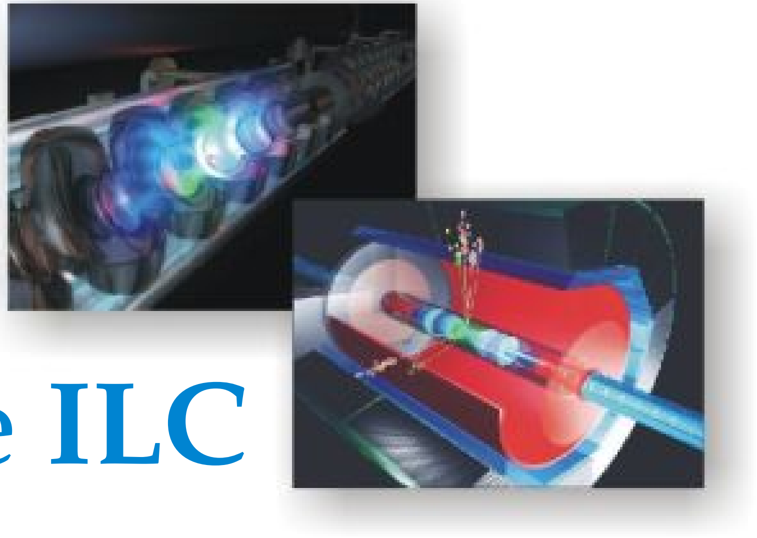

H → ssbar in the **ILC**

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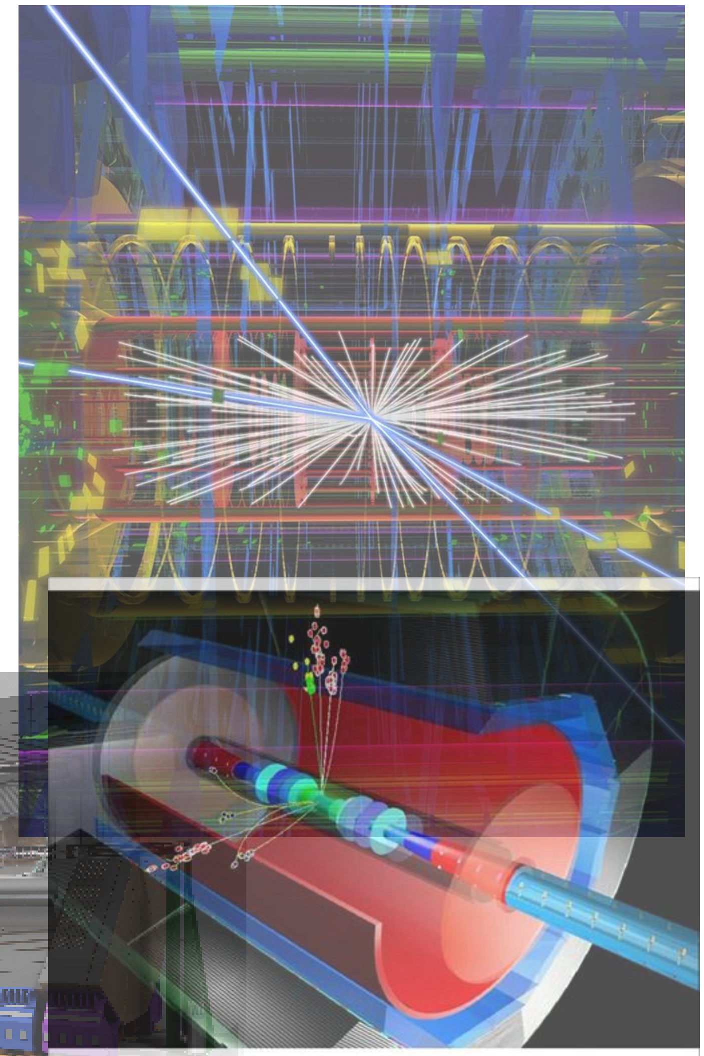
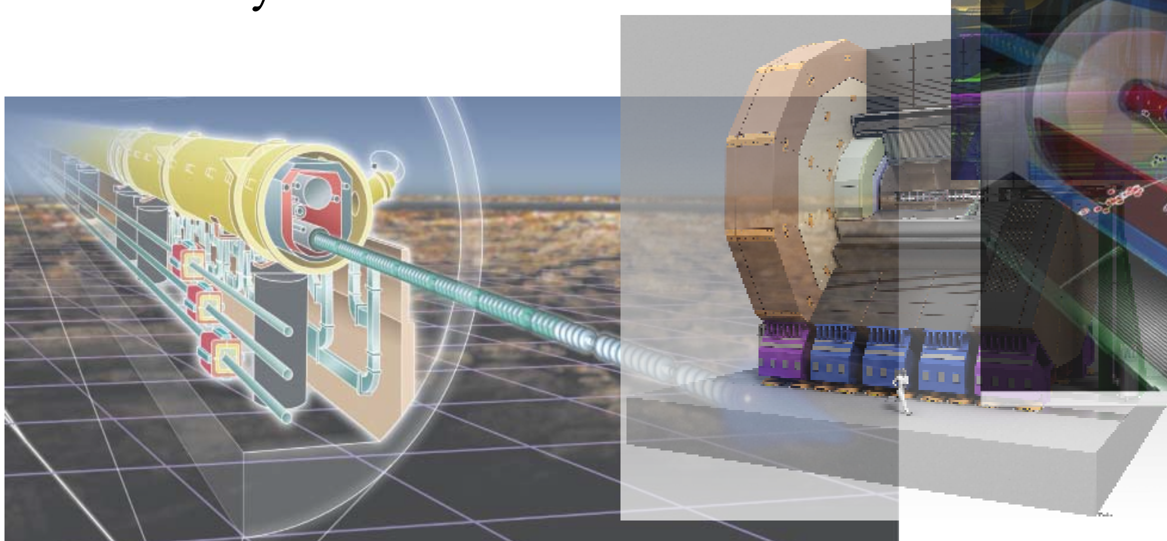
29th FCAL collaboration Workshop

Outline

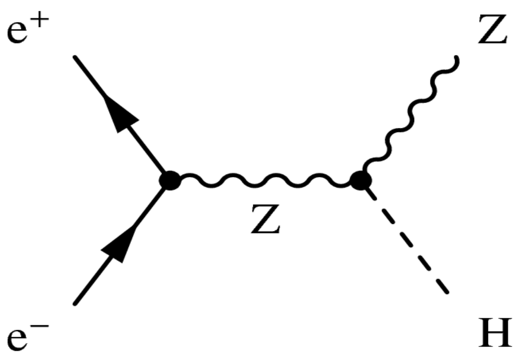
- Introduction
- Tagging s-quarks at ILC
- Higgs to ssbar analysis
- Simulation studies and results
- Summary and conclusions



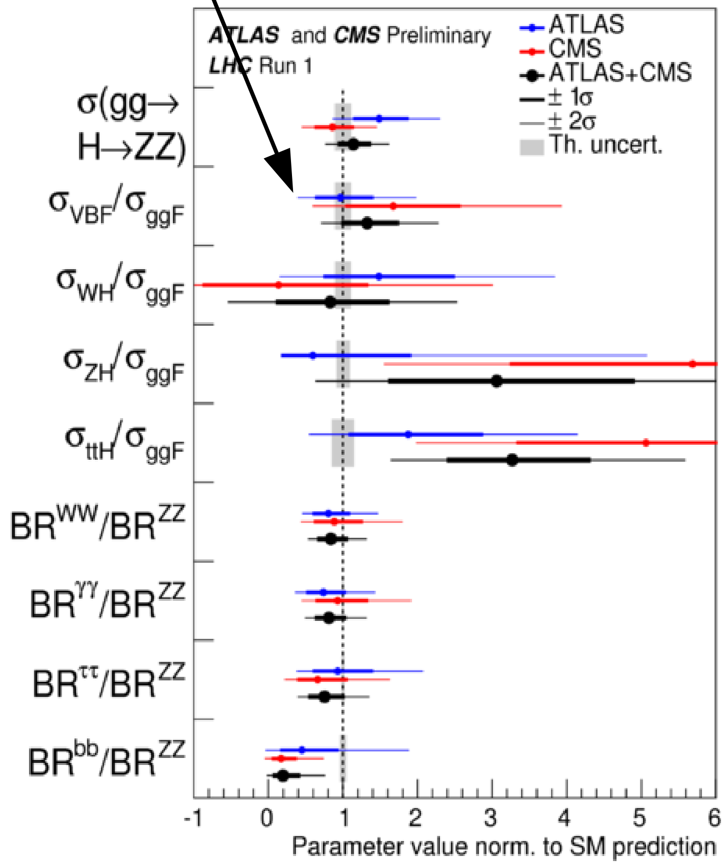


Introduction

- 2012 ATLAS and CMS discovered a new mass resonance… measured properties so far are largely consistent with the (SM) Higgs boson
  - spin, parity, cross-sections, couplings. …
- High-precision measurements: an electron-positron collider (ILC, for instance)
  - In particular at $\sqrt{s}$ = 250 GeV, the Higgsstrahlung process provides a clean experimental environment to make absolute measurements of Higgs couplings



ATLAS-CONF-2015-044



Introduction (II)

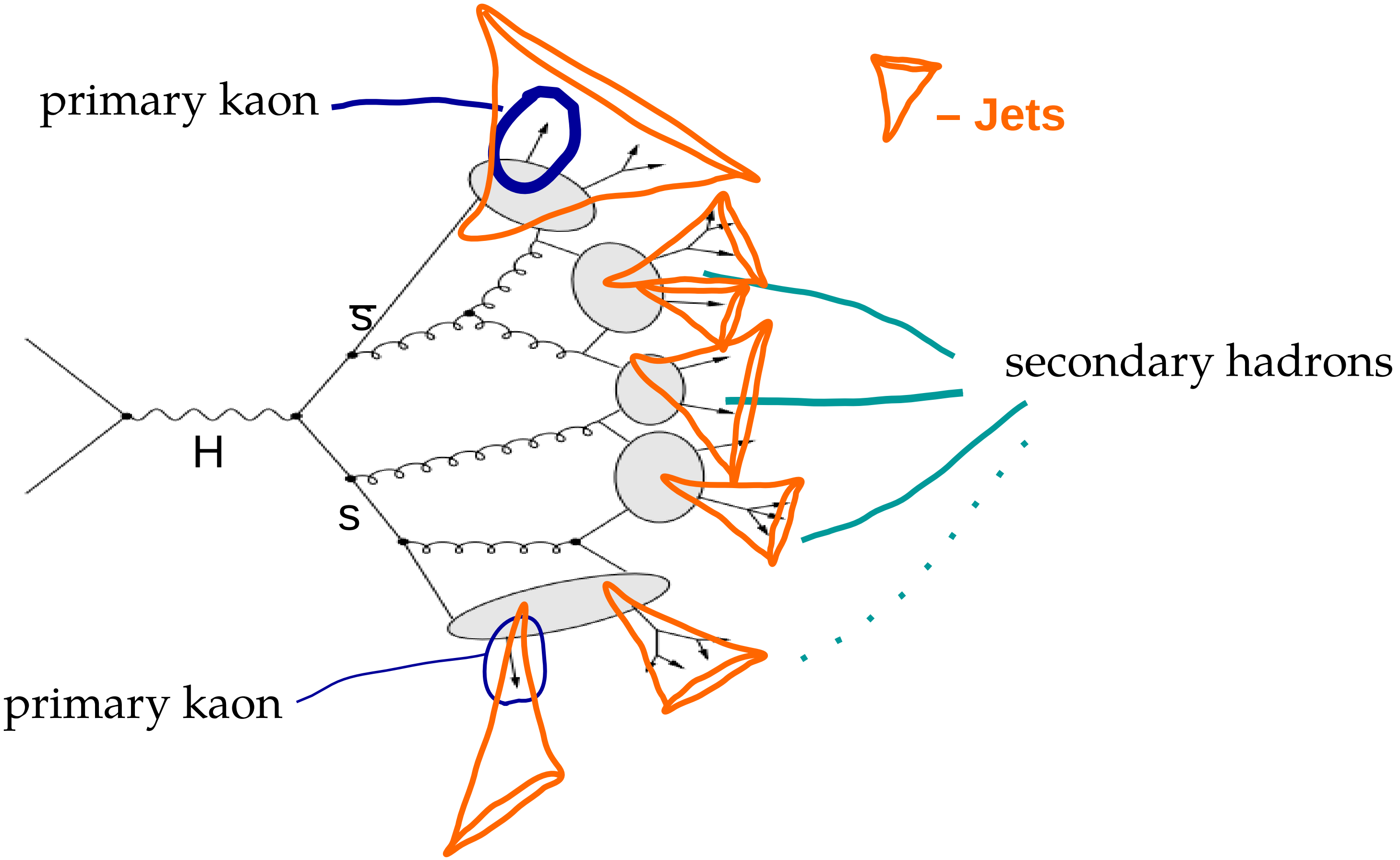
- Higgs mechanism behind the fermion masses?
  - not verified yet, especially for the first two generations [http://arxiv.org/abs/1508.01501]
- A suitable measurement: BR(H → ssbar)
  - helpful to test new-physics models, but very challenging!
    - small branching ratio (≈ 10^{-4}) and huge background from QCD dijet events
  - LEP and SLD detectors performed the equivalent Z → ssbar measurements by tagging s-quarks.
    - however, $Z \to s\bar{s}$ much larger than $H \to s\bar{s}$

	HL-LHC @3000 fb^{-1}	ILC @250 fb^{-1}
$\frac{\Delta\sigma \cdot BR}{\sigma \cdot BR}(H \to b\bar{b})$	13 %	1 %
$\frac{\Delta\sigma \cdot BR}{\sigma \cdot BR}(H \to c\bar{c})$	N/A	7 %
Number of Higgs produced	170 M	150k

Table extracted using ILC Higgs White paper (http://arxiv.org/pdf/1310.0763.pdf)
Prospects for Higgs physics at energies up to 100 TEV (http://arxiv.org/pdf/1511.07853v1.pdf)
and http://arxiv.org/pdf/1509.08721v1.pdf

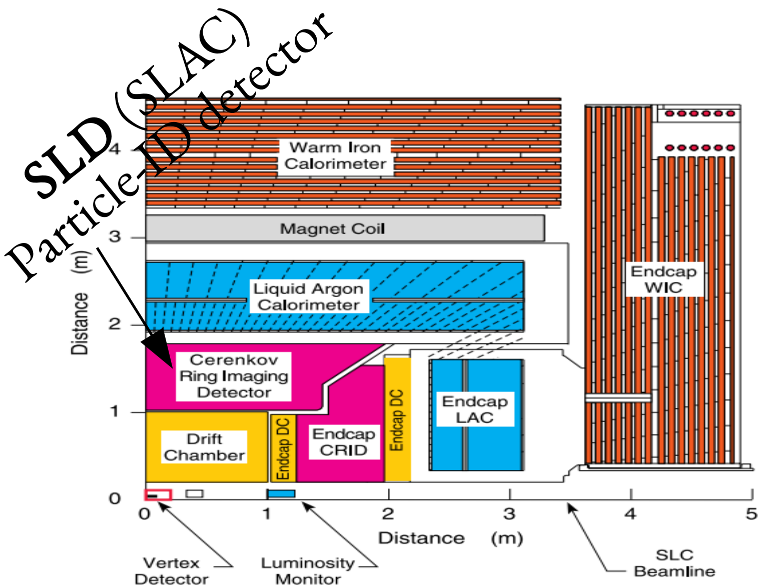
Tagging s-quarks at ILC

- Main idea: measurement of H → ssbar cross-section by tagging strange-quark jets with hard strange hadrons: kaons (K^0_S, $K^{\pm}$) o lambdas (Λ_s)



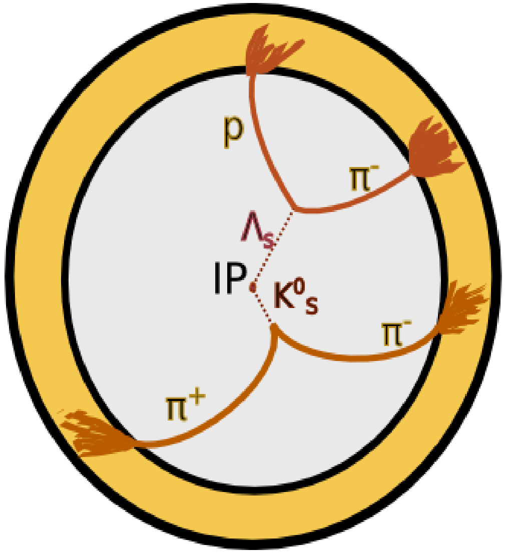
Tagging s-quarks at ILC (II)

use a particle-ID detector to identify **charged-kaons** $K^{\pm}$



- easy to identify H->cc and H->bb background
- increases overall detector size
- increase detector cost

reconstruct the decay signatures of the K^0_S and Λ_s



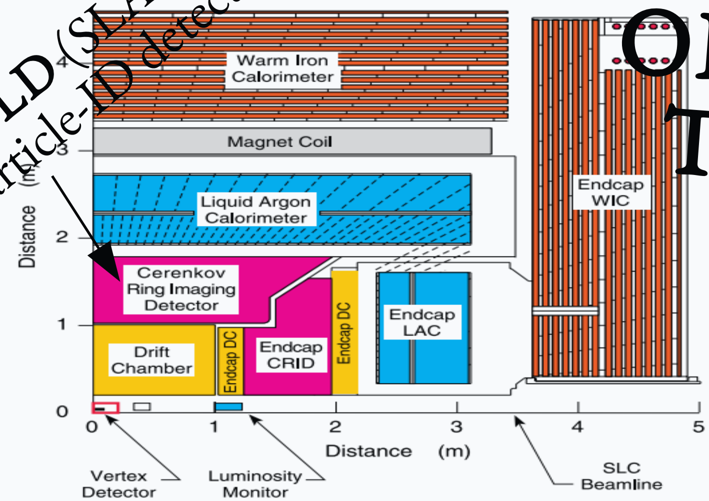
- uses tracker detector
- many K_S and Λ decay outside the tracker
- difficult to remove cc/bb background (bad pointing accuracy to the b/c vertex)

Tagging s-quarks at ILC (II)

use a particle-ID detector to identify **charged-kaons** $K^{\pm}$

THE FOCUS OF THIS TALK!

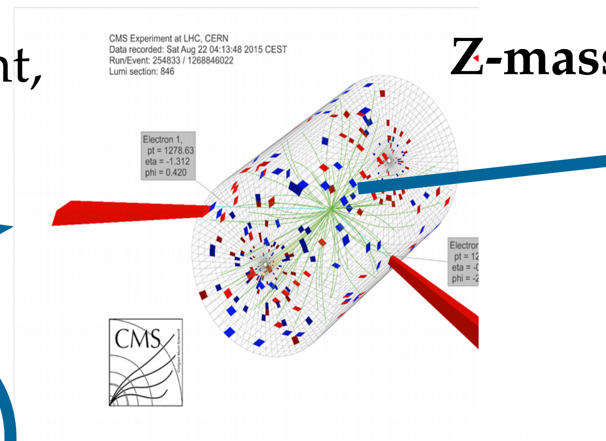
SLD (SLAC)
Particle-ID detector



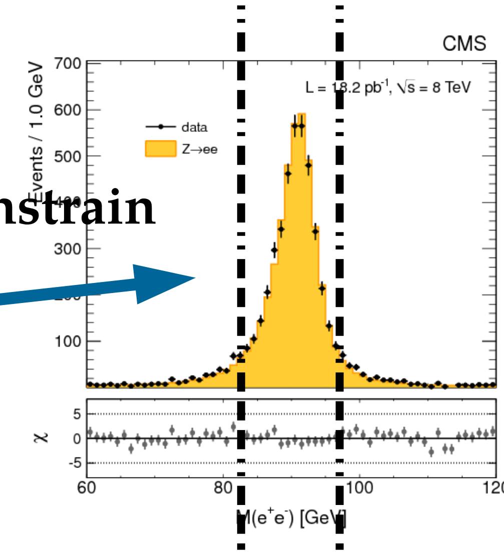
- easy to identify H->cc and H->bb background
- increases overall detector size
- increase detector cost

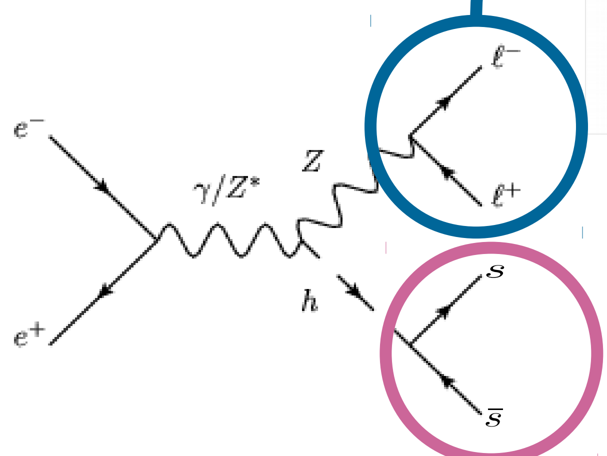
Higgs to ssbar analysis

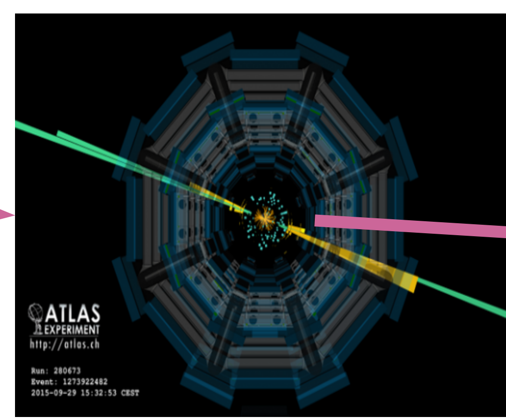
1. Identify an ee->HZ event,

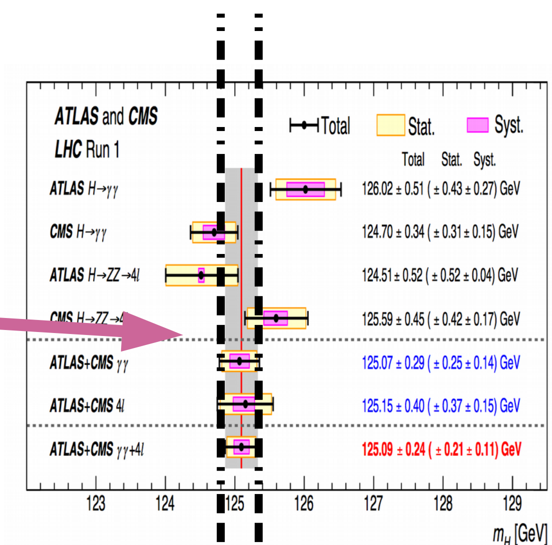


Z-mass constrain





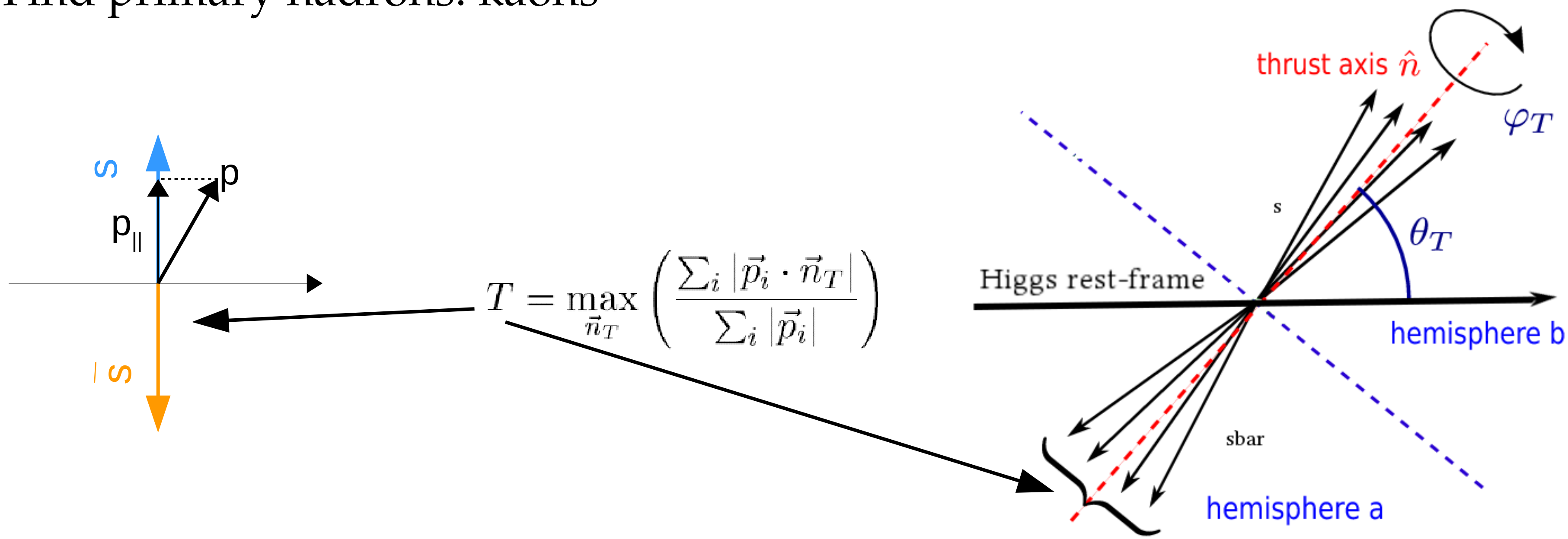




Higgs-mass for the recoiled dijet system

Higgs to ssbar analysis (II)

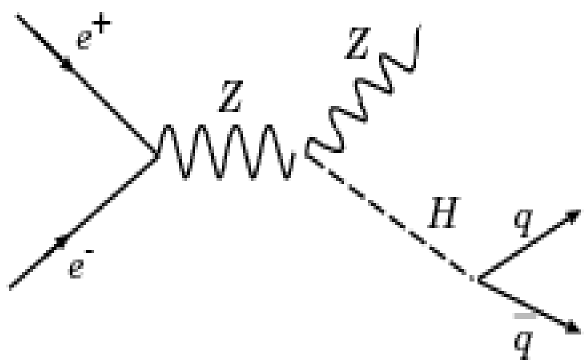
2. Find primary hadrons: kaons



3. Suppress H->b$\bar{b}$ and H->c$\bar{c}$ background by requiring that both kaons originate from the interaction point and not from a displaced vertex.

Simulation: proof of concept

- generated Higgsstrahlung production with Higgs decaying into a quark-antiquark



Pythia 8.2 [arXiv:1410.3012 [hep-ph]]

ILC @250 GeV, L_{int}=500 fb^{-1}

$$\sigma^{@250GeV}_{e^+e^-\to HZ} = 2.5 \cdot 10^2\ fb$$
$$m_H = 125.7 \pm 0.4\ \text{GeV}$$
$$BR(H \to s\bar{s}) = 2.41 \cdot 10^{-4}$$
$$BR(H \to c\bar{c}) = 2.85 \cdot 10^{-2}$$
$$BR(H \to b\bar{b}) = 5.66 \cdot 10^{-1}$$

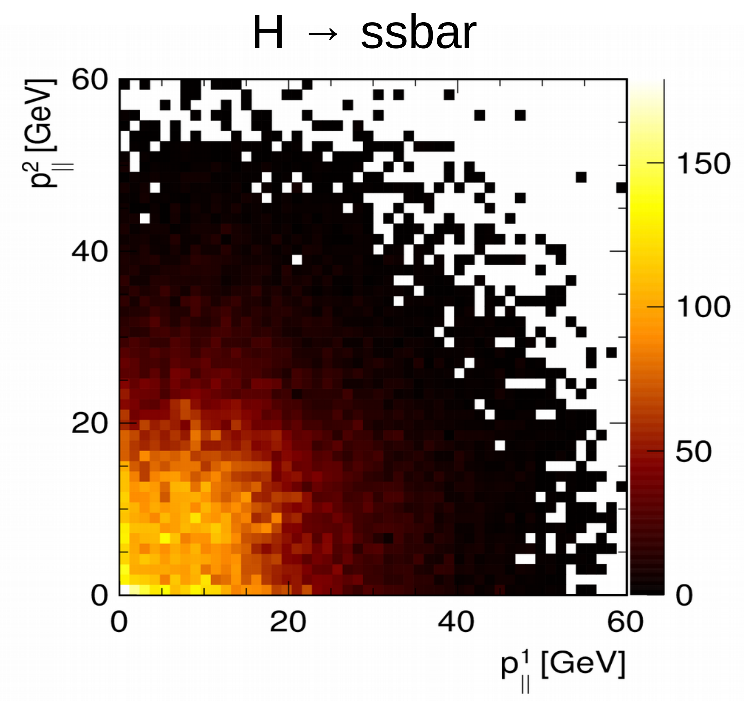
Simulation parameters (*)

Simulation done with 100% kaon efficiencies and no detector effects

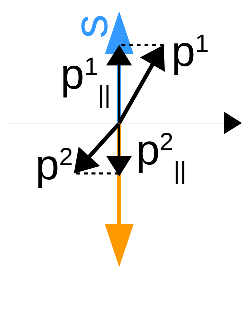
(*) http://arxiv.org/abs/1501.02614
http://pdg.lbl.gov/2014/tables/rpp2014-sum-gauge-higgs-bosons.pdf
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CERNYellowReportPageBR3

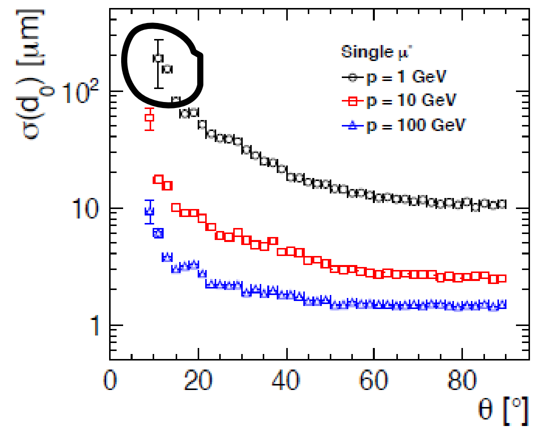
ATLAS+CMS combination (May, 2015)
m_H=125.09±0.24 GeV https://physics.aps.org/featured-article-pdf/10.1103/PhysRevLett.114.191803

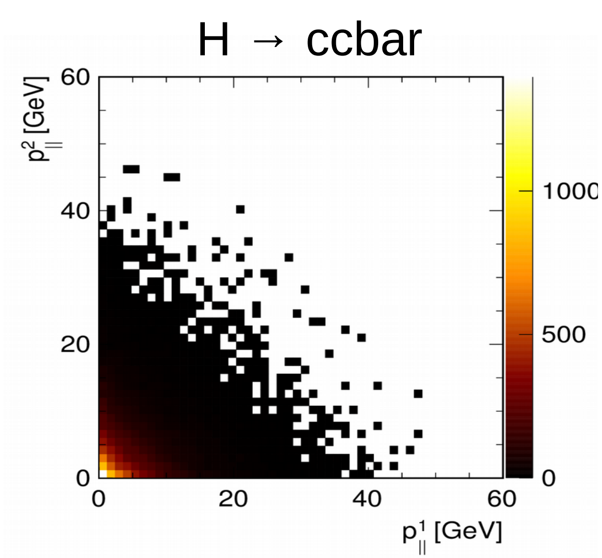
Parallel momentum spectra

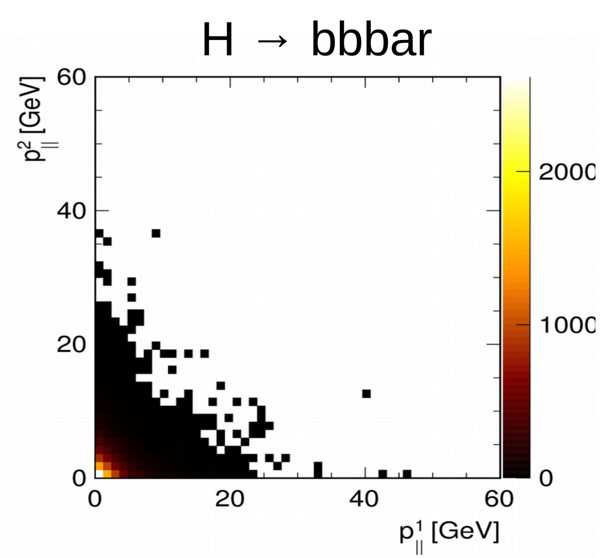


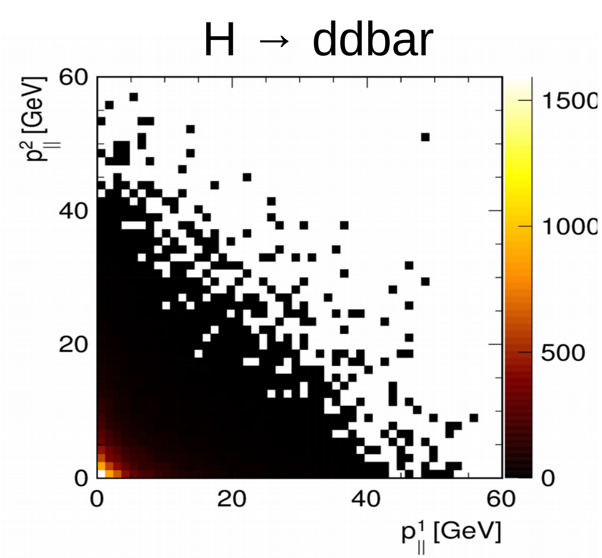
- parallel momentum of highest momentum kaons in each s-jet candidate (hemisphere)
  - $d_0 < 0.5$ mm



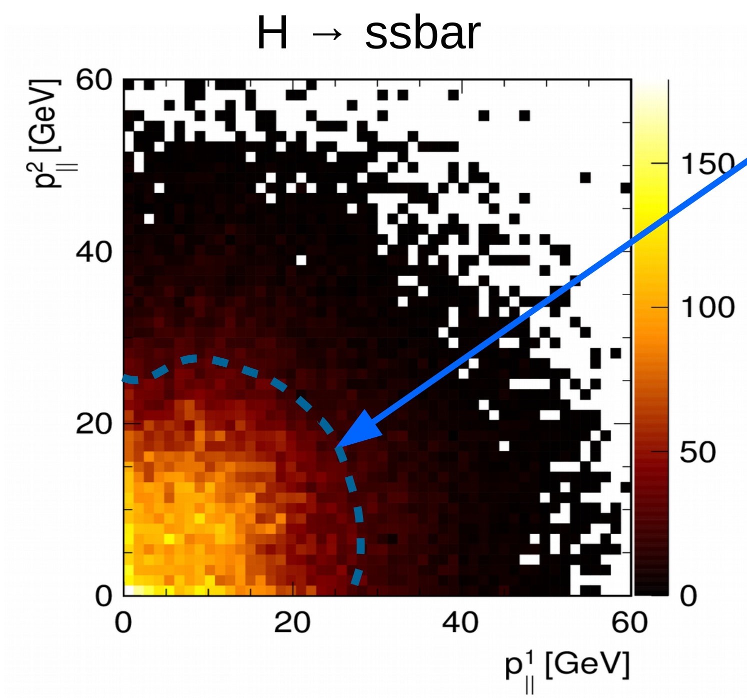




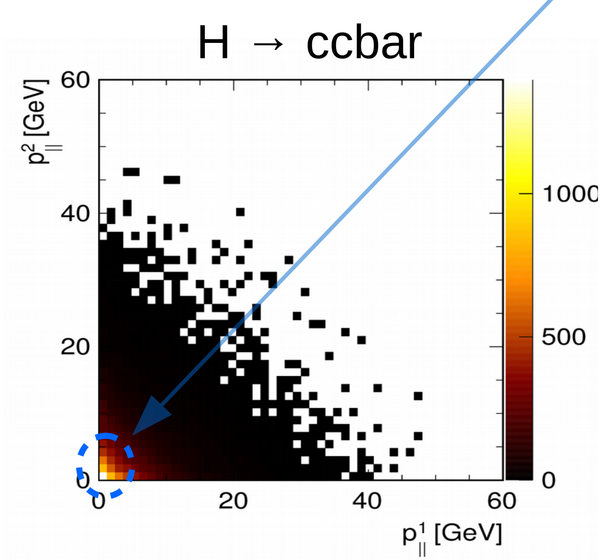


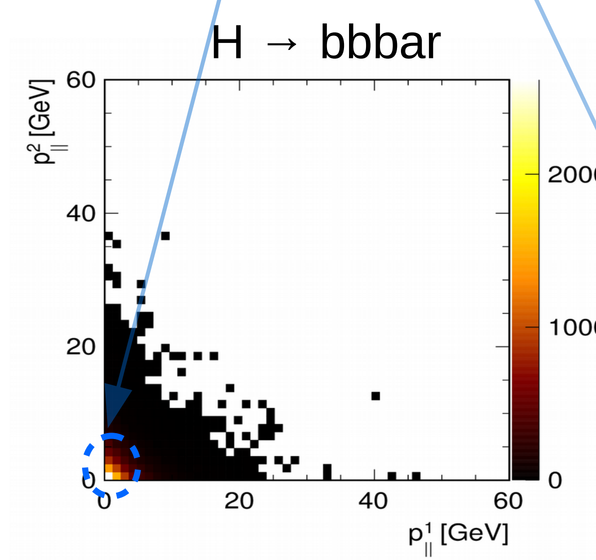


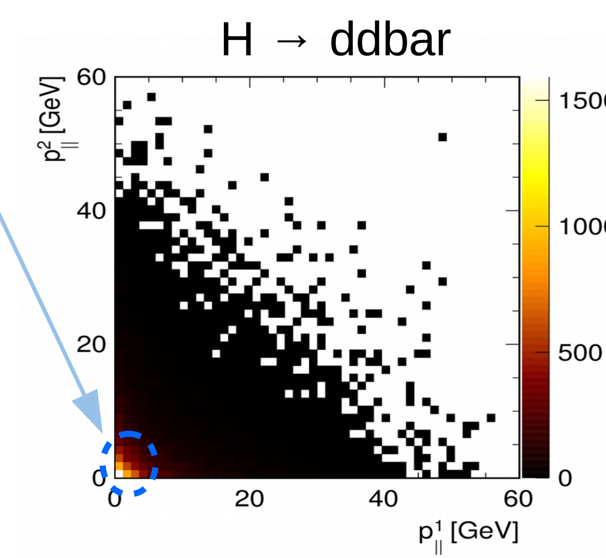
Parallel momentum spectra (II)



- H → ssbar shows a wider distribution due to the fact that the kaons are carrying much of the momentum of the initial s-quark
  - allows to cut circularly in the parallel momentum space to get rid of the background
- background peaks narrowly around (0,0)

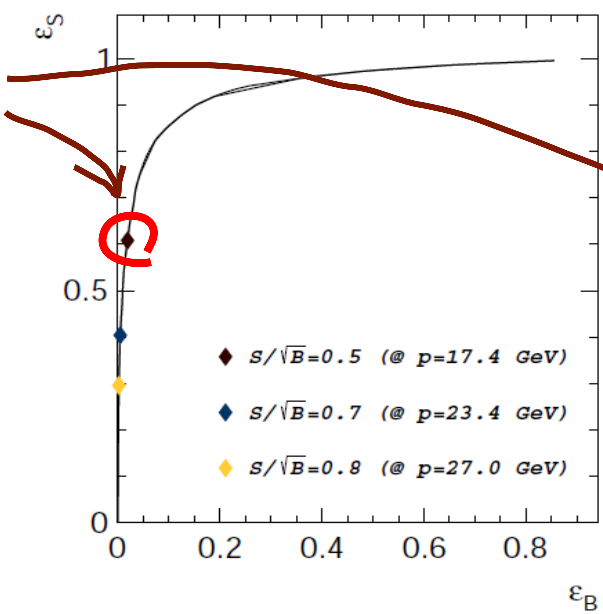


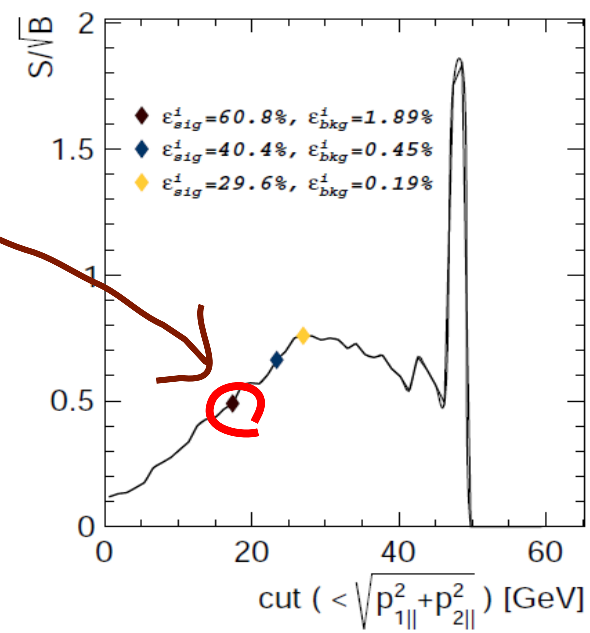


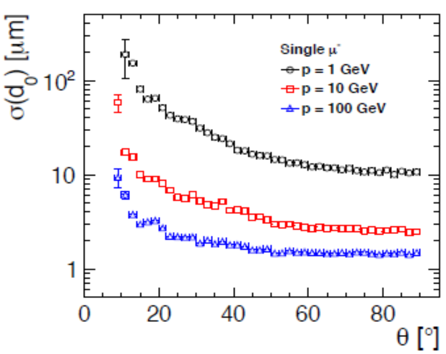


Signal significance

Circular cut around 20 GeV allows to select more than 60% of signal and less than 2% of background, with a significance around 0.7







- some other cuts on impact parameter, expected resolution: $\sigma_{d0}=5 \oplus 15/(p \sin^2\theta)$ μm

	$d_0 < 0.1mm$			$d_0 < 0.3mm$			$d_0 < 0.5mm$			$d_0 < 1mm$		
	p	N_S	N_B	p	N_S	N_B	p	N_S	N_B	p	N_S	N_B
$S \simeq 0.5$	9.8	24	2366	11.9	21	1874	15.1	16	1057	23.8	6	142
$S \simeq 1$	22.9	7	45	30.6	2	2	30.8	2	4			
$S \simeq 2$	35.8	2	1									

significance $S = \frac{N_S}{\sqrt{N_B}}$; circular cut, $p > \sqrt{(p^1_{||})^2 + (p^2_{||})^2}$ [GeV]

Summary

- We propose an analysis to measured the H $\rightarrow$ ssbar branching ratio
- The analysis can be performed by tagging s-quark events with charged kaons, using a particle-ID detector
- A first analysis-simulation has been performed showing that the 's-tagging' technique is feasible and presents promising results
  - sensitivity of order the SM expectation can be obtained, allowing to test new-physics models that have > SM contributions to H->ss.
- Need to include more detailed detector effects to give realistic results and expectations
- Paper in preparation