



# Issue with SixTrack Post-Processing

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# Outline

1 Description

2 Fix

3 Impact

# Stacking Bugs...

- Combination of two issues:
  - issue in SixTrack where quickly-lost particles are not stored
  - post-processing in SixDB (and common other tools) defines DA as **first unstable** particle instead of **last stable**
- In the presence of disconnected stable islands, this can lead to a (potentially severe) over-estimation of the DA

# Zeroed-Out Lines in Fort.10

- SixTrack writes intermediate tracking data to file regularly (controlled by the `writebin1` parameter in SixDesk)
- If particle lost, all info is lost as well, i.e. all columns in fort.10 are zero for the row corresponding to that particle.
- Well-known issue, workarounds are used

# Zeroed-Out Lines in Fort. 10

fort.10

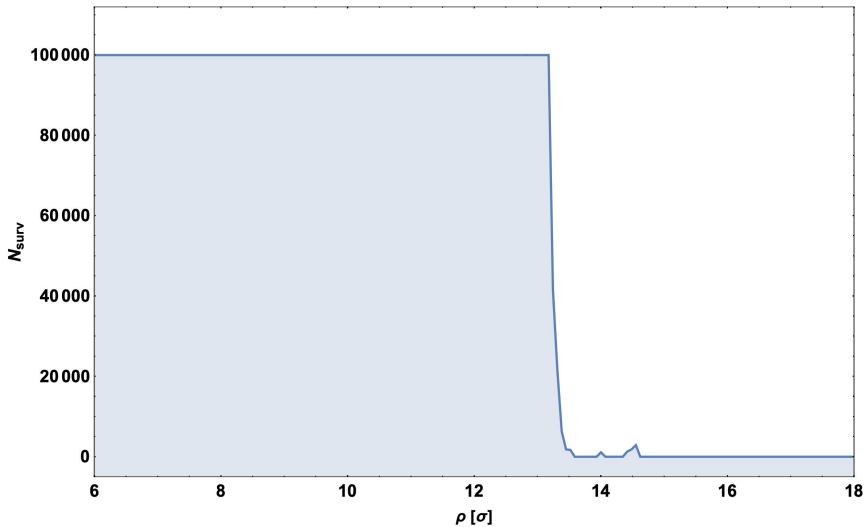
	Nmax	Stability	Qx	Qy	Betax	Betay	Ampx (1)	Ampy (1)	delta	distance	slope	d0x	spread	d0y	spread	resx
1	100000	0	62.3098	60.3198	117.662	220.433	0.32650	3.23583	2.70E-04	2.54E-04	7.28E-01	-9.31E-02	2.86E-02	-3.79E-01	7.80E-03	9.00
2	100000	0	62.3098	60.3198	117.662	220.433	0.32837	3.25442	2.70E-04	1.12E-04	7.94E-01	-9.53E-02	2.79E-02	-4.01E-01	7.82E-03	2.00
3	100000	0	62.3098	60.3198	117.662	220.433	0.33025	3.27302	2.70E-04	1.45E-04	9.47E-01	-1.12E-01	3.15E-02	-4.13E-01	7.84E-03	6.00
4	100000	0	62.3098	60.3198	117.662	220.433	0.33213	3.29162	2.70E-04	4.76E-05	-1.52E+00	-1.68E-01	3.78E-02	-4.12E-01	7.41E-03	2.00
5	100000	0	62.3098	60.3198	117.662	220.433	0.33400	3.31021	2.70E-04	1.99E-03	2.24E+00	-4.03E-01	2.98E-02	-3.29E-01	1.08E-02	1.00
6	100000	0	62.3098	60.3198	117.662	220.433	0.33588	3.32881	2.70E-04	2.10E-04	9.87E-01	-1.77E-01	3.68E-02	-4.62E-01	7.79E-03	0
7	100000	0	62.3098	60.3198	117.662	220.433	0.33775	3.34741	2.70E-04	2.43E-05	3.63E-01	-9.56E-02	2.76E-02	-5.07E-01	7.75E-03	2.00
8	100000	0	62.3098	60.3198	117.662	220.433	0.33963	3.36600	2.70E-04	8.35E-05	1.44E+00	-1.13E-01	2.49E-02	-5.35E-01	7.69E-03	4.00
9	100000	0	62.3098	60.3198	117.662	220.433	0.34151	3.38460	2.70E-04	1.84E-04	2.55E+00	-8.42E-02	1.85E-02	-5.52E-01	7.32E-03	1.00
10	100000	0	62.3098	60.3198	117.662	220.433	0.34338	3.40320	2.70E-04	3.53E-01	4.98E+00	-1.92E-01	2.59E-02	-5.46E-01	8.23E-03	2.00
11	100000	0	62.3098	60.3198	117.662	220.433	0.34526	3.42179	2.70E-04	3.15E-01	1.31E+00	-2.57E-01	2.58E-02	-5.43E-01	8.85E-03	2.00
12	100000	0	62.3098	60.3198	117.662	220.433	0.34714	3.44039	2.70E-04	4.37E-01	6.05E-01	-2.59E-01	2.47E-02	-5.51E-01	8.43E-03	6.00
13	100000	0	62.3098	60.3198	117.662	220.433	0.34901	3.45899	2.70E-04	3.74E-01	7.08E-01	-2.00E-01	2.38E-02	-5.64E-01	9.38E-03	2.00
14	100000	0	62.3098	60.3198	117.662	220.433	0.35089	3.47759	2.70E-04	5.30E-01	5.26E-01	-3.05E-01	2.59E-02	-5.47E-01	1.00E-02	1.00
15	100000	0	62.3098	60.3198	117.662	220.433	0.35277	3.49618	2.70E-04	4.52E-01	3.86E-01	-2.79E-01	2.87E-02	-5.32E-01	1.10E-02	7.00
16	100000	0	62.3098	60.3198	117.662	220.433	0.35464	3.51478	2.70E-04	5.34E-01	6.03E-01	-2.82E-01	2.47E-02	-5.47E-01	9.34E-03	5.00
17	100000	0	62.3098	60.3198	117.662	220.433	0.35652	3.53338	2.70E-04	5.37E-01	5.30E-01	-3.18E-01	2.73E-02	-5.63E-01	8.54E-03	3.00
18	100000	0	62.3098	60.3198	117.662	220.433	0.35840	3.55197	2.70E-04	4.80E-01	2.40E-01	-3.32E-01	2.44E-02	-5.38E-01	1.15E-02	4.00
19	100000	0	62.3098	60.3198	117.662	220.433	0.36027	3.57057	2.70E-04	4.53E-01	3.03E-01	-2.51E-01	2.80E-02	-4.08E-01	2.41E-02	3.00
20	100000	0	62.3098	60.3198	117.662	220.433	0.36215	3.58917	2.70E-04	5.21E-01	3.88E-01	-2.57E-01	3.14E-02	-4.72E-01	2.44E-02	3.00
21	100000	0	62.3098	60.3198	117.662	220.433	0.36402	3.60776	2.70E-04	4.05E-01	4.00E-01	-4.02E-01	2.80E-02	-4.77E-01	2.30E-02	4.00
22	100000	0	62.3098	60.3198	117.662	220.433	0.36590	3.62636	2.70E-04	4.36E-01	3.77E-01	-3.64E-01	2.88E-02	-4.51E-01	2.35E-02	1.00
23	100000	0	62.3098	60.3198	117.662	220.433	0.36778	3.64496	2.70E-04	3.53E-01	4.55E-02	-3.52E-01	1.49E-02	-6.13E-01	1.48E-02	7.00
24	100000	0	62.3098	60.3198	117.662	220.433	0.36965	3.66355	2.70E-04	4.37E-01	7.62E-02	-3.48E-01	2.69E-02	-4.13E-01	2.38E-02	5.00
25	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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# Post-Processing in SixDB

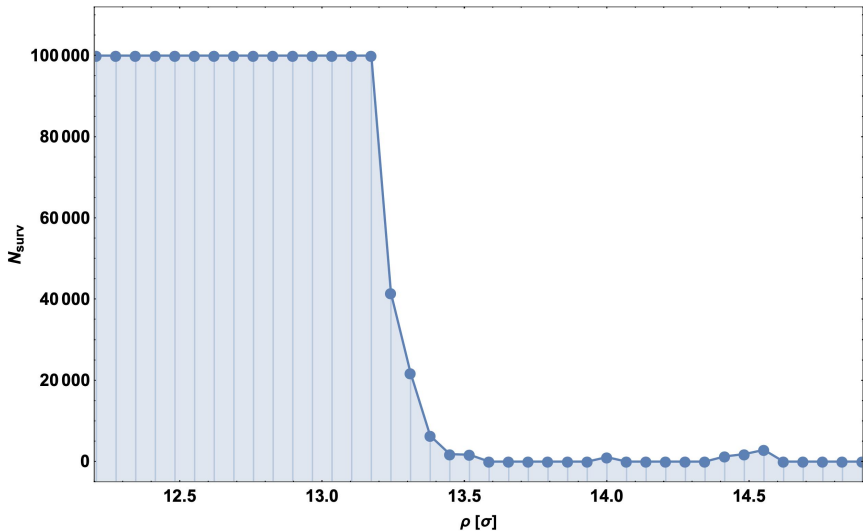
- DA is scanned over a polar grid:
  - angle-by-angle
  - in equal amplitude steps
- DA is defined as the phase-space volume that exhibits stable motion
- Hence, last stable particle per angle should be selected
- However, in SixDB the first unstable particle is used

# Post-Processing in SixDB

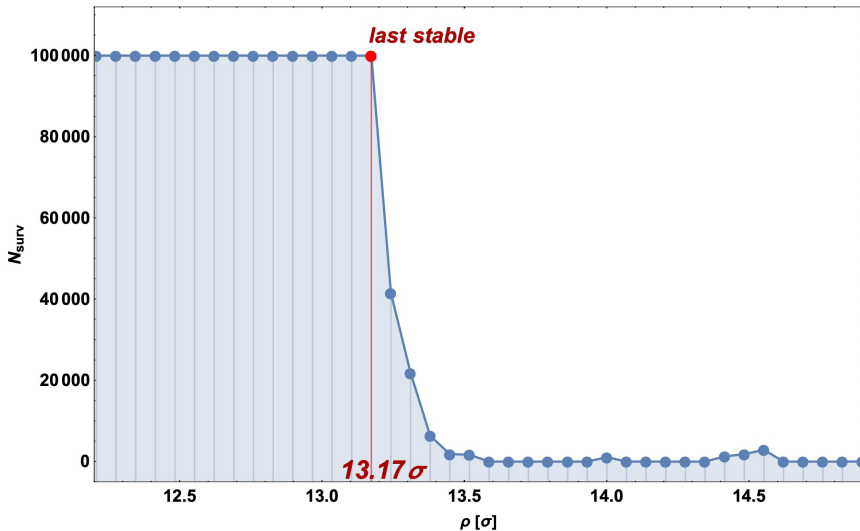




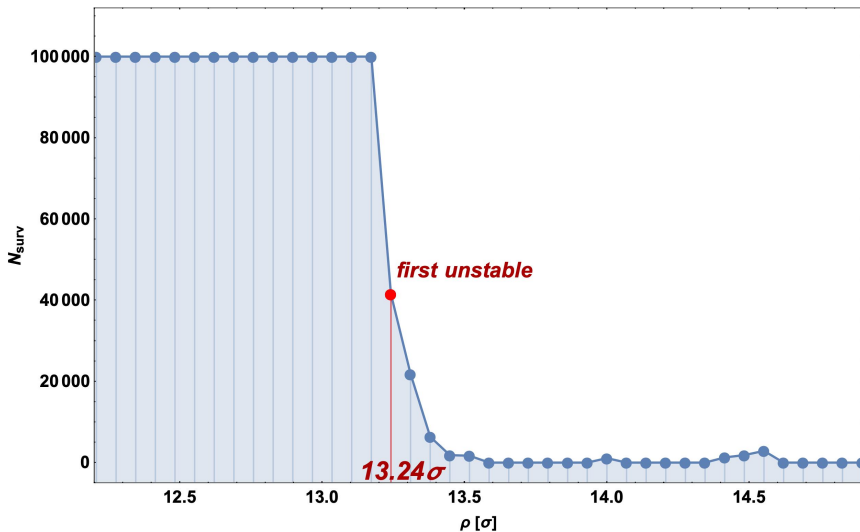
# Post-Processing in SixDB



# Post-Processing in SixDB



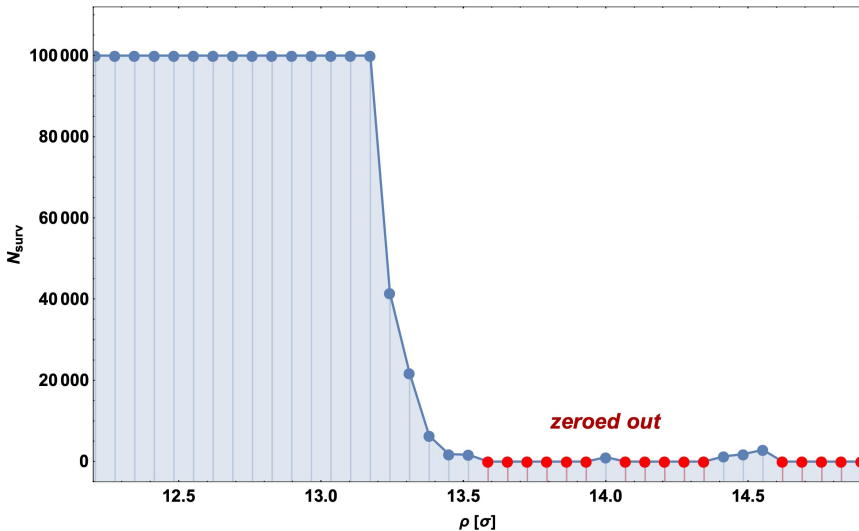
# Post-Processing in SixDB



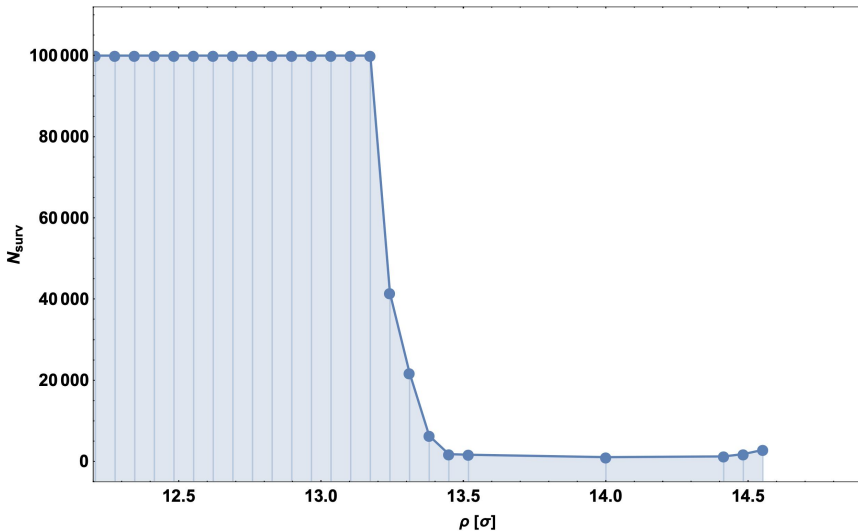
# Post-Processing in SixDB

- Amplitude is calculated from the action as given in fort.10
- Zero entries have also zero action  $\Rightarrow$  no value for amplitude

# Post-Processing in SixDB



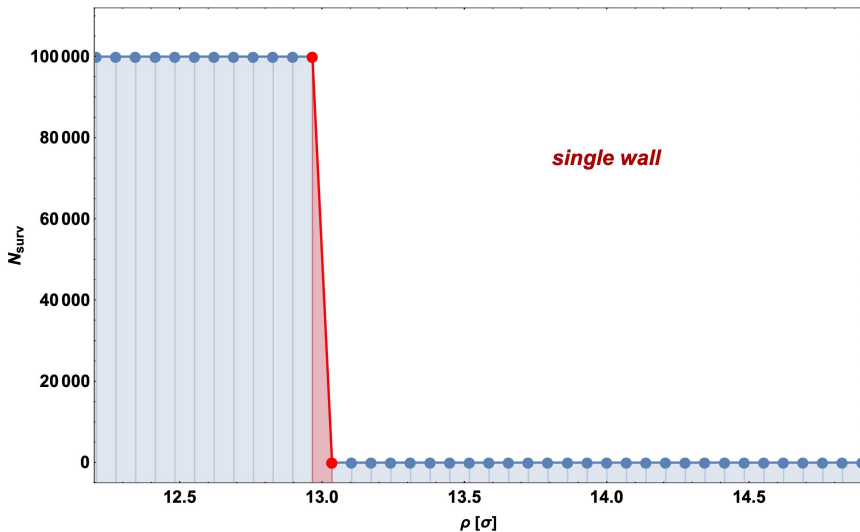
# Post-Processing in SixDB



# Walls

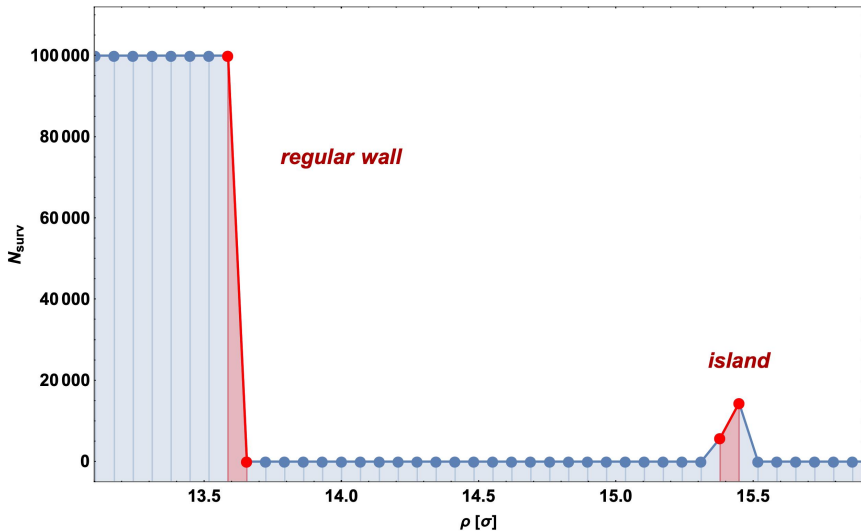
- Wall: particle stability drops from  $N_{\max}$  to 0 in one amplitude step
- Three types:
  - Single Wall: all particles at higher amplitude are also lost
  - Regular Wall: some particles at higher amplitude survive (islands)
  - Double Wall: only one particle lost, next amplitude step: back to  $N_{\max}$
- Single walls are interesting for physics
- Regular walls are sensitive to issue
- Double walls are probably numerical error or software issue

# Walls

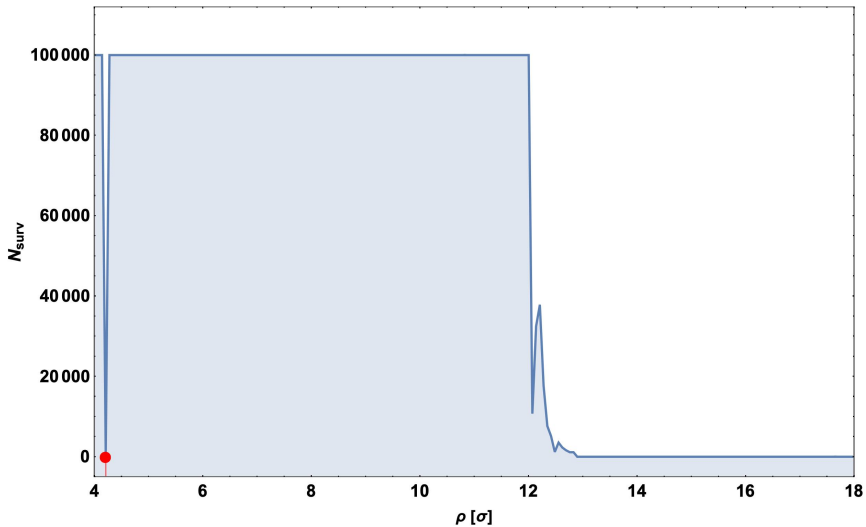




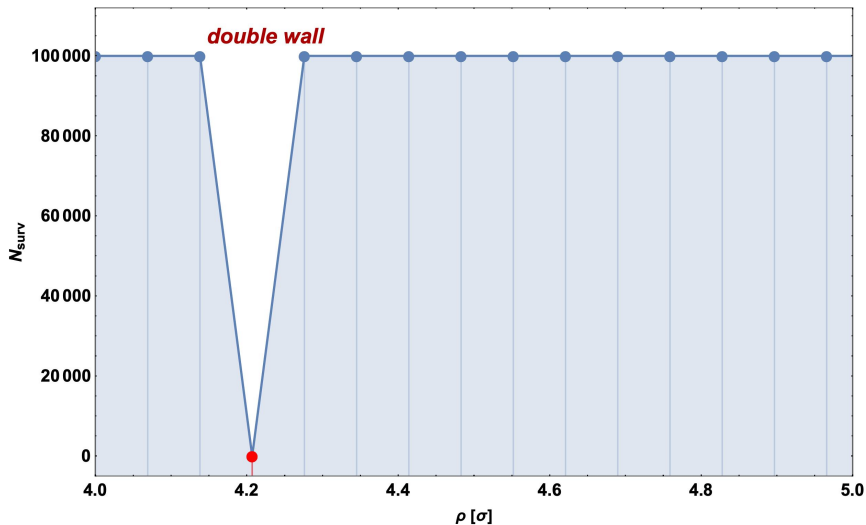
# Walls



# Walls



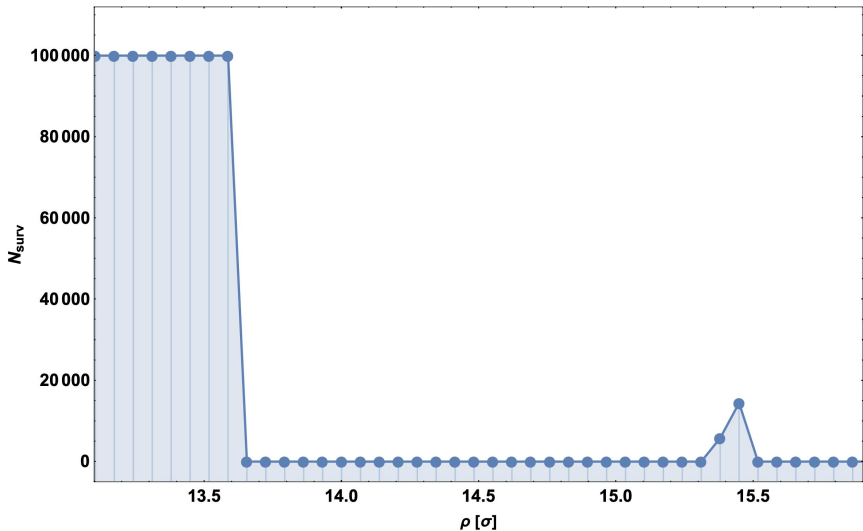
# Walls



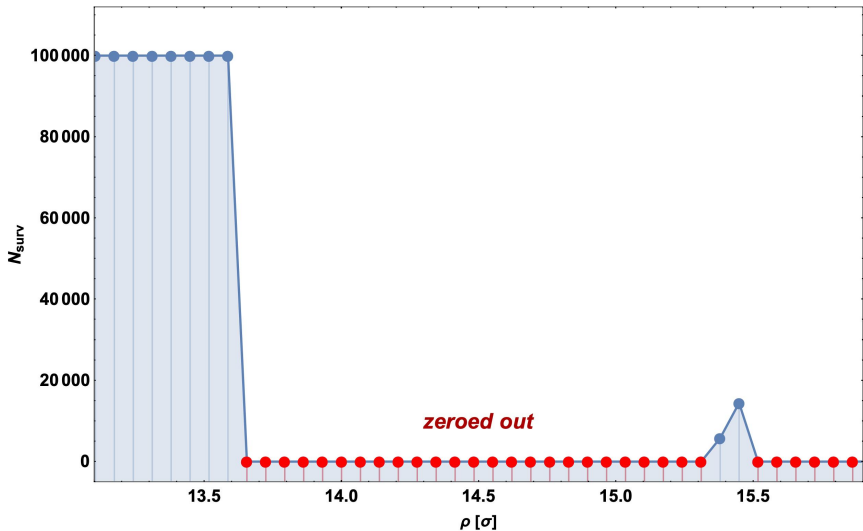
# Issues with Walls

- Regular walls:
  - SixTrack zeros out all lost particles
  - SixDB takes first unstable, but this will be much further away
  - biggest issue
- Single walls:
  - SixDB deals with these walls automatically
  - though will assign last stable instead of first unstable
  - inconsistency with other points
- Double walls:
  - SixDB deals with these walls automatically
  - because lost particle is removed

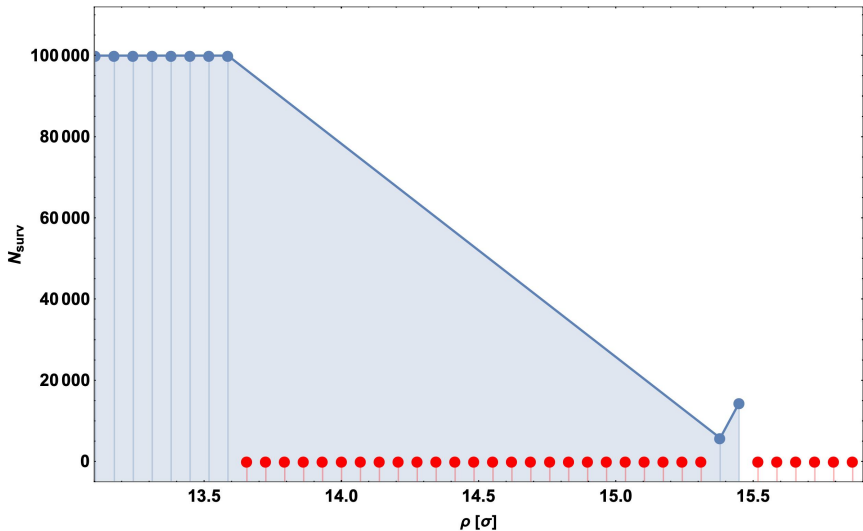
# Issues with Walls



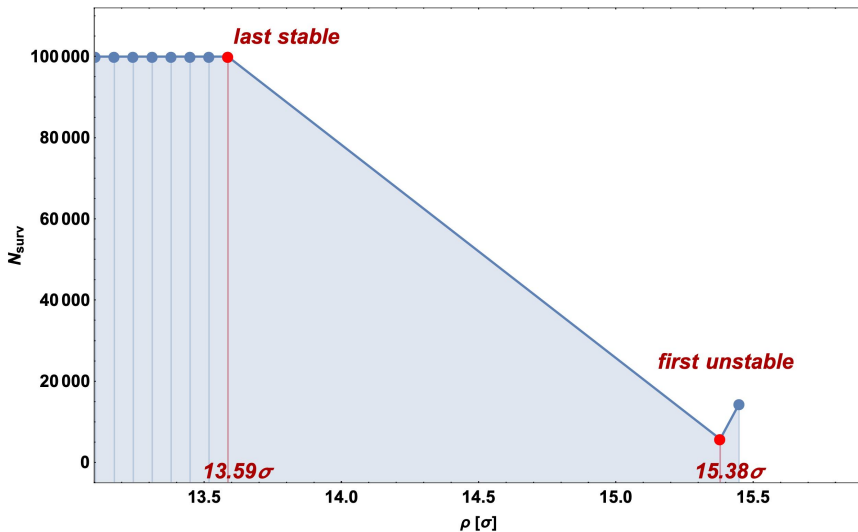
# Issues with Walls



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# Issues with Walls





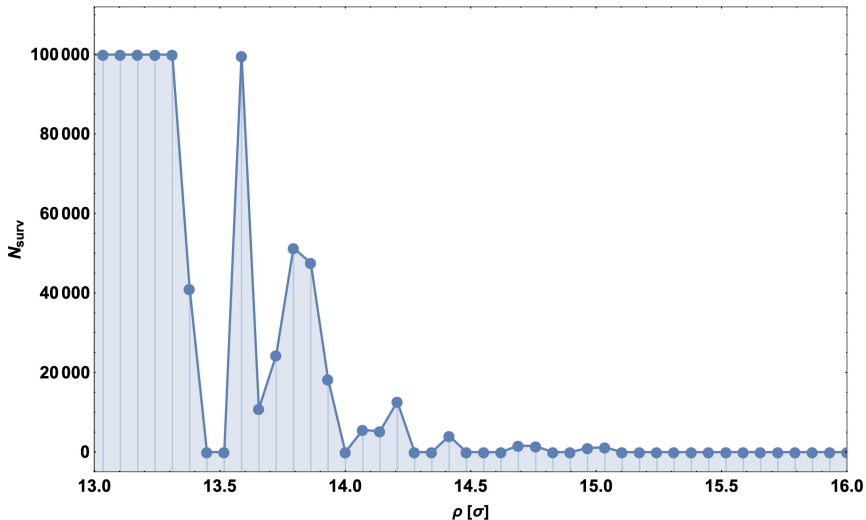
# Issues with Walls

- For this example, overestimation of  $1.79\sigma$ !
- For this particular angle and seed
- Of course not every seed and angle have walls

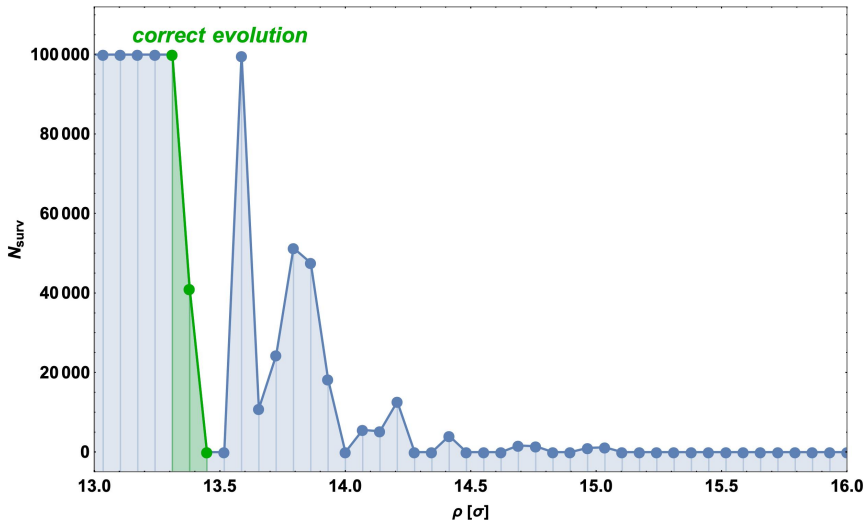
# Impact on Evolution of DA

- So far, discussed situation for **final** DA (i.e. at  $N_{\max}$  turns), where walls are defined as jump from  $N_{\max}$  to 0
- But when looking at DA evolution, **every** jump to 0 is like a wall, because evolution should have stopped at first 0, but it will continue as long as there are islands

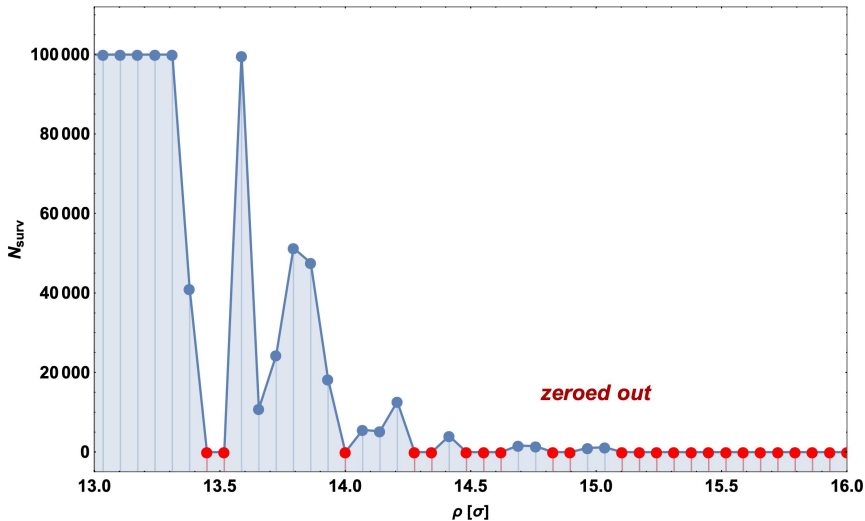
# Impact on Evolution of DA



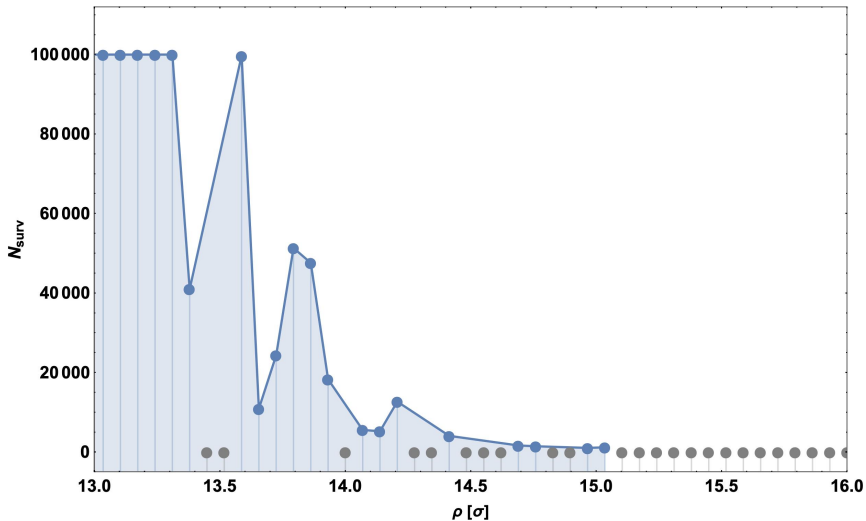
# Impact on Evolution of DA



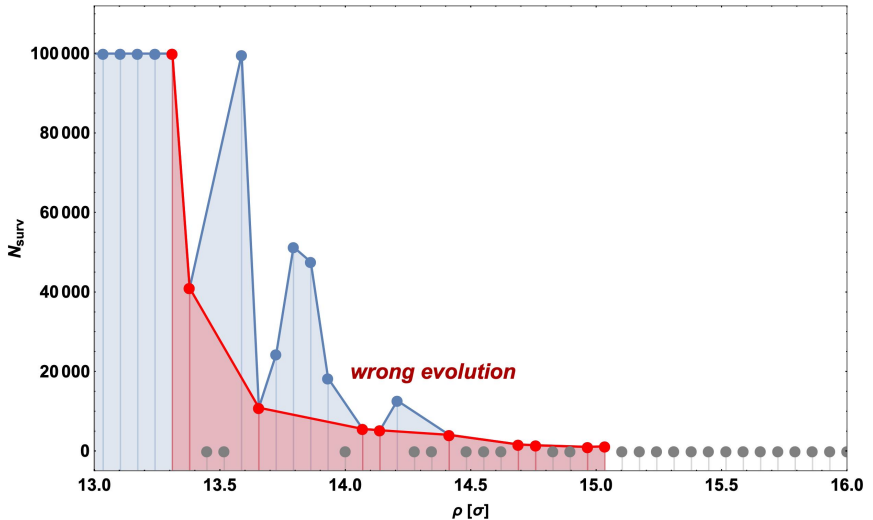
# Impact on Evolution of DA



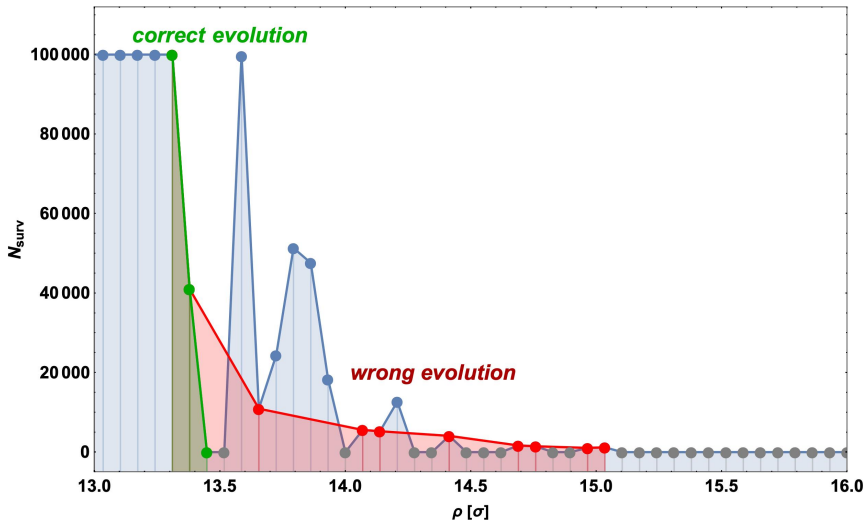
# Impact on Evolution of DA



# Impact on Evolution of DA



# Impact on Evolution of DA





# Outline

1 Description

2 **Fix**

3 Impact

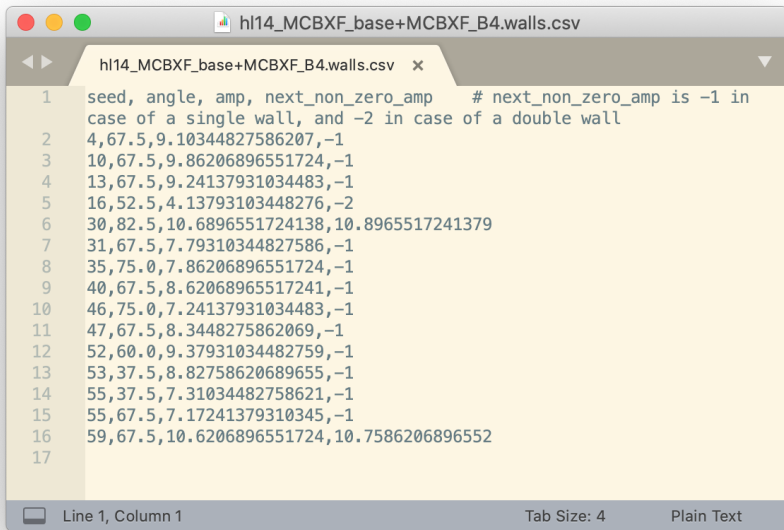
# Fix in SixDB

- Riccardo implemented a quick fix in SixDB (latest version on GitHub)
- Will be implemented in SixDesk soon
- Comments:
  - only way to implement it consistently, was to use **last stable** particle as definition for DA
  - hence breaks backwards compatibility!  
(in most cases, DA goes down by one amplitude step)
  - single and regular walls are no longer an issue, but now **double walls** are a problem!
  - as the latter are expected to be a hardware/file system error, these should be manually found and that job resubmitted
  - evolution of DA is not fixed yet

# Verify Existing Studies

- `CheckForWalls.sh` on EOS, to test if studies are affected  
`/eos/project/d/da-and-diffusion-studies/DA_Studies/Simulations/`
- Argument is `*.db` file, e.g.  
`./CheckForWalls.sh h114_MCBXF_base+MCBXF_B4.db`  
(first need to run `DBtoCSV.sh` to generate additional `*.csv`)
- Script generates `*.walls.csv` that gives a list of walls by seed, angle, and amplitude
- Single walls are tagged with `-1`, double walls with `-2`
- Regular walls are tagged by next stable particle (start of island) as to estimate the impact

# Verify Existing Studies



```
hl14_MCBXF_base+MCBXF_B4.walls.csv x
1 seed, angle, amp, next_non_zero_amp # next_non_zero_amp is -1 in
  case of a single wall, and -2 in case of a double wall
2 4,67.5,9.10344827586207,-1
3 10,67.5,9.86206896551724,-1
4 13,67.5,9.24137931034483,-1
5 16,52.5,4.13793103448276,-2
6 30,82.5,10.6896551724138,10.8965517241379
7 31,67.5,7.79310344827586,-1
8 35,75.0,7.86206896551724,-1
9 40,67.5,8.62068965517241,-1
10 46,75.0,7.24137931034483,-1
11 47,67.5,8.3448275862069,-1
12 52,60.0,9.37931034482759,-1
13 53,37.5,8.82758620689655,-1
14 55,37.5,7.31034482758621,-1
15 55,67.5,7.17241379310345,-1
16 59,67.5,10.6206896551724,10.7586206896552
17
```

Line 1, Column 1 Tab Size: 4 Plain Text

# Verify Existing Studies

- Potential issues:
  - walls are defined as a jump from  $N_{\max}$  to 0
  - hence only recognises issues with final DA (**not evolution**)
  - bash seems to be less reliable (in particular paste command)... If no walls found, retry later to be sure

# Outline

1 Description

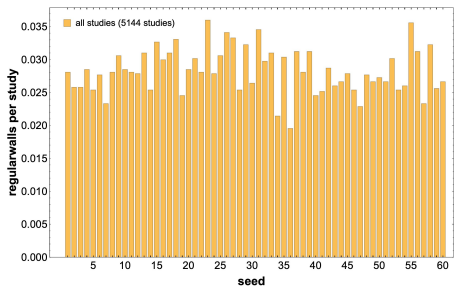
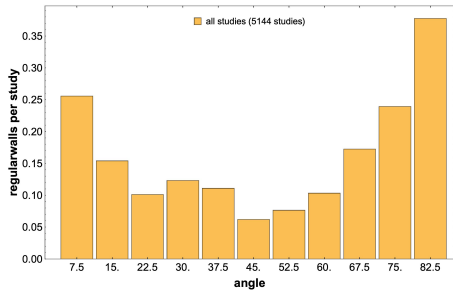
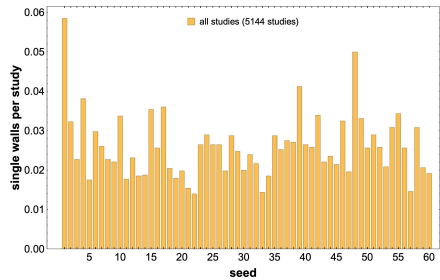
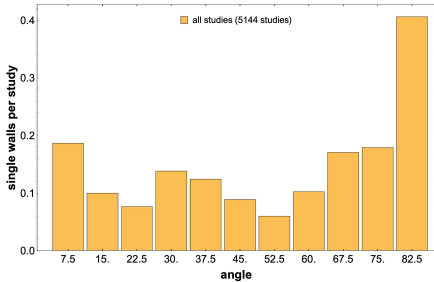
2 Fix

**3 Impact**

# Impact on Previous Studies

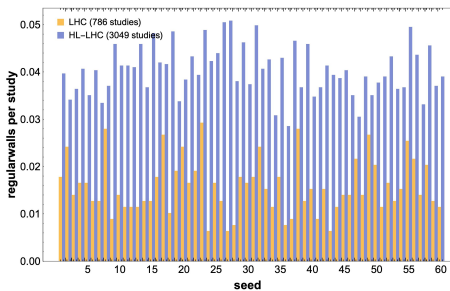
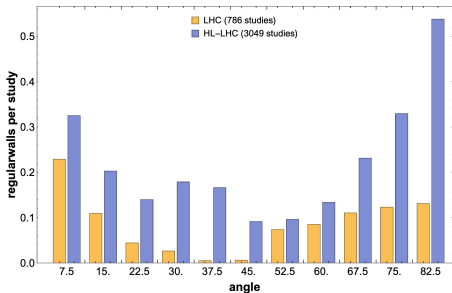
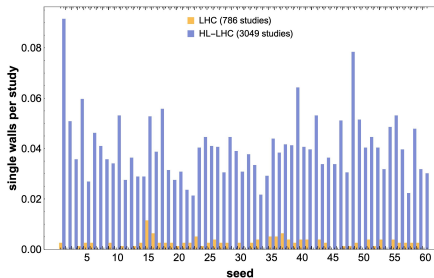
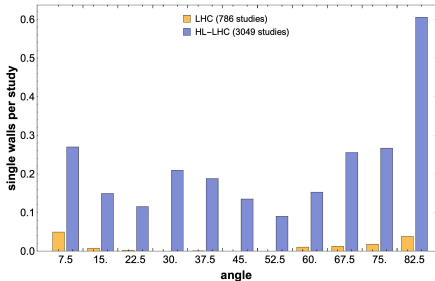
- Focus on impact on final DA (**not evolution**)
- Verified all \*.db's on EOS (5 145 studies)
- Found 24 991 walls, of which
  - 12 164 single walls
  - 225 double walls
  - 12 602 regular (possibly problematic) walls
- Investigate distribution of walls for seed, angle, type
- Investigate overestimation of  $DA_{\min}$  and  $DA_{av}$

# All Studies

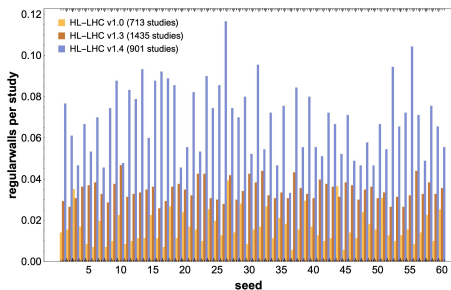
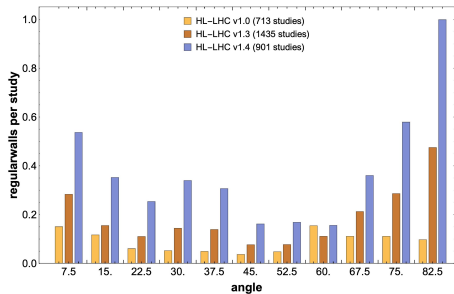
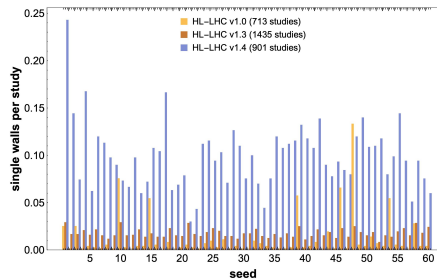
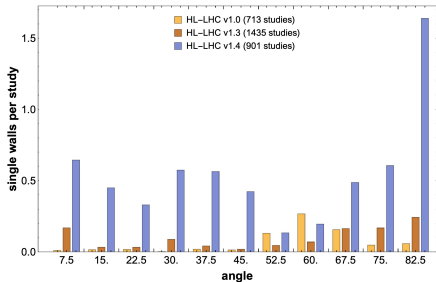




# LHC vs HL-LHC



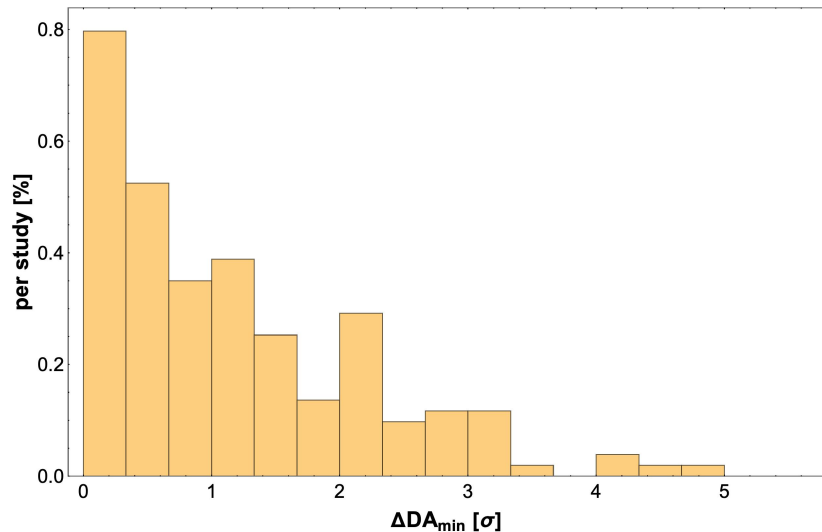
# HL-LHC Optics



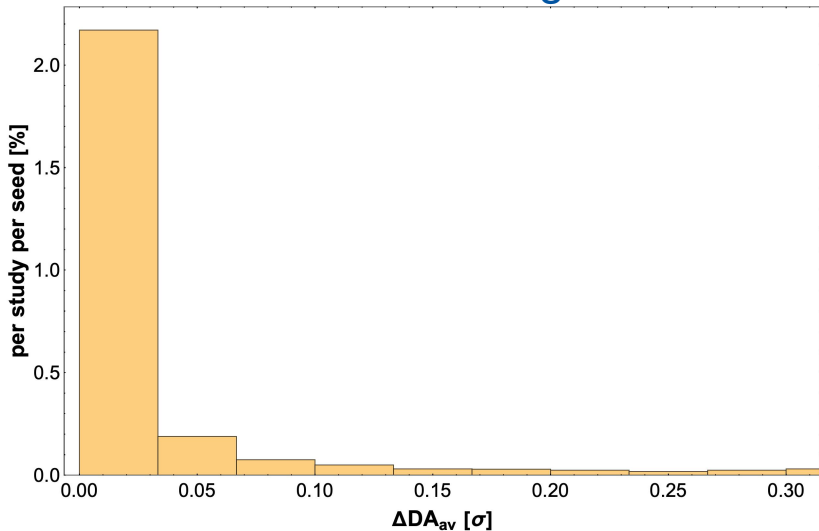
# Walls in Previous Studies

- Most walls (both single and regular) in:
  - high angles
  - HL-LHC
  - optics v1.4
- Check impact on DA (only taking into account the effect of walls, not the difference last stable vs first unstable)

# Overestimation of Minimum DA



# Overestimation of Average DA



# Impact on DA

- Impact on  $DA_{av}$  is negligible: around 2% of studies\*seeds (a bit more than 1% of studies) have overestimation of  $0.025\sigma$
- Impact on  $DA_{min}$  is weak, with around 2% of studies having an overestimation of  $0.5\sigma$ , and very few studies with a higher overestimation
- Those extreme cases are probably due to double walls (not yet implemented)

# Conclusion

- Nasty bug was found due to combination of a specific feature in SixTrack and issue in SixDB
- Strong impact on DA evolution with turn (in presence of islands)
- Weak impact on final DA
- Fix implemented in SixDB (latest version on GitHub)
- Will be pushed to SixDesk
- Double walls still need to be taken into consideration

# Thank you for your attention!

