LIGO

Upper Limits Groups: Status and Plans

Alan Wiseman
LSC Software Coordinator

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Introduction to Upper Limit Investigations

- Origins and Underlying Motivations
- Specific Areas of Research
  - » Bursts (unmodelled) Things that go bump in the night
  - » Inspiral
  - » Stochastic Background
  - » Continuous Waves (pulsar)
- Early Goals
- E7 (“upper limits” run)
- Details about each effort
- S1
- Closing Out E7 work
- Thoughts about the future

Origins and Goals

- Origins …
  - » White Paper lays out a mechanism to establish research groups
  - » Proposal Driven
    - – Each group has a proposal on file
  - » Sociological aspects
    - – Open, advertised process
    - – Turn over
  - » Rai's reason: Mix Experimentalists and Theorists.
  - » … It may be the case that for years we will be setting upper limits.
- Goals
  - » Use engineering data, demonstrate that we can do science (from end to end) in the manner we will science with science-run data.
  - » (Co-opted) Sequence of mock data challenges to test the analysis pipeline.
  - » Software development
  - » Integrate detector characterization into the analysis stream.
  - » Intellectual exercise of finding methods of determining upper limits

Mock Data Challenges

- **Method for testing code and pipeline**
- **Each is undertaken as a working group**
- **Monitored by the Software Coordinator and Committee**

1) Data Conditioning MDC Sam Finn. [Done]

2) MPI MDC (wrapperAPI) Patrick Brady. [Done]

3) Database MDC Peter Shawhan. [Done]

4) Scientific Inchpebbles

Sequential Integration of all the search algorithms into the LDAS system

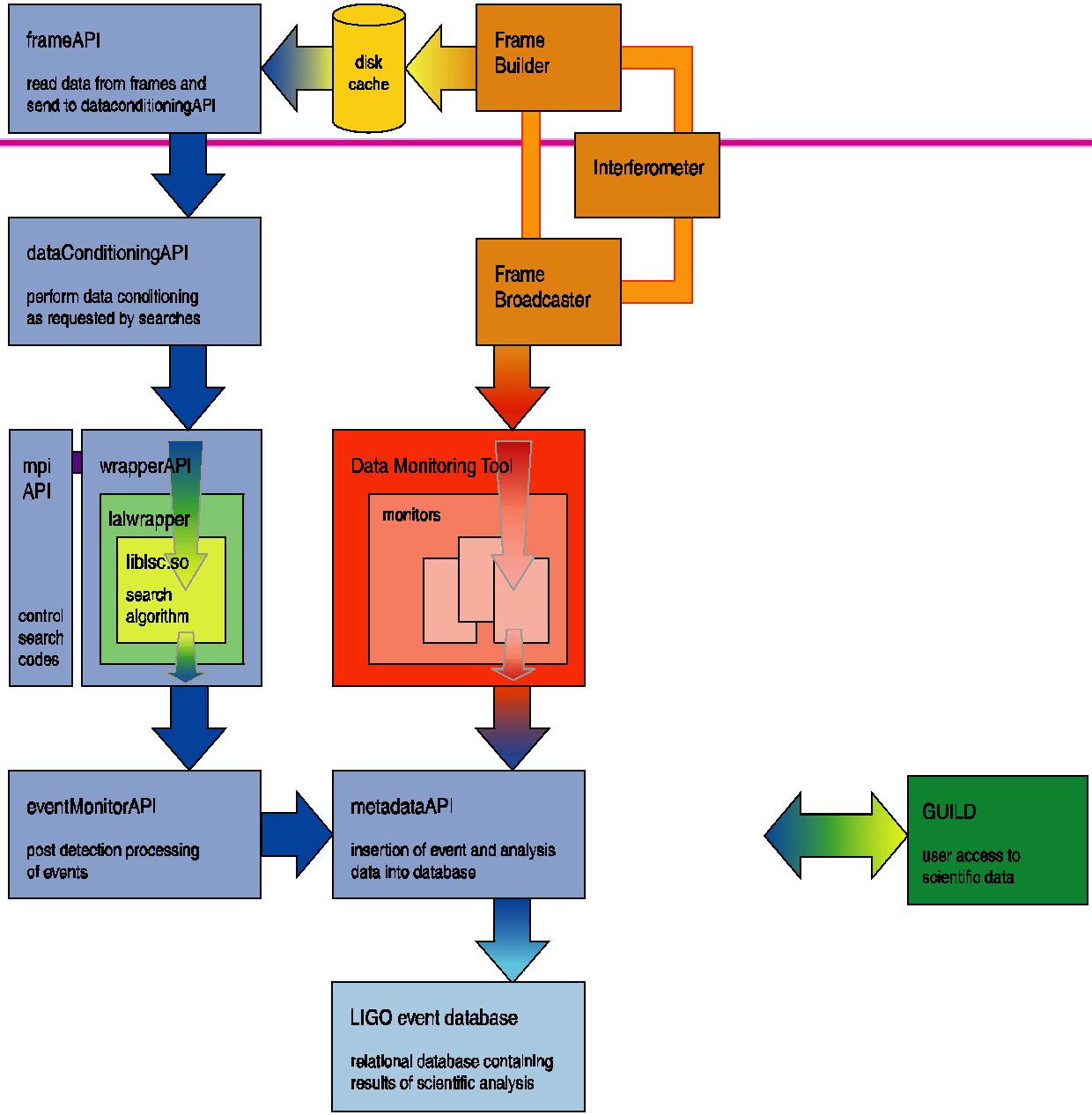
-- Inspiral: [May 16-18, Caltech] Done

-- Stochastic Background: [August 2001] Done

-- Burst (unmodeled sources): [August 2001] Done

-- Continuous Waves (pulsar): [Fall 2001] Done

5) Integrated Science MDC


frameAPI
read data from frames and send to dataconditioningAPI
disk cache
Frame Builder
Interferometer
Frame Broadcaster
dataConditioningAPI
perform data conditioning as requested by searches
mpi API
control search codes
wrapperAPI
lalwrapper
libIsc.so
search algorithm
Data Monitoring Tool
monitors
eventMonitorAPI
post detection processing of events
metadataAPI
insertion of event and analysis data into database
GUILD
user access to scientific data
LIGO event database
relational database containing results of scientific analysis

LDAS-LAL Interface

- LAL Code (search code written by the LSC in C)
- → fits into LDAS (written by the Lab in C++)
- → through the wrapperAPI

Features of the wrapperAPI

-- executable run on the Beowulf (uses MPI) [**main.c**]
-- Individual searches are loaded as a shared object
-- Same interface for all searches
-- Flexible enough to accommodate any gravitational wave search algorithm the LSC can write

-- Bullet-proof enough to work in the real-time LDAS environment

Status: Operational. Many things to do.

Web interface (Burst Group)

Burst Searches

- … ”two lines of analysis are proposed” …
  - » Untriggered: LIGO only
  - » Triggered: Conjunction with other non-gravitational observations: gamma ray bursts, neutrinos, super nova
- See Peter Saulson’s view graphs
  - » www.ligo.caltech.edu/~ajw/bursts/
- Untrigerred
  - » Combine results from DMT with …
  - » Search –code output
  - » Spectacular how the instrument information can

Burst Untriggered (cont)

- Three time-frequency methods of searching for eventss
  1. t-f clusters (Julien Sylvestre)
  2. Excess Power Statistic (Anderson, Brady , Creighton, Flannagan)
  3. Slope search (Ed Daw)
- All three have an operational “DSO” s
- All three methods have been used on the Playground data.

- Extensive use of vetos from the other channels.

Burst Triggered

- Look for events correlated with other types of events
  e.g. Gamma ray bursts (Bepposax)

- Statistical Method has been worked out by Finn, Romano, Mohanty.
  - » Cross correlate time series: When trigger is present, When trigger is not present
  - » Look at “ON” – “Off” distribution

Inspiral Searches

- Templated (Well modelled signal)
- Signal sweeps in time and frequency
- Difficult for instrument glitches to mimic the signal
  - » None the less large overlap with burst group on vetoes.
  - » Instrumental vetoes are important (but not as important as burst searches)
  - » B. Allen (Chi-squared) statistic: Signal strength must accumulate In frequency bands (or in time) according to the chirp.
  - » Large instrumental blips give huge signal to noise, but seldom pass the chi-squared test
- Well-studied method of taking the event list and producing a result: Loudest Event Statistic

Stochastic Bakground

- E7 Playground Data has been analyzed
- See the group web page
  - » www.phys.utb.edu/stochastic
- Cross Corrrelate data from two detectors
  - » (taking into account the time delay)
  - » Overlap reduction function
- Vigorous collaboration with bar detectors.

Continuous Waves

- All-sky all-frequency search:
  - » Effort led by AEI
  - » Hough Transform
    - – Demodulation (approx) in the freq domain
    - – Easily distributes across nodes of a cluster
  - » LAL Code is complete
  - » Chosen not to use LDAS infrastructure
- Front end to the CW searches is the SFT
  - » DSO exists
  - » Run in LDAS

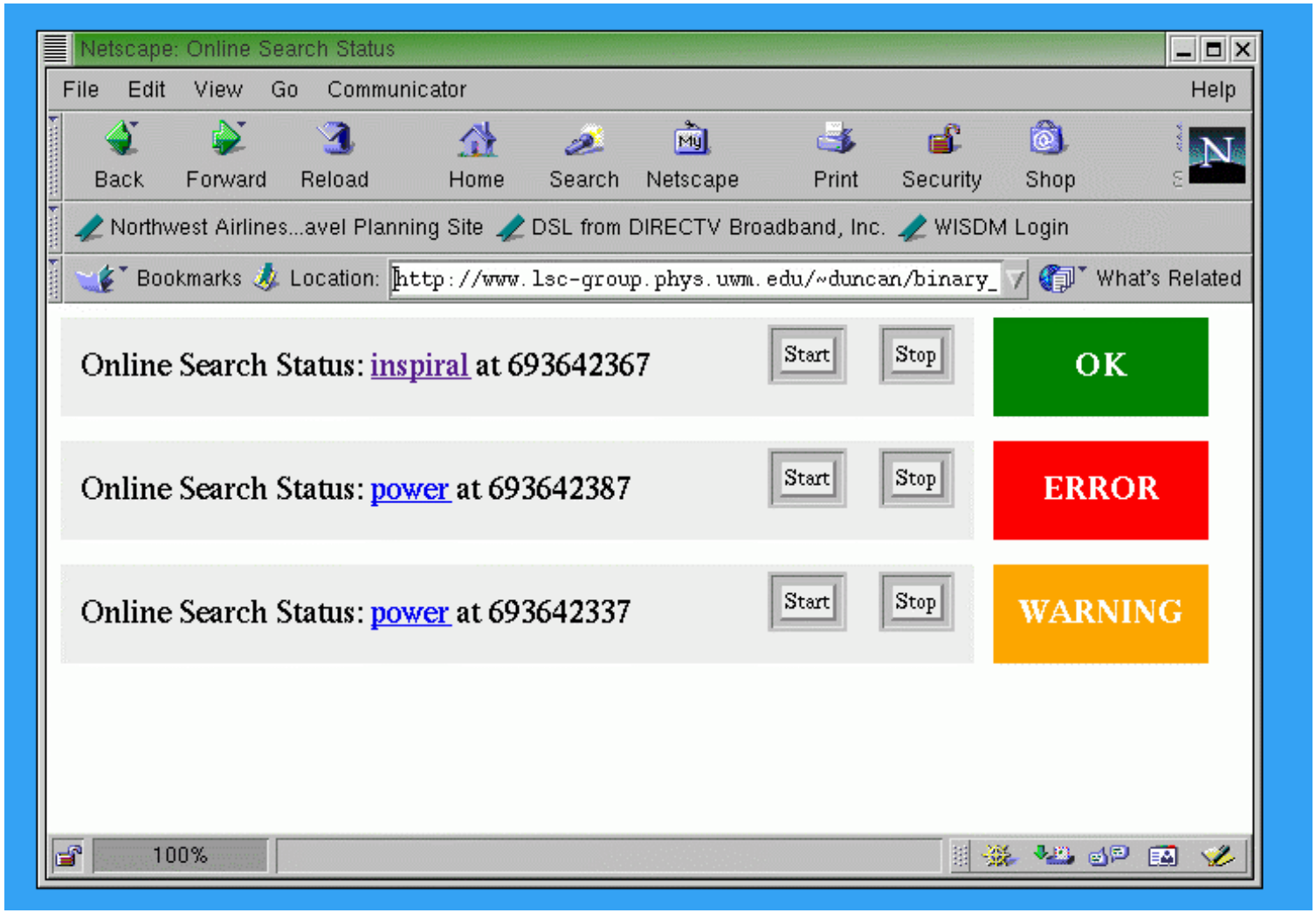
Assessment of E7 Progress

- It is coming to a close (Or being pushed aside by S1)
- Has been slow, eg only now working on all the data
  - » Reason behind this …
  - » Desire not to “data dredging”
  - » Answer as many questions as possible on subset of the data (Playground data)
  - » What thresholds to use, what methods work
  - » Then plow through the data
- Conflicting With S1 work. But moving on.
- My Concern: Haven’t completely addressed the issue of moving from an event list to a publication.

Moving on to S1

- Proposals for the UL groups addressed E7 only
  - » (Correctly) chosen to ignore this and keep going for now.
- Vigorous effort to run on line is under way
  - » Burst and inspiral searches will run in real time
  - » LSUG [LSC Software Users Group, Patrick Brady chair]
  - » Resource allocation
    - – Plans originates with the users
    - – Discussed in the UL chairs group
    - – Discussed in the LSC Computing Committee
    - – Not hardware limited in the search code running on the cluster
    - – All searches (and generation or reduced data sets) tax LDAS front-end

LIGO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Start
Stop
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Start
Stop
ERROR
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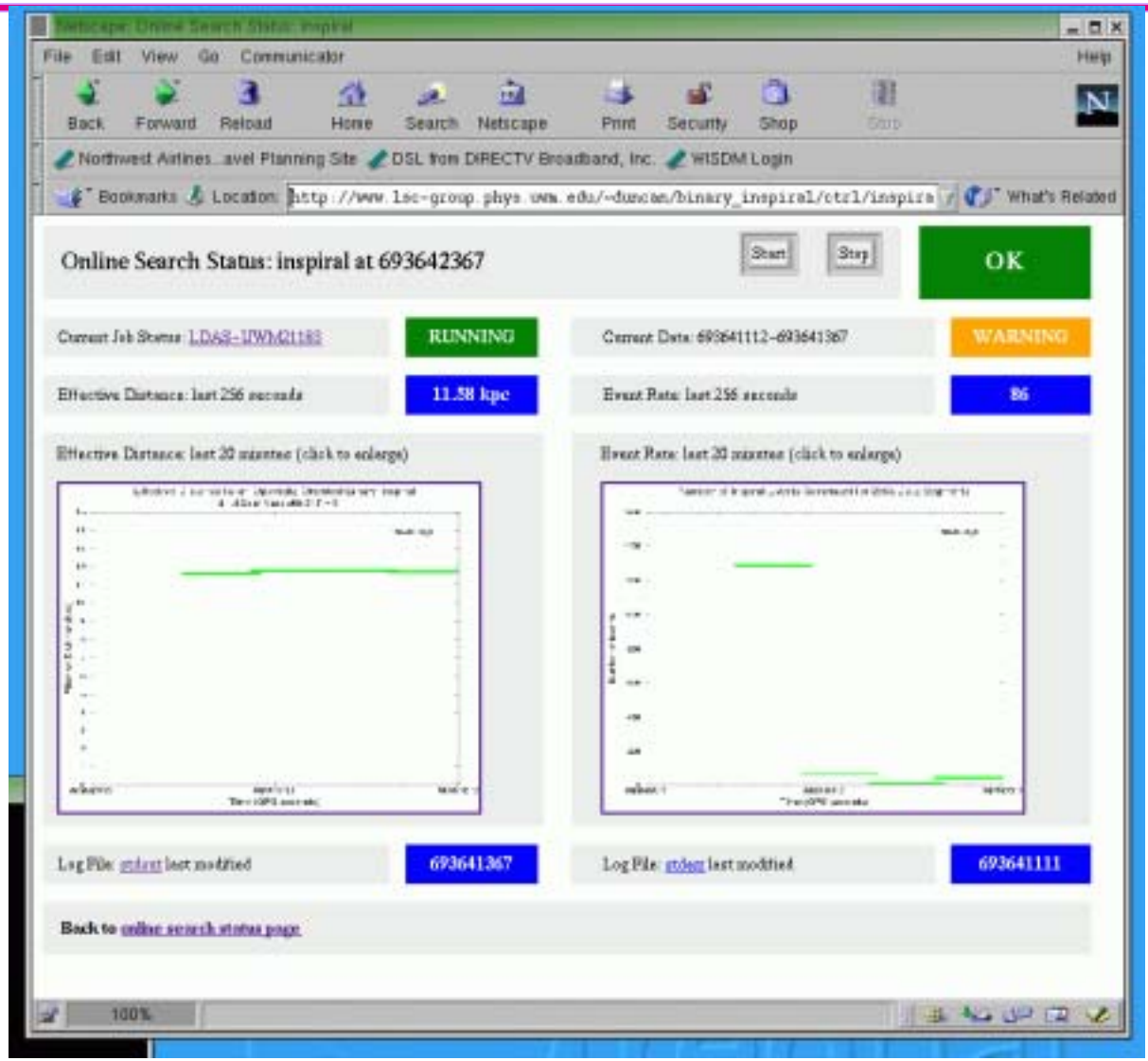
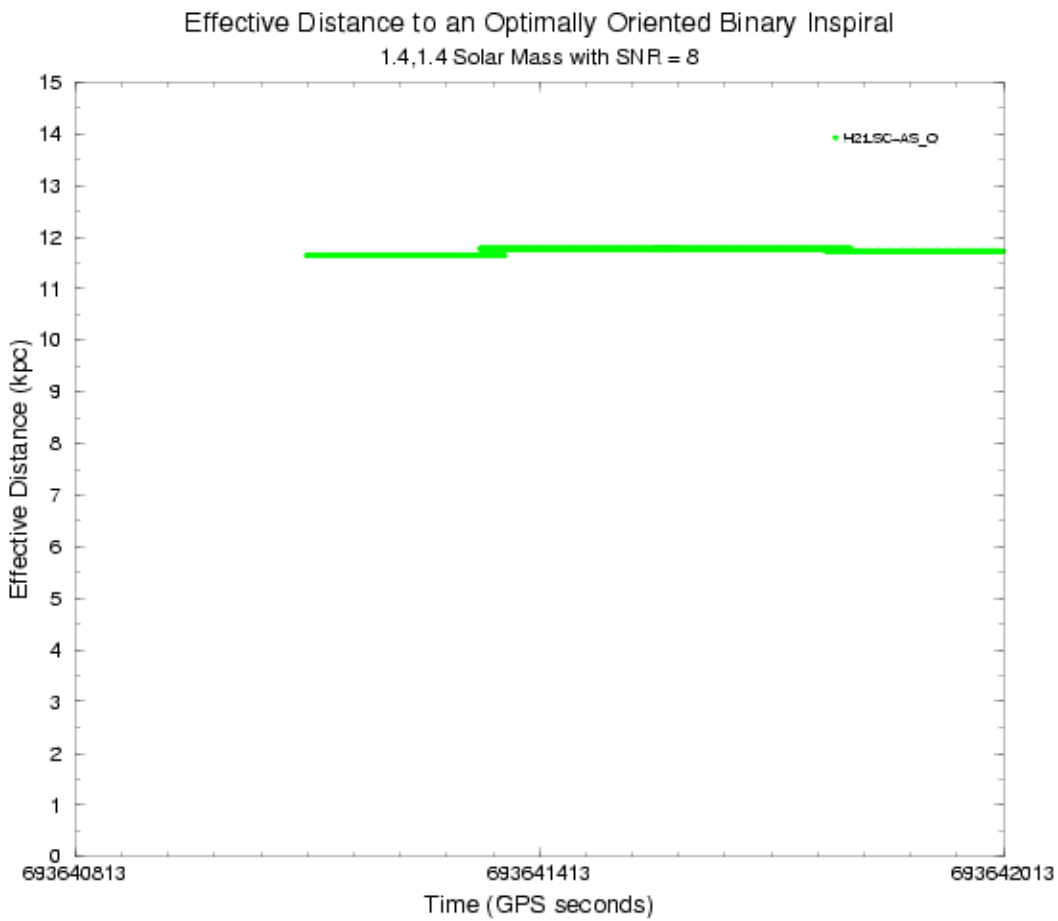
Start
Stop
WARNING
100%

S1: Online Monitors



S1: Online Monitor



Closing out the E7 Analysis

- Sequence of telecons for groups to present results to the entire collaboration
  - » Burst group last Friday
  - » Inspiral Tomorrow (28 June, 3pm EDT)
  - » Stochastic Background (5 July 3pm EDT)
  - » Continuous Waves (12 July, 3pm EDT)
- Write-up distributed before August LSC Meeting
- Presentations of results at August LSC Meetings
- Revisions
- …. On to S1 data

… Sequence of Telecons

- Analysis Proposals (e.g. the Upper Limit Group Proposals) keen on spelling what is to done
- … short on mechanisms for bringing the intermediate results back to the collaboration
- 6 months between LSC meetings is a long time to wait for these reports.

- Science Telecons every other week:
  - First four will be UL Groups
  - Emphasis on communicating results with the collaboration
  - Run somewhat like a department seminar series.
  - Mario Diaz has volunteered to run this.