Fermilab

U.S. Department of Energy

Analysis of H signal at a multi-TeV Muon Collider

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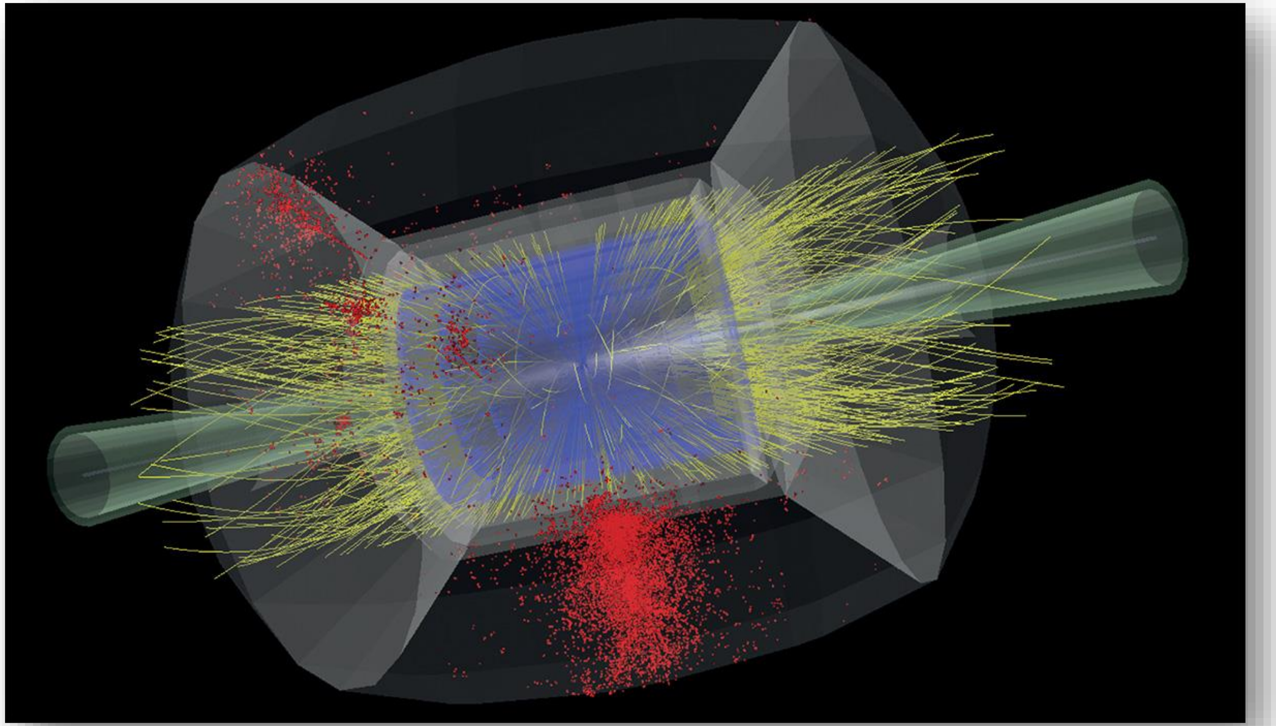
Muon Collider



- What:

  Collision of $\mu^+\mu^-$
  at $\sqrt{s} = 3\ TeV, \sqrt{s} = 10\ TeV$

- Where:

  Fermilab or CERN

- When:

  2026 → Cost and Performance Estimation
  2033 → Ready to Commit
  2037 → Ready to Construct
  2043 → Ready to Operate

- Who:

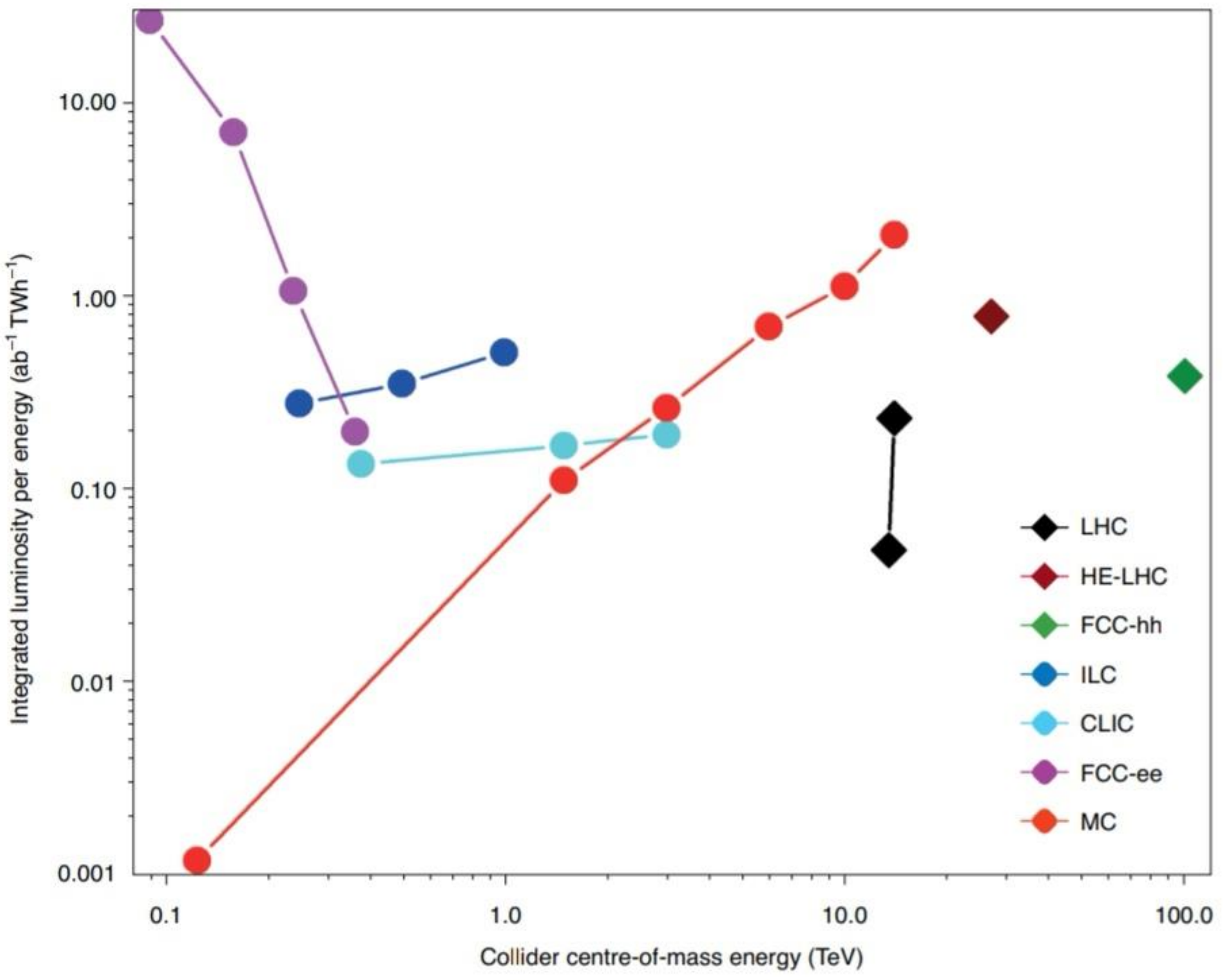
  International Muon Collider Collaboration (IMCC) hosted by CERN

Benefits of Muon Collider

- ✓ Compared to circular e^+e^- accelerators, less synchrotron radiation thanks to the mass of the muons:

$$P = \frac{1}{6\pi\varepsilon_0}\frac{e^2}{c^2}\frac{v^2}{r^2}\left(\frac{E}{m}\right)^4$$

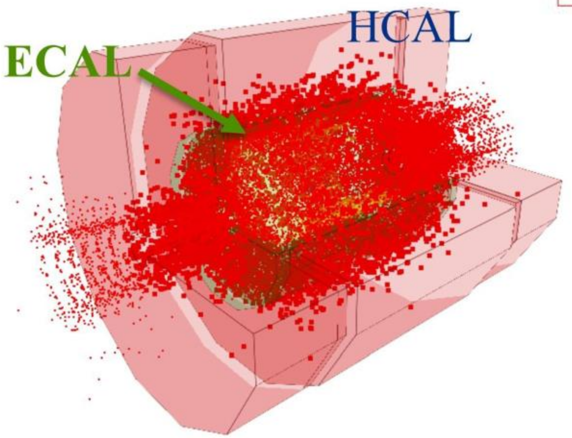
- ✓ Colliding elementary particles
- ✓ Compared to linear accelerators, elements can be used several times
- ✓ Luminosity per energy consumed

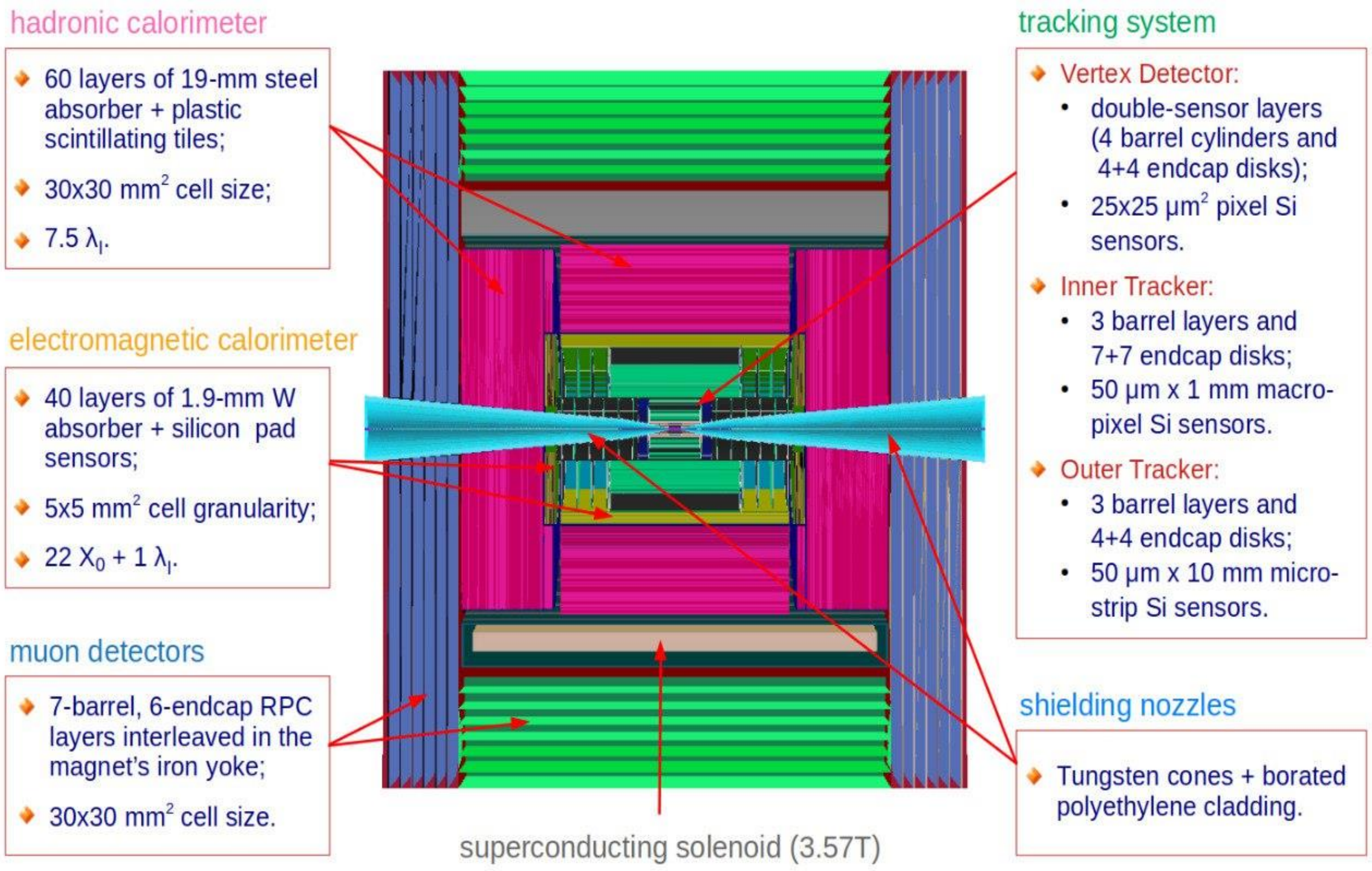


K. R. Long, Muon colliders to expand frontiers of particle physics, Nature Physics, VOL 17, Marzo 2021

BIB challenge

Muons decay with an average lifetime of $\tau_\mu = 2.2\ \mu s$ at rest. Decay products interact with machine elements and produce the Beam Induced Background (BIB) that degrades the performance of detector





DETECTOR, based on CLIC detector

Strategy of work

- We want to study if we can have an efficient trigger based on the presence of one or more tracks above a certain PT threshold
- We need Trigger and Data Acquisition (TDAQ) systems to store not all events and select interesting physics events
  - Collisions are expected to happen at the maximum rate of 100 kHz, corresponding to the minimum time between crossings of 10 μs

➢ Study of physics signal

➢ Study of BIB properties

➢ Comparison between the two

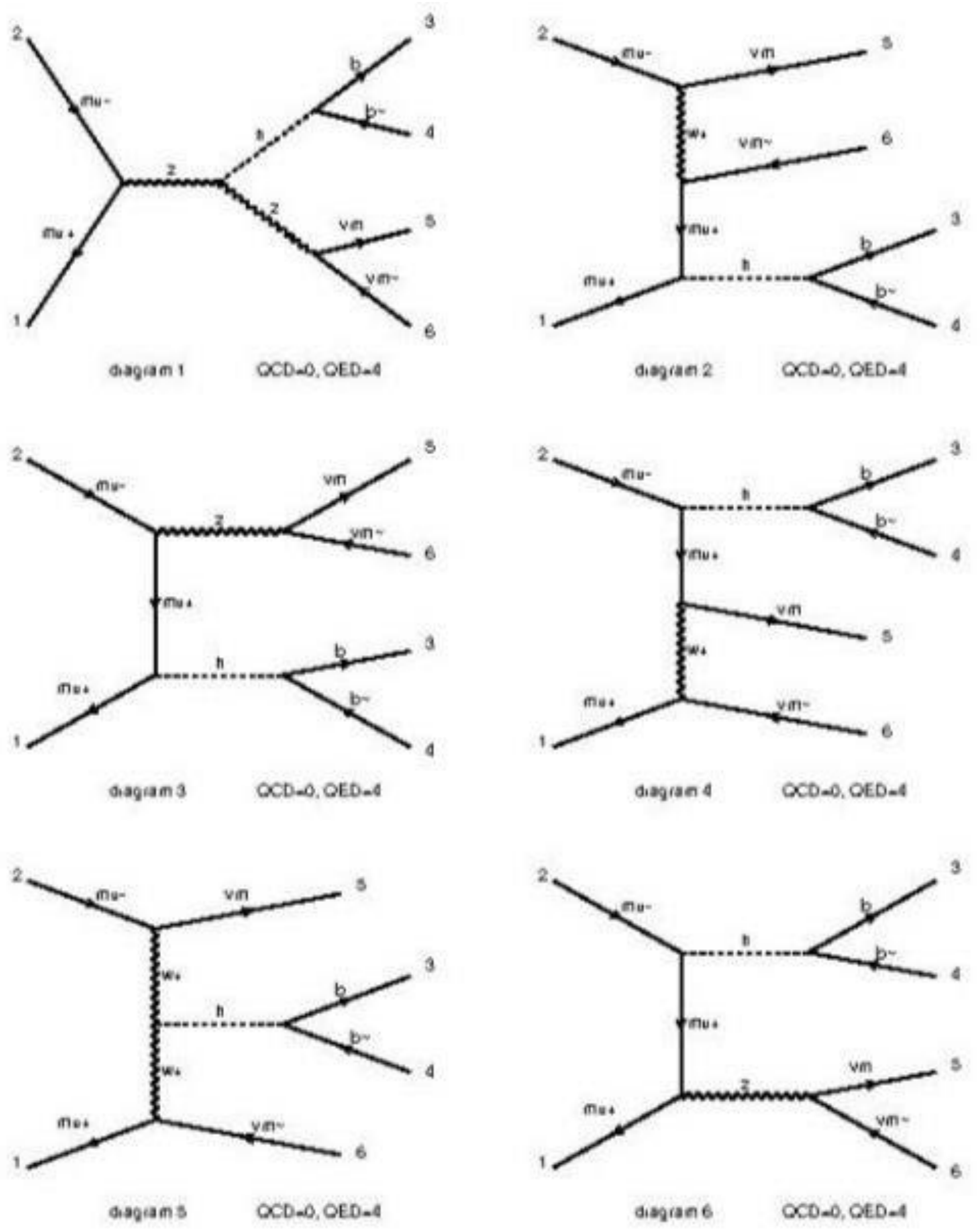
Signal

Generation of 10000 events with **Madgraph** implemented with Pythia of

$$\mu^+\mu^- \to H\nu_\mu\overline{\nu_\mu}\,, H \to b\bar{b}$$

at $\sqrt{s} = 3\,TeV$ with the full standard model.

It produces 6 diagrams:



Analyses with CERN-ROOT

- Selection of charged particles in the final state

$$(K, \pi, p, e, \mu)$$

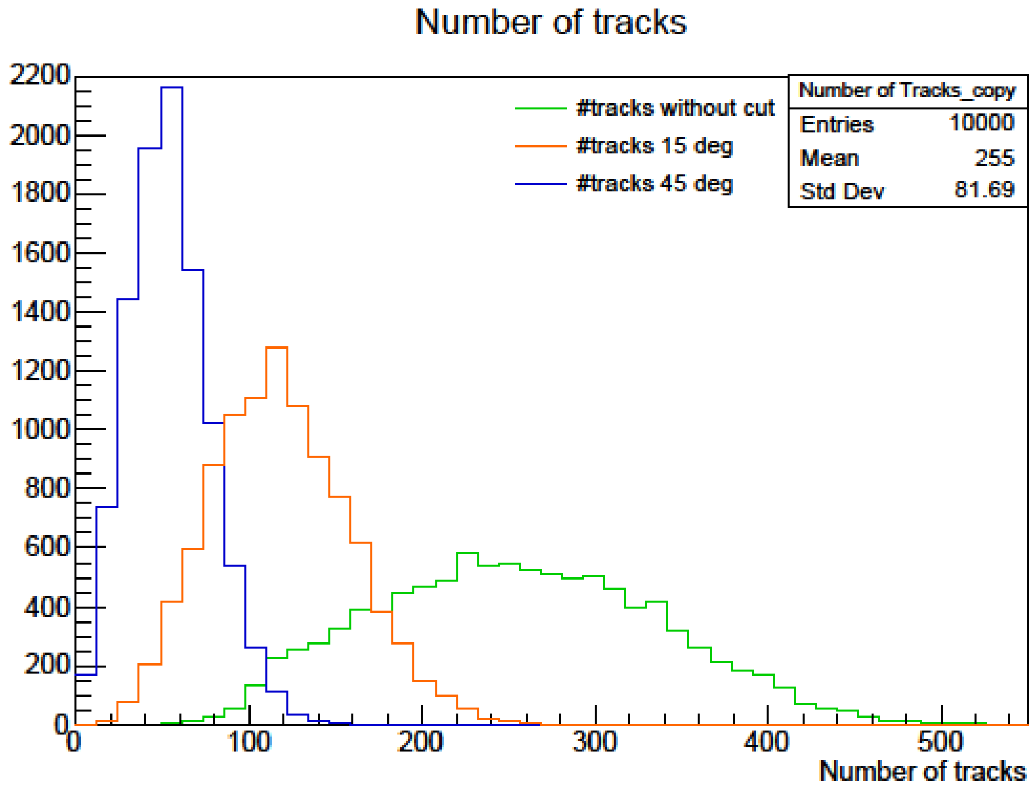
- Distributions analysed: P_T, θ, φ, E
- Different selections on *Theta*:

$$0 < \theta < 180°$$

$$15° < \theta < 165°$$

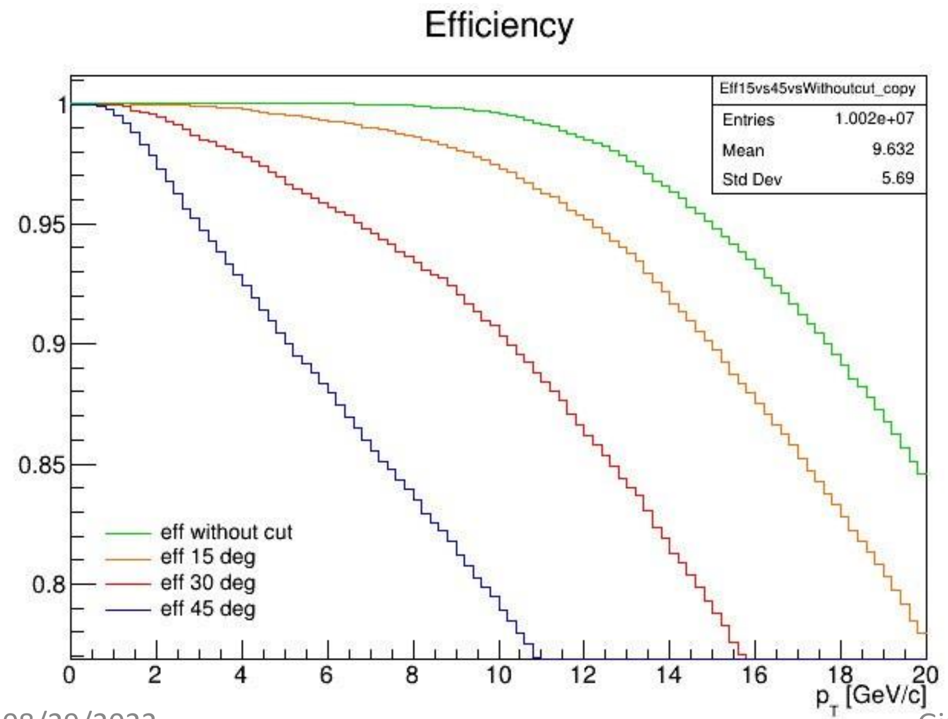
$$30° < \theta < 150°$$

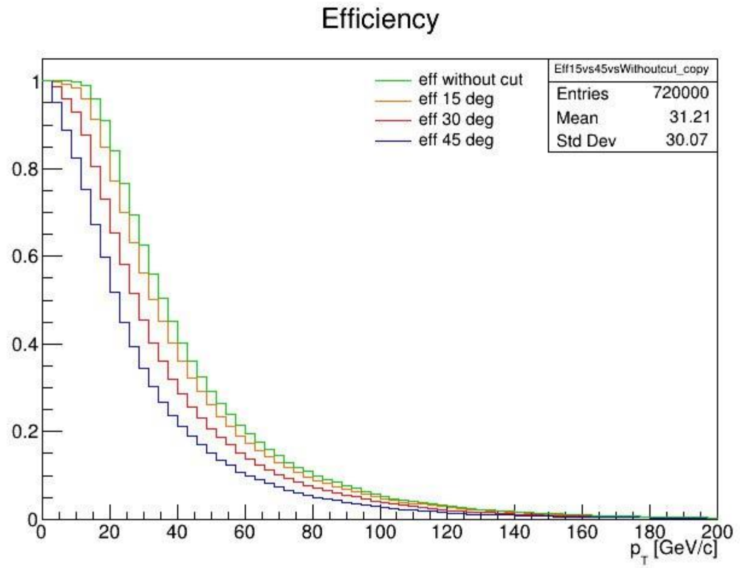
$$45° < \theta < 135°$$

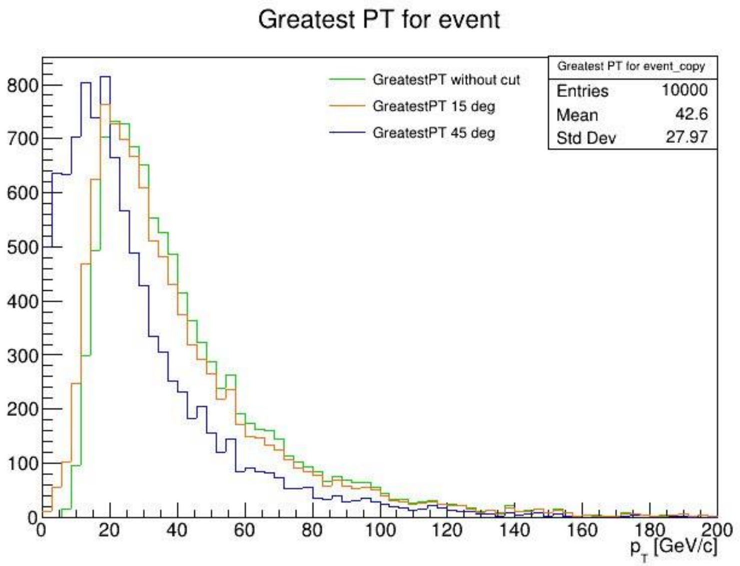


Trigger strategy

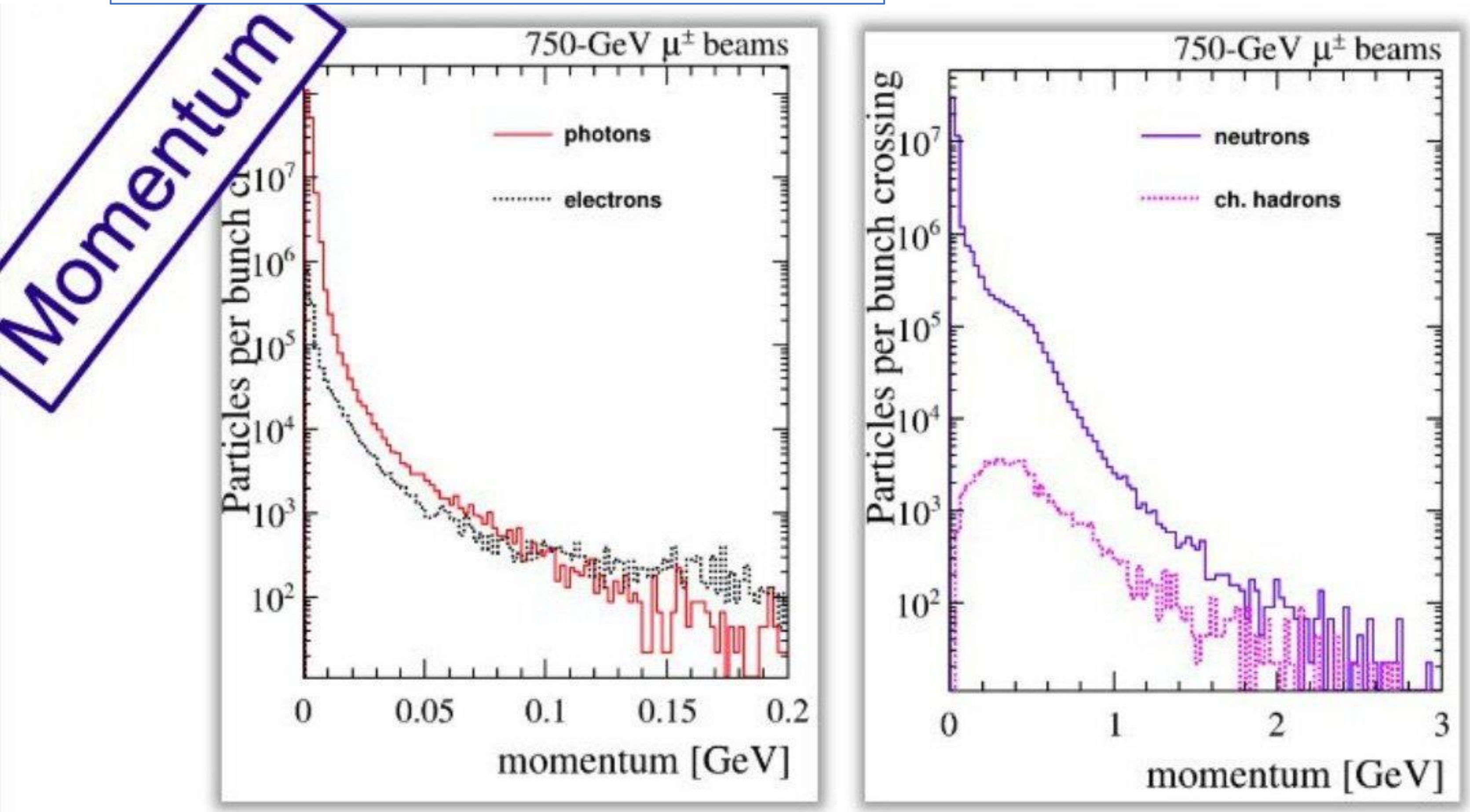
- A common trigger strategy is to look for one or more tracks with a large transverse momentum (PT)
- As a first step in this direction we plot the fraction of events containing at least one track with a PT above a certain threshold. This would represent the efficiency of a single track trigger for this particular process.
- We do this for different angular regions.
- The PT threshold is on the horizontal axis.







BIB properties

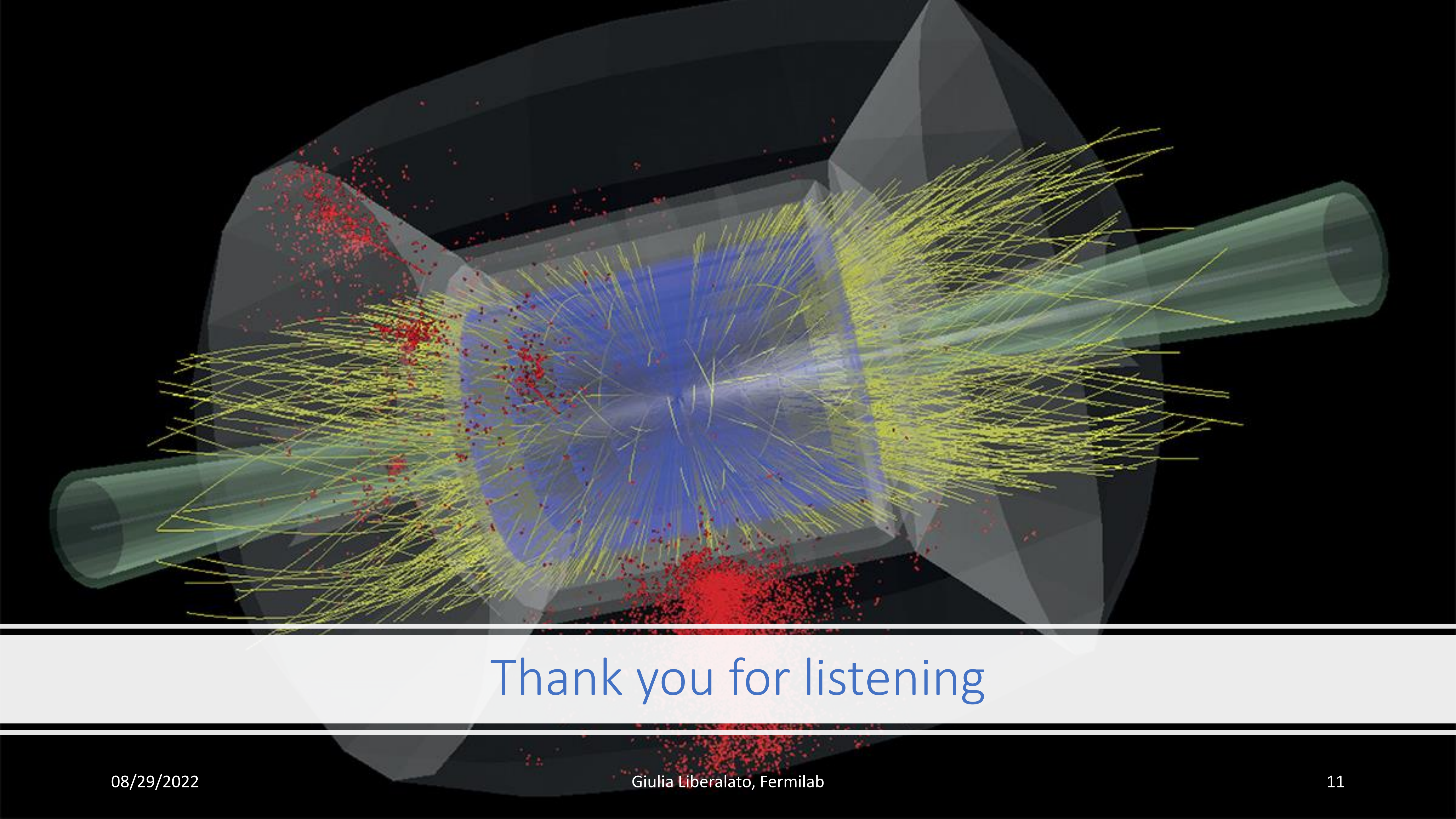


Low momentum particles

$\sqrt{s} = 1.5\ TeV$

In the next month…

- Other physics events (HH, W, …)
- Analyses of other tracks and how close they are
- My analyses of BIB



Thank you for listening