

g4e を用いた EIC detector の simulation particle gun の導入

EIC 日本グループ会合

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Introduction

- 目標
beam 軸付近に設置するハドロンカロリメータ
ZDC (zero degree cal) での放射線量を知りたい
- 前回までの問題点と取り組んだこと
generator として default の herwig を使うと、neutron が広が
りすぎていて sample として良くない
⇒ particle gun を直接撃ち込めるように edit する
- g4e に Geant4 official の汎用性の高い particle gun tool kit
GPS (General Particle Source)を導入
particle を cone 状に一様分布させる、energy distribution を
設定できる、source の形状、サイズ等を customize できる

GPS の導入

- g4e/g4e-dev/src/generator/PrimaryGeneratorAction.cc (.hh) を edit する ⇒ G4GeneralParticleSource.hh を include

Geant4 で用意されている class を導入

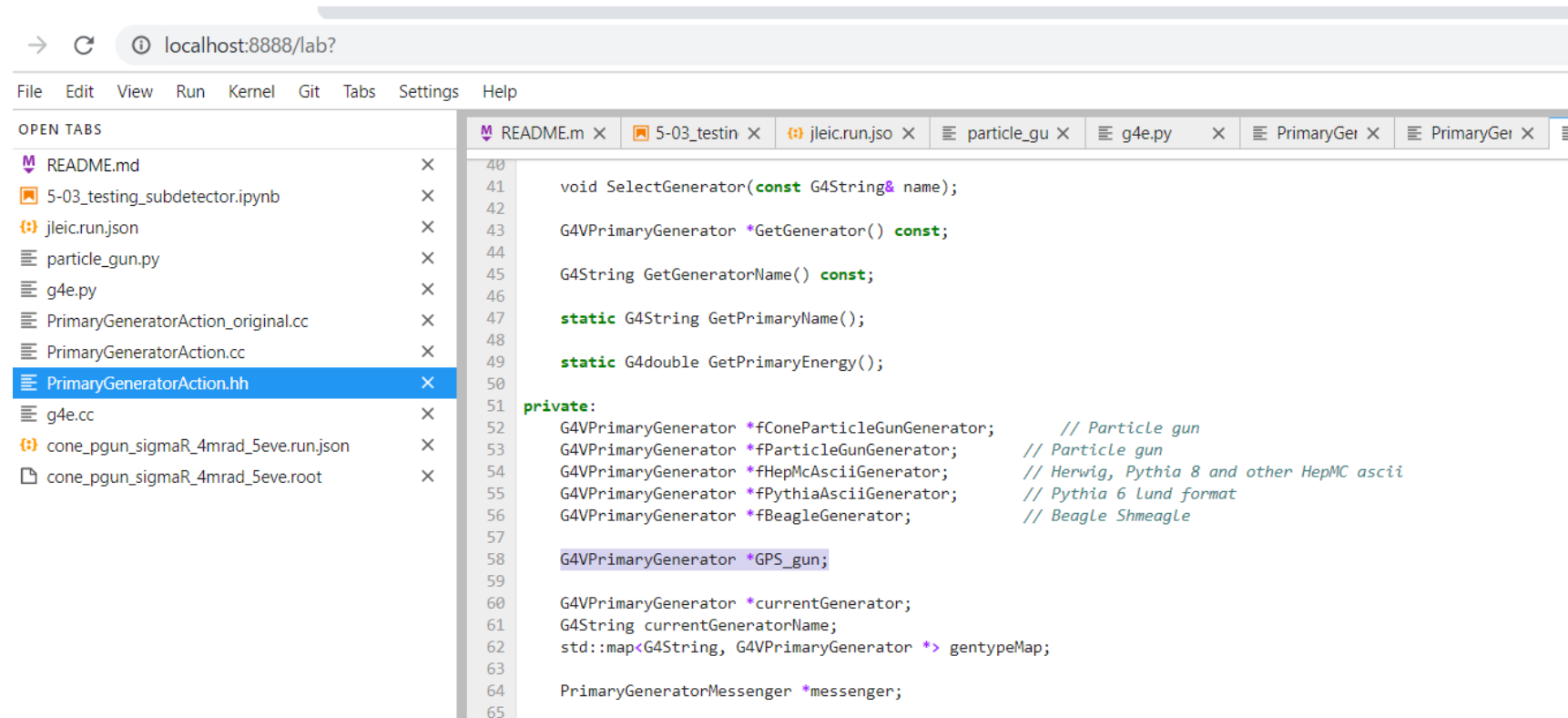
generator に
particleGun を select
すると、GPS が
呼び出されるように
登録

```
File Edit View Run Kernel Git Tabs Settings Help
OPEN TABS
README.md x
5-03_testing_subdetector.ipynb x
jleic.run.json x
particle_gun.py x
g4e.py x
PrimaryGeneratorAction_original.cc x
PrimaryGeneratorAction.cc x
PrimaryGeneratorAction.hh x
g4e.cc x
cone_pgun_sigmaR_4mrad_5eve.run.json x
cone_pgun_sigmaR_4mrad_5eve.root x

1 #include "PrimaryGeneratorAction.hh"
2 #include "PrimaryGeneratorMessenger.hh"
3
4 #include "G4Event.hh"
5 #include "G4ParticleGun.hh"
6 #include "G4GeneralParticleSource.hh"
7 #include "PythiaAsciiReader.hh"
8 #include "HepMcAsciiGenerator.hh"
9 #include "BeagleGenerator.hh"
10
11 #include "ConeParticleGun.hh"
12
13 #include <spdlog/fmt/ostr.h>
14
15 PrimaryGeneratorAction::PrimaryGeneratorAction(): G4VUserPrimaryGeneratorAction()
16 {
17     // default generator is particle gun.
18     fConeParticleGunGenerator = new ConeParticleGun();
19     fParticleGunGenerator = new G4ParticleGun();
20     fHepMcAsciiGenerator = new HepMcAsciiGenerator();
21     fPythiaAsciiGenerator = new PythiaAsciiReader();
22     fBeagleGenerator = new g4e::BeagleGenerator();
23
24     GPS_gun = new G4GeneralParticleSource(); // change for /gps commands 12/21
25
26     gentyeMap["coneParticleGun"] = fConeParticleGunGenerator;
27     //gentyeMap["particleGun"] = fParticleGunGenerator;
28     gentyeMap["particleGun"] = GPS_gun;
29     gentyeMap["hepmcAscii"] = fHepMcAsciiGenerator;
30     gentyeMap["pythiaAscii"] = fPythiaAsciiGenerator;
31     gentyeMap["beagle"] = fBeagleGenerator;
32
33     messenger = new PrimaryGeneratorMessenger(this);
34 }
35
```

GPS の PrimaryGeneratorAction.hh に private 変数に宣言

- PrimaryGeneratorAction.hh に、.cc で呼び出される GPS を導入した generator (particleGun) を登録

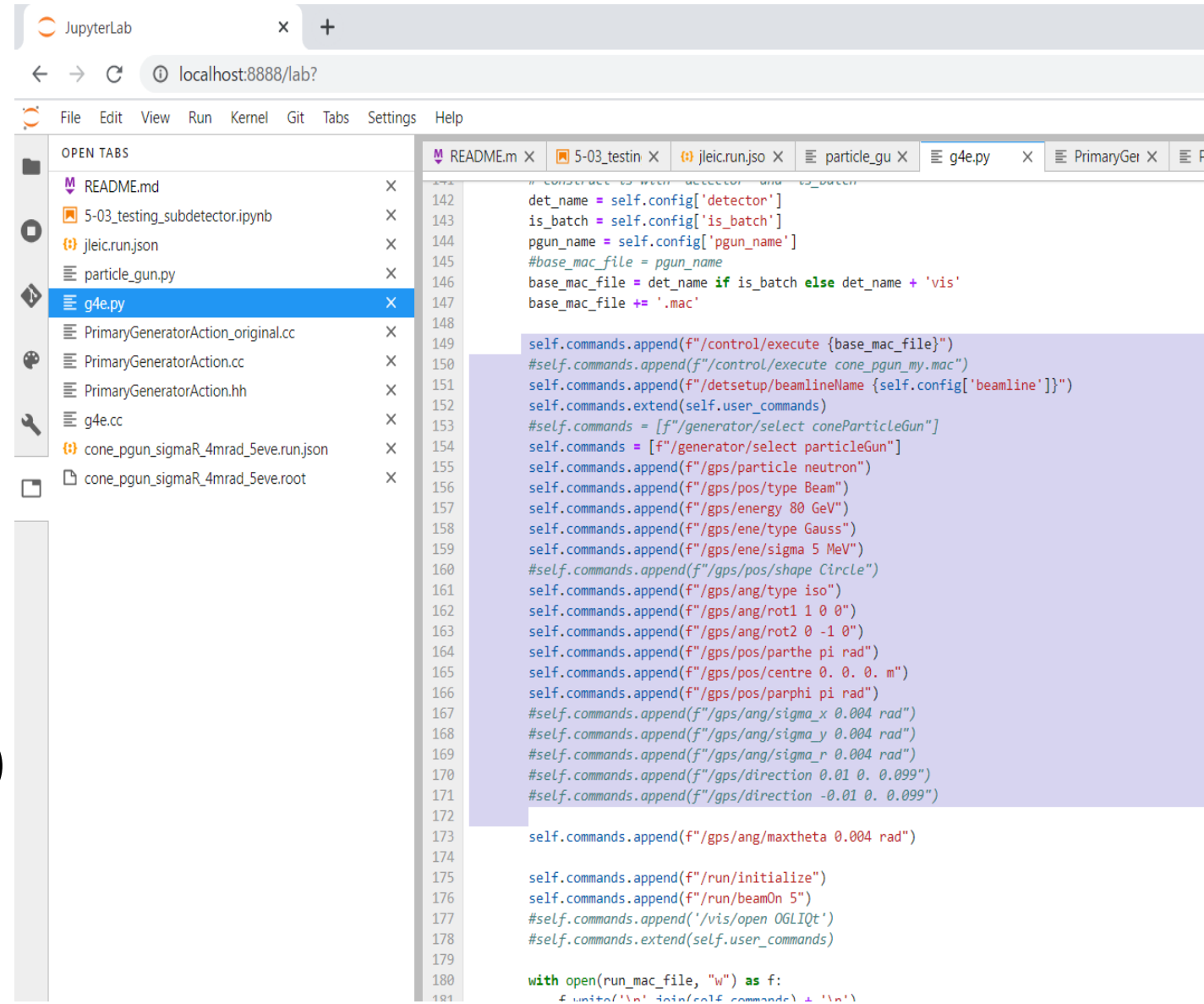


```
→ ↻ localhost:8888/lab?
File Edit View Run Kernel Git Tabs Settings Help
OPEN TABS
README.md x
5-03_testing_subdetector.ipynb x
jleic.run.json x
particle_gun.py x
g4e.py x
PrimaryGeneratorAction_original.cc x
PrimaryGeneratorAction.cc x
PrimaryGeneratorAction.hh x
g4e.cc x
cone_pgun_sigmaR_4mrاد_5eve.run.json x
cone_pgun_sigmaR_4mrاد_5eve.root x

40
41 void SelectGenerator(const G4String& name);
42
43 G4VPrimaryGenerator *GetGenerator() const;
44
45 G4String GetGeneratorName() const;
46
47 static G4String GetPrimaryName();
48
49 static G4double GetPrimaryEnergy();
50
51 private:
52 G4VPrimaryGenerator *fConeParticleGunGenerator; // Particle gun
53 G4VPrimaryGenerator *fParticleGunGenerator; // Particle gun
54 G4VPrimaryGenerator *fHepMcAsciiGenerator; // Herwig, Pythia 8 and other HepMC ascii
55 G4VPrimaryGenerator *fPythiaAsciiGenerator; // Pythia 6 Lund format
56 G4VPrimaryGenerator *fBeagleGenerator; // Beagle Shmeagle
57
58 G4VPrimaryGenerator *GPS_gun;
59
60 G4VPrimaryGenerator *currentGenerator;
61 G4String currentGeneratorName;
62 std::map<G4String, G4VPrimaryGenerator*> gentypeMap;
63
64 PrimaryGeneratorMessenger *messenger;
65
```

GPS commands

- 実際に g4e を走らせる
メインの python コード、
g4e.py に GPS commands
を書き込む
- neutron 5 GeV
z 軸を中心に 30 mrad の
範囲に等方的に撃つ
⇒ /gps/particle neutron
/gps/energy 5 GeV
/gps/ang/type iso
(等方的に撃つ commands)
/gps/ang/maxtheta
0.004 rad



The screenshot shows a JupyterLab window with a browser address bar at localhost:8888/lab/. The left sidebar displays a file explorer with a list of files including README.md, 5-03_testing_subdetector.ipynb, jleic.run.json, particle_gun.py, g4e.py, PrimaryGeneratorAction_original.cc, PrimaryGeneratorAction.cc, PrimaryGeneratorAction.hh, g4e.cc, cone_pgun_sigmaR_4mrad_5eve.run.json, and cone_pgun_sigmaR_4mrad_5eve.root. The g4e.py file is selected and open in the main editor. The code in the editor is a Python class that configures a particle gun and sets GPS parameters. The code is as follows:

```
142 det_name = self.config['detector']
143 is_batch = self.config['is_batch']
144 pgun_name = self.config['pgun_name']
145 #base_mac_file = pgun_name
146 base_mac_file = det_name if is_batch else det_name + 'vis'
147 base_mac_file += '.mac'
148
149 self.commands.append(f"/control/execute {base_mac_file}")
150 #self.commands.append(f"/control/execute cone_pgun_my.mac")
151 self.commands.append(f"/detsetup/beamlineName {self.config['beamline']}")
152 self.commands.extend(self.user_commands)
153 #self.commands = [f"/generator/select coneParticleGun"]
154 self.commands = [f"/generator/select particleGun"]
155 self.commands.append(f"/gps/particle neutron")
156 self.commands.append(f"/gps/pos/type Beam")
157 self.commands.append(f"/gps/energy 80 GeV")
158 self.commands.append(f"/gps/ene/type Gauss")
159 self.commands.append(f"/gps/ene/sigma 5 MeV")
160 #self.commands.append(f"/gps/pos/shape Circle")
161 self.commands.append(f"/gps/ang/type iso")
162 self.commands.append(f"/gps/ang/rot1 1 0 0")
163 self.commands.append(f"/gps/ang/rot2 0 -1 0")
164 self.commands.append(f"/gps/pos/parthe pi rad")
165 self.commands.append(f"/gps/pos/centre 0. 0. 0. m")
166 self.commands.append(f"/gps/pos/parphi pi rad")
167 #self.commands.append(f"/gps/ang/sigma_x 0.004 rad")
168 #self.commands.append(f"/gps/ang/sigma_y 0.004 rad")
169 #self.commands.append(f"/gps/ang/sigma_r 0.004 rad")
170 #self.commands.append(f"/gps/direction 0.01 0. 0.099")
171 #self.commands.append(f"/gps/direction -0.01 0. 0.099")
172
173 self.commands.append(f"/gps/ang/maxtheta 0.004 rad")
174
175 self.commands.append(f"/run/initialize")
176 self.commands.append(f"/run/beamOn 5")
177 #self.commands.append('/vis/open OGLQt')
178 #self.commands.extend(self.user_commands)
179
180 with open(run_mac_file, "w") as f:
181     f.write('\n'.join(self.commands) + '\n')
```

summary

- GPS (Genaral Particle Source) の方が particle gun の汎用性が高いと思う
- g4e で particle gun を撃ち込むため、 Geant4 official の particle gun class GPS を導入
- EIC User Group の人も最近 particle gun を撃つ python コードを書き始めている
(<https://gitlab.com/eic/escalate/g4e/-/tree/master/examples>)
- ただ、自分たちで用意した、普通の particle gun がベース
- GPS の導入が簡単なので、 g4e official の particle gun として入れたい

取り組んでいること

- 今の g4e detector での座標系がわからない
aperture がどこか見つからない
⇒ とりあえず大きな ZDC
192×192×150 cm をさらに 12×12 の
cell に分割 (16×16×150 cm)
を置いて、particle gun を 10000 ほど撃って、(できれば) 来
週までには結果をまとめる

Back up

GPS

- <https://geant4-userdoc.web.cern.ch/UsersGuides/ForApplicationDeveloper/html/GettingStarted/generalParticleSource.html>
- GPS commands の例
<https://indico.lucas.lu.se/event/932/contributions/2737/attachments/725/1379/PrimaryParticle.pdf>

Example commands of General Particle Source

SLAC

```
# two beams in a generator
#
# beam #1
# default intensity is 1 now change to 5.
/gps/source/intensity 5.
#
/gps/particle proton
/gps/pos/type Beam
#
# the incident surface is in the y-z plane
/gps/pos/rot1 0 1 0
/gps/pos/rot2 0 0 1
#
# the beam spot is centered at the origin and is of
# 1d gaussian shape with a 1 mm central plateau
/gps/pos/centre 0. 0. 0. mm
/gps/pos/radius 1. mm
/gps/pos/sigma_r .2 mm
#
# the beam is travelling along the X_axis with
# 5 degrees dispersion
/gps/ang/rot1 0 0 1
/gps/ang/rot2 0 1 0
/gps/ang/type beam1d
/gps/ang/sigma_r 5. deg
#
# the beam energy is in gaussian profile
# centered at 400 MeV
/gps/ene/type Gauss
/gps/ene/mono 400 MeV
/gps/ene/sigma 50. MeV

(macro continuation...)
# beam #2
# 2x the intensity of beam #1
/gps/source/add 10.
#
# this is a electron beam
/gps/particle e-
/gps/pos/type Beam
#
# it beam spot is of 2d gaussian profile
# with a 1x2 mm2 central plateau
# it is in the x-y plane centred at the origin
/gps/pos/centre 0. 0. 0. mm
/gps/pos/halfx 0.5 mm
/gps/pos/halfy 1. mm
/gps/pos/sigma_x 0.1 mm
# the spread in y direction is stronger
/gps/pos/sigma_y 0.2 mm
#
# the beam is travelling along -Z_axis
/gps/ang/type beam2d
/gps/ang/sigma_x 2. deg
/gps/ang/sigma_y 1. deg
# gaussian energy profile
/gps/ene/type Gauss
/gps/ene/mono 600 MeV
/gps/ene/sigma 50. MeV
```

