

Uncordinated egress An experiment

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The Kiss nightclub tragedy

- 27th January 2013, Santa Maria, Brazil
- fireworks on flammable sound insulation
- obstacles, bad signaling and inappropriate doors
- doors blocked by people
- result: 242 deaths



Lessons Learned

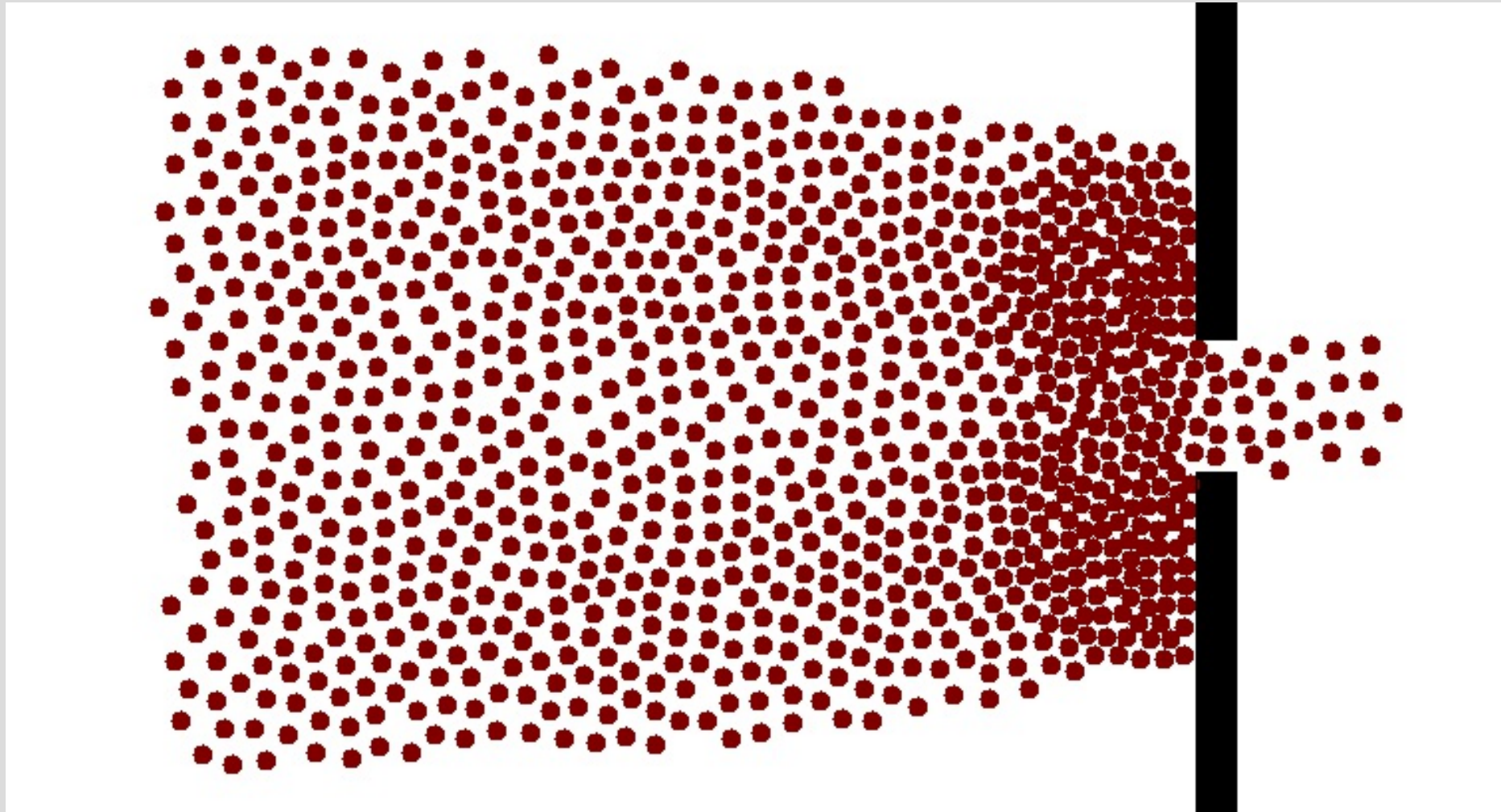
- later on 2013, Santa Catarina Military Fire Department launched new fire safety code
- requirements for nightclubs:
 - fireworks prohibited
 - flammable insulation prohibited
 - population density up to $2/\text{m}^2$
 - doors width calculated for allowed population
- **Problem: are the calculus safe for an uncoordinated egress?**

Uncoordinated Egress Model

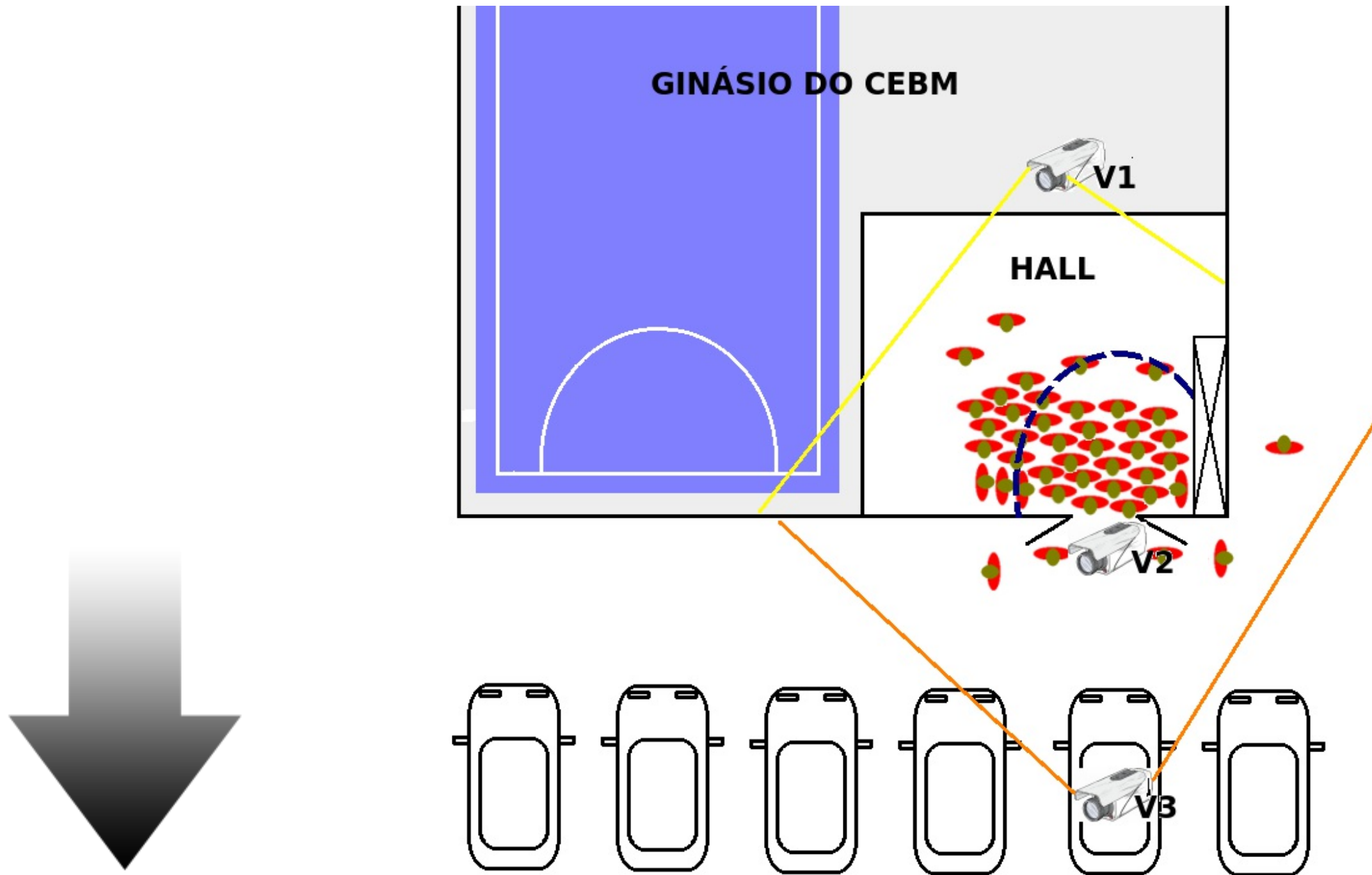
- “Simulating Dynamical Features of Escape Panic.” by Helbing, Farkas, and Vicsek (Nature 407):
 - people move faster and start pushing
 - moving becomes uncoordinated (**turbulence**)
 - **arching and clogging at exits**
 - jams build up, pressures become dangerous
 - escape is further slowed by fallen or injured people
 - people show a tendency towards mass behaviour;
 - alternative exits are often overlooked or not efficiently used.



“Panic Package”



Experiment



Videos

V1



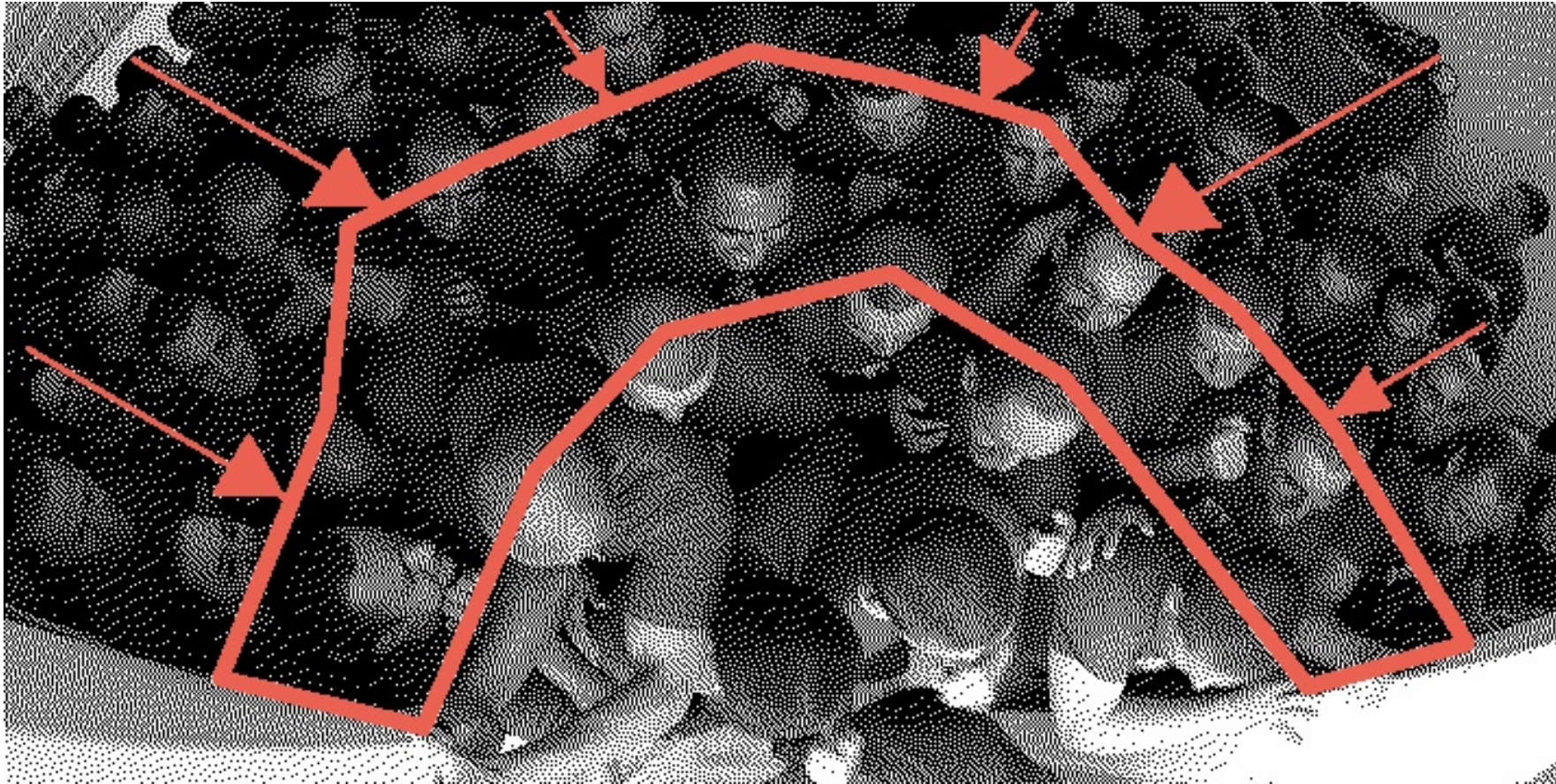
V2



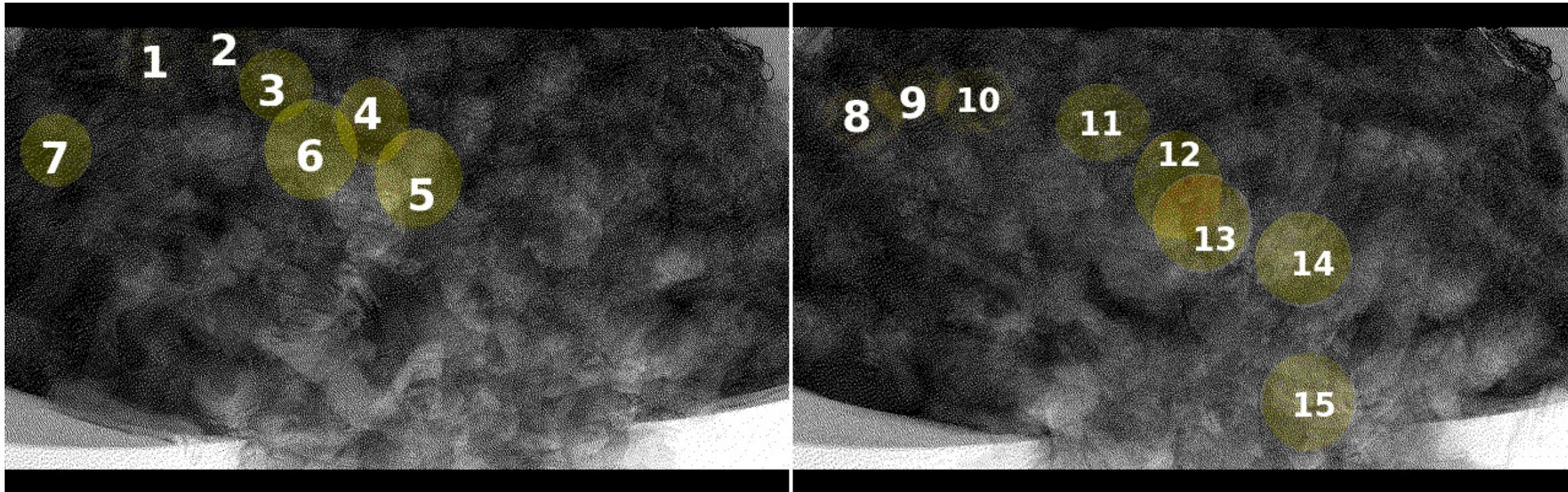
V3

<https://youtu.be/E2WNhcgIzuQ>

Arch



Crowd Turbulence



<https://youtu.be/h72-I5E96uU>

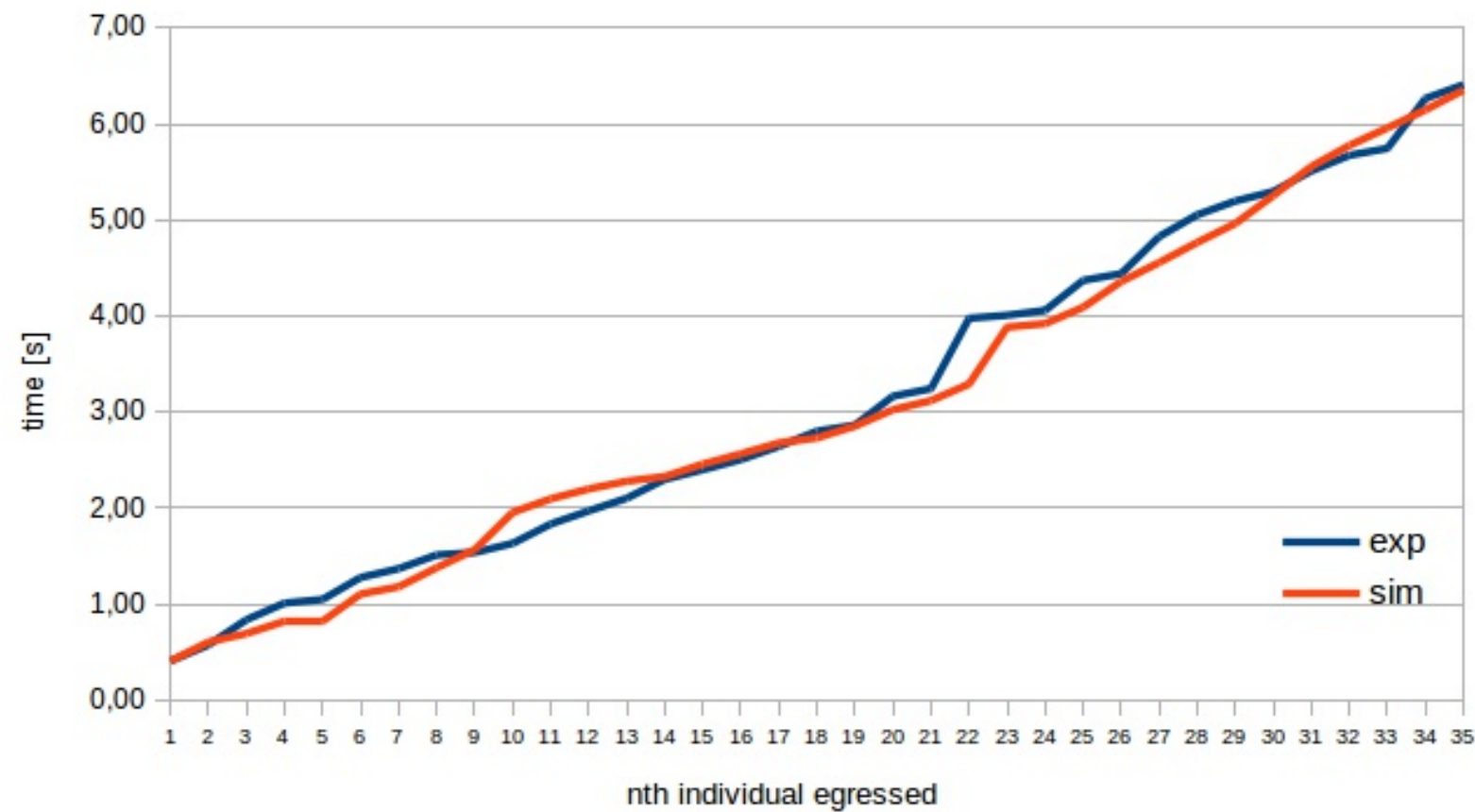
Egress time and flow

initial population	experiment		IN 09	
	uncoordinated egress		coordinated egress	
	time s	mean flow s^{-1}	time s	mean flow s^{-1}
35	6.41	5.46	10.50	3,33
70	17.25	4.06	21.00	3,33
105	26.95	3.90	31.50	3,33
140	36.61	3.82	42.00	3,33
175	54.55	3.19	52.50	3,33
210	73.26	2.87	63.00	3,33
280	85.00	3.29	84.00	3,33

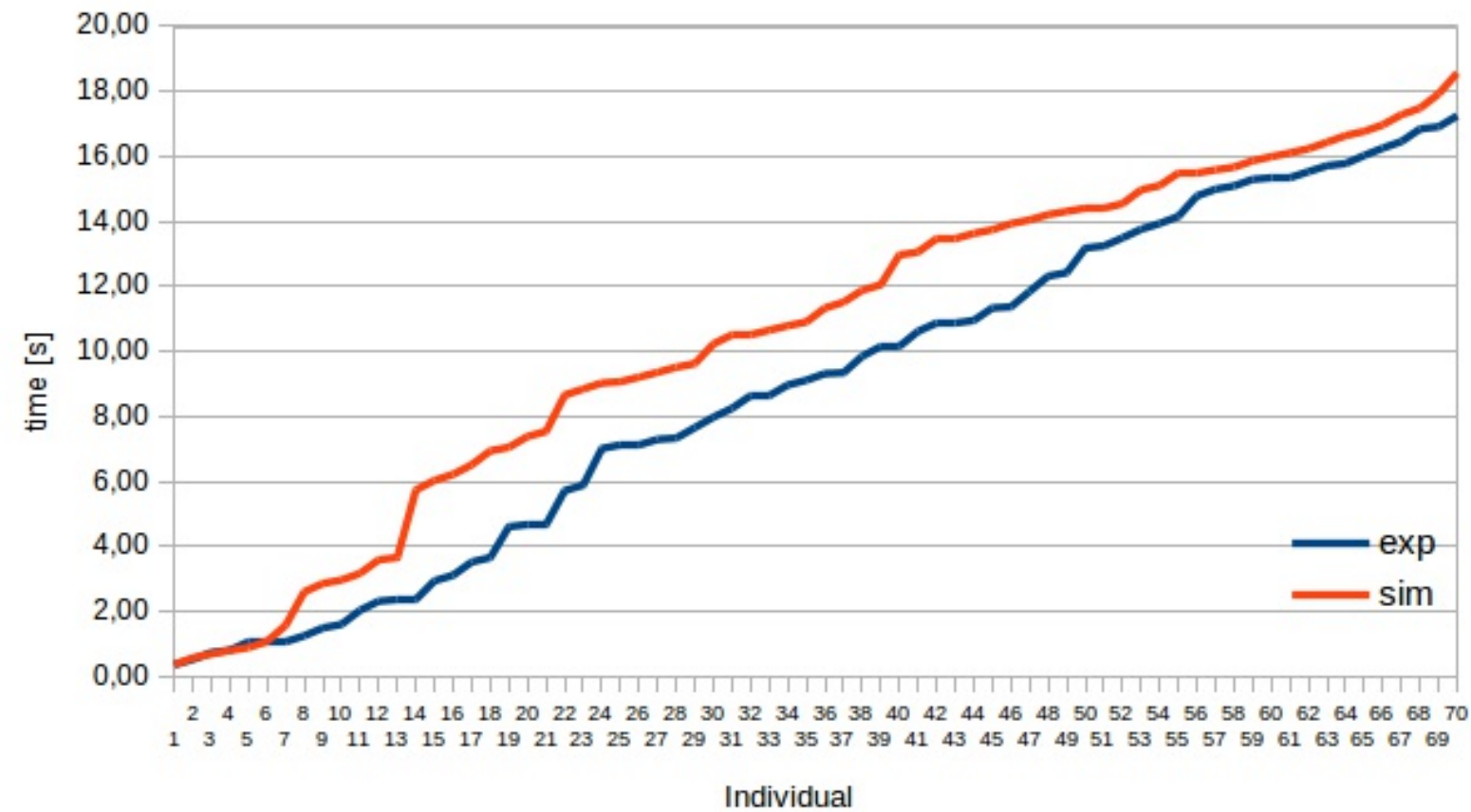
Table 1. Egress time and mean flow versus population

Simulation Results

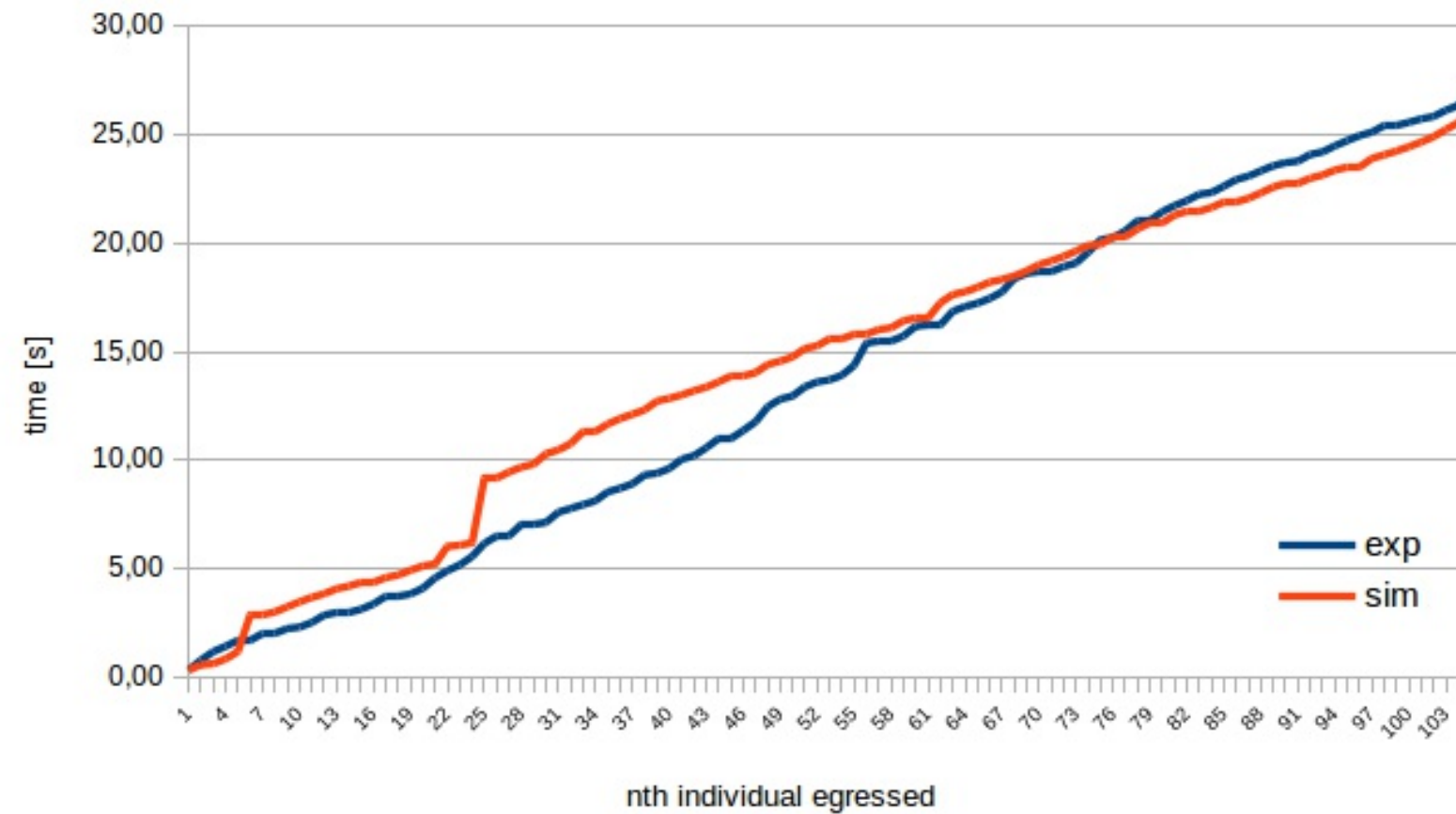
- Experiment versus Simulation: 35 or 0.5/m²



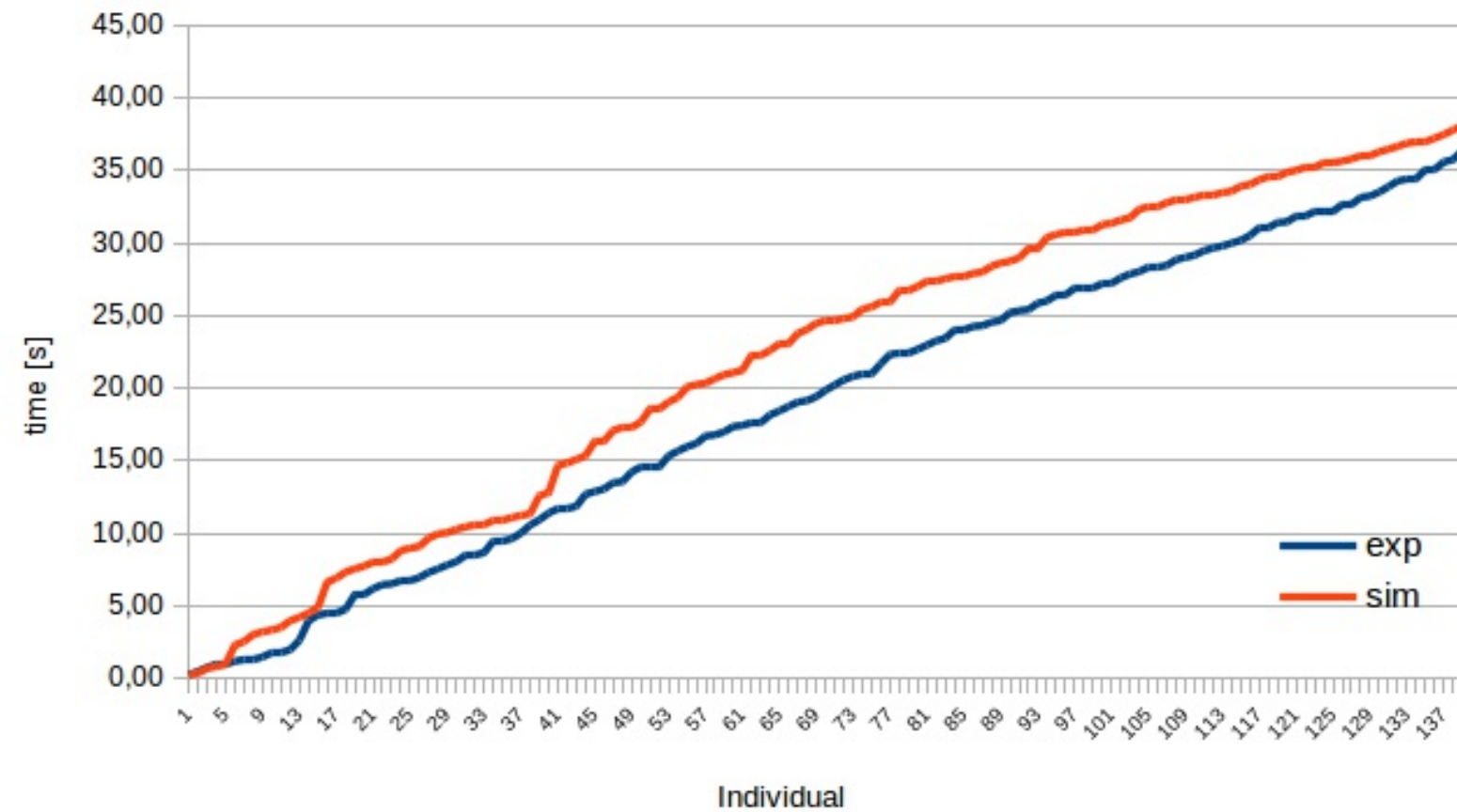
- Experiment versus Simulation: 70 or 1.0/m²



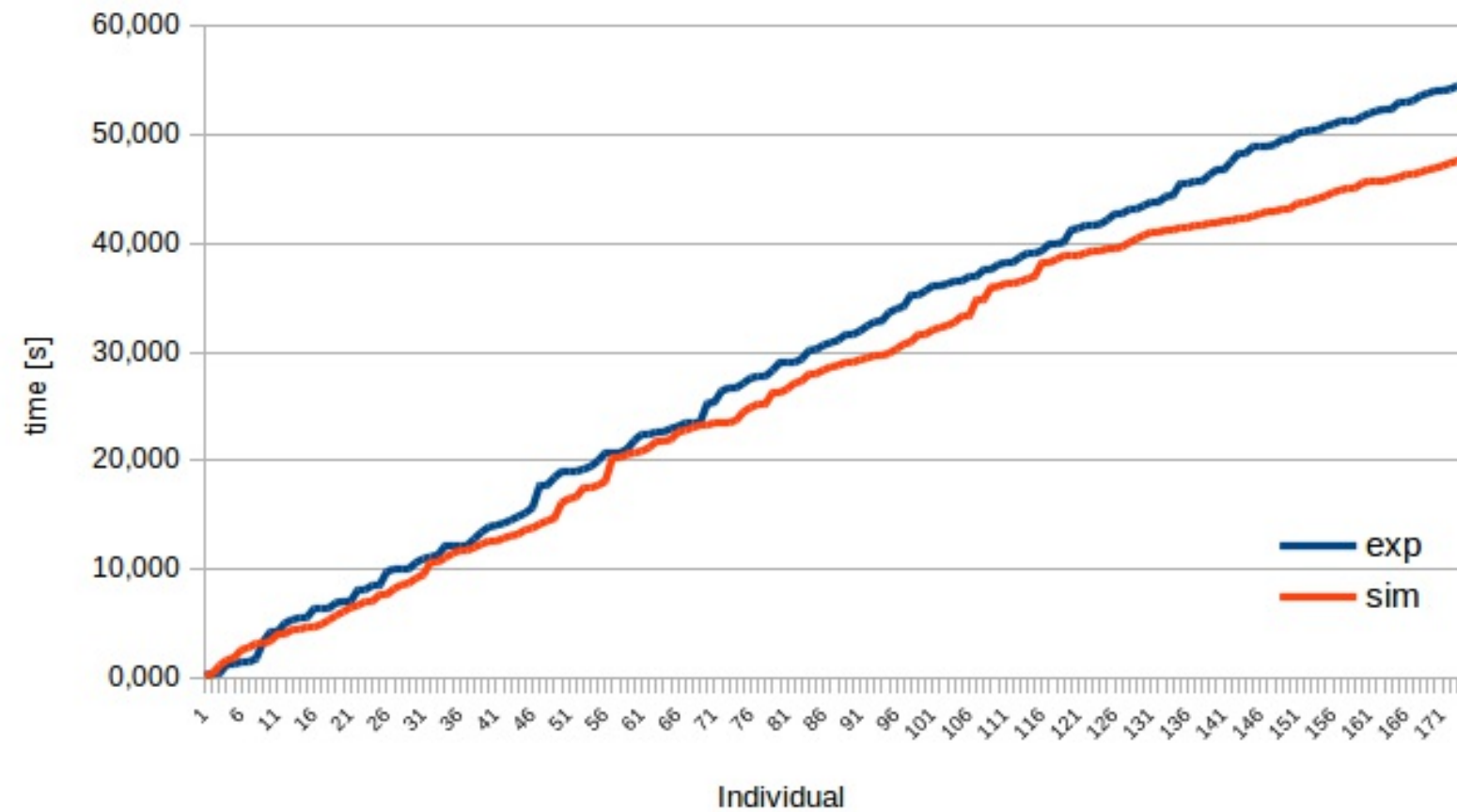
- Experiment versus Simulation: 105 or 1.5/m²



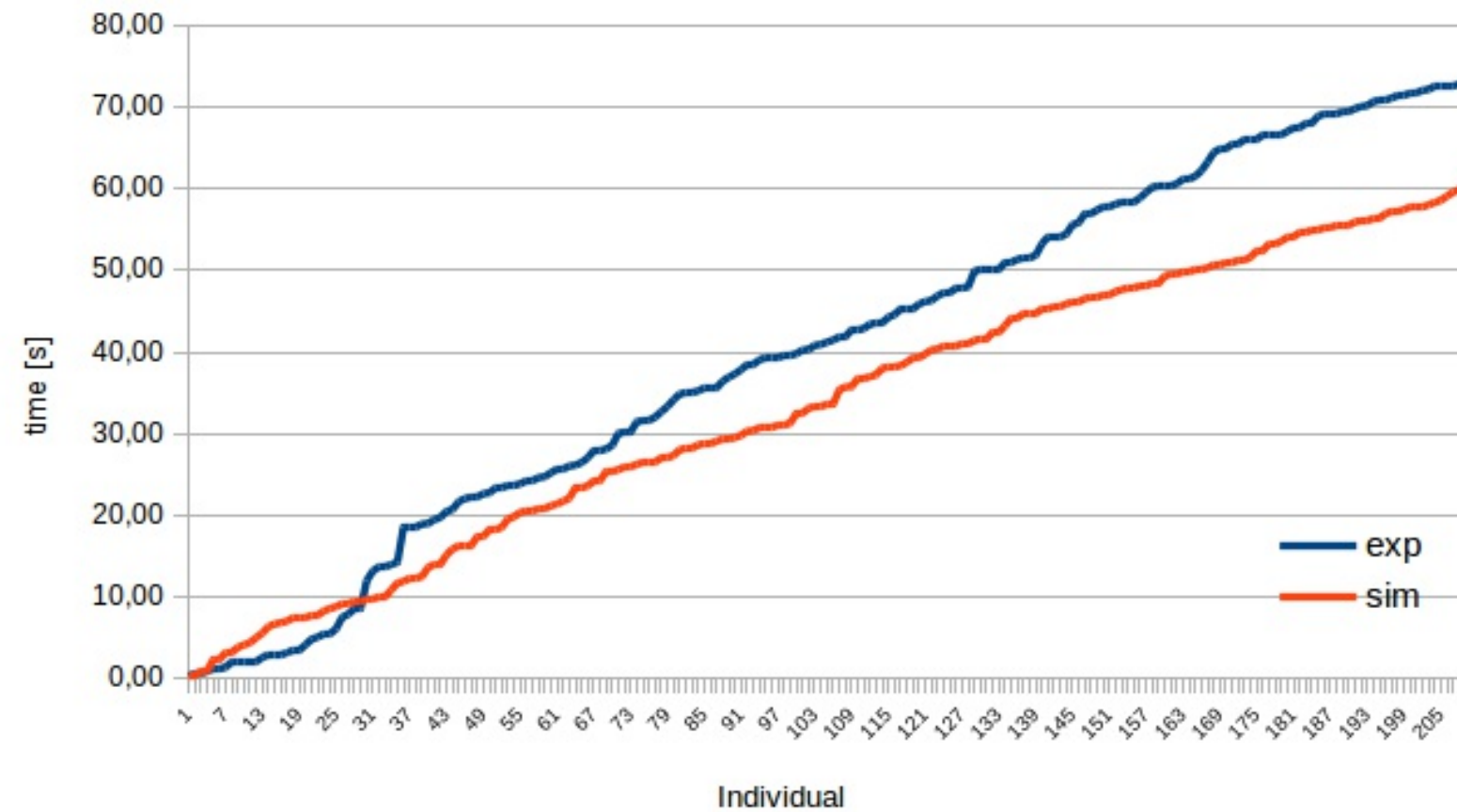
- Experiment versus Simulation: 140 or 2.0/m²



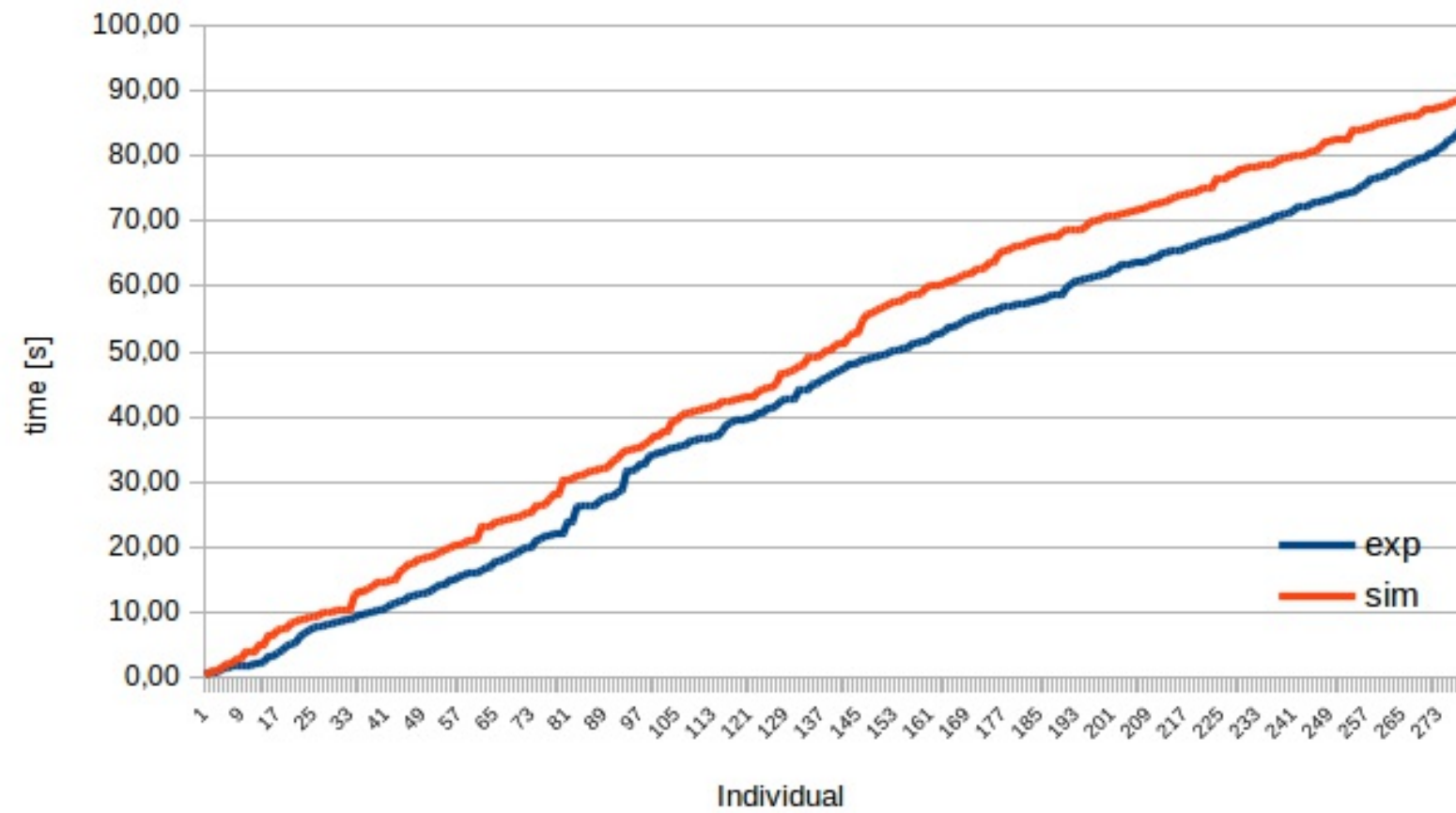
- Experiment versus Simulation: 175 or 2.5/m²



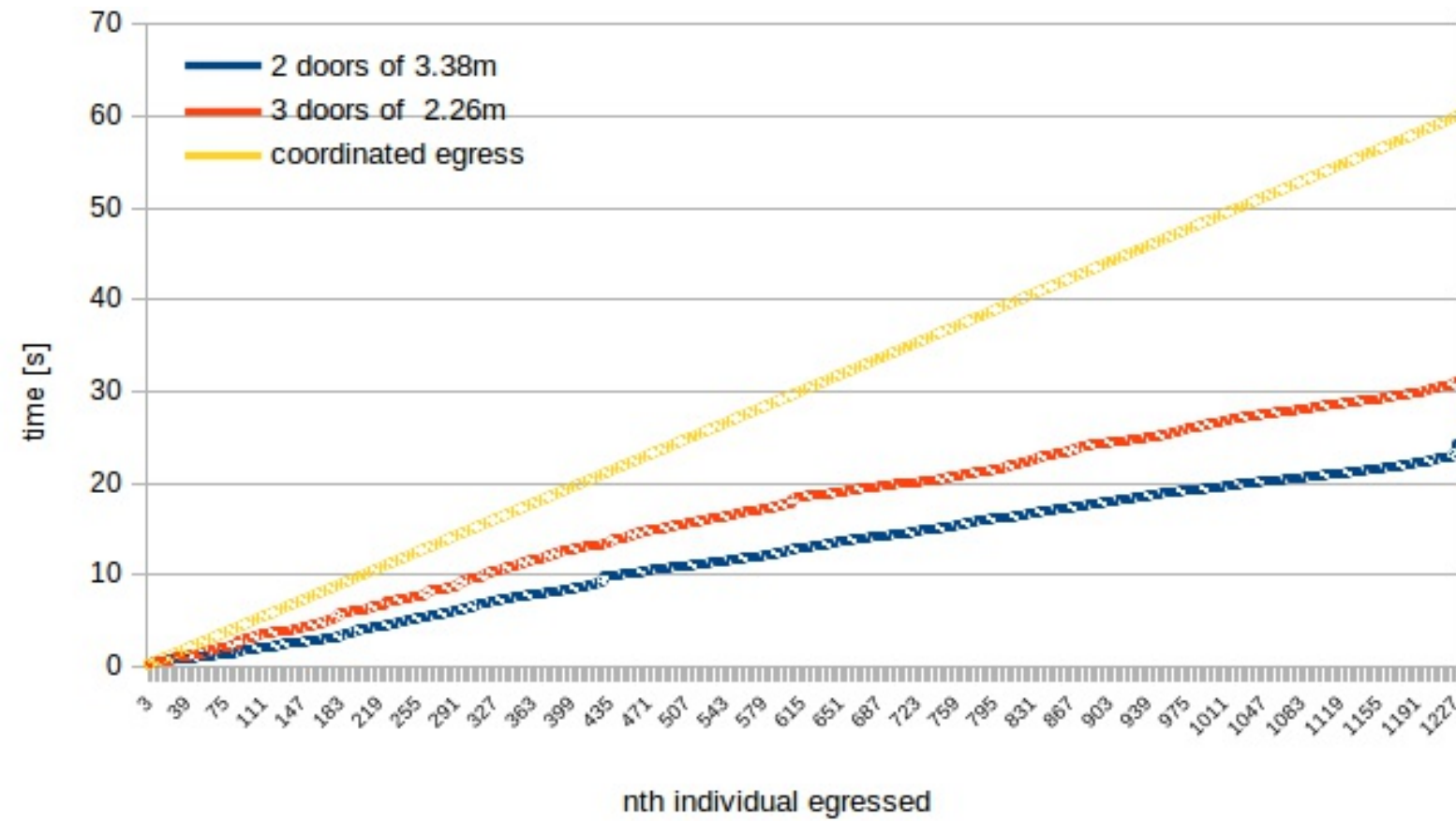
- Experiment versus Simulation: 210 or 3.0/m²



- Experiment versus Simulation: 280 or 4.0/m²



Kiss simulations



Conclusion

- Uncoordinated egress experiment
 - arches and turbulence were observed
 - the greater the crowd the lower the egress flow rate
 - when crowd stops pushing, flow increase
- Simulation
 - although simplified, model fits experiment
 - door width applicable in Santa Catarina is safe