

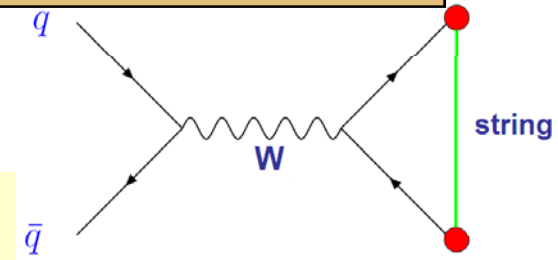
# New Exotica Scenario for the LHC: Quirks

A. De Roeck  
CERN

Quirks are exotic vector-like fermions that transform as a fundamental under a hidden confining group, but also carry Standard Model charges.

The quirk mass  $M$  is much larger than the confinement scale  $\Lambda$ .

⇒ Macroscopic strings!?!



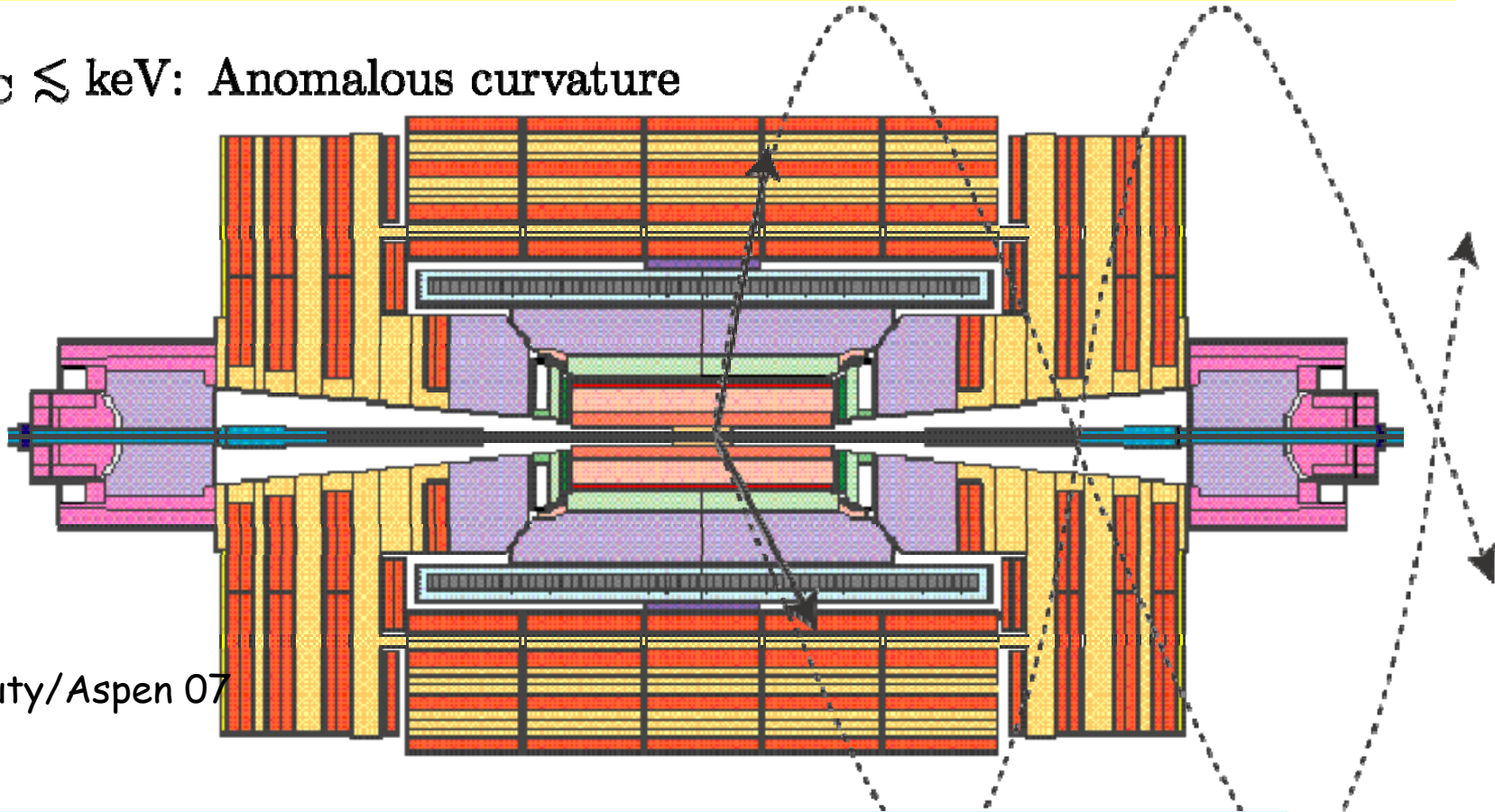
## • Signatures Catalogue

- Quirks with strange curvature in the B-field of the detectors
- Quirks emitting many soft photons
- Quirks emitting many soft hadrons
- Quirks emitting glueballs
- Quirks losing energy in the detector (like R-Hardons?)
- Quirks causing displaced vertices
- Quirk pairs causing unusual ionization.
- Timing of the signals?

# Macro-Strings at the LHC?

New strong interactions with small  $\Lambda$  & new quarks  $m_Q \gg$  several hundred GeV

$\Lambda_{IC} \lesssim \text{keV}$ : Anomalous curvature



Markus Luty/Aspen 07

- Strings do not break up  $\Rightarrow$  Stringy objects in the detector.
- End points are massive quarks (quirks)
- The strings can oscillate  $\Rightarrow$  strange signature in detectors

# Proposal

- Quirks move 'connected' through the magnetic field. Weird signatures.
- **Can G4 be made to deal with such a case?**
- If yes: Markus Luty (UC-Davis) interested in collaborating with 2 graduate students
- More details in
  - **Macroscopic Strings and 'Quirks' at Colliders.** [Junhai Kang](#), [Markus A. Luty](#) .  
**arXiv:0805.4642**



Backup

# Quirk Signatures

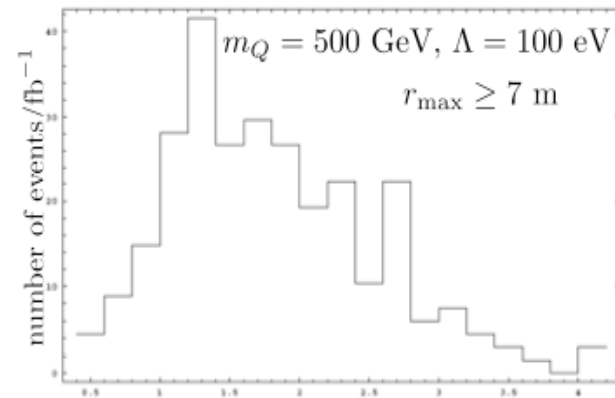
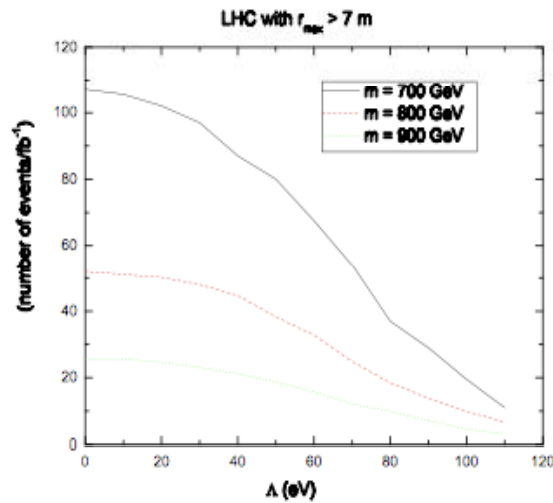
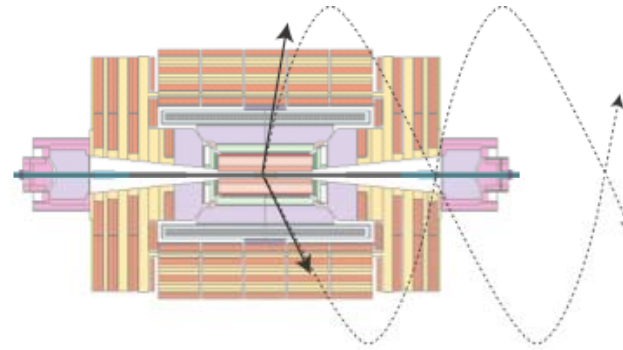
Particles remain connected with a 'string'  
 $\Rightarrow$  Strange curvature in the detector

M. Luty

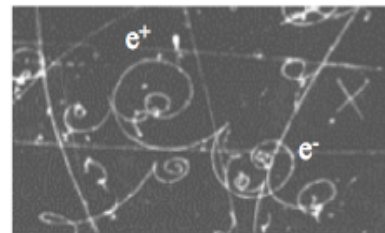
$$r_{\max} \sim \frac{m}{\Lambda^2} \gtrsim \text{meters}$$

$$(\Lambda \lesssim \text{keV})$$

$\Rightarrow$



Ionization = muon-like  
 Anomalous curved track  
 Triggering?



Particles remain connected with a short 'string'  
 $\Rightarrow$  Bound state moves through the detector

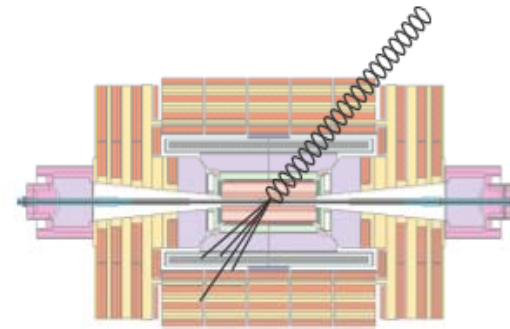
M. Luty

$$\text{\AA} \ll r_{\text{max}} \ll \text{mm}$$

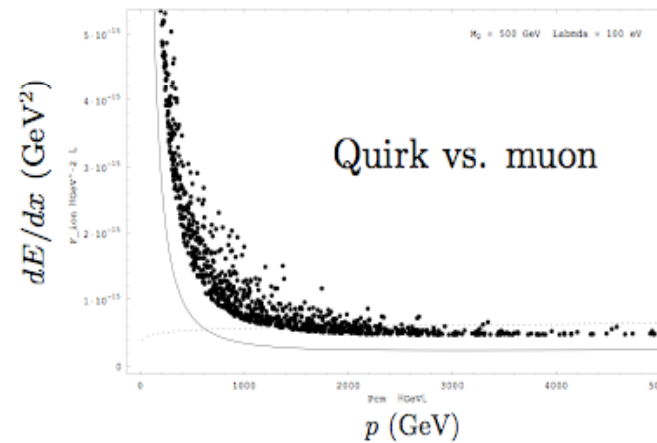
$$(10 \text{ keV} \ll \Lambda \ll 100 \text{ MeV})$$

$\Rightarrow$  "mesoscopic" bound state

$c\tau \gtrsim 10 \text{ m}$  possible



Anomalous ionization



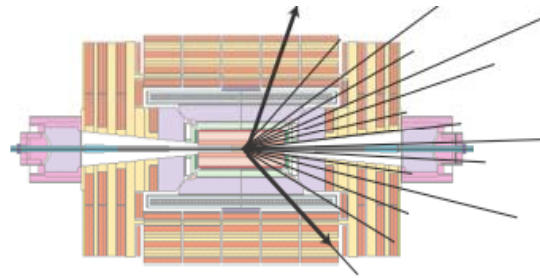
Invariant mass varies event by event!

Timing?

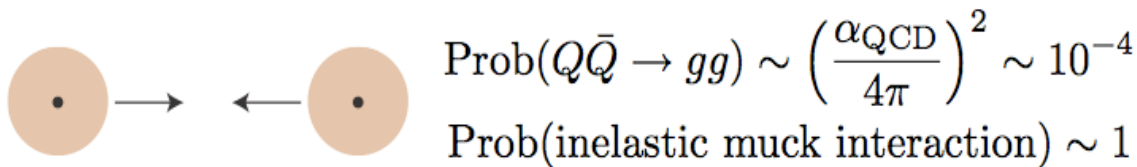


Particles yoyo around and loose energy  
 $\Rightarrow$  emission of many soft hadrons, photons, and possible glueballs

$100 \text{ MeV} \lesssim \Lambda \lesssim \text{GeV}$   
 Hadronic fireball + hard jets  
 (colorful quirks)



M. Luty



Quirks lose energy, angular momentum  $\Rightarrow$  re-annihilation

$$E_{\text{fireball}} \sim E_{\text{jet}} \sim m_Q \sim \text{TeV}$$

$$\text{GeV} \lesssim \Lambda \lesssim 100 \text{ GeV}$$

$\Rightarrow$  new strong interactions important

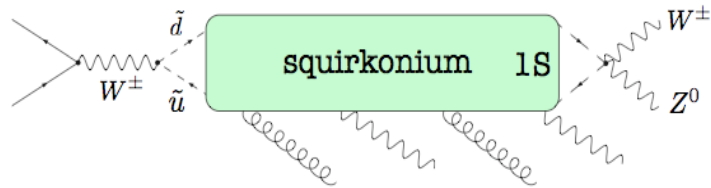
$$E_{\text{fireball}} + E_{\text{missing}} \sim \text{TeV} \quad \text{Prob}(\text{hard jets}) \ll 1$$

Can we see this?

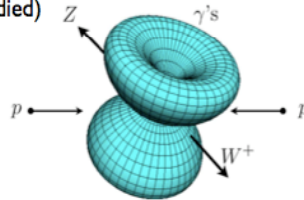
All these signatures  
 are challenging  
 for the experiments  
 starting with the  
 trigger

# Quirks shower photons

$\Lambda \sim 5 - 10 \text{ GeV}$  , uncolored Quirks (Folded SUSY - hep-ph/0609162)



- \* Annihilation occurs near the ground state: Expect a peak in the WZ invariant mass  $\sim m_{1S}$ .
- \* Background from SM continuum WZ events. Cuts on angular distributions? (to be studied)
- \* Additional antenna photons may be useful to reduce backgrounds.



Photon Shower:  $\Lambda \sim 5 - 10 \text{ GeV}$ ,  $\omega \sim 0.1 - 1 \text{ GeV}$

- \* Soft photons initiate mini-EM showers
- \* Material budget: About 10% of photons convert in the tracking system. About 50% of energy reaches Ecal.

- \* Many soft tracks and hits w/o Ecal towers.
- \* What's the observable? Perhaps occupancy of hits in the eta-phi plane.
- \* What information is kept?
- \* Can we flag this event?

Cheu and Parnell-Lampen

