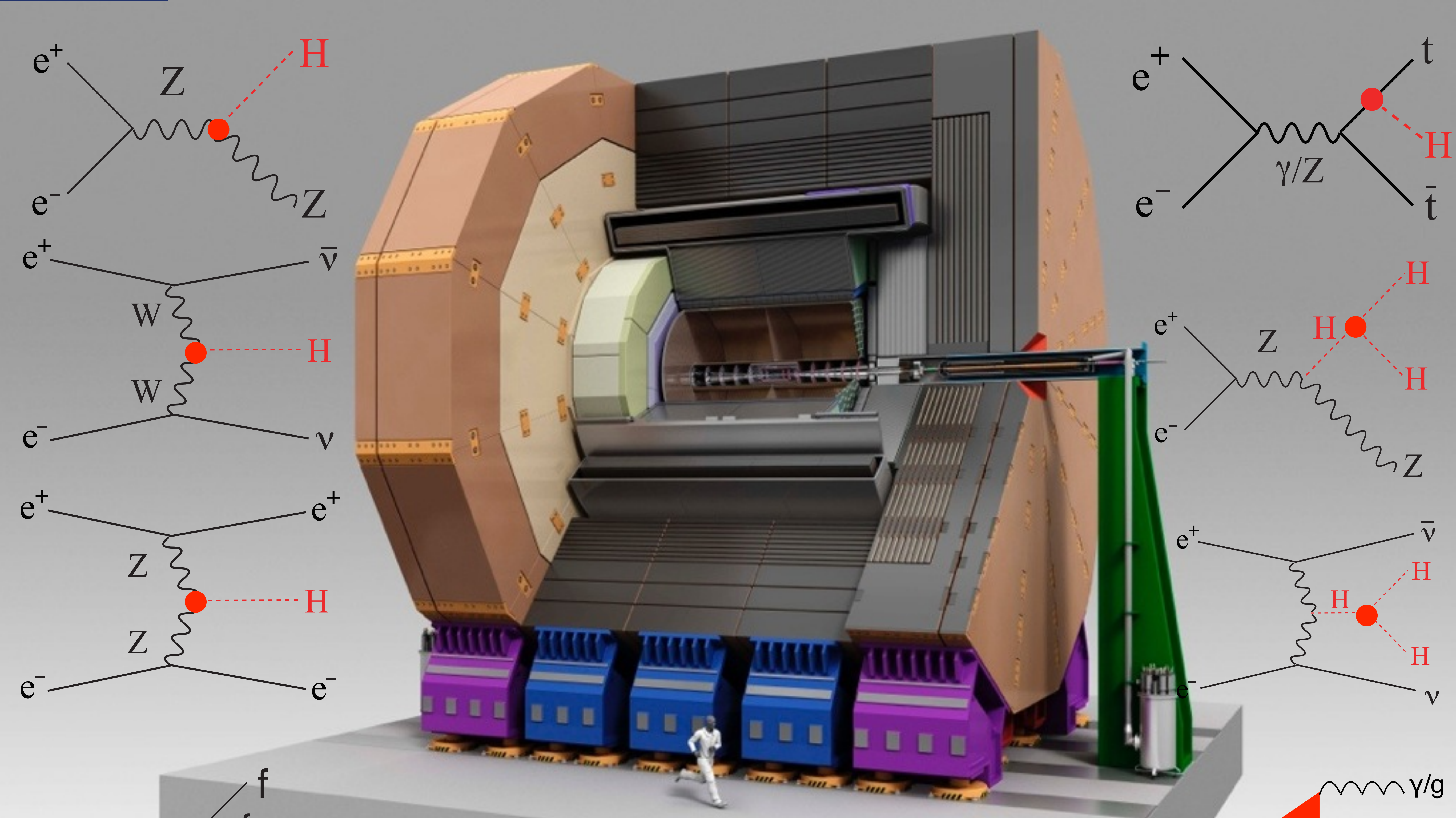
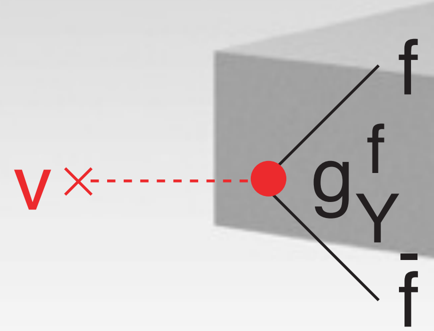
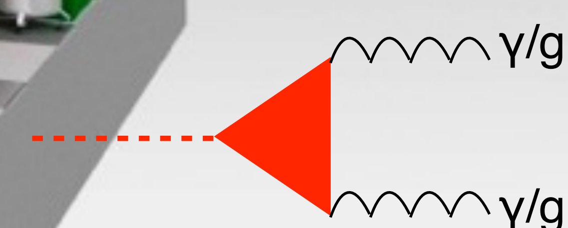
Study of ILC Staging Scenarios







Junping Tian, Keisuke Fujii (KEK)

for ILC Parameter WG Meeting, May 8, 2014

Update of the April 25 slides

Starting Points

= Input Observables

Summary table of Higgs measurements @ ILC

Baseline

w/ new extrapolated results @ 350 GeV

ECM	@ 250 GeV		@ 350 GeV		@ 500 GeV		@ 1 TeV
luminosity · fb	250		330		500		1000
polarization (e-,e+)	(-0.8, +0.3)		(-0.8, +0.3)		(-0.8, +0.3)		(-0.8, +0.2)
process	ZH	ννH	ZH	ννH	ZH	ννH	ννH
cross section	2.6%	-	*X%*		-	-	-
	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br
H-->bb	1.2%	10.5%	1.3%	1.3%	1.8%	0.66%	0.32%
H-->cc	8.3%		9.9%	13%	13%	6.2%	3.1%
H-->gg	7%		7.3%	8.6%	11%	4.1%	2.3%
H-->WW*	6.4%		6.8%	5.0%	9.2%	2.4%	1.6%
H-->ττ	4.2%		4.6%	19%	5.4%	9%	3.1%
H-->ZZ*	19%		22%	17%	25%	8.2%	4.1%
H-->γγ	29-38%		29-38%	39%	29-38%	19%	7.4%
H-->μμ	-						31%
H-->Inv. (95% C.L.)	< 0.95%				-		
ttH, H-->bb	-				28%		6%

mostly from White Paper; being updated by new studies with mH = 125 GeV (see backup)

From the Observables to Couplings

limiting factors of coupling precisions

$$Y_1 = \sigma_{ZH} \propto g^2_{HZZ}$$

$$Y_2 = \sigma_{\nu\bar{\nu}H} \cdot \mathrm{Br}(H \to b\bar{b}) \propto \frac{g^2_{HWW} g^2_{Hbb}}{\Gamma_H}$$

$$Y_3 = \sigma_{ZH} \cdot \mathrm{Br}(H \to b\bar{b}) \propto \frac{g^2_{HZZ} g^2_{Hbb}}{\Gamma_H}$$

$$Y_4 = \sigma_{\nu\bar{\nu}H} \cdot \mathrm{Br}(H \to WW^*) \propto \frac{g^4_{HWW}}{\Gamma_H}$$

$$\Delta g_{HZZ} \sim \frac{1}{2}\Delta Y_1$$

$$\Delta g_{HWW} \sim \frac{1}{2}\Delta Y_1 \oplus \frac{1}{2}\Delta Y_2 \oplus \frac{1}{2}\Delta Y_3$$

$$\Delta g_{Hbb} \sim \frac{1}{2}\Delta Y_1 \oplus \Delta Y_2 \oplus \frac{1}{2}\Delta Y_3 \oplus \frac{1}{2}\Delta Y_4$$

$$\Delta \Gamma_H \sim 2\Delta Y_1 \oplus 2\Delta Y_2 \oplus 2\Delta Y_3 \oplus \Delta Y_4$$

both ZH and ννH productions matter!

see more details: JT @ Tokusui Workshop 2013

Sample Results

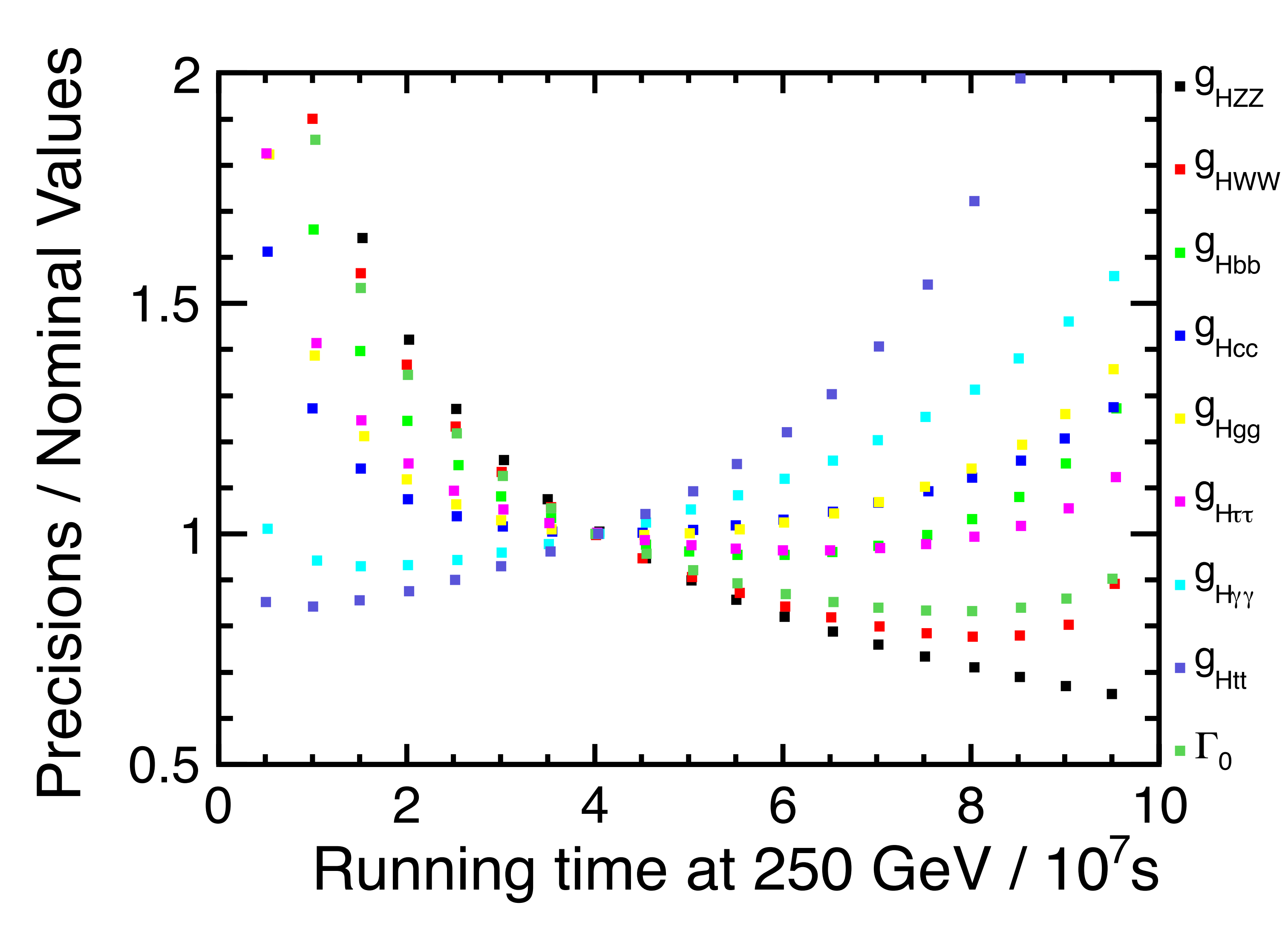
to show what kind of results we expect
from the on-going analysis

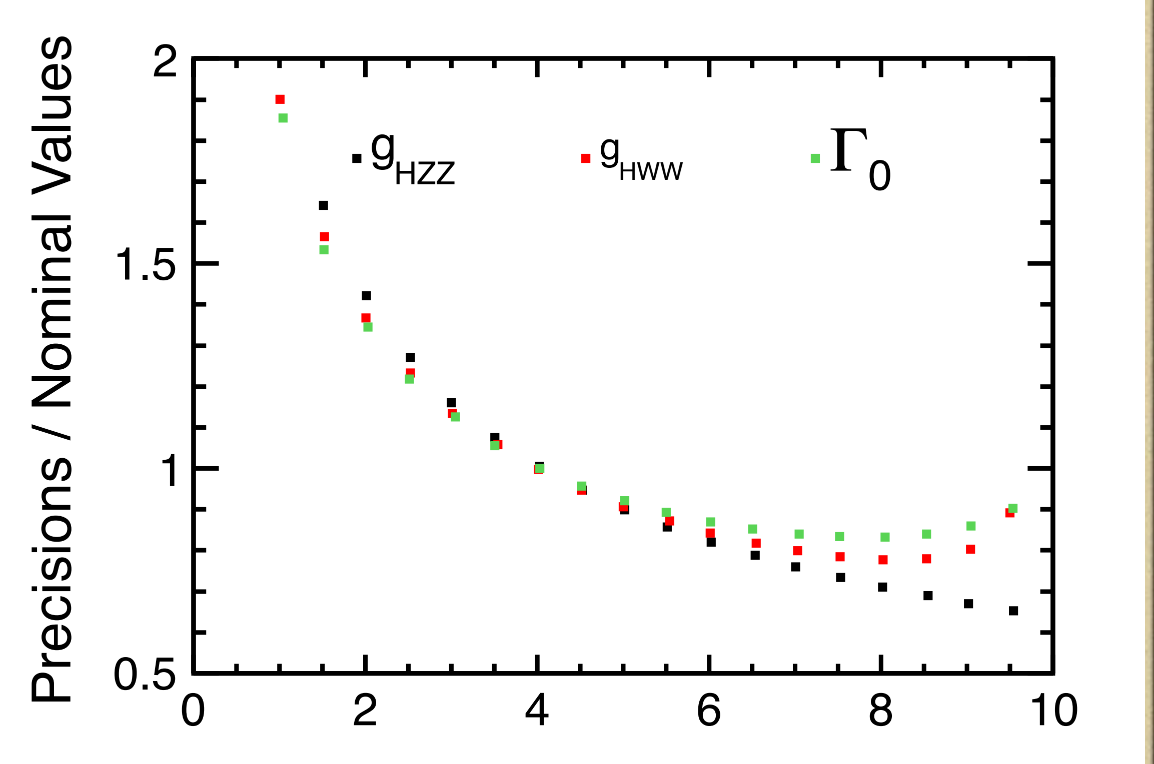
Very preliminary depending on extrapolations
(the most crucial is the σ_{ZH} at 350 GeV)

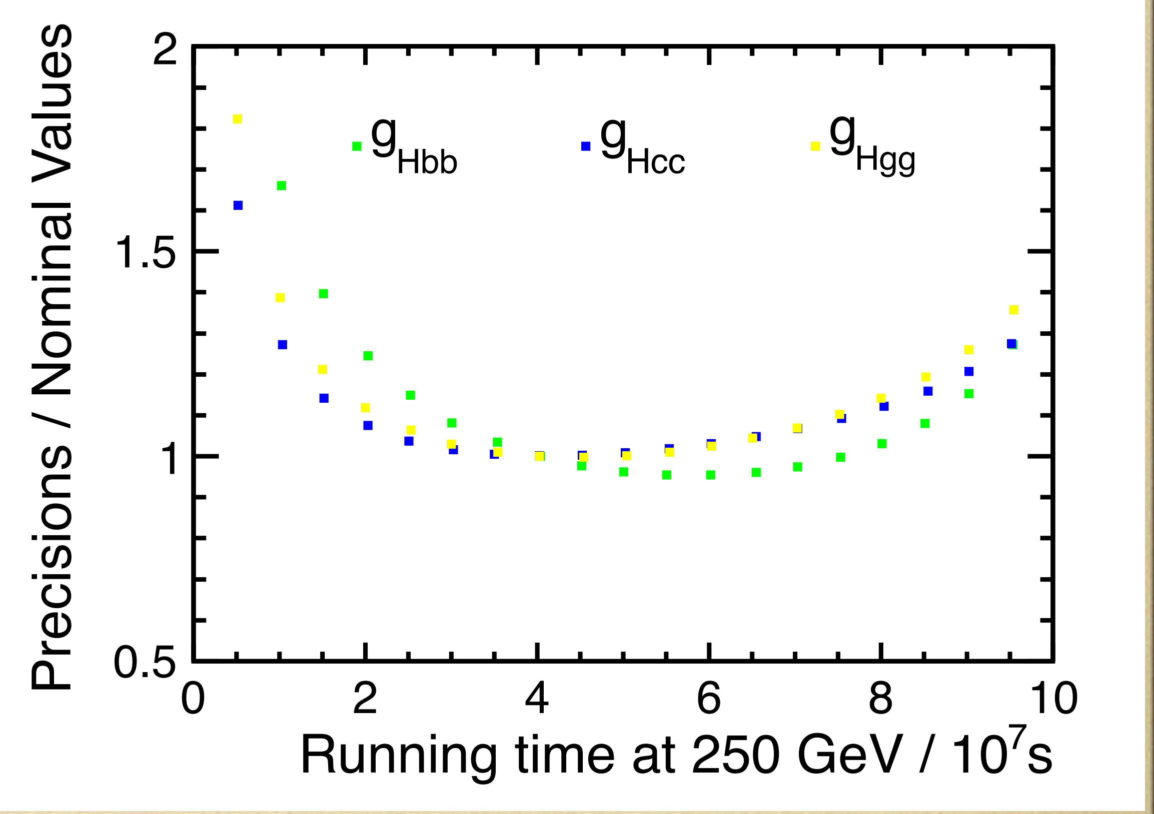
staging: 250 + 500 GeV

fraction dependence

- for comparison, first consider nominal running: 4y @ 250 GeV + 6y @ 500 GeV (1y ~ 10^7s)
- then vary running time @ 250 GeV (in total 10y) to see how precisions depend on run time @ 250 GeV





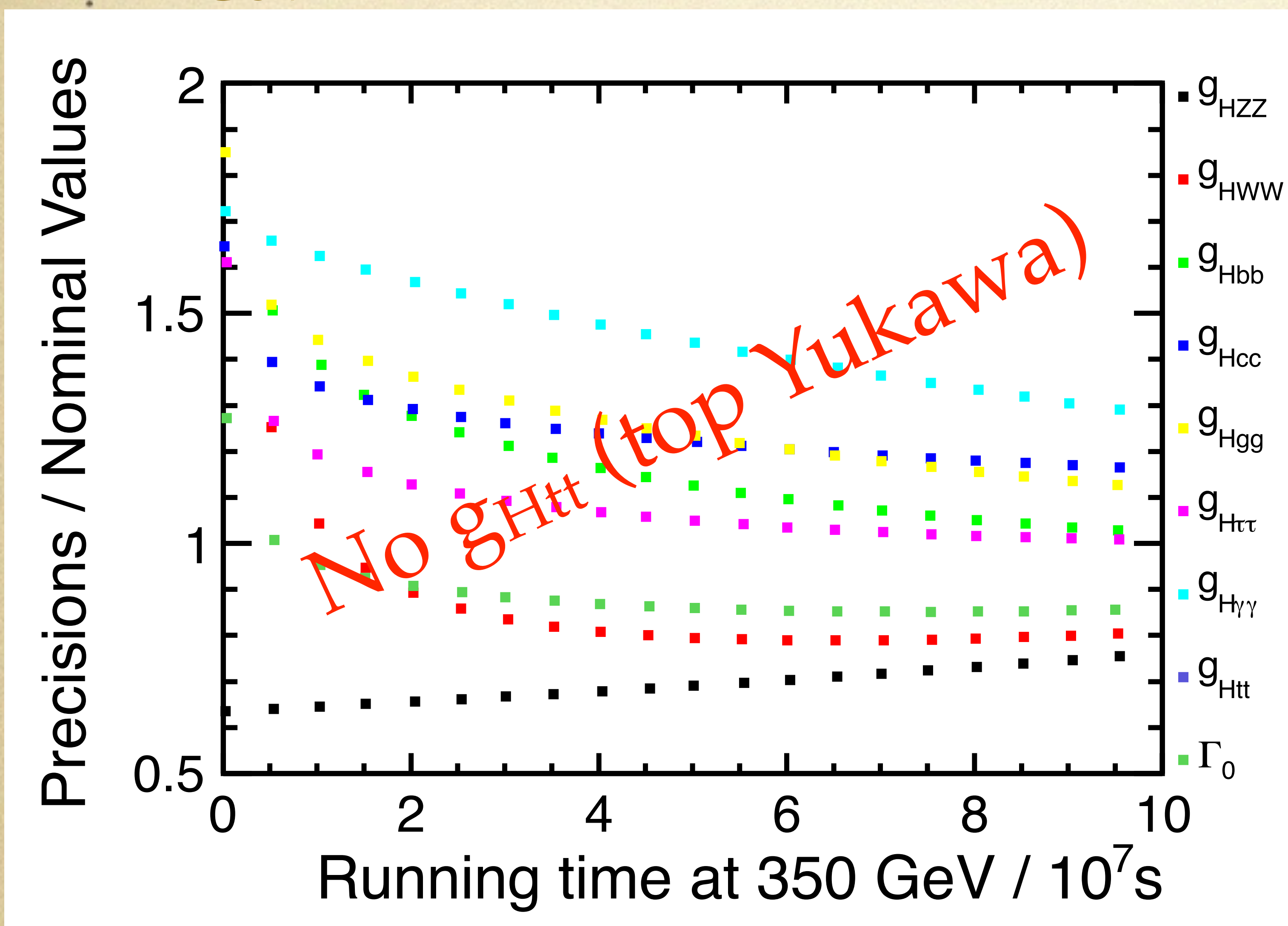


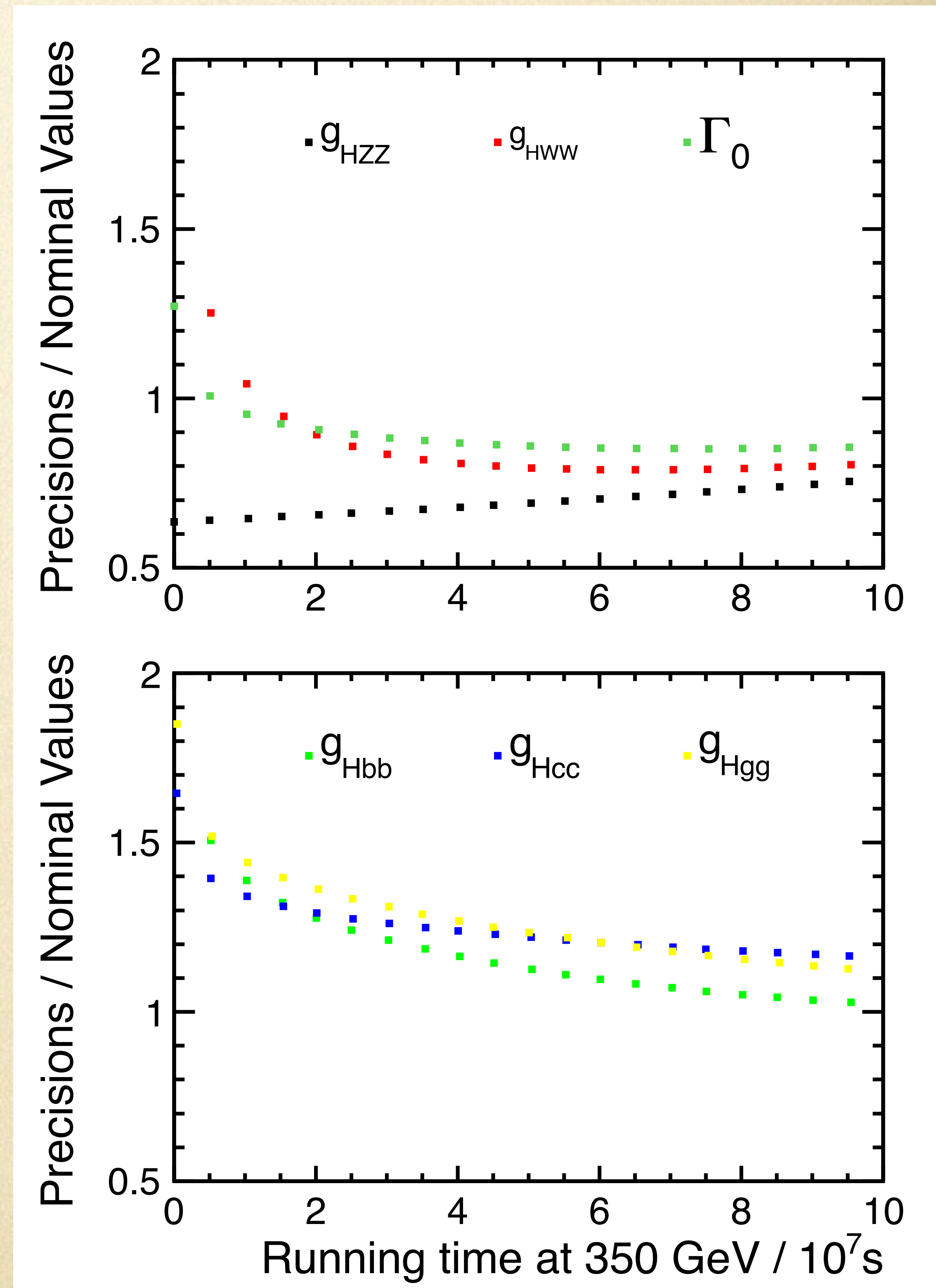
Assuming full luminosity from t=0

staging: 250 + 350 GeV

fraction dependence

- w/o 500 GeV data: vary running time @ 350 GeV (in total 10y) to see how precisions depend on run time @ 350 GeV



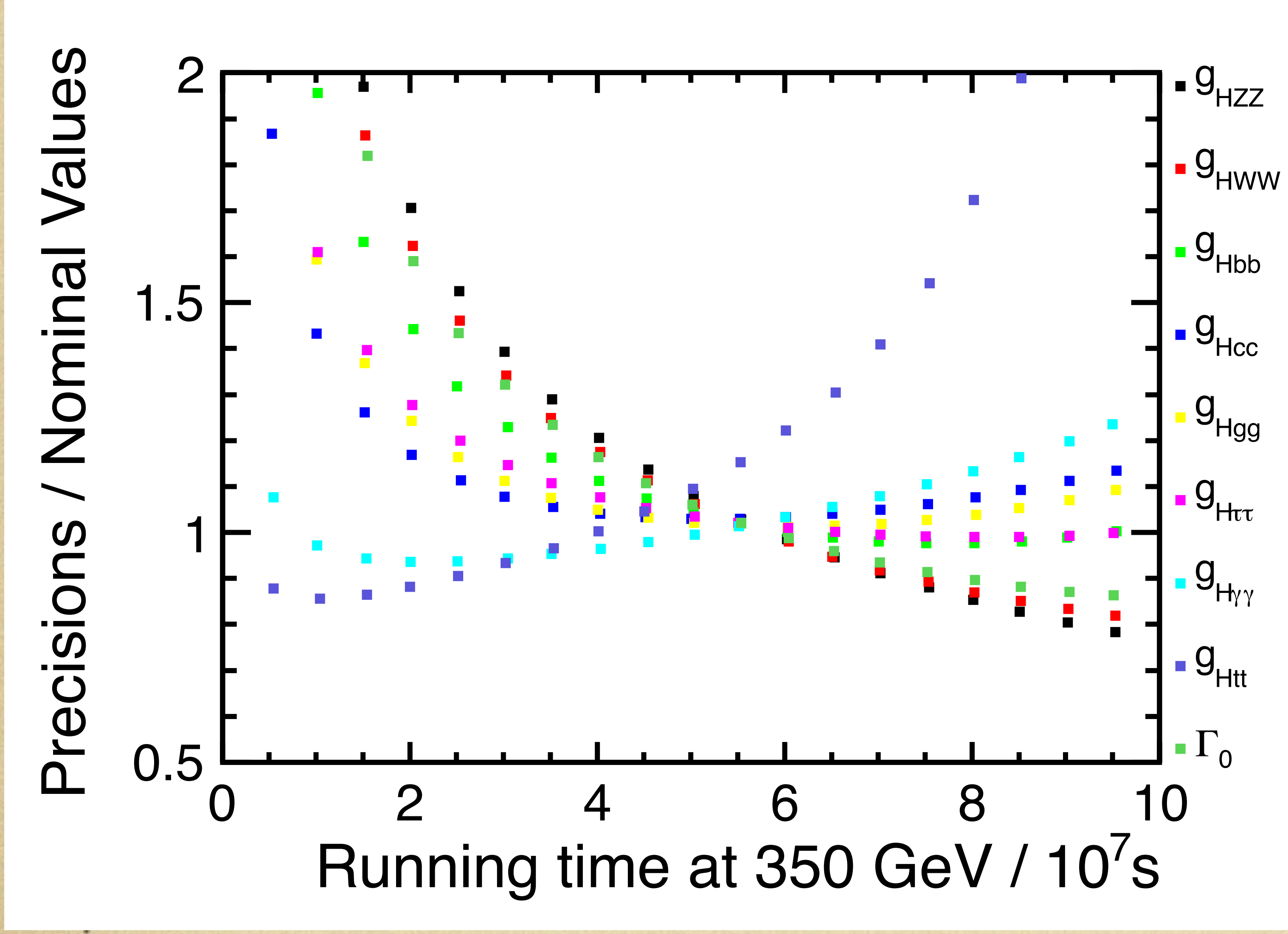


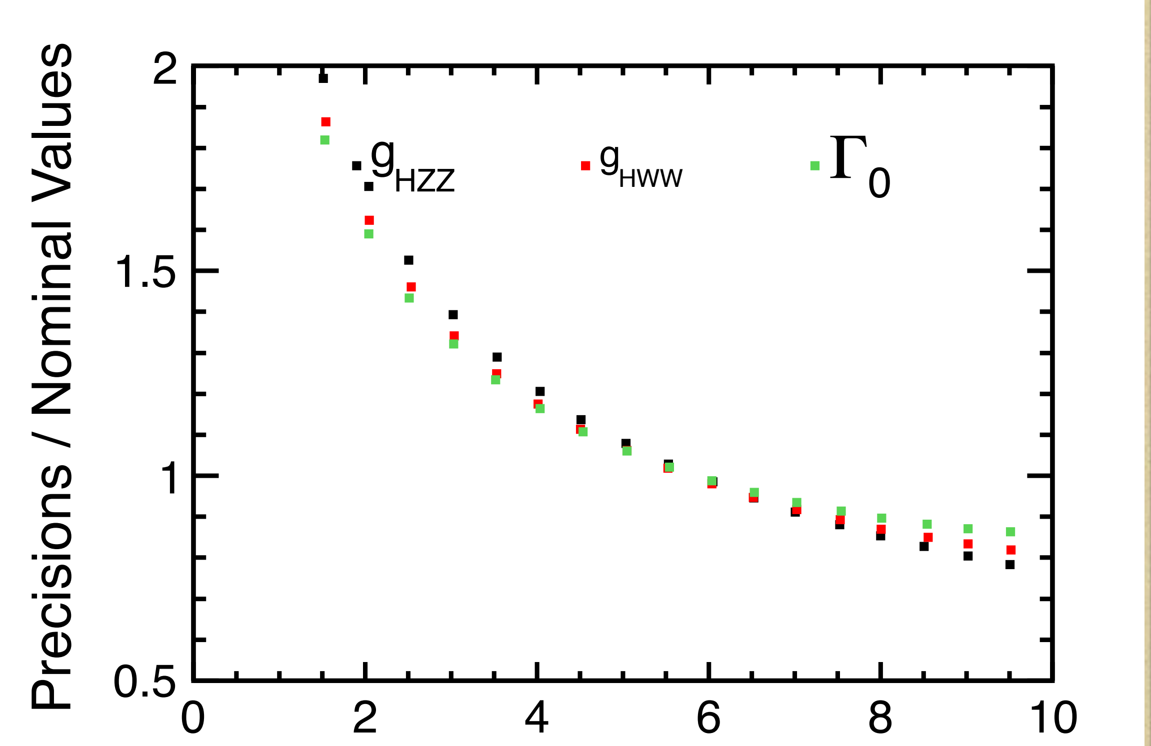
Assuming full luminosity from t=0

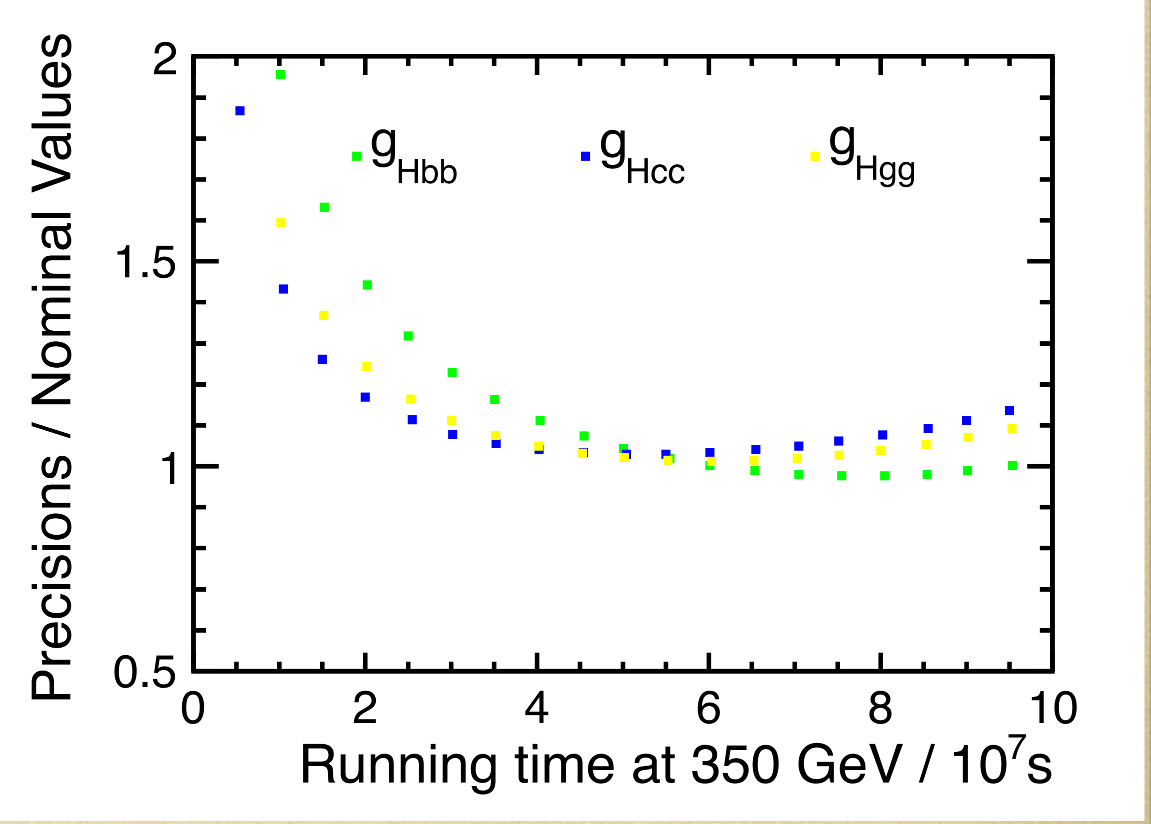
staging: 350 + 500 GeV

fraction dependence

- vary running time @ 350 GeV (in total 10y) to see how precisions depend on run time @ 350 GeV



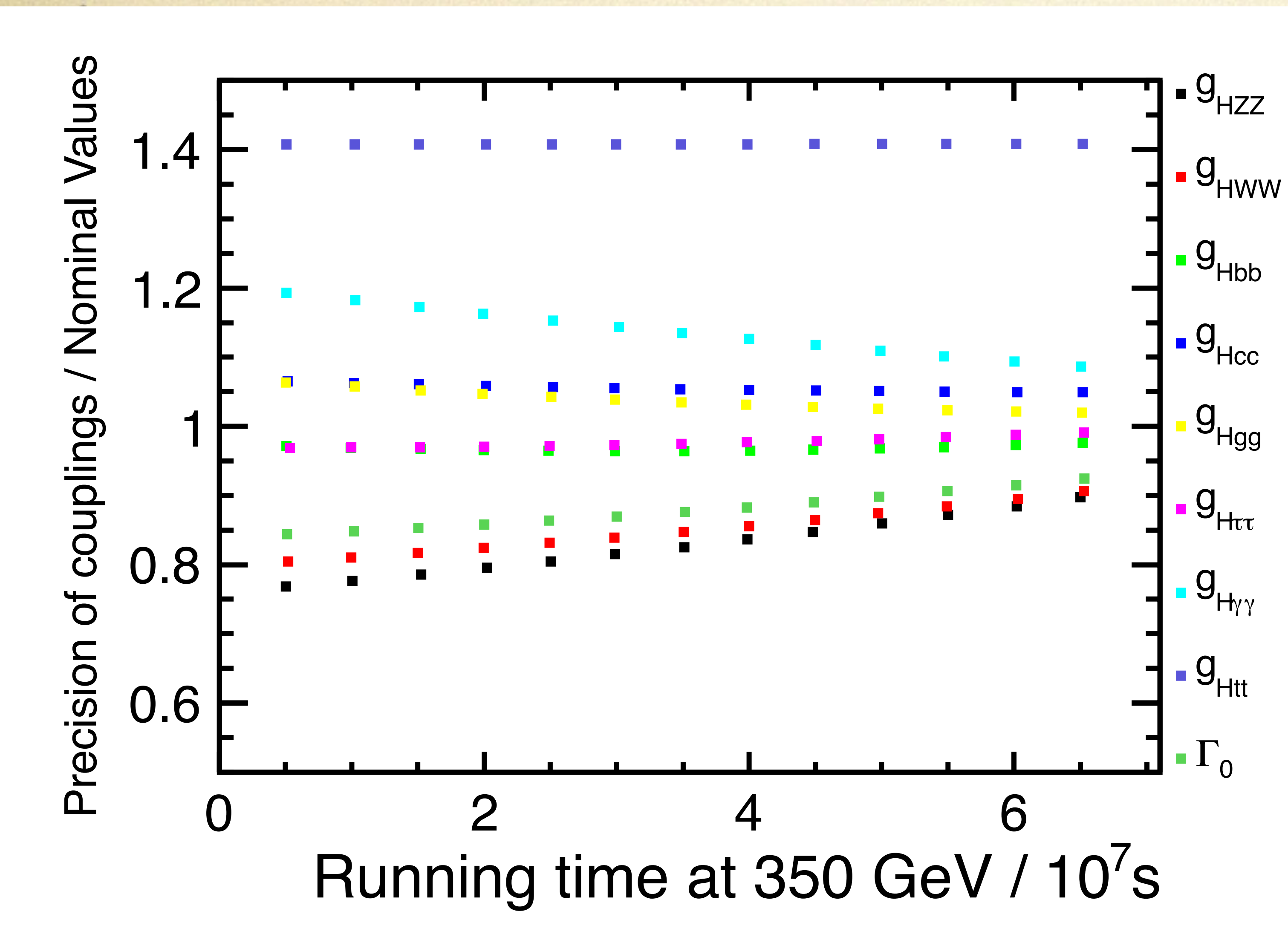


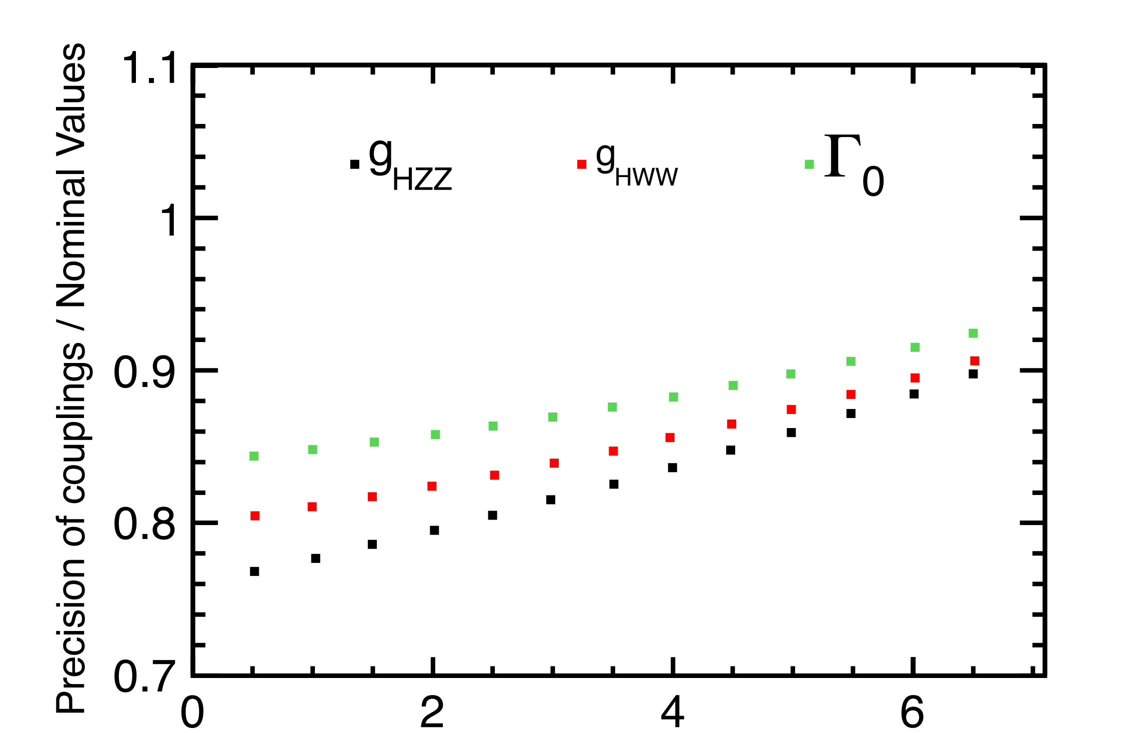


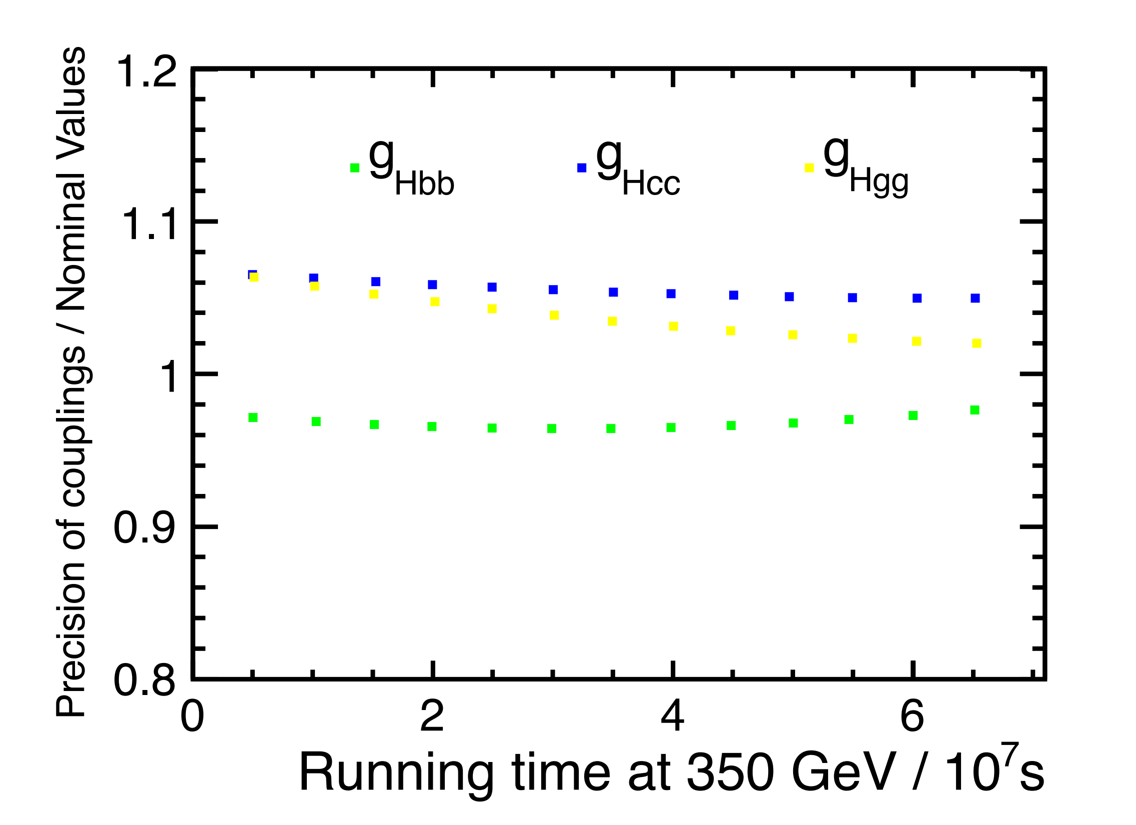
Assuming full luminosity from t=0

staging: 250 + 350 + 500 GeV

- assume 10y in total, of which 3y @ 500 GeV.
- then vary running time @ 350 GeV.







One 500 GeV data become available,
the role of 350 GeV data diminish.

Assuming full luminosity from t=0

some benchmark scenarios

(defined by ILC Parameter group)

a. 250 inv.fb @ 250, 500 inv.fb @ 500

b. 250 inv.fb @ 250, 500 inv.fb @ 550

c. 250 inv.fb @ 250, 1000 inv.fb @ 500 (for comparison with scenario b)

d. 100 inv.fb @ 250, 200 inv.fb @ 350, 500 inv.fb @ 500

e. 100 inv.fb @ 250, 200 inv.fb @ 350, 500 inv.fb @ 550

f. 25 inv.fb @ 250, 350 inv.fb @ 350, 500 inv.fb @ 500

g. 500 inv.fb @ 250, 500 inv.fb @ 500

a*. 350 inv.fb @ 350, 500 inv.fb @ 500

h. 50 inv.fb @ 250, 200 inv.fb @ 350, 500 inv.fb @ 500, 1 inv.ab @ 250

i. 50 inv.fb @ 250, 200 inv.fb @ 350, 500 inv.fb @ 550, 1 inv.ab @ 250

precisions for benchmark scenarios

coupling Δg/g	a	b	c	d	e	f	g	h	i	a*
HZZ	1.3%	1.3%	1.3%	1.4%	1.4%	1.4%	0.92%	0.6%	0.6%	1.5%
HWW	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%	1%	0.71%	0.71%	1.6%
Hbb	1.8%	1.7%	1.6%	1.9%	1.8%	1.8%	1.5%	1.1%	1.1%	1.9%
Hcc	2.9%	2.8%	2.4%	2.9%	2.8%	2.9%	2.5%	1.9%	1.9%	2.9%
Hgg	2.4%	2.3%	2%	2.5%	2.4%	2.4%	2.1%	1.6%	1.6%	2.4%
Hττ	2.5%	2.4%	2.1%	2.5%	2.5%	2.5%	2%	1.5%	1.4%	2.6%
Hγγ	7.6%	7.2%	5.7%	7.3%	7%	7%	6.9%	5.6%	5.4%	7.1%
Htt	14%	6.2%	10%	14%	6.2%	14%	14%	14%	6.1%	14%
Γ	5.9%	5.9%	5.7%	6.4%	6.4%	6.3%	4.5%	3.2%	3.1%	6.7%

assumptions

i) X=20% worse for σ(ZH) at 350 GeV

ii) extrapolation for 350 GeV shown in backup slides

iii) much simpler extrapolation for 550 GeV (just scale σ(ZH) and σ(ννH))

Requests

We would like to know the number of years of running each scenario corresponds to so that we can add this as an extra line in each table. Maybe even two numbers:

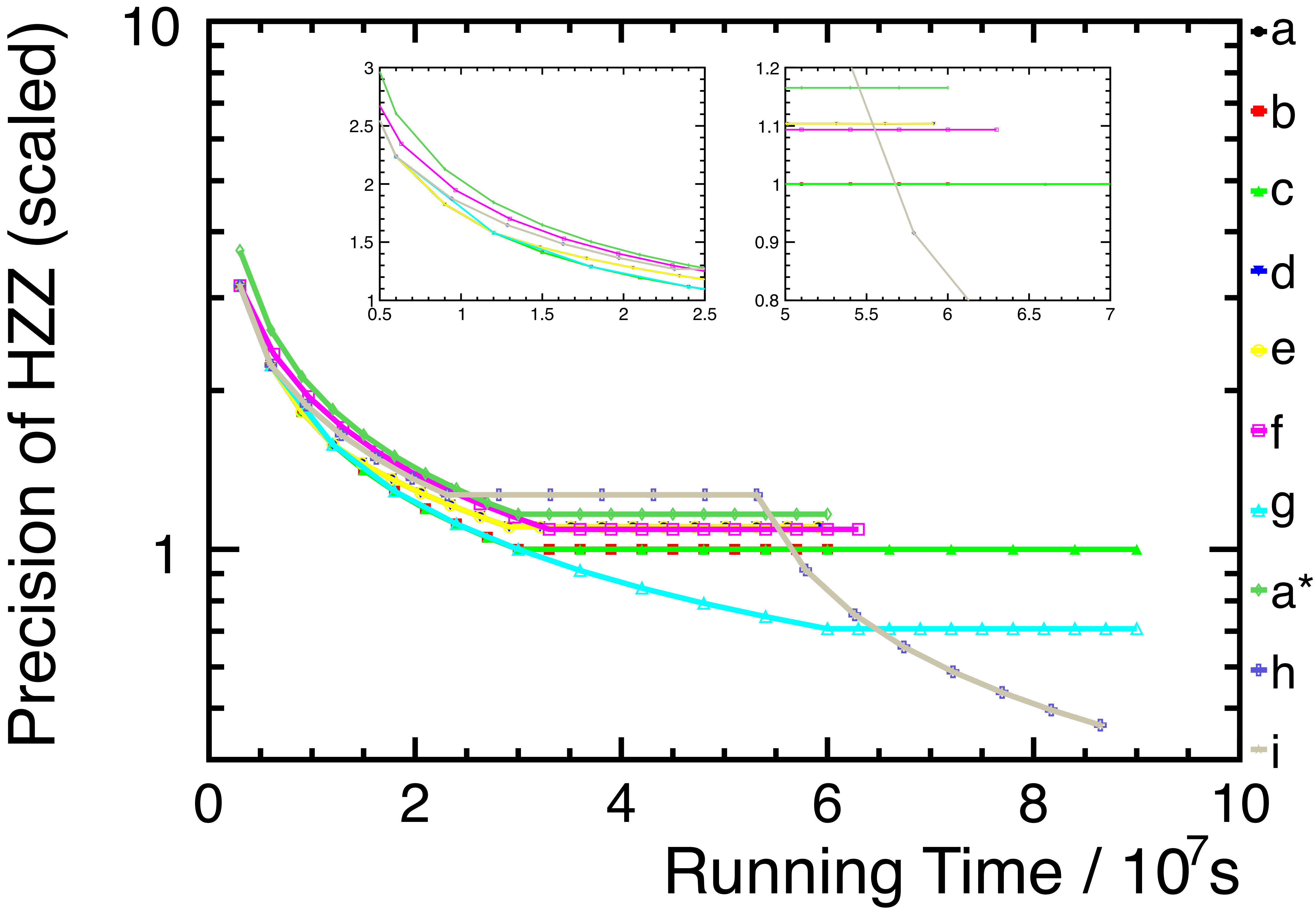
- the running time at peak luminosity
- a running time including commissioning and slow ramp up of lumi in the first years = lowest energies.

Evolution of Precisions over Time

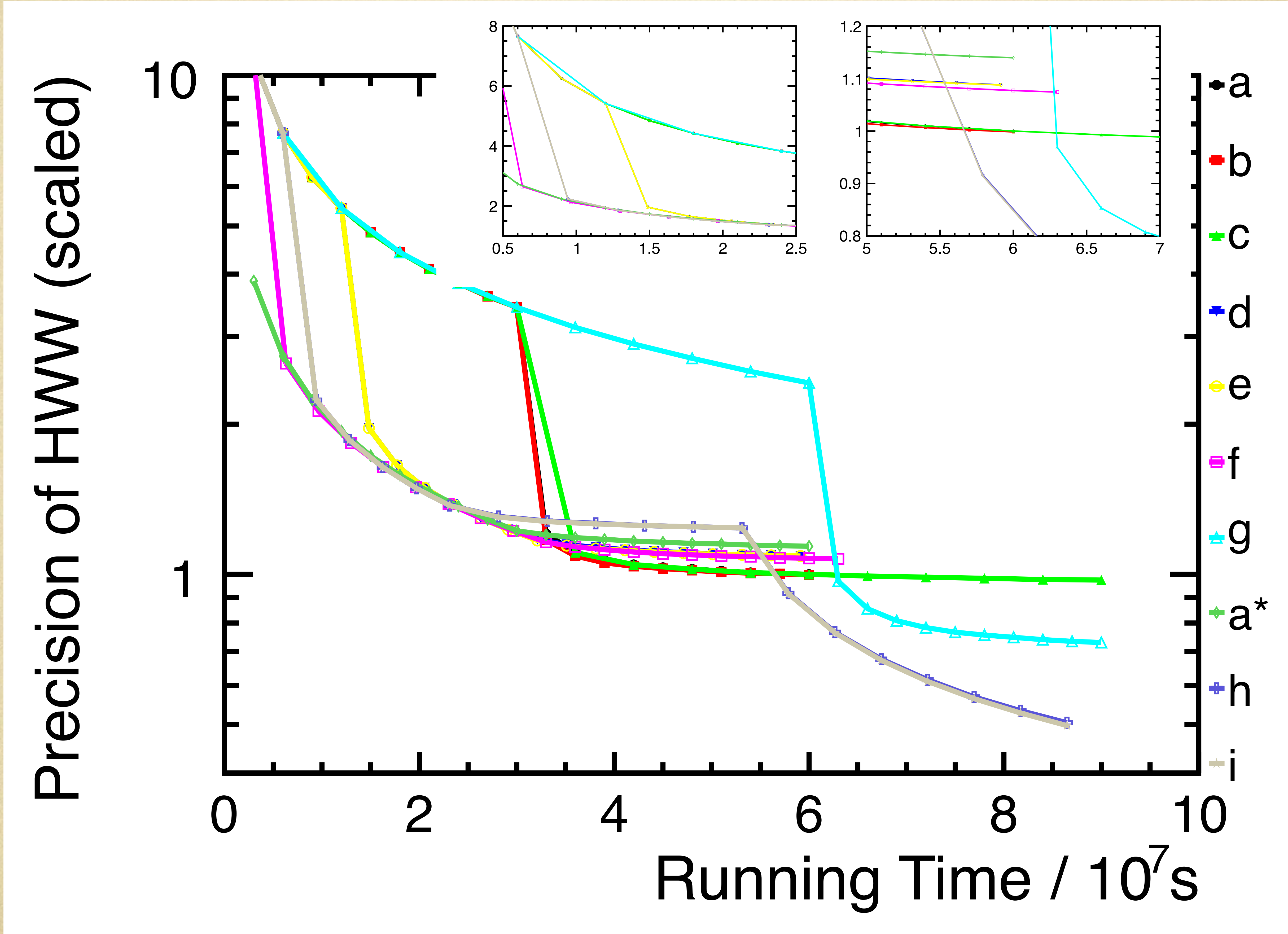
(all precisions are scaled to their values at the end of scenarios a, which are shown in table)

Assuming full luminosity from t=0

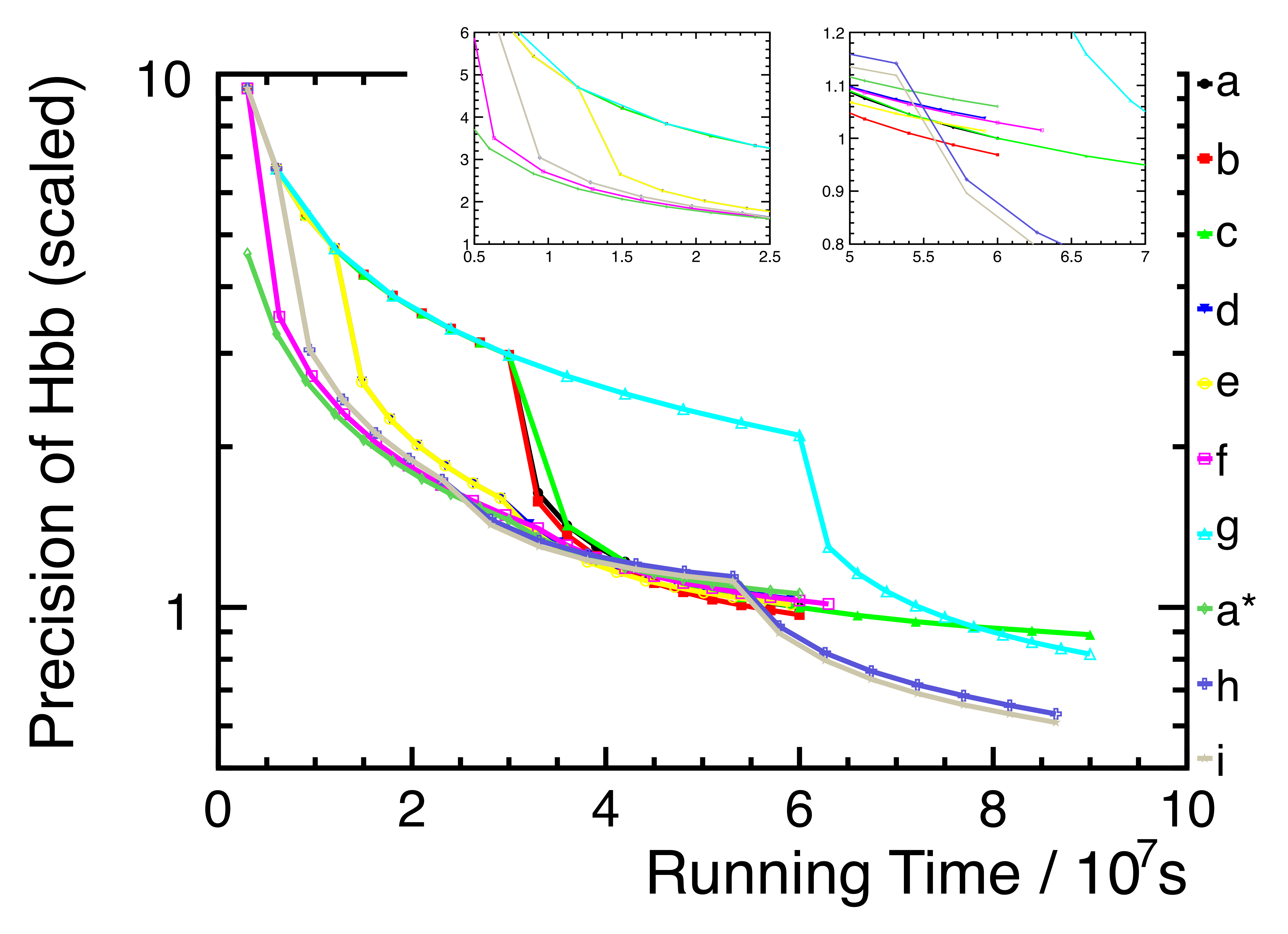
evolution: g_{HZZ}



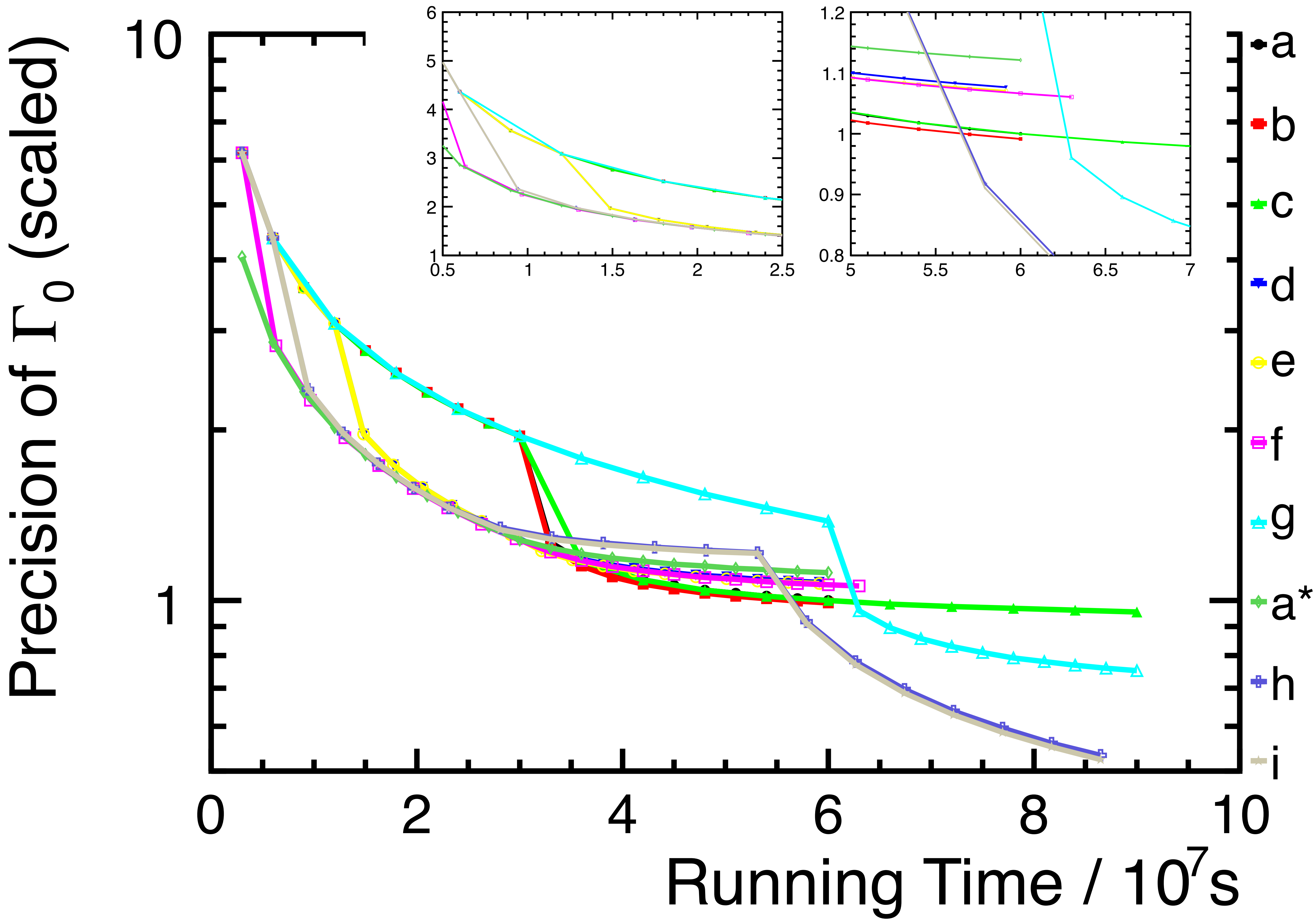
evolution: g_{HWW}



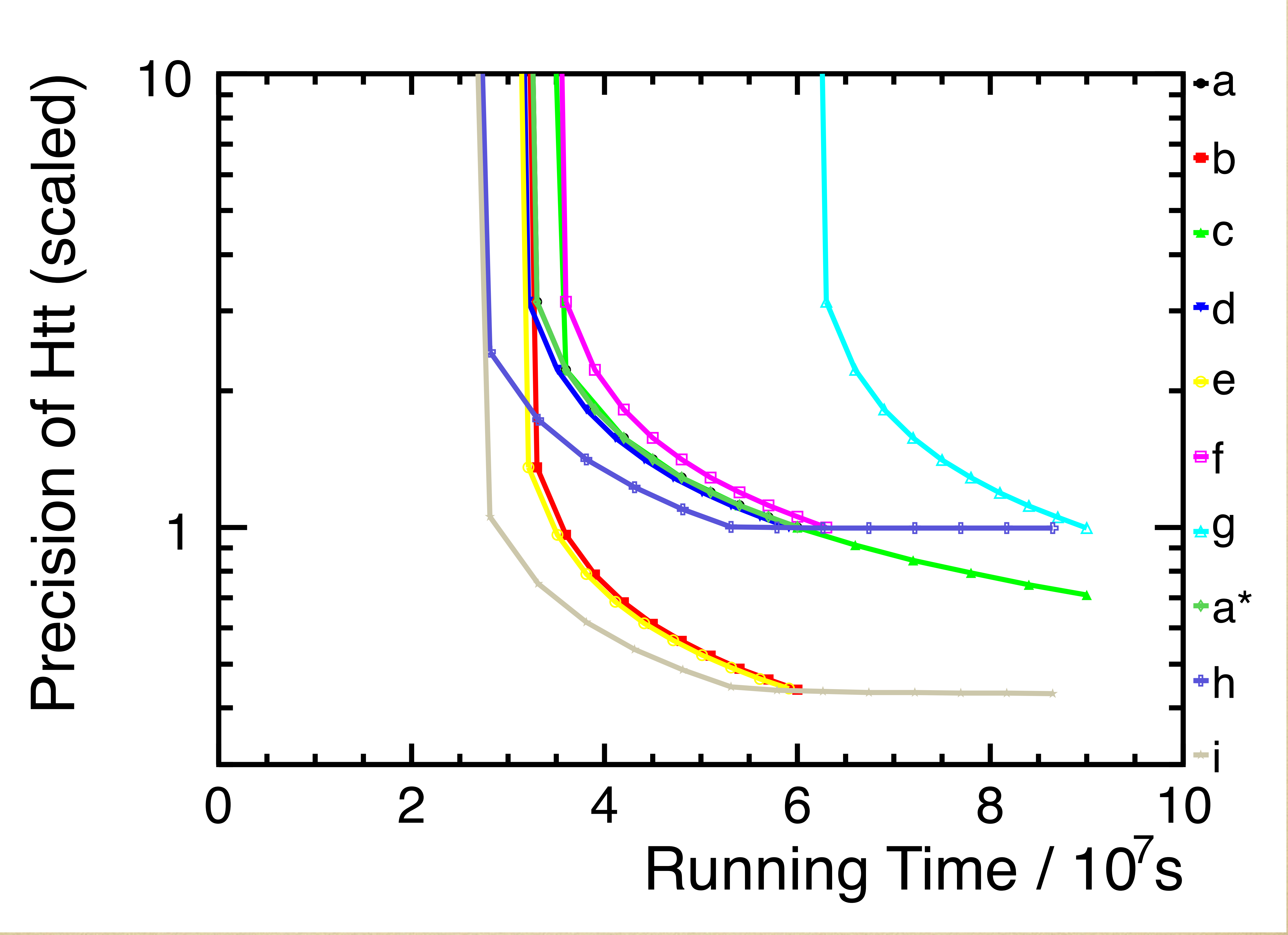
evolution: g_{Hbb}



evolution: Γ_H



evolution: g_{Htt}



General Observations

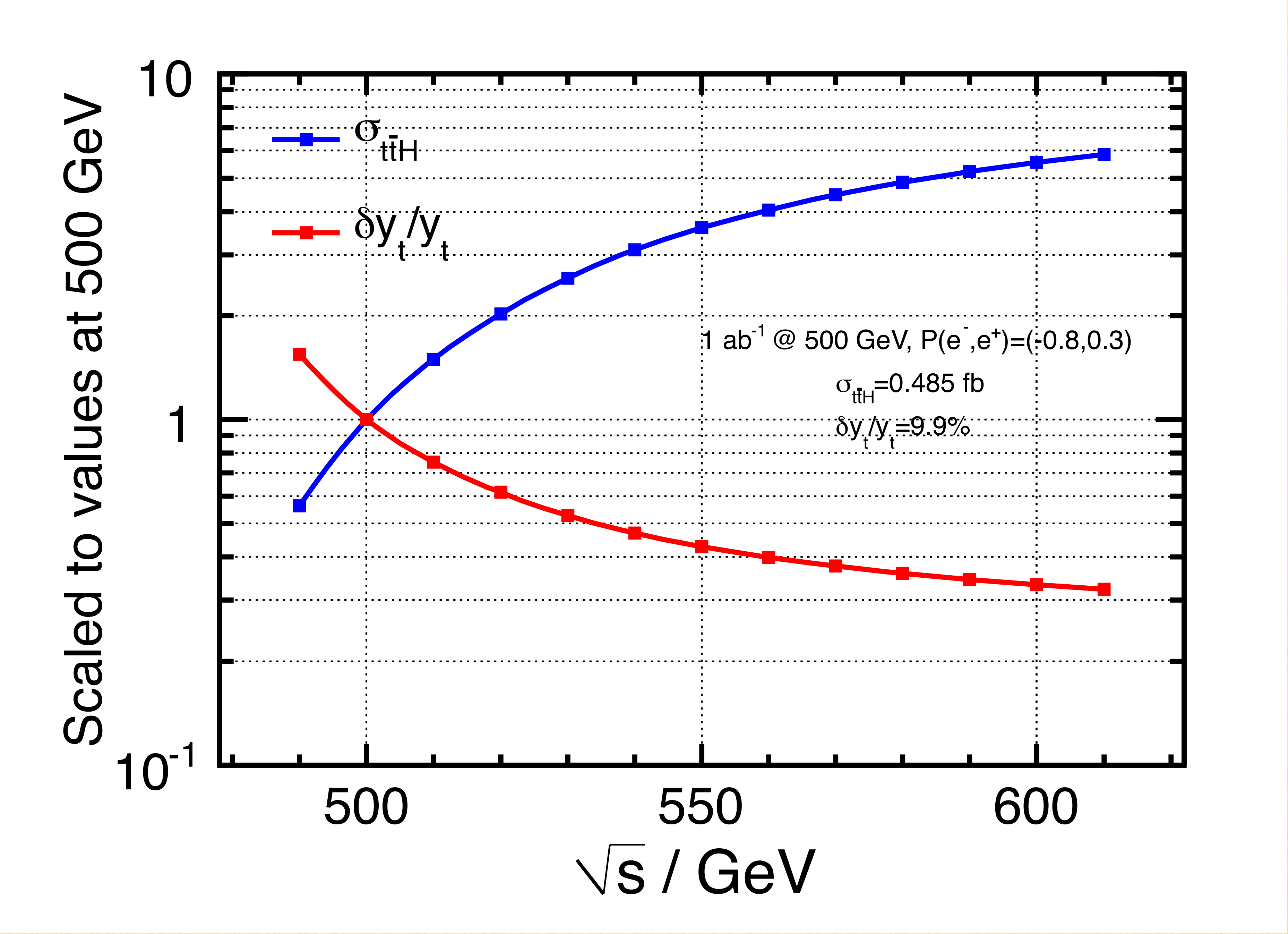
no conclusion yet

General Observations (no conclusions yet)

- staged running of ILC is a choice to optimize measurements through physics processes ZH, ννH, ttH, ZHH and ννHH.
- starting at 350 GeV can provide nicer measurements at earlier lifetime of ILC; overall importance of 350 GeV running highly depends on results of recoil mass analysis @ 350 GeV (waiting for Jacqueline's results); the benefit from the WW-fusion process at 350 GeV will quickly diminish when data at 500 GeV become available.
- increasing energy a bit from 500 GeV makes big difference for top-Yukawa coupling measurement.
- different couplings have different dependence on running scenarios; usually HVV and Γ_H are mainly limited by recoil mass channel, others are limited by just statistics.
- hence, adding more data at 250GeV with full luminosity after accumulating enough data at the highest energy will benefit us significantly in general.

back up

top-Yukawa coupling



many thanks to Y. Sudo!

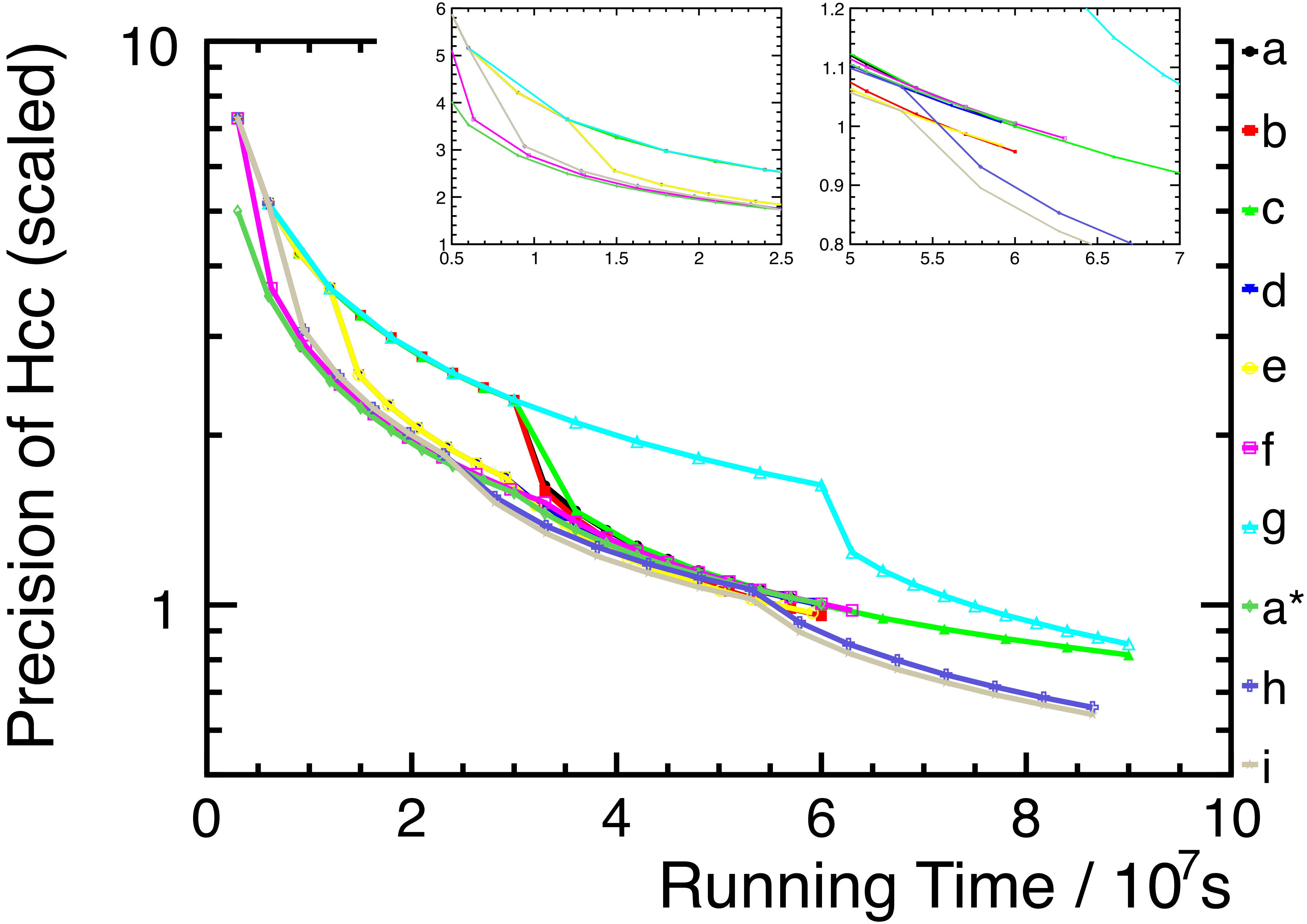
Extrapolation to 350 GeV and some update

- No full simulation results with TDR machine parameters and detector configurations available for 350 GeV and mH=125GeV
- according to TDR luminosities, nominal 330 fb^{-1} data assumed at 350 GeV corresponding to 250 fb^{-1} at 250 GeV. (luminosity: 1.0 versus 0.75 x 10^{34})
- results for both production channels, ZH and $\nu_e\nu_e H$, are extrapolated to 350 GeV; ZH part from 250 GeV results, $\nu_e\nu_e H$ part from 500 GeV results.
- For ZH @ 350 GeV, nominal N_S = 0.87 x N_S @ 250 GeV, dominant background is WW/ZZ, N_B = 0.96 x N_B @ 250 GeV.
- For $\nu_e\nu_e H$ @ 350 GeV, nominal N_S = 0.26 x N_S @ 500 GeV, dominant background is $\nu_e\nu_e Z$, N_B = 0.30 x N_B @ 500 GeV.
- update: H—>$\gamma\gamma$ @ 500 GeV and 1 TeV new results by C.Calancha, better than previous estimates.

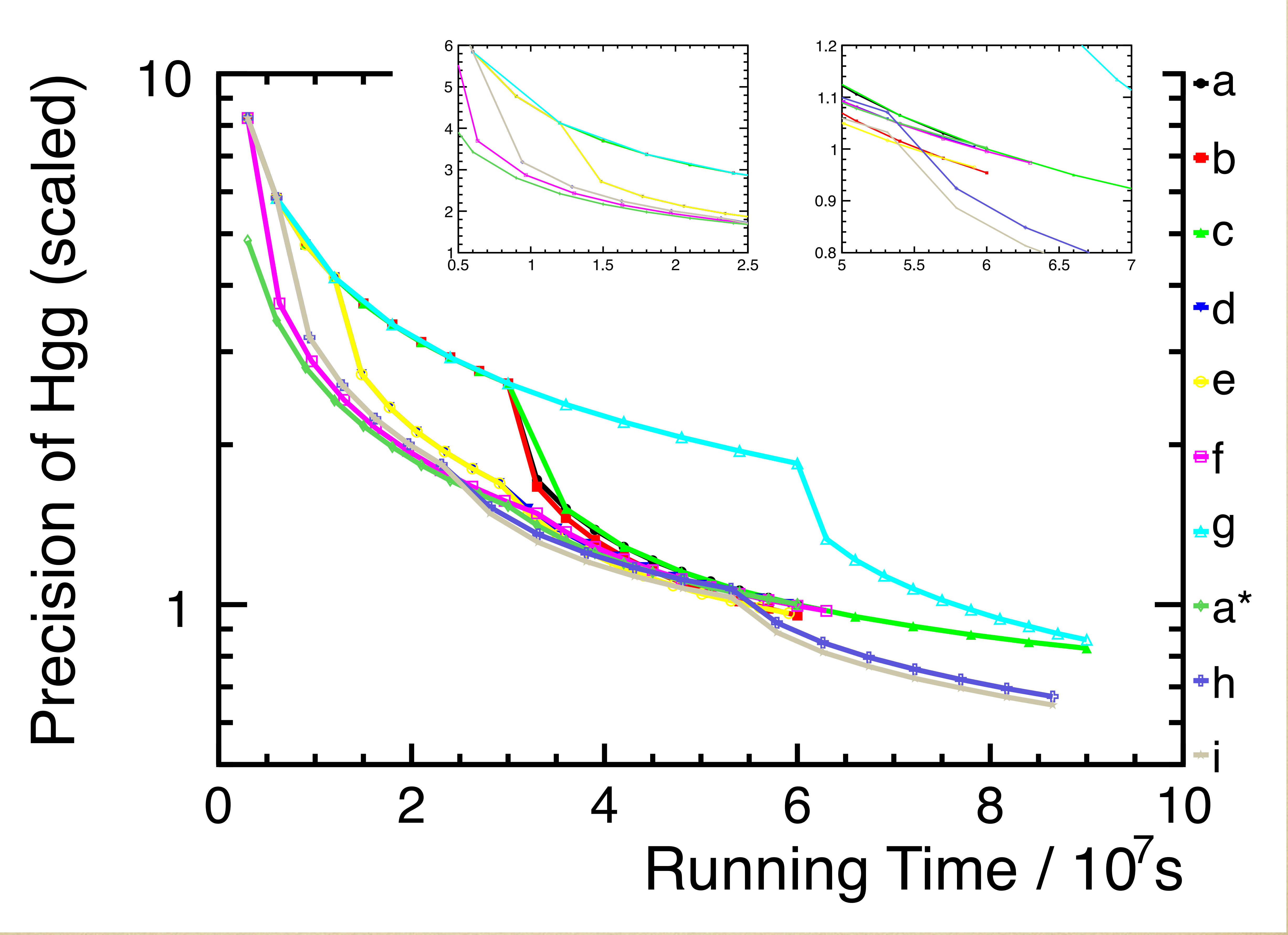
recoil mass analysis at 350 GeV

- most critical measurement is σ(ZH) @ 350 GeV, however not available now; analysis based on DBD full simulation is ongoing (by Jacqueline from Tokyo U'), preliminary results show much wider Higgs peak; results might be ~10-20% worse than 250 GeV (wait for completion of the analysis).
- comments on previous study by H.Li: RDR luminosities assumed, 188 fb^{-1} @ 250 GeV and 300 fb^{-1} @ 350 GeV; fast simulation; only WW and ZZ backgrounds considered.
- just as an example, let us assume two cases, precision would be 20% or 10% worse on σ(ZH) @ 350 GeV, and consider optimization of running plan in next slides.

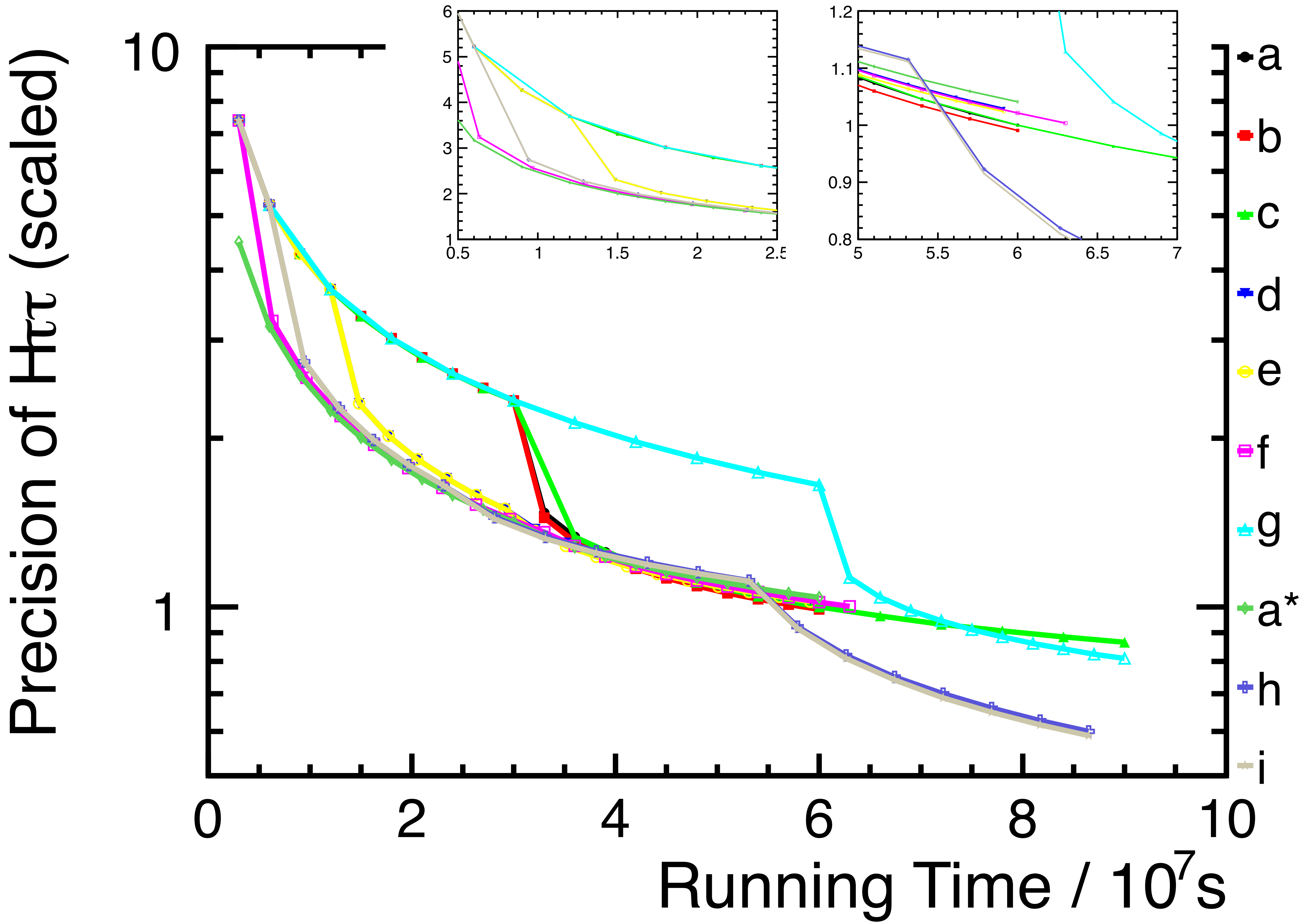
evolution: g_{Hcc}



evolution: g_{Hgg}



evolution: $g_{H\tau\tau}$



evolution: $g_{H\gamma\gamma}$