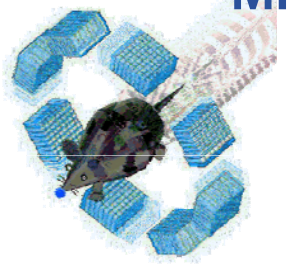
# Electron Dose point kernels calculations in water using GATE/G4.8

GATE/G4 collaboration meeting, 12-09-07

Lydia Maigne (LPC, Clermont-Ferrand), maigne@clermont.in2p3.fr

Credits: Cheick Thiam (LPC, Clermont-Ferrand), Nicolas Chouin, Ludovic Ferrer (Inserm, Nantes), Michel Maire (G4 collaboration)

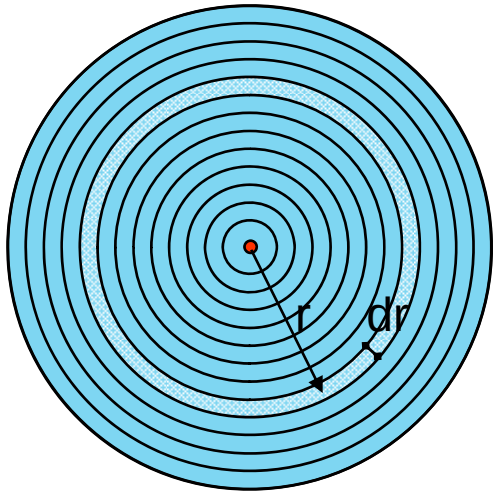
http://clrpcsv.in2p3.fr



# DPK calculations methodology

Plateforme de Calcul pour les Sciences du Vivant

## Simulations characteristics:




- Isotropic point source
- Monoenergetic emission, 5M e- generated
- Scoring of the dose in a spherical water phantom of 400 mm in diameter containing 22 spherical shells each of thickness of 0.05 rE
- Cut of 2 kev on e-
- Standard EM package

Formalism to calculate the dose (Berger and TG43): fraction of emitted energy that is deposited in a spherical shell of scaled radius r/rE to r/rE + d(r/rE).

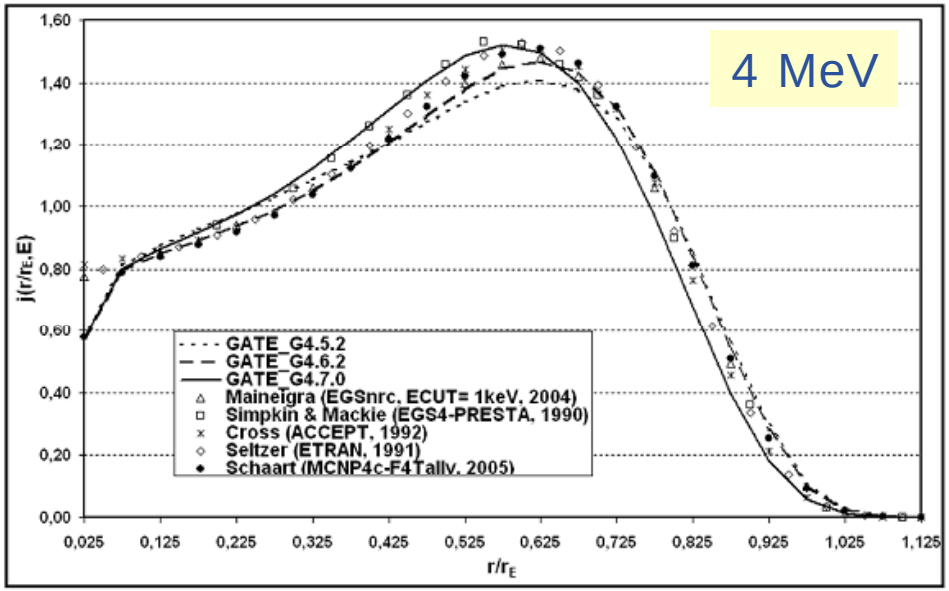
$$j(r/r_g, E) = 4\pi\rho r^2 D(r, E) r_g / E$$

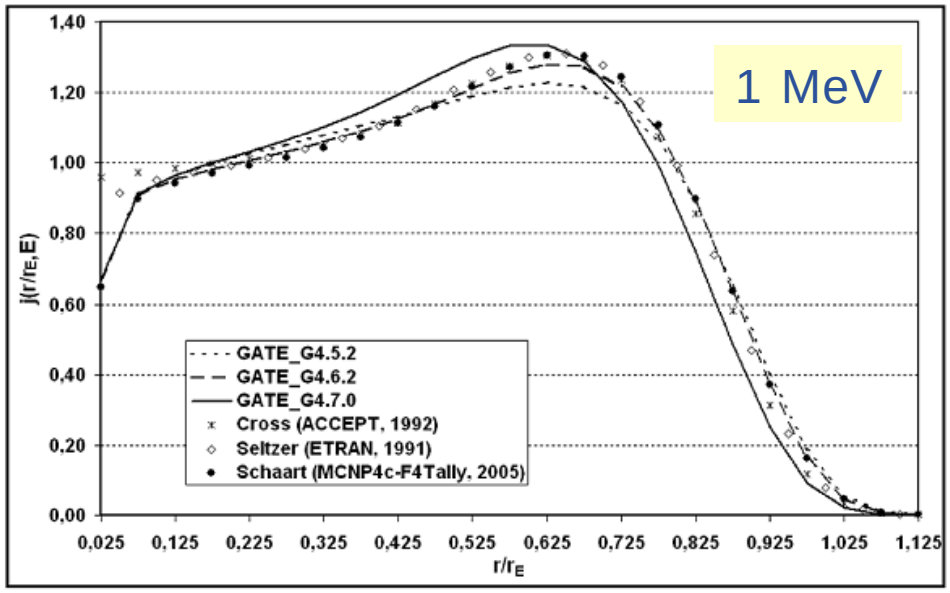
With:

r being the radial distance to the middle of the spherical shells,
rE the nominal CSDA range
ρ the density of the medium,
D(r,E) the dose per incident particle at distance r.

# Comparisons G4 versions and other Monte Carlo

Plateforme de Calcul pour les Sciences du Vivant

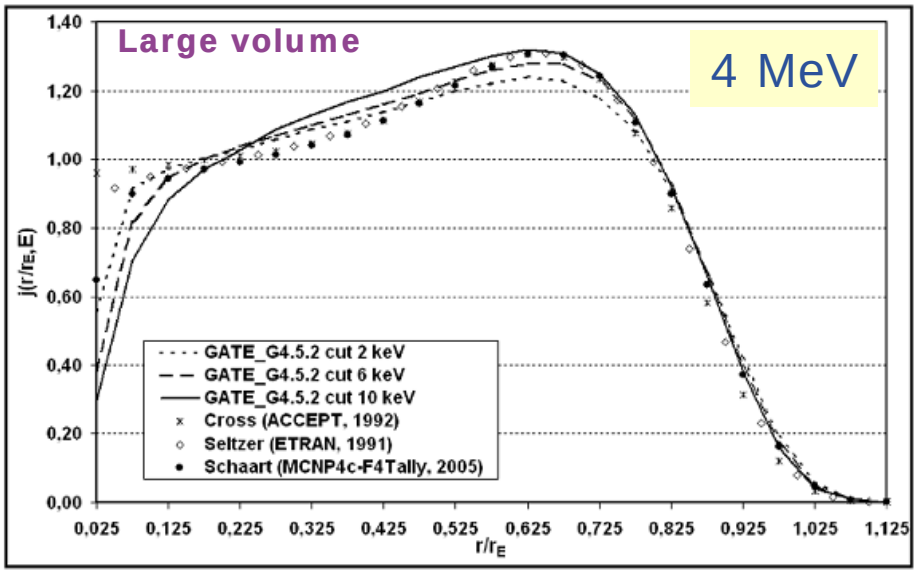


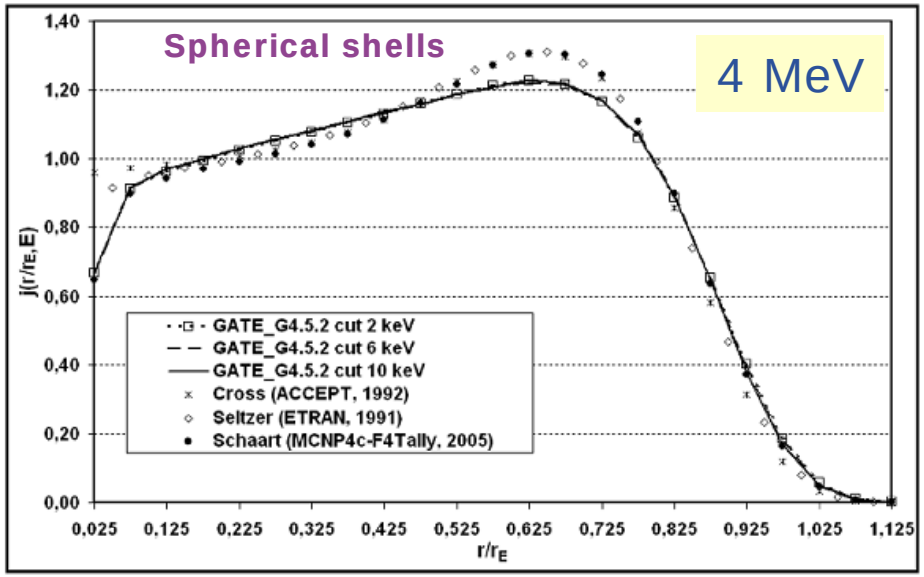



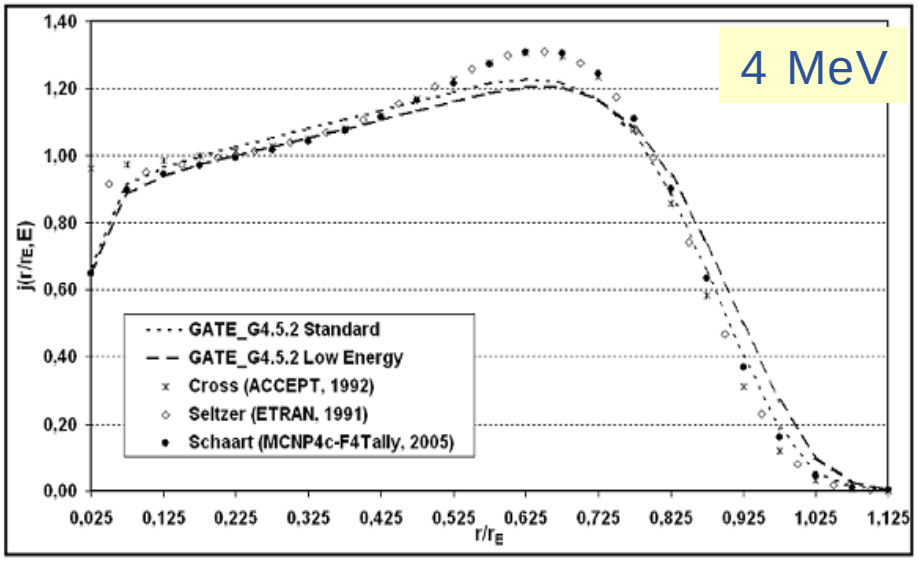
# Comparisons:

## Cuts, detector volumes, EM packages

Plateforme de Calcul pour les Sciences du Vivant



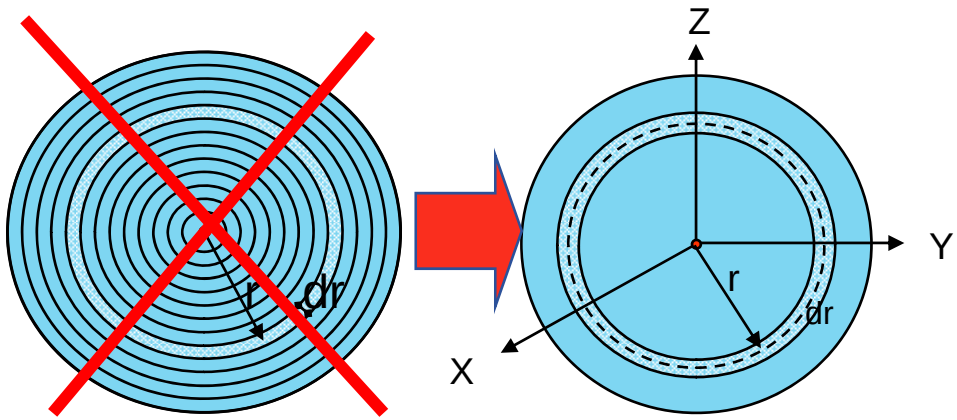




- **By considering a large volume of water:**
  Cut values have a non negligeable influence
- **By considering spherical shells:**
  Changes on cut values have no influence

**Results obtained with a cut value of 2 keV (0.0043 mm) in a large volume of water give comparable results to spherical shells.**

**Problems but where do they come from??**

- **Important modifications to simulate the dose deposited:**
  - No more spherical shells
  - Use of a large sphere in water




Modifications in the code of GATE:

➢ To fix the maximal step length on electron transport, StepMax

➢ To obtain an homogeneous distribution of the dose deposited along the step

# Control the step length « StepMax »

Plateforme de Calcul pour les Sciences du Vivant

**GEANT4 class to manage the step « G4Step.cc »**

**In GATE: Addition of the class « GateStepMax » to call « GateSteppingAction » and « G4Step » classes:**

- Consequence in GATE macros, add the following command line:

```
# StepMax Control !!!
  /gate/StepMax/stepMax 7 µm
```

- Consequence on the dose deposited by electrons:

  No influence, results stay the same

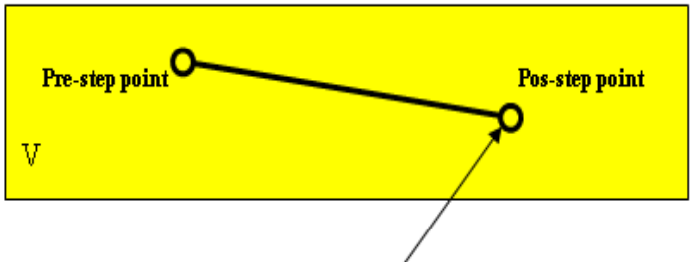
**So, what to do?.....**

# Control the energy deposited along the step



**GEANT4:**

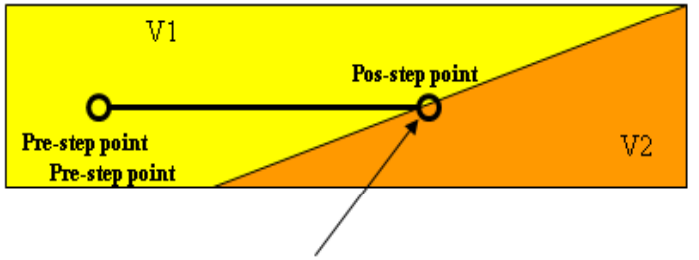
By default, energy is deposited at the end of the step: "Post-step point"




**Energy deposited**

**Modification of the « GateSteppingAction.cc » class:**

```
//....ooo00000ooo........ooo00000ooo........ooo00000ooo........ooo00000ooo......

void SteppingAction::UserSteppingAction(const G4Step* aStep)
{
 G4double edep = aStep->GetTotalEnergyDeposit();
 if (edep <= 0.) return;

 eventAction->AddEdep(edep);

 // longitudinal profile of deposited energy

 G4ThreeVector prePoint  = aStep->GetPreStepPoint() ->GetPosition();
 G4ThreeVector postPoint = aStep->GetPostStepPoint()->GetPosition();
 G4ThreeVector point = prePoint + G4UniformRand()*(postPoint - prePoint);
 G4double r = point.mag();

 ........

 ......

 ...

}
```




**Energy deposited**

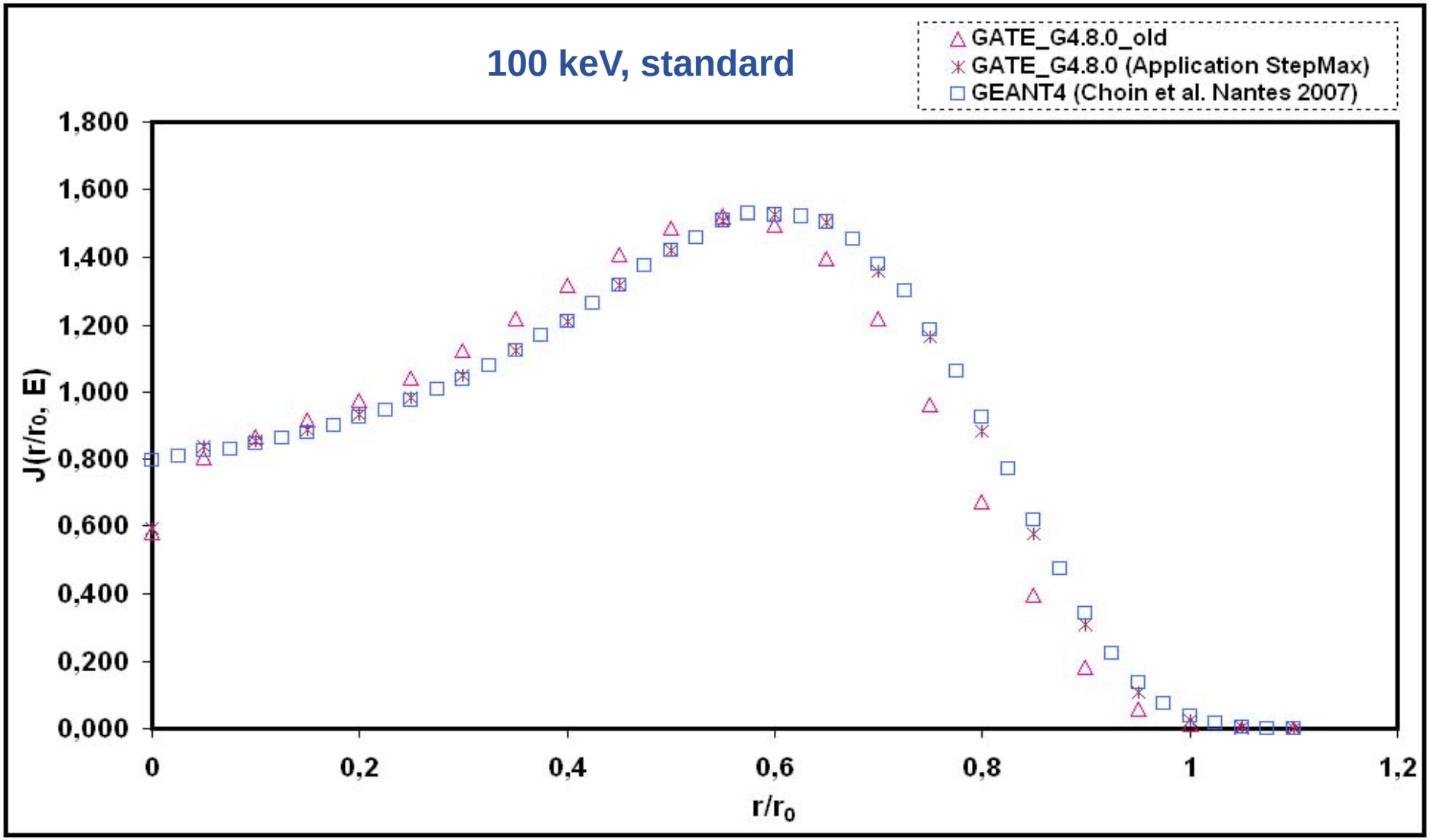
**-Random distribution of energy deposited along the step**

**-Continue energy loss along the trajectory**

**- Enable to fit well the dose deposited inside a volume**

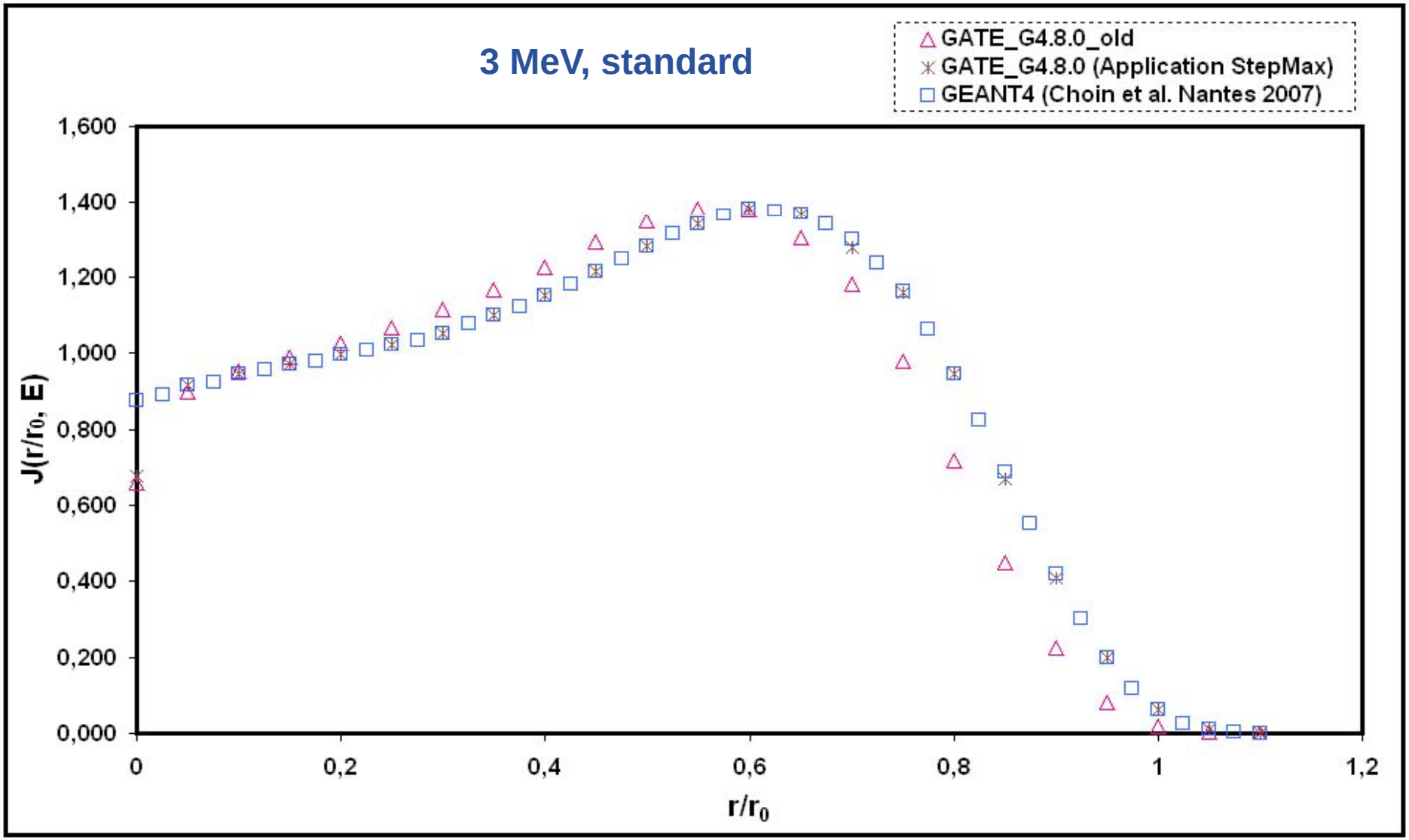
# Results: 100 keV

Plateforme de Calcul pour les Sciences du Vivant



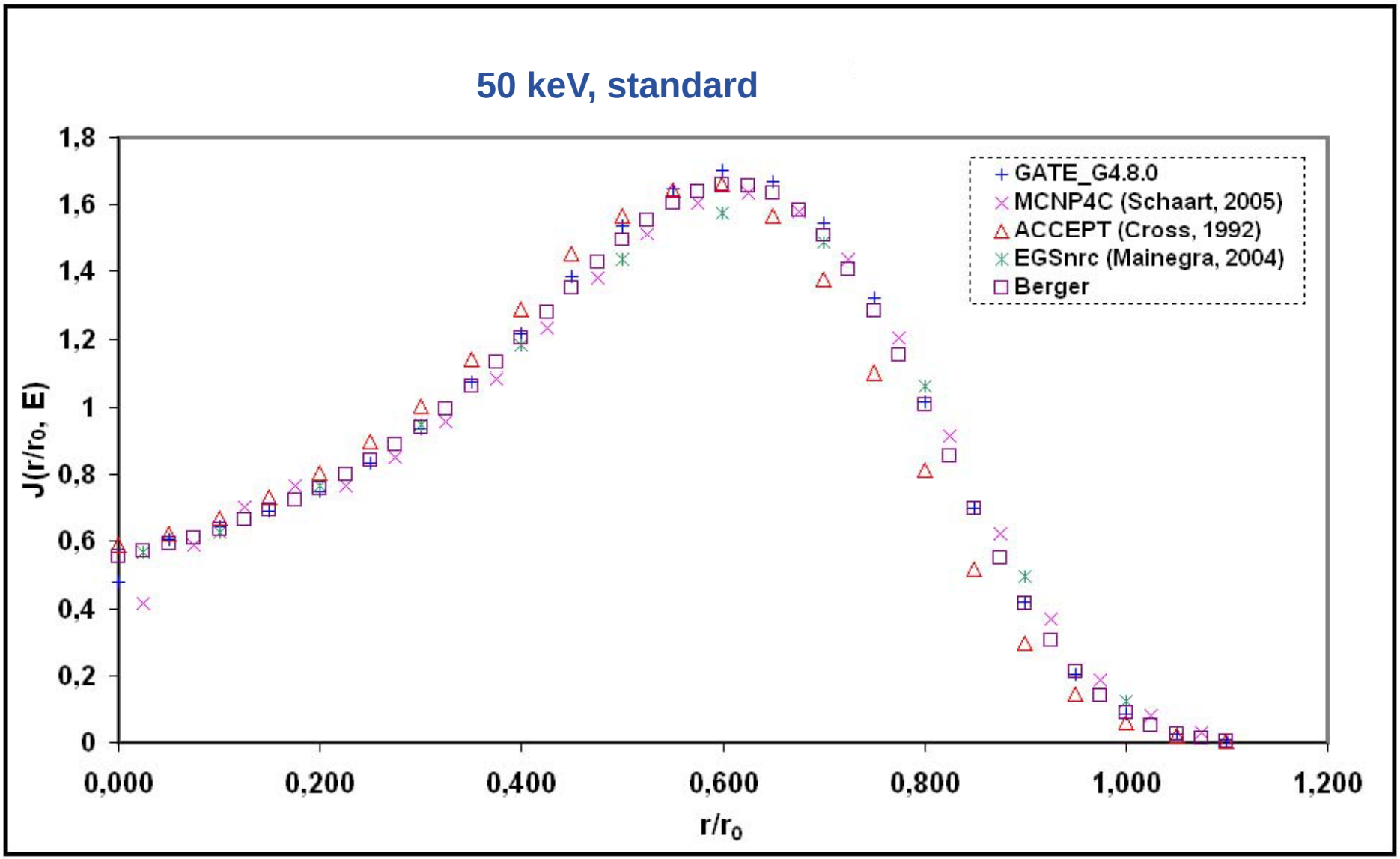
# Results: 3 MeV

Plateforme de Calcul pour les Sciences du Vivant



# Comparisons GATE versus other MC codes

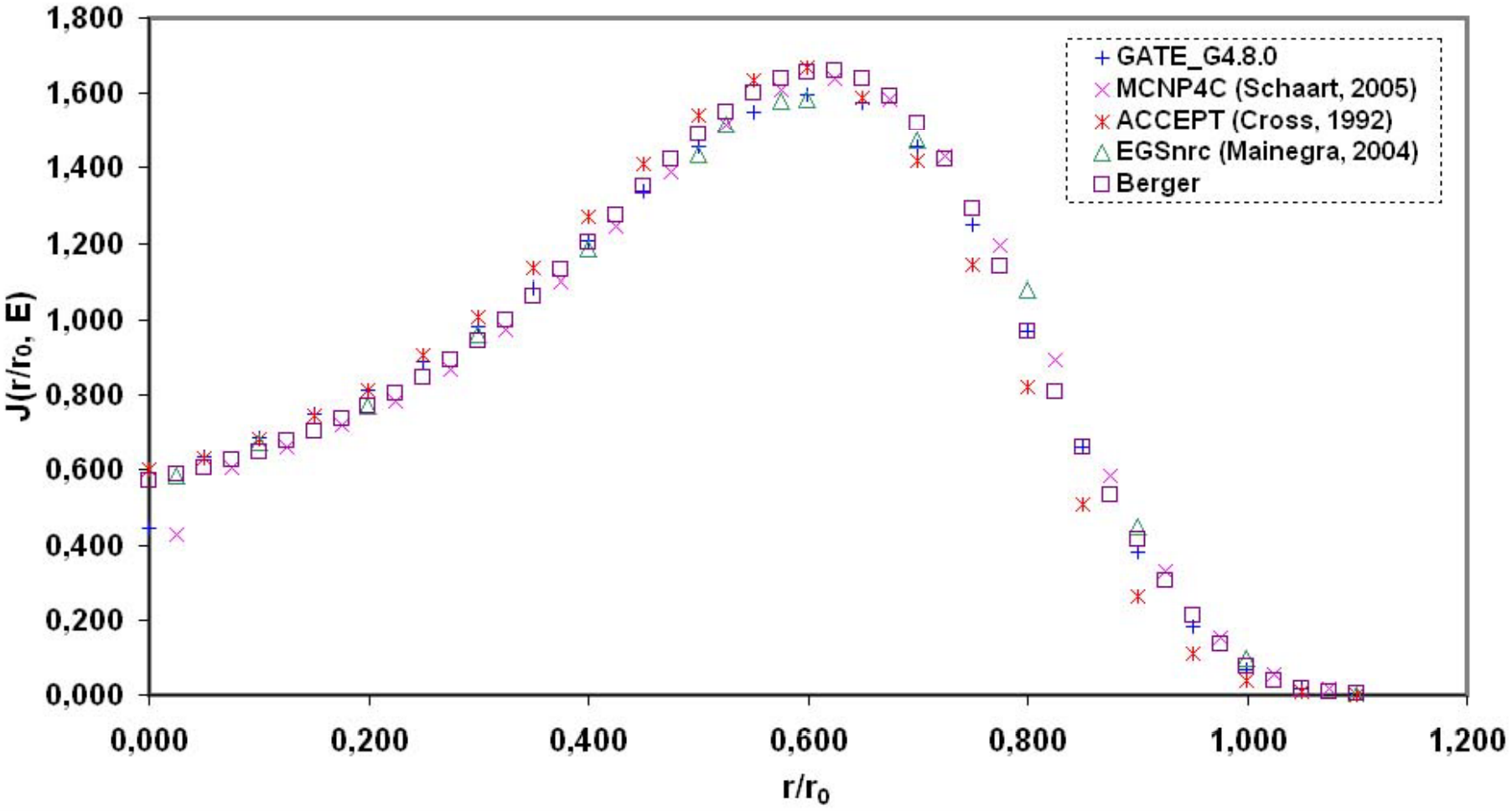
Plateforme de Calcul pour les Sciences du Vivant



# Comparisons GATE versus other MC codes

Plateforme de Calcul pour les Sciences du Vivant

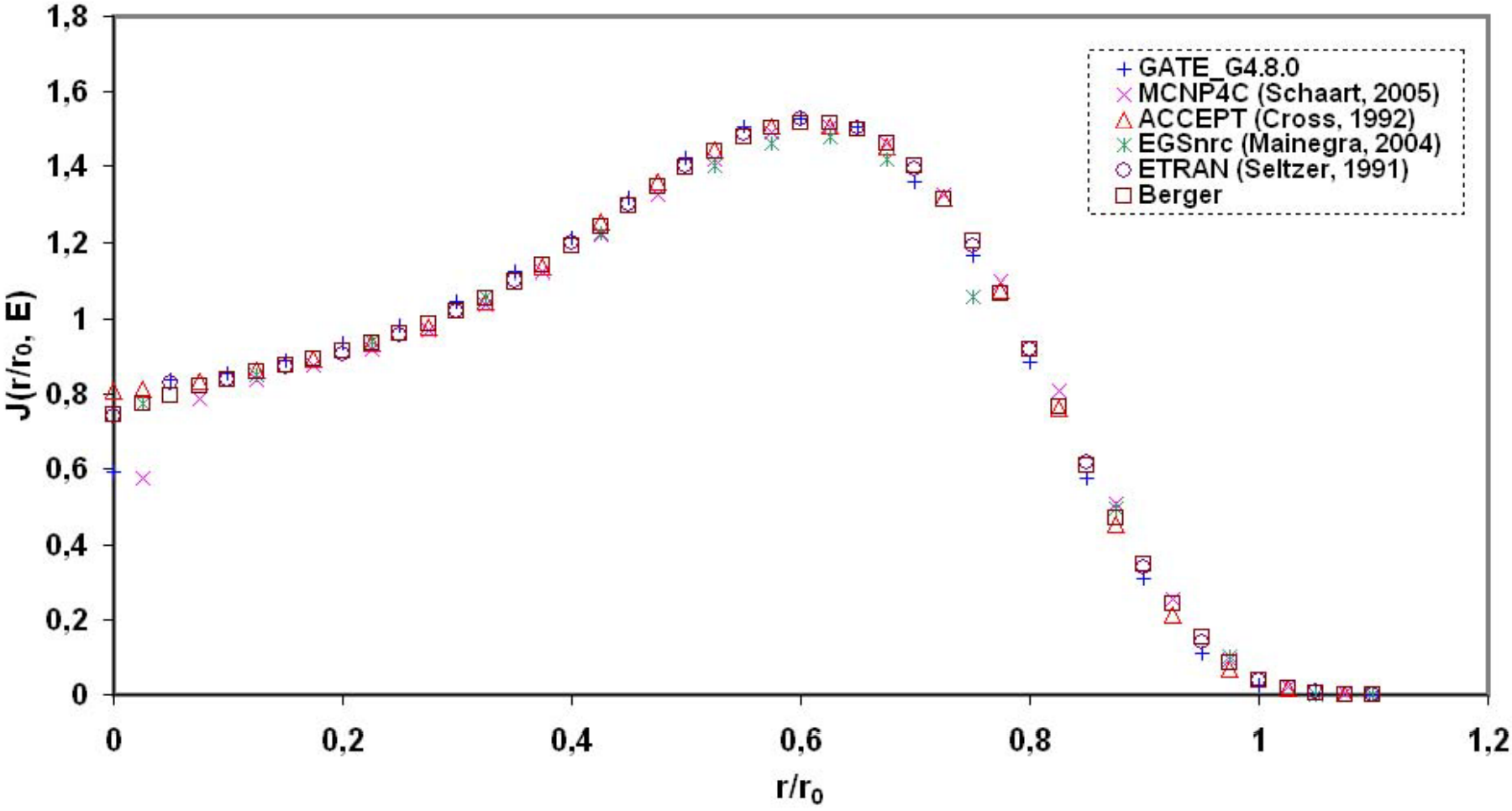
## 100 keV, standard



# Comparisons GATE versus other MC codes

Plateforme de Calcul pour les Sciences du Vivant

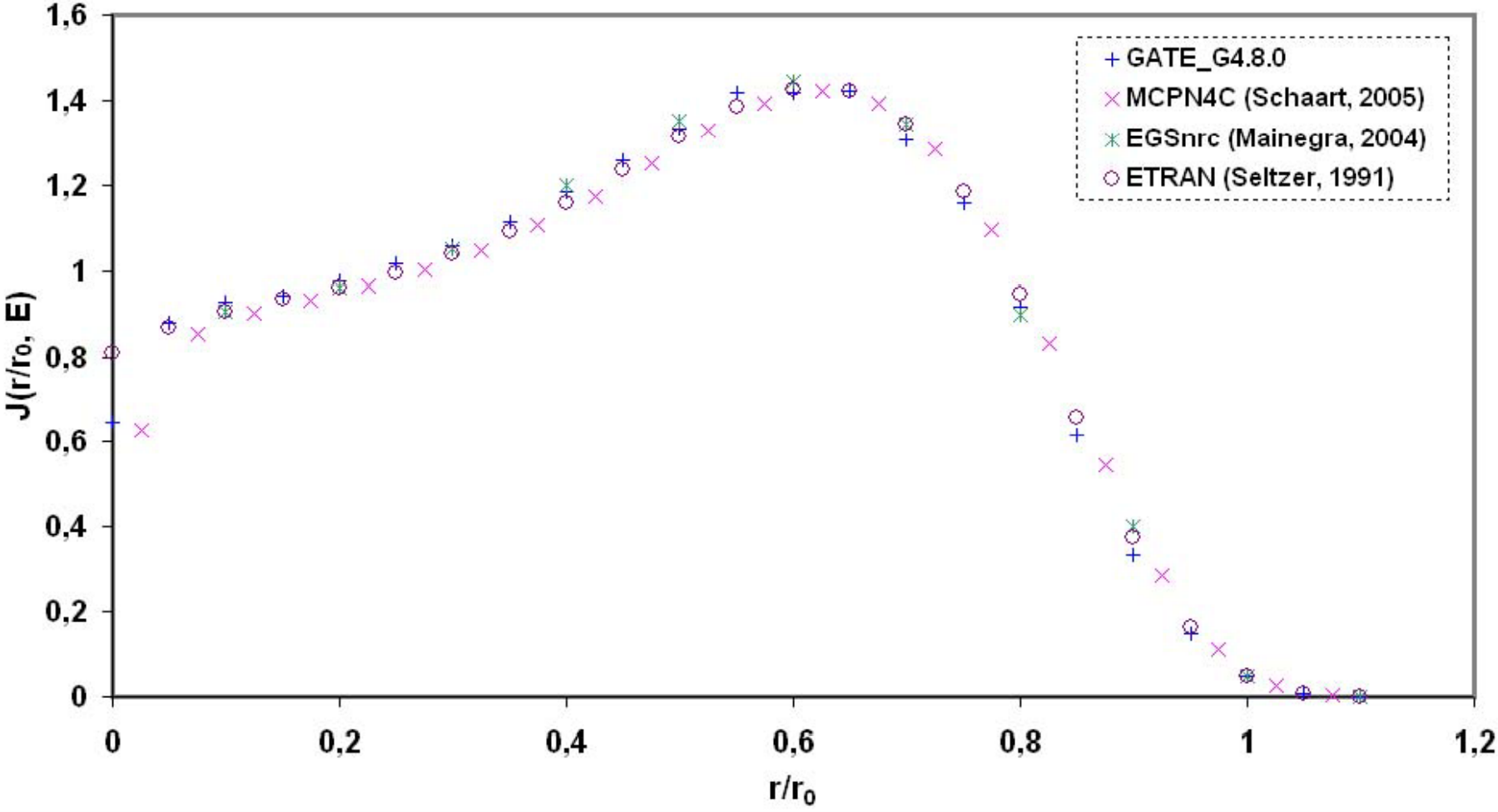
## 1 MeV, standard



# Comparisons GATE versus other MC codes

Plateforme de Calcul pour les Sciences du Vivant

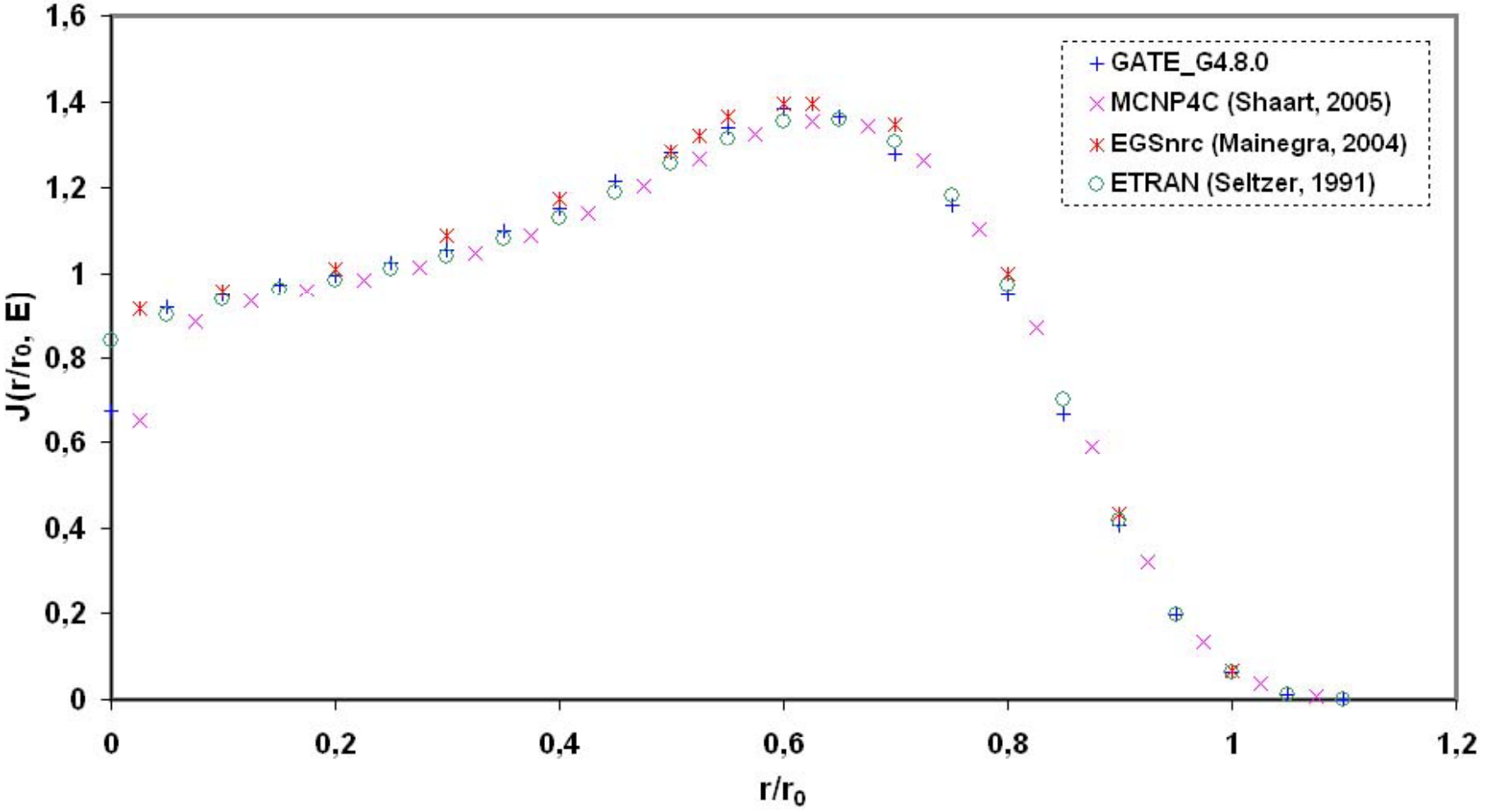
## 2 MeV, standard



# Comparisons GATE versus other MC codes

Plateforme de Calcul pour les Sciences du Vivant

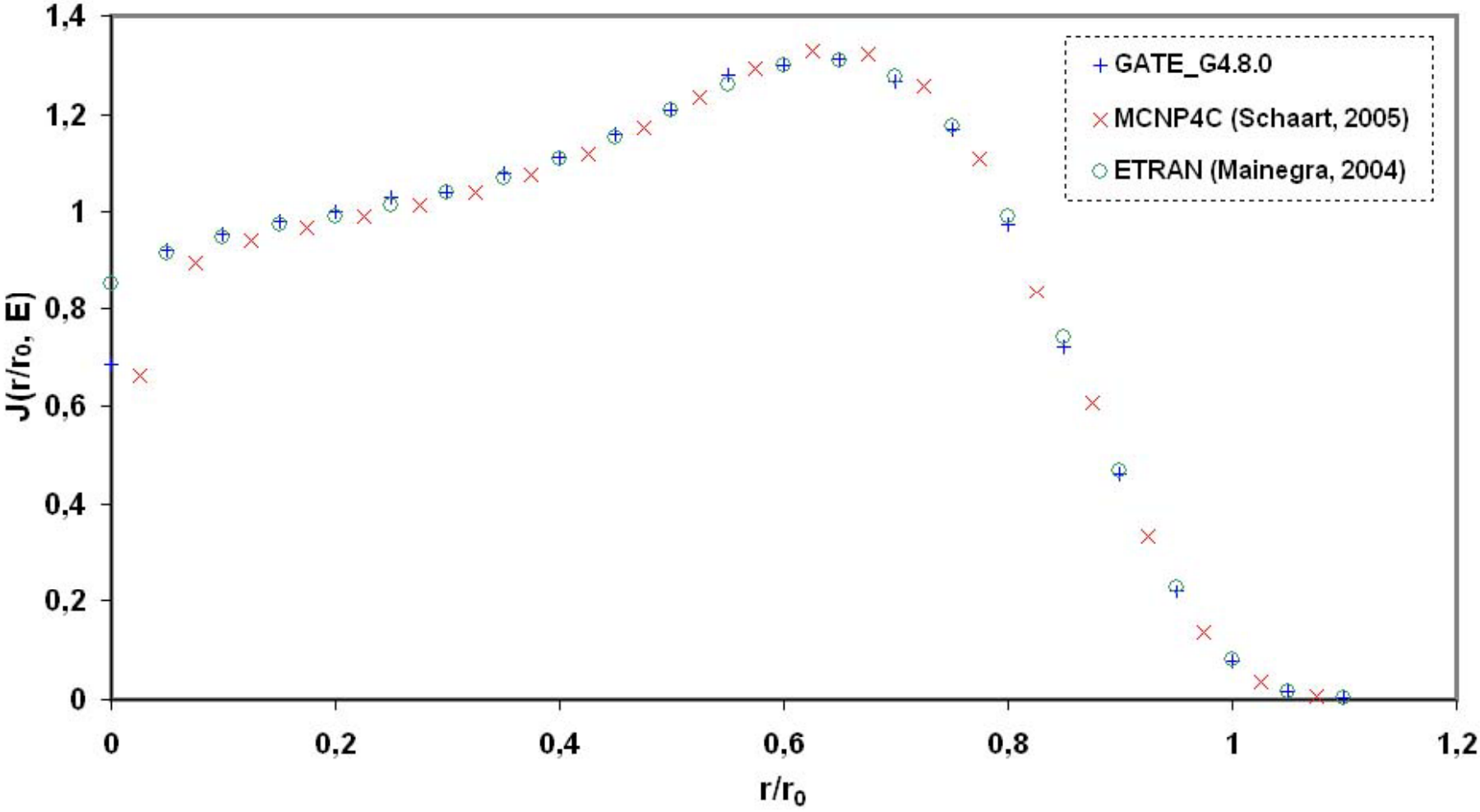
## 3 MeV, standard



# Comparisons GATE versus other MC codes

Plateforme de Calcul pour les Sciences du Vivant

## 4 MeV, standard



# Conclusions

Plateforme de Calcul pour les Sciences du Vivant

- **Random deposition of the energy along the step is the the most important parameter to change in the simulation to obtain reliable results**
- **Comparisons show:**
  - Deviation less than 1% between GATE and Berger results for 50, 100 keV and 1 MeV
  - Deviation less than 0.5% with other Monte Carlo

- **GATE and G4 are now trusted and well validated for dose deposited by electrons especially for very high dose gradient on short distances.**