Z+ττ analysis

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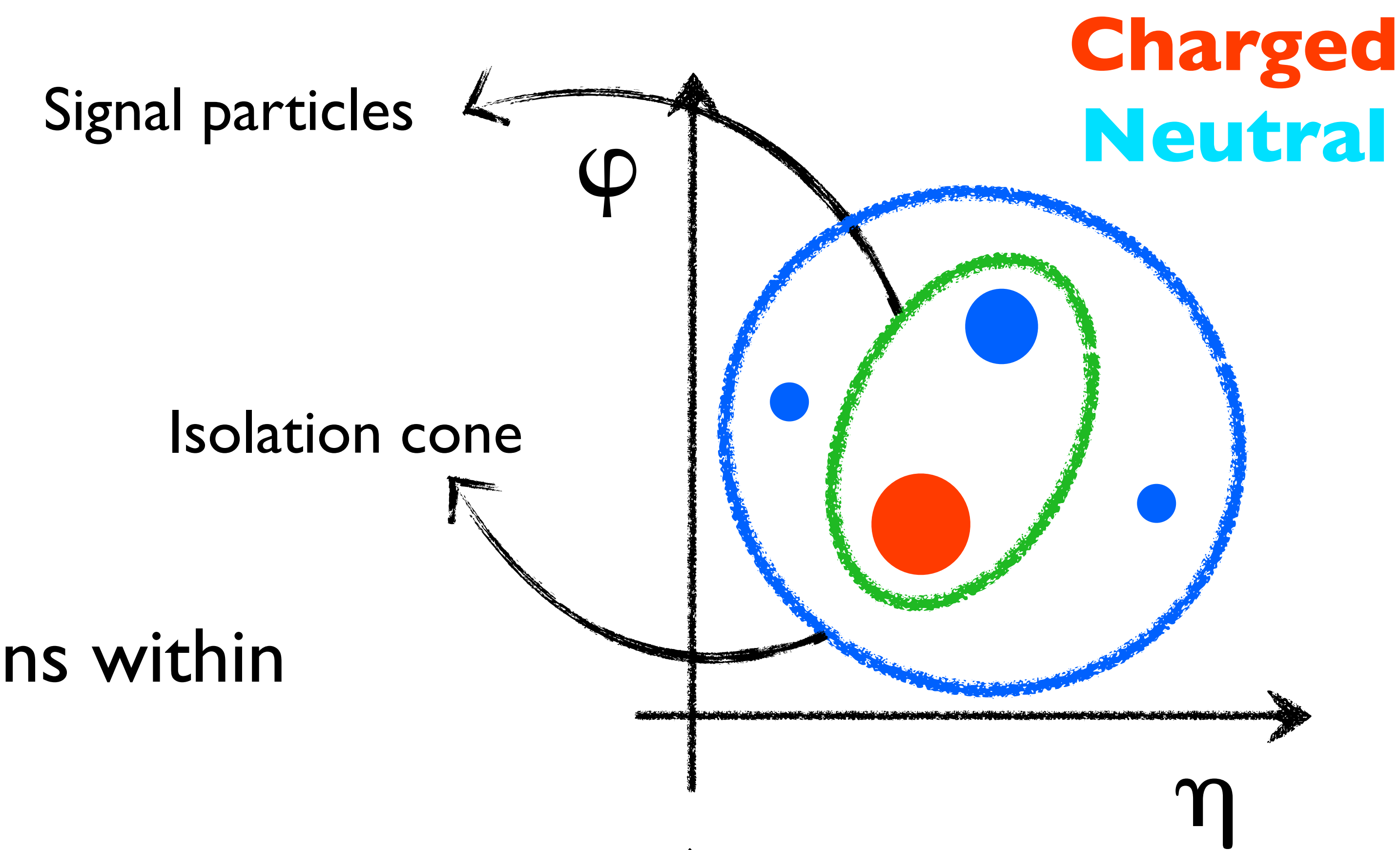
A Two Higgs Doublets Model

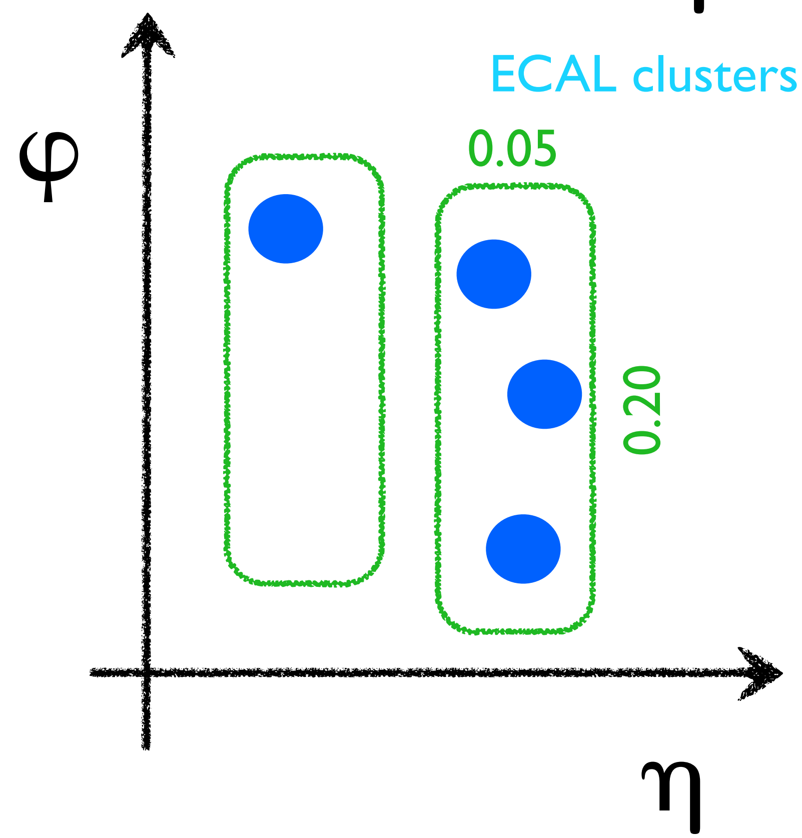
- SM Higgs scalar sector enlarged with an additional $SU(2)_L$ doublet:
  - A peculiar interplay of CP and custodial symmetries leads to the invariant scalar potential
    - $V = - m_1^2\varphi_1^\dagger\varphi_1 - m_2^2\varphi_2^\dagger\varphi_2 + \lambda_S/2(\varphi_1^\dagger\varphi_1 + \varphi_2^\dagger\varphi_2) + \lambda_{AS}/2(\varphi_1^\dagger\varphi_2 - \varphi_2^\dagger\varphi_1)$
  - with 4 free parameters:
    - m_h - mass of the SM-like higgs boson h^0
    - m_T - mass of the degenerate triplet $(H^\pm, H^0)$
    - m_A - mass of the pseudoscalar boson A^0
      - One of possible mass hierarchies: $m_A^2 < m_T^2 < m_h^2$
    - $\tan\beta$ (Higgs doublets VEVs ratio)
      - which rescales the non-SM bosons interactions
- Unconventional processes arise, interesting for collider physics
  - $h^0 \to A^0A^0, H^0H^0, H^+H^-$
  - $H^\pm \to W^\pm A^0$
  - $H^0 \to ZA^0$, the sought one, possibly with $m_A \lesssim 100$ GeV
- More about this on arXiv:0904.0705v2

Hadron Plus Strip

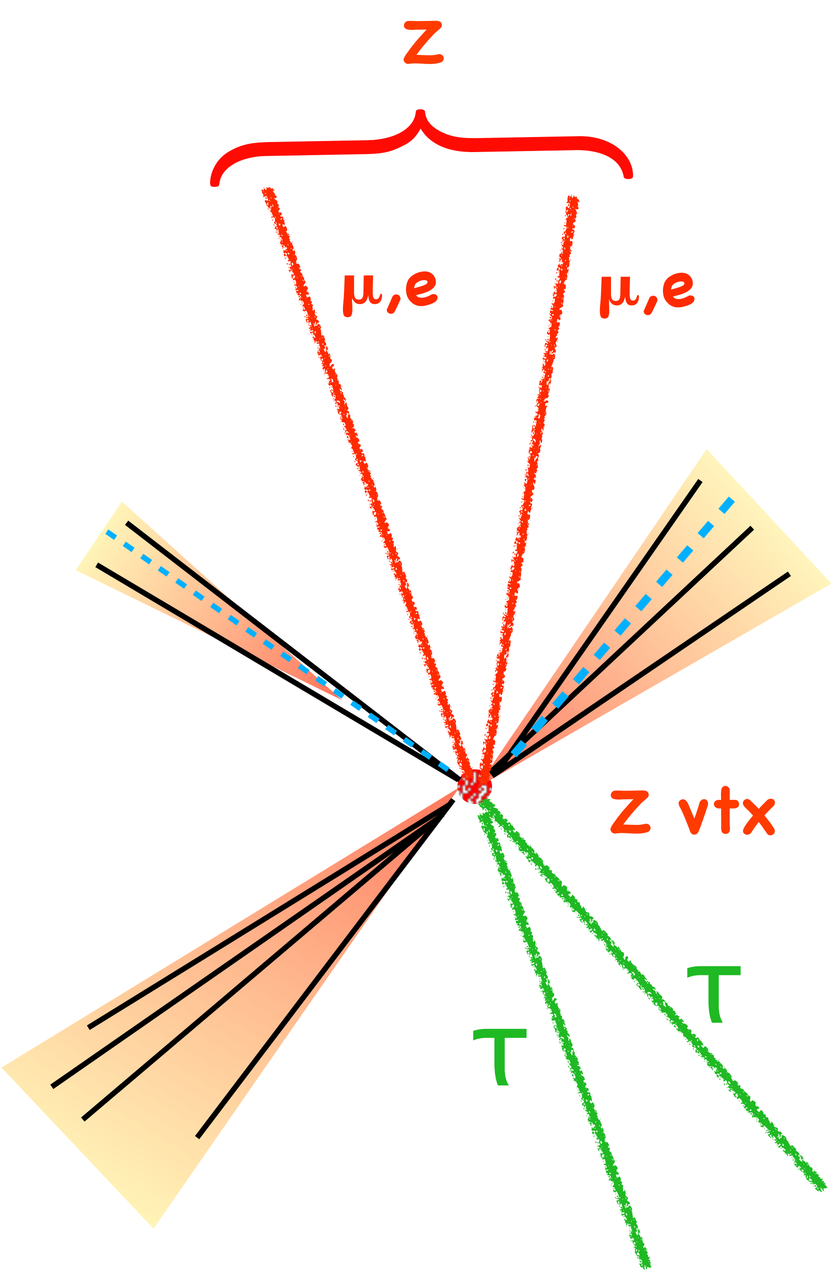
Two main features:

- Decay Mode Finding:
    - Builds all possible combinations within (π,$\pi\pi^0$,$\pi\pi\pi$)
    - Chooses among them the most isolated with compatible visible mass
- π^0's are formed summing clusters in a strip along φ.





Event Topology



- EW part: a pair of same type, opposite sign leptons (e or μ)
- EW(?) part: opposite sign taus:
  - τ_μ τ_e: cleanest channel available, but low statistics
  - τ_{had} τ_μ: large statistics and good purity, the most interesting one
  - τ_{had} τ_e: same statistics as the previous, but much lower purity
  - τ_{had} τ_{had}: probably hopeless due to problems in treating collinear taus and very large backgrounds.

Analysis strategy

The analysis shares the same final state of ZZ→2l2τ and therefore we plan to use that analysis as a benchmark

Main differences:

- If $m_A \sim m_Z$ the analysis turns out to be a ZZ cross section measurement with limits on ZA^0 process
  - then we'll begin scanning the low-m_A range
- The mass hierarchy hints we may have a very boosted A^0 which would turn into very collimated taus (up to the collinearity). Therefore we implemented a strategy that allows us to identify and select taus even in the collinear case
- In case the whole system is light we have to push our tau identification to lower pt (and of course no visible mass window required)

(Roughly) the analysis step by step:

- We select a pair of opposite sign loosely isolated leptons
- We require that the two leptons originated from the same vertex and we apply some quality requirements to it
- We identify one or two other leptons originating from the same vertex of the previous two
- If hadronic taus are needed we build them masking the third lepton (the one not forming the Z)
- We correct the isolation of the candidates taking into account the effects of possible collinearity

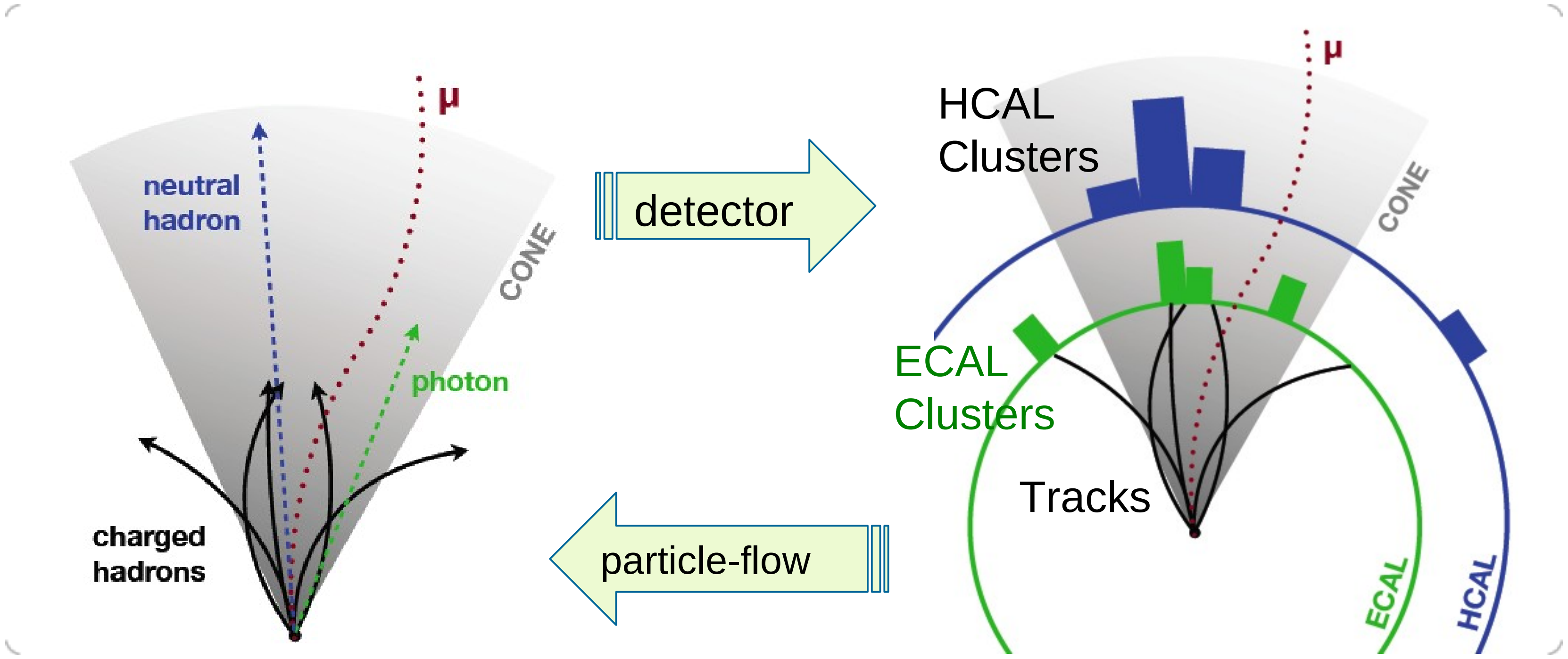
Backup

Characteristics of tau decay

- Tau is the heaviest (known) lepton
  - Mass: 1.78 GeV
  - $c\tau = 87\ \mu m$
- Electroweak decay, with neutrinos
- It decays into other leptons (~17% μ,e)
- It mainly decays into hadrons (usually π's)
- Jets from tau decays are collimated due to large boost.
- Tau jets can be identified due to low detector activity around decay products

Particle Flow

- Particle Flow (PF) is an algorithm that gives a complete description of the event
- Links all the signals from different subdetectors
- produces a list of particle candidate (e, μ, γ, hadron)
- Taus are built from PF objets



Collinear taus handling

Several tricks to treat collinear taus ($\Delta R \lesssim 0.5$) correctly

- Tau Building:
  - Problem: the hard lepton coming from one tau may spoil several steps of the hadronic tau building process.
  - Solution: to avoid any bias the lepton is removed from PF collection and the jets and taus are built again
- Measuring isolation:
  - Is the key tool to discriminate signal from background
  - Problem: if constituents coming from different taus are too close they may spoil each other isolation.
  - Solution:
    - hadronic tau need no correction since correctly treated in building
    - isolation of leptons are corrected for other signal particles within isolation cone