Ground-based TeV-PeV gamma-ray detection

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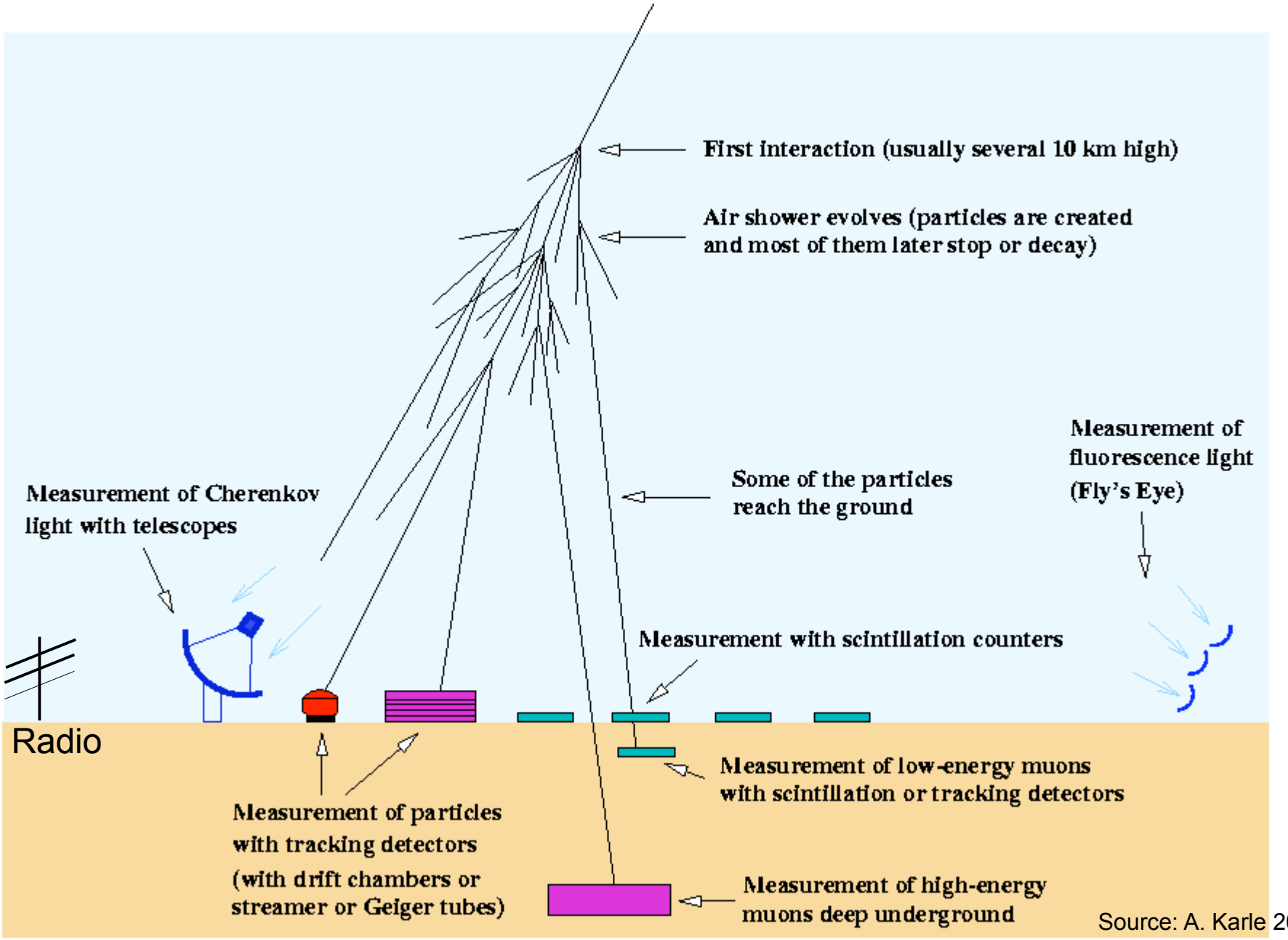
Measuring cosmic-ray and gamma-ray air showers



Source: A. Karle 2006


Tibet AS-Gamma
Argo YBJ
LHAASO
HESS
Tunka-133
Tunka-Rex
HAWC
TAIGA-IACT
TAIGA-HiSCORE
PACT
STACEE
HAGAR
MAGIC

comparison between techniques

(Few examples, non-comprehensive)

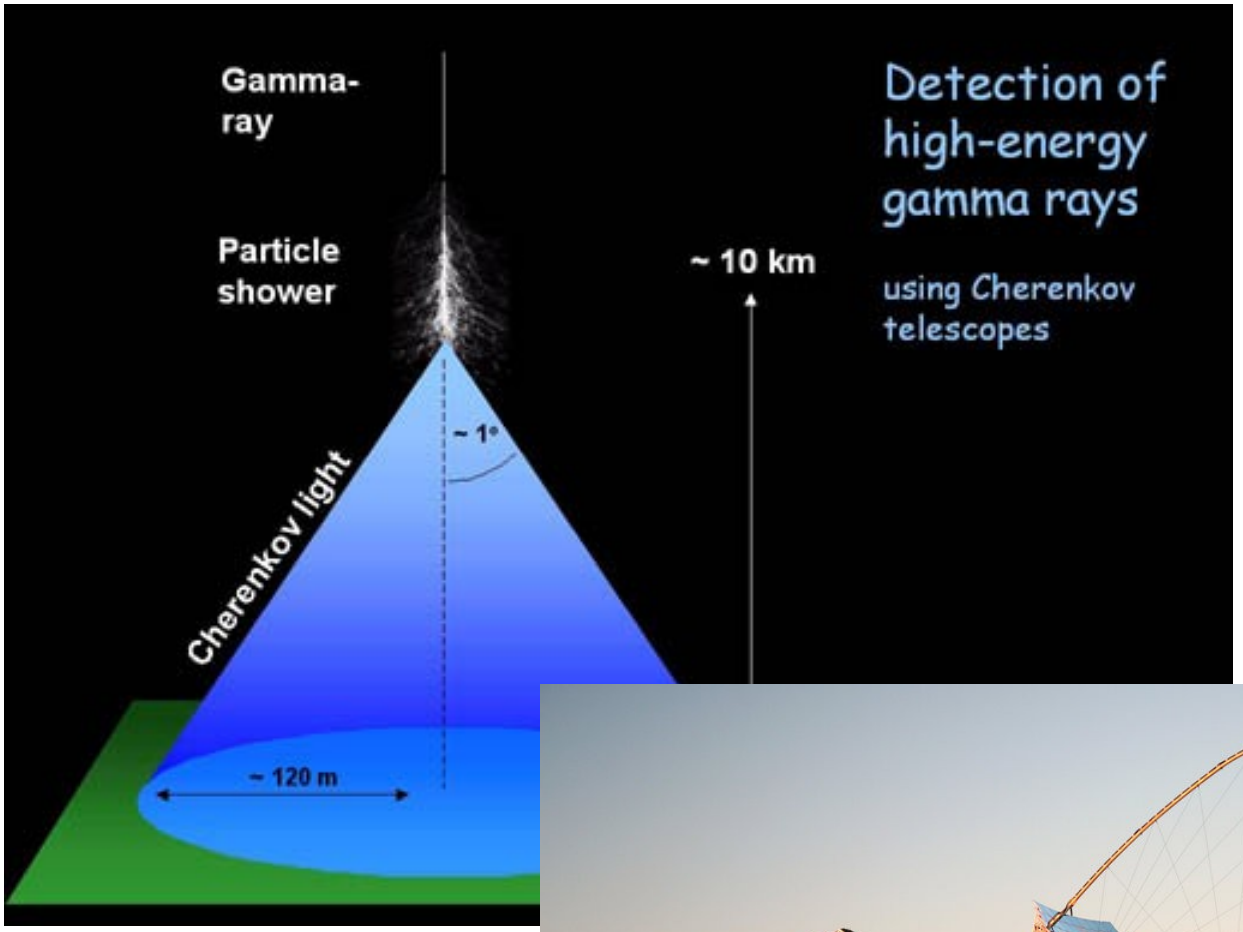
Air Cherenkov vs. Particle detection

	Air Cherenkov	Particle
Principle	Full atmosphere calorimeter	Tail-catcher calorimeter
Detection	Photons from longitudinal shower development	Particles at observation level
Statistics	Large photon statistics	Smaller particle statistics
Shower component	e.m.	e.m. + muon
Duty cycle	~15%	~100%
Shower front width @ 100m	<10 ns	~30ns

IACT arrays

- Detection of Cherenkov photons from secondary particles → photons from full longitudinal development
- Historical: breakthrough technique
- At core of existing and planned future experiments

IACT arrays



HESS web mpi-hd

The best technique for sensitivie observations in the TeV energy range

g/h separation: image shape

PeV range: limitation due to required number of R/O channels per km²

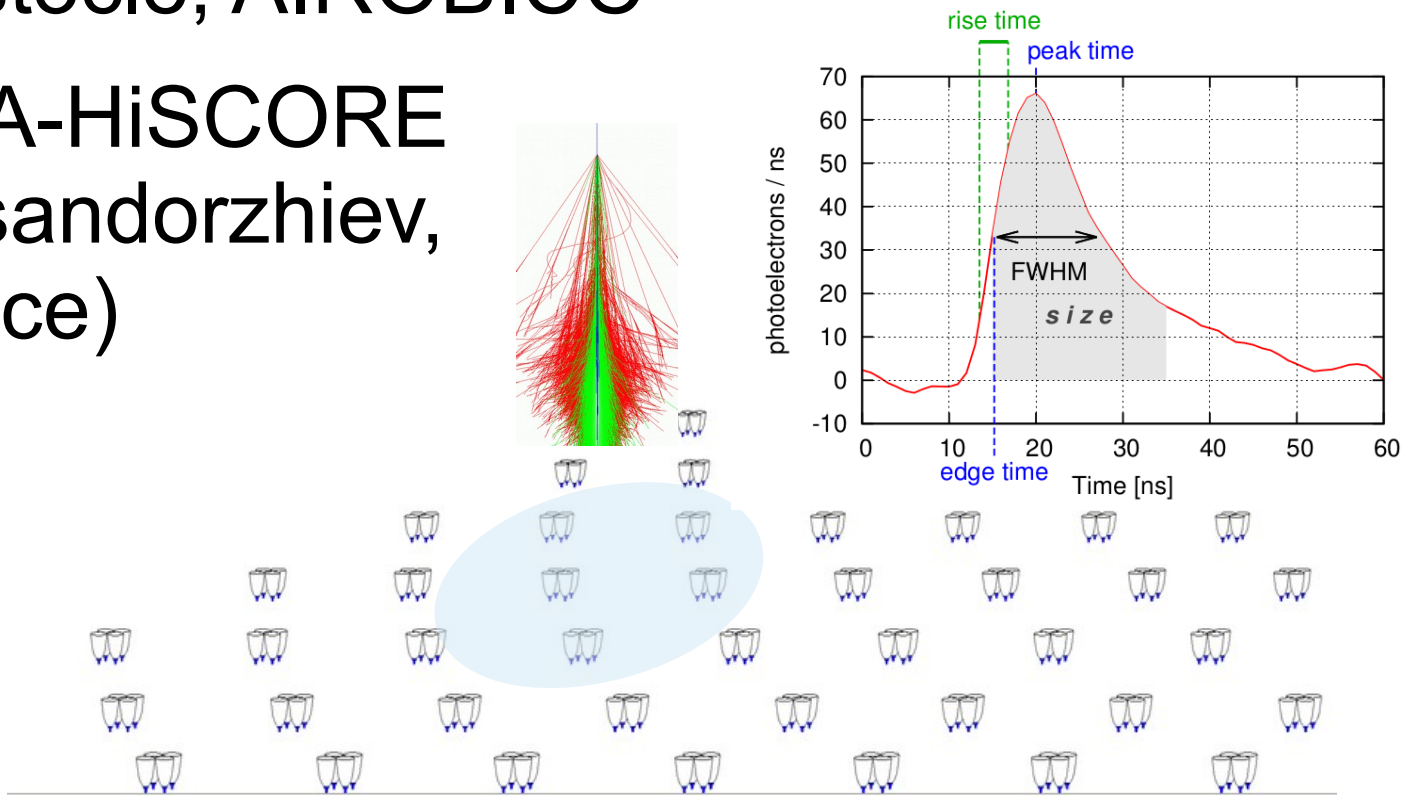
IACT arrays

- ✔ Energy resolution
- ✔ Angular resolution
- ✔ Gamma-hadron separation

- ✗ Duty-cycle – bound to darkness and weather
- ✗ Comparatively small field of view
- ✗ Large number of r/o channels per km²

Air Cherenkov timing arrays

- Angle integrating Cherenkov light detectors
- Using timing and amplitude for reconstruction
- Past: Themistocle, AIROBICC
- Today: TAIGA-HiSCORE (See N. Lubsandorzhiev, this conference)



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Air Cherenkov timing arrays

- ✔ Energy resolution
- ✔ Angular resolution
- ✔ Large field of view
- ✔ Large instrumented areas possible

- ✗ Duty-cycle – bound to darkness and weather
- ✗ Poor g/h separation

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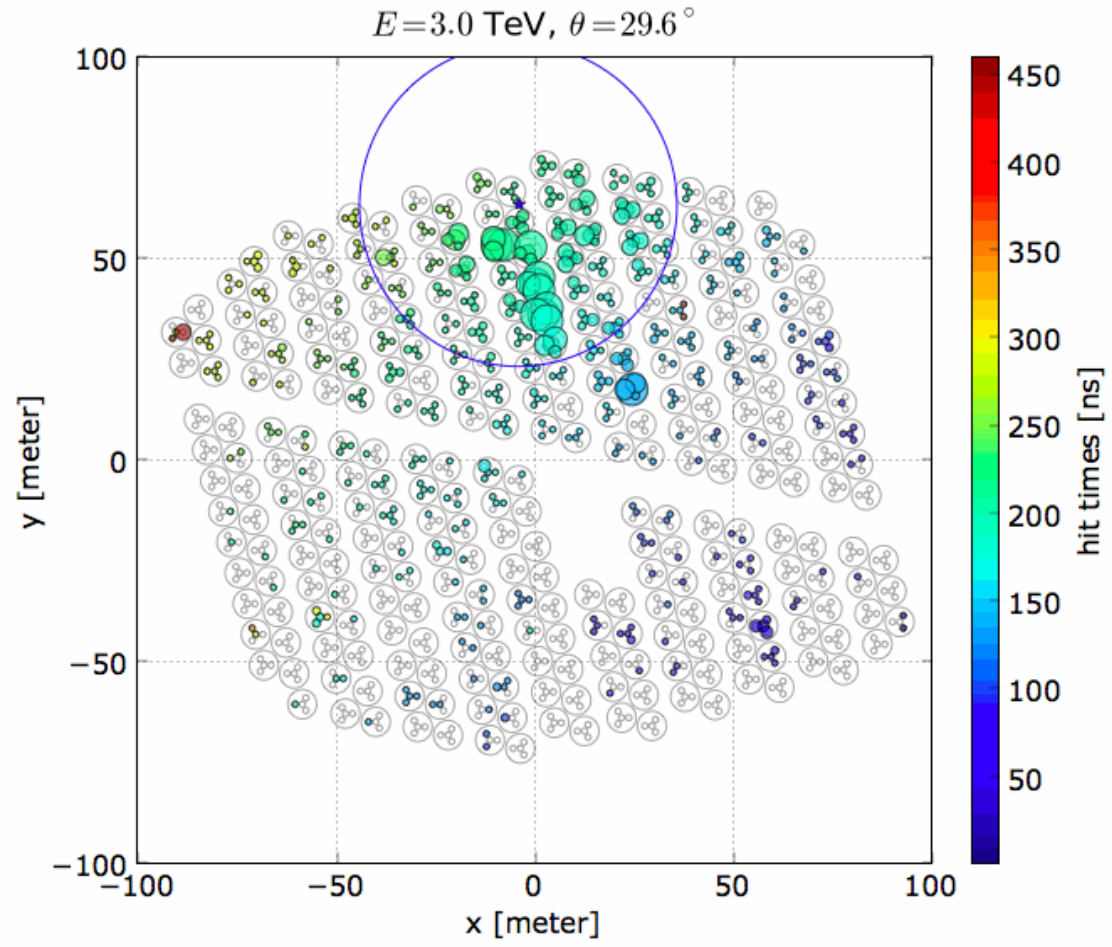
Particle shower front detectors

- Detection of particle shower front: shower-tail



- Also see Y. Becherini, this session

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Particle shower front detectors

- ✔ Large field of view
- ✔ Large instrumented areas possible
- ✔ Duty-cycle – bound to darkness and weather
- ✔ g/h separation

- ✗ g/h separation
- ✗ Energy resolution
- ✗ Angular resolution

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Detection methods for gamma astronomy

Method	E_{thr}	Angular resolution	ΔE/E	γ/h	Duty cycle
Particles	~3 TeV Water: 100 GeV	~1° <0.5°	30-50%	~1 ~6	100%
Cherenkov	IACTs: 5GeV NonI: 10 TeV	~0.1°	10-15%	~4 ~1.5-2	10%
Fluoresc.	10^{17} eV	>1°	10-15%	?	10%
Radio	10^{17} eV	>1°	10-15%	?	100%

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Summary

- Different experiments use different approaches to access TeV – PeV astronomy
- Comparison between techniques must take into account many different parameters
- A combination of different techniques appears interesting for maximization of information available for reconstruction