



# Transient Response Astronomy

## *How & Why*

Rob Seaman, *NOAO*  
Roy Williams, *Caltech*

*(present & past Chairs of the IVOA VOEvent WG)*

# Many meetings since 2005



- ✦ VOEvent workshops
- ✦ HTN workshops
- ✦ Transient Universe 2006 meeting
- ✦ Hotwired meetings (<http://hotwireduniverse.org>)
- ✦ IVOA sessions (VOEvent & Semantics WGs)
- ✦ ADASS BoFs
- ✦ NVO Summer Schools
- ✦ SPIE 2006
- ✦ VOEventNet meeting
- ✦ Robots at the Austin AAS

# More meetings coming...

- ✦ IVOA InterOp – 9-13 Nov 2009
- ✦ dotAstronomy – 30 Nov - 4 Dec 2009
- ✦ *The Eventful Universe* (NOAO 50<sup>th</sup>) – 17-20 Mar 2010
- ✦ IVOA InterOp – 17-21 May 2010
- ✦ VAO @ AAS – 23-27 May 2010
- ✦ SPIE 2010, *Observatory Operations III* – 27 Jun - 2 Jul 2010
- ✦ ADASS XX BoF – 7-11 Nov 2010
- ✦ 2011 – Hotwired III
- ✦ 2012 – Joint Discussion @ IAU General Assembly?
  - ✦ Comm. 5 (WG-VO) & Comm. 6 (Astronomical Telegrams)

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Comm. 5 (*WG-VO*) & Comm. 6 (*Astronomical Telegrams*)

The background features a collage of various postage stamps and postmarks. Visible elements include a red circular postmark from 'COSTA RICA', a rectangular postmark from 'MADRID', and several other stamps with numbers and text like 'PART AVION', 'PETERA', 'BARB', and 'POSTAGE'. The overall color scheme is warm, with shades of yellow and orange.

# Transient Response Astronomy

## *How & Why*

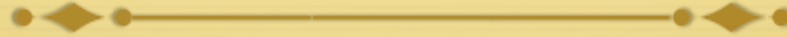


# Sherlock Holmes



The patron saint of How & Why,  
suggesting a different title...

*...or*



# The Giant Rat of Sumatra

*“...a story for which the world  
is not yet prepared.”*

- “The Adventure of the Sussex Vampire”  
by Sir Arthur Conan Doyle

# Why transient response?



- ✦ Things go bump in the night
  - ✦ the sky is big
  - ✦ transients are rare
  - ✦ events occur randomly in space & time
  - ✦ ...and have obscure physical signatures
  - ✦ *vs.* contention for observing resources
- ✦ Even giant rats can be hard to find





“A halfassed comeback containing only one good joke.” - *Rolling Stone*

# Why? The Rat has friends



- ✦ Large Synoptic Survey
- ✦ Pan-STARRS
- ✦ Dark Energy Survey
- ✦ ...

# The Rat is rare & valuable



✦ Gamma-Ray Bursts

✦ Neutrinos

✦ Gravitational waves

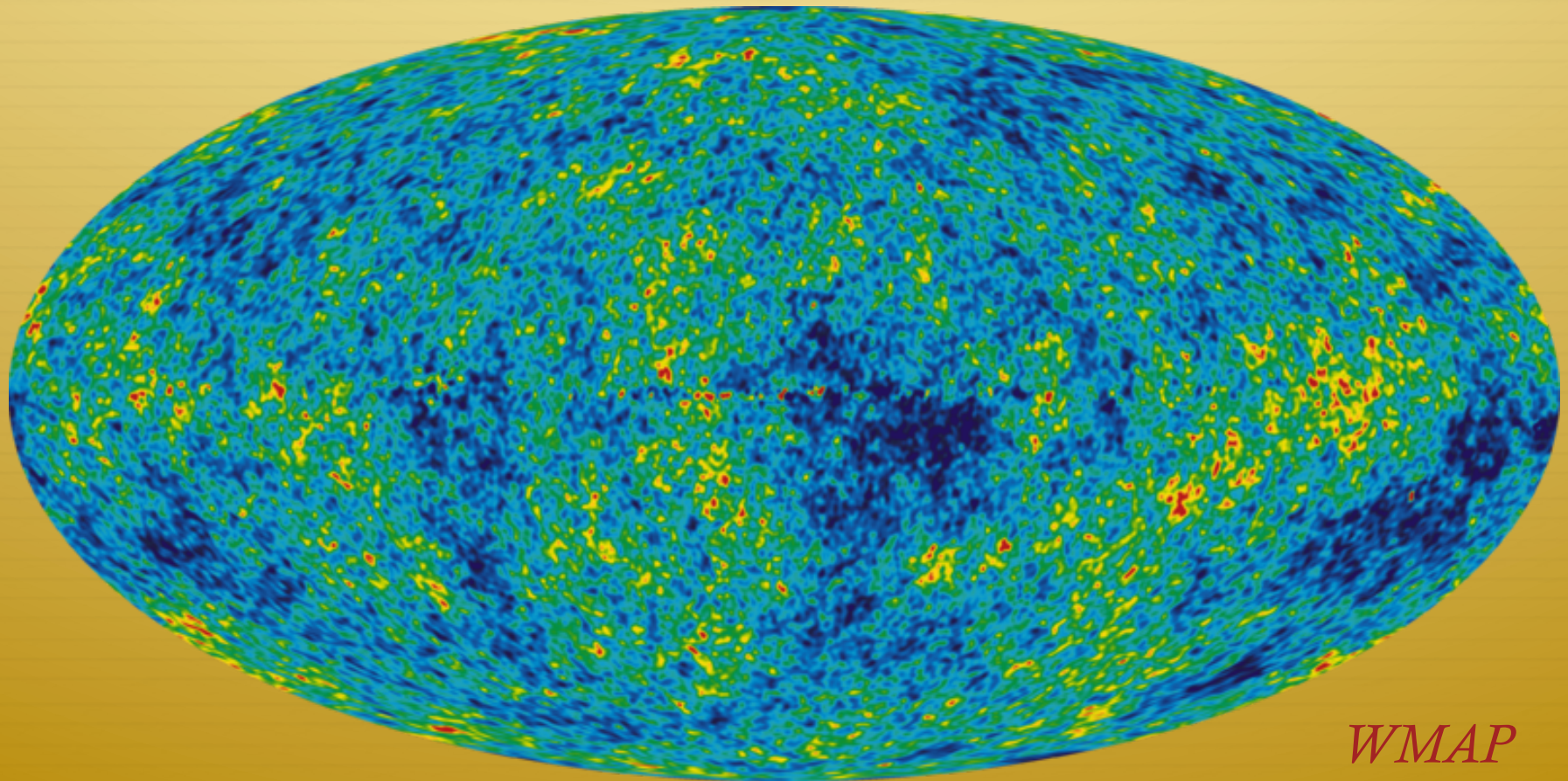
✦ Solar system debris

✦ ...

# The Rat will always remain a target-of-opportunity, requiring:

- ✦ Rapid response
- ✦ Ubiquitous delivery
- ✦ Diverse subscribers
- ✦ Flexible follow-up
- ✦ Reliable semantic classification
- ✦ Autonomous workflows
- ✦ We must build a better rat-trap

But the Rat lives within a  
background limited universe



✦ Further in space,  
Deeper in time

✦ Transients are  
milestones in the  
master timeline of  
cosmic history

✦ Distant transients  
probe the moment  
of creation

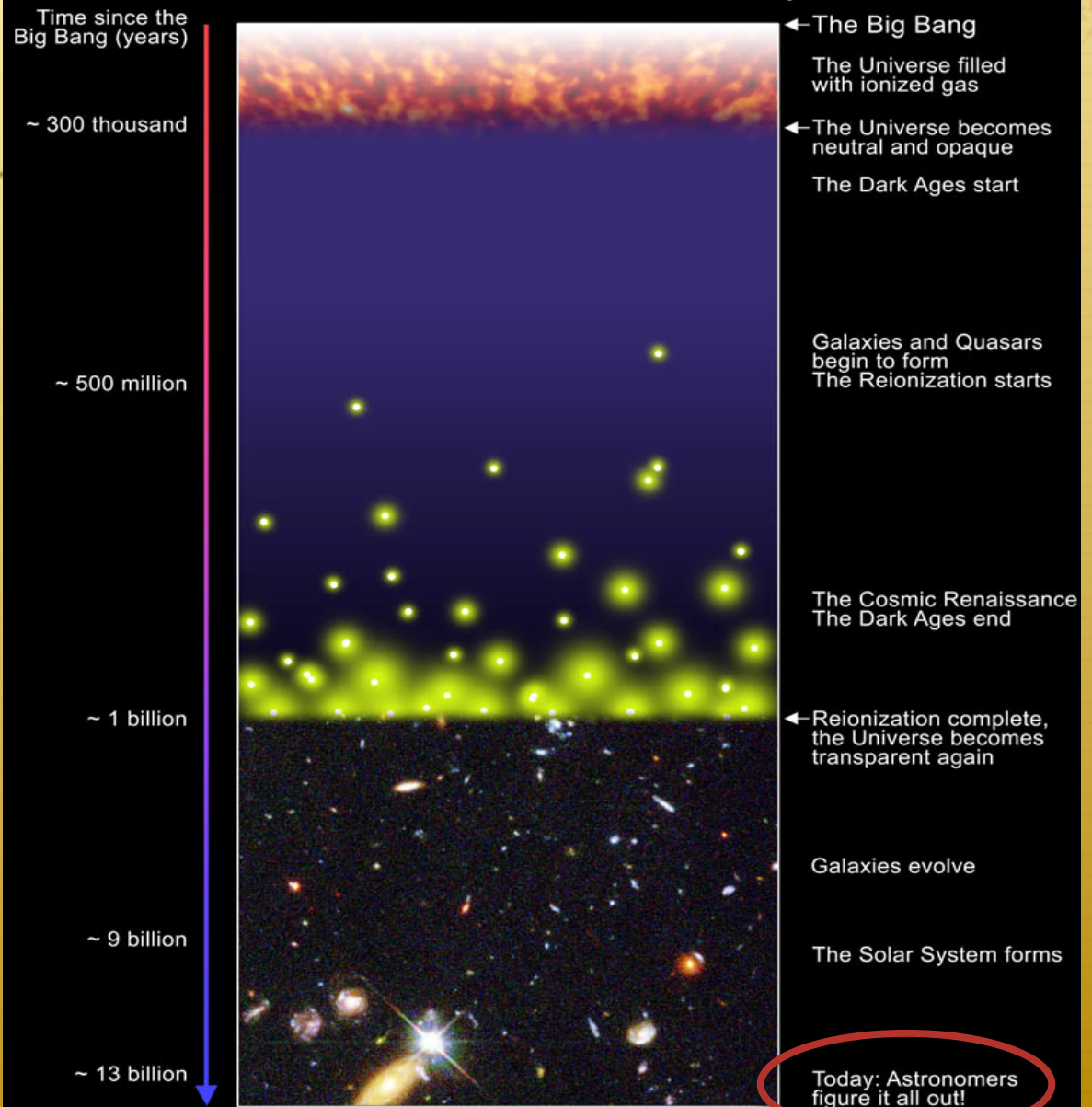
✦ Local transients  
are close enough  
to touch

*meteors, comets, ...*

ADASS XIX, Sapporo, Japan

## What is the Reionization Era?

A Schematic Outline of the Cosmic History



S.G. Djorgovski et al. & Digital Media Center, Caltech

# How to respond to transients?



✦ To quote from Sherlock Holmes:

*“Results without causes are much more impressive.”*

# How?



- ✦ The **VOEvent** standard of the IVOA is one ingredient for constructing flexible, efficient, autonomous architectures for carrying out experimental investigations when time is of the essence.



# How?

- ✦ “**VOEvent** defines the content & meaning of a standard information packet for representing, transmitting, publishing & archiving the **discovery** of a transient celestial event, with the implication that **timely follow-up** is being requested.”

# VOEvent

- ✦ Who
- ✦ What
- ✦ Where
- ✦ When
- ✦ How
- ✦ Why

# VOEvent



- ✦ Who – author's provenance
- ✦ What
- ✦ Where
- ✦ When
- ✦ How
- ✦ Why

# VOEvent



- ✦ Who – author's provenance
- ✦ What – empirical measurements
- ✦ Where
- ✦ When
- ✦ How
- ✦ Why

# VOEvent

- ✦ Who – author's provenance
- ✦ What – empirical measurements
- ✦ Where – targeting in space
- ✦ When – constraints in time
- ✦ How
- ✦ Why

# VOEvent

- ✦ Who – author's provenance
- ✦ What – empirical measurements
- ✦ WhereWhen – targeting in spacetime
- ✦ How
- ✦ Why

# VOEvent



- ✦ Who – author's provenance
- ✦ What – empirical measurements
- ✦ WhereWhen – targeting in spacetime
- ✦ How – instrumental signature
- ✦ Why

# VOEvent

- ✦ Who – author's provenance
- ✦ What – empirical measurements
- ✦ WhereWhen – targeting in spacetime
- ✦ How – instrumental signature
- ✦ Why – scientific characterization



# VOEvent



## ✦ IVOA recommendation:

✦ *<http://www.ivoa.net/Documents/latest/VOEvent.html>*

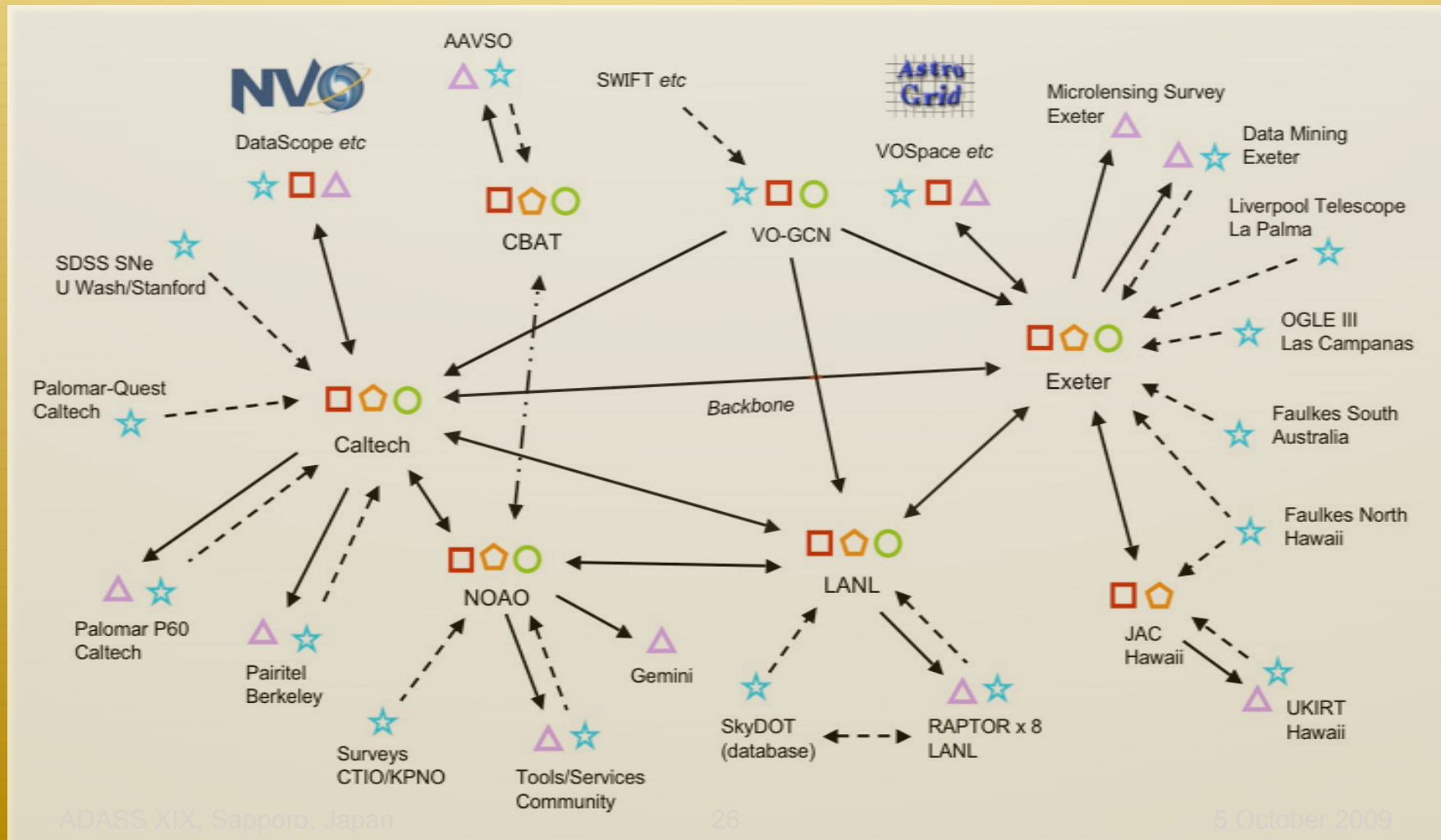
## ✦ XML schema:

✦ *<http://www.ivoa.net/xml/VOEvent/VOEvent-v1.1.xsd>*

## ✦ Working group:

✦ *<http://voevent.org>*

# VOEventNet



# VOEventNet



- ✦ Publish / Subscribe paradigm
- ✦ Backbone sites – full packet feeds
- ✦ Network of brokers
  - ✦ forwarding
  - ✦ filtering
  - ✦ bridging

# VOEvent is transport-neutral



## ✦ Backbone:

- ✦ TCP “vanilla”

- ✦ Jabber

- ✦ XML-RPC

## ✦ Clients:

- ✦ SMTP, SMS, RSS, ...

# VOEvent is IVOA-aware

- ✦ SEAP – Simple Event Access Protocol
- ✦ STC
- ✦ Vocabularies & semantics
- ✦ VOTable
- ✦ SAMP-enabled
- ✦ ...

# VOEvent is **growing**

- ✦ V2.0 (time series, orbital elements, ...)
- ✦ VOEventStreams in registry
- ✦ SEAP
- ✦ Infrastructure (& transport)
- ✦ Client applications (author & subscribe)
- ✦ Community (eg., LSST data challenge)

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# Sherlock Holmes on Transient Response Astronomy

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- ✦ “When you have excluded the impossible, whatever remains, however improbable, must be the truth.”
- ✦ In the time domain, astronomers study unprecedented phenomena subject to dramatically differing interpretations.

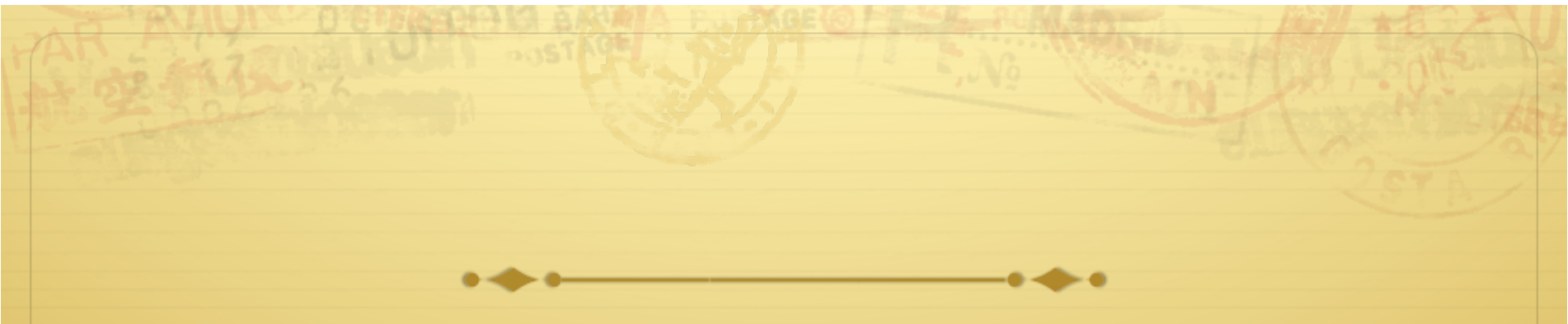




✦ “Chance has put in our way a most singular and whimsical problem, and its solution is its own reward.”


✦ Serendipity is the engine of discovery.


✦ VOEvent is a luck management system.

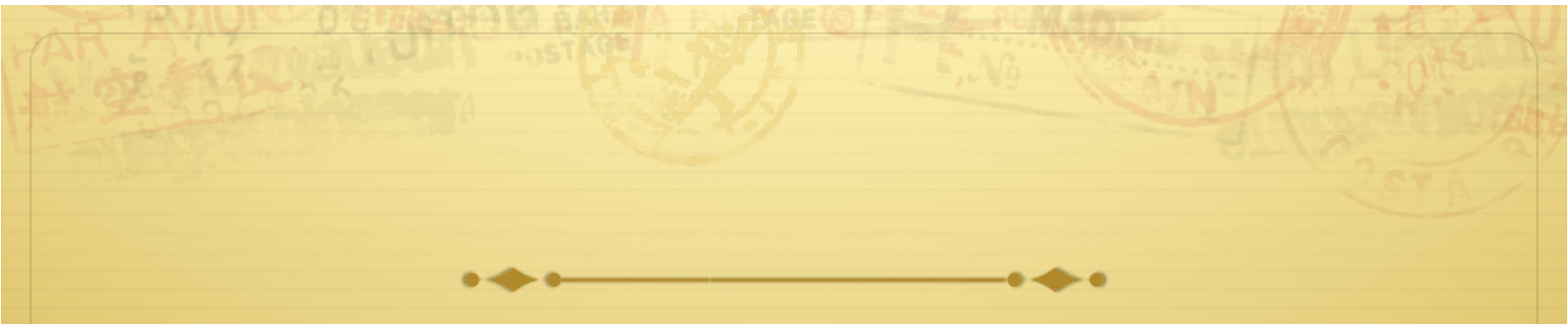



✦ “The world is full of obvious things which nobody by any chance ever observes.”


✦ Taking advantage of rare opportunities requires careful planning and the deployment of resources in advance.


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- ✦ “It is a capital mistake to theorize before you have all the evidence. It biases the judgment.”
  - ✦ Science depends on synthesizing diverse observations to discover underlying rules, that is, on building empirical workflows.

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- ✦ “I am glad of all details, whether they seem to you to be relevant or not.”
  - ✦ Filtering of data should be postponed to as late in the workflow as possible.
  - ✦ Different investigators need different things from the event stream.

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- ✦ “The reasoner can produce an effect which seems remarkable to his neighbor, because the latter has missed the one little point which is the basis of the deduction.”
  - ✦ Information without efficient access and effective query tools is useless.

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- ✦ “I have no desire to make mysteries, but it is impossible at the moment of action to enter into long & complex explanations.”
  - ✦ Autonomous systems are needed to allow removing humans from the loop.

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- ✦ “What one man can invent, another can discover.”
  - ✦ Astronomy requires a standard transient alert protocol
  - ✦ ...only a *single* transient alert protocol.

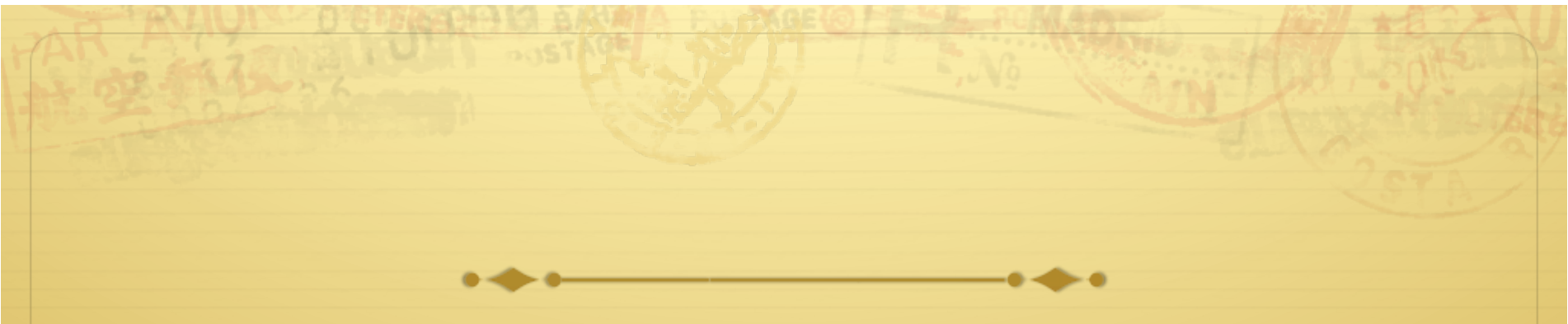


✦ “I wonder how a battery feels when it pours electricity into a non-conductor.”

✦ Astronomy requires a common transient alert network


✦ ...only a *single* transient alert network.






✦ “My life is spent in one long effort to escape from the commonplace of existence.”


✦ Time domain projects (synoptic as well as transient-response) require commitment to a lengthy and diligent search process.



✦ “Nothing clears up a case so much as stating it to another person.”

✦ A publish-subscribe paradigm is needed to connect surveys that discover celestial transients with the astronomical assets used to study these events.

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- ✦ “Only one important thing has happened in the last three days, and that is that nothing has happened.”
  - ✦ Steady state behavior is also significant in classifying, characterizing and understanding phenomena.

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- ✦ “It is the second most interesting object that I have seen in the North.”
  - ✦ Celestial transient alerts must convey human-oriented context and semantics.
  - ✦ ...even as humans recede from direct control of observatory systems.

# Two more quotes from Holmes



- ✦ “Mrs. Hudson has been knocked up!”
- ✦ “If you approach me, Watson, I shall order you out of the house.”

The game is afoot!



Coming soon, our book:

*<http://hotwireduniverse.org>*

Questions?