Feedback BPM background environment and BDS design

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FONT collaboration

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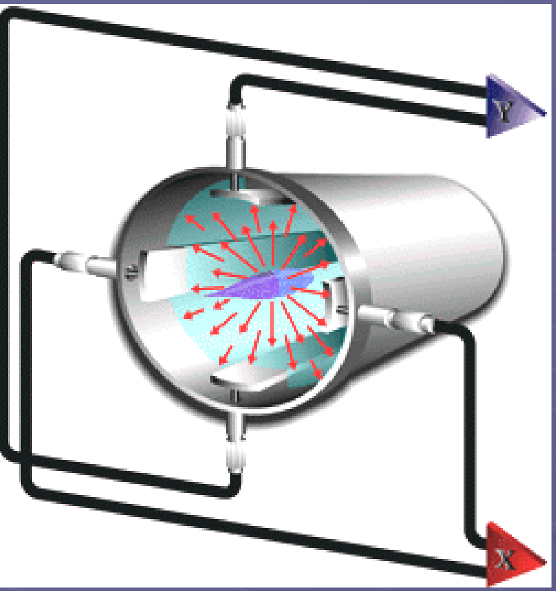
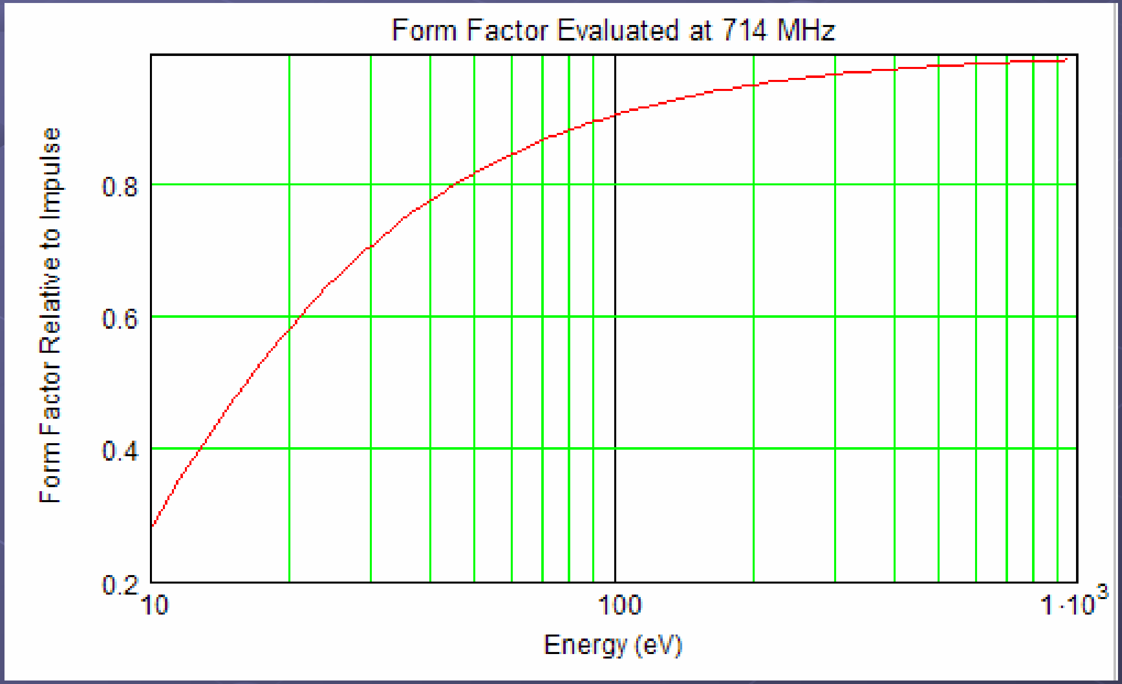
Outline

- Low Energy e-m background hits on the feedback BPM
  - Why do we care about low energy background hits?
  - Modify GEANT to decrease the low energy cutoffs
  - Characteristics of the hits on the BPM
- BPM background hit variation with BDS design
  - 20mrad and 2 mrad design
  - different sets of accelerator parameters
  - Solenoid Field
  - BPM, QFEX1 z position, L*
  - Mask hole radius and beampipe radius



BPM noise from backgrounds

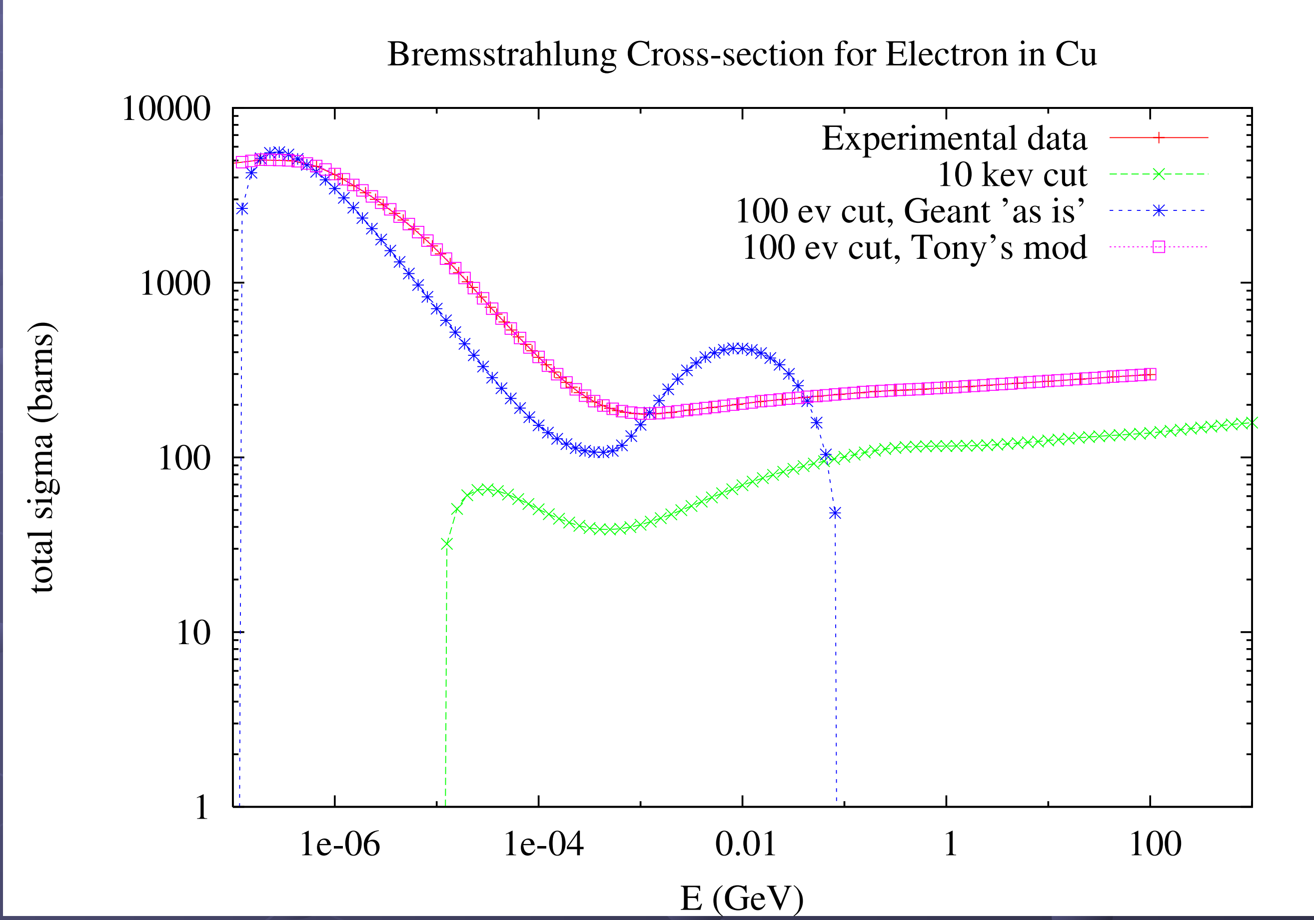
- Copper strips with 1 mm gap to wall
- Noise from secondary charges crossing strip-wall gap
- ~1pm error for each charge absorbed or emitted. 1e6 hits per b.c. would be a problem!



- Noise form factor sinc(π.f.T)
- Secondary emission down to 100 eV needs to be considered
- Geant3 minimum transport is 10 keV!

Geant3/4 mod for Low Energy Transport

- Geant3 X-section parametrization wrong below 10kev cut
- Recode Geant3 to parametrize real data from NEA site



AEN NEA Agence pour l'énergie nucléaire Nuclear Energy Agency

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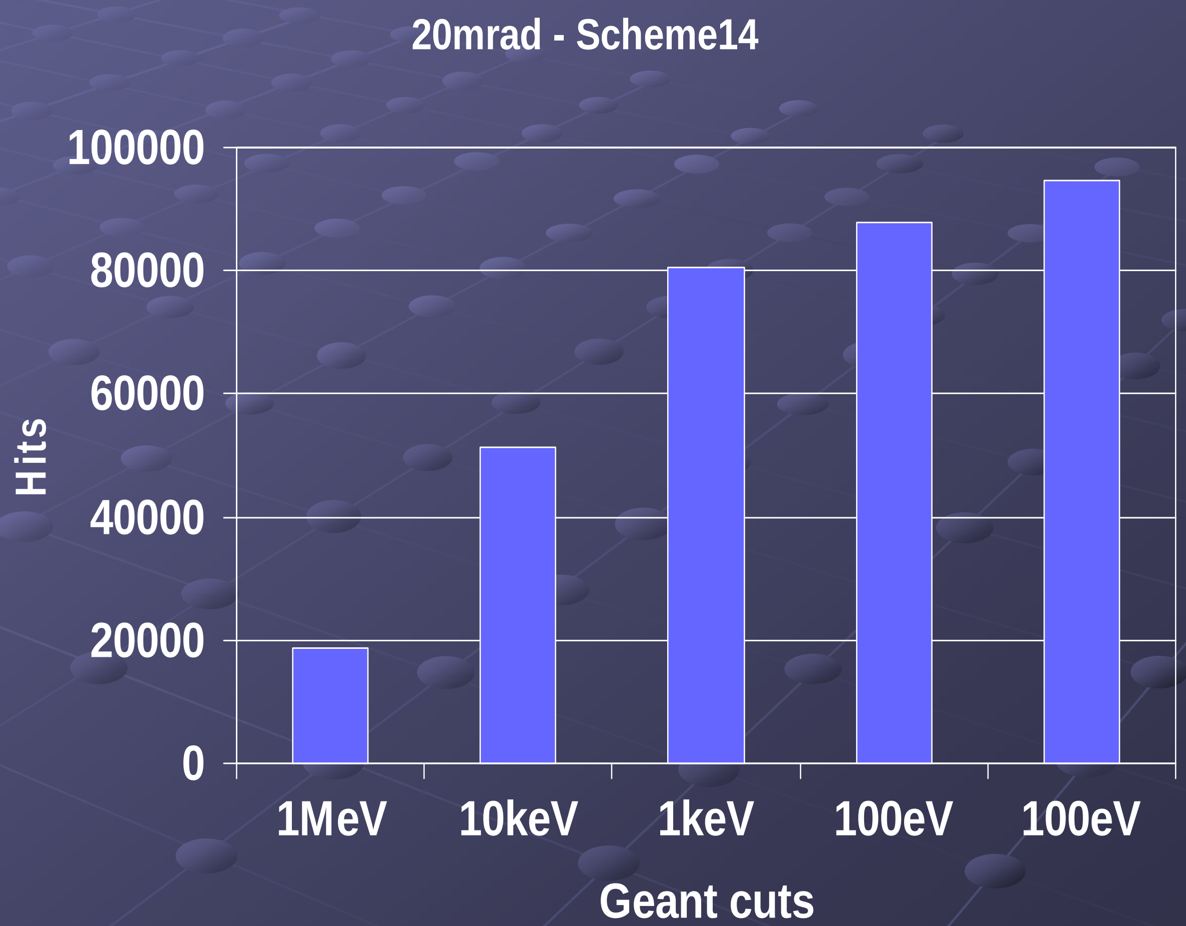
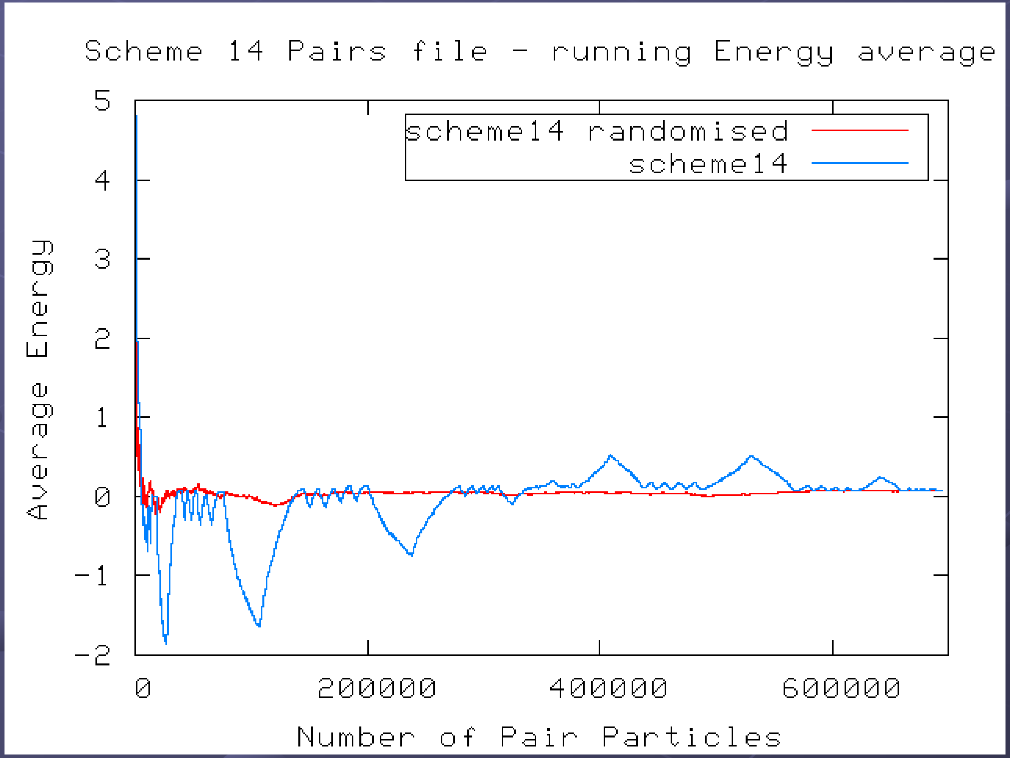
Geant3 total BPM hits and emitted charges

- LowE mods reveal significant increase in BPM hits at 100eV cut.
- Generally Factor of 5 increase in BPM compared to default Geant cut of 1 MeV, and factor of 2 increase against Geant default minimum cut
- Can define Geant areas (ROIs) around BPMS which are tuned for Low Energy particles
- Worst case scenario (scheme14 in the 20mrad case) ~ 10^5 hits per strip per bc



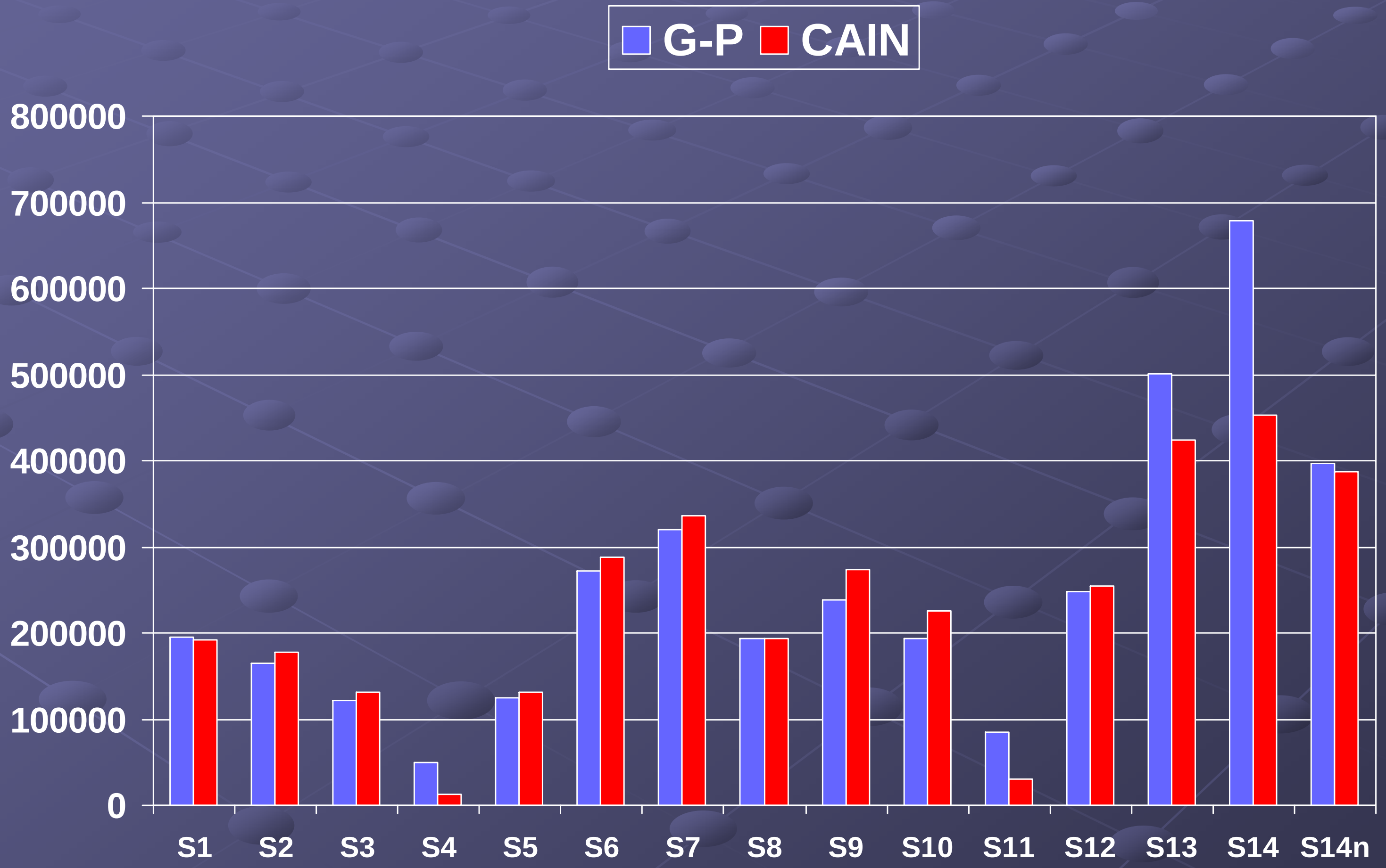
Randomising Guinea-Pig output

- Geant runs with lowE cuts and high sensitivity are computing intensive
- Can shorten the runs by randomising the guinea-pig pair files
- A good result for hits per bc can be obtained after processing ~10% of the randomised pair file



Benchmarking with different Parameter Sets

- Run the schemes through G-P and Cain and produce pair files
- Data will appear on the QMUL FONT page



Scheme 1	500 GeV TESLA
Scheme2	USSC
Scheme3	Nominal
Scheme4	Low Q
Scheme5	Large Y
Scheme6	Low P
Scheme7	High Lumi
Scheme 8	1 TeV TESLA
Scheme9	USSC
Scheme10	Nominal
Scheme11	Low Q
Scheme12	Large Y
Scheme13	Low P
Scheme14	High Lumi

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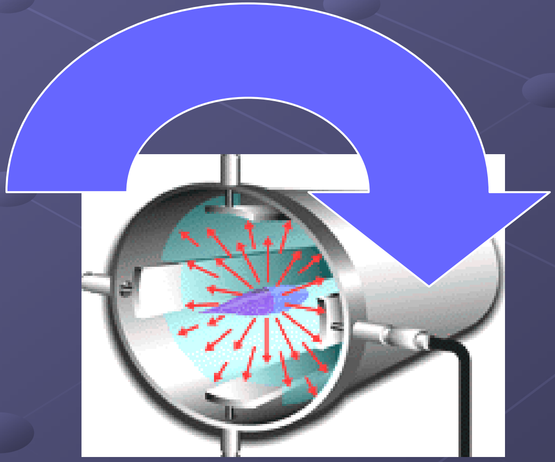
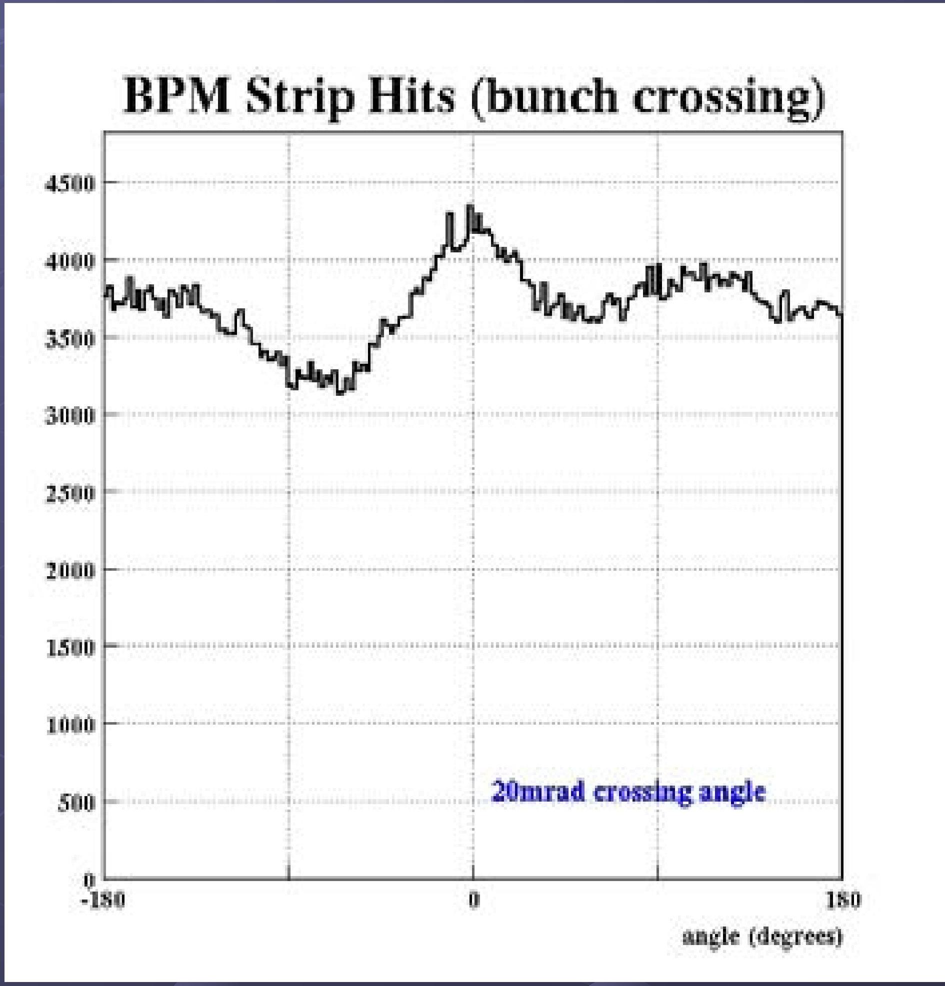
Azimuthal dependence on BPM hits in 20mrad scheme

- ~25% variation in BPM hits as we rotate BPM position azimuthally
- Probably a factor of the crossing angle and solenoid field orientation





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Bunch to bunch variation in BPM hits

- Bunch to bunch variation in BM hits can add an extra complication
- For example, process 40 scheme 8 bunches through the 20mrad design
- std dev of hits is 23%
- average up/down hits asymmetry is 18±5%, left/right 13±2%

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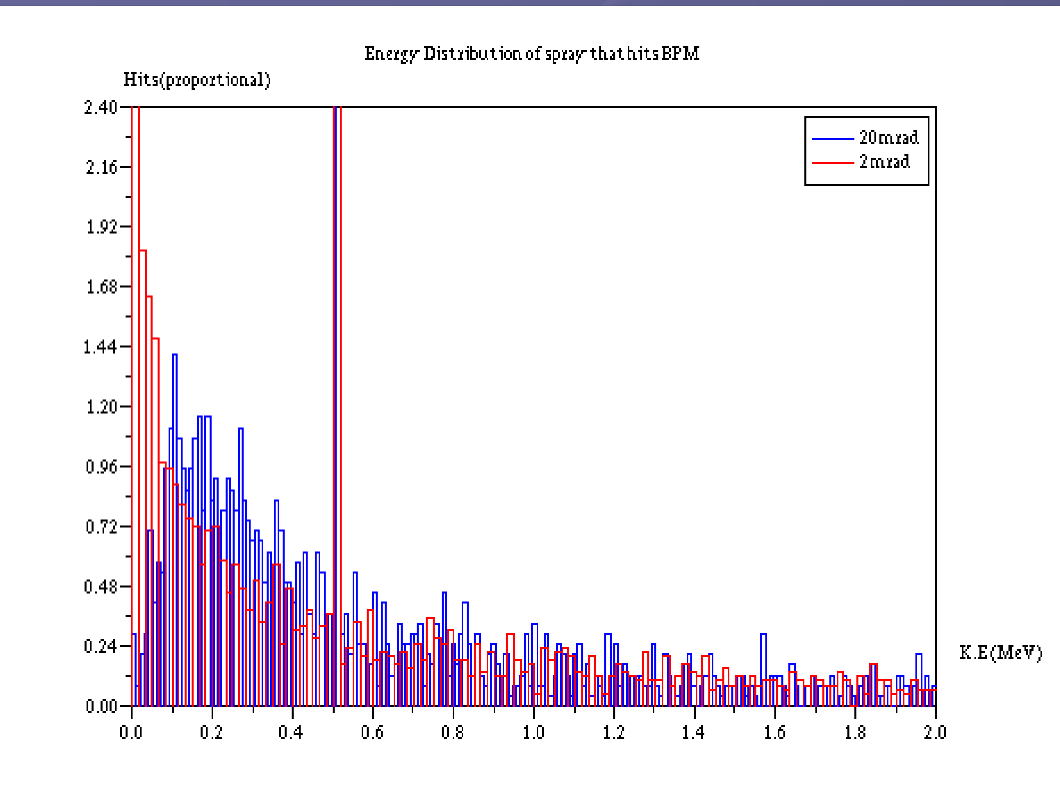
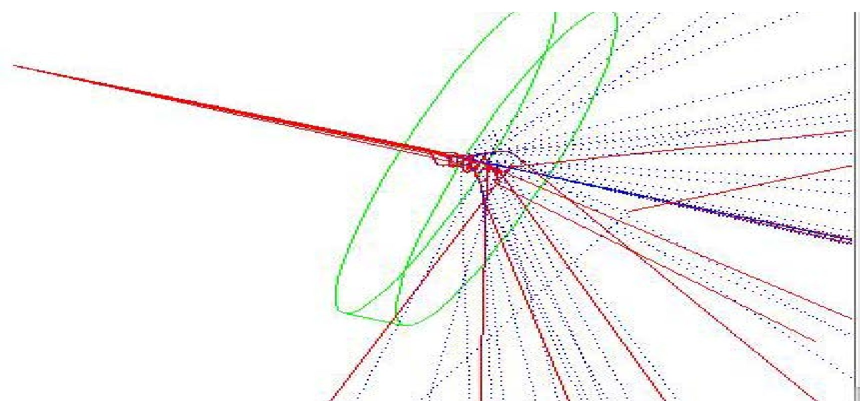
So how many charges are ejected from the BPM?





- Feed position and momentum of BPM hits into geant model of BPM strip.
- Take into account incident angle, energy and particle type
- For every 3 gammas that hit the BPM, 2 charges are ejected.
- For every 1 e-e+, 3 charges are ejected.
- So…for S14, *73,000* gammas and *10,440* e-e+ = *80443* ejected e-e+ per strip per bunch crossing (1keV cut)

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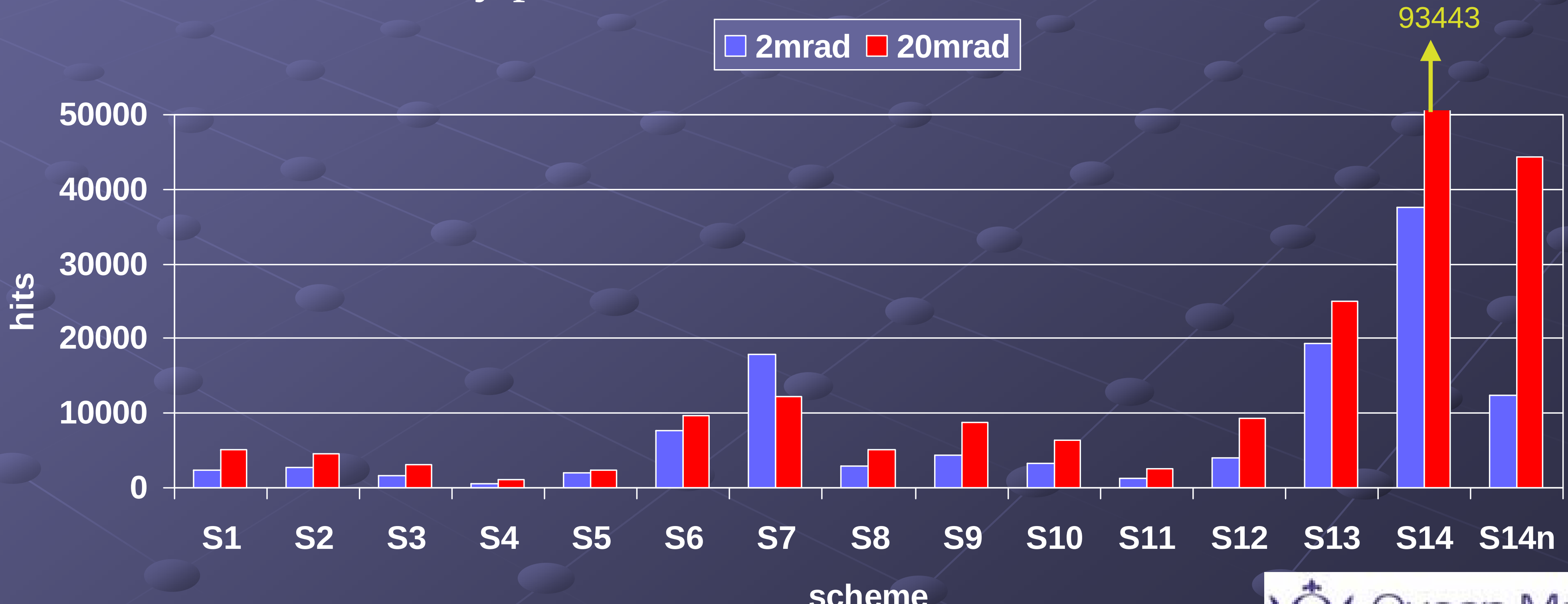
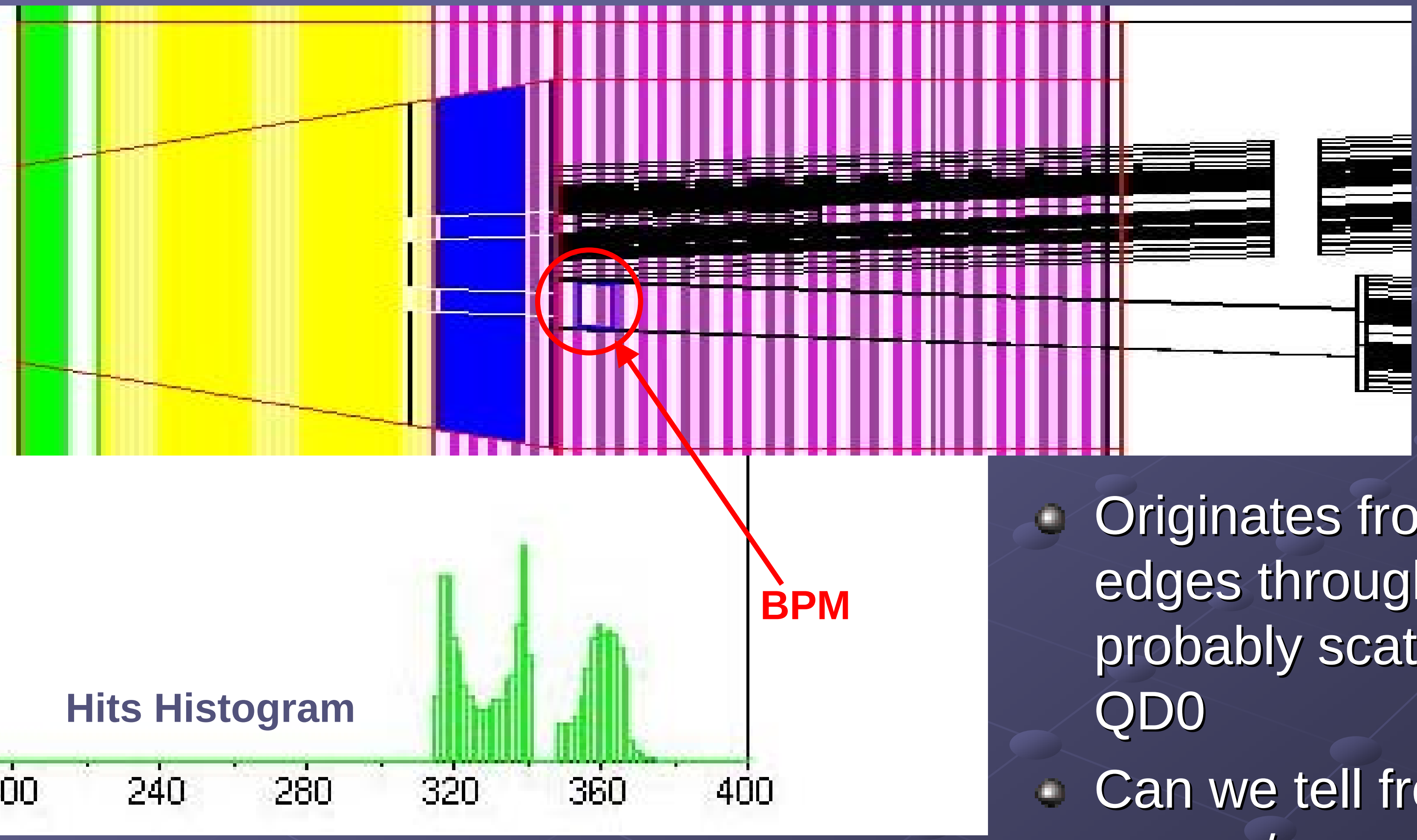
PART2: BPM hits per strip per bunch crossing - different schemes, different crossing angles

- In most cases there are less hits for the 2mrad scheme
- Low Q options (S4 and S11) are definitely the best for least hits on feedback BPM
- S14 new is clearly preferred to S14



20mrad

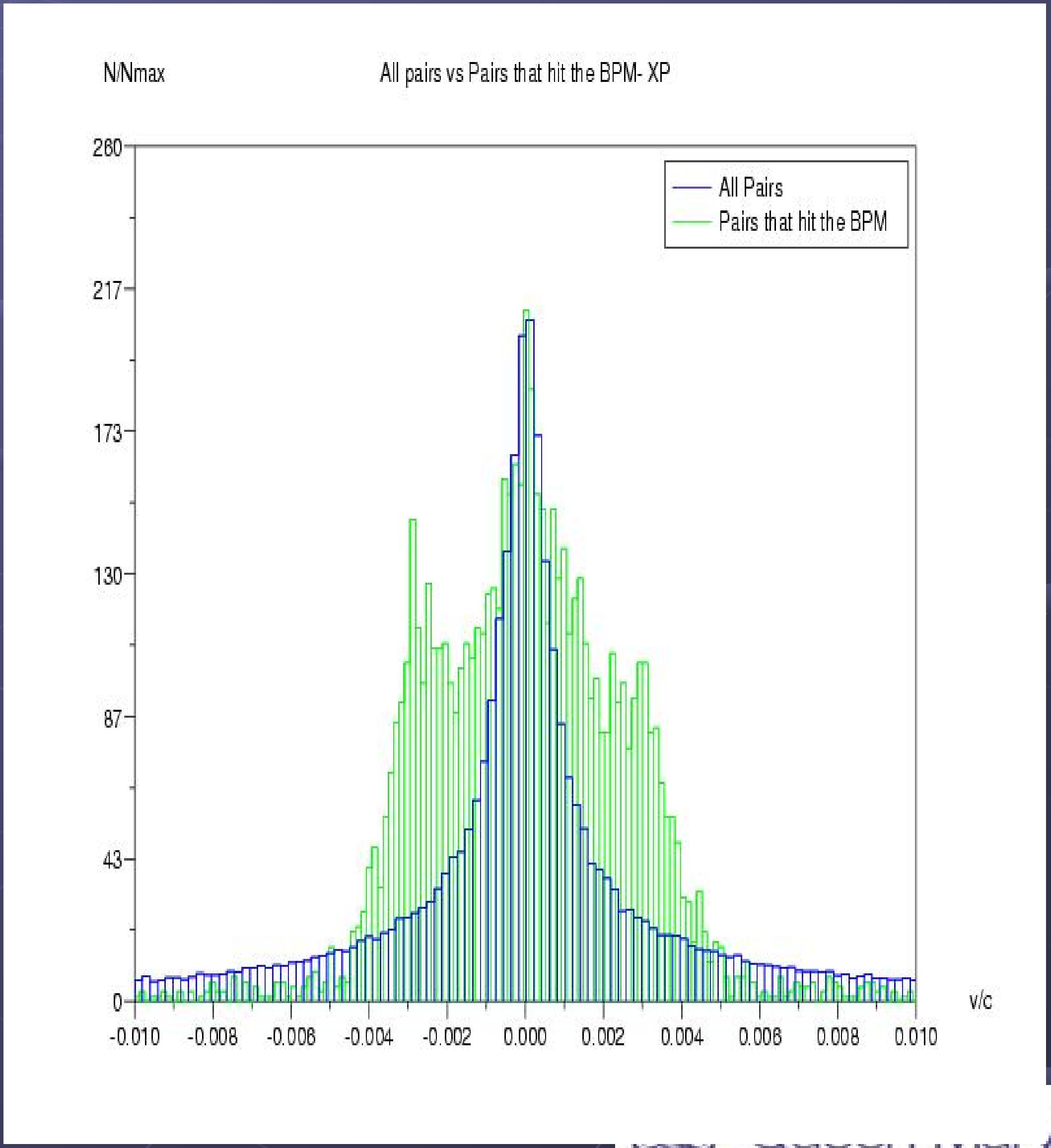
Where does the spray come from?



- Originates from hole edges through mask and probably scatter from QD0
- Can we tell from energy/momentum distribution of IP pairs, the extent of BPM spray?

Which Pairs produce BPM spray? (1) Momentum Distribution

- Compare momentum distribution at IP of all pairs to the subset of pairs that produce BPM spray
- Pairs with greater transverse momentum are favoured



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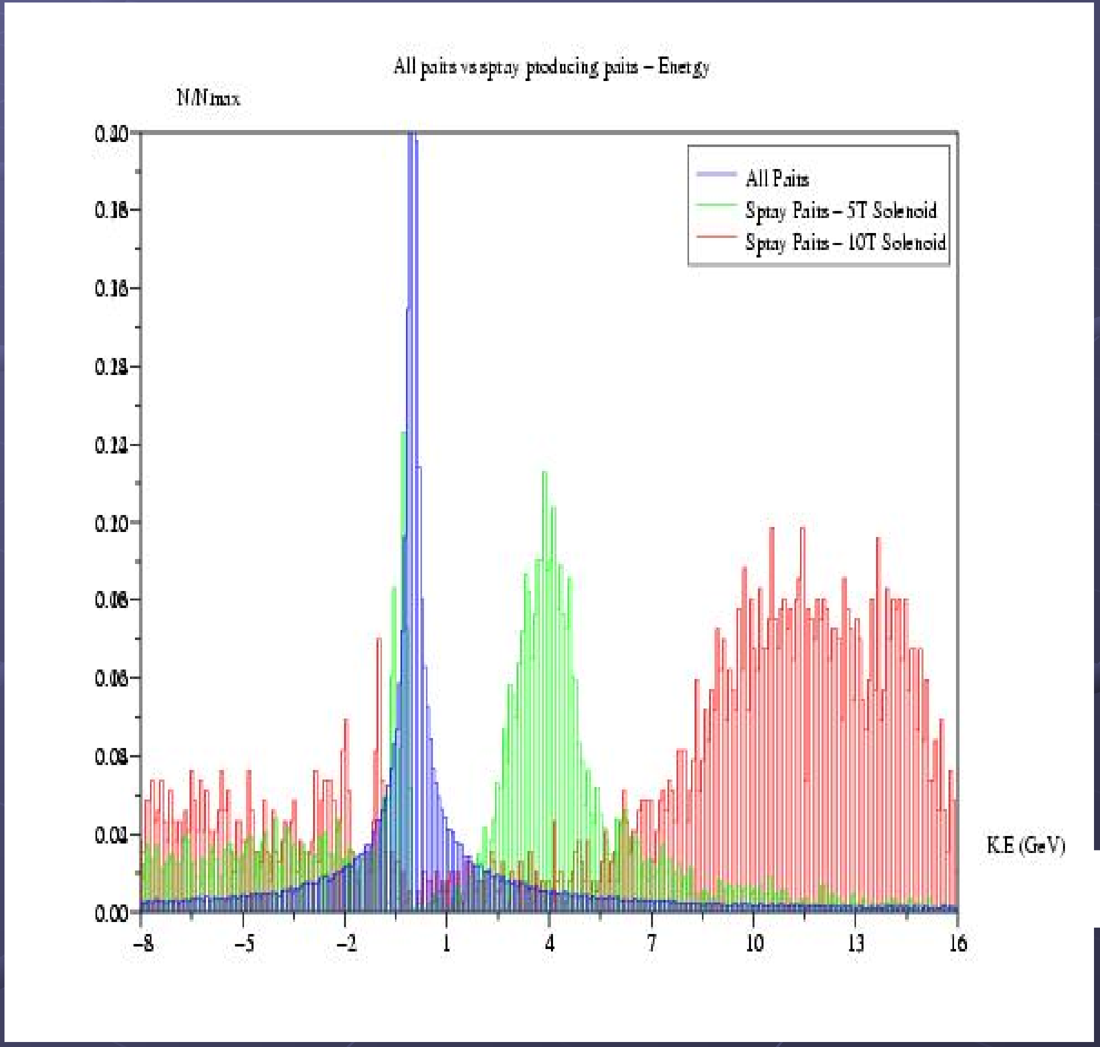
Which Pairs produce BPM spray? (2) Energy Distribution

- Compare energy distribution at IP of all pairs with pairs that produce BPM spray
- For 5T SolB, 4 MeV e-'s at IP favoured to produce spray that will hit BPM
- For 10T, 11 MeV e-'s at IP are favoured



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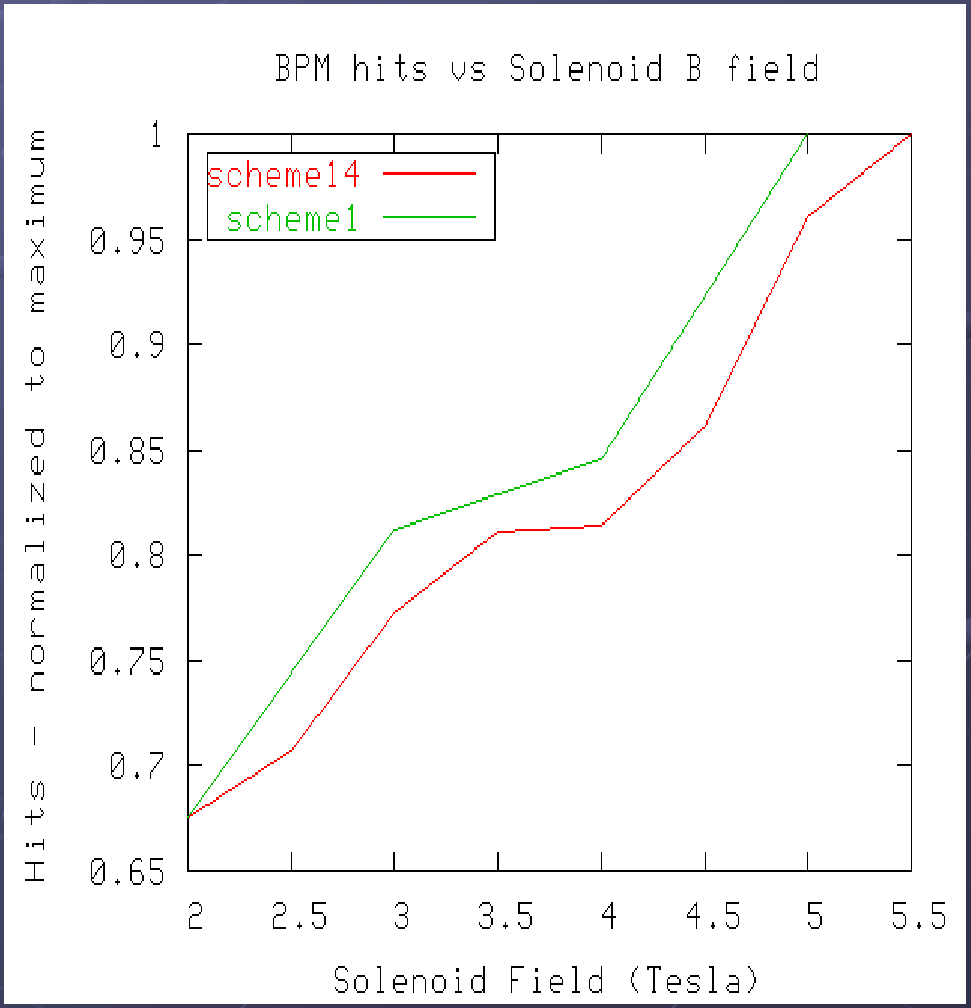
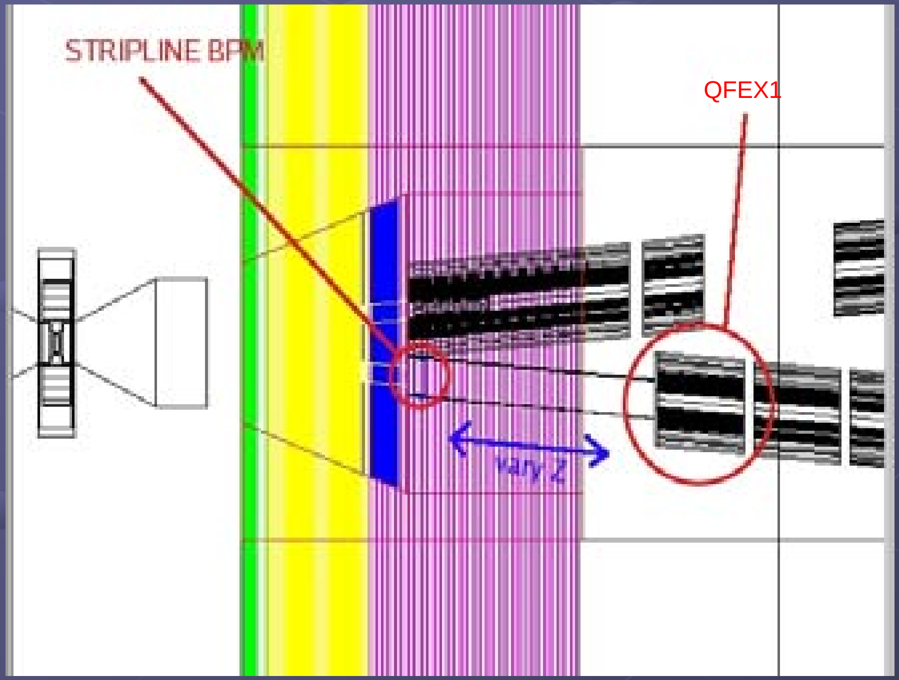
Solenoid field (S_B) effect on BPM hits

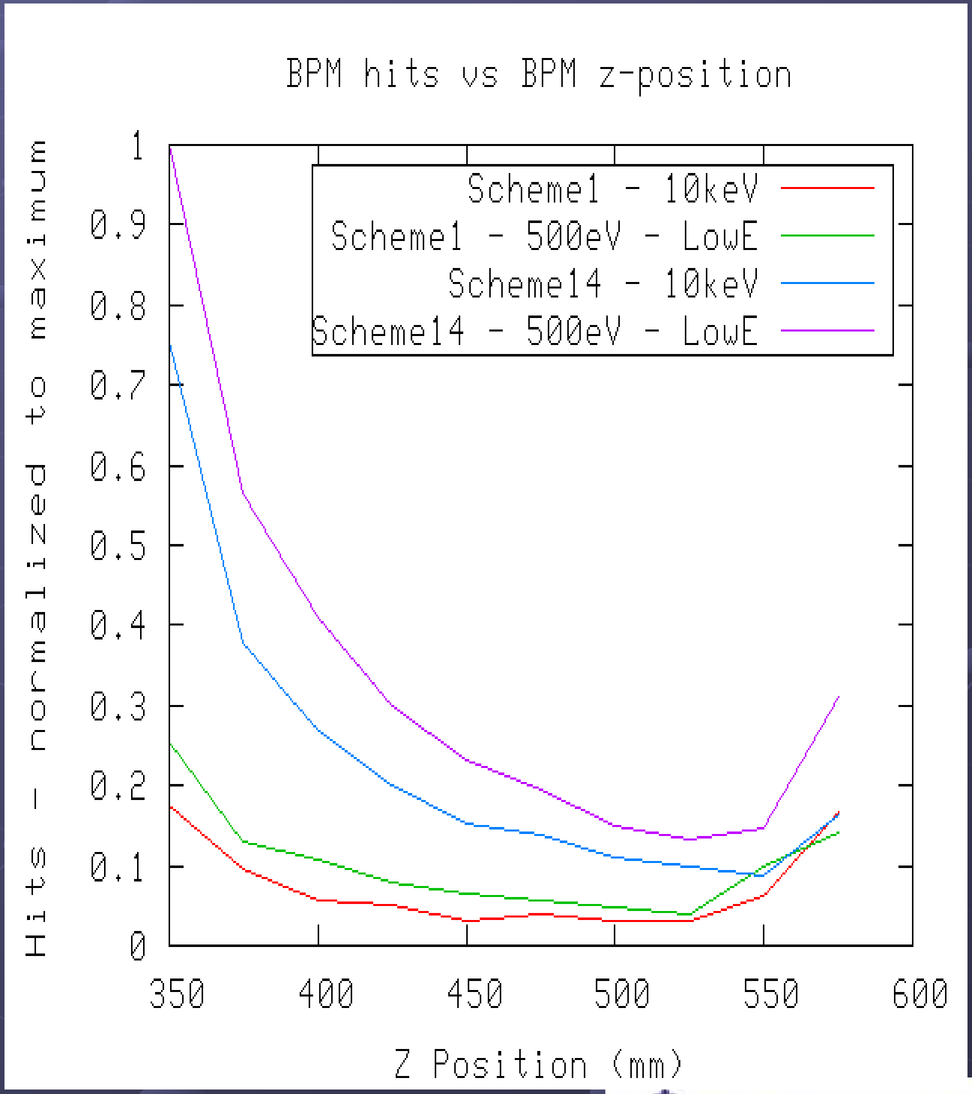
- Increase in S_B leads to increase in BPM hits
- Though there are less higher energy pairs to produce BPM spray, more lower transverse momentum pairs are available



Effect of shifting BPM z position

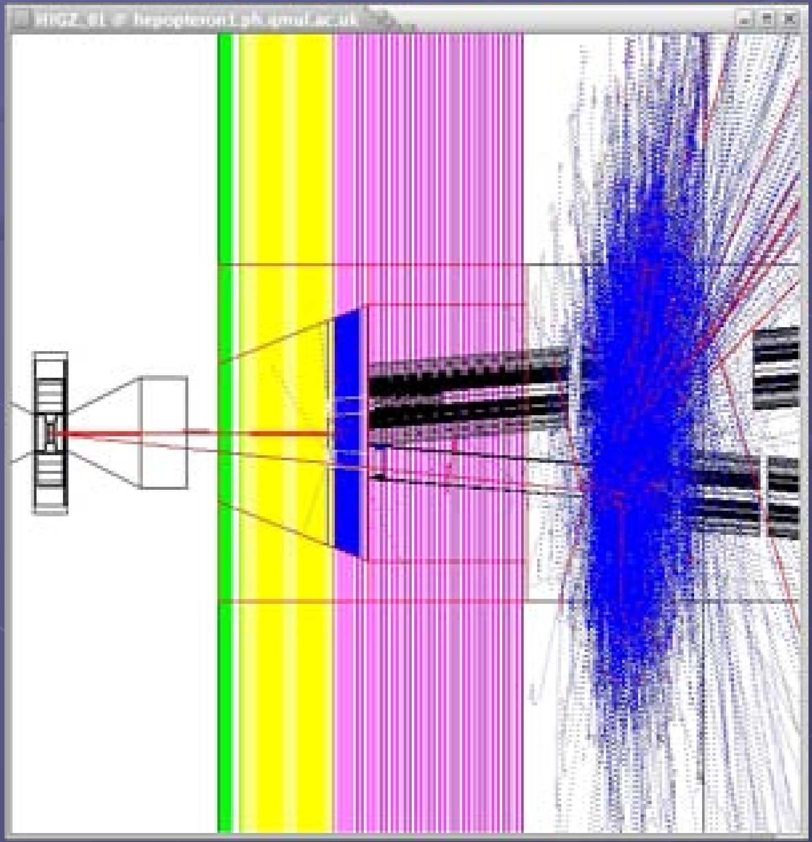
- Spray increases close to mask and close to QFEX1
- Worst position is next to the mask

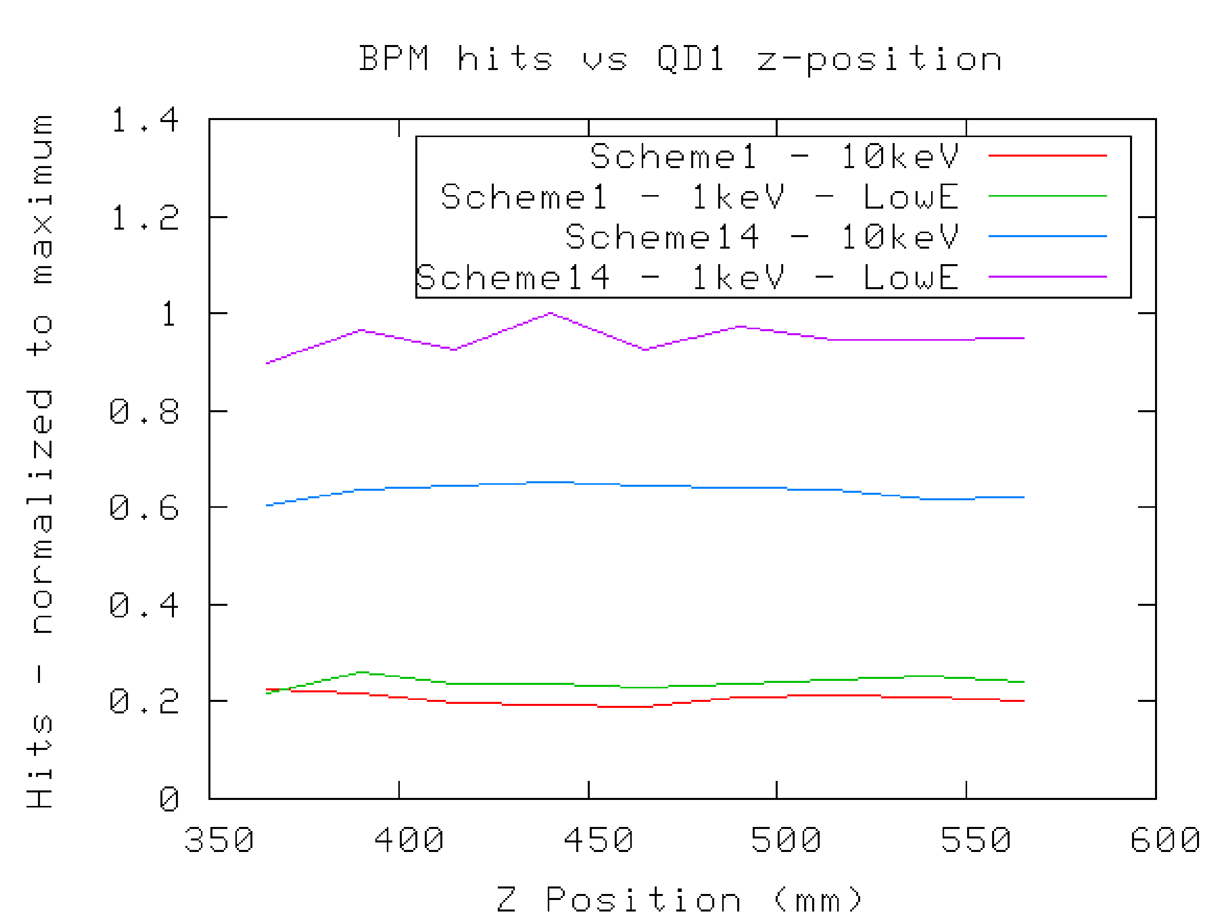




Effect of shifting QFEX1 z position

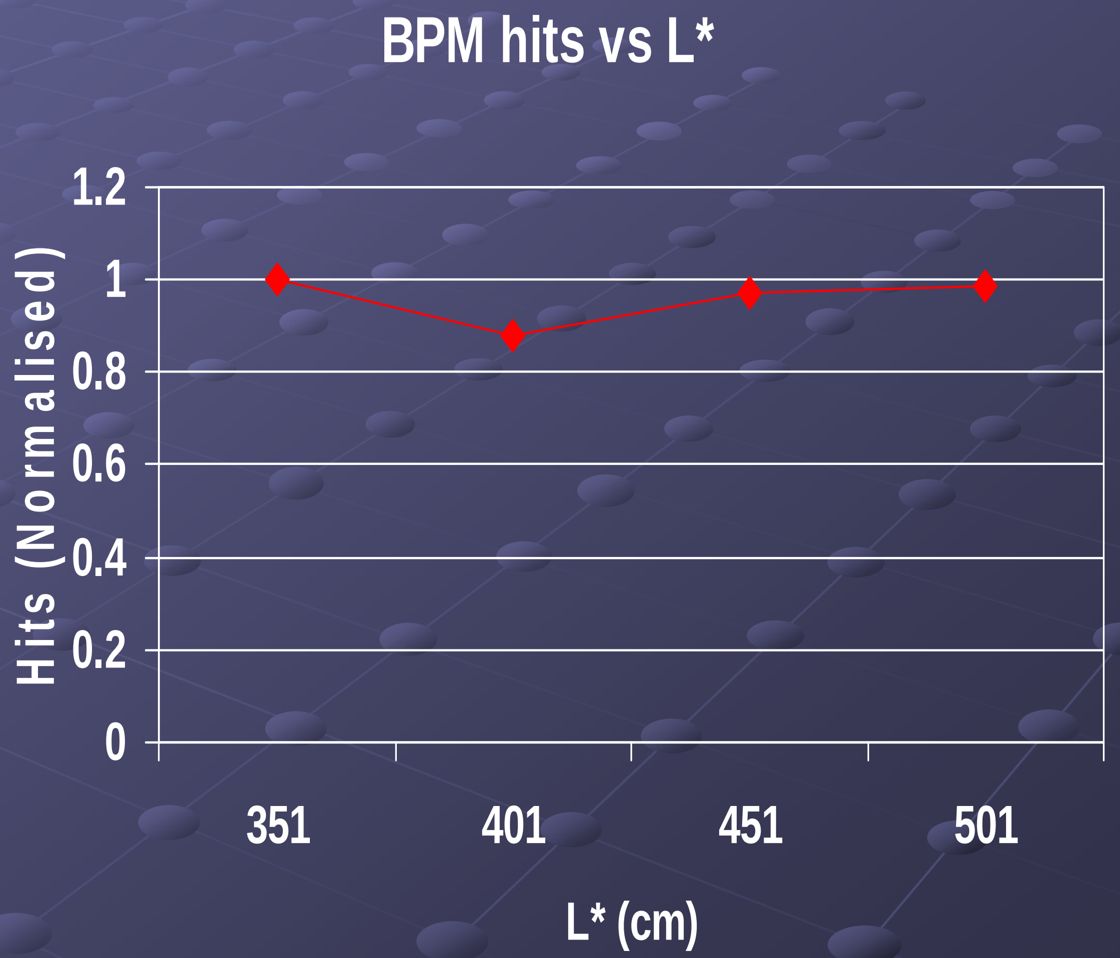
- Not much variation in BPM hits with QFEX1 position
- Most spray from QFEX1 is transverse





How about increasing L* ?

- Little Variation with L*
- Not enough points, but if trend continued for other parameter schemes, then L*=401 slightly favoured



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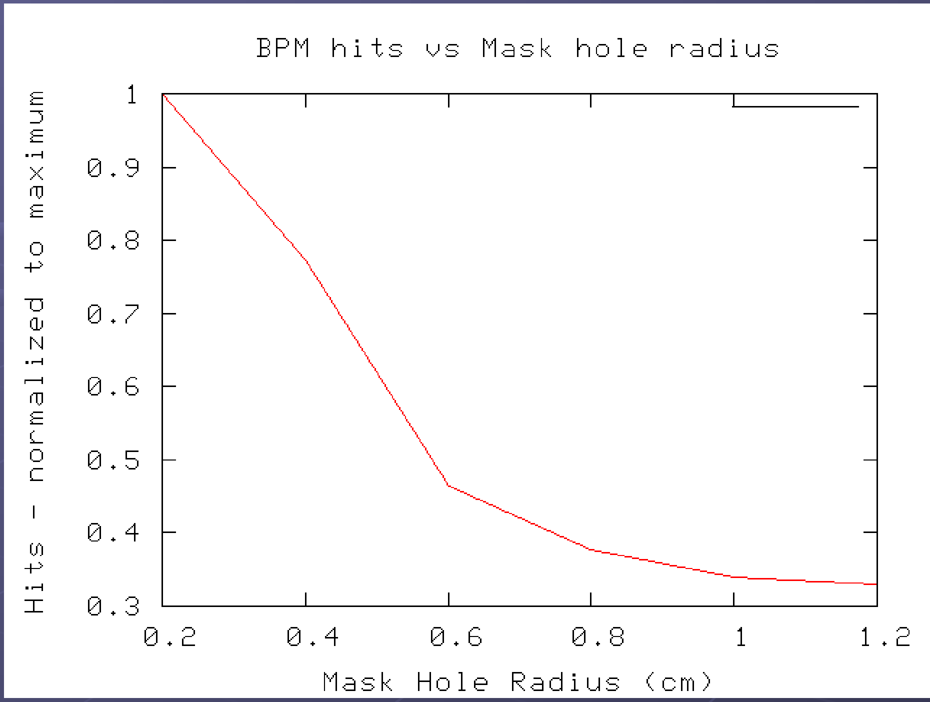
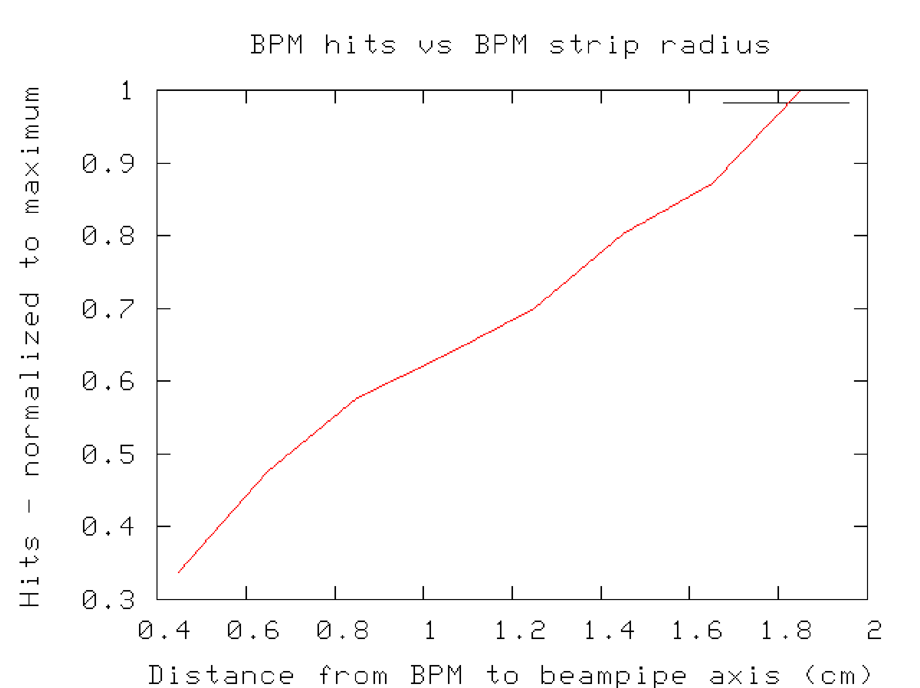
What about decreasing the beampipe or mask hole radii?

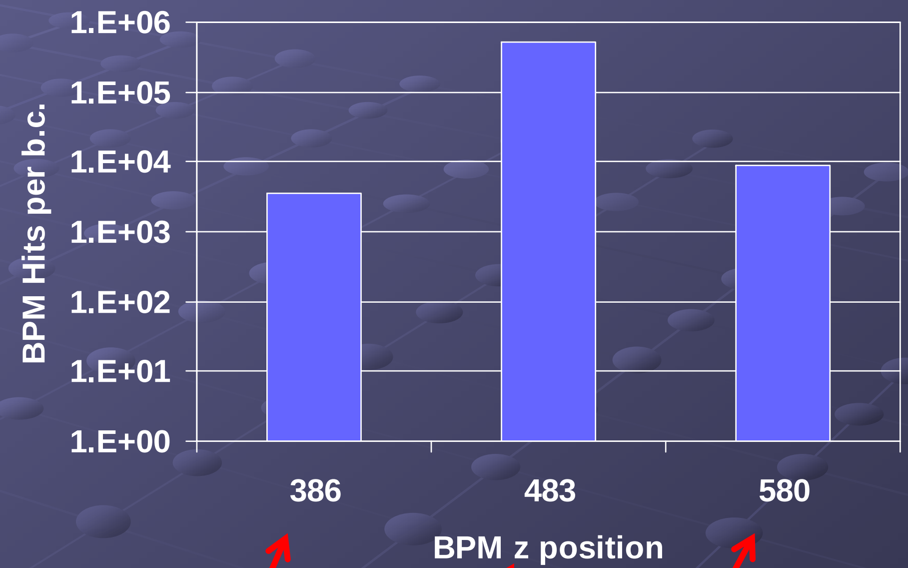
- Less BPM hits at nominal value of 1cm for mask hole radius
- Curiously, BPM hits diminish as the BPMs bought closer to the axis – within limits!

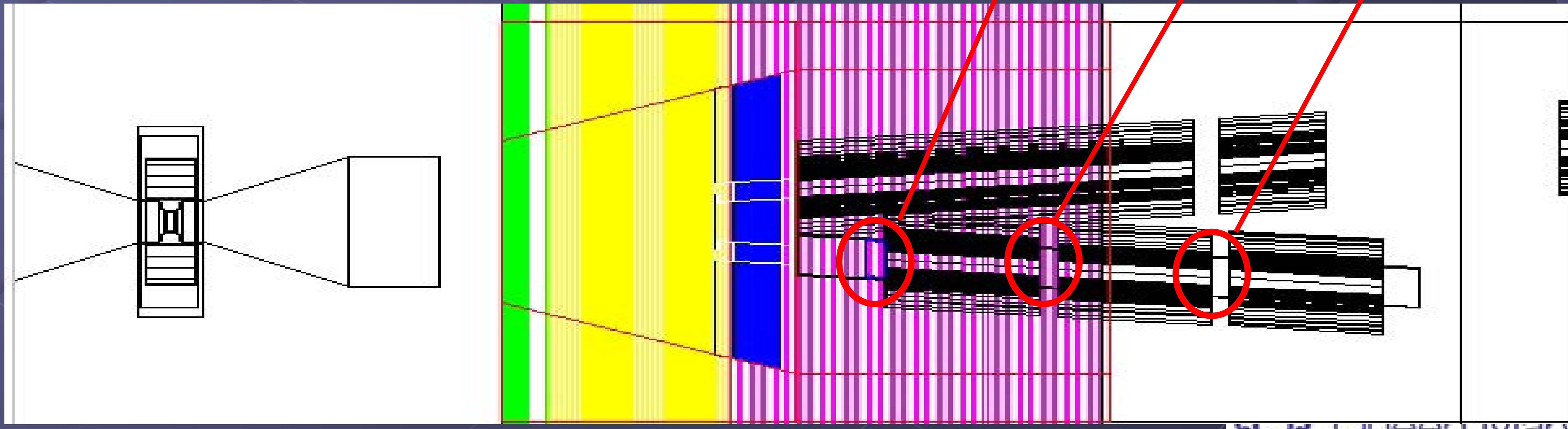




What if we move the BPM further down the extraction line?

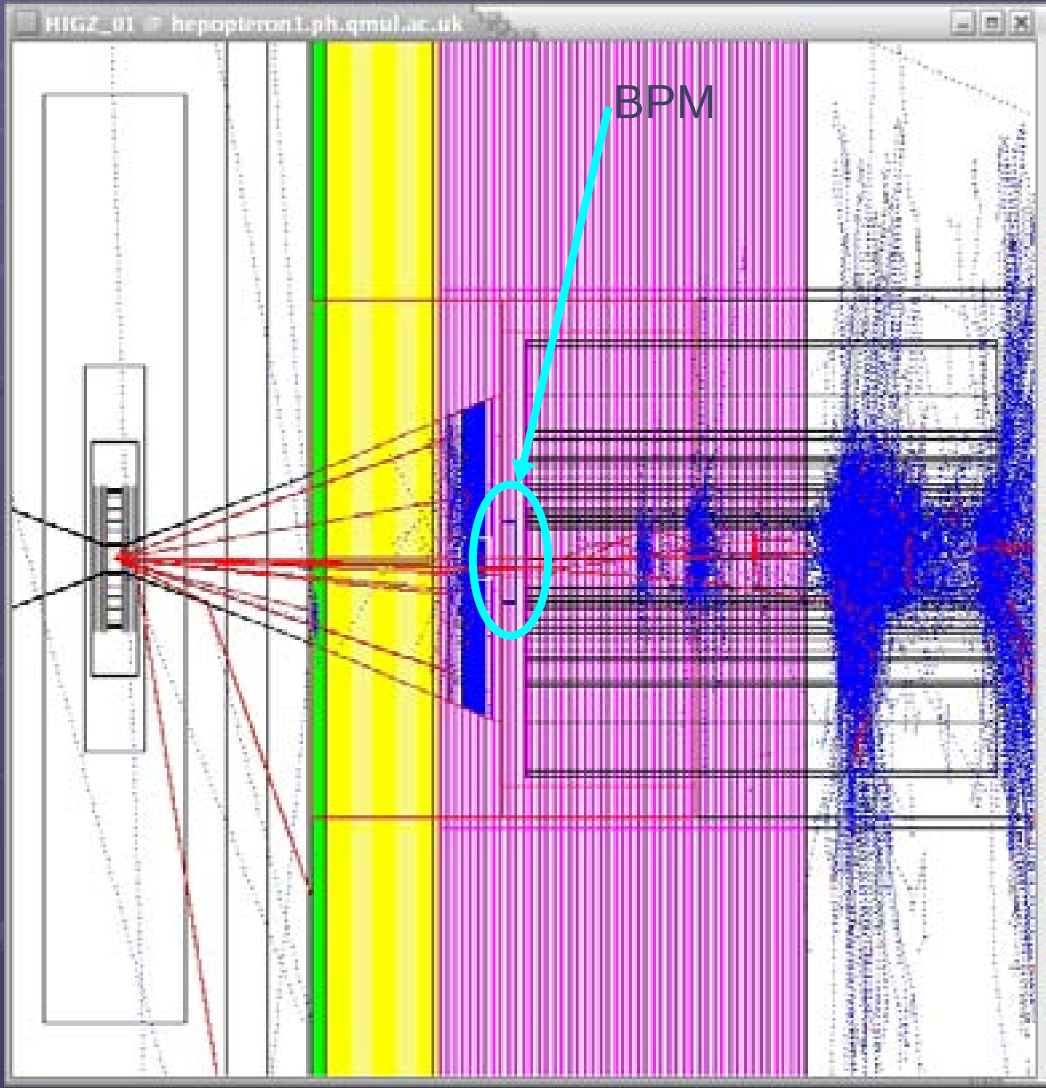
- Note the logarithmic scale. BPM would be unworkable between first and second extraction quads
- BPM is best located between mask and first extraction quad
- Not modelled further down the extraction quad yet





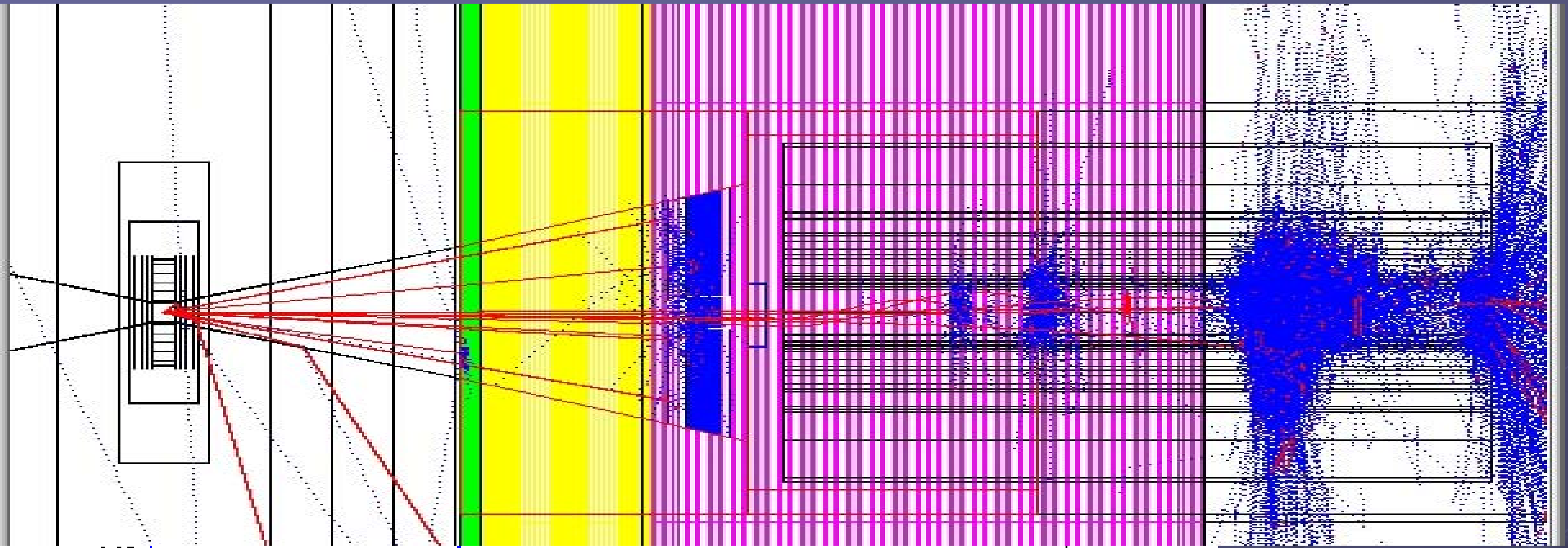
The 2mrad design

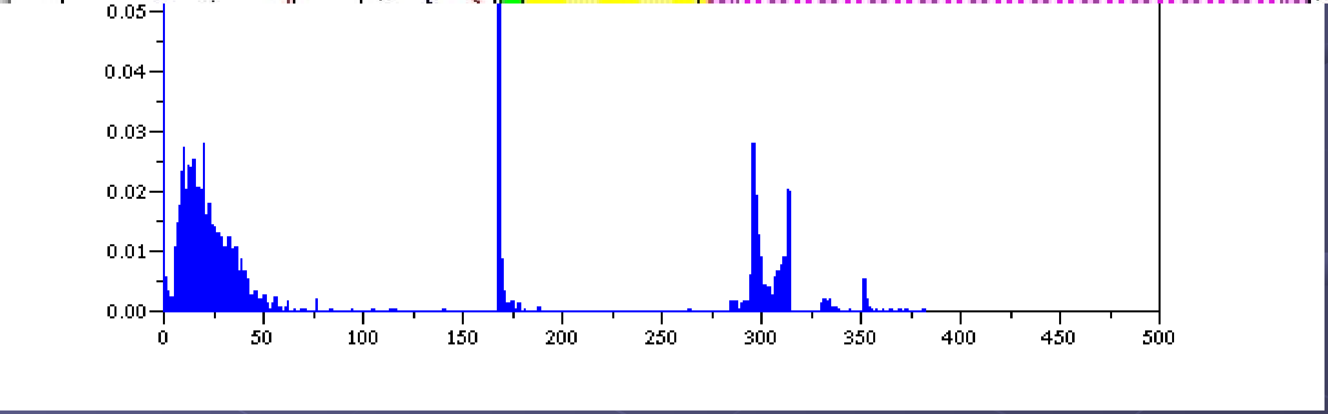
- Mask hole has nominal radius 2cm vs 1cm for 20mrad
- Beampipe radius nominally 4cm vs 2cm for 20mrad
- QD0 specially designed to allow passage of spent beam. Not sure if L* variation is legal
- Vary Solenoid field, mask hole radius, parameter scheme



2mrad

Where does the spray come from?

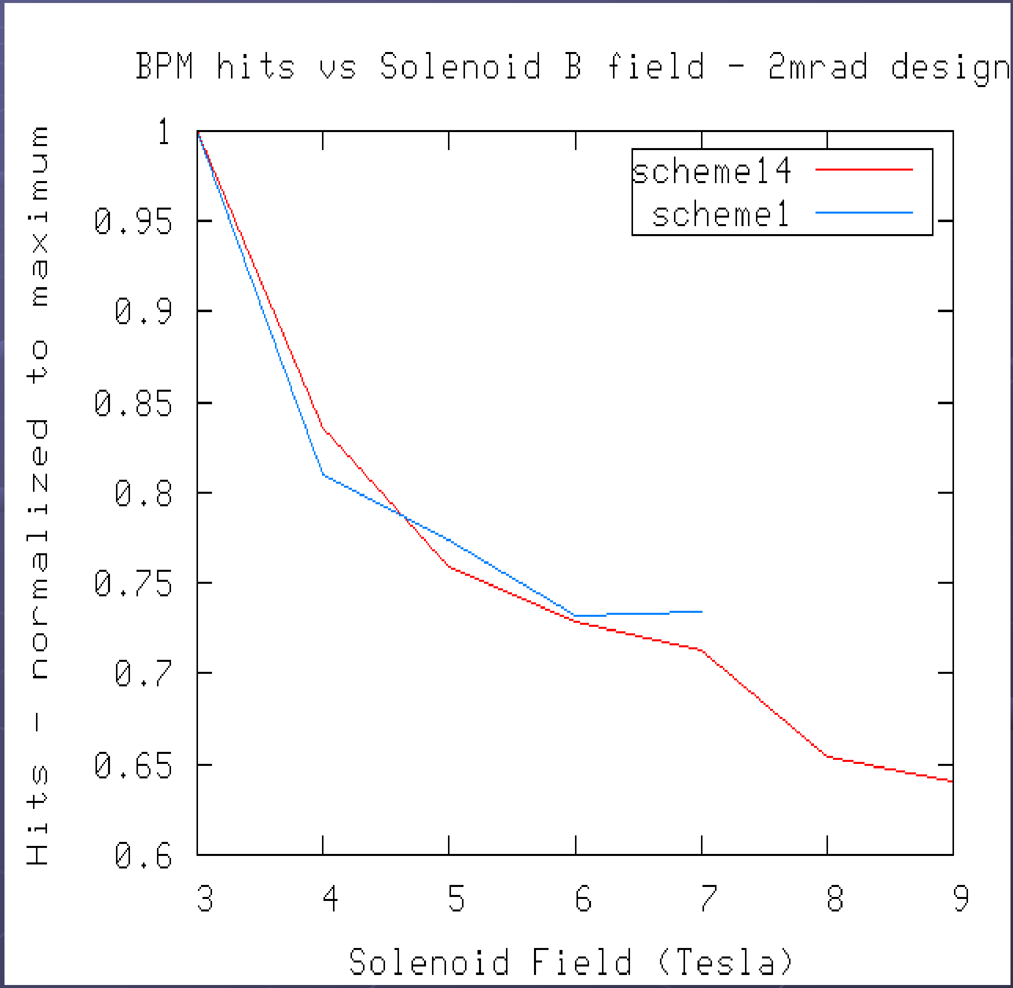




- From mask hole as well as additional sources from detector elements
- Different sources compared to those for 20mrad

Solenoid field (S_B) effect on BPM hits

- Increase in S_B leads to decrease in BPM hits
- Opposite effect to the 20mrad design
- The mask hole has greater radius, so increasing S_B means more spray goes down the beampipe

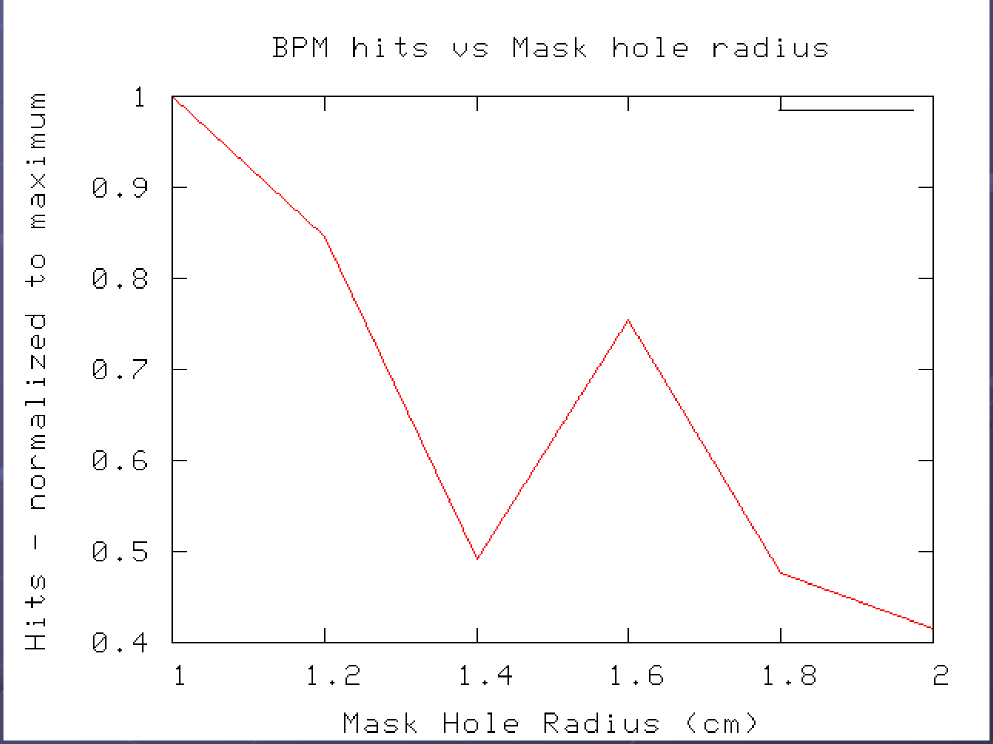


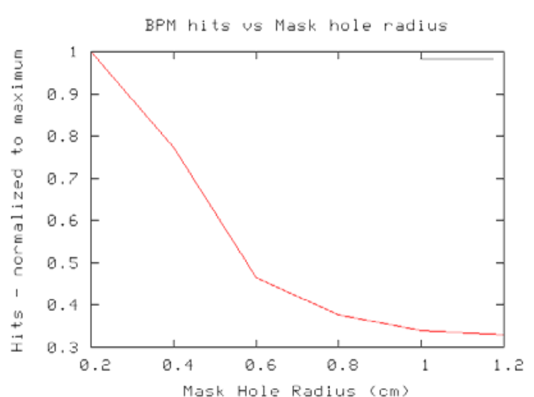
2mrad

Decreasing the mask hole radius

- Genrally… the trend is for decrease in BPM hits with increase in hole radius – same as 20mrad case

- As hole radius increases more background is let through but less secondary spray from contact with hole edge





20mrad case dependence

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2mrad

Shift BPM further away from the IP?

- BPM hits decreases as we move it further away from IP
- Not modelled further down the extraction quad yet

Summary

- BPM hits per bunch crossing 20mrad worst for:
  - Scheme14
  - Bpm z close to mask
  - High Solenoid B
  - Small mask hole radius
  - Don't put BPM between QFEX1 and QFEX2!!
- BPM hits per bunch crossing 2mrad worst for:
  - Scheme14
  - Bpm z close to mask
  - Low Solenoid B
  - Small mask hole radius
- 500GeV/1TeV Low Q schemes are clearly the best scenarios
- Generally speaking BPM hits are a factor of 10 below problem levels
- LowE modification's reveal an increase in hits by a factor of 2 and were important to take into account

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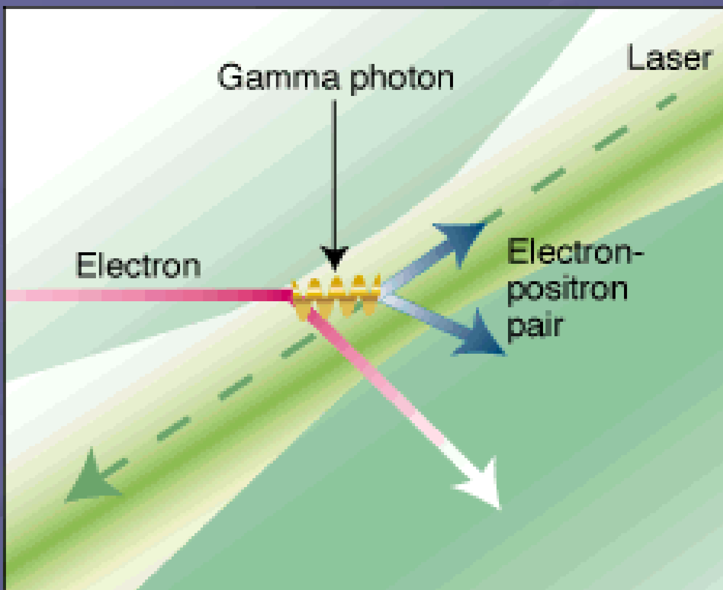
Is there another non-linear source of pairs at the IP?



- **Known**: multiphoton pair production

$$k_b + nk \to e^- + e^+$$

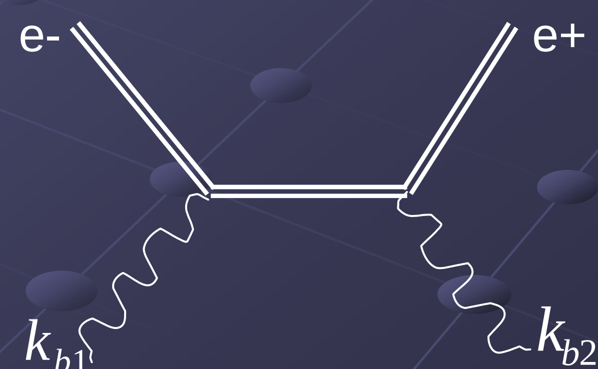
rate described by Sokolov-Ternov and onset governed by beam parameter $Y=E/E_c \sim 0.3$. Scheme1 has $Y=0.054$, Scheme14 has $Y=0.376$

- **Unknown**: multiphoton Breit-Wheeler $k_{b1} + k_{b2} + nk \to e^- + e^+$

•2nd order process rather than 1st order

•Rules for onset are different

•Calculation is complicated, but simplified when the photons are co-linear



Resonances in multiphoton B-W

- Pairs created in intense e-m field have a quasi-level structure
(Zeldovich, 1967) $$(q+nk)^2 = m^2(1+\nu^2)$$

- Resonant transitions can occur between quasi-levels

- The Electron Self Energy must be included in the Multiphoton Breit-Wheeler process

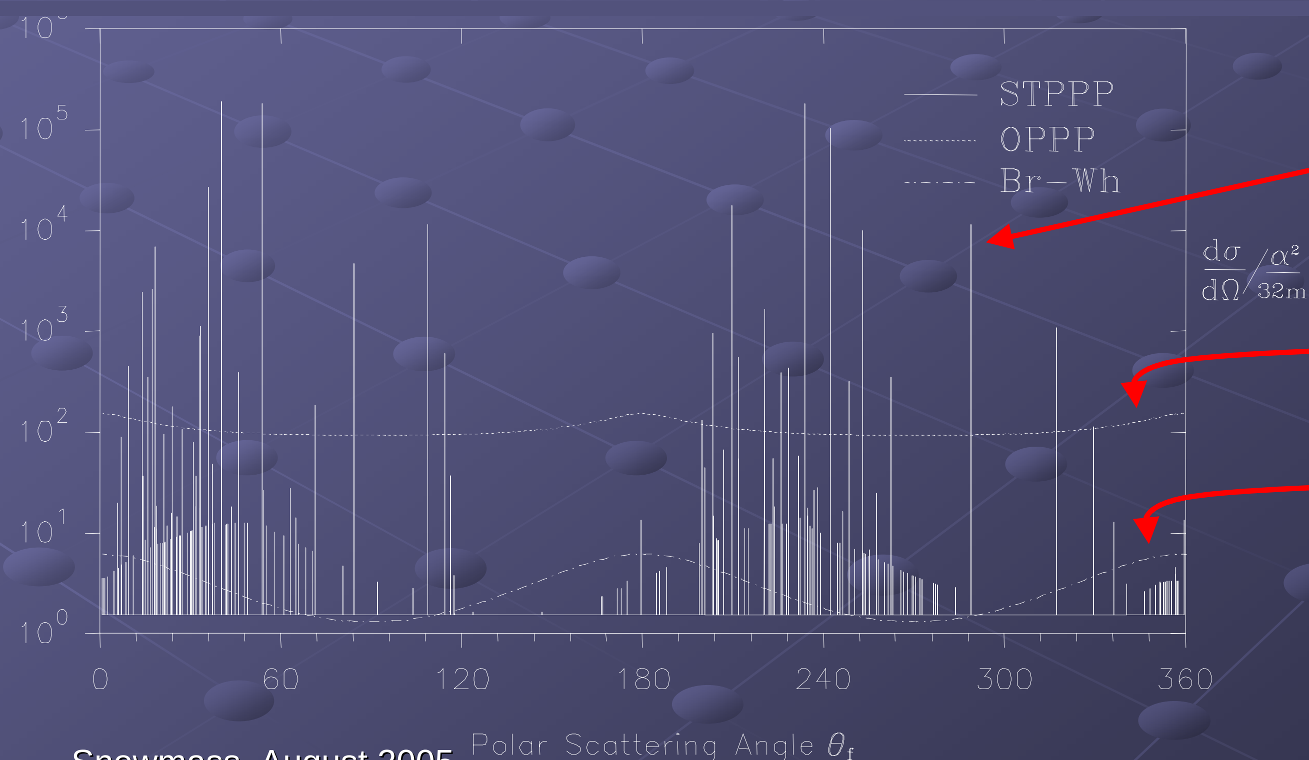
- The Electron Self Energy in external e-m field originally due to Becker & Mitter 1975 for low field intensity parameter ν
Has been recalculated for general ν

Resonances in multiphoton B-W

- Non-linear B-W $\frac{d\sigma}{d\Omega}$ can exceed normal B-W by orders of magnitude (Oleinik, JETP 25(4) 697, 1967)

- A detailed study is needed (and underway)

http://hepwww.ph.qmul.ac.uk/~hartin/intense_field_qed

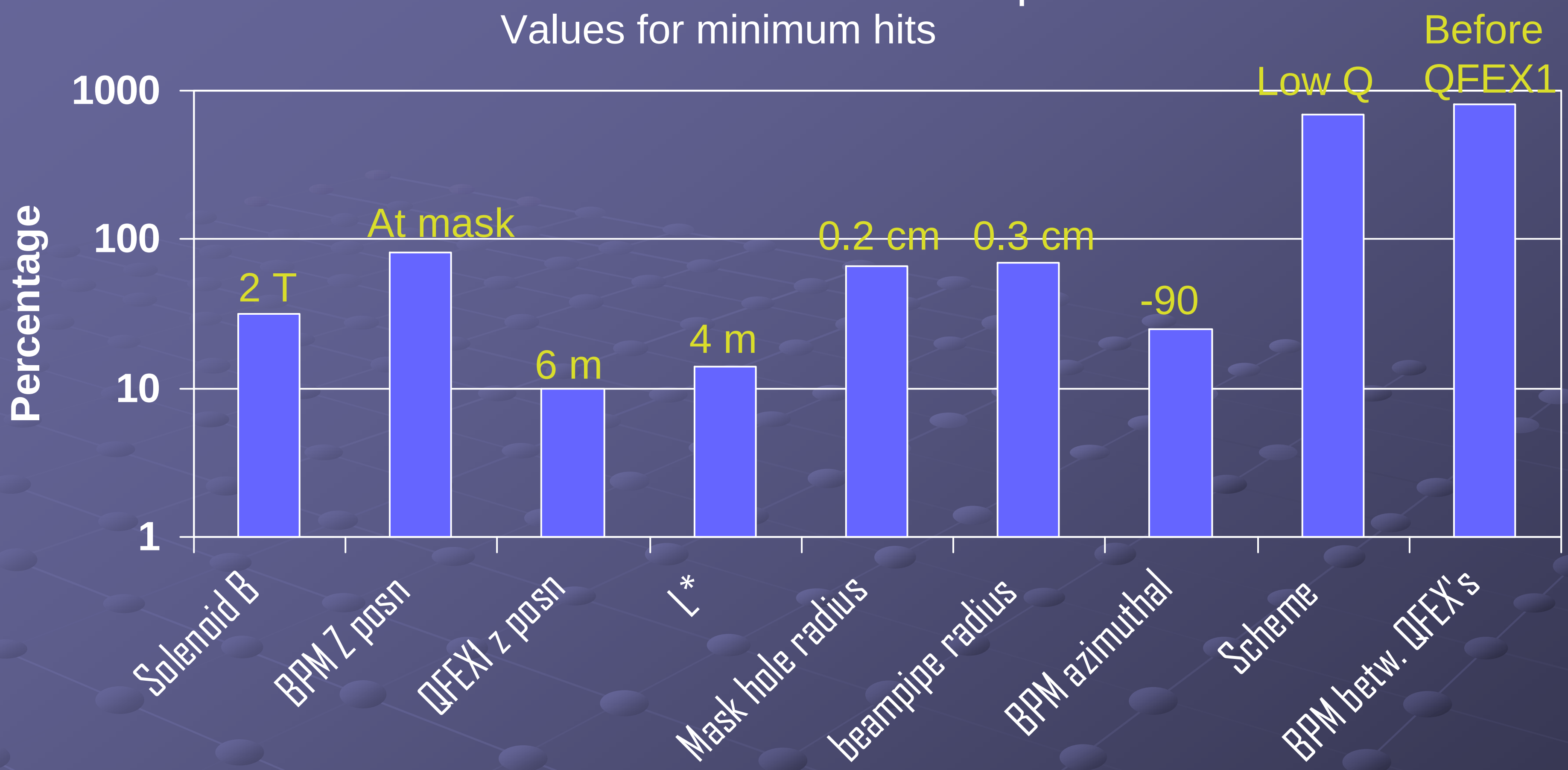


Multiphoton Breit-Wheeler Resonances

Multiphoton Bremstrahlung (non-resonant)

Ordinary Breit-Wheeler

Variation in BPM hits for different parameters



Future simulation plans

- **Analysis of 2mrad design**
- **Analysis with respect to anti-solenoids**
- **anything else?**