Sudden Beam Loss and A Beam Test

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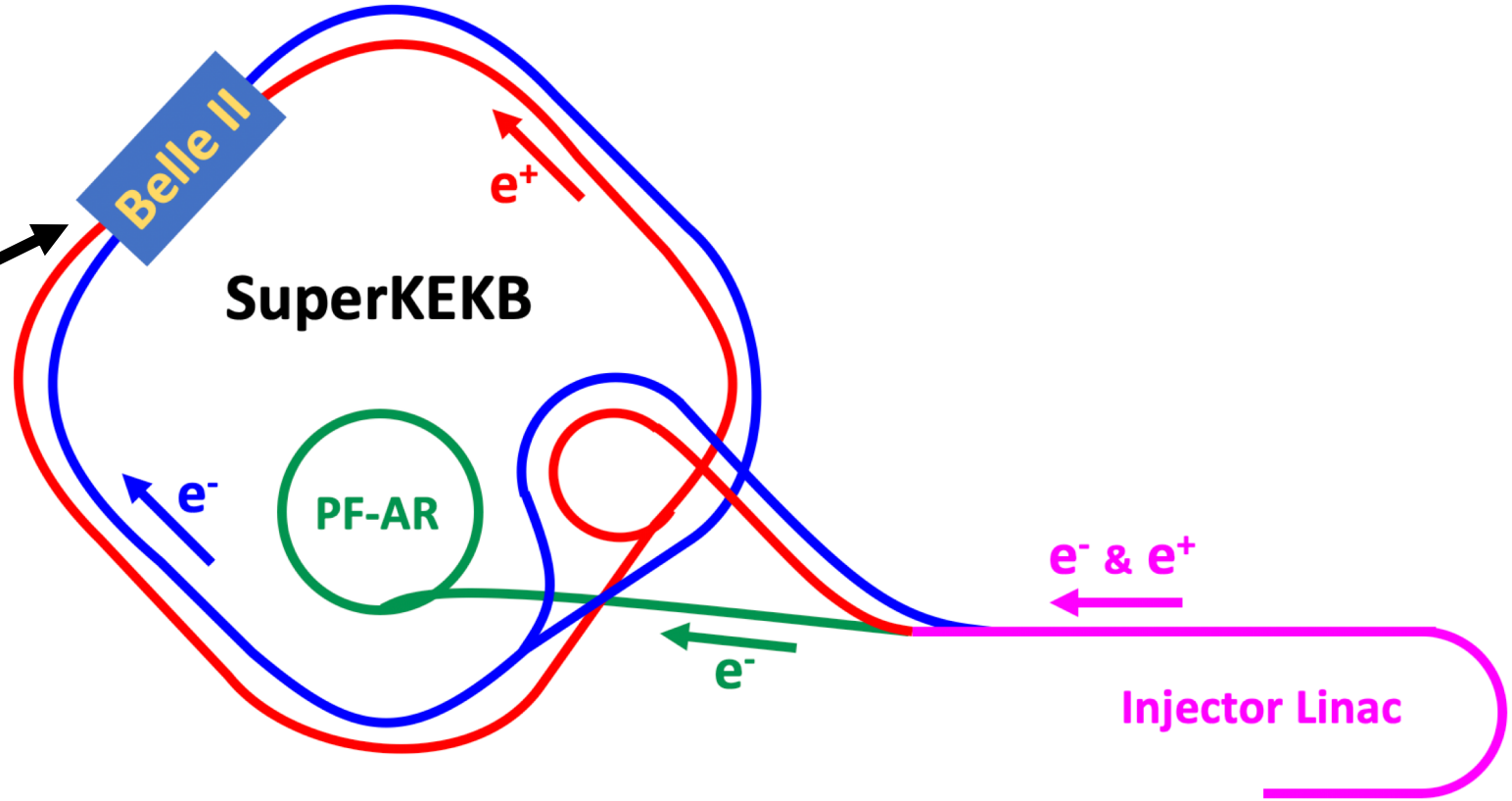
The SuperKEKB and Belle II

- The Belle II experiment surrounds the SuperKEKB accelerator where the electron and positron beams collide
- To take data, Belle II requires SuperKEKB to run stably



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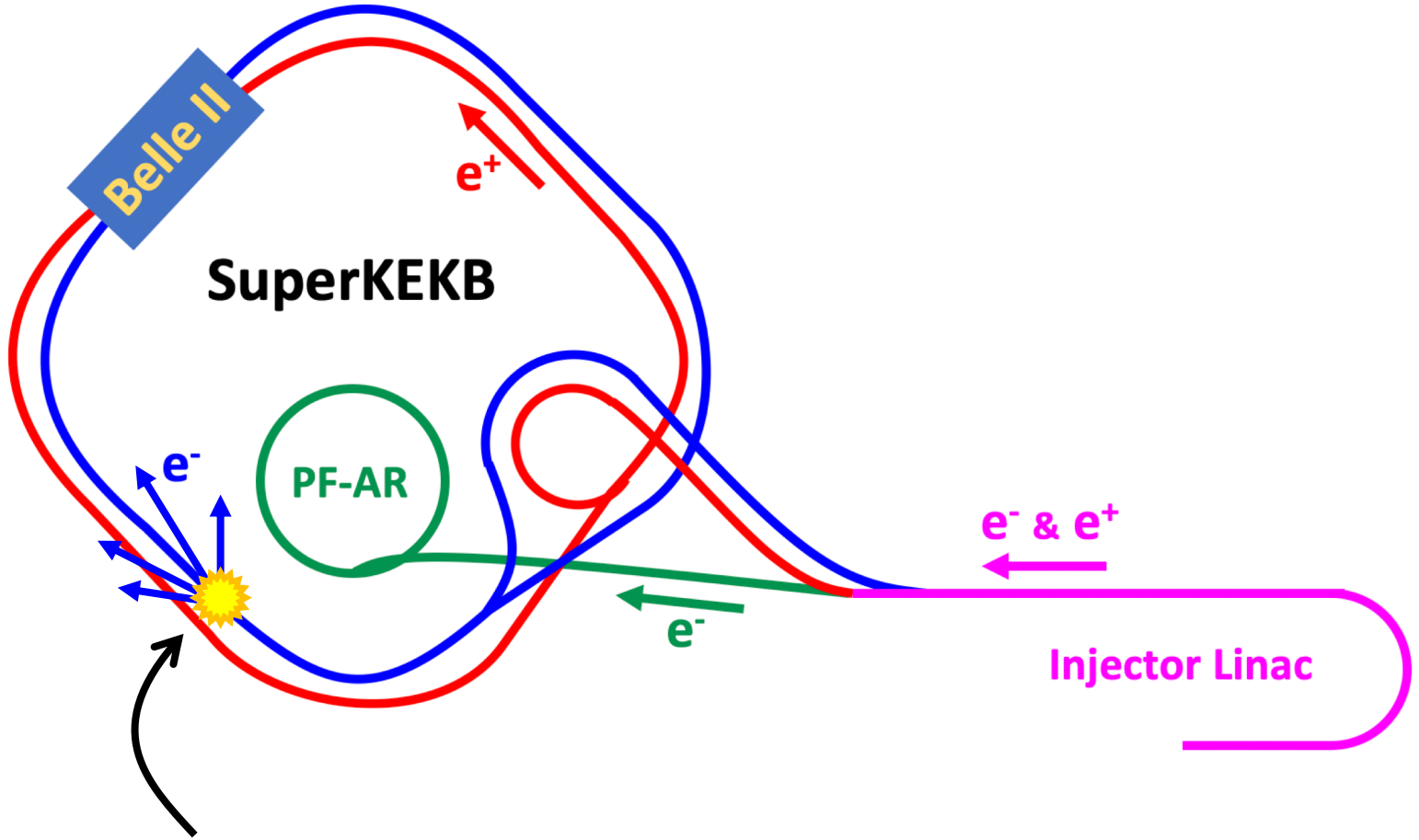
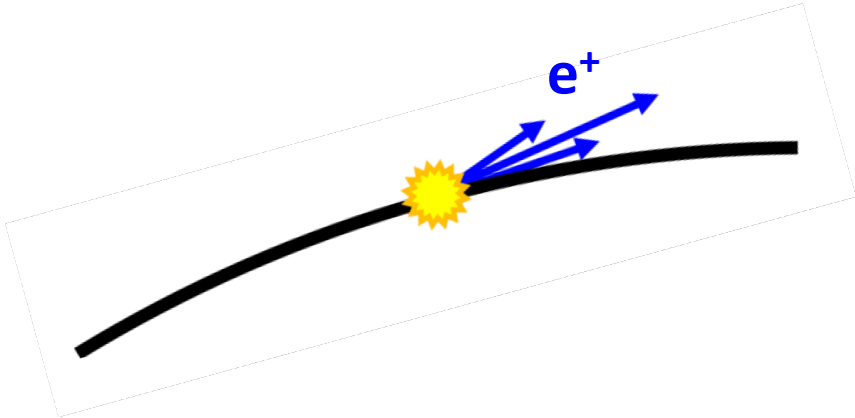


Sometimes the SuperKEKB does not run stably
and will lose the beam!
This is called “Sudden Beam Loss”

Sudden Beam Loss

- Sudden Beam Loss seems to happen randomly and without warning
- The loss occurs in ~10 to 30 μs or ~1 to 3 revolutions around the SuperKEKB ring
- This is bad for Belle II in many ways!



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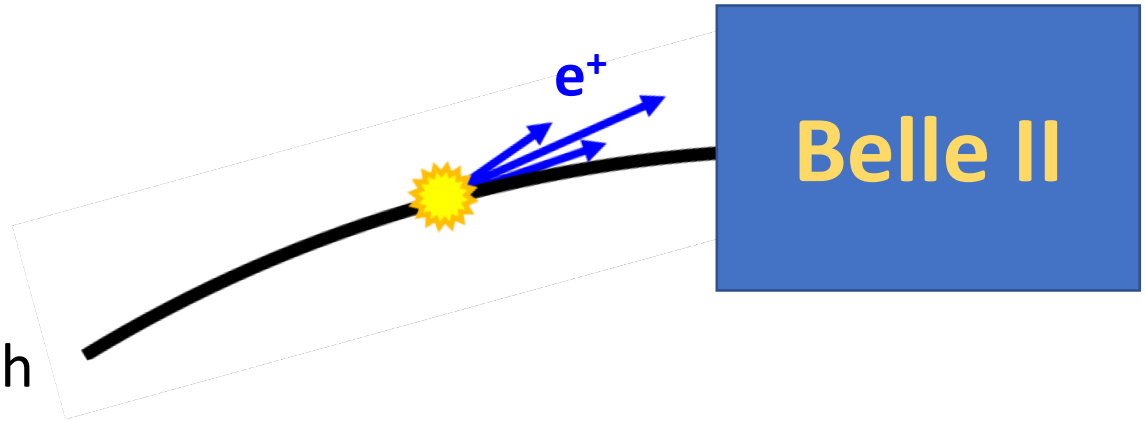
  - Damages important SuperKEKB components
  - Causes the superconducting magnets to quench



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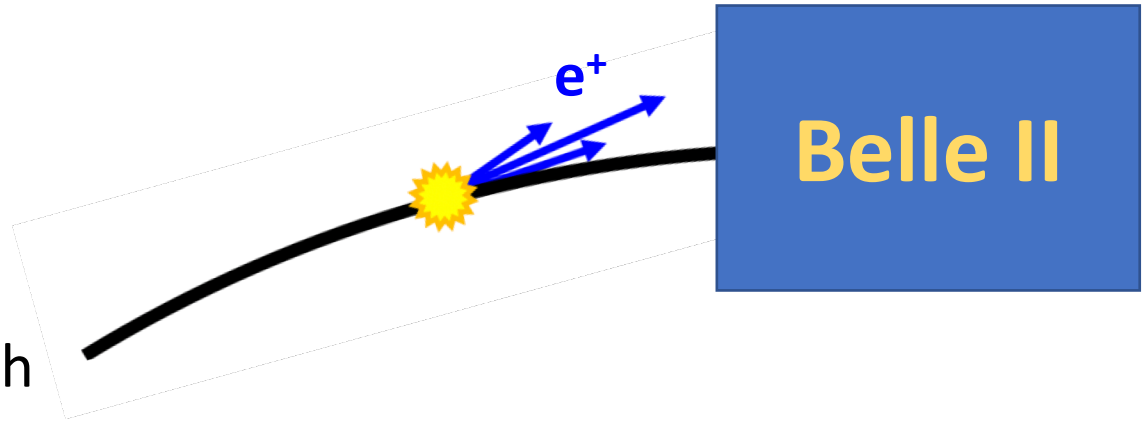
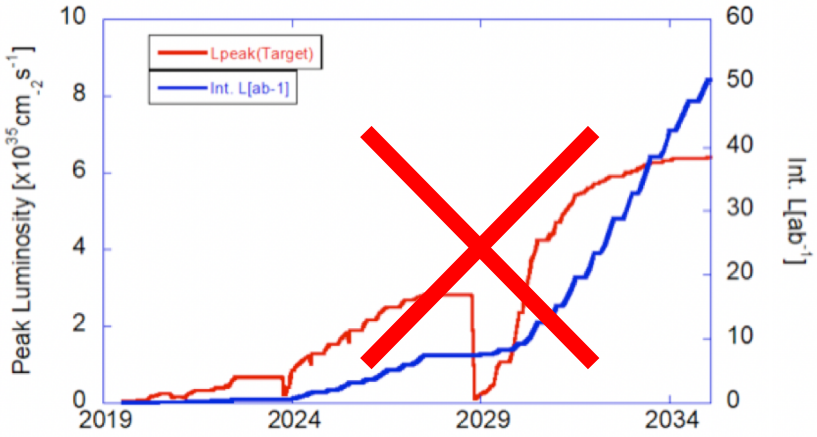
  - Causes the superconducting magnets to quench
  - The accelerator can not collide the beams while the beam is filled again
  - Prevents SuperKEKB from increasing the beam intensity





https://confluence.desy.de/display/BI/Belle+II+Luminosity

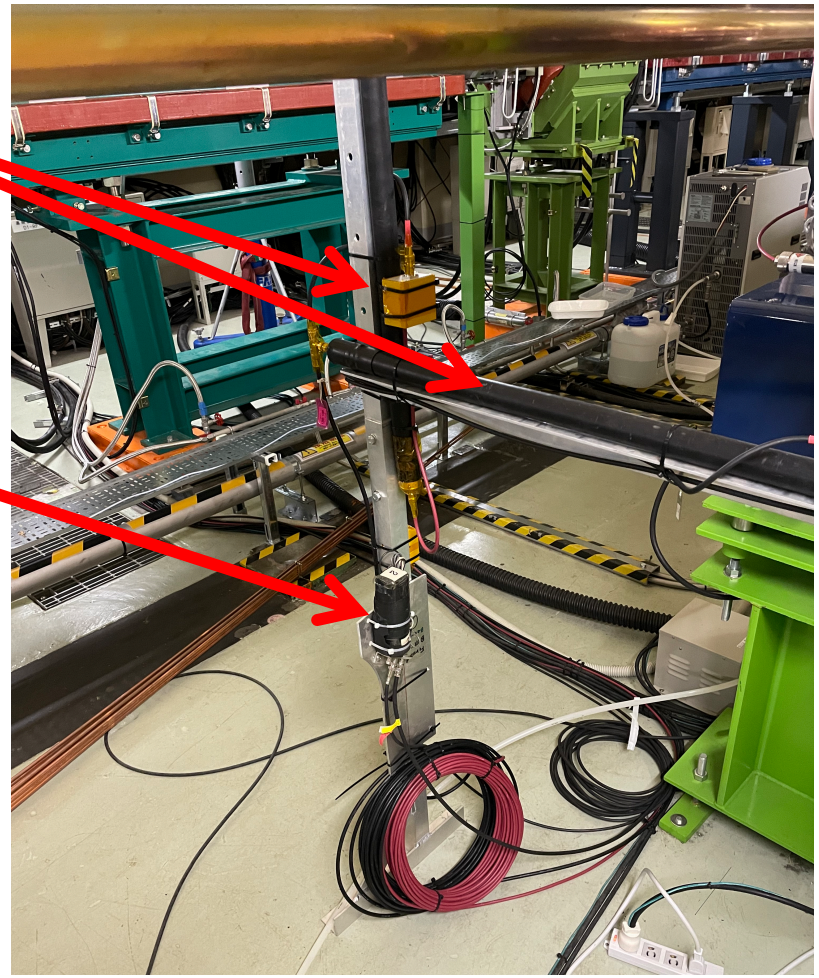
Monitoring Sudden Beam Loss

So how to we begin to learn about Sudden Beam Loss?

- There are already SuperKEKB monitors set up around the ring
  - Help the SuperKEKB during operation
  - Not enough to learn where the loss starts

- We have some dedicated monitors in the ring
  - They don't live very long in the high radiation environment

- We need to install more monitors!
  - Has to withstand high levels of radiation
  - Has to have a fast response (~1 to 10 ns)
  - The Electron Multiplier Tube (EMT) is a good candidate



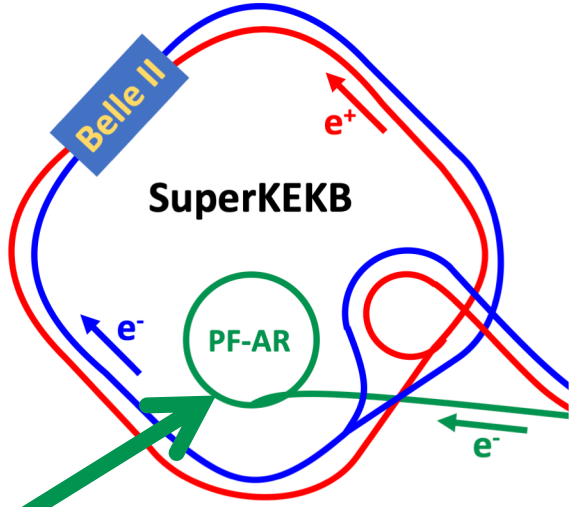
Electron Multiplier Tube

- An Electron Multiplier Tube (EMT) will withstand the radiation

- We need to test the EMT to make sure it will work for our application
  - How fast does it respond?
  - How large is the signal pulse when it gets hit?
  - How can we make sure only particles from sudden beam loss trigger the EMT?

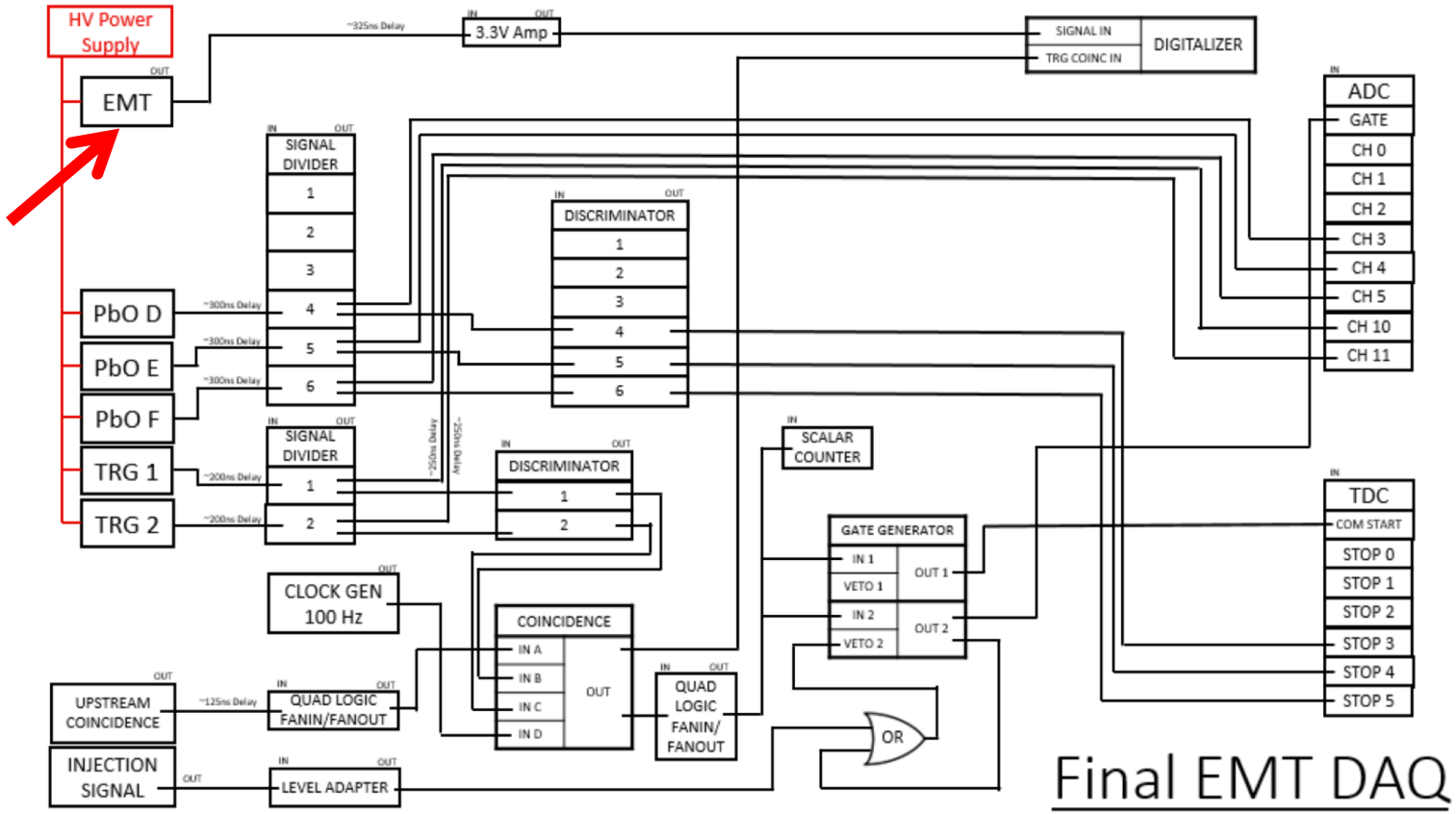
- To answer these questions we do a beam test

- In this beam test we used a beam of electrons to mimic what would hit the EMT during Sudden Beam Loss

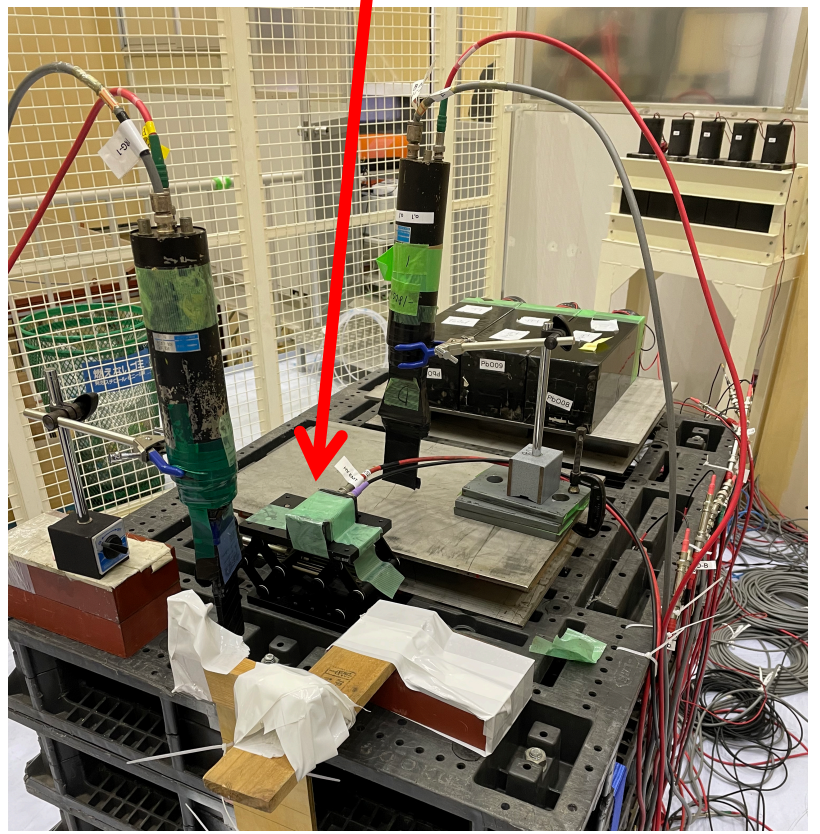


Beam Test – Taking Data

- To test our EMT we need to setup a way to take data
- This is known as data acquisition (DAQ)

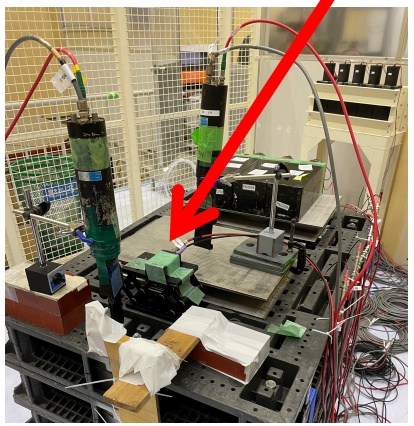


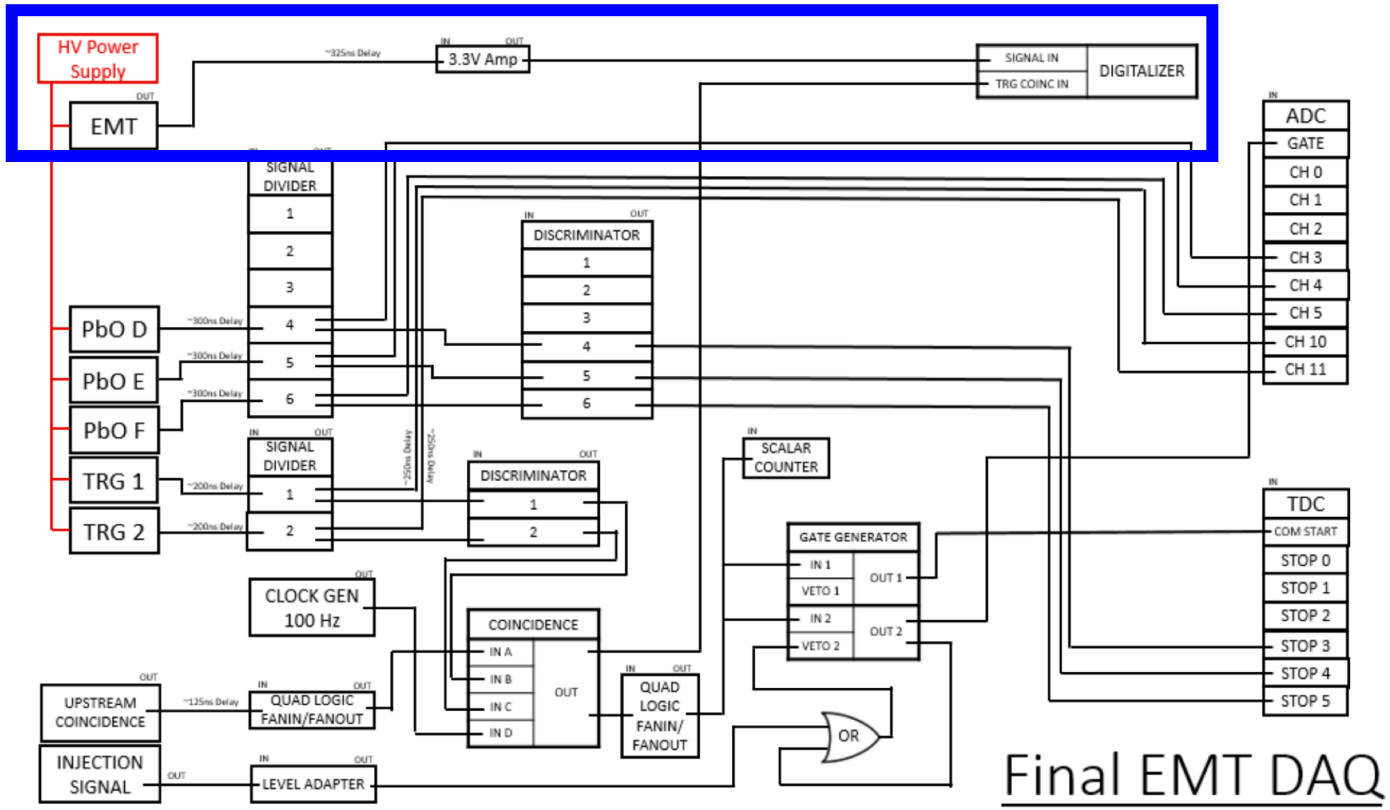
EMT



Beam Test – Taking Data

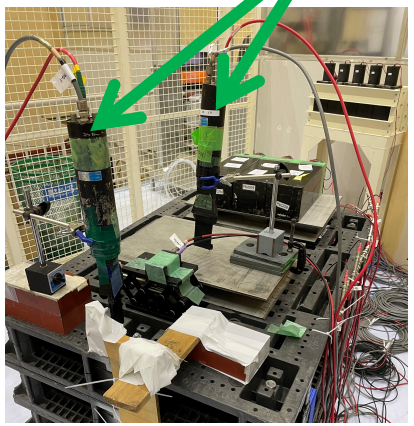
- First we need to get the EMT signal from the EMT to an oscilloscope on a computer

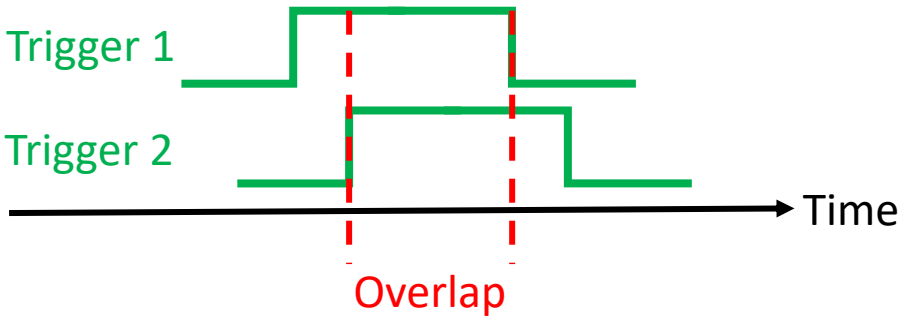


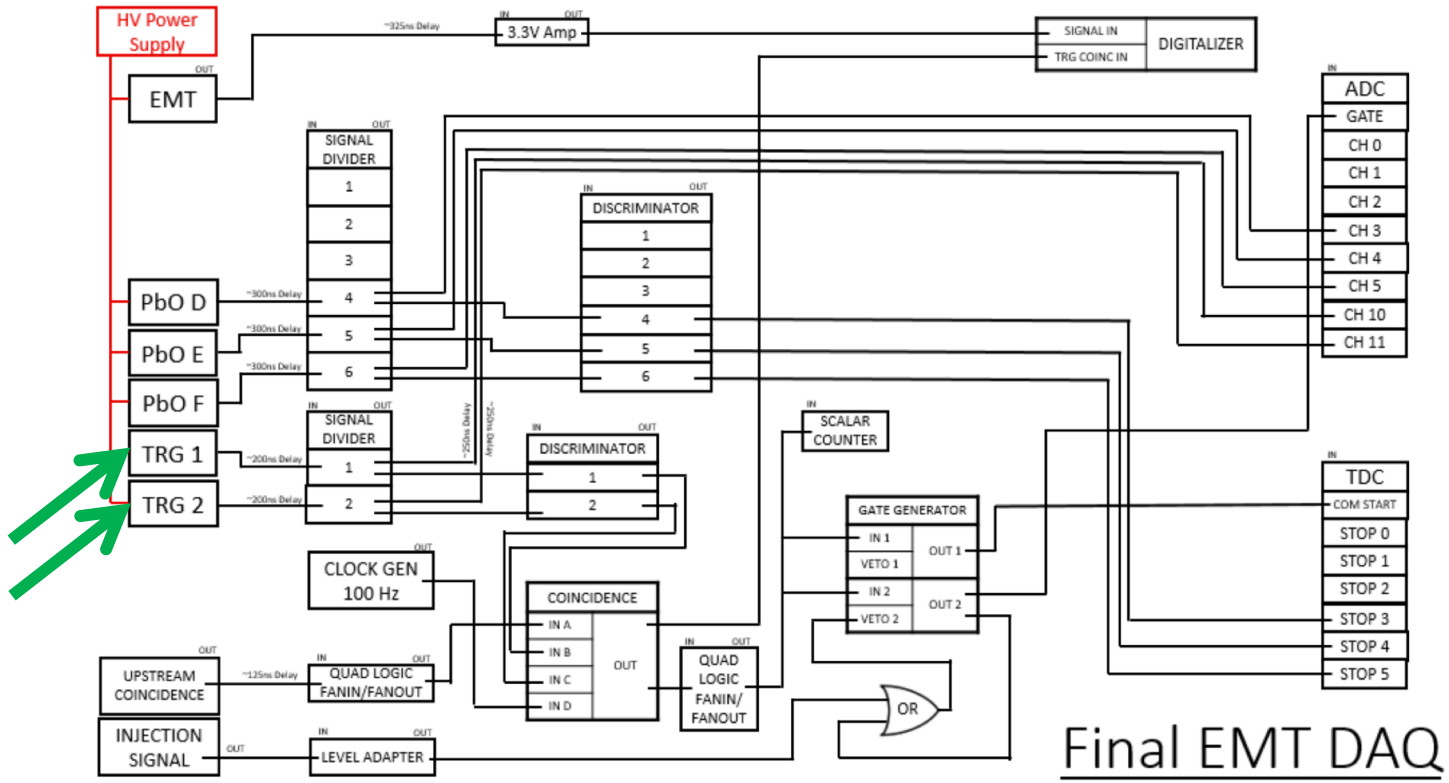


Beam Test – Taking Data

- First we need to get the EMT signal from the EMT to an oscilloscope on a computer
- Next we put two sensors in front and behind the EMT
  - These are called triggers
  - If it passes through both triggers, it is an electron from the beam
  - If the trigger pulses overlap, this is called a coincidence and we take data







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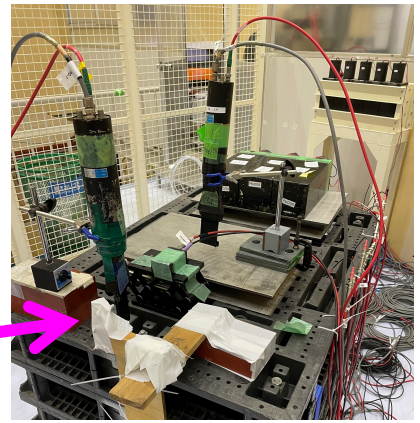
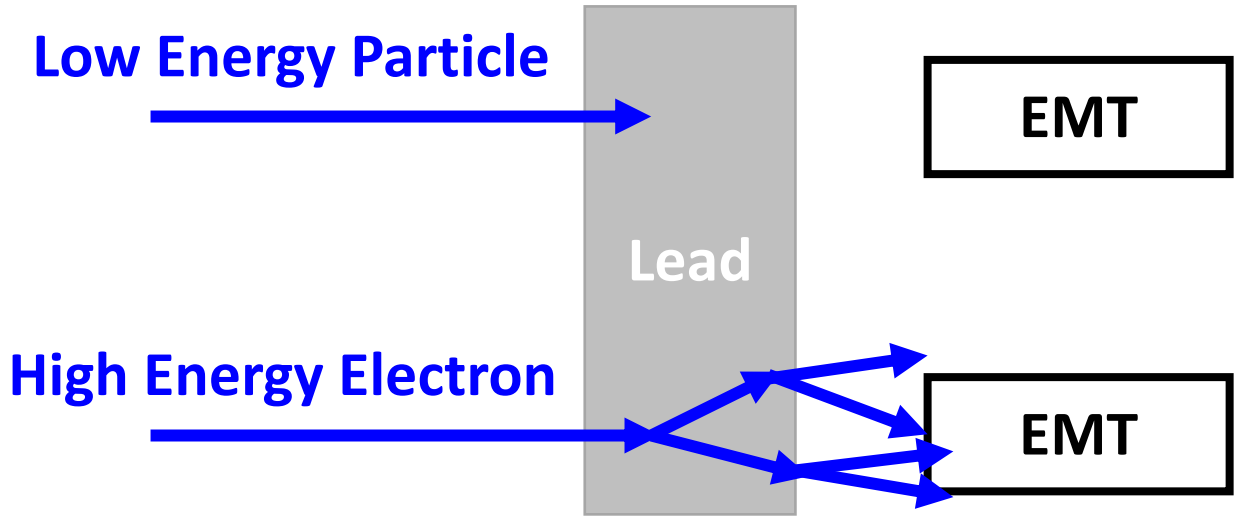
- Finally we put some lead in front
  - Does not allow low energy particles through
  - Only allows high energy electrons trough like in Sudden Beam Loss
  - Showering helps us see the signal





Beam Test – Results

- Did we answer our questions from earlier during the beam test? – Yes!
  - How fast does it respond? ~1 – 5ns, very fast!
  - How large is the signal pulse when it gets hit? Very small, we needed to add an amplifier to see the pulse!
  - How can we make sure only sudden beam particles trigger the EMT?
    A chunk of lead!

- We can use these around the ring to look for where Sudden Beam Loss starts to occur!
  - Helping understand what causes Sudden Beam Loss
  - Protecting Belle II and SuperKEKB from damage
  - Allowing us reach our data collection goals

Thank You!