Plasma accelerator physics case

aka very high energy + very low energy demonstrator

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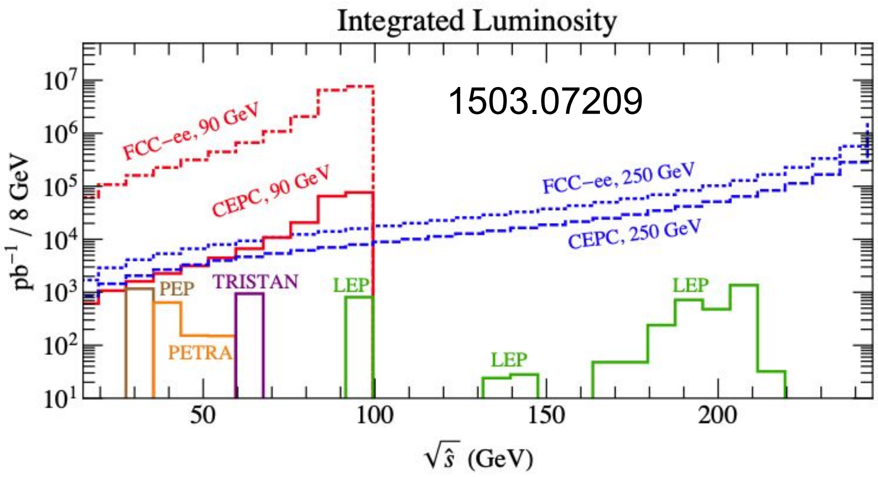
Simon Knapen, Ben Nachman, Simone Pagan Griso

Motivation for a Very High Energy (VHE) collider

- The physics case of a Higgs factory (ILC, FCC, CEPC, C^3) and multi-TeV (CLIC) have been well-fleshed out.
- It is clear that the main technologies proposed for the above e^+e^- colliders can't go higher than multi-TeV on any realistic budget
- After that, we need new accelerator technologies - perhaps plasma?
- The physics case for > multi-TeV is being fleshed out right now in the context of muon collider proposals. The physics case of a 10 TeV muon collider is not so different than a 10 TeV e^+e^- collider.

Towards a (V)HE plasma collider

- It will be essential to have a “demonstrator” at lower energy to show the technology works
- Natural question: could we do “physics” with such a demonstrator?
- If we could build a multi-10 GeV collider on sight, is there a physics case?



We have been to this energy before - what is the motivation for going there again?

Physics case of a multi-10 GeV demonstrator

- See physics program of TRISTAN, PETRA, LEP, SLC

  a. If the lumi/detector is not better, then can't beat the analyses they did.
  b. However, our understanding of QCD, etc. has gotten (much) better - possible to redo some analyses with lower uncertainties.
  c. There are also searches and measurements that these collaborations did not do at the time and they could be done (in some cases, empowered by new techniques like machine learning)
  d. Of course, if we had the raw data of these experiments and the complete knowledge of their collaborations, we could do (b) and (c). The reality is that this is essentially not possible. Any new experiment would future proof its data.

- New analyses enabled by new detectors

  a. Perhaps advanced timing/vertexing detectors would allow for unique sensitivity to exotic new physics? (e.g. long lived particles, …)

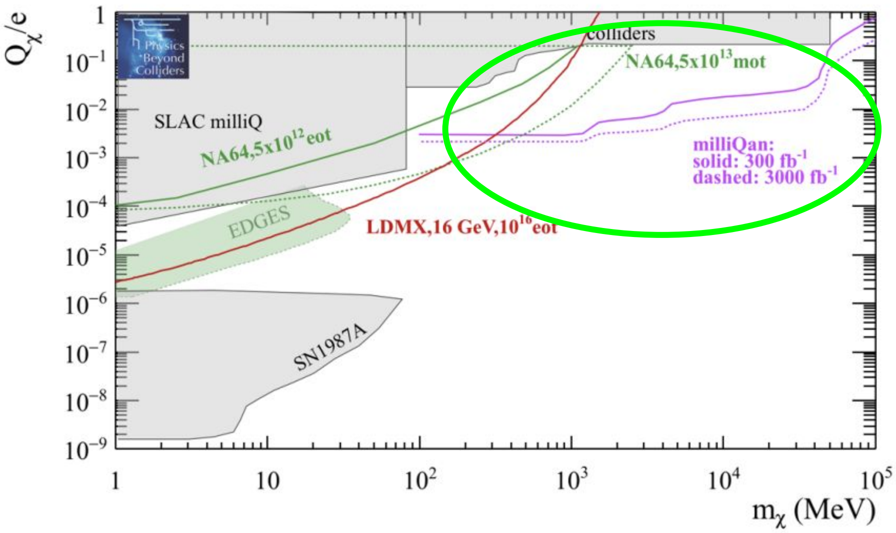
Beyond the standard model

- Mass must probably be above > 10 GeV, or Belle II would find it first
- Anything that LEP didn’t find because:
  - They didn’t look (data is unanalysable)
  - Their detectors were not suitable for the signal

Beyond the standard model (examples)

- Milicharged particles
- Soft, displaced vertices (e.g. inelastic DM)
- Axion-like particles
- Low mass resonances decaying to hadronic final states
- ….

Studies needed to verify viability!



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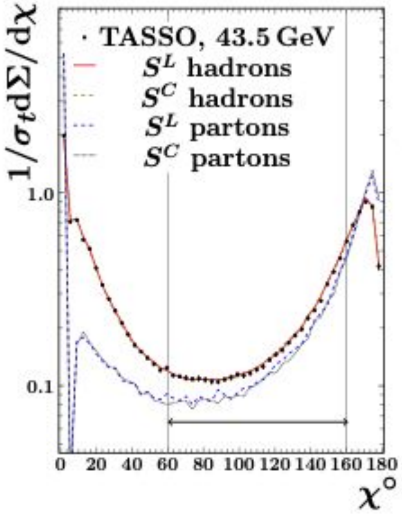
Standard model measurements

Precision QCD - α_s? There is currently a 3-sigma tension between lattice and e^+e^- extractions. A modern measurement would be able to shed light on this.



40 GeV is not hopelessly non-perturbative (higher E is obviously better)

Experiment	$\sqrt{s}$, GeV, data	$\sqrt{s}$, GeV, MC	Events
SLD [47]	91.2(91.2)	91.2	60000
OPAL [50]	91.2(91.2)	91.2	336247
OPAL [51]	91.2(91.2)	91.2	128032
L3 [48]	91.2(91.2)	91.2	169700
DELPHI [49]	91.2(91.2)	91.2	120600
TOPAZ [52]	59.0 – 60.0(59.5)	59.5	540
TOPAZ [52]	52.0 – 55.0(53.3)	53.3	745
TASSO [53]	38.4 – 46.8(43.5)	43.5	6434
TASSO [53]	32.0 – 35.2(34.0)	34.0	52118
PLUTO [58]	34.6(34.6)	34.0	6964
JADE [54]	29.0 – 36.0(34.0)	34.0	12719
CELLO [57]	34.0(34.0)	34.0	2600
MARKII [56]	29.0(29.0)	29.0	5024
MARKII [56]	29.0(29.0)	29.0	13829
MAC [55]	29.0(29.0)	29.0	65000
TASSO [53]	21.0 – 23.0(22.0)	22.0	1913
JADE [54]	22.0(22.0)	22.0	1399
CELLO [57]	22.0(22.0)	22.0	2000
TASSO [53]	12.4 – 14.4(14.0)	14.0	2704
JADE [54]	14.0(14.0)	14.0	2112

Standard model measurements

Monte Carlo Modeling. Much of our parton shower Monte Carlos are tuned to LEP data. With new showers, etc. it would make sense to identify new measurements to help constrain these (e.g. essentially only g→bb total rates were measured, not differential)

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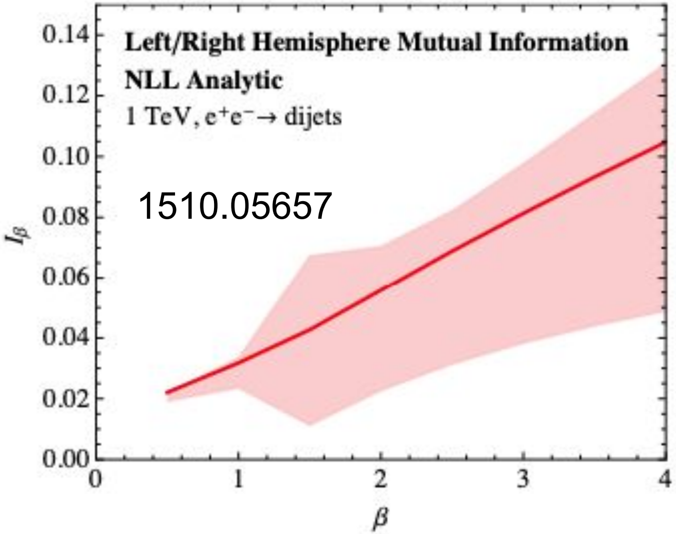
Standard model measurements

Probing QCD in new ways. Can explore QCD in the context of QIS, e.g. entanglement between hemispheres

Mutual information between hemispheres



Inverse Grooming strength

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