

FROM PETABYTES TO A

BLACK HOLE

IMAGE | THE EVENT HORIZON TELESCOPE

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Lead, Calibration & Error Analysis, EHT

Designing Storage Architectures Meeting

Library of Congress

September 9–10, 2019



# Event Horizon Telescope: The Collaboration

*EHT Collaboration Meeting — November 2018 — Nijmegen, NL*



**207 members, 59 institutes, 18 countries in Europe, Asia, Africa, North and South America**

LoC Designing Storage Architectures meeting — September 9-10, Washington D.C.

# THE EVENT HORIZON TELESCOPE

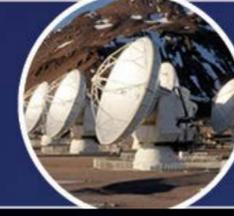


30-M



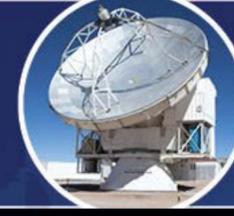
IRAM 30-M Telescope  
PICO VELETA, SPAIN

ALMA



Atacama Large Millimeter/  
submillimeter Array  
CHAJNANTOR PLATEAU, CHILE

APEX



Atacama Pathfinder EXperiment  
CHAJNANTOR PLATEAU, CHILE

SPT



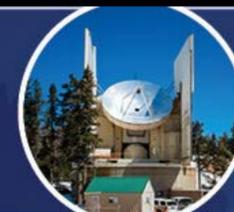
South Pole Telescope  
SOUTH POLE STATION

LMT



Large Millimeter Telescope  
SIERRA NEGRA, MEXICO

SMT



Submillimeter Telescope  
MOUNT GRAHAM, ARIZONA

SMA



Submillimeter Array  
MAUNAKEA, HAWAII

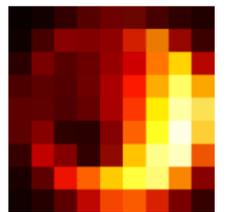
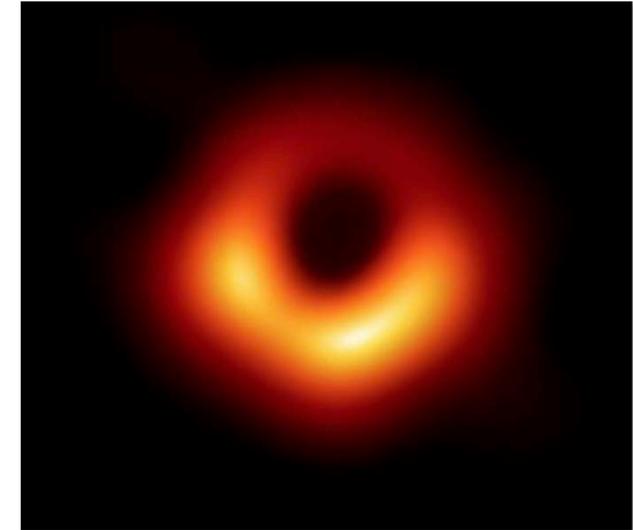
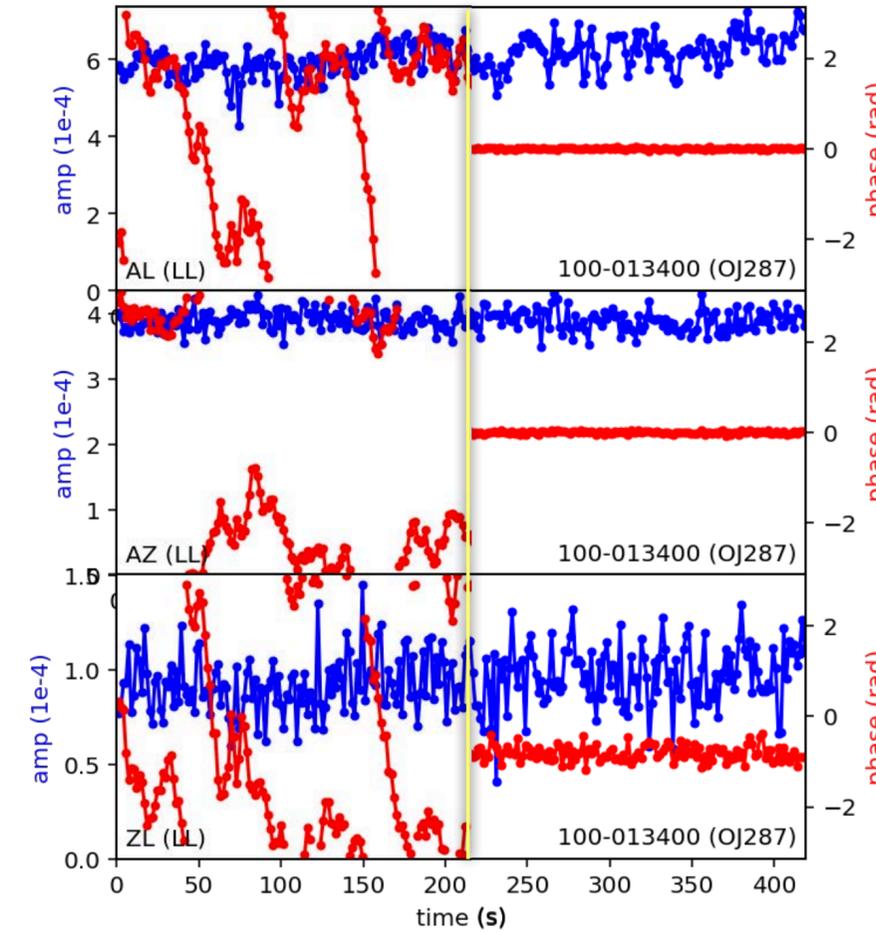
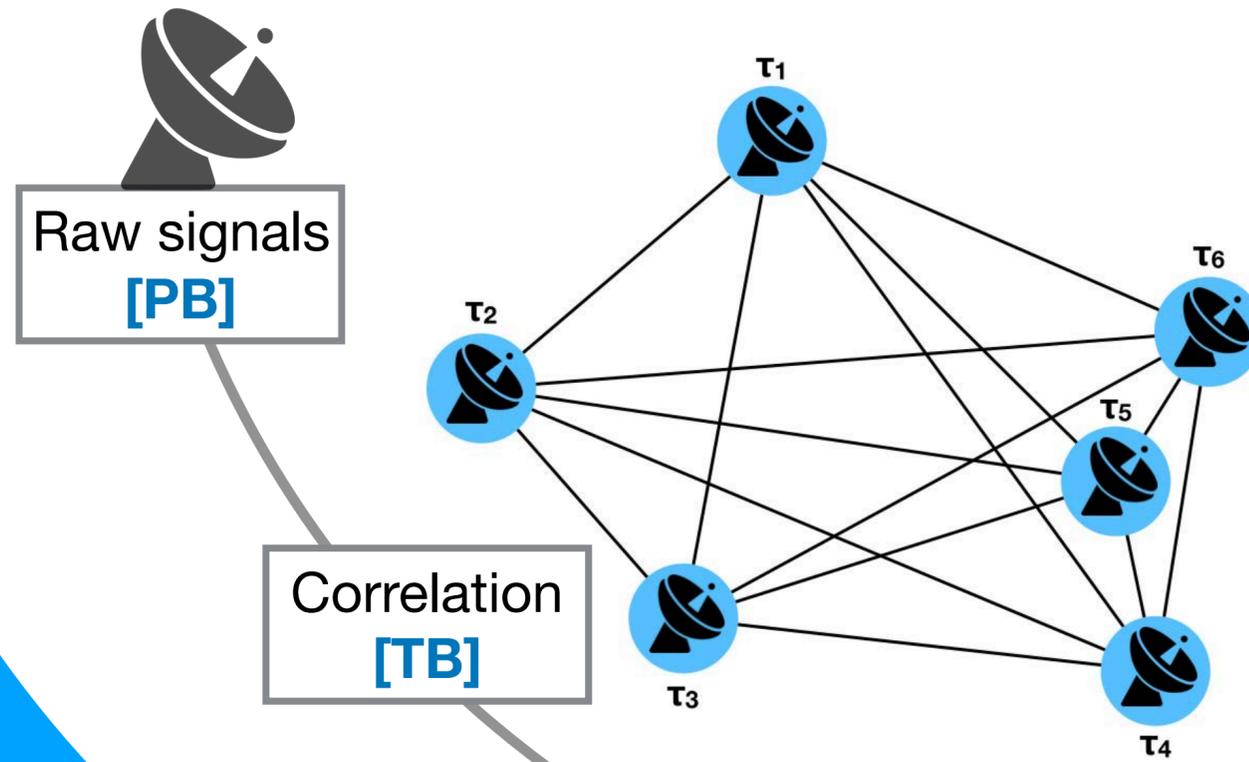
JCMT



James Clerk Maxwell Telescope  
MAUNAKEA, HAWAII



# EHT Data Pathway

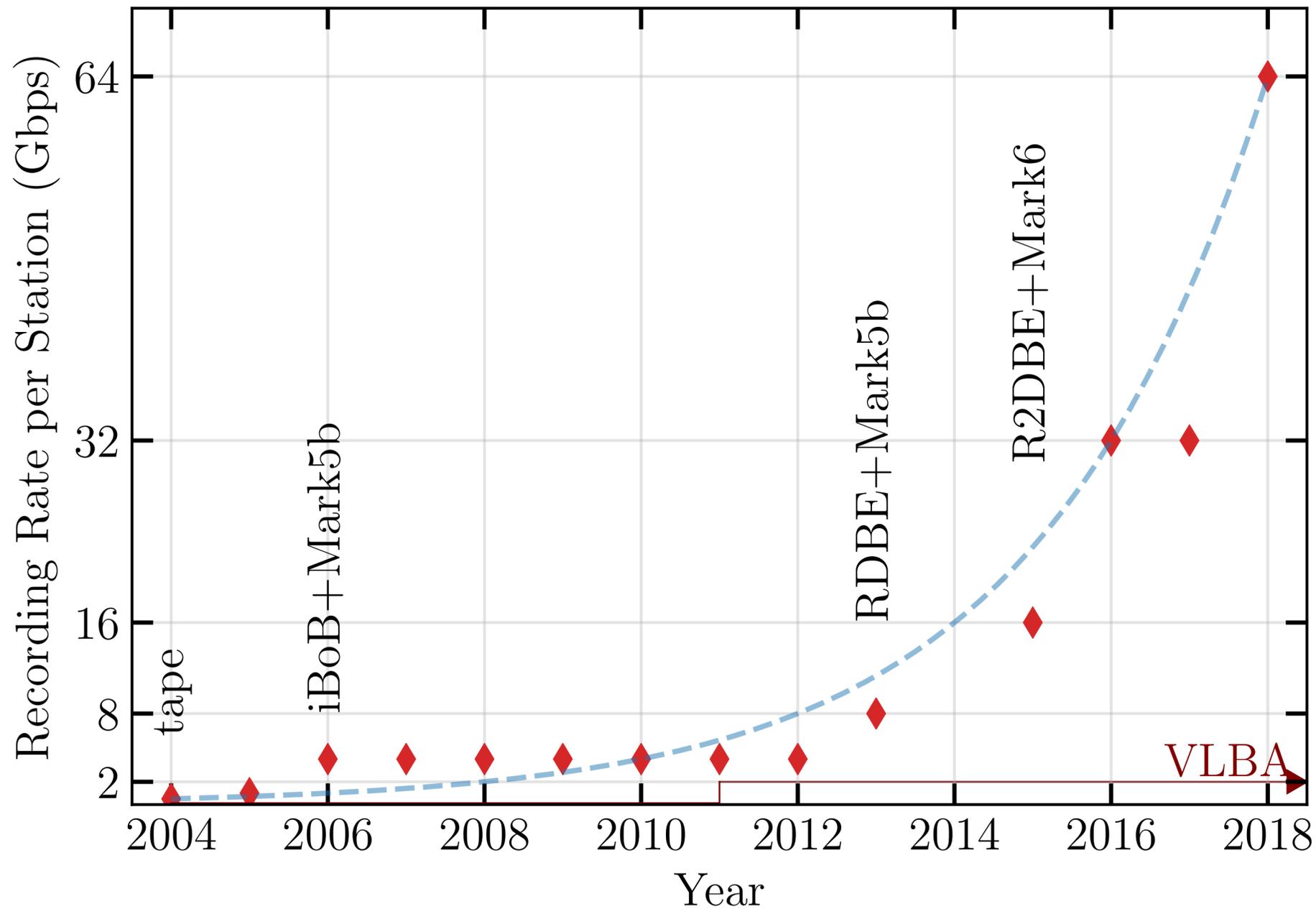


**12 orders of magnitude in data reduction!**



# Sensitivity increase through bandwidth

*EHT recording rate tracks Moore's law for over a decade*



## *Enabling technologies*

- **Fast ADC + FPGA DSP**
- **High-speed ethernet + switch**
- **He-filled sealed hard drives**

## *Corresponding increase in Dish size*

$$25 \text{ m} \times \sqrt{\frac{32 \text{ Gbps}}{2 \text{ Gbps}}} = 100 \text{ m}$$



# Data transport



*South Pole Telescope*

*target: PB/month or ~3 Gbps*  
*infeasible from remote sites without physical transport*  
*several month delay to wait out winter at South Pole*



*Haystack Observatory  
Boston, MA*



# Data Management and Archival

## *Unique simultaneous requirements*

- High bandwidth on-demand recording and playback (**hot**)
- Archival for months+ (**cold**)
- Portable (**flexible transport**)



*MPIfR  
Bonn, Germany*



# Future requirements and technologies

*Capabilities of the EHT limited by ability to record, transport, process massive volumes of data*

*For the Next Generation EHT*

- **Double number of sites**
- **Quadruple bandwidth**
- **All-year observing**
- **Space antenna**

*Enabling technologies may be*

- **Larger HDDs (or SSD/LTO)**
- **Free-space optical communication**
- **Cloud storage and processing**
- **Commodity transport**

*Simulation by Monika Moscibrodzka (Radboud)*

*allowing for high-resolution movies of the dynamics surrounding a black hole*