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The flux distribution and Energy Deposition Along Helical Undulator (250GeV)

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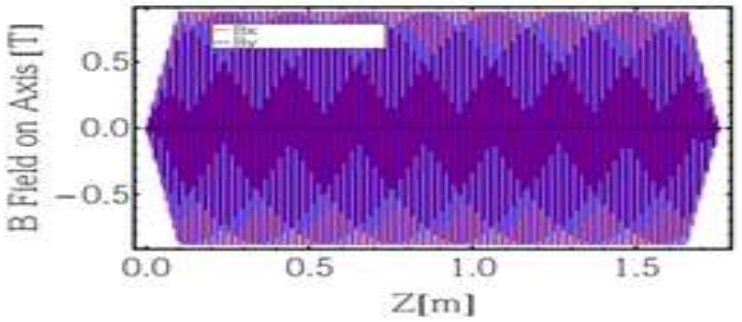
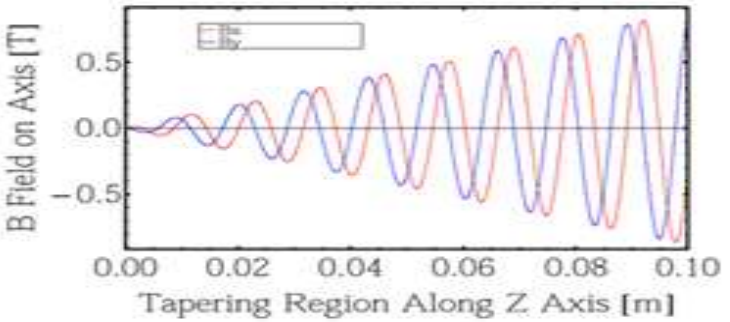
Introduction

- Introduction to HUSR/GSR software
- Comparison between three ideal and realistic modules (125GeV Undulator): in terms of Flux, average photon energy and Power.
- The whole Helical Undulator (125GeV) (Ideal and Realistic) were simulated.
- Energy Deposition inside the Undulator was studied.
- The effect of adding masks inside the undulator on the Photon Numbers and Polarization was studied.
- Conclusion

HUSR/GSR Software Spectra

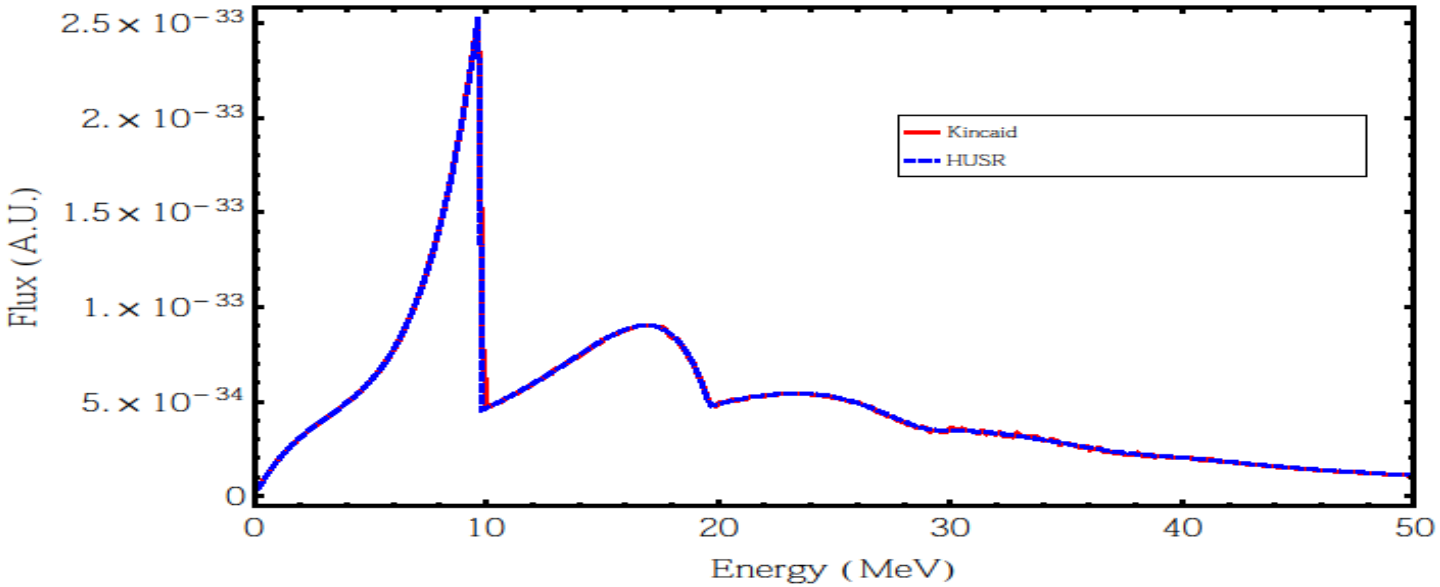
- Can simulate photon spectra produced by Helical Undulator
- **Developed at Cockcroft Institute by David Newton.**
- How HUSR work? Interplot Magnetic data **then** Fourier transformated **at the end** photon spactra
- HUSR/GSR simulates a photon spectrum from an arbitrary magnetic field map.
- Using different arbitrary maps is possible in HUSR e.g. include errors in the magnet, tapering, etc.
- Some HUSR advantages? Speed of the calculation and can be extended to more functionality as it is a C++ code





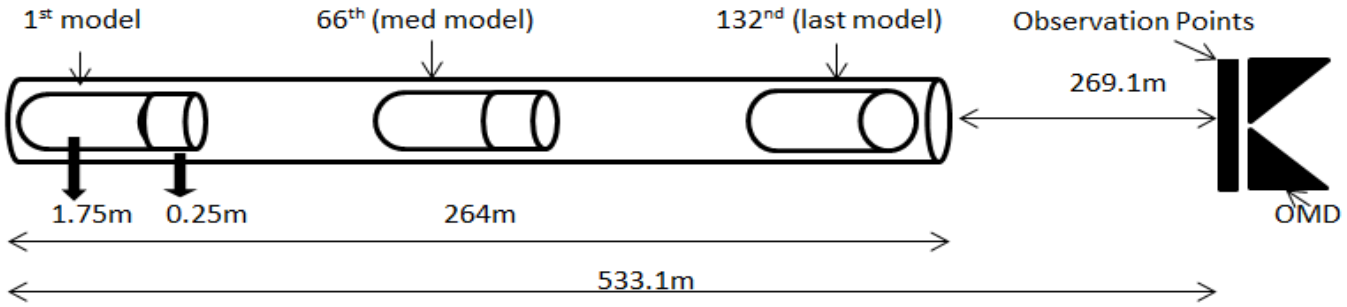
Bench marking HUSR/GSR energy spectra with Kincaid energy spectra.

- The photon energy spectrum generated by 125 GeV electron by Kincaid Equation in red, and HUSR in blue.
- They **agreed** as we see



an Undulator-based Positron Source

- Schematic of an Undulator-based Positron Source showing the main components including the helical undulator, conversion target (observation points), Optical Matching Device (OMD)
- Undulator length: 132 modules * 1.75 = 231 m , Total length = 264 m
- The first, the 66th and the last module were chosen for comparison with ignoring all deposition or lost energy inside/outside undulator.



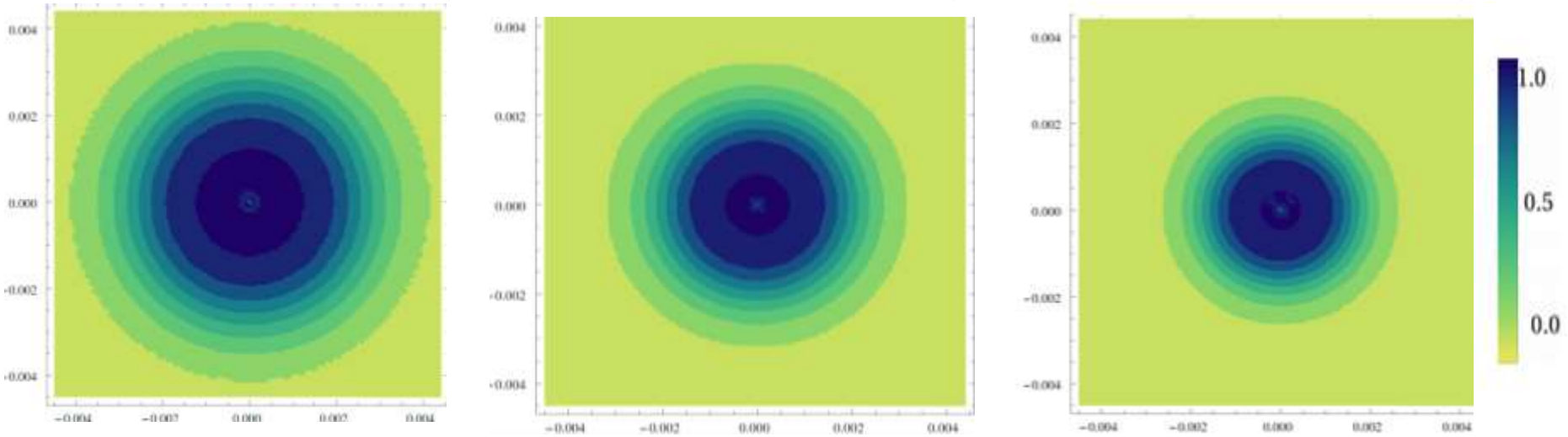
Parameters Used

Parameters	
Electron Energy (GeV)	125
Bunch population	2.00E+10
Number of bunches	1312
Repetition rate (Hz)	5
Unit Length (m)	1.75
Number of undulators	132
Net length of undulator (m)	231
Total length of undulator section (m)	264
Distance between undulator section to the target (m)	269.1
Period (m)	0.0115
K value	0.85
Magnetic field	0.79
Inner radius (mm)	2.9

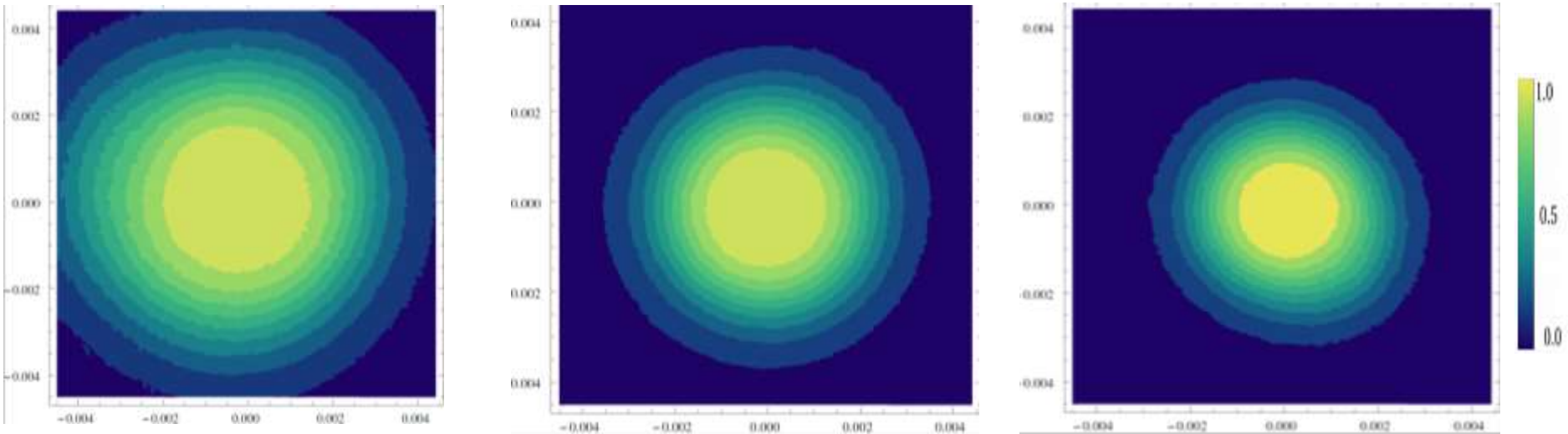
Flux distribution contour plot

Flux were normalized by dividing all numbers by the maximum number where 1 means highest value. We can see from right to left: flux concentration increase, when distance decreases between undulator module observation point.

Ideal: 1st modul (531m away) 66th modul (401.1m away) last modul(269.1 m away)



Realistic: 1st modul (531m away) 66th modul (med) (401.1m away) last modul(269.1 m away)

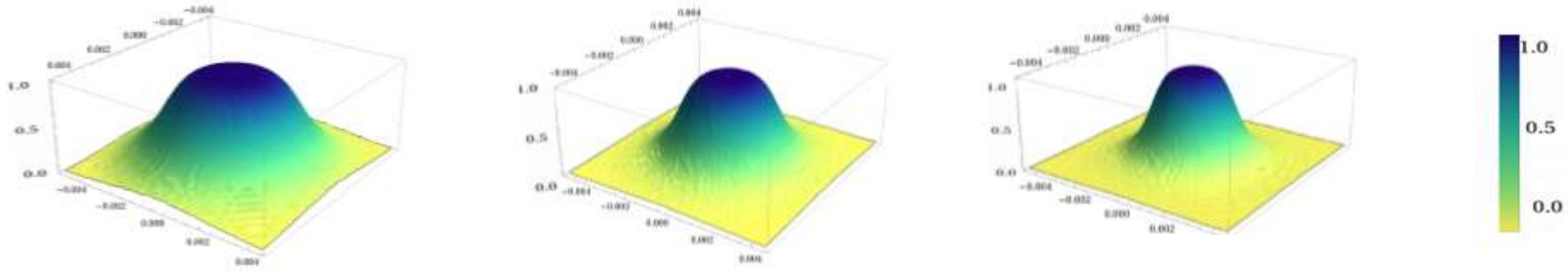


The flux distribution on the target

We can see the differences on Flux Distribution on the target each time the module becomes closer to the target.

Flux was normalized by dividing all numbers by the maximum number where 1 means highest value.

Ideal: 1st modul (531m away) 66th modul (401.1m away) last modul(269.1 m away)



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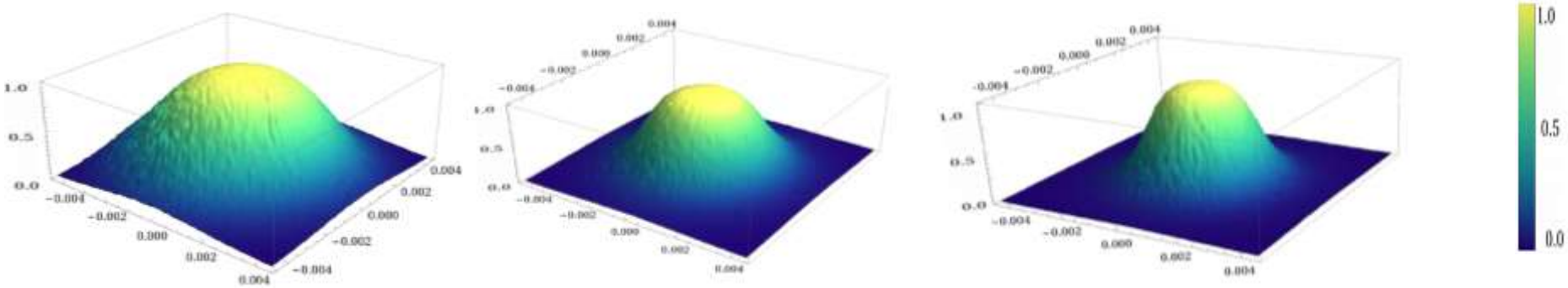


Average Photon Energy and Flux Distribution from Ideal and realistic modules

	Ideal			
	Flux (A.U.)	**Photons/Sec**	**Average Energy (MeV)**	**Power (W)**
1st module	**6.83E-32**	**2.704755E+14**	**7.4 MeV**	**454.3988618**
66th module	**7.03E-32**	**2.783957E+14**		**467.7048314**
last module	**7.21E-32**	**2.855239E+14**		**479.6802041**
	Realistic			
	Flux (A.U.)	**Photons/Sec**	**Average Energy (MeV)**	**Power W**
1st module	**6.62E-32**	**2.621593E+14**	**7.2 MeV**	**440.4275938**
66th module	**6.94E-32**	**2.748316E+14**		**461.7171451**
last module	**7.05E-32**	**2.791878E+14**		**469.0354284**

Power on the target (IDEAL & REALISTIC)

The whole helical undulator was simulated both Ideal and Realistic.

132 ideal undulator modules were simulated.

132 realistic undulator modules were simulated as well.

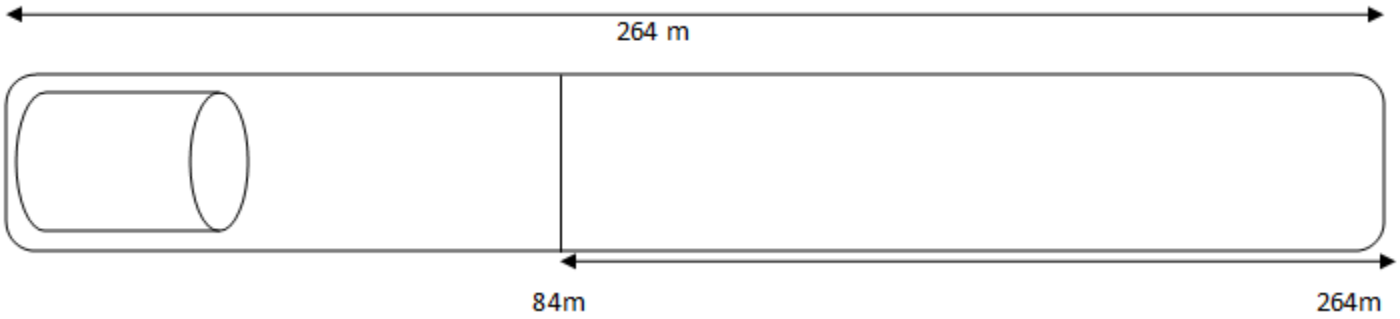
	Average Photon energy (MeV)	Power (KW)
Ideal	7.4 MeV	63.2
Realistic	7.2 MeV	60.1

Energy Deposition on the undulator

Due to time consuming, I simulated only the energy deposition along undulator from the 1st module by steps (15 m per step).

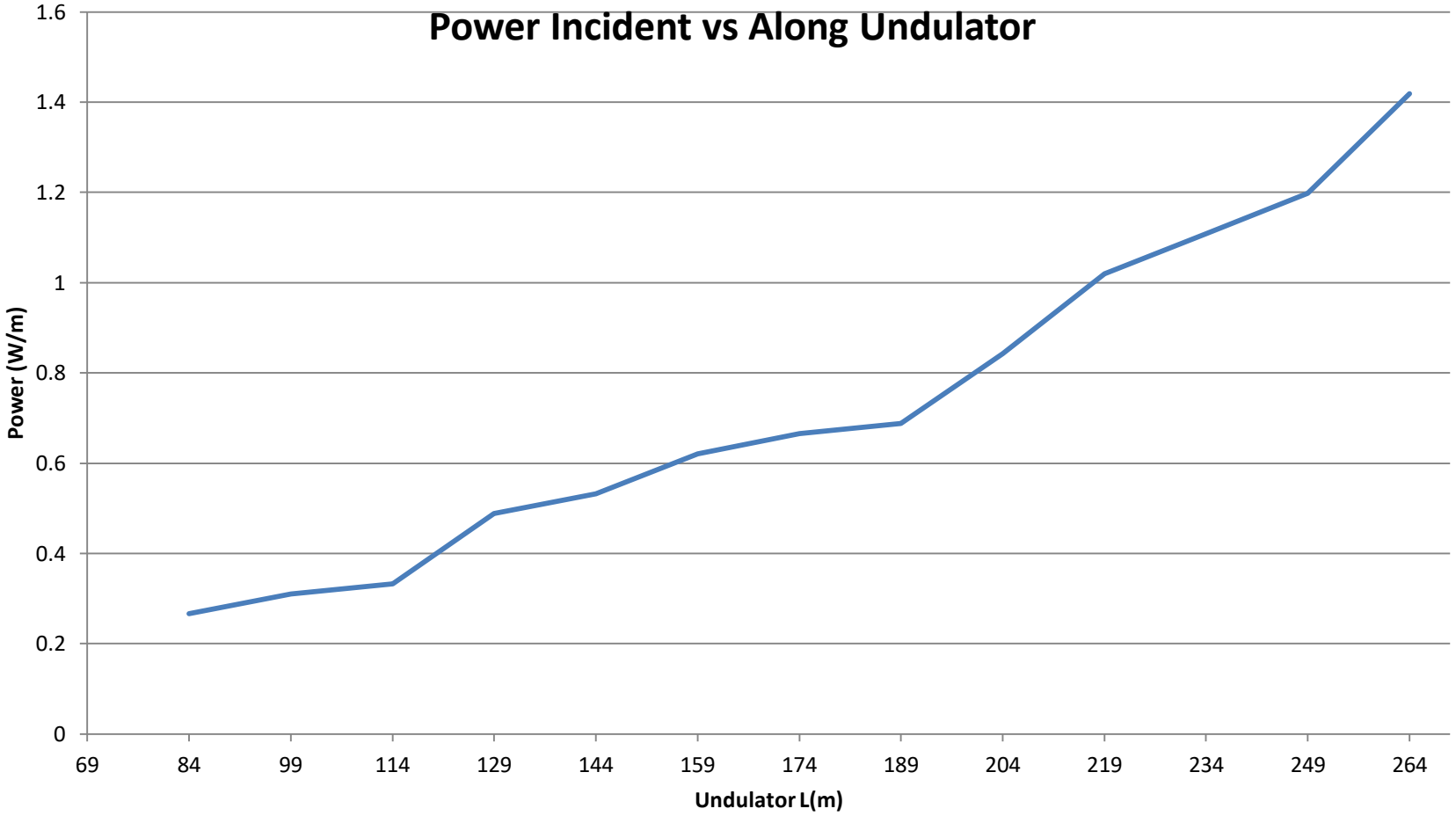
Distance below 84 m between Module and the observation point no clear spectrum.

The energy deposition in undulator area from 84 m to the end of the undulator (264 m) was studied at 84. 99.114 ……264 m.



Energy Deposition on the undulator

This plot shows, TEMPORARILY, the energy deposition from a single module..



Energy Deposition on the undulator

Average Incident Power, temporarily, is about 23.4 W/m from all modules, it means heat load for cryogenic system is too great.
The maximum allowable heat load in the undulator is 1 W/m (Duncan-Scott thesis)

Masks

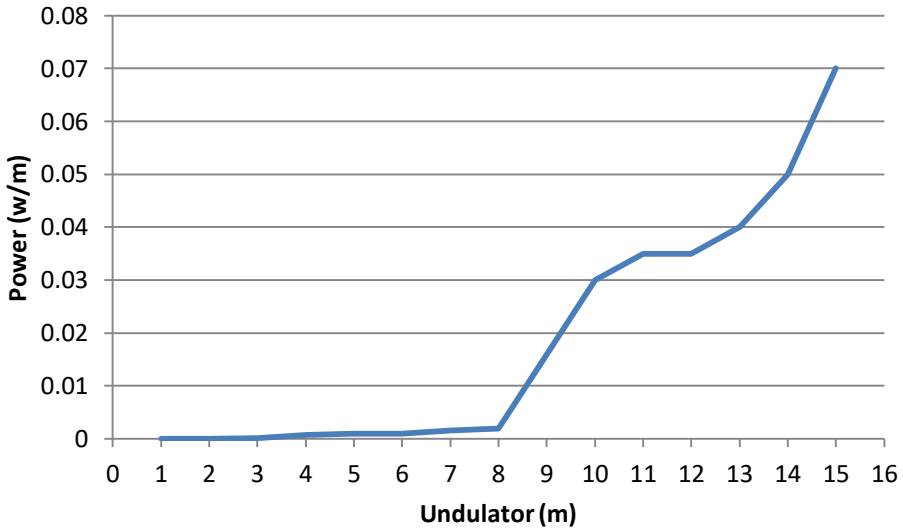
To protect our undulator wall we need to add some masks to absorb some of this power.

Masks should be designed to achieve the required vacuum.

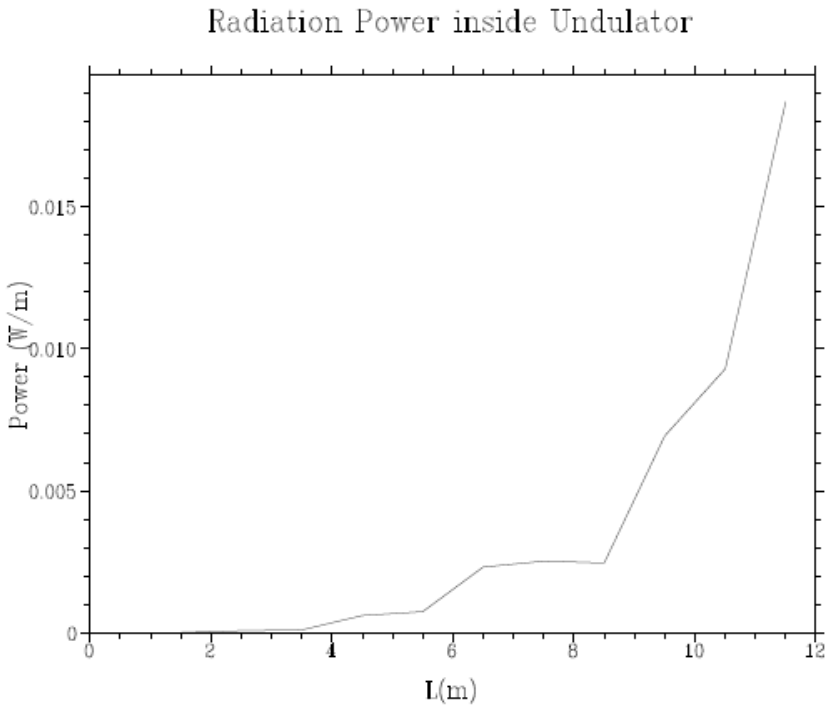
If we assume masks with 4.4 mm Diameter inside the undulator (6 mm).

Masks are placed by steps (15 m per a step) along undulator, masks will absorb some of this power.

Energy deposition after a Mask (4.4mm)



Yokoya's plot

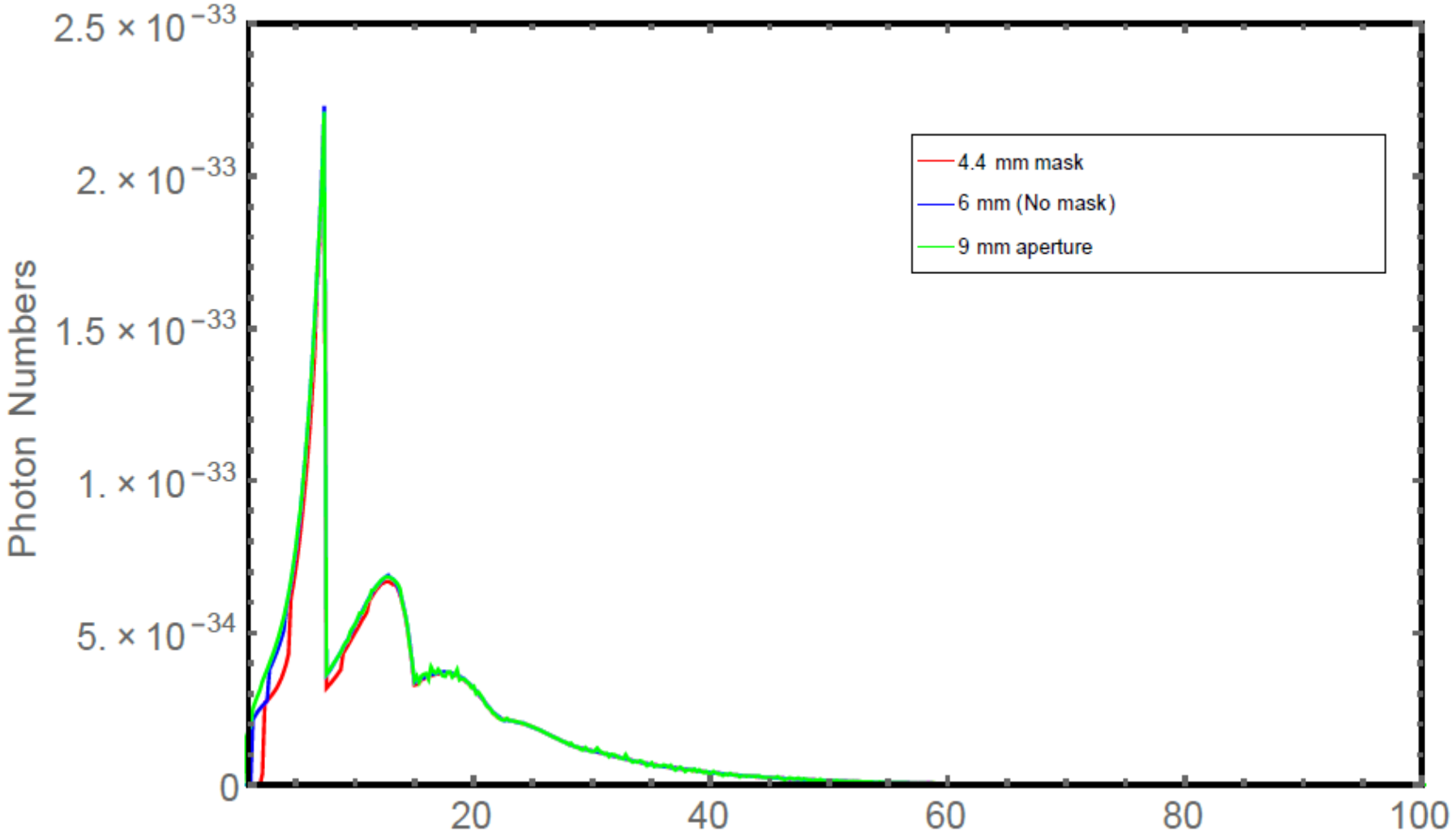


Comparison with K.Yokoya Calculation

		K.Yokoya Calculation
Power lost in the whole undulator (W)	**2195.76**	**1884**
Power lost between the 2 masks (W)	**0.07 in (15 m)**	**0.044 in (12 m)**

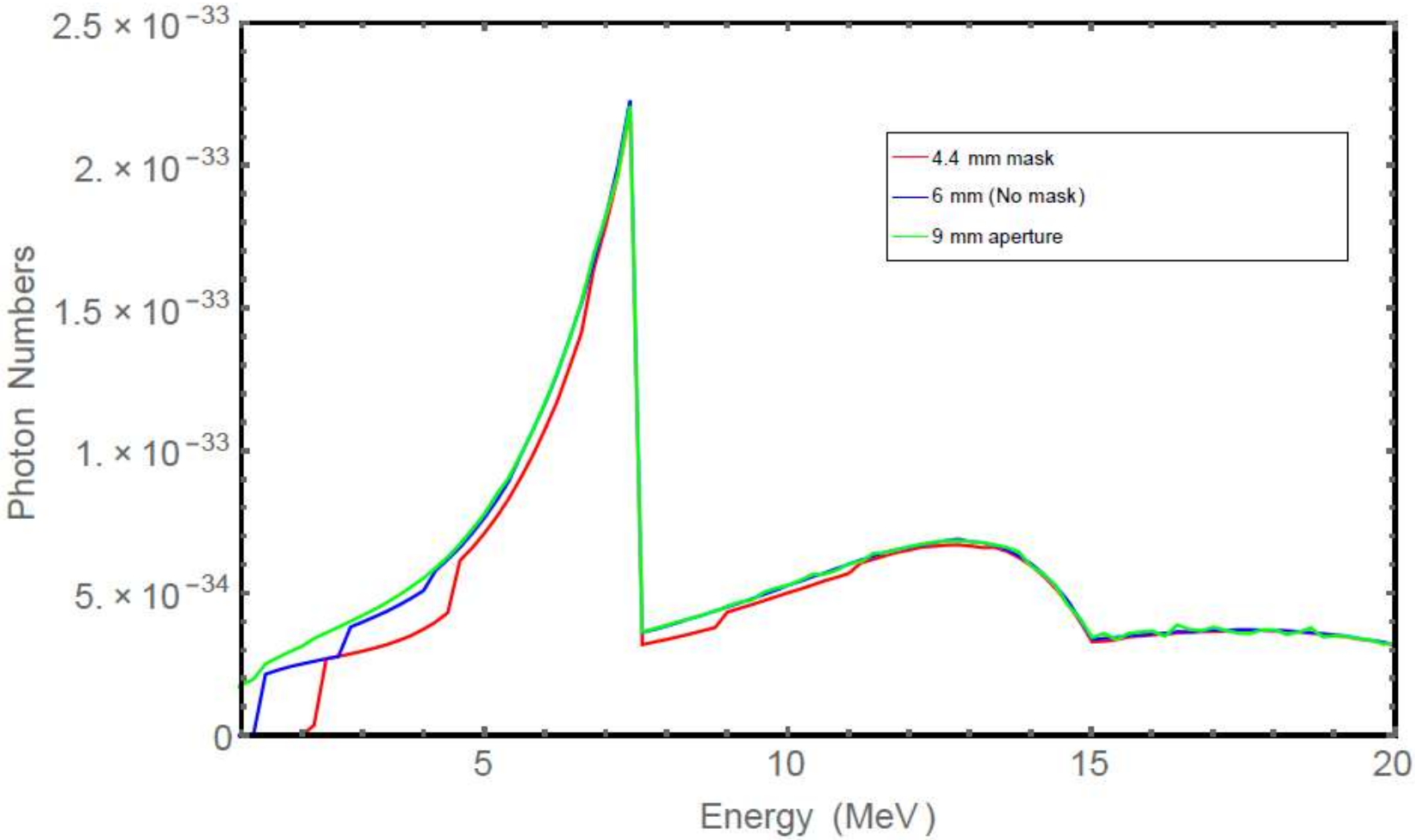
Masks

This plot shows the spectrum with and without mask



Masks

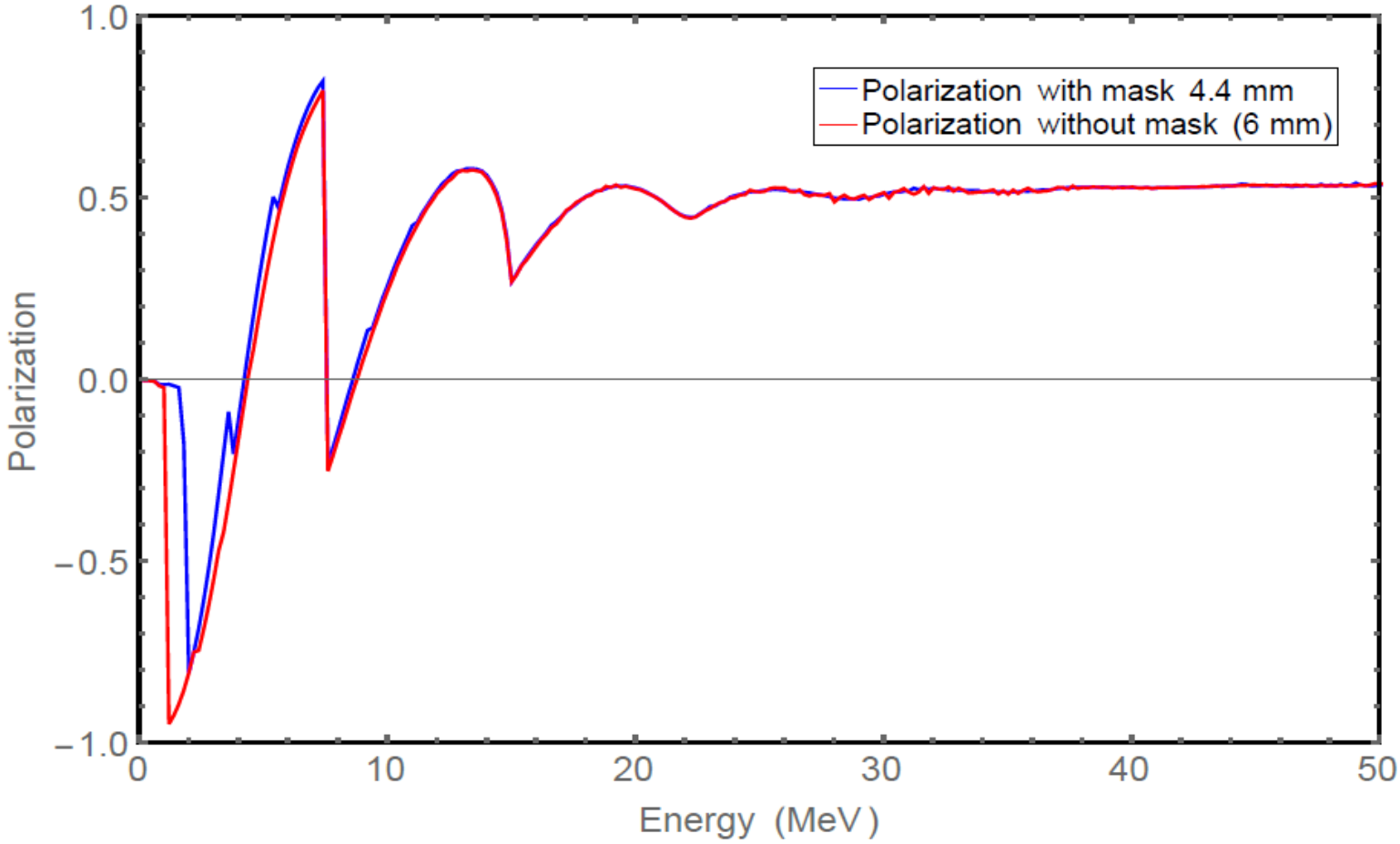
This plot is a zoomed-in version of the previous plot showing the first three harmonics.
Photons with energy less then 2MeV will be absorbed with mask(RED).



Photon Polarization with Mask

With masks photon numbers will decrease and the polarization of Photons, P, increases.

Photon P=(left photons-right photons)/(left photon+right photons)



Conclusion

Comparison between ideal and realistic chosen modules were studied and the flux distribution on the target was shown on both cases (With 125 GeV electron energy).

The whole 250GeV Helical Undulator was simulated for both Ideal & Realistic case with ignoring the energy deposition.

The energy deposited on the undulator wall was studied.

The Photon spectrum and polarization were studied when mask with 4.4 mm diameter were added inside the Undulator.

In case using masks, power deposition on Undulator wall will decrease, whereas Photon Polarization will increase.

Future Plans

More studies on energy deposition along undulator will be done.

Energy Deposition along Realistic Undulator will be studied and will be compared with the ideal one.

Photon Collimator between Undulator and target will be studied.

Thank you
for your attention