I have a primary neutron at PreStepPoint:

$E_{kin} = 8.66851E-08\ MeV$

$\vec{p} = (-0.00579051,\quad 0.0111418,\quad 0.00228551)\ MeV/c$

$|\vec{p}| = 0.012763\ MeV/c$

And the C-12 target which is sampled in G4ParticleHPElasticFS::ApplyYourself (here it is transformed from reaction plane back to Lab system):

$E_{kin} = 1.91023E-08\ MeV$

$\vec{p} = (0.00676632,\quad -0{,}0179413,\quad 0.0077815)\ MeV/c$

$|\vec{p}| = 0.0206661\ MeV/c$

The total before the interaction:

$E_{kin} = 1.05787E-07\ MeV$

$\vec{p} = (0.00097581,\quad -0.0067995,\quad 0.0099937)\ MeV/c$

$|\vec{p}| = 0.0121268\ MeV/c$

After the interaction I have elastically scattered neutron at PostStepPoint:

$E_{kin} = 9.06803E-08\ MeV$

$\vec{p} = (-0.000673047,\quad 0.00658468,\quad 0.0112512)\ MeV/c$

$|\vec{p}| = 0.0130538\ MeV/c$

The recoiled C-12 nuclei in the vector of secondaries corresponding to the current step:

$E_{kin} = 1.51122E-08\ MeV$

$\vec{p} = (-0.00567584,\quad -0.0160092,\quad -0.00701742)\ MeV/c$

$|\vec{p}| = 0.0183781\ MeV/c$

The total after the interaction:

$E_{kin} = 1.05793E-07\ MeV$

$\vec{p} = (-0.0063489, \quad -0.00942452, \quad 0.0042338)\ MeV/c$

$|\vec{p}| = 0.0121266\ MeV/c$

The momentum $\vec{p}$ is not conserved. This is caused by G4HadronElasticProcess::PostStepDoit():

when it returns the results it rotates the momentum of incident particle here –

> http://www-geant4.kek.jp/lxr/source/processes/hadronic/processes/src/G4HadronElasticProcess.cc#L246
>
> and the momentum of recoil here –
>
> http://www-geant4.kek.jp/lxr/source/processes/hadronic/processes/src/G4HadronElasticProcess.cc#L269
>
> These rotations are not inversed to those ones in G4HadProjectile. So they are incorrect (AT LEAST!) for particleHP model.

The fix:

In G4HadronElasticProcess::PostStepDoit

On entering the function declare

```
G4bool isParticleHP = false;
```

Then change the try-block here

http://www-geant4.kek.jp/lxr/source/processes/hadronic/processes/src/G4HadronElasticProcess.cc#L161

```
try
{
hadi = ChooseHadronicInteraction( theProj, *targNucleus, material, elm );
G4ParticleHPElastic* itsHP = dynamic_cast<G4ParticleHPElastic*>(hadi);
if (itsHP) isParticleHP = true;
```

}

Then change this if-block

http://www-geant4.kek.jp/lxr/source/processes/hadronic/processes/src/G4HadronElasticProcess.cc#L245

```
if(efinal > 0.0) {
if (isParticleHP) {
G4LorentzRotation toLab = theProj.GetTrafoToLab();
G4LorentzVector outdir4vector = G4LorentzVector(outdir);
outdir4vector.transform(toLab);
outdir = outdir4vector.vect();
}
else {
outdir.rotate(phi, it);
outdir.rotateUz(indir);
}
  theTotalResult->ProposeMomentumDirection(outdir);
}
```

And do the same in this if-block:

http://www-geant4.kek.jp/lxr/source/processes/hadronic/processes/src/G4HadronElasticProcess.cc#L264

```
if (isParticleHP) {
G4LorentzRotation toLab = theProj.GetTrafoToLab();
G4LorentzVector pdir4vector = G4LorentzVector(pdir);
pdir4vector.transform(toLab);
```

```
pdir = pdir4vector.vect();

}

else {

pdir.rotate(phi, it);

pdir.rotateUz(indir);

}
```

After the fix I have a primary neutron ar PreStepPoint:

$E_{kin} = 8.66851E-08\ MeV$

$\vec{p} = (-0.00579051,\quad 0.0111418,\quad 0.00228551)\ MeV/c$

$|\vec{p}| = 0.012763\ MeV/c$

And the C-12 target which is sampled in G4ParticleHPElasticFS::ApplyYourself (here it is transformed from reaction plane back to Lab system):

$E_{kin} = 1.91023E-08\ MeV$

$\vec{p} = (0.00676632,\quad -0{,}0179413,\quad 0.0077815)\ MeV/c$

$|\vec{p}| = 0.0206661\ MeV/c$

The total before the interaction:

$E_{kin} = 1.05787E-07\ MeV$

$\vec{p} = (0.00097581,\quad -0.0067995,\quad 0.00999366)\ MeV/c$

$|\vec{p}| = 0.0121268\ MeV/c$

After the interaction I have elastically scattered neutron at PostStepPoint:

$E_{kin} = 9.06803E-08\ MeV$

$\vec{p} = (0.00494123,\quad 0.0106337,\quad 0.00573664)\ MeV/c$

$|\vec{p}| = 0.0130537\ MeV/c$

The recoiled C-12 nuclei in the vector of secondaries corresponding to the current step:

$E_{kin} = 1.51122E-08\ MeV$

$\vec{p} = (-0.00396537, \quad -0.0174329, \quad 0.00425696)\ MeV/c$

$|\vec{p}| = 0.018378\ MeV/c$

The total after the interaction:

$E_{kin} = 1.05793E-07\ MeV$

$\vec{p} = (0.00097586, \quad -0.0067992, \quad 0.0099936)\ MeV/c$

$|\vec{p}| = 0.0121266\ MeV/c$

Now momentum is conserved.