Mass composition measurement with the Auger Surface Detector

and

Upgrade of the Pierre Auger Observatory: AugerPrime

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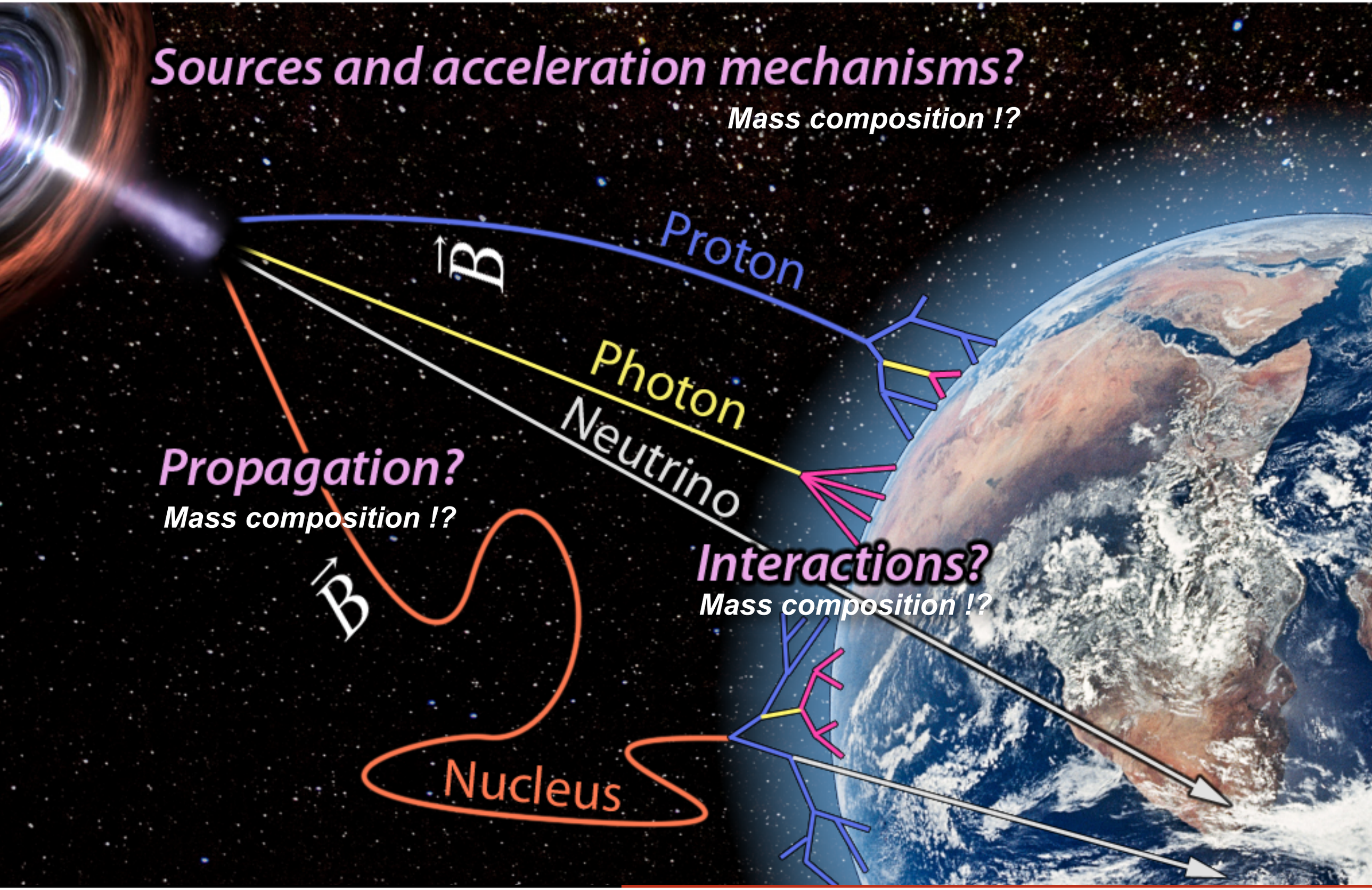
Nikhef Jamboree
15 December 2015

PIERRE AUGER OBSERVATORY

Nikhef

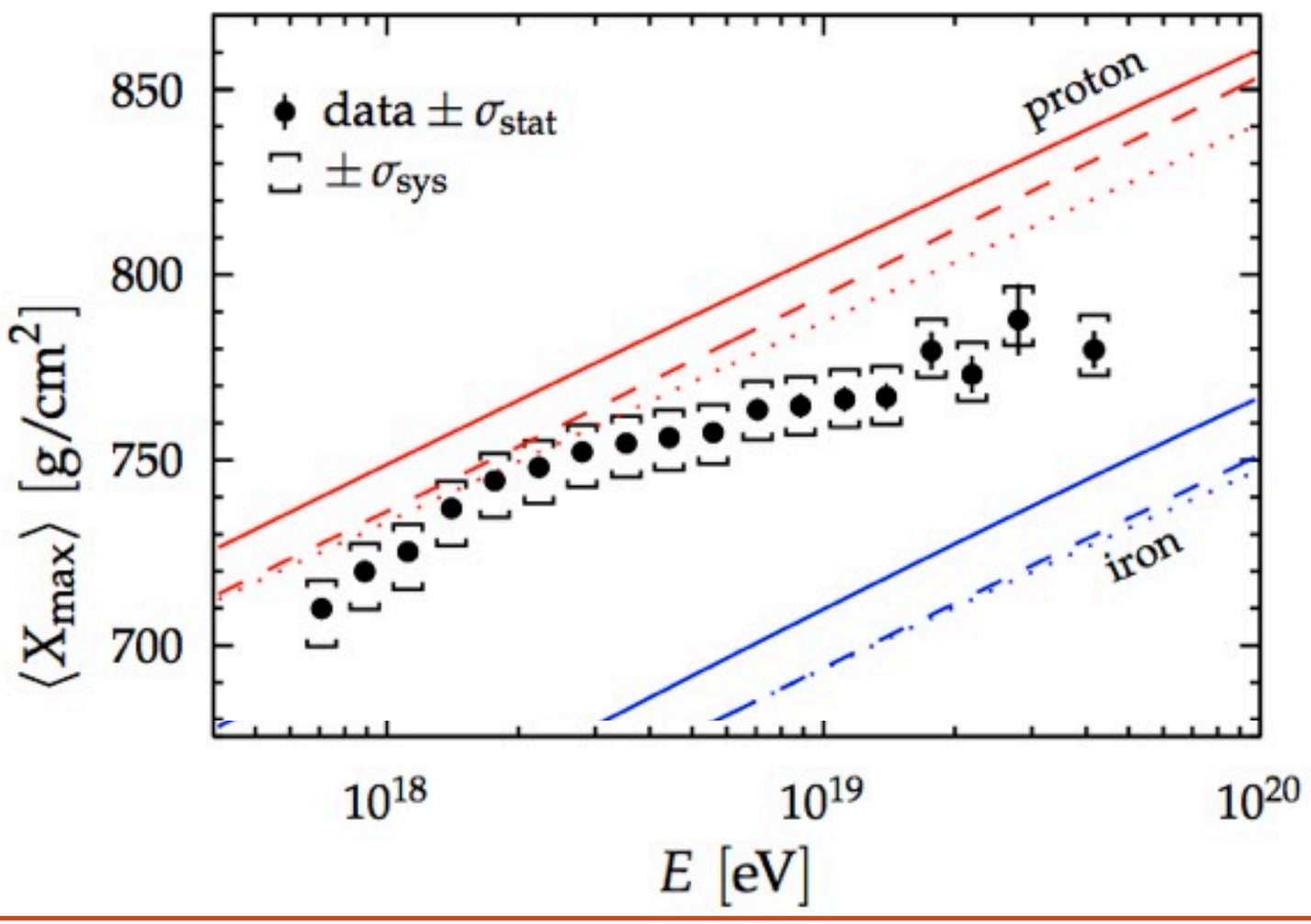
Radboud University Nijmegen

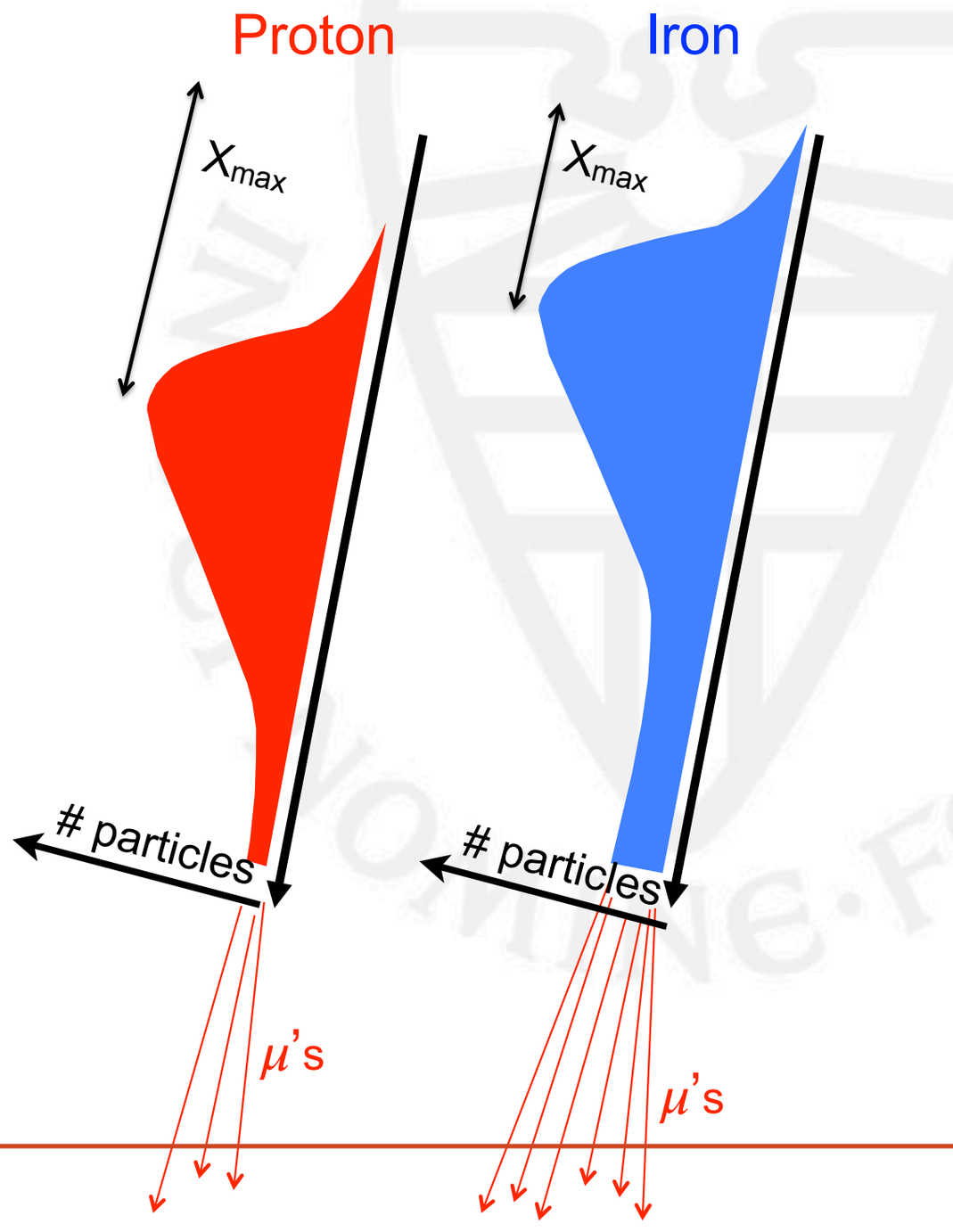

Sources and acceleration mechanisms?
Mass composition !?
B
Proton
Photon
Neutrino
Propagation?
Mass composition !?
B
Interactions?
Mass composition !?
Nucleus

How to measure cosmic ray mass composition?

Heavy CRs (Iron) interact earlier and showers develop faster

⇒ Earlier at maximum shower size





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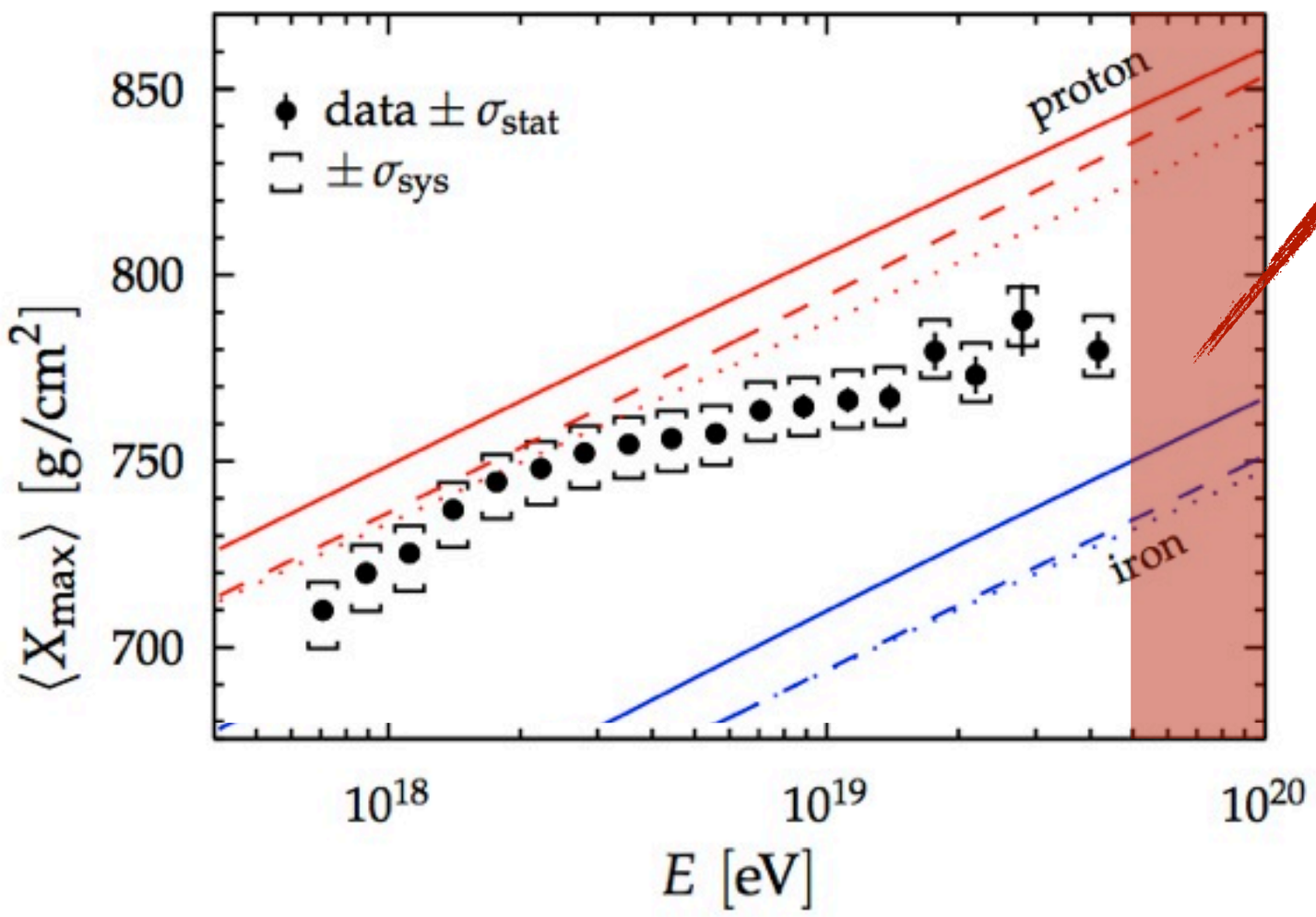
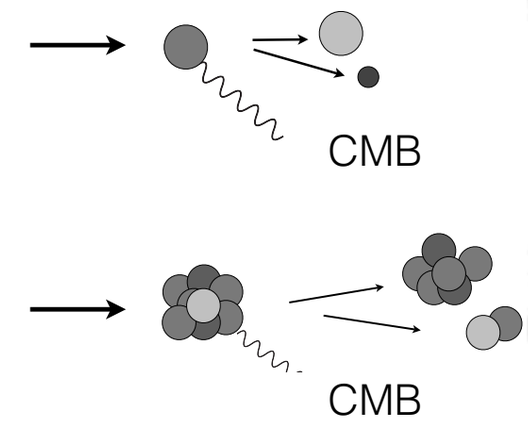


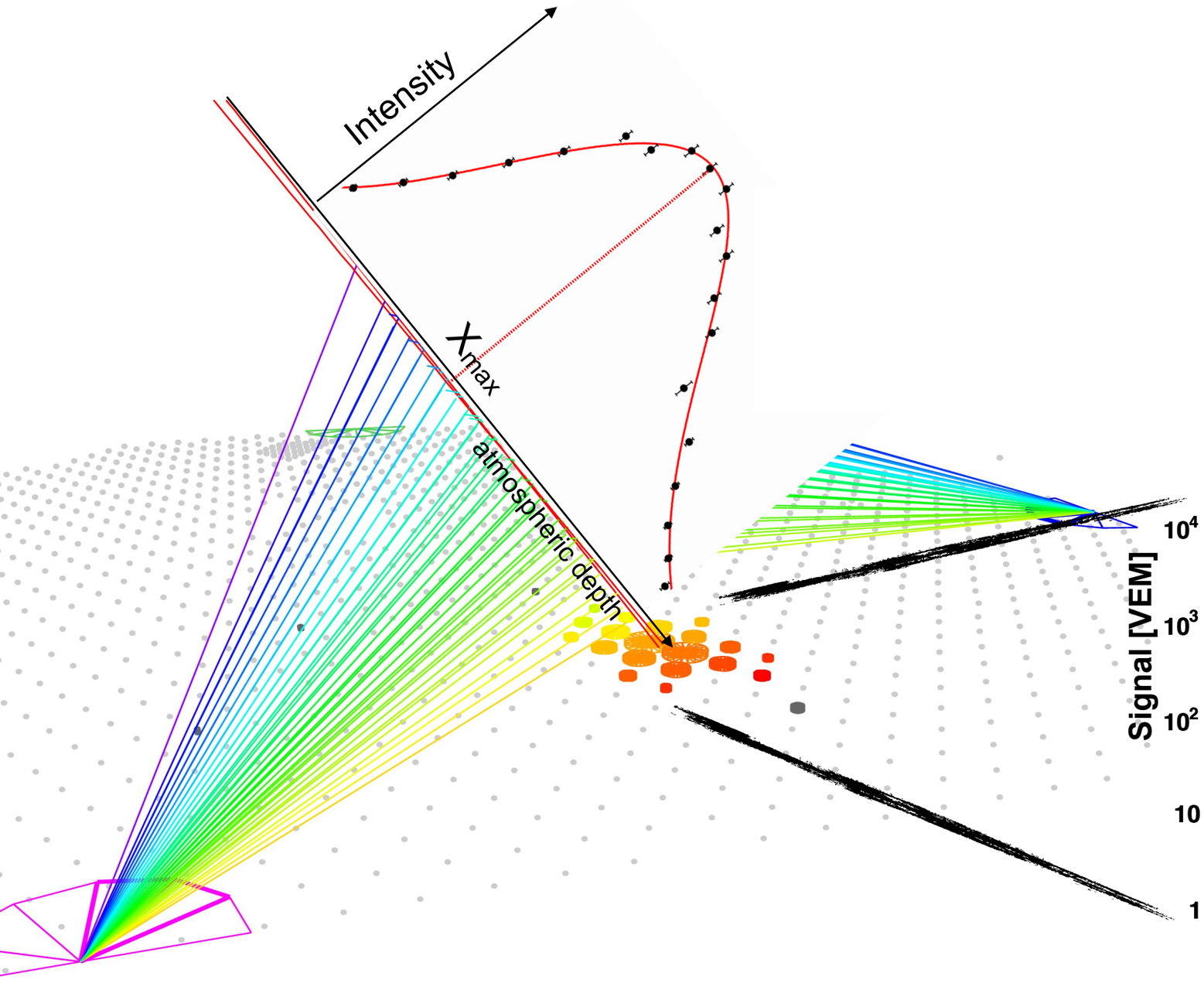
GZK region:
potential to find sources of CRs

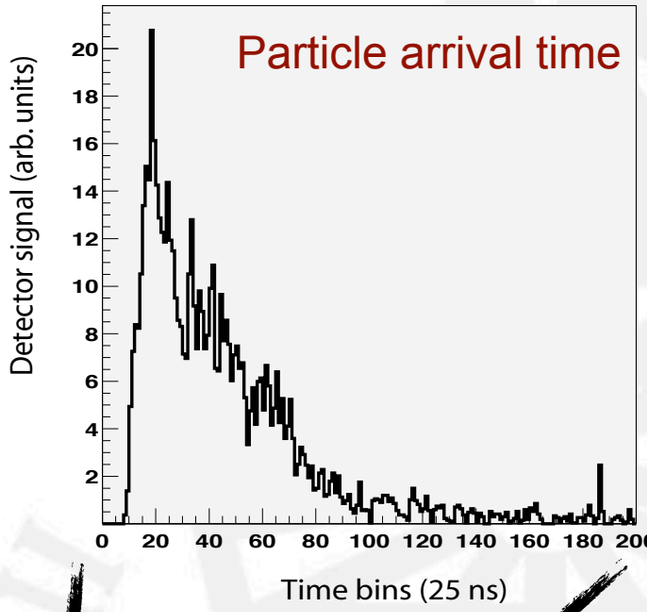
GZK effect:

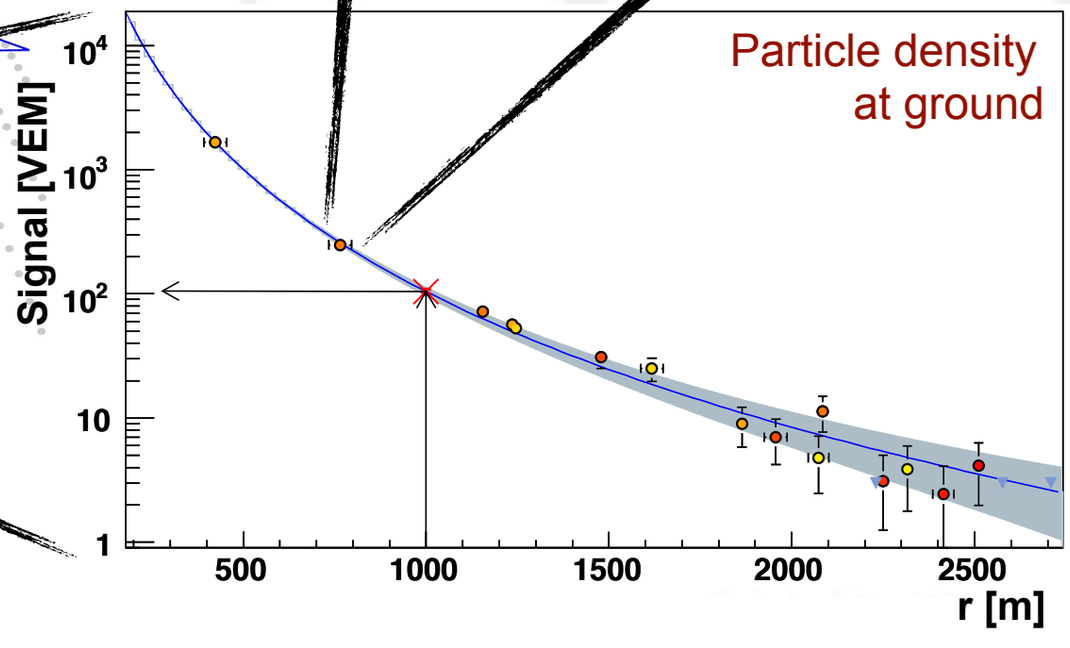
suppression due to energy loss during propagation



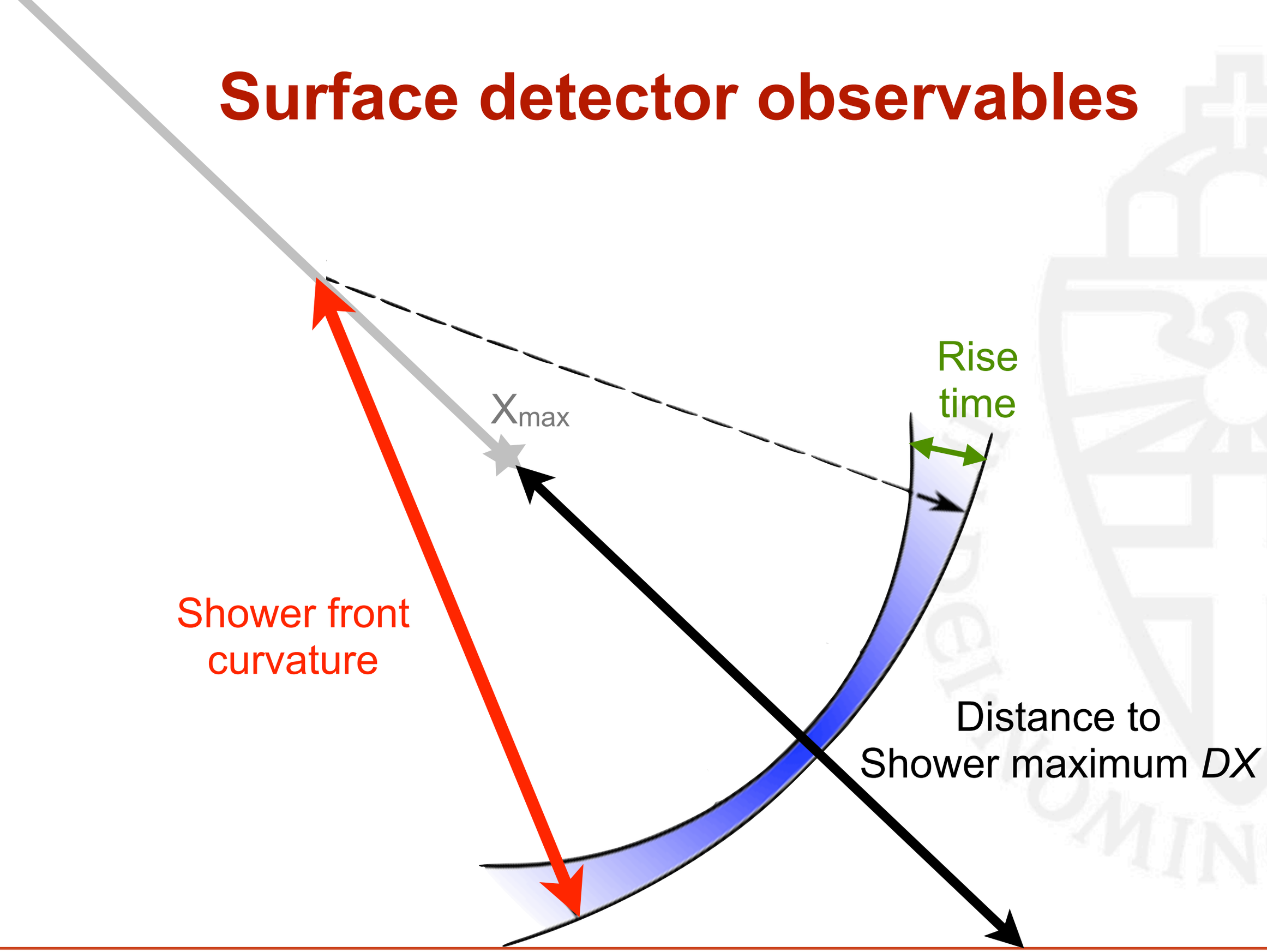
Measurement of an air shower







Surface detector observables



Calibration

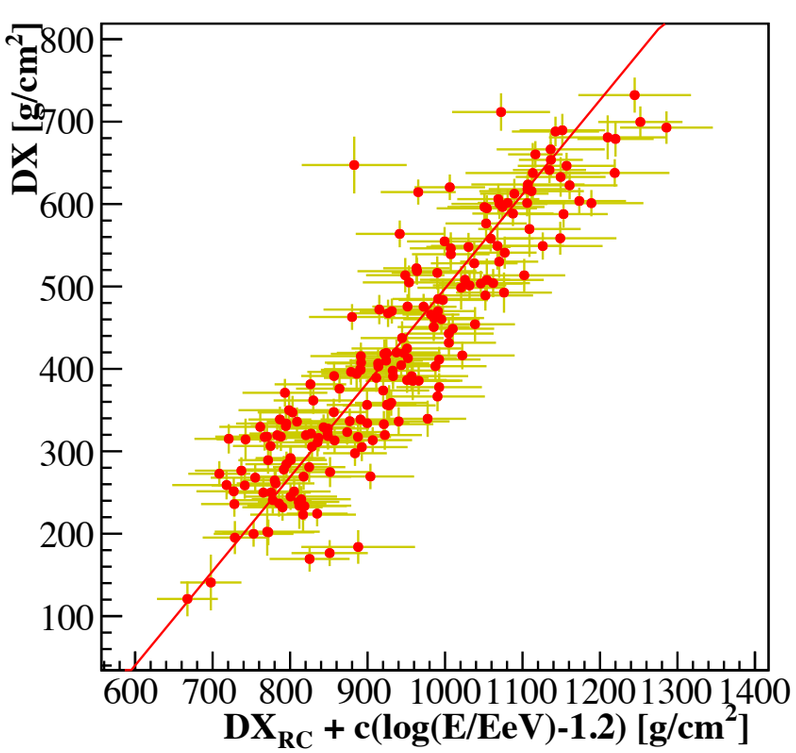
- Use data measured by both detectors to calibrate Sd parameter *S* versus distance to shower maximum *DX*

$$DX = \frac{X(H_{ground})}{\cos\theta} - X_{max}$$

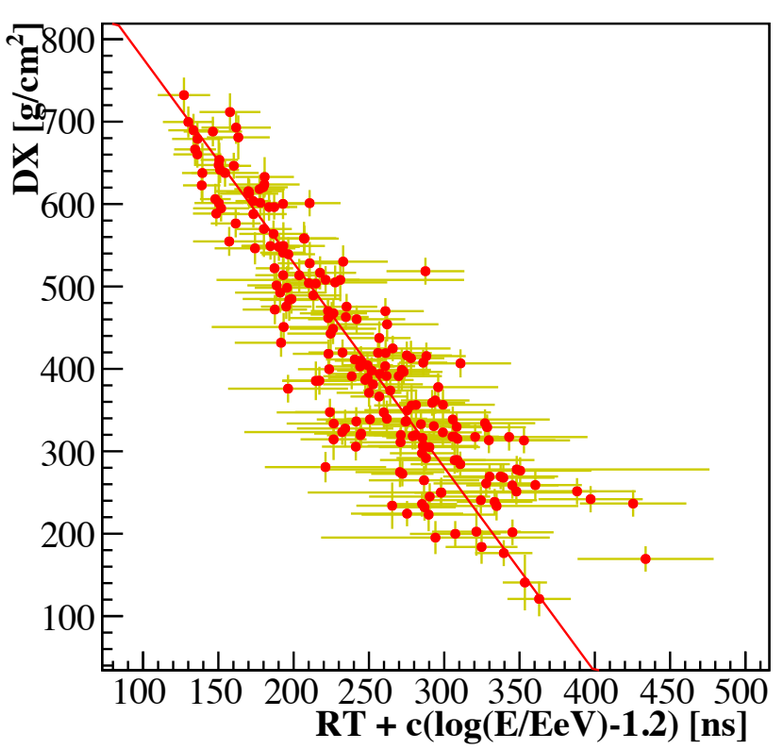
- And fit with

$$DX = a + b(S + c\log_{10}(\frac{E}{\mathrm{EeV}})).$$

Radius of curvature

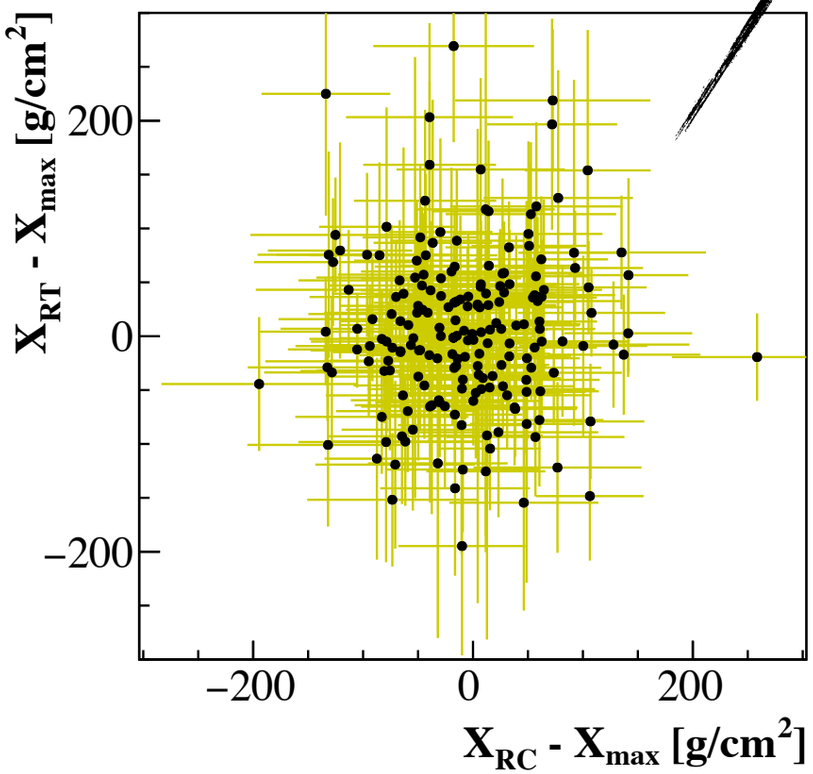


Rise time



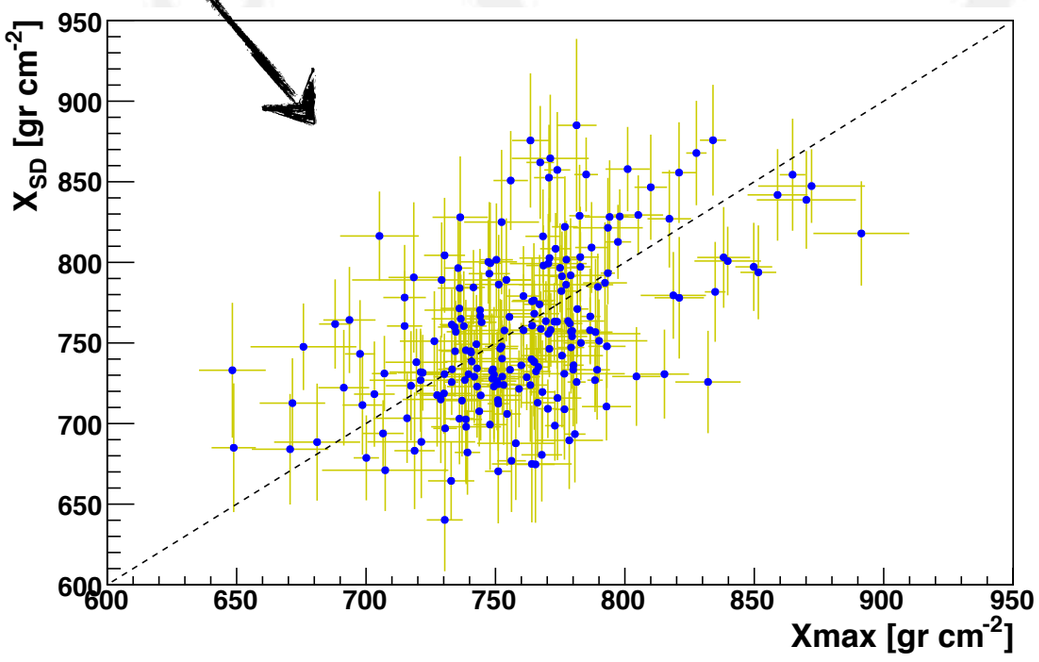
X_{max} measured with the SD

Correlation between curvature and rise time information

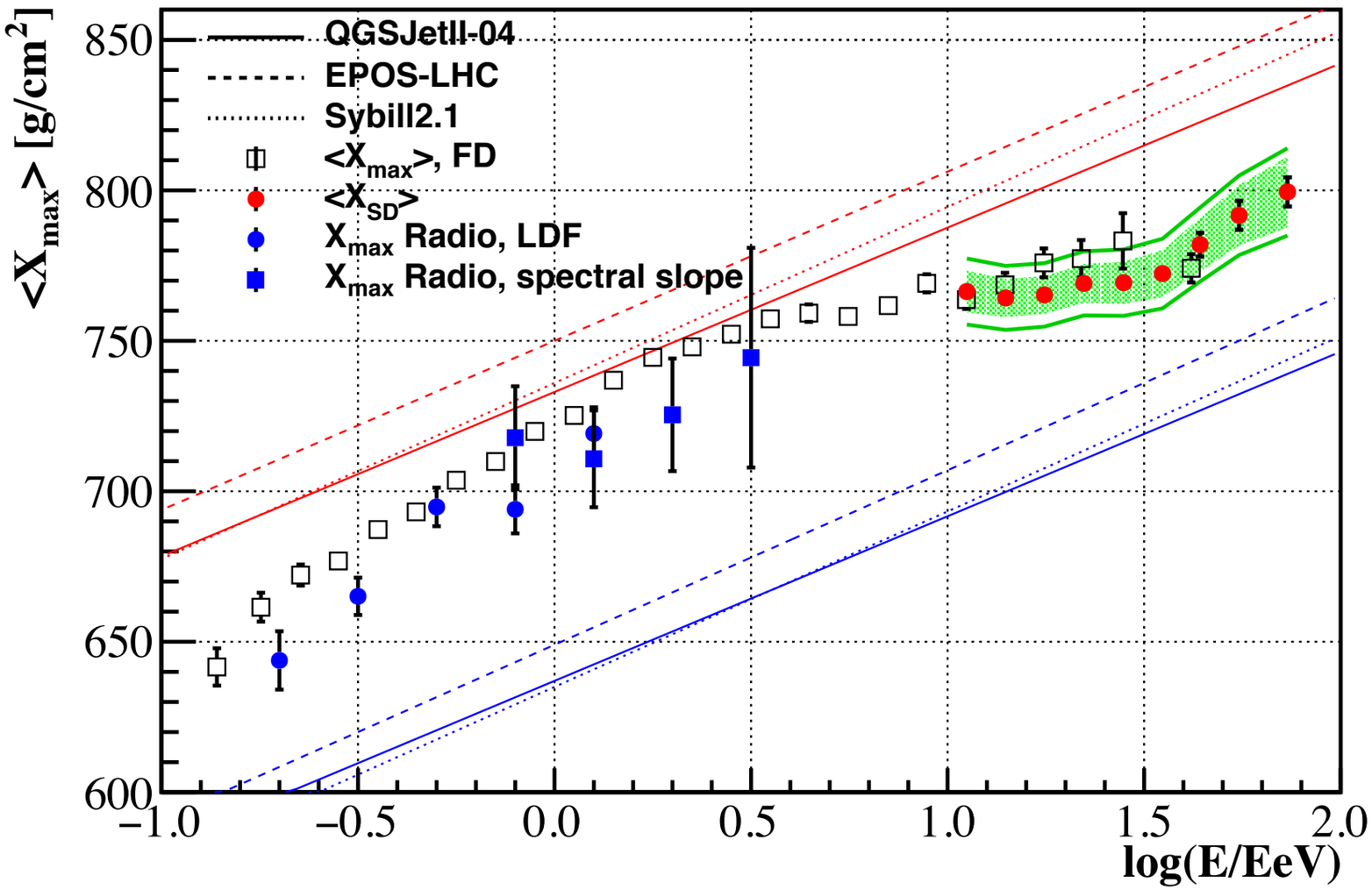


Use weighed mean of Curvature X_{max} and Rise time X_{max}

Correlation between X_{max}FD and X_{max}SD



Mass measurement with the SD: Result and conclusions



GvA, PhD thesis

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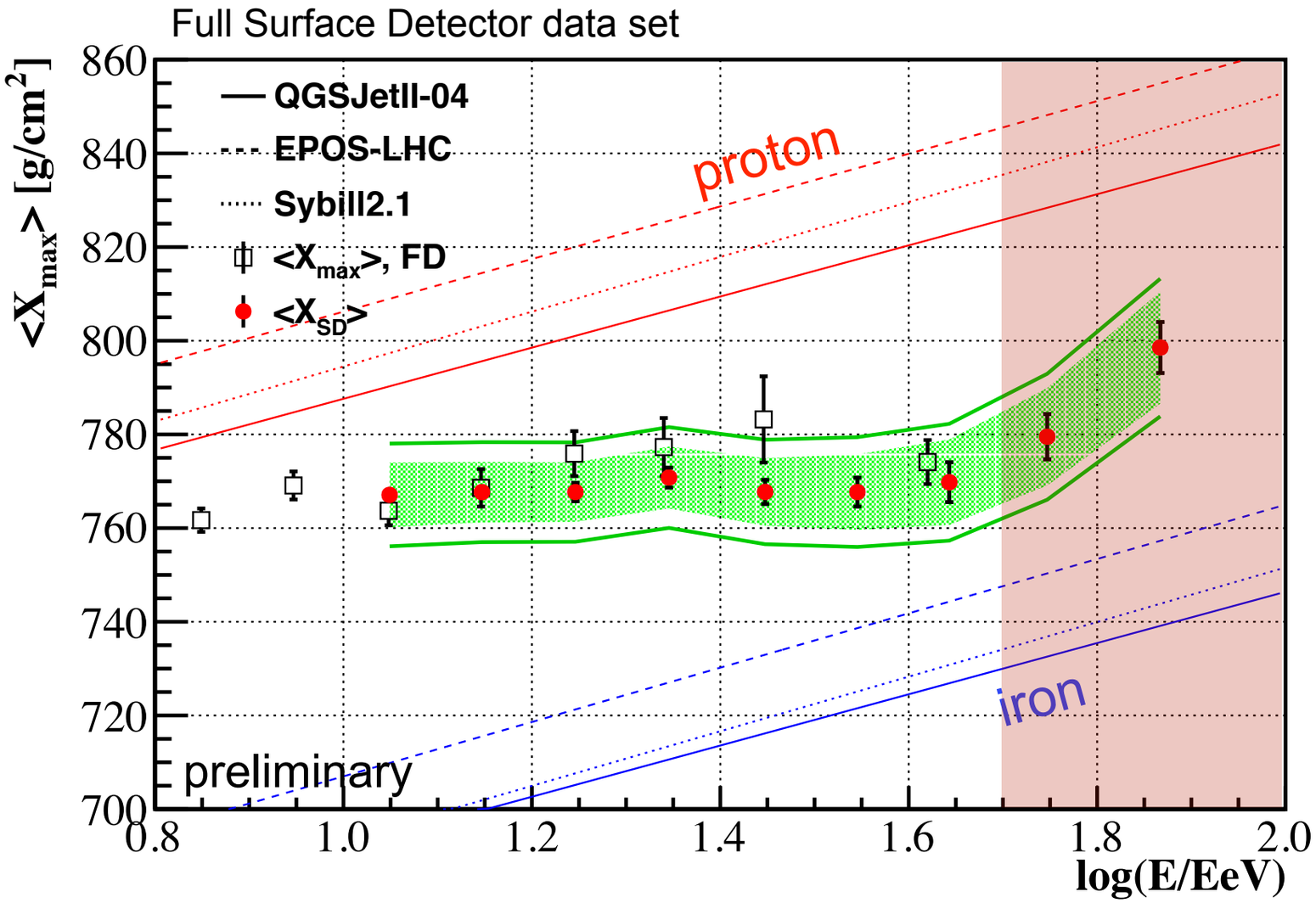


-Three more data points at high E

-Measurement cuts into GZK-limit

-A break of the trend towards Iron

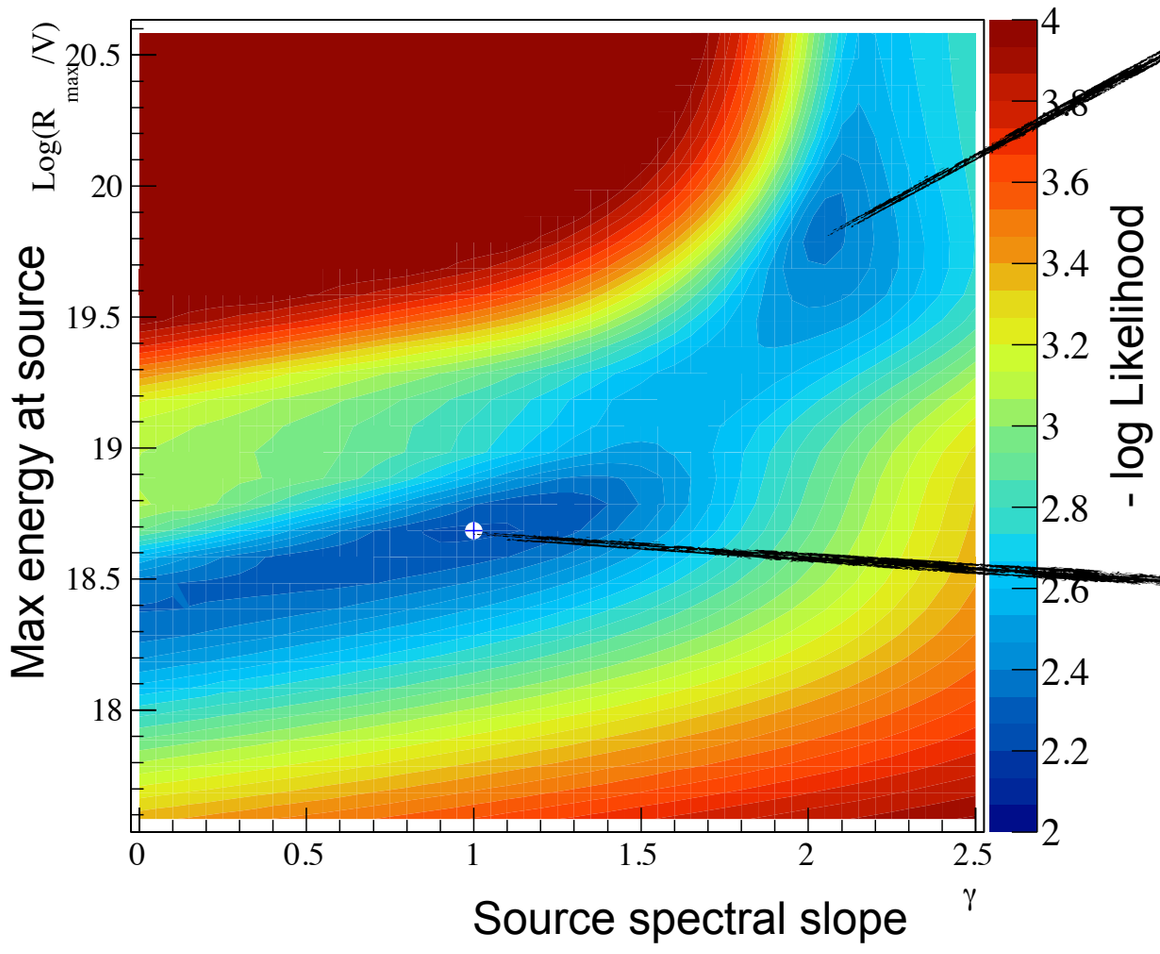
-Heavier mass composition above 40 EeV excluded at 2σ

GvA, PhD thesis

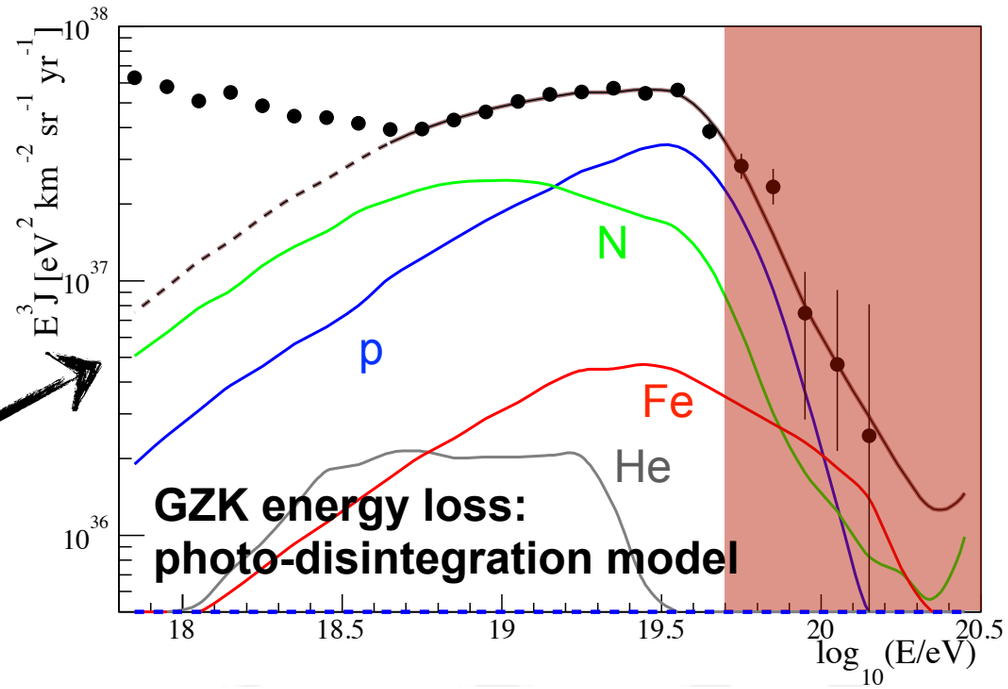
Upgrade of the Pierre Auger Observatory: AugerPrime

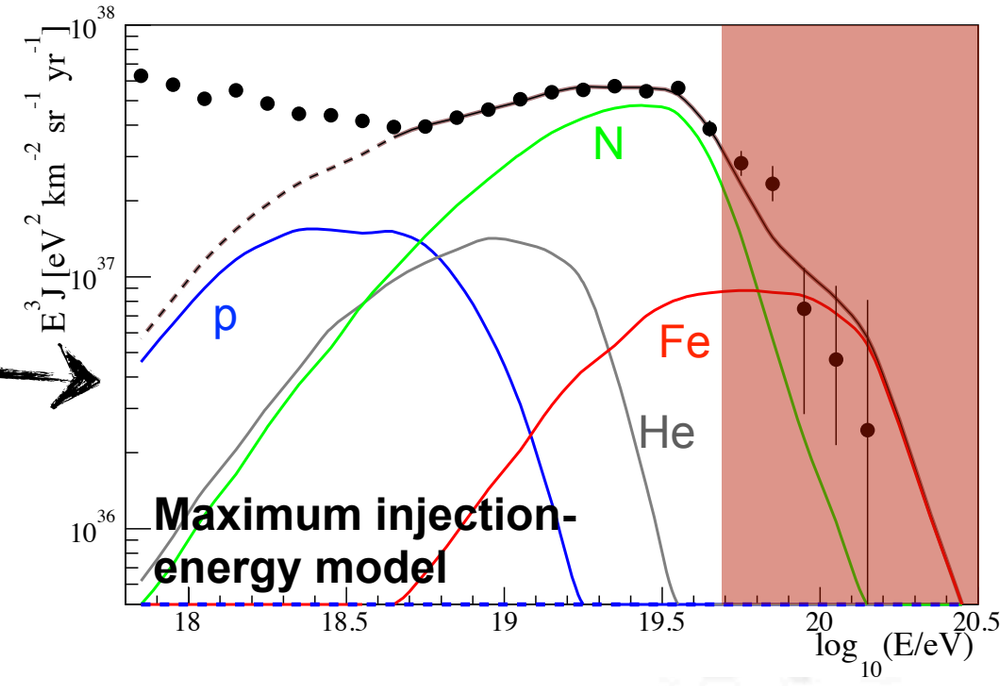
Auger Upgrade: Science case

Fit of cosmic ray source model to mass composition and spectrum:



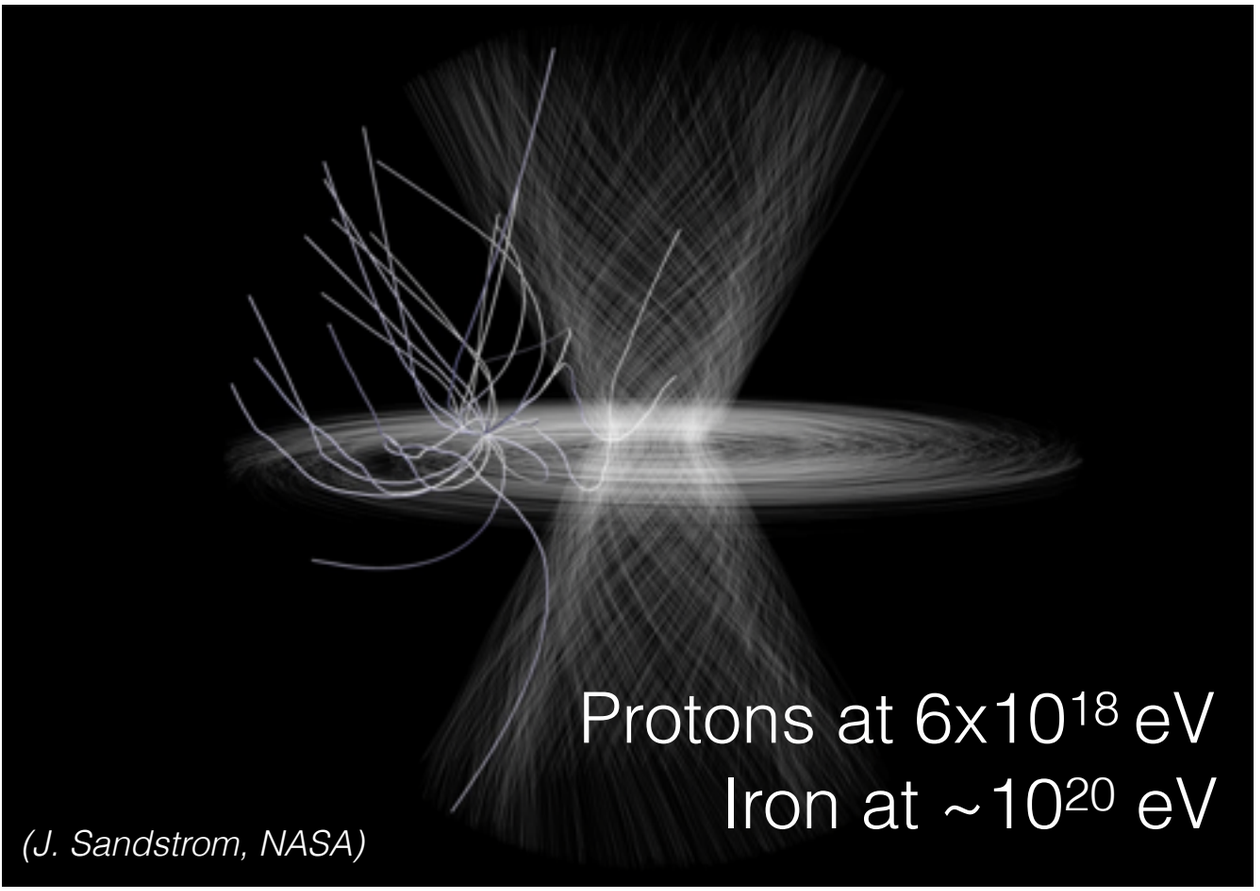
Two minima in fit:

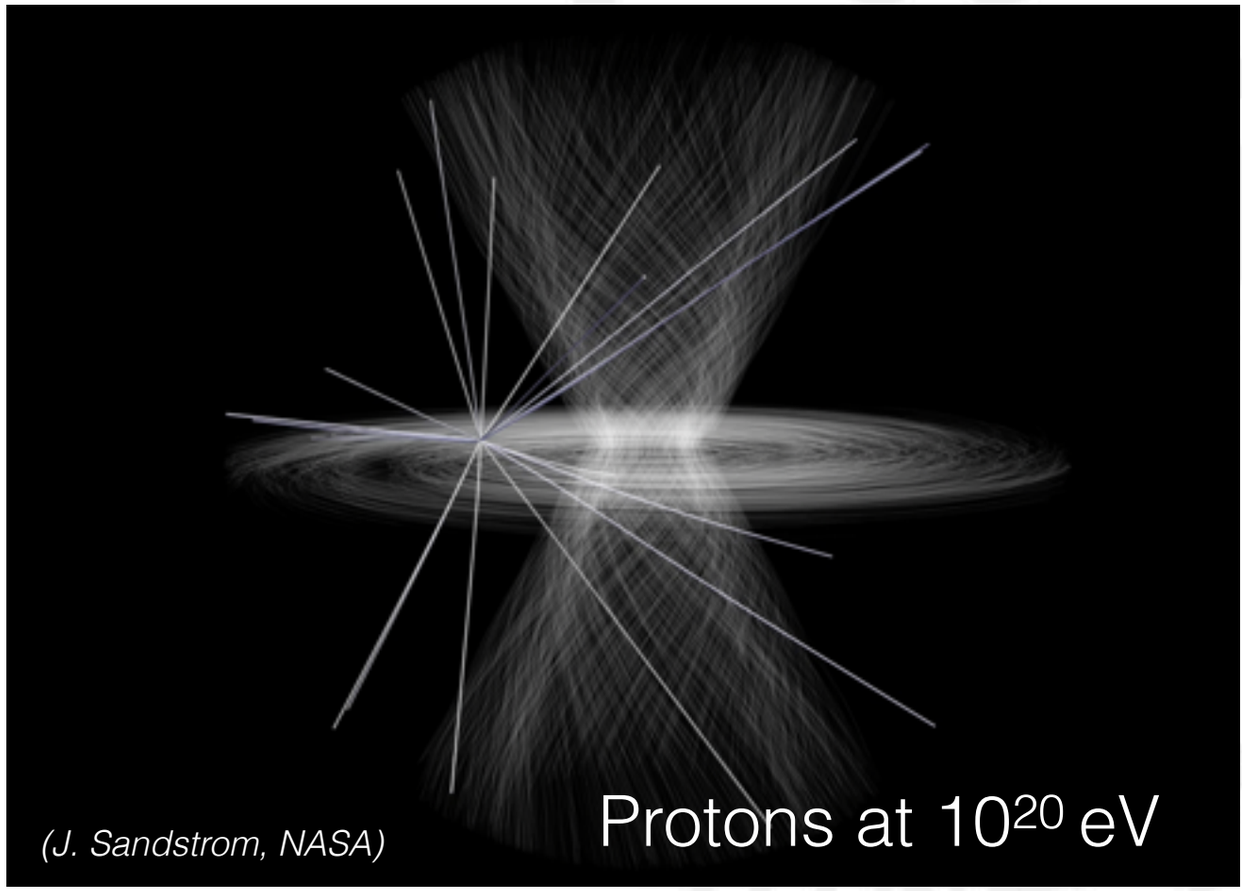




Which scenario is real?

Auger Upgrade: Science case
Deflection in magnetic field





Upgrade of the Auger Observatory

Goal:
- Get mass composition measurement in the GZK region
- Be able to detect a 10% proton flux in the GZK region
- Get mass composition per event
- To know the beam at the highest energy interactions

This requires 10x more data with a mass measurement

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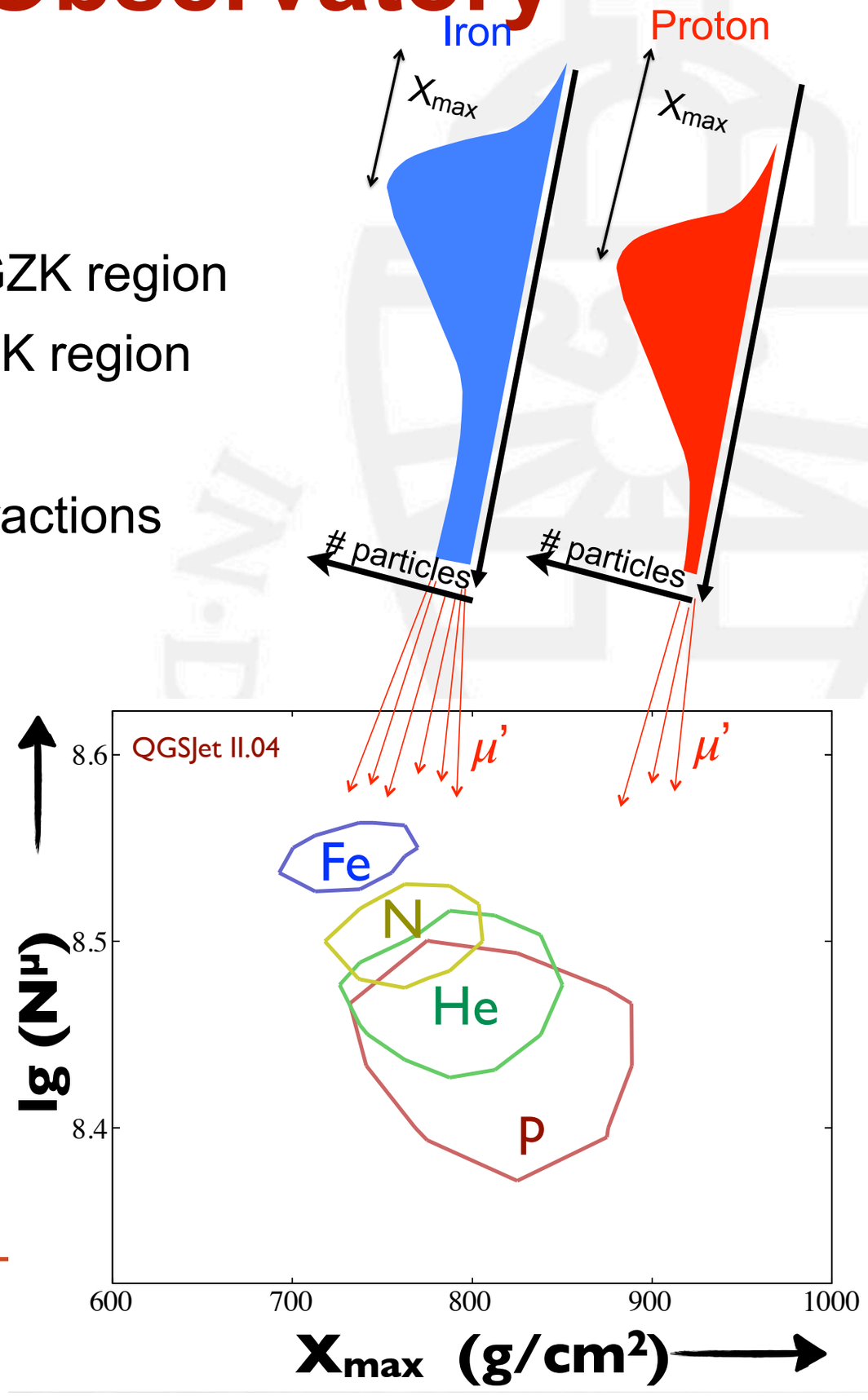
Means:
- Upgrade SD array
- Measure muon content of showers

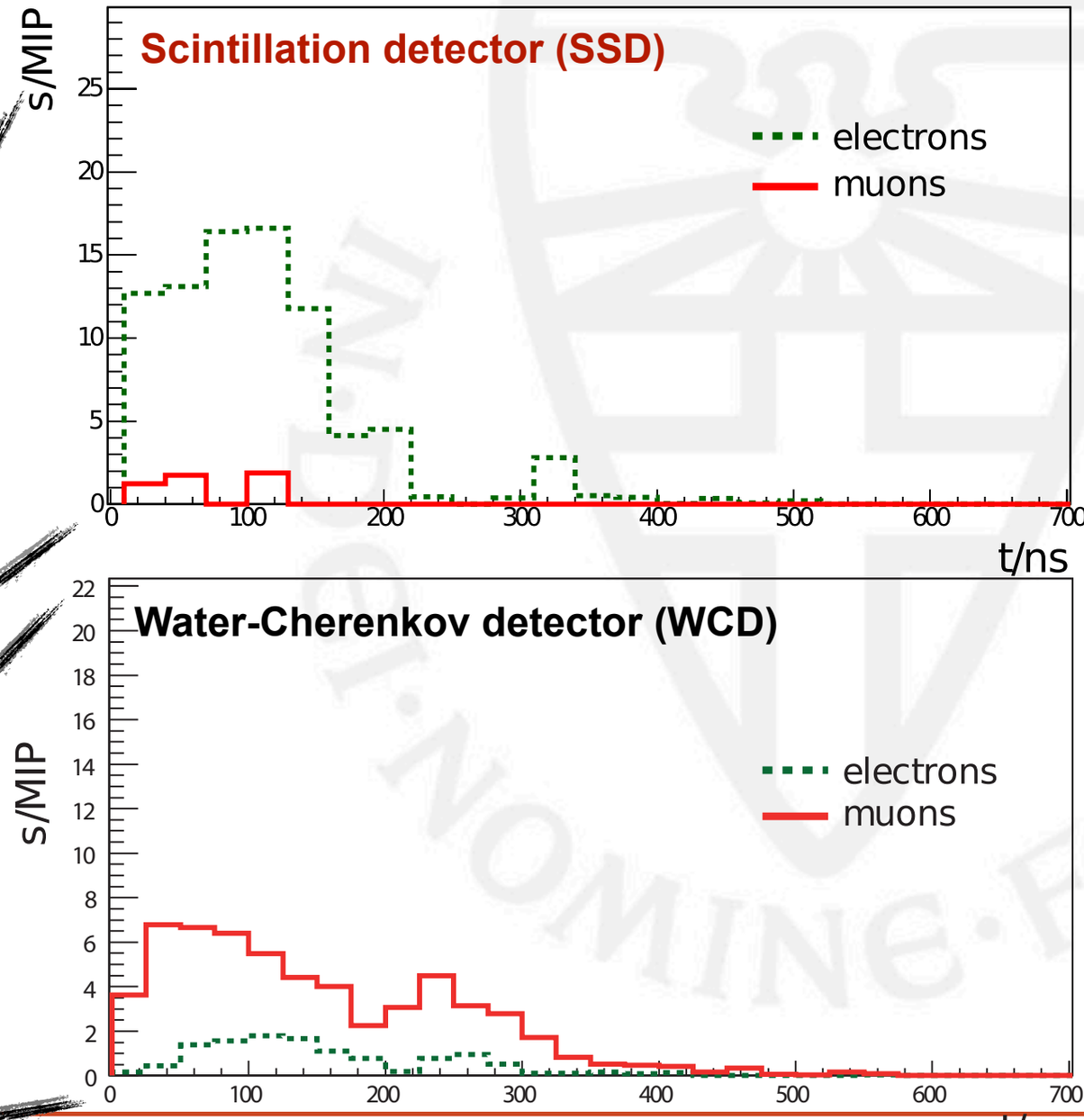


Upgrade of the Surface Detector

- Water-Cherenkov detector and Scintillator have different response to electrons and muon

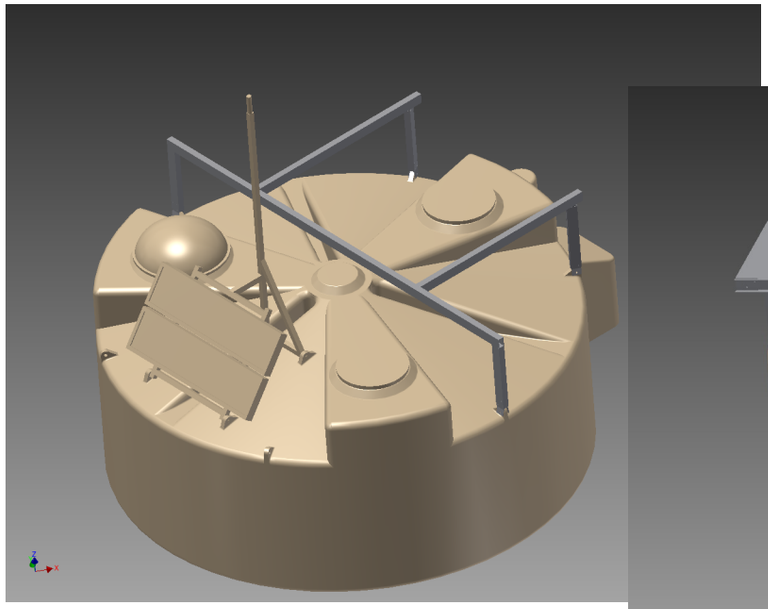
- Improve detector time resolution for X_{max} analysis

Unfolding the two detector signals yield N_μ and N_{EM}

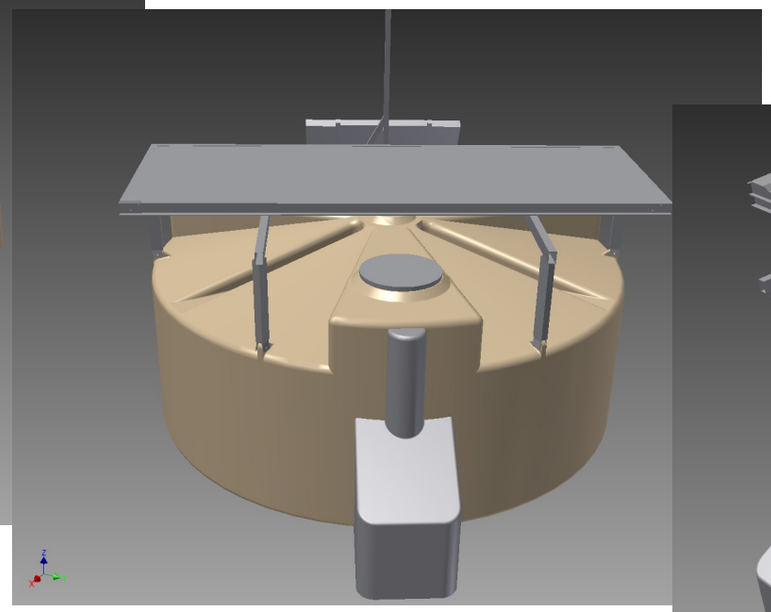


Practical implementation

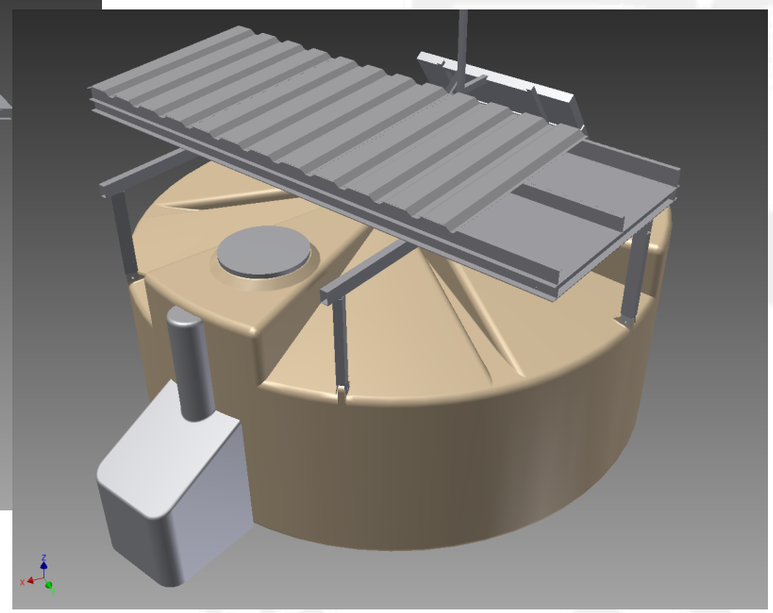
Frame



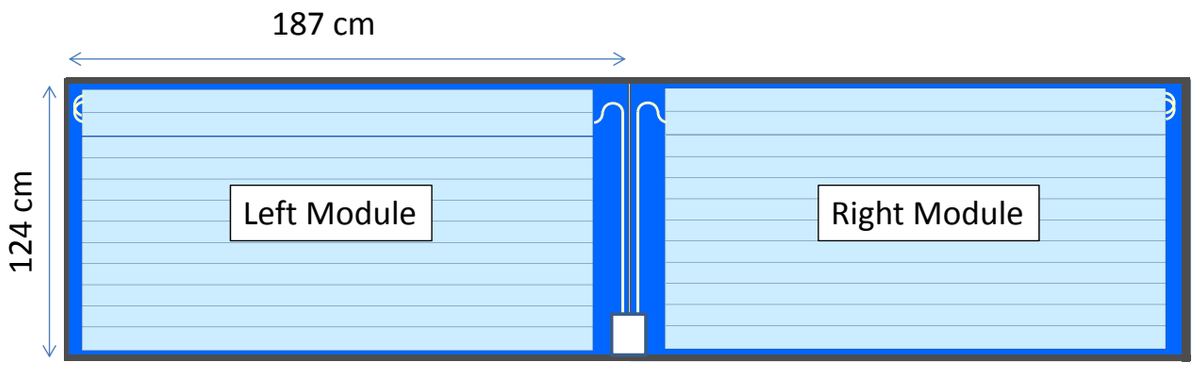
Scintillator



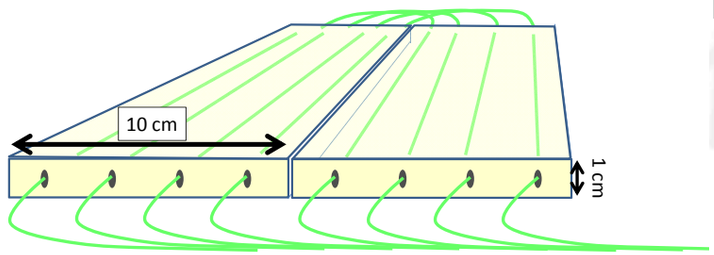
Sun roof



Two modules in one box per station,
read out by one PMT, area ~4m^2



Read out of scintillators
with WLS fibers



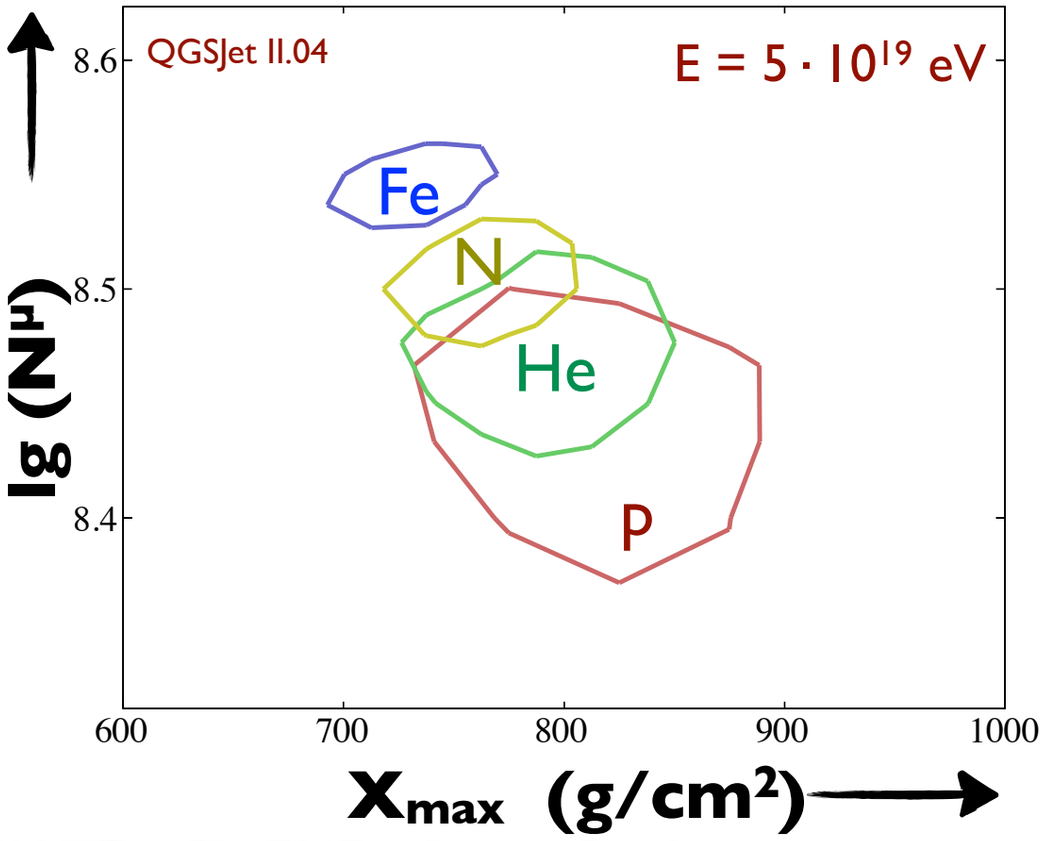
Both WCD and SSD will
be connected to new
120MHz electronics

The design is finalized in Nikhef, Lecce and Karlsruhe

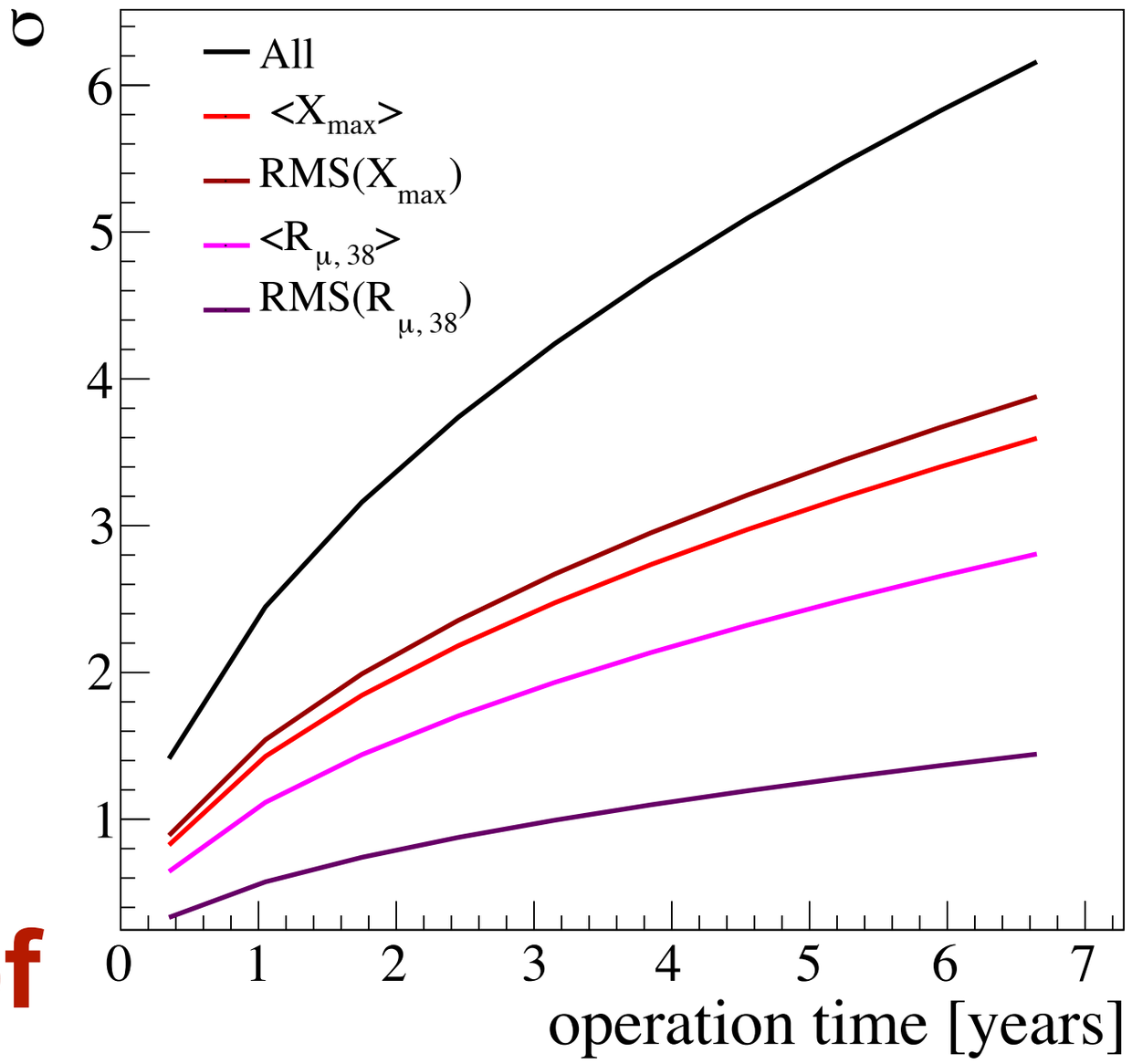
Timeline for AugerPrime

Now	- Mar 2016	Construction of engineering array
Mar 2016	- Jun 2016	Shipment to Argentina
Jul 2016		Installation of engineering array
Jul 2016	- Oct 2016	Operation & analysis of engineering array
Nov 2016		Production Readiness Review
Jan 2017	- Dec 2018	Construction and installation of full array
Jan 2017	- Dec 2024	Data taking with AugerPrime

Discovery potential of AugerPrime



Significance of discovering a 10% proton flux



... And the discovery of CR sources!

Questions?


El Alamosano
Bodas Blancas
Reina de la Minería
Malargüe
Ranquil Norte

Resolution of upgraded SD