Considerations on the lifespan of SiPMs over the years of EIC operation

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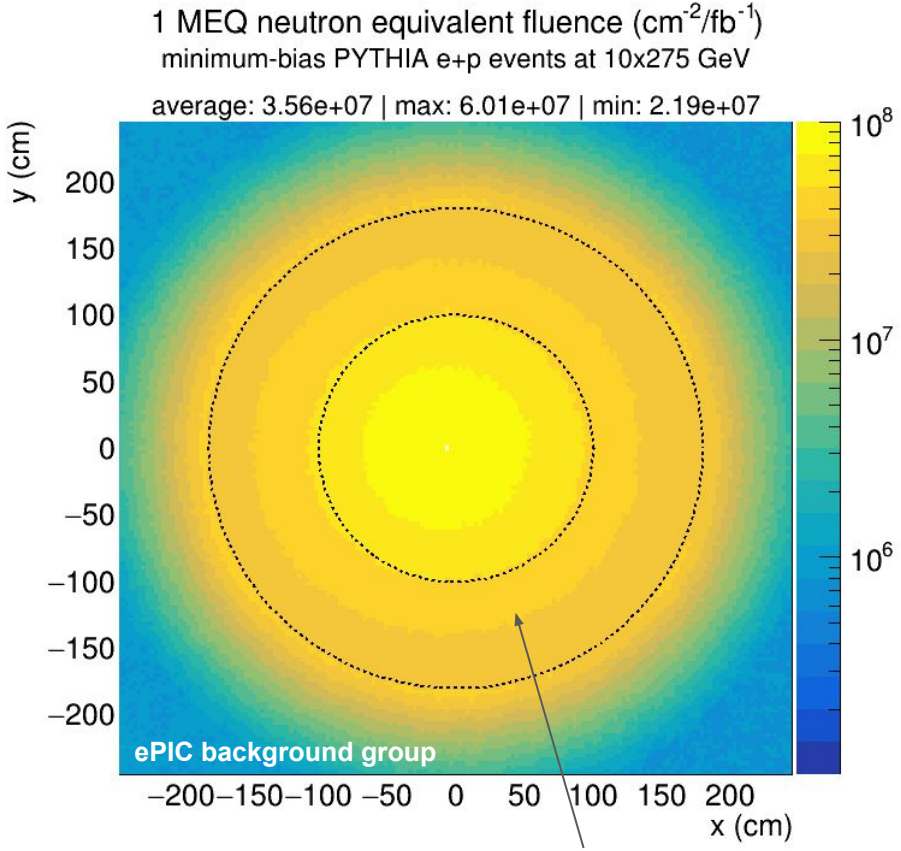
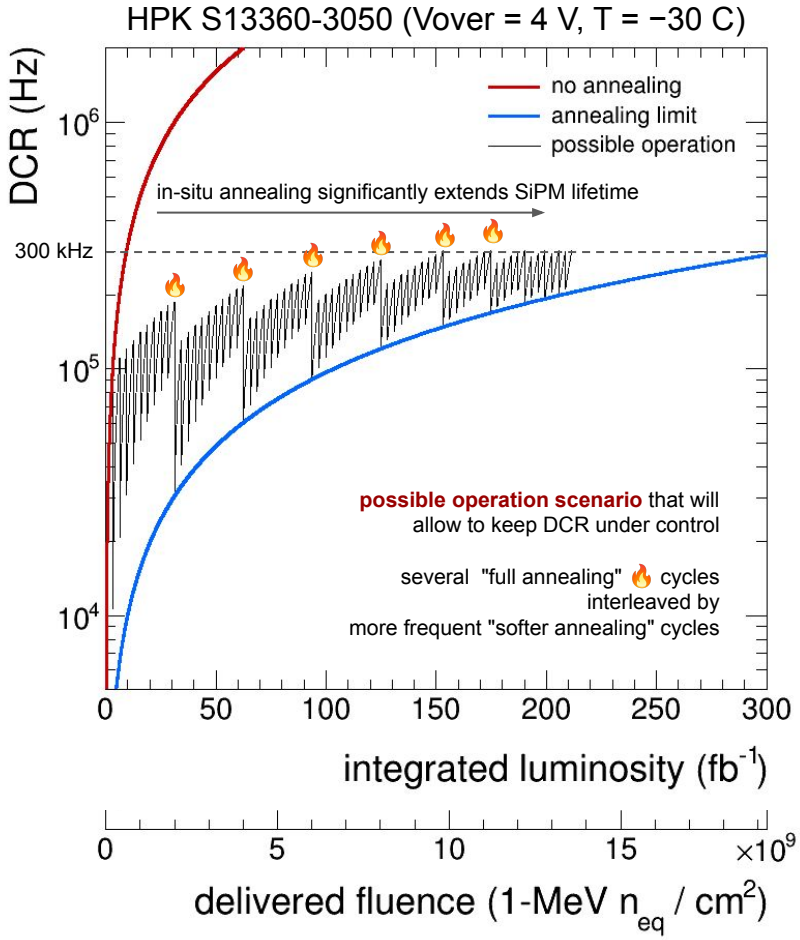
Radiation Level Estimates Update





max fluence = 6.38 10^7 neq/fb^{-1} at the location of dRICH photosensors

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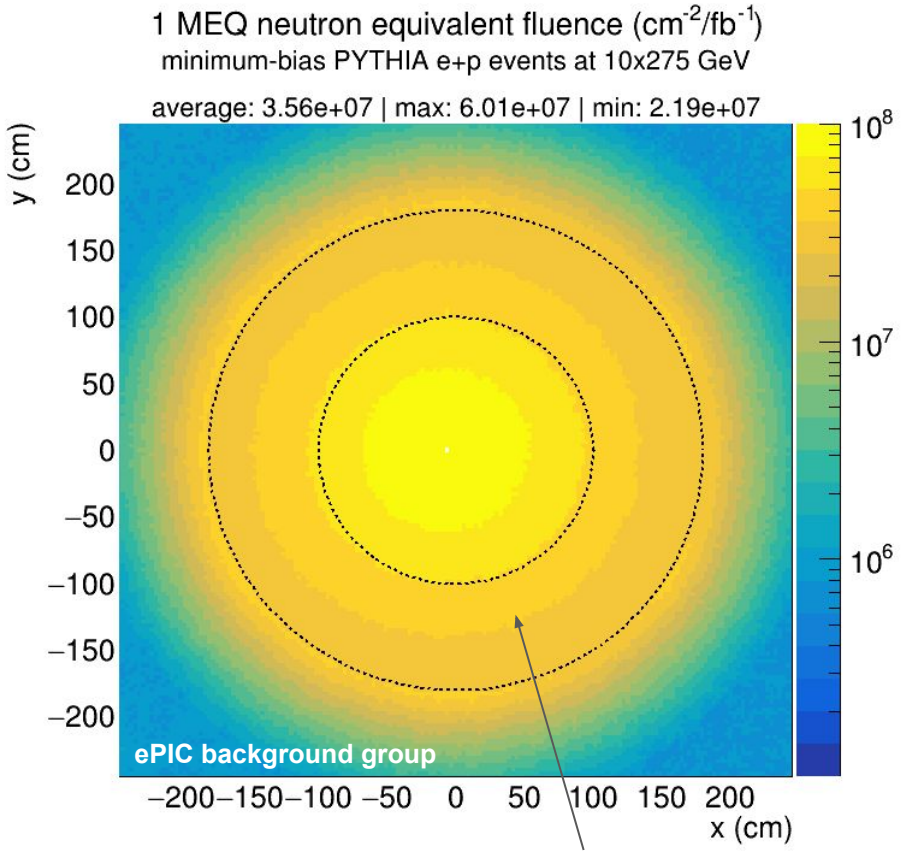
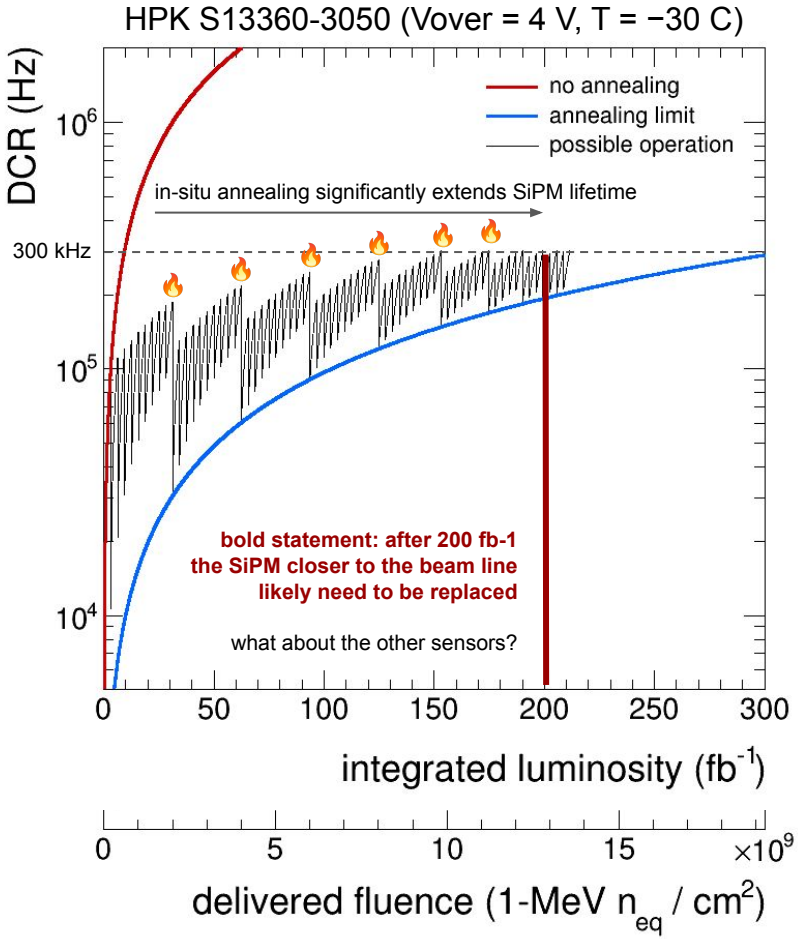
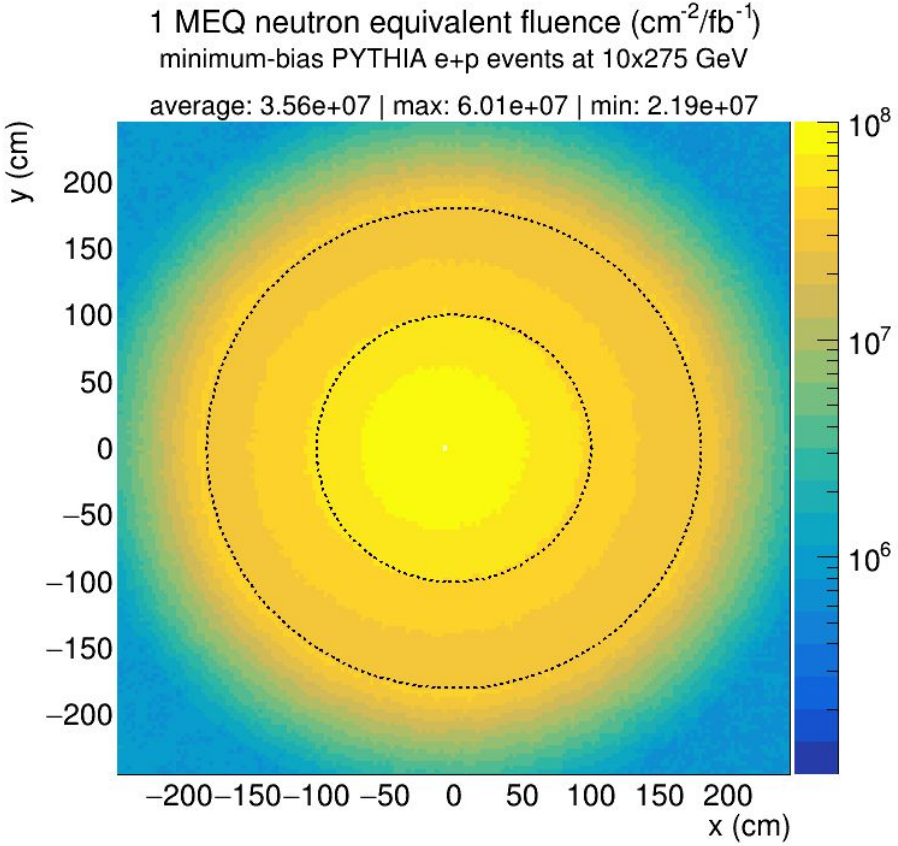
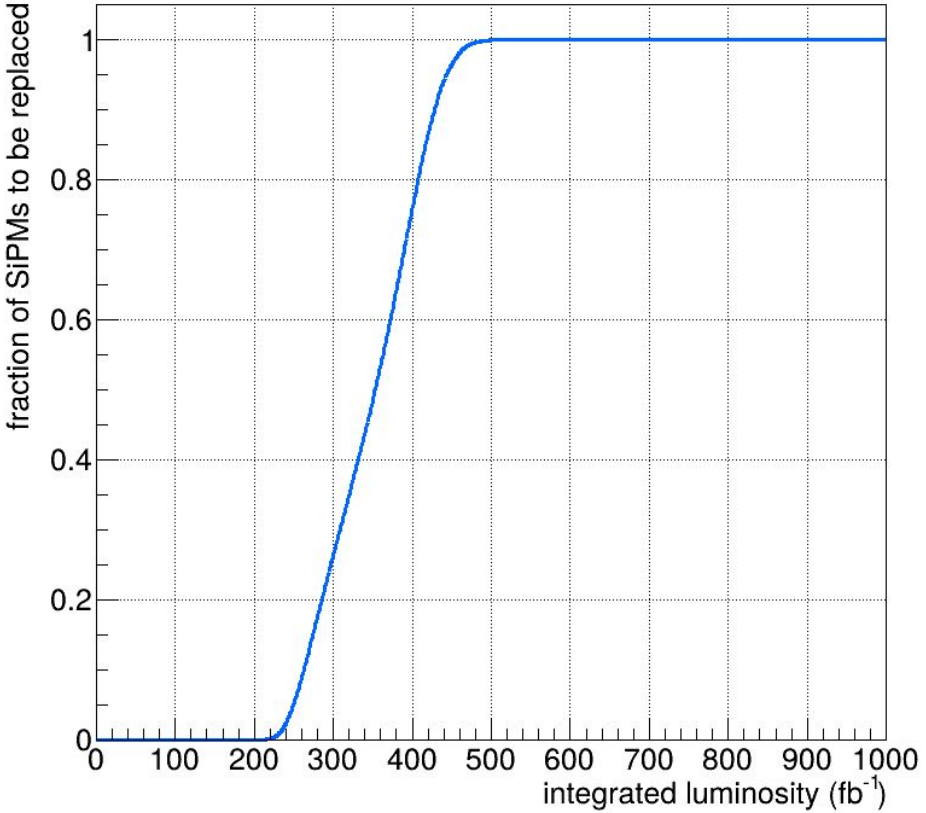




max fluence = 6.38 10^7 neq/fb^{-1} at the location of dRICH photosensors

the farther you go from the beamline, the longer the SiPM will survive. But still, after some point with the increase of the integrated luminosity, the fraction of SiPMs that will likely need to be replaced increases





how does this translate in years?

EIC a full capacity

from Elke's slides

Species	proton	electron	proton	electron	proton	electron	proton	electron	proton	electron
Energy [GeV]	275	18	275	10	100	10	100	5	41	5
CM energy [GeV]	140.7		104.9		63.2		44.7		28.6	
Bunch intensity [10^{10}]	19.1	6.2	6.9	17.2	6.9	17.2	4.8	17.2	2.6	13.3
No. of bunches	290		1160		1160		1160		1160	
Beam current [A]	0.69	0.227	1	2.5	1	2.5	0.69	2.5	0.38	1.93
RMS norm. emit., h/v [µm]	5.2/0.47	845/71	3.3/0.3	391/26	3.2/0.29	391/26	2.7/0.25	196/18	1.9/0.45	196/34
RMS emittance, h/v [nm]	18/1.6	24/2.0	11.3/1.0	20/1.3	30/2.7	20/1.3	26/2.3	20/1.8	44/10	20/3.5
β^*, h/v [cm]]	80/7.1	59/5.7	80/7.2	45/5.6	63/5.7	96/12	61/5.5	78/7.1	90/7.1	196/21.0
IP RMS beam size, h/v [µm]	119/11		95/8.5		138/12		125/11		198/27	
K_x	11.1		11.1		11.1		11.1		7.3	
RMS $\Delta\theta$, h/v [µrad]	150/150	202/187	119/119	211/152	220/220	145/105	206/206	160/160	220/380	101/129
BB parameter, h/v [10^{-3}]	3/3	93/100	12/12	72/100	12/12	72/100	14/14	100/100	15/9	53/42
RMS long. emittance [10^{-3}, eV·s]	36		36		21		21		11	
RMS bunch length [cm]	6	0.9	6	0.7	7	0.7	7	0.7	7.5	0.7
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9	6.8	5.8	9.7	5.8	9.7	6.8	10.3	6.8
Max. space charge	0.007	neglig.	0.004	neglig.	0.026	neglig.	0.021	neglig.	0.05	neglig.
Piwinski angle [rad]	6.3	2.1	7.9	2.4	6.3	1.8	7.0	2.0	4.2	1.1
Long. IBS time [h]	2.0		2.9		2.5		3.1		3.8	
Transv. IBS time [h]	2.0		2		2.0/4.0		2.0/4.0		3.4/2.1	
Hourglass factor H	0.91		0.94		0.90		0.88		0.93	
Luminosity [10^{33}cm^{-2}s^{-1}]	1.54		10.00		4.48		3.68		0.44	

These are the first 10 years of EIC a full capacity

from Elke's slides

Electron Energy			Hadron Energy		
5 GeV	10 GeV	18 GeV	41 GeV	100 GeV	275 GeV
3 years	~~3~~ 4 years	4 years	2 years	~~4~~ 3 years	~~4~~ 5 years

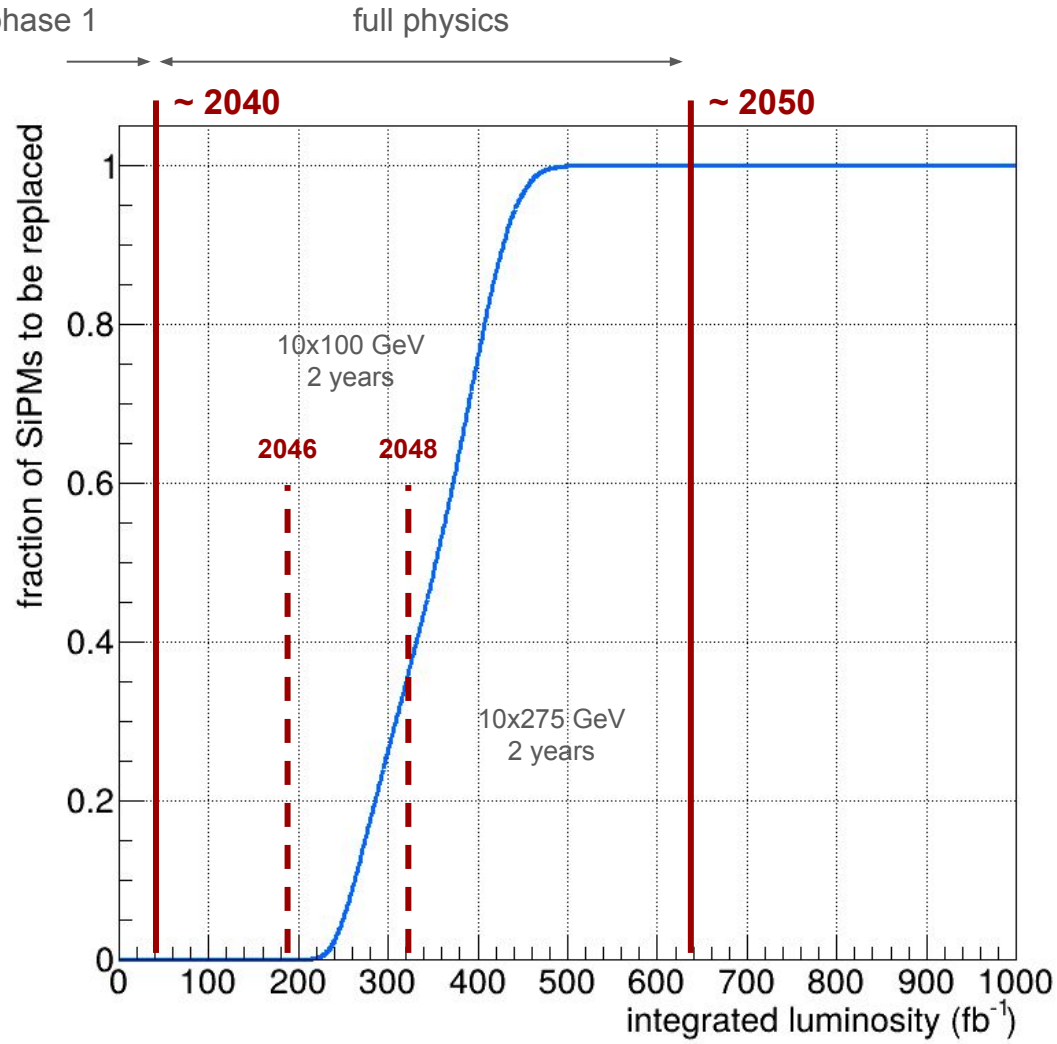
lumi = 0.44 10^{33} cm^{-2} s^{-1}	5 x 41 GeV --> 2 years	∫ lumi = 13.9 fb^{-1}
lumi = 3.68 10^{33} cm^{-2} s^{-1}	5 x 100 GeV --> 1 year	∫ lumi = 58.2 fb^{-1}
lumi = 4.48 10^{33} cm^{-2} s^{-1}	10 x 100 GeV --> 2 years	∫ lumi = 141.3 fb^{-1}
lumi = 10.00 10^{33} cm^{-2} s^{-1}	10 x 275 GeV --> 2 years	∫ lumi = 315.4 fb^{-1}
lumi = 1.54 10^{33} cm^{-2} s^{-1}	18 x 275 GeV --> 3 years	∫ lumi = 72.8 fb^{-1}

assumes 6 months/year
at top luminosity kept
at 100% duty time

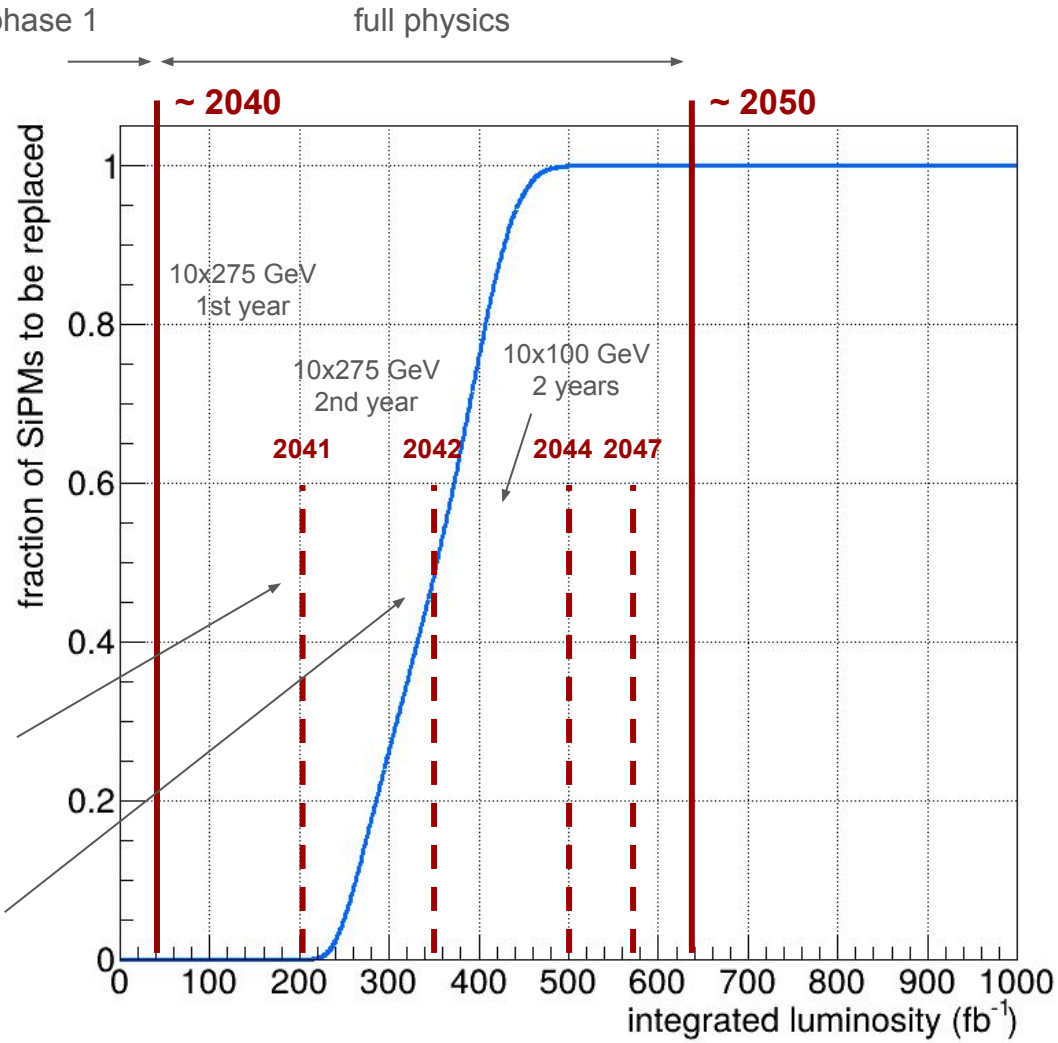
best-case scenario

we start with beam configurations that give the lowest luminosities

10x275 GeV running comes at the end



worst-case scenario



if we start with 10x275 GeV, after one year we might be here

after a second year we might need to replace ~ 50% of the SiPMs

Summary

- this is a very crude estimate
  - unlikely a real prediction yet
- assumption of 6 months / year at 100% duty cycle at full lumi
  - might be too much, might be overestimated (asked Elke)
- EIC Phase-1
  - will be relatively easy to reach 2040
- EIC full physics
  - if we start with ep at 1034 full steam, we might need to replace SiPMs in early 2040
  - if we start with combinations at lower luminosities, we might comfortably get up to 2045