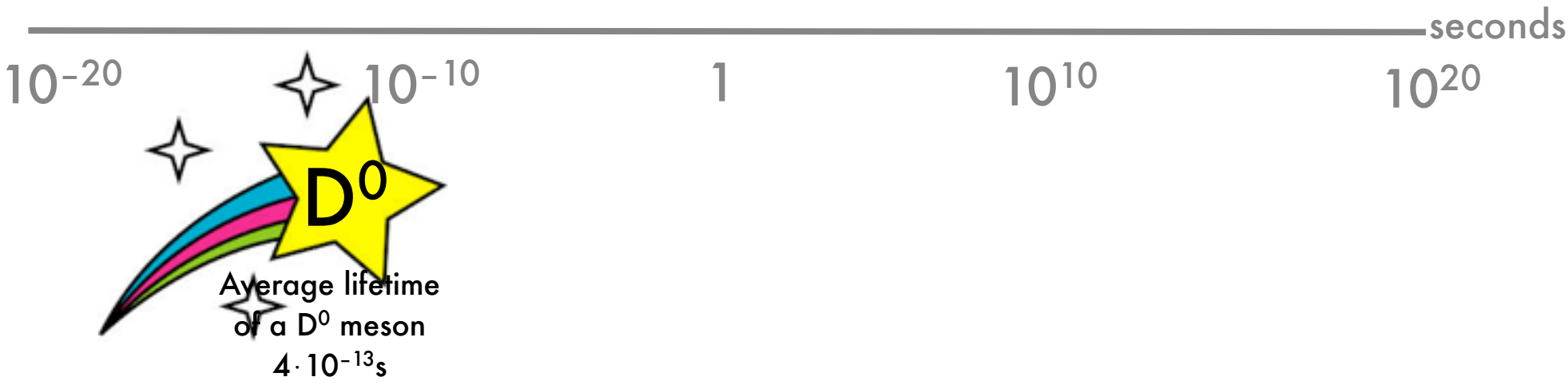
LHCb Masterclass

Good Times

Time scales

Time scales


seconds
10^{-20}
10^{-10}
1
10^{10}
10^{20}
D^0
Average lifetime
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$4 \cdot 10^{-13}$s

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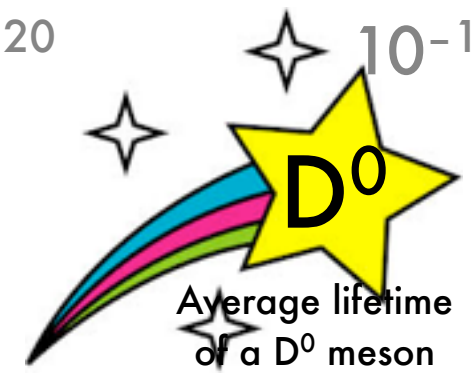

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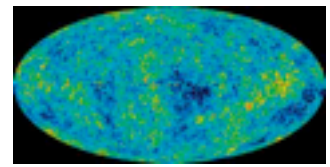

birth of the universe $4 \cdot 10^{17}$s ago

Time scales

typical life-span
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$2.4 \cdot 10^9$s

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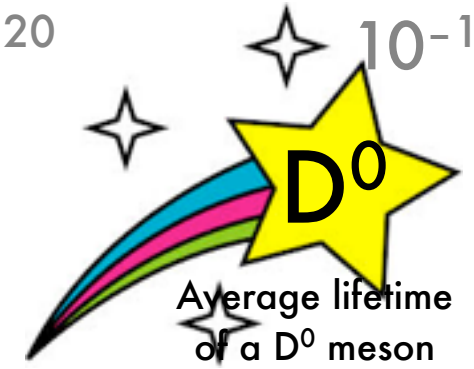

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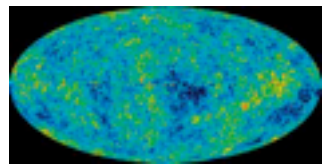

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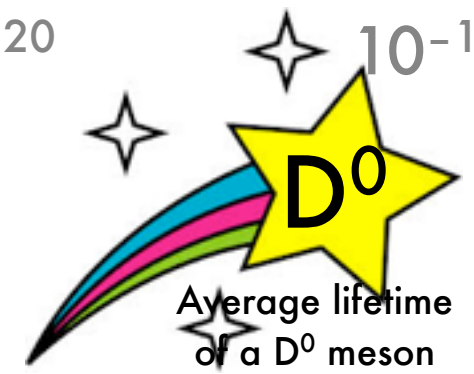

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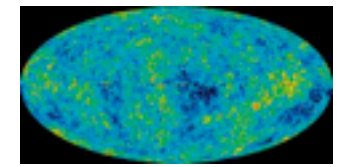

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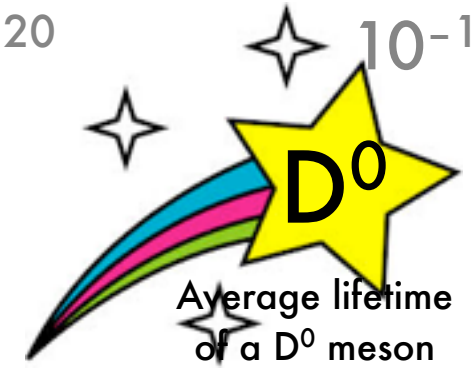

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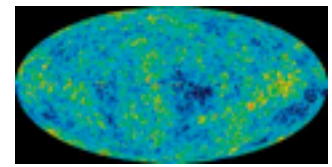

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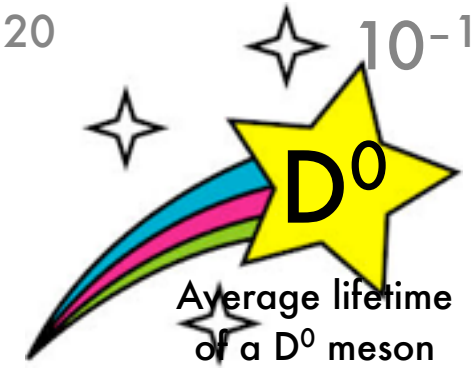

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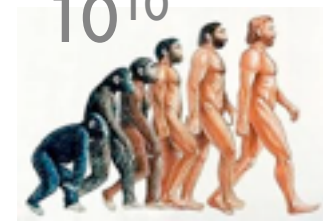

First homo
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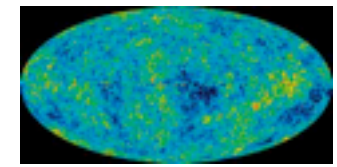
$6 \cdot 10^{12}$ s ago



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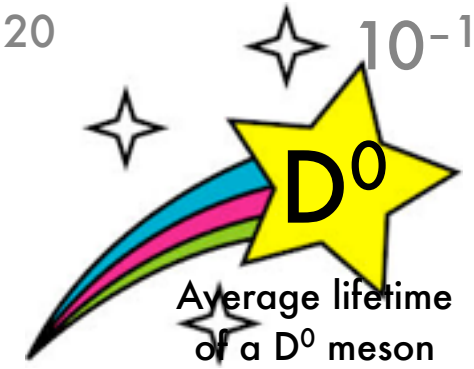

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This talk: ca
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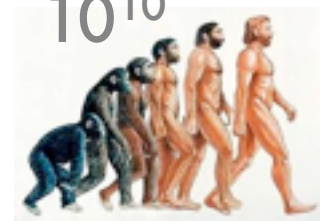
10^{10}



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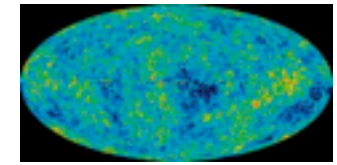

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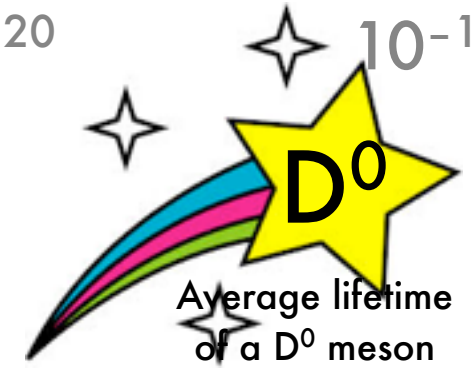

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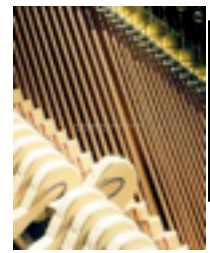

T=1/f of a
piano string
$4 \cdot 10^{-3}$ s

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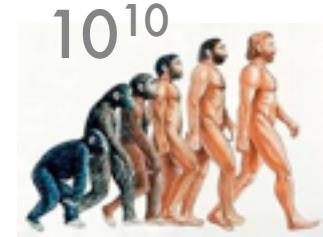

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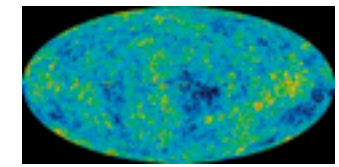

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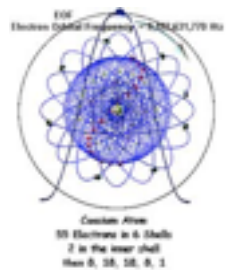

T=1/f of an atomic clock
10^{-10} s

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extinction of dinosaurs
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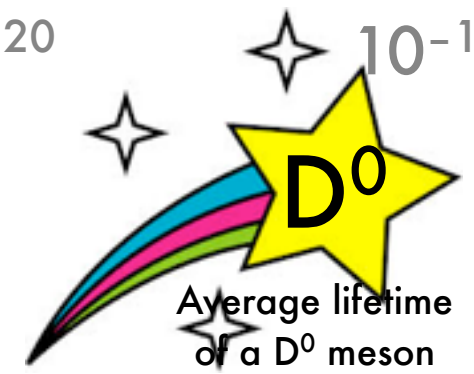

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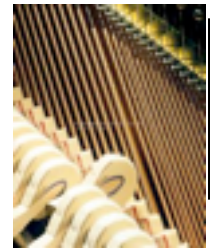

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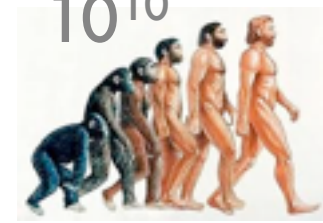

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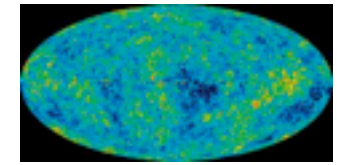

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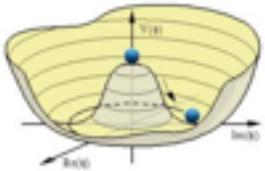
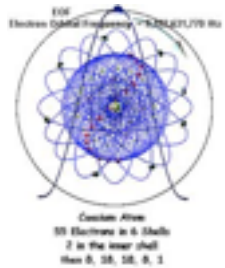


Average lifetime of a Higgs boson $1.6 \cdot 10^{-22}$s



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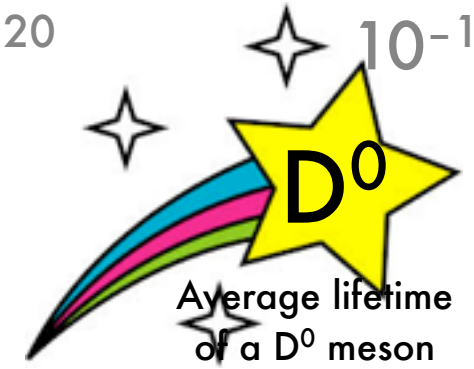
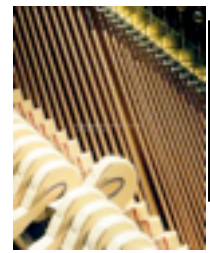


Average lifetime of a D^0 meson $4 \cdot 10^{-13}$s



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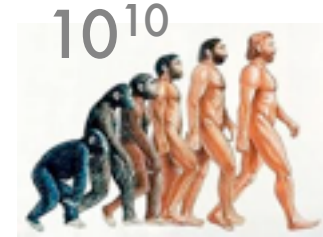
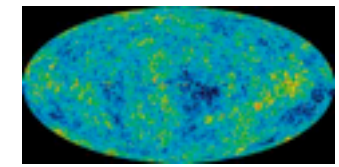


First homo sapiens $6 \cdot 10^{12}$ s ago



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You measured an incredibly short amount of time!

Average lifetime of a D^0 meson $4 \cdot 10^{-13}$s

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2h

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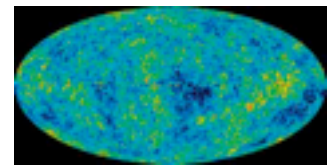

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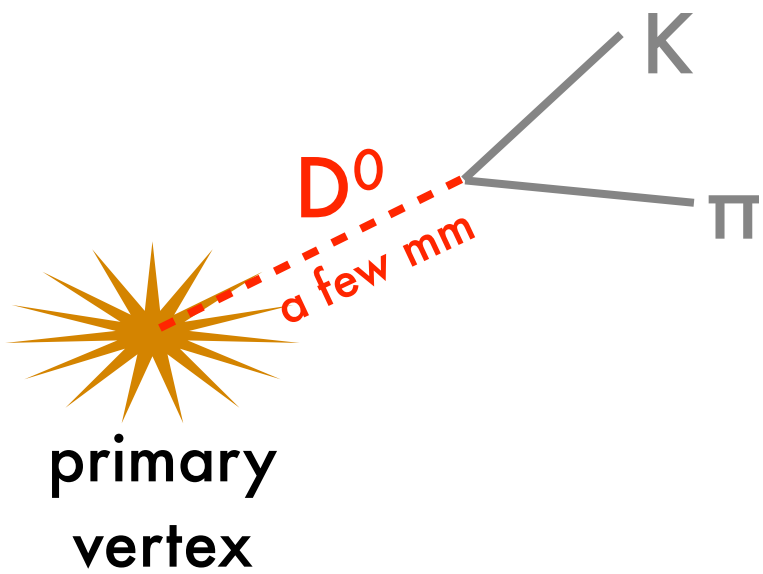
- This is because of time dilation (Special Relativity). Fast D^0 mesons live longer. A lifetime at rest of 0.41 ps means a lifetime inside our experiment of ca 10ps
- So with incredibly high speeds, we win twice: The D^0 travels further in any given time, plus it lives longer -> measurable distances (several mm).

What you found

- It's tricky. There is background, and there are D mesons that don't come from the primary vertex



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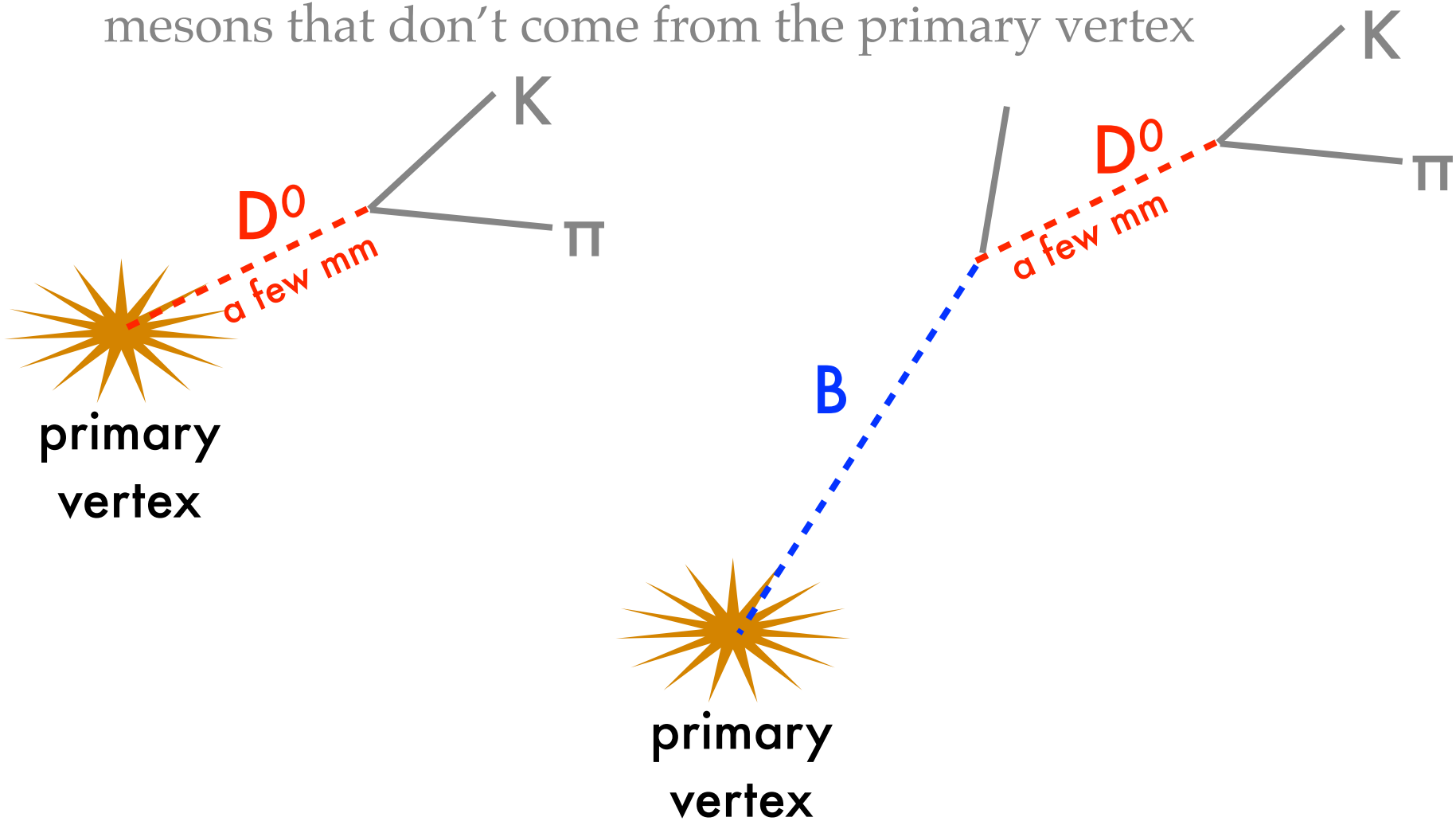

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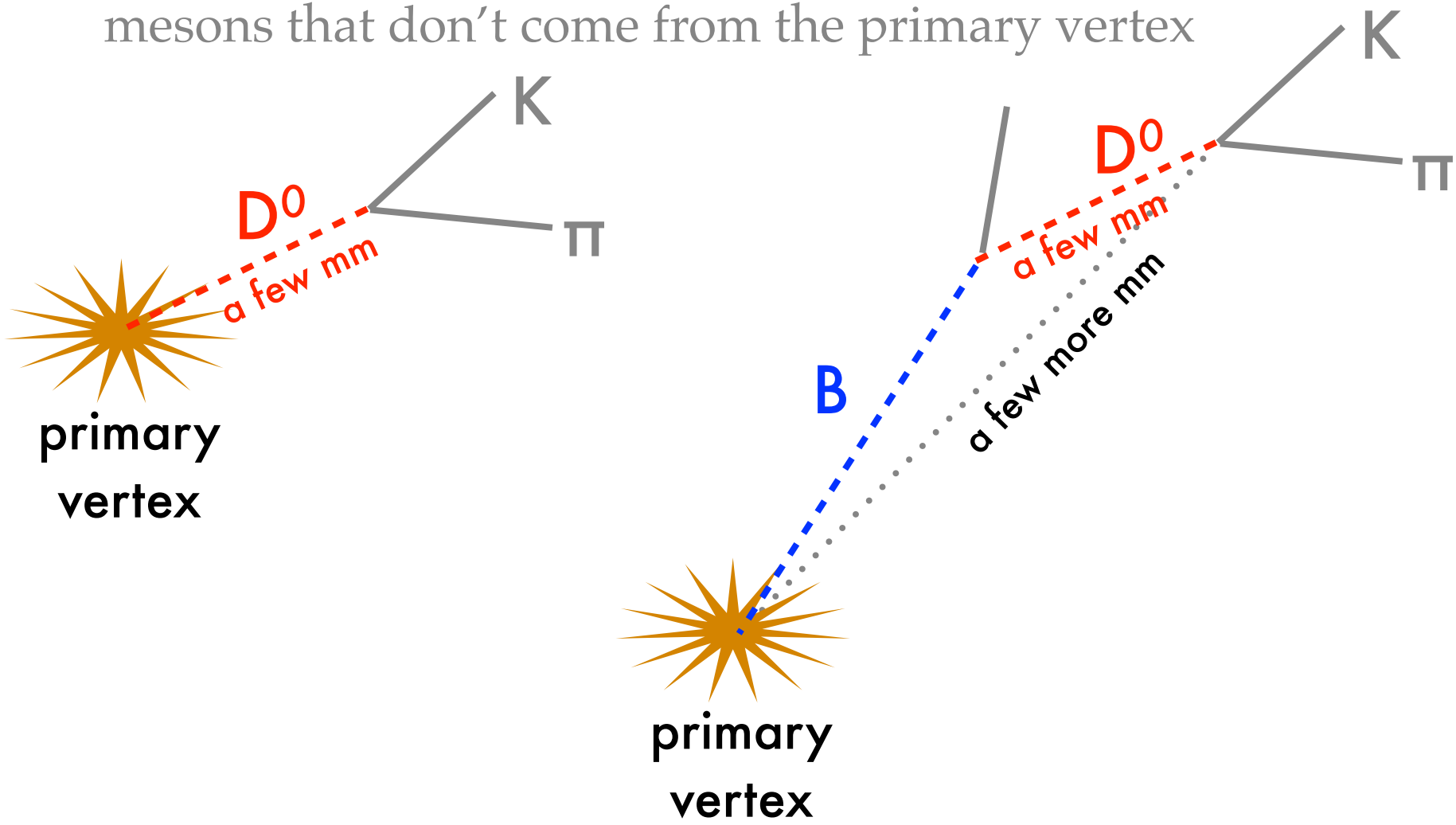

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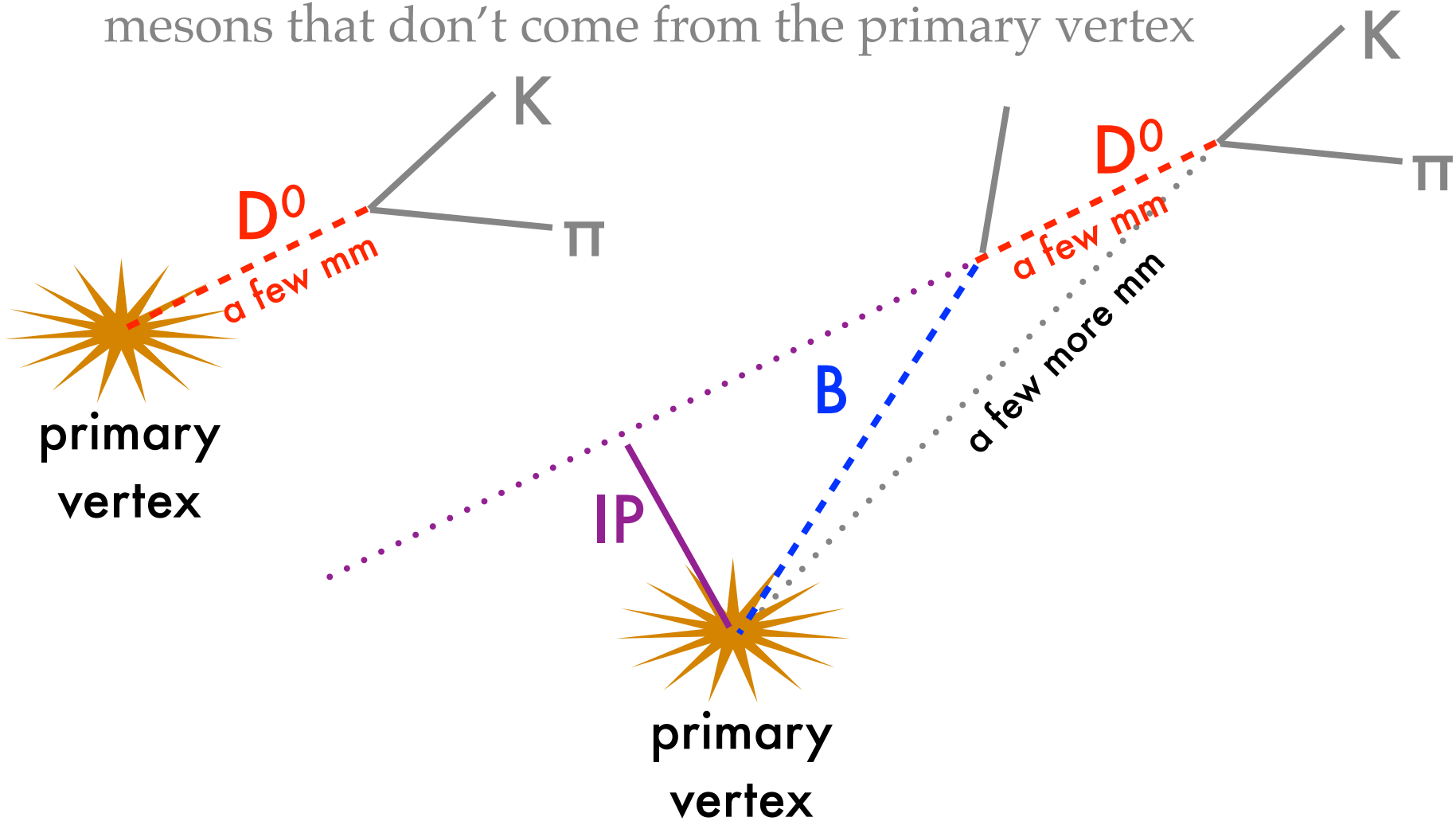

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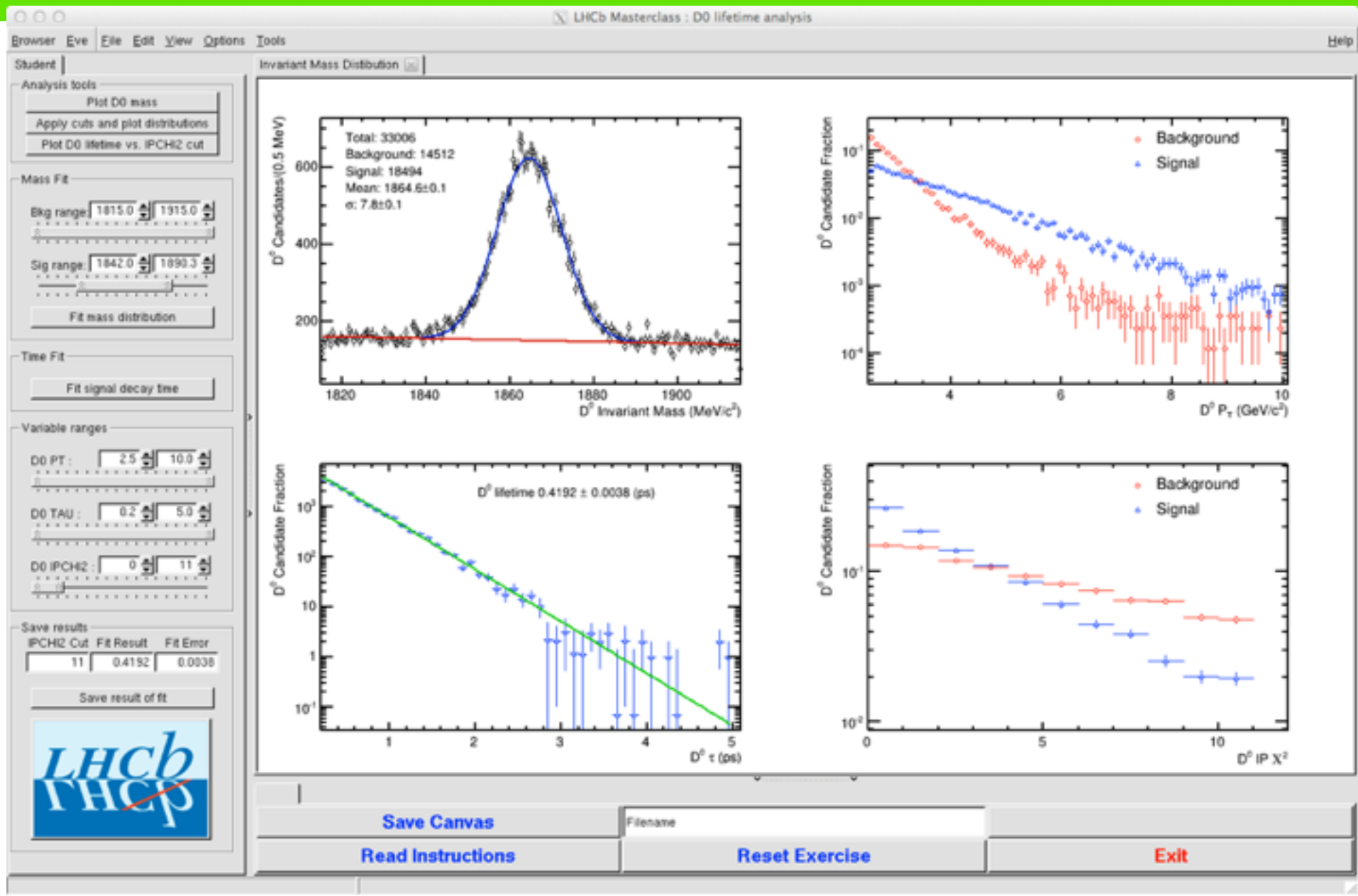
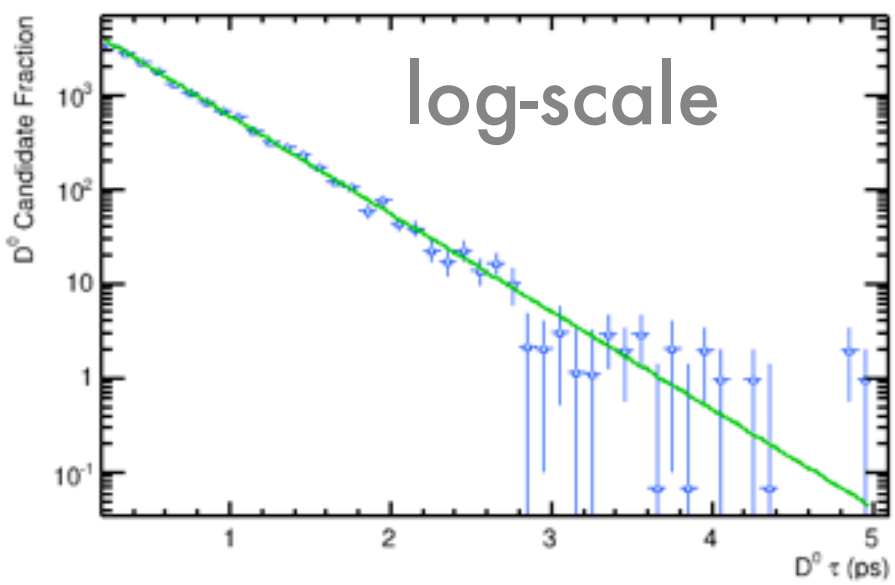
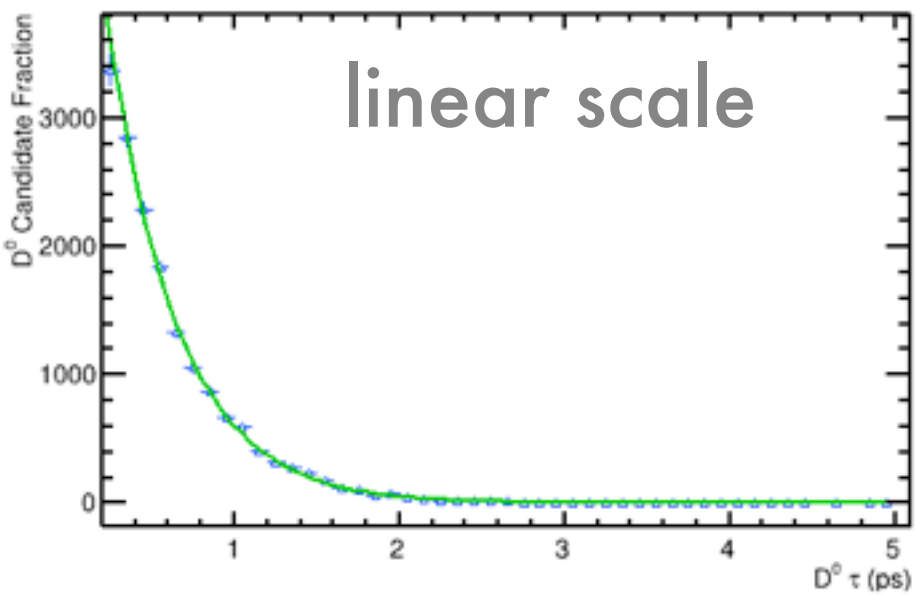


Decay time distribution

You found an exponential decay time distribution.





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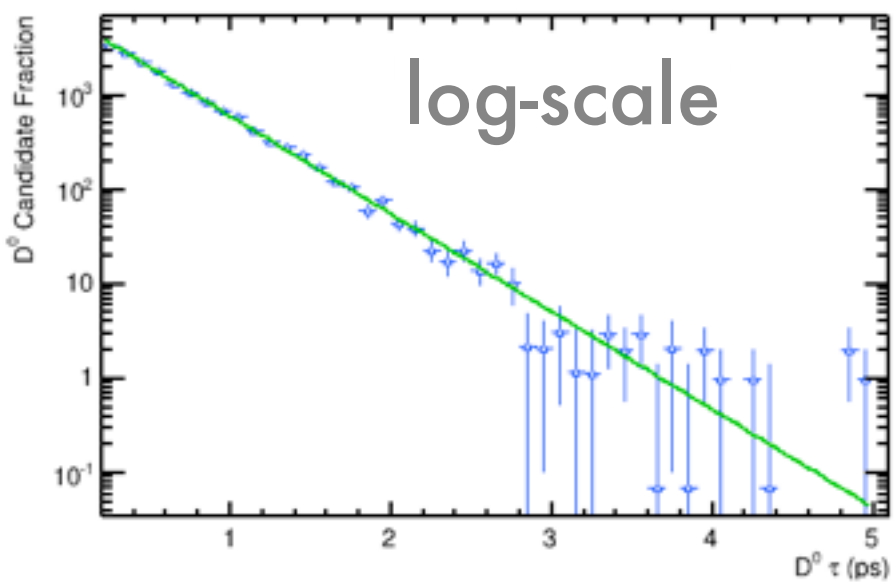
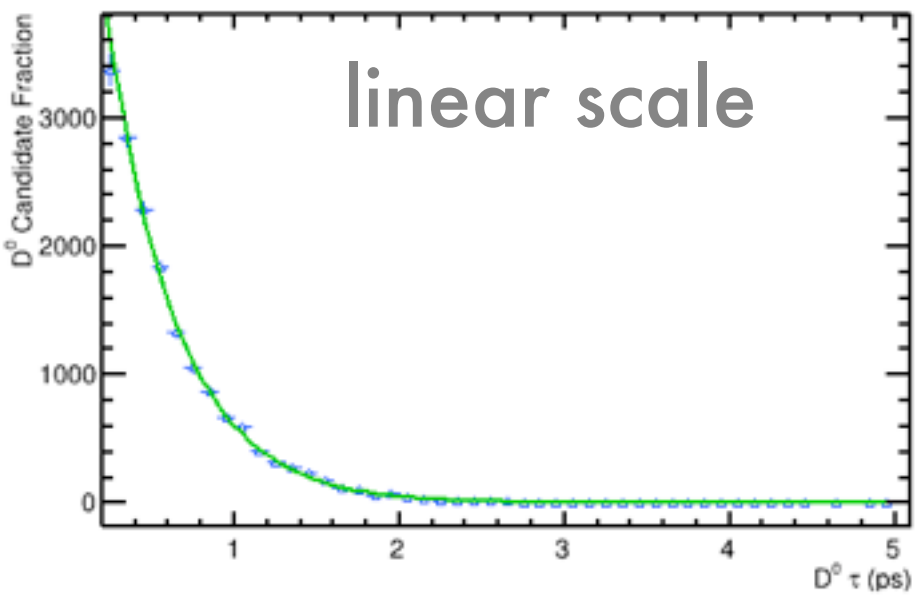
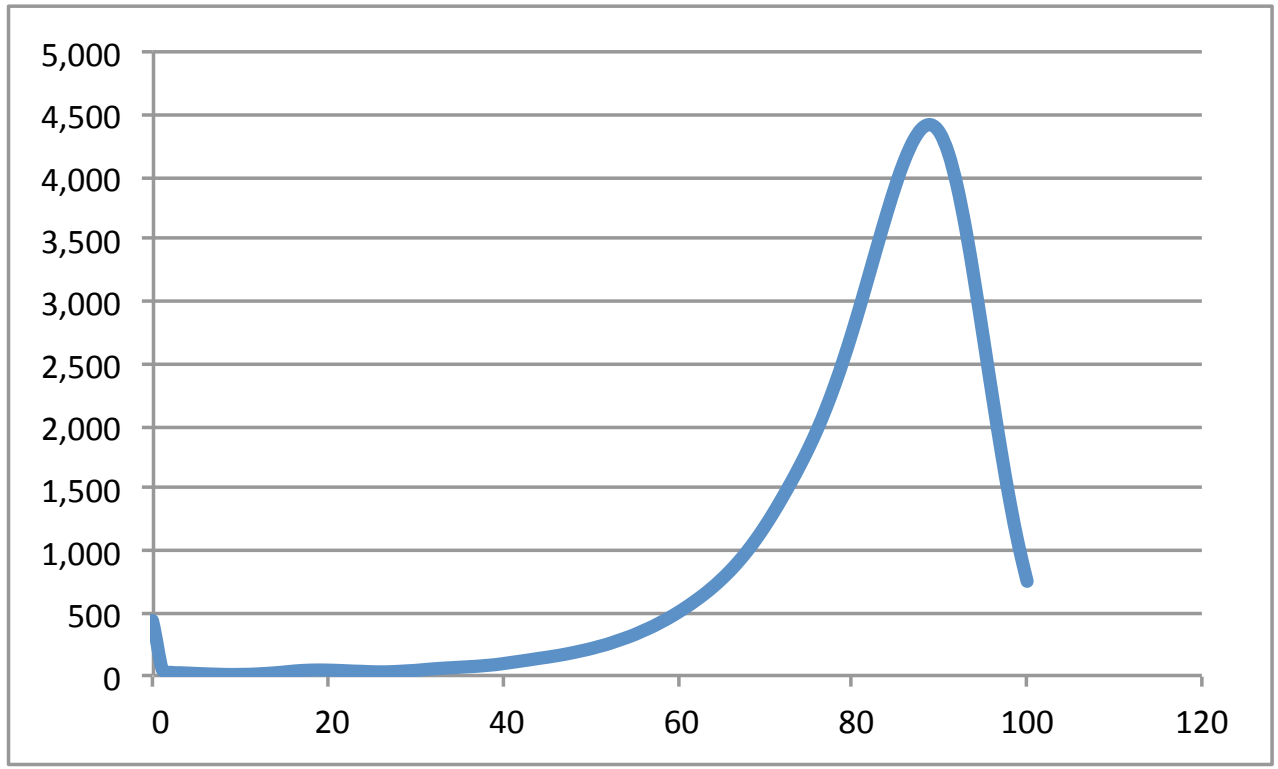




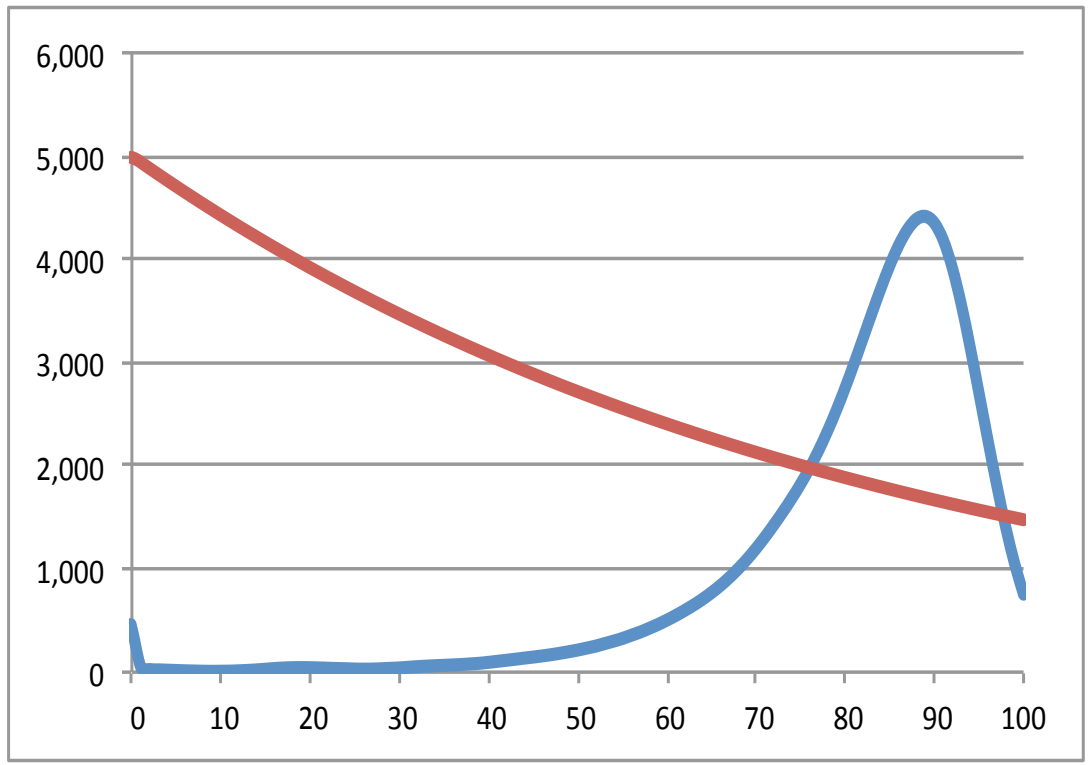
Is this really expected?

Same distribution for humans

(death probability vs age for female New Zealanders)



Decay/death probability

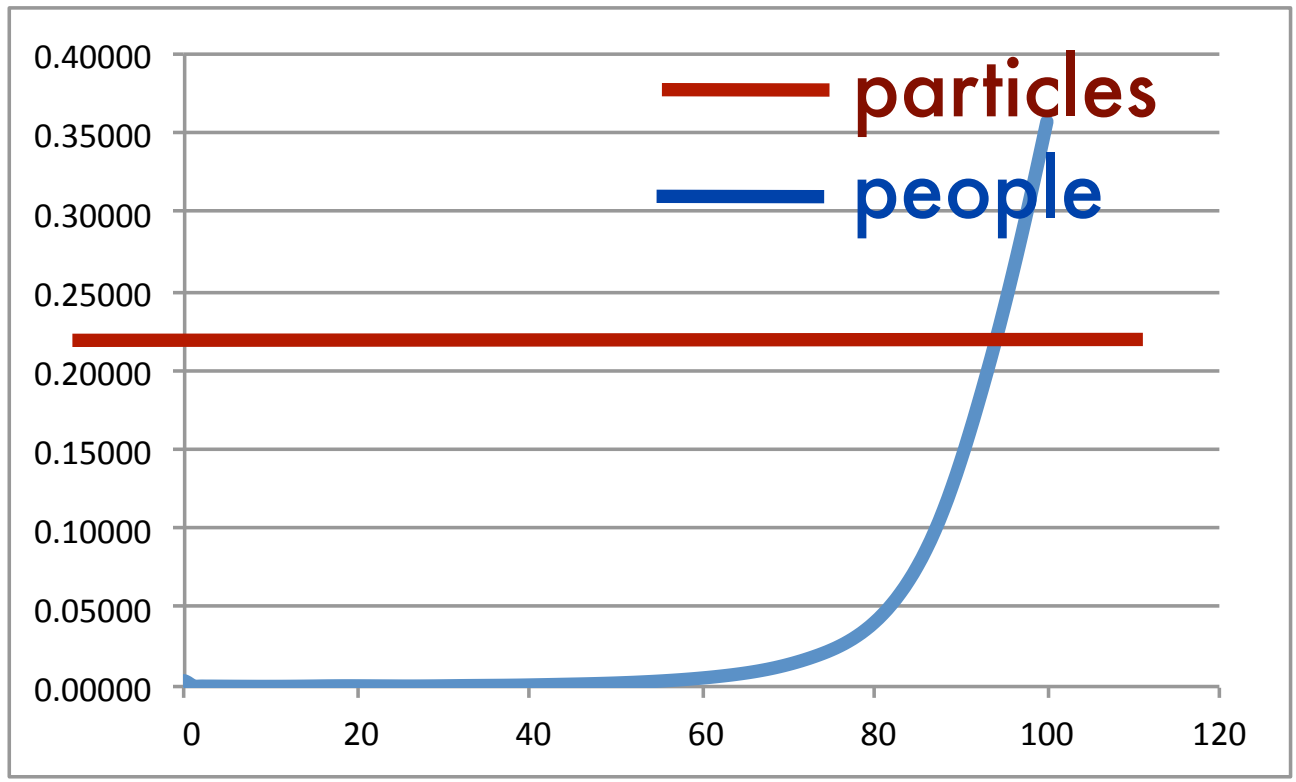


particles

people

Probability to die/decay next year

probability that, given person/particle survived until year x, she/it will die/decay within the following year.

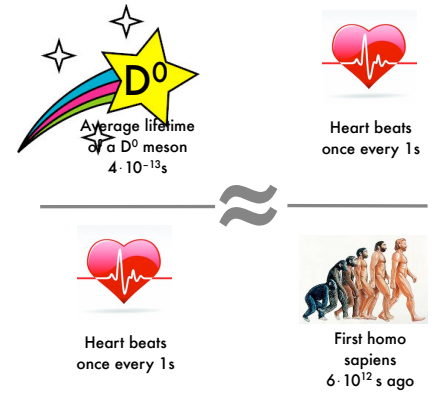


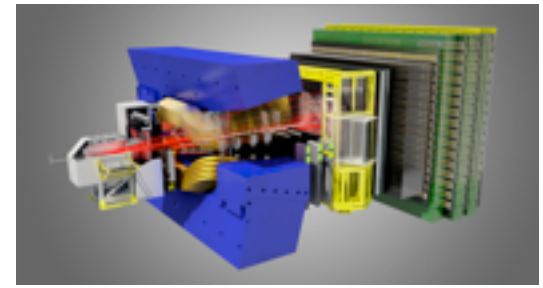
Particles can decay, but they don't age.

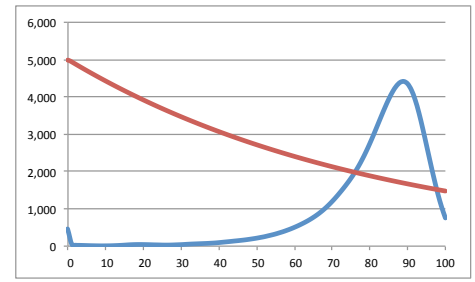
The shape of the decay time distribution is a direct consequence of that.

Summary

- You measured an incredibly short amount of time!
- You did so exploiting enormous speeds, and special relativity.
- ... and one of the most sophisticated machines in the world.
- You found an exponential decay rate -> particles don't age.
- The exact value of your fit result is an important parameter in particle physics.



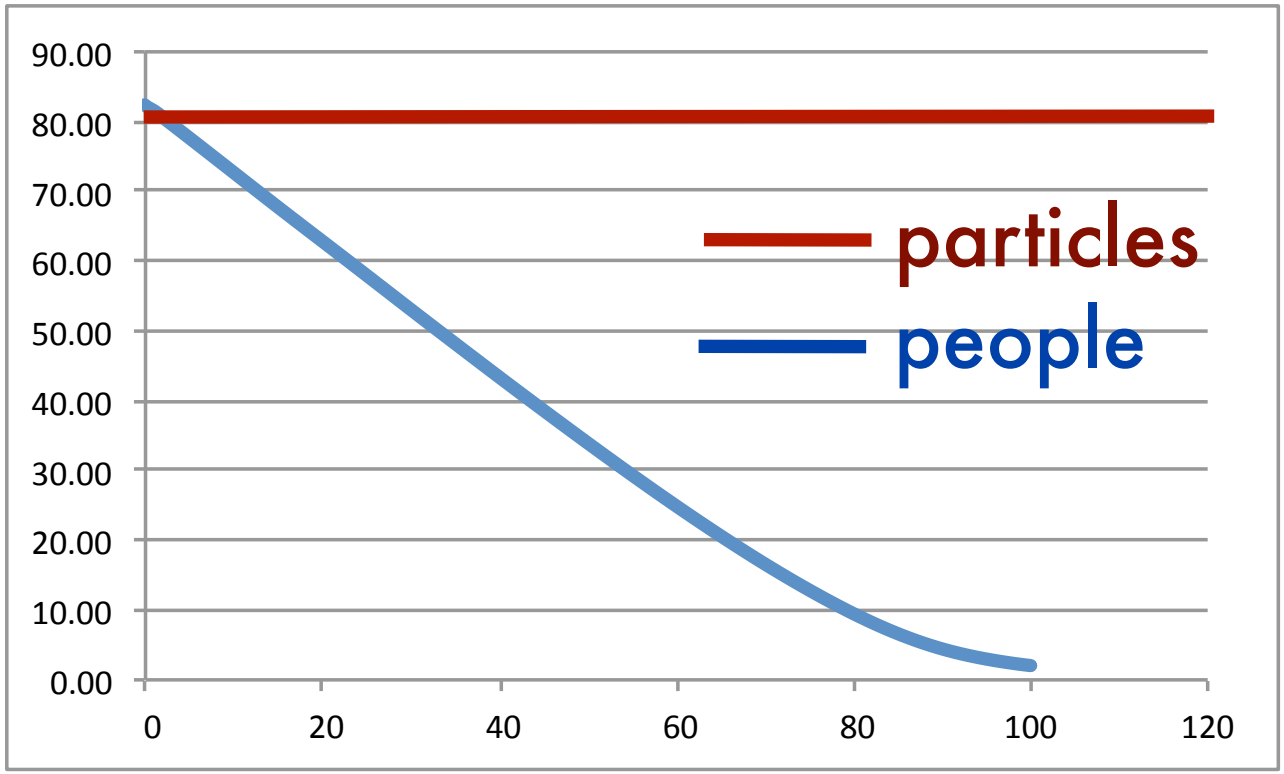




Backup

- Higgs: 1.56e-22
- D0: 4.1e-13
- Middle C: 261.63 Hz -> 3.8e-3
- second: 1e0
- minute: 6.0e1
- hour: 3.6e3
- day: 8.6e4
- year: 3.2e7
- human lifetime: 2.4e9
- Fall of Rome 4.7e10 (ca 1,500 years ago)
- end of last ice age 3.2e11 (10,000 years ago)
- Last neanderthal: 9.5e11 (30,000years ago)
- first homo sapiens 6.3e12 (200,000 years ago)
- end of dinosaurs: 2.1e15 (66 M years ago)
- The alpes: 1.0e16
- planet earth: 1.4e17
- universe: 4.3e17 (13.77 billion years)
- 2 hours/age of univers = tauDo/1 second.

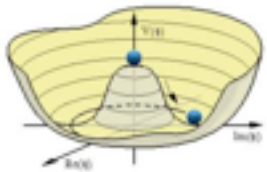
Probability to die/decay next year



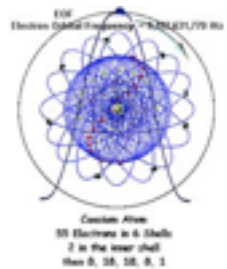
Particles can decay, but they don't age.

The shape of the decay time distribution is a direct consequence of that.

Time scales



Average lifetime of a Higgs boson $1.6 \cdot 10^{-22}$s



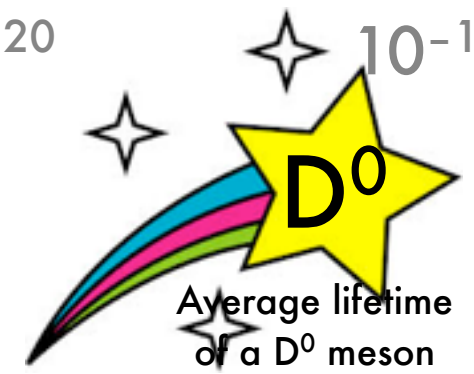
T=1/f of an atomic clock 10^{-10} s

Heart beats once every 1s

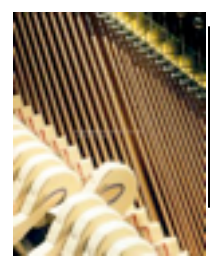
typical life-span of a person $2.4 \cdot 10^{9}$s

extinction of dinosaurs $2 \cdot 10^{15}$ s ago

10^{-20} 10^{-10} 1 10^{10} 10^{20}

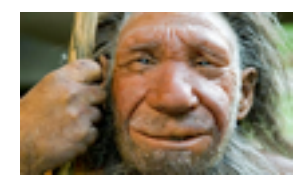


Average lifetime of a D^0 meson $4 \cdot 10^{-13}$s

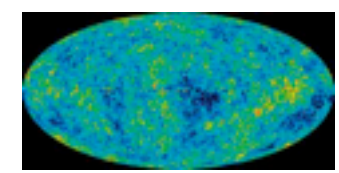


T=1/f of a piano string $4 \cdot 10^{-3}$ s

This talk: ca 10^{3}s



Last Neanderthal ca10^{12} s ag



birth of the universe $4 \cdot 10^{17}$s ago