Conceptual design of the Hybrid positron source

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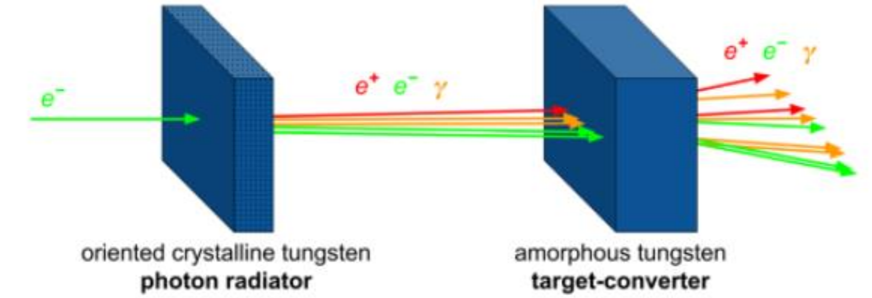
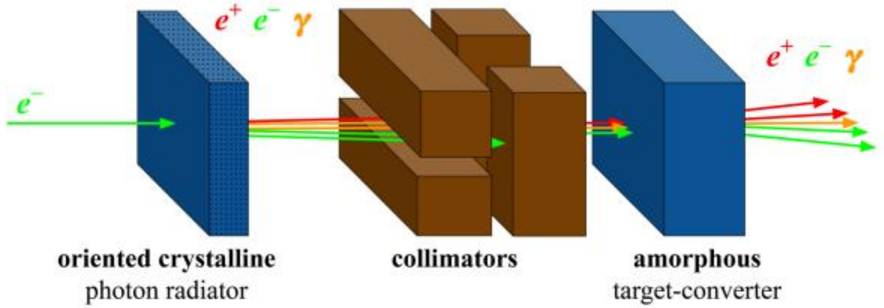
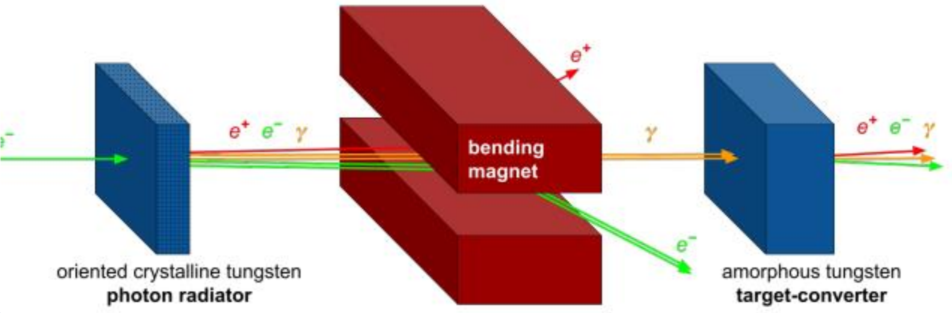
Hybrid scheme for the positron production (channeling radiation)

- Innovative scheme for positron production in collaboration with INFN- Ferrara.
- Production scheme is composed of two elements :
  1) Oriented crystal (Channeling radiation)
  2) Amorphous target (Pair production)
- Advantage : Lower energy deposition in the target.
- 8 different configurations (0.6m, 1m, 2m)
  - **W-Crystal <111> thickness = 2mm**
  - **Amorphous target thickness = 11.6mm (optimized)**

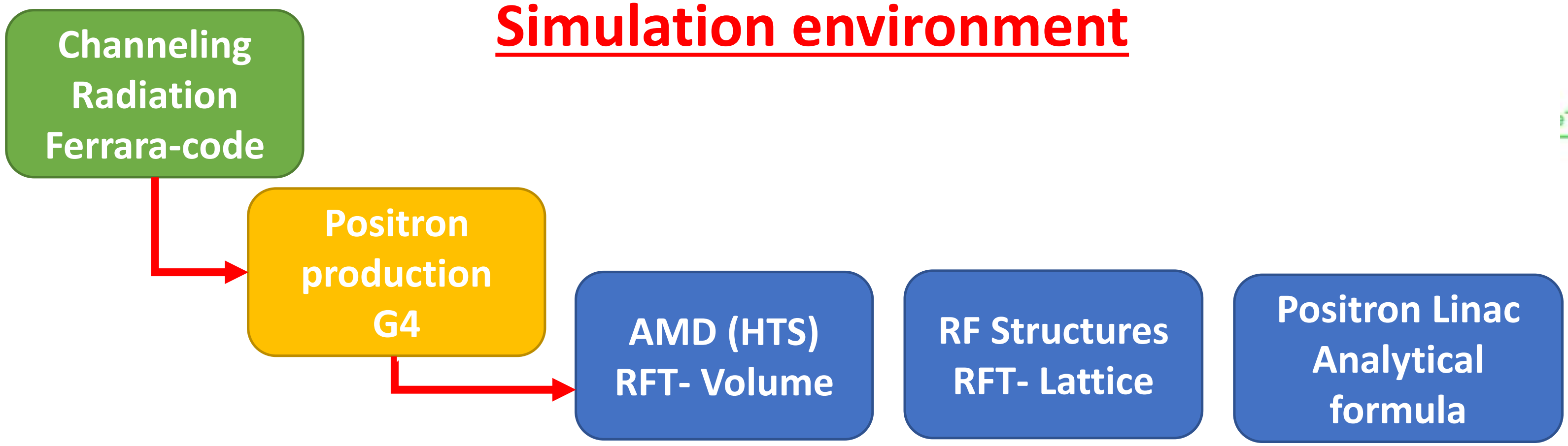
* “ Radiation in oriented crystals: innovative application to future positron sources”







Simulation environment



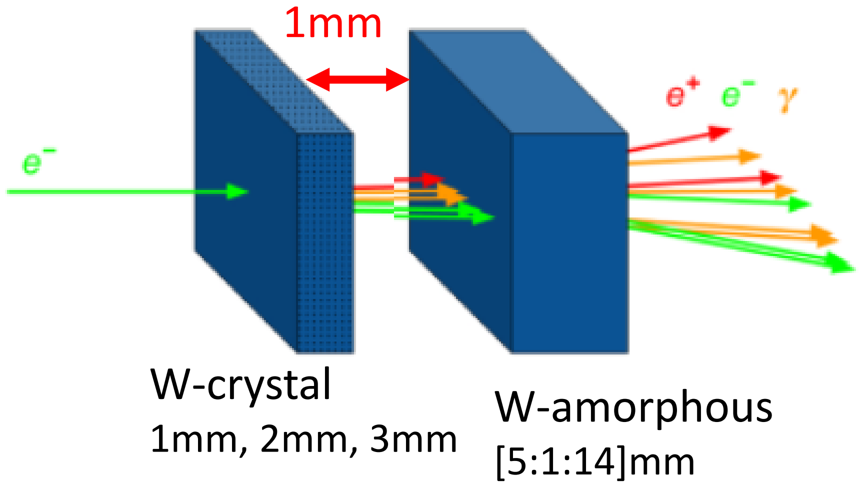
Summary table

13.5nC at DR

Case	Target				AMD		Capture Linac			Positron Linac		e- beam	Target	
	Rate	σx [mm]	Edep [GeV/e-]	PEDD [$\frac{MeV}{mm^3}/e^-$]	Yield (AMD) R = 30mm	Coll. Eff. [%]	Yield	Mean Energy [MeV]	Energy Spread [%]	Bunch Length [mm]	Accept Yield	Drive beam charge [nC]	PEDD [J/g]	Deposited Power [kWs]
0 – Conv.	14.4	0.85	1.46	38.3	13.1	91.3	8.6	196.0	23.2	3.1	7.0	1.93	7.67	1.13
1-0.6m_drift	15.1	2.02	1.34	12.8	11.8	78.5	6.3	190.6	20.8	3.0	5.0	~2.7	3.61	1.45
2- 0.6m_coll	13.6	1.71	1.13	12.5	11.9	87	6.4	190.4	20.8	3.1	5.1		3.43	1.22
3 - 1m_drift	15.1	3.03	1.32	8.4	10.4	69.2	5.1	189.7	22	3.0	4.0	~ 3.4	2.95	1.80
4- 1m_coll	12.6	2.54	1.13	8.2	10.4	76.7	5.1	190	22	3.0	4.0		2.89	1.54
5- 1m_magn	15	3.01	1.32	8.4	10.4	69.2	5	189.9	22.6	3.0	3.98		2.97	1.80
6- 2m_drift	15	5.54	1.27	4.1	7.7	51.3	3.3	188.6	22.5	3.1	2.59	~5.2	2.2	2.64
7- 2m_coll	13.7	4.68	1.11	3.8	7.7	56.4	3.3	189.1	26.8	3.1	2.6		2.06	2.31
8- 2m_magn	15	5.54	1.27	3.9	7.7	51.3	3.3	188.7	22.5	3.1	2.58		2.11	2.64

Crystal radiator adjacent to the amorphous converter.

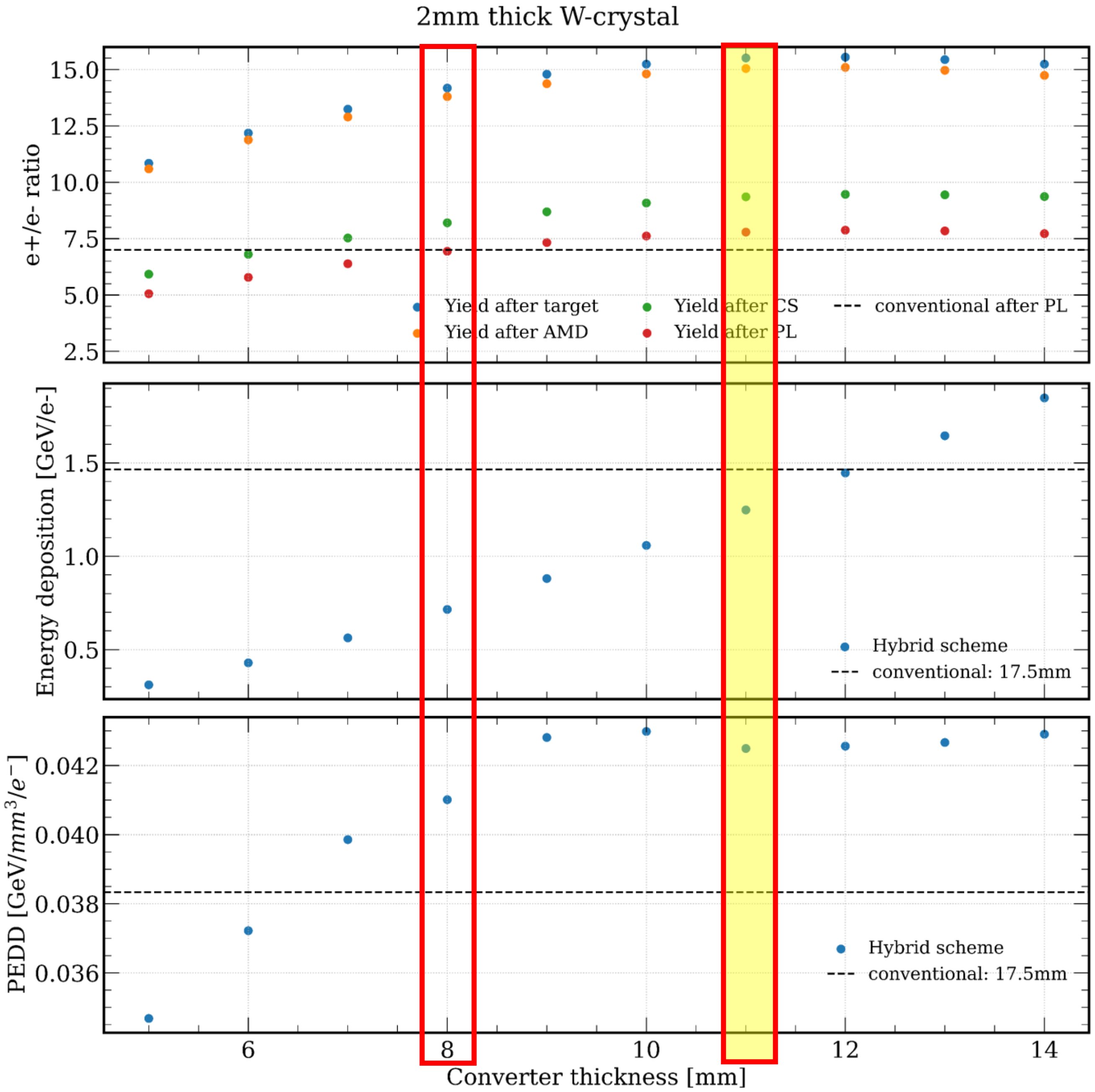
- In order to keep the beam size after the crystal as small as possible : crystal is placed adjacent to the converter (1mm gap).
- W-crystal <111> thickness: 1mm, 2mm, 3mm.
- For each crystal thickness a scan is performed to optimize the converter thickness [5:1:14] mm



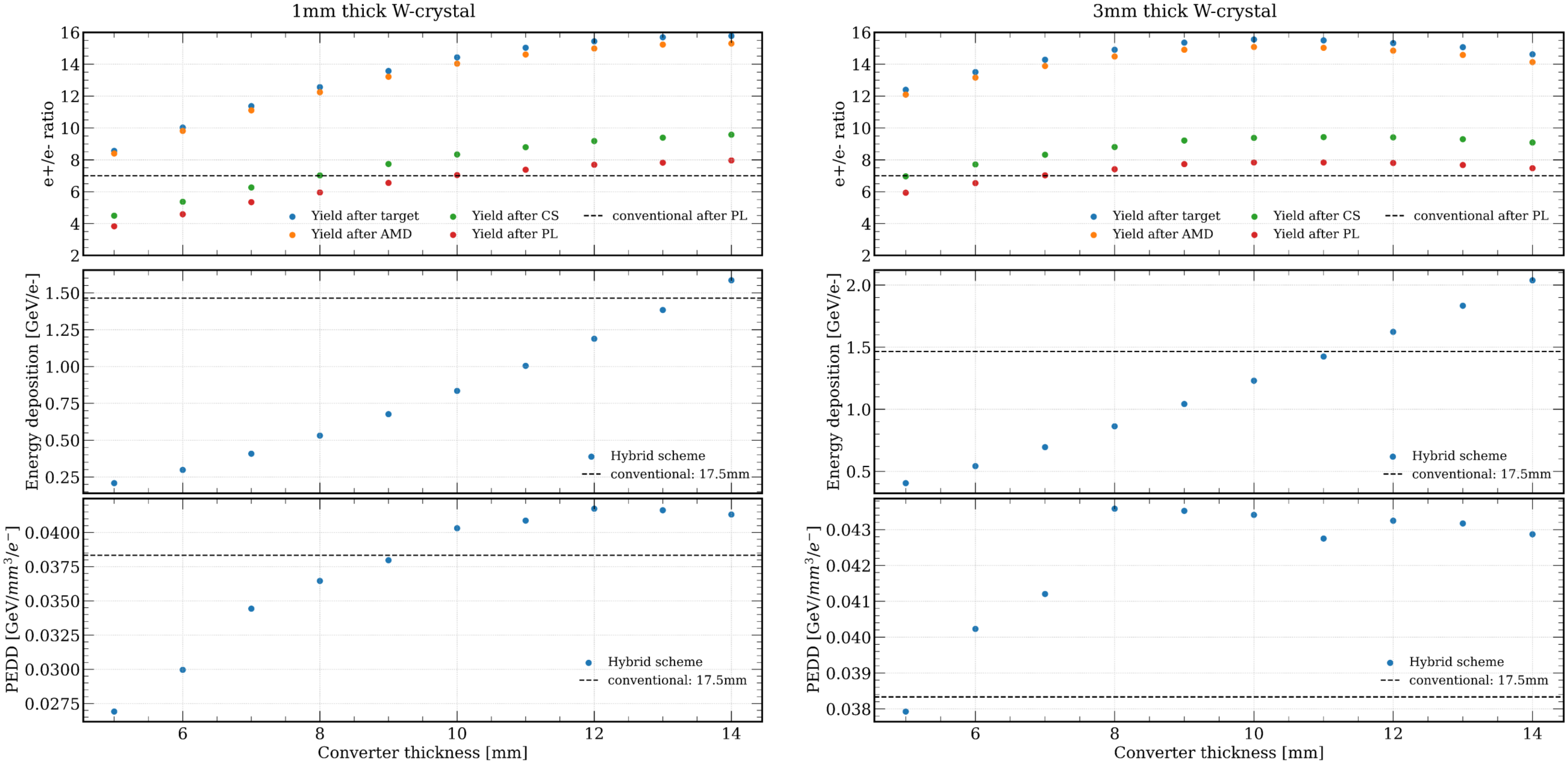
Converter thickness optimization:

- An example of the optimization study with 2mm thick W-crystal in comparison with the conventional scheme.
  - Accepted yield: is comparable to the conventional for a shorter overall thickness (2mm + 8mm)
  - Energy deposition: significantly lower than the conventional (~50%).
  - PEDD: slightly higher than conventional (~7%)

It is necessary to optimize the accepted yield not only the production rate after the target.



Hybrid scheme converter thickness optimization



Cases with final accepted yield is comparable with the conventional scheme

									13.5nC at DR		
Case	Thickness [mm]	Target				AMD	Capture Linac	Positron Linac	e- beam	Target	
		Rate	σx [mm]	Edep [GeV/e-]	PEDD $[\frac{MeV}{mm^3}/e^-]$	Yield (AMD) R = 30mm	Yield	Accept Yield	Drive beam charge [nC]	PEDD [J/g]	Power Deposited [kWs]
Conventional	17.5	14.4	0.85	1.46	38.3	13.1	8.6	7.0	1.93	7.67	1.12
1mm – 10mm	11	14.4	0.64	0.81	40.1	14	8.3	7.04	1.91	8	0.62
2mm – 8mm	10	14.2	0.64	0.73	41	13.8	8.2	6.9	1.96	8.33	0.57
3mm – 7mm	10	14.3	0.63	0.7	41.2	13.9	8.3	7.03	1.92	8.22	0.54

Hybrid scheme advantages in comparison with Conventional scheme :

- Shorter overall thickness (lower radioactive environment around the target) ?
- Comparable yield and PEDD with significantly lower power deposited in the target

Summary

- First check with Alexei previous output is done. (Positron capture simulation)
- Next steps: validation of the G4 simulation with previous results, then proceed with our plan: Timeline is extremely important.

- Hybrid scheme for positron production shows good advantages in comparison with the conventional scheme :

(lower power deposited => lower cooling requirements)

Further studies:

- Smaller primary beam size , thinner crystal.
- Applying one thick crystal instead of two targets (define a reasonable thickness and do simulation).

Thank you