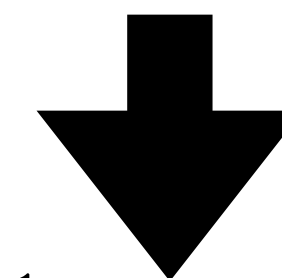


Random events

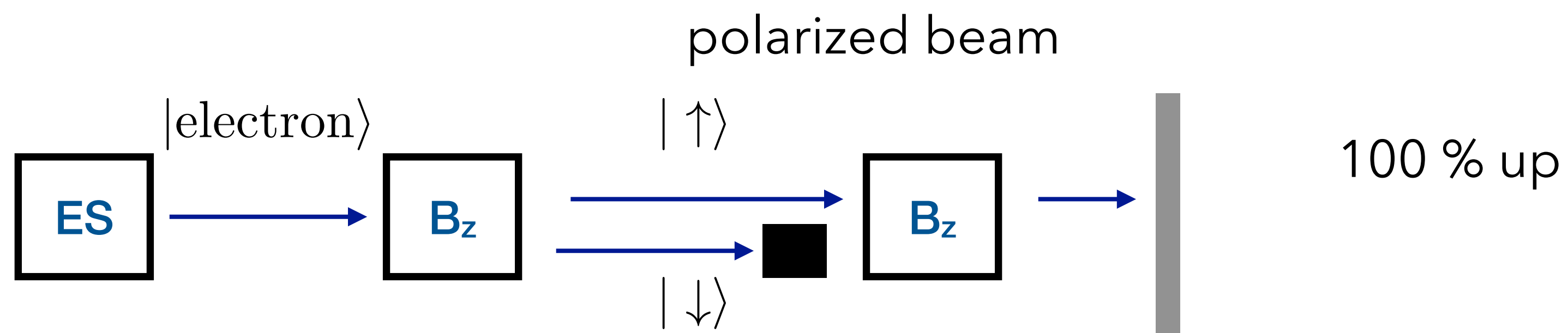
50% up / 50 % down



$$|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle = |+\rangle$$

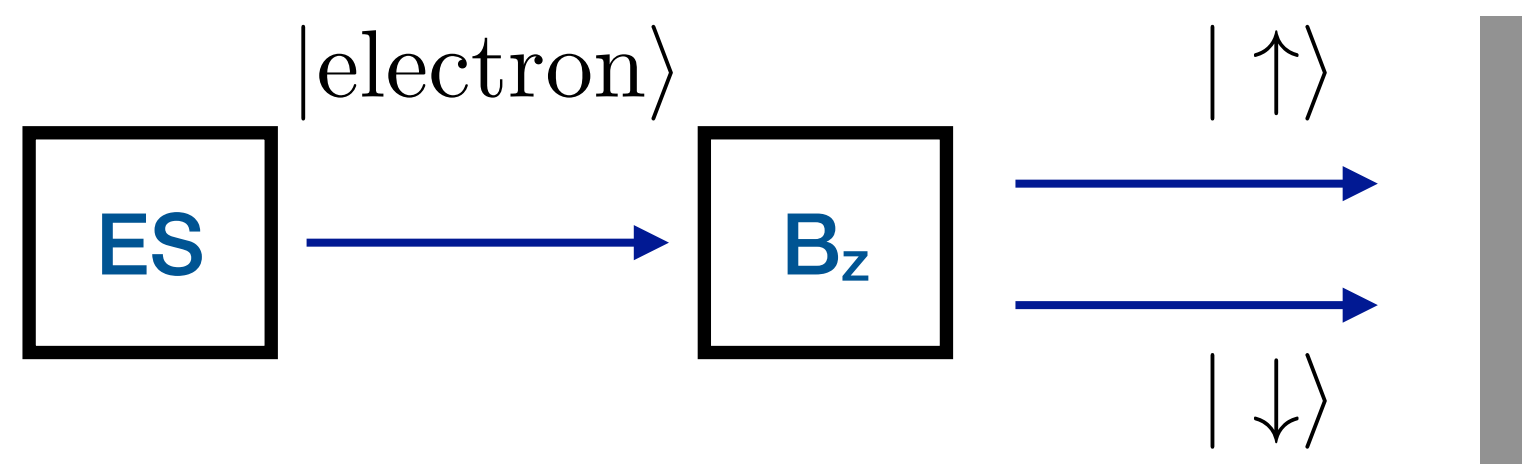
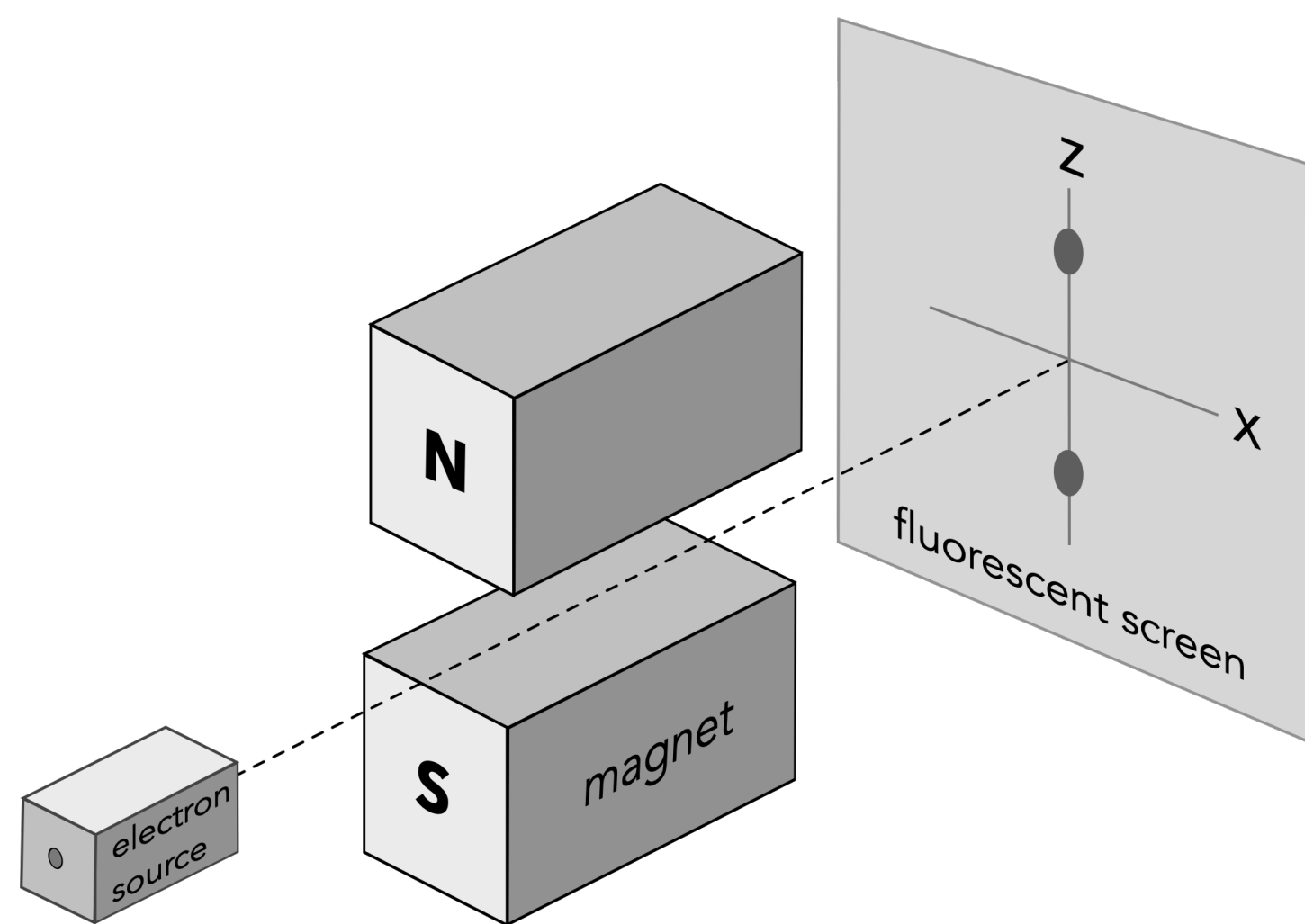
or

$$|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle - \frac{1}{\sqrt{2}}|\downarrow\rangle = |-\rangle$$



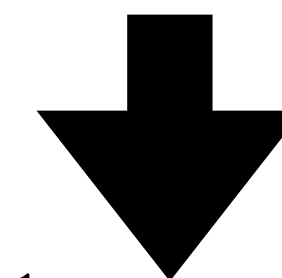
100 % up

Spin moment in z:  $+\frac{1}{2}\hbar$



Random events

50% up / 50 % down

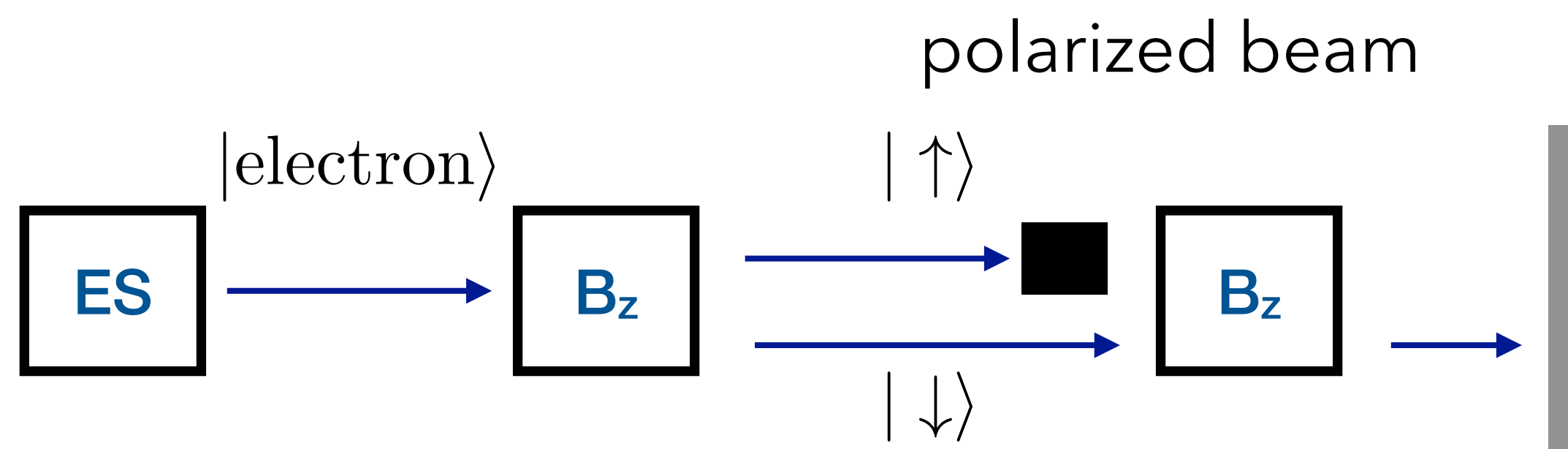


$$|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle = |+\rangle$$

or

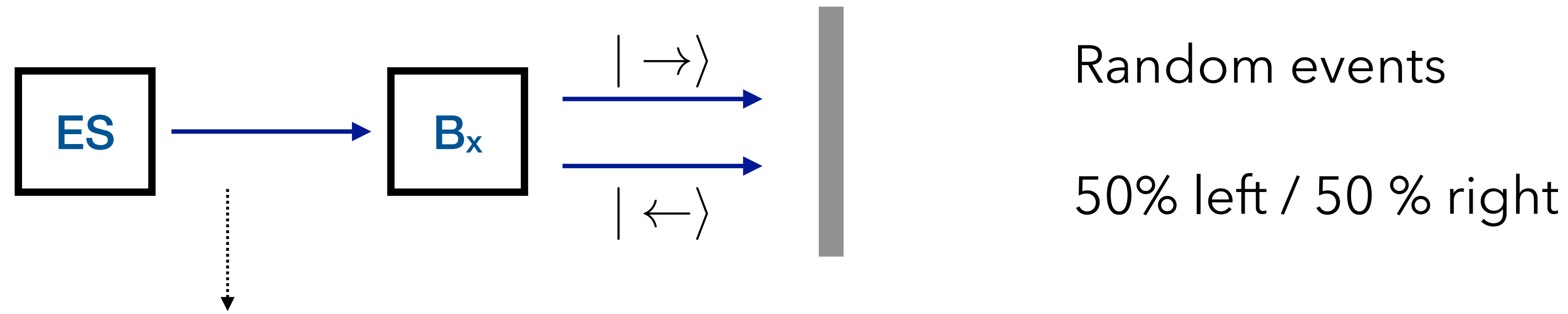
$$|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle - \frac{1}{\sqrt{2}}|\downarrow\rangle = |-\rangle$$

or



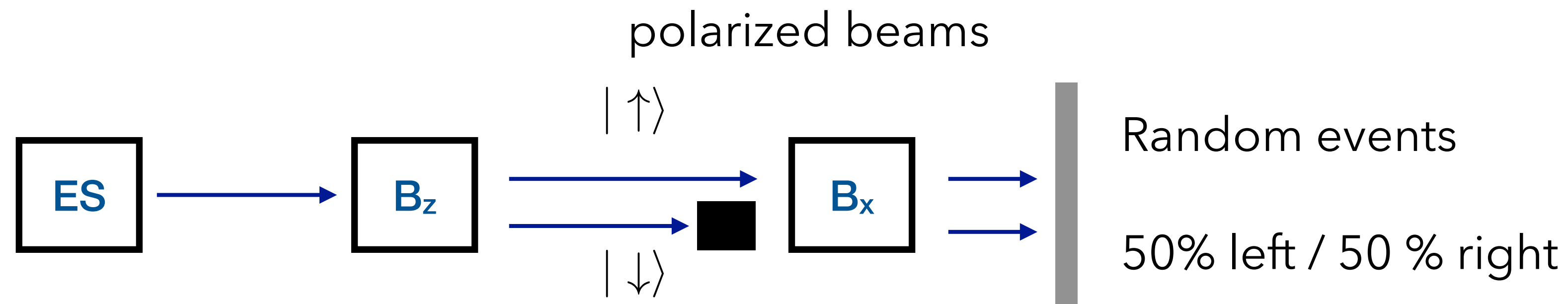
100 % down

Spin moment in z:  $-\frac{1}{2}\hbar$



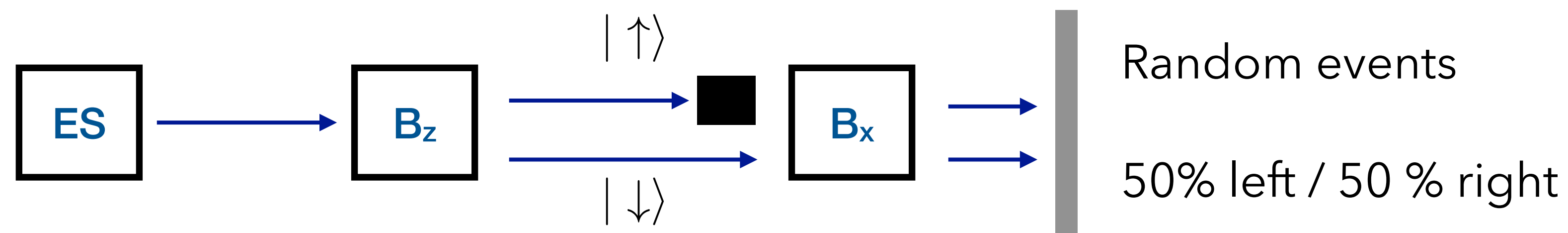
Spin moment in x:  $\pm \frac{1}{2} \hbar$

$$|\text{electron}\rangle = \frac{1}{\sqrt{2}} |\uparrow\rangle + \frac{1}{\sqrt{2}} |\downarrow\rangle$$



$$|\uparrow\rangle = \frac{1}{\sqrt{2}} |\rightarrow\rangle + \frac{1}{\sqrt{2}} |\leftarrow\rangle$$

$$|\downarrow\rangle = \frac{1}{\sqrt{2}} |\rightarrow\rangle - \frac{1}{\sqrt{2}} |\leftarrow\rangle$$



$$|\uparrow\rangle = \frac{1}{\sqrt{2}}|\rightarrow\rangle + \frac{1}{\sqrt{2}}|\leftarrow\rangle$$

$$|\downarrow\rangle = \frac{1}{\sqrt{2}}|\rightarrow\rangle - \frac{1}{\sqrt{2}}|\leftarrow\rangle$$

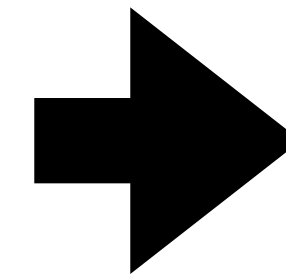
$$|\rightarrow\rangle = |+\rangle$$

$$|\leftarrow\rangle = |-\rangle$$

but we also have:

$$|+\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle$$

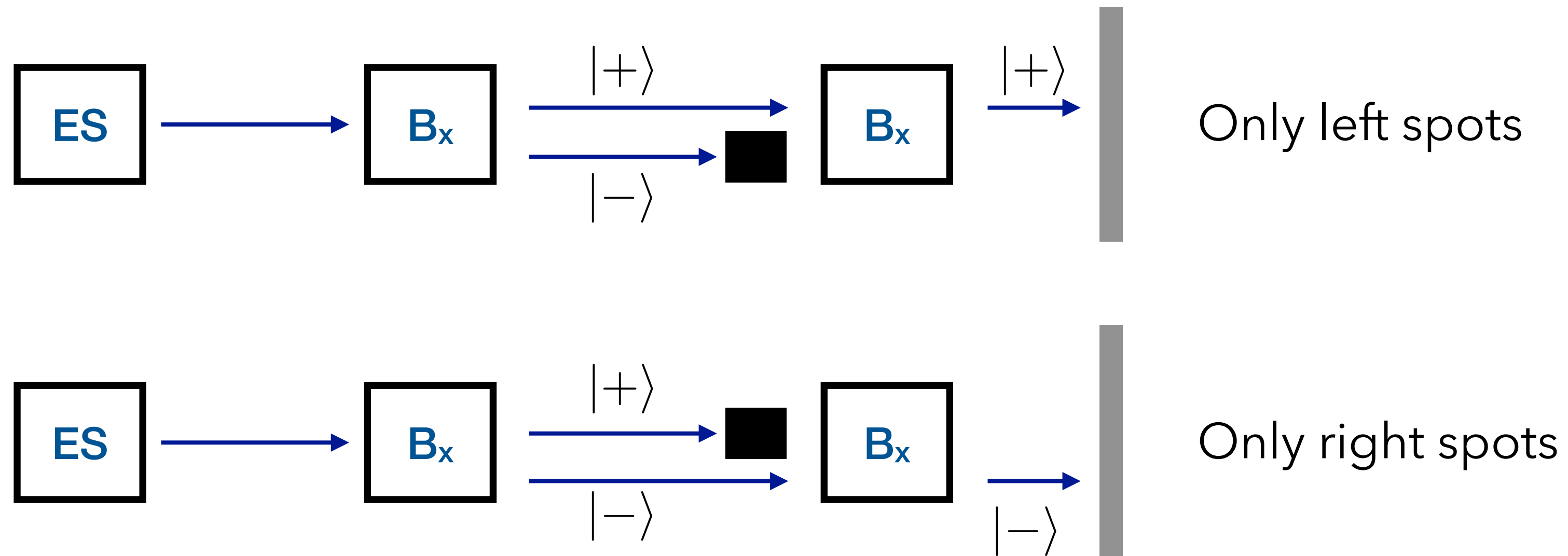
$$|-\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle - \frac{1}{\sqrt{2}}|\downarrow\rangle$$

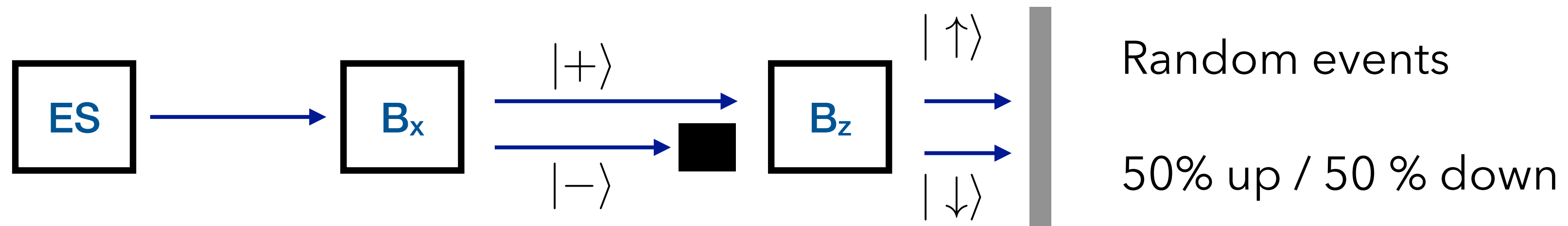


$$|\uparrow\rangle = \frac{1}{\sqrt{2}}|+\rangle + \frac{1}{\sqrt{2}}|-\rangle$$

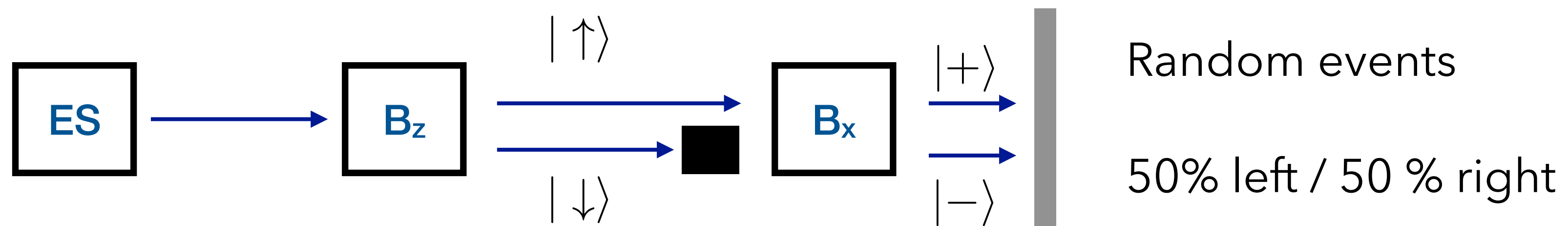
$$|\downarrow\rangle = \frac{1}{\sqrt{2}}|+\rangle - \frac{1}{\sqrt{2}}|-\rangle$$

polarized beams





$$|+\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle$$



$$|\uparrow\rangle = \frac{1}{\sqrt{2}}|+\rangle + \frac{1}{\sqrt{2}}|-\rangle$$

ES



B<sub>z</sub>

B<sub>x</sub>

B<sub>z</sub>



N times:  $|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle$



ES



B<sub>z</sub>



B<sub>x</sub>

B<sub>z</sub>



N times:  $|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle$



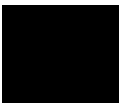
ES



B<sub>z</sub>



B<sub>x</sub>



B<sub>z</sub>



N times:  $|\text{electron}\rangle = \frac{1}{\sqrt{2}}|\uparrow\rangle + \frac{1}{\sqrt{2}}|\downarrow\rangle$

