WELCOME to NuSTEC Workshop

Improving the art of neutrino nuclei modelling with charged lepton scattering data

28/3/22 - 1/4/22

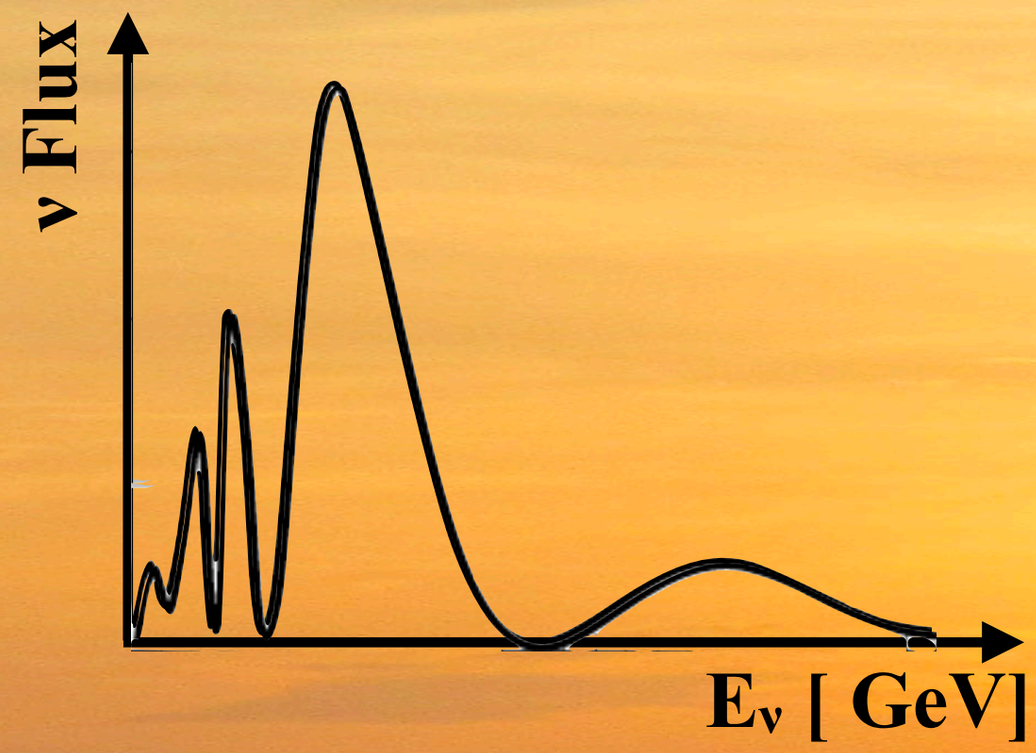
Tel Aviv University

Our Challenge

Extract neutrino oscillation

mixing parameters by measuring:

$$N(E, L)$$



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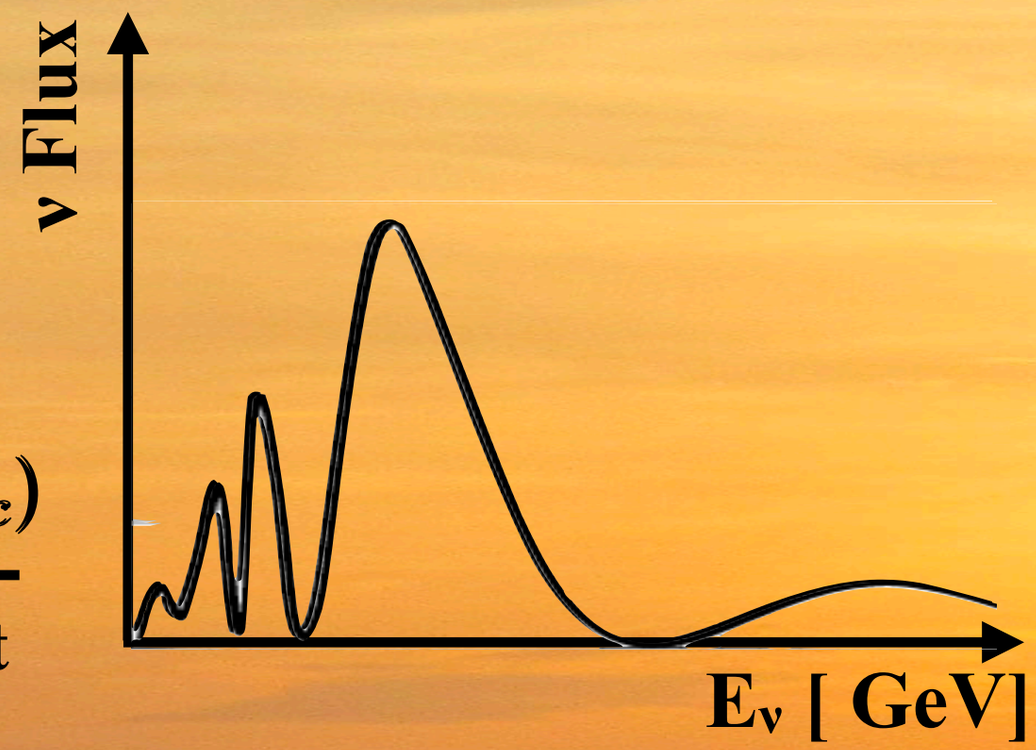
Our Challenge

When in fact the actual measurements is:

$$N(E_{rec}, L) \propto \int \phi(E, L)\sigma(E)f(E, E_{rec})$$

Modeling Input



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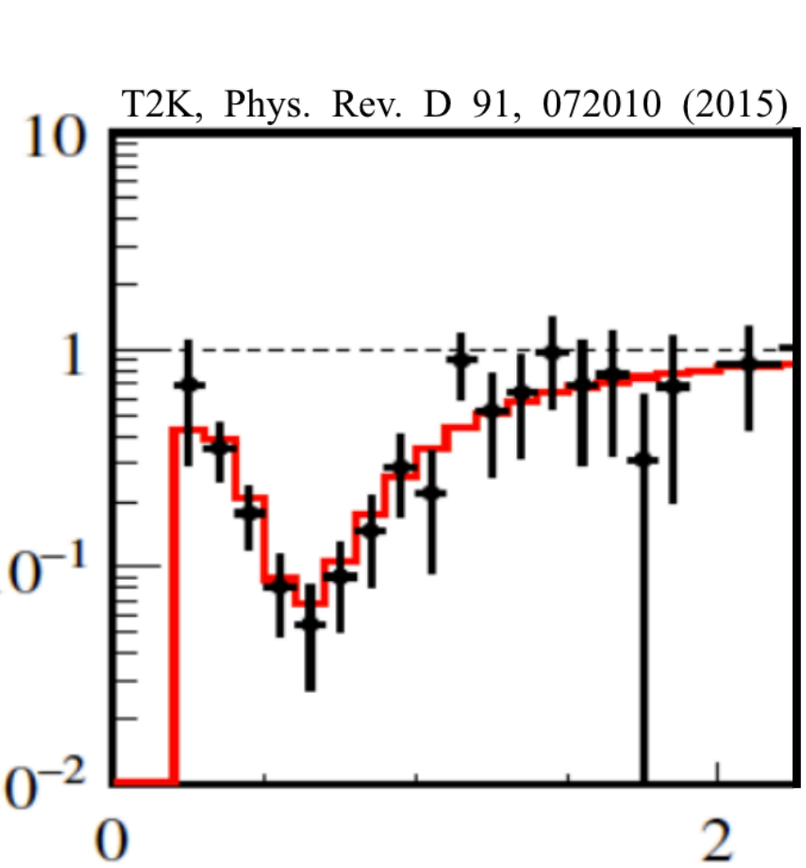
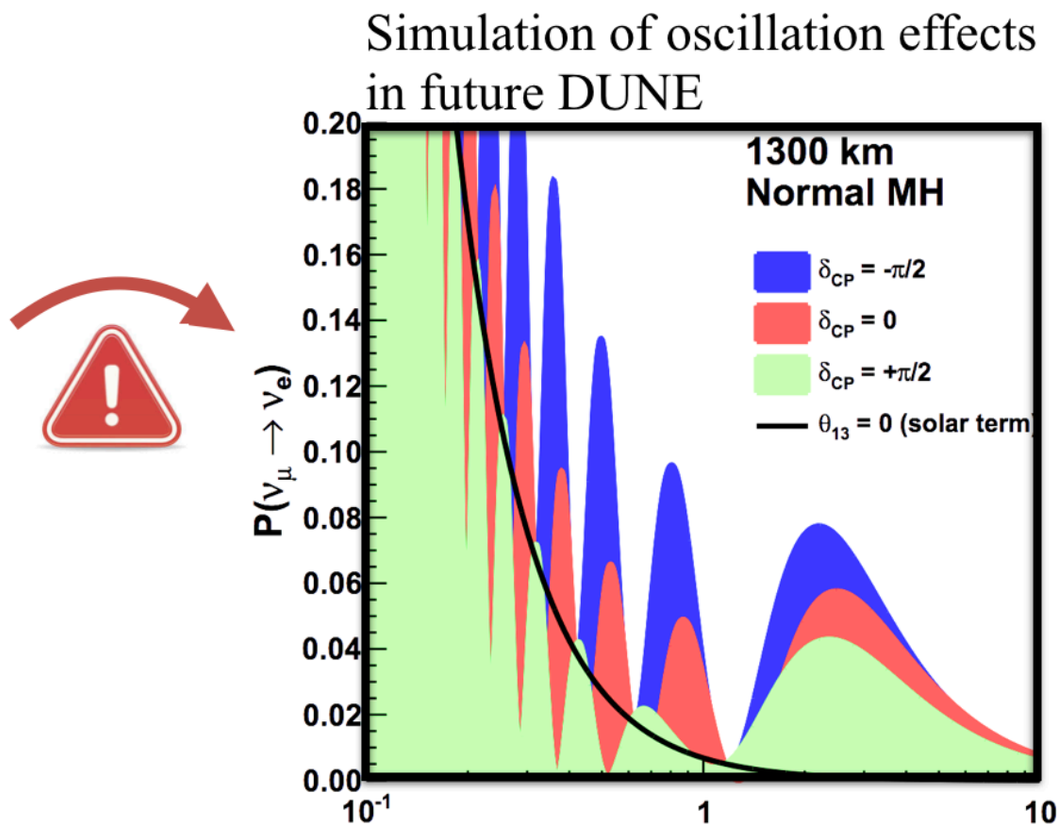
The challenge - next generation high precision





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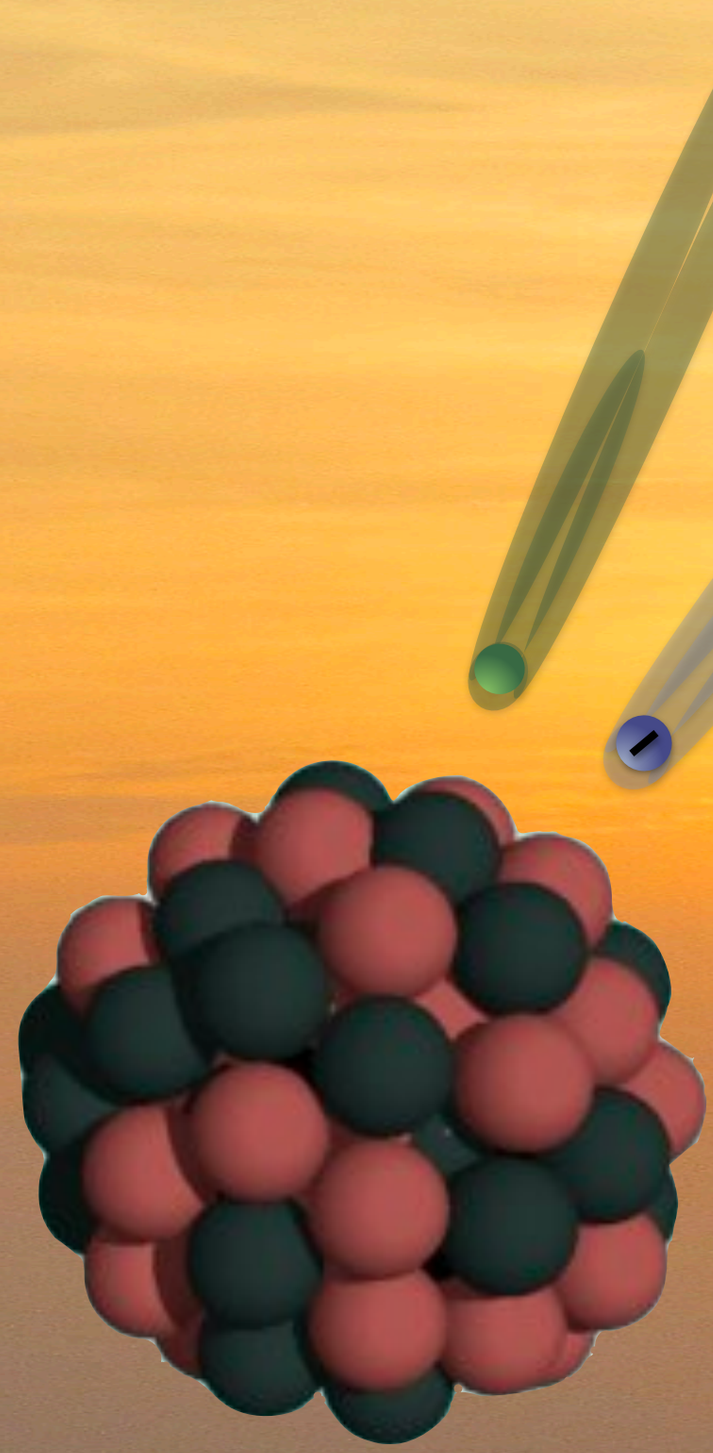
Using Charged Leptons to Improve νA Modelling

- Charged and neutral leptons have:
  - Similar interactions with nuclei
    - Vector vs. Vector + Axial Vector
  - Many identical nuclear effects
    - Ground state (spectral function)
    - Final state interactions

Charged leptons can have known energies



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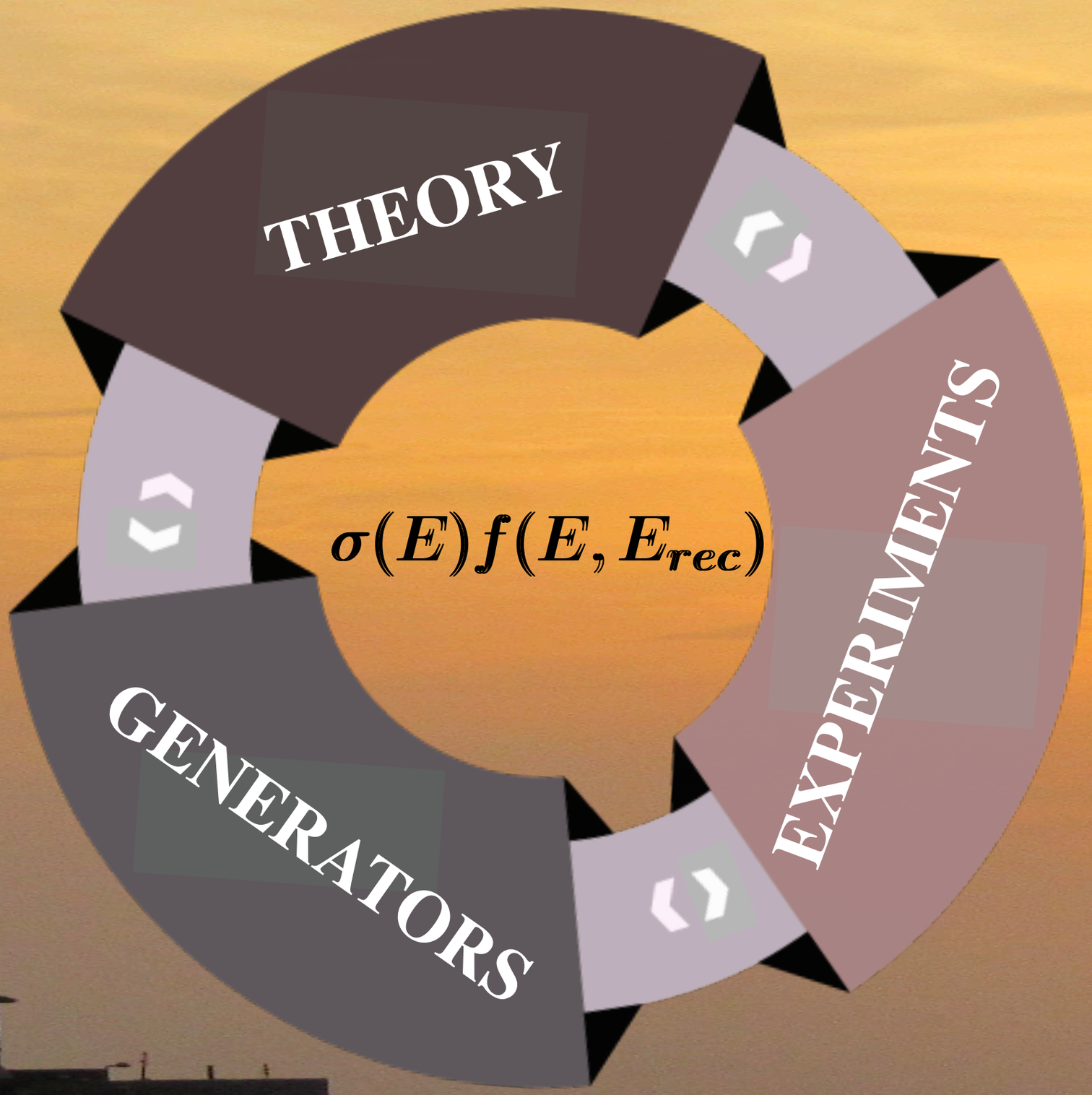
The Way to Improve Modelling Input



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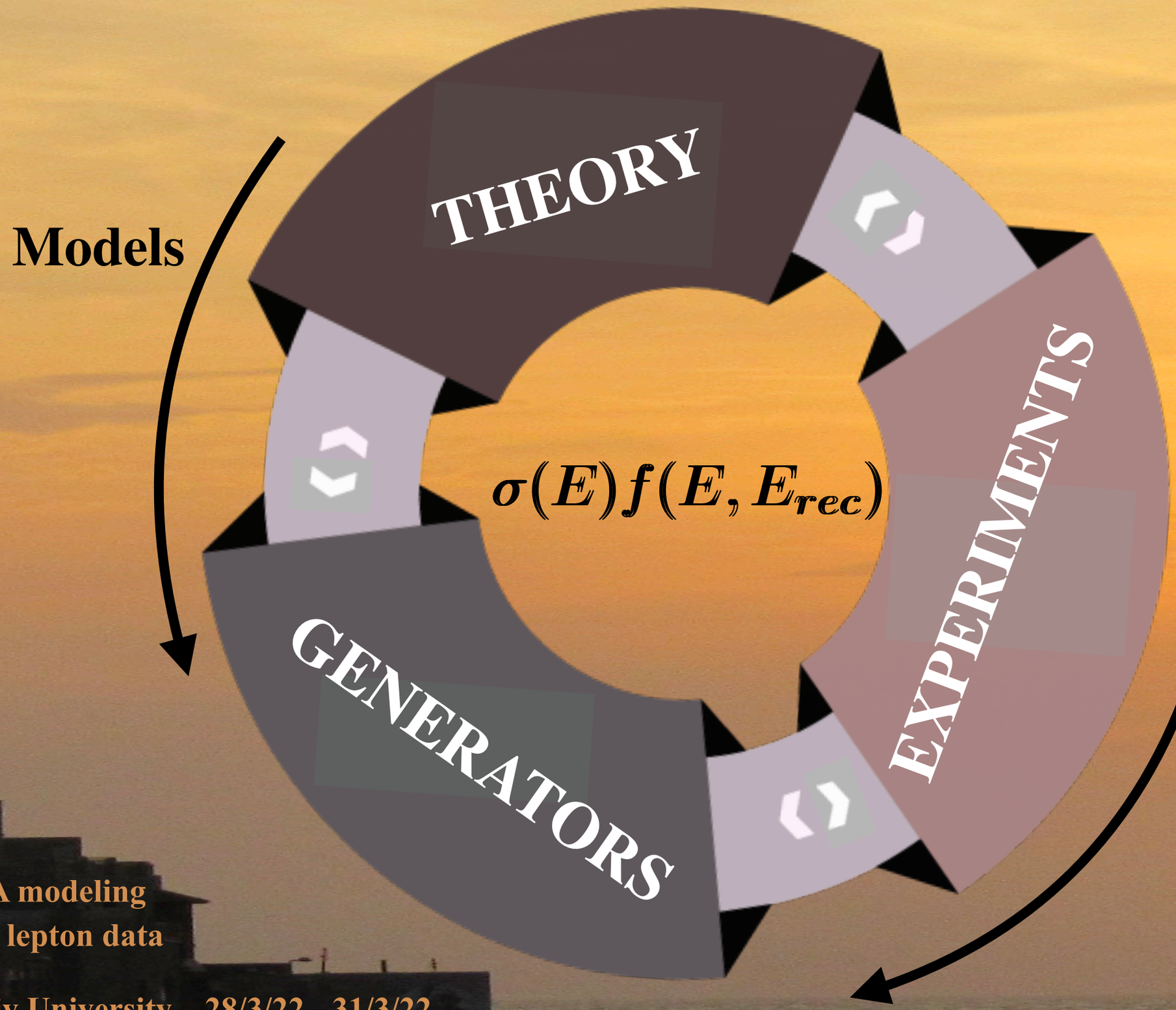
Ways to Improve Modelling Input



Models

Empirical Models

Input for tuning

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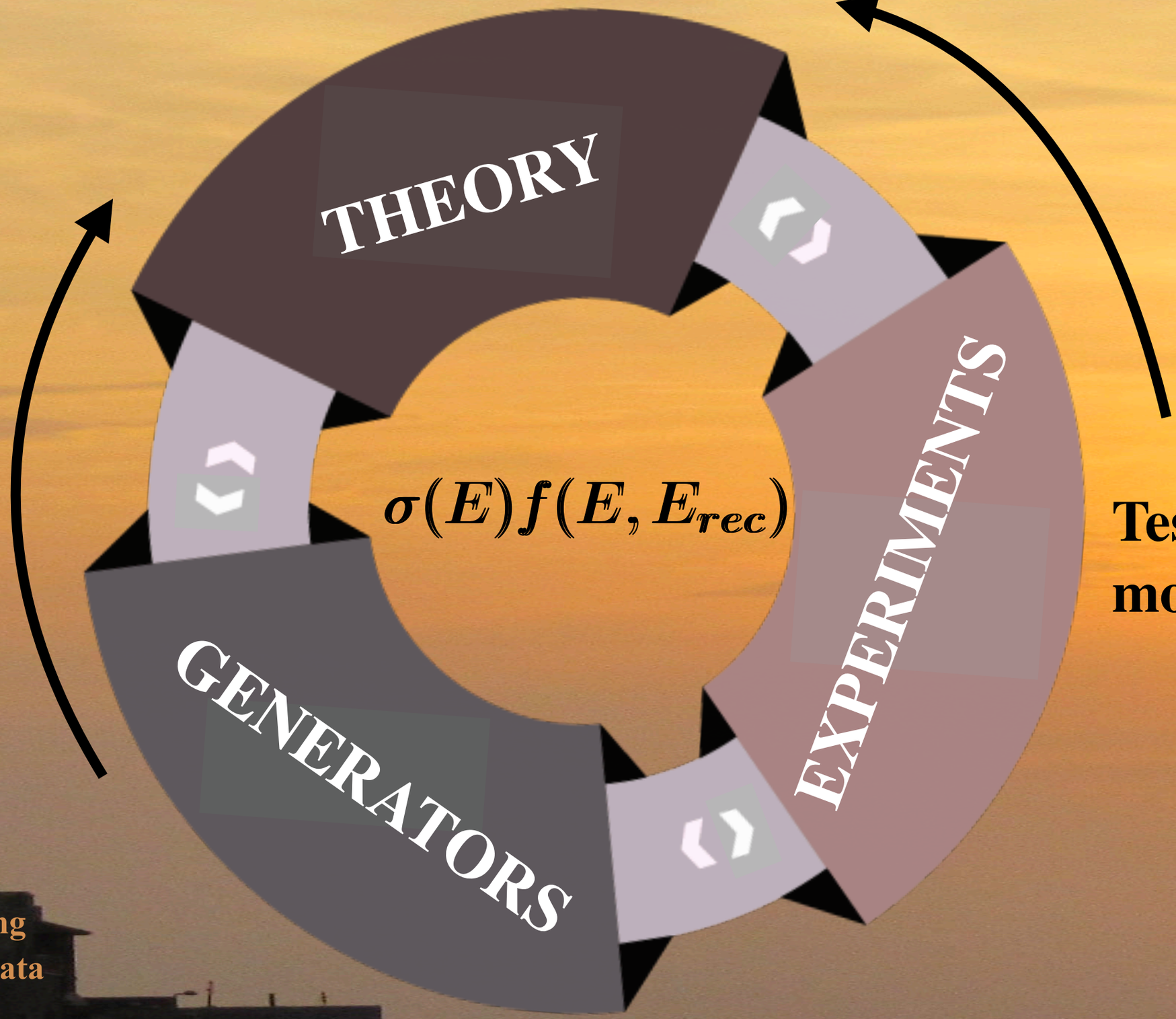
Ways to Improve Modelling Input



Testing models

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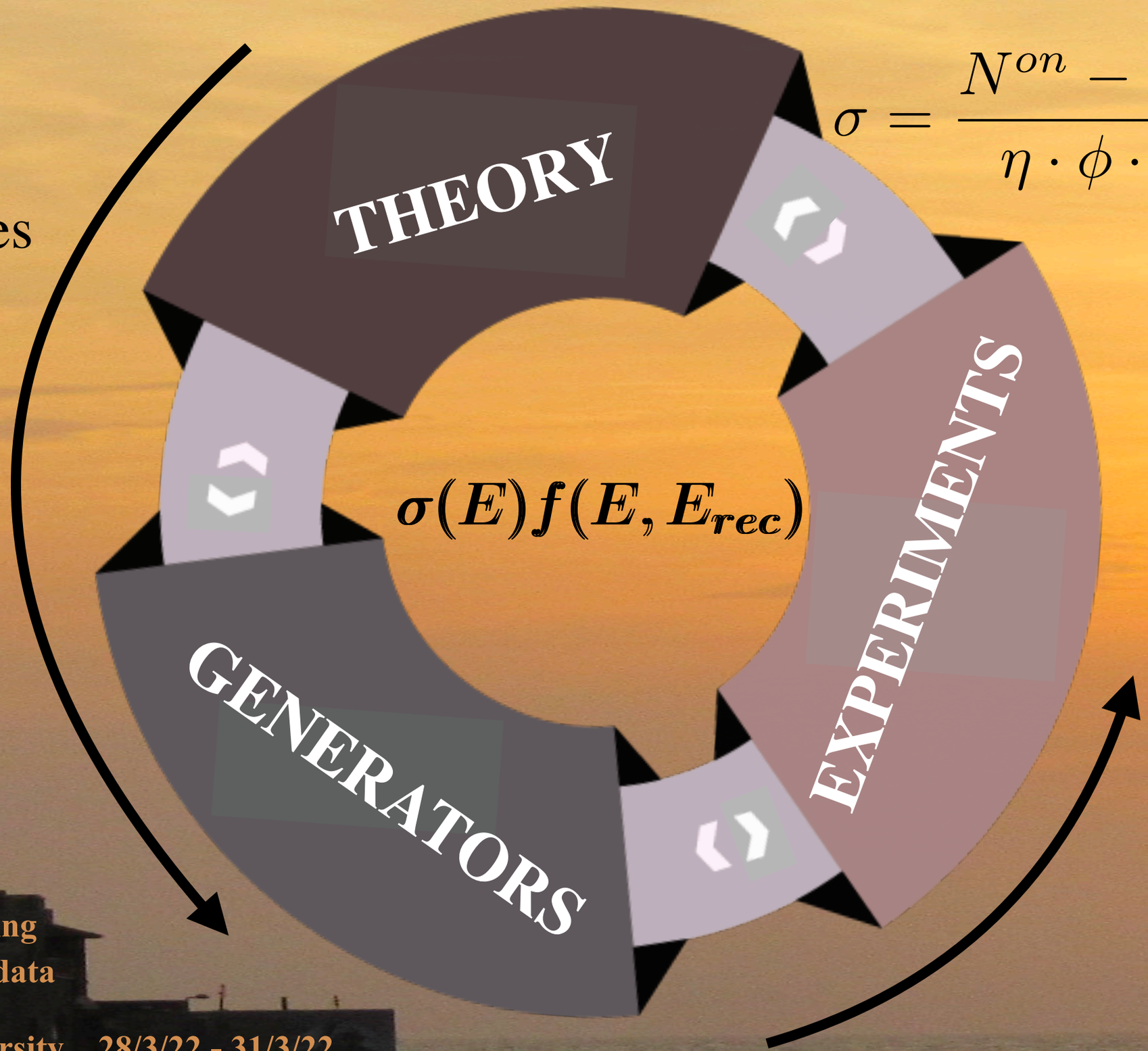
Ways to Improve Modelling Input

The background & efficiencies are model dependent



$$\sigma = \frac{N^{on} - N^{off} - B}{\eta \cdot \phi \cdot N_{targets}}$$

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Experimental Efforts

Collaborations	Kinematics	Targets	Scattering
E12-14-012 (JLab) (Data collected: 2017)	$E_e = 2.222$ GeV $15.5° \leq \theta_e \leq 21.5°$ $-50.0° \leq \theta_p \leq -39.0°$	Ar, Ti Al, C	(e, e') e, p in the final state
e4nu/CLAS (JLab) (Data collected: 1999, 2022)	$E_e = 1$, 2, 4, 6 GeV $\theta_e > 5°$	H, D, He, C, Ar, ^{40}Ca, ^{48}Ca, Fe, Sn	(e, e') e, p, n, π, γ in the final state
LDMX (SLAC) (Planned)	$E_e = 4.0$, 8.0 GeV $\theta_e < 40°$	W, Ti, Al	(e, e') e, p, n, π, γ in the final state
A1 (MAMI) (Data collected: 2020) (More data planned)	50 MeV $\leq E_e \leq 1.5$ GeV $7° \leq \theta_e \leq 160°$	H, D, He C, O, Al Ca, Ar, Xe	(e, e') 2 additional charged particles
A1 (eALBA) (Planned)	$E_e = 500$ MeV - few GeV	C, CH Be, Ca	(e, e')

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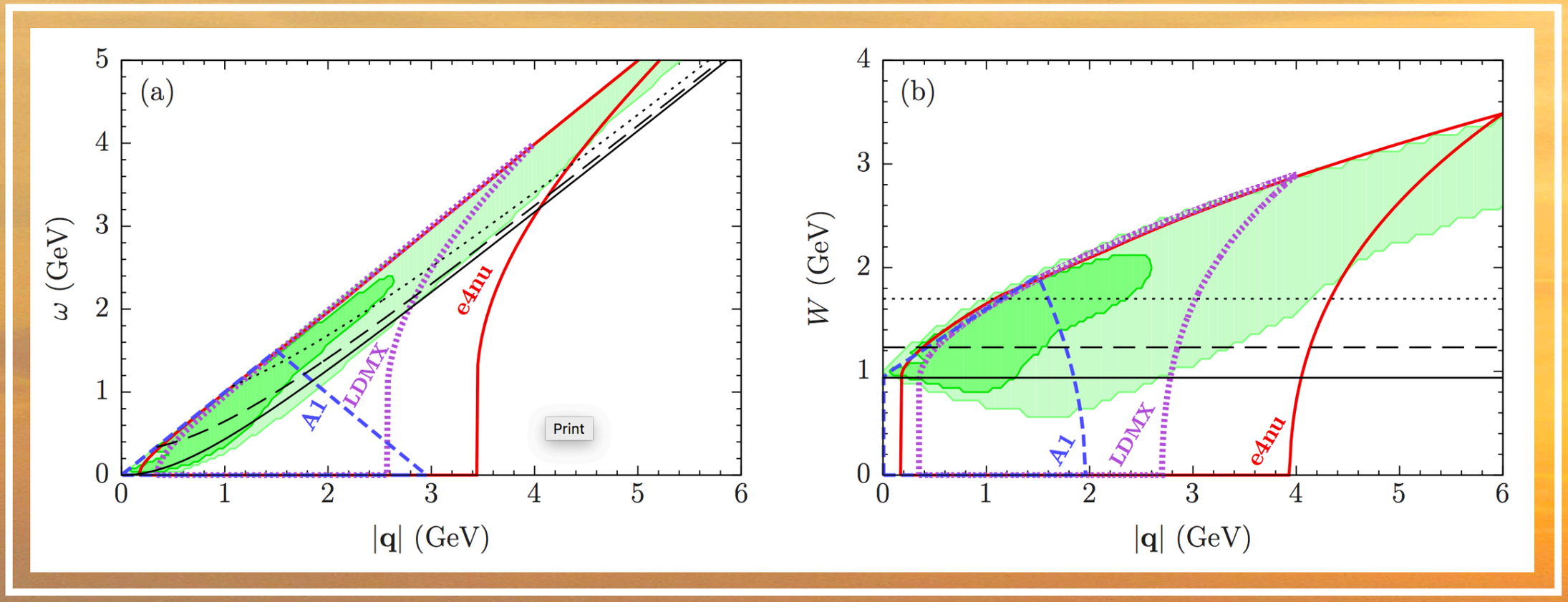
Electron Scattering and Neutrino Physics, Snowmass white paper arXiv:2203.06853 [hep-ex]

Complementary efforts



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Electron Scattering and Neutrino Physics, Snowmass white paper arXiv:2203.06853 [hep-ex]

Workshop Goals

- Gather experts from both nuclear and neutrino and electron communities: Theorists, Experimentalists, Event generator experts.
  - Showcase the most recent developments
  - Facilitate knowledge sharing

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Workshop Goals

- Gather experts from both nuclear and neutrino and electron communities: Theorists, Experimentalists, Event generator experts.
    - Showcase the most recent developments
    - Facilitate knowledge sharing
- Clarify requirements for present and next-gen accelerator based neutrino experiments.
- Coordinate the efforts between electron and neutrino physics sectors
    - Map and prioritise the needs from: the theory community, event generators and electron scattering experiments.
        - Get ready for coming tuning efforts

Workshop Schedule

	Mon 28/3	Tue 29/3	Wed 30/3	Thu 31/3
4 pm IST 8 am CT 2 pm GMT	Intro & Motivation	Initial State	Pion Production	Special Discussion + workshop photo
8 pm IST 12 pm CT 6 pm GMT	Inclusive vs. Exclusive	Low Energy, QuasiElastic MEC	Higher Energies, FSI	

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In Each Block

Low Energy, QuasiElastic

Theory input

Modelling in Event Generators

Relevant charged lepton experiment

Each talk is 15+5 minutes
Please keep the schedule &
upload your slides in advance

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In Each Block

Please Join our new slack channel using this link

During the week we expect discussion to occur also there

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Thanks to the organisers

Luca Doria
Minerba Betancourt
Noemi Rocco
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Joshua L. Barrow
Paola Sala
Adi Ashkenazi

From NuSTEC:
Natalie Jachowicz
Jonathan Paley
NuSTEC workshop & school:
Artur Ankowski
Clarence Wret
Adi Ashkenazi

and Thank You All for Joining

Let's get charged!

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