THE DSTAU EXPERIMENT: A STUDY OF TAU NEUTRINO PRODUCTION

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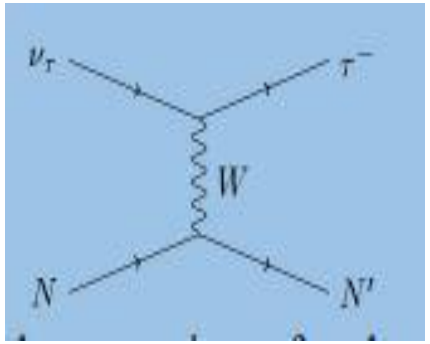
Helmholtz – DIAS International Summer School "Quantum Field Theory at the Limits: from Strong Fields to Heavy Quarks
22 July –2 August 2019

Content

1. The DsTau experiment – following DONuT

- Motivation: neutrino tau production from $D_s \rightarrow \tau$ events



→ Charged-current interaction cross section

- DONuT – 9 events → 33% statistical uncertainty (2% in future ShiP experiment)
  → >50% systematic uncertainties
- DsTau proposes uncertainties < 10% (1000 events from 2.3 x 10^8 proton interactions) – important for future tau-neutrino experiments

- By products : charm particles production (4.9 x 10^5 events)

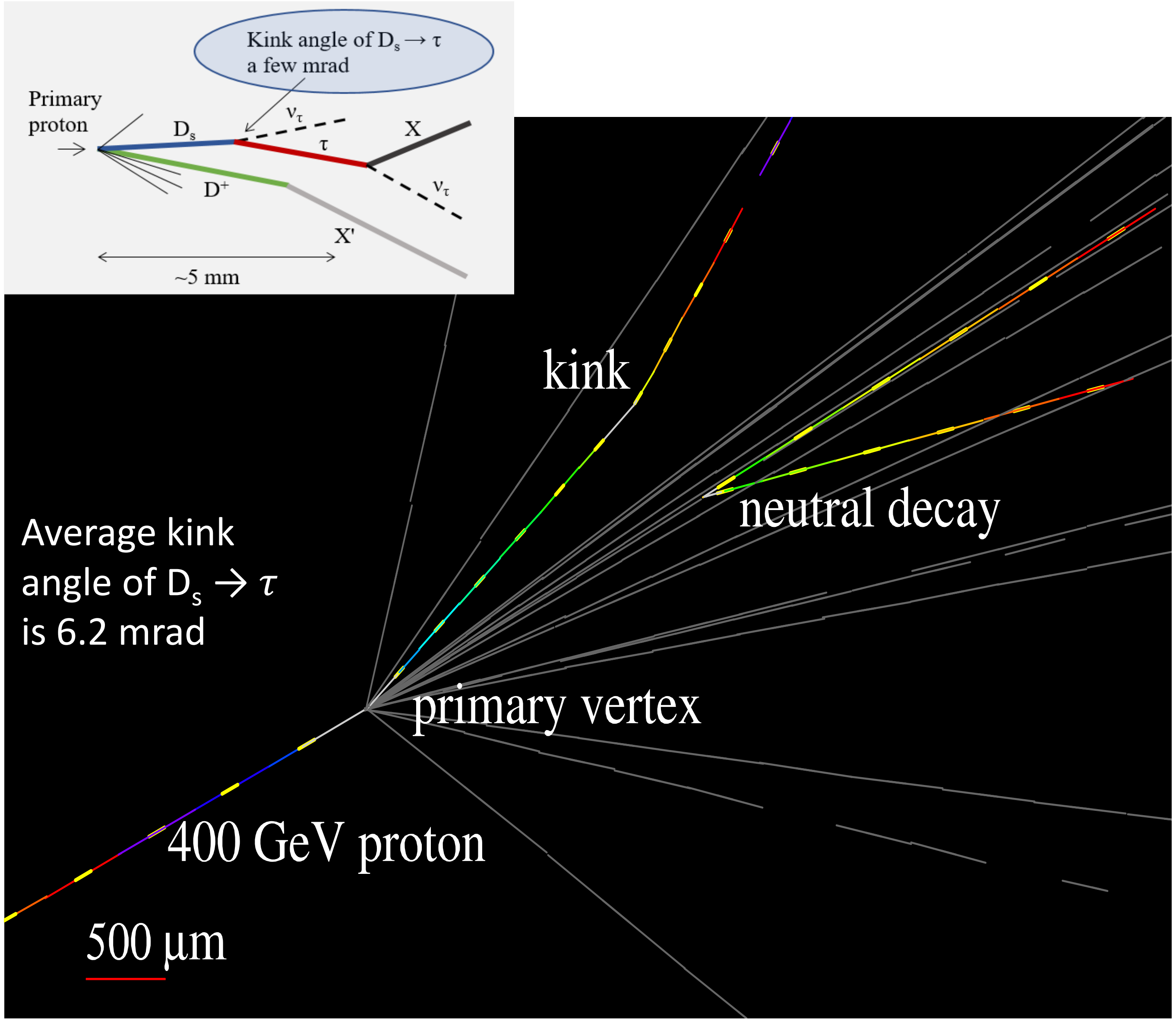
Neutrino-nucleus interactions

Lepton Universality – New Physics

Standard Model

Irradiations at CERN –SPS with 400 GeV proton beam on Tungsten target

1. The DsTau experiment – following DONUT



Reaction topology
$D_s \to \tau \to X$

(double kink topology)

Detectors with a very good spatial resolution

2. The nuclear track emulsion technique

- NTE = in essence, a photographic plate

- When a charged particle is traversing the NTE, it produces ionization along its trajectory, leaving traces

Traces will characterize the particle that passed: charge, kinetic energy, momentum etc

- One of the oldest detecors ever (100 years), but still the one with the best spatial resolution

2. The nuclear track emulsion technique

Why so old detectors as NTEs are still used into experiments nowadays ?

- The best spatial resolution (nanometric resolution)
- Complete 3-dimensional perspective of each event
- Individual study of each event
- Good in all energy ranges
- Register all the particles that pass thorugh emulsion → good detection efficiency → good in the detection of rare events

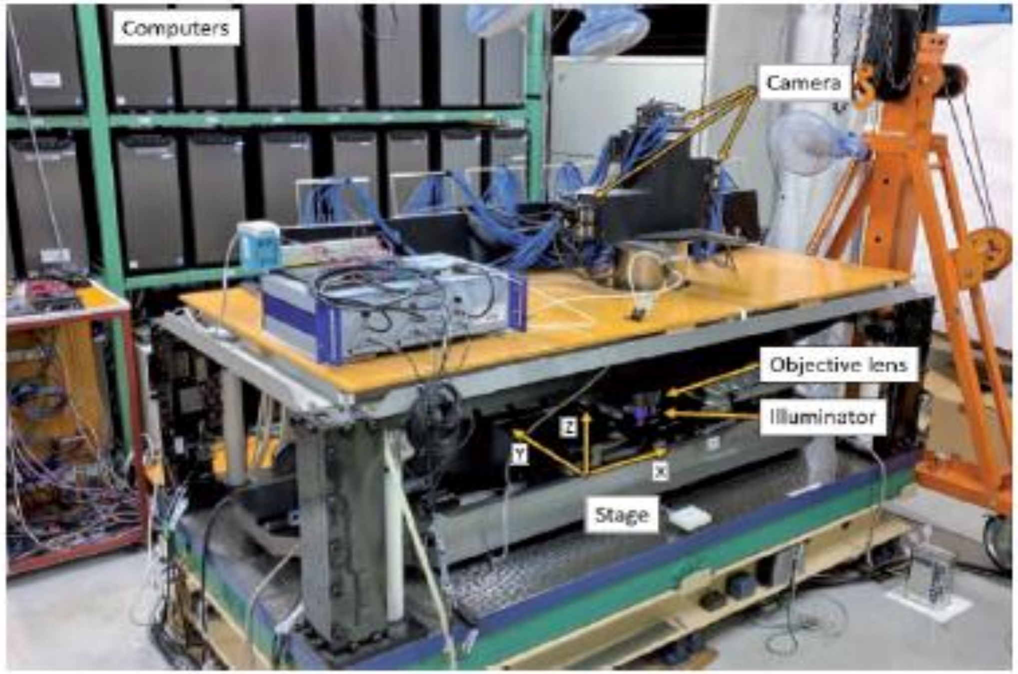
- It is the target, the detector and the storage volume in the same time
- Cheap $1\$/cm^3$
- Do not need energy supply

No modern detector has such properties

2. The nuclear track emulsion technique

Steps for working with NTEs in DsTau

- Gel preparation (40% AgBr) and films production
- Irradiation
- Chemical fixation – development
- Surface metallic silver removal
- Fast scanning (HTS)
- Tracks reconstruction – vertex reconstruction
- Deep/precise scanning
- Data analysis

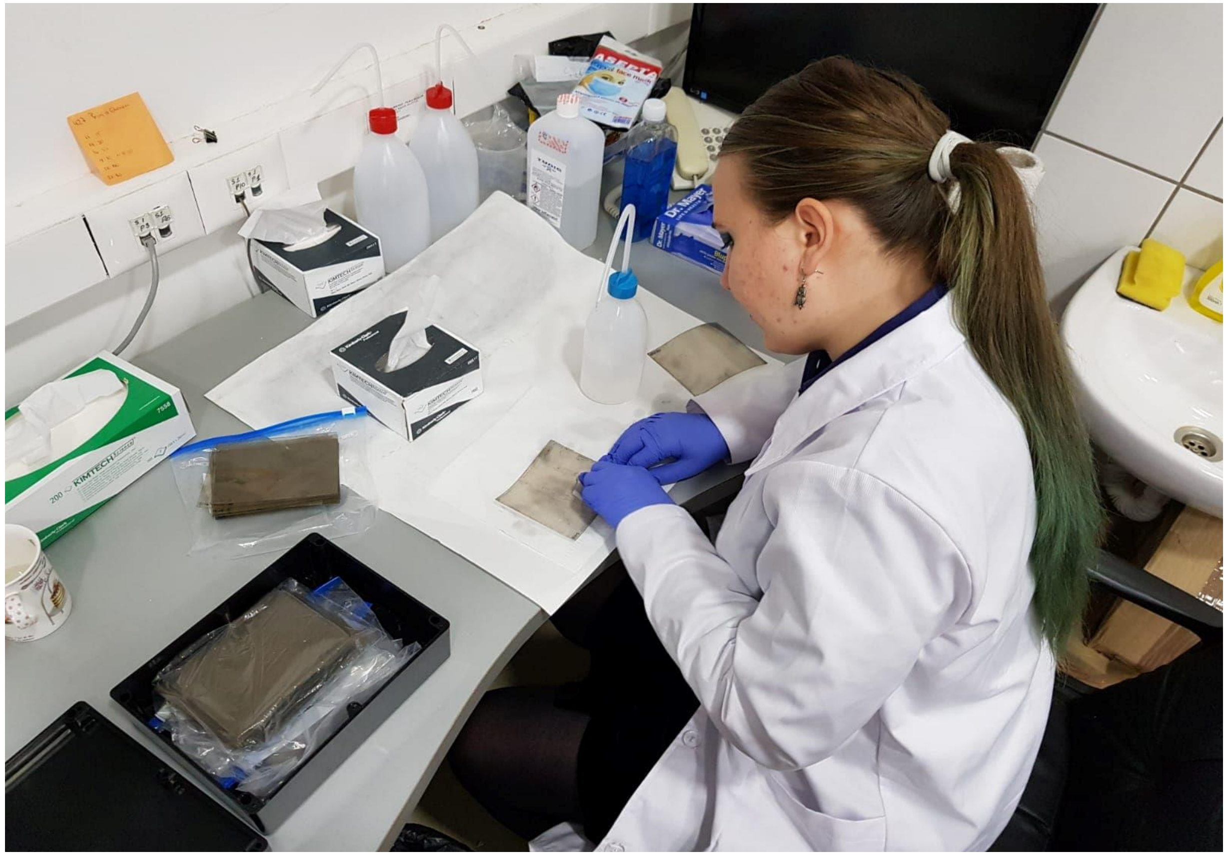


HTS – Hyper Track Selector

5 minutes / plate

Laboratory work ☺ Surface metallic silver removal

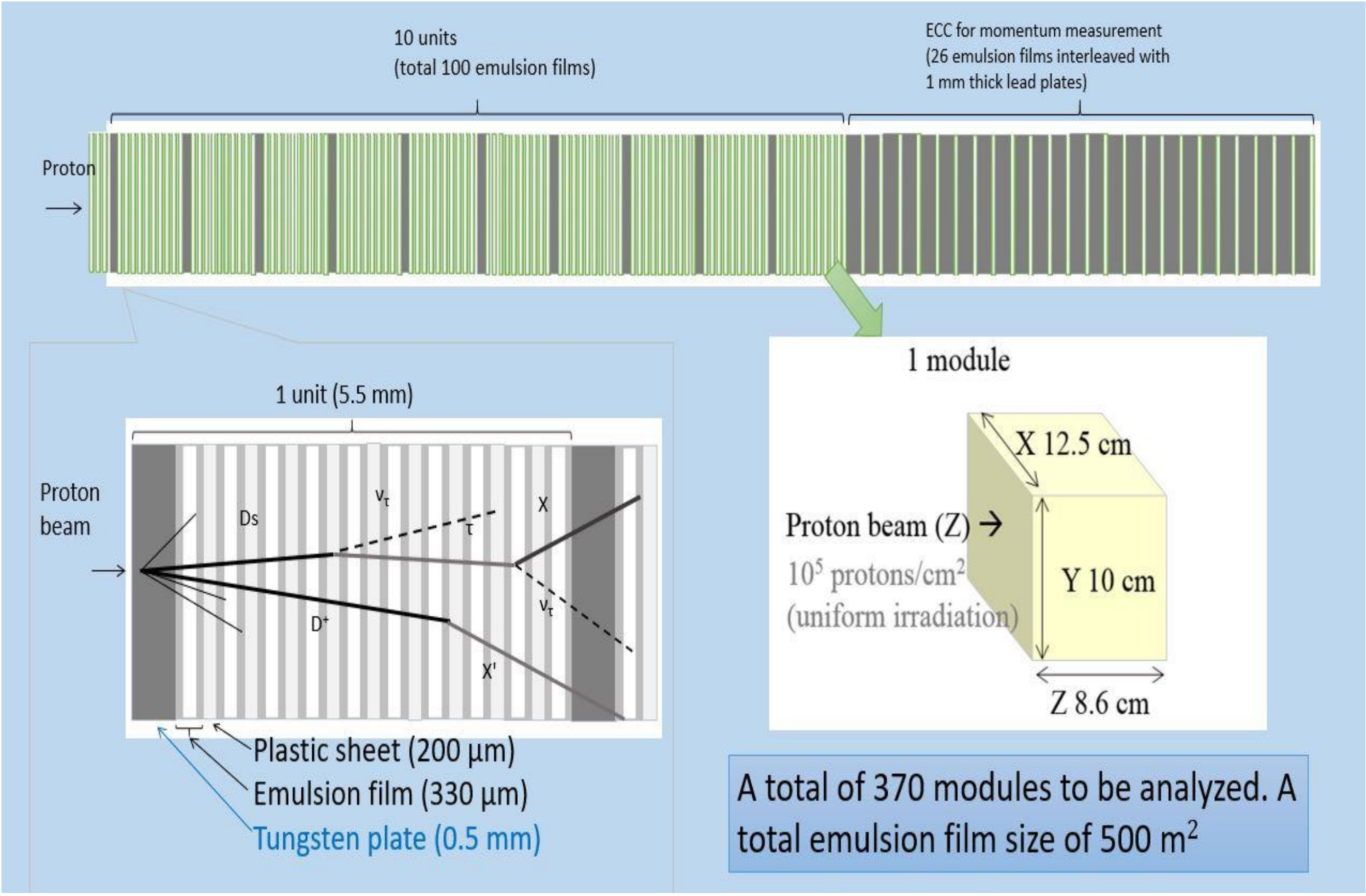
Tired me, after 8 hours of plates cleaning

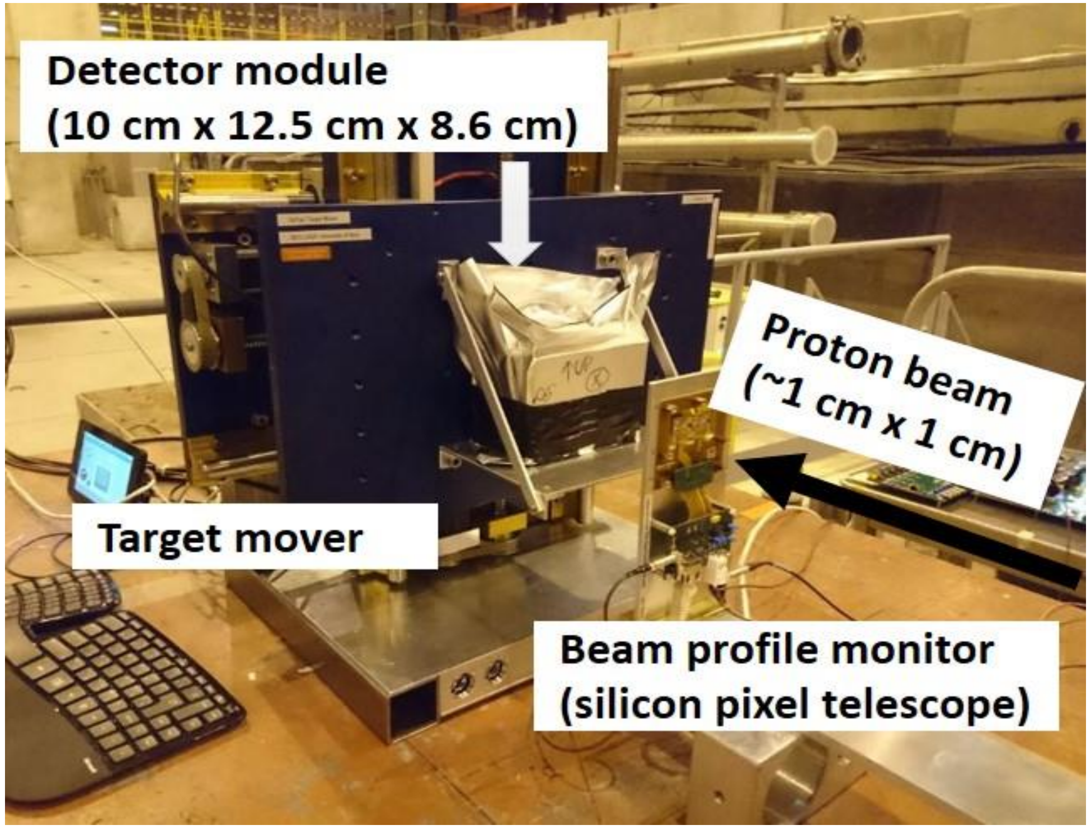


Until now, 945 plates are cleaned by me (9 modules)

(from a total of 4000 in the entire 2018 physics run)

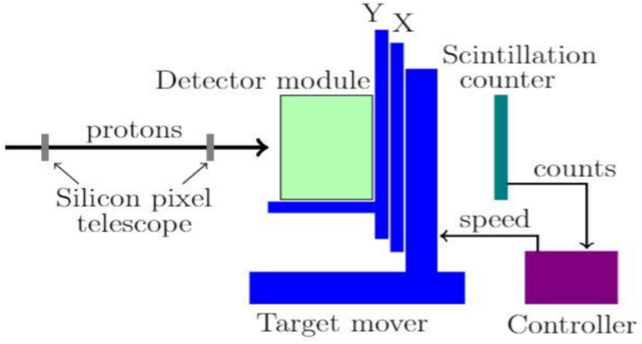
3. The experimental set-up for DsTau



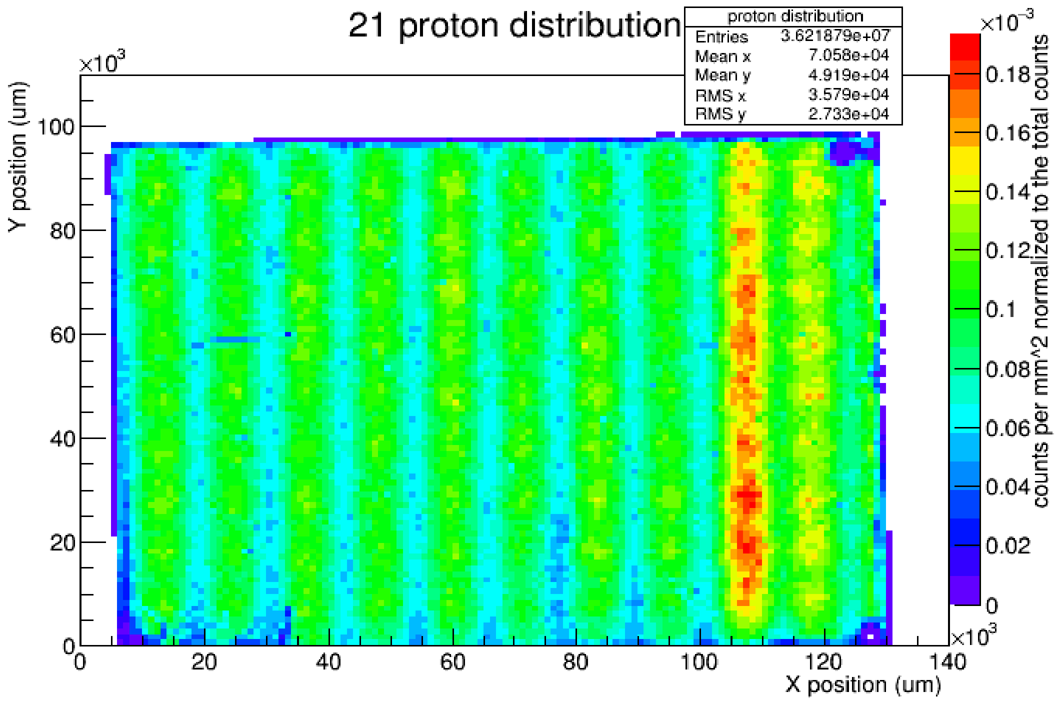


2018 physics run – 30 modules – 4000 plates

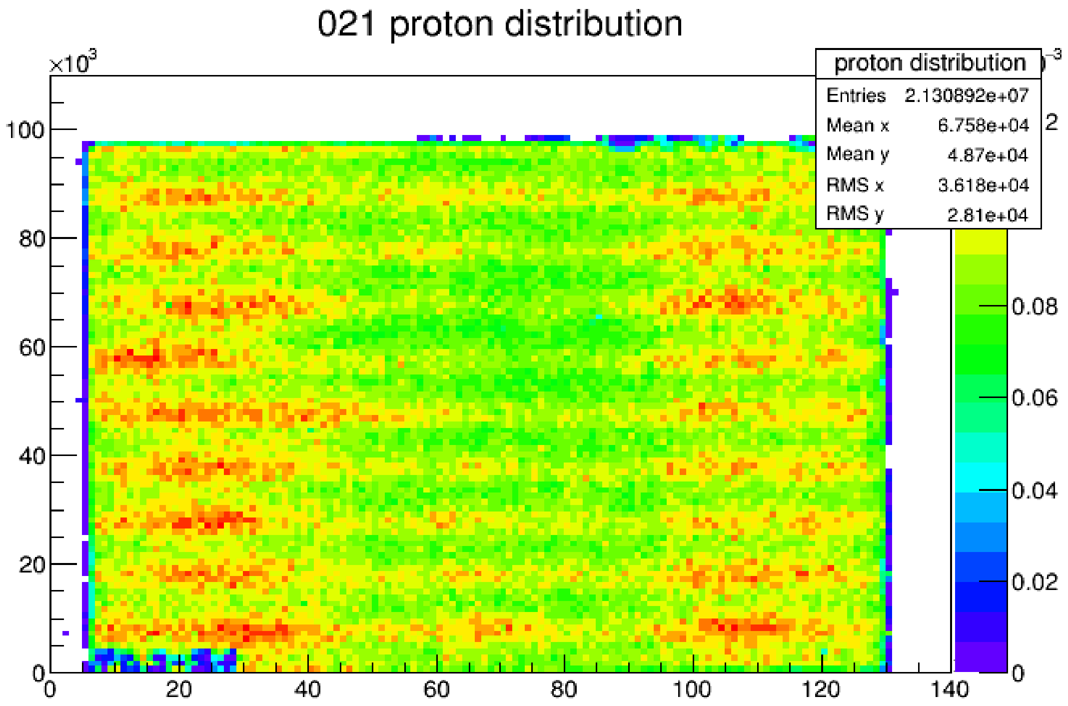
5. Proton beam profile



- Goal: uniform irradiation ~ 3 x 10^5 / cm^2

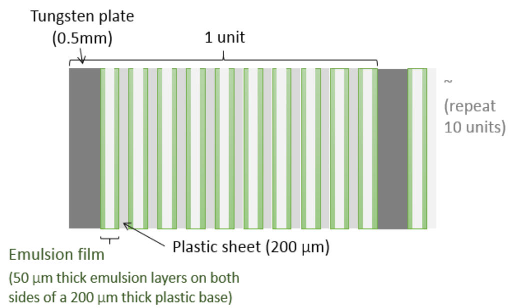


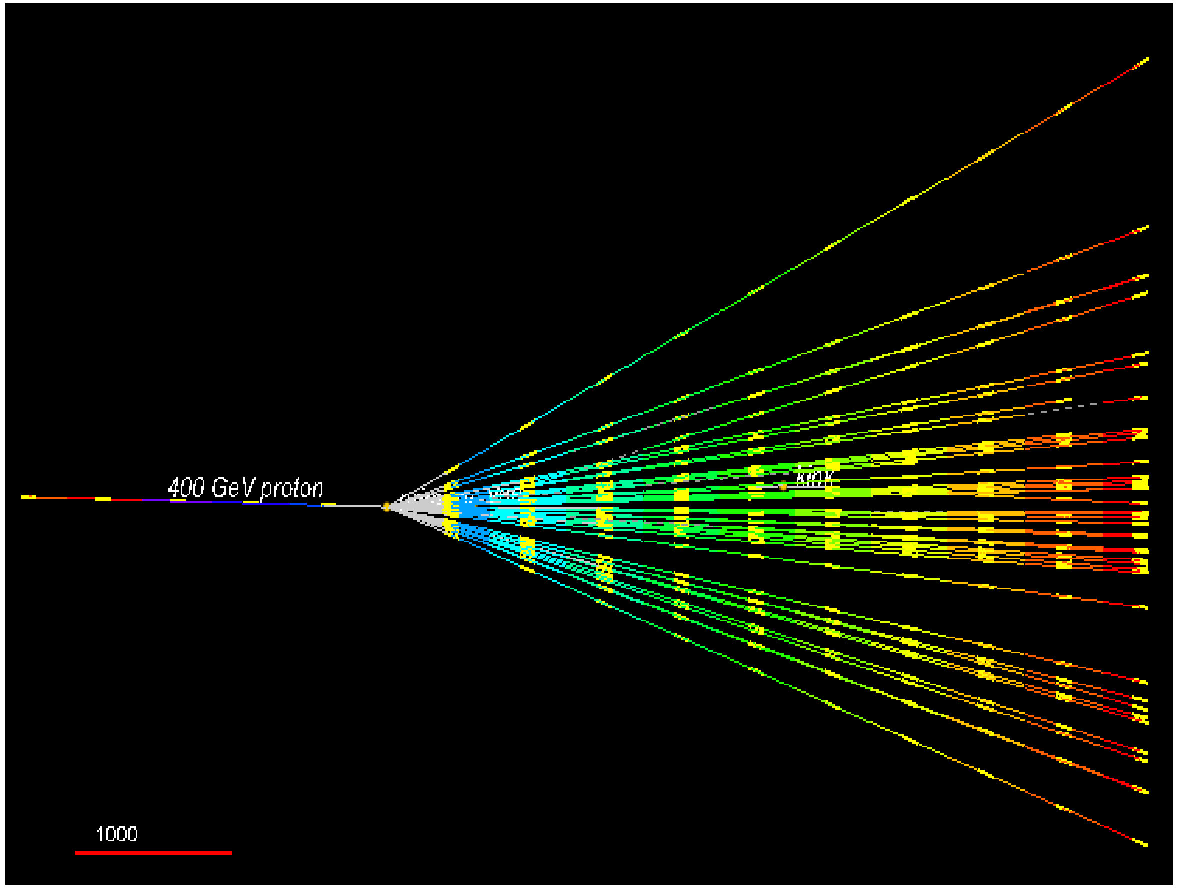
2016 run proton profile



2018 run proton profile

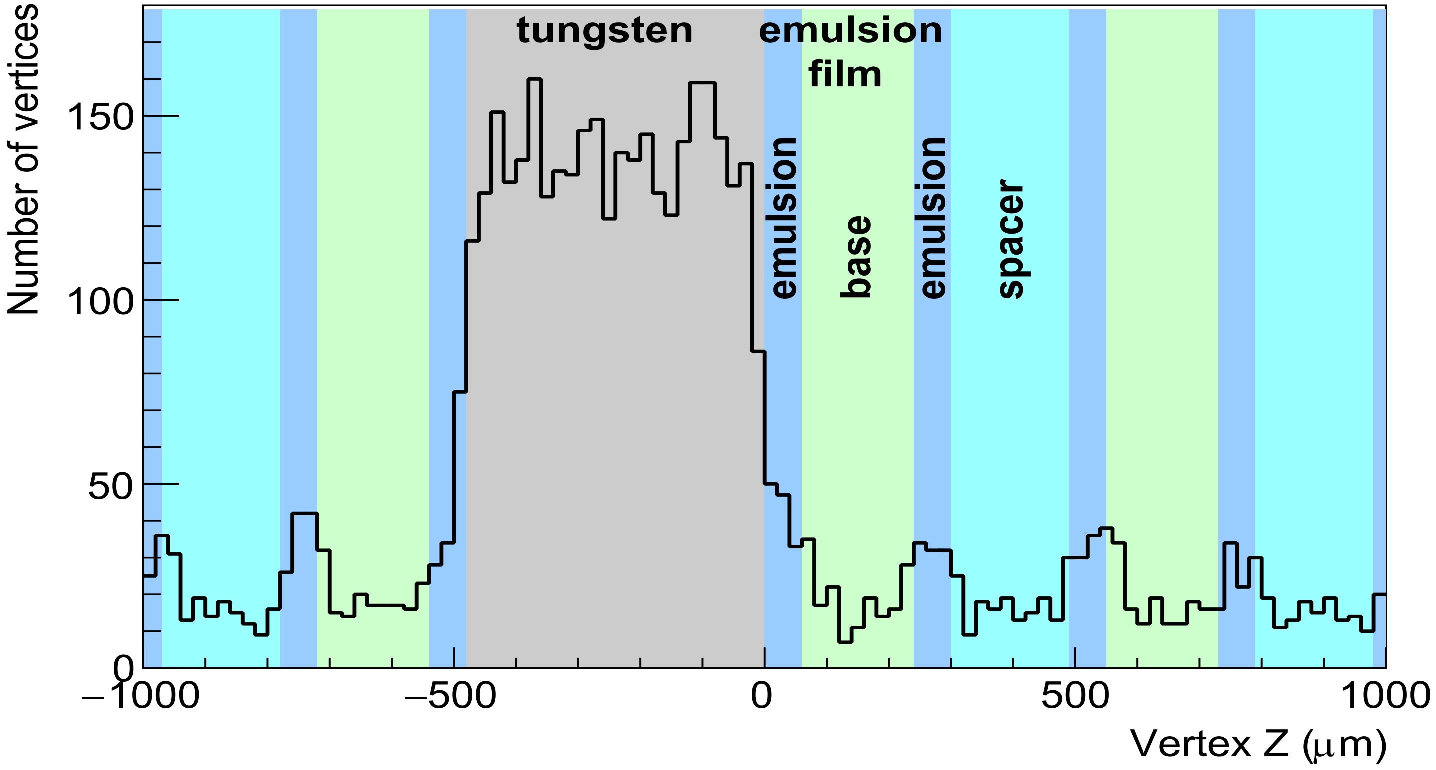
Observation ☺





- (in the photo, some yellow segments are observed)
- The yellow segments are observed/scanned in the emulsion films = tracks from the particles
- After this, the trajectories are reconstructed and the full image of an event/interaction is obtained

4. Primary analysis

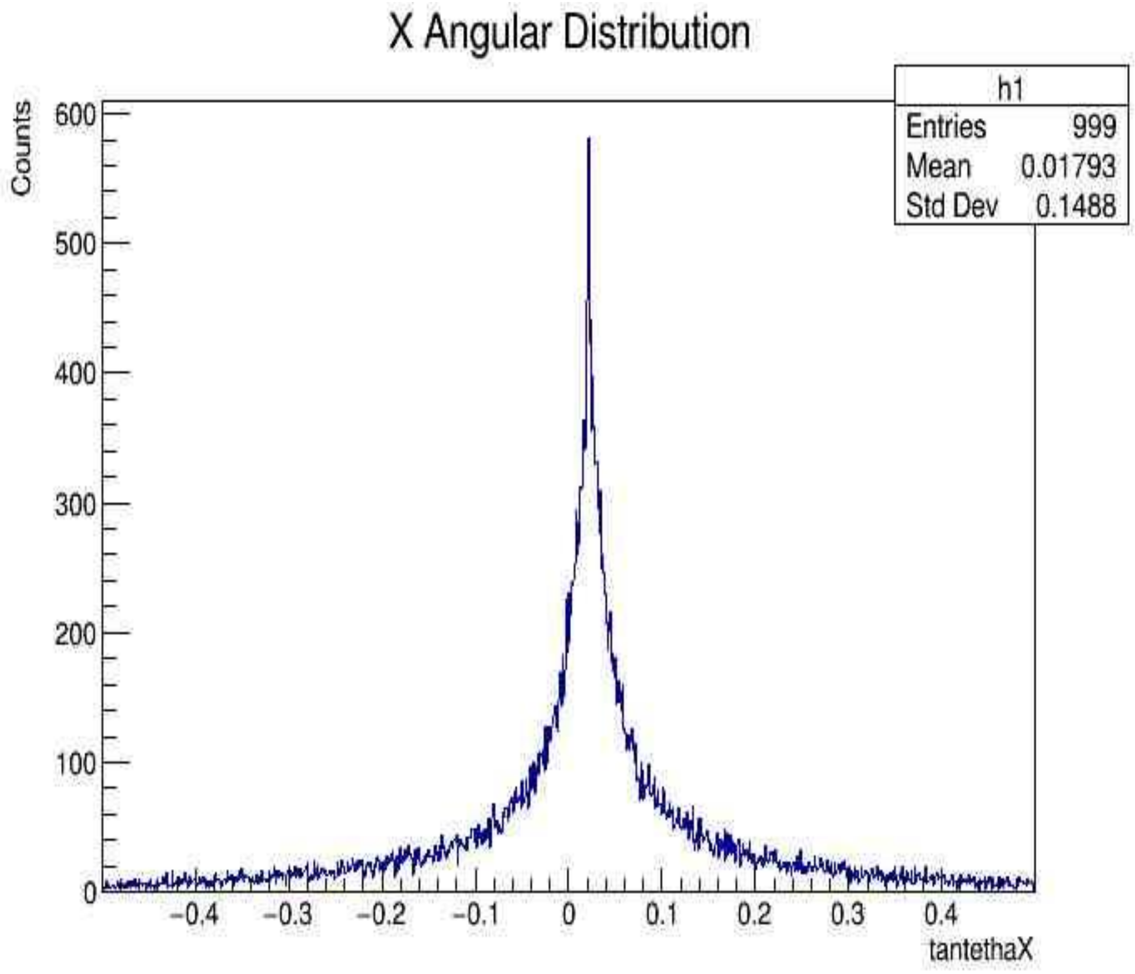


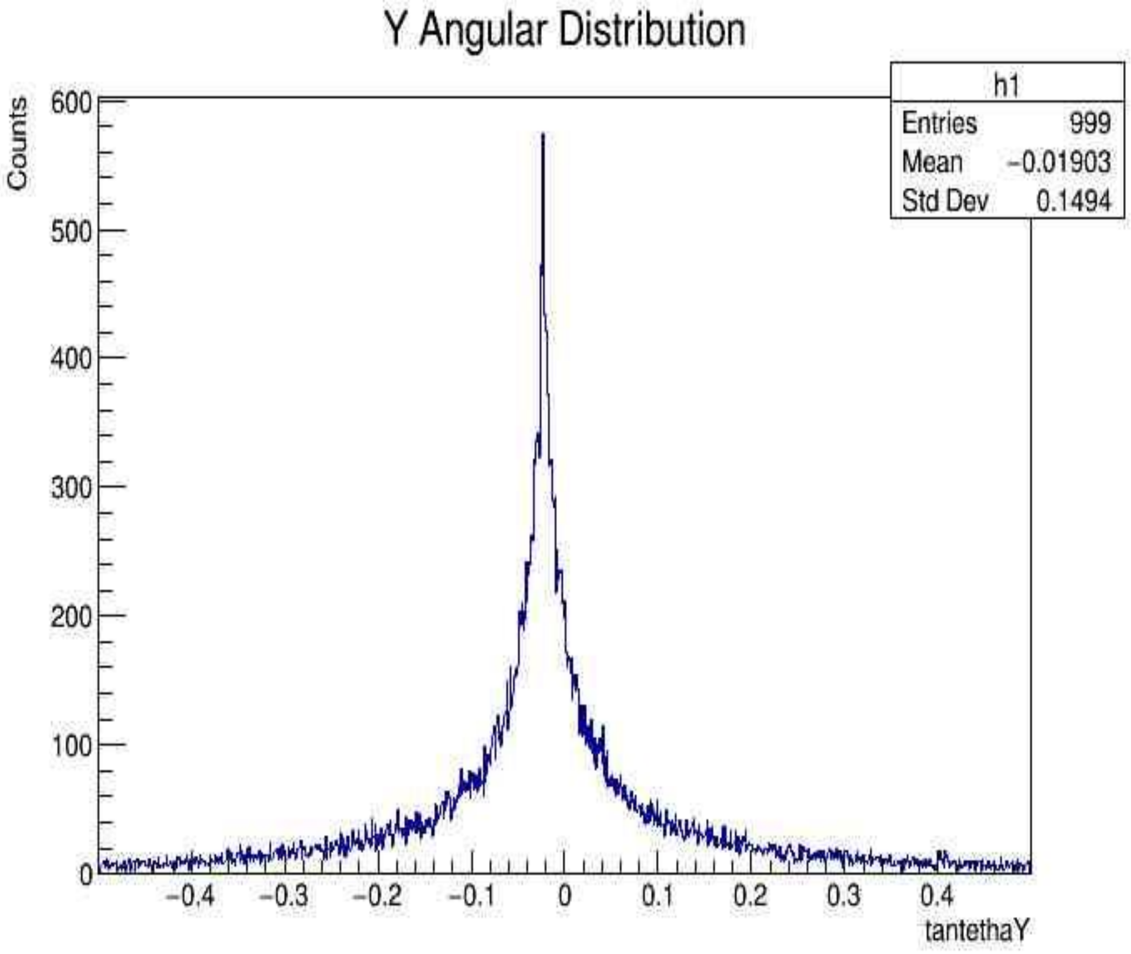
The number of vertexes in the detector depth

The detector structure is observed

10 NTE plates and 1 Tungsten foil

4. Preliminary analysis





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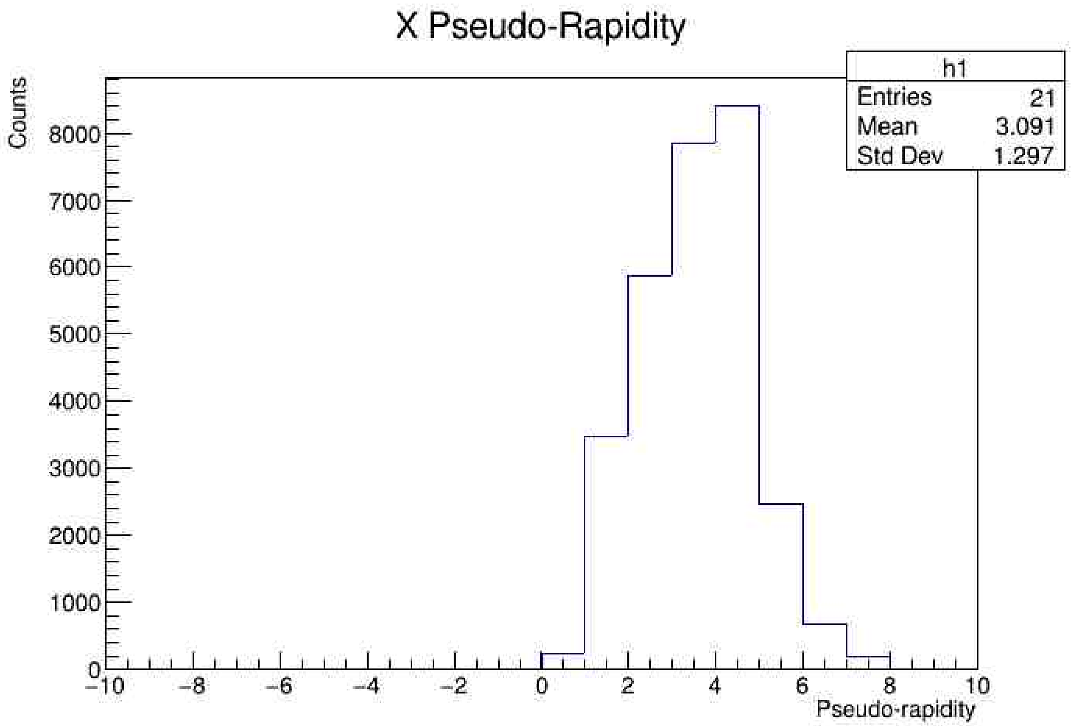

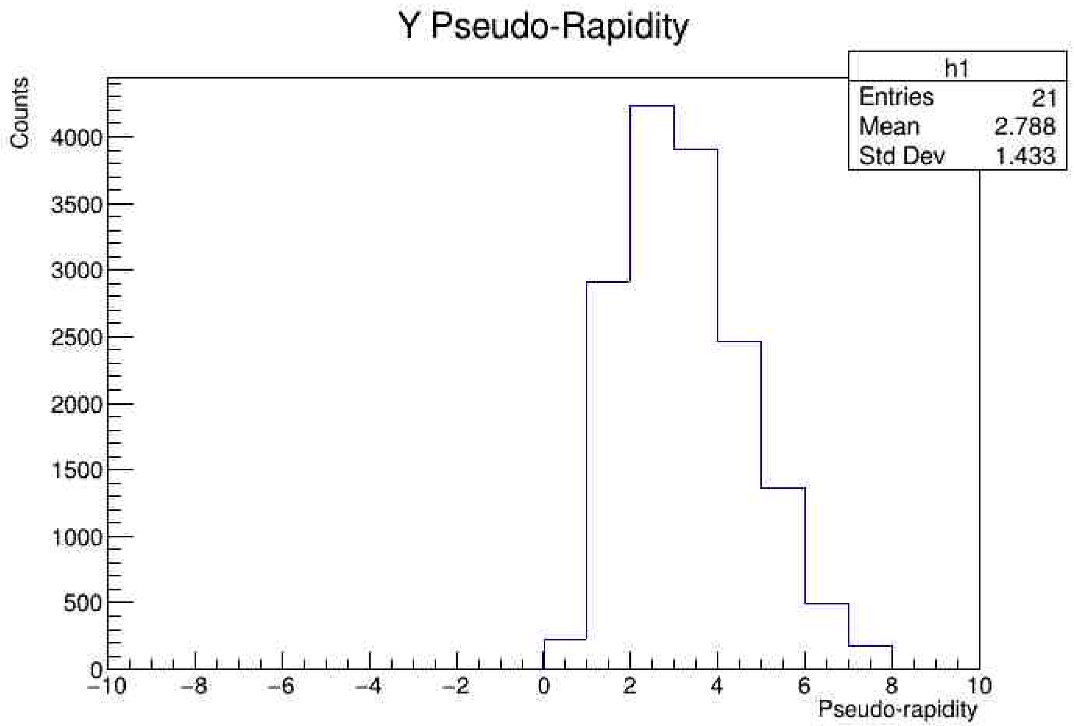

$\eta = -\ln tg\, \Theta/2$

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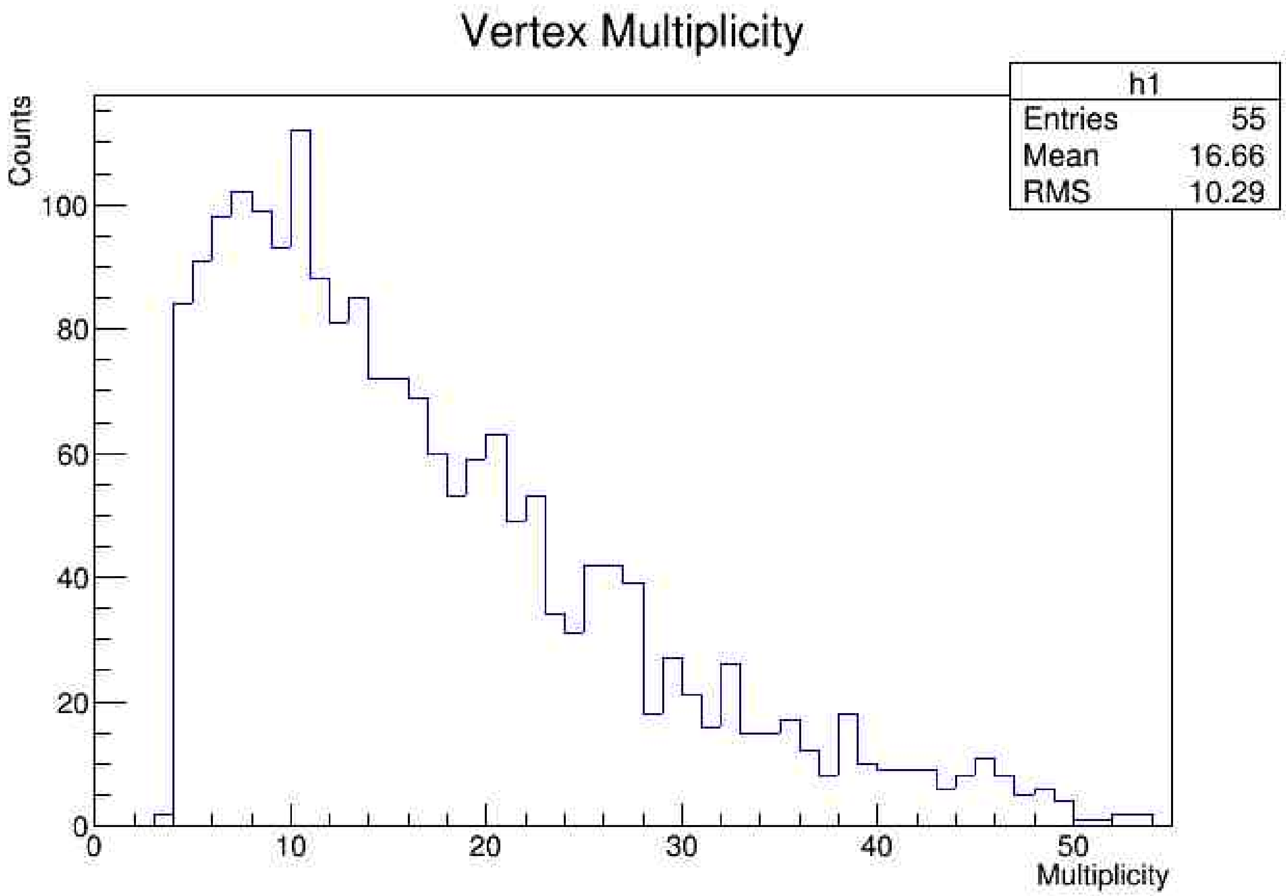

Number of particles produced in each vertex

6. Perspectives

- Ongoing work : chemical treatment of NTE, measurements at HTS in Nagoya, data analysis (ROOT, FEDRA-Framework for Emulsion Data Reconstruction and Analysis) & simulations (Fluka & GEANT4) in parallel

- DsTau (SPSC-P354) was approved at the CERN Research Board meeting in June 2019 for the physics run (two weeks of running in each 2021 and 2022)

- Next exposures will provide flux estimations for future experiments and the study of intrinsic charm content in protons

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DsTau poster
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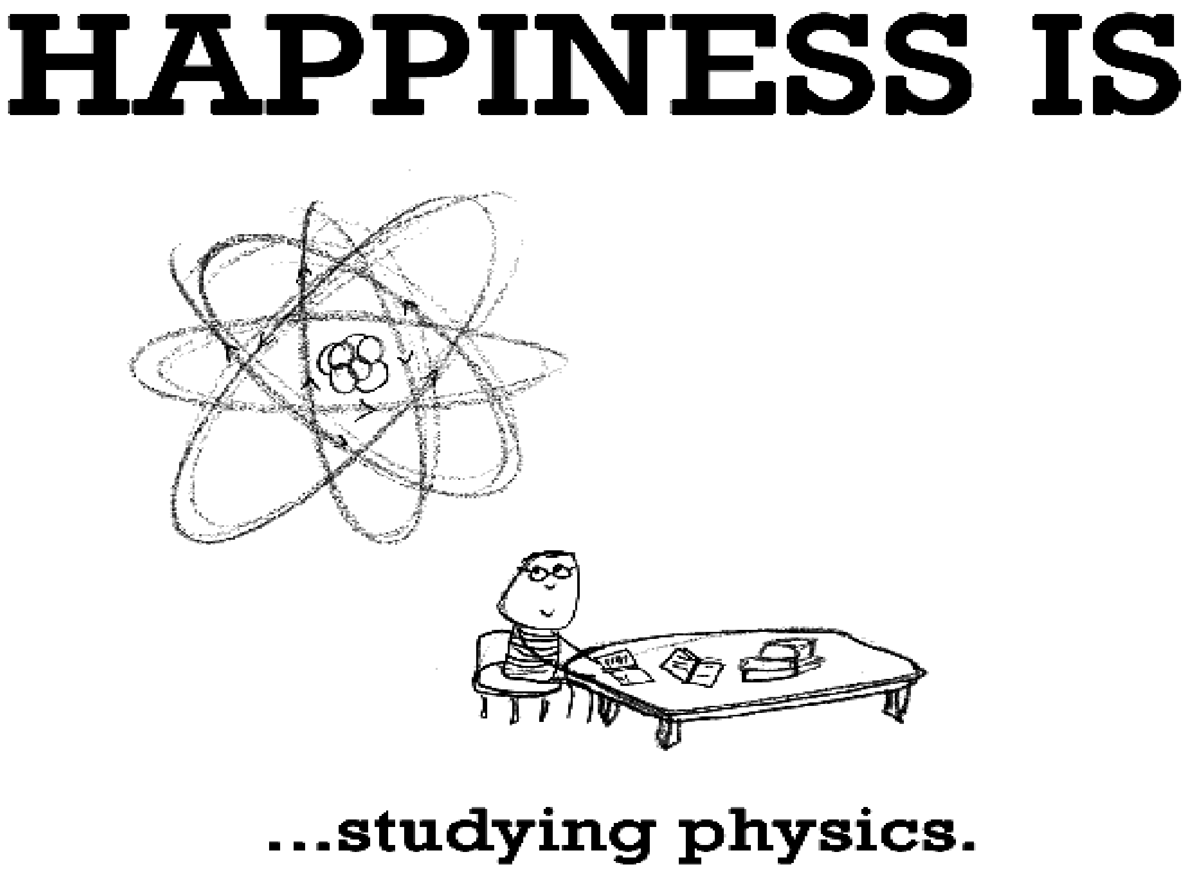
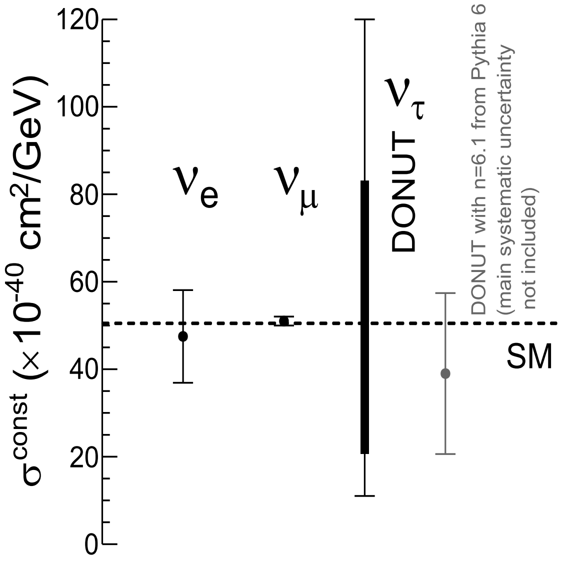
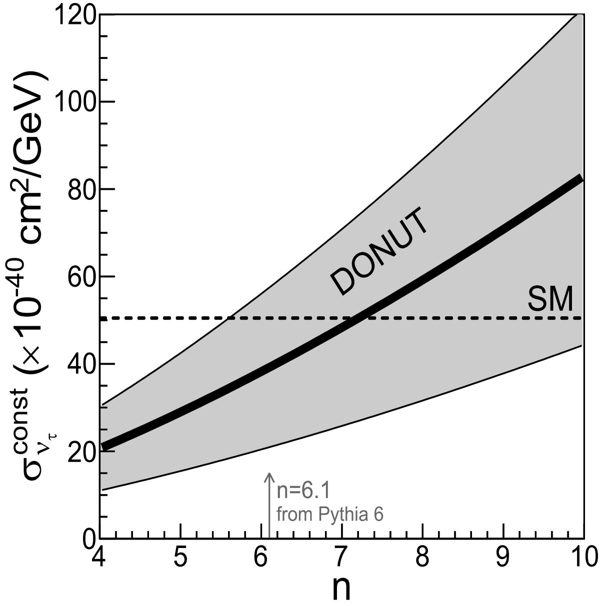


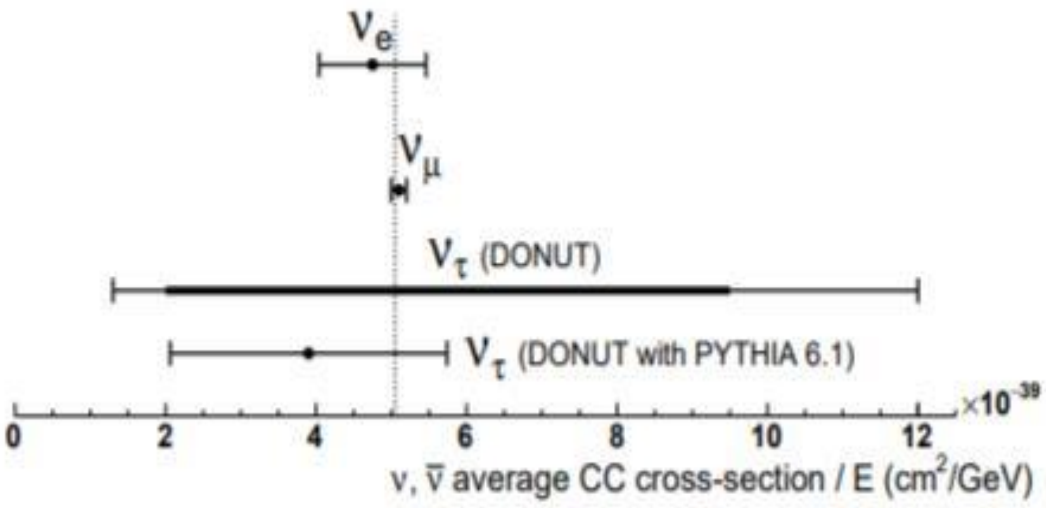
Thank you for your attention!

Acknowledgements: dr. Bogdan Dumitru & DsTau collaboration

Backup slides

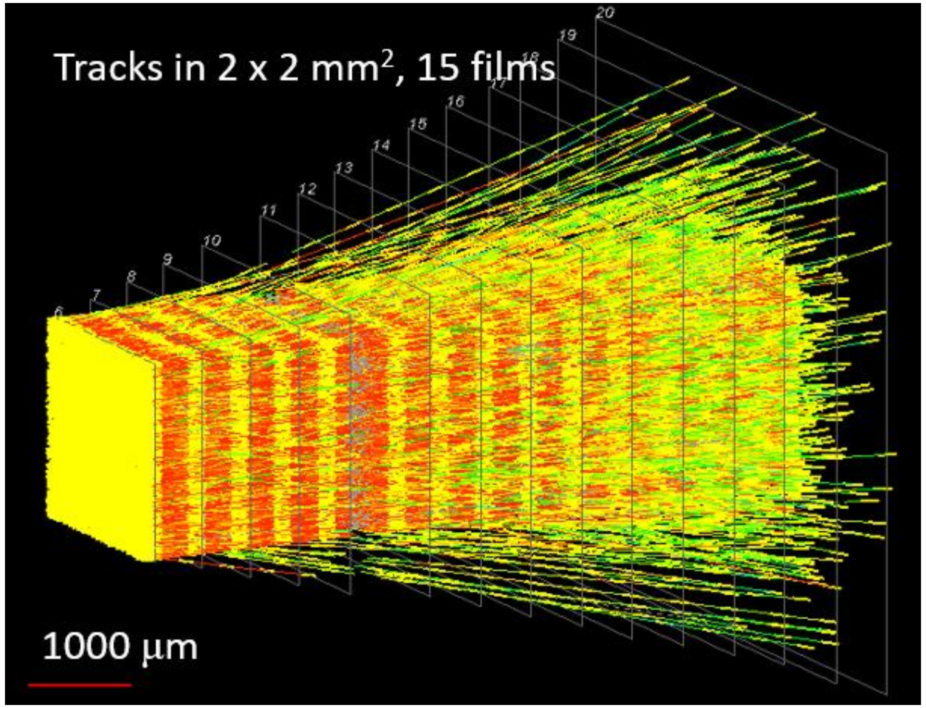


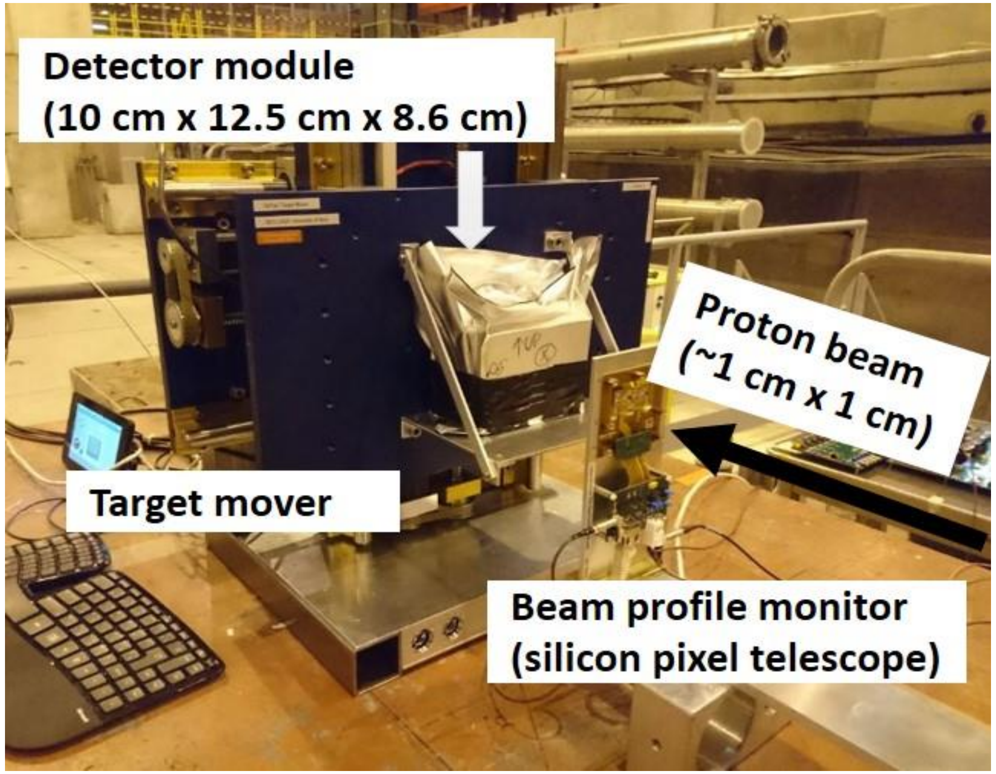




Total cross section for neutrinos interactions

Backup slides





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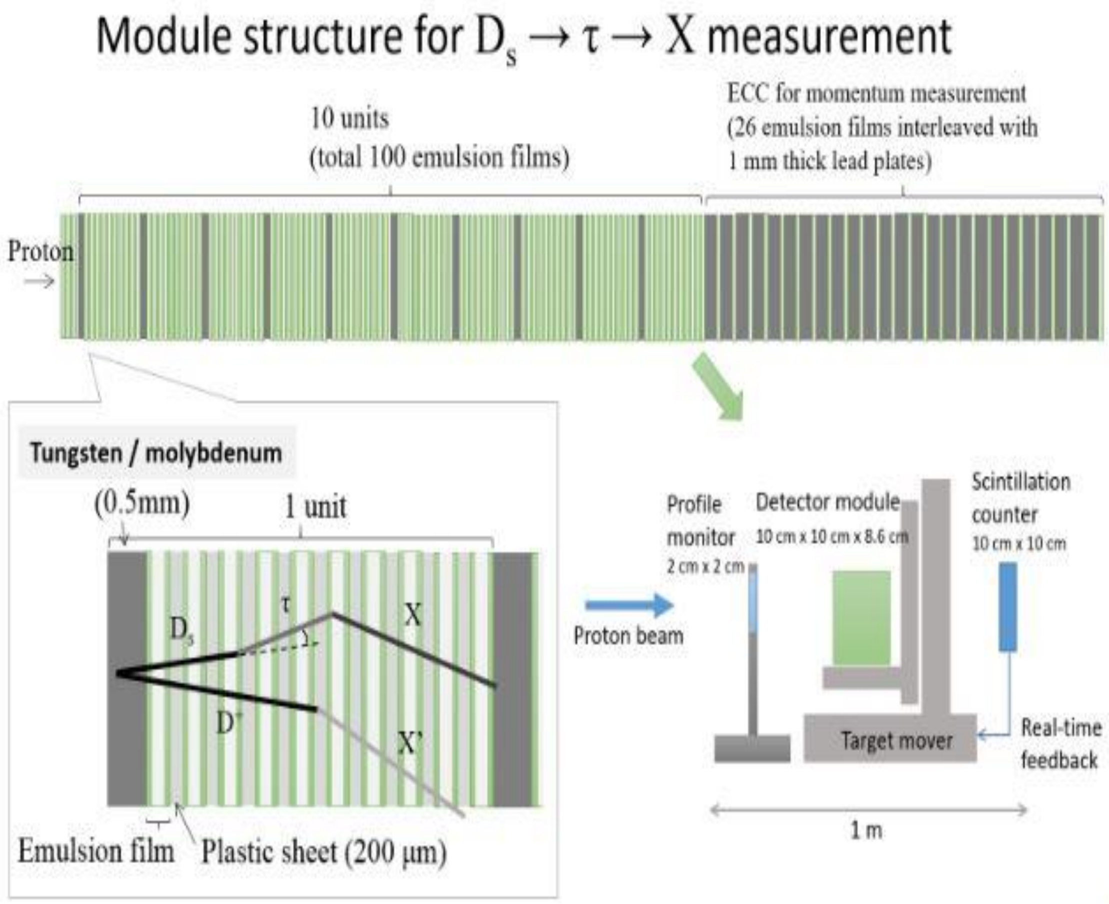

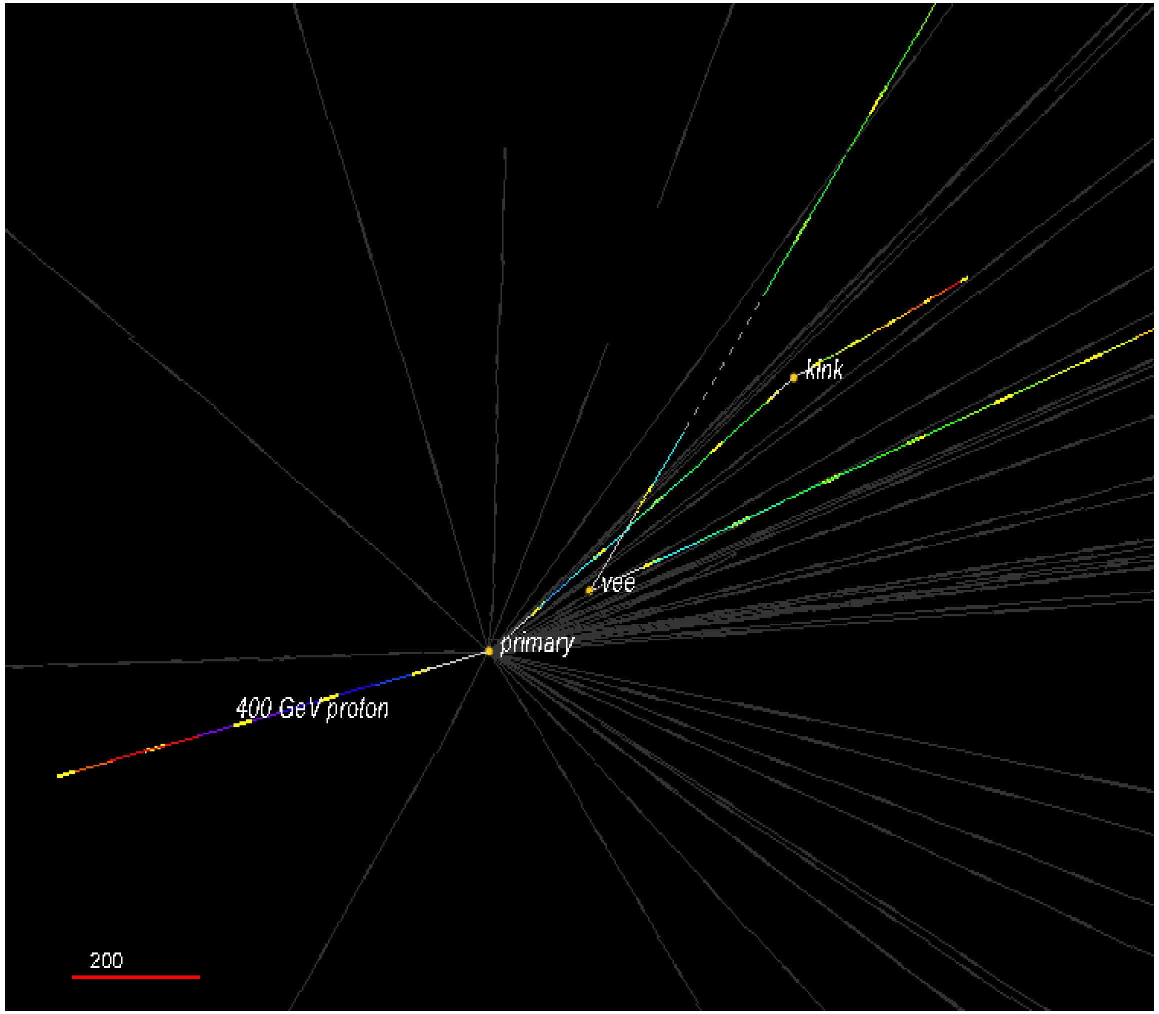

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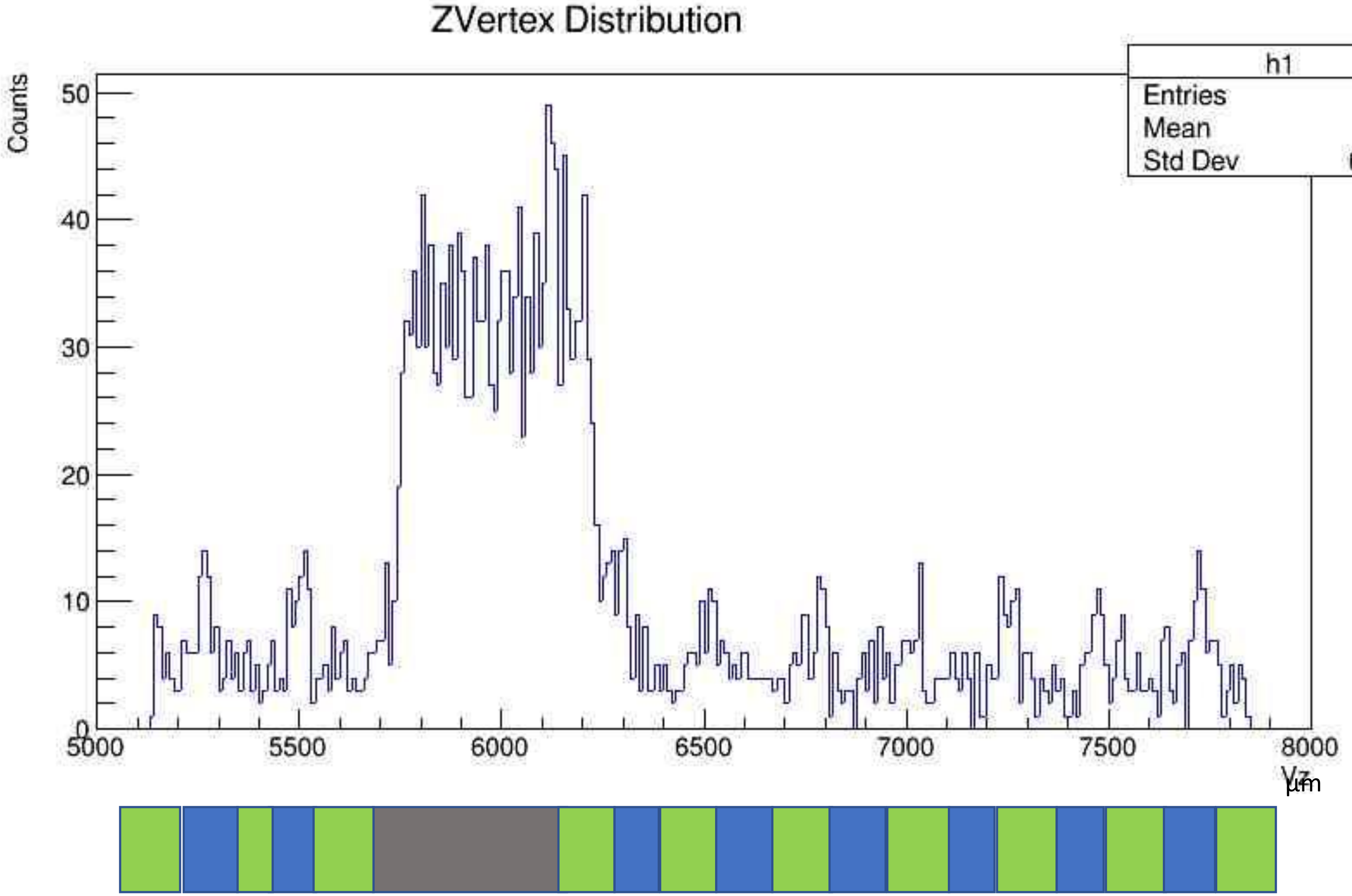

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