Journée Rencontre des Jeunes Chercheurs 2018

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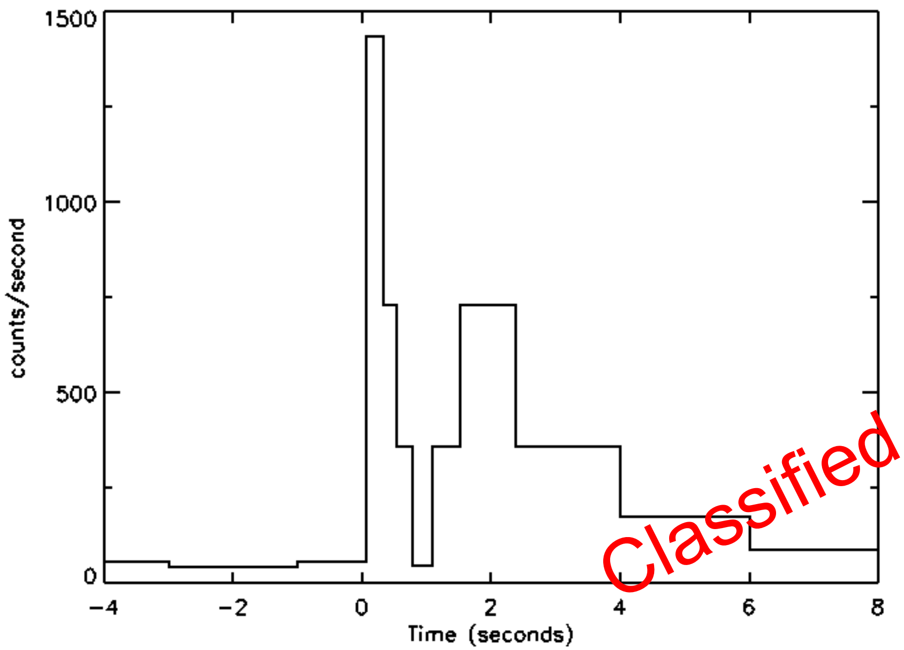
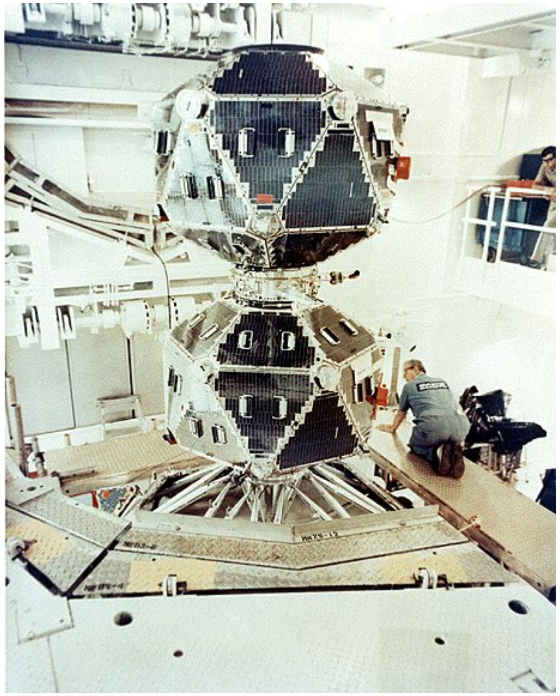
  - What is a GRB ?
  - A released energy boundary ?
- Current GRB observations with H.E.S.S.
  - The H.E.S.S. array
  - GRB observations with H.E.S.S.
- Future of GRB observation with CTA
  - The Large Size Telescope (LST) as a GRB finder
  - Estimation of GRB detection with CTA

An unexpected discovery in 1962…



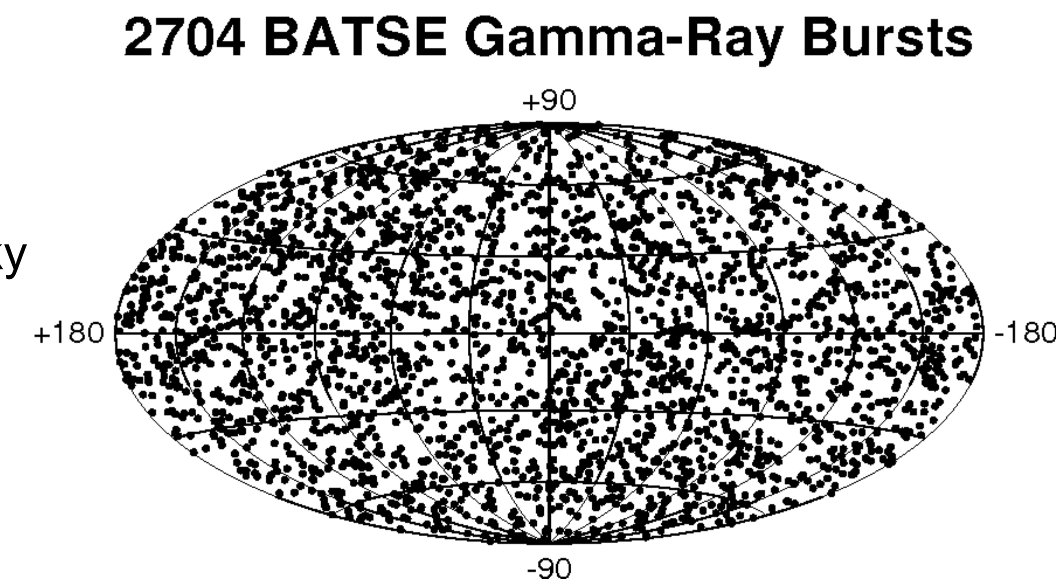
First GRB detection with VELA



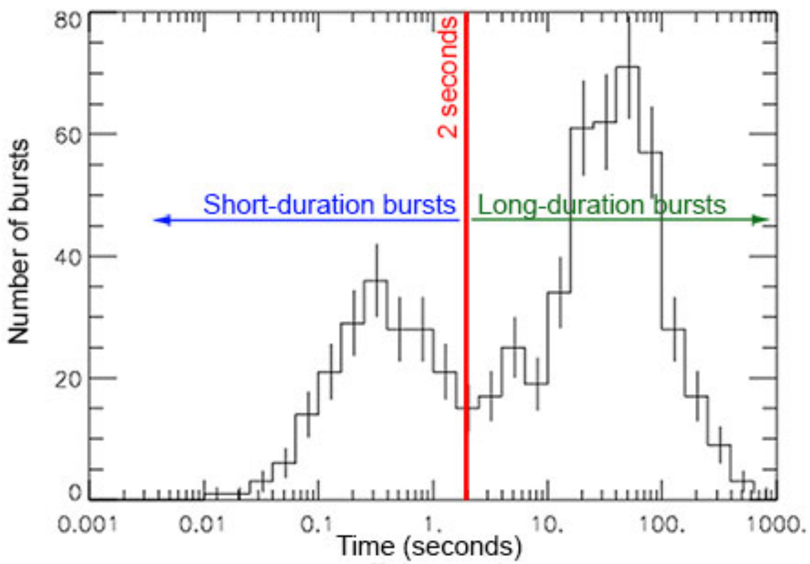
Picture of VELA satellite

…Classified until 1973

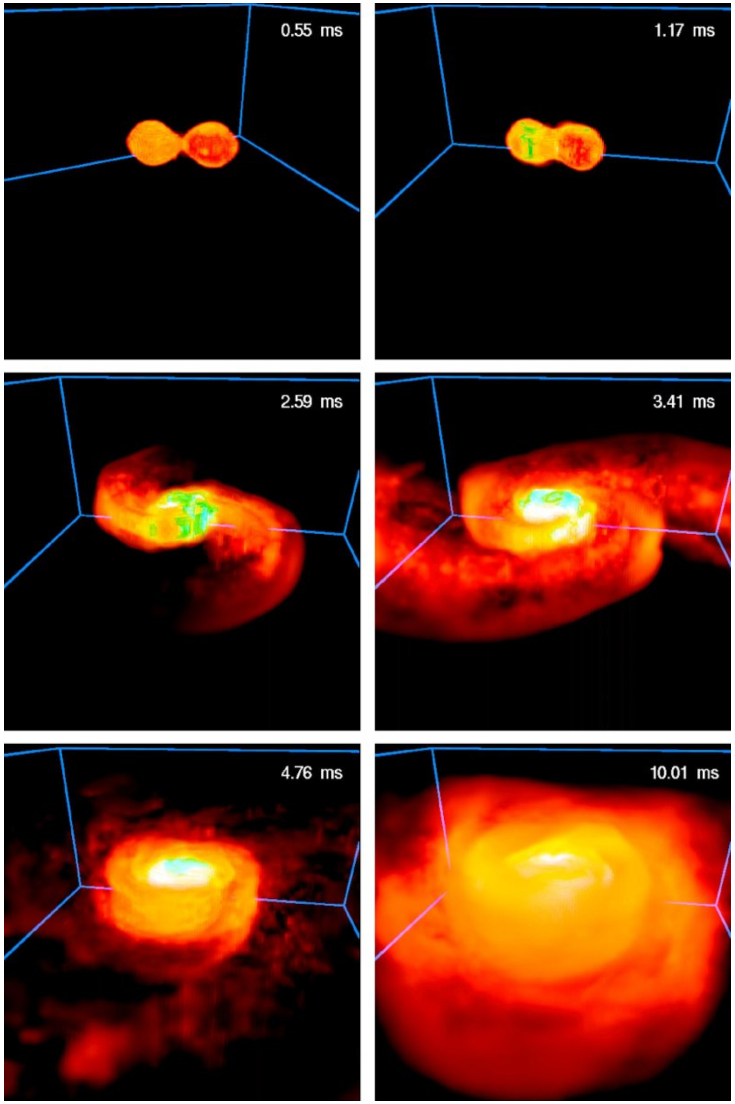
Uniform distribution of GRB in the sky



2 types of GRBs for 2 scenari



Short Bursts: NS-NS (NS-BH) merger



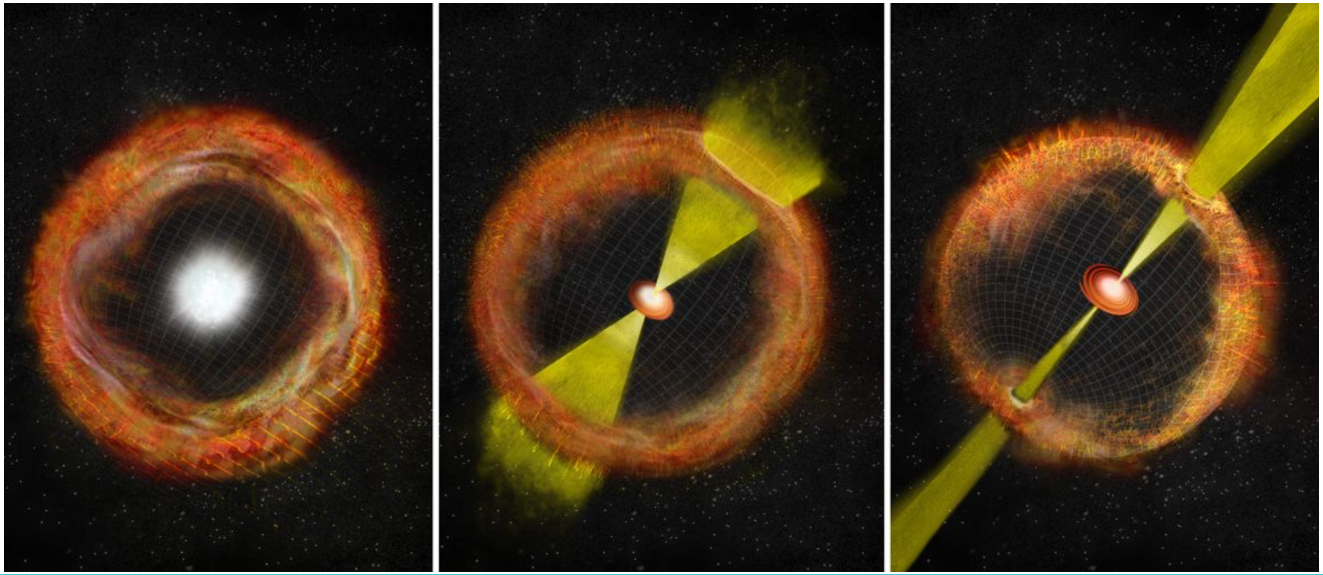
- NS-NS (NS-BH) in a binary system will loose energy through gravitational waves
- The 2 objects will get closer until tidal forces rip the NS apart and matter falls into a BH.
- merging has ms timescale

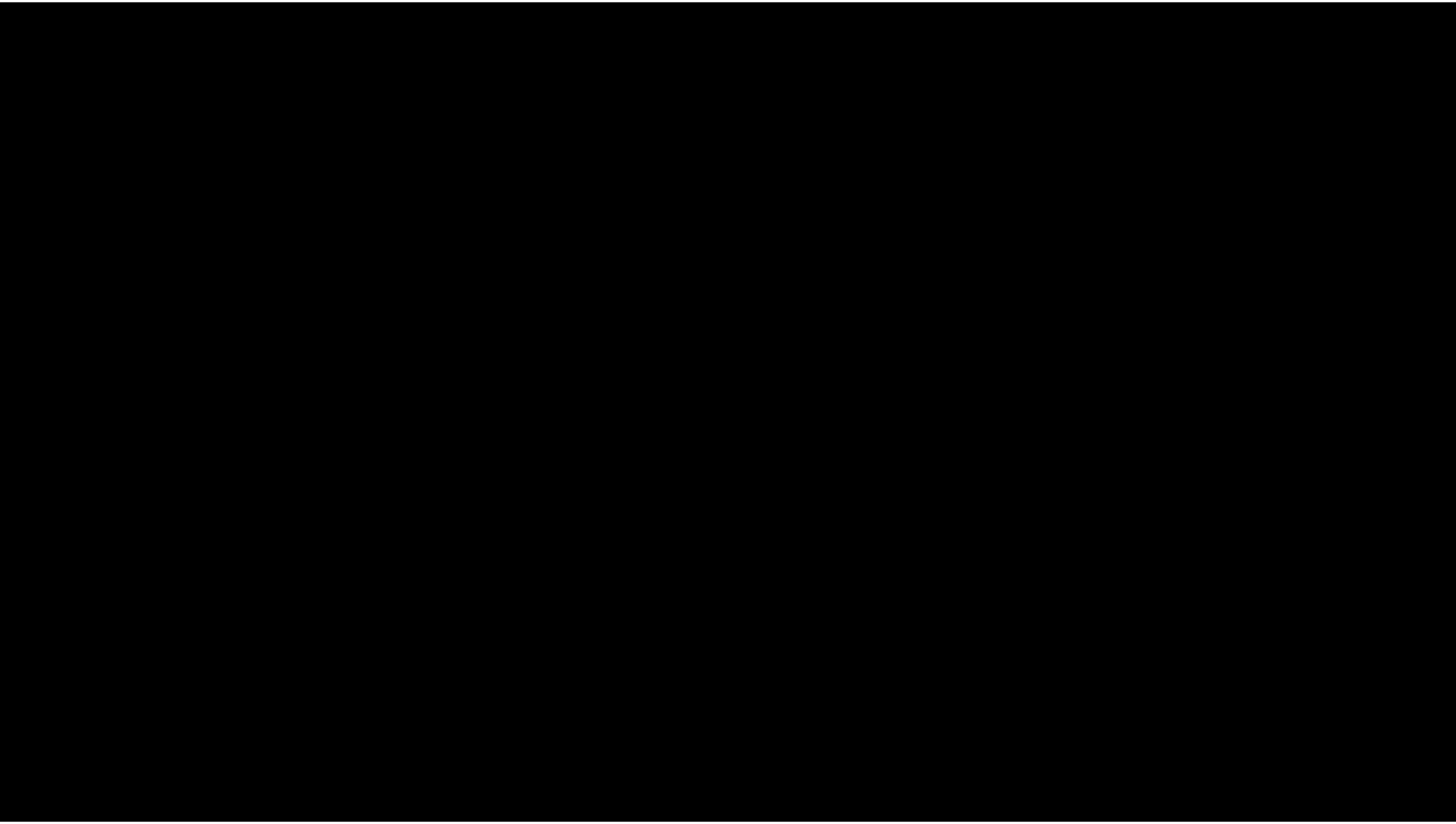
Projenitors


GW170817
Animation

Long bursts: Collapsar of a massive (> 40 Msun), rotating, low-metallicity star:

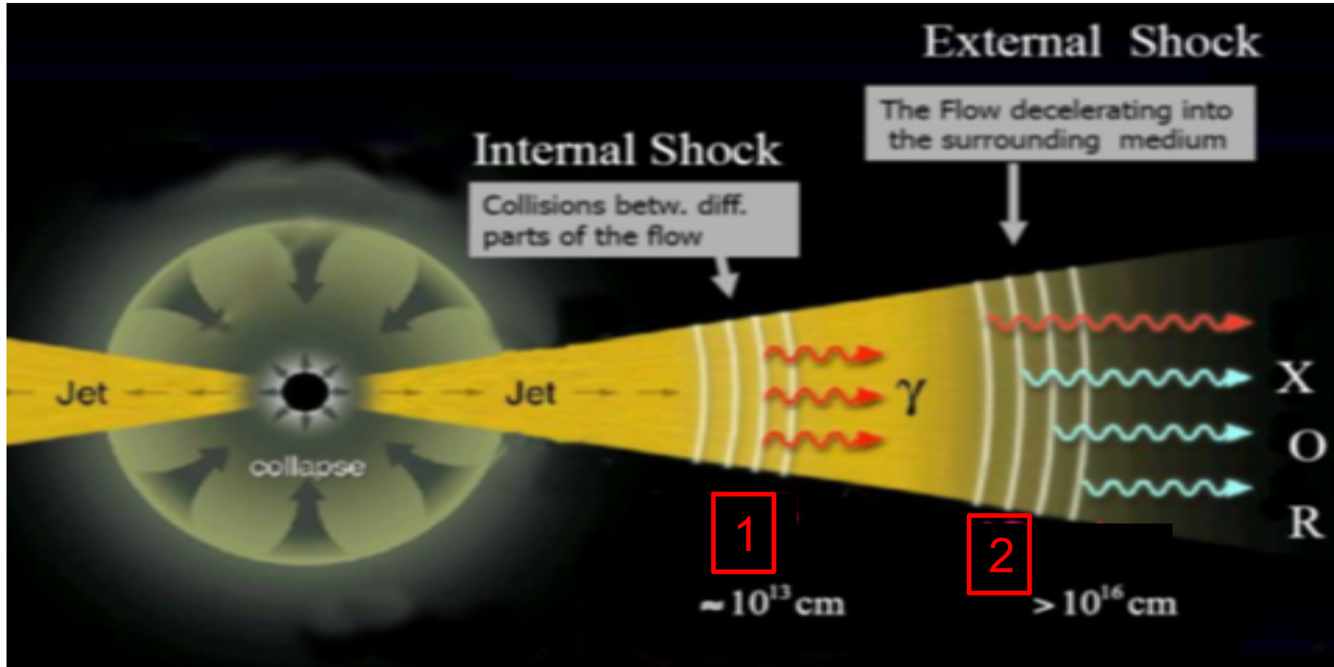
- Massive for a core-collapse forming a BH
- Rotating to drive a pair of jet along the rotation axis
- located in star forming region (irregular galaxies, arms of spiral galaxies) were massive stars are always found

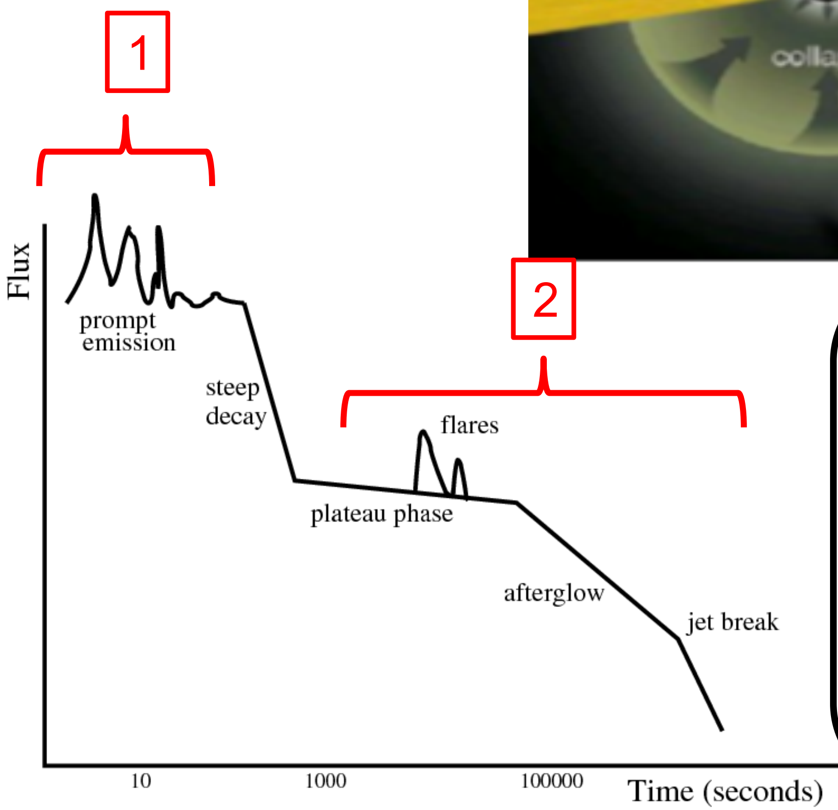


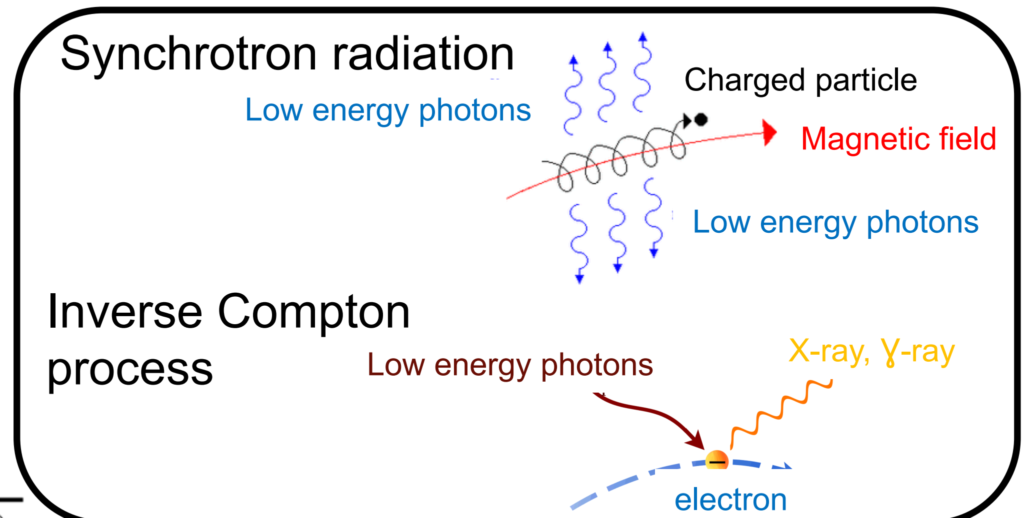


The Internal and external shocks models

A common process made of 2 phases of emission







Some GRB properties but a lot of remaining questions

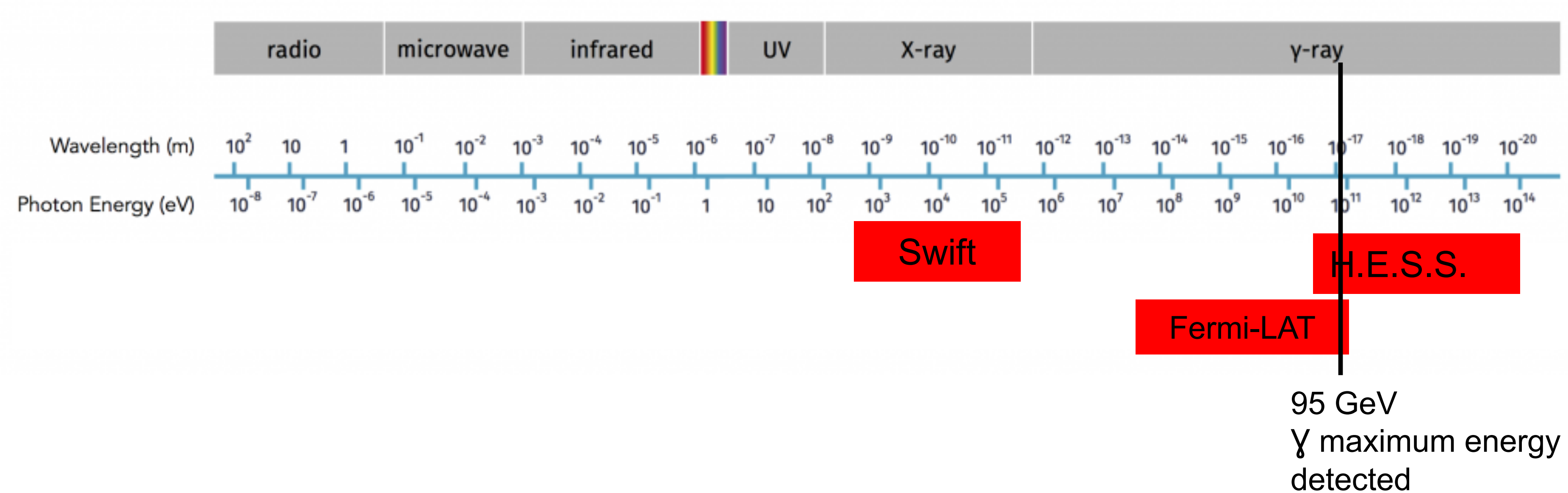
- Tremendous isotropic-equivalent energy:
  - 10^{50} -10^{54} ergs released in a short time scale (ms) only in the form of gamma-rays.

  (sun: 10^{33} erg/s; supernova: 10^{51} erg on a month time scale)
- The internal model could explain observations (but still not perfect)
- GRBs have been observed up to z ~ 6.3 (belong to the furthest detected objects)

-> hope to use GRB as cosmological tool (similar as Type Ia supernovae)

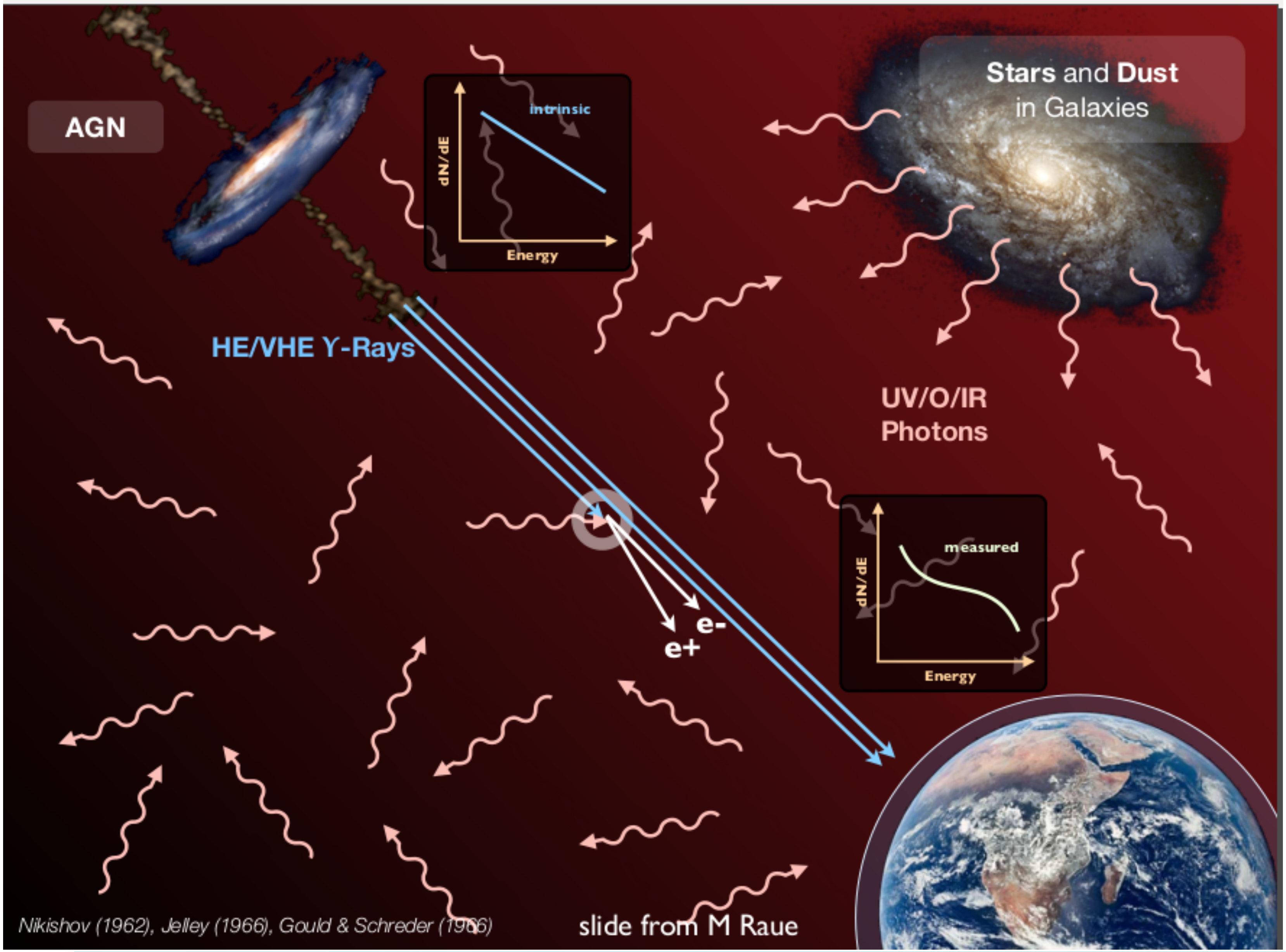
- GeV emission is delayed of 5-10s from keV one. Why ?
- How such an energy is released ?
- What are the conversion processes ?
- What are the processes inside jets ?
- …

A boundary energy ?

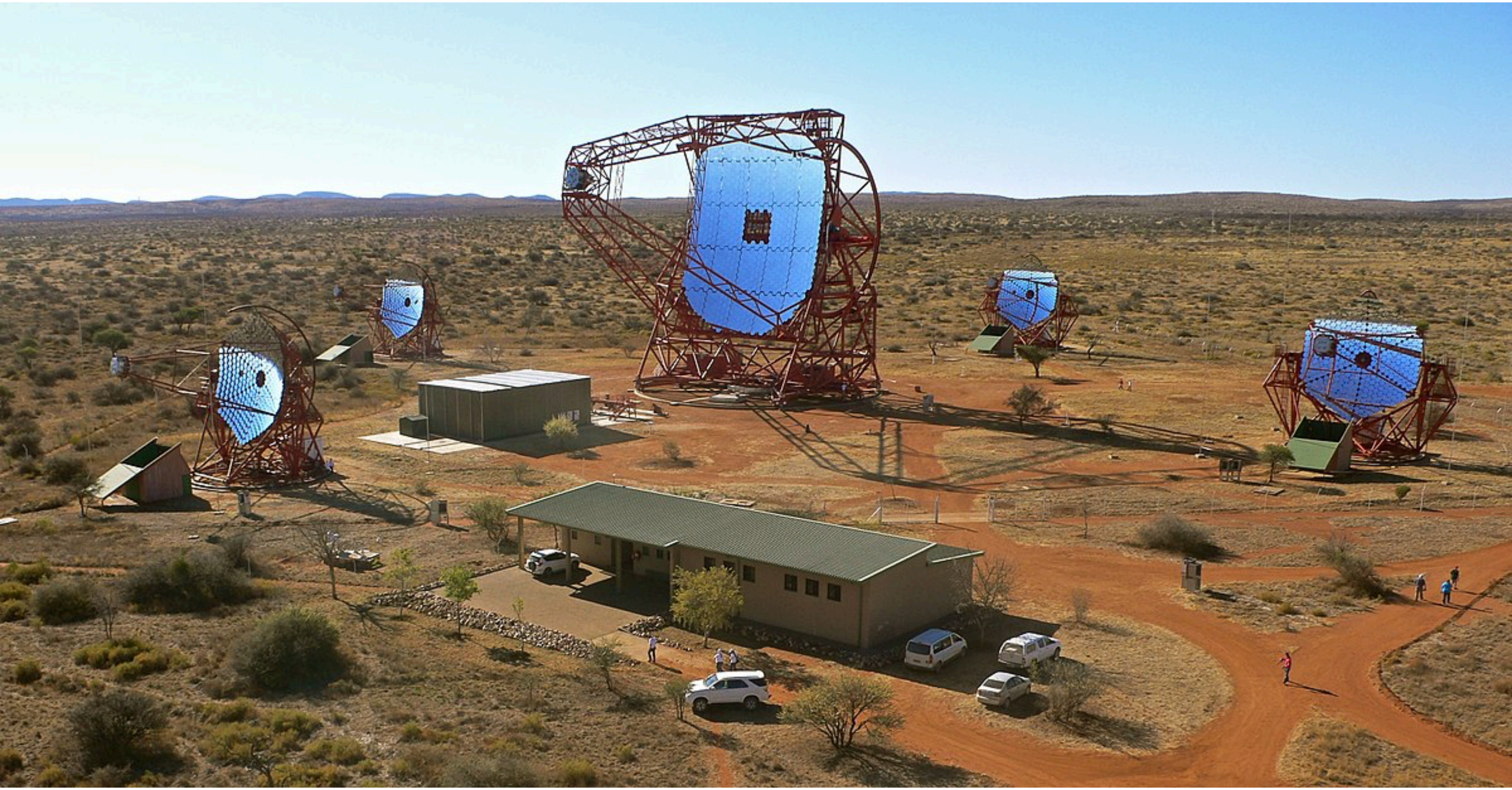


Instrument (Domain in energy)	Number of detection per year
Swift (X)	> 100
FERMI-LAT (gamma basse énergie)	10
Réseau de télescopes Cherenkov (gamma haute énergie)	0

The Extra-galactic background light



H.E.S.S. II era

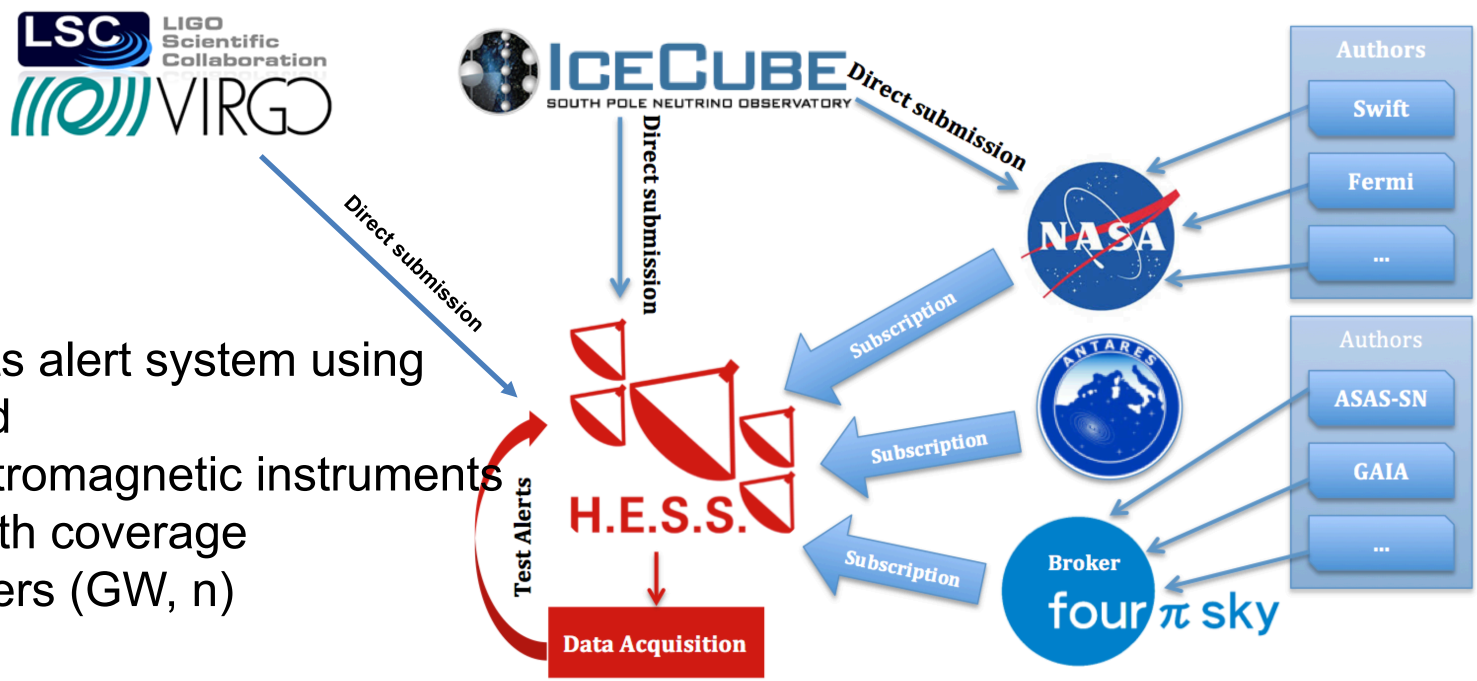


Alert system

- GRB position and moment are (for the moment) unpredictible
- H.E.S.S. FOV diameter = 5°

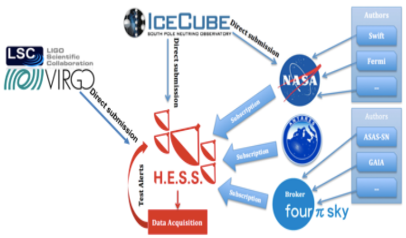
H.E.S.S. transients alert system using VOEvent standard

- Wide FoV electromagnetic instruments
- Multi wavelength coverage
- Multi messengers (GW, n)



Several ways to improve the GRB detection with H.E.S.S.

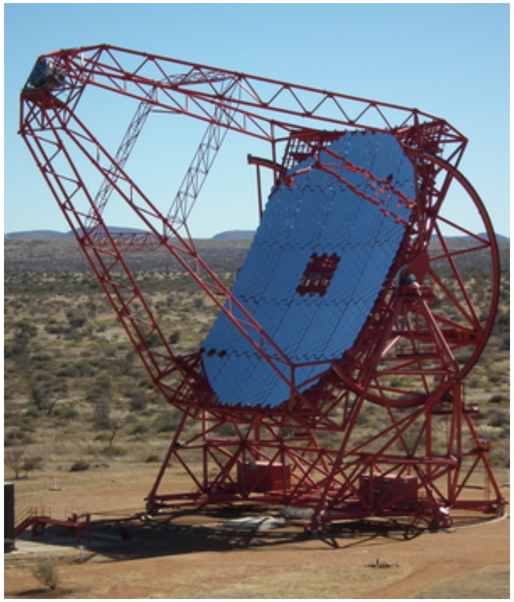
Alert network



Alerts

Delay of alerts sending and treatment

H.E.S.S. site



Repositionning time of telescopes

Raw data

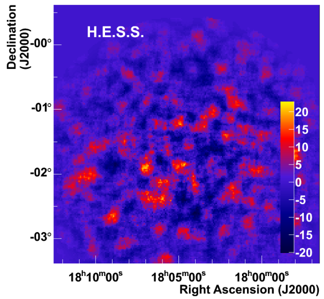
Improve the calibration

Calibration

Target	Run Duration (mn)	Status	Date	Calib
BZB J0316-2607	28	DONE	2017-07-14 04:58:10	paris-0-8-34
BZB J0316-2607	28	DONE	2017-07-14 09:17:16	paris-0-8-34
BZB J0316-2607	25	DONE	2017-07-14 05:42:18	paris-0-8-34
ACO 400	26	DONE	2017-08-05 03:30:52	paris-0-8-34
SMC pos 4	28	DONE	2017-08-02 21:29:34	paris-0-8-34
SMC pos 1	28	DONE	2017-07-14 02:51:16	paris-0-8-34
SMC pos 1	28	DONE	2017-07-14 02:27:01	paris-0-8-34
SMC pos 1	20	DONE	2017-07-14 04:46:53	paris-0-8-34
SMC pos 1	19	DONE	2017-07-14 02:35:50	paris-0-8-34

High level data

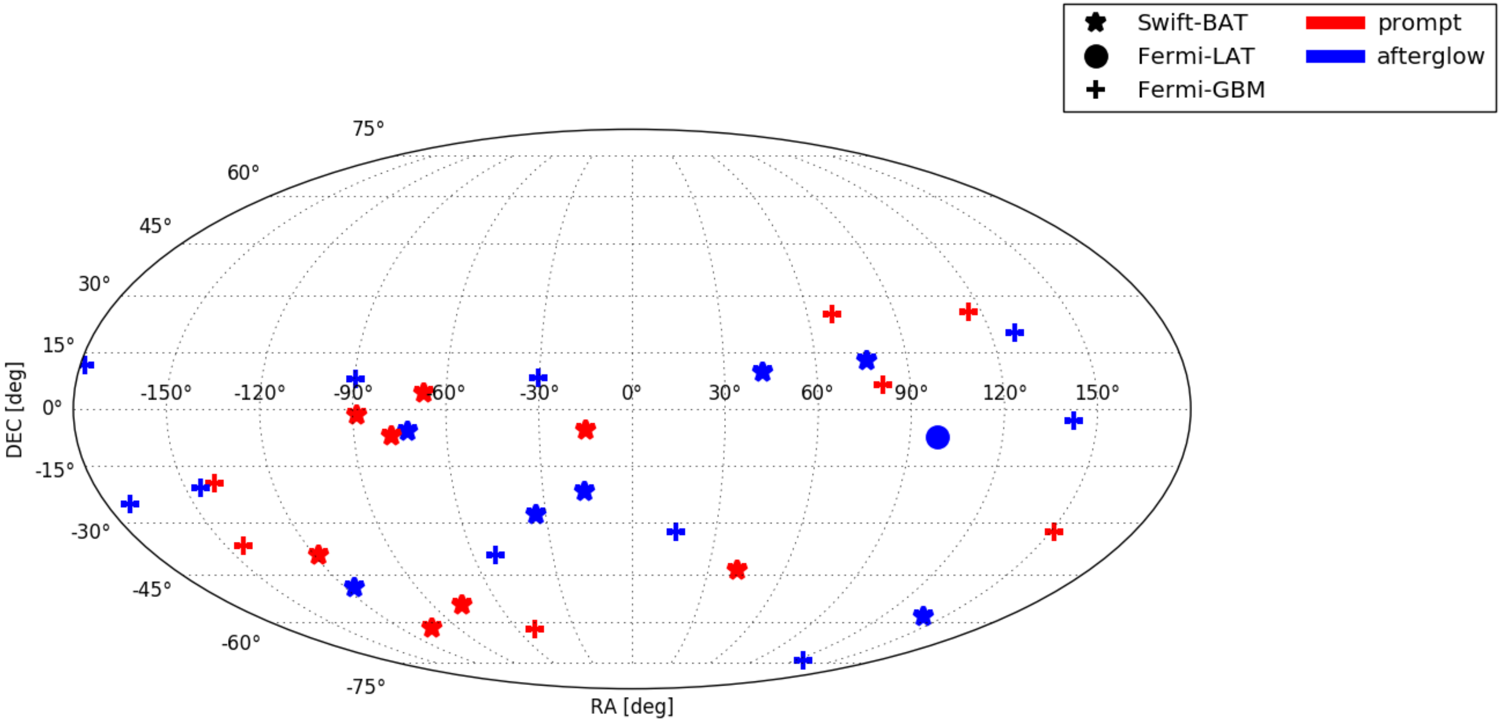
Results



Analysis chain

GRB observations with H.E.S.S.

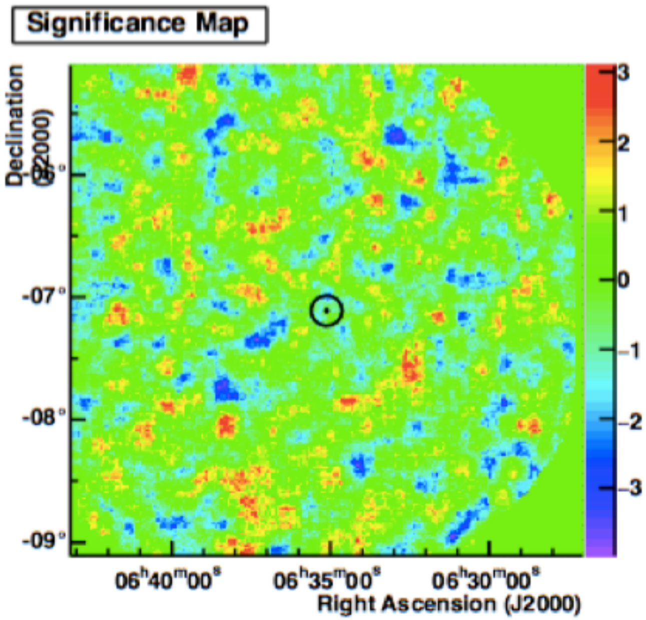
- 41 GRBs observed since 2012
- Current rate is 1/month

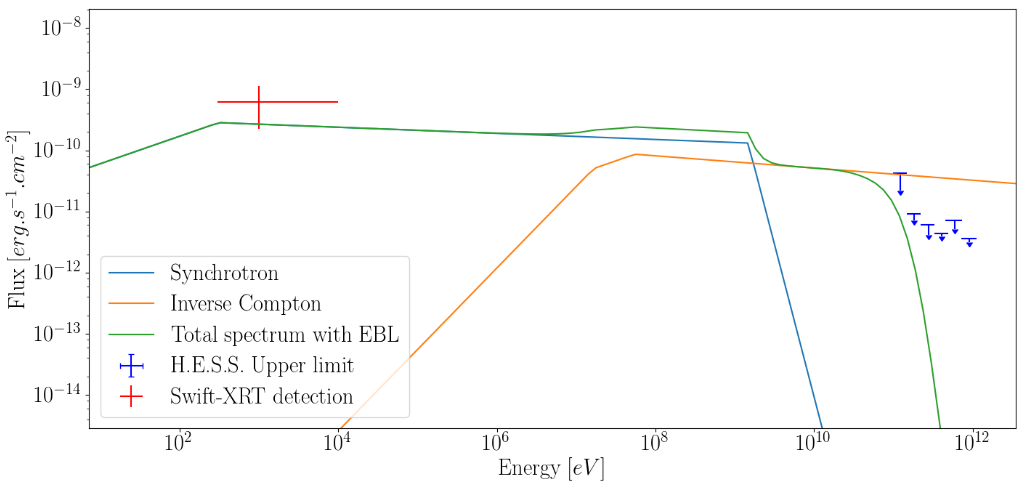


Only a small fraction is shown here

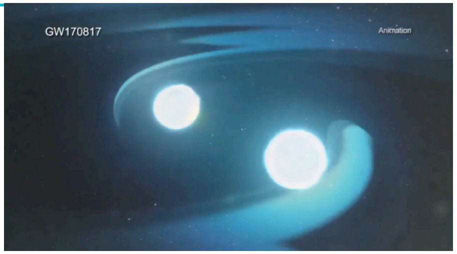
GRB observations with H.E.S.S.

- Ongoing effort (new observations every month)
- Example for GRB 131030





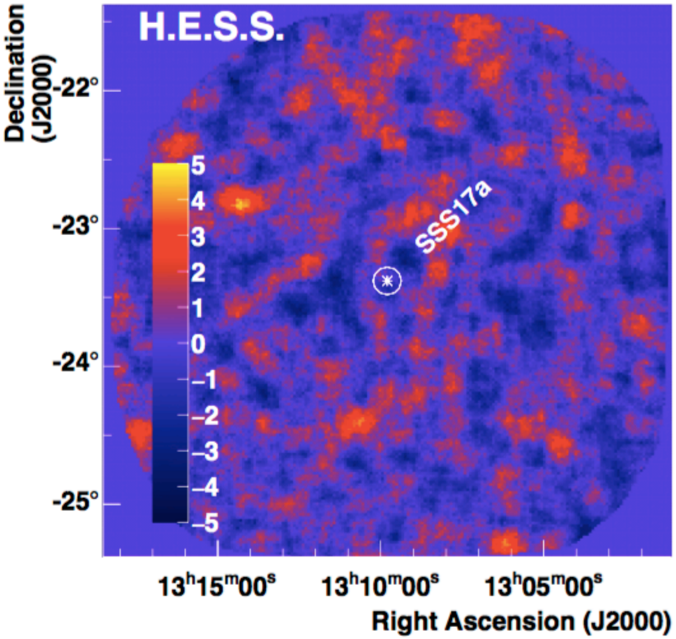
No detection until now (empty sky maps)
Only upper limits on the maximum emitted flux (Constraint on physical parameters)



The GW170817 case

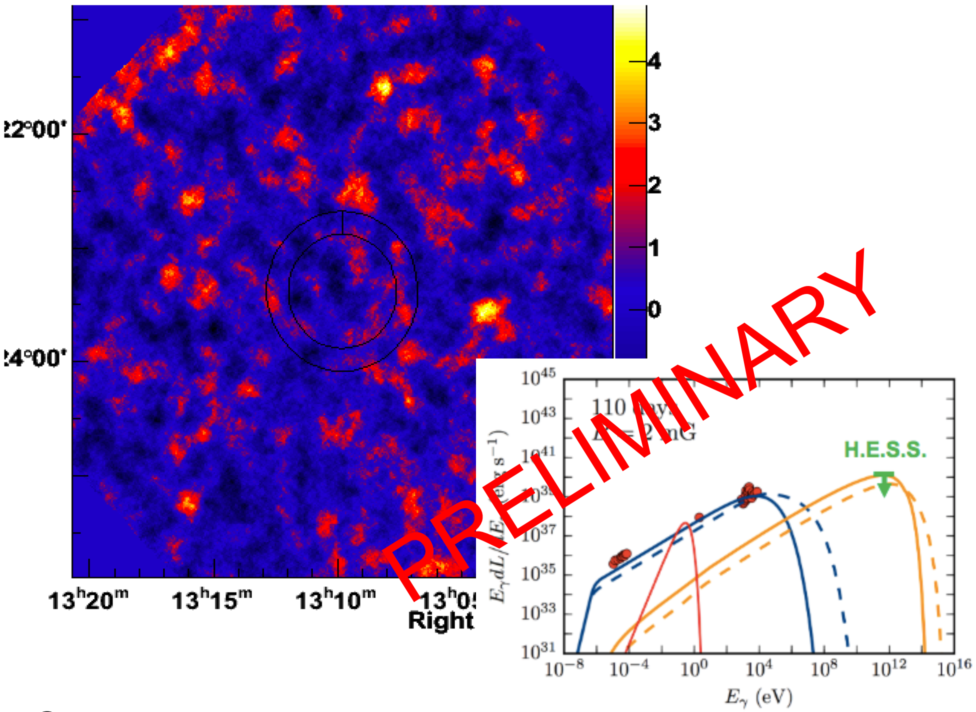
- First detection with GW and EM
- Neutron star merging

First H.E.S.S. observation



No detection

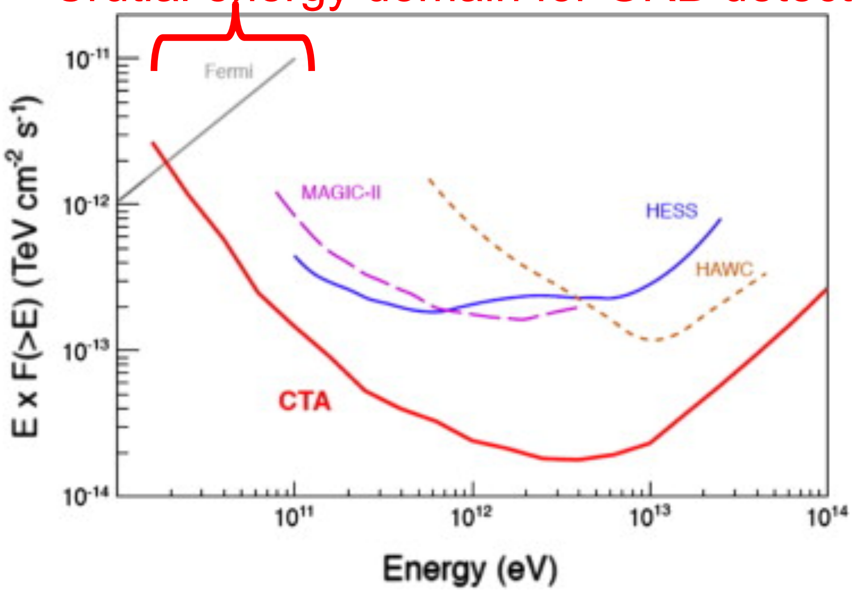
Long-term Monitoring (75h of observation)



Can put some constraint on the magnetic field inside the jet

Future of GRB observation with CTA

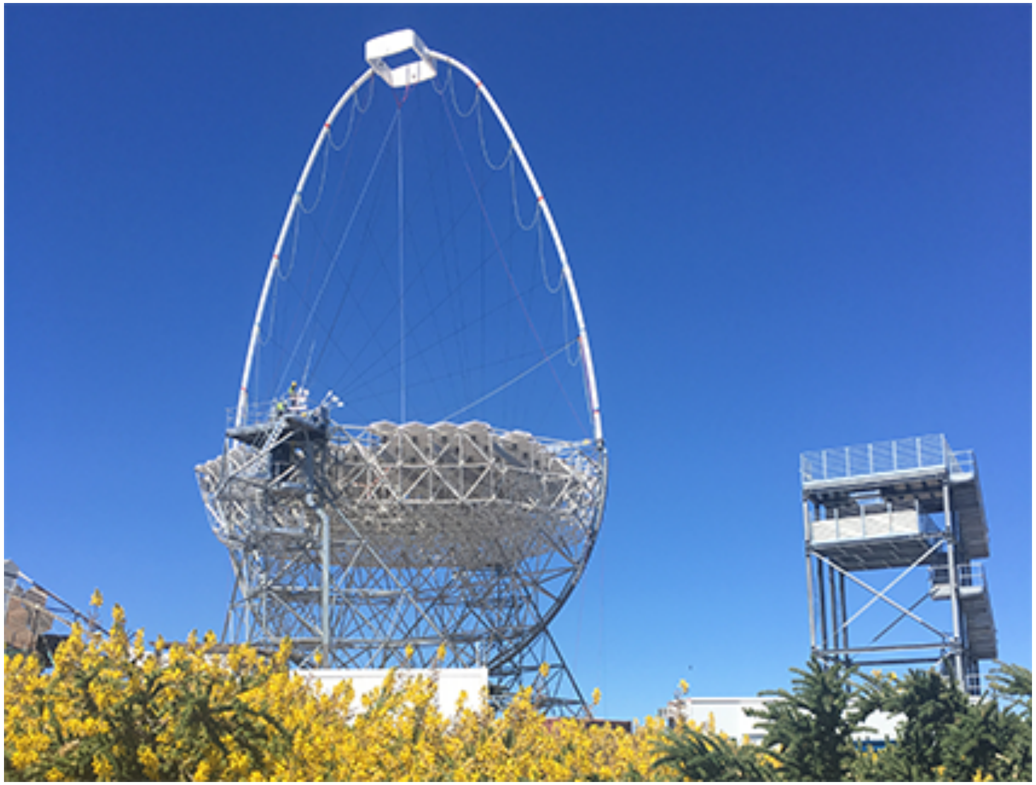
Crutial energy domain for GRB detection



- X10 sensitivity
- Energy range: 15GeV – 100TeV
- Fast slewing capabilities

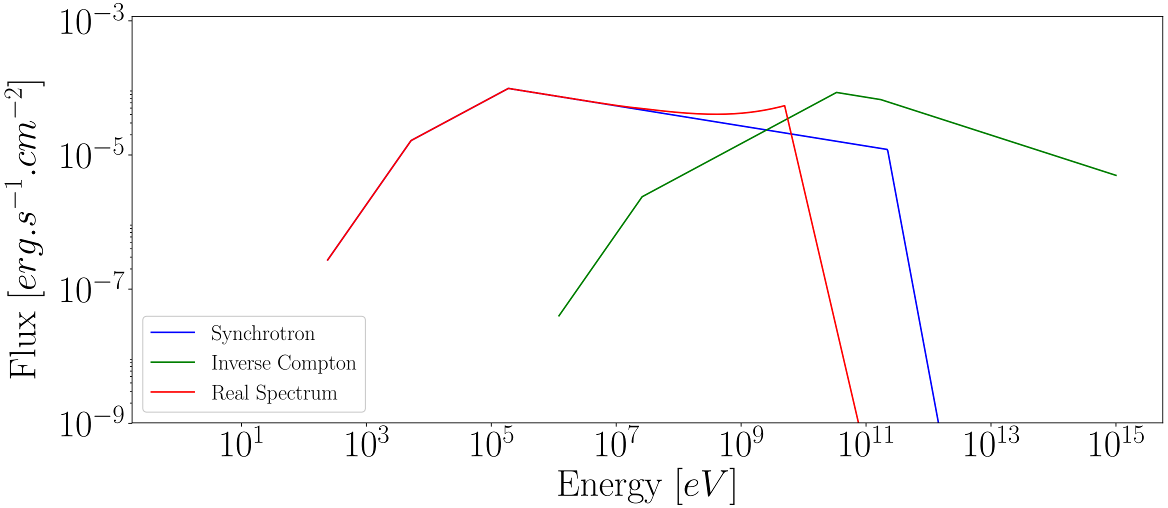
The Large Size Telescope

- Telescope dedicated to GRB detection
- Repoint any position in the sky in less than 20s
- First LST prototype under construction on La Palma island (see picture)

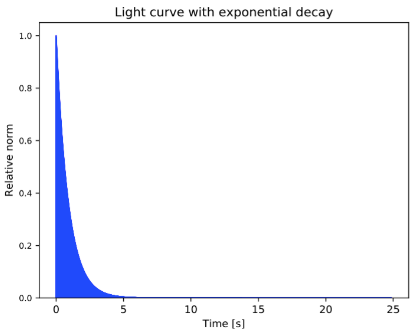


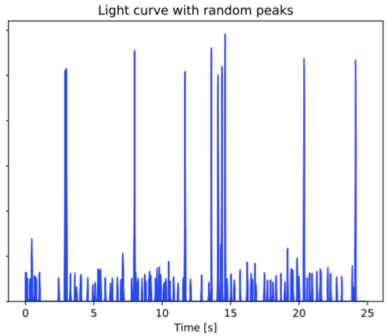
Expectation of GRB detection with CTA

Simple leptonic model with 2 processes (Synchrotron, Inverse Compton) + EBL attenuation

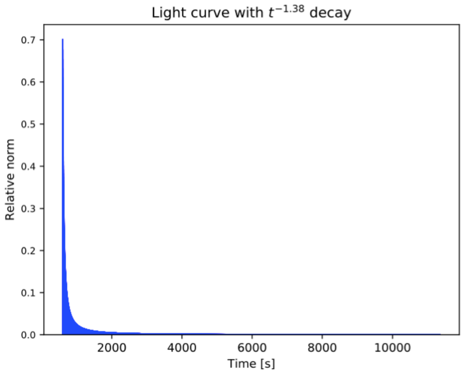


Prompt phase





Afterglow phase



Future of GRB observation with CTA

Considering 1 observable GRB/month

Prompt : LSTs for both sites (20s delay: standard expected delay)

2.0±1.0 GRB/year x 2 sites

Afterglow : Entire North and South array (10min delay: standard afterglow delay)

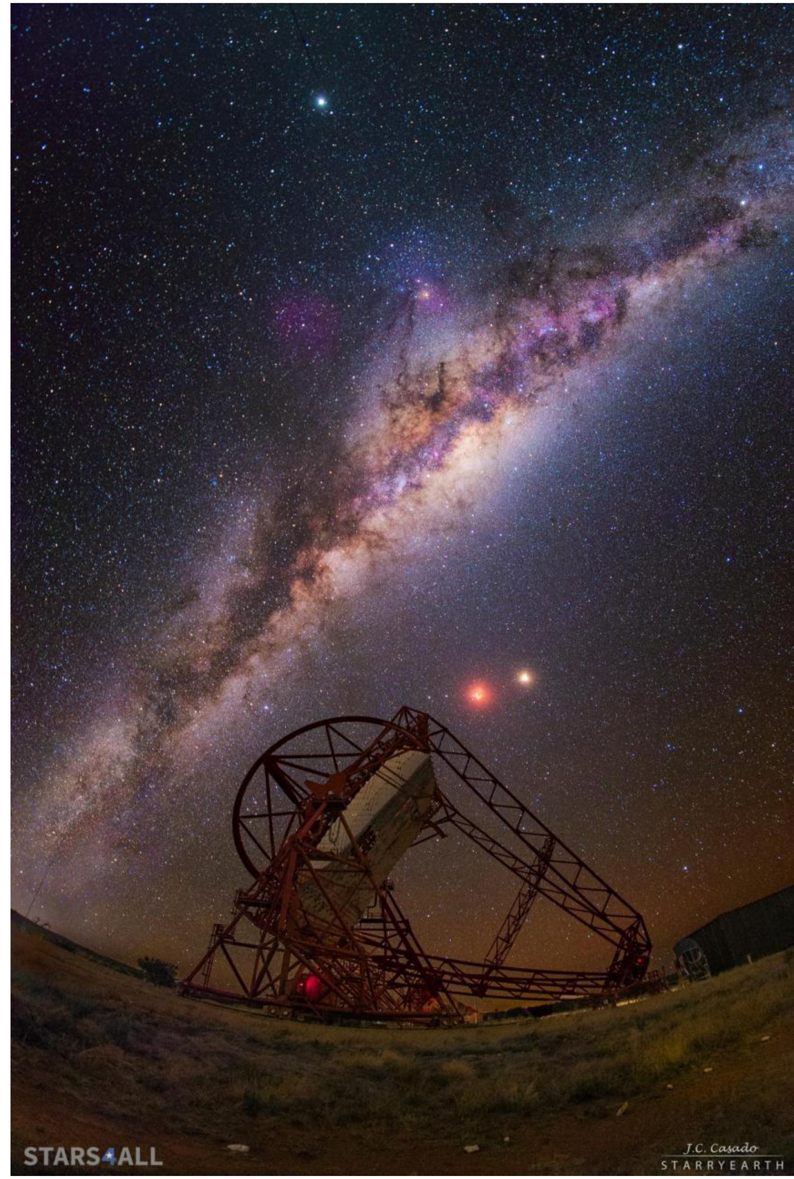
8.3± GRB/year x 2 sites

CTA should detect GRBs during its first years of operation

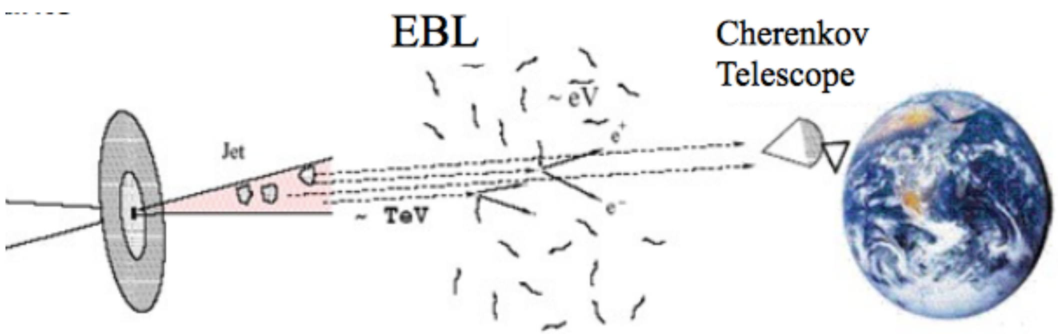
Conclusion

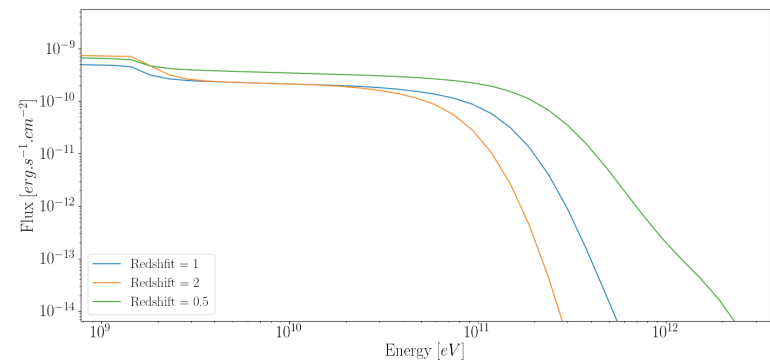
H.E.S.S. did not detect anything yet…
…But we are getting better

CTA will (hopefully) detect the first
GRBs above 100 GeV



The Extragalactic Background light





me SSC modeling of GRB for different
dshifts (EBL model from Dominguez, 2011)

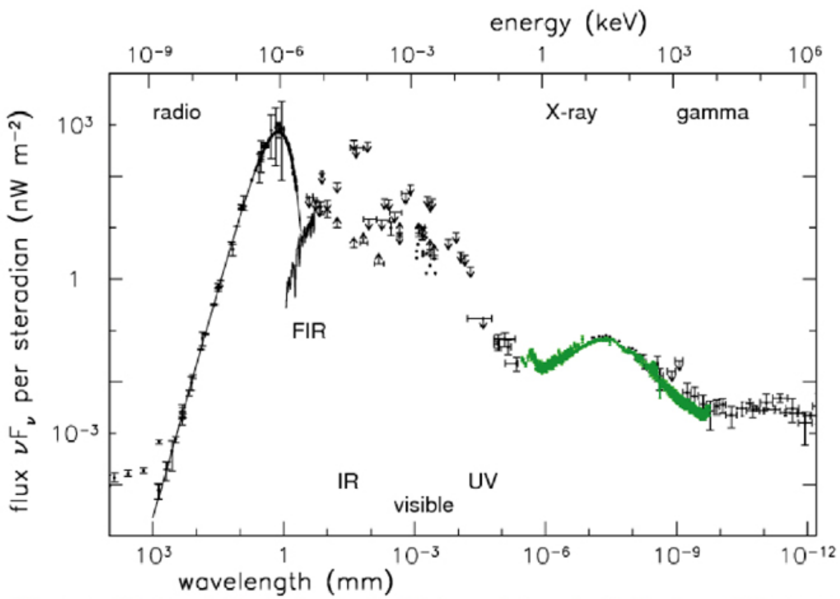
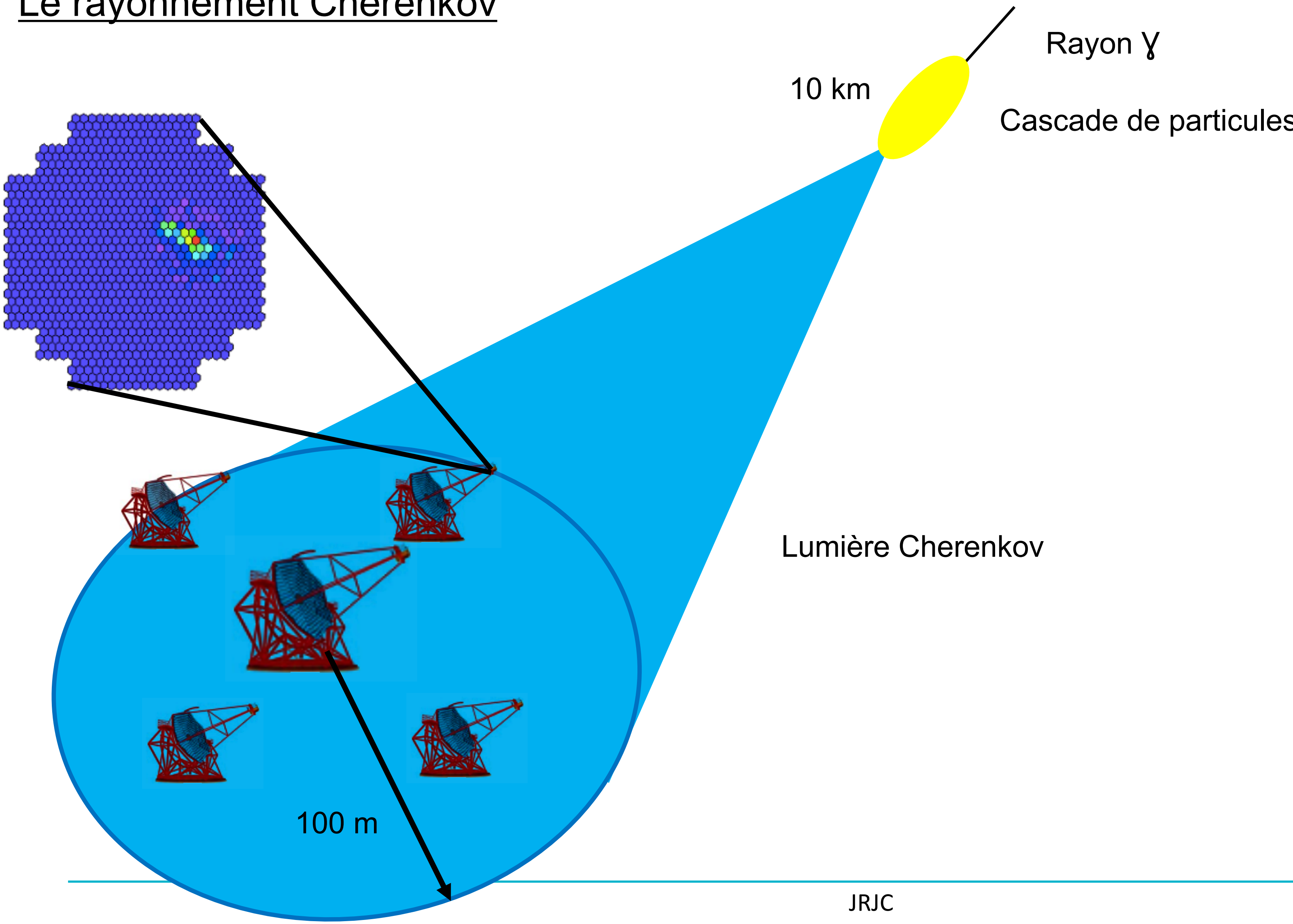
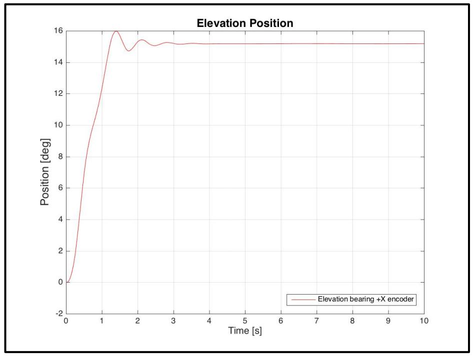


Fig 1.19 (D. Scott) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

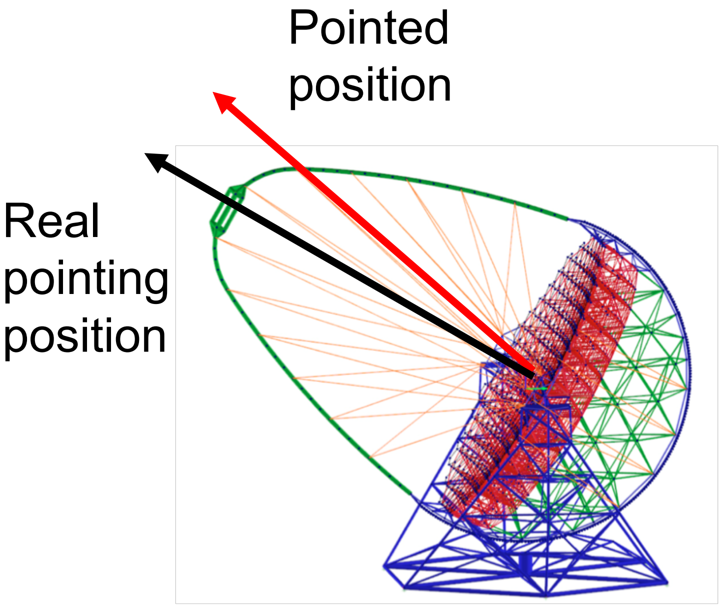
Le rayonnement Cherenkov



- Simulate the telescope's behavior for different movements during different weather conditions (Matlab/simulink simulation)



- Bending model



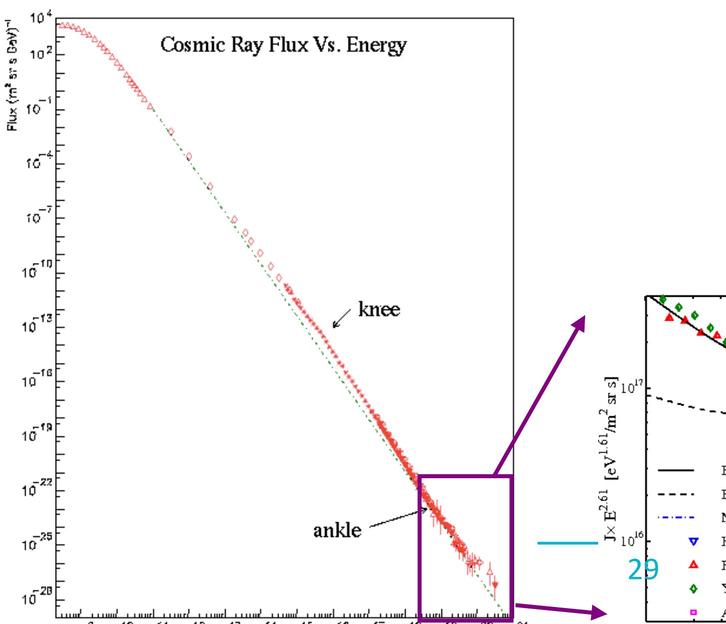
- Drive system (telescope movements)

Backup

- <u>Extra galactic background light:</u>
  - Estimate the effects of EBL at VHE
  - GRB090423 z >8
- <u>Quantum gravity</u>:
  - test for possible energy dependence of the speed of light
  - 13.2 GeV photon detected 16.5 sec after trigger
  - – Conservative lower limit on the quantum gravity mass (assuming linear energy scaling): M_{QG}> (1.50 +/- 0.20) x 10^{18} GeV/c^2

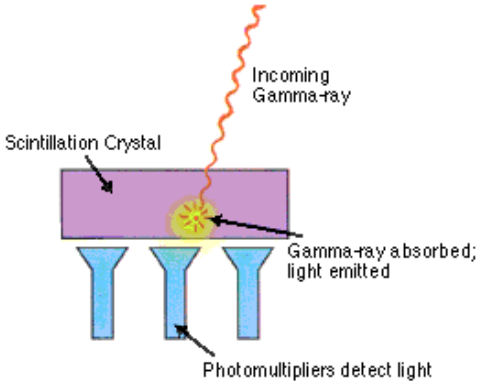
- Cosmic rays at Ultra High Energy

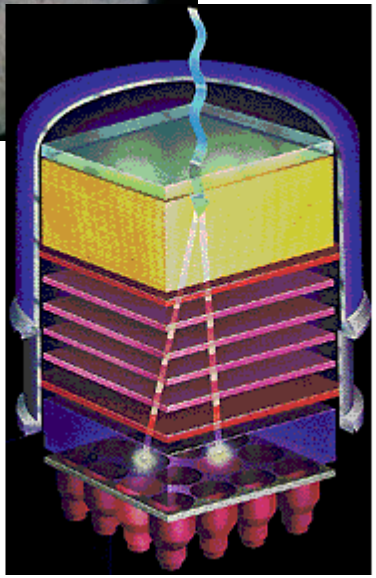
GRB is one of the leading candidate for the production of Ultra-relativistic CR (>10^{18} eV-10^{20} eV)



Compton Gamma-Ray Observatory
(CGRO)

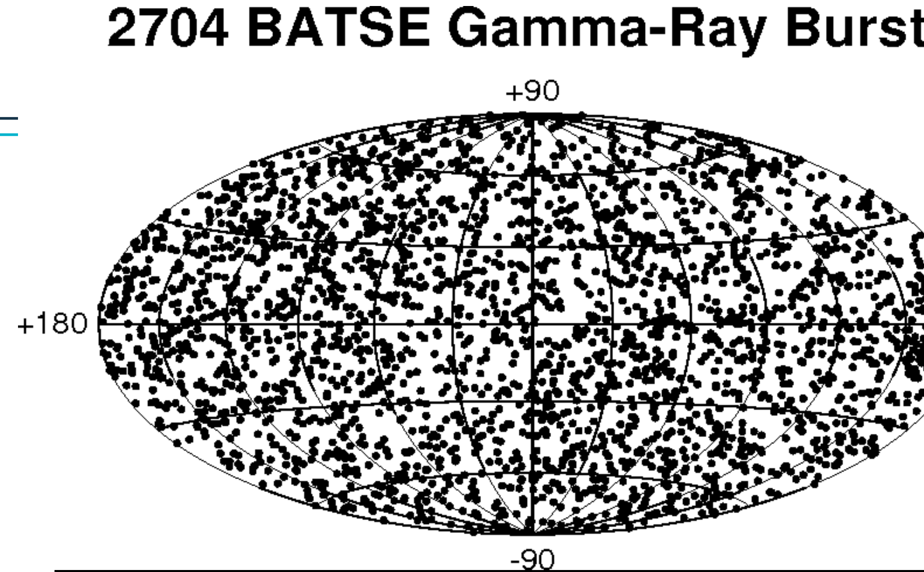
- BATSE (20 keV-1 MeV):
  - extremely sensitive gamma-ray detector (scintillator)
- EGRET (20 MeV-30 GeV):
  - Pair production detector





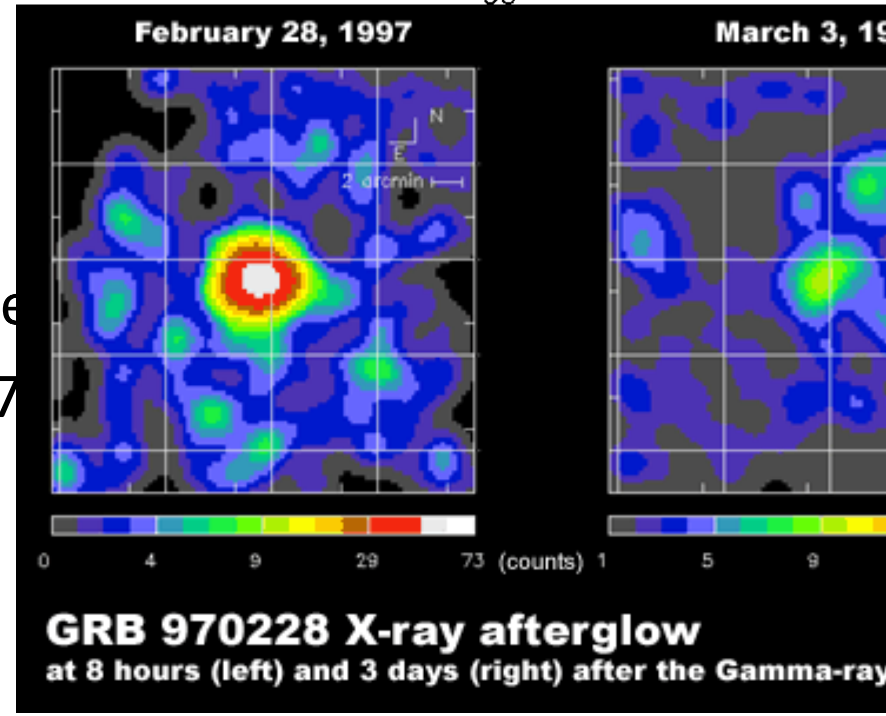
- looked at the whole sky
- GRB detection rate ~ 1 GRB/day
- thousands of GRBs detected

over the whole mission



Isotropic distribution

-> rules out most galactic model



- BeppoSAX: GRB 970228
- 1st X-ray/Optical afterglows detecte
- Host galaxy was identified at z ~ 0.7

They are extragalactic !