ALEPH results in year 2000

F. Cerutti CERN and LNF-INFN
on behalf of the ALEPH collaboration

- Data sample and detector performance in year 2000 : *ALEPH is still working fine after 12 years running*
- SM processes: *We still have results in agreement with the SM*
- SUSY searches: *Low energy SUSY strongly challenged*

The excitement of the year

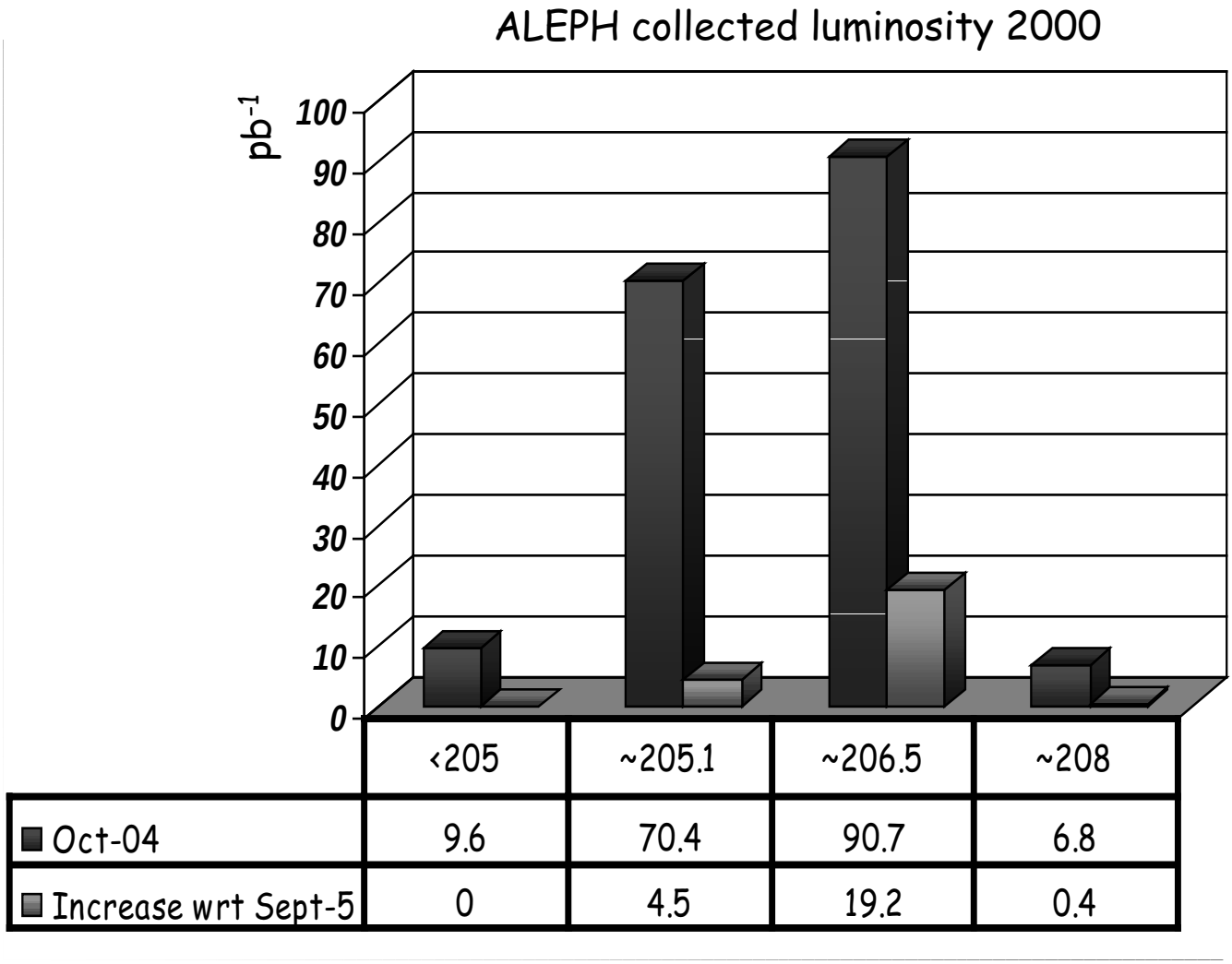
- SM Higgs: *WHY is LEP still running ?*

General Remarks

- Year 2000 has been a special year for LEP experiments: DO not miss any SIGNAL of new physics !
  - Higgs and SUSY results combined every 1-2 months with very preliminary systematic estimates
- The ALEPH results presented here are *very preliminary !*
- All limits given are at 95% CL (and deviations from SM should be considered as discoveries only if they reach the 5σ significance)

Data sample

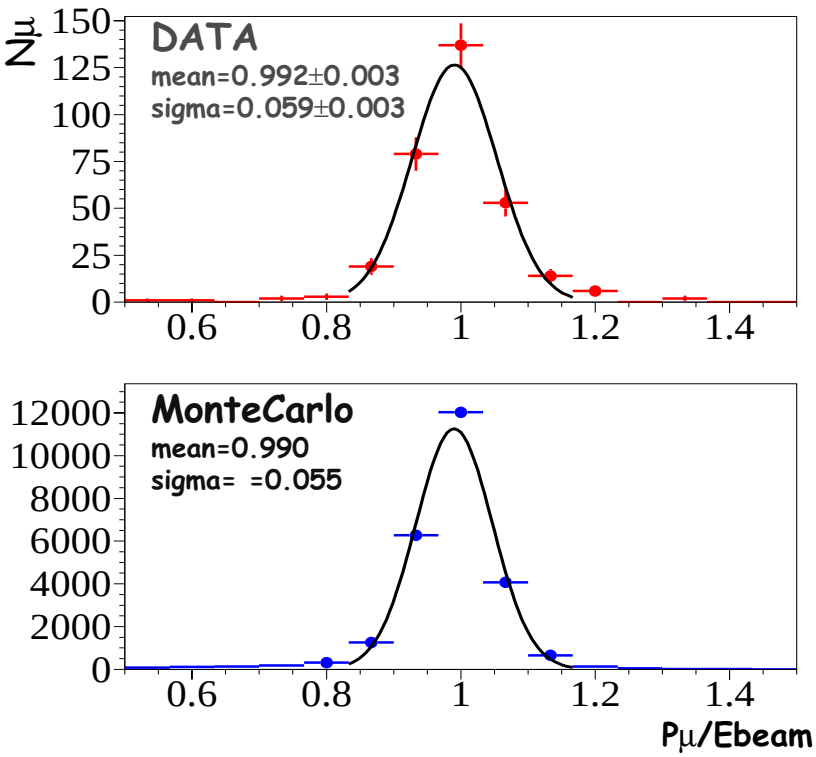
- Excellent LEP performance in y2k



	<205	~205.1	~206.5	~208
Oct-04	9.6	70.4	90.7	6.8
Increase wrt Sept-5	0	4.5	19.2	0.4

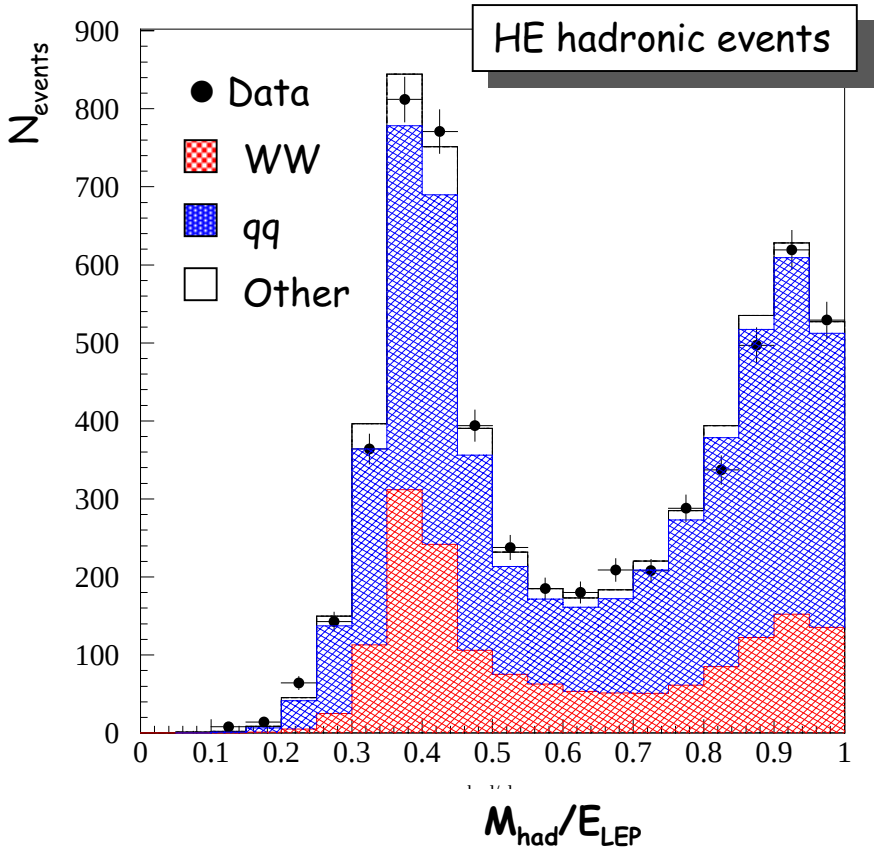
- Total of 178.3 pb^{-1} (~9 different E_{CM}) collected
- ALEPH efficiency in y2k has been 95.7% !
- 4.3 pb^{-1} at $E_{LEP}=M_Z$ used for calibration

Data quality checks



|P| calibration checked on $e^+e^- \rightarrow \mu^+\mu^-$ at $\sqrt{s}$=206 GeV

Energy flow performance on HE data

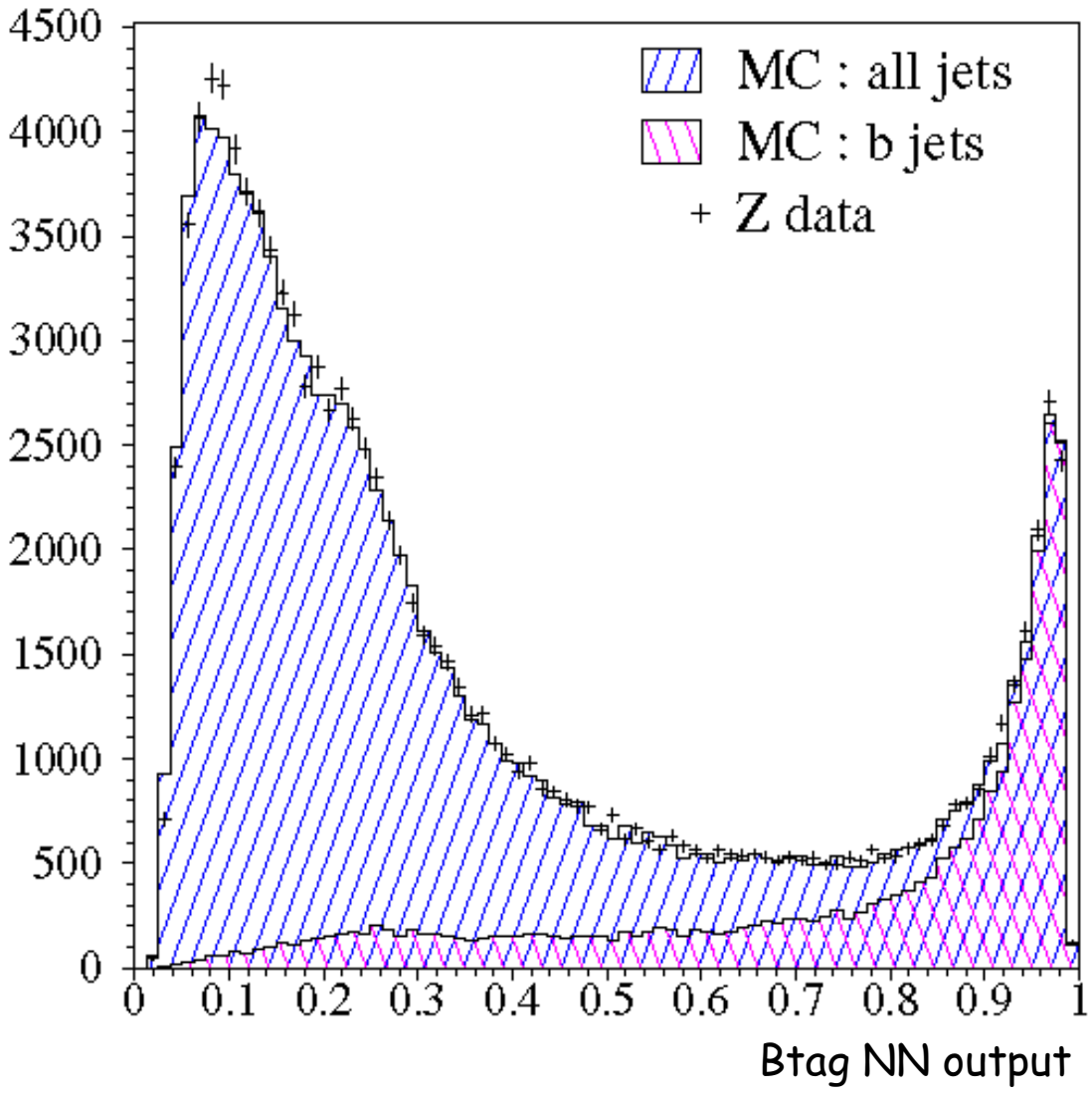


Data quality checks

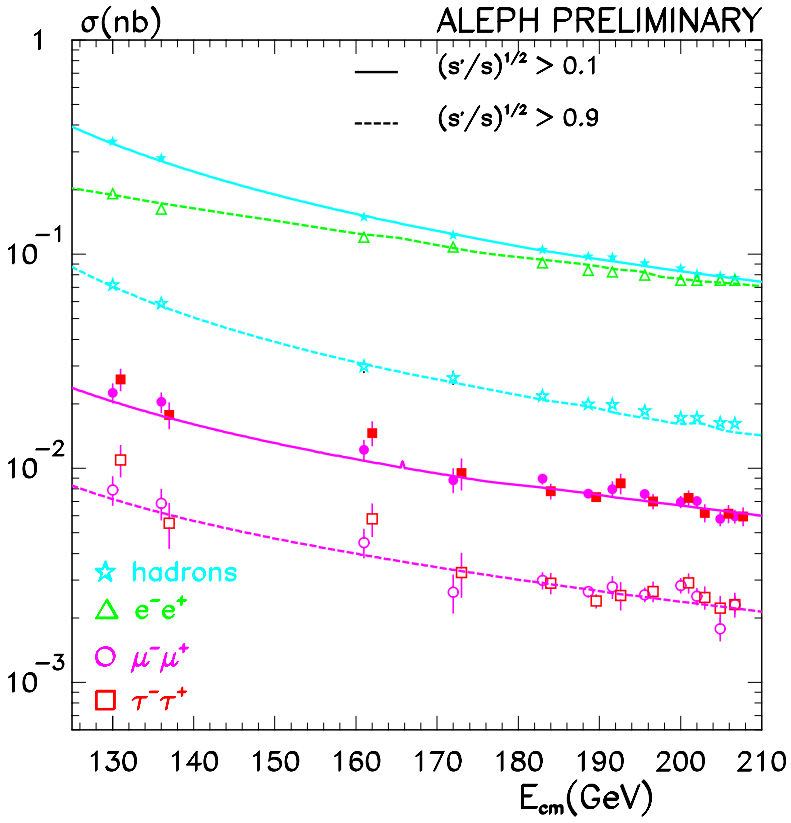
btag performance on udsc and b jets

calibrated on Z peak data

Residual difference taken into account in systematic error computation

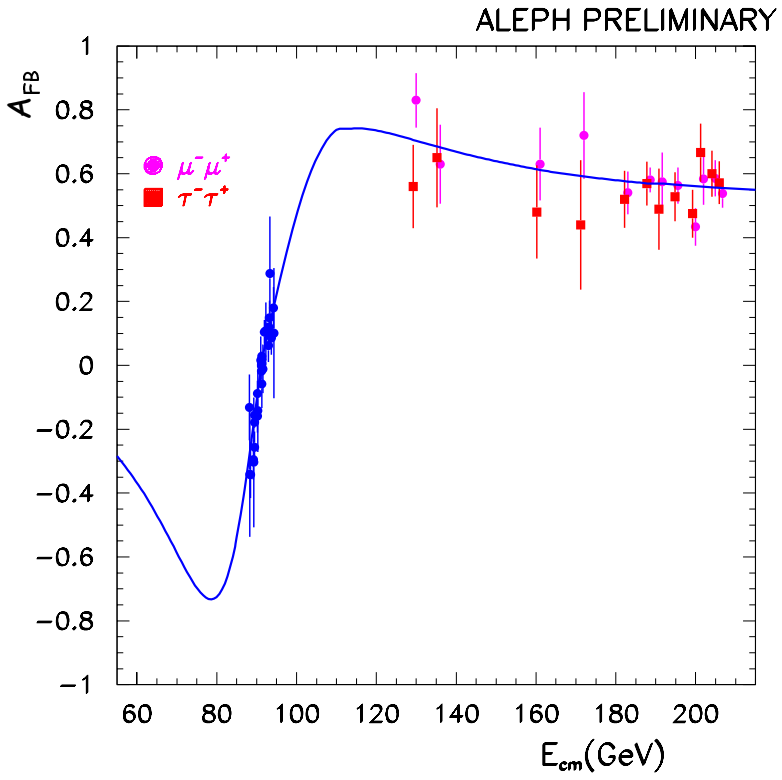


SM processes: 2-fermion processes



2-fermion cross-sections

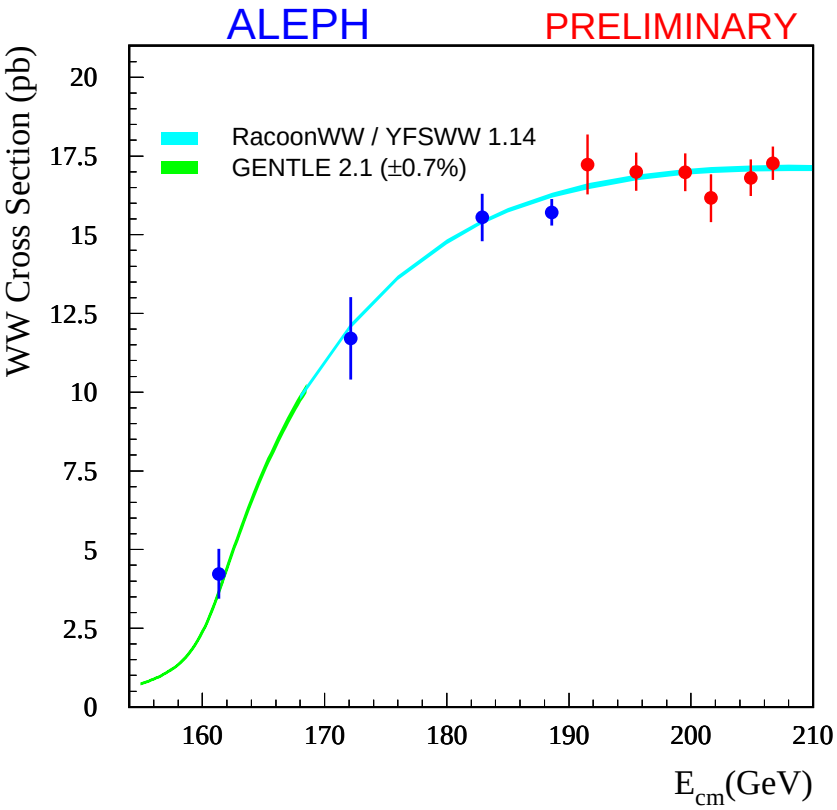
σ_{qq} slightly above SM expectation at high s'/s



Lepton A_{FB}

Good agreement with SM for both channels

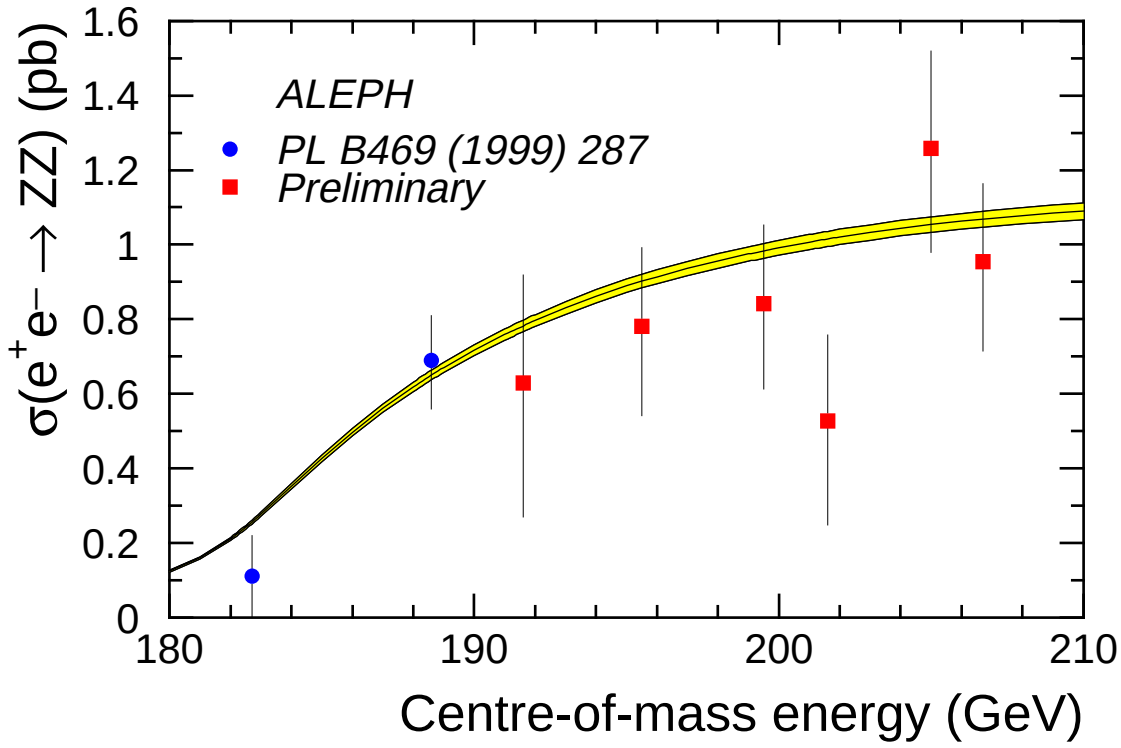
SM processes: 4-fermion processes



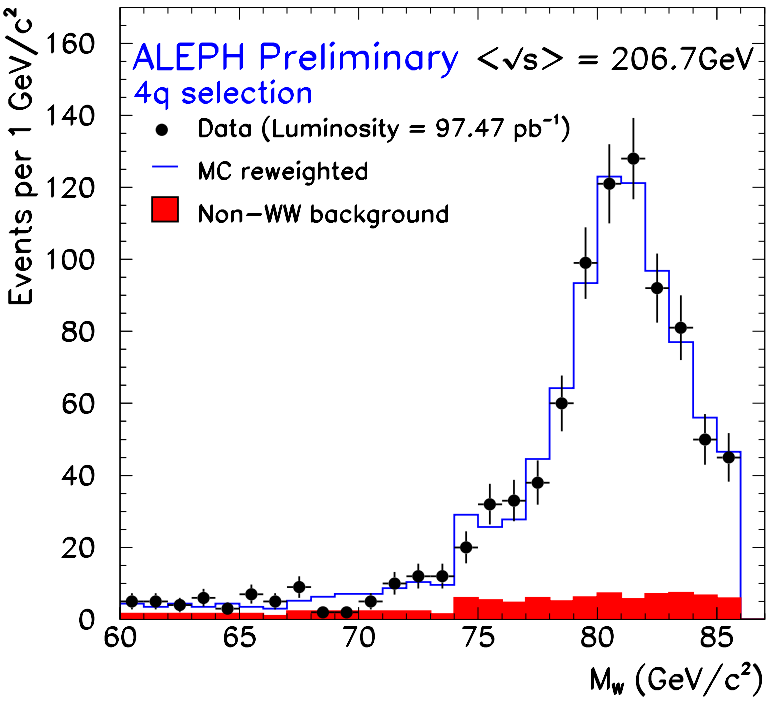
WW and ZZ cross-sections

y2k results are the last 2 points

Good agreement with SM for all channels



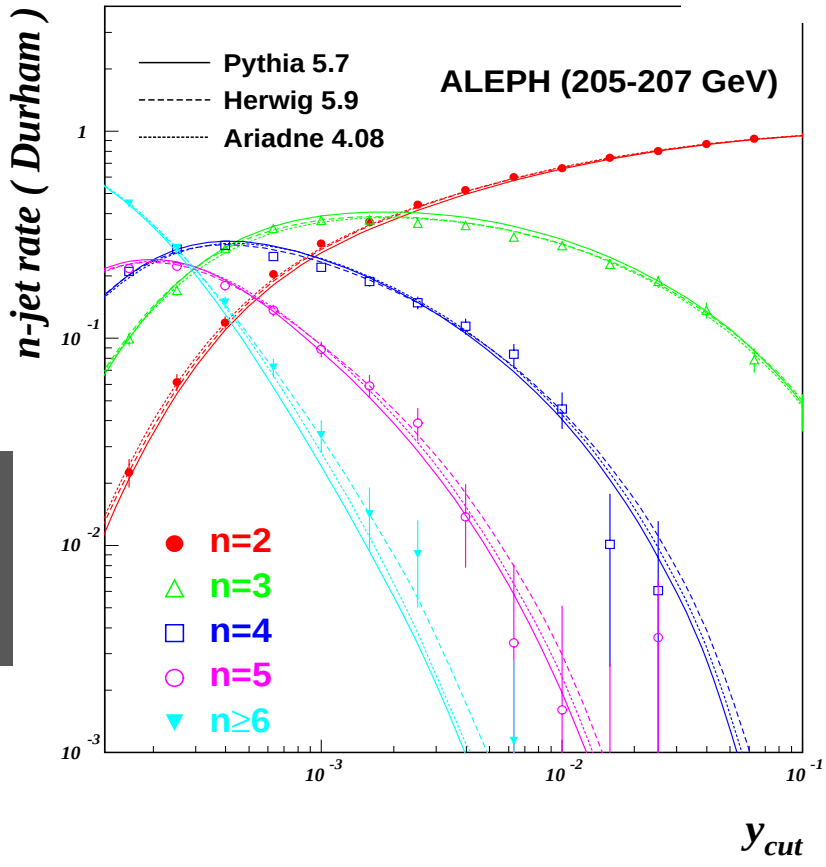
SM processes: W mass and QCD



y2k W Mass plot !

Good agreement DT MC in 4jet MW shape

PRELIM, Stat.Err



N-jet rate vs y_{cut}

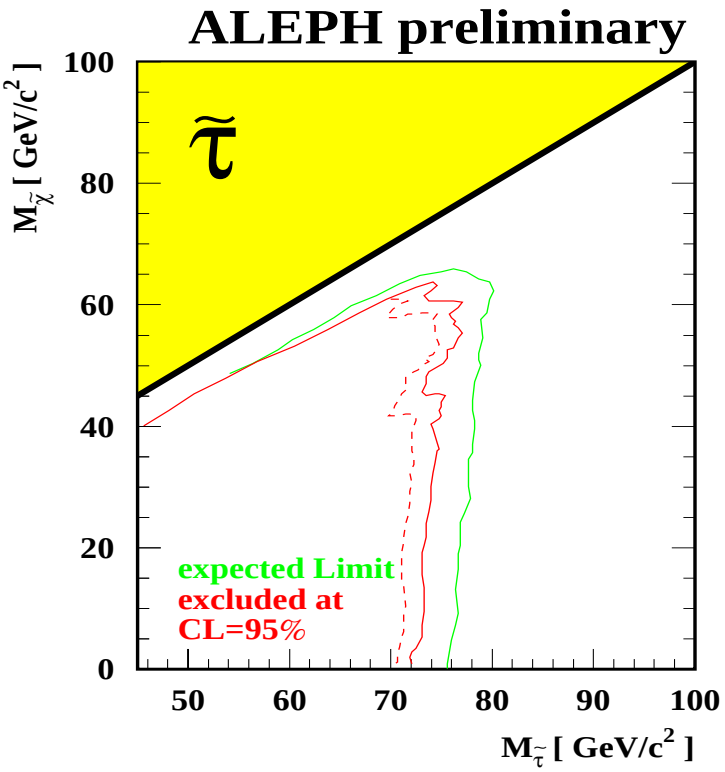
Good agreement in 4-jet rate for y_{cut}~0.01

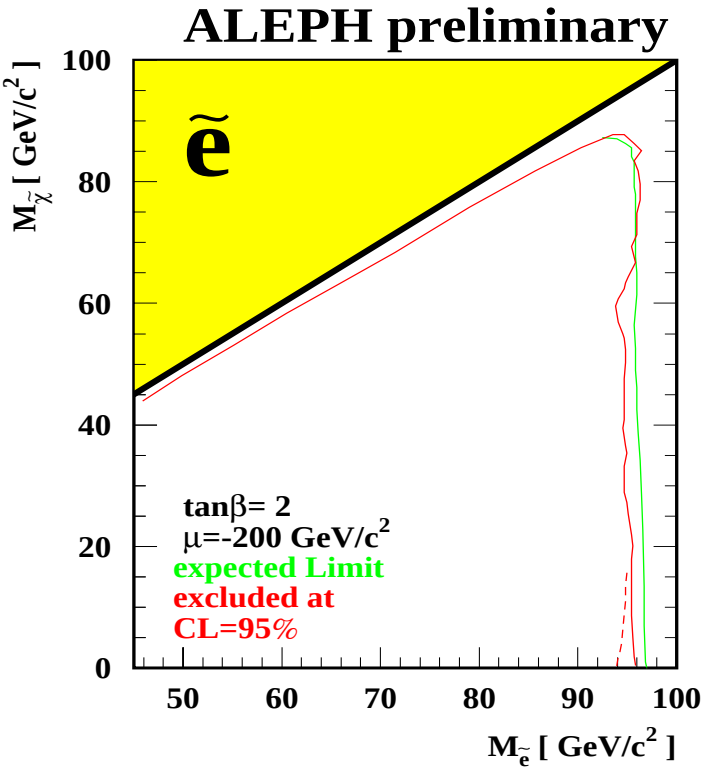
SUSY searches

- 3 different SUSY scenarios searched for
  - MSSM: missing energy
  - GMSB: photons, long-lived sleptons
  - RPV: large jet and/or lepton multiplicities
- Large variety of experimental topologies
  - Statistically independent topologies ~60
  - Tested at ~14 different E_{LEP} (at LEP2)
  - In total (up to now) ~840 statistically independent comparison of SUSY topologies with SM expectations
- In spite of that no significant deviations from SM expectations found this year

MSSM

Channel	Expected bkg	Data
Selectron	33.2	36
$e_R e_L$ (sinlge e)	17.1	11
Smuon	29.9	32
Stau	24.2	27
Stop -> $c\chi$	8.6	11
Stop->$c\chi$ (VL δM)	0.7	0
Stop -> $b\ell\nu$	1.5	2
Sbottom -> $b\chi$	2.6	2
Chargino (any m_0)	24.4	23



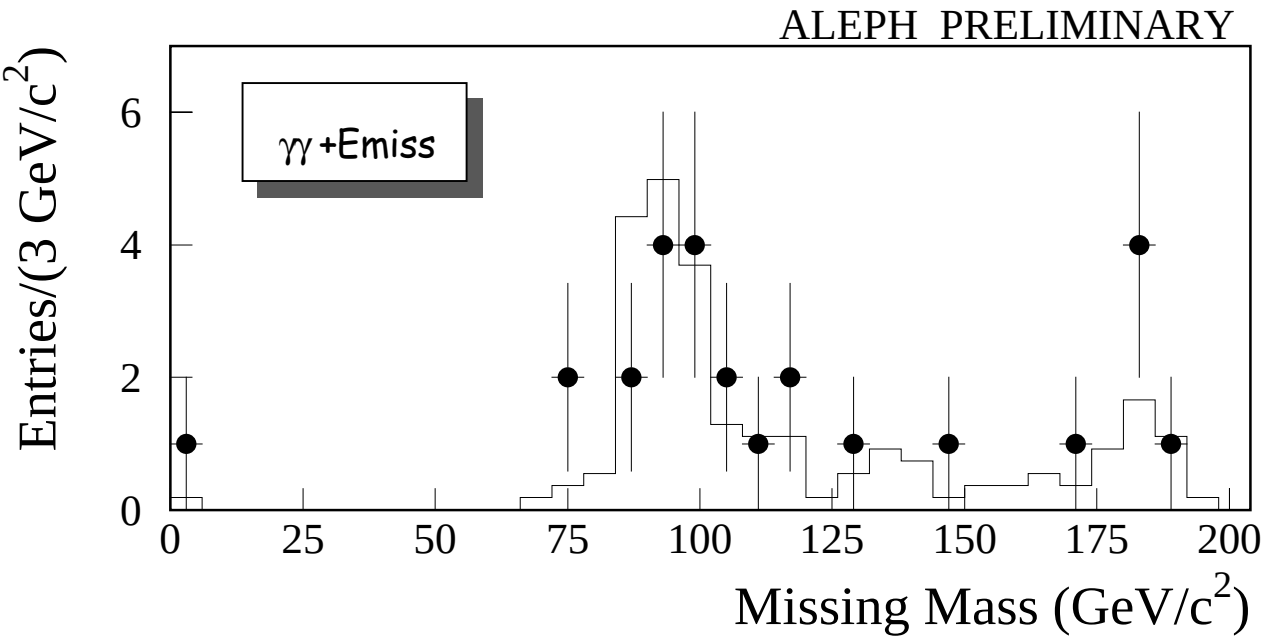


For heavy sneutrinos
Chargino mass limit close to kinematic threshold

~103 GeV

GMSB

Topology	Expected bkg	Data	Limit(GeV)
$\chi\chi$ 2γ+Emiss	2.0	0	99 ($Me_R=1.1M_\chi$)
Long-lived slepton	0.3	0	95 ($c\tau=10^{-9}$ s)
Stable slepton	1.1	0	97



RPV dominant LLE coupling

Topology	Expected bkg	Data	Limit(GeV)	
Leptons+hadrons	7.9	10	103.1	chargino
6 leptons+Emiss	1.2	0	96.3	selec. ind.
			96.7	smuon ind.
			94.6	stau ind.
4 leptons+Emiss	6.1	4	98.1	snu e ind.
			88.7	snu mu/tau ind.
4 leptons	10.3	9	100.0	snu_e dir.
			90.2	snu_mu/tau dir.
2 leptons	170.0	156	96.3	selec. dir.
			86.9	smu/stau dir.

RPV dominant LQD coupling

Topology	Expected bkg	Data	Limit(GeV)	
Multi-jets+lept.	10.0	12	102.9	chargino
2jets+2tau	9.8	9	85.6	stopL ind.
2jets+Emiss	20.0	23	80.1	sbottomL ind.
4jets+2 lept.	17.2	16	93.1	seles. Ind.
5jets+1lept.			89.6	smu ind.
			76.1	stau ind.
4jets	703.	689	81.0	smu/stau dir.
			79.0	snu_mu dir.

SUSY searches

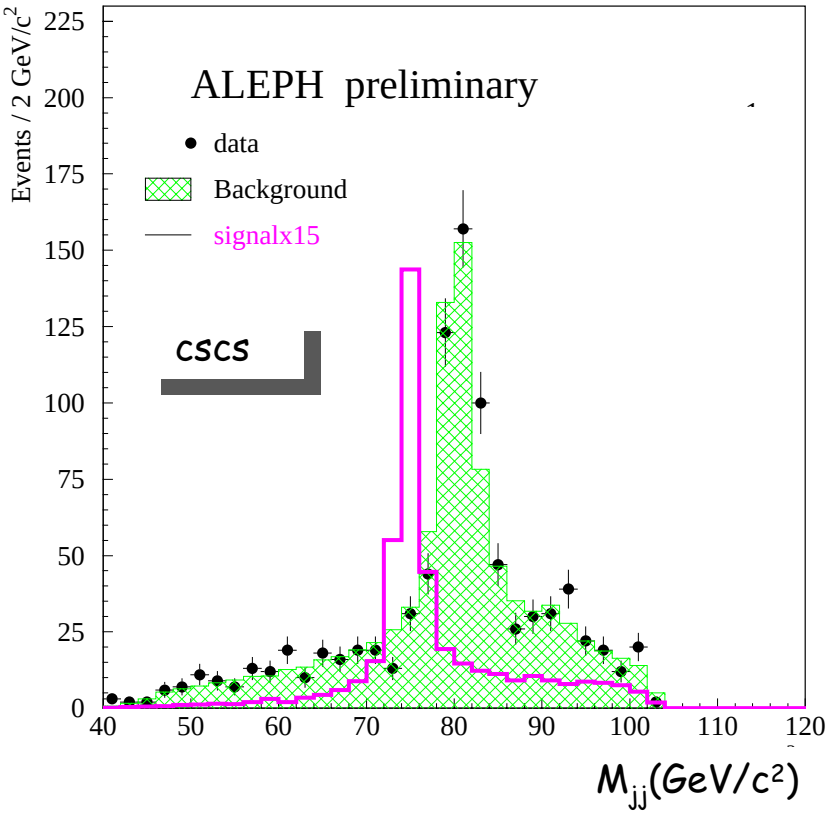
RPV dominant UDD coupling

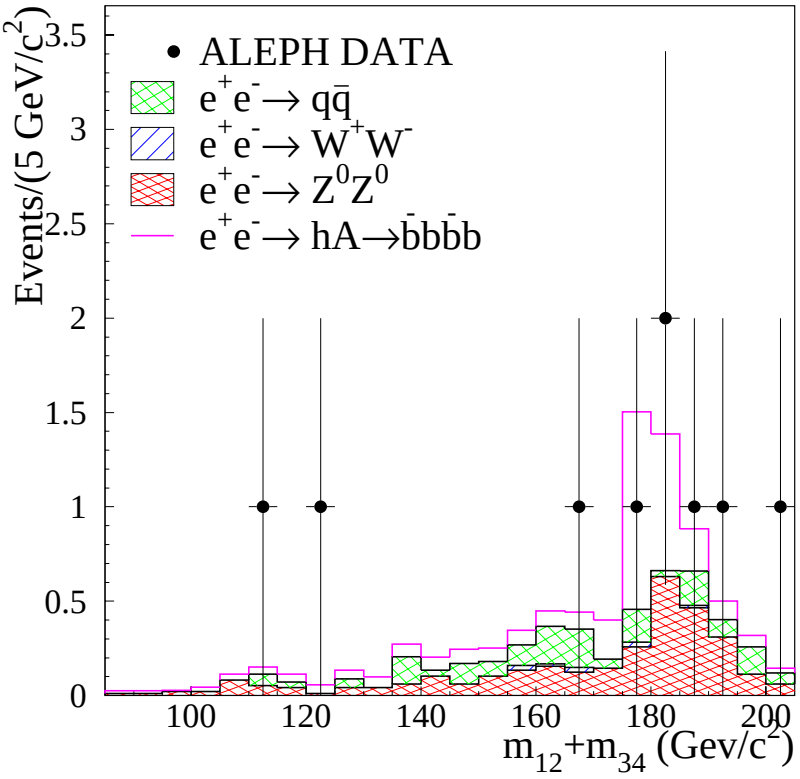
Topology	Expected bkg	Data	Limit(GeV)
4jets+2lept.	0.6	1	91 selec. ind.
Multi-jets+2lept.	0.3	1	85 smuon ind.
4jetb	4.2	2	72 stop1 ind.
4jets	672.2	686	103.0 chargino
multi-jets	0.32	1	

For all 3 RPV scenarios chargino mass limits are close to 103 (assuming heavy sneutrinos) as for MSSM

Non SM Higgs

$H^{\pm}$ results	Bkg	Data
τντν	17.3	9
csτν	89.2	96
cscs	822.4	790





MSSM hA->bbbb	
$\sin^2(\beta-\alpha)=0$	
Bkg	= 5.0
Sig.(mh=mA=90)	= 3.2
Data	= 9

The SM Higgs search

- Look for e^+e^- -> HZ with [H->bb or $\tau\tau$] and with [Z-> qq,$\nu\nu$,$\ell\ell$,$\tau\tau$]
- Two streams of analysis used, NN and CUT:
  - 4-jets (NN and CUT)
  - 2-jets + Missing energy $h\nu\nu$ (NN and CUT)
  - 2-Jets + 2 leptons (e or μ) $h\ell\ell$ (CUT)
  - 2-jets + 2 τ $qq\tau\tau$ (NN)
- Main ingredients: btag, E_{LEP} constr., M_Z constr.
- NN analysis has a slightly better sensitivity but CUT is a valid alternative: different sensitivity to systematic effects
- Analyses and statistical estimator (LR) frozen before data taking started: statistically unbiased results
- Analyses updated ON LINE: BEHOLD !

The SM Higgs results

178.2 pb^{-1} collected in y2k

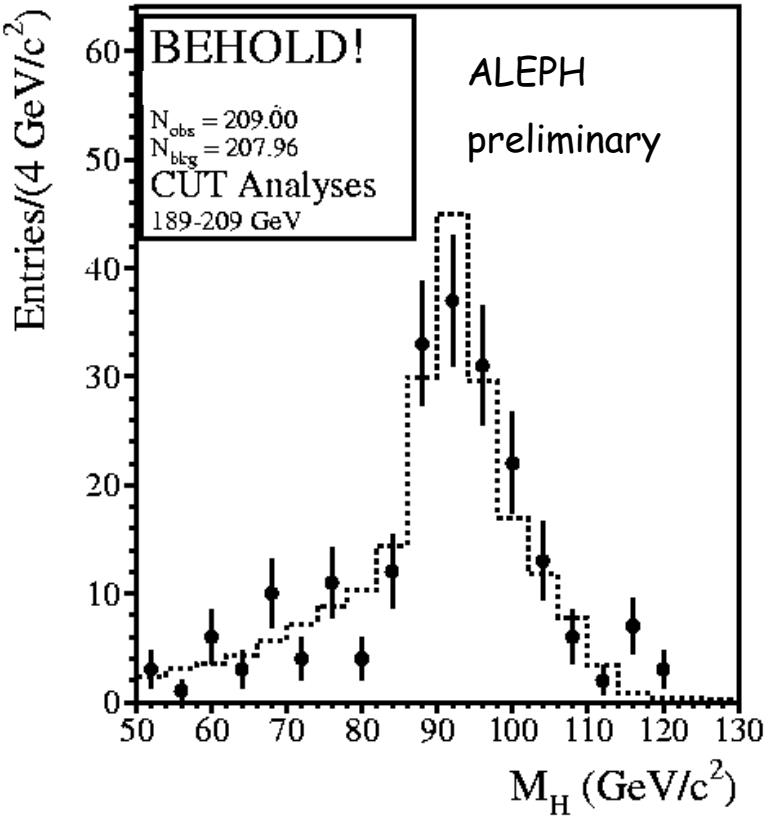
Channel	Nbkg	Nsig M_h=114	N data	Exp. Sens. (M_H=114)
4-jet NN*	38.6 (5.7)	3.6 (2.3)	41 (11)	1.45
4-jet CUT	26.0 (2.0)	2.5 (1.5)	37 (6)	1.15
hνν NN*	31.2 (2.9)	1.1 (0.6)	32 (3)	0.75
hνν CUT	16.2 (0.8)	1.0 (0.5)	15 (0)	0.60
Hℓℓ *	24.5 (1.6)	0.53 (0.51)	24 (4)	0.69
qqττ	11.2 (0.7)	0.30 (0.23)	13 (3)	0.38
Tot NN	105.5 (10.9)	5.5 (3.6)	110 (21)	1.88
Tot CUT	78.0 (5.1)	4.4 (2.7)	87 (13)	1.59

* In addition to M_H one other discriminating variable (btag driven) used in the c_b and c_{s+b} determination

( ) Numbers in parenthesis refer to reconstructed M_H>109 GeV

- Slight excess of events at M_H>109 GeV
- Following results include 98 and 99 data (414 pb^{-1} at E_{LEP} ~189-202 GeV)

The updated results



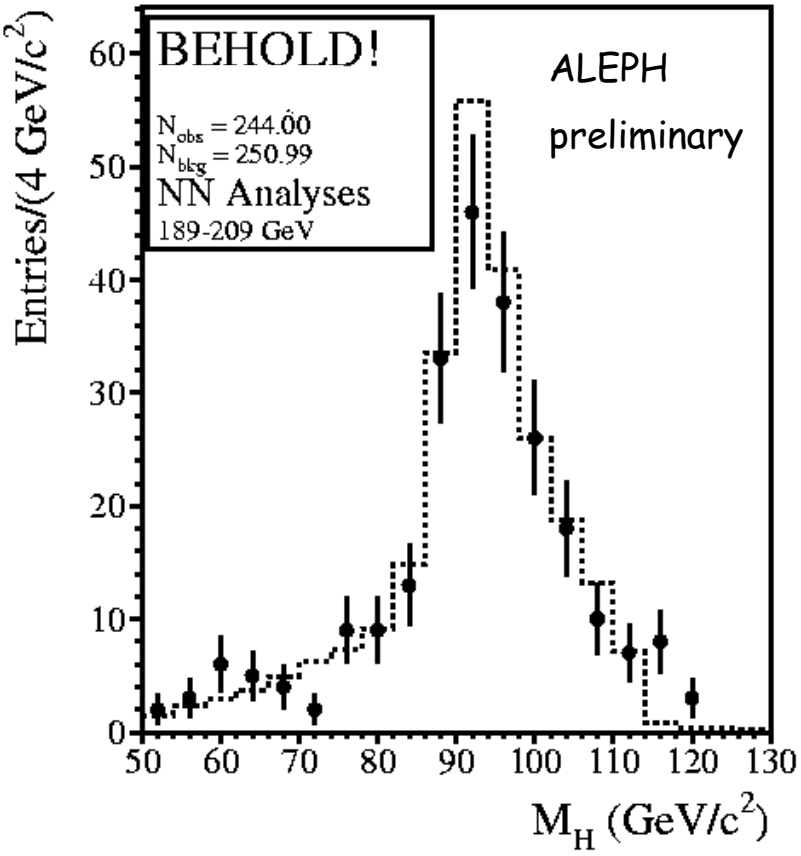
Good agreement with b expectation in the ZZ region

Slight excess of candidates in the high-M_H region seen by both streams

Only partial information contained in M_H plot

Some channels use btag information as second discriminating variable in the test statistics

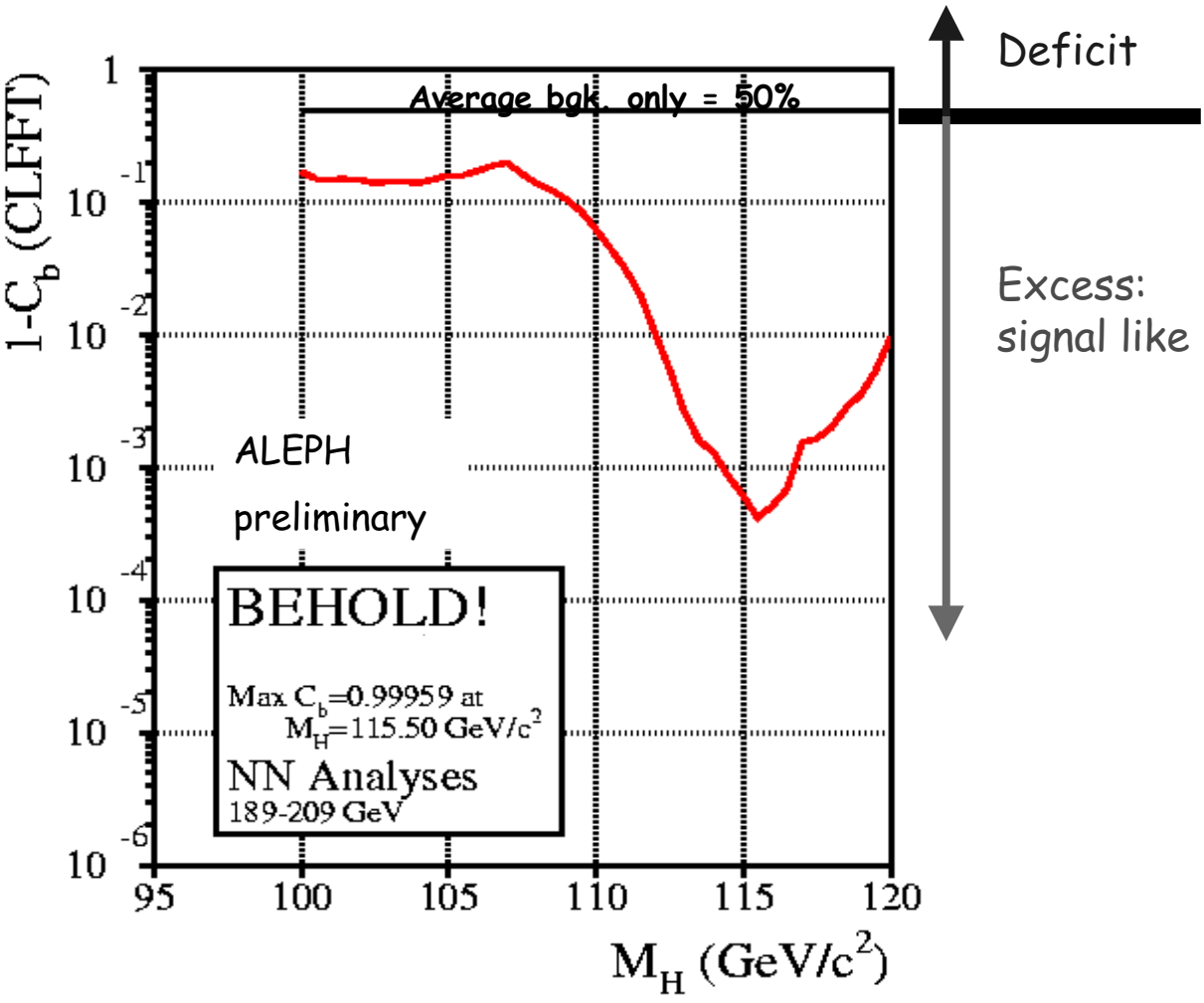
Deviation from SM bkg only hypothesis quantified with $(1-c_b)$



Compatibility with bkg only hypothesis

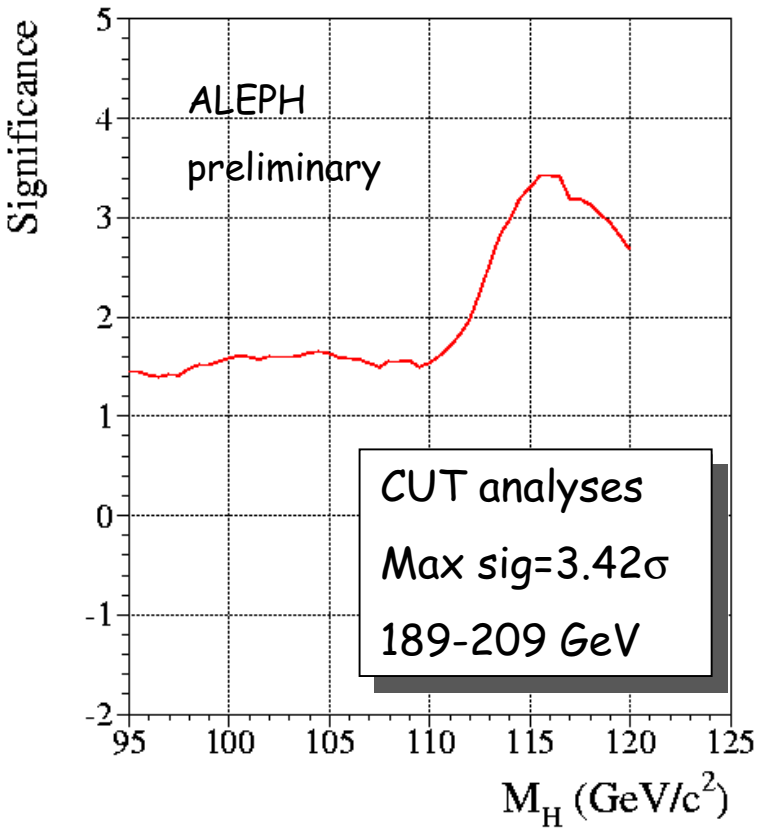
- Test statistics used is $LR(M_H|m_H^i,x^i)=L_{s+b}/L_b$
- Deviation from bkg only hypothesis quantified in $(1-c_b)$ = $Prob(LR \geq LR_{observed})$ for bkg experim.

  probability (as a function of M_H) that observed data are as or more signal like than the expected background

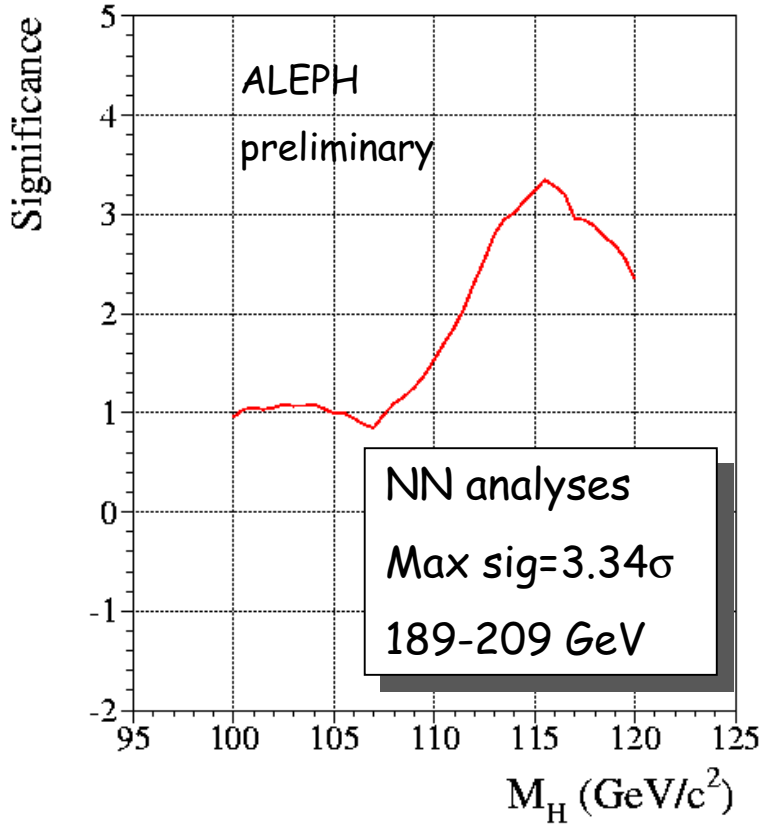


- Minimum in $(1-c_b)\sim 4\times10^{-4}$ observed at $M_H\sim115$ GeV in both streams

Compatibility with bkg hypothesis



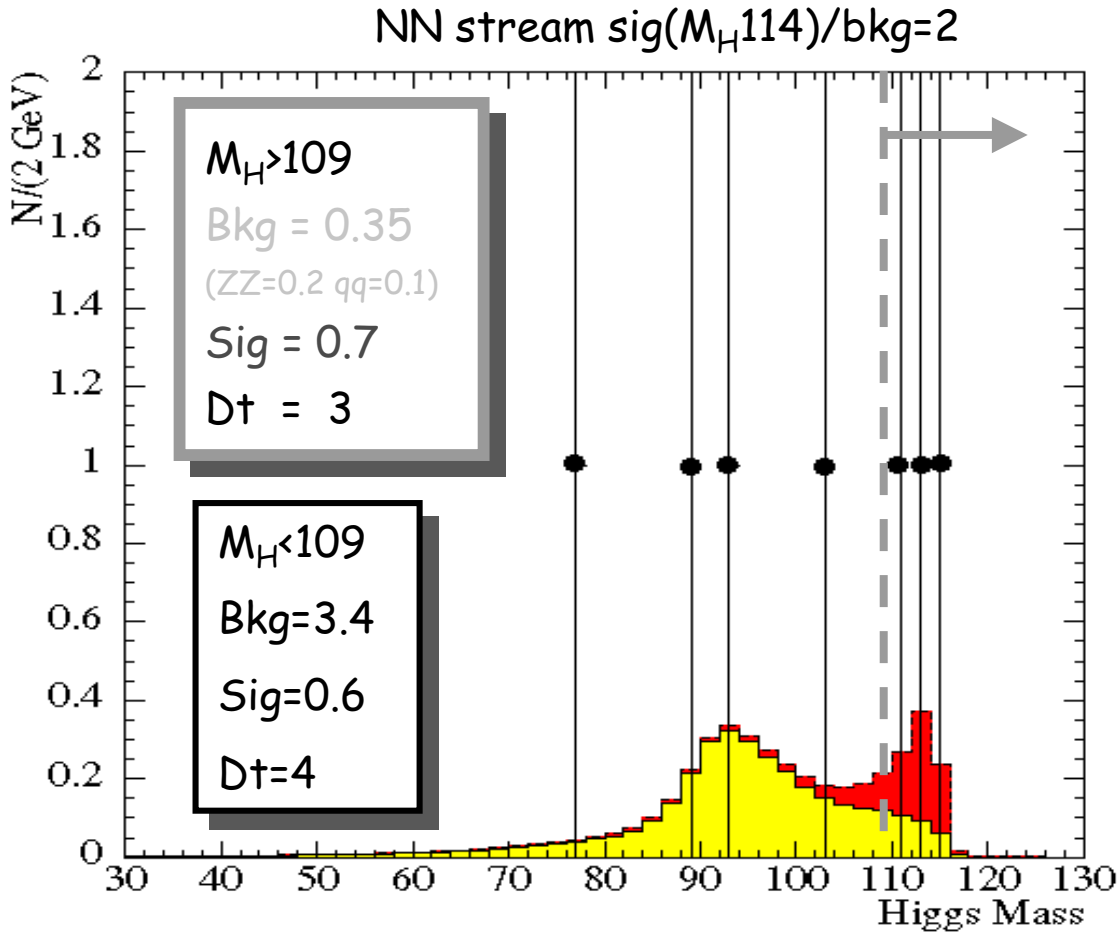
(1-c_b) converted in number of Gaussian (one sided) σ: Significance



3.3 (3.4) σ Significance for NN (CUT) stream @ M_H~115 GeV

A closer look to the excess

- Origin of the excess investigated in NN stream by selecting "sensitive" events: cut at sig/bkg=2 for M_H>109

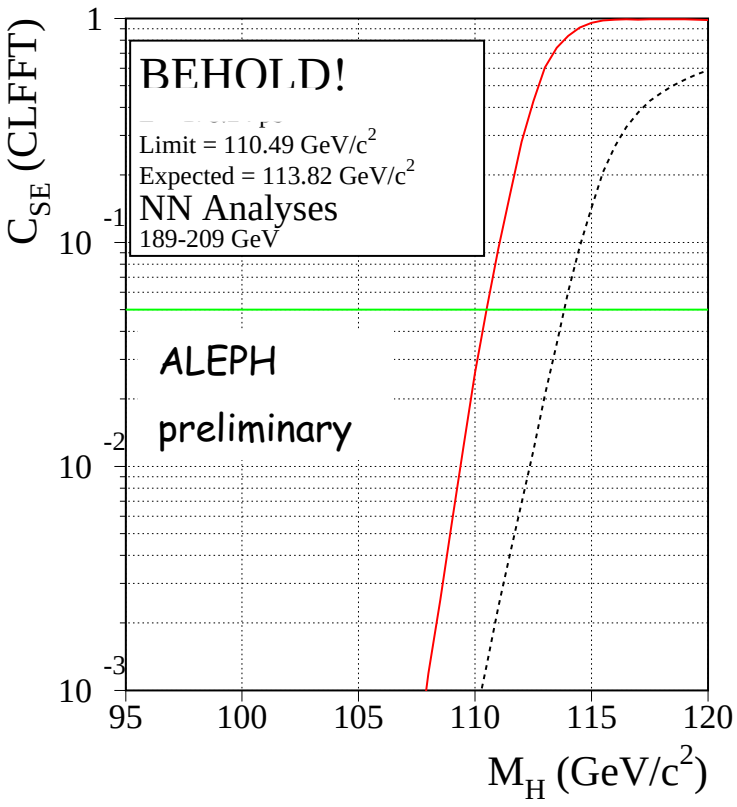


- 4-jet candidates (1 in the bbqq branch, 2 in the bbbb branch)
- Collected at at E_{LEP}~206.5 GeV
- Selected also by CUT stream

A closer look to the excess

- In CUT stream the minimum in $(1-c_b)$ is driven by 6 high mass 4-jet candidates (3 are the "sensitive" NN ones)
- Their masses are: 114.6, 114.5, 114.3, 112.9, 110.0, 109.9
- 5 are collected at E_{LEP}~206.5 and 1 at 204 GeV
- Since btag is not used as additional discriminating variable their weight in $(1-c_b)$ depends only on the reconstructed M_H: higher for 3 events clustered ~114.5 GeV
- The origin of the minimum in $(1-c_b)$ in the two streams is partially but not completely correlated
- Some systematic uncertainties would have different impacts on the two results

Compatibility sig+bkg



Fluctuation scenario:

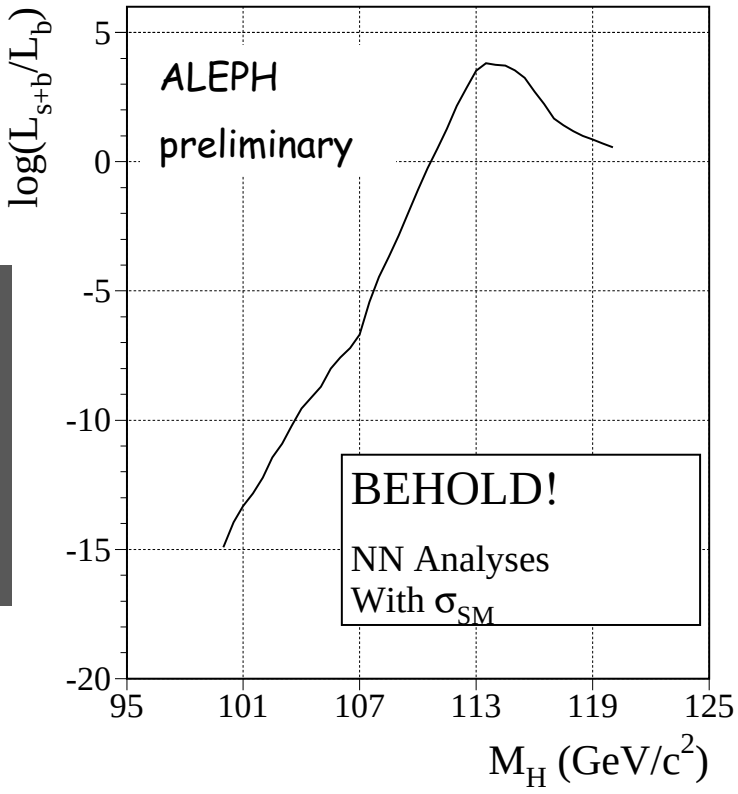
derive limits

NN stream limit

exp. M_H>113.8 GeV

observ. M_H>110.5 GeV

55



Signal scenario:

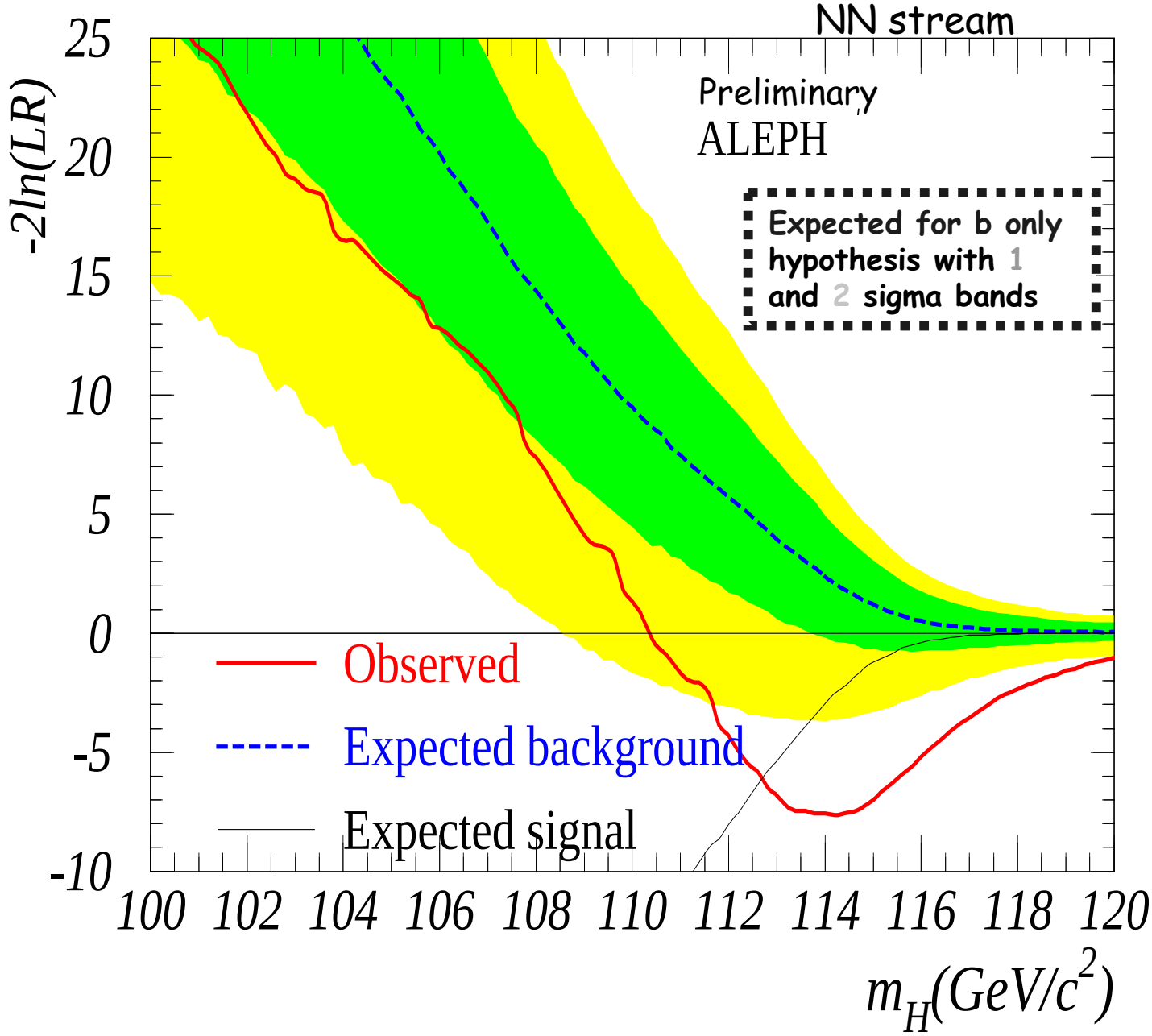
determine M_H

SM σ_H included in LR:

M_H~114GeV

Compatibility with sig+bkg hypothesis

- Observed *-2ln(LR)* minimum at M_H~114 GeV about 1σ below (probability~17%) than what expected for a SM Higgs of that mass



Comparison with 5 September LEPC results

- The $(1-c_b)$ significance showed at the 5 September LEPC was 3.9 (3.8) σ for NN (CUT) stream at M_H~115 GeV
- Change w.r.t. these results:
  - Correction of background shapes of 4-jet NN stream -> -0.3σ (does not affect CUT results)
  - Correction in the g->bb and g->cc expected rates in CUT stream -> -0.16σ (already corrected in NN)
  - Additional ~19 (5) pb^{-1} collected at E_{LEP}~206.5 (205) GeV
  - NO new "significant" candidates found in any of the 2 streams (less than 0.3 expected events for sig+bkg hypothesis in NN 4-jet stream)
- The Significance of the excess went down by ~0.6 (0.4) σ in NN (CUT) stream

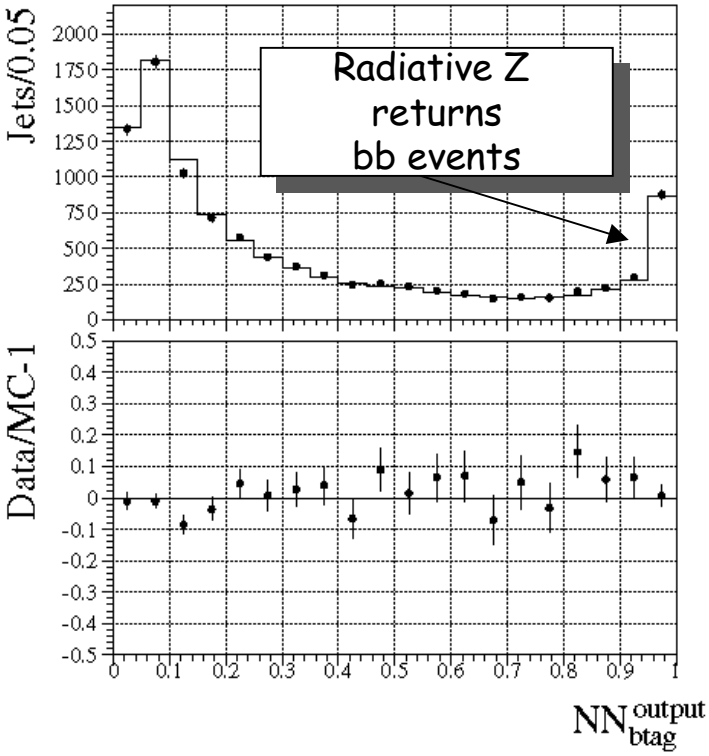
systematic checks: btag

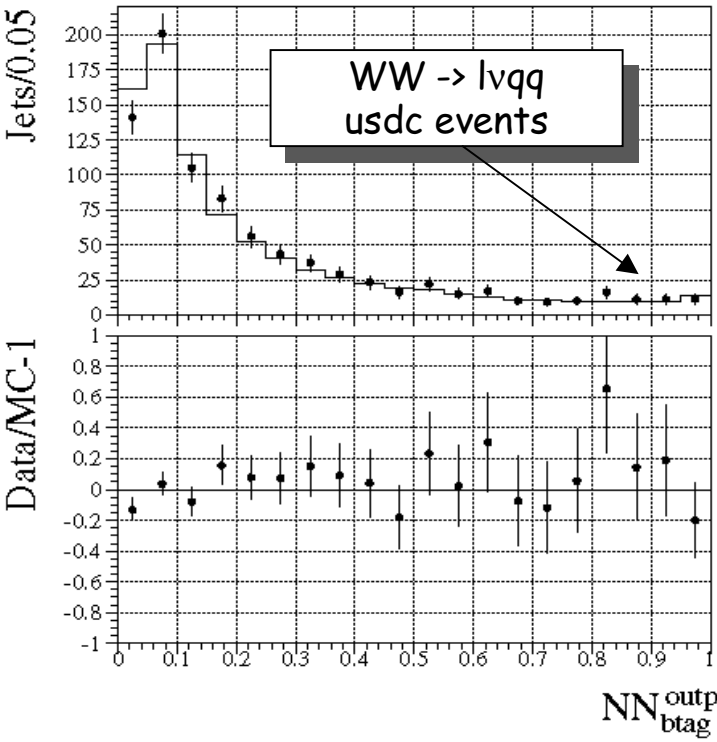
btag calibrated with y2k Zpeak data

MC *IPs smeared* until ε_{udsc} and ε_b agree with Data

agreement cross-checked with HE data

Half of the correction taken as systematic error





Effect on expected bkg

All M_H

ZZ =1% qq=1% WW=10%

Tot=3%

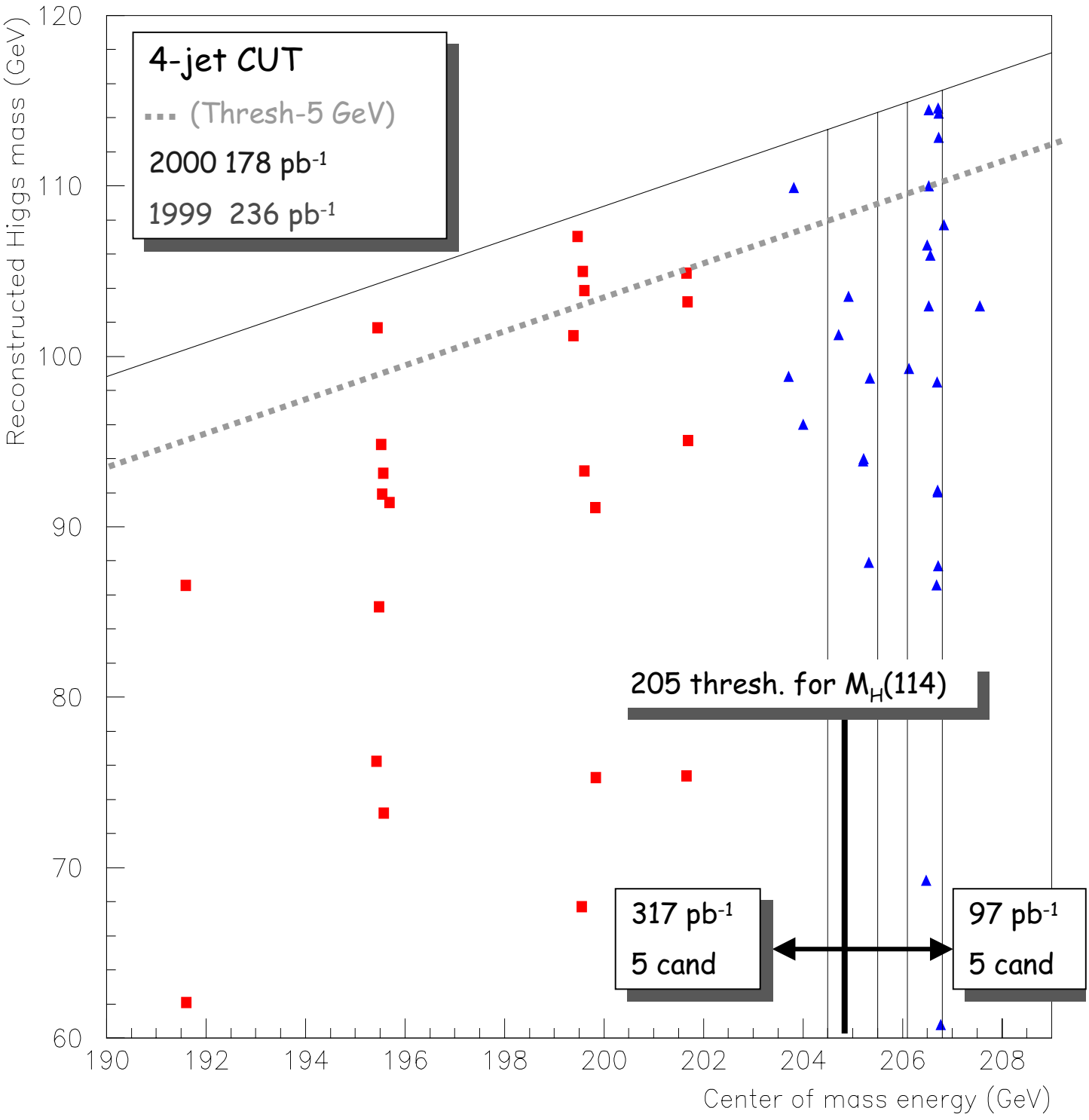
M_H > 109 GeV

ZZ=4 % qq=4% WW=10%

Tot=5%

M_H bias cross-checks

Is there a (E_{LEP} independent) mass bias toward threshold in 4-jet channel ?

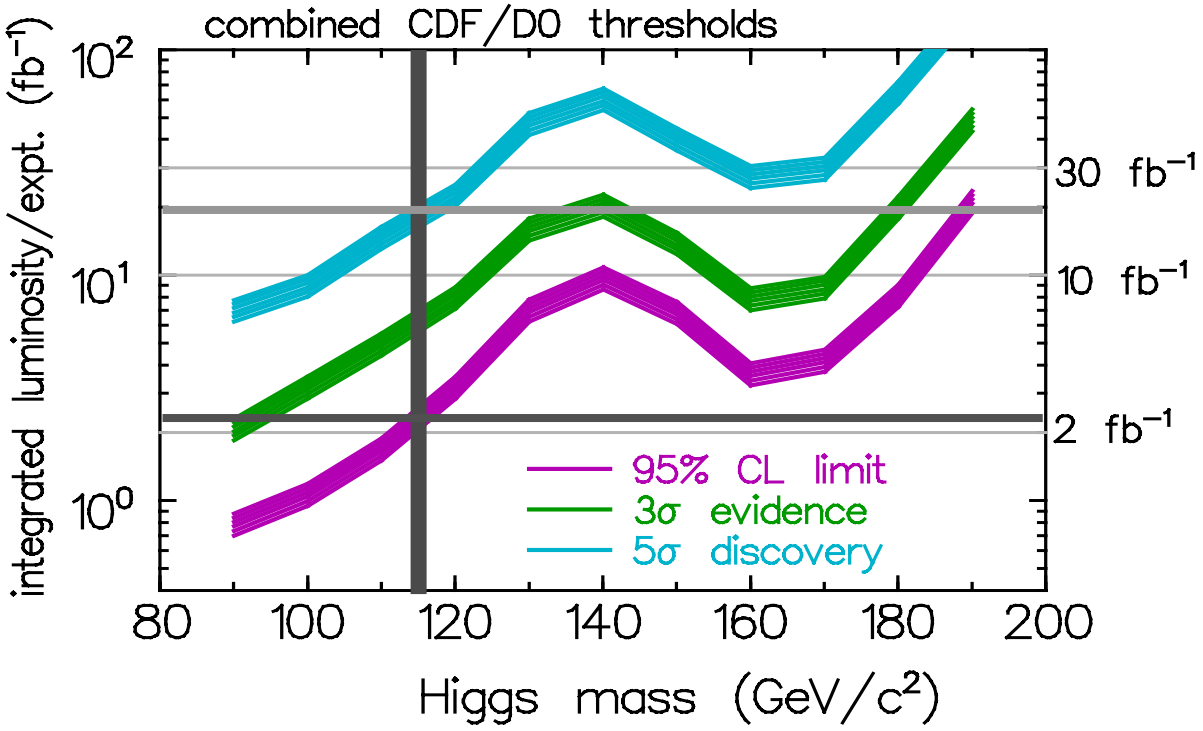


Systematic checks

- Systematic evaluation in progress (be patient ALEPH is still in the data taking period) !
- Sources of systematic uncertainties studied up to now in the 4-jet channel:
  - btag on b and udsc jets
  - NN variables
  - gluon splitting into heavy flavors
- Preliminary systematics on expected bkg in the 4-jet channel
  - ~ 5% on ZZ (btag uncertainty + MC stat)
  - ~20% on qq (error on g->bb g->cc + MC stat)
  - ~20% on WW (btag uncertainty + MC stat)
- If bkg is increased by these quantities the impact on $(1-c_b)$ significance is small ~0.2σ
- No large effect found up to now but the work is still continuing .....

The competitor

- If LEP doesn't reach the discovery significance the main competitor is TEVATRON RUNII



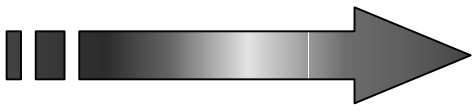
Plot taken from Physics at Run II Workshop

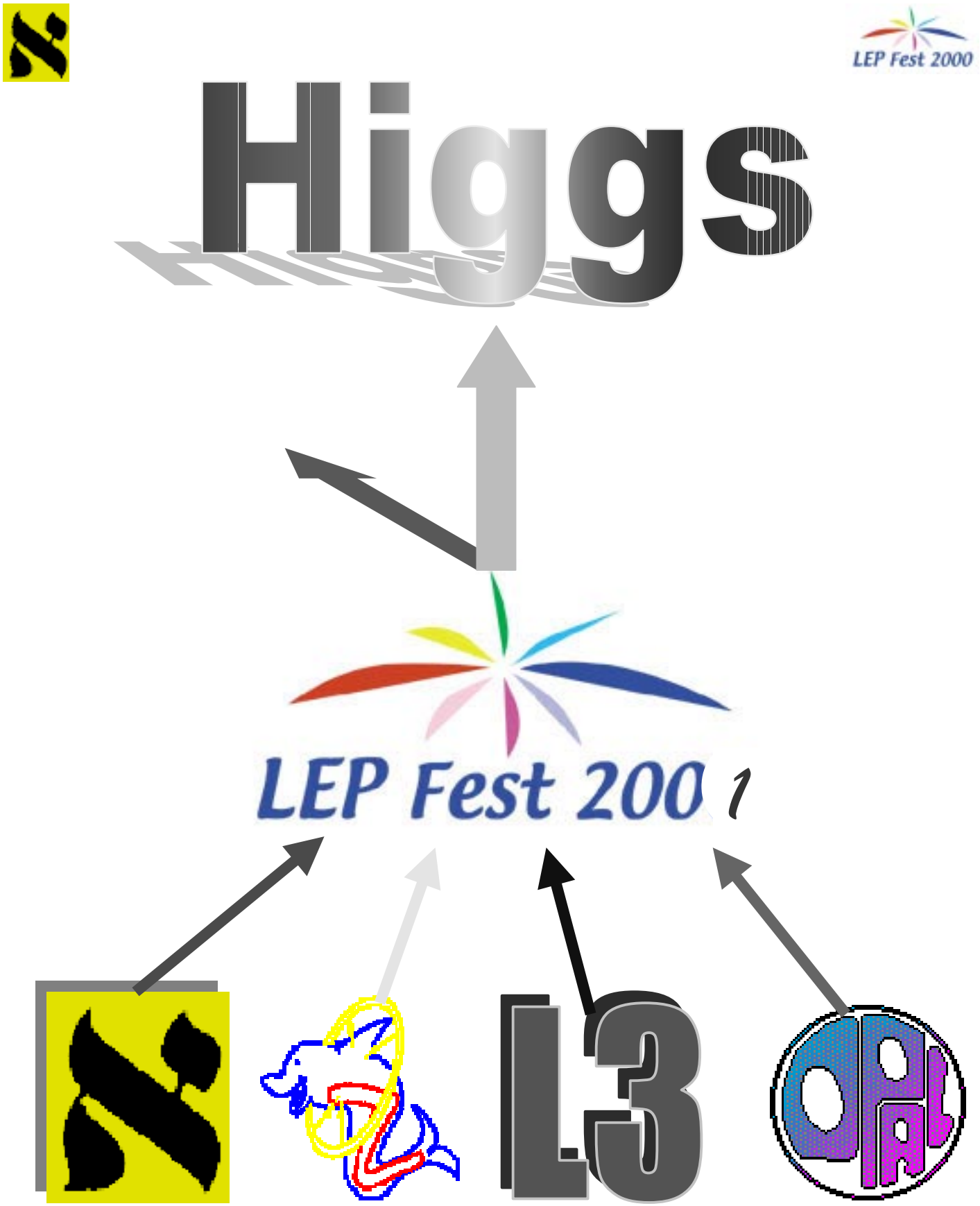
http://fnth37.fnal.gov/higgs/higgs.html

- Fluctuation scenario: ~2fb^{-1} needed to exclude MH~115 GeV
- Signal scenario: ~20 fb^{-1} needed for discovery (and CDF/D0 combination) !

Conclusions for the SM Higgs

- Interesting excess of events observed in y2k ALEPH data in both streams of analyses
- Deviation from SM bkg only hypothesis is at ~3.3σ (statistical only) level
- Compatible with a sig+bkg hypothesis with M_H~114 GeV (with a cross-section ~1σ above SM exp.)
- No new "sensitive" candidates in the additional ~25pb^{-1} of data collected since the last LEPC
- Systematic studies are in progress
- LEP combination should increase the sensitivity (LEPHiggs talk Tom Junk)
- Additional ~50pb^{-1} expected until the end of LEP run (November the 2nd): not enough to reach 5σ at 114 GeV (even LEP combined)
- Stay tuned for the next 20 days……and then be patient for the next 5-10 years …… or make a wish




Higgs
LEP Fest 200 1
L3
OPAL