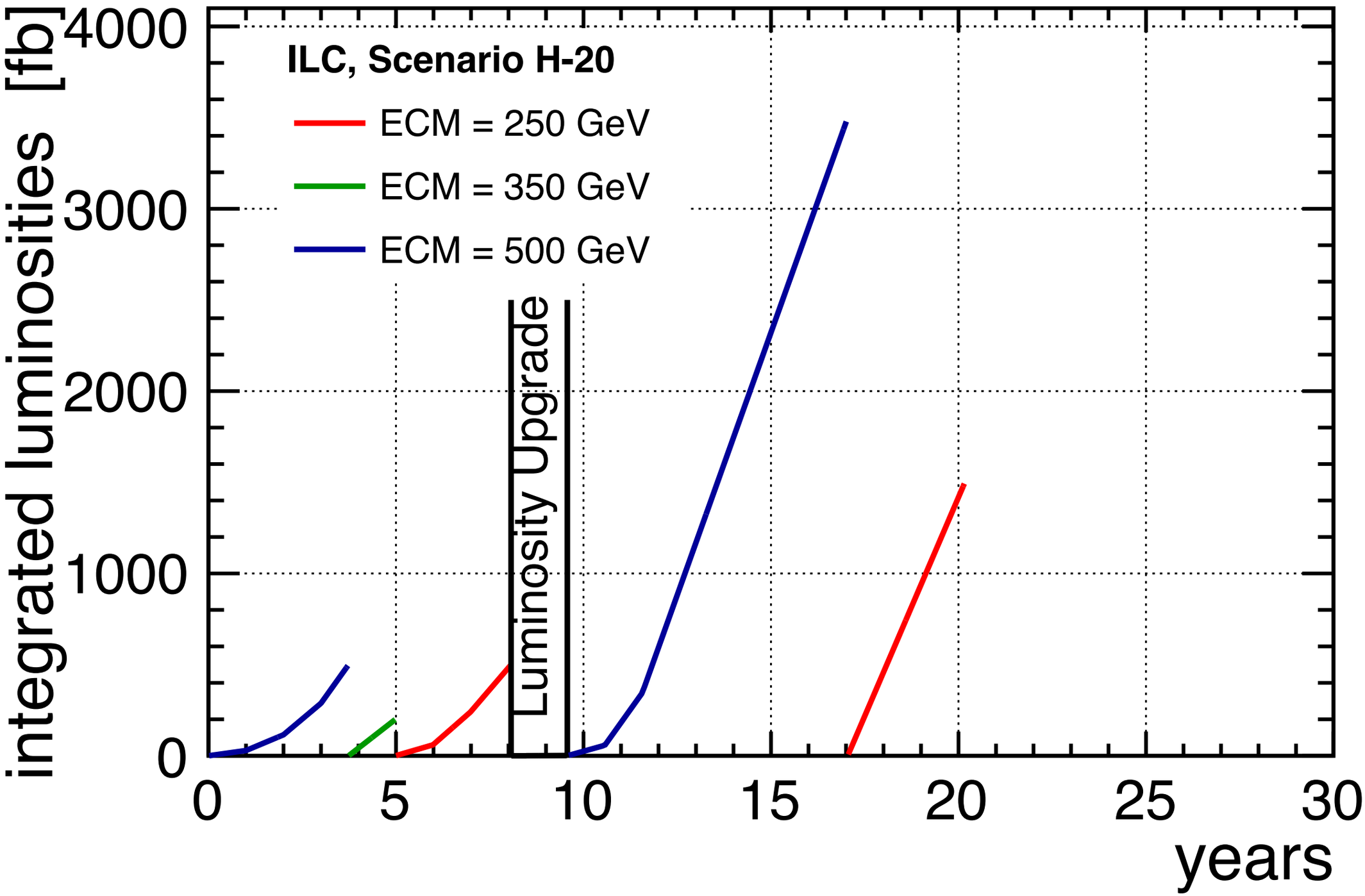


Staged Running Scenarios

J. List, June 16 2017
Parameter Group Meeting

Part - I

Update from the LCC Physics WG

Recent Activities in the LCC Physics WG

- "The Potential of the ILC for Discovering New Particles" => arXiv:1702.05333

- since then: staging, staging, staging :
  - focus on 250 GeV physics case
  - paradigm shift in Higgs coupling measurement interpretation => effective field theory!
  - paper in preparation on "Improved Formalism for Precision Higgs Coupling Fits"
  - using Higgs and electroweak measurements

NEW: role of polarisation for Higgs measurements

- some EFT parameters cannot be constrained from unpolarised total cross sections
- need either: polarised cross sections or angular distributions and high luminosity

+ 500 GeV

	$2\ ab^{-1}$ w. pol.	$5\ ab^{-1}$ no pol.	$20\ ab^{-1}$ no pol.	full ILC EFT fit
$g(hb\bar{b})$	1.5	1.1	0.8	0.6
$g(hc\bar{c})$	2.1	1.6	1.0	1.1
$g(hgg)$	1.9	1.5	0.9	0.9
$g(hWW)$	1.0	0.9	0.7	0.31
$g(h\tau\tau)$	1.6	1.2	0.8	0.8
$g(hZZ)$	1.0	0.9	0.7	0.31
$g(h\mu\mu)$	14	9.0	1.5	8.6
$g(hbb)/g(hWW)$	1.1	0.8	0.4	0.5
$g(hWW)/g(hZZ)$	0.34	0.38	0.04	0.02
Γ_h	3.1	2.5	1.7	1.5
$\sigma(e^+e^- \to Zh)$	0.70	0.51	0.27	0.56
$BR(h \to inv)$	0.3	0.3	0.2	0.3
$BR(h \to other)$	1.6	1.2	0.6	1.1

NEW: confronting BSM models with ILC precisions

- define global chi^2 based on all fit parameters g:

$$(\chi^2) = g^T\ [VCV^T]^{-1}\ g$$

- test two model hypotheses A & B against each other:

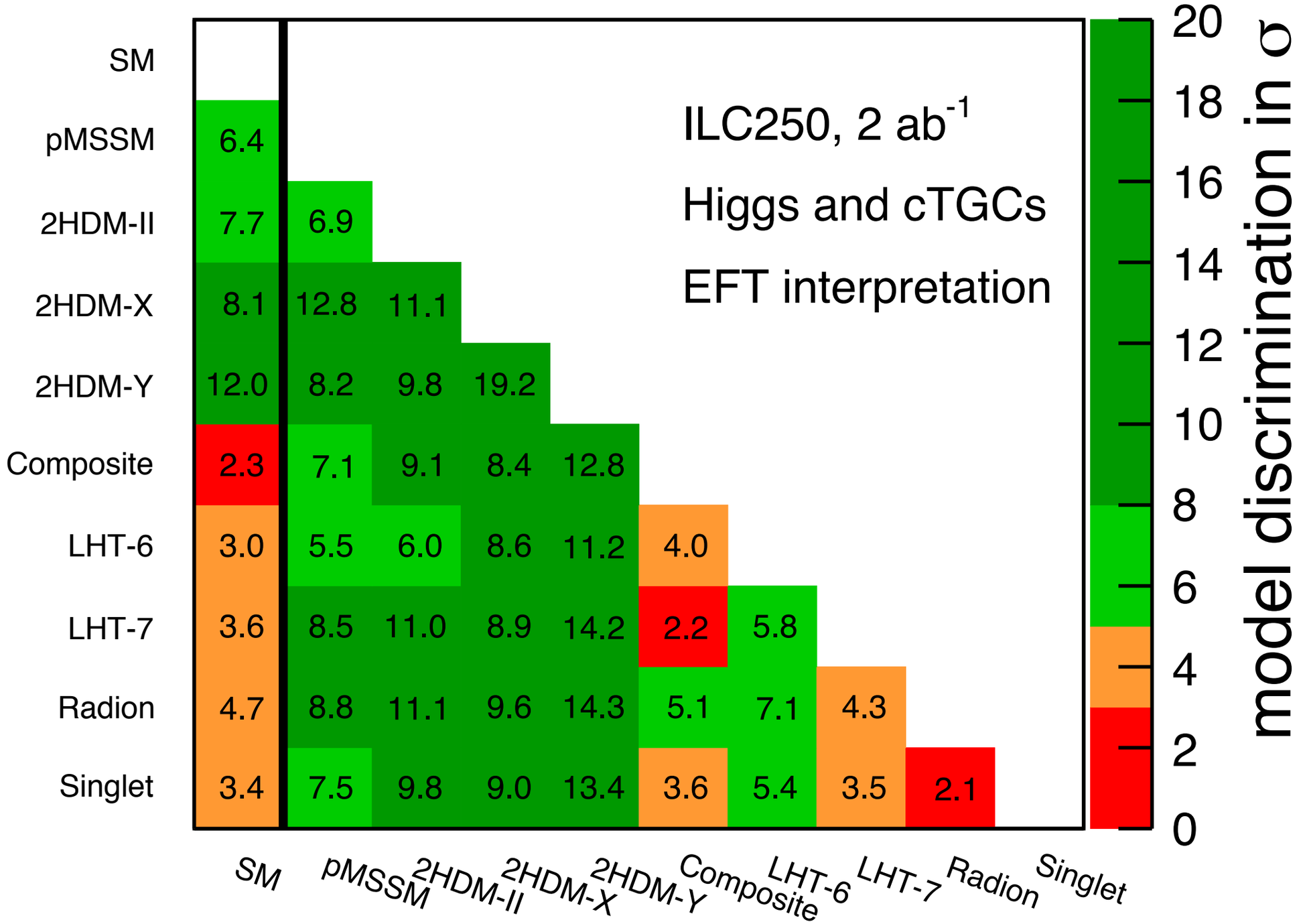
$$(\chi^2)_{AB} = (g_A^T - g_B^T)\ [VCV^T]^{-1}\ (g_A - g_B)$$

- A,B: either SM or various BSM models
- obtain “matrix” of discrimination power

List of models:

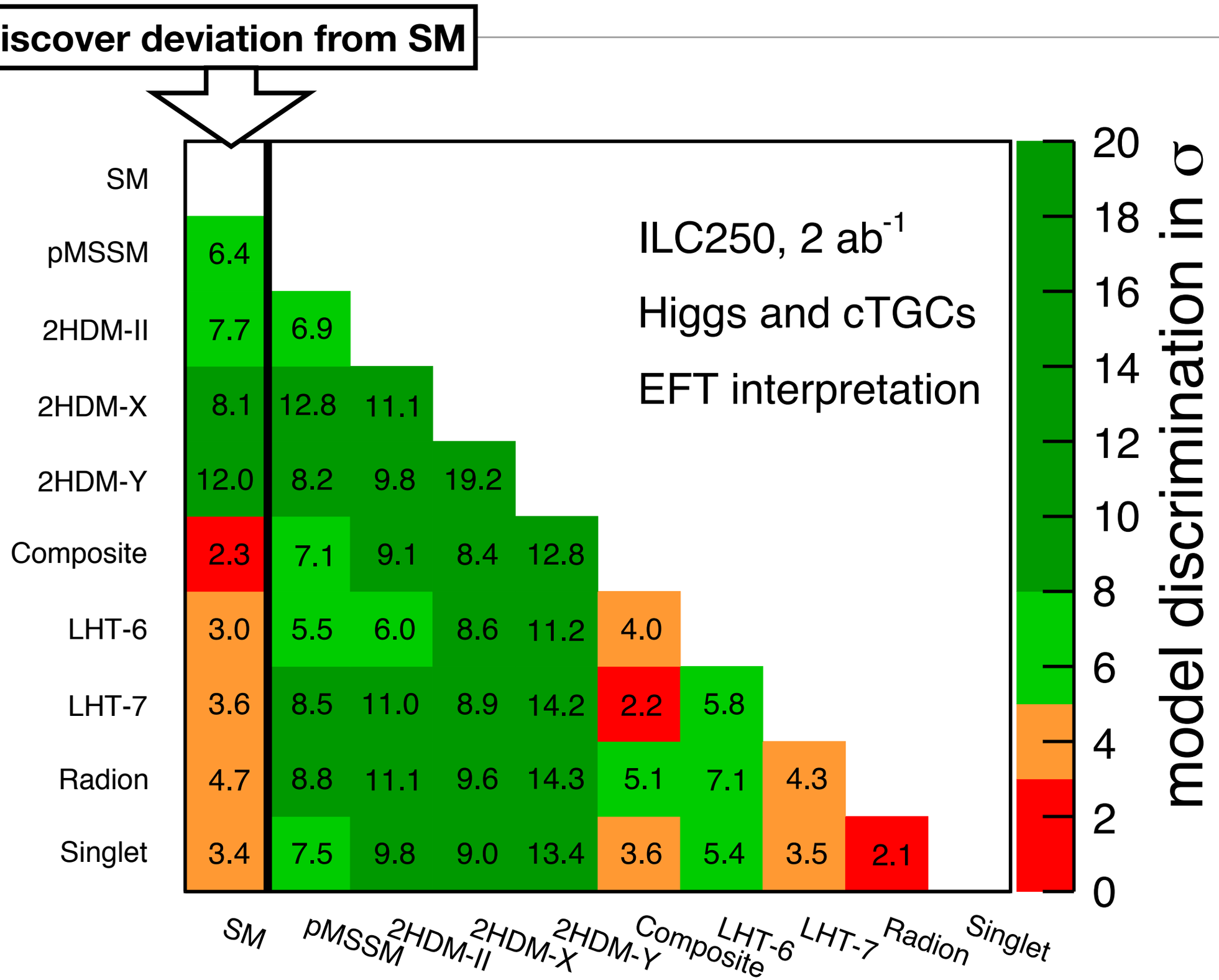
- BSM1: pMSSM with m (sbottom, gluino) = 3-4 TeV,
  Higgsino LSP at 515 GeV
- BSM2-4: 2HDM type II, X, Y
  with heavy Higgses at 150 - 600 GeV
- BSM5: Higgs Compositeness, vector-like top quark at ~1.7 TeV
- BSM6,7: Little Higgs with T-parity
  with f~1TeV, top partners at ~2 TeV
- BSM 8: Extra Dimensions with Higgs-Radion mixing,
  m_radion = 500 GeV, others multi-TeV
- BSM 9: Electroweak baryogenesis model with additional
  Higgs-singlet, m ~ 3TeV

Discrimination power of ILC250, 2ab-1

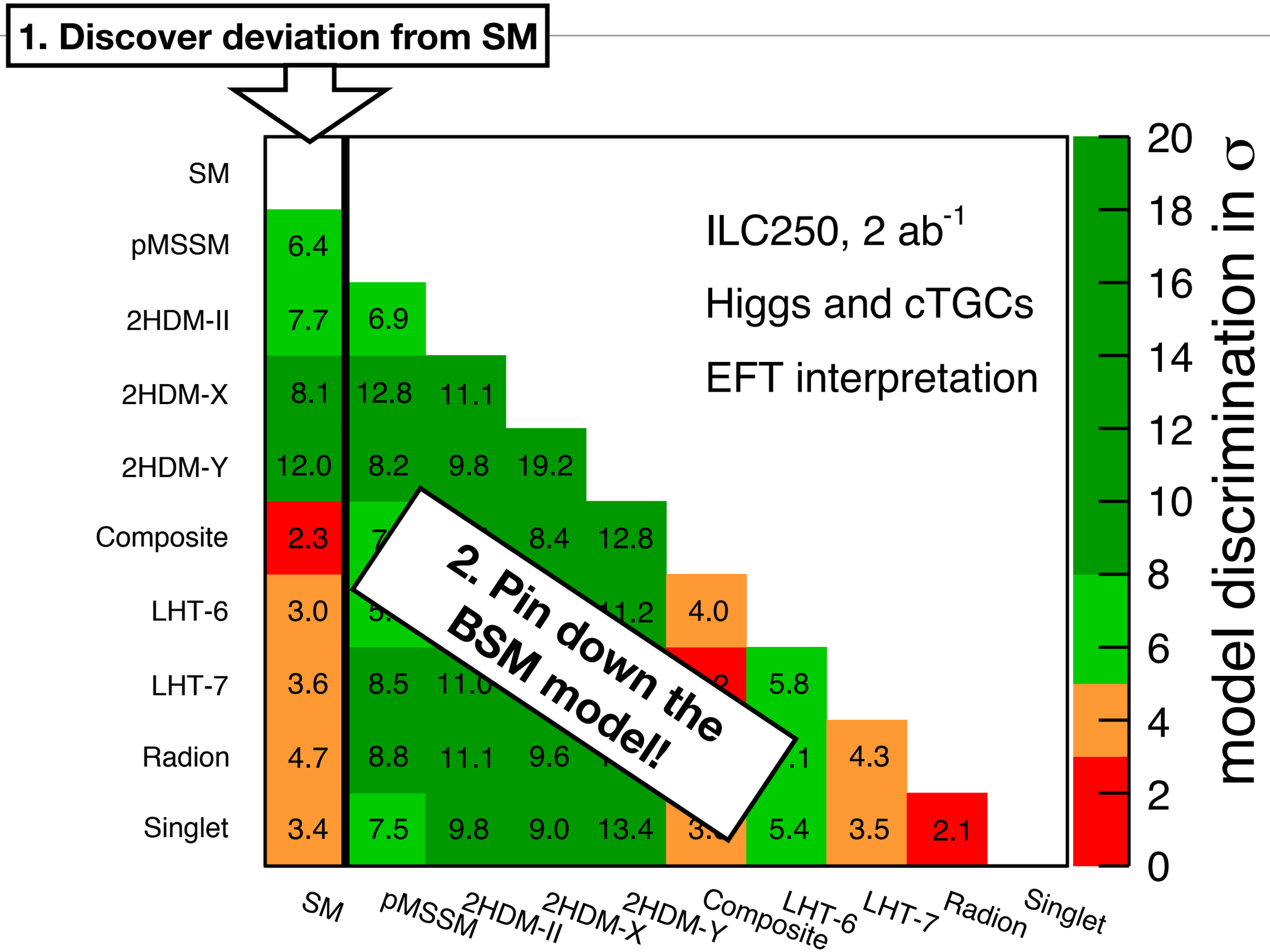


Discrimination power of ILC250, 2ab-1

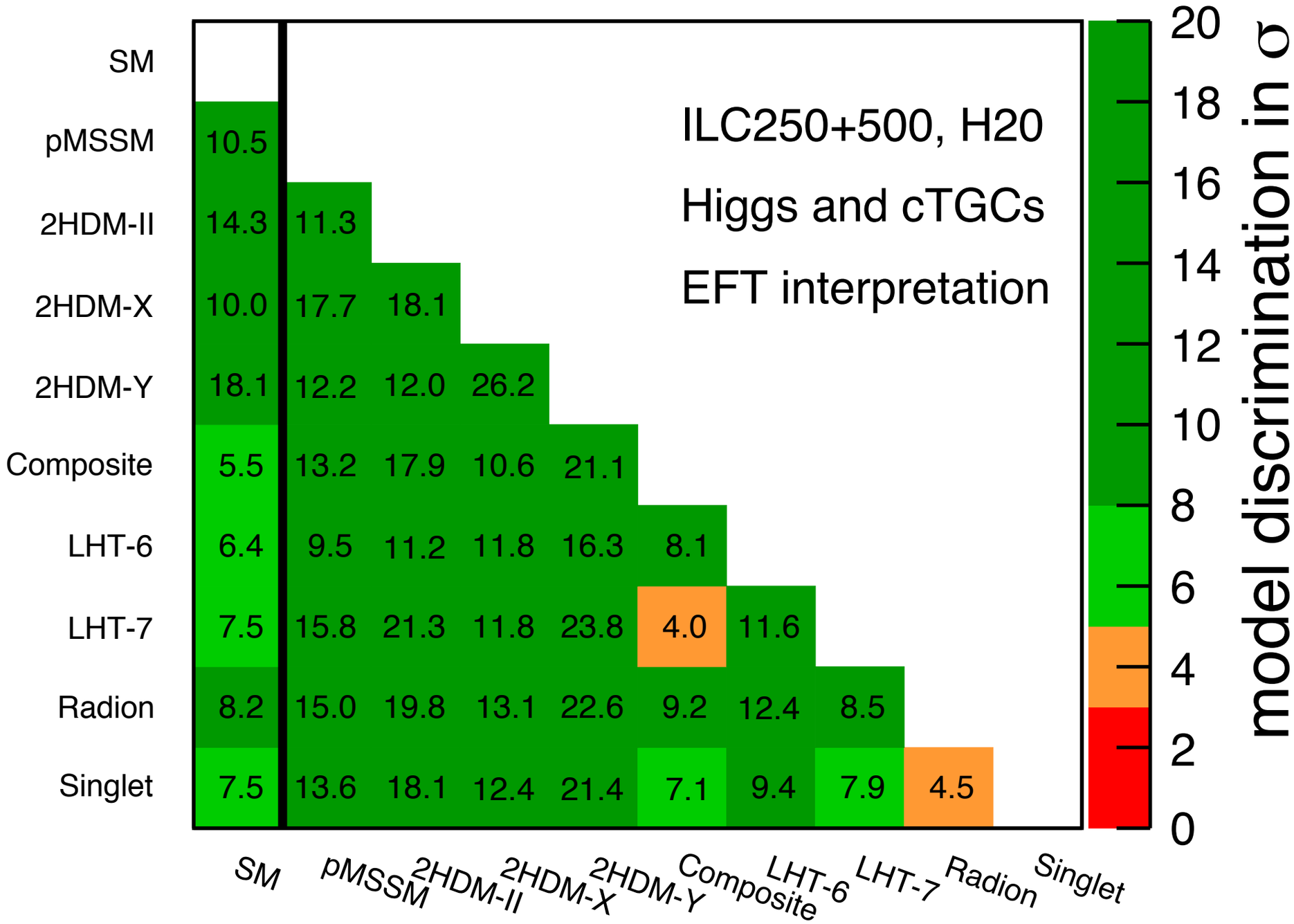
1. Discover deviation from SM



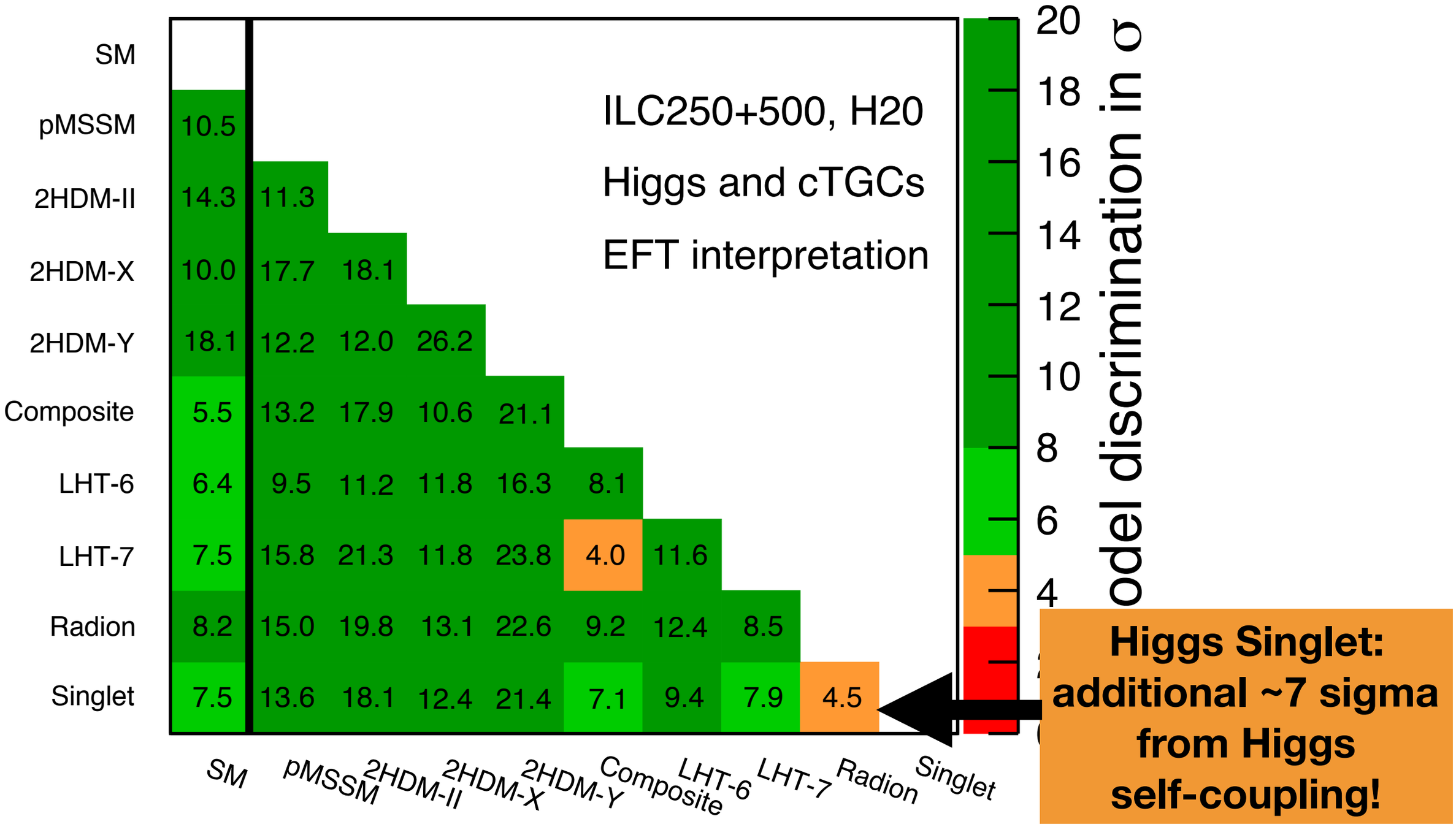
Discrimination power of ILC250, 2ab-1



Discrimination power of ILC250, 2ab-1 + ILC500 4ab-1 (~H-20)



Discrimination power of ILC250, 2ab-1 + ILC500 4ab-1 (~H-20)



Part - II

Running Scenarios

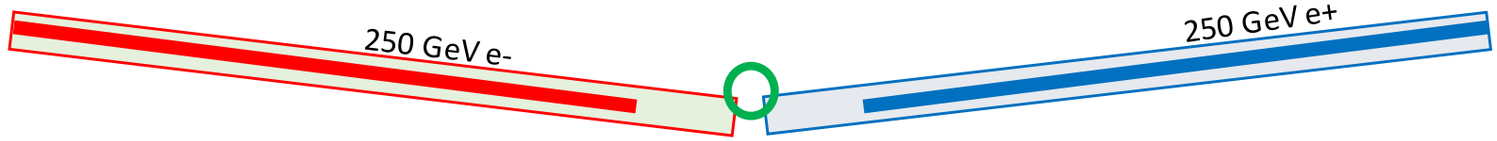
Preparation of Staging Discussion at AWLC

Wed 28/06

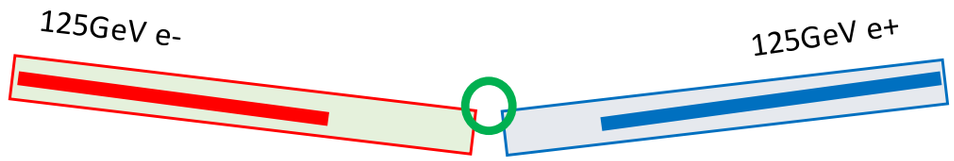
- Shinichiro Michizono: Staged design plan for the ILC
- **Junping Tian:**
  Luminosity and energy evolution for the staged ILC
- **=> on behalf of Joint WG on ILC Beam Parameters**
- Philip Burrows: Staged design plan for CLIC
- Panel discussion of ILC staging options

Staged Main Linac Configurations (S.Michizono)

500GeV **TDR:**



250 GeV **Option C:**

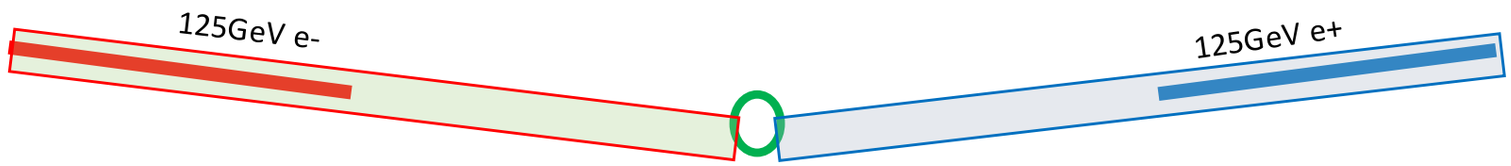


Option D:

350GeV Option D':

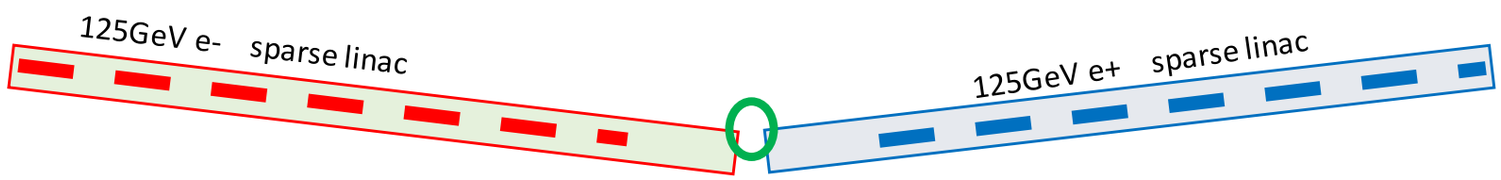
Option E:

350GeV Option E':



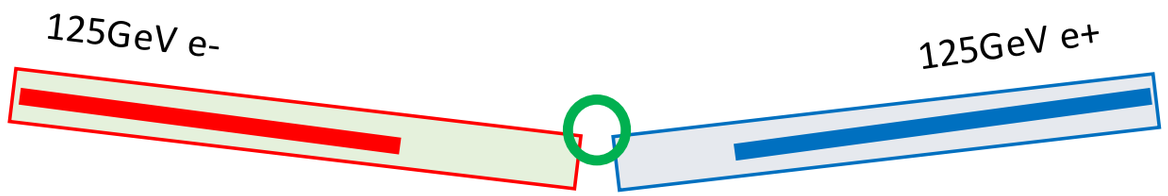
Option F:

350GeV Option F':



Option C: “no empty tunnel”

Option C:



more luminosity:

- **no 10 Hz operation** (would need to install power in the “wrong” places for 500 GeV!)
- **TDR => RDR**: more power, 2nd damping ring **=> ~ 1.5 years**

more energy:

- **tunnel construction** and installation of cryomodules during physics operation, only “short” break for connecting new & old parts **=> ~1 year**
- need to **build new turn-around** (~1 km of beamline!)
  => intermediate steps (eg 350 GeV) highly discouraged

Option D: “simple tunnel”

Option D:

350GeV Option D’:

more luminosity:

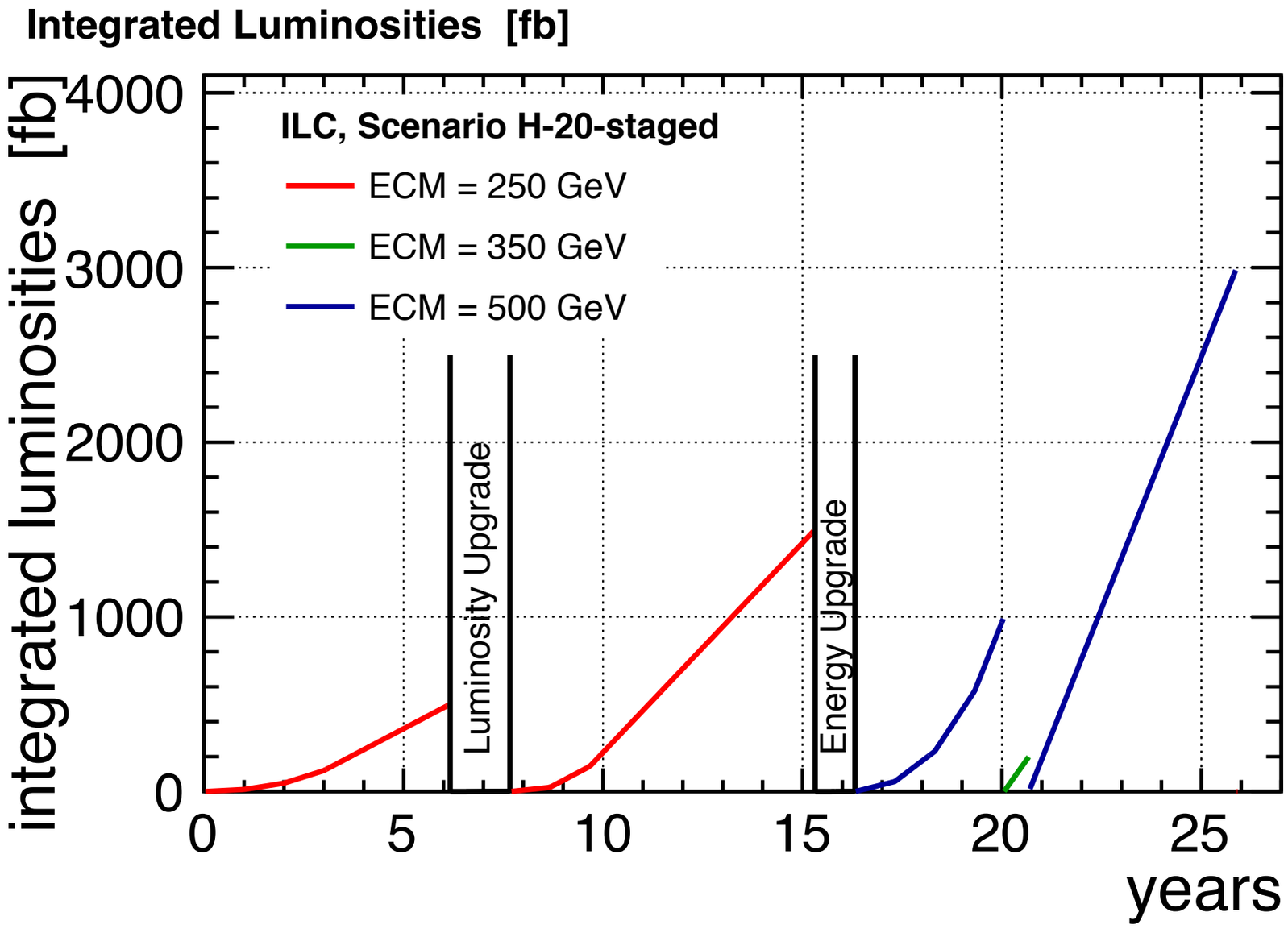
- **no 10 Hz operation** (would need to install power in the “wrong” places for 500 GeV!)
- **TDR => RDR**: more power, 2nd damping ring **=> ~ 1.5 years**

more energy:

- simple tunnel exists => energy upgrade a bit cheaper than in C
- **tunnel preparation** and installation of cryomodules during physics operation, only “short” break for connecting new & old parts **=> ~1 year**
- need to **build new turn-around** (~1 km of beamline!)
  => intermediate “physical” 350 GeV step highly discouraged

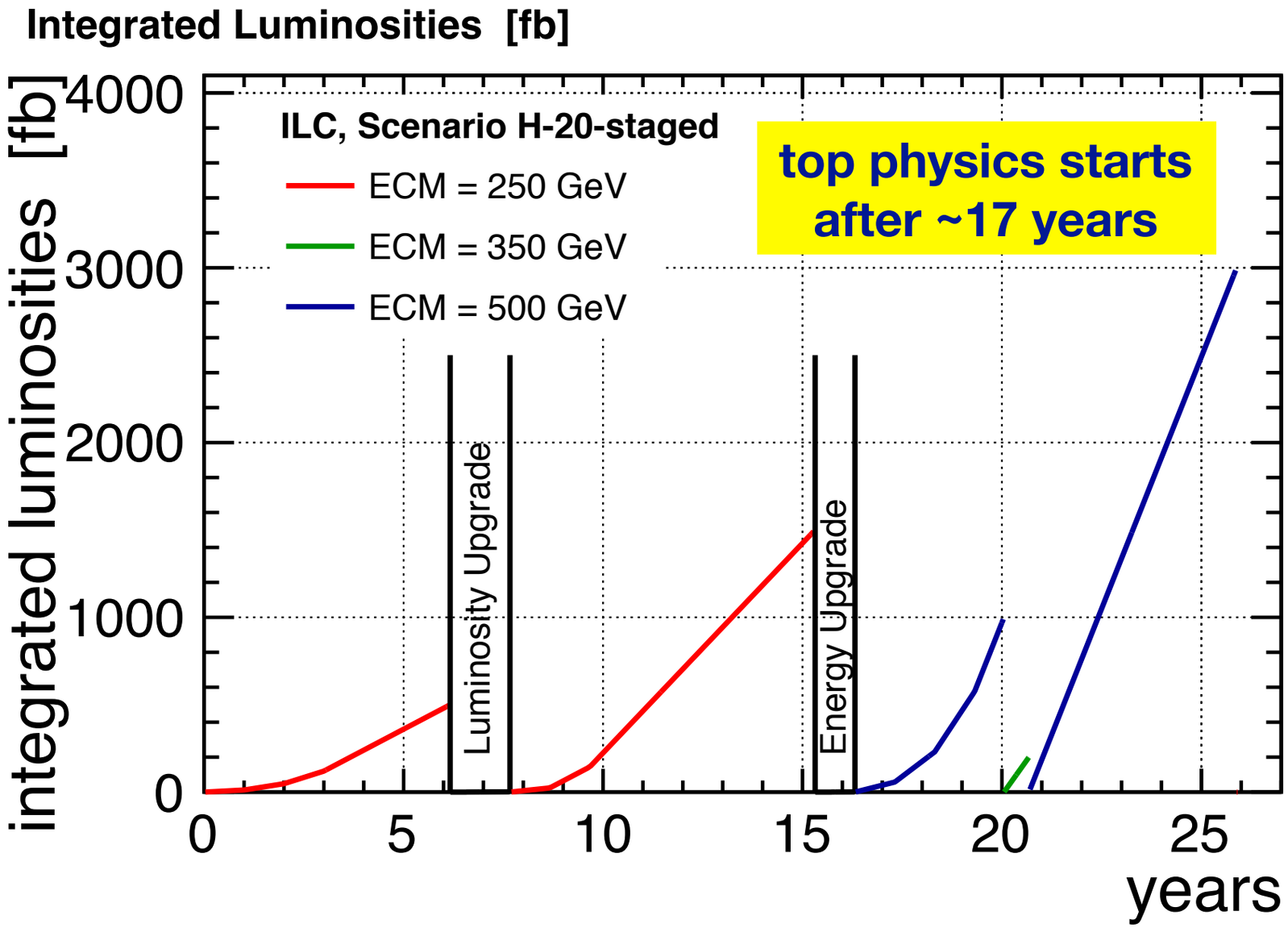
Option C “no empty tunnel” vs D: “simple tunnel”

- **big** difference in credibility of energy upgrade!
- but hardly any difference wrt the running scenario, in both cases the candidate is:



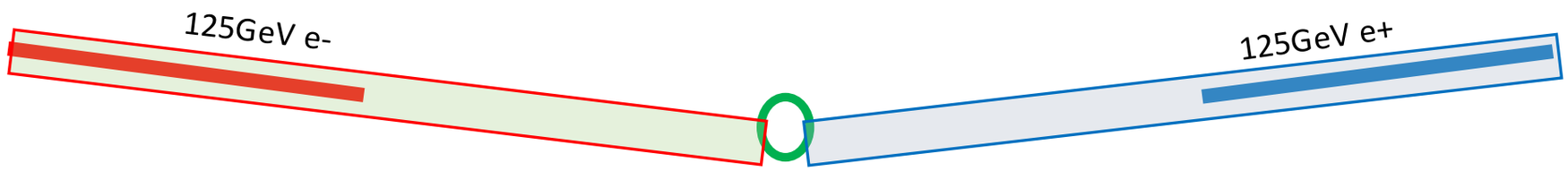
Option C “no empty tunnel” vs D: “simple tunnel”

- **big** difference in credibility of energy upgrade!
- but hardly any difference wrt the running scenario, in both cases the candidate is:



Option E: “high-E transport”

Option E:
350GeV Option E’:



more luminosity:

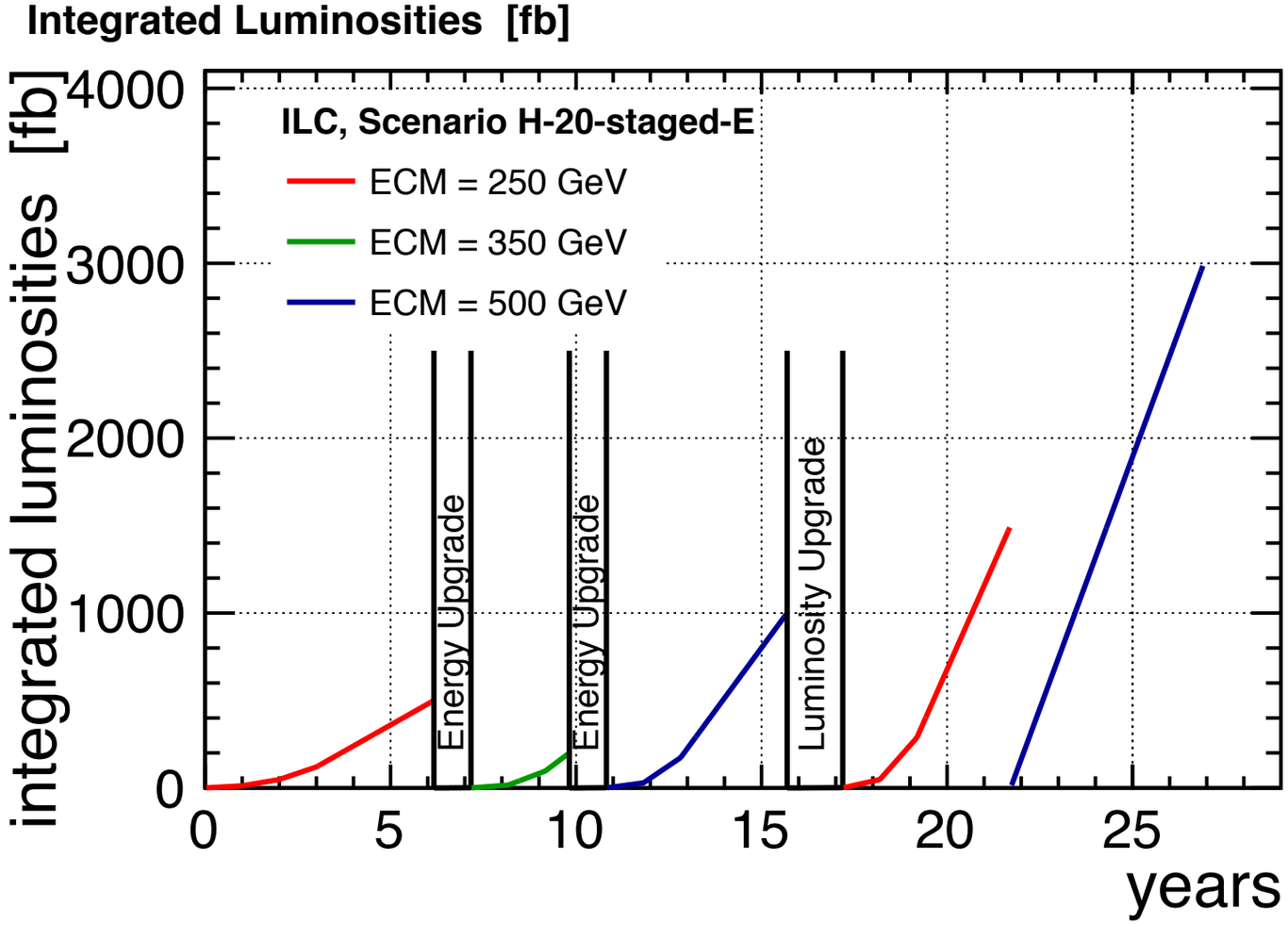
- **no 10 Hz operation** (would need to install power in the “wrong” places for 500 GeV!)
- TDR => RDR (more power, 2nd damping ring) **=> ~ 1.5 years**

more energy:

- a real **promise !**
- installation of cryomodules **=> ~1 year**
- **no need to build new turn-around** => intermediate steps “easy”

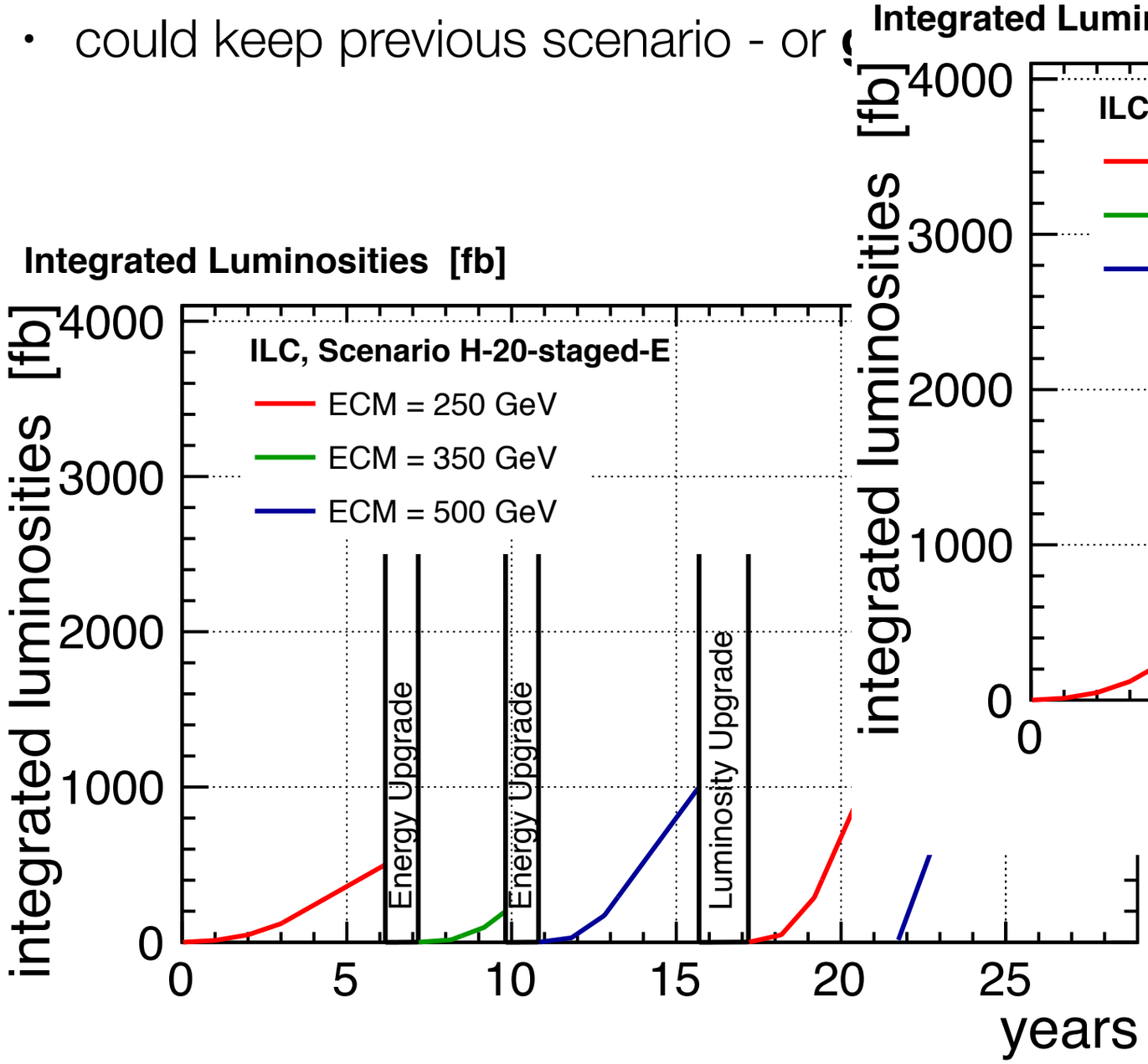
Option E “high-E transport” vs C/D

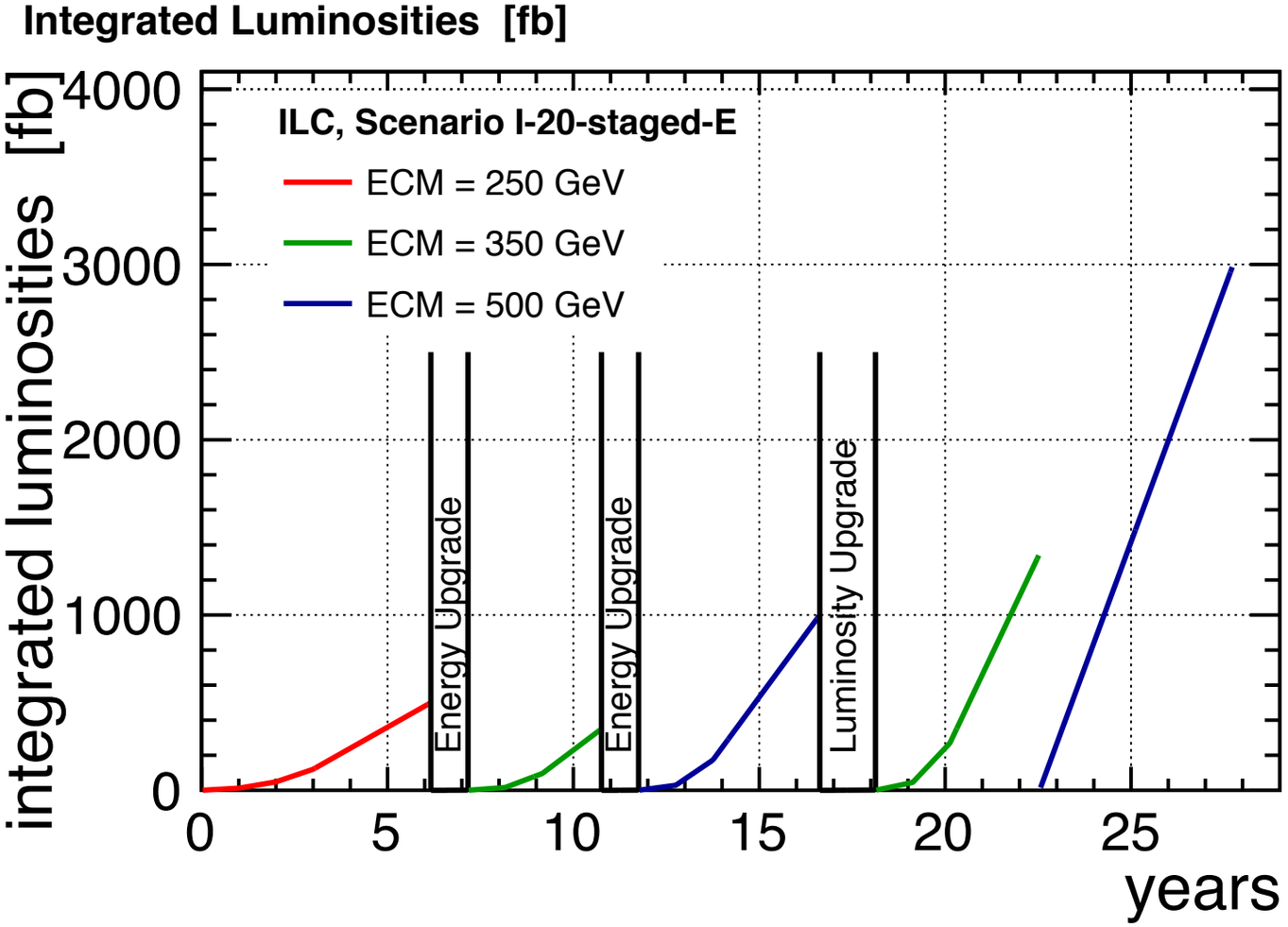
- **even much stronger** credibility of energy upgrade!
- could keep previous scenario - or **go for higher energies first:**



Option E “high-E transport” vs C/D

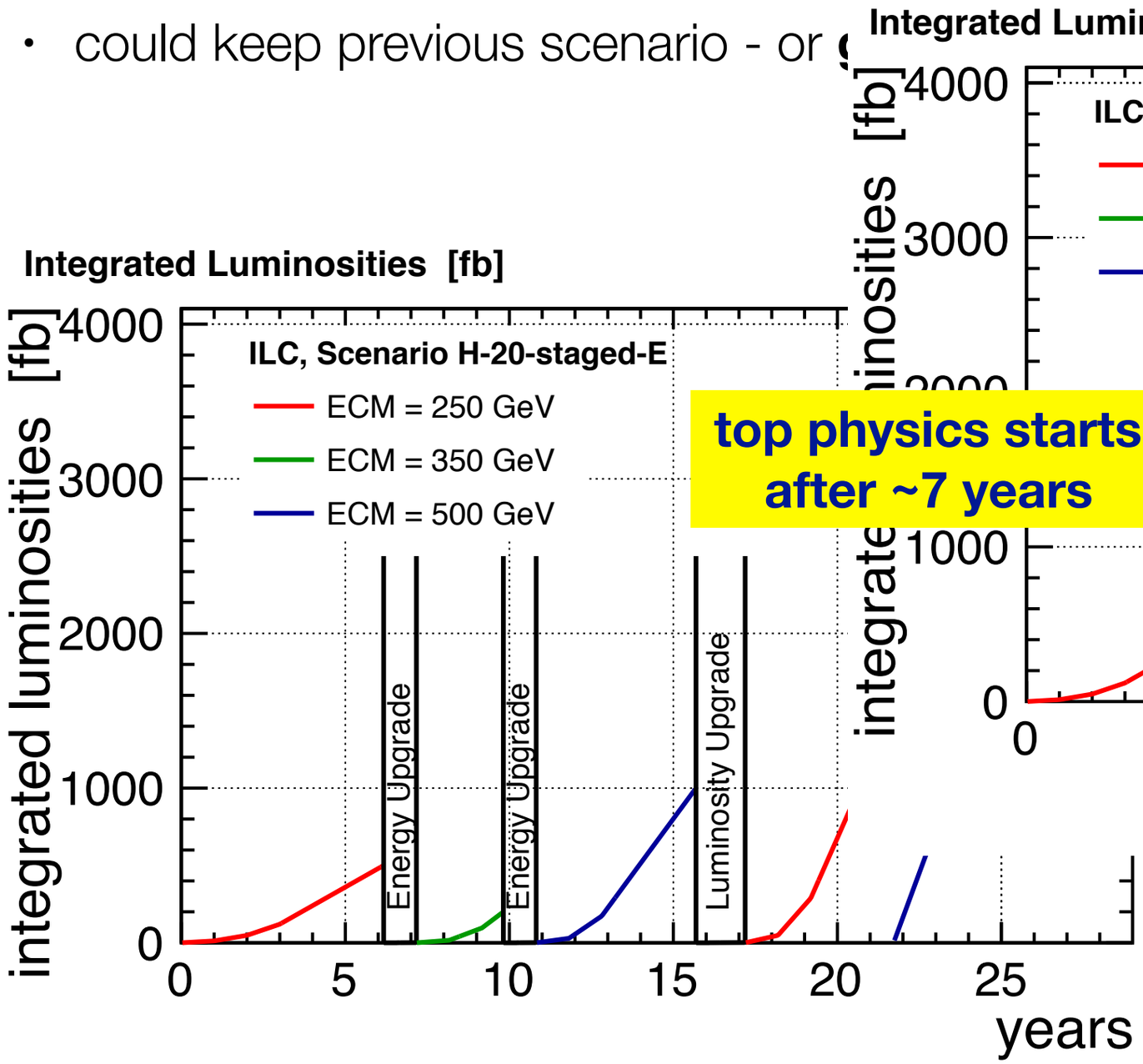
- **even much stronger** credibility of energy upgrade!
- could keep previous scenario - or



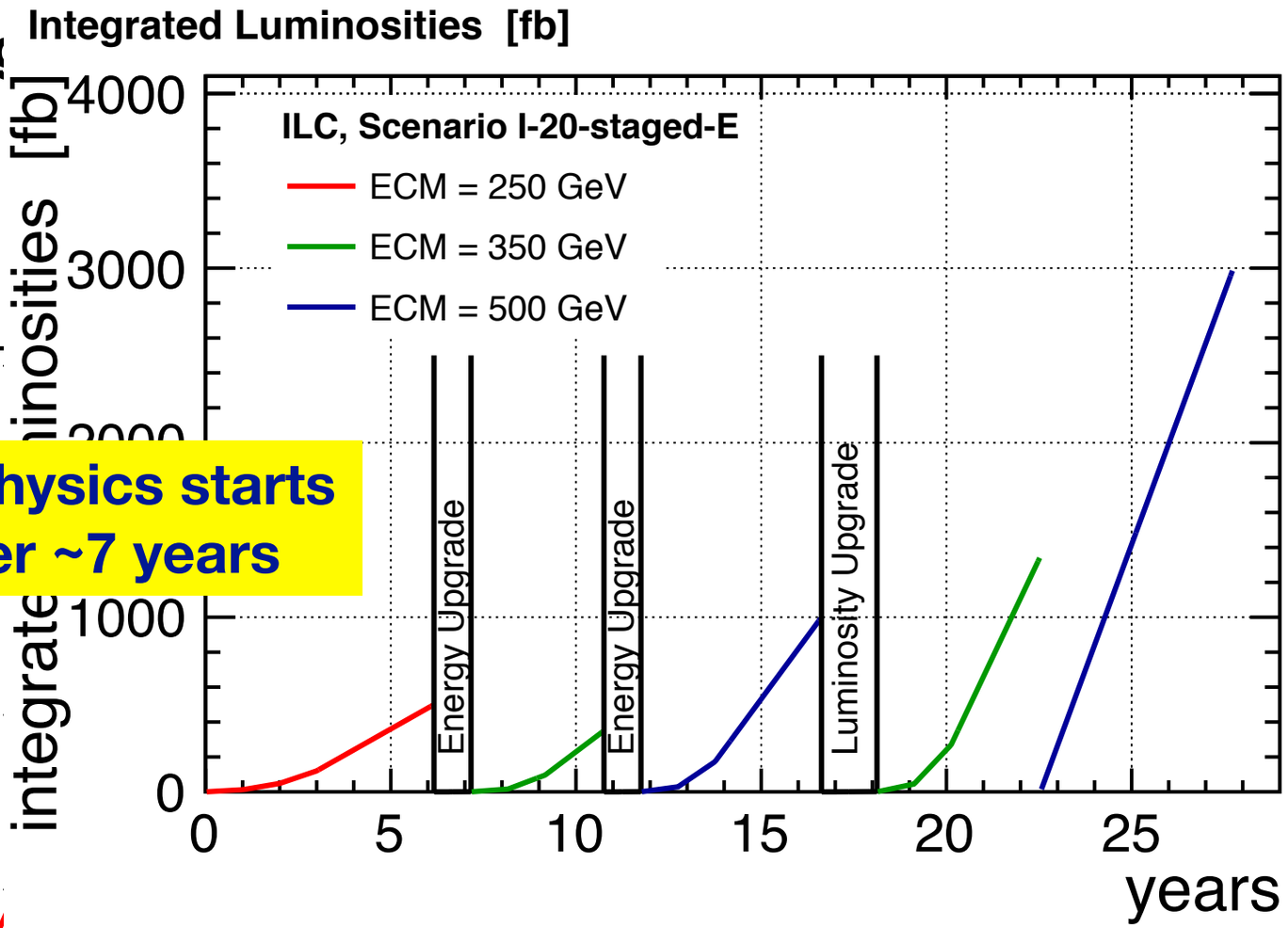


Option E “high-E transport” vs C/D

- **even much stronger** credibility of energy upgrade!
- could keep previous scenario - or

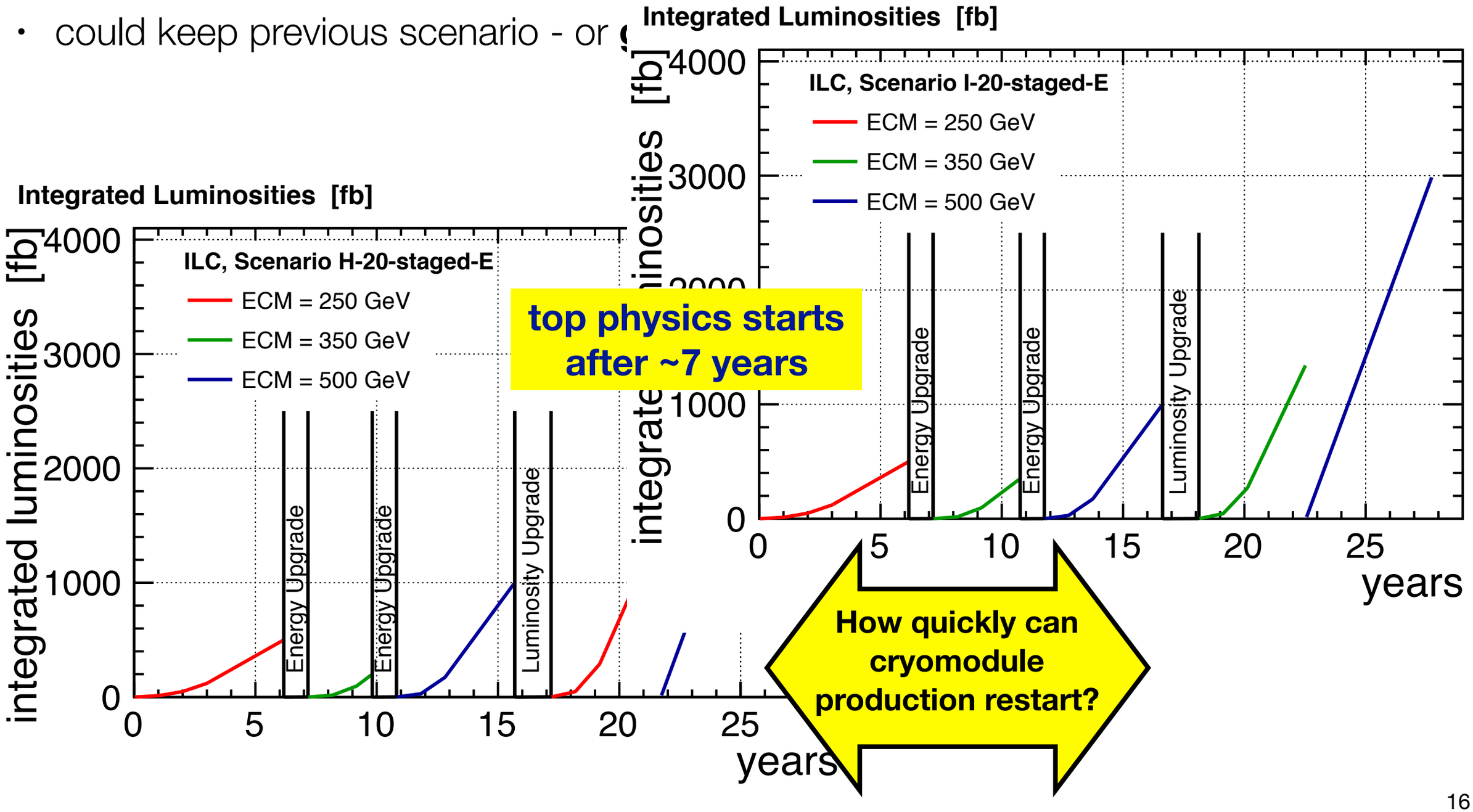


top physics starts after ~7 years



Option E “high-E transport” vs C/D

- **even much stronger** credibility of energy upgrade!
- could keep previous scenario - or



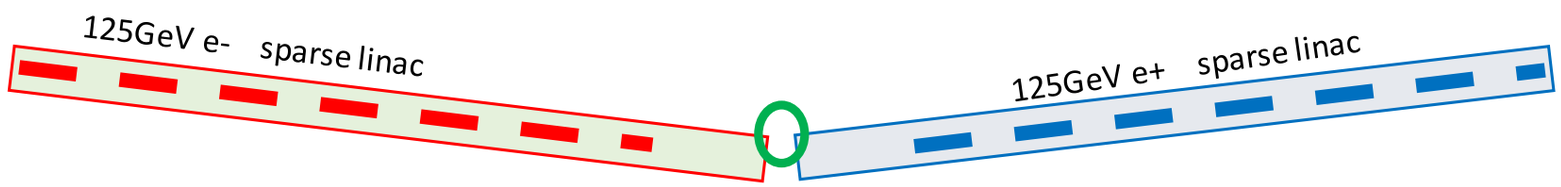
top physics starts after ~7 years

How quickly can cryomodule production restart?

Option F: “sparse linac”

Option F:

350GeV Option F’:



more luminosity:

- **10 Hz operation possible** (by installation of cryo & RF power needed for 500 GeV anyhow)
  => lumi x2 without significant shutdown
- TDR => RDR (more power, 2nd damping ring) **=> ~ 1.5 years**

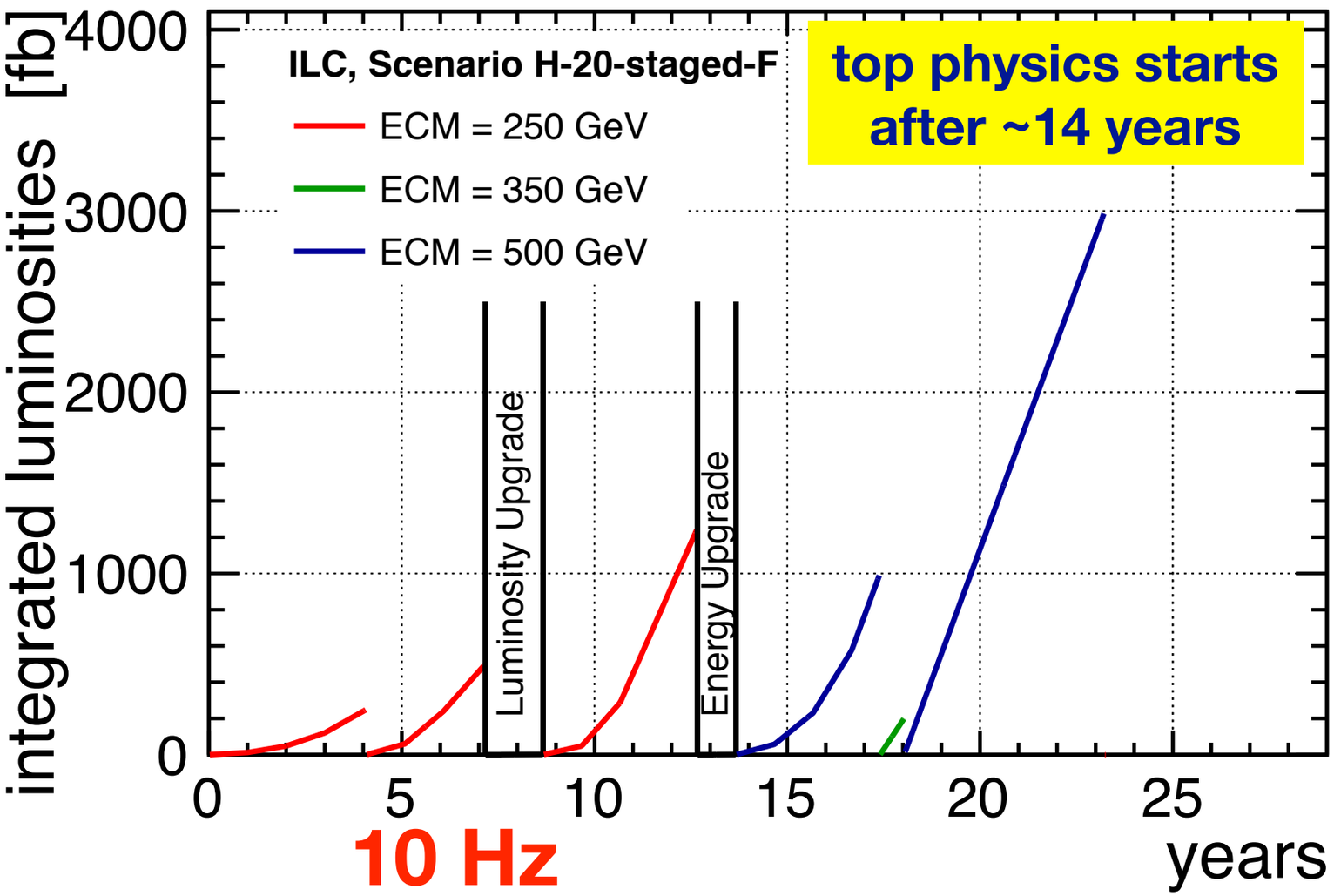
more energy:

- a real **promise !**
- installation of cryomodules **=> ~1 year**
- **no need to move turn around** => intermediate steps “easy”

Option F “sparse linac” vs E

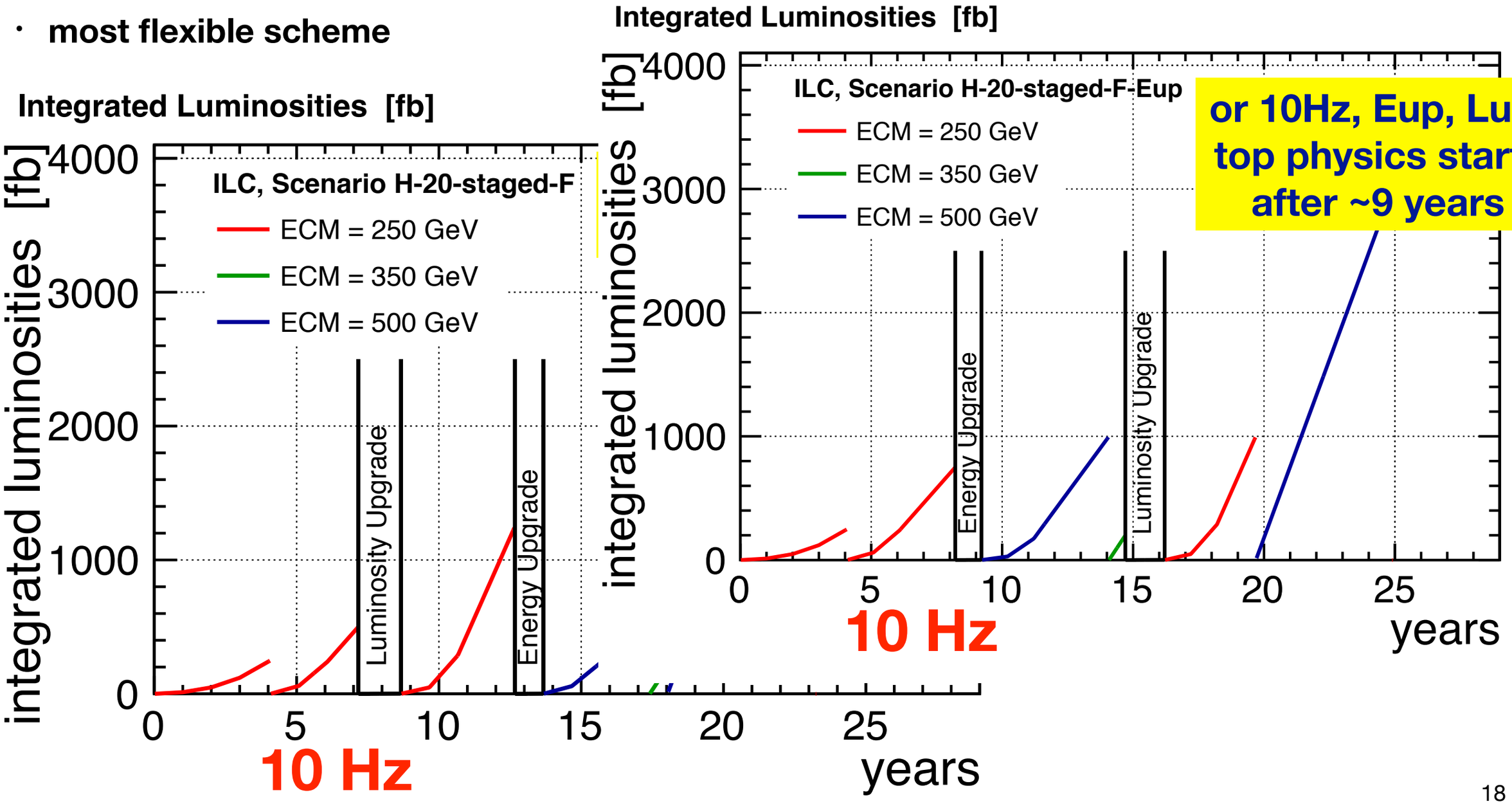
- **10 Hz** offers **option** to go to **higher luminosity first**
- **e.g. if energy upgrade not yet financed**
- **most flexible scheme**

Integrated Luminosities [fb]



Option F “sparse linac” vs E

- **10 Hz** offers **option** to go to **higher luminosity first**
- **e.g. if energy upgrade not yet financed**
- **most flexible scheme**



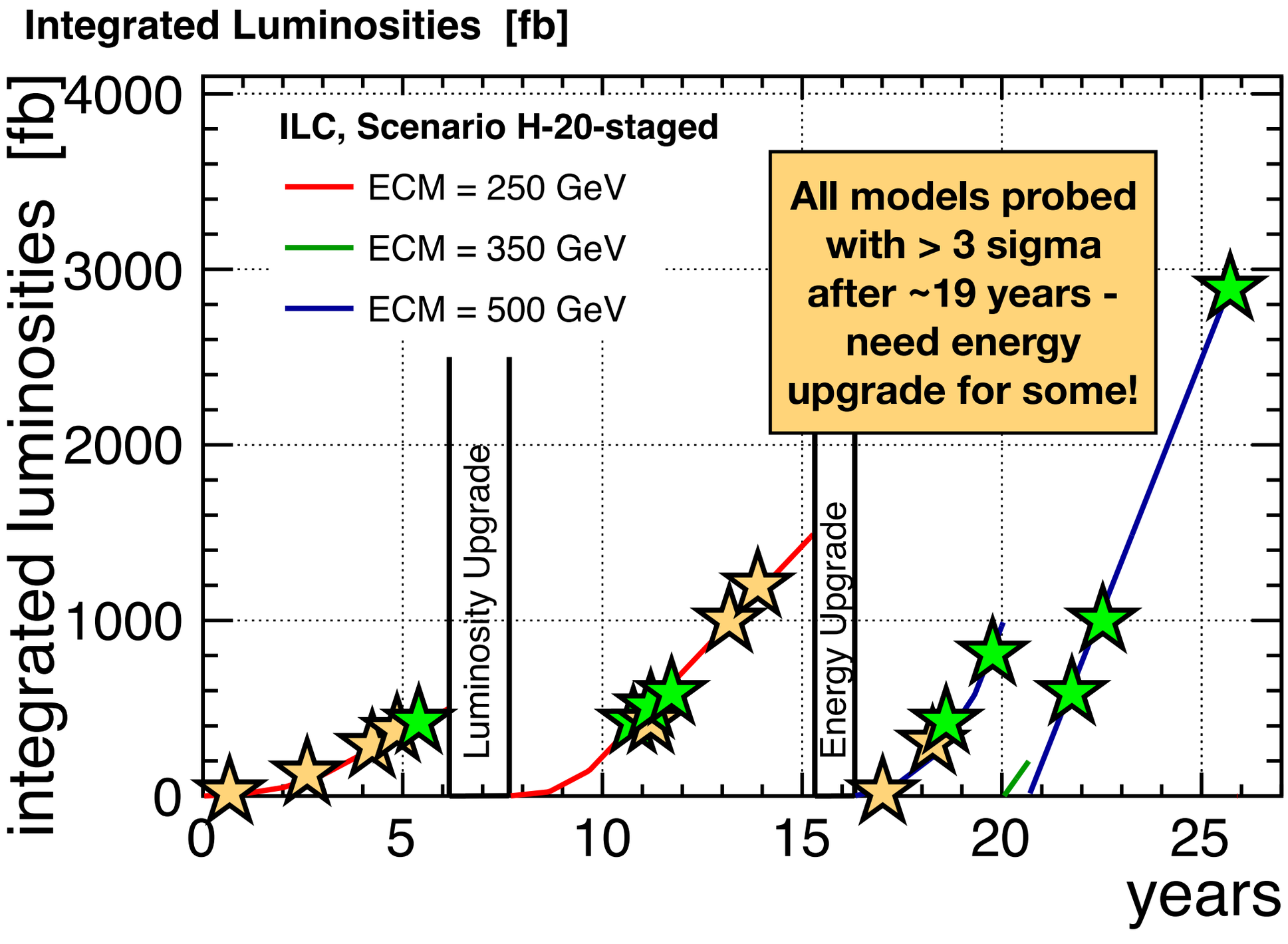
Some milestones

	total years	years til top physics	years til direct BSM up to 250 GeV
H20-staged-CD	26	17	17
H20-staged-EF	27	7	11
I20-staged-EF	28	7	12
H20-staged-F-Eup	25	9	9
H20-staged-F-Lup	23	14	14

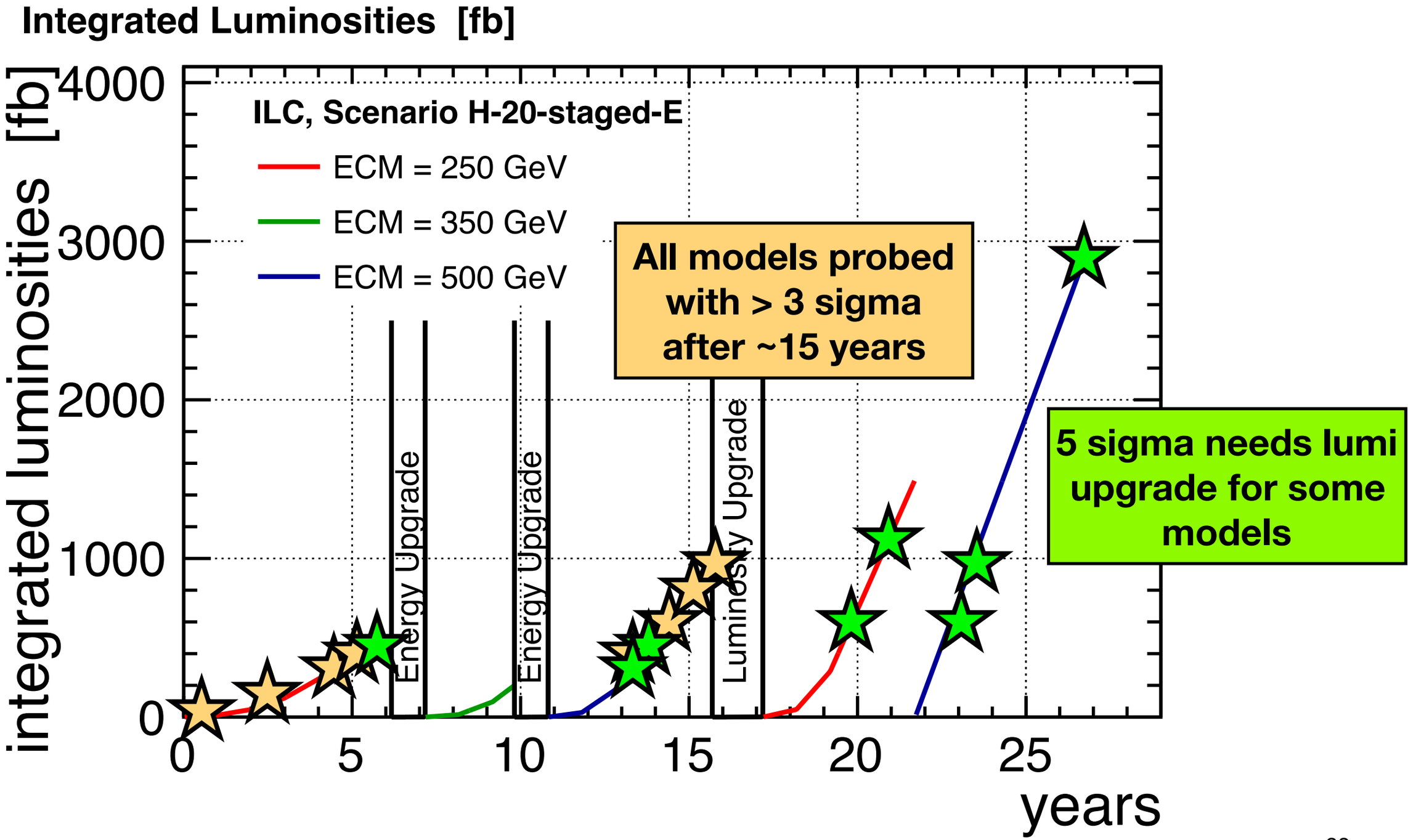
Preliminary discovery times

	X @ 250 GeV 3		500 fb-1 @ 250 GeV + X @ 500 GeV		1 ab-1 @ 250 GeV + X @ 500 GeV		2 ab-1 @ 250 GeV + X @ 500 GeV	
	3 sigma	5 sigma	3 sigma	5 sigma	3 sigma	5 sigma	3 sigma	5 sigma
pMSSM	20 fb-1	1000 fb-1	0	300 fb-1	0	0	0	0
2HDM-II	350 fb-1	950 fb-1	0	400 fb-1	0	0	0	0
2HDM-X	300 fb-1	900 fb-1	0	1500 fb-1	0	0	0	0
2HDM-Y	150 fb-1	400 fb-1	0	0	0	0	0	0
composite Higgs	> 2 ab-1	> 2 ab-1	1750 fb-1	> 4 ab-1	1000 fb-1	> 4 ab-1	350 fb-1	4000 fb-1
Little Higgs 6	> 2 ab-1	> 2 ab-1	1000 fb-1	> 4 ab-1	500 fb-1	3750 fb-1	50 fb-1	2000 fb-1
Little Higgs 7	1500 fb-1	> 2 ab-1	700 fb-1	2500 fb-1	250 fb-1	2200 fb-1	0	1500 fb-1
Higgs-Radion	950 fb-1	> 2 ab-1	400 fb-1	2250 fb-1	0	1500 fb-1	0	400 fb-1
Higgs Singlet	1750 fb-1	> 2 ab-1	500 fb-1	3250 fb-1	100 fb-1	2200 fb-1	0	750 fb-1

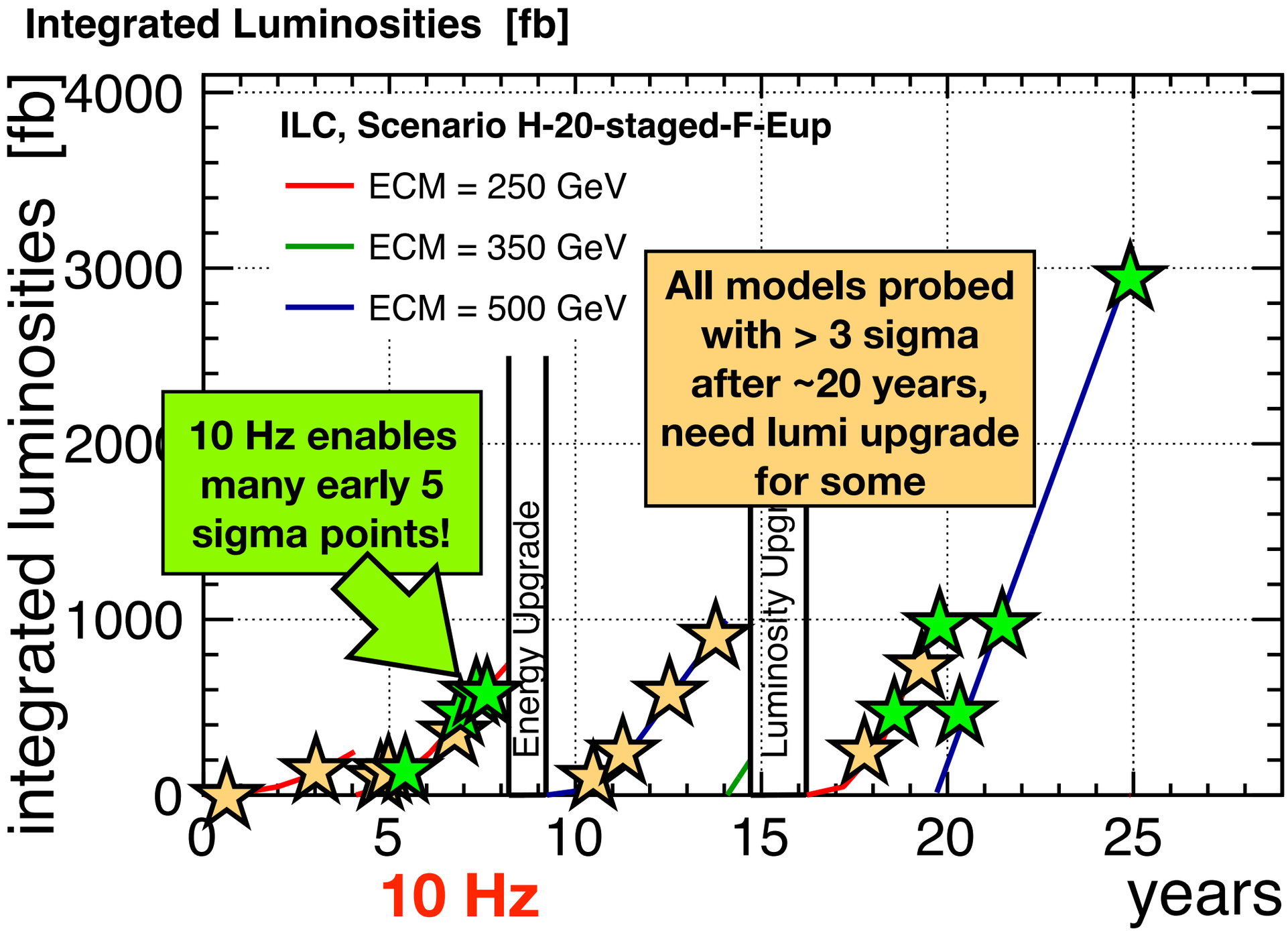
H20-staged-CD and BSM probing (preliminary)



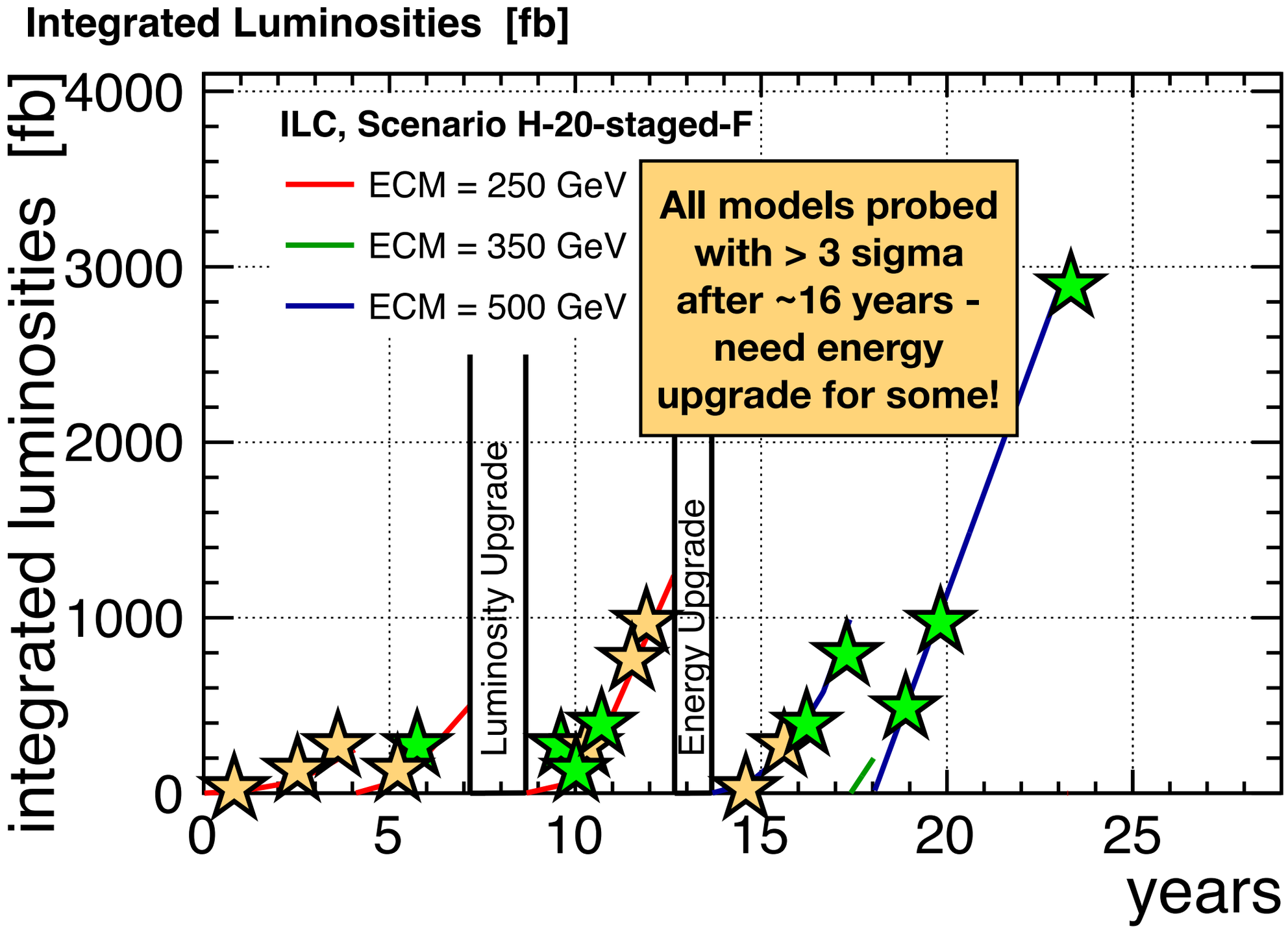
H20-staged-EF and BSM probing (preliminary)



H20-staged-F-Eup and BSM probing (preliminary)



H20-staged-F-Lup and BSM probing (preliminary)



Some Points for Discussion

- note that previous plots did not include:
  - top physics
  - top Yukawa coupling, Higgs self-coupling
  - direct discovery potential

  => c.f. table p19

Which time evolution plots would we like to present ?

- can we agree on a (small) set of running scenarios for the different staging scenarios?
  - C,D -> H20-staged as discussed in March
  - E,F -> no 10 Hz, E up first
  - F -> 10Hz + Lup first
  - F -> 10Hz + Eup first

reduce options?

- all this is based on “normal” instantaneous luminosities
  => any real option to increase per-bunch luminosity at 250 GeV?
- **additional cost by either interruption of cryo-module production or storage of cryo-module?**

Backup

preliminary discovery times

	X @ 250 GeV 3		500 fb-1 + X @ 250 GeV + 1ab-1 @ 500 GeV		1 ab-1 @ 250 GeV + X @ 500 GeV		2 ab-1 @ 250 GeV + X @ 500 GeV	
	3 sigma	5 sigma	3 sigma	5 sigma	3 sigma	5 sigma	3 sigma	5 sigma
pMSSM	20 fb-1	1000 fb-1	0	0	0	0	0	0
2HDM-II	350 fb-1	950 fb-1	0	0	0	0	0	0
2HDM-X	300 fb-1	900 fb-1	0	fb-1	0	0	0	0
2HDM-Y	150 fb-1	400 fb-1	0	0	0	0	0	0
composite Higgs	> 2 ab-1	> 2 ab-1	1750 fb-1		1000 fb-1	> 4 ab-1	350 fb-1	4000 fb-1
Little Higgs 6	> 2 ab-1	> 2 ab-1	0		500 fb-1	3750 fb-1	50 fb-1	2000 fb-1
Little Higgs 7	1500 fb-1	> 2 ab-1	0		250 fb-1	2200 fb-1	0	1500 fb-1
Higgs-Radion	950 fb-1	> 2 ab-1	0		0	1500 fb-1	0	400 fb-1
Higgs Singlet	1750 fb-1	> 2 ab-1	0		100 fb-1	2200 fb-1	0	750 fb-1