Strange jet tagging in SiD

Alexander Albert, Chester Mantel, Jan Strube

Motivation

- We currently have b- and c-jet tagging (LCFIplus)
  - This is relevant for the dominant quark decays of the Higgs boson, bb and cc
  - There is **no** gluon tagging. We assume gluons / strange BR is SM-like
- Adding strange jet tagging would allow us to test this directly
- H --> ss is extremely small in the SM (~10^{-4})
- Is strange tagging useful?
  - Some new physics scenarios enhance the rate (https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.123.031802, https://inspirehep.net/literature/1751956)
  - H --> bs would be an extremely interesting discovery. Maybe the H has a flavor component?

Research question

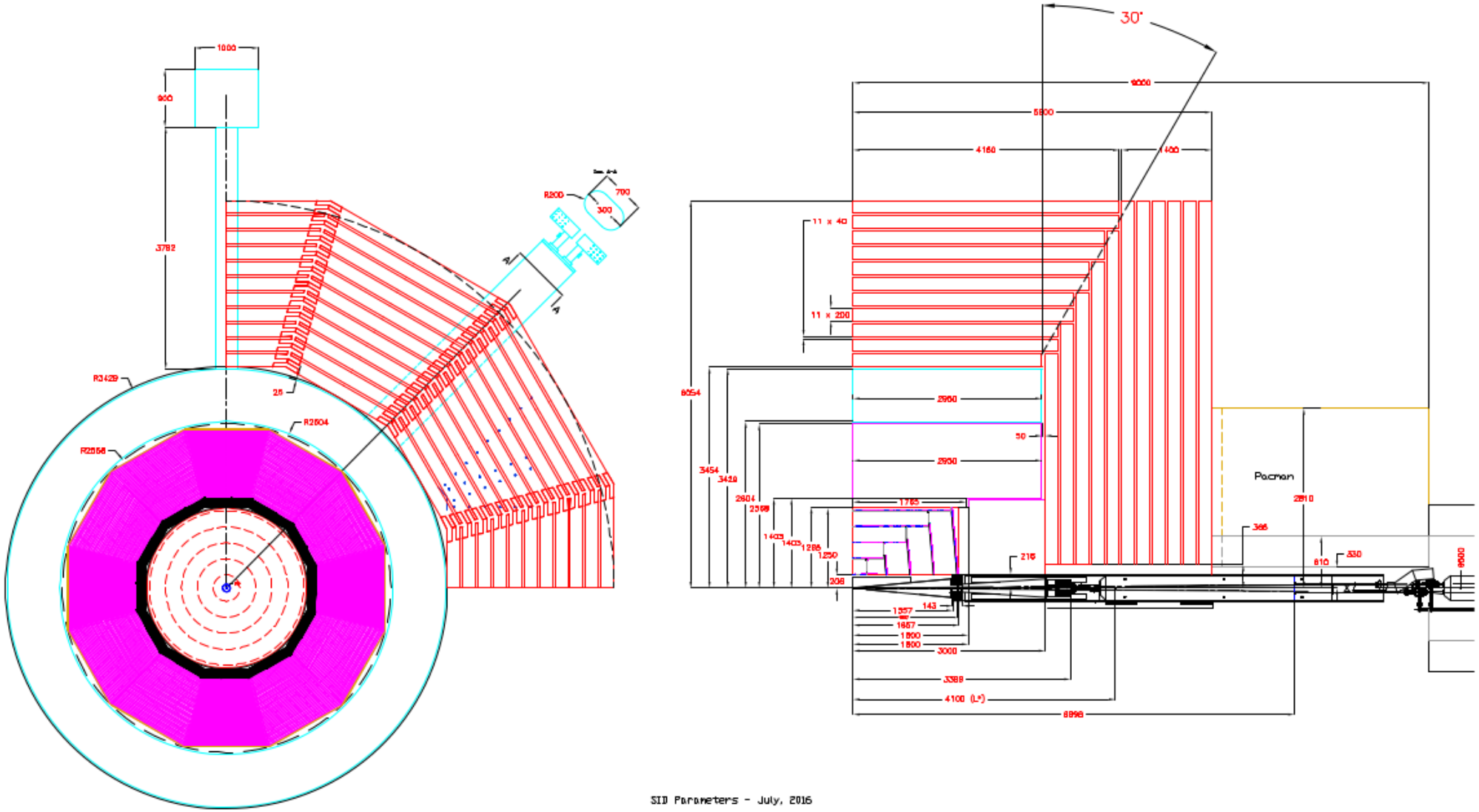
- Can we tag strange jets in SiD?
  - Weak decays of strange quarks are extremely long lived: K0_s, K0_l, Lambda0
    - Those decays need excellent tracking and a special vtx finder
  - Focus on particle ID of charged Kaons instead
    - Could use dE/dx in the silicon
    - We're trying time of flight to layer 0 in the ECAL
- Layer 0 in the ECAL has no absorber in front of it. We can make it as thick and as fast as we want without sacrificing momentum resolution.
  - Unfortunately, it's only 1.25m out. Is that good enough to measure time of flight in 250 GeV collisions?

Experimental setup

- Start with four samples: H->bb, H->cc, H->gg, H->ss
  - H->ss needed a fix to Whizard to enable the matrix element. Now in v2.84
  - The three background samples are the ones that include strange quarks and have no kinematic constraints to remove them (like ZZ or WW)
- Processed through dd4hep and MarlinReco
  - Some modifications were necessary. Probably buggy.
- Processed on DESY NAF
  - Allows interactive access through jupyterhub

Data Samples

- ZH --> (mm XX)
  - Let's start simple. We need to get a feeling for the analysis first.
- Find the two muons from the Z and remove them
  - --> Chester's analysis
- Force the rest of the event into two jets
  - Overkill for this signature, but then we have everything in place to look at Z --> jj as well
- Look at the composition of the jets
  - How many events have a jet with one strange hadron? How many have two?
- Try to identify charged Kaons to tag those jets
  - --> Alex's analysis



Reminder: ECAL Layer0 has no absorber in front

Reconstructed Particle content

We are using the OPAL tune that has been used in all large-scale productions of ILC and CLIC samples. To the right is a breakdown of reconstructed particle types.

Category	ss	bb	cc	gg
neutral hadrons	0.217	0.140	0.166	0.161
photons	0.261	0.287	0.285	0.288
charged hadrons	0.505	0.509	0.516	0.531
leptons	0.011	0.059	0.0278	0.017

For comparison, this is a breakdown of the MCParticle content of the jets, by energy.

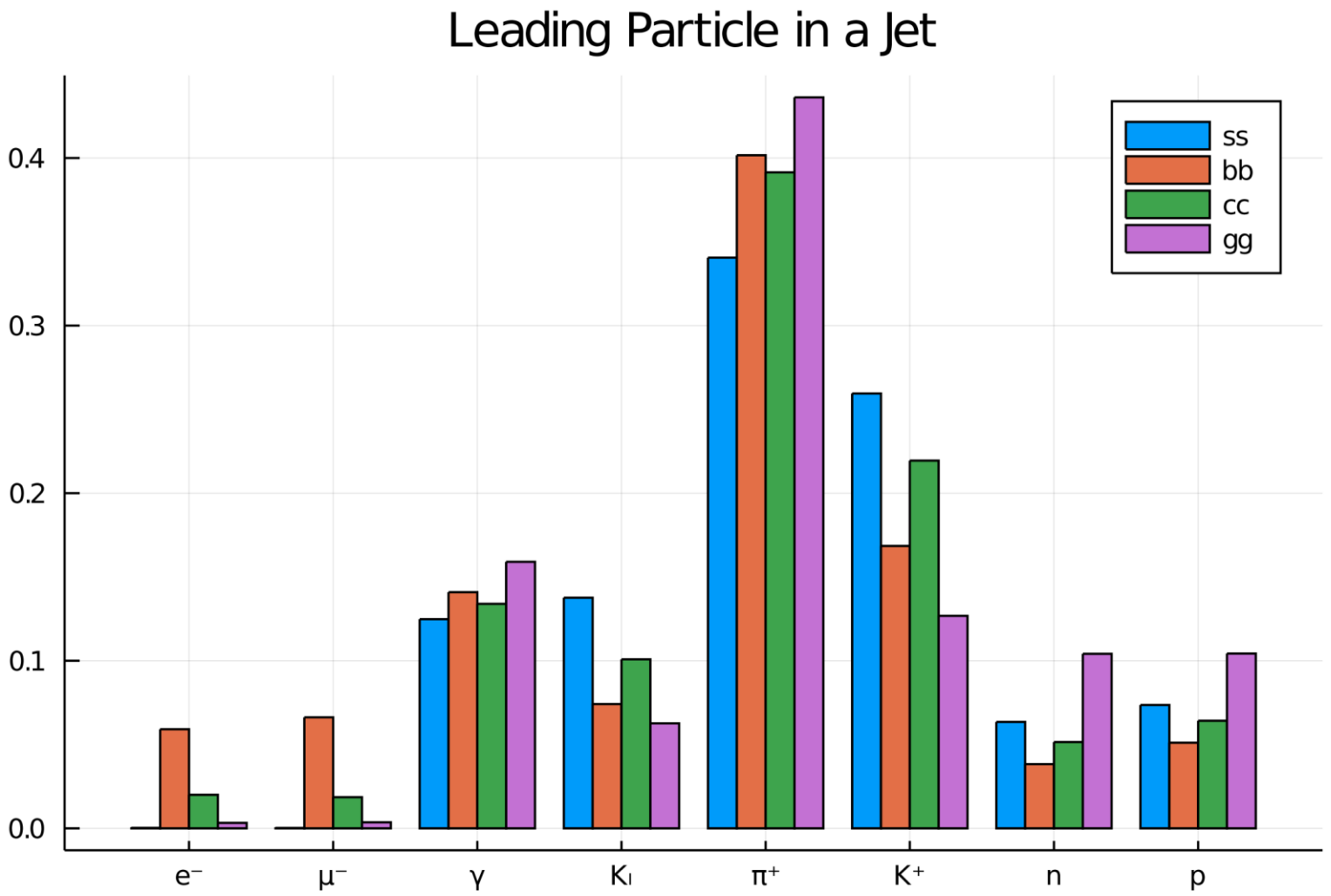
Category	ss	bb	cc	gg
neutral hadrons	0.132	0.079	0.100	0.104
photons	0.243	0.274	0.268	0.279
charged hadrons	0.624	0.581	0.606	0.611
leptons	0.002	0.066	0.026	0.005

Leading particle in a jet

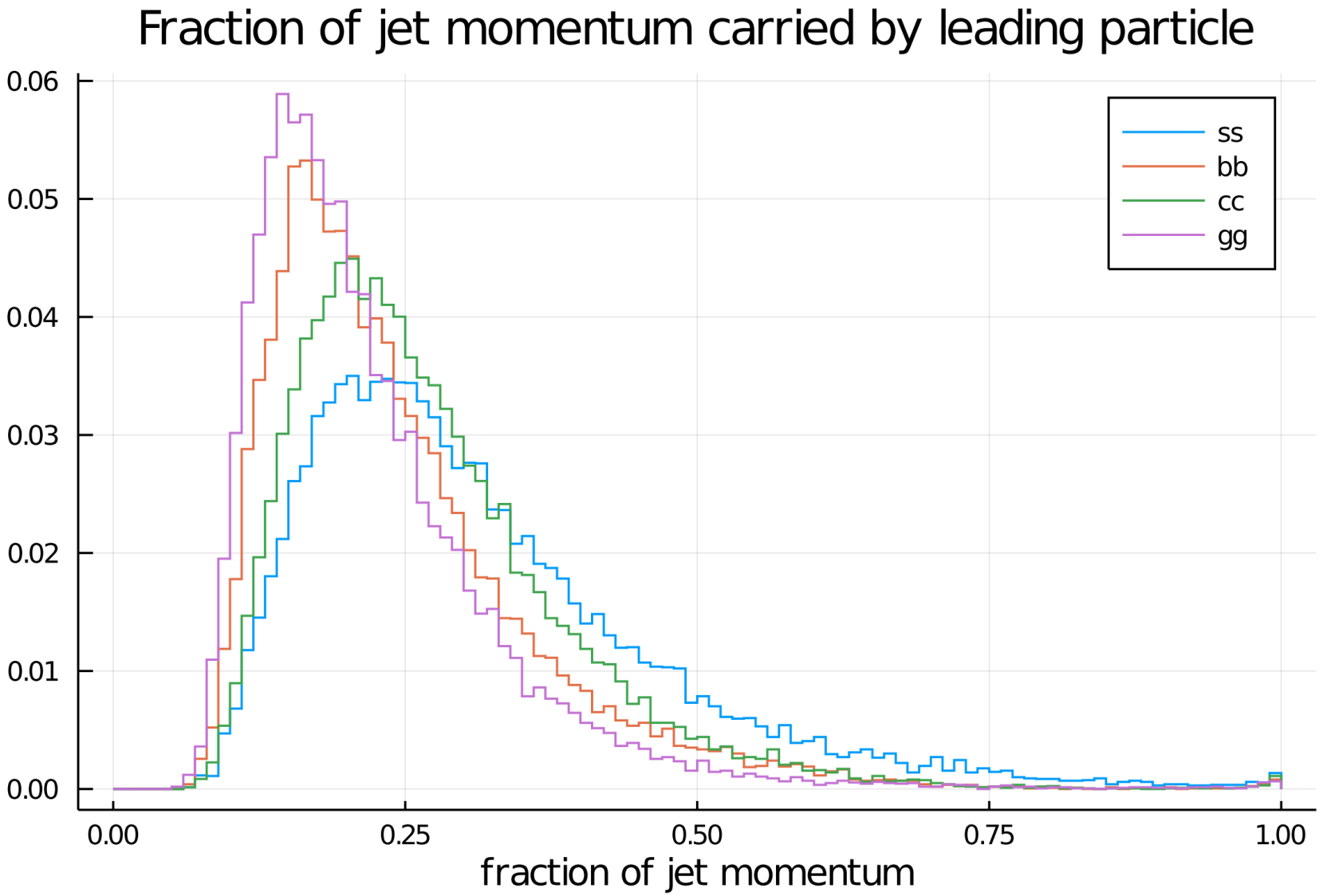
For each jet, we figured out which particle carries the largest fraction of the jet momentum.

These are only particles that are labeled as "MCParticle final states", minus neutrinos and very soft particles (E < 0.05 GeV).

I assume many of the pions are from K_s, and many of the protons are from Lambda_0, but I haven't checked that explicitly.



Fragmentation properties



Strange tagging status

- We'll have to get as much information from ILC events as possible
- We have taken a first look at the feasibility for strange jet tagging
  - At 250 GeV, it's not hopeless
- Getting a faint idea about Higgs to strange decays might be possible when we combine the measurements from 250 GeV and later stages
- Nevertheless, we should push hard for particle ID
  - This will improve greatly the limits we can put on new physics like H->bs and the like
- Time-of-flight, dE/dx, shower shapes will all play a role in this
  - We should push on all three