Welcome to our first meeting in 2022!

News item 1: a few changes in our WG organisation, some very recent (Simone), some less so.
Conveners (and affiliation!) as of now are: Fulvio (theory), Aleko and Simone (CMS), Mika (LHCb), Aram and Daniel (ATLAS)

News item 2: we are now about to enter year 5 of our benchmarking work started in April 2018. Priority in 2022 has to be to document and publish even if we have to descope some aspects.

News item 3: we are indeed reaching the end-game of ongoing calculations and this is a great achievement, thanks to all contributors!
Example of QED status overview in next slides
Summary of status of QED corrections

• Overall summary including update from KKMC-hh by Scott last November

IFI Contribution to "$A_4$" $= \frac{8}{3} A_{FB}$: Updated

The table shows the difference in $A_4 \times 10^4$ with IFI on minus IFI off. The numbers are from Stefan Dittmaier’s May presentation with new KKMCChh results for 38 billion events. KKhhFoam is a soft photon approximation to KKMCChh. It agrees when hard photon corrections are not important.

<table>
<thead>
<tr>
<th>version</th>
<th>$89 &lt; M_\ell &lt; 93$</th>
<th>$60 &lt; M_\ell &lt; 81$</th>
<th>$81 &lt; M_\ell &lt; 101$</th>
<th>$101 &lt; M_\ell &lt; 150$</th>
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<td>KKMChh</td>
<td>-2.2(2)</td>
<td>-16.7(6)</td>
<td>-2.4(2)</td>
<td>-59(1)</td>
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<td>KKhhFoam</td>
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<td>-17 (1)</td>
<td>-4.1(5)</td>
<td>-46(3)</td>
</tr>
<tr>
<td>KKMChh (NISR)</td>
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<td>-17(1)</td>
<td>-3.2(5)</td>
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<tr>
<td>KKhhFoam (NISR)</td>
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<td>-3.8(5)</td>
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<td>-2.3(5)</td>
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<td><strong>-62(1)</strong></td>
<td><strong>-2.5(4)</strong></td>
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<tr>
<td>RADY (CMS)</td>
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<td>A. Huss</td>
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<td>-33.9(6)</td>
<td>-2.57(7)</td>
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</table>
Next steps, outstanding issues for QED calculations

• Resolve issue of definition of ISR and IFI contributions:
  - formulae as discussed above by Powheg-EW
  - differences outside pole region: do these really correspond to somehow theoretical uncertainties related to these calculations or should we dig deeper?
  Clearly, the most important numbers are those in the pole region which are in excellent agreement ...
  - question of usage or not of QED PDFs raised initially by Alessandro and emphasised more recently by work reported by Scott
  Here we need a definite decision on how to proceed but bearing in mind that QED PDFs are not used at all yet in any large-scale MC production of the experiments.

• Get missing updates (certainly from WZGRAD2 in February and possibly also from MC-SANC?)

• Associate an uncertainty to the QED calculations (Stefan?)

• Document these results starting with a nice pedagogical introduction linking the work presented based on pure $\gamma^*/Z$ DY with the more correct and general framework of calculations including photon-induced processes (Alessandro)!
  Please also remember to start writing appendices for each calculation 😊
Theoretical uncertainties on virtual corrections (Ayres)

Comments and discussion points

- Dependence of form factors on $s = m_{\ell\ell}$ and box contributions not taken into account so far.

- IFI box and other QED requires separate uncertainty estimate.

- Large corrections for $G_\mu$ scheme from photon exchange contribution:
  $\alpha = \frac{\sqrt{2} G_\mu s_W^2 M_W^2}{\pi} (1 - \Delta r)$
  $\rightarrow$ Anything different being done in generators?

- Plan for $\mathcal{O}(\alpha \alpha_s)$:
  include in analysis, or use available results for error estimate? [should be added in quadr. to $\mathcal{O}(\alpha^2)$ estimate]
Upcoming Meetings

- LHC EW WE General Meeting
  - February 15-17
  - https://indico.cern.ch/event/1108518/

- As usual we plan to organize a precision subgroup meeting one day before the general meeting (February 14th)
  - The goal of the meeting would be to discuss the contributions from our subgroup to the General meeting
  - We expect to have a separate report on the pT V ressumation benchmarking on the last day of the general meeting

- We expect also to have a separate report on the QED/EW status on the last day of the general meeting

- As usual we will ask for speakers on a rotational basis, so we will be searching for two “victims” one of whom will probably have to cover also in a couple of slides the status of the documentation.