The Status of FP420

A Proposal for seedcorn funds to develop the FP420 experiment at the LHC

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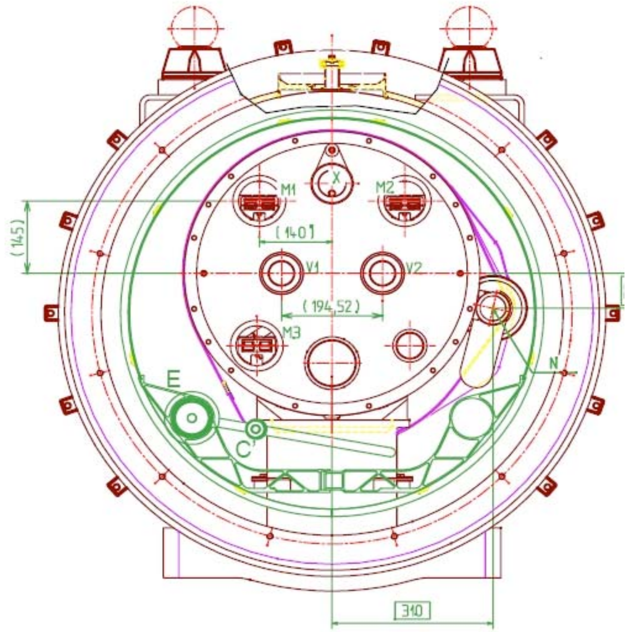
1. The University of Manchester
2. The Cockroft Institute
3. The University of Glasgow
4. Brunel University
5. Institute for Particle Physics Phenomenology, Durham
6. Bristol University
7. Rutherford Appleton Laboratory

Successful funding request at UK 'PPRP' meeting in March this year.

Organisation and effort in the UK

1. 420m Cryostat Design



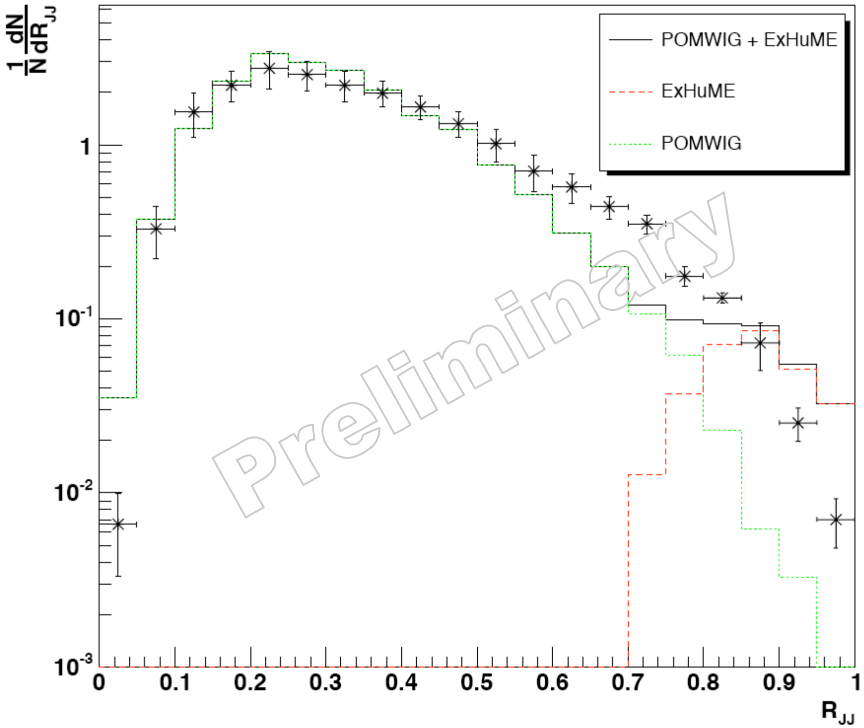
Subject to LHCC approval of the FP420 R&D project, the UK Cockroft accelerator institute plans to place cryostat design engineer in the CERN AT-CRI group for 24 months from this summer

University of Durham

Organisation and effort in the UK

2. Phenomenology

- Durham and Manchester working to produce the vital physics simulation tools:
- ExHuME (Monte Carlo implementation of the KMR calculations)
- POMWIG (Monte Carlo implementation of the 'resolved pomeron' backgrounds, using HERA diffractive structure functions)



www.exhume-me.com

www.pomwig.com

Plot from B.C. and A. Pilkington, to be published

Organisation and effort in the UK

3. Trigger electronics and DAQ

Rutherford Appleton Lab. and Bristol undertaking level 1 trigger studies:
Key question is retention of the Higgs -> bb signal at L1

Manchester engineers can / would like to provide DAQ and electronics for test-beam (at FNAL?)

Selection cuts	Higgs Mass (GeV)	Efficiency	Signal σ (fb)	Events / 30 fb^{-1}
Generated	120	100%	0.40	12
	140	100%	0.93	28
	160	100%	1.16	35
	180	100%	0.84	25
	200	100%	0.48	15
Single lepton trigger: an electron with $p_T >$ 25 GeV or a muon with $p_T >$ 20 GeV within $\lvert\eta\rvert < 2.5$	120	14 %	0.06	2
	140	19 %	0.18	5
	160	23 %	0.27	8
	180	25 %	0.21	6
	200	26 %	0.12	4

Preliminary

Table from B.C. , DeRoeck, Khoze et. al. to be published

Organisation and effort in the UK

4. Beam simulation (Peter Bussey)

5. 3D Silicon (Cinzia DaVia)

Summary : 100k pounds for next 12 months for R&D, plus cryostat design engineer from Cockroft Institute (subject to LHCC approval of FP420 R&D)

UNIVERSITEIT ANTWERPEN

- TOP project (Eddi De Wolf)

University of Antwerp Bid, 1st round success

100k euros for detector development / electronics

100k travel

3 positions (2 PhD, 1 Engineer)

Project can start fall 05 / early 06

- NOI project (Pierre Van Mechelen)

1 RA for 4 years for FP420 / Forward Physics (CMS)

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Timescales : Installation Fall 2008

LOI to LHCC on 29th June (actually aim for 2 weeks before this)

Why ? To open up Cockroft engineering money

- Meeting:

  Monday 30th - 31st May to prepare LOI ~ 20 pages

  (subgroups at CERN morning 31st)

- Test Beam at FNAL (available anytime) this fall: request should be made now - Mike Albrow to co-ordinate for FNAL

- Decision by end of 2005 on detectors and mechanics (US - no money (except prototype) before mid 2006)

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FP420 Organisational Structure Proposal

Management Board

Co-chairs (Cox, De Roeck)

Grant holders from each country ?

- Detectors (DaVia, Diamond?)
- Mechanics and interaction with machine (Albrow, Orava)
- DAQ and Trigger (Grothe,ATLAS?,FNAL?)
- Beams - acceptance, radiation, resolution (Bussey,Osterberg,Piotrzkowski)
- Monte Carlo Tools (Cox, ?)
- Interaction with current projects (Eggert, ATLAS?)
- Cryostat engineering (Cockroft, CERN)
- FP420 Contact Persons (Cox, De Roeck)

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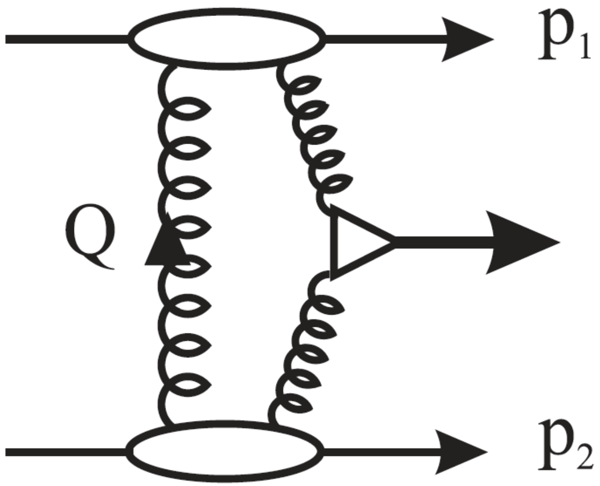
Forward Physics at the LHC

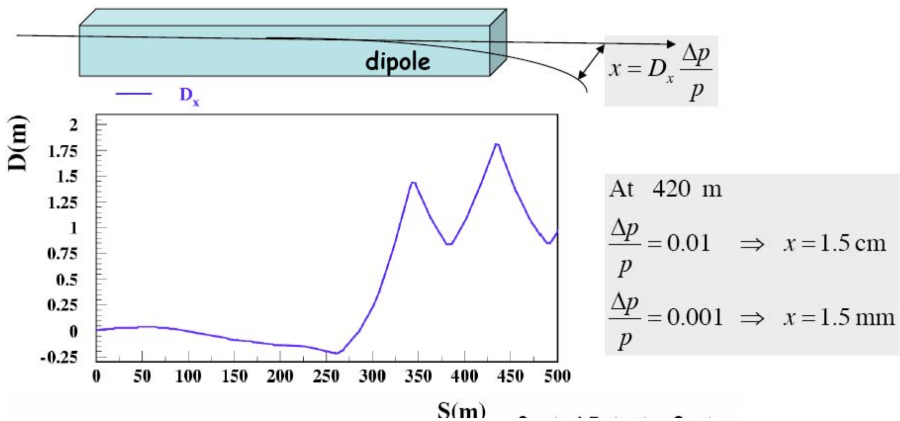


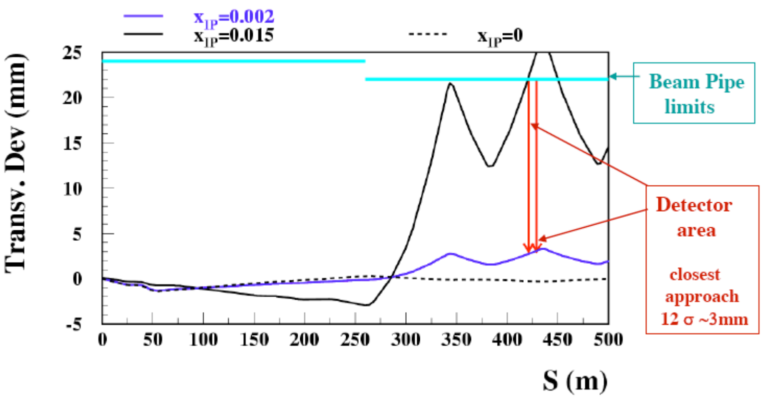
- Selection rules mean that central system is (to a good approx) 0^{++}
- If you see a new particle produced exclusively with proton tags you know its quantum numbers
- CP violation in the Higgs sector shows up directly as azimuthal asymmetries
- Proton tagging may be the discovery channel in certain regions of the MSSM
- Tagging the protons means excellent mass resolution (~ GeV) irrespective of the decay products of the central system
- Unique access to a host of interesting QCD

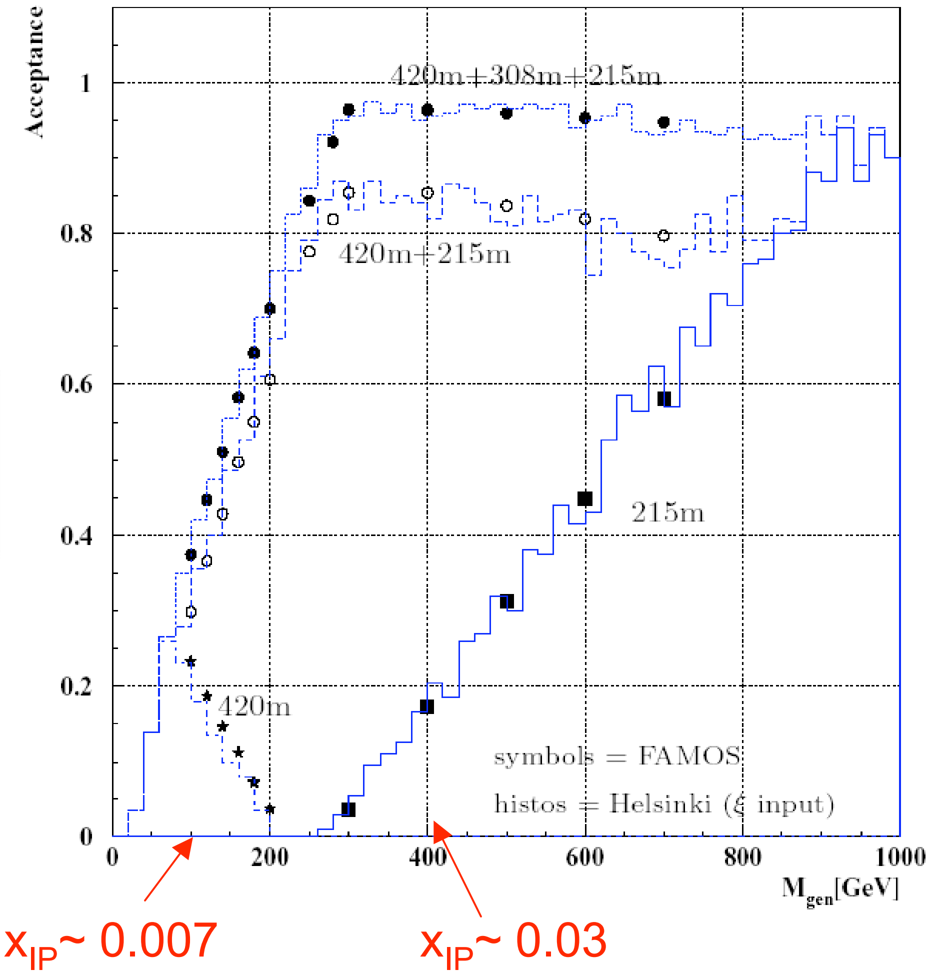
Very schematically it's a glue – glue collider where you know the beam energy of the gluons - source of pure gluon jets - and central production of any 0^{++} state which couples strongly to glue is a possibility …

Central Production at LHC

Dispersion



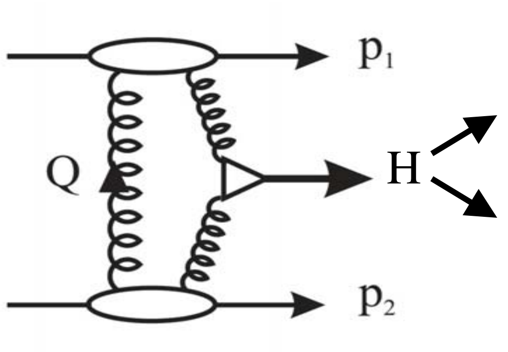




Plots from Henri Kowalski, Ken Osterberg, this workshop

The benchmark : Standard Model Higgs Production

Standard Model Higgs



b jets : M_H = 120 GeV σ = 2 fb (uncertainty factor ~ 2.5)

M_H = 140 GeV σ = 0.7 fb

M_H = 120 GeV : 11 signal, S/B ~ 1 in 30 fb^{-1}

WW^* : M_H = 120 GeV σ = 0.4 fb

M_H = 140 GeV σ = 1 fb

M_H = 140 GeV : 8 signal / 1? background in 30 fb^{-1}

0^{++} Selection rule

QCD Background ~ $\frac{m_b^2}{E_T^2} \frac{\alpha_S^2}{M_{b\bar{b}}^2 E_T^2}$

Also, since resolution of taggers > Higgs width:

$$S/B \propto \Gamma(H \to gg)/\Delta M \propto G_F M_H^3/\Delta M$$

- The b jet channel is possible, with a good understanding of detectors and clever level 1 trigger
- The WW^* (ZZ^*) channel is extremely promising : no trigger problems, better mass resolution at higher masses (even in leptonic / semi-leptonic channel)
- If we see Higgs + tags - the quantum numbers are 0^{++}

De Roeck, Khoze, Martin, Orava and Ryskin, Eur. Phys. J. C 25 (2002)391

The MSSM can be very proton-tagging friendly

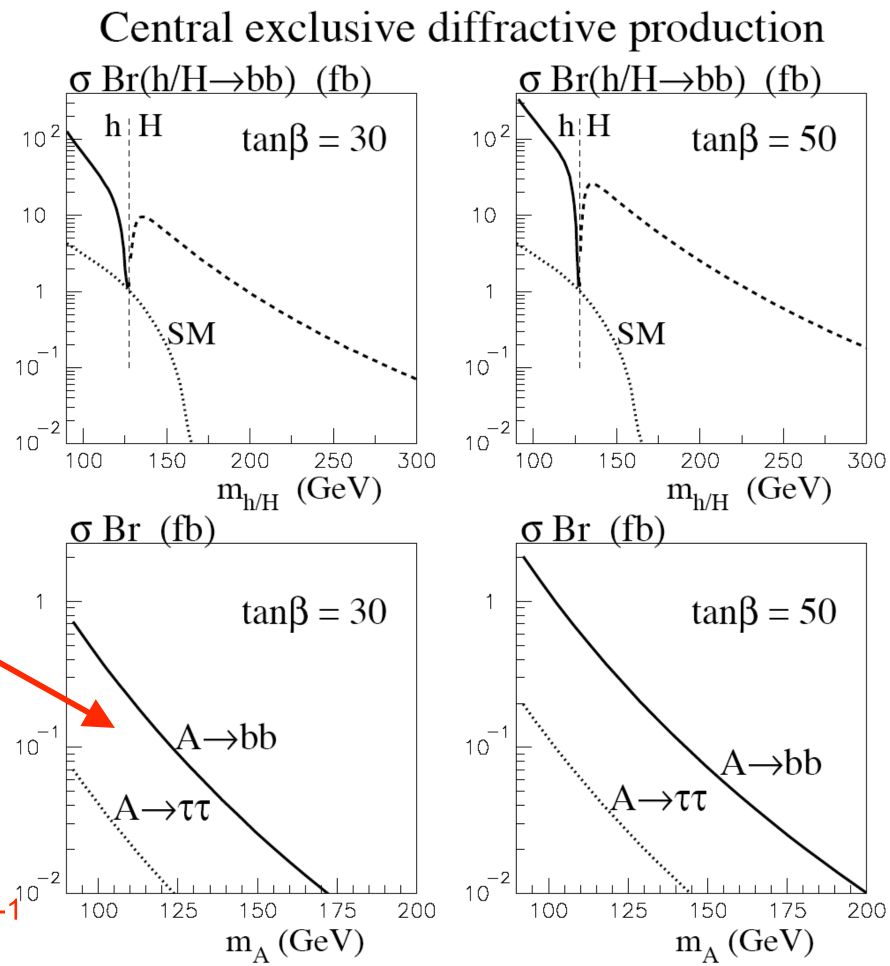
The intense coupling regime is where the masses of the 3 neutral Higgs bosons are close to each other and tan β is large

$\gamma\gamma, WW^{\star}, ZZ^{\star}$ suppressed

$gg \rightarrow \phi$ enhanced

0^{++} selection rule suppresses A production:

CEDP 'filters out' pseudoscalar production, leaving pure H sample for study



M_A = 130 GeV, tan β = 50

M_h = 124 GeV : 71 signal / 3 background in 30 fb^{-1}

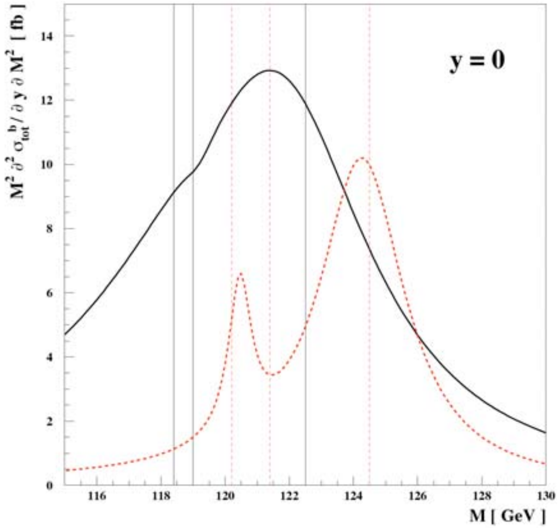
M_H = 135 GeV : 124 signal / 2 background in 30 fb^{-1}

M_A = 130 GeV : 3 signal / 2 background in 30 fb^{-1}

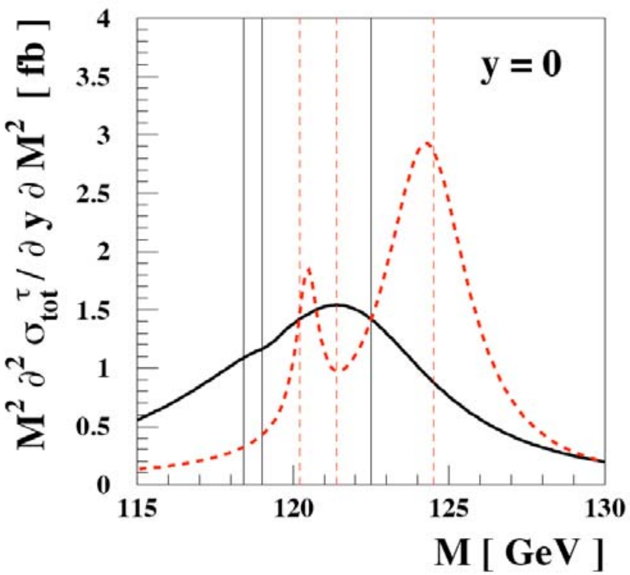
Well known difficult region for conventional channels, tagged channel may well be the discovery channel, and is certainly a powerful spin/parity filter

CP violation in the Higgs Sector

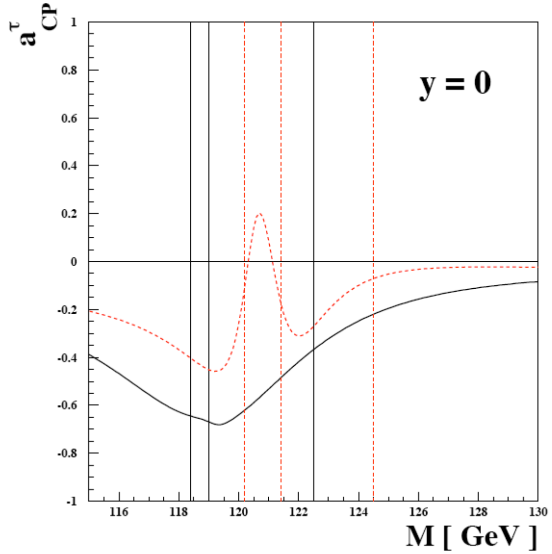
bb decay



ττ decay



ττ decay



This example shows that exclusive double diffraction may offer unique possibilities for exploring Higgs physics in ways that would be difficult or even impossible in inclusive Higgs production. In particular, we have shown that exclusive double diffraction constitutes an efficient CP and lineshape analyzer of the resonant Higgs-boson dynamics in multi-Higgs models. In the specific case of CP-violating MSSM Higgs physics discussed here, which is potentially of great importance for electroweak baryogenesis, diffractive production may be the most promising probe at the LHC.

J. Ellis et. al. hep-ph/0502251

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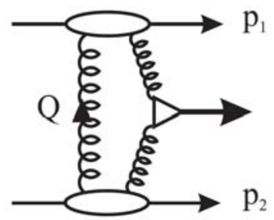
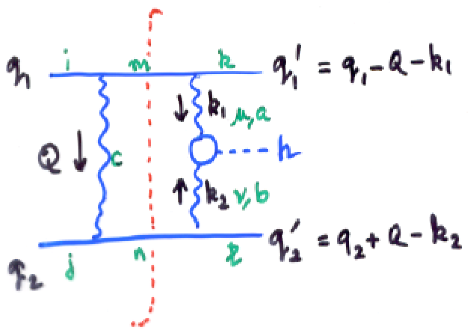
The KMR Calculation of the Exclusive Process



$qq \rightarrow q + H + q$



q -> Proton

$$\frac{d\sigma}{dy_H} \simeq \frac{1}{256\pi b^2} \frac{\alpha_s^2 G_F \sqrt{2}}{9} \left[\int \frac{d^2 Q_\perp}{Q_\perp^4} f(x_1, Q_\perp^2) f(x_2, Q_\perp^2) \right]^2$$

$$f(x, Q_\perp^2) = \frac{\partial G(x, Q_\perp^2)}{\partial Q_\perp^2} \quad (x_i = \alpha_i)$$

Dominant uncertainty: KMR estimate factor of 2-3. Independent estimate by Lund group "definitely less than 10".

assuming $f \sim (Q^2)^\gamma$

$$Q \sim \frac{M_H}{2} \exp\left(-\frac{2\pi}{N_c \alpha_s} \frac{\left[\frac{n}{2} - 1 - 2\gamma\right]}{2} \right)$$

$\alpha_s = 0.2$, $M_H = 100$ GeV, $n = 4$, $\gamma = 0.2$

→ 2 GeV

Divergent: controlled by Sudakov

exponentiating generates a factor in amplitude of

$$\exp(-S) = \exp\left(-\frac{C_A}{\pi} \int_{Q_T^2}^{M_H^2/4} ds \frac{dp_T^2}{p_T^2} \int_{p_T}^{M_H/2} \frac{dE}{E} \right) \leftarrow \text{double logs}$$

Jeff Forshaw, this workshop

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The case for FP420

• If you have a sample of Higgs candidates, triggered by any means, accompanied by proton tags, it is a 0^{++} state.

• Standard model Higgs will be seen in WW / WW* modes. b decay mode opens up if mass resolution and trigger acceptable, with S/B > 1

• In certain regions of MSSM parameter space, S/B > 20, and double tagging is THE discovery channel

• In other regions of MSSM parameter space, explicit CP violation in the Higgs sector shows up as e.g. azimuthal asymmetry in the tagged protons -> direct probe of CP structure of Higgs sector at LHC

• "Exclusive double diffraction may offer unique possibilities for exploring Higgs physics in ways that would be difficult or even impossible in inclusive Higgs production" J. Ellis et. al.

• The commissioning phase will produce a wealth of interesting physics, including detailed probe of gap survival / underlying event

For a review and references, see hep-ph/0409144