



The MINOS Experiment and the Grid

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The MINOS Experiment

- **Neutrino oscillation search experiment** – currently running and taking data
- Designed to look for the oscillation of ν_μ to ν_τ , but can also be used to study $\nu_\mu \rightarrow \nu_e$, atmospheric neutrinos, sterile neutrinos, etc.

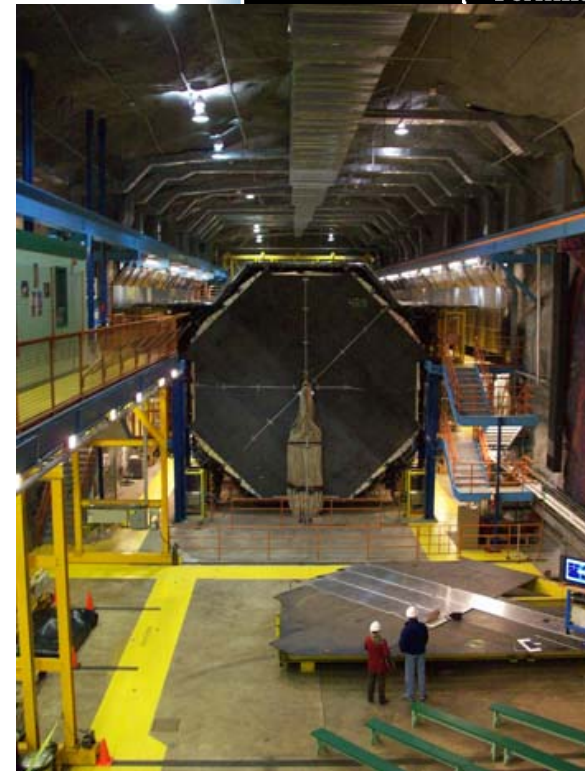
- **Location:** one smaller Near Detector at FNAL (outside Chicago), one larger Far Detector (Soudan Mine, Minnesota), 735 km away

- **NUMI beam:** ν_μ beam produced at Fermilab, aimed at Near and Far Detectors

- Two detectors = can better understand beam characteristics, compare oscillated/unoscillated signal

Detectors: alternating hexagonal planes of steel calorimeter and plastic scintillator

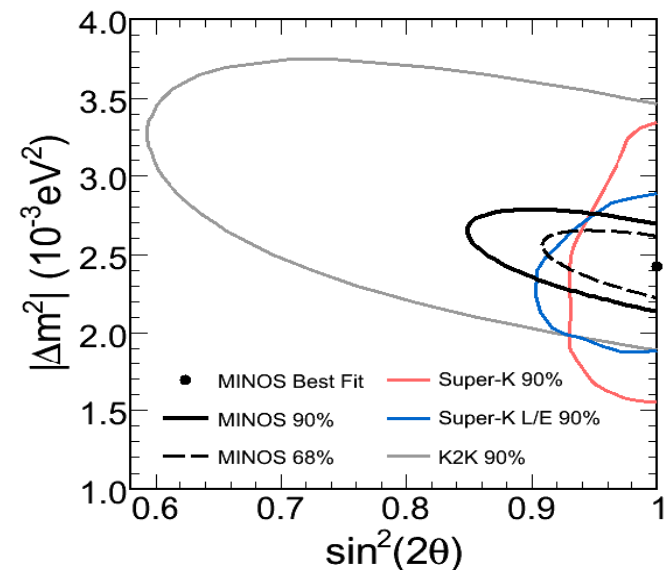
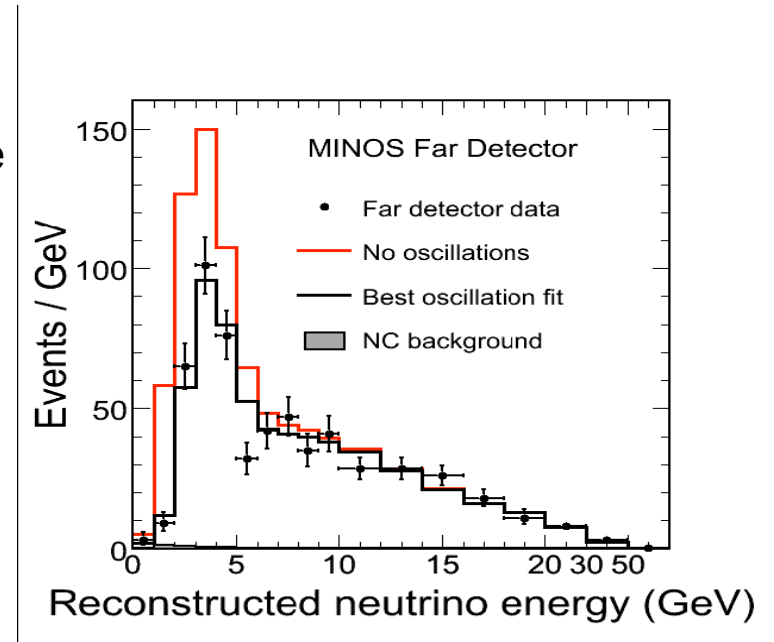
- Use orthogonal scintillator planes for 3D reconstruction – PMT readout
- 1.2 T toroidal magnetic field





MINOS: Physics

- **ν_μ disappearance:** search for oscillation signal
 - compare of the rate of charged current ν_μ interactions in the Near and Far detector
 - Monte Carlo data predicts a different Far Detector signal for oscillation versus no oscillation
 - oscillation definitely observed
 - MINOS = most sensitive measurement in world of neutrino mass (squared) difference:
 $|\Delta m_{32}^2| = (2.43 \pm 0.13) \times 10^{-3} \text{ eV}^2$
- **NC analysis:** Neutral Current event disappearance, search for sterile neutrinos
- **ν_e appearance analysis:** (see next slide)
- atmospheric neutrino analysis, anti-neutrinos, etc
- All of the above studies rely in numerous ways on simulated Monte Carlo data
 - while much of this production is done at FNAL, RAL and the UK Grid are an important second location for MC production and other MINOS analysis
 - **Nick West** oversees and coordinates MINOS' work on the Grid
 - MC production at RAL: currently Phil Rodrigues
 - other work: LEM processing (myself)





Example: LEM processing

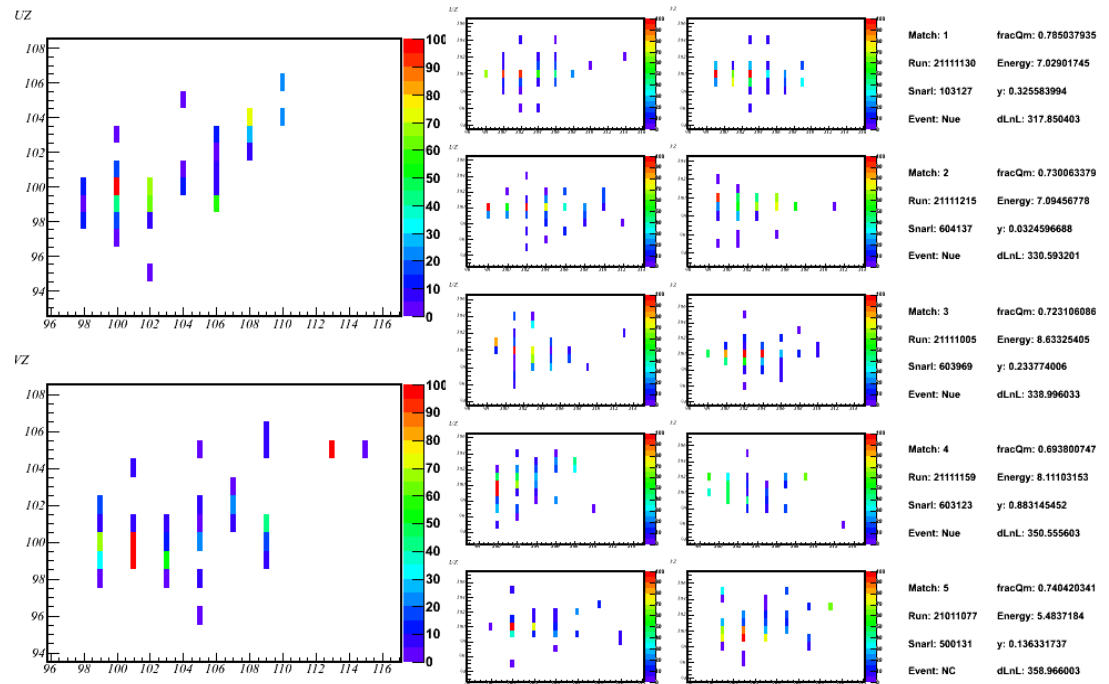
ν_e Appearance analysis:

- In addition to main ν_μ disappearance analysis, MINOS also capable of investigating the possibility of $\nu_\mu \rightarrow \nu_e$
 - determination of θ_{13} mixing angle, leading to possibility of CP violation

- Smallness of expected signal, poor detector resolution require careful PID design

“Library Event Matching” (LEM) PID:

- Idea is simple: take input event and compare it to a very large library of NC and nue CC template events
 - take N best matches and construct a discriminant
- Previous analysis: 20 million library events, produced at Caltech (slow)
- Next analysis: 50 million events with up-to-date MC and MINOS reconstruction \rightarrow *to be produced at RAL on Grid*



Run: 21411003 Snarl: 64 Event: Nue
 Energy: 7.90309238 Y: -1 fracCC: 0.699999988

Quit Root Quit Display Next Event Previous Event 0 5 10 15



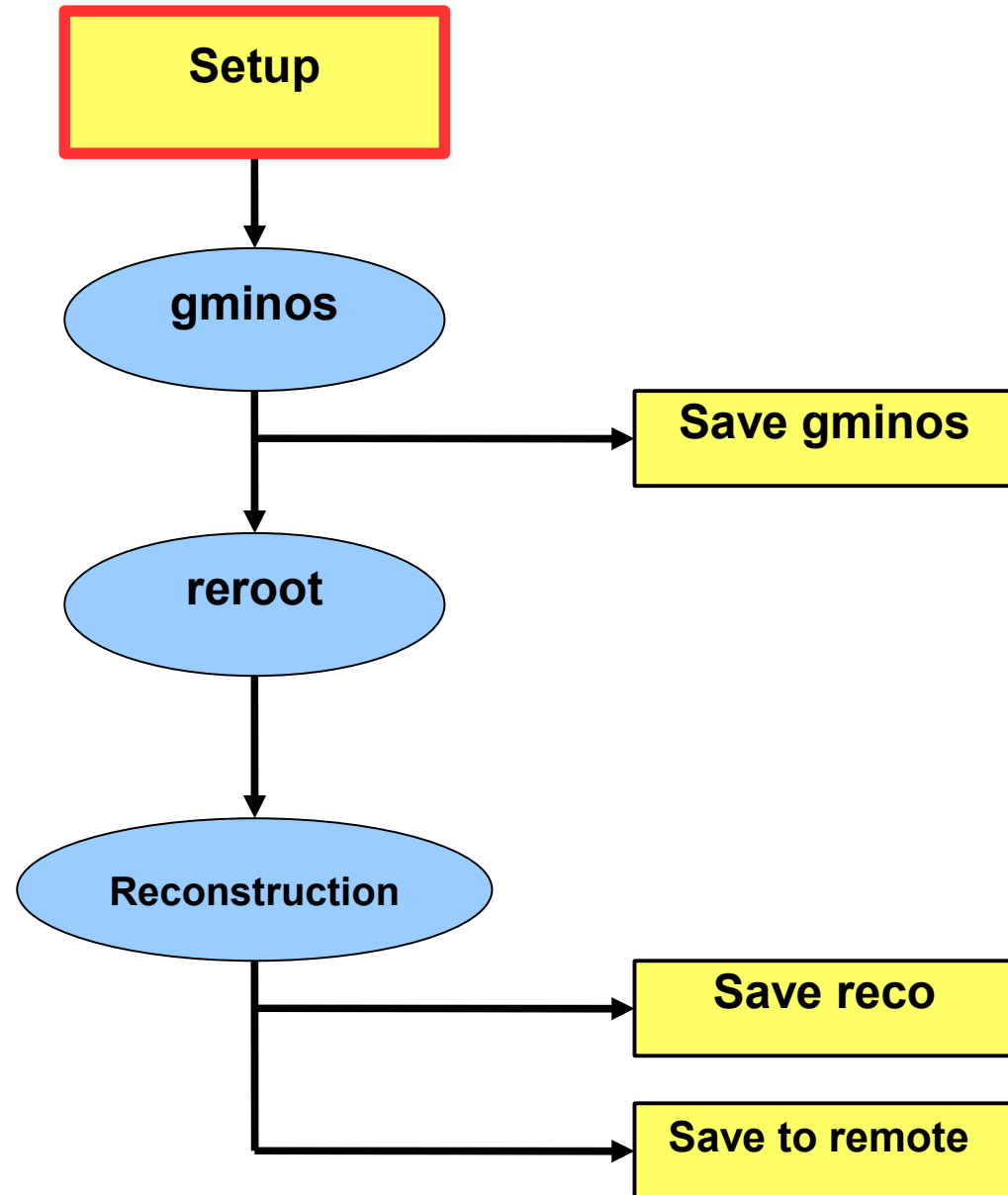
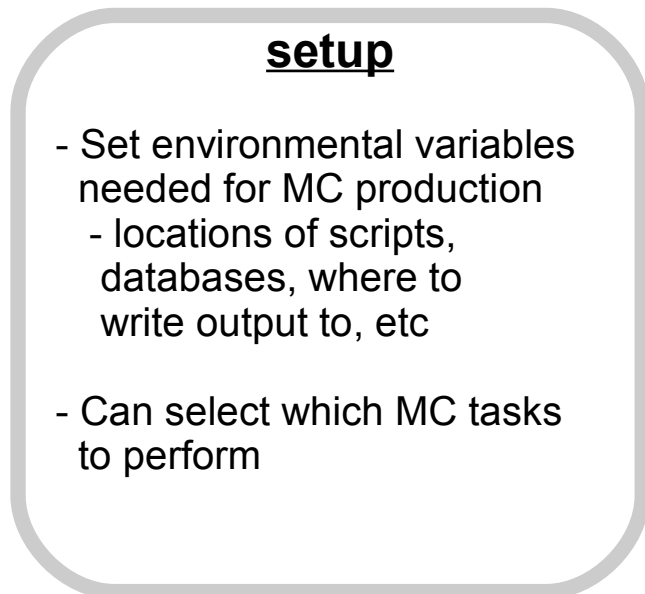
MINOS on the Grid: GBS

- MINOS runs majority of jobs (esp. MC production) via **Ganga-based Batch Submission (GBS)** layered over Ganga
- **GBS** = a fault tolerant batch submission method (python-oriented)
- **Basic concepts:** all job submission is done via a **task**
 - **task** = collection of similar **jobs**, all of which share the same application script and global arguments
 - GBS task provides means of handling submission and failure
 - useful tools for job creation, testing, perusal; support for both global and local sandboxes, etc
- **Fault handling framework:** when job exits, GBS reports back on status in GBS Log File (GLF), e.g.:
 - **SUCCEEDED**: everything okay
 - **FAILED**: GBS cannot correct problem, requires attention and fixing by user
 - **RETRY**: a fault has been found which GBS cannot handle at the moment, but which it may be able to deal with later; reattempt job a set number of times
 - identified errors can occur at any stage in progress, whether early (disk containing script failed to load), middle (MC job needs new seed), or late (SE was not writeable)
 - using GLF, can design appropriate response for **error recovery**



The MINOS MC pipeline

As designed by Nick West





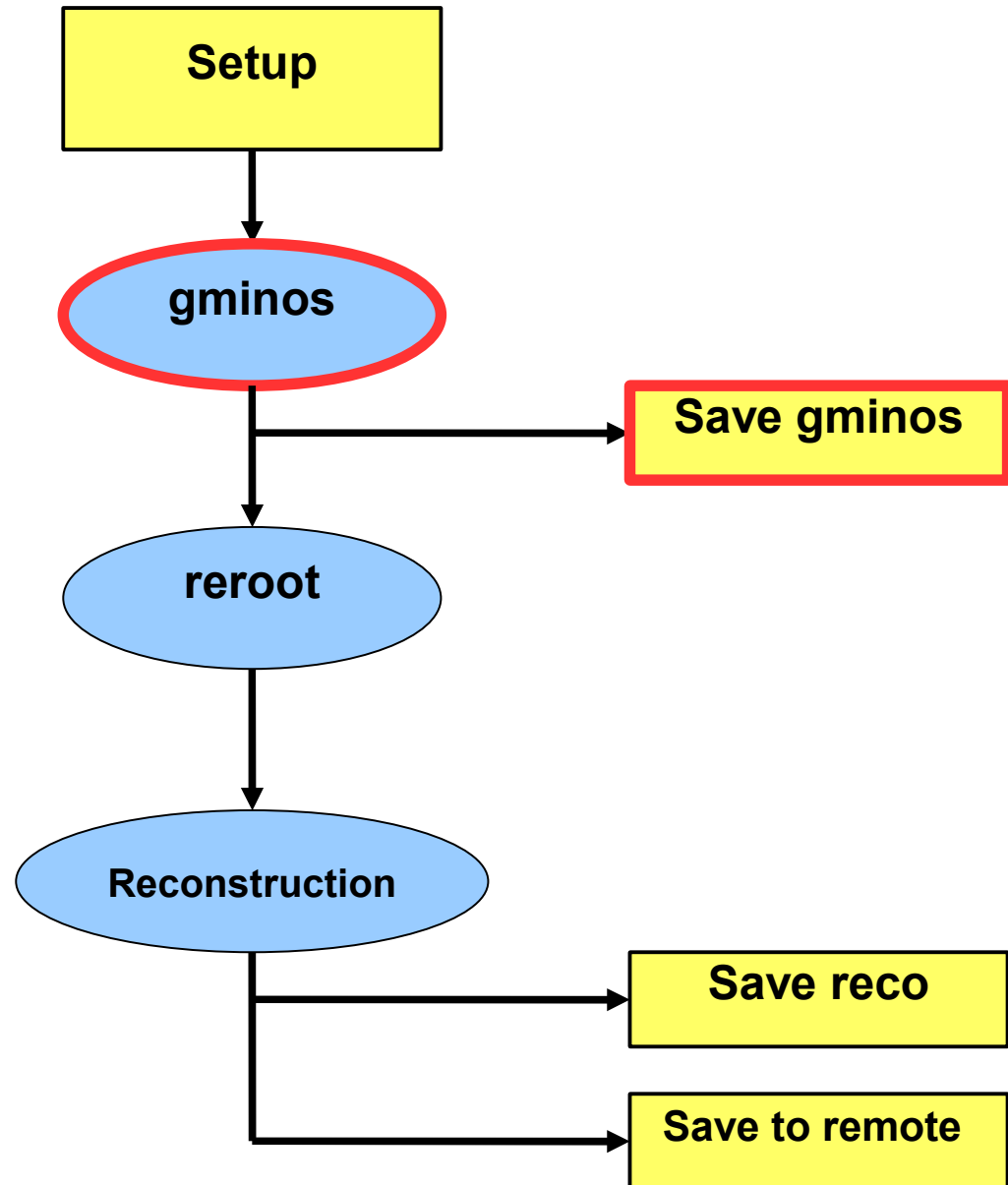
The MINOS MC pipeline

gminos

- FORTRAN/CERNLIB/GEANT3 based
- Simulates particle interactions in the MINOS detector
- Very basic information about where energy has been deposited by interactions
- probably longest step in MC process

Save gminos

- Saves output files to CASTOR SE

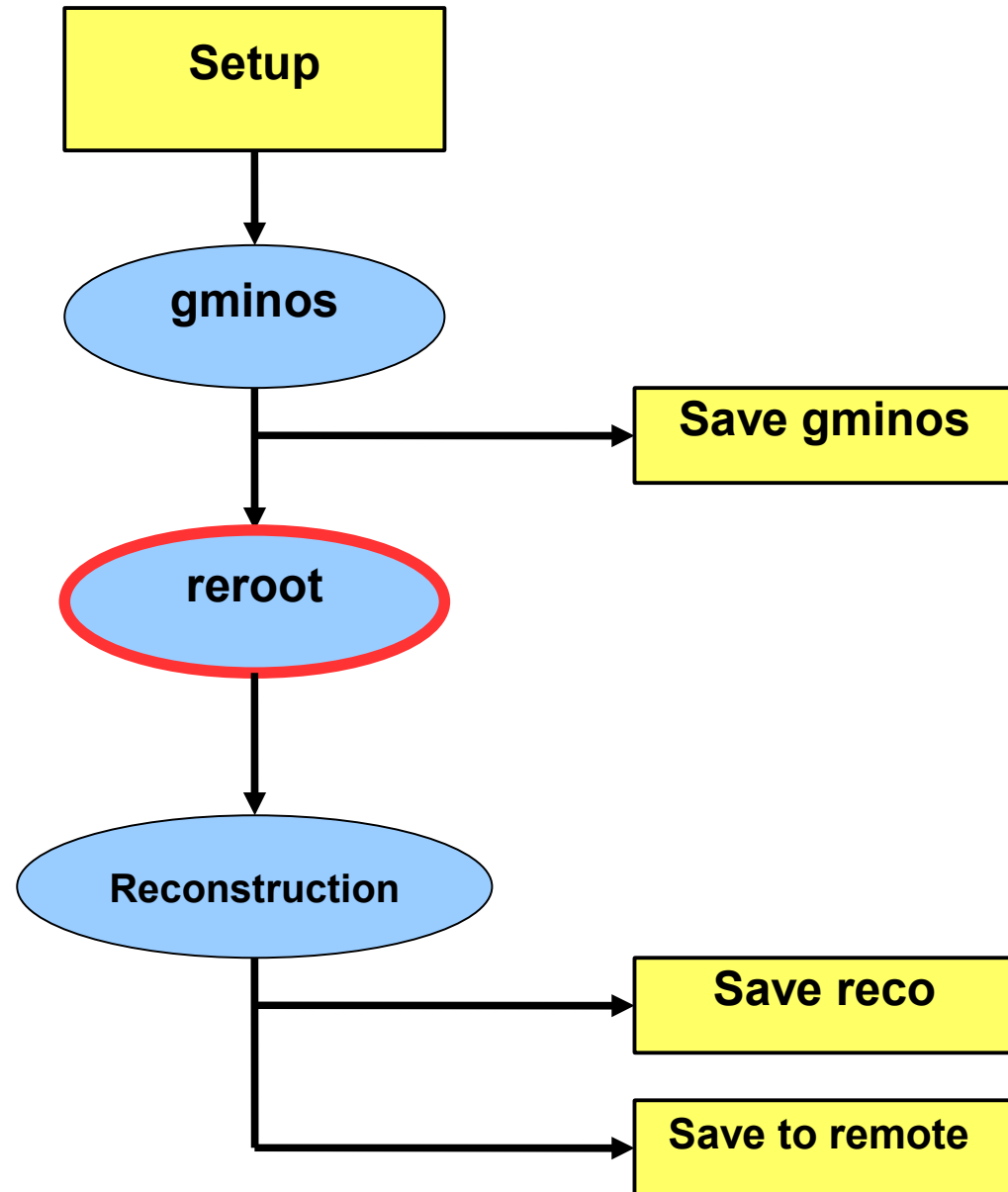




The MINOS MC pipeline

reroot

- Fast step – converts file into root-compatible form
- Still not reconstructed
- Very fast step

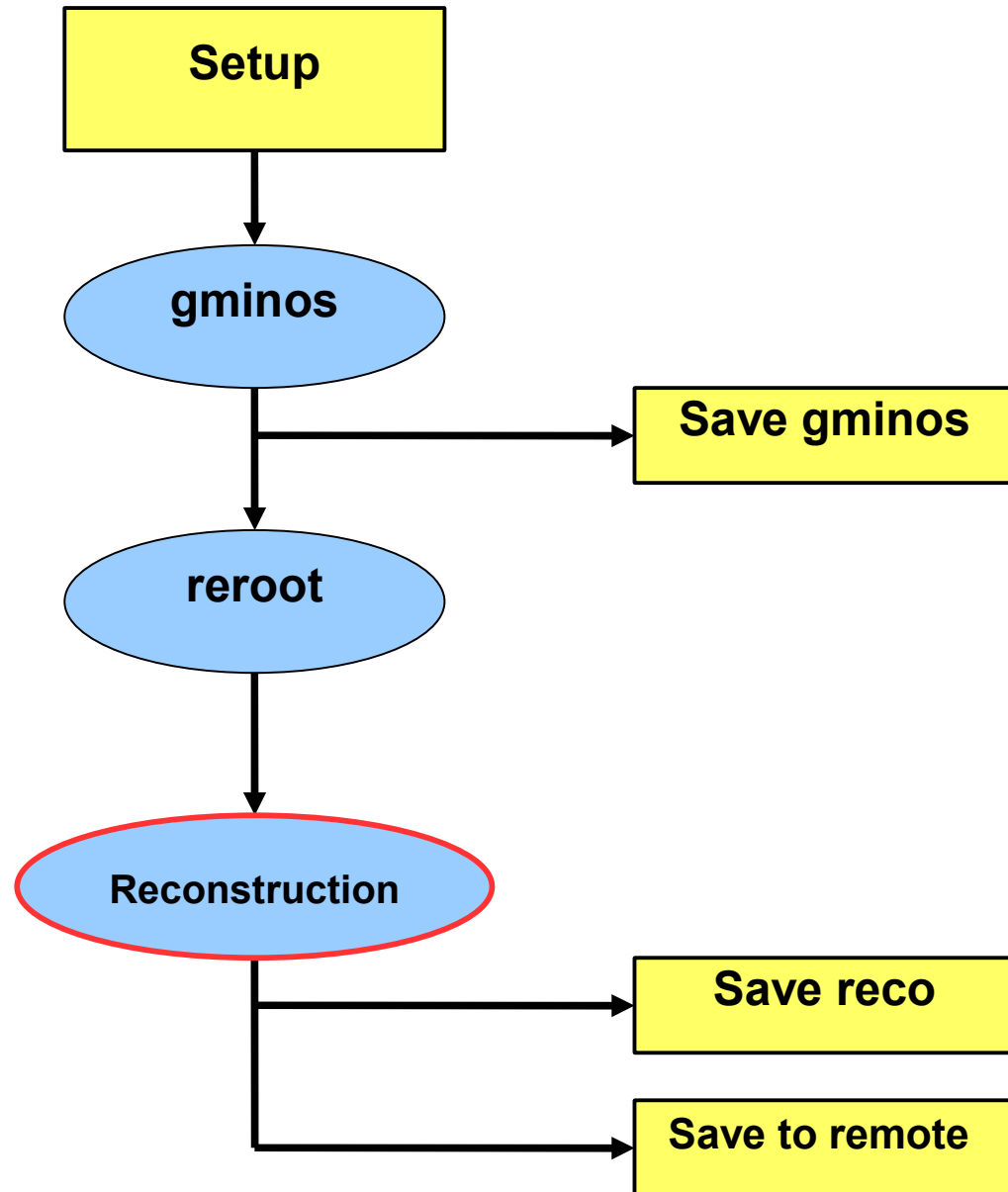




The MINOS MC pipeline

Reconstruction

- Turns MC output into information usable for analysis
- breaks data down by stages into various “candidates” (tracks, showers, events, etc)
- standard Ntuple output usable by rest of collaboration
- Requires access to up-to-date MINOS database on MySQL server

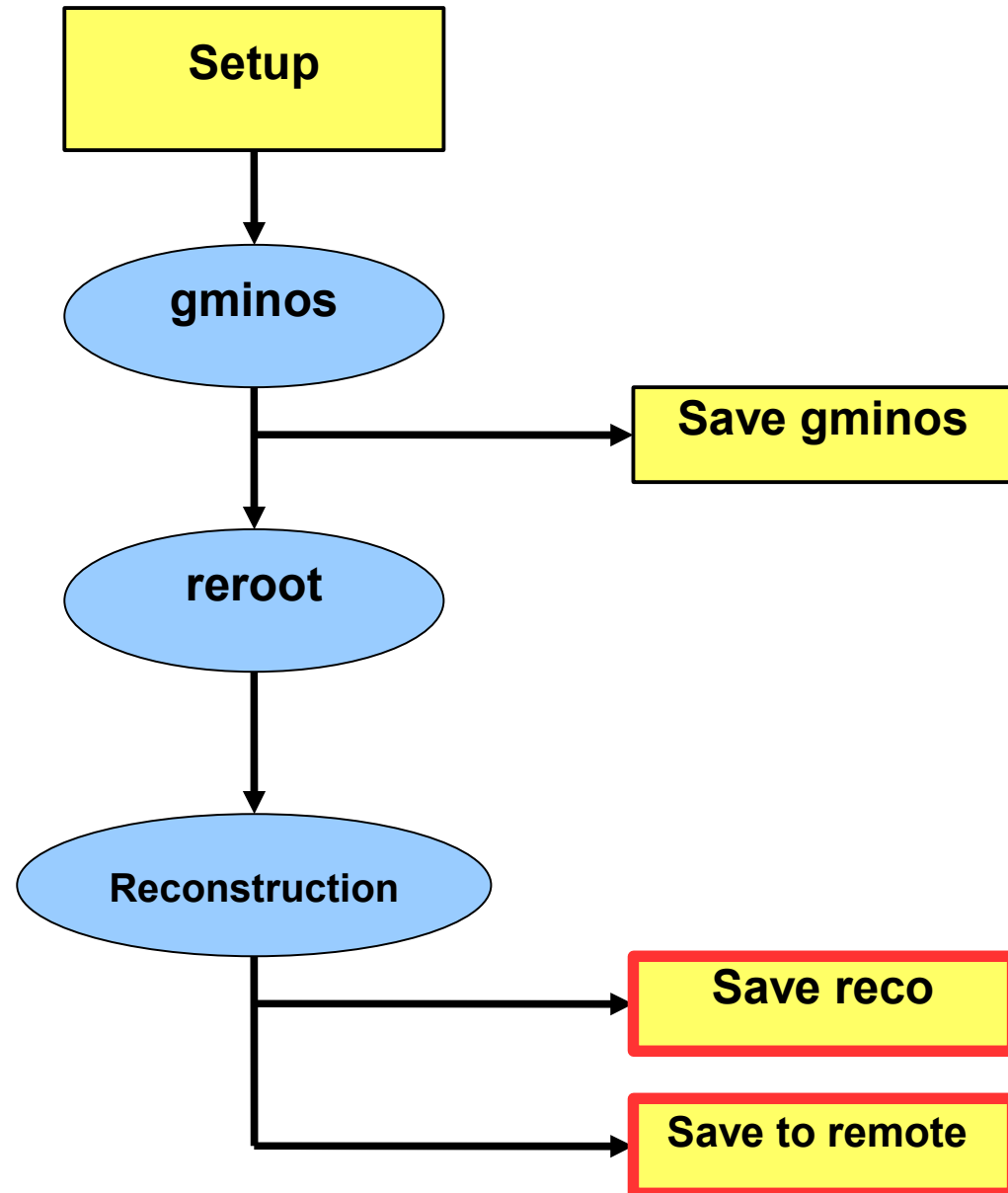




The MINOS MC pipeline

Save reconstruction
- Save root file to local CASTOR SE

Save final output to Remote location
- Send final output to FNAL disks for storage and use by rest of MINOS collaboration





Broader Picture

- **MINOS' presence on the Grid different from that of the LHC:**
 - No large dedicated support network
 - Currently only using a single grid farm
 - Tier 0 = FNAL
 - Currently using SAM as data catalogue
- **Current production:**
 - Assorted MC production by MINOS batch group, via Phil Rodrigues
 - Reconstruction stage of 50 million MC LEM event library (Ruth Toner)
 - Additional analysis?

Thank you, Nick West!