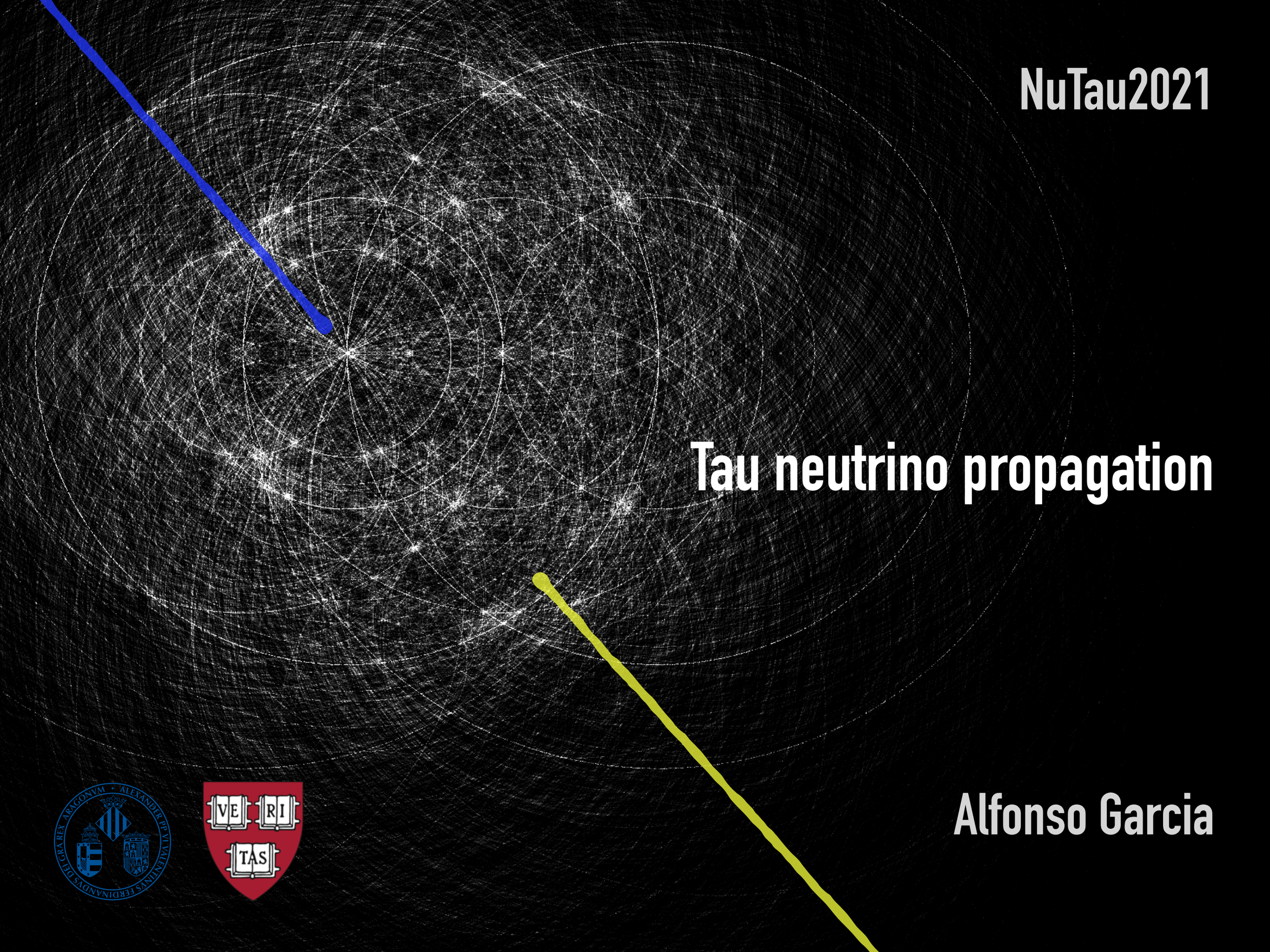
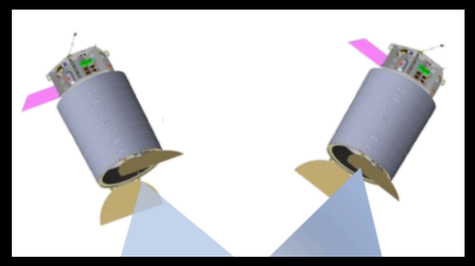
NuTau2021

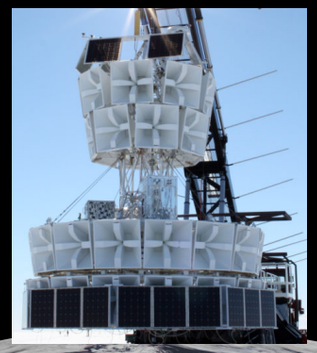
Tau neutrino propagation



Alfonso Garcia

Several technologies trying to detect PeV/EeV tau neutrinos





Physics of neutrino is
the same for all of them

DETECTION

interactions

light simulation

trigger

PROPAGATION

oscillations

interactions

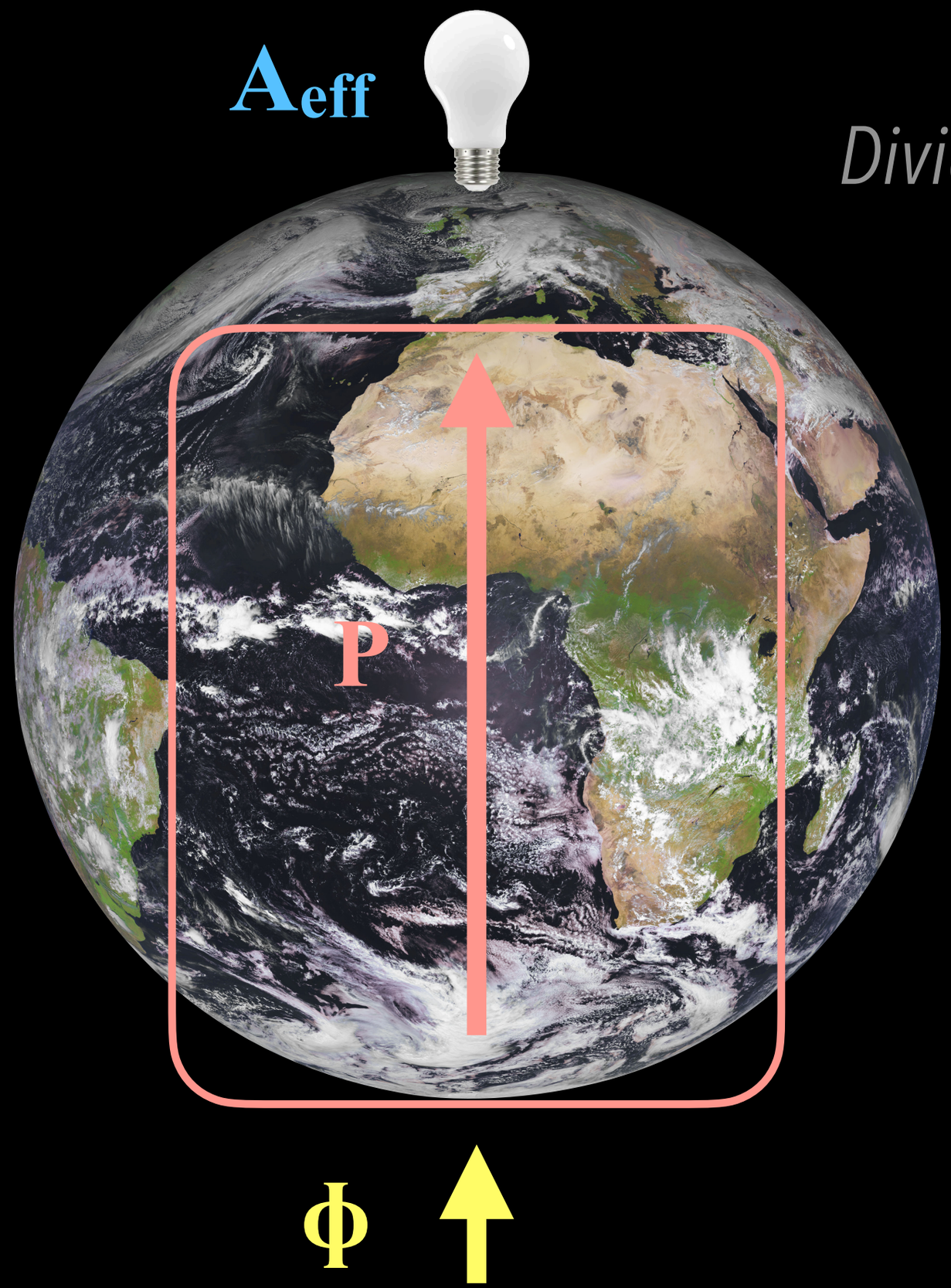
SOURCE

atmospheric

astrophysical

Simulation

Divide and conquer



Various framework can compute this step

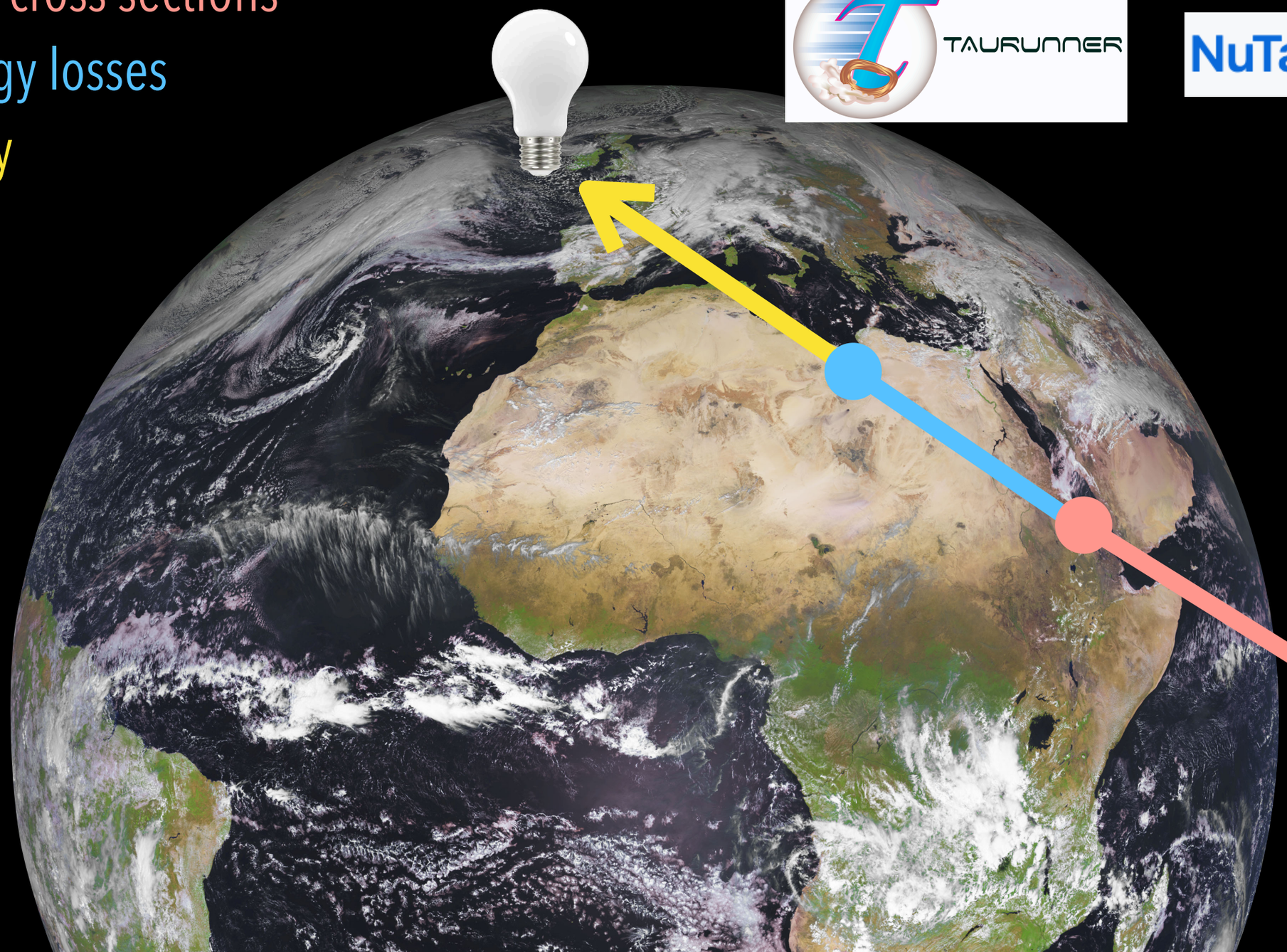
What do we need to model?

Medium

Neutrino cross sections

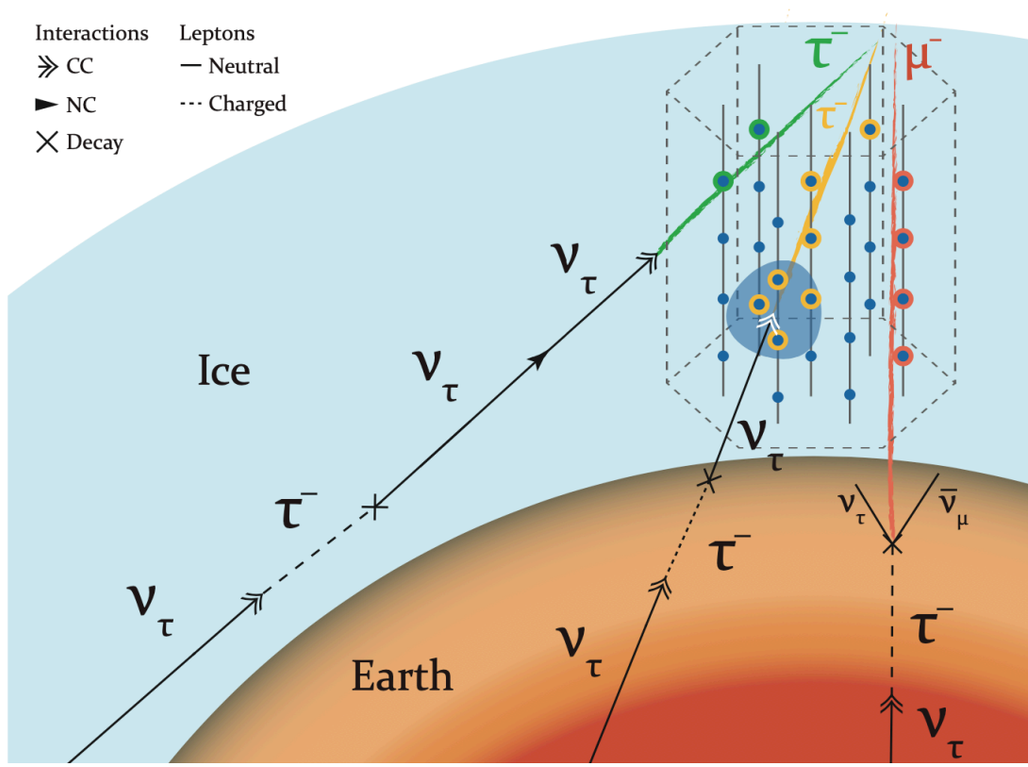
Tau energy losses

Tau decay

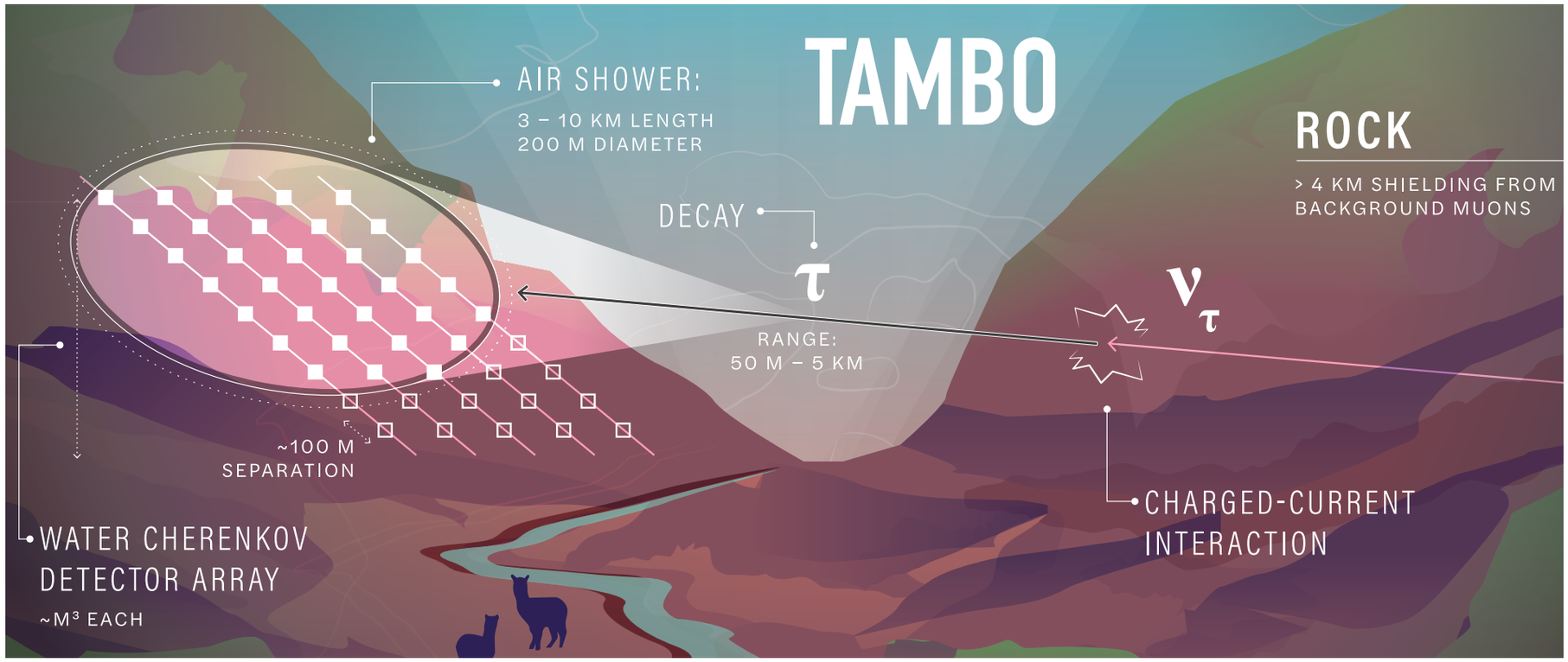


Mediums

- PeV neutrinos -> local features less relevant.
  - Spheres with different layers (PREM model).



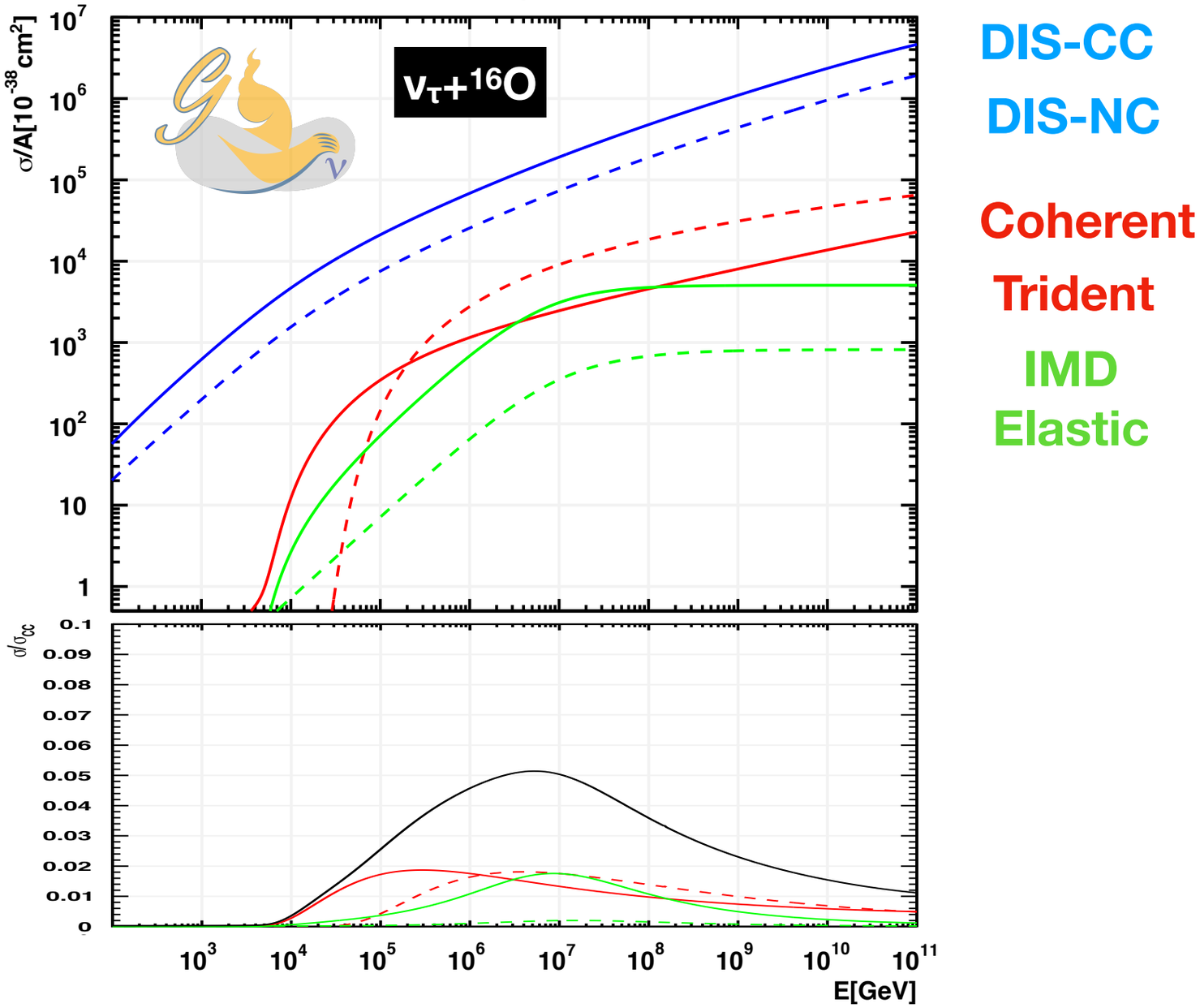
- EeV neutrinos -> Earth skimming.
  - Model more details about the target geometry (montains, valleys, etc).



https://arxiv.org/pdf/2002.06475.pdf

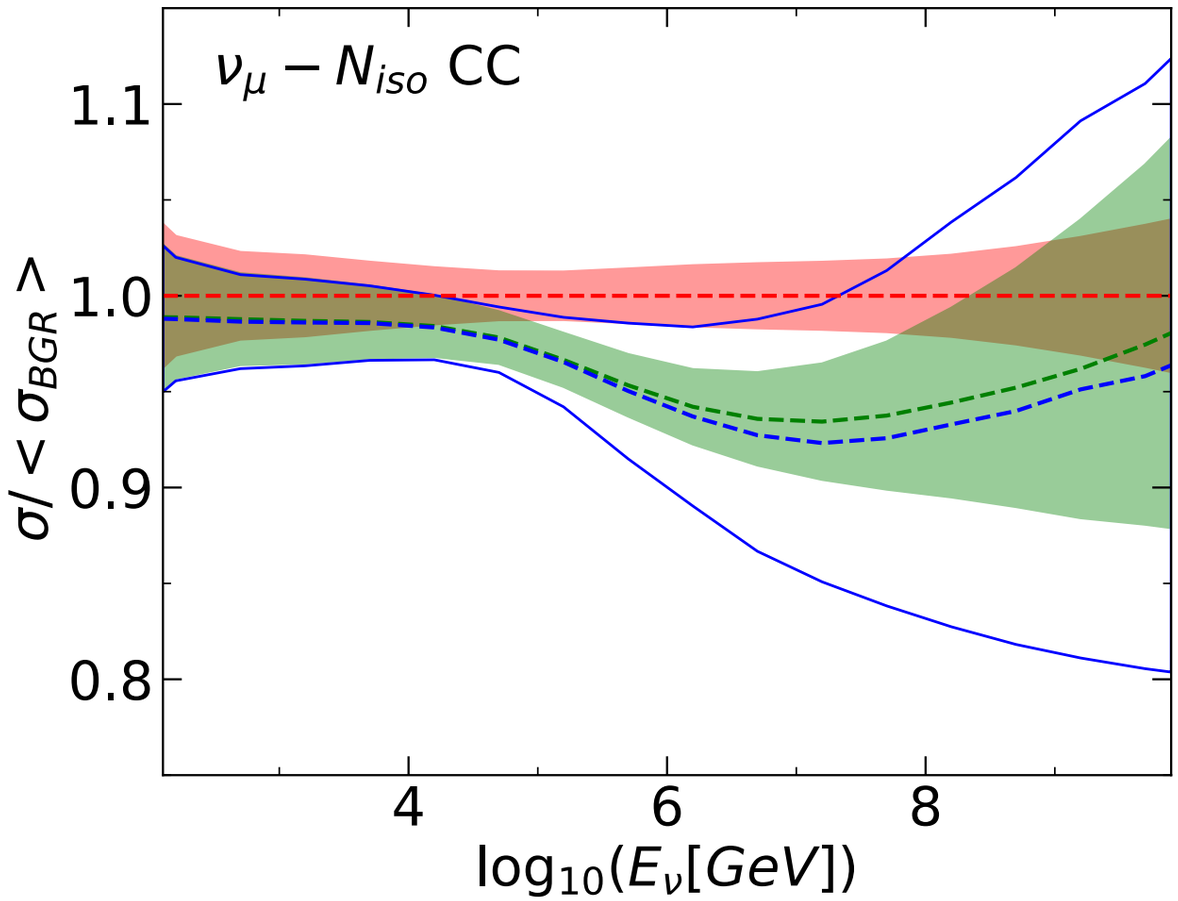
Cross sections

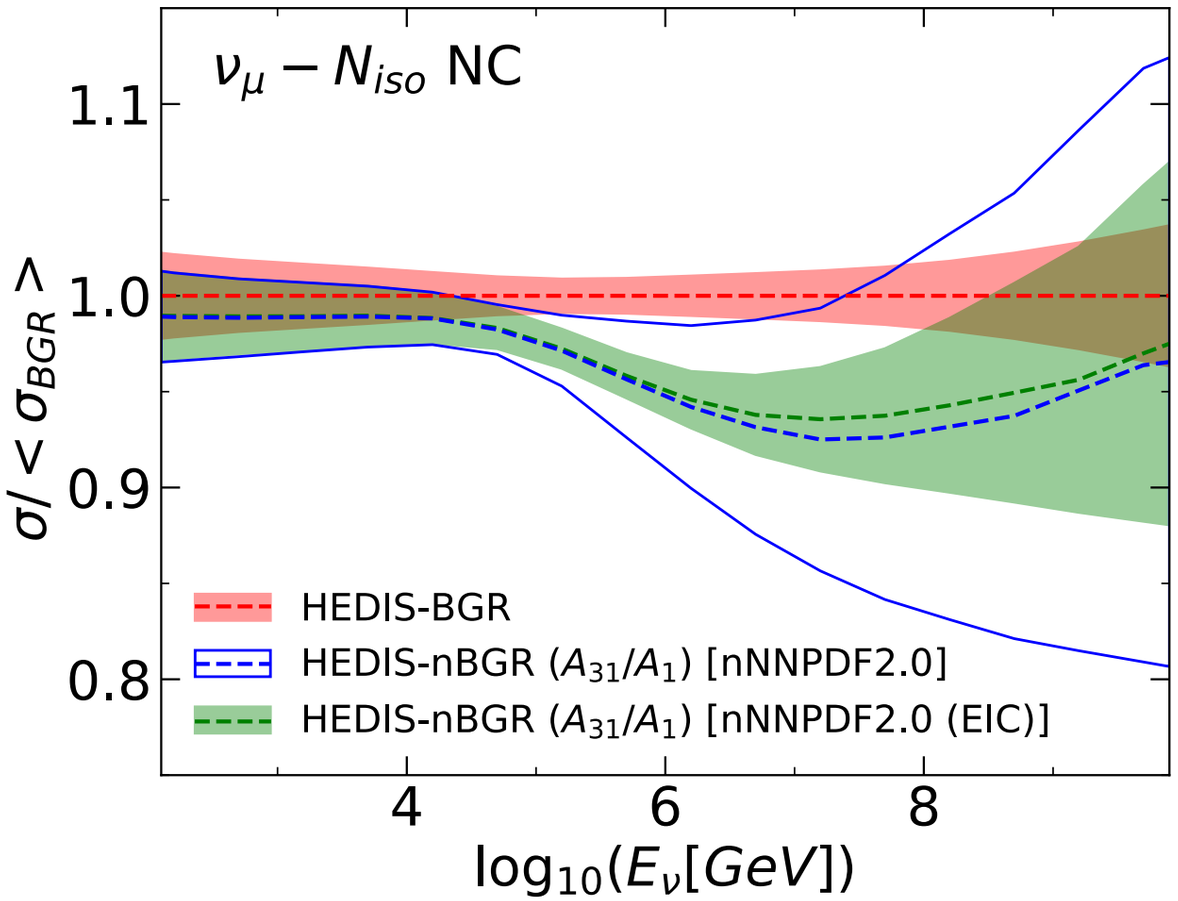
- Total cross section
  - Neutrino nucleon DIS dominates at these energies.
  - Non-negligible contribution from other processes.



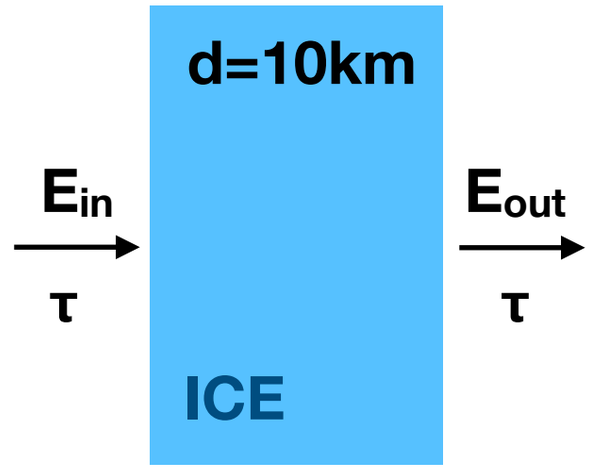
Cross sections

- Total cross section
  - Nuclear effects may reduce cross sections ~10% at PeV energy.

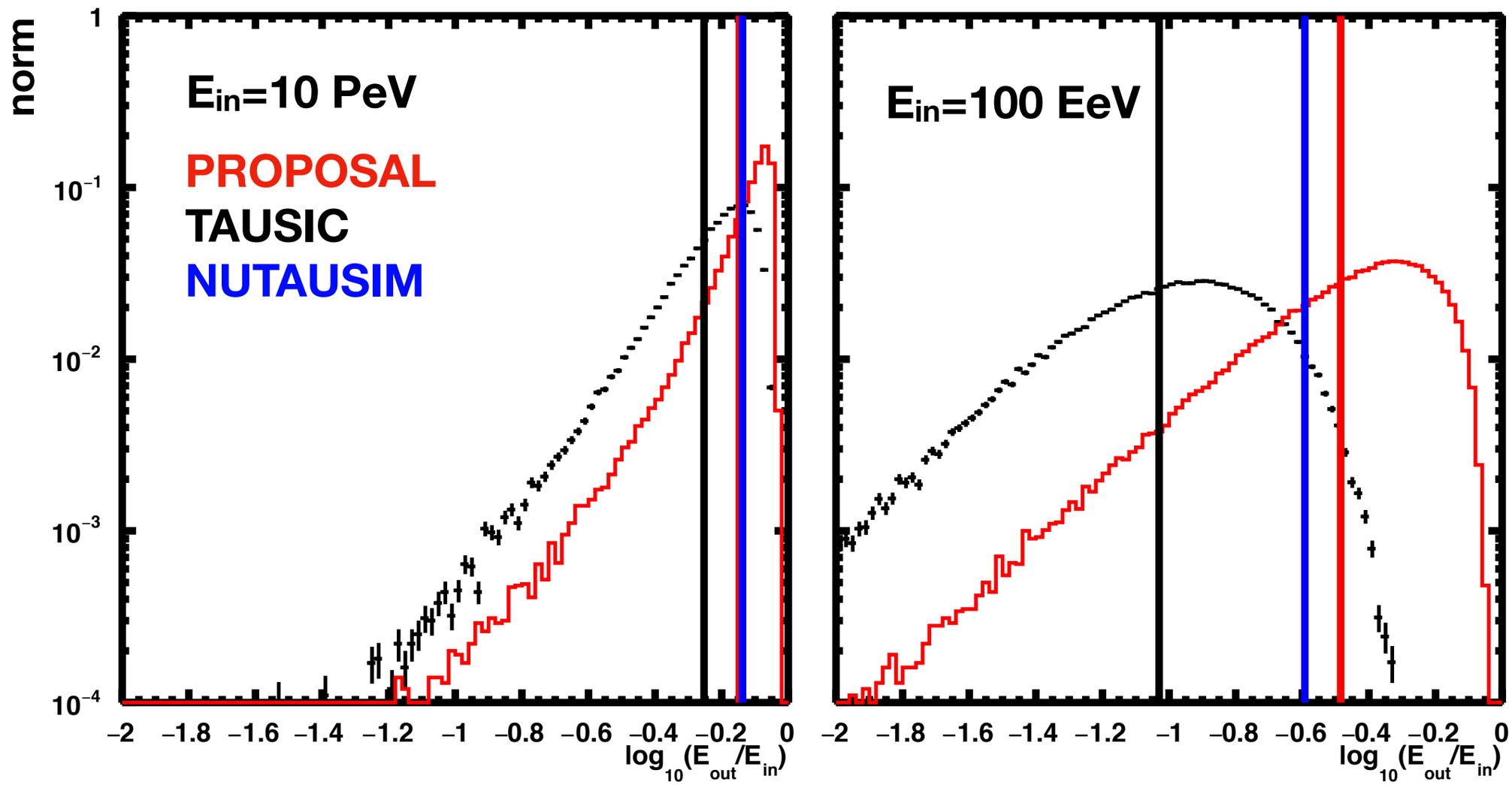




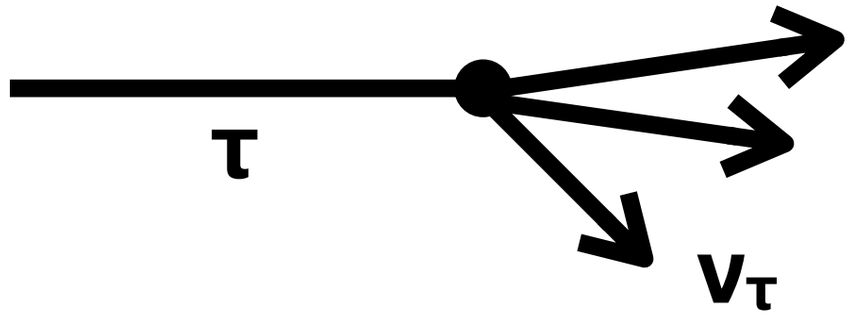
Energy losses



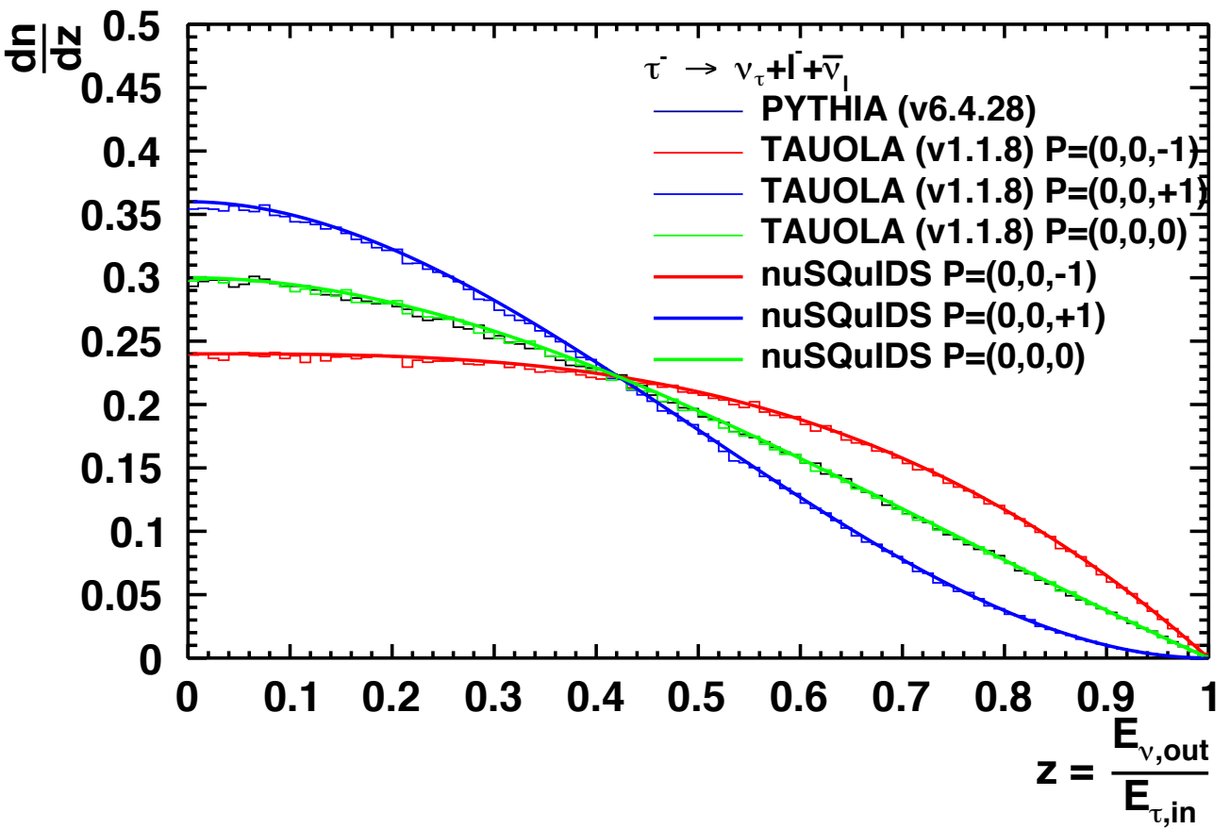
- Different softwares available to compute tau energy losses.
  - Photonuclear interactions dominate above 100TeV.
  - Tau leptons MUST be propagated stochastically.

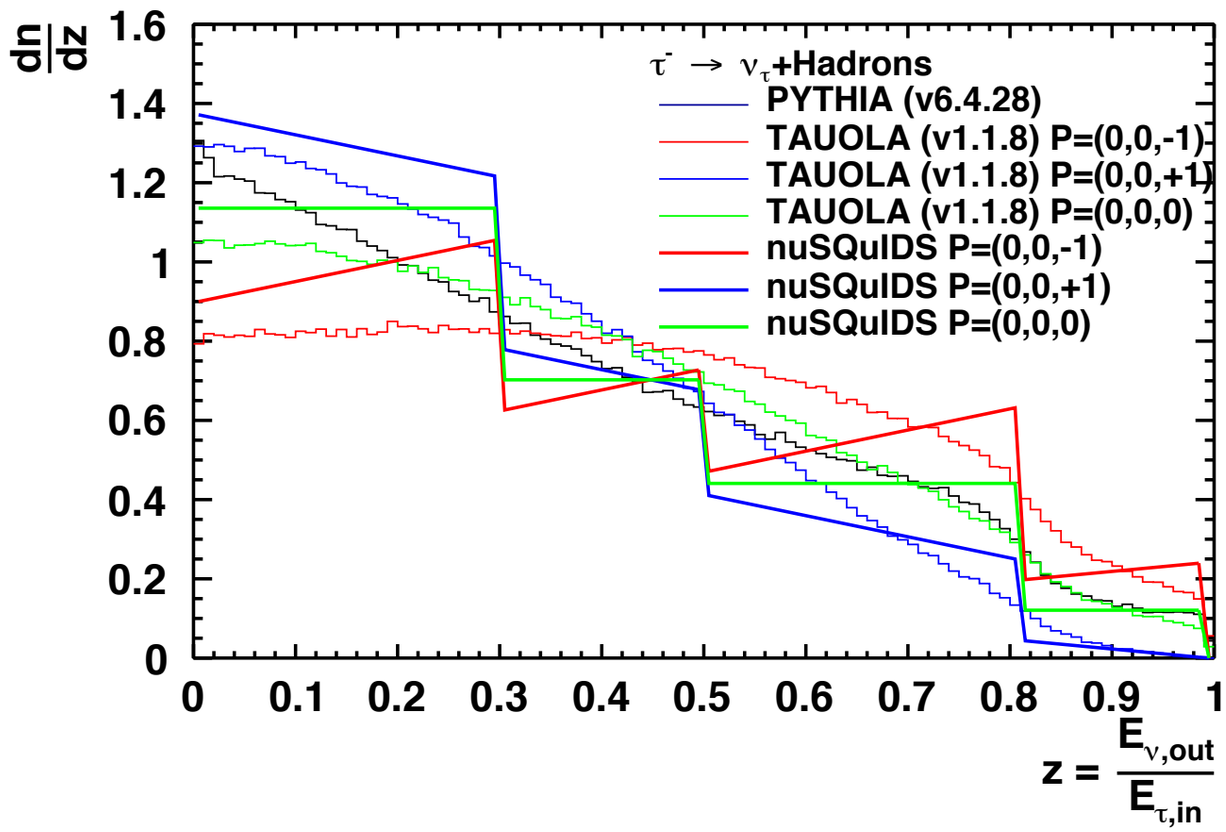


Tau decay



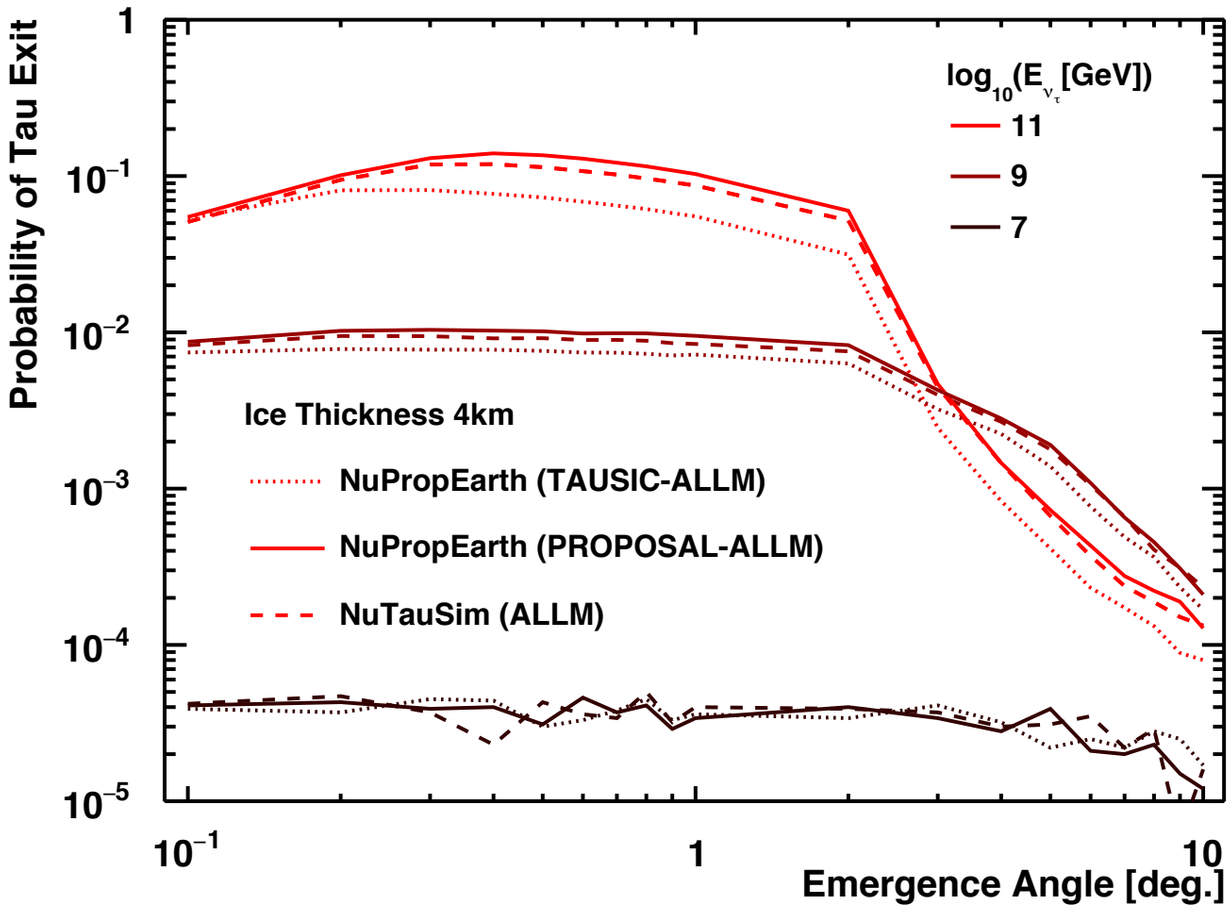
- Tau polarisation defines the energy distribution of outgoing particles
  - Left handed taus are produced at high energies.

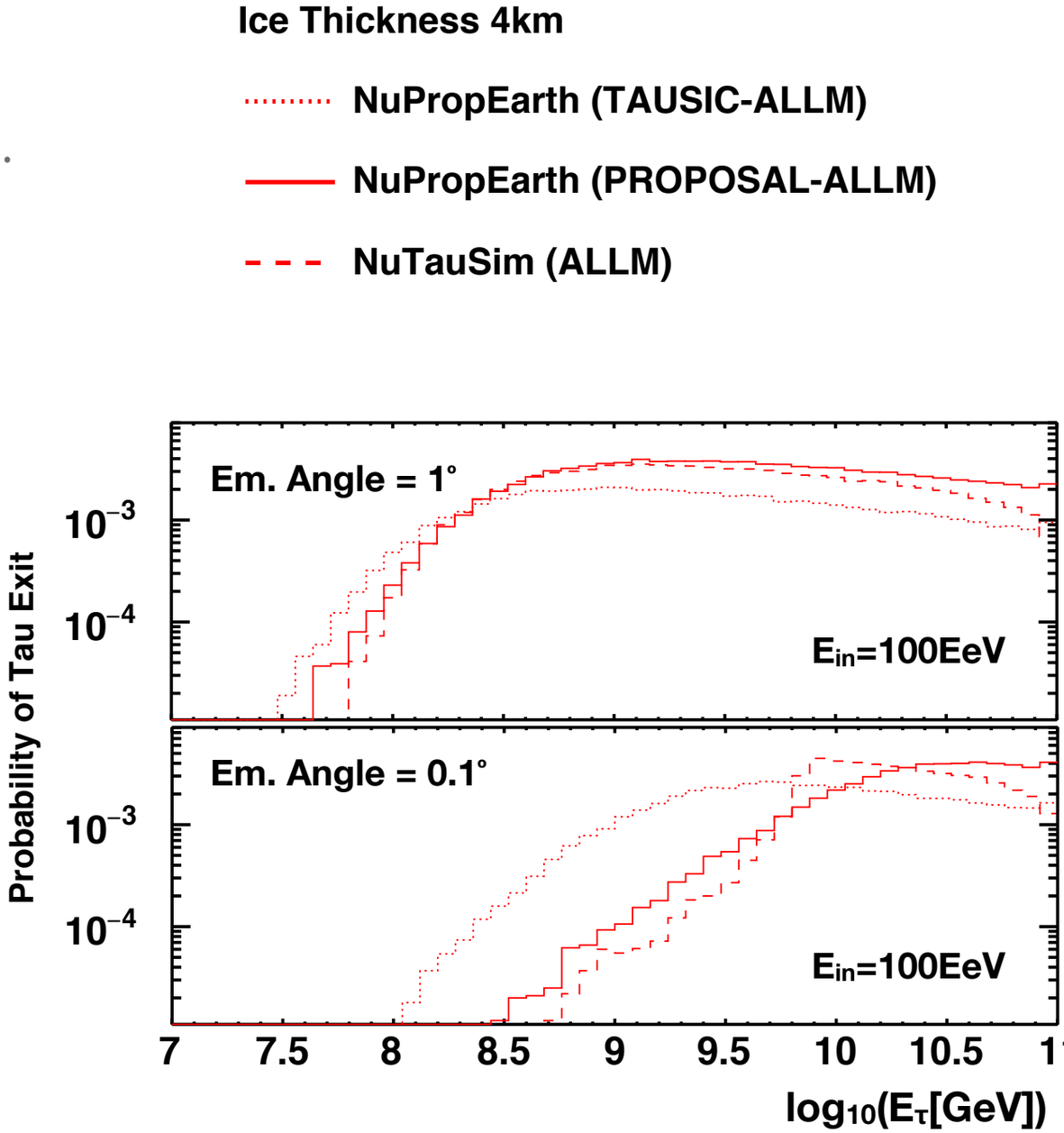




Comparisons

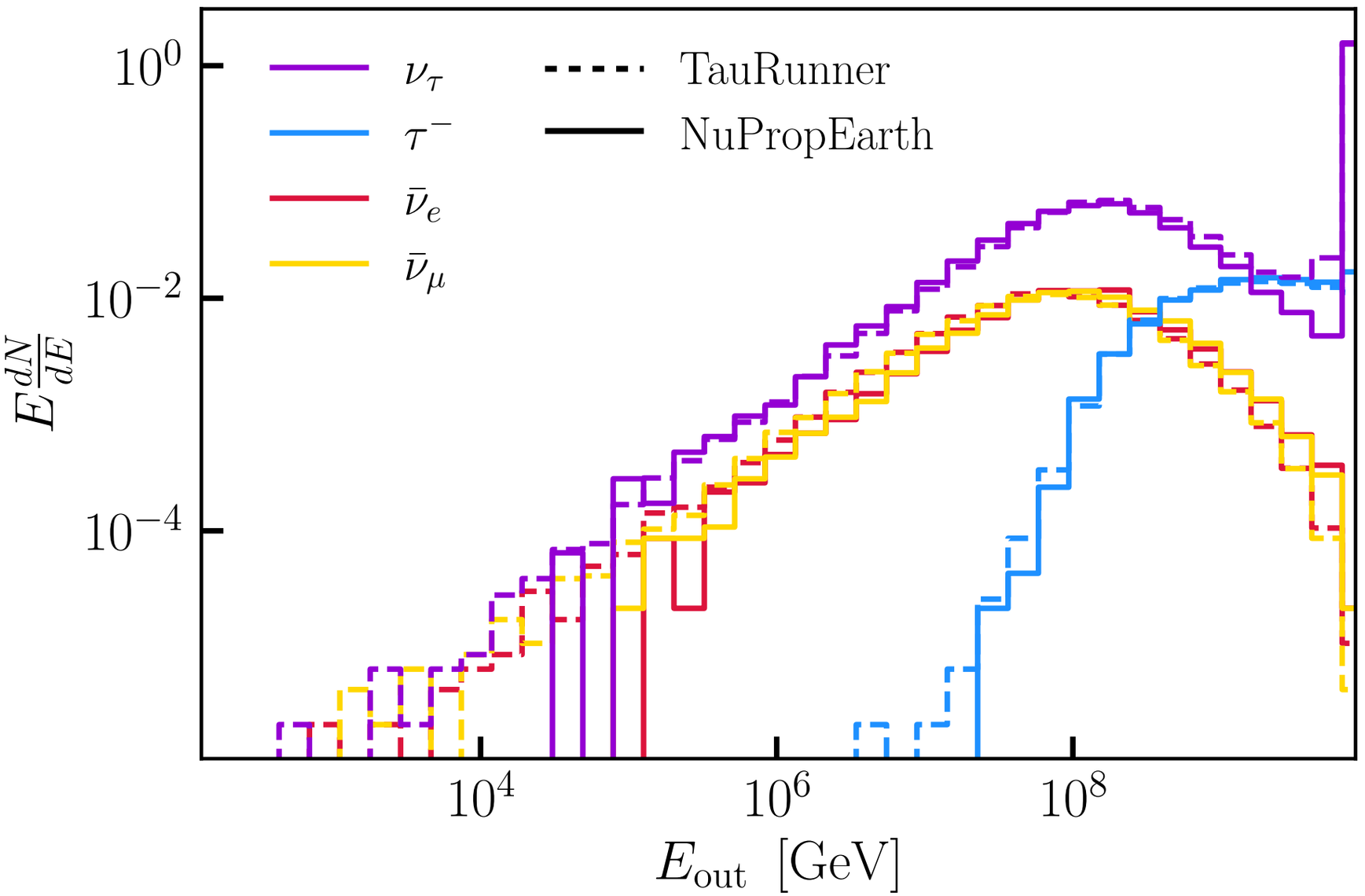
- Tau exit probability:
  - Very relevant for Earth skimming neutrinos.
  - Energy distributions can be quite different.





Comparisons

- Neutrino absorption and secondaries yield.
  - Very relevant for neutrino telescopes.



Summary

SOFTWARE	MEDIUM	XSEC	ELOSS	DECAY	SECONDARIES	SPEED
NuPropEarth	PREM*	DIS+GLRES+DIF (HEDIS)	PROPOSAL TAUSIC	TAUOLA	nu (all), tau	Slow
TauRunner	PREM,Sun, Moon*	DIS (Table)	PROPOSAL	Parametrization	nu (all), tau	Fast
NuSpaceSim	PREM*	DIS (Table)	Table	Parametrization	nu (all), tau, mu	?
NuTauSim	PREM	DIS (Parametrization)	Parametrization**	Table	nutau, tau	Fast
DANTON	PREM, WGS84+Topo.	DIS+GLRES (ENT)	PUMAS	ALOUETTE	nu (all), tau	Slow (Forward) Fast (Backward)
...						

***Other geometries can be imported**

****Not stochastic**

Conclusions

- High-energy tau neutrino propagation in Earth plays a key role in ongoing and projected experiments.

- Different physics processes must be accurately modelled to determine neutrino flux.

- Various simulation framework are publicly available.
  - Redundant? NO!!!
  - Thorough comparison between them is essential.

Acknowledgements

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