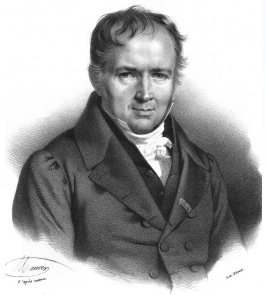
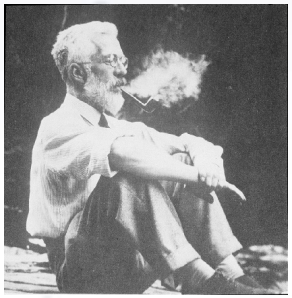
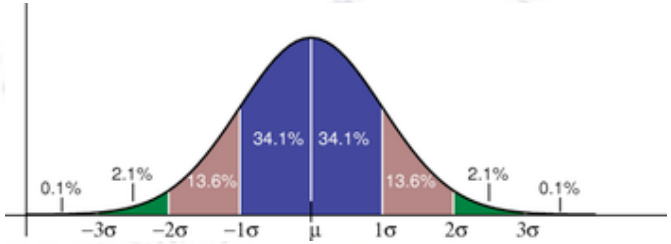
Applied Statistics

ATLAS test beam data analysis



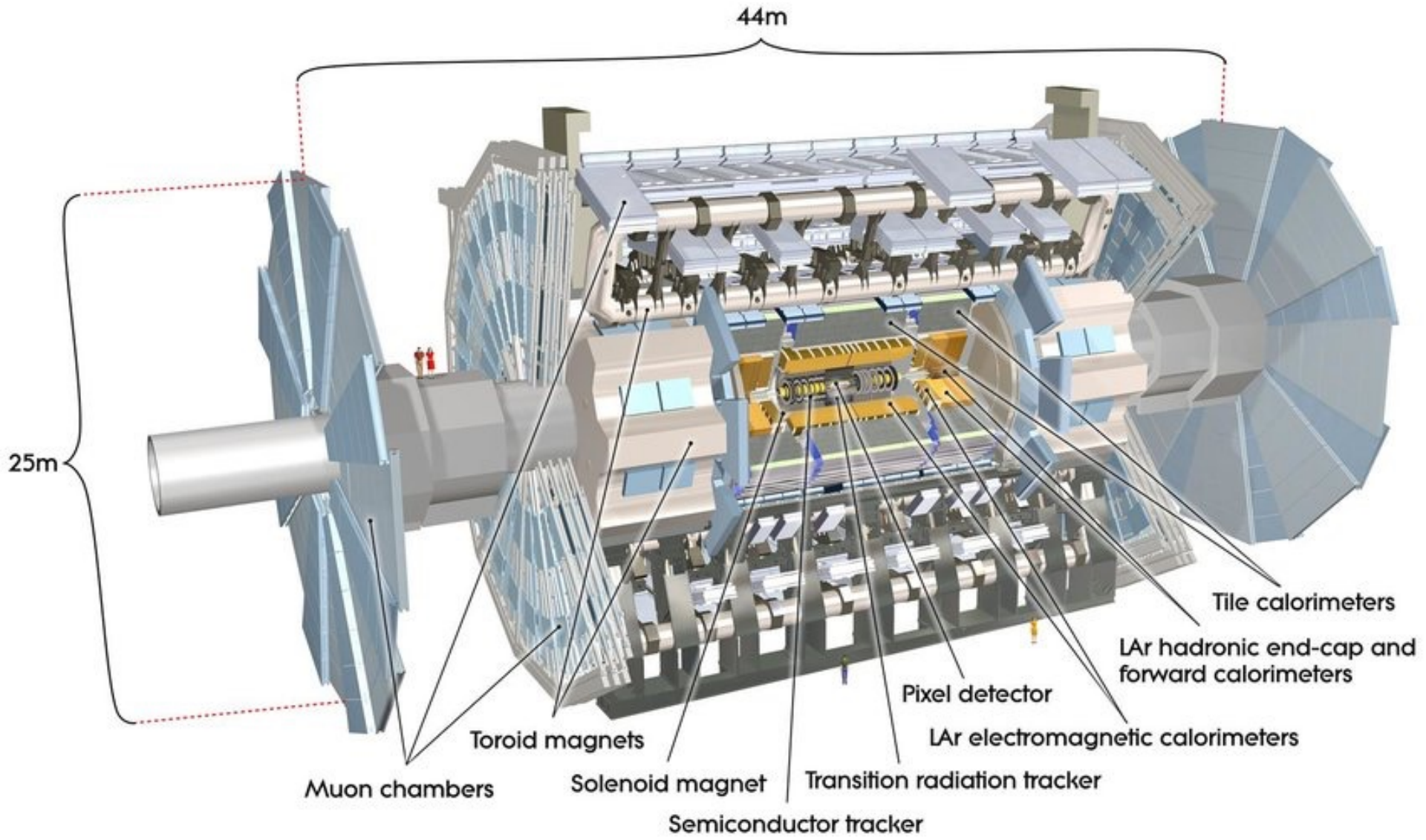





Troels C. Petersen (NBI)

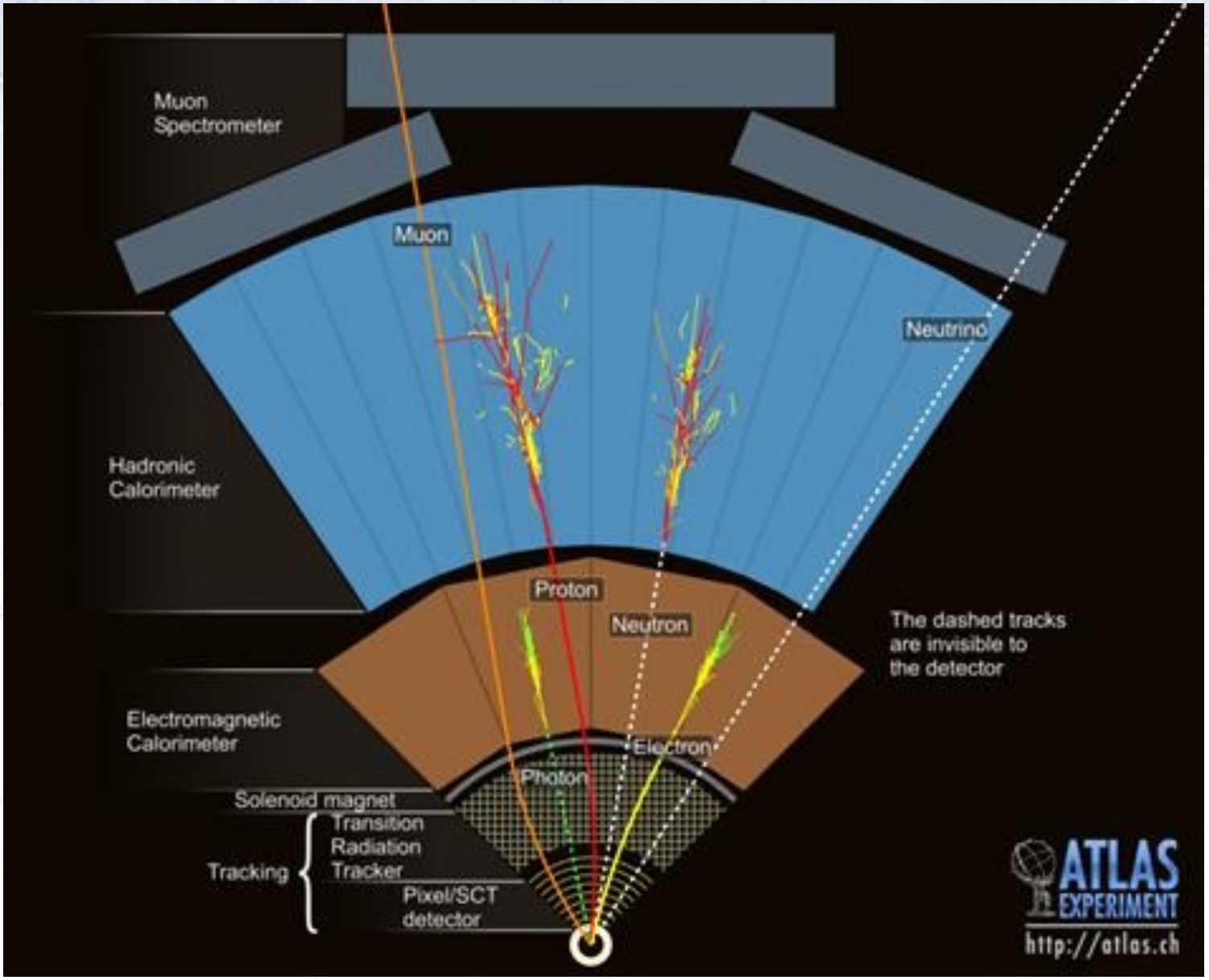


"Statistics is merely a quantisation of common sense"

ATLAS detector

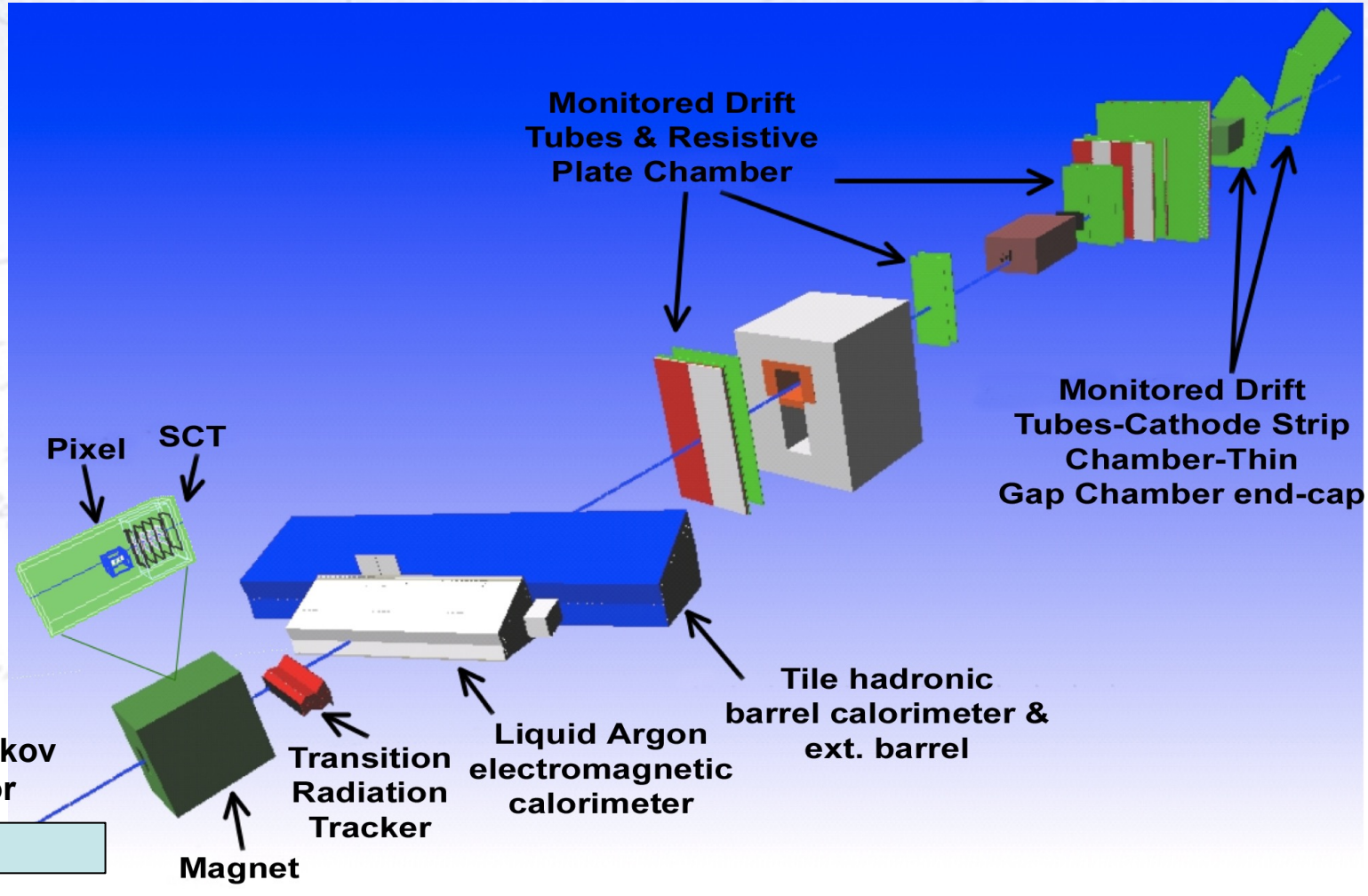


ATLAS cross section

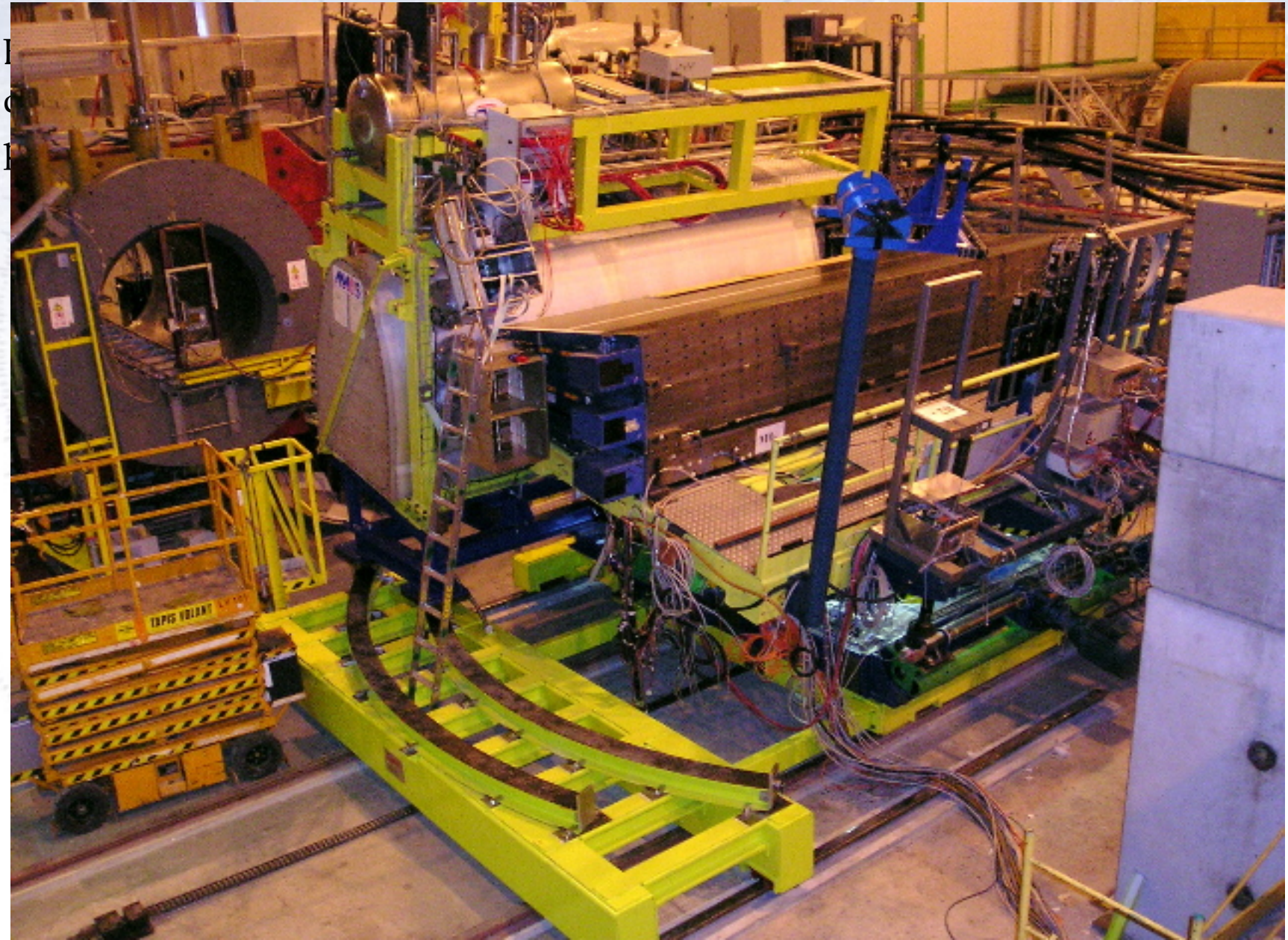


ATLAS test beam

Before the startup of CERN's LHC accelerator, a cross section of the ATLAS detector was submitted to (extensive) test beam, to **measure its performance** and prepare software.



ATLAS test beam



ATLAS test beam data

The test beam we consider had an energy of 2 GeV and consisted of a mixture of **electrons and pions** (and a few muons).

The raw data is very complicated, but has been boiled down to something fairly basic, which consists of around **33000 entries**, each with:

- **Cherenkov counts (1 number).** The Cherenkov counter reacts on particles, which travels faster than the speed of light IN THAT MEDIUM, thus electrons will tend to give a larger signal.
- **Transition Radiation Tracker (2 numbers, both integer).** Number of hits for tracking in the TRT (first) and number of High Threshold (HT) hits (second) for identifying electrons, since these have a higher chance of creating such a hit.
- **ElectroMagnetic Calorimeter (4 numbers).** This type of detector stops particles interacting electromagnetically (i.e. electrons), which thus tend to deposit their energy AS EARLY as possible. The four numbers correspond to the energy deposit (in GeV) in each of the 4 layers of the ATLAS EM calorimeter.
- **Hadronic Calorimeter (3 numbers).** Much thicker than the EM calorimeter, this detector stops all particles except muons with more than 3-4 GeV in energy. Gives no signal, if no particle reaches the detector. Electrons hardly ever reach this detector.
- **Muon detector (1 number).** If a muons passes through, this detector gives a higher signal than when not. However, the coverage of the muon detector used was very small, and thus only few muons gives a signal.

ATLAS test beam data

Cher	nLT	nHT	EM0	EM1	EM2	EM3	Had1	Had2	Had3	Muon
634.0	32	8	0.123	0.468	0.868	-0.037	0.000	0.000	0.000	417.0
816.0	42	12	0.049	0.870	0.768	-0.006	0.000	0.000	0.000	388.0
943.0	46	8	0.188	0.534	0.965	0.012	0.000	0.000	0.000	377.0
907.0	33	3	0.198	0.740	0.724	0.022	0.000	0.000	0.000	372.0
775.0	35	4	-0.010	0.822	0.574	0.023	0.000	0.000	0.000	392.0
773.0	39	9	0.100	1.236	0.272	-0.033	0.000	0.000	0.000	398.0
782.0	30	7	0.355	0.885	0.596	-0.042	0.000	0.000	0.000	369.0
700.0	39	9	0.031	1.141	0.602	0.023	0.000	0.033	0.757	408.0
542.0	42	1	-0.028	-0.014	0.133	-0.054	0.000	0.000	0.000	412.0
752.0	40	7	0.092	0.659	0.574	0.098	0.000	0.000	0.000	387.0
576.0	29	1	0.076	0.018	0.044	0.025	0.000	0.000	0.000	392.0
772.0	46	6	0.151	1.107	0.489	0.090	0.027	0.000	0.000	393.0
735.0	39	8	-0.018	0.723	1.044	0.088	0.000	0.000	0.000	413.0
751.0	44	7	0.431	1.110	0.328	0.029	0.000	0.000	0.000	359.0
903.0	37	6	0.261	0.580	0.667	-0.044	0.000	0.000	0.000	394.0
557.0	44	3	-0.059	-0.007	0.378	-0.039	0.302	1.325	0.810	505.0
635.0	45	7	0.079	-0.072	0.040	0.010	0.000	0.000	0.000	378.0
801.0	36	3	0.452	0.926	0.474	-0.004	0.000	0.000	0.000	425.0
940.0	27	3	0.267	1.049	0.559	-0.099	0.000	0.000	0.000	373.0
760.0	39	10	0.229	1.107	0.316	-0.041	0.000	0.000	0.000	421.0
1003.0	48	3	-0.070	0.585	0.600	-0.089	0.000	0.000	0.000	412.0
894.0	44	10	0.095	0.911	0.623	-0.055	0.000	0.000	0.000	393.0

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Variables to be used!
They are from three INDEPENDENT detectors…

Measuring performance

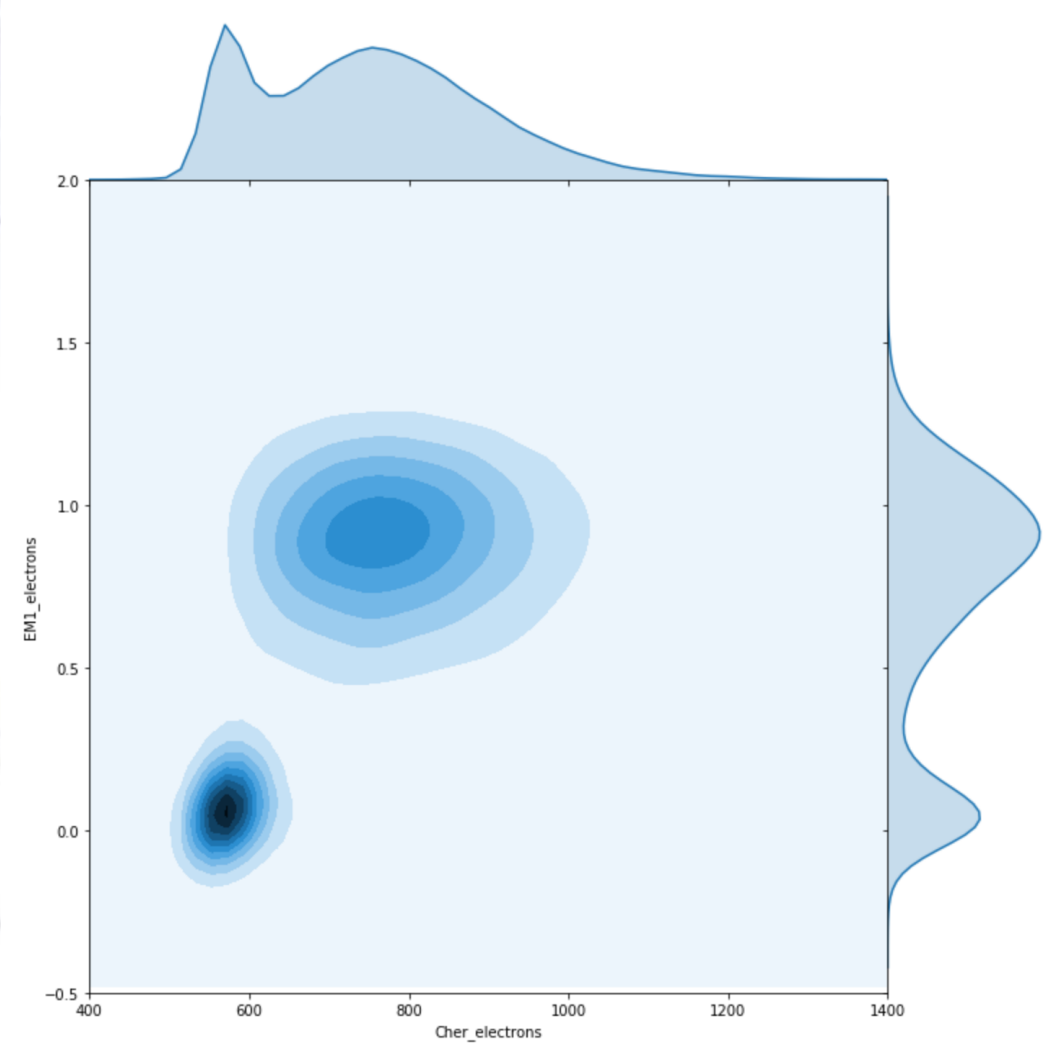
Purities of the data…

Before the startup of CERN's LHC accelerator, a cross section of the ATLAS detector was submitted to (extensive) test beam, to **measure its performance** and prepare software.

Q: How do you measure performance, when you have an UNKNOWN MIX of electrons and pions?

A: Given three independent detectors, one can use TWO of these to get pure samples for the third one!

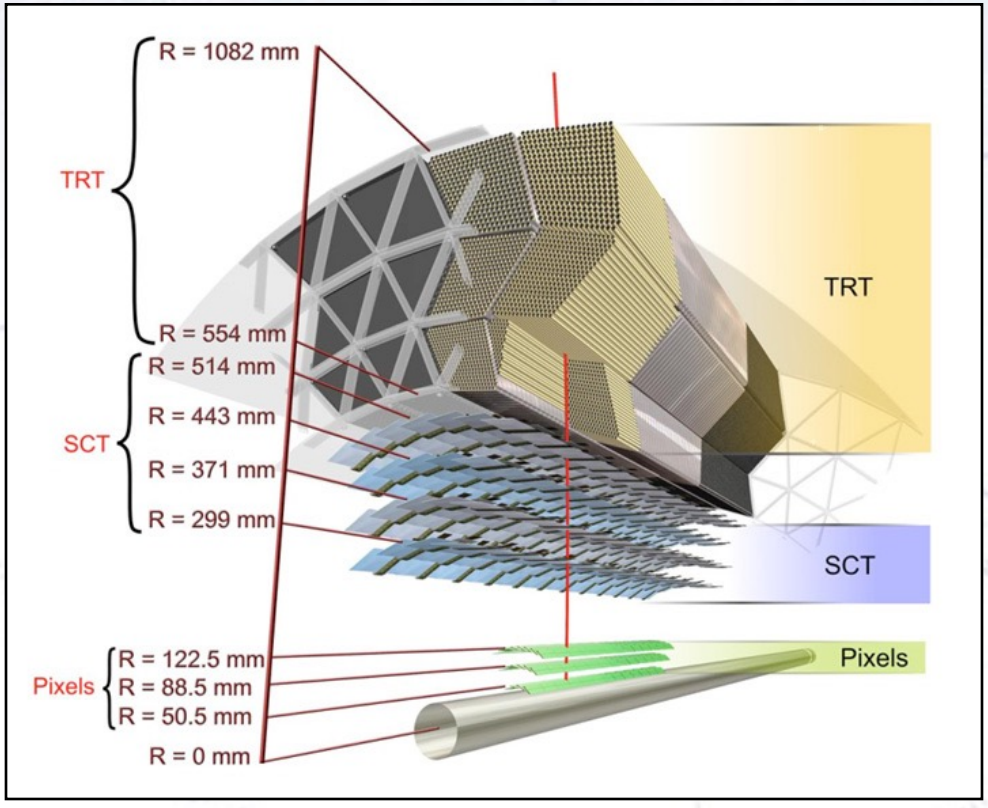
Your job is to try to do exactly this, and measure both purities and efficiencies along with **electron/pion separation performance**.

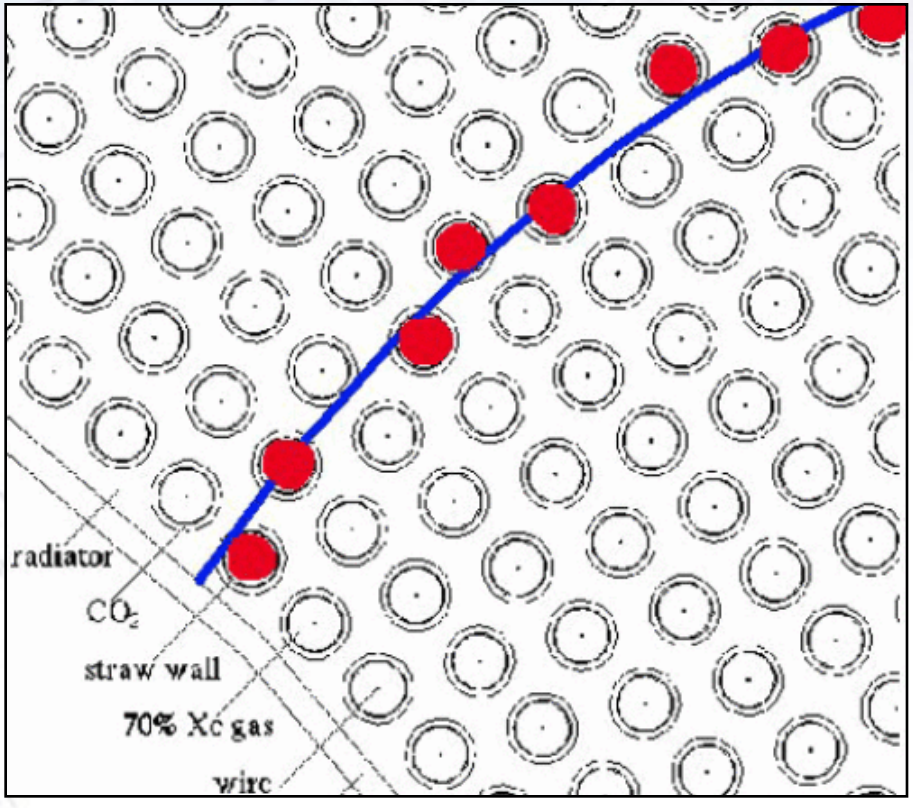


ATLAS TRT detector

ATLAS TRT detector

The ATLAS TRT detector works by measuring the ionisation of charged particles passing through. In addition, it can measure Transition Radiation from electrons!

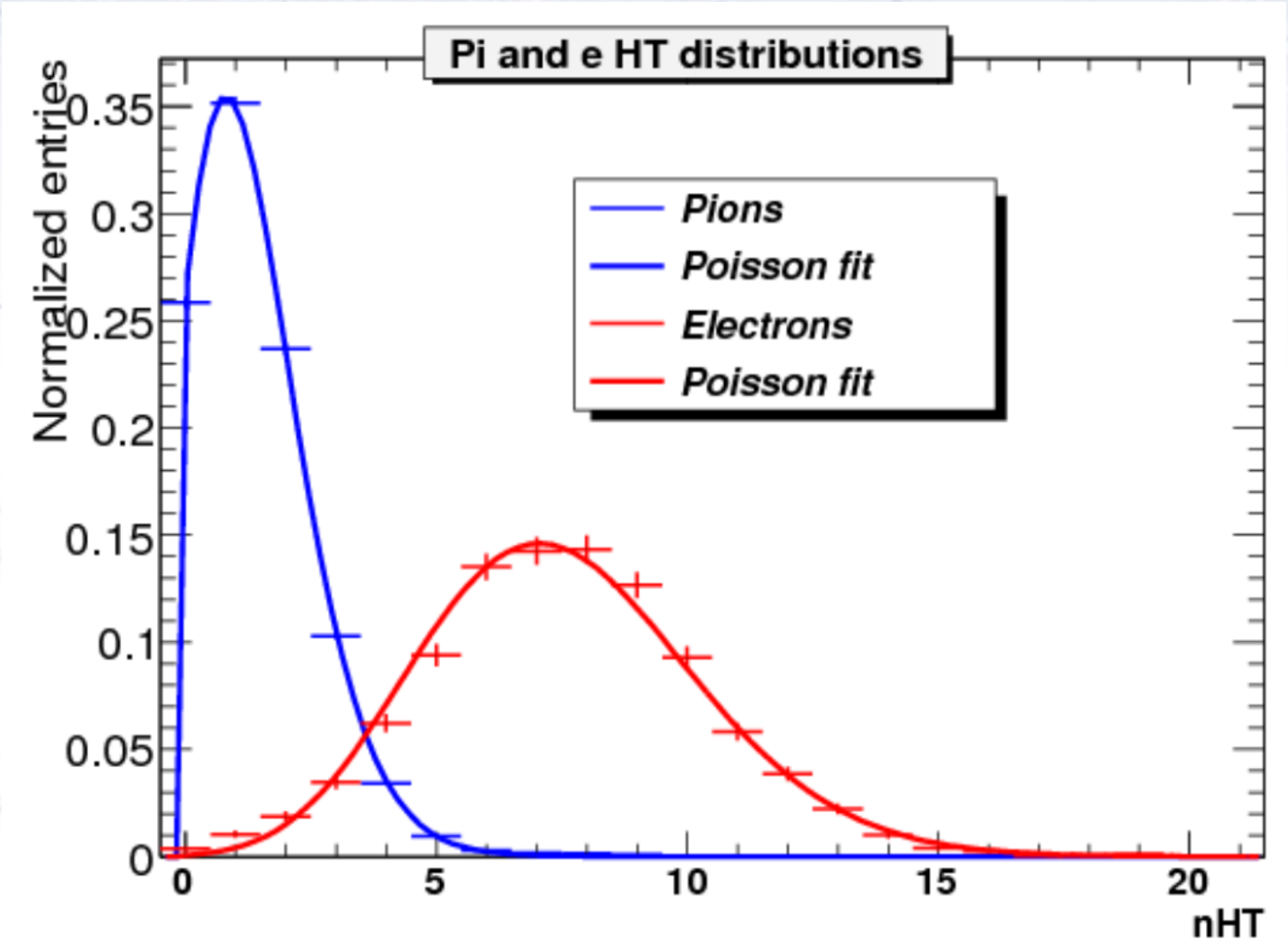




The probability of TR hit (called High-Threshold hit) is about 20-25% for electrons, while it is 4-6% for pions. Given 30-35 hits, this gives a difference.

ATLAS TRT detector

Given a FIXED number of TRT hits, the distribution of HT hits is Binomial (and to some approximation Poisson).



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