Future machines: e^+e^- colliders

- **Our next collider could be an e^+e^- project**
  - Large rings (100 km), high luminosity at 250-350 GeV
  - Linear machines, 250-350-500 and beyond 1 (ILC) - 3 TeV (CLIC)
- **Boosted objects at high energy e^+e^- :**

  focus on W-Z-H-t discrimination (as opposed to fighting QCD)

  → jet substructure resolution will be excellent

  → every Higgs/top is sacred: high efficiency mandatory

  → must control systematics to per mil level
- **Jet reconstruction more demanding than at LEP/SLC:**
  - presence of $\gamma\gamma \rightarrow$ hadrons "pile-up"
  - abundant multi-jet final states

ILC: "shovel-ready"
TDR 2013
Cavities deployed in industry

CLIC: "proof of principle"
CDR 2012
CLIC test facility

CEPC: "moving fast"
preCDR 2015

FCC-ee: "concept stage"
CDR 2018-19?

experiment with new algorithms → long inv k_t, VLC, Georgi's global jets, Xcone?
adapt grooming algorithms & taggers to e^+e^- environment/requirements

Full simulation of most relevant benchmark processes are available
Some interest + manpower, special session during LCWS

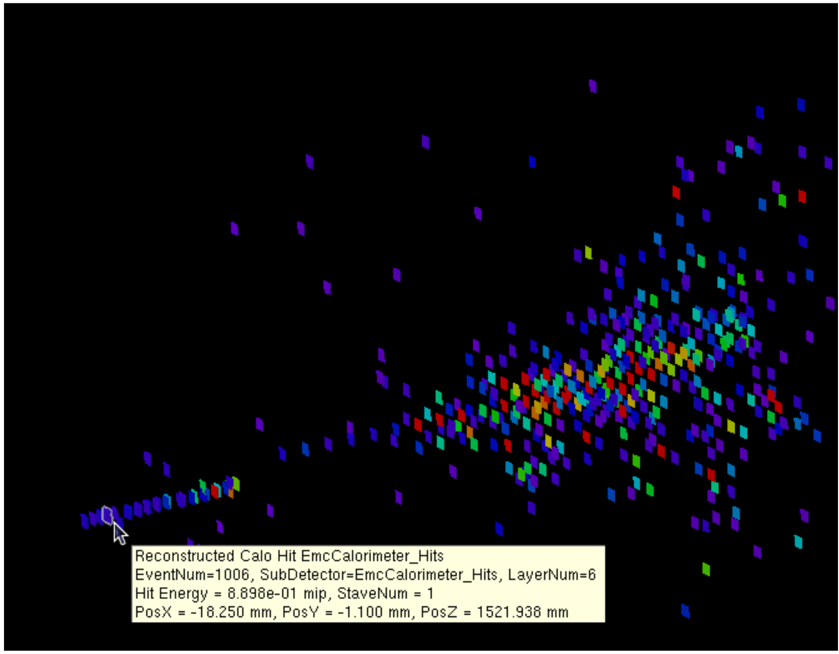
Ultra-granular detectors

- **highly granular calorimeters (CALICE)**
  - Lateral segmentation, well below shower size << Moliere radius (~50 um-1 cm)

    ½ the interaction length (~5-10 cm)
  - Longitudinal segmentation:

    30 EM + 30 Hadronic
- **Particle Flow Jet Energy resolution**
  - Theoretical limit: δE/E ~ 21%/√E.
  - In practice: δE/E ~ 3%

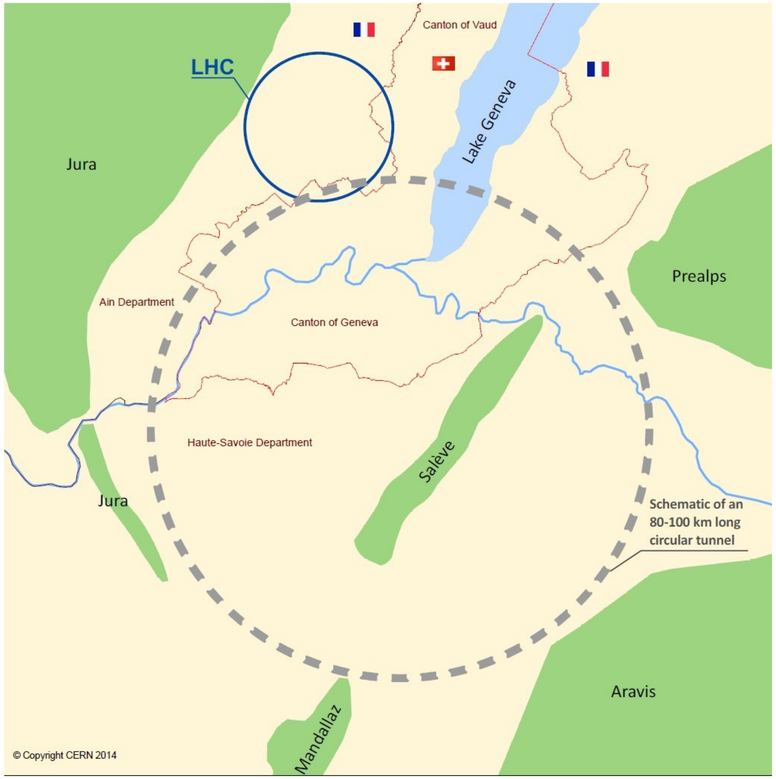
    (confusion, even at few 100 GeV)
  - Is the real gain in jet substructure?

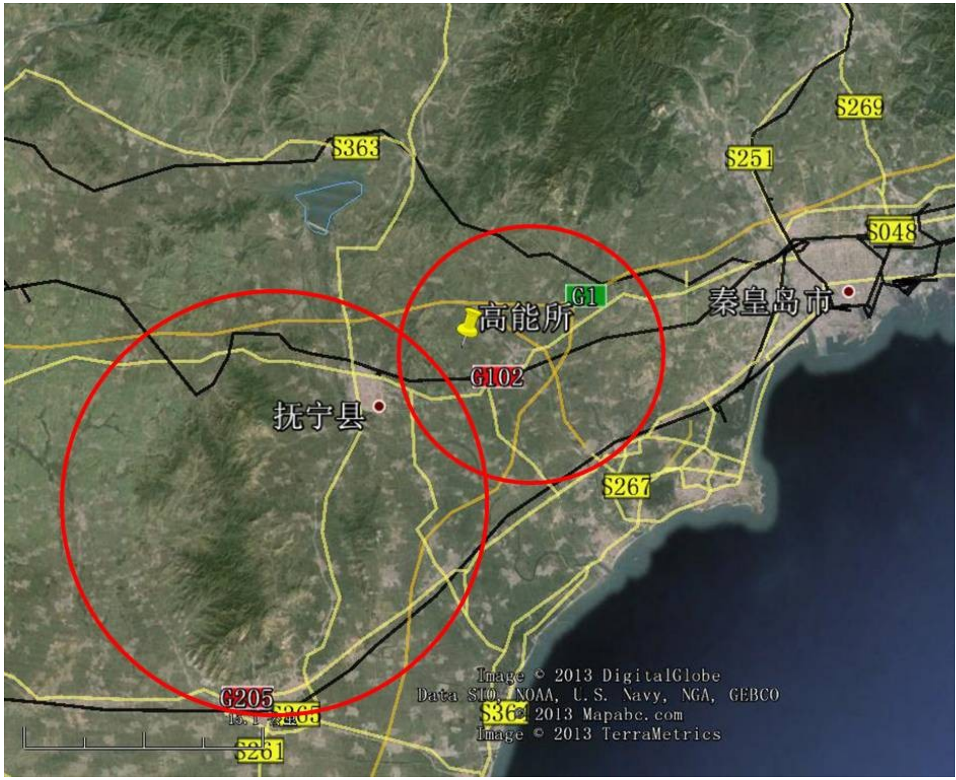


Detailed MC + data for two-track separation, potential and limitations of PF e^+e^- experiments → CMS forward calorimeter → FCC-hh?

Future machines: hadron colliders

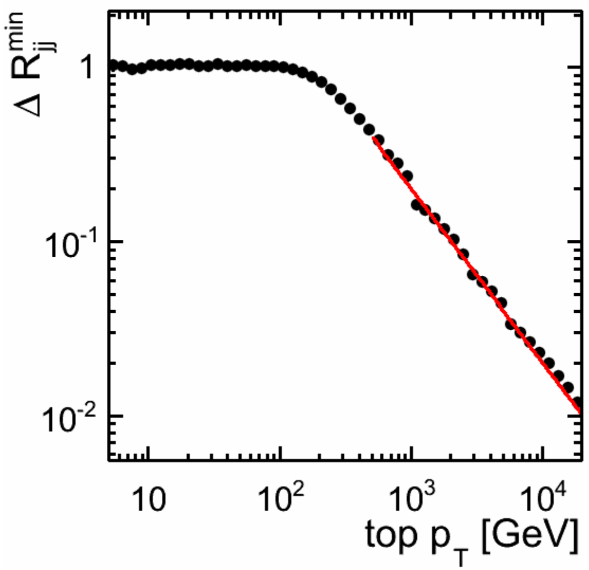
- 50-80-100 km ring full of 16 T magnets
- pp collisions up to 100 TeV





If you like boosted objects, you are going to love this machine
Can detectors, jet reconstruction and substructure analysis simply be scaled up?

Questions for FCC-hh



Substructure analyses may drive detector granularity / size

Insist on resolving sub-jets in at least some detectors?

For top: separation between partons in t → Wb → bqq system

To distinguish W, Z, H (QCD rejection not unlike τ-tagging)

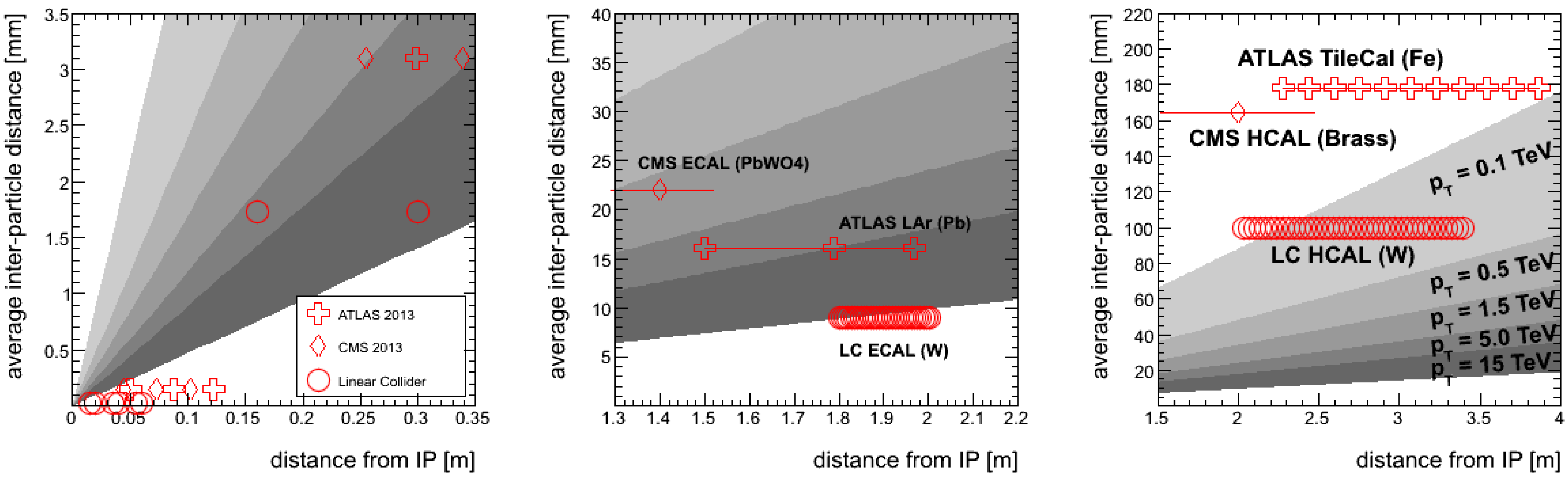
Granularity << 0.01 at 10 TeV (increase R, B → solenoid cost μ stored energy)

Insist on connecting tracks to clusters for particle flow?

Tracker segmentation, Moliere radius OK

Hadronic system seems daunting even with Tungsten (λ=10 cm)

Ultra-segmented many-layer calorimeter (cost >> tracker cost)



Detailed MC + data for two-track separation, potential and limitations of PF

Questions the LHC can answer

- Understand cores of highest p_T jets:
  - Fine-grained jet shapes? Multiplicities?
- Do boosted objects behave as expected?
- Test tracker-based (or EM-based) substructure in realistic environment

Questions the BOOST report could answer

- Does Delphes' model predict jet substructure performance?
- MC studies to derive granularity/size requirement for FCC-hh
- Which techniques can deal with hyper-boost best?
- (Comparison of jet algorithms for e^+e^- machines)