CORSIKA: Beyond Air Showers

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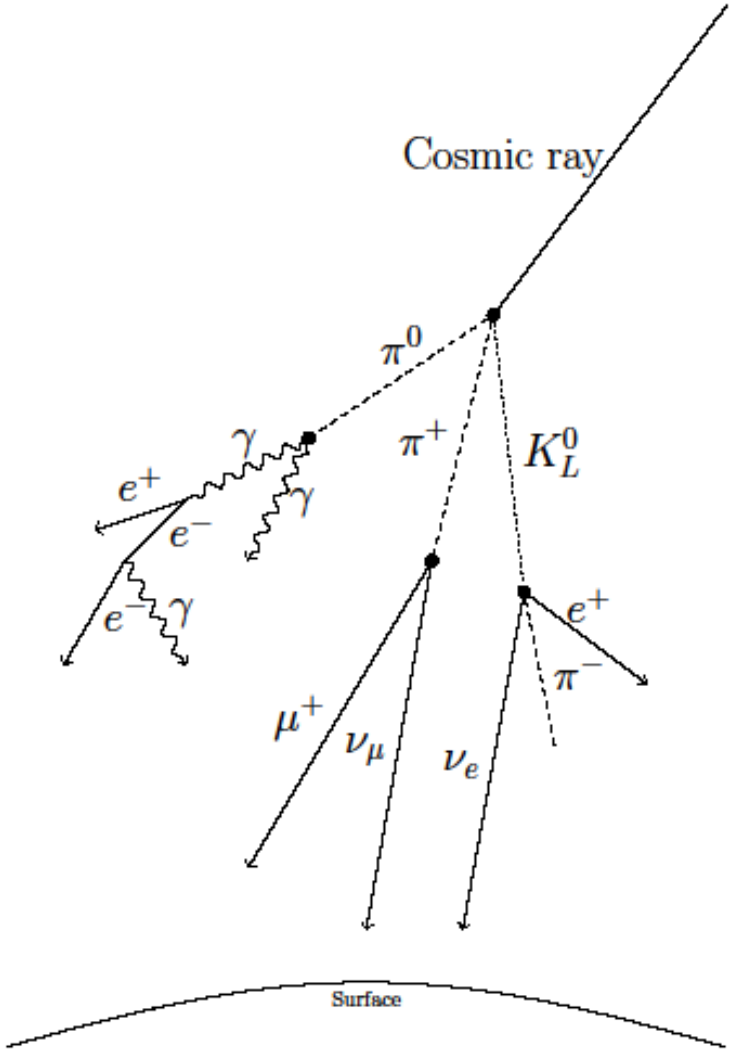
CORSIKA Workshop 2020

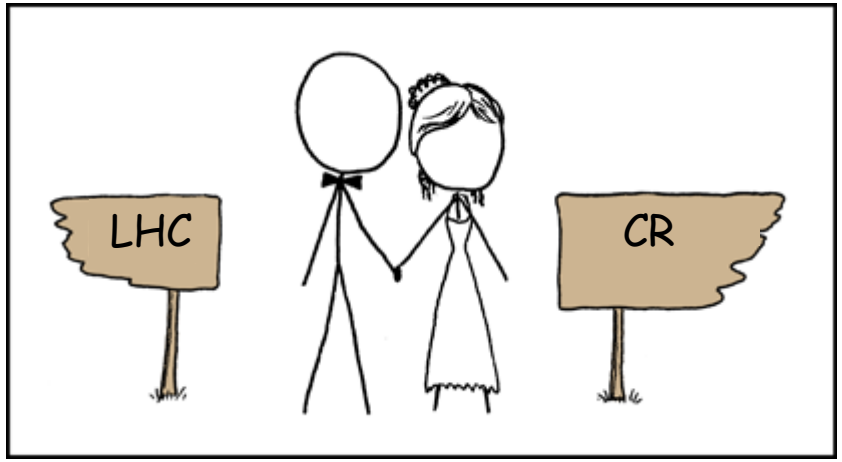
Contents

- Beyond the Standard Model Physics
  - Production
  - Analysis
  - Hypothetical Signal
- Bioluminescence
  - Relevance for deep-sea telescopes
  - The unknown factors
  - Some results
- Pandemic
  - Unnecessary introduction
  - Model
  - Some details



Beyond the Standard Model Physics I

- Energy far out of reach of the LHC
  - Up to PeV energies
- Every LHC interaction takes place in the atmosphere
  - And more…
- Constant Particle Production
  - Don’t need to spend $1 billion per year
- An assortment of detectors are readily available
  - Auger, IceCube, KM3NeT…

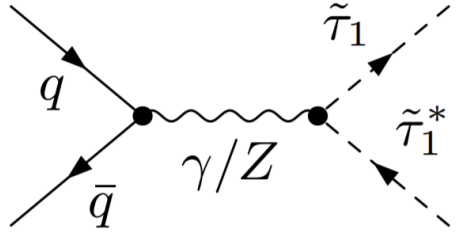


Modified https://imgs.xkcd.com/comics/a_better_idea.png

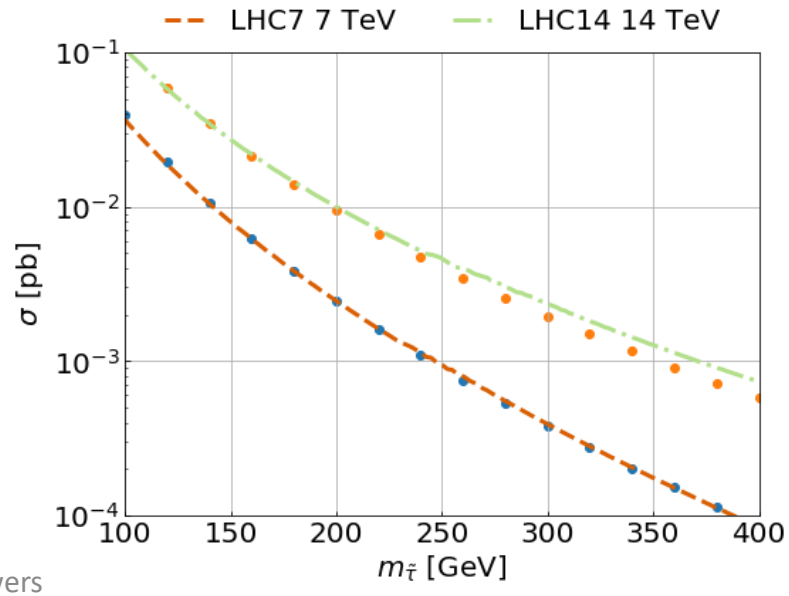
Beyond the Standard Model Physics II

SFB 1258 Neutrinos Dark Matter Messengers

- Based on arXiv:2005.07523
- How to introduce BSM physics?
  - Production probability $P_X^h(E) \approx \frac{A\sigma_X^{hN}}{\sigma_T^{ha}}$
  - A… Number of targets
  - σ_X^{hN}… Cross section for $h + N \rightarrow X$
  - σ_T^{ha} … Total cross section for h with air
- Use your favorite MC event generator
  - E.g. MadGraph arXiv:1405.0301
- Fold the production probability with the simulated hadron count from CORSIKA in air showers.

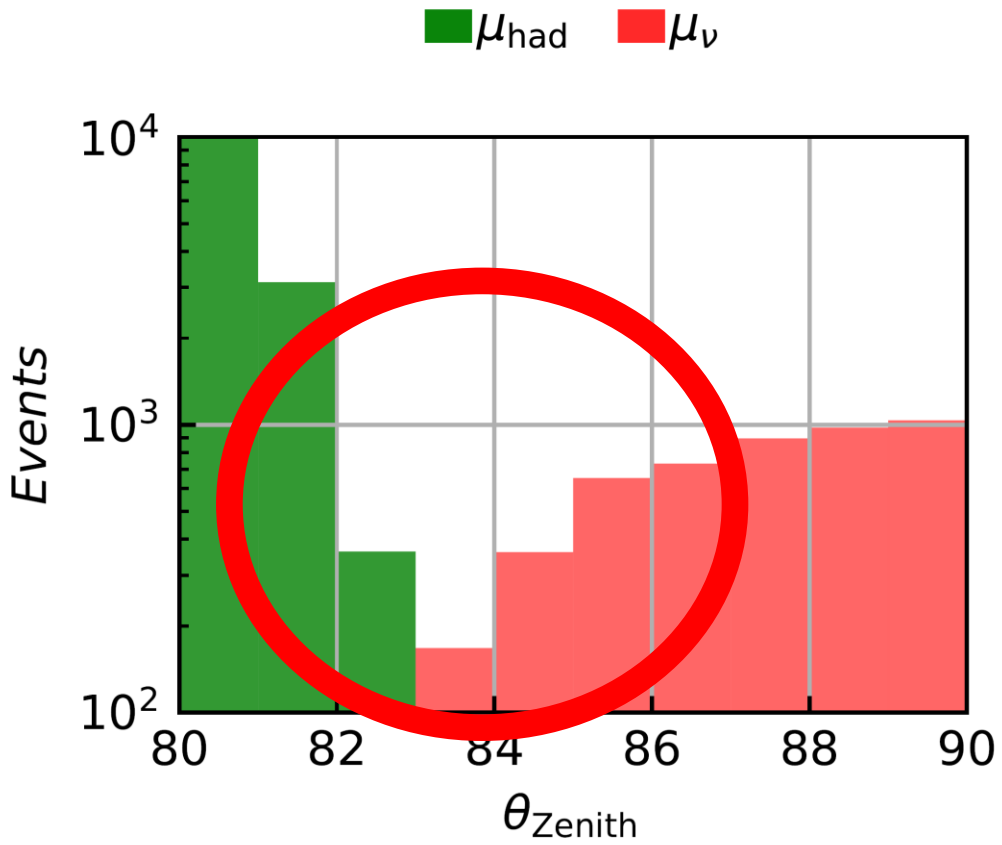


arXiv:1204.2379



Beyond the Standard Model Physics III

- Depending on the depth, buried neutrino detectors will have a ‘dip’ in the expected muon count.
  - The material (water/ice) acts as a screen
- Can we use this?



Beyond the Standard Model Physics III

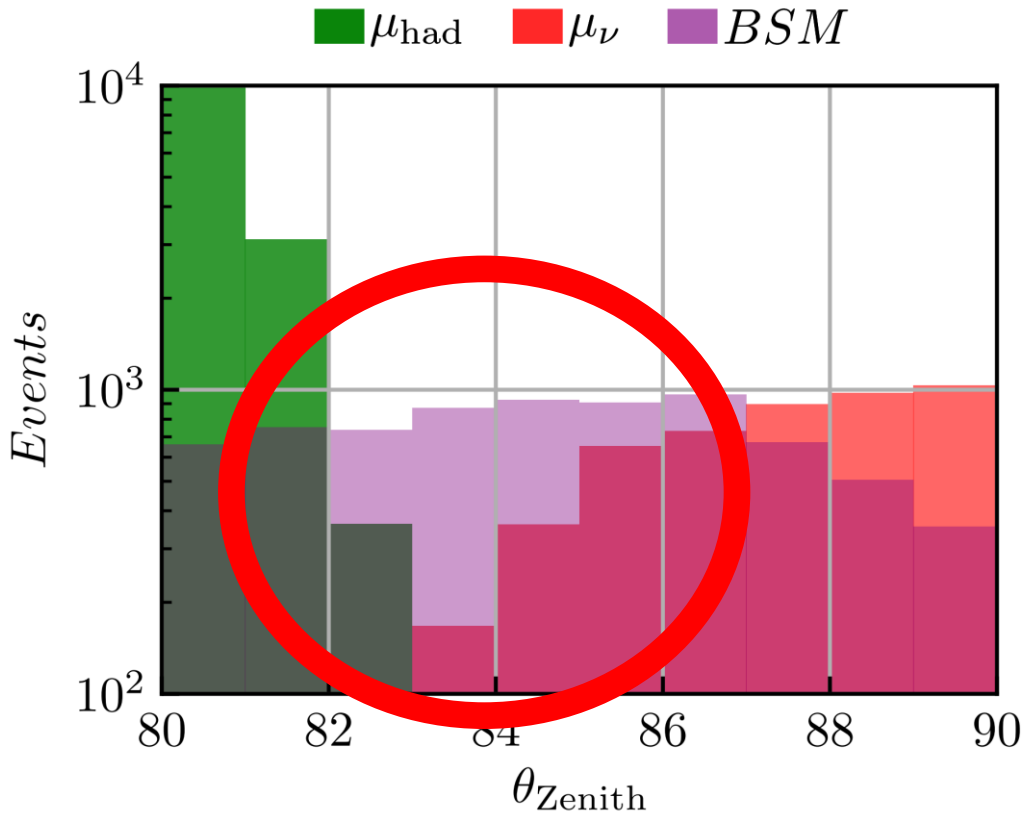
- Depending on the depth, buried neutrino detectors will have a ‘dip’ in the expected muon count.
  - The material (water/ice) acts as a screen

- Can we use this?

  → Yes! Constrain long-lived charged particles

  → We used this to constrain staus

  → Competitive with Collider Experiments



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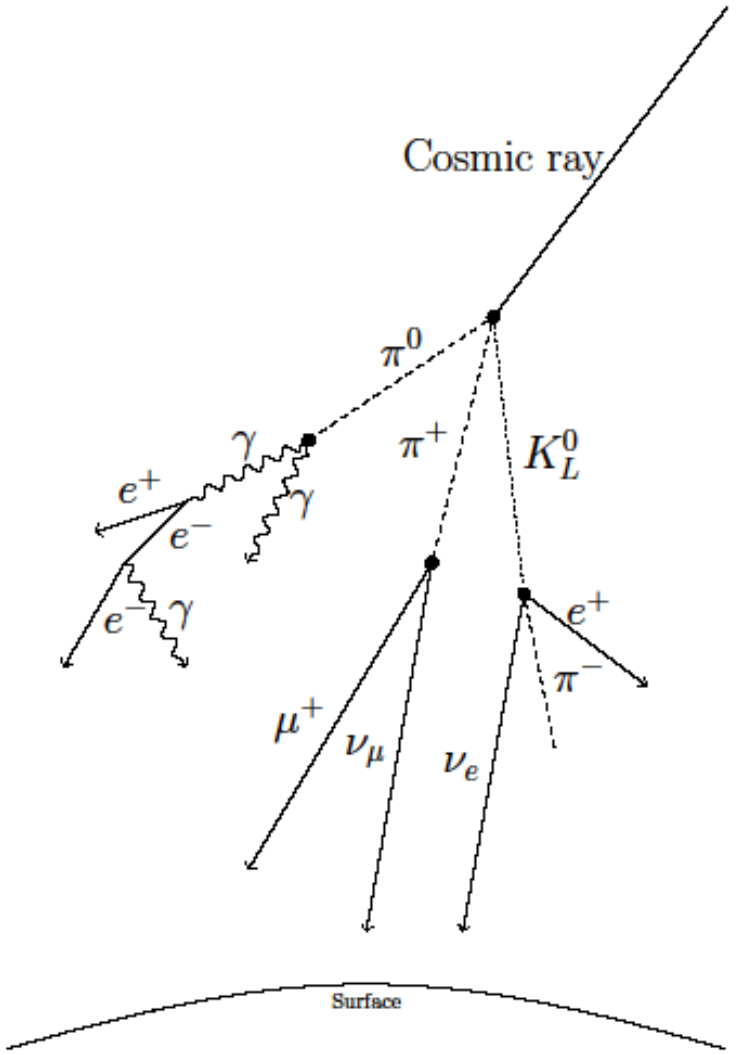
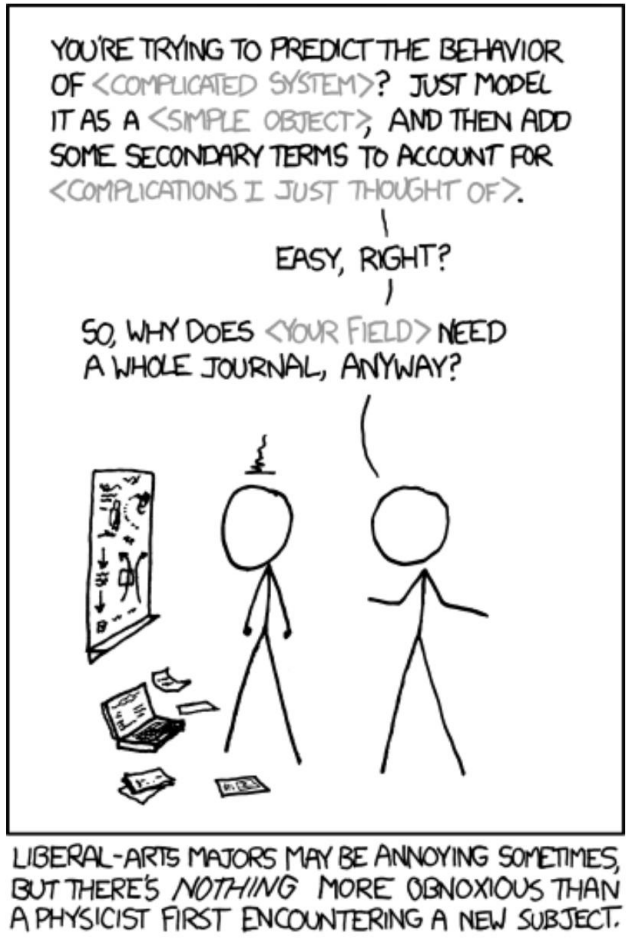


Bioluminescence I

- For detectors in the (deep) ocean a background source is light produced chemically by organisms
  - P-ONE
- Background for our measurements (Maxima at 450nm-490nm, Herring 1983)
  - Steady glow and intermittent flashes
  - Response to turbulence caused by the detectors
  - Cascading effect in response to each other flashes
- Simulate emission and propagate it to the detector
  - MC particle simulation!

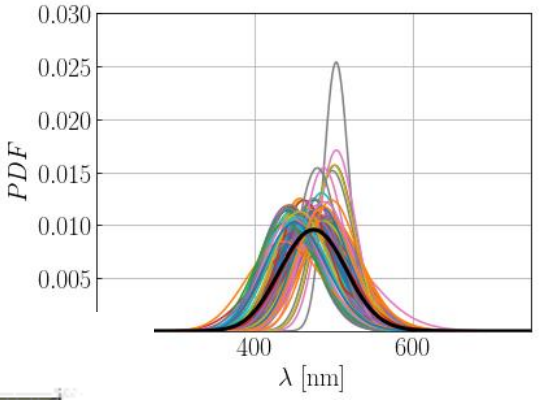


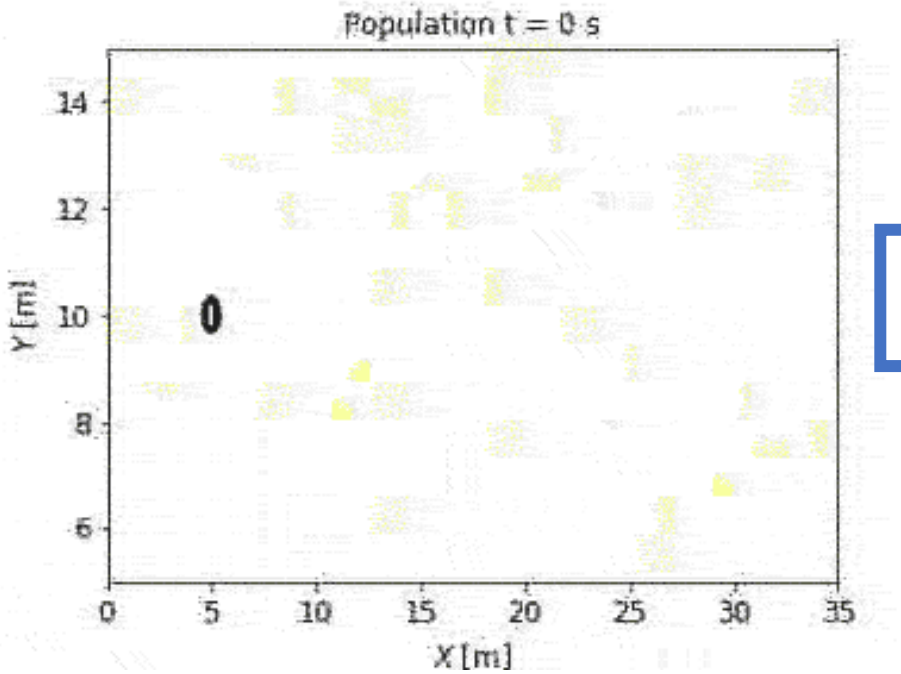
https://xkcd.com/793/

Bioluminescence II

- Complex system with many unknowns
  - Species
    - A host of possible species ranging from micro organisms to larger fish
  - Abundance
    - Approximately 100 / m^3
    - Depends on temperature and oxygen content
  - Response
    - Required stimuli unknown
    - Interaction radius and shear stress?

Emission profiles of possible candidates





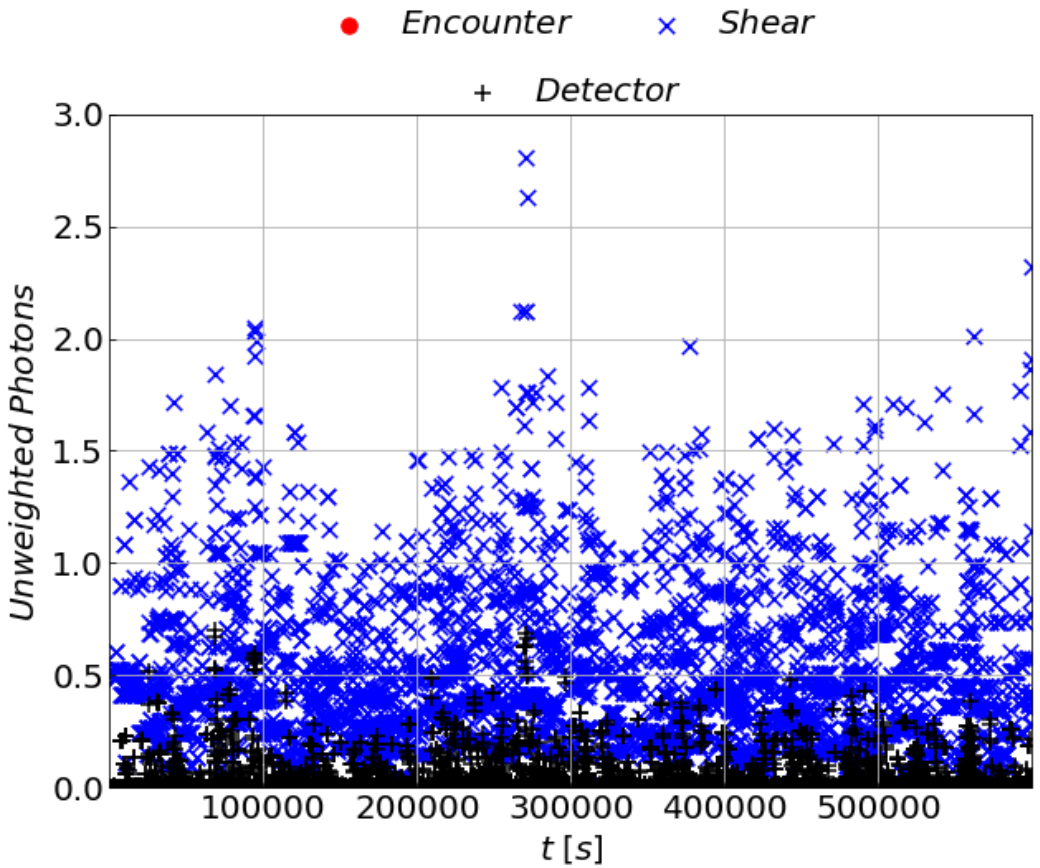
High density example simulation

Bioluminescence III

- Complexity of the system requires a large Monte Carlo framework which allows a range of models
  - → Experience with CORSIKA comes in handy
  - → Basic simulation principles are the same

species	Paraphyllina ransoni Russell
pos_x	0.5042
pos_y	0.682592
velocity	0.00409511
angle	2.27632
radius	0.00105776
energy	1
observed	True
max_emission	27.5055
emission fraction	0.5
regeneration	0.001
is_emitting	False
emission_duration	-200
encounter photons	0
shear photons	0
photons	0

Simulate each individual organism with properties such as interaction length, emission count etc.



No emission by encounters -> sub-leading process for the densities we expect. Simulation confirms current measurements

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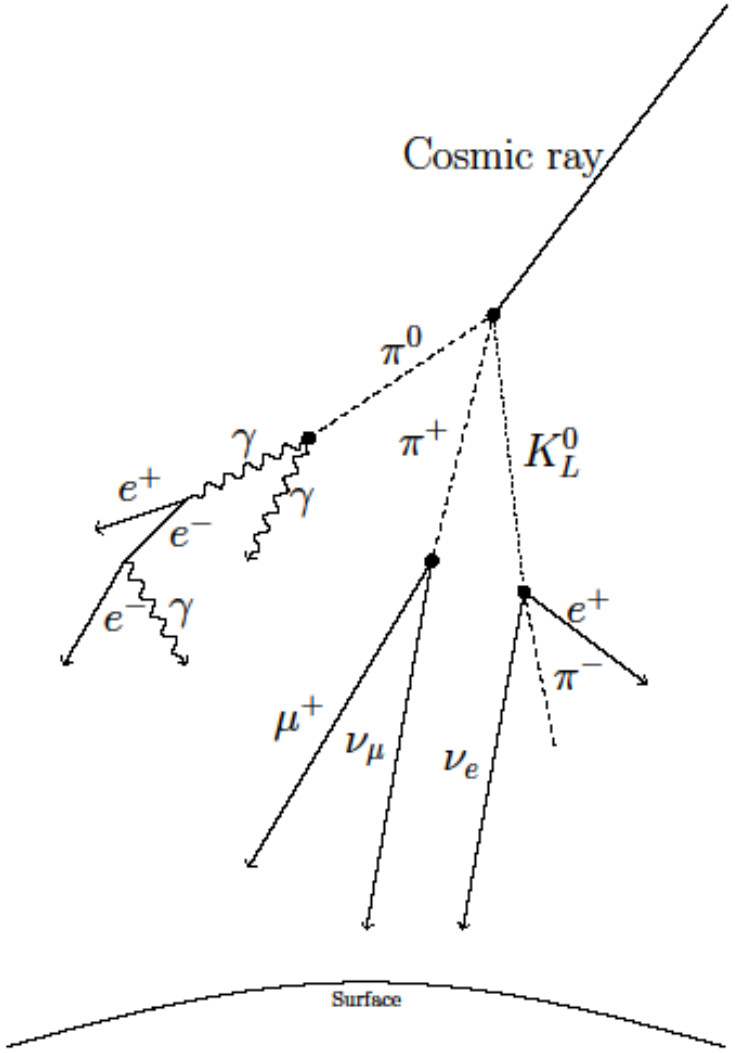


Pandemic I

- TUM is analyzing the feasibility of contact tracing.
  - https://github.com/corona-warn-app
  - Amongst other things

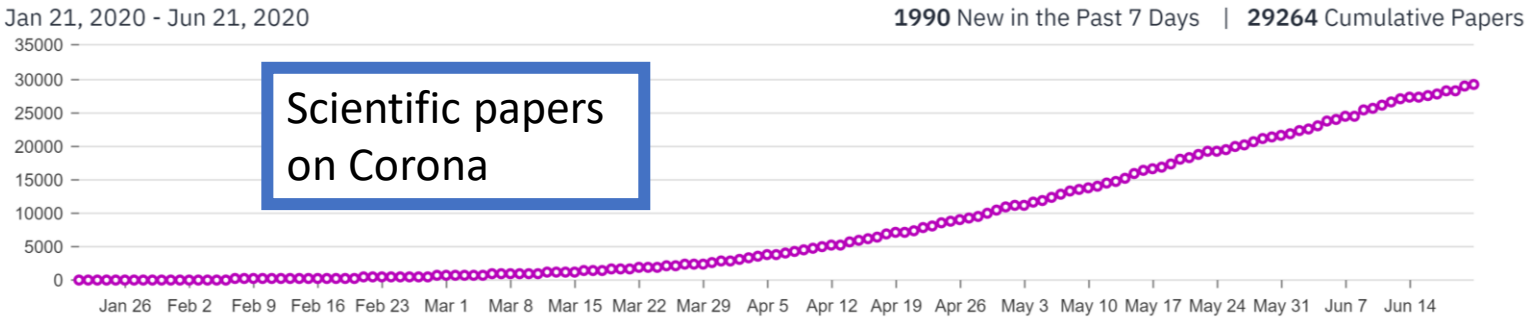
- To this end one aspect is the modelling of an infection spread in any given population.
  - With the aim of reducing the reproductivity number R

- Huge amount of research is being currently done in the field

New infections per day

https://en.wikipedia.org/wiki/Template:COVID-19_pandemic_data

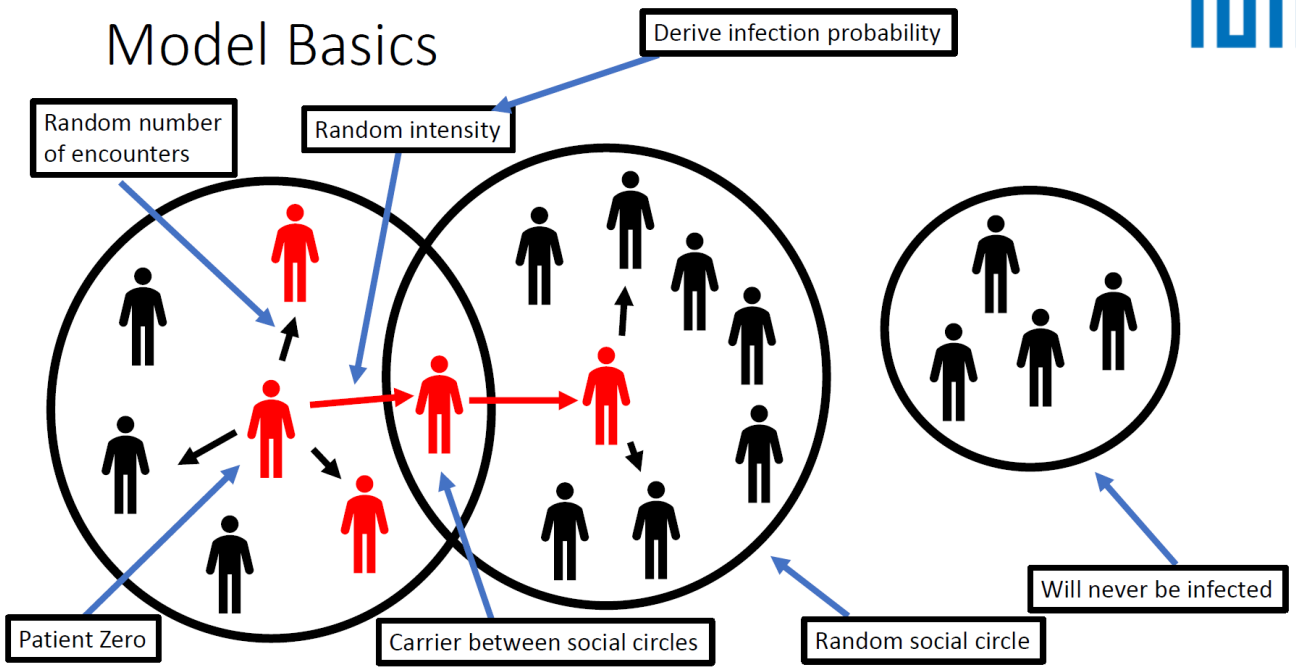
Scientific papers on Corona



https://covid19primer.com/dashboard

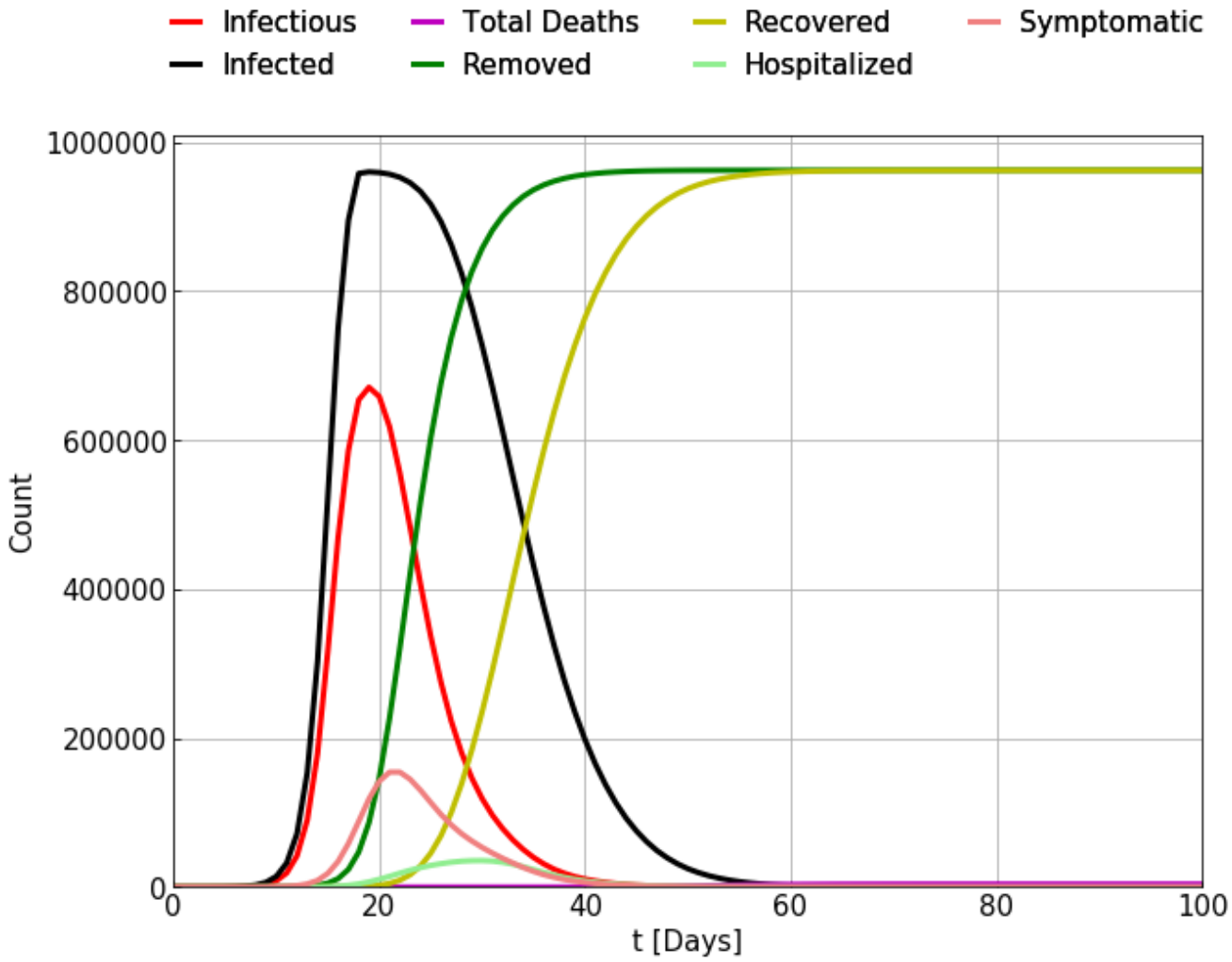
Pandemic II

- Interest for obvious current reasons
- Assume people live in their social ‘bubble’ (social circle)
- Interactions outside of these are sporadic and short-lived
- Infection probability depends on encounter duration, intensity, incubation period etc.
- Infection spread modelled using an extended **SEIR** (**S**usceptible -> **E**xposed -> **I**nfectious -> **R**ecovered) model.
- Again modelling experience from CORSIKA come in handy



Pandemic III

- Create a framework to fit the measured data
- Allow for a wide range of population distributions.
  - Schools
  - Age
  - ‘Super-Infectors’
- Benchmark the required number of people we need to trace for the app to work.



Conclusion

- Working on CORSIKA provides a large variety of skill-sets applicable in a broad range of fields
- Benchmarking and pushing current bounds of physics
- Applying to new developments in background calculations for up-coming neutrino telescopes
- Applying the developed skills for current developments

Thank you for your attention
Questions?