Polarization requirements at the Z-pole

Gudrid Moortgat-Pick (IPPP)

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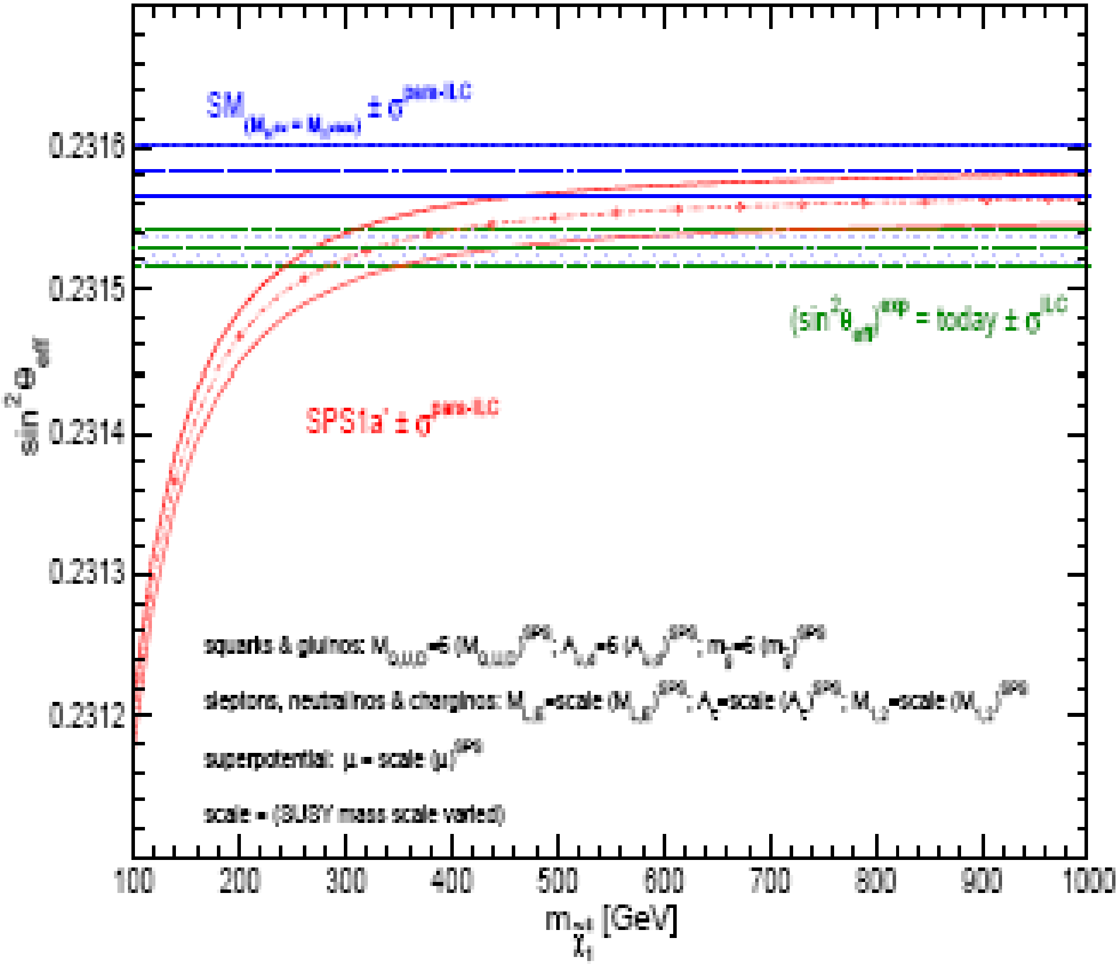
- Short summary
- Impact of polarization at the Z-pole
- Physics issues at 150 vs. 250 position
- Open issues

Short summary

- Extrapolated from LEP2, we need for calibration
  - 10 pb/detector + couple of pb's over the year
- For calibration: large emittance, low lumi tolerable
- But rather stable energy, not yet completely worked out
  - Only at GigaZ: energy stability, calibration accuracy < 0.1% (scope)
  - Only at WW threshold: beam enrgy calibration ~ few 10^{-5} (scope)
- We talk only about 'using calibration data for physics', not the high precision measurements
  - Resolving A_{LR} and A_{FB} discrepancy
  - Providing accurate $\sin^2\theta_{eff}$

Physics gain with $\sin^2\theta_{eff}$=3 x 10^{-5}

- **Hints for new physics in worst case scenarios:**
  - Only Higgs @LHC
  - No hints for SUSY



- **Deviations at Zpole**
  - Hints for SUSY

- **Discrepancy**

$$\text{SLD:} \quad \sin^2\theta_{\text{eff}} = 0.23098$$

$$\text{LEP:} \quad \sin^2\theta_{\text{eff}} = 0.23221$$

A_{LR} and $\sin^2\theta_{eff}$

- **Accuracy in $\sin^2\Theta_{eff}$**

$$A_{\rm LR} = \frac{2(1-4\sin^2\theta_W^{\rm eff})}{1+(1-4\sin^2\theta_W^{\rm eff})^2}$$

- precision in ALR directly transferred to $\sin^2\Theta_{eff}$

- GigaZ will provide $\Delta \sin^2\Theta_{eff} \sim 1.3 \times 10^{-5}$ (if Blondel scheme)
- only electron polarization at GigaZ: $\sim 9.5 \times 10^{-5}$
- current value: 16×10^{-5}
- What could we gain with a 'fraction' of GigaZ ?

Possible low lumi Z-data

$\int \mathcal{L}$	No. of Z's	$\int_{\text{days}} \mathcal{L}_{\text{cal}}$	$P(e^-)$	$P(e^+)$	ΔA^0_{LR}	ΔA_{LR}	$\sin^2\theta_{\text{eff}}$
6 pb^{-1}	1.8×10^5	1	90%	0	–	2.7×10^{-3}	3.4×10^{-4}
			90%	40%	3.3×10^{-3}	4.4×10^{-3}	5.6×10^{-4}
			90%	60%	2.2×10^{-3}	3.0×10^{-3}	3.8×10^{-4}
24 pb^{-1}	7.3×10^5	4	90%	0	–	1.5×10^{-3}	1.9×10^{-4}
			90%	40%	1.6×10^{-3}	2.2×10^{-3}	2.8×10^{-4}
			90%	60%	1.1×10^{-3}	1.5×10^{-3}	1.9×10^{-4}
60 pb^{-1}	1.8×10^6	10	90%	0	–	1.1×10^{-3}	1.4×10^{-4}
			90%	40%	1.0×10^{-3}	1.4×10^{-3}	1.8×10^{-4}
			90%	60%	7.0×10^{-4}	9.4×10^{-4}	1.2×10^{-4}
0.6 fb^{-1}	18×10^6	100	90%	0	–	8.1×10^{-4}	1.0×10^{-4}
			90%	40%	3.3×10^{-4}	4.4×10^{-4}	5.6×10^{-5}
			90%	60%	2.2×10^{-4}	3.0×10^{-4}	3.8×10^{-5}
0.9 fb^{-1}	27×10^6	150	90%	0	–	7.9×10^{-4}	1.0×10^{-4}
			90%	40%	2.7×10^{-4}	3.6×10^{-4}	4.6×10^{-5}
			90%	60%	1.8×10^{-4}	2.4×10^{-4}	3.1×10^{-5}
1.2 fb^{-1}	36×10^6	200	90%	0	–	7.9×10^{-4}	1.0×10^{-4}
			90%	40%	2.3×10^{-4}	3.1×10^{-4}	4.0×10^{-5}
			90%	60%	1.6×10^{-4}	2.1×10^{-4}	2.7×10^{-5}
1.8 fb^{-1}	54×10^6	300	90%	0	–	7.8×10^{-4}	1.0×10^{-4}
			90%	40%	1.9×10^{-4}	2.6×10^{-4}	3.2×10^{-5}
			90%	60%	1.3×10^{-4}	1.7×10^{-4}	2.2×10^{-5}

Table 4: Lumi at Z-pole $\mathcal{L}_{\text{cal}} = 7\times10^{31}\ \text{cm}^{-2}\text{s}^{-1}$, $\sigma(e^+e^- \to Z \to had) \sim 30$ nb, $A_{\text{LR}} = 0.154$, $\Delta P/P = 0.5\%$, $\mathcal{L}_{++,--}/\mathcal{L} = 0.1$

What's the role of polarization?

- **Derive the statistical uncertainty of A_{LR}**
  - **If only polarized electrons:**
    ΔA_{LR} determined by polarimeter uncertainty

    $A_{LR} = 1 / P(e-) \times [\sigma_L - \sigma_R] / [\sigma_L + \sigma_R]$
  - **Pure error propagation:**
    uncertainty depends on $\Delta\sigma_L$, $\Delta\sigma_R$, $\Delta P/P$
  - **For large statistics, σ (ee -> Z -> had) ~ 30 nb:**
    main uncertainty from $\Delta P/P \sim 0.5$ % up to 0. 25%
  - **Since 'only' calibration and begin of ILC: $\Delta P/P = 0.5$ %**
  - **Higher P(e-) better, assumed 90%**

Blondel Scheme

- Two polarized beams available
  - Express A_{LR} only by cross sections

$$\sigma = \sigma_{\mathrm{unpol}}[1 - P_{e^-}P_{e^+} + A_{\mathrm{LR}}(P_{e^+} - P_{e^-})],$$

$$A_{\mathrm{LR}} = \sqrt{\frac{(\sigma_{++} + \sigma_{+-} - \sigma_{-+} - \sigma_{--})(-\sigma_{++} + \sigma_{+-} - \sigma_{-+} + \sigma_{--})}{(\sigma_{++} + \sigma_{+-} + \sigma_{-+} + \sigma_{--})(-\sigma_{++} + \sigma_{+-} + \sigma_{-+} - \sigma_{--})}}$$

  - Pure error propagation:

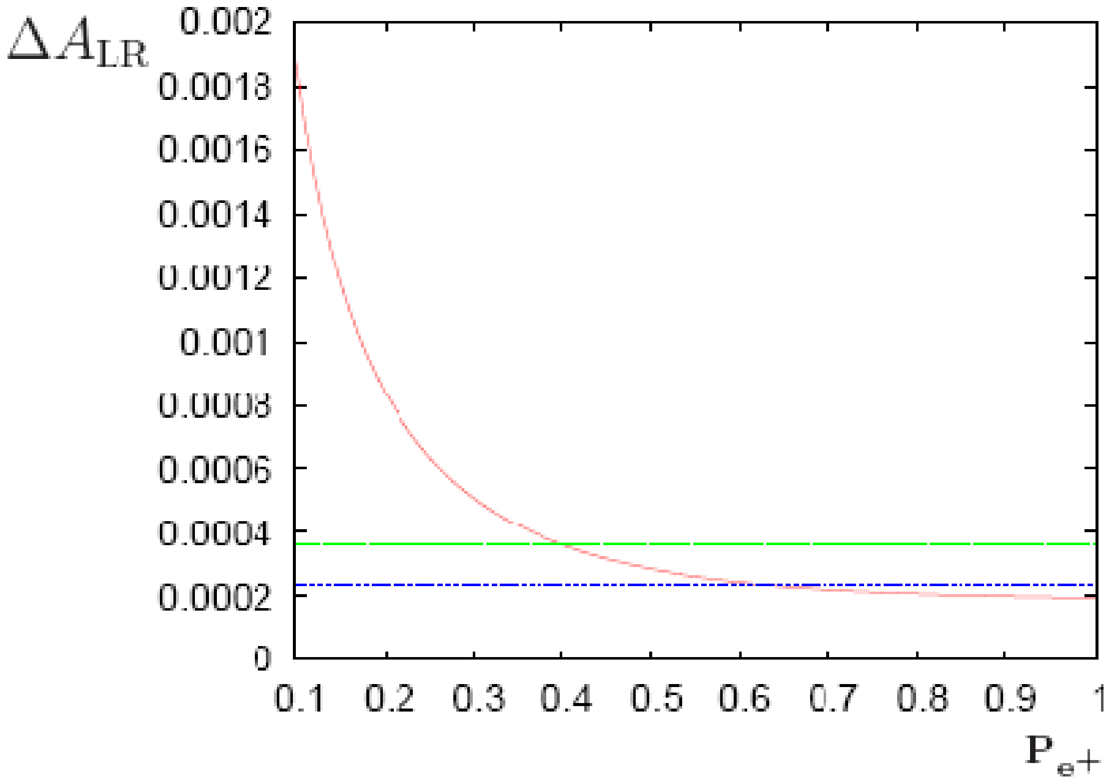
    uncertainty depends on $\Delta\sigma_{LL}$, $\Delta\sigma_{LR}$, $\Delta\sigma_{RL}$, $\Delta\sigma_{RR}$ not on $\Delta P/P$
  - Only relative measurements wrt flipping polarization needed

    $\Delta P / P = 0.5$ % sufficient
  - Some calibration time in LL and RR required

    assumed 10%, but that's not the optimum
  - Different anal. powers: $\Delta A_{LR} = \Delta A^0_{LR} \times \sqrt{(1+8/x)}$, x~10=Ce/Ze

Dependence of A_{LR} on $P(e^+)$

- On basis of 10^6 Z's
- $P(e^+)$ important
- Strictly speaking:
  $P(e^+)$=60% desirable

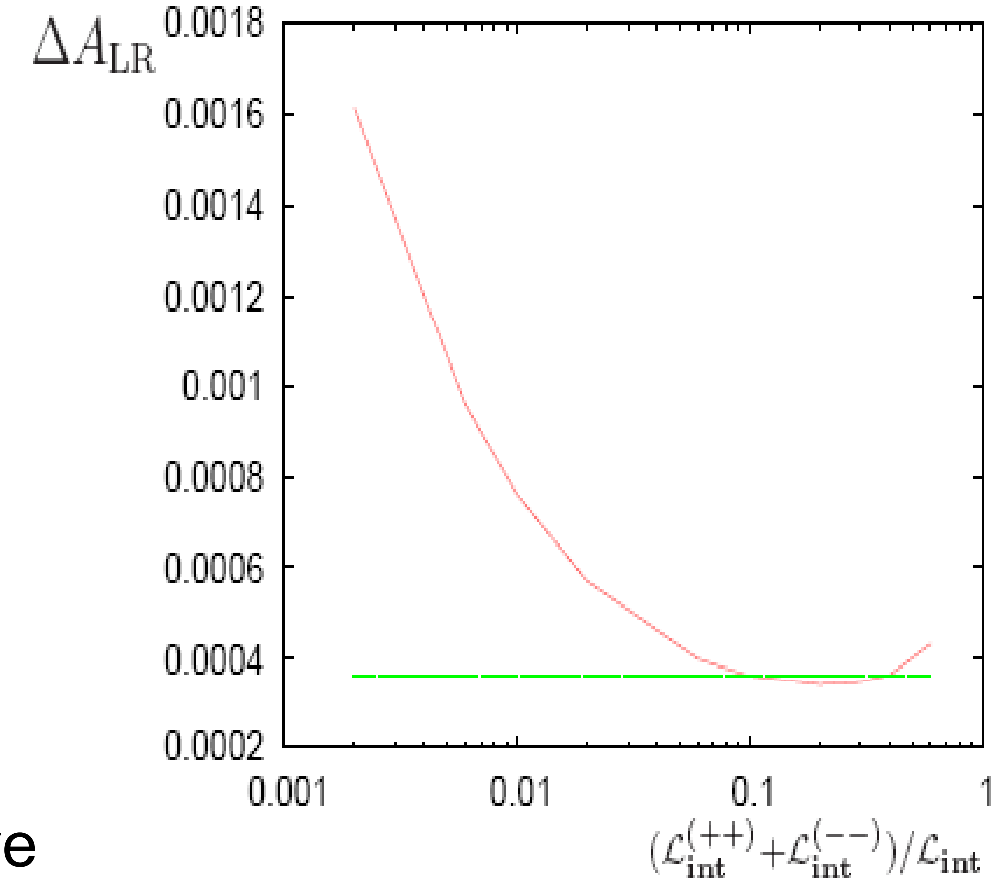


Dependence of A_{LR} on L_{++} and L_{--}

- What is the optimum time running in (++) and (--) mode?
- Assume $P(e^+)$=40%
- Best value at about

$(L_{++} - L_{--})/L_{int}$=25%

- But does not significantly reduce the uncertainty!
- Higher P(e+) more effective



Other topic: und@150 vs 250 GeV

(See also EUROTEV-Report-2005-015-1)

- Only some physics thoughts (see also weblog, July 08)
- 250 position: higher yield (about a factor ~3)
  but lumi problems for low $\sqrt{s}$
  - For current parameters: drops below design value 1.5 from $\sqrt{s}$=300 GeV downwards
  - Possible lumi loss could be compensated by using bypass and half rate if lumi drops by factor 2
  - For current parameters this should happen between 200-240 GeV
- What's about expected physics in this energy range?

Physics at $\sqrt{s}$=200-240 GeV

- Light Higgs:
  - should be in range [115 – 210] GeV, that means σ(HZ) -> [220-300] GeV
  - Already at the upper edge of this region
  - Anyway: first measurements will be done at 500 and 350 GeV and predict optimal steps for threshold scans …………….. Should be ok
  - Higgs mass in continuum up to 50 MeV
  - Threshold scans needed, e.g. for spin verification: 3 steps needed
  - Couplings measurements optimal at 50GeV+threshold: -> almost beyond critical region

    or at top threshold: anyway ok

Which other physics is crucial?

- Top threshold: happens at 350 GeV…..ok
- Light SUSY: …..would be lovely, but even if…
  - studies will anyway be done first at 500 GeV
  - If threshold scans required, number of needed energy steps optimized via the continuum measurements (similar as for Higgs)
- Undulator position at 250 should be ok (even without by-pass)

Open Issues and Conclusions

- **What is the calibration lumi?**
  - **For deceleration scheme (only for 150 GeV applicable)**
  - **For 50 GeV scheme (for 150 GeV and 250 GeV applicable)**
- **What is the e^+ polarization at which lumi?**
- **Z-data required to solve A_{LR} vs A_{FB} and to enable powerful tests even in worst case scenarios**
  - We should not miss this opportunity!

- **Undulator position 150 vs 250: should be ok for physics**
  - **Expected lower lumi for $\sqrt{s}$=200 – 240 GeV bearable**