14TeV CMS Simulations and Webtools

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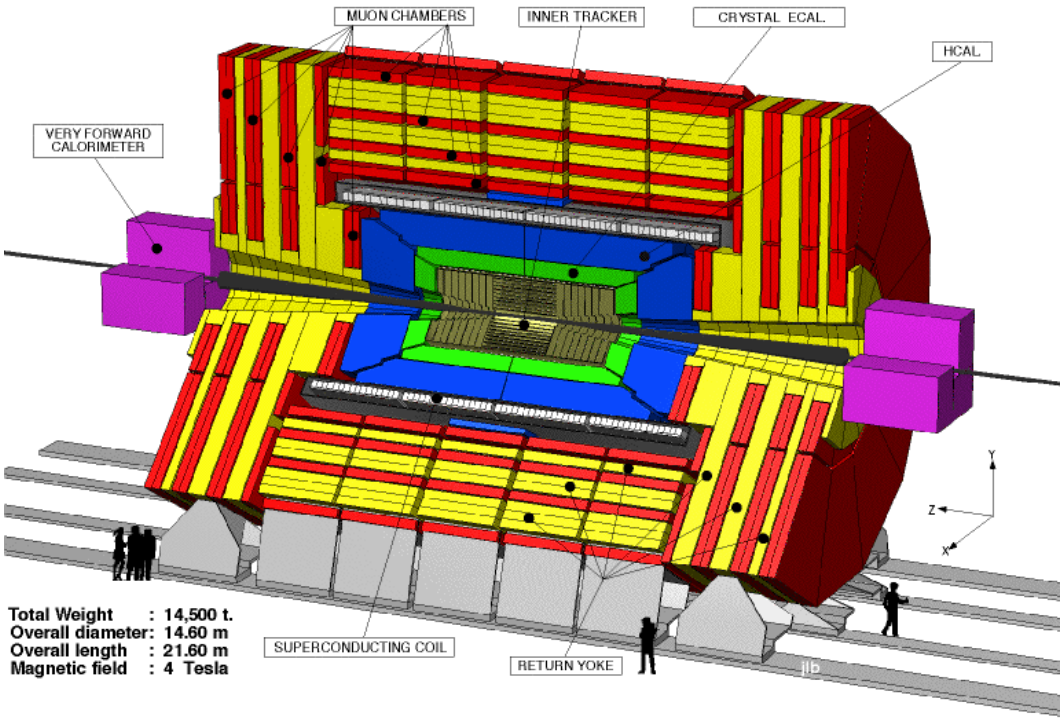
LHC Status

- Operated at 8TeV and 5×10^{33} cm^{-2} s^{-1} in 2012.
- Upgrading to run at 14TeV and 10^{34} cm^{-2} s^{-1} in 2015.
- Increased radiation dose can damage electronics.
  - Silicon in the Tracker particularly sensitive



Solution: Simulations

- Monte Carlo: mathematical experiment using theoretical models
- Have simulation data in CMS geometry for proton-proton collisions at 14TeV
- Uses a Monte Carlo simulation program called MARS

Dose/Fluence Calculator

Goal: create an easy-to-use way for physicists to create and view publication-quality graphs and maps of fluence and dose data generated by Monte Carlo simulation.

Authors: John Farmer and Jake Callahan

Former work: D. Haznar, P. Sharma

CMS Radiation Simulation Data @ 14TeV

CMS Dose/Fluence Calculator

Luminosity: in fb^{-1}

Simulation FLUKA Mars

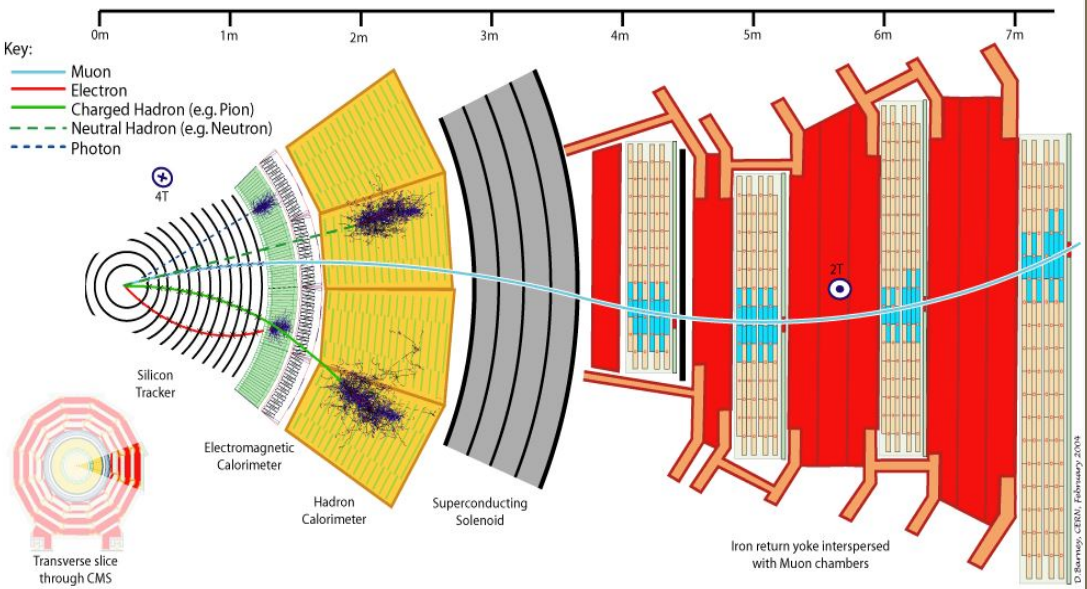
Choose Volume: Full CMS Detector Tracker Calorimeters

Action: Calculator Detector Maps Slice Graphs

Help Reset Next

Calculator Design

- Three data sets:
  - CMS full geometry
  - CMS tracker
  - CMS calorimeters
- Three options:
  - point calculator
  - 2D interactive maps
  - slice graphs



- Languages used:
  - html/CSS/JavaScript/PHP (web tools)
  - C++/ROOT (plots)
  - MySQL (database)
  - Python (running jobs on grid, data analysis)
  - bash (data analysis)

(1) Point Calculator

- Written in PHP.
- Outputs a simple table of fluence or dose data for one (R, Z) point.

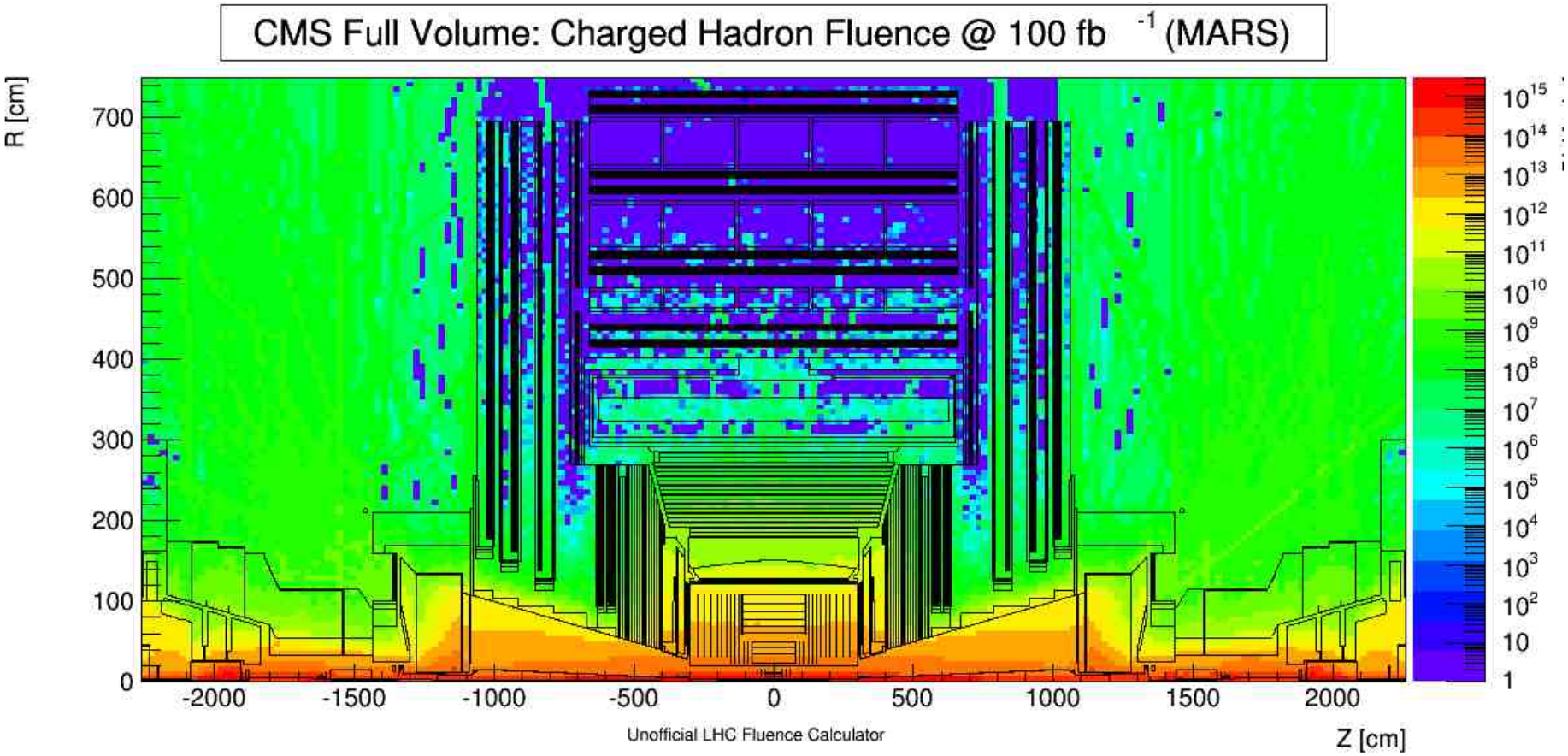
Neutral Hadron Fluence

Radial Distance	Distance Along Beam	Luminosity	Calendar Time (@10^{34})	Fluence
0 cm	0 cm	100 fb^{-1}	2.0 yr	3.97e+14 particles/cm^2

Back to Fluence Calculator

(2) 2D Interactive Maps

- Uses a C++ program (plotFluence from the Fluence Package) originally written by Charles Dietz from CERN.
- Heavily modified to suit the calculator.
- Creates interactive fluence/dose maps over CMS geometry.


CMS Full Volume: Charged Hadron Fluence @ 100 fb -1 (MARS)
R [cm]
700
600
500
400
300
200
100
0
-2000
-1500
-1000
-500
0
500
1000
1500
2000
Z [cm]
Unofficial LHC Fluence Calculator
10^15
10^14
10^13
10^12
10^11
10^10
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10
1

(3) Slice Graph

- Creates a plot of fluence or dose values sliced along R or Z.
- Uses lineGraph, a C++ Program written by John Farmer and Jake Callahan
- Outputs:
  - Optional table of data
  - .txt file of data
  - ROOT line graph of data
  - .root file containing line graph
- Graph options:
  - linear/logarithmic scaling
  - data point markers
  - curve fit or linear fits
  - Include data table

Radial Graphs

Luminosity: 100 fb^{-2}
Distance along beam: 0 cm

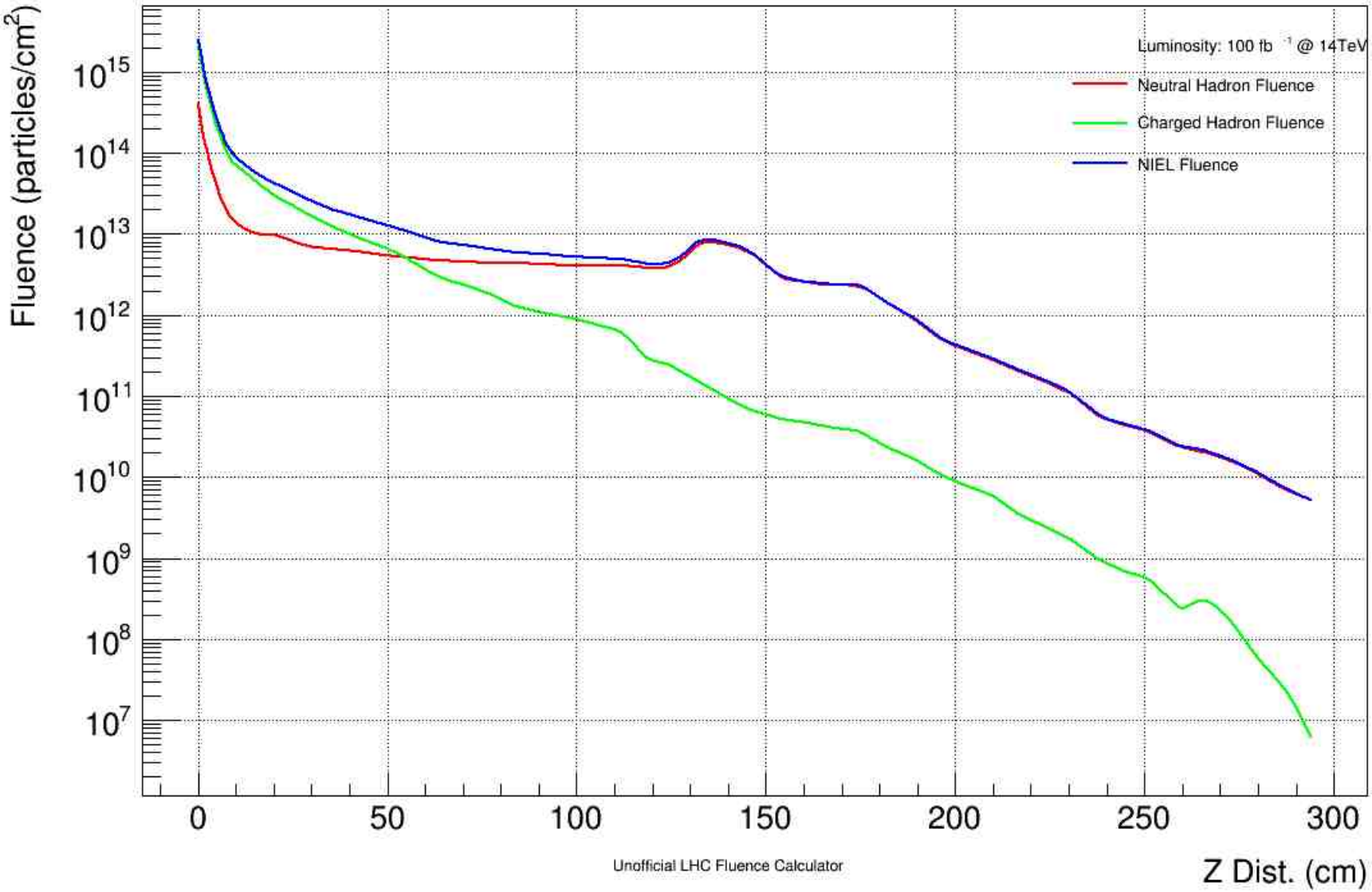
View Graphical Representation of the Data

Download .txt

Radial Distance in cm	Neutral Hadron Fluence in particles/cm^2	Charged Hadron Fluence in particles/cm^2	Niel Fluence in particles/cm^2
0	3.974328E+14	2.020448E+15	2.449707156E+15
10	22264080000000	1.18628E+14	1.46833752E+14
20	9475920000000	28528240000000	40558939200000
30	7326640000000	18827120000000	28152957600000
40	6036280000000	8987440000000	16208915200000
50	5370352000000	6797688000000	13016803200000
60	4820872000000	3704736000000	9073692400000
70	4487624000000	2333632000000	7222214000000
80	4383064000000	1835192000000	6601813200000
90	4222064000000	1073512000000	5595914640000
100	4097800000000	906152000000	5284577280000

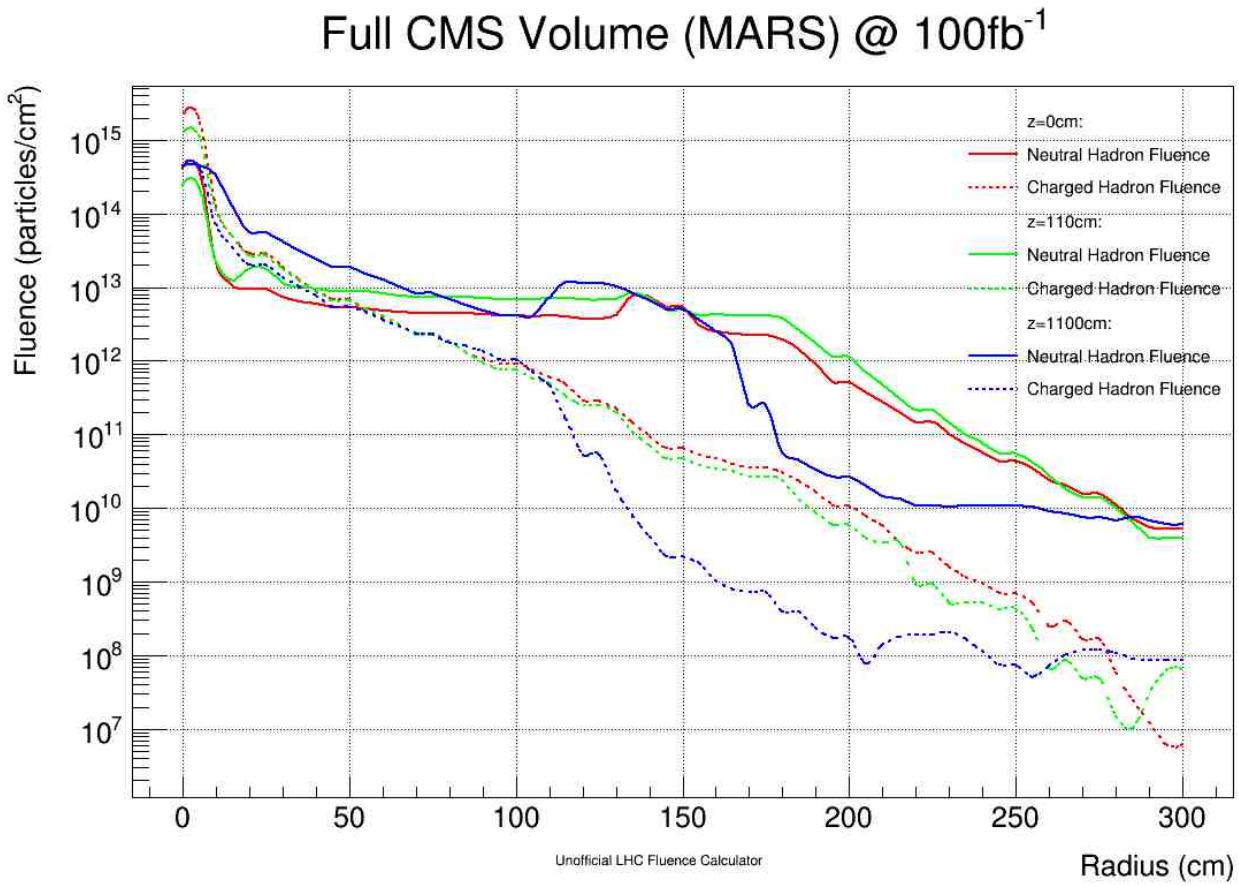
Back to Fluence Calculator

Full CMS Volume (MARS) @ Z = 0 cm



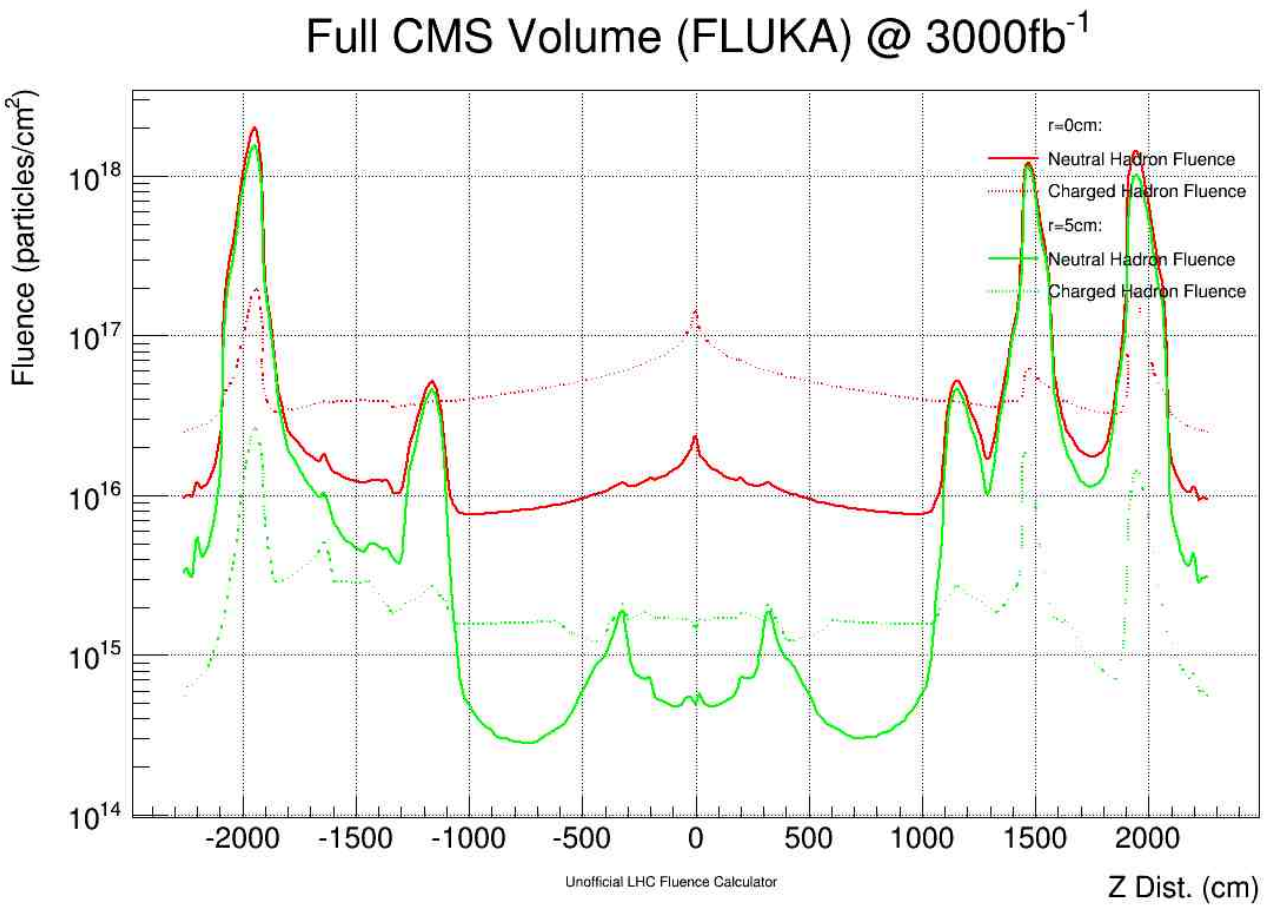
(3) Radial Graph cont.

- Can also graphs up to 3 different fluences at 3 different z locations along the detector.



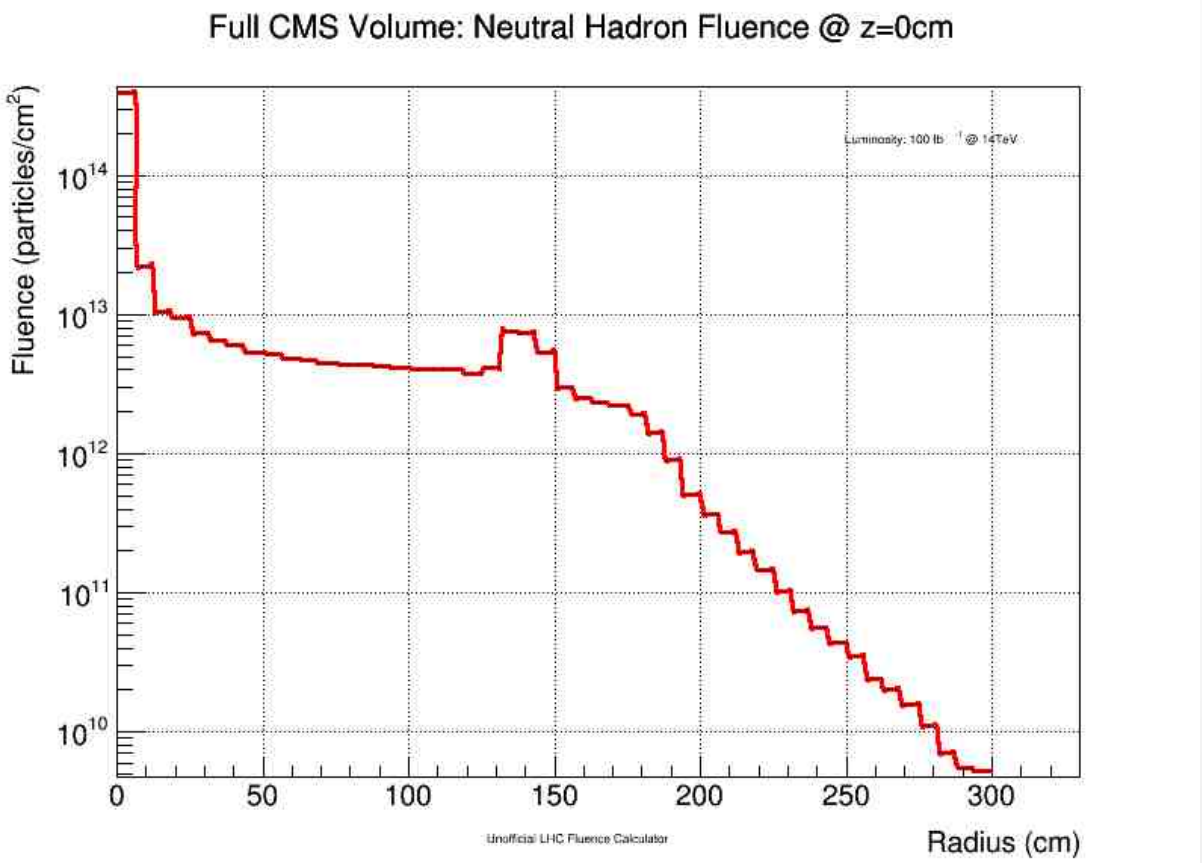
(3) Radial Graph cont.

- Can also slice along the detector's Z axis
- Easy to see effect of geometry on fluence



Limitations

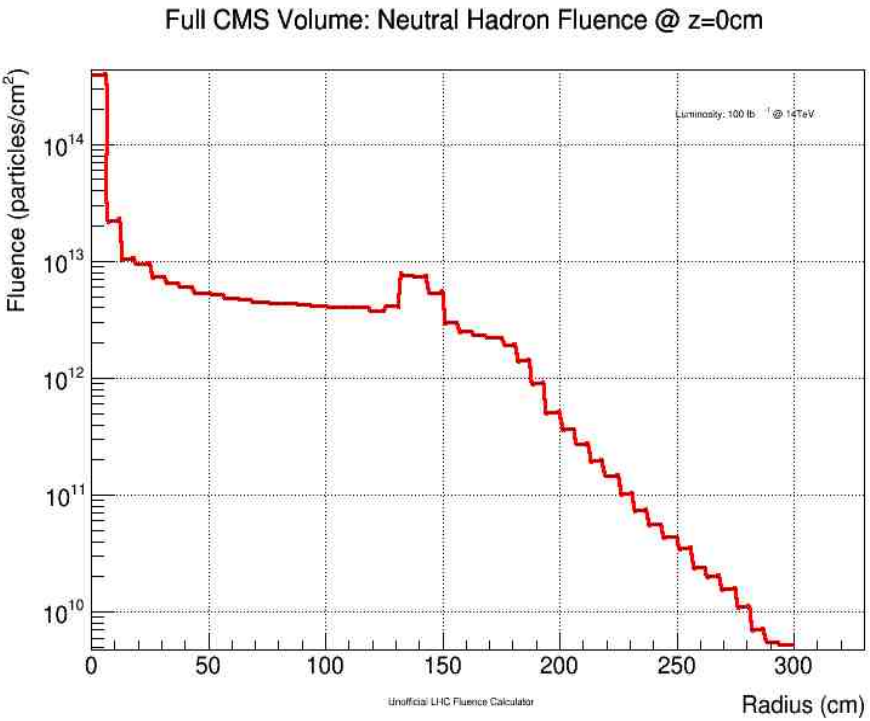
- Data granularity
- Multi-user support

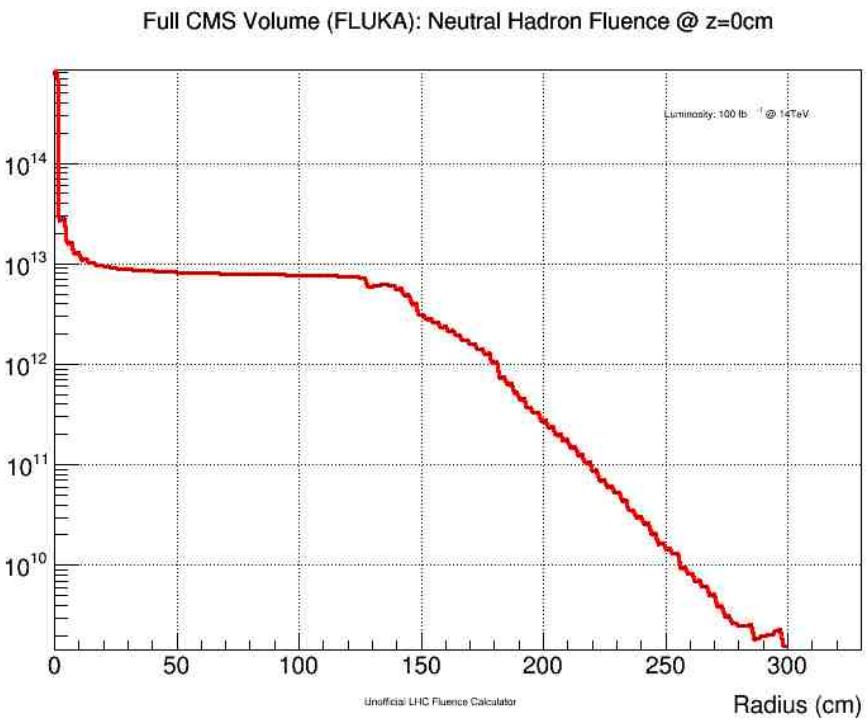


FLUKA simulations

Simulation Data Statistics					
Volume	Simulation	R Granularity (cm)	Z Granularity (cm)	Approx. # bins	# collisions
Tracker	MARS	0.92	2.90	24000	13,000
	Fluka	1.009	2.003	34800	52,000
Calorimeters	MARS	2.00	2.00	34500	13,000
	Fluka	2.00	2.00	34500	53,225
Full Geometry	MARS	6.25	22.6	24000	13,000
	Fluka	3.004	7.535	150,000	78,750

- Ran jobs on CMSLPC Batch cluster
- Collected data from 183,975 collisions
  - Statistically more accurate
  - Finer granularity


Full CMS Volume: Neutral Hadron Fluence @ z=0cm
Fluence (particles/cm^2)
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
0
50
100
150
200
250
300
Radius (cm)
Unofficial LHC Fluence Calculator


Full CMS Volume (FLUKA): Neutral Hadron Fluence @ z=0cm
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
0
50
100
150
200
250
300
Radius (cm)
Unofficial LHC Fluence Calculator

Scoring Cutoff Thresholds		
Particle	MARS	Fluka
Charged Hadrons	1 MeV	1 MeV
Neutrons	100keV	10^{-5}eV
Photons	200 keV	30KeV
Electrons/positrons	200 keV	≤ 1MeV, most ≈ 100KeV*
Delta-ray production	100 keV	≤ 10MeV, most ≈ 100 KeV
*e+/e- and δ vary by region		

- Thresholds: particles beyond which particle is no longer transported
- The lower, the better, generally speaking
- FLUKA:
  - excellent neutron/photon transportation
  - Electron/positron/delta ray thresholds vary over CMS geometry; generally comparable to MARS, but could be finer

Future Work

- More statistics (greater number of collisions)
  - Trivially easy for a trained worker with our script architecture
- Multi-user support on the calculator

- Lower e-/e+ and δ-ray transport thresholds
- (1,1) granularity in (R,Z)
  - Requires filling 3,395,271 bins
- Break assumption of Φ-symmetry

Conclusions

- Created webtools for graphical display of MARS simulations
- Ran high-statistics FLUKA simulations
- Support both datasets
- Useful tools for detector design/upgrade

References

- *"The FLUKA code: Description and benchmarking"* **G. Battistoni, S. Muraro, P.R. Sala, F. Cerutti, A. Ferrari, S. Roesler, A. Fasso`, J. Ranft,** Proceedings of the Hadronic Shower Simulation Workshop 2006, Fermilab 6--8 September 2006, M. Albrow, R. Raja eds., AIP Conference Proceeding 896, 31-49, (2007)
- *"FLUKA: a multi-particle transport code"* **A. Ferrari, P.R. Sala, A. Fasso`, and J. Ranft,** CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773

Acknowledgements

- Charles Dietz (Fluence Package)
- D. Haznar and P. Sharma (original calculator)
- Jake Callahan (coworker)
- Patrick Gartung (technical support)
- Pushpa Bhat and Leonard Spiegel (supervisors)
- Alfredo Ferrari (Fluka lead developer)
- SIST committee