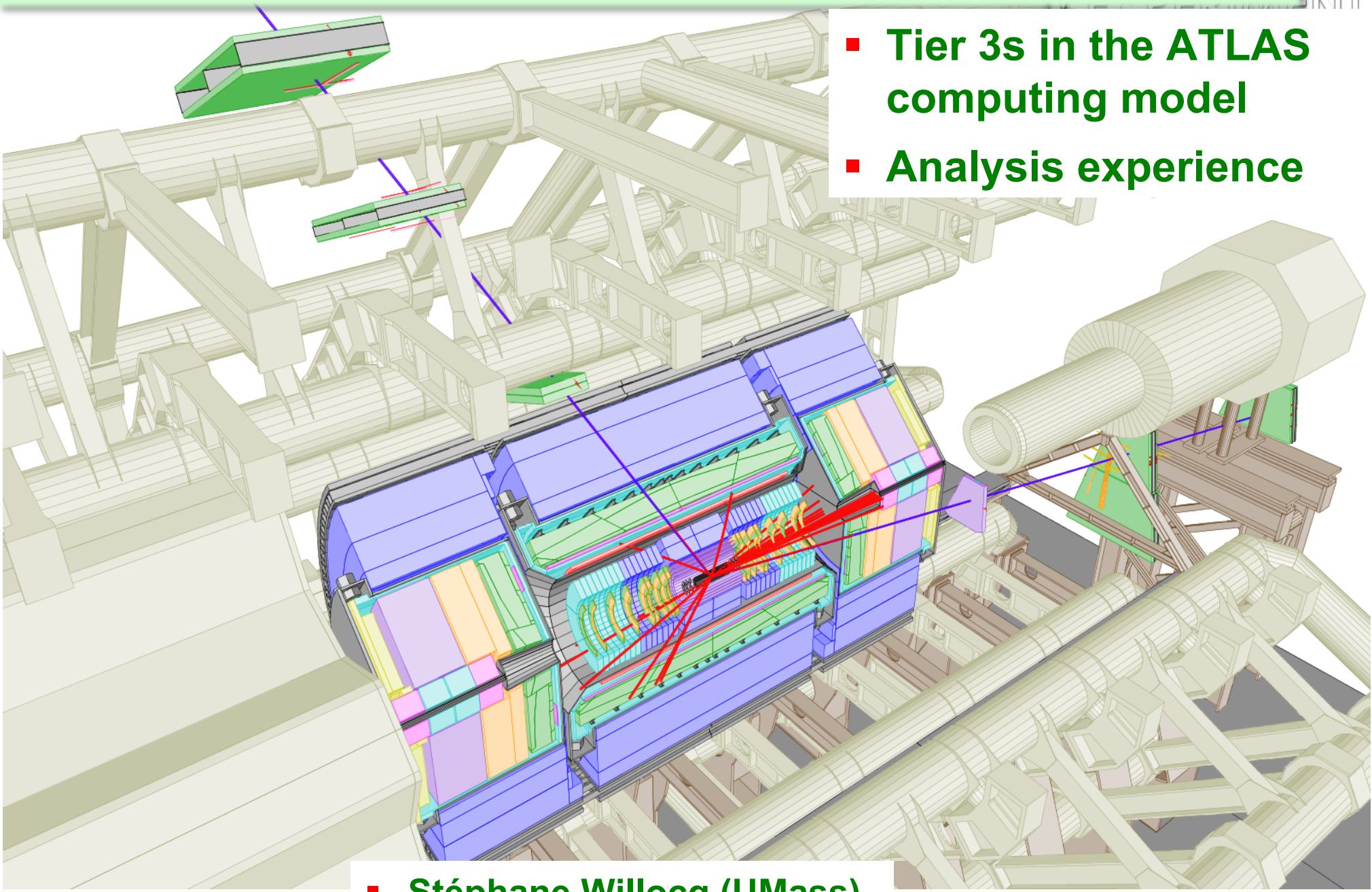
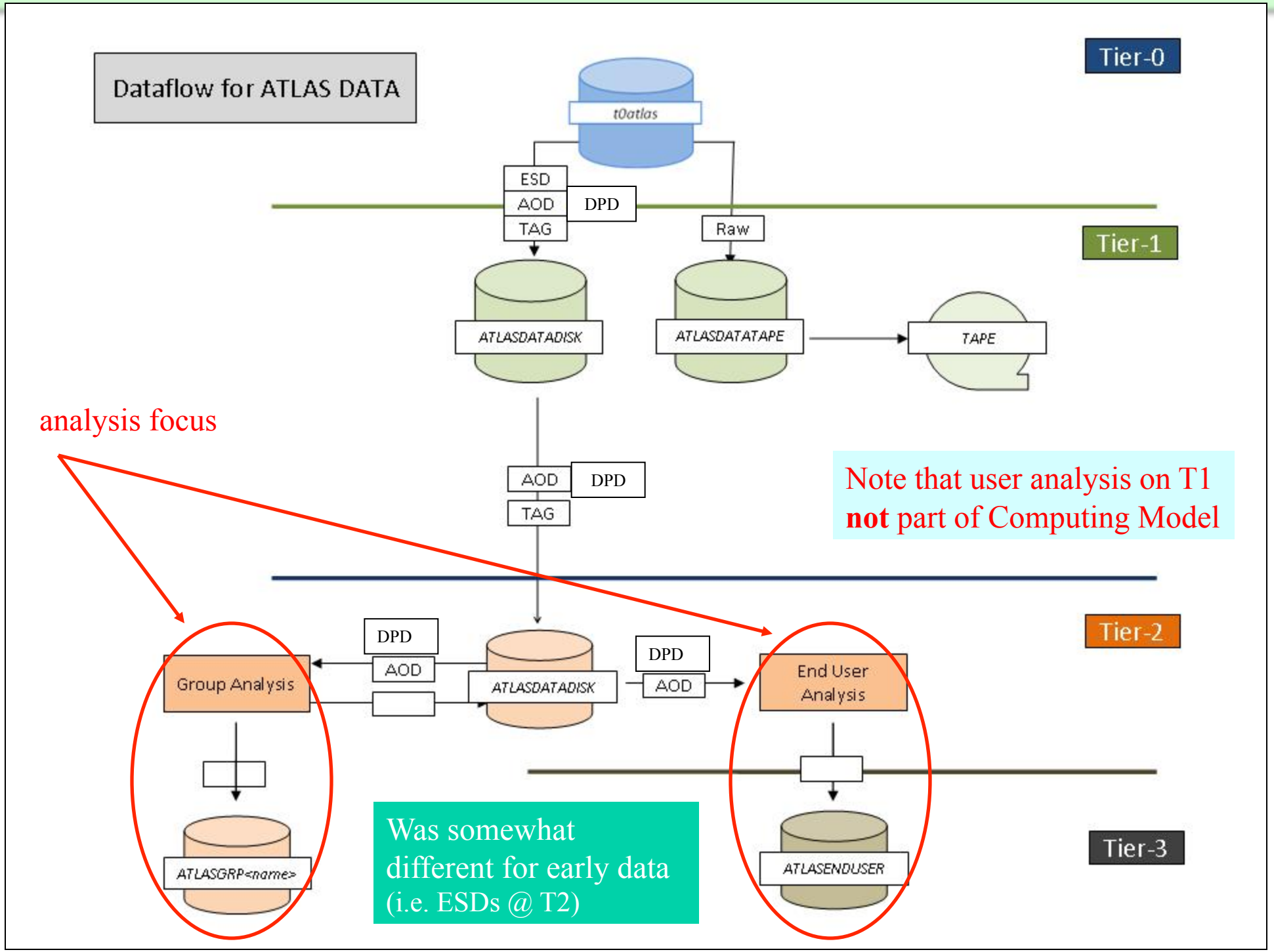
ATLAS Tier 3 Analysis Experience



- Tier 3s in the ATLAS computing model
- Analysis experience

- Stéphane Willocq (UMass)

(slightly outdated) ATLAS Computing Model



ATLAS Computing for Physics Analysis

- **Primary collision data and Monte Carlo samples provided by production system**

  RAW → ESD → AOD

  ~1.3 MB/evt ~1.6 MB/evt ~180 kB/evt

- **Primary chain supplemented with production of DPDs (derived physics data)**

  ESD/AOD → DPD

  ~50 kB/evt (varies with analysis)

- **Above processing chain done for different streams: egamma, muon, JetsTauEtmiss**
- **Skimming of data for specific event signatures (e.g. single lepton with minimum pT cut or dilepton) also done**
  → derived ESD and AOD (may include further data reduction)
  → will become more critical this year with larger datasets
- **D3PDs (ntuples) are the main data used in physics analysis**
  → specialized versions for W/Z, top, B, SUSY, jets, e/γ physics

ATLAS Computing for Physics Analysis

- **Grid computing has been exceedingly successful so far**
  - Production system (Tier 0, Tier 1 & Tier 2 Centers) takes care of primary chain + production of D3PDs for physics groups + detector performance groups
  - User production of analysis ntuples from ESD & AOD also quite popular → will become less feasible with growing datasets and diminishing access to ESDs in particular
- **End user analysis**
  - Data reduction done on the grid (→ D3PD/ntuples), including event skimming
  - Physics analysis can use either grid or local computing resources
  - Important for end user to have access to dedicated local resources
    → *fast turn around critical* at some stages of analysis (many iterations)
    → event selection / cut tuning
    → data / MC comparisons
    → background suppression & estimates
    → statistical ensemble tests
    → fast or generator-level MC production
    → tight schedules prior to conferences

Analysis development requires interactive or near interactive response

A specific analysis example

- **Search for new physics with dimuon events (2010 data)**
  - **Data reduction done on the grid to produce D3PD/ntuples**
    - Single-muon and dimuon data skims + event picking
    - Submission from Tier 3
    - This step performed twice over several months due to data reprocessing
  - **Data transfer to Tier 3**
    - Used dq2-get
    - Took a few days to acquire all data and MC samples (performed twice)
  - **Cut tuning / performance studies performed @ Tier 3**
    - Cut tuning for muon selection based on data/MC comparisons
    - Processed full set of ntuples many times (~50 times)
    - Turn around time about 10 mins per iteration thanks to dedicated small ntuple + running in batch on ~50 cores
  - **Full event selection + analysis @ Tier 3 + laptop**
    - Processing single-muon data skim + all MC samples using working group D3PDs took ~8 hours on same batch system (clearly too long, so done only a small number of times)
    - Statistical analysis took ~1 hour; also ran *event display* on selected events
    - Final plots + some of the statistical analysis made on laptop

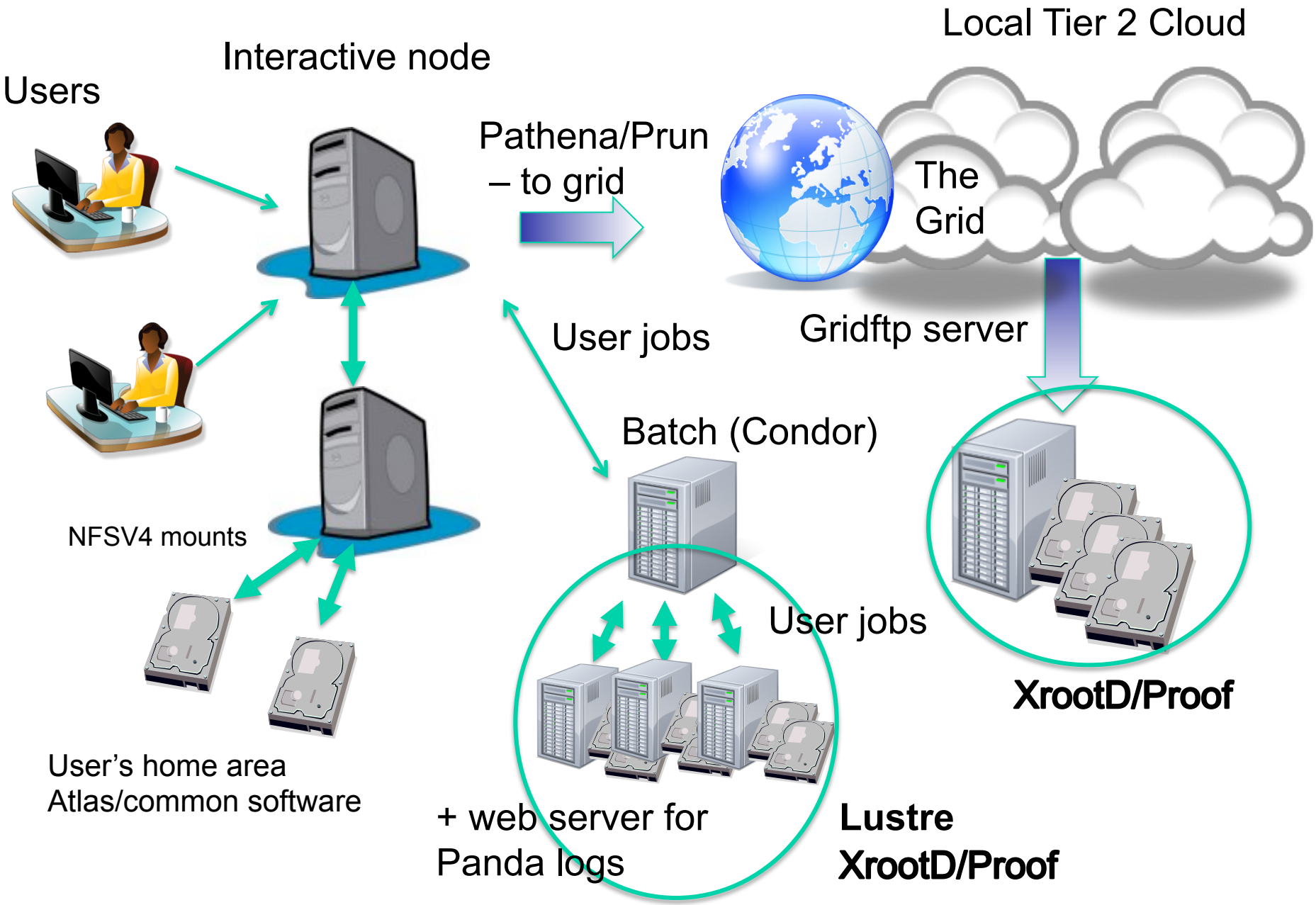
A second specific analysis example

- **Standard Model physics with W/Z events (2010 data)**
  - **Data reduction done on the grid to produce D3PD/ntuples**
    - Single-muon data skims + event picking
    - Submission from Tier 3
    - This step performed once
  - **Data transfer to Tier 3**
    - Used dq2-get
    - Took a few days to acquire all data and MC samples
  - **Cut tuning / performance studies performed @ Tier 3**
    - Cut tuning for muon selection & jet cleaning/selection
    - Processed full set of ntuples many times (~50 times)
    - Turn around time about 2 hours per iteration thanks to some ROOT optimization (file merging, reading only branches that are needed, TTree caching) + running in batch on ~50 cores
  - **Final analysis @ Tier 3**
    - Analysis of histogram files produced in previous step
    - Runs in ~5 mins
    - Final plots and results run interactively on single processor

Tier 3g Configuration: What do you need?

- Interactive nodes
- Can submit grid jobs
- Batch system with worker nodes
- ATLAS code available
- Client tools used to fetch data (dq2-ls, dq2-get)
- Storage
  - Located on worker nodes
    - Lustre/GPFS
    - XROOTD
  - Located on dedicated file servers
    - NFS/XROOTD

Tier 3g Configuration



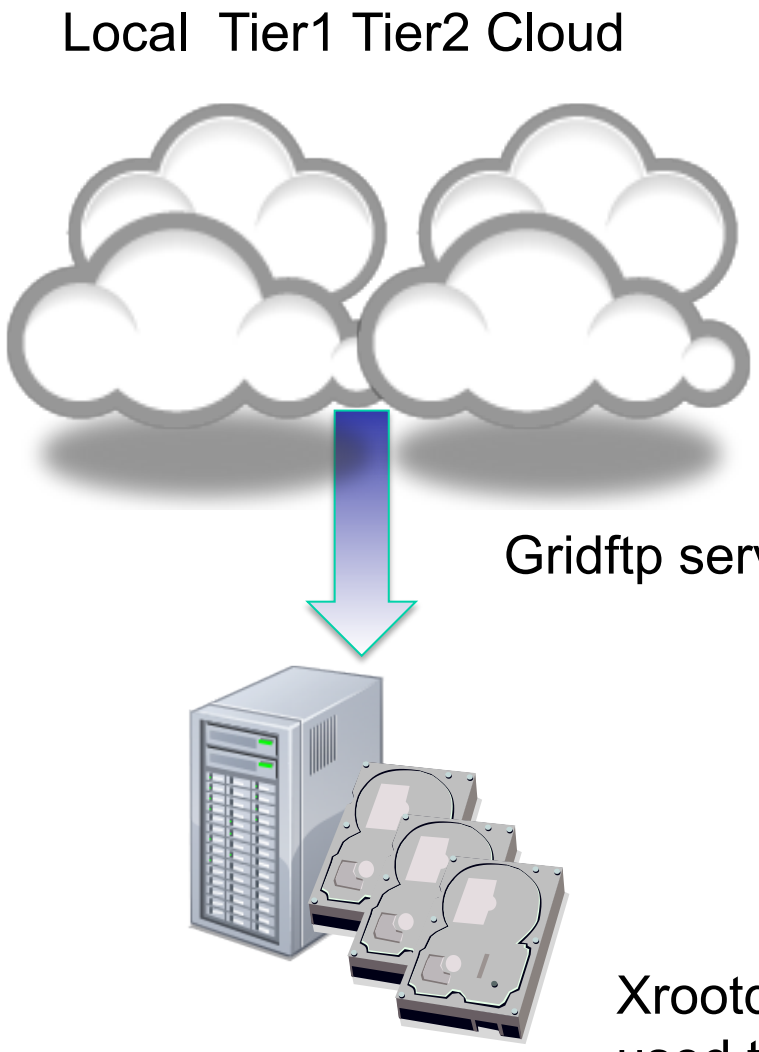
Data Transfers to Tier 3

Two methods

- Enhanced dq2-get (uses fts channel)
- Data subscription
  - SRM/gridftp server part of DDM Tiers of Atlas (ToA)

Bestman Storage Resource Manager (SRM) (fileserver)

- Sites in DDM ToA will be tested frequently
- Troublesome sites will be blacklisted (no data) extra support load

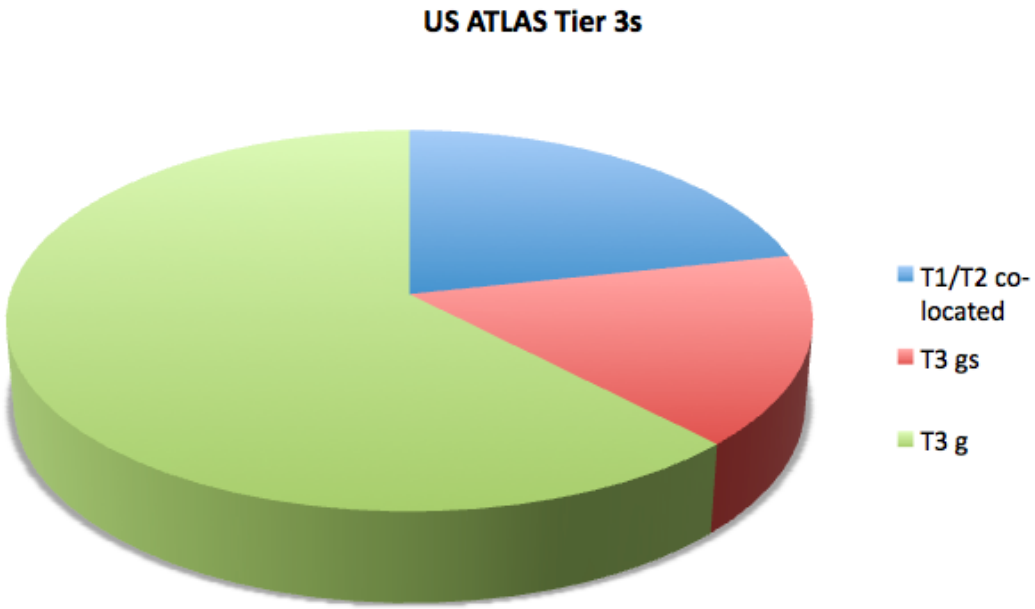


Software for Tier 3

- **Required software to operate Tier 3**
  - Installed and maintained via ManageTier3SW package
    → e.g. grid tools
- **ATLAS releases**
  - Downloaded via release kits
  - New solution based on CERN VM uses cvmfs to cache ATLAS release software on demand
    → same mechanism can also provide *conditions DB*
  - cvmfs will be used at Tier 1 and Tier 2 also
- **Documentation and analysis examples**
  - Documentation for complete setup available via wiki
  - Complete analysis examples specifically aimed at Tier 3 setup available via wiki (ATLAS Physics Workbook)
- **D3PD analysis**
  - New effort on efficient reading and software examples for D3PD analysis at T3

Survey of US ATLAS Tier 3 Centers

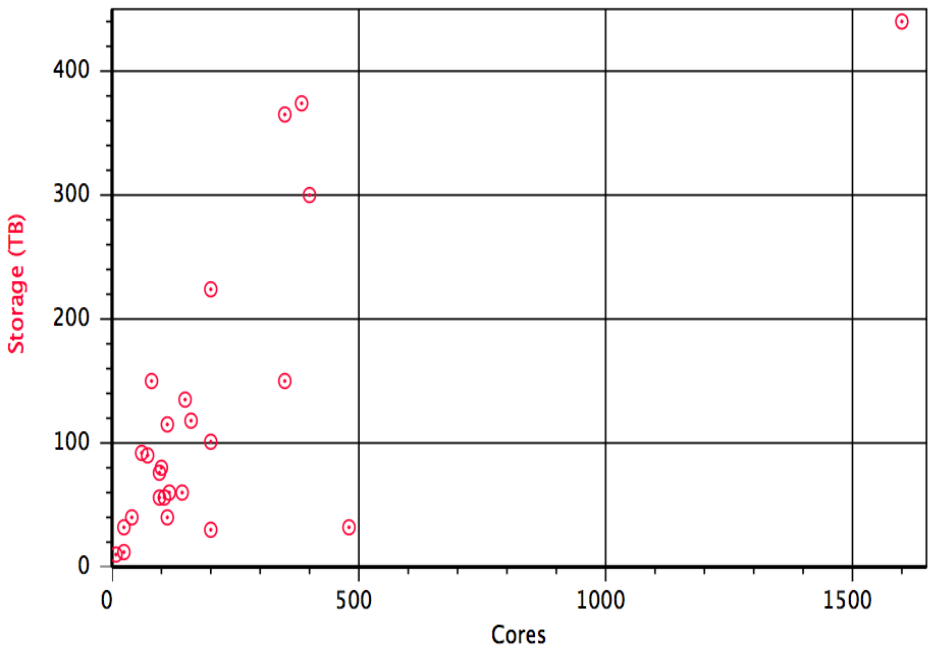
- **Jan-Feb 2011 survey of all US ATLAS T3s**
  - **42 potential sites (information not yet available for all of them)**
    - **8 co-located with T1 or T2**
    - **6 T3 gs (w/ grid services)**
    - **23 T3 g (w/ connectivity to the grid)**

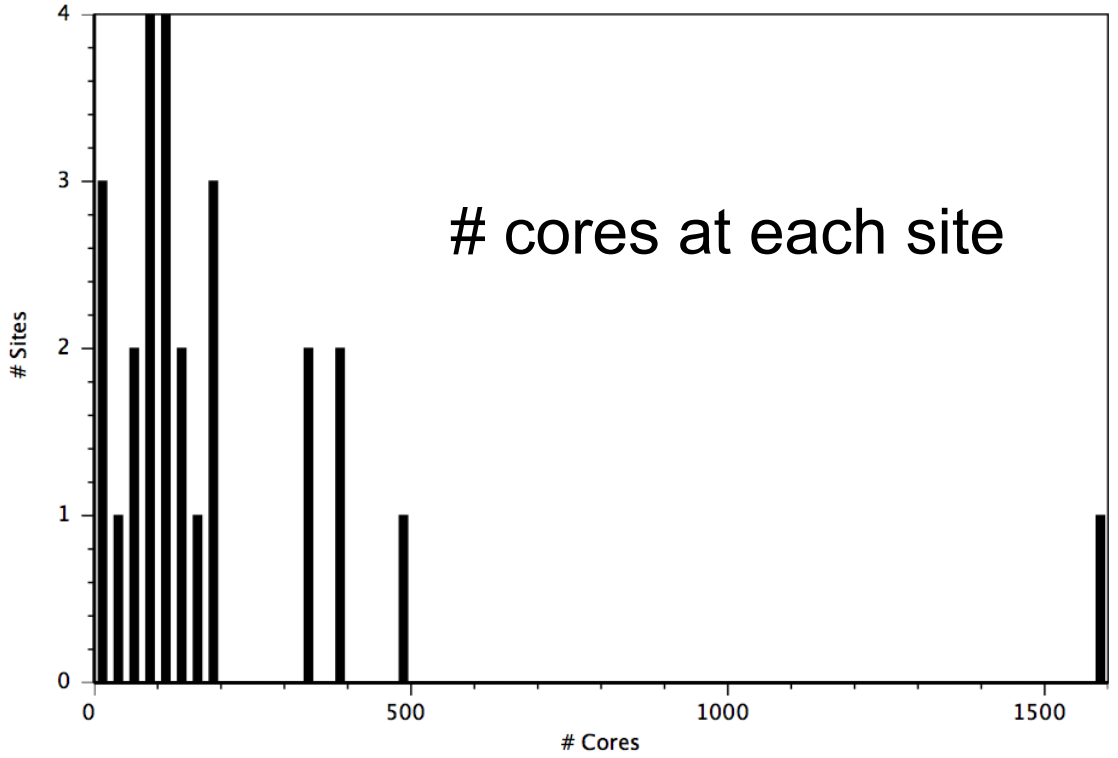


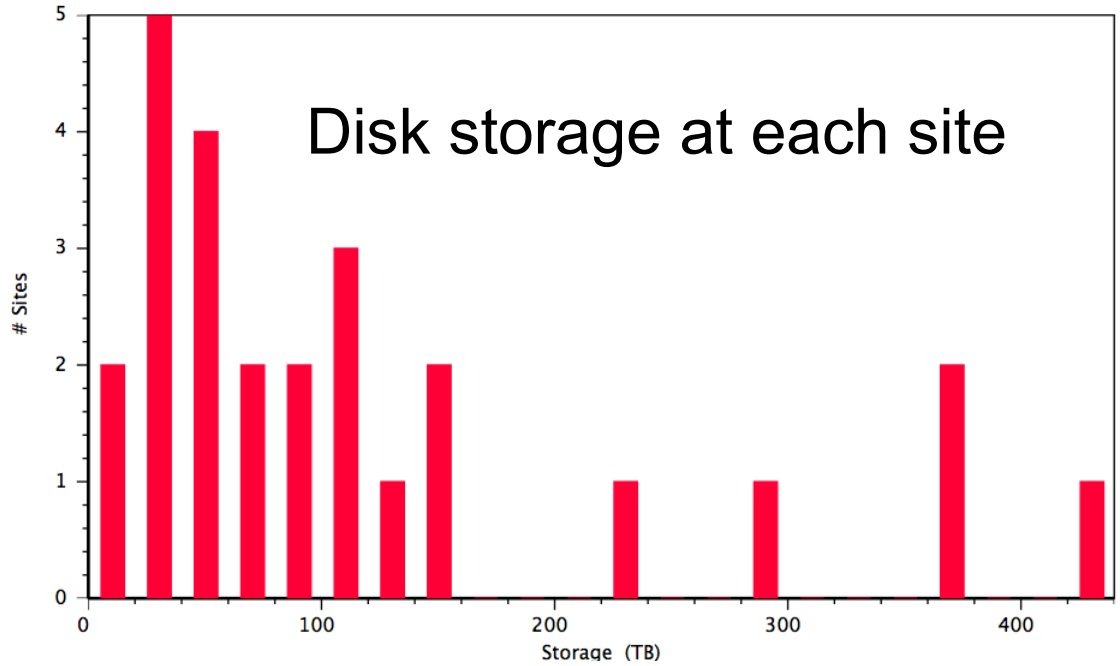
  - **Current status**
    - **25 sites functional**
    - **7 sites setting up**
    - **1 site just received hardware**
    - **2 sites waiting for hardware**
    - **3 sites planning purchase**
  - **Many institutes able to purchase Tier 3 equipment thanks to ARRA funding**

Survey of US ATLAS Tier 3 Centers

- **Most sites are relatively small computing facilities:**
- **# cores < 200**
- **Storage < 160 TB**







Summary & Outlook

- **Many Tier 3 centers have and will come online soon**
- **Rapidly becoming critical computing component for production of physics analysis results**
- **Tier 3 model in place with good documentation and support**
  → will continue to evolve with the computing model for ATLAS
- **Promising features coming soon**
  - **Software distribution via CERN VM File System (cvmfs)**
    → particularly useful for conditions data + ease local management load
  - **Data distribution between sites via Xrootd federation**
    → promising for collaborating groups at different institutes