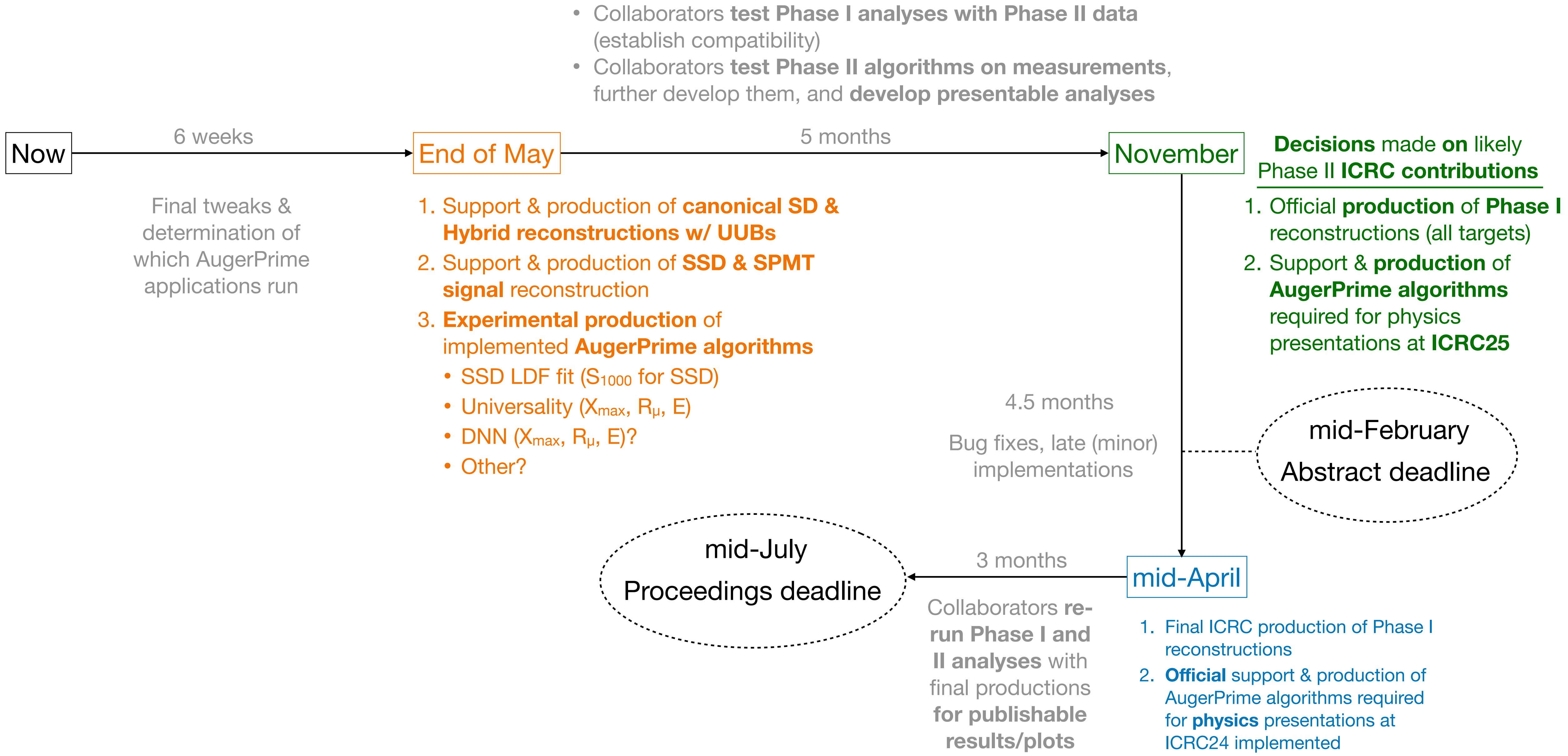


Towards high-level analysis

Timeline | First AugerPrime Offline tag and Observer production



- Collaborators **test Phase I analyses with Phase II data** (establish compatibility)
- Collaborators **test Phase II algorithms on measurements**, further develop them, and **develop presentable analyses**

Now

6 weeks

Final tweaks & determination of which AugerPrime applications run

End of May

1. Support & production of **canonical SD & Hybrid reconstructions w/ UUBs**
2. Support & production of **SSD & SPMT signal** reconstruction
3. **Experimental production** of implemented **AugerPrime algorithms**
 - SSD LDF fit (S_{1000} for SSD)
 - Universality (X_{max} , R_{μ} , E)
 - DNN (X_{max} , R_{μ} , E)?
 - Other?

5 months

November

Decisions made on likely Phase II ICRC contributions

1. Official **production of Phase I** reconstructions (all targets)
2. Support & **production of AugerPrime algorithms** required for physics presentations at **ICRC25**

4.5 months

Bug fixes, late (minor) implementations

mid-February
Abstract deadline

3 months

mid-April

Collaborators **re-run Phase I and II analyses** with final productions for **publishable results/plots**

1. Final ICRC production of Phase I reconstructions
2. **Official** support & production of AugerPrime algorithms required for **physics** presentations at ICRC24 implemented

mid-July
Proceedings deadline

Simplified Timeline | First AugerPrime Offline tag and Observer production

March Meeting

6 weeks

End of May

Official production with Phase II / AugerPrime data required to develop ICRC analyses

5.5 months

Start of November

Phase I & Phase II reconstructions finalized + first full production performed

3.5 months

mid-February
Abstract deadline

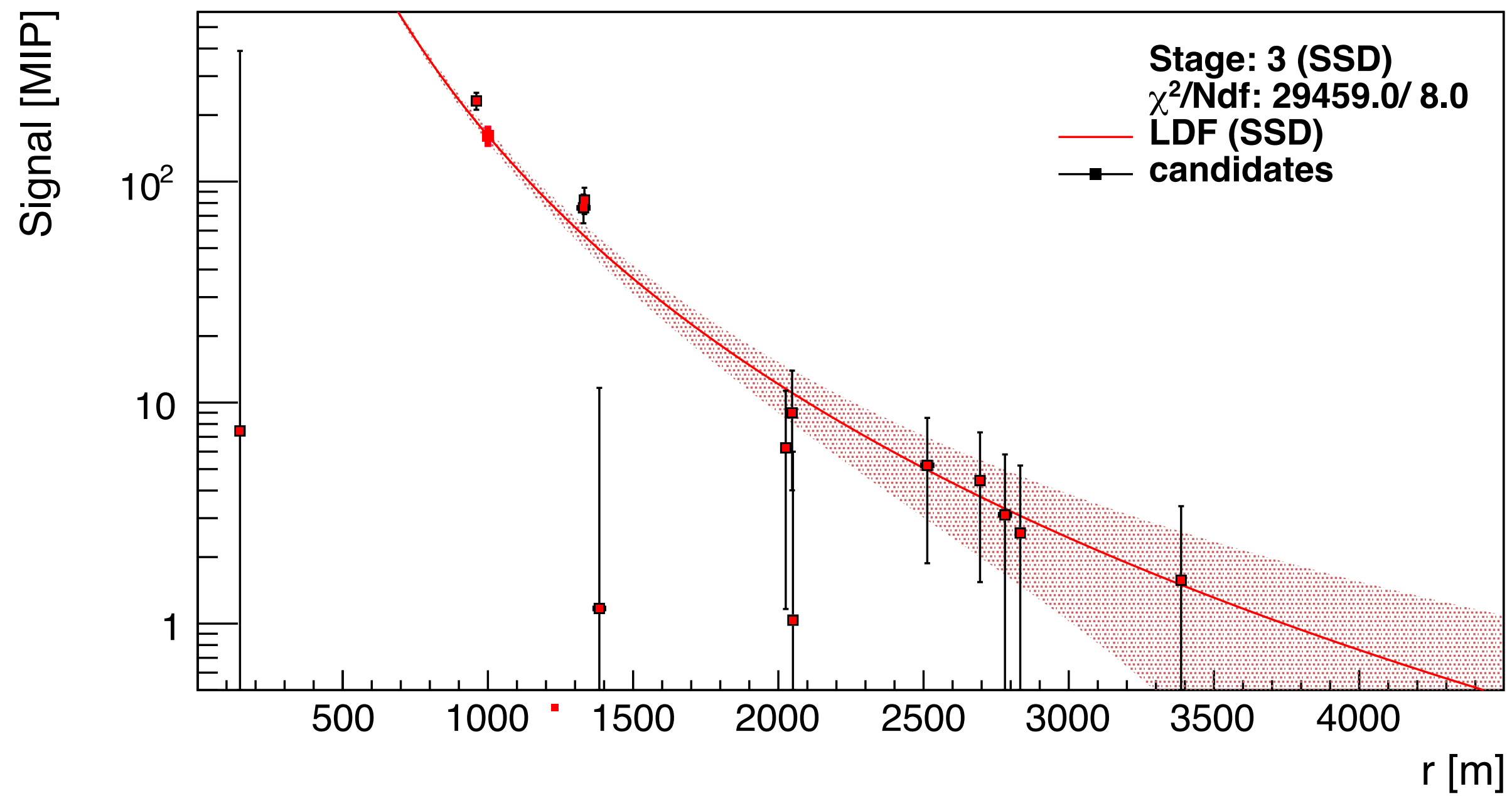
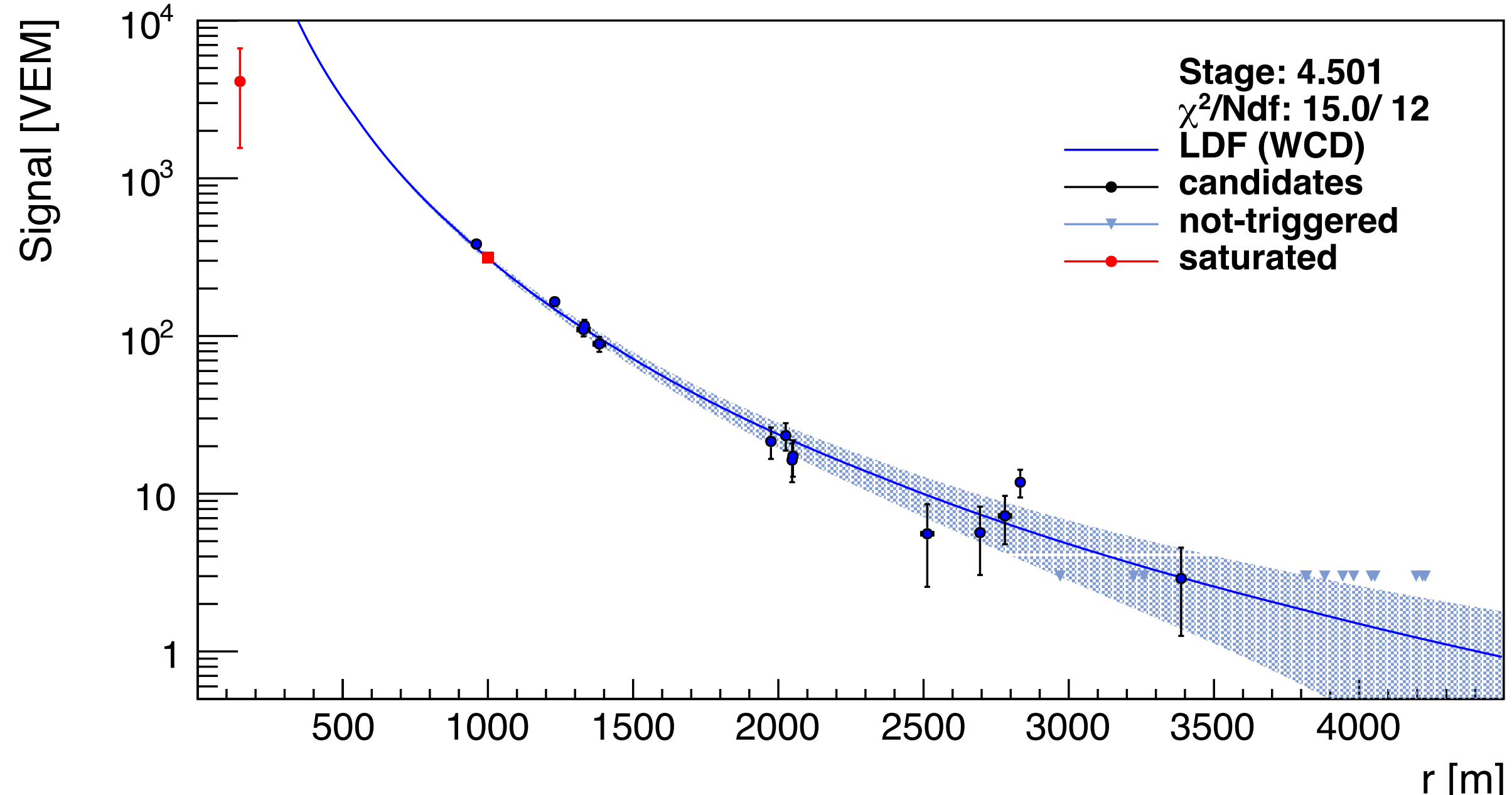
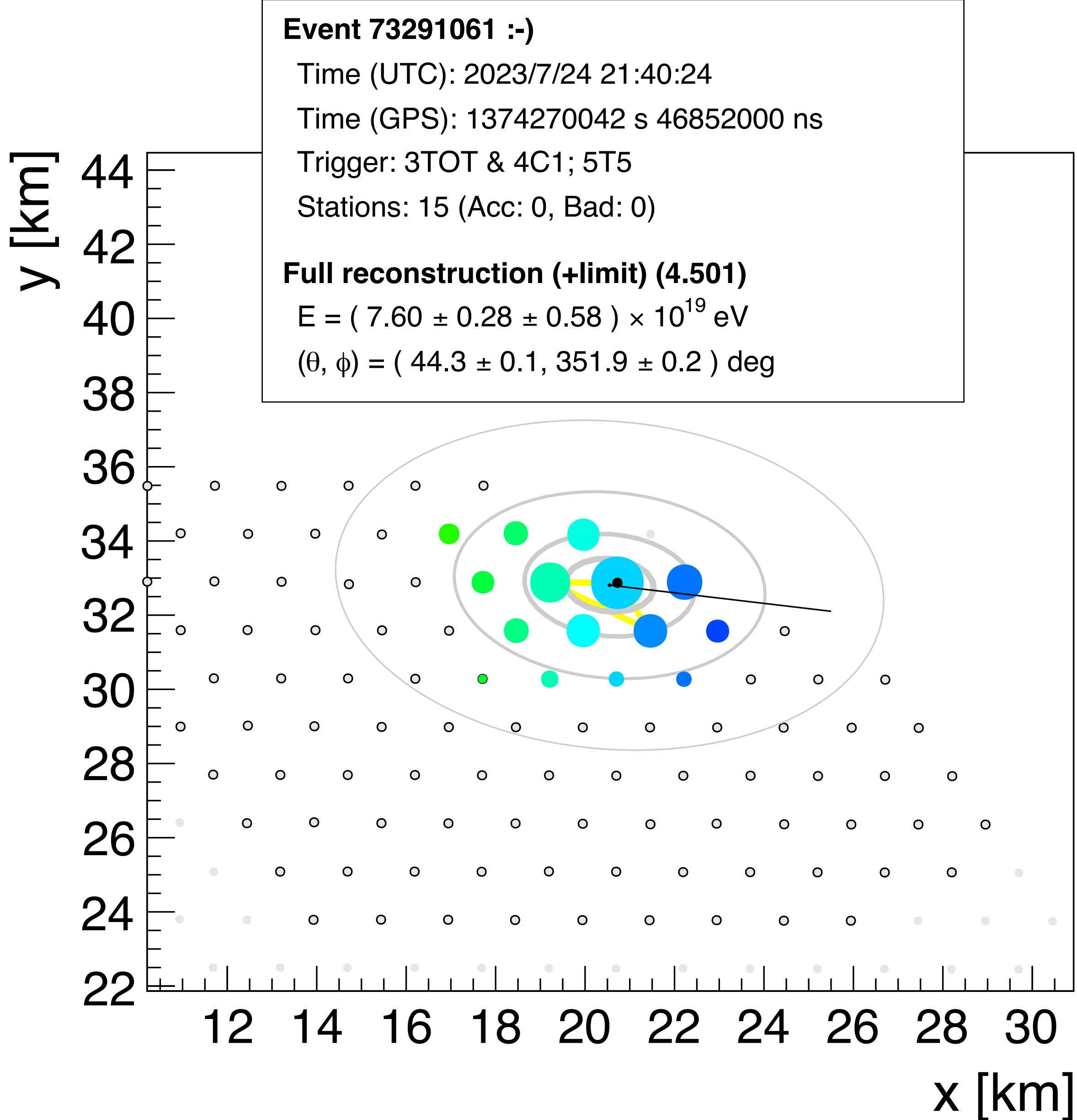
End of February

Deadline for final Phase I & Phase II production

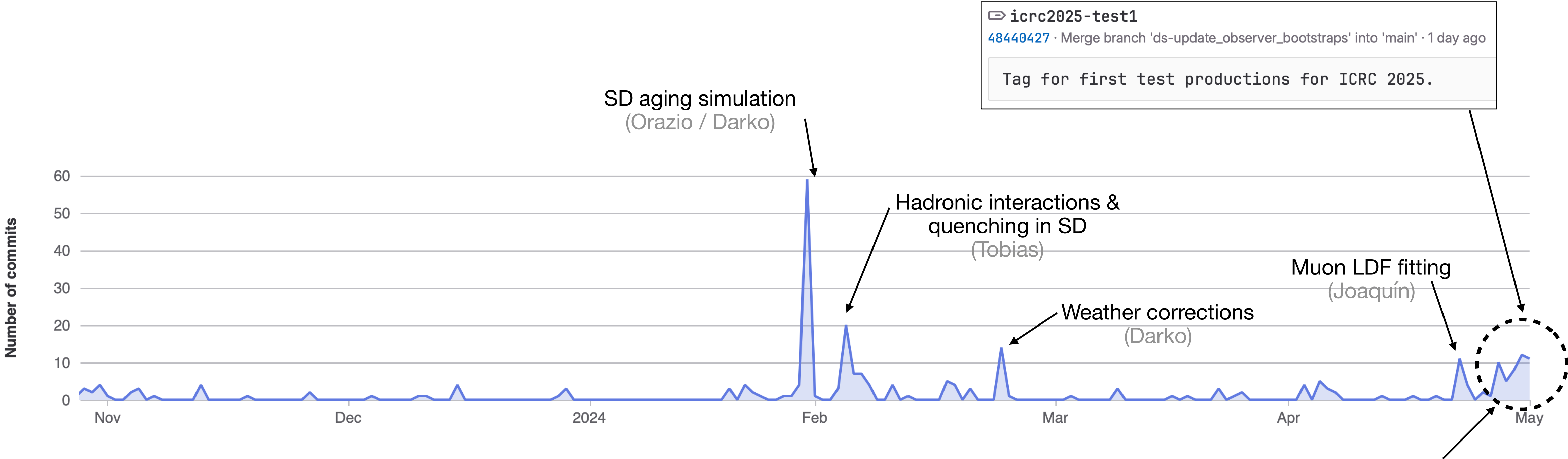
4.5 months

mid-July
Proceedings deadline

Missing SSD status



Offline release and Observer productions



Supported for Phase II / AugerPrime / UUB analysis:
(starting from V128R0B0P15 - Dec. 5, 2022)

- Standard SD WCD event reconstruction
- Calibrated WCD (LPMT & SPMT) & SSD traces
- SSD shower size from LDF fit*
- Universality reconstruction module that runs
- Calibrated SPMT traces in production (incl. new targets)
- Hexagons and BadPeriod files

Kevin and Gasper have agreed to have a critical look at the production data set

Final push for Phase II /AugerPrime tag

- Darko
- Ezequiel
- Joaquín
- Marvin
- David
- Gialex
- Felix
- Federico

*Signal uncertainty and LDF shape derived from simulations

First application of AugerPrime reconstruction algorithms to Phase II measurements

Two joint calls of Foundations and DNN tasks announced:

June 13 @ 13:30 UTC

June 24 @ 11:00 UTC

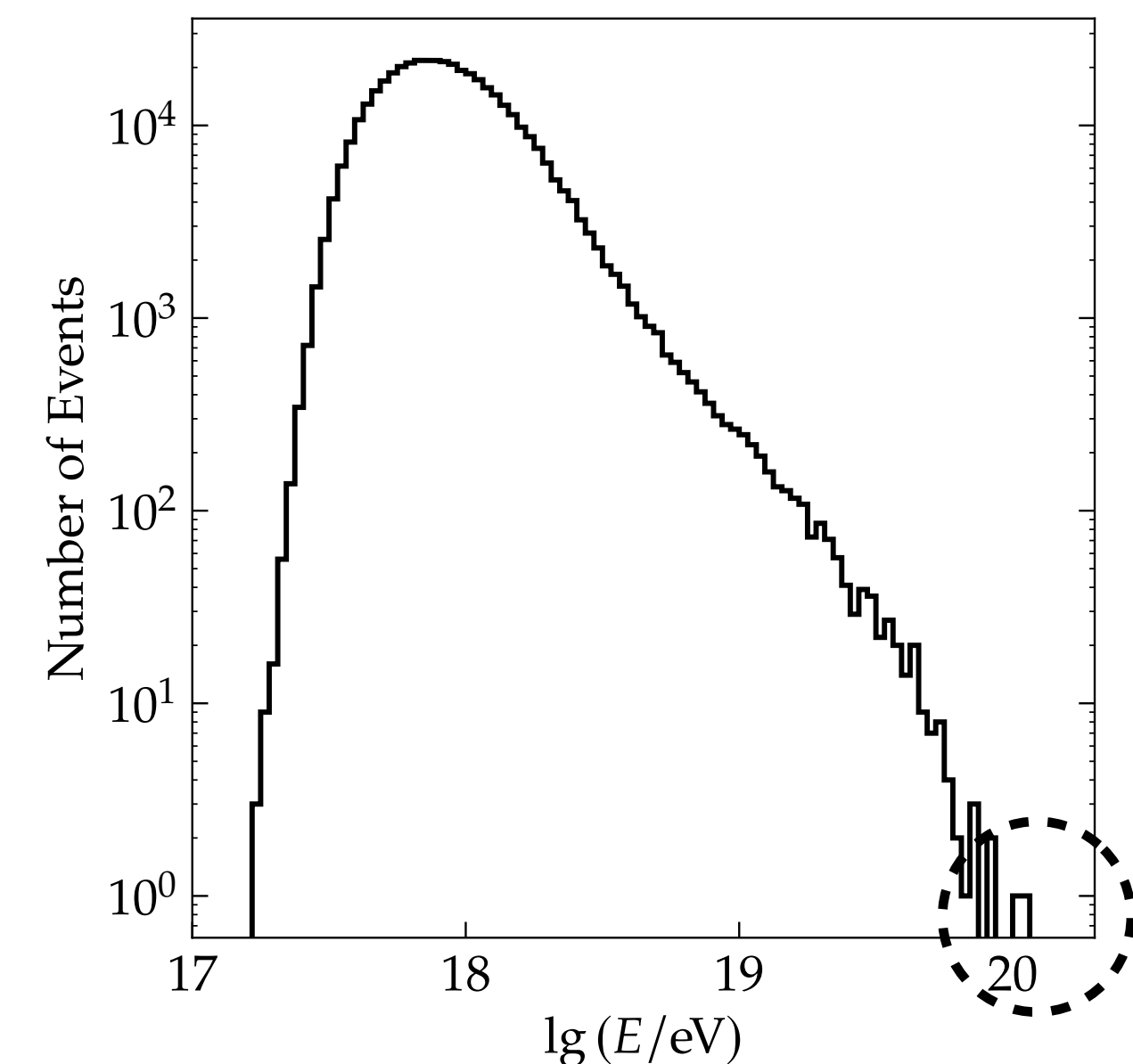
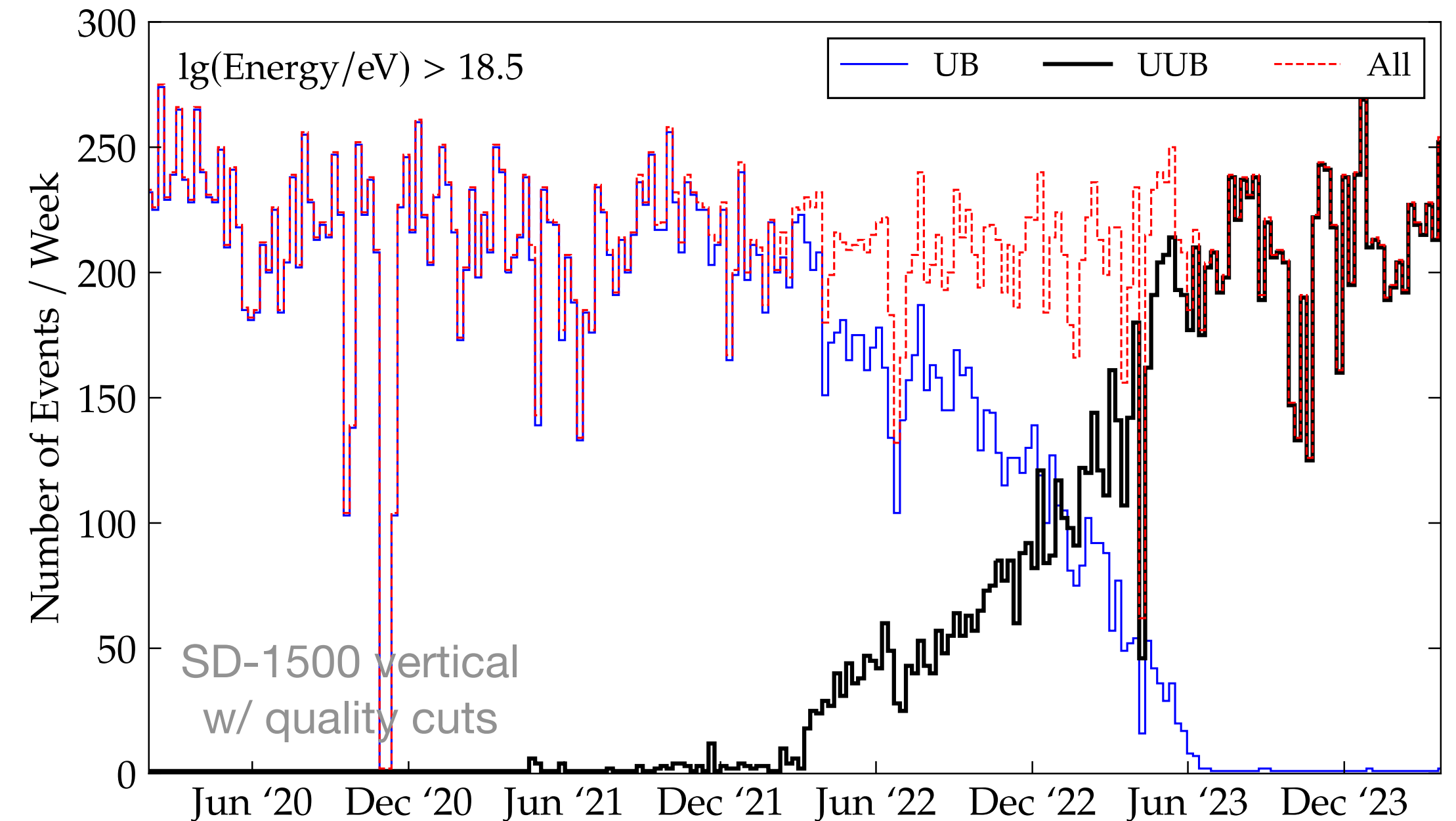
Universality reconstruction of Phase II measurements
Max Stadelmaier

PrimeNet DNN reconstruction of mass sensitive parameters from Phase II measurements
Niklas Langner

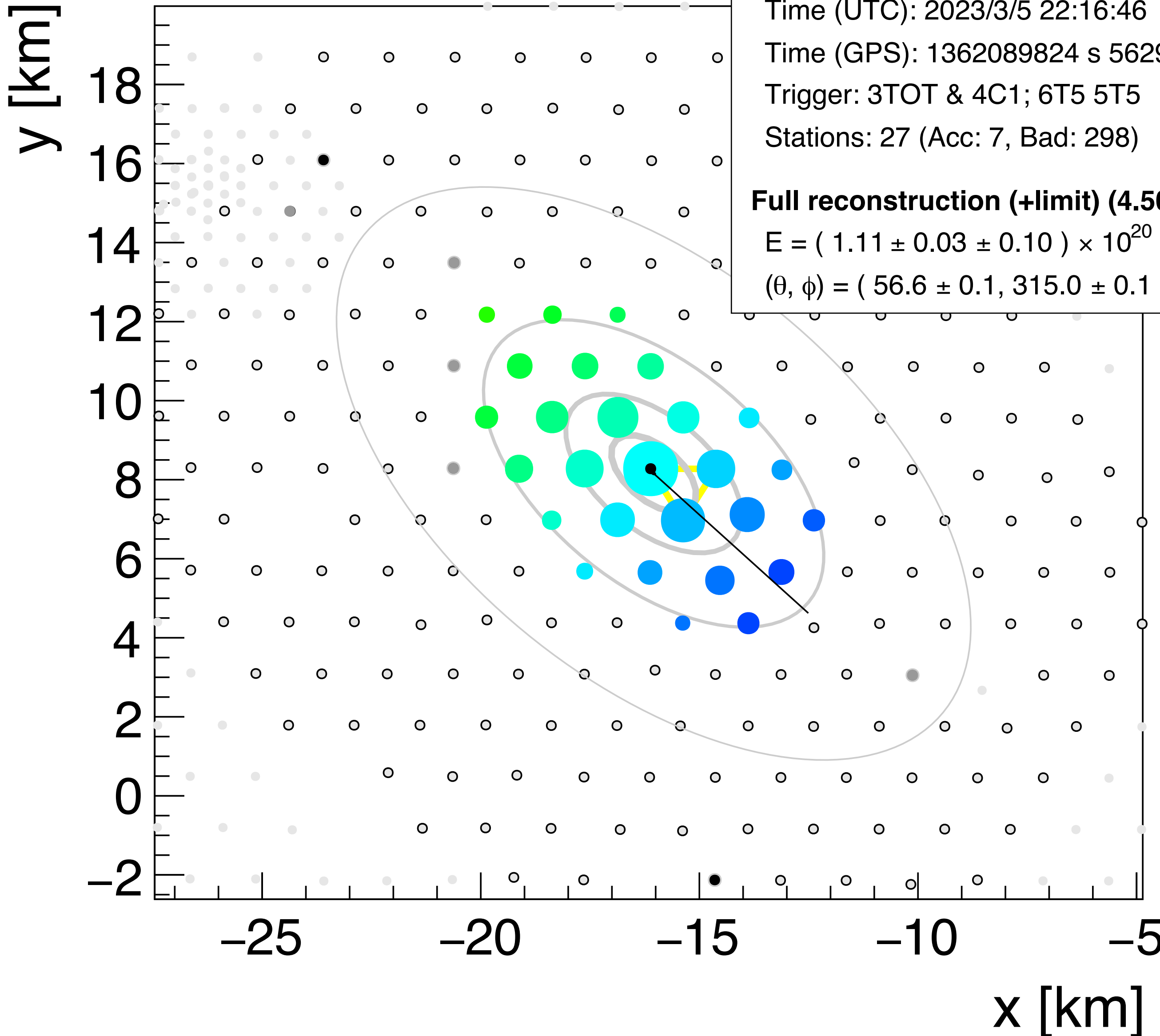
DNN reconstruction of mass sensitive parameters from Phase II measurements
Steffen Hahn

DNN reconstruction of primary energy from Phase II measurements
Fiona Ellwanger

+ other contributions?

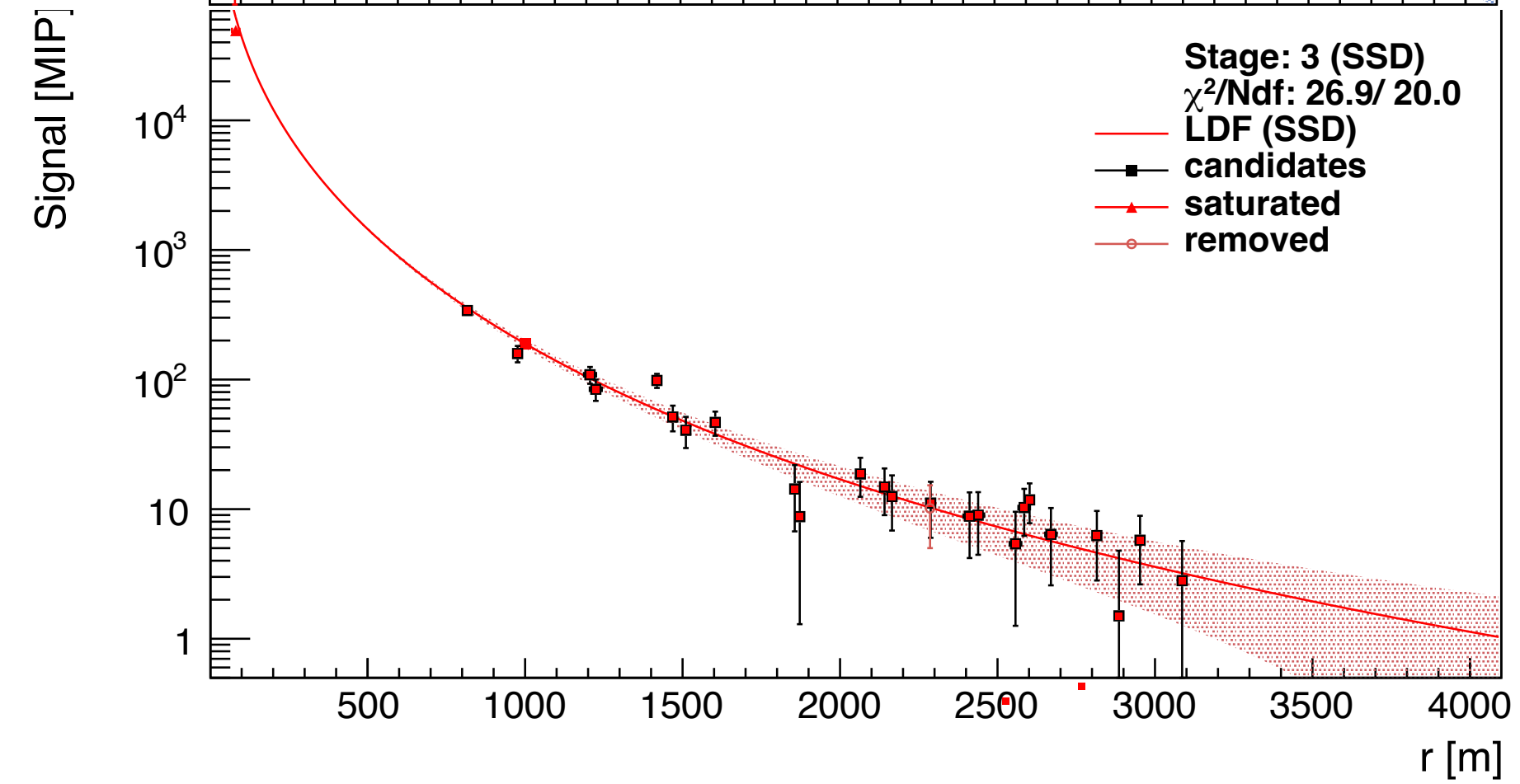
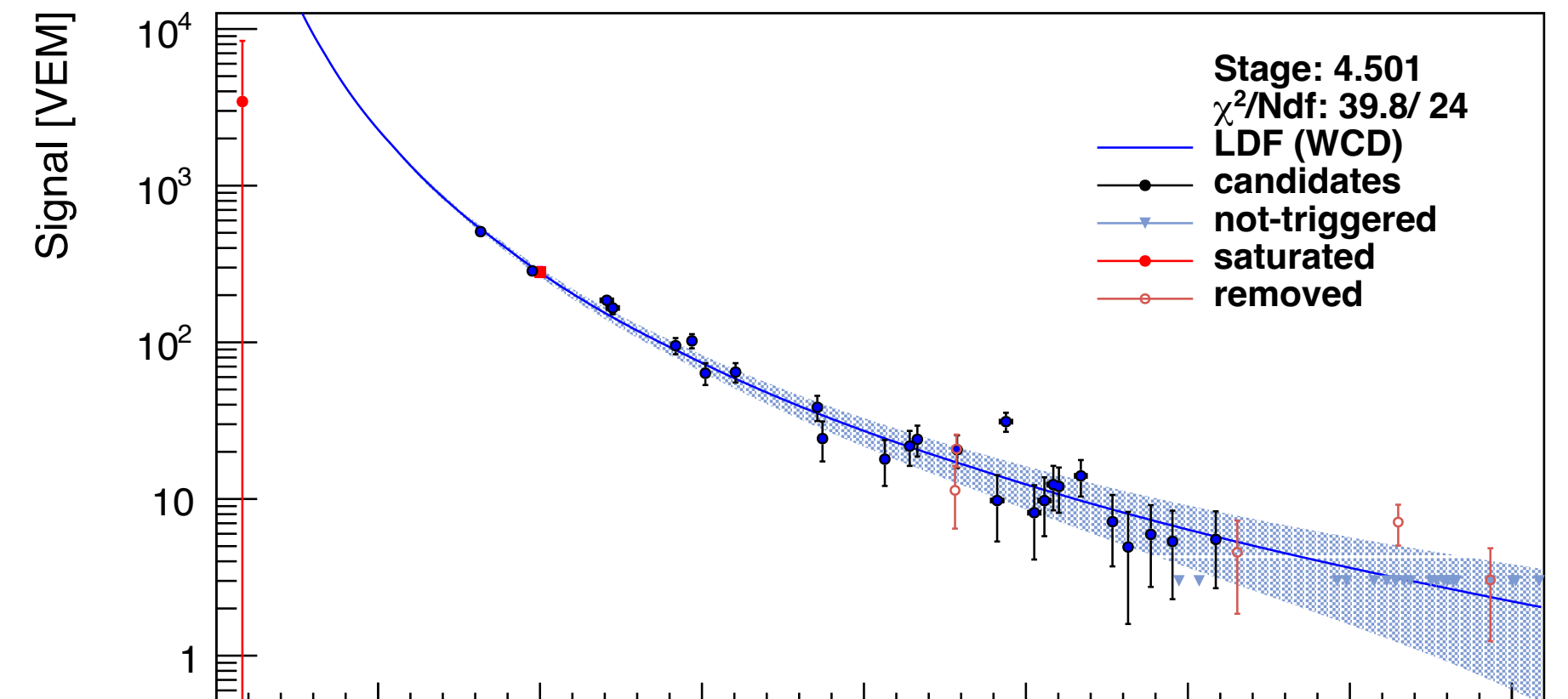
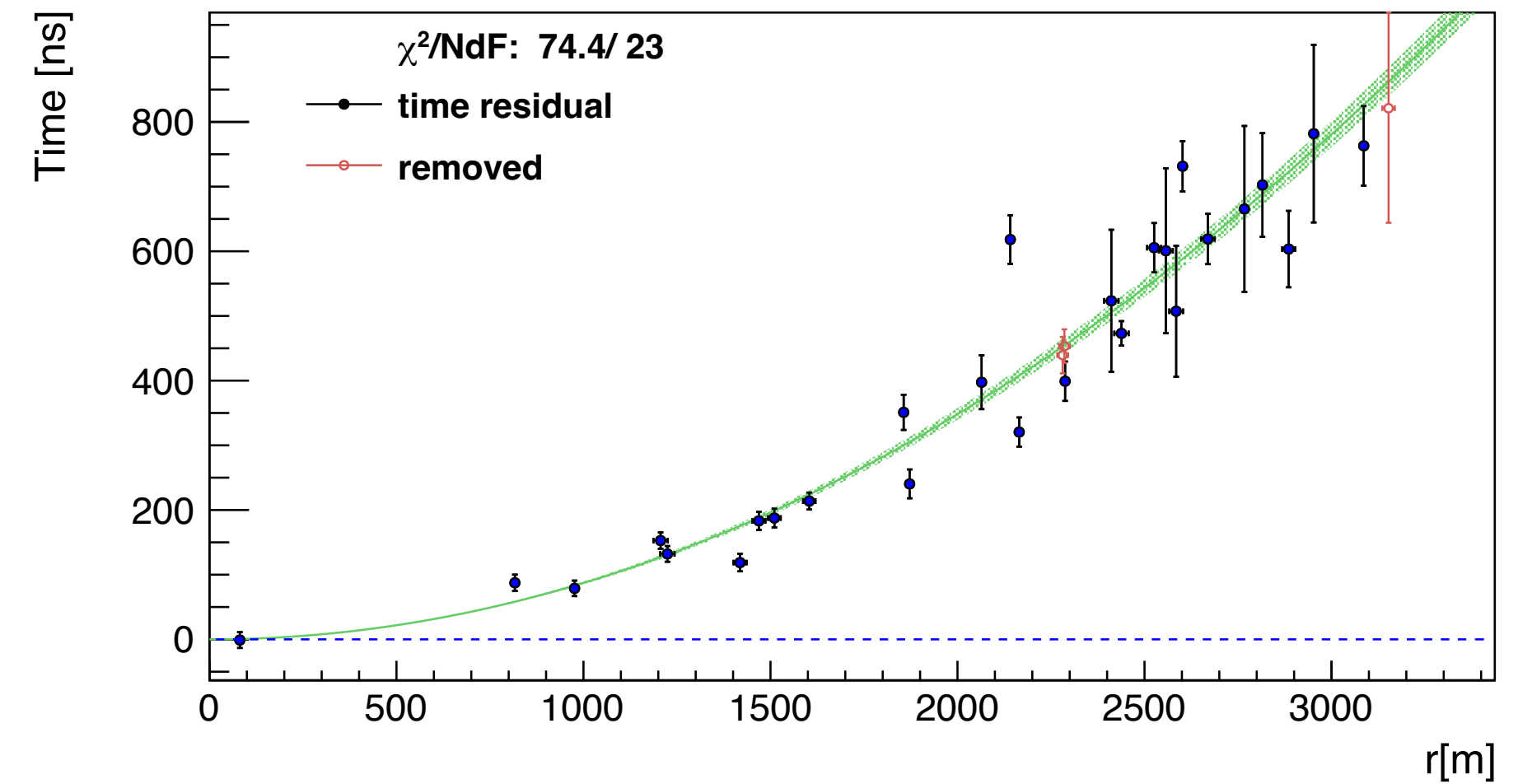


Phase II data set - Highest energy events

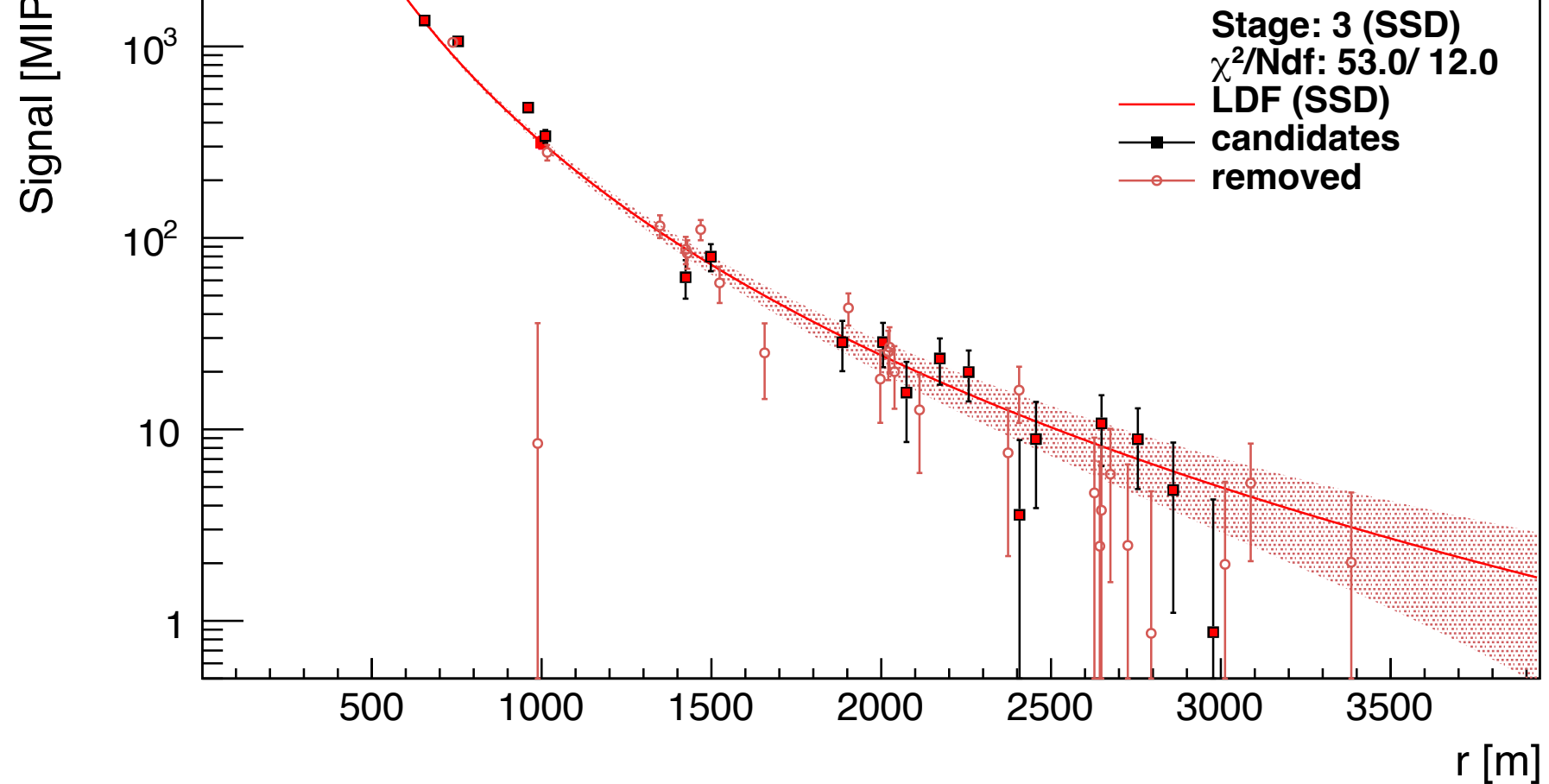
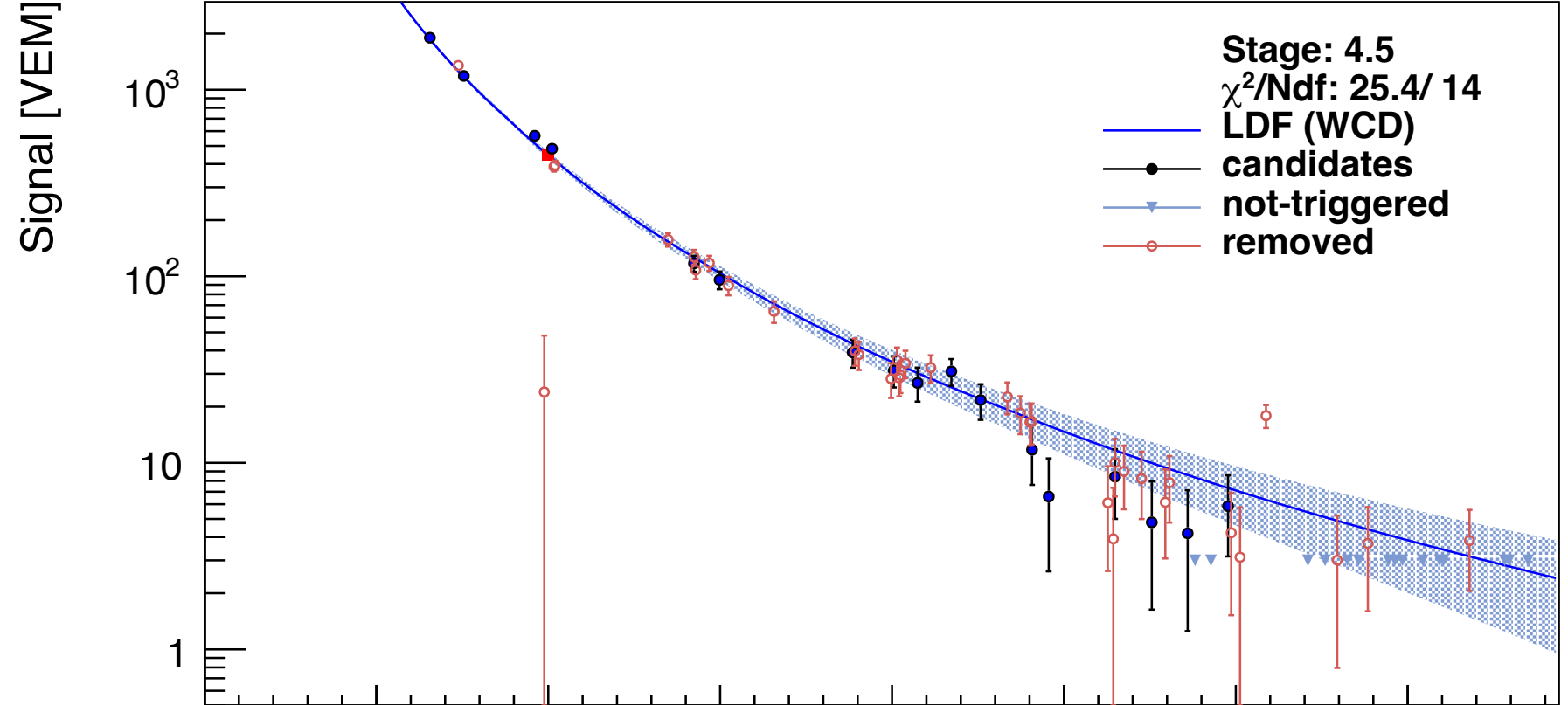
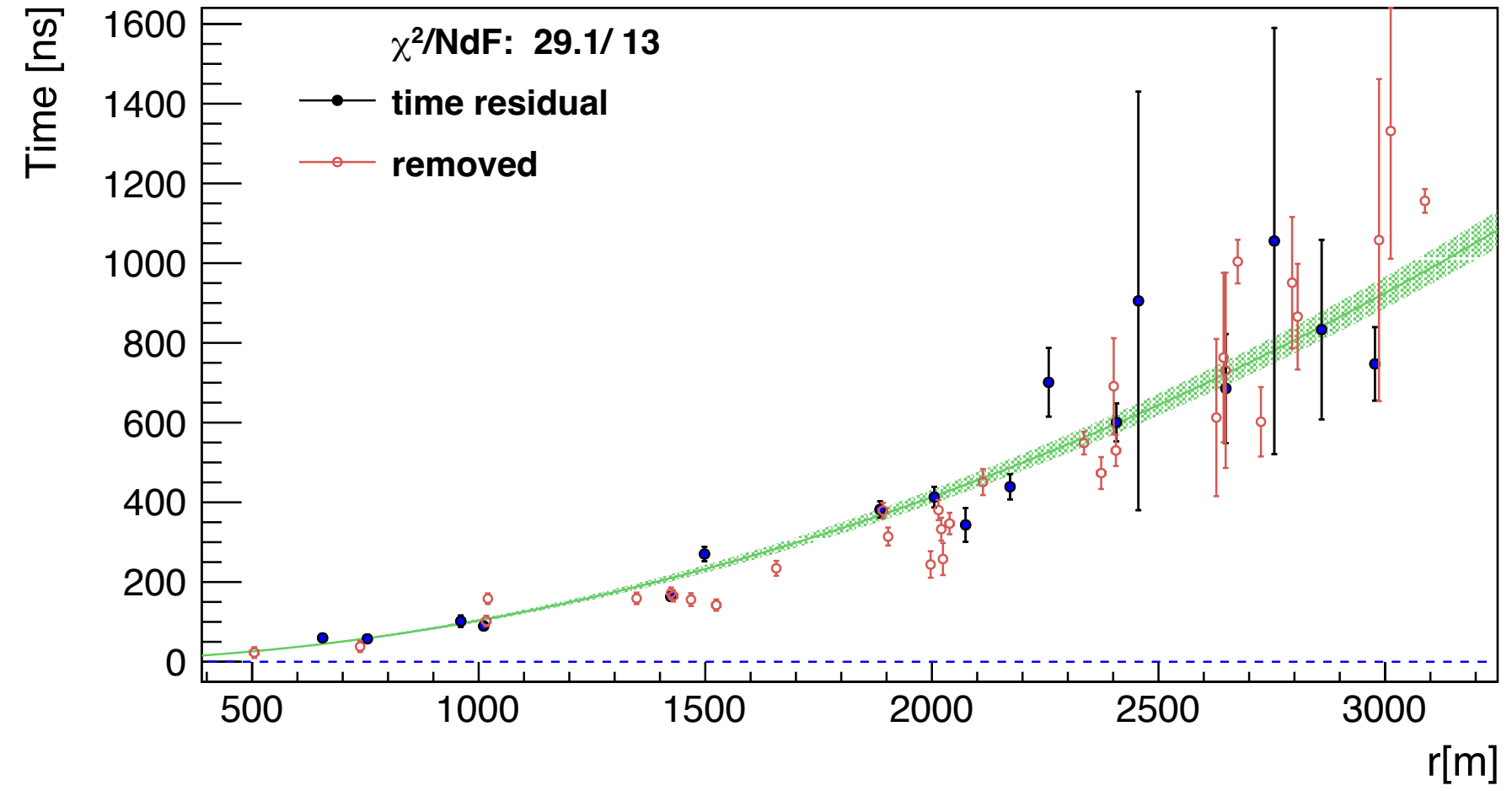
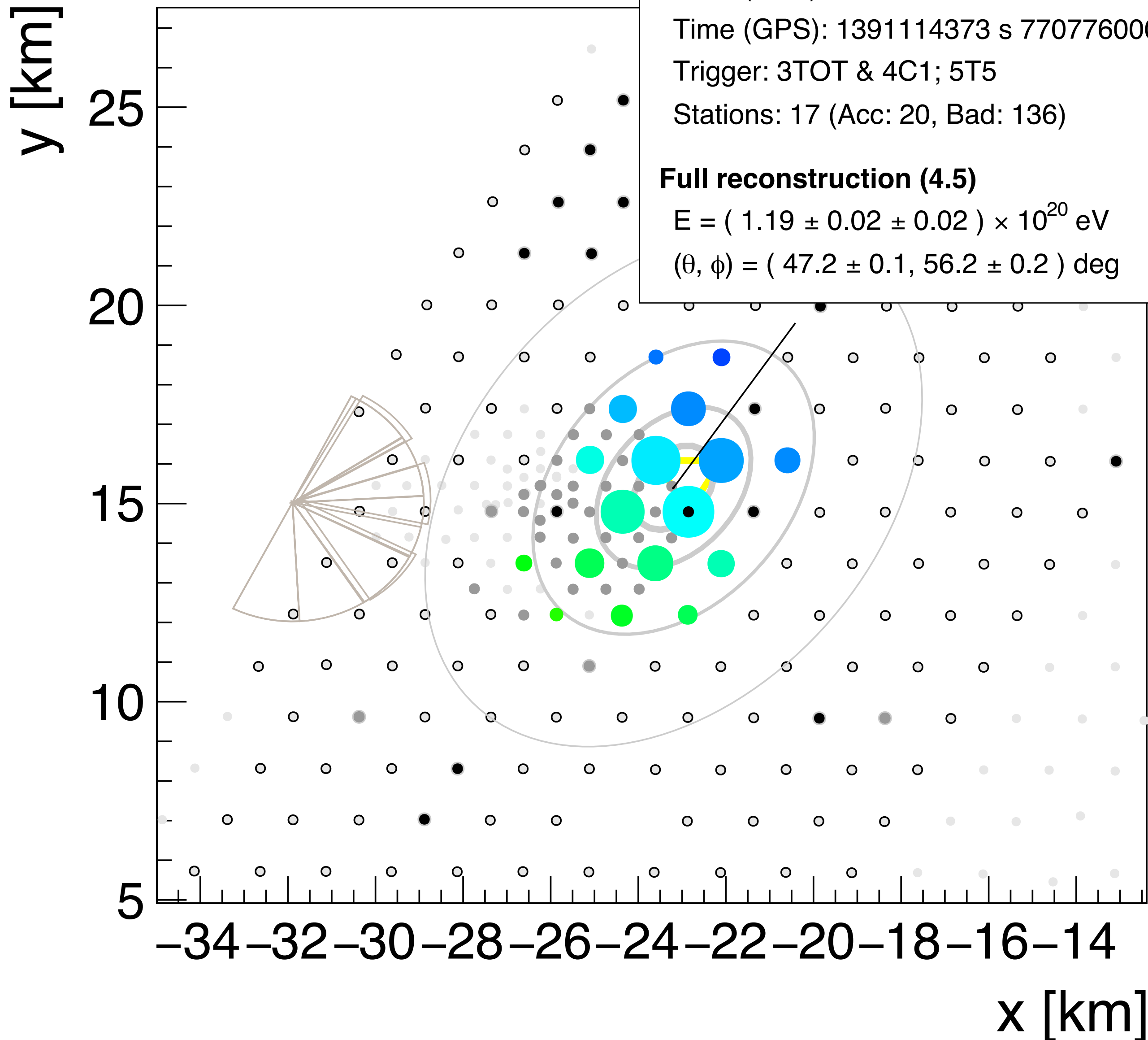


Event 71924245 :-)
 Time (UTC): 2023/3/5 22:16:46
 Time (GPS): 1362089824 s 56299000 ns
 Trigger: 3TOT & 4C1; 6T5 5T5
 Stations: 27 (Acc: 7, Bad: 298)

Full reconstruction (+limit) (4.501)
 $E = (1.11 \pm 0.03 \pm 0.10) \times 10^{20}$ eV
 $(\theta, \phi) = (56.6 \pm 0.1, 315.0 \pm 0.1)$ deg

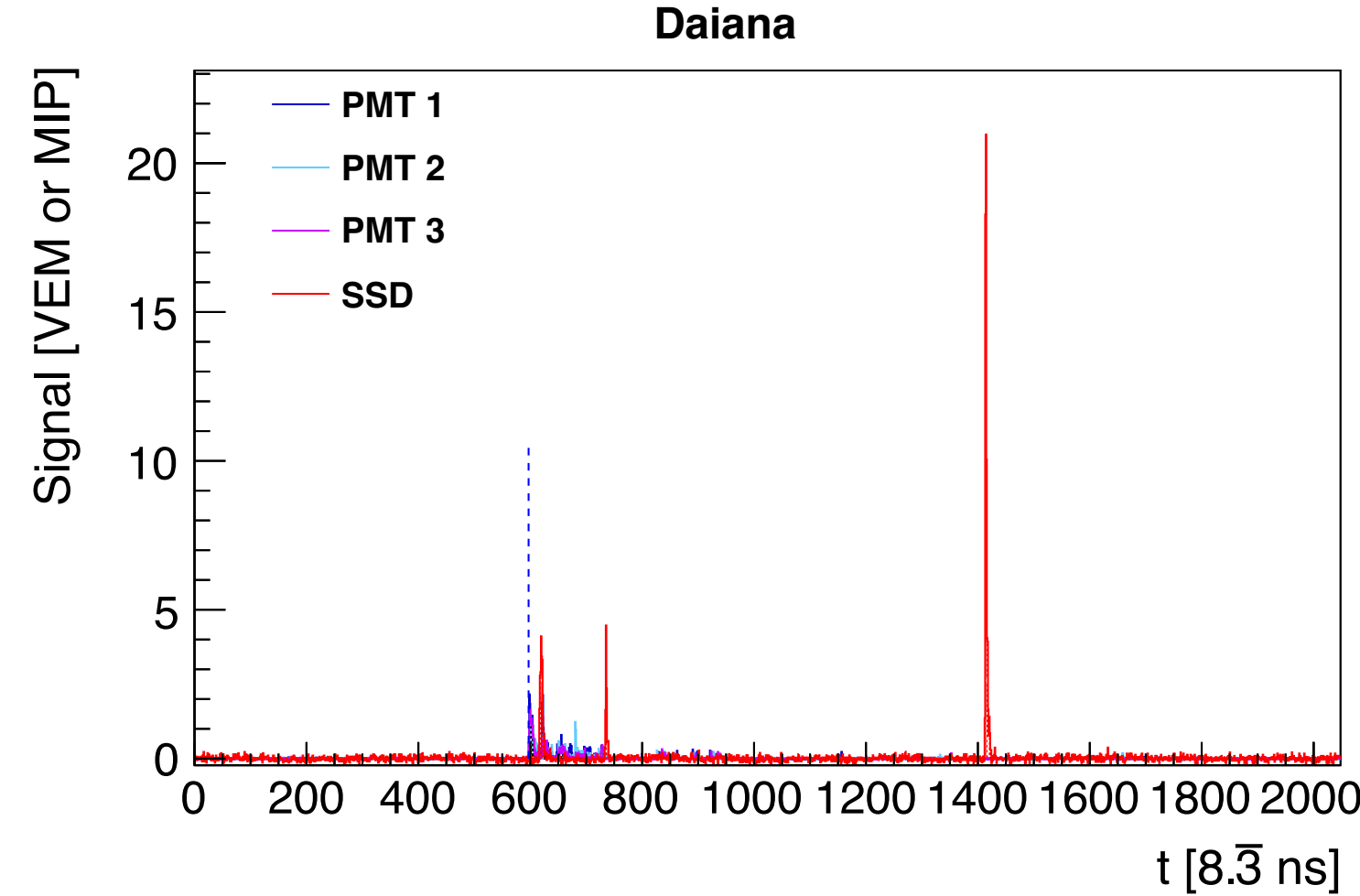
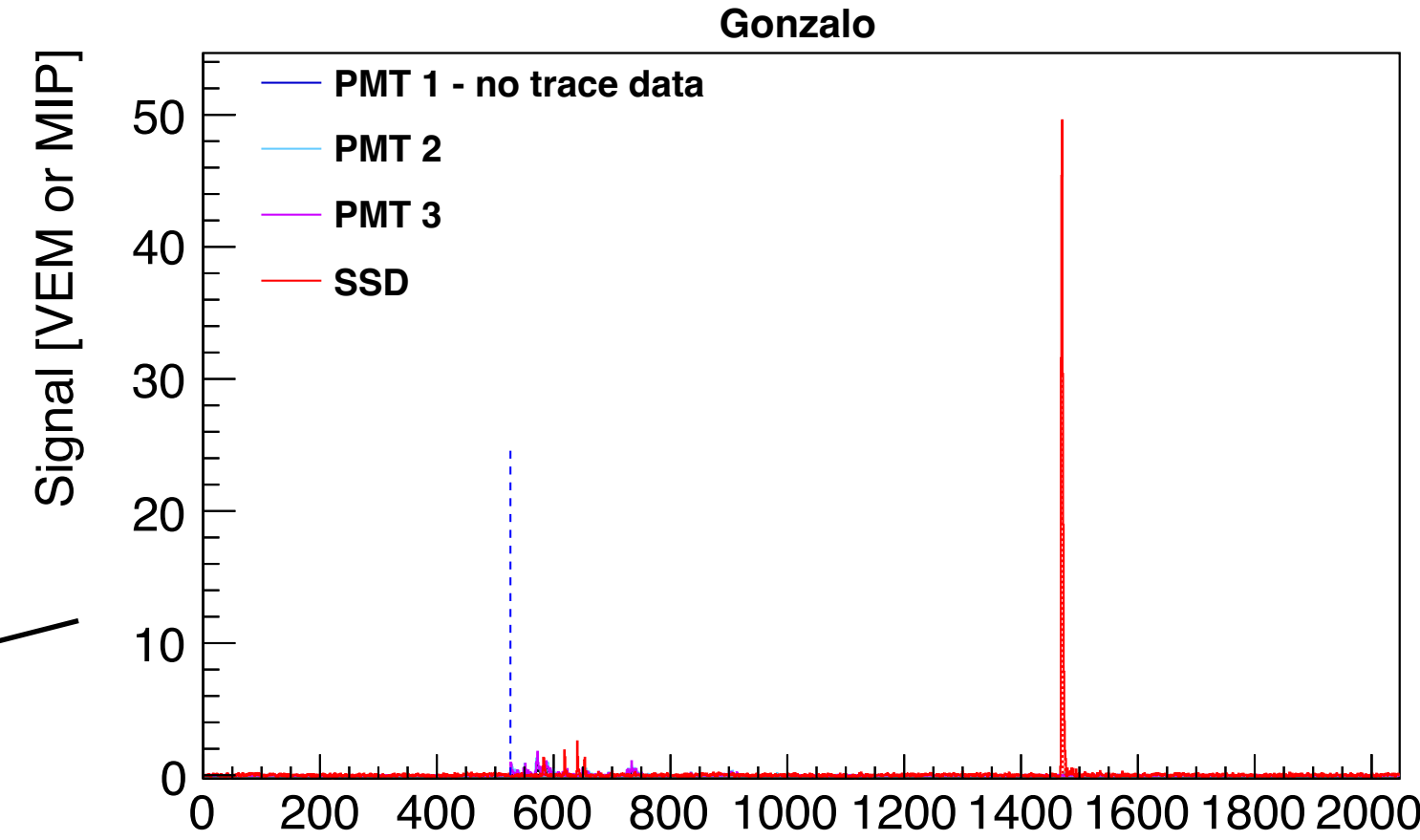
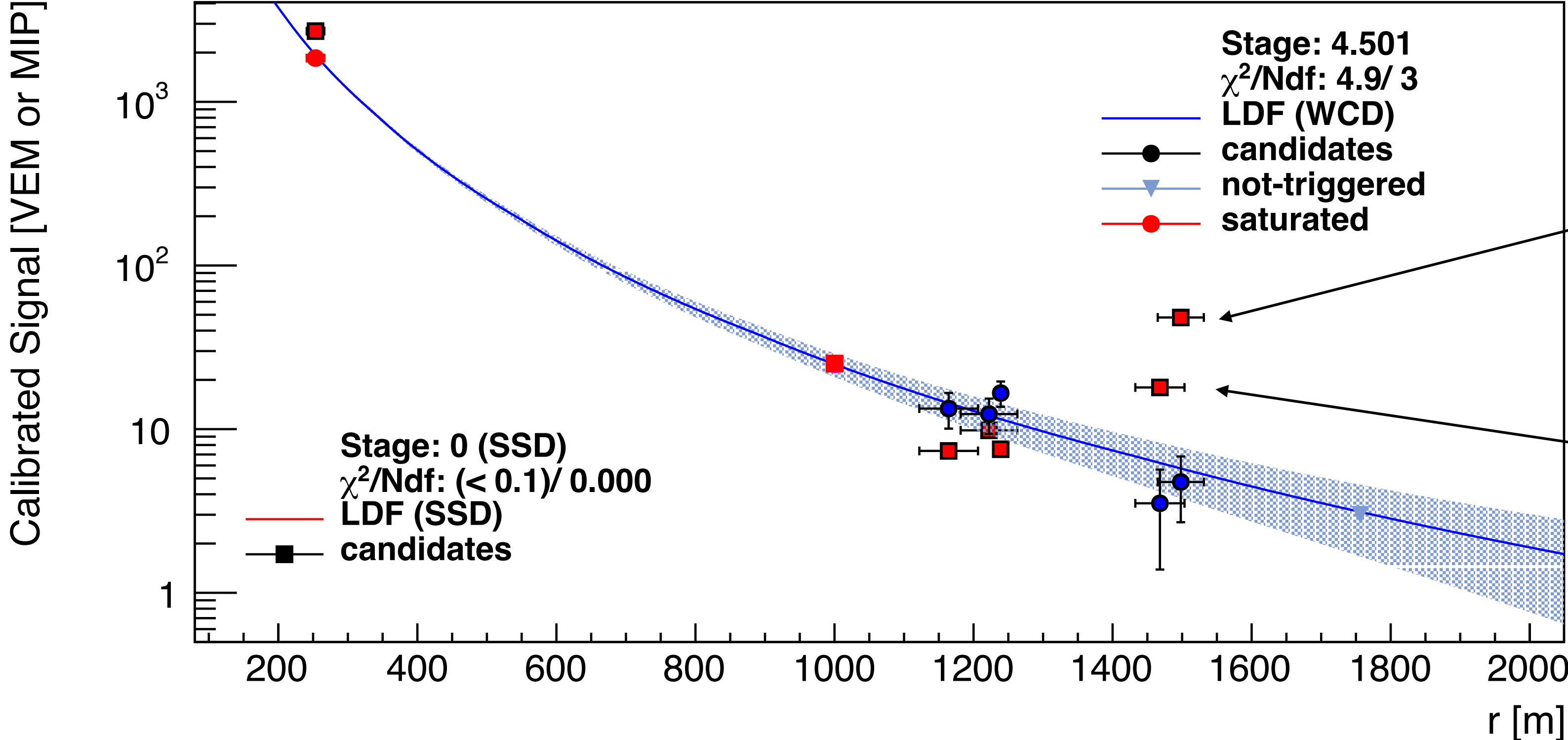


Phase II data set - Highest energy events



Example of physics-related work on reconstruction ahead

Tobias Schulz



Documented high(er)-level analysis on measurements w/ production UUBs

Parameters / models (to be) explicitly used in signal estimation + event reconstruction

- Signal uncertainties Marta Bianciotto et al.; WCD: GAP2023-053
 Gialex Anastasi: SPMT ; [GAP reference]
- Baseline determination Tobias Schulz et al.; WCD: GAP2023-007, SSD: GAP2024-XXX
- Gain ratio validation in field Tobias Schulz et al.; WCD: GAP2023-047
- VEM coincidence histograms Katarina Simkova et al.; [GAP reference]

Signals and reconstructed primary properties

- Signal sizes
 - Arrival angle
 - Energy
- ┌
| UB-UUB
| hexagon
└
- Allan Payeras et al.
 GAP2023-032 (station-level)
 GAP2023-033 (event-level)

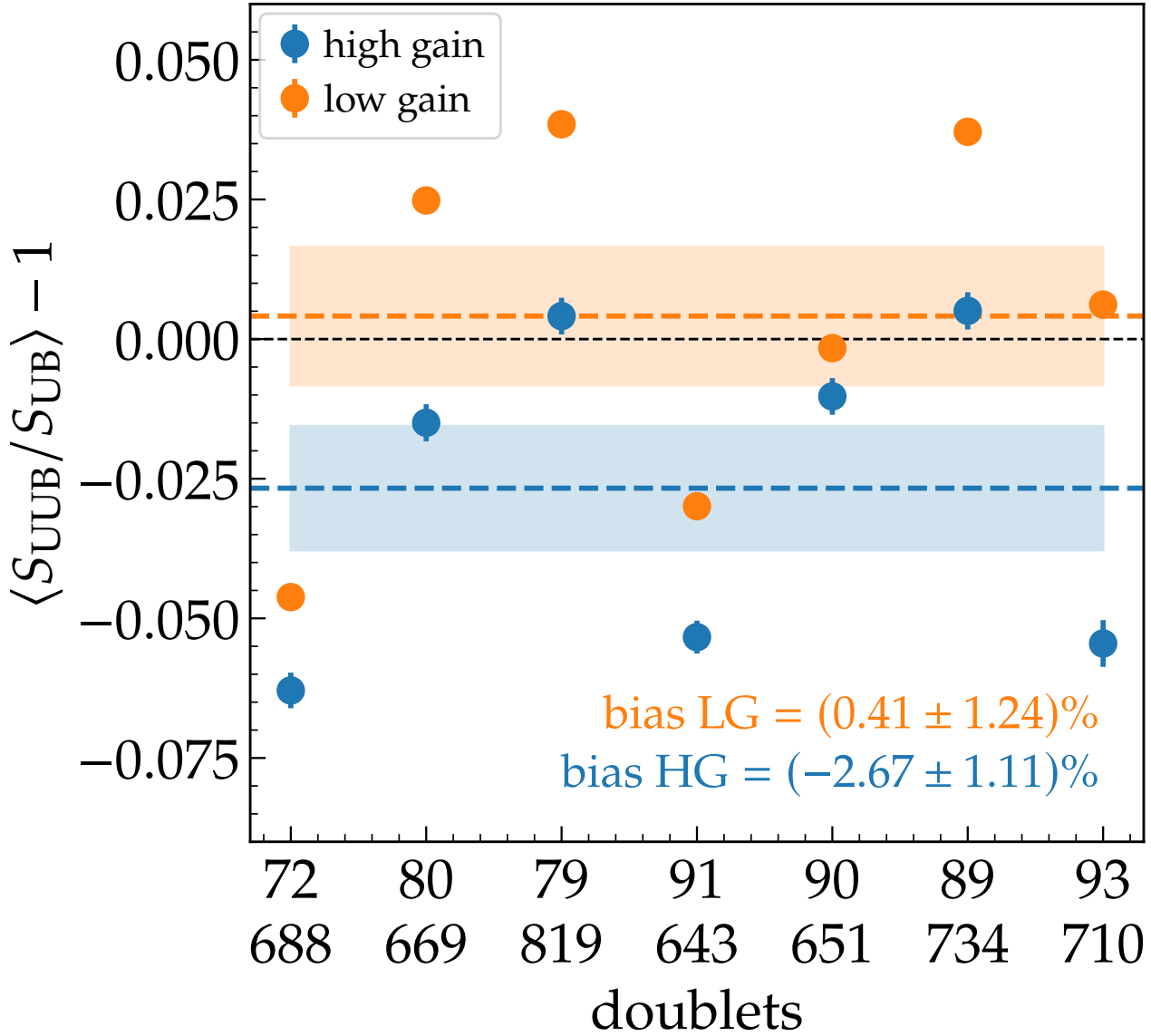
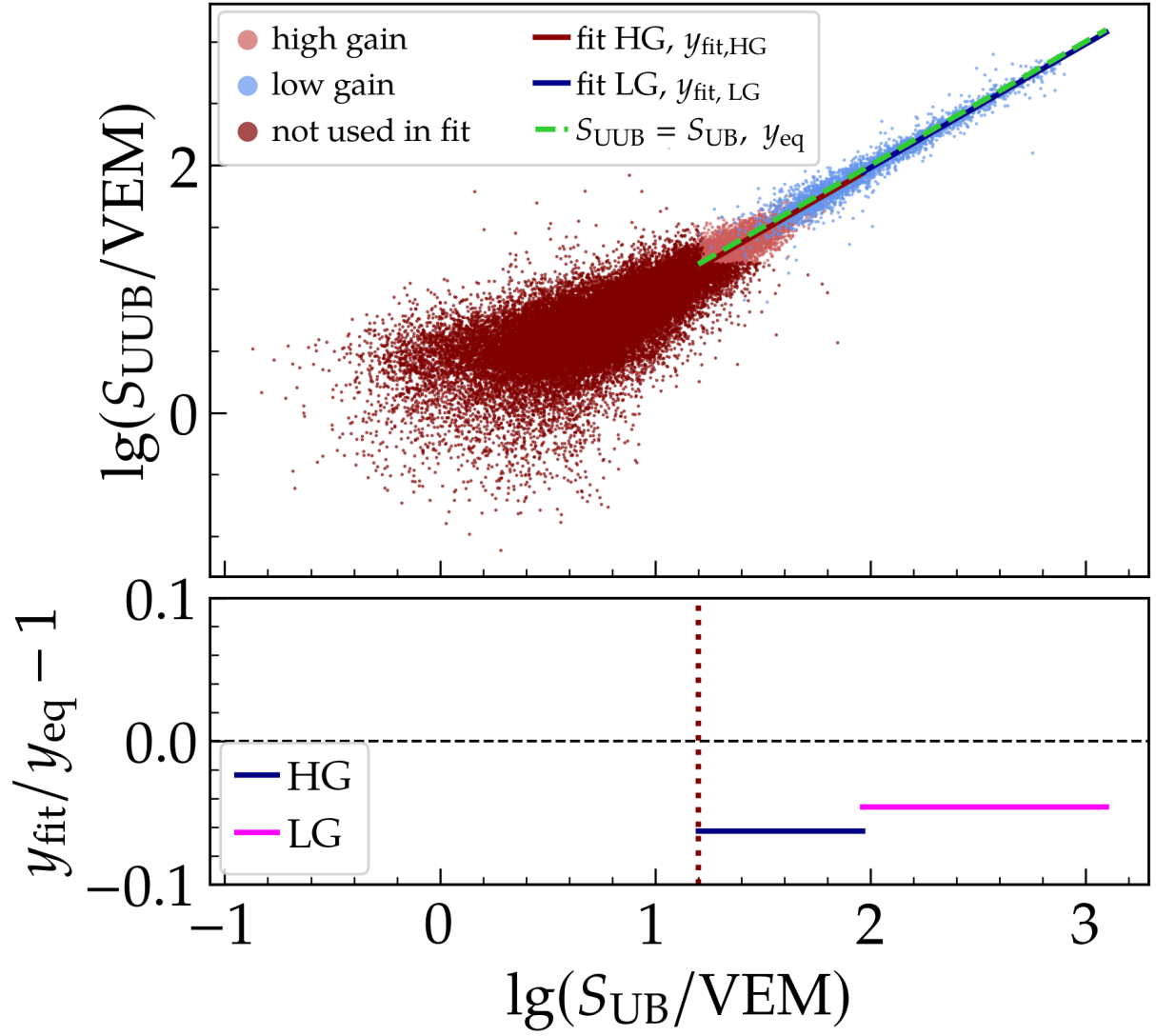
Physics

- Late pulses in SSD Tobias Schulz et al.; WCD: GAP2024-001
- Muon deficit Tobias et Schulz al.
- “Shower AoP” for vs Srijan Sehgal, Therese Paulsen et al.
- Signal ratios Quentin Luce, Fabio Convenga

Results | Station level

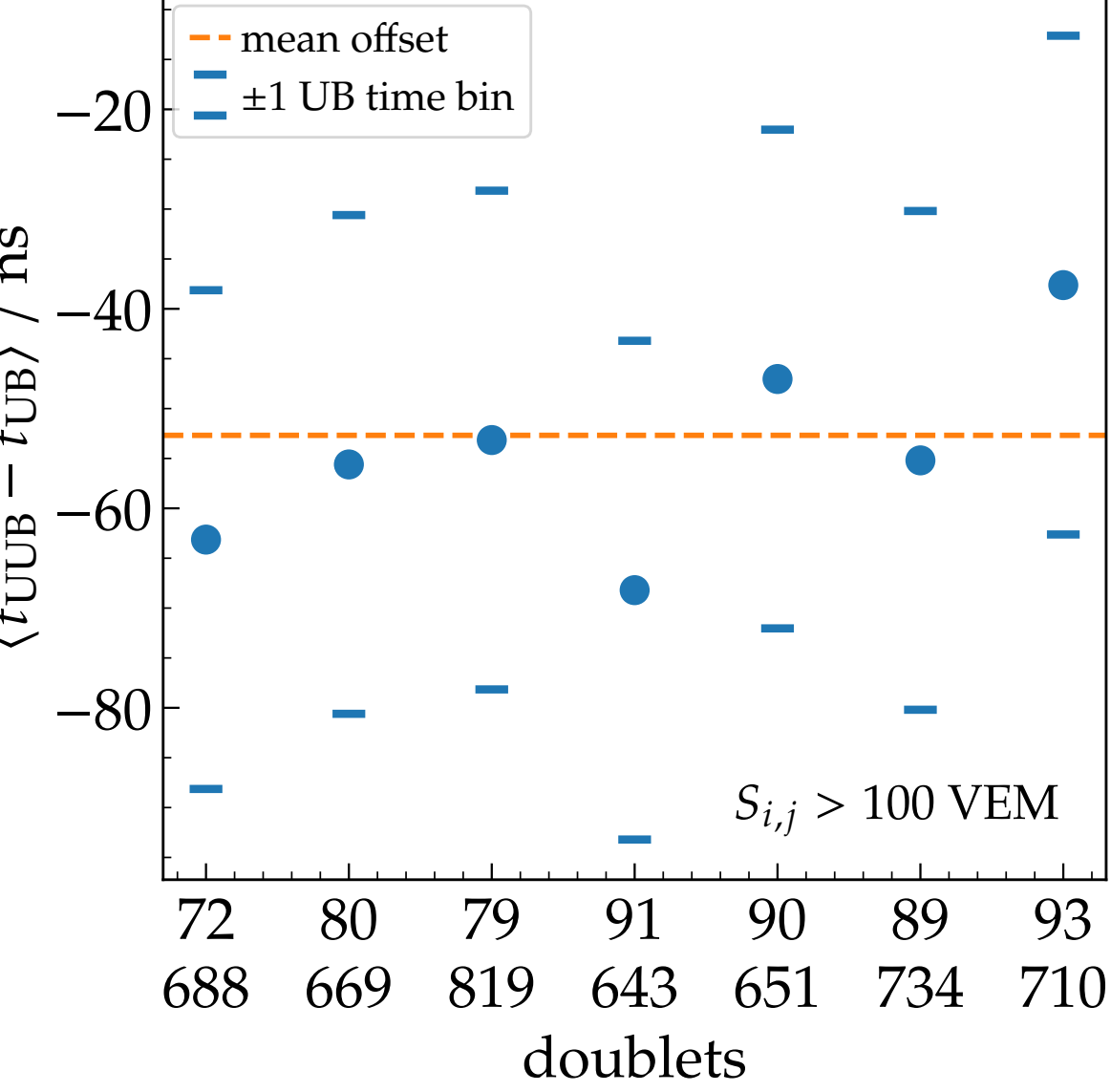
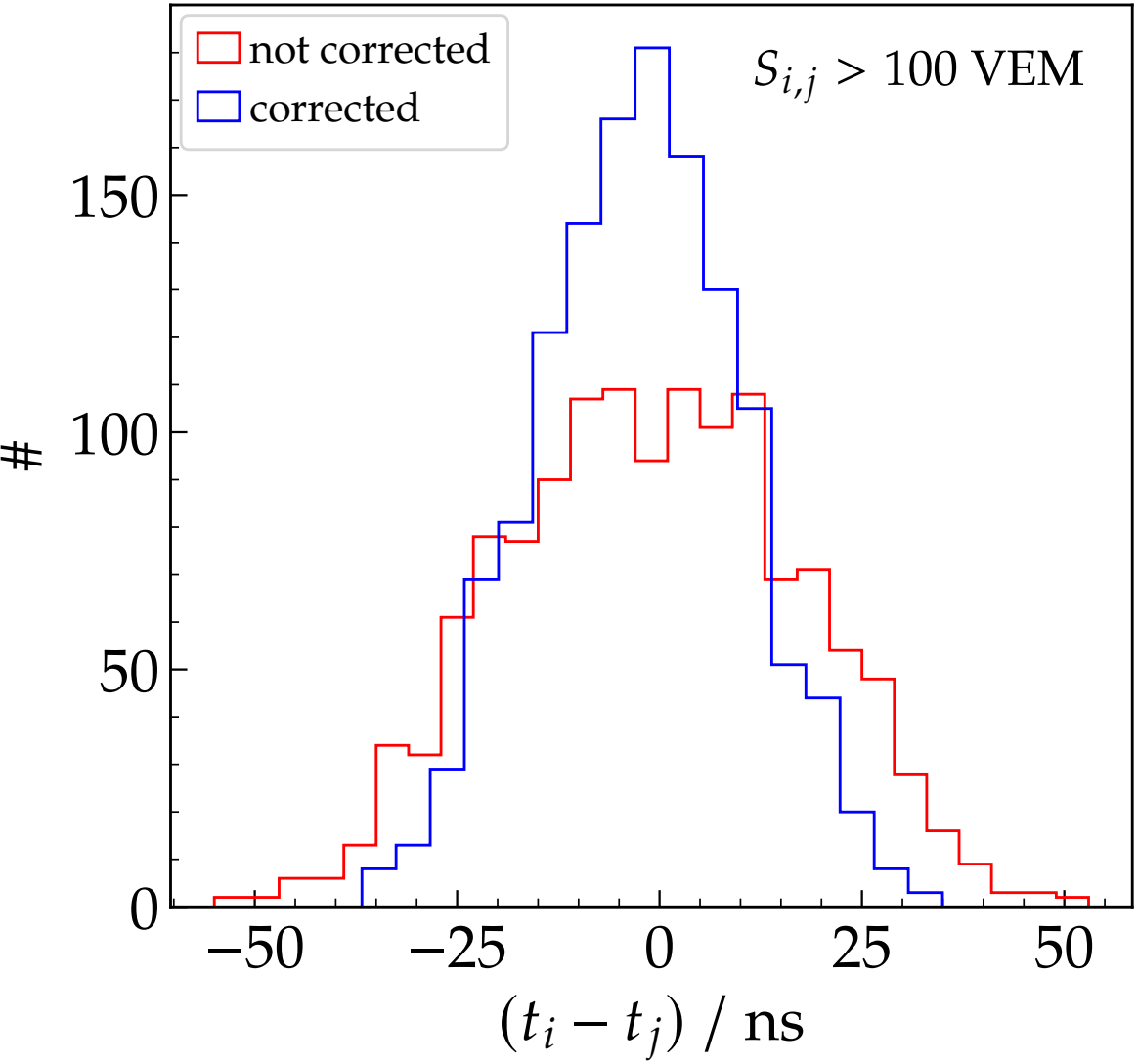
SIGNALS

doublet 72/688



START TIMES

UB doublet 80/669



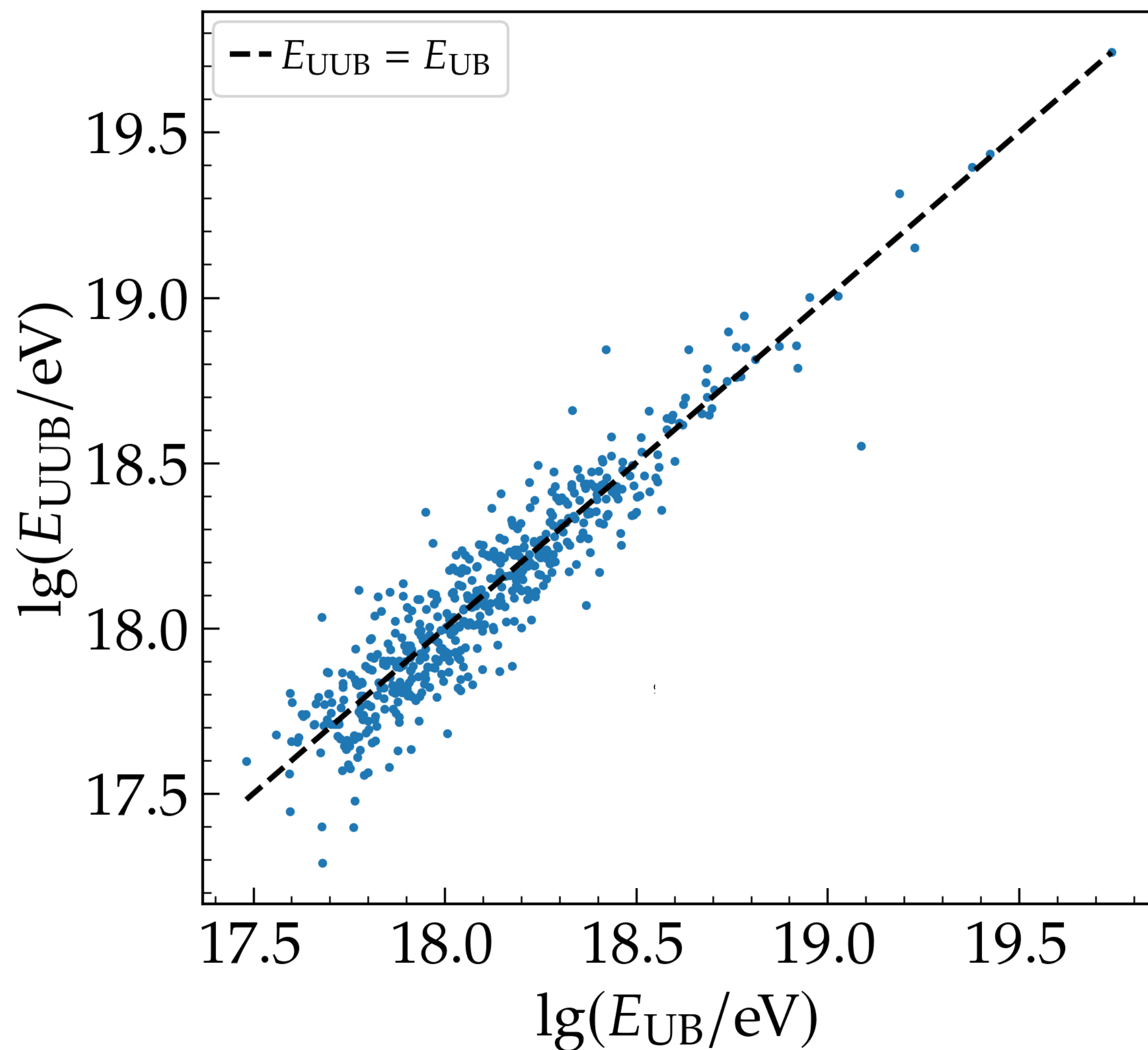
Conclusions

- High gain UUB signals $(2.67 \pm 1.24)\%$ smaller than UB
- Low gain UUB signals $(0.41 \pm 1.11)\%$ larger than UB
- UUB start times (53.3 ± 0.2) ns earlier than UB
- No indications of non-linearity

Notes

- Sufficient statistics to cover full dynamic range well
- Sufficient stations to investigate station-to-station bias resolution

Results | Event level



Conclusions

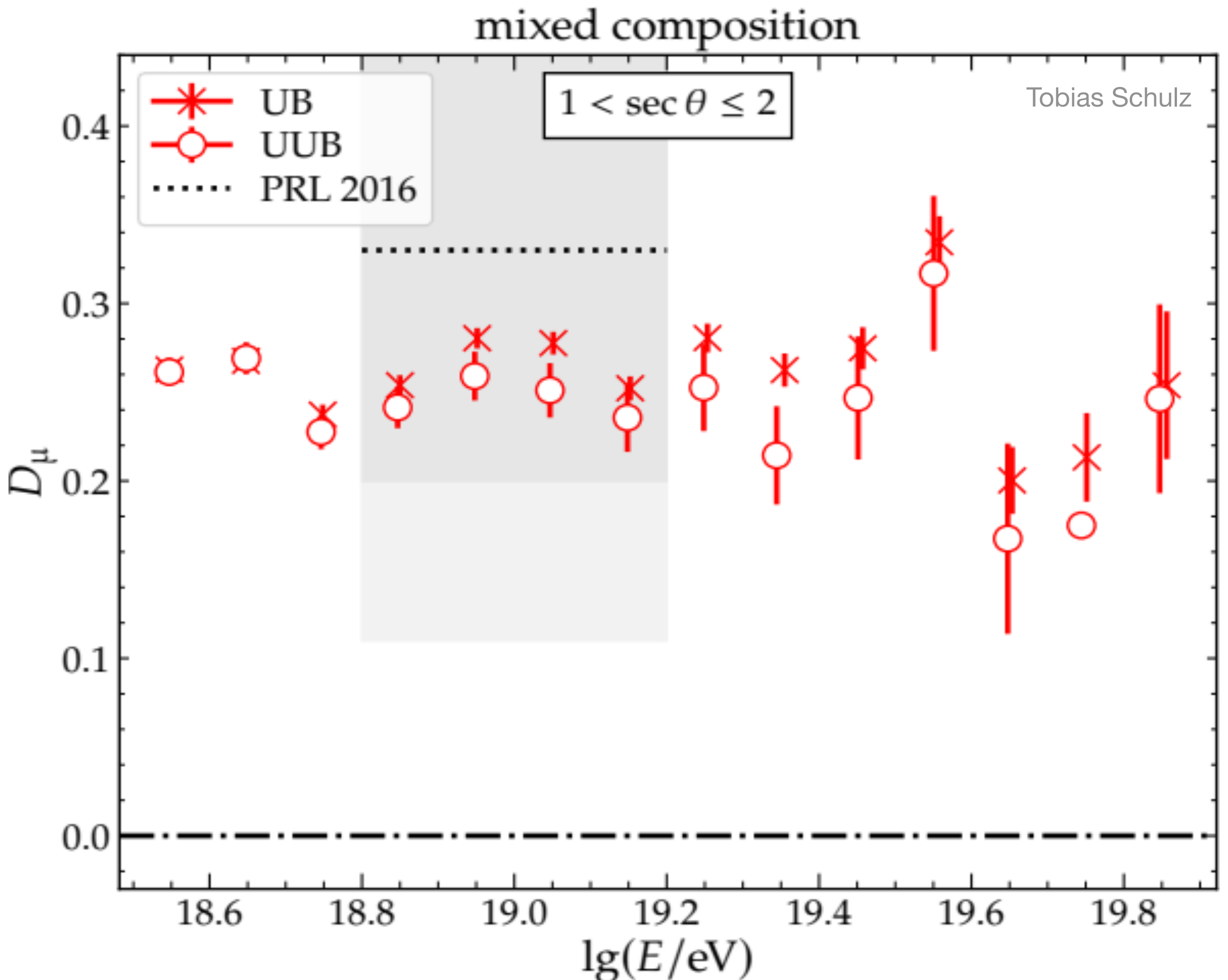
- Reconstructed primary energy agrees to within 5%
- Systematic difference in arrival directions within 0.1°
- Compatible reconstruction of core

Notes

- Statistics only sufficient to investigate UB-UUB systematics in reconstructed energy at and below full-efficiency threshold
- Statistics not sufficient to properly investigate resolution in arrival direction reconstruction (UUB-UUB doublets maybe better for this anyway)
- Extensive studies of trigger efficiency not performed (complicated by situation of doublet hexagon in mixed UB/UUB infill)

Example ~physics analysis

- Deficit in muon signal in simulations assuming:
- correct energy scale
 - correct simulated EM shower component
 - AugerMix



Important tasks with limited or no active effort

- Identify falsely (un)masked WCD PMTs
- General look at FD hybrid reconstruction with UUBs
- Analysis of (stability of) trigger efficiencies at event-level
- Tests of standard physics analyses with UUB data set
- Validation of online VEM charge estimation (as backup to histogram)
- WCD/SSD integration windows
- Understand UB/UUB discrepancy in SSD/WCD signal ratios in measurements
- SSD LDF parameterization on measurements
- Confirmation of UUB upgrade timestamps with event data (required for correct 6T5+exposure)
- SPMT incorporation into WCD LDF fit
- Assessment of performance of all algorithms on measurements
- (Further) development of existing/new algorithms
 - Universality
 - DNNs
 - Matrix formalism
- Signal and timing uncertainty models for WCD & SSD re-derived

Requirements

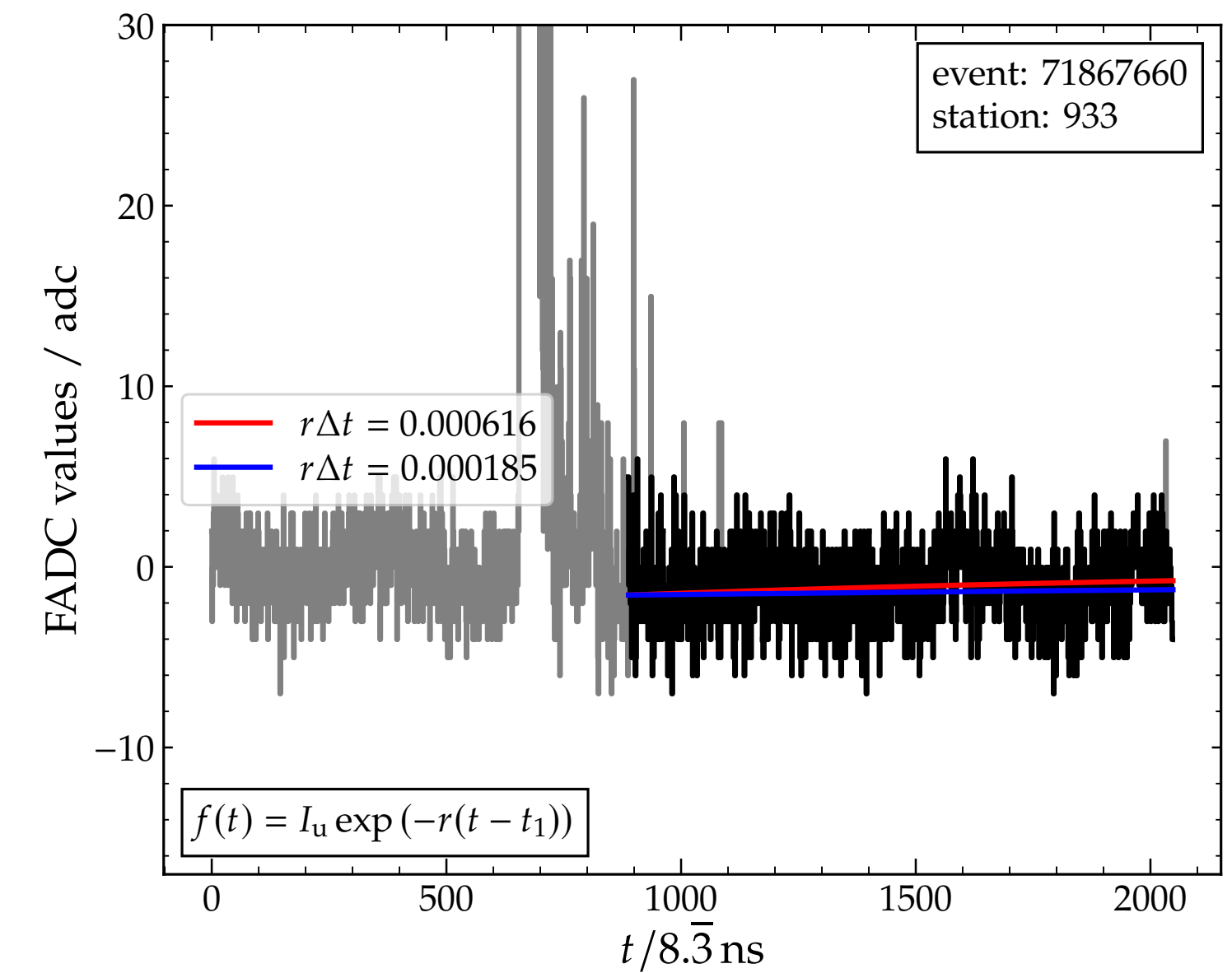
Depends if working above or near/below full efficiency

In general

- Identification of non-existent or improperly functioning SSDs
- Correct masking of WCD PMTs (un)suitable for trigger at time of trigger
- Stable trigger configuration
- Complete documentation of testing (and minimization of impact on data set acquired with main CDAS DAQ instance)
- Input on how to improve bad periods definition?

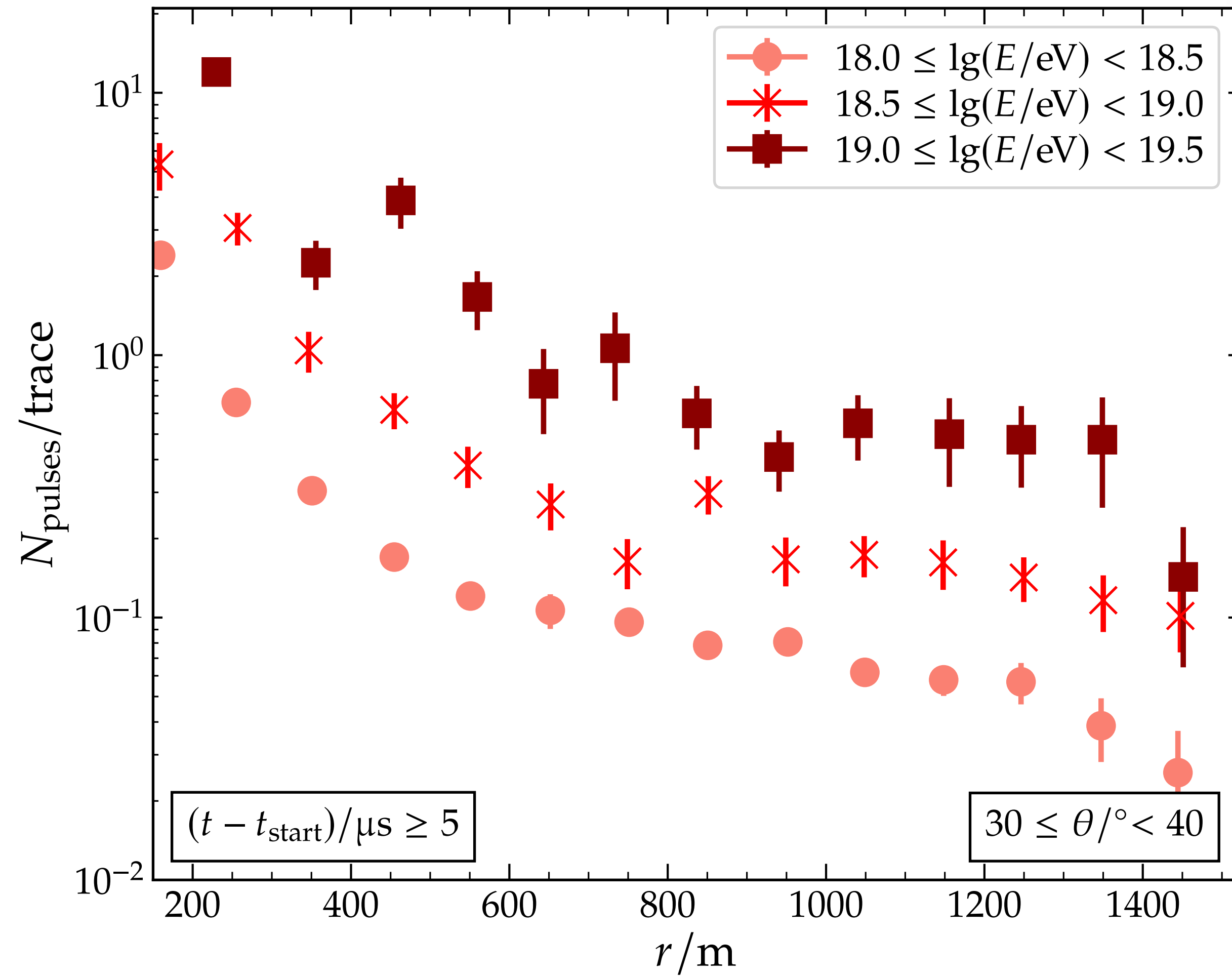
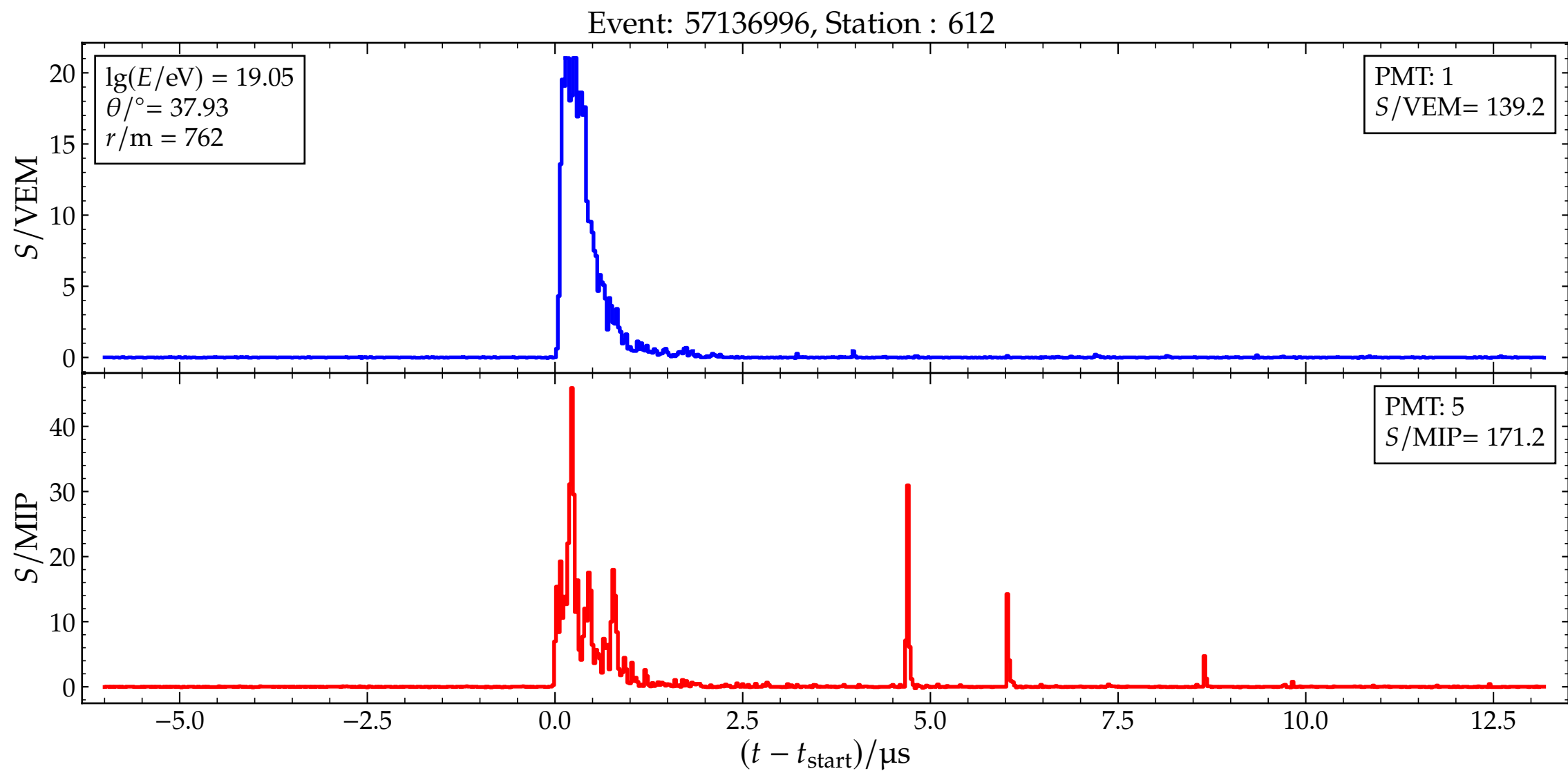
Near/below full efficiency

- Stable trigger efficiencies for different trigger types
- New triggers?

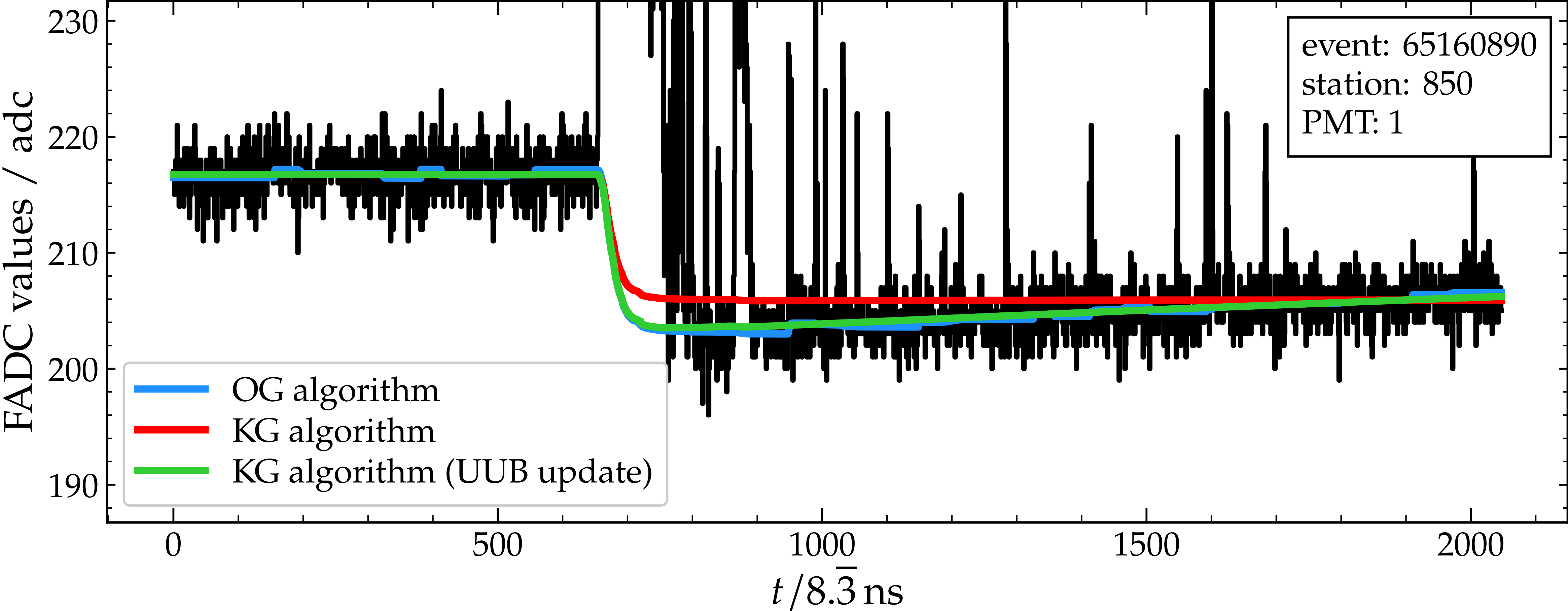


Supplementary material

Late pulses



Baseline determination



AugerPrime Reconstruction (reconstructions using AugerPrime hardware)

SSD LDF

- LDF parameterized on simulations
(T. Schulz, A. Taboada, B. Manning)
- Fit using propagated uncertainties of WCD geometry reconstruction
(T. Schulz, Q. Luce)
- Parameterization of signal uncertainty with simulations and low-statistics measurements
(T. Schulz, A. Taboada, B. Manning)
- Models of SSD response
(M. Pothast et al.)

Universality

- Reconstruction of X_{\max} and, with inclusion of SSD, R_{μ} developed
(Max Stadelmaier)

Matrix Formalism / Signal Ratios

- Adaptations from LSD method to reconstruct EM and muon signals
(D. Schmidt, A. Letessier-Selvon, P. Billoir, A. Payeras, C. Perez-Bertolli, B. Manning, D. Martello)
- SSD/WCD signal ratios
(B. Manning, F. Convenga, Q. Luce)

DNNs

Inclusion of SSD in X_{\max} , R_{μ} estimation
(N. Langer, S.Hahn)

See DNN task overview (Steffen Hahn)

No significant testing of algorithms on measurements

Plan is to have preliminary productions of implemented Phase II reconstructions by ~end of May to facilitate development of AugerPrime ICRC analyses (see DPA session)

November Collaboration Meeting:

