# FCCee IR workshop

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# Outline

- Some slides from M. Boscolo's excellent wrapup
- IR layout at start of workshop
- Some evolution
- Current layout
  - How Lumi-monitor fits in
- Next steps
- Summary

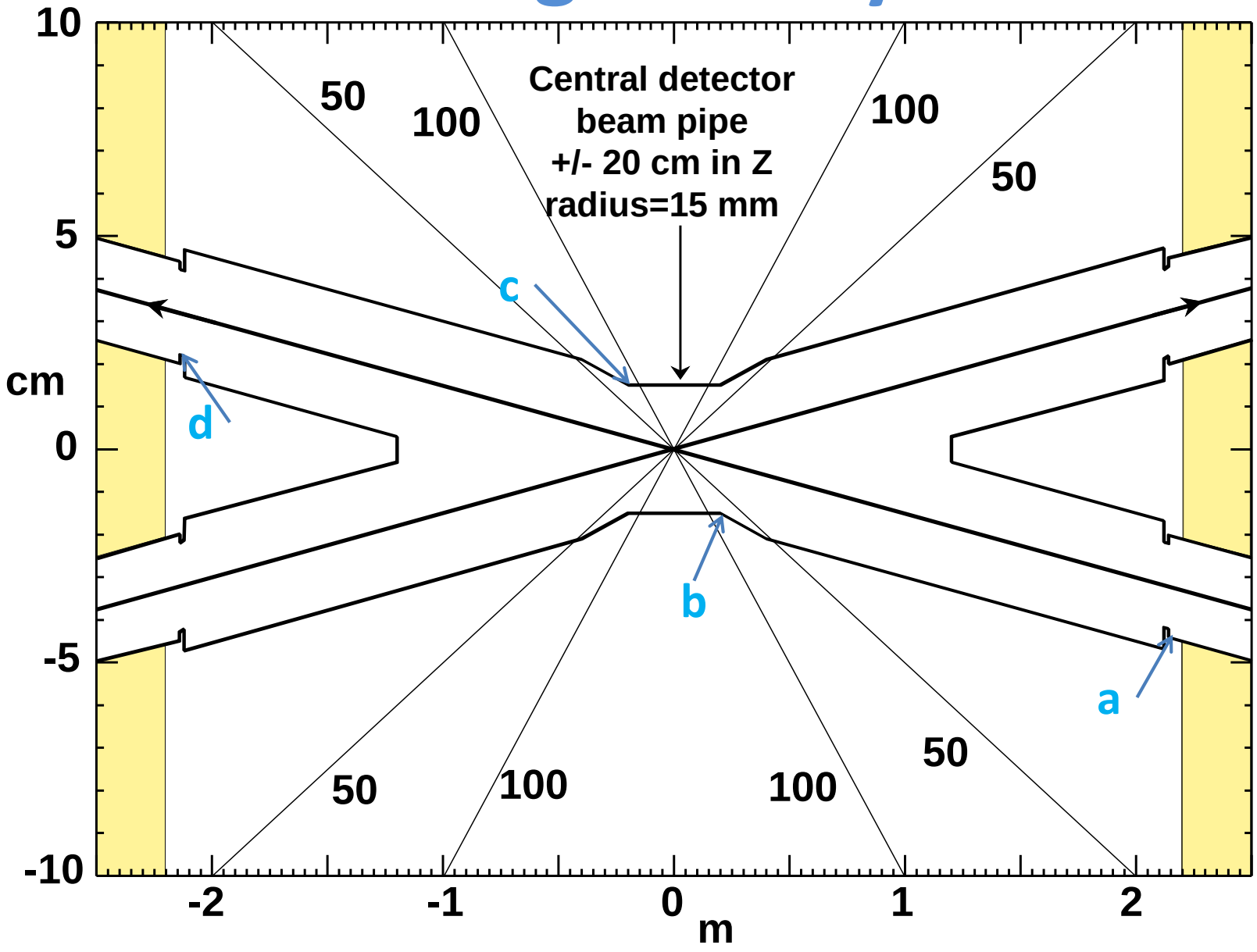
# Main Topics discussed

- Baseline KO optics with L* = 2.2 m
- IR Layout and many issues connected to it, like:
- beam pipe (shape, apertures, thickness, material)
- shieldings and masks (location, material, thickness)
- IR vacuum, water cooling, coating, HOM absorbers
- IR Trapped modes analyses for symmetric/asymmetric pipes
- Luminosity monitor design
- Solenoid compensation scheme
- Detector magnet integration
- IR quadrupole design
- IR collective effects, i.e. electron cloud, and mitigation

# Outcomes from the discussions

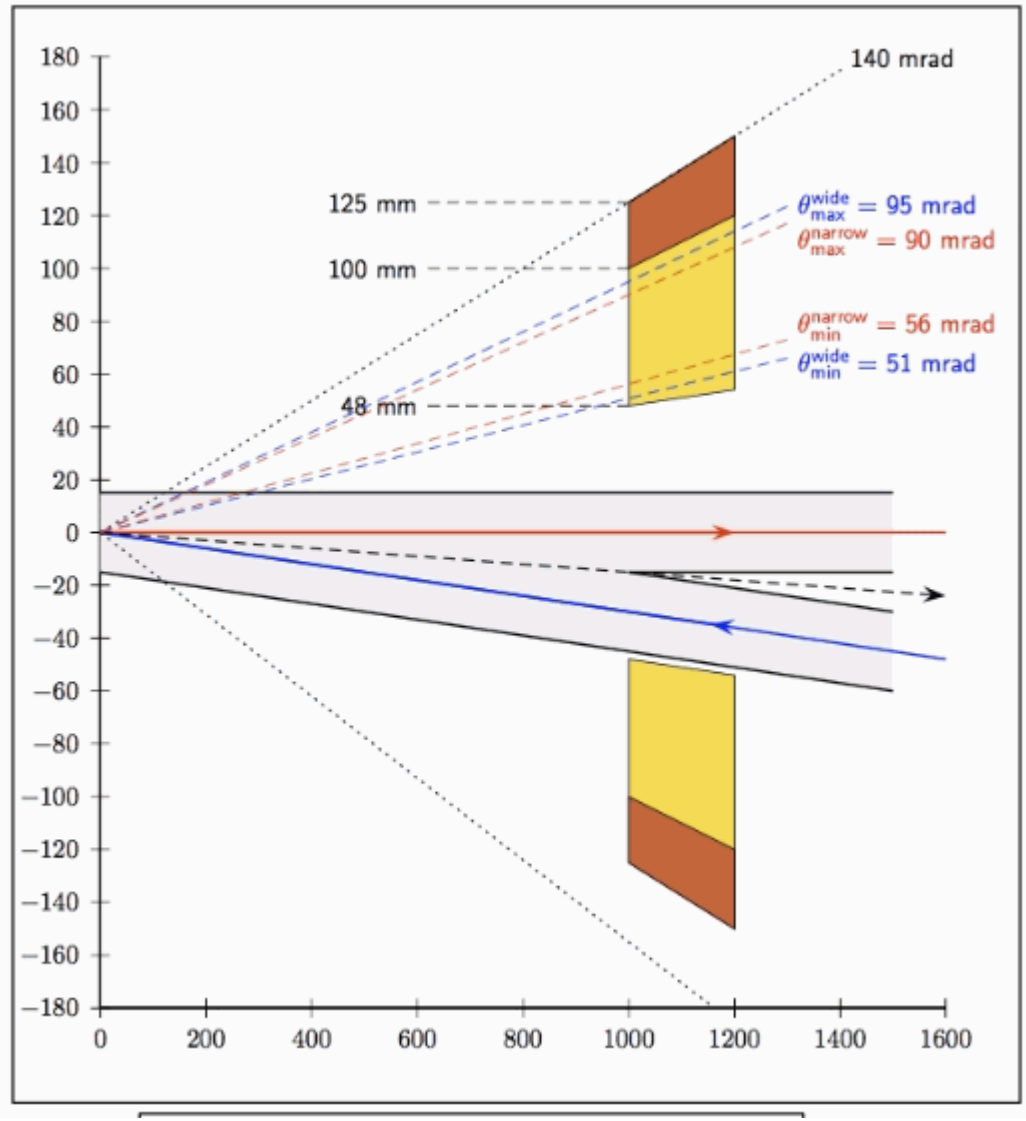
- Present baseline optics works well for all the beam energies.
- L*=2.2m is confirmed to fulfill the requirements.
- A new improved IR layout has been developed.
- Symmetric beam pipes in the FF are confirmed as baseline option by first results of trapped modes analysis. Simulations are in progress to optimize this symmetric design.
- HOM analyses and estimate of the HOM power.
- A feasible Lumical design places it from 1m to 1.2m from the IP.
- Compensating solenoid in present design starts at 1.25 m. The corresponding $\varepsilon_y$ blow-up is 0.3 pm rad. This is an acceptable value.

# Detector geometry view



- **Central chamber now 30 mm diameter but…**
  - Lumi-monitor not shown
  - Tagging angles for LumiCal incorrect
  - Beam pipe not optimized for LumiCal
- **After Mogens presented the LumiCal and Mike Koratzinos presented the latest on the solenoid compensation**
  - Settled on putting the LumiCal at 1.0-1.2 m from the IP
- **We also settled on making the beam pipe warm and 30 mm diameter inside the QC1**
- **The diameter of the beam pipe in QC2 (second FF magnet) is probably even larger (~40 mm)**

# LumiCal at 1-1.2 m (Mogens case ‘b’)




**Services are squeezed into 100-140 mrad cone to maximize SA acceptance**

**Note minimum angle of 50 mrad**

Cross section: σ = 24 nb
Geometric precision needed for absolute normalization to $10^{-4}$

- $\delta z = 53\ \mu m$
- $\delta r_{min} = 1.7\ \mu m$
- $\delta r_{max} = 7.0\ \mu m$

Courtesy Mogens

- **Mogens was asked how much radiation length of material can he stand in front of his detector and it can still function**
  - 10% of RL
- **Armed with this information went back to the drawing board**

- **And first made a table of RL vs angle of incidence**

| | $X_0$ mm |
|---|---|
| Be | 651.9 |
| Al | 240.1 |
| Au | 64.6 |

wall= 0.005

| Incident angle | | | Thickness | | Be | | Al | | Thick | Au (5 um) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| deg | mrad | rad | wall | actual | $x/X_0$ | % $x/X_0$ | $x/X_0$ | % $x/X_0$ | actual | $x/X_0$ | % $x/X_0$ |
| 0.5 | 8.73 | 0.008727 | 1 | 114.59 | 0.1758 | 17.6 | 0.4773 | 47.7 | 0.573 | 0.0089 | 0.9 |
| 1 | 17.45 | 0.017453 | 1 | 57.30 | 0.0879 | 8.8 | 0.2386 | 23.9 | 0.286 | 0.0044 | 0.4 |
| 1.5 | 26.18 | 0.02618 | 1 | 38.20 | 0.0586 | 5.9 | 0.1591 | 15.9 | 0.191 | 0.0030 | 0.3 |
| 2 | 34.91 | 0.034907 | 1 | 28.65 | 0.0440 | 4.4 | 0.1193 | 11.9 | 0.143 | 0.0022 | 0.2 |
| 2.5 | 43.63 | 0.043633 | 1 | 22.93 | 0.0352 | 3.5 | 0.0955 | 9.5 | 0.115 | 0.0018 | 0.2 |
| 3 | 52.36 | 0.05236 | 1 | 19.11 | 0.0293 | 2.9 | 0.0796 | 8.0 | 0.096 | 0.0015 | 0.1 |
| 4 | 69.81 | 0.069813 | 1 | 14.34 | 0.0220 | 2.2 | 0.0597 | 6.0 | 0.072 | 0.0011 | 0.1 |
| 5 | 87.27 | 0.087266 | 1 | 11.47 | 0.0176 | 1.8 | 0.0478 | 4.8 | 0.057 | 0.0009 | 0.1 |
| 6 | 104.72 | 0.10472 | 1 | 9.57 | 0.0147 | 1.5 | 0.0398 | 4.0 | 0.048 | 0.0007 | 0.1 |
| 10 | 174.53 | 0.174533 | 1 | 5.76 | 0.0088 | 0.9 | 0.0240 | 2.4 | 0.029 | 0.0004 | 0.0 |

Tried this first

| Incident angle | | | Thickness | | Be | | Al | |
|---|---|---|---|---|---|---|---|---|
| deg | mrad | rad | wall | actual | $x/X_0$ | % $x/X_0$ | $x/X_0$ | % $x/X_0$ |
| 0.5 | 8.73 | 0.008727 | 0.5 | 57.30 | 0.0879 | 8.8 | 0.2386 | 23.9 |
| 1 | 17.45 | 0.017453 | 0.5 | 28.65 | 0.0439 | 4.4 | 0.1193 | 11.9 |
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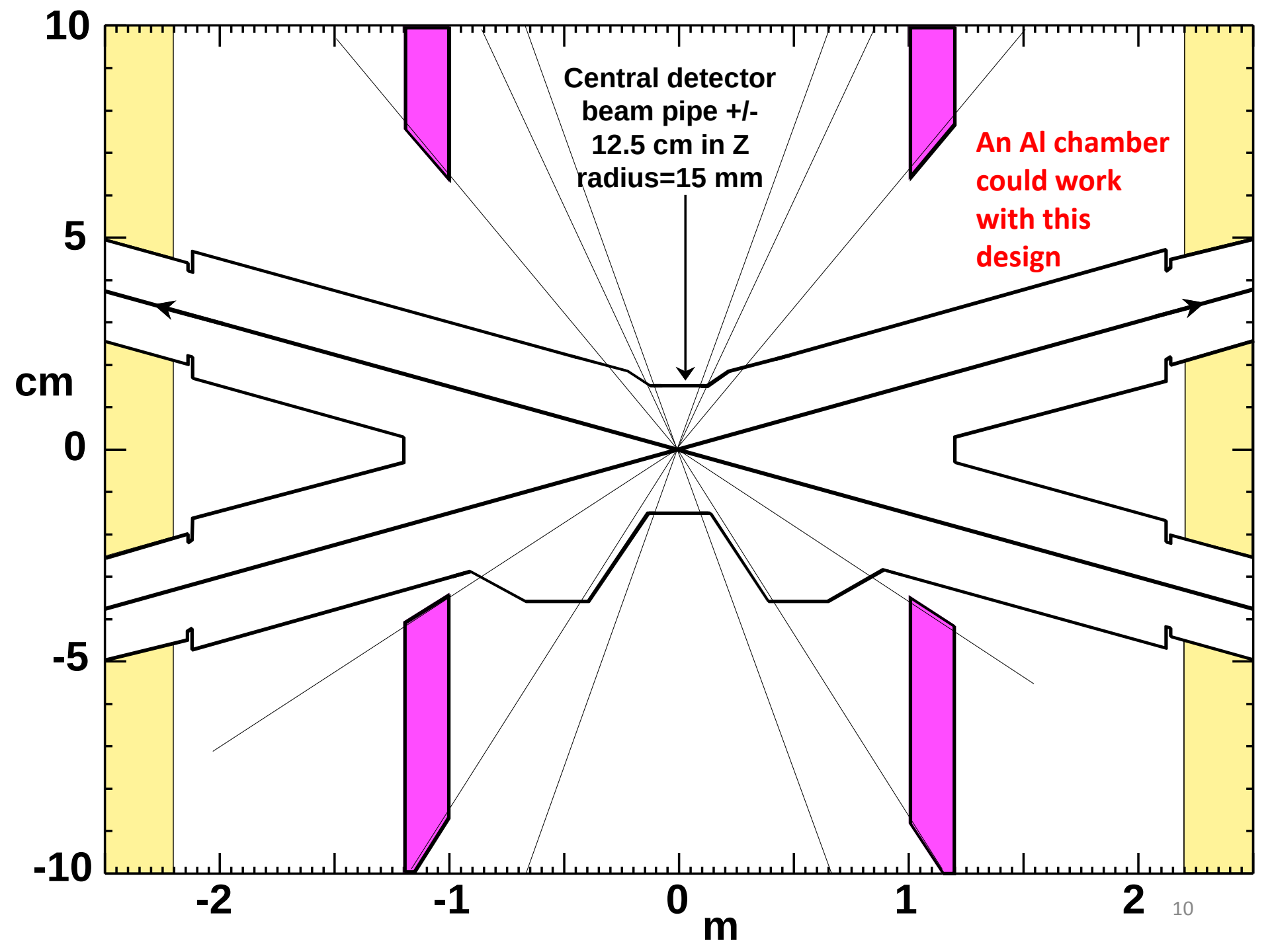
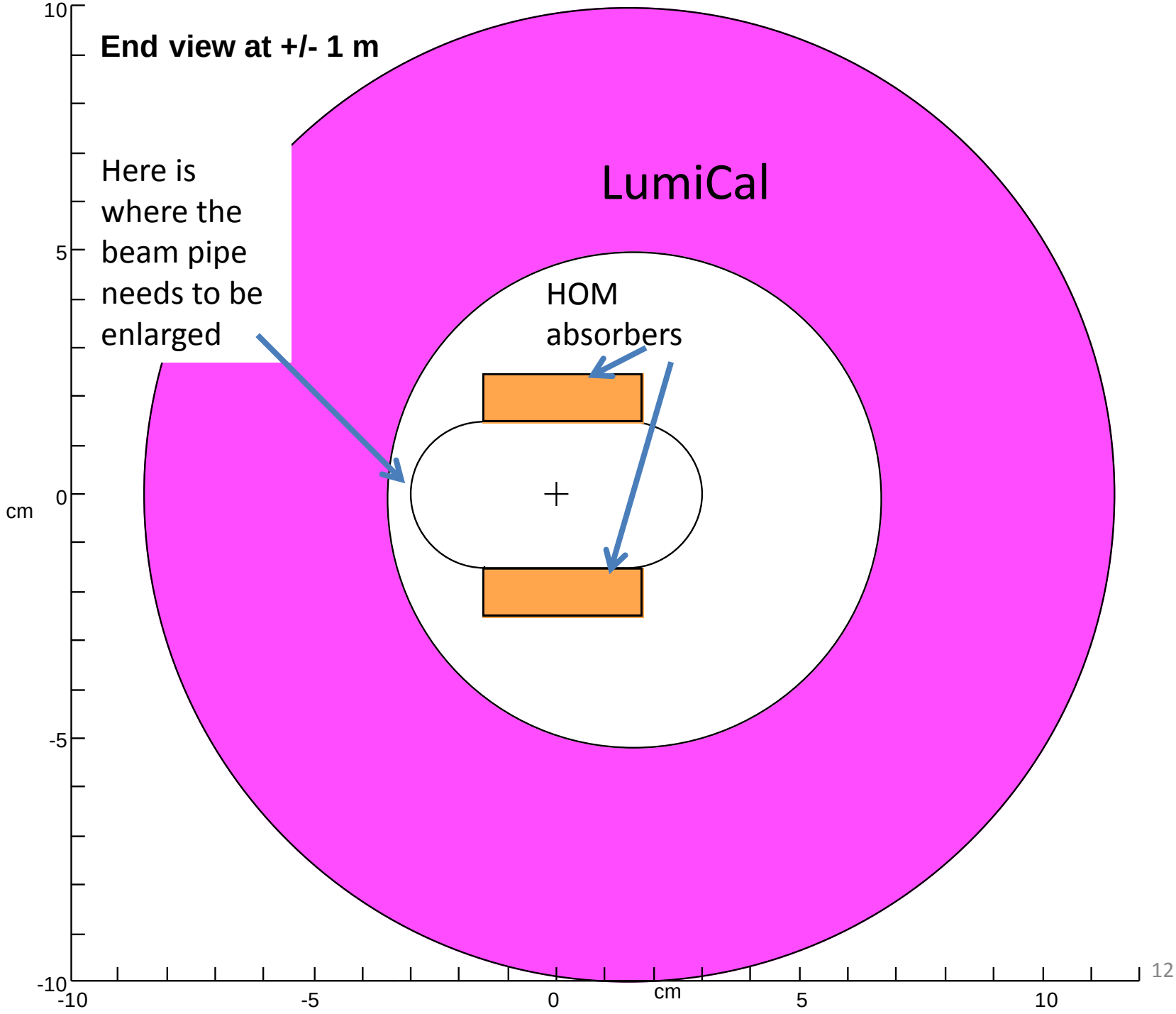
| 2 | 34.91 | 0.034907 | 0.5 | 14.33 | 0.0220 | 2.2 | 0.0597 | 6.0 |
| 2.5 | 43.63 | 0.043633 | 0.5 | 11.46 | 0.0176 | 1.8 | 0.0477 | 4.8 |
| 3 | 52.36 | 0.05236 | 0.5 | 9.55 | 0.0147 | 1.5 | 0.0398 | 4.0 |
| 4 | 69.81 | 0.069813 | 0.5 | 7.17 | 0.0110 | 1.1 | 0.0299 | 3.0 |
| 5 | 87.27 | 0.087266 | 0.5 | 5.74 | 0.0088 | 0.9 | 0.0239 | 2.4 |
| 6 | 104.72 | 0.10472 | 0.5 | 4.78 | 0.0073 | 0.7 | 0.0199 | 2.0 |
| 10 | 174.53 | 0.174533 | 0.5 | 2.88 | 0.0044 | 0.4 | 0.0120 | 1.2 |

- **Which led to …..**


Central detector
beam pipe +/-
12.5 cm in Z
radius=15 mm
An Al chamber
could work
with this
design
10
5
0
-5
-10
cm
-2
-1
0
1
2
m

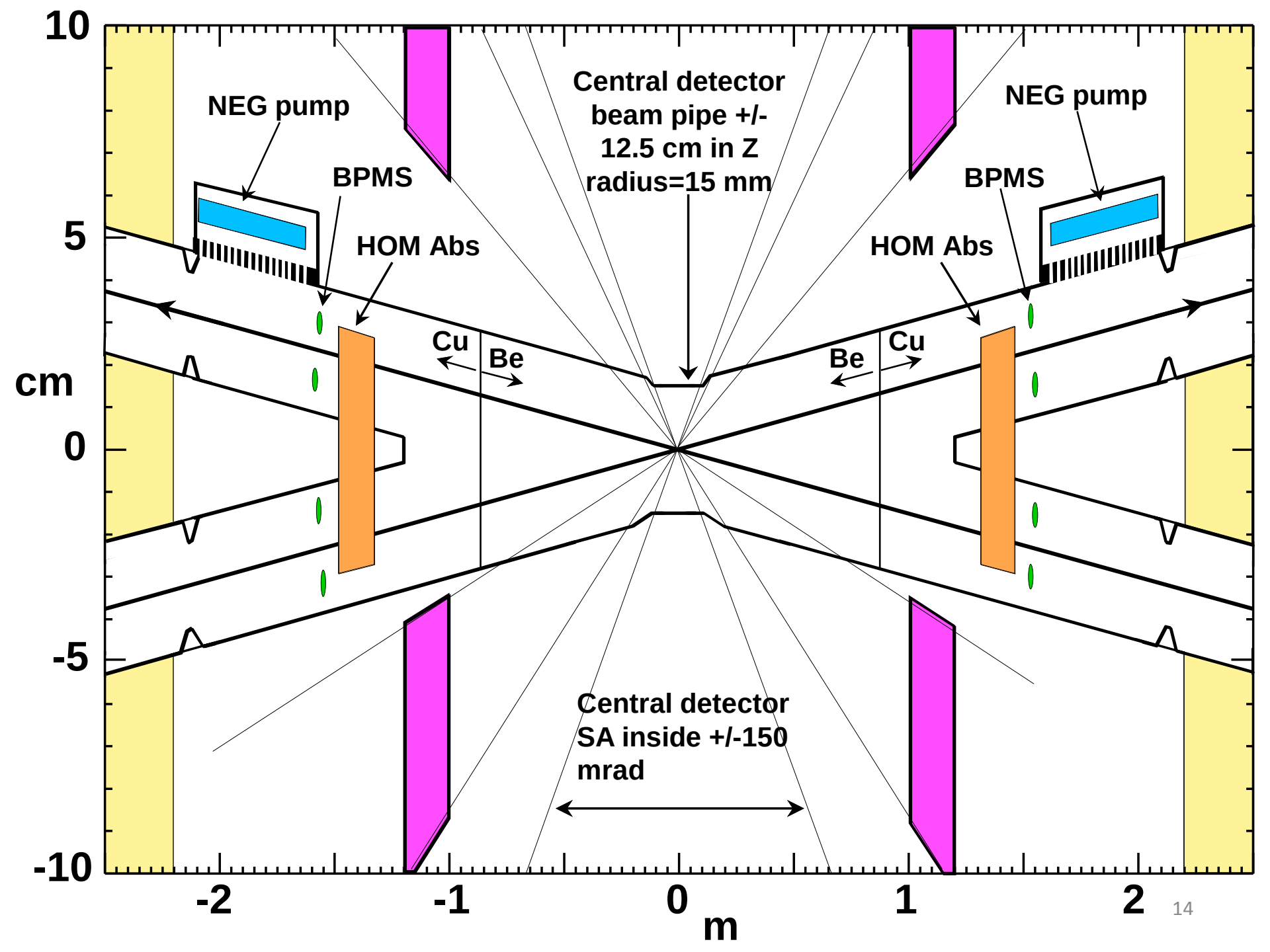
# HOMs

- **Attempt to make minimum angle of incidence 3 deg (50 mrad)**
  - Then chamber could be Al
- **Showed this to Sasha Novokhatski and it was not well received**
  - It makes the cavity larger and adds more HOM power to the region
  - Also the beam pipe bulge is only needed at the part of phi that is close to the other beam pipe


End view at +/- 1 m
Here is where the beam pipe needs to be enlarged
LumiCal
HOM absorbers
10
5
0
-5
-10
cm
-10
-5
0
5
10
cm

# How about Be?

- **So went back to the RL table and decided to be more aggressive and ask for Be**
  - Then we can go down to 1 deg of incident angle and still be below 9% of a RL. This is for a 1 mm thick beam pipe wall
  - Perhaps we can use a thinner wall?
- **Using Be then gets us to this design**


NEG pump
BPMS
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Central detector
beam pipe +/-
12.5 cm in Z
radius=15 mm
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Cu
Be
Be
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Central detector
SA inside +/-150
mrad
10
5
0
-5
-10
cm
-2
-1
0
1
2
m

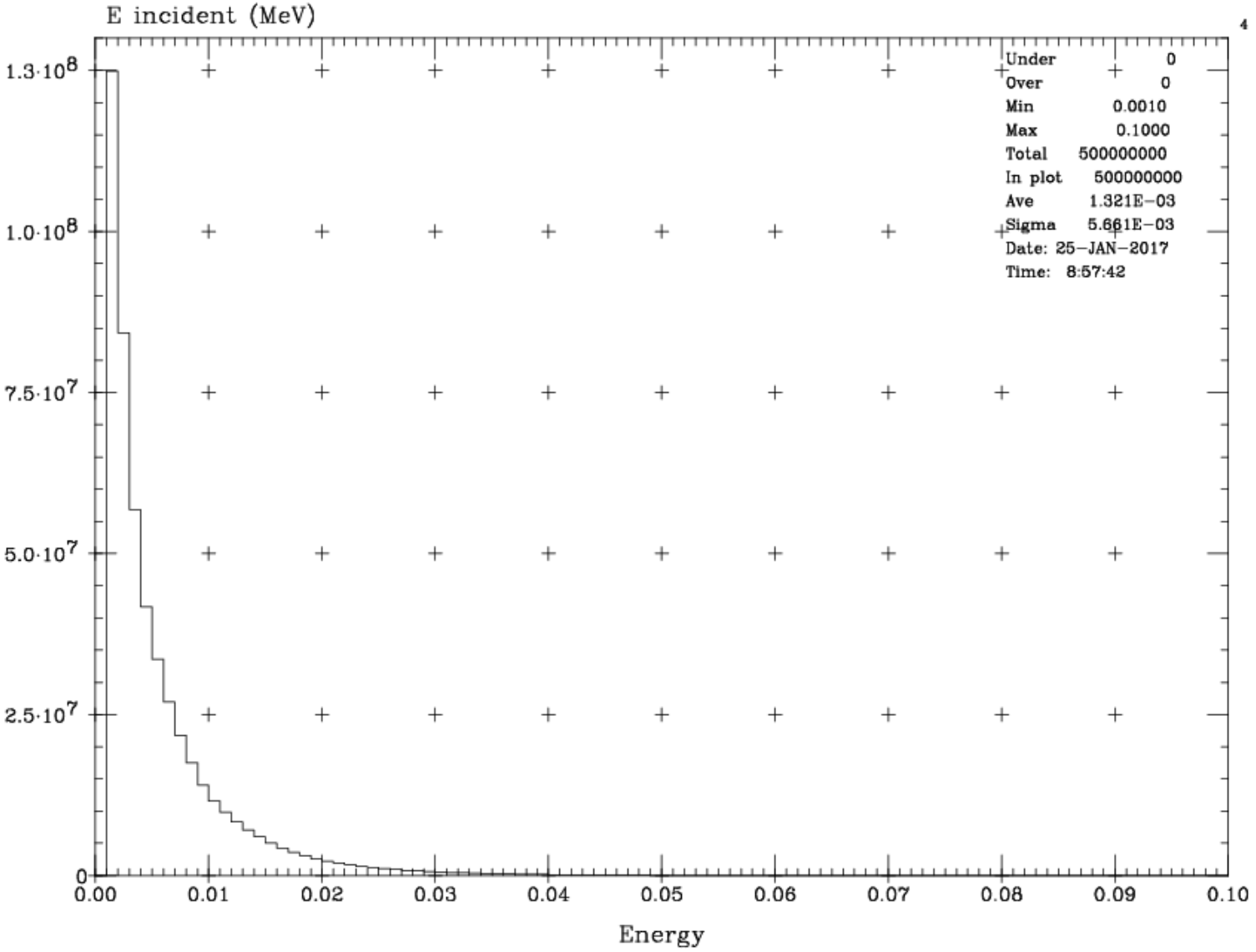
# Features

- The natural chamber wall geometry is OK
- All LumiCal tracks now have a 20 mrad or higher angle of incidence to the beam pipe walls
- There looks to be enough room on the other side of the beam pipe for a NEG vacuum pump
- Now we come to the next question…..

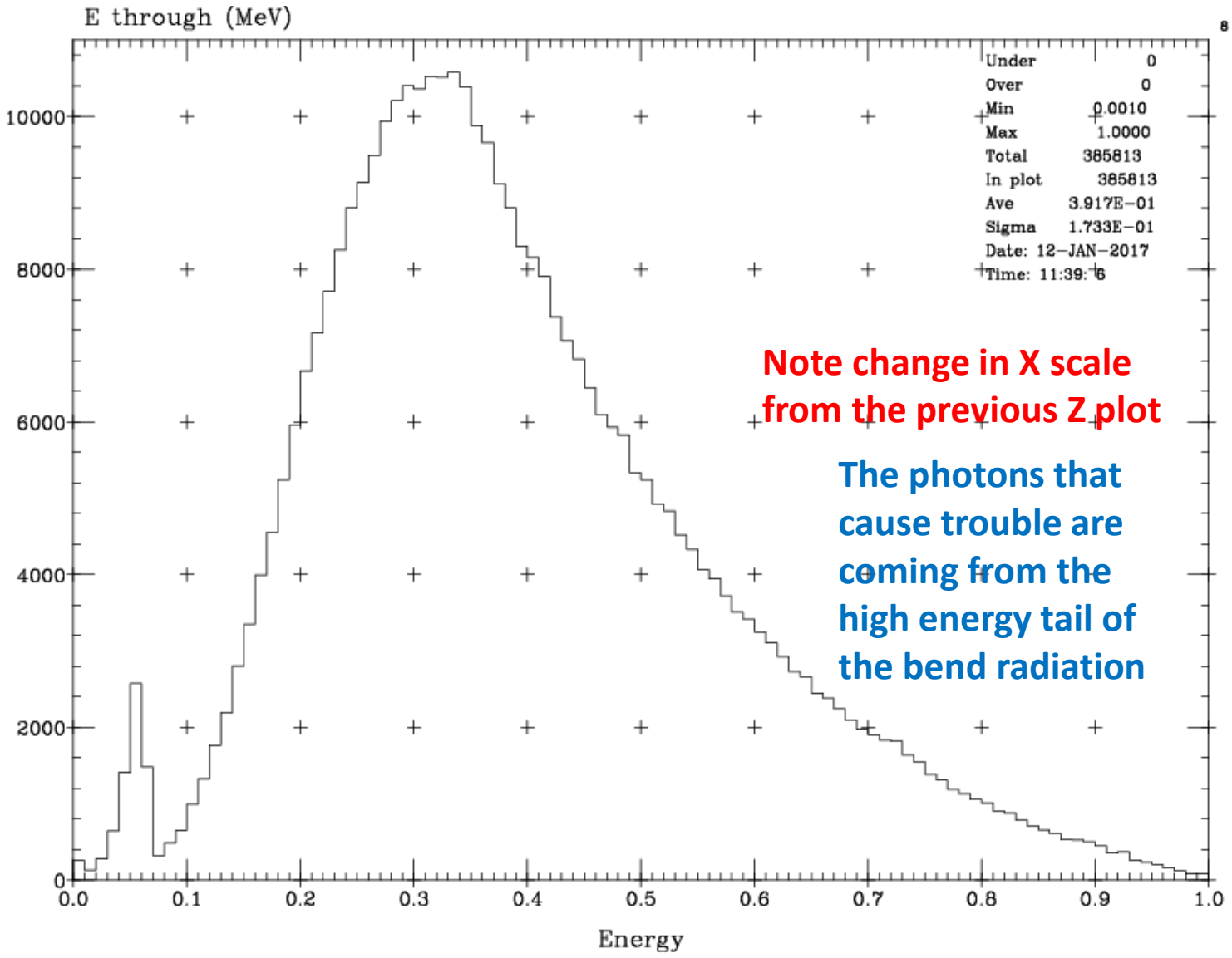
# Shielding

- **The question now arises about shielding the central detector from SR from the last bend magnet**
- **The LumiCal needs a window in the beam pipe where we can no longer put shielding**
- **For the Z running this may not be a big issue**
  - The photon energies are very low (Ave scattered=1.3 keV)
- **But for the Top running this becomes an issue**
  - Ave scattered is 390 keV
  - Effectively the central part of the beam pipe increases from +/-12.5 cm to +/-50 cm due to the LumiCal window
  - This will increase the number of photons going into the central chamber (factor of 10? More?)
  - Simulation comparison will tell us the answer

# Z scattered photon energy spectrum

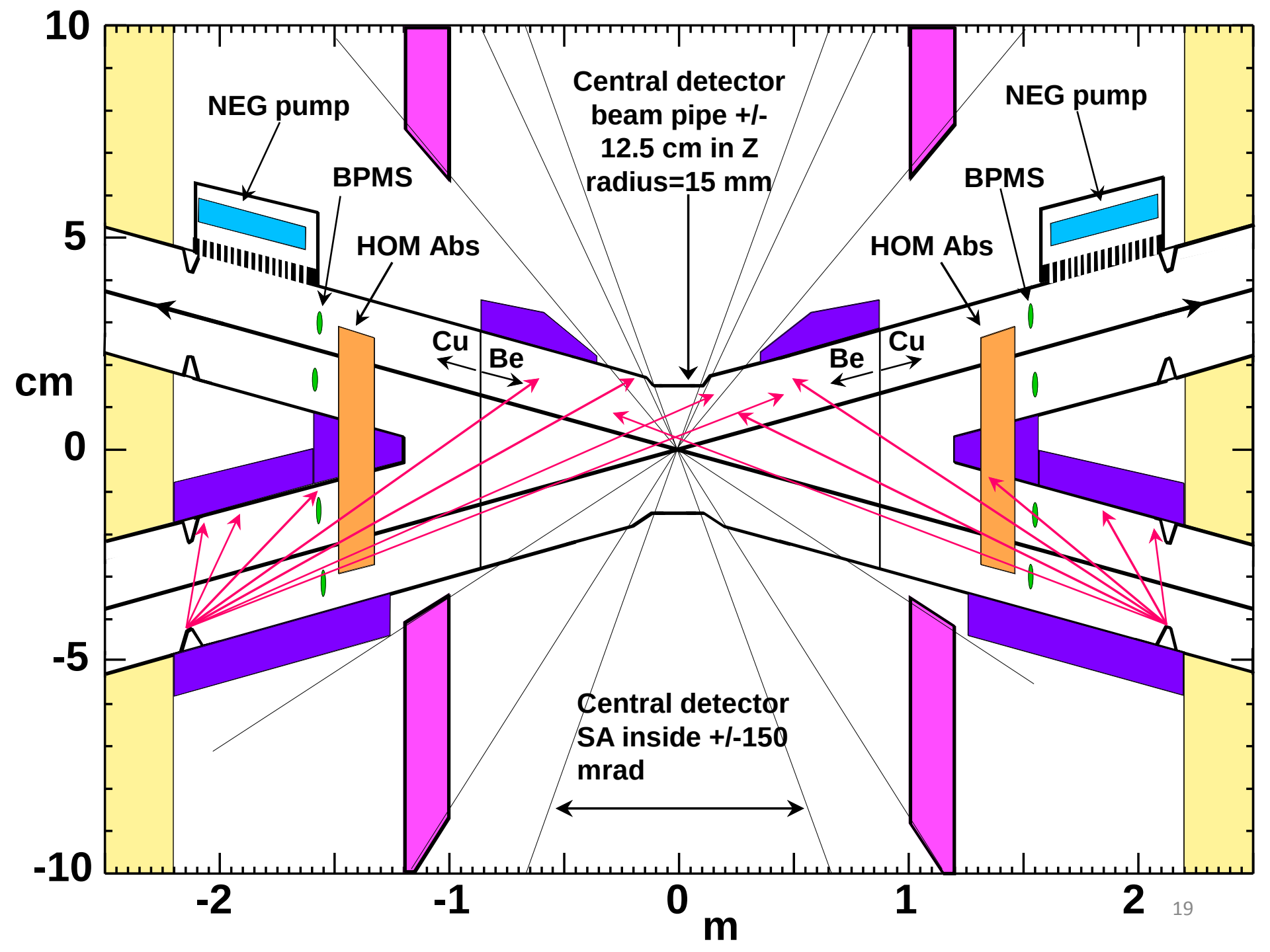


# Top scattered photon energy spectrum




**Note change in X scale from the previous Z plot**

**The photons that cause trouble are coming from the high energy tail of the bend radiation**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beam pipe +/-
12.5 cm in Z
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Central detector
SA inside +/-150
mrad
10
5
0
-5
-10
cm
-2
-1
0
1
2
m

# For the Top running

- $1.9 \times 10^9$ photons incident on the mask tip every beam bunch
- 3.87% scatter through the mask tip
- About 1% can scatter through 2 cm of Ta
- This means about 700,000 photons go into the central detector region every beam crossing – too many
- We will need to add as much shielding as we can in order to cut this rate down
- We may need to ask for a yet softer bend magnet for the last 10% of the current soft bend

# What about the Higgs?

- **Scattered SR photon energies will increase from the Z**
  - The critical energy of the last soft bend magnet
  - For the Top – 100 keV
  - For the Higgs – 40 keV
  - For the Z – 1.7 keV
- **Needs to be looked at as a separate case**
- **More simulation runs with the GEANT4 model of the beam pipe**
- **Do we want/need the LumiCal for the Higgs?**
- **Stay tuned……**

# Summary

- The LumiCal looks OK at the Z running
- We need a Be beam pipe for the LumiCal window in order to minimize the RL to the LumiCal and to minimize the HOM power in this region
- The LumiCal window will cause central detector SR backgrounds to increase at the Top running because of the high energy of the scattered photons and some reduced shielding

# FF quads

- Magnet designs are converging and the next big step is to get initial dimensions for the cryostats
- Can we have warm bores as asked?
- How much actual space is needed for the magnets and correction coils and compensation coils

# Conclusions

- A great deal of progress has been made in deciding on baseline parameters and general layout of the IR
- SR at the Z does not seem to be a big concern due to the very low photon energies
- SR backgrounds at the Higgs and Top will be more of an issue. The photon energies are significantly higher.