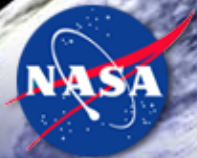


# Physics of the Cosmos (PhysPAG)

## Gamma-ray Science Interest Group (GammaSIG)

John Tomsick (UC Berkeley)  
**HEAD Meeting (2018)**





# Gamma-ray Science Interest Group (GammaSIG)

## Agenda

- **GammaSIG = Gamma-ray discussion group that has a line of communication to NASA leadership**
- **Recent activity/meetings**
- **White paper discussion**



# Gamma-ray Science Interest Group (GammaSIG)

Group coordinators and membership

- Sylvain Guiriec (The George Washington University)  
[sguiriec@gwu.edu](mailto:sguiriec@gwu.edu) (Chair)
- Henric Krawczynski (Washington University)  
[krawcz@wustl.edu](mailto:krawcz@wustl.edu)
- John Tomsick (University of California, Berkeley)  
[jtomsick@berkeley.edu](mailto:jtomsick@berkeley.edu)
- ...and 128 people on the GammaSIG mailing list



# Gamma-ray Science Interest Group (GammaSIG)

## GammaSIG Meetings and Telecons

- 2017/08/24 (16<sup>th</sup> HEAD):
  - **COSI** (Steve Boggs)
  - **TAP** (Judith Racusin)
  - **AMEGO** (Julie McEney)
  - **High-Energy Polarimetry session** (organized by GammaSIG coordinators)
- 2017/11/16 (telecon):
  - **GRB 170817A** (Leo Singer and Colleen Wilson-Hodge)
- 2017/12/14 (telecon):
  - **HAWC/Fermi synergies** (Petra Huentemeyer and Giacomo Vianello)
- 2018/01/08 (231<sup>st</sup> AAS meeting):
  - **e-ASTROGAM** (Dave Thompson)
  - **AMEGO** (Julie McEney)
- 2018/01/25 (telecon):
  - **Optical/IR coverage of prompt GRB emission** (Bruce Grossan)
  - **BurstCube** (Jeremy Perkins)



# Gamma-ray Science Interest Group (GammaSIG)

## Decadal WPs

- **Timeframe not official, but:**
  - **Expect call for White Papers (WPs) during summer 2018**
  - **Expect deadline by end of 2018**
  - **Usually ~5 pages unless invited (Flagship, Probes)**
- **GammaSIG is keeping a list of planned WPs:**
  - **To facilitate teaming**
  - **To make sure that all of our most important topics are being covered**
- **Earlier this month, we asked people to send us their WP plans: Missions and Science**



# Gamma-ray Science Interest Group (GammaSIG)

List of responses to request for WP plans: Missions

- U.S. participation in e-ASTROGAM (Alessandro de Angelis)
- Lunar Occultation Technique and LOX (Richard Miller)
- SMILE: electron-tracking MeV Compton (Kenji Hamaguchi)
- SCOTTI: transition edge sensors (Fabian Kislak)
- Swift+: with rapid optical/IR response to GRBs (B. Grossan)

From presentations:

- COSI: MeV Compton telescope (Boggs/Tomsick)
- TAP (**probe selected for concept study**): Transient Astrophysics Probe (Racusin/Camp)
- AMEGO: MeV-GeV Compton telescope and tracker (McEnerly)
- BurstCube: CubeSats for Multi-messenger (Jeremy Perkins)



# Gamma-ray Science Interest Group (GammaSIG)

List of responses to request for WP plans: Science-focused

- **AGN (Eileen Meyer, Filippo D'Ammando, Rani Bindu)**
- **Inverse Compton in Star-Forming Galaxies (Tonia Venters)**
- **GRB polarimetry (Mark McConnell)**
- **Type Ia SNe and All-Sky MeV (Richard Miller)**
- **Radionuclide Astrophysics (Chris Fryer)**
- **MeV Dark Matter (Regina Caputo)**
- **Colliding Wind Binary systems (Kenji Hamaguchi)**
- **Rapid optical/IR response to GRBs (Bruce Grossan)**
- **Flare stars (Lisa Winter)**

From presentations:

- **Synergies between HAWC and Fermi (P. Huentemeyer and G. Vianello)**
- **High-Energy Polarimetry**

# Response from Chris Fryer

- “I'm organizing a meeting this summer at LANL on Radionuclide Astronomy with a focus on putting together a white paper supporting a hard X-ray/Gamma-ray mission.”
- Chris wanted me to advertise this to the Gamma-SIG community.
- Google “RA2020 radionuclide astronomy”



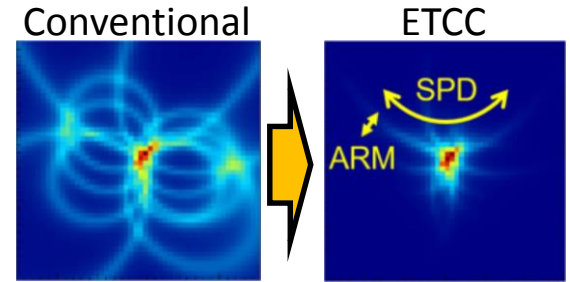
Aug. 20-24, 2018  
Los Alamos, NM



# Electron Tracking MeV Compton Camera

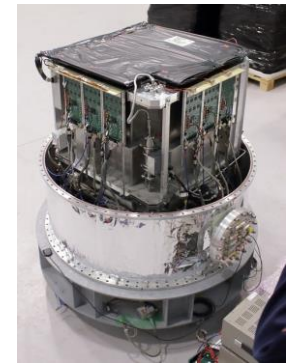


- Tracking Compton recoiled electrons
  - Proper Imaging Spectroscopy by 2D-PSF
  - Efficient *BG* rej, Large *FOV*, polarization
  - Developed by Kyoto-U (PI: T. Tanimori)

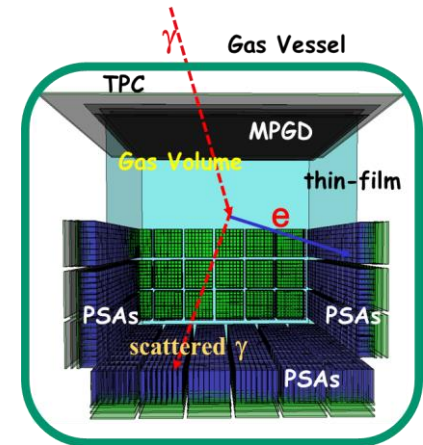
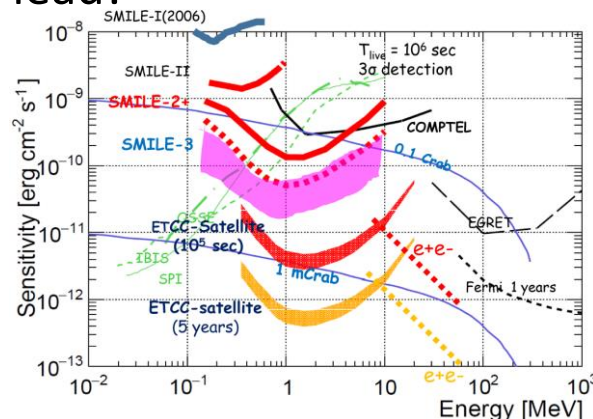
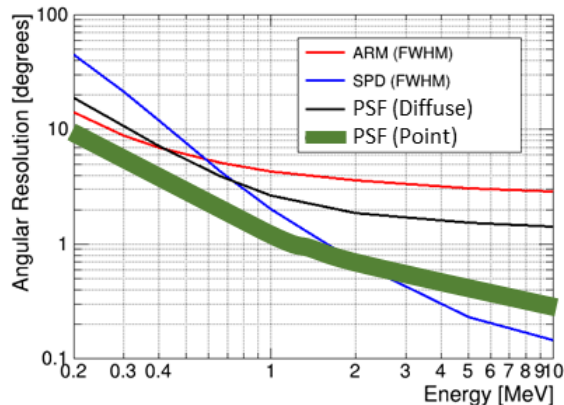


- SMILE-2+ (*PSF*: 10deg, *EA*: 1 cm<sup>-2</sup>@300keV)
  - 8 hour balloon flight this spring
  - Goal: detect the GC 511 keV line

- ETCC Satellite (*PSF* : 0.1-1deg, *EA*: 200 cm<sup>-2</sup>@1MeV)
  - Sub-degree 2D-PSF -> beyond 1mCrab
  - Looking for a US mission lead!



Performance Goal

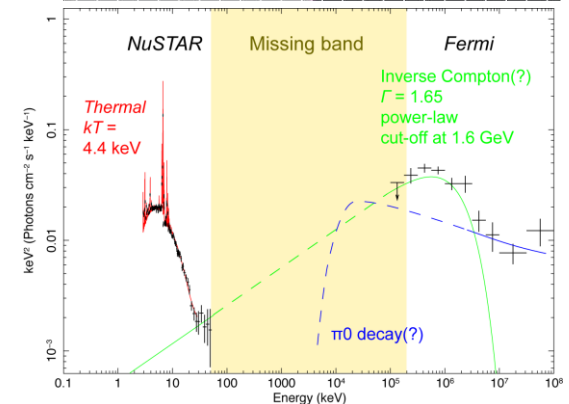
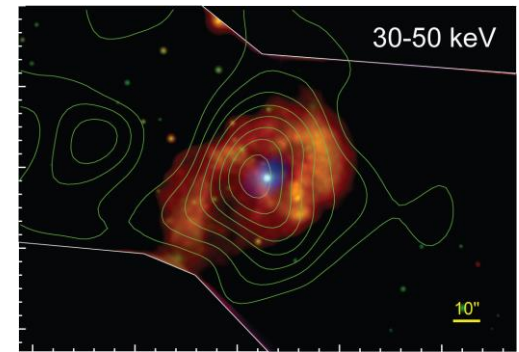
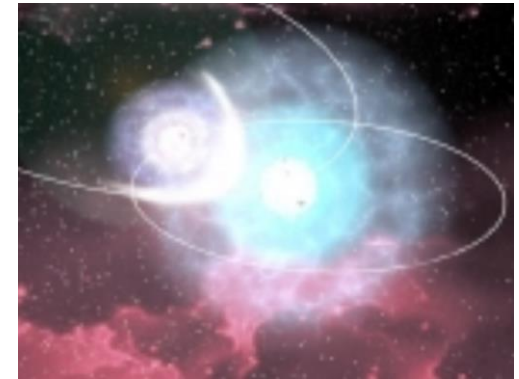


# Particle Acceleration in Colliding Wind Binaries

Slide from Kenji Hamaguchi

## Binaries

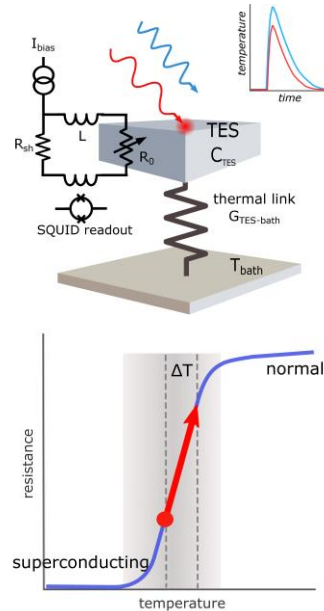
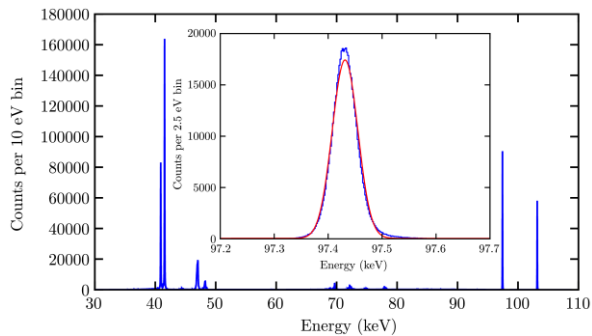
- Colliding Wind Binaries (CWBs)
  - Massive binary stars have strong winds.
  - Their wind collision produces strong shock.
- The shock drives non-thermal acceleration.
  - The NT X-/ $\gamma$ -rays are detected from  $\eta$  Carinae.
  - Inverse Compton and/or  $\pi^0$  decay (?)
  - How electrons and protons are accelerated?
- CWBs for particle acceleration study
  - The shock occurs steadily and persistently.
  - The shock parameters (wind speed, mass loss rate) are known (unlike SNRs etc.)
- MeV  $\gamma$ -ray information is missing
  - Crucial band as  $\pi^0$  decay should be strong.
  - Study time variation in a binary orbit and difference between systems.



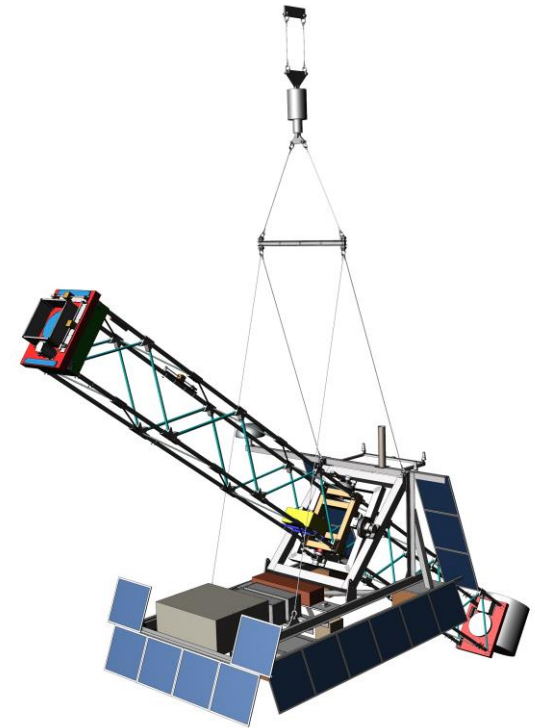
# Imaging Spectroscopic Observatory for X-rays – ISO-X

*Fabian Kislak, Henric Krawczynski, et al.*

- Superconducting NuSTAR follow-up mission for Broadband X-ray and Gamma-ray Spectroscopy: **500eV to 100keV**
- Transition Edge Sensor microcalorimeter detectors:
  - Energy resolution **55eV FWHM** at 97keV (proven).
  - Microwave SQUID multiplexed readout:  $O(10^3)$  channels per coax.
- High-resolution Ni/C X-ray mirror:
  - Angular resolution **<10"**,
  - No cutoff at 78.4keV (Pt K edge),
- **Science:**
  - Black hole spins;
  - Black hole census (unobscured, obscured up to  $z^{\sim 6}$ );
  - $^{44}\text{Ti}$  in different types of supernova remnants;
  - Accreting neutron stars (Fe  $K\alpha$  and CRSF), neutron star EOS.

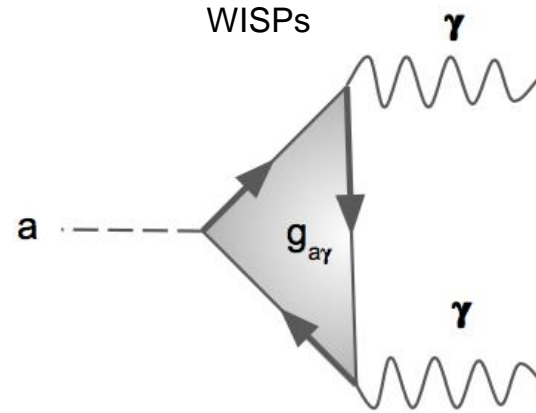
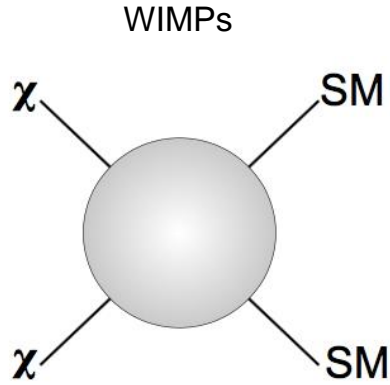


## Prototype: SCOTTI SuperCONducting Titanium Imager



# Working title: Dark Matter in the MeV regime

Regina Caputo, T. Linden, M. Meyer, M. Sánchez-Conde + others are welcome to join!



Look for Spectral/temporal features in MeV gamma rays

## WIMPs

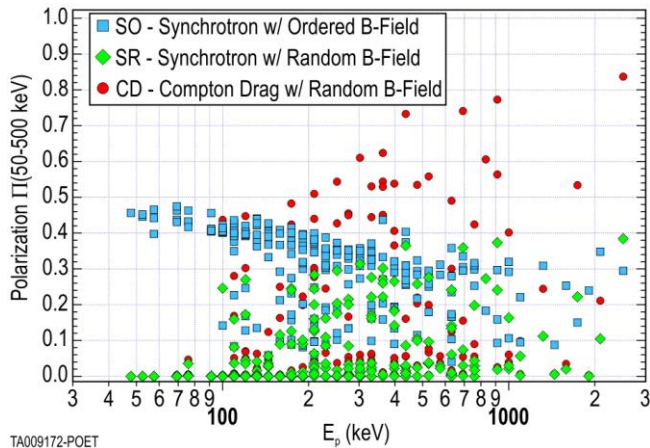
- Interact via gravity and “weak” force
- Thermal:  $\langle\sigma v\rangle \sim 3 \times 10^{-26} \text{cm}^3 \text{s}^{-1}$
- Dark matter ( $\chi$ ) and dark mediators ( $A'$ )
- $m_\chi$ :  $\sim 10 \text{ MeV to } > \text{TeV}$

## WISPs

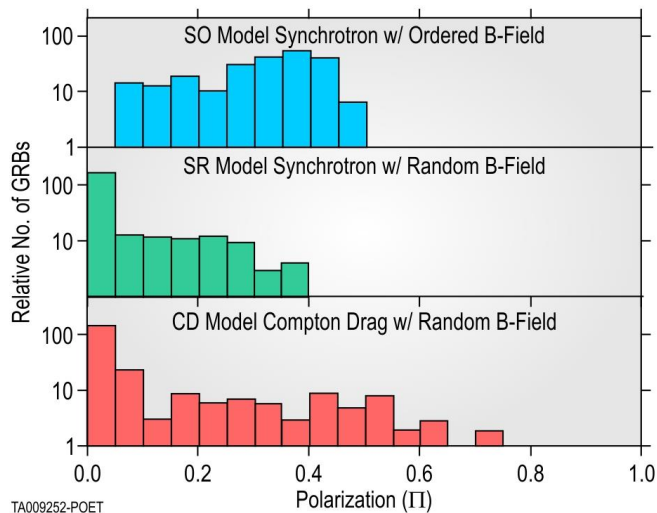
- Not thermally produced
- Oscillate to  $\gamma$  in B fields
  - QCD axion ( $m_a \propto g_{a\gamma}$ )
  - ALPs, etc.
- WISP-induced spectral features
- Polarization

# Polarization Distributions

Toma et al., ApJ, 698, 1042 (2009)



A large sample of high confidence polarization measurements could be used to identify the dominant class of GRB models and constrain the role of magnetic fields in the formation of GRB jets.



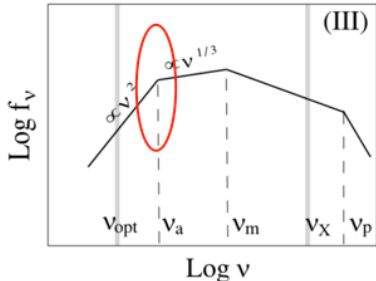
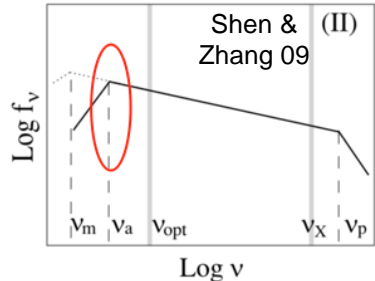
	Intrinsic Model	Geometric Models	
	SO	SR	CD
Radiation Mechanism	synchrotron	synchrotron	inverse Compton
B-field	ordered	random	random
Jet Composition	Poynting flux	matter-dominated	matter-dominated
Energy Dissipation	reconnection	shocks	shocks or reconnection
<b>Gamma-Ray: 50-500 keV</b>			
$\Pi$ dist	peaks near 40%	peaks near 0%	peaks near 0%
$\Pi$ max	~60%	~40%	~85%
Fraction with $\Pi > 30\%$	62%	3%	17%

# GRB Polarimetry - Observations

Several results suggest very high polarization levels,  
but all are of limited statistical significance.

<i>Event</i>	<i>Mission</i>	<i>Energy (keV)</i>	<i>Result</i>	<i>Reference</i>
GRB 930131	CGRO/BATSE	20 - 1000	(35-100%)	Willis et al. (2005)
GRB 960924	CGRO/BATSE	20 - 1000	(50-100%)	Willis et al. (2005)
GRB 021206	RHESSI	150 - 2000	80% $\pm$ 20%	Coburn & Boggs (2003)
GRB 041219a	INTEGRAL/SPI	100 - 350	98% $\pm$ 33%	Kalemci et al. (2007)
GRB 041219a	INTEGRAL/SPI	100 - 350	96% $\pm$ 40%	McGlynn et al. (2007)
GRB 041219a	INTEGRAL/IBIS	200 - 800	43% $\pm$ 25% (variable $\pi$ )	Götz et al. (2009)
GRB 061122	INTEGRAL/IBIS	250 - 800	> 60%	Götz et al. 2013
GRB 100826a	IKAROS/GAP	70 - 300	27% $\pm$ 11% (variable PA)	Yonetoku et al. (2011)
GRB 110301a	IKAROS/GAP	70 - 300	70% $\pm$ 22%	Yonetoku et al. (2012)
GRB 110721a	IKAROS/GAP	70 - 300	80% $\pm$ 22%	Yonetoku et al. (2012)
GRB 140206a	INTEGRAL/IBIS	200 - 800	> 48%	Götz et al. (2014)

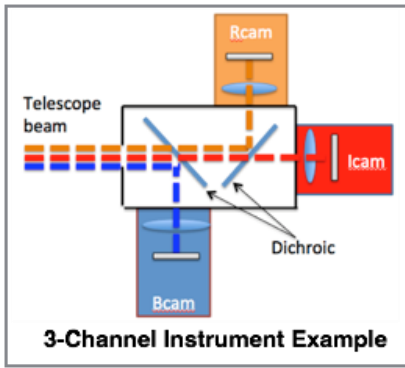
# GRB Prompt Optical-IR Spectral Shape



- **Important, overlooked science- GRB Emission Mechanism**  
 Prompt optical colors identifies mechanism, allows measurement of  $r_{\text{emission}}$ ,  $\Gamma_e$ , etc.  
 -Needs 1) fast  $\sim$  arcmin localization 2) fast telescope 3) multi-channel camera  
 -necessarily encourages wide community participation  
**GOAL: Encourage this capability (Don't care how)**

----- > **NEED STRATEGY** < -----

- **Mission White Paper?**  
 -BG has a mission ready to go, but needs wider science scope, constituency (BAT + fast OITel? No, "make more people want it")  
 -John T: "others" could do  $\gamma$ /X instrument, Grossan does OIR Tele



- **Science WP?** – BG has very good case

- **"NASA Capability" WP?**

John Tomsick: "Another thought would be to write a white paper about just prompt optical spectral shape, and saying that it is an important capability for the next GRB mission. If the Decadal Committee writes about it in the report, then other missions (e.g., TAP) might think it is something they should add ..."