

Analysis of H signal at a multi-TeV Muon Collider

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Muon Collider

- What:

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

- Where:

Fermilab or CERN

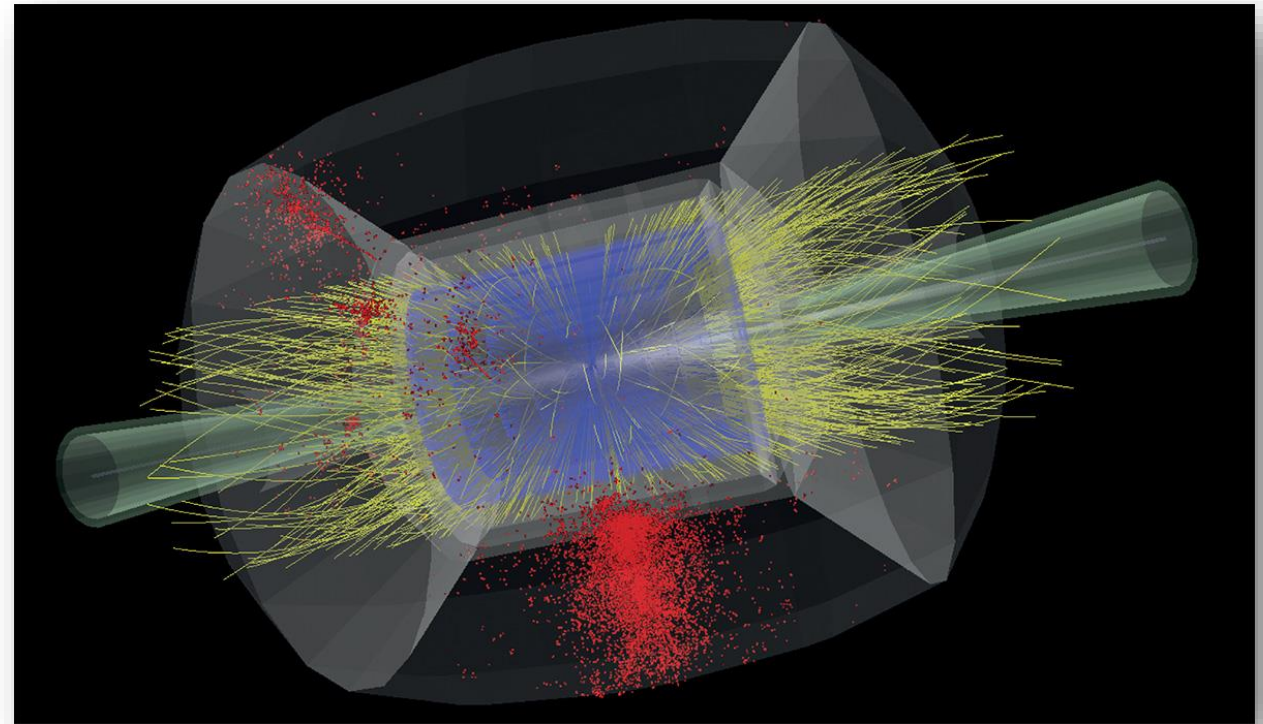
- When:

2026 → Cost and Performance Estimation

2033 → Ready to Commit

2037 → Ready to Construct

2043 → Ready to Operate



- Who:

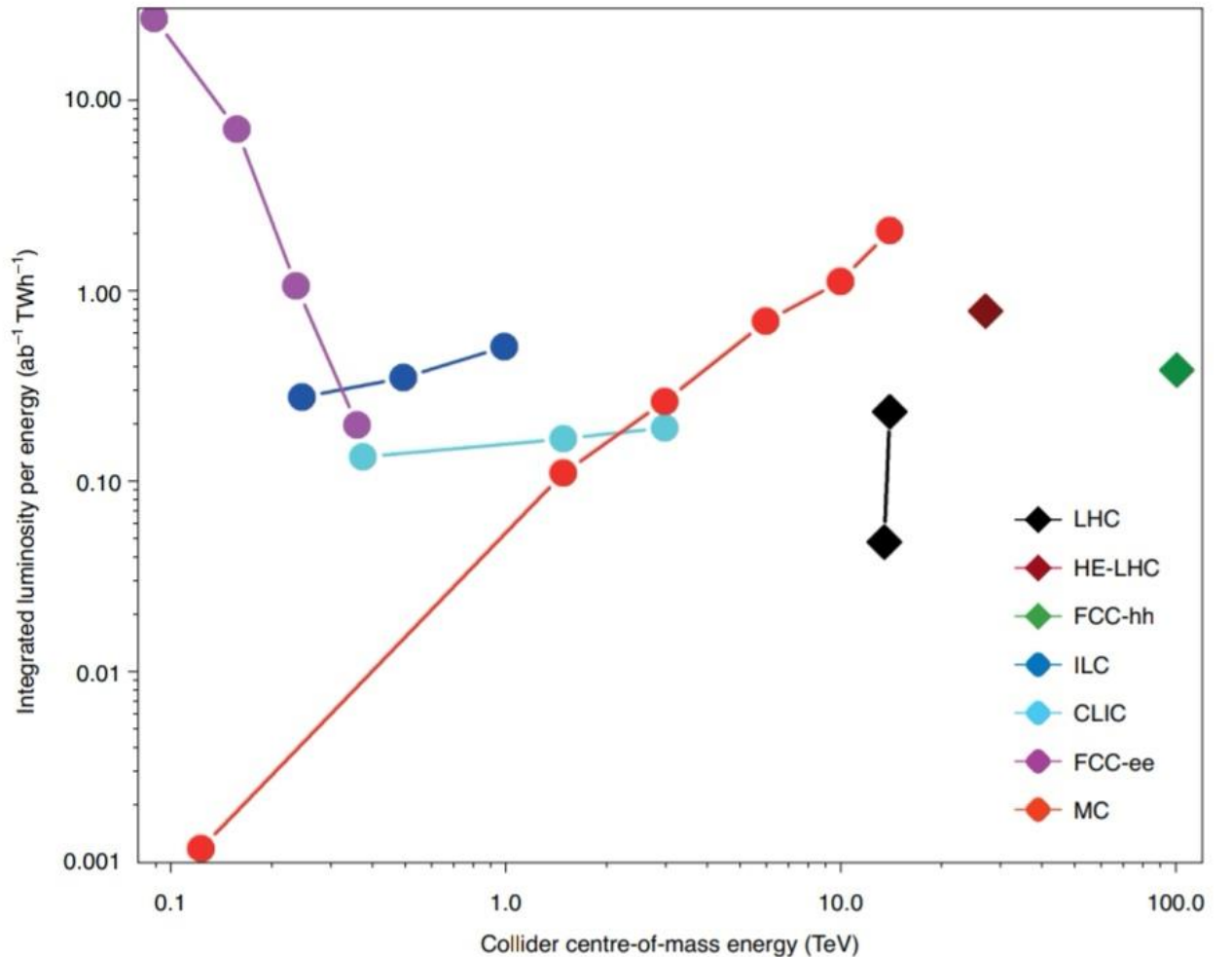
International Muon Collider
Collaboration (IMCC) hosted
by CERN

Benefits of Muon Collider

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

$$P = \frac{1}{6\pi\epsilon_0} \frac{e^2 v^2}{c^2 r^2} \left(\frac{E}{m} \right)^4$$

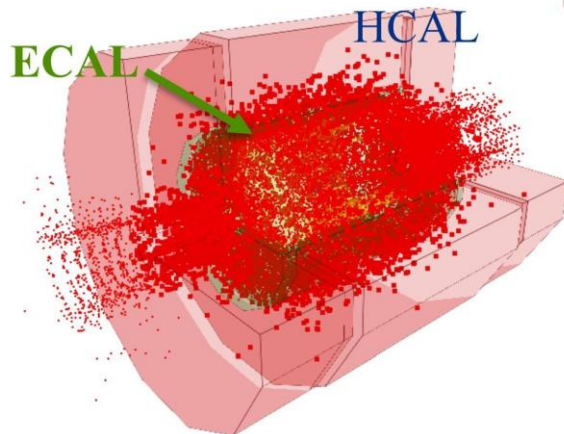
- ✓ Colliding elementary particles
- ✓ Compared to linear accelerators, elements can be used several times
- ✓ Luminosity per energy consumed



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



hadronic calorimeter

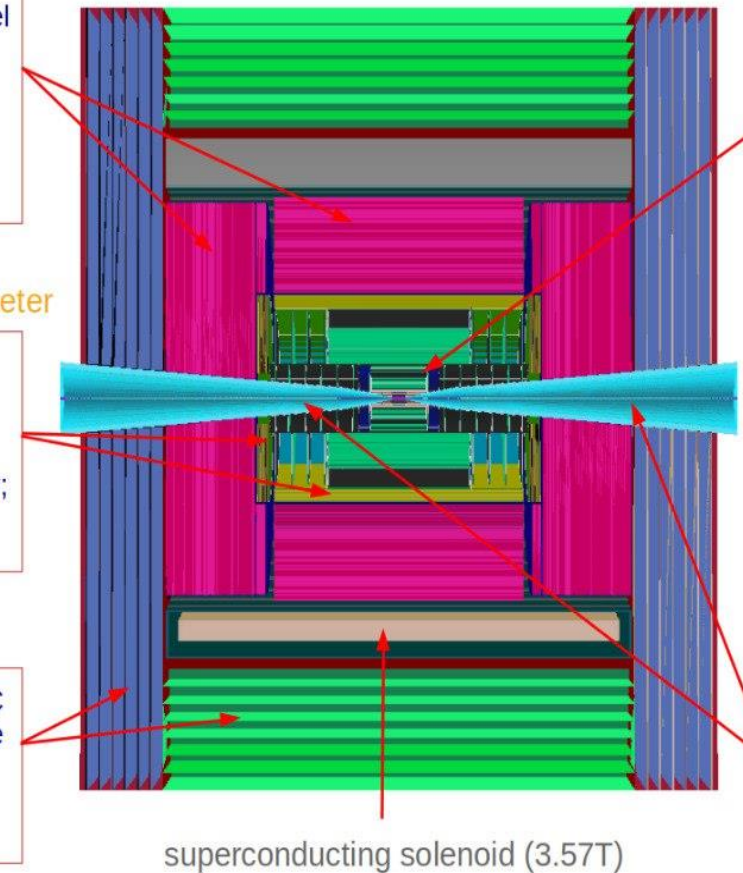
- ◆ 60 layers of 19-mm steel absorber + plastic scintillating tiles;
- ◆ 30x30 mm² cell size;
- ◆ 7.5 λ_I .

electromagnetic calorimeter

- ◆ 40 layers of 1.9-mm W absorber + silicon pad sensors;
- ◆ 5x5 mm² cell granularity;
- ◆ 22 $X_0 + 1 \lambda_I$.

muon detectors

- ◆ 7-barrel, 6-endcap RPC layers interleaved in the magnet's iron yoke;
- ◆ 30x30 mm² cell size.



tracking system

- ◆ **Vertex Detector:**
 - double-sensor layers (4 barrel cylinders and 4+4 endcap disks);
 - 25x25 μm^2 pixel Si sensors.
- ◆ **Inner Tracker:**
 - 3 barrel layers and 7+7 endcap disks;
 - 50 $\mu m \times 1$ mm macro-pixel Si sensors.
- ◆ **Outer Tracker:**
 - 3 barrel layers and 4+4 endcap disks;
 - 50 $\mu m \times 10$ mm micro-strip Si sensors.

shielding nozzles

- ◆ Tungsten cones + borated polyethylene cladding.

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 $10 \mu\text{s}$
 - Study of physics signal
 - Study of BIB properties
 - Comparison between the two

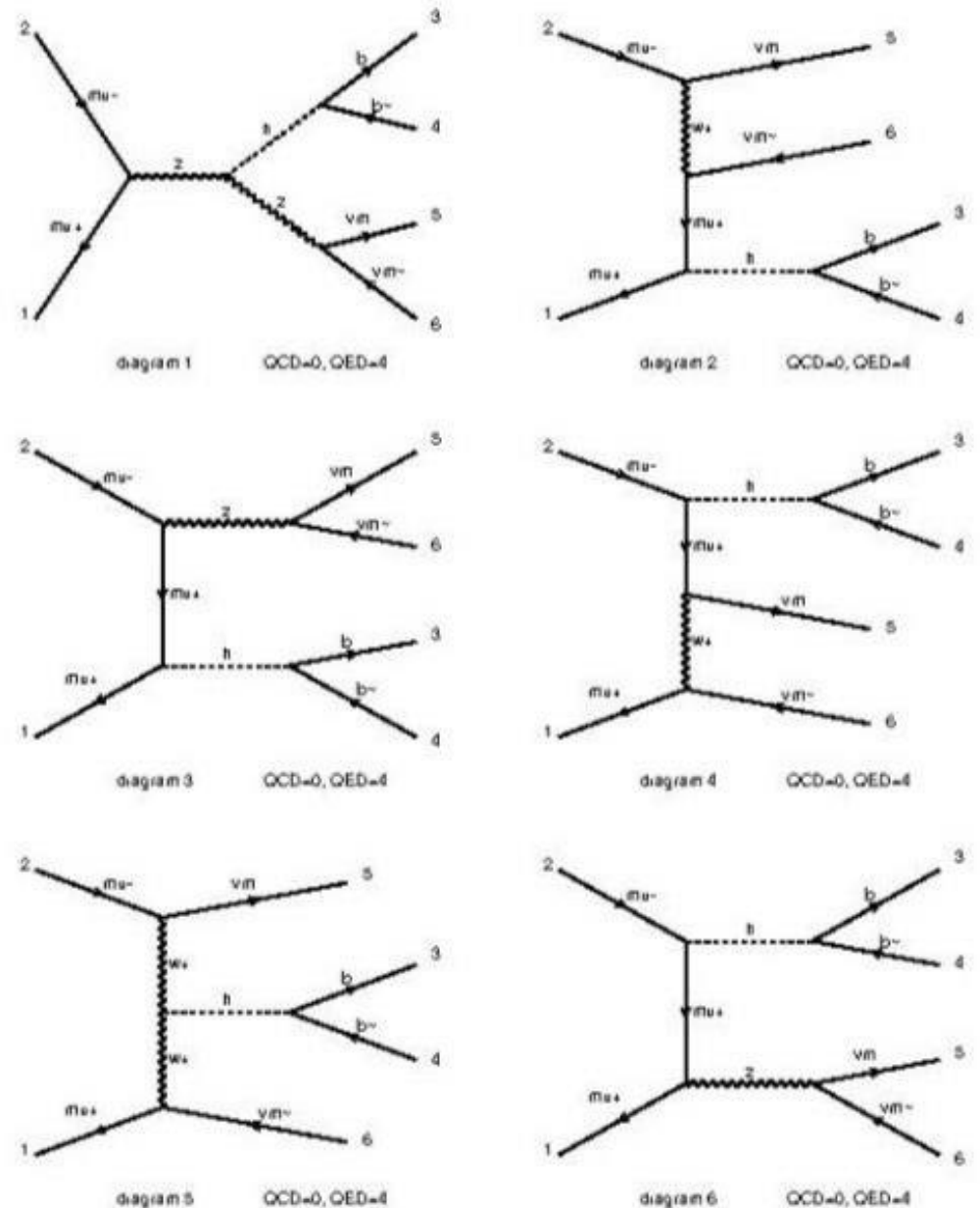
Signal

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

$$\mu^+ \mu^- \rightarrow H \nu_\mu \bar{\nu}_\mu, H \rightarrow b \bar{b}$$

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

It produces 6 diagrams:



Analyses with CERN-ROOT

- Selection of charged particles in the final state

(K, π, p, e, μ)

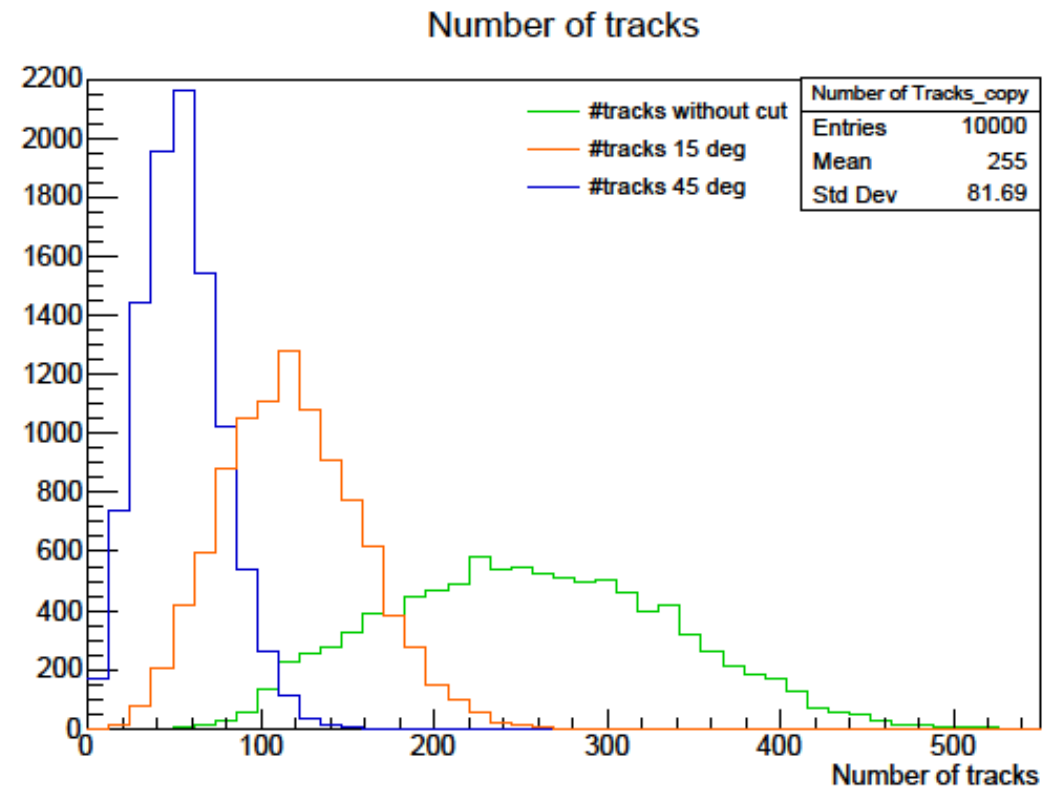
- Distributions analysed: P_T, θ, φ, E
- Different selections on θ :

$$0 < \theta < 180^\circ$$

$$15^\circ < \theta < 165^\circ$$

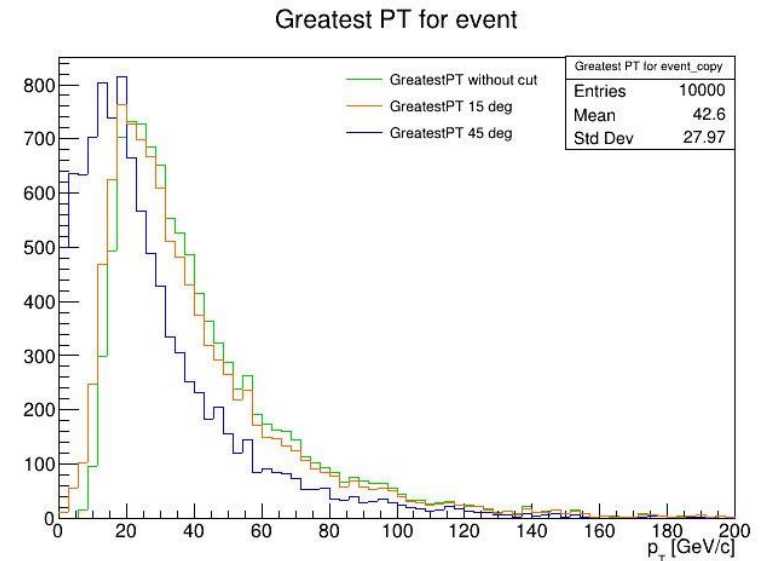
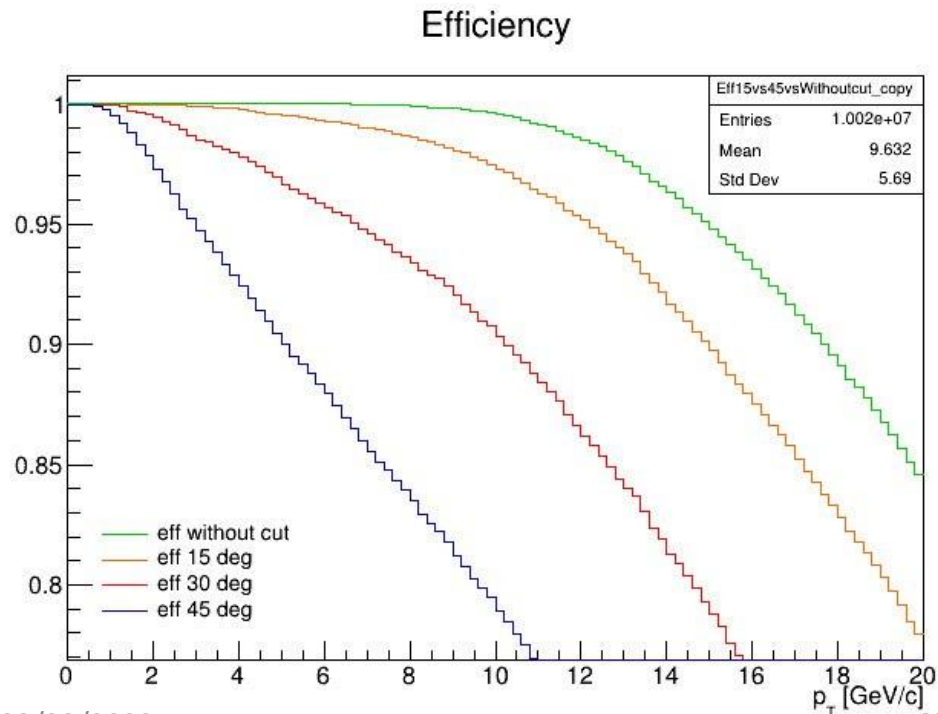
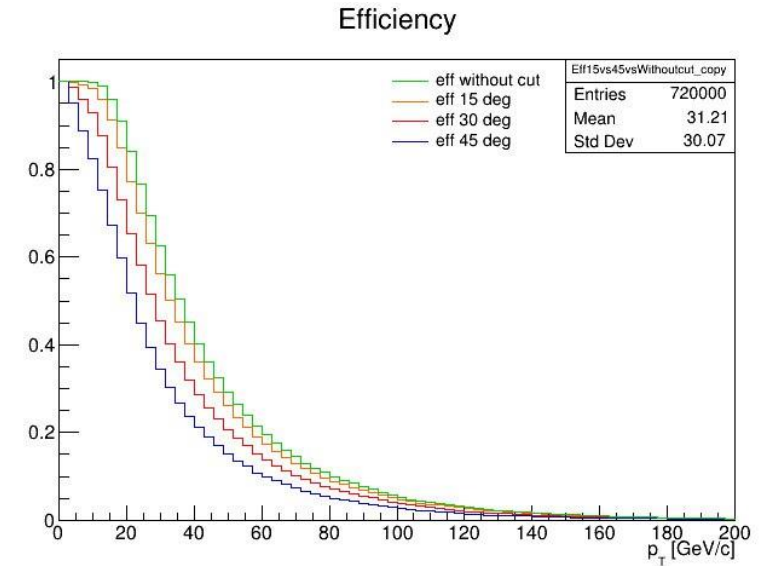
$$30^\circ < \theta < 150^\circ$$

$$45^\circ < \theta < 135^\circ$$



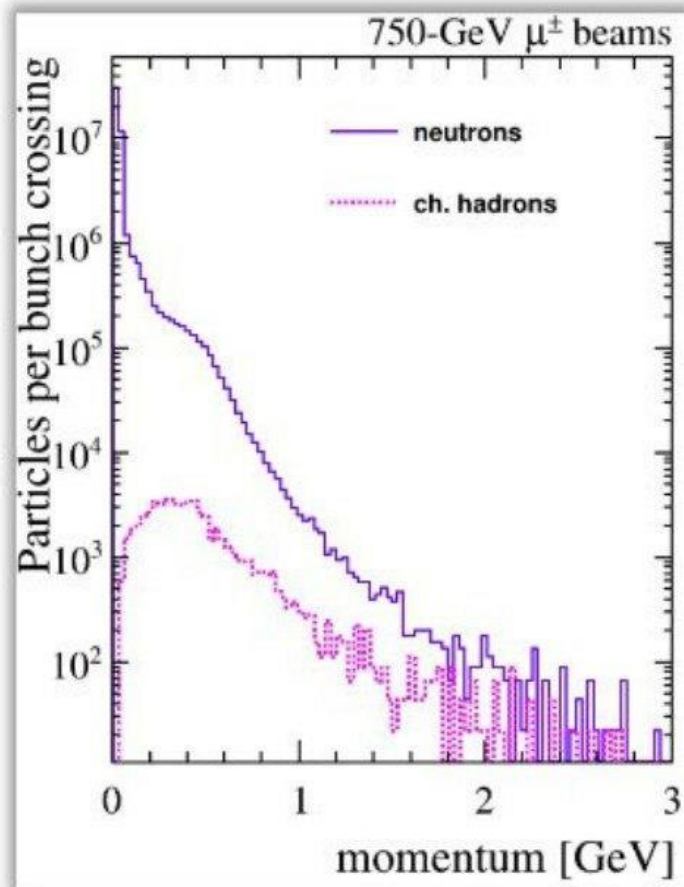
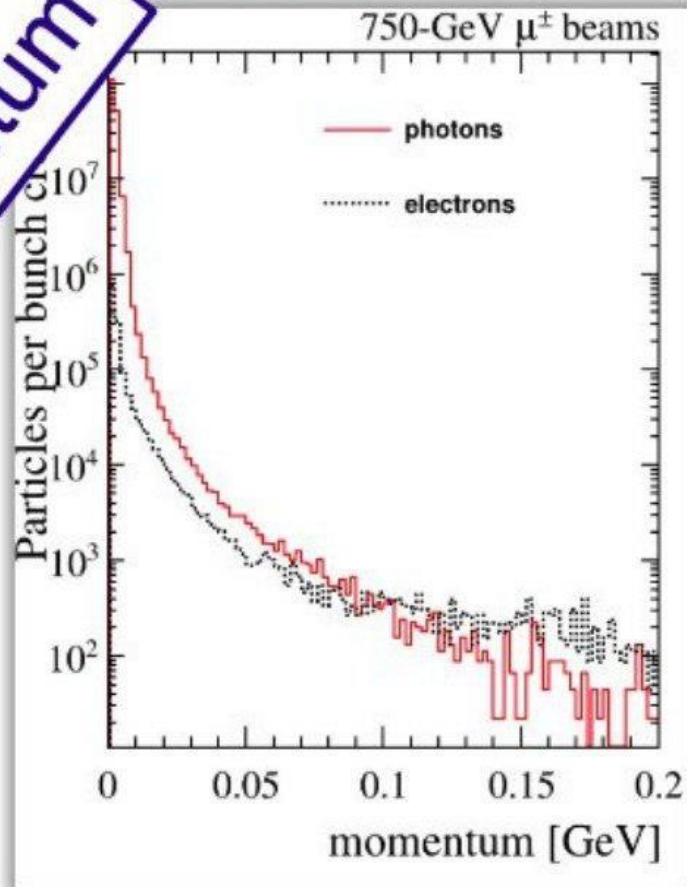
Trigger strategy

- 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

Momentum

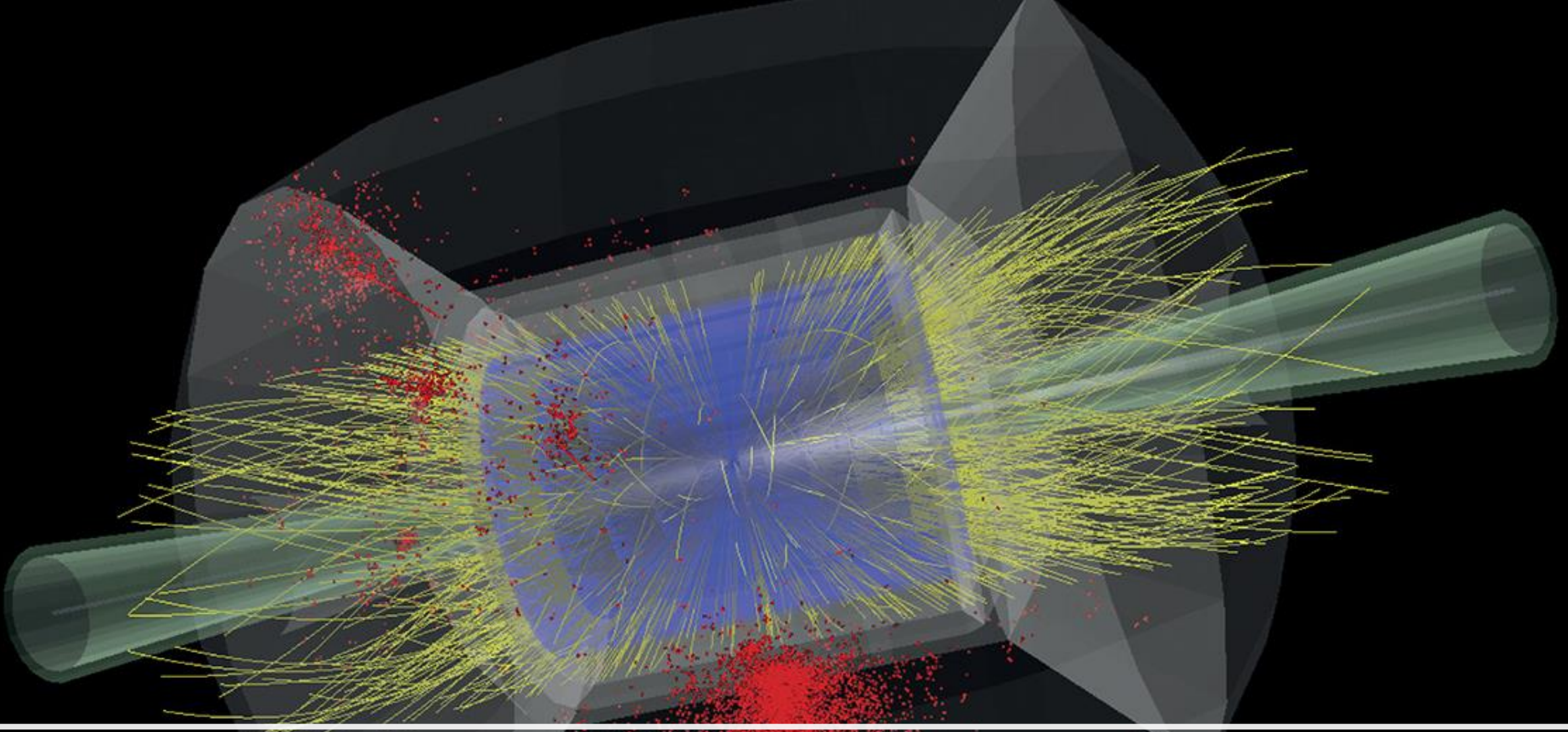


Low momentum
particles

$$\sqrt{s} = 1.5 \text{ TeV}$$

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