Measuring the charm production cross-section

C. Betancourt, A. Buonaura, D. De Simone
Physik Institut, Universität Zürich

MEASURING THE CHARM CROSS-SECTION

What to measure

- Charm production in 400 GeV proton beam on target
- Hadronic cascade effects

Previous experiments

NA27 exp. σ[μb]=18.1±1.7
- p beam :)
- No angle/energy info
- No measures for the cascade

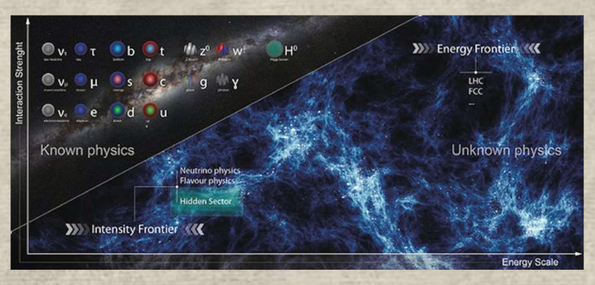
E791 exp.
- Angle/energy info :)
- π beam
- No measures for the cascade

Standard Model and Hidden Sector

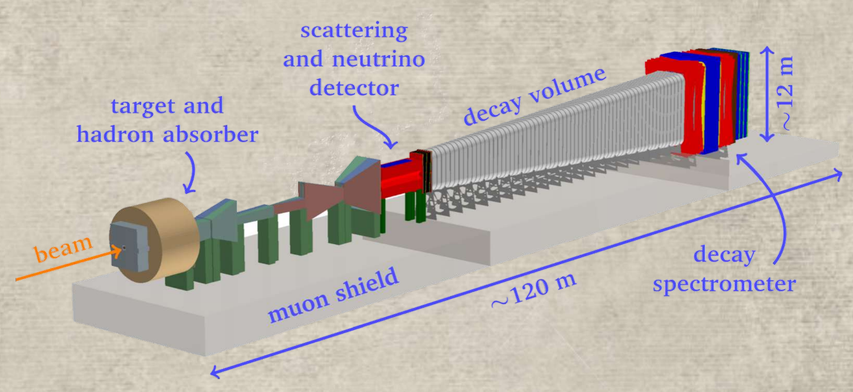
Most validated theory to describe the fundamental constituents of Nature and their interactions.

Problems:

1. Neutrino masses (seen from neutrino oscillations)
2. Matter over antimatter (Baryon asymmetry)
3. Presence of non-baryonic Dark Matter



SHiP: Beam dump experiment proposed at the CERN SPS



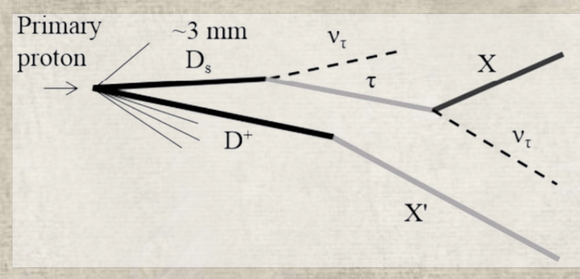
Aims:

- Observation of long lived particles very weakly coupled with matter (Hidden Particles, HP) foreseen by many Beyond SM theories;
- Study of tau neutrino properties;
- First observation of tau anti-neutrino;
- Measurement of tau neutrino cross-section.

Utility of the measurement:

Both Hidden Particles and tau neutrinos produced in the decay of charmed hadrons.

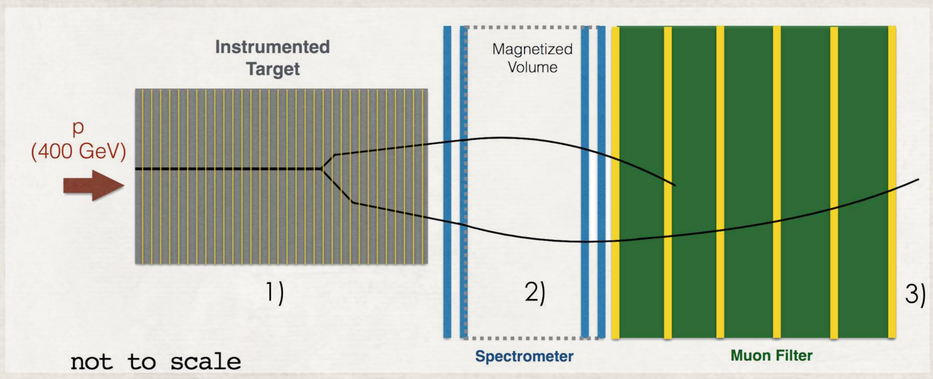
The accurate prediction of charm hard production rate produced by a 400 GeV/c proton beam is fundamental to:
- estabilish the sensitivity of the SHiP experiment;
- make a precise estimation of the tau neutrino flux.



HOW TO MEASURE THE CHARM CROSS-SECTION

The SHiP-Charm Experiment

The experimental apparatus for the charm cross-section measurement



Detector:
1. Instrumented replica of the SHiP target (2λI) Instrumented
2. Magnetic Spectrometer
3. Muon filter

Purposes:
1. Vertexing and tracking
2. Momentum and charge of decay daughters
3. Identify muons

- Data taking foreseen between 2021 and 2022
- $8x10^7$ p.o.t. to integrate

Target instrumentation

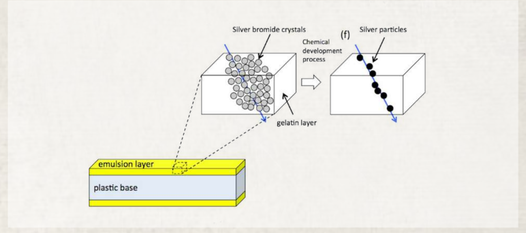
- Use of a replica of the SHiP target with smaller section:
10x10 cm^2
- **Emulsion Cloud Chamber (ECC) technique** employed:
target material sampled with nuclear emulsions

1. Passive material for protons interaction
2. Nuclear emulsion used as micrometric tracking device to identify charm production and decay.

Optimization run

- Performed in July 2018
- Located at H4 beam line of SPS
- $15x10^5$ p.o.t. integrated

Nuclear emulsions and Scanning System



Nuclear emulsions
- 3D tracking detectors;
- AgBr scattered in a gelatine binder;
- Resolution of the order of 1 μm or less in position and of 0,003 rad in angle;
- Passage of charged particles sensities AgBr crystals along the path;
- After exposure, emulsions are developped to allow the growth of silver clusters => visible to optical microscope.

The scanning system

- Emulsion scanning performed by means of a **fully automated optical microscope**
- Series of tomographic images taken moving the focal plane of the objective inside the sensitive emulsion layer and then digitized
- Cluster recognition of emulsion grains
- 3D sequences of aligned clusters (grains) are recognised and used to reconstruct tracks.

Data Analysis

- Application of tracking and vertexing algorithms
- Identification of proton interaction vertices;
- Identification of charm production vertices through the topology of their decay.

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[1] A facility to Search for Hidden Particles (SHiP) at the CERN SPS - SHiP Collaboration (Anelli, M. et al.) arXiv:1504.04956 [physics.ins-det] CERN-SPSC-2015-016, SPSC-P-350
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[4] A. Ereditato, G. De Lellis and K. Niwa, "Nuclear Emulsions", Elementary Particles: Detectors for Particles and Radiation, Springer, 216-241, 2011.