LUMI expert team notes

Notes/comments/thoughts for meeting 8 May 2024 https://indico.cern.ch/event/1412306/:

- On di-photon production in the note. i) Suggest adding “avoids EM deflections issues” in addition to avoiding severe metrology and significant hadronic vacuum polarization. ii) While |costh| < 0.9 acceptance should be straightforward it is too conservative, iii) One does not need to reduce Bhabha contribution by 10^6 to 10^-4 to control this background. This assumes 100% uncertainty on Bhabhas! [Graham]
- Graham: I was wondering whether e+e- -> e+e- mu+mu- may be another process that should be considered. See eg. https://link.springer.com/article/10.1007/BF01558388 (OPAL).
  1462 gamma gamma->mu+mu- events with 40 inv pb at the Z. [Graham]. This was for one forward tagged electron - so visible cross-section of 33 pb. “A study of muon pair production and evidence for tau pair production in photon-photon collisions at LEP”
- Could also use e+e- -> mu+mu-. Some preliminary studies expected by October [Ivanka Bozovic]
  One would need to assume validity of SM.
- Graham working to try to understand precision of low angle gamma-gamma and ee events using a mini-tracker in front of the low-angle calo.
- For FCC-ee minimum polar angle of forward detector position is larger than for ILC, but for low angles, 1/theta^3 dependence leads to steep increase of uncertainty due to misplacements.
- Expect updated studies of ILC LumiCal configurations, including systematics for metrology and mechanics before October [Ivanka]
  Juergen: How are these systematics affected by the push-pull detector system?
- Fulvio: plans to improve BabaYaga parton shower and matching to (N)NLO, as well as look at LBL contribution for e+e- -> gamma gamma, but no new results expected before October.
- Bennie, Wieslaw: extensive plans to improve BHWIDE and BHLUMI. First steps include EW NLO corrections and 4-fermion final states. Progress limited by available funding, i.e. uncertain if any news before end of 2024.
- Add more info to “theoretical challenges” subsections in focus topic write-up [Bennie/Wieslaw/Fulvio]

Notes from previous meeting 11 May 2023 https://indico.cern.ch/event/1285690/

- Current studies aim for an absolute lumi precision of 10^-4 and a point-to-point precision of 10^-5.
  - Is this realistic? Can one do better?
  - How precisely can we determine the correlations between measurements at different energies ?
  - Since the luminosities are orders of magnitude larger than at LEP: are there processes other than low-angle Bhabha and large-angle ee->gamgam that

can be used for the monitoring. Their energy dependence needs to be known precisely.
- How and how far could one reduce the theory uncertainty for low-angle Bhabha?
- How to control/calibrate geometrical acceptance of Bhabha LumiCal?
- For ee->gamgam, can the Bhabha background be reduced to the required level?
- Control/calibrate acceptance for ee->gamgam
- How is the absolute (relative) lumi measurement affected by beamstrahlung?
- How precisely would the luminosity *spectrum* need to be reconstructed for physics goals?
- For Bhabha scattering, the most problematic theory uncertainty is from the hadronic vacuum polarization. How would that affect the point-to-point precision?
- For ee->gamgam, are higher-order electroweak corrections relevant?
- For ee->gamgam: hadronic vacuum polarization enters at two loops, which is good, w.r.t. Bhabha. At the same order also light-by-light enters. Can we give any estimate to the overall uncertainty?

Meetings

- https://indico.cern.ch/event/1285690/ (May 11, 2023)

Other comments / questions:

- It seems that many team members lean toward ee->gamgam as the more promising option for high-precision total lumi determination, given its relaxed requirements for hadronic theory uncertainties and detector alignment. [MD: detector alignment requirements for this channel are certainly not relaxed!]
- The Bhab sha background to ee->gamgam is probably manageable, but further study would be desirable.
- When using ee->gamgam for lumi measurement, do we need to worry about confusion with Z->pi gamma?
  -> probably not, SM calculations for BR(Z->pi gam) are O(1e-11)
  [https://arxiv.org/pdf/1501.06569.pdf]
- How precisely can we determine the correlations between measurements at different energies ?
- Since the luminosities are orders of magnitude larger than at LEP: are there processes other than low-angle Bhabha and large-angle ee->gamgam that can be used for the monitoring? Their energy dependence needs to be known precisely.
- What are the best available MC programs for Bhabha and gamgam studies? Are LEP era MC programs adequate for sensitivity/design studies?
- For precise measurements redundancy is important key. Hence, one should pursue both channels, low-angle Bhabha and large-angle gamgam and compare and learn.
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From the ECFA-WG1 Benchmark document:

7 LUMI – Precision of the luminosity measurement from low-angle Bhabha scattering

(JL)
including the best MC generators available on the short-term, requirements for and conceptual work
towards the ultimately required theory and MC precision, detector-level simulations, requirements on
forward detector, strategies for calibration and alignment, methods to extract the luminosity
The luminosity at a future Higgs factory needs to be controlled to unprecedented precision, both
in terms of the absolute scale, but also in terms of point-to-point precision for threshold or line-shape
scans.
This has been studied in detector-level simulations at higher center-of-mass energies for Linear
Colliders, but less so at typical Higgs factory energies or even the Z pole.

MC samples needed:
Basic samples based on Whizard available as listed in Section 0, those based on dedicated generators
will be needed.

people / groups working (will be kept internal, just yes/no and ECFA conveners to contact here)
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