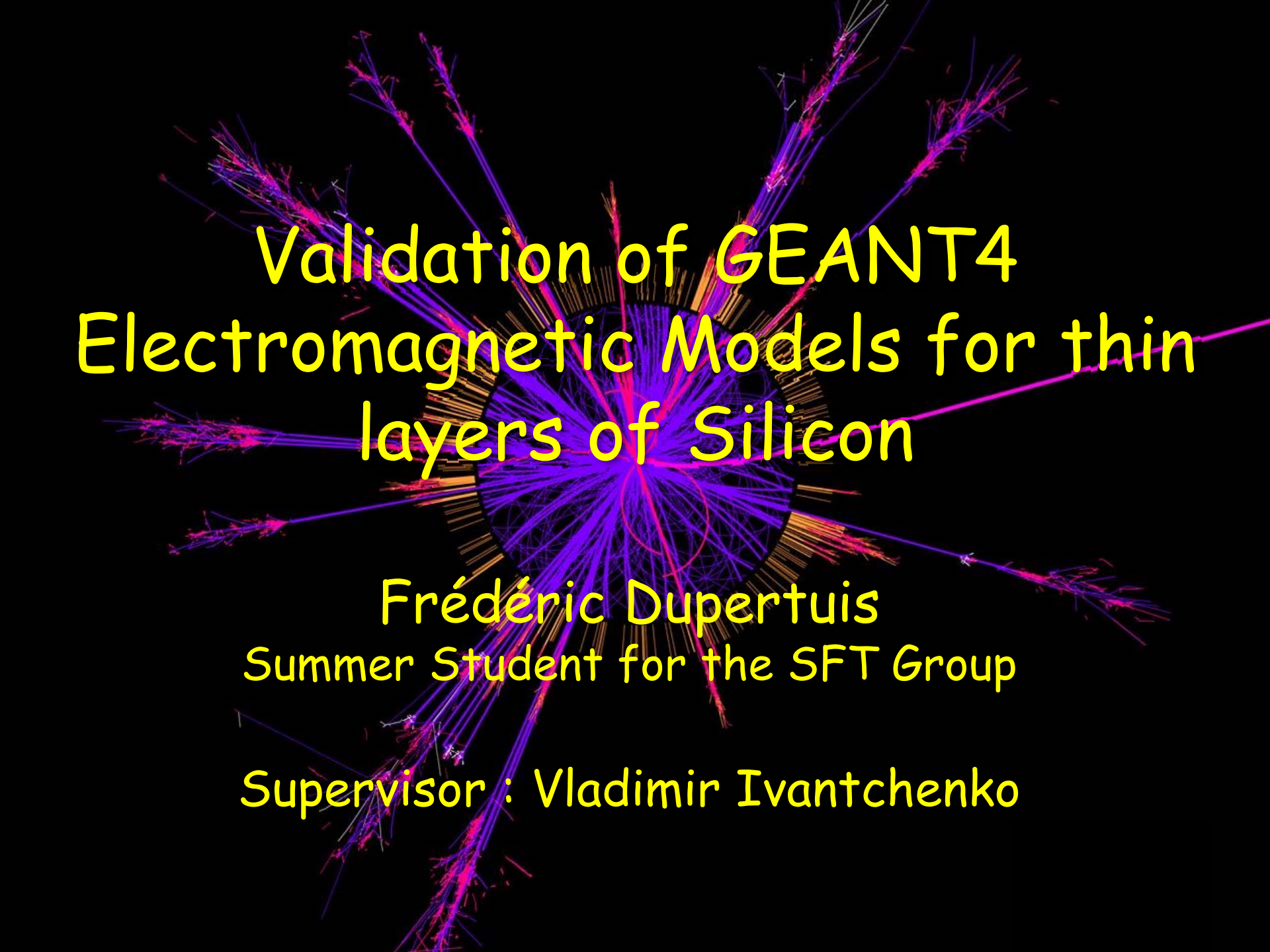

Validation of GEANT4 Electromagnetic Models for thin layers of Silicon

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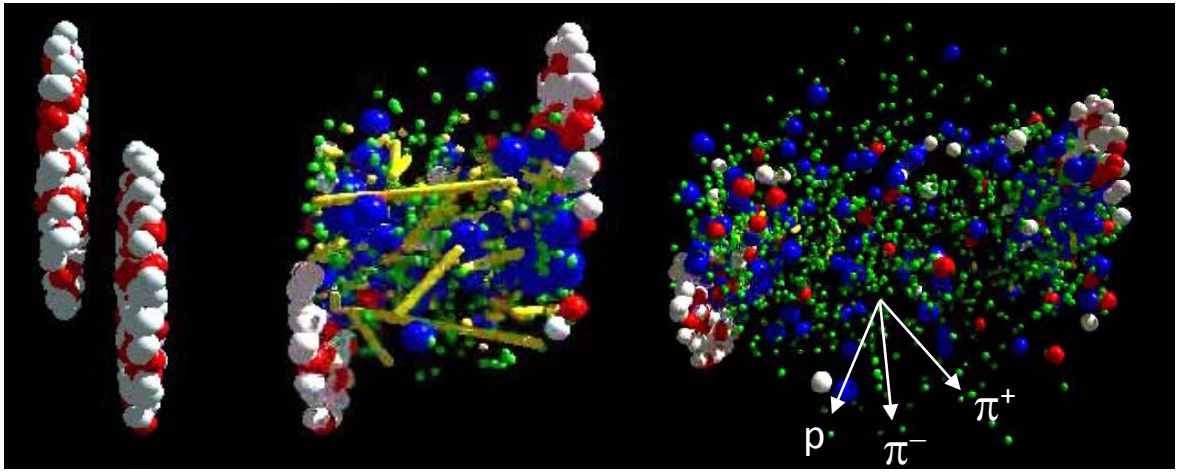
Summer Student for the SFT Group

Supervisor : Vladimir Ivantchenko

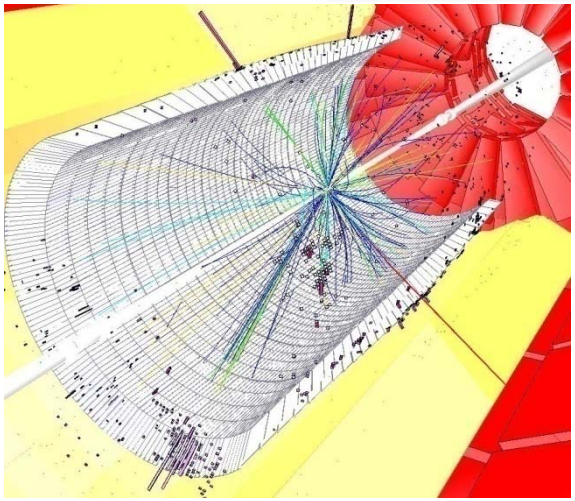
MC Generation

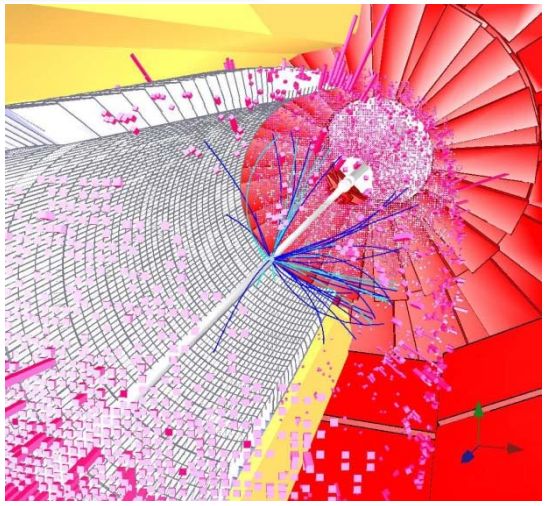
- Interaction pp
- Interaction with matter
- Digitalization
- Reconstruction
- Data Analysis

Pythia



GEANT4



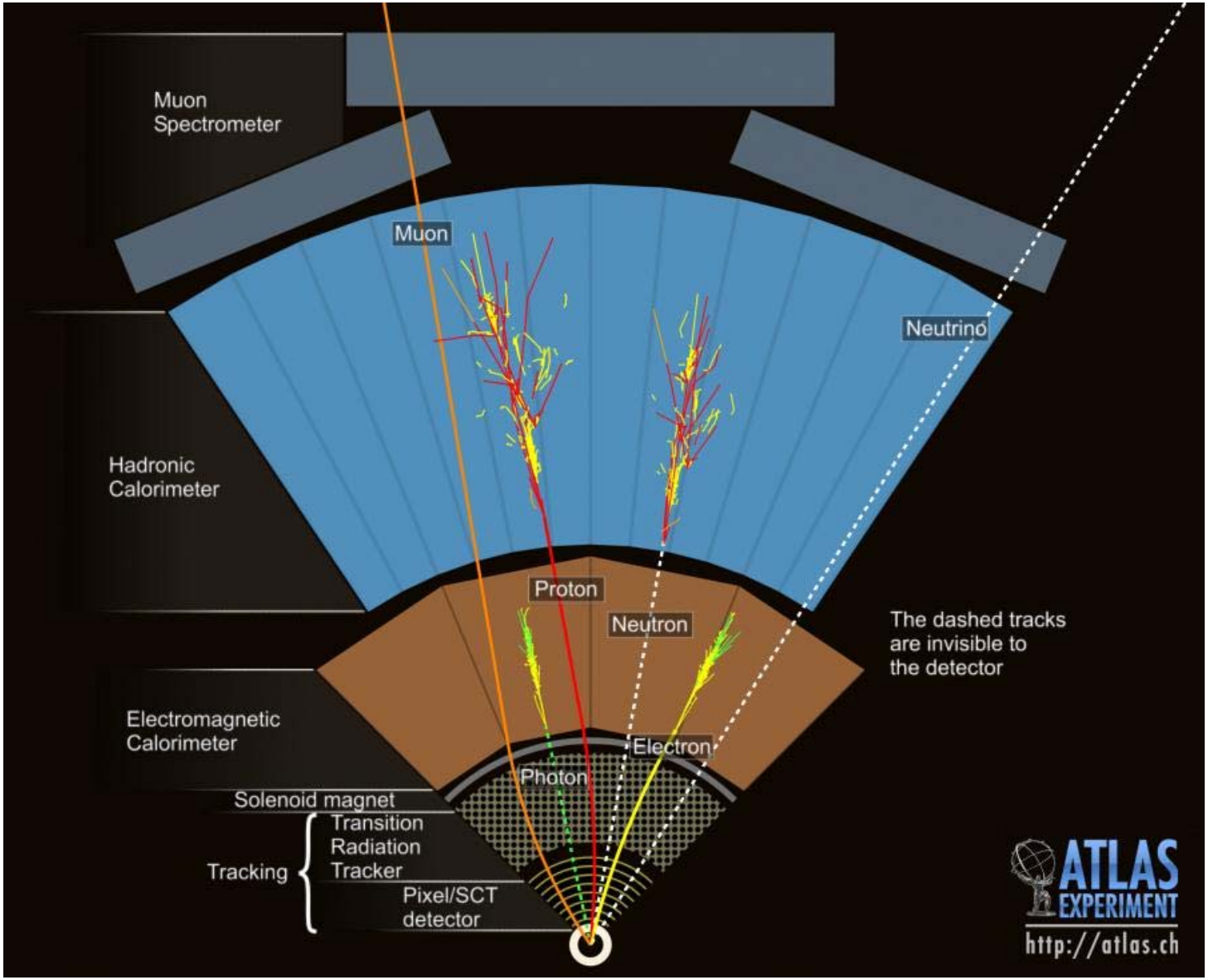


GEANT4

GEANT4 is a *toolkit* that provides :

- Geometry Methods for Detector Construction
- Tracking in Fields
- Material (Simple, Composite, Isotopes, …)
- Interaction with matter Models (EM, Hadronic, …) for MC Simulations
- Scoring and Visualization

GEANT4


Muon
Spectrometer
Muon
Neutrino
Hadronic
Calorimeter
Proton
Neutron
The dashed tracks
are invisible to
the detector
Electromagnetic
Calorimeter
Electron
Photon
Solenoid magnet
Tracking
Transition
Radiation
Tracker
Pixel/SCT
detector
ATLAS
EXPERIMENT
http://atlas.ch

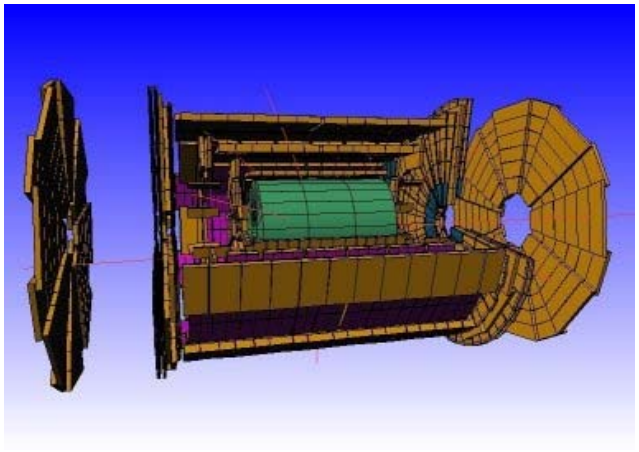
GEANT4 Applications

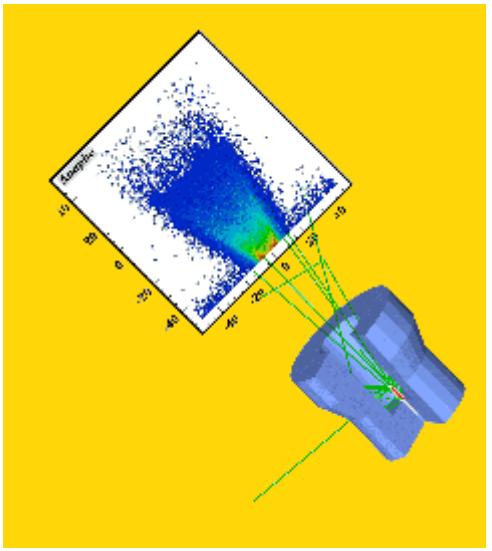
GEANT4

HEP

Space

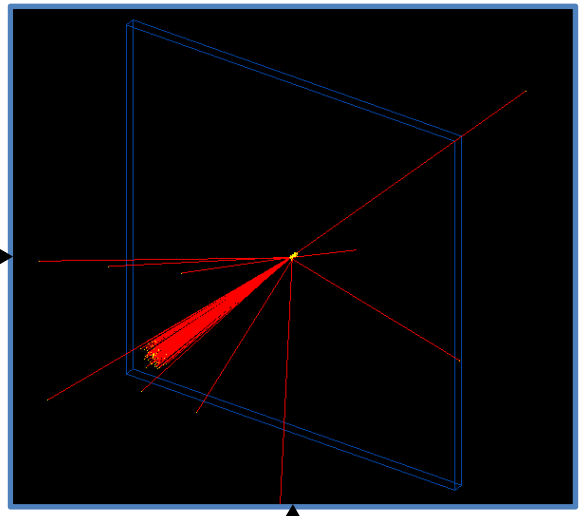
Medical

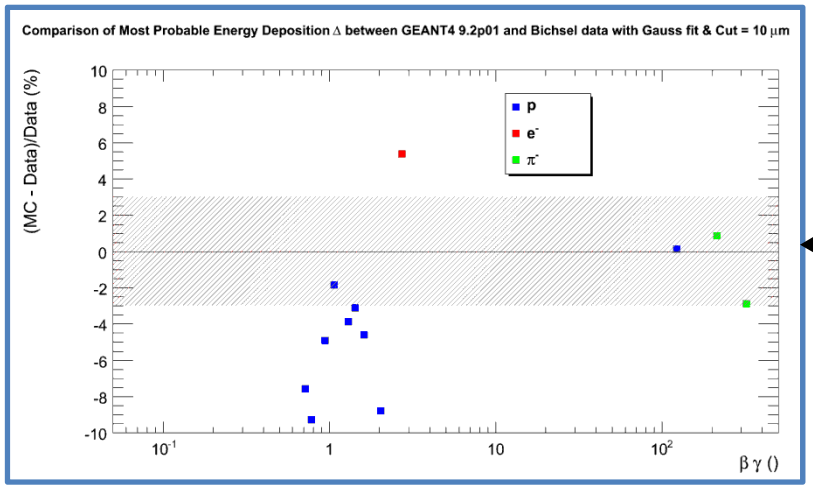




My Summer Job

```
int main(int argc,char** argv) {

  //choose the Random engine
  CLHEP::HepRandom::setTheEngine(new CLHEP::RanecuEngine());

  //Construct the default run manager
  G4RunManager * runManager = new G4RunManager();

  //set mandatory initialization classes
  runManager->SetUserInitialization(new DetectorConstruction());

  //G4PhysListFactory factory;
  //G4VModularPhysicsList* phys = factory.ReferencePhysList();
  runManager->SetUserInitialization(new PhysicsList());

  runManager->SetUserAction(new PrimaryGeneratorAction());

  //set user action classes
  runManager->SetUserAction(new RunAction());
  runManager->SetUserAction(new EventAction());

  //get the pointer to the User Interface manager
  G4UImanager* UI = G4UImanager::GetUIpointer();
  G4VisManager* visManager = 0;

  if (argc==1)   // Define UI terminal for interactive mode
    {
#ifdef G4VIS_USE
      //visualization manager
      visManager = new G4VisExecutive;
      visManager->Initialize();
#endif
```





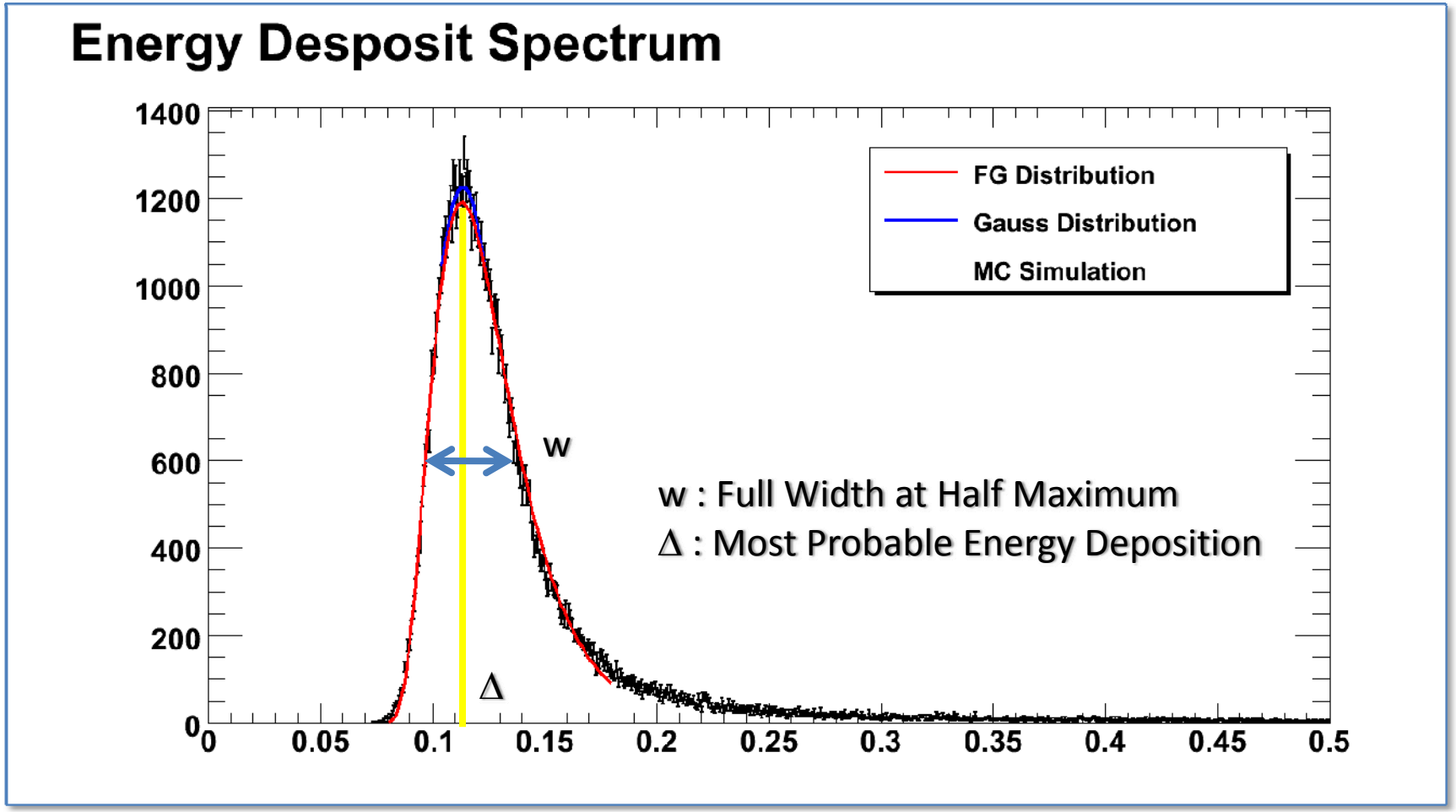
	t	T	$\beta\gamma$	σ_n	w	w_i	w_s	$_i\Delta_p$	$_s\Delta_p$
Kolata *et al.* (1968)									
p	196	38	0.29	8	140.2	141.5	141	537	534
p	196	42.4	0.30	8	138.3	139.4	139	484	485
		average differences				$\langle r_w\rangle = -0.3$		$\langle r_p\rangle = 0.2$	
Maccabee *et al.* (1968)							$\approx \pm 3\%$		$\pm 2\%$
α	245	895	0.73	9	197.0	198.4	200	671	678
α	884	910	0.74	10	598.3	598.8	619	2587	2610
p	464	730	1.47	10	53.8	60.6	59.6	161	157
				15		68		163	
p	1 772	730	1.47	10	188.4	190.4	184	664	659
		average differences				$\langle r_w\rangle = 0.3 \pm 3$		$\langle r_p\rangle = 0.3 \pm 2$	
Aitken *et al.* (1969)									
p	2 160	315	0.89	20	333.6	338.0	360	1246	1329
π	2 160	65.3	1.07	20	281.2	286.5	296	1031	1061
e	2 160	458	897	20	166.8	176.1	176	686	687
				10		169.2		683	
		average differences				$\langle r_w\rangle = 3$		$\langle r_p\rangle = -3$	
Hancock *et al.* (1983, 1984)							$\pm 8\%$		$\pm 3\%$
p	300	220	0.72	5	66.5	67.9	71	192	210
p	300	254	0.78	4	60.6	61.6	68	174	196
p	300	350	0.94	5	50.3	52.2	56	142	153
p	300	433	1.07	4	45.1	46.4	48	126	131
p	300	600	1.3	5	39	41.4	44	108	115
p	300	700	1.43	5	36.8	39.4	40	102	108
p	300	850	1.62	5	34.6	37.3	38	95	102
p	300	1195	2.04	4	31.7	33.5	37	87	97.2
e	300	0.98	2.73	4	29.5	31.5	32.5	81.4	87
p	300	114 000	123	4	29.6	31.5	30	85.1	85.5
π	300	29 900	215	4	29.8	31.6	29.6	85.6	85.6
π	300	44 900	322	4	29.8	31.7	29.6	85.7	88.8
				3		30.9		84.9	
		average differences				$\langle r_w\rangle = -1 \pm 6$		$\langle r_p\rangle = -5 \pm 4$	
Esbensen *et al.* (1978)									$1.5 \pm 5\,\%$
p	900	1 280	2.13	4	85.0	85.7		277	279
p	900	5 135	6.4	4.3	73.9	74.9		254	252
p	900	14 100	16	4.3	75.0	75.9		268	259
K	900	5 530	12.1	4	73.5	74.4		260	254
K	900	14 500	30.4	4	74.1	74.9		267	264
π	900	1 865	14.3	4	73.6	74.4		261	262
π	900	5 860	43	4	74.4	75.2	76.4	269	264
π	900	14 900	107	4	75.0	75.8		272	264
		average differences				$\langle r_w\rangle = 1.6$		$\langle r_p\rangle = 1.4 \pm 1.5$	

My Validation Test

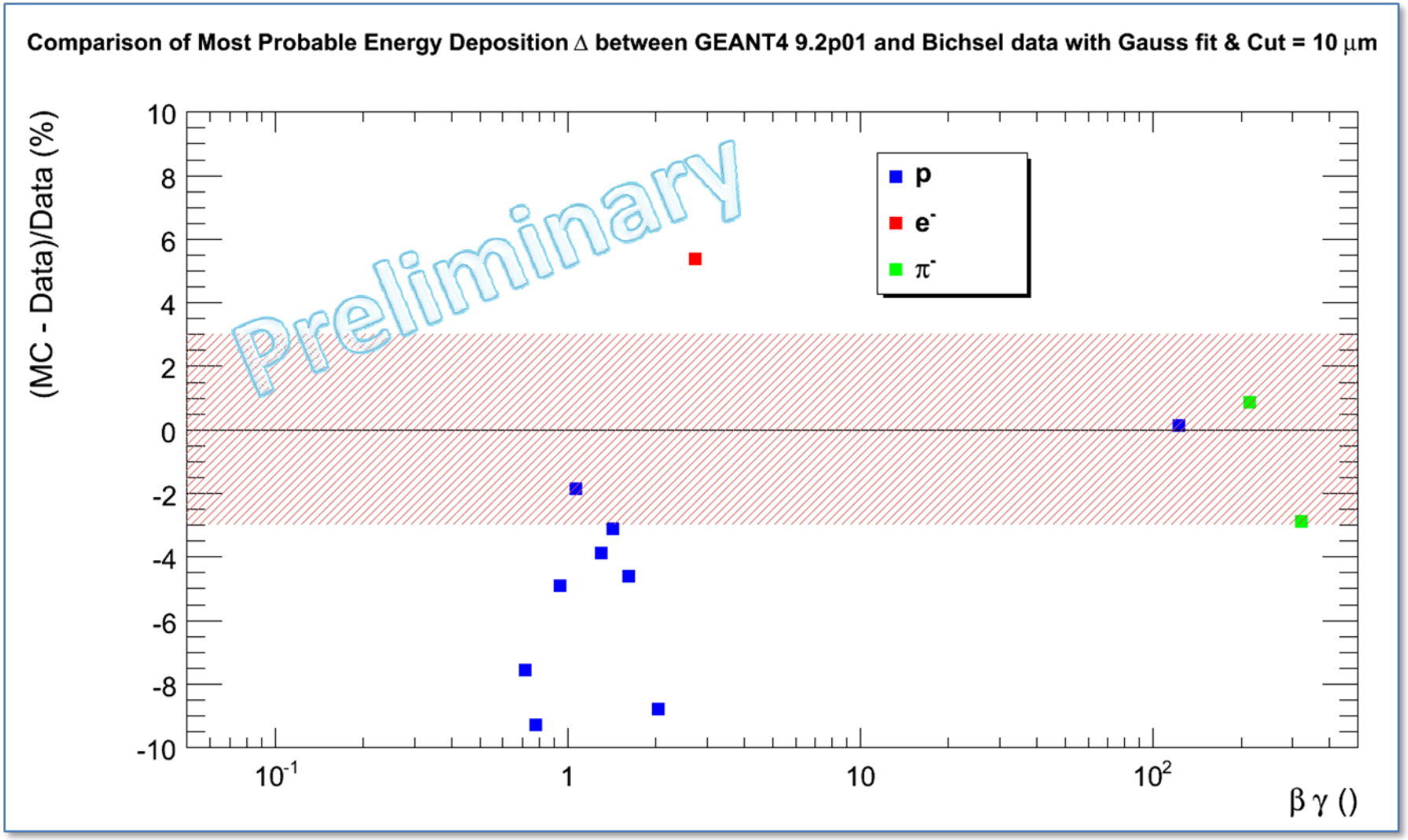
- Release : GEANT4 9.2p01
- Detector : Silicon Layer of 300 μm thickness
- Models : GEANT4 Standard EM Physics List
- Further investigations :
  - Different Models.
  - Different Releases of GEANT4.
  - Effect of magnetic field on the results.
  - …

Results : Energy Deposit Spectrum

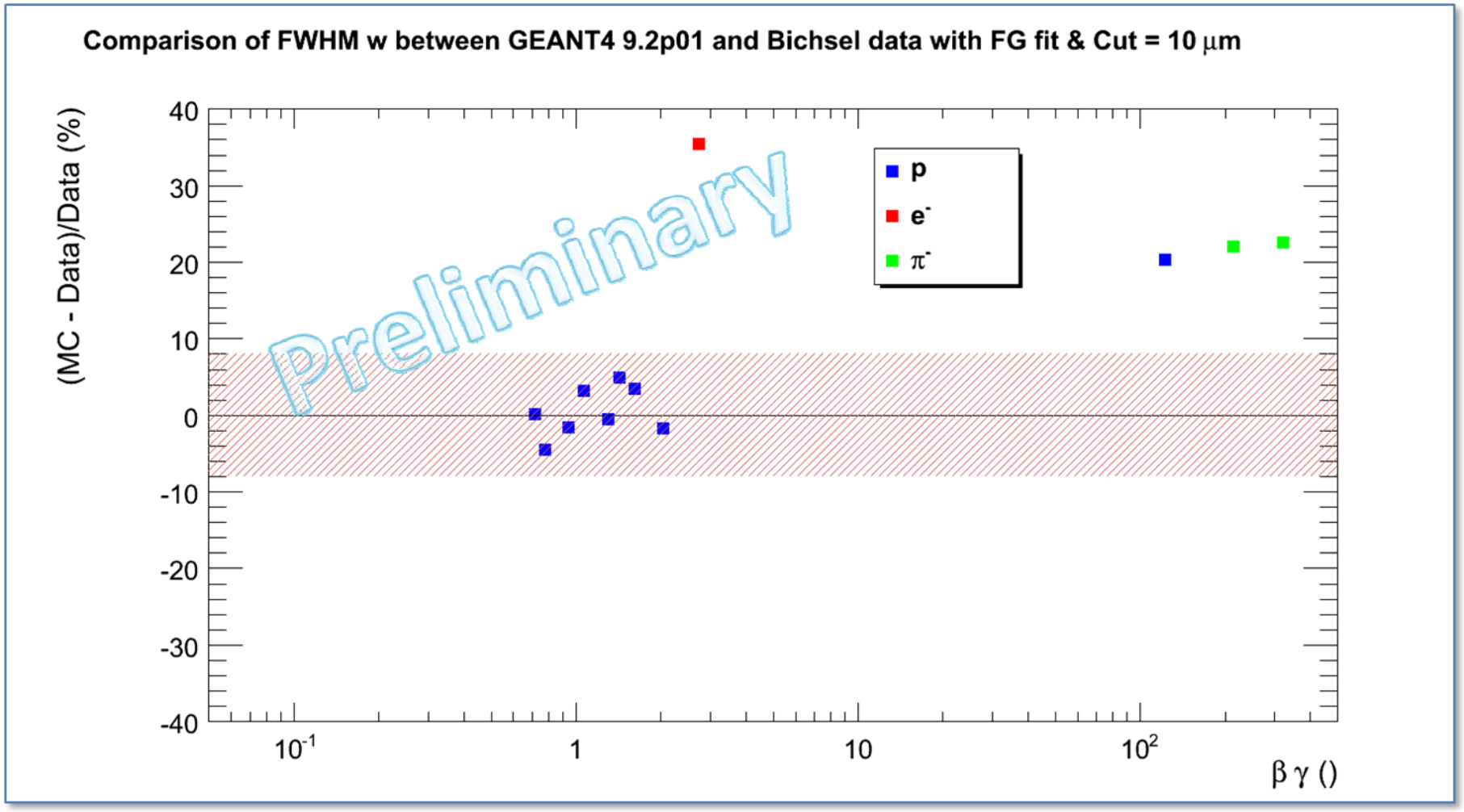
- Energy Deposit Spectrum : Energy left by the primary and secondary particles in the layer.



Results : Most Probable Energy Deposition



Results : Full Width at Half Maximum



Conclusion

- GEANT4 is a crucial step in the MC Generation Chain. Its domain of use and applications.
- Validation of EM Models of GEANT4 for thin layers of Silicon is important for tracking systems (that become more and more essential nowadays in HEP → LHC).
- Methods to fit the Energy Deposit Spectrum were studied (Gauss for the peak position and FG for the FWHM).

- The Test Software has been created within this project and will be included into GEANT4 Test Facility to compared different Models and Releases.

- Second part of my project will be dedicated to the investigation and perhaps improvement of the corresponding GEANT4 Models (Contact with Authors).