Muon g-2 Detectors

Muon g-2 PGM
1/22/2013

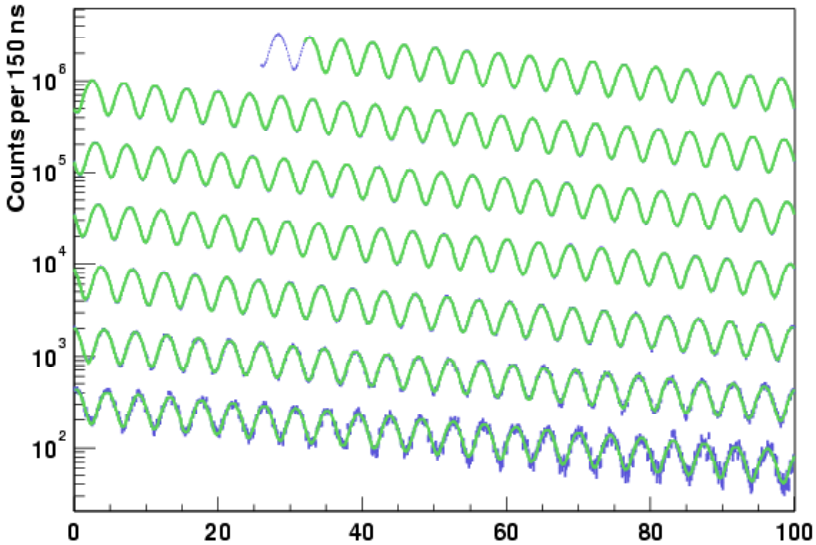
Brendan Casey
Detector L2 Manager

U.S. DEPARTMENT OF ENERGY | Office of Science

Detector Physics Goals

- The L2 detector branch of the WBS contains all instrumentation required to measure the muon precession frequency
- This includes:
  - Calorimeters to measure positron energy and time
    - This data is fit to extract the precession frequency
  - Tracking and other auxiliary detectors to measure characteristics of the muon beam
    - This data is used to make corrections to the extracted precession frequency and help constrain systematics
  - Readout electronics, data acquisition, and slow controls

# of positrons over threshold versus time



This plot x 40

Detector Scope

WBS 4 Detectors
Brendan Casey
Fermilab

4.1 Project Management
Brendan Casey
Fermilab

4.2 Calorimeters
David Hertzog
Washington

4.3 Trackers
Brendan Casey
Fermilab

4.4 Back-end electronics
Lawrence Gibbons
Cornell

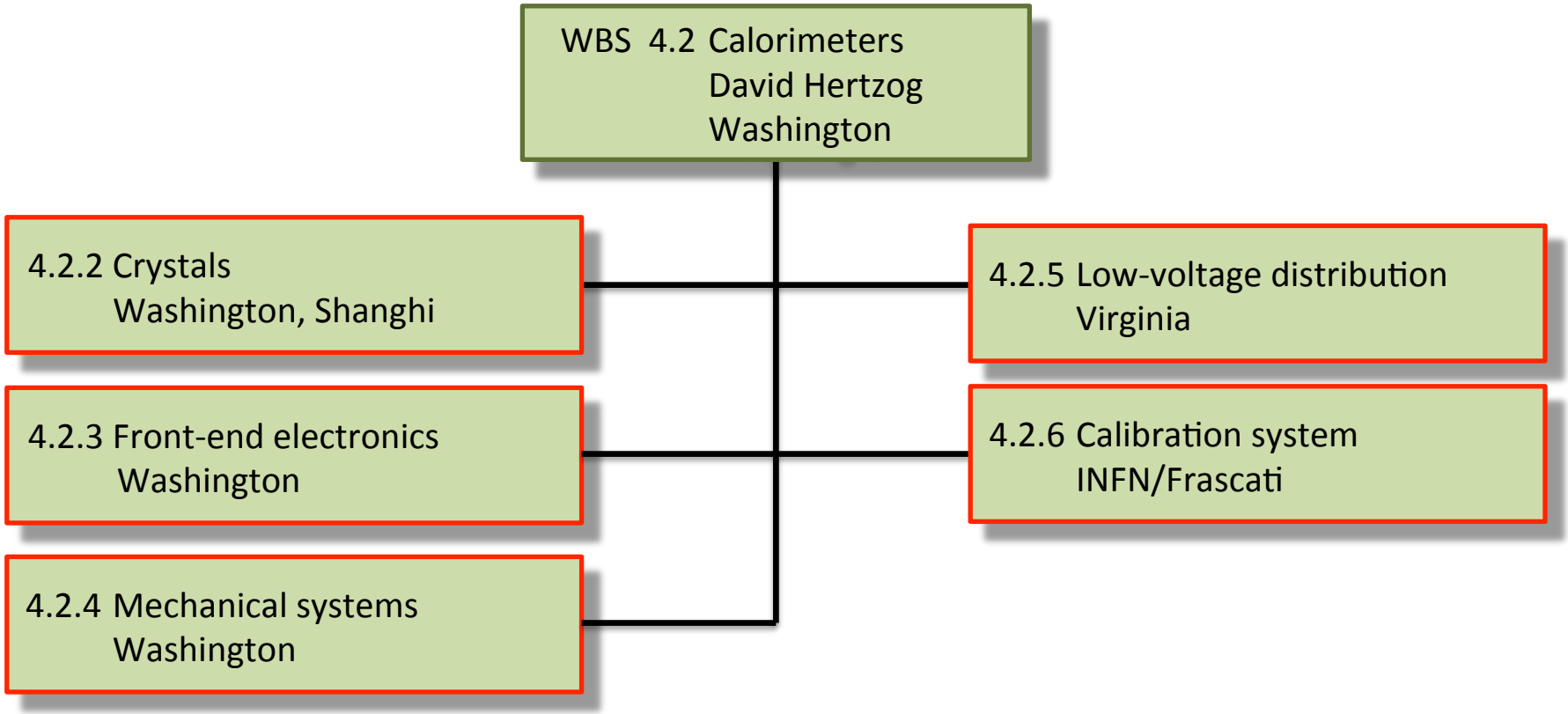
4.6 Auxilliary detectors
Fred Grey
Regis

4.5 Data acquisition
Tim Gorringe
Kentucky

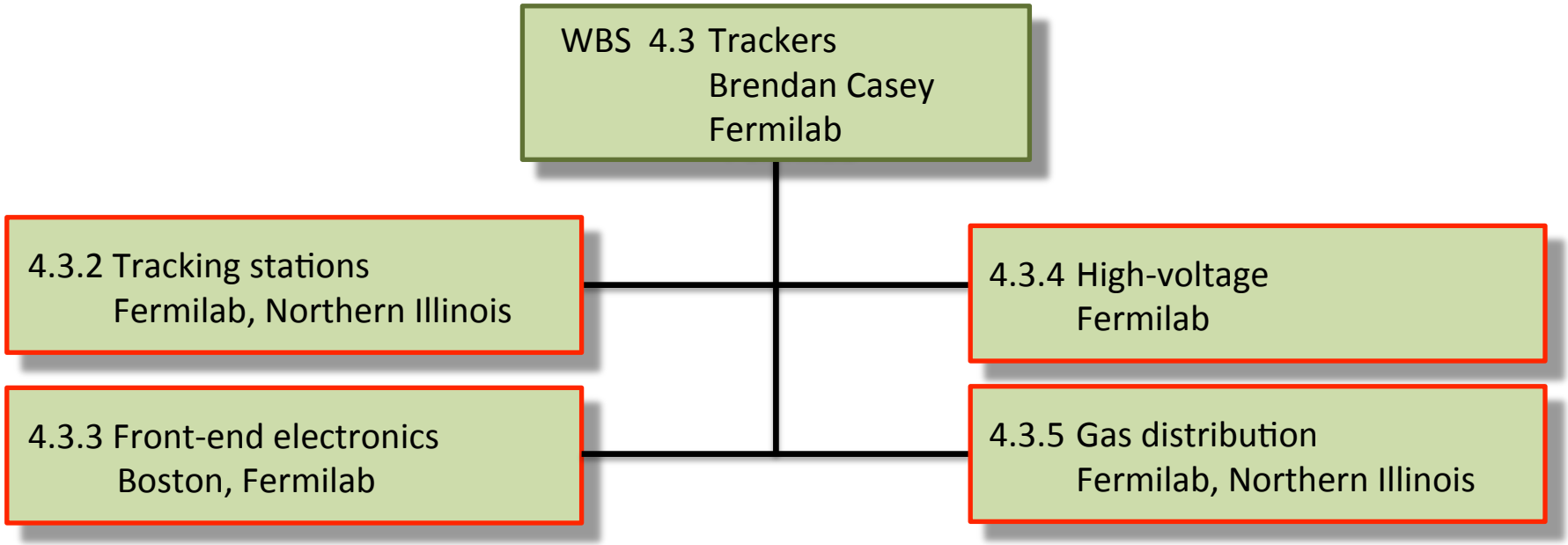
4.7 Slow controls
Peter Winter
Argonne

Plan to fund with NSF MRI

Calorimeter Scope

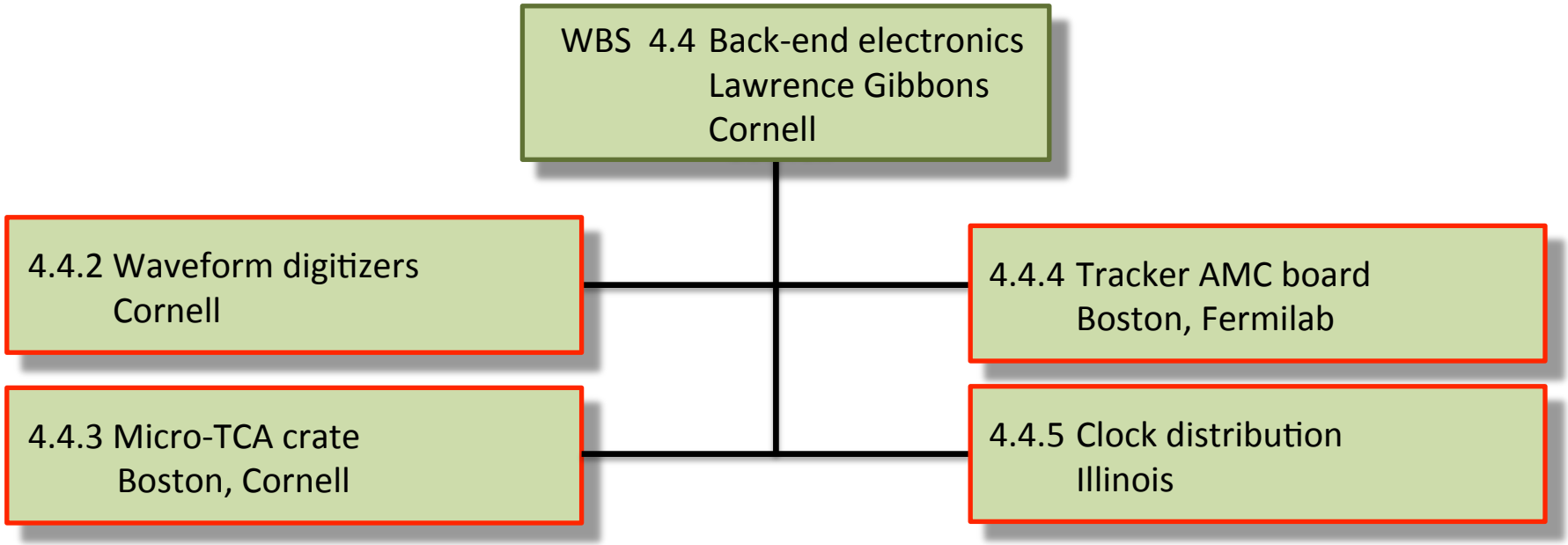


Tracker Scope

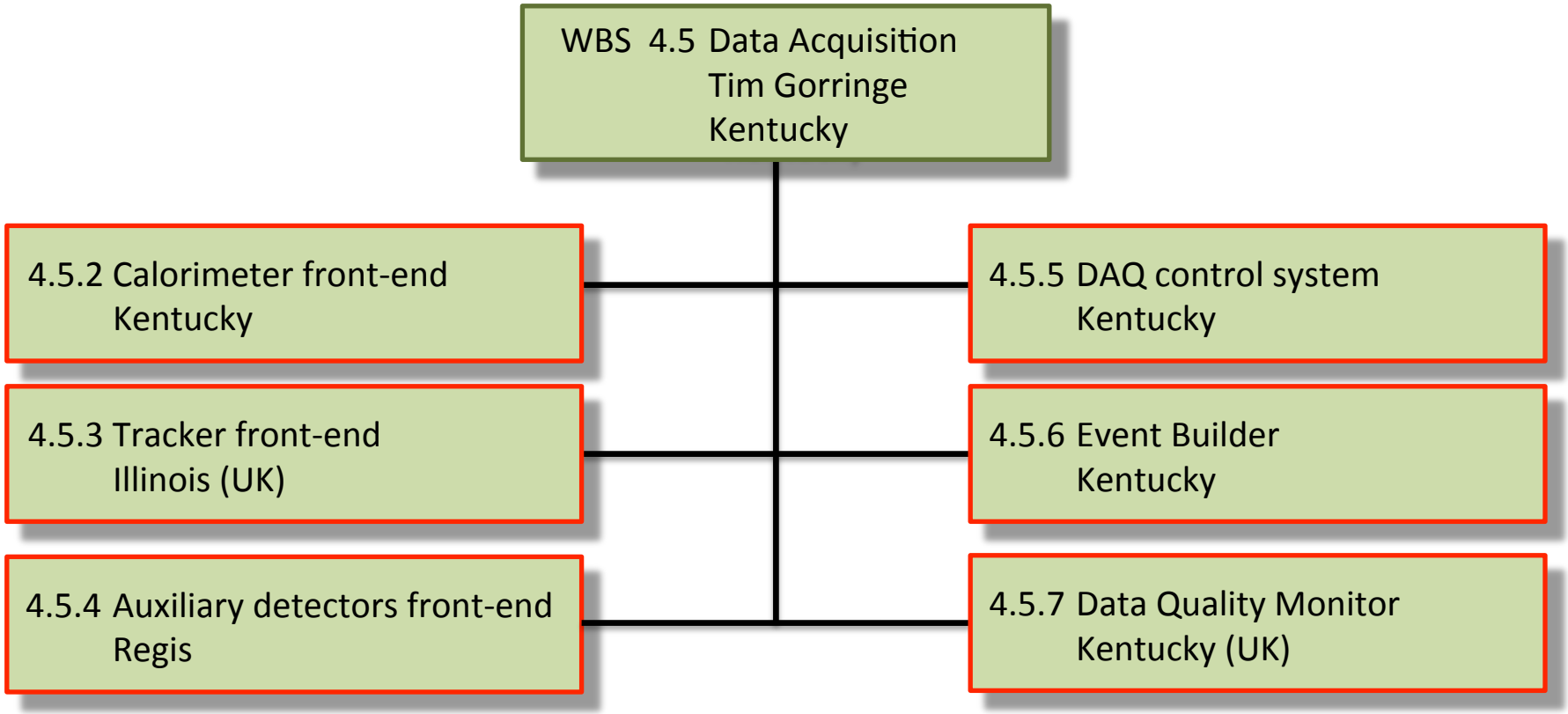


Removed L3 for vacuum modifications.
Merged with other vacuum modifications in the ring WBS

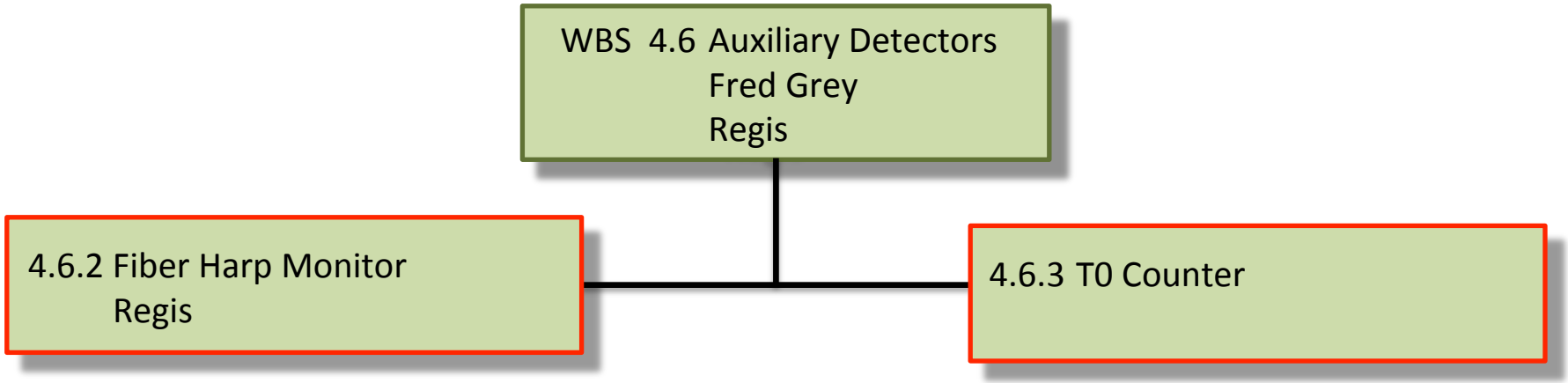
Back-end electronics Scope



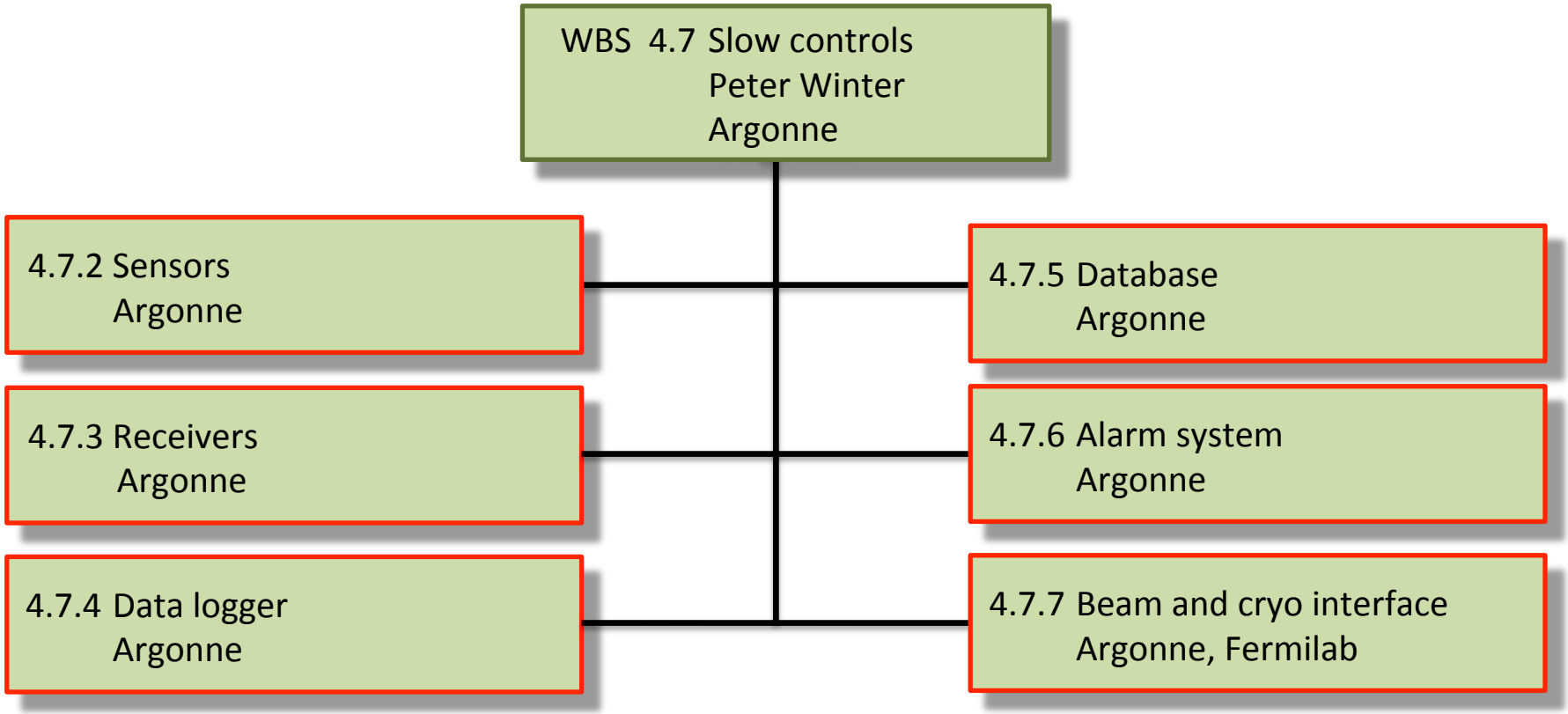
DAQ Scope


WBS 4.5 Data Acquisition
Tim Gorringe
Kentucky
4.5.2 Calorimeter front-end
Kentucky
4.5.3 Tracker front-end
Illinois (UK)
4.5.4 Auxiliary detectors front-end
Regis
4.5.5 DAQ control system
Kentucky
4.5.6 Event Builder
Kentucky
4.5.7 Data Quality Monitor
Kentucky (UK)

Auxiliary Detectors Scope



Slow Controls Scope



Progress on MRI

- NSF MRI is being submitted February 21
  - ~$4M including 30% matching and in-kind contributions
  - Funds 3 out of 6 L3 boxes
    - Calorimeter, back-end electronics, data acquisition

- Institutions:
  - DOE Nuclear: Washington (lead)
  - DOE HEP: Cornell (lead), Illinois
  - NSF Nuclear: Kentucky, Virginia, James Madison

- Each lead institution must compete for one of three allowed MRI submissions per University per year across all NSF funded disciplines.
  - Successful competition at both University of Washington and Cornell
  - Muon g-2 proposal ranked 1st out of all proposals submitted to University of Washington

- Large overlap between requirements for CD1/2/3 and MRI
  - Conceptual design, baseline cost required in proposal
  - Proposal award is equivalent to CD3

Progress on MRI

VERSION 4: JANUARY 21, 2013 PROJECT SUMMARY

MRI Consortium: Development of Instrumentation to Measure the Spin Precession Frequency in the Fermilab Muon $g-2$ Experiment

1. Project Summary placeholder

Overview: The new g-2 Experiment aims to resolve the discrepancy between the Standard Model theory and experimental measurement of the muon anomalous magnetic moment, a_μ. The measurement hinges on a precise measurement of the anomalous precession frequency, ω_a. This proposal is for the calorimeter to collect the data from which the value ω_a will be extracted. The calorimeter will be installed alongside the g-2 Muon storage ring at Fermi National Accelerator Laboratory in Batavia, Illinois.

- First draft of text, budget, schedule complete
  - Reducing text to fit in page limits
  - Double checking with NSF to understand the rules for the 30% matching funds
  - Started putting things into fast lane

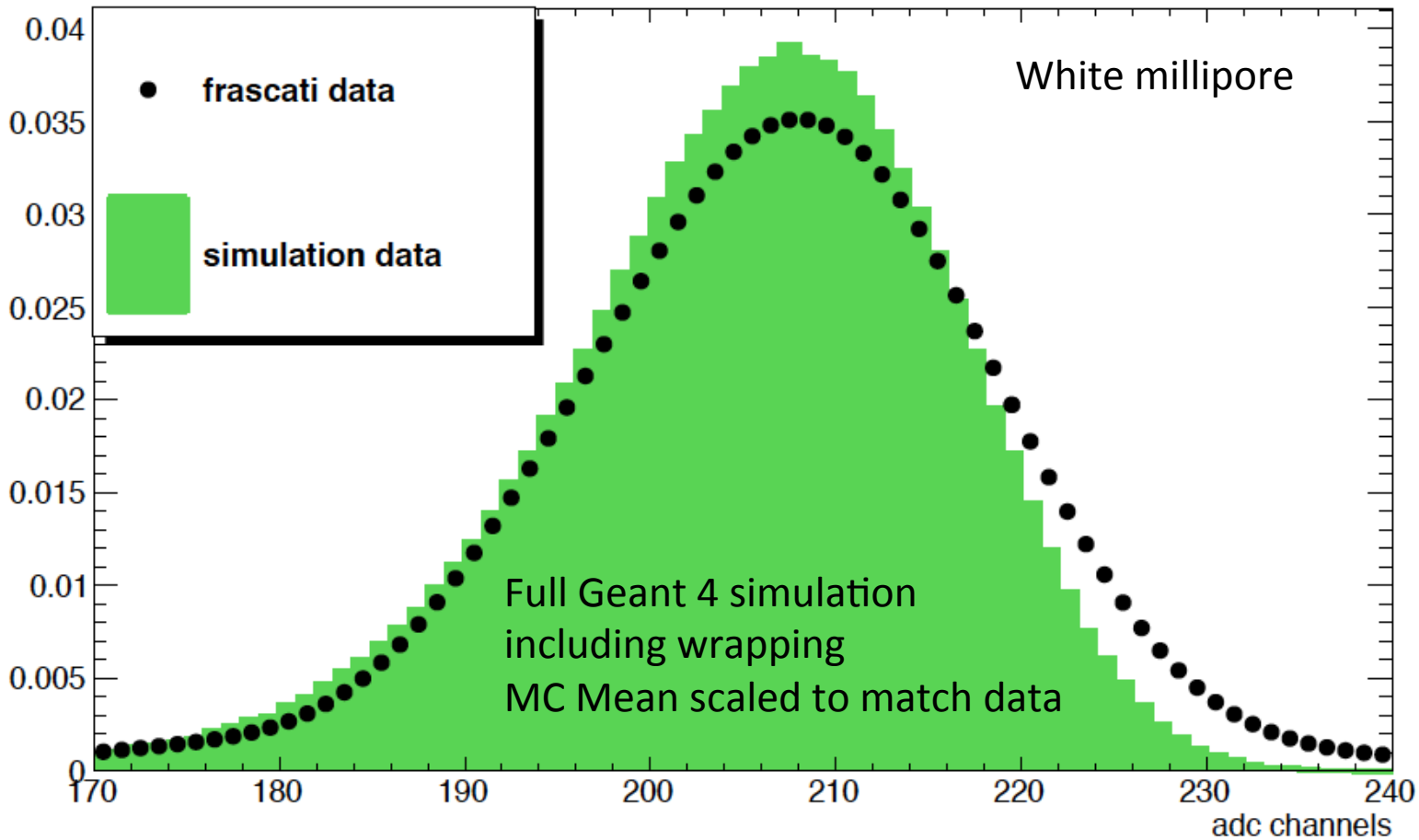
Other progress

- Successfully conducted beam test at Frascati for the PbF2 crystals
  - 4th beam test of the calorimeter system
- Goal was to get a better handle on effects of wrapping materials
  - Issue that came up at the last beam test.
- Examples of different wrappings:

	Mean	Sigma	Ped	Res(%)	Nphe
Hertzog Wh	539	16.3	243	5.5	330
Hertzog Bl	402	10.1	242	6.3	251
Na62	446	11.0	242	5.4	344
QCalT (New Beam)	537	14.8	241	5.0	400
Hertzog Wh 2 (New Beam)	449	10.3	241	5.0	404

Other progress

500 MeV electrons shot into center of crystal



CDR progress

WBS	1st draft	reviewed	collaboration review	final
4.2 Calorimeters	MRI			
4.3 Trackers	In progress			
4.4 Backend electronics	MRI			
4.5 Data acquisition	MRI			
4.6 Auxiliary detectors	In progress			
4.7 Slow controls	In progress			

BoE progress (Calorimeters)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.2.2 Crystals	D Hertzog	2nd pass	In progress			
4.2.3 Front-end electronics	D Hertzog	2nd pass	In progress			
4.2.4 Mechanical systems	D Hertzog	2nd pass	In progress			
4.2.5 low voltage dist.	D Hertzog	2nd pass	In progress			
4.2.6 Calibration system	G Venanzoni	1st pass	In progress			

BoE progress (Trackers)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.3.2 Tracking stations	B Casey	2nd pass	In progress			
4.3.3 Front-end electronics	B Casey	2nd pass	In progress			
4.3.4 Vacuum mods.	B Casey	2nd pass	In progress			
4.3.5 High voltage	B Casey	2nd pass	In progress			
4.3.6 Gas	B Casey	2nd pass	In progress			

BoE progress (BE Electronics)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.4.2 WFDs	L Gibbons	2nd pass	In progress			
4.4.3 micro-TCA crate	L Gibbons	2nd pass	In progress			
4.4.4 Tracker AMC card	B Casey	2nd pass	In progress			
4.4.5 Clock distribution	K Pitts	2nd pass	In progress			

BoE progress (DAQ)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.5.2 Calo front-end	T Gorringe	2nd pass	In progress			
4.5.3 Tracker front-end	T Gorringe	2nd pass	In progress			
4.5.4 Aux det front-end	T Gorringe	2nd pass	In progress			
4.5.5 DAQ control system	T Gorringe	2nd pass	In progress			
4.5.6 Event builder	T Gorringe	2nd pass	In progress			
4.5.7 Data quality monitor	T Gorringe	2nd pass	In progress			

BoE progress (Aux detc)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.6.2 Fiber harp monitor	F Grey	2nd pass	In progress			
4.6.3 T0 counter	F Grey	1st pass	In progress			

BoE progress (Slow controls)

WBS	responsibility	activities defined	costing	risks listed	reviewed	sign off
4.7.2 Sensors	P Winter	1st pass	In progress			
4.7.3 Receivers	P Winter	1st pass	In progress			
4.7.4 Data logger	P Winter	1st pass	In progress			
4.7.5 Database	P Winter	1st pass	In progress			
4.7.6 Alarm system	P Winter	1st pass	In progress			
4.7.7 Beam/cryo interface	P Winter	1st pass	In progress			

Risks

Risk	Owner	Type	Prob.	Level of Impact	Impact	Mitigation
MRI grant unsuccessful	Hertzog, Gibbons	cost	low	$3M	Increased TPC	Need good communication between DOE and NSF
Detector electronics perturb precision field beyond shimming capabilities	Hertzog, Casey, Gibbons	Cost, schedule	low	high	Cannot start experiment	Small precision test magnet in TD commissioned last summer. Large MRI test magnet being shipped from LANL
Muon yield into ring much higher than expected	Convery, Casey	schedule	low	low	Less than optimal use of protons	Simulations, beam tests, adequate padding

Opportunities

Opportunity	Owner	Type	Prob.	Level of Impact	Impact	strategy
Possibility to recycle 1000 PbF2 crystals from completed experiment	Hertzog	cost	low	high	Lower cost	Spare crystals being shipped to SIC to evaluate feasibility of cutting and polishing
Expression of interest from consortium of groups in England	Roberts, Casey	cost	mod	mod	~0.5 M in kind contribution s to detector systems	Tasks are being defined and they are submitting funding request
Might be able to make use of 1 GHz sampling of calo data to further reduce systematics	Hertzog, Gibbons, Gorringe , Casey	cost	med	unknown	Lower systematic uncertainty	bench tests, beam tests