

Some Little-Known
Discovery Opportunities
for
2010

Matthew Strassler

Rutgers University

Informal comments!!

(special thank you to M. Cacciari, G. Salam)

The Fast Start

LHC detector startup is much faster than expected!

We could, if there were any signals to see, look for them already!

Can there be any? How much data do we need?

Naïve Logic:

- Tevatron \rightarrow LHC gg,qg parton luminosities increase of order 30
- Need $5000/30 \sim 100 - 200$ inv pb to match Tevatron

Loopholes:

- Heavy objects, ratio of LHC/TeV $\gg 30$
- Some physics effects grow very rapidly with energy
 - Compositeness and other strong coupling effects
- There are things the Tevatron experiments
 - Can't do as well or at all
 - Or haven't done in years or ever
- Trigger thresholds very low now (e.g. ISR trigger still efficient)

Opportunities at High H_T : Di-lepton/Di-photon Resonances

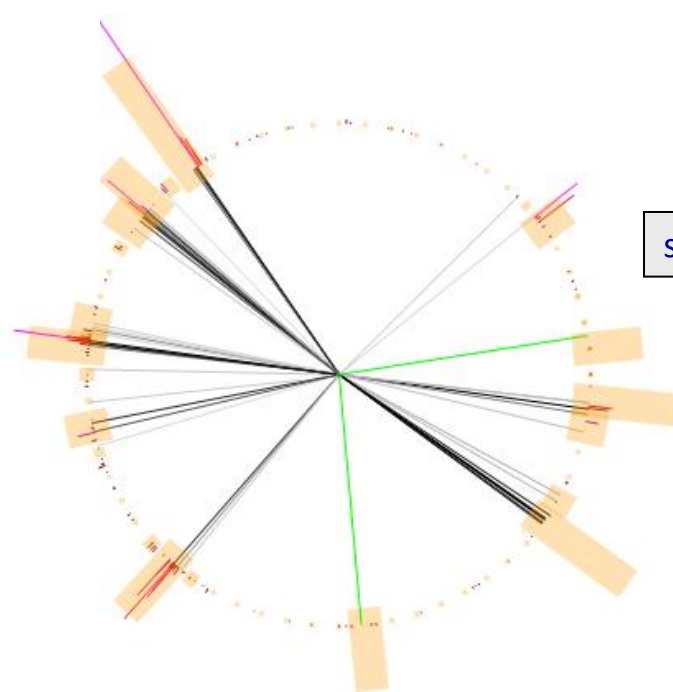
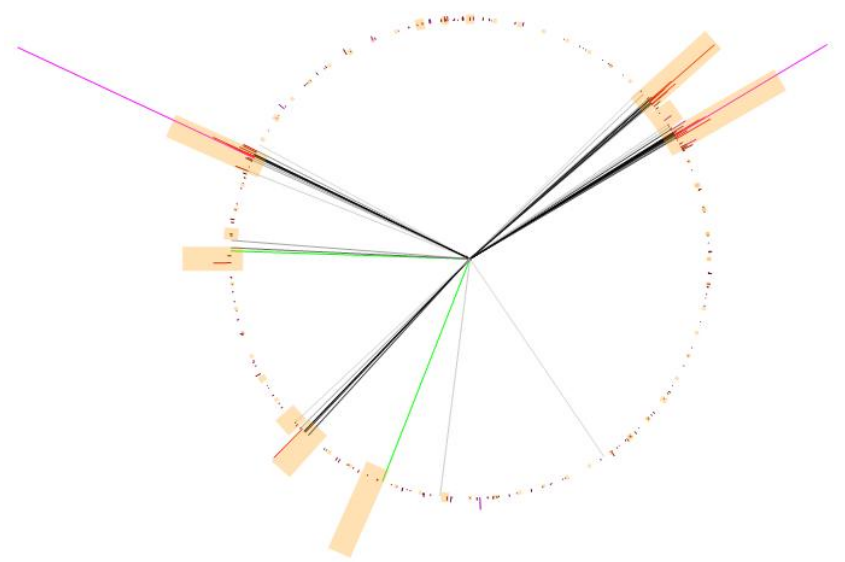
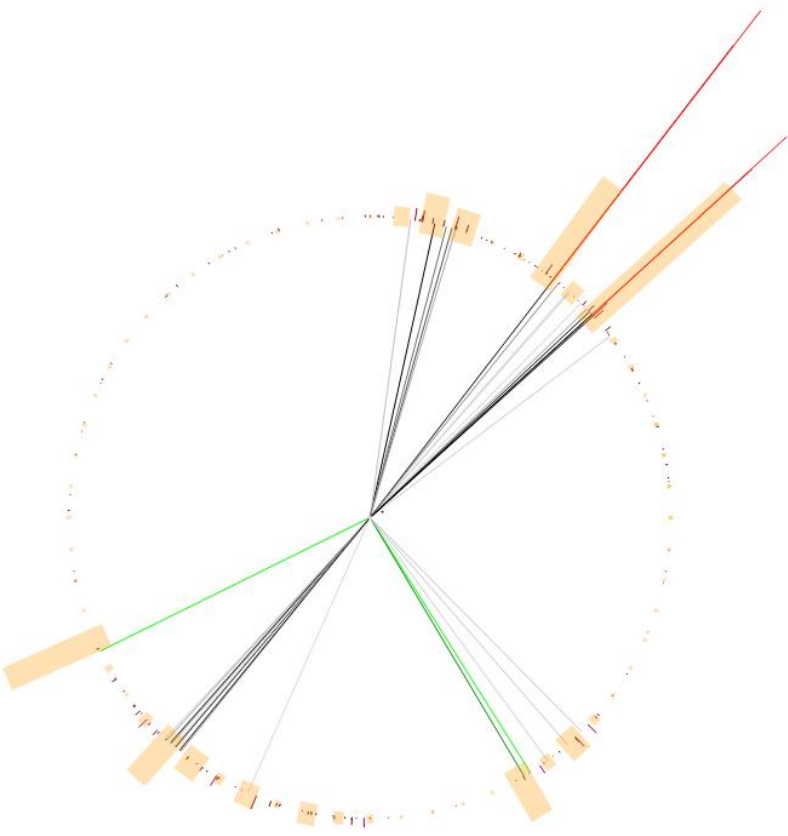
Yes, Z' \rightarrow dileptons above 1 – 3 TeV

- What about dilepton resonances at [MJS&Zurek 06; Han, Si, Zurek, MJS 08]
 - 300 GeV? 30 GeV? 3 GeV?
 - 0.3 GeV? [see Arkani-Hamed and Weiner 08 \rightarrow lepton-jet studies]
- Ruled out?! Not if weakly coupled!
 - Low direct production \rightarrow swamped by Drell-Yan in inclusive sample
 - Produced indirectly: **decays of rare new heavy particles**

So – in dilepton sample, plot dilepton mass **only after** selecting events with

- high- H_T , or
- >4 jets with high p_T , or
- Dilepton $p_T > 200$ GeV, or
- Etc.,etc.,etc...

Also true for diphotons.



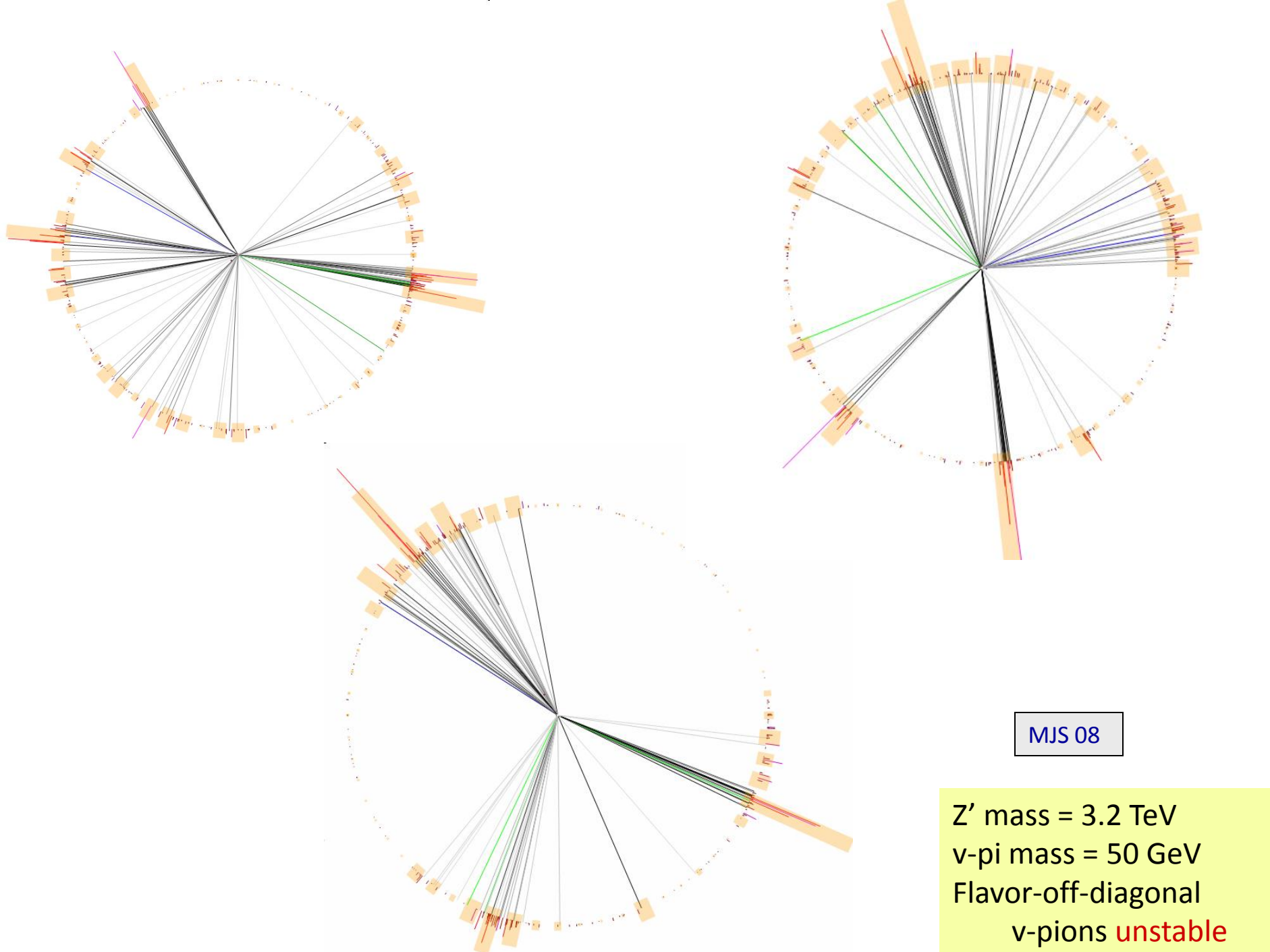
see Han, Si, Zurek & MJS 08

Opportunities at High H_T : Jets

- Dijets (resonances, rising cross-sections, etc)
- Trijet/Dijet ratios, angular distributions (sensitive to $\text{tr } G^3$ operator)
- Many (> 6) jets with substantial p_T (say, 50 GeV)
 - QCD in an unfamiliar and essentially uncalculable regime
 - Could also have new particles decaying dominantly
- Possible approaches [Needs QCD-theory Input]
 - Pick an H_T range
 - Plot distribution of # jets
 - Plot distribution of Event Shape [Banfi,Salam,Zanderighi]
 - Repeat for many H_T ranges
 - SCALE THE p_T CUTS!!! (for example, jet $p_T > H_T/10$)
 - Study changes in distributions as H_T increases

Opportunities at High H_T : SCALING in Jets

- Why use scaled cuts? Naïve argument [needs study!]
 - QCD is a largely scale-invariant theory
 - Except top
 - Therefore changes as function of H_T should come from top
 - And top contribution can be measured from leptonic decays
- Any other changes
 - Will be interesting and important for QCD-theorists to explain
 - Argument might be too naïve – but that's interesting!
 - Might be signs of new phenomena
 - Data in deviating bins might contain clear signs of new physics
 - For example, many b tags, or unusual jet substructure...



MJS 08

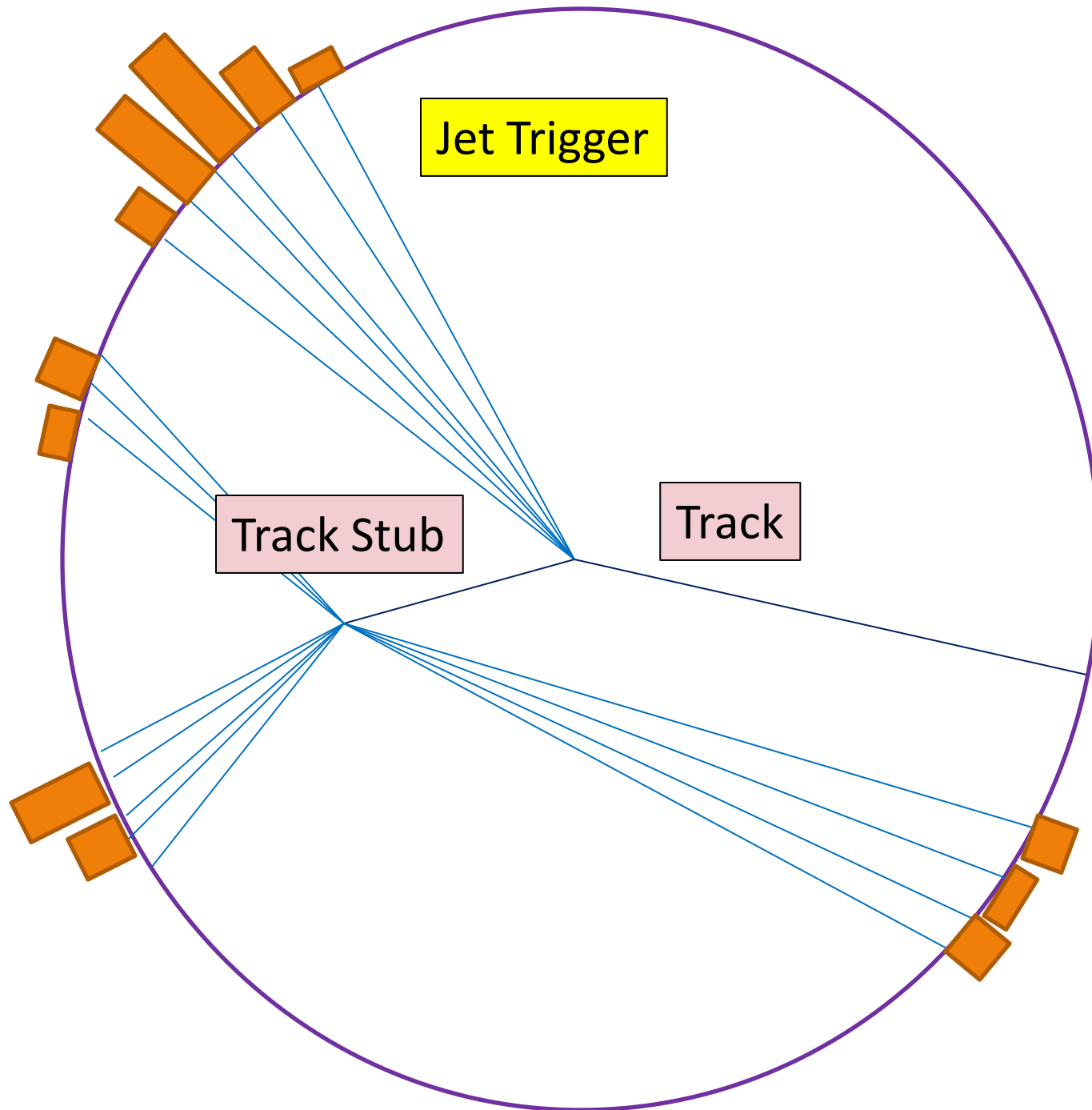
Z' mass = 3.2 TeV
 ν - π mass = 50 GeV
Flavor-off-diagonal
 ν - π s **unstable**

Opportunities in Exotics: Exotic Tracks

- Several Tevatron searches for long-lived stable charged or colored particles
 - All Run II searches use muon trigger
 - But colored hadrons, decaying particles rarely reach muon system
 - Colored decaying hadrons (e.g. unstable gluinos) little constrained
- Objects with unusual-shaped tracks may not be reconstructed often
- Mesoscopic dipole → straight track with high dE/dx
- Search looking for high- p_T anomalous- dE/dx track ?
 - Most Recent: Run I, CDF, 90 inverse pb [thanks P. Mermod for pointing it out]
 - Trigger: muon candidate OR MET35
 - Simply repeating this search is worth doing NOW!

Phys.Rev.Lett.90:131801,2003

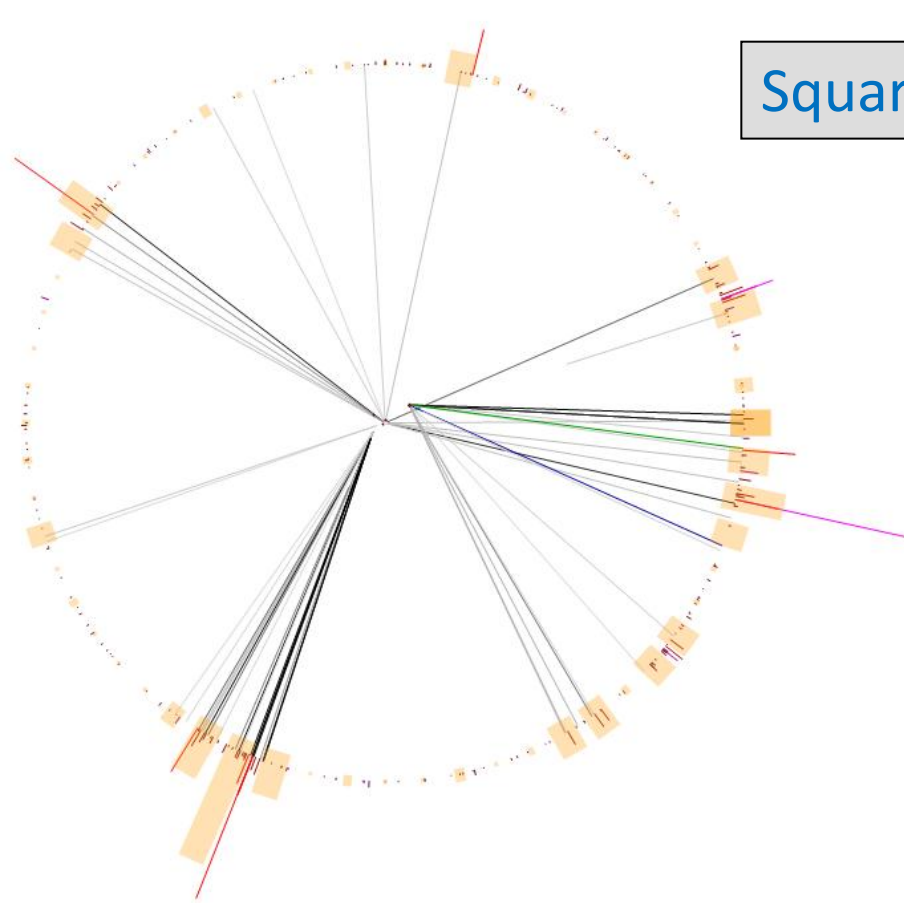
Two track stubs?
Track stub plus vertex?



Opportunities in Exotics: Highly Displaced Vertices

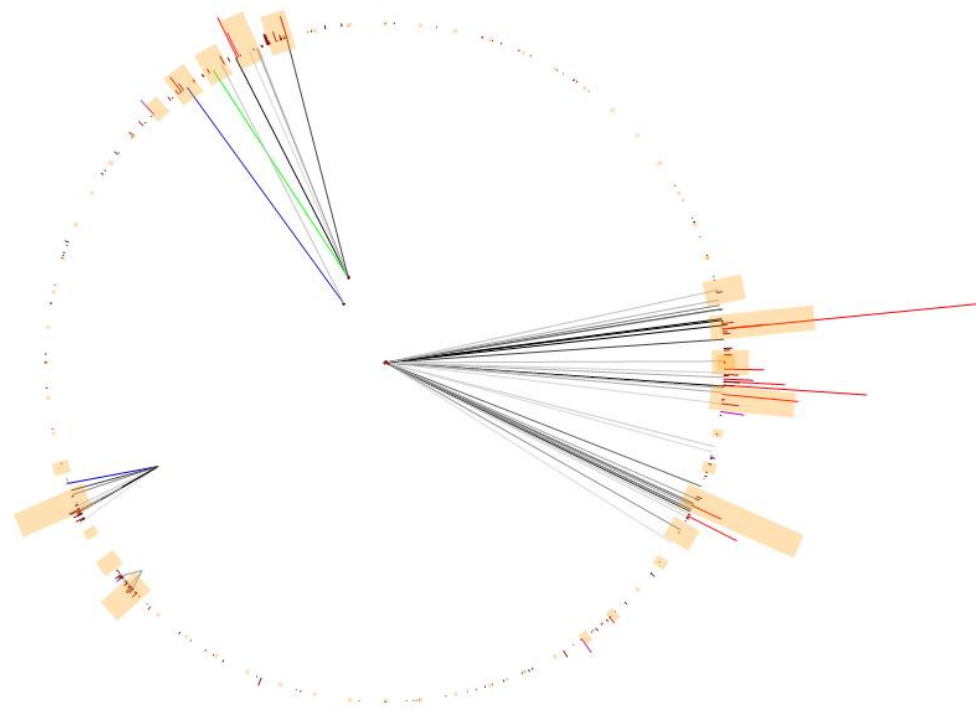
- Long-lived (neutral or charged, colored or not) particles may decay in flight
 - Tevatron searched for displaced leptons, photons
 - But commonly, **dominant decay is to jets**
- Only Tevatron search for long-lived particle decaying to jets: D0 3.6 inv fb
 - Requires **2 vertices in 1.5 – 20 cm range** Phys.Rev.Lett.103:071801,2009
 - Soft muon trigger (muon in jet near vertex)
- **Many** other searches are possible!
 - Use: Tracking (outside-in? muon-system?), Timing, Pointing, ???
- Good opportunity to study backgrounds to future searches.
- Note: Trigger will be an issue someday – but not yet!

Squark-Antisquark Production at LHC



Long-Lived Neutralino
Prompt ν -Hadron Decay

Prompt Neutralino Decay
Long-Lived ν -Hadrons



Hacked simulation using Hidden
Valley Monte Carlo 1.0
Mrenna, Skands and MJS

Conclusion: 2010 is a special year

- Opportunities for non-standard discoveries with 3 – 30 inverse pb
 - Light dilepton/diphoton resonances (maybe easy)
 - Events with many jets (tough but very interesting)
 - Unusual tracks with high dE/dx (perhaps rather easy)
 - Long-lived particles with highly displaced vertices
 - Many possible searches, almost all new (very tough, but original)
- **Urgency: Right now trigger thresholds are low! Don't wait!!!**
 - There is still time to change your trigger table if you see a hint...
- Motivation for Experimentalists:
 - Room for considerable experimental creativity and ingenuity
 - At worst, will help understanding of backgrounds for future searches
 - Might make extraordinary discovery!!

p.s. Need a Model or Monte Carlo? Talk to me...