Finalizing Spectrometer Orientations

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Roadmap:

1. Efforts to validate Jan's TDR event rates revealed an ambiguity in the Mainz Generator source code ("pre-swap" v. "post-swap")

2. Without GEM or E-linac constraints, sensitivity-angle distributions are found to change significantly depending on "pre-swap" v. "post-swap" builds

3. Constraints on E-linac (300 μA ≤ I ≤ 330 μA) & electron background (e- ≤ 5 MHz) in our GEMs mitigate effect of "swap" on peak sensitivity orientation

4. Peak-sensitivity orientations vary depending on beam energy but generally achieve sensitivities between 2.1 and 3.1.

Mainz Generator “Pre-Swap” v. “Post-Swap”

It is unclear which generated particle (electron v. positron) defines the reference frame used to compute QED cross sections:

“Pre-Swap” ⟷ original code in src/IntegrateQED.cc

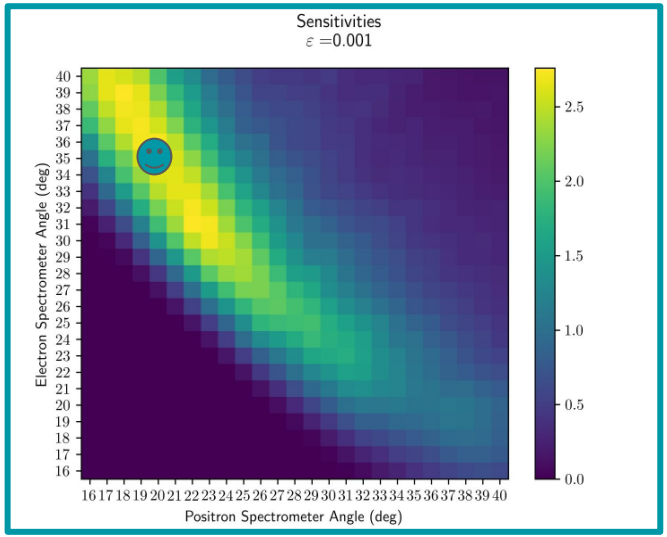
```
double thetaD = e2out.Lorentz(-q_out).rotate(q_out).theta();
double phiD   = e2out.Lorentz(-q_out).rotate(q_out).phi();
// 0 for muon - not currently being changed
double weight = QEDBackground(e_in,e_out,q_out,m,thetaD,phiD, 0, ((struct args*)input)->trident, ((struct args*)input)->asymm)*Solidangle;
```

“Post-Swap” ⟷ modified code in src/IntegrateQED.cc

```
double thetaD = e1out.Lorentz(-q_out).rotate(q_out).theta();
double phiD   = e1out.Lorentz(-q_out).rotate(q_out).phi();
// 0 for muon - not currently being changed
double weight = QEDBackground(e_in,e_out,q_out,m,thetaD,phiD, 0, ((struct args*)input)->trident, ((struct args*)input)->asymm)*Solidangle;
```

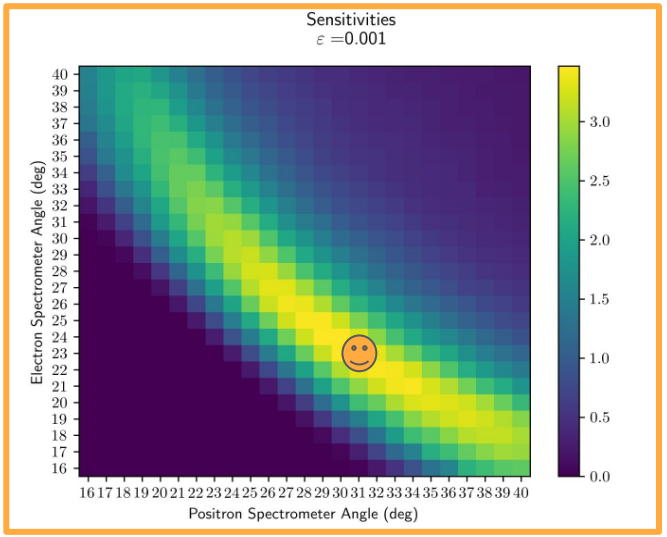
Initial Pre/Post-Swap Sensitivity Differences:

Config: 13@31; I = 150μA



Pos angle	20 degrees
Elec angle	35 degrees

Peak Sensitivity ≅ 2.7



Pos angle	31 degrees
Elec angle	23 degrees

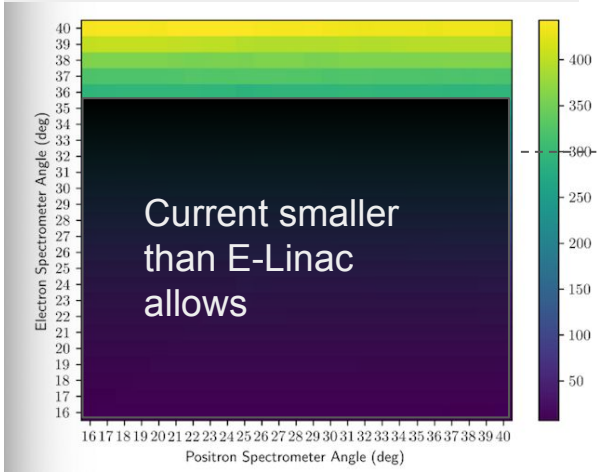
Peak Sensitivity ≅ 3.3

Note: sensitivity scale is different in each plot

Machine Constraints:

- E-linac stability bounds current between 300μA and 330μA
- GEMs assumed to require electron event rate to be less than 5 MHz **

Max. Current (μA) : e- ≤ 5 MHz

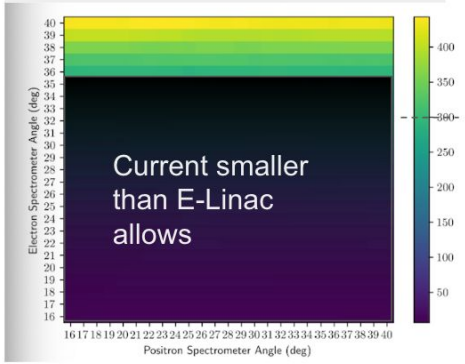


Constraints imply the electron spectrometer must be approximately ≥ 36(7) degrees away from the beamline

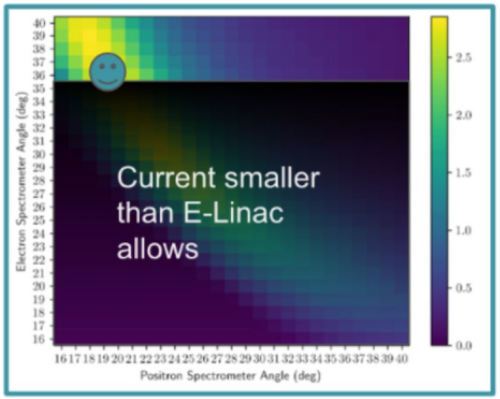
** confirmation needed

Constrained Pre/Post-Swap Sensitivities:

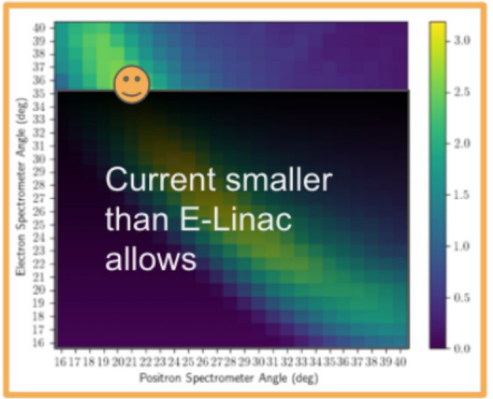
Max. Current (μA) : e- ≤ 5 MHz



Config: 13@31; I = max. allowed



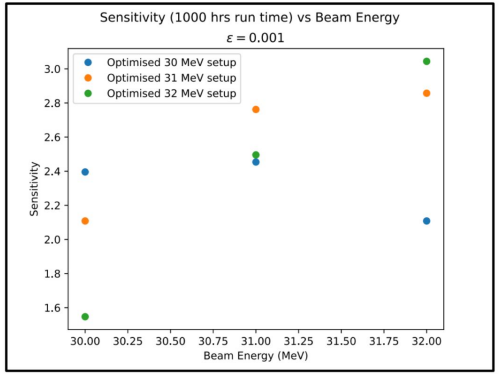
Pos angle	20 degrees
Elec angle	36 degrees
Peak Sens	2.7



Pos angle	21 degrees
Elec angle	36 degrees
Peak Sens	2.7

After machine constraints, orientations converge with roughly equal peak sensitivities

Sensitivity Comparisons at Different Beam Energies



Peak Sensitivities for optimized set-up:	
13@30 (20/38)	2.395
13@31 (20/35)	2.762
13@32 (20/33)	3.108

Notes:

- Sensitivity increases as beam energy increases for an optimized set-up
- Optimising for 30 MeV allows for ~ same sensitivity at 30 and 31 MeV.
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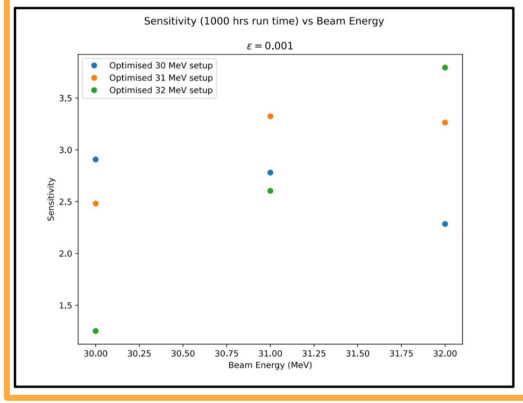


Peak Sensitivities for optimized set-up:	
13@30 (32/24)	2.907
13@31 (31/23)	3.323
13@32 (26/25)	3.794

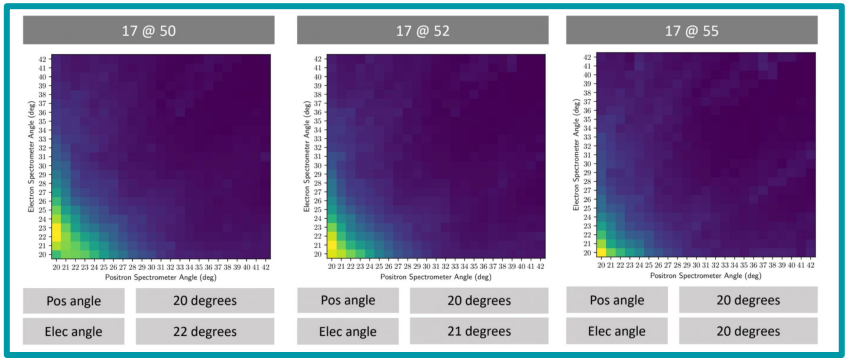
Notes:

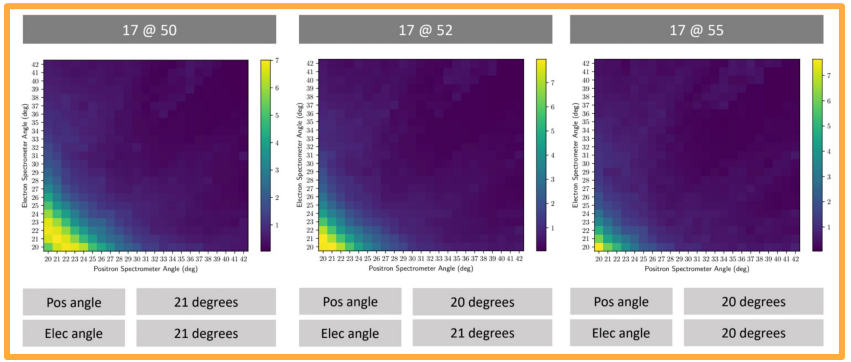
- Sensitivity increases as beam energy increases for an optimized set-up.
- Optimising for 30 MeV allows for ~ same sensitivity at 30 and 31 MeV.
- Optimising for 31 MeV allows for ~ same sensitivity at 31 and 32 MeV.

Note: these plots neglect machine constraints but indicate trends

Limitations at higher beam energies

- Electron spectrometer orientation (pre-swap and post-swap) at higher energies is **too close (< 36°) to the beamline**:





- If the GEMs can't handle more than 5 MHz, the detectors can't be positioned close enough to the beam to detect anything…

To Do:

- **Confirm machine constraints**
- Simulations still need to model multiple scattering events inside GEMs
- Compare peak-sensitivity orientations at different beam energies provided machine constraints

Pre-swap (top) v. post-swap (bottom): (13@30)