Bremsstrahlung photon beam monitoring.

LUXE weekly meeting

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DESY

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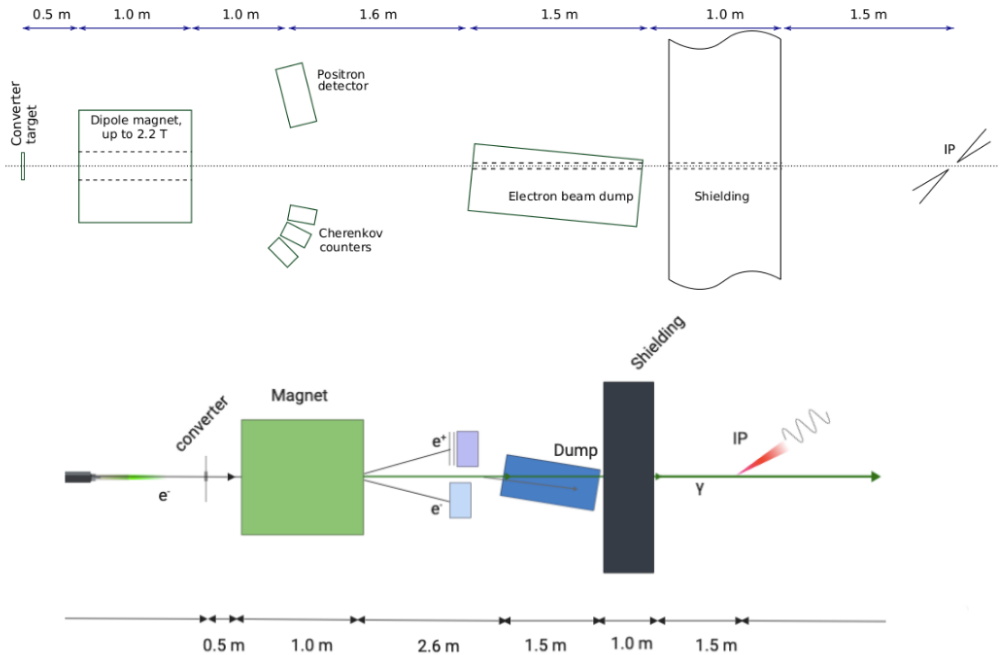
HELMHOLTZ
SPITZENFORSCHUNG FÜR
GROSSE HERAUSFORDERUNGEN

DESY.

Motivations

- Monitoring of the bremsstrahlung photon beam upstream from the IP
  - **most important:** determine number of photons at the IP (with $E > 7$ GeV?)
  - **bonus:** energy spectrum, repartition (x, y, z) of these photons
- Measurement of $\gamma^* \to e^+e^-$ after the conversion target
  - e^+ and e^- deflected by a 1 meter-long, 2T magnet
  - Cherenkov counters (e^-), possibility for a more evolved detector for e^+



Simulation and analysis tools

- **GEANT4 simulation** performed by Sasha
  - ROOT ntuples containing e^-, e^+ and γ, 10cm downstream from the conversion target (no magnet)

    /afs/desy.de/group/flc/luxe/bremsstrahlung/
  - 1 unique XFEL bunch with 100 times less electrons simulated
  - simulation setup described here

- **Analysis code** started by myself (work in progress)
  - ROOT-based analysis running on the batch system on the NAF

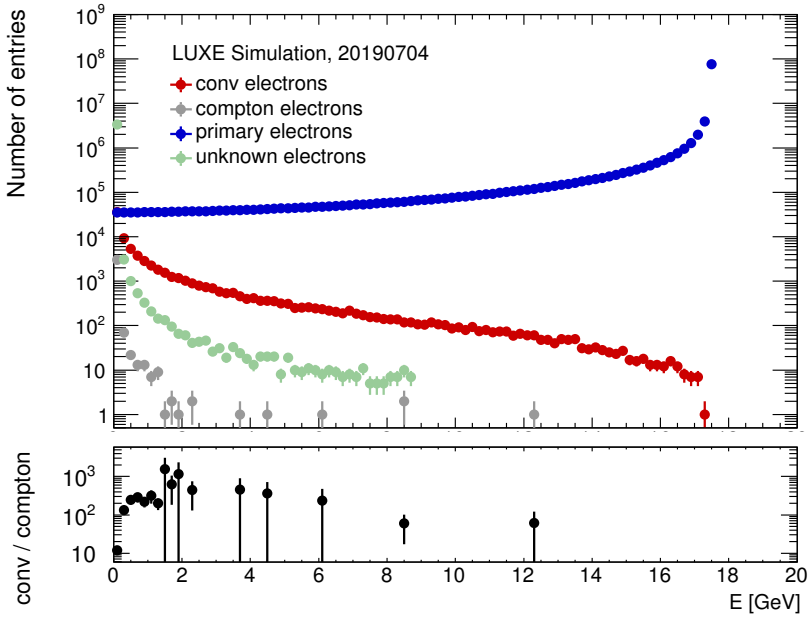
    https://username@stash.desy.de/scm/brem/bremphoton_analysis.git
  - README included, everbody welcome to test the code and to contribute

First results

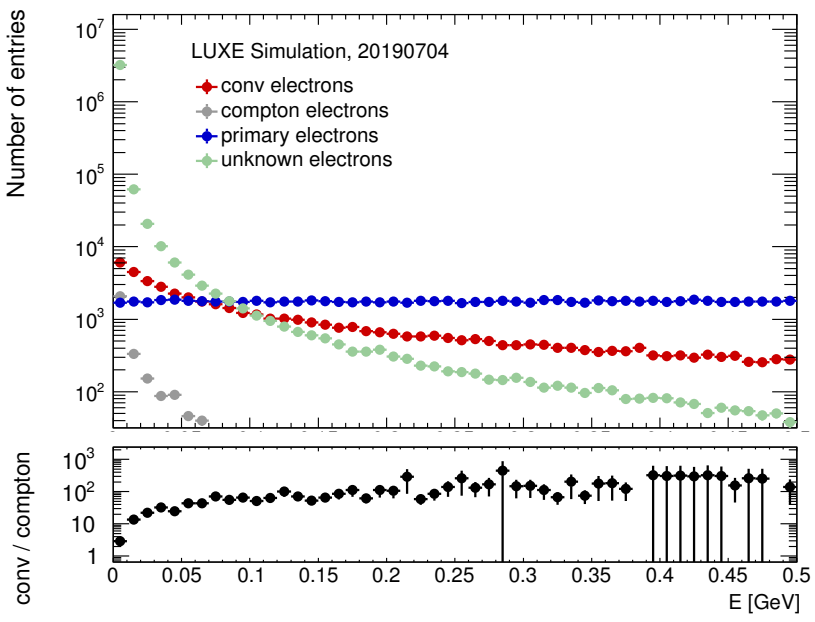
- **Particles in the ntuples:**
  - 96,941,816 electrons: → 96.5% primaries, 3.4% unknown, 0.08% from conversions, 0.003% from Compton
  - 27,004,279 photons → only 72 not from brem (classified as "unknown")
  - 79,263 positrons → all from conversions
- **First plots made:**
  - **properties** of electrons, positrons and photons
  - **comparison** between the various types of electrons, positrons and photons, etc
- Very first (naive) thoughts/considerations for a measurement

Electron energy spectrum

complete spectrum [0-20 GeV]



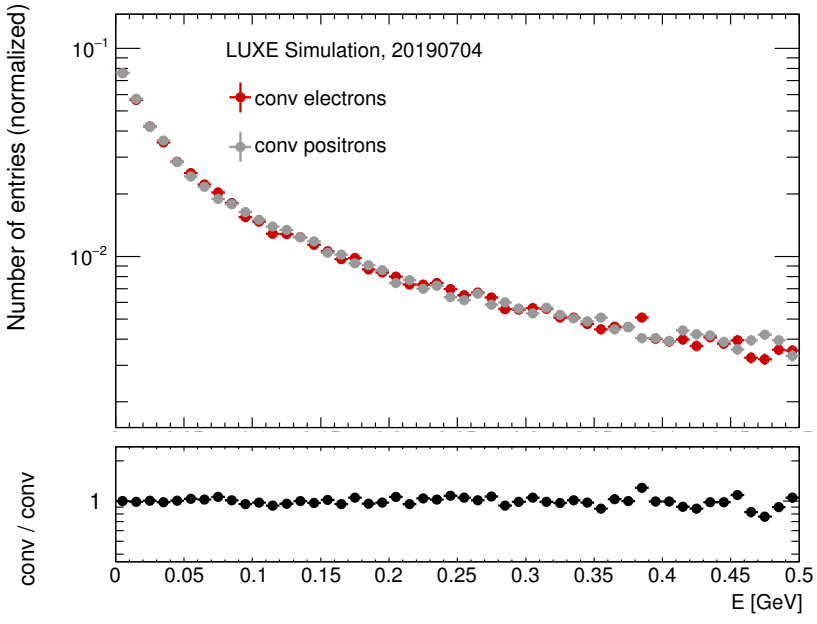
low energy spectrum [0-0.5 GeV]



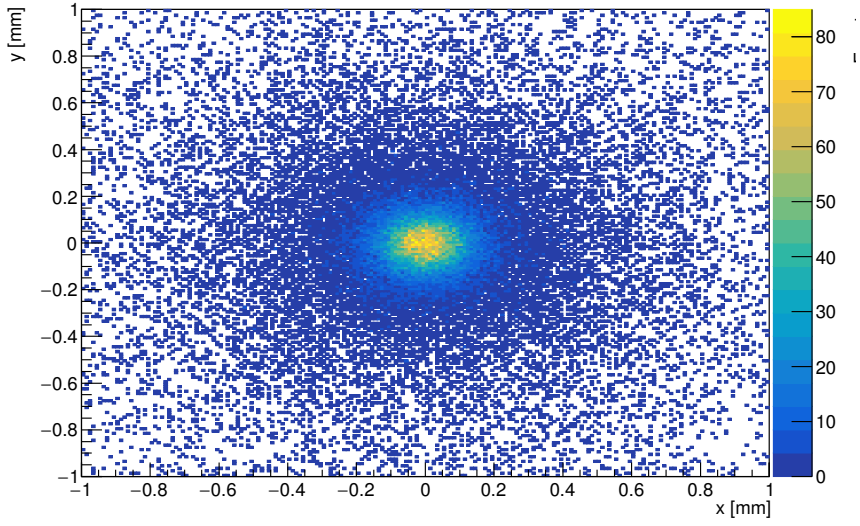
- large tail of primary electrons at low energy $\rightarrow$ large background for e^- detector
- "unknown" electrons peaks at very low energy, sizable also at higher E ($S/B \sim 10$)
- Compton electrons sub-dominant, S/B $\sim$ 100 for $E > 200$ MeV

Positrons (1/2)

low energy spectrum [0-0.5] GeV (normalized)



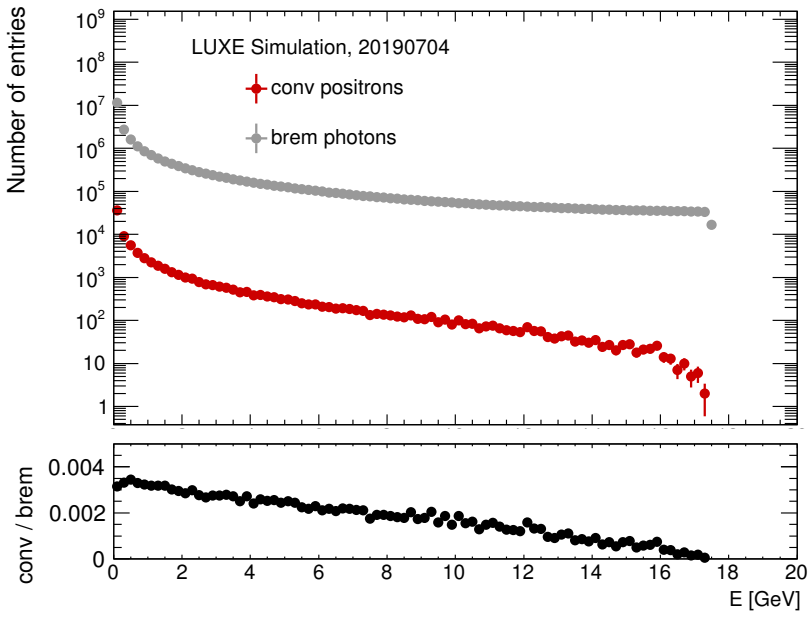
$x - y$ distribution



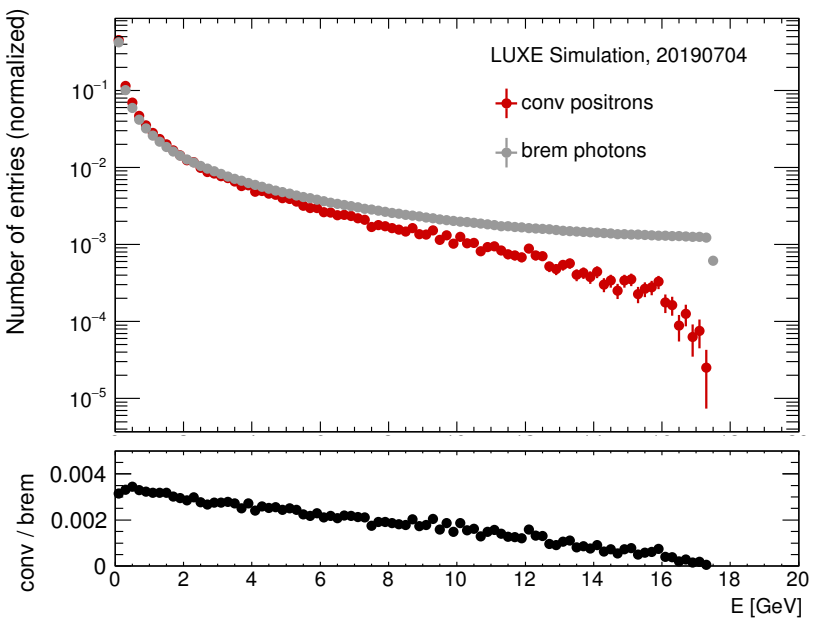
- same energy spectrum and number of e^+ than e^- from conversion $\rightarrow$ OK
- $\sigma_x \sim \sigma_y \sim 100\mu m$, $\sigma_z \sim 25\mu m$. 57% of the positrons have $E < 500$ MeV,
- Magnet: 2T, 1 meter long
  - acceptance starts at $E \sim p_z \sim 500$ MeV (curvature radius ~ 1 m)?

Positrons (2/2)

positrons vs photon spectrum



positrons vs photon spectrum (normalized)



- $N_{e^+}/N_\gamma \sim$ few 1e-3 and decreases linearly with E
- positron carries on average half converted γ energy, softer e^+ spectrum expected
- conversion rate and energy dependence? to be studied

Measurement idea (positrons)

1. **count the number of positrons falling in the counter acceptance**

   $\rightarrow$ deduce $N_{e^+}^{\mathrm{acc}}$ within 500 MeV - XXX GeV range (from acceptance)

2. use positrons/photons correlations to reconstruct total number of photons

3. use electron measurement to derive data-driven corrections to the correlation model (?)

- Remarks
  - **critical parameters:** detector acceptance (positron energy range) and efficiency (number of positrons), positrons/photons correlation model
  - **correlation model:** conversion rate as a function of photon energy, $\gamma \rightarrow e^+$ energy splitting function (1/2?)
  - **electron measurements:** helpful to derive data-driven corrections?

Conclusion and outlook

- **First look at bremsstrahlung photon beam monitoring**
  - ntuples produced by Sasha
  - analysis code started on bitbucket, people welcome to use it and contribute
- **Electron detector will be busy**
  - significant low energy XFEL e^- beam remnant ($S/B \sim 0.01$, decrease with E)
  - "unknown" electrons to investigate further ($S/B \sim 10$)
  - Compton electrons a priori not an issue ($S/B > 100$)
- **Positron detector**
  - acceptance (energy range) and efficiency (multiplicity) crucial parameters
  - acceptance < 0.4 with a 1-meter long 2T magnet (to be checked ...)?
  - **$e^+ \rightarrow \gamma$ extrapolation model inputs:**
    - conversion rate (+E-dependence)
    - $e^+ \rightarrow \gamma$ energy splitting function (1/2?)
    - use electrons to constrain/correct extrapolation model?

Bremsstrahlung photon beam monitoring.

Back-up slides

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