Vinca Belgrade
http://hep.vinca.rs

Luminosity measurement at CepC

CepC PD meeting, 20. 3. 2017

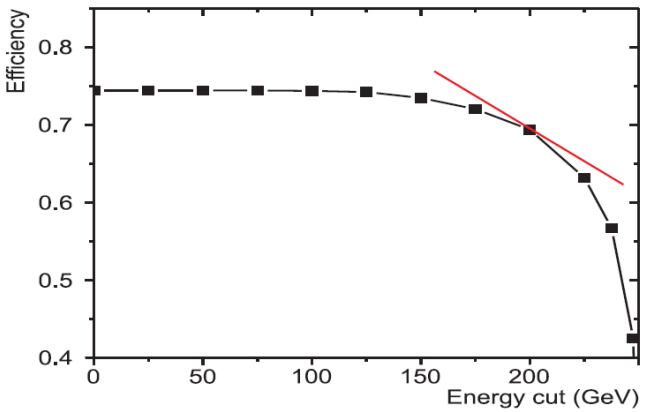
Relevant experience of the Vinca HEP group

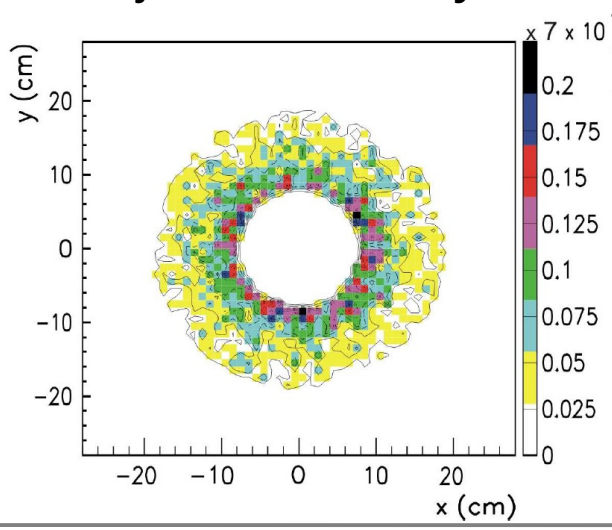
- ✓ **Luminosity measurement at ILC, systematic studies**
- Impact of the uncertainty of the beam energy (center-of mass)
- Uncertainty of the stochastic term of the luminometer
- Physics background from 2-photon (Landau-Lifshitz) processes

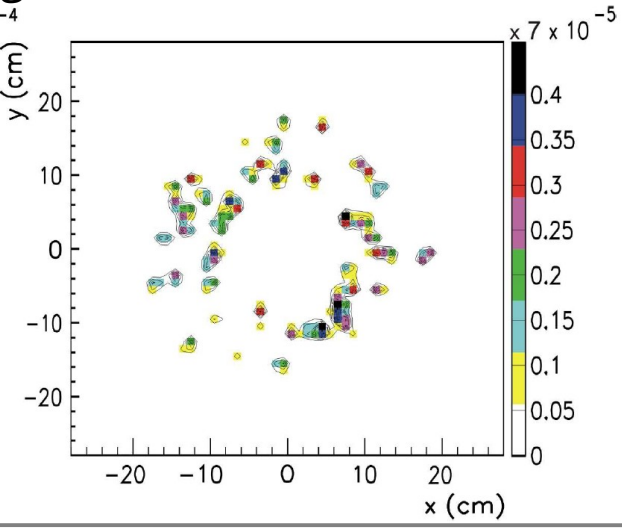
Selected references:

1. I. Bozovic Jelisavcic, S. Lukic, G. Milutinovic Dumbelovic, M. Pandurovic and I. Smiljanic, *Luminosity Measurement at ILC*, JINST 8 (2013) P08012 arXiv:1304.4082
2. H. Abramowicz, I. Bozovic Jelisavcic, T. Jovin, M. Pandurovic, I. Smiljanic et.al. [FCAL Collaboration], *Forward Instrumentation for ILC Detectors*, 28pp. JINST 5 (2010) P12002

2 PhD theses, M. Pandurovic, I. Smiljanic, University of Belgrade





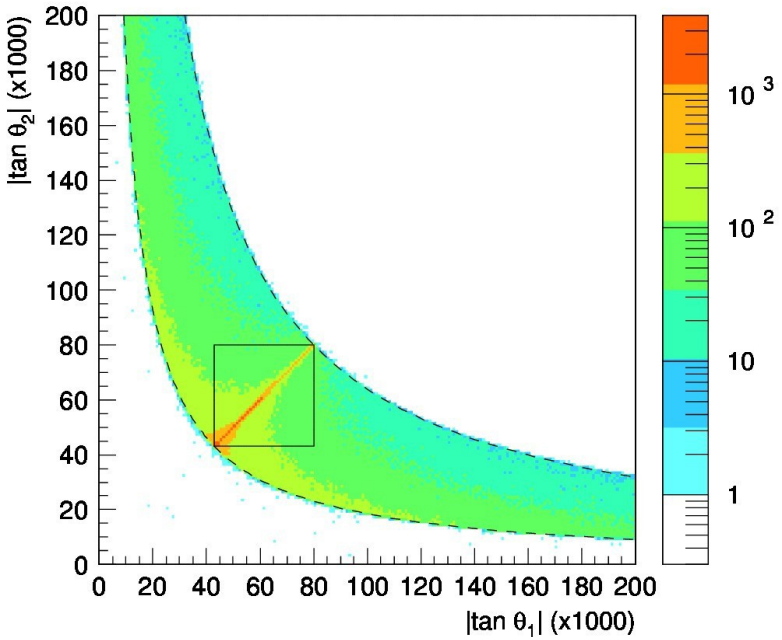


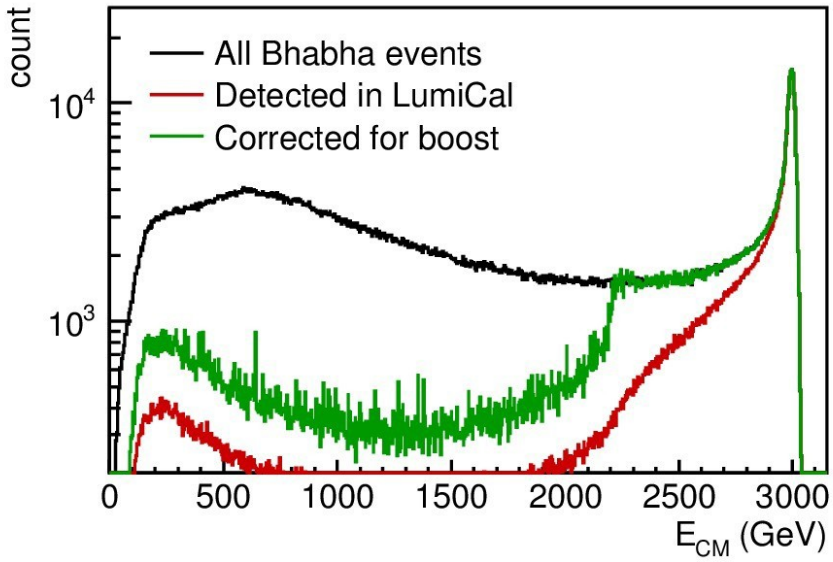
Relevant experience of the Vinca HEP group

- ✓ **Data driven correction of losses caused by acollinearity (mostly due to Beamstrahlung at lin. colliders) in luminosity measurement at ILC and CLIC**

S. Lukic, I. Bozovic Jelisavcic, M. Pandurovic, I. Smiljanic, JINST 8 (2013) P05008

Relevance for CepC: Many systematic effects “work” by creating acollinearity. Generic correction possible.





Relevant experience of the Vinca HEP group

- ✓ **Luminometer design**
  - Segmentation and occupancy

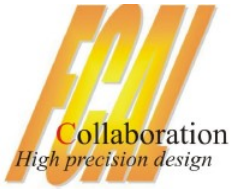
- ✓ **Luminometer test-beam (2014, 2015, 2016)**
  - Simulation of the test-beam setup and data analysis (*ongoing*)
  - Development of a multidimensional template fit method for the analysis of transverse shower profiles in 2014 test-beam data.

- ✓ **Software development**
  - BeamCal and Pair Monitor (within HORIZON2020 E-JADE) integration in DD4HEP (*ongoing*)

Selected references (FCAL Collaboration papers):

- ECFA Detector R&D Panel, Review Report, arXiv:1411.4924 [physics.ins-det], LCD-DET-2013-029.
- Performance of fully instrumented detector planes of the forward calorimeter of a Linear Collider detector, JINST 10 (2015), P05009.

The work is being done within the FCAL Collaboration
http://fcal.desy.de/



Integral luminosity measurement at CEPC

ACTION LIST – Short term

- ✓ **Starting assumption: Bhabha counting using LEP-like selection**

1. **Statistical uncertainties**: Bhabha event statistics, fluctuations of the 2-photon Background
2. **Dominant systematics** (fast simulation, no MDI effects, no theoretical uncertainties)
   - Beam-energy uncertainty
   - 2-photon background
3. **Solid angle coverage** –
   - Assuming 5 ab^{-1} at Z-pole, $N_{Bh} \approx 6 \times 10^8 \left(\theta_{min}^{-2} - \theta_{max}^{-2} \right)$
   - Relative statistical precision better than 10^{-4} can be achieved with LumiCal at relatively large angles ($\theta_{min} \approx 100$ mrad)

     → profit from this to set feasible requirements on r_{min} precision?

     Is there enough space?
     Design ECAL endcap for the luminosity measurement?

Integral luminosity measurement at CEPC

ACTION LIST – Long term

1. **Statistical uncertainties**: Bhabha event statistics, fluctuations of the 2-photon Background
2. **Dominant systematics** (fast simulation, no MDI effects, no theoretical uncertainties)
3. **Full list of systematic effects, comparison of Bhabha counting methods** (next slide)
4. **Optimization of the luminometer design** – Assess the requirements w.r.t. the luminosity uncertainties, occupancies, etc.
   - Solid angle coverage (fiducial and the full range)
   - Mechanical precision requirements.
   - Compactness, segmentation, sampling term.
   - Interaction with MDI regarding mechanical and spatial constraints
5. **Collaborate with theorists** at a later stage towards the required precision of the calculation of the cross sections for the Bhabha scattering (including the contribution of the Z exchange) and for the 2-photon processes.

Systematic uncertainties (current understanding)

Create and maintain a list of systematic uncertainties of the luminosity measurement. The above includes e.g.,

- Uncertainty of the beam energy
- Physics backgrounds processes
- Beam energy spread
- IP position fluctuation and size
- Uncertainty of the beam polarization (if polarized beams)
- Uncertainty of the LumiCal inner radius
- Positioning of the LumiCal (longitudinal, transverse)
- Mechanical displacements of the LumiCal (vibrations, thermal stress)
- Uncertainty of the detector sampling term
- Bhabha acollinearity (due to ISR and FSR, beam energy spread, BS)
- Machine-related backgrounds (interactions with the beam halo etc.)

Evaluate systematic uncertainties under several alternative methods of counting Bhabha events (Lep-style cuts, collision frame – correction of acollinearities).

Key question: **Is 10^{-4} relative precision feasible?**

- ✓ Our contribution, personnel, AOB:

  - **In principle, items 1-5 from the slides above**.

  Estimates of the uncertainties using beam-beam collision simulations and with the interplay between the effects (i.e. radiative Bhabha -> acolinearity-> selection criteria -> physics background), which **requires input from the accelerator simulation.**

  - **People** (interested in luminosity measurement), in total 1.5 up to 3 FTE
    - Ivanka Božović-Jelisavčić
    - Mila Pandurović
    - Strahinja Lukić
    - Possibly 1 PhD student
  - **MoC signed last year between IHEP and VINČA on CEPC** (luminosity measurement, Higgs studies).
  - **Bilateral project application ongoing** (IHEP (Ruan Manqi) and VINCA (Ivanka Bozovic Jelisavcic)).

✓ Desired input from MDI and accelerator:

- Input to the simulations: Distribution of the beam particle momenta and coordinates at IP (or estimate)
- Input to the conceptual design: Mechanical and spatial constraints in the very forward region
    - Perhaps the very forward region is work in progress / can evolve together with the luminometer design

✓ Conclusions

- A plan for the activity “Luminosity measurement at CepC” is presented
- Main goals:
  - Conceptual design of the luminometer
  - Estimate of measurement uncertainties
- 3-4 people from Vinča involved
- Regular (ca. monthly) exchange with MDI desired in the beginning.