

CF6. Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities

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Two White papers submitted to CF6:

- "Opportunities from Cross-survey Analyses of Static Probes", Eric J. Baxter, Chihway Chang, Andrew Hearin, Jonathan Blazek, Lindsey E. Bleem, et al. [arXiv:2203.06795](https://arxiv.org/abs/2203.06795).
- "Multi-Experiment Probes for Dark Energy – Transients", Alex G. Kim, Antonella Palmese, Maria E. S. Pereira, Greg Aldering, Felipe Andrade-Oliveira, et al. [arXiv:2203.11226](https://arxiv.org/abs/2203.11226).

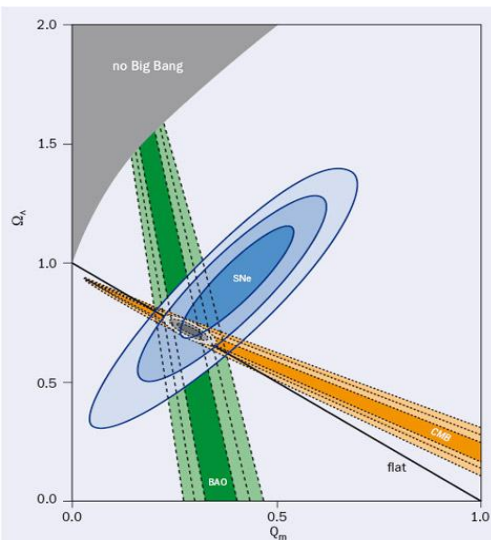
Many facilities motivated and discussed in CF1-7 white papers for example:

- "Observational Facilities to study Dark Matter" [arXiv:2203.06200](https://arxiv.org/abs/2203.06200)
- "CMB-S4 White Paper" [arXiv:2203.08024](https://arxiv.org/abs/2203.08024)
- "The Sanford Underground Research Facility", [arXiv:2203.08293](https://arxiv.org/abs/2203.08293)
- "A Next-Generation Liquid Xenon Observatory for Dark Matter and Neutrino Physics", [arXiv:2203.02309](https://arxiv.org/abs/2203.02309)
- "Rubin Observatory after LSST", [arXiv:2203.07220](https://arxiv.org/abs/2203.07220)
- "CMB-HD White Paper", [arXiv:2203.05728](https://arxiv.org/abs/2203.05728)
- "Future Gravitational-Wave Detector Facilities", [arXiv:2203.08228](https://arxiv.org/abs/2203.08228)

Guidance is that Snowmass reports should focus on science motivation

Old way of thinking the infrastructure (2203.06795)

- Independent & Isolated Surveys
- In house analysis & simulations
- Proprietary data kept secret for years
- Uncoordinated choices in modeling syst.
- Duplication of effort (waste of \$\$)

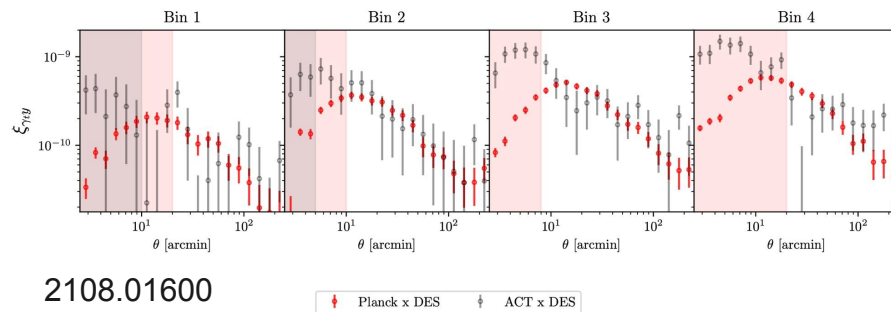


Joint analyses
happen only in the
cosmological
parameter space
(just stack
likelihoods)

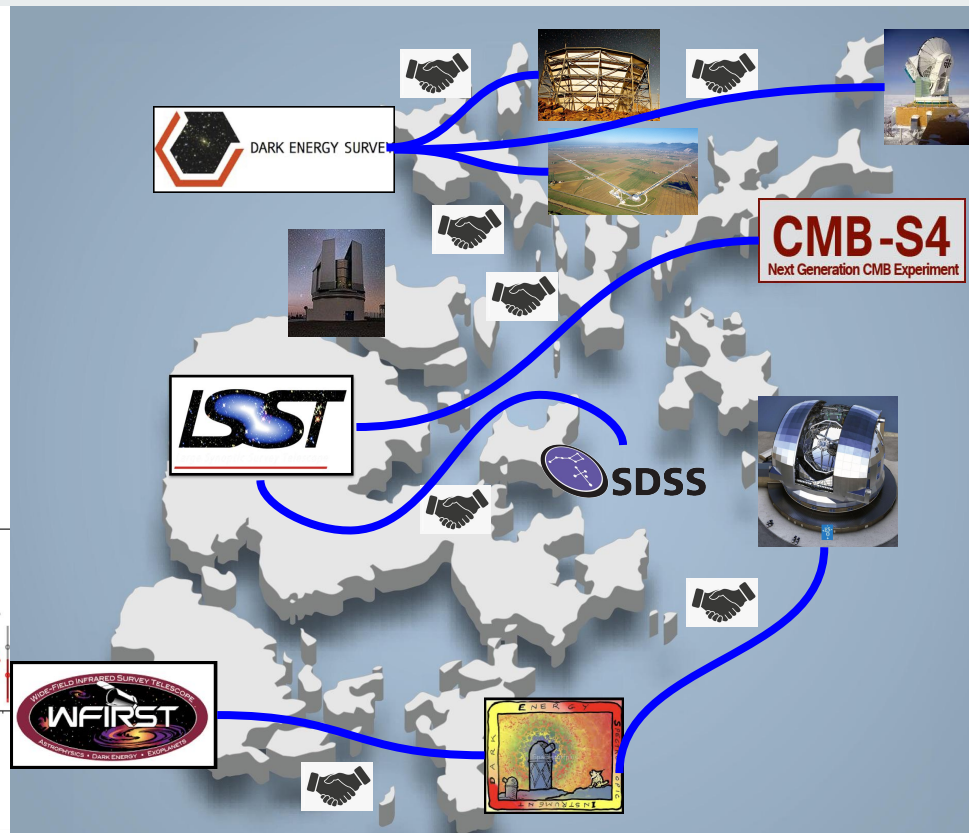


Current way of thinking the infrastructure (2203.06795)

- Independent & Isolated Surveys
- In house analysis & simulations
- Proprietary data kept secret for years
- Uncoordinated choices in modeling syst.
- **(new)** Bilateral agreements "handshakes"
(Limited data sharing in the agreement)

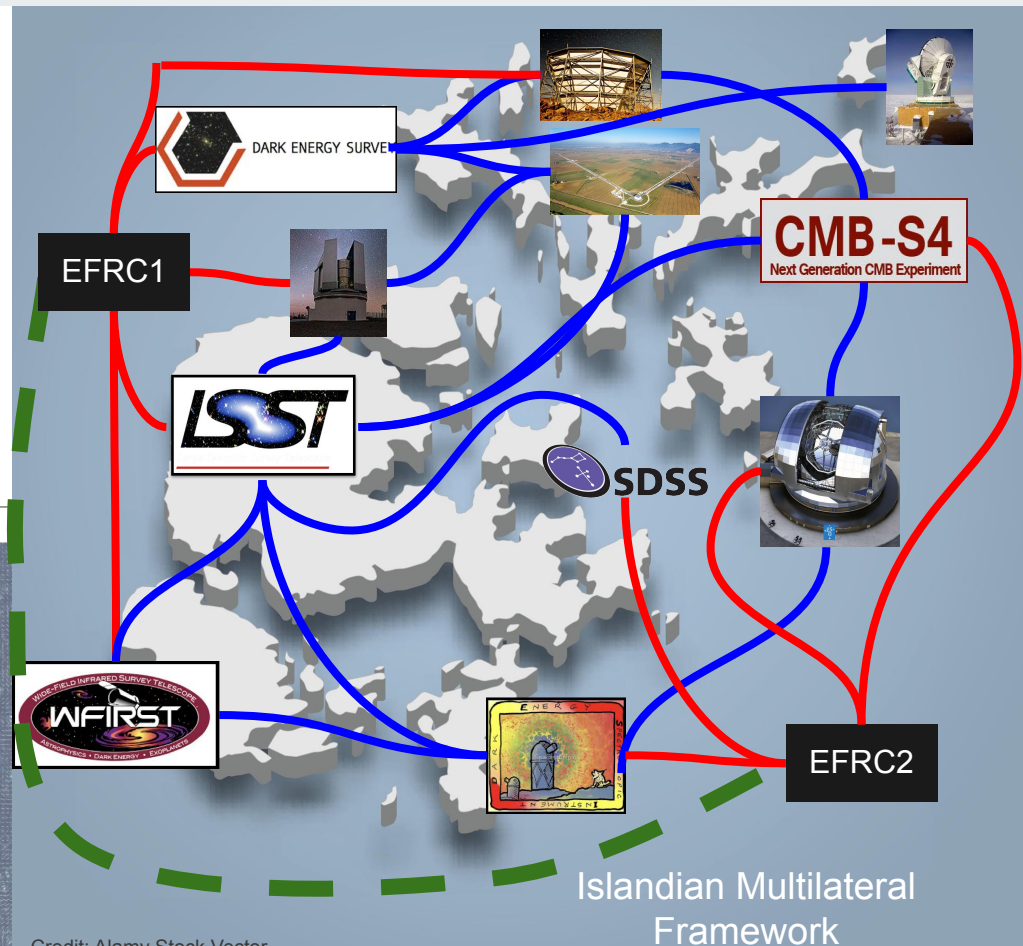
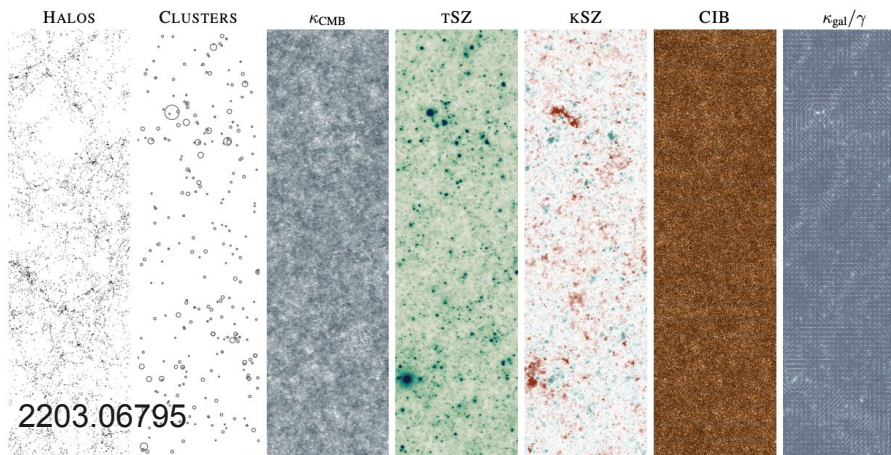


Good side: joint analyses does not happen
only in cosmological parameter space



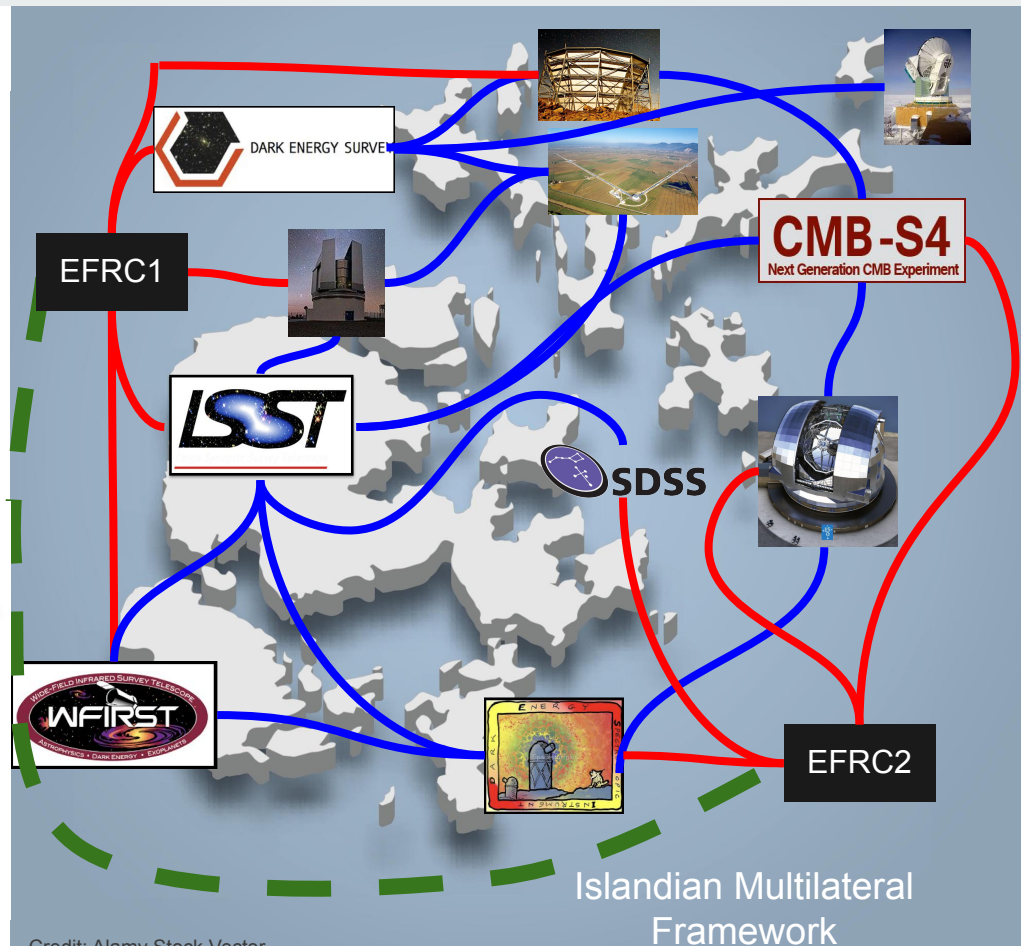
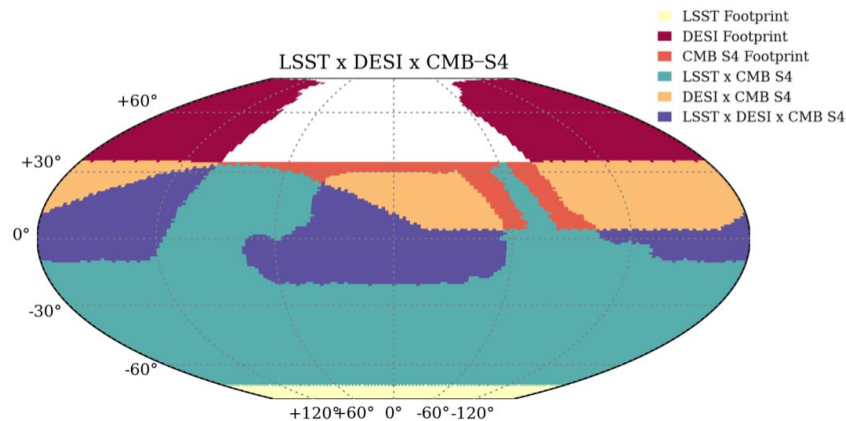
Future way of thinking the infrastructure (2203.06795)

- Coordination of survey strategies
- Coordination of simulations
- Extensive data-sharing
- Coordinated choices in modeling syst.
- **Multilateral** agreements "handshakes"
- Centers that coordinate crosstalk



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Future way of thinking the infrastructure (2203.06795)

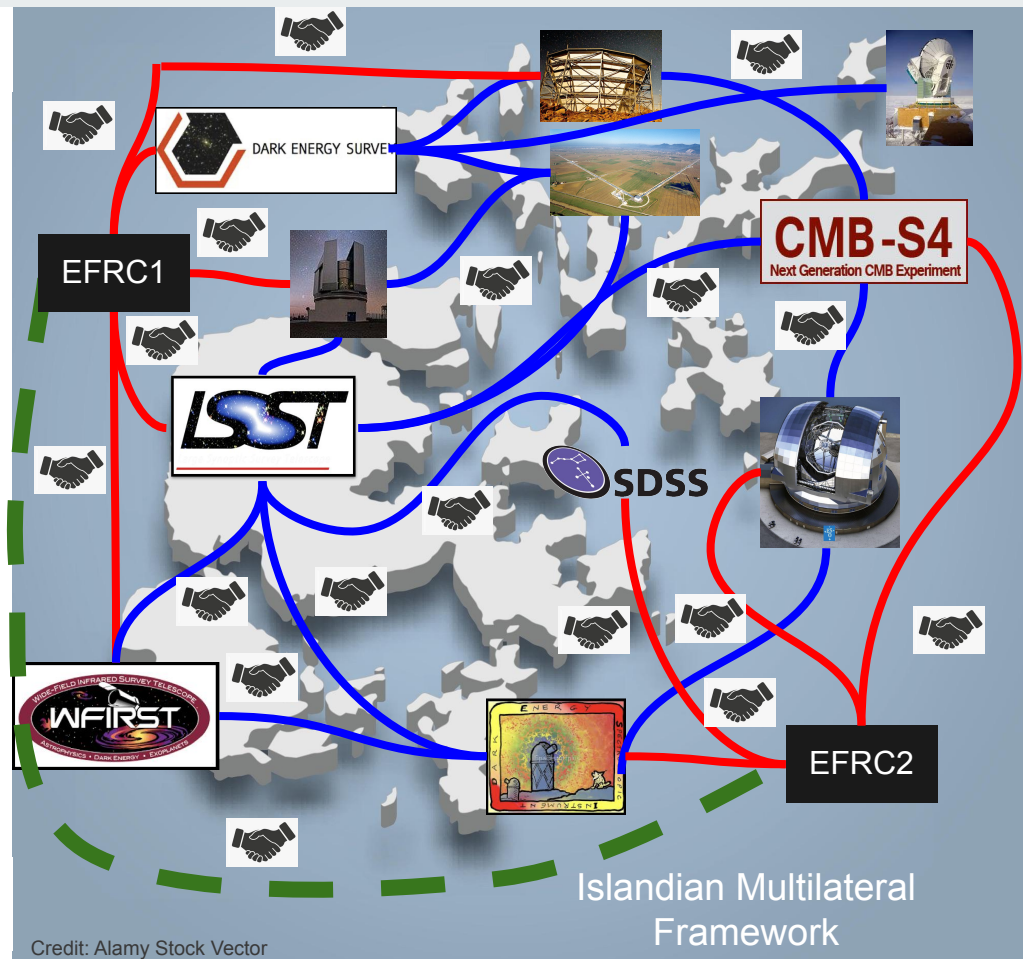
Collaboration agreements

How to create common ground for $n(n-1)/2$ agreements?

or..

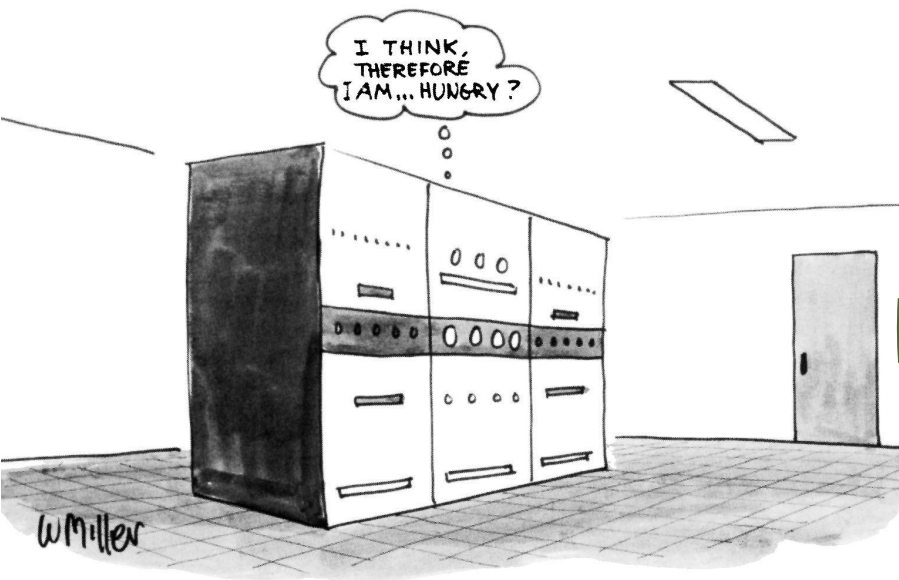
should EFRCs (or multi-agency centers) concentrate the cross-correlation work in n agreements between the facilities and the DoE?

 talk/slack us (not clear from the WP)



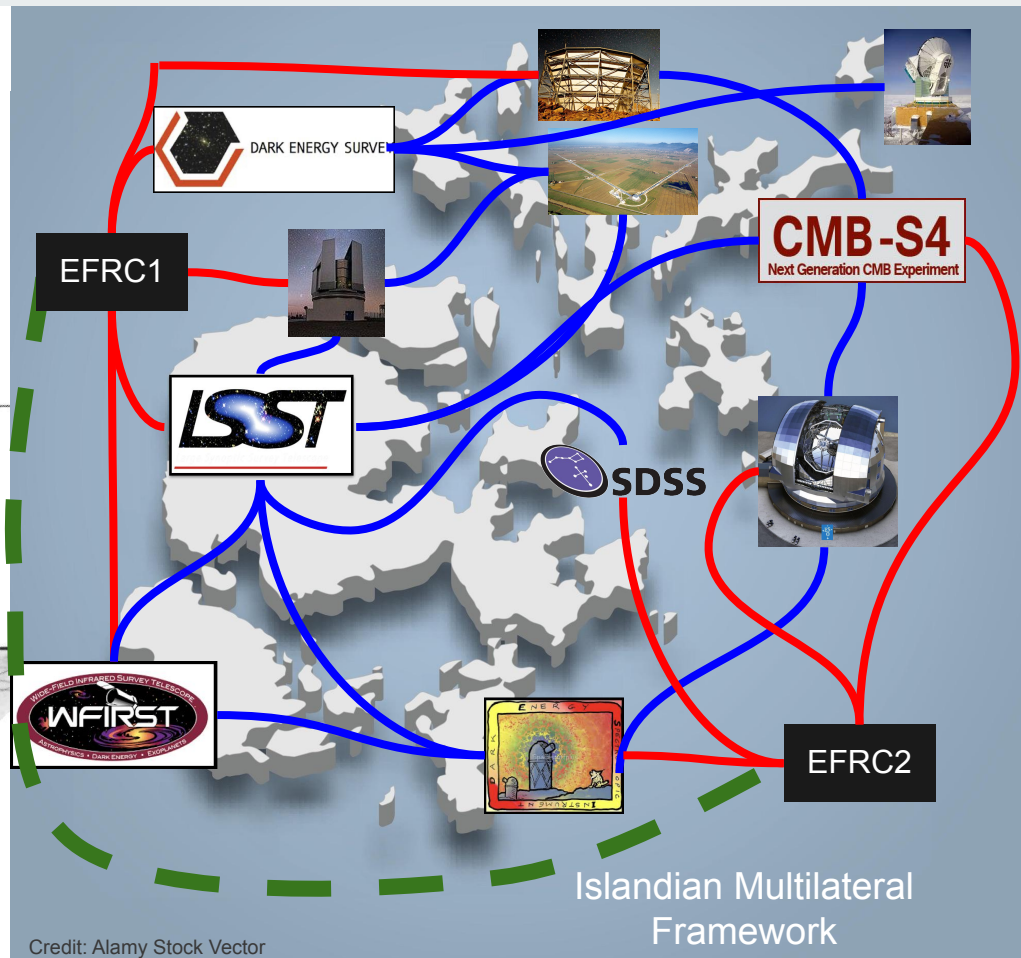
Future way of thinking the infrastructure (2203.06795)

Management of computational resources



Credit: cartoon stock

Cost and Carbon footprint of simulations
We can but should we duplicate efforts?



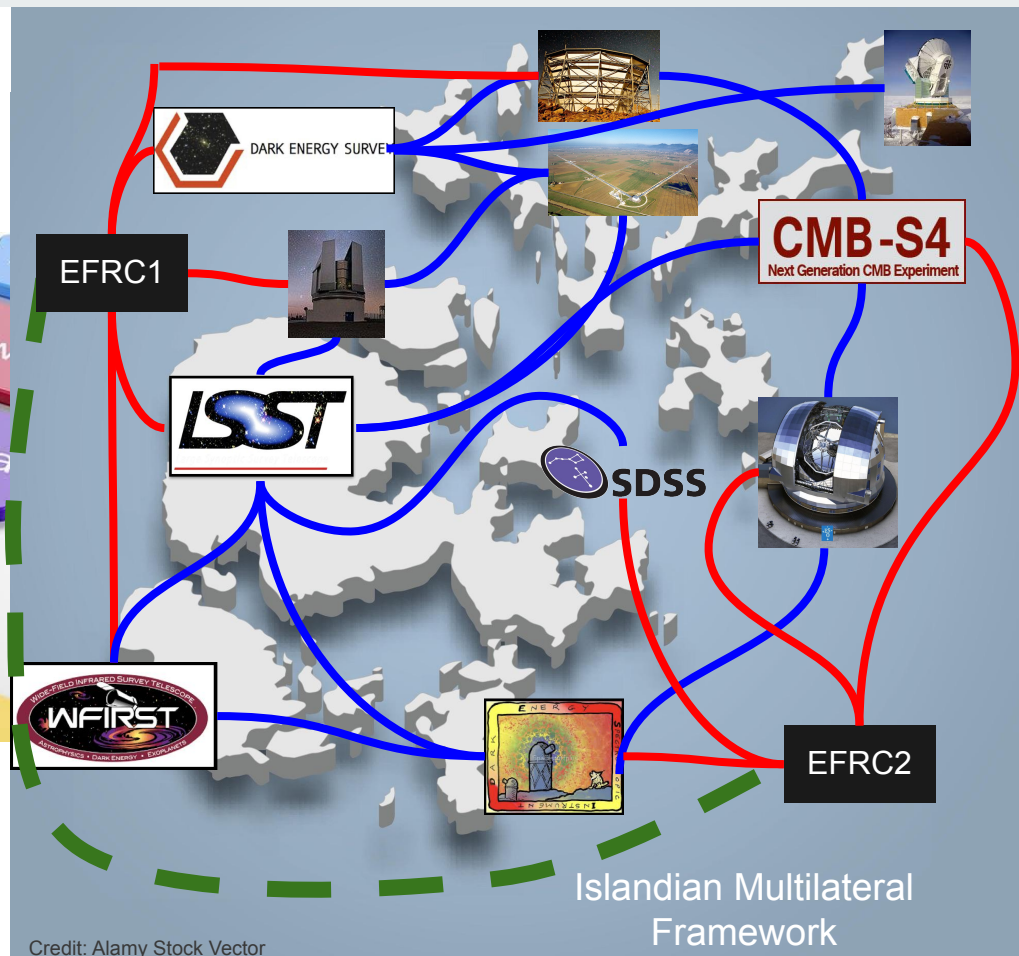
Credit: Alamy Stock Vector

Future way of thinking the infrastructure (2203.06795)

Refactoring of code (aut. diff, GPU, ML)



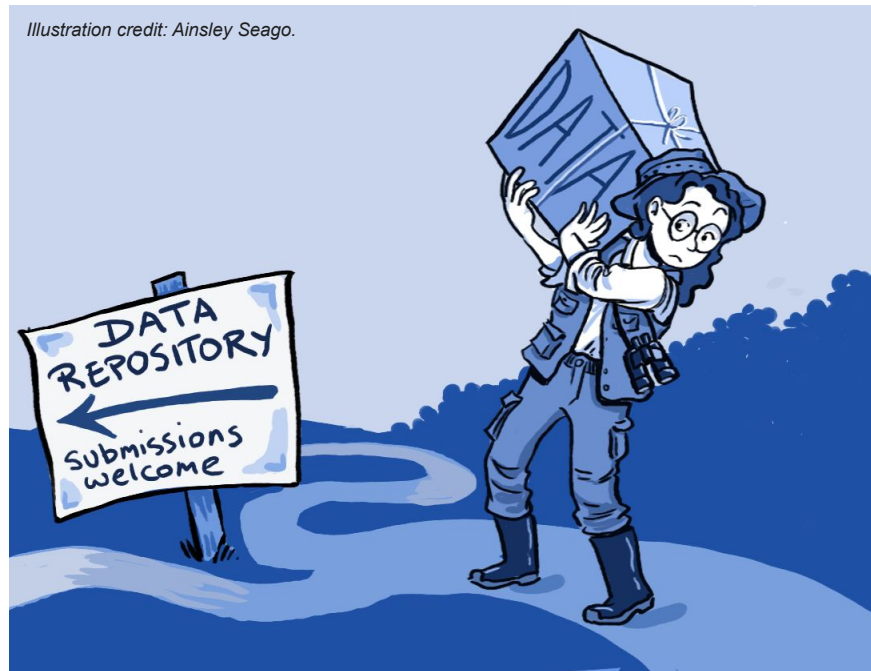
Significant overburden if the work is left
on the shoulder of students/postdocs
(also too many languages?)



DOE Archival data: critical infrastructure (multi-site archival network - WP: 2203.08113)

Petabytes of heterogeneous data worth billions of dollars

- How data can be efficiently accessed in various DOE supercomputers?
- Need homogeneous code infrastructure to access them (avoid chaos). (not the current model)
- Multi-site google model for robustness?
- Would we need fiber optic infrastructure to transmit data between archival sites and DOE supercomputers?
- In-site computation resources



US-HEP multi-messenger program - (WP:2203.11226)

Do we need a higher cadence (than LSST) dedicated survey to start the trigger?

- Open to unknown: used-supply algorithms that identify targets of interest
- Challenge: decisions about targets in heterogeneous database infrastructure
- Challenge: negotiate w/ schedule from multiple facilities.
- Challenge: access Management of follow-up observation
- HPC to understand events using diverse, heterogeneous and complex set of data.

The complexity is managing all that in a large set of (expensive) facilities.

Events can be rare and short-lived

Repurposing expensive facilities (WP: 2203.07220)

We just built or are going to build expensive facilities & cameras

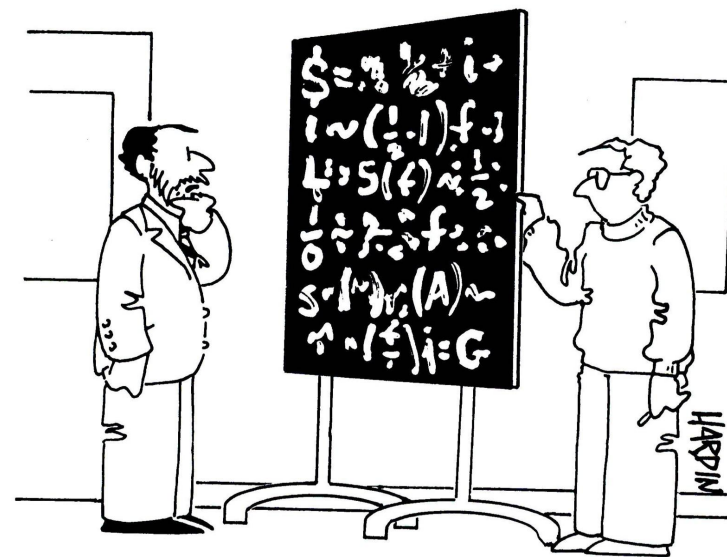
Strategic: \$1-20M proposals that repurpose facilities (ex: DECam, DESI-II, Rubin...)

- New filters (narrow filters)
- Follow up for GW
- Microlensing continue searches (DM science)
- Higher cadence survey
- Larger Area (DECam)
- time-delay measurements of lensed quasars and SNe



Before talking about new facilities in depth, conclusions from the *"Islandian Multilateral Framework"*

- **Use** near near-future facilities to **their full potential**
(via: cross-correlations w/ other observatories and repurposing of current cameras/facilities)
- **Reduce costs** by managing HPC, people (pipeline scientists, staff scientists...) in active collaboration (avoid duplication of work)
- **Create more opportunities** to discover unique unknown (new) physics



"Good Heavens, you're right — Money
IS everything!"

To checkmate LCDM in the 2020's (and 2030's), measurements of LSS & CMB must work harmoniously to expand our knowledge of the Universe at early, intermediate, and late times.

Like in chess, premature (single effort) attacks on the standard model will probably be unsuccessful

- CMB facilities: **critical** (WP: 2203.08024, 2203.05728)
- LSST: **critical** (WP: 2203.07252)
- 2D vs 3D (spectrography): **critical** (WP: 2203.07506)
- GW: **critical** (WP: 2203.08228)

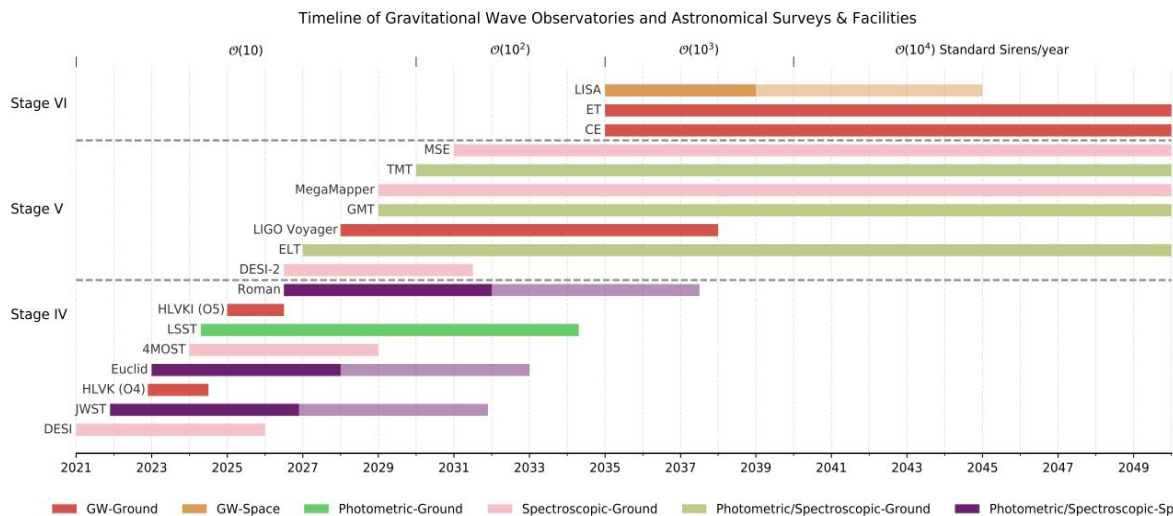
Such facilities are multi-purpose discovery machines that will inform our understanding of dark energy, dark matter, and inflation.



Example from White Paper (2203.11226): Classify facilities in terms of schedule (and cost)

Given the multi-faceted physics reach of these experiments, it doesn't make sense to classify them solely w/ respect to the dark energy FoM (isolated analyses)

- S-IV: long-term, medium/high-cost projects proposed back then or soon (DESI, JWST, LSST)
- S-V: near-term, low/medium-cost future projects. (DESI-2, MegaMapper, LIGO Voyager, CMB-S4)
- S-VI: long-term, medium/high-cost future projects. (CMB-HD, Cosmic Explorer, MSE, SpecTel, Einstein Telescope)

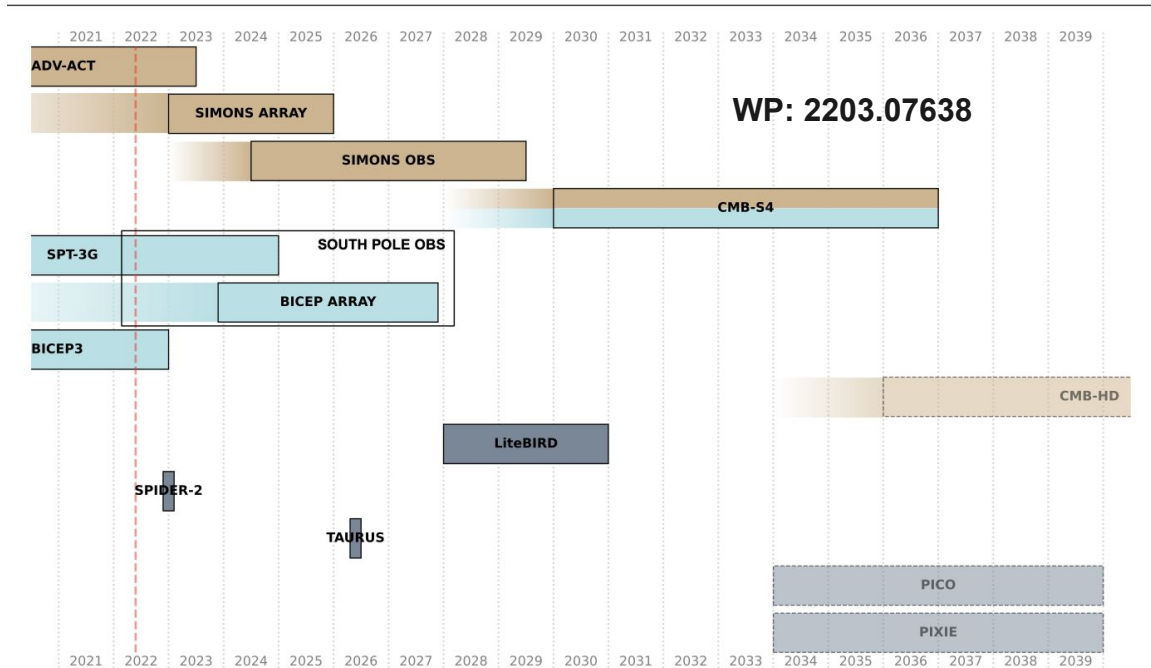


Can we fund them all? If not, what are the critical facilities that need to be online to reach the science goals (checkmate SM)?

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Thank You. Questions?