KPT: Conceptual Design & Radiation Effects

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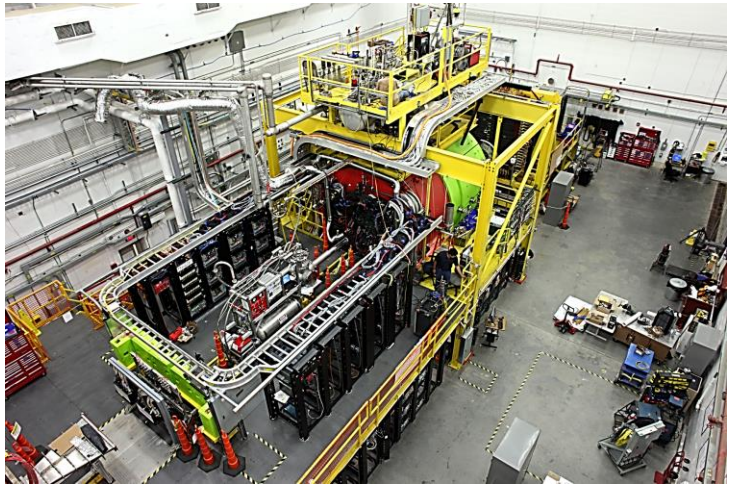

- ***ERR-I*** charge for KPT.
- Kaon beamline.
- Hall D setting.
- Equivalent prompt dose rate for Exp Hall.
- Prompt dose rate for Collimator Cave.
- KPT Assembly.
- Activation dose rate for Collimator Cave.
- KPT cooling.
- Summary.

https://www.overleaf.com/project/6302c989eb137630a435e21c

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Experiment Readiness Review Phase I Jefferson Lab, 2023 Charge

From: ***Patrizia Rossi***

Hall D E12-19-001 *ERR* Phase I Jefferson Lab, 2023 Charge

- What is status of *Kaon Production Target* (***KPT***)**?** Specifically**:**
  a) Conceptual design.
  b) Evaluation of produced radiation. In particular, following points should be discussed**:**
    1. Approximations made in *MC* simulations & which code has been used;
    2. Energy deposition & temperature in ***KPT***; See Tim's report
    3. Prompt dose & activation around ***KPT*** & ***Cave***;
    4. Water-cooling system & possible contaminations. See Tim's report
- Will civil constructions be needed in ***Cave*** to contain radiation**?**
- What is estimated *annual boundary dose* when running E12-19-001 experiment**?**
- What is decommissioning plans for ***KPT*** & activated components**?** See Tim's report
  A brief outline is sufficient.

- *Geometry* of *Experimental Hall* & *Collimator Cave* came from *Tim Whitlatch*.
- *Engineering* design, water cooling, & contamination were done by *Tim Whitlatch*.
- *RadCon* calculations were under *Pavel Degtyarenko* & *Lorenzo Zana* suggestions.



- Following *codes* were used for ***KPT*** development: MCNP6 FLUKA SIEMENS NX Ansys see pg 15

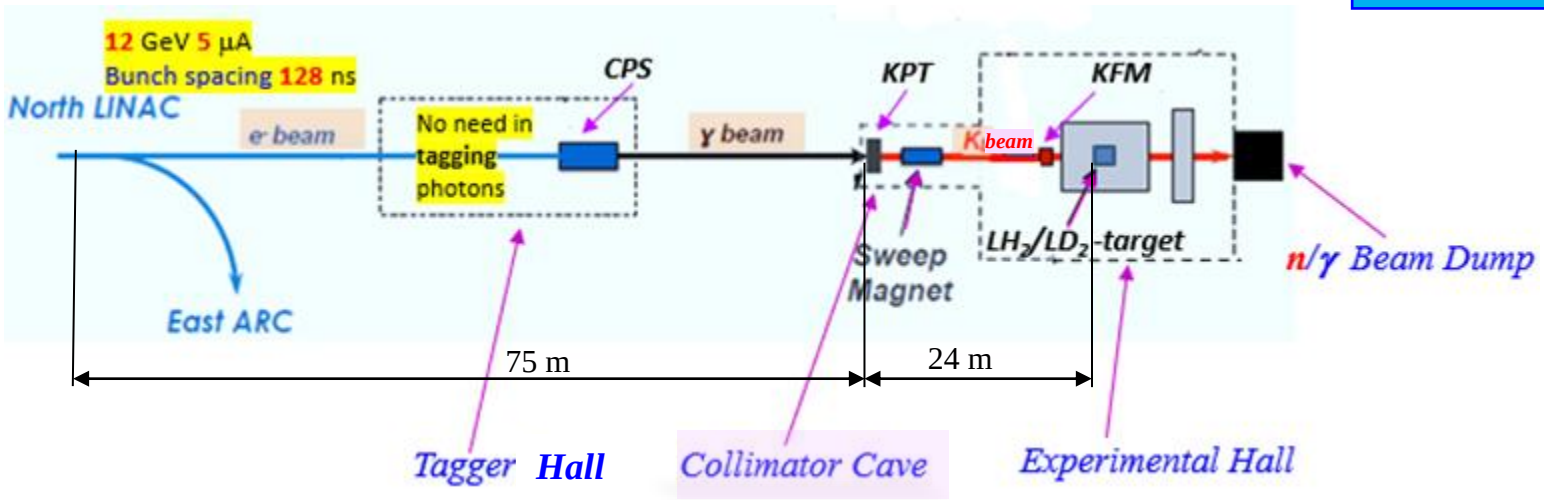




Hall D: Beam Line for K-long

- Electrons (**3.1 x 10^{13} e**/sec) are hitting Cu-radiator [10% X_0] @ *CPS* located in *Tagger Hall*.
- Photons (**4.7 x 10^{12} γ**/sec, E_γ > 1.5 GeV) are hitting Be-target located in *Collimator Cave*.
- K_Ls (**1 x 10^4** K_L/sec) are hitting Cryo target within ***GlueX*** spectrometer.

See Hovanes' report



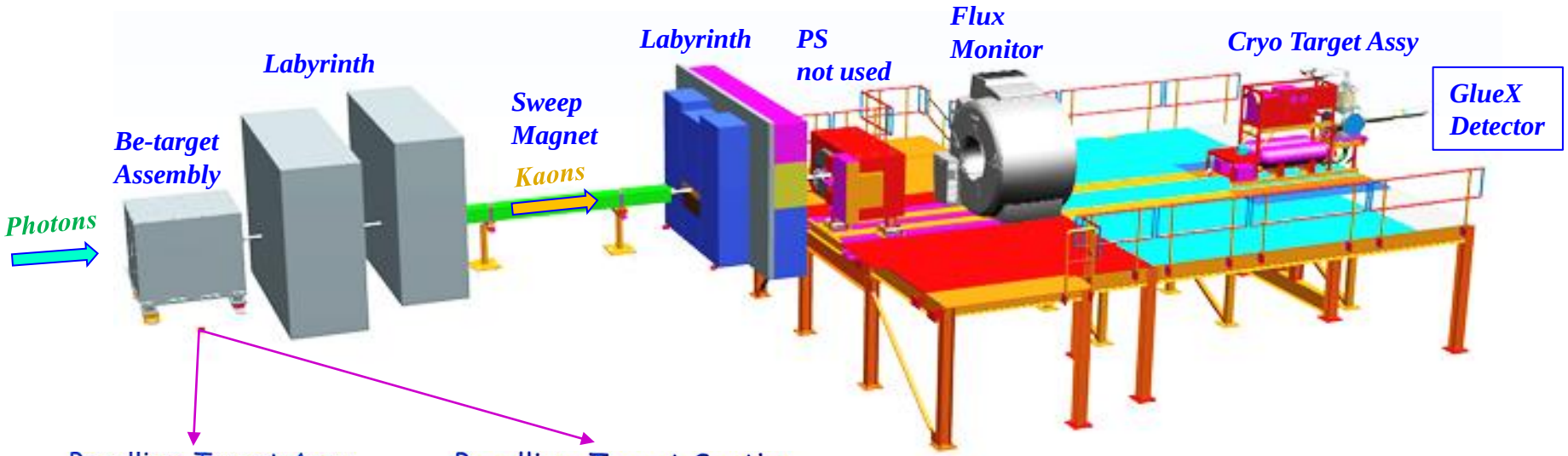
Hall D Setting [Engineering Design]

See Tim's report

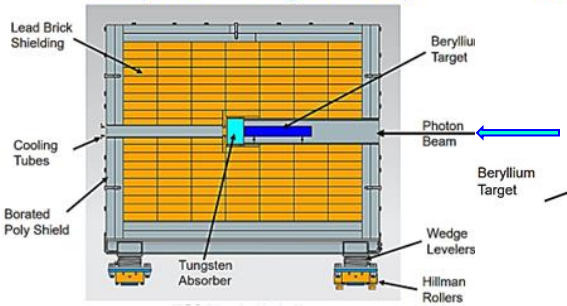
See Mikhail's report

Collimator Cave

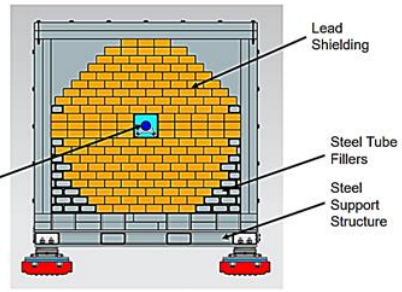
Experimental Hall



Beryllium Target Assy



Beryllium Target Section

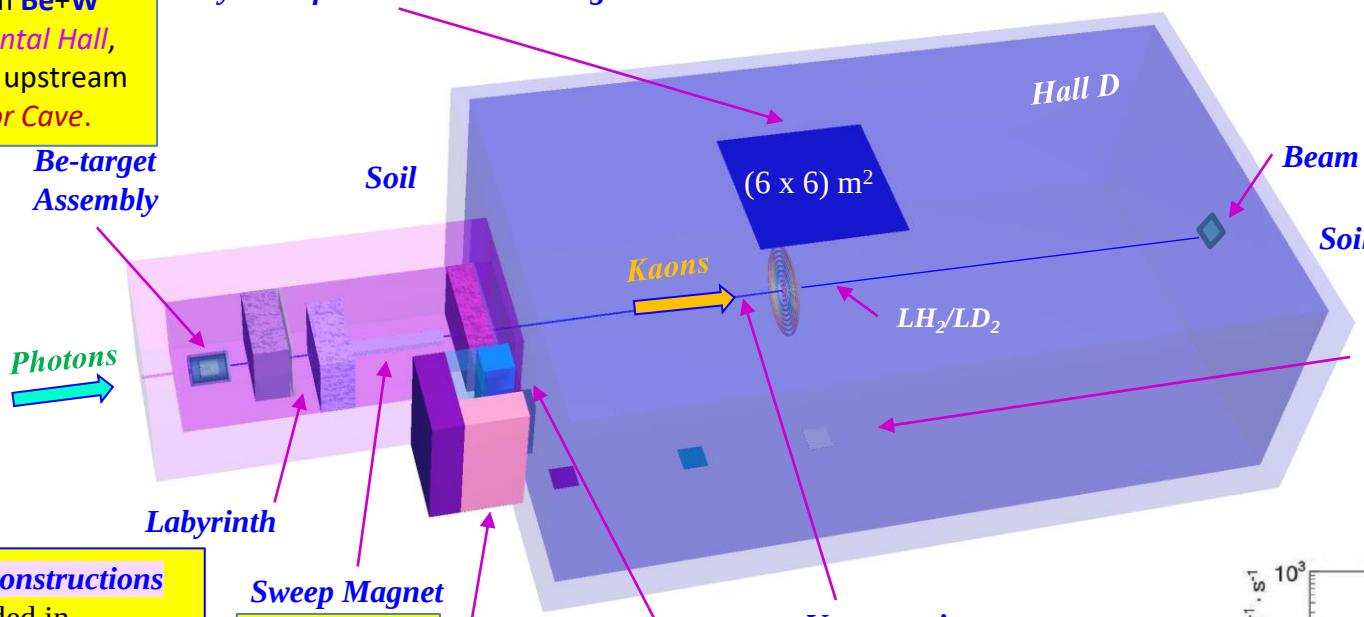


Hall D Setting - 2

RadCon figure-of-merit =1 mrem/h

@ key area for RadCon on ceiling

To reduce effect of **n** & **γ background**, coming from **Be+W** in *Experimental Hall*, we put **KPT** upstream in *Collimator Cave*.

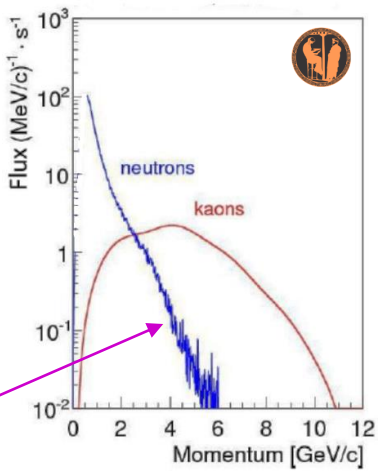


Civil Constructions be needed in *Collimator Cave* to contain radiation to minimize **n** & **γ background** in *Experimental Hall*.

See Tim's report

To clean up charged component of beam.

Vacuum beam pipe prevents re-scattering neutrons in air.

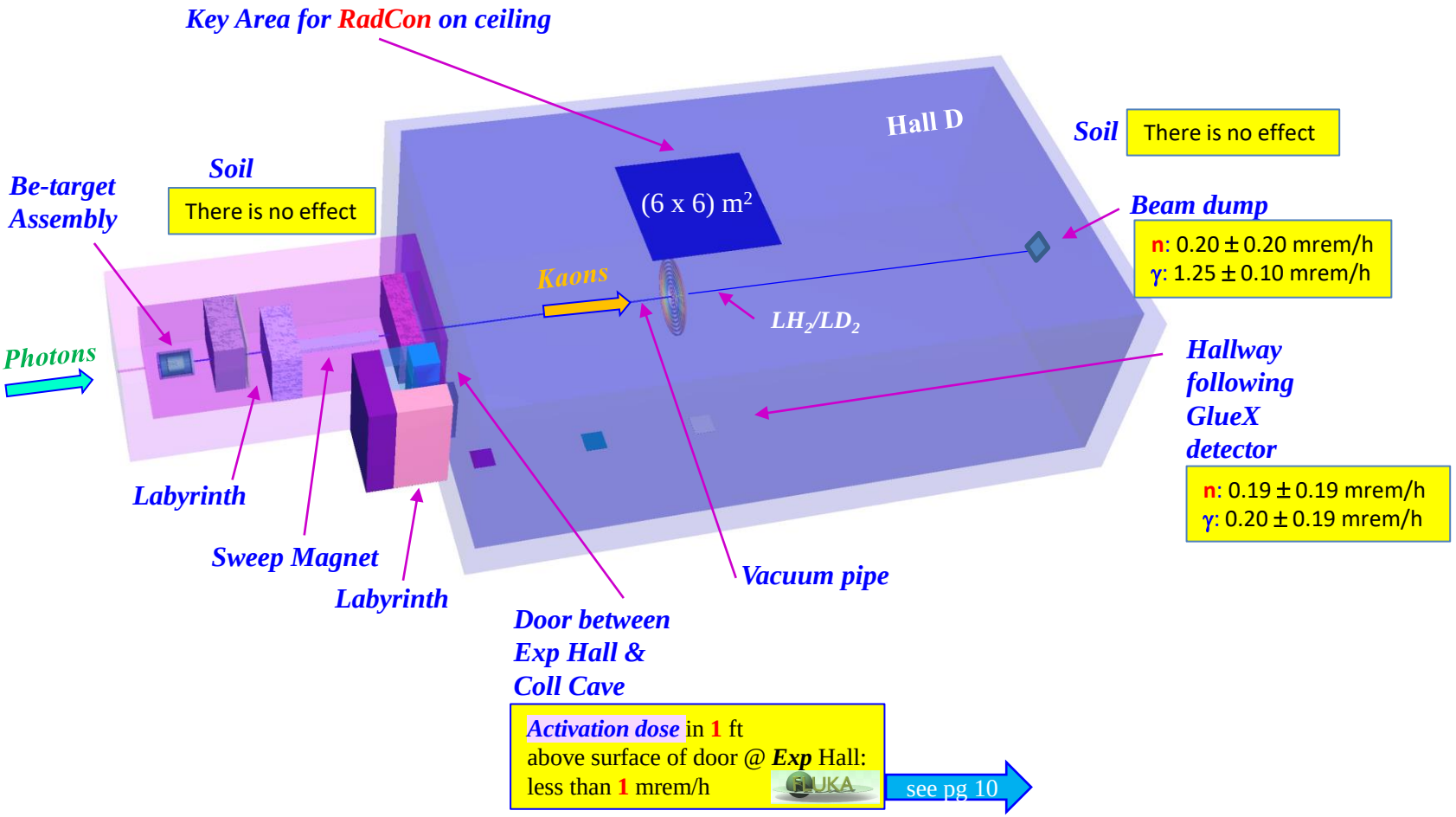


- Most important & unpleasant *background* for K_L beam comes from neutrons.

Hall D Setting & Equivalent Prompt Dose Rate - 1

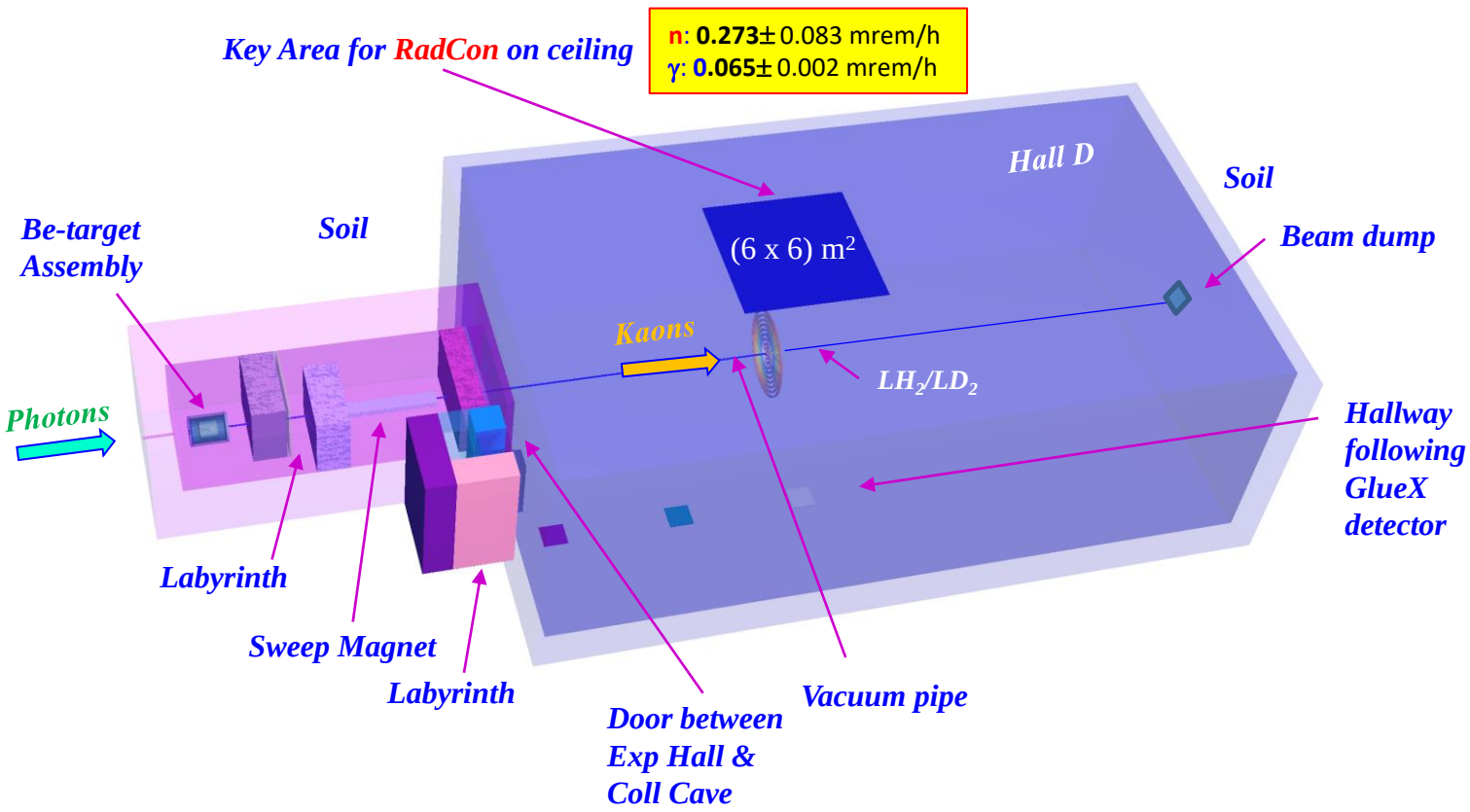
*RadCon figure-of-merit =**1** mrem/h*

@ key area for RadCon on ceiling



Hall D Setting & Equivalent Prompt Dose Rate – 2 [Final]

RadCon figure-of-merit =1 mrem/h
@ key area for RadCon on ceiling

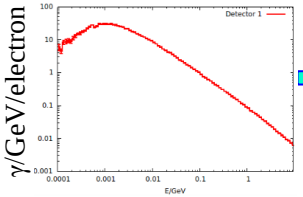


• *Prompt radiation* in ***Experimental Hall*** is acceptable.

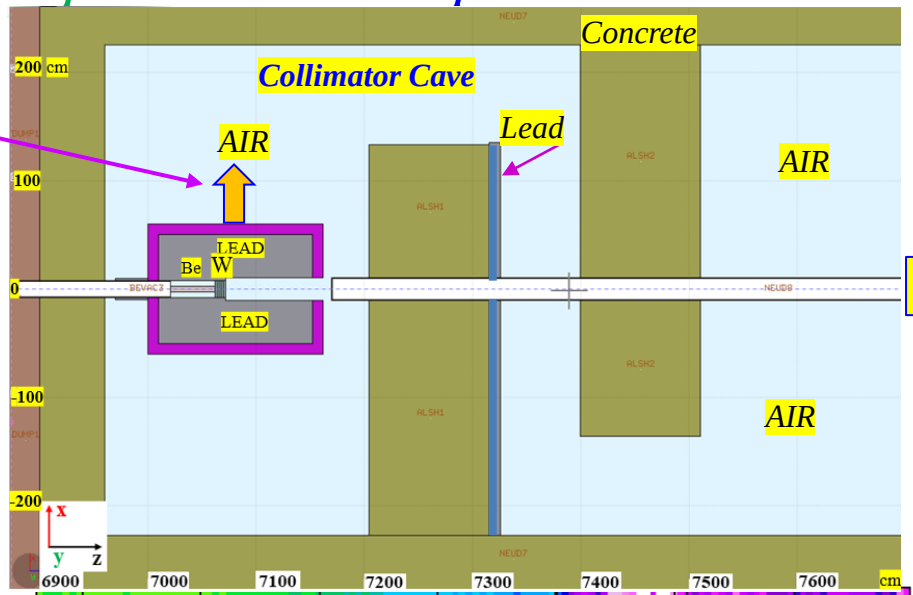
Equivalent Prompt Dose in Collimator Cave

Collimator Cave has enough space (**4.52** m width) for ***KPT*** to remain far enough from beamline.

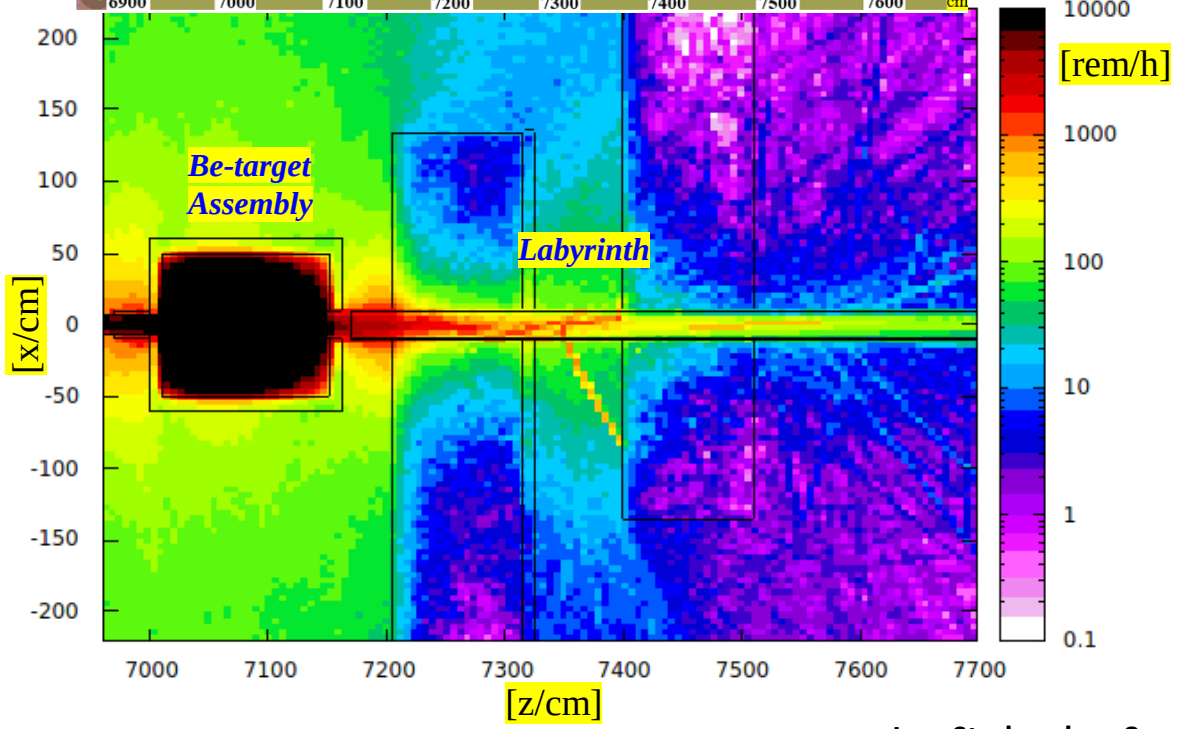
5 μA **e**$^-$ of **12** GeV



γ



γ

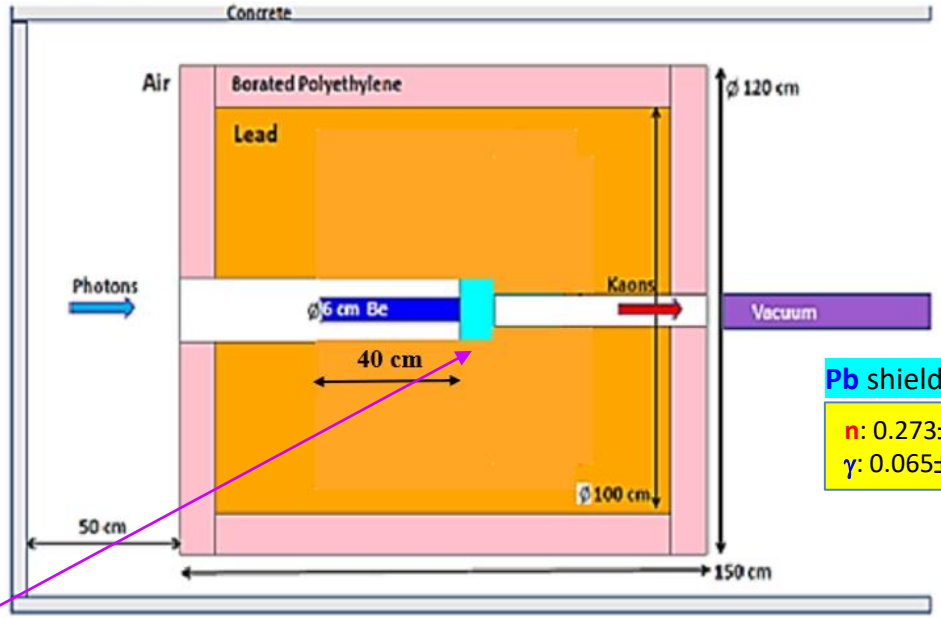


- *Prompt radiation* in ***Collimator Cave*** *is acceptable.*

Be-Target Assembly

RadCon figure-of-merit =1 mrem/h

@ key area for RadCon on ceiling



Pb shielding & **W**-plug

n: 0.273±0.083 mrem/h
γ: 0.065±0.002 mrem/h

Concrete **walls** are out of scale

W-plug
16 cm in **diam**
10 cm in **length**

- Increasing **plug length** will reduce **kaon** flux.

15 cm in length: **n**: 0.16 ± 0.06 mrem/h
γ: 0.003±0.001 mrem/h

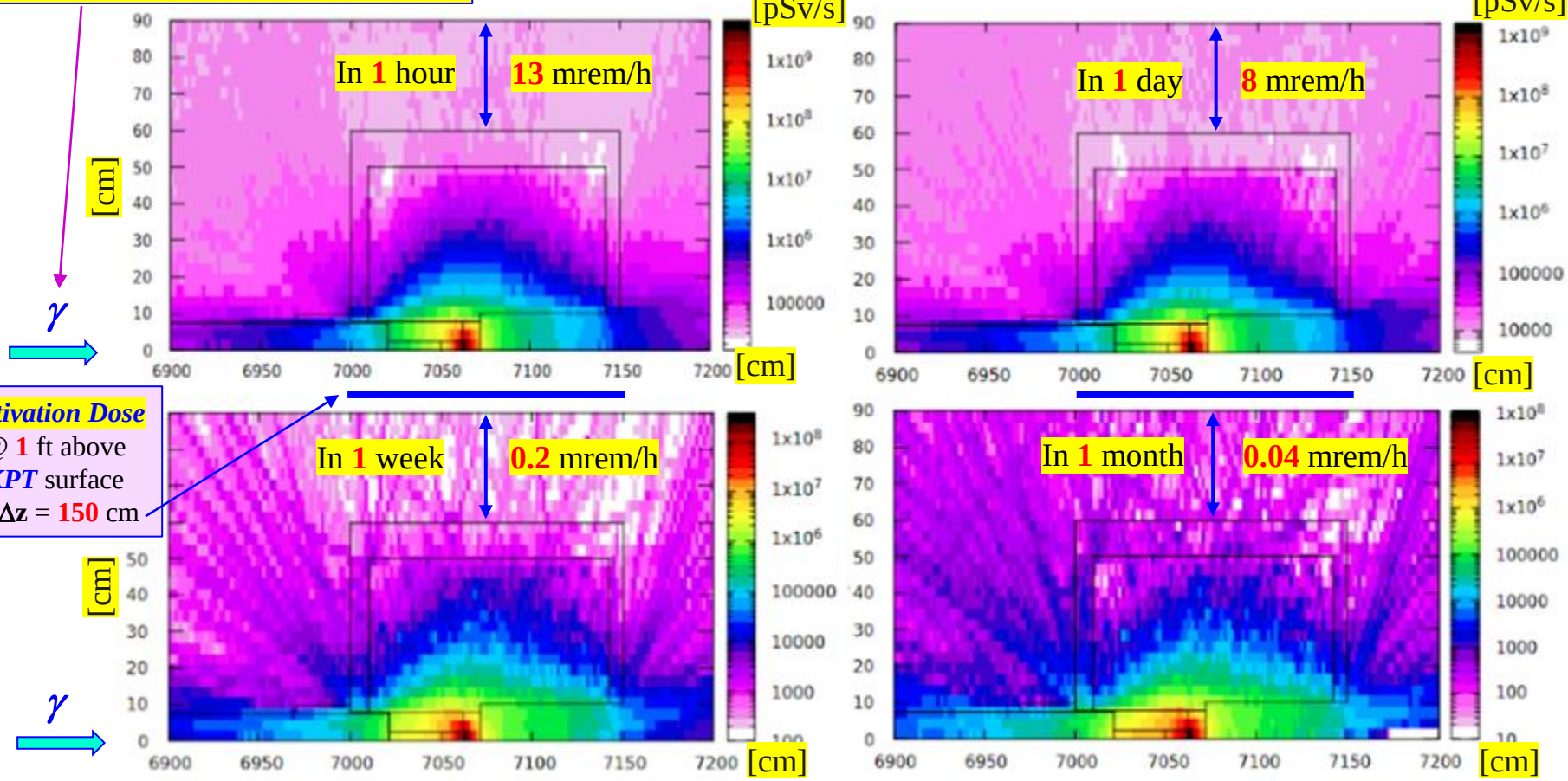
Corresponds to lost of **70%** of **kaons**

- *Prompt radiation* in ***Exp Hall*** *due to* ***Be-target*** *&* ***W-plug*** *is acceptable.*

Activation Dose @ KPT

RadCon figure-of-merit = 1 mrem/h

1000 h of operation with **5** μA **e⁻** of **12** GeV



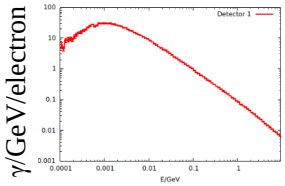
Activation Dose
@ **1** ft above
KPT surface
& **Δz** = **150** cm

Equivalent dose:
10^5 pSv/s = **36** mrem/h

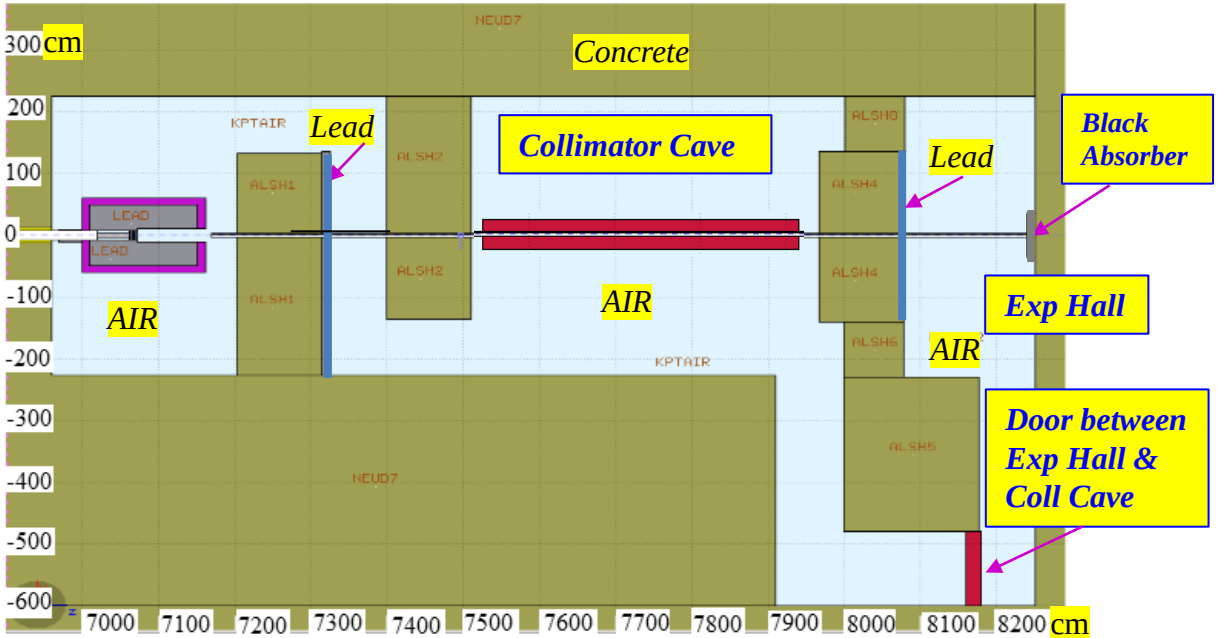
- *KPT* is kept in *Cave* & moved sideways.
- All other modifications in *Cave* are restored to GlueX.

Activation Dose for Door between Exp Hall & Coll Cave

5 μA e^- of 12 GeV

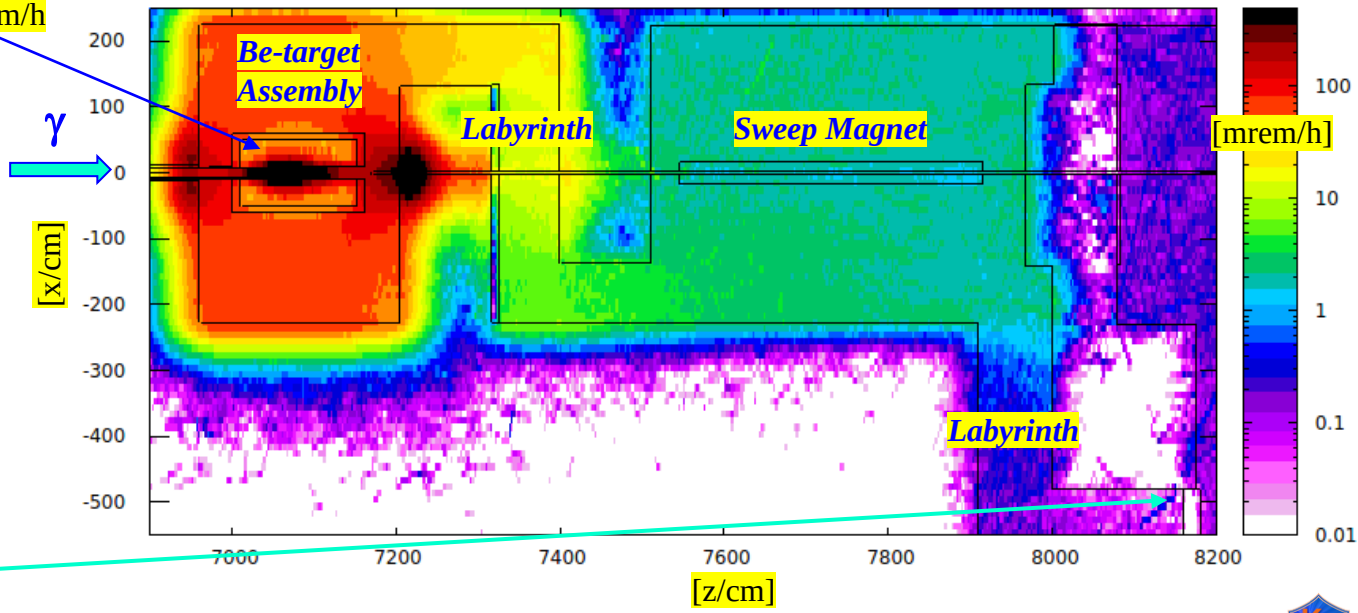


γ



Black > 500 mrem/h

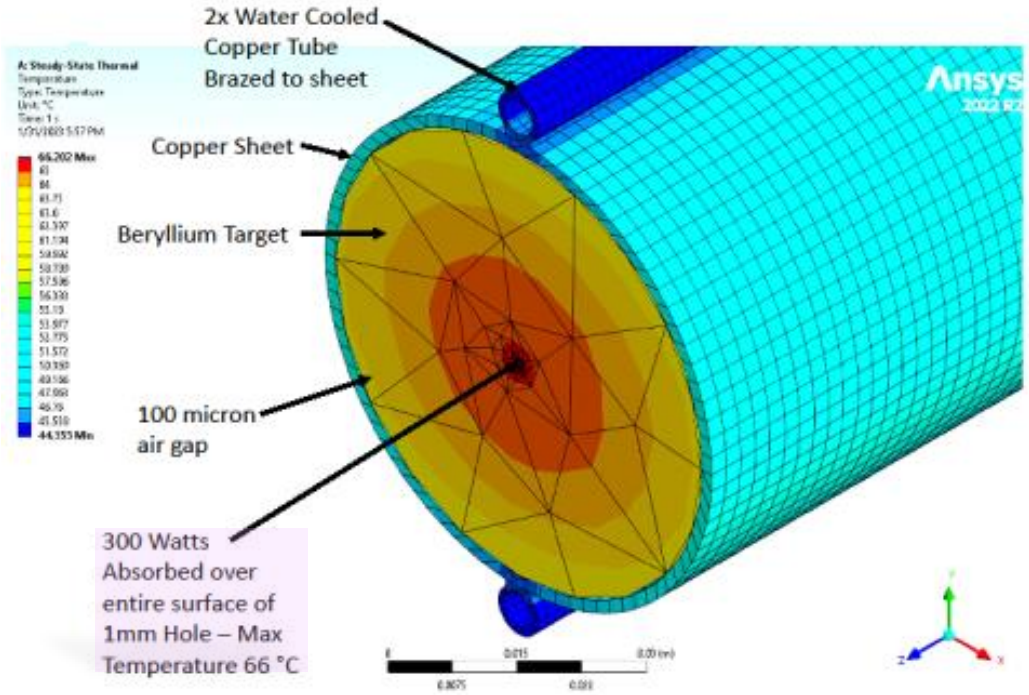
γ



Activation dose in 1 ft above surface of door @ ***Exp Hall*** [in 1 h of 1000 h of operation with 5 μA e^- of 12 GeV @ -80<y/cm<+80]: less than 0.1 mrem/h which is acceptable.

Beryllium Target Cooling

See Tim's report



- Since there is concern with *air contamination* from Be if air is blown onto surface for cooling, it is decided to use *water cooling* for this Be target.
- Maximum *temperature* of 66^{o}C was found in Be.
- Target is wrapped with **0.065** in thick copper sheet in which **0.25** in cooling tubes are brazed on to.
- Inner surface of water-cooling tube is assumed to have a convection coefficient of **5** kW/m^2 K & water *temperature* of 40^{o}C on average.
- This is *conservative* since there will be some actual contact.

- *KPT* is ready to be assembled and installed in *Hall D beamline*.

- Report addressed to ##5,6,7, & partly 12 of ERR-I charge.
  - Radiation in *Experimental Hall* & *Collimator Cave*, & *ground* is acceptable.
  - We have been working closely together to *Pavel Degtyarenko* & *Lorenzo Zana*.
  - Civil constructions be needed in *Collimator Cave*. See Tim's report
  - Decommissioning of *Collimator Cave* does not require long time. See Tim's report

- Design for *Be-target Assembly* & *Collimator Cave* completed – drawings finalizing.
- Thermal analysis of *Beryllium Target Tungsten Absorber* completed. See Tim's report
  Designer from ***Engineering Group*** loan.

Do you have any questions to speaker?


BACKUP

Codes Used for MC Simulations

is general MC N-particle transport *code*.
MCNP simulations are based on advanced nuclear cross section libraries created & maintained by several DOE National Laboratories.
Physical models, implemented in *MCNP6* code, consider bremsstrahlung photon production, photo nuclear reactions, neutrons & photons multiple scattering processes.

T. Goorley *et al*, Nucl Tech **180**, 298 (**2012**); https://mcnp.lanl.gov/

is general purpose MC *code* simulating interaction & transport of hadrons, heavy ions, & EM particles.

T.T. Boehlen *et al*, Nucl Data Sheets **120**, 211 (**2014**)

G. Battistoni *et al*, Annals Nucl Energy **82**, 10 (**2015**)

Pythia is *code* for generation of high-energy physics collision events.

T. Sjoestrand *et al*, Comput Phys Commun **191**, 159 (**2015**)

is *workbench* 2022 R2 finite element program.

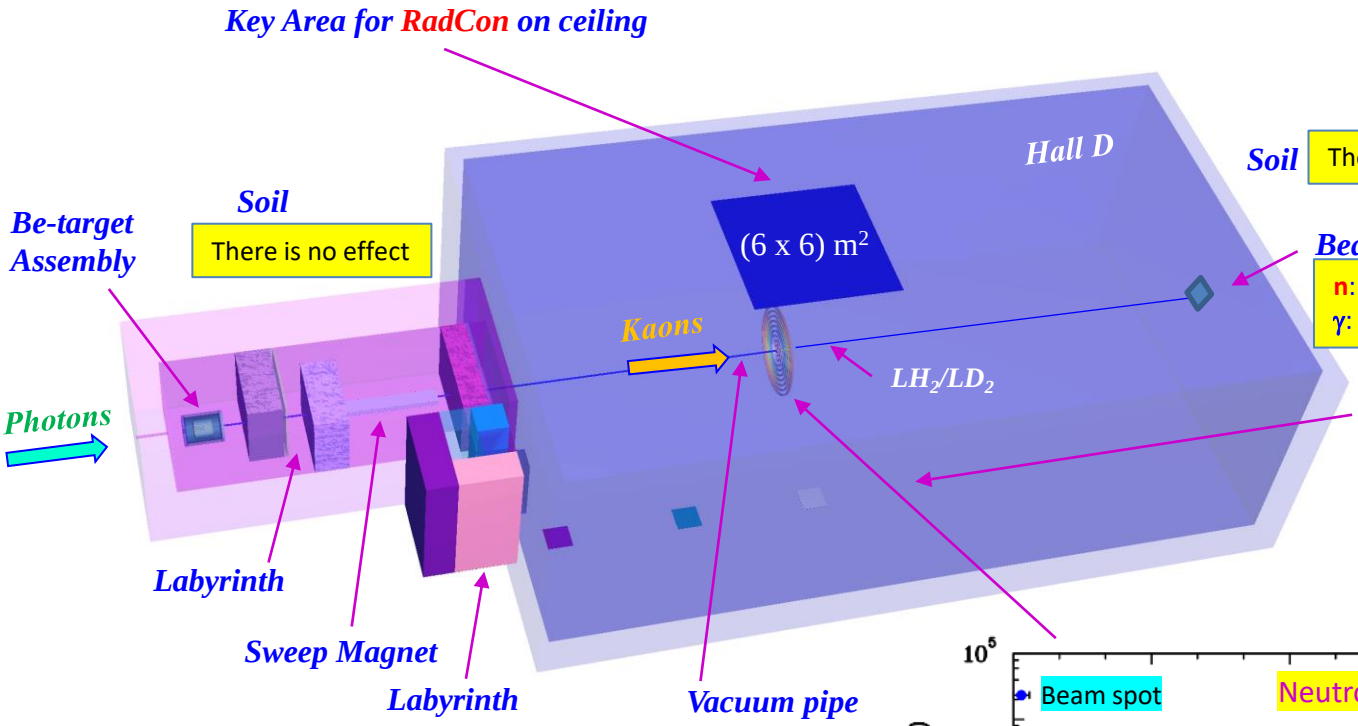
ANSYS inc. Workbench **2022** R2 *Finite Element Program*

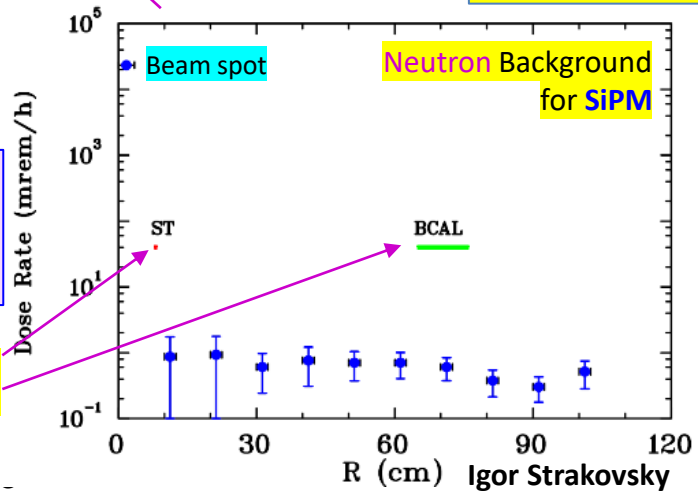
is software which is flexible & powerful integrated solution that helps to deliver better products faster & more efficiently.

Hall D Setting & Equivalent Prompt Dose Rate

RadCon figure-of-merit = 1 mrem/h

At key area for RadCon on ceiling



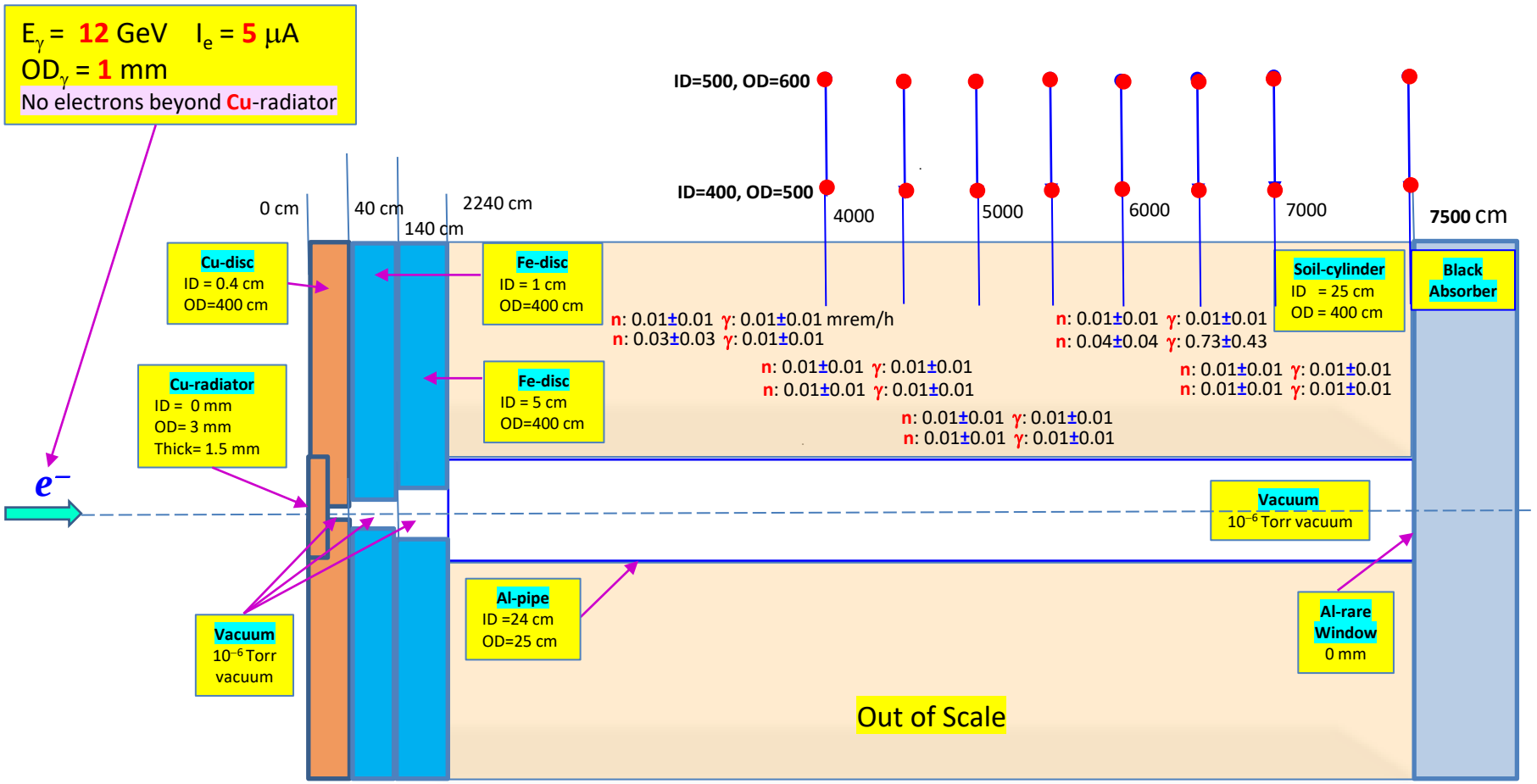


Previous studies stand that prompt dose rate of **30** mrem/h increases *dark current* @ **SiPM** by factor of **5** after **75** days of running period.

ST: E. Pooser *et al*, Nucl Instrum Meth A **927**, 330 (**2019**)
BCAL: T.D. Beattie *et al*, Nucl Instrum Meth A **896**, 24 (**2018**)

Radiation Budget on Ground above Tagger Cave

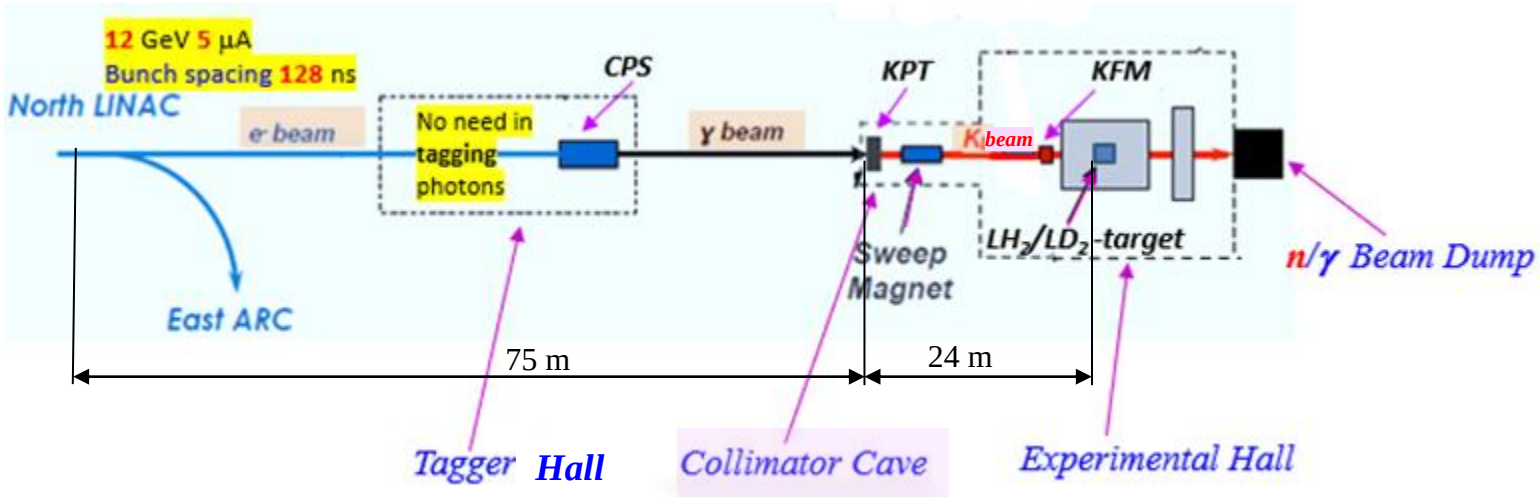
RadCon figure-of-merit = 1 mrem/h



• *Radiation* on *ground* above *Tagger Cave* is acceptable.

Hall D: Beam Line for K-long

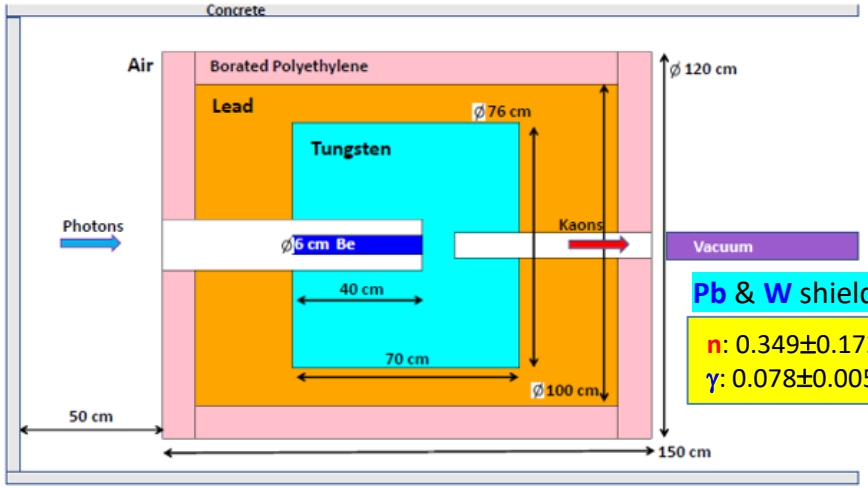
- Electrons (**3.1 x 10^{13}** e/sec) are hitting Cu-radiator [10% X_0] @ *CPS* located in *Tagger Hall*.
- Photons (**4.7 x 10^{12}** γ/sec, E_γ > 1.5 GeV) are hitting Be-target located in *Collimator Cave*.
- K_Ls (**1 x 10^4** K_L/sec) are hitting Cryo target within ***GlueX*** spectrometer.
- Neutrons (**6.6 x 10^5** n/sec) are hitting Cryo target within ***GlueX*** spectrometer.
- Photons (**6.5 x 10^5** γ/sec, E_γ > 100 MeV) are hitting Cryo target within ***GlueX*** spectrometer.



Be-Target Assembly

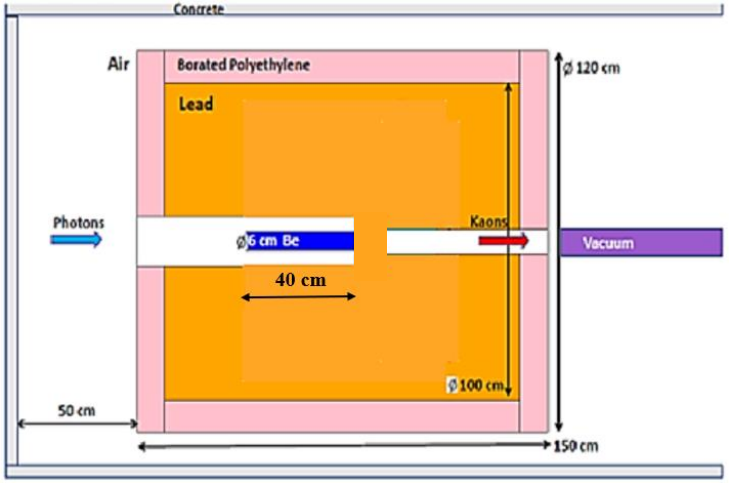
RadCon figure-of-merit =1 mrem/h

@ key area for RadCon on ceiling



Pb & W shielding

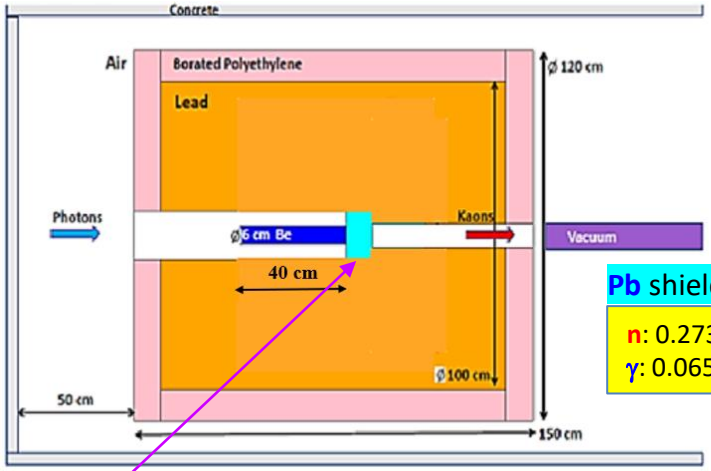
n: 0.349±0.172 mrem/h
γ: 0.078±0.005 mrem/h



Pb & no W shielding

n: 0.614±0.246 mrem/h
γ: 0.527±0.006 mrem/h

Concrete **walls** are out of scale



Pb shielding & W-plug

n: 0.273±0.083 mrem/h
γ: 0.065±0.002 mrem/h

- *Prompt radiation* in ***Exp Hall*** *due to* ***Be-target*** *&* ***W-plug*** *is acceptable.*

W-plug
16 cm in **diam**
10 cm in **length**

- Increasing **plug diam** will increase **n** background.
- Increasing **plug length** will reduce **kaon** flux.

24 cm in **diam**: **n**: 0.77 ± 0.33 mrem/h
γ: 0.074±0.002 mrem/h

15 cm in **length**: **n**: 0.16 ± 0.06 mrem/h
γ: 0.003±0.001 mrem/h

Corresponds to lost of **70%** of **kaons**