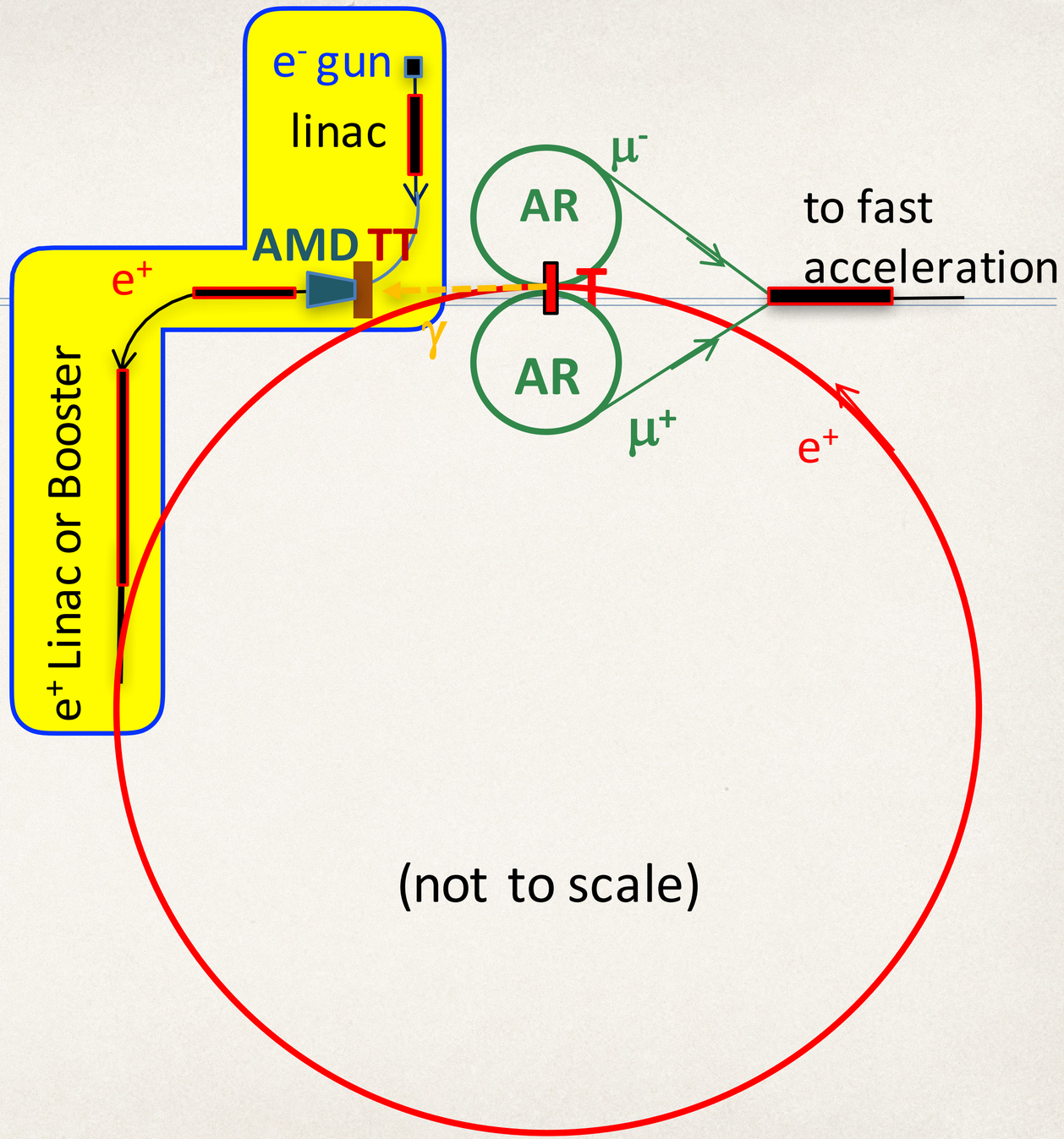
Positron Regeneration

F. Collamati
on behalf of the LEMMA Collaboration

Muon Collider Workshop - 1/3 07 2018 - Padova

Challenges

The positron source



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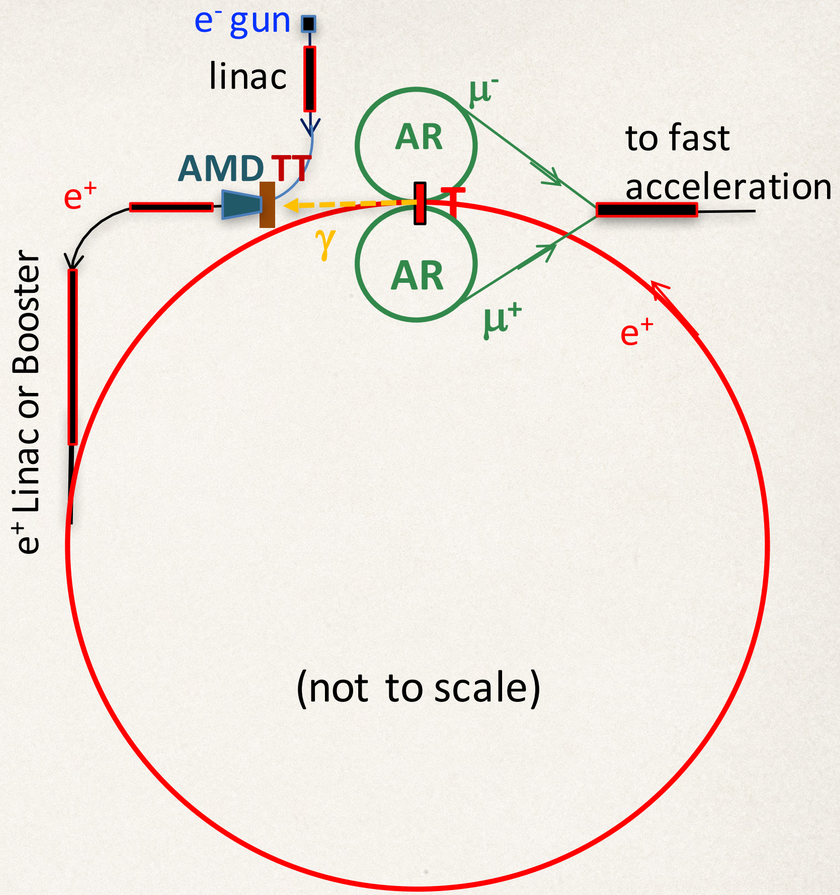

- Given the very low cross section of the muon production process, a **very intense positron source** is needed (10^{18} e^+/s @T, ~FCCee)

- Moreover, a key feature of the LEMMA scheme is the **recirculation** of the positron beam to have it interact several times in the target thus enhancing the production

  - Monte Carlo simulations suggest that **~3% of primary positrons are lost** due to interaction **in the target**

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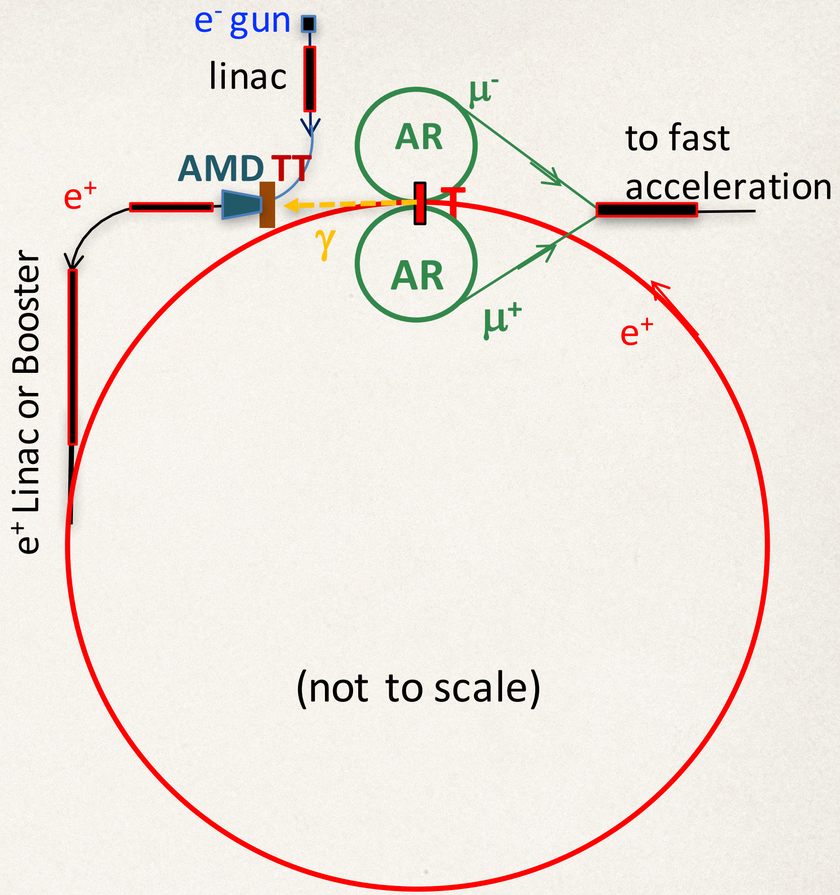
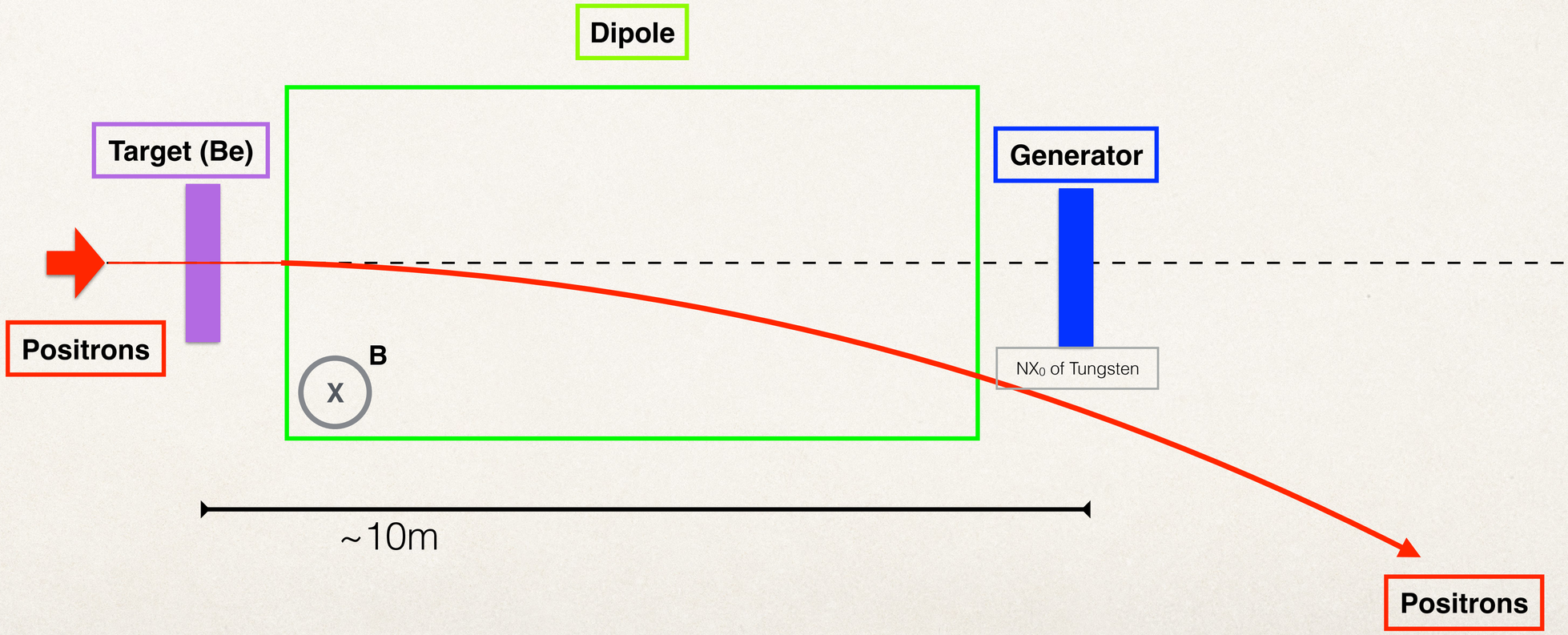


Is it possible to recover them?

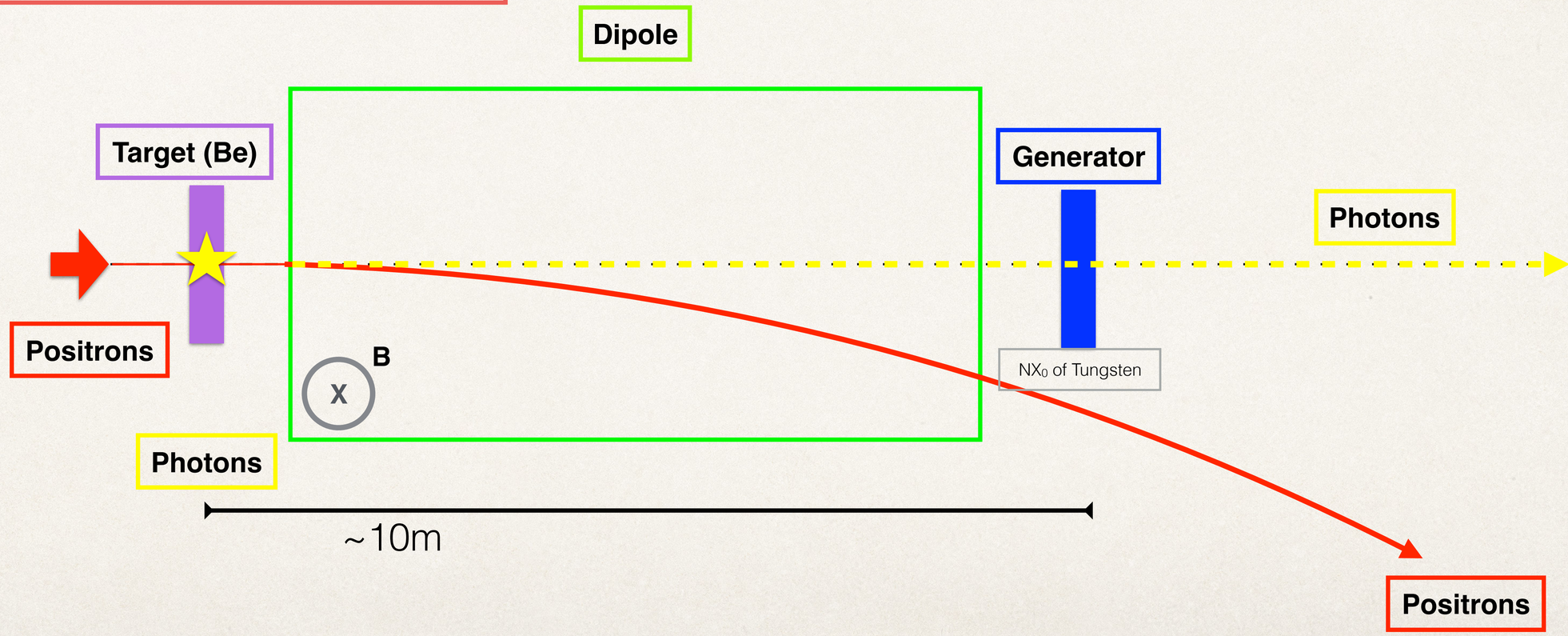
Collection Scheme

Collection scheme



Collection scheme

Positrons in the target create **photons** at very small angles wrt to the beam
(via Brem and (little) radiative bhabha: e+ e- → e+ e- γ)



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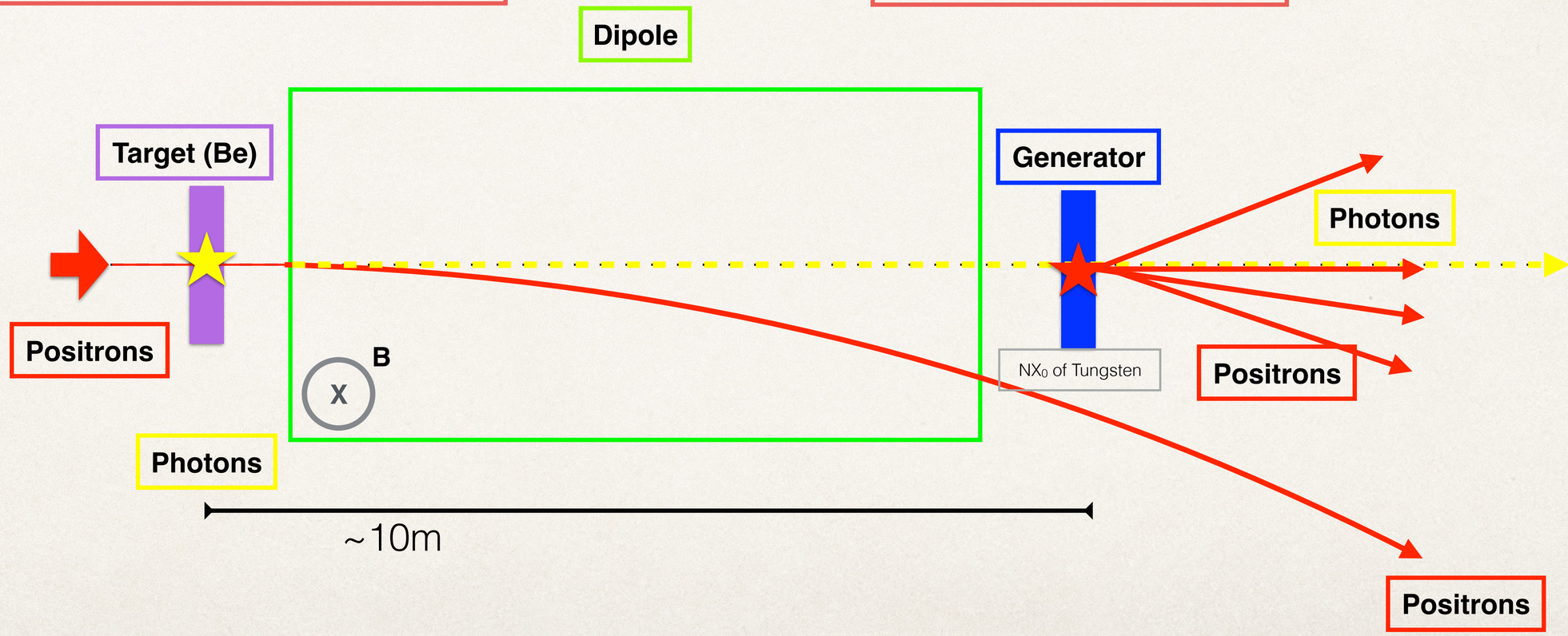

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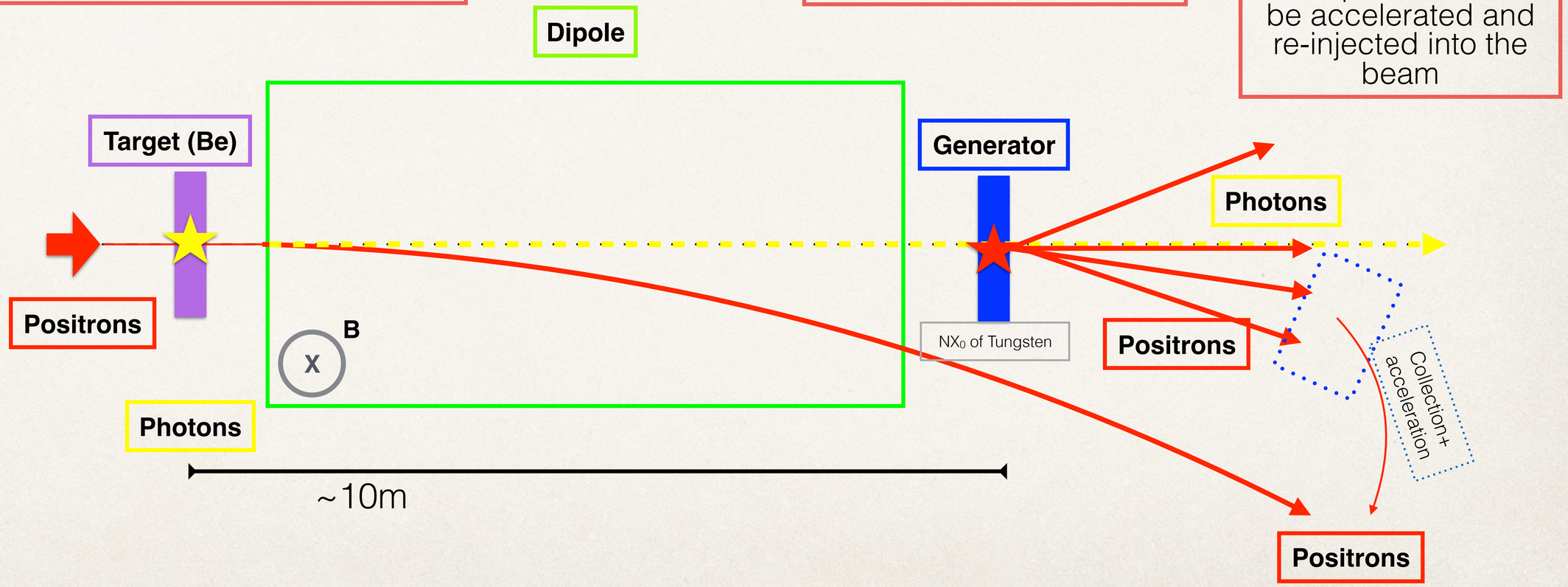
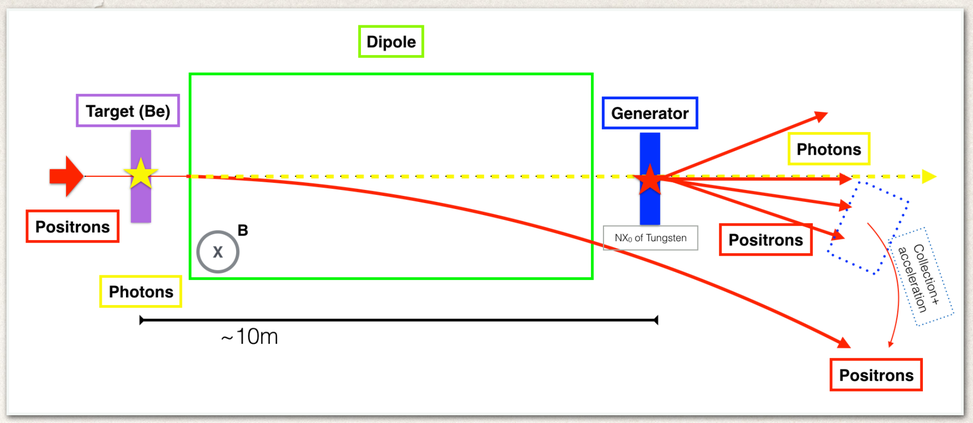
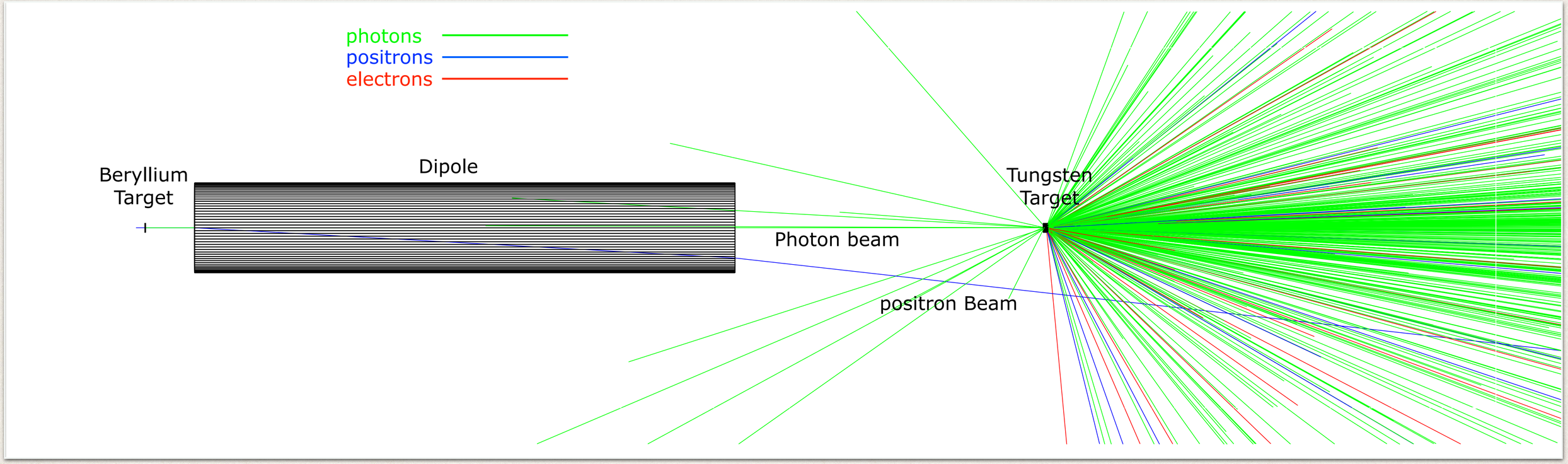
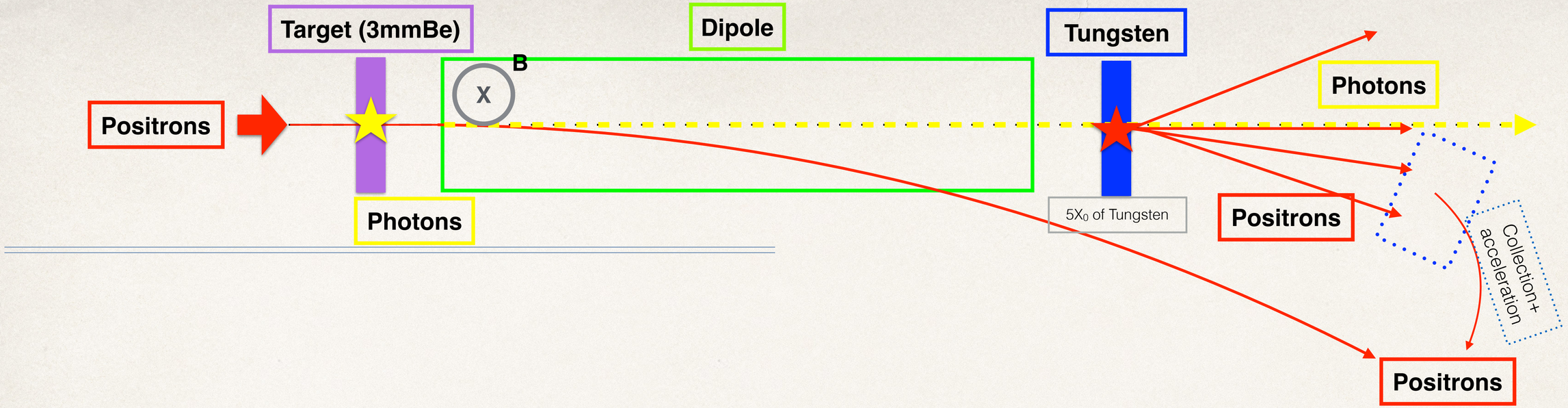
These positrons could be accelerated and re-injected into the beam



Geant4 simulation






Target (3mmBe)
Dipole
Tungsten
B
X
Positrons
Photons
Photons
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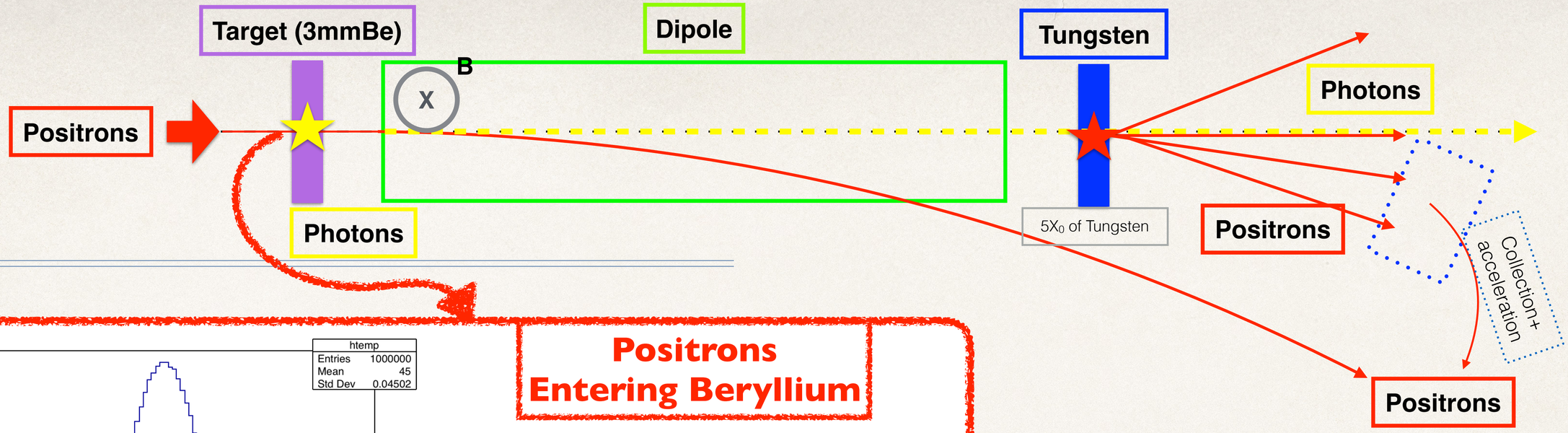
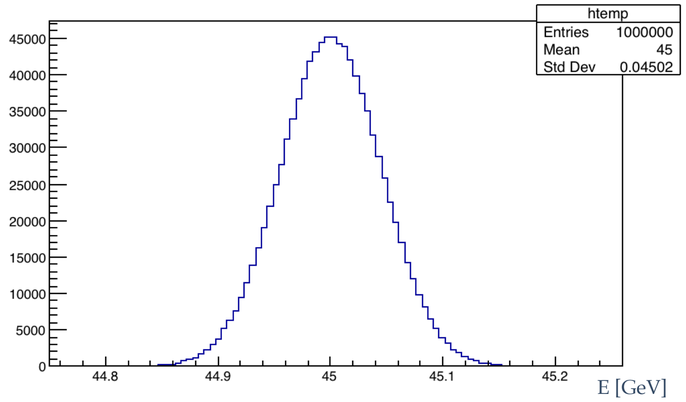
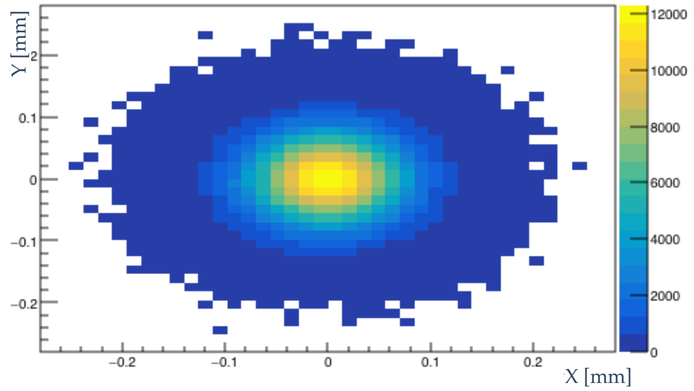
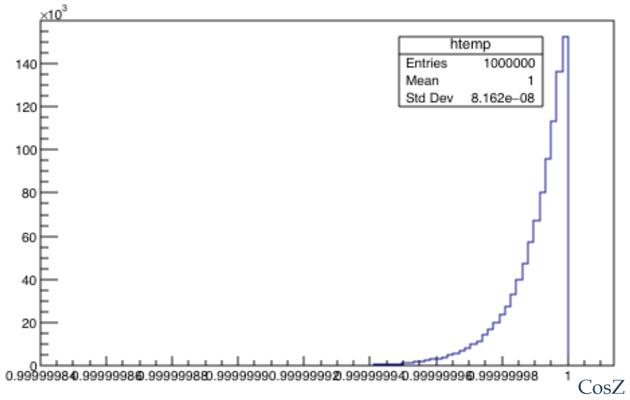
Collection+ acceleration
Positrons



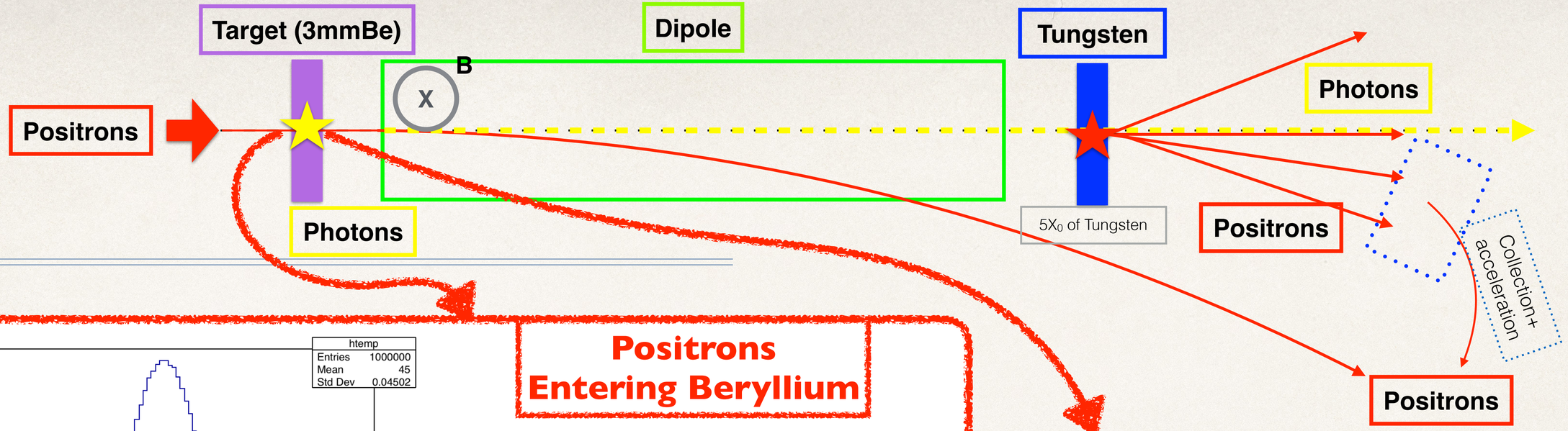
Positrons Entering Beryllium







Beam characteristics as in 1st turn of multi turn simulations



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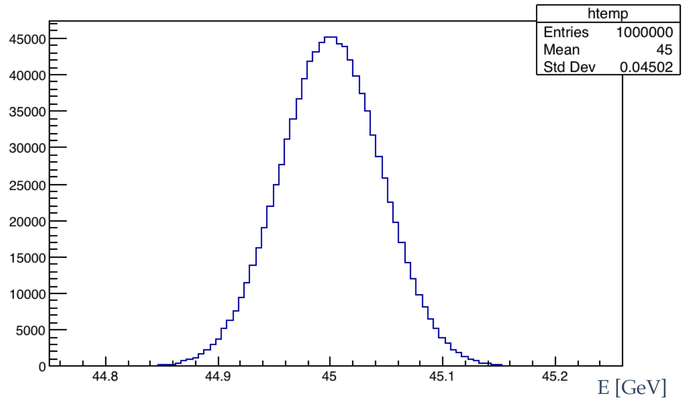

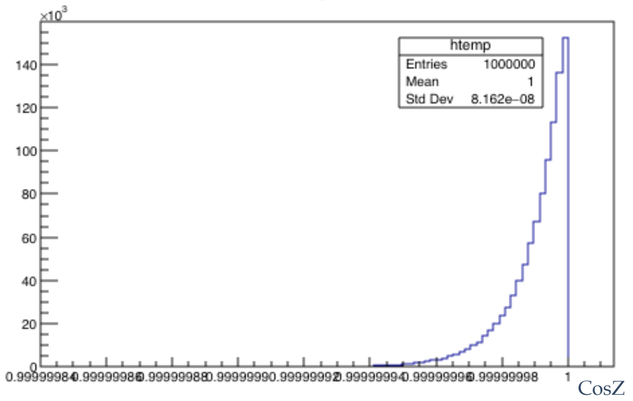

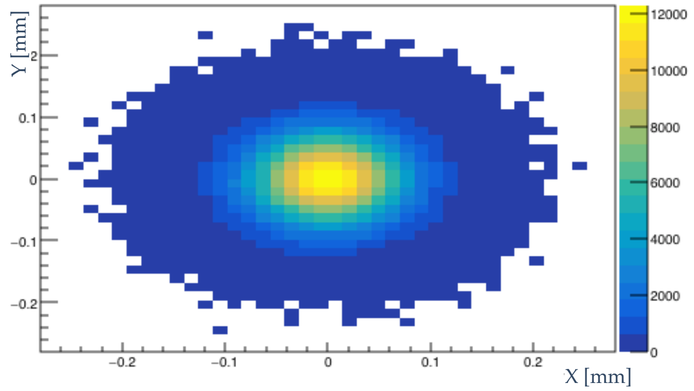

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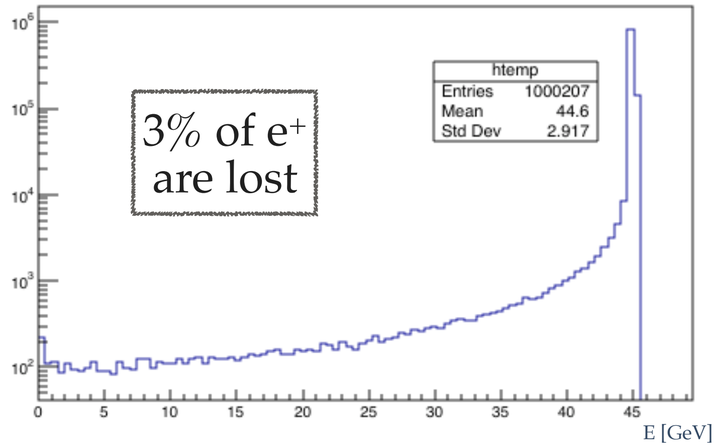
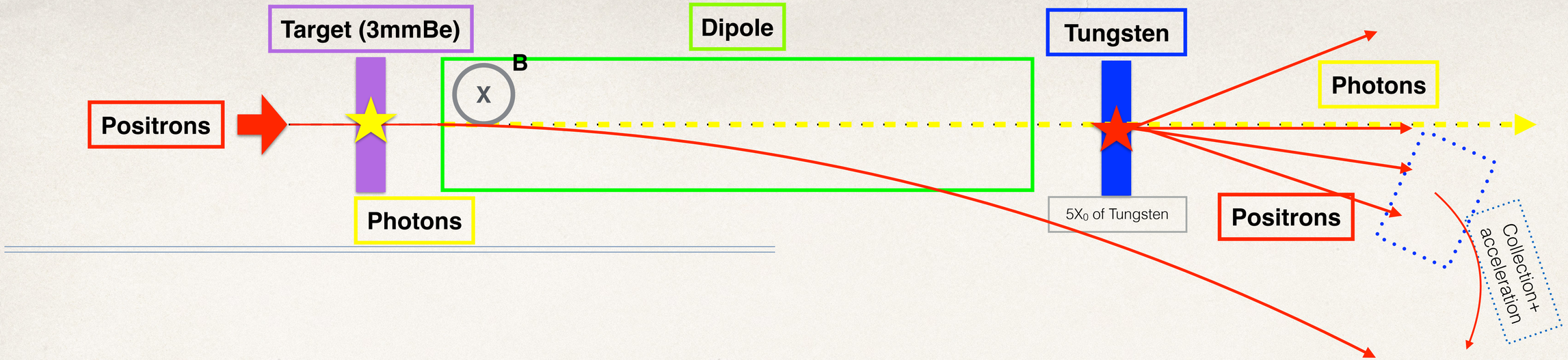


About ~97% of e^+ remain within ±4% of initial energy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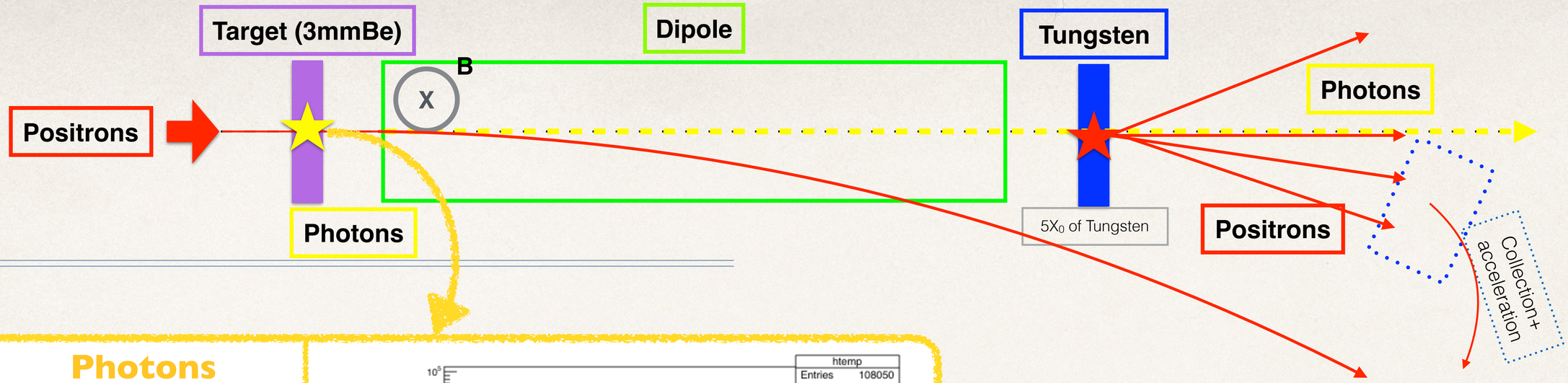

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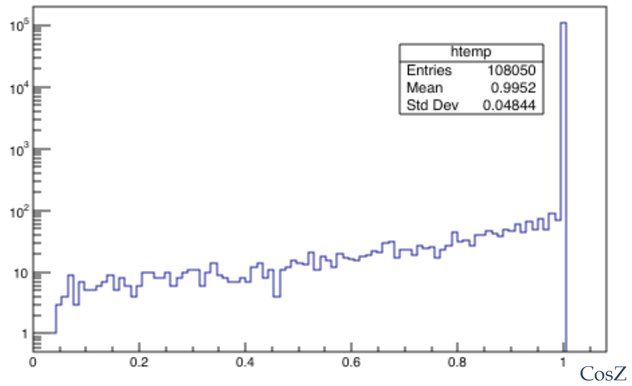

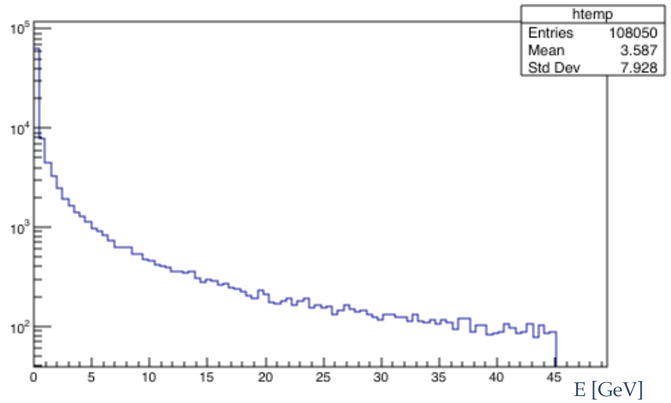

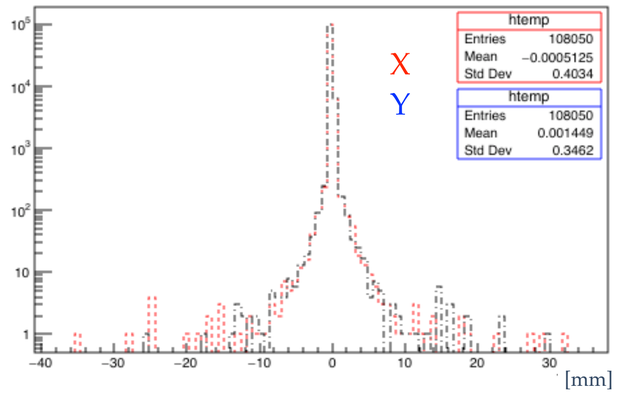

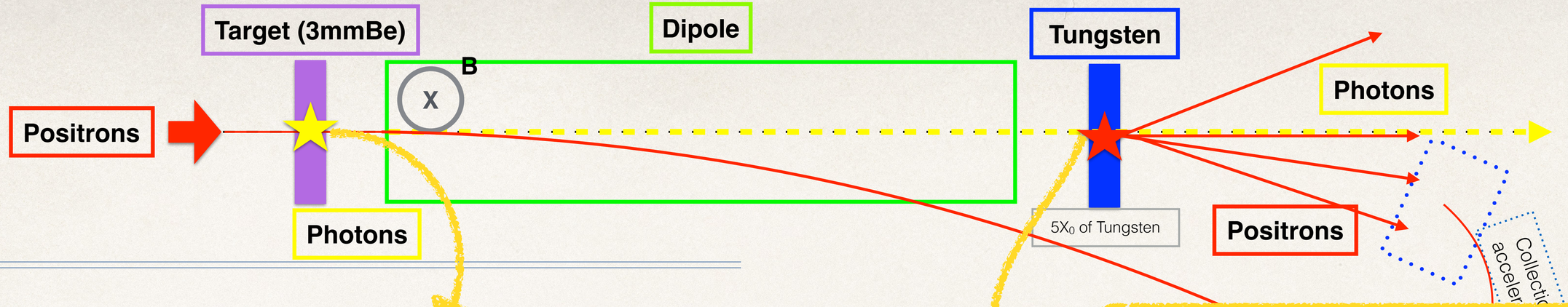

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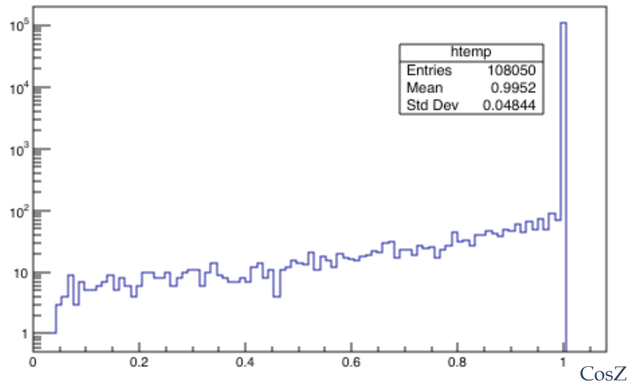
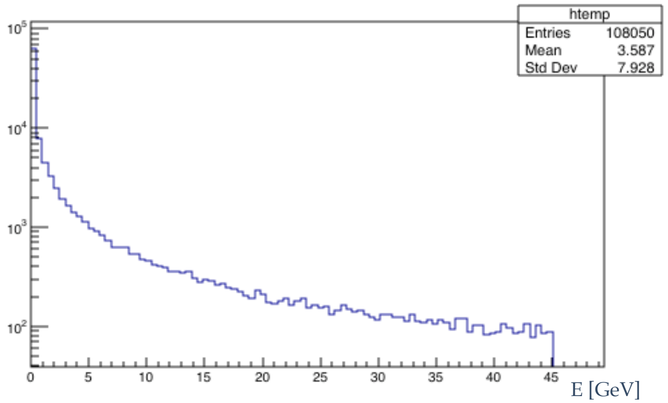
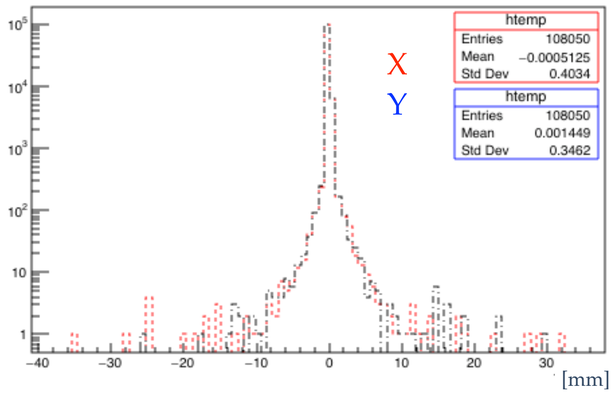
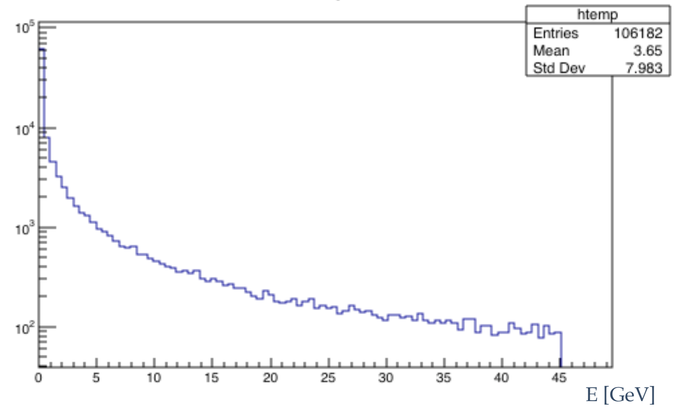
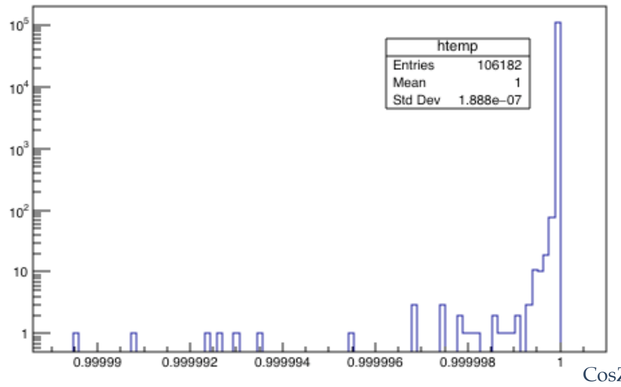


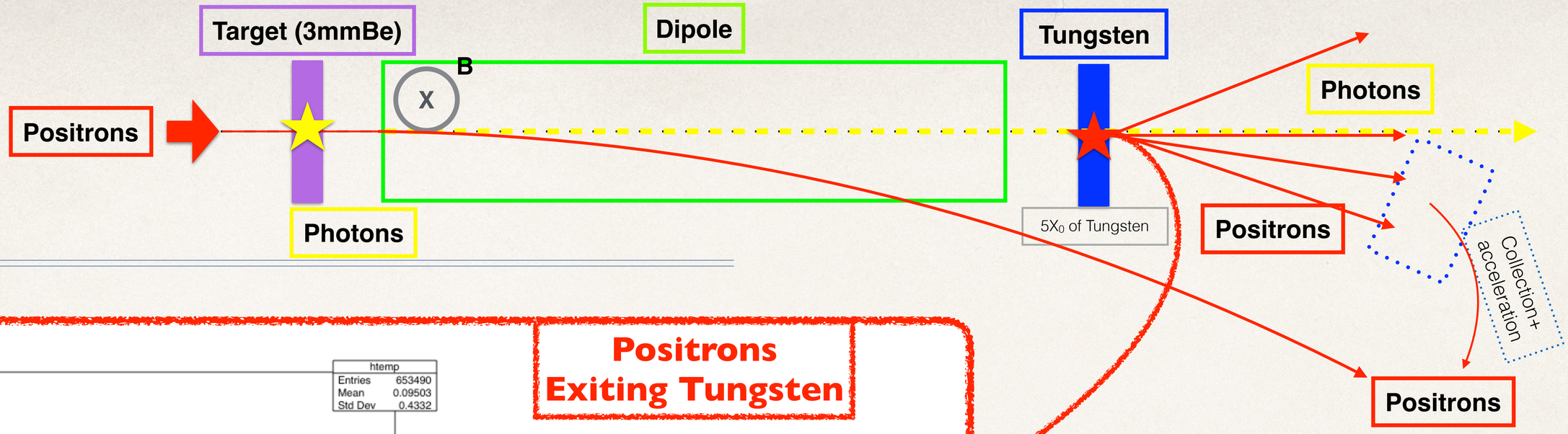




Photons Entering Tungsten







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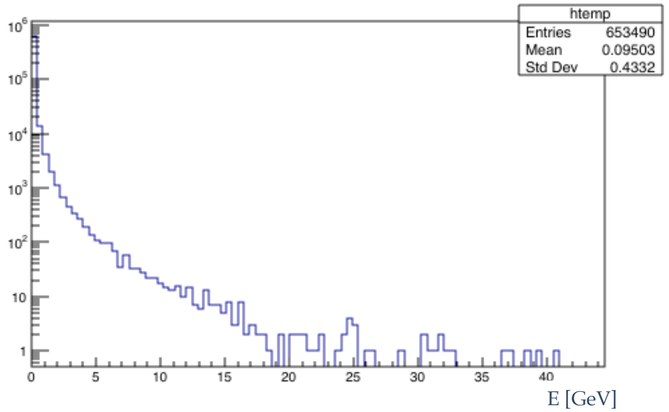
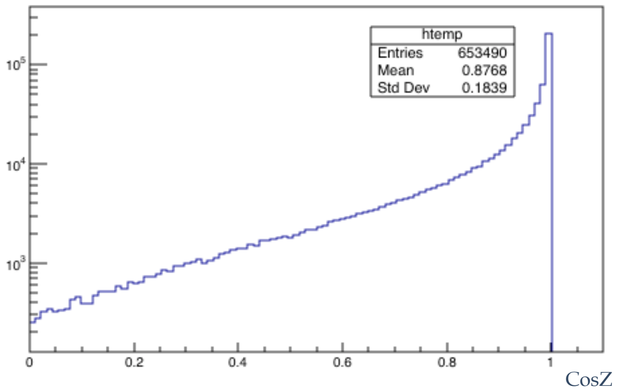
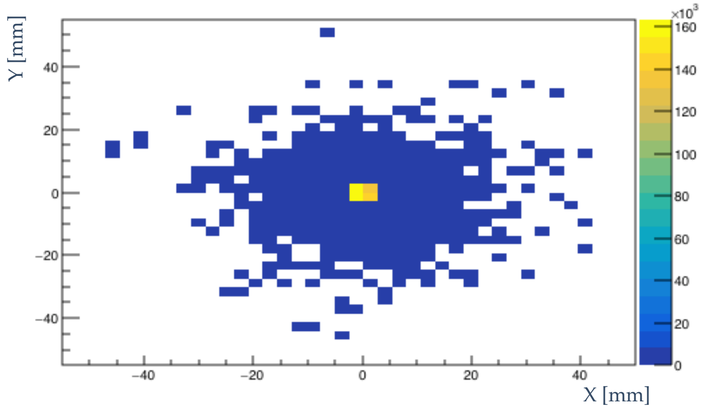
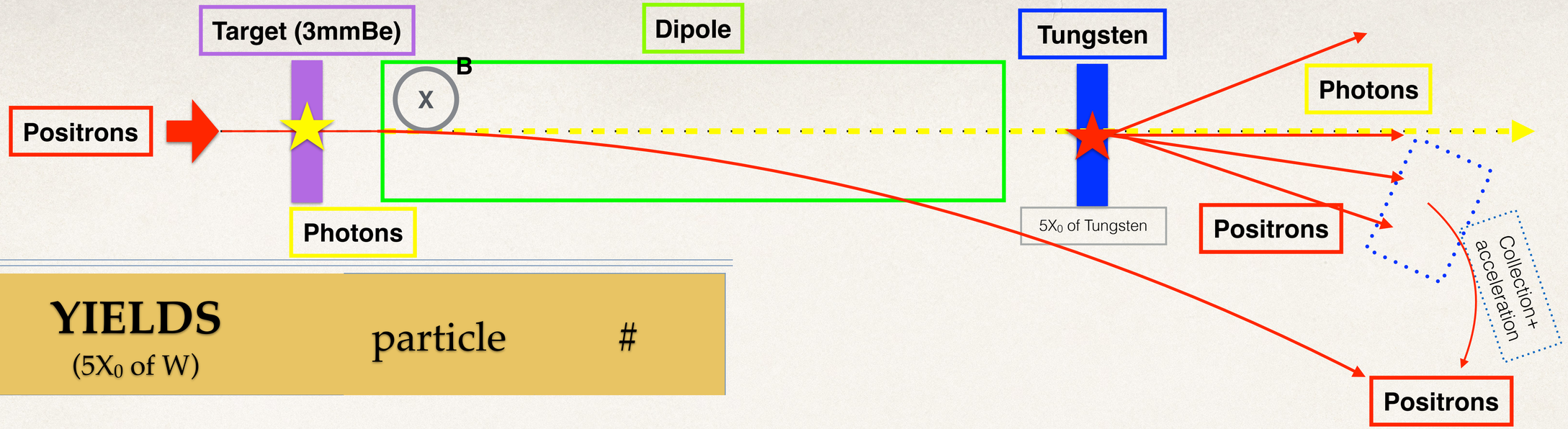
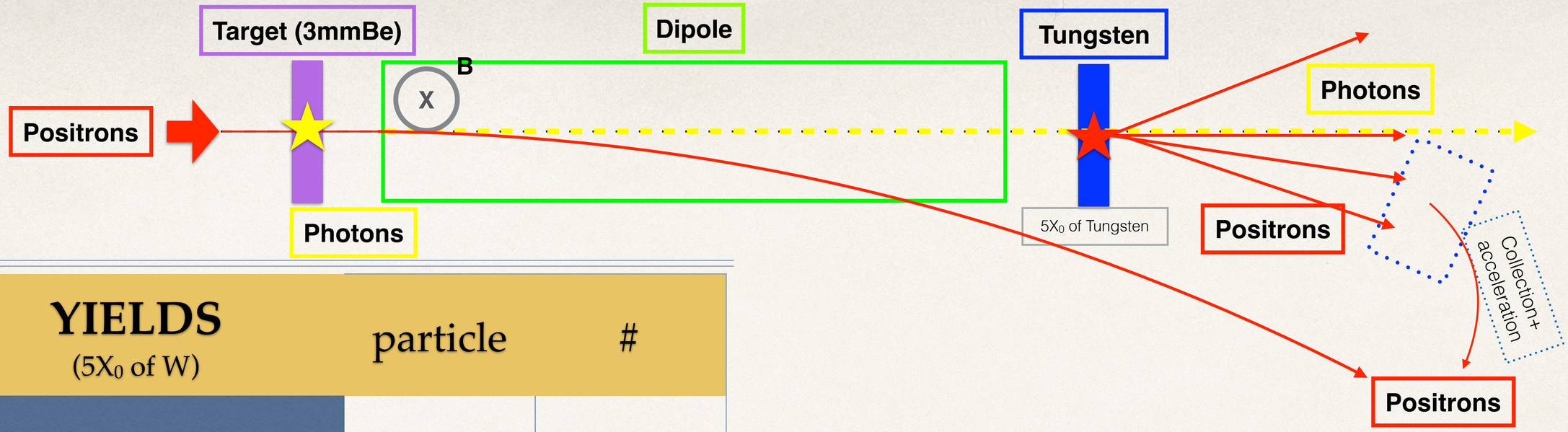








YIELDS ($5X_0$ of W)	particle	#



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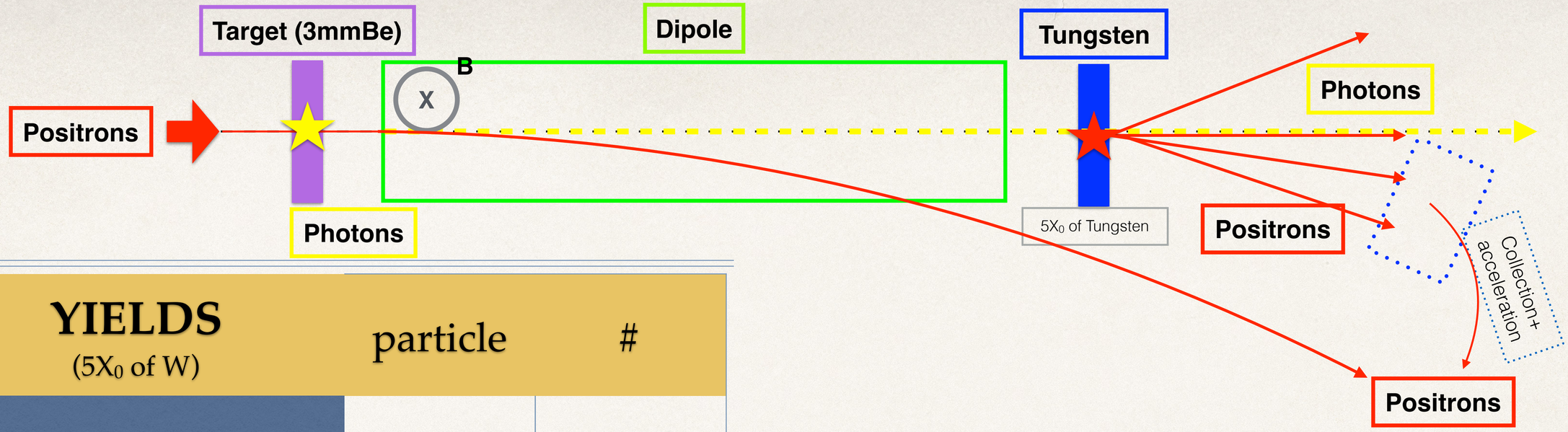

YIELDS ($5X_0$ of W)	particle	#
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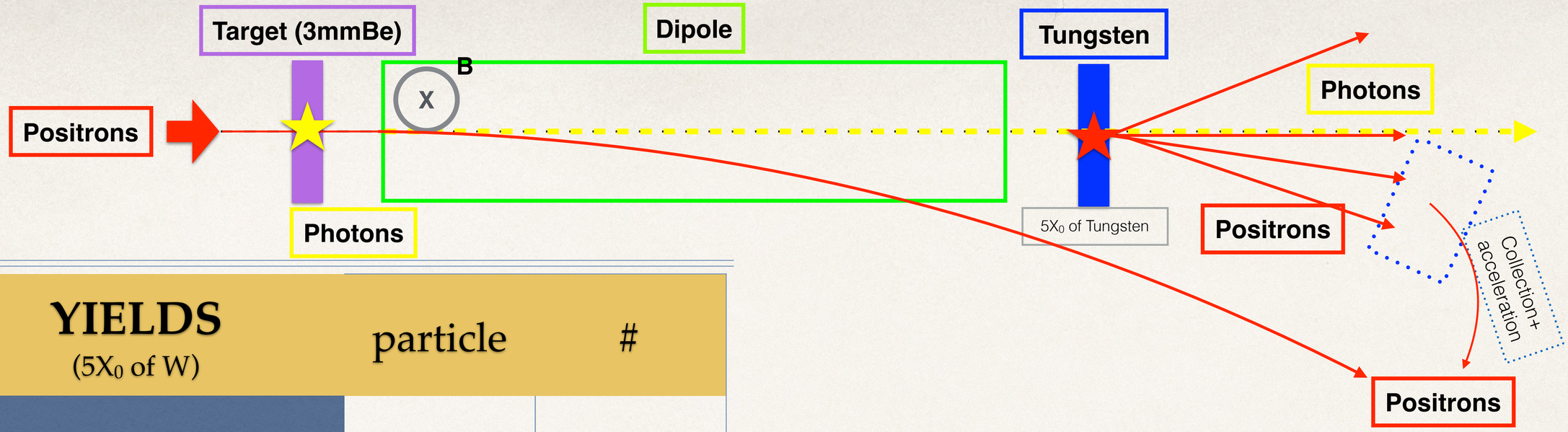
Primary Particles lost due to target (DE 4%)	e^+	3



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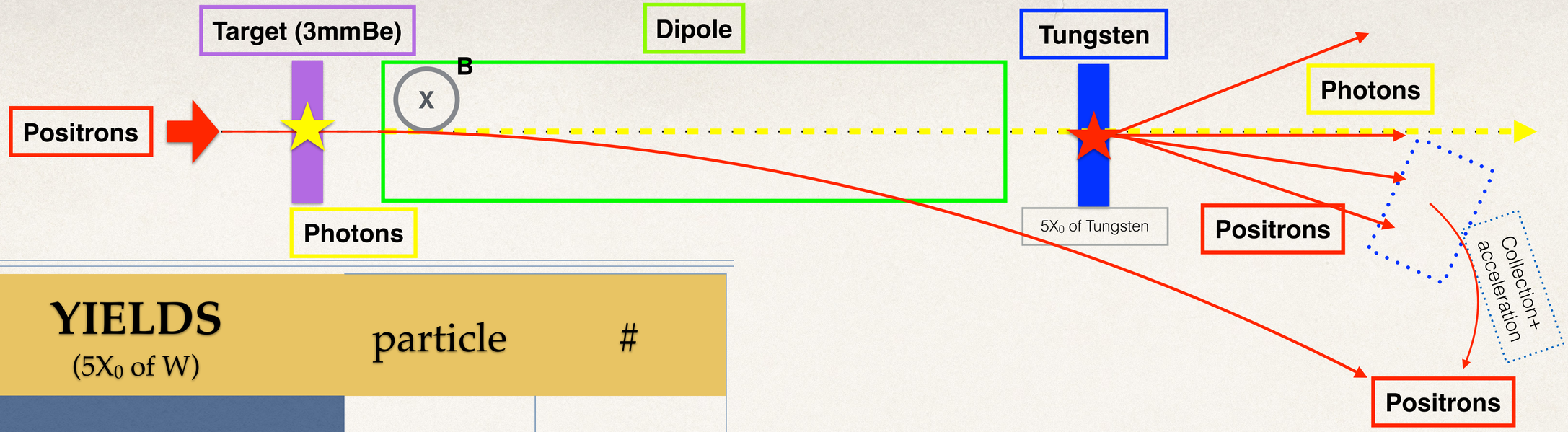

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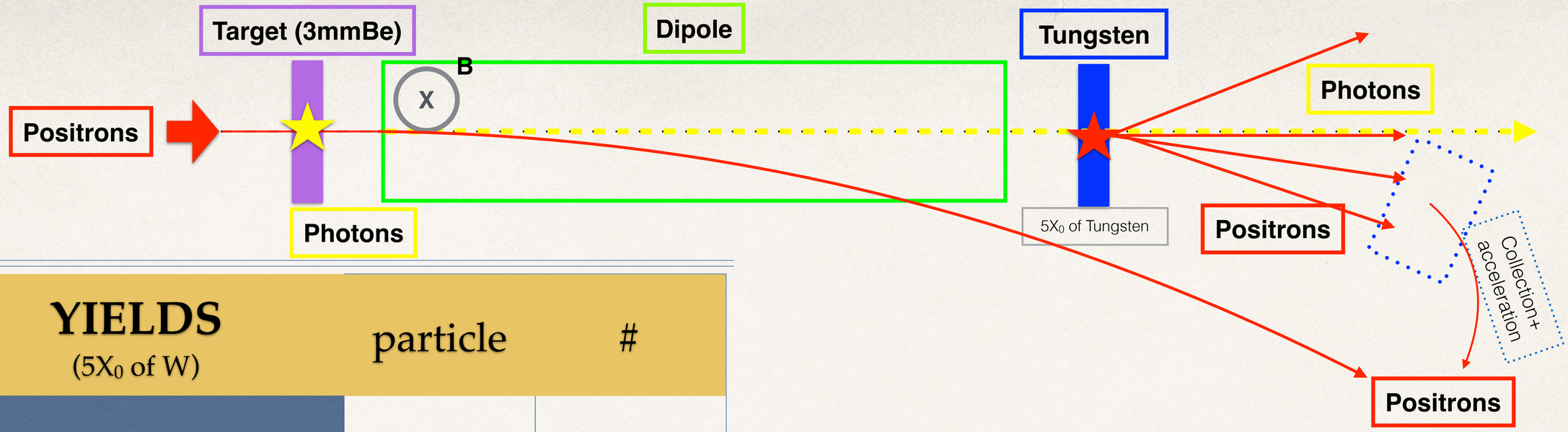

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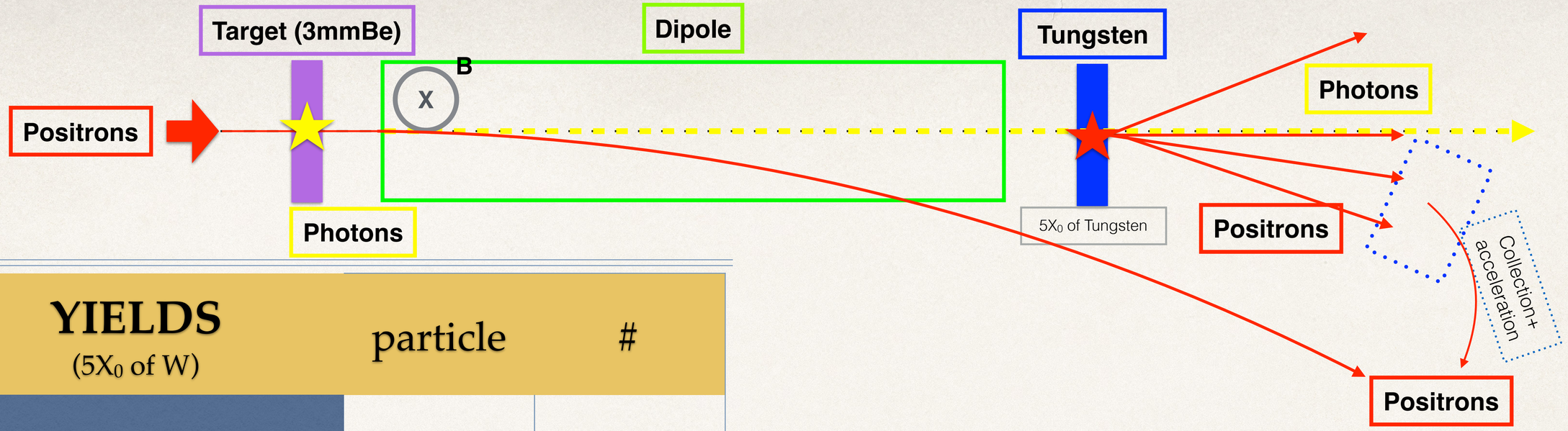

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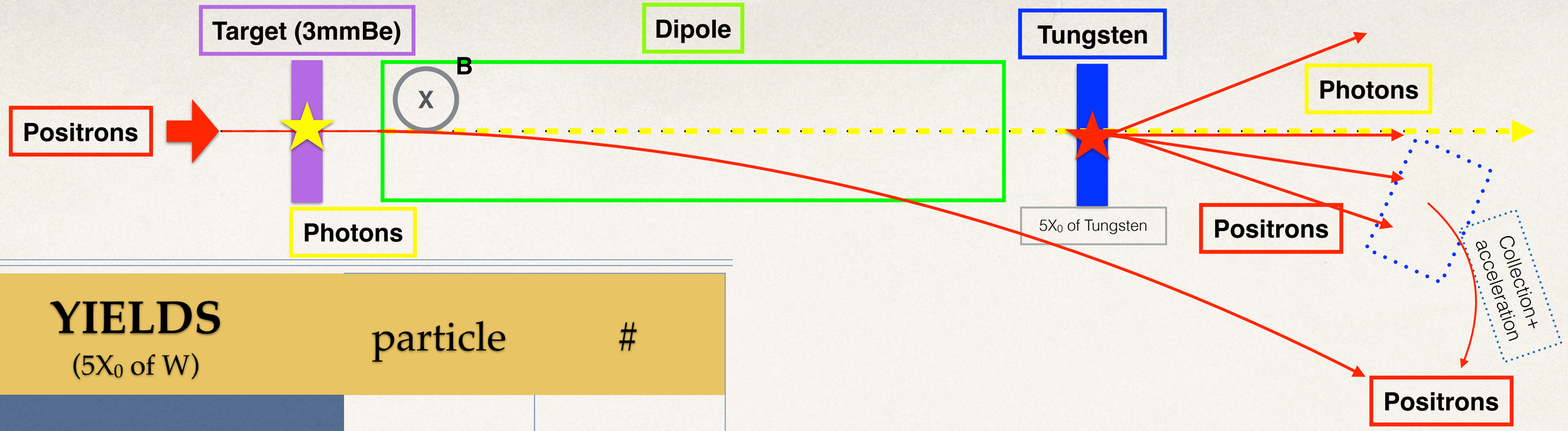
It would be sufficient to be able to collect **5%** (3/65) of these e^+ to compensate the loss of primary positrons in the target



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Collection Efficiency?

Collection Efficiency Maximization

Collection efficiency maximization

- **Collection efficiency** deeply depends on:

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  The **amount** of positrons produced in the Tungsten

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Collection efficiency maximization

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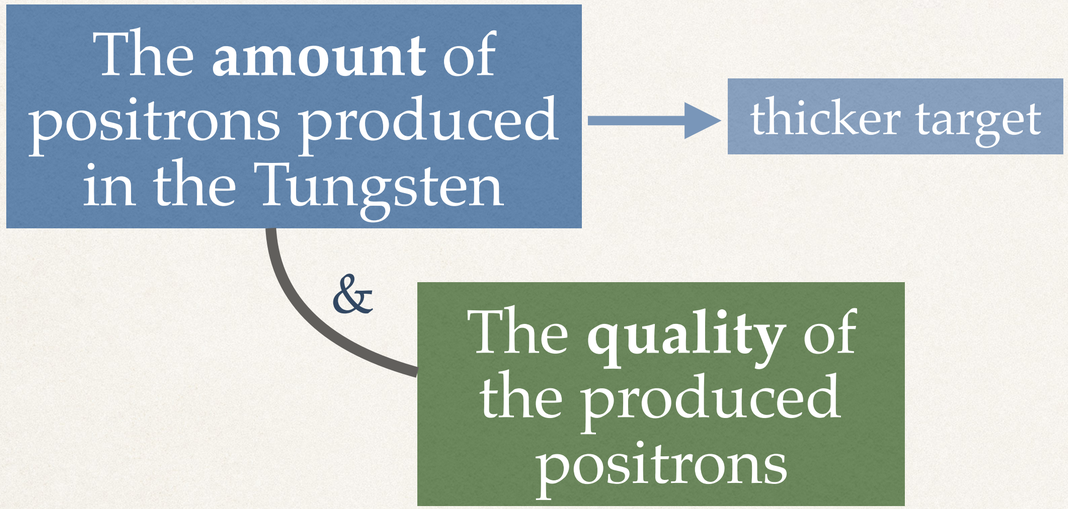

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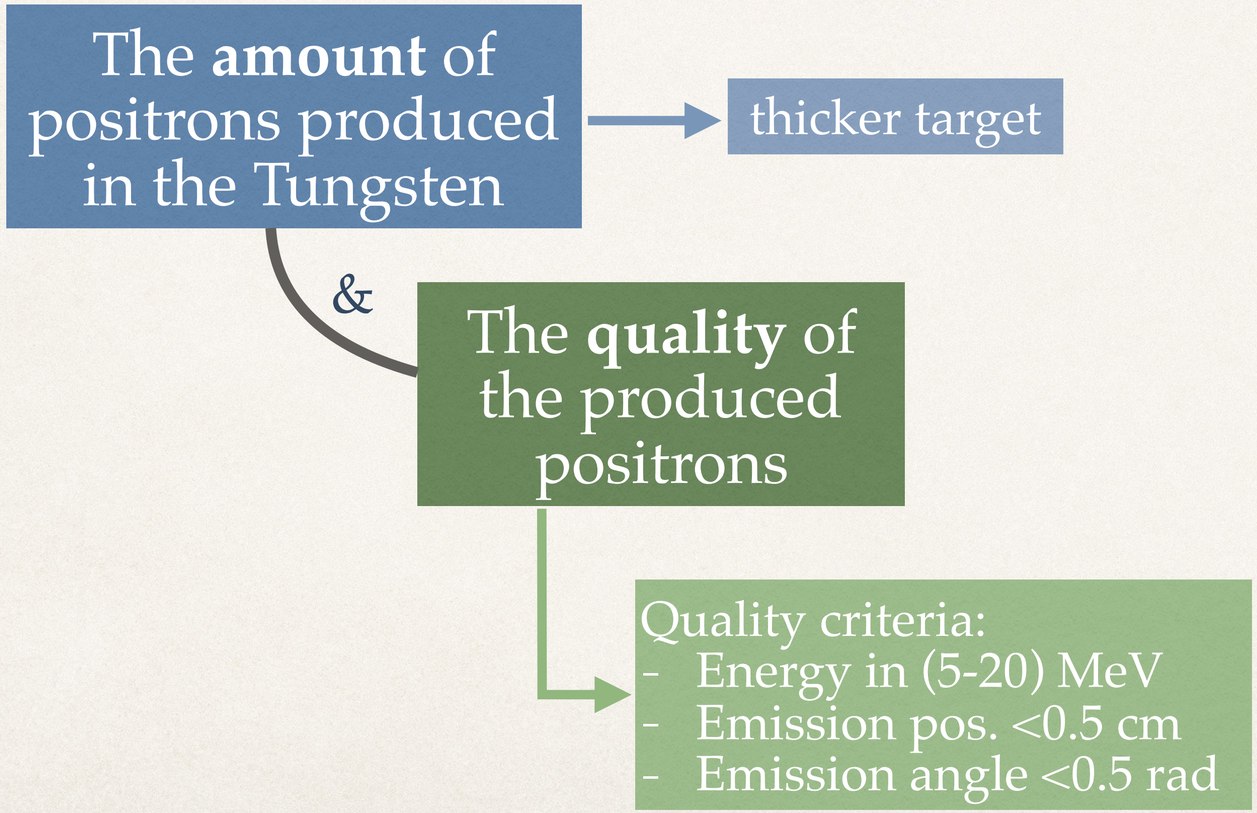

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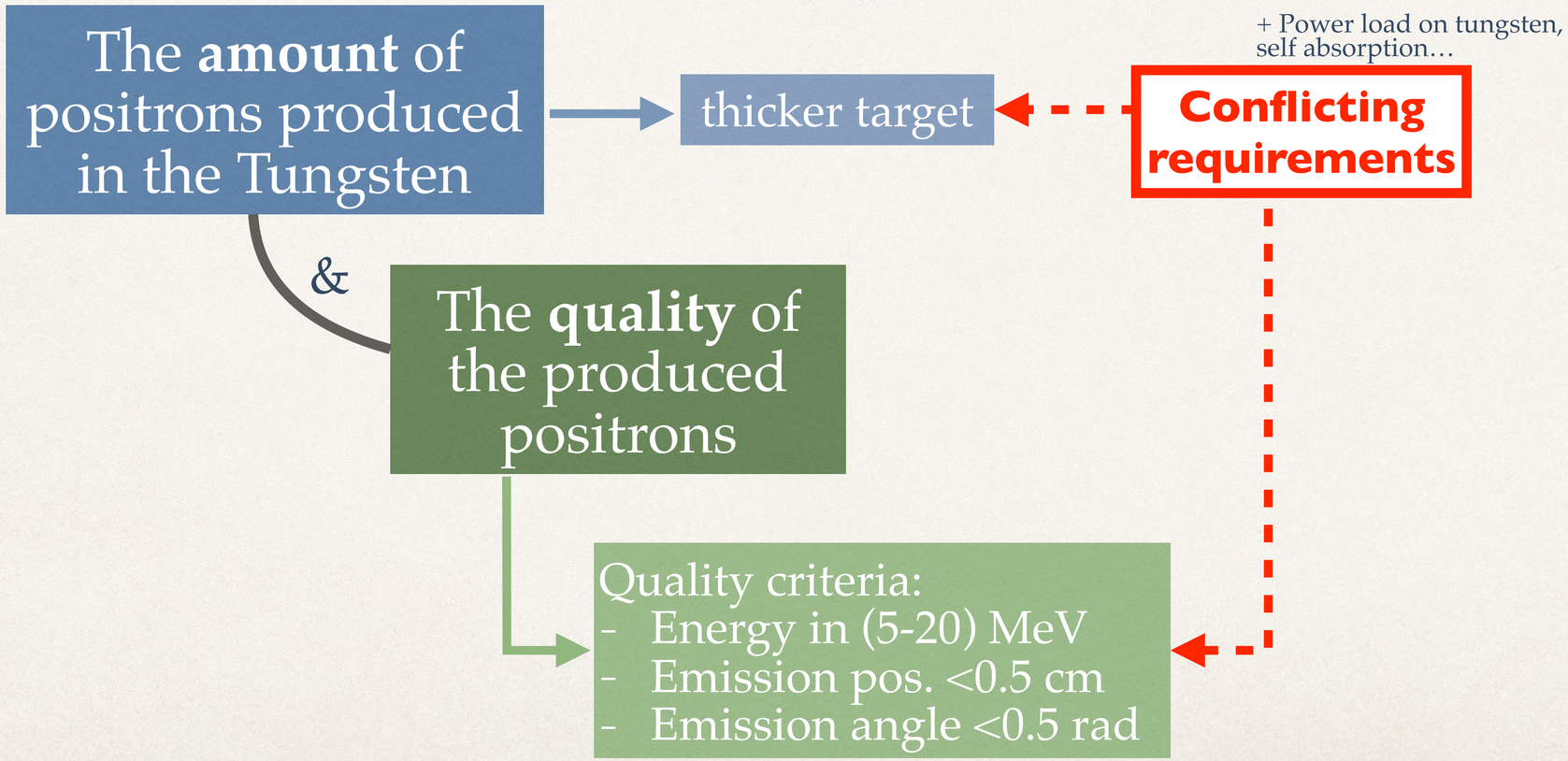

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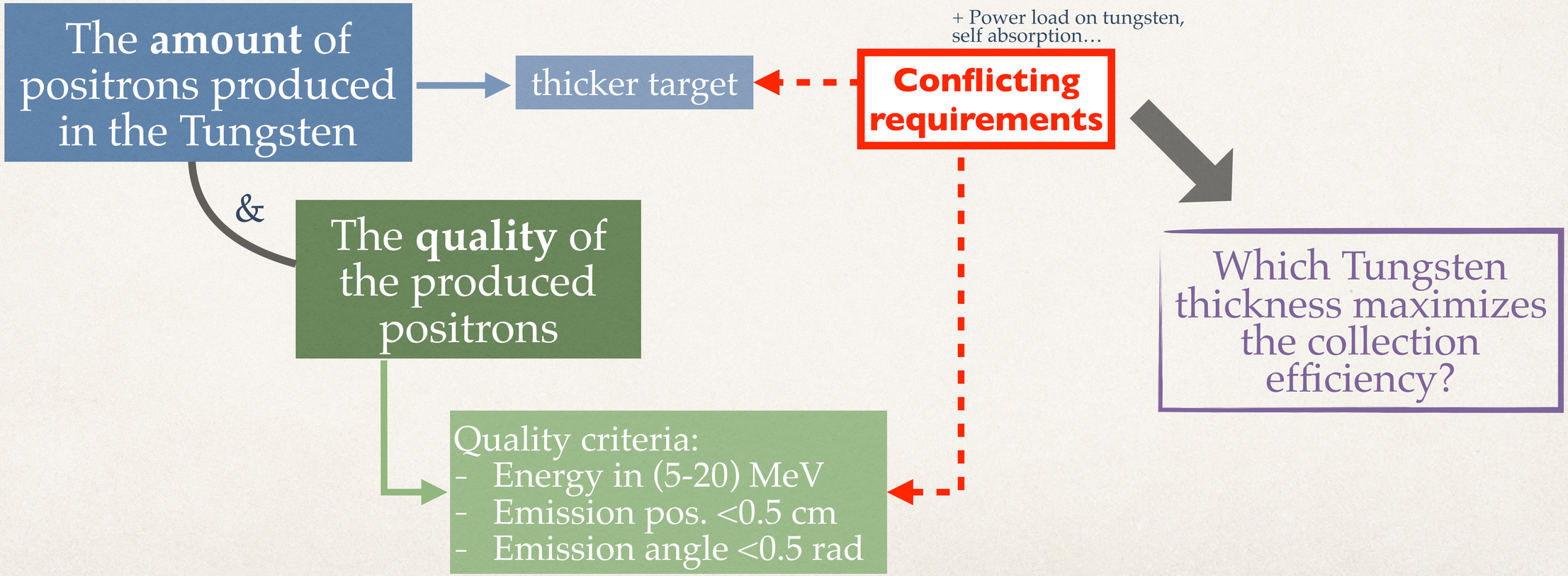

Collection efficiency maximization

- **Collection efficiency** deeply depends on:

The **amount** of positrons produced in the Tungsten

&

The **quality** of the produced positrons

thicker target

+ Power load on tungsten, self absorption…

Conflicting requirements

Quality criteria:
- Energy in (5-20) MeV
- Emission pos. <0.5 cm
- Emission angle <0.5 rad

Which Tungsten thickness maximizes the collection efficiency?

Collection efficiency maximization (II)

- The **Geant4** simulation was performed variating the Tungsten thickness from *1* to *10* X_0
- For each configuration the **fraction of positrons matching** each **requirement** was evaluated

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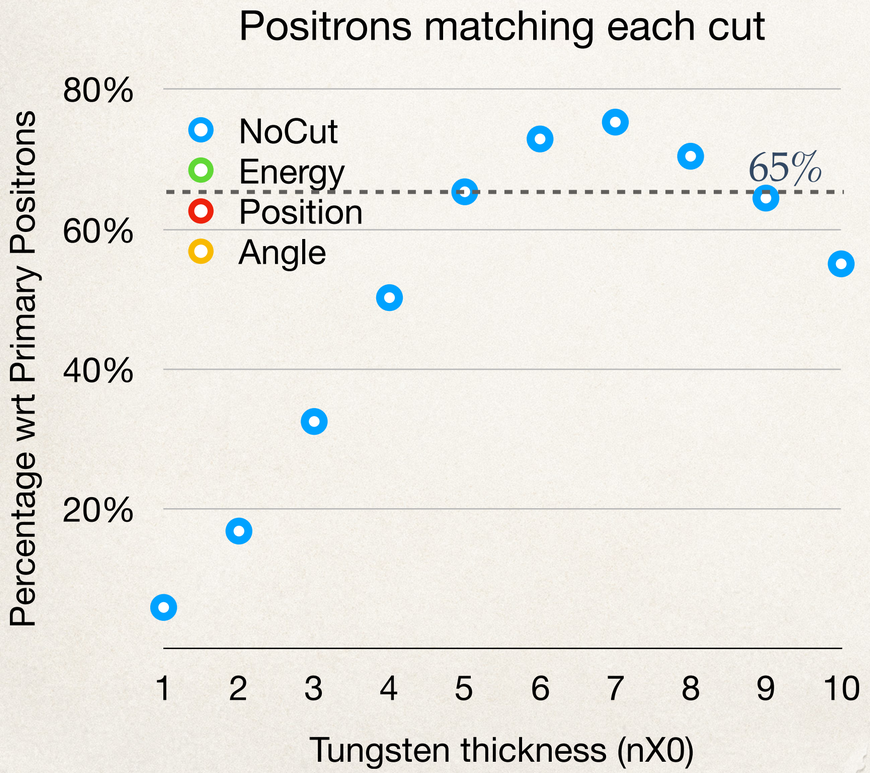

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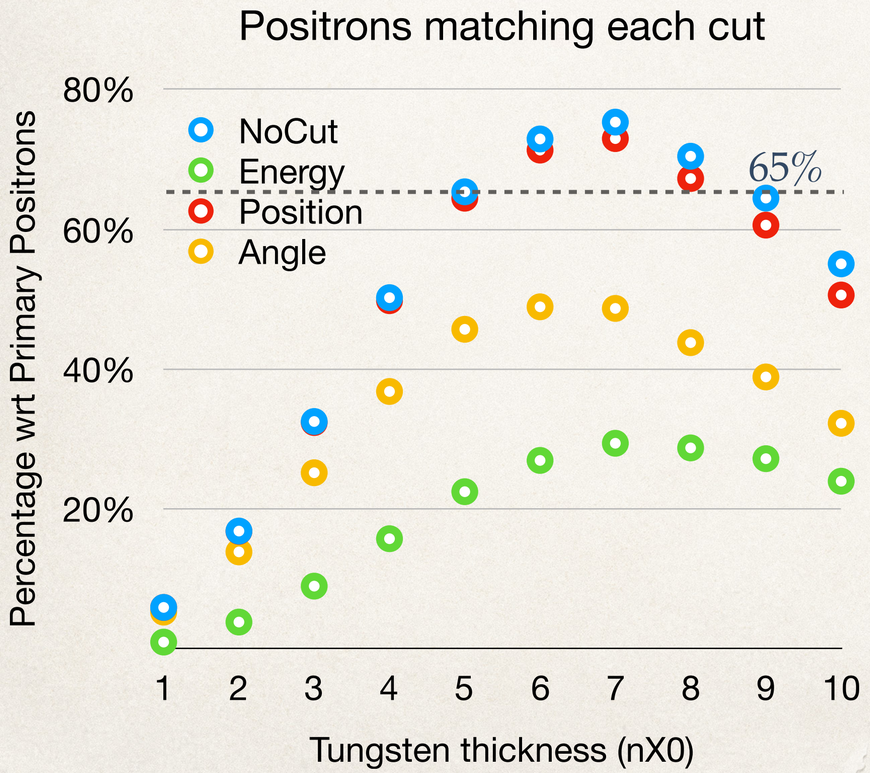

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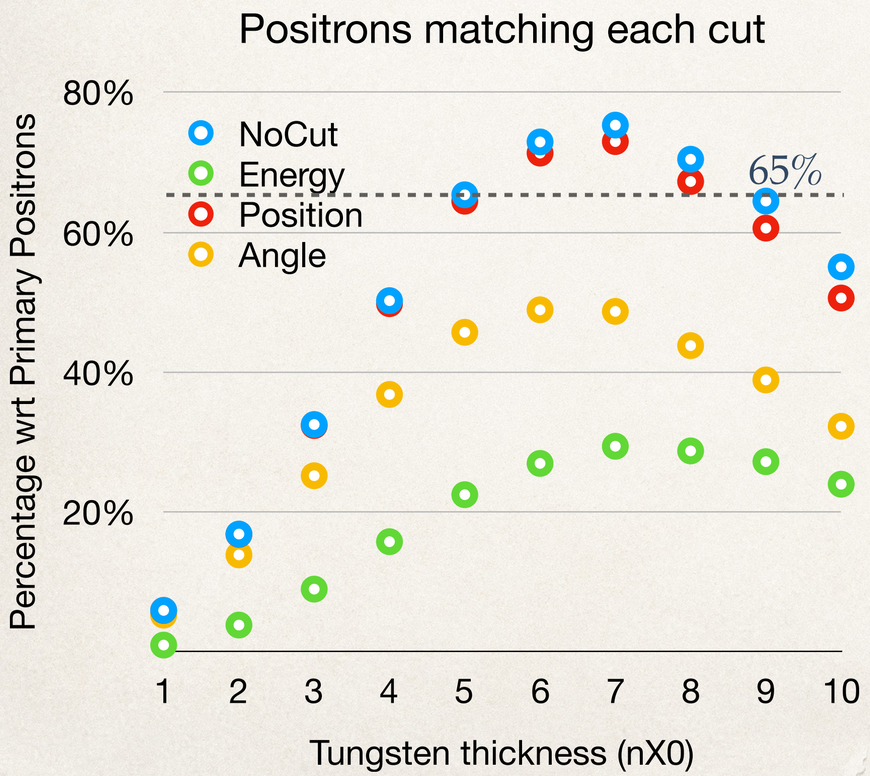

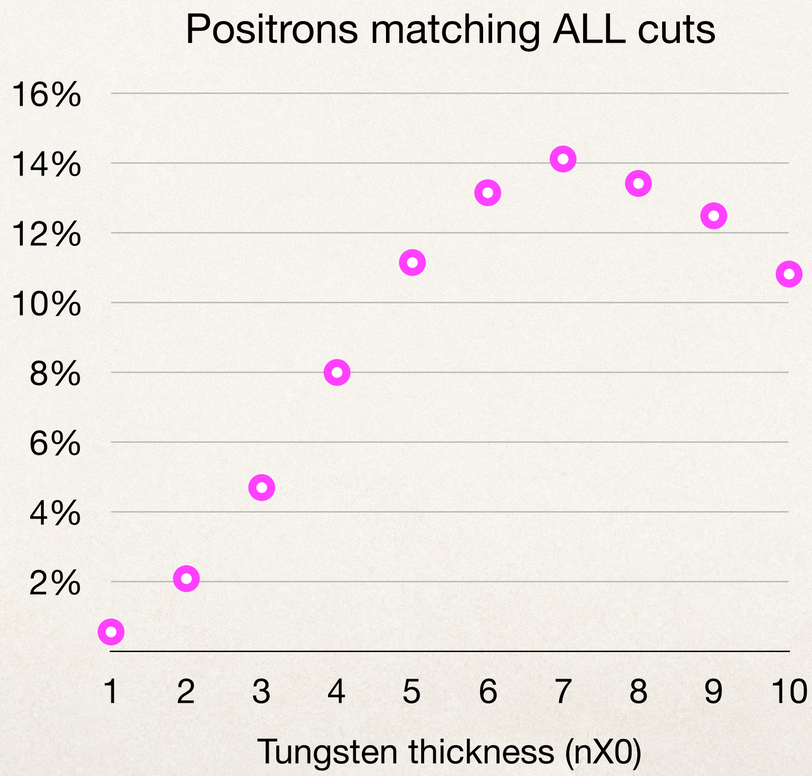

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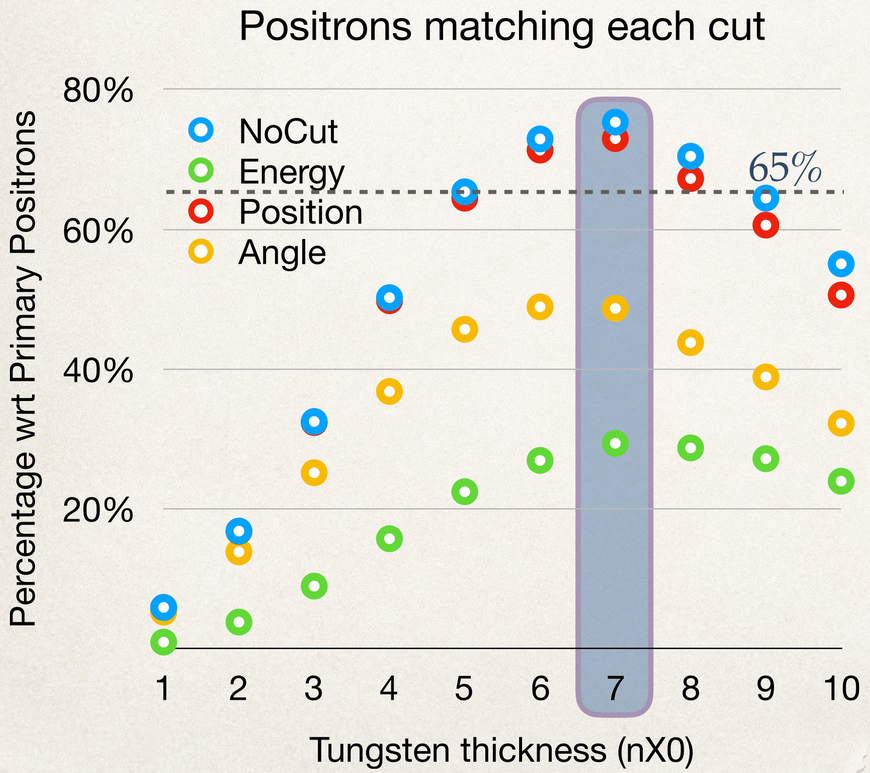
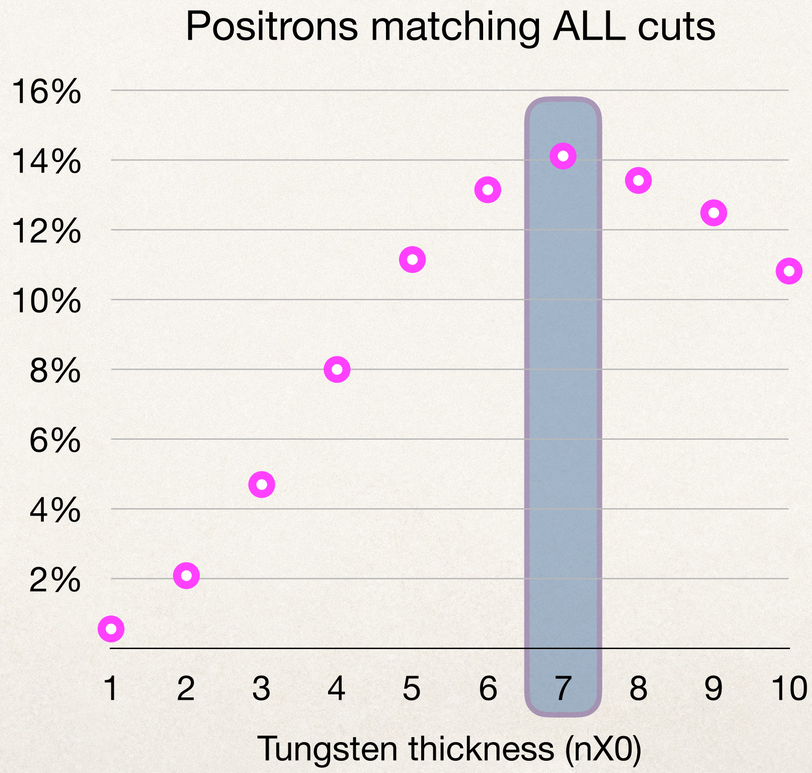
- The **Geant4** simulation was performed variating the Tungsten thickness from *1* to *10* X_0
- For each configuration the **fraction of positrons matching** each **requirement** was evaluated



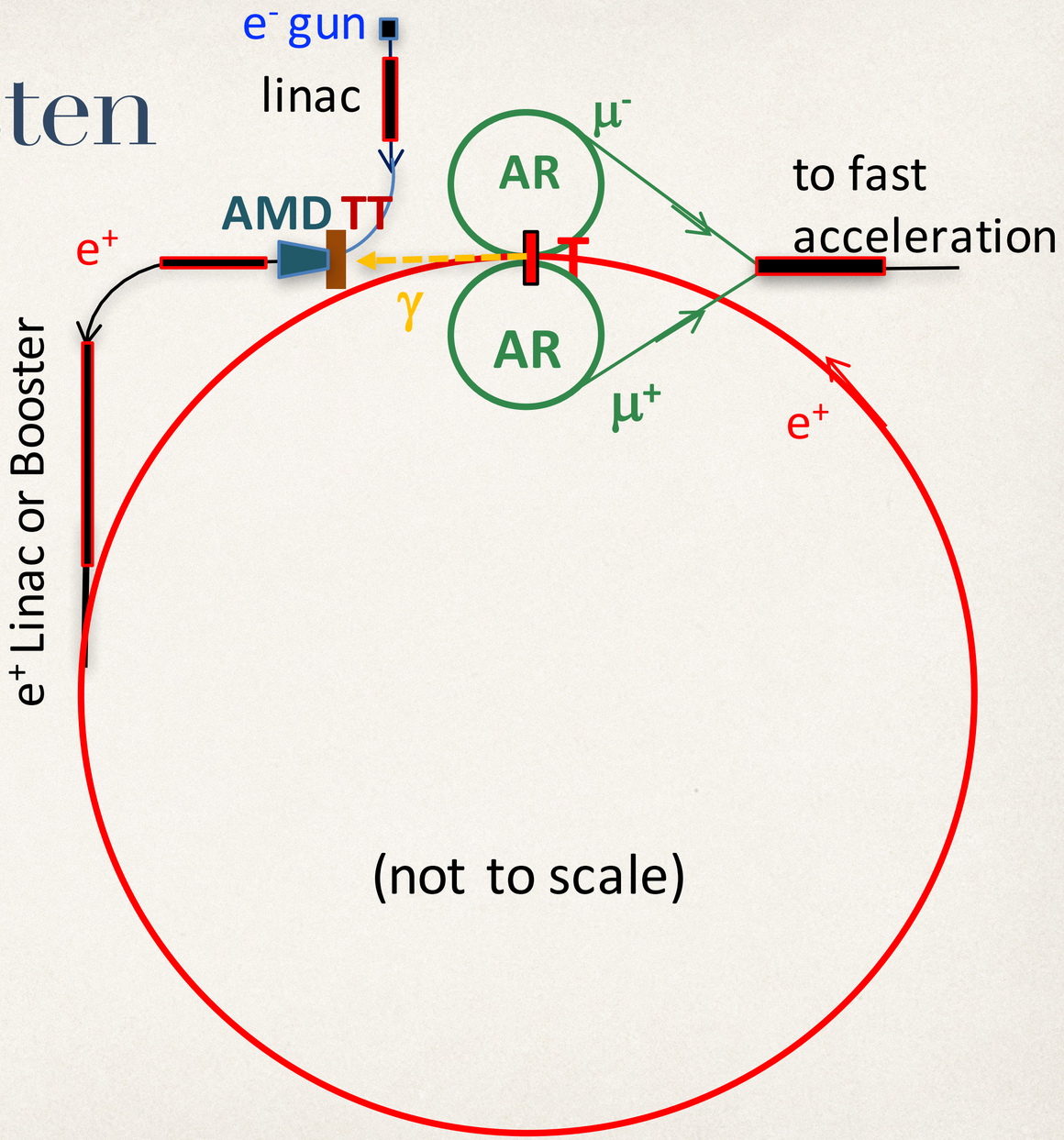


Quality cuts:
- Energy in (5-20) MeV
- Emission pos. <0.5 cm
- Emission angle <0.5 rad

$7X_0$ (2.45cm) of Tungsten seems to **maximize both** the absolute **number** and the **quality** of produced positrons

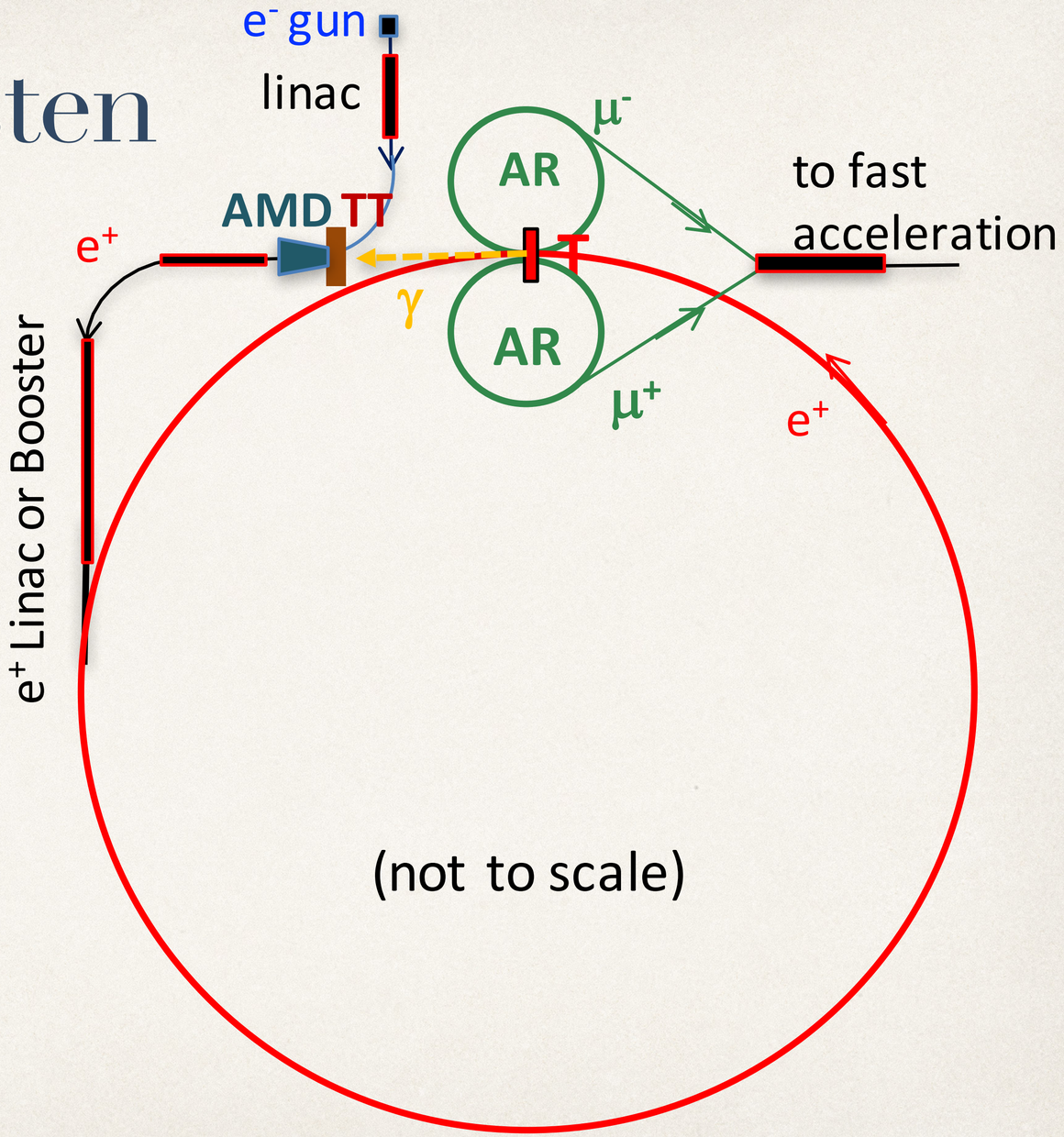
Power Load on Tungsten

Power load on the Tungsten



Power load on the Tungsten

- In order to produce a significant flux of muons, the positron beam must have the highest intensity achievable



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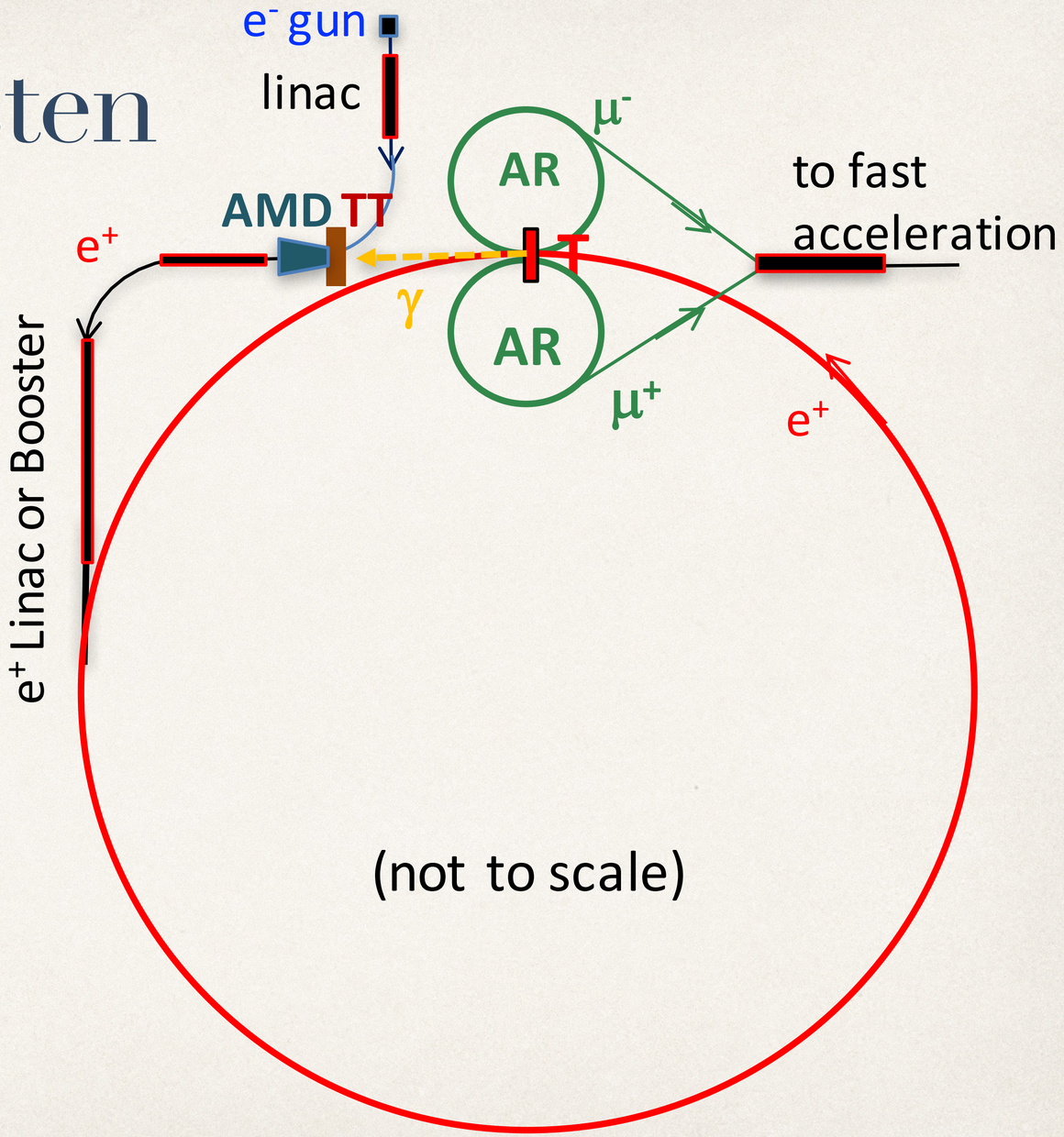

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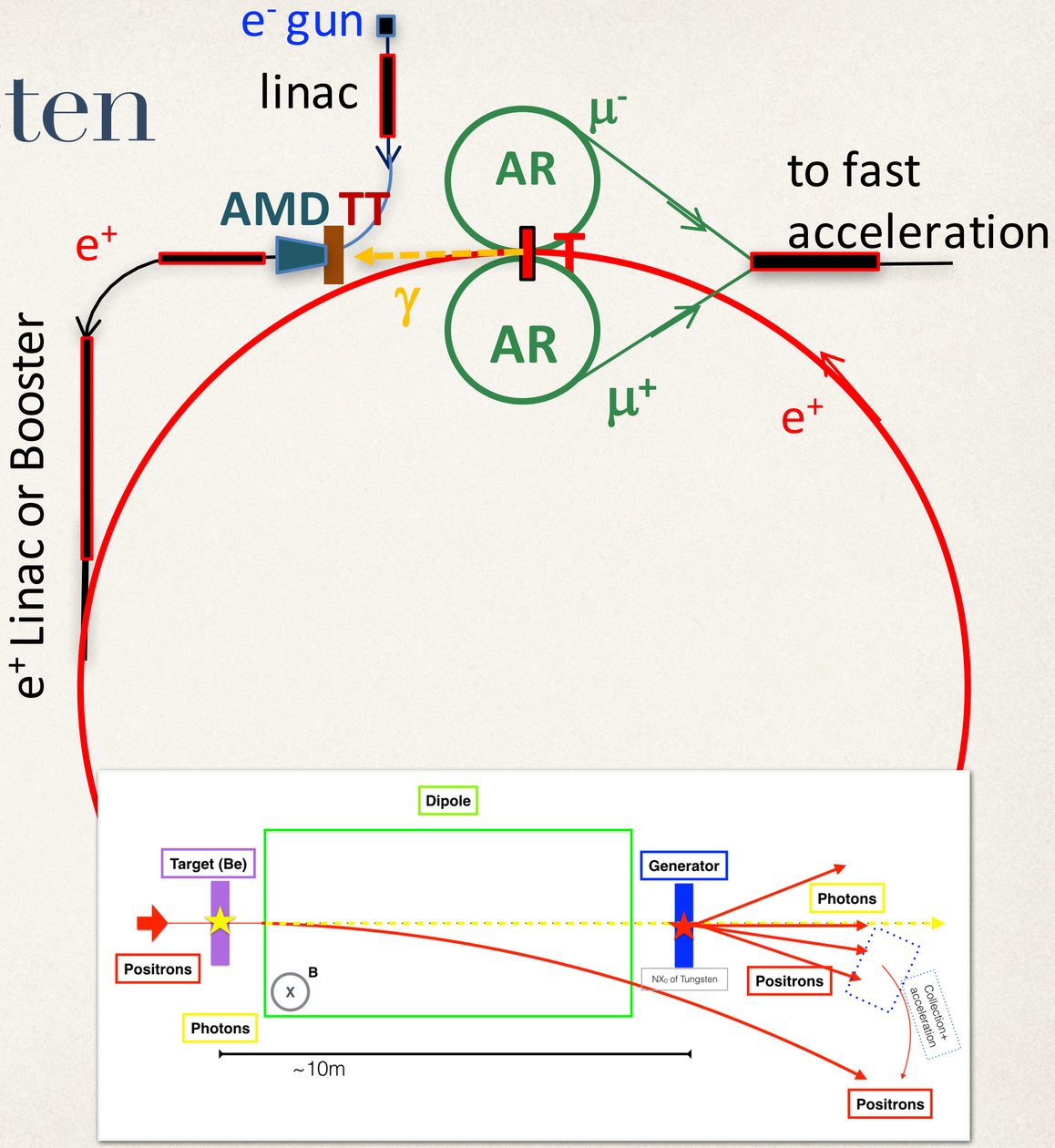

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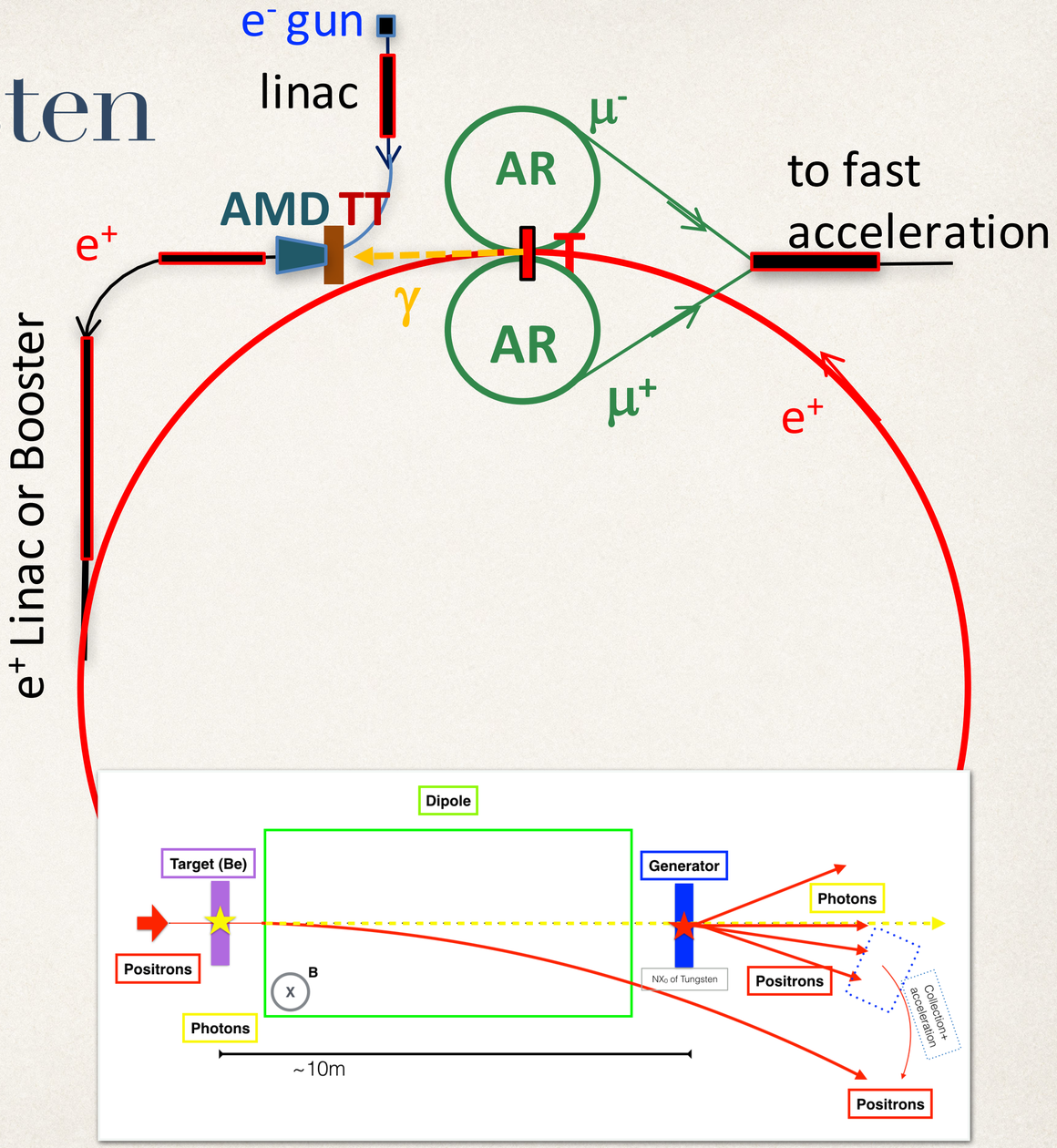
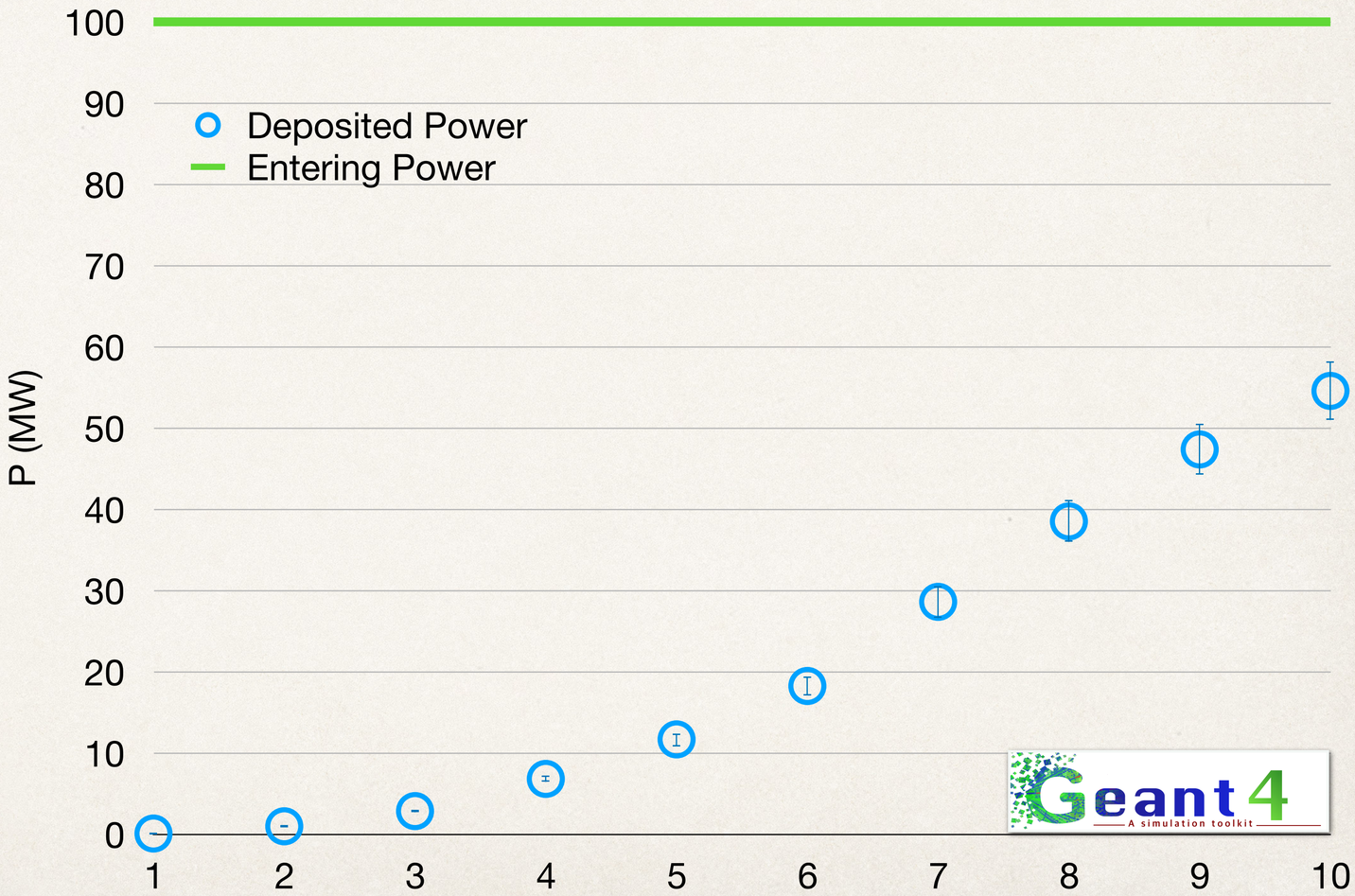
➜ The Power on the Tungsten target deeply depends on its thickness



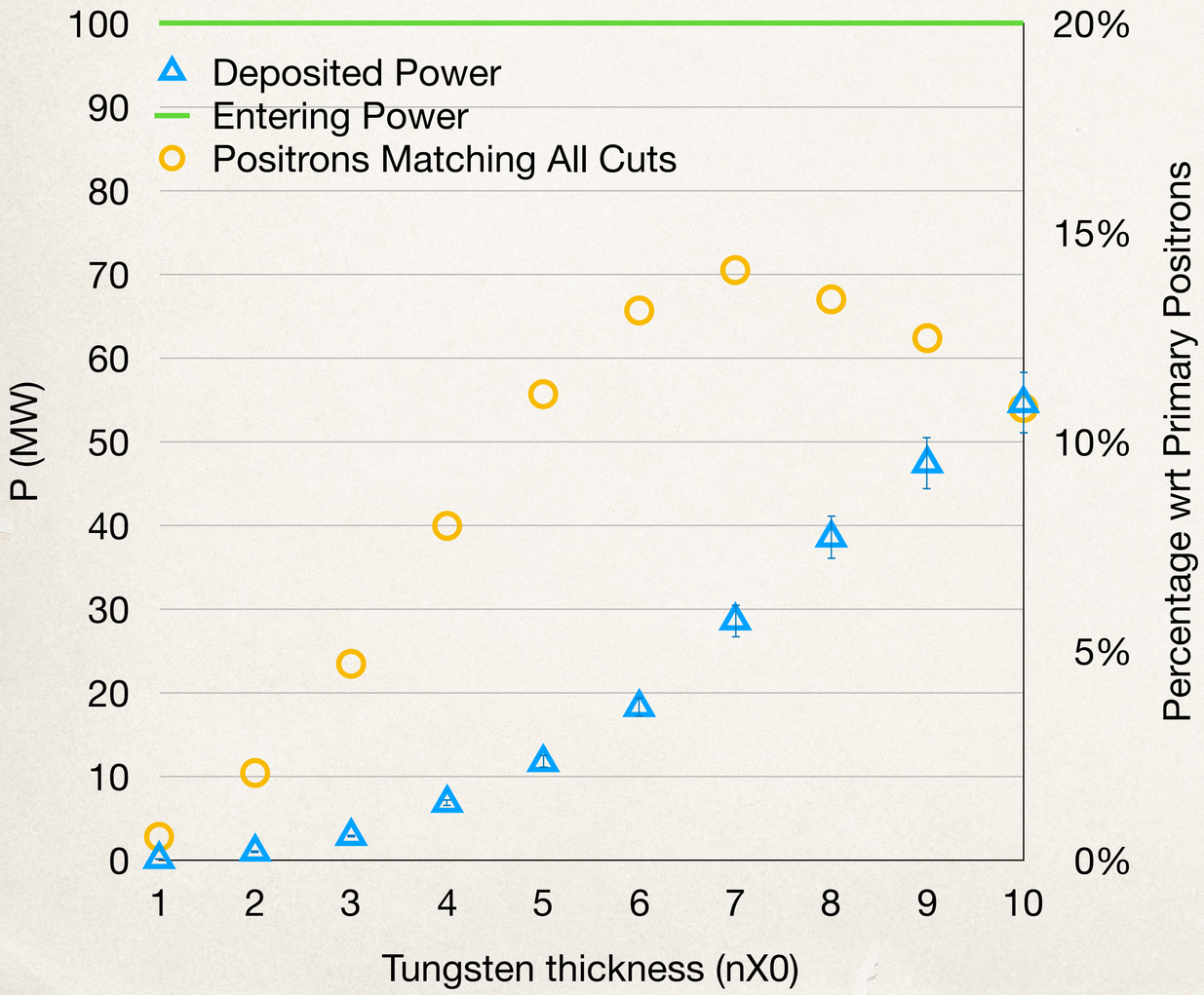
Power load on the Tungsten (II)

W thickn.	E	P
nX_0	J	MW
1	3	0,2
2	21	1,0
3	58	2,9
4	137	6,9
5	235	11,7
6	366	18,3
7	573	28,7
8	771	38,6
9	948	47,4
10	1092	54,6
Tungsten Entering P **~100 MW**		
Primary Beam P ~11 GW		



X_0^W=0.3504 cm

Optimal configuration



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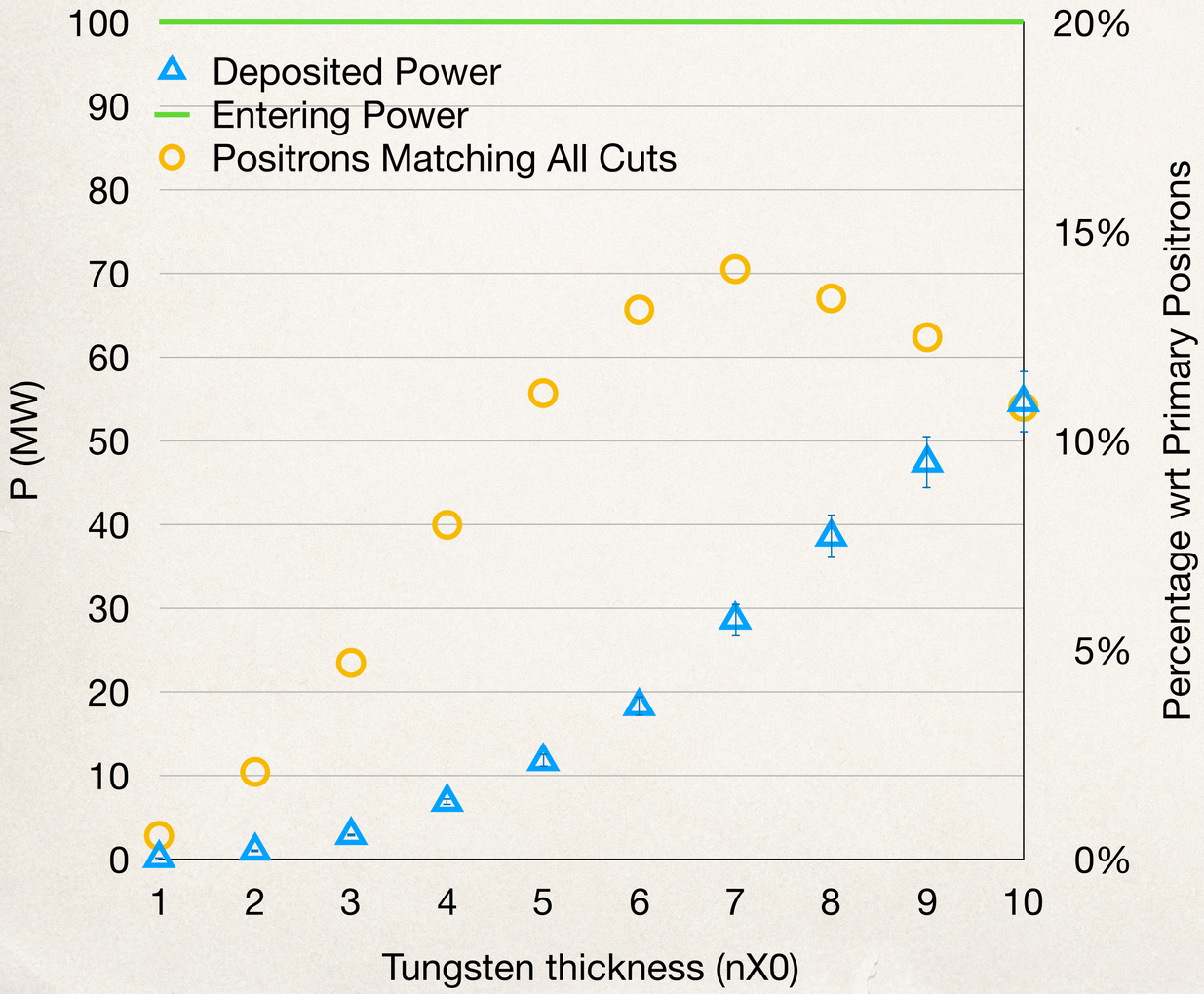

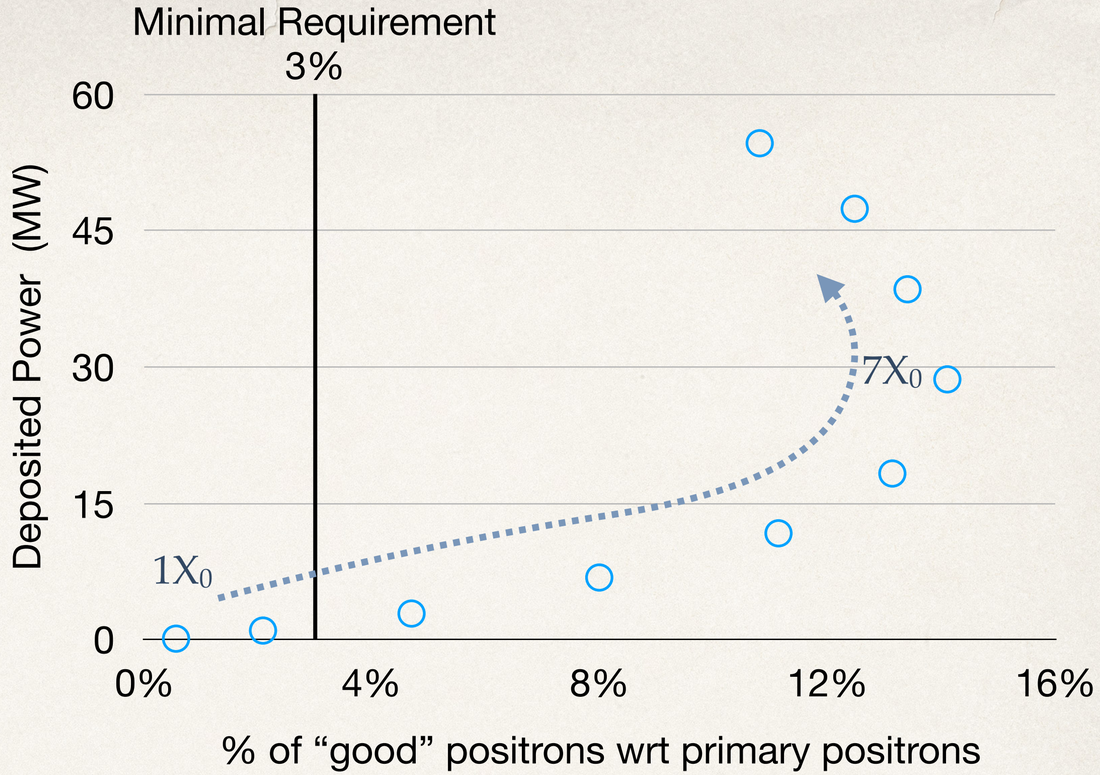

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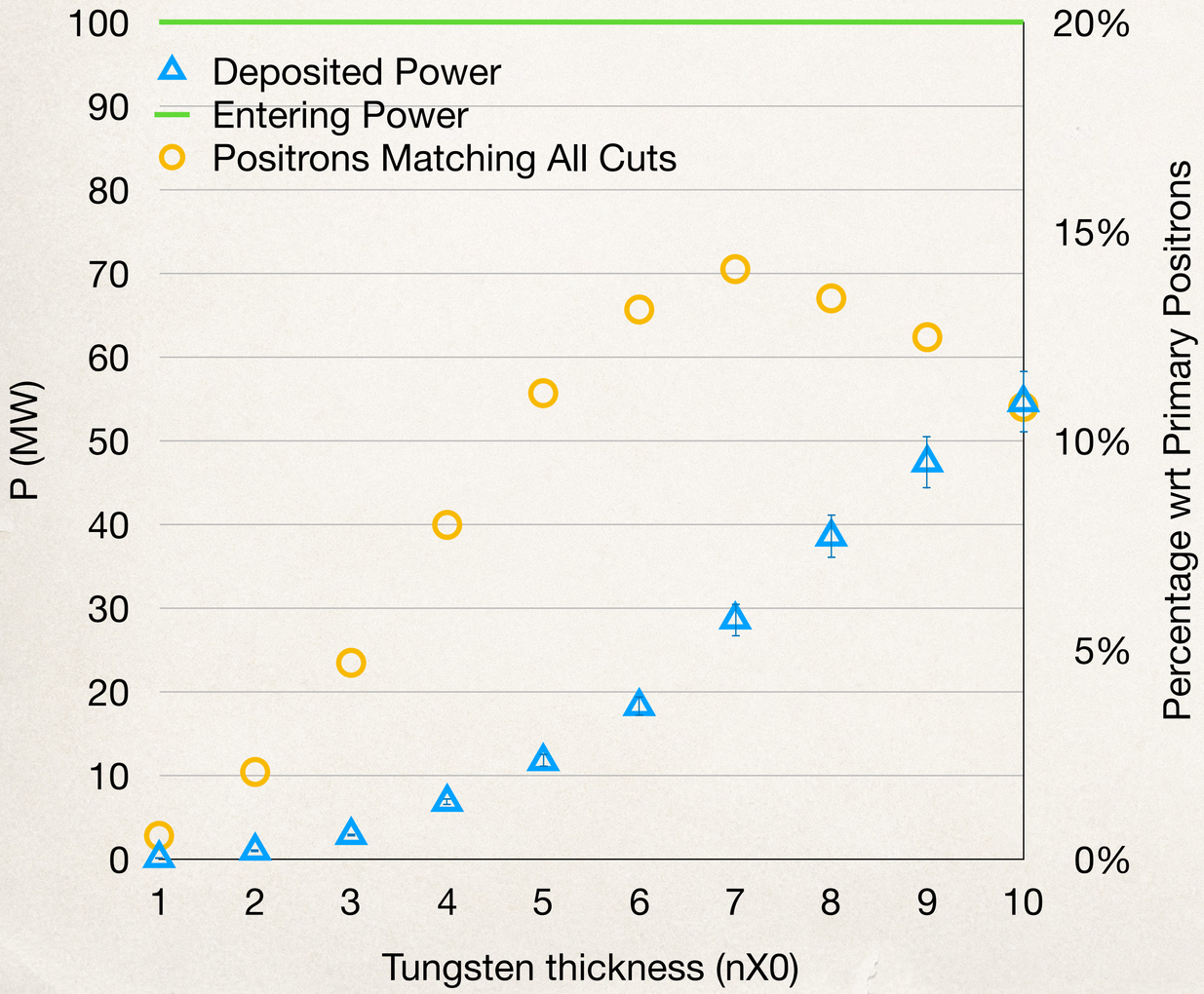

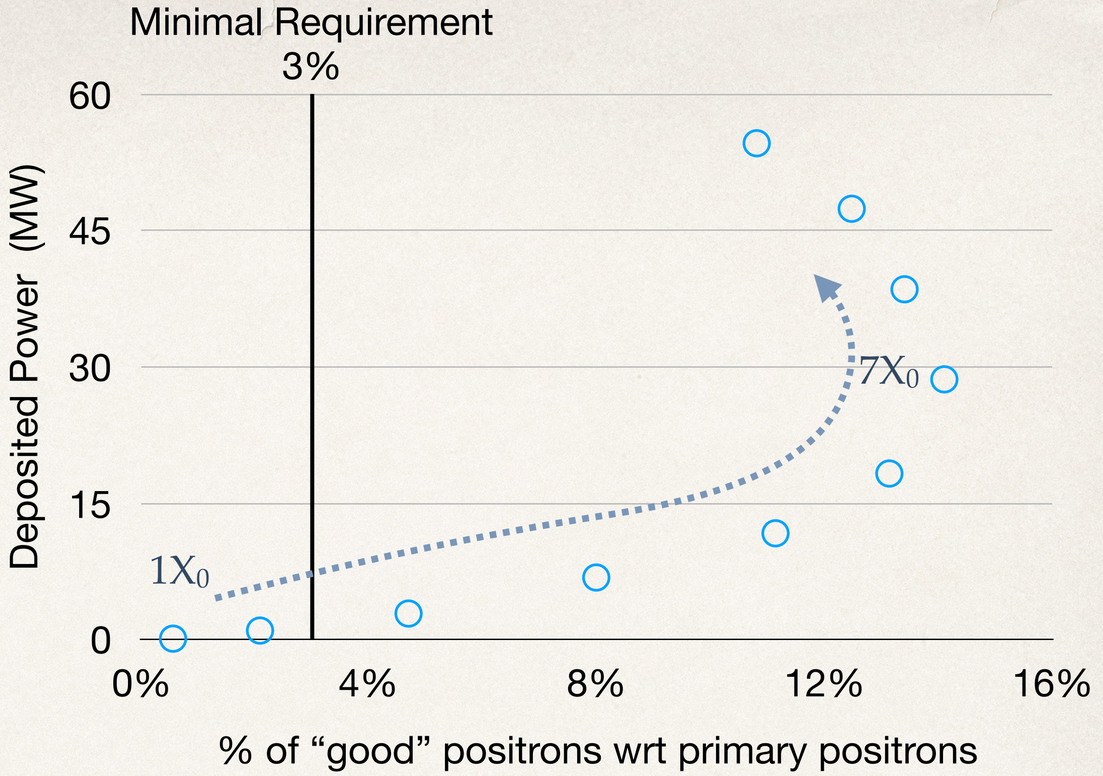

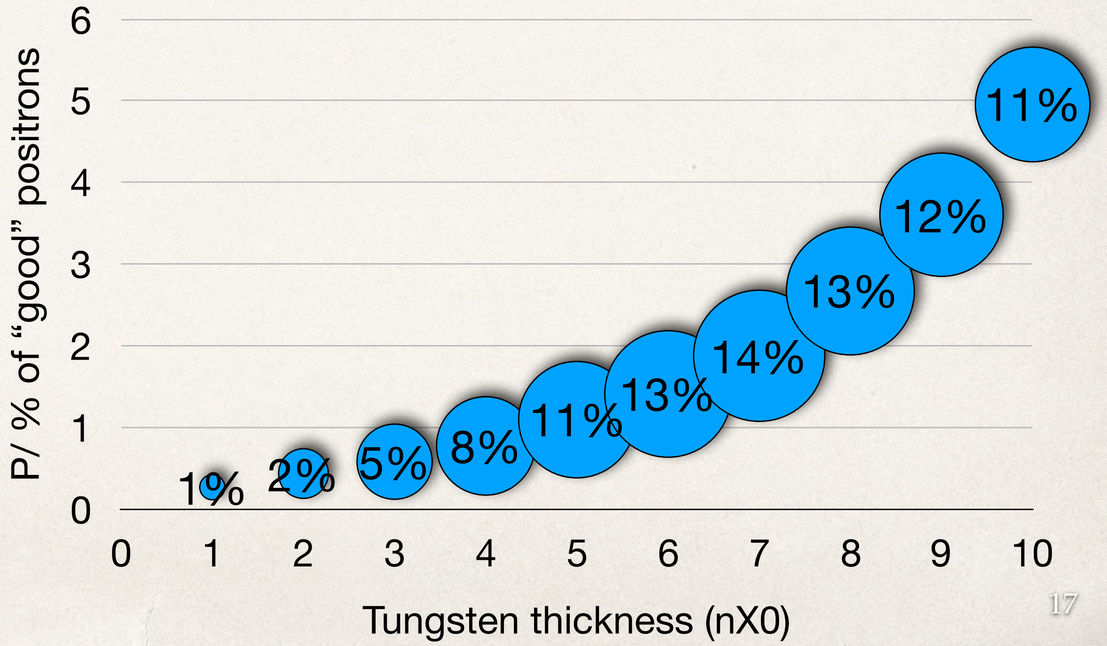

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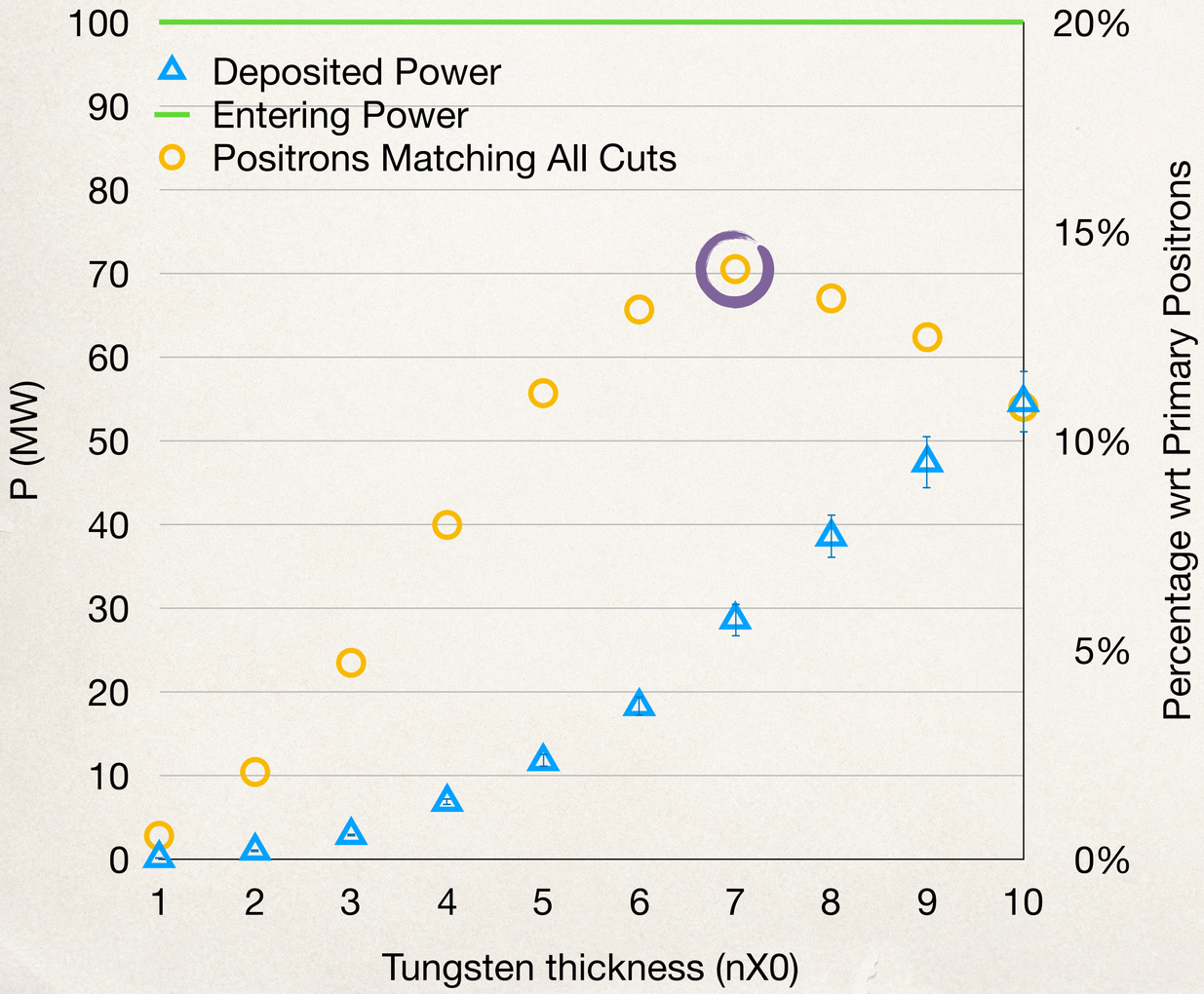

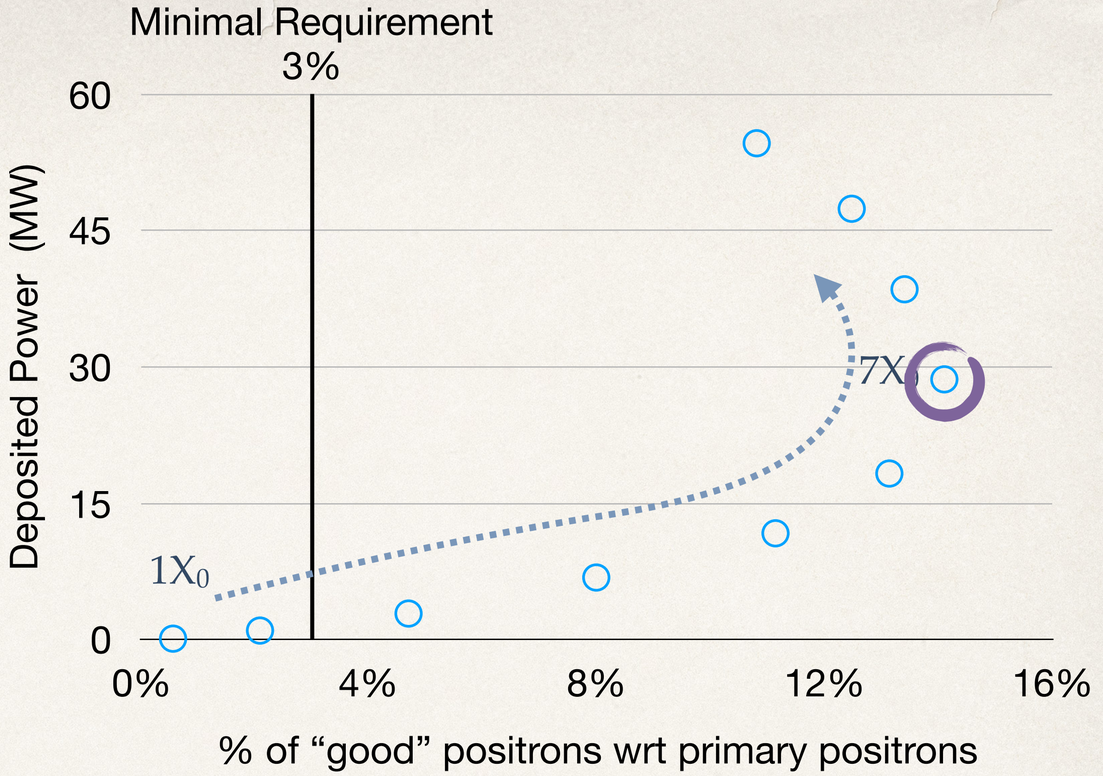

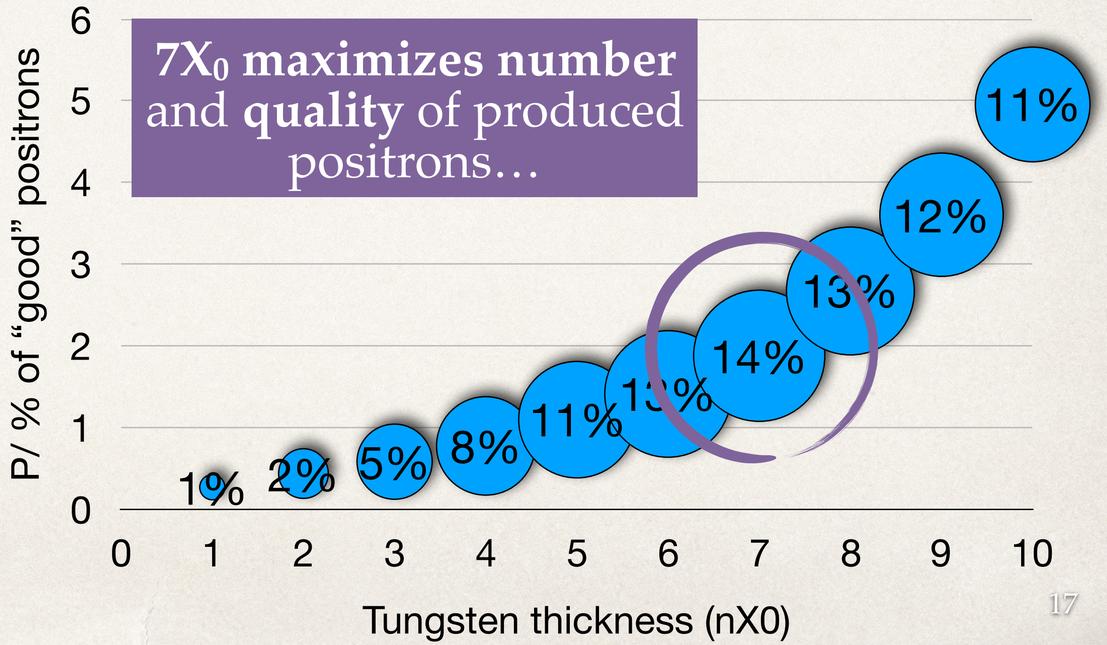

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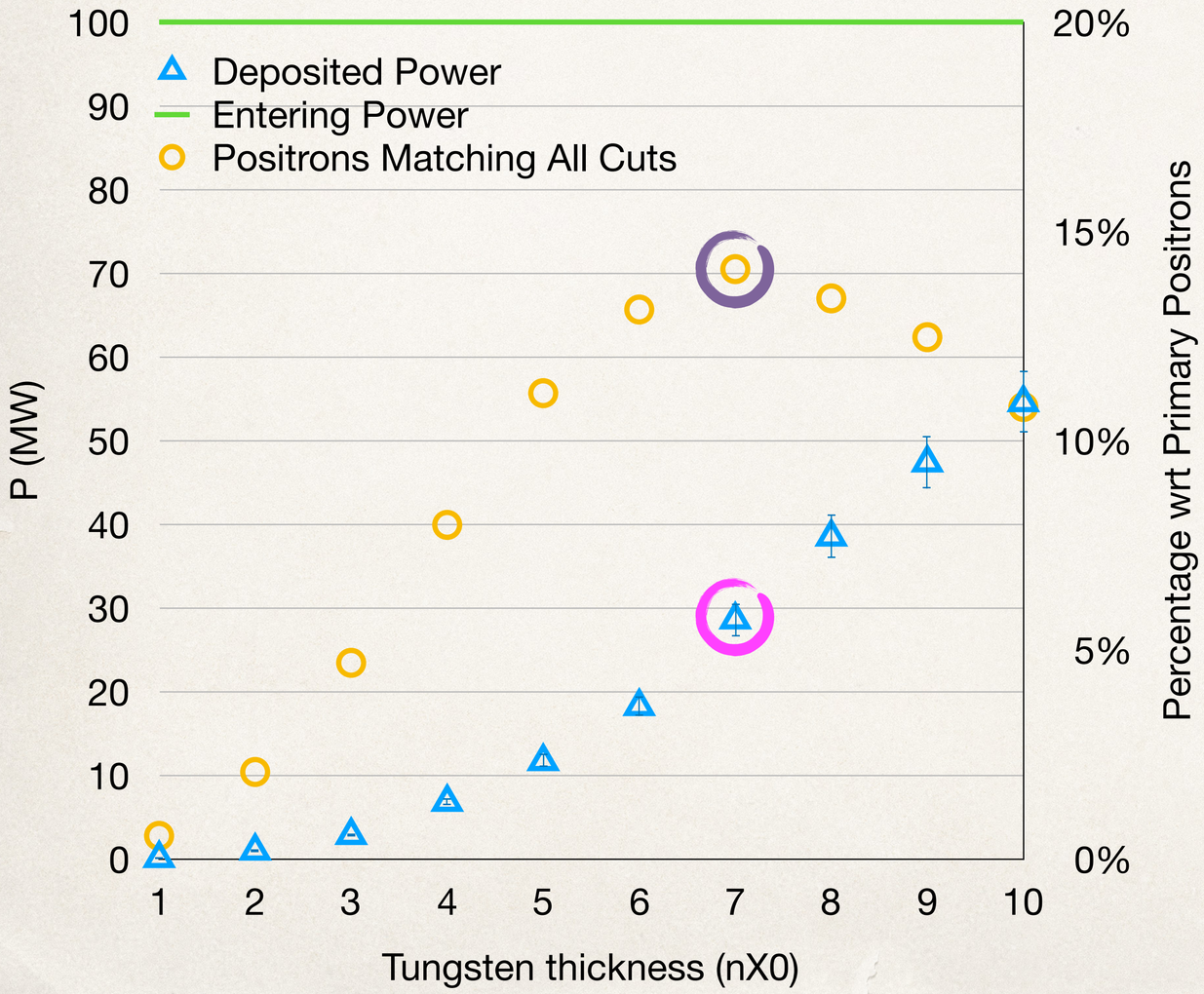

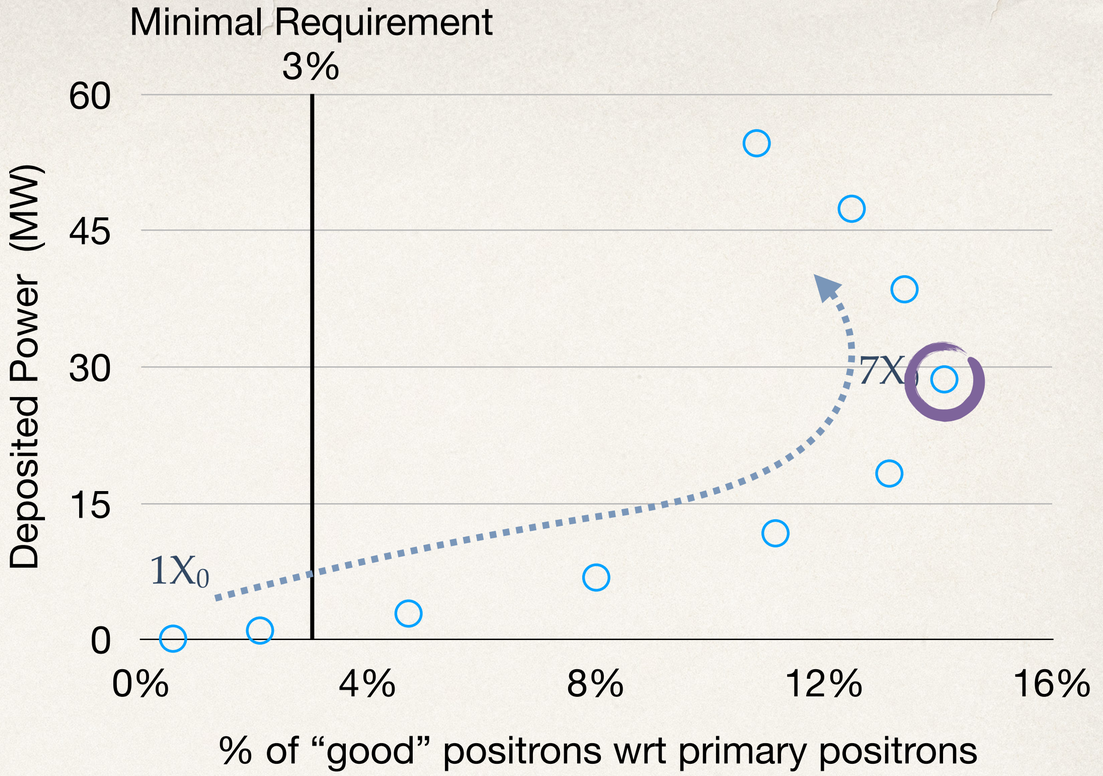

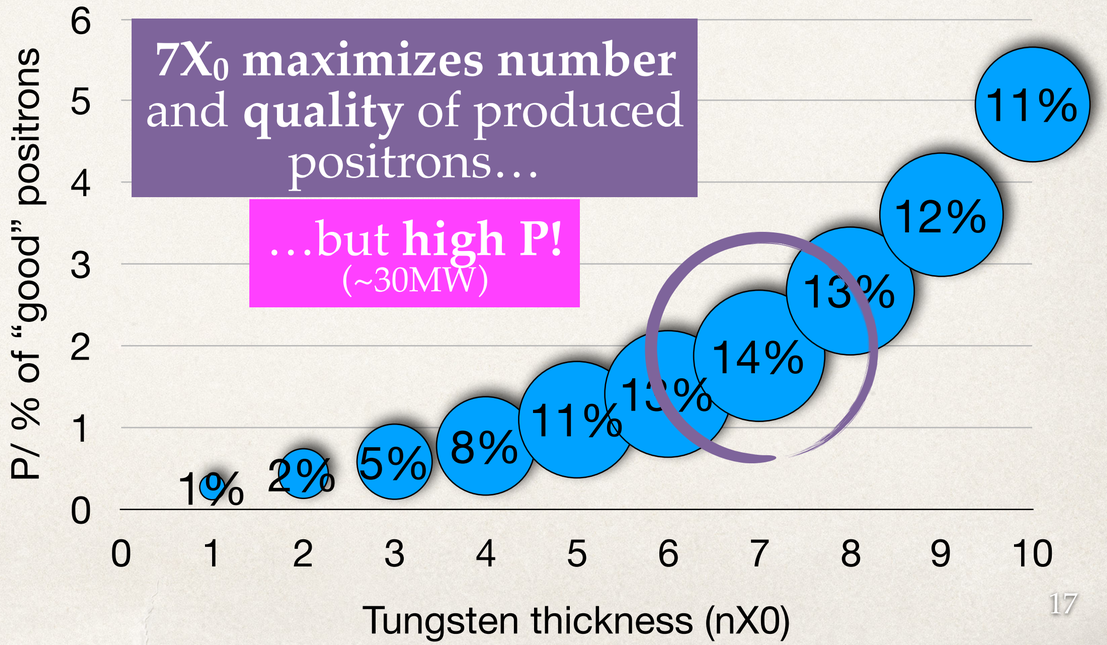

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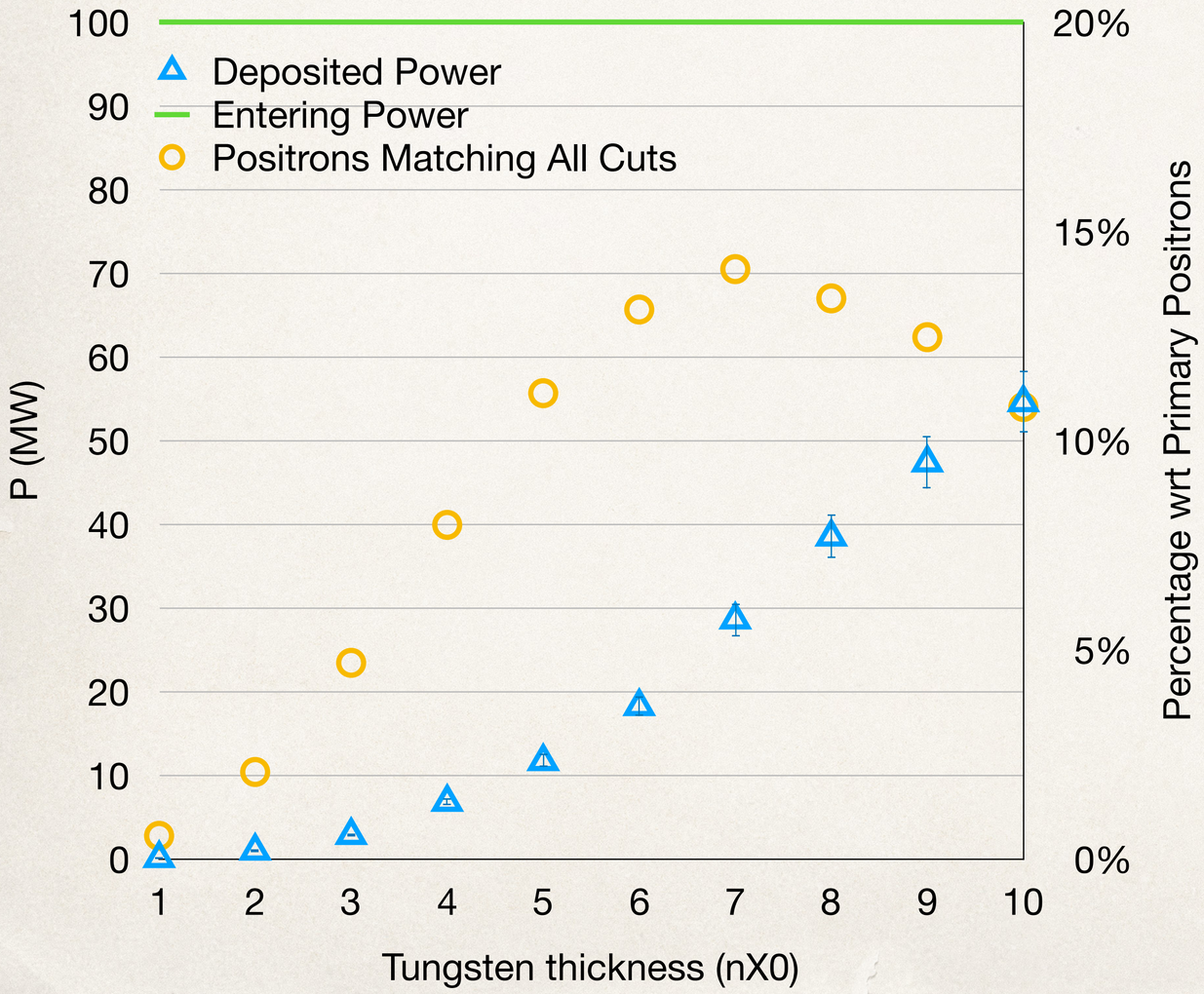

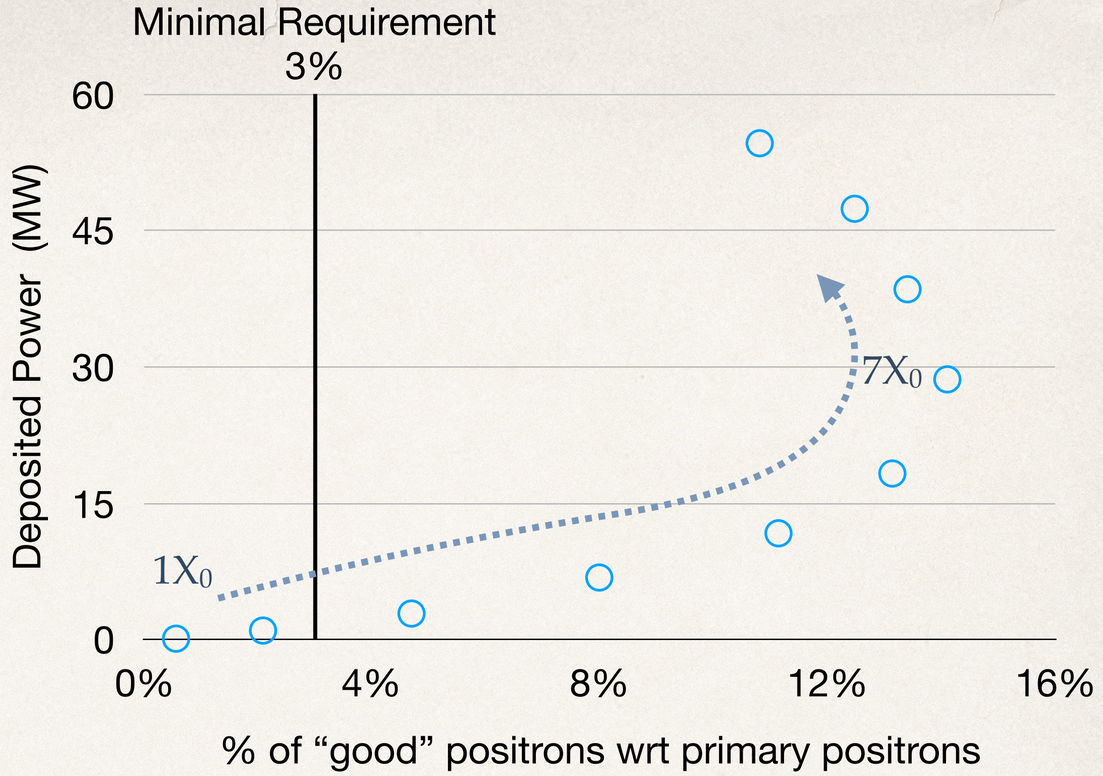

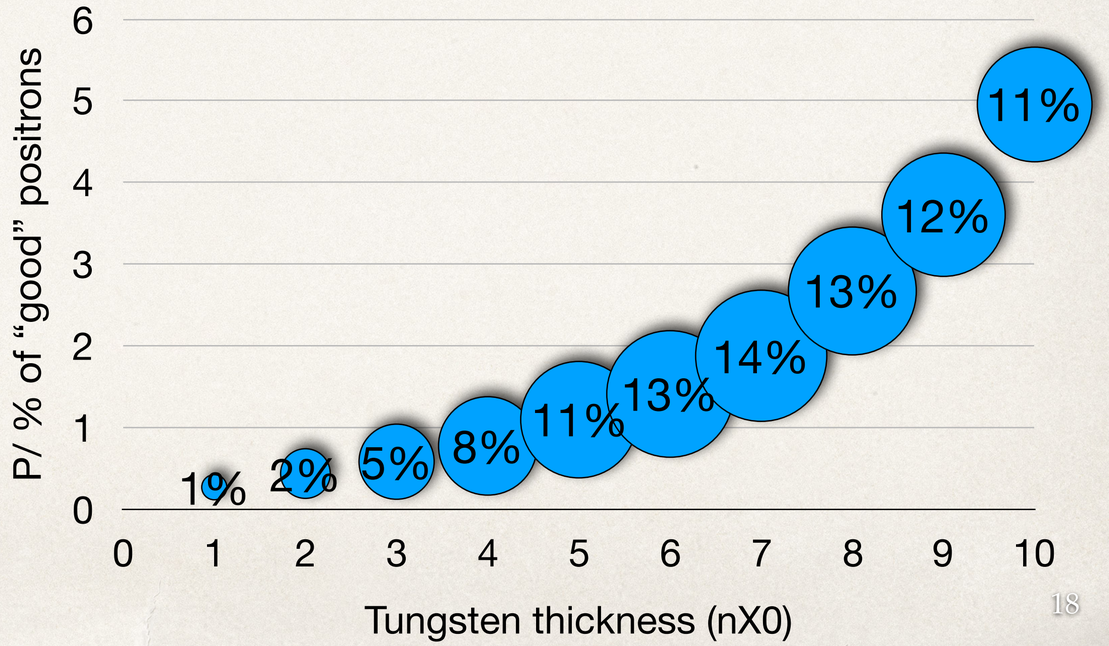

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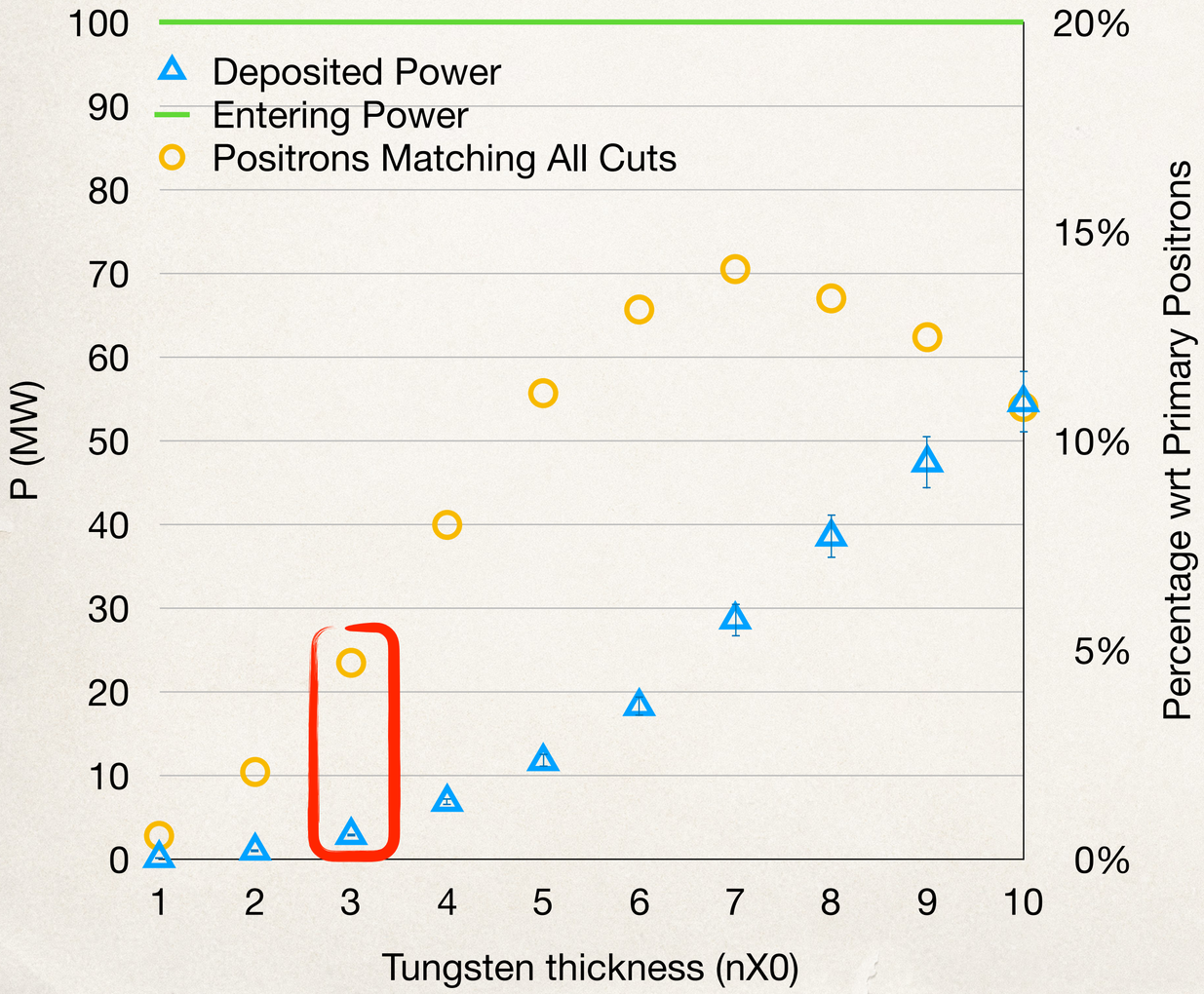
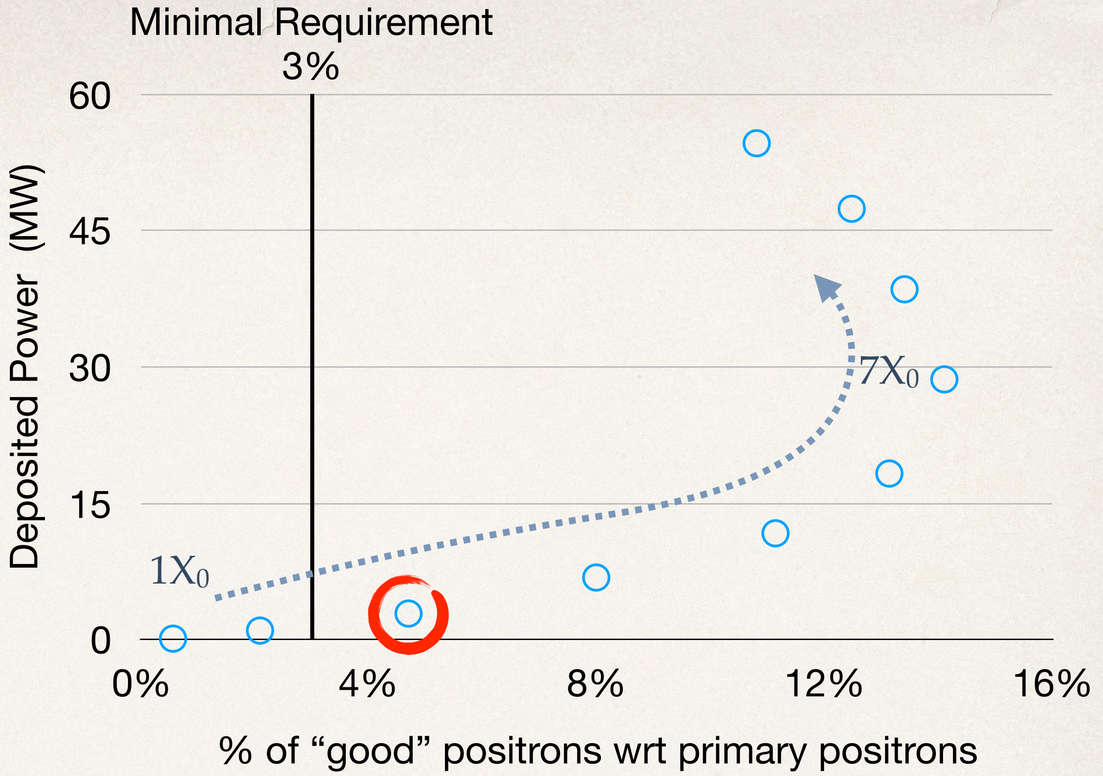
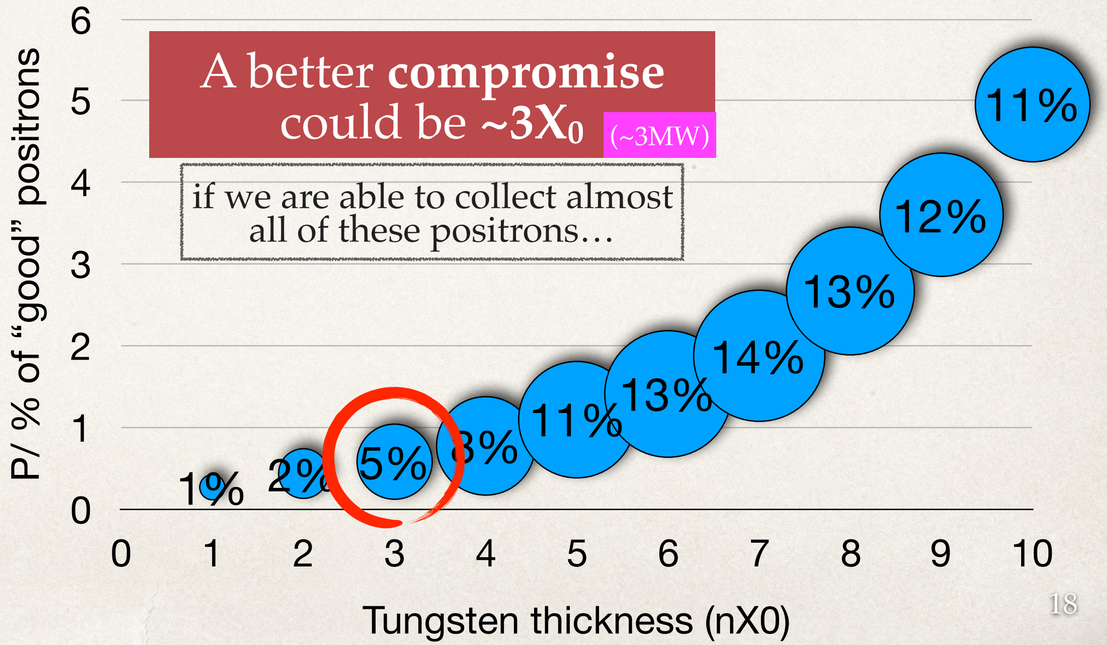
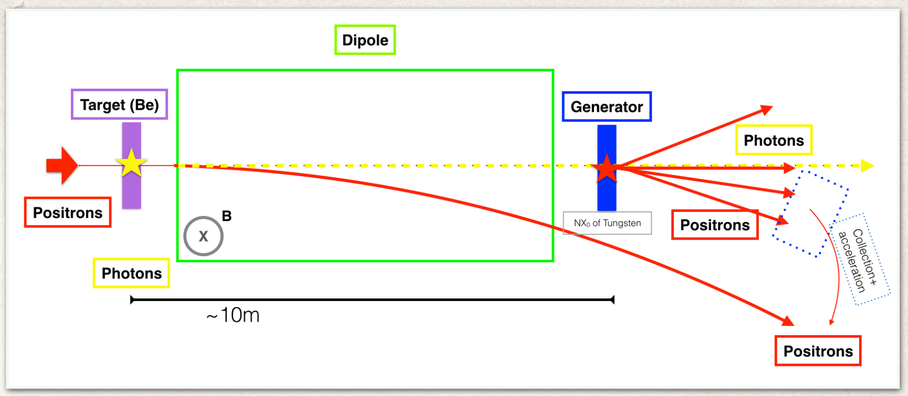


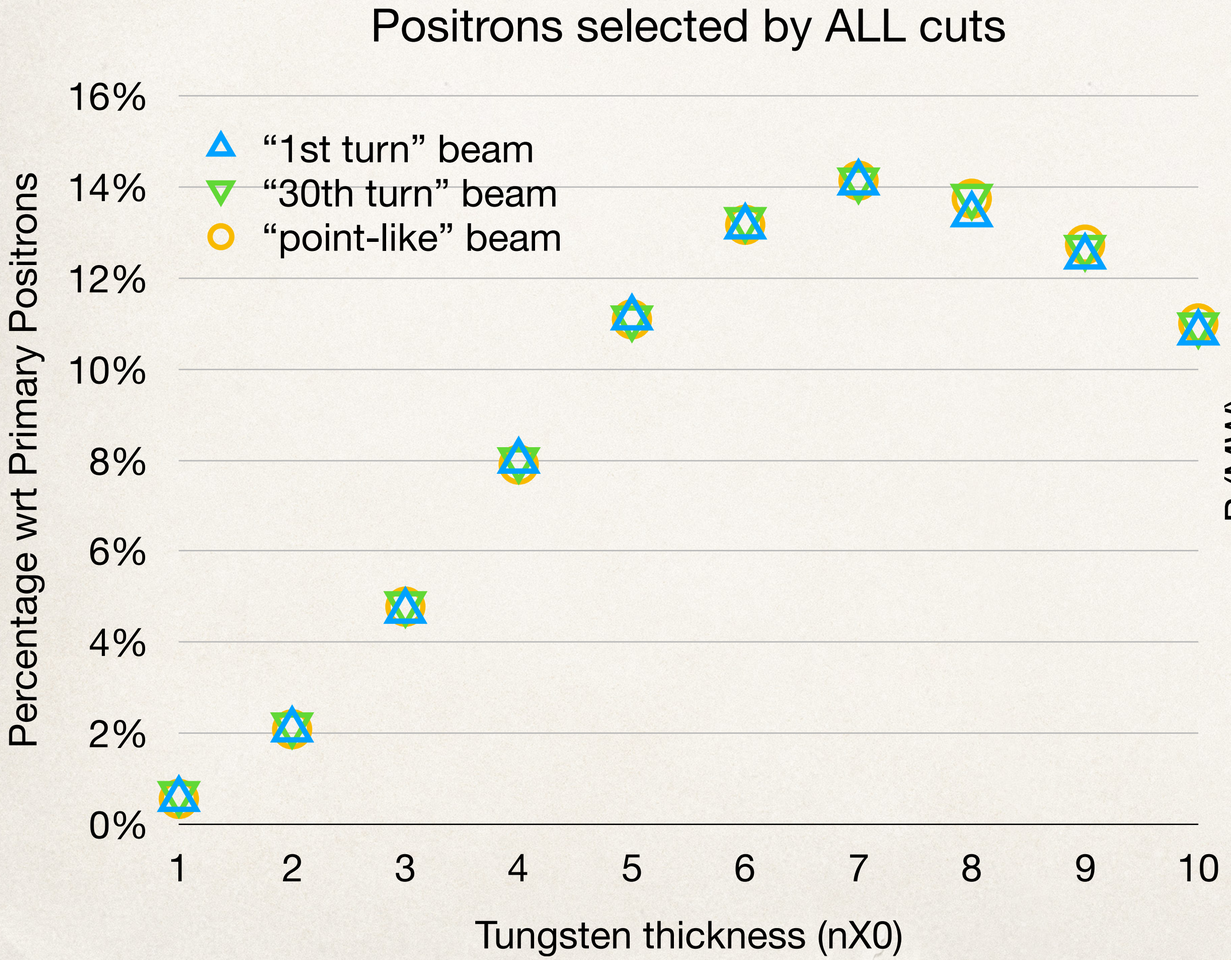


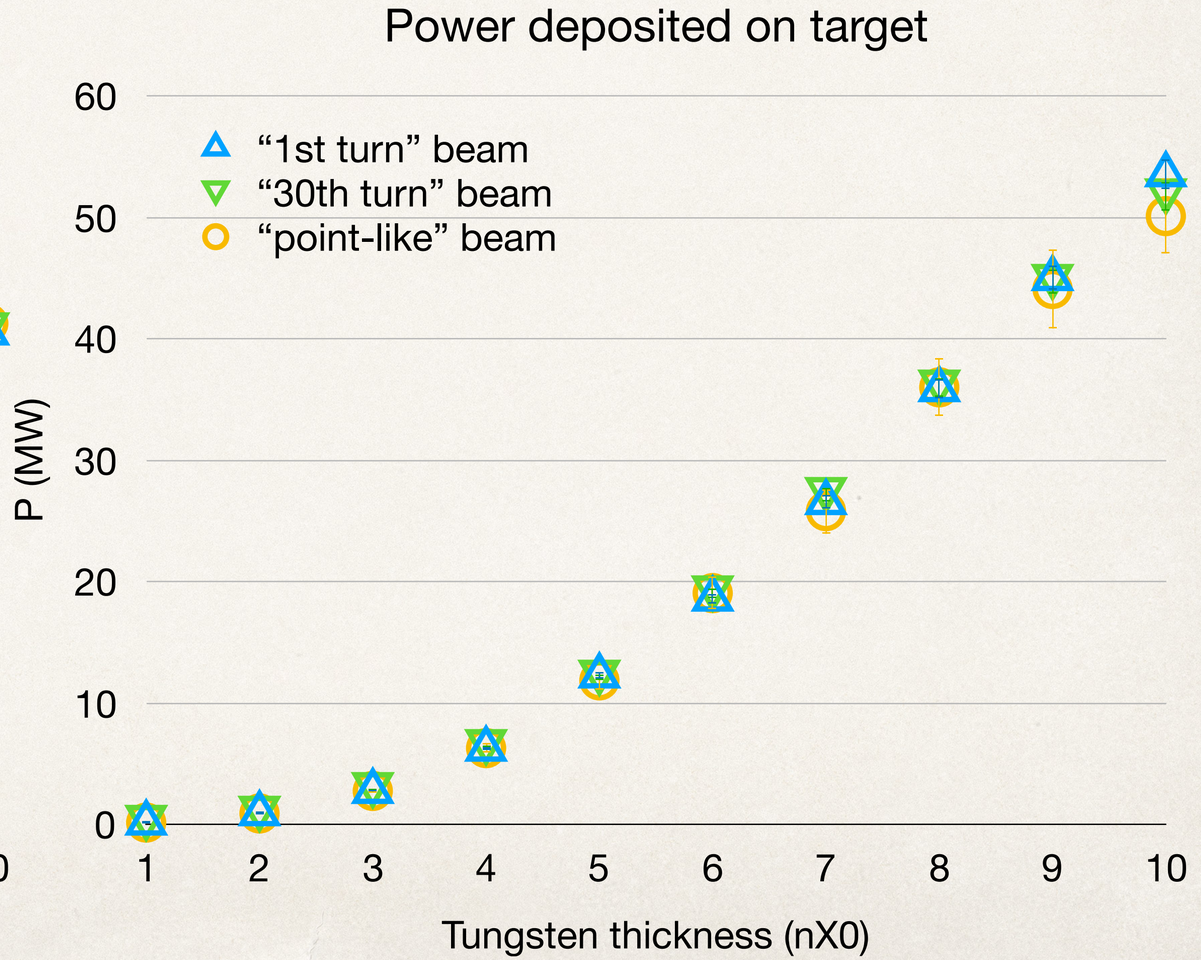


Effect of the size of the original positron beam

As in 1st, 30th turn or "point-like ideal beam"







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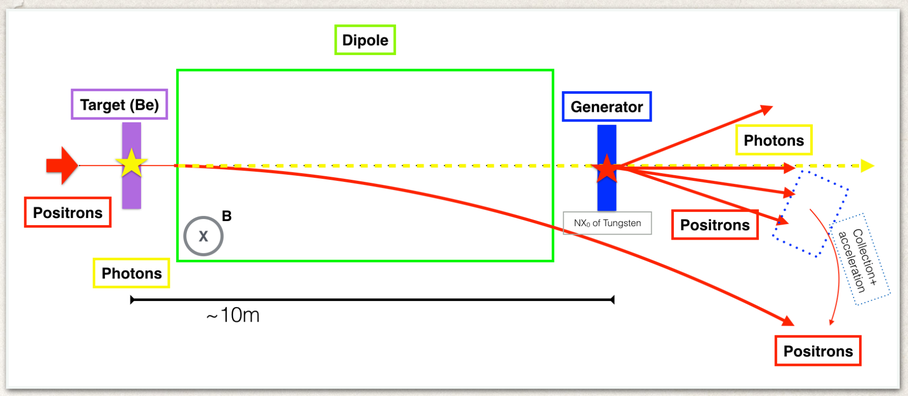

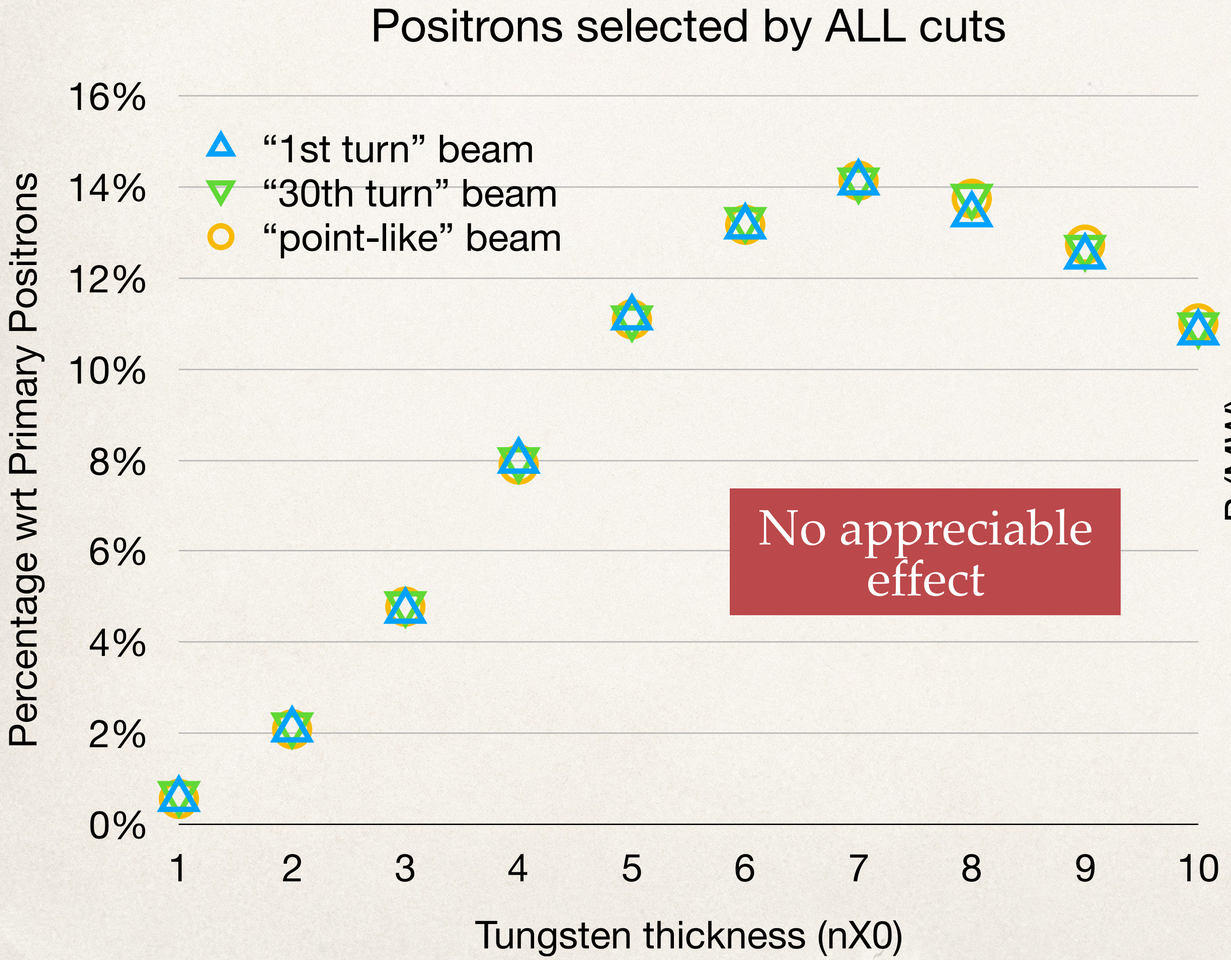

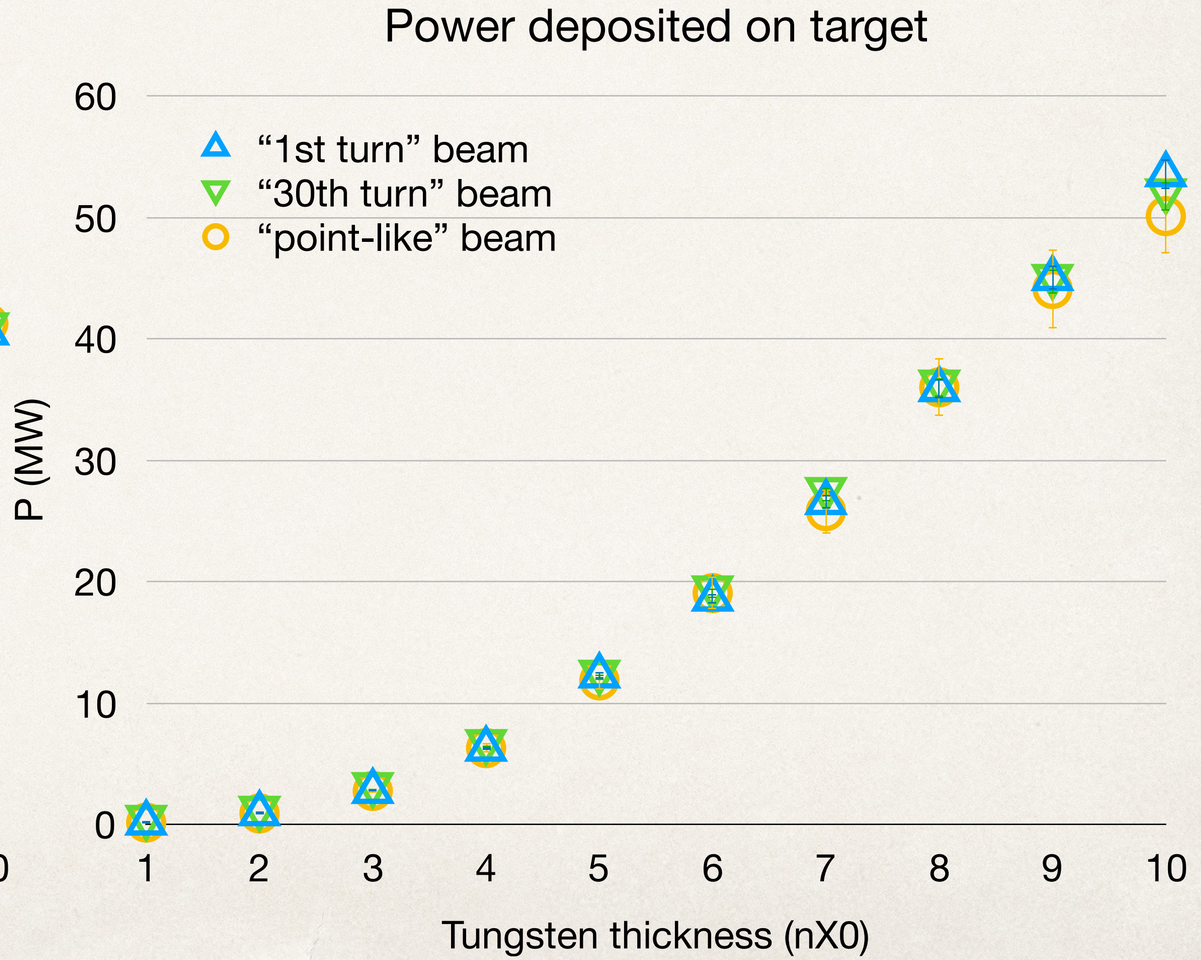

Conclusions and perspectives

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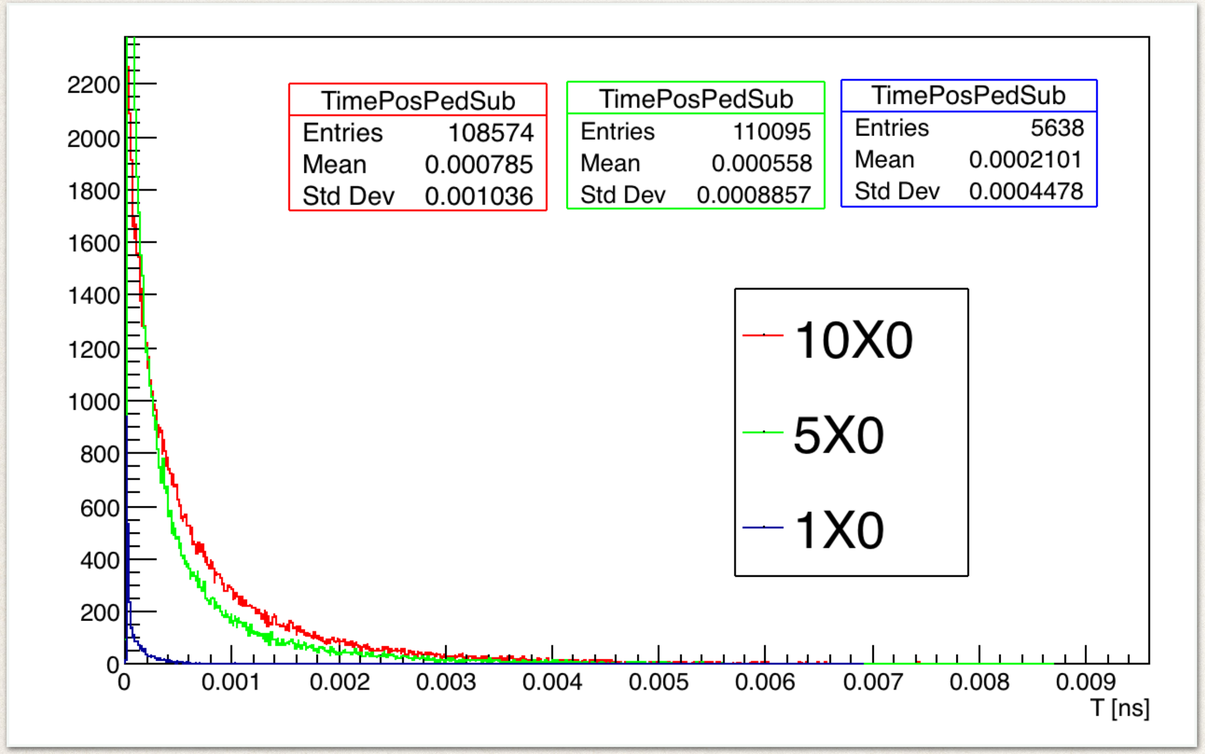
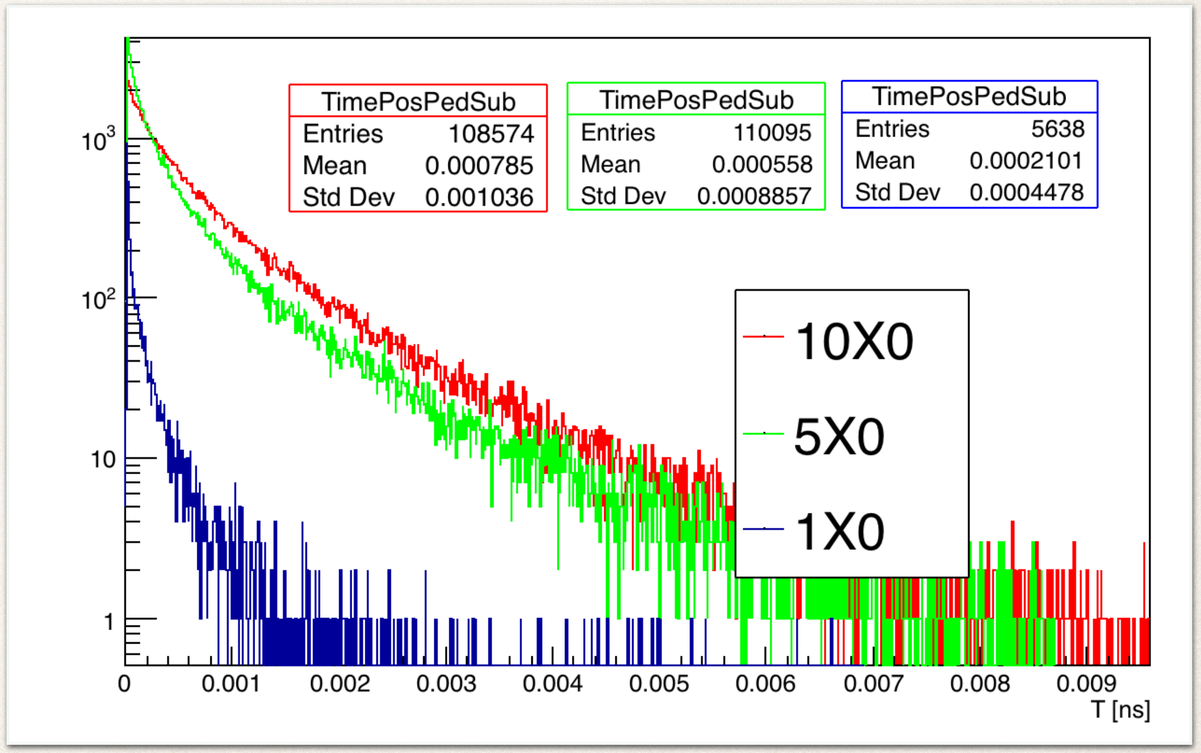
Simulation of the collection + accelerator complex is needed

backup

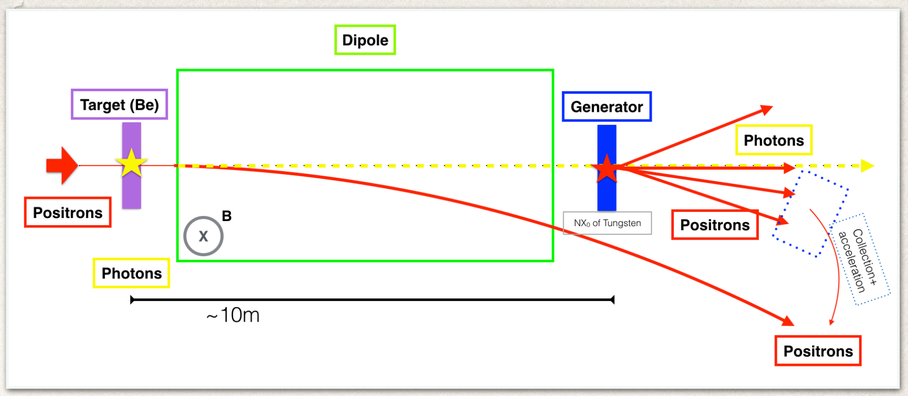
Optimal configuration

Tungsten **exiting time** distribution for produced positrons

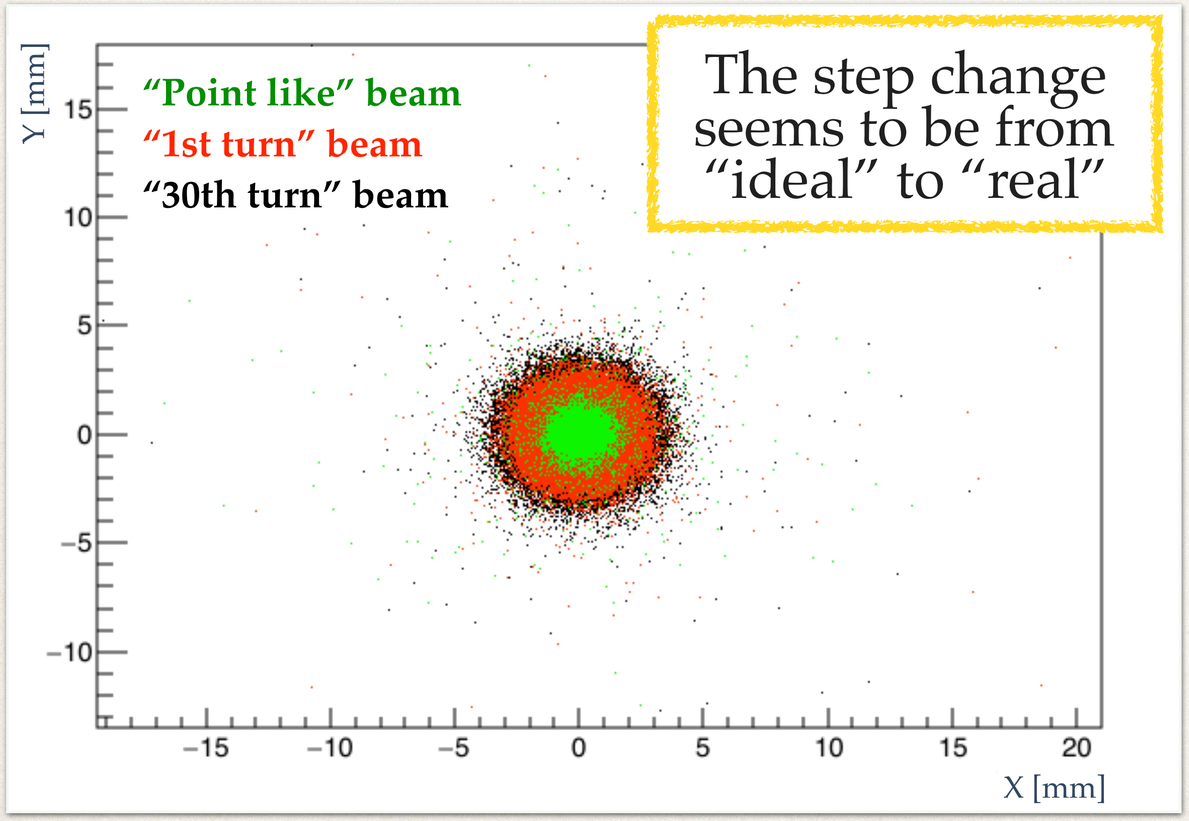


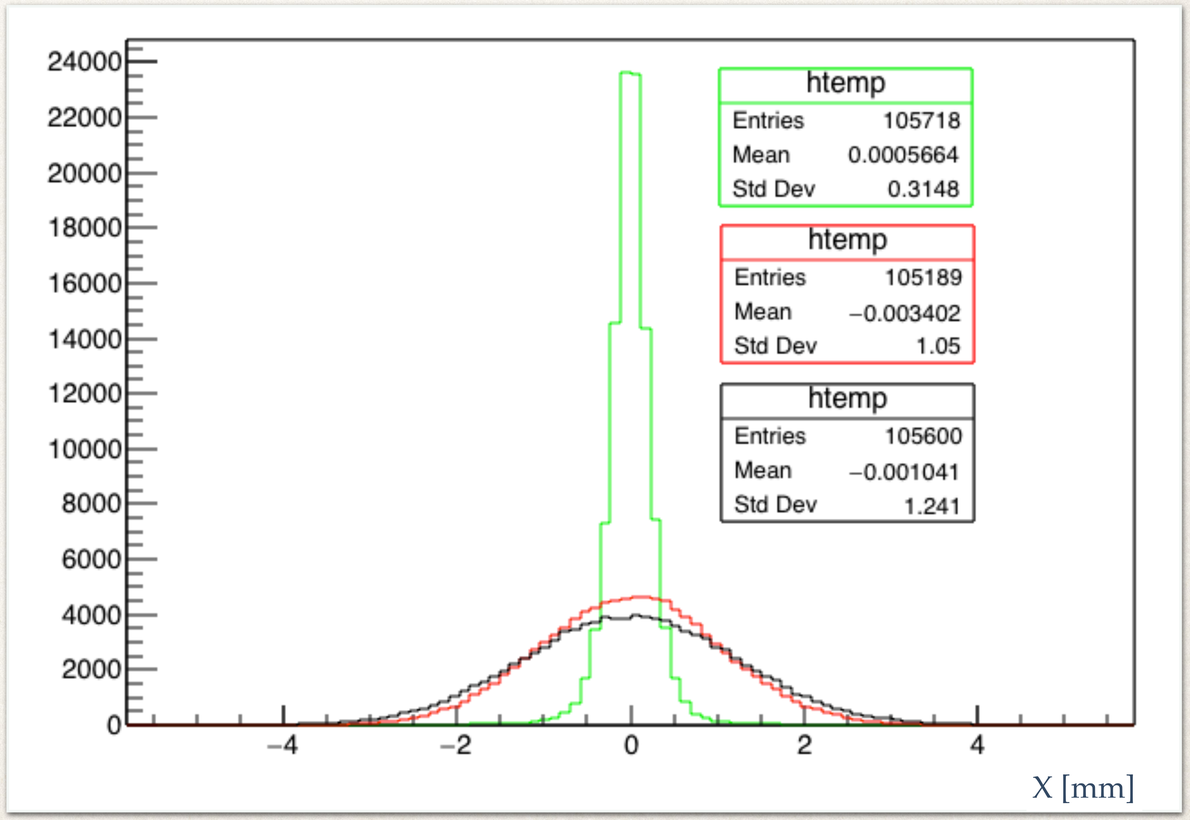


Effect of the size of the original positron beam

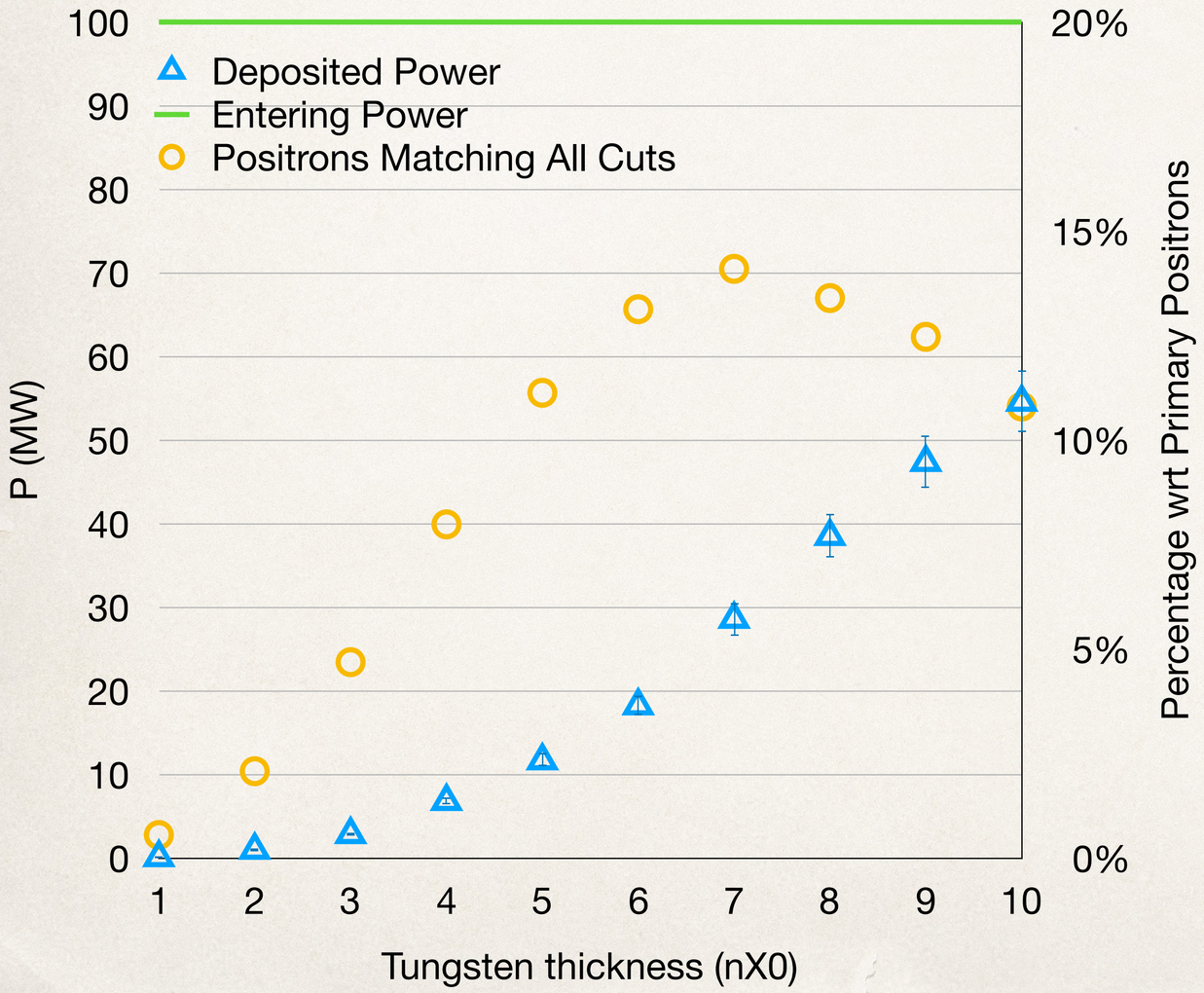


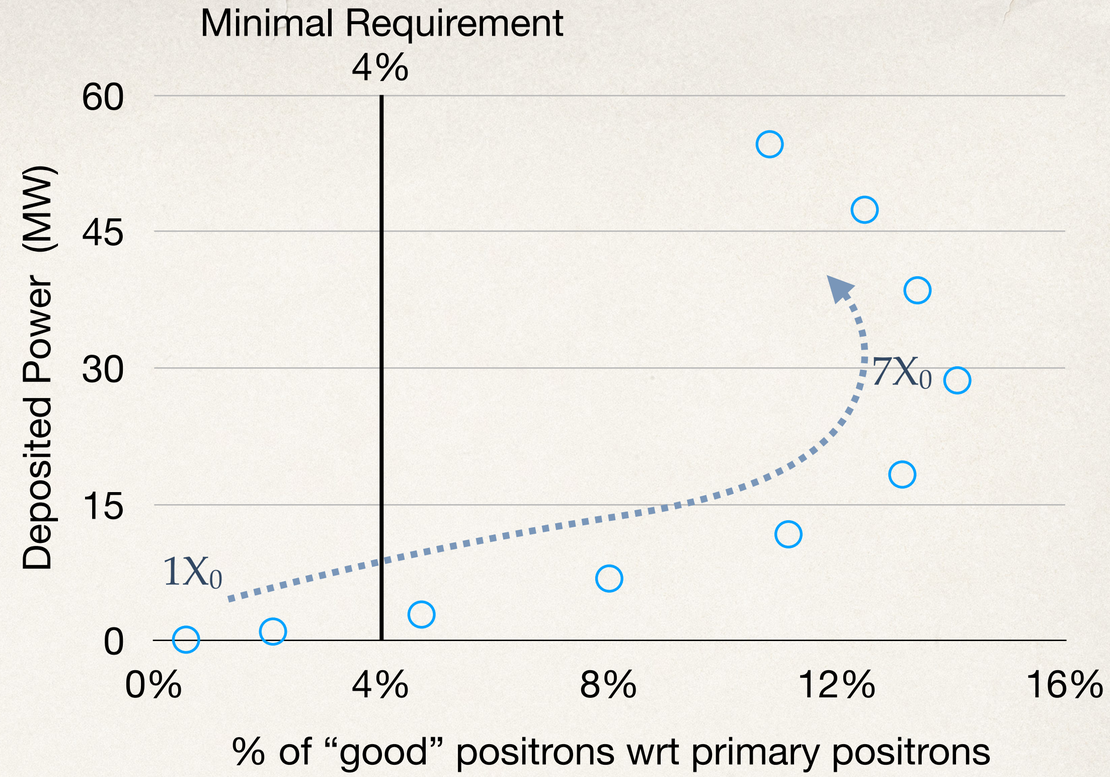
Spatial distribution of photons hitting the tungsten

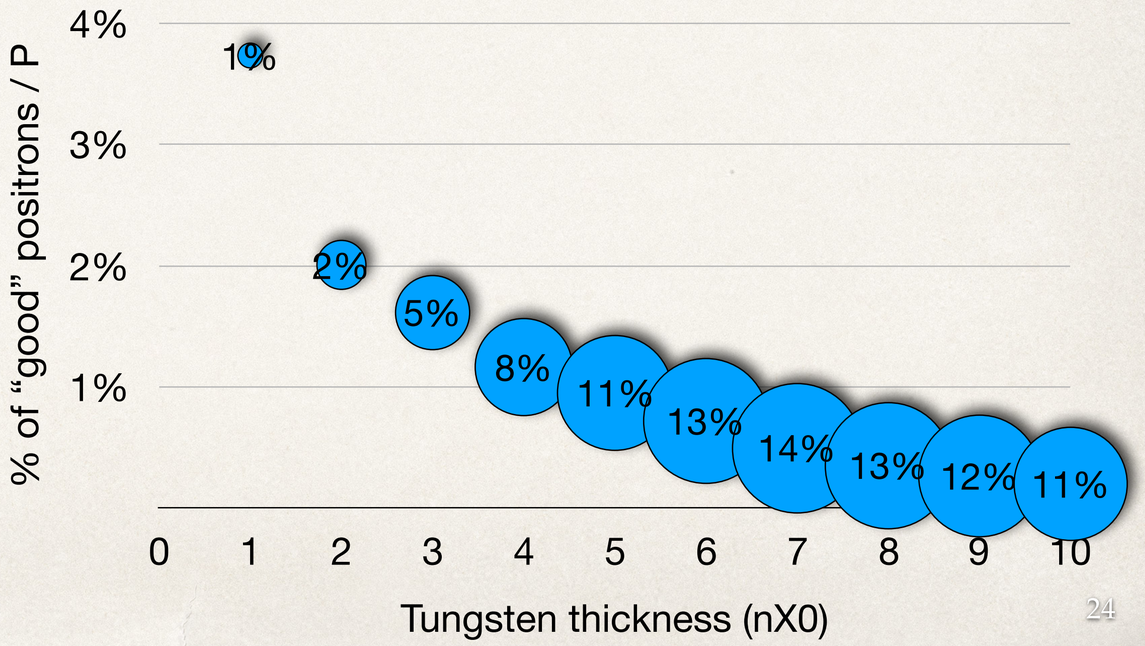




Optimal configuration







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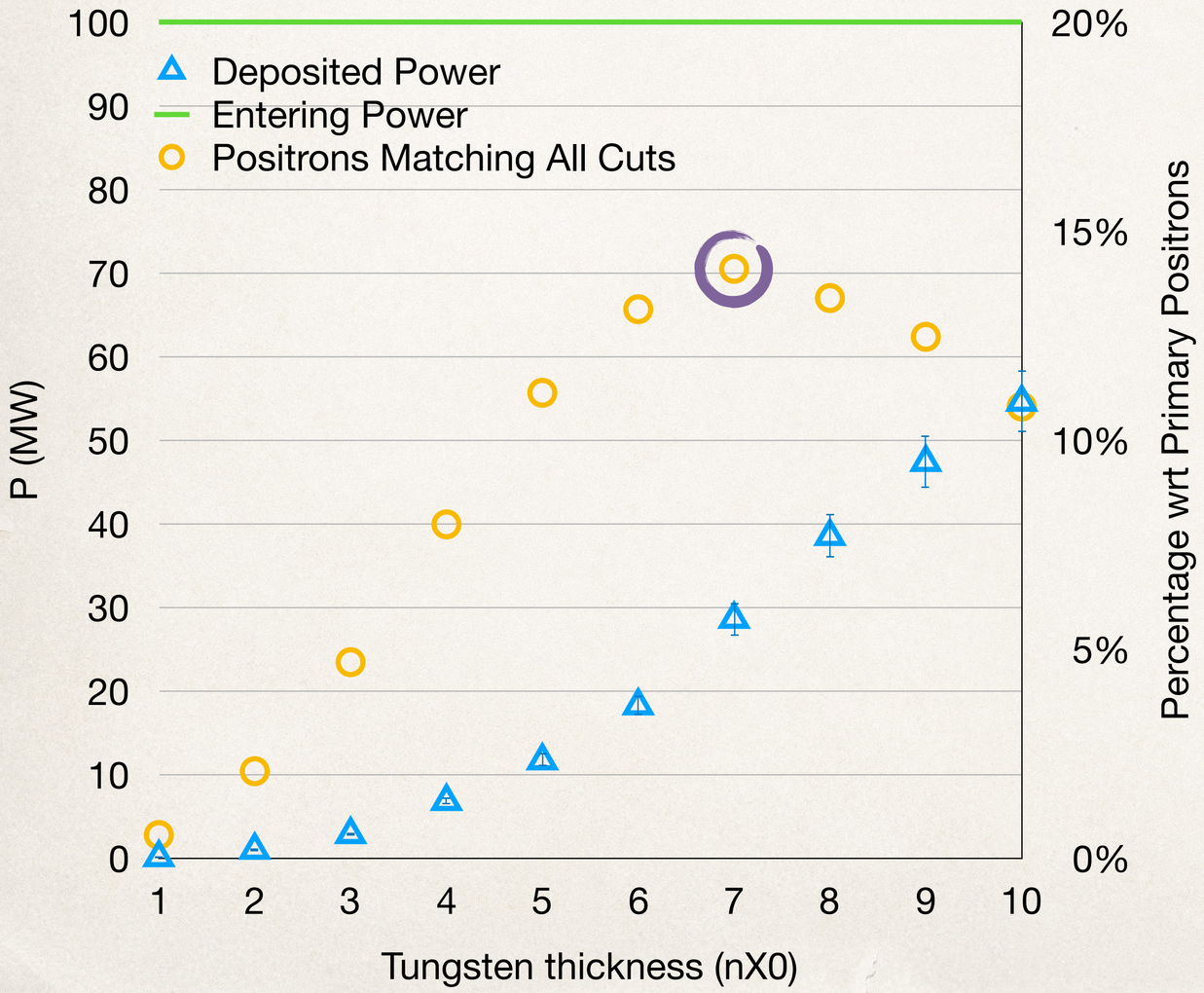

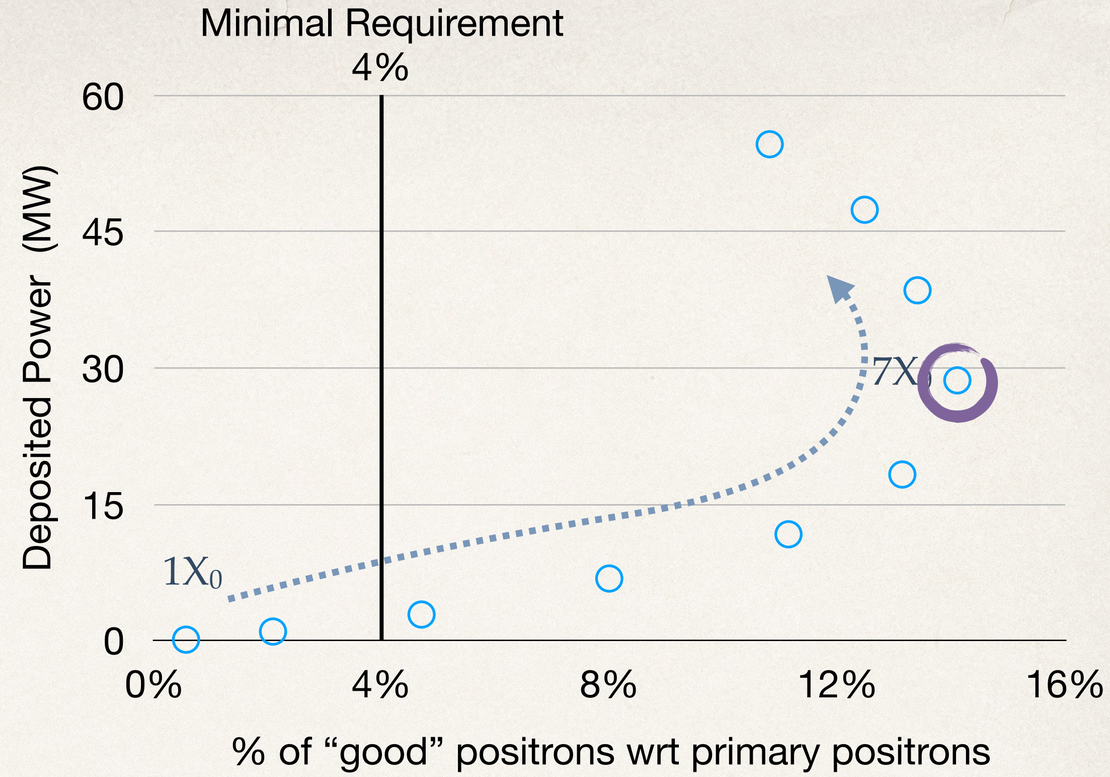

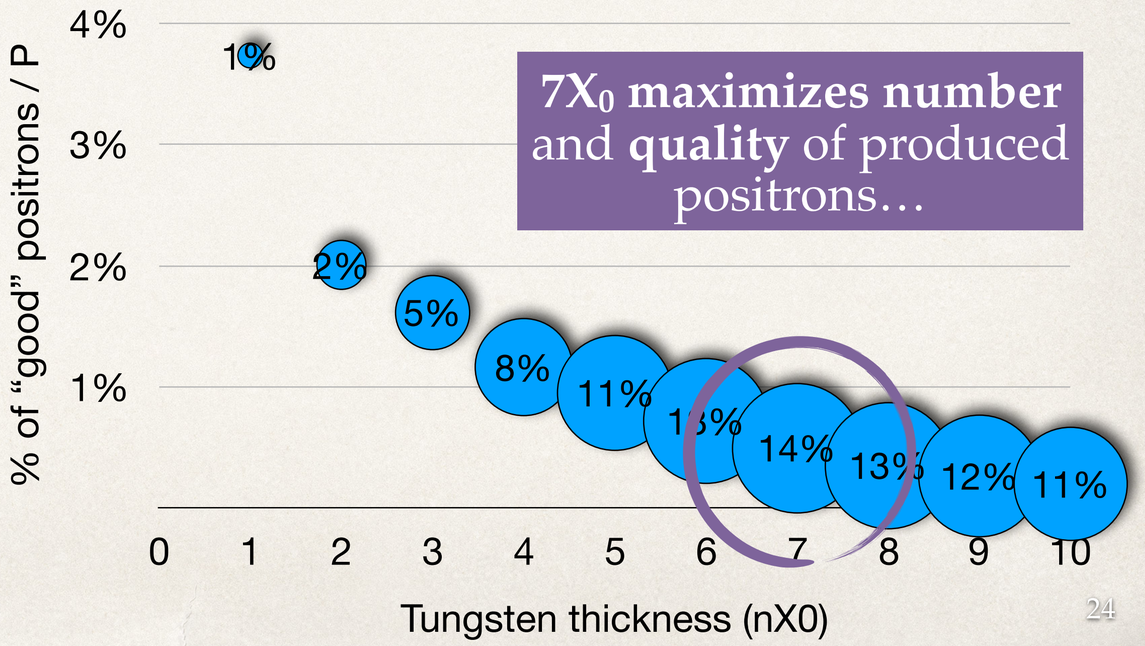

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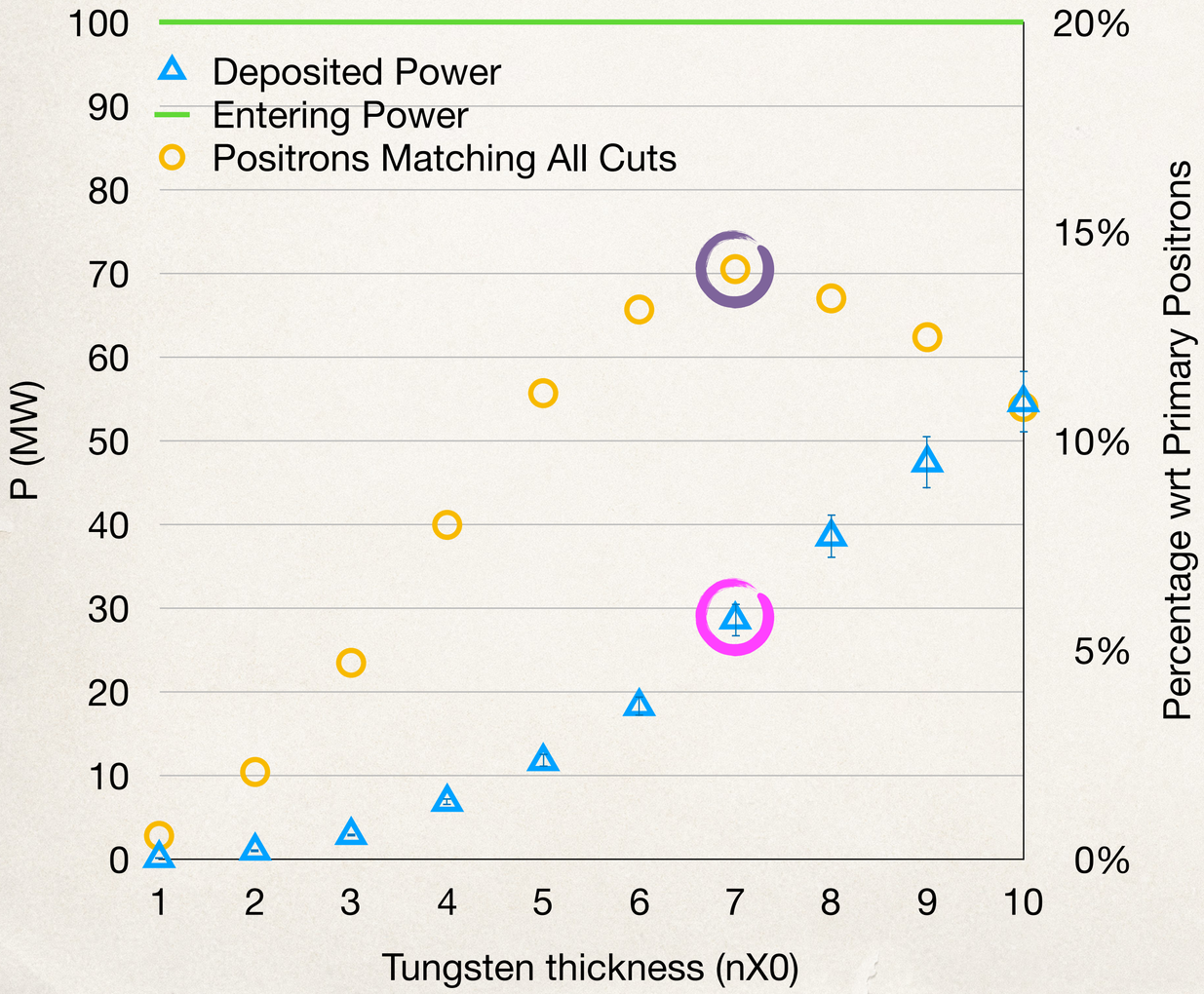

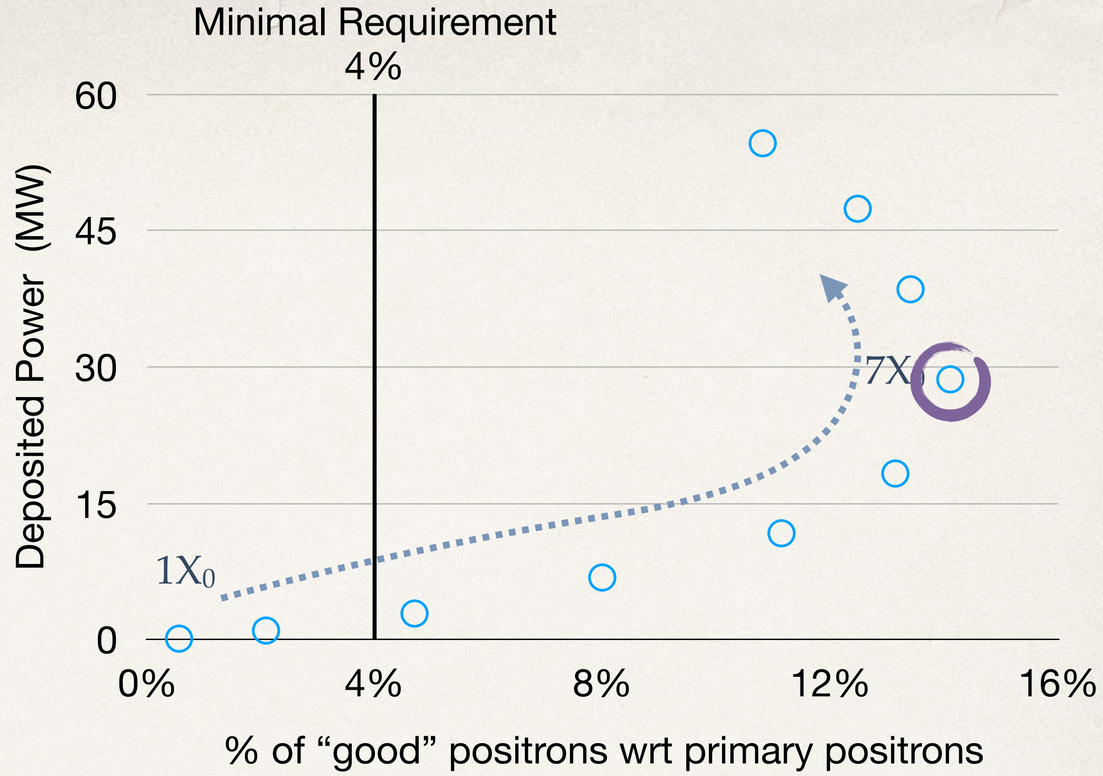

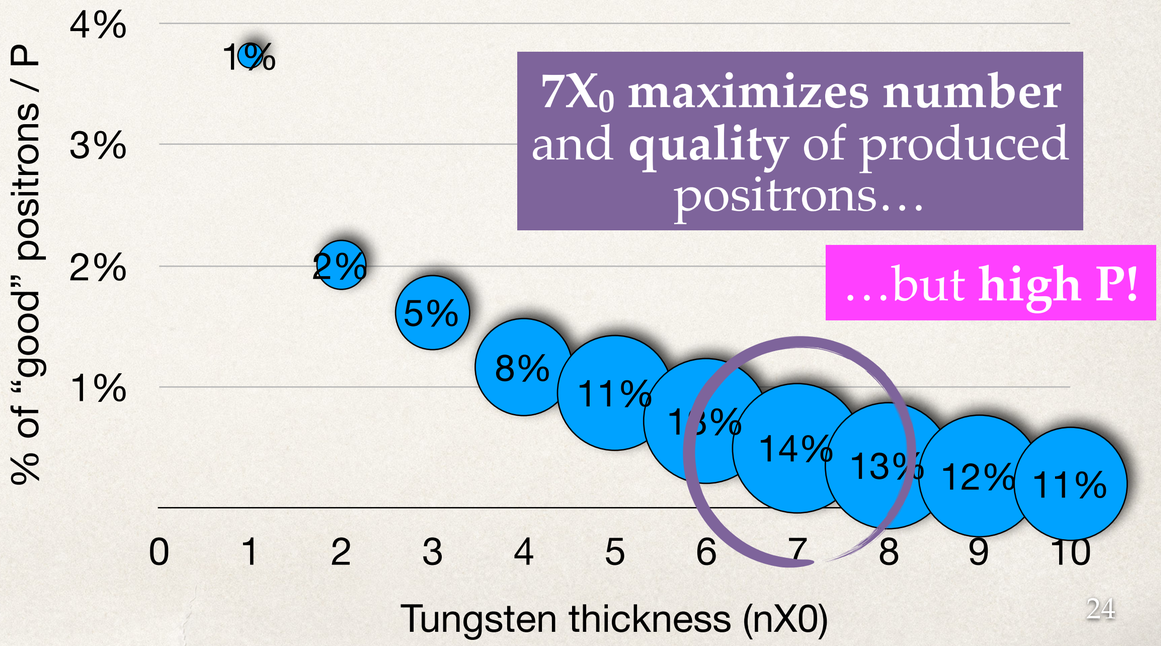

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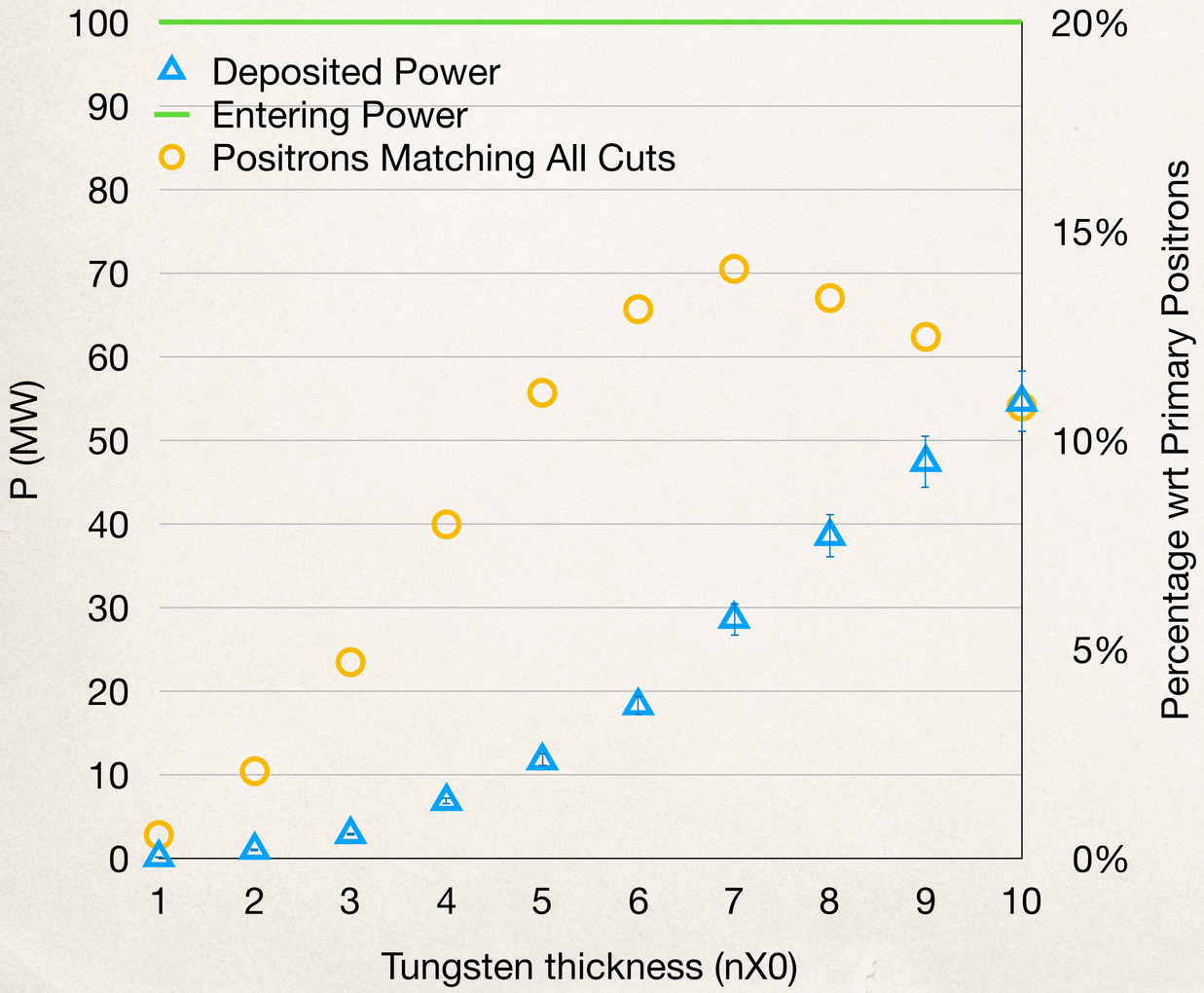

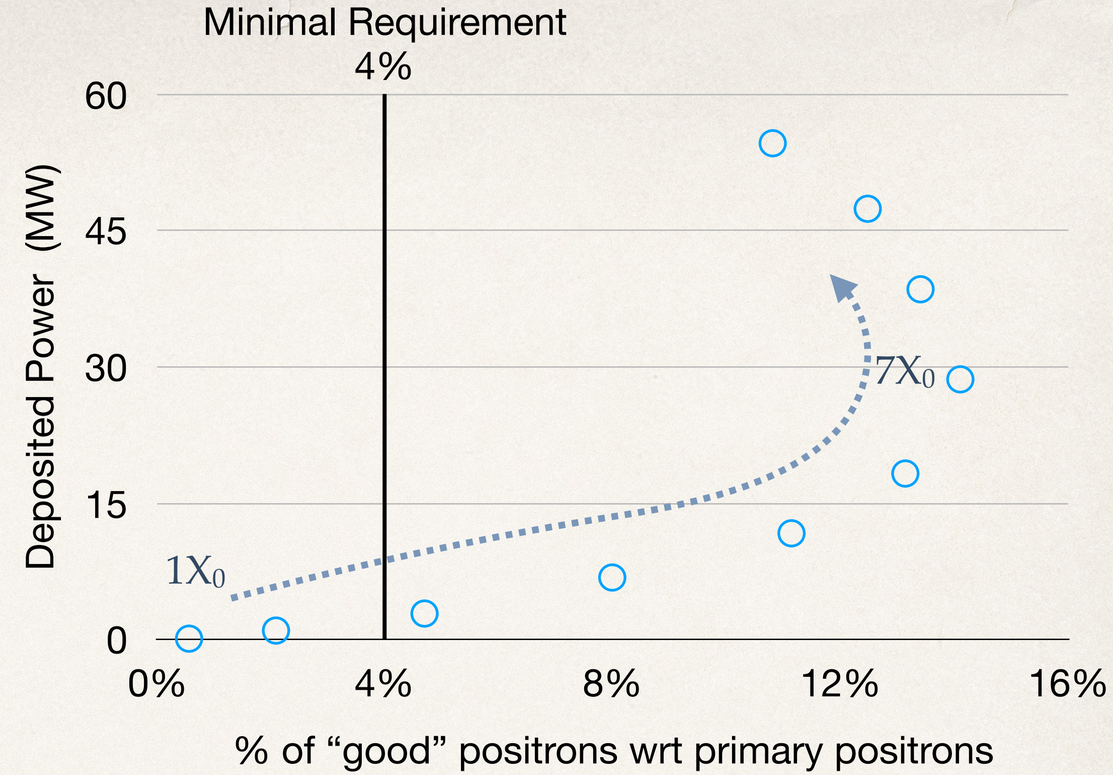

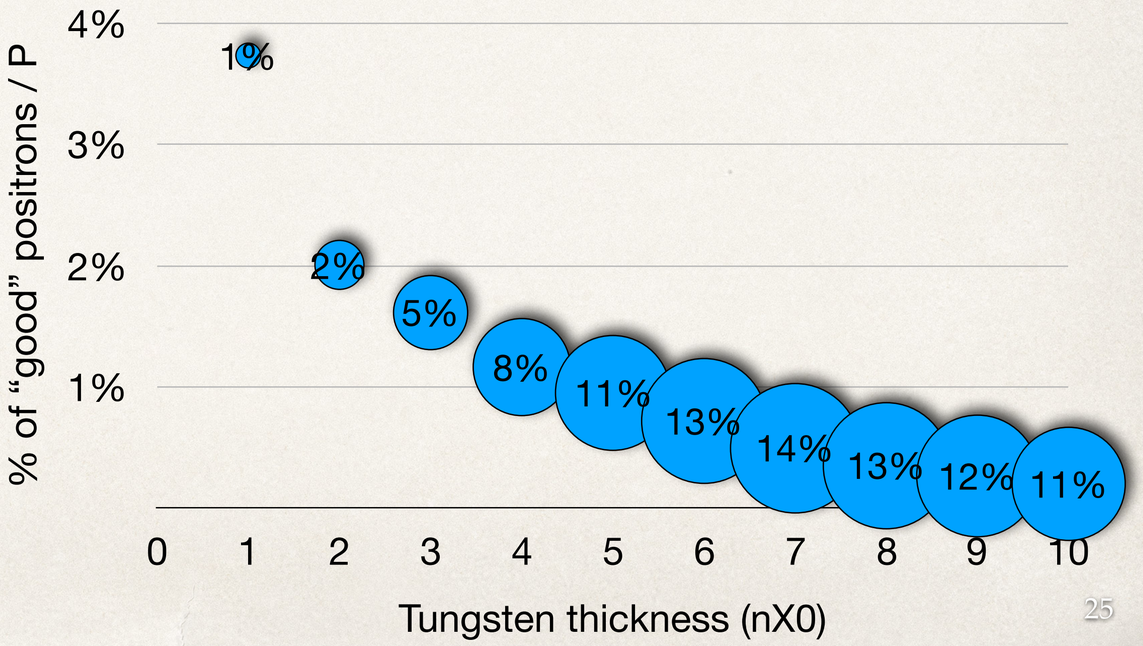

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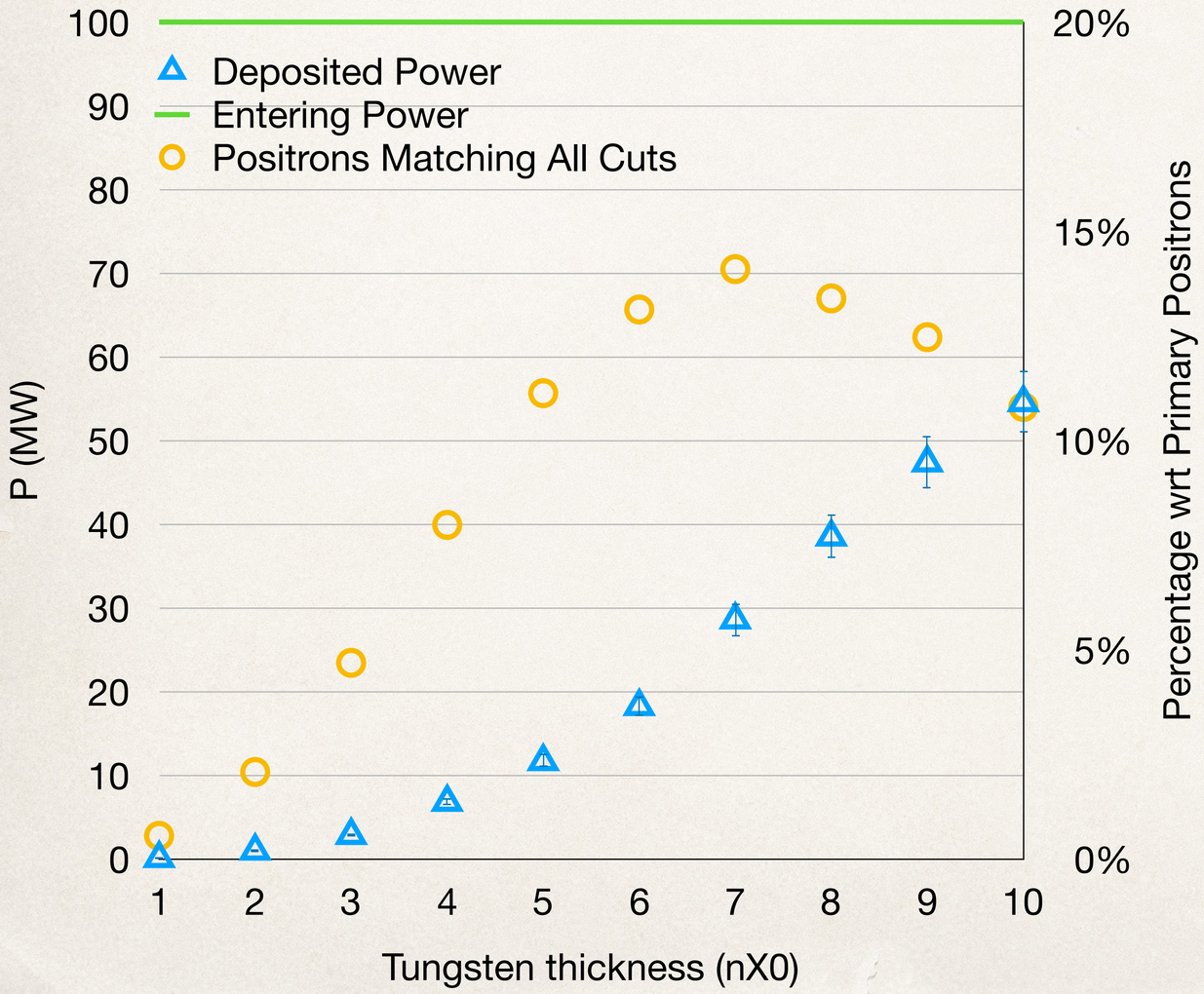

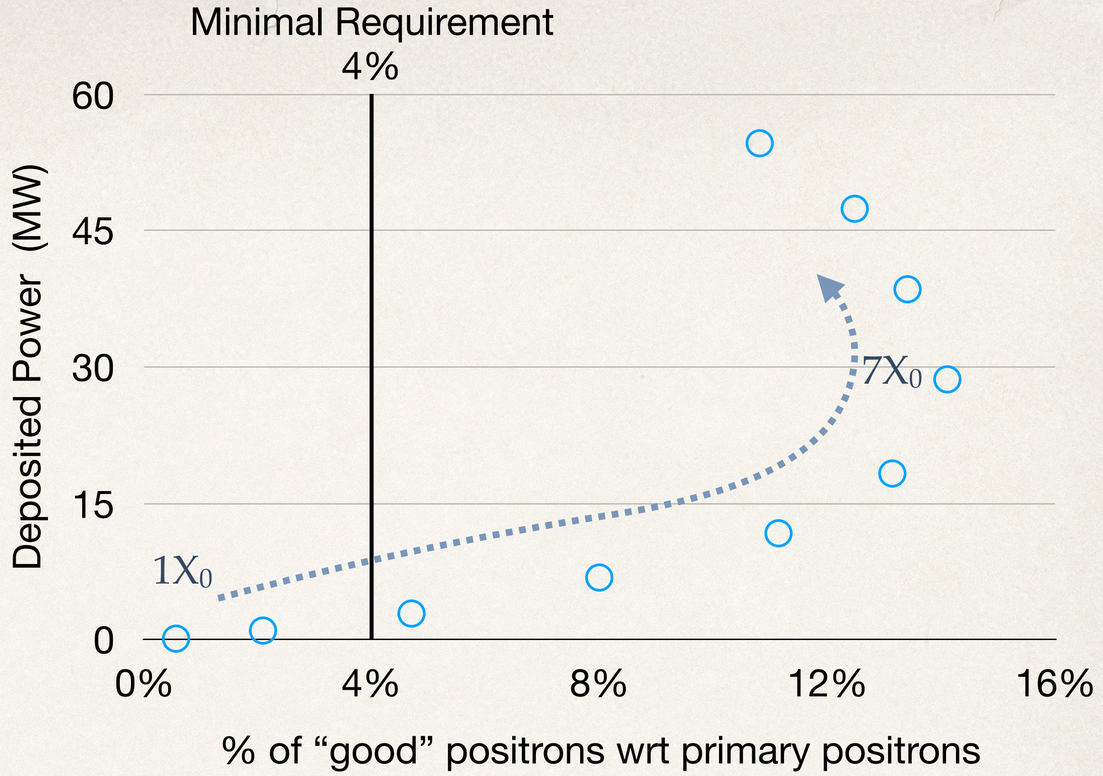

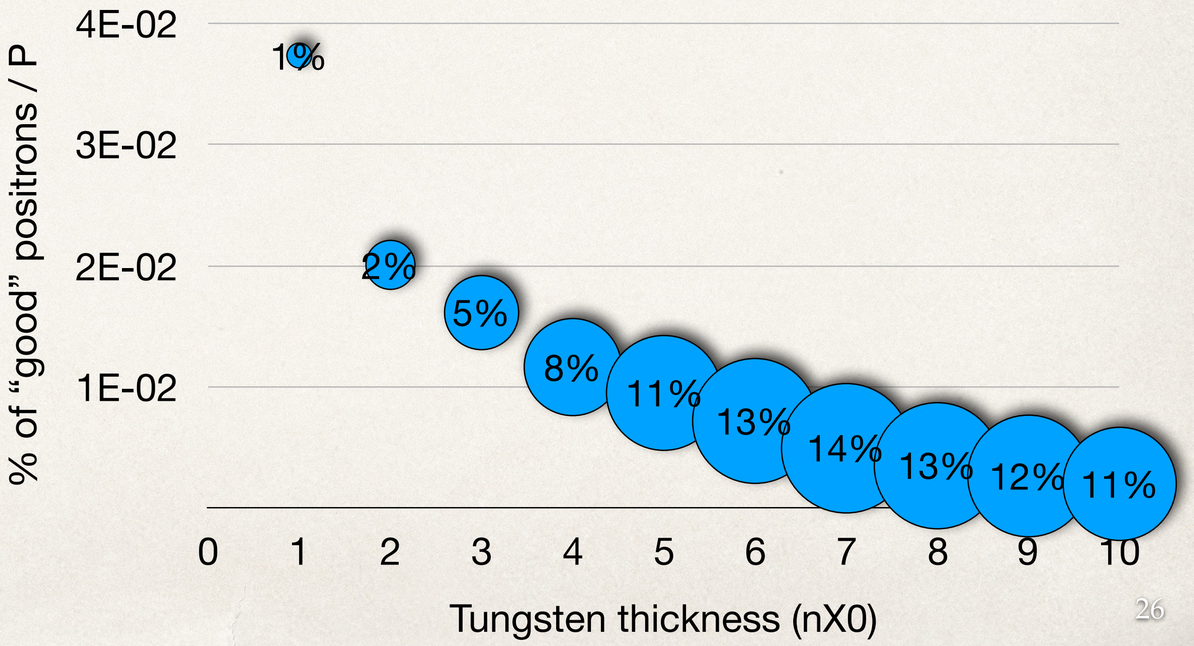

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