Running Scenarios for ILC500 – First Considerations

Jenny List, Nov 21 2014

Trivia

- 550 GeV is still better than 500 GeV,
  so 500 GeV always means 500 or higher...
- If we have a 500 GeV machine, we want to see what's there -> initial run ~5 years at 500 GeV
- We'll need a top threshold scan
- We still want a luminosity upgrade
- Future discoveries will change the picture

BUT:
Are there measurements which require lower centre-of-mass energies?

Candidate Reasons for E_{CM}<500 GeV

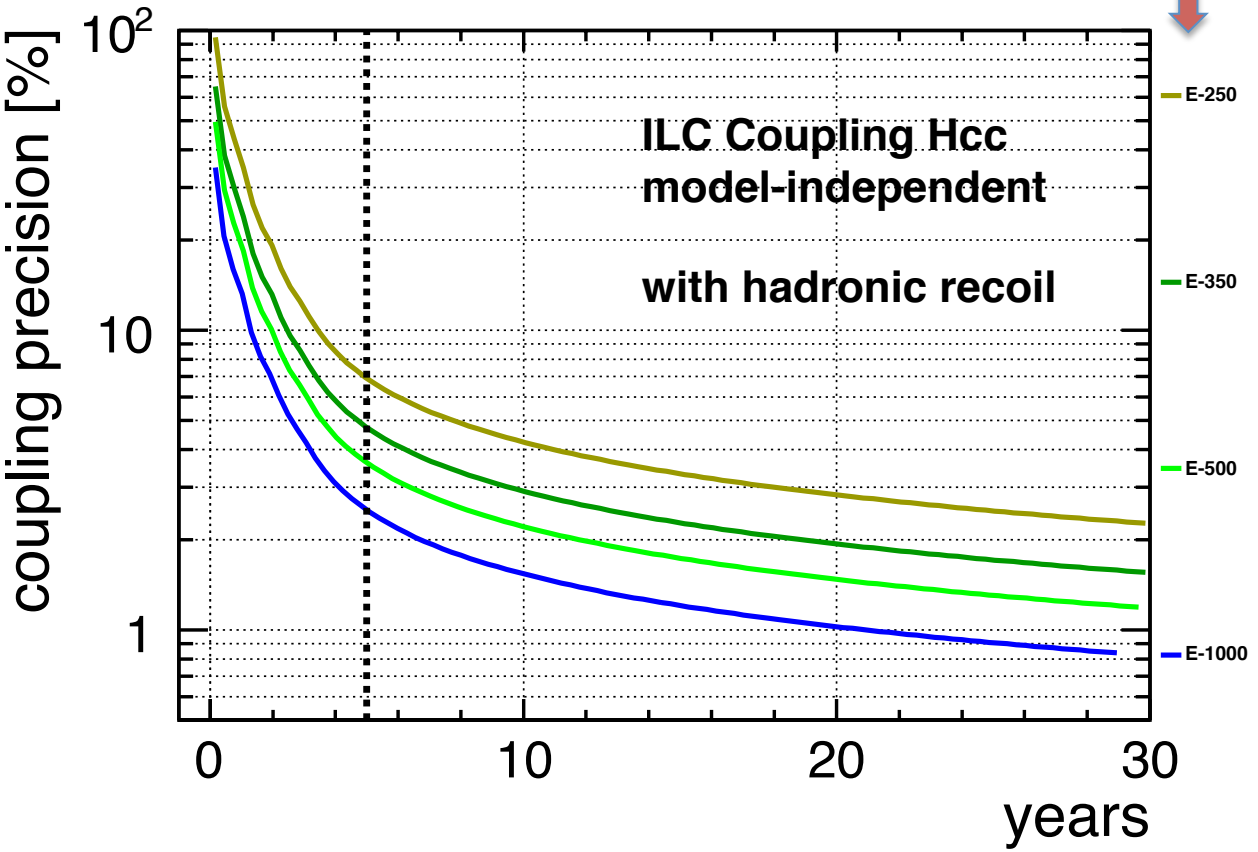
- Top threshold scan -> 200fb^{-1} @ 350 GeV ✔
- Higgs: ZH dies out at higher E_{CM}
  - ZH coupling
  - BR measurements in "difficult" modes which profit a lot from reconstruction of Z ?
    - H->ττ ? incl. CP properties of H-fermion coupling?
    - H-> invisible ?
  - Higgs mass ?
- W mass ?
- New Physics: threshold scans, sub-threshold running
- GigaZ

Higgs Couplings

Run only at **this** E_{CM} (with baseline lumi after inital ramp-up)

The higher E_{CM} the better for:

- H->bb, H->cc, H->gg, H- μμ, H->γγ
- ttH, ZHH

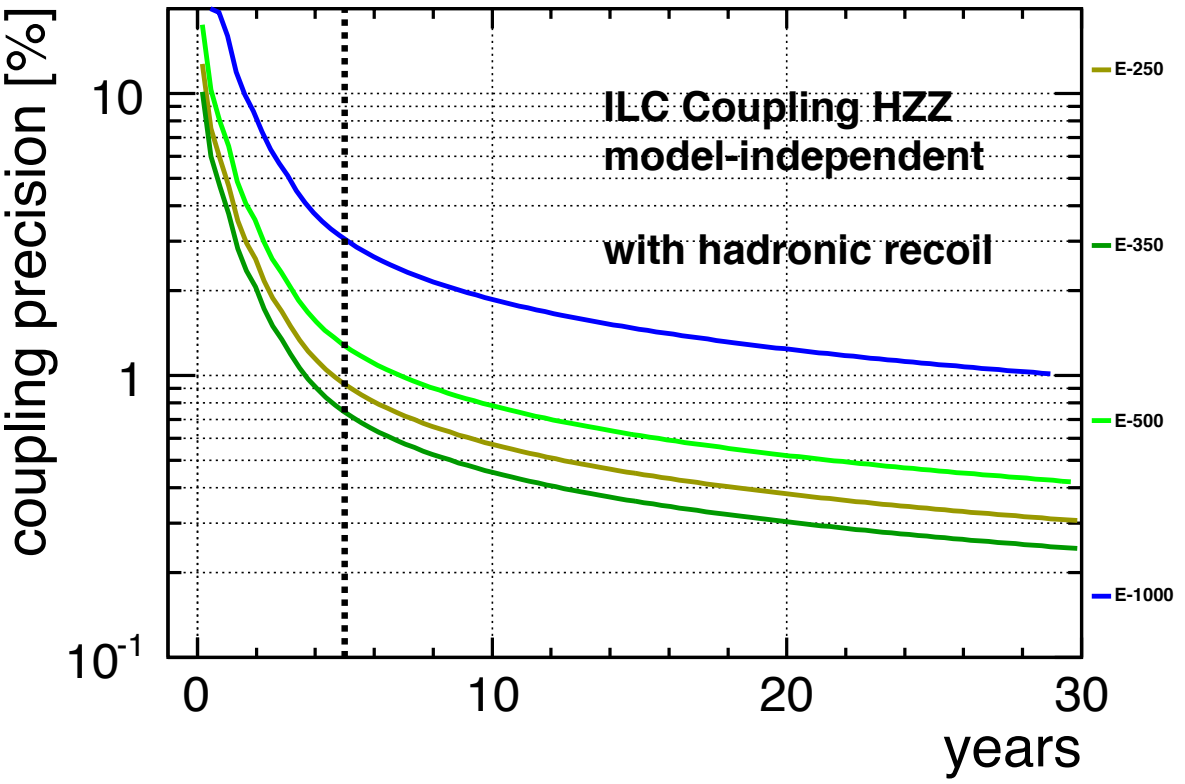


Higgs Couplings: Special Cases

HZZ coupling:

- naively expect best performance at 250 GeV
- but 350 GeV wins in fit since HWW also contributes via Σ(BR)=1

similar:
H->ττ
(absolute value of coupling, CP properties not yet studied!)



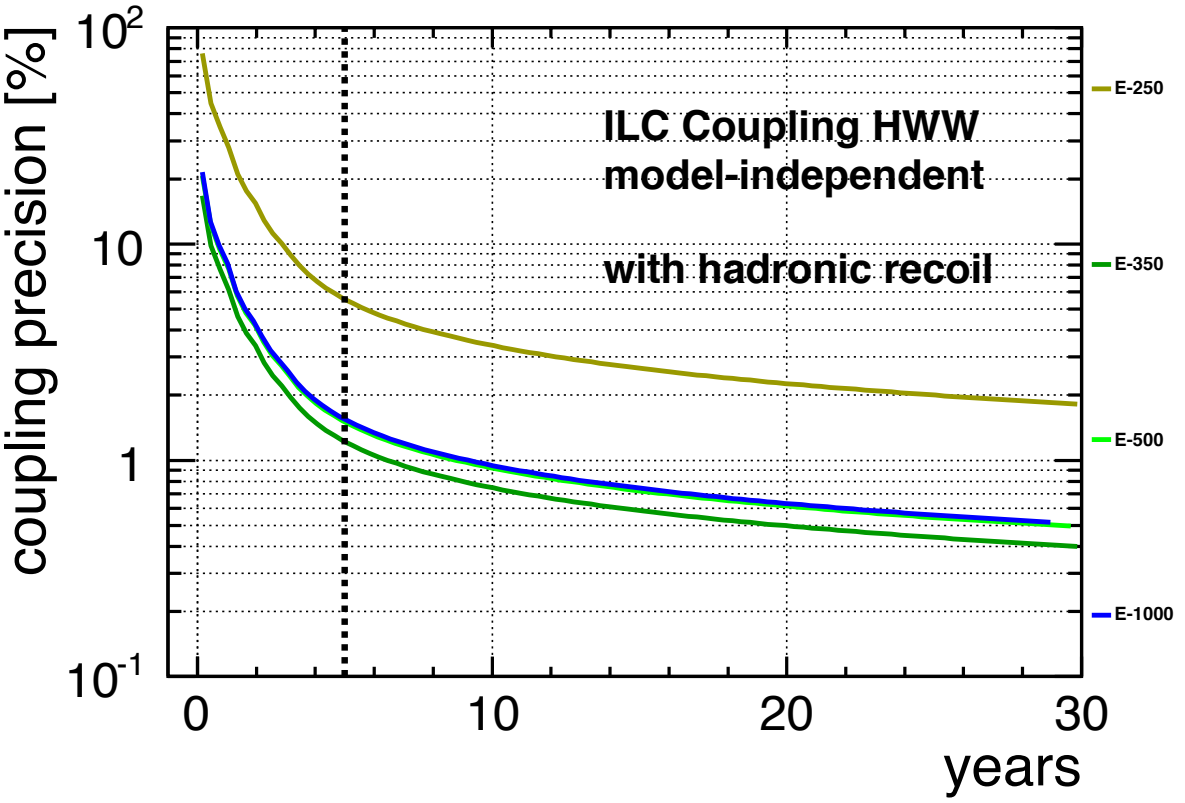
Higgs Couplings: Special Cases

HWW coupling:

- naively expect best performance at highest energy
- but **again** 350 GeV wins in fit since HZZ also contributes via Σ(BR)=1

Conclusion: extended 350 GeV run?

... it depends!



Candidate Reasons to prefer 250 GeV over 350 GeV

- Higgs mass from leptonic recoil
  - need δm_H < 20-30 MeV
  - doable at high E_{CM} from H->bb & Co?
  - probably, but currently not yet proven
  - only proven alternative:
    leptonic recoil => ~3ab^{-1} @ 250 GeV ☹

- Higgs -> invisible (95%CL limit)
  - new full sim studies coming in, but still work in progress
  - best sensitivity at 250 GeV with P=(+80%,-30%) (!)
  - impact from global fit?

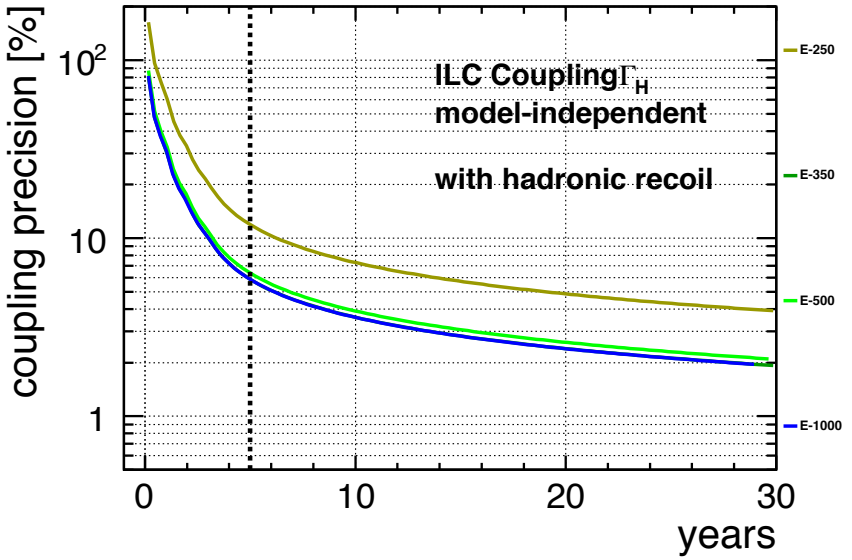
- Higgs -> ττ: CP properties of H-fermion coupling
  - existing studies rely on Z to reconstruct angles in Higgs restframe
    => 250 GeV
  - but: in principle Higgs restframe not needed => could also use
    WW-fusion => higher E_{CM} ???

Higgs -> invisible (95% CL)

	previous P=(-80%,+30%)	Mark Thomson	Akimasa Ishikawa	A.I. P=(+80%,-30%)
250 fb-1 @ 250 GeV	0.95%		0.95%	0.69%
350 fb-1 @ 350 GeV	1.5% (Extrap)	1.2%	1.5%	1.4%
500 fb-1 @ 500 GeV	3.2% (Extrap)		3.2%	2.3%

However, from global fit:

- Γ_H better at higher energies
- so BR(H->inv) should behave the same in fit?
- however: remember there is a tiny, tiny model-dependence!



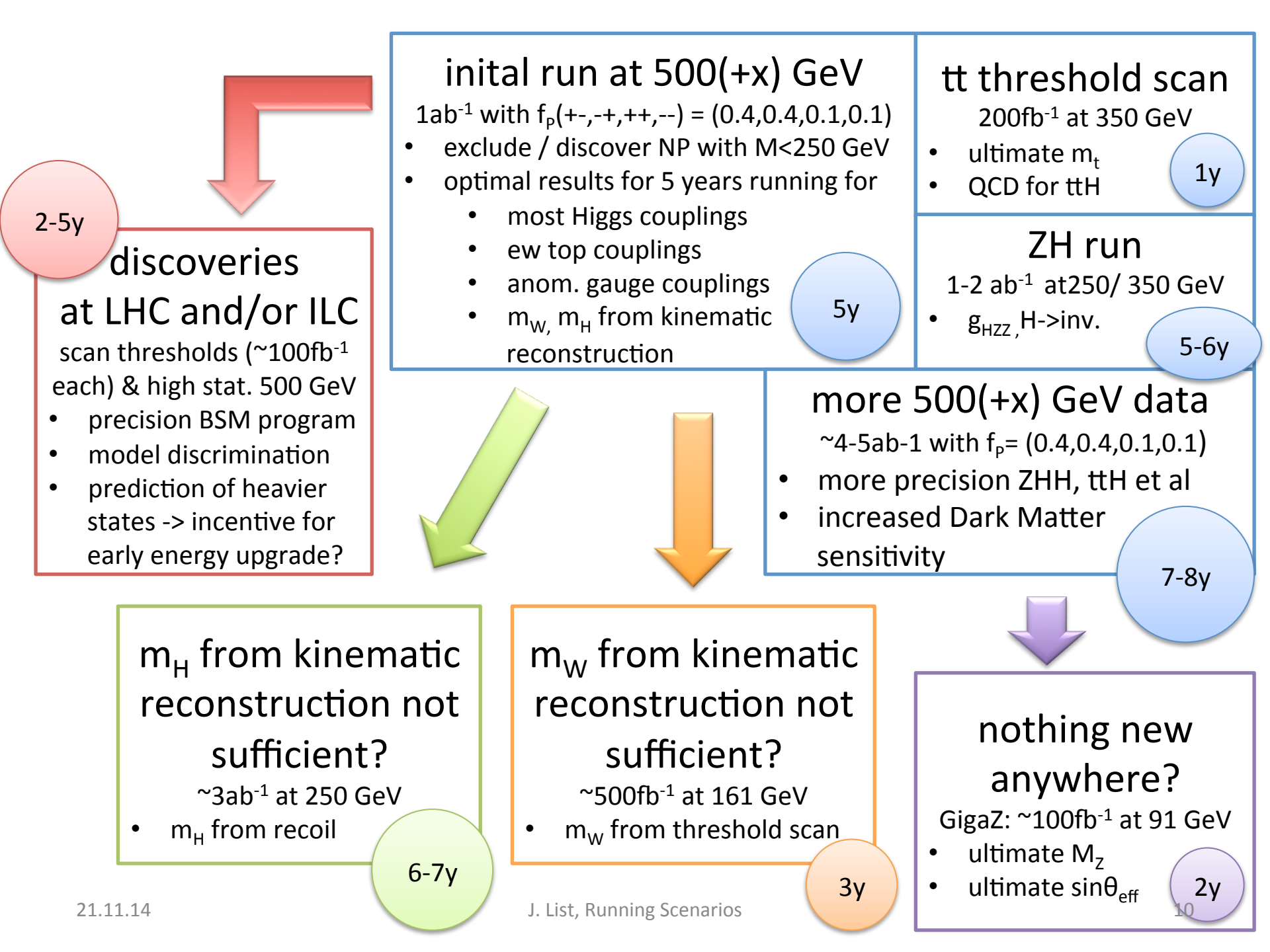
Polarisation Sharing

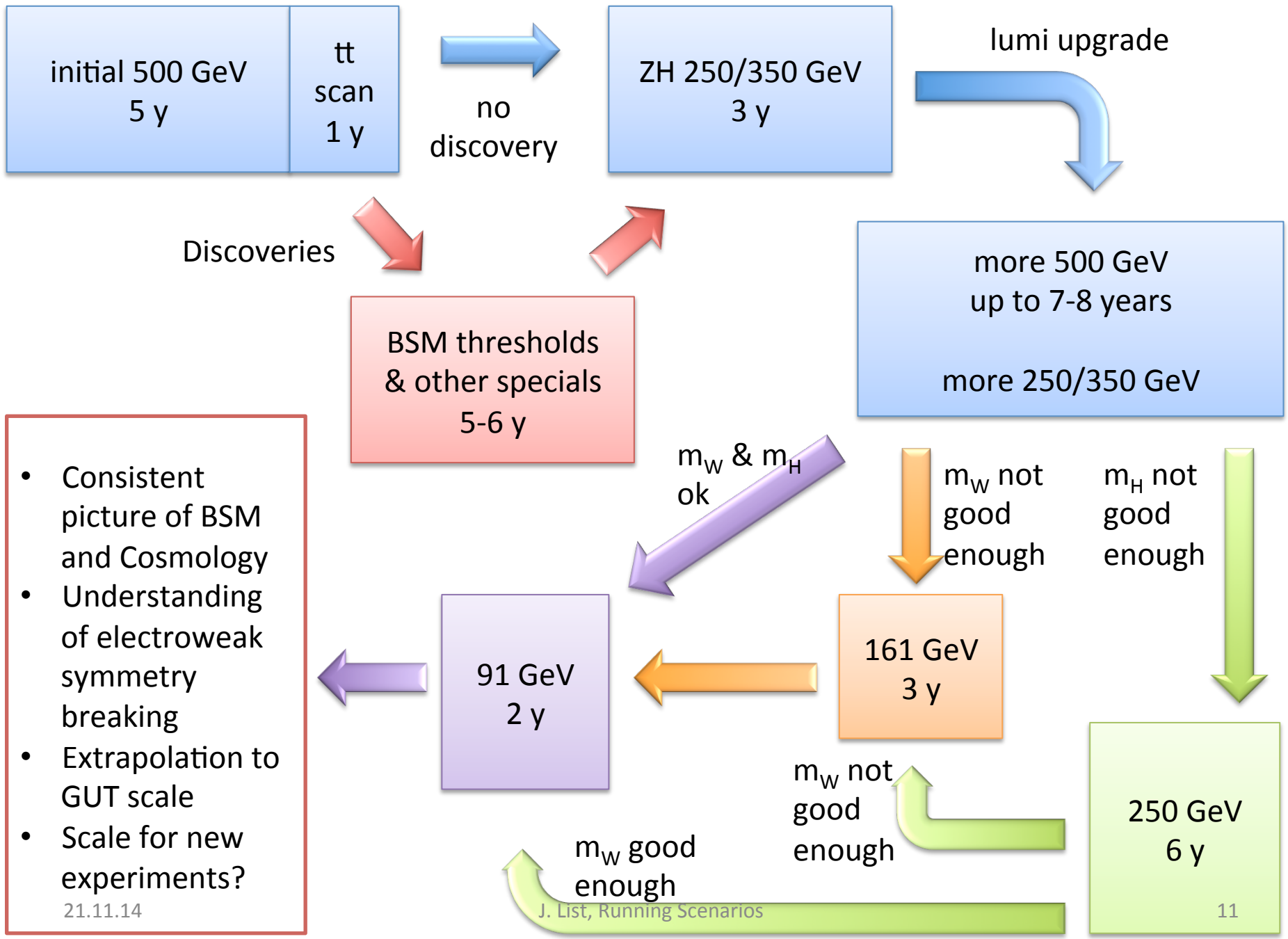
- sofar, many Higgs studies considered only left-handed electron case P=(-80%,+30%)
- since summer studies for P=(+80%,-30%) coming in => often better due to suppressed WW background!

$\Rightarrow$ should revisit suggested sharing at lower E_{CM}:

250 GeV / 350 GeV:

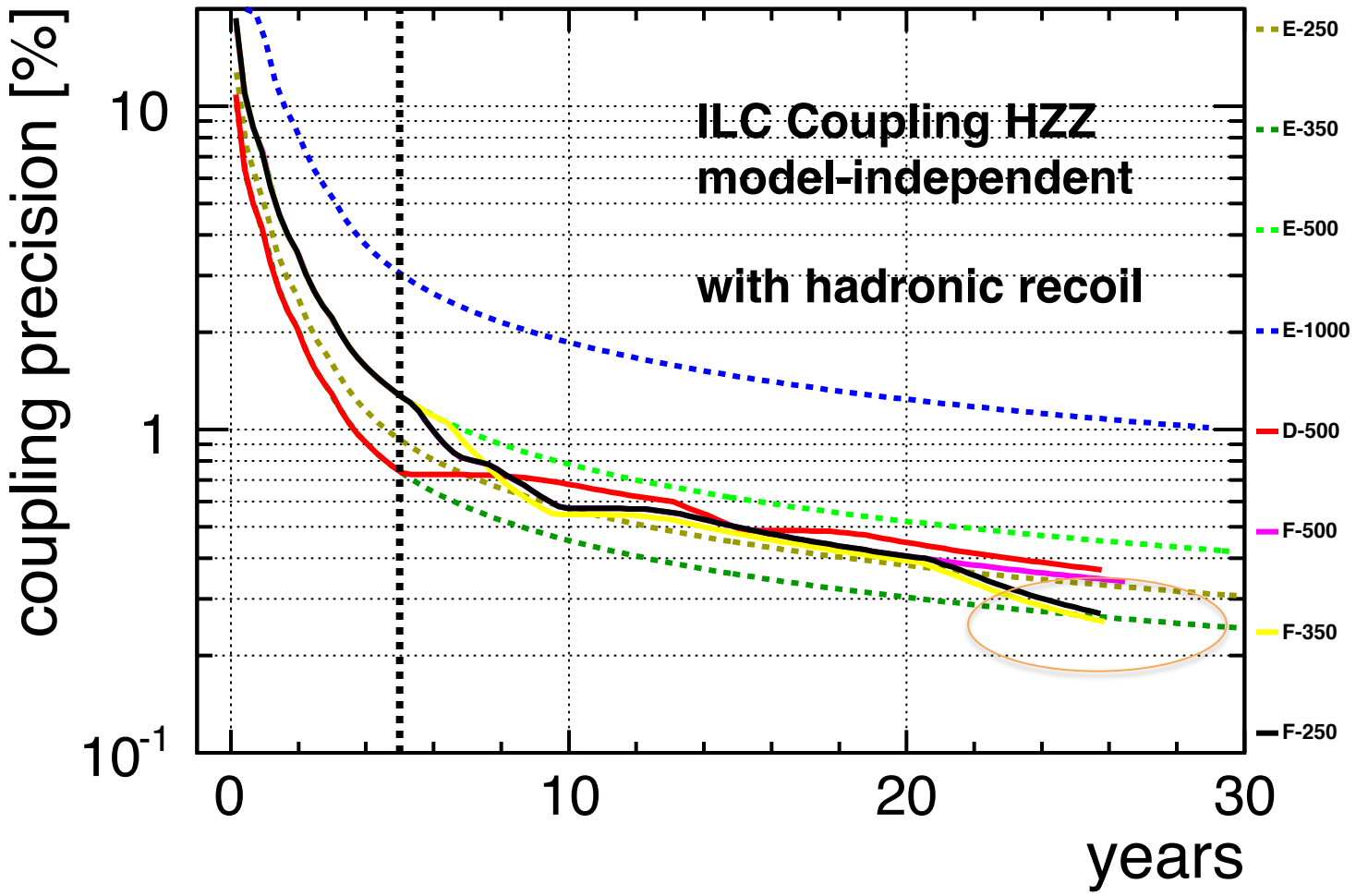
67%, 22.5%, 5%, 5% => 45%, 45%, 5%, 5% ?


inital run at 500(+x) GeV
1ab-1 with fP(+-,-+,++,--) = (0.4,0.4,0.1,0.1)
• exclude / discover NP with M<250 GeV
• optimal results for 5 years running for
• most Higgs couplings
• ew top couplings
• anom. gauge couplings
• mW, mH from kinematic reconstruction
5y
tt threshold scan
200fb-1 at 350 GeV
• ultimate mt
• QCD for ttH
1y
ZH run
1-2 ab-1 at250/ 350 GeV
• gHZZ , H->inv.
5-6y
2-5y
discoveries at LHC and/or ILC
scan thresholds (~100fb-1 each) & high stat. 500 GeV
• precision BSM program
• model discrimination
• prediction of heavier states -> incentive for early energy upgrade?
more 500(+x) GeV data
~4-5ab-1 with fP= (0.4,0.4,0.1,0.1)
• more precision ZHH, ttH et al
• increased Dark Matter sensitivity
7-8y
mH from kinematic reconstruction not sufficient?
~3ab-1 at 250 GeV
• mH from recoil
6-7y
mW from kinematic reconstruction not sufficient?
~500fb-1 at 161 GeV
• mW from threshold scan
3y
nothing new anywhere?
GigaZ: ~100fb-1 at 91 GeV
• ultimate MZ
• ultimate sinθeff
2y

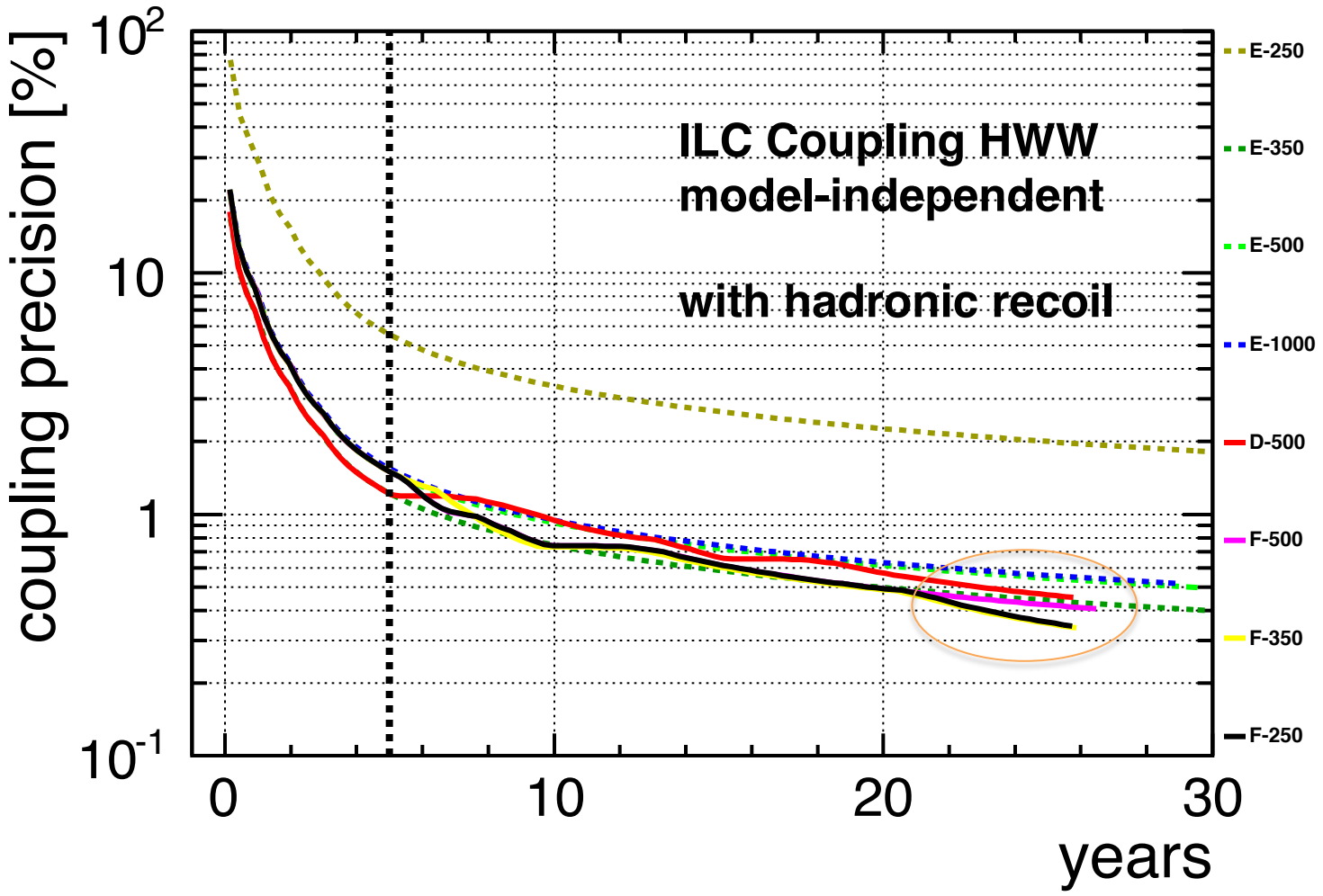

initial 500 GeV
5 y
tt
scan
1 y
no
discovery
ZH 250/350 GeV
3 y
lumi upgrade
Discoveries
BSM thresholds
& other specials
5-6 y
more 500 GeV
up to 7-8 years
more 250/350 GeV
m_W & m_H
ok
m_W not
good
enough
m_H not
good
enough
91 GeV
2 y
161 GeV
3 y
m_W not
good
enough
250 GeV
6 y
m_W good
enough
• Consistent picture of BSM and Cosmology
• Understanding of electroweak symmetry breaking
• Extrapolation to GUT scale
• Scale for new experiments?

Some Running Scenarios

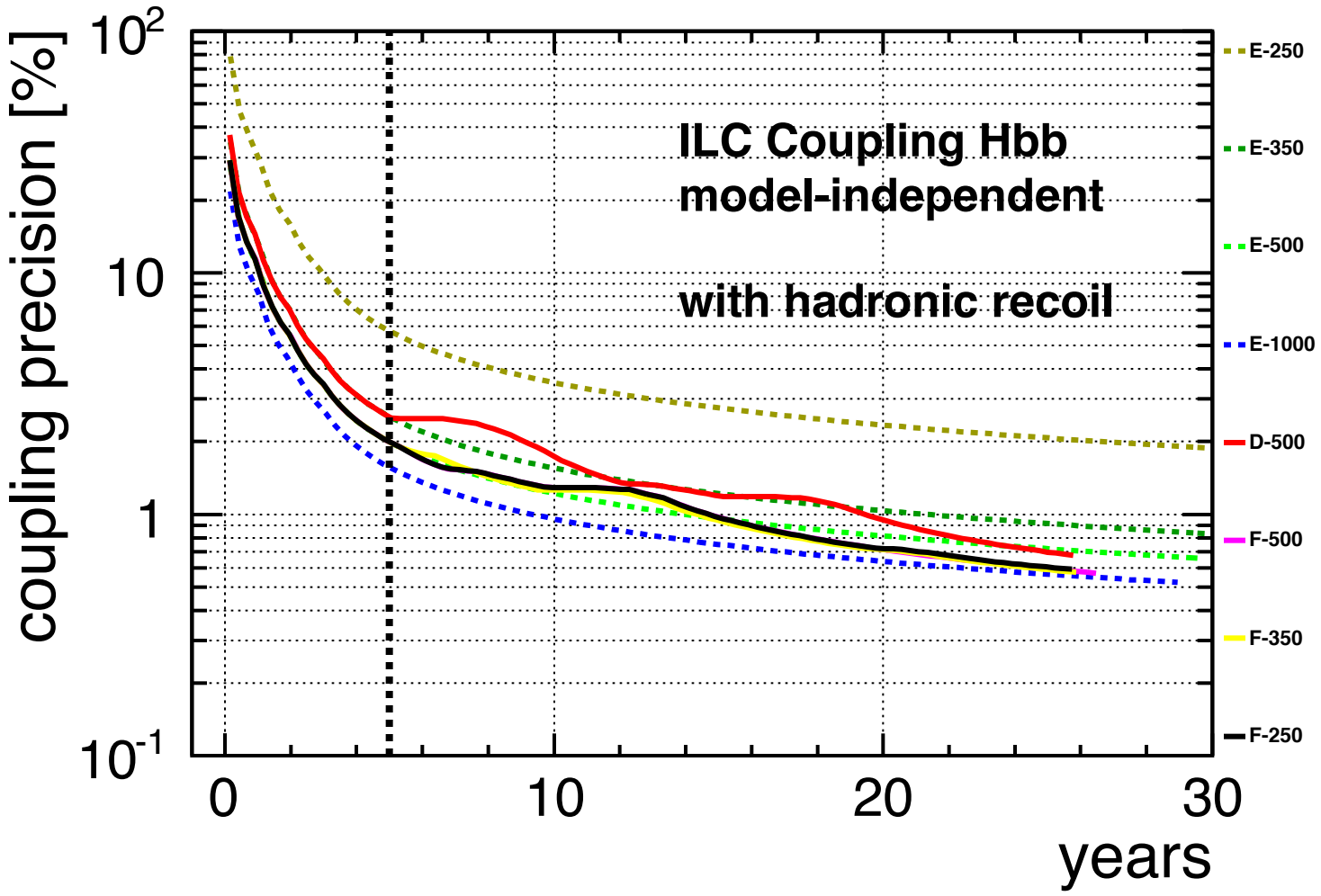
- F-250
  - baseline: 1ab^{-1}@ 500 GeV, 200fb^{-1} @ 350 GeV, 500fb^{-1} @250 GeV (10Hz)
  - lumi-up: 4ab^{-1} @ 500 GeV, 2.5 ab^{-1} @ 250 GeV (10 Hz)
- F-350
  - baseline: 1ab^{-1}@ 500 GeV, 700fb^{-1} @ 350 GeV (7Hz)
  - lumi-up: 4ab^{-1} @ 500 GeV, 2.5 ab^{-1} @ 350 GeV (7Hz)
- F-500
  - baseline: 1ab^{-1}@ 500 GeV, 200fb^{-1} @ 350 GeV, 500fb^{-1} @250 GeV (10Hz)
  - lumi-up: 8ab^{-1} @ 500 GeV



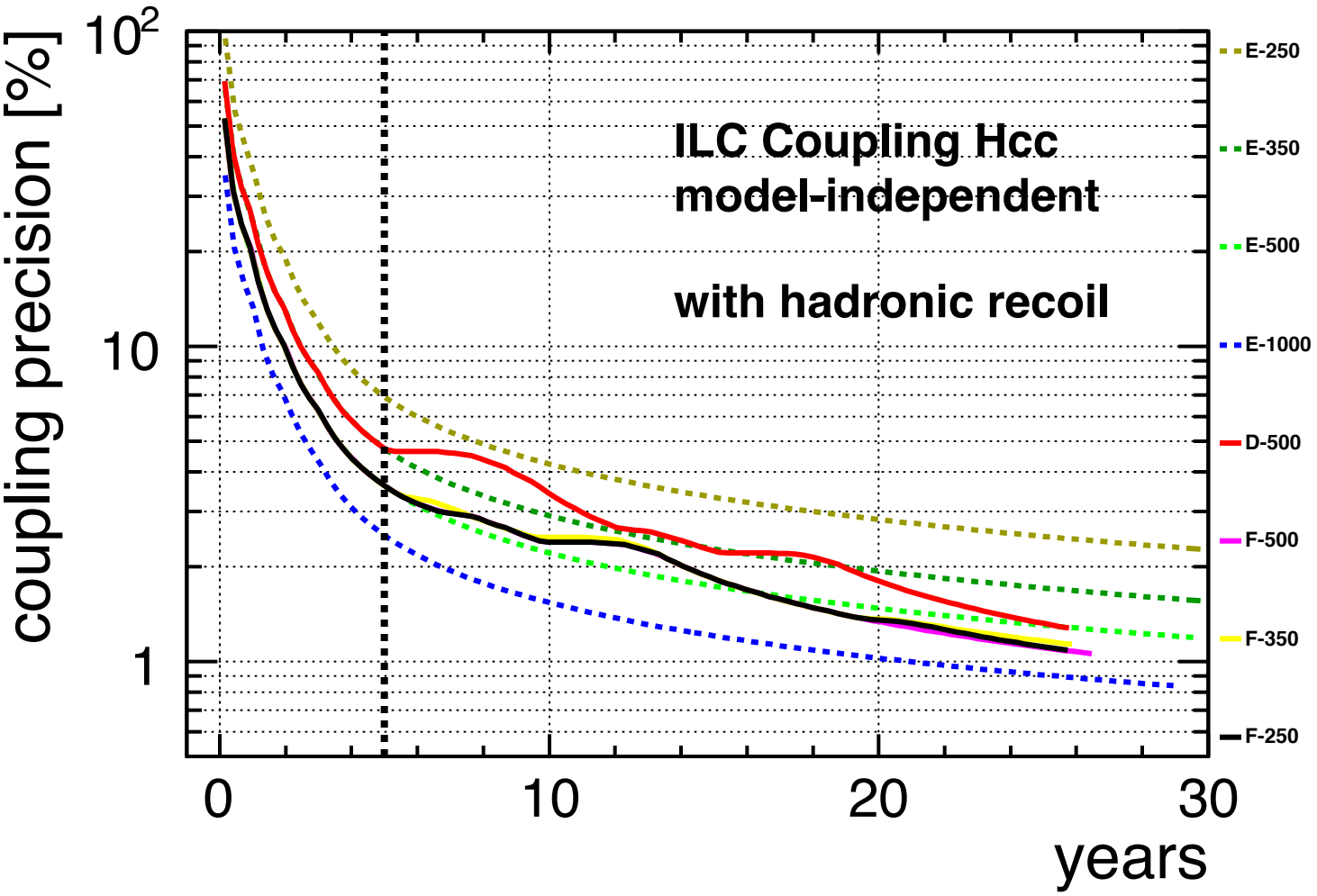
HZZ:
250 GeV
or
350 GeV



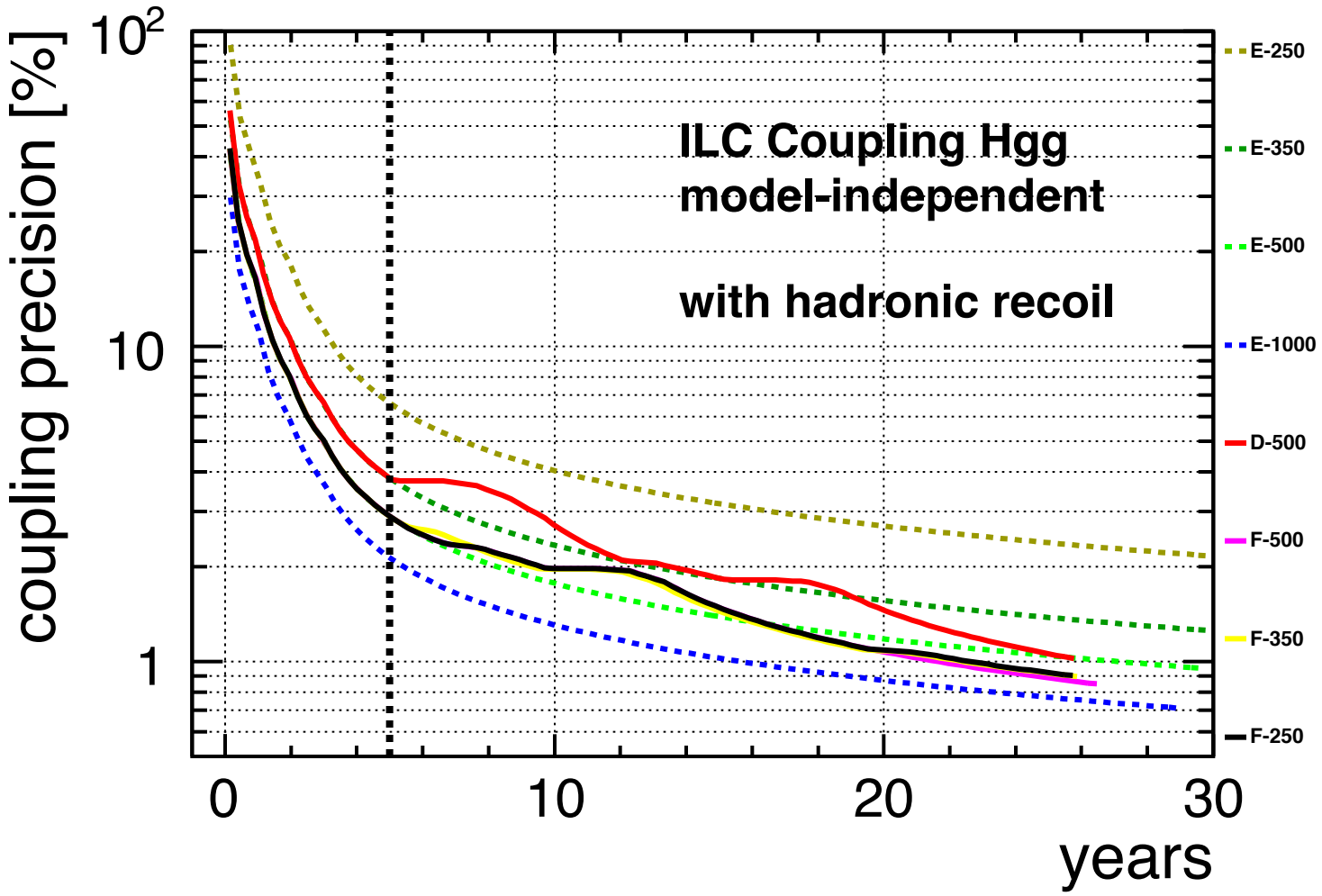
even HWW does not prefer 500 GeV!


ILC Coupling Hbb
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
1
10^{-1}
0
10
20
30
years
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

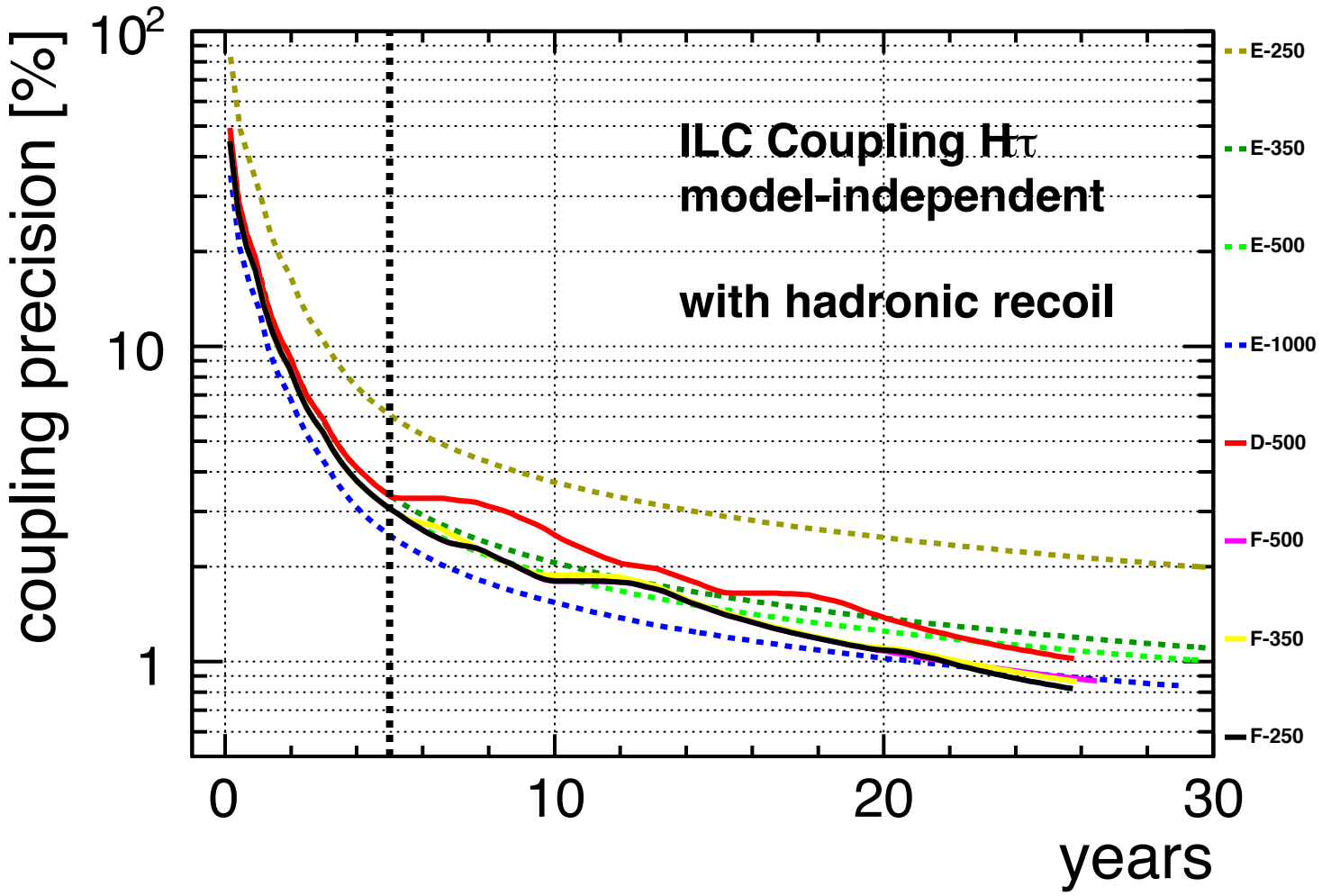
doesn't care


ILC Coupling Hcc
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
1
0
10
20
30
years
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

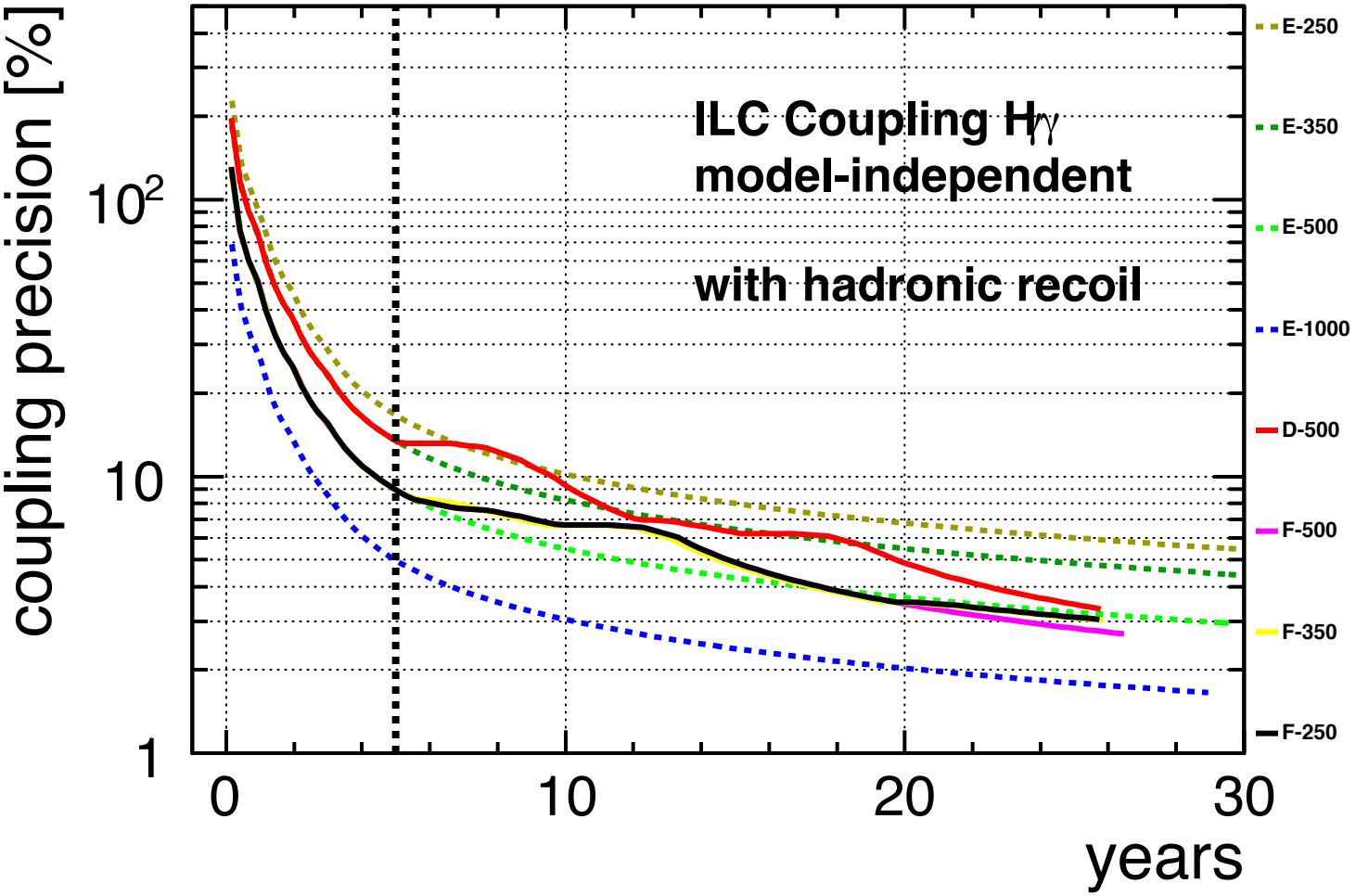
doesn't care


coupling precision [%]
10^2
10
1
0
10
20
30
years
ILC Coupling Hgg
model-independent
with hadronic recoil
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

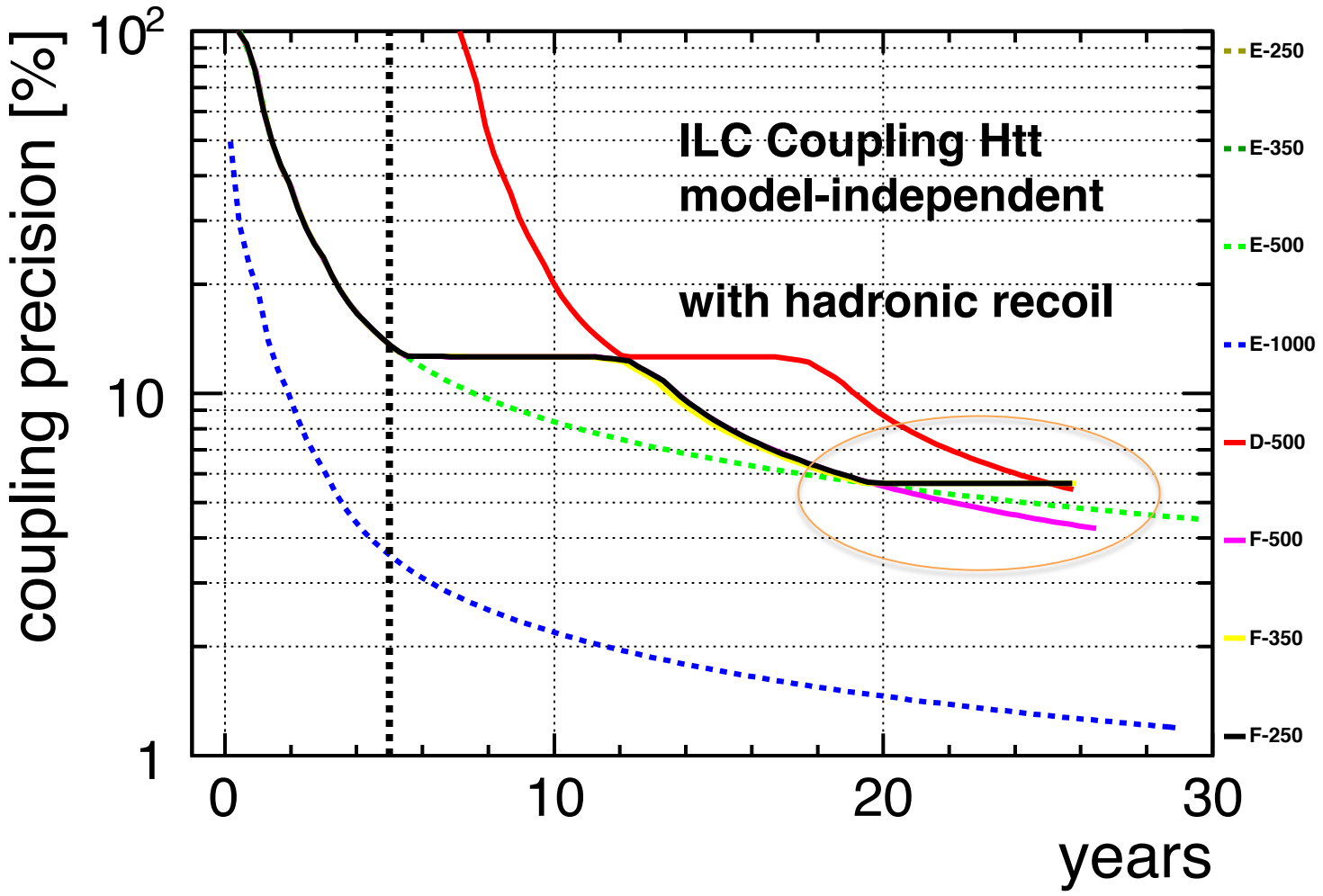
doesn't care


ILC Coupling Hτ
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
1
0
10
20
30
years
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

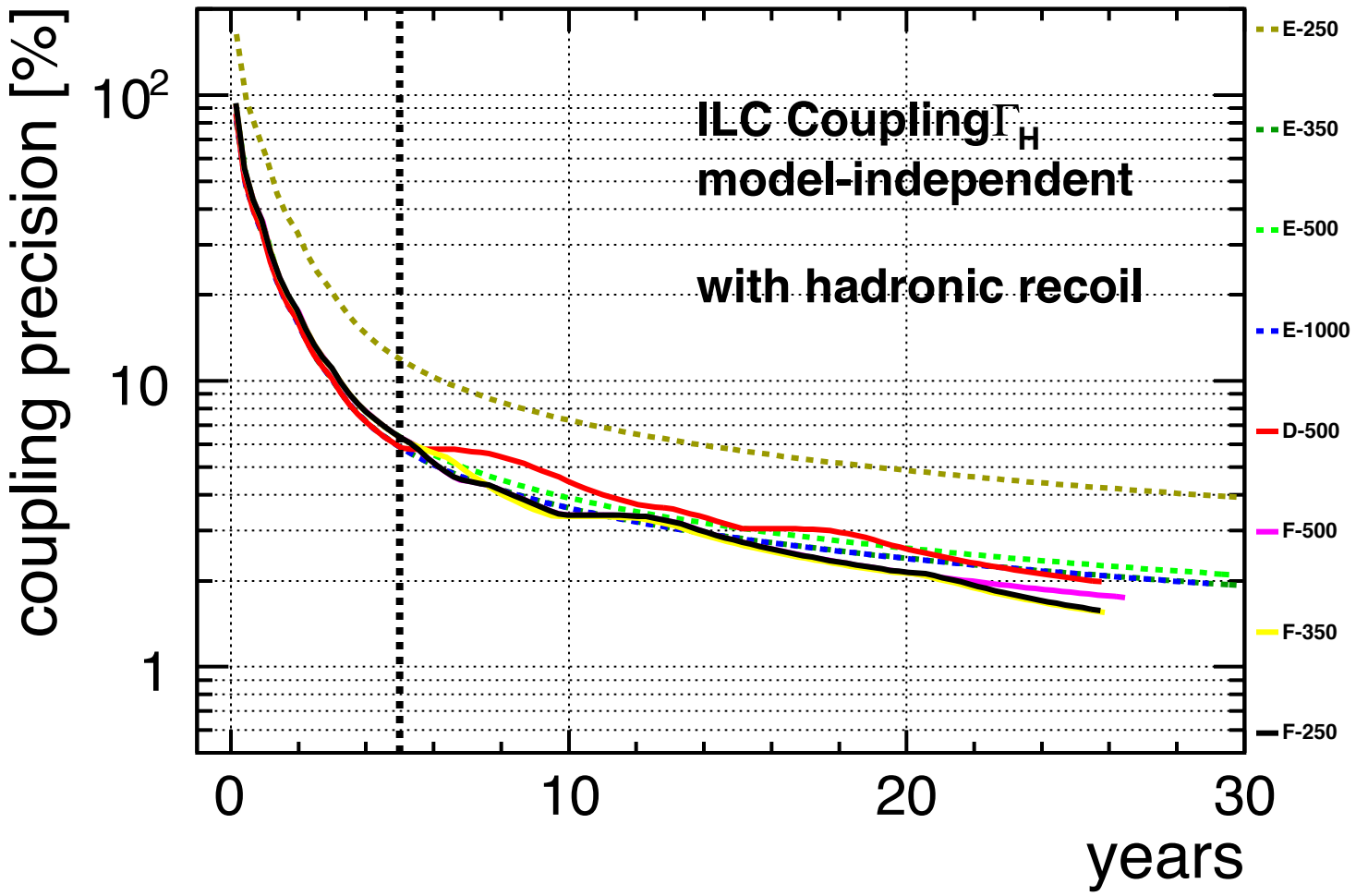
doesn't care


ILC Coupling Hγγ
model-independent
with hadronic recoil
coupling precision [%]
10²
10
1
0
10
20
30
years
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

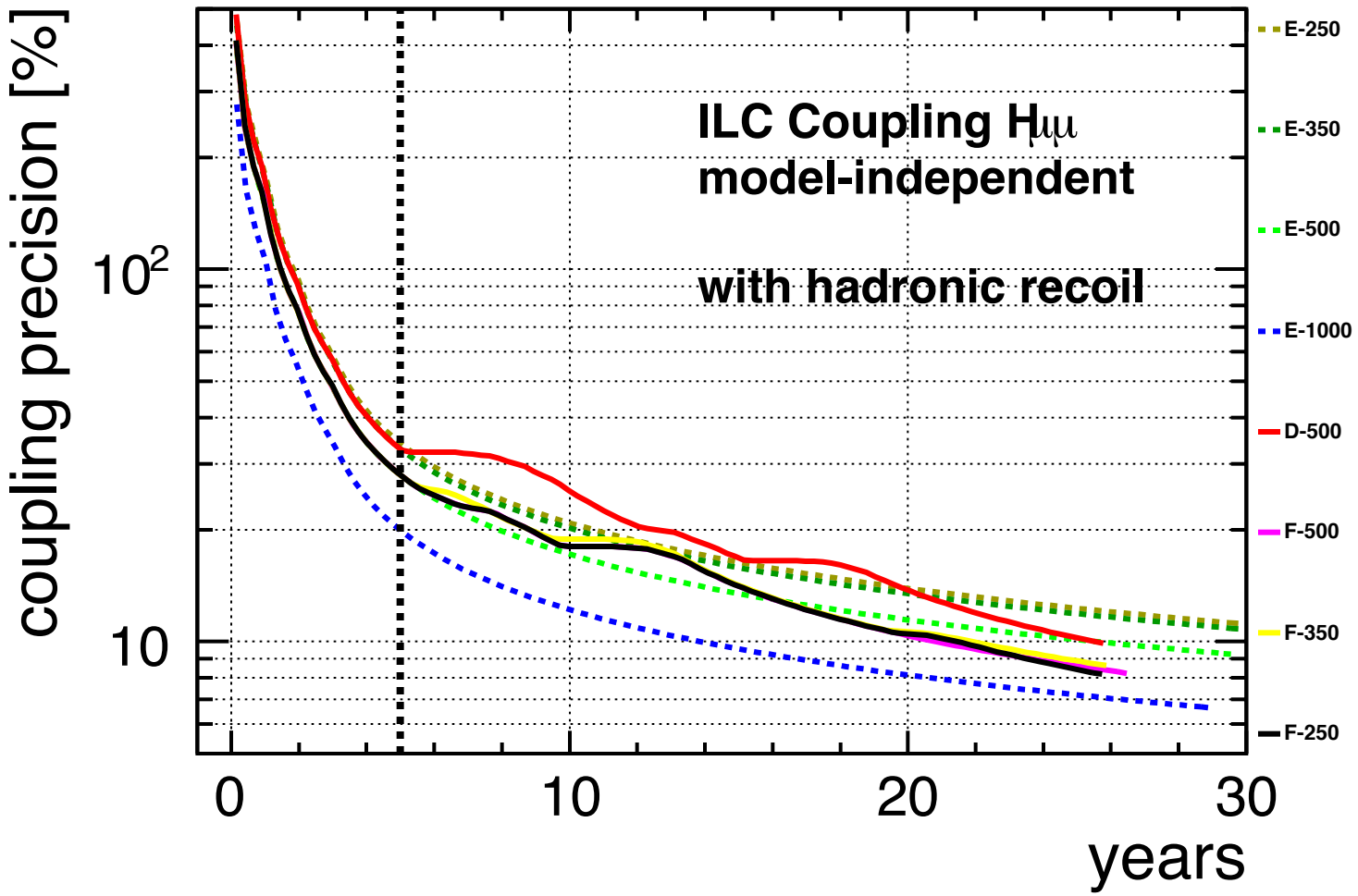
doesn't care



obviously
500 GeV


coupling precision [%]
10^2
10
1
0
10
20
30
years
ILC Coupling Γ_H
model-independent
with hadronic recoil
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

doesn't care


ILC Coupling Hμμ
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
0
10
20
30
years
E-250
E-350
E-500
E-1000
D-500
F-500
F-350
F-250

doesn't care

Conclusions?