

MONITORING SYSTEM OF THE AMS SCIENCE OPERATION CENTRE

B. SHAN¹ ON BEHALF OF AMS COLLABORATION

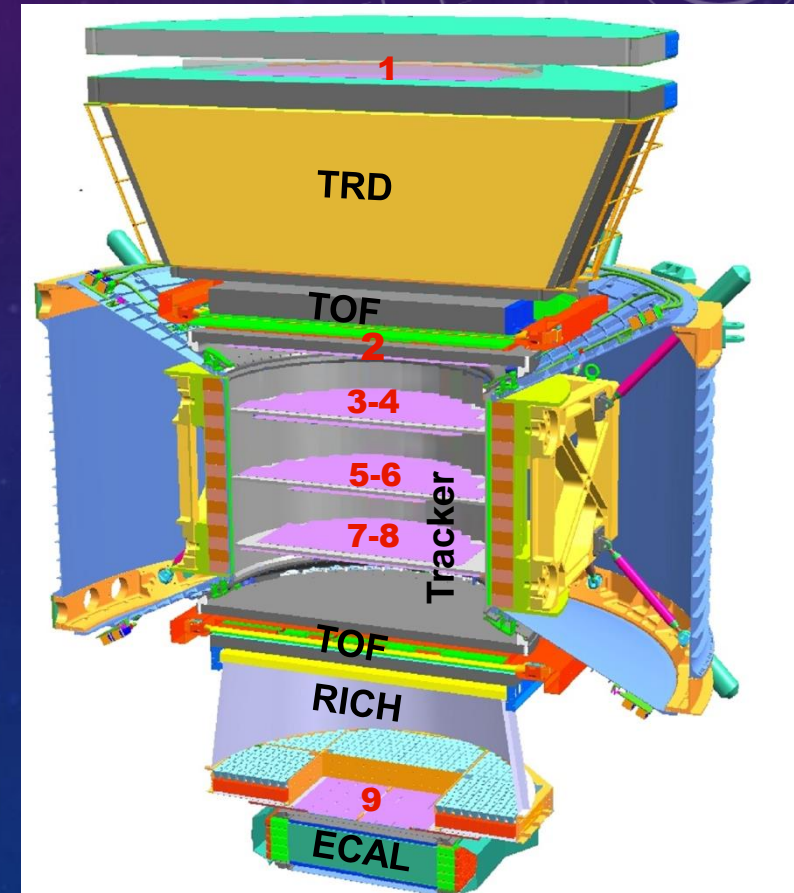
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CHEP 2018, SOFIA



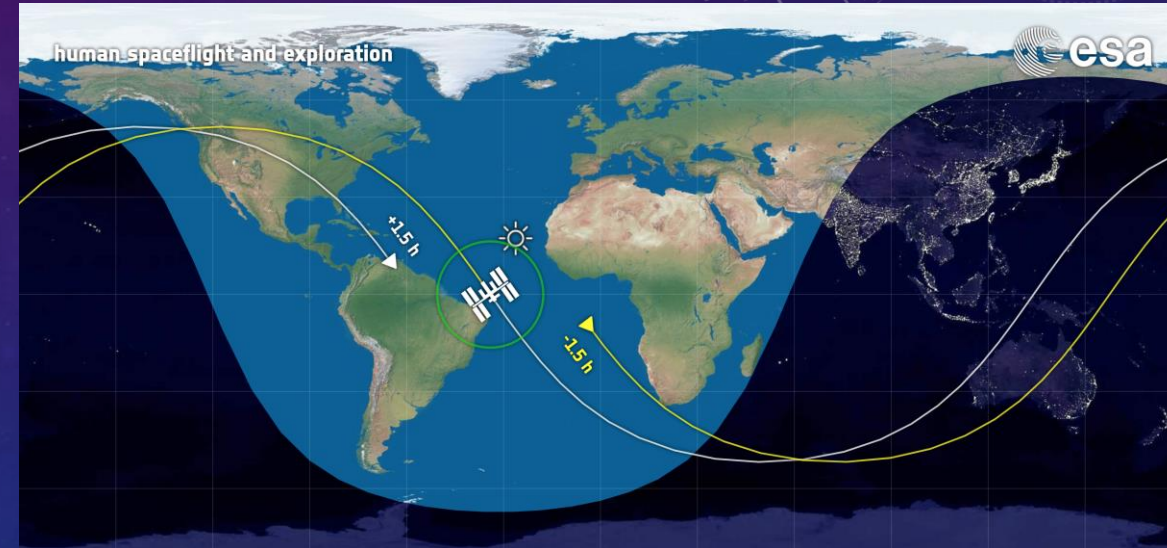
AMS EXPERIMENT

- The Alpha Magnetic Spectrometer (AMS) is a high energy physics experiment on board the International Space Station (ISS), featured:
 - Geometrical acceptance: $0.5 \text{ m}^2 \cdot \text{sr}$
 - Number of Read-out Channels: $\approx 200\text{K}$
 - Main payload of Space Shuttle Endeavour's last flight (May 16, 2011)
 - Installed on ISS on May 19, 2011
 - 7x24 running
 - Up to now, over 122 billion events collected
 - Max. event rate: 2KHz



AMS DATA FLOW

- Data transferred via relay satellites to Marshall Space Flight Center, then to CERN, nearly real-time, in form of one-minute-**frames**
- **Preproduction**: Frames → runs (**RAW**): 1 run = $\frac{1}{4}$ orbit (~23 minutes)
- **Standard Production**
 - Runs 7x24 on freshly arrived data
 - Initial data validation and indexing
 - Produces Data Summary Files and Event Tags (ROOT) for fast events selection
 - Usually be available within 2 hours after flight data arriving
 - Used to produce various calibrations for the second production as well as quick performance evaluation





SCIENCE OPERATION CENTER (SOC)

- Processing of the AMS science data for detector evaluation and physics analysis
 - Data production
 - Monte-Carlo simulation
- Maintaining local production farm
 - 20 hosts, 302 cores
 - 400 TB storage
- Operations on the services/resources provided by CERN IT
 - Batch (HTCondor & LSF), EOS, CASTOR, AFS, CVMFS, ELOG, PDB-R, etc.

Monitoring (all of the above) is important and challenging!

CHALLENGES OF SOC MONITORING

- Data taking and processing is 7x24 running
 - For detector performance evaluation
- Long data transmission path
- Widely distributed compute facilities
 - Europe: CERN, RWTH, CNAF, IN2P3, ...
 - Asia: SEU, Acad. Scinica, ...
 - America: NERSC, ALCF, ...
- Various service providers



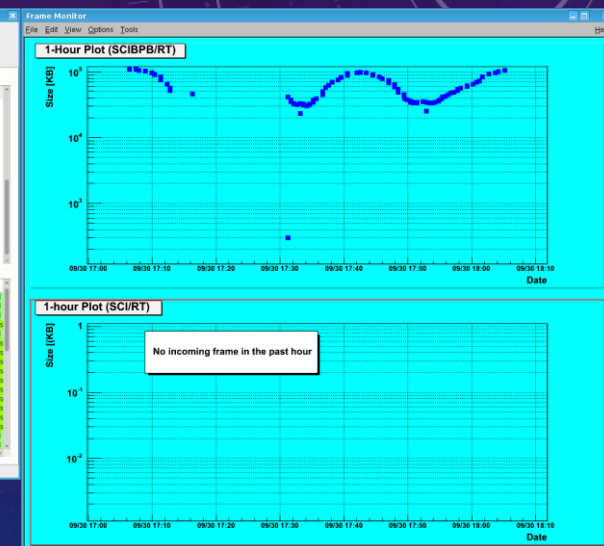


WHAT WE ALREADY HAVE

- Frame monitor
 - delay of frames
- Production monitor
 - standard production jobs
- Data files list
 - Summary of raw and ROOT files
- NetMonitor
 - Hardware/storage monitoring of local production farm

We need more centralized monitoring

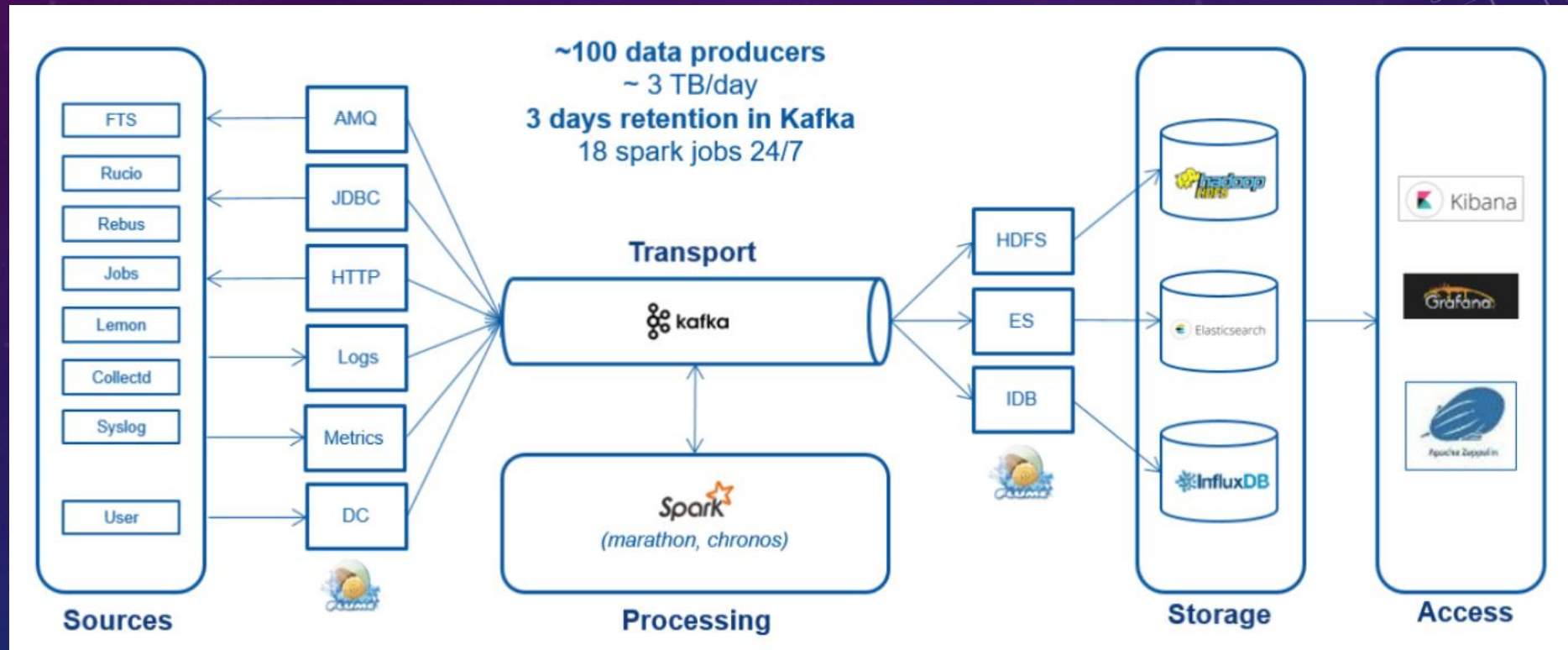
| Run | LId | Time | FirstEvent | LastEvent | Priority | History | Fails | DataMC | Host | Status |
|------------|--------|---------------------|------------|-----------|----------|----------|-------|--------|-----------------|------------|
| 1475239725 | 120464 | 2016.09.30 17:35:47 | 1 | 1089 | 0 | TableRun | 0 | 1 | spkub.cern.ch | Finished |
| 1475239722 | 120464 | 2016.09.30 17:37:28 | 1 | 1090 | 0 | TableRun | 0 | 1 | pcamss1.cern.ch | Finished |
| 1475239708 | 120455 | 2016.09.30 17:31:40 | 1 | 1085 | 0 | TableRun | 0 | 1 | pcamss1.cern.ch | Finished |
| 1475242460 | 120460 | 2016.09.30 17:58:41 | 1 | 404 | 3 | TableRun | 0 | 1 | pcamss1.cern.ch | Finished |
| 1475242426 | 120459 | 2016.09.30 17:58:49 | 1 | 404 | 3 | TableRun | 0 | 1 | pcamss1.cern.ch | Finished |
| 1475239281 | 120468 | 2016.09.30 17:18:53 | 1 | 589304 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475234134 | 120429 | 2016.09.30 16:24:05 | 1 | 637795 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475227105 | 120426 | 2016.09.30 15:11:16 | 1 | 927286 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475227271 | 120426 | 2016.09.30 16:23:39 | 1 | 728012 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475229944 | 120432 | 2016.09.30 16:24:04 | 1 | 919063 | 1 | TableRun | 0 | 1 | pcamss0.cern.ch | Processing |
| 1475235001 | 120438 | 2016.09.30 17:19:03 | 1 | 654187 | 1 | TableRun | 0 | 1 | pcamss0.cern.ch | Processing |
| 1475231356 | 120431 | 2016.09.30 16:24:23 | 1 | 580171 | 1 | TableRun | 0 | 1 | pcamss1.cern.ch | Processing |
| 1475228976 | 120425 | 2016.09.30 16:11:25 | 1 | 918753 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475226914 | 120427 | 2016.09.30 17:18:55 | 1 | 591937 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475224380 | 120426 | 2016.09.30 13:12:30 | 1 | 101048 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475239731 | 120426 | 2016.09.30 17:18:48 | 1 | 500525 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Processing |
| 1475232018 | 120421 | 2016.09.30 13:12:24 | 1 | 1147670 | 1 | TableRun | 0 | 1 | scamss0.cern.ch | Finished |



| Run | FilePaths | StartTime | Events | Type | SizeMB | Origin |
|-----------------------------|--|---------------------|--------|-----------------|--------|-------------------------------------|
| 1475104050 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475104050 | 02/10/2016 14:14:18 | 622159 | SCI 5 10 4 / OK | 1249 | SCIBP/RT/2527/328 SCIBP/RT/2527/331 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 14:37:49 | 473238 | SCI 5 10 4 / OK | 1005 | SCIBP/RT/2527/331 SCIBP/RT/2527/374 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 15:00:36 | 783507 | SCI 5 10 4 / OK | 1704 | SCIBP/RT/2527/374 SCIBP/RT/2527/398 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 15:24:06 | 602434 | SCI 5 10 4 / OK | 1207 | SCIBP/RT/2527/398 SCIBP/RT/2527/421 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 15:46:33 | 591960 | SCI 5 10 4 / OK | 1197 | SCIBP/RT/2527/421 SCIBP/RT/2527/445 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 16:10:24 | 304729 | SCI 5 10 4 / OK | 1046 | SCIBP/RT/2527/445 SCIBP/RT/2527/469 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 16:33:11 | 705795 | SCI 5 10 4 / OK | 2330 | SCIBP/RT/2527/469 SCIBP/RT/2527/492 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 16:56:43 | 100285 | SCI 5 10 4 / OK | 1005 | SCIBP/RT/2527/492 SCIBP/RT/2527/515 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 16:59:29 | 377538 | SCI 5 10 4 / OK | 1149 | SCIBP/RT/2527/515 SCIBP/RT/2527/539 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 17:19:30 | 596785 | SCI 5 10 4 / OK | 1205 | SCIBP/RT/2527/539 SCIBP/RT/2527/562 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 17:43:01 | 590558 | SCI 5 10 4 / OK | 1200 | SCIBP/RT/2527/562 SCIBP/RT/2527/586 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 18:05:48 | 619038 | SCI 5 10 4 / OK | 1204 | SCIBP/RT/2527/586 SCIBP/RT/2527/610 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 18:29:19 | 620912 | SCI 5 10 4 / OK | 1204 | SCIBP/RT/2527/610 SCIBP/RT/2527/633 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 18:52:06 | 605892 | SCI 5 10 4 / OK | 1221 | SCIBP/RT/2527/633 SCIBP/RT/2527/656 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 19:15:37 | 715797 | SCI 5 10 4 / OK | 1444 | SCIBP/RT/2527/656 SCIBP/RT/2527/680 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 19:38:24 | 774414 | SCI 5 10 4 / OK | 2886 | SCIBP/RT/2527/680 SCIBP/RT/2527/703 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 20:01:55 | 632260 | SCI 5 10 4 / OK | 1259 | SCIBP/RT/2527/703 SCIBP/RT/2527/727 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 20:24:42 | 617910 | SCI 5 10 4 / OK | 1237 | SCIBP/RT/2527/727 SCIBP/RT/2527/750 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 20:48:12 | 914319 | SCI 5 10 4 / OK | 1779 | SCIBP/RT/2527/750 SCIBP/RT/2527/775 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 21:10:59 | 806275 | SCI 5 10 4 / OK | 1637 | SCIBP/RT/2527/775 SCIBP/RT/2527/798 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 21:34:32 | 681502 | SCI 5 10 4 / OK | 1351 | SCIBP/RT/2527/798 SCIBP/RT/2527/821 |
| 1475110701 / 370f01b / f114 | /afs/cern.ch/ams/Offline/ReadDir/SC1/1475000000/1475110701 | 02/10/2016 21:57:18 | 630563 | SCI 5 10 4 / OK | 1276 | SCIBP/RT/2527/821 SCIBP/RT/2527/844 |

WHAT CERN IT PROVIDES

- MONIT Infrastructure [1]



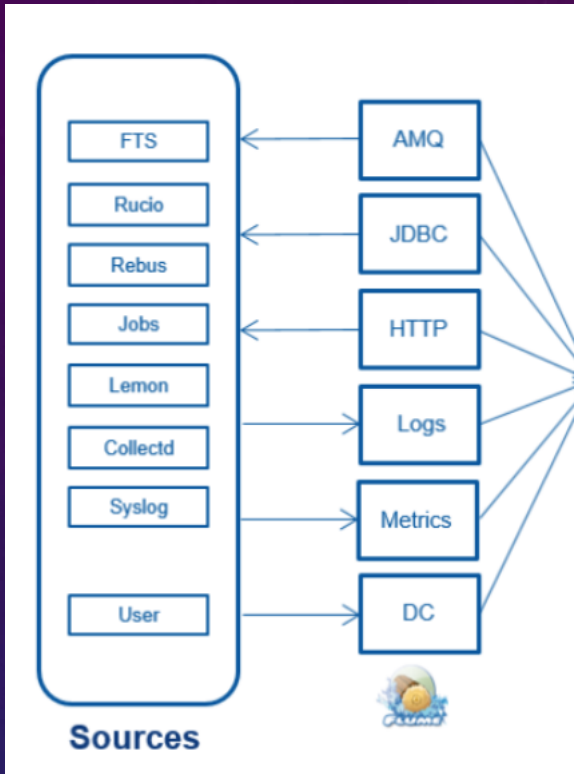
[1] <http://monitdocs.web.cern.ch/monitdocs/training/index.html>

ROADMAP – CERN IT SERVICES/METRICS

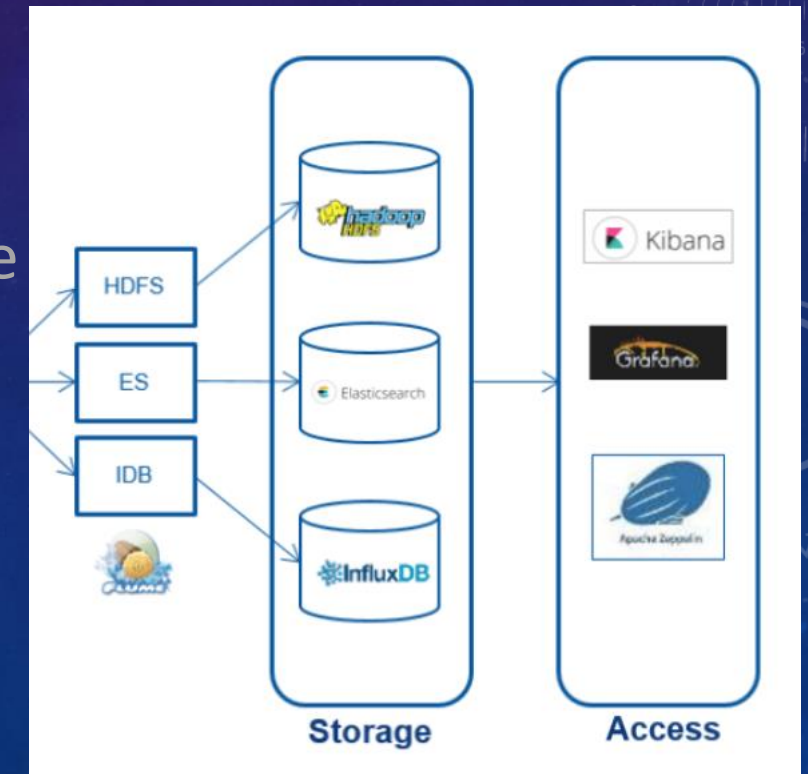
- Sources
 - Taken care of service providers (EOS/batch/FTS/... teams)
- Transport, processing, and storage
 - Taken care by MONIT
- Access
 - Modify dashboards from service providers to concentrate on the services/hosts which affect us
 - Create relevant Alerts with notifications



ROADMAP – OUR SERVICES/METRICS



- Sources
 - Modify our existing monitoring tools to send “Metrics” to InfluxDB
 - Use Collectd to gather the standard hardware/storage data of hosts
 - Log files to HDFS
 - And more...
- Transport, processing, and storage
 - Taken care by MONIT
- Access
 - Build dashboards
 - With Alerts



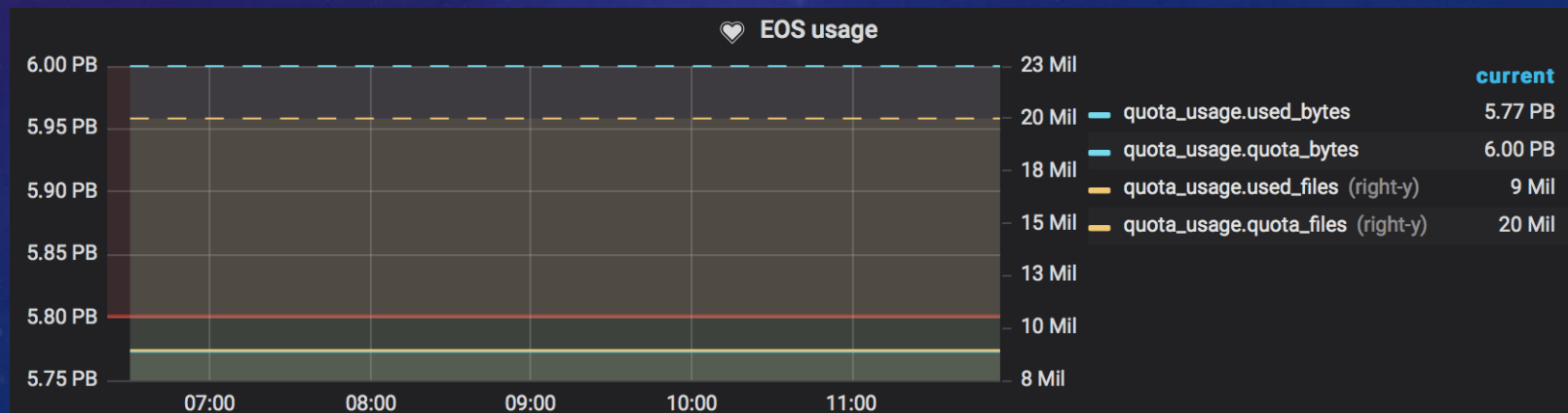
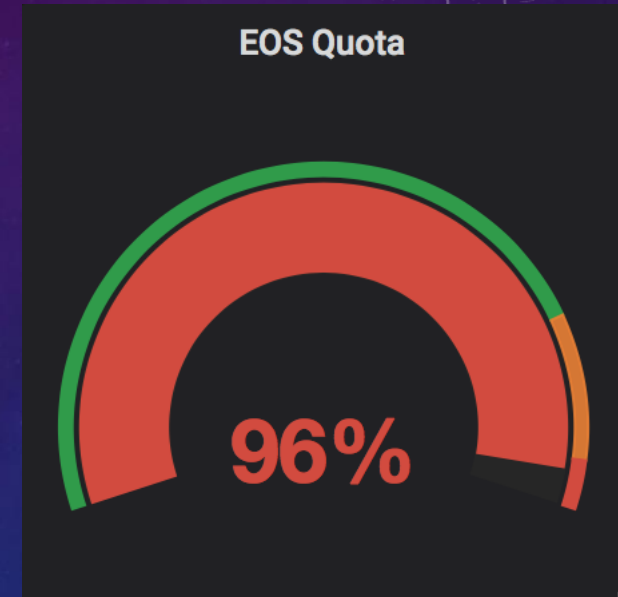
IMPLEMENTATION

- Request a new organization in monit-grafana
- Request the access right for the data sources we concern
 - `monit_idb_eos`, `monit_idb_tape`, `monit_idb_transfers`,
`monit_idb_collectd_XXX`
- Request to create our own InfluxDB data source
 - `monit_idb_amssoc`
 - Modify/write scripts/programs to send data to the data source
- Modify/write dashboards for data access



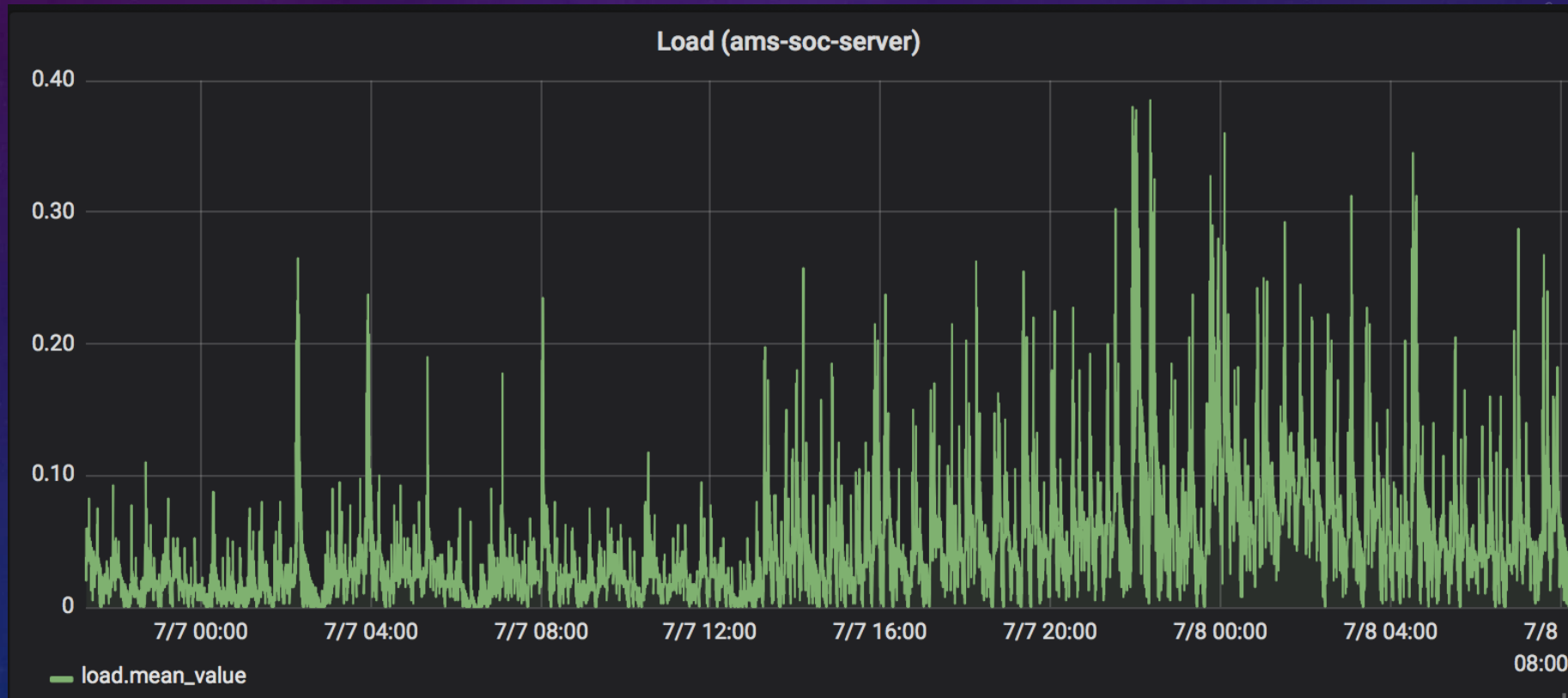
EXAMPLE — EOS QUOTA

- Digging data from monit_idb_eos
- Singlestat to show the percentage of byte usage
- Graph to show the data and history of:
 - used_bytes and quota_bytes
 - used_files and quota_files
- Alert to warn when approaching the quotas



EXAMPLE – HOST LOAD

- Digging data from monit_idb_collectd_load: load
- Graph to show the data and history of the load of specific host(s)





EXAMPLE – STANDARD PRODUCTION DELAYS

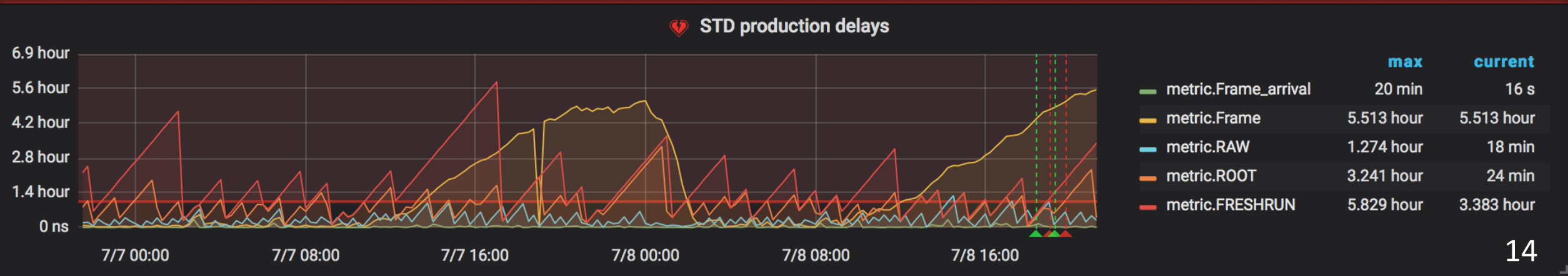
- Data format and structure
 - The last frame data arriving time
 - The last frame data collecting time
 - The last raw file validation time
 - The last ROOT file validation time
 - The latest reconstructed run collecting time
- A script running every 15 minutes to get the above data and post to <http://monit-metrics:10012/>

```
[{  
  "producer": "amssoc",  
  "type_prefix": "raw",  
  "type": "metric",  
  "timestamp": 1531077980243,  
  "experiment": "ams",  
  "frame_arr_delay": 32,  
  "raw_delay": 144,  
  "root_delay": 2075,  
  "frame_delay": 19580,  
  "fresh_run_delay": 12811,  
  "idb_tags": ["experiment"],  
  "idb_fields": ["frame_delay", "frame_arr_delay",  
    "raw_delay", "root_delay", "fresh_run_delay"]  
}]
```

EXAMPLE – STANDARD PRODUCTION DELAYS (CONT.)



| | | | | | |
|-----|---|--------------------|-----------|--------|-------------------|
| | Data Source | monit_idb_amssoc ▾ | ► Options | ► Help | ► Query Inspector |
| ► A | SELECT last("frame_arr_delay") AS "Frame_arrival" FROM "metric" WHERE \$timeFilter GROUP BY time(\$__interval) fill(none) | | | | |
| ► B | SELECT last("frame_delay") AS "Frame" FROM "metric" WHERE \$timeFilter GROUP BY time(\$__interval) fill(none) | | | | |
| ► C | SELECT last("raw_delay") AS "RAW" FROM "metric" WHERE \$timeFilter GROUP BY time(\$__interval) fill(none) | | | | |
| ► D | SELECT last("root_delay") AS "ROOT" FROM "metric" WHERE \$timeFilter GROUP BY time(\$__interval) fill(none) | | | | |
| ► E | SELECT last("fresh_run_delay") AS "FRESHRUN" FROM "metric" WHERE \$timeFilter GROUP BY time(\$__interval) fill(none) | | | | |



FURTHER WORKS

- Add more data sources:
 - Hardware: CPU/memory/disk/...
 - Batch service: under negotiation
 - MC production monitoring
 - Data from remote computing centers
- Add more alerts and connect to our FE
- Tune the dashboard structure



SUMMARY



- 7x24 data taking and processing brings more challenges for monitoring.
- SOC monitoring tools have been modified for the integration with MONIT infrastructure.
- Metrics Source provides a flexible way for our monitoring data ingestion.
- Grafana dashboard is used for visualization of the monitoring data from our own monitoring tools as well as from the CERN IT public services (EOS, Condor, FTS, etc.)

THANKS TO:

- Alberto Aimar, Simone Brundu, Pedro Andrade (monitoring)
- Herve Rousseau (EOS)
- Ben Jones (batch)
- Xavier Espinal Curull (IT contact)

