

# Physics analysis and detector optimization for CEPC: Status & plan

Manqi RUAN

IHEP, Beijing

# Why an $e^+e^-$ Higgs factory

$g(hAA)/g(hAA)|_{SM}-1$  LHC/ILC1/ILC/ILCTeV

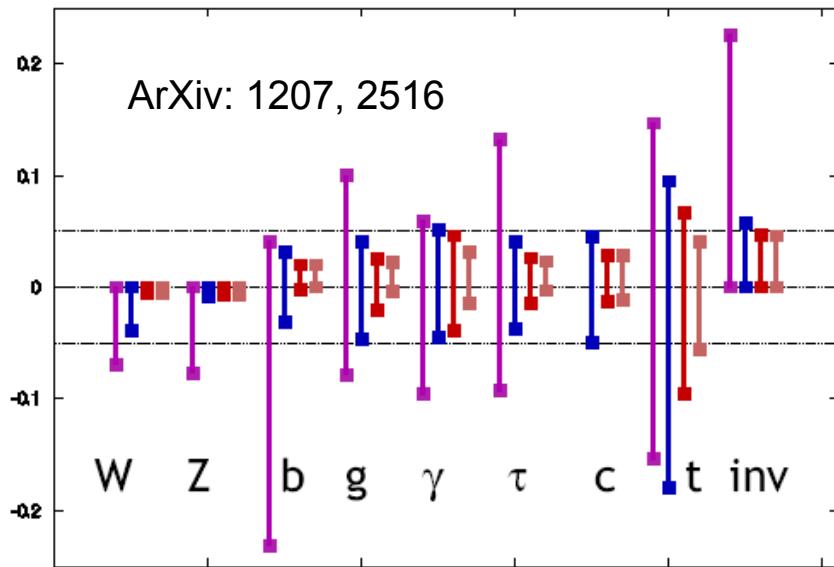


Figure 2: Comparison of the capabilities of LHC and ILC for model-independent measurements of Higgs boson couplings. The plot shows (from left to right in each set of error bars) 1  $\sigma$  confidence intervals for LHC at 14 TeV with  $300 \text{ fb}^{-1}$ , for ILC at 250 GeV and  $250 \text{ fb}^{-1}$  (ILC1), for the full ILC program up to 500 GeV with  $500 \text{ fb}^{-1}$  (ILC), and for a program with  $1000 \text{ fb}^{-1}$  for an upgraded ILC at 1 TeV (ILCTeV). The marked horizontal band represents a 5% deviation from the Standard Model prediction for the coupling.

Precisely verify the standard model – searching for possible new physics  
Higgs couplings must be measured to at least 10% ( $\delta \sim 3\text{-}5\%$ )

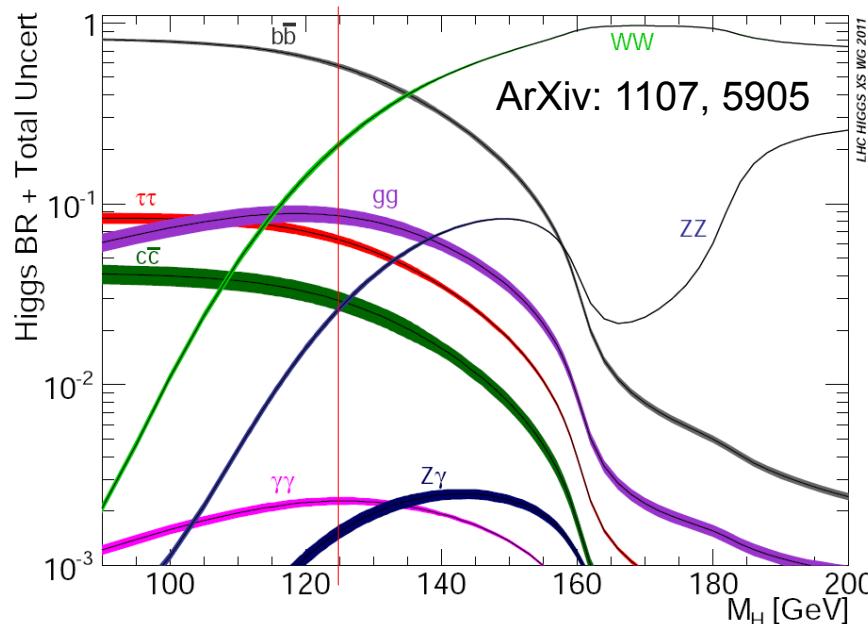
LHC: high productivity, no tagging signal, huge backgrounds & systematics.

Ultimate precision in Higgs coupling limited to  $\sim 10\text{ - }20\%$

$e^+e^-$  machine: low background – no trigger mode, precisely known/adjustable initial state, allowance of model independent measurement...

a precise Higgs factory must be a lepton machine (ILC, LEP3, TLEP..., **CEPC**)

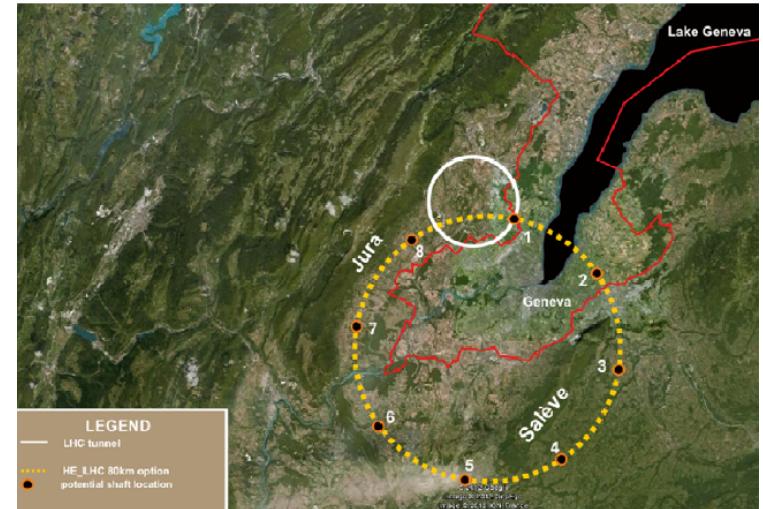
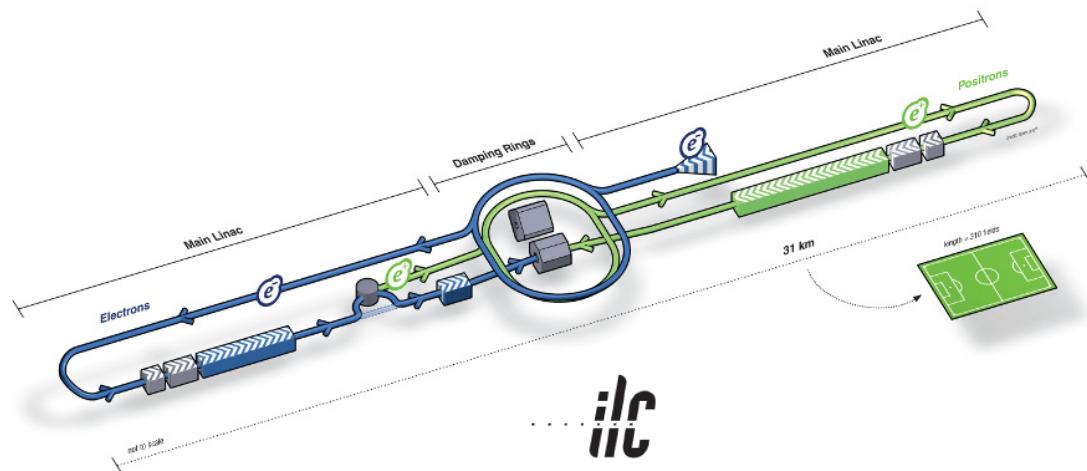
标准模型 Higgs 衰变分支比



Bb: 58%; WW, 21%; gg, 9%; tt, 6%; cc, 3%;  
ZZ + others, 3%

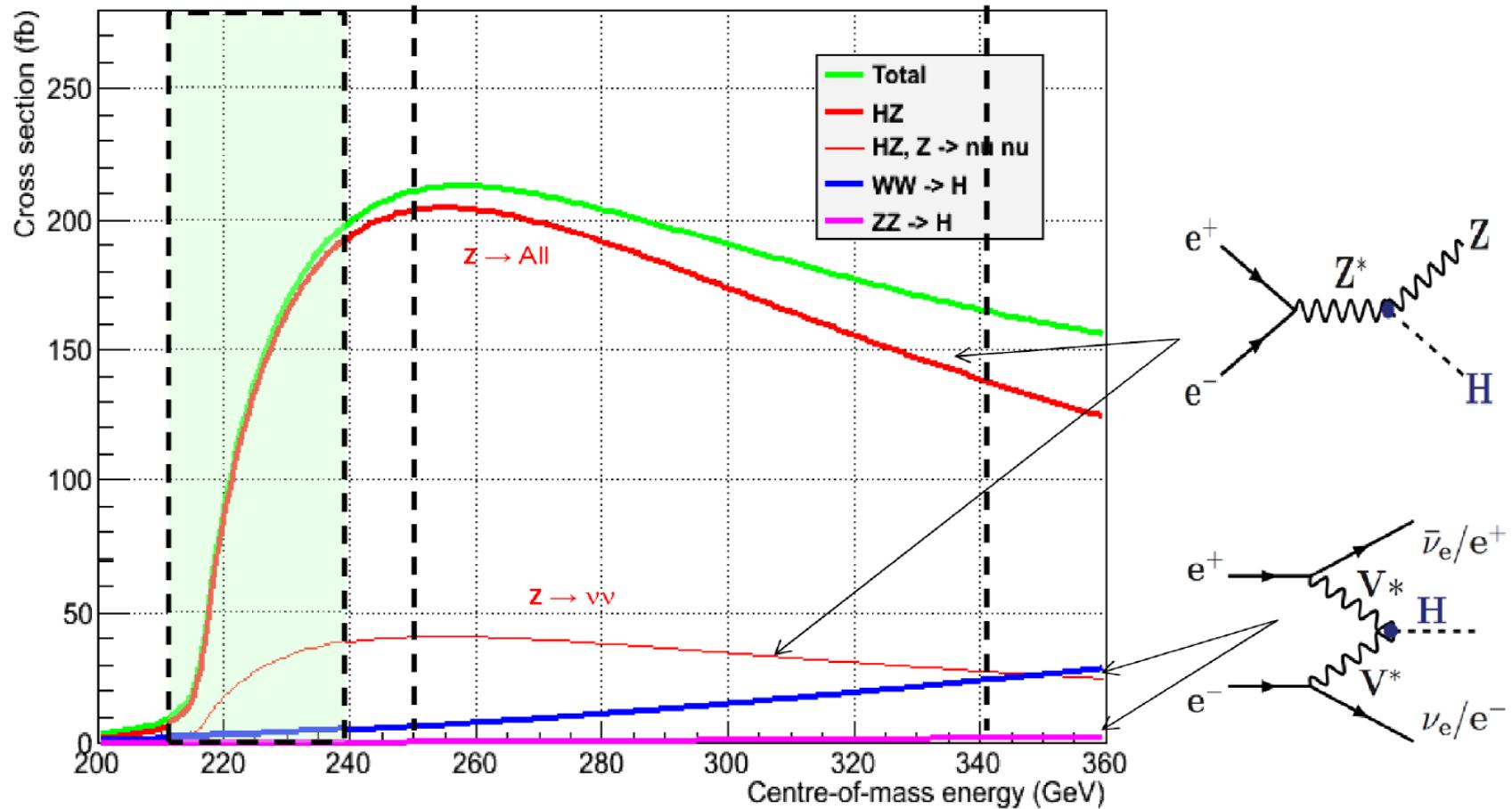
$$\frac{g_{HXX}}{g_{HXX}^{SM}} \approx 1 + \delta \times \left( \frac{1 \text{ TeV}}{\Lambda_{NP}} \right)^2$$

# Higgs factory: Linear or Circular



	Linear: ILC, CLIC	Circular: CEPC, TLEP
Pro	Center of mass energy can be upgraded to 1-3 TeV Longitudinal polarized beam Power pulsed detector	Cost-efficient, mature technology Multiple interaction point High luminosity & beam quality
Con	Expensive ( $\sim 8 - 10$ B euros) Single interaction point, might need push-pull	Center of mass energy limited in $e^+e^-$ phase (and can be upgraded to $\sim 100$ TeV in pp phase) No beam polarization at high energy No power pulse

# Higgs productivity at $e^+e^-$ machine



$\sigma(HZ, 240 \text{ GeV}) \sim 200 \text{ fb}$  with non-polarized beam

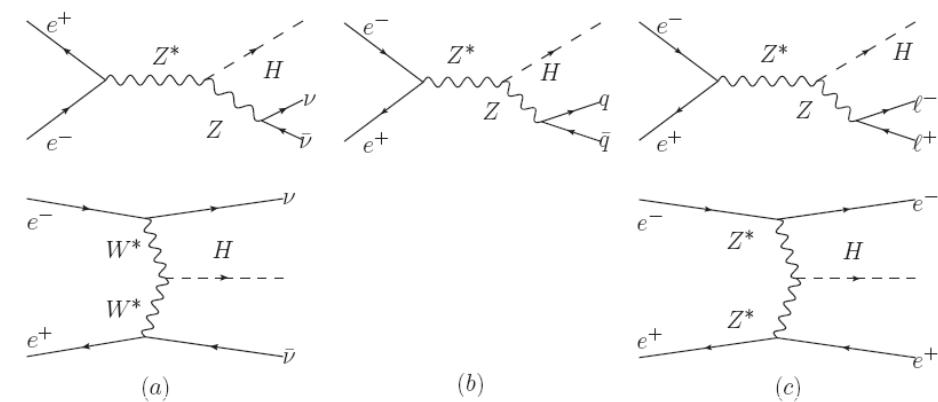
$L \sim 10^{34} \text{ cm}^{-2}\text{s}^{-1} \sim 100 \text{ fb}^{-1}/\text{y}$  : Nominal luminosity  $500 \text{ fb}^{-1} \sim 10^5 \text{ Higgs/IP}$

Benchmark: **100 k Higgs**, but can be (largely) increased

*Beam polarization can enhance the Higgs productivity by  $\sim 50\%$  at ILC, and reduce the SM Background at the same time. However, it's not crucial for Higgs measurement*

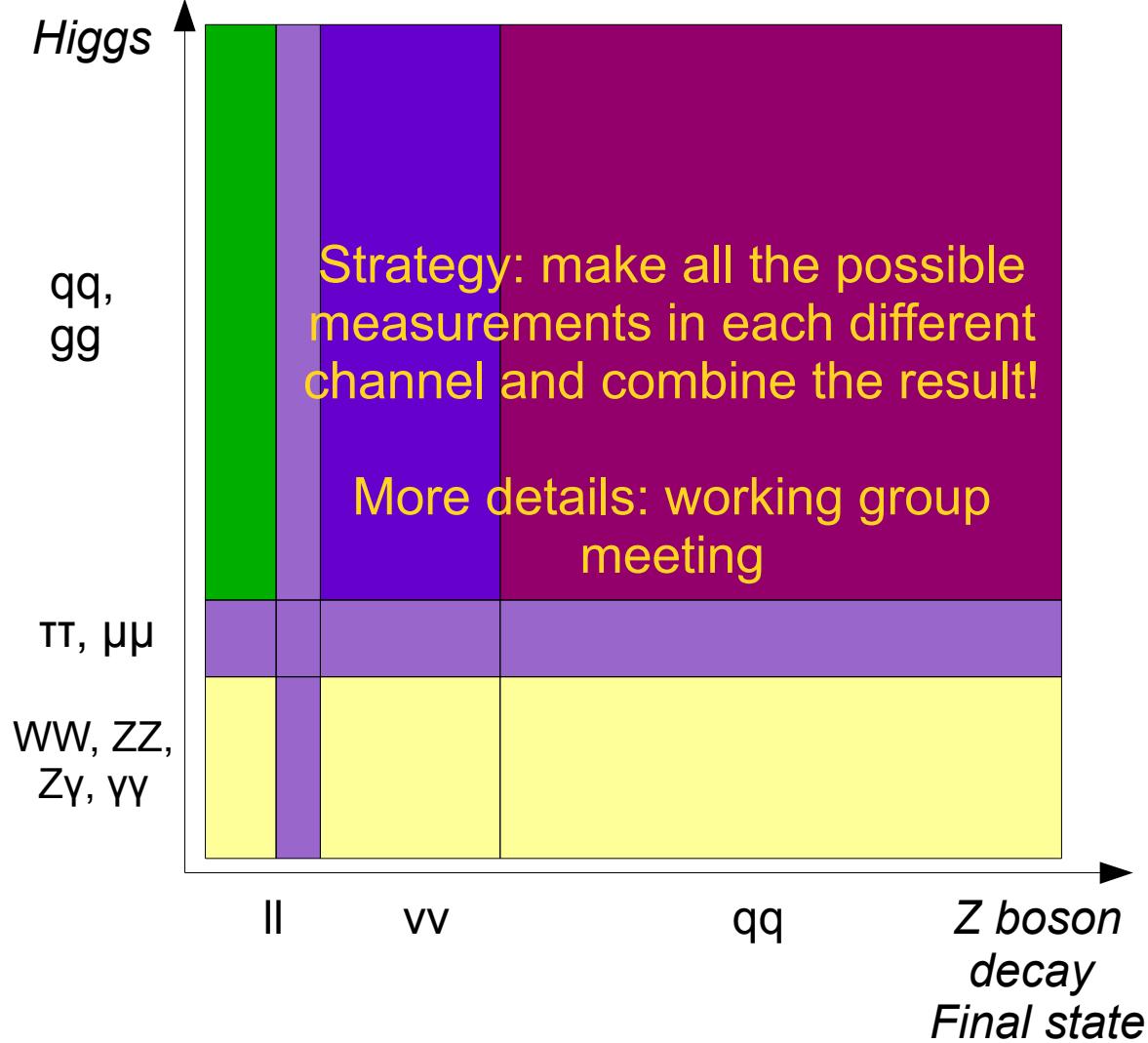
# CEPC: 8 + 2 measurements for SM higgs

- Mass, spin, total cross section
- Branching ratios (b, c, tau, g, W)
- Branching ratios (gamma, mu)
- Calculate: width – coupling
- Other measurements, SM & exotics...

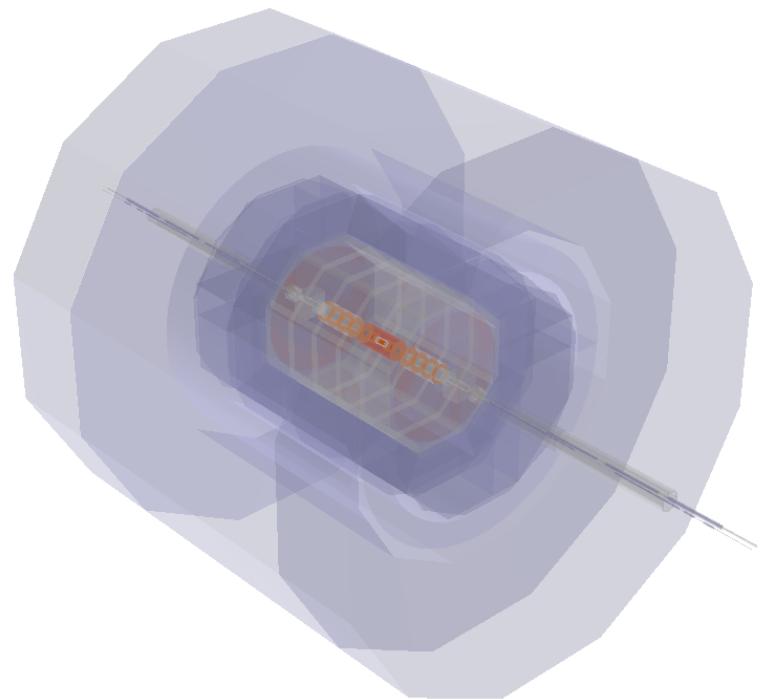


Mode	$b\bar{b}$	$c\bar{c}$	$gg$	$WW^*$	$\mu^+\mu^-$	$\tau^+\tau^-$	$ZZ^*$	$\gamma\gamma$	$Z\gamma$
BR (%)	57.8	2.7	8.6	21.6	0.02	6.4	2.7	0.23	0.16
g(Hbb), g(Hcc), g(Htt), g(HWW)/ $\Gamma_H$ , g(Hmu mu),					g(Htau tau), g(HZZ)/ $\Gamma_H$ , g(HWW)/g(Htt)				

# Signal events and reference detector(s)



Reference detectors: **ILD**, CMS,...

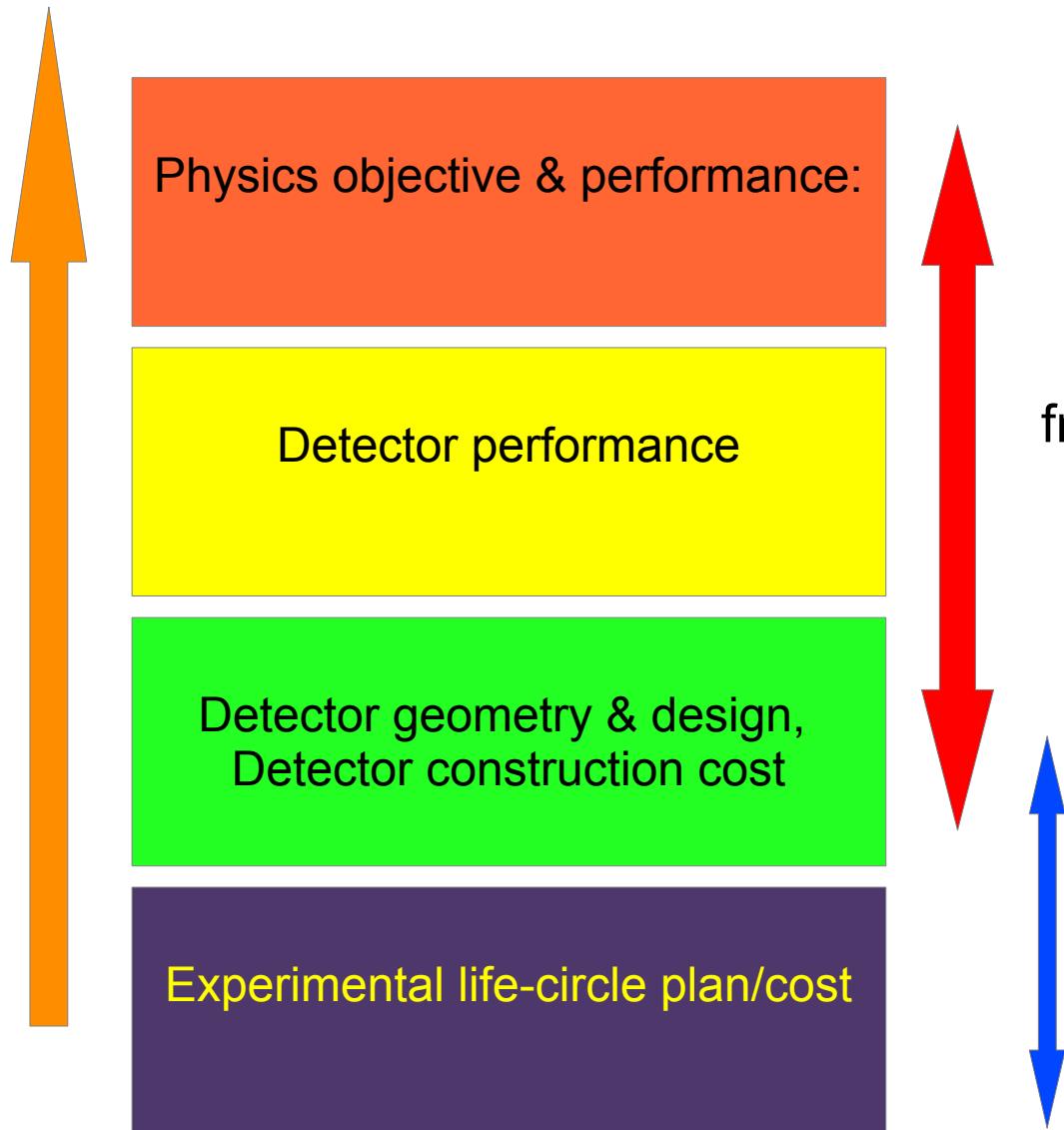


ILD, Power pulsed detector with Ultra-high granularity

Vertex: Impact parameter  $\sim 5 \mu\text{m}$   
Tracker:  $\delta(1/P) \sim 2 \cdot 10^{-5}/\text{GeV}$   
Calo (+ Tracker):  $\delta(E_J)/E_J \sim 3 - 4\%$

...

# Detector optimization: objective



**Full & Fast simulation:**

from generator to physics performance,  
parametrized the performance to  
detector design/cost...

Profound understanding, reliable reference,  
Communication, PR, decision making...

# Observables and expected accuracy

Accelerator → Physical Quantity ↓	LHC 300 fb <sup>-1</sup> /expt	HL-LHC 3000 fb <sup>-1</sup> /expt	ILC 250 GeV 250 fb <sup>-1</sup> 5 yrs	Full ILC 250+350+ 1000 GeV 5 yrs each	CLIC 350 GeV (500 fb <sup>-1</sup> ) 1.4 TeV (1.5 ab <sup>-1</sup> ) 5 yrs each	LEP3, 4 IP 240 GeV 2 ab <sup>-1</sup> (*) 5 yrs	TLEP, 4 IP 240 GeV 10 ab <sup>-1</sup> 5 yrs (*) 350 GeV 1.4 ab <sup>-1</sup> 5 yrs (*)
$N_H$	$1.7 \times 10^7$	$1.7 \times 10^8$	$6 \times 10^4$ ZH	$10^5$ ZH $1.4 \times 10^5$ Hvv	$7.5 \times 10^4$ ZH $4.7 \times 10^5$ Hvv	$4 \times 10^5$ ZH	$2 \times 10^6$ ZH $3.5 \times 10^4$ Hvv
$m_H$ (MeV)	100	50	35	35	100	26	7
$\Delta\Gamma_H / \Gamma_H$	--	--	10%	3%	ongoing	4%	1.3%
$\Delta\Gamma_{inv} / \Gamma_H$	Indirect (30%?)	Indirect (10%?)	1.5%	1.0%	ongoing	0.35%	0.15%
$\Delta g_{H\gamma\gamma} / g_{H\gamma\gamma}$	6.5 – 5.1%	5.4 – 1.5%	--	5%	ongoing	3.4%	1.4%
$\Delta g_{Hgg} / g_{Hgg}$	11 – 5.7%	7.5 – 2.7%	4.5%	2.5%	< 3%	2.2%	0.7%
$\Delta g_{Hww} / g_{Hww}$	5.7 – 2.7%	4.5 – 1.0%	4.3%	1%	~1%	1.5%	0.25%
$\Delta g_{HZZ} / g_{HZZ}$	5.7 – 2.7%	4.5 – 1.0%	1.3%	1.5%	~1%	0.65%	0.2%
$\Delta g_{HHH} / g_{HHH}$	--	< 30% (2 expts)	--	~30%	~22% (~11% at 3 TeV)	--	--
$\Delta g_{H\mu\mu} / g_{H\mu\mu}$	< 30%	< 10%	--	--	10%	14%	7%
$\Delta g_{H\tau\tau} / g_{H\tau\tau}$	8.5 – 5.1%	5.4 – 2.0%	3.5%	2.5%	≤ 3%	1.5%	0.4%
$\Delta g_{Hcc} / g_{Hcc}$	--	--	3.7%	2%	2%	2.0%	0.65%
$\Delta g_{Hbb} / g_{Hbb}$	15 – 6.9%	11 – 2.7%	1.4%	1%	1%	0.7%	0.22%
$\Delta g_{Htt} / g_{Htt}$	14 – 8.7%	8.0 – 3.9%	--	5%	3%	--	30%

ArXiv: 1302.3318

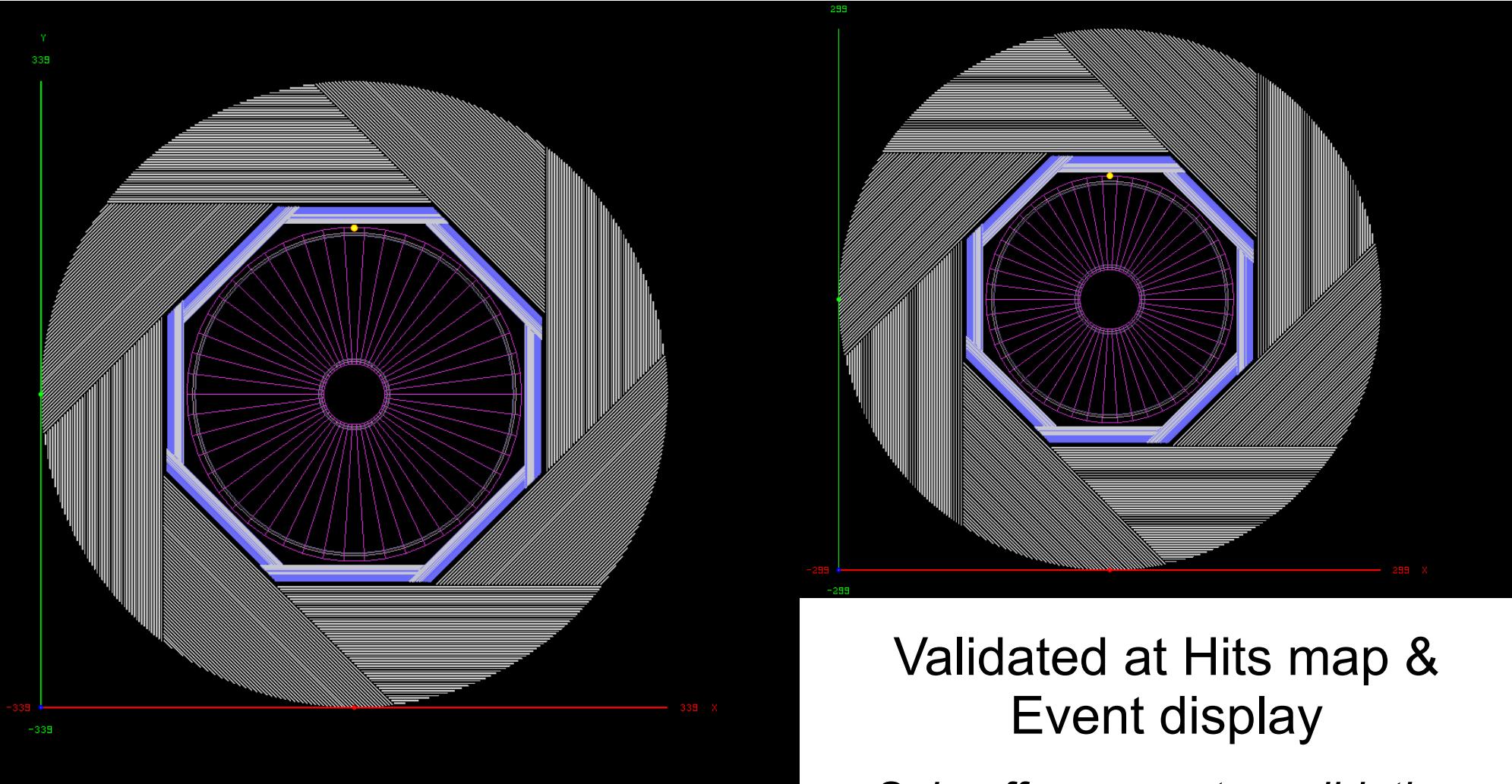
13/09/2013

Objective: similar tables at different scenarios, with  
Fast – Full Simulation

# 物理分析及探测器优化工作现状

- 工作环境
  - ILD 软件环境和数据流：设置完毕
  - 50 CPU, 5 + 5 TB, Higgsq 队列，本地数据库服务 ...
- 成员
  - 杨迎, Ph.D
  - 杜春, Postdoc
  - Postdoc 招募：[http://www.ihep.cas.cn/zszp/zsxx/201307/t20130704\\_3892718.html](http://www.ihep.cas.cn/zszp/zsxx/201307/t20130704_3892718.html)
- 同 ILC 组的国际合作：法国，日本等
- 分析工作各项进展：
  - 探测器几何：由 ILD 基础上进行相应优化得到（进行中）
  - 产生子：ILD 样本，验证 - 快速模拟分析已完成 ~50%
  - 全模拟：进行中 (~500G data generated + access to ILD samples)。
  - 重建 - 分析：测试完成，需进行优化工作

# Design new geometry

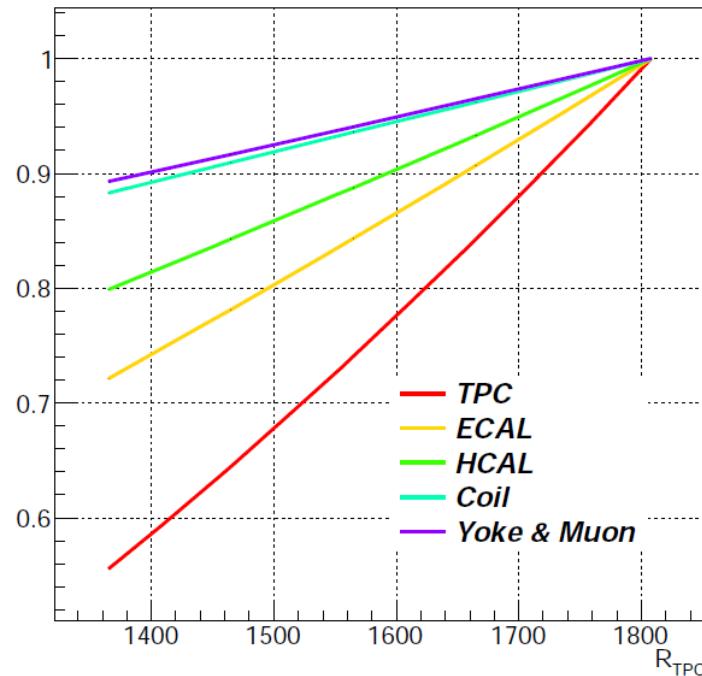


Validated at Hits map &  
Event display

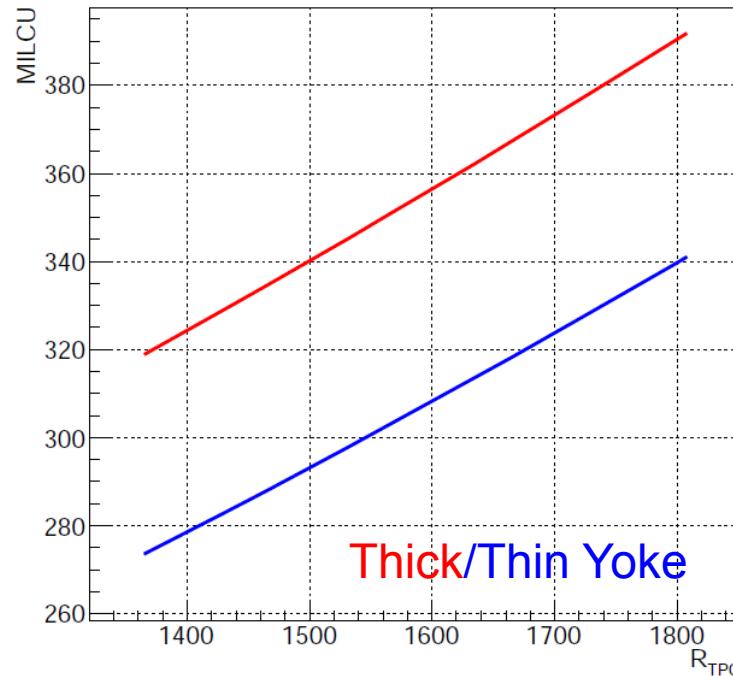
*Spin off – geometry validation  
analysis chains*

# Cost estimation: extrapolate from ILD

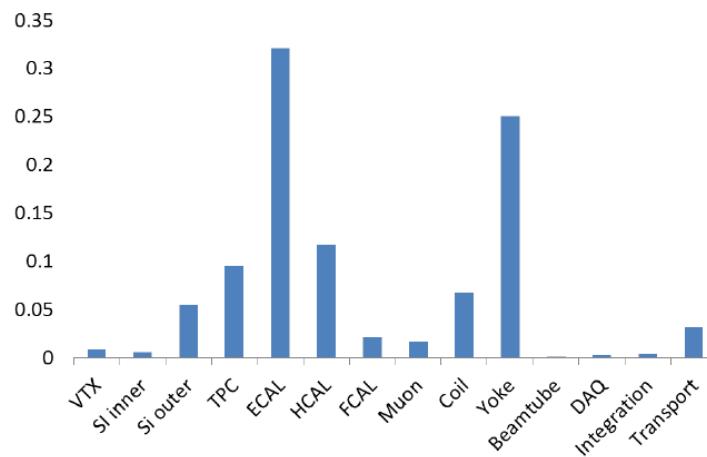
Sub Detector Cost Scale With TPC Radius



Total Cost as a function of TPC Radius



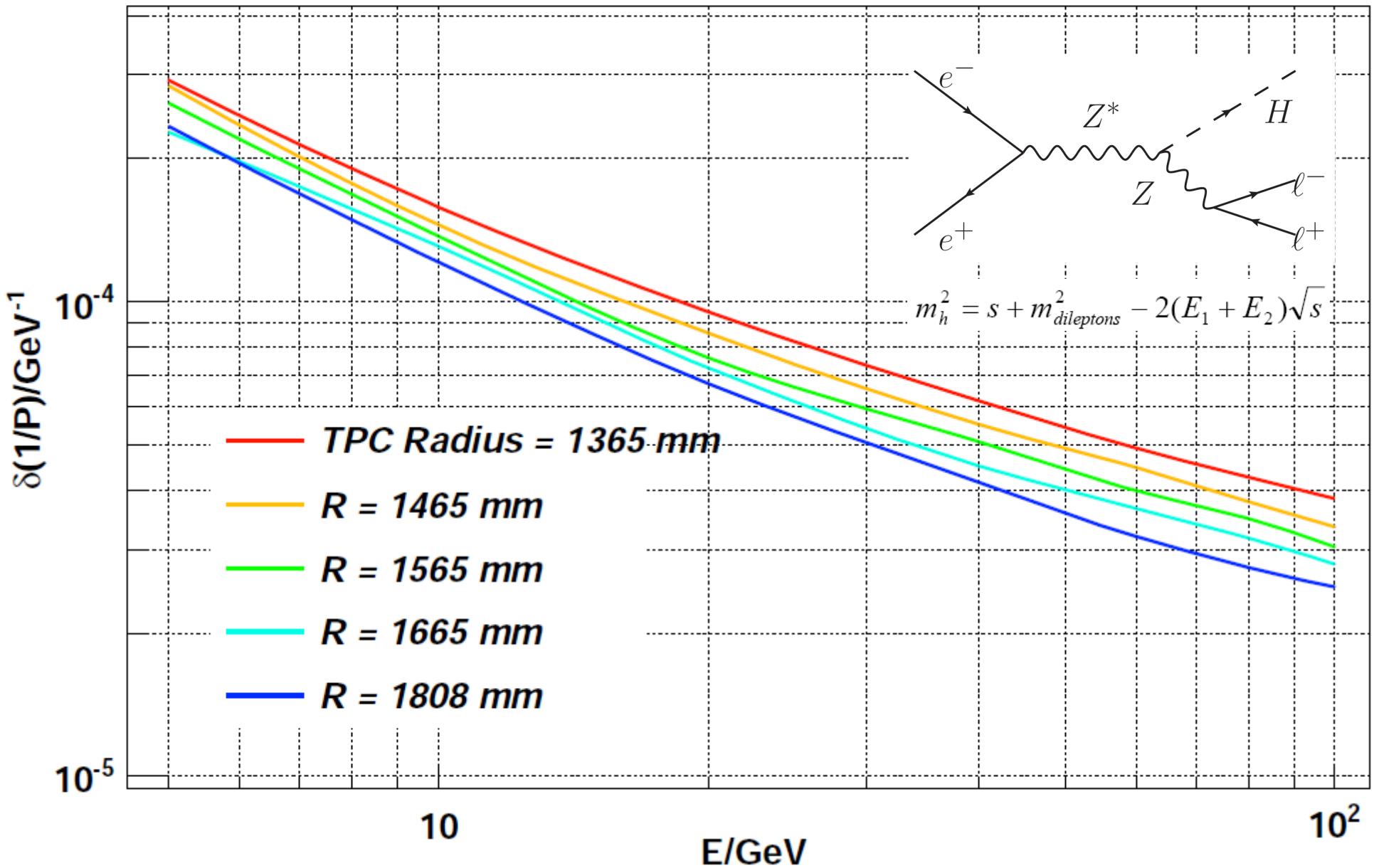
Thick/Thin Yoke



$ILD \text{ Cost} \sim 400 \text{ MILCU}$   
 $CEPC \text{ detector} \sim 270 \text{ MILCU}$   
 $\sim 1.6 \text{ Billion CNY}$   
 $\sim 3 \text{ B CNY for 2 detectors};$

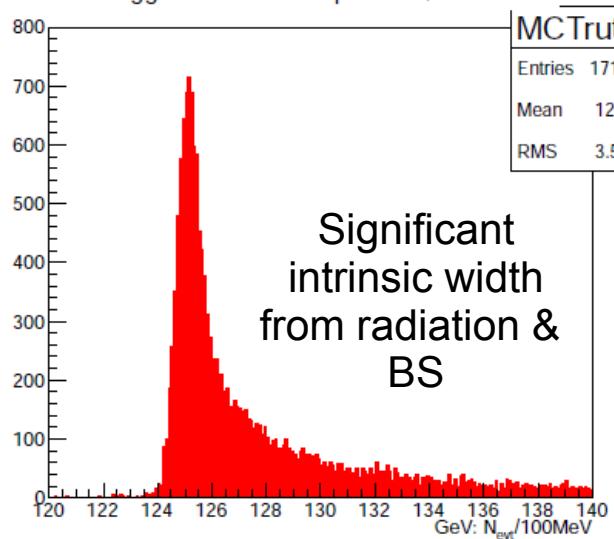
*Without manpower*

## Tracker performance tested on $\mu^-$ sample with flat $\cos(\theta)$

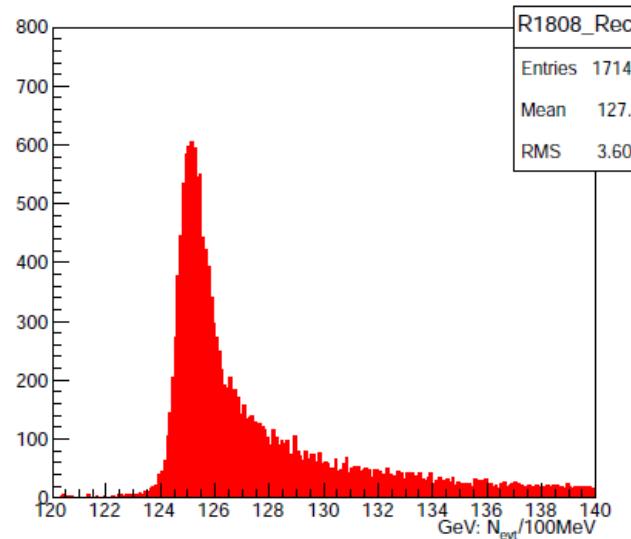


# Recoil mass to $Z \rightarrow \mu\mu$ at different TPC Radius

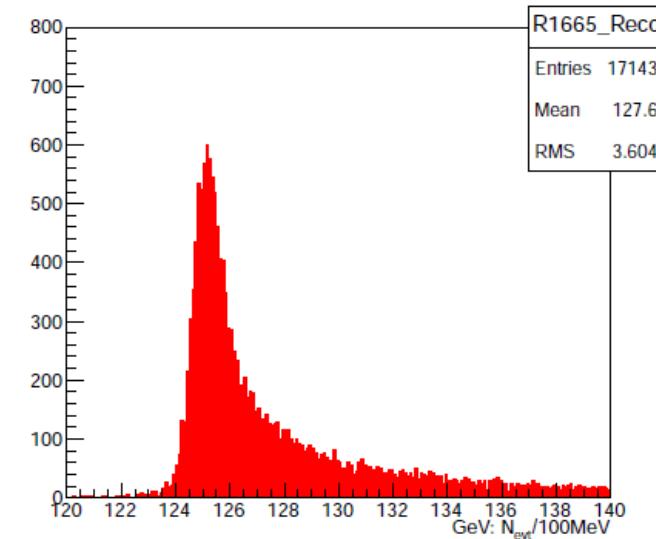
Higgs Recoil Mass spectrum, MC Truth



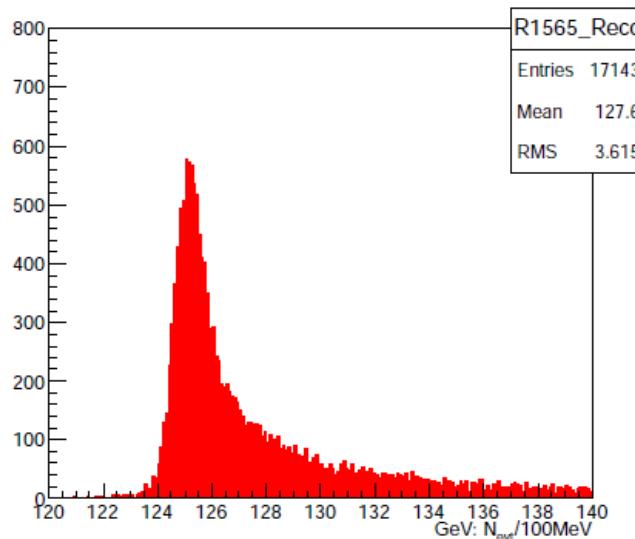
Fast Simulation, TPC Radius = 1808 mm



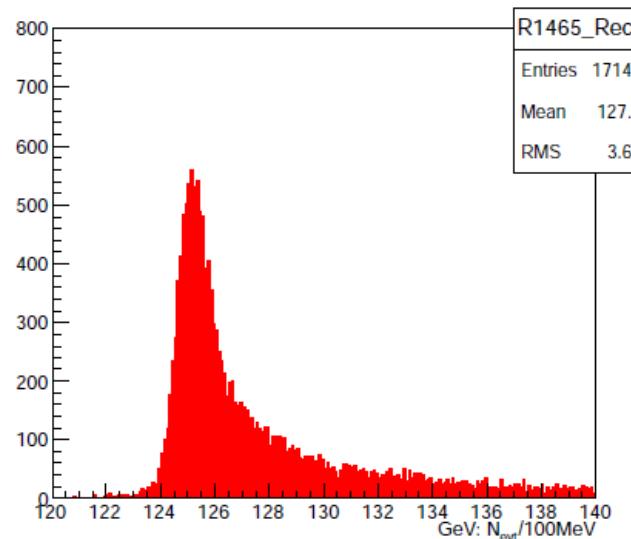
Fast Simulation, TPC Radius = 1665 mm



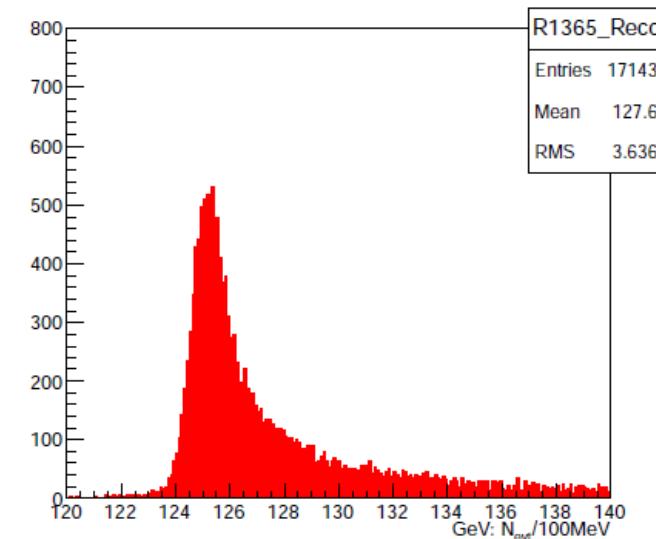
Fast Simulation, TPC Radius = 1565 mm



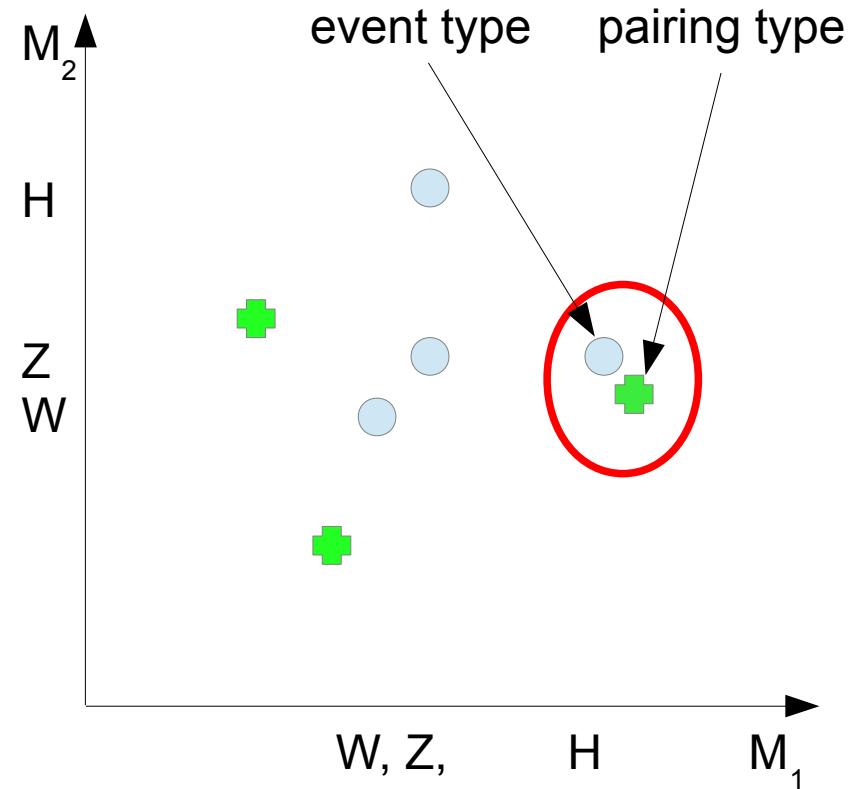
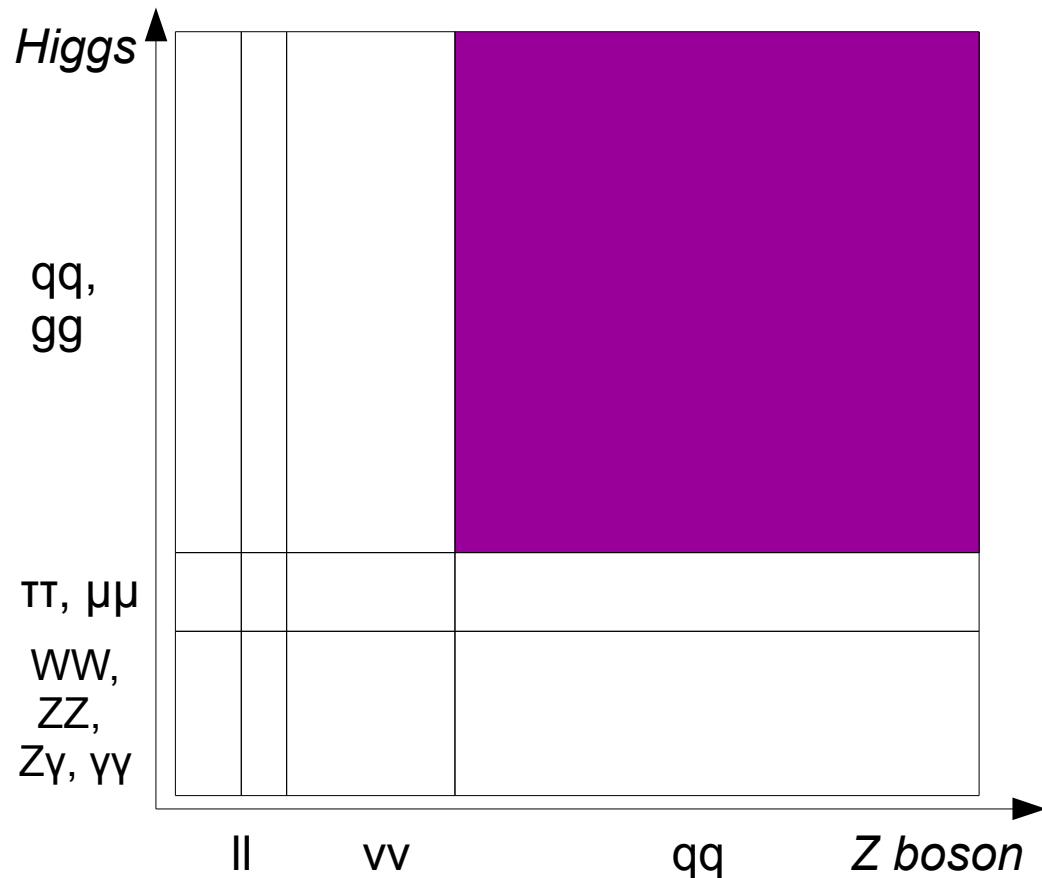
Fast Simulation, TPC Radius = 1465 mm



Fast Simulation, TPC Radius = 1365 mm



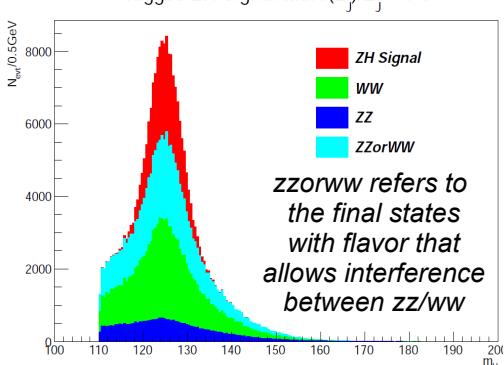
# Measurement of $\sigma(HZ)^*\text{Br}(H \rightarrow 2j)$



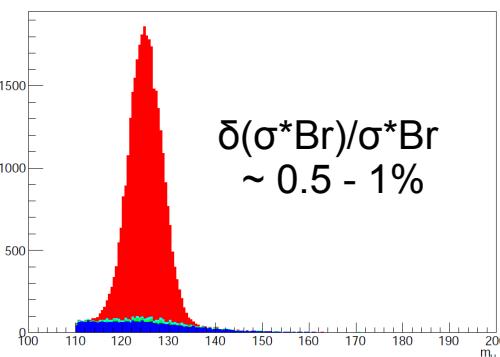
- Represent reconstructed jets by MC Truth quark \* percentage energy smearing
- Main backgrounds  $ZZ$ ,  $WW$  events into 4 jets
- Define  $\text{Chi2} = ((M_{i,j} - MB_1)/\sigma_1)^2 + ((M_{k,l} - MB_2)/\sigma_2)^2$ ,  $ijkl$  runs over all 3 combinations
- The minimal chi2 indicates both event type and jet pairing

# Performance at different Jet E resolution

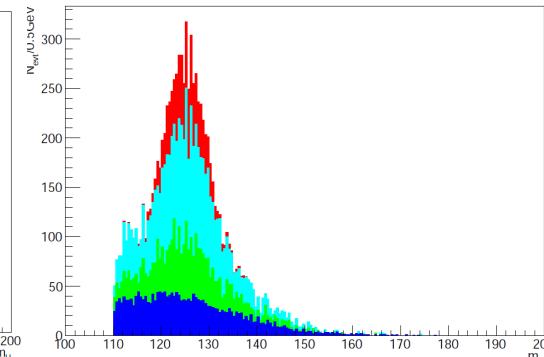
Tagged ZH Signal with  $\delta(E_j)/E_j = 4\%$



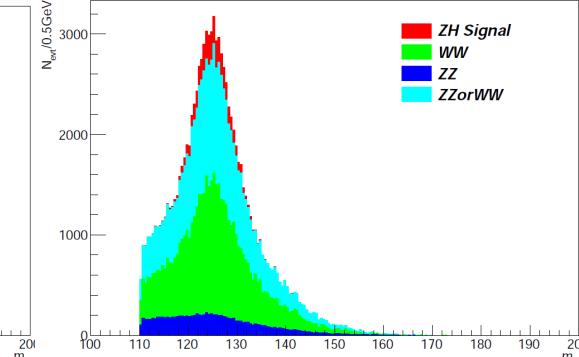
$\delta(E_j)/E_j = 4\%$ , request both b-jets from tagged Higgs



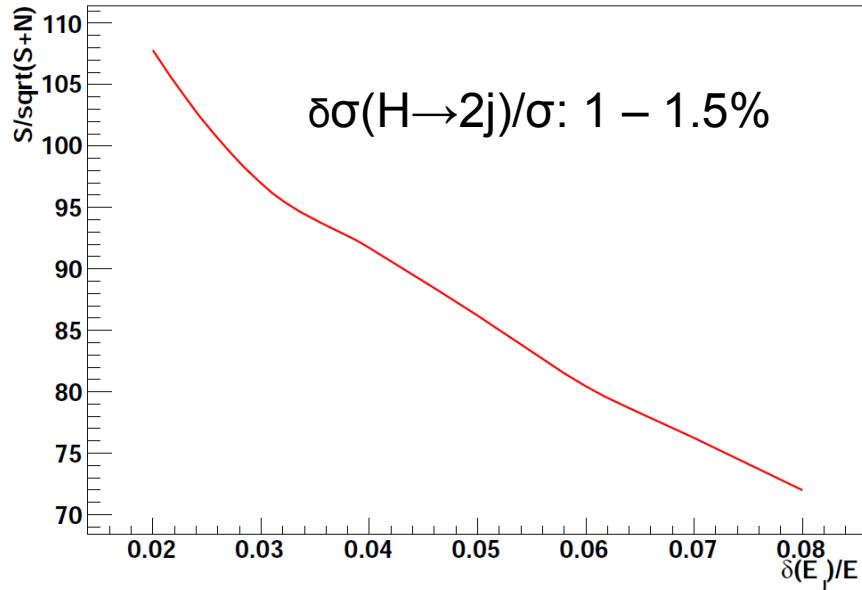
$\delta(E_j)/E_j = 4\%$ , request both c-jets from tagged Higgs



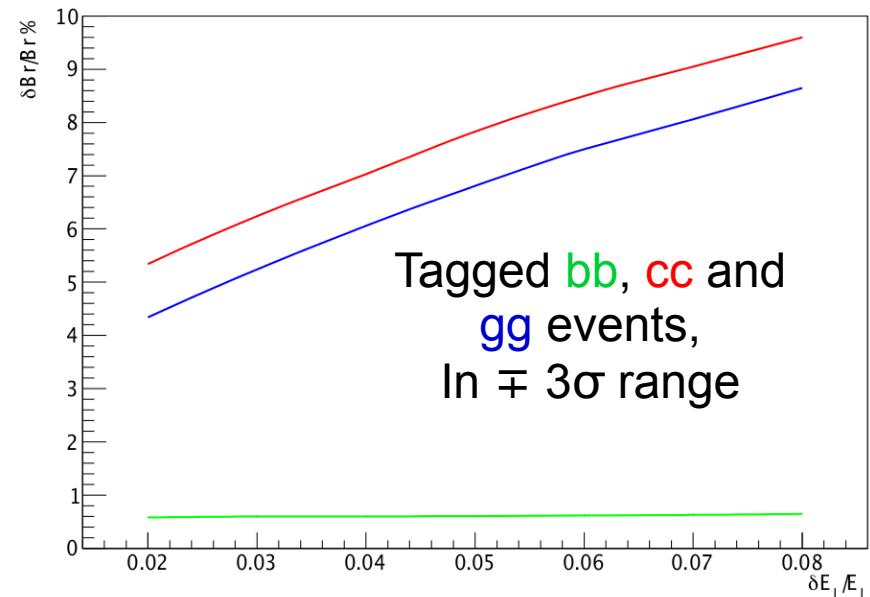
$\delta(E_j)/E_j = 4\%$ , request both uds-jets from tagged Higgs



Signal over Noise Ratio



Accuracy of  $\sigma(ZH)\text{Br}(H \rightarrow X)$  Measurement from 4 jet final state



$\sigma(H \rightarrow 2j, j = b, c, g)$  measurement: Depends on Flavor Tagging, Jet tagging, clustering & Jet energy resolution...

# Status of on going analysis



$\sigma(\text{HZ})/\text{Mass}$



$\sigma(\text{HZ})^* \text{Br}(\text{H} \rightarrow 2j)$   
J = b, c, q...  
 $Z \rightarrow 2j$



**5/8 observables touched.**  
Remaining:  $\text{Br}(H \rightarrow WW, \tau\tau)$ , spin

$\sigma(\text{HZ})^* \text{Br}(\text{H} \rightarrow 2X)$   
 $Z \rightarrow 2j, 2l$



Full Simulation  
/reconstruction



**Priority:**  
Development & optimization on **PFA**  
and other reconstruction, recognition  
Algorithms on full simulation basis  
(preferably, after we summarize  
the knowledge from fast simulation...)

**Need manpower & time!**

# Full simulation & Reconstruction

DRUID, RunNum = 0, EventNum = 9001

# Full simulation

*Started: 50 busy CPUs*

*Target geometry*

*Default one*

*1-2 benchmark models (to be fixed)*

*Tactics*

*Signal (~300k) at each model: 1 week (done)*

*Background (~10M) at 1 model: 7 month...*

*Fast simulation tools validation: Fast – Full  
Simulation comparison: enable extrapolation*

*Reconstruction algorithm development,  
validation & optimization: hardcore*

*PFA optimization*

*Lepton id & Tau id*

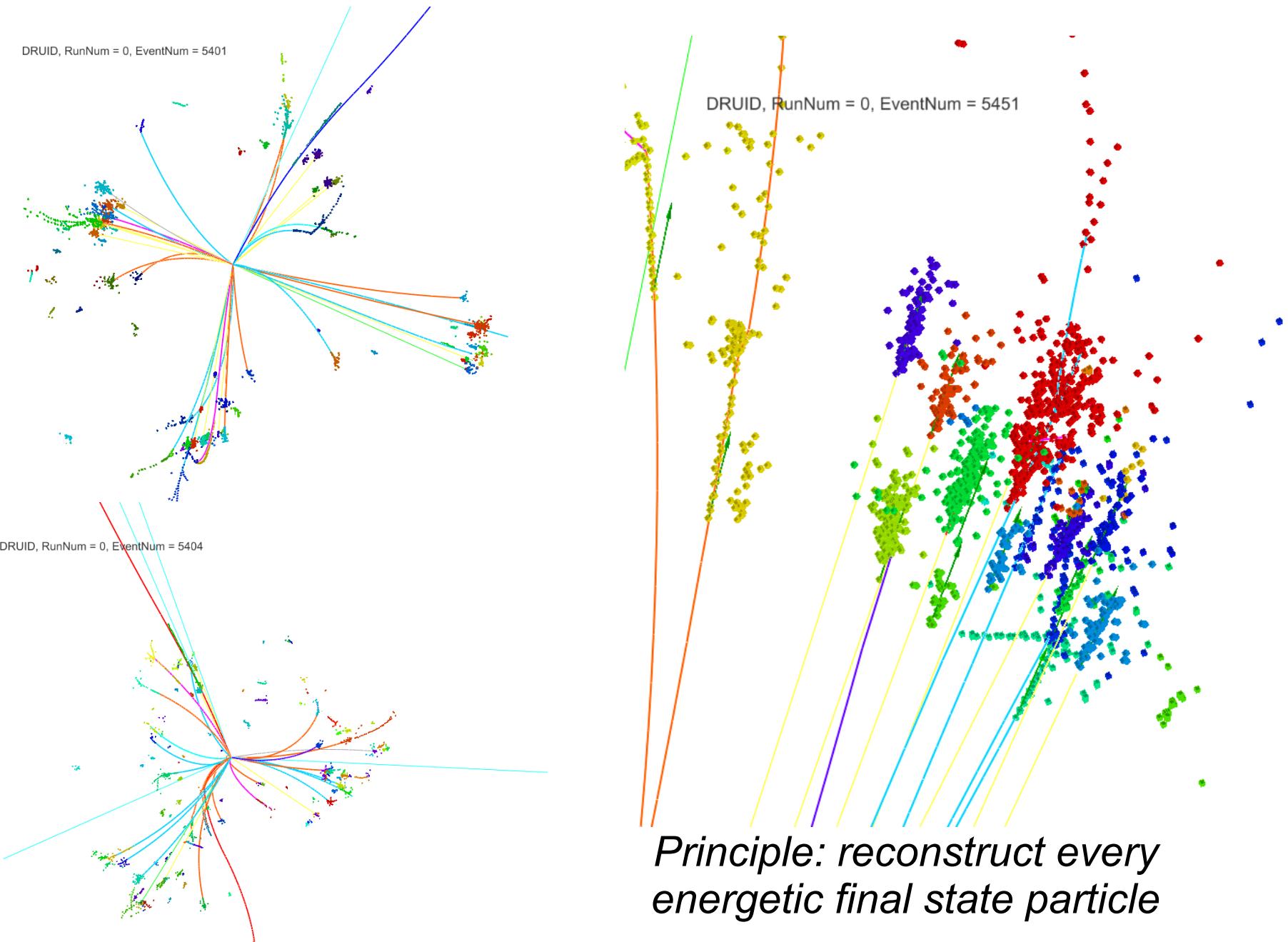
*Jet tagging & clustering...*

[manqi@lxsc508 ~]\$ qstat -u yangy

pbssrv.ihep.ac.cn:

Job ID	Username	Queue	Jobname	Req'd SessID	Req'd NDS	Elap TSK	Memory	S Time
9671113.pbssrv.i	higgsq	sub_job16.sh	23831	--	--	--	R 20:25	
9671114.pbssrv.i	higgsq	sub_job17.sh	10669	--	--	--	R 20:24	
9671118.pbssrv.i	higgsq	sub_job21.sh	1319	--	--	--	R 20:25	
9671120.pbssrv.i	higgsq	sub_job23.sh	10897	--	--	--	R 20:25	
9671123.pbssrv.i	higgsq	sub_job26.sh	20671	--	--	--	R 20:25	
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9671127.pbssrv.i	higgsq	sub_job30.sh	878	--	--	--	R 20:25	
9671129.pbssrv.i	higgsq	sub_job32.sh	20941	--	--	--	R 20:21	
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9671134.pbssrv.i	higgsq	sub_job37.sh	7259	--	--	--	R 20:22	
9671135.pbssrv.i	higgsq	sub_job38.sh	21268	--	--	--	R 20:22	
9671136.pbssrv.i	higgsq	sub_job39.sh	2067	--	--	--	R 20:21	
9671139.pbssrv.i	higgsq	sub_job42.sh	1407	--	--	--	R 20:22	
9671141.pbssrv.i	higgsq	sub_job44.sh	21462	--	--	--	R 20:22	
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9682299.pbssrv.i	higgsq	sub_job13.sh	12874	--	--	--	R 09:28	
9682301.pbssrv.i	higgsq	sub_job14.sh	23660	--	--	--	R 09:28	
9682302.pbssrv.i	higgsq	sub_job15.sh	28101	--	--	--	R 09:28	
9682304.pbssrv.i	higgsq	sub_job18.sh	18918	--	--	--	R 09:27	
9682308.pbssrv.i	higgsq	sub_job20.sh	22549	--	--	--	R 09:27	
9682314.pbssrv.i	higgsq	sub_job22.sh	24973	--	--	--	R 09:26	
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9682320.pbssrv.i	higgsq	sub_job25.sh	9852	--	--	--	R 09:26	
9682323.pbssrv.i	higgsq	sub_job27.sh	23447	--	--	--	R 09:26	
9682325.pbssrv.i	higgsq	sub_job28.sh	25637	--	--	--	R 09:26	
9682327.pbssrv.i	higgsq	sub_job29.sh	469	--	--	--	R 09:26	
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9682778.pbssrv.i	higgsq	sub_job5.sh	32347	--	--	--	R 09:14	
9682779.pbssrv.i	higgsq	sub_job6.sh	607	--	--	--	R 09:14	
9682780.pbssrv.i	higgsq	sub_job7.sh	4843	--	--	--	R 09:14	
9682781.pbssrv.i	higgsq	sub_job8.sh	30955	--	--	--	R 09:14	
9682782.pbssrv.i	higgsq	sub_job9.sh	22228	--	--	--	R 09:14	
9682792.pbssrv.i	higgsq	sub_job4.sh	10038	--	--	--	R 09:11	

# Reconstruction with Arbor



# 工作计划

- 物理分析现状
  - 所有必需的软件工具，包括产生子，模拟，重建和分析等，已经就绪。
  - 基于产生子的快速模拟分析正在进行，预期将于 11 月初结束。该分析将对和 Higgs 粒子相关的主要测量结果给出一阶近似下的估计
- 工作重点
  - 物理分析：
    - 重建算法在不同探测器几何下的开发和优化
    - 各物理测量的全模拟分析
  - 探测器研发：
    - 子探测器硬件和电子学原型机开发，验证，响应分析，相关模拟工具的开发以及合成，优化。。。
    - 全探测器几何优化
  - CEPC 项目整体优化：对撞点个数，取数时长，等等

# 工作组织

- 组织安排
  - 模拟和重建在目前将统一由高能所负责完成
    - 模拟和重建: 杨迎
    - 软件维护: 曼奇
  - 物理分析及硬件开发将由各个大学和机构分担完成
    - 针对各个物理测量的全模拟分析
    - 探测器几何的细致优化
    - 重建算法开发及优化
    - 硬件开发及相应模拟
- 联系 [Manqi.ruan@ihep.ac.cn](mailto:Manqi.ruan@ihep.ac.cn) 或 [Wensp@ihep.ac.cn](mailto:Wensp@ihep.ac.cn)
  - 申请高能所计算环境账号以获得数据的读取权限和软件的使用权限
- 会议和交流:
  - 物理分析电话会议: 两周一次
  - 年会: 一年一到两次

# 集中培训

- 目的：让参与者全面了解 Higgs 工厂上的物理分析，探测器设计，以及相关软件的使用方法
- 暂定 10 月中旬在高能所举行模拟和物理分析的集中培训，预期为期 2 - 3 天。
  - 请给 [Manqi.ruan@ihep.ac.cn](mailto:Manqi.ruan@ihep.ac.cn) 发邮件
  - 时间尚未完全确定，请尽快来信告知您倾向的时间
- 培训内容：
  - CEPC 上的 Higgs 物理：标准模型 Higgs 在 CEPC 上的测量，以及其他物理可观测量的测量
  - 主要参考探测器： ILD , CMS , ATLAS 等探测器的主要性能及预期精度
  - 软件工具介绍
    - 数据流和数据控制
    - 模拟工具的使用方法
    - 重建和分析工具的使用方法和基本开发

# 欢迎大家加入！

申请 IHEP 上的计算**账户**

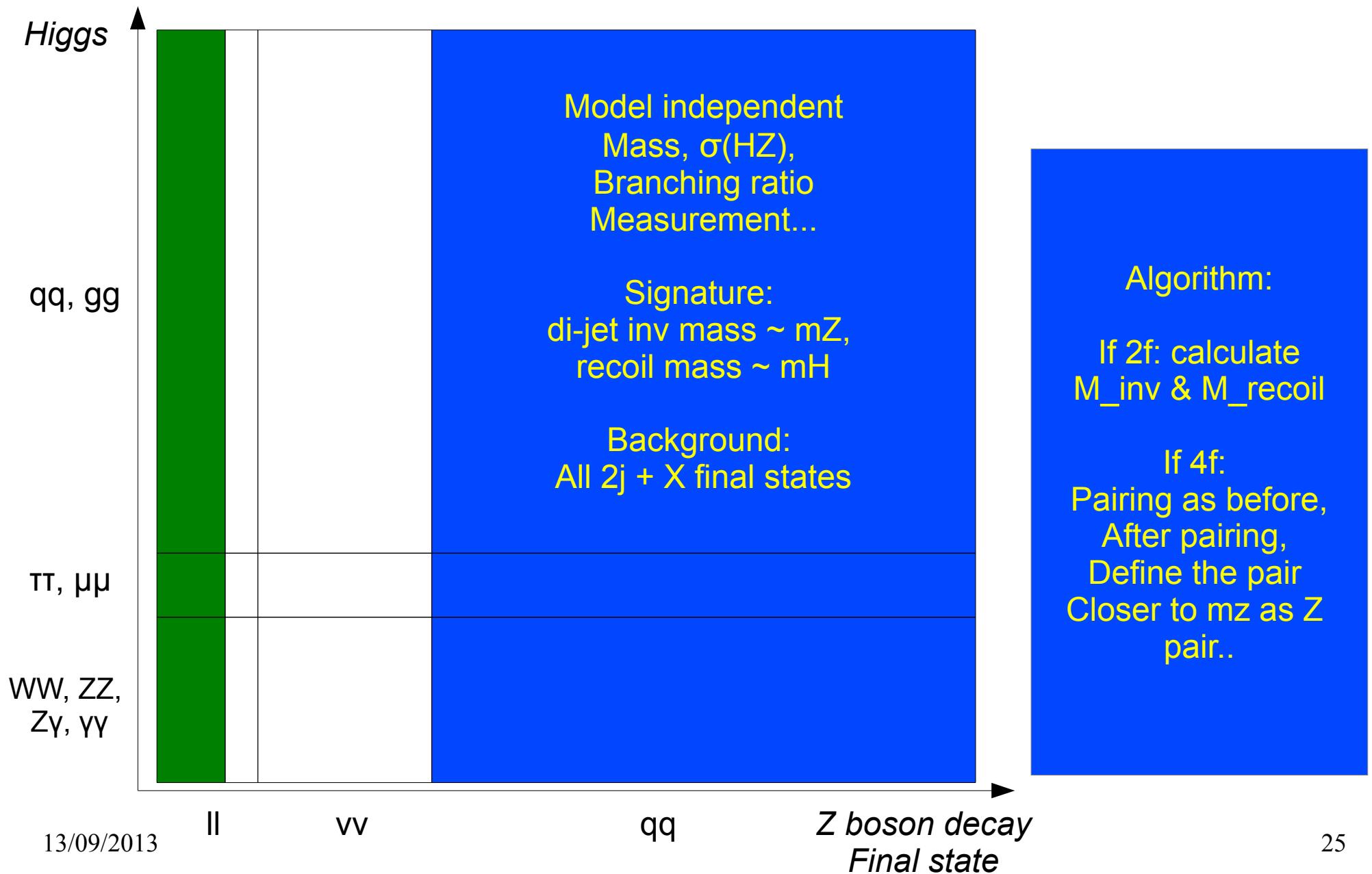
**急需** 1-2 名有分析和重建经验的**博士后**

10 月中旬，**集中培训** 软件和分析工具的使用方法

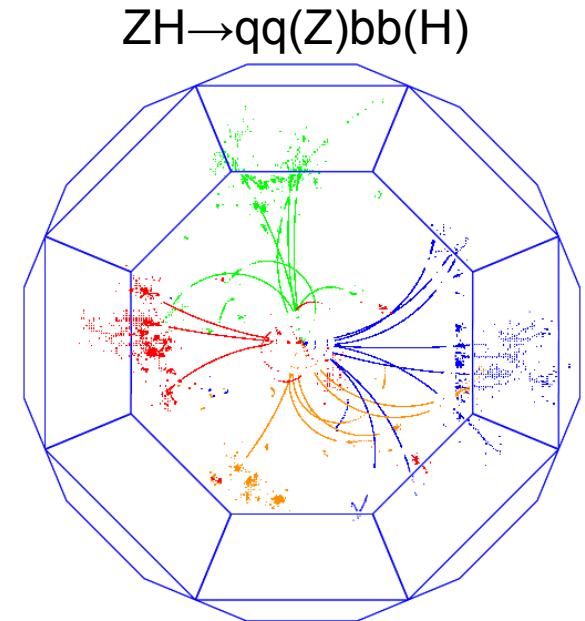
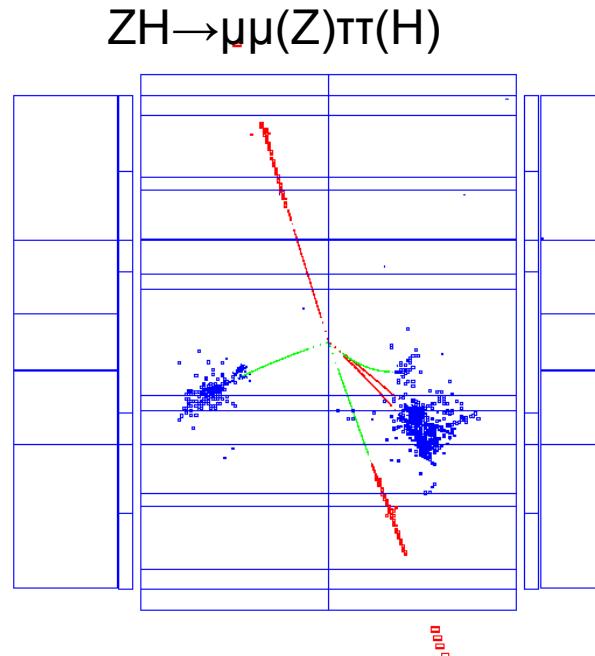
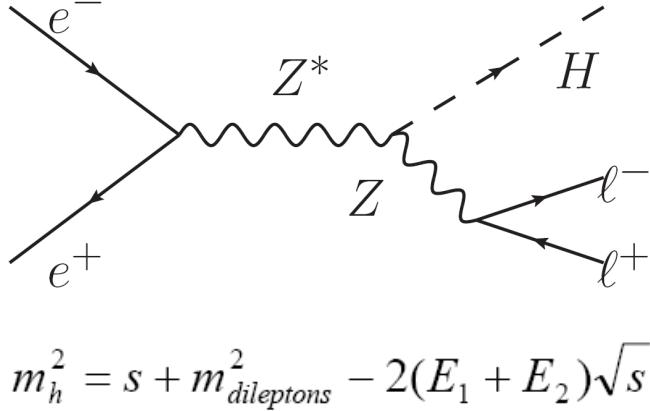
Contact: Manqi.ruan@ihep.ac.cn...

# Spared slides

# Model - independent tagging of ZH



# Higgs recoil mass spectrum: mH and $\sigma(ZH)$ measurement

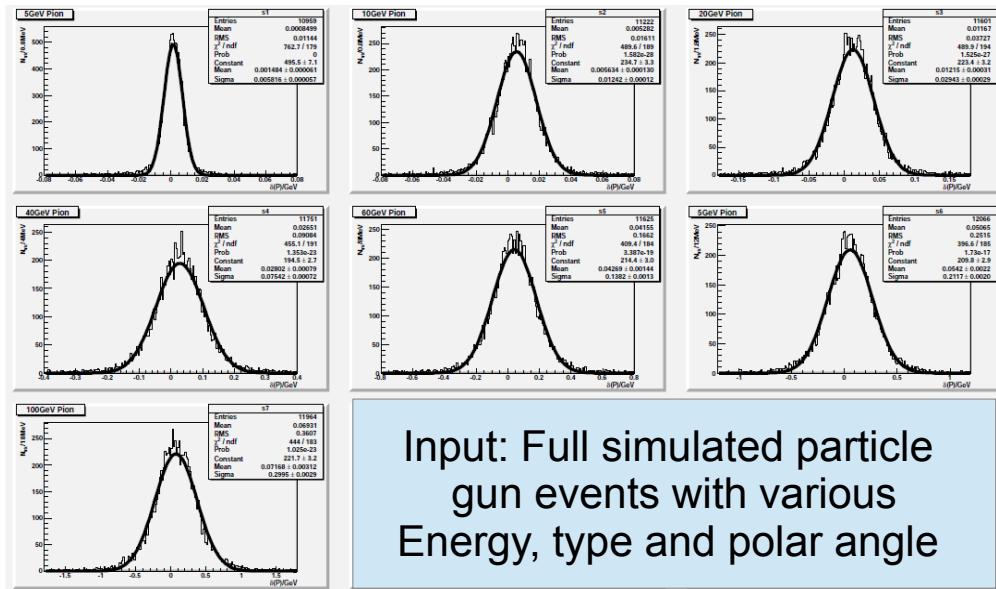


反冲质量方法：

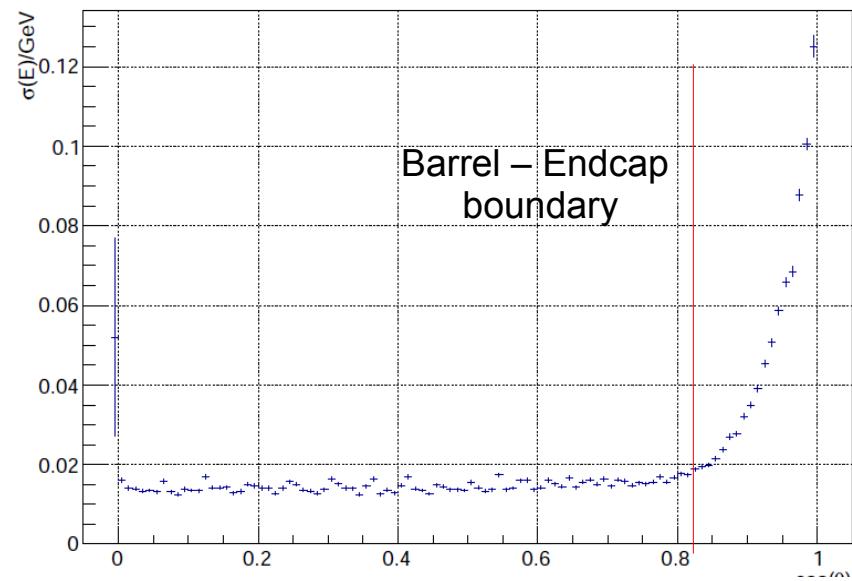
通过质心能量及  $Z$  的四动量推算 Higgs 粒子四动量，进而计算其不变质量。  
对 Higgs 衰变末态的信息不做任何要求：模型无关的测量。

利用 LC 探测器精良的径迹系统，通过  $Z$  衰变轻子道 ( $Z \rightarrow \mu\mu$ ) 测量 Higgs 反冲质量。  
该方法可同样用于  $Z \rightarrow qq$  末态：需要好的喷注能量分辨，依赖粒子流算法

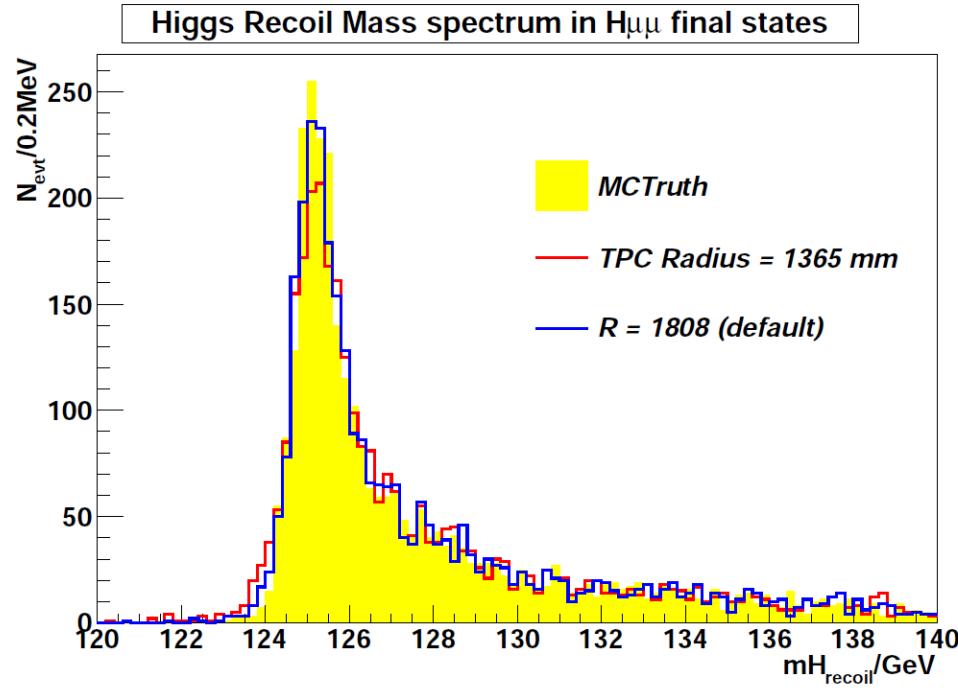
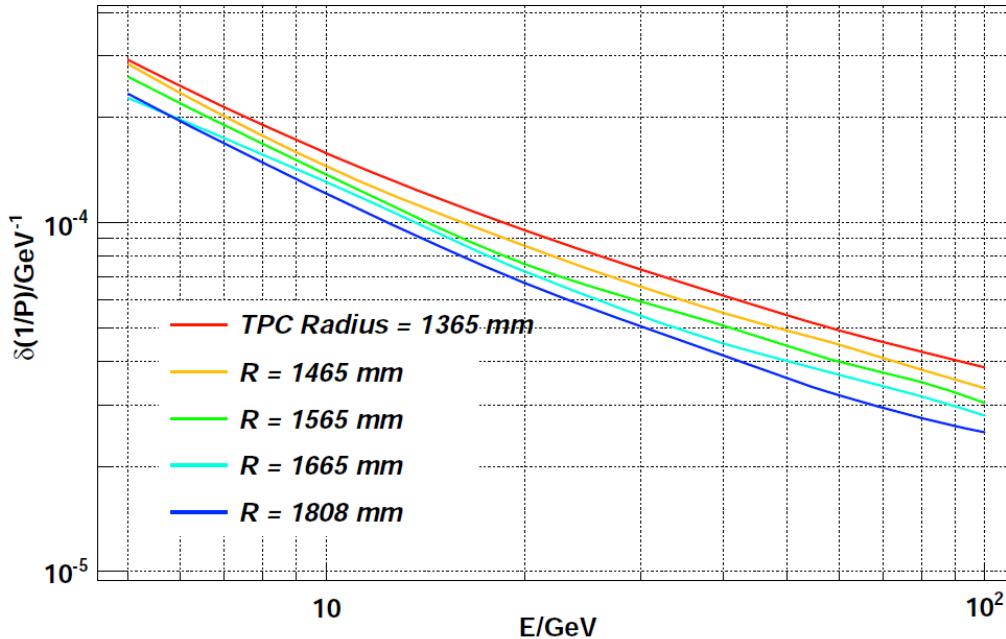
# Fast simulation of recoil mass spectrum



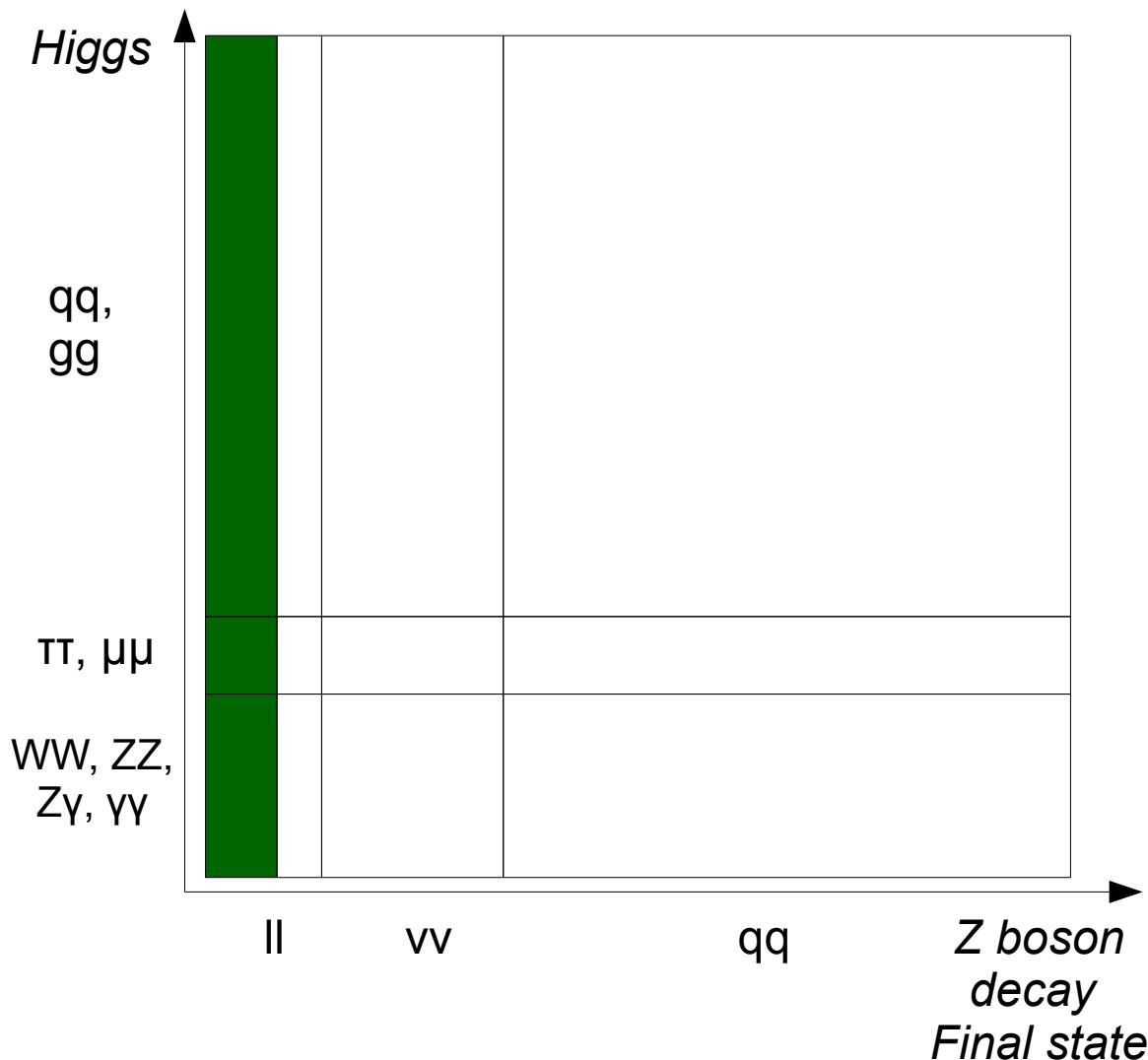
Resolution Vs Polar Angle: 10 GeV Muon, R = 1400Z = 2000



Tracker performance tested on  $\mu^+$  sample with flat  $\cos(\theta)$



# Measurements at different final states: $ZH$ , $Z \rightarrow 2l$ ( $l = ee, \mu\mu$ ), $H \rightarrow X$



Model independent tagging of  $ZH$  events from recoil mass spectrum to di-lepton system. Statistic  $\sim 6.7k$  evts

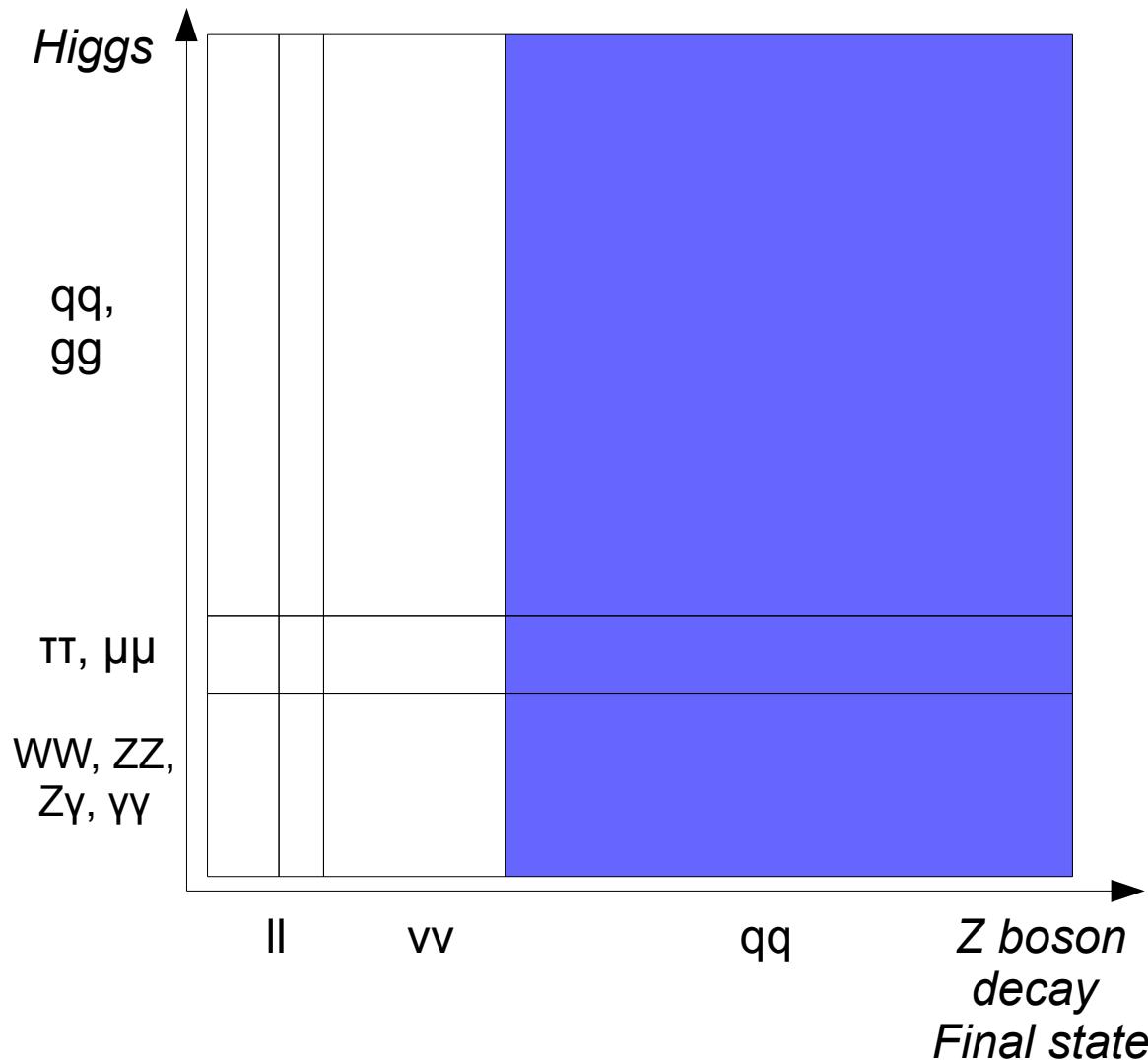
Objective Observables:

Recoil mass spectrum:  
Higgs mass,  $\sigma(HZ)$

Tagged  $ZH$  events + Higgs final states classification:  
 $\text{Br}(H \rightarrow X)^* \sigma(HZ)$

Critical performance/algorithms:  
Tracking & final states  
Classification (Tagging of Tau,  $WW^*/ZZ^*$ , jet flavor):

# $ZH, Z \rightarrow 2q, H \rightarrow X$



Model independent tagging of  $ZH$  events from recoil mass spectrum to di-jet system. Statistic  $\sim 70k$  evts

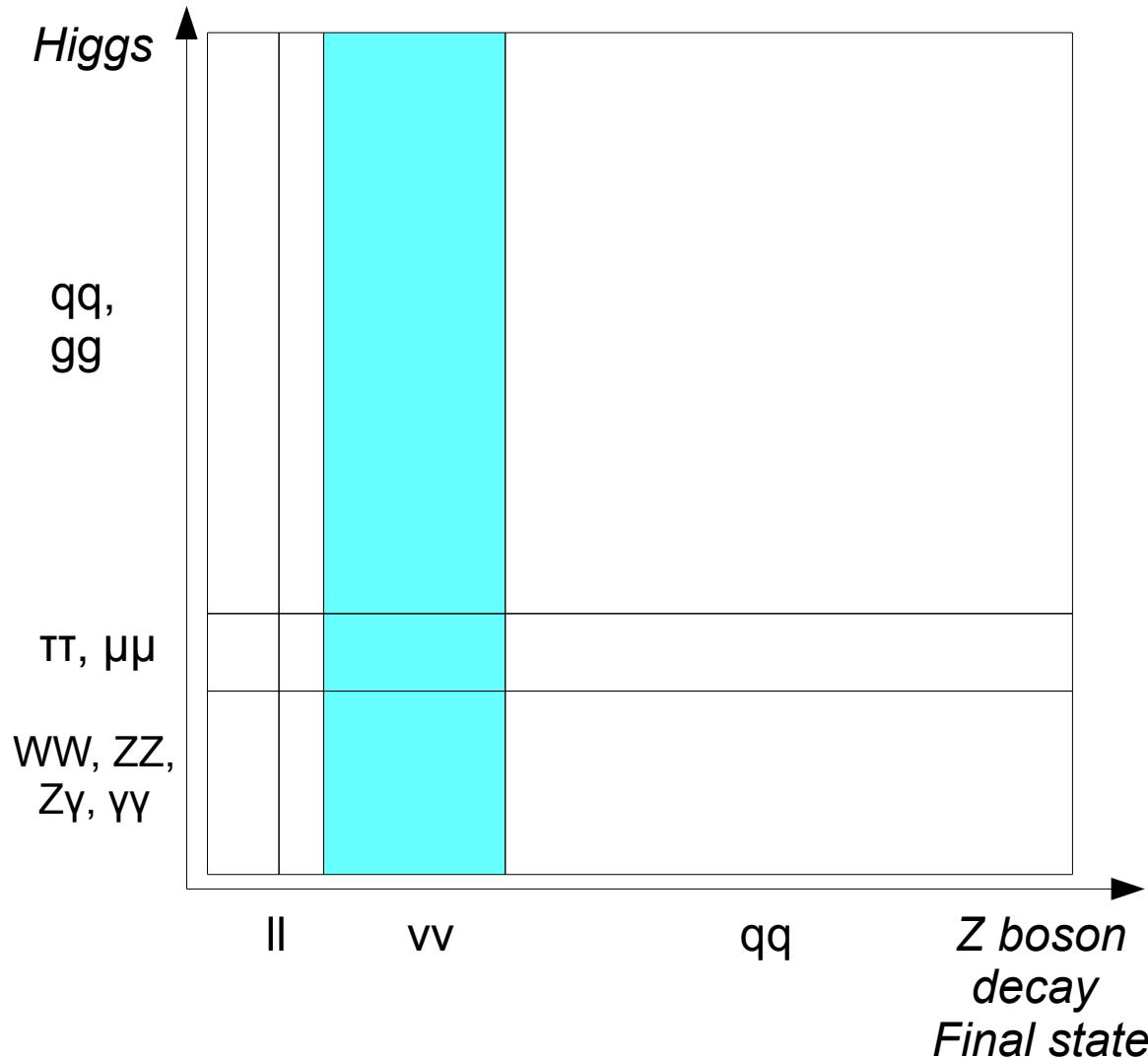
Objective Observables:

Recoil mass spectrum:  
Higgs mass,  $\sigma(HZ)$

Tagged  $ZH$  events + Higgs final states classification:  
 $\text{Br}(H \rightarrow X) * \sigma(HZ)$

Critical performance/algorithms:  
PFA (jet energy resolution),  
Jet clustering & final states classification:

# $ZH$ , $Z \rightarrow 2\nu$ , $H \rightarrow X$



Tag the  $ZH$  events from di-jet Invariant mass. Statistic  $\sim 20k$  evts

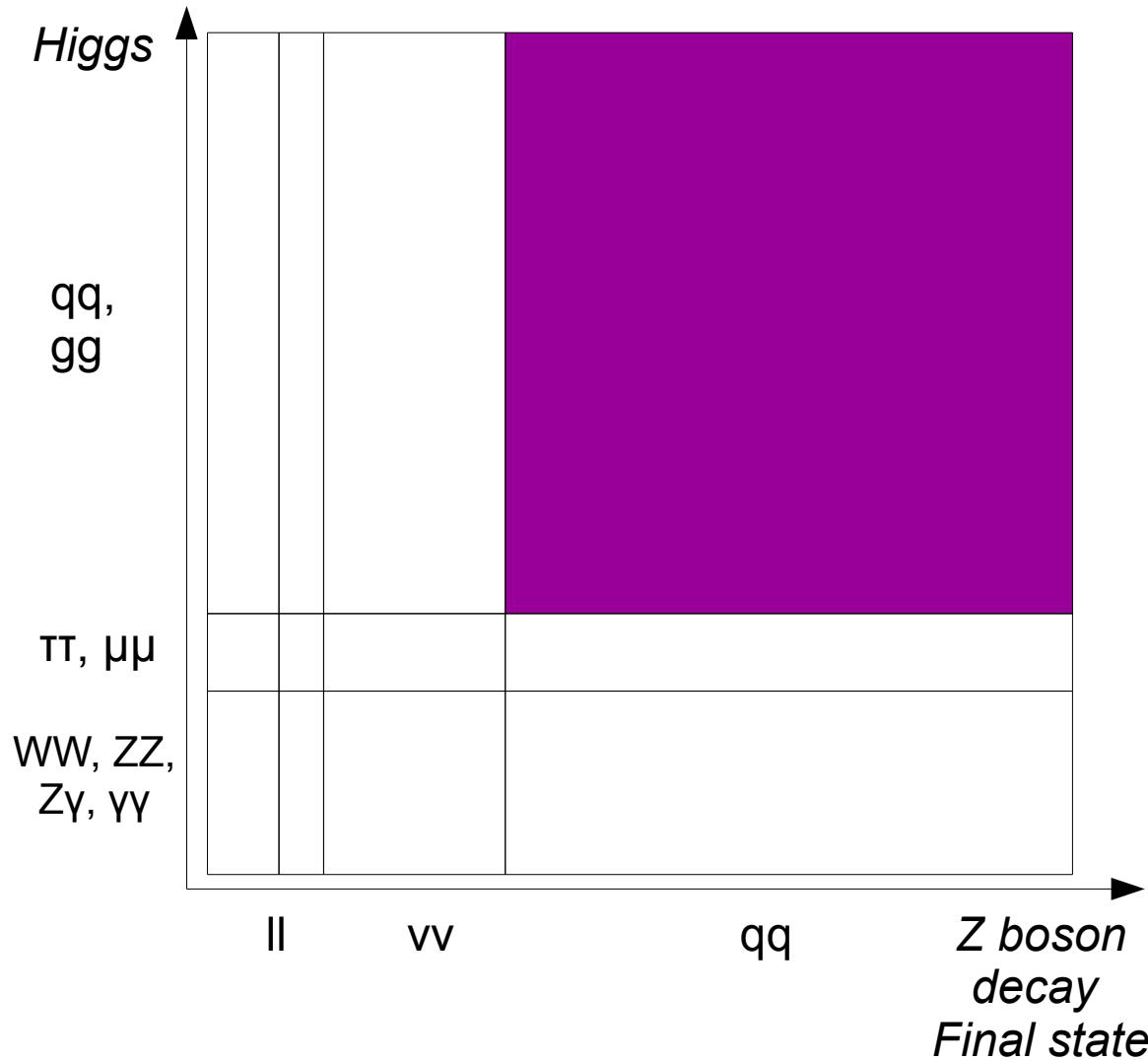
Objective Observables:

Higgs mass,  $\sigma(HZ)^*\text{Br}(H \rightarrow X)$

Critical performances/algorithms:

Jet clustering,  
PFA (Jet energy resolution,  
Missing energy reconstruction)  
Final states classification

# $ZH$ , $Z \rightarrow 2q$ , $H \rightarrow 2q$



Tag the  $ZH$  events from invariant Mass of all 2-jets combinations.  
Statistics  $\sim 50k$  evts

Objective Observables:

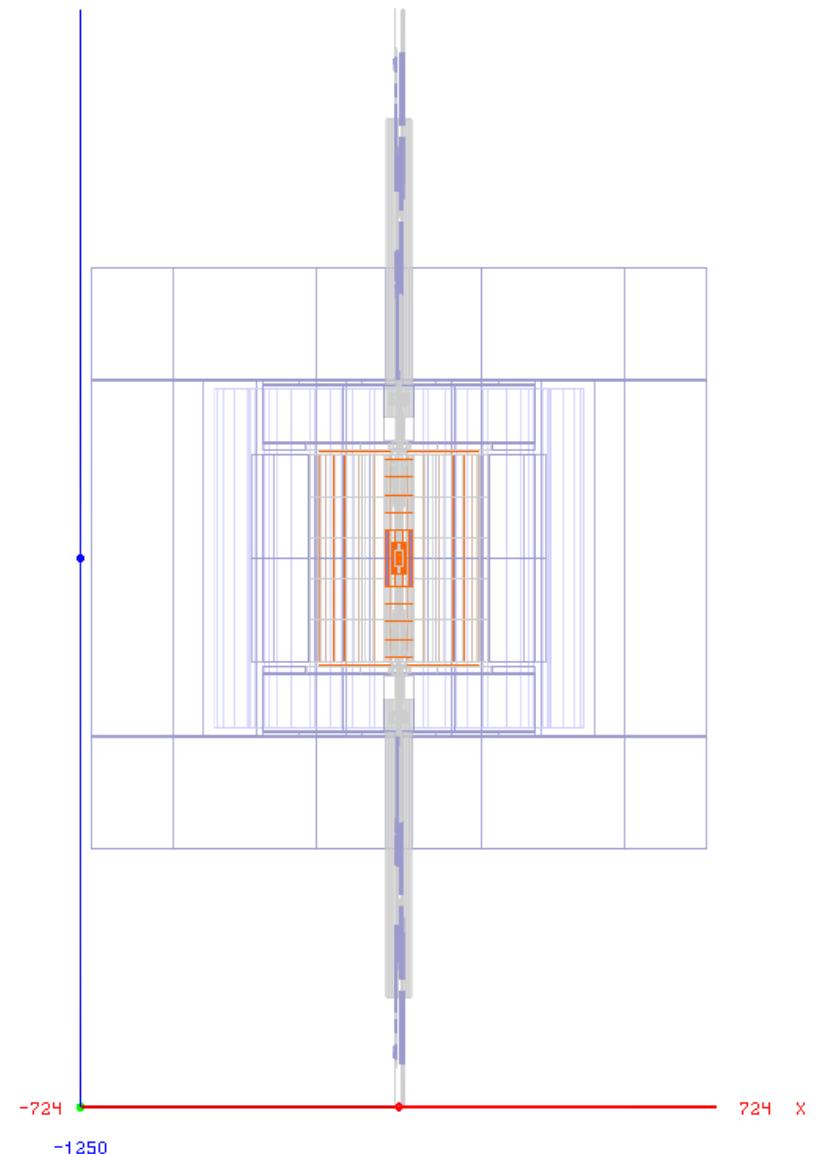
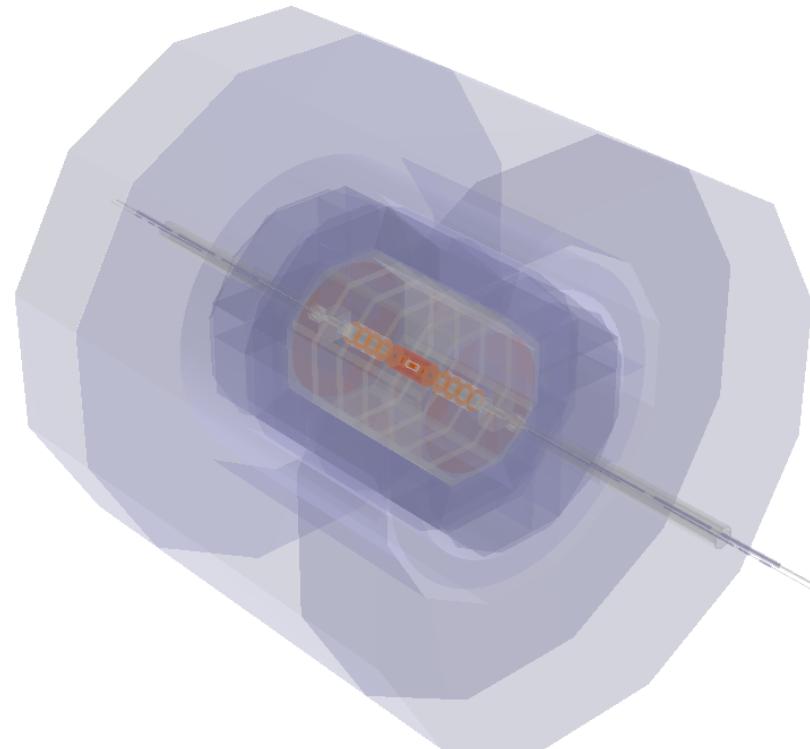
Higgs mass,  $\sigma(HZ) * Br(H \rightarrow 2j)$ ,  
 $\sigma(HZ) * Br(H \rightarrow 2b, 2c, 2g)$ ,

Critical performances:  
Jet clustering,  
Jet energy resolution (PFA),  
Flavor tagging

# Reference detector: ILD

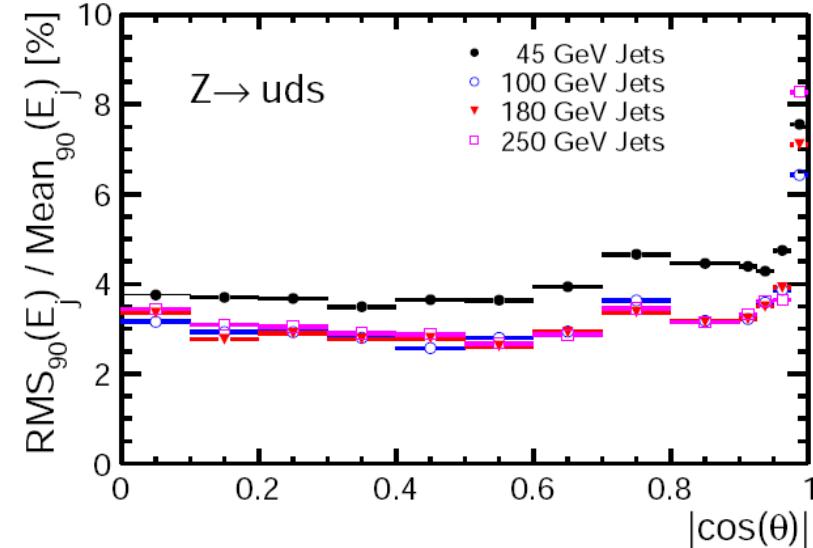
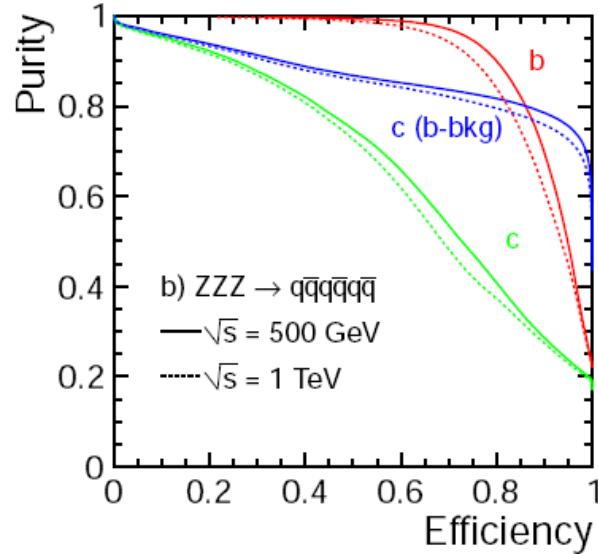
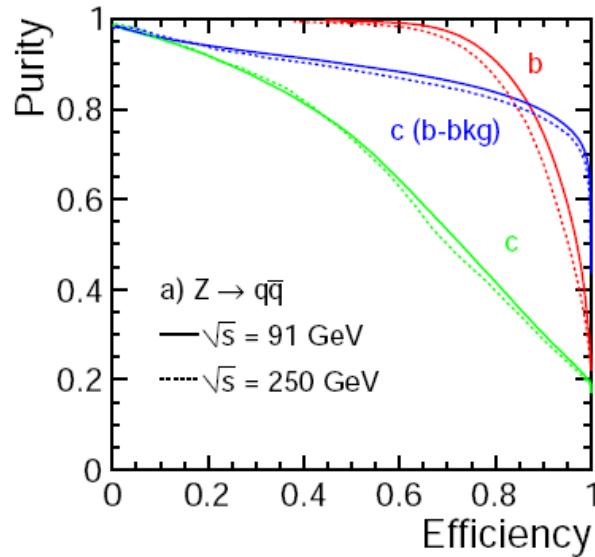
尺度: 半长 12.5/6.62 米, 半径 7.24 米

由内而外: VTX, SIT, FTD, TPC, SET/ETD(optional),  
Ecal, Hcal, Coil, Muon



# ILD Performance

*b Vs udsc; c Vs b; c Vs udsb*



Flavor tagging: eff = 80%, purity > 90% for b-tagging (Impact parameter resolution  $\sim 5 \mu\text{m}$ )  
 Algorithm: LCFIPlus, Tokyo University (Tomohiko Tanabe)

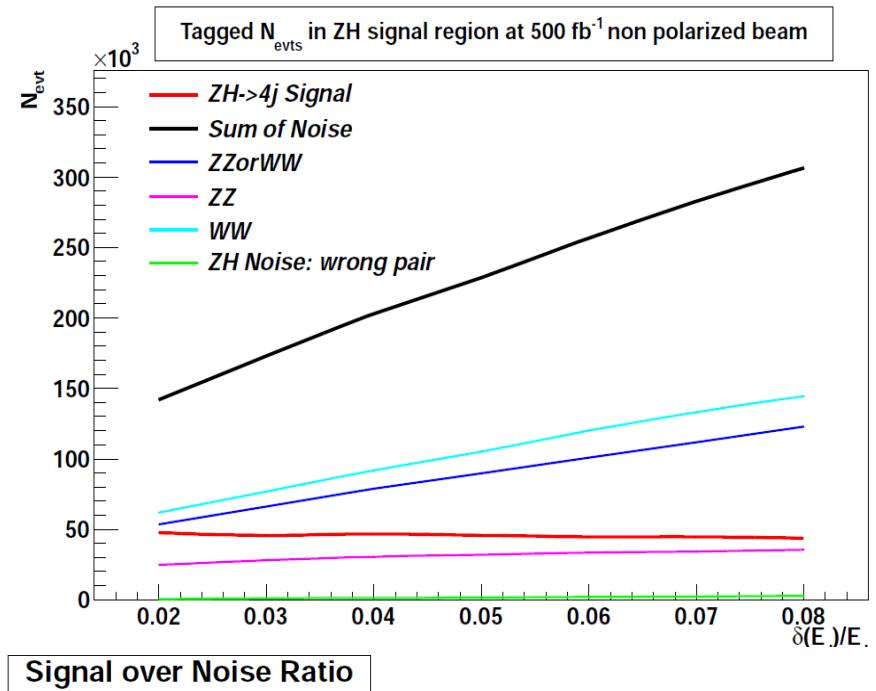
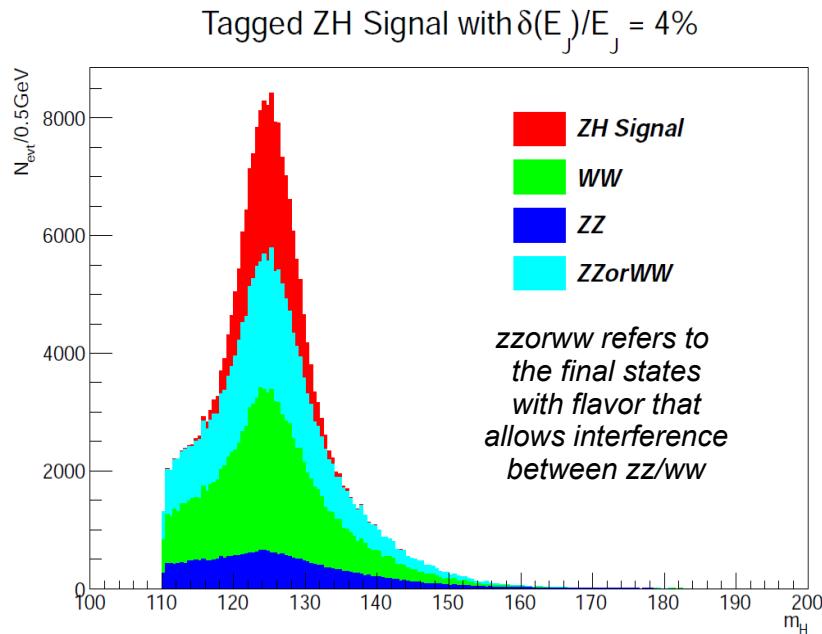
Tracking:  $\delta(1/P_T) \sim 2-5 \cdot 10^{-5}(1/\text{GeV})$

Algorithm: Clupatra, DESY (Frank Gaede); KalTest, KEK (Keisuke Fujii), etc

PFA :  $\delta E_j/E = 3 - 4\%$

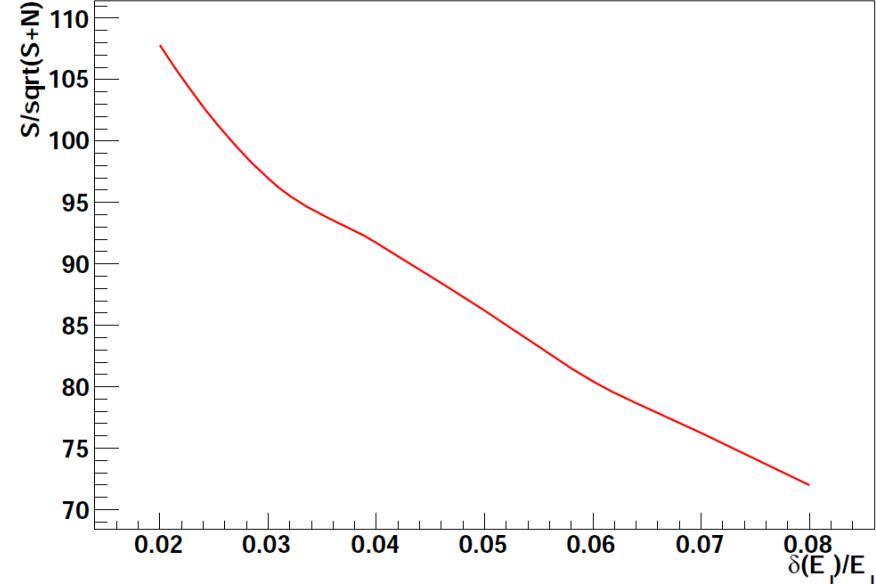
Algorithm: PandoraPFA, Cambridge (Mark Thomson); Arbor, LLR & IHEP (Manqi, Henri)

# Performance at different Jet E resolution



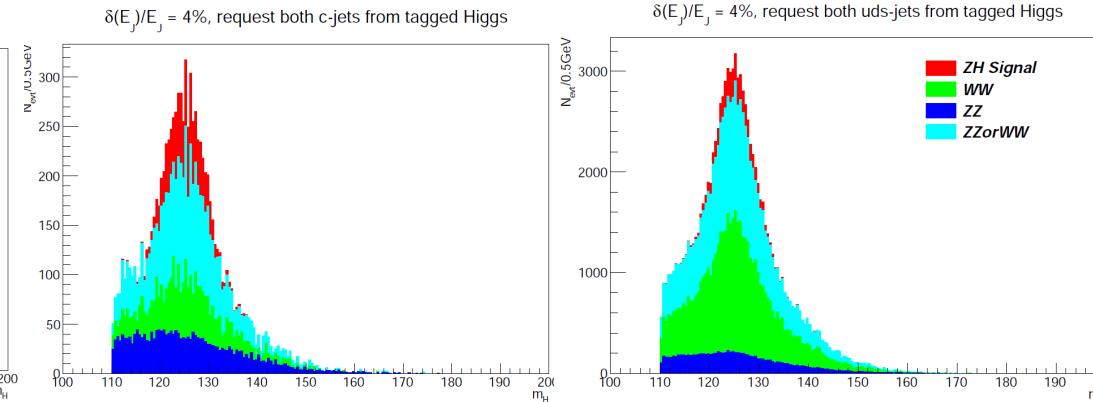
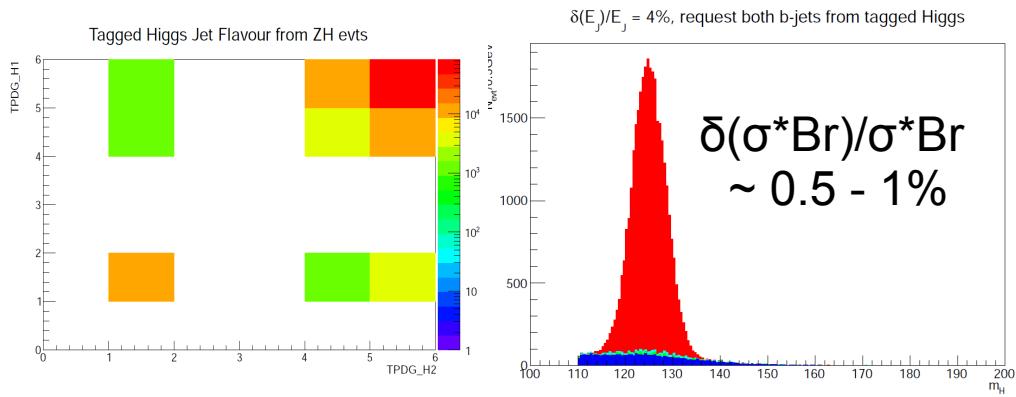
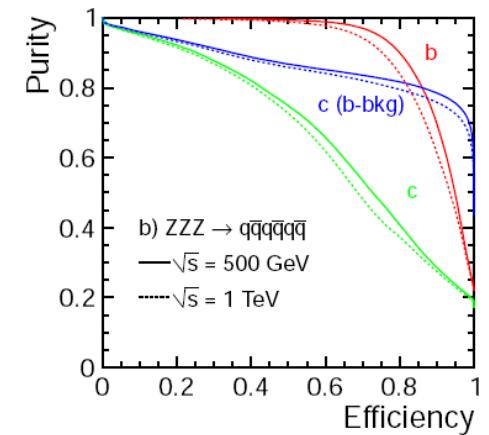
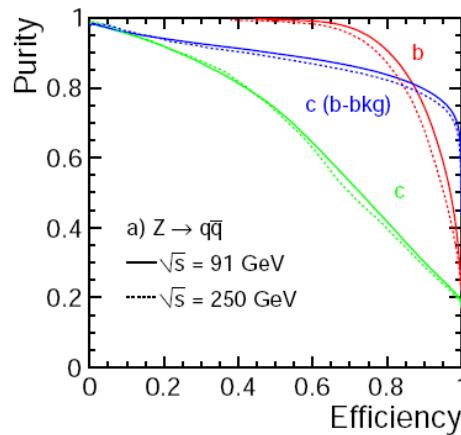
$\sigma(H \rightarrow 2j)$  measurement easily reaches percentage level accuracy;

Performance weakly depends on the jet Energy resolution:  $\delta\sigma/\sigma \sim 1-1.5\%$



# Modeling of Flavor tagging

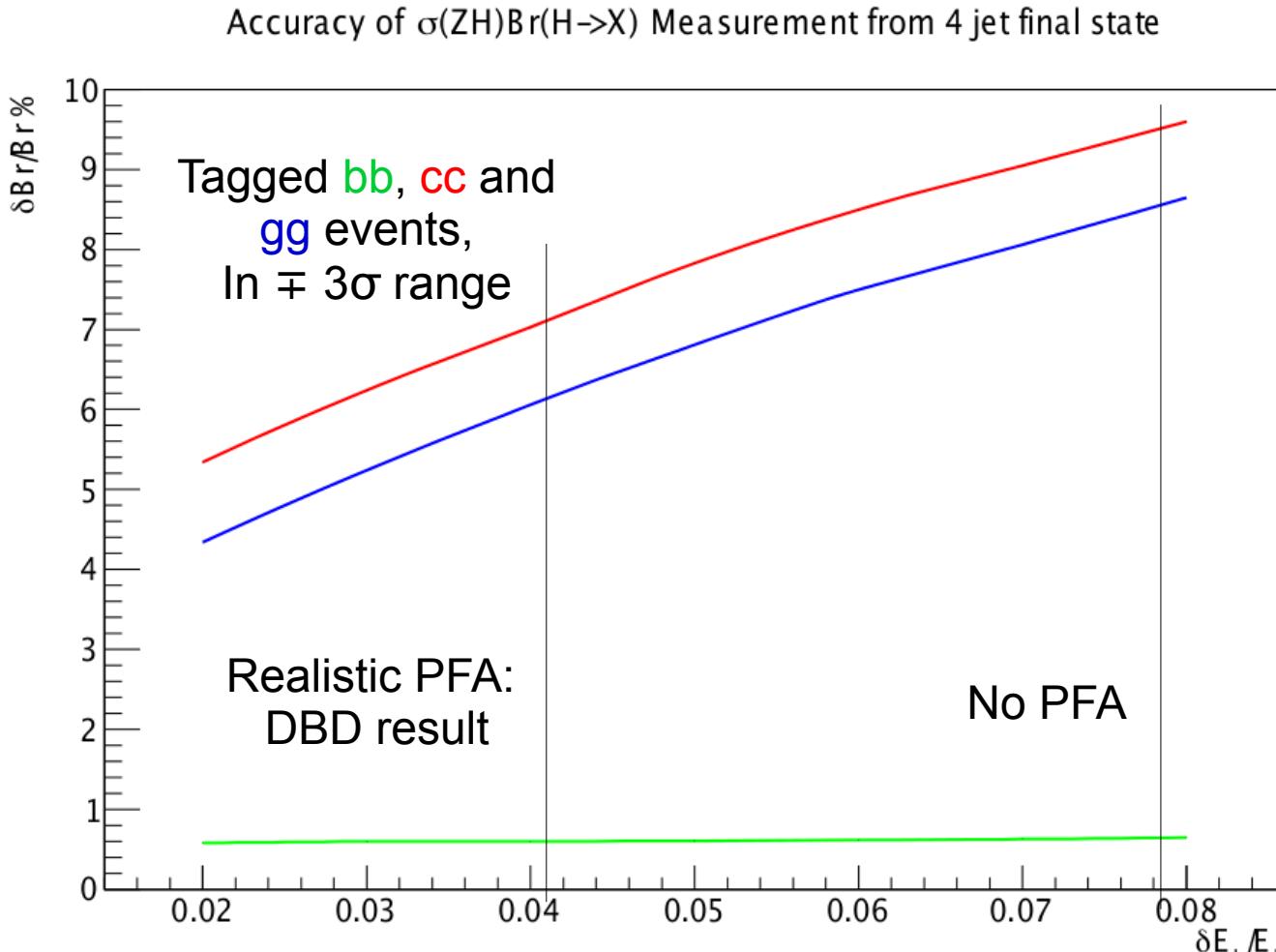
	b	c	uds	undef
b	0.90	0.08	0.02	
c	0.25	0.70	0.05	
uds	0.03	0.06	0.91	



$$O = M^* T; M, \text{Migration Matrix}$$

$O, T$ : vector of number of events in each final state, Observed & Truth  
 $T = T(\text{Branching ratios})$

# Measuring $\sigma(HZ)^* \text{Br}(H \rightarrow 2i)$ , $i = b, c, g$



Particle Flow Algorithm – jet energy resolution accuracy is critical for  $\text{Br}(H \rightarrow gg, cc)$  measurement...

Remarks:

Measurements from  
HZ,  $Z \rightarrow ll, vv$   
Can be combined to  
Improve the result

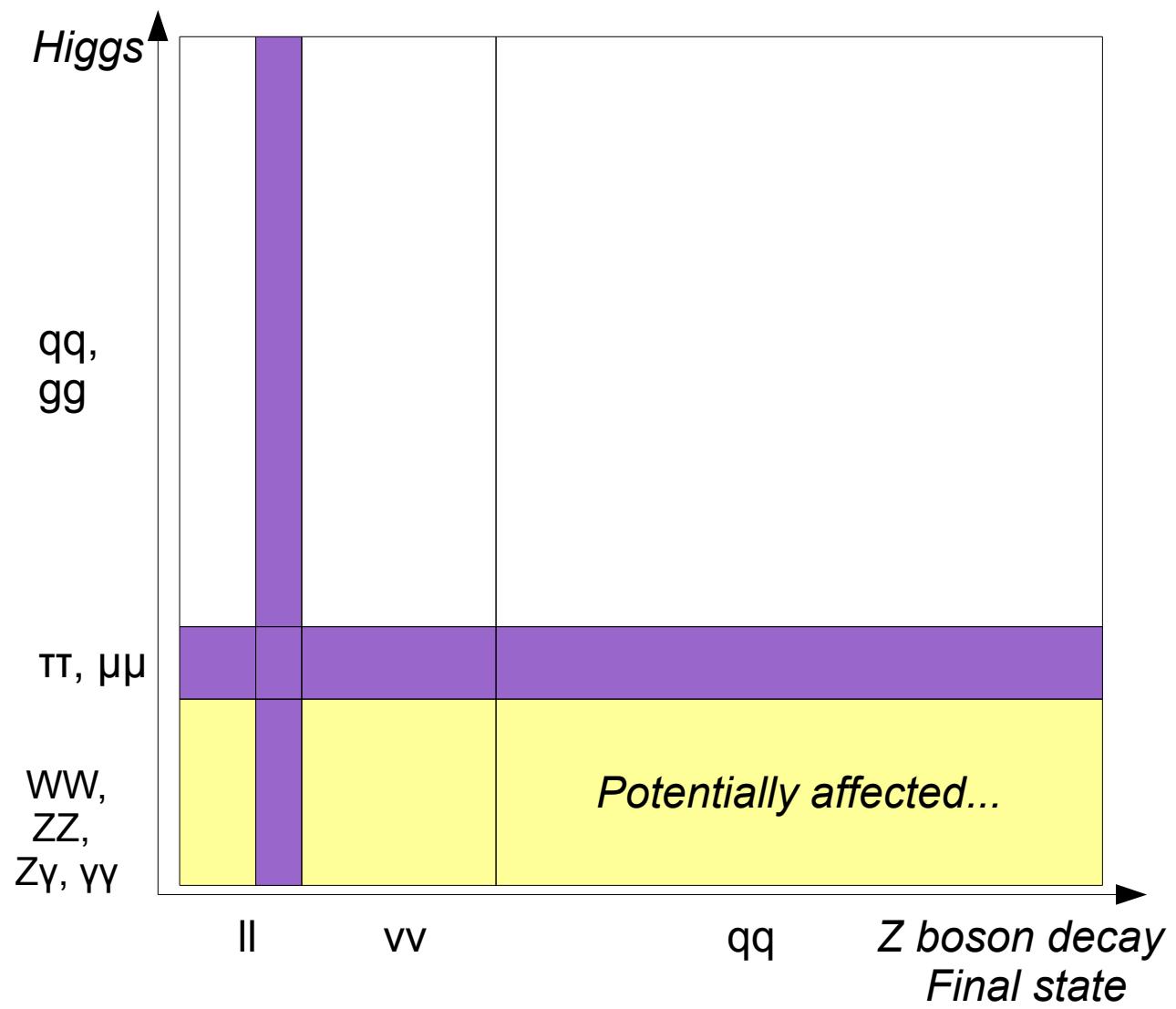
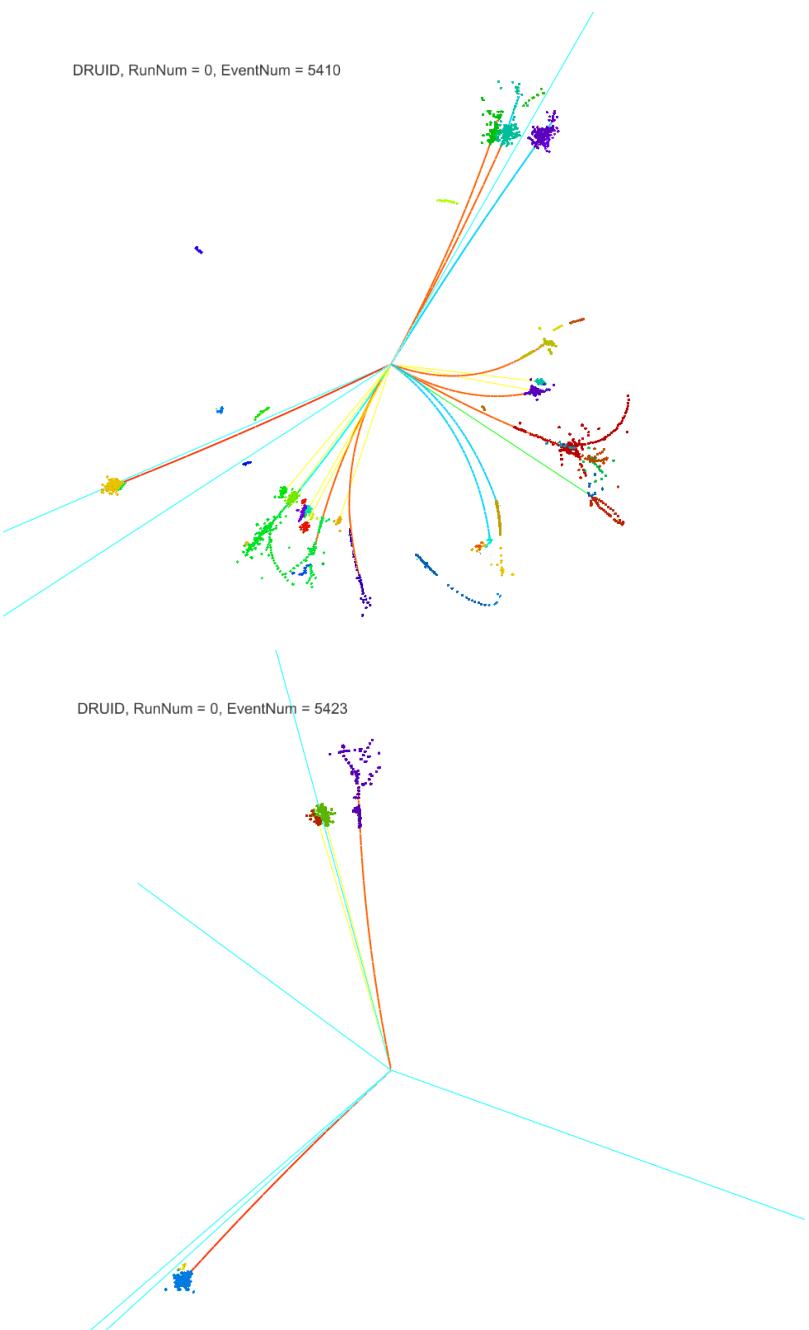
Fit range and event  
Selection can be improved

Migration Matrix information  
Should be used

bb, cc accuracies  
Should be worse in  
realistic because of  
Neutrinos

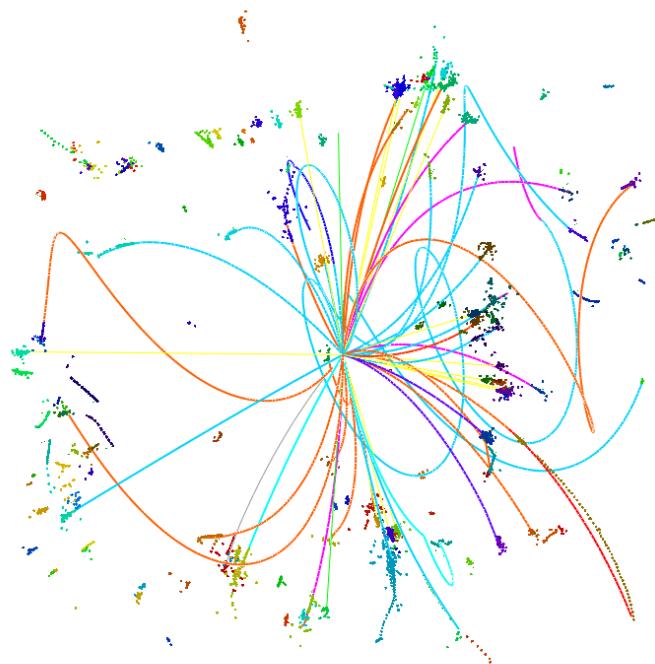
Trends shall not be  
Changed after including  
All above effects

# To do: PFA Tau tagging & Reconstruction

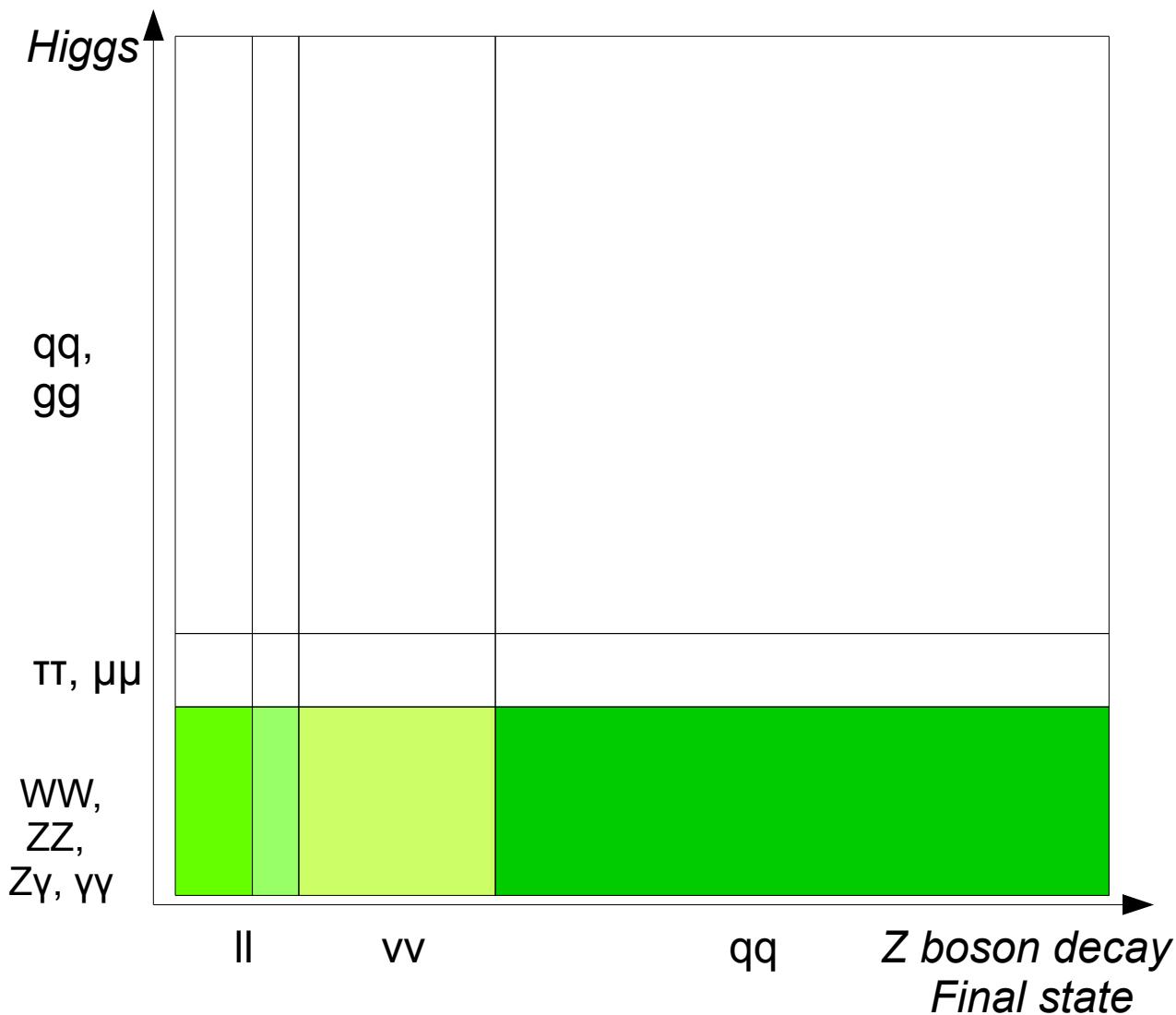


# To do: $\text{Br}(\text{H} \rightarrow \text{WW}, \text{ZZ}) \sim \text{Width}$ Measurement

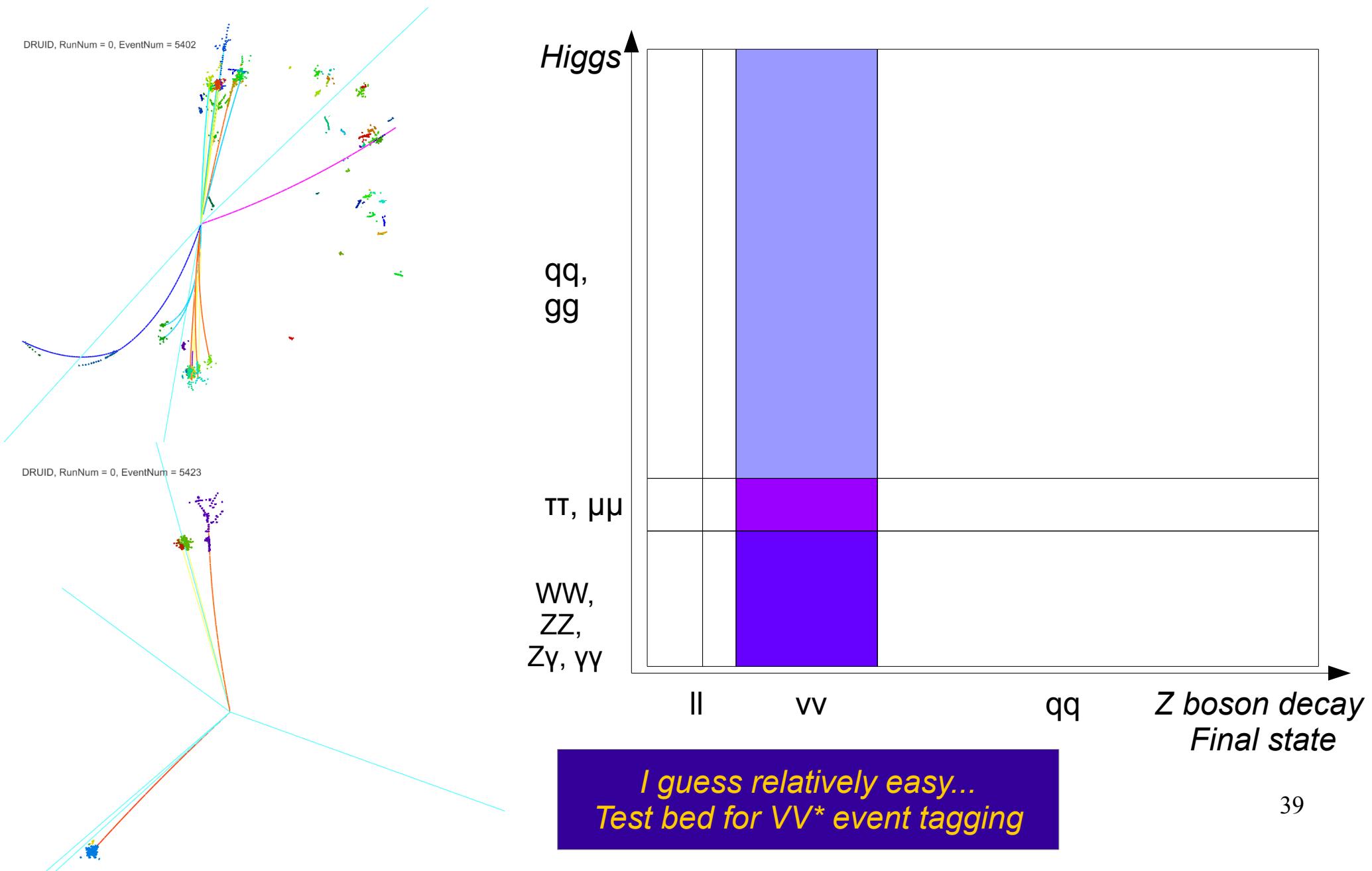
DRUID, RunNum = 0, EventNum = 5447



Important,  
challenging,  
Exciting.

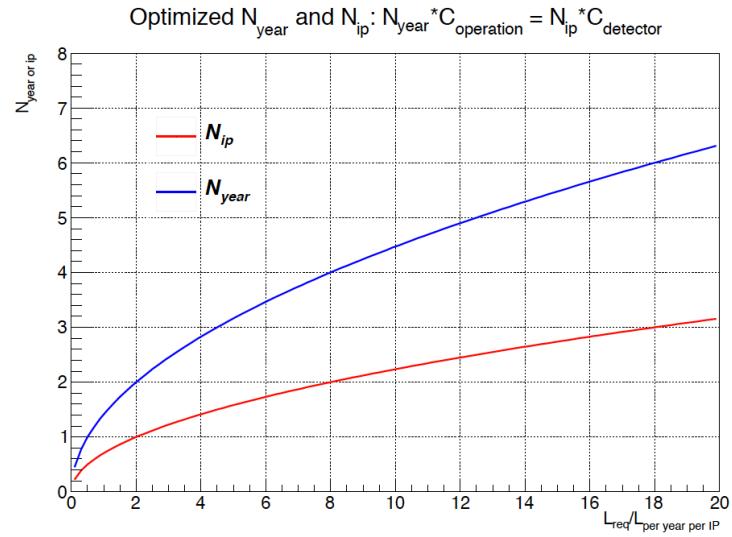


# To do: ZH, $Z \rightarrow VV$ channel



# Open discussing

- Operation program: 100 k Higgs, or more?
  - Electricity cost  $\sim 10^9$  CNY/y (half a detector)
    - Site power 200 MW,  $2 \times 10^7$  s/y, 0.5 CNY/kwh
  - Objective: 100k Higgs, or more?
    - $200 - 400 \text{ fb}^{-1}$  per IP per year?
    - ILC:  $250 \text{ fb}^{-1}/5 \text{ year}$ ;
    - LEP3:  $100 \text{ fb}^{-1}/(\text{year} * \text{IP})$ ,  $2 \text{ ab}^{-1}$  with 4 IP.
    - TLEP:  $10 \text{ ab}^{-1}$
- Detector: as precise as possible
  - hardware + reconstruction
- Detector geometry: tell me your concern!
- Logo & Name?



	ILC-250	TLEP-240
$\sigma_{\text{HZ}}$	2.5%	0.4%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow bb)$	1.0%	0.1%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow cc)$	6.9%	1.3%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow gg)$	8.5%	1.4%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow WW^*)$	8.0%	0.9%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow \tau\tau)$	5.0%	0.9%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow ZZ^*)$	28%	3.1%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow \gamma\gamma)$	27%	3.0%
$\sigma_{\text{HZ}} \times \text{BR}(H \rightarrow \mu\mu)$	—	13%
$\Gamma_{\text{INV}} / \Gamma_H$	< 1.5%	< 0.3%
$m_H$	40 MeV	8 MeV
	ILC-350	TLEP-350
$\sigma_{WW \rightarrow H}$	3%	0.5%
$\Gamma_H$	5.5%	1.1%