Running Scenarios for ILC500

Jenny List, Feb 17 2015

Outline

- Jim's question about CEPC
- new running scenarios

Jim's question about CEPC

- "I think we should think about how the ILC Higgs precision compares to the VERY HIGH LUMINOSITY that CEPC is planning for."
- integrated luminosity at 250 GeV
  from ICFA-Seminar presentation: 5 ab^{-1}
- priv. comm. Jie Gao:
  - instantaneous lumi: 1.8 – 2.0 x 10^{34} /cm^2 /s x 2 IPs
  - total power consumption (prel.): **498 MW**

How does this compare to ILC operated at 250 GeV?

	CEPC	5 Hz, 1315 bunches	10 Hz, 1315 bunches	10 Hz, 2625 bunches
inst. lumi [10^{34} / cm^2 / s]	**3.6 - 4**	0.75	1.5	**3**
total power [MW]	**498**	100	160 ?	**190**

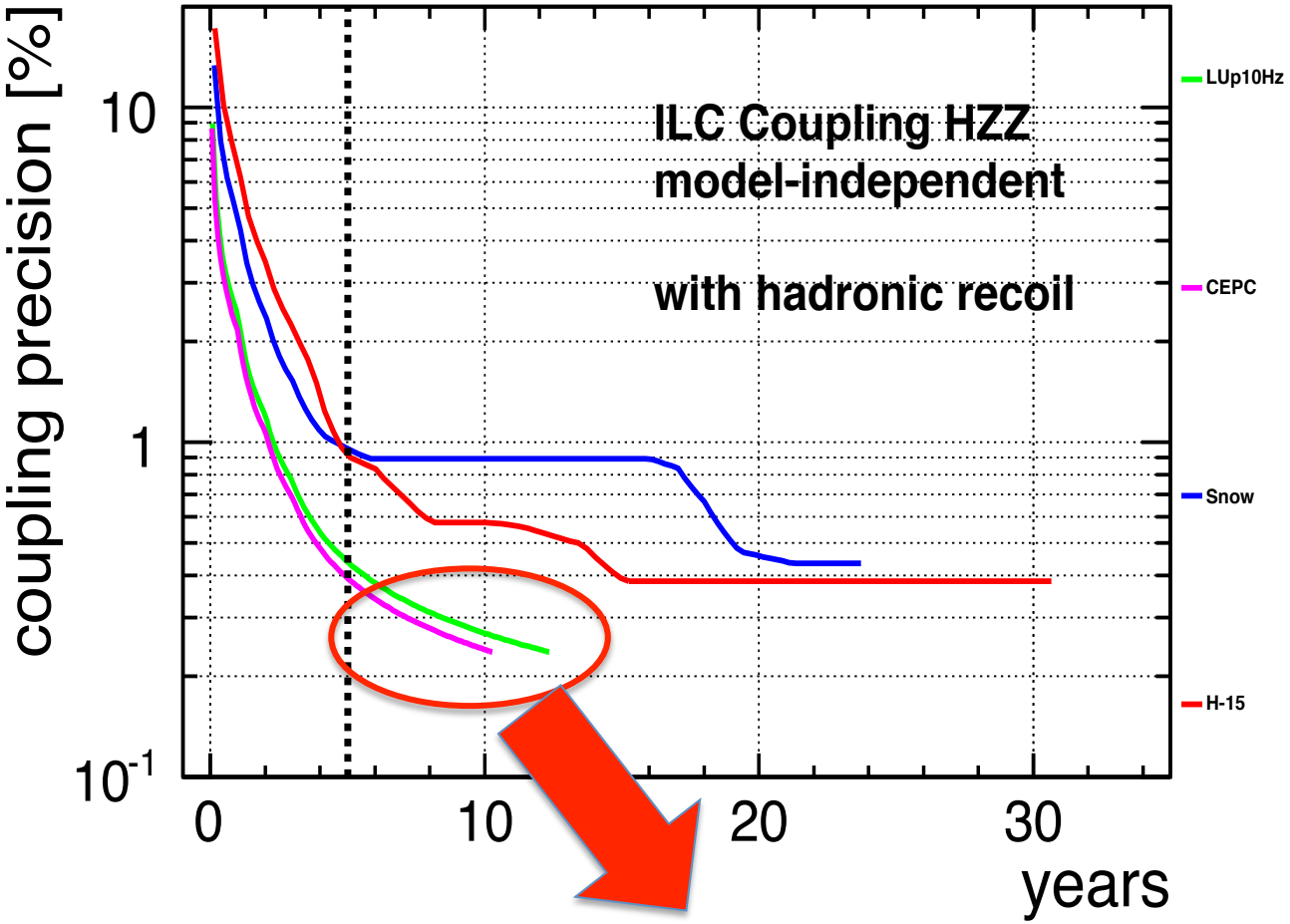
⇒ ILC: 75% of CEPC lumi for ~40% of CEPC power

- not a bad deal !!!

[also interesting: how do CEPC and FCC-ee numbers compare? Are their assumptions consistent?]

=> we don't have a scientific problem
– but a communication / presentation problem!

But for the fun of it...



Build 500 GeV full power (~RDR) right away and run it at 250 GeV in 10 Hz mode

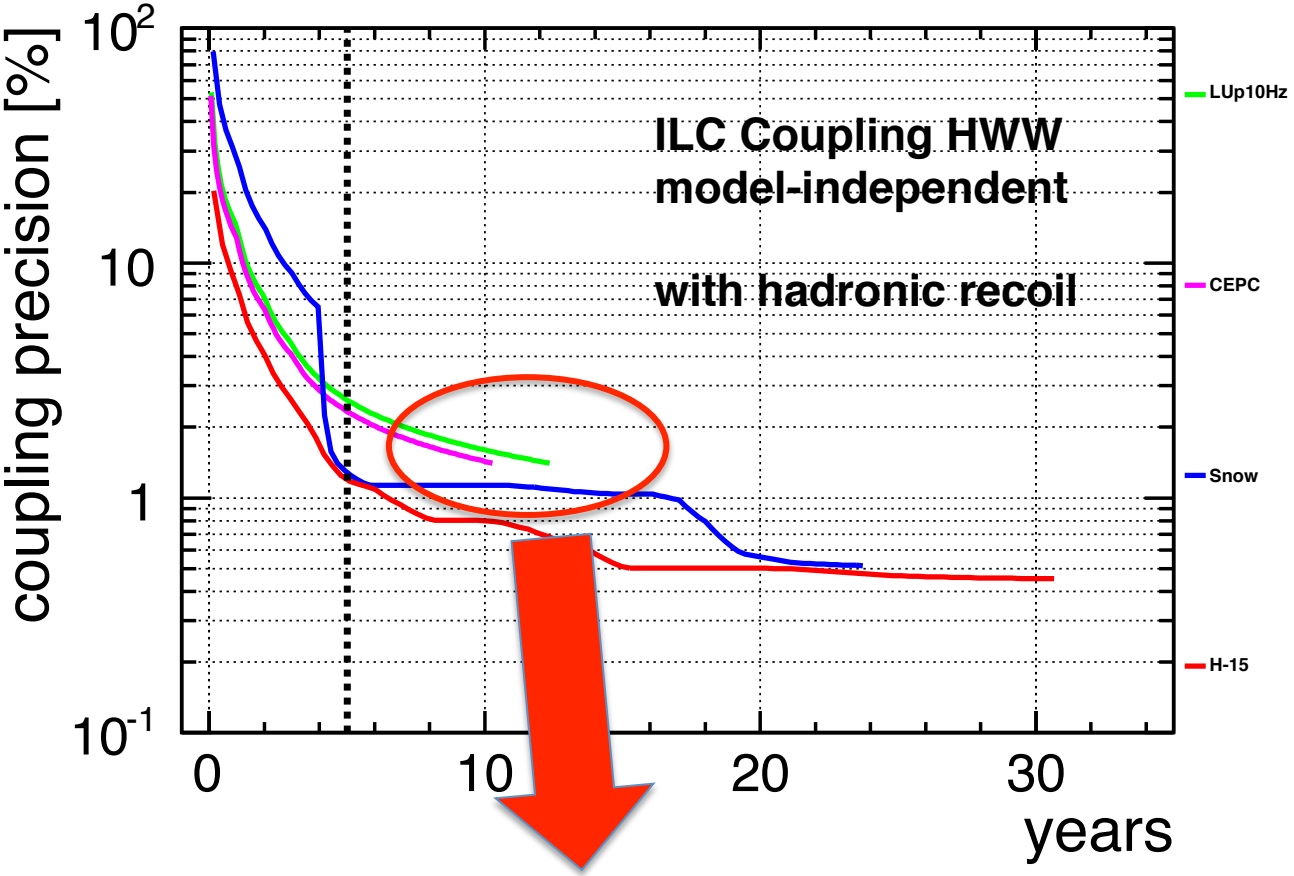
CPEC

Snowmass

our new 15 year scenario

nearly the same for less than half the power!

But for the fun of it...



Build 500 GeV full power (~RDR) right away and run it at 250 GeV in 10 Hz mode

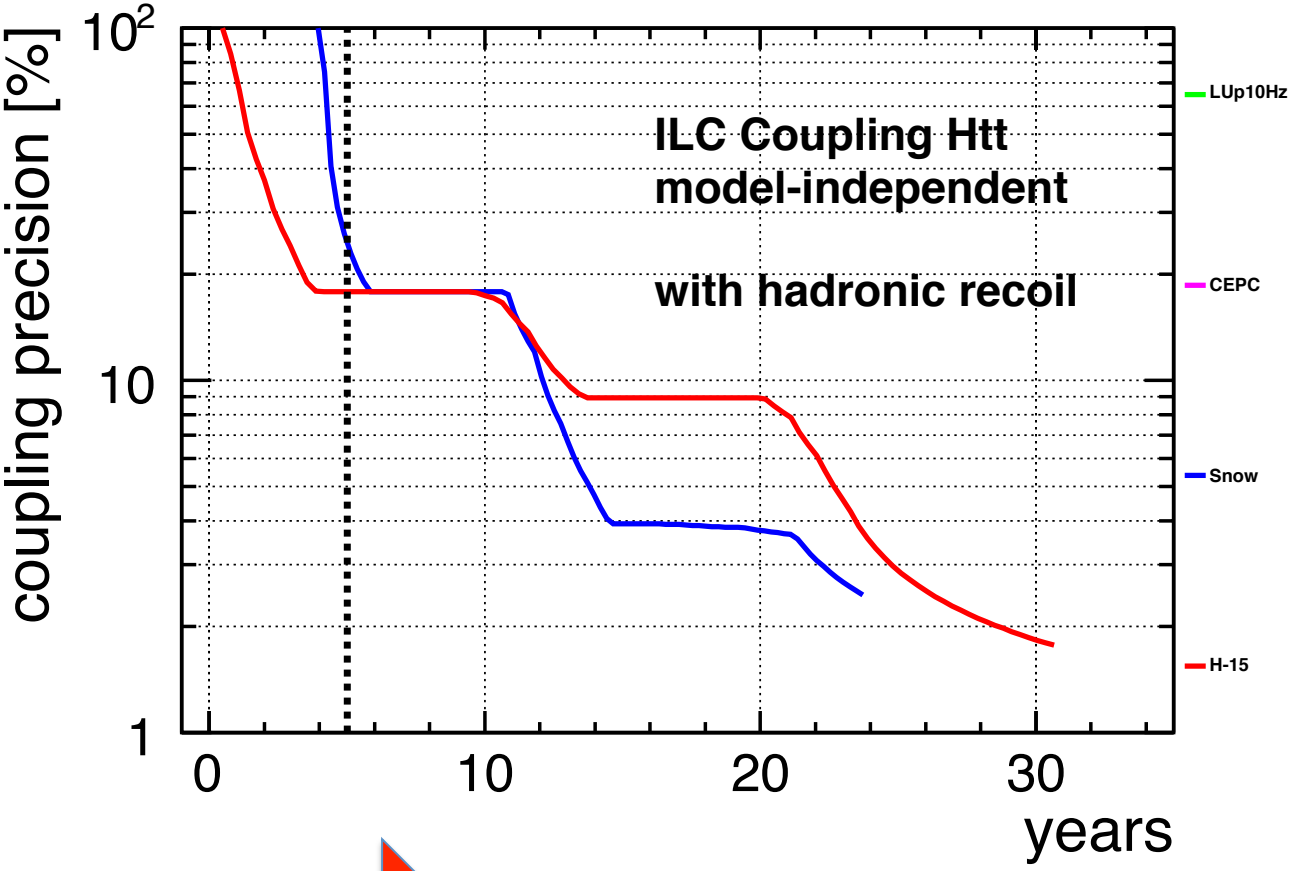
CPEC

Snowmass

our new 15 year scenario

HWW difficult with 250 GeV only

But for the fun of it...



Build 500 GeV full power (~RDR) right away and run it at 250 GeV in 10 Hz mode

CPEC

Snowmass

our new 15 year scenario

no ttH at all with 250 GeV only

New Running Scenarios

- years before 1 TeV upgrade: 15, 20, 25
- consider 2 options for the first 5 years:
  - **G**: only 500 GeV running => ~ 1000 fb-1
    => best for ttH, ZHH, top, BSM
    => g_HZZ will be weak spot
    lumi upgrade after ~10 years
  - **H**: 500 fb-1 @ 500 GeV
    200 fb-1 @ 350 GeV
    => top mass from threshold, good g_HZZ
    lumi upgrade after ~8 years

Comparison with Snowmass

- Snowmass numbers assume first 1 TeV upgrade, then lumi upgrade (Tab 2.3 in ILC Higgs WP)

Nickname	Ecm(1) (GeV)	Lumi(1) (fb^{-1})	+	Ecm(2) (GeV)	Lumi(2) (fb^{-1})	+	Ecm(3) (GeV)	Lumi(3) (fb^{-1})	Runtime (yr)	Wall Plug E (MW-yr)
ILC(250)	250	250							1.1	130
ILC(500)	250	250		500	500				2.0	270
ILC(1000)	250	250		500	500		1000	1000	2.9	540
ILC(LumUp)	250	1150		500	1600		1000	2500	5.8	1220

=> comparison without 1 TeV upgrade meaningless

=> attach 1 TeV upgrade to each of the G/H scenarios:

5 years installation time (just ad-hoc guess...)

after that again inital lumi ramp-up (0.1, 0.3, 0.6, 1.0)

Other differences wrt Snowmass

- inclusion of top threshold running
- Polarisation:
  - Snowmass: pure LR running $P(e^-,e^+)=(-80\%,+30\%)$
    - this excludes / heavily degrades several non-Higgs measurements
    - also several Higgs measurements actually better for RL helicity due to background suppression
  - now consider all four configurations:
    - ECM <= 350 GeV: f (LR,RL,LL,RR) = (0.45, 0.45, 0.05, 0.05)
    - ECM >= 500 GeV, "SM friendly": f (LR,RL,LL,RR) = (0.75, 0.15, 0.05, 0.05)
    - ECM >= 500 GeV, "BSM friendly": f (LR,RL,LL,RR) = (0.40, 0.40, 0.10, 0.10)

G-15

- 1000 fb-1 @ 500 GeV "scouting"

til here 5.5 years

- 200 fb-1 @ 350 GeV "top threshold"
- 500 fb-1 @ 250 GeV "ZH"

til here 9.8 years

- lumi-upgrade
- 1500 fb-1 @ 500 GeV "lumi-up 500"

total til here 15.3 years

- 1 TeV upgrade
- 5000 fb-1 @ 1 TeV

total: 31 years

G-20

- 1000 fb-1 @ 500 GeV "scouting"

til here 5.5 years

- 200 fb-1 @ 350 GeV "top threshold"
- 500 fb-1 @ 250 GeV "ZH"

til here 9.8 years

- lumi-upgrade
- **4000 fb-1** @ 500 GeV "lumi-up 500"

total til here 19.7 years

- 1 TeV upgrade
- 5000 fb-1 @ 1 TeV

total: 35.3 years

H-15

- **500 fb-1** @ 500 GeV "scouting"
- **200 fb-1 @ 350 GeV "top threshold"**

til here 5.0 years

- 500 fb-1 @ 250 GeV "ZH"

til here 8.1 years

- lumi-upgrade
- 1500 fb-1 @ 500 GeV "lumi-up 500"
- **750 fb-1 @ 250 GeV "lumi-up 250"**

total til here 15.1 years

- 1 TeV upgrade
- 5000 fb-1 @ 1 TeV

total: 30.8 years

H-20

- 500 fb-1 @ 500 GeV "scouting"
- 200 fb-1 @ 350 GeV "top threshold"

til here 5.0 years

- 500 fb-1 @ 250 GeV "ZH"

til here 8.1 years

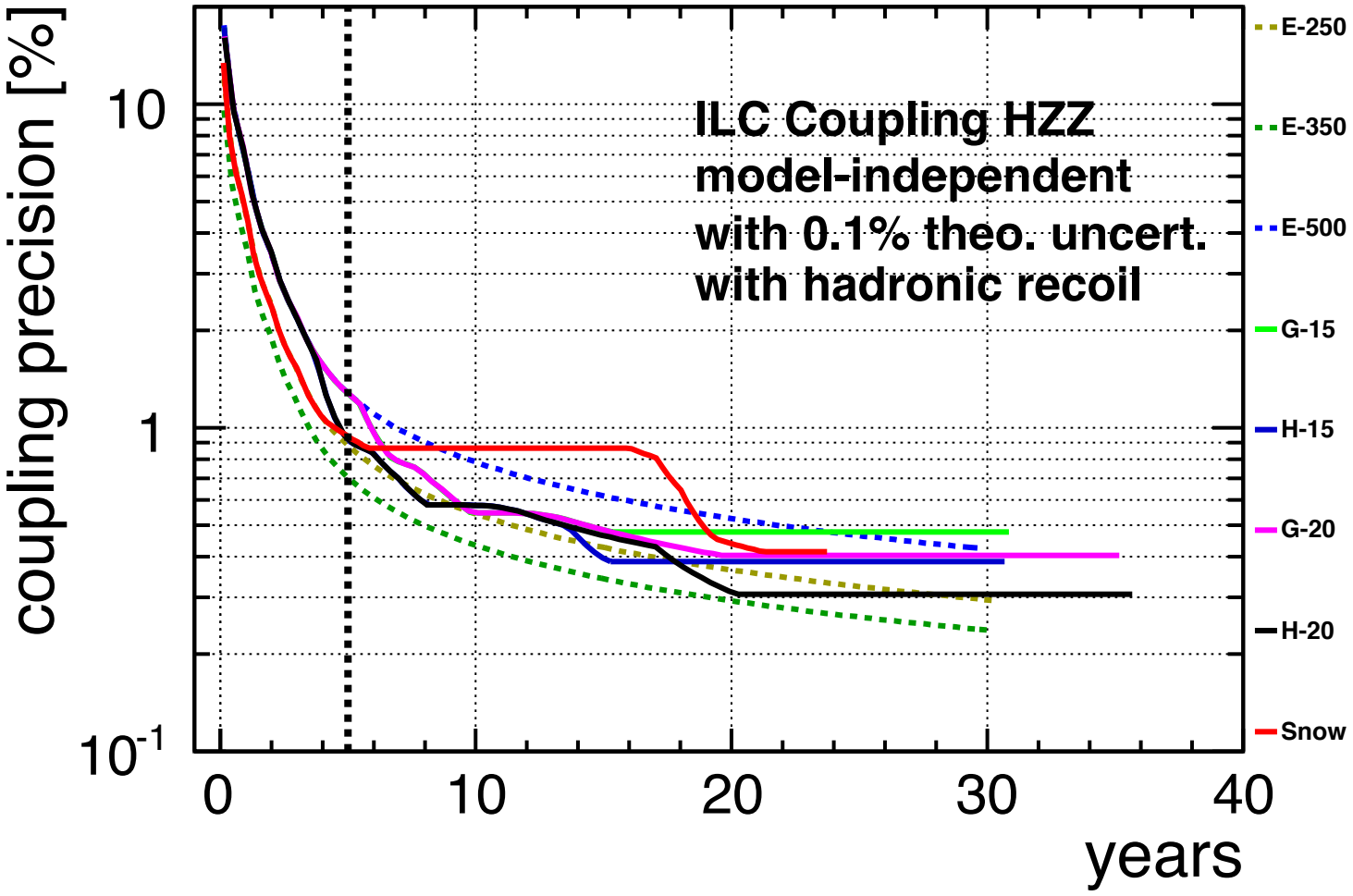
- lumi-upgrade
- **3500 fb-1** @ 500 GeV "lumi-up 500"
- **1500 fb-1** @ 250 GeV "lumi-up 250"

total til here 20.2 years

- 1 TeV upgrade
- 5000 fb-1 @ 1 TeV

total: 35.9 years

some favourites



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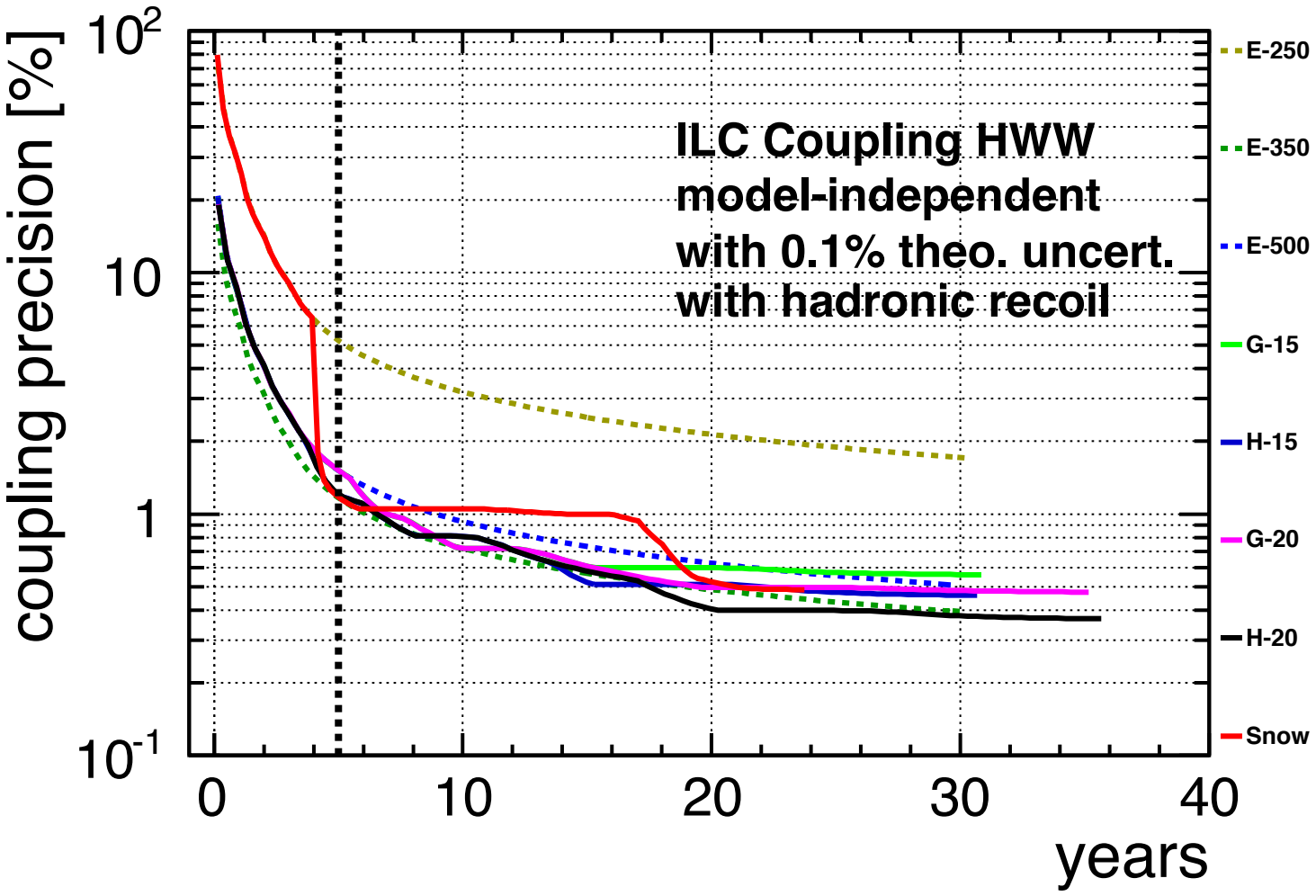

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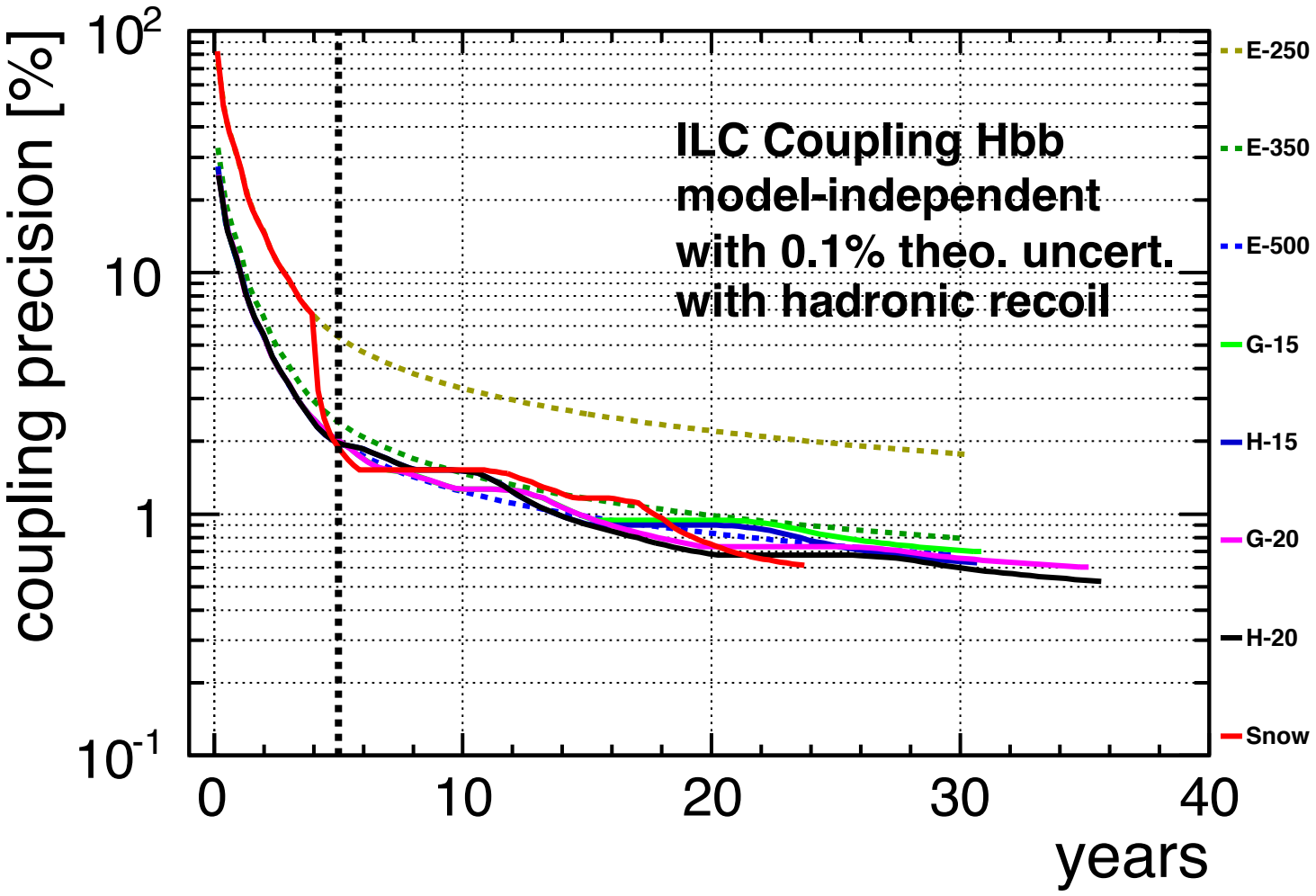

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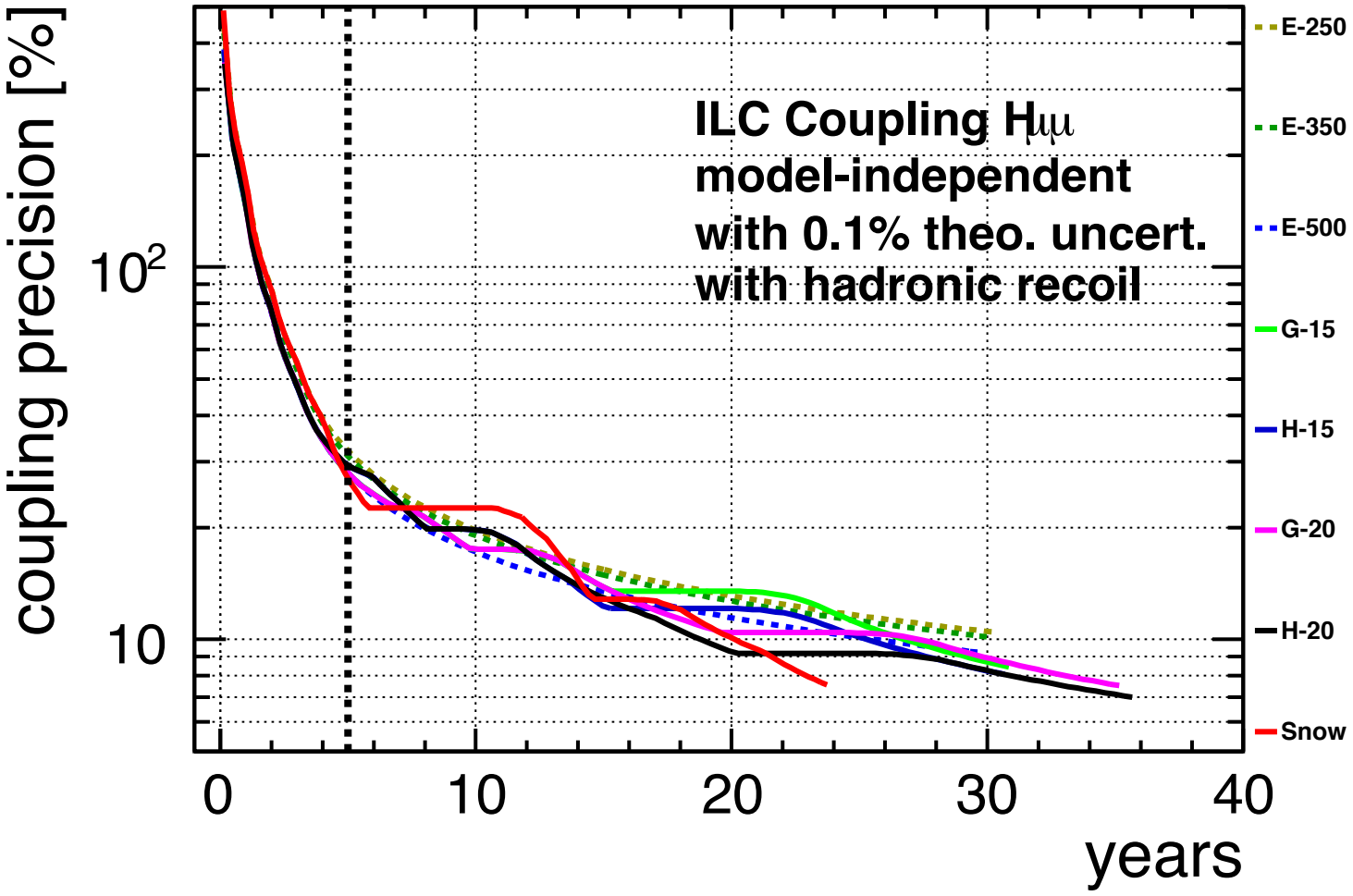

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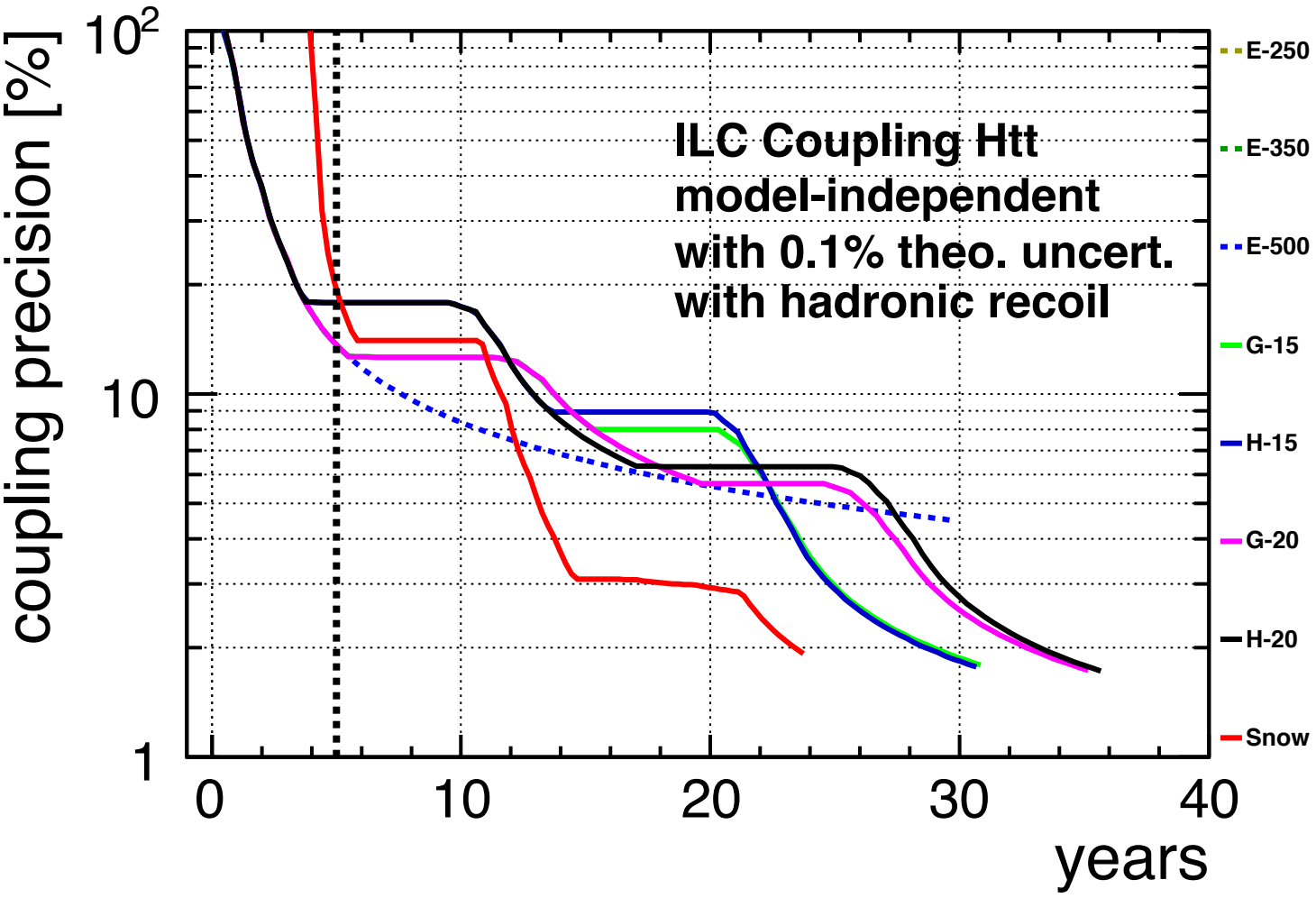


and now the BIG table...

please look at the .xlsx posted at the agenda page!

Conclusions

- prefer “H” line over “G” line
- what about 25 years?
  - trivial: just take more luminosity in Lup mode
  - but is this the most convincing use?
  - alternative proposal:
    declare 5 years of “joker time”
    - highlights the importance of the flexibility of the machine!
    - How to display / illustrate this ?

Joker Time - Examples

- threshold scans for discoveries
- more like-sign helicity data for exotics
- **low background runs with less beamstrahlung / less per-bunch-lumi (= less gammagamma->hadrons!)**
  - Higgs recoil mass (beamstrahlungs tail costs twice!)
  - "soft" signatures, eg from Natural SUSY or BSM with small mass differences in general
  - Higgs self-coupling at 1 TeV:
    25% degradation from 4.1 gamma-gamma pile-up events / BX ?
  - mass determination from kinematic edges
  - ...
- Z pole running (in particular if nothing new found)
- W threshold (dito, and if W mass from continuum turns out to be limiting global fits)

inital run at 500(+x) GeV

500fb^{-1} with f_P(+-,-+,++,-- =(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
  - m_W, m_H from kinematic reconstruction

~4 y

tt threshold scan

200fb^{-1} at 350 GeV

- ultimate m_t
- QCD for ttH

~1y

ZH run

500 fb^{-1} at250/ 350 GeV

- g_{HZZ}, H->inv.

~3 y

?y

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 f_P= (0.4,0.4,0.1,0.1)

- more precision ZHH, ttH et al
- increased Dark Matter sensitivity

? years

m_H from kinematic reconstruction not sufficient?

~1-2ab^{-1} at 250 GeV

- m_H from recoil
- *plus sufficient calibration runs at 91 GeV*

?y

m_W from kinematic reconstruction not sufficient?

~500fb^{-1} at 161 GeV

- m_W from threshold scan

?y

nothing new anywhere?

~100fb^{-1} at 91 GeV

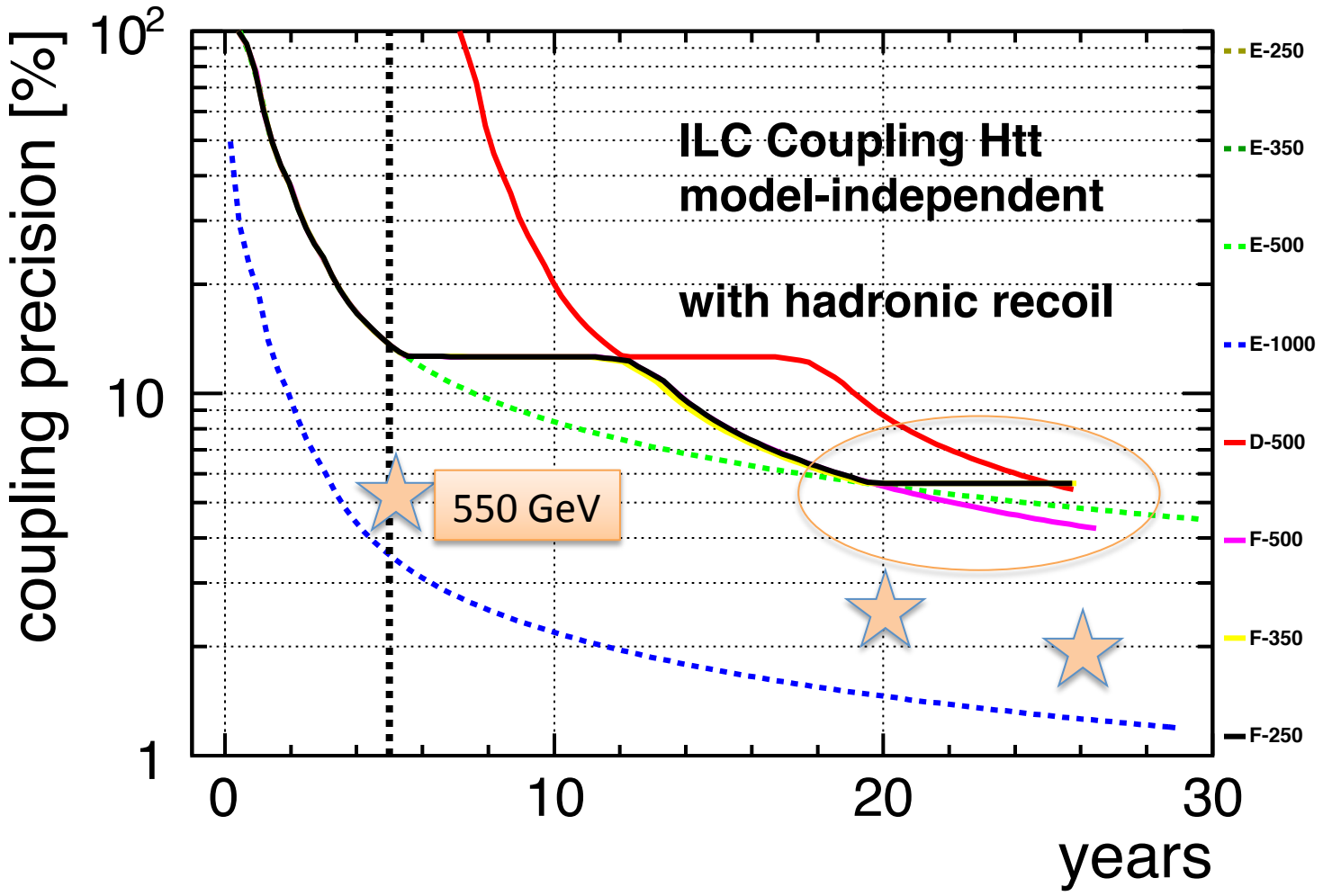
- ultimate M_Z
- ultimate $\sin\theta_{eff}$

?y

Some Running Scenarios

(Not considering: Zpole, WW, New Physics, 1 TeV)

- 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**



F500 slightly prefered, but small effect compared to increase in ECM!