Synchrotron radiation background studies for the FCC-ee at @182.5 GeV

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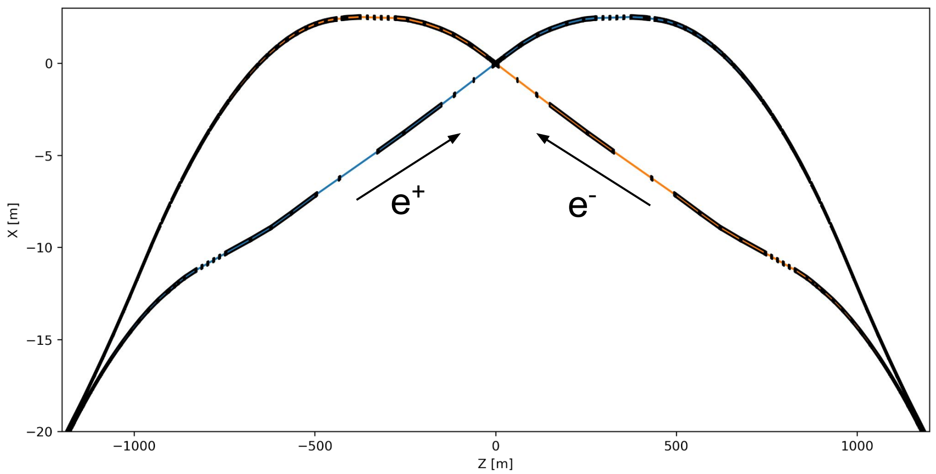
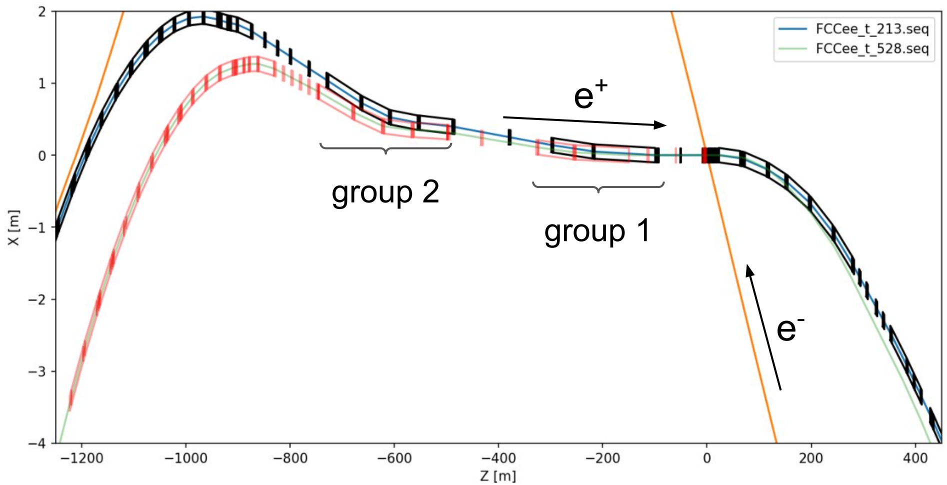
Outline

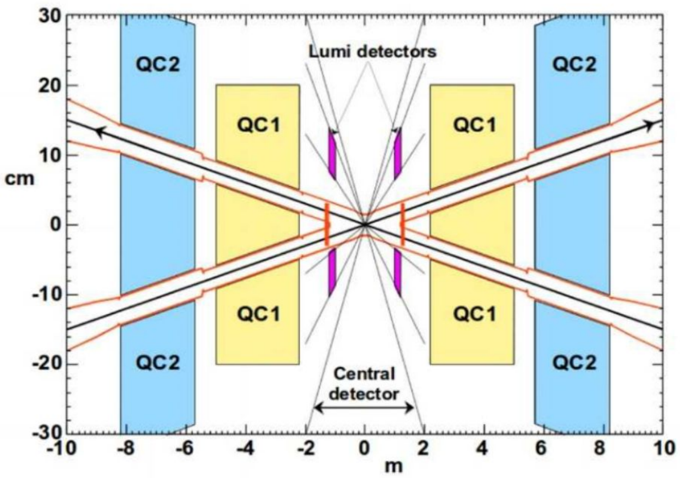
- FCC-ee lattice at 182.5 GeV and IR lattice
  - Magnetic lattice
  - Masks and collimators
- Direct hits studies
  - From the dipoles
  - From the quadrupoles
- Influence of particles in the tails
- Collimators
- Summary and outlook

	Beam Energy	Beam Current	H Beam Emittance	V Beam Emittance
@ ttbar	182.5 GeV	5.0 mA	1.49 nm	2.98 pm

FCC-ee lattice | 4 IPs





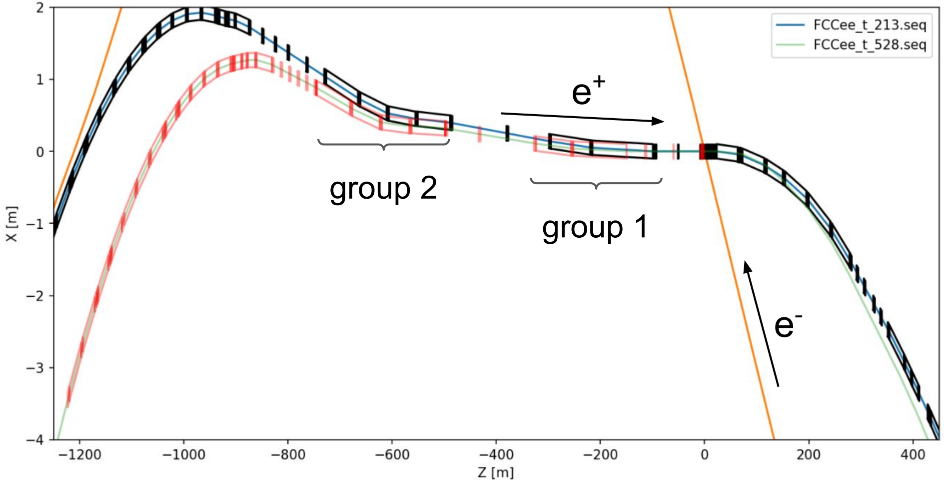


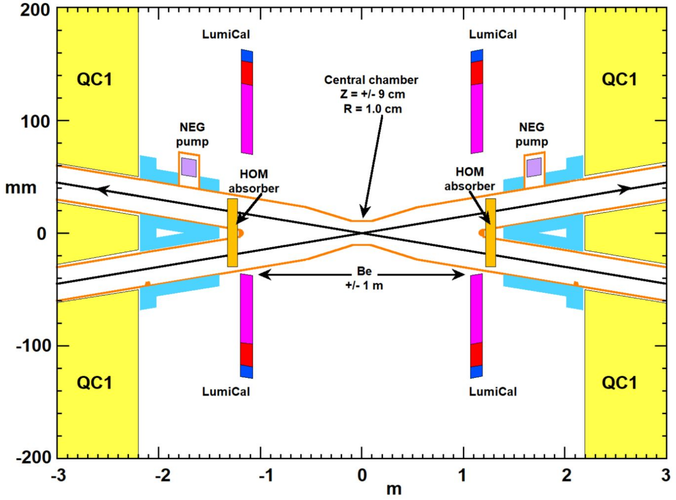
The studies focus on the section from s=-800m to 100m around the IP and specifically on the photon hits in the detector region.

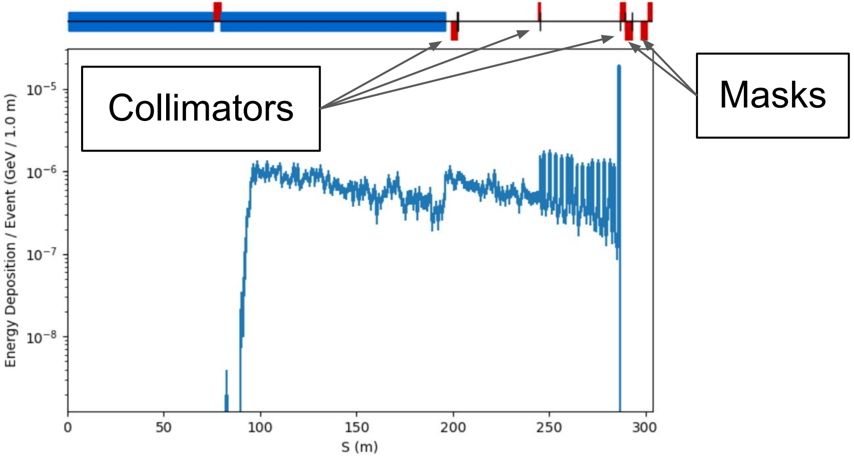
There is a **30 mrad crossing angle** at the IP.

Lattice design upstream the IP is based on weak dipoles and long straight sections. **BC1L and BWL dipoles** have **critical energies below 100 keV** and are located > 150m from the IP.

FCC-ee lattice | Masks and collimators







The central beam pipe radius has been reduced from **15mm to 10mm** and shorten from 25cm to 18cm along the Z axis.

Masks: s = -2.10m with **9mm** aperture radius, s=-5.56m with **15mm** aperture radius.

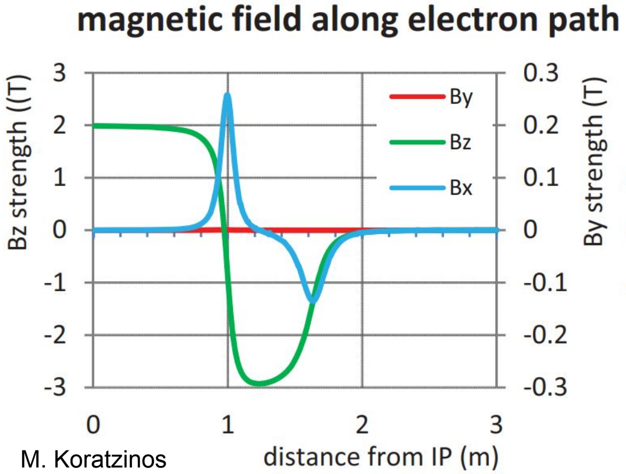
Collimators: at QC3L (s=-90m), QT1L (s=-50m), PQC2LE (s=-10m)

Simulation tool, field map and central chamber geometry

BDSIM simulation tool (ref & website) that is based on Geant4.

BDSIM results have been successfully compared against previous studies on V18 lattice with M. Lückhof PhD's using MDISim also based on Geant4.

Implementation of the solenoid and anti-solenoid field map combined with the realistic central beam pipe.

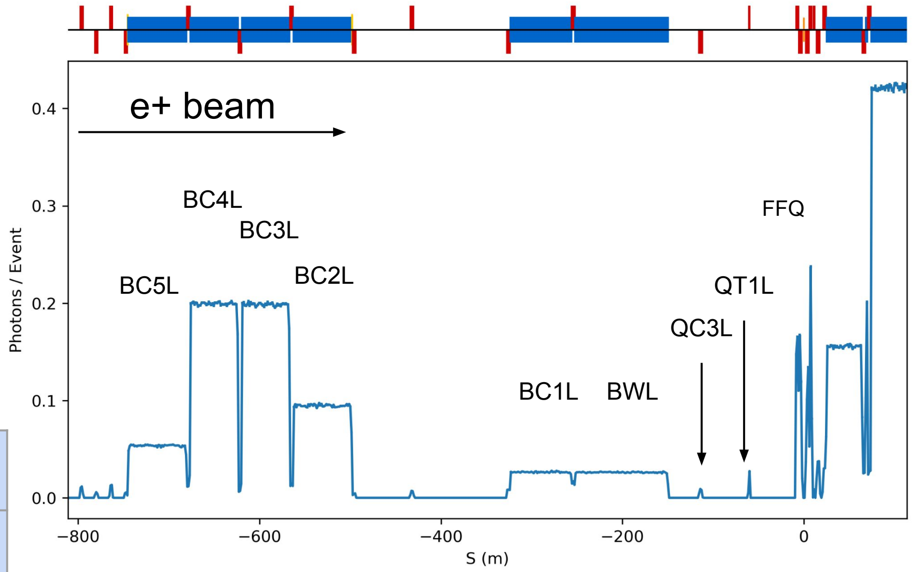


M. Koratzinos

M. Lückhof

Origin of SR photons

	L /m	rho /m	P /W	P /W	Z pole
BC1L	67.4	138343	275	275	
BWL	102.4	139574	411	410	
QC3L	3.5	k1=0.0036 m^{-2}	3	3	3
QT1L	1.0	k1=0.0126 m^{-2}	15	15	12
QC2L2	1.25	k1=0.1264 m^{-2}	555	584	9
QC2L1	1.25	k1=0.0540 m^{-2}	65	73	2810
QC1L3	1.25	k1=0.1474 m^{-2}	199	241	1
QC1L2	1.25	k1=0.1612 m^{-2}	114	135	746
QC1L1	0.7	k1=0.1610 m^{-2}	33	37	174

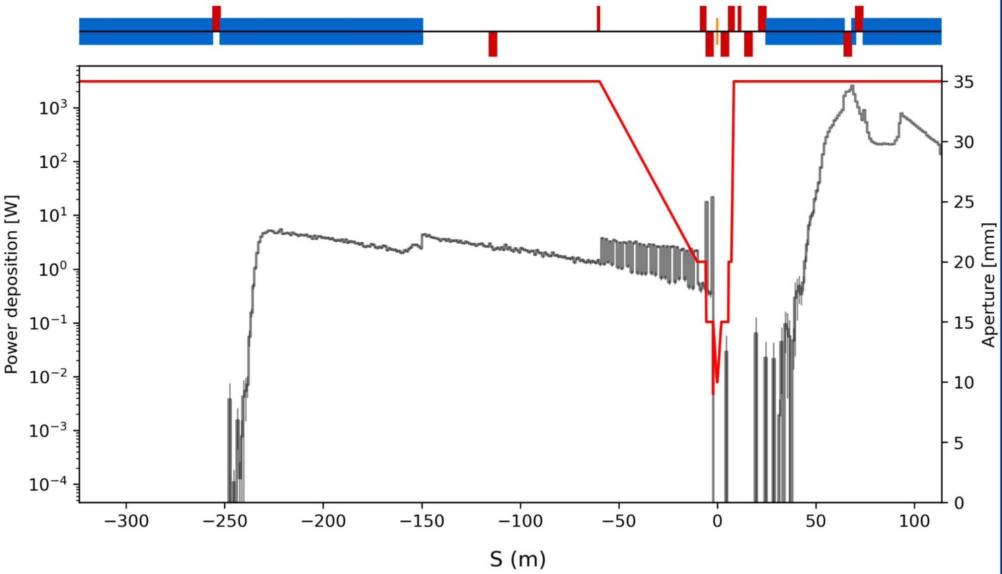


N. Bernard analytic estimate for SR in quads [ref]

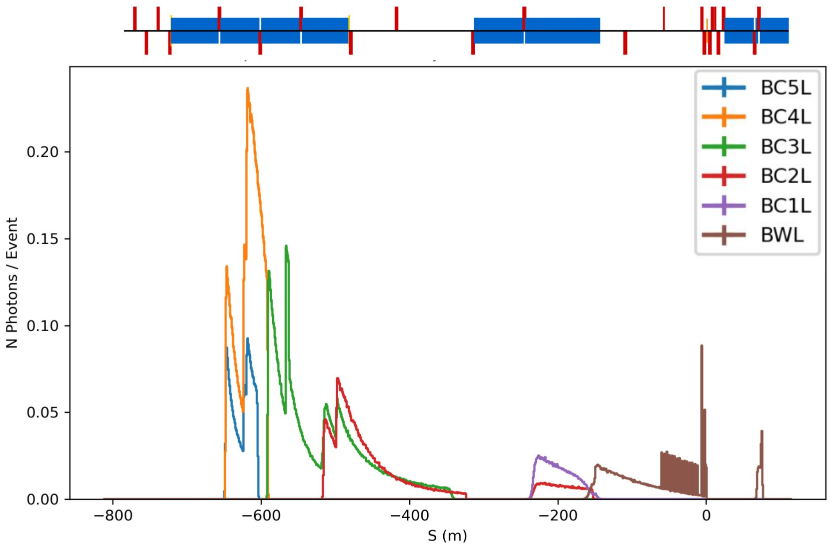
$$P = P_o I_o B_q^2 \left[\epsilon_x \int_0^L \beta(z)_x \, dz + \epsilon_y \int_0^L \beta(z)_y \, dz \right]$$

With the Z mode, the synchrotron radiation power from quadrupoles will be different as the optics design differs. As a result, a non negligible amount of SR background could be produced (to be looked at).

Direct hits on the beam pipe



SR photons hits and beam pipe aperture including masks but no collimator.



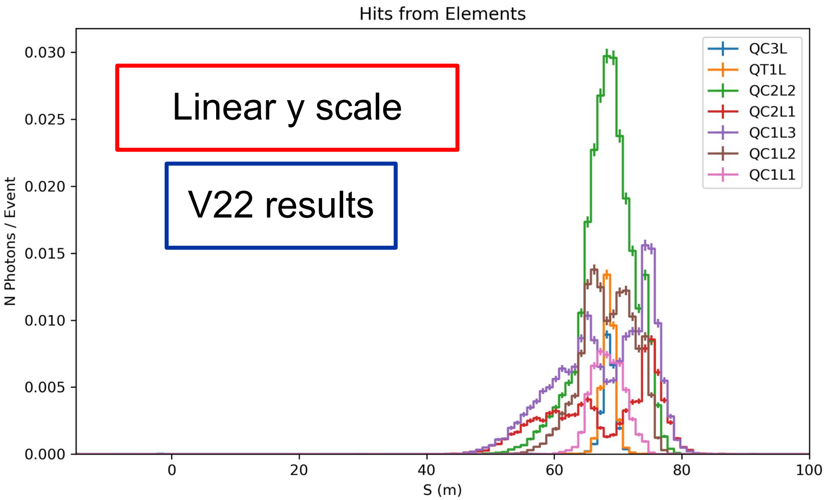
SR photon hits from the dipoles

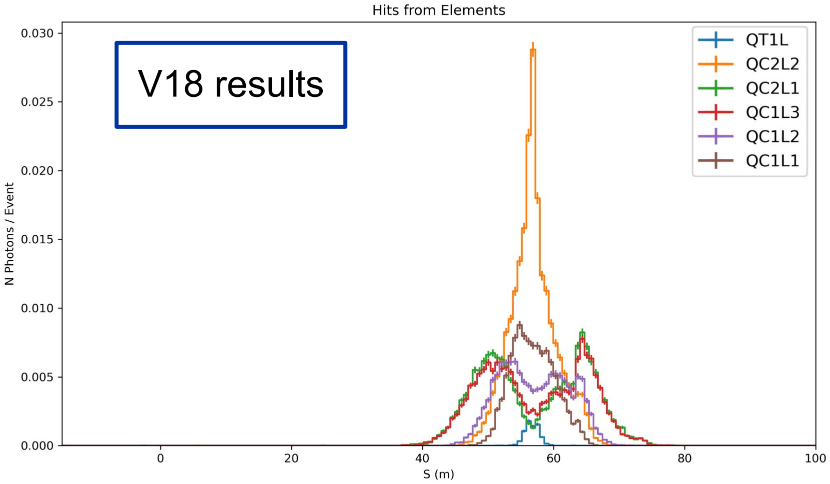
Direct hits on the beam pipe

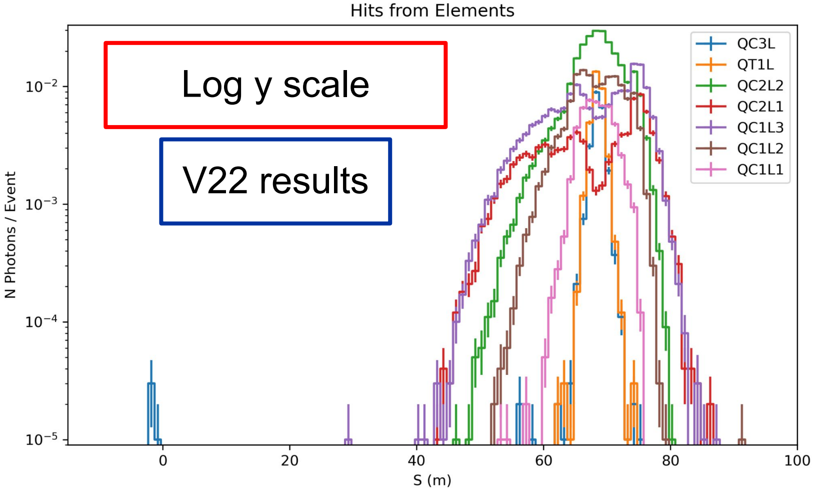
Only considering the quadrupole contributions.

Photon hits centered around 70 m.

All quadrupoles considered between BWL and the IP, QC2L2 radiates the most photons.

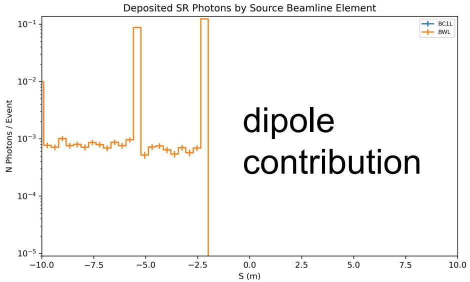


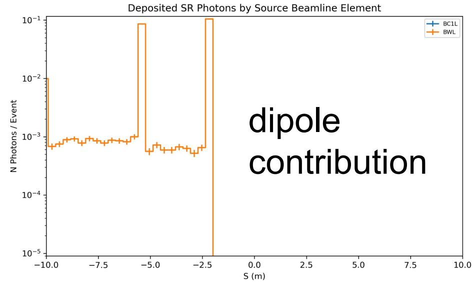


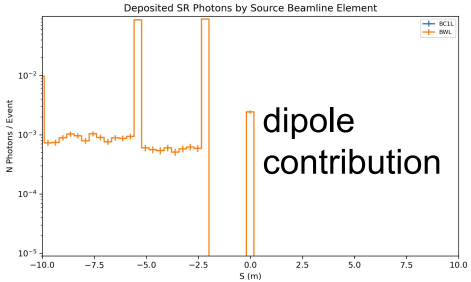


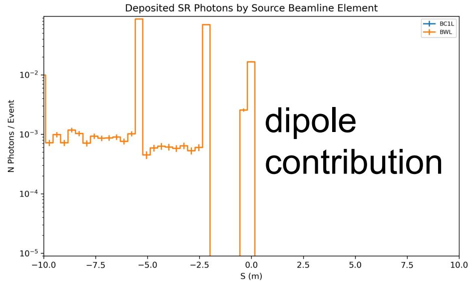
Direct hits on the beam pipe | Mask aperture for V22 lattice

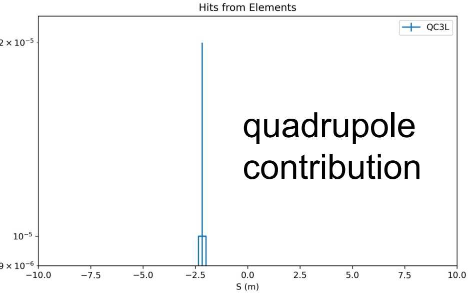
8 mm aperture | 9 mm aperture | 10 mm aperture | 11 mm aperture

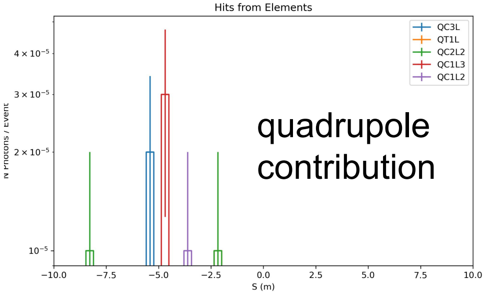


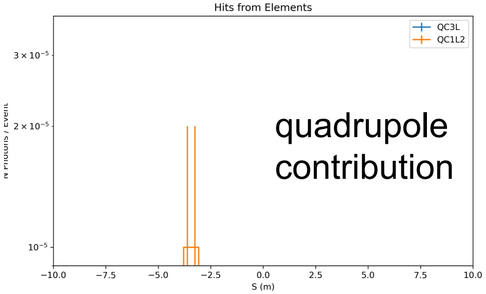


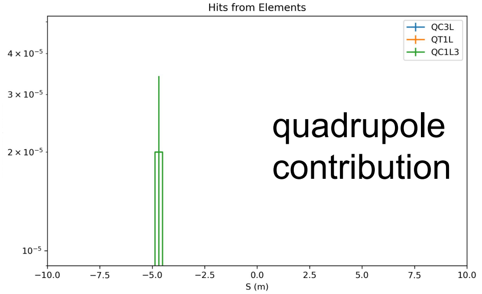












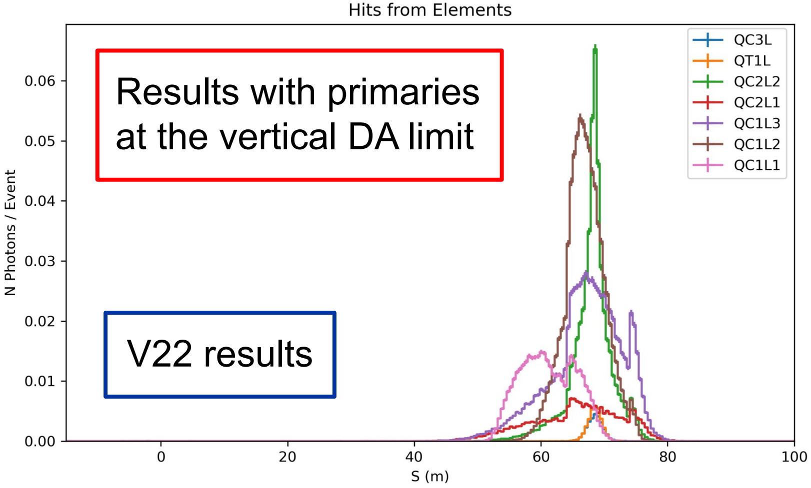
Requires **more statistics** regarding the quadrupole contributions and particle distributions that vary from a Gaussian distribution to highlight the impact of halo particles. M. Sullivan showed that 7mm was necessary at the Z mode (ref)

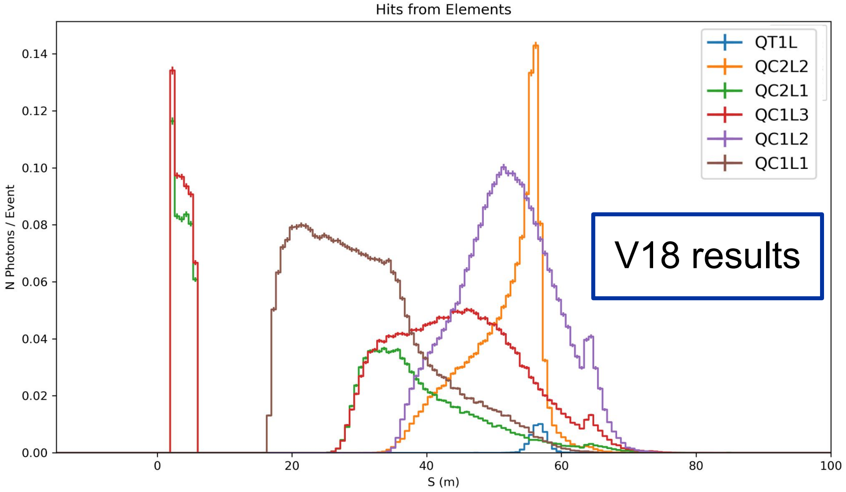
Primaries in the vertical tails

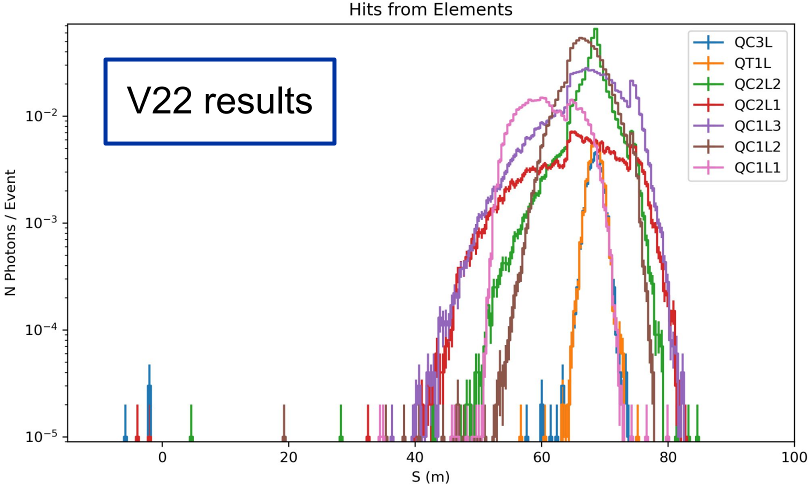
Initial distribution with particles up to the **vertical DA limit ~ 24-25 sigmas**.

QC3L and QT1L create photons 100 to 150m from the IP.

Smaller QC1L mask aperture (12mm → 9mm) and reduced vertical DA limit w.r.t. V18 studies (49-50 sigmas)





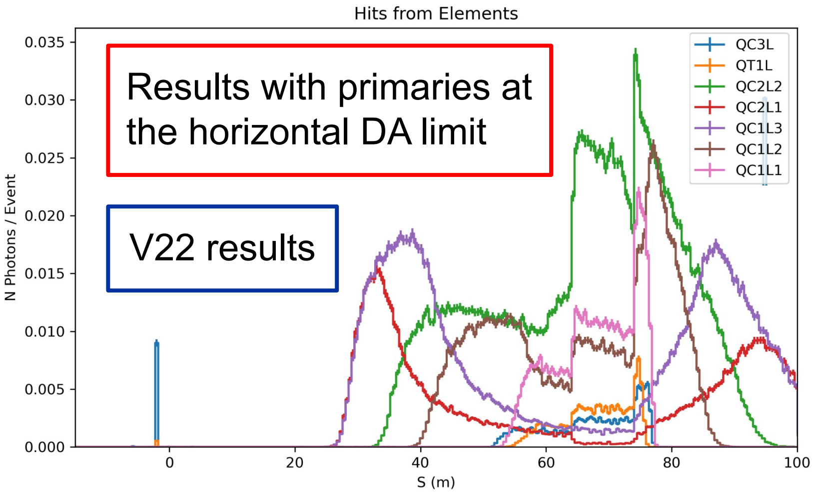


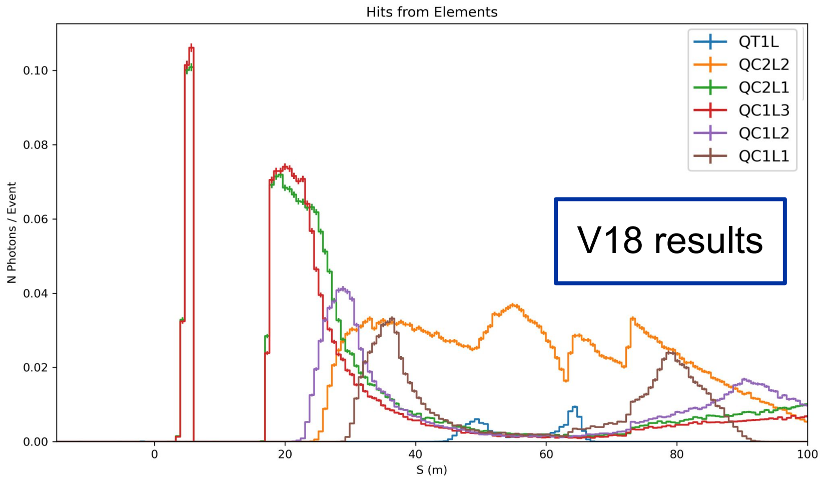
Primaries in the horizontal tails

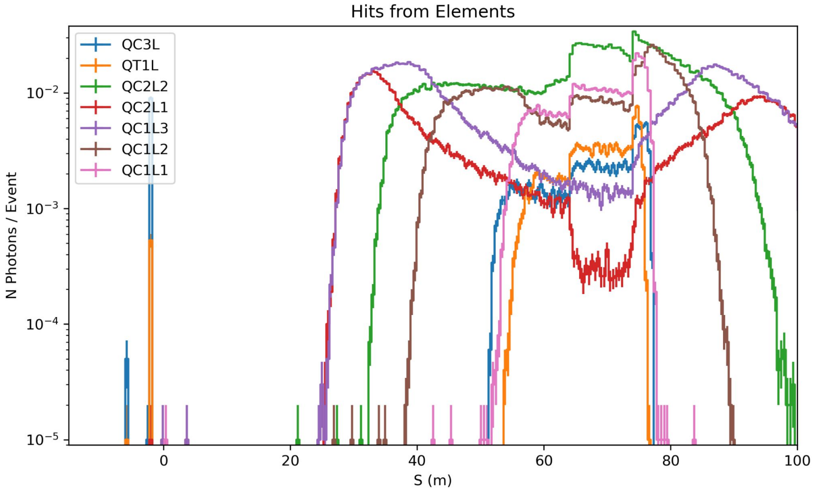
Initial distribution with particles up to the **horizontal DA limit ~ 15-16 sigmas**.

QC3L and QT1L create photons 100 to 150 m from the IP.

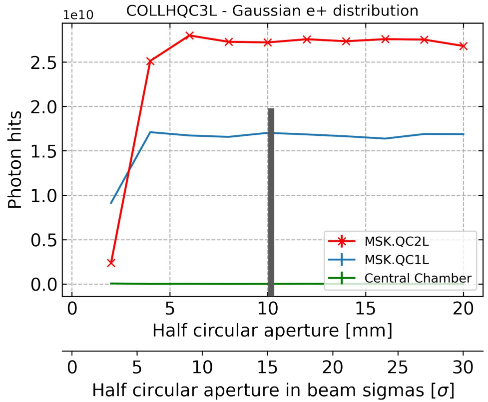
Smaller QC1L mask aperture stopping the SR radiation w.r.t. the studies with the V18 lattice.

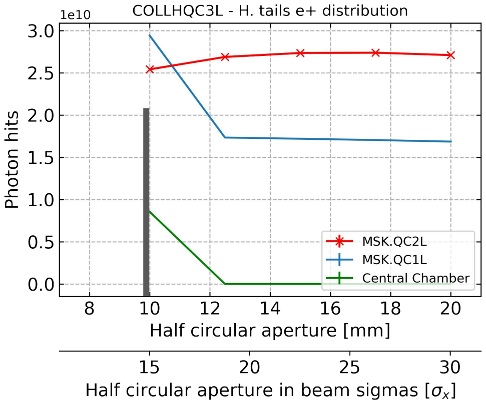


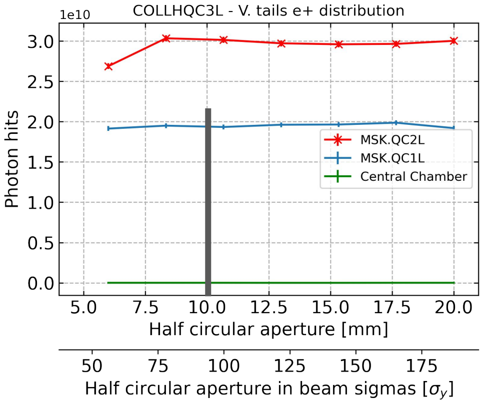


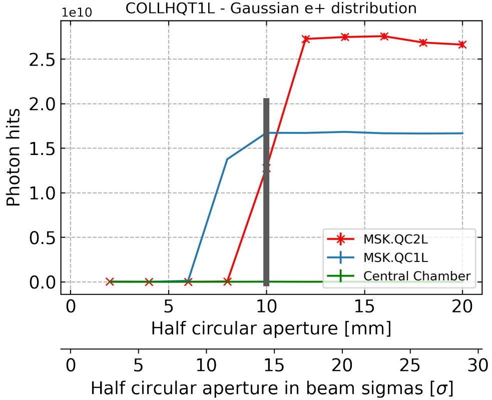


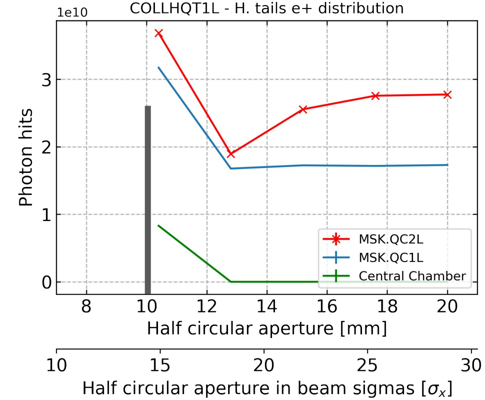
Collimators with V18 lattice

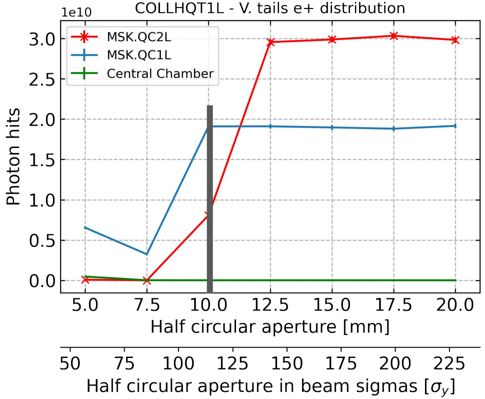




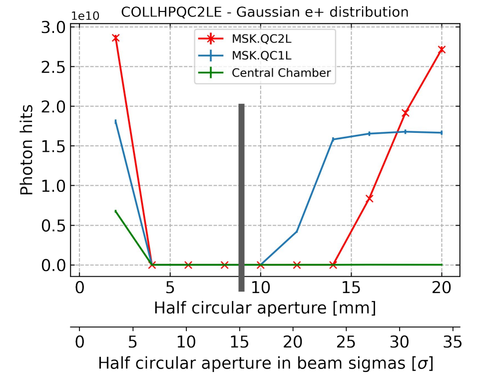


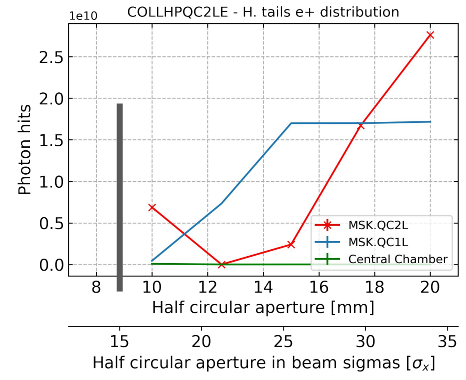


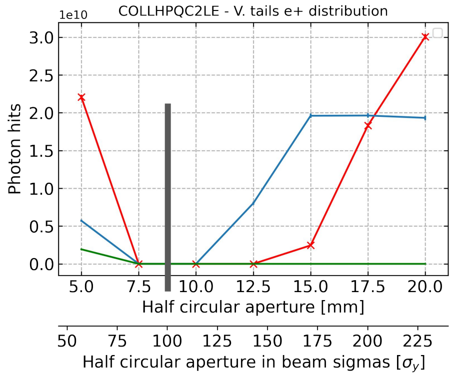




Collimators with V18 lattice







Horizontal tail distribution represents particles up to 15 σ_x in a ring in X-X' phase space and vertical tail distribution have particles up to 50 σ_y in a ring in Y-Y' phase space.

The collimators are located after QC3L2 (**far-out** collimator, s=-90m) proved to be very effective for LEP, after QT1L (**intermediate** collimator, s=-50m) and at PQC2LE (**near** collimator, s=-10m)

The nearest collimator is the most efficient at reducing photon hits on the masks. But halo primaries may require larger collimator aperture. The **combination of the collimators may help**.

Summary & outlook

- BDSIM **has been successfully compared** with MDISim (M. Lückhof PhD) using the V18 interaction region lattice (2 IPs & 98 km circumference).
- Work in progress to **transfer to the V22** interaction region lattice with the installation of the CAD design of the central beam pipe with reduced diameter (30mm → 20mm).
- **Only BWL, QC3L, QT1L, QC2L, QC1L** produce **direct SR** propagating until/past the IP
- The masks do not perfectly absorb all the photons (scattering) and the collimators shielding the masks limit the SR from primaries in the tails of the e+ distribution.

Next steps:

- Study the effect of combining the collimators to mitigate the SR from halo primaries
- Description of the photons hitting the central beam pipe for A. Ciarma working on the optimisation of the shielding around the beam pipe.
- Position and aperture of the collimators for A. Abramov to include them in the collimation hierarchy.
- Study the influence of orbit misalignment and top-up injection.