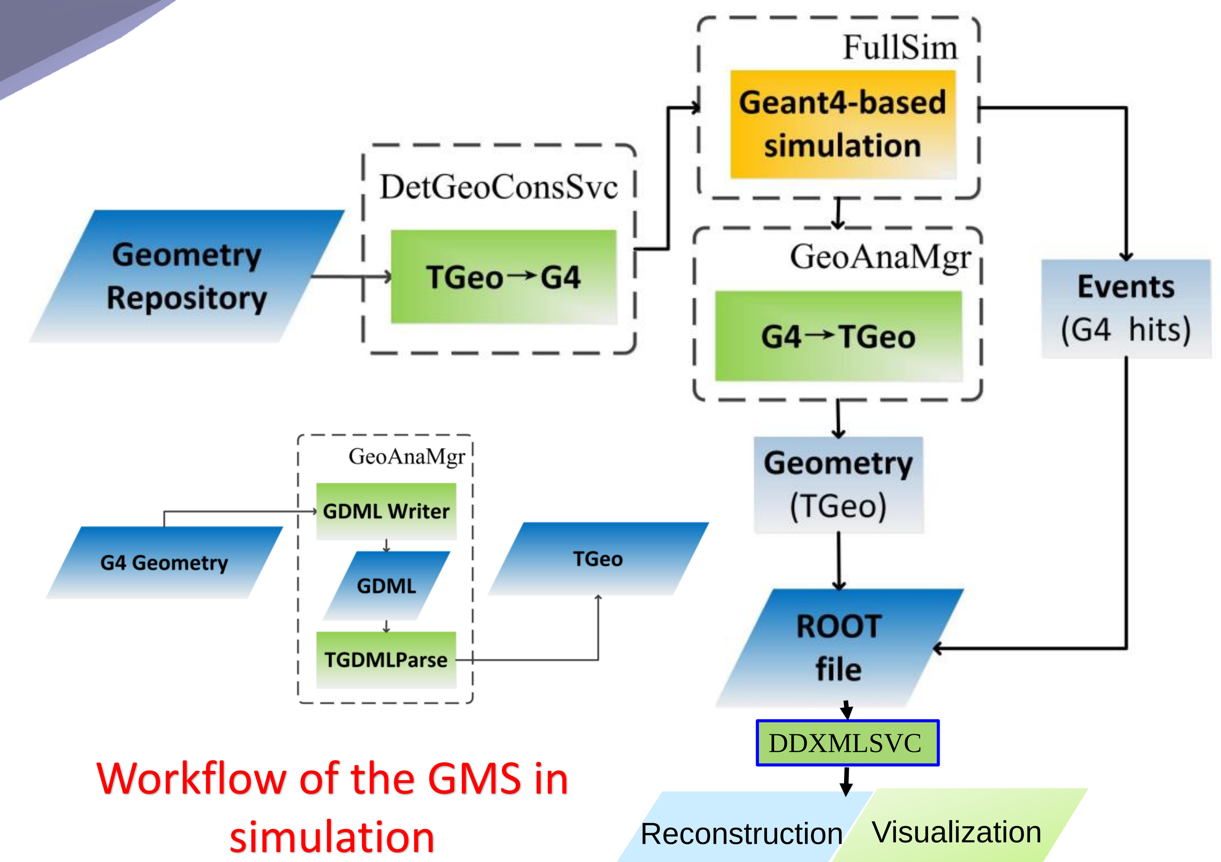
Detector simulation based on the GMS



STCF detector

- Detector model was initialized by the GMS
- After simulation, detector geometry is saved in ROOT file for further usage of reconstruction, visualization

- Easy switch and assembly of different sub-detectors
- Single sub-detector scenario
- Full detector scenario



Workflow of the GMS in simulation

Conclusions and outlook

- GMS was developed in OSCAR to provide a consistent geometry description for different offline applications.
- A unified and user-friendly software environment for detector designers with several SNiPER[3]-Type packages.
- Detector simulations with GMS are performed to help optimize the detector.
- In the future, OSCAR will provide whole capabilities of offline data analysis, and DDXMLSVC is under developing to extract geometric information for simulation, reconstruction and visualization.

References

[1] H.P. Peng,, talk at Charm2018, Novosibirsk, Russia, 21–25 May (2018), pg. 501.
[2] M. Frank, *et al.*, J. Phys. Conf. Ser. 513 (2014) 022010.
[3] JUNO collaboration, J. Phys. Conf. Ser. 898.(2017) 042029