Origin of Matter; Quarks

:Through Studying Hadrons

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Quarks

Hadrons : Particles consist of some quarks.

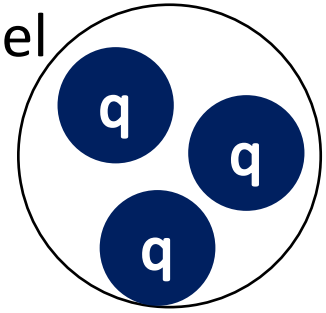
Baryons : Hadrons consist of 3 quarks. Ex). Proton

Mesons : Hadrons consist of 2 quarks. Ex). π meson
(Quark and anti-quark)

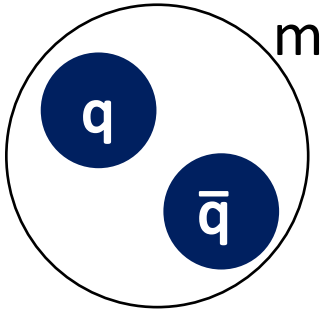
Quarks : Most fundamental particles.

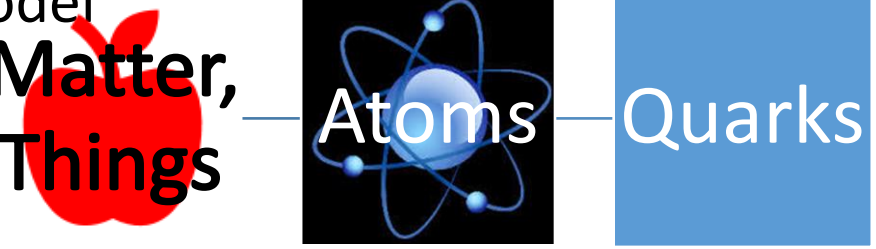
;We have no means to see them directly, so we use hadrons to "see" quarks.

Baryons' model



Mesons' model





The Aim of Our Study

1. Reconstruct hadrons

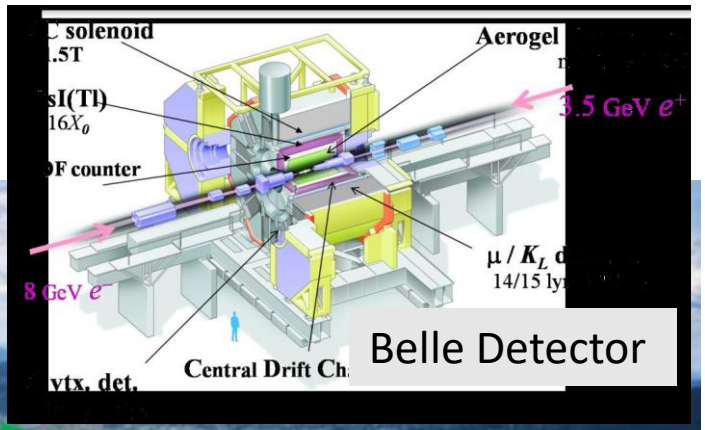
2. Find evidence which show that hadrons consist of quarks

Accelerator

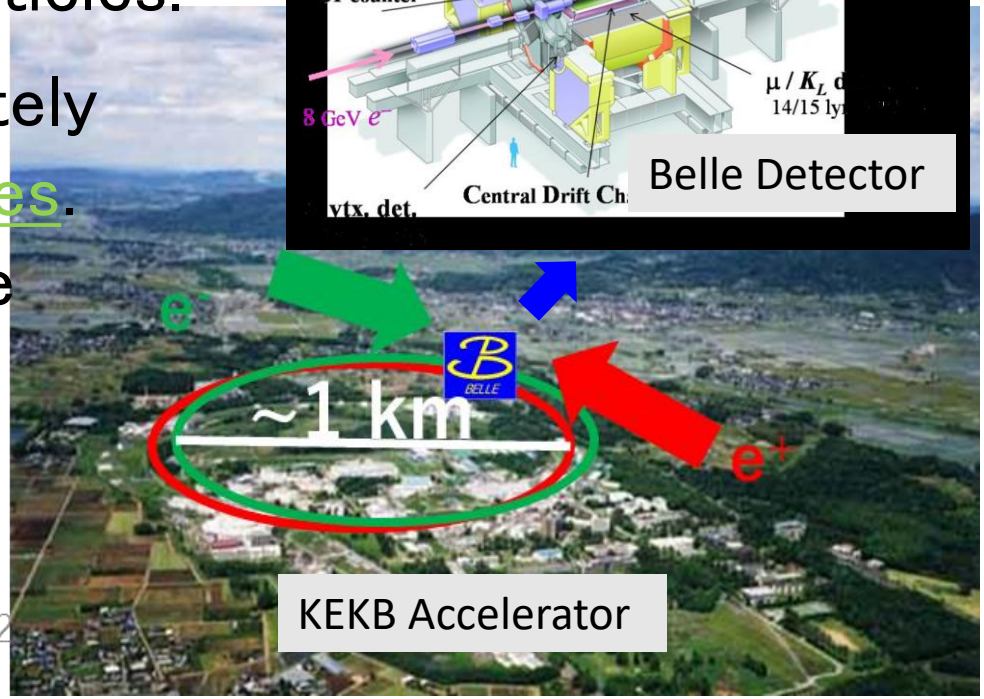
$E=mc^2$ show that we need high energy to create heavy particles like hadrons.

Accelerator is machine which accelerate and collide particles.

A heavy hadron immediately decays into lighter particles. These lighter particles are measured by detector.

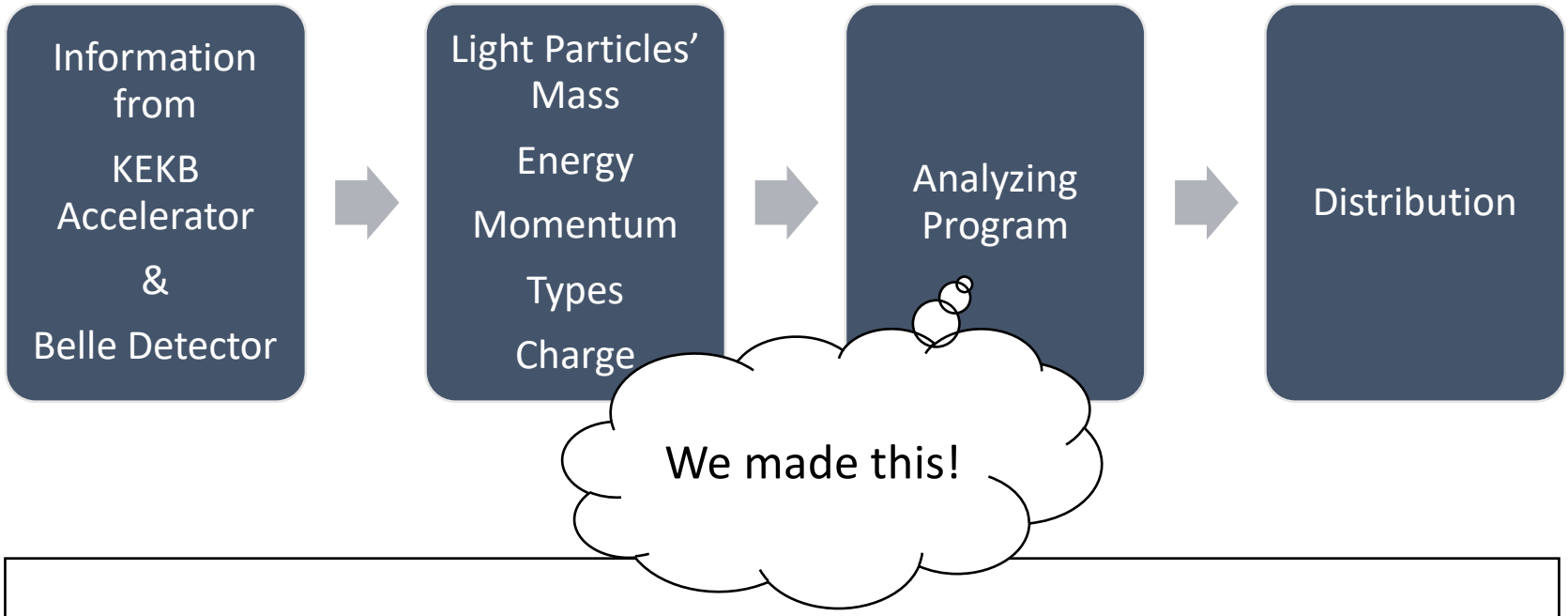


Belle Detector



KEKB Accelerator

Reconstructing

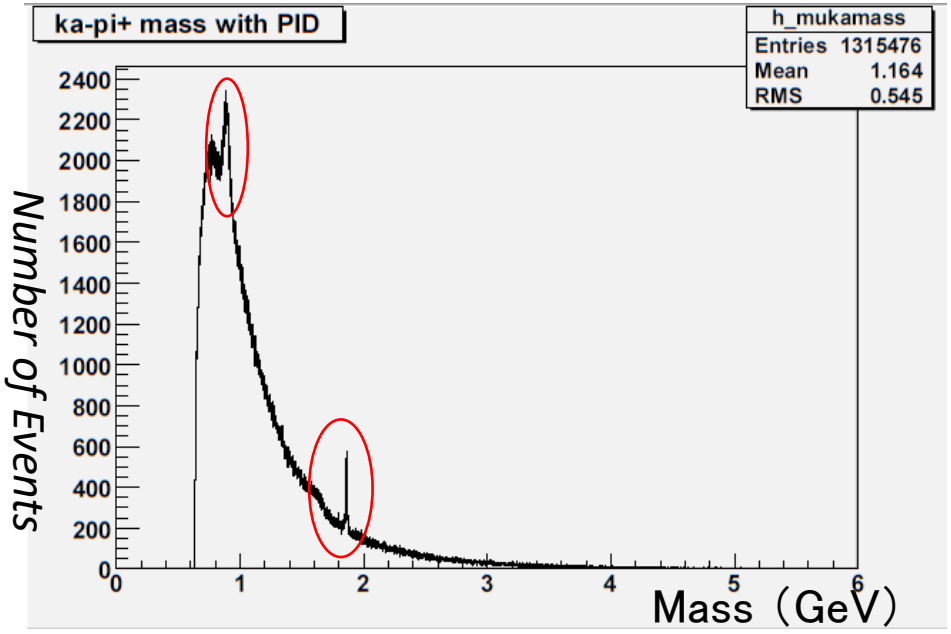


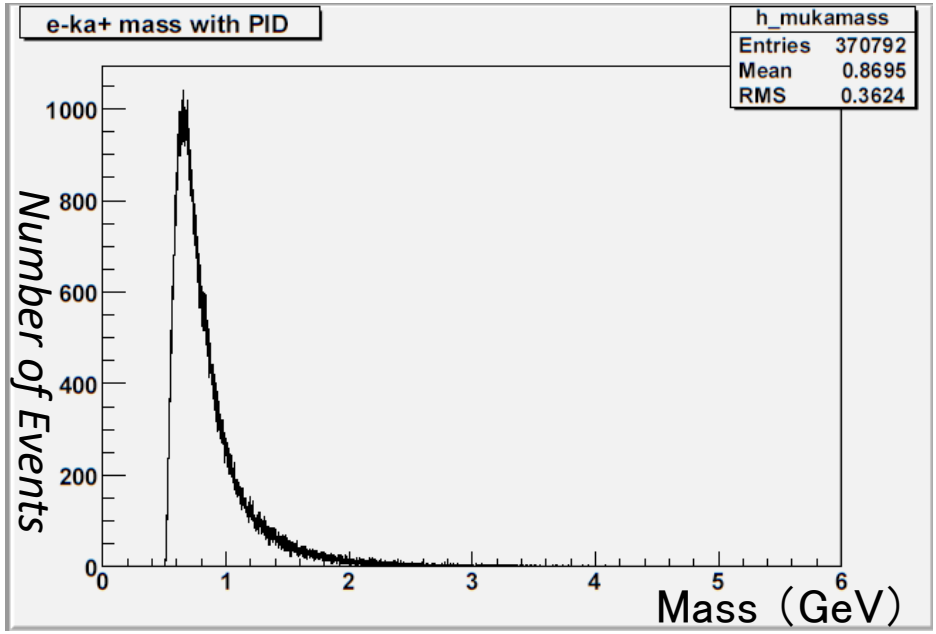
$$m = \sqrt{E^2/c^4 - p^2/c^2}$$

(m : Mass, E : Energy, p : Momentum,
c : The velocity of light)

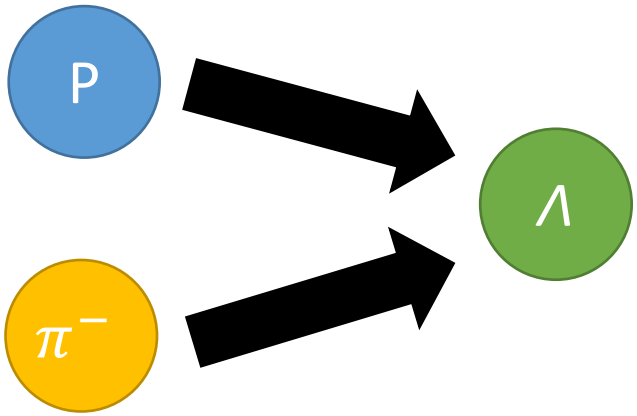
Making Mass Distributions

We made mass distributions of reconstructed hadrons. Peaks in mass distributions are the evidence of them.





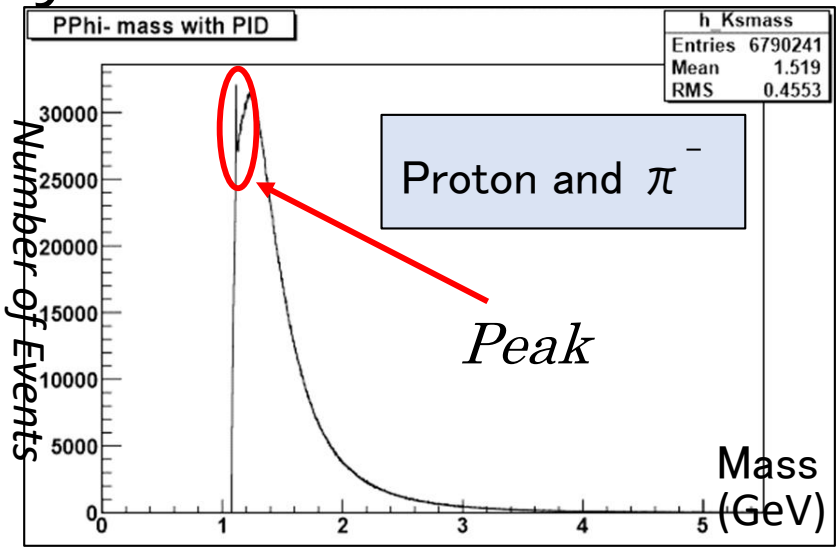
Reconstruction of Baryons



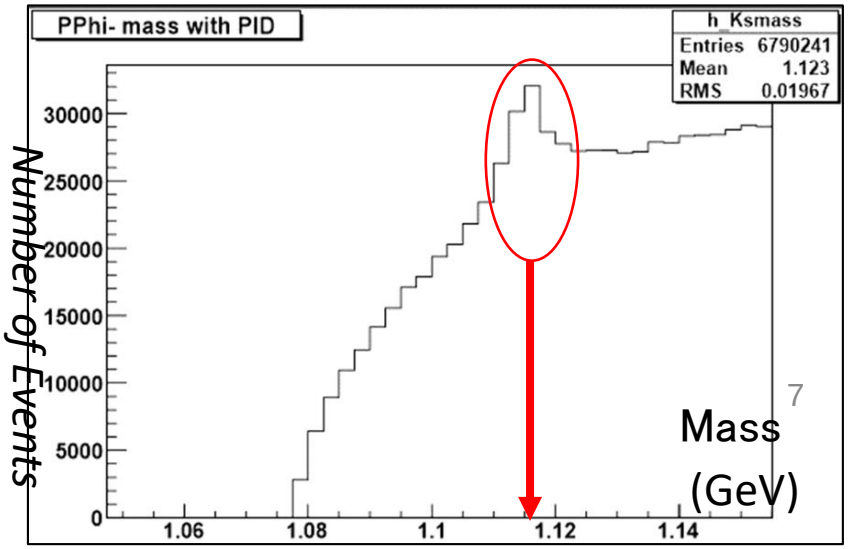
About Λ Particles
Decay Mode : $\Lambda \rightarrow p\pi^-$
Mass : 1.116GeV

Mass of Proton : 0.938GeV
Consisting Quarks ;
Λ : u d s
Proton: u d u

☆*Difference of kinds of quarks causes the difference of hadrons' mass*



Expanded Distribution



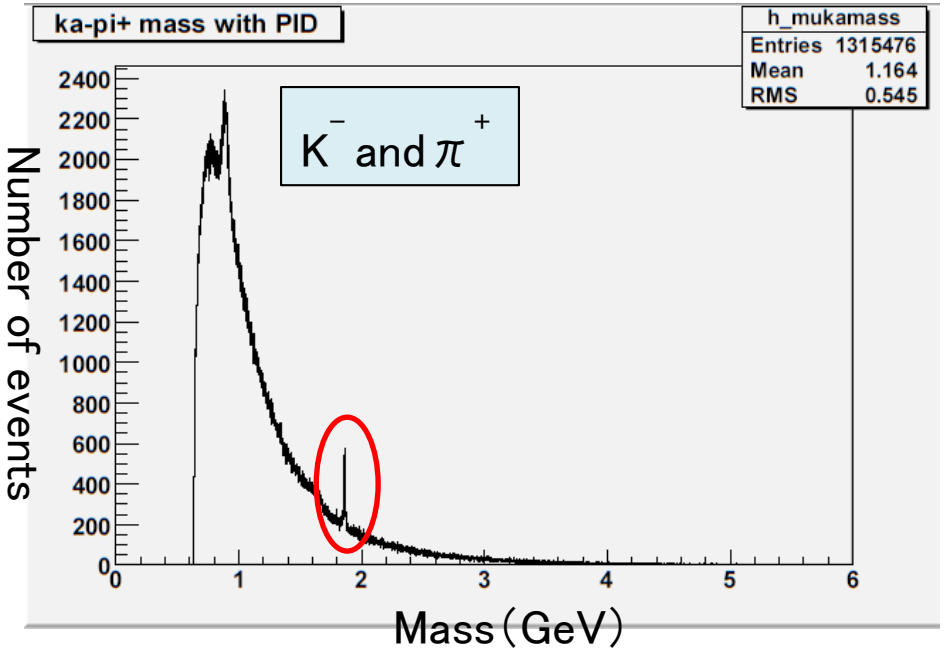
Reconstructions of Mesons

From K^- and π^+

$D^0 \rightarrow K^- \pi^+$

Mass of D^0 : 1.864GeV

<u>Discovery of D^0 !</u>



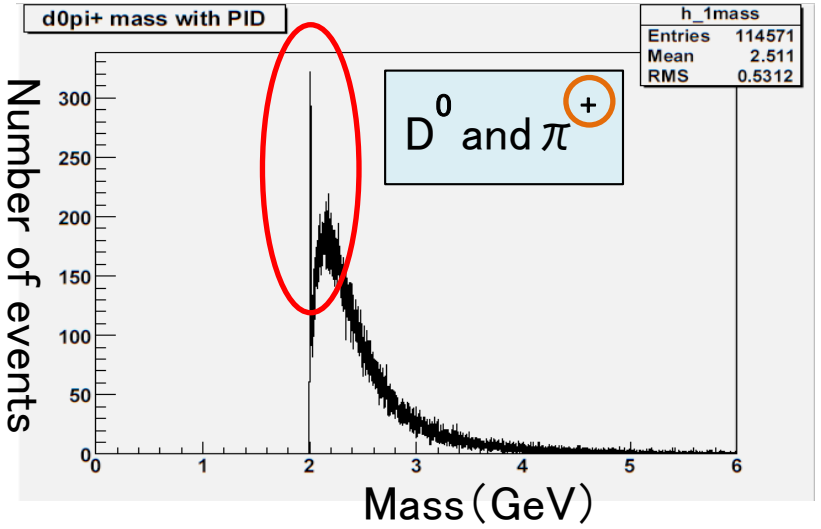
Reconstruction of Mesons

- From D^0 and π^+

$D^{*+} \rightarrow D^0 \pi^+$

Mass of D^{*+} : 2.010GeV

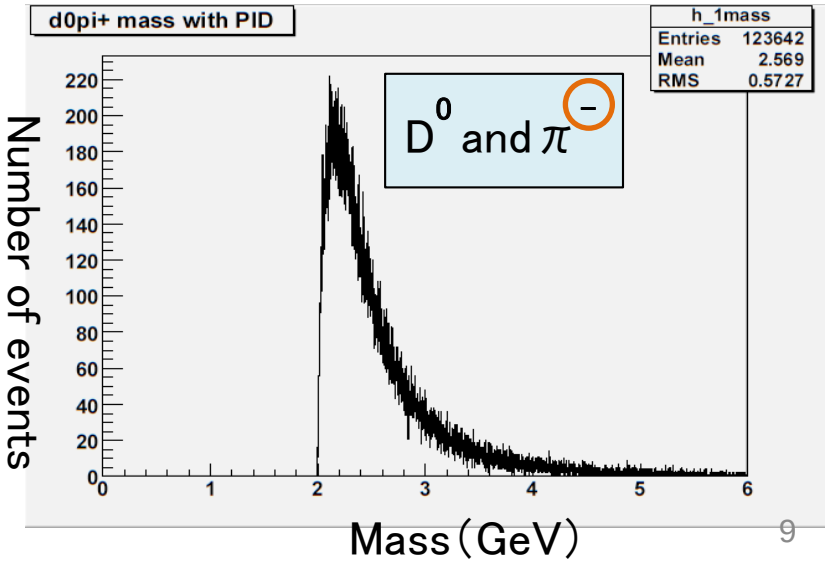
Discovery of D^{*+}!



- From D^0 and π^-

There is No peak!

→It can be explained by quarks.

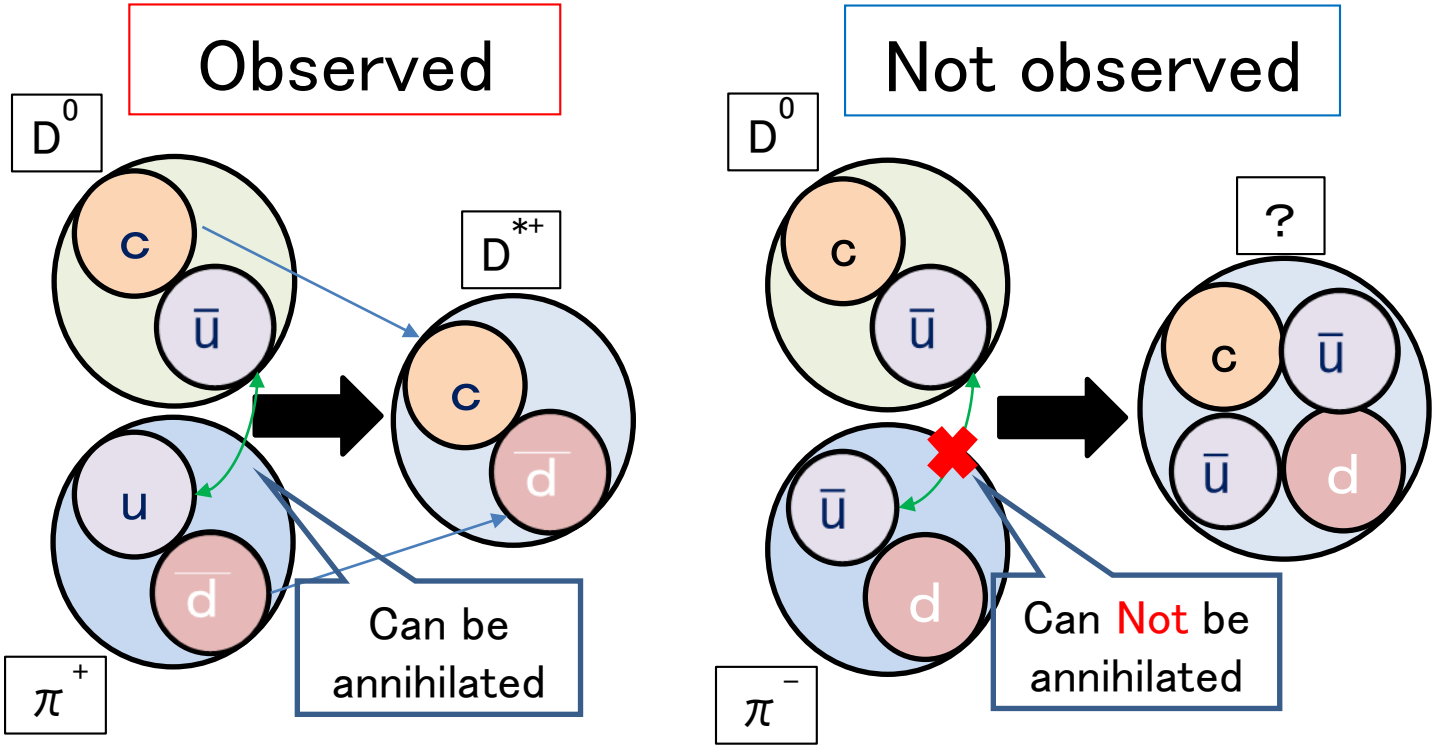


Explanation by Quarks

Mesons : Hadrons consisted by 2 quarks

- u : up quark
- d : down quark
- c : charm quark
- $\bar{u}$, $\bar{d}$, $\bar{c}$: anti-quarks

D^{*+}, D^{0}, π^{+}, and π^{-} are all mesons.



Conclusion

- We reconstructed baryons（Λ）and mesons (D^{*+}).
- Difference of kinds of quarks causes the difference of hadrons' mass.
- We can see a peak in D^0 and π^+
  and can not see in D^0 and π^-.
  This can be explained by quarks.

Origin of Matter is Quarks!