Muon Detectors

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Why muons?

… also punch-through monitoring

Muons can come from the primary collision in (prompt) pairs : μ+μ-
from a very short-lived heavy flavour (Q = charm or bottom) hadron
from π or K decay. Lifetimes very long
from upstream interactions in pipe, materials

Muons : from primary collision:
>> Drell-Yan pairs: q-qbar annihliation. $M^2/s = x_1.x_2$ say ~ $(2/13{,}000)^2 = 2.36 \times 10^{-8}$
x_1 large (only q) drives x_2 (qbar) very small. u-ubar >> d-dbar (x16 if pdf's same)
Probe of very low-x sea quarks.
>> Photoproduced J/ψ, ψ(2S), $\Upsilon_{1,2,3}$ (γ + pomeron → X). Different regime cf HERA
>> γγ → μ+μ- (especially in AA)
Some acceptance for measuring both! What is it?
==========
gg → χc → J/ψ + γ → μ+μ-γ (with γ measurement in EM calorimeter)
Handle on very low-x gluons.
Almost prompt, from c, b decays. Note BR (D0 → μ+X) = 6.7%
Background from π, K etc decays. γcτ(π) at 2.8 TeV = 150 km, . γcτ(K+) = 70 km
(But there are many to start with!) , and π/K spectra measured.
Precision tracking before TRDs, calorimeter, helps eliminate upstream interactions

Muon Measurement behind calorimeter

Area to cover same as calorimeter ~ 20 cm x 30 cm, can take length 1m if wanted.
Do not need high precision (scattering upstream), p comes from front tracking.
Muon dE/dx at 1 TeV is ~ 4 GeV/m of tungsten, rising slowly with p. (Calo range)

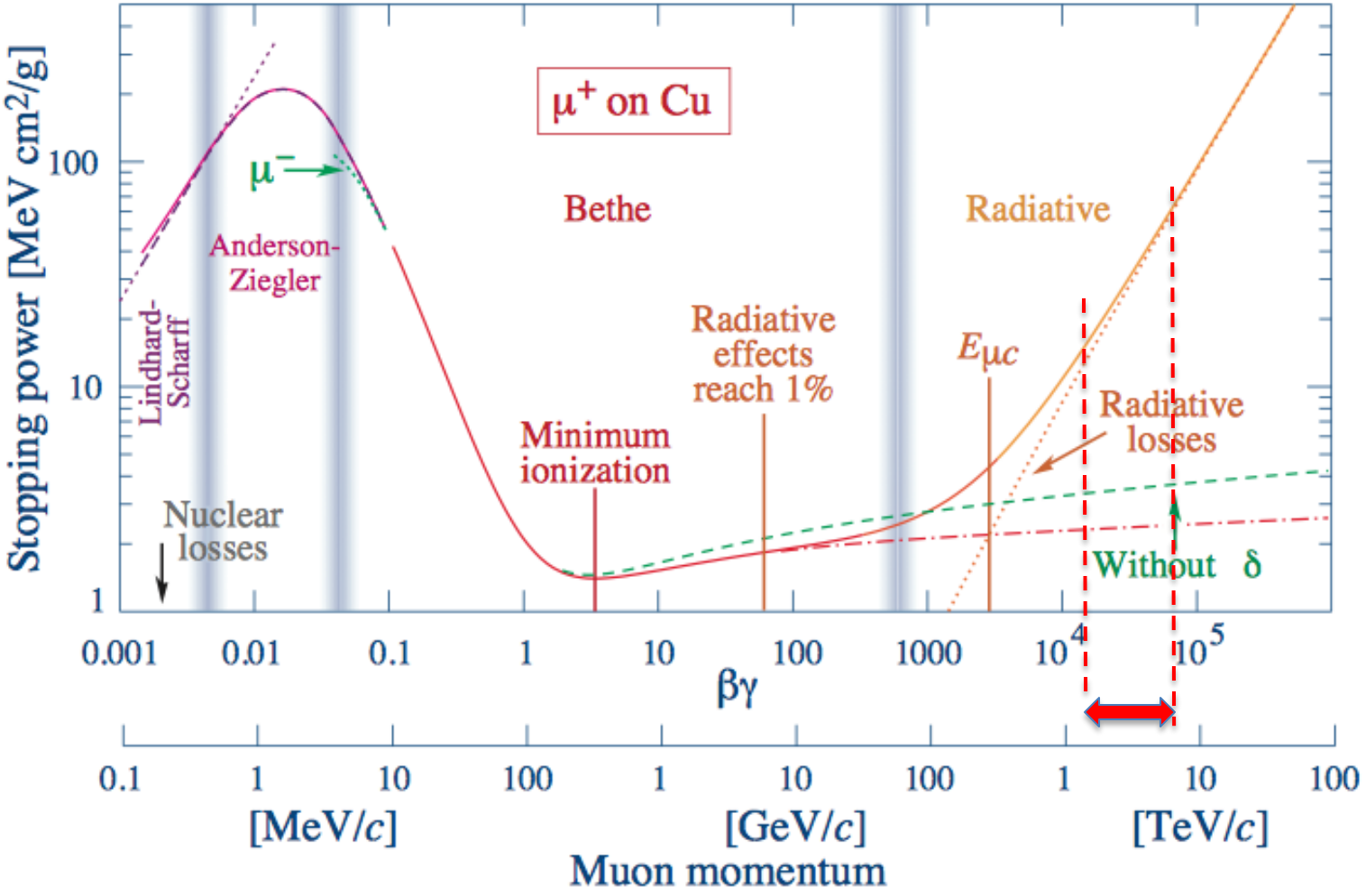
Want trigger capability. Some x vs p correlation so trigger fn(x) may be useful.

Many possible techniques. Radiation relatively low (well shielded both directions)
Scintillating bars or fibers, wire chambers of many types. 3-views u,v,x or x,y,u preferred.
Could use any of several technologies, used by much larger central systems.
CMS has Cathode Strip Chambers, upgrade plans Triple-GEMS

This “real estate” between calorimeter and TAN could allow real-life LHC experience of
Interesting new designs “parasitically” behind a simple but adequate muon detector.

From PDG : passage of particles through matter.

In range of increasing energy loss



Muon tracking behind calorimeter

High-tech example (overkill) :
Abusleme et al (ATLAS) http://arxiv.org/abs/1509.06329

Full-Size Small-Strip Thin Gap Chamber
ATLAS New Small Wheel Muon Upgrade

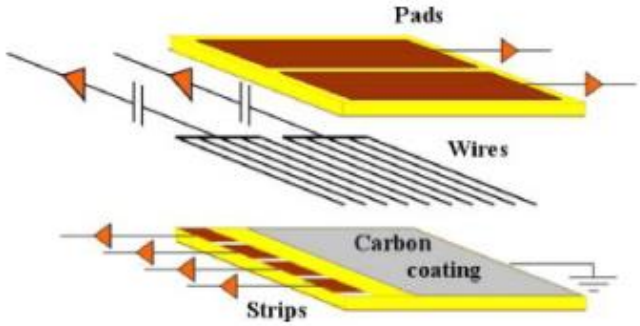
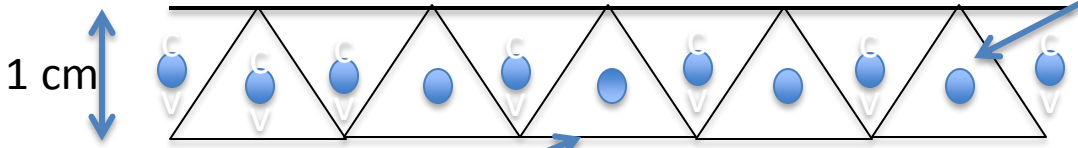


Figure 2: Schematic diagram of the basic sTGC structure.

Prototype tested about 1 m^2, real thing in ATLAS upgrade orders of magnitude larger.
High luminosity capability, 50 µm resolution. Not needed, reduce channel count.

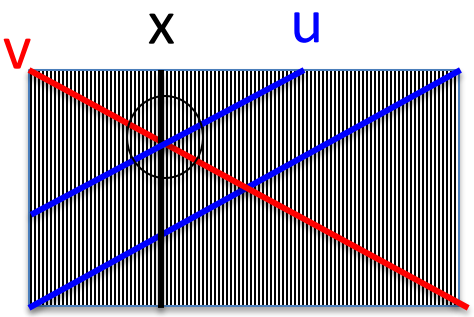
Lower tech, scintillator hodoscope

Scintillator hodoscope arrangement



Wavelength-shifting fibers ~ 2mm
SiPM readout each end

Scintillator bars ("Toblerone")
solid (extruded) or liquid in Al matix



H = 20 cm

W =28.3 cm = √2 x H

E.g. 3 planes in u,v,x orientation. At 60° {x+u+v} = K
Check sum, maybe be useful for fast trigger)