

AMON ミーティング報告

AMON ホームページ

<http://amon.gravity.psu.edu/index.shtml>

Overview

The Astrophysical Multimessenger Observatory Network (AMON) is a program currently under development at The Pennsylvania State University, in collaboration with a growing list of U.S. and international observatories. AMON seeks to perform a real-time correlation analysis of the high-energy signals across all known astronomical messengers - photons, neutrinos, cosmic rays, and gravitational waves - in an effort to:

1. Enhance the combined sensitivity of collaborating observatories to astrophysical transients by searching for coincidences in their sub-threshold data; and
2. Enable rapid follow-up imaging or archival analysis of the putative astrophysical sources.

AMON participants can be characterized as "triggering," "follow-up," or both. Triggering participants are generally observatories that monitor a large portion of the sky and feed a stream of sub-threshold events into the AMON system. These events are processed to search for temporal and spatial correlations, leading to secondary "AMON alerts." Follow-up participants generally search for electromagnetic counterparts to the AMON alerts with high-throughput, narrower field-of-view telescopes.

For more information, please see the AMON paper at

<http://www.sciencedirect.com/science/article/pii/S0927650513000479>

プロジェクトチーム

AMON Advisory Team

Name	Affiliation
Abhay Ashtekar	Penn State - Department of Physics; Institute for Gravitation and the Cosmos
Imre Bartos	Columbia University
Stephane Coutu	Penn State - Departments of Physics and Astronomy and Astrophysics; Institute for Gravitation and the Cosmos
Farhan Feroz	Cambridge University
Padma Raghavan	Penn State - Computer Science and Engineering; Institute for CyberScience

AMON Development Team

Name	Affiliation
Scott Barthelmy	Goddard Space Flight Center
Doug Cowen	Penn State - Departments of Physics and Astronomy and Astrophysics; Institute for Gravitation and the Cosmos
Abe Falcone	Penn State - Department of Astronomy and Astrophysics; Institute for Gravitation and the Cosmos
Derek Fox	Penn State - Department of Astronomy and Astrophysics; Institute for Gravitation and the Cosmos
Azadeh Keivani	Penn State - Department of Physics; Institute for Gravitation and the Cosmos
Peter Mészáros	Penn State - Departments of Physics and Astronomy and Astrophysics; Institute for Gravitation and the Cosmos
Miles Smith	Mars Science Laboratory, JPL
Ignacio Taboada	Georgia Institute of Technology
Gordana Tesic	Penn State - Department of Physics; Institute for Gravitation and the Cosmos

- Founded and hosted at Penn State
 - Internal initial funding
- Official NSF funded project as of 2014

Previous Workshops

- Third AMON Workshop, DESY/Zeuthen, Berlin, December 11-12, 2014
- Second AMON Workshop, Penn State, October 24-26, 2013
- Inaugural AMON Workshop, Penn State, October 1-2, 2011

Members and Prospective Members

Observatory	Contact	Letter of Collaboration	MoU in Review	MoU Signed
ANTARES	Juergen Brunner	✓	✓	✓ MOU
Auger	Miguel Mostafa	✓	✓	✓ MOU
Fermi	Julie McEnery	✓		
HAWC	Ignacio Taboada	✓	✓	✓ MOU
IceCube	Doug Cowen	✓	✓	✓ MOU
LIGO	Gabriela Gonzalez	✓		
Large Millimeter Telescope	Alberto Carramiñana	✓	✓	
Palomar Transient Factory	Tom Prince	✓		
Swift	Scott Barthelmy	✓	✓	✓
VERITAS	Abe Falcone	✓	✓	✓

Membership to AMON is open to any relevant facility, subject to signing of the AMON MOU.

Third AMON Workshop

December 11 - 12, 2014

DESY/Zeuthen

Berlin, Germany

<https://indico.desy.de/conferenceDisplay.py?confId=11043>

Workshop Description

The AMON workshop will bring AMON partners and prospective partners together to address the transition from network-in-preparation to live prototype system with a particular focus on:

- AMONpy software capabilities, distribution and installation plans
- AMON Alerts: Approaches, algorithms, and validation strategies
- Partner facility stats and science updates
- Integrating partner facilities into AMON
- Preparing for neutrino doublets and gravitational-wave observatories
- AMONpy software bootcamp and/or mini data challenge



ワークショップ

- ワークショップは、**DESY Zeuthen**の3階のカンファレンスルームで行われた。人数としては大凡プレゼンする人で、30人位の印象。
- **AMON(the Astrophysical Multimessenger Observatory Network)**という、主に提携プロジェクトが観測したトランジェントイベントのデータベース+イベントアラートを提供するPenn Stateが中心となって組織しようとしている観測所のコンソーシアムの活動報告と、それに参加しているorしそうなプロジェクトが集められてその進捗状況を報告する会議だった。
- テーマとしては次の2つ
 - 現在参加していないプロジェクトにAMONを知ってもらおう。
 - AMONで現在開発されているツールの紹介。

以下では、開発の中心となっていると思われるCordana Tesicという人のAMONステータストークを引用して簡単に報告。

- AMON is a *consortium* of observatories and a system of cyber infrastructure for joint analysis of data and alert distribution.
- AMON is intended as a *service* to the participating collaborations, but is not in of itself a scientific collaboration.
 - The AMON development team will not publish data, other than performance reports.
- Decisions about data sharing and analysis are made by the participating collaborations.
 - Collaborations are represented by working groups and the AMON Executive Board.

See AMON Memorandum of understanding (MOU):

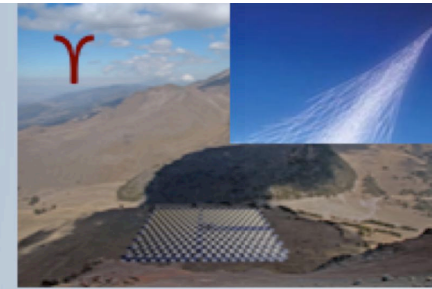
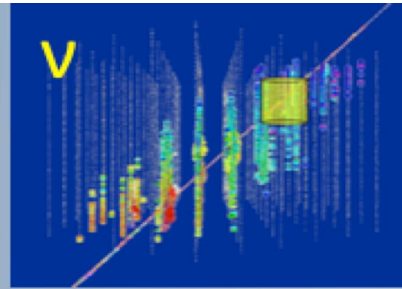
http://amon.gravity.psu.edu/mou_aug2012.shtml

The AMON Idea

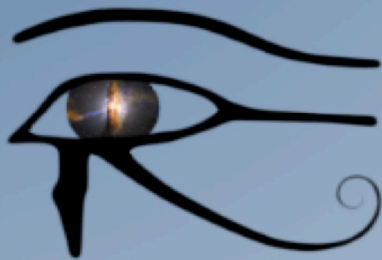
Use messenger particles of all four fundamental forces

Triggering observatories

- Provide **sub-threshold** candidate events to AMON in real time



AMON



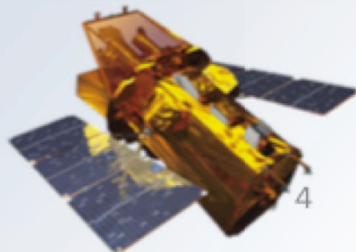
- Seeks **coincidences** in time and space
- Generates **alerts** - broadcast and archived
- Enables archival analyses

Follow-up observatories

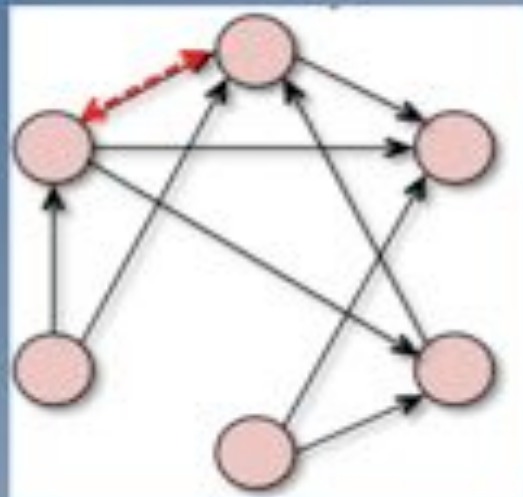
- respond to AMON alerts



x, UV, optical



Status quo

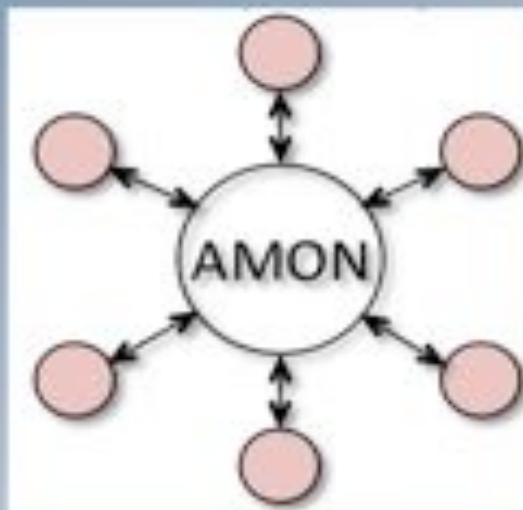


Many bilateral agreements among various observatories and cross-collaborative analyses

No unified multilateral agreement and unified analyses of multimessenger data

Mostly unidirectional

Future



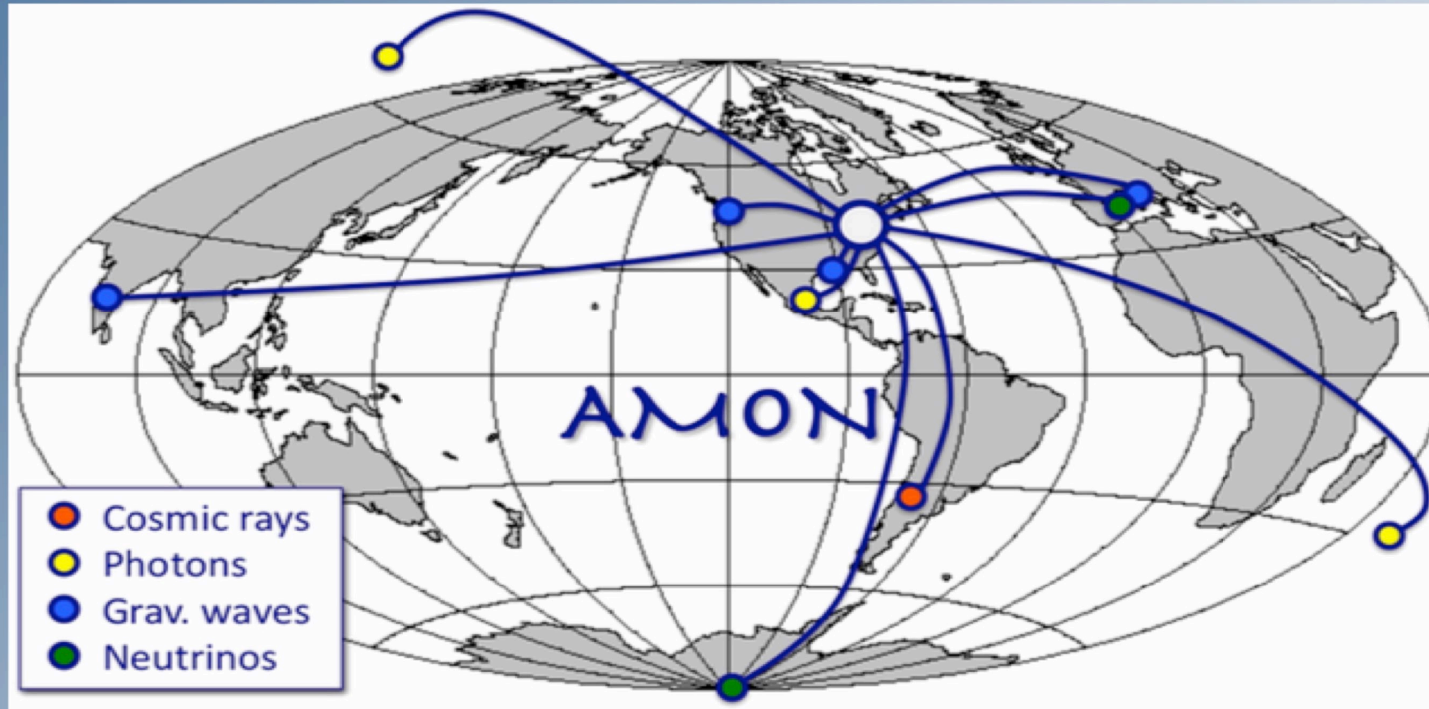
AMON serves as a central hub for collecting data from various multimessenger facilities

Performs unified analyses on multimessenger data

Gain in effective aggregate sensitivity

Simplified protocols of cross-collaborative analyses

6 Memoranda of Understandings (MoUs) signed
+ 1 MoU in review
+ 2 more letter of collaboration
+ many more in the future



Triggering:

Astrop.Phys. Vol. 45, 56–70, 2013

Follow-up:

IceCube
ANTARES
Auger
HAWC
VERITAS
Swift BAT...

Swift XRT & UVOT
VERITAS...

AMON

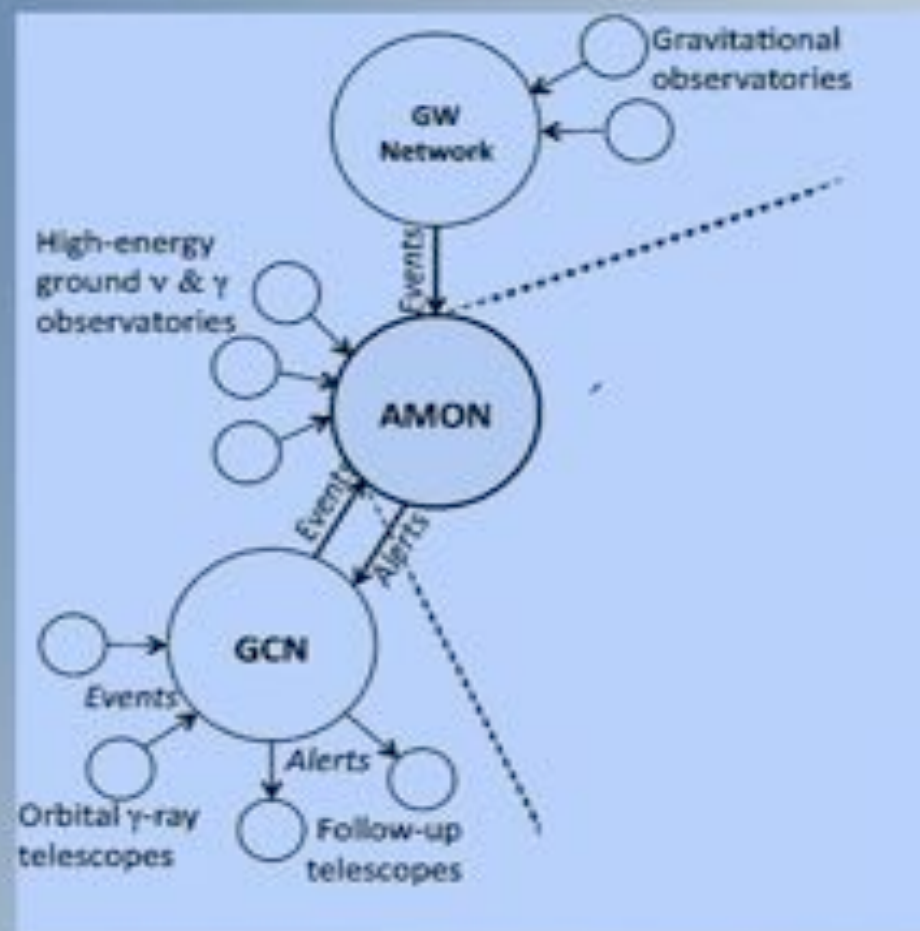
<http://amon.gravity.psu.edu>

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The goals of AMON:

- **Evoke**
 - Multi-facility sub-threshold coincident search
 - Convert *noise* to *signal*
 - Increase sensitivity for sources emitting in >1 channel
- **Exploit**
 - Many such sources expected to be transient (GRBs, SNe, AGN flares...)
 - Prompt identification *required* for follow-up and exploitation
- **Explore**
 - Follow-up + exploitation of first sources will be difficult
 - Organize follow-up network, practice with subthreshold alerts
 - Carry out archival analyses
 - Ready for best-case scenario science





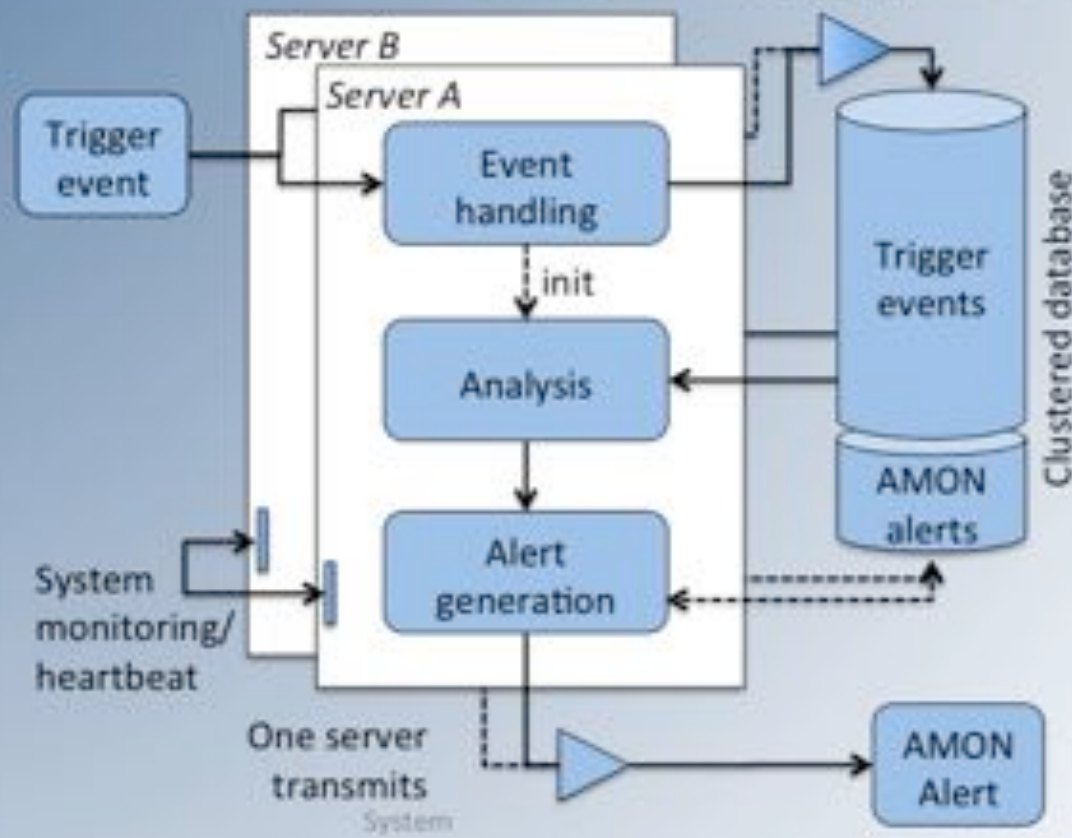
AMON will utilize existing:

Gamma-ray Coordinates Network (GCN)
Gravitational Wave (GW) Network
Open to other networks (e.g. SNEWS)

Data flow

Main systems housed at Penn State:

- Dual servers and “clustered” database for redundancy
- Systems physically and cyber-secure
- Very high level of uptime
- Modest data needs: 10 kB/sec (av), 1 MB/sec (peak),
storage: 2 TB (5 yr), processing: < 0.1 CPU



Event content common to each observatory

event	
eventStreamConfig_stream	INT
id	INT
rev	SMALLINT
time	DATETIME
time_msec	INT
Dec	FLOAT
RA	FLOAT
sigmaR	FLOAT
nevents	INT
deltaT	FLOAT
sigmaT	FLOAT
false_pos	FLOAT
pvalue	FLOAT
type	SET(...)
point_RA	FLOAT
point_Dec	FLOAT
longitude	FLOAT
latitude	FLOAT
elevation	FLOAT
psf_type	SET(...)
eventStreamConfig_rev	INT
Indexes	

Event content:

(stream number, id number, revision number)

trigger time: *time*, *time_msec*

position: *RA/Dec*

positional error: *sigmaR*

number of events: *nevents*

time window: *deltaT*

error on time: *sigmaT*

false positive rate density: *false_pos*

p-value: *pvalue*

type of the event: *type* ("observation",
"prediction", "utility", "test", "sim")

pointing: *point_RA*, *point_Dec*

observatory location: *longitude*, *latitude*,
elevation

type of the PSF: *psf_type* ("skymap", "fisher",
"king", "kent")

Define AMON alert content

alert	
alertConfig_stream	INT
id	INT
rev	TINYINT
time	TIMESTAMP
time_msec	INT
Dec	FLOAT
RA	FLOAT
sigmaR	FLOAT
nevents	INT
deltaT	FLOAT
sigmaT	FLOAT
false_pos	FLOAT
observing	INT
trigger	INT
type	SET(...)
pvalue	FLOAT
skymap	BOOL
alertConfig_rev	INT
Indexes	

Alert content:

(stream number, id number, revision number)

time – *time*, *time_msec*

position of the best fit: *Dec/RA*

positional error - *sigmaR*

number of events: *nevents*

time window: *deltaT*

error on time: *sigmaT*

false positive rate density: *false_pos*

experiments observing [sum 2^k]: *observing*

experiments triggered [0- not reporting,
sum 2^k]: *trigger*

type of the event: *type* ("observation",
"prediction", "utility", "test", "sim")

p-value: *pvalue*

skymap

AMON will receive events and send alerts in VOEvent format

- Standardized data packet format simplifies protocols for data handling (e.g. adding new observatory will not require new methods for injection of data into database and analysis stream)
- VOEvent is used by larger astronomical community i.e. became a standard for **real-time** event distribution (e.g. GCN notices, Swift, Fermi, LIGO, AMON etc.)
- Well structured in XML format with simple schema
- Easily interpreted by software, can be read by robotic telescopes (important for real-time analysis and near real-time follow-up)

Phase I-
archival operations
(ongoing)

- using archival data to tune analysis algorithms:
- **public data** (Swift BAT, Fermi LAT, IceCube-40, LIGO-S5)
- **private data** (more recent IceCube, ANTARES, HAWC, Auger – pending permissions)
- may lead to discovery of new astrophysical sources

Phase II –
real time operations
(starting)

- real-time reception of data streams from triggering observatories
- identification of statistically significant candidate sources in real-time
- alert distribution to triggering facilities
- False alarm rate (FAR) < 0.1 per year may lead to publication

Phase III-
triggered
follow-up operations

- final phase
- alert distribution to follow-up facilities enabling the near real-time search for electromagnetic counterparts
- FAR < 100 per year => follow-up
- FAR < 0.01 per year => publication

データベース (MySQL)

First full version of AMON database designed and implemented, now being used and tested:

- Data from triggering observatories inserted
 - done: IceCube, Swift, Fermi [public]
 - in progress: IceCube, HAWC, Auger, VERITAS
[private – pending permissions]
LIGO [public]
- Real-time test with fake data performed

AMONソフトウェア

- ソフトウェアの概要はAMON Software Hands-on (<https://indico.desy.de/getFile.py/access?contribId=25&resId=0&materialId=slides&confId=11043>) に詳しくある。

Conclusion

1. **Evoke** discovery of multimessenger transients from within observatory subthreshold data streams
2. **Exploit** these transients for purposes of astronomy and fundamental physics
3. **Explore** archival multimessenger datasets in search of rare or exotic astrophysical phenomena

Conclusion

- AMON has made a significant progress toward real-time and archival analysis
- AMON server is online - open for authorized connections!
- AMON is ready to start issuing alerts in spring 2015
- Our current and future collaborators are encouraged to take advantage of what AMON has to offer