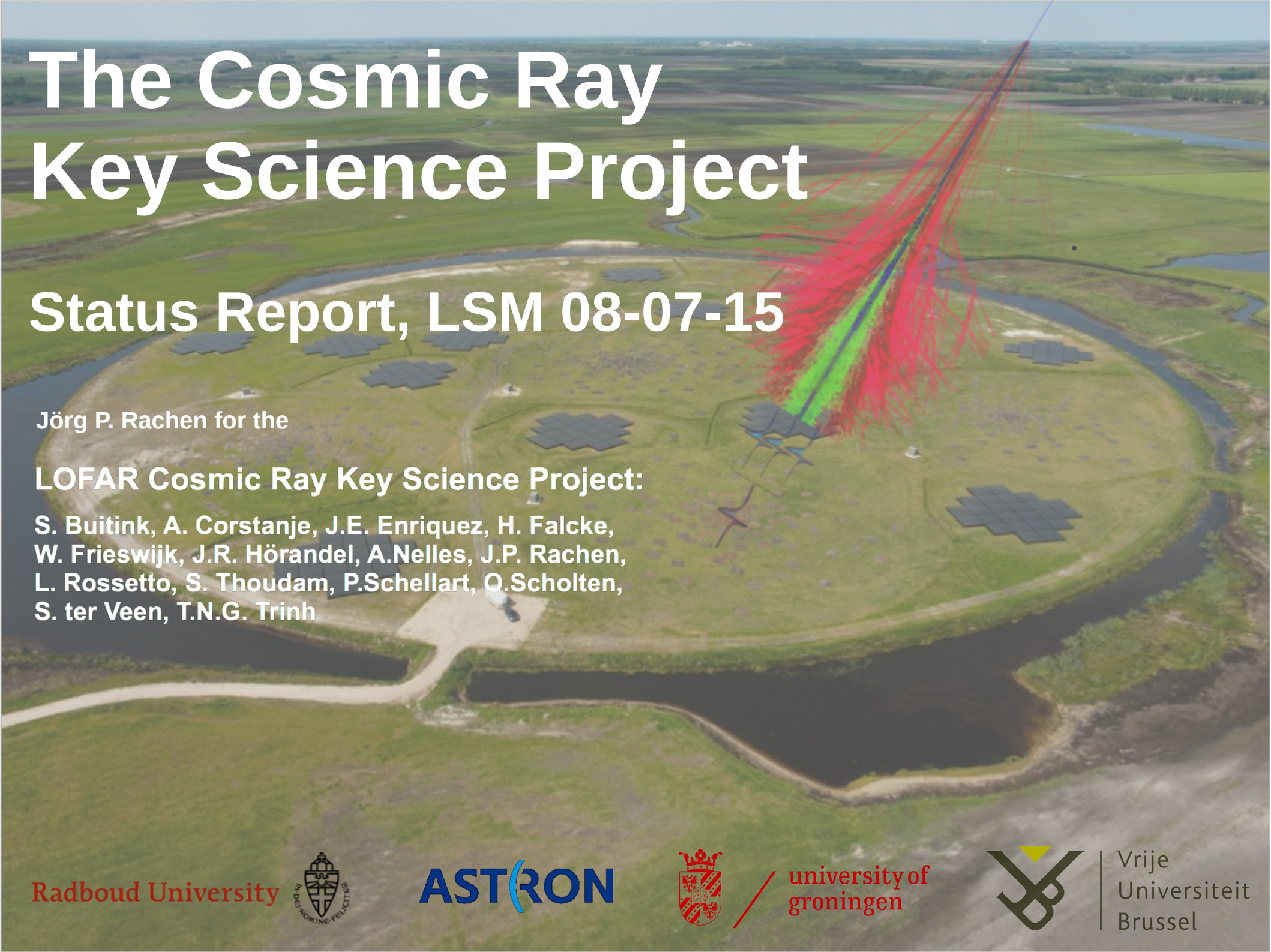
The Cosmic Ray Key Science Project

Status Report, LSM 08-07-15



Jörg P. Rachen for the

LOFAR Cosmic Ray Key Science Project:

S. Buitink, A. Corstanje, J.E. Enriquez, H. Falcke, W. Frieswijk, J.R. Hörandel, A.Nelles, J.P. Rachen, L. Rossetto, S. Thoudam, P.Schellart, O.Scholten, S. ter Veen, T.N.G. Trinh

Radboud University

ASTRON

university of groningen

Vrije Universiteit Brussel

Journal papers published:

Schellart+, **A&A 560, A98 (2013):** **Detecting cosmic rays with the LOFAR radio telescope**

Schellart+, **NIMPA 742, 115 (2014):** **Recent results** from cosmic-ray measurements with LOFAR

Schellart+, **JCAP 10, 014 (2014):** **Polarized radio emission** from extensive air showers measured with LOFAR

Buitink+, **PRD 90, 082003 (2014):** Method for **high precision reconstruction of air shower X_{max}** using two-dimensional radio intensity profiles

Thoudam+, **NIMPA 767, 339 (2014):** **LORA** – A **scintillator array for LOFAR** to measure extensive air showers

Nelles+, **APh 60, 13 (2015):** A parameterization for the radio emission of air showers as predicted by **CoREAS simulations** and **applied to LOFAR measurements**

Corstanje+, **APh 61, 22 (2015):** The **shape of the radio wavefront** of extensive air showers as measured with LOFAR

Schellart+, **PRL 114, 165001 (2015):** **Probing Atmospheric Electric Fields in Thunderstorms** through Radio Emission from Cosmic-Ray-Induced Air Showers

Nelles+, **APh 65, 11 (2015):** Measuring a **Cherenkov ring in the radio emission** from air showers **at 110-190 MHz** with LOFAR

Nelles+, **JCAP 5, 018 (2015):** The **radio emission pattern of air showers** as measured with LOFAR – a tool for the reconstruction of the energy and the shower maximum

….. plus about 10 conference presentations!

Papers to be published soon:

Thoudam+: **Measurement of the cosmic-ray energy spectrum** above 10^{16} eV **with the LOFAR Radboud Air Shower Array**. ← **accepted Astropart. Phys. (arxiv:1506.09134)**

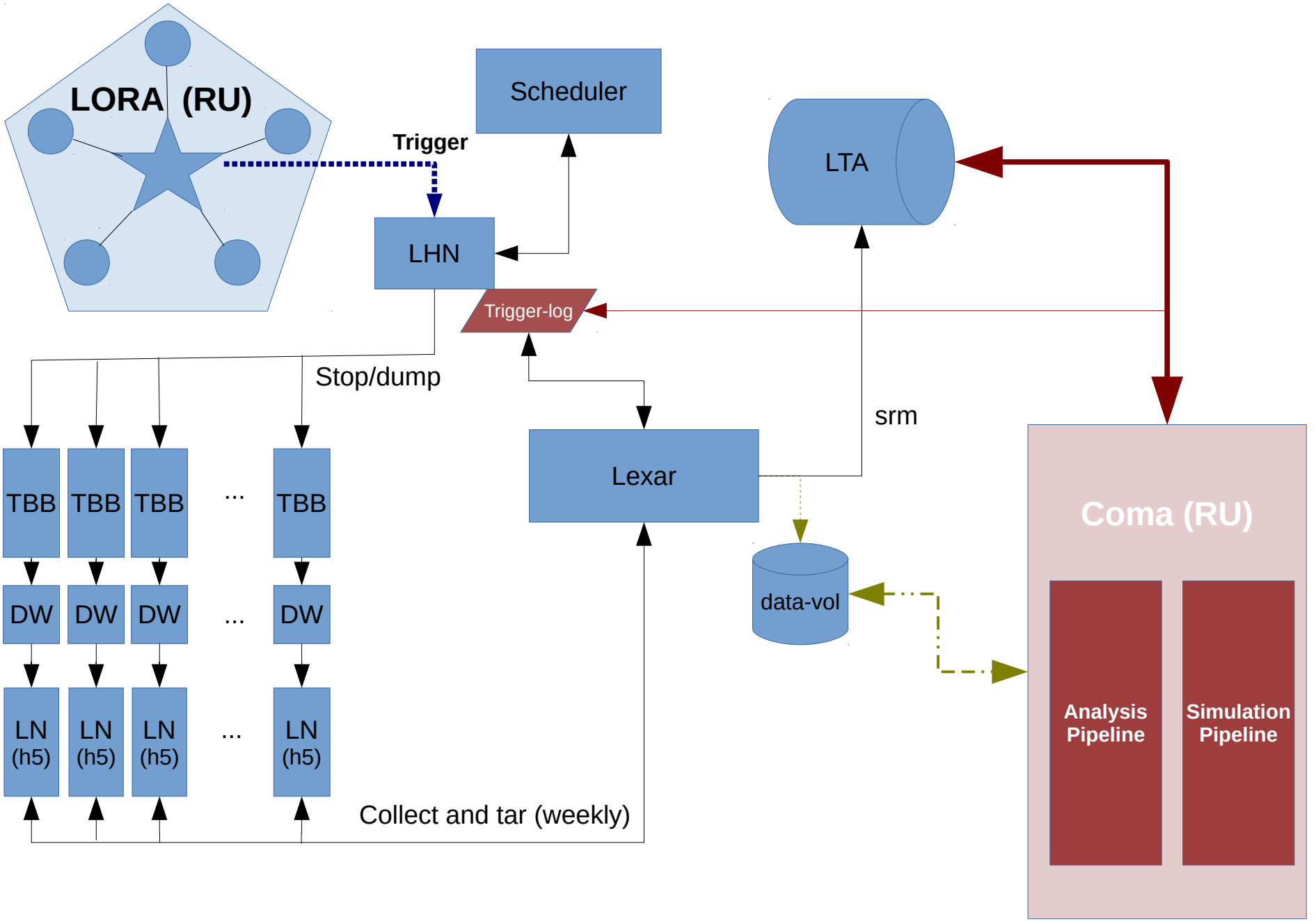
Nelles+: **Calibrating the absolute amplitude scale** for air showers measured at LOFAR. ← **Internal LOFAR review**

Corstanje+: **Timing calibration** and spectral cleaning of LOFAR time series data.

Buitink+: Radio detections of cosmic rays reveal a **strong light mass component at 10^{17} – $10^{17.5}$ eV**. ← **Re-submitted to Nature**

Trinh+: Influence of **Atmospheric Electric Fields** on Radio-wave Emission from Cosmic-Ray Induced Air Showers.

10 contributions submitted to ICRC


LORA (RU)
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Scheduler
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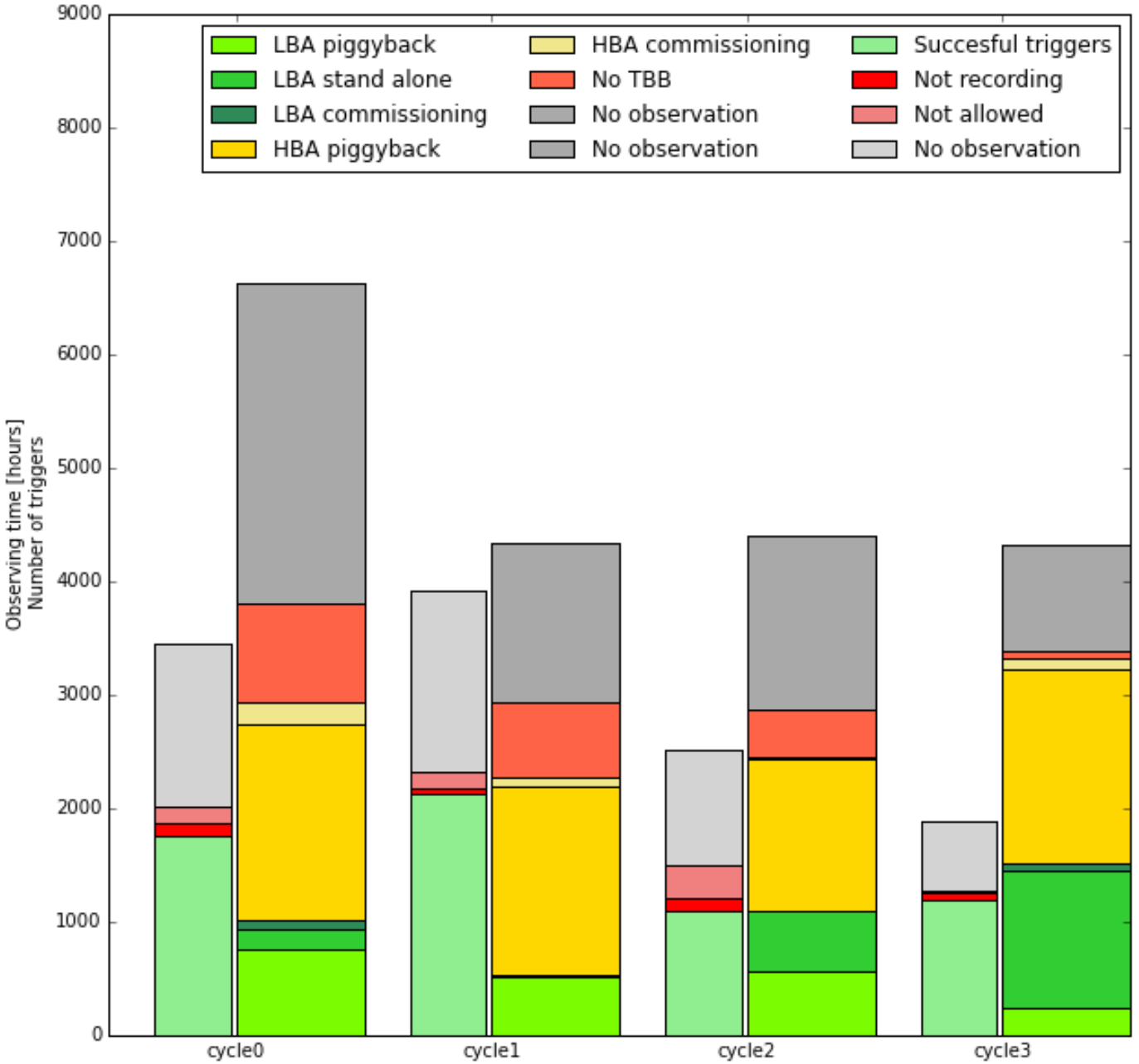
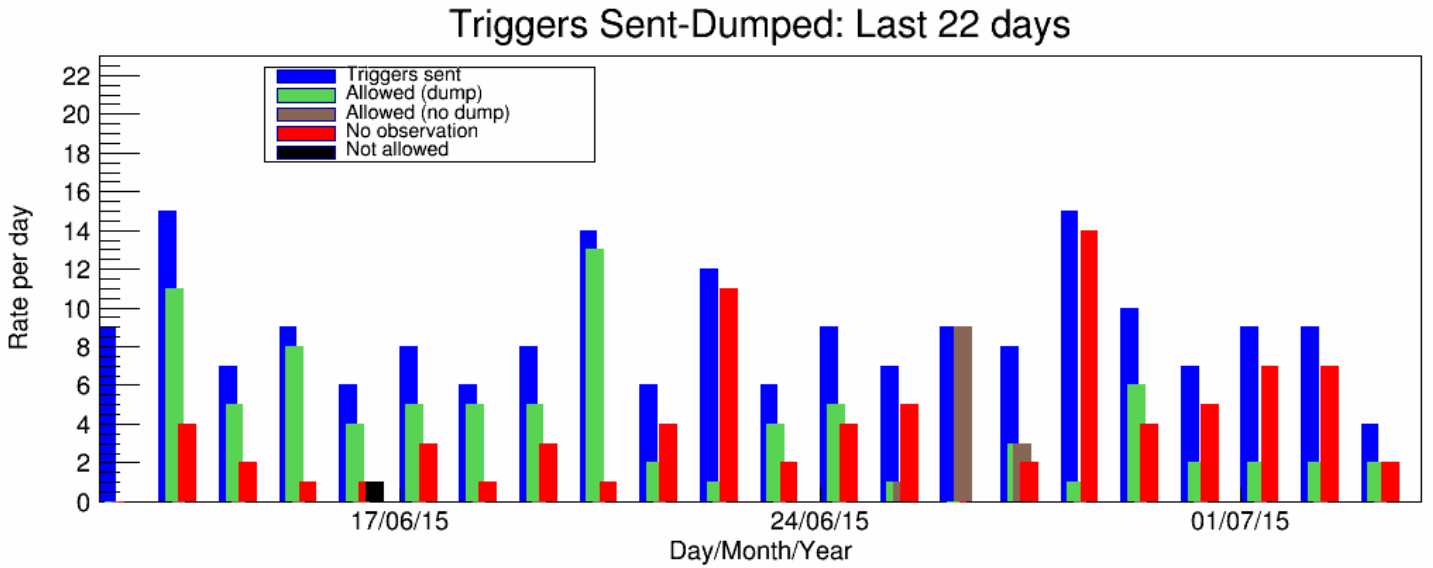
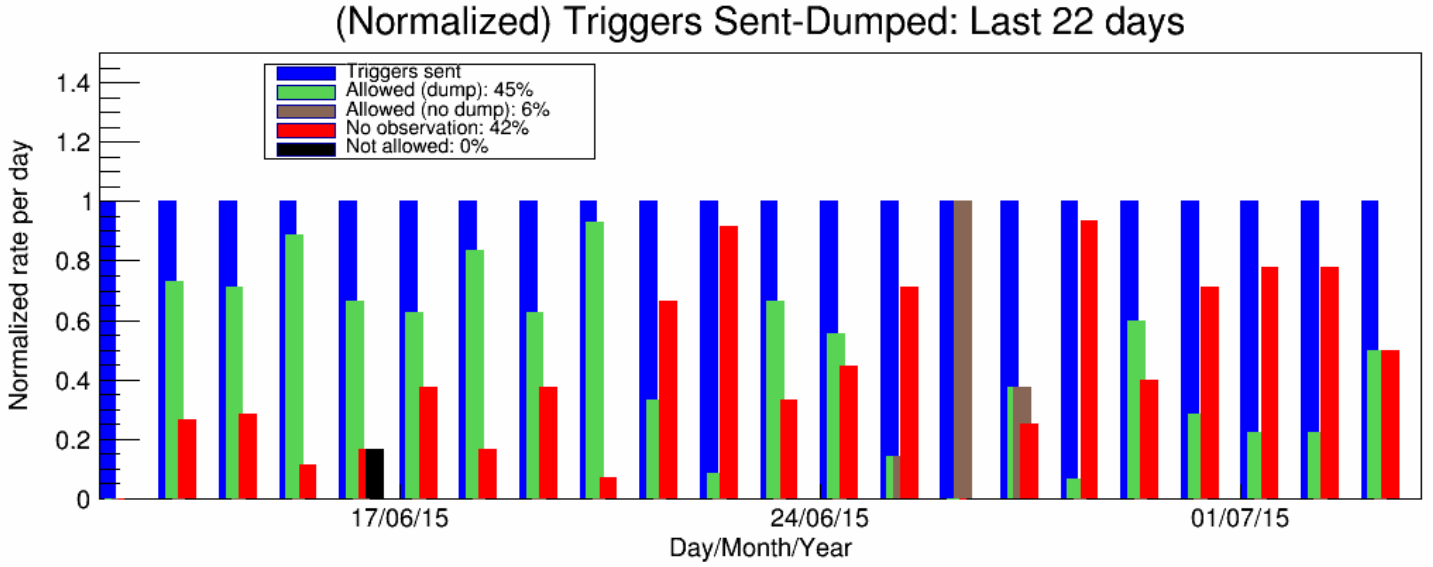
Analysis Pipeline
Simulation Pipeline
Collect and tar (weekly)



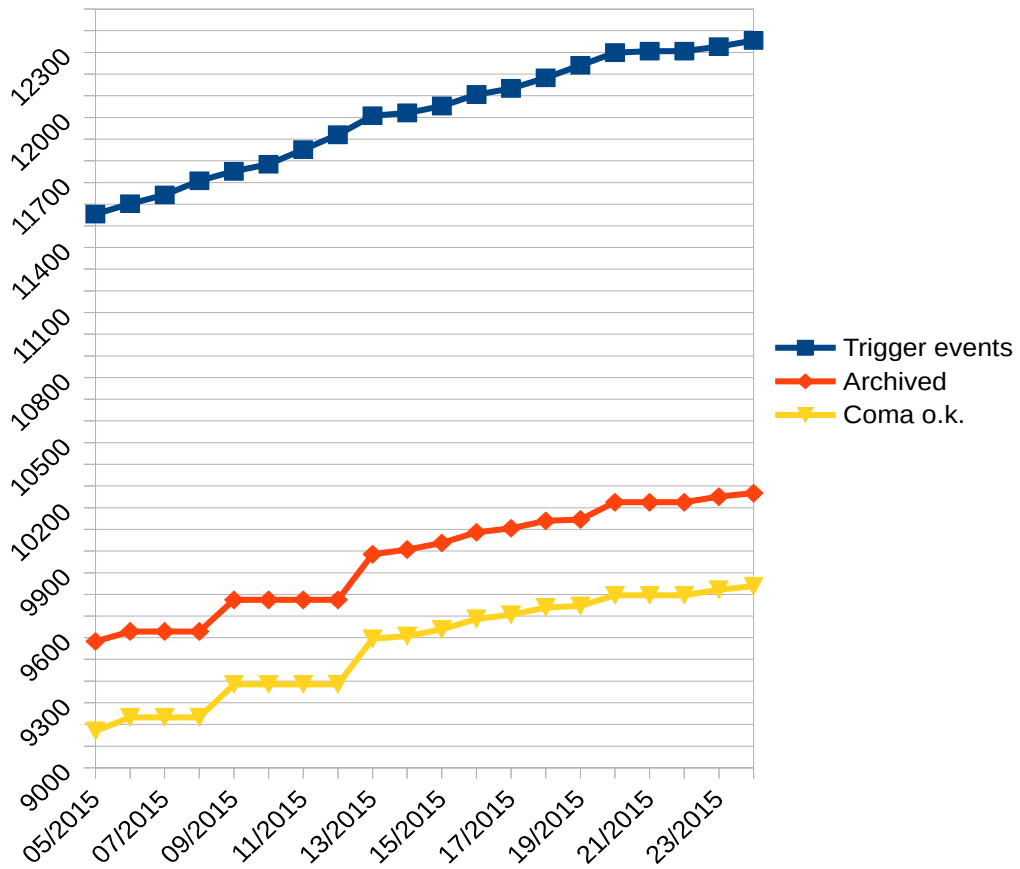
Provided by Sander ter Veen

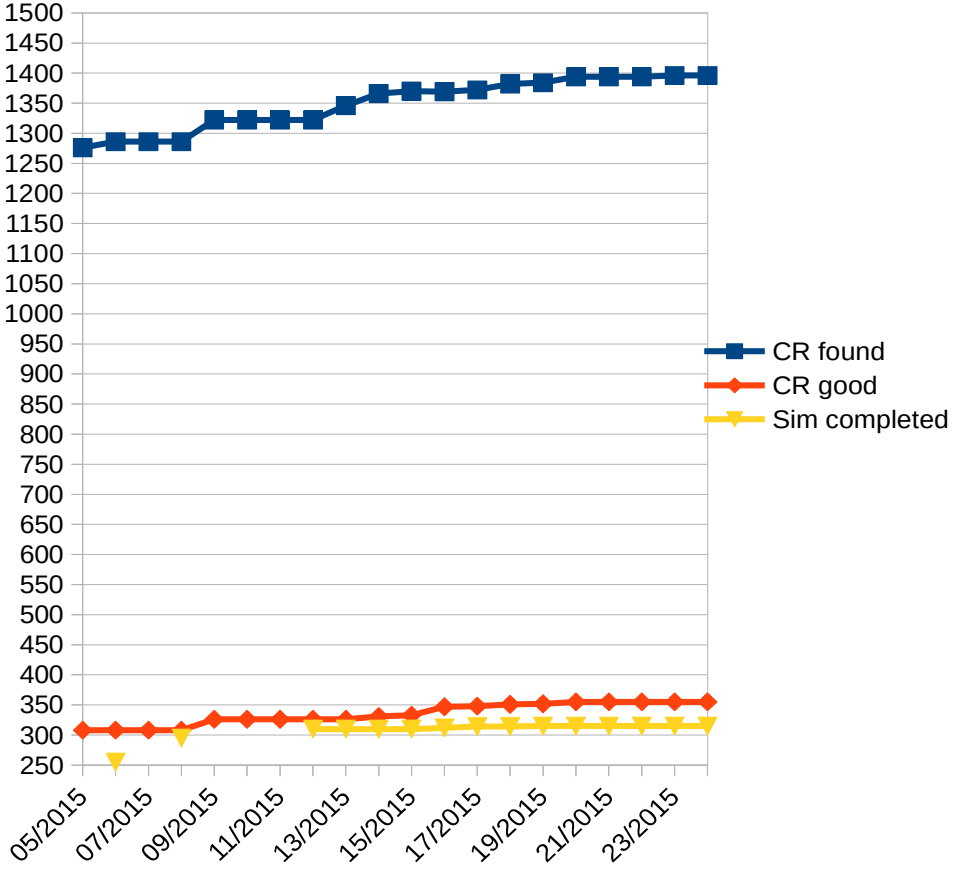
System Monitoring





Observatory Performance





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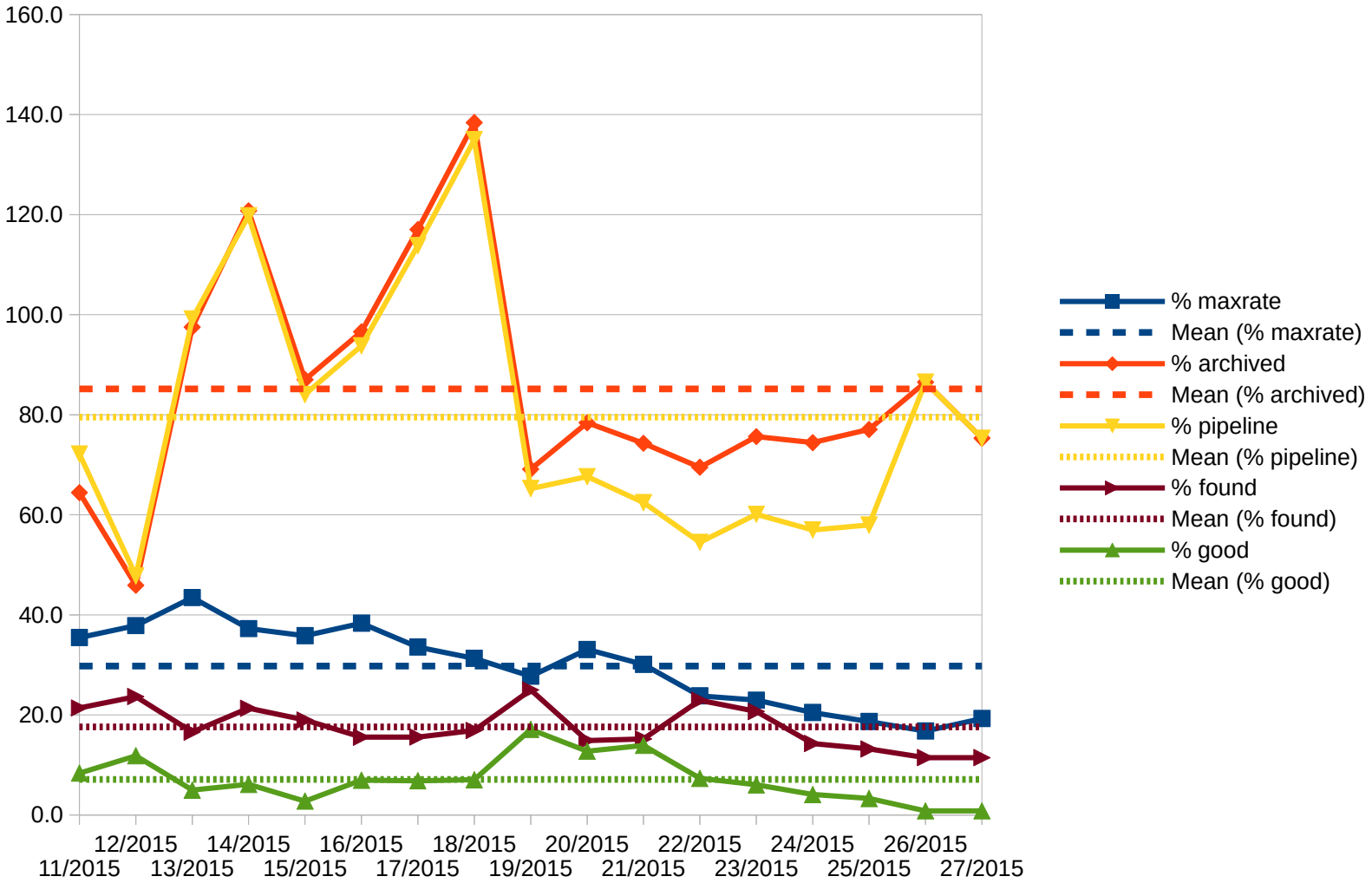
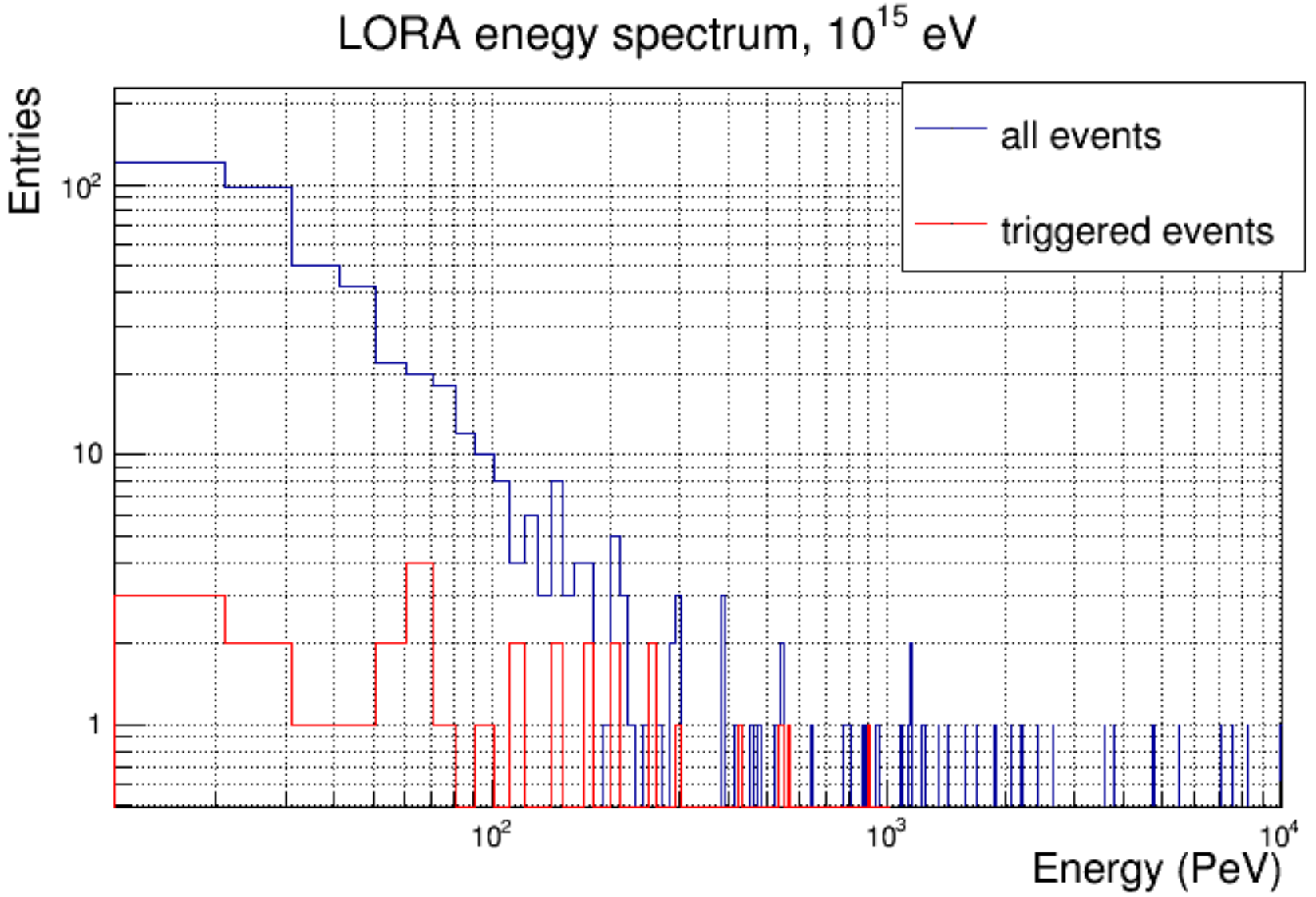


Self triggering



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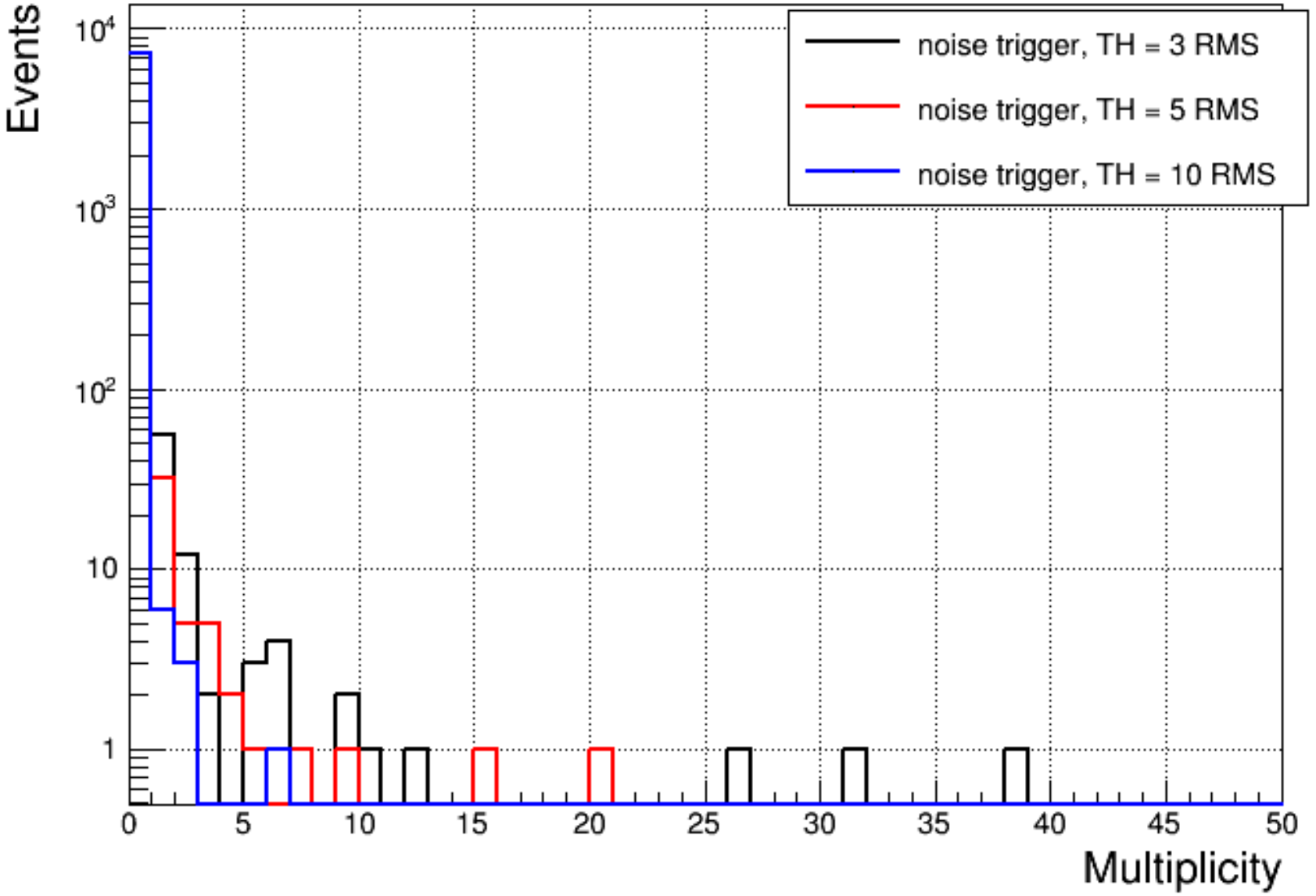

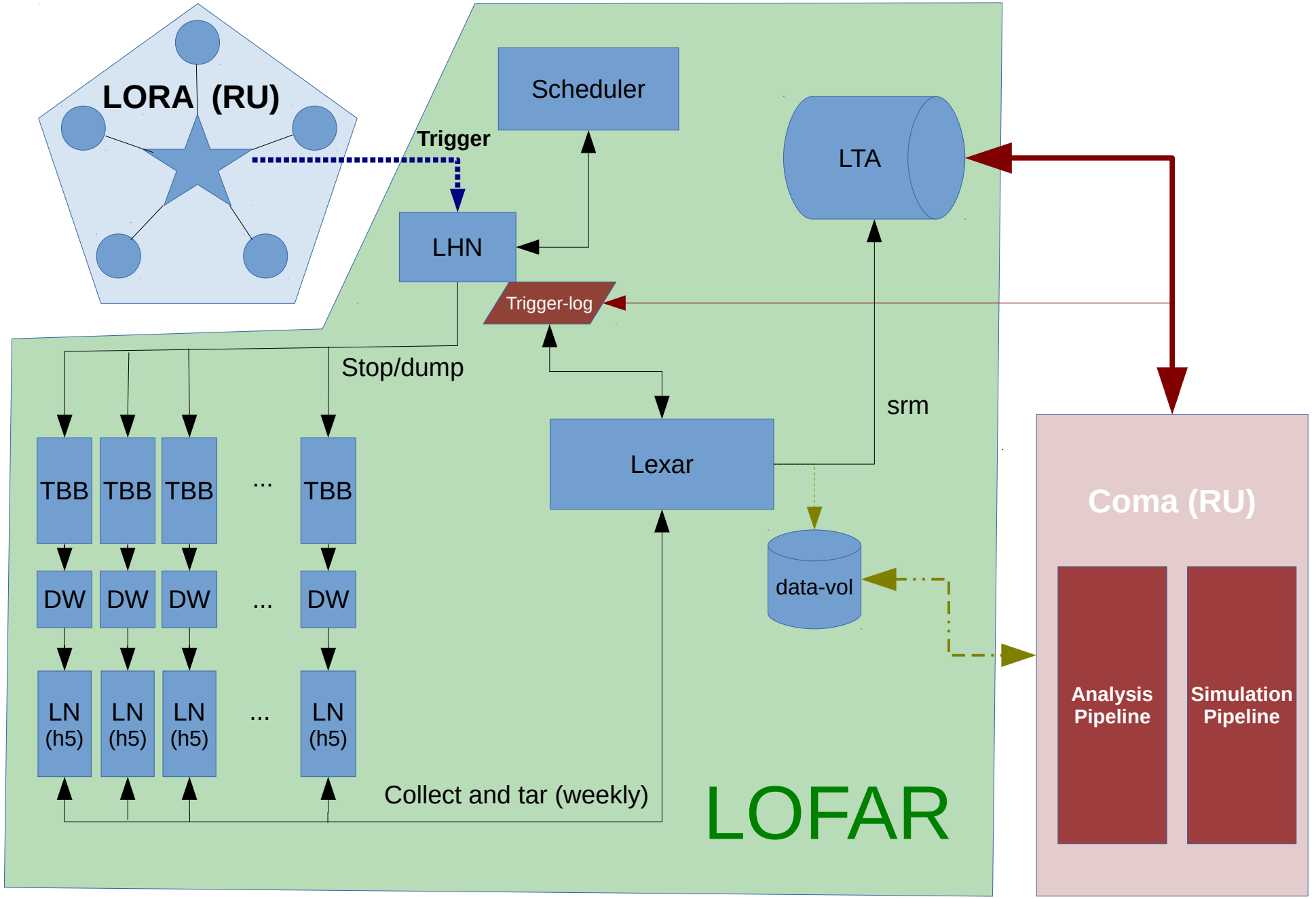
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LOFAR

TBB Integration

- System and Status Review January 28, 2015
- Requirements discussion June 11
  - Covering requirements from VHECR and Transient (FRB) searches
  - TBB Firmware extensions (subband operation / self-triggering)
  - TBB Observation Mode
- Design and Planning Document Draft July 6
  - **Discussion this afternoon!**
- Continue to consider (cosmic) transient search mode
  - Implement handling of external triggers (VOEvent based)
  - Coordinated observations with GHz radio telescopes (Effelsberg, ARTS)
    - ➔ TBB images with may allow localisation of event
    - ➔ Detection at low frequencies difficult (dispersion, scattering)
  - FRB observations use HBA, complementary to VHECR (mostly LBA)