physics benchmarks for detector optimisation

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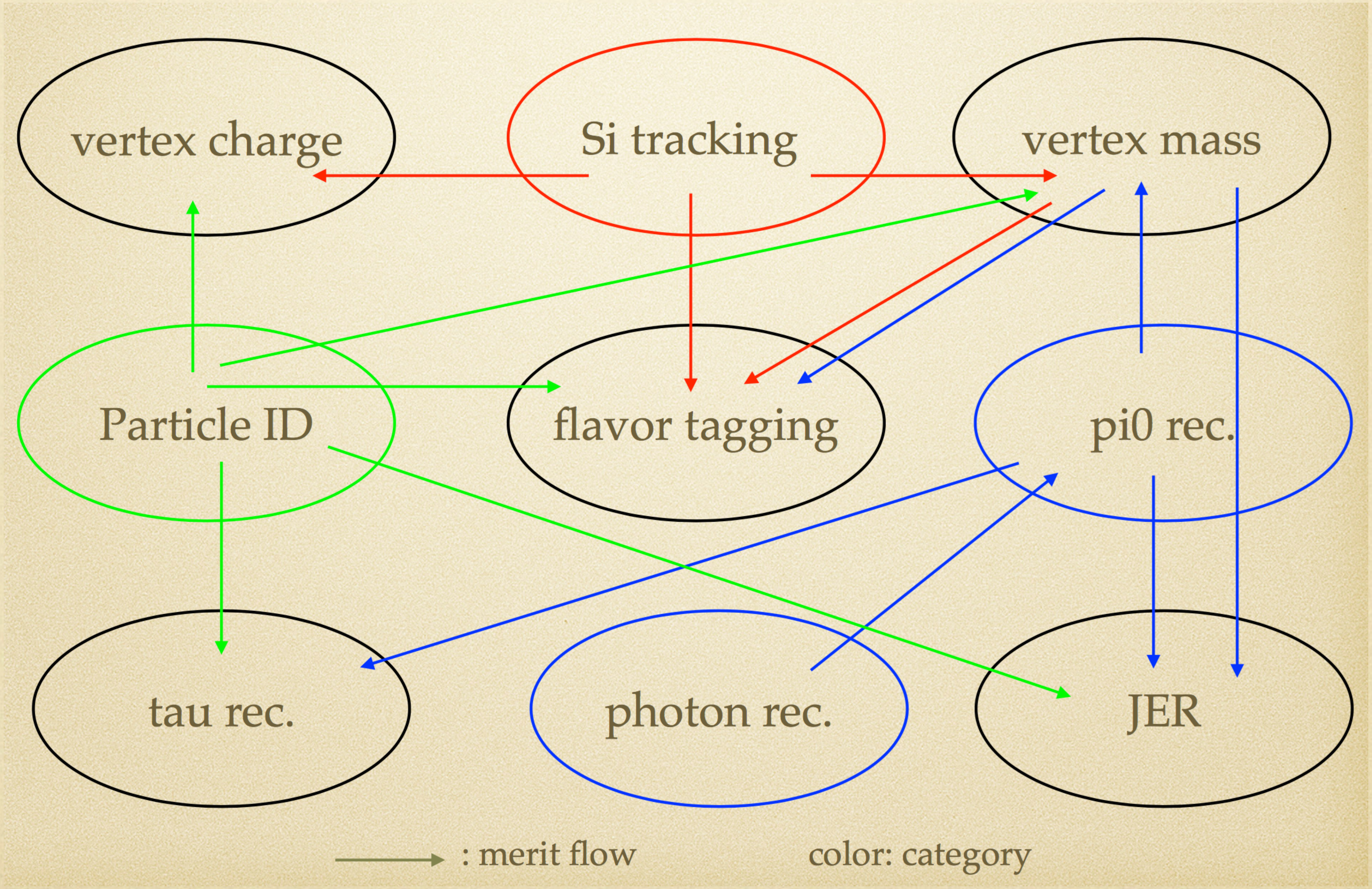
we have agreed on

- performance of new detector models will be evaluated eventually based on physics performance

process	physics	detector performance	Ecm
H—>cc	BR	c-tag, JER	any
H—>μμ	BR	high P tracking	500 GeV
H—>ττ	BR, CP	τ recon., PID, track separation	250 GeV
H—>bb	M_H, BR	JES, JER, b-tag	500 GeV
H—>invisible Z—>qq	Higgs Portal	JER	250 GeV
eνW—>eνqq	M_W, TGC	JES, JER	500 GeV
tt-bar—>6-jet	top coupling, A_{FB}	b-tag, jet charge	500 GeV
$\chi_1^+\chi_1^-, \chi_2^0\chi_1^0$ near degenerated	natural SUSY	low P tracking, PID	500 GeV
γXX	WIMPs	Photon ER & ES, Hermiticity	500 GeV

**this is just a minimum list

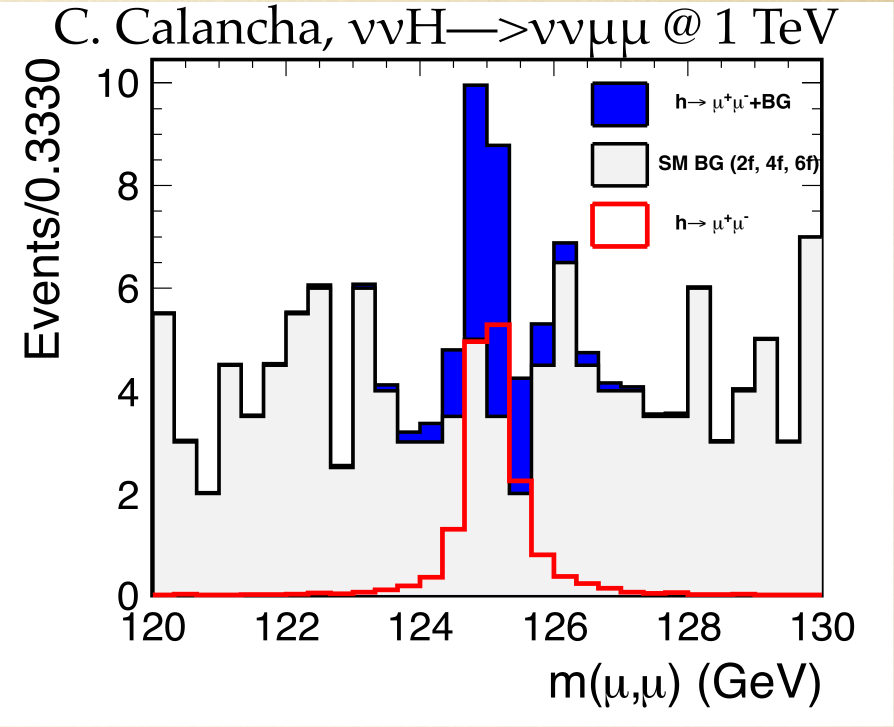
- physics performance should be obtained based on proper tools which maximally utilise the detectors



brief reminder for each benchmark process

- physics, and what kind of detector performance to look at.
- status of relevant tool development and available/missing resources for analyses

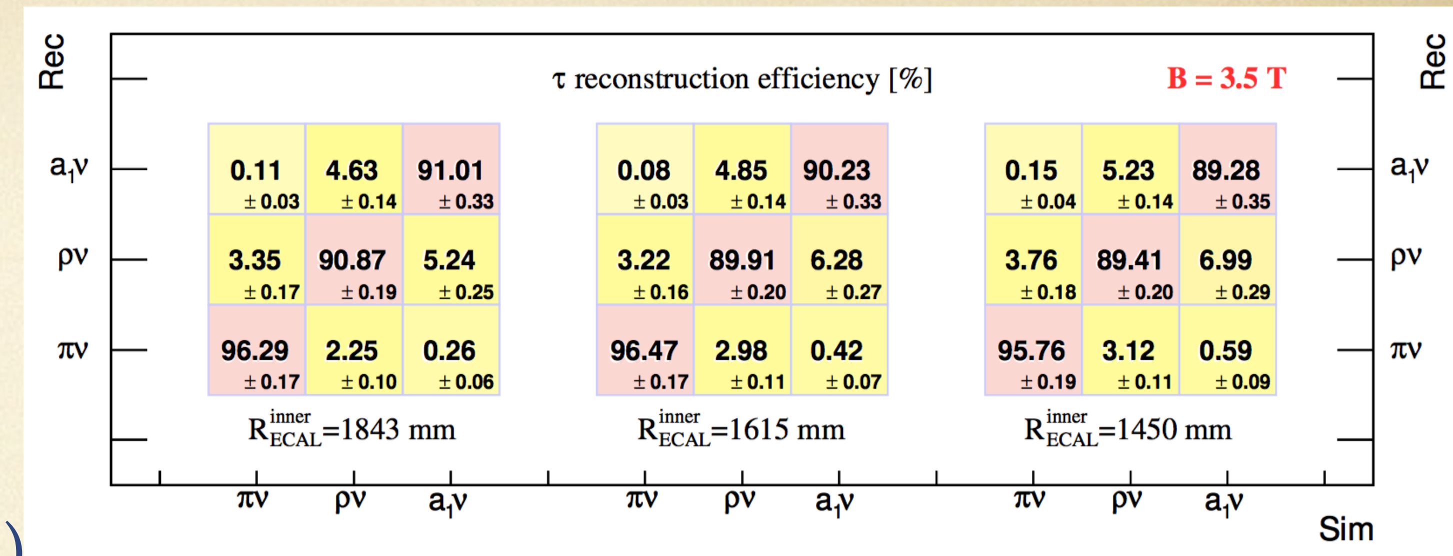
H—>μ μ



- physics
  - 2nd gen. Yukawa coupling (l)
- detector performance
  - high momentum tracking (TPC outer radius, SET)
  - PID using muon chamber
- tools and analysis
  - isolated lepton finder (done)
  - DBD analysis at 1 TeV (Tino, LC-REP-2013-006), ongoing studies (Michele @ LCWS15)
  - need new studies at 500 GeV

*leptonic recoil is relevant as well, but affected by σ_{beam},
benchmark studies done with SGV by T.Ogawa

H—>τ τ



- physics
  - 3rd gen. Yukawa coupling (l)
  - Higgs CP admixture
- detector performance
  - tau reconstruction (PFA, γ/π^0 rec., ECAL granularity, VTX)
  - track separation (TPC read out techs., pad width)
  - PID (e, μ, π)
- tools and analysis
  - tau decay mode identification (T.H.Tran, 1510.0522)
  - tau reconstruction using impact parameters (Daniel, 1507.01700)
  - DBD analyses (S.Kawada, 1509.01885)
  - ongoing CP study (Daniel)

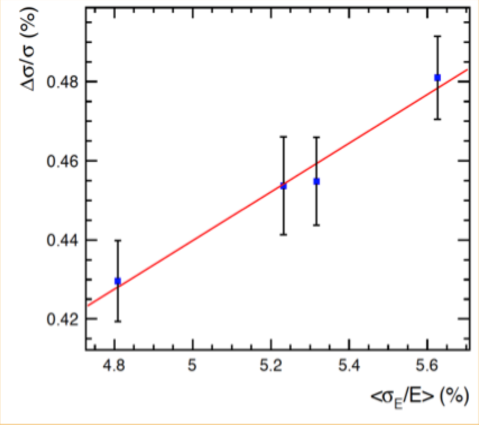
H—>c c

Error on	Pol (e-;e+) = (-0.8;+0.3); L=330 fb^{-1} h→other fitted	h→other fixed	Pol (e-;e+) = (+0.8;-0.3); L=330 fb^{-1} h→other fitted	h→other fixed
σ(ZH)BR(h->bb)	1.9	1.9	2.3	2.2
σ(ZH)BR(h->cc)	17.9	16.7	20.1	17.8
σ(ZH)BR(h->gg)	10.6	7.6	12.9	8.4
σ(ZH)BR(h->other)	25.7	-	24.7	-
σ(WW)BR(h->bb)	1.7	1.6	9.4	9.5
σ(WW)BR(h->cc)	18.5	16.7	117.0	116.7
σ(WW)BR(h->gg)	9.8	6.7	49.6	36.8
σ(WW)BR(h->other)	23.2	-	129.2	-

- physics
  - 2nd gen. Yukawa coupling (q)
  - flagship measurement (w.r.t. LHC)
- detector performance
  - c-tagging (VTX point res., low p tracking)
  - in separation with b-vertices
  - vertexing with beam background
- tools and analysis
  - flavour tagging (LCFIPlus, T.Suehara, et al.; M.Kurata, talk on Wed.)
  - Silicon tracking (Yorgos, talk on Wed.)
  - LoI/DBD analyses (H.Ono, Euro.Phys.J.C73, 2343; LC-REP-2013-005; F.Mueller @ LCWS14, ILD soft/ana meeting)
  - ongoing (H.Ono)

H—>invisible
Z—>q q

Model	$\Delta\sigma_{inv} / \sigma_{SM}$	σ_m /m	< σ_E /E >
30 layers: 5 x 5	0.43 %	4.8 %	3.4 %
30 layers: 15 x 15	0.45 %	5.3 %	3.8 %
15 layers: 5 x 5	0.45 %	5.2 %	3.7 %
15 layers: 15 x 15	0.48 %	5.6 %	4.0 %



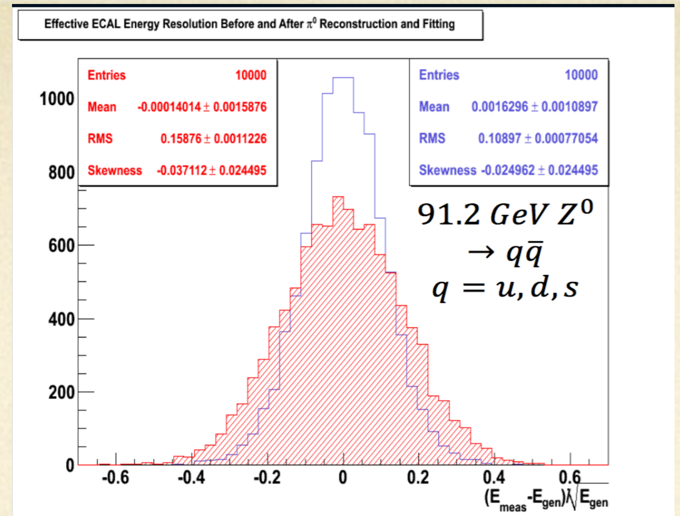
17 % increase in jet E resolution

⇨ **12 ± 3 % decrease in sensitivity**

⇨ **17 ± 4 % decrease in integrated luminosity**

- physics
  - Higgs Portal, H—>DM
- detector performance
  - jet energy resolution (PFA, CAL granularities, #λ_I, etc.)
- tools and analysis
  - PFA (Pandora, S.Green talk on Wed.; Arbor, B.Li talk on Thur.)
  - DBD analyses (M.Thomson, arxiv:1509.02853; A.Ishikawa @ LCWS14)
  - ongoing (X?)

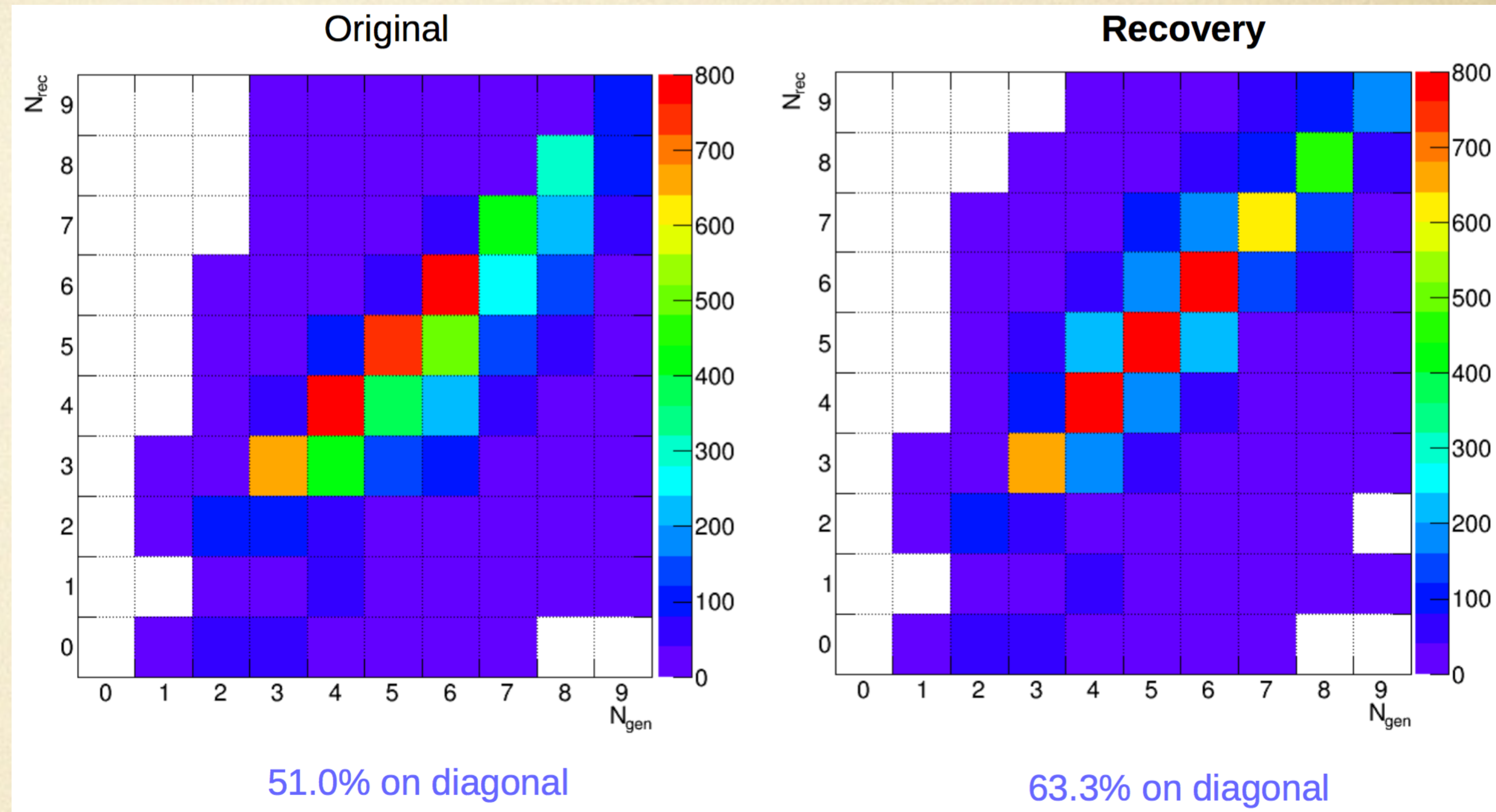
H—>b b



evW, W—>q q

- physics
  - H—>b b:
    - direct m_H measurement
    - complementary to recoil
  - evW, W—>q q:
    - direct m_W measurement
    - comp. to thres. scan, kin. fit.
- detector performance
  - H—>b b:
    - jet energy resolution
    - jet scale calibration
    - π^0(in jet) reconstruction
    - b-tagging
  - evW, W—>q q:
    - jet energy resolution
    - jet scale calibration
    - π^0(in jet) reconstruction
    - forward electron tagging
- tools and analysis
  - π^0 reconstruction (G.Wilson, talk on Tues.)
  - DBD analyses (m_W, control sample, K.Tsuchimoto @ Tokusui WS 2016)
  - ongoing analyses (mH, A.Ebrahimi; X for m_W?)

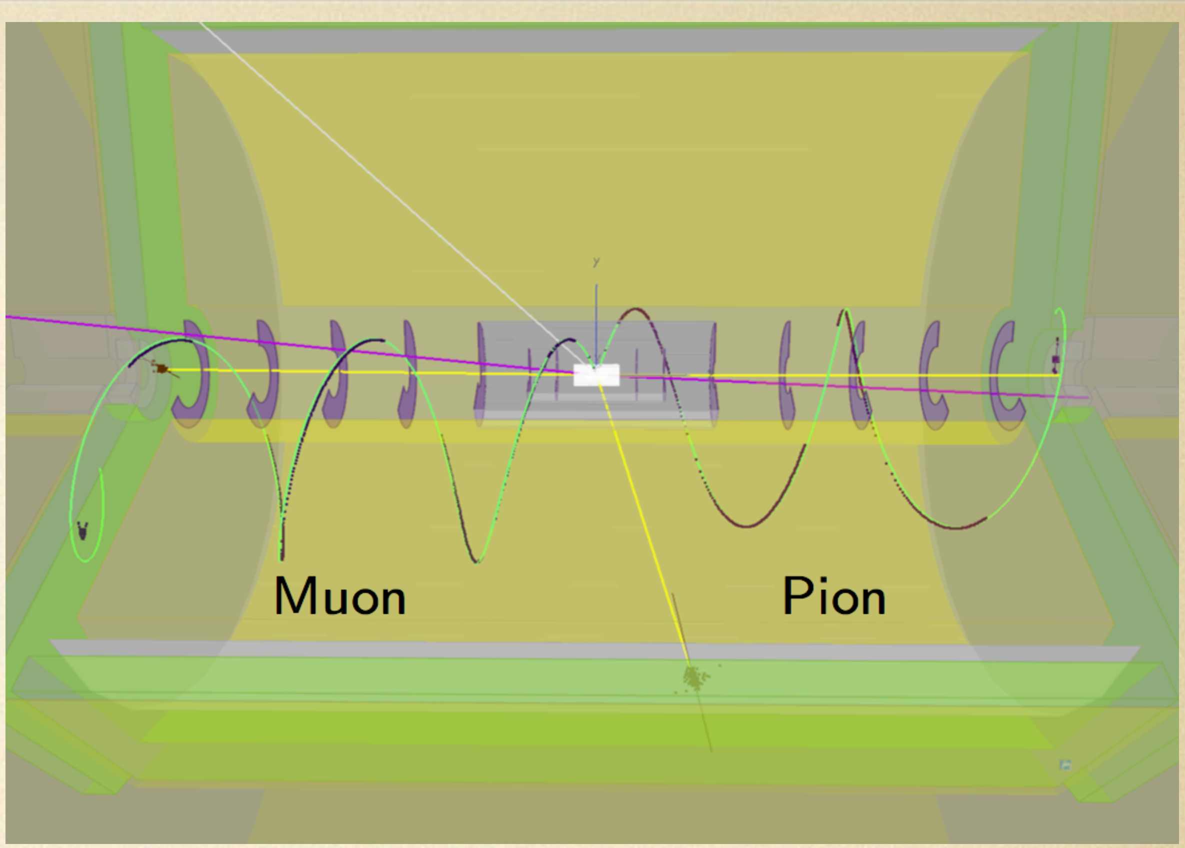
t t—>6j



- physics
  - chiral top coupling, A_{FB}
- detector performance
  - b-tagging
  - jet charge
  - jet energy resolution
- tools and analysis
  - LCFIPlus (M.Kurata)
  - jet charge reconstruction (S.Bilokin, talk on Tues.)
  - DBD analyses (M.S. Amjad, Roman, 1307.8102)
  - ongoing (S.Bilokin, Y.Sato)

near degenerate Higgsino

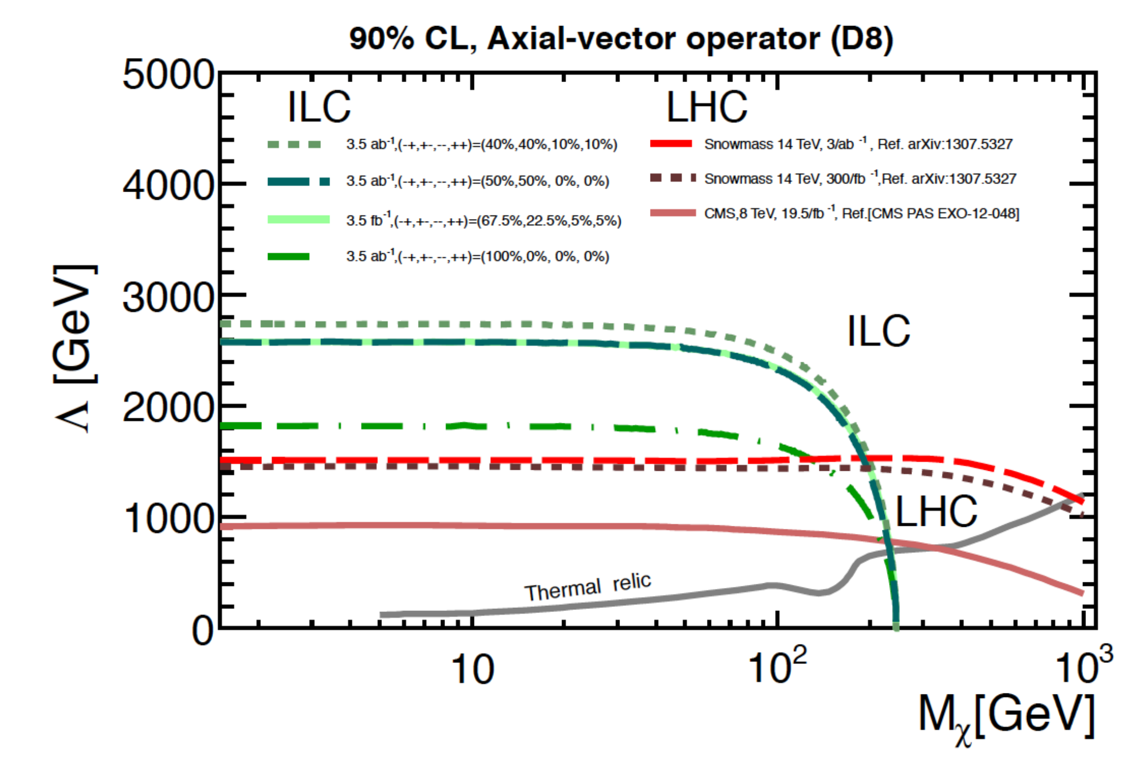
$$\chi^+\chi^-, \ \chi_2^0\chi_1^0$$



- physics
  - core of natural SUSY (complementary to LHC)
- detector performance
  - low momentum tracking (TPC, VTX, FTD, B-field, fake tracks)
  - PID (dE/dx, shower in endcap CAL)
  - ISR tagging (foward region, angular & energy res.,)
- tools and analysis
  - PID (M.Kurata, S.Lukic, H.Sert, D.Yu talks on Wed.); Si-tracking (Yorgos)
  - SGV/DBD analyses (H.Sert, ILD ana/sw meeting, Mar. 15, 2015)
  - ongoing (Yorgos, J.Yan)

mono-photon WIMPs

$\gamma\chi\chi$



- physics
  - dark matter @ colliders (comp. to LHC)
  - model discrimination
- detector performance
  - photon energy res. & scale
  - hermeticity
  - bhabha suppression, beam spectrum
- tools and analysis
  - photon reconstruction (B.Xu, talk at HLRec WS)
  - beam cal reconstruction (A.Sailor, etc., M.Habermehl, talk on Thur.)
  - fullsim studies back to LDCPrime
  - ongoing ILD full sim studies (M.Habermehl, T.Tanabe)

summary

- we have a set of benchmark processes for physics performances —> still open for ideas that can exploit/evaluate more aspects of detectors.
- development of HLRec tools are well on the way, will be in good shape at the time of mass production.
- analyses for benchmark are relatively covered well for the DBD studies —> welcome to join the analyses for detector optimisations.

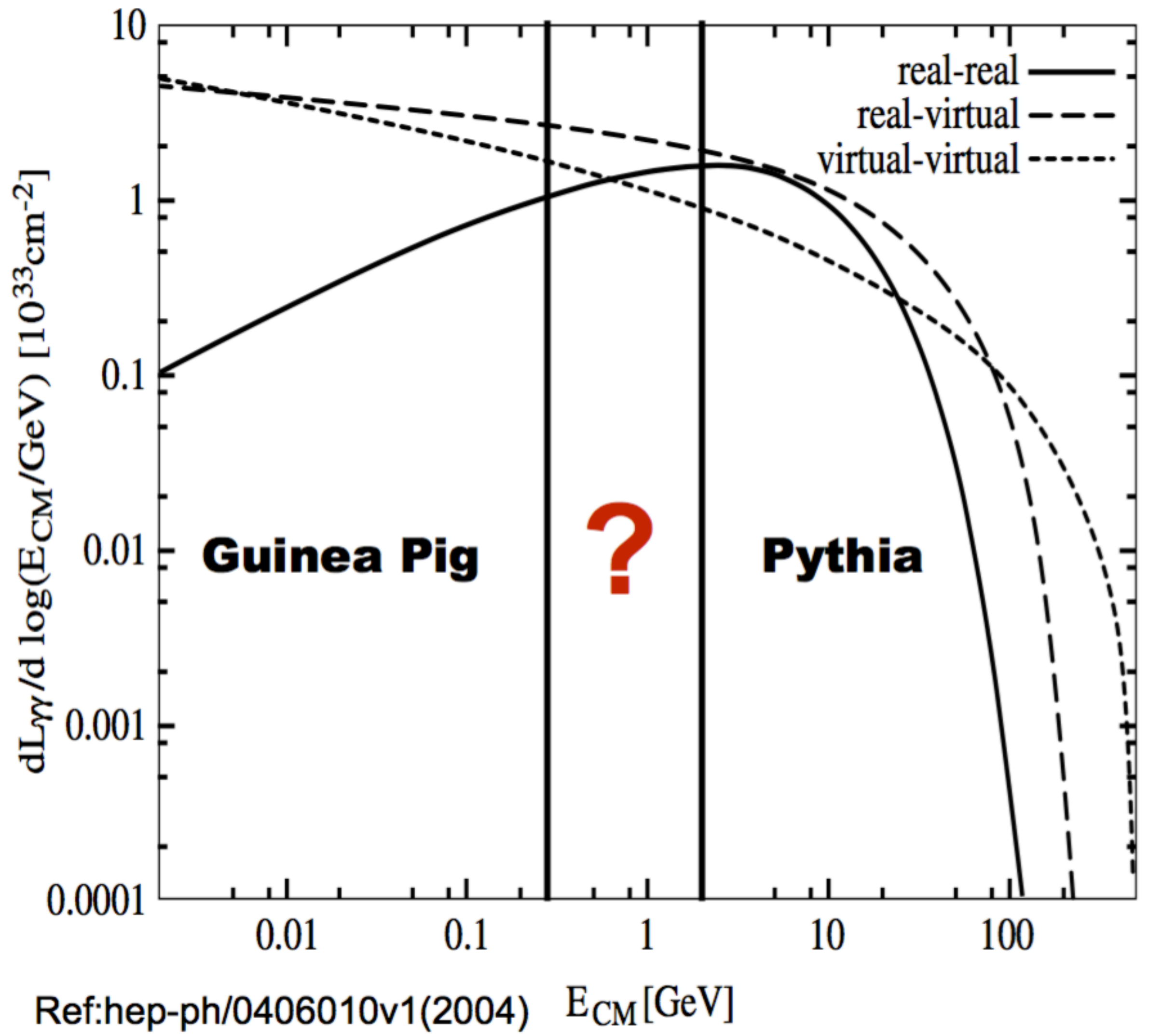
backup

C: status of systematics activities (experimental)

- systematics working group contact persons: M.Vos, G.Wilson, T.Suehara
- uncertainty of beam spectrum becomes possible common systematics for many analyses: tt-bar threshold, recoil mass, WIMP search, etc.; a task force on beam spectrum study shall be need shortly
- impact of beam induced background, in particular $\gamma\gamma$—>low-pt hadrons turns out to be important in many analyses; news: (talk by S.Sasikumar) modelling of $\gamma\gamma$—>low-pt hadrons has been investigated;
- ongoing: (J.Tian) improve overlay removal by finding the vertices of those $\gamma\gamma$ interactions —> need vertex finder for low-pt tracks
- news: (studies by K.Tsuchimoto) estimation of Z control samples for JES uncertainty; same things can be done for momentum calibration, flavour tagging eff. uncertainties, etc.

Shortcomings with Pythia

- Hadron productions initialized at 300MeV
- Crucial to understand processes at these energies
- Pythia cannot simulate for energies below 2.5GeV
- Trying for various solutions
  - By changing few parameters
  - Looking at Barklow's methods



Ref:hep-ph/0406010v1(2004)

Available number of control samples

- Beam helicity configurations and total integrated luminosities for each E_{CM} are based on the ILC operation under the scenario H20.
- Be noted that in H20 scenario the total integrated luminosities are shared by different beam polarizations.
  - 250GeV : 67.5%(-0.8,+0.3), 22.5%(+0.8,-0.3), 5%(-0.8,-0.3), 5%(+0.8,+0.3)
  - 500GeV : 40%(-0.8,+0.3), 40%(+0.8,-0.3), 10%(-0.8,-0.3), 10%(+0.8,+0.3)
- Effective numbers resulting from the selection efficiencies for each process previously described.

E_{CM}	Process	N_{H20} [$\times10^6$] (Z—>had.)	N_{eff} [$\times10^6$] ($\lvert\cos\theta\rvert<0.99$)	N_{eff} [$\times10^6$] ($\lvert\cos\theta\rvert<0.95$)	N_{eff} [$\times10^6$] ($\lvert\cos\theta\rvert<0.90$)
250GeV	ZZ	0.25	0.11	0.1	0.09
	γZ	20	16	10	8.0
	ννZ	0.09	0.08	0.08	0.08
	eeZ	6.1	0.09	0.04	0.03
500GeV	ZZ	0.19	0.08	0.06	0.04
	γZ	9.7	6.2	3.9	3.0
	ννZ	0.83	0.73	0.73	0.73
	eeZ	13	0.15	0.07	0.04
Sum of All		50.0	23.5	15.4	12.0

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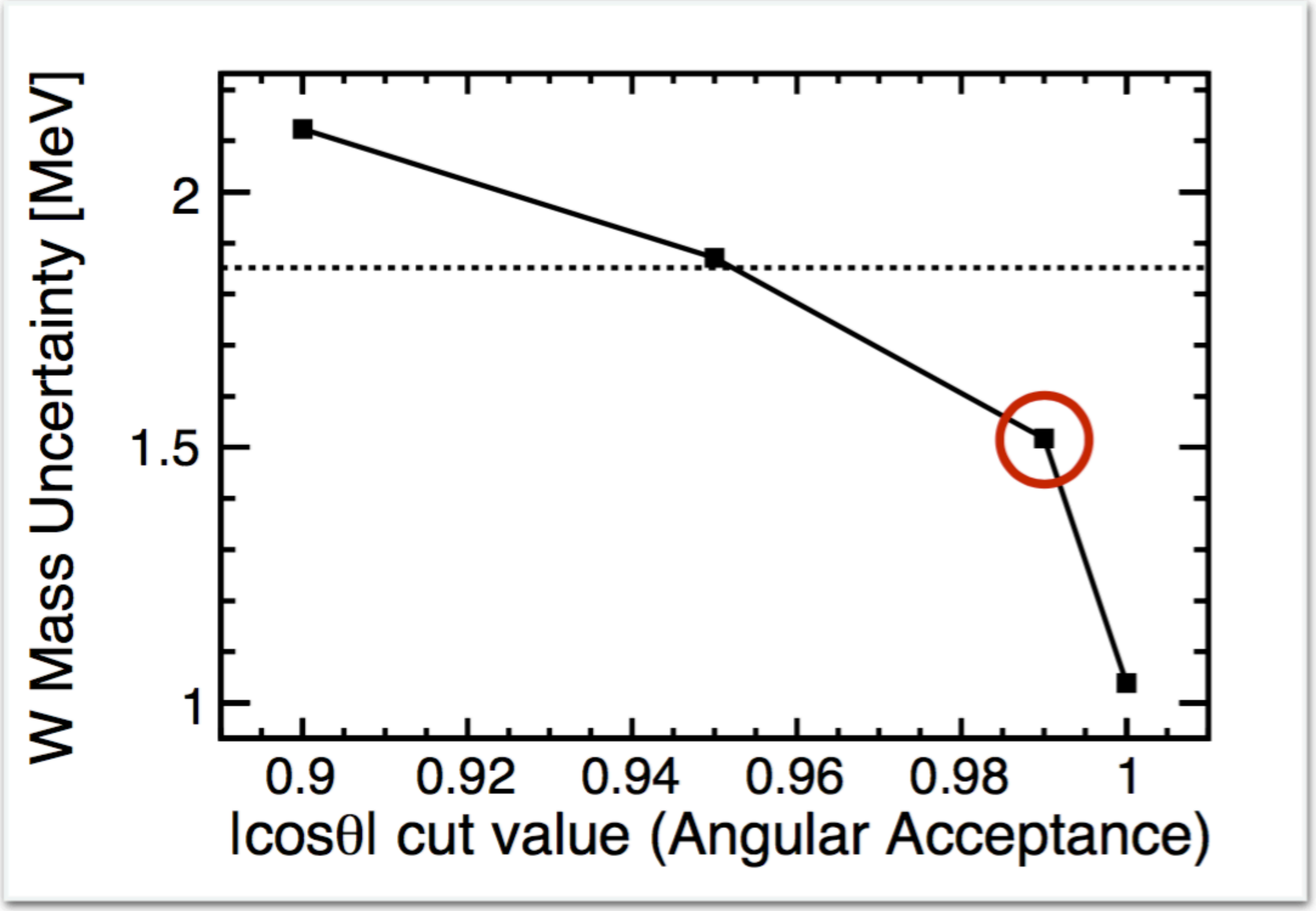
(K.Tsuchimoto @ 44th general meeting of ILC physics subgroup)

Impact of detector acceptance on W mass



- plotted with the estimated W mass systematic error from JES uncertainty as the vertical axis and the value of detector acceptance as the horizontal axis
- dashed line indicates $\Delta M_Z/M_Z$ ~ 23ppm (from LEP result)

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(K.Tsuchimoto @ 44th general meeting of ILC physics subgroup)