FCC-ee

looking for anomalies

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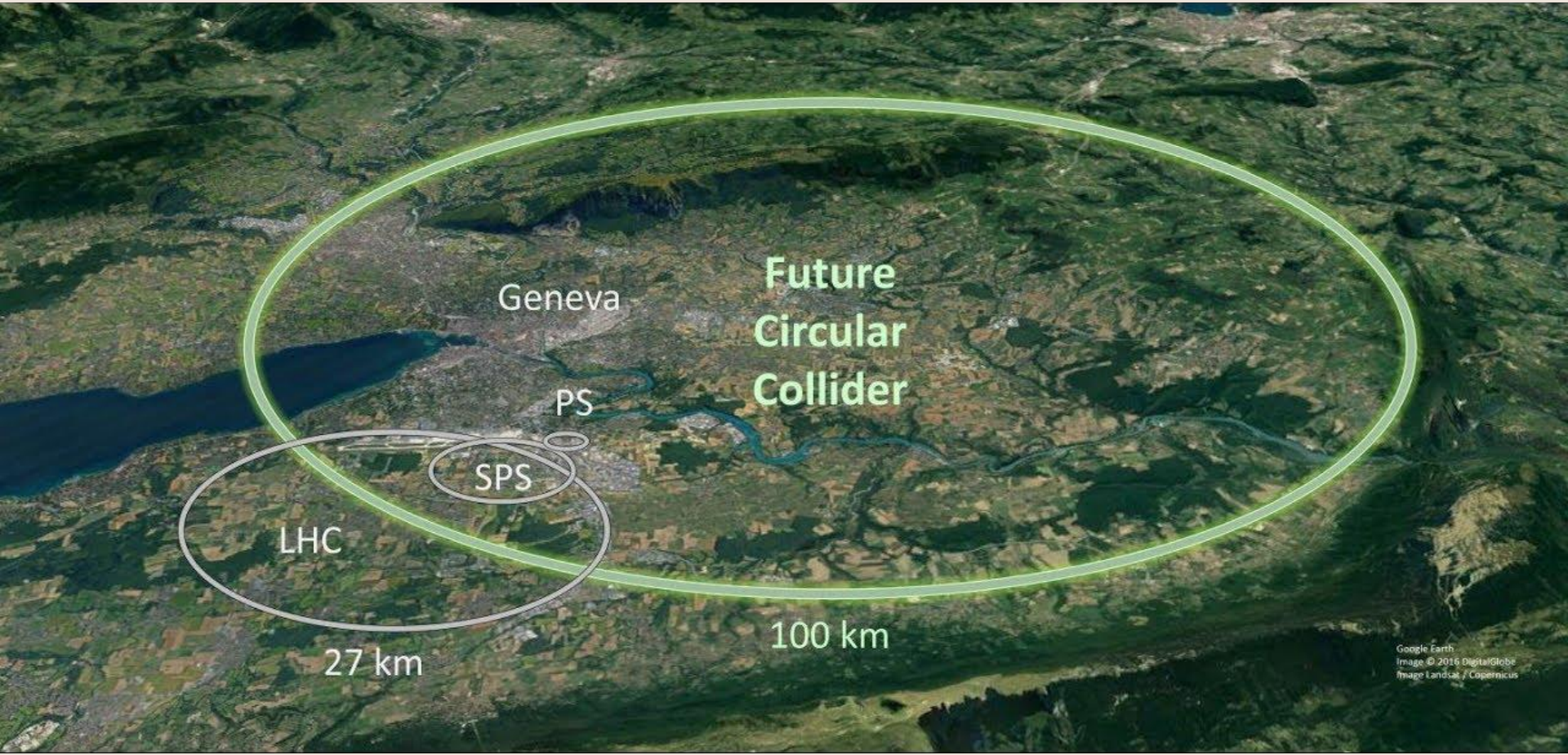
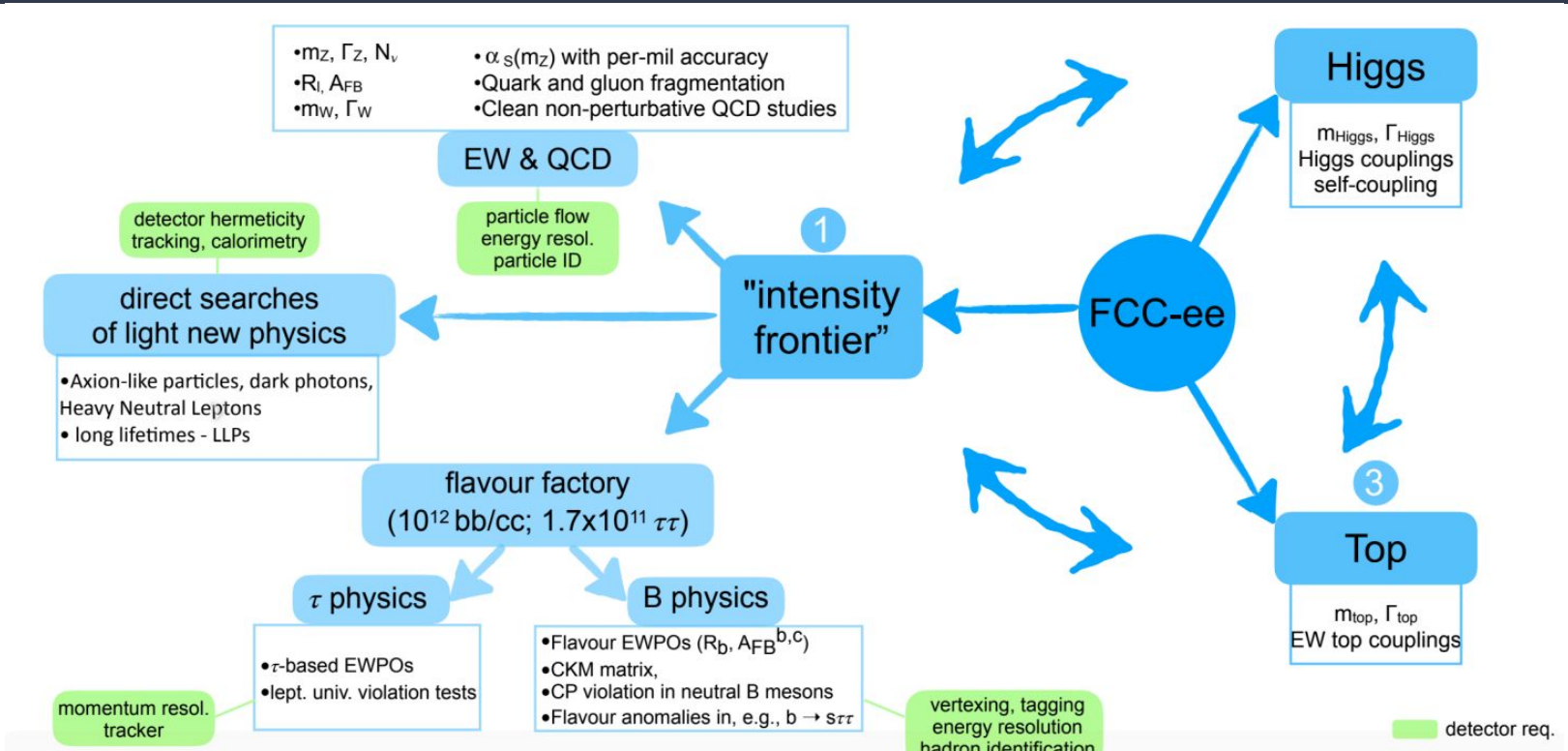
From the CERN website



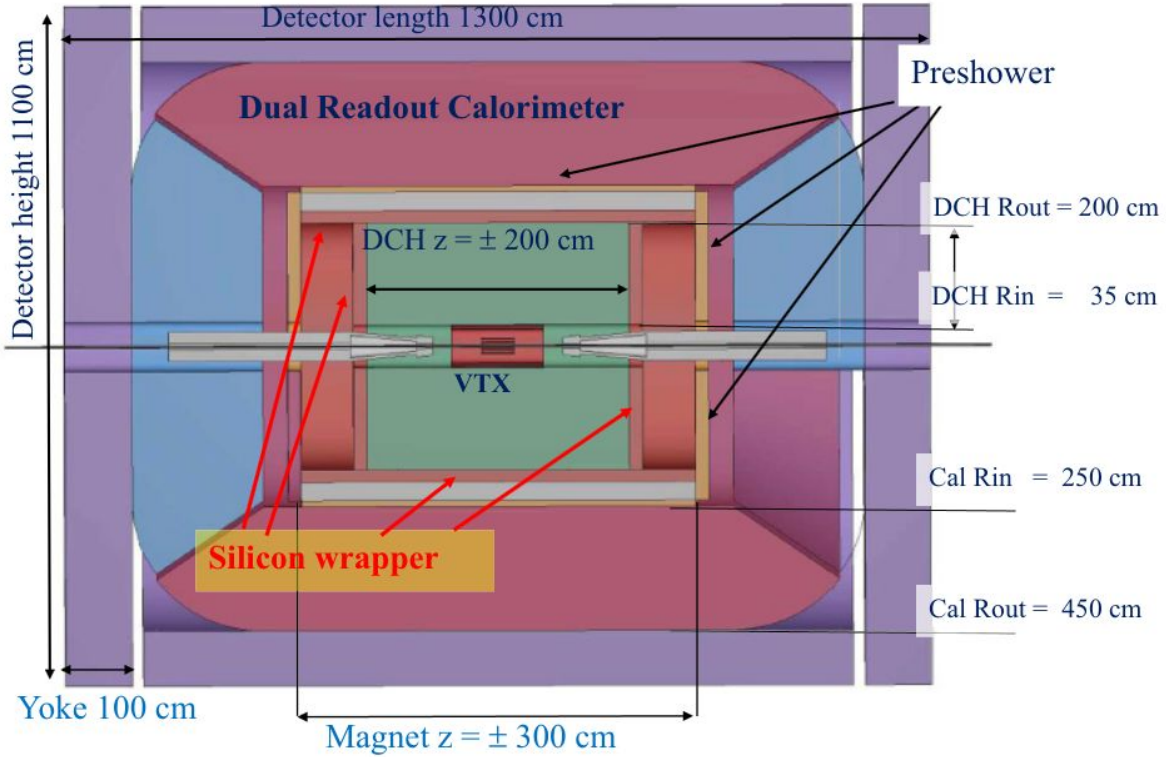
FCC-ee physics program



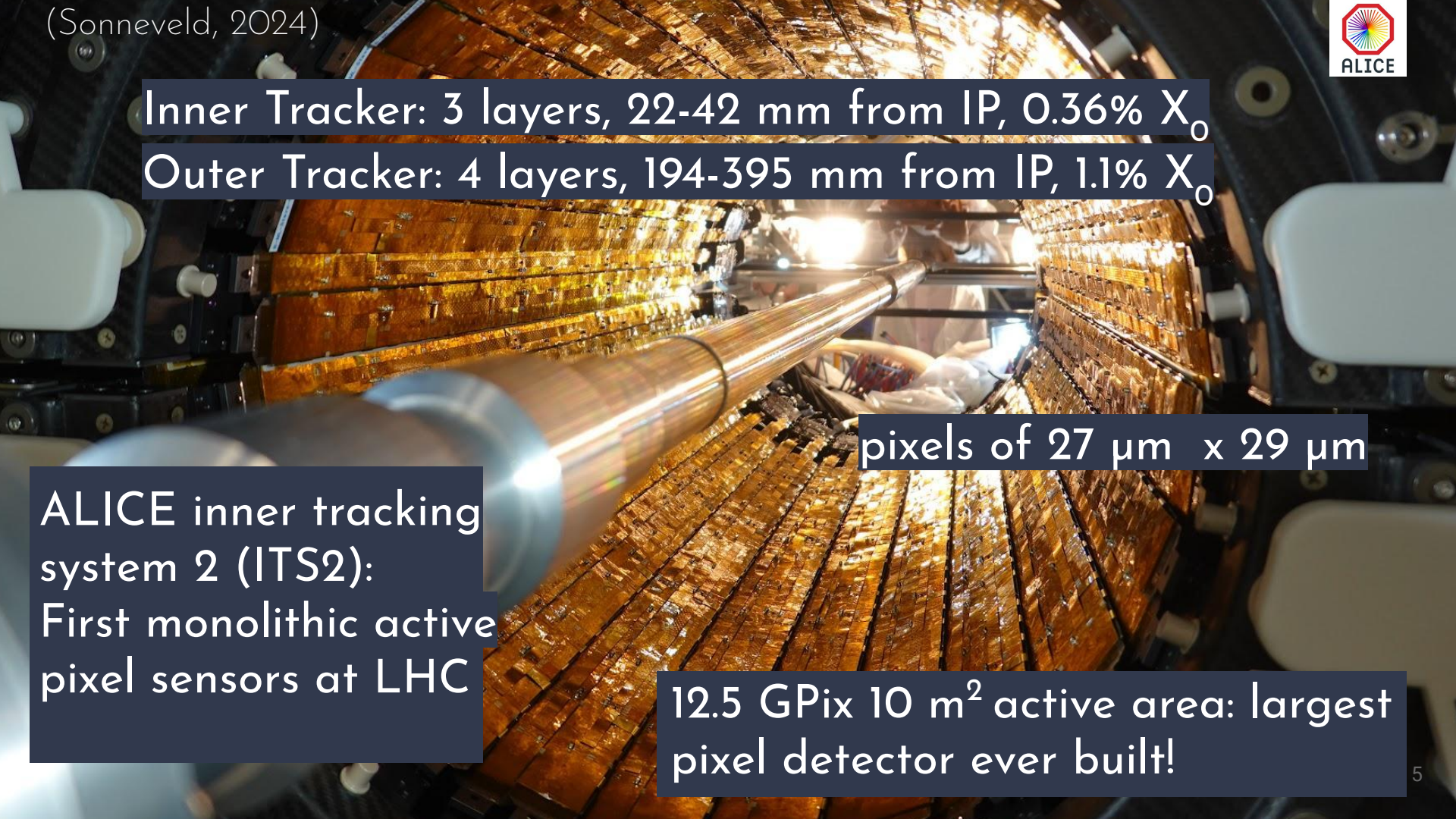
(Sonneveld, 2024)

From the FCC-ee CDR or conceptual design report as opposed to technical design report (TDR)

Example: the IDEA detector



Vertex detector based on: **ALICE ITS upgrade detectors** based on the ALICE PIxel DEtector (ALPIDE): 0.3 (1.0)% X_0 per innermost (outermost) layer and 5 μm resolution


(Sonneveld, 2024)
ALICE
Inner Tracker: 3 layers, 22-42 mm from IP, 0.36% X_0
Outer Tracker: 4 layers, 194-395 mm from IP, 1.1% X_0
pixels of 27 μm x 29 μm
ALICE inner tracking system 2 (ITS2): First monolithic active pixel sensors at LHC
12.5 GPix 10 m^2 active area: largest pixel detector ever built!

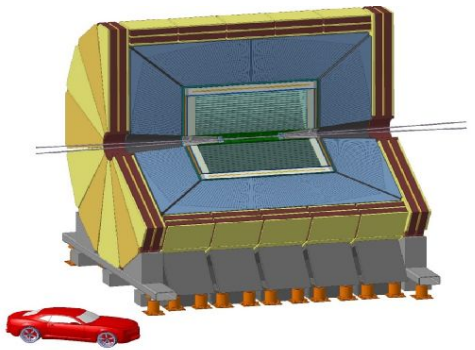
(Sonneveld, 2024)

From the FCC-ee CDR and the 7th FCC workshop

Build on current R&D and existing detectors

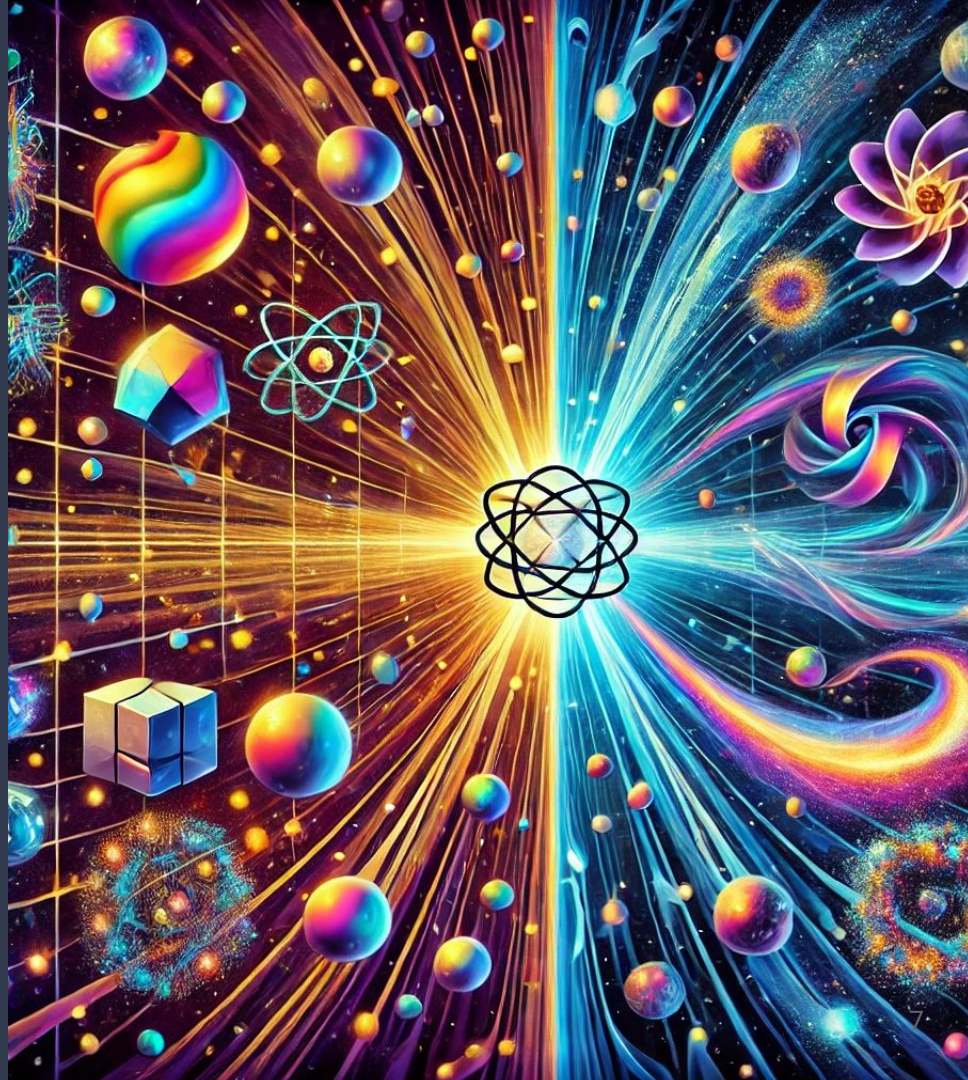
"International Detector for Electron-positron Accelerators" (IDEA):

- **Dual readout calorimeter**
  - Cherenkov and scintillation light
- **Drift chamber for muons**
  - with 1.6% X_0 in radial and 5% X_0 in forward direction
- **Vertex detector based on MAPS**
  - ~5 μm resolution
  - 350 hits per bunch crossing



SM searches

- Higgs physics
- EW precision measurements
- Top physics



(Mogens Dam, 2019)

From Physics at FCC, CERN

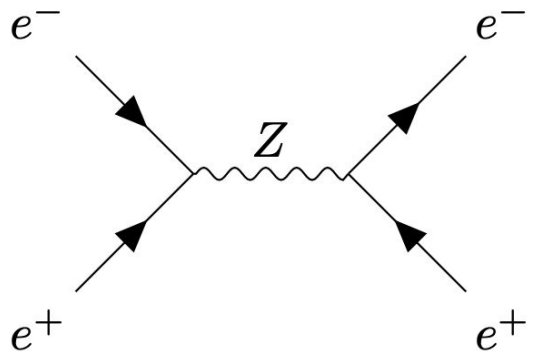
Standard Model Physics

FCC-ee parameters		Z	W^+W^-	ZH	ttbar
√s	GeV	91.2	160	240	350-365
Luminosity / IP	10^{34} cm^{-2} s^{-1}	**230**	28	8.5	1.7
Bunch spacing	ns	19.6	163	994	3000
"Physics" cross section	pb	40,000	10	0.2	0.5
Total cross section (Z)	pb	40,000	30	10	8
Event rate	Hz	**92,000**	8,400	1	0.1
"Pile up" parameter [μ]	**10^{-6}**	1,800	1	1	1

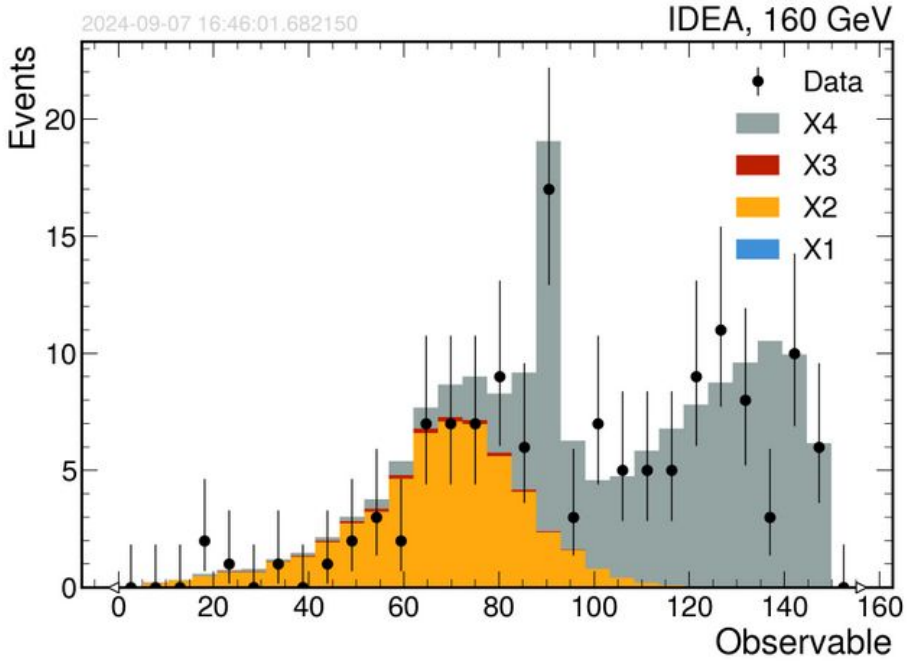
√s=91 GeV: Z production

Requirements for final state:

- 2 electrons
- $p_{T,e}$ > 25 GeV



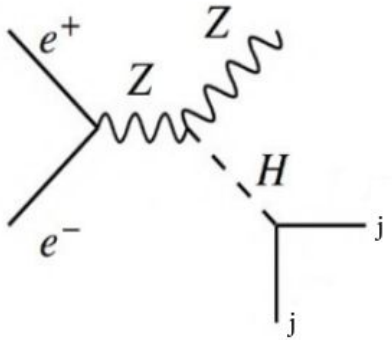
Observable: $m_{inv}(ee)$



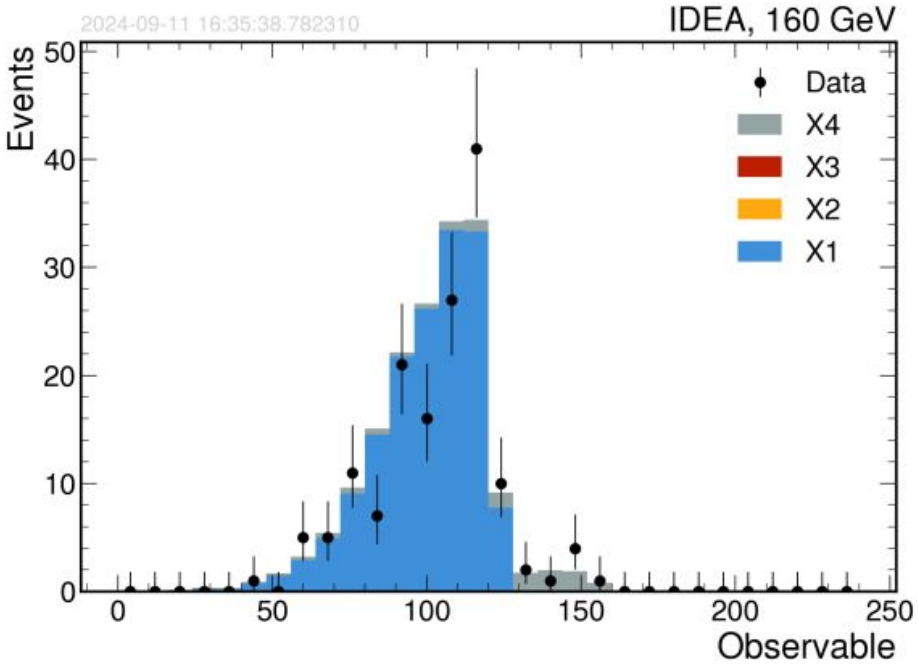
√s=160 GeV: H production

Requirements for final state:

- ≥ 2 b-jets



Observable: $m_{inv}(jj)$

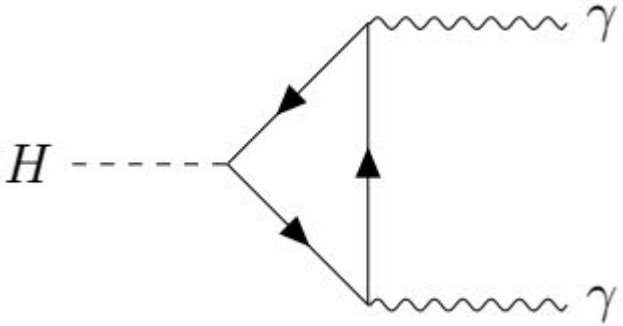


Mass of Higgs boson

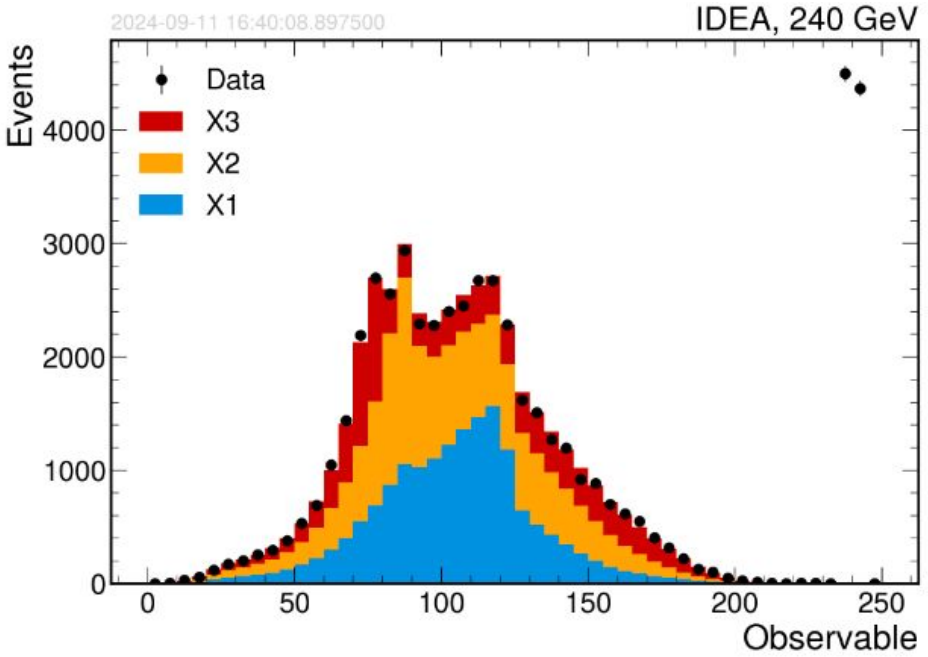
√s=240 GeV: H (and Z) production

Requirements for final state:

- ≥ 2 photons



Observable: $m_{inv}(\gamma\gamma)$

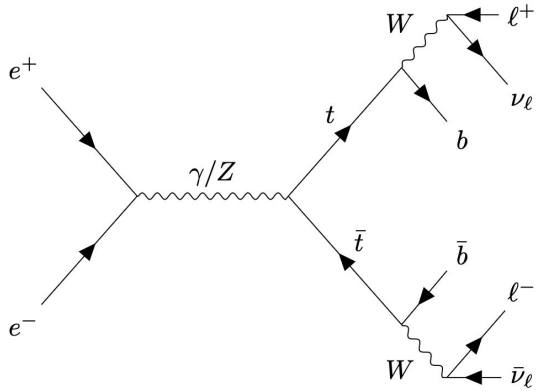


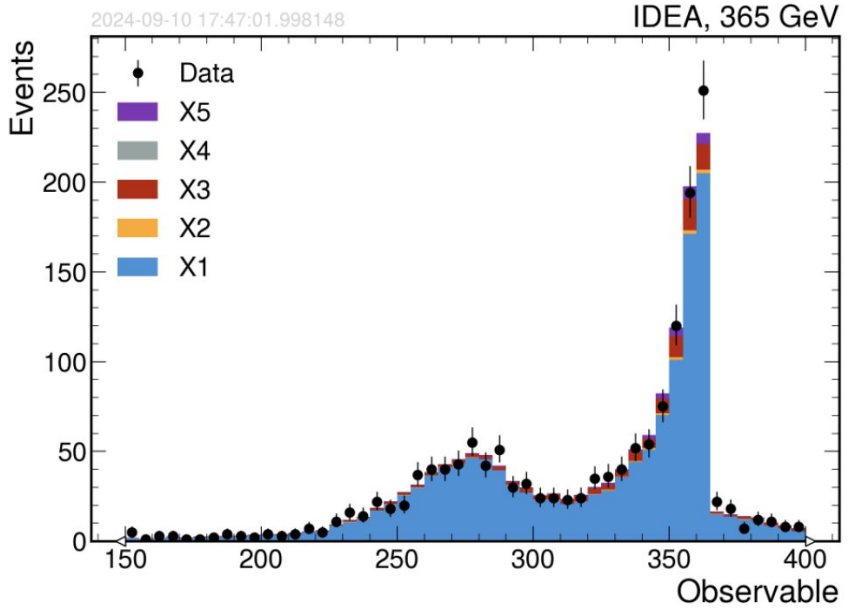
Invariant mass of 2 photons

√s=365 GeV: ttbar production

Final state selection:

- Two b-tagged jets (>0.7)
- Two leptons



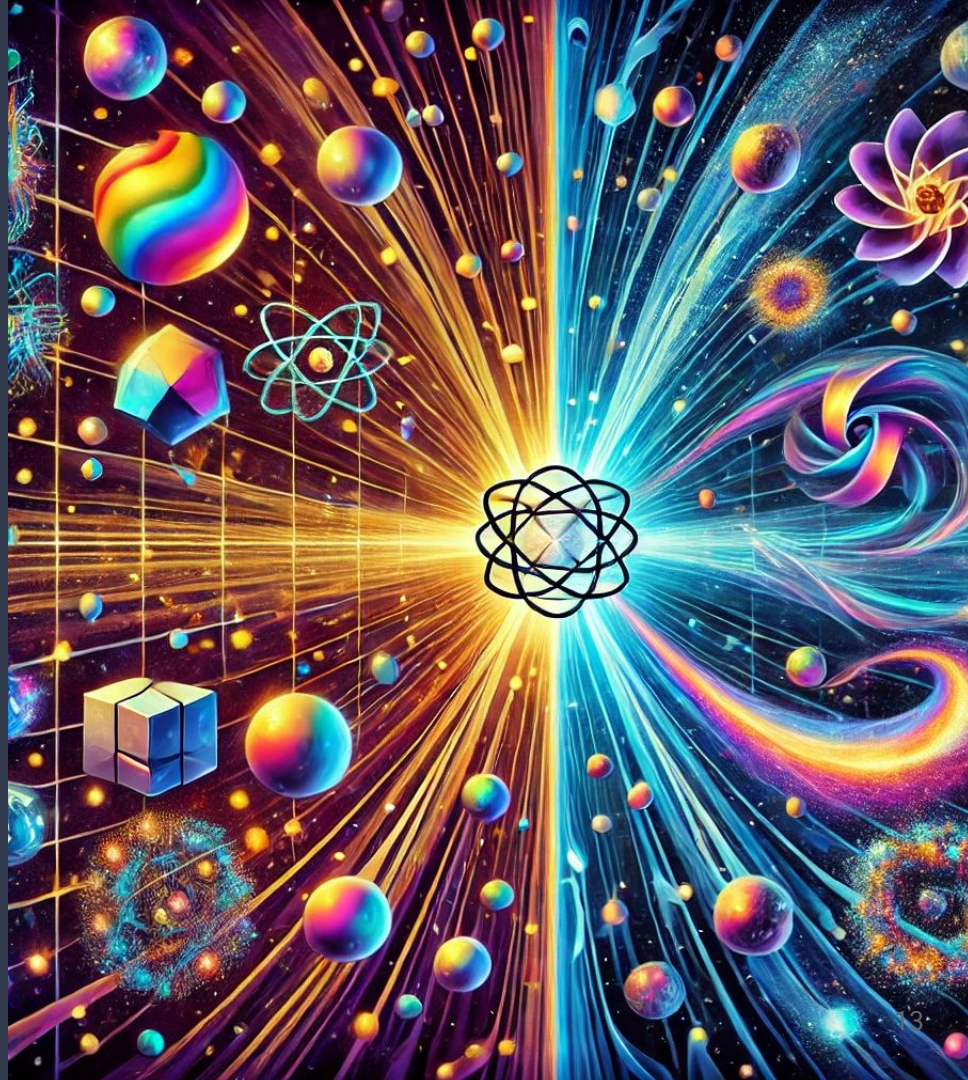


Mass top-quark pair

Invariant masses of the 2 jets, 2 leptons and of the missing transverse energy

BSM searches

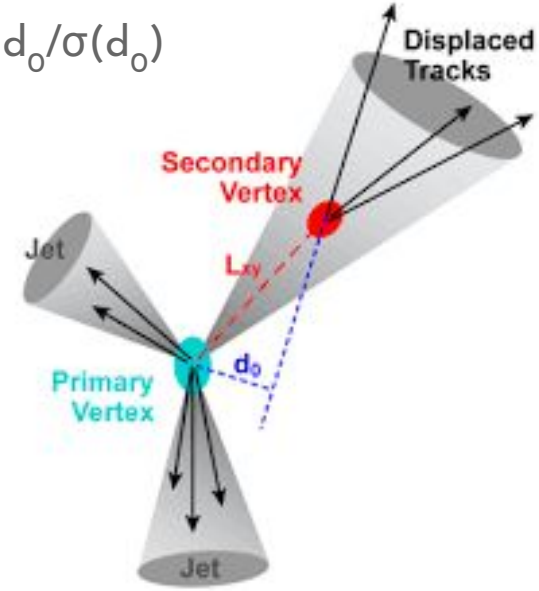
- Heavy Neutral Leptons (HNLs)
- Axion-like Particles (ALPs)
- BSM Higgs physics

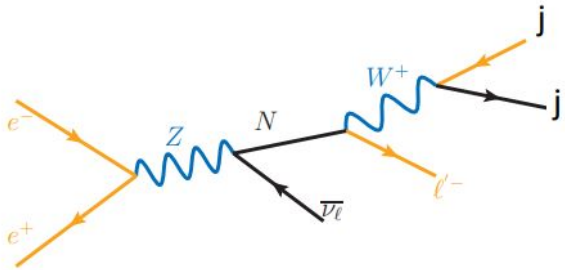


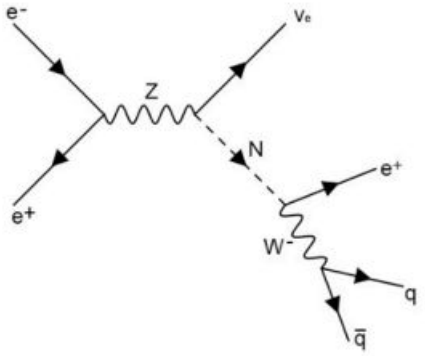
√s=91 GeV: long-lived New Physics– intro

Observable: d_0 significance; $m_{inv}(e, \mu)$:

$S(d_0)=d_0/\sigma(d_0)$



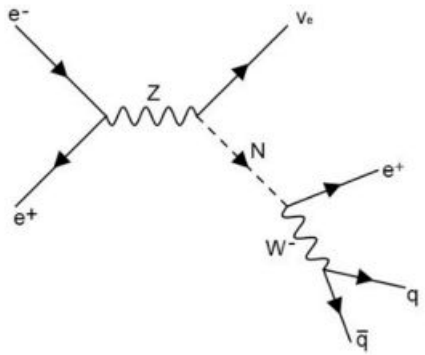




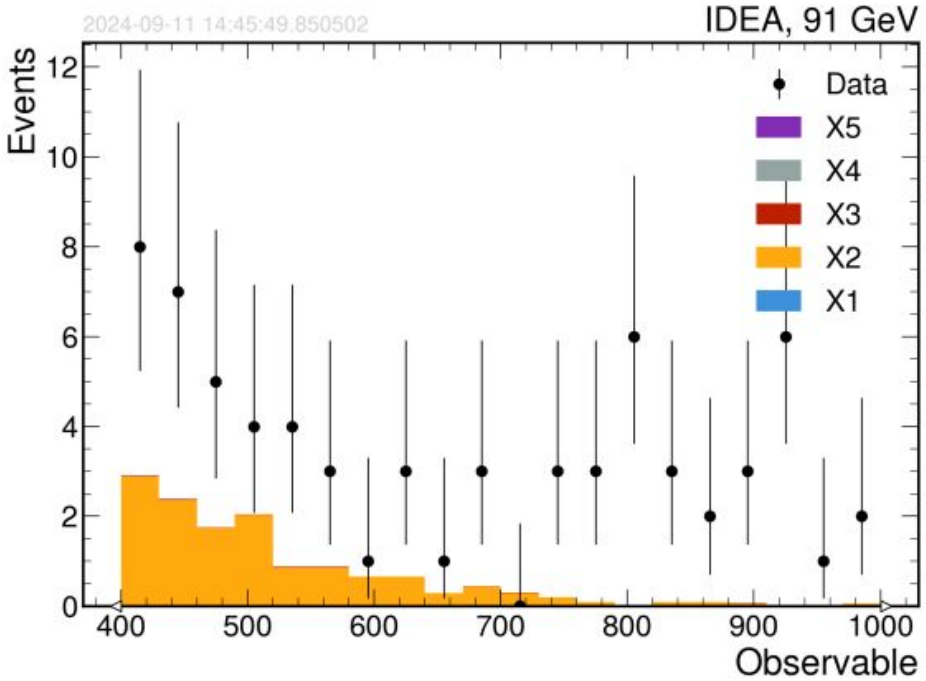
√s=91 GeV: long-lived Heavy Neutral Leptons

Restrictions for the final state

- 1 e or 1 μ



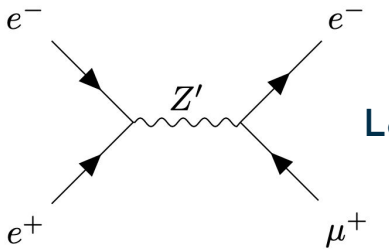
Observable: d_0 significance: $d_0(e, \mu)$



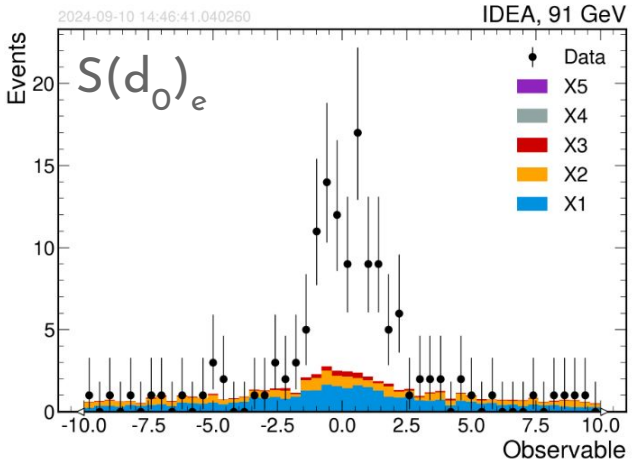
√s=91 GeV: Z' search

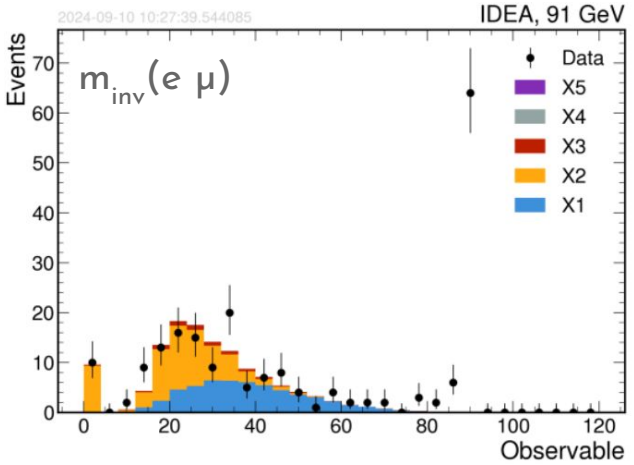
Restrictions for the final state: 1 μ & 1 e

Observable: d_0 significance; $m_{inv}(e\ \mu)$



Lepton Flavor Violation!

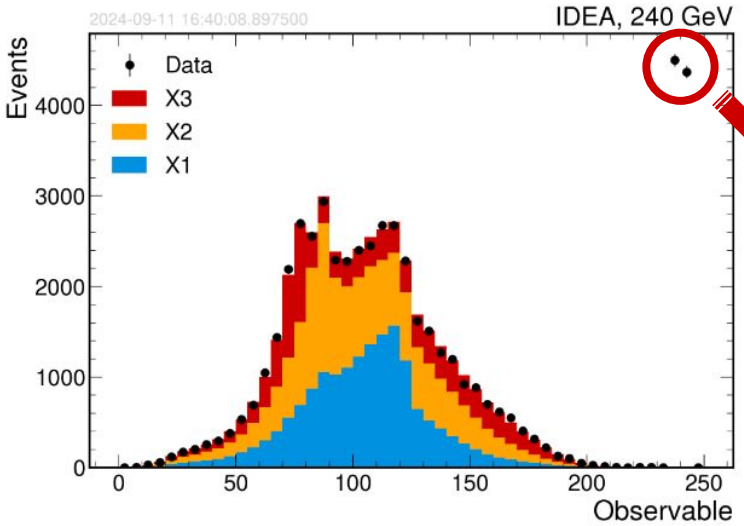




√s=240 GeV: H (and Z) production

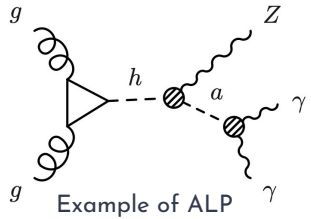
Requirements for final state:

- ≥ 2 photons



Invariant mass of 2 photons

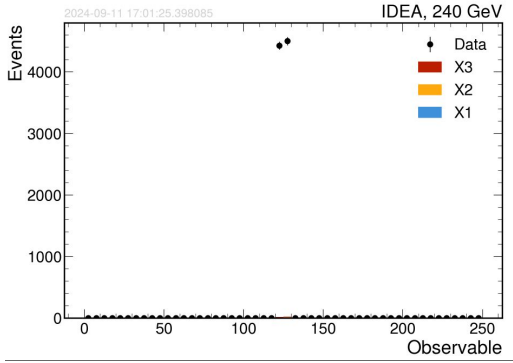
It is an ALP !!!



Example of ALP

Requirements for final state:

- ≥ 2 photons with pt>20GeV
- Invariant mass of 2 photons>200GeV



Invariant mass of missing energy transverse

Coming from the decay of the particle that is produced at the same time as the ALP

FCC-ee looking for anomalies
Conclusion

- Z and ttbar production studied
- Additional cuts are needed to reconstruct (more precisely) the Higgs, WW and ZH
- New physics was discovered at 91GeV

Lepton flavour violating Z′ (90GeV)

Hints of displacement in lepton pairs (HNL?)

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