Light Standard Model Higgs at LHCb: prospects

- The LHCb experiment : a forward spectrometer
  - Physics program
  - Detector design
- Light Higgs signal in forward region
- Jet finding in LHCb
  - Reconstruction / trigger of Higgs'es
- Prospects: background studies
- Conclusion

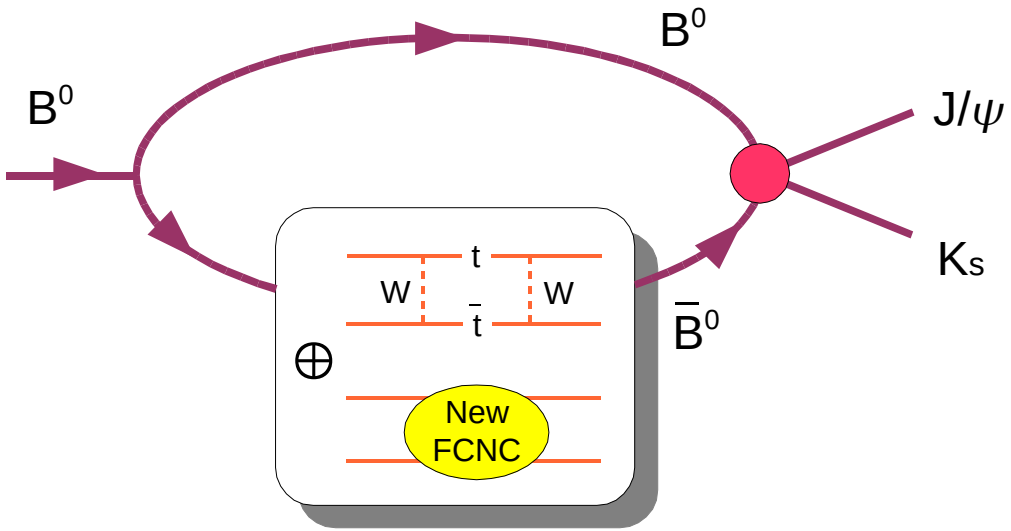
LHCb physics program

- LHC = copious source of b's : σ_{bb} = ~500 μb
- LHCb designed for precision studies of CP asymmetries in B mesons: over−constrain the unitarity triangles with many measurements of

angles + *sides*

⇨ Search for inconsistency in CKM picture

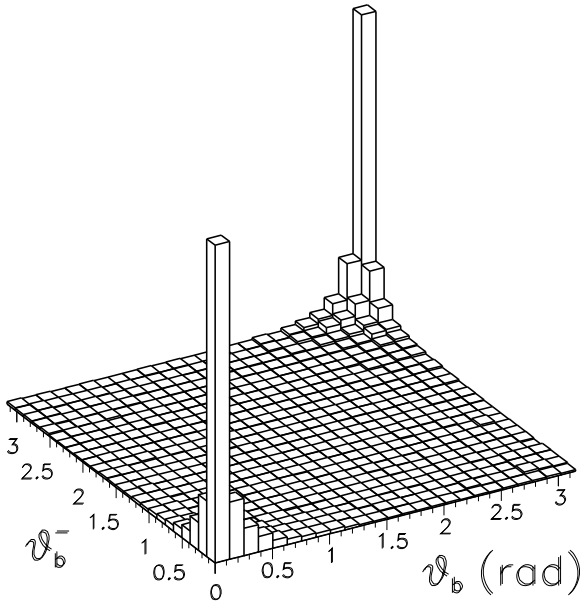
☞ *indirect search for new physics*

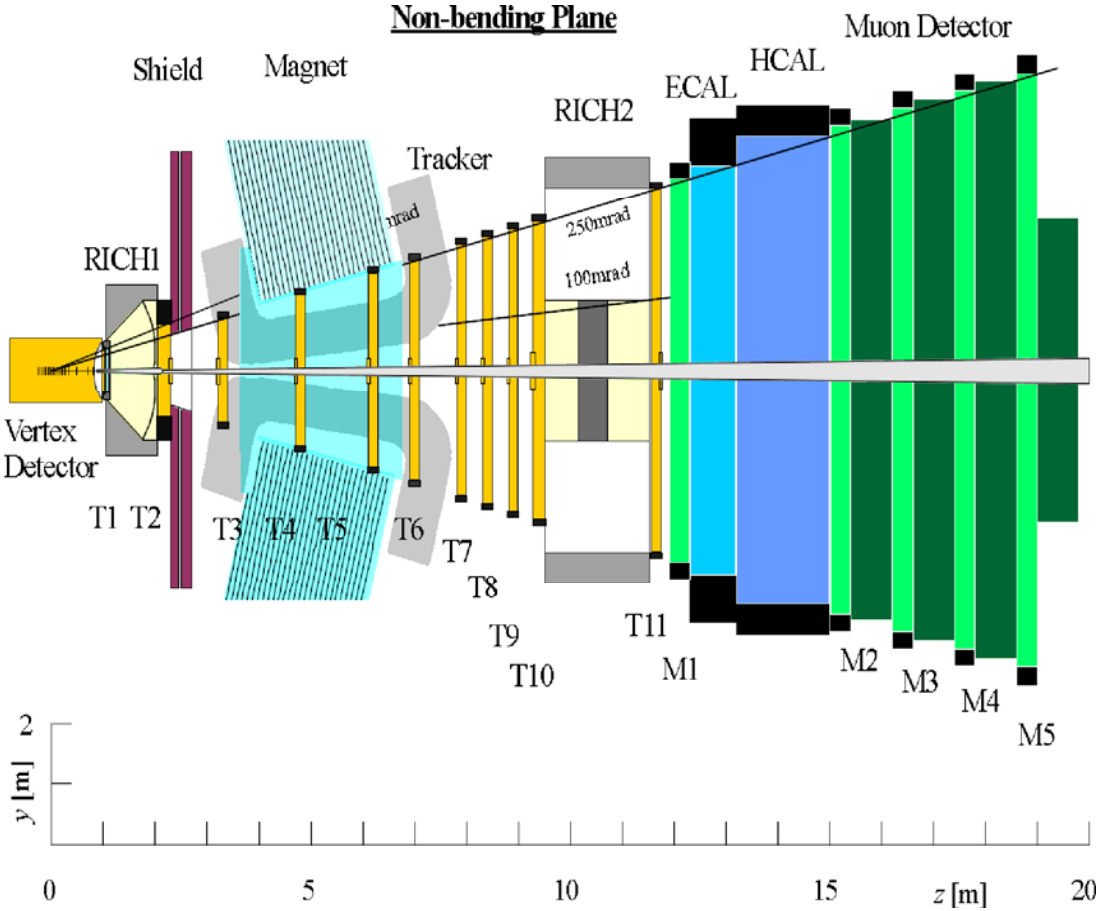


CP asymmetry ~ sin [2(β+ϕ_{new})]

LHCb detector (1)

- Angular distribution of $b\bar{b}$−pair is peaked forward, pair correlated within ~1 unit of rapidity





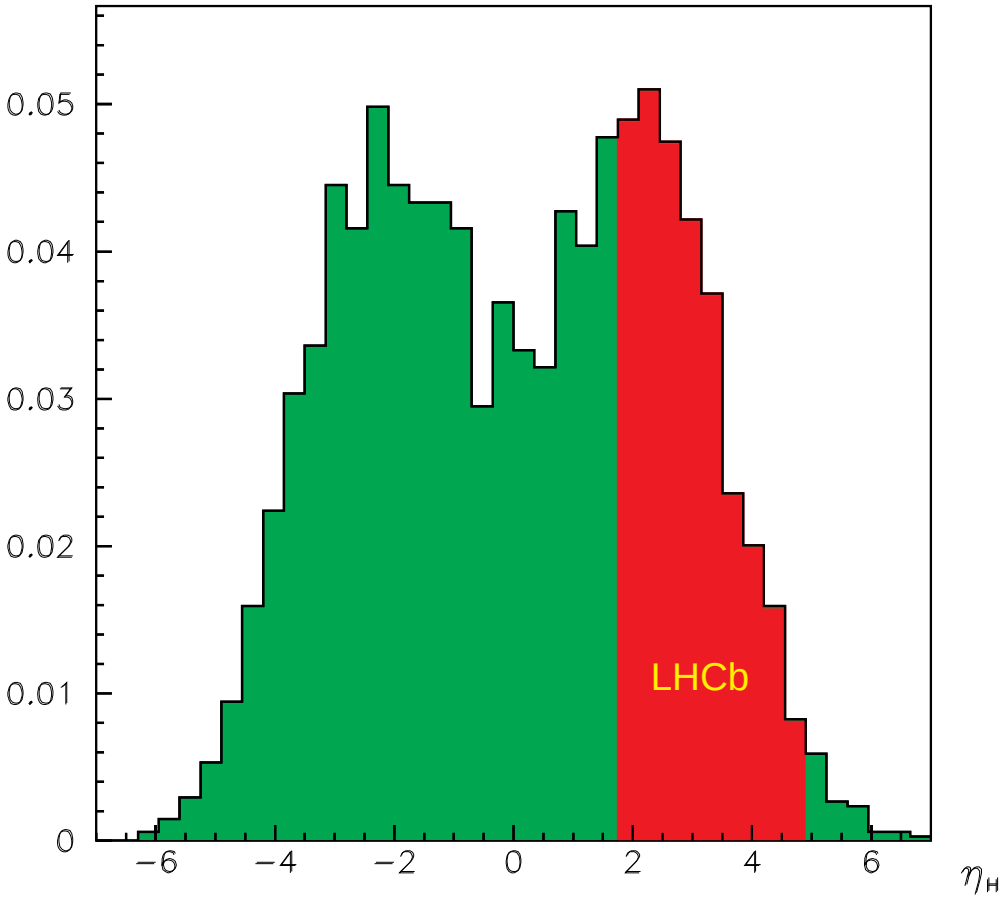
- LHCb luminosity (tunable) 2×10^{32} $cm^{-2}s^{-1}$ from day one (~ single interaction/bunch crossing) ☞ 10^{12} bb−pairs/year produced

LHCb detector (2)

- Rapidity coverage: $1.8 < \eta < 4.9$
- Particle identification
- Performant vertex detector ⇨ excellent decay time resolution ~40 fs
- Flexible and optimized B−physics trigger based on 4 levels
  ☞ min. bias reduction + extraction of B decays of interest
  - **L0**: μ,e,hadron high−p_T triggers
  - **L1**: vertex trigger: events with $\geqslant$ 1 secondary vertices
  - **L2+L3**: event filter (reconstruction of b−hadrons specific final states) using all detector components, including RICHes

Forward light Higgs

- More generally at LHC, light objects are forward/backward peaked: significant fraction of forward light Higgs'es

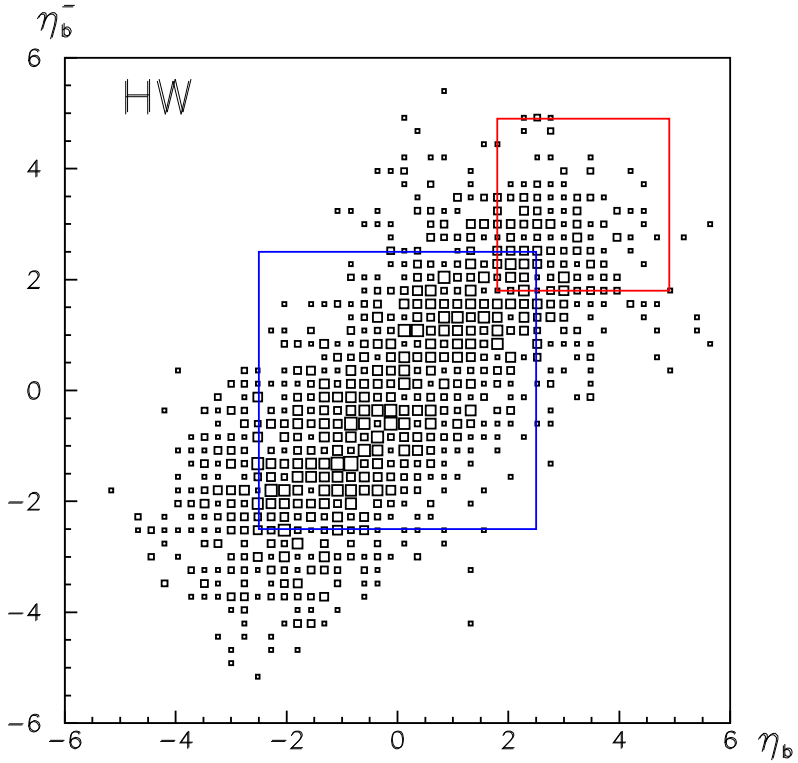


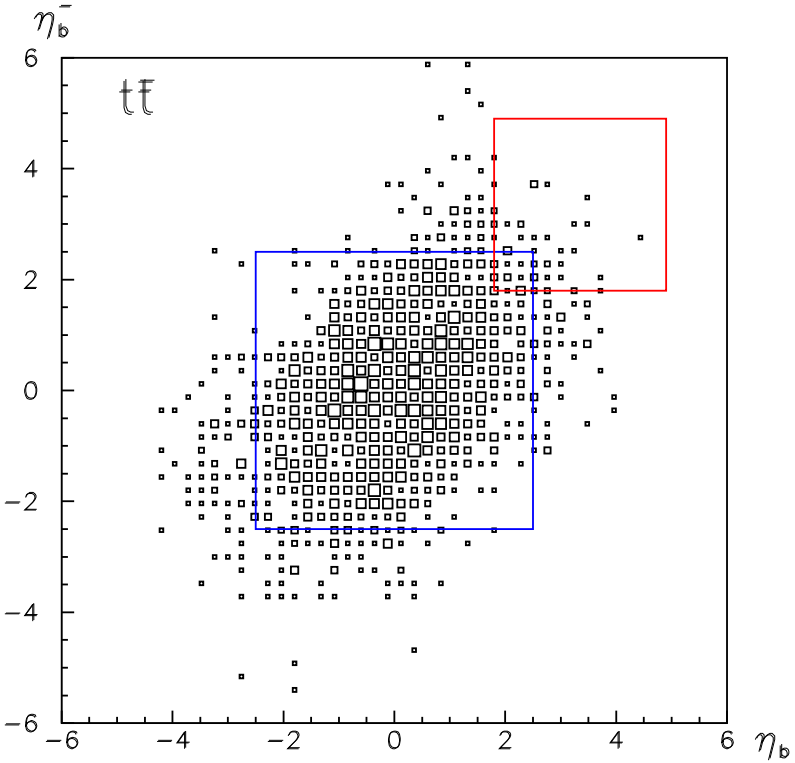
☞ 30% of Higgs'es in HW production (m_H~115 GeV/c^2) in LHCb acceptance

Top versus Higgs

- Forward top pairs are kinematically suppressed:
  - Ratio of bb+lepton events Higgs/Top in forward region is enhanced by factor ~7 with respect to central region (with 80<M(bb)<125 GeV/c^2)

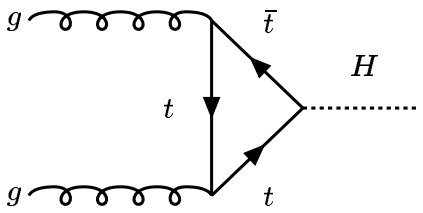
Forward (LHCb): $1.8<(\eta_b,\eta_b)<4.9$ Central: $|\eta_b,\eta_b|<2.5$

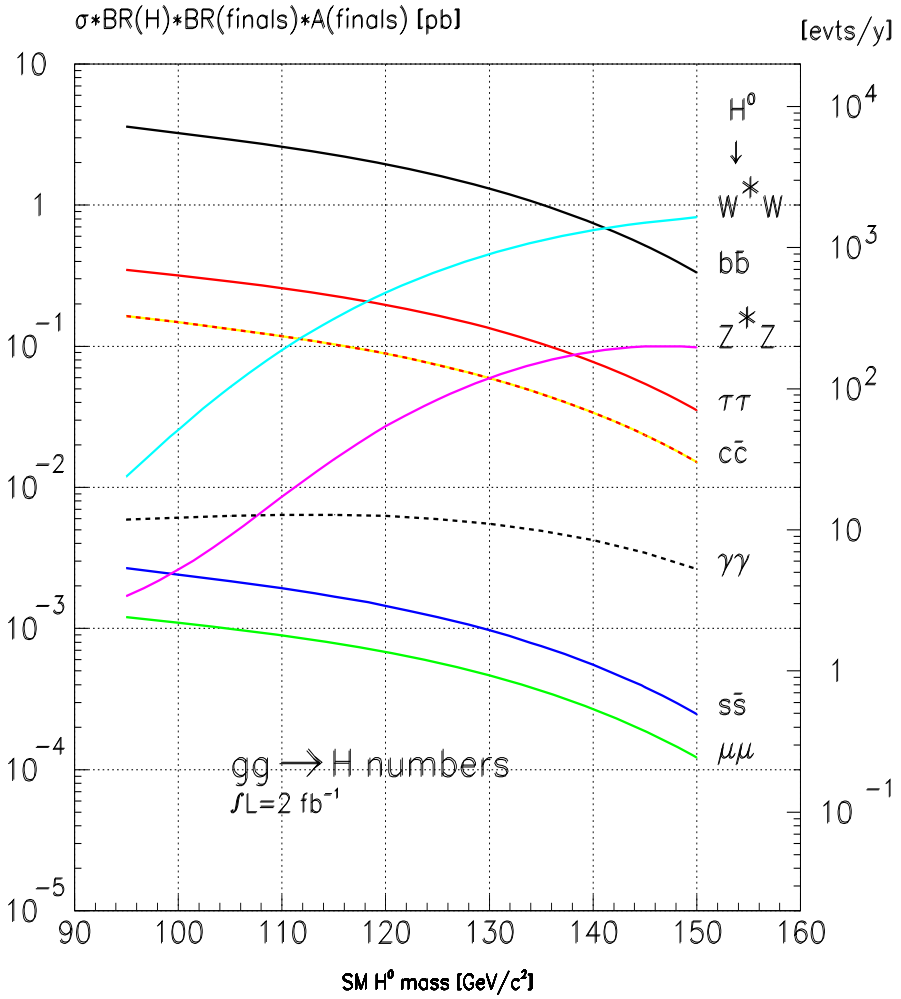




Light Higgs signal

- Production mechanism: gluon fusion

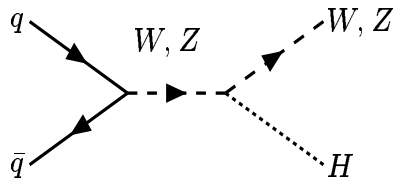


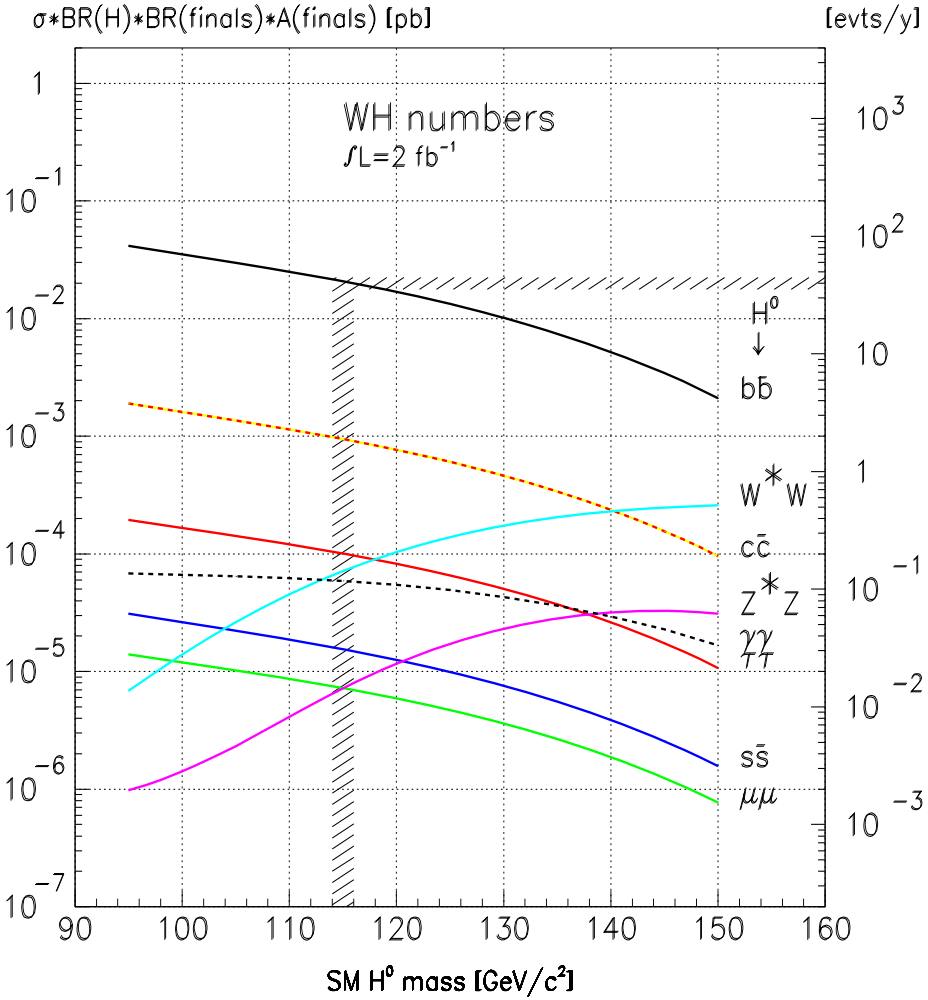


- «final state» signal in LHCb geometrical acceptance
- Signal is hard to isolate (continuums) :
  - Too low luminosity for H→$\gamma\gamma$
  - H→$b\bar{b}$ with around 10^9 background $b\bar{b}$−pairs of M(bb)>80 GeV/c^2

Light Higgs signal

- Production mechanism: Higgsstrahlung





⇦ «final state» signal in LHCb geometrical acceptance

☑ Only one signature exploitable (m_H=115 GeV/c^2):

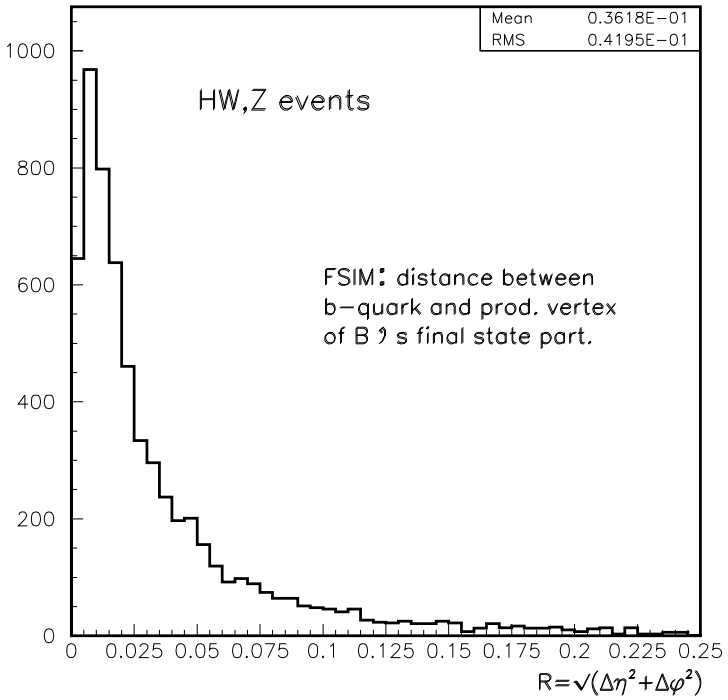
$b\bar{b}+lepton$	~40 evts/year (HW)
	~10 evts/year (HZ)

☞ lepton tag

- ☑ Isolation from jets
- ☑ High p_T

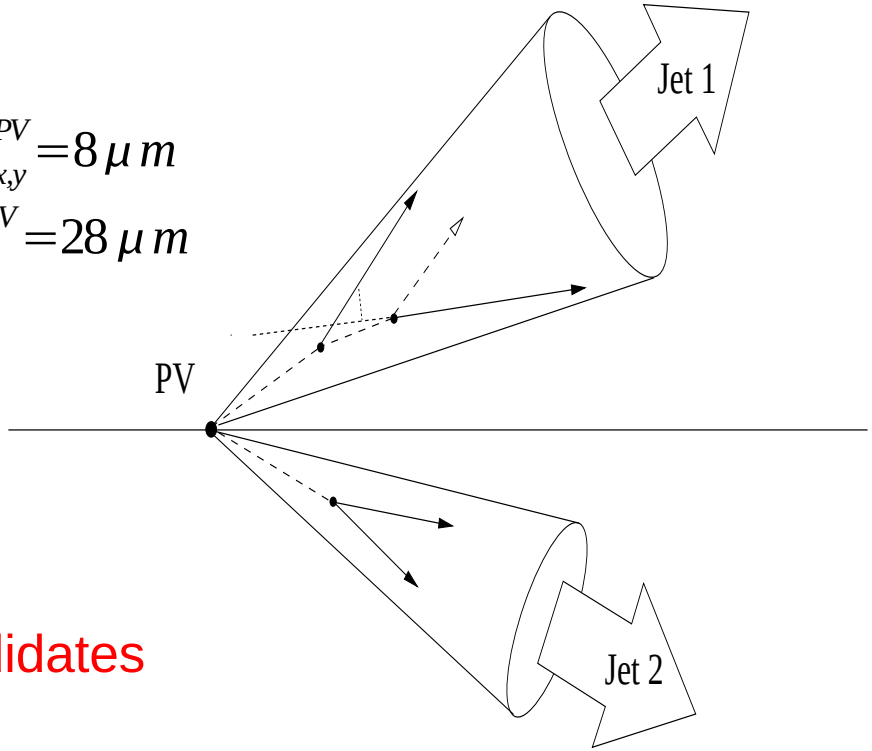
b−jets reconstruction (1)

- *b*−quark fragmentation is hard



- Clusterize all 2−tracks displaced vertices, using tracks with large impact parameter (IP>30 μm with significance IP/σ_{IP}>3)

$$\sigma_{x,y}^{PV} = 8\,\mu m$$
$$\sigma_{z}^{PV} = 28\,\mu m$$



- Cone approach, get b−hadron direction as cone axis
  - ☞ obtained from 2^{ry} vertices candidates

b−jets reconstruction (2)

- Jet reconstruction efficiency for b−jets in acceptance from «seed finder» method

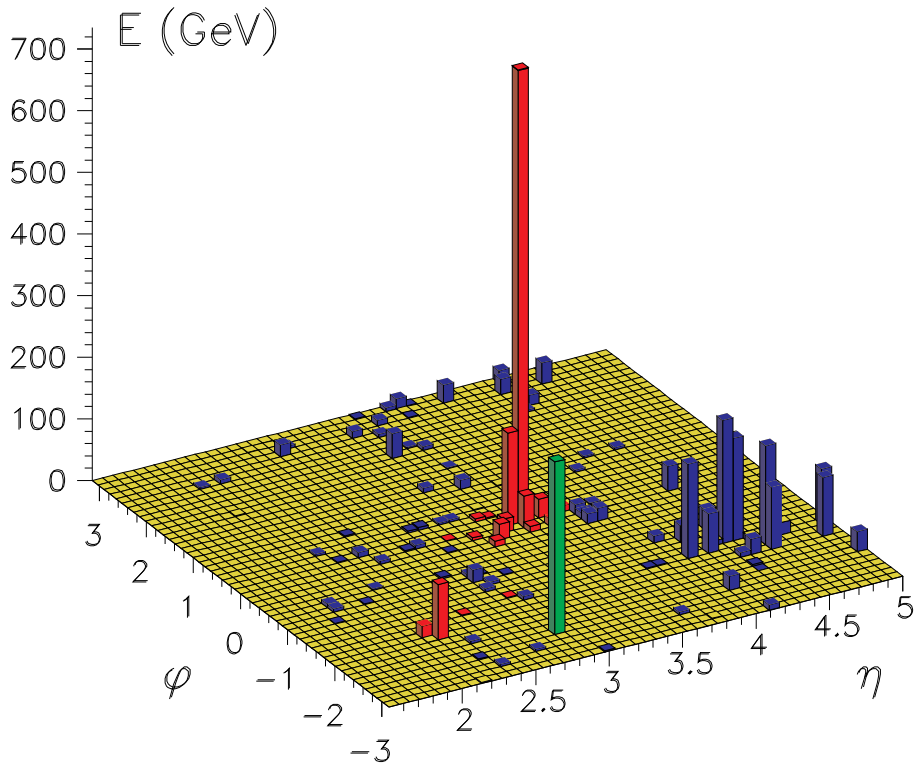
  ~90%

  - ~4% loss from decay channel with low # tracks
  - ~6% loss from IP resolution and decay length

    ☞ ~80% on di−jets

- HW event seen in LHCb in the bb+lepton channel (full simulation) ⇩

- ⇩ **2 b−jets** found with «seed finder»
- ⇩ **Isolated electron**
- ⇩ **Beam jet**



Higgs reconstruction

- Jet 4−momentum reconstruction:
  - Magnetic analysis for charged

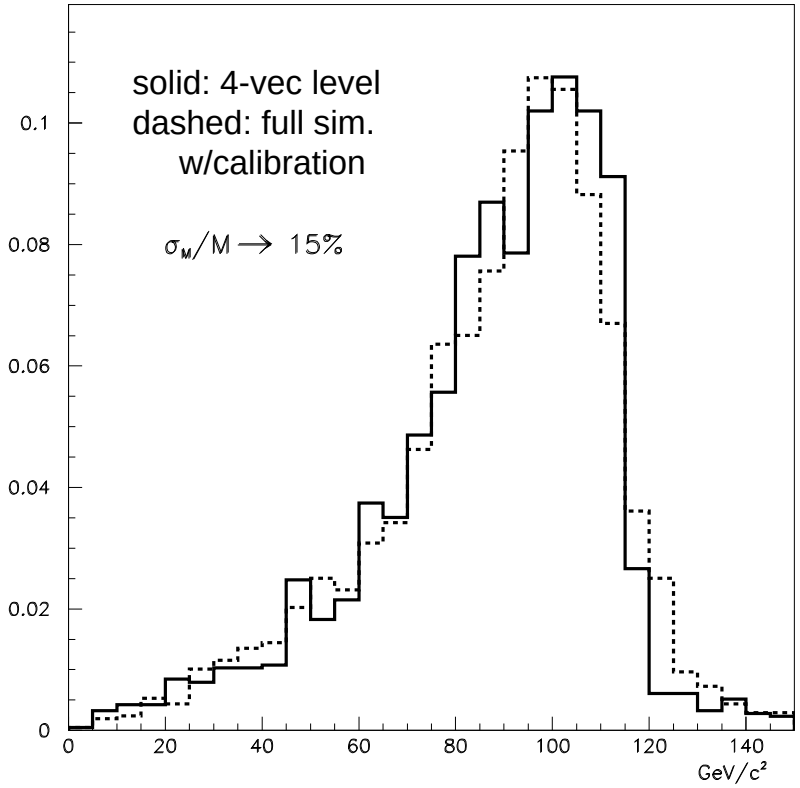
$$\frac{\sigma_p}{p} = (3.6\times10^{-5}\cdot p)\oplus 0.33\%$$

  - Calorimetry for neutrals

$$\frac{\sigma_E}{E} = \frac{10\%}{\sqrt{E}}\oplus 1.5\% \quad ECAL$$

$$\frac{\sigma_E}{E} = \frac{80\%}{\sqrt{E}}\oplus 10\% \quad HCAL$$

$m_H = 115\ GeV/c^2$



☞ Dijet mass resolution:

σ_M/M~15%

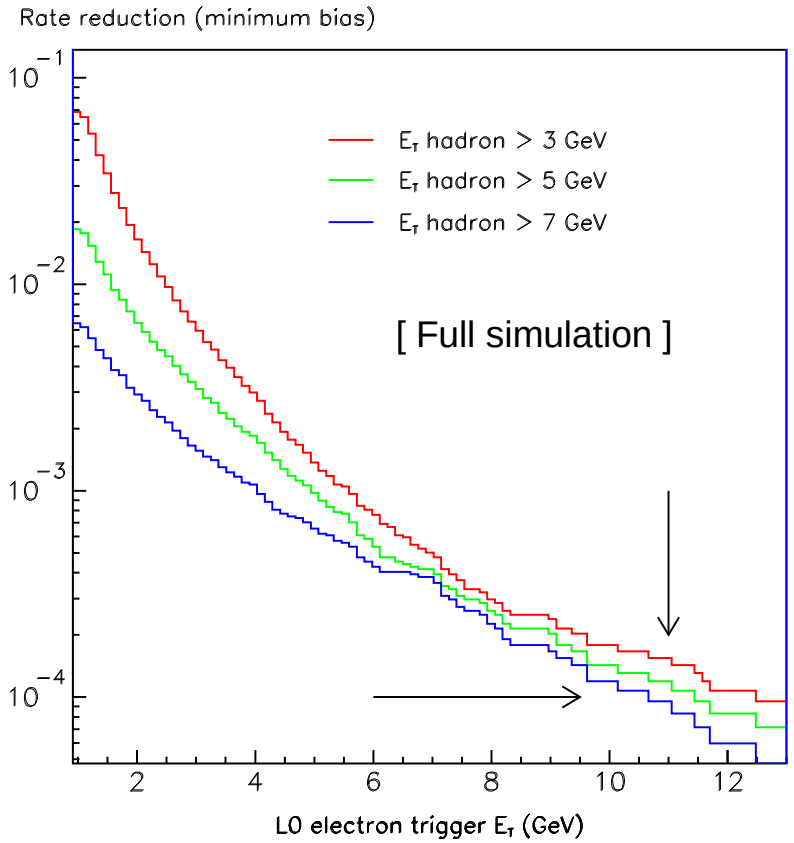
dominated by ν and hadronization

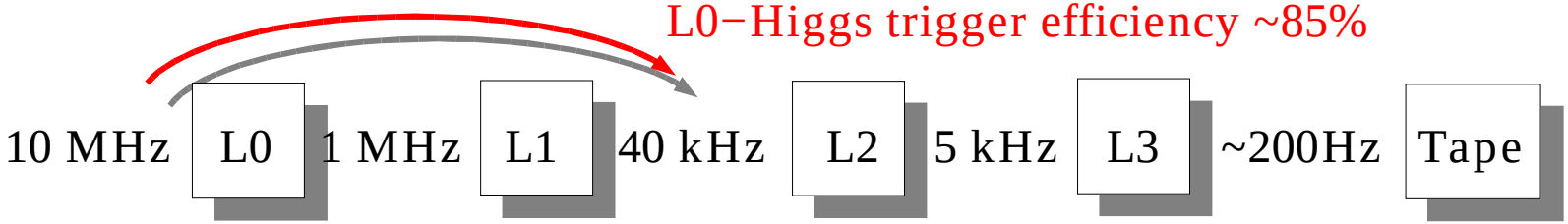
⇨ best mass resolution for cone aperture $\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.45$

Trigger performance

- L1 selection O(40%) for HW events ⇨ stronger p_T requirement needed at L0
  - $p_T(e,\mu)$ > ~11 GeV/c
  - p_T(hadron) > ~5 GeV/c
  - ☞ Rate reduction ~10^{-4} enough to bypass L1:

    2% of L2 bandwidth





Backgrounds

- Generator 4−vec level, explicit bb+lepton channels
  - H/W,Z ~30 evt/y
  - $t\bar{t} \rightarrow WbW\bar{b}$ ~1000 evt/y
  - $Wb\bar{b}$ ~100 evt/y
  - QCD $b\bar{b}$ O(1) evt/y

* bb+lepton in LHCb acceptance
* p_T(lepton)>20 GeV/c
* Lepton isolated from jets
* 80<M(bb−jets)<125 GeV/c^2

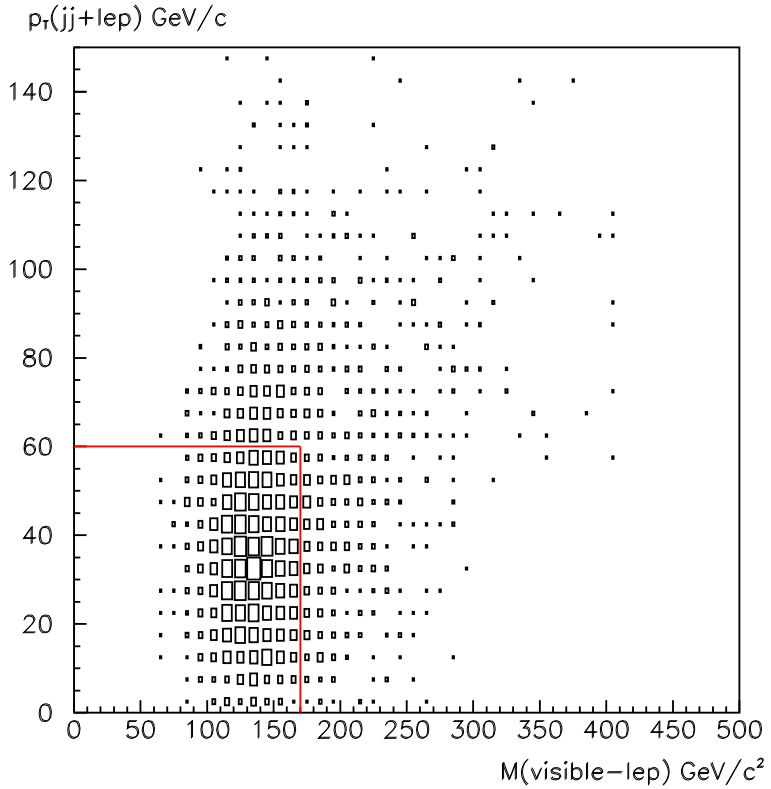
- Further studies which include ...
  - using fast detector simulation (momentum and imp. parameter smearing)
  - applying the seed finder
  - investigation of other backgrounds source such as W+light flavour jets
  - looking for various reconstruction cuts to reduce the background

  ... are well underway ☞ looks encouraging
- However, no final result can be shown at the moment

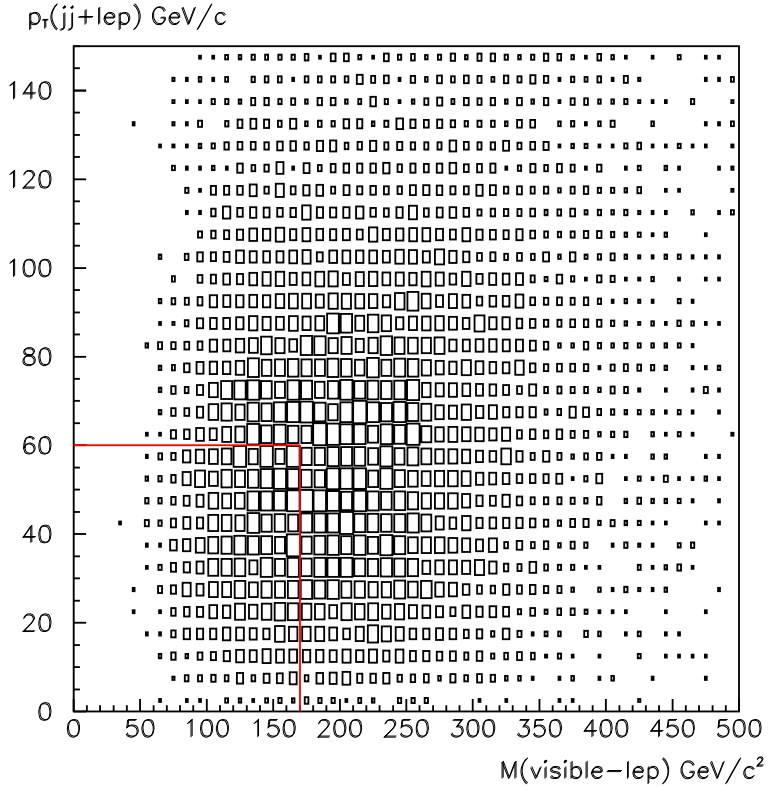
Background cuts

- ... against $b\bar{b}$: prompt isolated lepton
- ... against Wjj : tighter b−tagging (tracks with large IP/jets>N_{min}, signed IP's)
- ... against top : reduced extra activity ⇩

HW



Top



Conclusion

- Main physics goal of LHCb is CP violation in B−mesons, running at low $\mathscr{L}$, but from day 1
- However, for light Higgs in HW,HZ→bb + lepton channel, we have found:
  - adequate acceptance
  - excellent trigger
  - very good b−jet reconsruction and b−tag !
- Preliminary studies with fast simulation and simple analysis encouraging : study will continue !
- Way to discovery will be hard for light Higgs masses, every σ is worth giving the try !