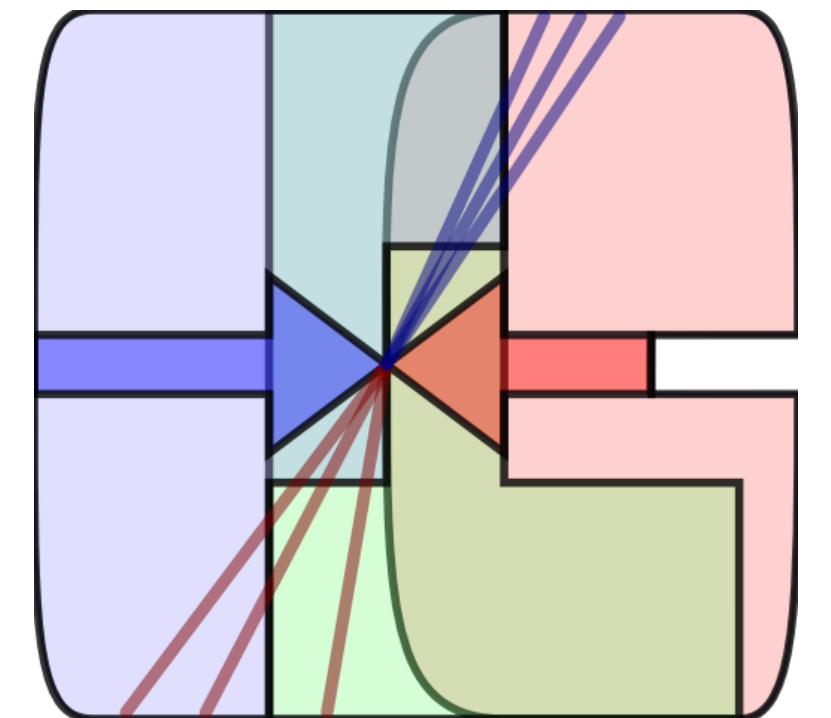


Why do we need a collider after the LHC - and how should it look like?



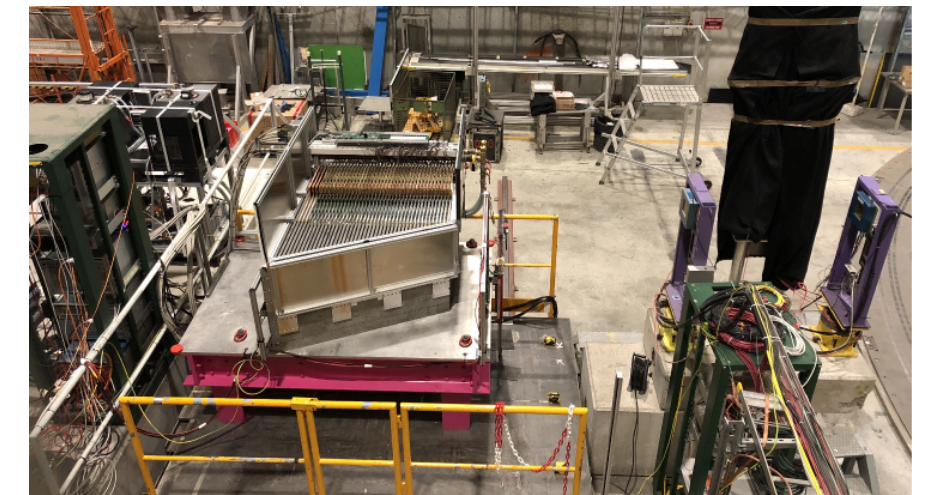
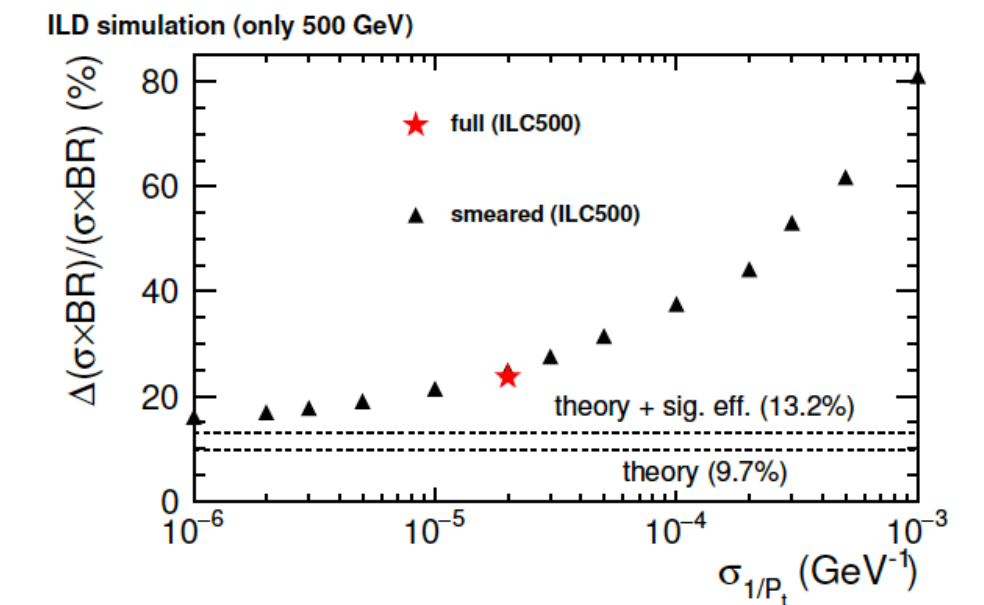
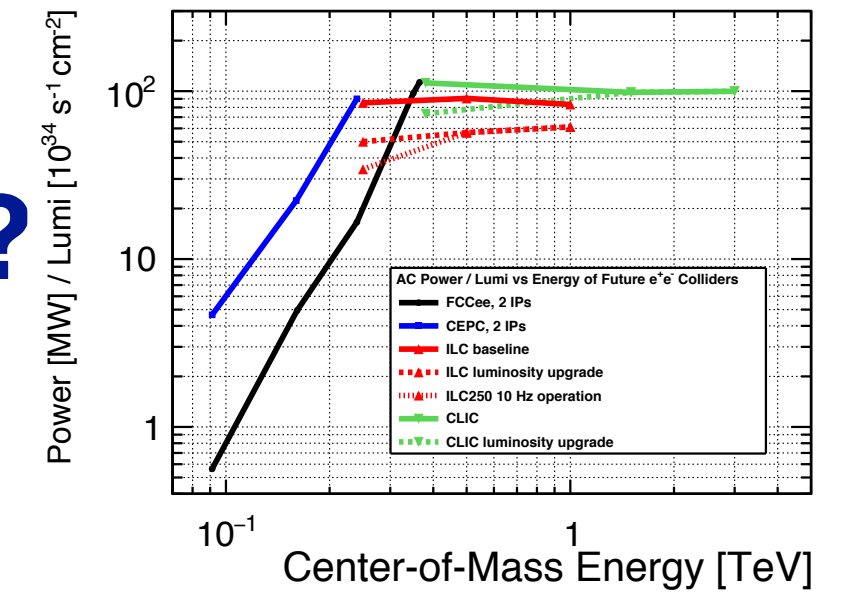
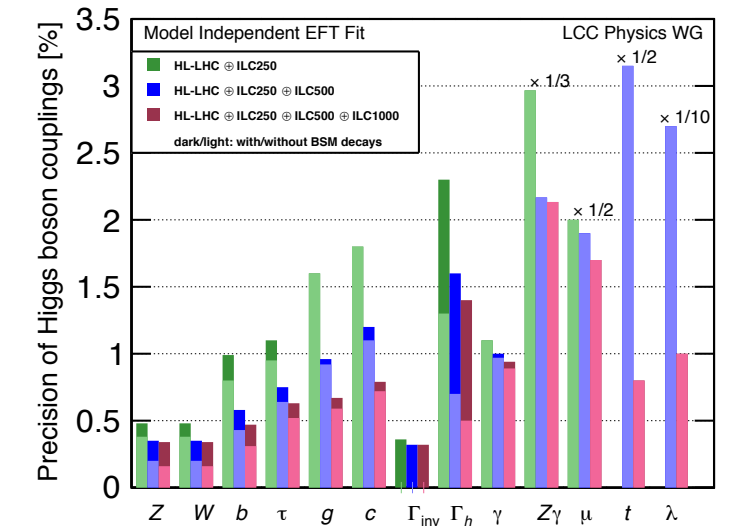
J. List (DESY)
December 6, 2019



CLUSTER OF EXCELLENCE
QUANTUM UNIVERSE

Planning the future

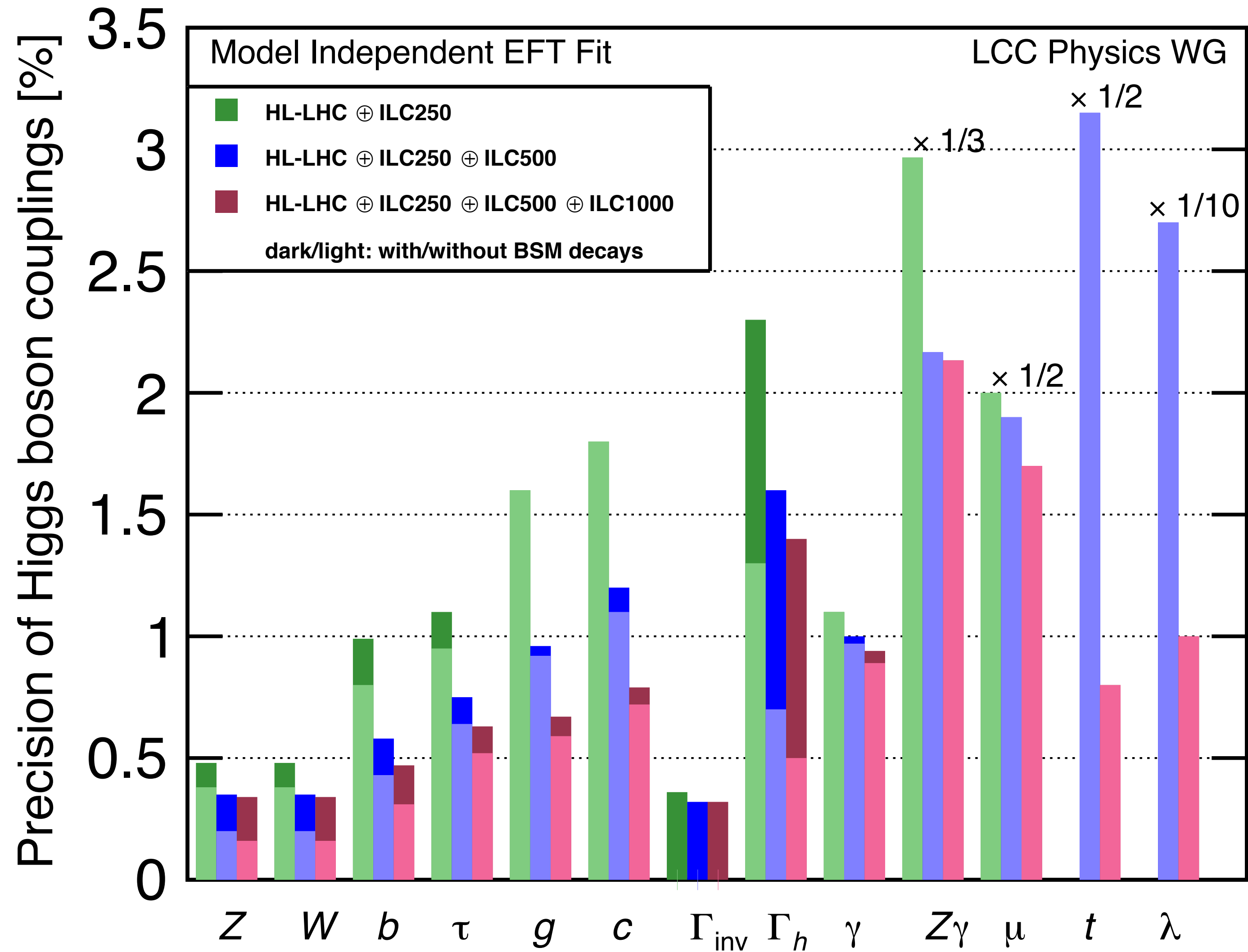
1. What will be the open physics questions after HL-LHC?
=> physics studies & gloabl fits in close collaboration with theorists
2. What are realistic requirements on the next collider after HL-LHC?
=> optimize physics program of a realistic accelerator in close collaboration with accelerator physicists
3. What are the requirements on the detectors at such a collider?
=> study the impact of the detector performance on physics observables
4. How can such detectors be built?
=> construction and test beam operation of prototypes



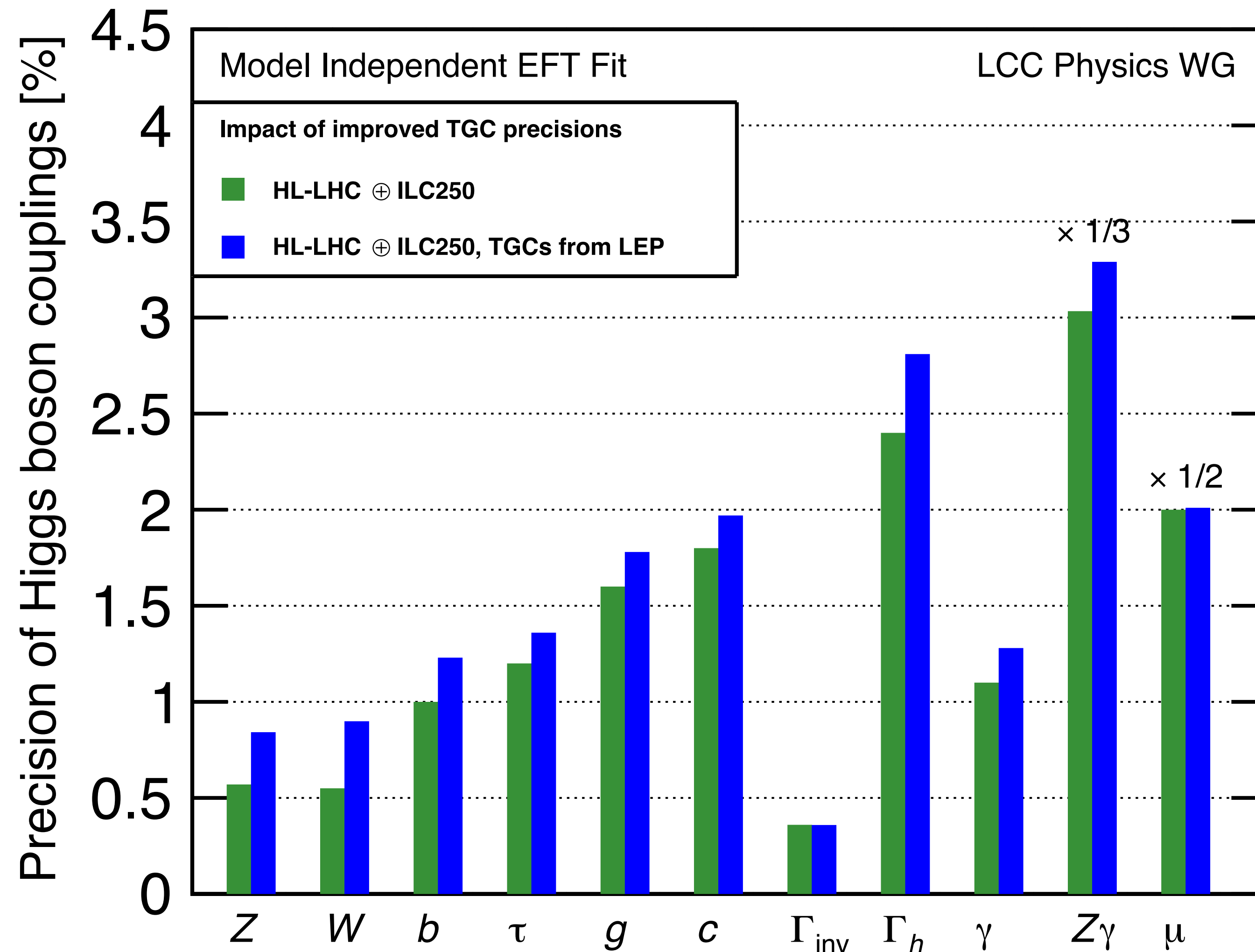
Contacts for further information

- General, Physics Analyses, Detector Optimisation: Jenny.List@desy.de
- General, tracking detectors: Ties.Behnke@desy.de
- HCAL: Katja.Krueger@desy.de
- Software, Deep Learning: Frank.Gaede@desy.de
- Group home page flc.desy.de
- Thesis offers (examples!)
https://flc.desy.de/education/thesistopics/index_eng.html

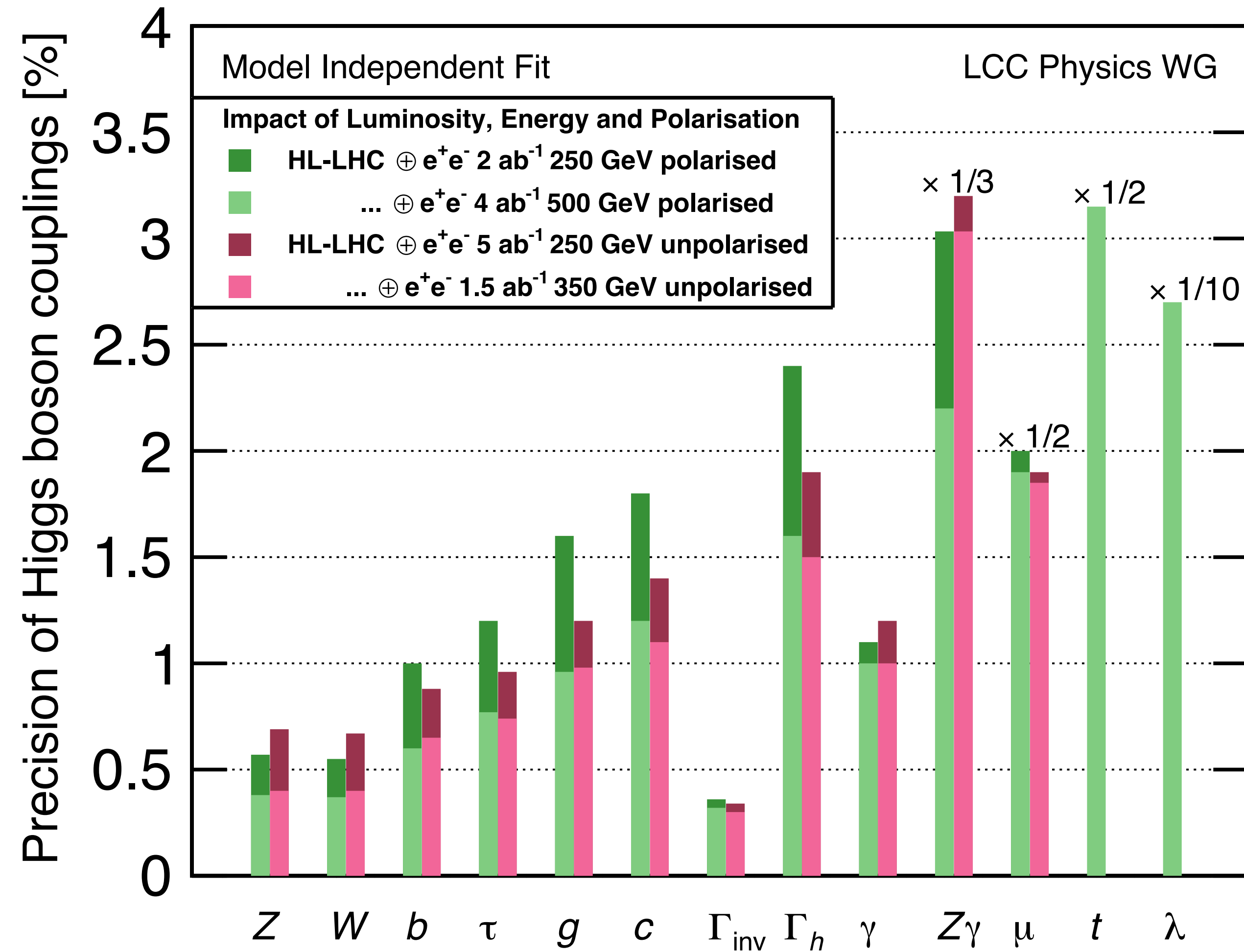
Impact of (no) BSM Assumption



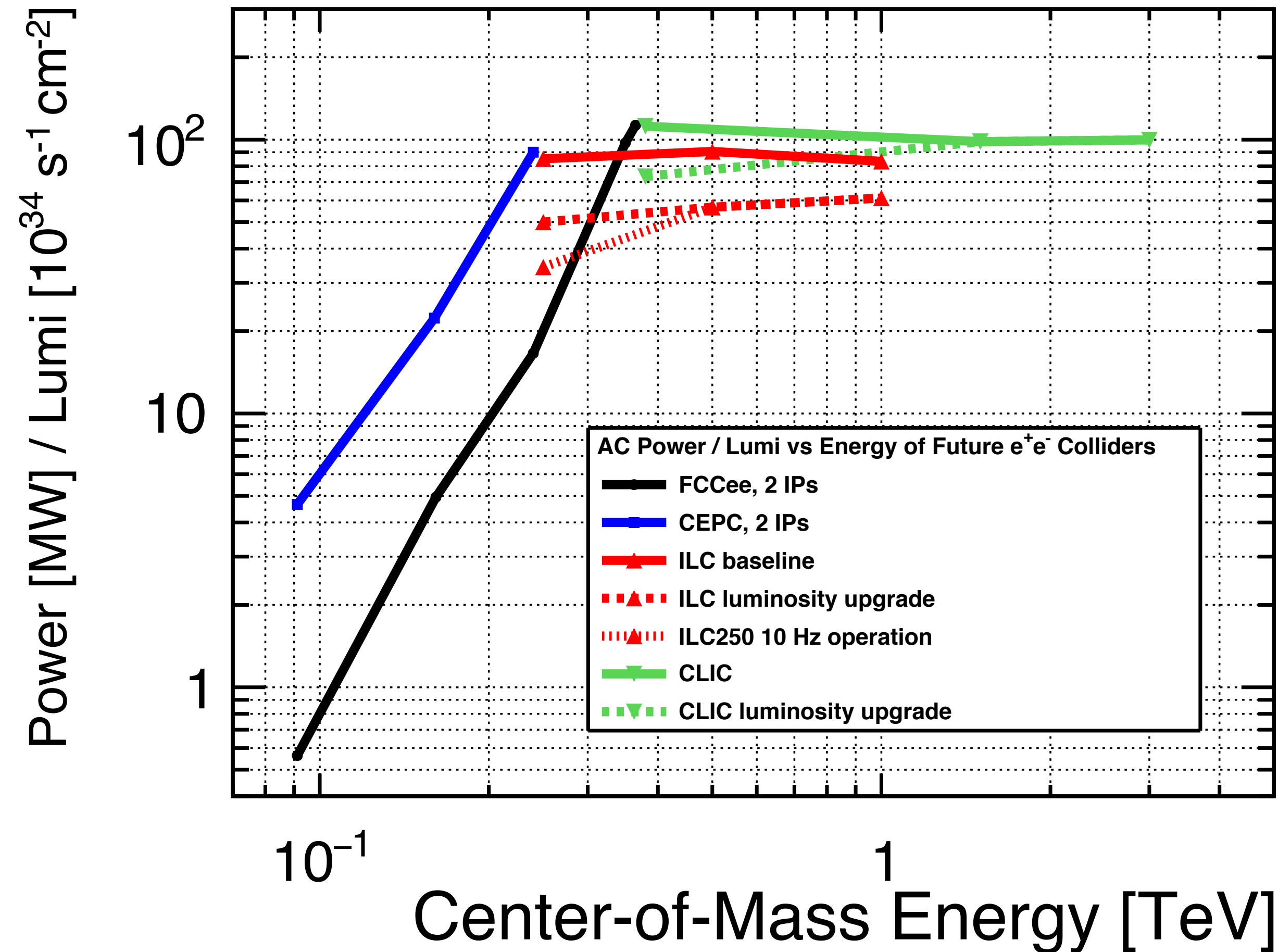
Role of Triple Gauge Coupling Measurements



Role of Luminosity, Energy & Polarisation



Energy, Luminosity and Electrical Power



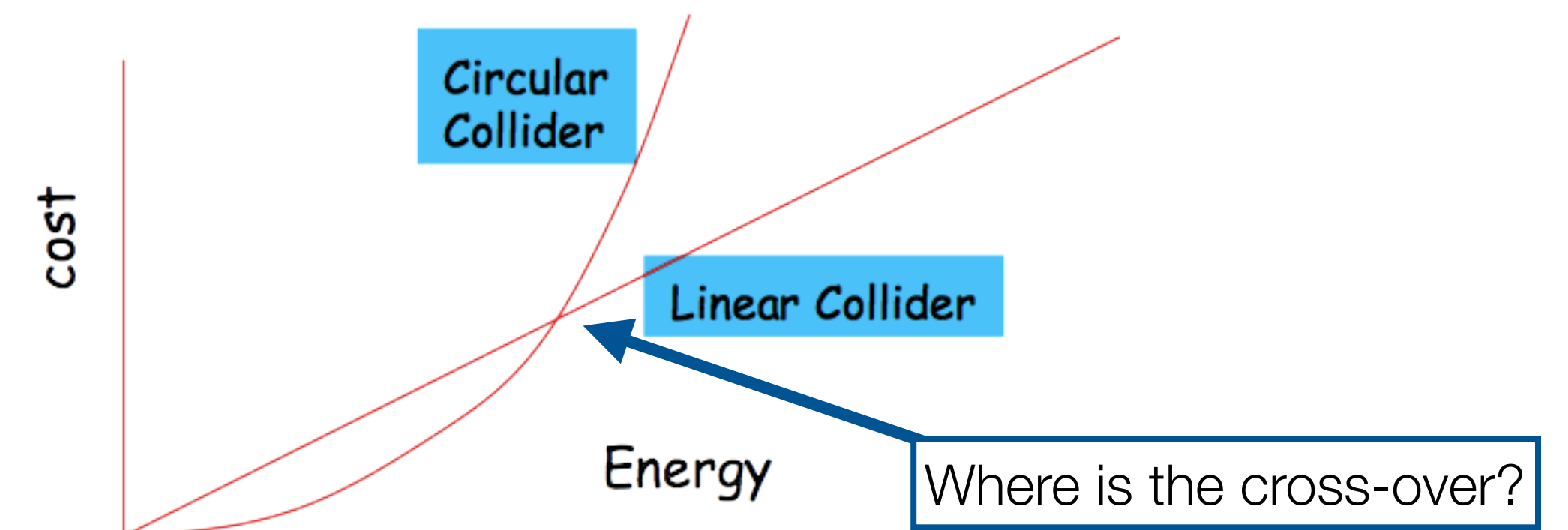
- **synchrotron radiation:**

- $\Delta E \sim (E^4 / m^4 R)$ per turn $\Rightarrow$ 2 GeV at LEP2

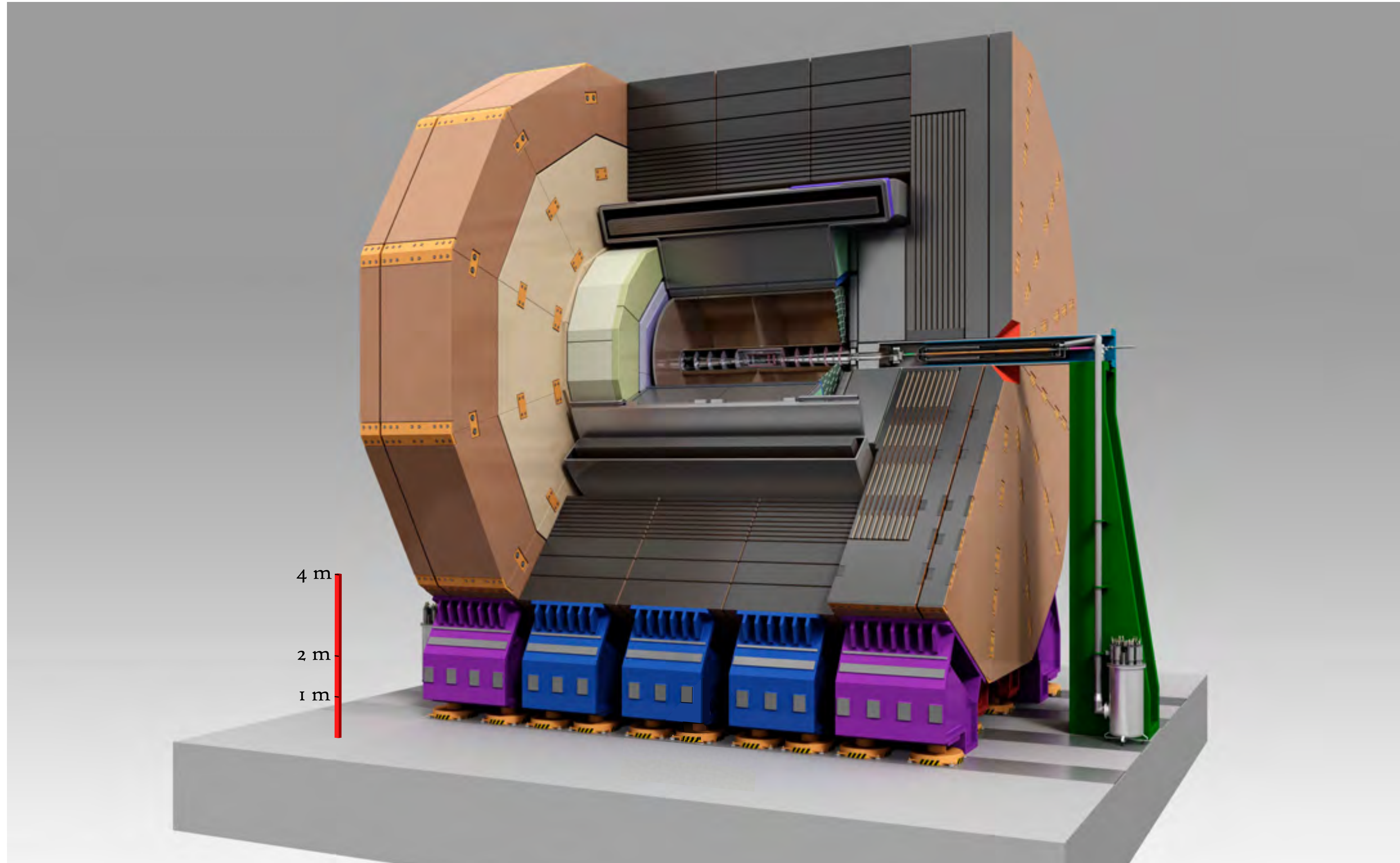
- **cost in high-energy limit:**

- **circular :** $$$ \sim a R + b \Delta E \sim a R + b (E^4 / m^4 R)$
optimisation $\Rightarrow R \sim E^2$ $\Rightarrow$ $$$ \sim E^2$

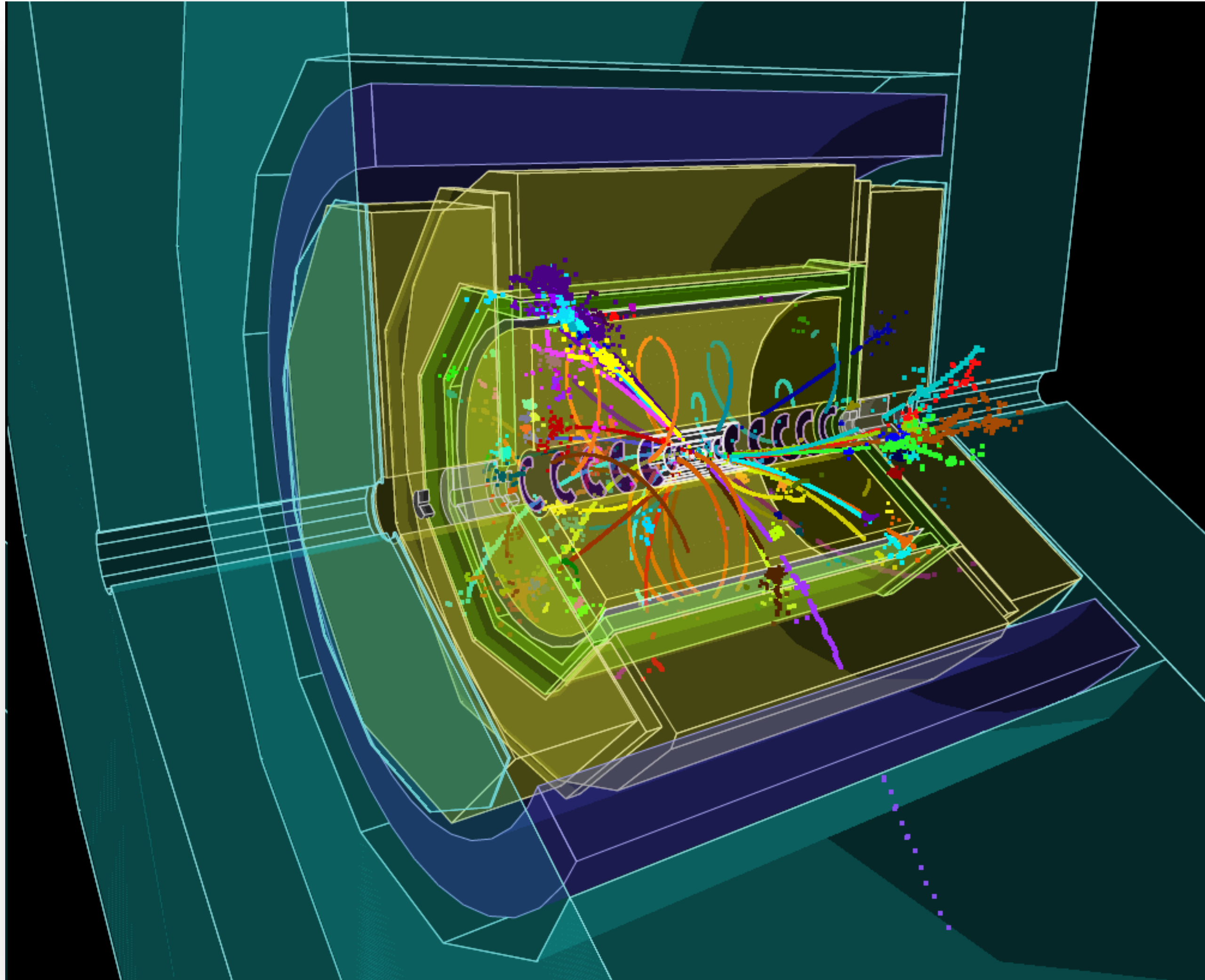
- **linear :** $$$ \sim L$, with $L \sim E$ $\Rightarrow$ $$$ \sim E$
 $\Rightarrow$ **scalable**



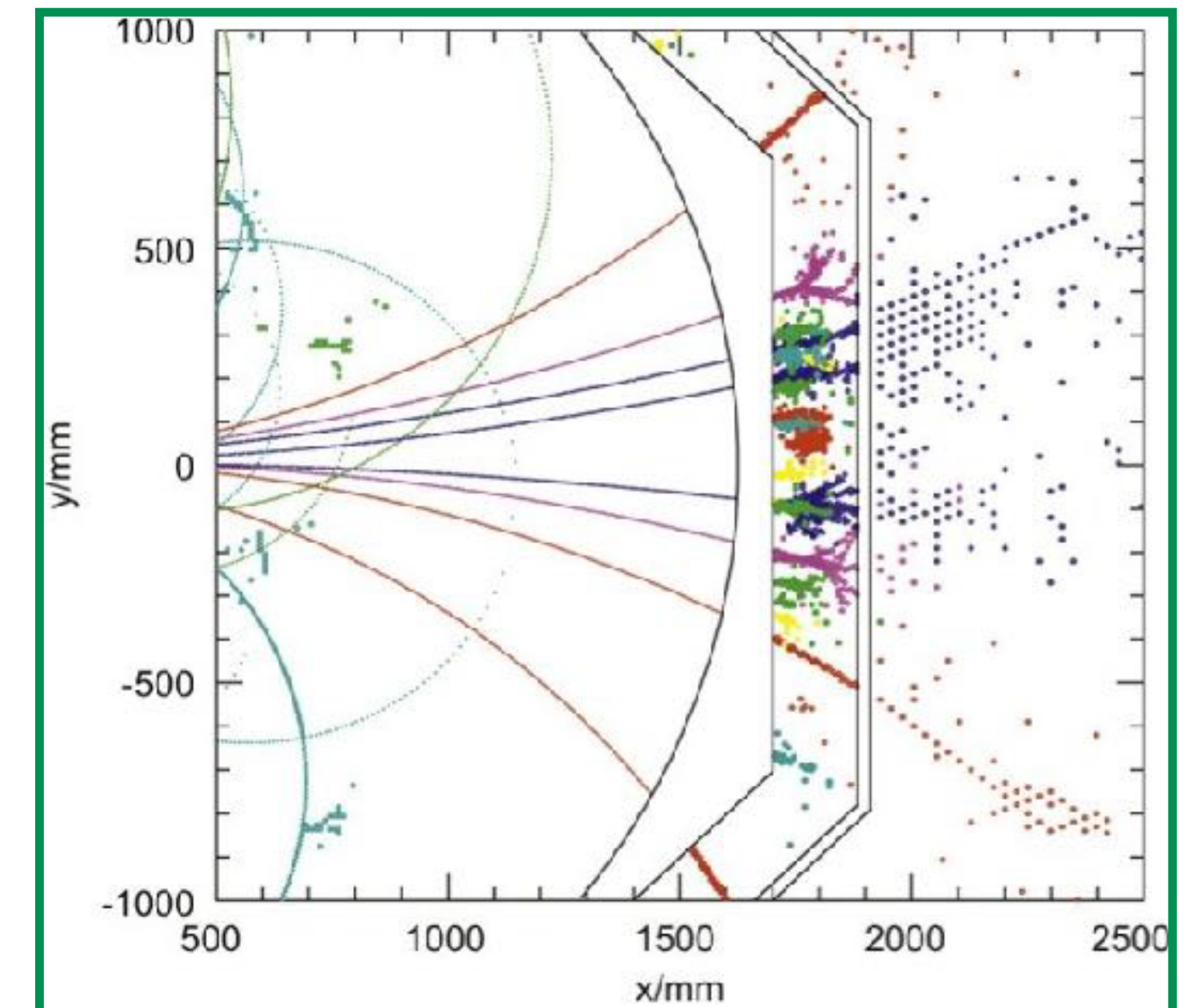
The ILD Detector Concept



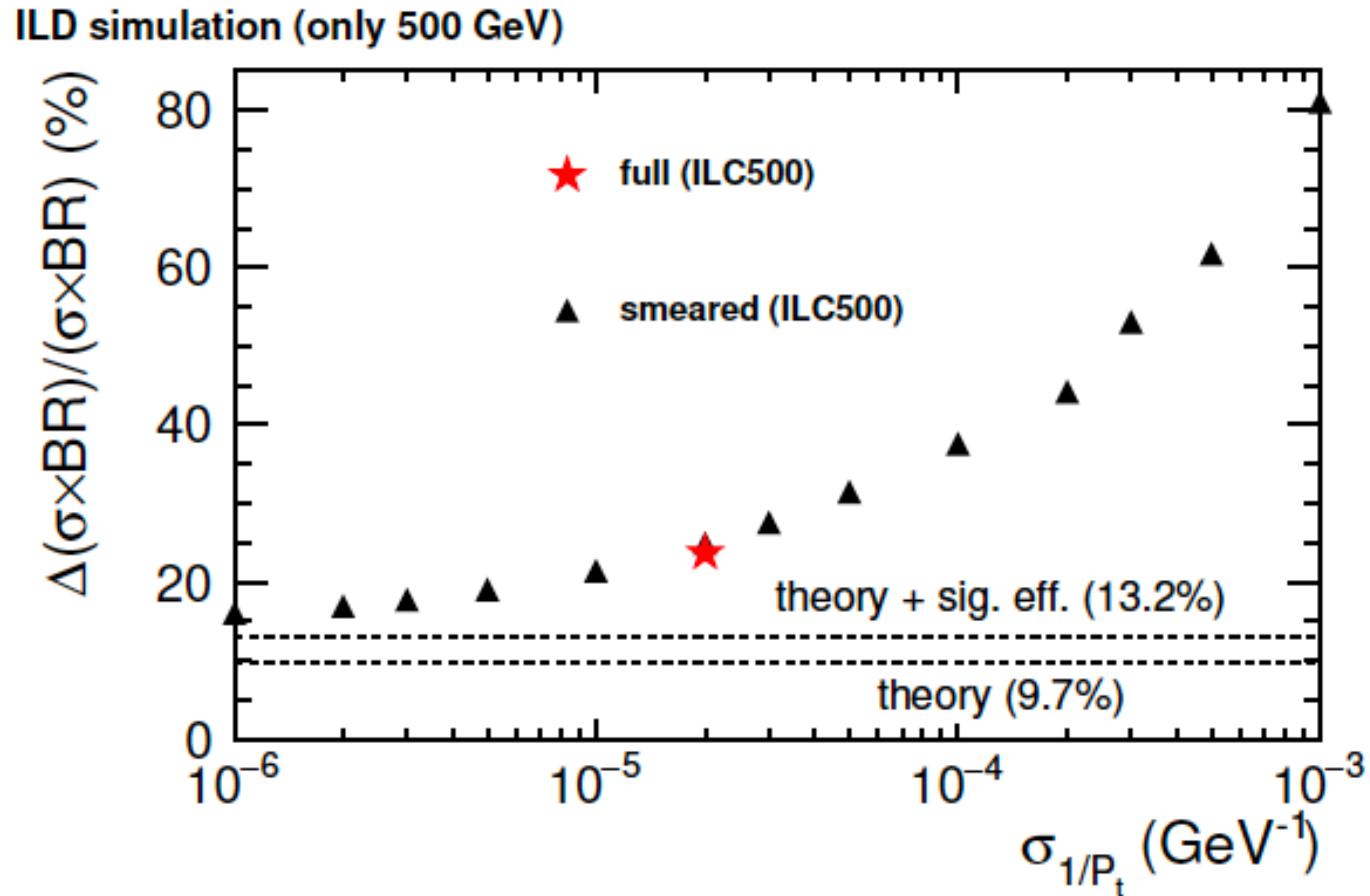
The Particle Flow Concept



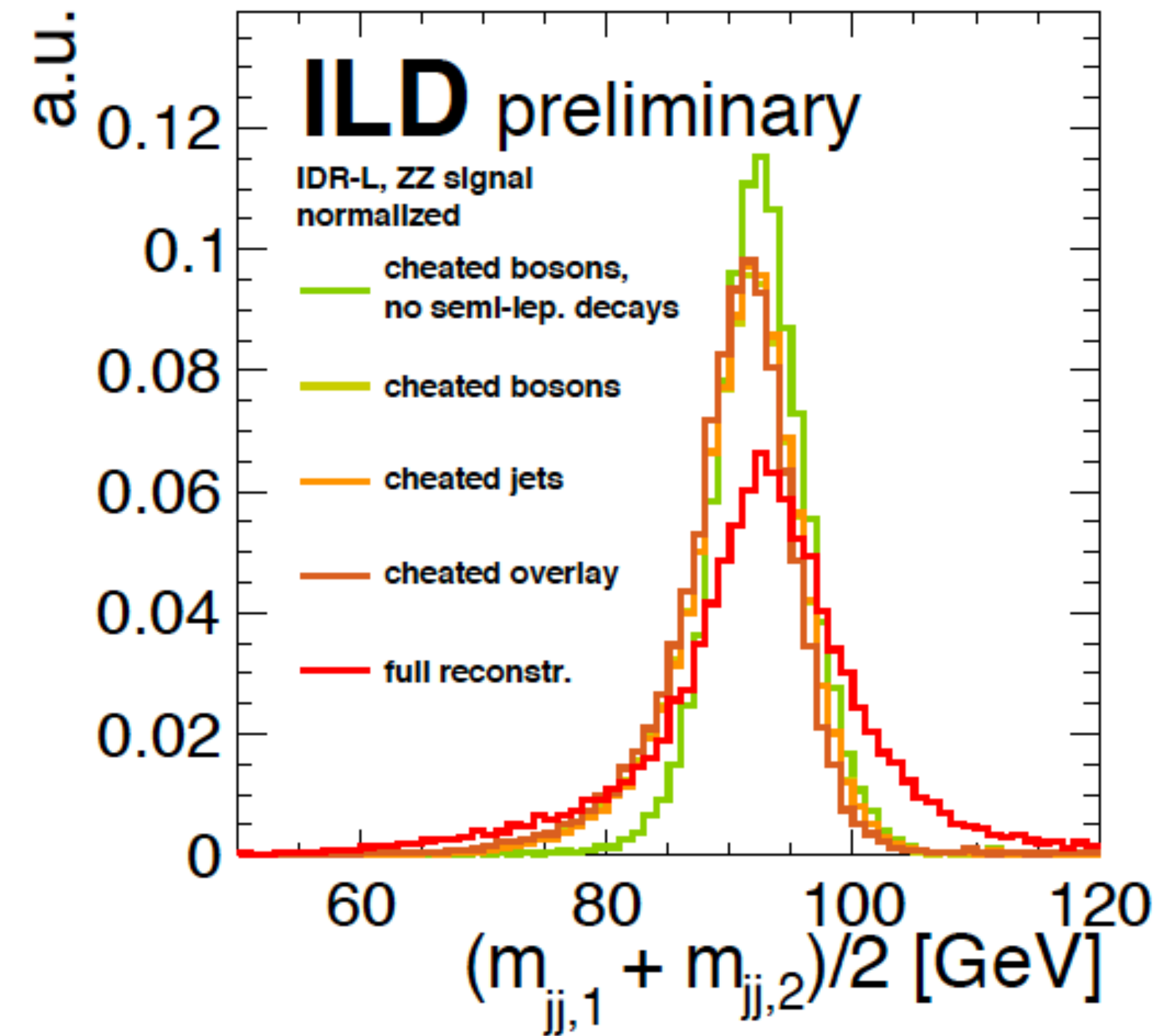
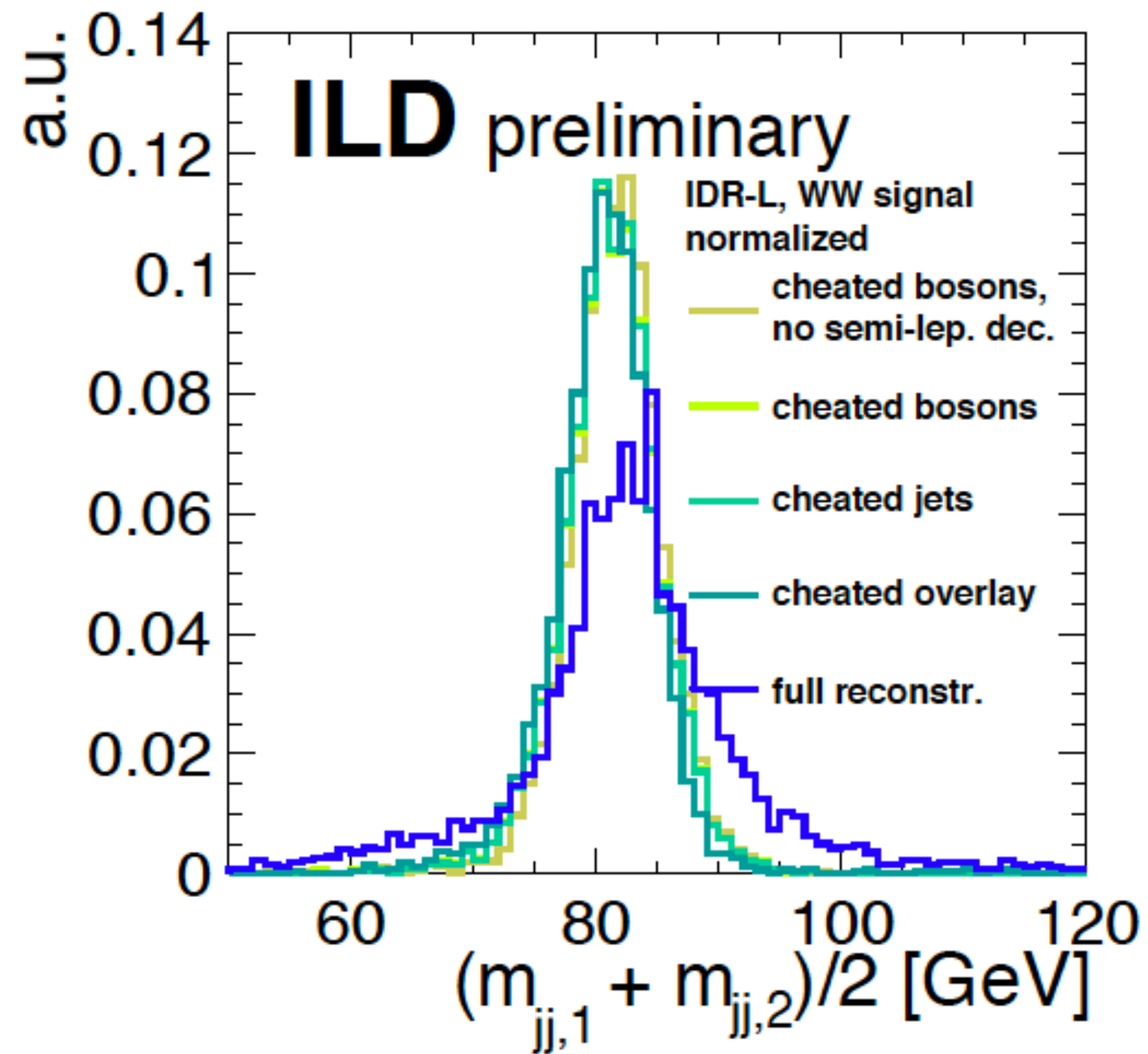
**Colours are according
to RECONSTRUCTION!**



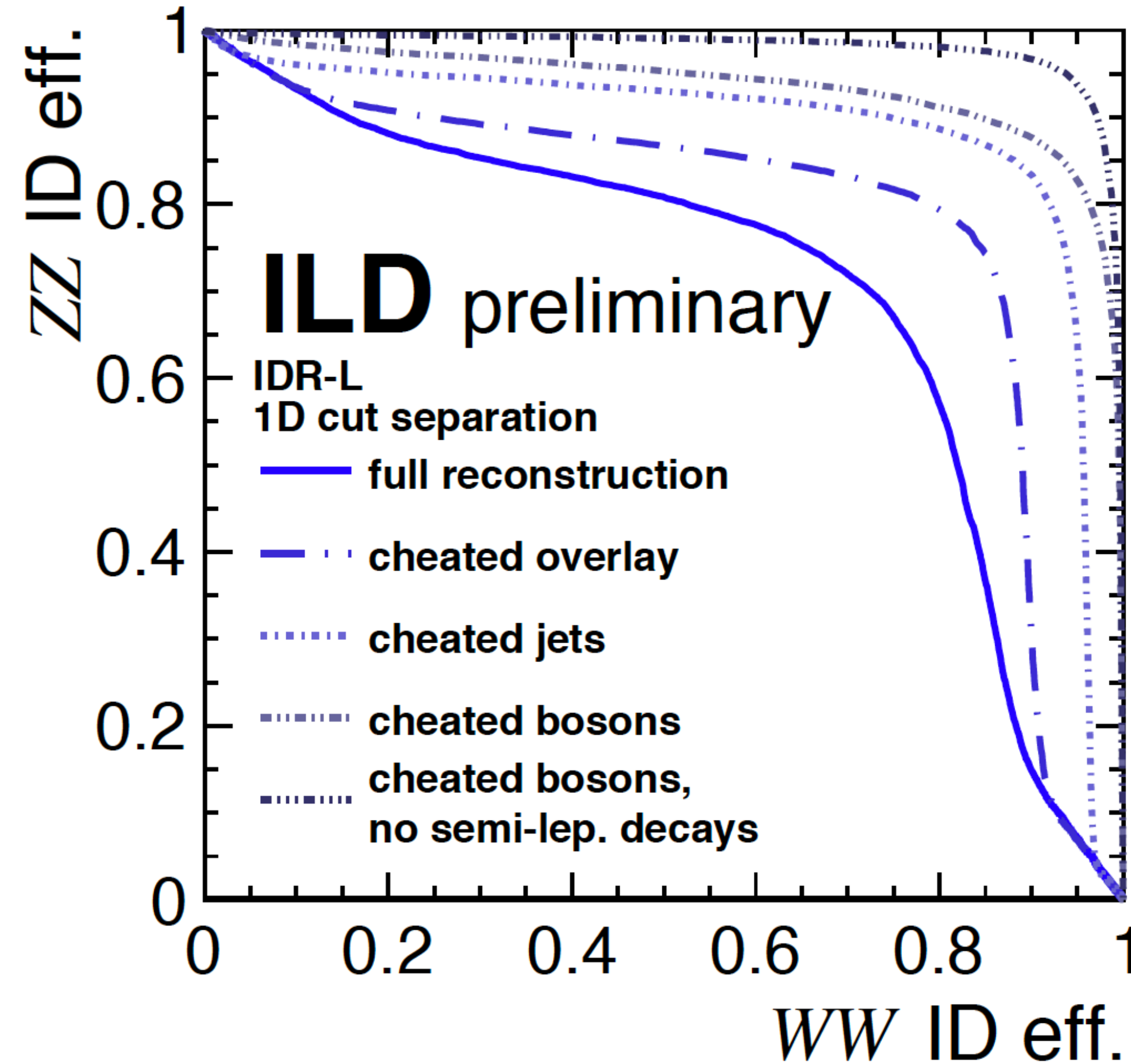
How does precision on $\text{BR}(H \rightarrow \mu\mu)$ depend on momentum resolution?



How well can we separate $WW \rightarrow 4\text{jets}$ from $ZZ \rightarrow 4\text{jets}$?

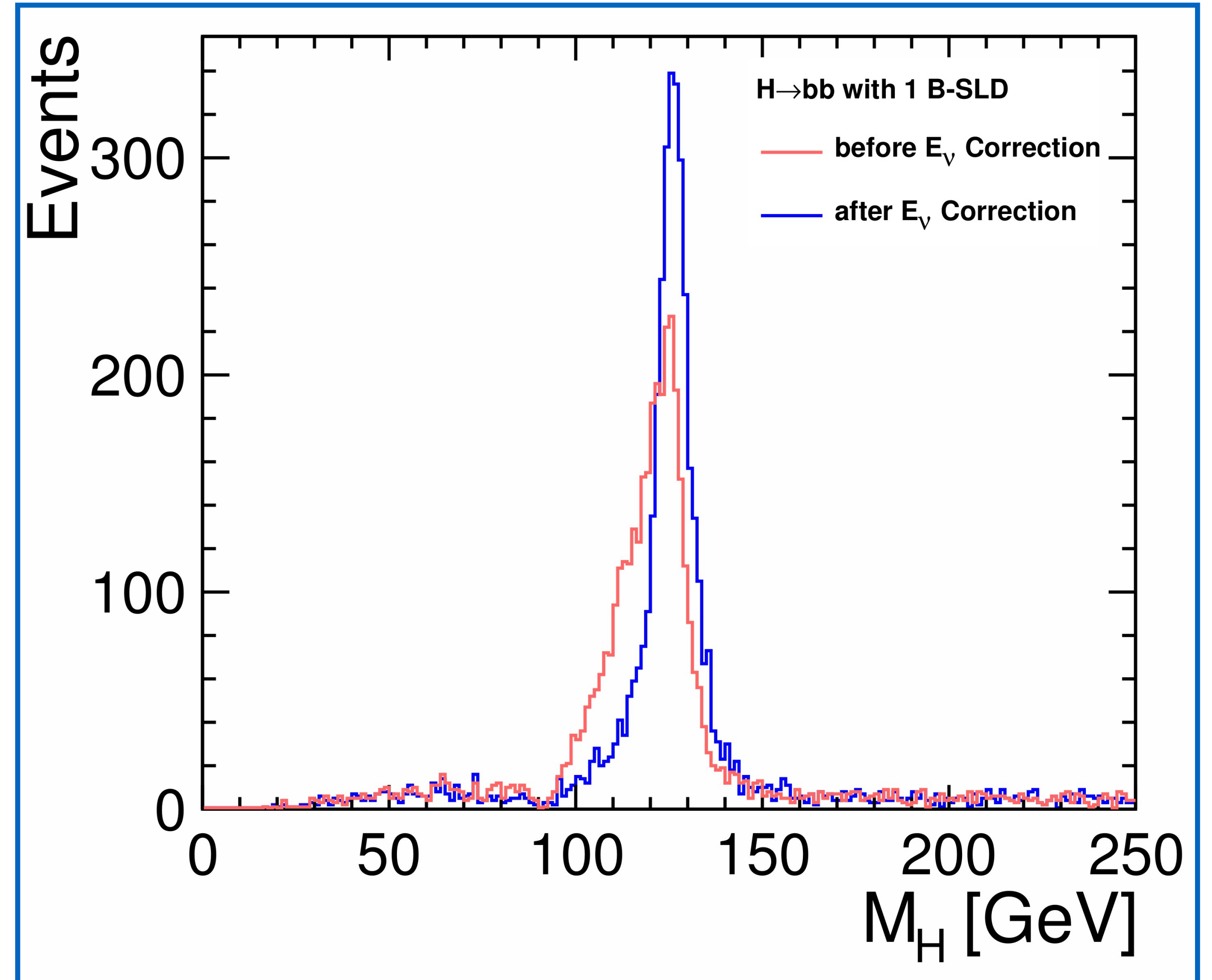


How well can we separate $WW \rightarrow 4\text{jets}$ from $ZZ \rightarrow 4\text{jets}$?

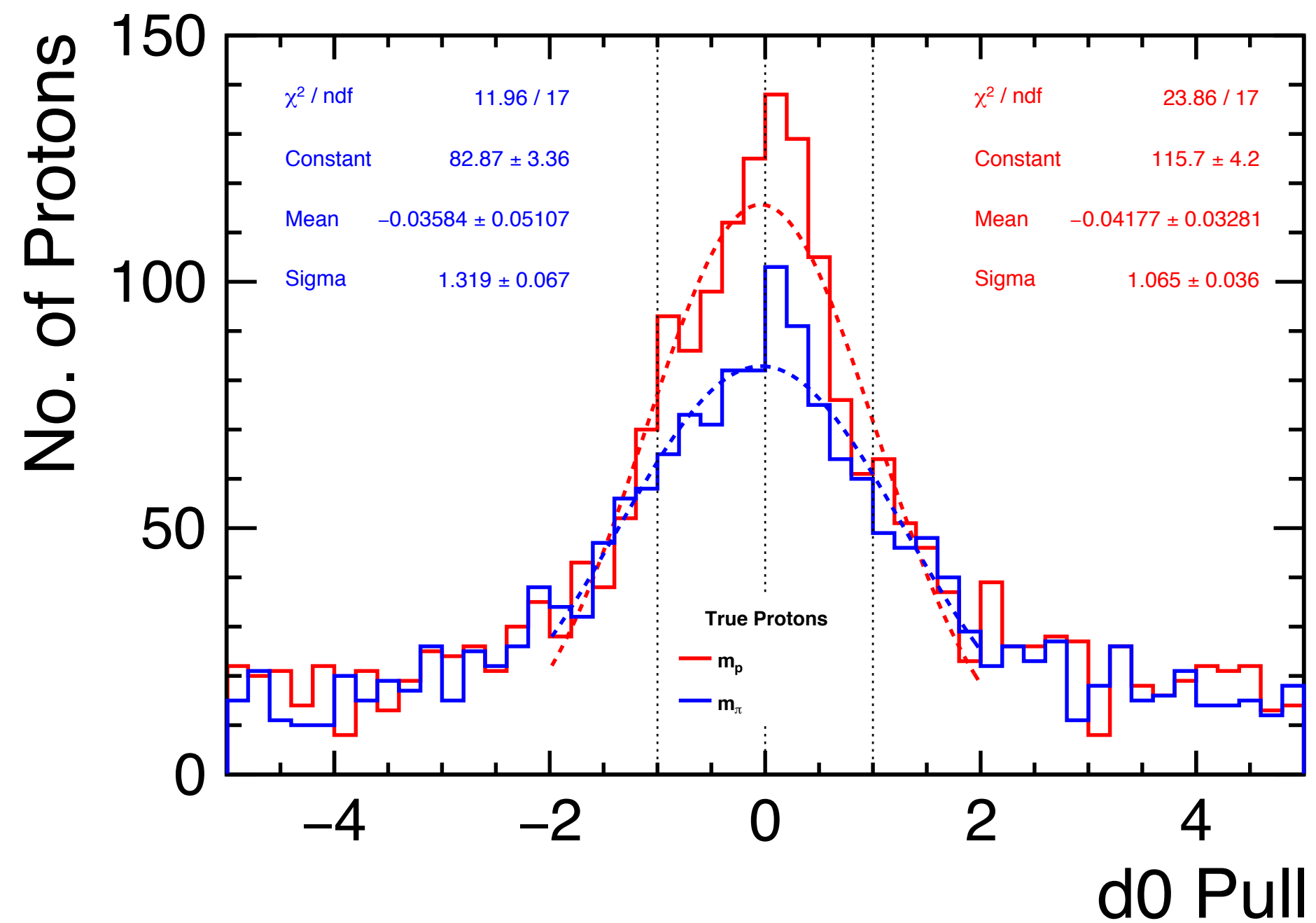


Can we improve $H \rightarrow b\bar{b}$ reconstruction?

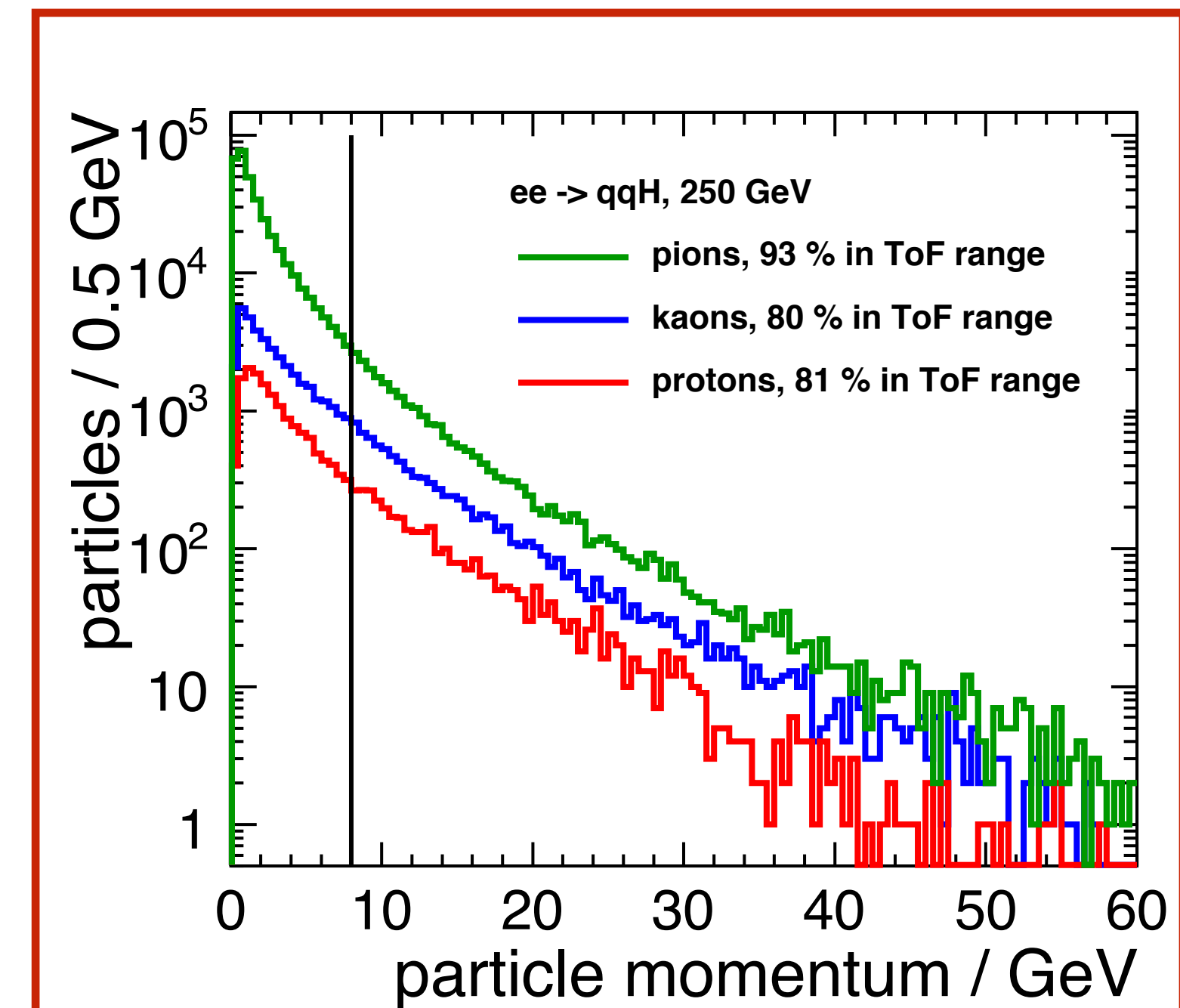
- Decay chain reconstruction:
 - e.g. with semi-leptonic $b \rightarrow c\ell\nu$ decay
 - Know decay chain $\Rightarrow$ can recover neutrino momentum
 - **huge** improvement potential on $H \rightarrow b\bar{b}$ mass reconstruction!



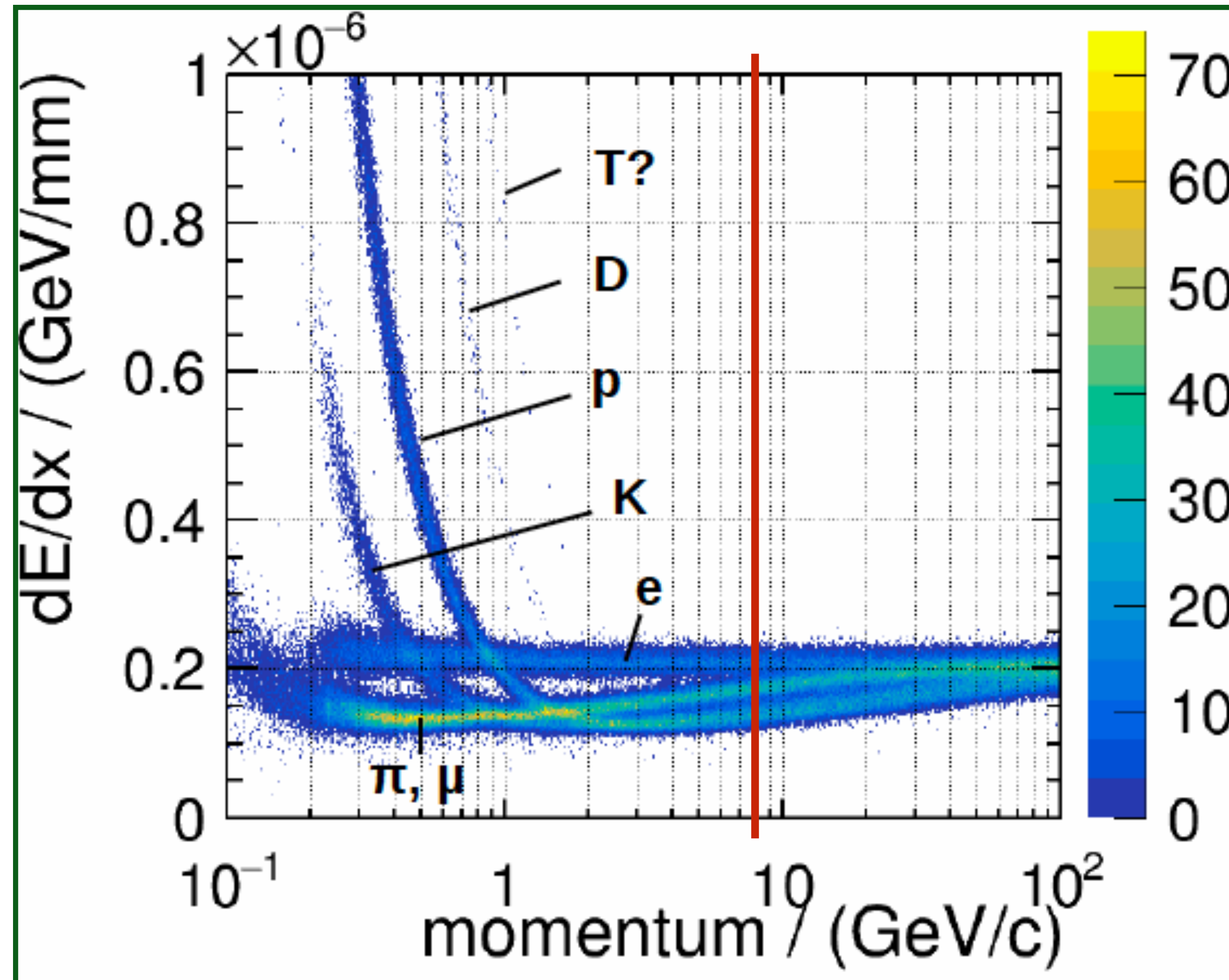
Particle ID => track fit with correct mass



- Clear improvement on track fit with correct mass hypothesis
- eg pull on impact parameter for **correct** and **wrong** mass hypothesis



Particle ID : specific energy loss (dE/dx) in TPC

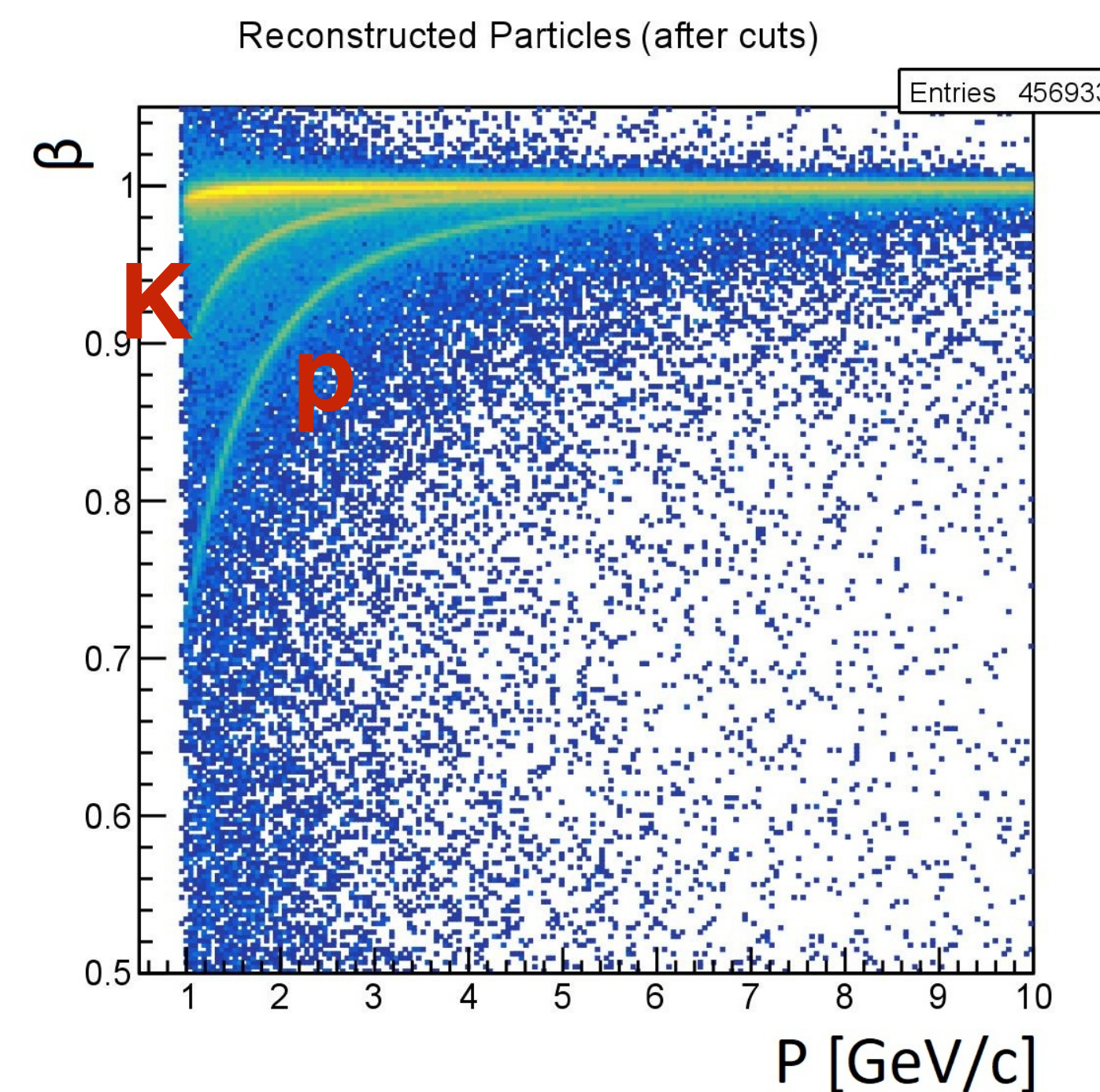
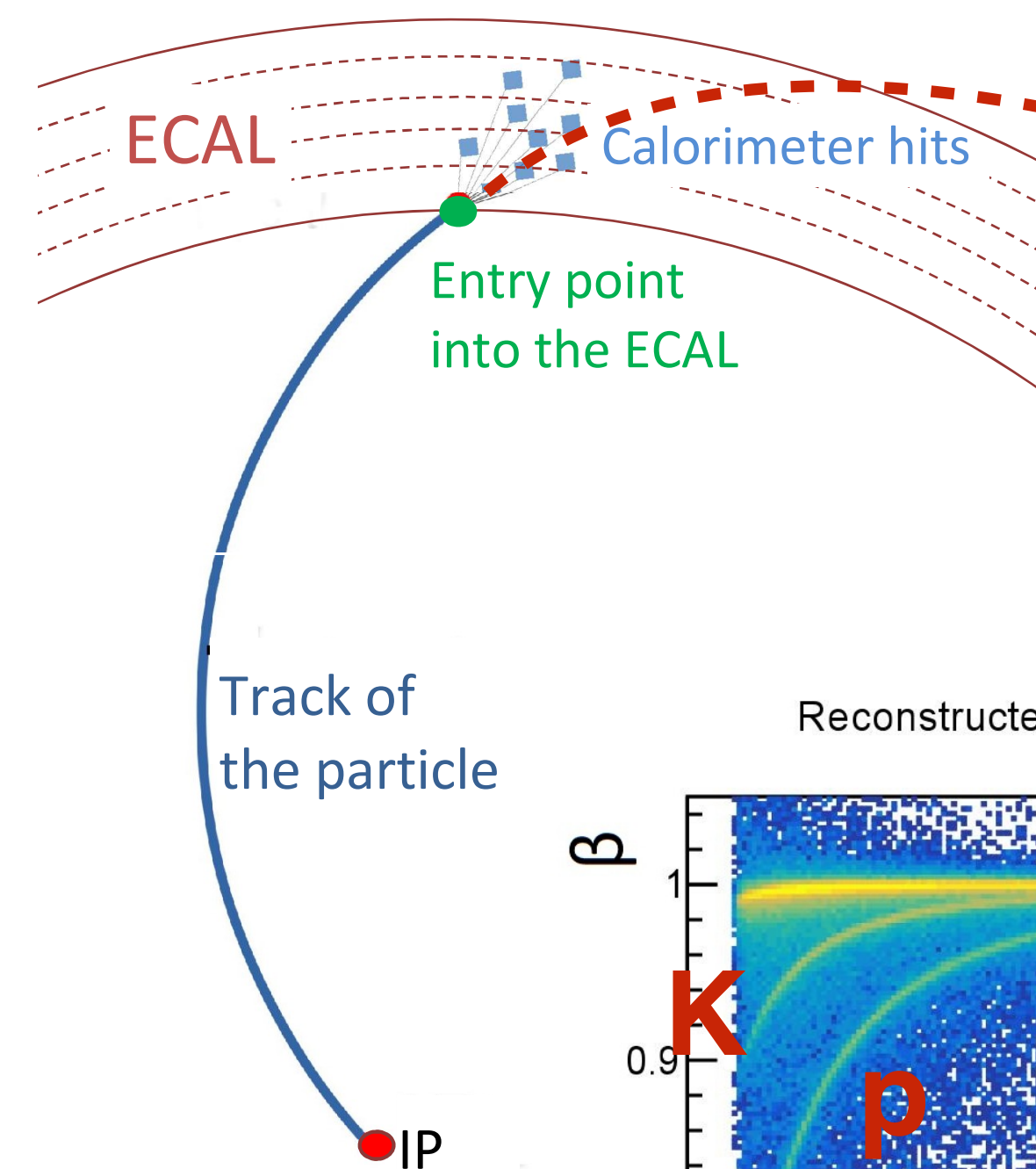
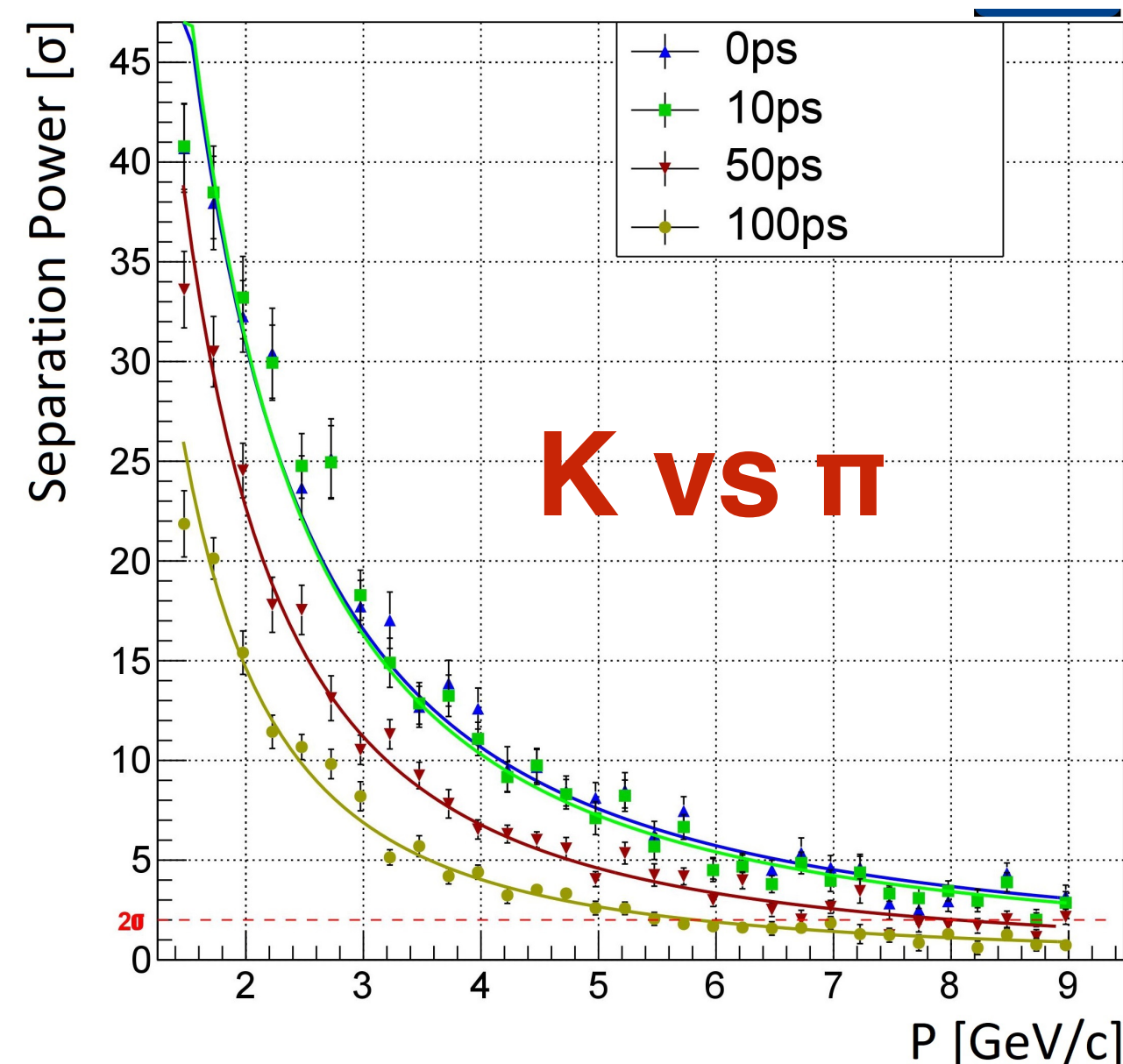
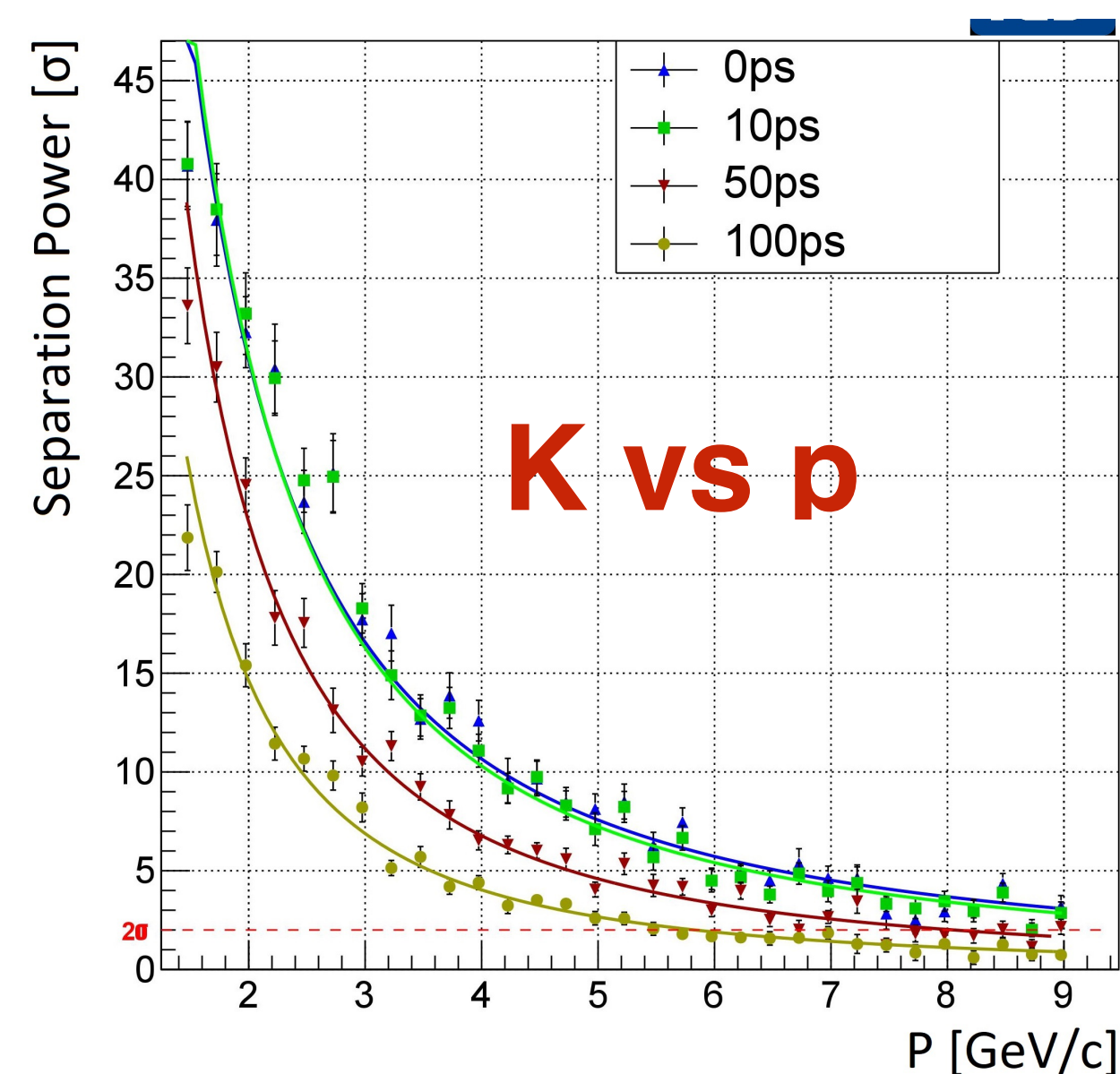


Time-of-Flight measurement => your thesis? :-)



Bachelor Thesis S. Dharani (U Leipzig & DESY-FLC, 2018):
“Particle Identification using Time of Flight in the International Large Detector ILD”

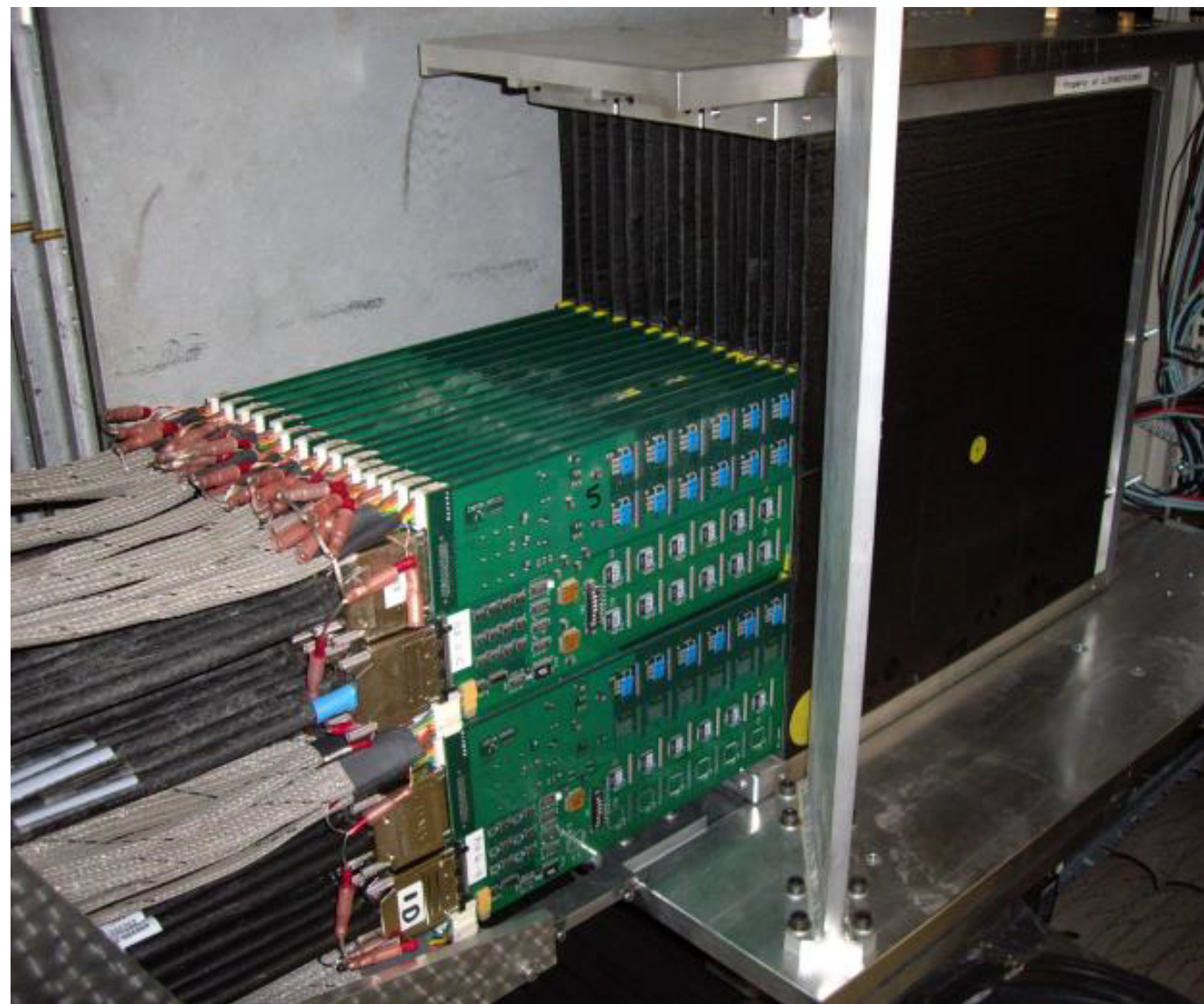
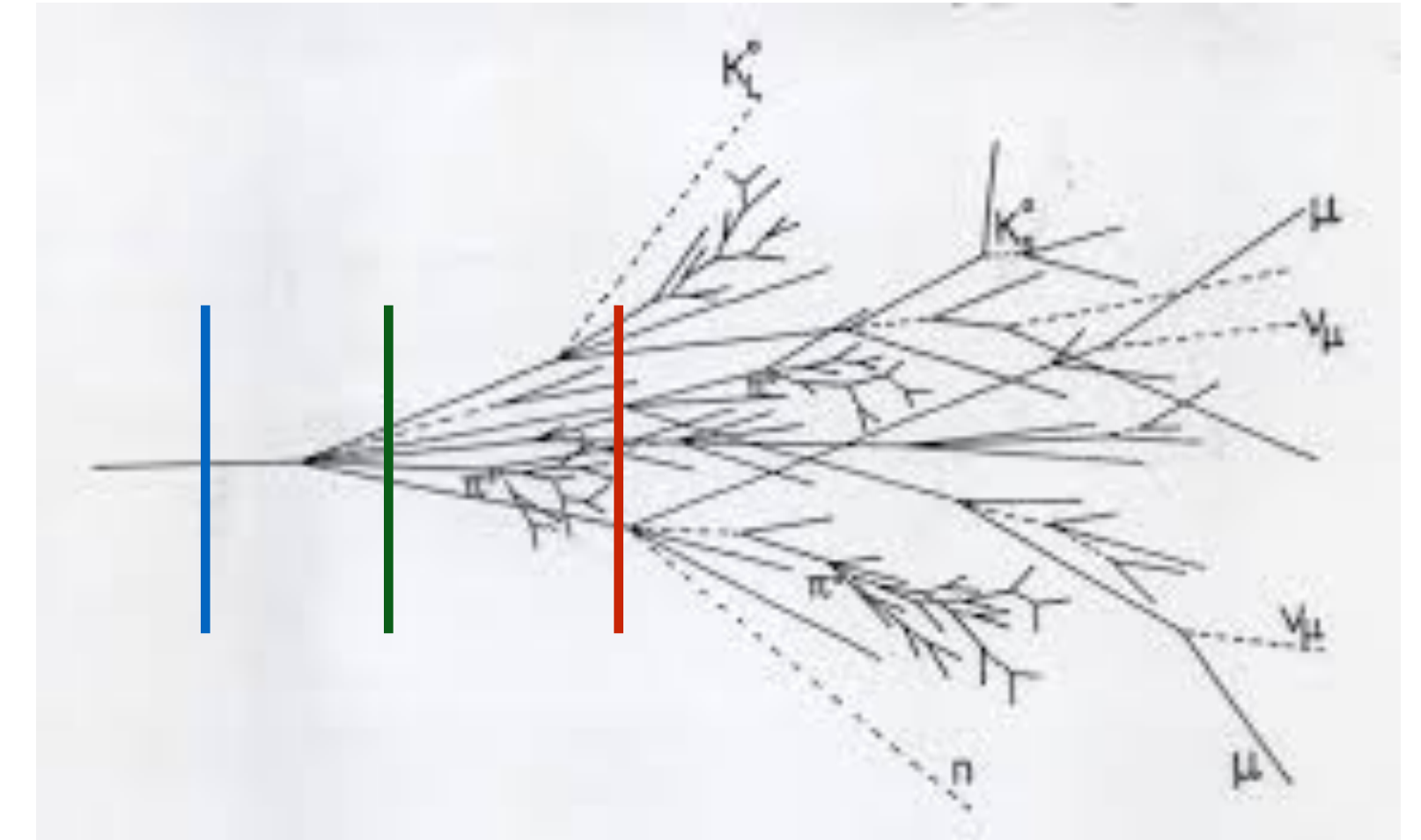
- Assume 10, 50, 100 ps single hit resolution in ECal
- Extrapolate track into ECal, combine time of 10 closest hits
=> “ad hoc” procedure, not optimized!



“When” to measure for best time resolution ?



- “Before” shower: only MIP signal — resolution not optimal ?
- “Early” in shower:
several MIPs /hit and/or several hits / initial particle — better ?
- “Later” in shower: shower propagation itself adds uncertainty to estimate of particle arrival time — worse again ?
- => **What is “early”/“late” quantitatively ? Is there an optimum?**

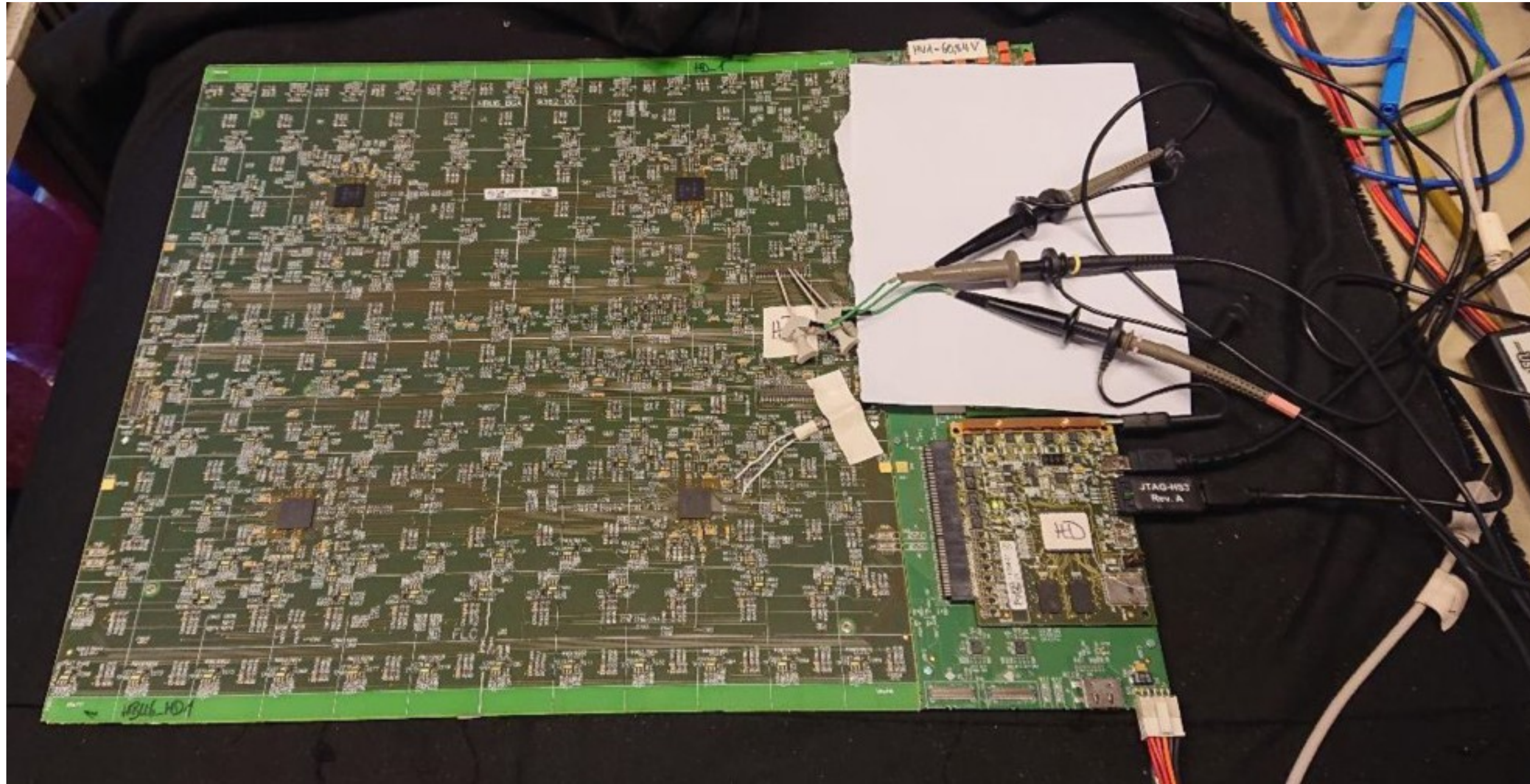


- As extension of QU Project on construction of LGAD layer for pixel telescope (E.Garutti, I.M.Gregor)
- Combine LGAD sensor with Calice ECal absorber stack (available at DESY)
- Measure resolution on arrival time behind different amounts of tungsten!
- **DESY Testbeam: electrons!**
=> **test with electromagnetic showers**
=> **compare to simulation**
- Hadrons (CERN) beyond scope of this project, could possibly be follow-up

Hadronic Calorimeter in the Testbeam



Hadronic Calorimeter Layer in the Lab



TPC & Silicon Tracker in the Testbeam

