



# Exploring the Universe with Large Astronomical Surveys

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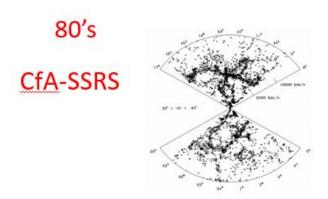
### **Outline**



- Brief scientific motivation
- □ Examples of surveys
- □ Introducing LineA
- □ Brazil in the LSST era
- □ Final Remarks

### **Modern Cosmology – large scale surveys**





90's **ENEAR/SCI** 

Galaxy distribution



J. Huchra



M. Geller



M. Davis



Peculiar velocity Field



M. Haynes



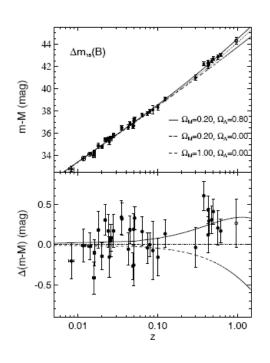
R. Giovanelli



G. Wegner

# **Dark Energy Discovery – expansion history**





SN Type Ia







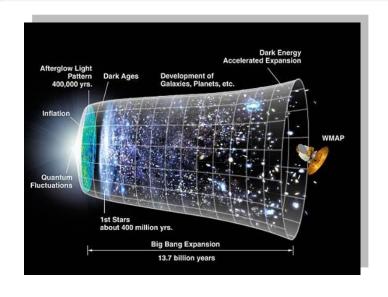


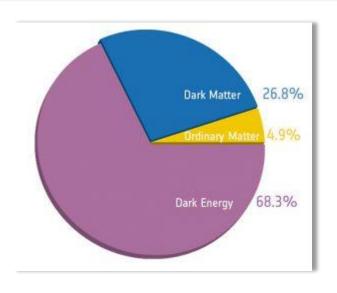




# **Implications**







- ☐ Cosmological constant ?
- ☐ Quantum vaccum energy?
- ☐ A new kind of field?
- Modified gravity theory ?



**New Physics** 

# **Consensus Cosmology**

LHC



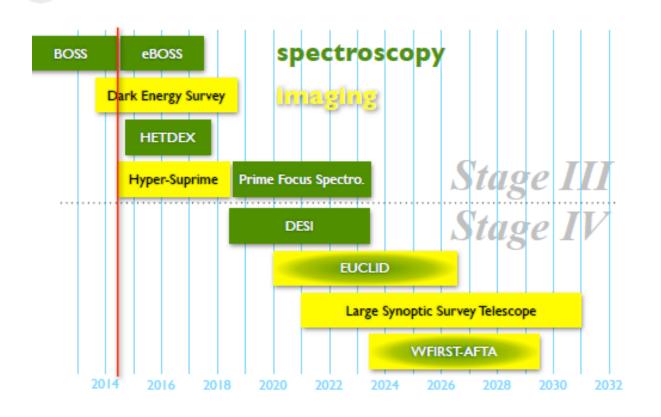
### Astronomy



CMB

# **DOE Proposed Roadmap**

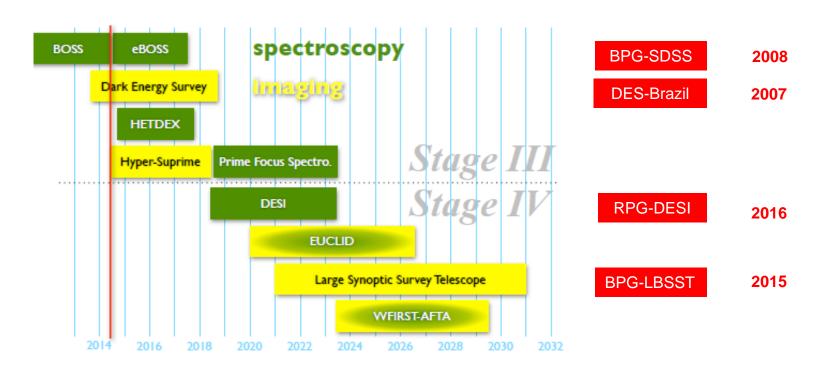




- Large multi-year surveys
- International collaborations
- ☐ Large number of scientists
- Dedicated telescope time
- Large volumes of data
- Different applications

## **Brazilian Participation**

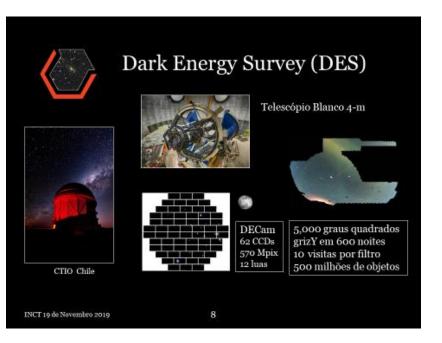


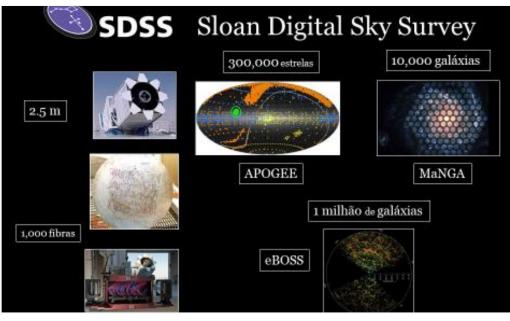


Membership: in-kind or combination of cash + in-kind

# **Ongoing Projects**



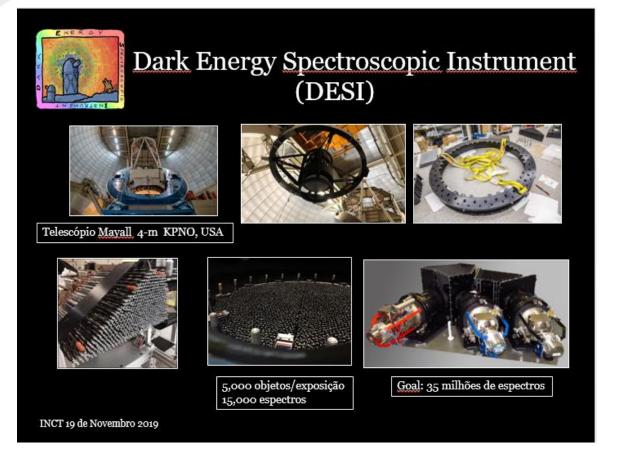




Observations complete

# **Upcoming Projects: DESI**





**DESI Key Numbers** 

- ☐ 5 year project
- **□** 5,000 objects
- ☐ 15,000 spectra
- ☐ 35 million objects

# **Upcoming Projects: LSST**





2022-2032 (10 anos) 20,000 graus quadrados 800 visitas em cada filtro ugrizy

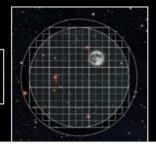
15 Tb/noite 10 milhões de alertas/noite 36 bilhões de objetos







3.2 Gpix 189 CCDs 40 luas



## LSST key numbers



- 10 years of observations
- Half the sky in 6 filters
- Each image 6.5 GB
- 1 image every 15 s
- ☐ 15 TB per night
- ☐ Image must be transferred to the USDF in < 20 s</p>
- 10 million alerts per night
- 800 visits => movie of the sky covering 10 years

- Census of Solar System Objects
- Catalogs with 40 billion objects
- Yearly data releases to the collaboration
- Public data every 2 years

### Laboratório Interinstitucional de e-Astronomia



**DES** 



**SDSS** 



2008

**DESI** 



2016

**LSST** 



2015

TON



2017



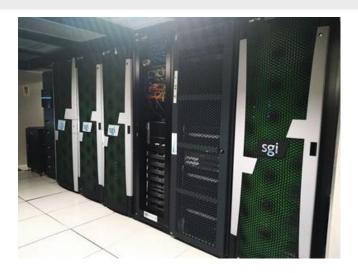






### Infrastructure







- □ Virtualization cluster
- □ Database (MS-SQL Server, Postgres)
- ☐ Storage (NAS, Lustre) 1.5 PB
- ☐ Processing (Altix, ICE-X, Apollo 2000) 25 Tflops



- □ Santos Dumont Supercomputer @ LNCC
- □ 36.472 cores
- ☐ 1134 nodes
- ☐ 5.1 PFLOPS
- Lustre 1.7 PB
- 2 million CPU-hours/year

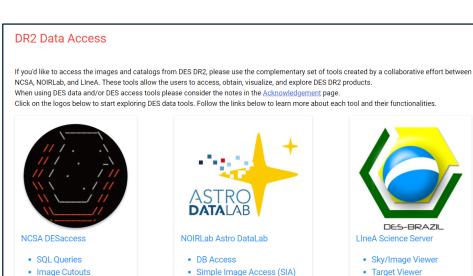
### **Services: Data Repositories**



**DR16** (20 TB)

DR2 (70 TB)





Cross Matching service

· Remote Compute and Jupyter

Tile Finder

DES File Server



### **Services: Science Platforms**





#### Jupyter

Oferece aos usuários acesso a ambientes e recursos computacionais sem sobrecarregálos com tarefas de instalação e manutenção.



#### Processamento (Cluster)

Disponibiliza 2 Clusters de processamento, somando um poder de processamento de 20 Tflop/s para que possa executar seus códigos.



#### Science Server

O Science Server permite acesso às imagens coadicionadas e aos catálogos do Dark Enery Survey, além do upload de user-catalogs e queries no DB.



#### Science Portal

Oferece funcionalidades que auxiliam desde a preparação de dados e criação de catálogos, até algoritmos científicos, com monitoramento e controle de proveniência.



#### SSO Portal

Oferece ao usuário ferramentas e produtos científicos para estudar pequenos corpos do Sistema Solar, com recursos avançados para ocultações estelares.

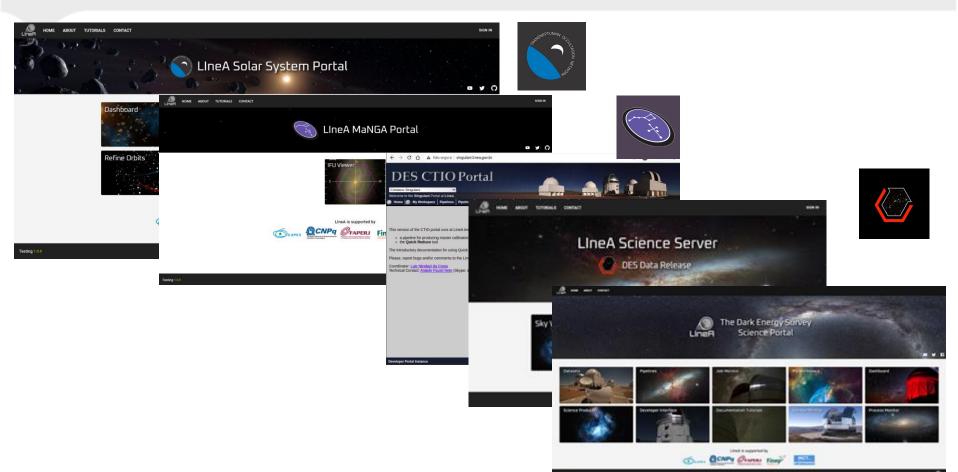


#### MaNGA Portal

Oferece visualização de ~10.000 galáxias próximas, com objetivo entender suas "história de vida", desde as pistas impressas de seu nascimento e montagem.

# **Software Development: science platforms**





### LineA new site – under development





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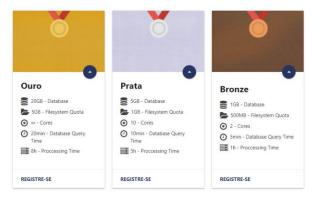


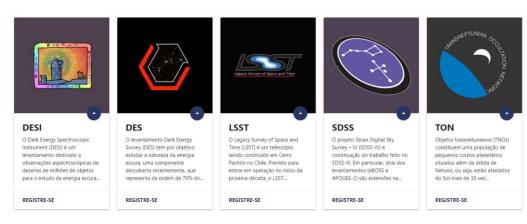




### **Users Profiles**

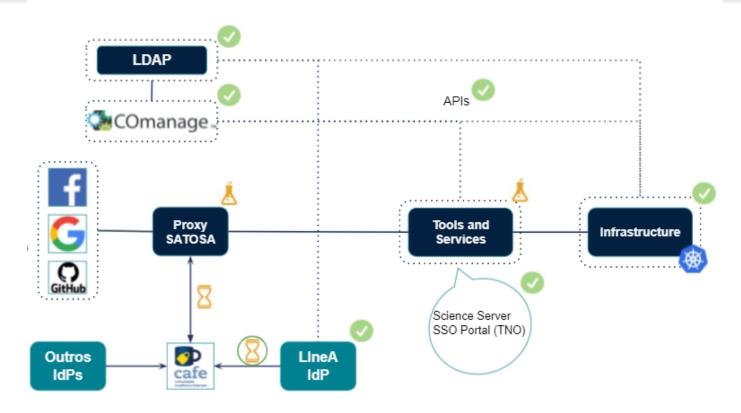






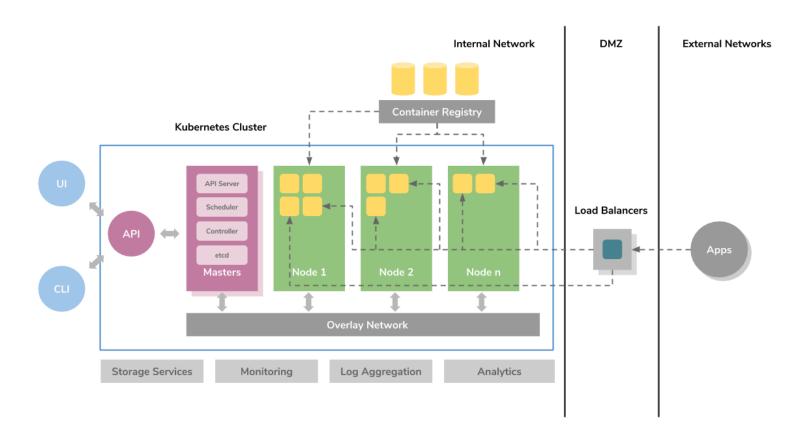
# LineA Identity Provider (IdP)





# **Kubernetes (K8S)**





### Brasil in the LSST era





Brazilian contributions:

Infrastructure: 10 PIs

Connection Santiago –Boca Raton

In-kind contributions: 10+ PIs

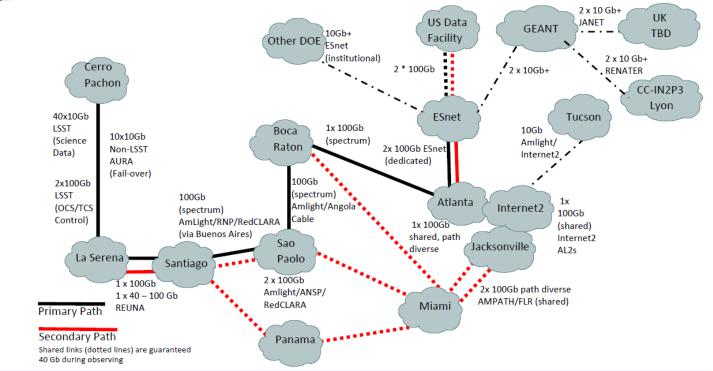
- ☐ IDAC
- ☐ LineA photo-z server
- ☐ Pipeline scientists





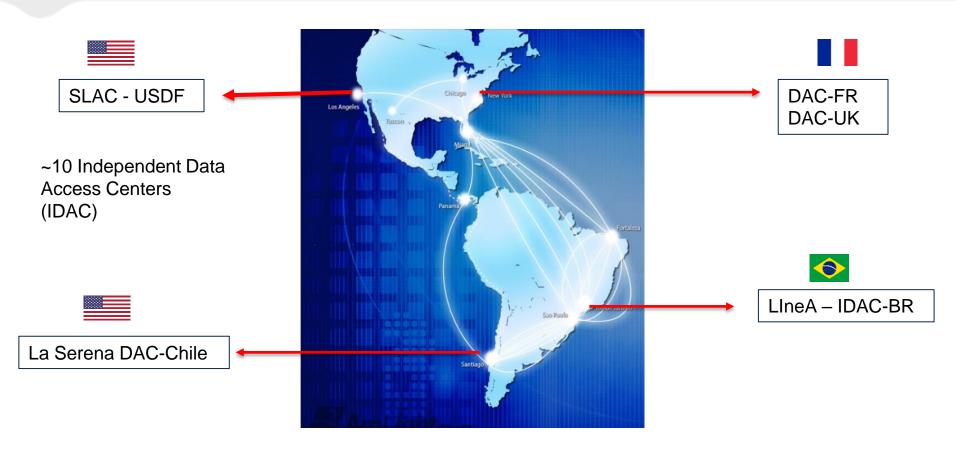
### LSST Long Haul Network Links (Baseline FY23)





### **LSST Data Flow**





### **IDAC** – Brazil



### Benefits

- More data rights for the Brazilian community
- Efficient access to the data
- Allows you to have the data close to the HPC processing and local infrastructure
- Enables the re-use of tools and algorithms developed by LineA for DES
- Support from a specialized local team
- Encourages investment in a data center/escience institute

# Requirements

- 500 TB database (Qserv)
- 5 PB of storage
- 500 cores
- 40 Gbps connection
- 5 FTEs
- 50 simultaneous users
- Provide support to any scientist with data rights

### **Final Remarks**



- Networks have contributed to enhance international collaborations.
- Network critical to the build the LSST IDAC network and the benefits it brings along.
- Networks literally bringing the Universe to the IDACs.
- Still carrying out end-to-end tests including the national connections to meet demand.
- Requirements involve bulk international transfers and national and international accesses from 9 different time zones.





# Thank you

