Introduction to Geant4

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Parts

1. Structure and Usage of Geant4 by Chanyoung
2. Hands on Tutorial by Jaeyoung

9th International Geant4 Tutorial in Korea 2022

https://hep0.kisti.re.kr/event/111

All the contents are public, feel free to download.

- You have to ignore the risk to connect KISTI web site.
- If you want to try hands on tutorial, you have to delete hidden files in its directory.
- Those contents may be useless in the next year.

Geant4

Stands for GEometry ANd Topology.

Geant4 is a general purpose Monte Carlo simulation tool for elementary particles passing through and interacting with matter.
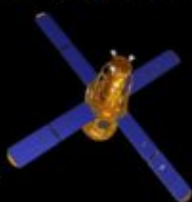
For the particle physicists, Geant4 is the detector simulation toolkit.
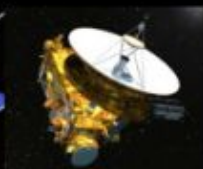
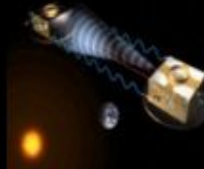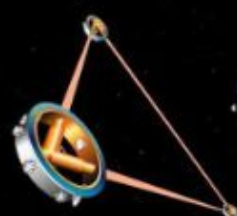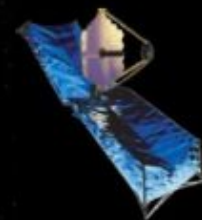All the particle accelerators use Geant, no exceptions.

Geant4 in space

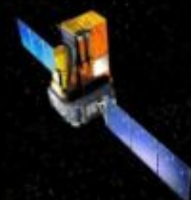Akebono RHESSI ACE New Horizons LISA Pathfinder LISA JWST INTEGRAL
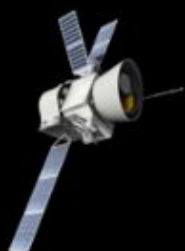
Messenger Fermi SOHO Herschel Cassini

BepiColombo Astro-H GAIA
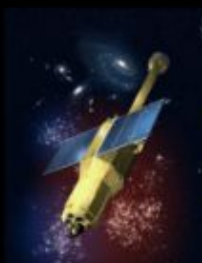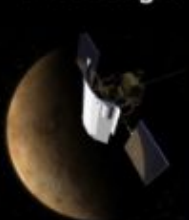
JUNO Kaguya

Suzaku SWIFT XMM-Newton JUICE Chandrayaan-1 Chandrayaan-2
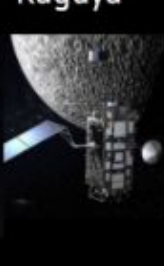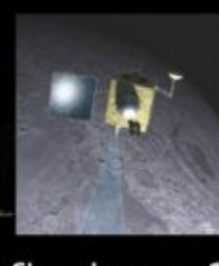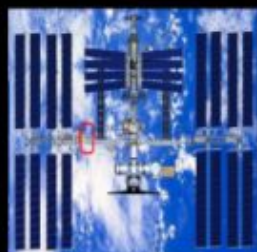
Columbus EUSO AMS MAXI ConeXpress Chang'e-1 LRO
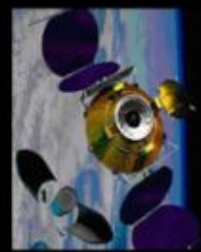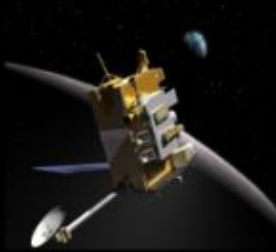
Geant4 @ Medical Science

- Four major use cases
    - Beam therapy
    - Brachytherapy
    - Imaging
    - Irradiation study
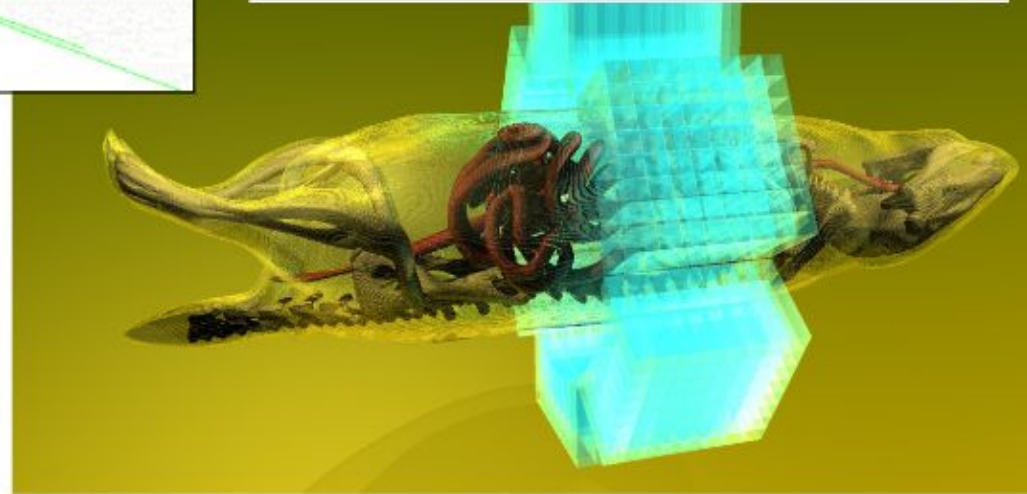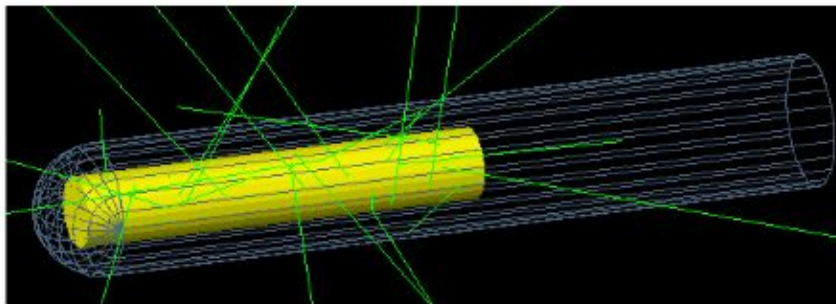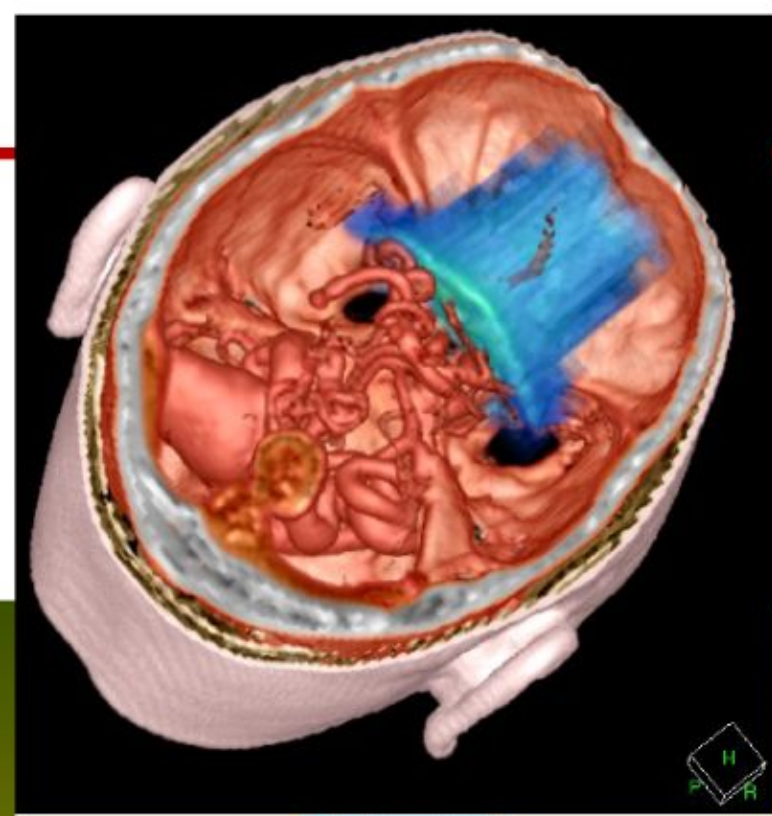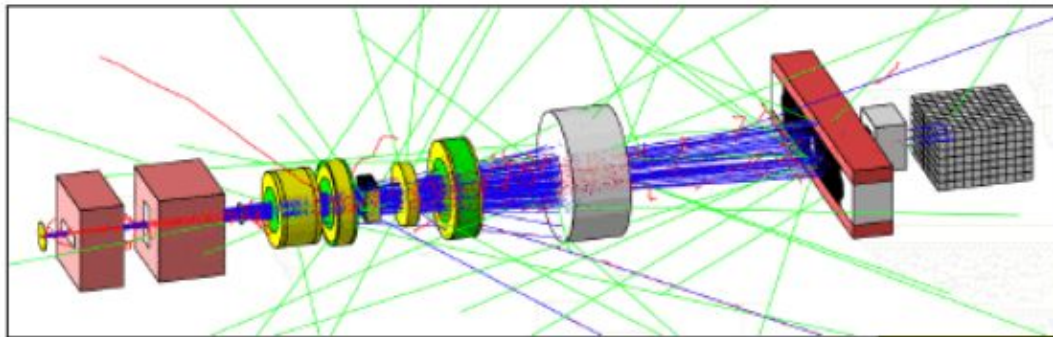
Geant4

Consists of...

1. Geometry
2. Physics List
3. Scoring

Geometry

Geometry

- G4VSolid
  - shape, size
- G4LogicalVolume
  - daughter physical volumes, material, user limits, etc.
- G4VPhysicalVolume
  - position, rotation

G4VSolid

Defines shape and size.

Various shapes are pre-defined with classes.
G4Box, G4Tubs, G4Cons, G4Sphere, G4Torus, etc.

You can import GDML or CAD.

G4VSolid

```
G4Tubs(const G4String& pName,
             G4double  pRMin,
             G4double  pRMax,
             G4double  pDz,
             G4double  pSPhi,
             G4double  pDPhi)
```
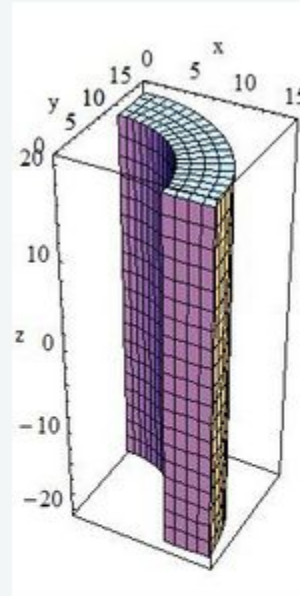

In the picture:

pRMin = 10, pRMax = 15, pDz = 20

G4LogicalVolume

G4LogicalVolume(**G4VSolid* pSolid**,
                             G4Material* pMaterial,
                             const G4String& Name,
                             G4FieldManager* pFieldMgr=0,
                             G4VSensitiveDetector* pSDetector=0,
                             G4UserLimits* pULimits=0,
                             G4bool Optimise=true
)

G4LogicalVolume

Only placement remains, but we can do something different.

- Logical Volume can be a root logical volume of a region.
- The region can be copied or divided to construct physical volumes.

```
G4PVReplica( const G4String&       pName,
             G4LogicalVolume*      pCurrentLogical,
             G4LogicalVolume*      pMotherLogical, // OR G4VPhysicalVolume*
       const EAxis                 pAxis,
       const G4int                 nReplicas,
       const G4double              width,
       const G4double              offset=0 )
```

G4VPhysicalVolume

G4PVPlacement(**G4Transform3D solidTransform**,
                    G4LogicalVolume* pCurrentLogical,
                    const G4String& pName,
                    G4LogicalVolume* pMotherLogical,
                    G4bool pMany,
                    G4int pCopyNo,
                    G4bool pSurfChk=false
)

Physics Lists

Physics Lists

G4VProcess defines how the particle interacts with the matter.

Physics List is the composition of those processes.

High Prec. Particle	QMD (ion-ion)
LEND	Wilson Abrasion
High prec. neutron	Photo-nuclear, eletro-nuclear

Eletro-nuclear dissociation

Evaporation
Fermi breakup
Multifragment
Photon Evap
Pre-compound

Quark Gluon string
Fritiof string

INCL++
Binary cascade
Bertini-style cascade

1 MeV   10 MeV   100 MeV   1GeV   10 GeV   100 GeV   1TeV
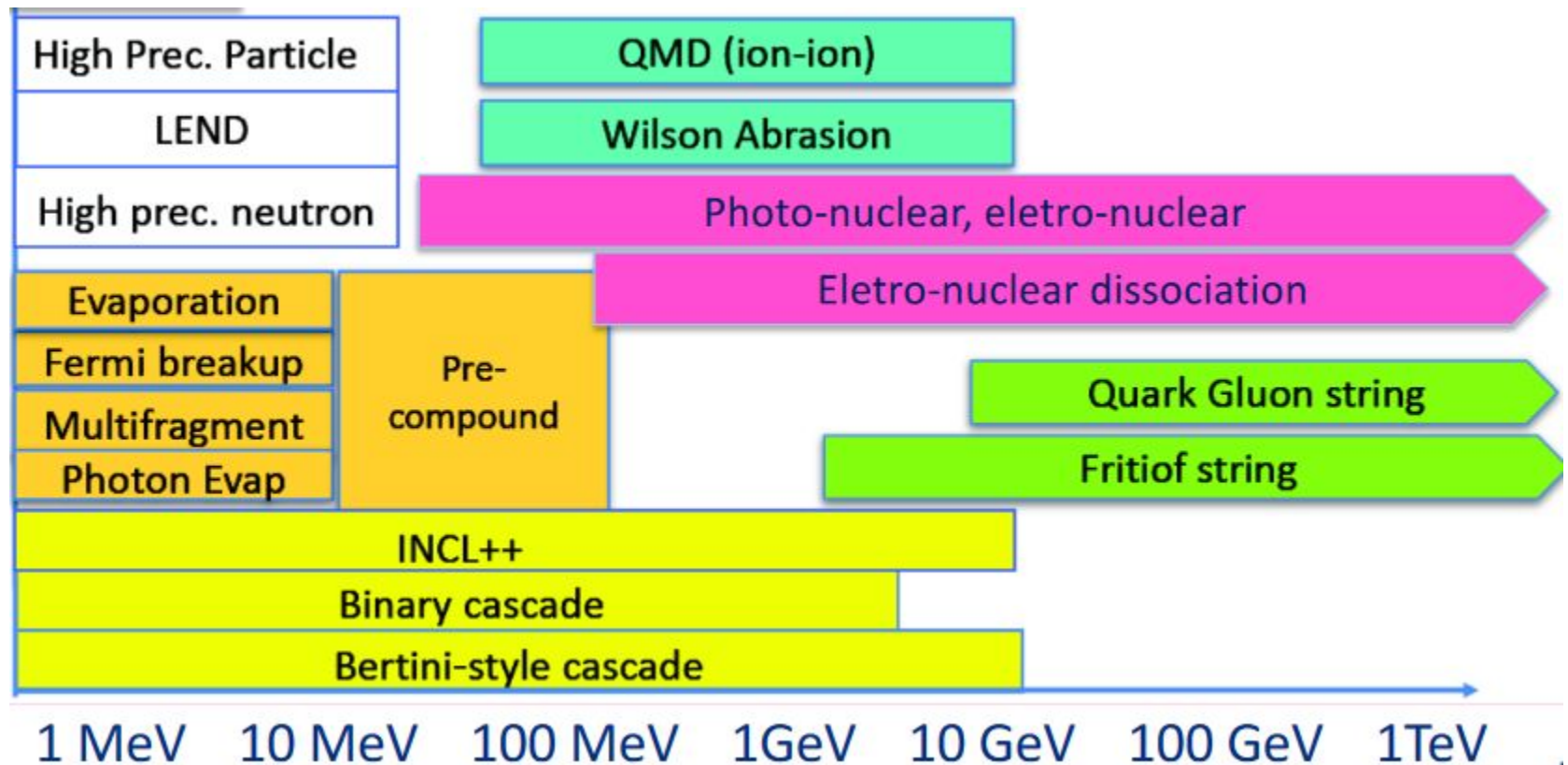
Physics Lists

The default list is FTFP_BERT. If you simulate the particle accelerator, use the default setup.

LHC also uses the modified FTFP_BERT.

But if you simulate low energy facility, under ~1 GeV, then you should test which list fits for your case.

Scoring

Track and Step

G4Track is a snapshot of a particle. It has physical quantities of current instance only.

G4Step stores the change between two point, PreStepPoint and PostStepPoint.

Track is not a set of steps. Track is updated by step.

Sensitive Detector

A tracker typically generates a hit for every single step of every single charged track.

A calorimeter typically generates a hit for every cell, and accumulates energy deposition in each cell for all steps of all tracks.

How to

How to install

Install via package managers.

conda, spack, AUR, and etc…

conda has an issue:
    if you have installed root via conda, root won't run after geant4 installation.
    solution: separate the environment or not to install via conda.

How to install

Build from source.

Geant4 follows the modern C++ standard quite rapidly, so you may have to install dependencies manually, including compilers and XML parsers.

How to install

Do not forget to install external data.

- if you have set the option GEANT4_INSTALL_DATA to ON while installing, no problem.
- if not, you have to download and extract data files manually from https://geant4.org/support/download.html

Use QT for visualization if you don't have any preference.

Do not Reinvent the Wheel

Under {prefix}/share/Geant4-{version}/examples/, you have the best practices.

Copy and paste the one similar to your case and modify the source code or macro.

Details of examples:
https://geant4-userdoc.web.cern.ch/UsersGuides/ForApplicationDeveloper/html/Examples/examples.html