Some Simulation Updates and Musings

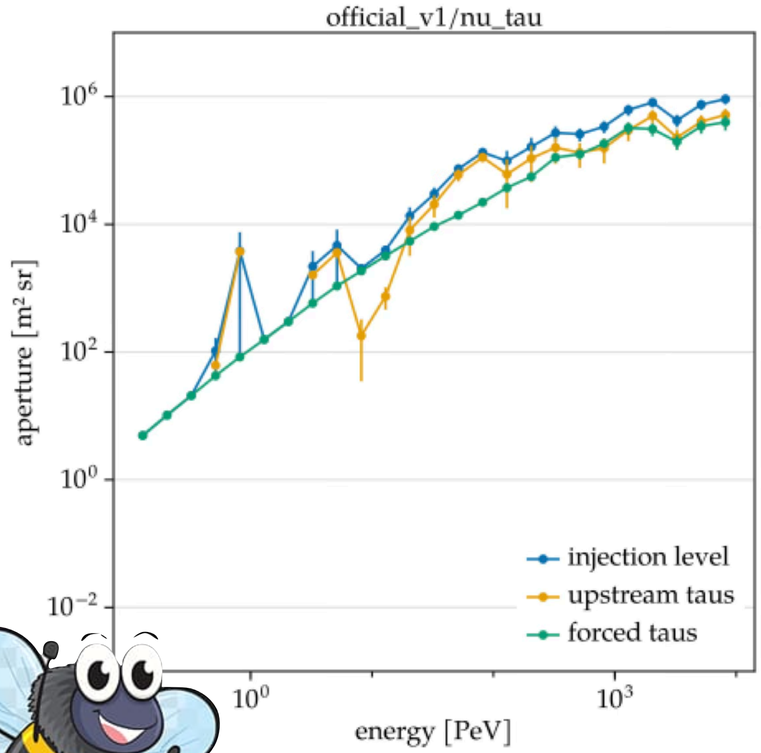
Jeffrey Lazar

18 Aug., 2026

TAMBO Collaboration Meeting

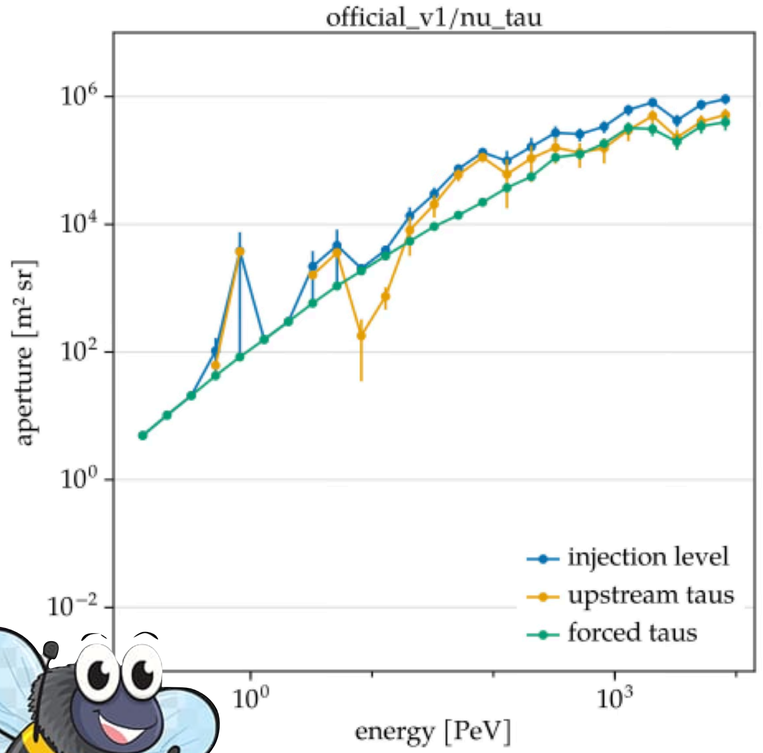
Lima, Peru

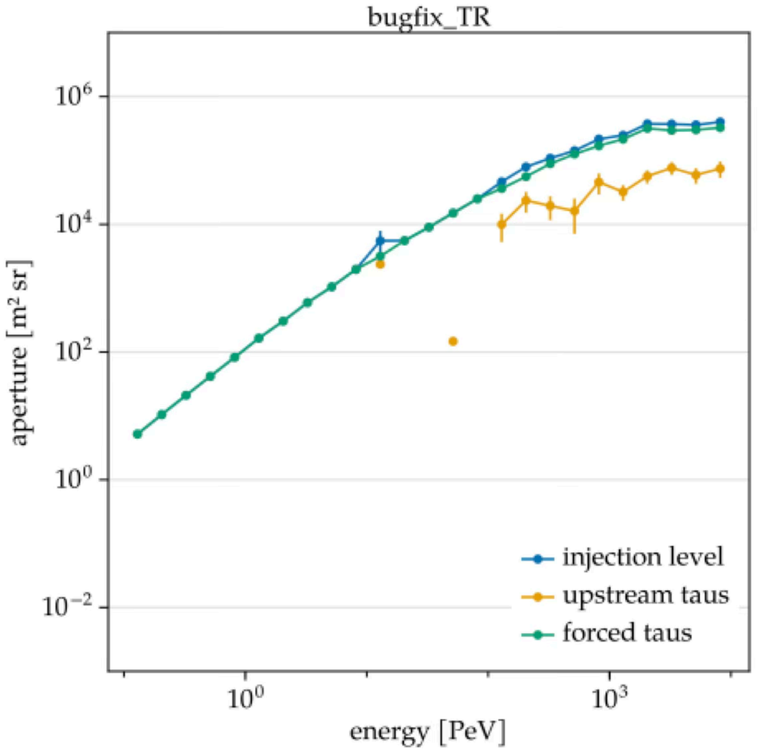
Going Bug Hunting



- Kiara noticed very jumpy effective area
- Driven by events that reach the detector region as tau leptons
  - Very high weight / low stats
- Investigating this turned up two different issues with injection logic

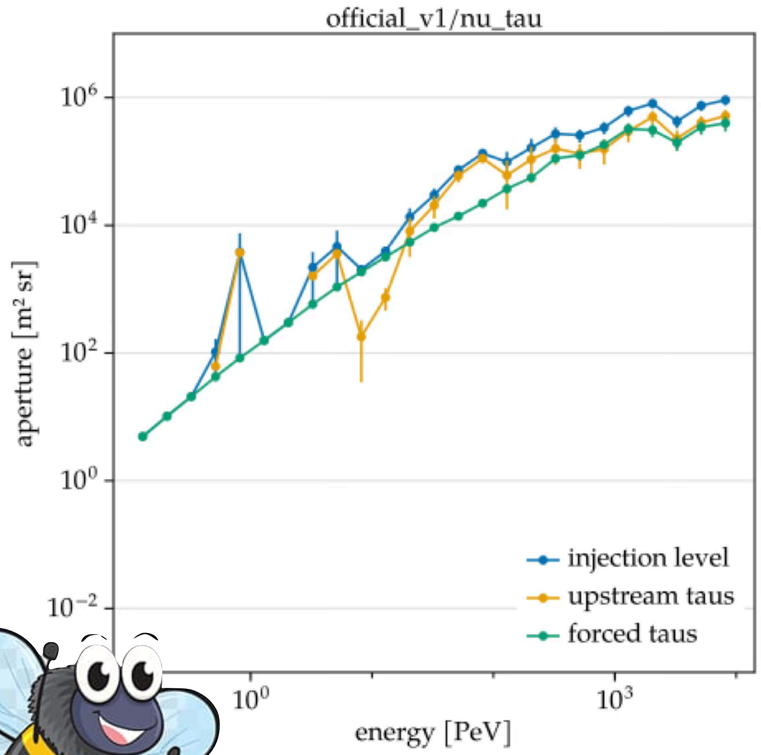
Going Bug Hunting

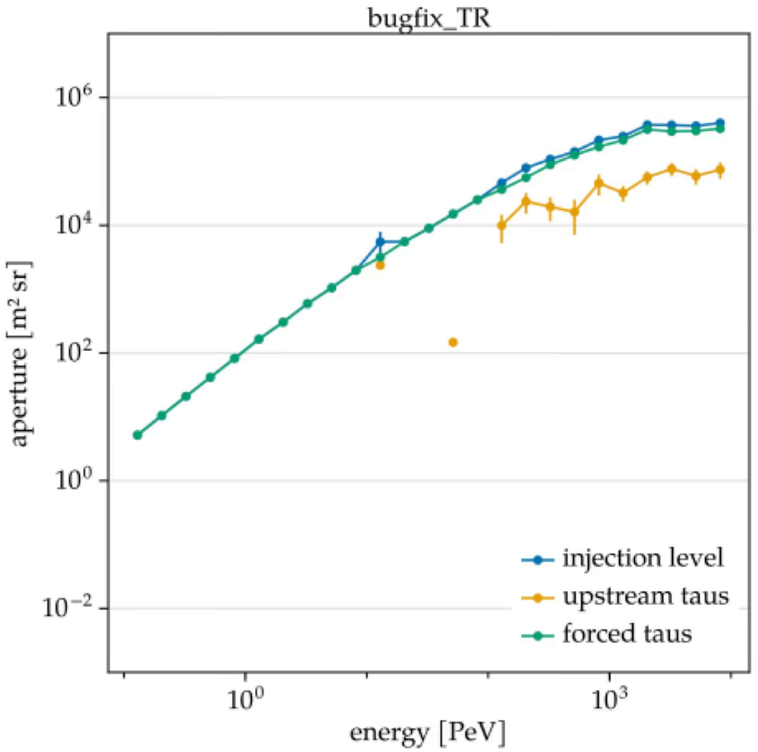


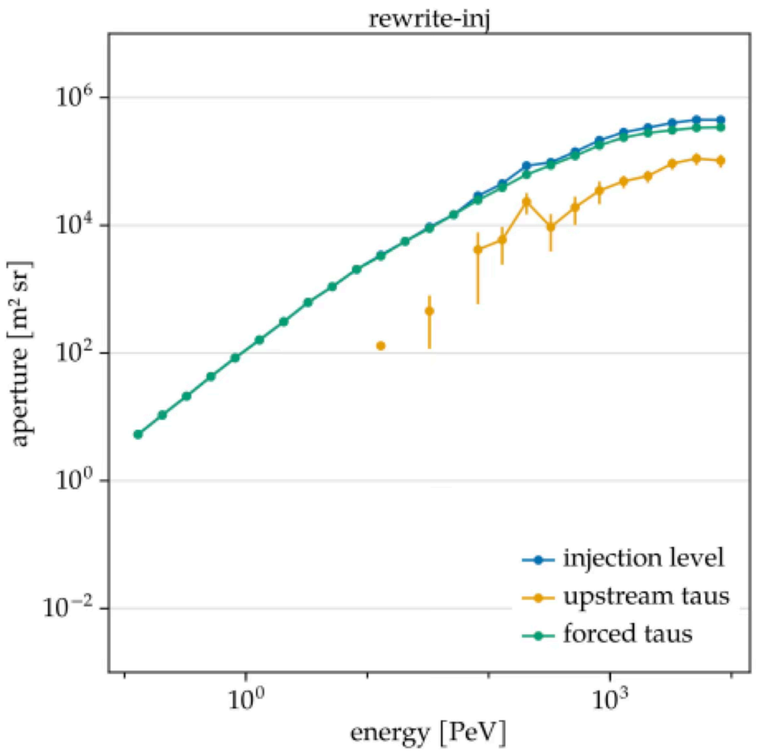


- One was a bug in TauRunner, that had a large impact
- Almost entirely resolved the issue

Going Bug Hunting





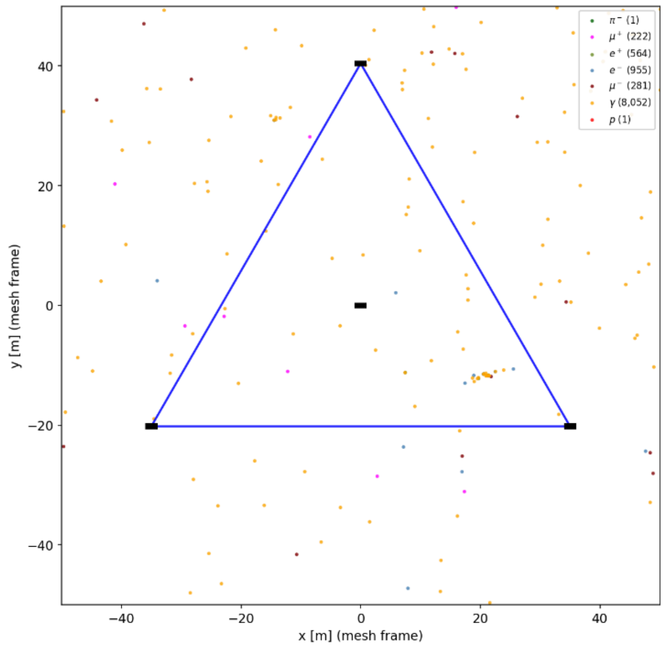


- Final fix caused minimal changes
  - (But it's good when your code is right)

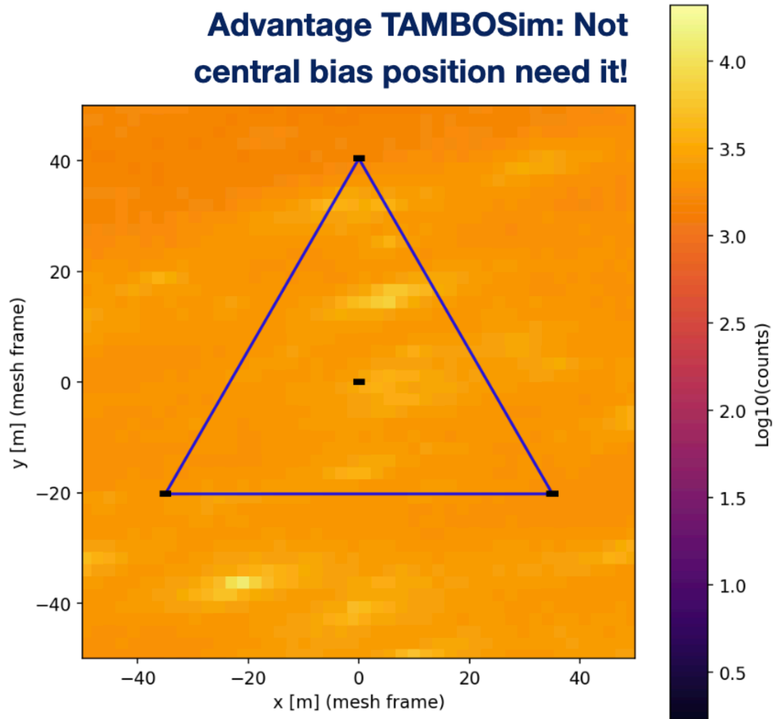
Expanding to TAMBO-4

Results

The 2D histogram of the secondary particle positions shows different “core positions” instead of the Gaussian pattern in the xy plane with only C8.



Advantage TAMBOSim: Not central bias position need it!



One shower: E (250 TeV), θ_{local} (151°), 10 076 particles

- Thank you, Luz!

A Long Digression

The TAMBO Utility Function

What do our array requirements look like?

Some are very physics-driven:

- "Aperture $\geq 400 \mathrm{m}^2\mathrm{sr} \times E_{PeV}^{1.5}$ from 1-10 PeV and 10x IceCube from 10-100 PeV"
- $\leq 1°$ air shower pointing resolution

Others are more operations driven:

- Power consumption less than xxx W per station
- Station failure rate less than xxx per year
- Construction compatible with local sourcing and repair

- Quantify if a choice makes us better or worse?
- Clearly, this is a complicated, multifaceted problem
- I think this is worth taking seriously

The TAMBO Utility Function

On the Utility Function of Experiments in Fundamental Science

Tommaso Dorigo[1,2,3], Michele Doro[4,2], Max Aehle[5], Nicolas R. Gauger[5], Muhammad Awais[1,2,4], Rafael Izbicki[10], Jan Kieseler[6], Luca Masserano[9], Federico Nardi[4,7], and Luis Recabarren Vergara[2,4,8]

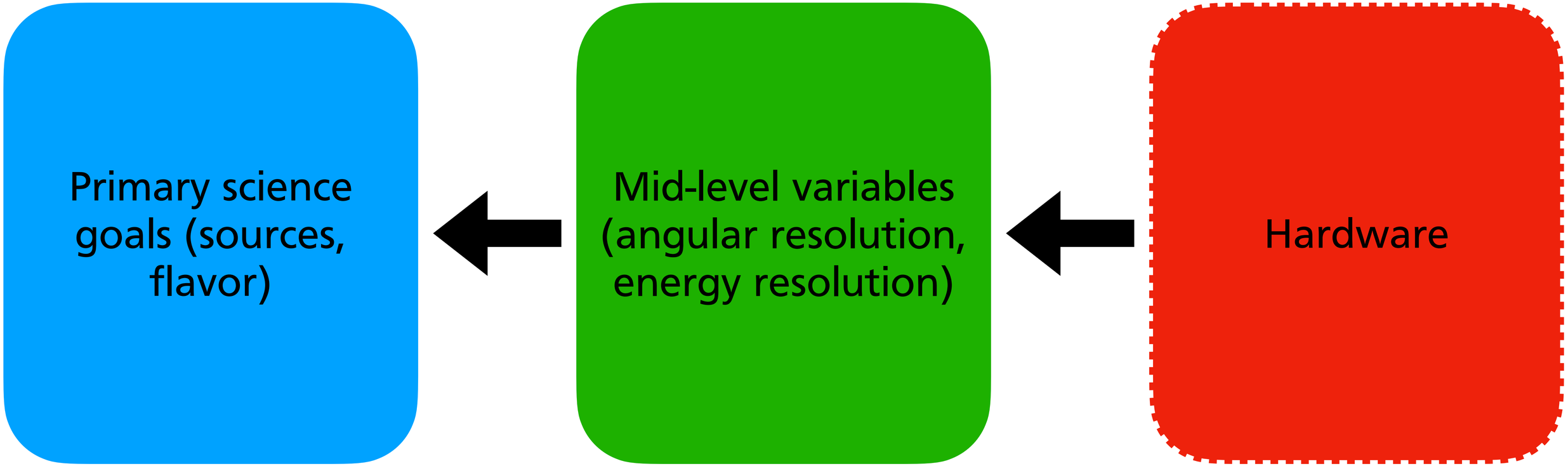
T. Dorrigo, et. al (2025)

A Multi-Objective Utility Function

$$U = \lambda_1 U_1 + \lambda_2 U_2 + \ldots$$

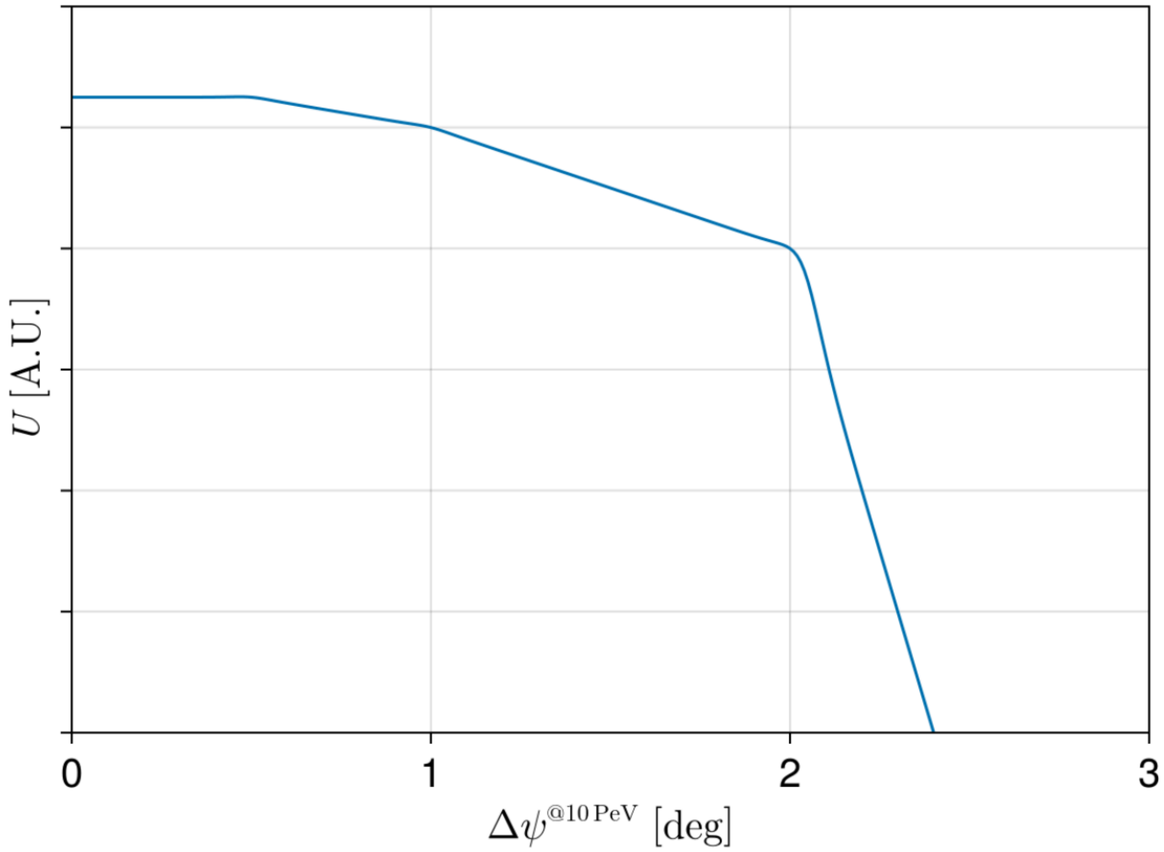
- You can always write your utility function as a weighted sum over your sub-goals, e.g.,
  - Acting as an external trigger for Cherenkov telescopes
  - Resolving the flavor triangle
- At the Pareto Front, no solution outperforms any other solution due to trade-offs among the objectives

Specificity Is Key



A Sketch for TAMBO

- Working with Cherenkov telescopes depends on the interplay of angular resolution and statistics
  - More neutrinos is better
  - Better angular resolution is critical, but only to a point
- Effective parametrizations let us translate detector performance to physics goals
- Further connecting these to hardware deepens the connection



A Note About Weights

- Deciding the relative merits will always be fraught
- T. Dorrigo, et al. use citations from previous experiments as guide
- H-index of papers on a subject may also offer insight into what the community values

Item	Abbreviated title	Year	Category	Citations
1	Observation of top quark production [...] [22]	1995	1	4288
2	The CDF Detector: an Overview [23]	1988	0	1988
3	Evidence for top quark production [...] (PRD) [24]	1994	1	1062
4	Evidence for top quark production [...] (PRL) [25]	1994	1	832
5	The Topology of 3-jet events [26]	1992	3	571
6	J/ψ and $\psi(2S)$ production [...] [27]	1997	2	515
7	Observation of the B_c meson [...] [28]	1998	2	469
8	Measurement of the $p\bar{p}$ Total Cross- Section [...] [29]	1993	3	452
9	Inclusive J/ψ, $\psi(2S)$ and b-quark production [...] [30]	1992	2	448
10	Double parton scattering in $\bar{p}$p collisions [...] [31]	1997	3	448
11	Inclusive jet cross section [...] [32]	1996	3	417
12	CDF central and end-wall calorimeter [33]	1988	0	403
13	Production of J/ψ mesons from χ_c meson decays [...] [34]	1997	2	396
14	Charged Jet Evolution and the Underlying event [...] [35]	2002	3	395
15	Transverse Momentum Distributions of Charged Particles [...] [36]	1988	3	361
16	Observation of B_c mesons [...] [37]	1998	2	358
17	The Silicon Vertex Detector [...] [38]	1994	0	354
18	A Measurement of the W boson mass [39]	1990	1	336
19	Study of four jet events and evidence for double parton [...] [40]	1993	3	322
20	A Measurement of the W boson mass [...] [41]	1990	1	322

T. Dorrigo, et. al (2025)

What Does This Buy You?

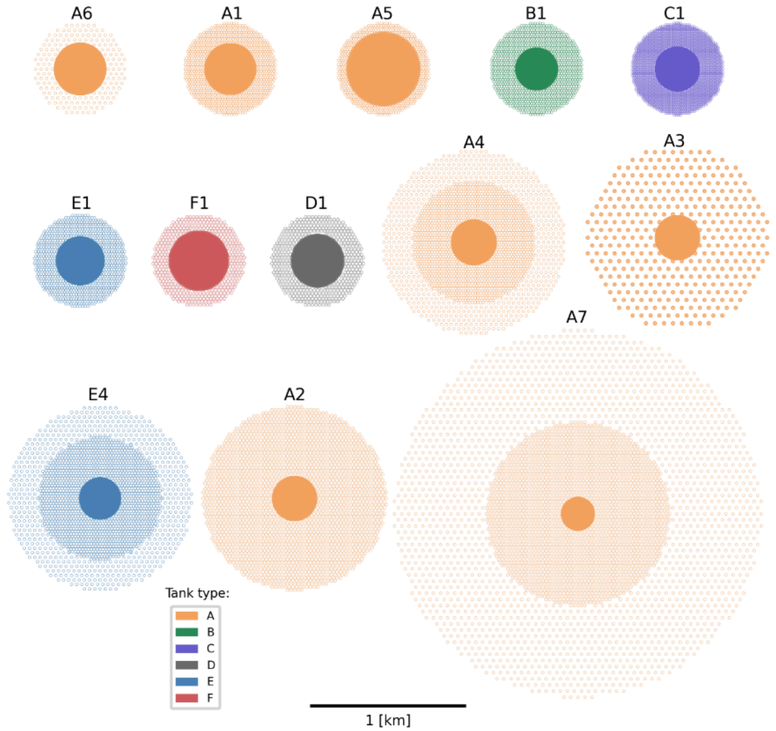
Or: But, Jeff, why

- This is a lot of effort, and we don’t really have excess person power
- I have been thinking about this in three contexts
  - Array optimization
  - Effort allocation
  - Engineering tolerances

A Case Study from SWGO

- T. Dorrigo, et al. use utility function that consists of terms that reward:
  - Determining the spectrum of gamma-rays
  - Good event-by-event energy resolution
  - Good event-by-event pointing
- They then run an explicit optimization and compare to thirteen benchmark arrays

$$U = \lambda_{\mathrm{GF}} U_{\mathrm{GF}} + \lambda_{\mathrm{ER}} U_{\mathrm{ER}} + \lambda_{\mathrm{PR}} U_{\mathrm{PR}}$$



T. Dorrigo, et. al (2025)

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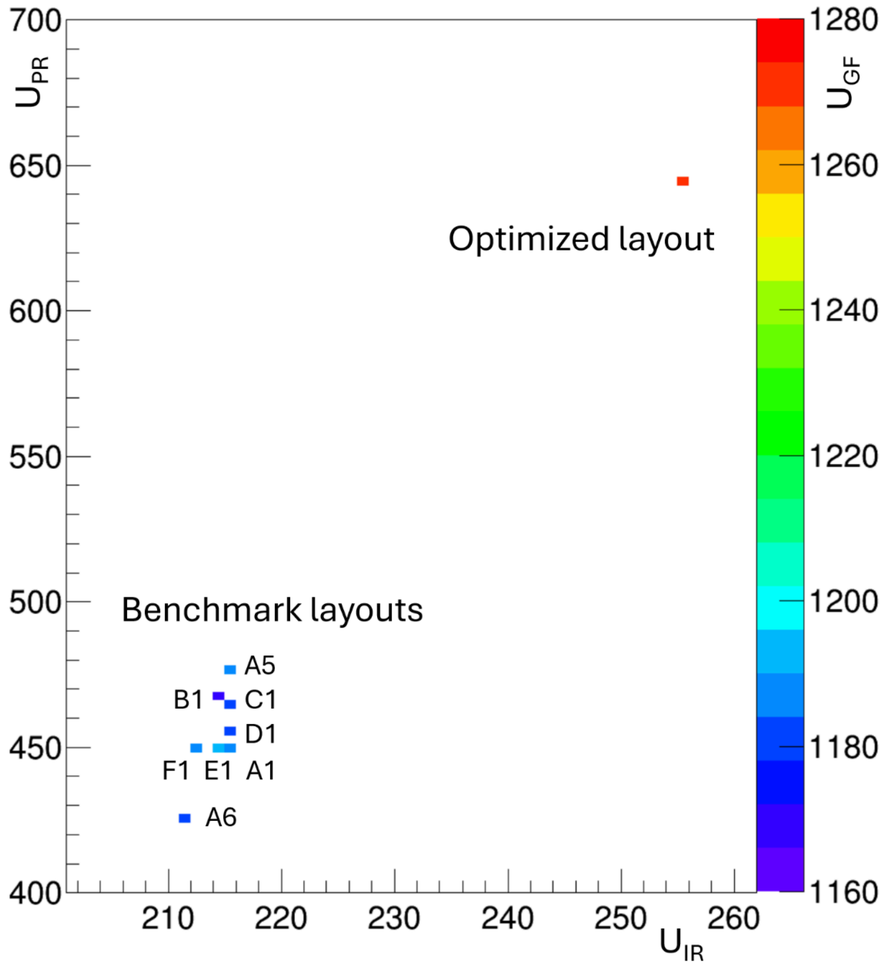
- Benchmarks are relatively near each other, giving false impression of Pareto Front



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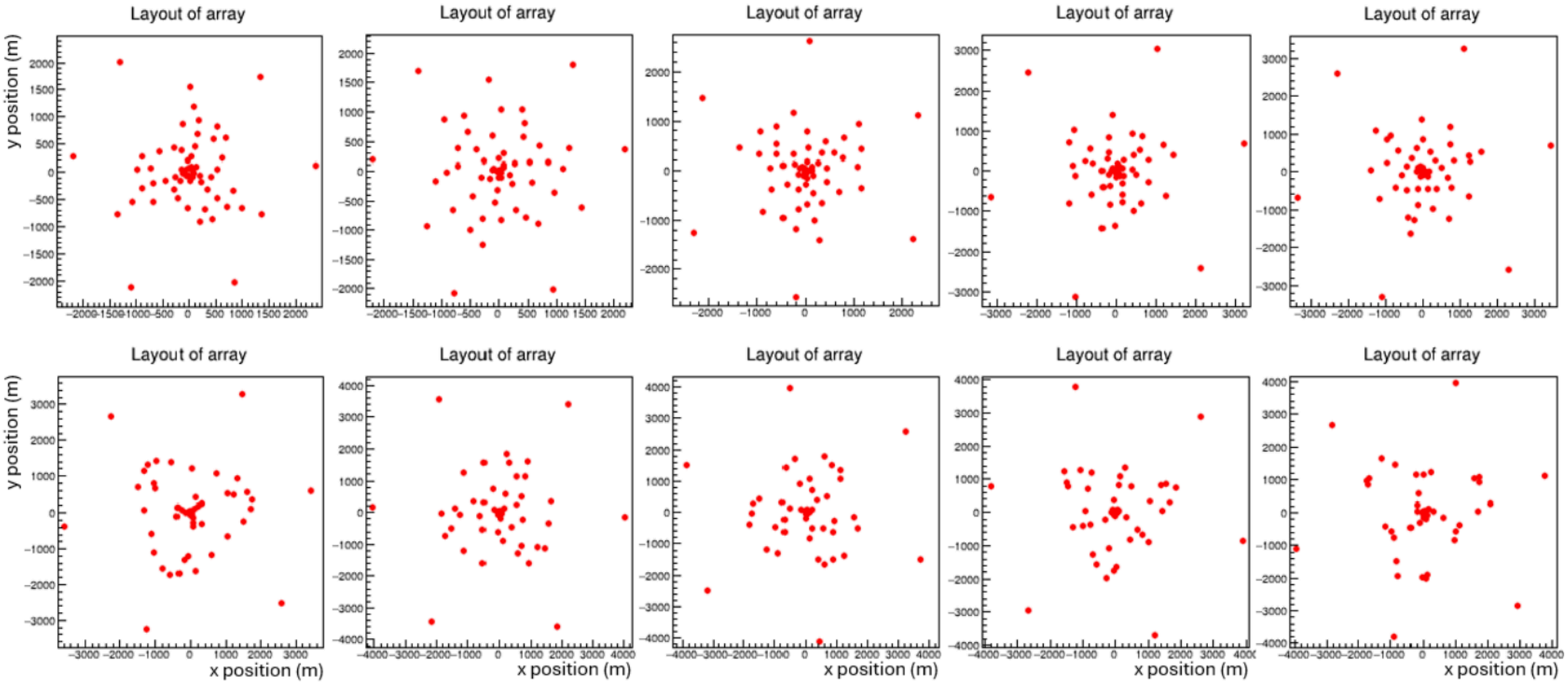

T. Dorrigo, et. al (2025)

Conclusions and a Final Plea

- The simulation is moving along, and I promise I'll have a draft soon (sorry Carlos)
- Having a single, quickly evaluable utility function ties decisions and risks to our science goals
  - We can optimize the array, prioritize projects, and evaluate engineering requirements
- **Can we please put some thought into what this should be so that we can incorporate it into the optimization. We're currently a bit blind**