University of Zurich[UZH]
Physik-Institut

Search for the rare decay $\mu^+ \rightarrow e^+ e^- e^+$

CHIPP PhD Winter School 2013

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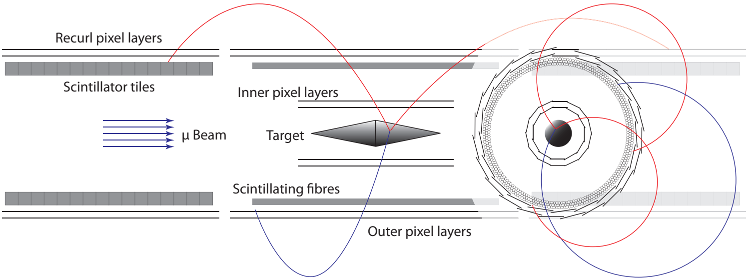
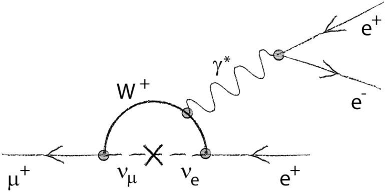


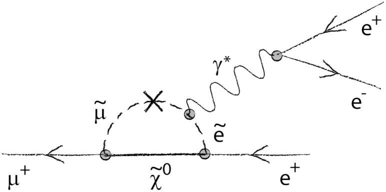
Lepton Flavor Violating Decay

Search for the lepton flavor violating decay $\mu^+ \rightarrow e^+e^-e^+$

- Lepton flavor not conserved
- we know it from neutrino oscillation
- but the charged leptons?



BR < 10^{-50}



if we see something $\Rightarrow$ new physics

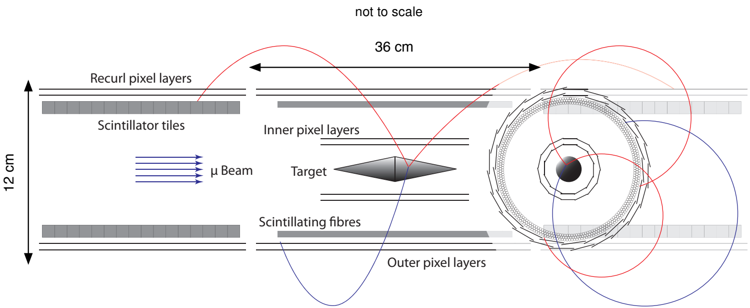
Design Parameters

- aimed sensitivity: B($\mu \rightarrow eee$) $< 10^{-16}$ (first phase: 10^{-15})
- stopped muons per second: $2 \cdot 10^9$ (first phase: $2 \cdot 10^8$)
- main background: $\mu \rightarrow eee\nu_e\nu_\mu$, with B $= 3.4 \cdot 10^{-5}$ and accidentals
- electron energies 0 – 53 MeV

We need:

- high vertex and time resolution ($\sim$ 100 µm, $\sim$ 100 ps): combinatorial background
- precise measurement of momentum ($\ll$ 1 MeV): $\mu \rightarrow eee\nu_e\nu_\mu$ background
- thin detectors ($<$ 50 µm): multiple scattering

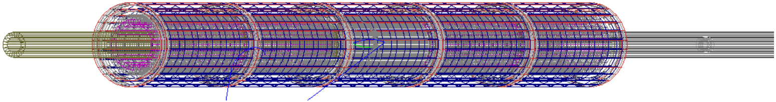
Detector Overview



- homogeneous magnetic field ($\sim$ 1 T)
- Al double cone to stop the muons
- Si pixel tracker
- plastic fibre tracker

Detector Simulation in Geant4

How to optimize detector geometry



existing simulation (Nik Berger):

- complete detector geometry implemented in Geant4
- scintillating fibres as “dead” material only

missing parts:

- scintillating light production and propagation in fibres
- readout

Optical Simulation

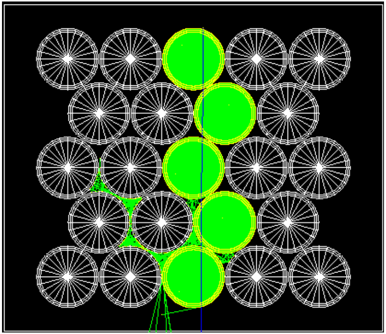
Zürich Contribution

Simulation of:

- scintillating process
- light propagation
- SiPM detection at both ends of fibres

a lot of configuration possible:

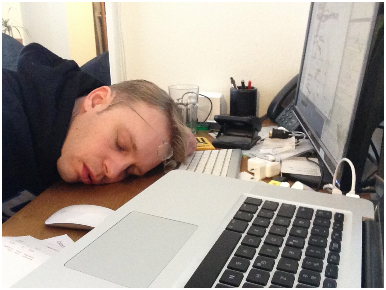
- fibre shape
- roughness
- coating (e.g. TiO)
- stacking



Optical Simulation

Nice, but...

- simulation of individual photon tracks needs a lot of cpu time and memory
- no one is actually interested in the tracks (at least for the main simulation)
  $\Rightarrow$ dedicated fibre simulation



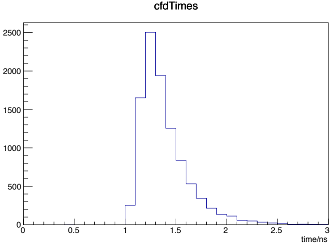
Optical Simulation

Dedicated fibre simulation

many questions can be answered by looking only at the fibres:

- light yield and distribution
- different fibre geometries
- timing (with SiPM signal simulation)
- results can be used in the main simulation with parametrization $\Rightarrow$ i.e. photons at fibre-end vs. energy deposit

round fibre



time resolution $\sim$ 300 ps (center hit)

Optical Simulation

Dedicated fibre simulation

many questions can be answered by looking only at the fibres:

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- different fibre geometries
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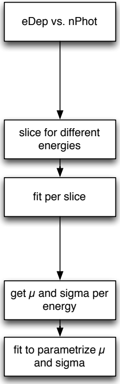
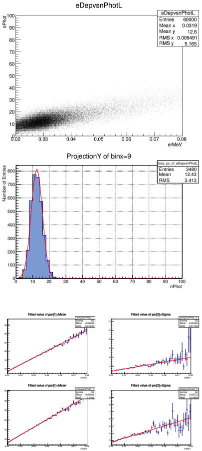
- results can be used in the main simulation with parametrization ⇒ i.e. photons at fibre-end vs. energy deposit





Outlook

Test setup to crosscheck the simulation