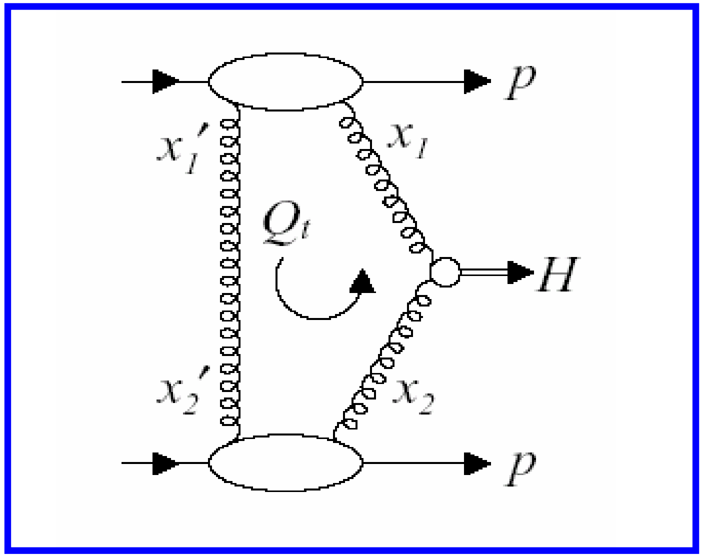
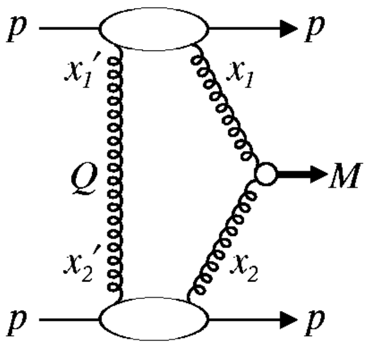
Diffractive Higgs Production

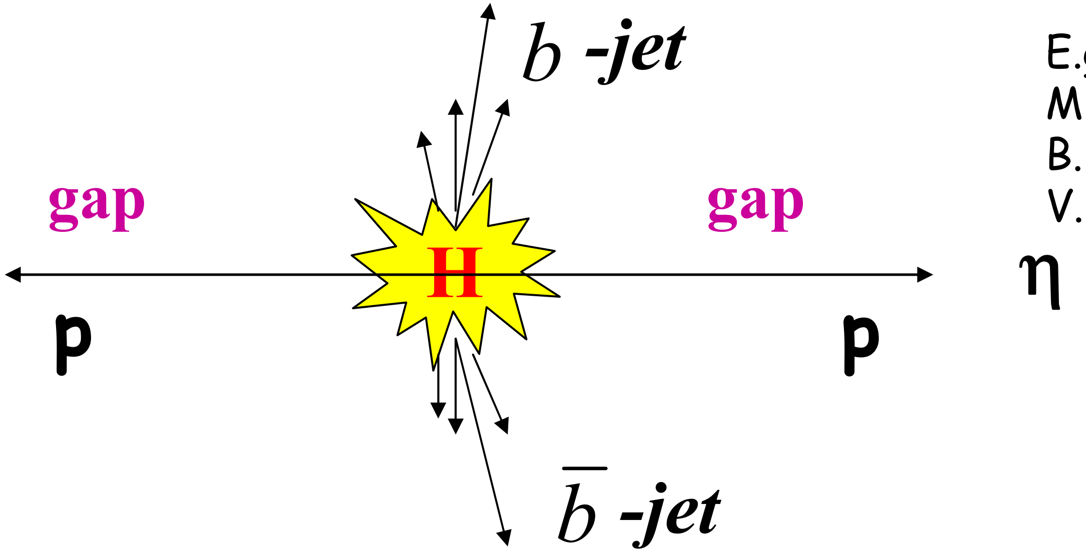
Albert De Roeck (CERN)



Diffractive Higgs Production

Exclusive diffractive Higgs production pp→ p+ H + p : 3-10 fb
Inclusive diffractive Higgs production pp → p+X+H+Y+p : 50-200 fb

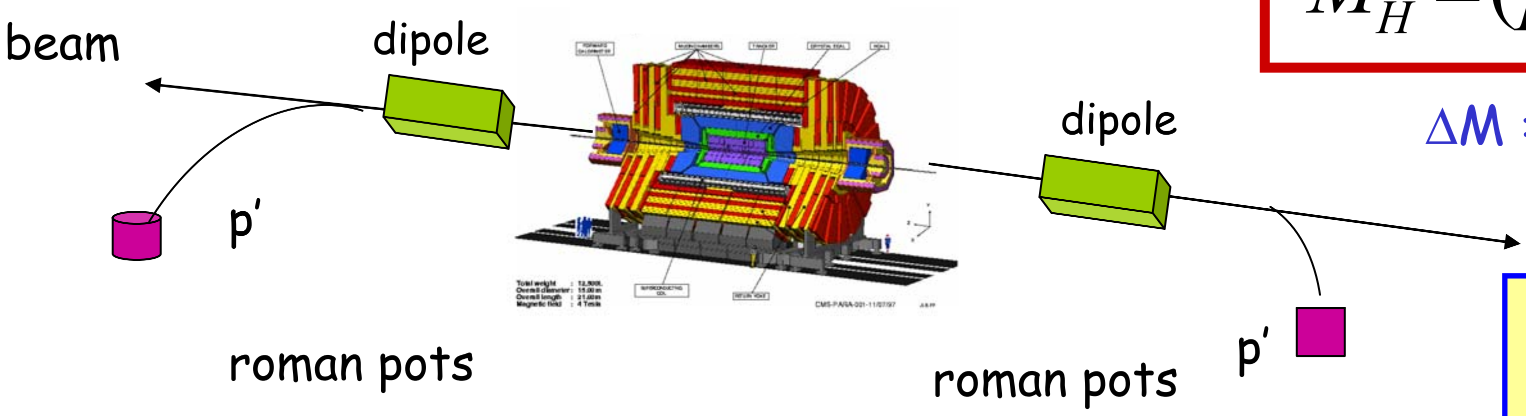




E.g. V. Khoze et al
M. Boonekamp et al.
B. Cox et al.
V. Petrov et al...

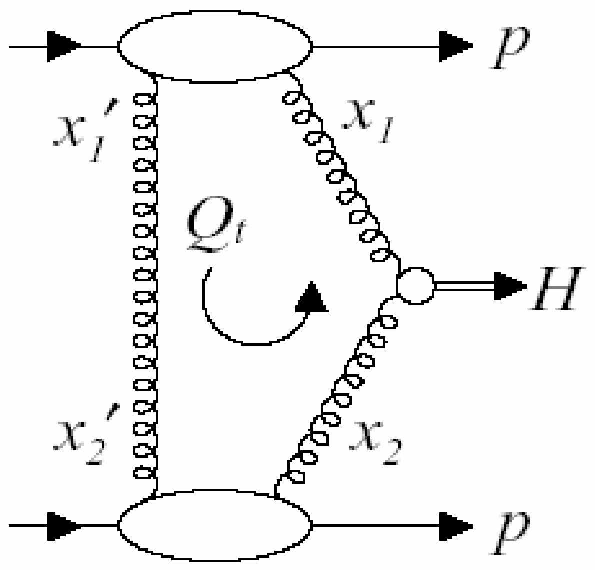
$$M_H^2 = (p + \bar{p} - p' - \bar{p}')^2$$

ΔM = O(1.0 - 2.0) GeV

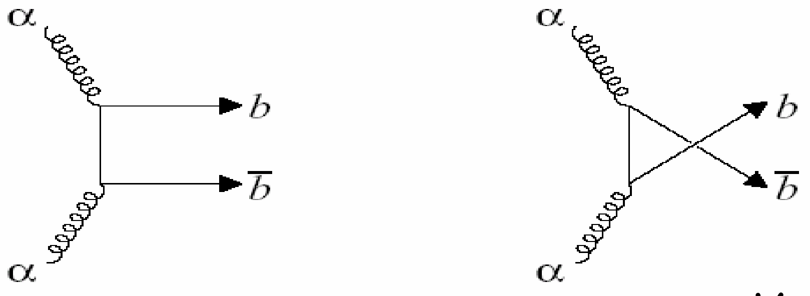


P. Landshoff not convinced that the cross sec. is small

Exclusive Diffractive Higgs Production



- For light Higgs, dominant decay mode is $H \longrightarrow b\bar{b}$
- For inclusive production, the QCD $b\bar{b}$ background is overwhelming
- For double diffractive production (2 tagged protons) there is a J_Z = 0, parity even selection rule :



e.g. V. Khoze et al

cancel each other in the $m_b \rightarrow 0$ limit

- Cross section suppressed as m_b^2 / E_T^2

where $E_T \sim M_H / 2$

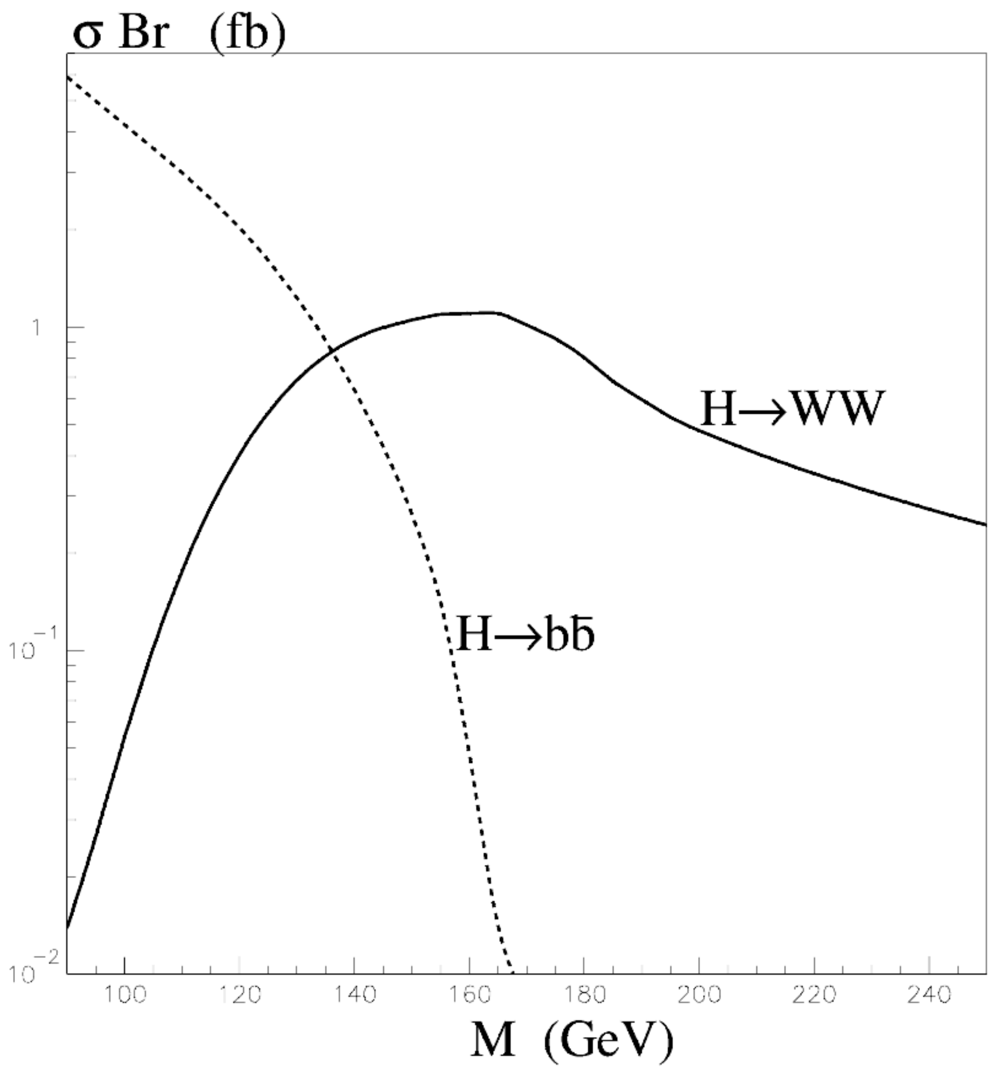
Also called: CEDP (central exclusive diffractive production)
or DPE (double pomeron exchange)

Exclusive Diffractive Higgs production

- Advantages
  - Measure the Higgs mass via the missing mass technique
    Mass measurements do not involve Higgs decay products
  - Suppression of LO QCD backgrounds via spin selection rules
    E.g. can see in principle $H \rightarrow bb$
  - Spin parity info: dominante 0++ (2++) final state
- Challenges
  - Tagging the leading protons
  - Selection of exclusive events & backgrounds
  - Triggering at L1 in the LHC experiments
  - Model dependence of predictions: resolve some/many of the issues with Tevatron data?

There is a lot to learn from present and future Tevatron diffractive data

Higgs Cross Section * BR



- Cross sections ~ fb

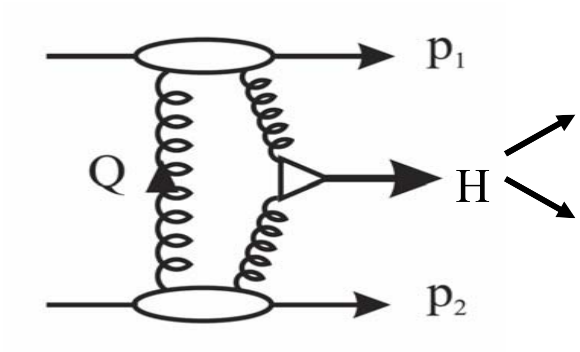
- Diffractive Higgs mainly studied for H→bb
  Khoze et al.,
  ADR et al.,
  Boonekamp et al.,
  Petrov et al...

- Recently study extended for the decay into WW can reach higher masses
  Cox, Khoze, ADR, to appear

Note H→bb (120 GeV) at Tevatron ⇒ 0.13 fb

Exclusive Higgs production

Standard Model Higgs



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

M_H = 140 GeV s = 0.7 fb

M_H = 120 GeV : 11 signal / O(10) background in 30 fb^{-1} with detector cuts

WW^* : M_H = 120 GeV s = 0.4 fb

M_H = 140 GeV s = 1 fb

M_H = 140 GeV : 8 signal / O(3) background in 30 fb^{-1} with detector cuts

- The b jet channel is possible, with a good understanding of detectors and clever level 1 trigger (need trigger from the central detector at Level-1)
- 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 SM Higgs + tags - the quantum numbers are 0^{++}

Phenomenology moving on fast

See e.g. J. Forshaw HERA/LHC workshop

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

$gg \to \phi$ enhanced

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

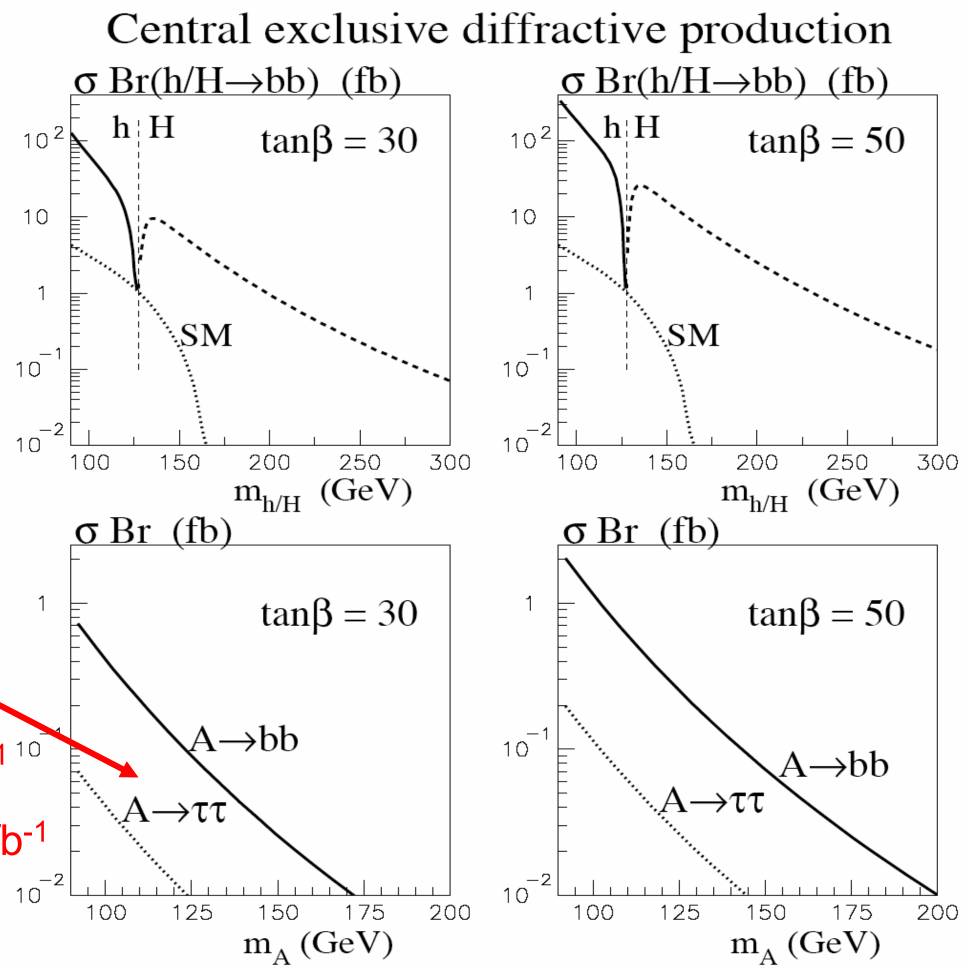
CEDP 'filters out' pseudoscalar production, leaving pure H sample for study

M_A = 130 GeV, tan β = 50

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

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

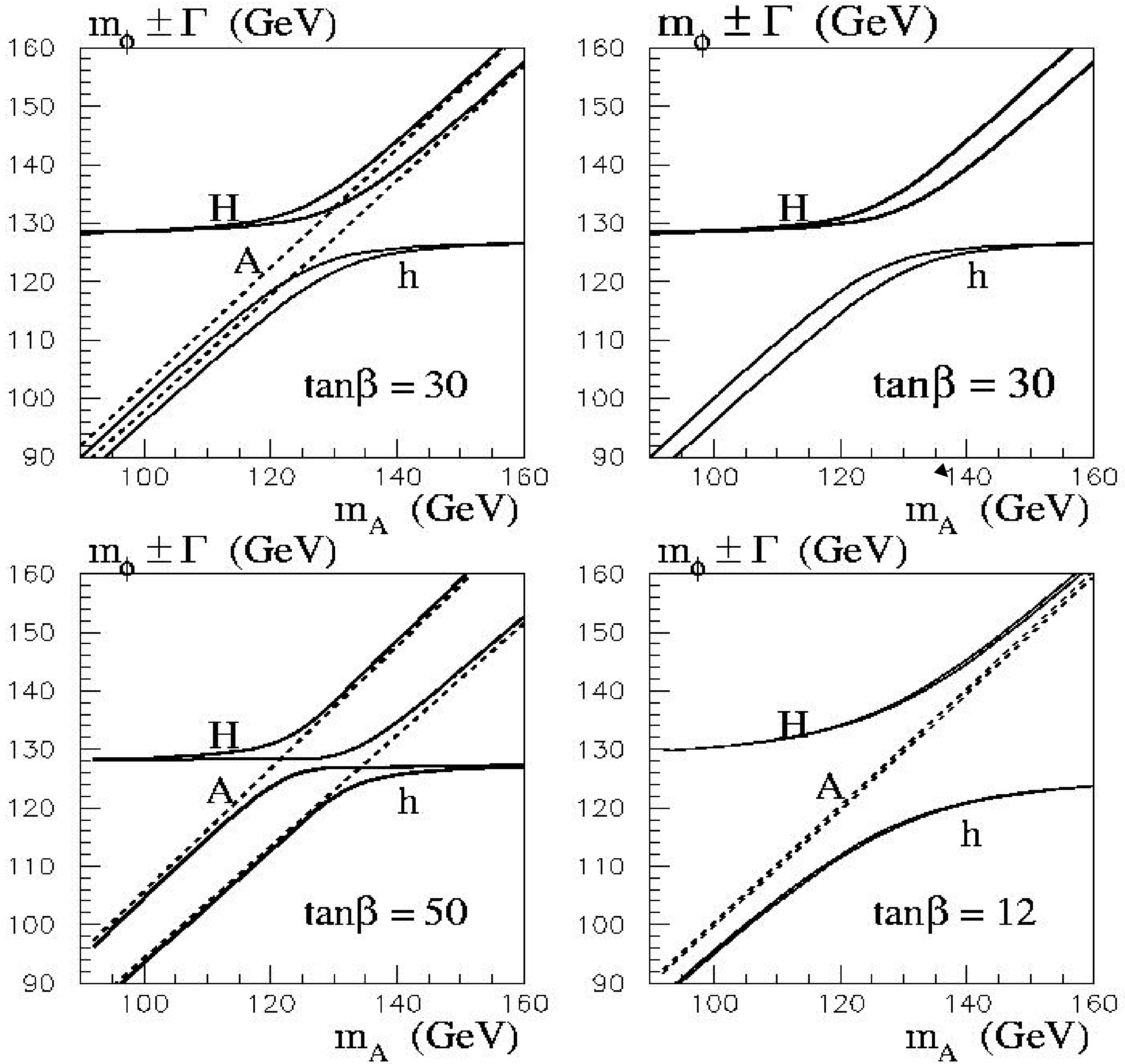
M_A = 130 GeV : 3 signal / 2 background/GeV in 30 fb^{-1}



Signal in ~ 5 GeV bins

σ×BR(bb) > 0.7fb (2.7fb) for 300 (30fb^{-1})

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



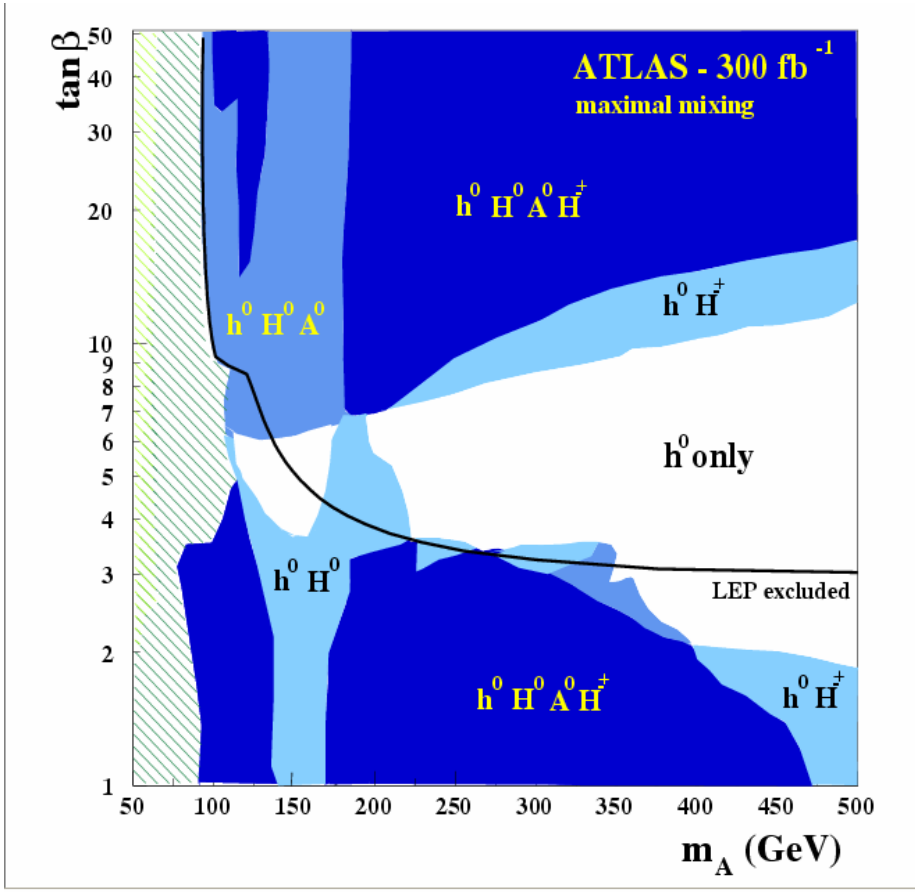
Mass bands for neutral MSSM Higgs

Parameters from Boos, Djouadi and Nikitenko Hep/0307079

EDP will select h,H states, suppress A
$\Delta M \sim 1$GeV allows h,H separation

•**h,H** can be clearly distinguished outside the M_A= 130+-5 GeV range,

Helping to cover the LHC gap?



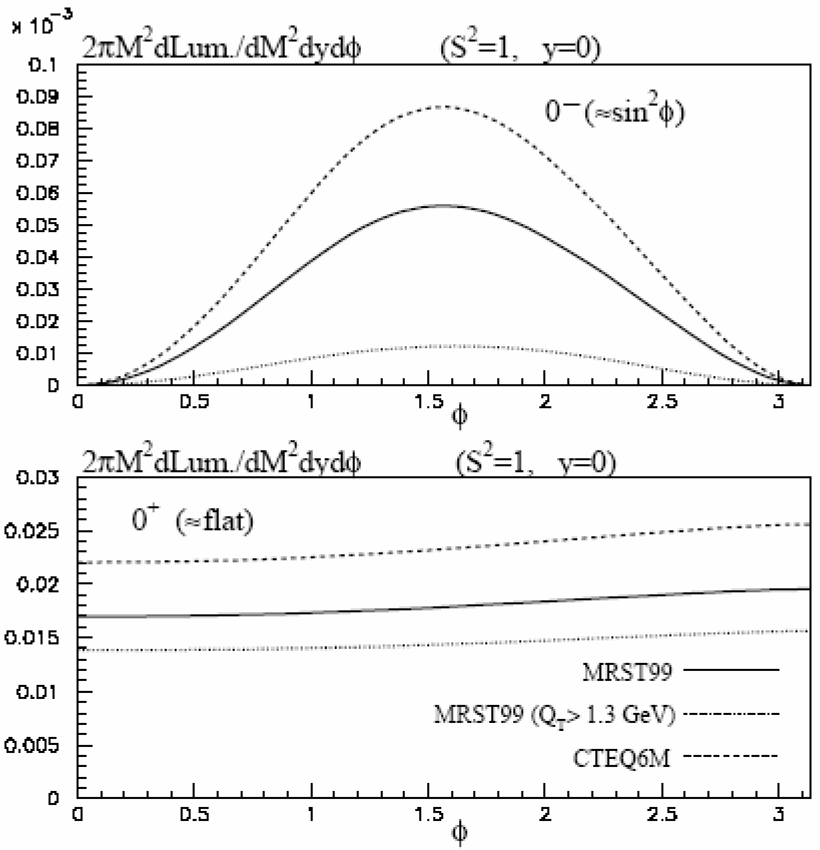
With EDP the mass range up to 160-170 GeV can be covered at medium tanβ and up to 250 GeV for very high tan β, with 300 fb^{-1}

Needs however still full simulation

Spin Parity Analysis

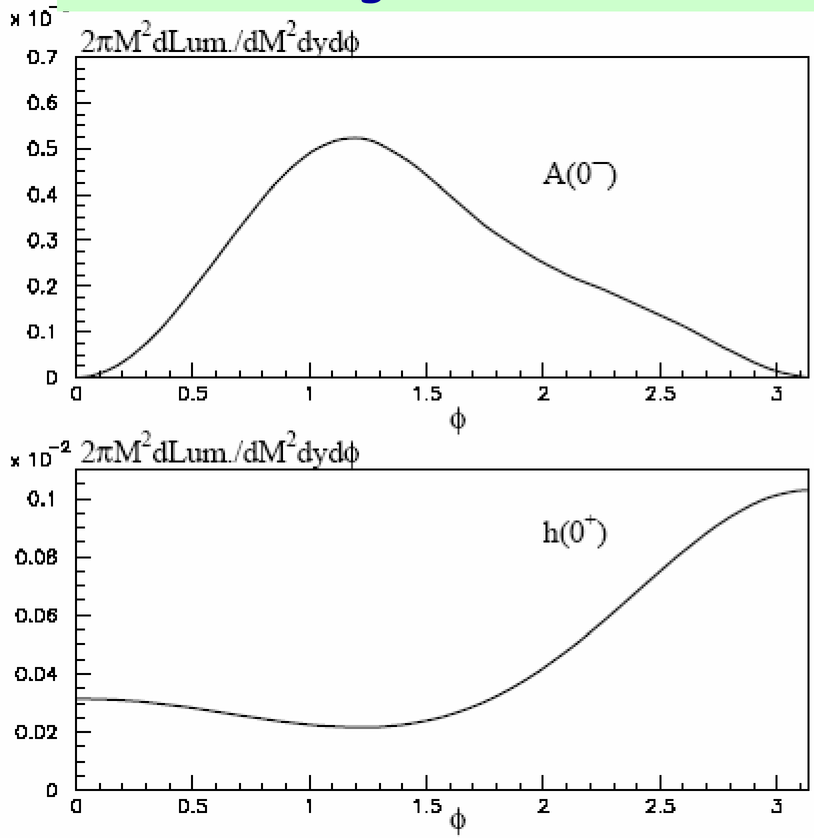
Azimuthal angle between the leading protons depends on spin of H

ϕ angle between protons



pro
the

ϕ angle between protons with rescattering effects included



A.B. Kaidalov et al. hep-ph/0307064

Probing the CP Violating Sector of the Higgs

Azimuthal asymmetry in tagged protons provides direct evidence for CP violation in Higgs sector

$$A = \frac{\sigma(\varphi < \pi) - \sigma(\varphi > \pi)}{\sigma(\varphi < \pi) + \sigma(\varphi > \pi)}$$

$M(H_1)$ GeV	cuts	30	40	50
$\sigma(H_1)\mathrm{Br}(\tau\tau)$	a, b	1.9	0.6	0.3
$\sigma^{\mathrm{QED}}(\tau\tau)$	a, b	0.2	0.1	0.04
$A_{\tau\tau}$	b	0.2	0.1	0.05

(b) $p_i^{\perp} > 300$ MeV for the forward outgoing protons

'CPX' scenario
σ in fb

$$\mathcal{M} = g_S \cdot (e_1^{\perp} \cdot e_2^{\perp}) - g_P \cdot \varepsilon^{\mu\nu\alpha\beta} e_{1\mu} e_{2\nu} p_{1\alpha} p_{2\beta} / (p_1 \cdot p_2)$$

CP even

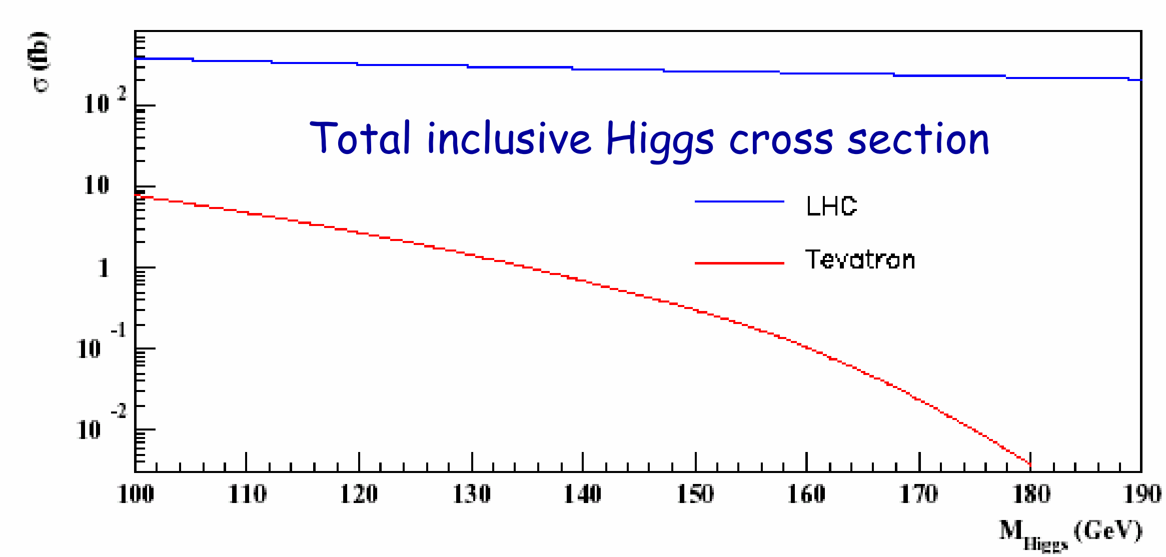
CP odd active at non-zero t

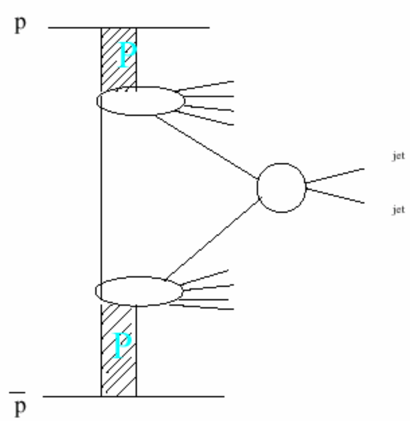
CPX: Carena, Ellis, Pilfatis, Wagner

Ongoing work - are there regions of MSSM parameter space where there are large CP violating couplings AND enhanced gluon couplings?

Inclusive Diffractive Higgs Production

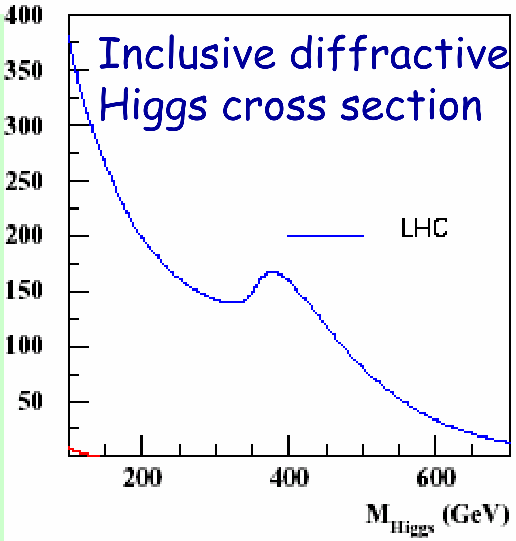
E.g. Boonekamp et al.

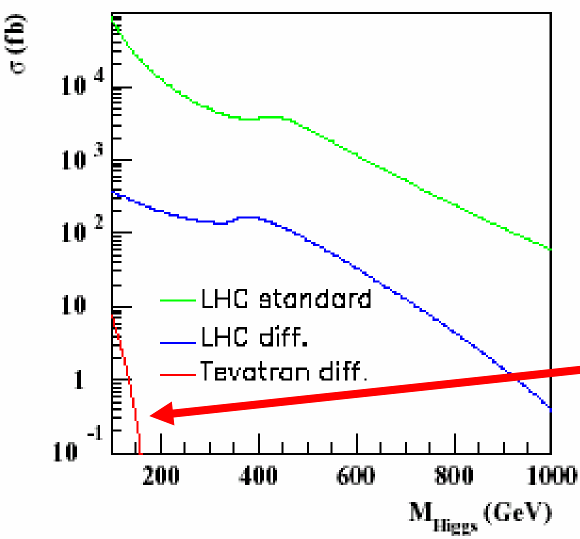




pp→p+HX+P

Cross section larger but no spin selection rules or mass reconstruction from the protons

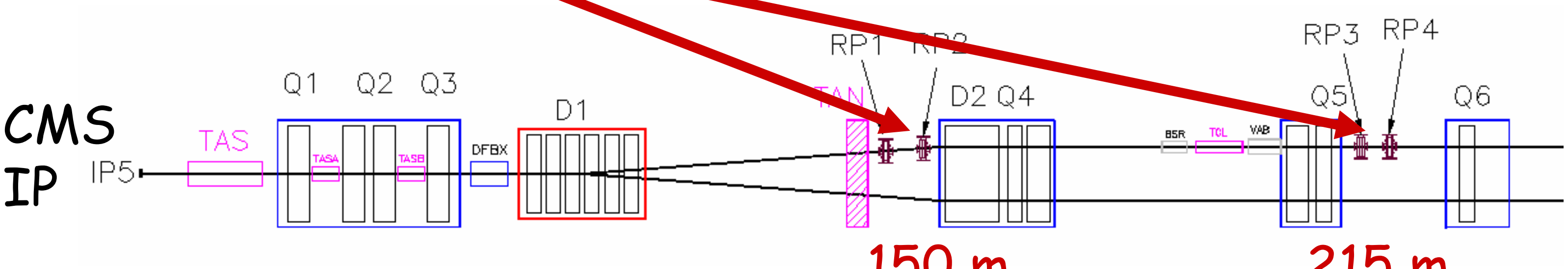




Rather hopeless at the Tevatron

Planned Roman Pot detectors@LHC

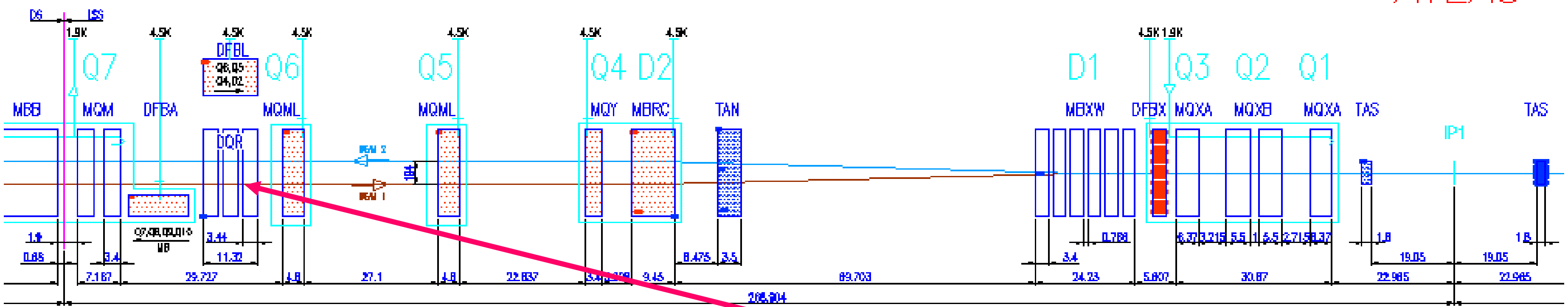
TOTEM physics program: total pp, elastic & diffractive cross sections
CMS+TOTEM Roman pots at high lumi



150 m

215 m

ATLAS

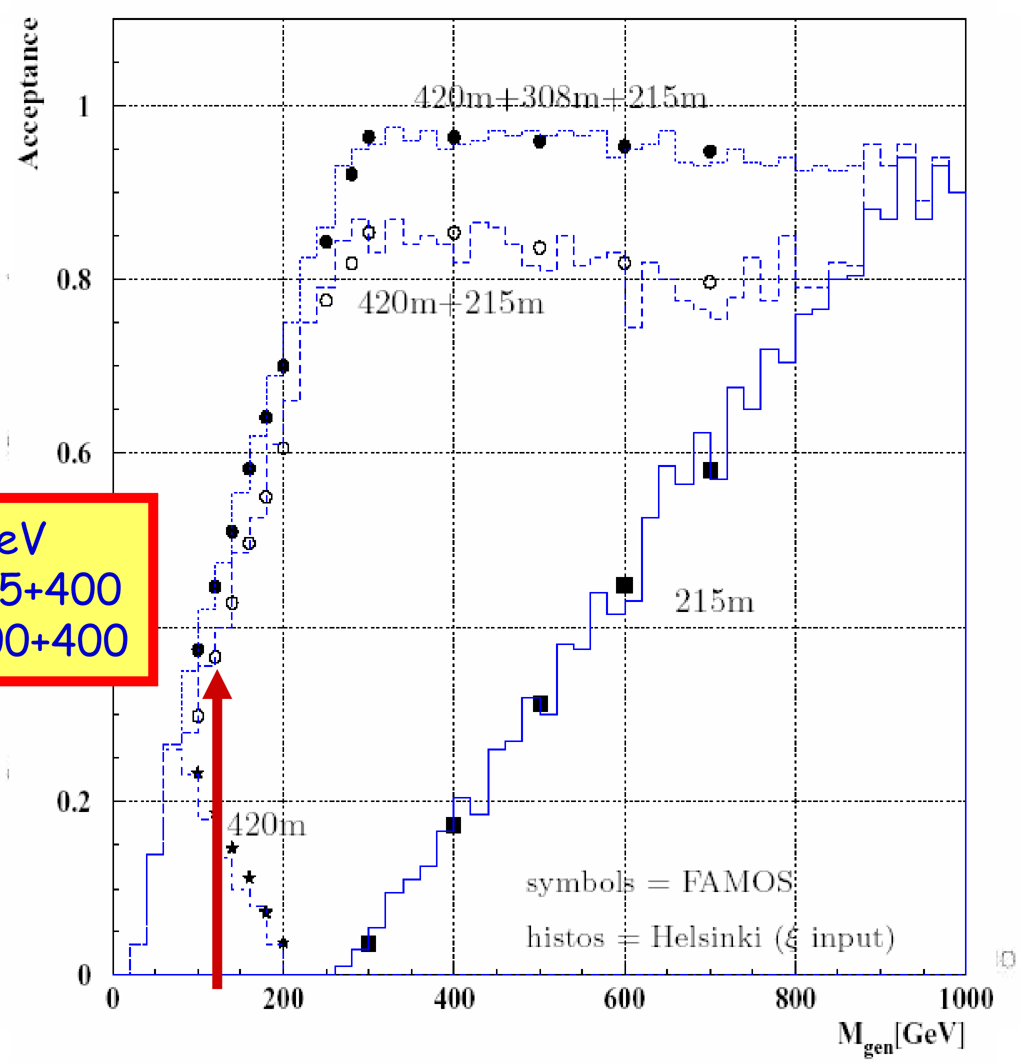


240 m
ATLAS Diffraction to be studied
Cannot use present RPs at high lumi

One **Roman Pot Station** per side
on left and right from IP1

Exclusive Diffractive Higgs Production

Acceptance of 200 m region not sufficient for Higgs detection
LHC optics: suitable positions with increased acceptance at 308/420 m



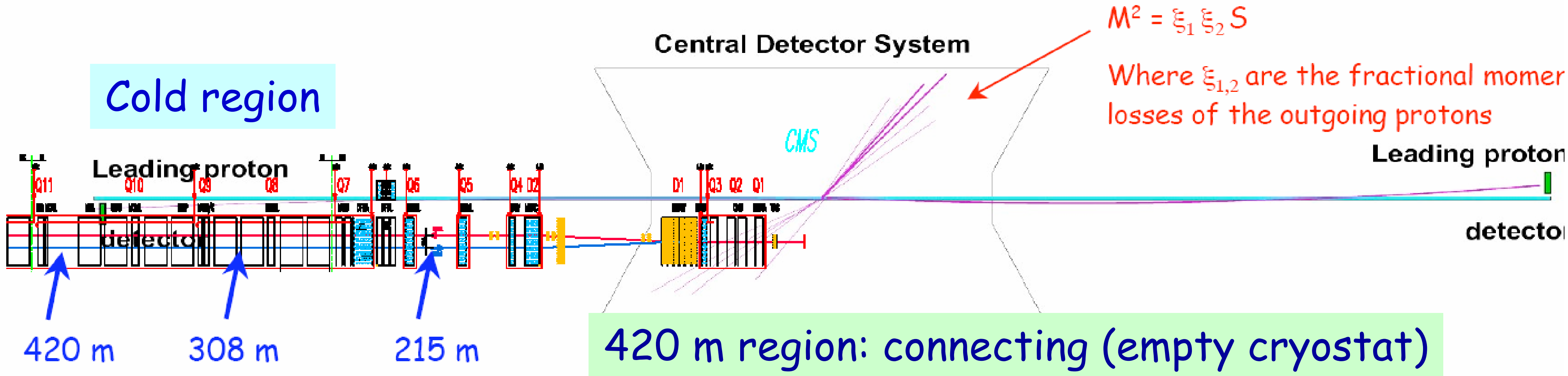
At 120 GeV
50% = 215+400
50% = 400+400

- Combined acceptance of
  - → All detectors
    - Dotted line
  - → 420 m + 215 m
    - Dashed line
  - → 215 m alone
    - Solid line
  - → 420 m alone
    - Dash-dotted line
- without 308 / 338 m location
  - → 10-15 % loss in acceptance

Curves:
Helsinki
Group

Dots
CMS/FAMOS
simulation

New Forward Detector Proposal (in prep.)

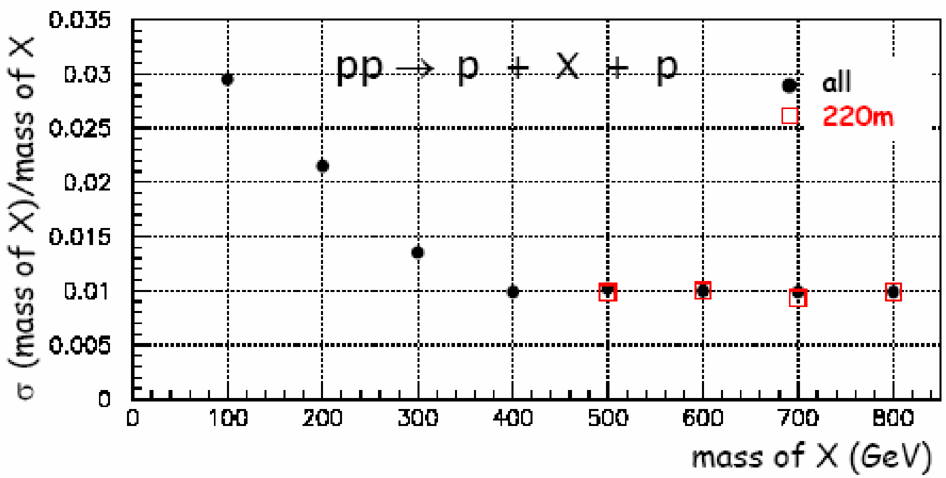


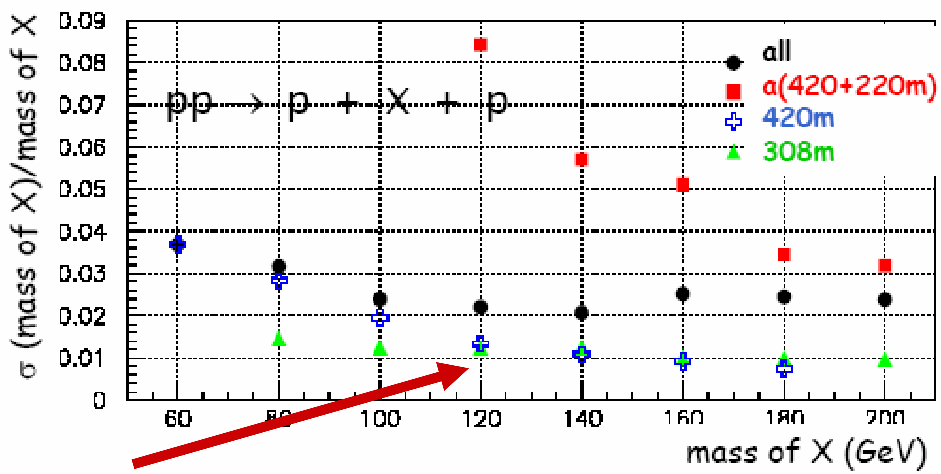
Proposal to study a modification of the cryostat and to operate compact detectors in the region of 400m (for ATLAS & CMS)
⇒R&D collaboration building: UK groups, Belgian & Finish institutes, CERN…

Mass Resolution

Mass resolution of central system

Helsinki group





Resolutions for separate locations and all combination ("naive" combination)

- resolution ranges from ~ 4 % at low masses to ~ 1 % at high mass
- optimal resolution ~ 1 % for symmetric pairs (i.e. $\xi_1 \approx \xi_2$)

NB! a(420+215m) = $\xi_1 \gg \xi_2$ or $\xi_1 \ll \xi_2$

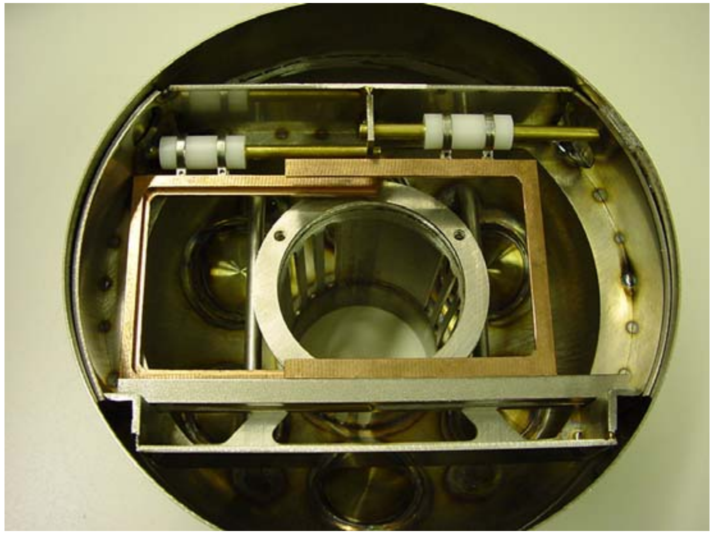
NB! Some effects are anticorrelated for ξ_1 & ξ_2 (e.g. transverse vertex position) ⇒ $\sigma(M)/M < \frac{1}{2}\sqrt{\Sigma_i \sigma(\xi_i)/\xi_i}$

Mass resolution 1-2% for symmetric events

Still being optimized

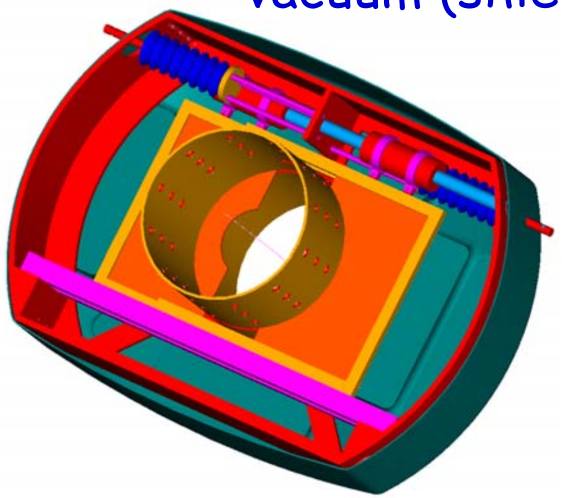
Can we improve the resolution? ⇒ would increase significance

Detectors: micro stations+3D silicon?



Very compact!

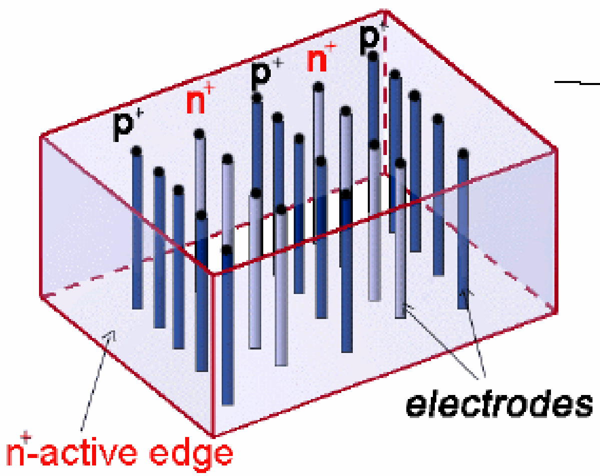
Silicon pixel or strip detectors in vacuum (shielded), 3D silicon...

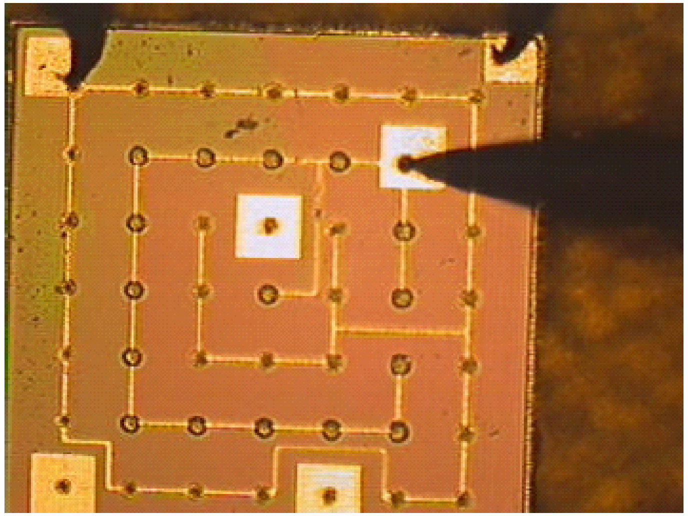


μ-station concept (Helsinki)

3D DETECTORS AND ACTIVE EDGES

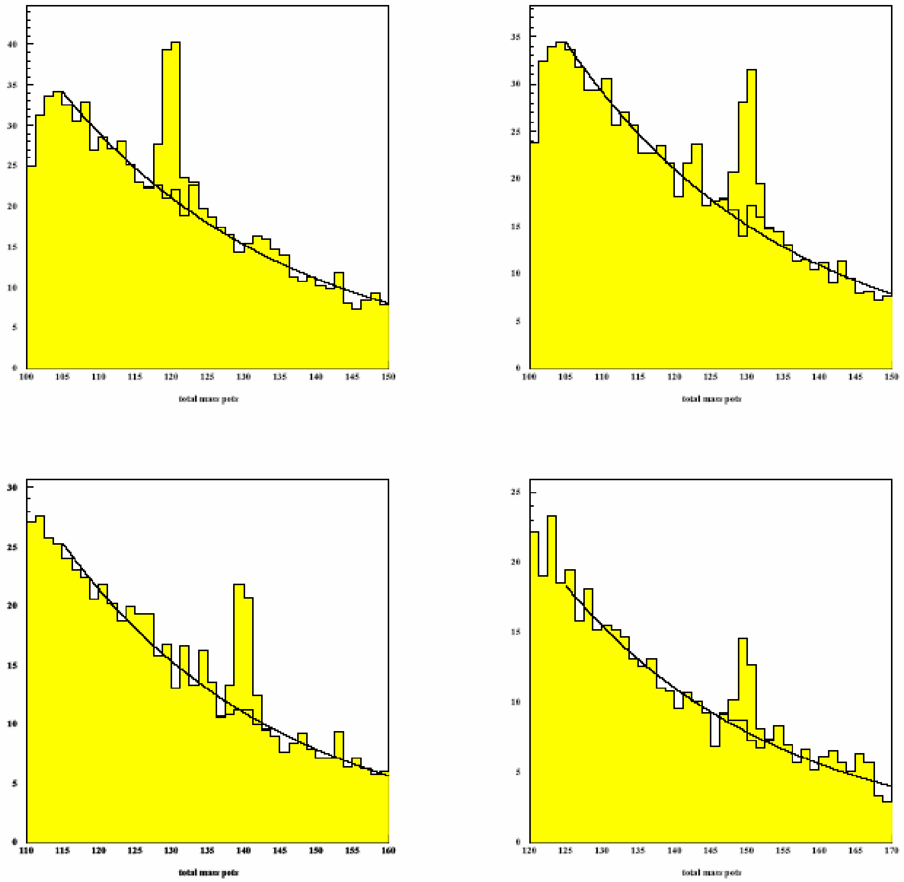
Brunel, Hawaii, Stanford





Detailed Simulation Studies

Signals and background for different Higgs masses



100 fb^{-1}

Detailed studies ongoing
Fast detector simulation

Boonekamp/ATLAS
Royon/CMS

Include exclusive and inclusive bb background

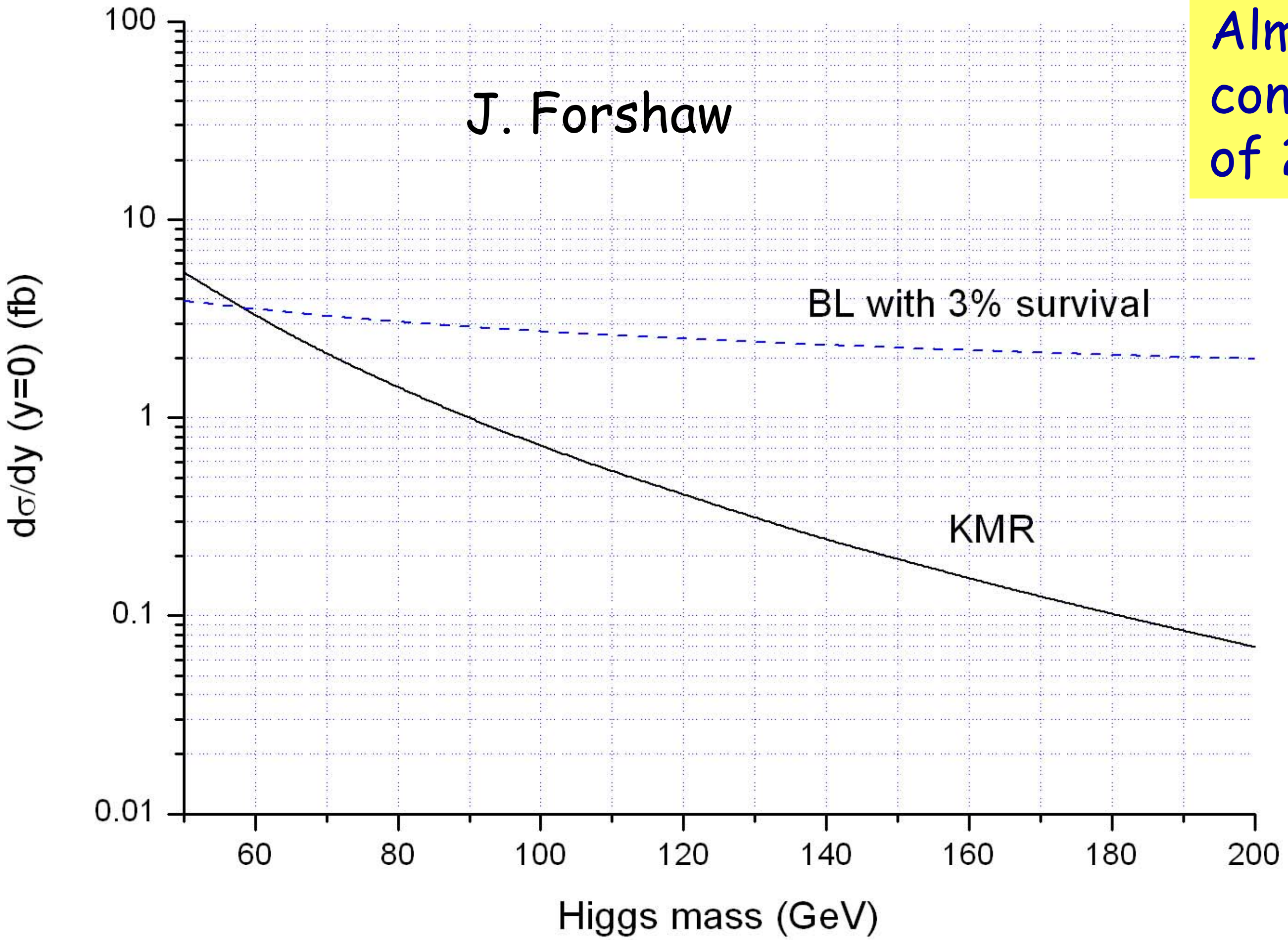
Include missing mass resolution from the tagged protons

Experimental issue: L1 trigger
400m signals are too late for the L1 trigger→L1 from central detector

First look/needs to be optimized

Models…

Different models give different predictions for
- The cross sections
- The mass/energy dependence of the cross sections



Almost all calculations now converge to a cross section of 2-10 fb for a light Higgs

BL Bialas Landshof (soft Pomeron)

KMR: Khoze Martin Ryskin

Tevatron can test these models

Test at the Tevatron

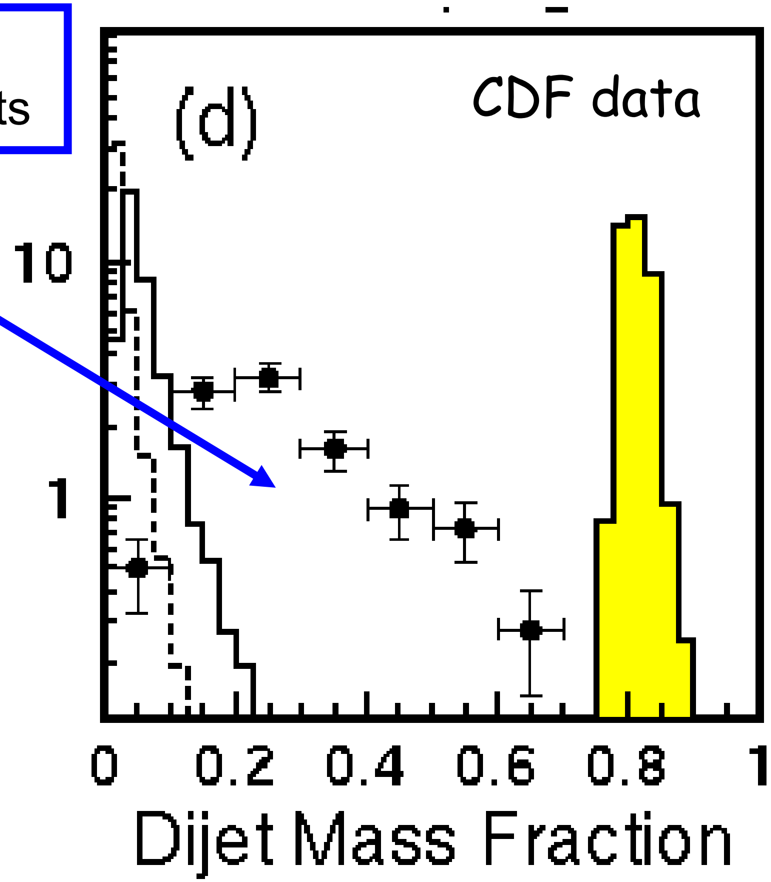
Test for exclusive production at the Tevatron
⇒Energy in the two-jets/all energy for DPE events

CDF di-jets in DPE
upper limit 3.7 nb

Generally old predictions of
>O(100) pb for the Higgs
overshoot this predictions
y a factor 10-100
Hence → ruled out!

CDF and D0 should find &
measure a signal with run IIa

Needs optimal jet finder
Cone algorithm not the best

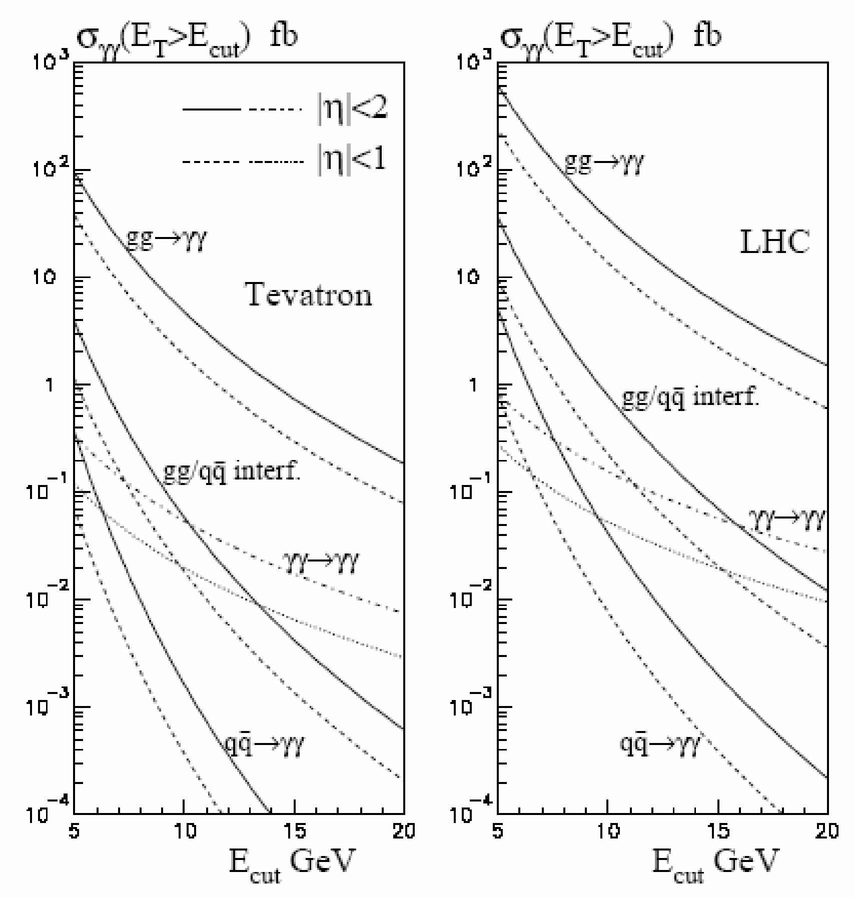


Smooth decrease of the cross section.
Can exclusive processes be seen on top
of the non-exclusive background?

More Information from Tevatron!

Study of diffractive exclusive processes

V. Khoze et al., hep-ph/0409037



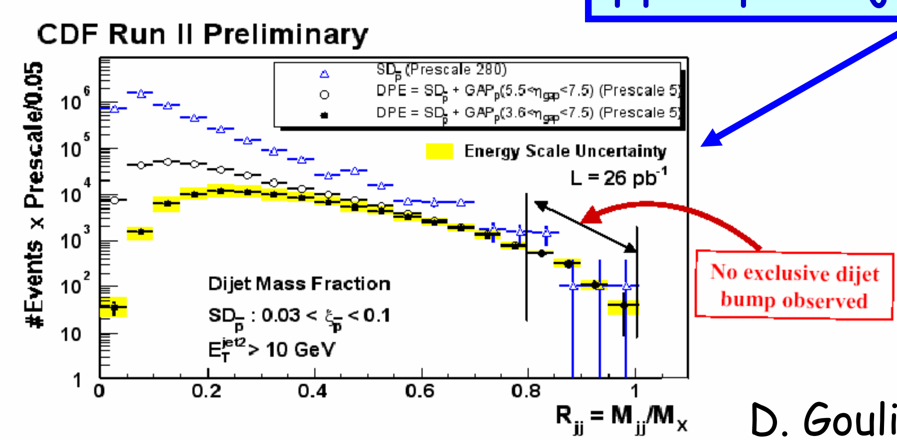
pp →p + γγ +p

V. Khoze et al., hep-ph/0403218

	Tevatron $\sqrt{s}=2$ TeV χ_c	Tevatron $\sqrt{s}=2$ TeV χ_b	LHC $\sqrt{s}=14$ TeV χ_c	LHC $\sqrt{s}=14$ TeV χ_b
$d\sigma_{\rm excl}/dy\|_{y=0}$	130	0.2	340	0.6
$\sigma_{\rm excl}$	650	0.5	3000	4
$d\sigma_{\rm incl}/dy\|_{y=0}$	13	0.06	30	0.2
$\sigma_{\rm incl}$	70	0.3	200	2

pp →p + χ_c +p

pp →p + dijets+p



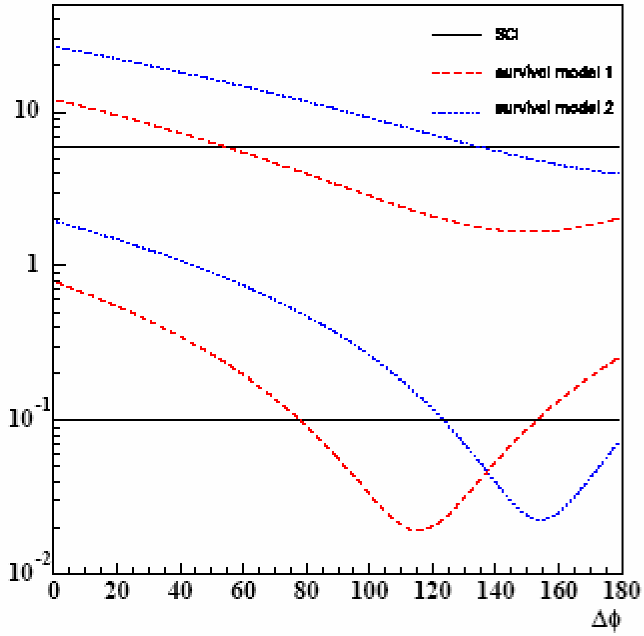
D. Goulianos

$|\eta_{jet1,2}|<2.5$, $0.03<\xi_{\bar{p}}<0.1$, $3.6<\eta_{gap}<7.5$, $R = 0.7$

Minimum E_T^{jet1}	Cross Section : $\sigma_{DPE}^{excl.\,jj}(R_{jj}>0.8)$
10 GeV	970 ± 65(stat) ± 272(syst) pb
25 GeV	34 ± 5(stat) ± 10(syst) pb

More Information from Tevatron

Kupco, Peschanski, Royon



- dijet production with $p_T > 5$ GeV at Tevatron
  - upper plots: $|t_p| > 0.6$, $|t_{\bar{p}}| > 0.1$ GeV^2
  - lower plots: $|t_p| > 0.5$, $|t_{\bar{p}}| > 0.5$ GeV^2
- Pomeron models
  - POMWIG interfaced with the calculation of survival probability
  - two-channel eikonal model (Model 1)
  - elastic channel model (Model 2)
- SCI model - modified version of Pythia with color string reconnection

Different azimuthal correlation between the two protons for different models for the gap survival
Important for CP studies in the Higgs sector @ LHC

Summary

- Diffractive Higgs@LHC studies under way
  - Both exclusive, inclusive, and also in single pomeron exchange
- Main issues for exclusive channel
  - Cross section ~ fb, but some die-hards believe it could be still larger
    - Calculations seem to start converging, but still differences
    - Tevatron will be the referee: DPE χ_c, χ_b, $\gamma\gamma$, dijet … production
  - New detectors needed at 400 m (mechanics, 3D silicon detectors?)
  - Optimize: acceptance of the detectors, mass resolution (alignment?)
  - L1 trigger: 400m RP signals are too late for L1 (ATLAS/CMS)
  - Background from inclusive and exclusive channels. Generators in place. Isolate exclusive events.
  - Study of other signals apart from bb ($\tau\tau$, WW in progress…)
- Note
  - Higgs is only part of a broad diffractive program @ LHC
  - Adding such detectors to LHC is NOT a walk in the park
  - Tevatron (HERA) RP experience at this stage of the project is vital!

Summary

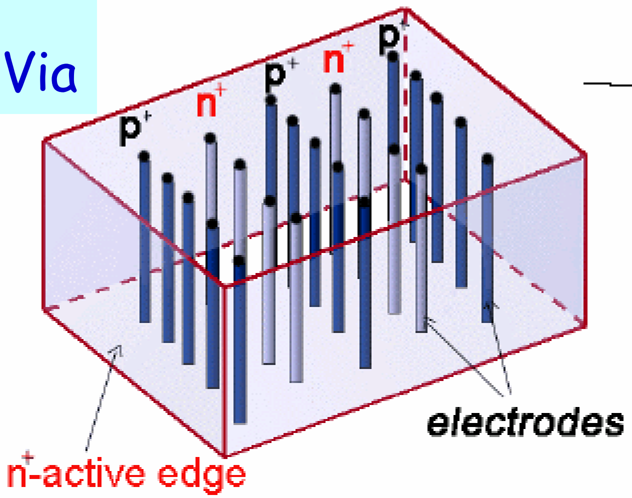
- Diffractive Higgs studies under way
  - Both DPE exclusive, inclusive, and also SPE
  - Plan for results for the LOI on diffraction and Forward Physics (spring 2005) and Physics TDR
- Main issues
  - Cross section ~ fb, but some diehards believe it could be still larger
    - SPE cross section large real gain still needs to be demonstrated
    - Tevatron will be the referee: DPE χ_c, χ_b, $\gamma\gamma$, dijet … production
  - Acceptance in the detectors, mass resolution (alignment?)
  - L1 trigger. Note: 215+400 m events should trigger via TOTEM+CMS
  - Background from inclusive and exclusive channels. Generators in place
  - New detectors at 400 m (mechanics, 3D silicon detectors?)
  - Study of other signals apart from bb ($\tau\tau$, WW…)

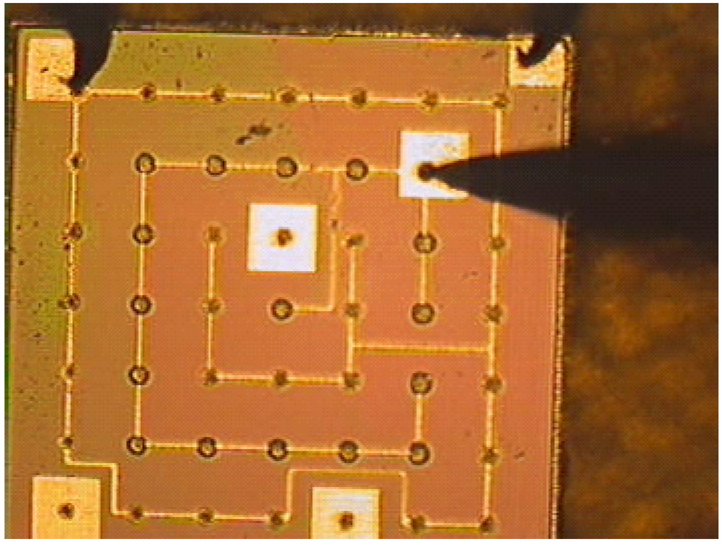
Detectors with Silicon: e.g.

3D DETECTORS AND ACTIVE EDGES

Brunel, Hawaii, Stanford

see:
C. Da Via



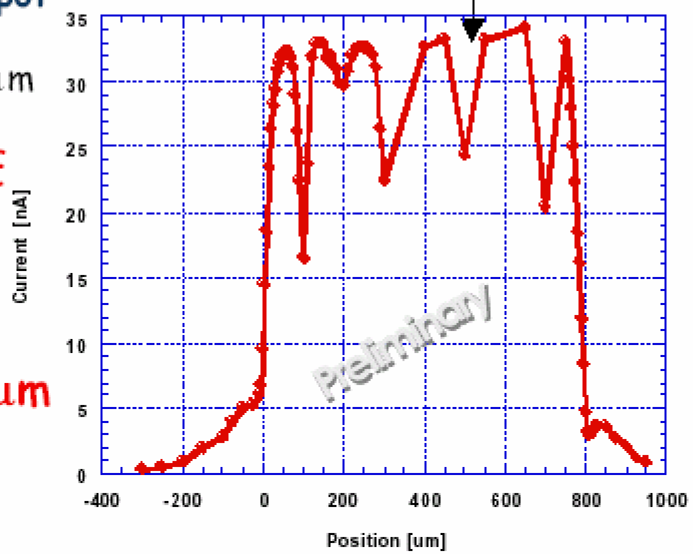


❖EDGE SENSITIVITY	<10 µm
❖COLLECTION PATHS	~50 µm
❖SPATIAL RESOLUTION	10-15 µm
❖DEPLETION VOLTAGES	< 10 V
❖DEPLETION VOLTAGES at 10^{15}n/cm^2	~105 V
❖SPEED AT RT	3.5 ns
❖AREA COVERAGE	3X3 cm^2
❖SIGNAL AMPLITUDE before Irradiation	24 000 e
❖SIGNAL AMPLITUDE at 10^{15}n/cm^2	15 000 e$^-$

❖15 µm InfraRed beam spot
❖FWHM = 772 µm
❖Edge Al strip width = 16 µm

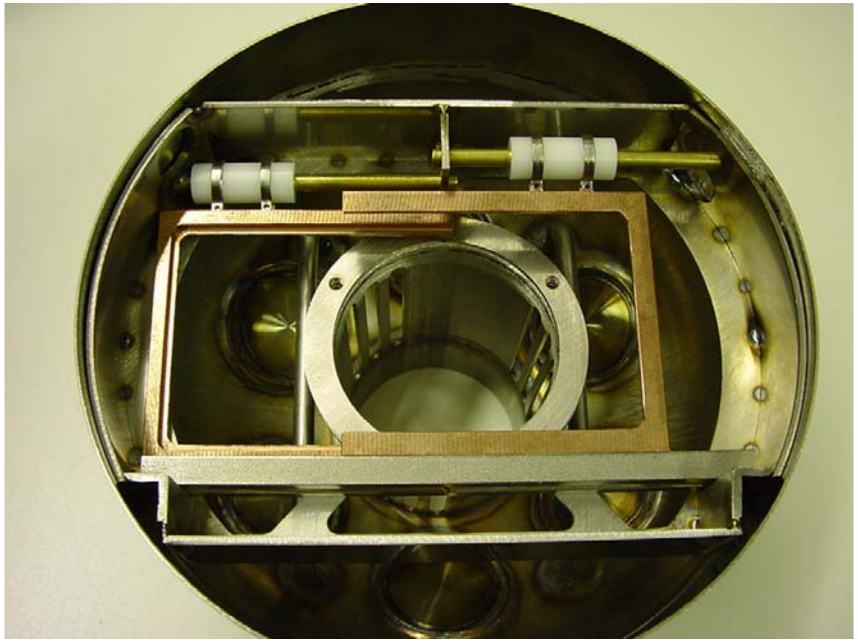
INSENSITIVE EDGE (INCLUDING 16 µm Al STRIP):

(813 - 772) / 2 = 21 µm



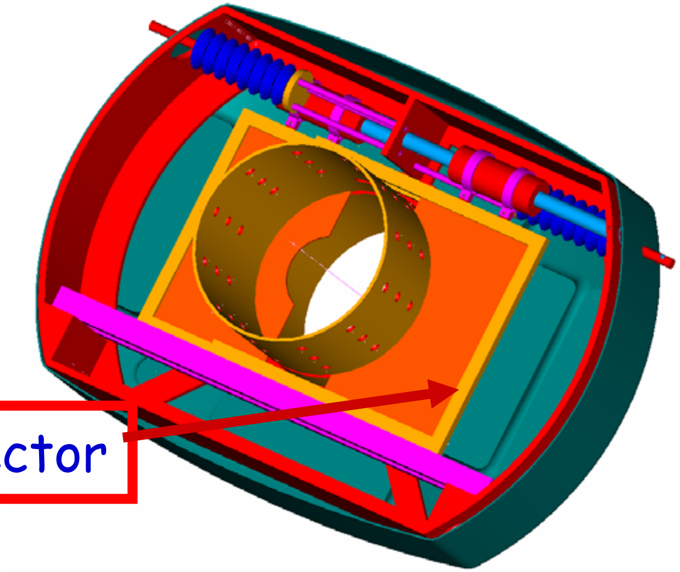
❖CERN Courier, Vol 43, Number 1, Jan 2003

Detectors: micro stations?



μ-station concept
(Helsinki proposal)

Silicon pixel or strip detectors in vacuum (shielded), 3D silicon...



Very compact!

Movable detector

- How close to mass shell are these detectors?
- They have not been in any testbeam/real environment yet.
- Which groups are interested to contribute to the developments?

It is the time for decisive R&D, test beam etc.

Summary

Problems with bb channel

- Trigger
  - 420 m signals are too late for the L1 trigger
  - The L1 trigger threshold in CMS for the jets is ~180 GeV
    - Even with topological tricks still a factor of ~10 is missing in rate (see studies from Helsinki, Wisconsin, Bristol)
    - Not final, but certainly not going to be easy
    - Note: rate determination contains a safety factor of 3-6
  - Probably ok for asymmetric events, ie. 1 proton tagged in the 220m Roman Pot + dijet trigger: needs testing.
    - However these events have a bad mass resolution measured in the pp system (1% $\rightarrow$6%)
- Background
  - QCD process gg$\rightarrow$bb(g), even when bb production suppressed at LO, gg$\rightarrow$qq(g) with misidentification…
  - S/B~1 at best, likely <1 (detector simulation)
- Detection efficiency of the bb
  - Need to identify b-quarks/loose typically factor of 2

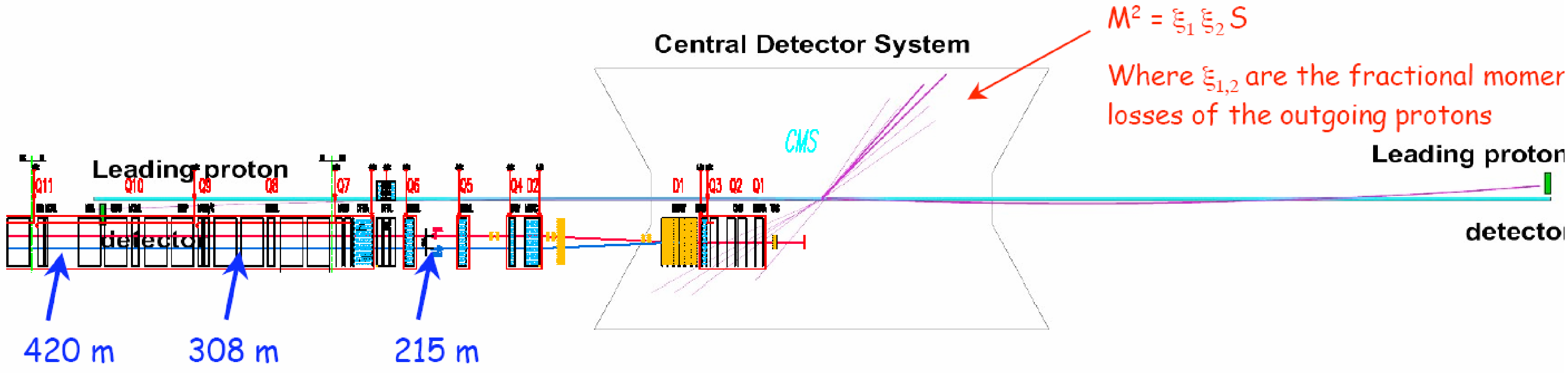
$\Rightarrow$ Are the other usable channels?

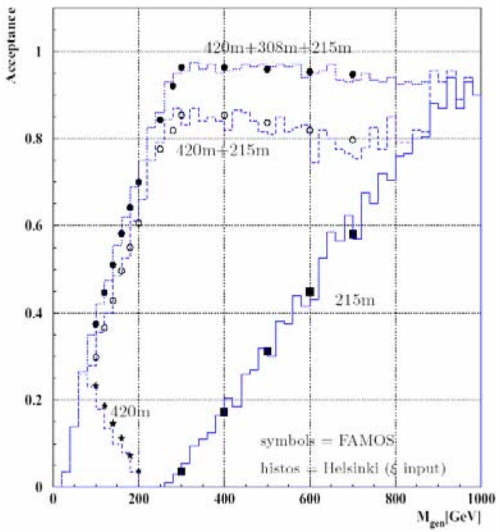
DPE Higgs event generators

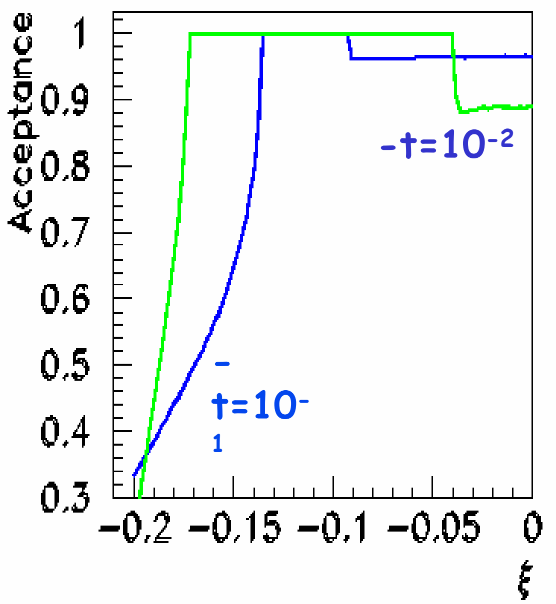
1. DPEMC 2.4 (M.Boonekamp, T.Kucs)
   - Bialas-Landshof model + rap.gap survival probability
   - Herwig for hadronization
2. EDDE 1.1 (V.Petrov, R.Ryutin)
   - Regge-eikonal approach
   - Pythia for hadronization
3. ExHuMe β version (J.Monk, A.Pilkington)
   - KMR model for exclusive diffraction
   - Pythia for hadronization

All three models available now in the fast CMS simulation!

Roman pot acceptances







High β* (1540m): Lumi 10^{28}-10^{31}cm^{-2}s^{-1}

- >90% of all diffractive protons are seen in the Roman Pots.
- Proton momentum measured with a resolution ~10^{-3}

Low β*: (0.5m): Lumi 10^{33}-10^{34}cm^{-2}s^{-1}

- 220m: $0.02 < \xi < 0.2$
- 300/400m: $0.002 < \xi < 0.2$
- (RPs in the cold region/ under discussion in CMS/ATLAS)

Excl.DPE H->WW:Event yields per L=10 fb-1

Both protons accepted in one of three RP stations (220,308,420):
57,66,68,75,80,85,90,100% for mh=120,135,140,150,160,170,180,200 GeV resp.

C1) single e: pt1 > 29 GeV, |η1| < 2.5

C2) two e: pt1,2 > 17 GeV, |η1,2| < 2.5

C3) single μ: pt1 > 14 GeV, |η1| < 2.1

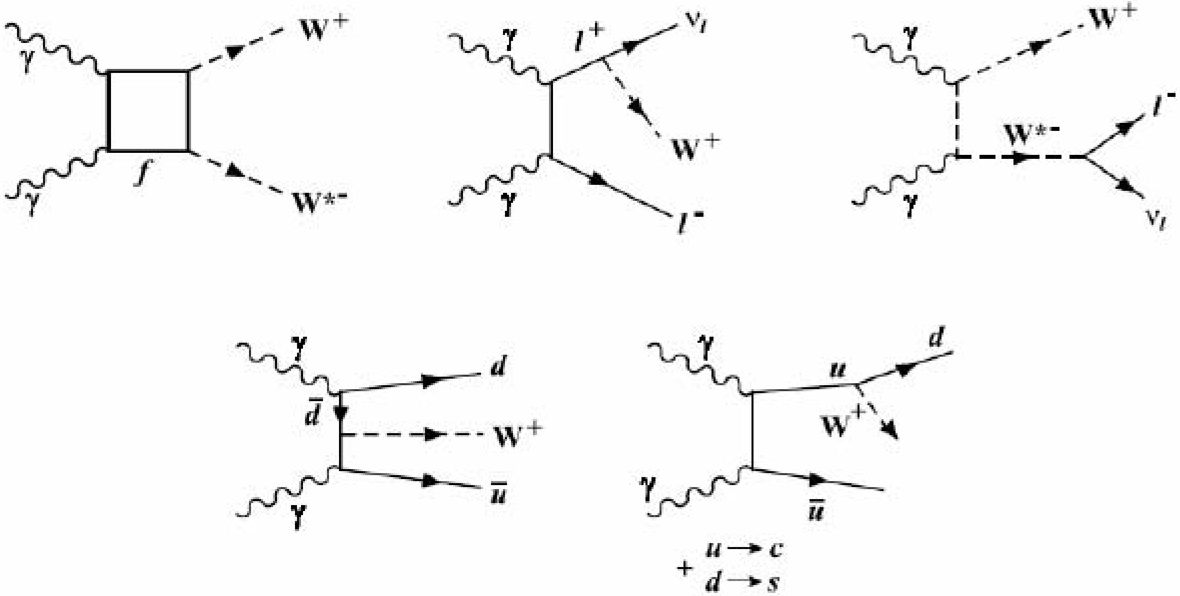
C4) two μ: pt1,2 > 3 GeV, |η1,2| < 2.1

C5) single e: pt1 > 20 GeV, |η1| < 2.5 + 2 quarks: pt1,2>25 GeV, |η1,2|<5

C6) single μ: pt1>10 GeV, |η1| < 2.1 + 2 quarks: pt1,2>25 GeV, |η1,2| < 5

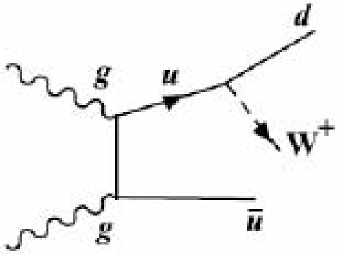
Numbers come from DPEMC generator level.
Only total numbers are scaled by KMR σxBR

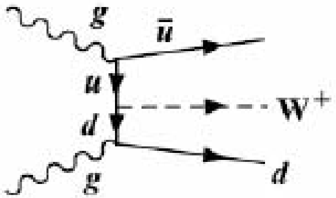
mh[GeV]	σxBR[fb	C1	C2	C3	C4	C5	C6	Total
120	0.34/0.40	0.14	0.01	0.27	0.02	0.02	0.07	0.5/0.6
135	0.98/0.81	0.51	0.04	1.04	0.06	0.15	0.28	2.1/1.7
140	1.23/0.92	0.71	0.07	1.38	0.07	0.24	0.37	2.8/2.1
150	1.72/1.05	1.32	0.10	2.19	0.12	0.58	0.71	5.0/3.1
160	2.26/1.10	2.22	0.17	3.08	0.17	1.37	1.34	8.4/4.1
170	2.36/1.01	2.50	0.20	3.62	0.16	1.54	1.59	9.6/4.1
180	2.22/0.80	2.46	0.18	3.60	0.16	1.45	1.45	9.3/3.3
200	1.69/0.48	2.20	0.15	3.00	0.14	1.16	1.18	7.8/2.2

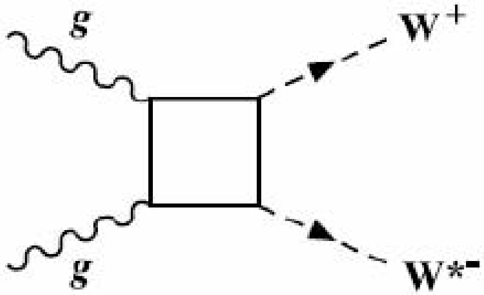


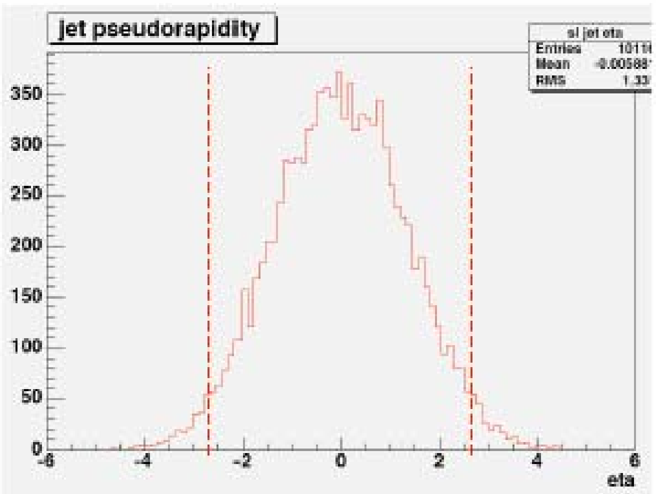
Calculated using CalcHEP

with centrality cuts ($|\eta|$ < 2.5 leptons and jets) and $\Delta M = 0.05\ M_H$
M_H = 120 GeV (140 GeV) $\sigma(WW^*)$ = 0.06 fb (0.12 fb)









$\sigma(M_H = 140 \text{ GeV}) = 0.8$ fb

Estimate reduction by factor of ~ 10 from jet / proton p_T cuts above WW threshold - more work needed below threshold.

Cross Section Calculations

- Fold either pomeron structure functions (as measured at HERA) or proton structure functions with the cross section $gg \to H$

$$\sigma_H \approx \frac{G_F \alpha_s^2}{288\pi\sqrt{2}} \tau \int_\tau^1 \frac{dx}{x} g_1(x, m_h^2) g_2(\tau/x, m_h^2)$$

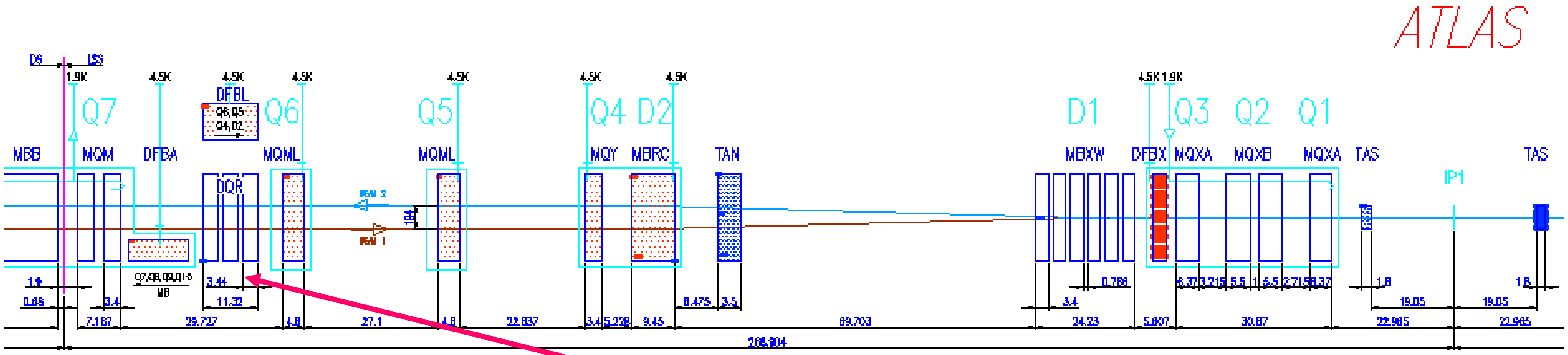
$$g_i(x, Q^2) = \int_x^{\xi_{max}} d\xi_i f_{\mathbb{P}/i}(\xi_i) g_{\mathbb{P}}(x/\xi_i, Q^2).$$

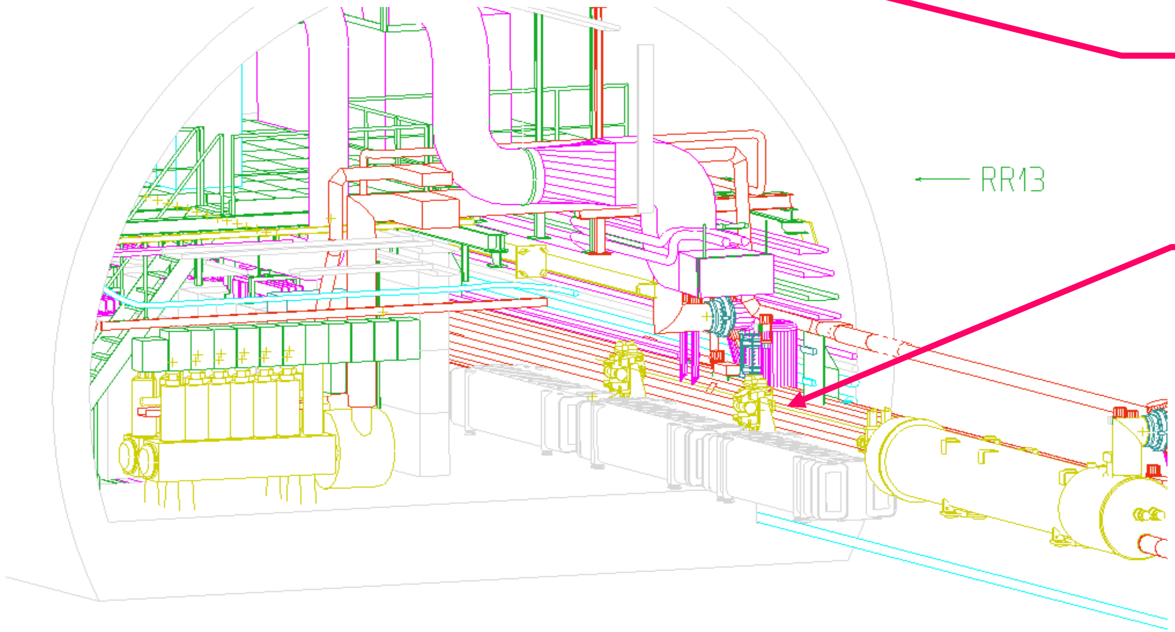
Important unknowns

- Energy dependence Pomeron flux factor $f_{\mathbb{P}/i}(\xi_i)$
- Normalization to di-jets (colour factor)
- Gap survival probability (SP) (factorization breaking)
  Normalize at Tevatron (di-jet data)
  Calculate (Khoze et al.: soft rescattering/QCD radiation in the gap)
  Some group do not take such SP into acount $\Rightarrow$ High cross sections!

Reliability of the cross section calculations?

Roman Pot Locations



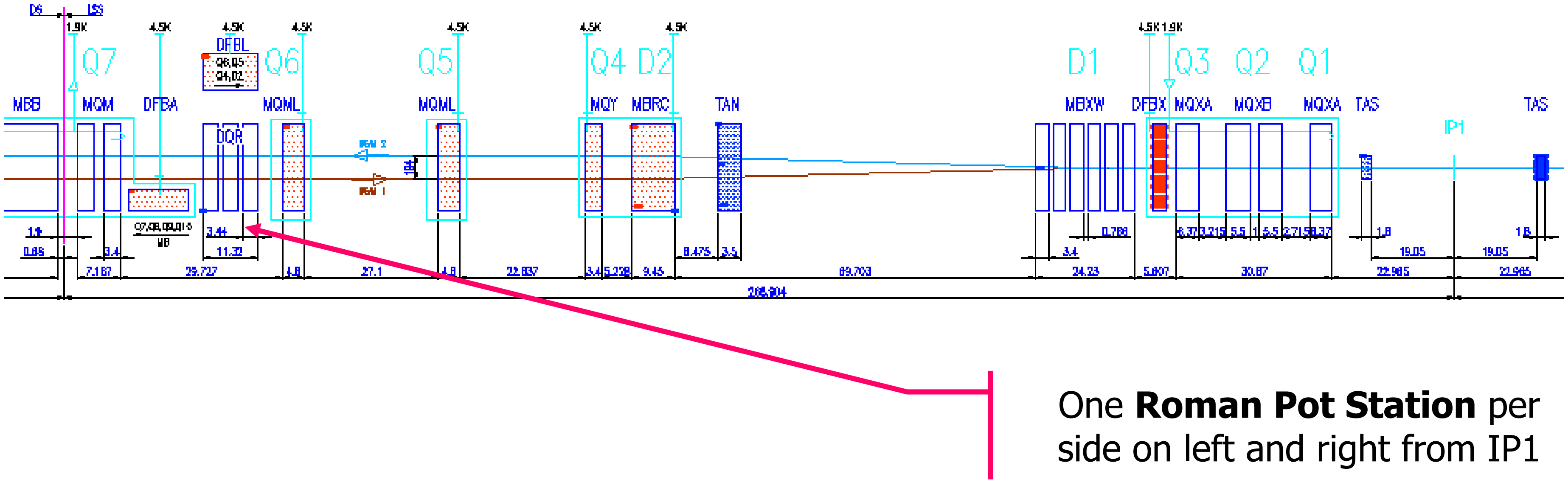


One **Roman Pot Station** per side on left and right from IP1

Each **RP station** consists of two **Roman Pot Units** separated by 3.4 m, centered at 240.0 m from IP1

Roman Pot Locations

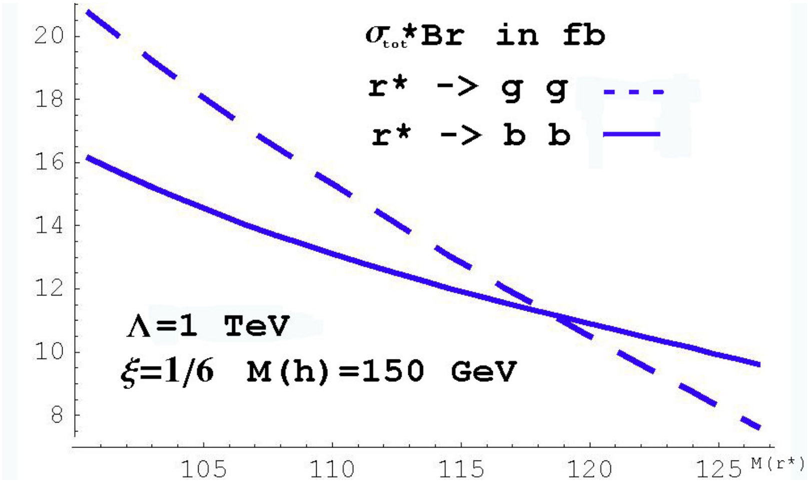
ATLAS

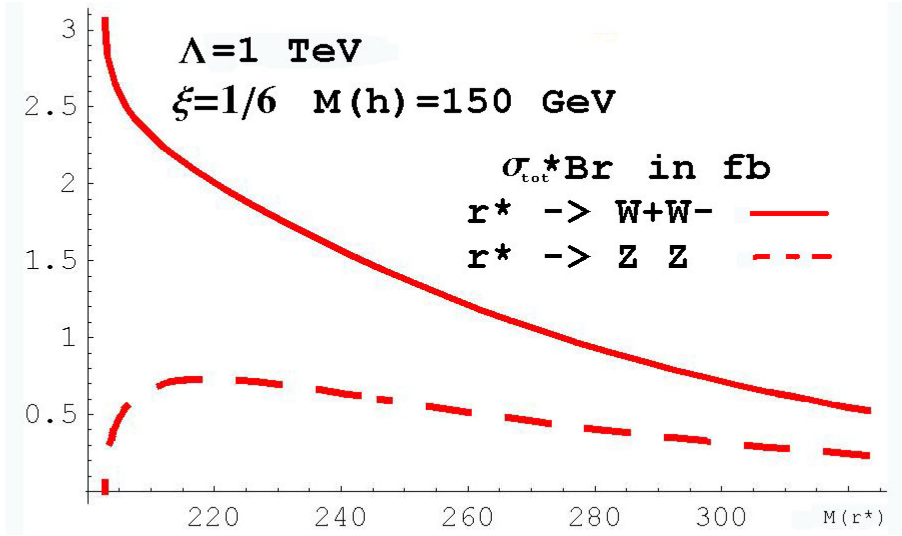


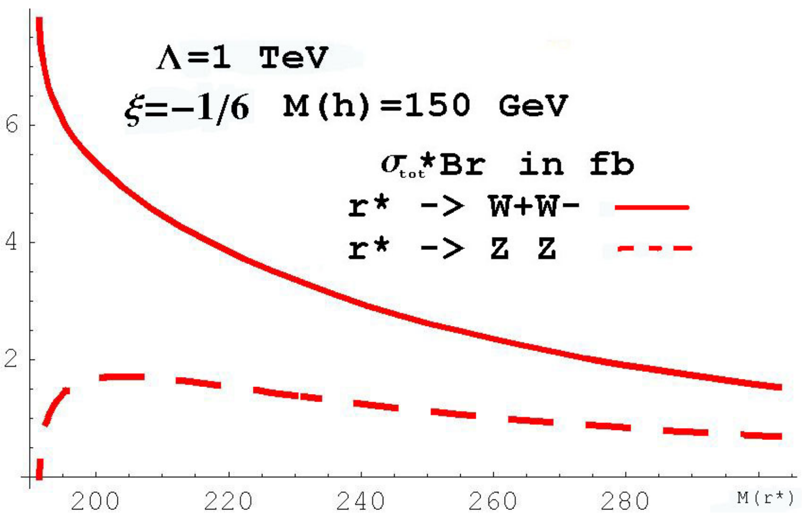
One **Roman Pot Station** per side on left and right from IP1

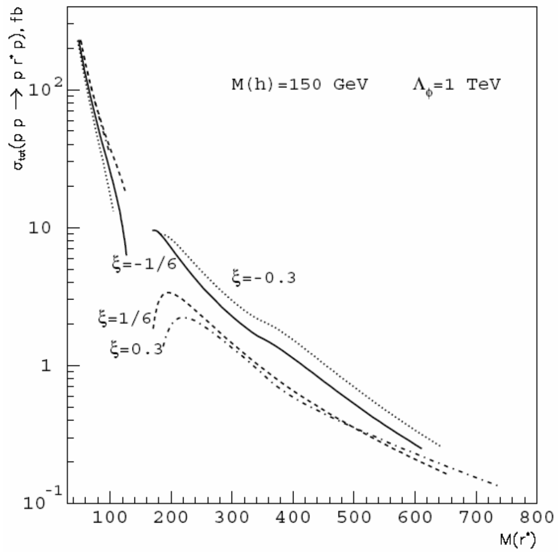
 

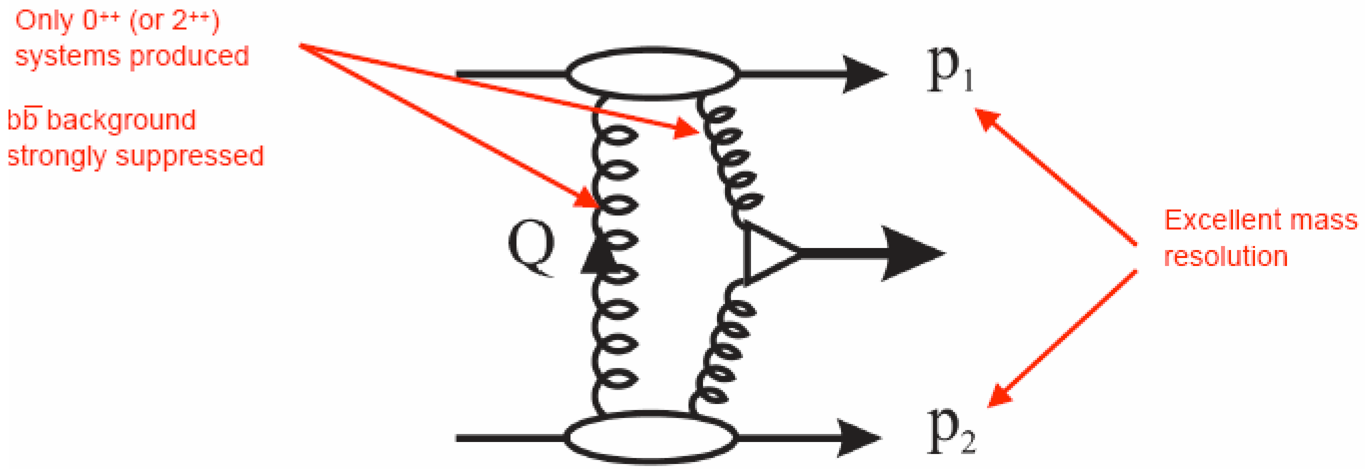
Radions


σtot*Br in fb
r* -> g g
r* -> b b
Λ=1 TeV
ξ=1/6 M(h)=150 GeV
20
18
16
14
12
10
8
105
110
115
120
125
M(r*)


Λ=1 TeV
ξ=1/6 M(h)=150 GeV
σtot*Br in fb
r* -> W+W-
r* -> Z Z
3
2.5
2
1.5
1
0.5
220
240
260
280
300
M(r*)


Λ=1 TeV
ξ=−1/6 M(h)=150 GeV
σtot*Br in fb
r* -> W+W-
r* -> Z Z
6
4
2
200
220
240
260
280
M(r*)


M(h)=150 GeV
Λφ=1 TeV
ξ=-1/6
ξ=-0.3
ξ=1/6
ξ=0.3
10^2
10
1
10^-1
100
200
300
400
500
600
700
800
M(r*)



Only 0++ (or 2++)
systems produced
bb̄ background
strongly suppressed
Q
p1
p2
Excellent mass
resolution

Where we stand in the UK now

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture. (Manchester, Bristol, Brunel, IPPP, RAL, Glasgow, Cockroft institute)

Design, fabrication, assembly and cold validation estimate 24 -30 months.

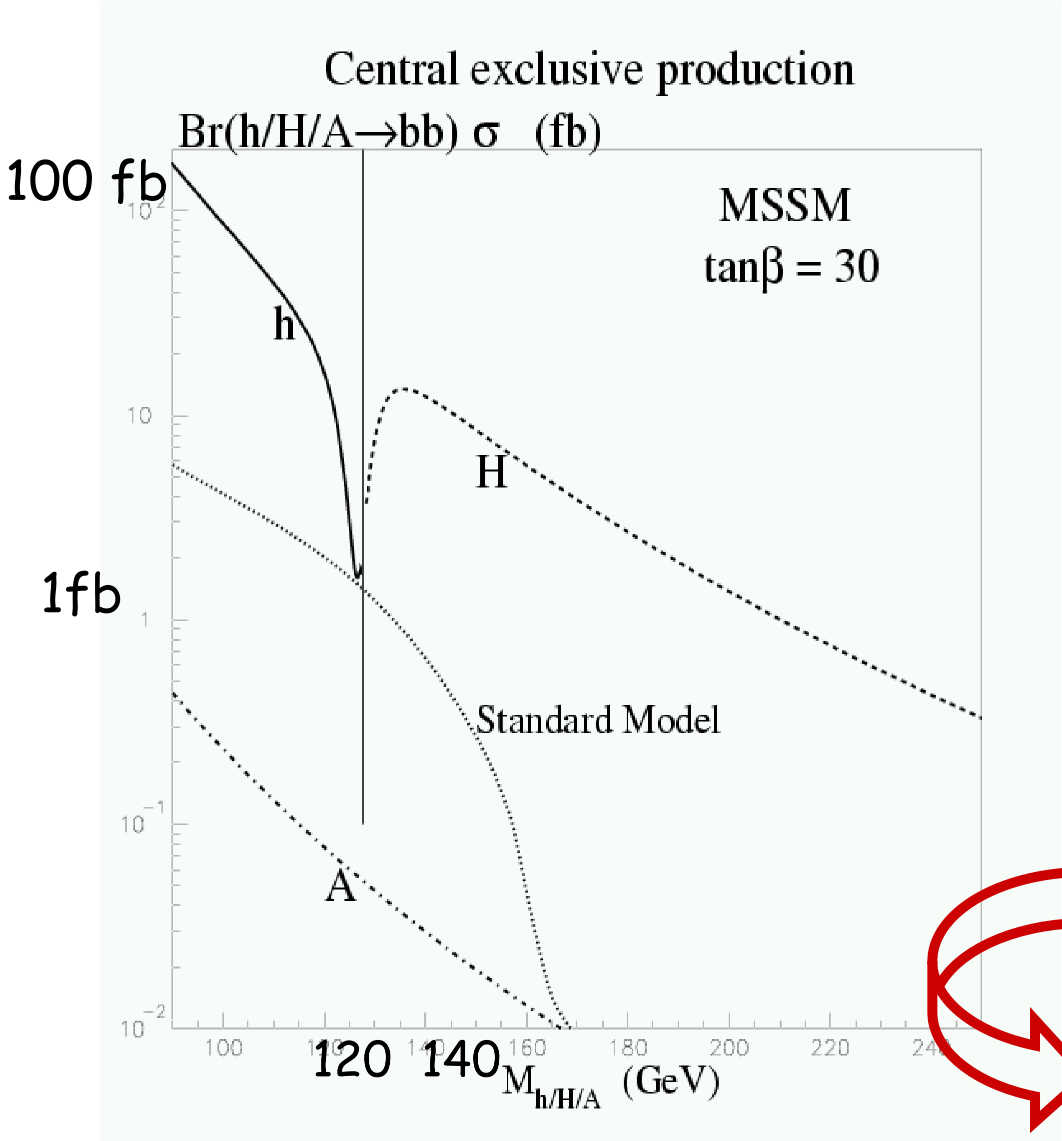
There is a planned shutdown long enough for installation in autumn 2008.

We will bid for a cryostat engineer to work on R&D with CERN - hope to start Oct 2005

We have been asked to submit a detailed bid to PPRP early next year, with the caveat :

• The FP420 consortium may not participate in the current 220m programs as part of this bid

Higgs Studies



SM Higgs: (30fb^{-1})
11 signal events (after cuts)
O(10) background events

Cross section factor
~ 10-20 larger in MSSM
(high tanβ)

Kaidalov et al.,
hep-ph/0307064

⇒Study correlations between the outgoing protons to analyse the spin-parity structure of the produced boson

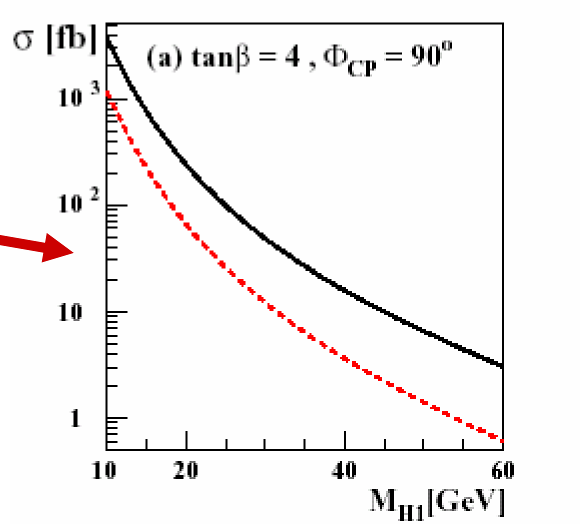
A way to get information on the spin of the Higgs
⇒ADDED VALUE TO LHC

Beyond Standard Model

Diffractive production of new heavy states pp→ p + M + p
Particularly if produced in gluon gluon (or γγ) fusion processes

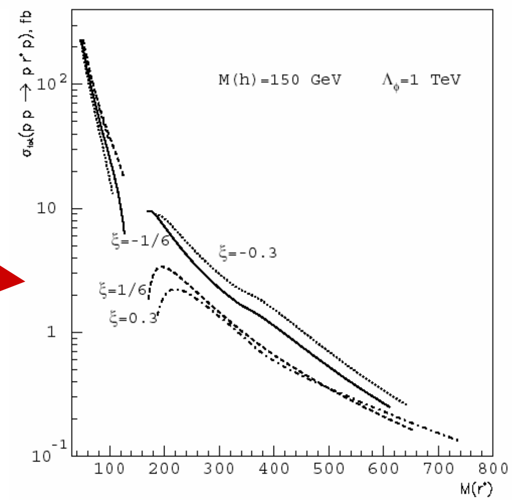
Examples:

Light CP violating Higgs Boson $M_H < 70$ GeV
B. Cox et al.



Light MSSM Higgs h→bb at large tan β
Light H,A (M<150 GeV) in MSSM with
large tan β (~ 30) → S/B > 10
Medium H,A (M=150-200 GeV) medium tan β?
V. Khoze et al.

Radion production - couples strongly to gluons
Ryutin, Petrov

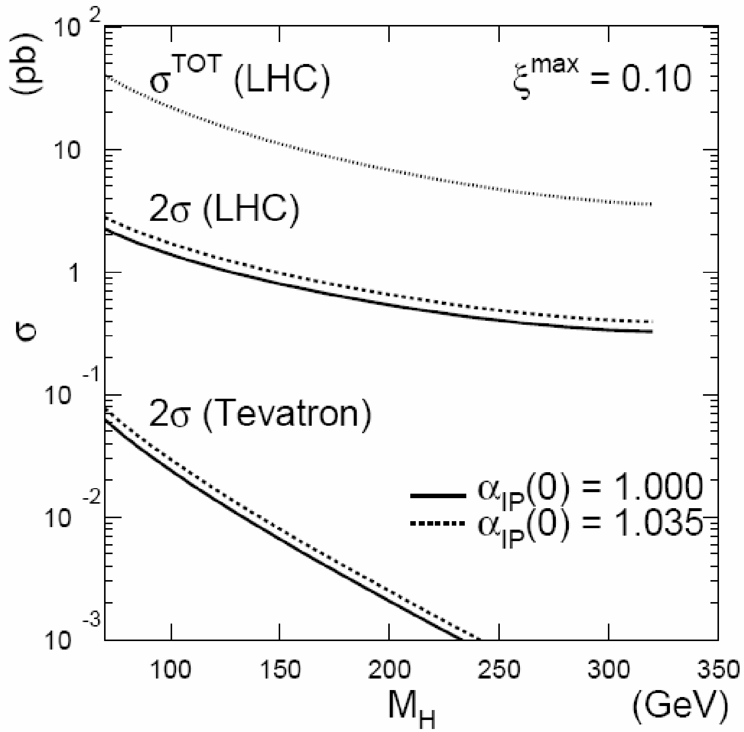


Exclusive gluino-gluino production?
Only possible if gluino is light (< 200-250 GeV)
V. Khoze et al.

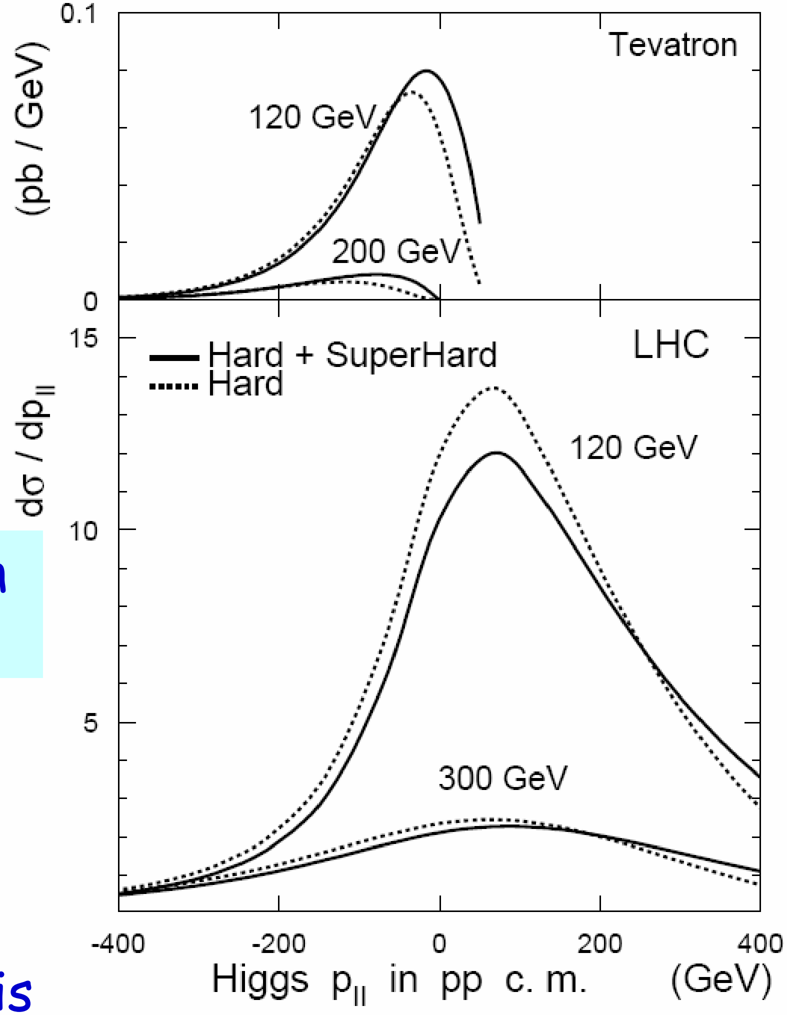
Single Pomeron Exchange

Erhan, Kim and Schlein hep-ph/0312342

SPE: ~7% of inclusive cross section



Gap suppression included?



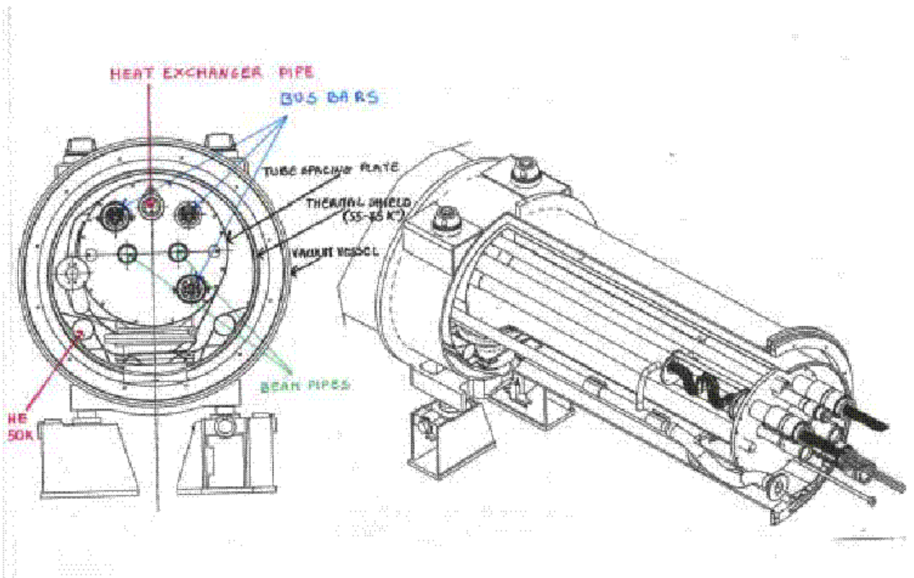
Ingelman-Schlein model implementation
⇒based on UA8 measured structure functions and Schlein et al. flux factor analysis

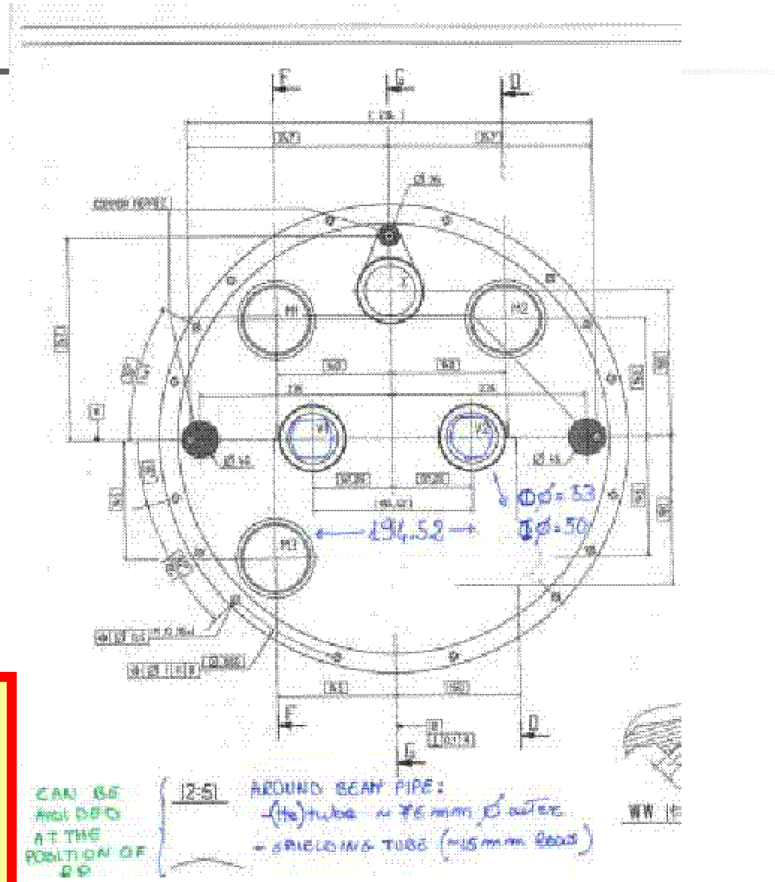
Gain e.g. w.r.t. total inclusive production is under study

Detectors at 300/400m

- Initial discussions with the machine group (early 2002; D. Marcina)
- Cold section: Detectors have to be integrated with cryostat

  Is a bypass an option? 15m cold-warm transition… SC services…

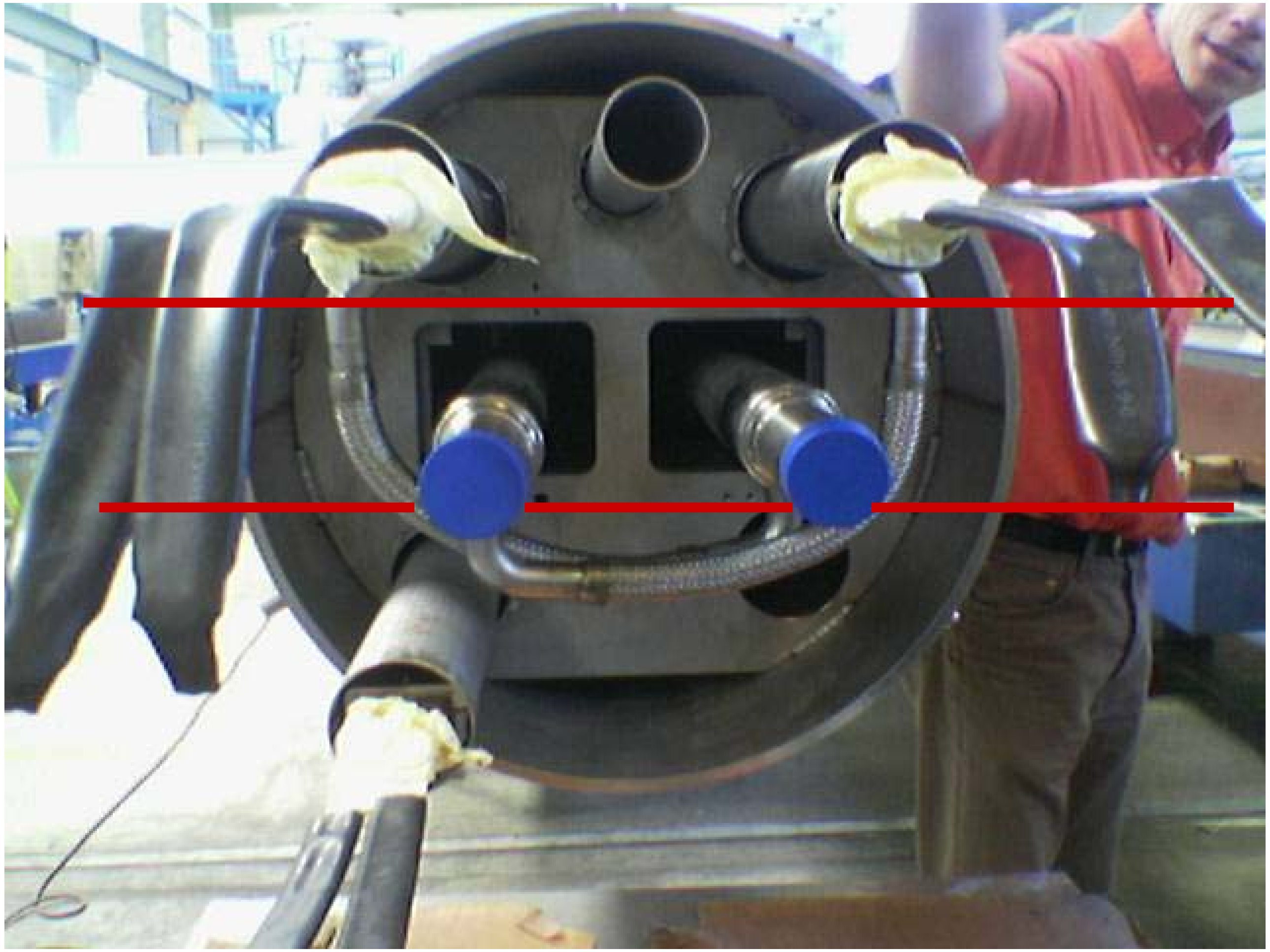




- Many machine components already ordered, some already delivered
- Machine wants "easy" start-up/no perturbation

  ⇒ Change means an "LHC upgrade" (phase II)

Cryostat upgrades



Very positive discussions with the machine group

Possible to modify the cryostat in future!

Two sections in cold but the detectors warm

Could be exchanged during a shutdown
Earliest autumn 2008

UK: Project submitted to PPARC for cryostat and detector R&D

Forward detectors in CMS software

OSCAR/ORCA

- CASTOR
  - in OSCAR (one side) done — S. Zohkin/CMS
  - in ORCA in progress — H. Neal/CMS
- Include T2/T1 (GEMs for T2)/ no ORCA yet — F. Ferro/Totem
- No simulation of Roman pot acceptance yet
  - Look-up tables or parametrization (⇒updated needed from TOTEM)

  ⇒ Plan to put M Tasevsky FAMOS version in ORCA
- ZDC work started in OSCAR — M. Murray,M Lehnher/CMS

FAMOS

- Includes RP acceptance tables — M. Tasevsky/CMS (based on work/thesis by the Helsinki group)
- Work started on CASTOR — E Sarkysian/CMS

Generators

- Several special diffractive Higgs generators interfaced (EDDE, DPEHiggs)
- Inclusive and exclusive DPE background (bb) available as well

Interested Groups & Activity

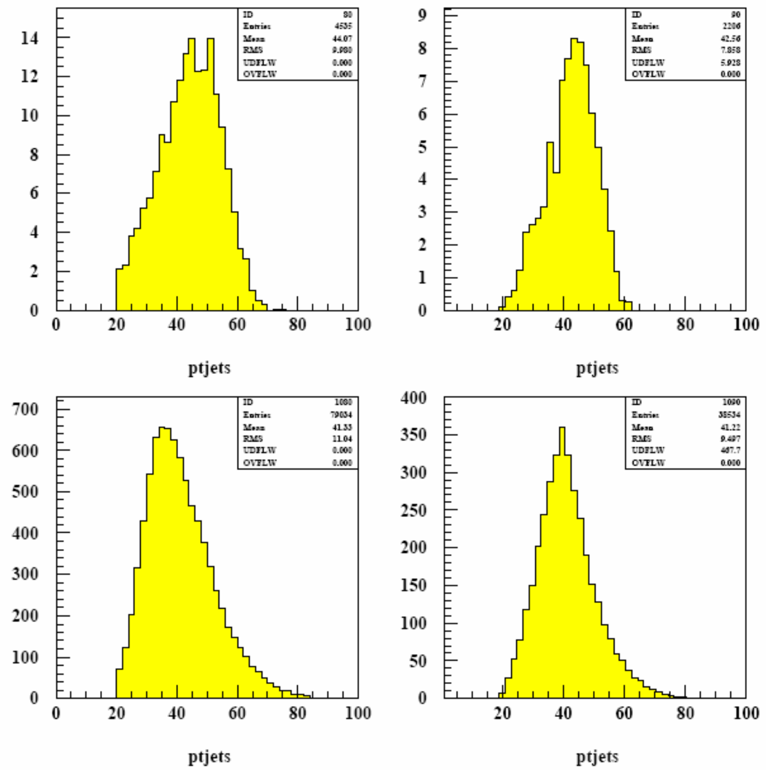
- Wisconsin C. Hogg, M. Grothe, S. Dasu (L1 trigger)
- Bristol D. Newbold, Richard Croft (L1 trigger)
- CERN/Antwerp M. Tasevsky, (ADR),+ (Simulation/analysis)
- Saclay C. Royon + students (Simulation/analysis)
- Helsinki R. Orava, K. Osterberg + students (trigger and analysis)
- UCLA/Caltech P. Schlein, S. Erhan, T. Lee, (H. Newman) (SPE channel)
- Protvino V. Petrov, R. Ryutin (theory studies)

- OSCAR Simulation (for studies with the central detector only)
  100 K signal events (Wisconsin) + 1M special QCD jet background events/ to be analysed
- FAMOS studies ongoing
- CMSJET "pre-studies"
- Development of generators (Saclay, Protvino, Annecy)

DPE Higgs Jet Characteristics

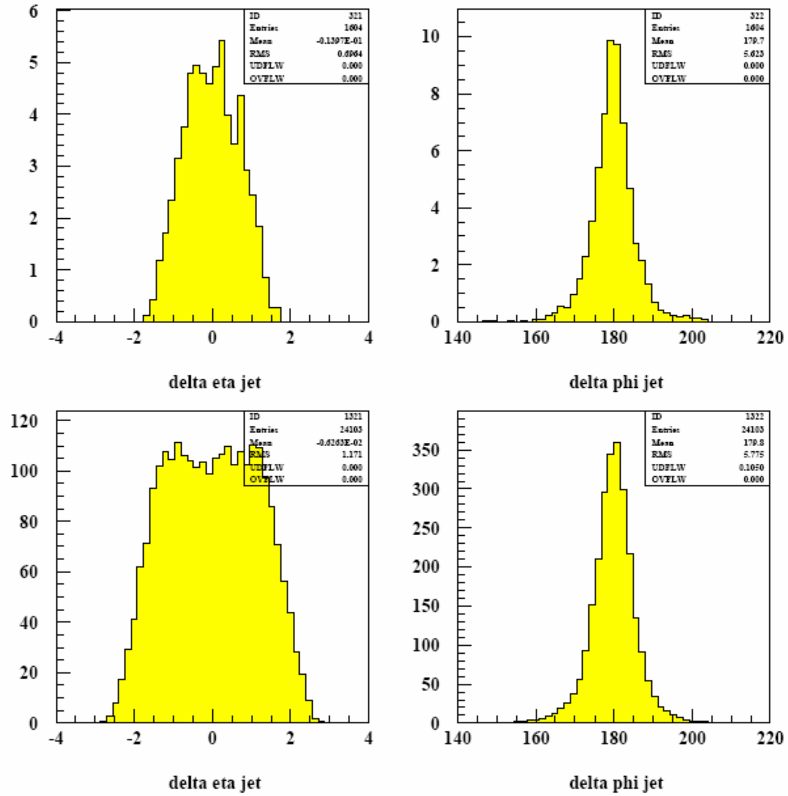
Jet p_T

2 leading jets p_T for signal and exclusive $b\bar{b}$ background



Jet $\Delta\eta$ and $\Delta\Phi$

2 leading jets $\Delta\eta$ and $\Delta\Phi$ for signal and exclusiv $b\bar{b}$ background

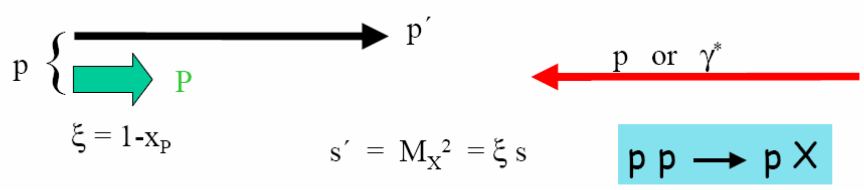


C. Royon/Detector study for CMS

SPE studies (very preliminary)

Study H→bb and H → τ τ → ljννν

T. Lee

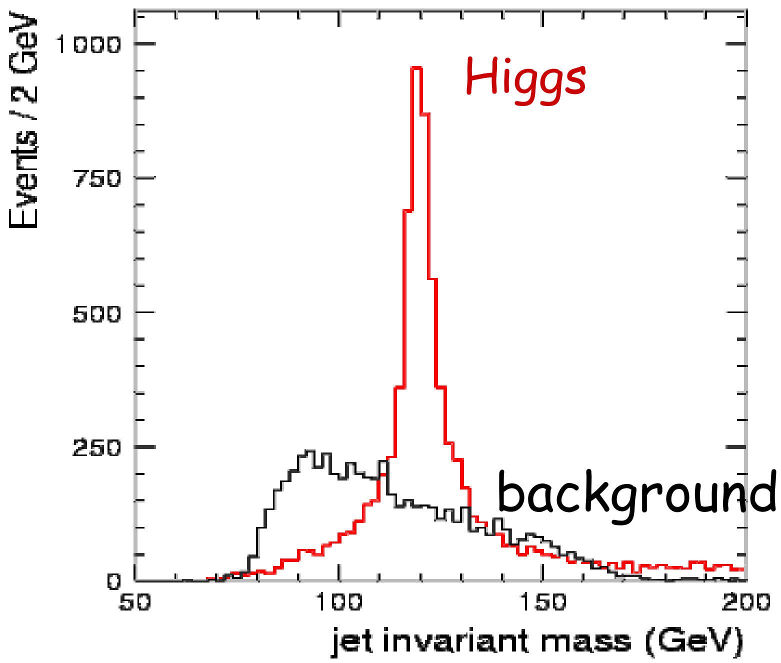


Generator study (pythia) H→bb
- Signal 580 fb
- Background (preselected) 2.10⁷ fb

Cut	Signal	Background
	12000	135000
$\geq$ 2 jets	8426	5922
110 GeV $\leq m_{jj} \leq$ 130 GeV	4710	1453
$E_{T1} \geq$ 55 GeV	3554	688

30% 0.1%

Shape only

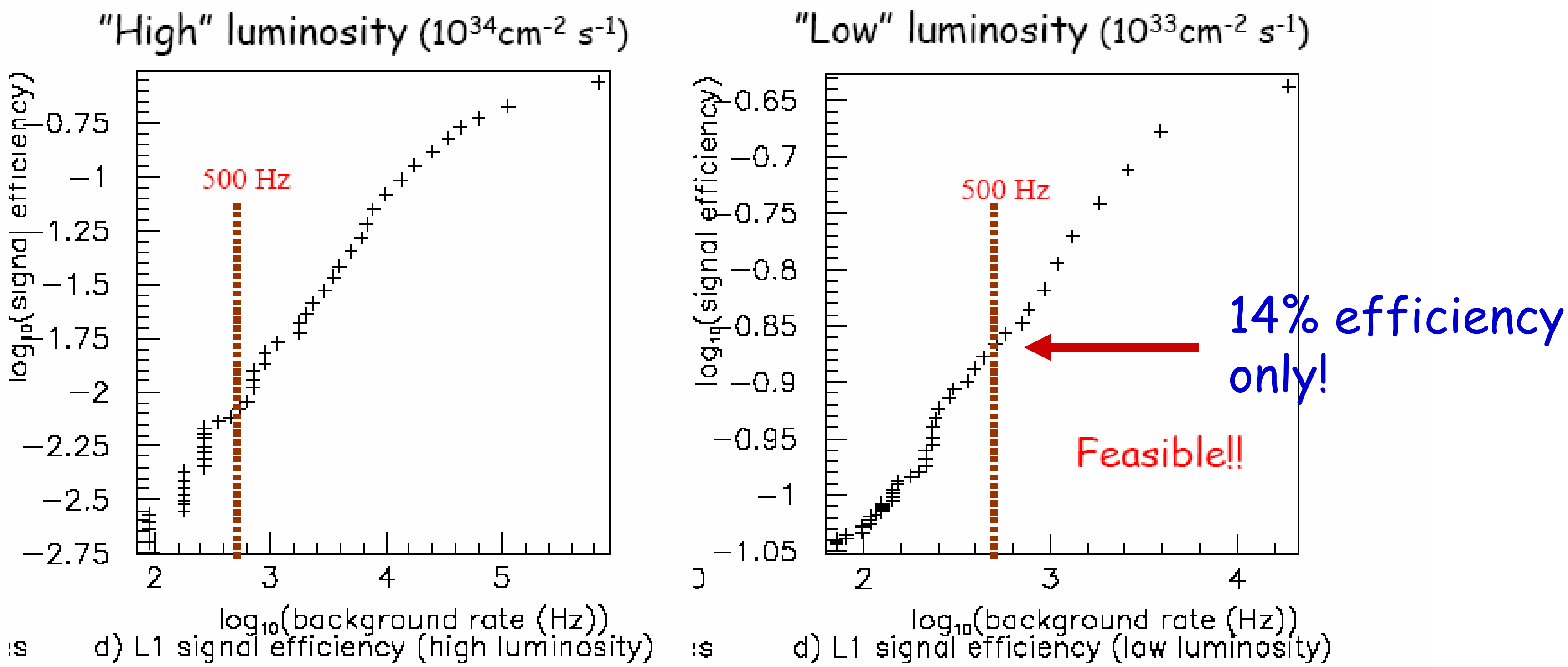


Background still 2-3 orders of magnitude larger than signal
So far no gain w.r.t. inclusive case

Trigger Studies

Preliminary results on L1 triggering of a 120 GeV Higgs

R. Orava et al



Preliminary first study

Will be repeated with complete CMS trigger simulation !!

Improvements should be possible by using also T2 & CASTOR !!

Resolutions

Leading proton acceptance & resolution studies

- $pp \to p + X + p$ simulated using PHOJET1.12
- Protons tracked through LHC6.2 optics using MAD8

Simulated experimental leading proton uncertainties:

- Initial conditions at interaction point
  - Transverse vertex position ($\sigma_{x,y}$ = 16 μm)
  - Beam energy spread ($\sigma_E = 10^{-4}$)
  - Beam divergence (σ_θ = 30 μrad)
- Conditions at detector location
  - Position resolution of detector ($\sigma_{x,y}$ = 10 μm)
  - Resolution of beam position determination ($\sigma_{x,y}$ = 5 μm)

T. Mäki, MSc (eng.) thesis;
HIP-2003-11/EXP

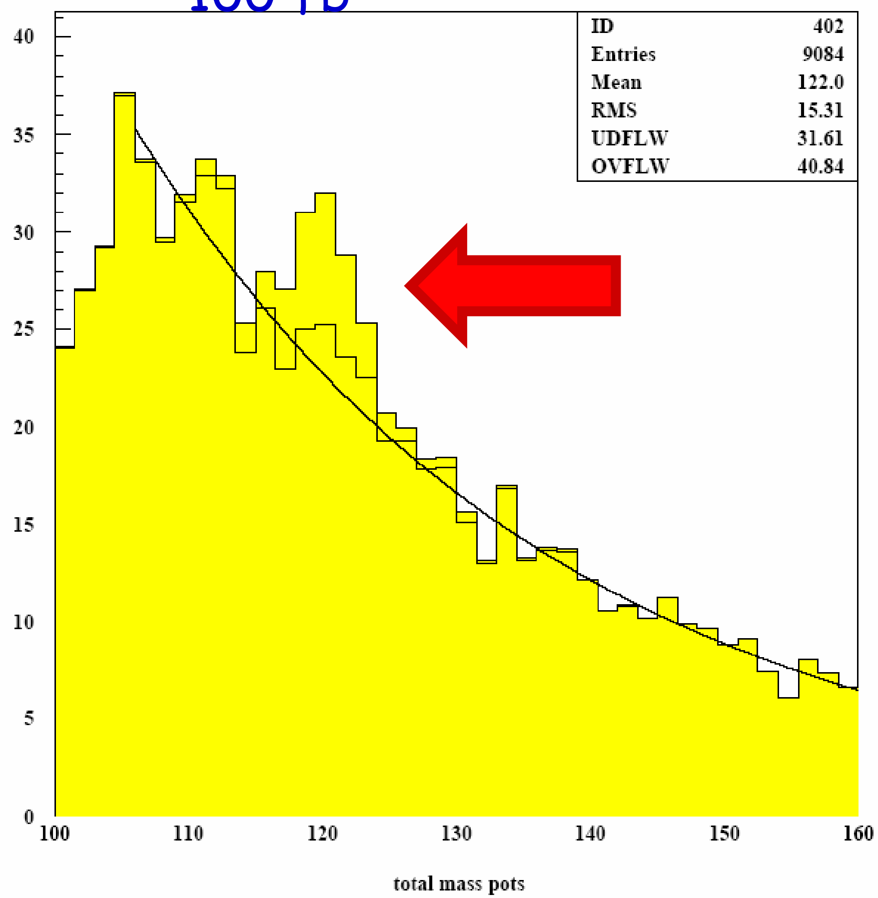
Also systematic offsets at detector locations has been studied.

Detailed simulation studies

Background and signal

For a Higgs mass of 120 GeV

100 fb^{-1}



Detailed studies are starting now

Boonekamp/ATLAS
Royon/CMS

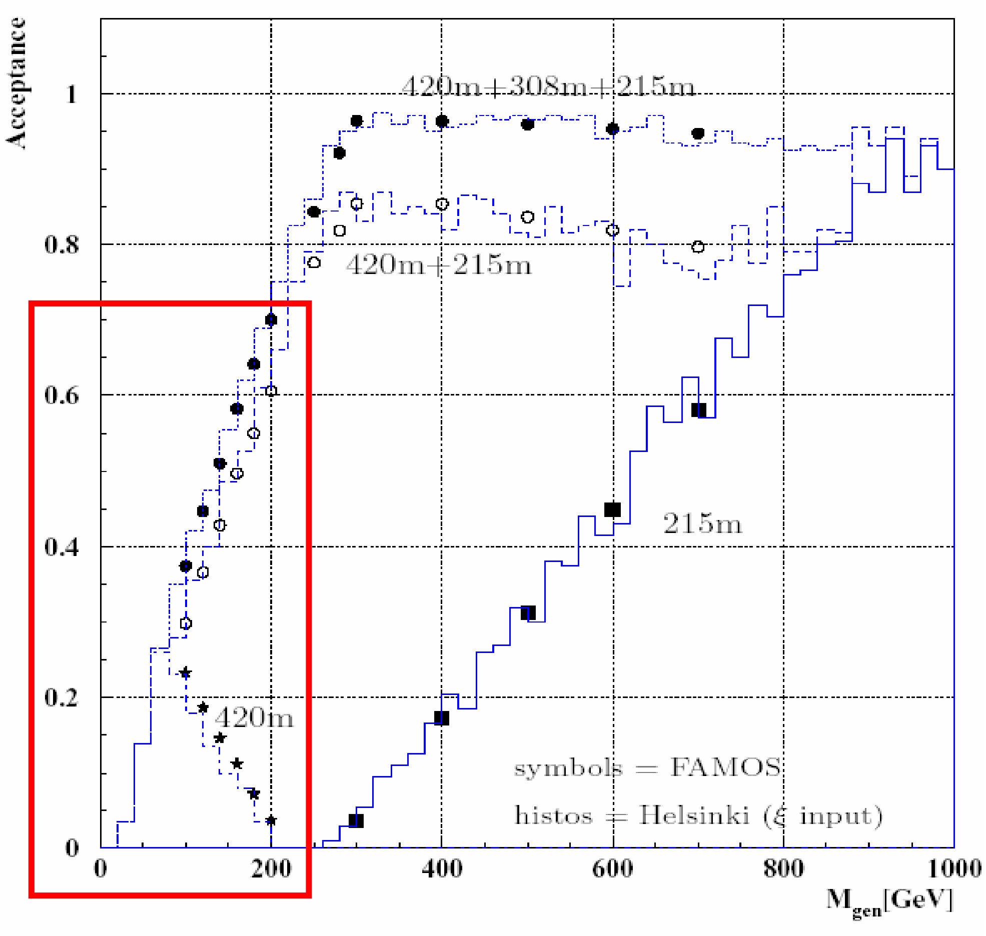
Include exclusive and inclusive bb background

Include missing mass resolution (not correctly used –correlations!!- resolution should be 1.5-2 better than shown here)

First look/needs to be optimized

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

How does the 420m program fit with the current 220m programs?



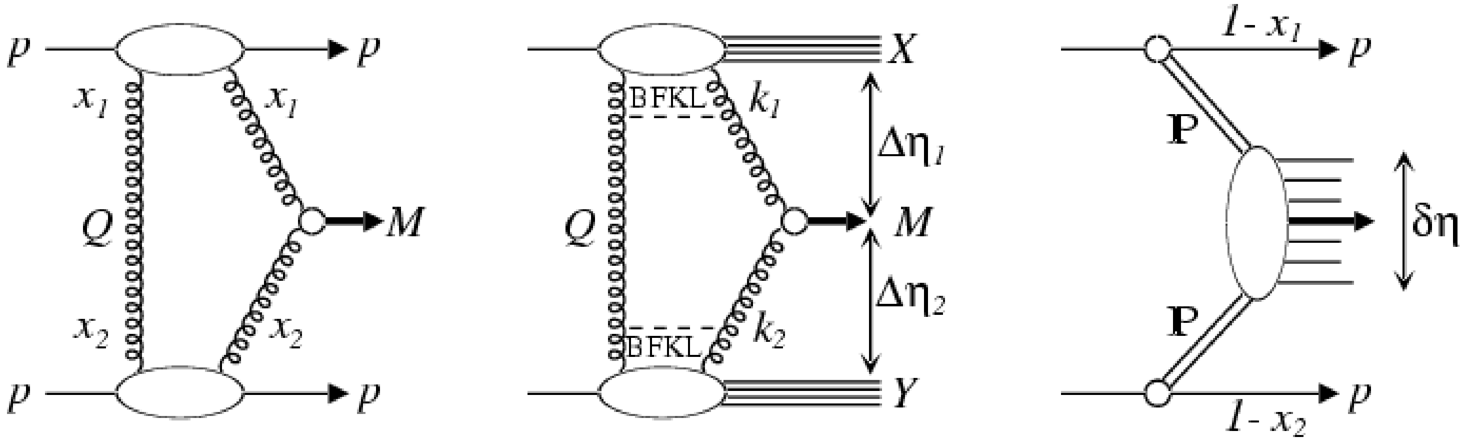
- Contributes largely for asymmetric events - i.e. one P at 220m, one P at 420m
- Increases acceptance by ~ 2 at 120 GeV
- Will provide a trigger for difficult central systems

Helsinki group

Studied Processes (DPE)

Exclusive processes

Inclusive processes



Bialas and Landhoff '91
Since then studied by many groups
Kaidalov, Khoze, Martin Ryskin **hep-ph/0111078**
ADR et al. hep-ph/02/07042
Boonekamp et al. hep/ph0205322
Endberg et al. **hep-ph/0210408**
V. Petrov and R. Ryutin **hep-ph/0210408**
Cox et al. hep-ph/0110173