# Boost of the center-of-mass frame in SuperB

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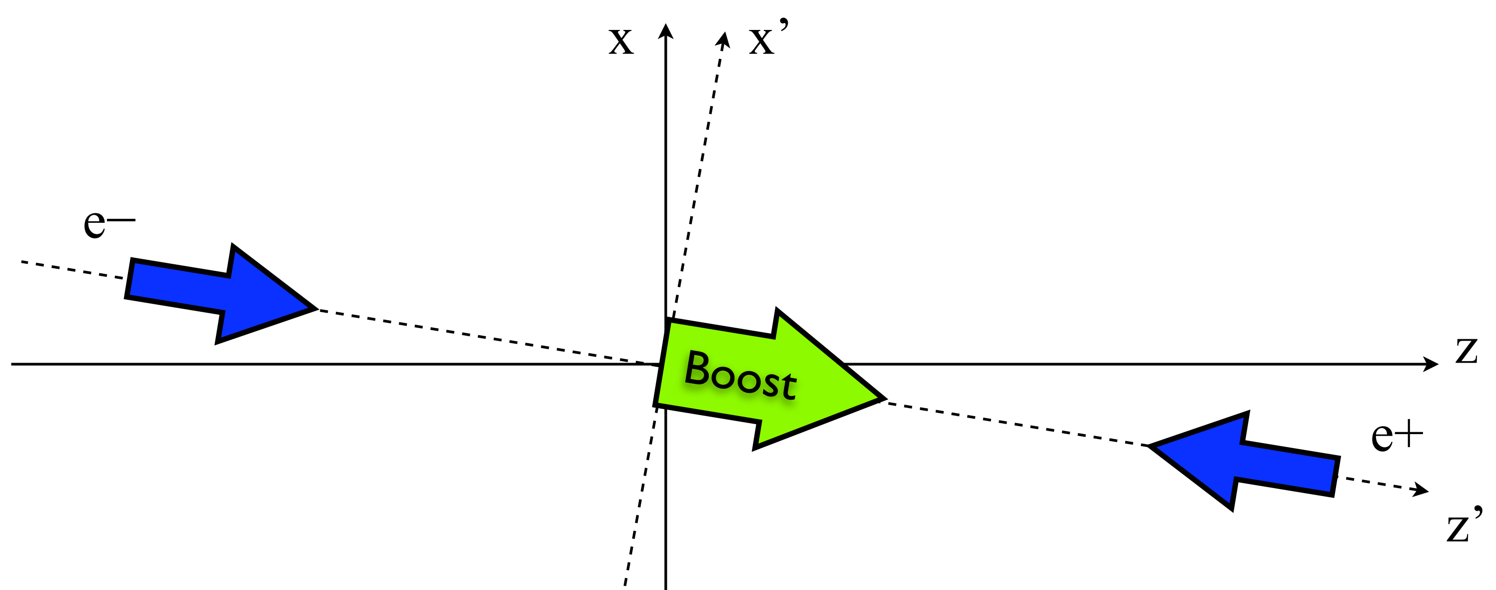
# Head-on beams

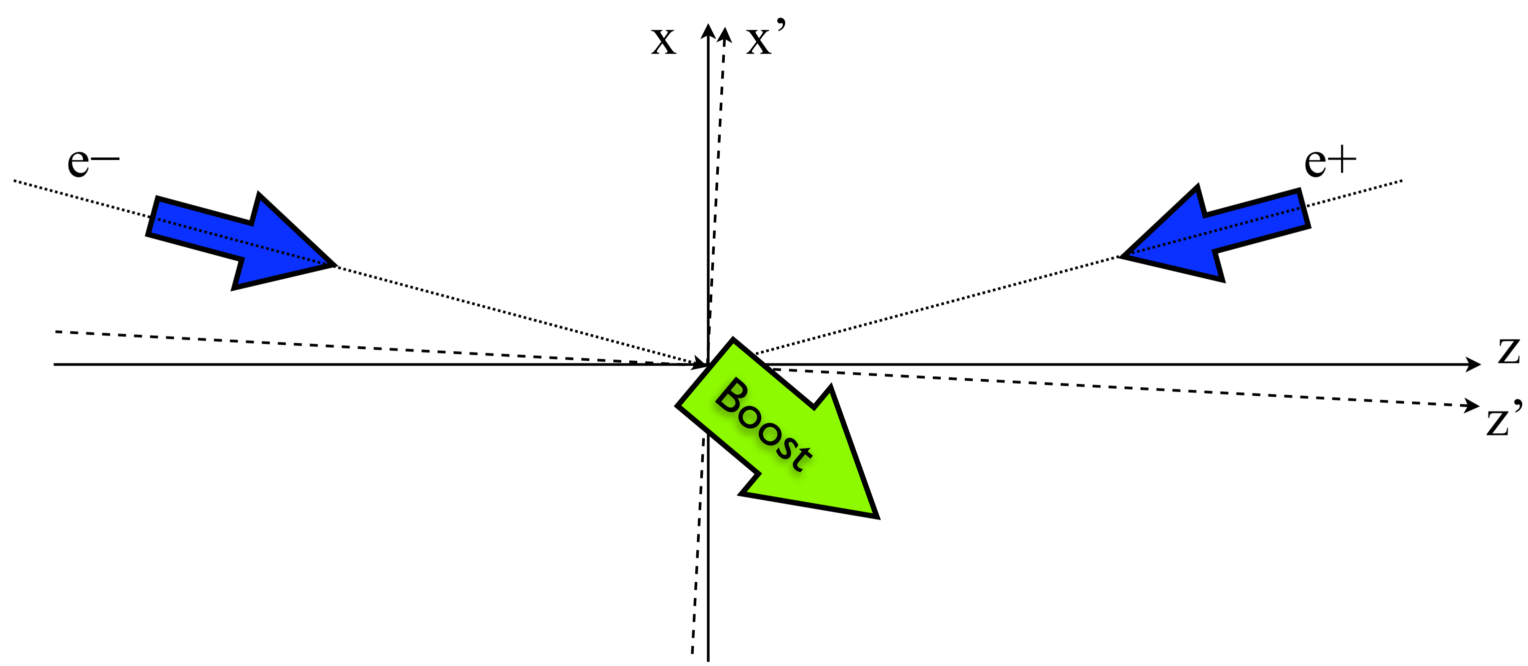
- In Babar the beams collide head-on. The beam axis is on the z-x plane with a small angle (~18mrad) w.r.t. the z-axis.
- Babar software always assumes head-on collision. To specify the beam configuration, it uses beam energies and a boost vector, total of 5 parameters, one more than necessary to describe head-on beams. So the internal inconsistency is possible if cares are not taken.
- To transform events from the c.m. frame to the lab frame, one simply boosts it along the the z-axis using the magnitude of the boost vector and then rotates the event by the polar angle of the boost vector.




boost vector, $\boldsymbol{b} = (\boldsymbol{p}_- + \boldsymbol{p}_+)/(E_- + E_+)$

# Crossing beams

- Six parameters are needed to describe the beam configuration.
- Boost direction, c.m. z-axis and beam momenta are all in different directions.
  - In SuperB, 6.7GeV/4.18GeV, crossing angle ±30mrad
  - => boost polar angle= $-7.4°$ ; c.m. z axis polar angle= $-0.20°$
- Babar's boost/rotation using boost vector will result in the wrong polar angle distribution. Up until recently, we did not consider large crossing angle in the boost config file, so you wouldn't have seen the effect.



# Proper boost procedure

- We need to specify the full momenta of both beams.
- Boost from c.m. frame to lab frame:

1. Determine the c.m. frame boost $\boldsymbol{b} = (\boldsymbol{p}_- + \boldsymbol{p}_+)/(E_- + E_+)$.
2. Boost $\boldsymbol{p}_-$ and $\boldsymbol{p}_+$ to the c.m. frame by $-\boldsymbol{b}$ (becoming $\boldsymbol{p}'_-$ and $\boldsymbol{p}'_+$ ). The z-axis direction of the c.m. frame, $\hat{z}'$, is now in the direction of $\boldsymbol{p}'_-$. The rotation axis is $\boldsymbol{a} = \hat{z} \times \hat{z}'$, and the angle is $\theta = \sin^{-1} |\boldsymbol{a}|$, where $\hat{z}$ and $\hat{z}'$ are unit vectors.
3. For each particle generated in the c.m. frame, it is first rotated about the axis $\boldsymbol{a}$ by the angle $\theta$.
4. And then it is boosted by the c.m. frame boost vector $\boldsymbol{b}$.

- Code changes: PepEnv, PepEnvData, etc. which are related to defining PepBeams; and generators, which boost events from c.m. frame to the lab; and analysis code that boost events from lab to the c.m. frame.