

Reviews, Tables, and Plots

Part 1: Overview, Astrophysics, Experimental Methods and Colliders



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PDG

LBNL

Advisory Committee Meeting
CERN 11 October 2008

First, my fascinating biennial overview of changes in REVIEWS, TABLES, AND PLOTS!

Constants, Units, Atomic and Nuclear Properties

1. Physical constants (revised)
2. Astrophysical constants (revised, especially first half)
3. International System of Units (SI)
4. Periodic table of the elements (revised)
5. Electronic structure of the elements
6. Atomic and nuclear properties of materials
(now generated by AtomicNuclearProperties code)
7. Electromagnetic relations
8. Naming scheme for hadrons

Standard Model and Related Topics

9. Quantum chromodynamics
10. Electroweak model and constraints on new physics (revised)
11. The Cabibbo-Kobayashi-Maskawa quark-mixing matrix (revised)
12. CP violation (revised)
13. Neutrino mass, mixing, & flavor change (revised)
14. Quark model (revised)
15. Grand Unified Theories
16. Structure functions (revised)
17. Fragmentation functions in e^+e^- annihilation (revised)

Astrophysics and cosmology

18. Experimental tests of gravitational theory (revised)
19. Big-Bang cosmology (revised)
20. Big-Bang nucleosynthesis (revised)
21. The cosmological parameters (revised)
22. Dark matter (revised)
23. Cosmic microwave background (revised, especially band-power spectrum and polarization cross-correlations)
24. Cosmic rays (rewrite by original authors Gaisser and Stanev)

Experimental Methods and Colliders

25. Accelerator physics of colliders (revised; rewrite awaits ILS progress)
26. High-energy collider parameters (revised)
27. Passage of particles through matter
28. Particle detectors (major revision; many new and replaced sections)
29. Radioactivity and radiation protection (revised; needs rewrite)
30. Commonly used radioactive sources

Mathematical Tools or Statistics, Monte Carlo, Group Theory

31. Probability
32. Statistics (revised)
33. Monte Carlo techniques (revised)
34. Monte Carlo particle numbering scheme (revised)
35. Clebsch-Gordan coefficients, spherical harmonics, and d functions
36. SU(3) isoscalar factors and representation matrices
37. SU(n) multiplets and Young diagrams

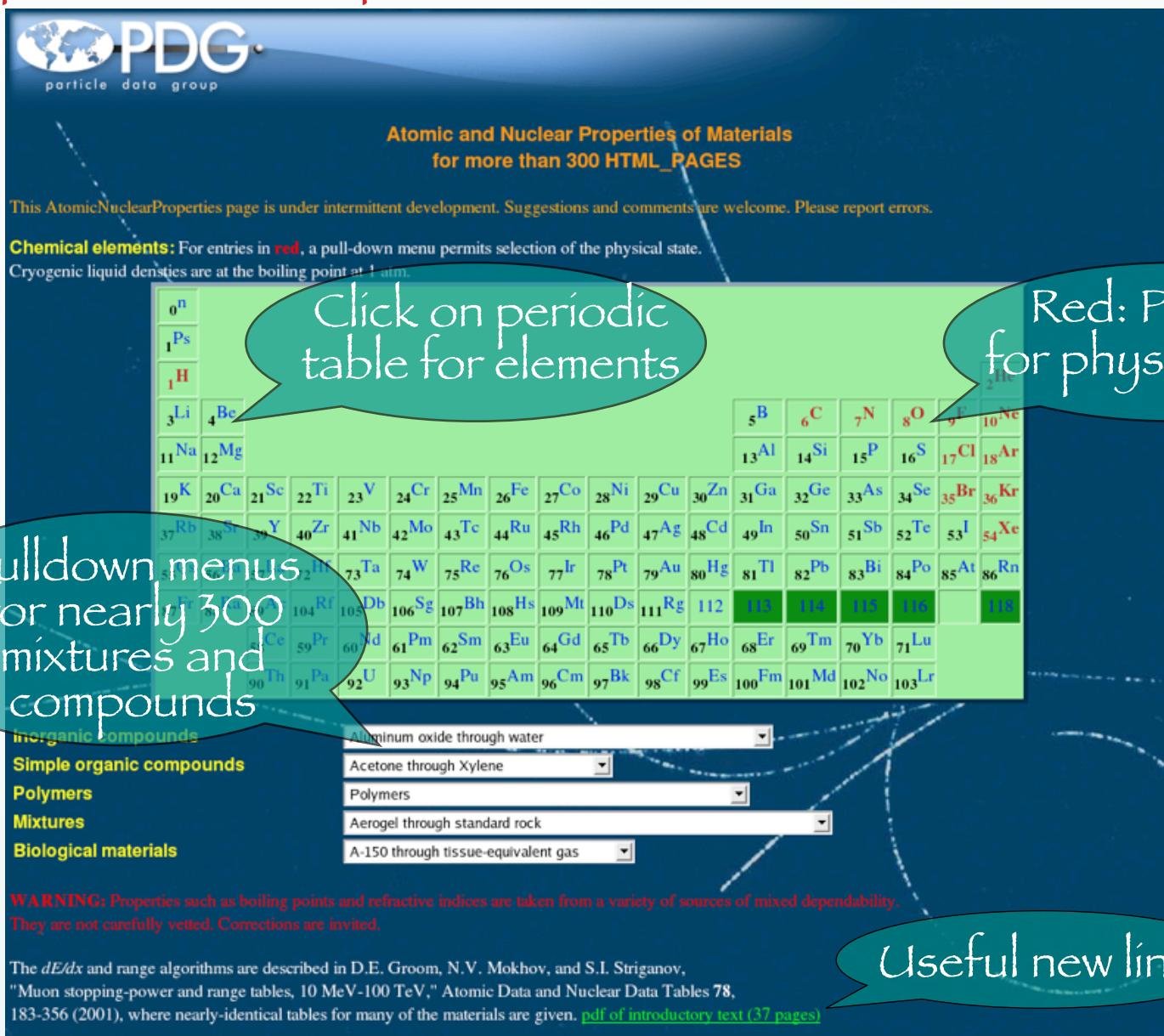
Kinematics, Cross-Section Formulae, and Plots

38. Kinematics
39. Cross-section formulae for specific proc. (revised)
40. Plots of cross sections and related quantities (revised)

In summary:

- 70% of the 40 REVIEWS, TABLES, AND PLOTS are new or revised for 2008 (and some, like Clebsch-Gordon coefficients, don't change much)
- If the 46 major minireviews are included, 78% of the 86 items are new or revised for this edition

AtomicNuclearProperties further upgraded --- Click from pdg.lbl.gov homepage



PDG
particle data group

Atomic and Nuclear Properties of Materials for more than 300 HTML_PAGES

This AtomicNuclearProperties page is under intermittent development. Suggestions and comments are welcome. Please report errors.

Chemical elements: For entries in red, a pull-down menu permits selection of the physical state.
Cryogenic liquid densities are at the boiling point at 1 atm.

Click on periodic table for elements

Red: Pulldown for physical states

Pulldown menus for nearly 300 mixtures and compounds

Useful new link

Inorganic compounds
Aluminum oxide through water

Simple organic compounds
Acetone through Xylene

Polymers
Polymers

Mixtures
Aerogel through standard rock

Biological materials
A-150 through tissue-equivalent gas

WARNING: Properties such as boiling points and refractive indices are taken from a variety of sources of mixed dependability. They are not carefully vetted. Corrections are invited.

The dE/dx and range algorithms are described in D.E. Groom, N.V. Mokhov, and S.I. Striganov, "Muon stopping-power and range tables, 10 MeV-100 TeV," Atomic Data and Nuclear Data Tables 78, 183-356 (2001), where nearly-identical tables for many of the materials are given. [pdf of introductory text \(37 pages\)](#)

Several new features---

Atomic and nuclear properties of materials:

Liquid argon (Ar) (Ar)

Quantity	Value	Units	Value	Units
Atomic number	18			
Atomic mass	39.948(1)	g mole ⁻¹		
Density	1.40	g cm ⁻³		
Minimum ionization	1.508	MeV g ⁻¹ cm ²	2.105	MeV cm ⁻¹
Nuclear collision length	75.7	g cm ⁻²	54.25	cm
Nuclear interaction length	119.7	g cm ⁻²	85.77	cm
Pion collision length	101.3	g cm ⁻²	72.58	cm
Pion interaction length	149.0	g cm ⁻²	106.7	cm
Radiation length	19.55	g cm ⁻²	14.00	cm
Critical energy	32.84	MeV (for e ⁻)	31.91	MeV (for e ⁺)
Molière radius	12.62	g cm ⁻²	9.043	cm
Plasma energy $\hbar\omega_p$	22.85	eV		
Muon critical energy	485	GeV		
Melting point	83.79	K	-189.4	C
Boiling point @ 1 atm	87.30	K	-185.9	C
Index of refraction (@ STP, Na D)	1.23			

New

For some things

For muons, $dE/dx = a(E) + b(E)E$. Tables of $b(E)$: [PS PDF TEXT](#)

Table of muon dE/dx and Range: [PS PDF TEXT](#)

[Explanation of some entries](#)

[Table of isotopes](#) Warning: may not be current

[x ray mass attenuation coefficients](#)

↑
Link to NIST

↑
Link to LBNL database
(not well maintained)

Atomic and nuclear properties of materials:

Carbon tetrafluoride (CF₄)

Quantity	Value	Units	Value	Units
<Z/A>	0.47721			
Specific gravity (20° C, 1 atm)	3.78E-03	g cm ⁻³		
Minimum ionization	1.688	MeV g ⁻¹ cm ²	6.382E-03	MeV cm ⁻¹
Nuclear collision length	64.1	g cm ⁻²	1.696E+04	cm
Nuclear interaction length	95.7	g cm ⁻²	2.530E+04	cm
Pion collision length	90.4	g cm ⁻²	2.391E+04	cm
Pion interaction length	125.9	g cm ⁻²	3.330E+04	cm
Radiation length	23.09	g cm ⁻²	8993.	cm
Critical energy	75.12	MeV (for e ⁻)	73.39	MeV (for e ⁺)
Molière radius	9.60	g cm ⁻²	2539.	cm
Plasma energy $\hbar\omega_p$	1.22	eV		
Muon critical energy	974.	GeV		
Melting point	89.55	K	-183.6	C
Boiling point @ 1 atm	145.3	K	-121.8	C

New for compounds and mixtures

For all compounds and mixtures

Composition:

Elem	Z	Atomic frac*	Mass frac*
C	6	1.00	0.136548
F	9	4.00	0.863450

* calculated from mass fraction data.

Explanation of some entries

For muons, $dE/dx = a(E) + b(E)E$. Tables of $b(E)$: [PS PDF TEXT](#)

Table of muon dE/dx and Range: [PS PDF TEXT](#)

Note: Physical properties such as gas density are not well vetted.

Table of Astrophysical Constants and Parameters

The first half of the table has been profoundly revised through the efforts of new mystery author Erik Bergren (this took months)

The cosmology parts have been updated and reorganized

Astrophysics and cosmology:

Keith Olive not only co-authors “Big-Bang Cosmology,” but also coordinates the “core set” of astrophysics reviews:

Big-Bang Cosmology

Primordial Nucleosynthesis

The Cosmological Parameters

Dark Matter

Cosmic Microwave Background

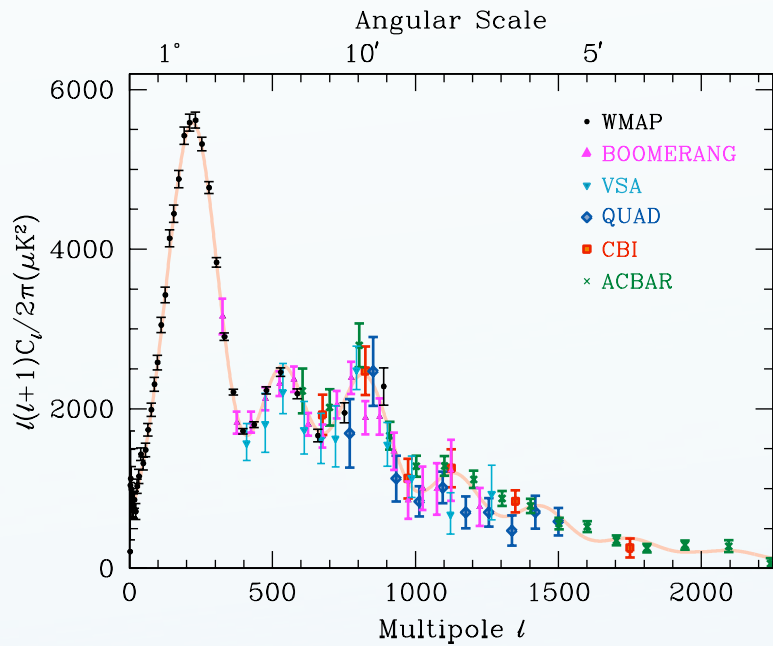
These have been reviewed and updated by the authors.

Some of the new results, e.g. in CMB, are a dramatic improvement

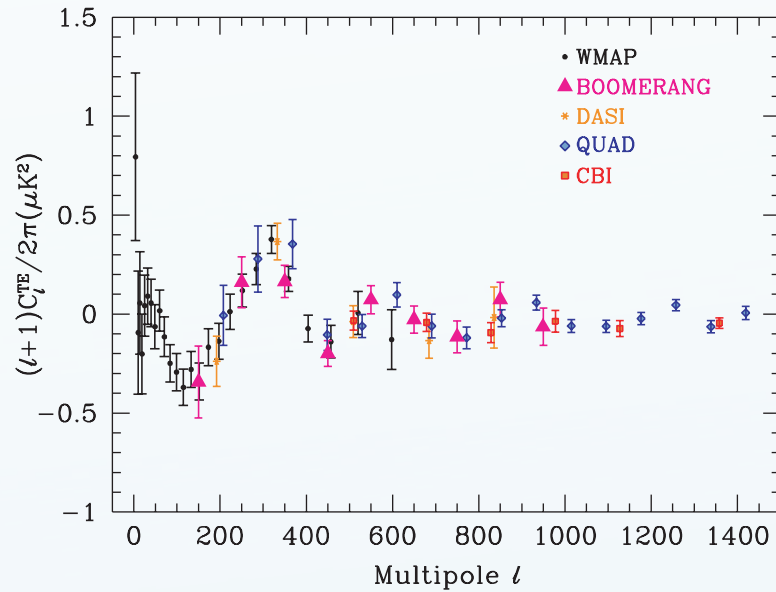
(The other two astrophysics reviews are Thibault Damour’s “Experimental tests of relativity”, which is self-propelled, and “Cosmic rays,” discussed later in this talk)

One example: George Smoot's and Douglas' Scott's "Cosmic Microwave Background" review, where new results have been coming rapidly.

Two examples:

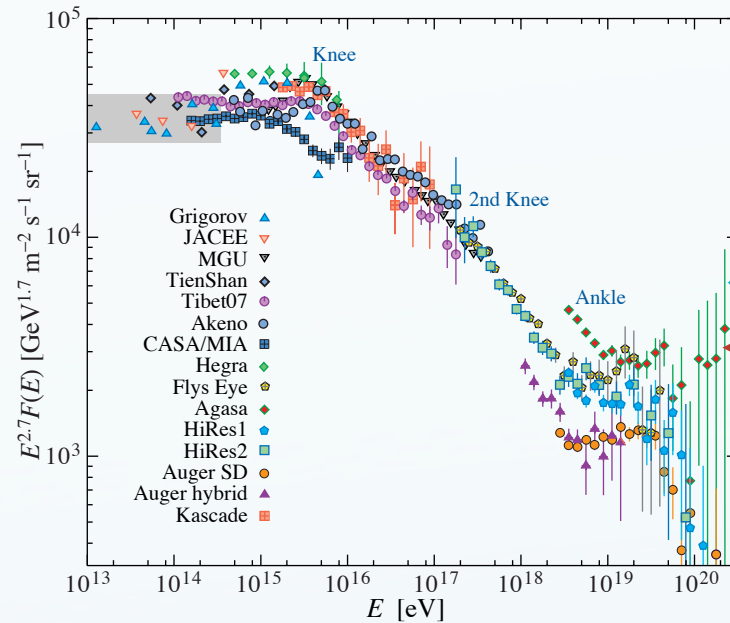
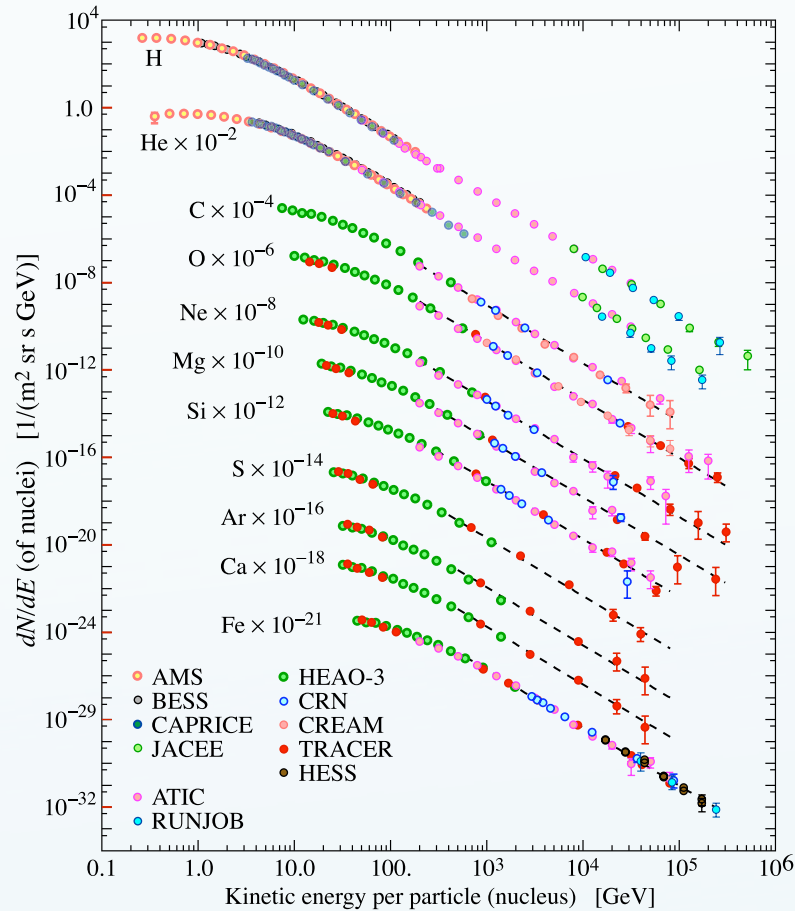


Much higher quality band-power estimates



First good polarization results:
 Cross power spectra of temperature anisotropies and E-mode polarization signal

COSMIC RAYS has been a perennial problem, but this time it was more or less rewritten and updated by the original authors, Tom Gaisser and Todor Stanev.



Older
AGASA
results

Post-ICCR08 summary for the tip of the spectrum; apparent confirmation of the GZK mechanism

Modern spectra with the help of JoJo Boyle of the Chicago group

New one-page Booklet version by Don Groom

Particle Detectors

Most “want list” sections and revisions have happened!*

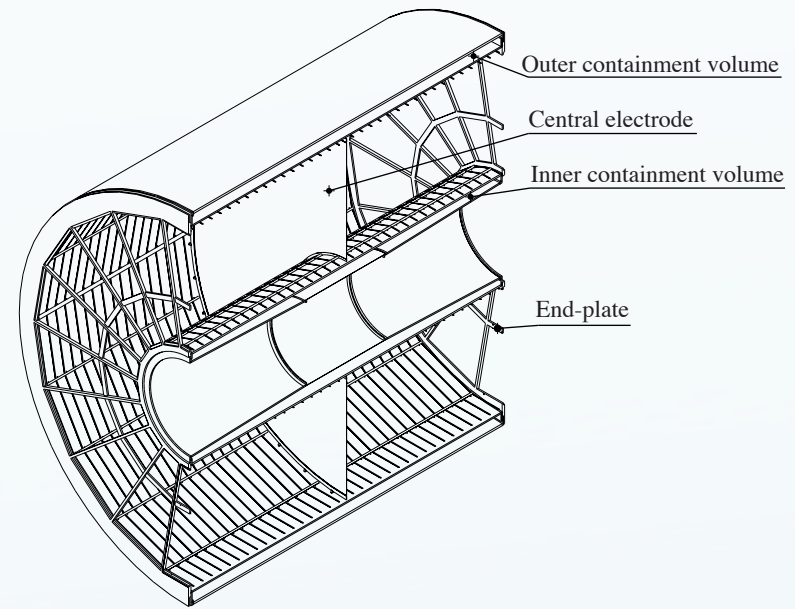
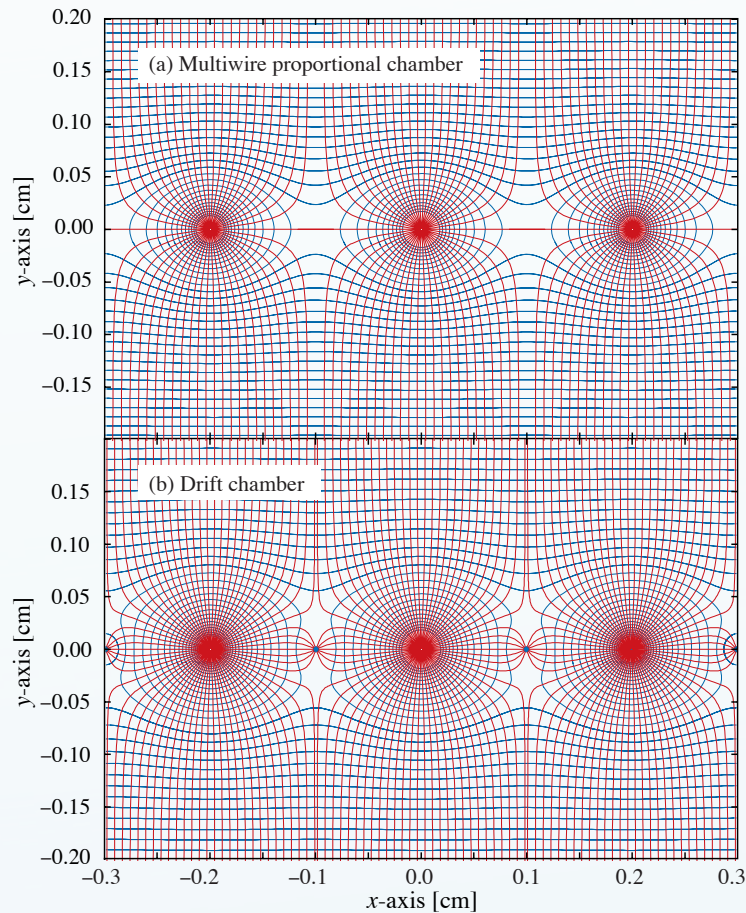
We asked **Fabio Sauli** for advice concerning authors; instead he suggested a consolidation of all the “gas-filled detectors” and volunteered to write the overview and MWPC sections:

28.7. Gaseous detectors

- new 28.7.1. Energy loss and charge transport in gases . . . Fabio Sauli & Maxim Titov
- new 28.7.2. Multi-Wire Proportional Chambers Fabio Sauli & Maxim Titov
- new 28.7.3. Micro-pattern Gas Detectors Maxim Titov
- new 28.7.4. Time-projection chambers Dean Karlen
- new 28.7.5. Transition radiation detectors (TRD's) Pavel Nevski & Antoli Romaniouk
- rev 28.7.6. Resistive-plate chambers Henry Band

* Several of these are the result of the unfortunate death of **Mike Ronan**, who ably authored several sections

A sampling from 10 new figures in the “Gaseous Detectors” section:



ALICE TPC (Dean Karlen)

Multiwire proportional chamber
 and drift chamber (Sauli)

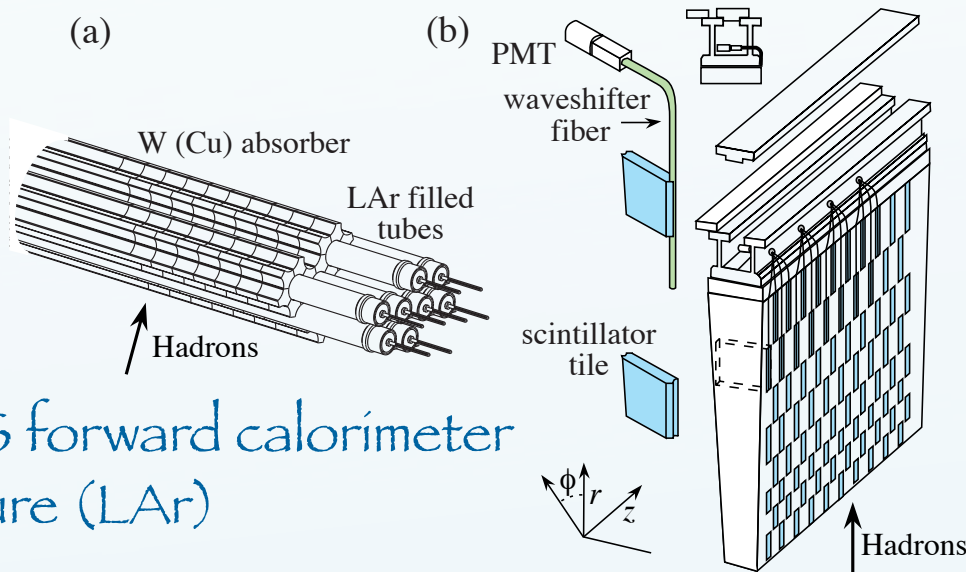
The Advisory Committee has long complained that the hadron calorimeter discussion was hopeless out of date. **This has been fixed.** The new introduction describes features common to both EM and hadronic calorimeter; part of the material was previously in 28.1.1

28.10. Calorimeters (Don Groom & Ren-Yuan Zhu)

(Generic - applies to both EM and hadron calorimeters)

rev 28.10.1. Electromagnetic calorimeters . . Ren-Yuan Zhu

new 28.10.2. Hadronic calorimeters Don Groom



ATLAS central barrel
 hadron calorimeter wedge
 (TileCal, scintillator tiles)

ATLAS forward calorimeter
 structure (LAr)

Finally, we should mention that Don Edward's and Kai Desler's "Accelerator Physics of Colliders" was quoted in connection with the LHC startup:

"Thus, to achieve high luminosity, **all one has to do** is make high population bunches of low emittance to collide at high frequency at locations where the beam optics provides as low values of the amplitude functions as possible."
PDG 2006, chapter 25

Machine parameters		450GeV Target	Stage A		Stage B		Stage C		Stage D	
			Target	Limit	Target	Limit	Target	Limit	Target	Limit
spacing	ns	2021	2021	566	75	75	25	25	25	25
bunch length	m	0.1124	0.0755	0.0755	0.0755	0.0755	0.0755	0.0755	0.0755	0.0755
crossing angle	urad	0	0	0	250	250	285	285	285	285
bunch intensity		4.00E+10	4.00E+10	9.00E+10	4.00E+10	9.00E+10	5.00E+10	5.00E+10	9.00E+10	1.15E+11
bunches		43	43	156	936	936	2808	2808	2808	2808
energy	eV	4.50E+11	7.00E+12	7.00E+12	7.00E+12	7.00E+12	7.00E+12	7.00E+12	7.00E+12	7.00E+12
F		1.00	1.00	1.00	0.96	0.92	0.90	0.84	0.90	0.84
normalised emittance	cm	3.75E-04	3.75E-04	3.75E-04	3.75E-04	3.75E-04	3.75E-04	3.75E-04	3.75E-04	3.75E-04
beta [*]	cm	1100	200	200	200	100	100	55	100	55
Commission hardware for high energy operation										
luminosity	/cm ² s	7.16E+28	6.12E+30	1.12E+32	1.28E+32	1.24E+33	1.13E+33	1.91E+33	3.65E+33	1.01E+34
total inel cross section	cm ²	6.00E-28	6.00E-28	6.00E-28	6.00E-28	6.00E-28	6.00E-28	6.00E-28	6.00E-28	6.00E-28
event rate per cross		0.01	0.76	3.85	0.73	7.09	2.14	3.63	6.94	19.18
Installation of phase II collimators and full beam dump diluters										
protons per beam		1.72E+12	1.72E+12	1.40E+13	3.74E+13	8.42E+13	1.40E+14	1.40E+14	2.53E+14	3.23E+14
current per beam	mA	3.09E+00	3.09E+00	2.53E+01	6.74E+01	1.52E+02	2.53E+02	2.53E+02	4.55E+02	5.81E+02
energy per beam	Joules	1.24E+05	1.93E+08	1.57E+07	4.19E+07	9.43E+07	1.57E+08	1.57E+08	2.83E+08	3.62E+08
beam size	um	293.3	31.7	31.7	31.7	22.4	22.4	16.6	22.4	16.6

Is progress measured in pages or kilograms?



- ← RPP08: 1339 pages 2.3 kg
- ← RPP06: 1231 pages 2.5 kg
- ← RPP04: 1109 pages 1.65 kg
- ← RPP02: 974 pages 1.5 kg
- ← RPP00: 878 pages 1.7 kg
- ← RPP98: 794 pages 1.5 kg

Thank you!



Thank you!