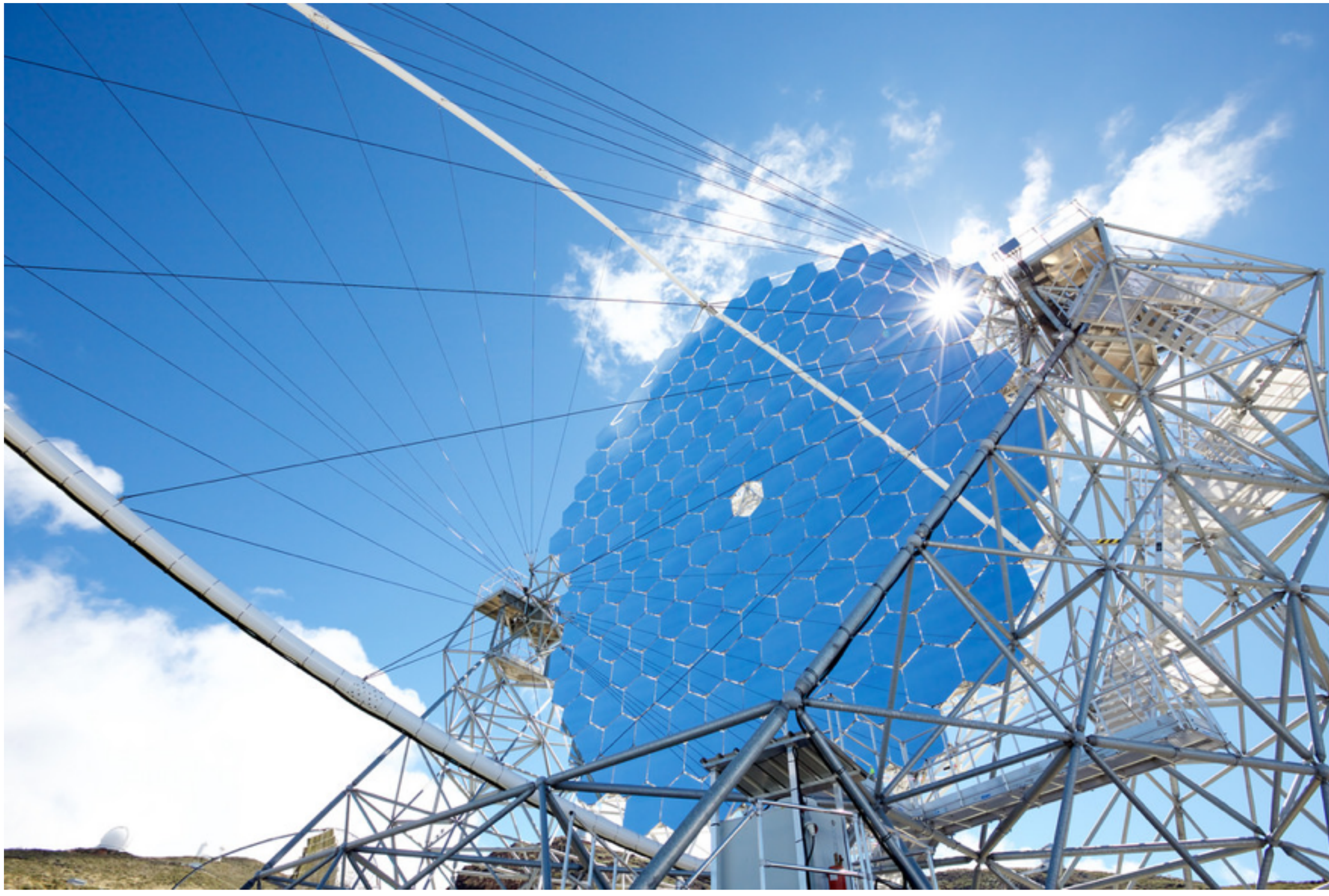


Transient/MWL
SWG status of activities
2019-11-18

Francesco Longo (Trieste) — deputy convener

GRB News

Transient / time domain astrophysics: a domain under rapid evolution

- Gamma Ray Bursts: breakthroughs after a decade of searches
  - short-GRB 160821B: hint of MAGIC detection (Berti et al. 2019, Proc. MG15), recently associated with a kilonova (Lamb et al. 2019 arXiV:1905.02159)
  - GRB190114C: >300GeV emission 50s after the burst (ATEL #12390)
  - GRB180720B: >100GeV emission 10h after the burst (E. Ruiz Velasco et al., CTA Symposium 2019)
  - **GRB190829A: VHE emission >4h after the burst (ATEL #13052)**

News from the PWG

- Consortium papers list
  - Reserved Targets for CTAC — Key Science Cases and the Science with CTA book.
- In the Transient PWG
  - Detection rates and studies of Gamma Ray Bursts with the Cherenkov Telescope Array
  - Chasing the counterpart of gravitational wave alerts with the Cherenkov Telescope array: prospect and strategy
  - Neutrino Target of Opportunity program for the Cherenkov Telescope Array
  - (Detectability of) Galactic Transient Sources with Cherenkov Telescope Array
- Other papers
  - CTA Sensitivity to Short Transients
  - Scientific Performance of Divergent Pointing

Consortium papers

Subject of the paper	SWG	Preliminary Editorial board
Prospects for the Detection of Gamma Ray Emission from the Perseus Galaxy Cluster with CTA	CR/Diffuse/Dark Matter	Gianfranco Brunetti, Moritz Hütten, Judit Pérez-Romero, Miguel Sánchez-Conde, Stephan Zimmer
The Sensitiviy of CTA to Electron at the Highest Energies	CR/Diffuse	Daniel Parsons, Harm Schoorlemmer, Rubén López-Coto
Prospects form a deep survey of the LMC with CTA	CR/Diffuse/Dark Matter/Galactic	Maria Isabel Bernardos, Fabio Iocco, Pierrick Martin
High-energy astrophysics of the Galactic Center region with the Cherenkov Telescope Array	Diffuse/CR, Galactic	Aion Viana, Daniele Gaggero, Dario Grasso, Dmitry Malyshev, Karl Kosack, Stefan Funk
PeVatron sensitivity with CTA	Galactic	Ekrem Oguzhan Anguner, Heide Costantini, Pierre Cristofari, Cyril Trichard, Gaia Verna
Survey of the Galactic Plane with the Cherenkov Telescope Array	Galactic	Acero F., et a. (lots of people)
(Detectability of) Galactic Transient Sources with Cherenkov Telescope Array	Transient/MWL	Alicia López Oramas, Sandro Mereghetti, Sylvain Chaty, Alessandro Papitto, Brian Humensky, Pierre Cristofari, Lara Sidoli
Neutrino Target of Opportunity program for the Cherenkov Telescope Array	Transient/MWL/ Extragalactic	Elisa Bernardini, Anthony Brown, Marcos Santander, Konstancja Satalecka, Fabian Schussler
Detection rates and studies of Gamma Ray Bursts with the Cherenkov Telescope Array	Transient/MWL	G. Ghirlanda et al. (lots of people)
Chasing the counterpart of gravitational wave alerts with the Cherenkov Telescope array: prospect and strategy	Transient/MWL	A. Stamerra, B. Patricelli, T. Di Girolamo, A. Carosi, F. Schüssler
Active Galactic Nuclei population studies at the very high energies in the Cherenkov Telescope Array era	Extragalactic	Tarek Hassan, A. Brown, A. Dominguez, B. Fraga, M. Nievas- Rosillo, A. Zech
Probing cosmological gamma-ray propagation with the Cherenkov Telescope Array	Extragalactic	Jonathan Biteau, Manel Meyer, Ievgen Vovk, Julien Lefaucheur, Humberto Martinez Huerta
Sensitivity of CTA to a dark matter signal from the Galactic center region	Dark Matter	Torsten Bringmann, Christopher Eckner, Anastasia Sokolenko, Lili Yang, Gabrijela Zaharijas
Search for Dark Matter in Dwarf Spheroidal Galaxies with the Cherenkov Telescope Array	Dark Matter	Michele Doro, Aldo Morselli, Gonzalo Rodriguez Fernandez, Francesco G.Saturni
Sensitivity of CTA to Line-like features from Dark Matter.	Dark Matter	Eirik Hatlen, Clara Bertinelli Salucci, Heidi Sandaker and Torsten Bringmann

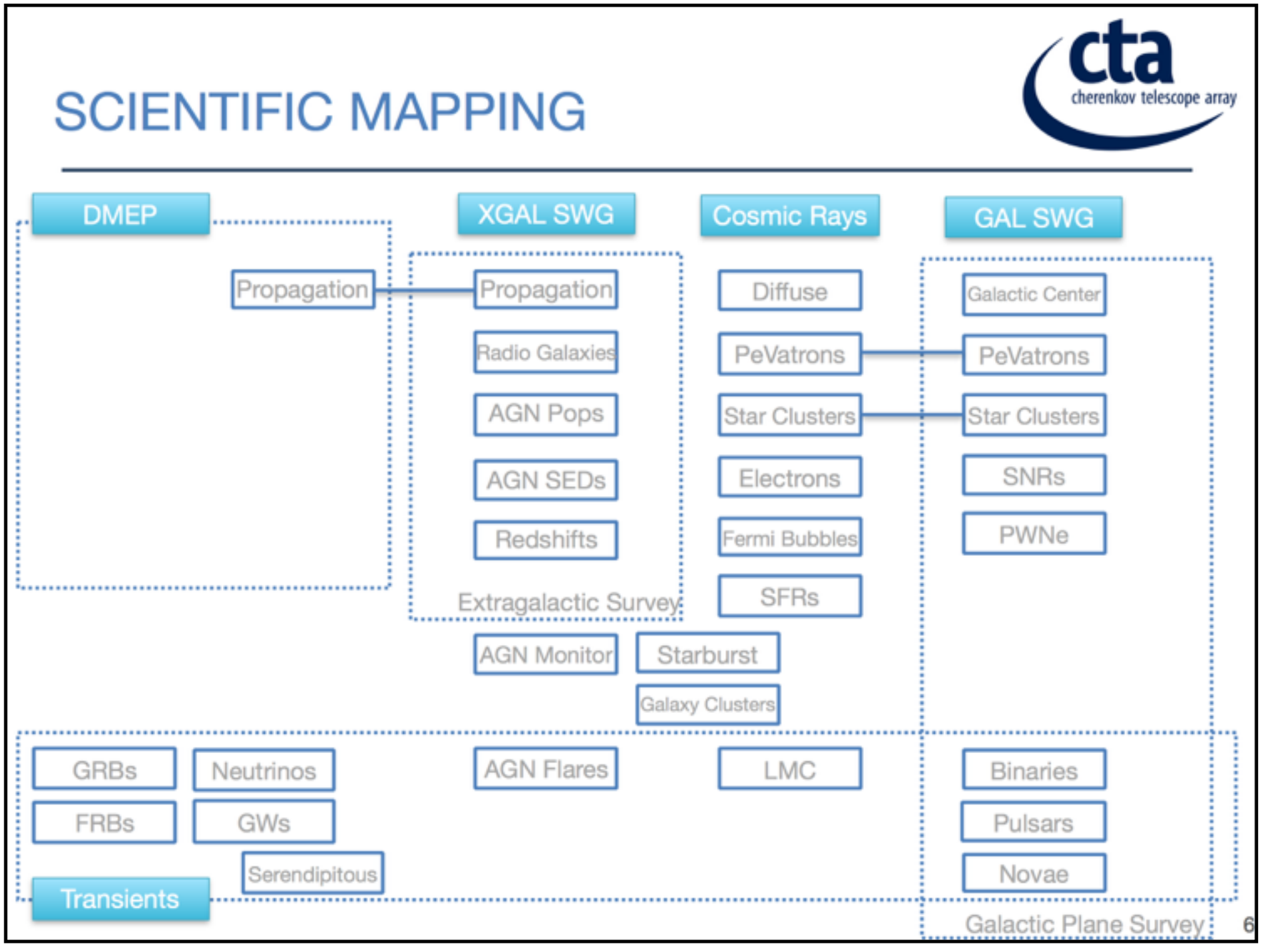
MWL activities

MWL/MM needs for the CTA Key Science Projects

- Goals
  - Phase 1: define+summarize the MWL / MM needs for achieving the CTA Science goals + identify synergies with other instruments
  - Phase 2: start planning of access to external data
- consultation between September - December 2018 through a series of survey tables, including 28 different CTA science cases
- presentation of the preliminary report document + discussions with the different groups + dedicated presentation in Lugano + consolidation over summer 2019

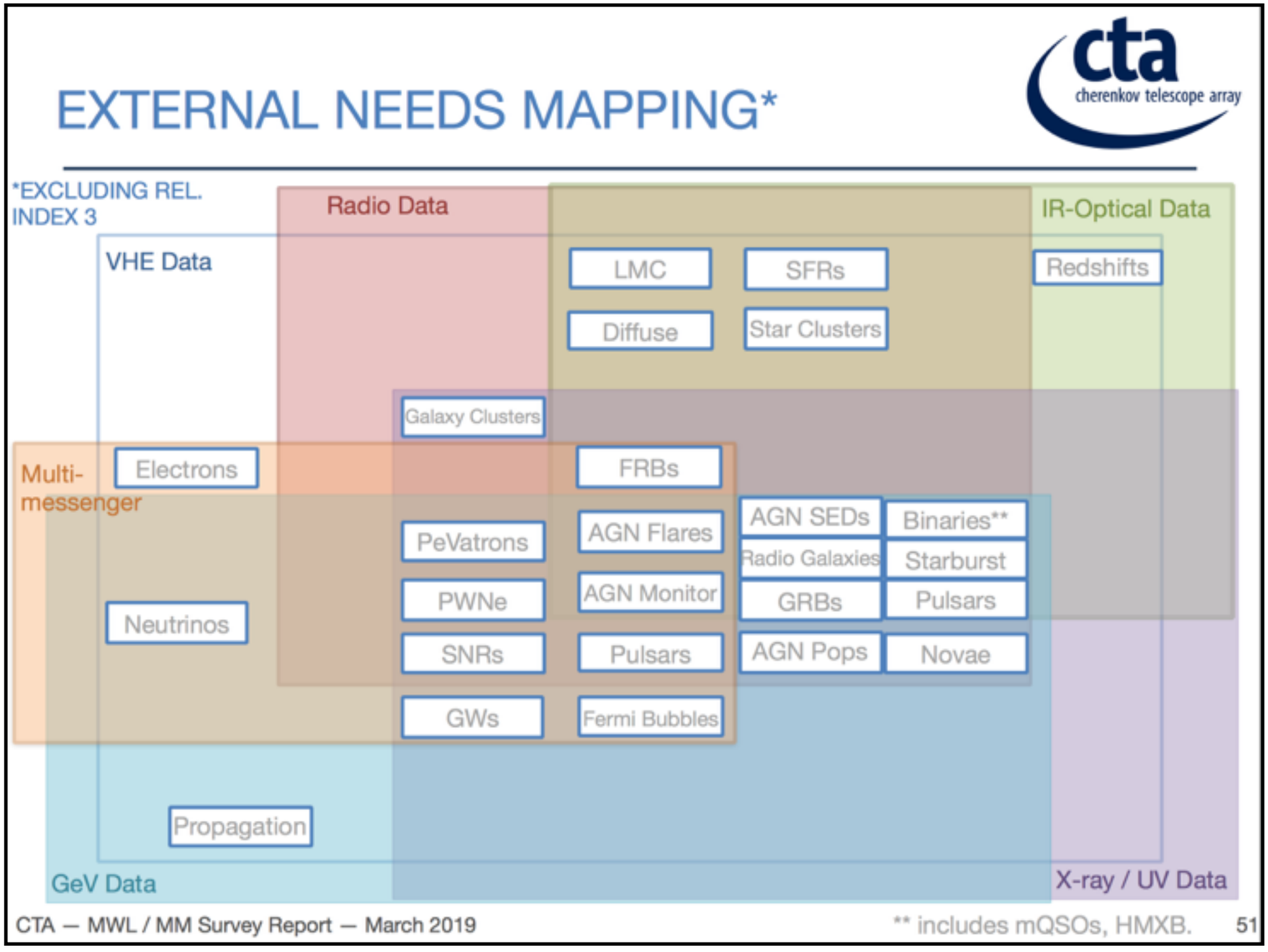
U.Barres de Almeida et al.

MWL activities



U.Barres de Almeida et al.

MWL activities



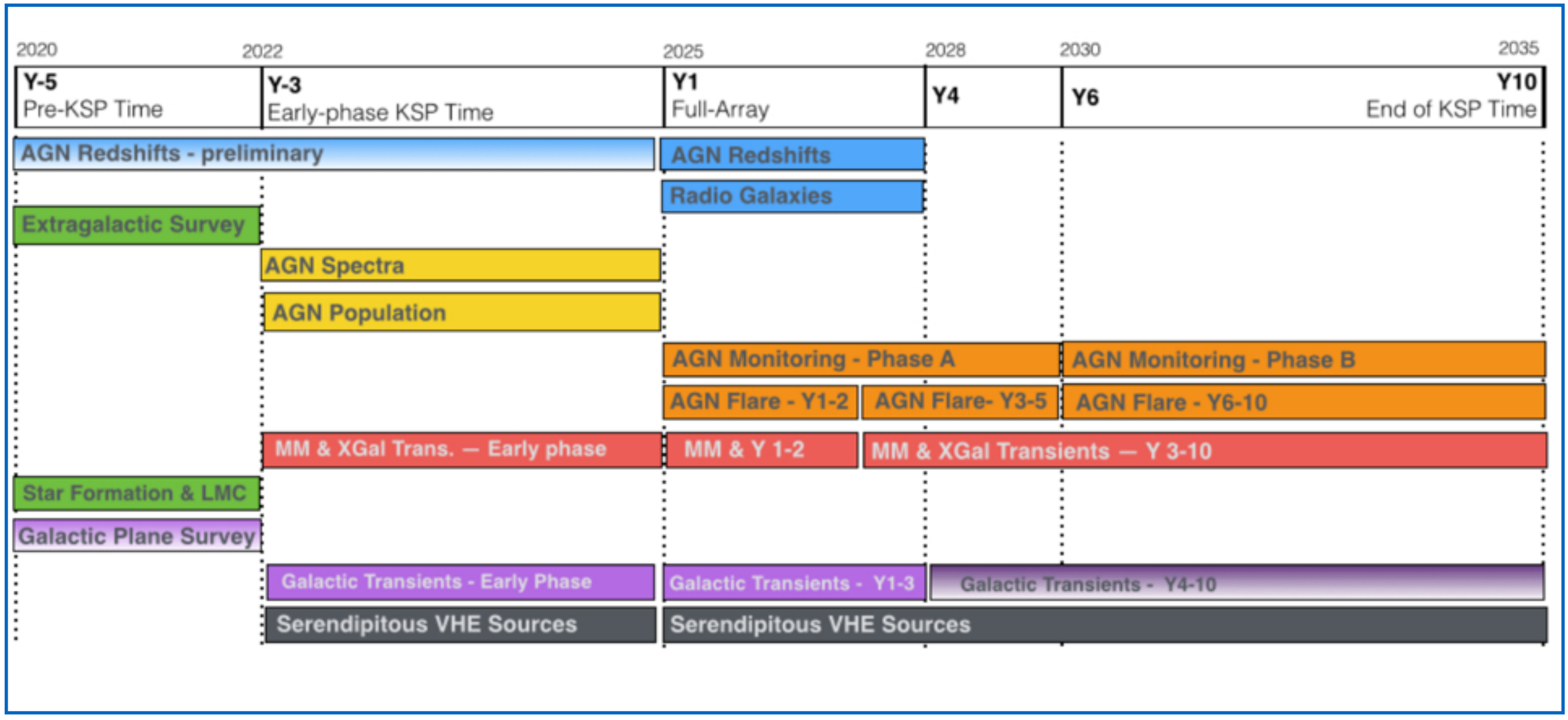
U.Barres de Almeida et al.

MWL activities

Band or Messenger	Astrophysical Probes	Galactic Plane Survey	LMC & SFRs	CRs & Diffuse Emission	Galactic Transients	Starburst & Galaxy Clusters	GRBs	AGNs	Radio Galaxies	Redshifts	GWs & Neutrinos
Radio	Particle and magnetic-field density probe. Transients. Pulsar timing.	✔	✔	✔	✔	✔	✔	✔	✔		✔
(Sub)Millimetre	Interstellar gas mapping. Matter ionisation levels. High-res interferometry.	✔	✔	✔		✔		✔	✔		
IR/Optical	Thermal emission. Variable non-thermal emission. Polarisation.	✔	✔	✔	✔	✔		✔	✔	✔	
Transient Factories	Wide-field monitoring & transients detection. Multi-messenger follow-ups.						✔	✔			✔
X-rays	Accretion and outflows. Particle acceleration. Plasma properties.	✔	✔	✔	✔	✔	✔	✔	✔		✔
MeV-GeV Gamma-rays	High-energy transients. Pion-decay signature. Inverse-Compton process	✔	✔	✔	✔	✔	✔	✔			✔
Other VHE	Particle detectors for 100% duty cycle monitoring of TeV sky.	✔	✔	✔		✔		✔			
Neutrinos	Probe of cosmic-ray acceleration sites. Probe of PeV energy processes.			✔			✔	✔			✔
Gravitational Waves	Mergers of compact objects (Neutron Stars). Gamma-ray Bursts.						✔				✔

U.Barres de Almeida et al.

MWL activities



U.Barres de Almeida et al.

ICRC contribution (July 24 - Aug 1)

- Contribution on Transient/MWL group related subjects
  - V.Fioretti — Cherenkov Telescope Array sensitivity to the transient sky (link)
  - M.Seglar-Arroyo— The gravitational wave follow-up program of the Cherenkov Telescope Array (link)
  - U.Barres de Almeida — CTA Science: A multi-wavelenght and multi-messenger perspective (link)
  - F.Schüssler — The Transient program of the Cherenkov Telescope Array (link)
  - K.Satalecka — Neutrino Target of Opportunity program of the Cherenkov Telescope Array (link)
  - I.Sadeh — POSyTIVE - a GRB population study for the Cherenkov Telescope Array (link)
  - A.Donini — The CTA Performance in Divergent Mode (link)
  - I.Sadeh — Deep learning detection of transients (non consortium publication) — (link)

Consortium paper on GRBs by the Transient/MWL PWG

Report on CTA F2F meeting

The start under best auspices → GRB 190114C !! :-)

Introduction (S. Inoue) on the previous Consortium Paper on GRB detection

PoSyTIVE project structure and discussion:

- ★ WP1: Population of Long and Short GRBs (G. Ghirlanda)
- ★ WP2: Prompt emission model (Z. Bosnjak)
- ★ WP3: Afterglow emission model (L. Nava)
- ★ WP4: Detection of GRBs (F. Longo & T. Stolarczyk)
- ★ WP5: MW follow up (S. D. Vergani)

STATUS

- First checks on Gammapy vs ctools

TO DOs:

- Study of differences in analysis
  - Ctools versus Gammapy
  - Differences in IRF
- Preparation for the population analysis

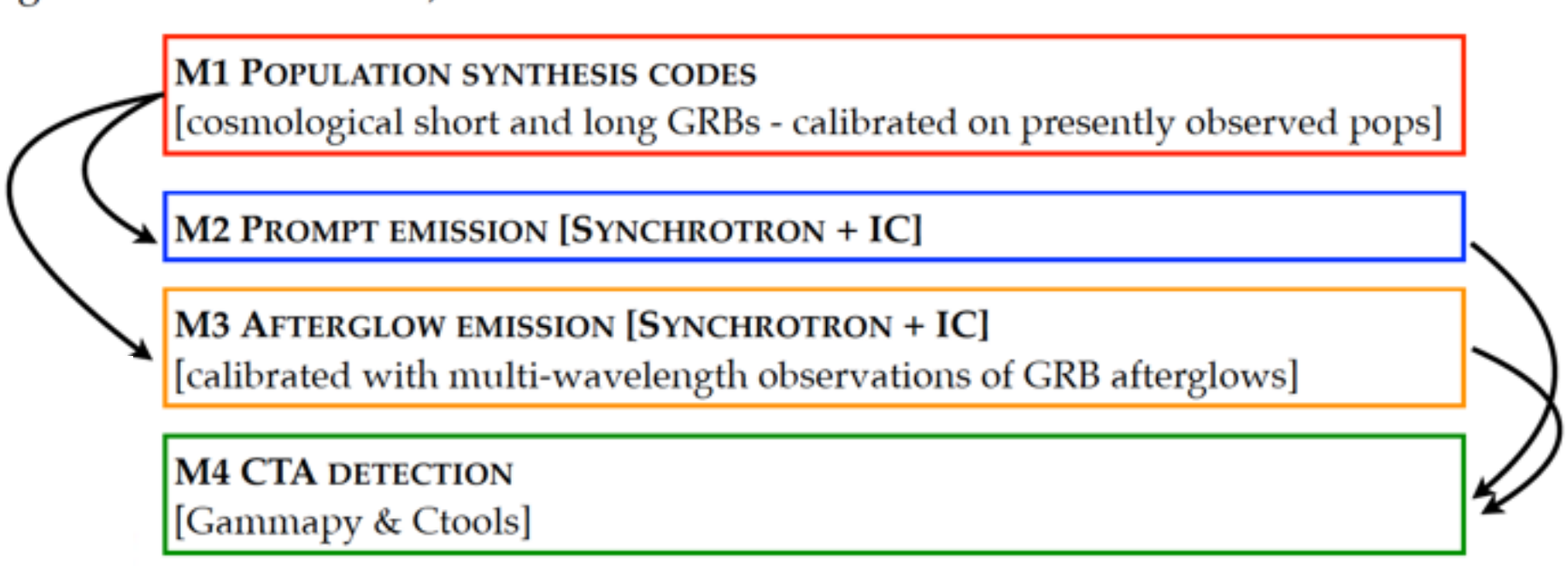
G.Ghirlanda et al.

Consortium paper on GRBs by the Transient/MWL PWG

POSYTIVE = POpulation SYnthesis Theory Integrated model for Very high energy Emission

- estimate CTA detection rate of Short and Long GRBs
- explore the physical parameter space (intrisic= e.g. luminositites, microphysics & extrinsic= e.g. environment density) accessible by CTA detections
- differentiate between prompt and afterglow emission detection

Modular structure (based on state of the art knowledge of GRB population and prompt/ afterglow emission models)



G.Ghirlanda et al.

Consortium paper on GRBs by the Transient/MWL PWG

Report on CTA F2F meeting

PAPER STRUCTURE

1. Introduction
   a. Comparison with previous paper
   b. Motivation
   c. State-of-the-art
2. Model
   a. Population
   b. Prompt
   c. Afterglow
3. SIMULATIONS
   a. Detectability
   b. Ctools
   c. Gammapy
4. RESULTS
   a. Detection rates (Swift and comment about bright and well localised GBM GRBs)
   b. Properties of population detected by CTA (physical parameter space)
   c. Impact on detection strategies (LST, MST, …)
5. GRB 190114C
   a. Compatibility with predicted rate
   b. Simulation for CTA (move at larger z)

G.Ghirlanda et al.

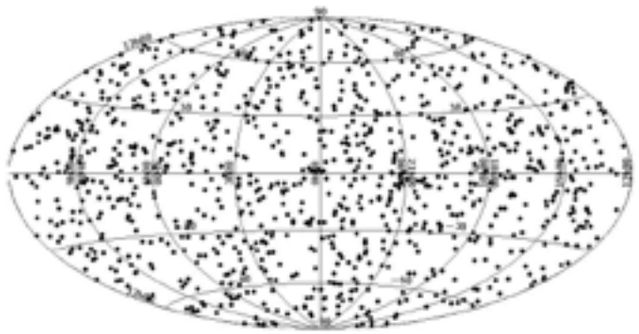
Consortium paper on GRBs by the Transient/MWL PWG

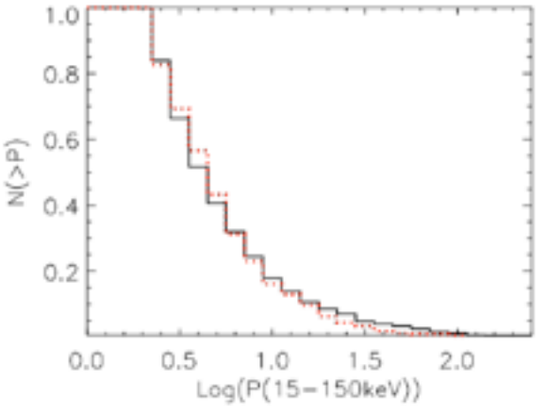
POSYTIVE: status

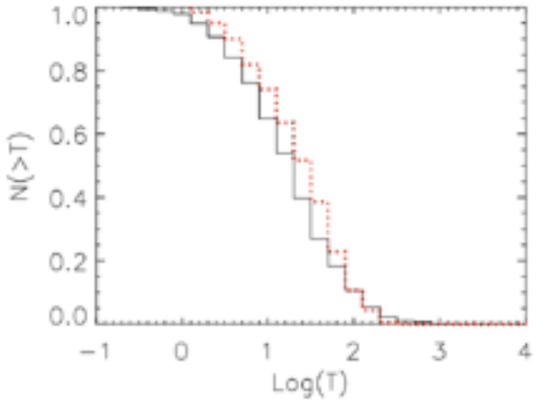
Repository of 1000 simulated GRBs representative of the Swift bright sample

Φ(15-150 keV) > 2.6 ph cm^{-2} s^{-1}

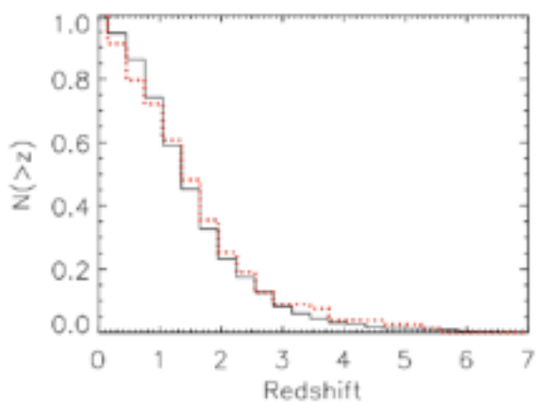
- Summary FITS table with sky position, redshift, intrinsic properties (e.g. energetics, peak spectral energy, spectral, properties, photon fluxes, bulk Lorentz factor
- input for prompt and afterglow simulations
- basis for CTA simulations (ctools + gammapy)

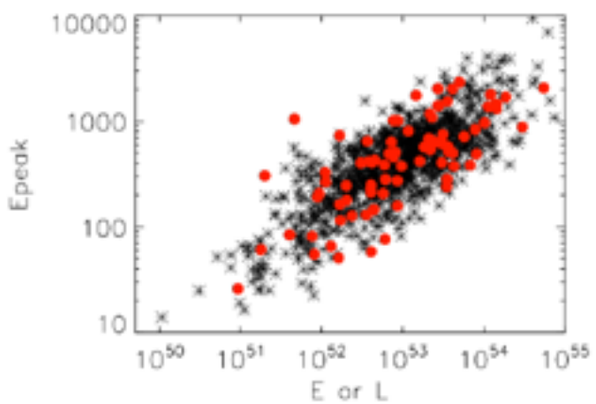






full population: ~2 million entries



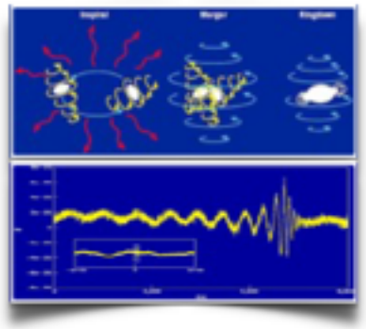


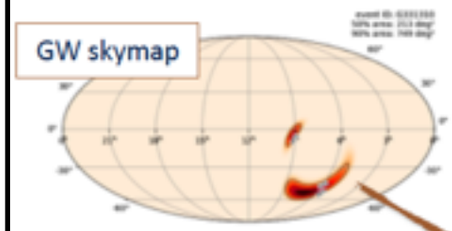
G.Ghirlanda et al.

GW Consortium paper by the Transient/MWL PWG

Follow-up of gravitational waves with CTA

- **Simulation of mergers** and GW signal in local universe





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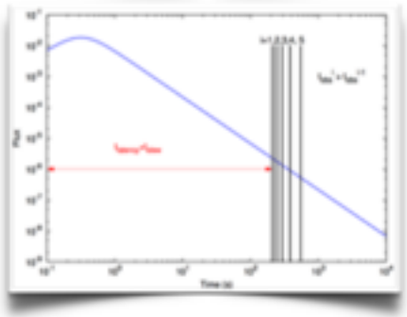
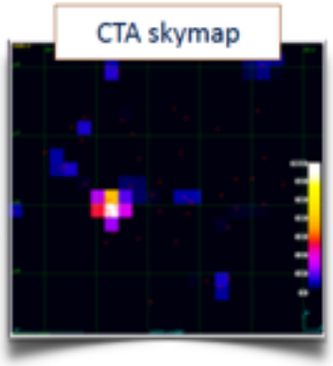


- **Phenomenological model** of VHE emission, from short-GRB templates
- Off-axis emission

⊗

- **CTA observing strategy**

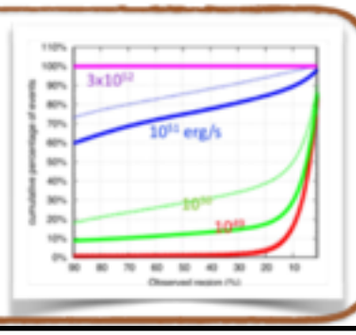


- **Simulation of CTA** response (IRFs, EBL)

=

Expected Results

- ✓ Joint GW-CTA detection rates and coverage
- ✓ Optimal observation strategies



A.Stamerra et al.

A joint effort of the **GW-CTA team:**

Alessandro Carosi, Antonio Stamerra, Barbara Patricelli, Brian Humensky, Deivid Ribeiro, Elisabetta Bissaldi Fabian Schüssler, Francesco Longo, Giulia Stratta, Julien.Lefaucheur, Lara Nava, Monica Seglar-Arroyo, Stefano Covino, Susanna Vergani, Susumu Inoue, Thomas Gasparetto, Tristano Di Girolamo and Giancarlo Cella, Massimiliano Razzano.

11

GW Consortium paper by the Transient/MWL PWG

Scheme of activities

FUTURE DEVELOPMENT **TO BE DONE**

Population of BNS mergers

19000 BNS merger with:
- sky map
- source in sky map
- uniformly distributed in sky
- clumpy galaxy distribution

sGRB model

Phenomenological model of on-axis sGRB.
Spectra + LC + vary PL index (between models)

simple modelling for off-axis emission.
rescale off-axis model

+ off-axis emission and afterglow/delayed emission

Pointing pattern

- Define pointing pattern from sky map
- get duration of pointing
- pointing optimization:
- - the sooner the better
- - source in the fov to simulate the pointing

Pointing duration

INPUT: SGRB model(s)
CTA sensitivity/IRF
OUTPUT: duration of pointing
Add a distribution of the time delay around 3 minutes (average for GW events).

For each pointing beginning at t_1, the observation ending time t_2 happens when the integrated flux is equal to the sensitivity of CTA for $t_2 - t_1$

Different model for simulation

Simulations

INPUTS: model, source position, pointings, duration, parameters for IRF choice
OUTPUT: simulate each pointing and find if the source is present

Merging: Either each pointing is simulated separately or it's merged with previous pointing(s) and then analised: then the source detection is performed.
Search: clustering algorithms in (x, y, t)? Li&Ma with ON/OFF for the significance. Wavelet for detection? others? False positives in the detection?
Stop criteria: next pointing is too long, we hit some maximum observation time (CTA plan, physical constraints, source below horizon, dawn, etc...).
Hot spot found! --> keep observing that place

Repository using redmine in preparation (similar to the GRB group)

A.Stamerra et al.

GW Consortium paper by the Transient/MWL PWG

GW: updates since Lugano

- Phase 1 completed
  - Basic working chain including:
  - Complete database of GW events 2D: COSMoS (https://doi.org/10.6084/m9.figshare.c.4243595.v1)
  - Set of GRB templates
  - CTA simulation scripts through Gamma-py and Ctools + basic observation strategy
- Implemented for ICRC proceeding
  - Rates of GW-CTA detections not yet provided ➜ phase 2
- Communication
  - Redmine project available and dedicated email-list
  - https://forge.in2p3.fr/projects/cta-gravitational-waves
  - cta-phys-gw@cta-observatory.org


The gravitational-wave follow-up program of CTA

cta cherenkov telescope array

ABSTRACT

Introduction

Simulations of VHE counterpart searches in GW follow ups with CTA

EM counterpart searches in GW follow-up observations with CTA

Outlook

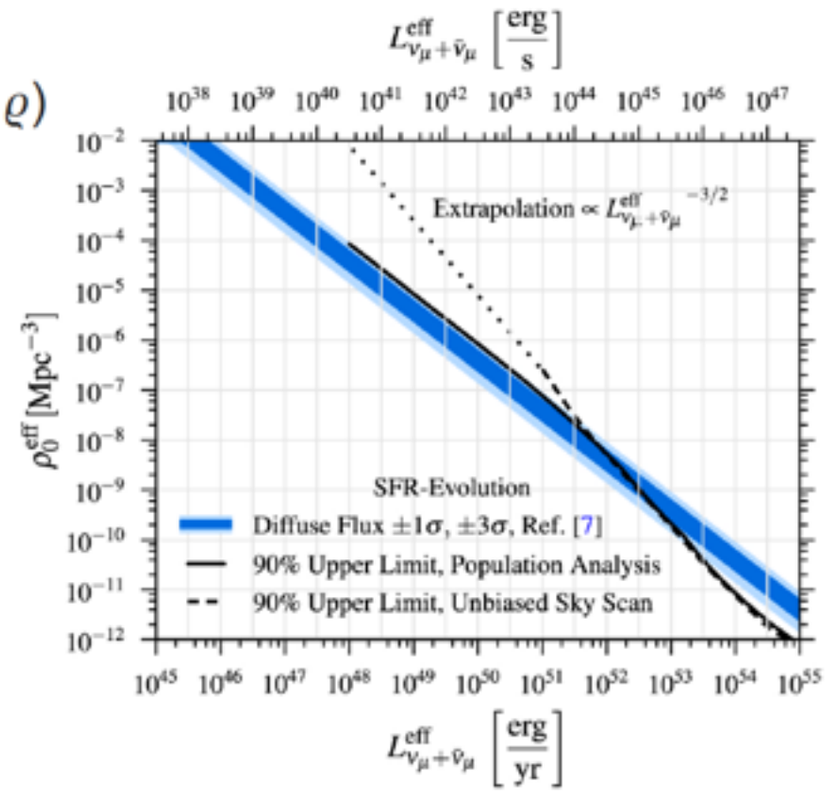
ACKNOWLEDGEMENTS

A.Stamerra et al.

Neutrinos ToO consortium paper

Neutrino follow-up

- Aim: constrain the general properties of the source population responsible for the diffuse neutrino flux
  - Searches for sources with neutrino telescopes: constrain L vs ϱ
  - Connect to gamma-ray emission
    - Can we detect these sources with IACTs?
    - What is the best observation strategy?
    - Improve limits on source population (L vs ϱ)



K.Satalecka et al.

Galactic Transients consortium paper

Galactic Transient Sources with CTA

- Some sources (magnetars, SFXTs, novae…) have no TeV emission model predictions
- New structure/approach of the paper based on:
  - Sensitivity curves
  - Short-timescale variability
  - Chances to find transients in the Galactic Plane Survey
  - Estimation of the expected variability over a steady flux
  - Strategies to follow transients after an external alert, real-time analysis
  - Multiwavelength view/ connection
  - Studies on temporal systematics and differences with extragalactic transients

A.Lopez Oramas et al.

Summer School in Sexten (June 24 - 28, 2019)

- Dedicated to Multimessenger analysis in the CTA era
- Around 40 partecipants
- Analysis of CTA, Fermi and GW data

SEXTEN CENTER FOR ASTROPHYSICS

- More info posted at this link

Conclusions

- Strong links with ASWG
  - RTA simulations/analysis of GRBs + GWs
  - source detection algorithms (e.g. ML to transient emission, likelihood fitting in gammapy, etc.

- Focussed F2F meetings of task groups proven very useful
- Reports on all tasks during monthly SWG calls
- Next F2F in January focused on GRB and GW