VXD Performance study using Higgs branching ratio measurements

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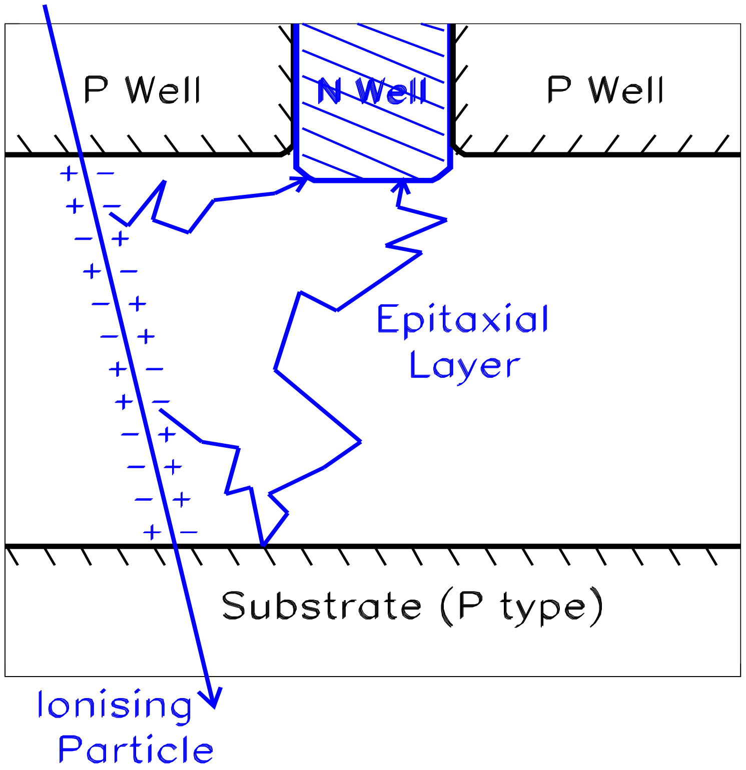
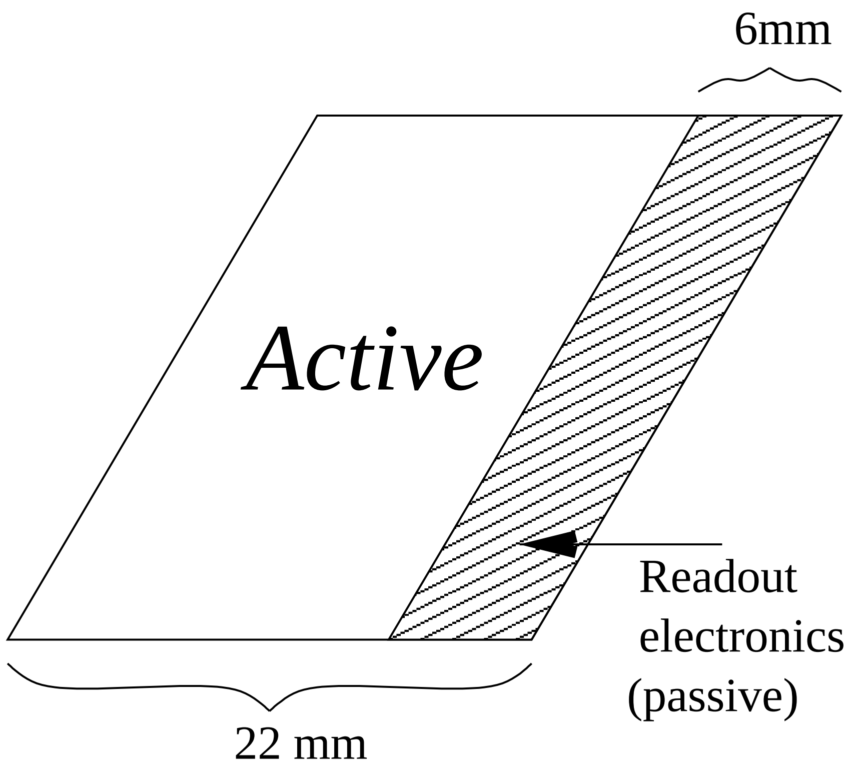
Outline

- MAPS technology
- Detector Layout
- SGV - fast simulation tool
- Results
- Conclusion

MAPS technology





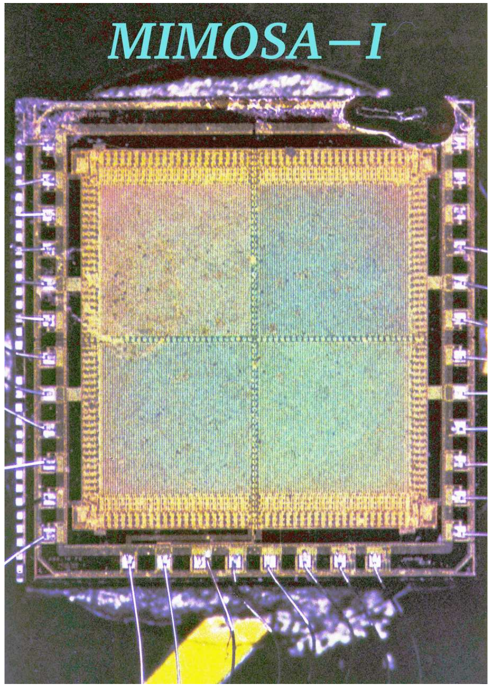
Questions specific to MAPS :

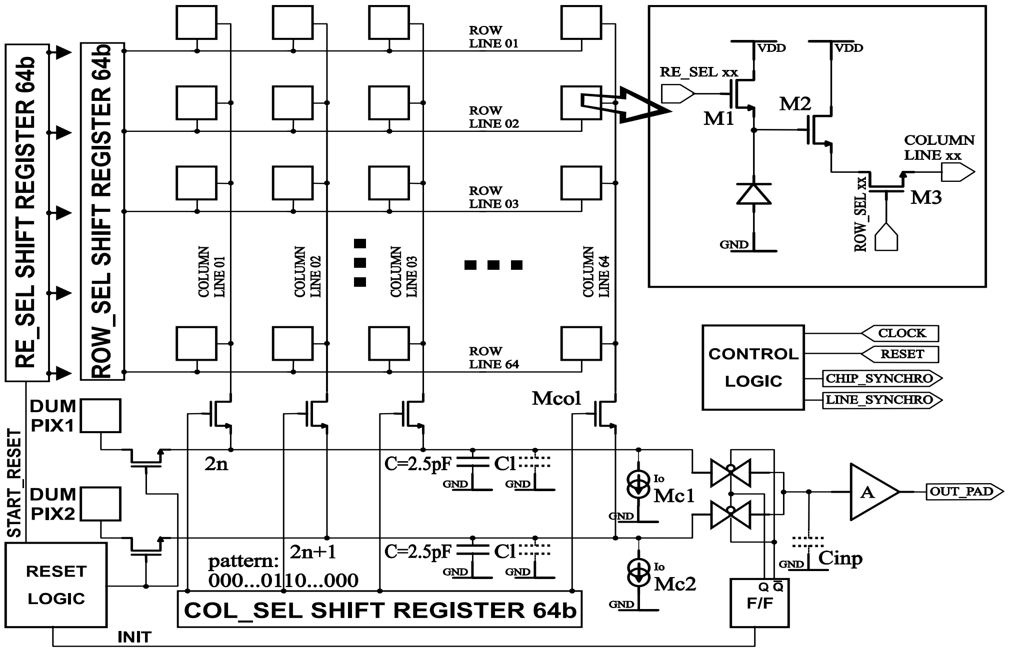
- Pixel size (space for readout electronics)
- Dead regions on sensors

More General :

- Thickness of sensors
- Need for cooling (additional dead material)

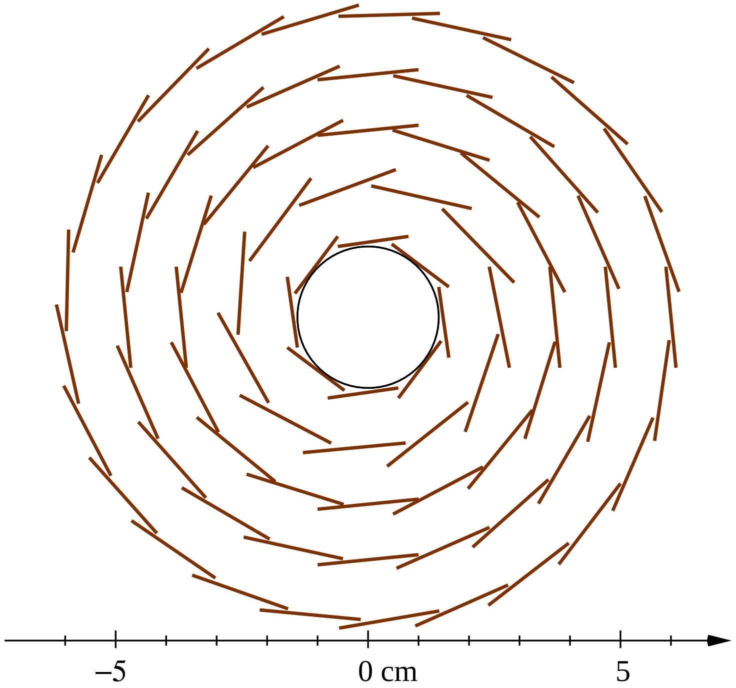
MIMOSA

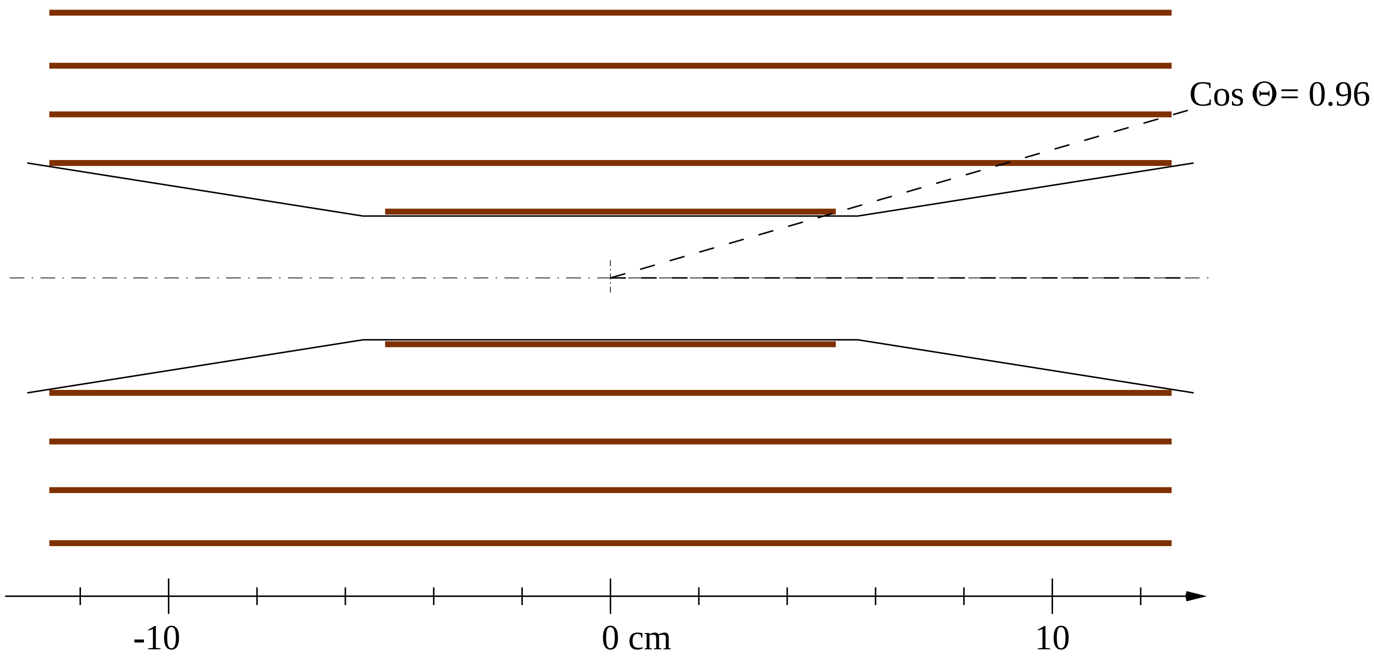




MIMOSA prototype	fabrication process	epitaxial thickness	noise	S/N ratio	spatial resolution	detection efficiency
1 (1 diode)	0.6 μm	14 μm	12 e^- ENC	42	1.4 $\pm$ 0.1 μm	99.5 $\pm$ 0.2 %
1 (4 diode)	0.6 μm	14 μm	24 e^- ENC	32	2.1 $\pm$ 0.1 μm	99.2 $\pm$ 0.2 %
2 (1 diode)	0.35 μm	4.5 μm	10 e^- ENC	22	2.2 $\pm$ 0.1 μm	98.5 $\pm$ 0.3 %

Detector layout





Layer	Radius	No. of ladders	Ladder width
1	15 mm	8	19 mm
2	26 mm	11	22 mm
3	37 mm	16	22 mm
4	48 mm	20	22 mm
5	60 mm	25	22 mm

B = 4T

Layer thickness 50μm

Spatial resolution 2μm

Simulation a Grande Vitesse 2.30 (M.Berggren)

$\Rightarrow$ Orginally created for DELPHI (interface to MC generators)

$\Rightarrow$ Adopted to TESLA

$\Rightarrow$ CVS version available

+ Quick and flexible

+ Easy to describe new detector geometries

+ Manages up to 9 different detector geometries simultanously

– Only simplified detector geometry definition possible

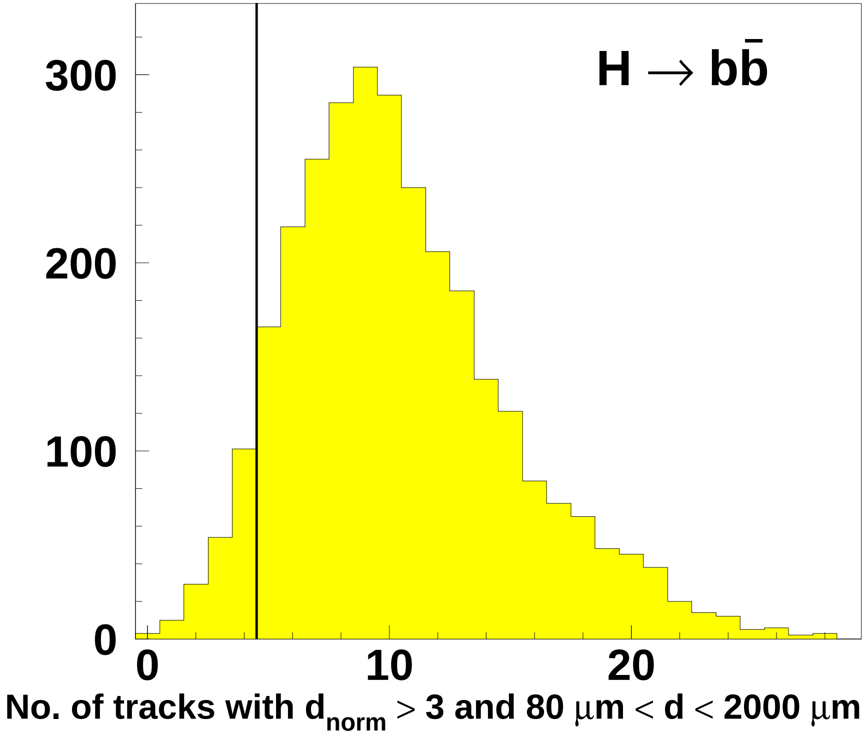
(planes and cylinders divided in repeating sectors in ϕ)

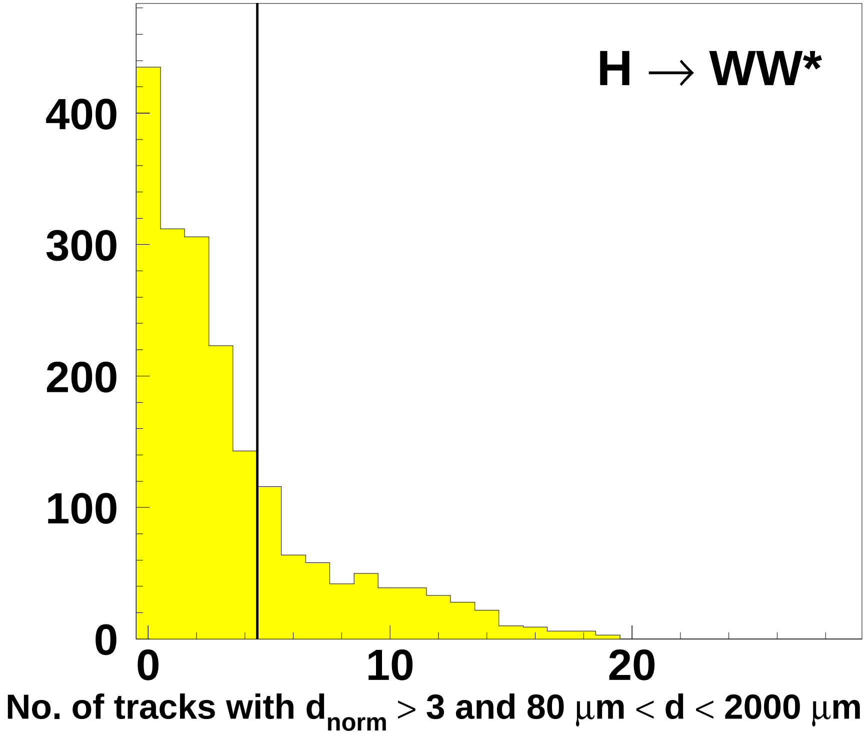
Measurement of SM Higgs branching ratios

	$\sigma(fb)$	events expected ($50 fb^{-1}$)	events simulated
Signal:			
$H \rightarrow b\bar{b}$	23	1 150	10 000
$H \rightarrow WW^*$	27	1 350	10 000
$H \rightarrow ZZ^*$	3.6	180	5 000
$H \rightarrow c\bar{c}$	1.4	70	5 000
$H \rightarrow gg$	2.0	100	5 000
$H \rightarrow \tau\tau$	2.0	100	5 000
Background:			
$e^+e^- \rightarrow W^+W^-$	7 690	384 500	1 927 500
$e^+e^- \rightarrow q\bar{q}$	11 230	561 500	2 812 500
$e^+e^- \rightarrow t\bar{t}$	575	28 750	145 000
$e^+e^- \rightarrow Z^oZ^o$	652	32 600	162 500

$E_{CMS} = 500\ GeV$, $M_{Higgs} = 140\ GeV$. Following method published by:
M. D. Hildreth, T. L. Barklow, D. L. Burke Phys. Rev. D 49 3441(1994)

Simple b-tagging algorithm





d - impact parameter (three dimensional distance of closest approach)

d_{norm} - impact parameter divided by its error

b-tag : more than 4 tracks with $d_{norm} > 3$ and $80\mu m < d < 2\,000\mu m$

Analysis

Initial cuts :

- $E_{vis} > 0.8\ E_{cms}$
- $P_t < 20\ GeV$
- $|P_z| < 30\ GeV$
- $|\cos(\theta_{thrust})| < 0.7$

$H \rightarrow WW^*$: 6 jet analysis

- Splitting event into 6 jets (JADE algorythm)
- Scaling up jet energies by 6%
- Assigning jet pairs to Z^o, W and W^*
- Making cuts on angles between jets

  $\rightarrow \psi_{JJ(Z^o)} < 90^o$

  $\rightarrow \psi_{JJ(W)} < 120^o$

- Making cuts on invariant mass:

  $\rightarrow |M_{JJ(Z^o)} - M_{Z^o}| < 10\ GeV$

  $\rightarrow |M_{JJ(W)} - M_W| < 10\ GeV$

  $\rightarrow |M_{WW^*} - M_{H^o}| < 10\ GeV$

- Calculating $ycut$ parameter needed to get 6 jets from JADE

  $\rightarrow ycut > 8 \times 10^{-4}$

- anti b-tag

Analysis

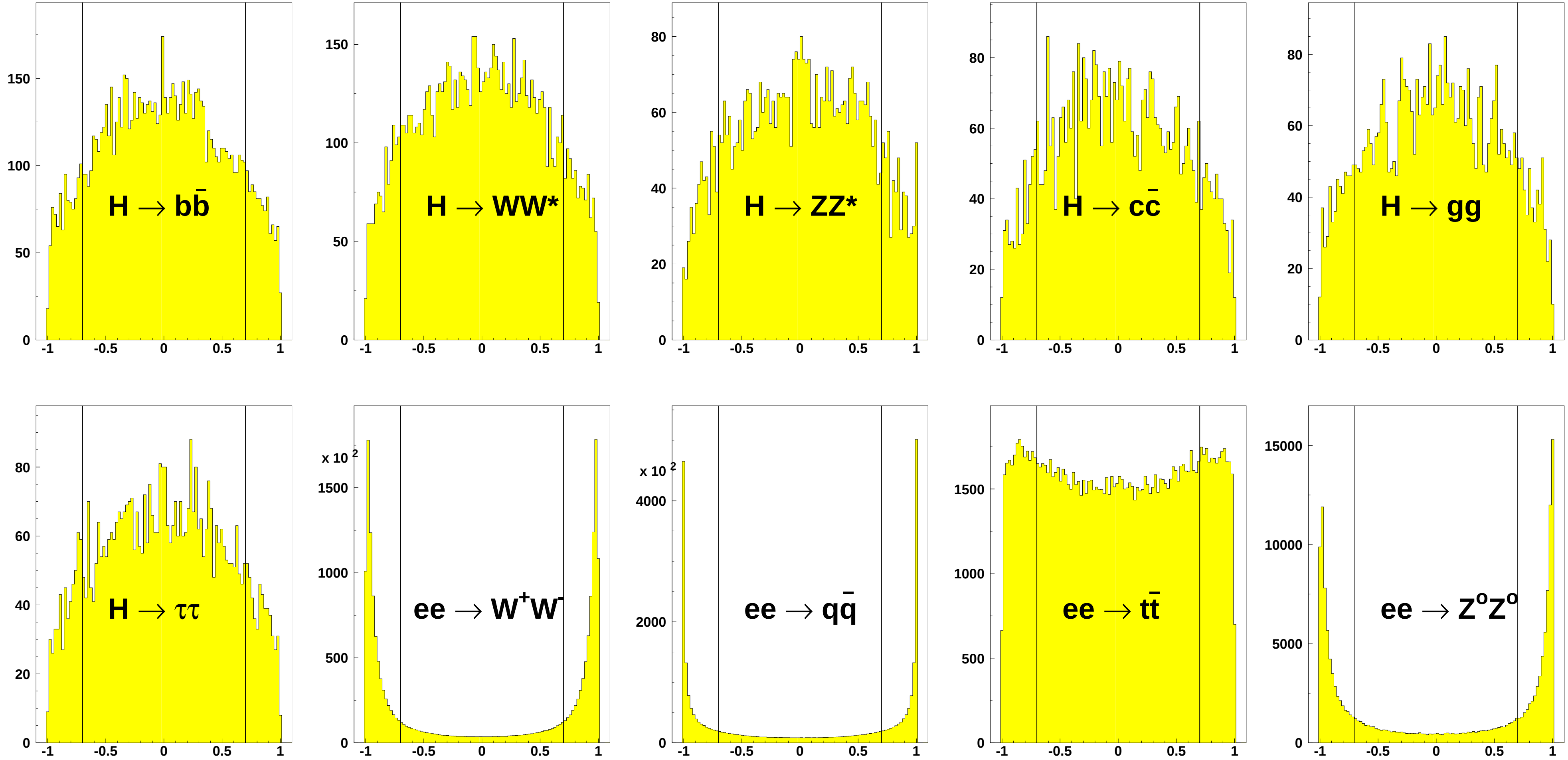
$H \longrightarrow b\bar{b}$ and $H \longrightarrow c\bar{c} + gg$: 4 jet analysis

- Splitting event into 4 jets (JADE algorithm)
- Rescaling jet energies to satisfy energy and momentum conservation (keeping jet velocities fixed)
- Assigning jet pairs to Z^o and H^o
- Making cut on invariant mass:

  $\longrightarrow |M_{JJ(Z^o)} - M_{Z^o}| < 10\ GeV$
- Calculating $ycut$ parameter needed to split Higgs part of event into 3 jets

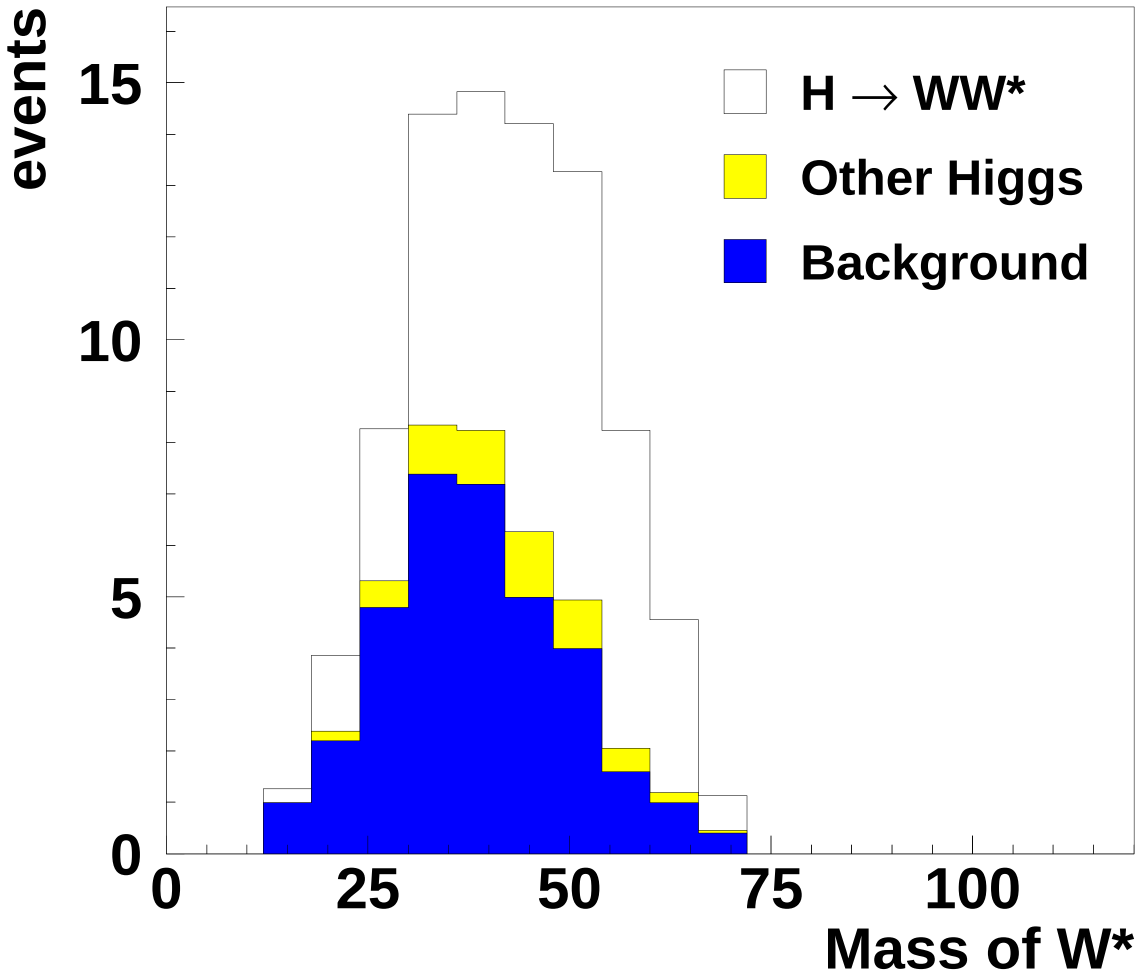
  $\longrightarrow ycut < 1.8 \times 10^{-2}$
- b-tag for $H \longrightarrow b\bar{b}$ channel
- anti b-tag for $H \longrightarrow c\bar{c} + gg$ channel

$\cos(\theta_{thrust})$ cut



$|\cos(\theta_{thrust})| < 0.7$

Results

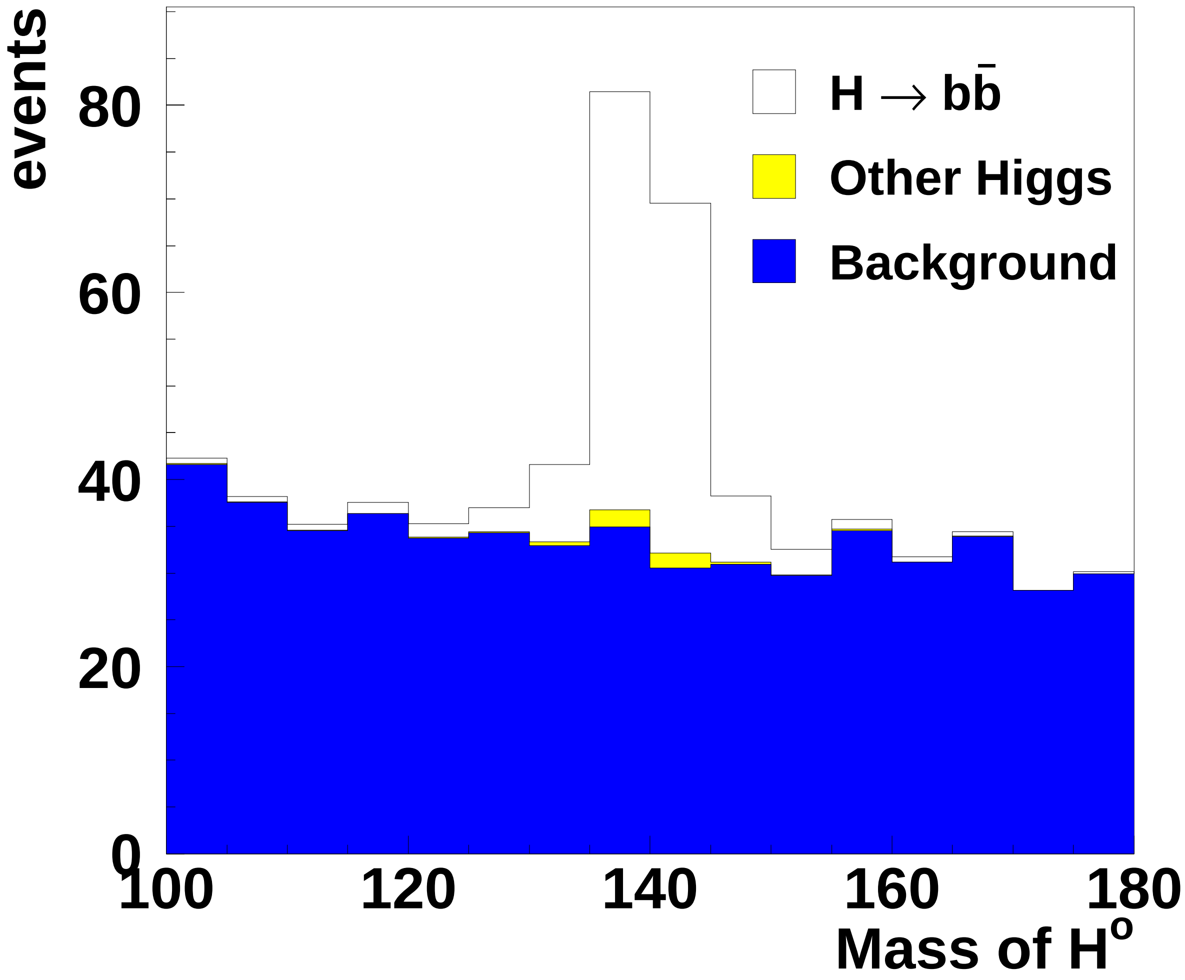


Signal - 43.8 events

Background - 40.2 events

$$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow WW^*))}{\sigma_{tot}\times\Gamma(H\rightarrow WW^*)} = 20.9\%$$

Results

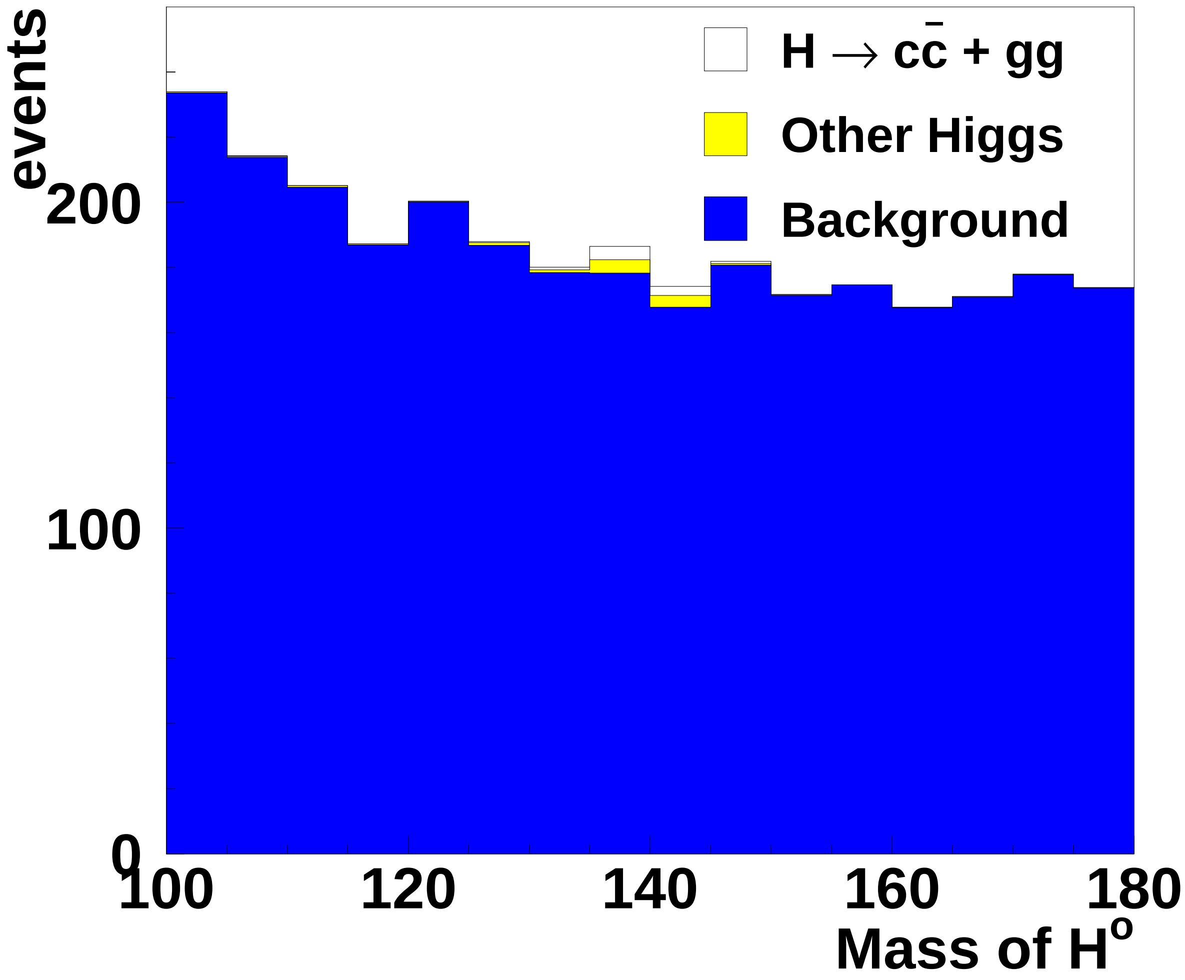


Signal - 97.5 events

Background - 133.4 events

$$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow b\bar{b}))}{\sigma_{tot}\times\Gamma(H\rightarrow b\bar{b})} = 15.6\%$$

Results



Signal - 8.3 events

Background - 714.4 events

$$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow c\bar{c}+gg))}{\sigma_{tot}\times\Gamma(H\rightarrow c\bar{c}+gg)} = 324\%$$

Results

	MAPS 50μm	MAPS 150μm	MAPS 50μm	CCD 60μm
	0.25 mm BP		without layer 1	1.5mm BP
$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow WW^*))}{\sigma_{tot}\times\Gamma(H\rightarrow WW^*)}$	20.9 %	22.1 %	20.5 %	21.6 %
$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow b\bar{b}))}{\sigma_{tot}\times\Gamma(H\rightarrow b\bar{b})}$	15.6 %	16.7 %	16.1 %	16.7 %
$\frac{\sigma(\sigma_{tot}\times\Gamma(H\rightarrow c\bar{c}+gg))}{\sigma_{tot}\times\Gamma(H\rightarrow c\bar{c}+gg)}$	324%	332 %	304 %	311 %

Conclusion

- Higgs branching ratios can be measured using the above simple analysis.
- Results obtained using SGV are comparable with results published in original analysis.
- This is a good tool to study effects of modifying detector parameters on physics results.
- In future more precise simulations will have to be performed to confirm results.