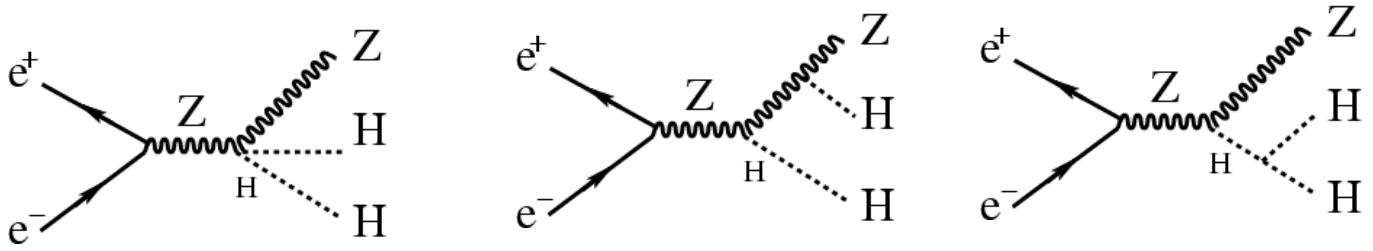
H self-coupling literature review

daniel jeans 10.08.2007

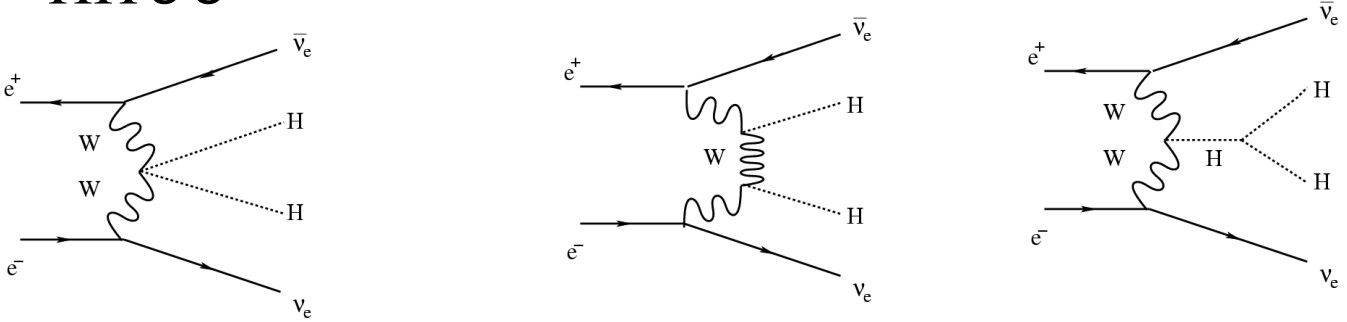
- various groups studying Higgs self-coupling now or in the recent past (= LCWS 06 & 07):
  - Moenig, Rosca – DESY, Timisoara
    - mh=140->200; HHvv; gen-level
  - Barklow – SLAC
    - mh = 120; ZHH; fastsim
  - Pascal et al – IN2P3
    - mh=120; ZZH + HHvv (W fusion); fastsim
  - Faucci Gianelli et al – Royal Holloway
    - mh = 120; ZHH; fullsim

signal diagrams

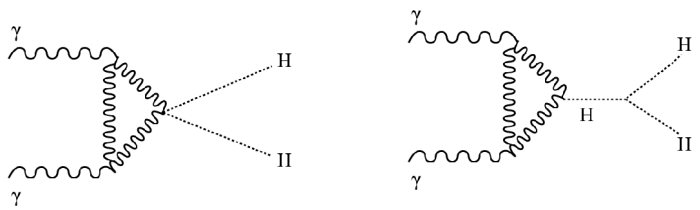
$e^+ e^- \to \mathrm{HHZ}$



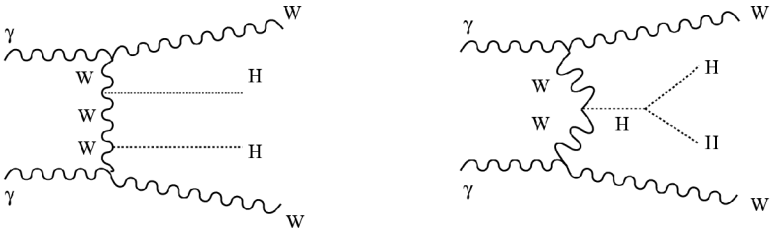
$e^+ e^- \to \mathrm{HH}\upsilon\bar{\upsilon}$



$\gamma\gamma \to \mathrm{HH}$



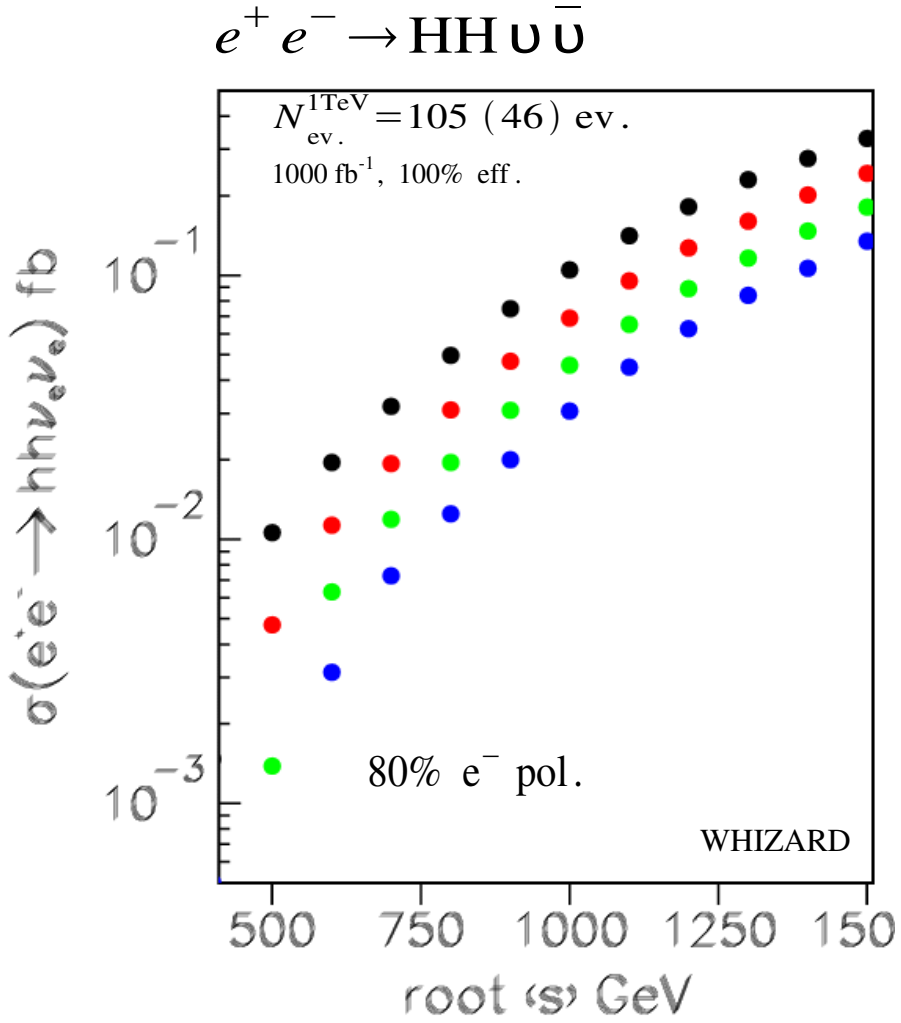
$\gamma\gamma \to \mathrm{HHWW}$

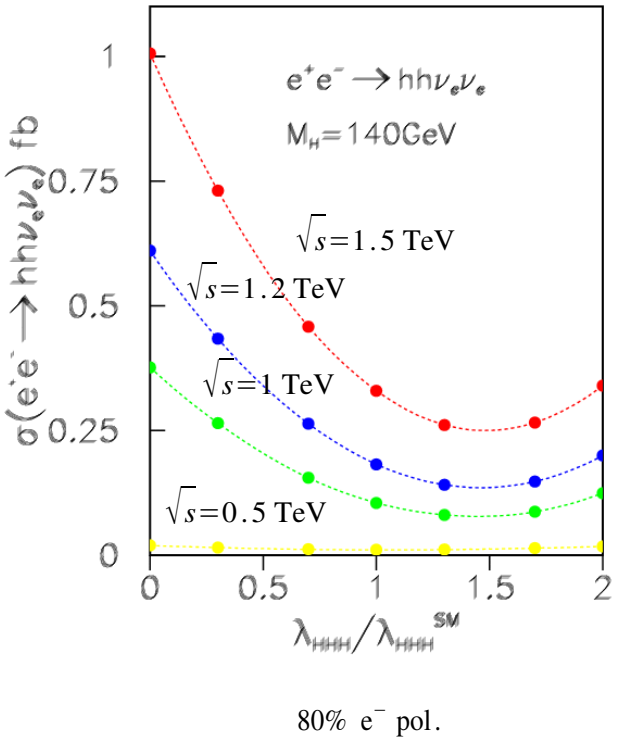


Monig, Rosca

- W fusion, e+e- -> Hhvv
- mh = 140 -> 200 GeV
- generator level, no simulation, selection
- xsecs vs energy, coupling, mh

W fusion xsec vs. energy, mh = 140, 160, 180, 200 GeV

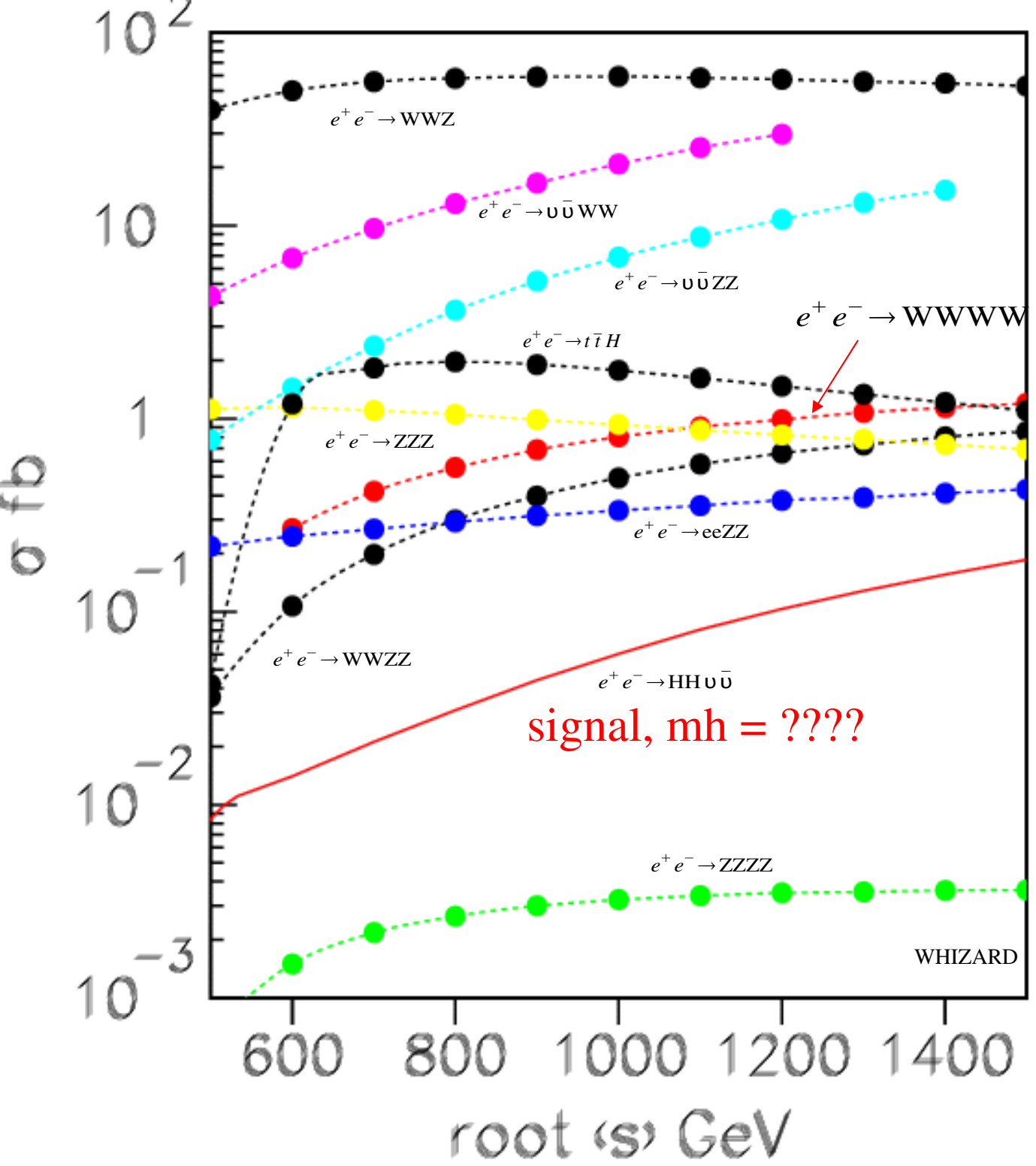




80% e$^-$ pol.

vs. energy,

anom. coupling const



signal & background processes vs energy

Cross sections for all processes are calculated with WHIZARD

Barklow

- ZHH, mh=120 @ 500 GeV
- full (SM) 0,2,4,6 fermion processes (WHIZARD)
- 8 fermions processes with t quark (WHIZARD)
- fast sim
- zvtop b tagging
- jet pair masses -> NN selection

SM Final States

0-fermion

$e^+e^- \to$	$\gamma\gamma$	
	$\gamma\gamma\gamma$	
	$\gamma\gamma\gamma\gamma$	
	$\gamma\gamma\gamma\gamma\gamma$	

2-fermion

$e^+e^- \to$	$f\bar{f}$	$f \neq \nu$
	$\nu\bar{\nu}\gamma$	
	$\nu\bar{\nu}\gamma\gamma$	
	$\nu\bar{\nu}\gamma\gamma\gamma$	
$e^-\gamma \to$	$e^-\gamma$	
$\gamma e^+ \to$	$e^+\gamma$	

4-fermion

$e^+e^- \to$	$\nu\bar{\nu}\nu\bar{\nu}\gamma$	6 total
	$u_j\bar{d}_j d_k\bar{u}_k$	25 total
		$\nu_e e^+ e^- \bar{\nu}_e$
		$\nu_e e^+ \mu^- \bar{\nu}_\mu$
		$\nu_e e^+ \tau^- \bar{\nu}_\tau$
		$\nu_e e^+ d\bar{u}$
		.
		.
		$c\bar{s}s\bar{c}$
	$u_j\bar{u}_j u_k\bar{u}_k$	9 total
	$u_j\bar{u}_j d_k\bar{d}_k$	25 total
	$d_j\bar{d}_j d_k\bar{d}_k$	21 total
$\gamma\gamma \to$	$f\bar{f}$	8 total
$e_L^-\gamma \to$	$\nu_e d_k\bar{u}_k$	5 total
$e^-\gamma \to$	$e^- f\bar{f}$	10 total
$\gamma e_R^+ \to$	$\bar{\nu}_e u_k\bar{d}_k$	5 total
$\gamma e^+ \to$	$e^+ f\bar{f}$	10 total

6-fermion

$e^+e^- \to$	$u_i\bar{u}_i u_j\bar{d}_j d_k\bar{u}_k$	125 total
	$d_i\bar{d}_i u_j\bar{d}_j d_k\bar{u}_k$	150 total
	$u_i\bar{u}_i u_j\bar{u}_j u_k\bar{u}_k$	25 total
	$u_i\bar{u}_i u_j\bar{u}_j d_k\bar{d}_k$	65 total
	$u_i\bar{u}_i d_j\bar{d}_j d_k\bar{d}_k$	75 total
	$d_i\bar{d}_i d_j\bar{d}_j d_k\bar{d}_k$	56 total
$\gamma\gamma \to$	$u_j\bar{d}_j d_k\bar{u}_k$	25 total
	$u_j\bar{u}_j u_k\bar{u}_k$	9 total
	$u_j\bar{u}_j d_k\bar{d}_k$	25 total
	$d_j\bar{d}_j d_k\bar{d}_k$	21 total
$e_L^-\gamma \to$	$\nu_e u_j\bar{u}_j d_k\bar{u}_k$	25 total
	$\nu_e d_j\bar{d}_j d_k\bar{u}_k$	30 total
$e^-\gamma \to$	$e^- u_j\bar{d}_j d_k\bar{u}_k$	20 total
	$e^- u_j\bar{u}_j u_k\bar{u}_k$	10 total
	$e^- u_j\bar{u}_j d_k\bar{d}_k$	20 total
	$e^- d_j\bar{d}_j d_k\bar{d}_k$	21 total
$\gamma e_R^+ \to$	$\bar{\nu}_e u_j\bar{d}_j u_k\bar{u}_k$	25 total
	$\bar{\nu}_e u_j\bar{d}_j d_k\bar{d}_k$	30 total
$\gamma e^+ \to$	$e^+ u_j\bar{d}_j d_k\bar{u}_k$	20 total
	$e^+ u_j\bar{u}_j u_k\bar{u}_k$	10 total
	$e^+ u_j\bar{u}_j d_k\bar{d}_k$	20 total
	$e^+ d_j\bar{d}_j d_k\bar{d}_k$	21 total

8-fermion

$e^+e^- \to$	$f\bar{f}t\bar{t}$
$\gamma\gamma \to$	$t\bar{t}$
$e^-\gamma \to$	$e^-t\bar{t}$
	$\nu_e b\bar{t}$
$\gamma e^+ \to$	$e^+t\bar{t}$
	$\bar{\nu}_e t\bar{b}$

WHIZARD Monte Carlo is used to generate all 0,2,4,6-fermion and t quark dominated 8-fermion processes.

Results for $\frac{\Delta E_{jet}}{\sqrt{E_{jet}}} = 0.0$ L=2000 fb^{-1}

process	resonances	before cuts	preselection	$NN_{ZHH} > 0.9$
$q\bar{q}b\bar{b}b\bar{b}$	ZHH	254	58	41
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$b\bar{b}b\bar{b}$	ZZ / ZH	46600	148	24
$q\bar{q}b\bar{b}$	ZZ / ZH	301600	39	0
$u\bar{d}s\bar{c}$	WW	6.5×10^6	0	0
$u\bar{d}d\bar{u}, c\bar{s}s\bar{c}$	ZZ / WW	6.5×10^6	0	0
$b\bar{b}u\bar{d}s\bar{c}$	$t\bar{t}$	322800	1760	0
$b\bar{b}u\bar{d}d\bar{u}, b\bar{b}c\bar{s}s\bar{c}$	$t\bar{t}$	322200	2670	16
$b\bar{b}u\bar{d}l^-\bar{\nu}_l, b\bar{b}c\bar{s}l^-\bar{\nu}_l$	$t\bar{t}$	670200	357	0
$b\bar{b}q\bar{q}q\bar{q}$	ZZZ / ZZH	720	4	0.2
$q\bar{q}b\bar{b}b\bar{b}$	ZZZ / ZZH	430	48	10.8
$l^+l^-b\bar{b}b\bar{b}$	ZZZ / ZZH	130	2	0.2
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TOTAL BGND			5026	51.6

120 GeV ZHH

signal & backgrounds

NN selection based on jet pair masses

Gay et al

- ZHH, HHvv, mh = 120
- “jet probability” b tagging
- selections for ZHH, HHvv
- fast simulation

signal & backgrounds for mh = 120, 800GeV, 500 fb-1

NN selection: dijet masses, b tag

generated (all by WHIZARD)

Process	N_{Gen}	σ (fb)	$\mathcal{L}_{sim}$(fb^{-1})
Signal	10k	0.1844	54227
hhZ *tri*	10k	0.0571	
ννhh *tri*	9k	0.0536	
tth	20k	2.498	8006
ttZ	25k	4.528	5521
tt	1M	260.4	3840
hZ	160k	22.65	7064
ννWW	60k	12.43	4827
eeZZ	3k	0.287	10400
ννZZ	25k	3.477	7190
WW	9.2M	668.8	13890
ZZ	1.5M	222.4	6744
ννtt	20k	0.787	25400
eνZW	12k	10.09	1176
ZZZ	25k	0.729	34280
WWZ	100k	56.96	1755

after selection

	hhZ-selection		*vvhh-sel.*	*Total*
Process	loose	Tight		
tth	17.36	2.62	-	
ttZ	10.14	1.81	-	
tt	98.0	-	-	
hZ	16.1	-	1.41	
eeZZ	0.43	-	-	
ννZZ	0.07	-	0.49	
ZZ	8.15	-	0.37	
ννtt	0.04	-	-	
ZZZ	2.74	1.03	-	
WWZ	0.28	-	-	
Backg	153.	5.46	2.27	7.73
signal	34.4	22.0	8.49	30.5
Eff. (%)	42.6%	30.2%	37.3%	33%
	2.5	4.2	2.6	4.93

Faucci Gianelli et al

- ZHH, mh = 120
- fullsim
- signal with pandora pythia & WHIZARD: consistent
- compare different PFAs, detector models
- selection based on jet jet masses
- consider ZZH, ZZZ backgrounds

references

- gay et al:
- http://indico.cern.ch/materialDisplay.py?contribId=15&sessionId=1&materialId=15&confId=568
- http://indico.cern.ch/materialDisplay.py?contribId=15&sessionId=1&materialId=slides&confId=568
- http://ilcagenda.linearcollider.org/getFile.py/access?contribId=155&sessionId=71&resId=1&materialId=slides&confId=1296
- rosca et al:
- http://indico.cern.ch/materialDisplay.py?contribId=162&sessionId=1&materialId=slides&confId=568
- barklow:
- http://indico.cern.ch/materialDisplay.py?contribId=232&sessionId=1&materialId=slides&confId=568
- http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=154&sessionId=71&materialId=slides&confId=1296
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- http://ilcagenda.linearcollider.org/getFile.py/access?contribId=241&sessionId=76&resId=0&materialId=slides&confId=1296
- WHIZARD generator http://www-ttp.physik.uni-karlsruhe.de/whizard/