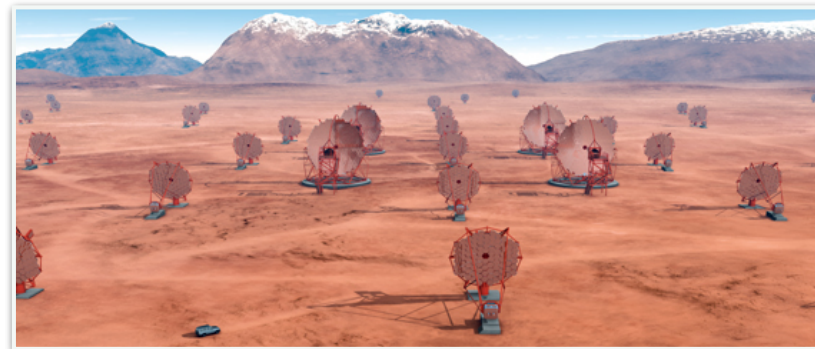


teresa.montaruli@unige.ch



## ***IceCube, CTA and MAGIC***

Multi-messenger strategy for High Energy Astrophysics

A very **successful line** of ApP research

### ◎ ***Outstanding science from IceCube & MAGIC;***

- ➔ IceCube data analysis on cosmic ray sources and dark matter; coordination of IceCube-Auger-Telescope Array joint analysis
- ➔ IC310 VHE flare (Science, 11/2014): very fast variability indicates emission region  $\ll$  than event horizon. Incompatible with Fermi shock acceleration in the jet but pulsar-like emission
- ➔ Crab: First TeV pulsed and bridge emission in 50-400 GeV.
- ➔ Detection of VHE emissions from farthest sources (gravitationally-lensed AGNs with  $z \sim 1$ ).

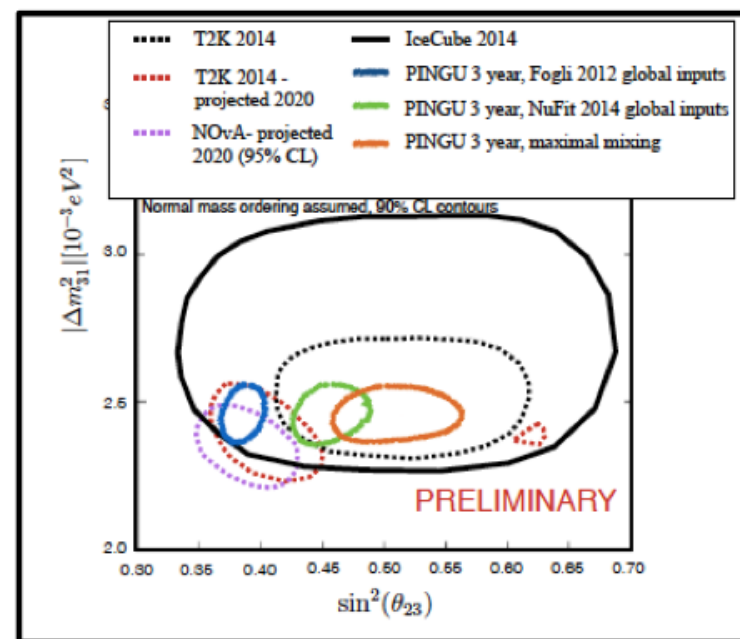
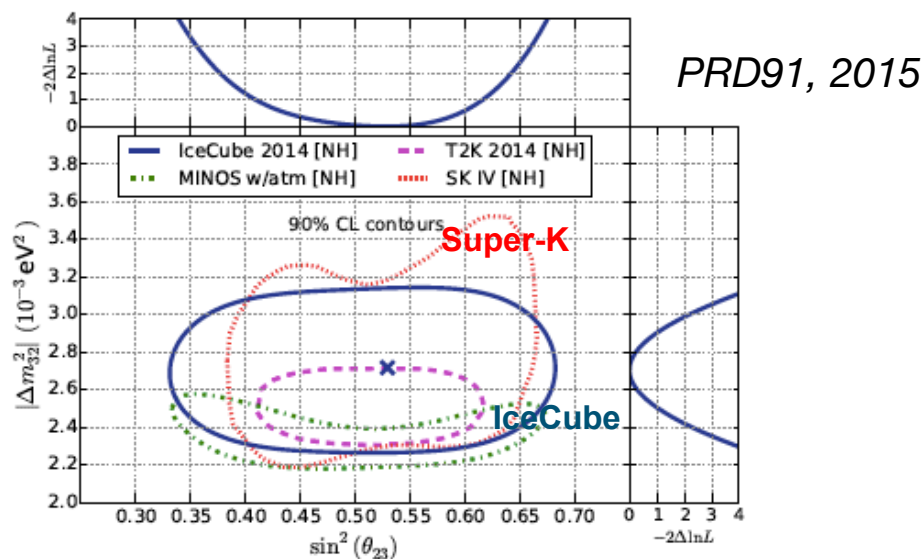
### ◎ ***CTA high scientific potential (Astrophysics and New Physics)***

- ➔ R&D and prototype construction of Digital cameras with PMTs and SiPMs (inheritance from FACT experience)
- ➔ FACT proves longterm stable and reliable operation of SiPM based camera; MWL campaigns for Mrk421 and Mrk501



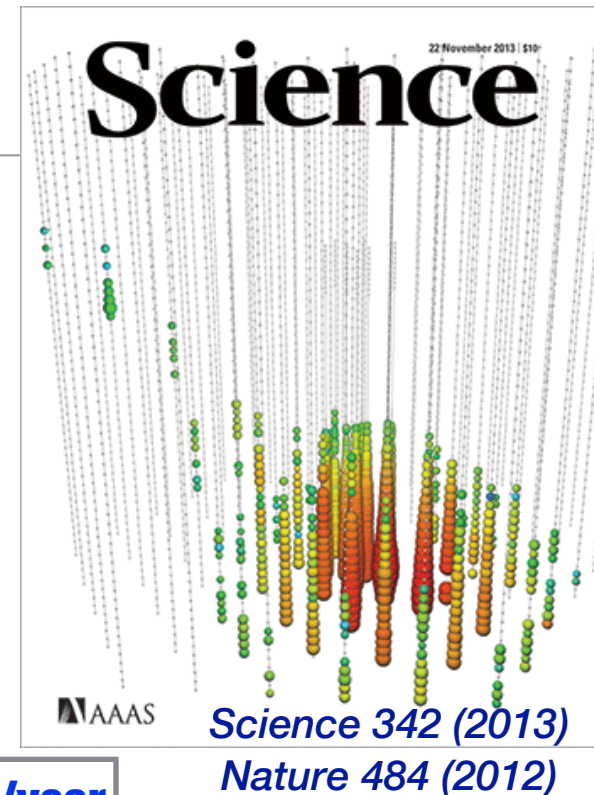
# Outstanding science of IceCube/CTA

- The discovery of IceCube of a diffuse flux of cosmic neutrinos, to which we substantially contributed, **inaugurates a New Astronomy**. IceCube is an **extremely successful ApP** experiment.
- IceCube/IceCube-Gen2 has great potential in neutrino physics:
  - coming results on neutrino sterile**
  - 5200 events for standard oscillation at 10 GeV contour approaching T2K one.**
  - PINGU will reach 1 GeV**
- CTA will bring the highest energy astronomy (related to the most violent processes in the universe and the most powerful accelerators) to the **precision** era and to the **open access domain of Science Data**.
- The CHIPP swiss community participates and wish to continue to work in the **World Wide First class Observatories** with **responsibility** roles.
- The construction project involves R&D on electronics & new photo-sensing techniques



# Scientific output

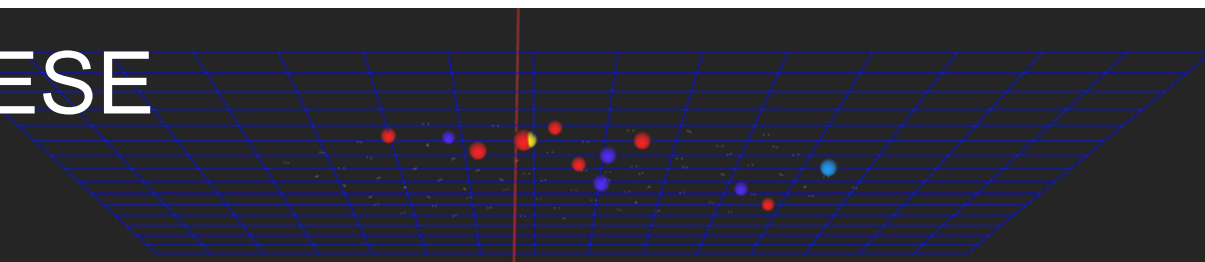
Experiment	Refereed papers	Proceedings of group	Year
IceCube	13	6	2015
	11+1 few authors	2	2014
	20+1 few authors	2	2013
MAGIC/ FACT	7	5	2015
	16	4	2014
	5	10	2013
CTA	1	3	2015
	3	7	2014
	4+(2 in prep)	4	2013



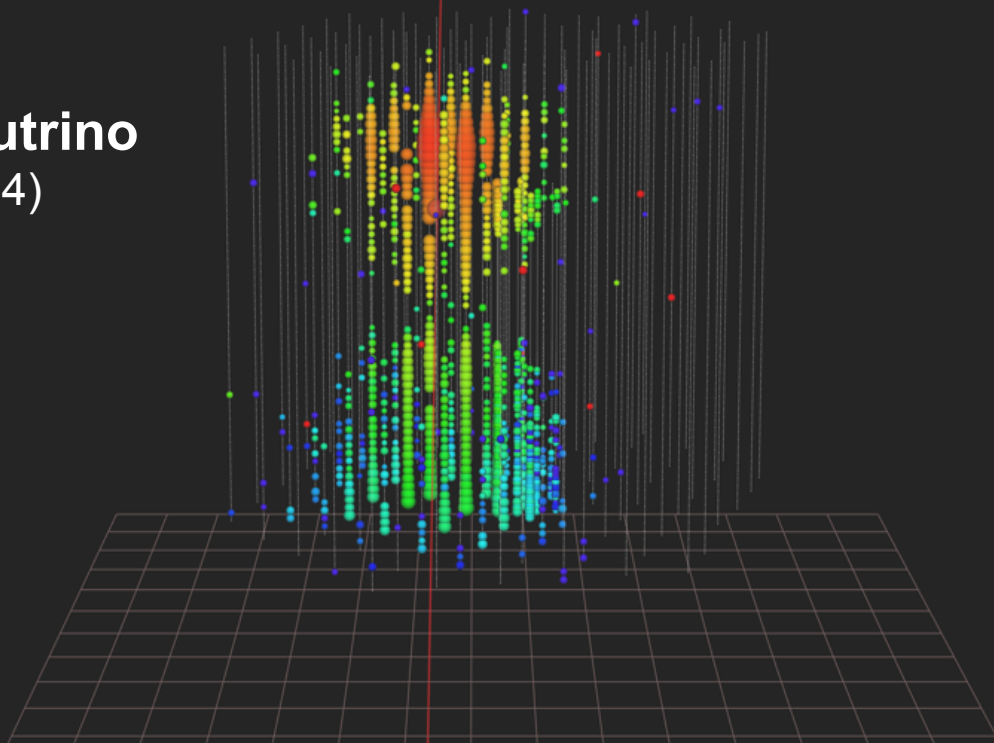
## Average of 2 grand public seminars/year

Meeting Name	Participants	Date
Texas Symposium	500	13-18/12/2015
IceCube Plenary	250	14-19/9/2014
MANTS - Global Neutrino Network	120	20-21/9/2014
SWAPS 2014	70	11-13/6/2014
2 <sup>nd</sup>	75	24-26/3/2014
7th SST-CTA meeting	45	16-18/12/2013

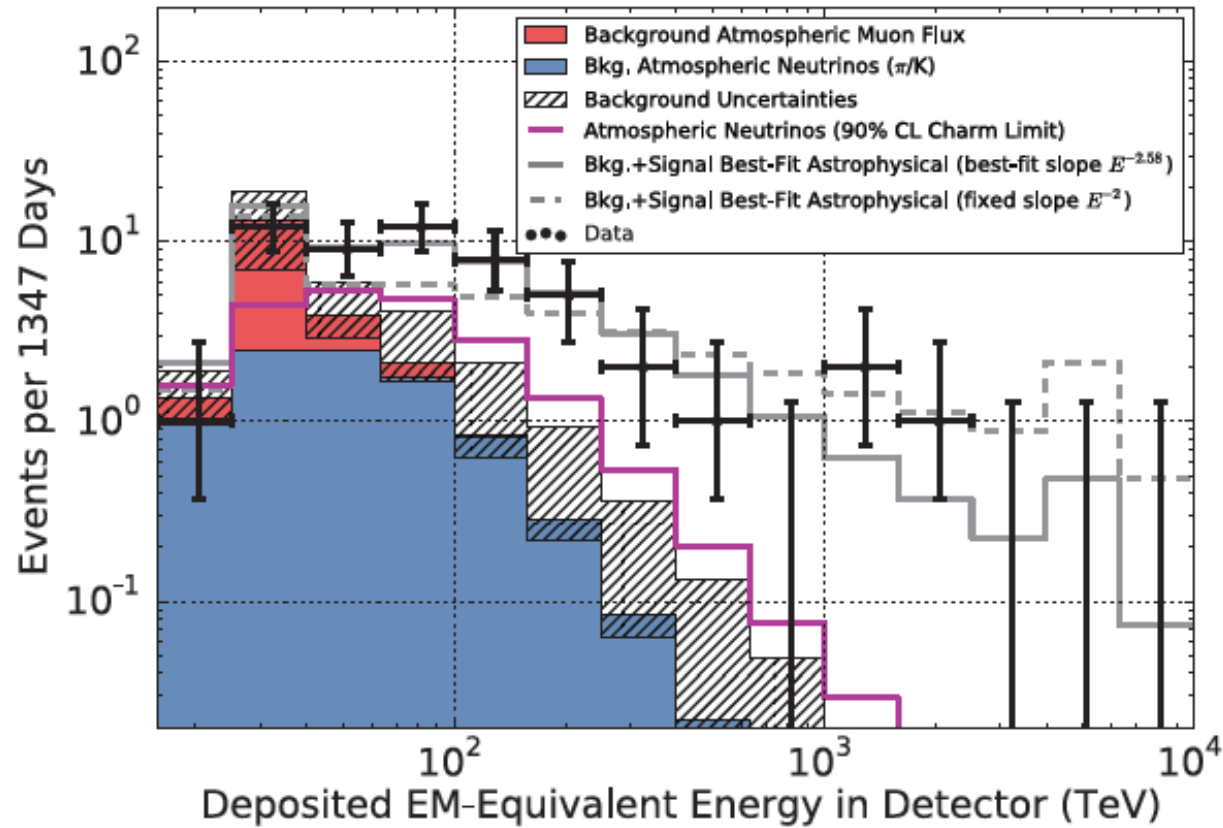
# 4 yr HESE



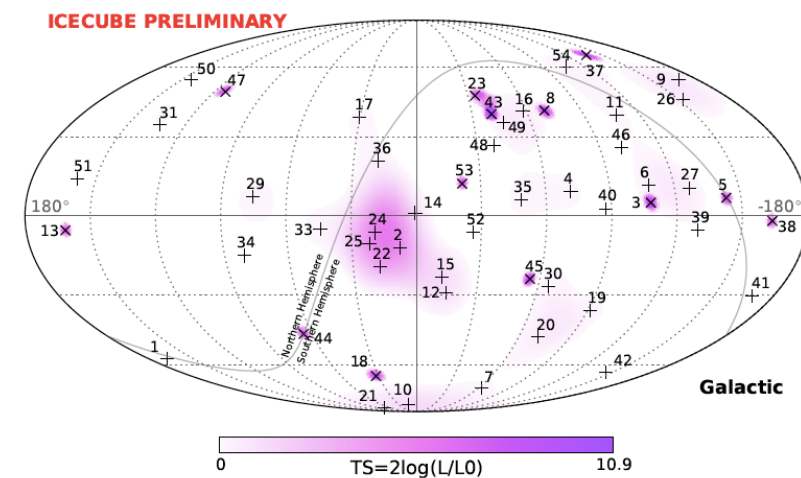
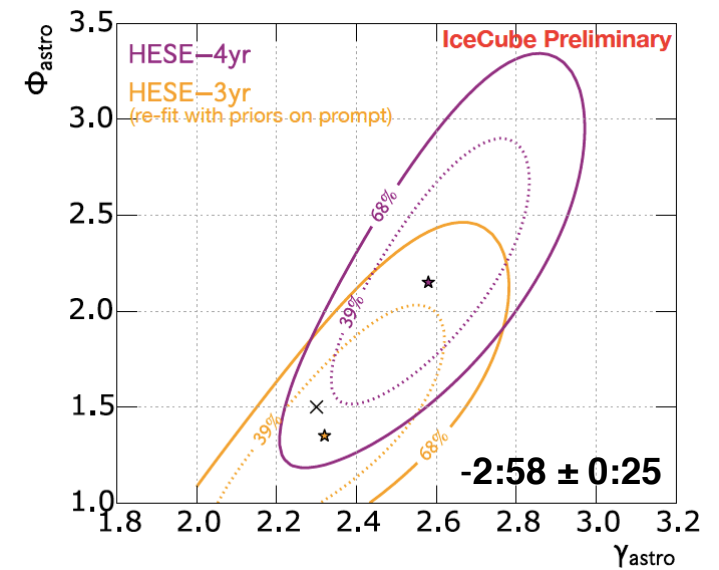
**cosmic neutrino**  
(detected 2014)



# 4 yr HESE



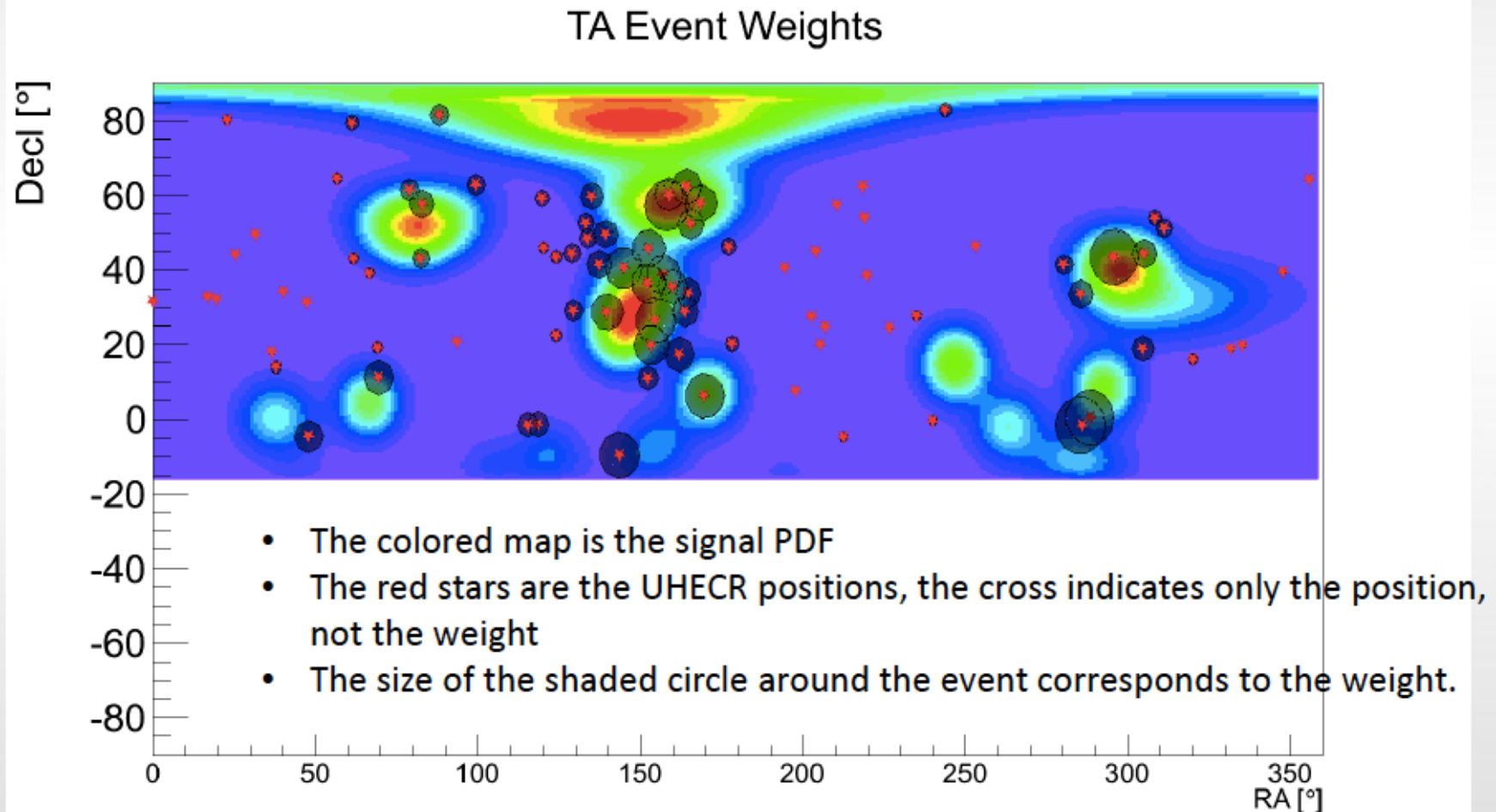
64 events above 60 EeV in 1347 d



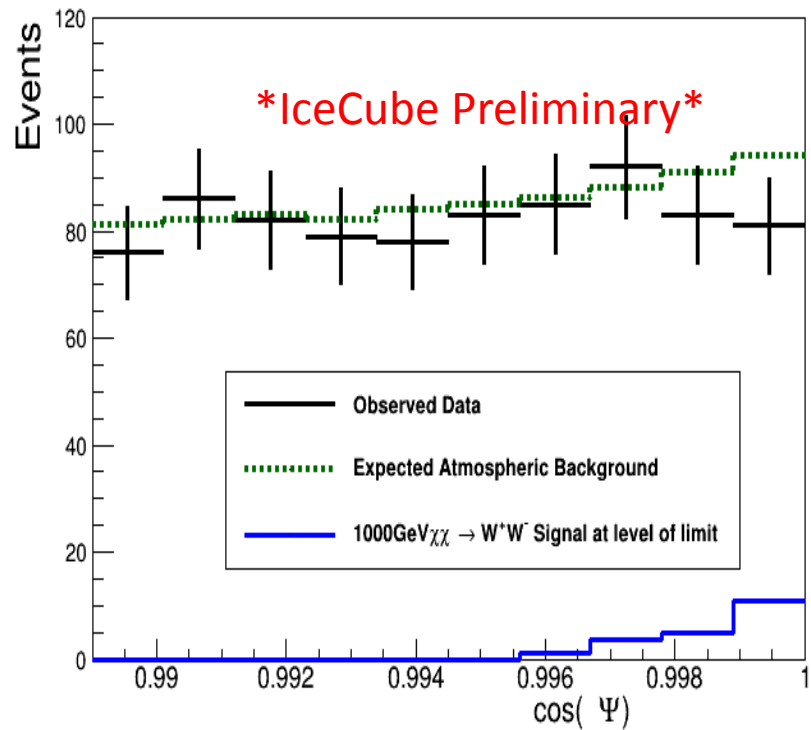
# IceCube-PAO-TA

Evidence of correlation between UHECRs and IceCube highest neutrinos (paper in preparation):  $3.1\sigma$  post-trial (A. Christov, UniGE)

“TA HotSpot”: R.A. = 146.7 , Dec. = 43.2  
Mrk 421: R.A. = 166.1 , Dec. = 38.2

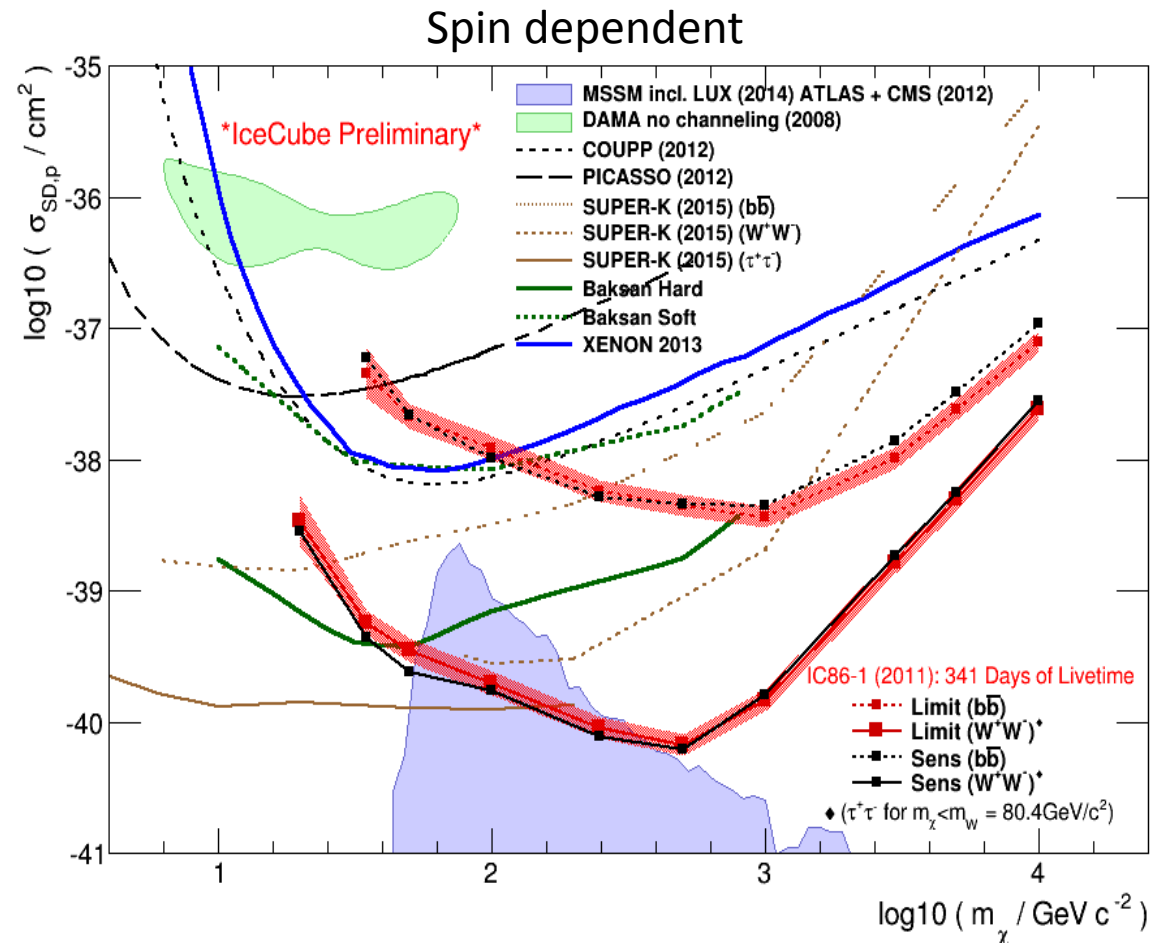


# WIMP from the Sun results (M. Rameez, UniGE)

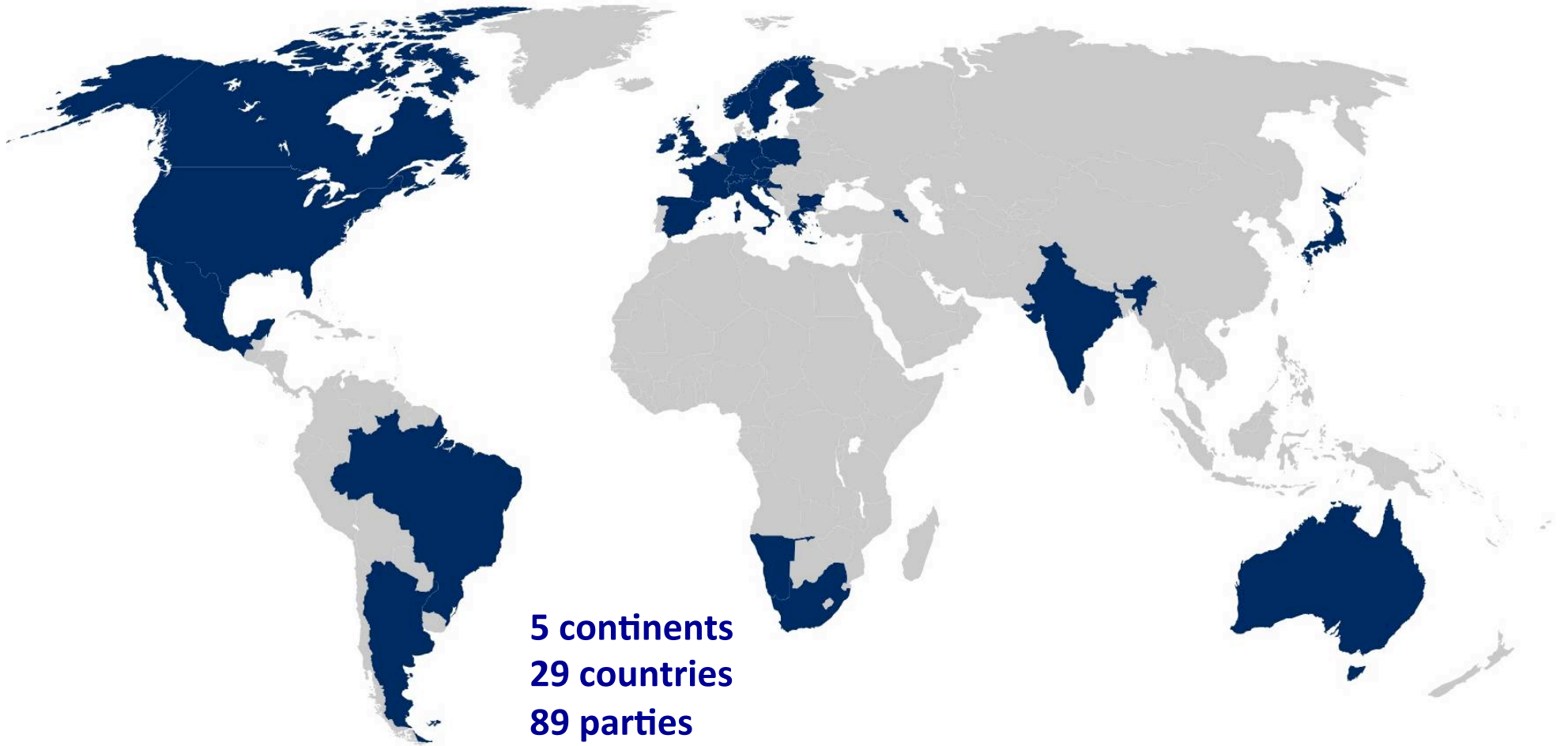


$\Psi$  = Angle from Sun

3 year result in preparation



# CTA Achievements

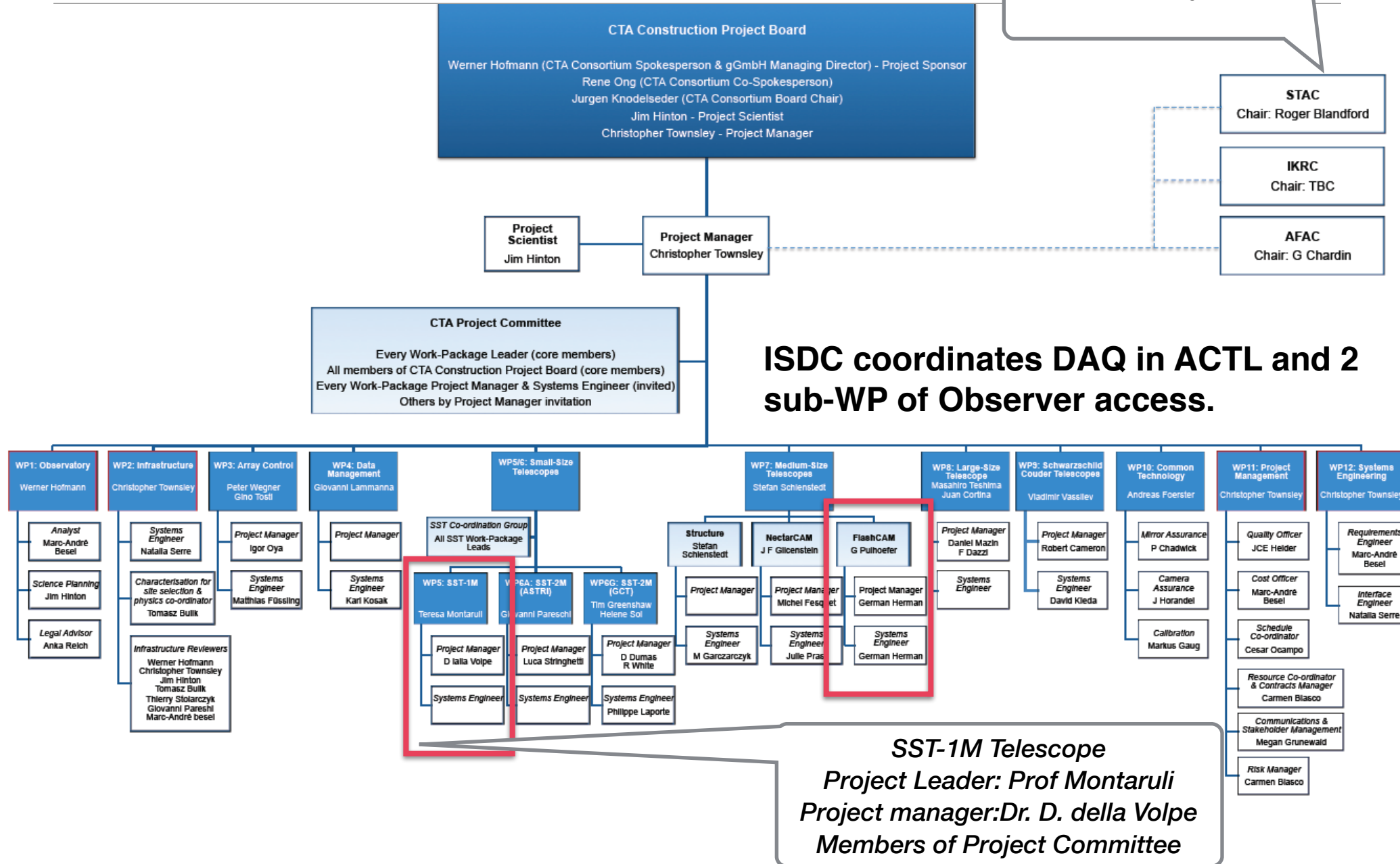


**5 continents**  
**29 countries**  
**89 parties**  
**181 institutes**  
**1218 members (413 FTE)**

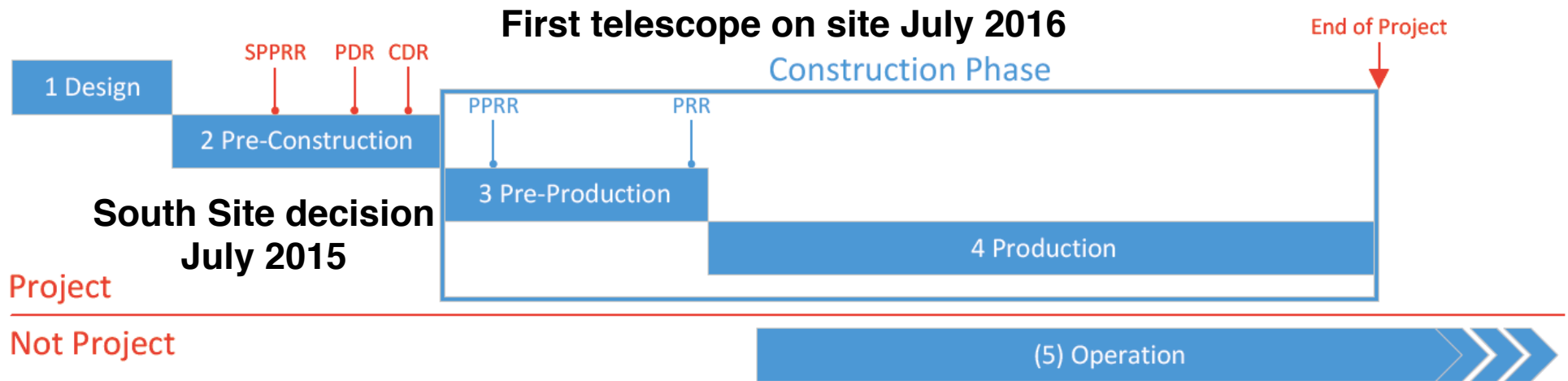


# Swiss roles

*U. Straumann & SERI  
repres. X. Reymond*



# PROJECT PHASES



## Site infra schedule now to Q3/2017

- Two major control points:
  - Pre-production readiness review
    - Before anything allowed on site
    - Requirements firmed up post site decision
  - Production readiness review
    - Before mass-production started by contributor

Title	Q2 / 2015		Q3 / 2015		Q4 / 2015		Q1 / 2016		Q2 / 2016		Q3 / 2016		Q4 / 2016		Q1 / 2017		Q2 / 2017		Q3 / 2017	
	05	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	12
<b>Infrastructure</b>																				
Site choice																				
Telescope Layout																				
Procurement strategy																				
<b>Site Investigation</b>																				
Tendering																				
Site Investigation																				
<b>Detailed Design</b>																				
Tendering																				
Design minimum for pre-production																				
Complete design																				
<b>Access Road, Perimeter Fence &amp; Security</b>																				
Tendering																				
Access Road construction for early construction																				
Access Road construction inc. electricity & water supply																				
Perimeter Fence & Security																				
<b>Site M&amp;E, Civil and Buildings</b>																				
Tendering																				
Infrastructure minimum for pre-production (inc. foundations)																				
Buildings minimum for pre-production																				
Buildings and other facilities full scope																				
<b>Telescopes</b>																				

- Recently approved INFRADEV grant from EC
  - ~€4.3m over 2 years (partly in addition to CTAO budget)

# COST (project cost books re-evaluated by PO)



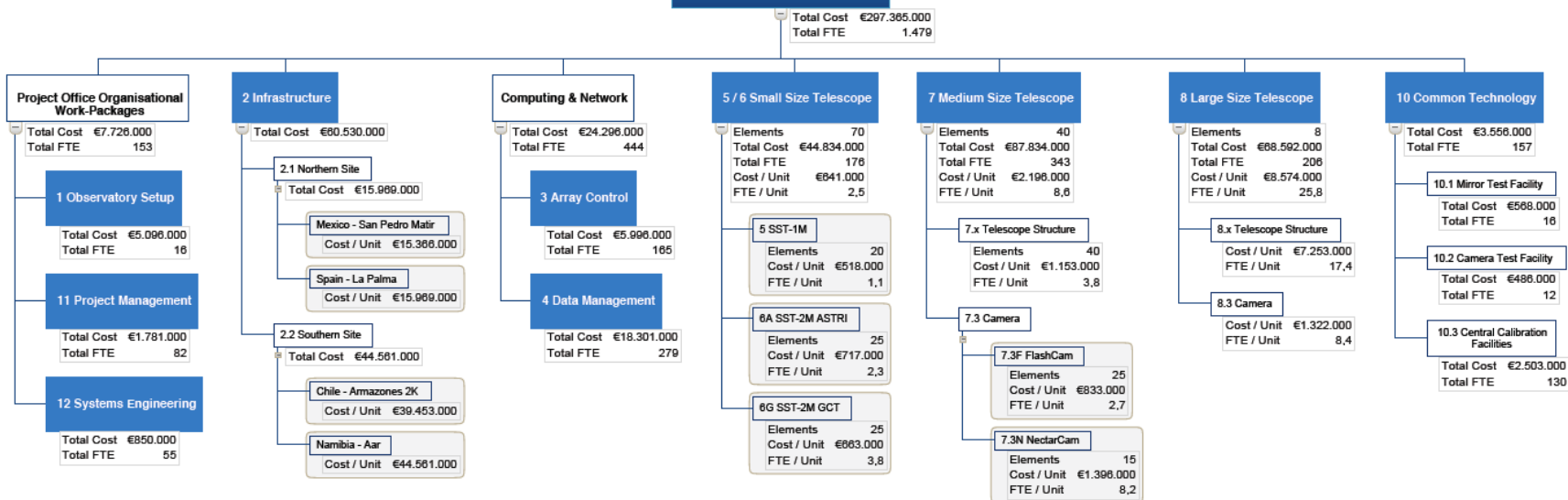
Installation Scenario	Pre-Production				Production			
	Work-package estimate based on ... # of elements	Installation Scenario # of elements	Equipment Costs	Labour [FTE]	Work-package estimate based on ... # of elements	Installation Scenario # of elements	Equipment Costs	Labour [FTE]
5 SST-1M	3	3	0.622 M€	1.4	20	17	0.500 M€	1.1
6A SST-2M ASTRI	7	3	1,362 M€	6,2	30	22	0,628 M€	1,7
6G SST-2M GCT	3	3	0,906 M€	17,0	32	22	0,630 M€	2,0
7F MST with FlashCam	2	2	2,192 M€	8,5	23	23	1,967 M€	6,3
7N MST with NectarCam	1	1	4,495 M€	60,6	22	14	2,409 M€	8,5
8 Large Size Telescope	1	1	9,537 M€	47,9	7	7	8,436 M€	22,6

## SST-1M

## ASTRI

Astronomical Observatory Construction Costs

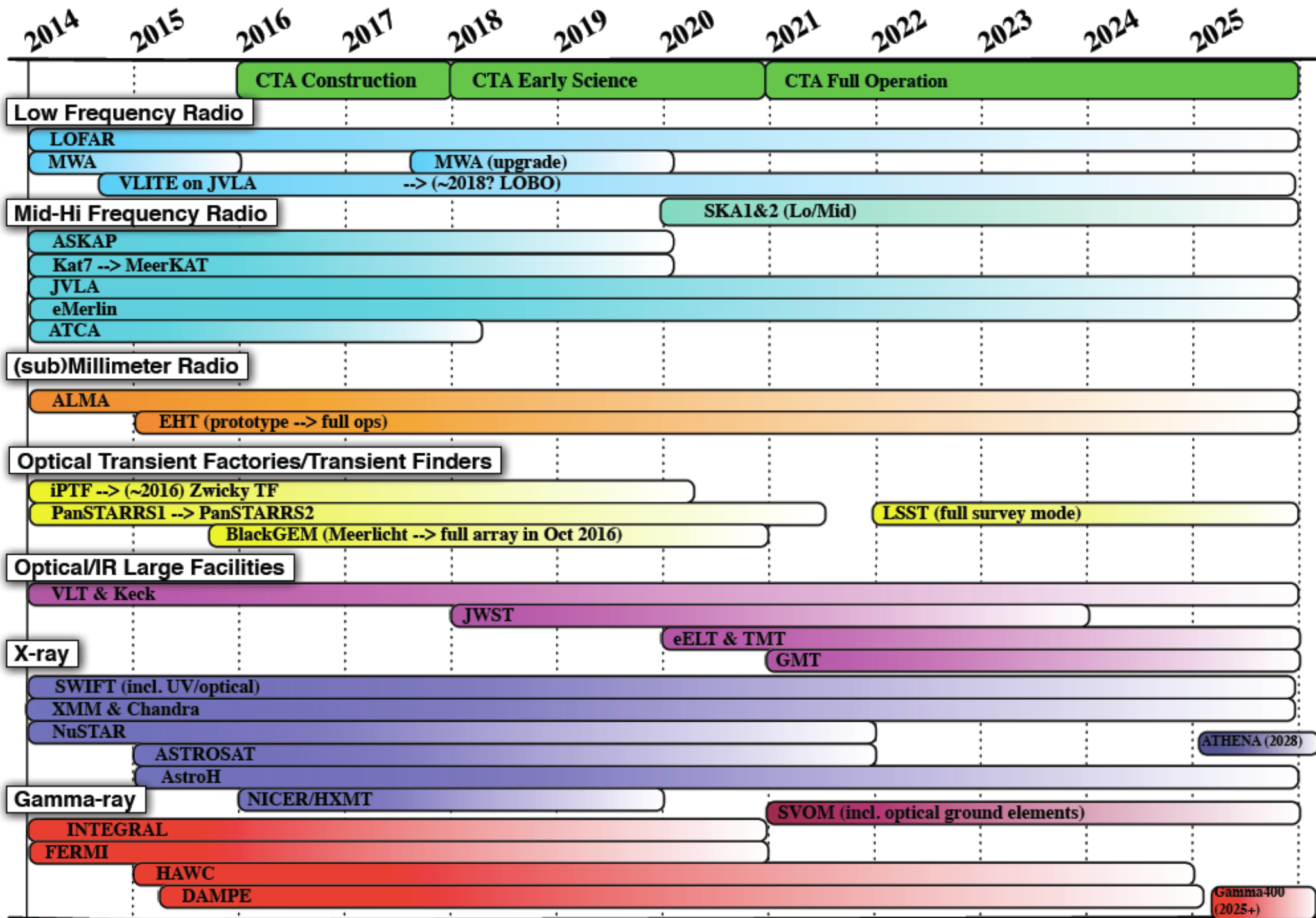
## GCT



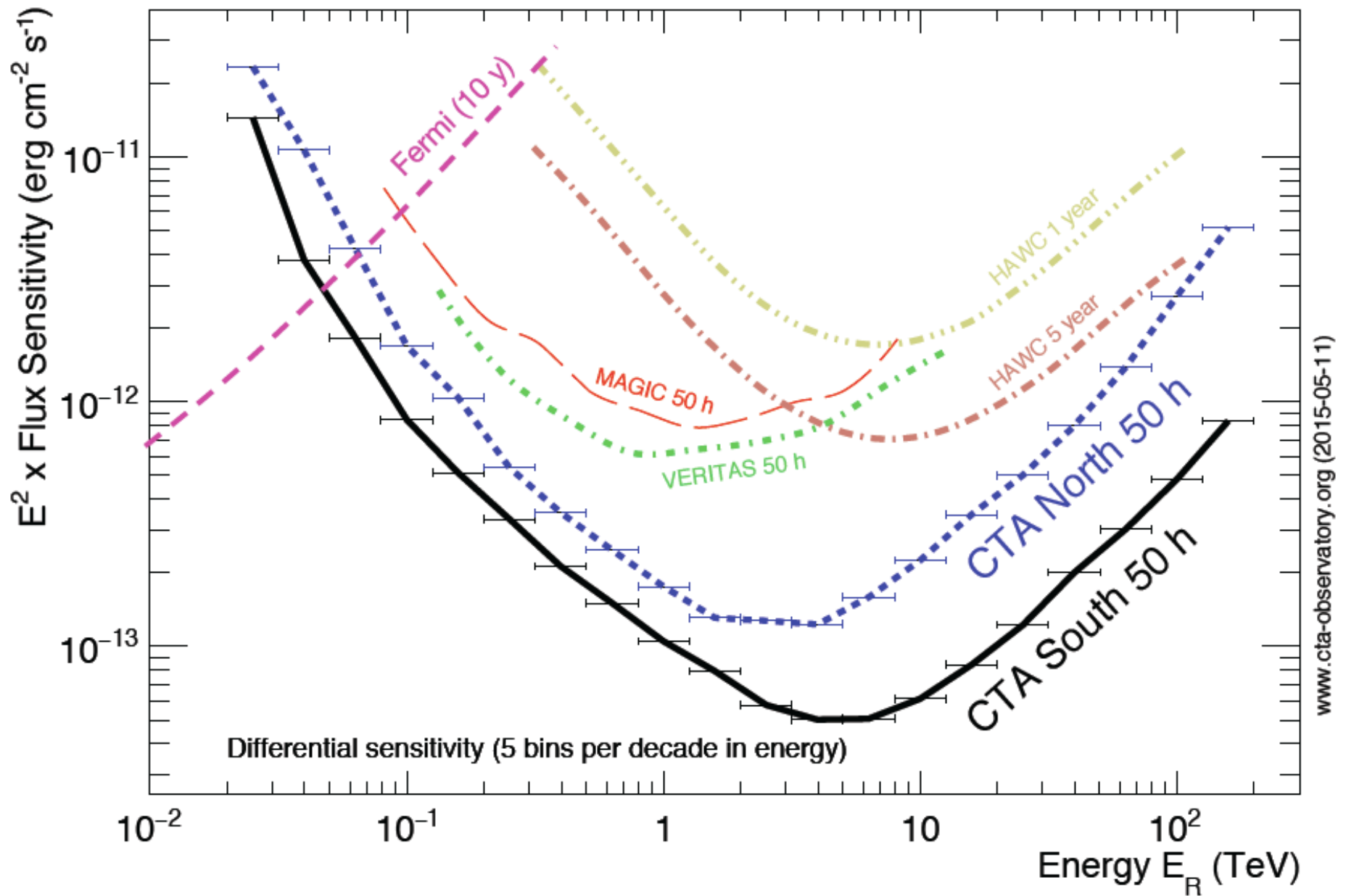
Total construction cost

South INFRA: 39.5 Chile, 44.5M Namibia  
North: 15.5M

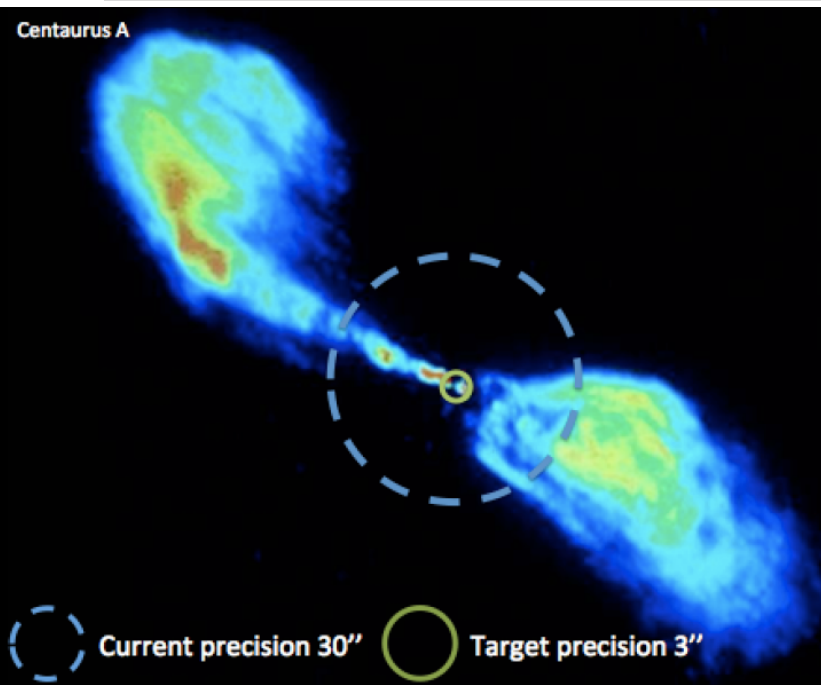
€297m + 1479 FTE



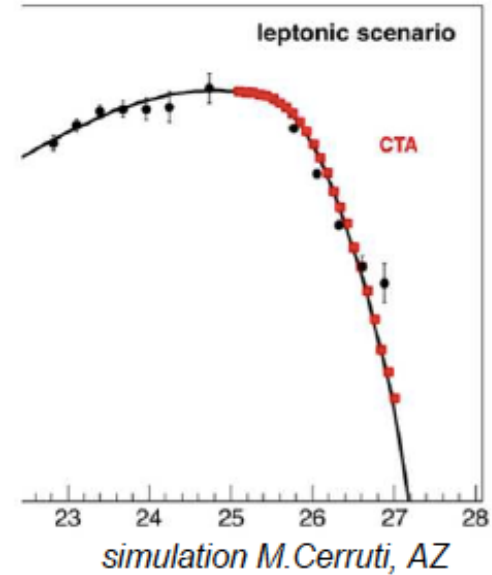
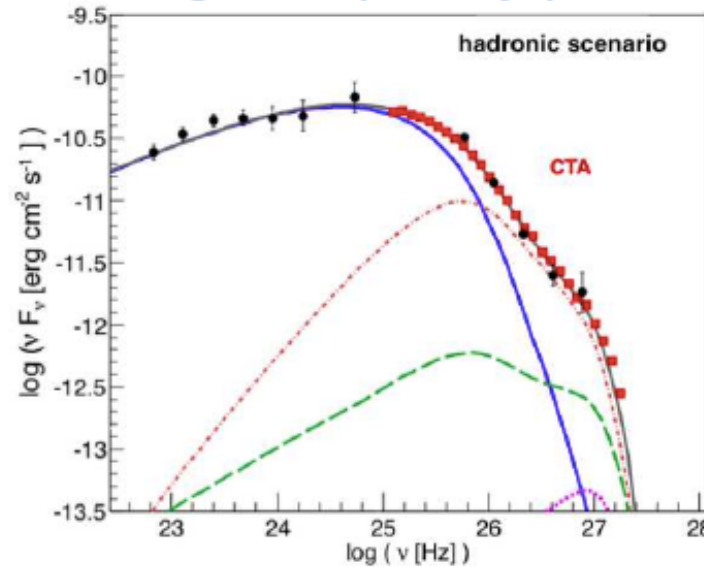
# CTA Sensitivity



# CTA pointing precision



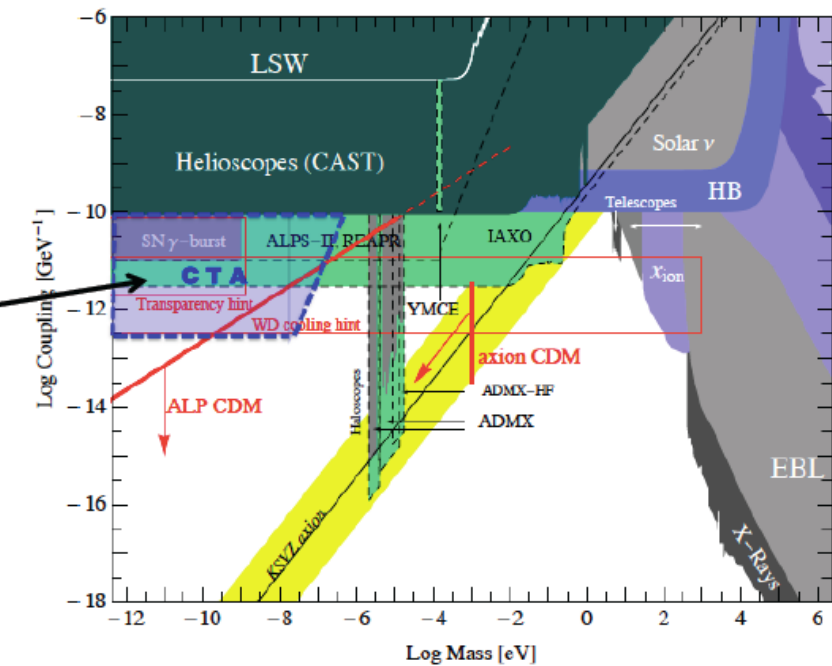
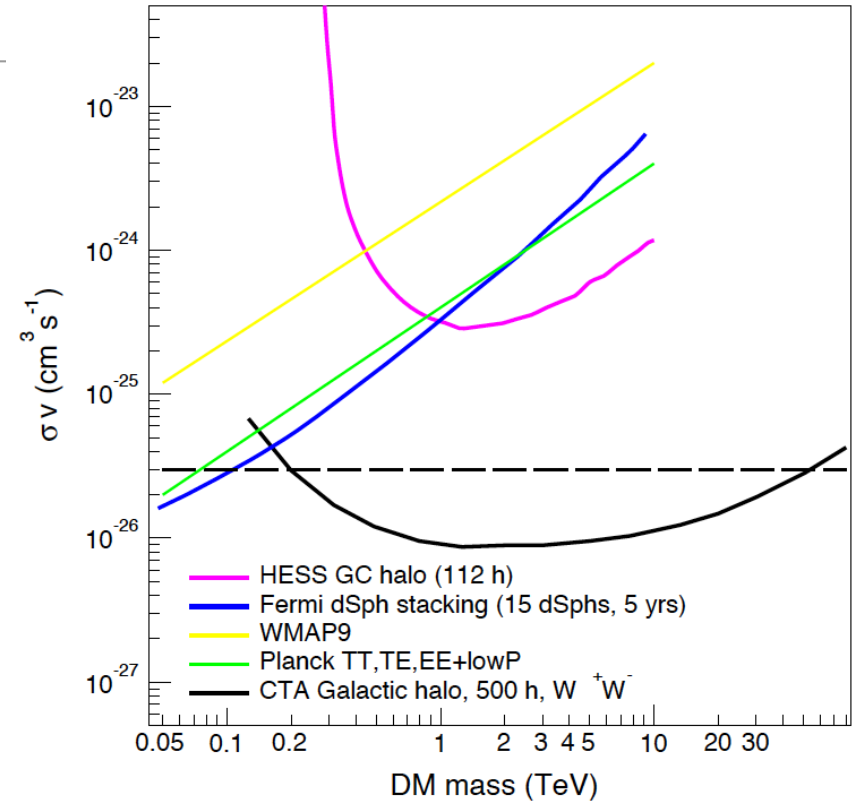
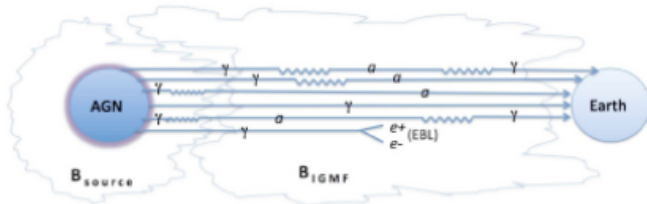
from high-frequency peaked blazars...



wide energy range, different AGN classes / redshifts  
-> Separation of intrinsic spectral features  
from propagation-induced effects.

# DM searches with CTA

## sensitivity to axions due to axion-gamma-rays oscillations

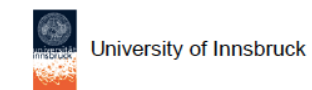
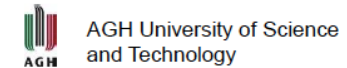
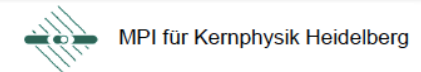
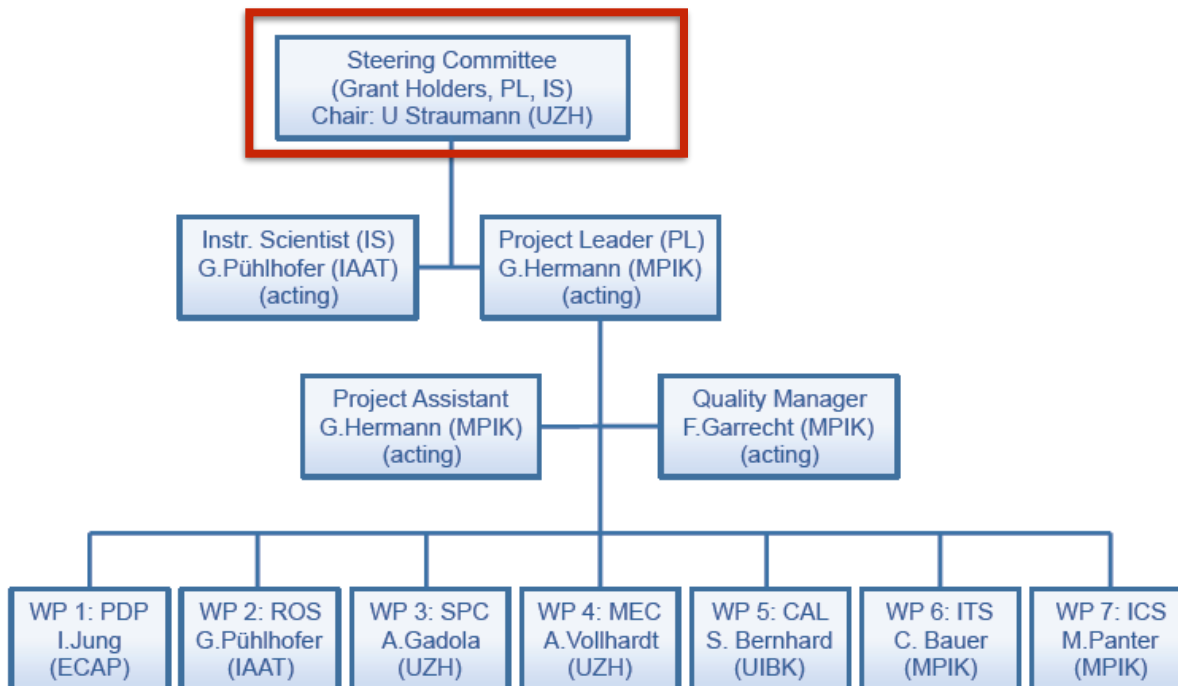


- Great possibility to discovery DM from Galactic Centre
  - CTA is the unique player in some parameter space regions
- CTA has good prospects for reaching WIMP models with thermal relic cross section for masses  $> 200$  GeV
  - First time ever that natural scale for the cross section can be probed
- CTA will be the lonely player for TeV DM
  - Besides detection, identification is possible
- CTA will be complementary to LHC/direct searches

# CTA Achievements: SST-1M and FlashCam

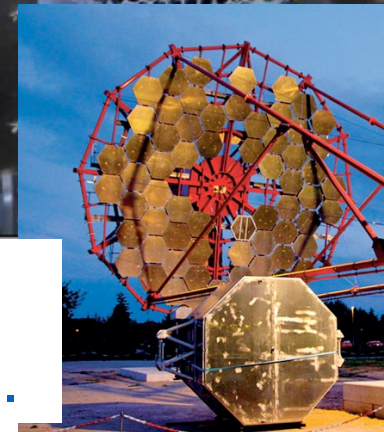
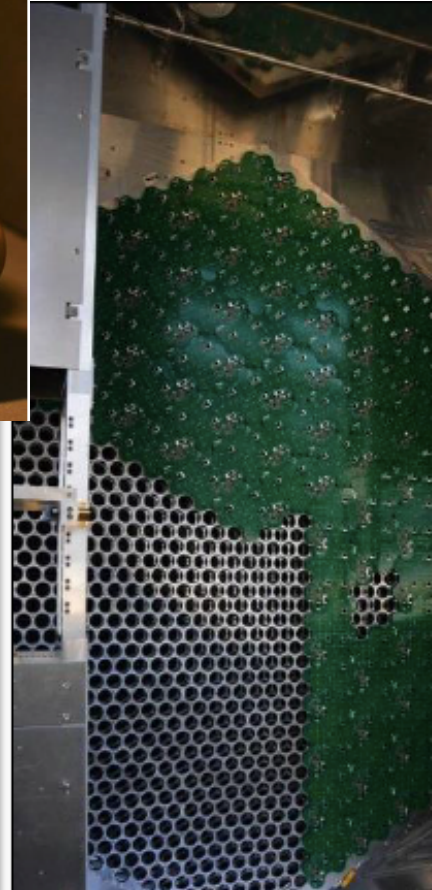
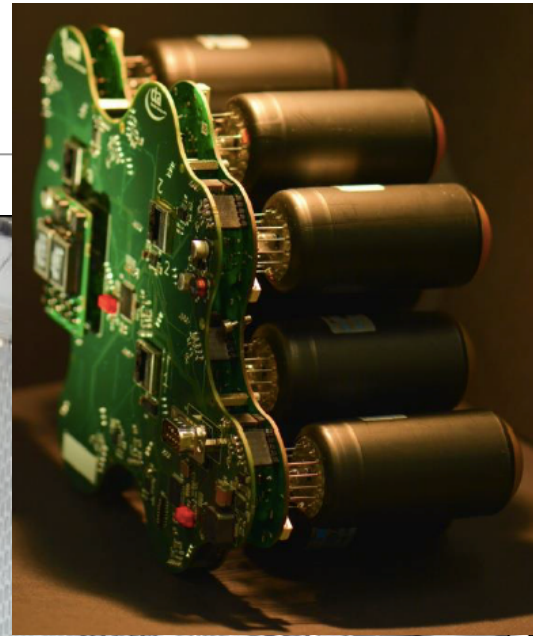
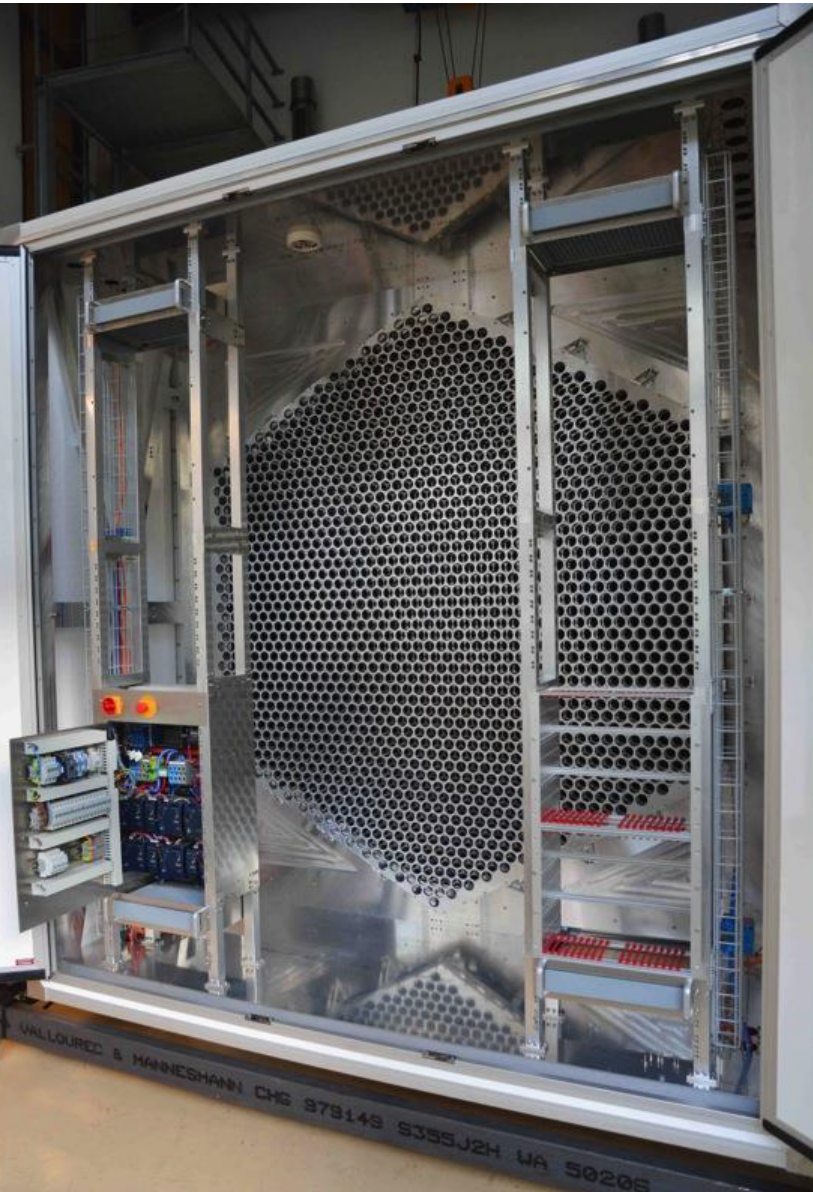


**SST-1M Consortium: 27 FTE**  
(in 2015: Ireland, Ukraine, Czech joined) ~4 FTE





# FlashCam in Zürich



The camera has been installed yesterday in Berlin on the MST prototype with a fully operative electronics cluster of 144 pixels.

# The SiPM camera

- SiPM based PDP separated from the Fully digital trigger and readout (High-speed/High-throughput)
- Pioneered by FACT/ETHZ & ISDC

