Contributions from simulations for BCM1F

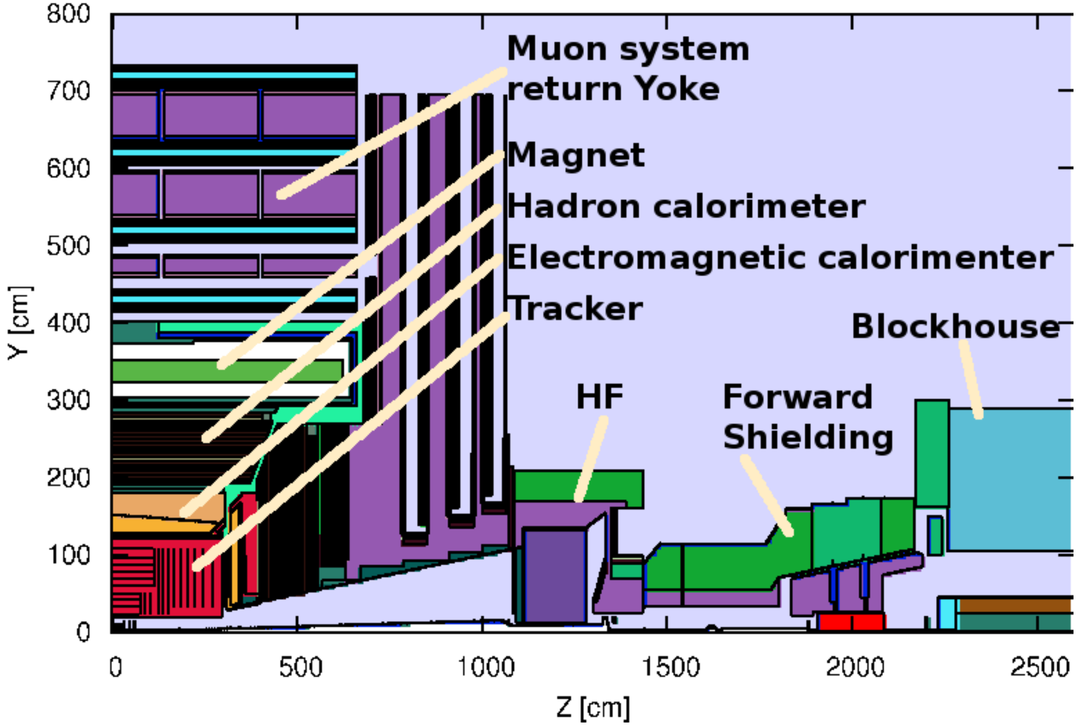
Current status and plans for future campaigns

Outline

- Simulation framework
  - FLUKA
  - DPMJET
  - Background
- What is already
  - Fluxes
  - Spectra
  - Full particle information for offline simulation
    - Per event for pp
    - Per second for each background
  - Comparisons to data
- What is possible to do
  - Several pp energies
  - Pb-Pb collisions at various energies
  - Background simulation input files on event by event basis ongoing work
  - Prediction for nominal machine parameters based on early simulation/data comparisons.
  - Radiation damage.
- Who is/will be working on this.
- Outlook/Conclusions

Simulation Framework - Geometry

- Based on a model coded by M. Huhtinen
- Materials updated to better fit the as built detector
- Added volumes for BRM detectors for more detailed response simulation
- One pp-event O(20min)



Simulation Framework - Background

·Beam Gas Elastic (BGE):

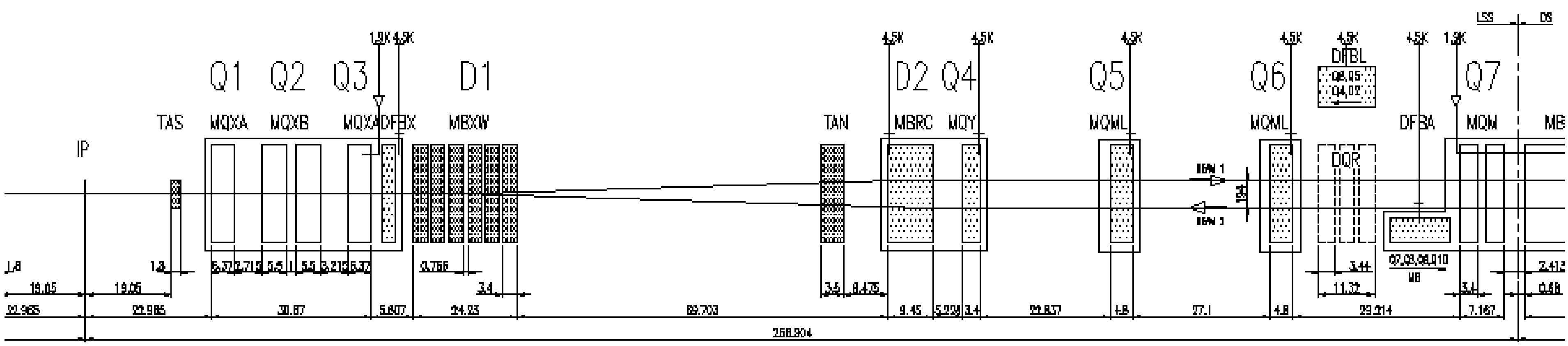
Multi-turn elastic scattering with beam gas. Typically the first hit of such a proton with the beam pipe aperture is the TCT collimator (~150m from IP)

·Beam Halo (BH):

Inefficiencies of the primary collimation system lead to particles intercepted by the tertiary collimator (TCT) in front of CMS. Therefore this contribution shows similar effects like BGE.

·Beam Gas Inelastic (BGI):

Inelastic interactions with the rest gas inside the beam pipe, highly depend on the vacuum. Origin of particles scattered all along the LSS.



Simulation Framework – Background steps

- Background simulation for CMS is a multi-step process:
- Beam halo:
  - SixTrack simulation of proton loss maps for nominal machine.
  - Shower generation of lost protons in the long straight sections with MARS (Fermilab group) up to 22.6m in front of CMS.
  - At 22.6m interface to FLUKA, then full tracking inside CMS.
- Beam Gas:
  - Beam gas interactions simulated with MARS between 550m and 22.6m in front of CMS.
  - At 22.6m interface to FLUKA, as for beam halo.
- Normalisation:
  - All background simulations normalised to per second at nominal machine parameters.
  - No event-by-event simulation possible yet
    - New background simulations files for LSS are work in progress (B. Roderick)

Simulation procedure

PP-events

- Using DPMJET III as included in FLUKA.
- Beam parameters:
  - 7Tev /450GeV
  - 150urad xangle
  - Vertex fluctuation along Z, Gaussian distribution with sigma=5.3cm and a hard cutoff at 15cm.
  - All pp numbers scaled to nominal luminosity of $10^{34}cm^{-2}s^{-1}$

Beam induced Background

- Split Nikolai's files into several runs, to deal with weight fluctuations:
  - Proton
  - Muon
  - Rest

For both cases CASTOR is handled, but not really important for BCM1F response.

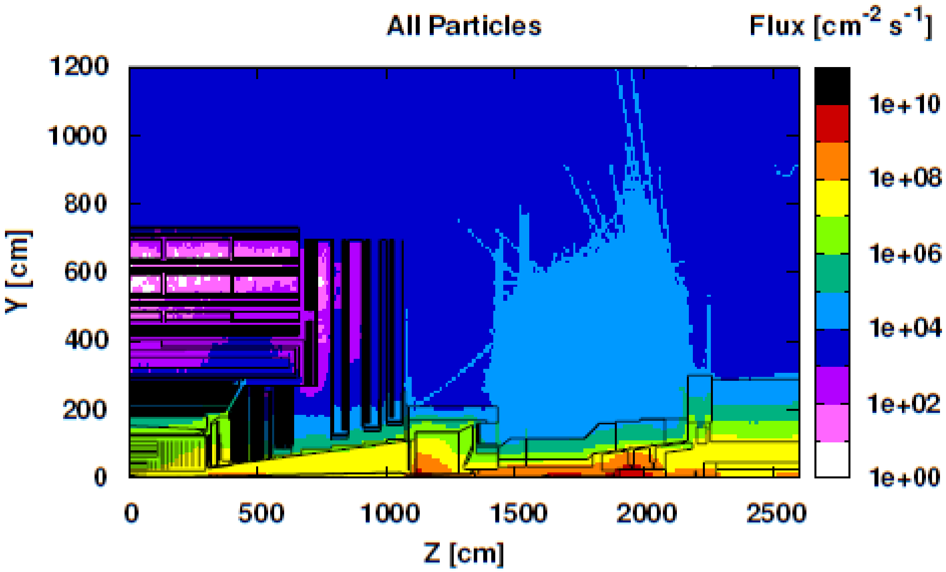
- Mild shielding effect for background.

Available data (PP and Background)

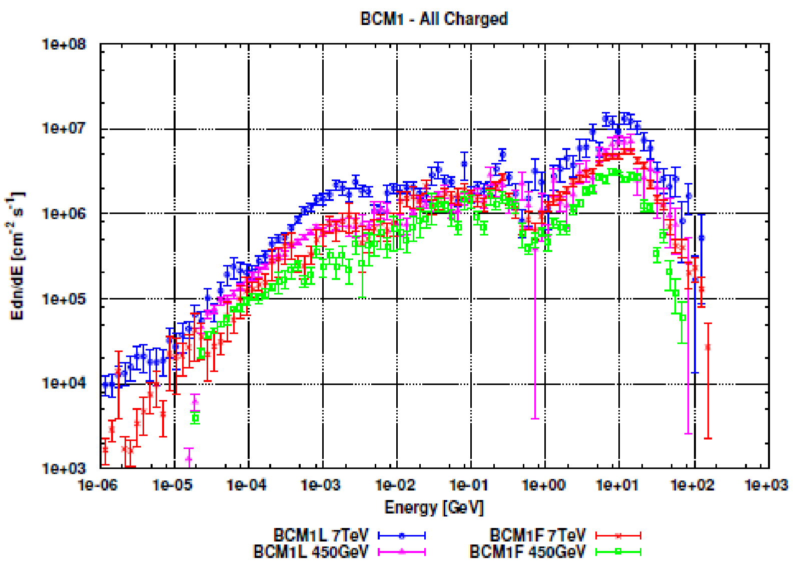
Tracklength densities for various particle types:

For whole cavern (10x10cm binning)
For R<3m (2.5x2.5cm binning)
For R<20cm (0.2x2.5cm binning)

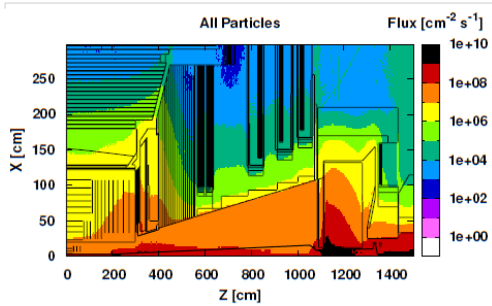
Also Dose and 1MeV N_{eq} available.
Radial plots and fluxes along the beam pipe for given radii are also available.



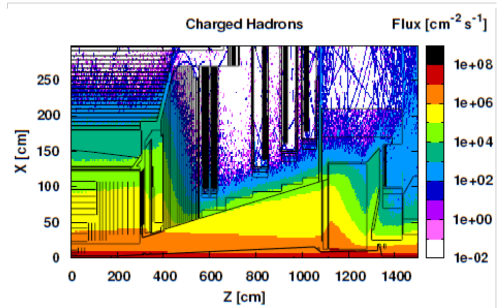
Particle energy spectra for all BRM detectors for various particles.



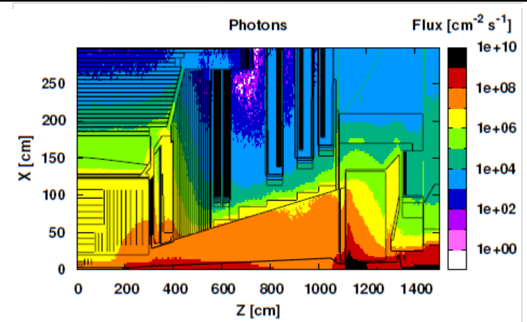
All fluxes for BCM1F (at 1e34cm^{-2}s^{-1})

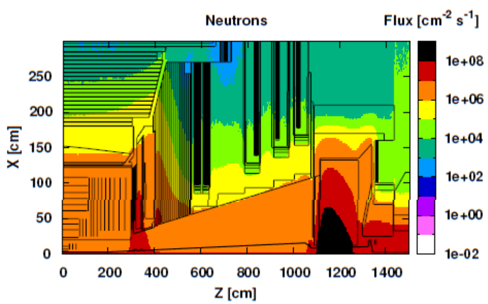


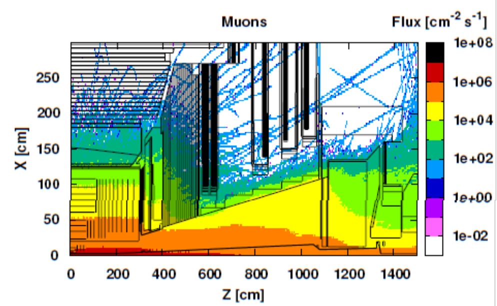
(a)

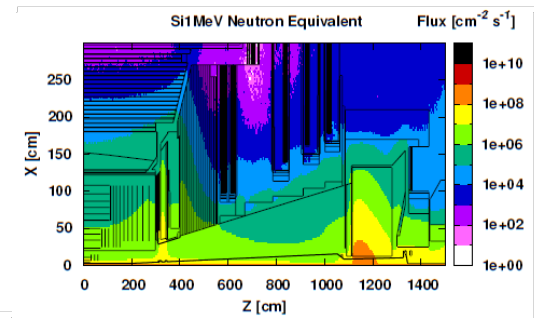


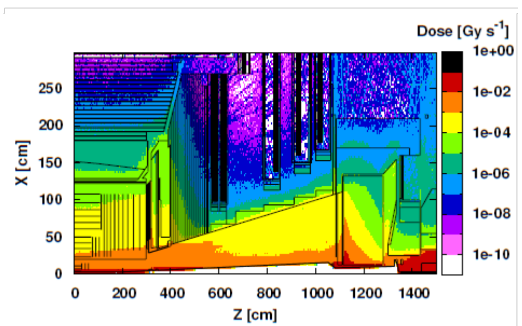
(b)

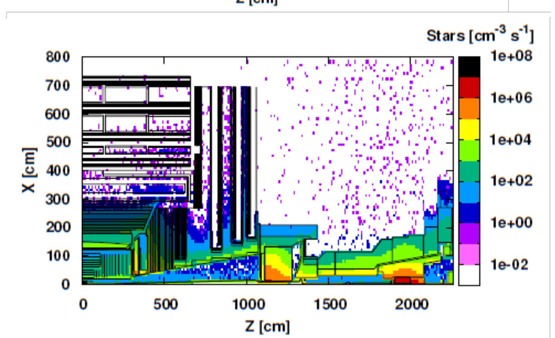






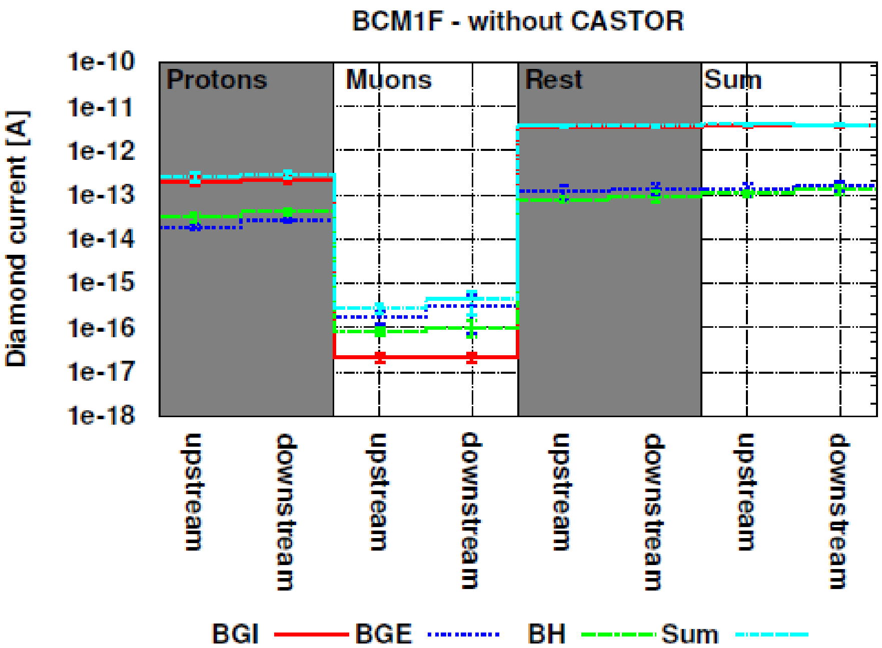


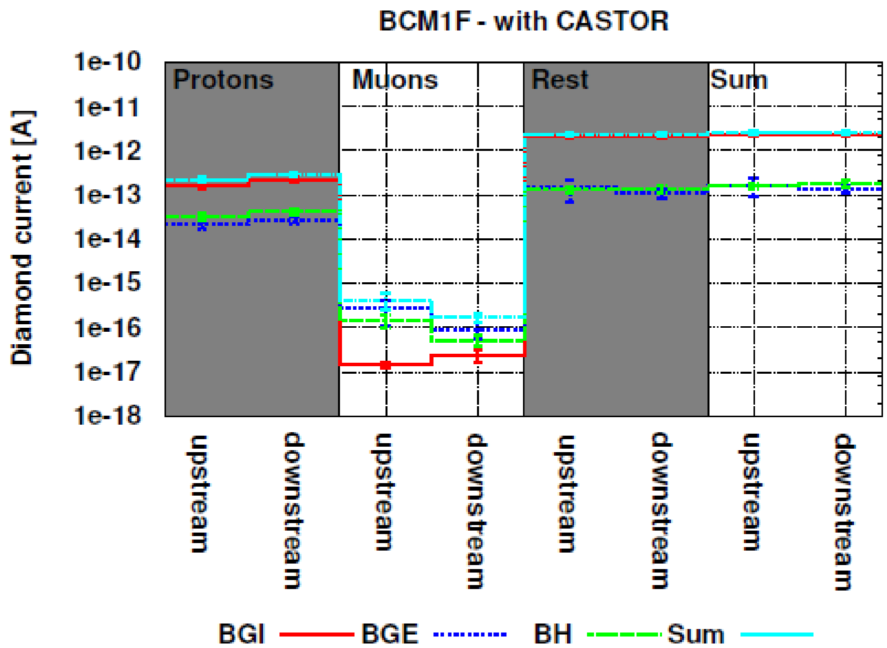


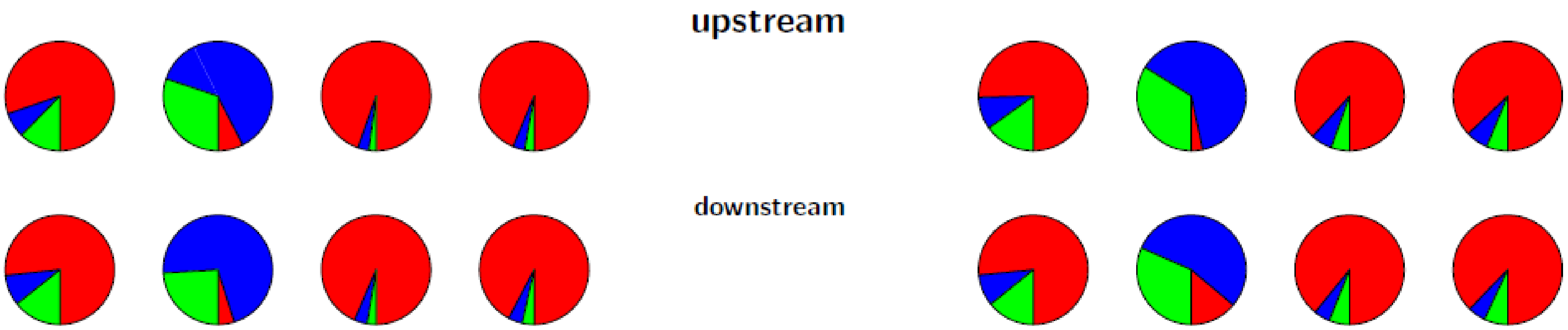


All available for background as well. Asymmetry a few %.

Background simulation results BCM1F







Existing results – Dump file

All information about a particle entering any BRM detector volume is dumped into a file.

File format:

Event number

OldRegion

NewRegion

Fluka Particle ID

Scoring Detector

Particle Generation

XYZ-Coordinates

Energy

Direction Cosines

Weight

Time of flight

Zhit (for background only, Z coordinate of primary proton loss)

stemu@pccmslx01: ~/fluka_simulations/work/cms_bkg/BG_HITfiles/BGE

50	490	66	7	65	25	3,5356E+01	9,2374E+00	-1,0848E+03	-2,5630E-02	3,8886E-02	1,2047E-02	-9,9917E-01	8,4663E+03	5,2434E-07	1,4634E+04
50	490	66	7	65	38	2,6897E+01	-3,2950E+01	-1,0848E+03	-9,6827E-04	9,4869E-02	-1,7470E-01	-9,8004E-01	8,4663E+03	5,2446E-07	1,4634E+04
50	490	66	7	65	50	-3,2428E+01	8,7401E+00	-1,0848E+03	-1,2981E-04	-7,9194E-01	3,9253E-01	-4,6771E-01	8,4663E+03	5,2486E-07	1,4634E+04
50	490	66	7	65	40	2,9247E+01	2,6096E+01	-1,0848E+03	-2,6792E-02	1,2910E-01	1,2843E-01	-9,8328E-01	8,4663E+03	5,2476E-07	1,4634E+04
50	490	66	7	65	51	1,2299E+01	2,6380E+01	-1,0848E+03	-1,8260E-02	1,0365E-01	2,8038E-01	-9,5428E-01	8,4663E+03	5,2478E-07	1,4634E+04
50	490	66	4	65	53	3,8729E+00	4,0884E+01	-1,0848E+03	-3,6871E-02	-4,3390E-02	5,4121E-01	-8,3977E-01	8,4663E+03	5,2498E-07	1,4634E+04
50	490	66	7	65	30	2,0847E+01	3,1030E+01	-1,0848E+03	-2,3831E-02	2,1102E-02	3,9406E-02	-9,9900E-01	8,4663E+03	5,2435E-07	1,4634E+04
50	490	66	7	65	24	1,6998E+01	1,7970E+01	-1,0848E+03	-2,7773E-03	2,5788E-01	5,3611E-01	-8,0380E-01	8,4663E+03	5,2445E-07	1,4634E+04
50	490	66	7	65	27	2,3983E+01	3,5483E+00	-1,0848E+03	-4,8201E-04	6,0689E-01	-2,2845E-01	-7,6125E-01	8,4663E+03	5,2448E-07	1,4634E+04
50	490	66	7	65	29	2,5005E+01	2,9636E+01	-1,0848E+03	-8,8366E-04	4,3399E-01	7,4320E-01	-5,0922E-01	8,4663E+03	5,2481E-07	1,4634E+04
50	490	66	7	65	32	2,3746E+01	1,3974E+00	-1,0848E+03	-5,1100E-04	6,6714E-01	-2,6558E-01	-6,9598E-01	8,4663E+03	5,2452E-07	1,4634E+04
50	490	66	7	65	34	3,8617E+01	-2,4265E+00	-1,0858E+03	-3,0245E-04	6,1919E-01	-4,0899E-02	7,8418E-01	8,4663E+03	5,2525E-07	1,4634E+04
50	490	66	7	65	27	8,4856E+00	-3,6663E+01	-1,0858E+03	-3,4213E-04	-3,2993E-02	-7,6023E-01	6,4881E-01	8,4663E+03	5,2580E-07	1,4634E+04
50	490	66	7	65	19	2,8622E+01	2,8826E+01	-1,0848E+03	-1,5214E-02	3,0320E-02	3,6311E-02	-9,9888E-01	8,4663E+03	5,2435E-07	1,4634E+04
50	490	66	4	65	34	2,0522E+01	-1,8300E+01	-1,0848E+03	-3,1311E-03	1,9276E-01	7,7761E-02	-9,7816E-01	8,4663E+03	5,2487E-07	1,4634E+04
50	490	66	7	65	35	2,4971E+01	-9,5430E+00	-1,0858E+03	-5,1100E-04	6,3646E-01	4,4949E-01	6,2680E-01	8,4663E+03	5,2544E-07	1,4634E+04
50	490	66	7	65	39	2,6390E+01	-2,9931E+01	-1,0848E+03	-3,4496E-03	1,1399E-01	-1,6912E-01	-9,7898E-01	8,4663E+03	5,2481E-07	1,4634E+04
50	490	66	7	65	43	-2,7639E+01	2,3000E+01	-1,0848E+03	-1,9838E-03	-3,9471E-02	2,9213E-02	-9,9879E-01	8,4663E+03	5,2435E-07	1,4634E+04
50	490	66	7	65	50	2,4092E+01	-1,9523E+01	-1,0848E+03	-1,2990E-02	7,4007E-02	-8,4267E-02	-9,9369E-01	8,4663E+03	5,2440E-07	1,4634E+04
50	490	66	7	65	54	-1,1796E+01	2,6251E+01	-1,0858E+03	-3,4201E-04	-1,7429E-02	8,6830E-01	4,9573E-01	2,2376E+04	5,2771E-07	1,4634E+04
50	490	66	7	65	55	2,9518E+01	-8,8788E+00	-1,0848E+03	-1,6407E-04	1,0808E-01	-1,7826E-02	-9,9398E-01	8,4663E+03	5,2440E-07	1,4634E+04
50	490	66	7	65	56	3,2604E+01	-7,8552E+00	-1,0848E+03	-1,3036E-03	1,2739E-01	-1,1301E-02	-9,9179E-01	8,4663E+03	5,2441E-07	1,4634E+04
50	490	66	3	65	56	2,5429E+01	-2,5218E+01	-1,0848E+03	-1,0625E-02	8,2441E-02	-1,8372E-01	-9,7952E-01	8,4663E+03	5,2443E-07	1,4634E+04
50	490	66	7	65	31	2,3402E+01	-2,1456E+00	-1,0858E+03	-5,1100E-04	8,4741E-01	-1,8504E-01	4,9765E-01	8,4663E+03	5,2506E-07	1,4634E+04
50	490	66	7	65	44	3,6449E+01	-8,2674E+00	-1,0848E+03	-3,1758E-02	4,1611E-02	-1,2538E-02	-9,9906E-01	8,4663E+03	5,2436E-07	1,4634E+04
50	490	66	3	65	28	3,0033E+01	2,7044E+01	-1,0848E+03	-7,5004E-03	9,3858E-03	2,7435E-01	-9,6158E-01	8,4663E+03	5,2450E-07	1,4634E+04

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Files available for pp-collisions and beam background (one file per contribution)

Suitable format for further more detailed detector response and radiation hardness simulations.

Simulation of BCM1F response

FLUKA simulation for PP 7TeV

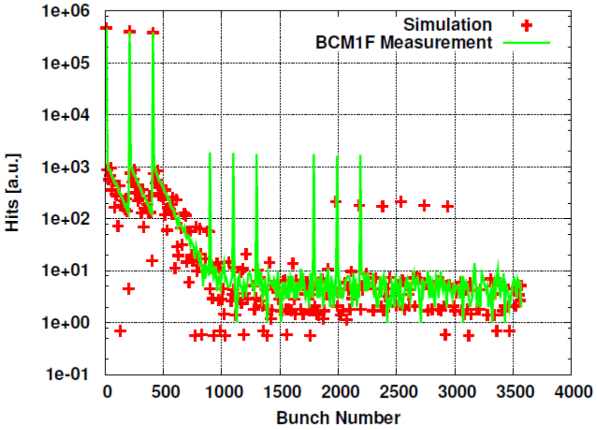
BCM1F response

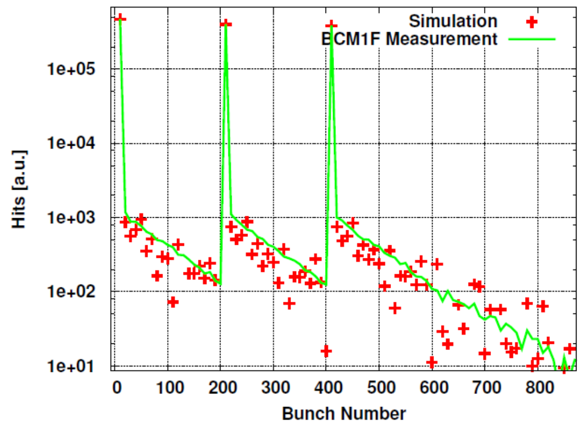
- energy cuts to account for aluminium cover which is not in the simulation:
  - Electrons: 1.5MeV (from independent simulation)
  - Positrons: 1 MeV (from independent simulation)
  - Neutrons: 13eV, ionisation energy of diamond
  - Photons: 100keV
- Weighting factors to account for detector response:
  - Neutrons: 1/6 from testbeam
  - Photons: 1/50 (back of the envelope calculation, taking into account the photon energy spectra)

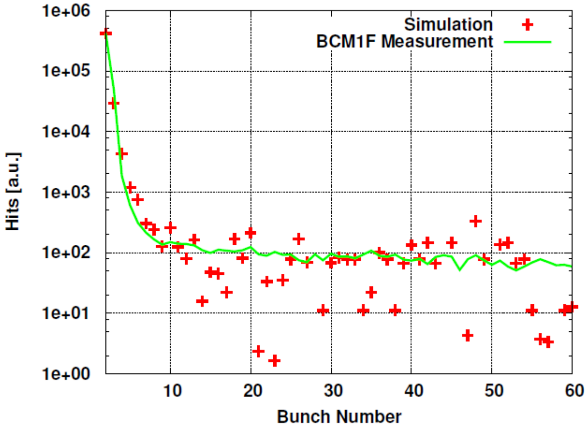
Better handling possible with dedicated simulation of the BCM1F detector using the hit-files.

Comparison to data (BCM1F)

PP-response for 3 colliding bunches (non colliding bunches not handled in simulation)

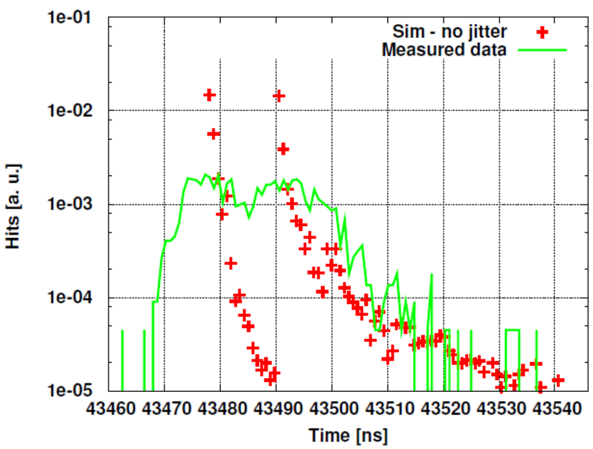


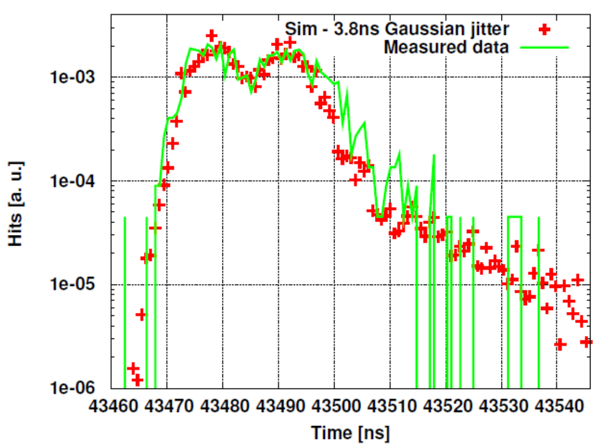




See Roberval's talk.

Absolute comparison to rates observed not formally done. But would be interesting!





Background:

Raw simulation comparison (left)

Simulation with 3.8ns jitter compared to measured data (right)

Comparison to data (Medipix, HF NRM14)

Comparison with Medipix detector installed near the cavern wall at Z+ end.
Preliminary numbers, detector efficiency calibration ongoing work.

Particle Type	Simulation $[\frac{Hits}{cm^2 s}]$	Sim. response	Factor	Measurement $[\frac{Hits}{cm^2 s}]$
All charged	0.004	0.004	1	
e^+e^-	0.003	0.003	1	
All Neutrons	0.266	0.005	0.02	
Neutrons $>$ 0.1 MeV	0.095	0.002	0.02	
Neutrons $>$ 20 MeV	0.0259	0.00052	0.02	
Photons	0.189	0.0037	0.02	
Sum	0.455	0.0127	0.028	0.01 [?]

Neutron Monitors installed by MSU in the HF forward region:
Preliminary comparison, no detector calibration included yet
(waiting for updated measurement results)

Detector	Measurement $[\frac{Hits}{cm^2 s}]$	Simulation $[\frac{Hits}{cm^2 s}]$	Ratio Sim./Mea.
$HF+_{int}$	1.75	6.97	3.98
$HF-_{int}$	12.6	38.5	3.05
$HF+_{ext}$	0.175	0.55	3.14
$HF-_{ext}$	0.35	1.6	4.5
$HF-_{ext}/HF+_{ext}$	2	2.9	1.45
$HF-_{int}/HF+_{int}$	7.2	5.5	0.764
$HF+_{int}/HF+_{ext}$	10	12.6	1.26
$HF-_{int}/HF-_{ext}$	36	24	0.67

Errors

Quoted are statistical errors only.

Systematics:

_ Machine setup will change simulation results.

_ Energy

_ Imperfect description of the detector and simulation response.

_ Simulation parameters (thresholds and other parameters)

From investigations so far the systematics are under control.

The last uncertainty comes from model validity. Here, this is a matter of validating the absolute prediction of the simulation for Dose, Dose-rates...

Limited comparison so far leads to following conclusion:

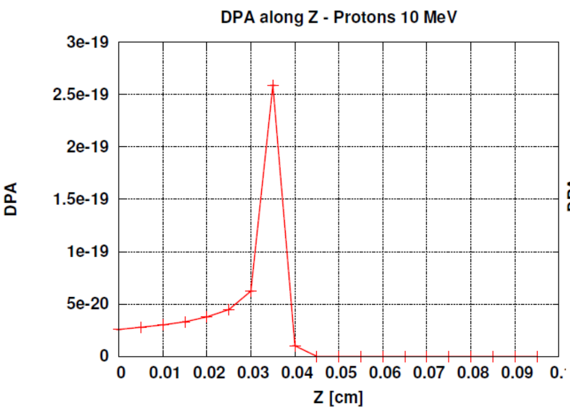
At the moment it is assumed that the observations so far are well within a safety factor of three. BCM1F comparisons so far all agree very well.

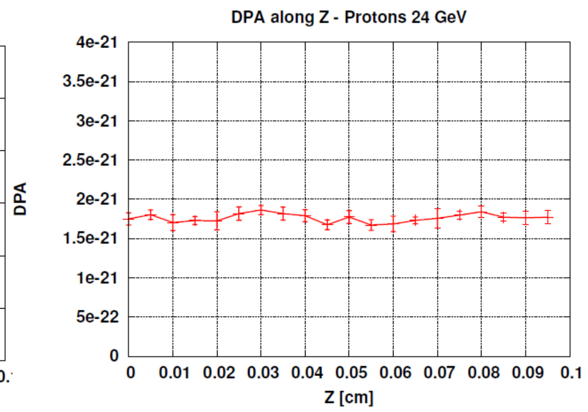
Radiation damage based on DPA

- Displacements per atom is a measure of how often each atom was displaced after an particle impact:
  - DPA=2 means each atom was displaced two times.
- FLUKA has a DPA scoring implemented
  - For details see Vasilis' Talk:

    http://info-fluka-discussion.web.cern.ch/info-fluka-discussion/lectures/Vlachoudis_DPA_271108.pdf
- DPA for all diamond based BRM detectors available.
- With the assumption that the detector efficiency scales linear with DPA one can predict the lifetime of the detectors.
- Test beam data of 24GeV protons is used to normalise the DPA with the detector efficiency.
- At the moment relatively low statistics/high errors as DPA comes from full CMS simulations. With the dump files a special offline simulation for DPA can be set up to gain much better statistics.

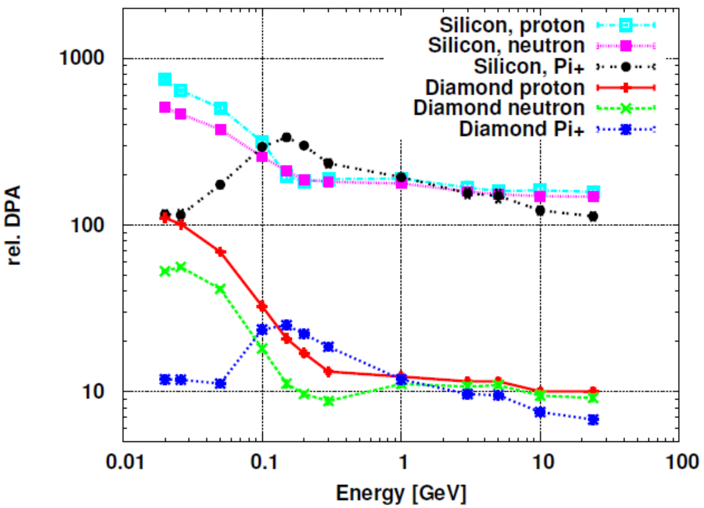
Radiation damage cont.





Simulated DPA along beam axis for two different proton energies. Low energetic particles lose a large fraction of energy resulting in a 'Bragg-peak' with high number of lattice displacements (left).

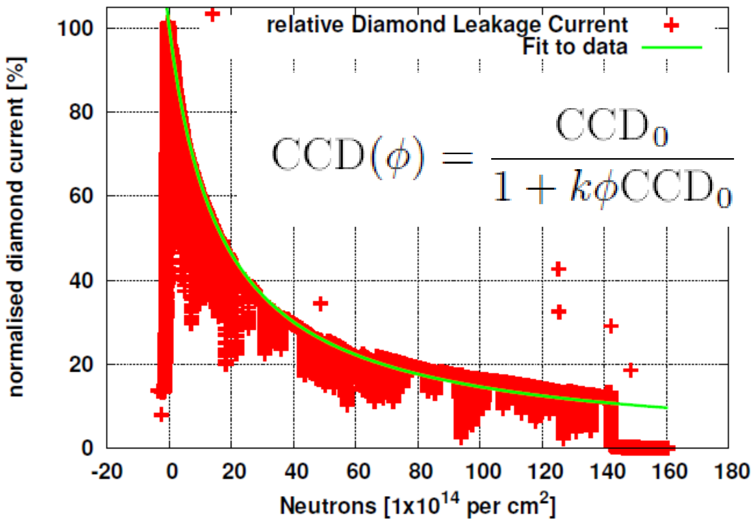
High energetic particles show a constant behaviour over a large path length (right).



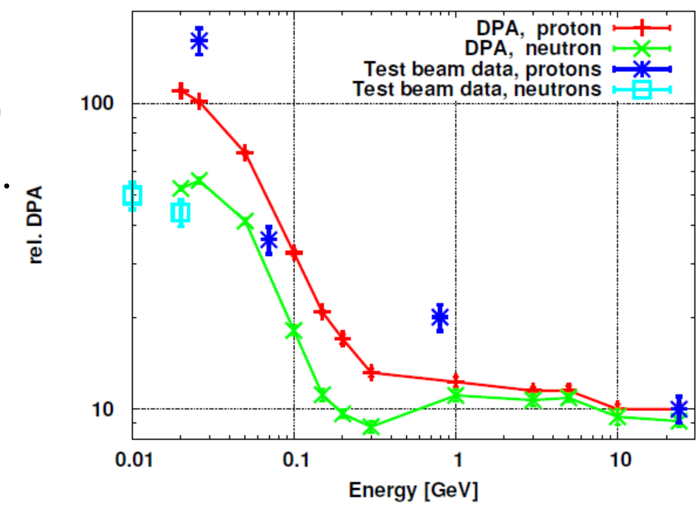
DPA simulation result for Silicon and Diamond. Shown are the simulations for Protons, Neutrons and Pions at energies between 20MeV and 24GeV.

Diamond is generally more radiation hard than silicon. At high impact energies Silicon shows a factor of 10 higher DPA. At low energies however, this factor decreases to about 5-6 for protons.

Radiation damage, comparison with data



This is input for the longevity of BCM1F detector and upgrade.



Neutron test beam, shown is the signal behaviour for fluences up to 140e14 neutrons. The decrease due to radiation damage is directly visible in the signal current measurement. The RD42 parameterisation is used for the fit.

Comparison with test beam results. Good qualitative description of the detector efficiency with the DPA/NIEL scaling.

Discussion point: Can we measure degradation of diamond during 2010/2011?

	BCM2I	BCM2O	BCM1F	BCM1L
DPA per pp	1.46×10^{-23}	5.92×10^{-23}	2.31×10^{-24}	4.95×10^{-24}
Error	1.14×10^{-24}	2.32×10^{-24}	5.22×10^{-25}	7.5×10^{-25}
Error %	7.82	3.92	22.62	15.16
Hardness factor	0.00835	0.03384	0.00132	0.00283
Seconds at nominal luminosity to reach 50% efficiency	1.06×10^{9}	2.61×10^{8}	6.68×10^{9}	3.12×10^{9}
in CMS years (1×10^{7} s/a)	105.7	26.1	668.5	312.2

Outlook and possible options for the future

- Pb-Pb-collisions
  - Same scoring as for pp (Flux, spectra, time of flight)
  - What can we get out of the HI run for BCM1F?
- New background simulations event by event
  - More important for pixels, but potentially also for BCM1F/PLT
  - This will not happen this year, but is ongoing work (R. Bruce)
- Detailed detector response simulation
  - Signal shape
  - Double hit behaviour
- Radiation damage
  - Gain statistics by a dedicated smaller setup using the CMS dump files for the various BRM systems.
  - Include detailed detector geometry (surrounding material).

Conclusions – possible input to paper

- Expectations from pp and background for BCM1F.
- Predictions for absolute rates available.
- Off time/albedo effect.
- Possibly prediction for HI running (needs modified source routine).
- Input for radiation damage measurement if possible.

- Manpower:
    - I will be available till end of this year, with limited time.
    - Moritz is probably available soon, but is just starting.
    - There are other efforts ongoing in terms of simulation, but independent of the paper.

Thesis draft available at: http://test-stemu.web.cern.ch/test-stemu/SM2010.pdf