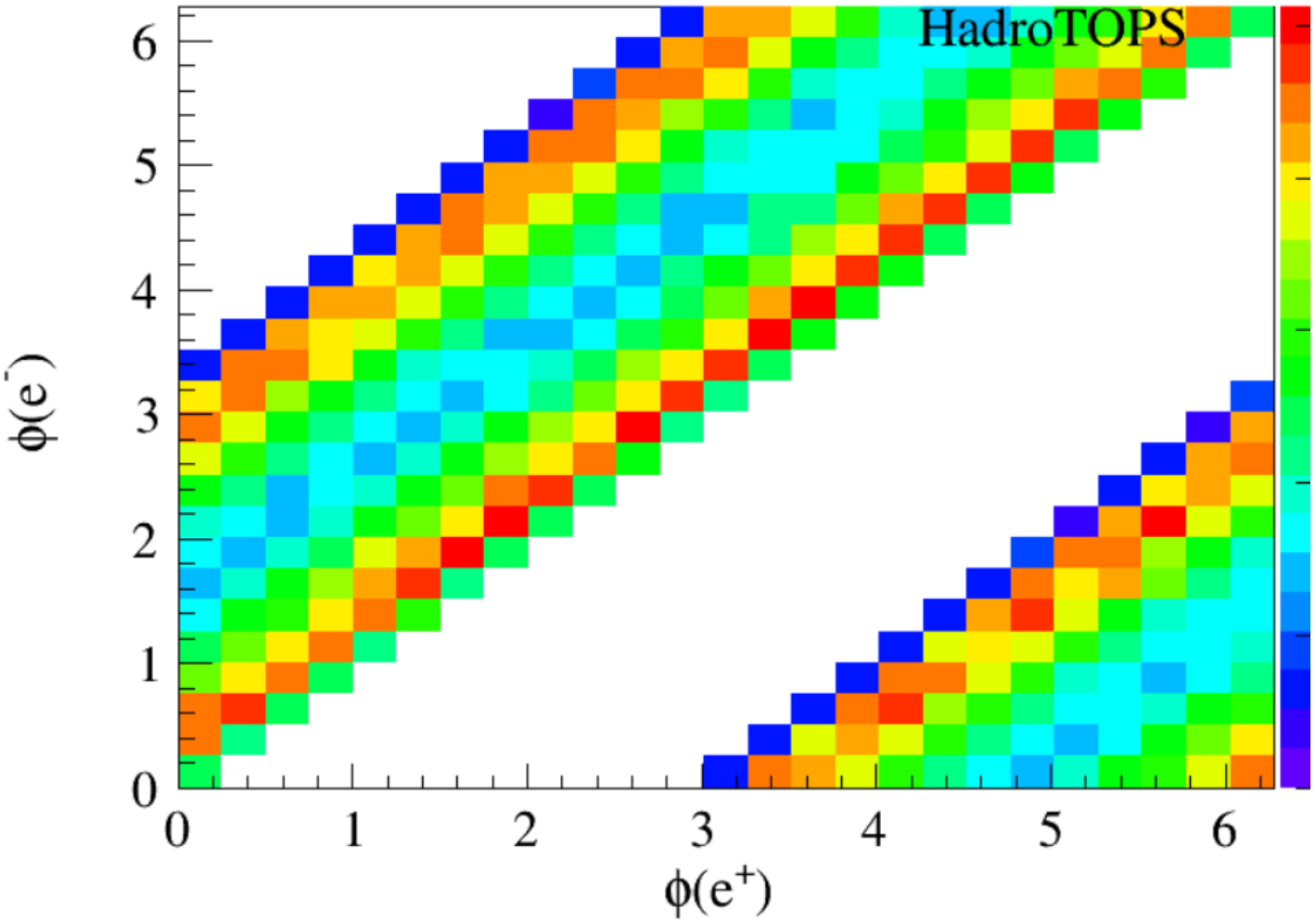
We generated $ee \rightarrow ee\pi^+\pi^-$ using HadroTOPS.

A clear correlation exists between the ϕ angles of e^+ and e^-.



My question:
Is such a correlation physically reasonable, or does it arise from flaws in my MC generation?

We have identified a minor potential bug in HadroTOPS.

At line 201 in src/hadrotops/HadroTOPS.generate.cc

```
201     quad Delta4 = -Delta * powq(sinq(x4 * pi), 2) / 64. / a;
```

Here uses $\sin^2(x4 * \pi)$, so the sign is lost.

Then at

```
286     quad sph1 = 2. * sqrtq(-Delta4) / fabsq(s* beta * Px * sthx * P1 * sth1);
292     quad sph2 = 2. * sqrtq(-Delta4) / fabsq(s* beta * Px * sthx * P2 * sth2);
```

Since 'sqrtq(-Delta4)' always return the positive root and 'fabsq()' is applied in the denominator, so sph1>=0 and sph2>=0, Also

```
    quad sth1 = 2. * sqrtq(D1) / s/ beta / P1;
    quad sth2 = 2. * sqrtq(D3) / s/ beta / P2;
```

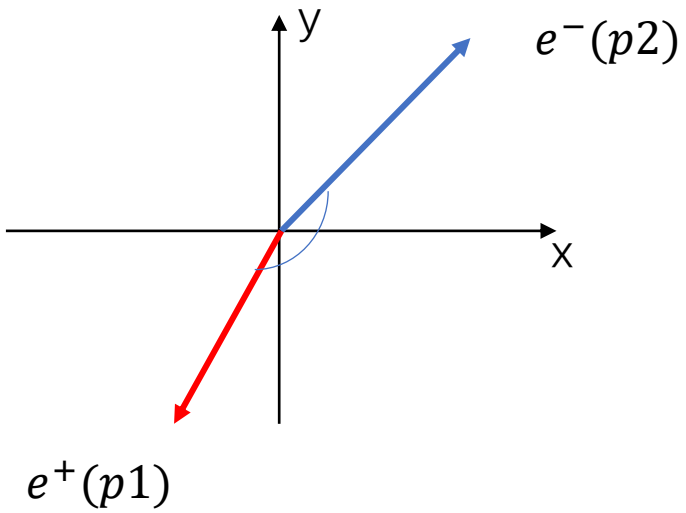
So sth1>=0 and sth2>=0

The part that determines the 4-momentum of final e^+e^- is

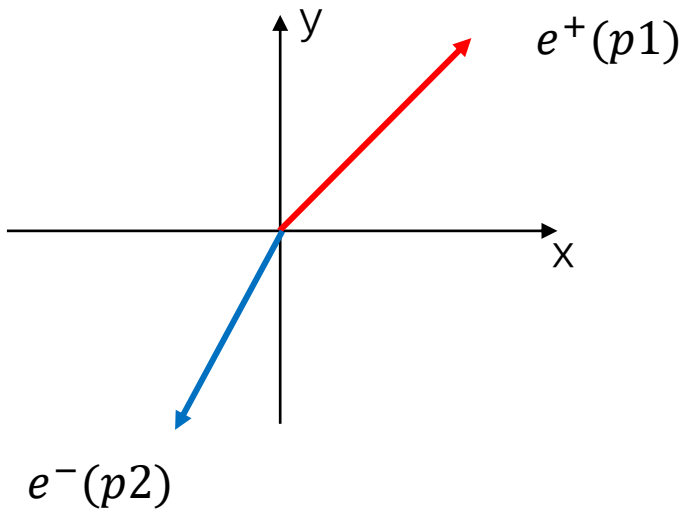
```
320     p1 = LorentzVector(P1 * sth1 * cph1, -P1 * sth1 * sph1, P1 * cth1,  E1);
321     p2 = LorentzVector(P2 * sth2 * cph2,  P2 * sth2 * sph2, -P2 * cth2, E2);
```

Therefore, we always have p1y<=0 and p2y>=0 before the rotation around z-axis

In other words, only case A is realized in the code, while case B never occurs.



Case A



Case B

In case A, with the additional condition $p1x + p2x = px * sthx > 0$, we have $\Delta\phi = \Delta\phi 2 - \Delta\phi 1 \in [0, \pi]$

Back Up

The path I use:
/besfs10/groups/jpsi/jpsigroup/user/haokd/twoGam/HadroTOPS