ALICE's Experience with Geant4, Geant3 and Fluka

14th Geant4 Users and Collaboration Workshop, Catania

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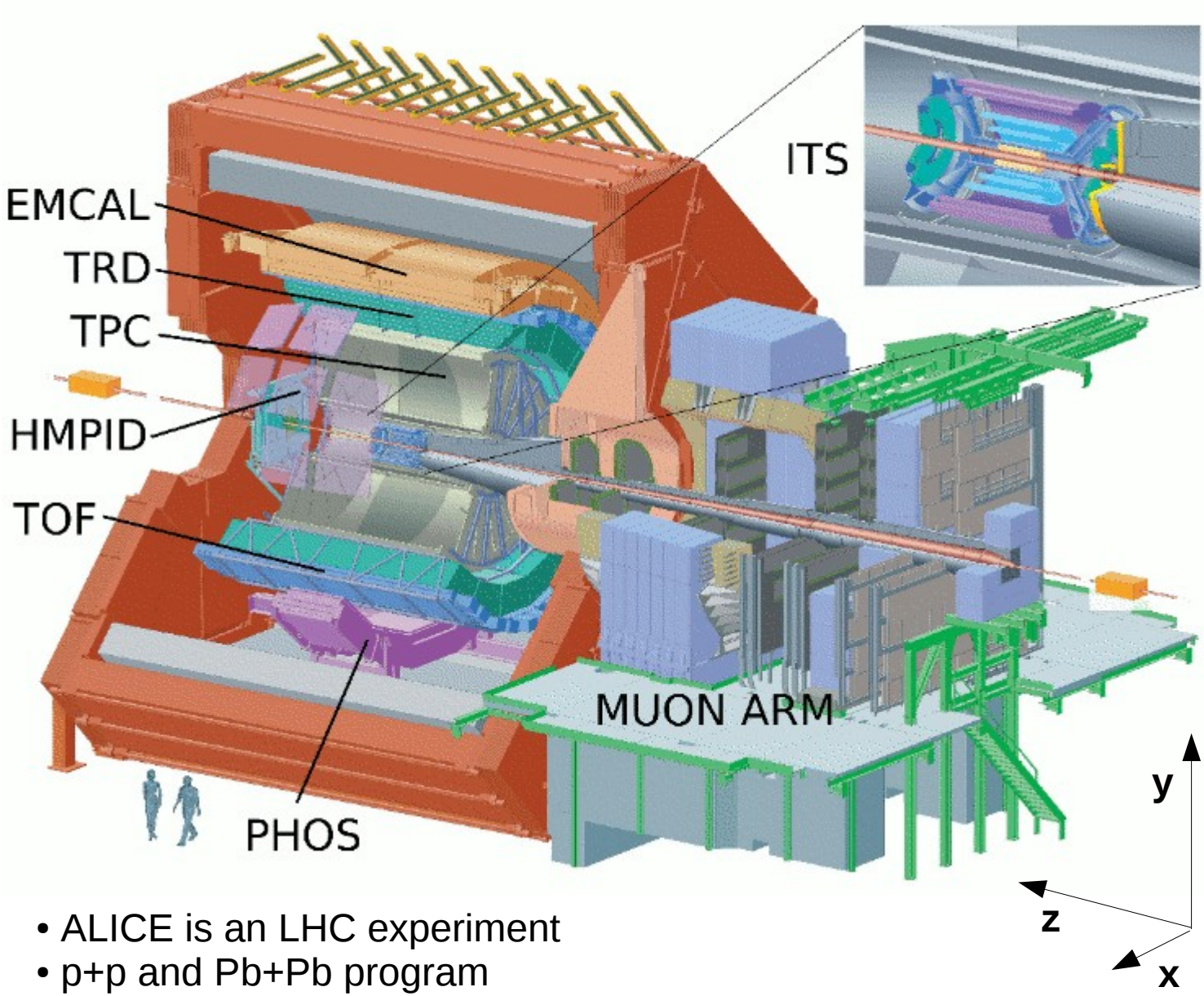
A Large Ion Collider Experiment



Detectors:

- **I**nner **T**racking **S**ystem
  tracking detector, measures secondary vertex, open heavy-flavor, c and b

- **T**ime **P**rojection **C**hamber
  tracks and identifies charged particles, (e,μ), π, K, p, largest TPC!

- **T**ransition **R**adiation **D**etector
  identifies electrons above 1 GeV, fast trigger (6μs)

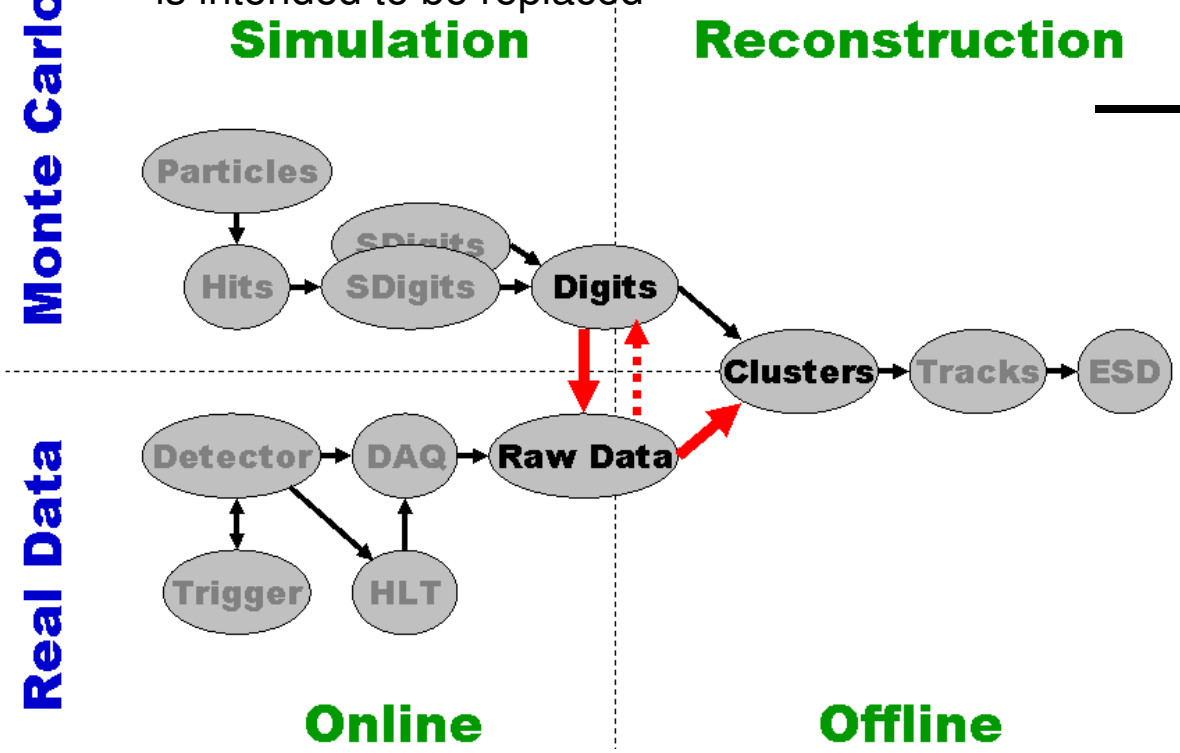
- **T**ime **O**f **F**light
  charged particle identification

- and many more...

- ALICE is an LHC experiment
- p+p and Pb+Pb program
- investigates strong interacting matter, quark-gluon plasma

ALICE's Software Framework

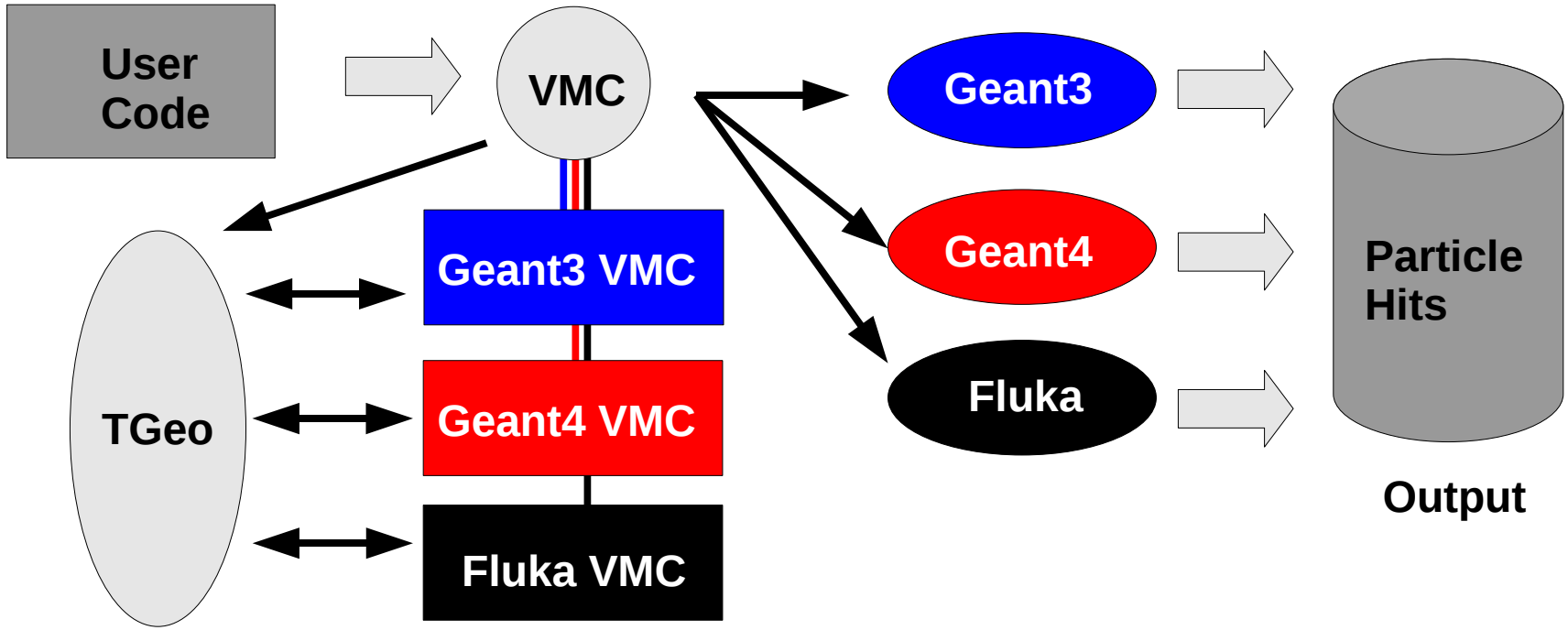
- AliRoot - ALICE offline framework for simulation, reconstruction and analysis
- ROOT as framework and **Geant3** as transport Monte Carlo (currently used in production)
  - **Geant3** is not maintained anymore and is intended to be replaced
- Virtual Monte Carlo (VMC)
  - allows user to develop just one MC application which runs with several transport codes
  - implemented for **Geant4**, **Geant3** and **Fluka**



compare Monte Carlos using

- hits and their energies
- sdigits
- digits
- clusters
- ...

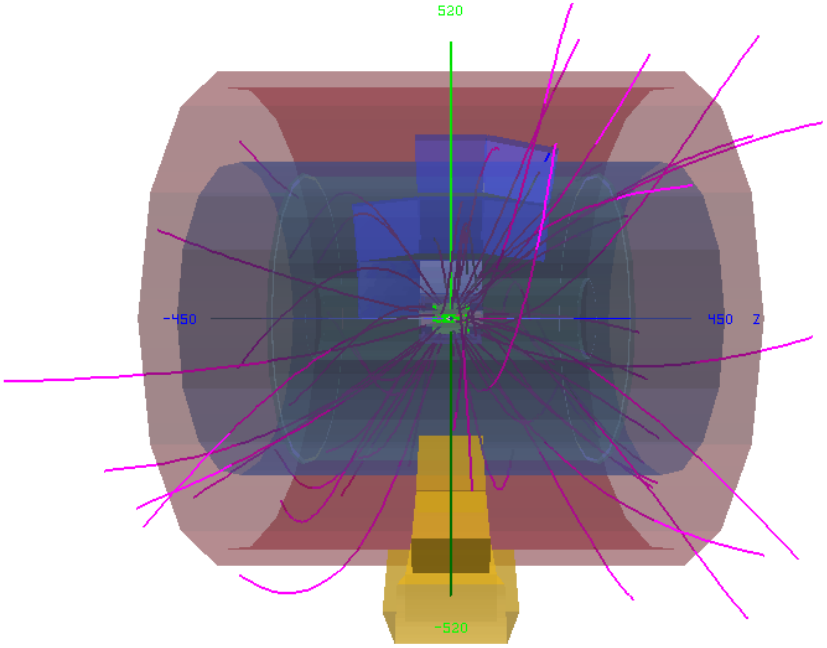
Virtual Monte Carlo (VMC)



- VMC is part of ROOT and provides abstract interface to transport codes
- VMC is implemented for **Geant4**, **Geant3**, and **Fluka**
- user code is independent from used MC
- **Geant4**/**Geant3**/**Fluka** VMC packages are distributed separately from ROOT via ROOT web site

Comparison Setup & Monte Carlos

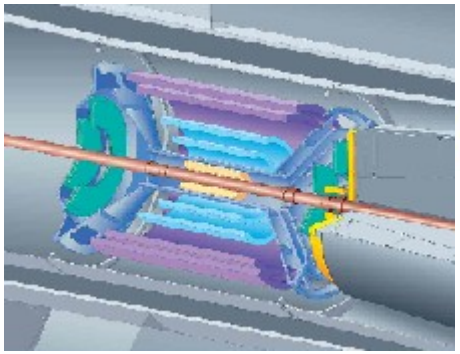
- p+p collisions simulated within ALICE framework
- 100 PYTHIA events with same set of primary particles, √s=14 TeV
  - **G4/G3** also 500 events
- AliRoot v4-17-Release



- **Geant4**
  - 9.2.p0, physics list "QGSP_BERT_EMV"
  - **geant4_vmc**
    - trunk revision 412
    - Ivana Hrivnacova (IPN Orsay)
- **Geant3**
  - geant321+_vmc v1-10
- **Fluka**
  - based on Fortran, slow but precise
  - "**Flu**ktuierende **Ka**skade"
  - fluka2008.3b-linuxAA
  - **fluka_vmc**
    - trunk revision 45

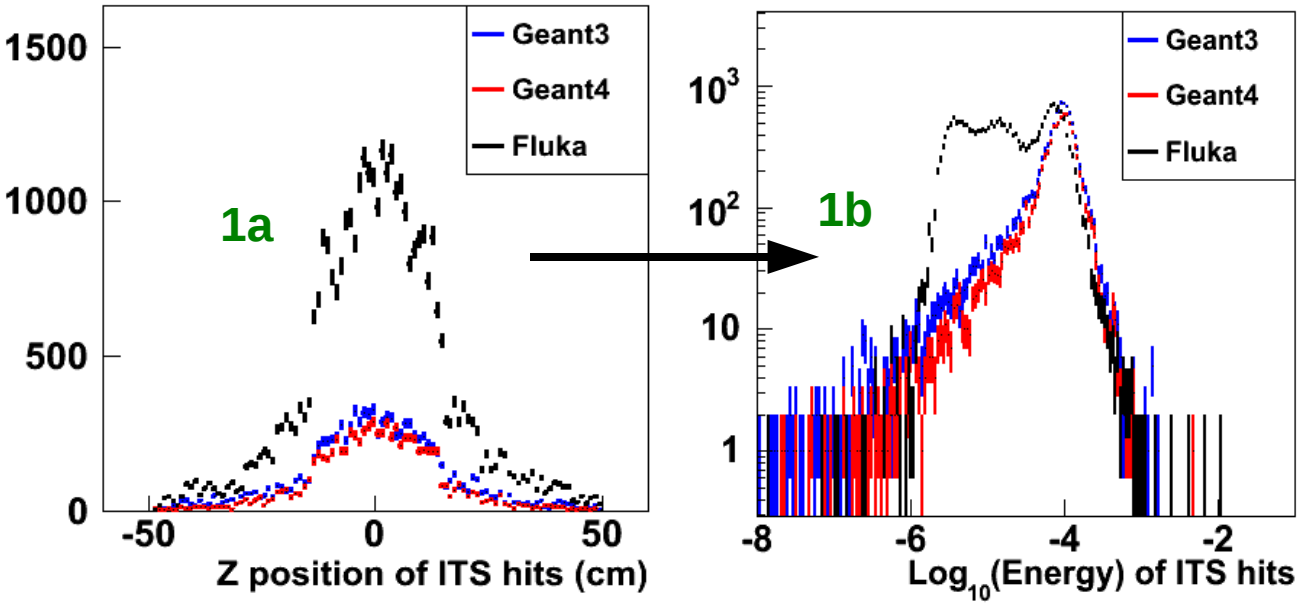
• cuts are applied via VMC in Geant3 way, and they are considered in all MCs

Inner Tracking System (ITS)



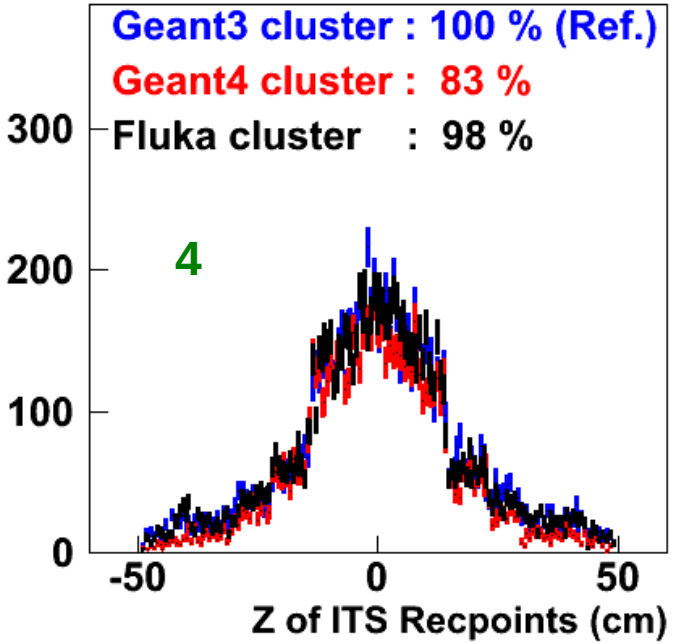
ITS: build out of 3 sub-detectors

Fluka produces many hits, but many of them have low energy deposit



MCs have different accuracies

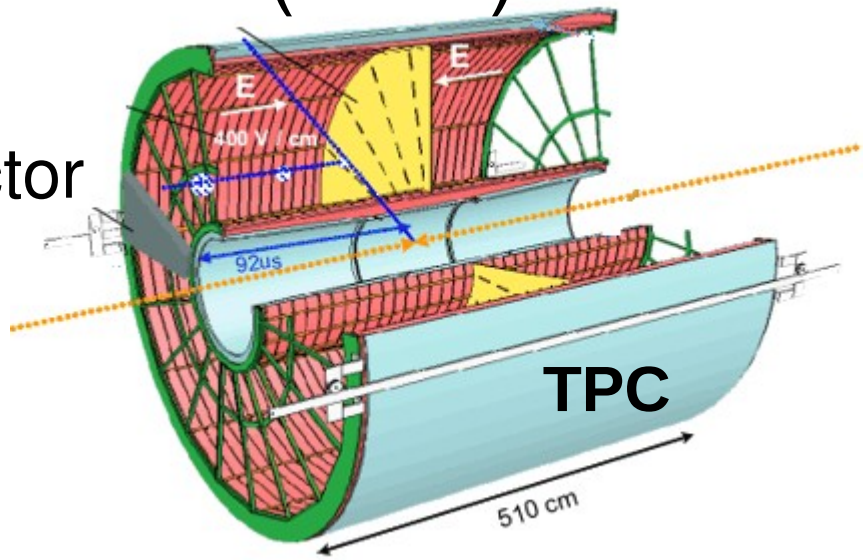
over SDigits (**2**) and Digits (**3**), nearly the same amount of clusters is generated



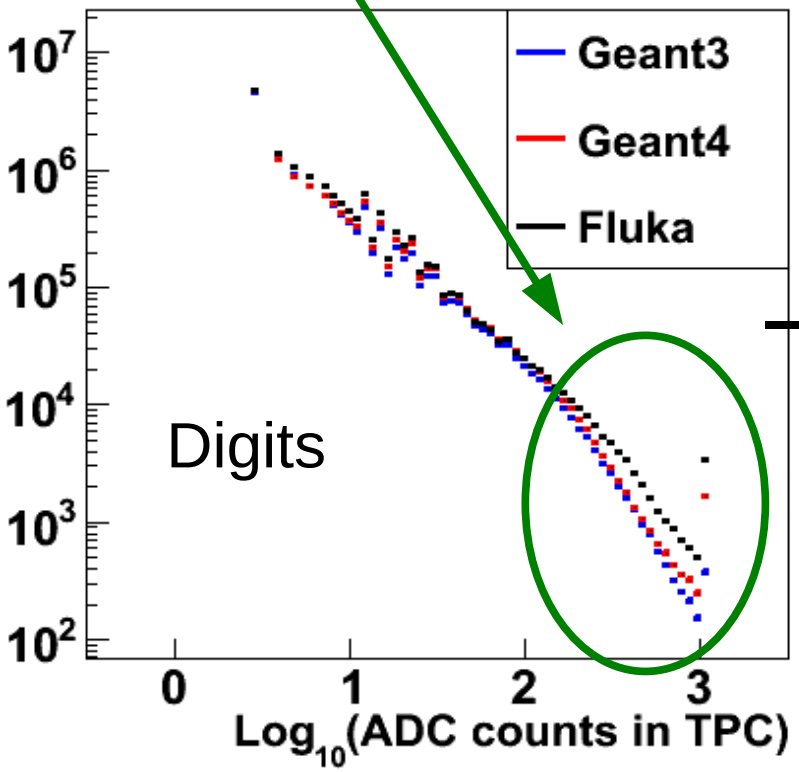
Geant4 generates lower number of clusters

Time Projection Chamber (TPC)

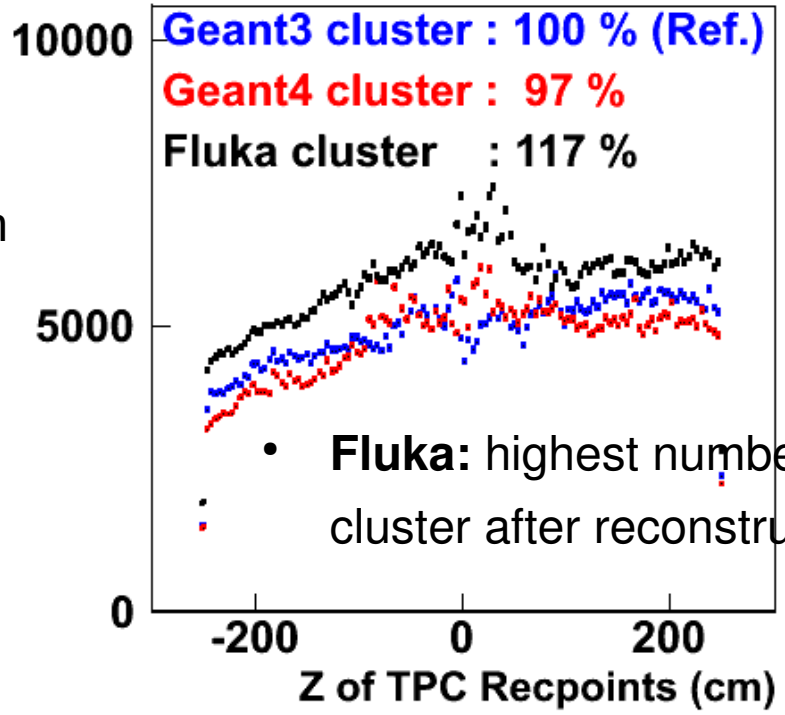
- ALICE's main tracking detector



- **Fluka** differs from **Geant3** and **Geant4** results at high numbers of ADC counts

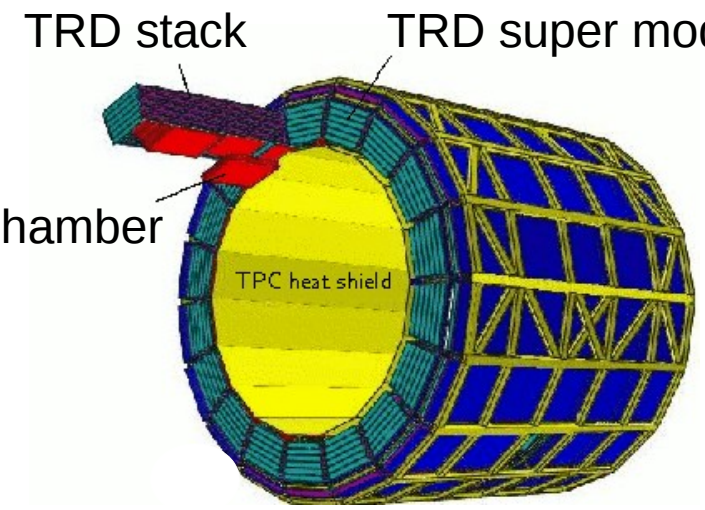


reconstruction



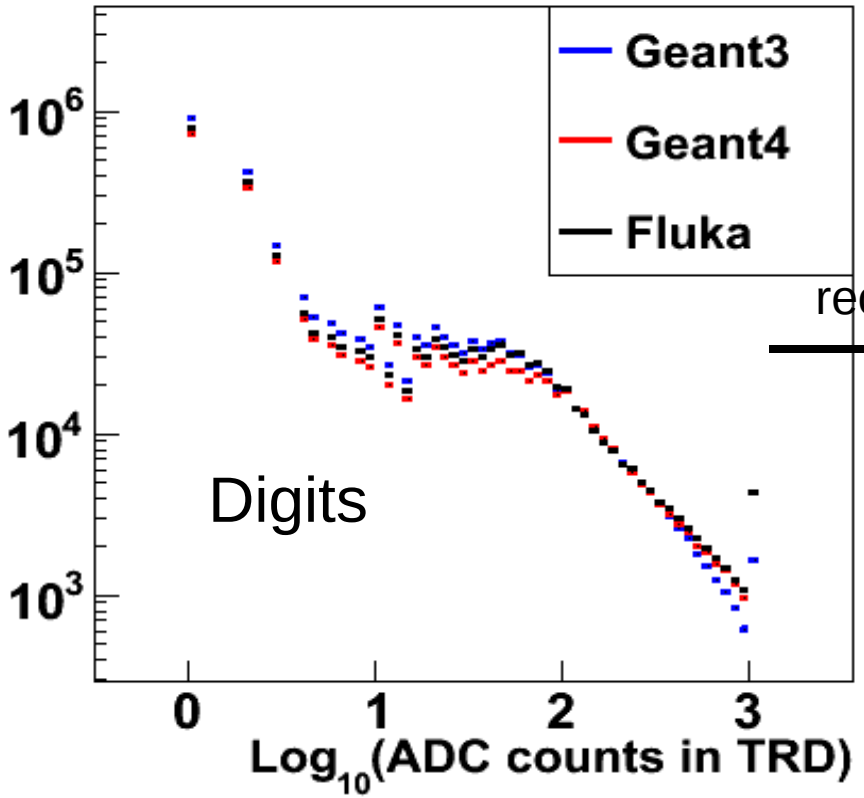
- **Fluka:** highest number of cluster after reconstruction

Transition Radiation Detector (TRD)

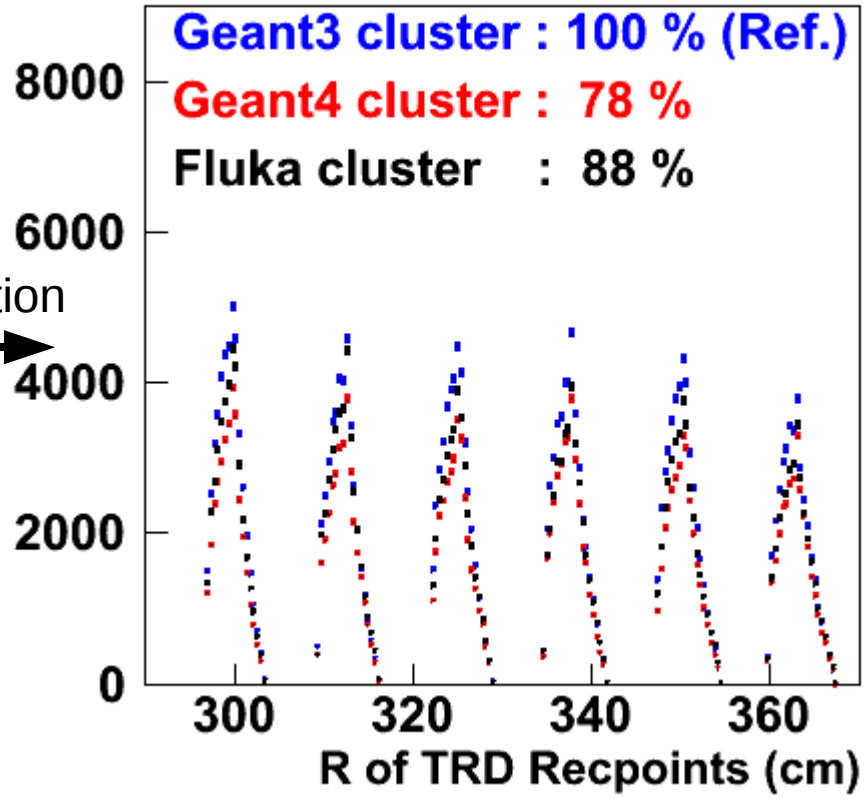


at low number of ADC channels, lower number of **Geant4** and **Fluka** counts

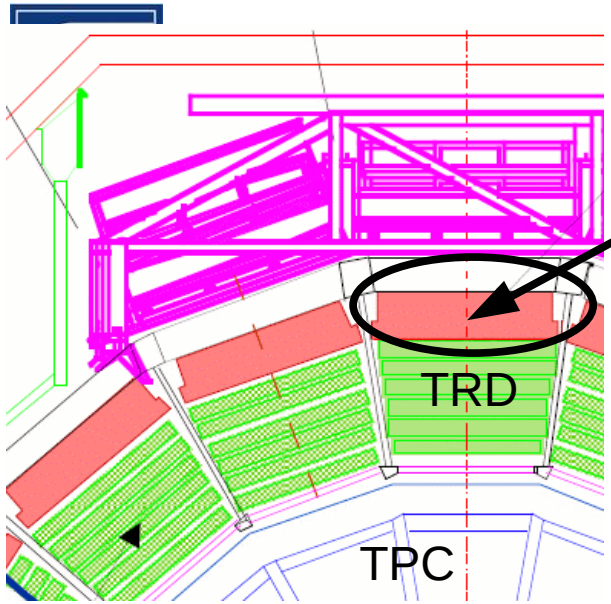
- **Geant4:** lowest number of clusters after reconstruction

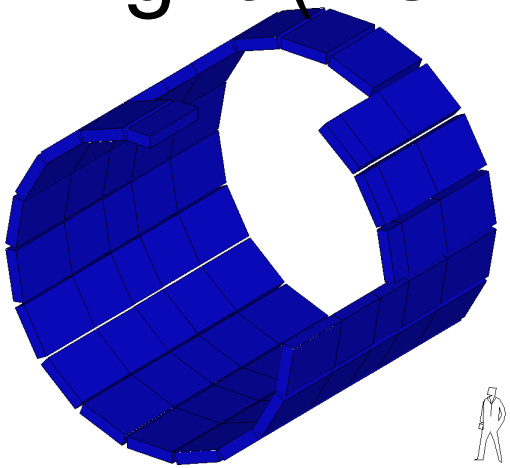


reconstruction

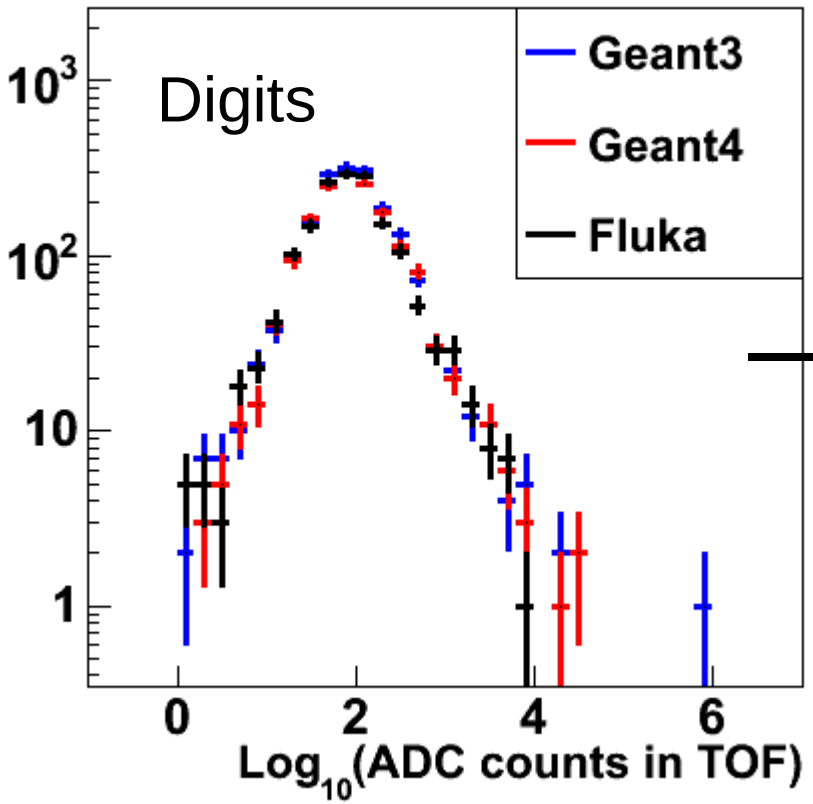


Time Of Flight (TOF)

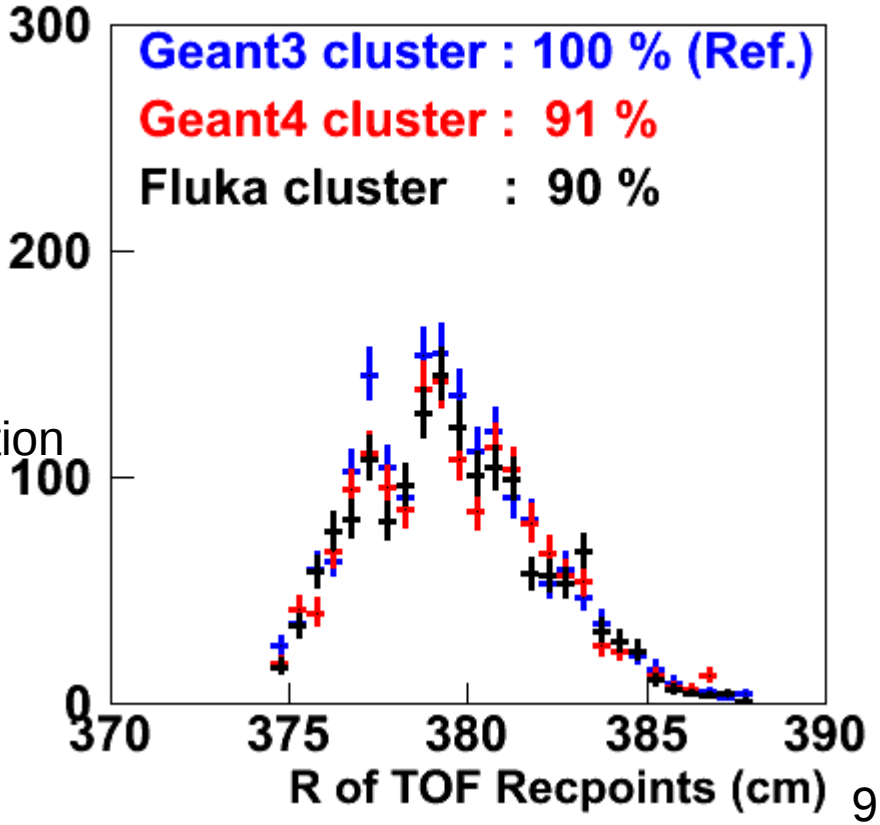




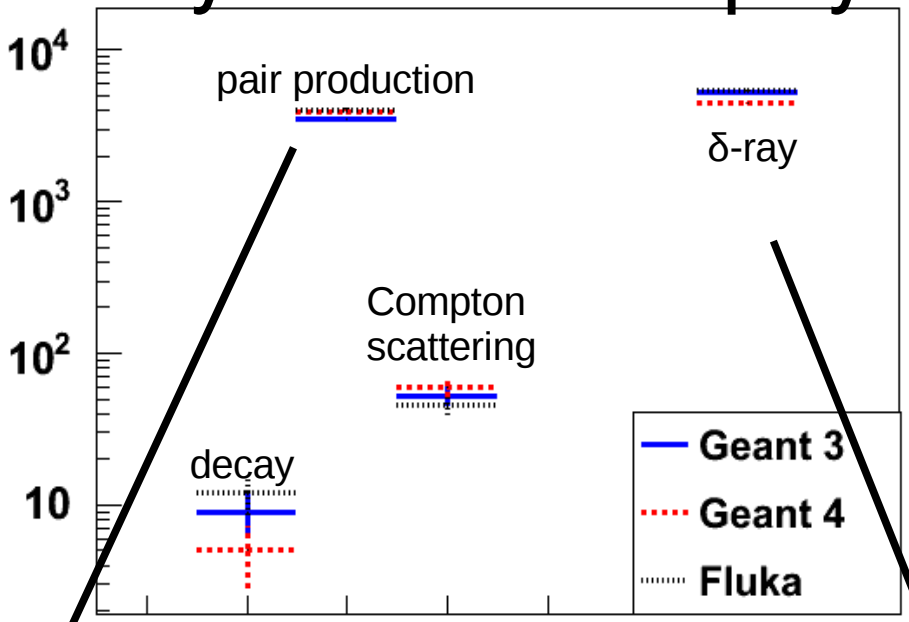
- ~10 % less **Geant4** and **Fluka** clusters compared to **Geant3**

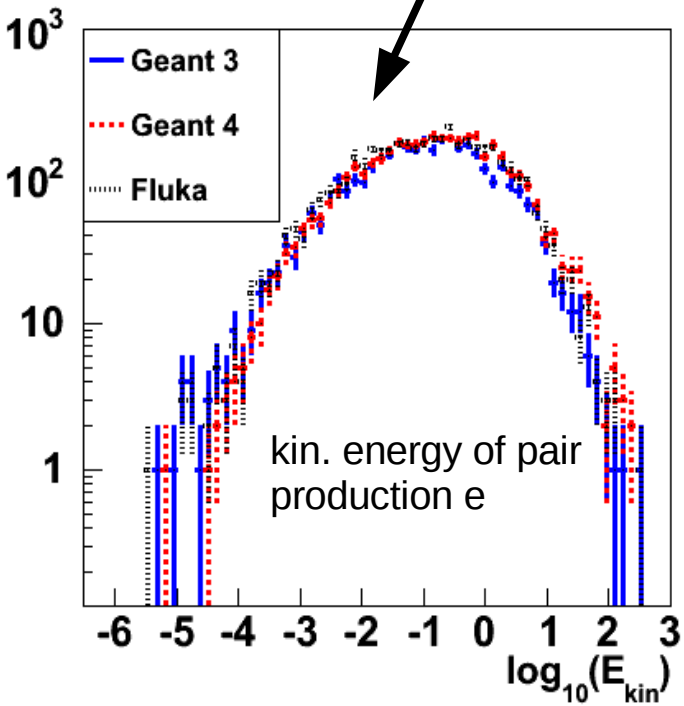


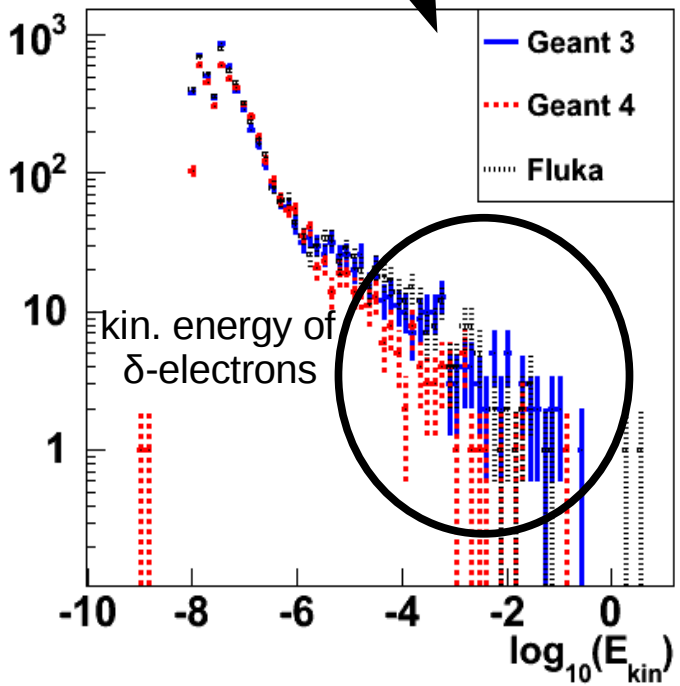
reconstruction



Secondary electrons - physics processes



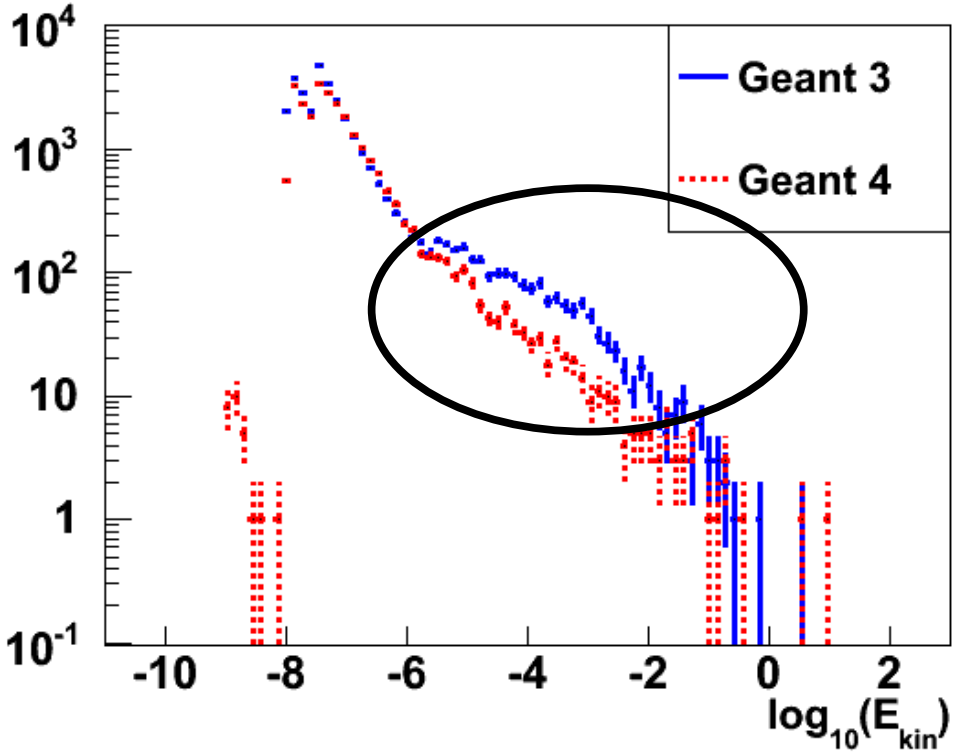




- good agreement on
  - number of particles produced with different processes
  - energy distribution of those particles

Ekin in GeV

δ-ray electrons of 500 G3/G4 events



- 2 times less entries for **Geant4** in energy region > 10^{-6} GeV
- under investigation

E_{kin} in GeV

Time consumption

- simulation with same set of primary particles within complete ALICE setup
  - **Geant3**: 8.8 min./event
  - **Geant4**: 19.5 min./event
  - **Fluka**: 110.1 min./event

x 2.2

x 12.5

System:
SLC 5.4, 64 bit
AMD Phenom, 4Core, 2 GHz
4 Gb RAM
compilation: gcc 4.1.2
options: -O2 -g -m32

But:
- 42 min./event of **Fluka** simulation are used for ZDC
- ZDCs are located 115 meters away from the interaction point on both sides
- optimization ongoing

Summary

- **Geant3** is intended to be replaced in ALICE simulations by another MC
  - soonest after the first data of LHC
- **Geant4**, **Geant3**, and **Fluka** are implemented via VMC
  - get **Geant4** and **Fluka** ready for production
- all simulation and reconstruction results are similar within ±20%
  - real collision data will help to tune the MCs

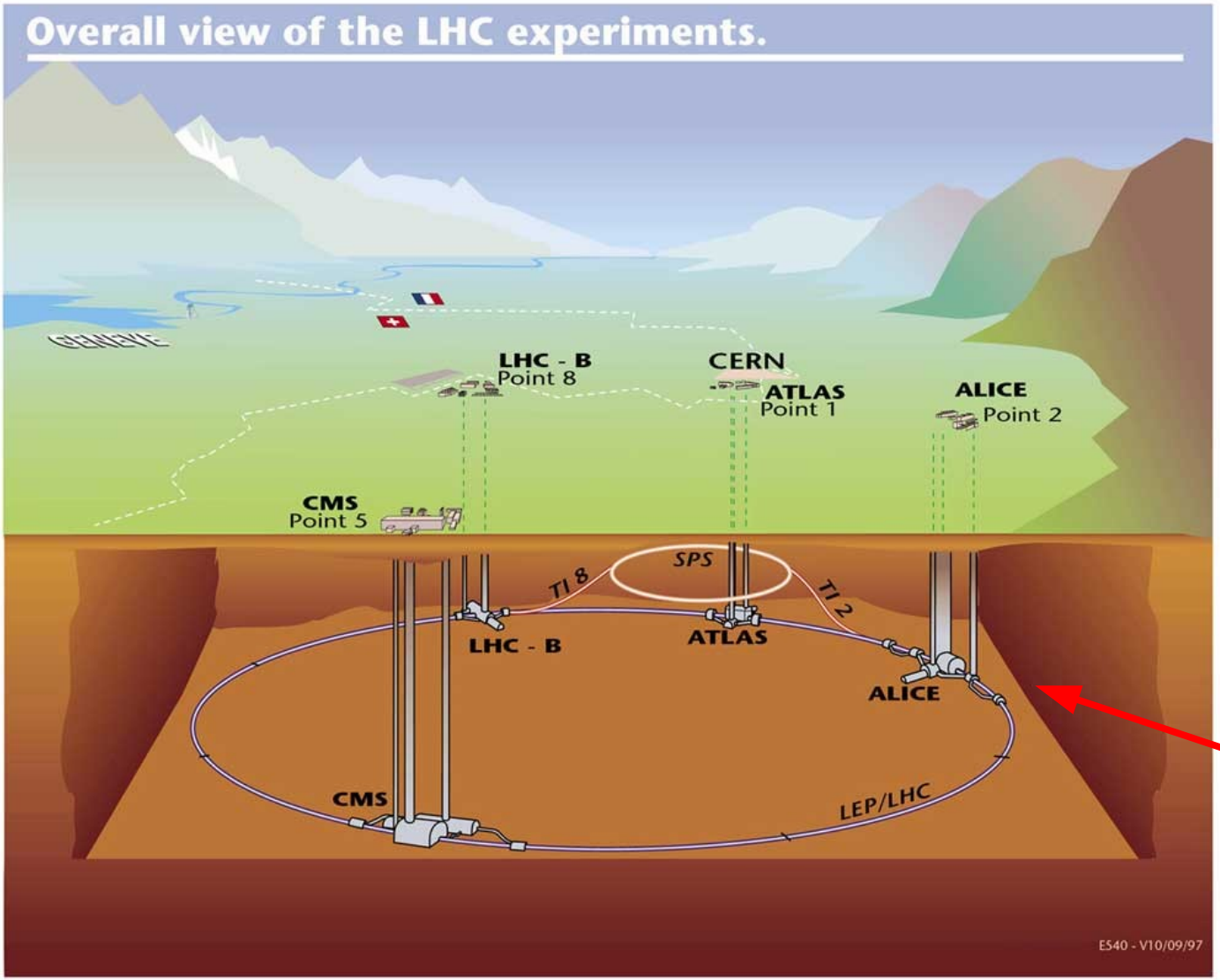
- **Fluka**
  - 12.5 times of G3 simulation duration
  - ±20% difference to G3 cluster number

- **Geant4**
  - 2.5 times of G3 simulation duration
  - up to -20% difference to G3 cluster number
  - investigate/develop physics lists, requirement Cerenkov process

Thanks a lot, Ivana Hrivnacova!

Backup

LHC @ CERN



CERN
Conseil Européen pour la Recherche nucléaire

LHC
Large Hadron Collider, 27 km circumference, p+p and heavy ions

ALICE
A Large Ion Collider Experiment
- 30 countries
- ~1000 members