Selection of Instrument Concepts and Proposition for organisation of work within the SWG

Following the call for instrument concepts issued June 15 by the IWG, five proposal were received (table 1). The call was open to the high-energy astrophysics community at large (AHEAD, ASTROMEV, ASTROGAM mailing lists), however four of the five proposals came from WP9 institutes.

Proposal name	proposers	labs	Instrument concept
ASCI	von Ballmoos et al.	IRAP, UCD UCB	All-Sky Compton Imager – study of a "homogeneous" array of cross-strip Ge detectors using COSI balloon data.
ASTENA	Rosati et al.	UNIFE, DTU Space, INAF Bologna & Brera U. Coimbra	Advanced Surveyor of Transient Events and Nuclear Astrophysics - composed of a wide field monitor/spectrometer and a narrow field telescope
Baseline e-ASTROGAM	Morselli et al.	INFN Roma Tor Vergata	Optimization the baseline design of the e-Astrogam concept
HE gamma-ray polarization	Cattaneo	INFN-Pavia	Measuring gamma-ray polarization in the ~100 MeV range with Si detectors
PACT	Tatischeff et al.	CSNSM, IAPS GSFC, INFN Padova, INAF Bologna APC, ICE, CLPU	Pair And Compton Telescope – consisting of a silicon tracker for Compton scattering / pair conversion and a position-sensitive Calorimeter

The proposals have been evaluated by the Instrument Working Group and a discussion took place via skype on July 22, 2016. While non of the proposals alone satisfies all the requirements formulated in the AO (Annex II), it was realized that each of the five proposals covers a more or less broad subset of the requirements. Having complementary strengths, the proposed concepts would cover essentially all the requirements together.
The IWG recognized that all of the five proposals can be realized when appropriately grouped in three teams. As the PACT and e-ASTROGAM proposals effectively concerns identical instrument concepts (proposed in M4 and M5); and with the Cattaneo proposal requiring the optimization of the same concept wrt to polarized gamma-rays (cross section and the kinematic features of the electron positron pairs), the following scheme was discussed and accepted :

team 1 : PACT / e-ASTROGAM / HE gamma-ray polarization
team 2 : ASCI
team 3 : ASTENA

The three teams form the Simulation Working Group (SWG) of AHEAD/WP9 (laboratories of the SWG are listed in Appendix III). The objective of the three SWG teams is the simulation of the selected mission concepts (as detailed below), and the assessment of the respective performances in the light of the SAG science priorities (appendix I) and according the IWG requirements (appendix II)).

team 1 : PACT / e-ASTROGAM / HE gamma-ray polarization

CSNSM (Orsay, France): V. Tatischeff, C. Hamadache, J. Kiener
INAF-IAPS (Roma, Italy): M. Tavani, A. Argan, I. Donnarumma
NASA/GSFC (Greenbelt MD, USA): J. McEnery, E. Hays, A.A. Moiseev, J.S. Perkins, J. Racusin, D.J. Thompson
INFN (Padova, Italy): A. De Angelis
INAF-IASF (Bologna, Italy): A. Bulgarelli, V. Fioretti
APC (Paris, France): P. Laurent, R. Terrier
ICE/CSIC-IEEC (Barcelona, Spain): M. Hernanz, J. Isern
IFAE (Barcelona, Spain): M. Martinez
CLPU (Salamanca, Spain): J. M. Alvarez
INFN (Roma Tor Vergata) : A. Morselli
University of Coimbra, Portugal: Rui Curado da Silva

position 1*
- 1 year at CSNSM, Orsay (resp. V. Tatischeff)
- 1 year at ICE/CSIC-IEEC, Barcelona (resp. M. Hernanz)

position 2*
- 1 year at INFN Roma Tor Vergata (resp. A. Morselli – external advisor P. W. Cattaneo)
- 1 year at University of Coimbra; collaboration with team 3 – ASTENA (resp. R. da Silva – external advisor P. W. Cattaneo)

Paolo Walter Cattaneo (polarization of HE gammas) is warmly invited to join the SWG laboratories working in Team 1. Besides of a role as advisor during the skype meetings of the collaboration, he is encouraged to apply for support from the AHEAD "Visitor Program" http://webserver.javalab.ua.es/ahead

team 2 : ASCI

IRAP Toulouse : P. von Ballmoos, P. Jean
University College Dublin : L. Hanlon
Space Sciences Laboratory, UC Berkeley : S. Boggs, A. Zoglauer

position 3*
- 1 year at IRAP, Toulouse (resp. P. von Ballmoos)
- 1 year at University College, Dublin (resp. L. Hanlon)

team 3 : ASTENA

UNIFE: Piero Rosati, Filippo Frontera, Cristiano Guidorzi, Enrico Virgilli
INAF-IASF Bologna: Lorenzo Amati, Natalia Auricchio, Loredana Bassani, Riccardo Campana, Ezio Caroli, Fabio Fuschino, Claudio Labanti, Angela Malizia, Mauro Orlandini, John B. Stephen
DTU Space, Copenhagen: Carl Budtz-Jorgensen, Irfan Kuvvetli, Soren Brandt
INAF, Osservatorio Astronomico Brera, Merate: Giancarlo Ghirlanda
INAF, Osservatorio Astronomico Bologna: Roberto Gilli
University of Coimbra, Portugal: Rui Curado da Silva

position 4*
- 1.5 years at the University of Ferrara (Italy) with short periods of stay at DTU Space (Lyngby, Denmark) (resp. P. Rosati)

* *In order to adapt to the tight ressources available, the positions to be filled can be on a post-doc* or *graduate research assistant level; also, the durations of the contracts given above are understood as beeing indicative.*

Work-method and Timeline of the SWG

The simulation / optimization / evolution of the mission concepts shall be performed as a collaborative effort under the supervision of the IWG. As the intercomparison of the performance results is crucial for identifying the concept(s) that best fulfill the IWG requirements, it is STRONGLY recommended to use the same tools (i.e. MEGALIB), BG models etc. to simulate the instruments. A regular exchange between the SWG teams is therefore needed to define conventions, discuss BG standards, and synchronize the models: the contribution of the four hired researchers is understood as a "service" to the entire AHEAD community.

Performance estimates shall be based on common assumptions (eg background and, where applicable, orbit and exposure). To achieve this, the teams shall pool their preliminary results early on, and thus identify respects in which the teams preliminary assumptions differ so that they may be reconciled to a common basis as the calculations are refined. This could also encourage cross-fertilisation and working as a single team.

In order to guarantee a regular exchange and interact with the IWG, SWG/IWG skype meetings will be scheduled on a bi-weekly basis - they are compulsory for every SWG team (at least one WP9 member per team – two for team 1 - and the four hired researchers).

Four physical progress meetings of the SWG/IWG will punctuate the simulation work. In preparation of the progress meetings, progress reports will be written by each team. A detailed report on the performance of the studied instrument concept of each team is due for the final meeting (deliverable 4 of WP9).

1st SWG/IWG meeting – Nov/Dec 2016 (TBC) : kickoff for the simulation activities with the SWG/IWG
2nd SWG/IWG meeting – July/Aug 2017 : progress meeting
3rd SWG/IWG meeting – Mar/Apr 2018 (TBC) : progress meeting
4th SWG/IWG final meeting - Nov/Dec 2018: simulation completed, presentation of results to the SAG

The actual dates of the SWG/IWG meetings will be adapted to the actual starting dates of the four researchers to be hired (ideally Oct 2016). At any rate, however, the AHEAD shedule requires that the kickoff meeting must occur in 2016.

The SWG teams are therefore expected to fill their positions ASAP - with starting dates not later than Nov 2016.

Appendix I Summary of the prioritary science objectives

Gamma-Ray Bursts

Since their serendipitous discovery more than four decades ago, most gamma-ray bursts (GRBs) have been shown to originate at cosmological distances, in the catastrophic death of massive stars. The collapse of a massive star into a black hole releases a huge amount of gravitational energy and surrounding material is accelerated to near the speed of light in a narrow jet, producing the luminous flash of gamma-rays that allows us to see these cosmic lighthouses across much of the observable universe. The nearest GRBs from such 'collapsars' are excellent electromagnetic counterpart candidates to gravitational wave (GW) events. In addition, coalescing binaries, thought to be the progenitors of the 'short' subset of GRBs, are widely viewed as the most promising sources of gravitational waves. The detection and localization of these events is therefore a priority in the new era of gravitational wave astronomy and in the future era of space-based GW measurements.

More in general, because of their huge luminosities (up to > 10^{53} erg radiated in few tens of seconds) emitted by the most relativistic jets known (Lorentz factor Γ > 100) and their redshift distribution extending up to at least z ~9, GRBs offer enormous potential as powerful probes of the early Universe (evolution of stars, galaxies and the inter-galactic medium up to the epoch of re-ionization, population III stars), as test-beds for fundamental physics (e.g., constraining limits on violations of Lorentz invariance), and as laboratories for matter and radiation under extreme conditions.

Sensitive measurements by next generation gamma-ray experiments, especially if complemented by lower-energy instrumentation, will allow a substantial step forward in these GRB-related research areas, which are of extreme interest for several fields of astrophysics, cosmology and fundamental physics, and will provide an ideal synergy with the large multi-wavelength and multi-messenger facilities that will be operative in the next decade (e.g., eLISA, E-ELT, SKA, CTA, ATHENA, neutrino observatories).

Nuclear Sciences (Stellar Explosions, Low Energy Cosmic-Rays, Positrons)

Gamma-ray line emission in the MeV domain is obtained through the decay/de-excitation of radioactive/stable nuclei, which have been produced/excited by high-energy astrophysical phenomena, like supernova explosions or cosmic rays. They provide unique information on the isotopic identity of the emitters, on the underlying physical processes (e.g. nucleosynthesis, spallation etc.) and on the physical conditions of the - otherwise inaccessible – emitting region. Progress in the field has been slow, being hampered by poor angular resolution (by astronomy standards) and sensitivity limitations, due to large instrumental backgrounds. Despite these drawbacks, the field offers great potential for the study of various high-energy astrophysical processes, concerning a large fraction of the astrophysical community. Three topics of high priority have been identified: the physics of thermonuclear supernovae, the puzzling origin of Galactic positrons and the yet unexplored field of low energy cosmic rays.

Legacy Science topics include

- Pulsars physics (high B fields, testing Lorentz invariance …)
- Extragalactic compact objects: jets, the disk/jet transition, testing Lorentz invariance
- Galactic compact obj / binaries : jets, the disk/jet transition, testing Lorentz invariance
- Nuclear lines from compact objects (neutron capture)
- Dark Matter signatures
- Galactic Centre Physics (central black hole, interaction with surrounding medium)
- High-z AGNs
- Origin of the "Fermi Bubbles"
- MeV extragalactic background / Baryon asymmetry at cosmological distances
- Solar flare physics
- Terrestrial Gamma-Ray Flashes

Appendix II - table of instrument requirements (elaborated by the IWG) a)

	E [MeV]	dE @ [MeV]	FOV [sr]	Angular Resolution	Timing [microsec]	Sensitivity	Realtime alert	polarimetry
GRB need	0.05-3000	<10% at 0.3 MeV	> 2-3 sr (~250 GRBs/yr)	Localization accuracy < 40' (120 GRBs/yr) to < 5' (~20 brightest GRBs/yr)*	< 10	0.05 ph cm^{-2} s^{-1} (peak, 0.2 – 2 MeV, 1s)	yes	MDP ~ 5-10 % (in ~100 GRBs)
GRB extended	0.05 – 2	<10% at 0.3 MeV	> 2-3 sr	Localization accuracy < 40' to < 5'	< 10	$5x10^{-4}$ ph cm^{-2} s^{-1} (1000s from onset, 1000 s duration, 0.2-2MeV)	Yes	MDP ~ 5-10 % (in ~100 GRBs)
GRB afterglow Good to have	0.05 - 1	<10% at 0.3 MeV	<5 arcmin	Angular resolution <1'	-	(Assumptions: brightest 15% GRBs, 12 hrs after events, 10 ks duration, ph cm^{-2} $s^{-1}keV^{-1}$) $1.8x10^{-7}$ (0.1-0.3 MeV)	Yes	MDP ~ 5-10 % (in ~100 GRBs)

Appendix II - table of instrument requirements (elaborated by the IWG) b)

	E [MeV]	dE @ [MeV]	FOV [sr]	Angular Resolution	Timing [μsec]	Sensitivity	Realtime alert
NS SN1a need	0.1 - 2	3%-5%	N/A	N/A	-	3.10^{-7} ph cm^{-2} s^{-1} keV^{-1} (1Ms/ 847 keV, 3 σ cont. sensitivity, line width 35 keV)	N/A
NS SN1a good to have	0.05 - 2	0.3%			-	10^{-7} ph cm^{-2} s^{-1} keV^{-1} (1 Ms / 847 keV) 3 σ cont sensitivity, line width 35 keV) 10^{-7} ph cm^{-2} s^{-1} keV^{-1} (1 Ms / 158 keV, 3 σ cont sensitivity, line width 20 keV)	158 keV line from ^{56}Ni should be observed around the maximum
NS e^{+} need	0.3 – 0.8	5%		< 1°		$5 \cdot 10^{-6}$ ph cm^{-2} s^{-1} point source everywhere (all-sky mapping)	
NS e+ good to have	0.1 - 2	0.2%		< 5 '(in GC) diffuse emission at Gal. anti-center		10^{-6} ph cm^{-2} s^{-1} point source $1.6x10^{-4}$ ph cm^{-2} s^{-1} sr^{-1}	
NS LECR need	0.1 - 10	2% at 5 MeV	>1 sr	1°	-	10^{-4} ph cm^{-2} s^{-1} sr^{-1} @ 3-8 MeV (inner Galaxy)	-
NS LECR good to have	0.1 - 10	1% at 5 MeV		< 1°	-	5 10^{-7} ph cm^{-2} s^{-1} in ~10^{-2} sr @ 3–8 MeV band (Orion A)	-

Appendix III - Working groups of WP9/AHEAD

Science Advisory Group (SAG)

Lorenzo Amati, INAF Bologna; Lorraine Hanlon, UC Dublin; Jordi Isern, CSIC-IEEC Barcelona
Aldo Morselli, INFN Rome; Uwe Oberlack, Uni Mainz; Nicolas Prantzos, IAP Paris
Constancia Providencia, ILL Coimbra; Piero Rosati, INFN Ferrara; Regis Terrier, APC Paris; Peter von Ballmoos, IRAP Toulouse

Instrument Working Group (IWG) of WP9

Ezio Caroli, INAF/IASF-Bologna; Filippo Frontera, INFN Ferrara; Gerry Skinner; Margarida Hernanz, CSIC-IEEC Barcelona; Gottfried Kanbach, MPE Garching; Vincent Tatischeff, CSNSM Orsay; Peter von Ballmoos, IRAP Toulouse

Simulation Working Group (SWG)

Laboratories that will be involved in the modeling the selected instrument concepts include:

IRAP Toulouse, CSNSM Orsay, APC Paris, CEA Saclay, UCD Dublin, CSIC-IEEC Barcelona, INFN Roma Tor Vergata, LIP Coimbra, University of Ferrara