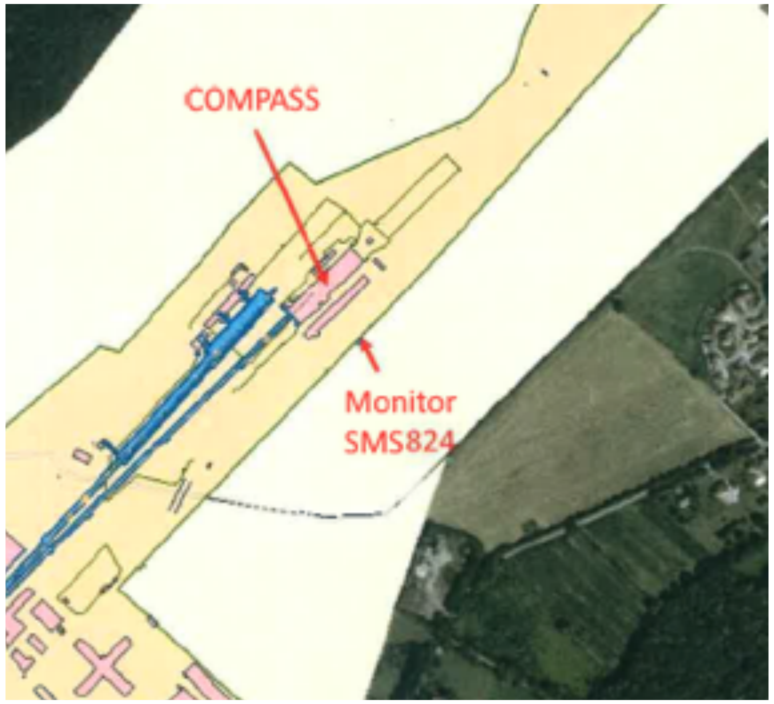
Monitoring of 2018 radiation dose

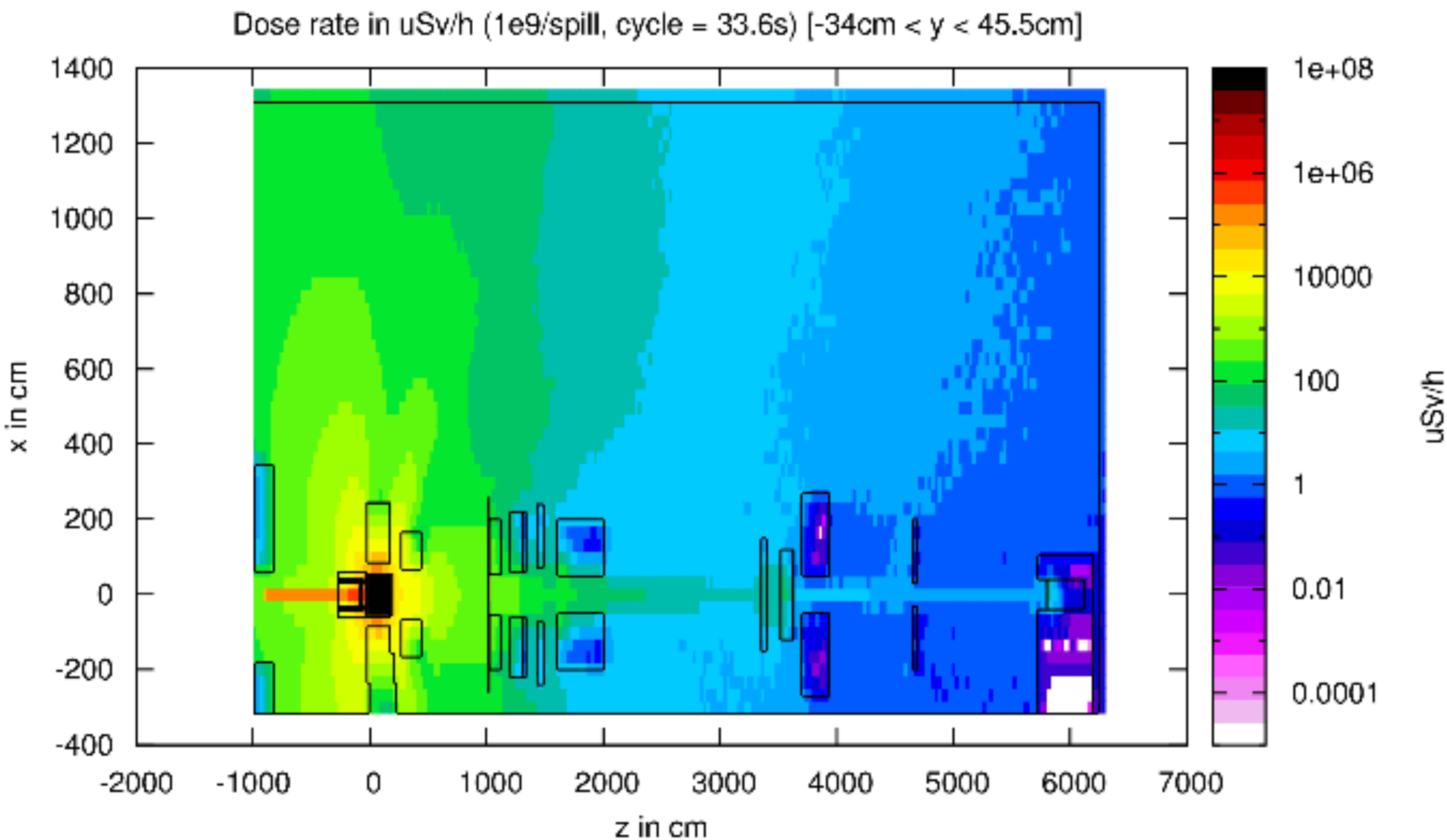
- Main players: Angelo from COMPASS and Heinz Vincke from Radio Protection. FLUKA simulations. Meetings with Heinz Oct. 19 & Nov 3.
- Max. allowed integrated dose is 1 mSv / year in public area, monitors PMSG824 for photons and PMSN824 for neutrons (Christophe added them to DCS).
  - 2015 measured: 0.745 mSv
  - FLUKA with 2e14 pions on target: 0.75 mSv
- Max. allowed instantaneous dose is 2.5μSv / hour in low-occupancy areas (<400h/y), this includes the street! **We are above this level.**
- 7% more beam days in 2018. To not exceed radiation limit:
  1.) Decrease beam intensity, in particular in the beginning during commissioning
  2.) Improve shielding. Very recent conclusions:
  - Extra shielding on top and side of absorber does not improve radiation level. We will in particular forget about the polyethylene, which is anyway a safety concern (flammability)
  - Only an "umbrella" that covers also (part of) the target is effective.

Michela about 2015 run:
- We were running at higher intensity (4.2*10^8) in the first periods.
- From period 5 we started to decrease a bit intensity running at <= 3.8*10^8 pions/spills, and data taking was more stable.



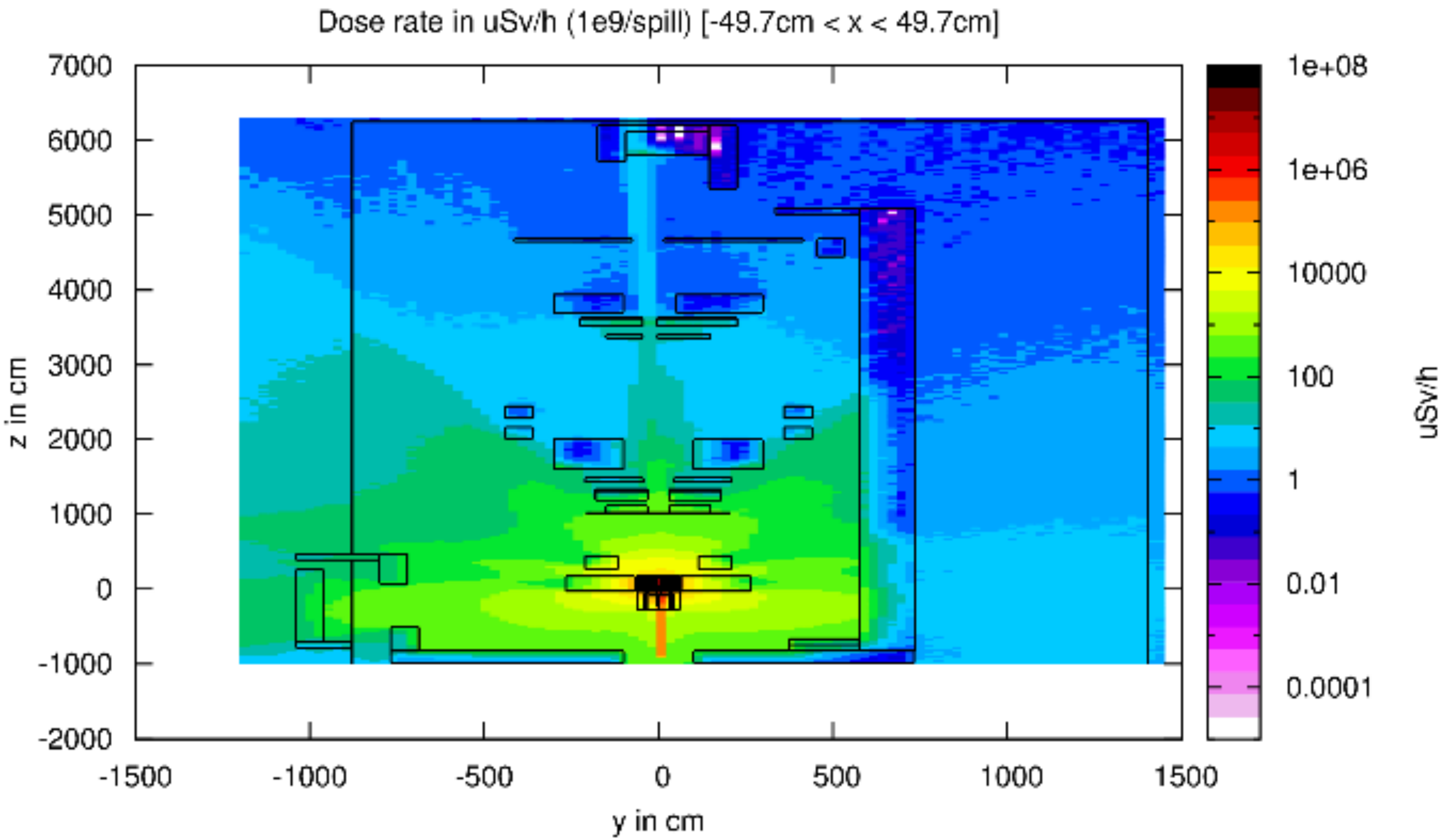
	2015	2018
beam period	April 27 - Nov 16	April 9 - Nov 11
days	203	217
physics days (w/o MD)	106	**140** (projected)
SPS efficiency	86%	
average beam intensity [pions/spill]	3.9E+08	
good spills delivered to COMPASS	486,476	217/203 x 486,476= **520,026** (projected)
pions on COMPASS target	1.9E+14	
integrated dose	0.75 mSv	

Heinz Vincke's FLUKA: side view

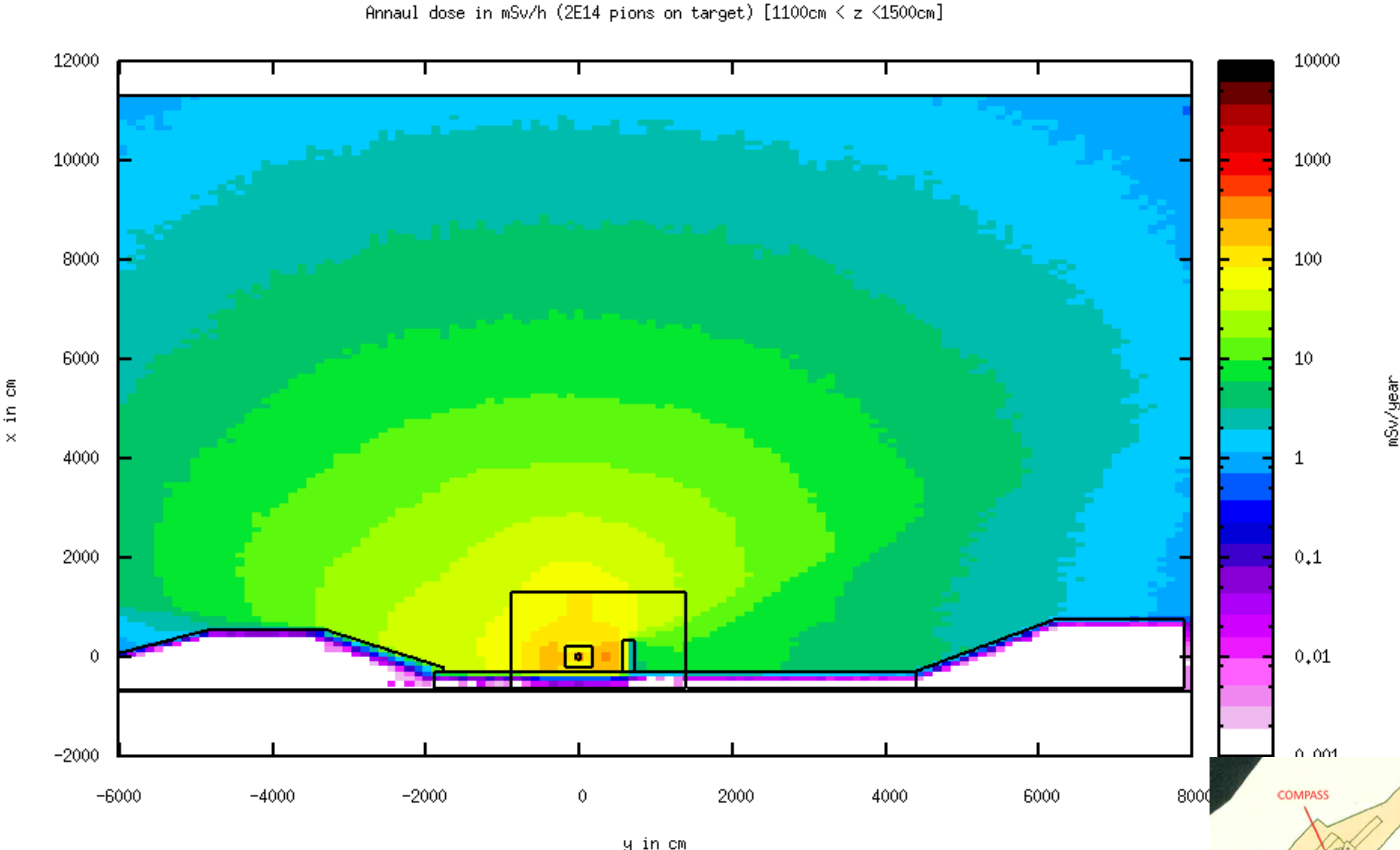


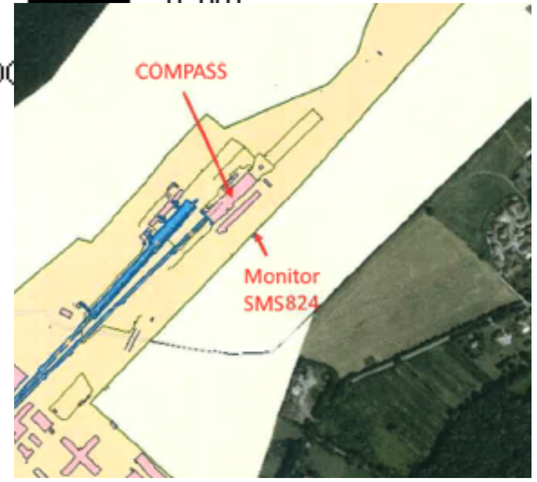
Lots of backward radiation, mostly high-energetic neutrons

Heinz Vincke's FLUKA: top view

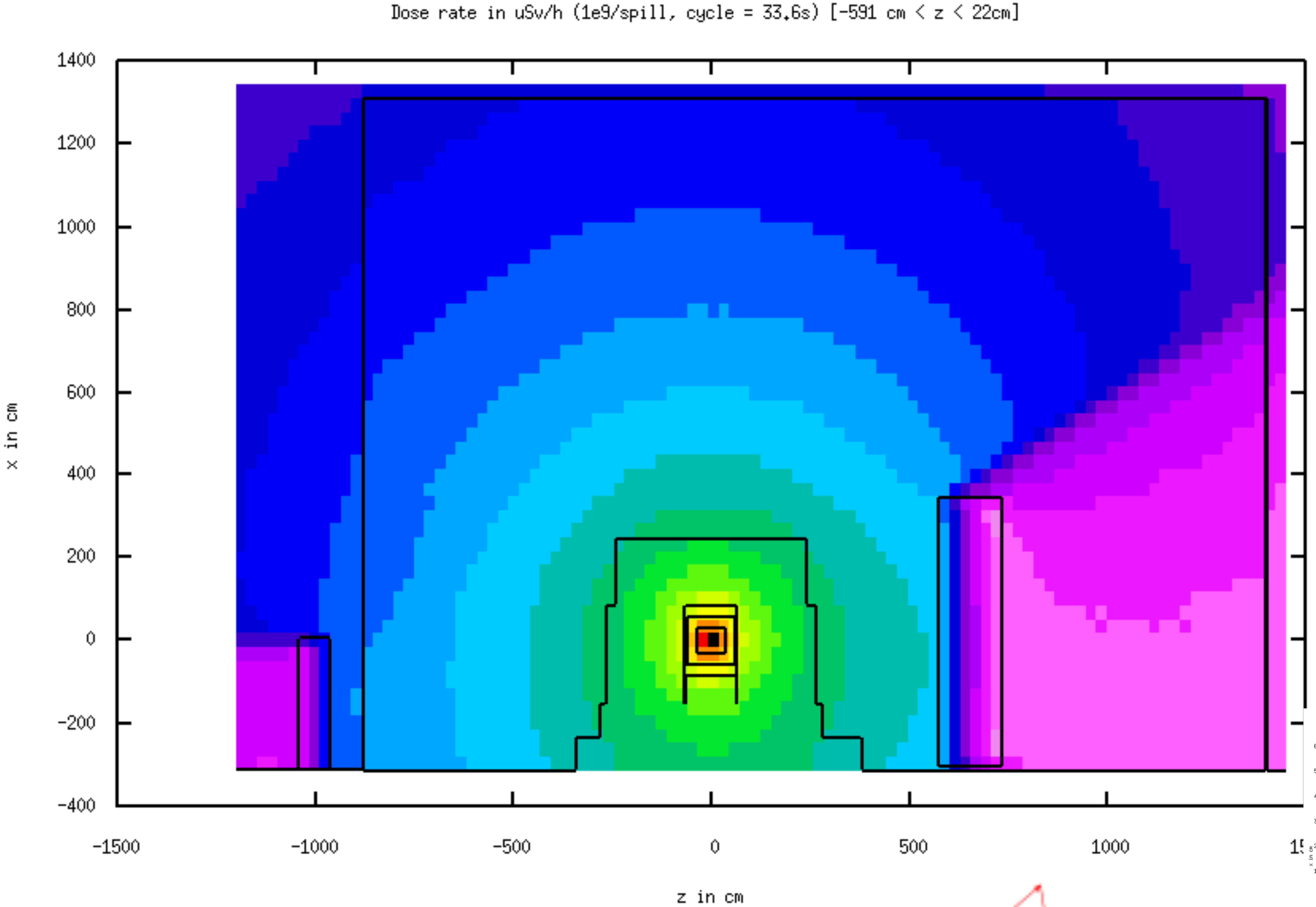


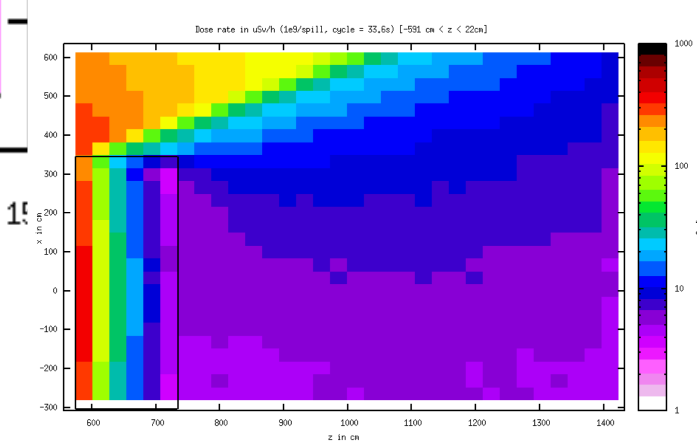
Heinz Vincke's FLUKA: front view

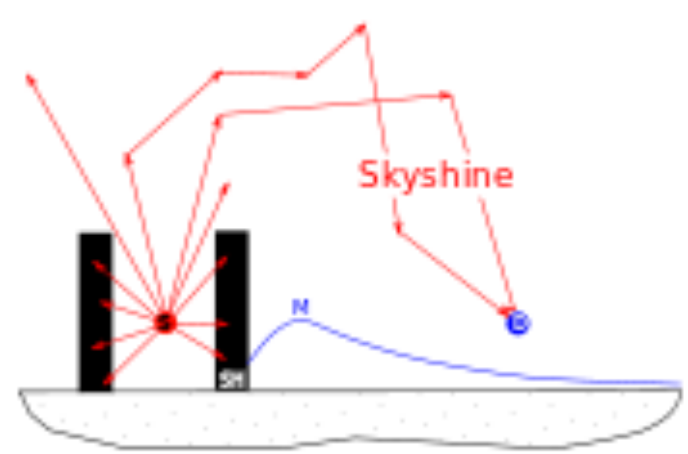




Heinz Vincke’s FLUKA: front view zoom

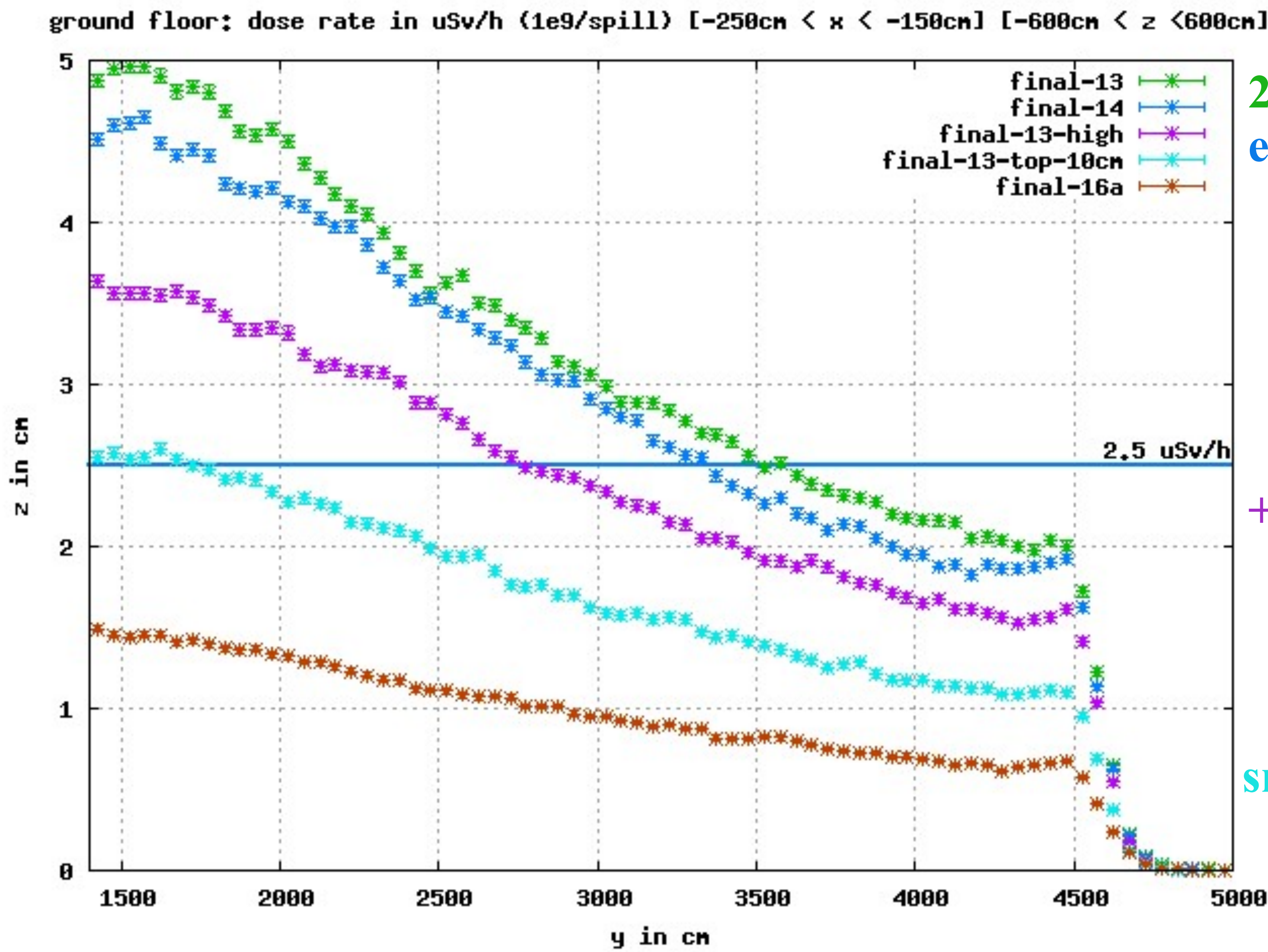






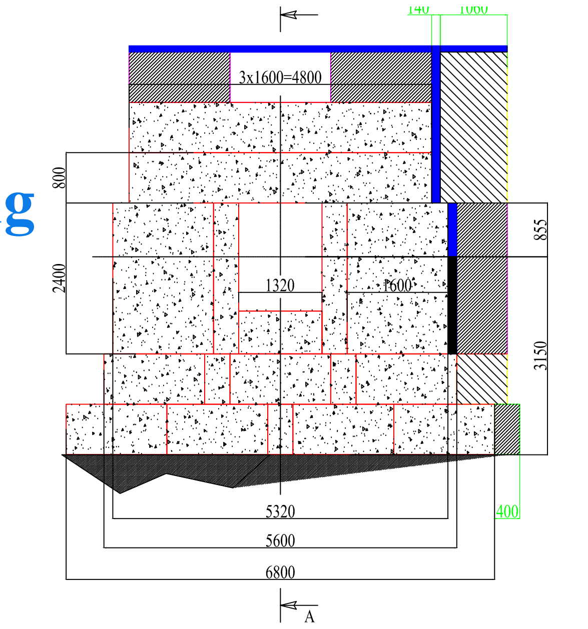
https://en.wikipedia.org/wiki/Skyshine

Heinz Vincke's FLUKA: different shieldings

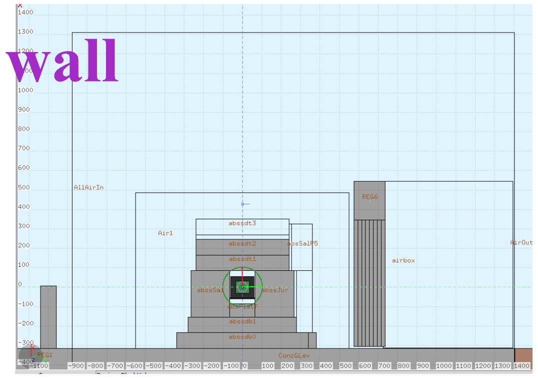


2015

extra shielding

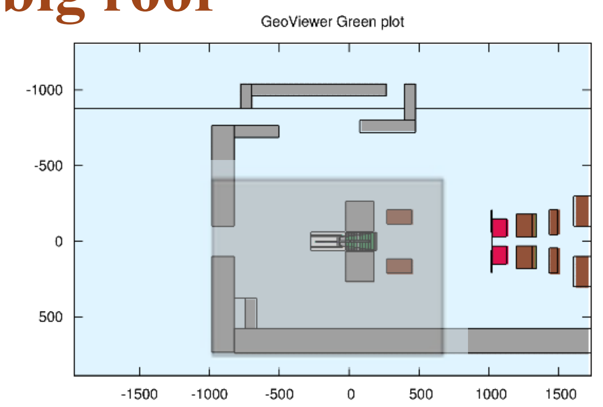


+2m concrete wall



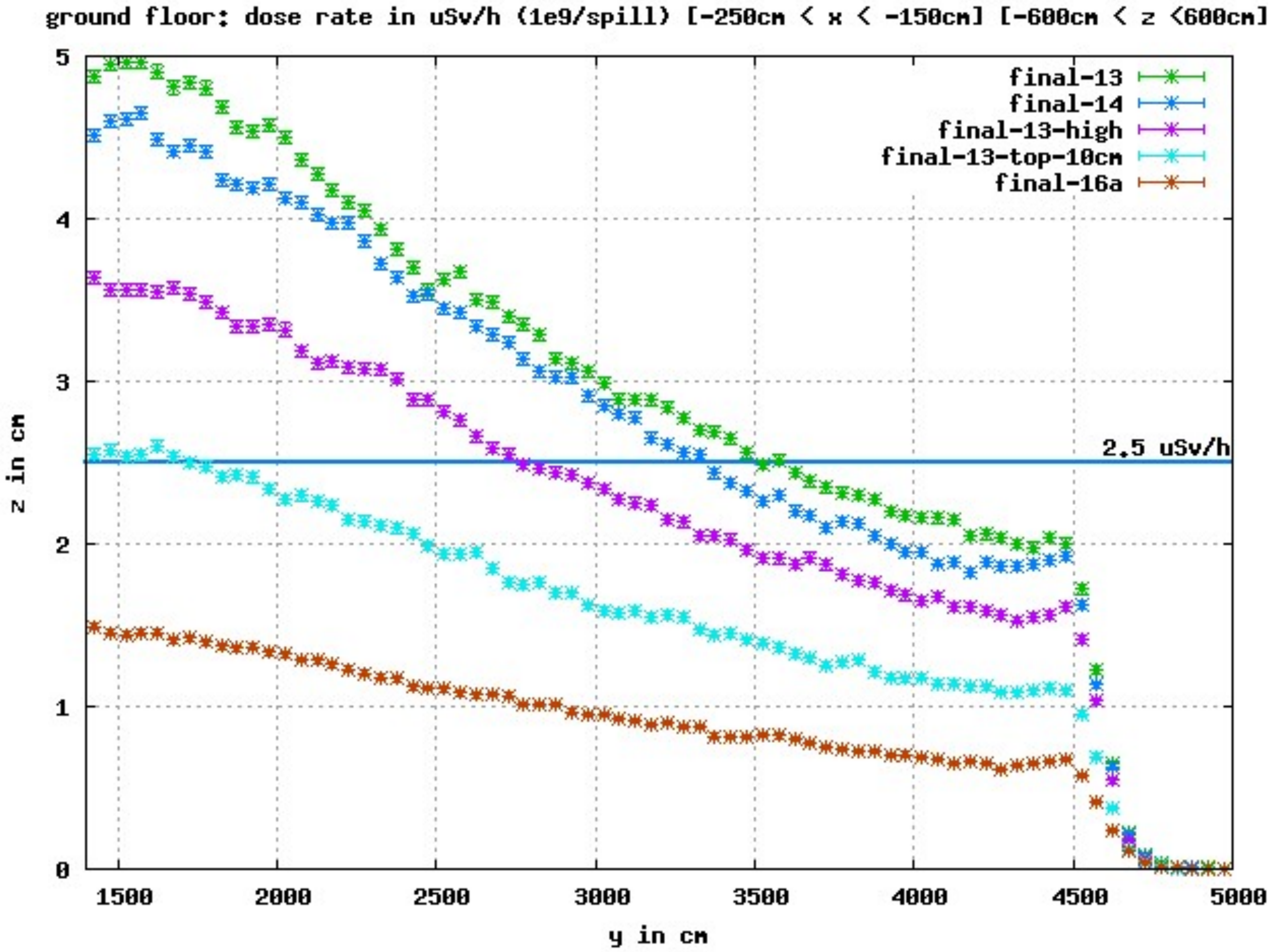
small roof

big roof



2018 beam conditions

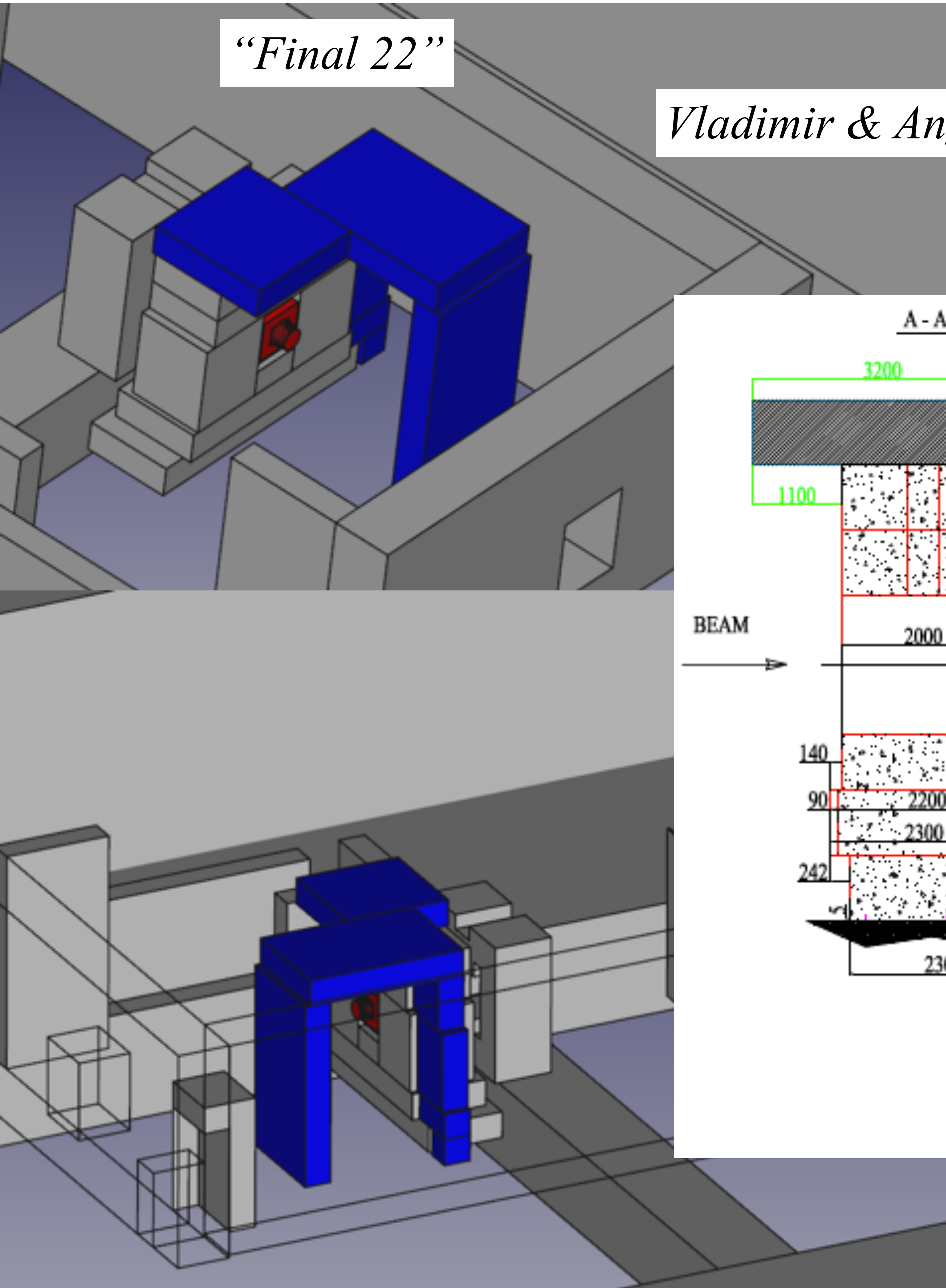
- **Simulation:** 1e9 pions / spill, 1 spill / 33.6 sec, **2.95e7 pions / sec**
- **2015**: 3.9e8 pions /spill
- **2017**: 1 spill / 23 sec
- **2018**: 3.8e8 pions / spill, with 2017 spill frequency: **1.65e7 pions / sec**
- Simulation overestimates by factor of 2.95/1.65 = 1.8

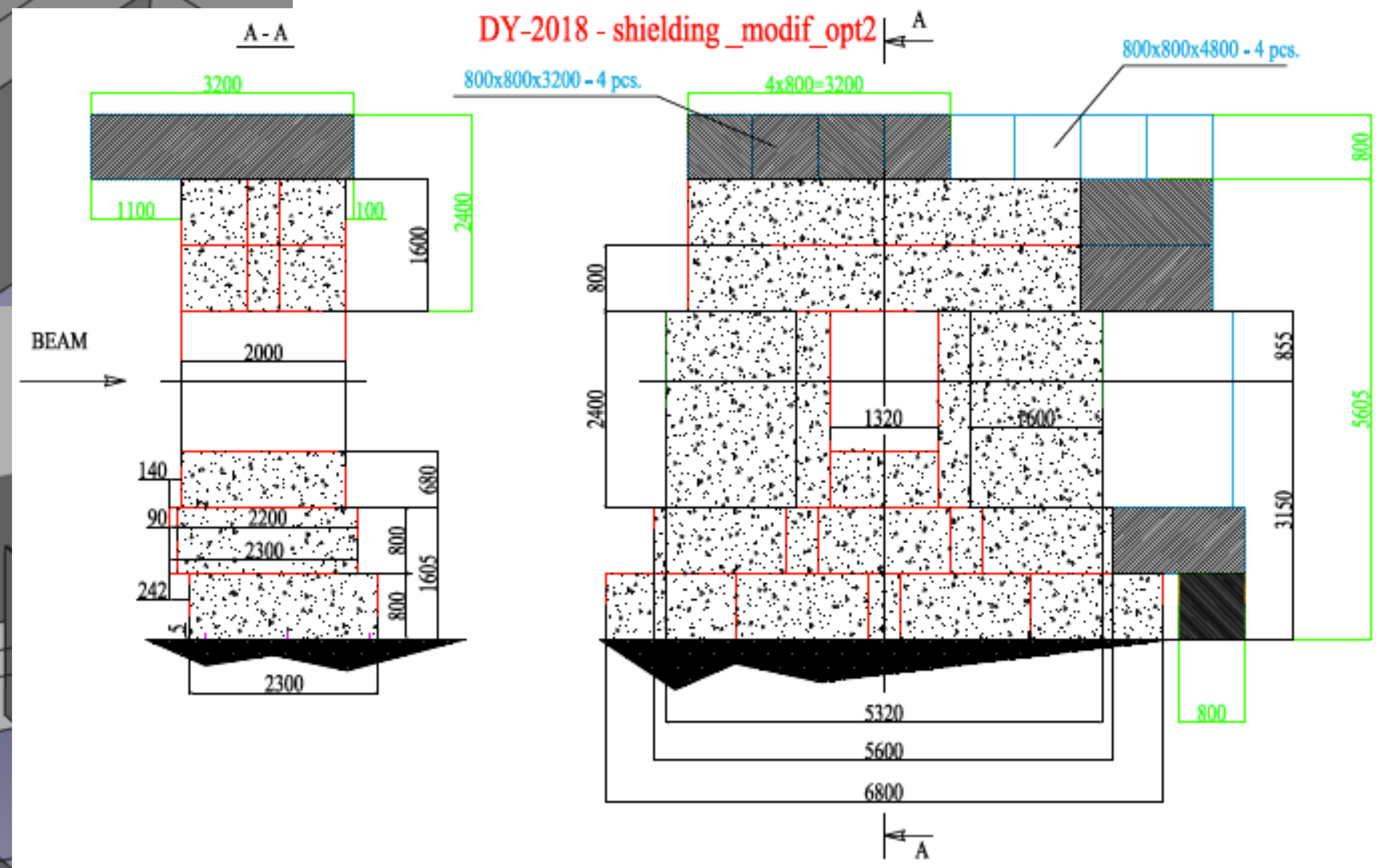


A new target umbrella?

"Final 22"

Vladimir & Angelo Nov 3/4



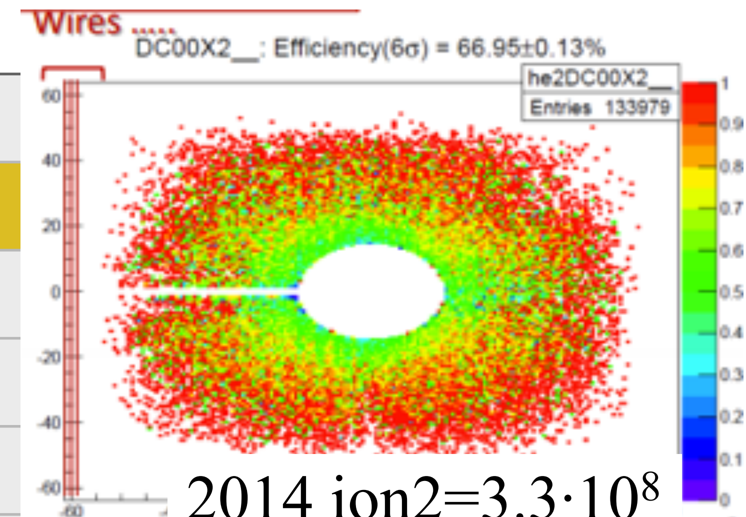


^{6}Li absorber

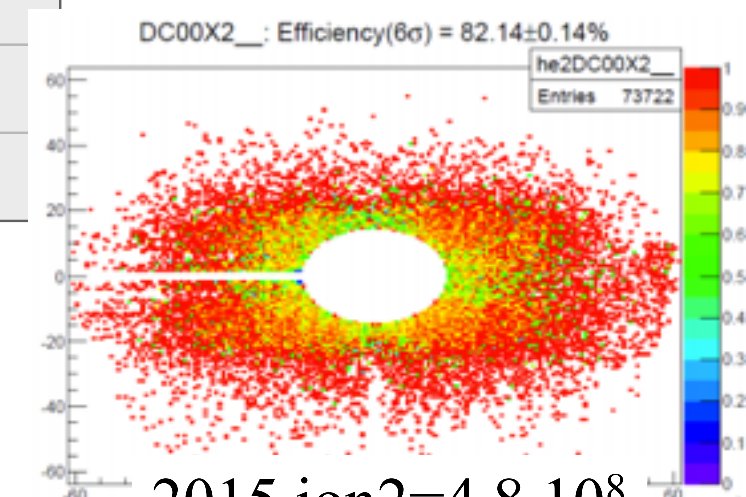
DC0 efficiency & MM rates 2014 vs. 2015

	no ^{6}Li	2 ^{6}Li sheets		
DC0-eff [%]	2014	2015	2015	2015
ion2 [10^8]	3.3	3.4	4.8	1.8
X1	83.0	91.5	89	92.3
X2	**66.9**	84.6	**82**	91.5
Y1	83.0	90.1		
Y2	83.3	90.6		
U1	74.7	84.6		
U2	72.1	84.1		

efficiency numbers based on one example run.



2014 ion2=$3.3\cdot10^8$

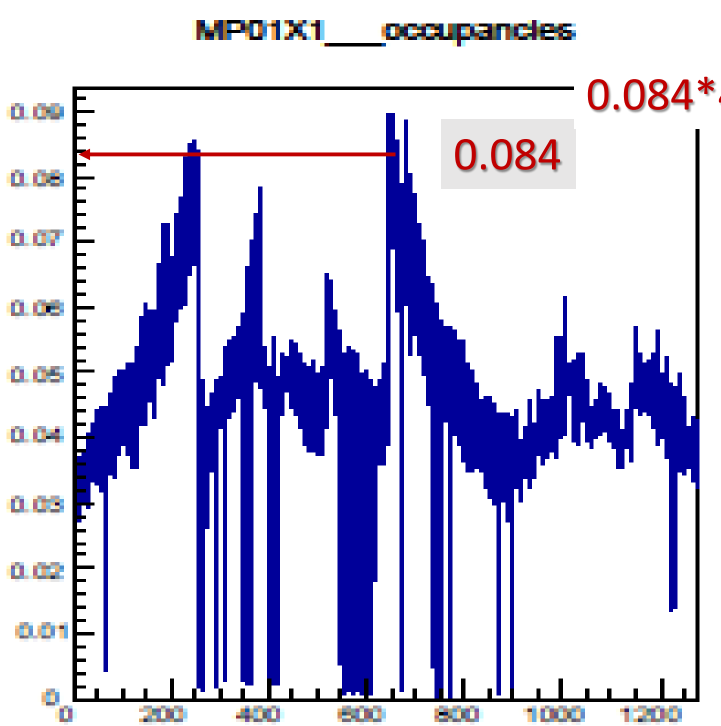


2015 ion2=$4.8\cdot10^8$

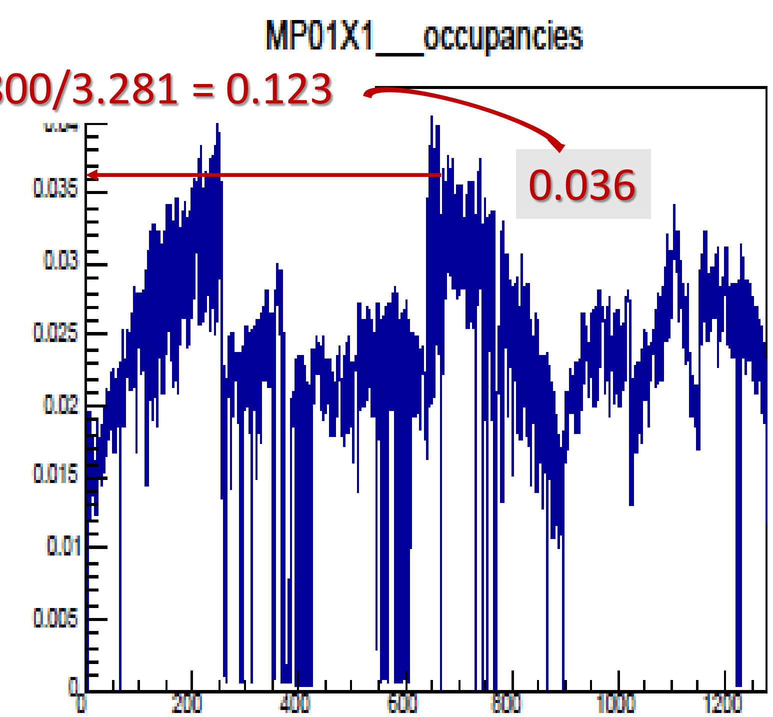
plots from Alain

DY 2014
Run 255039 μ_IonCh = 3.281*10^8

DY 2015
Run 258283 μ_IonCh= 4.800*10^8

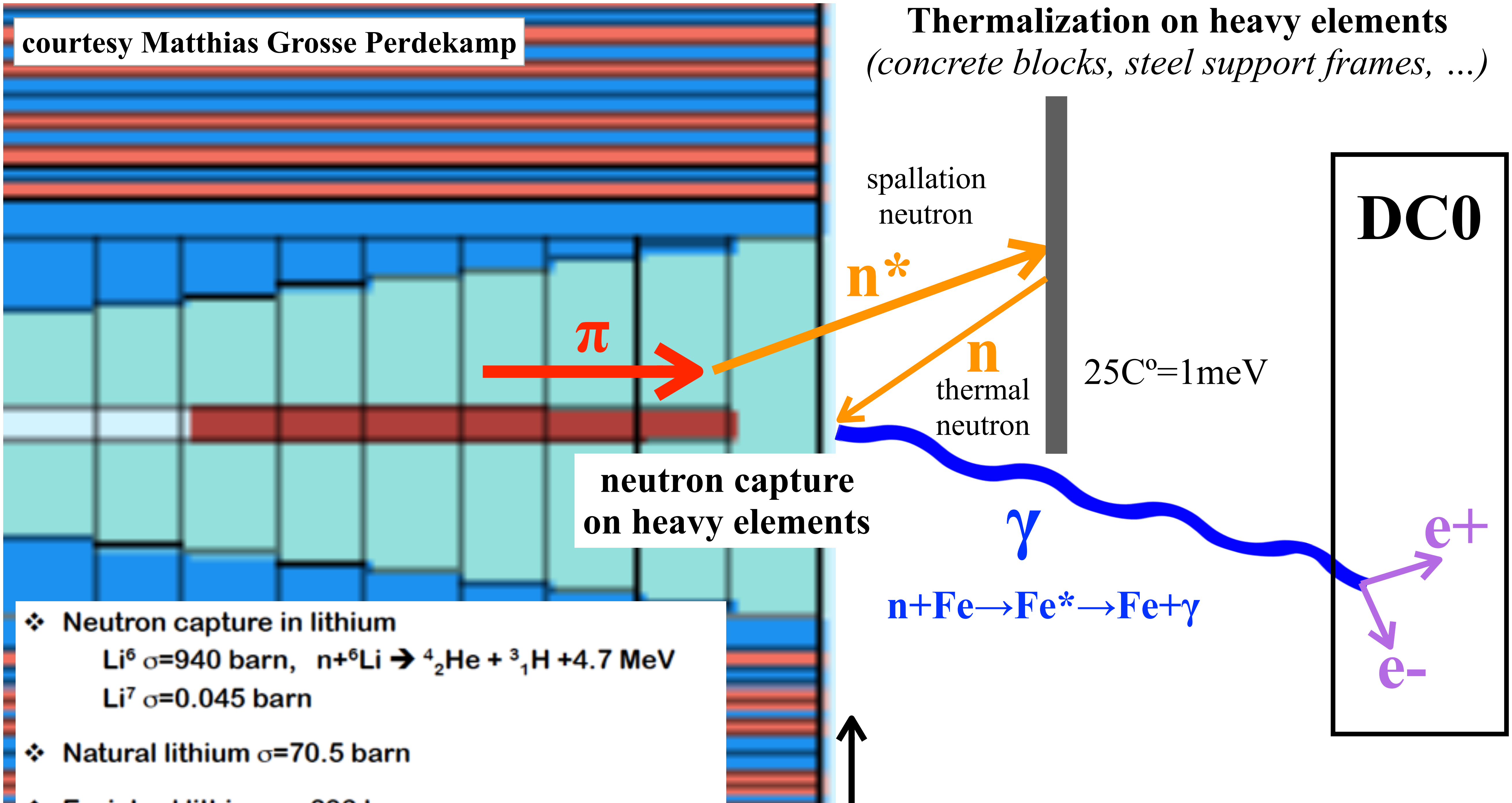


0.084*4.800/3.281 = 0.123



Might be difficult to judge because also DC0 protection resistors were exchanged - before or at the beginning of the 2015 run (?).
But: MM rates! (left)

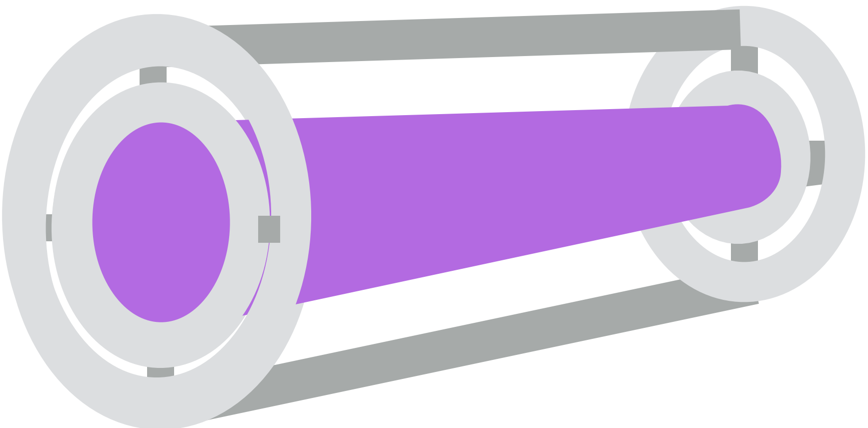
$^{6}LiCO_{3}$: principle



- Neutron capture in lithium
  - Li^6 σ=940 barn, $n+{}^6Li \rightarrow {}^4_2He + {}^3_1H$ +4.7 MeV
  - Li^7 σ=0.045 barn
- Natural lithium σ=70.5 barn
- Enriched lithium σ=893 barn
- Absorption length
  - Enriched d=1.5 mm reduce th. neutron flux to 1%
  - Natural λ=20mm reduce th. neutron flux to 1%

Insert neutron absorber here:
- Both Li and Bo are good in absorbing low-E neutrons
- **n + ^{6}Li → ^{3}H + ^{4}He :** ***stop in air, do not reach DC0***
- **n + B → B* → B + γ_500 keV :** ***reaches DC0***

Extra slides



Proposal for a secondary nickel target in 2018 (Alexey Gushkov)

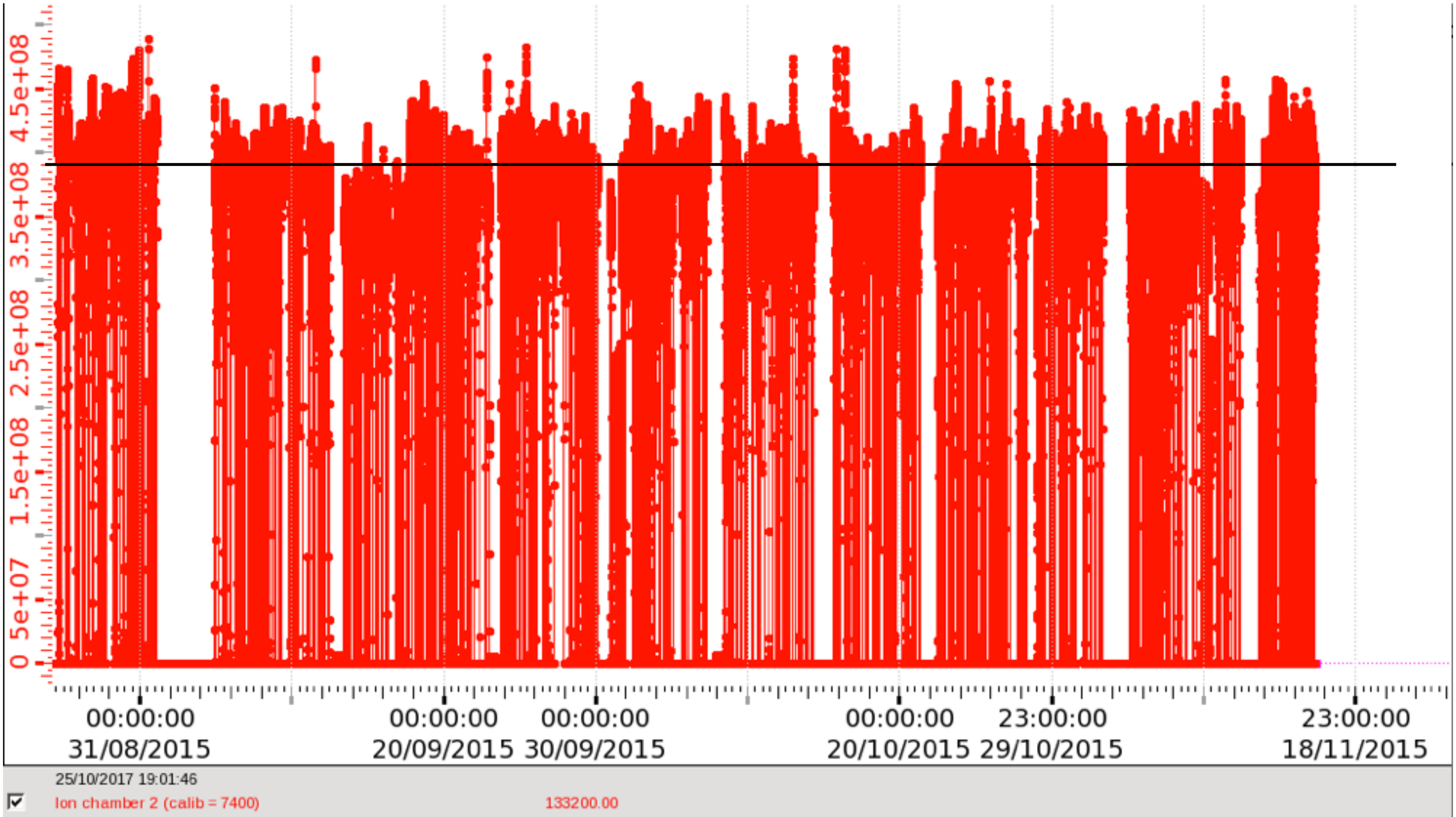
- 2015 statistics for M>5 GeV (we cannot use cut >4.3 or >4.5 due to worse mass resolution for tungsten plug.):
  ~600 evts in Al and ~11,000 events in the first 15cm of W.
  Mass resolution for DY >5 GeV in Al is about 5 cm, for J/psi - 7-8 cm.

- Assuming 2 times larger integrated luminosity in 2018 we would expect for 10 cm Ni target:

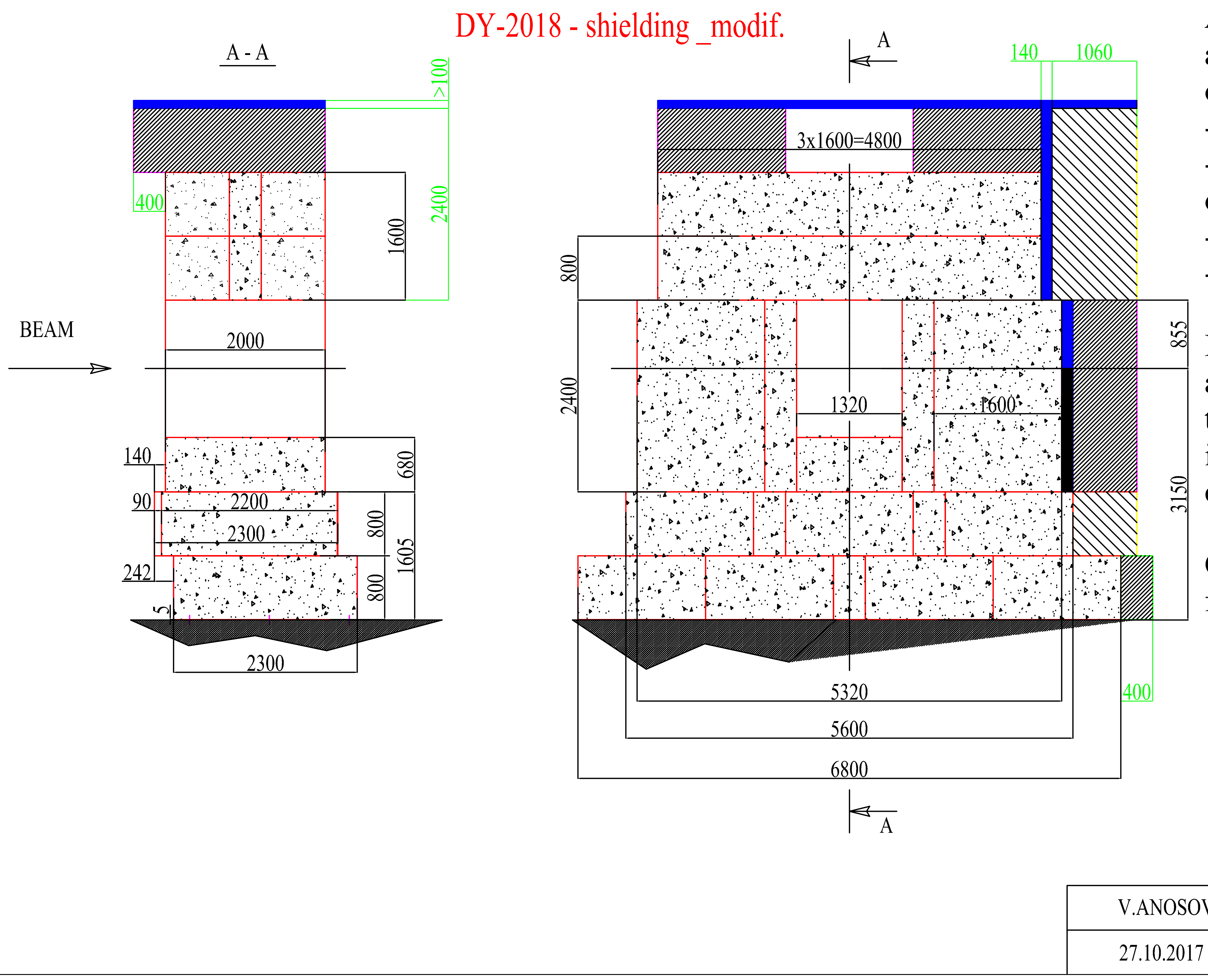
  - **Ni 10cm** : 4,000 events in Ni and 12,500 in the first 15cm of W .
  With this statistics we can expect the statistical accuracy for Ni in the region 0.3<x2<0.4 of about 6.5%, which is comparable with the EMC effect itself, and ~20% at x2>0.4.

  - **Ni 5cm**: 2,200 events in Ni and 16,700 in the first 15 cm of W.

Beam intensity: no reduction towards the end (despite radiation alarm)



2018 additional shielding (outdated…)



Additional shielding for hadron absorber:

on Saleve side:

- 80cm concrete
- 14cm borated polyethylene

on top:

- 80cm concrete
- 25cm borated polyethylene

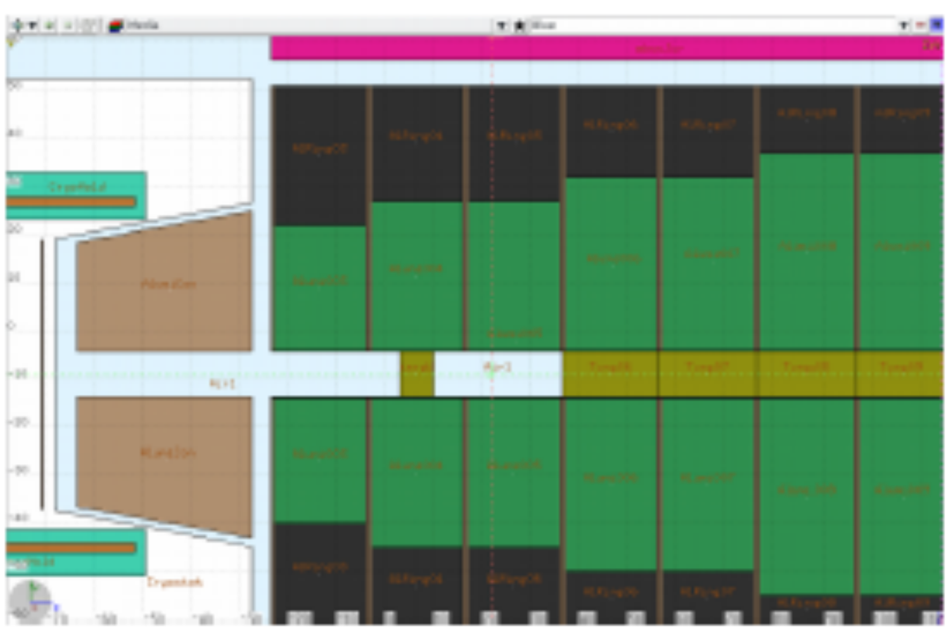
In addition considered: additional concrete blocks on top of the wall, where not impossible due to target cryogenics lines

Concern: polyethylene is flammable

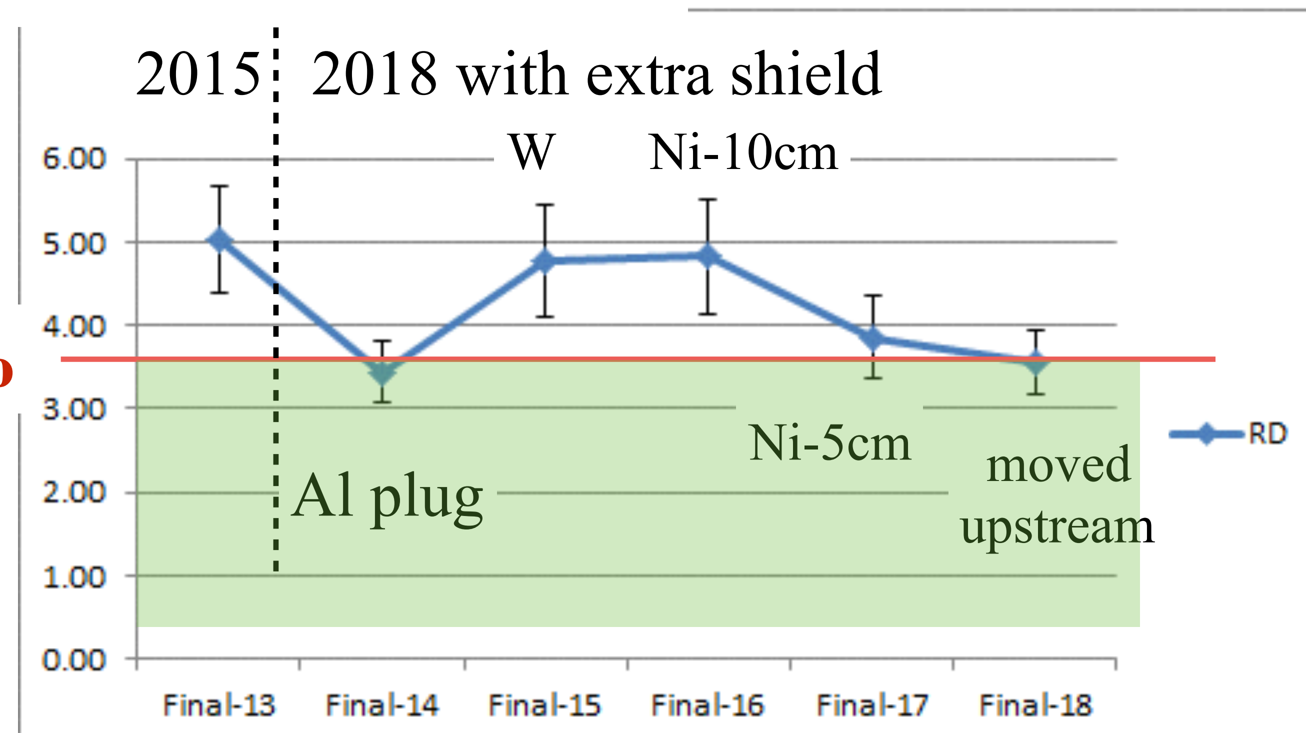
Angelo's FLUKA simulations October 2017

Additional shielding on top and Saleve side of hadron absorber:
14cm polyethylene (only Saleve), 80cm concrete

configu ration	Mean dose in control room (µSv/h)	Dose Reducti on	note	normalized to Fi-14
Final-13	5,04 ± 0,64	0%	configuration of 2015 run – secondary Al target included – no additional shield	147%
Final-14	3,44 ± 0,36	-31,7%	Final-13 + additional shield	100%
Final-15	4,76 ± 0,67	-5.5%	Final-14 + tungsten target	138%
Final-16	4,83 ± 0.69	-4.2%	Final-14 + 10cm nickel target	140%
Final-17	3,85 ± 0,50	-23,6%	Final-14 + 5cm nickel target	112%
Final-18	3,56 ± 0,39	-29,4%	Final-14 + 5cm nickel target, begin II layer	103%



-30%



40k primaries

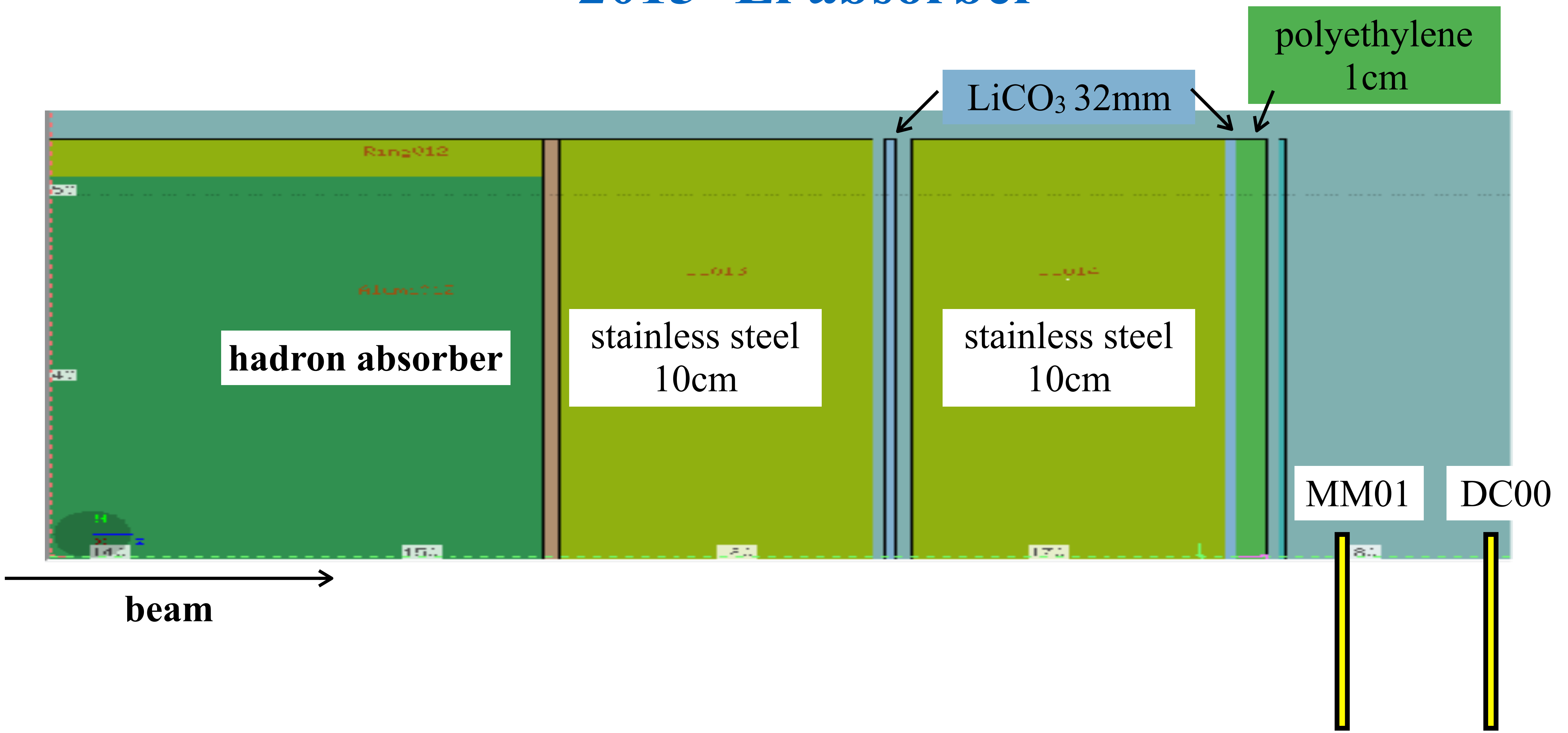
configuration	Mean dose in control room (µSv/h)	Dose Reduction	note
Final-13	5,04 ± 0,64	0%	configuration of 2015 run – secondary Al target included – no additional shield
Final-14	3,44 ± 0,36	-31,7%	Final-13 + additional shield
Final-15	4,76 ± 0,67	-5.5%	Final-14 + tungsten target
Final-16	4,83 ± 0.69	-4.2%	Final-14 + 10cm nickel target
Final-17	3,85 ± 0,50	-23,6%	Final-14 + 5cm nickel target
Final-18	3,56 ± 0,39	-29,4%	Final-14 + 5cm nickel target, begin II layer

80k primaries

1,600k primaries

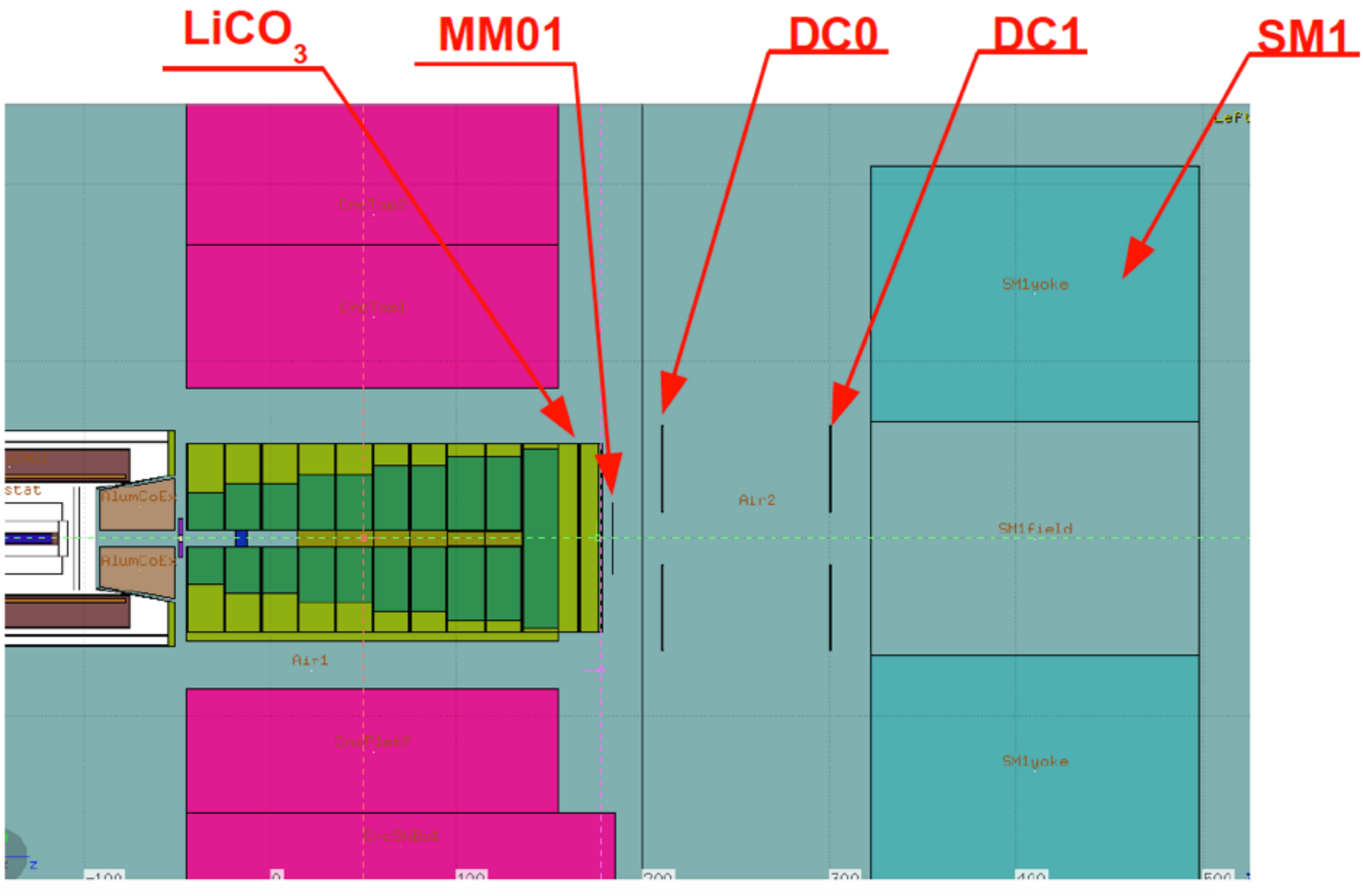
configuration	Mean dose in control room (µSv/h)	Dose Reduction	Mean dose in CR – BW (uSv/h)	note
Final-13	3,77 ± 0,04	0%	3,74 ± 0,02	configuration of 2015 run – secondary Al target included – no additional shield
Final-14	3,54 ± 0,04	-6,1%	3,42 ± 0,02	Final-13 + additional shield
Final-14ntnv	3,50 ± 0,05	-7,2%	3,44 ± 0,02	Final-14, no vertex, no target
Final-15	3,82 ± 0,05	1,3%	3,91 ± 0,02	Final-14 + tungsten target
Final-16	3,50 ± 0.05	-7,2%	3,60 ± 0,02	Final-14 + 10cm nickel target
Final-17	3,52 ± 0,06	-6,6%	3,51 ± 0,02	Final-14 + 5cm nickel target
Final-18	3,55 ± 0,04	-5,8%	3,58 ± 0,02	Final-14 + 5cm nickel target, begin II layer
Final-19	3,72 ± 0,07	-1,3%	3,75 ± 0,02	Final-18 + 10cm nickel target beginning of II layer

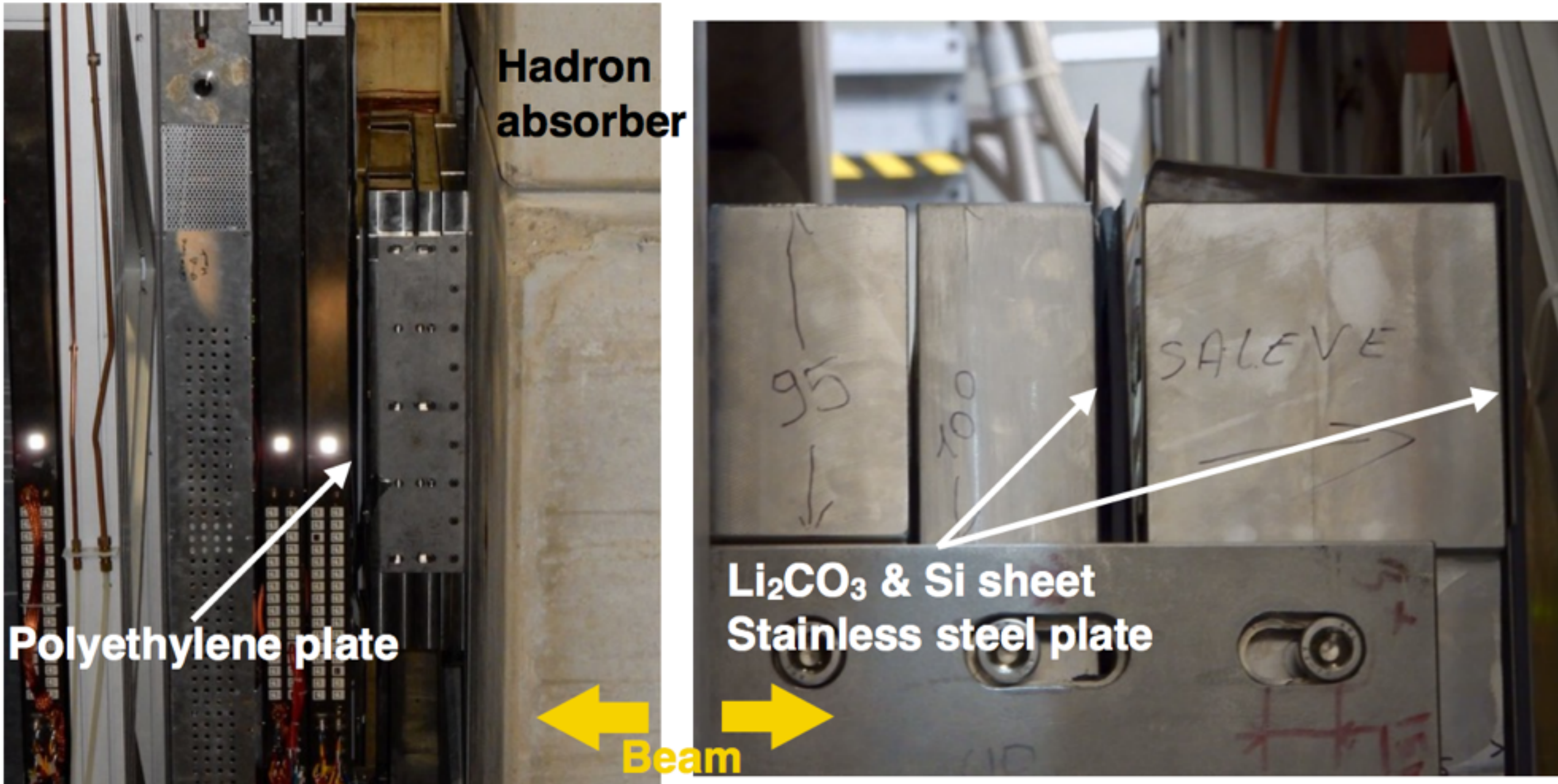
2015 ^{6}Li absorber



- Purpose: absorption of neutrons, which might be captured and emit $\gamma \rightarrow e^+e^-$
- Installed after 2014 DY run because of suffering efficiency in DC0.

Configuration of 2015 run



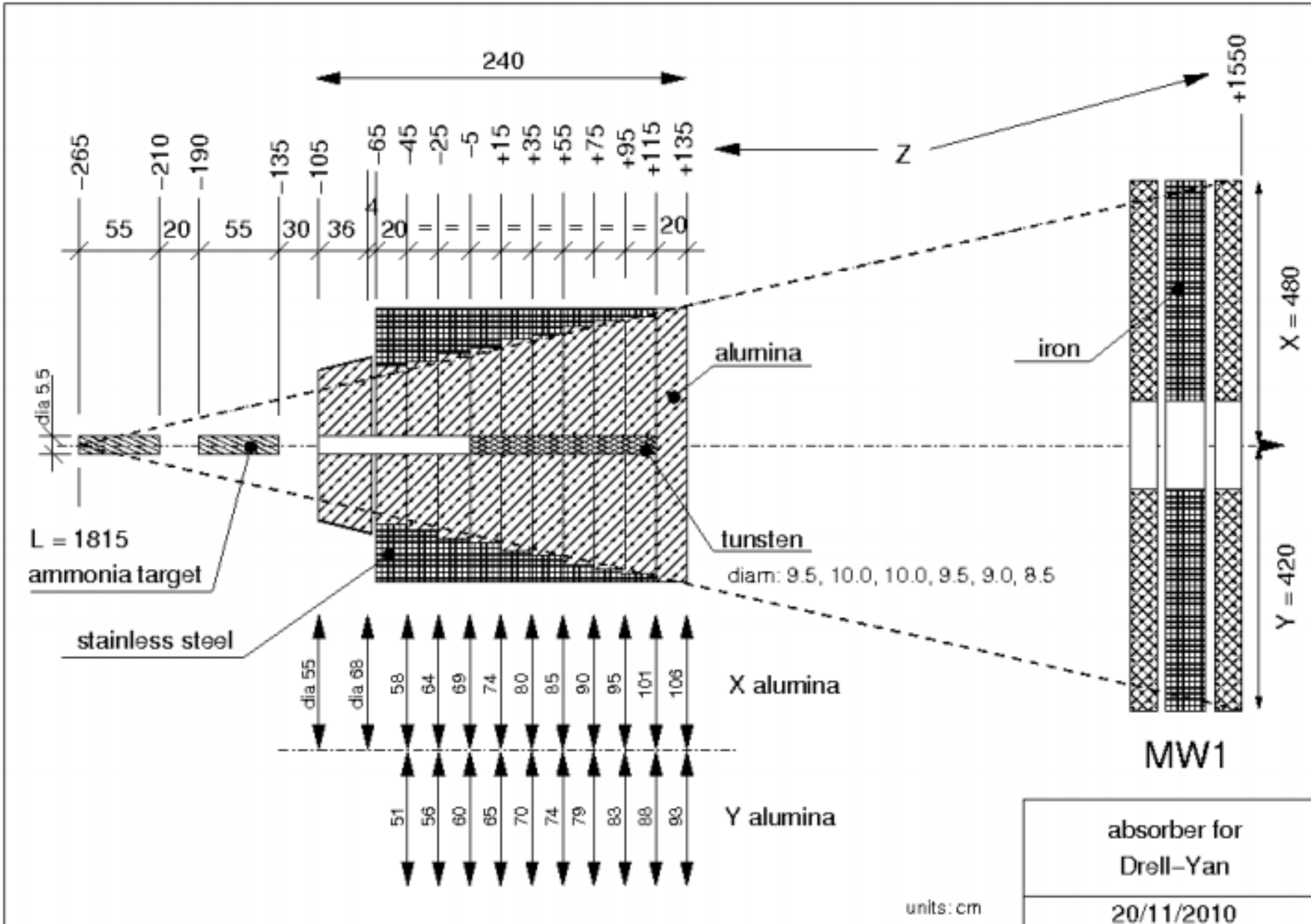


View from Jura side　　View from Saléve side

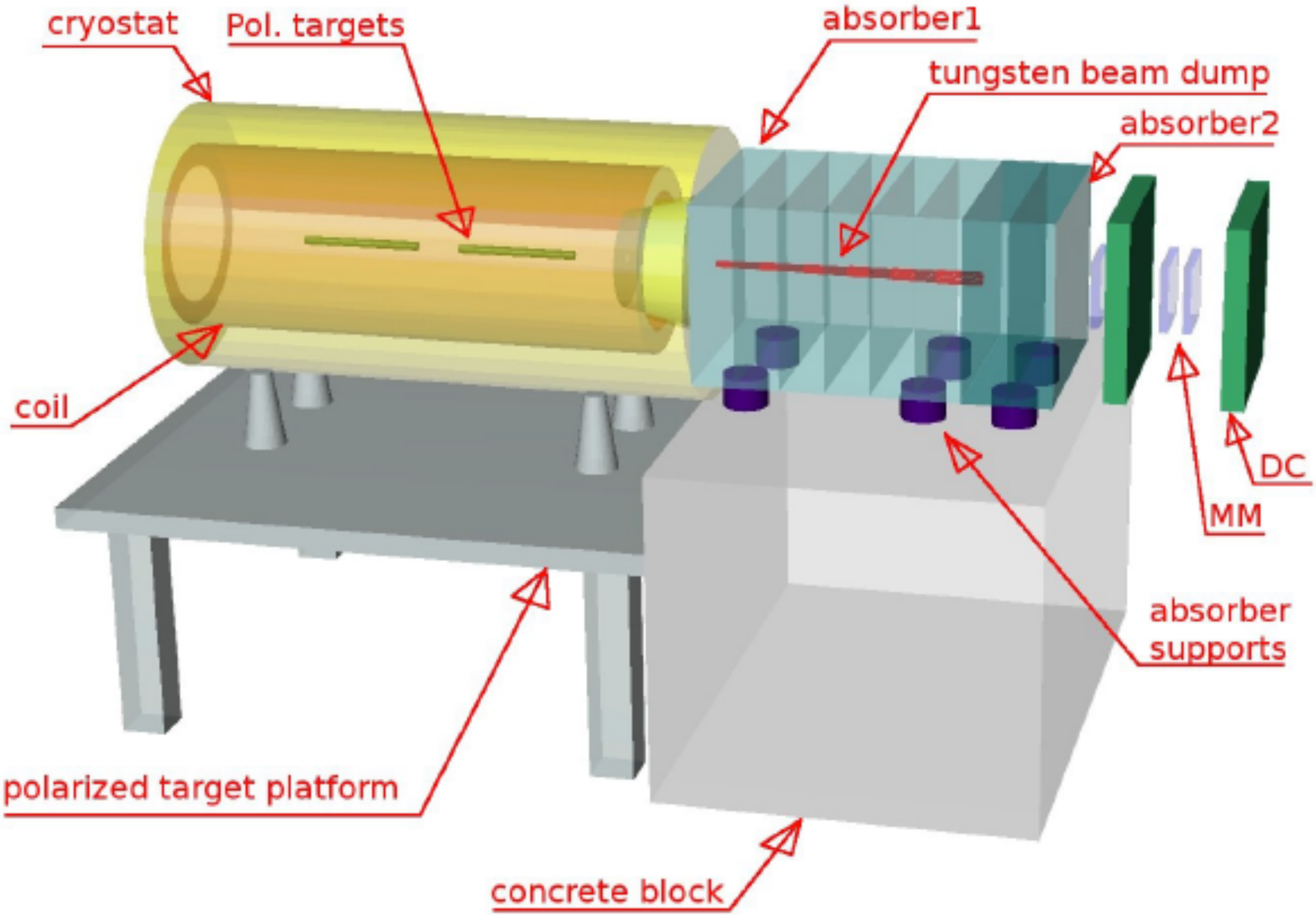
Jurà side

Saleve side

05 / Nov. / 2015 Genki Nukazuka 14 / 12

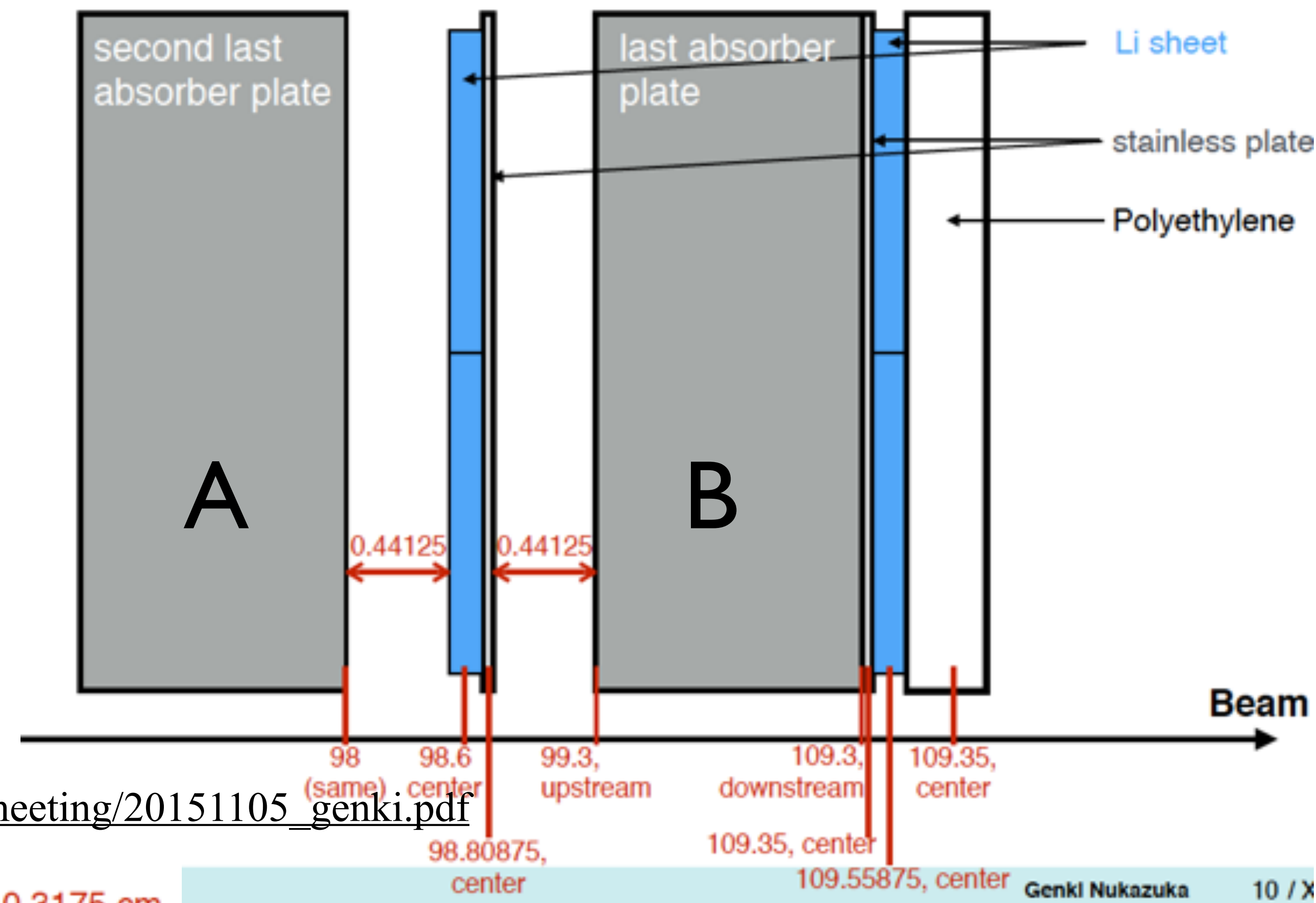

240
Z
+1550
-265
-210
-190
-135
-105
-65
-45
-25
-5
+15
+35
+55
+75
+95
+115
+135
55
20
55
30
36
4
20
20
dia 5.5
alumina
iron
X = 480
Y = 420
L = 1815
ammonia target
tunsten
diam: 9.5, 10.0, 10.0, 9.5, 9.0, 8.5
stainless steel
dia 55
dia 68
58 64 69 74 80 85 90 95 101 106
X alumina
51 56 60 65 70 74 79 83 88 93
Y alumina
MW1
absorber for Drell–Yan
units: cm
20/11/2010

2015 setup (Al target missing)

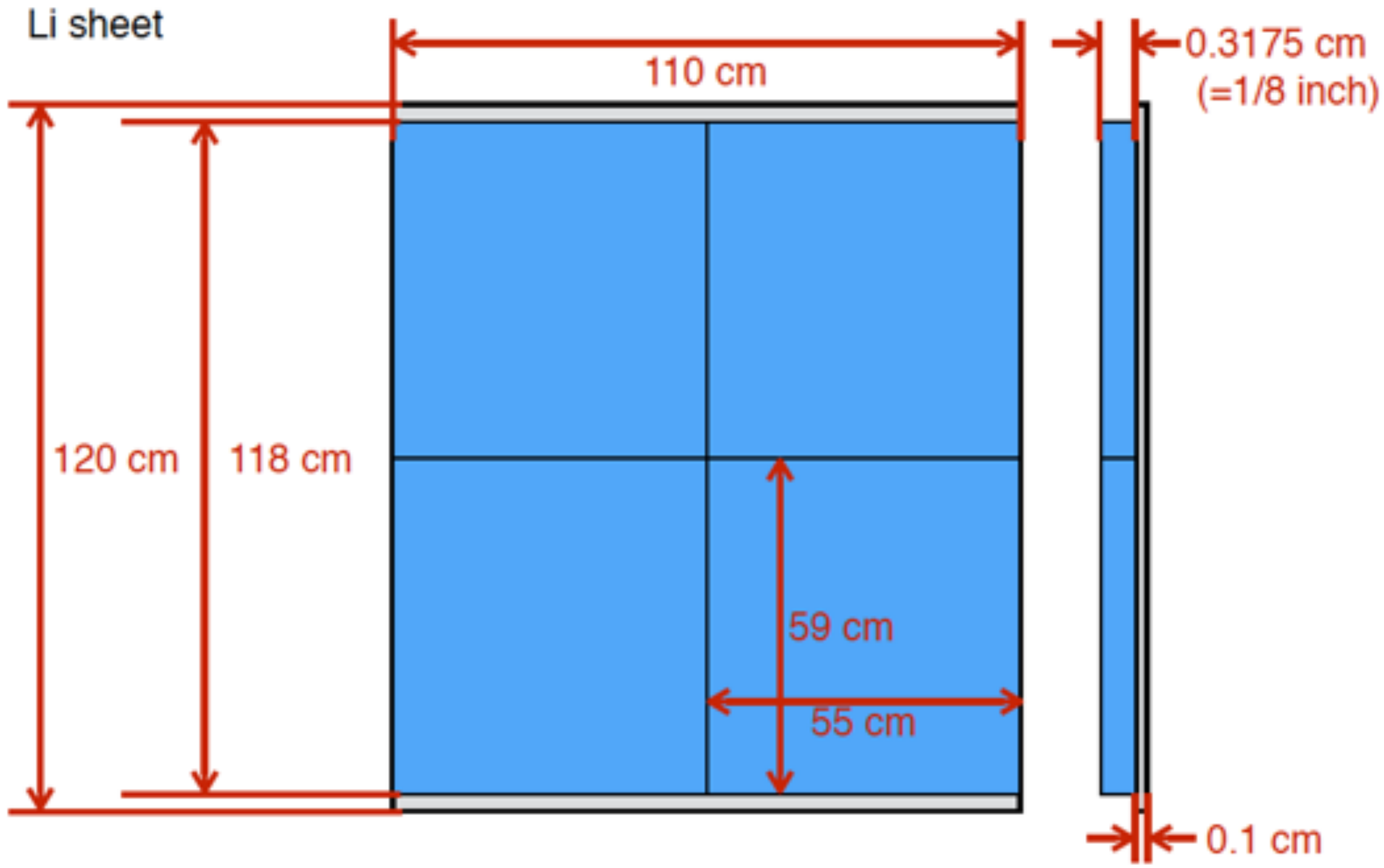


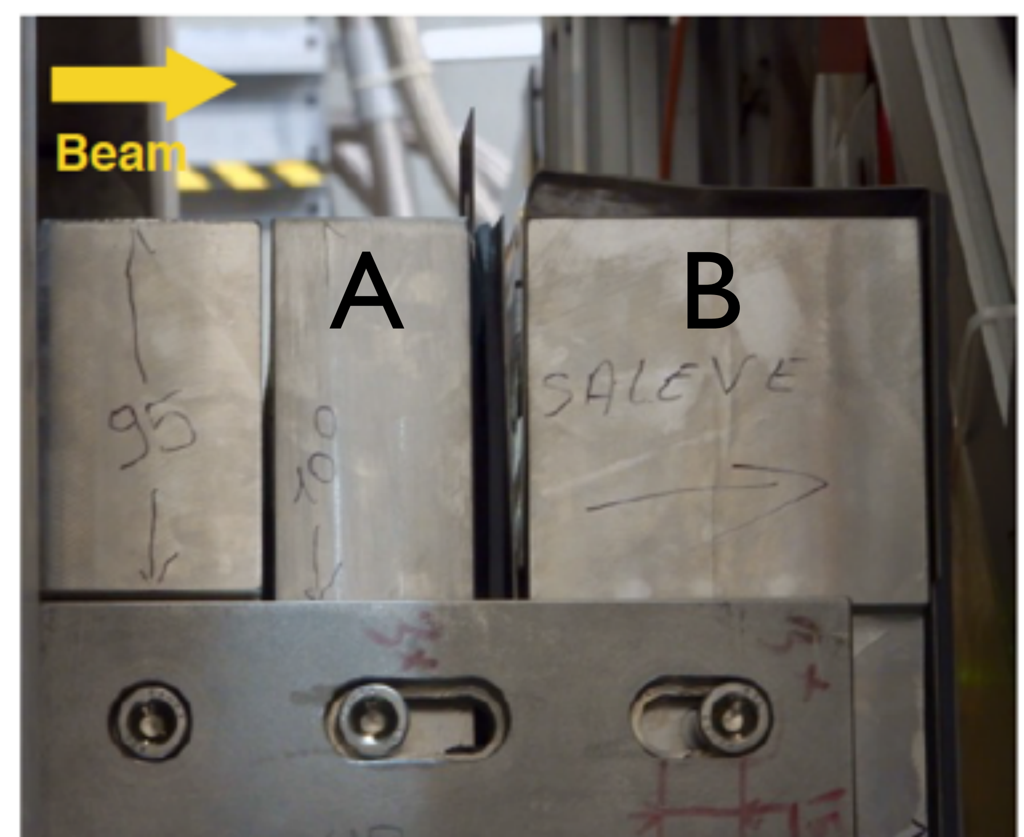
^{6}Li absorber 2015

photos & sketch courtesy Genki Nukazuka



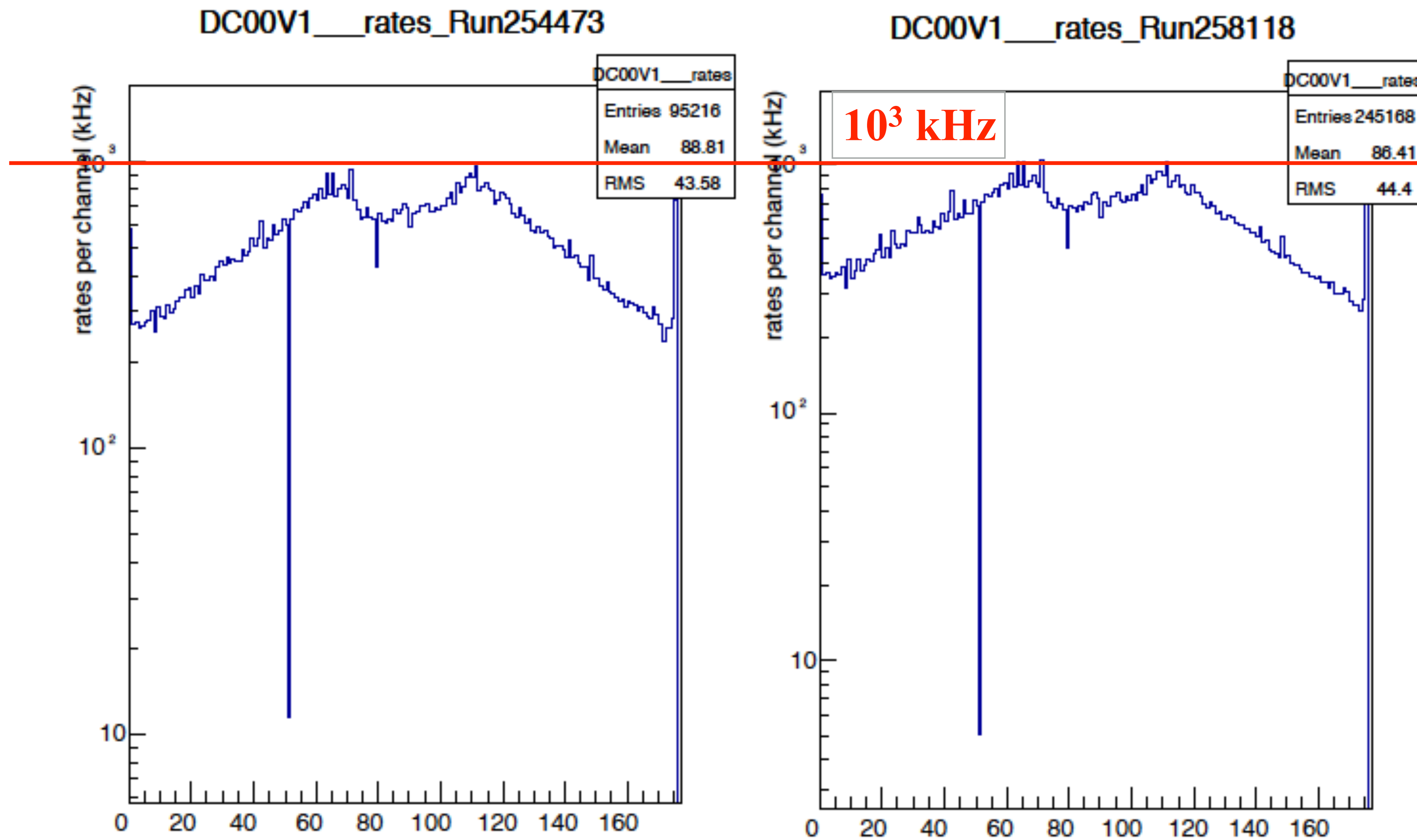
https://twiki.cern.ch/twiki/pub/Compass/Drell_Yan/Subgroupmeeting/20151105_genki.pdf





Reference runs before / after 6Li installation

- Before: 254473, ion2 = $3.93 \cdot 10^8$ (2014-11-29)
- After: 258118, ion2 = $4.10 \cdot 10^8$ (2015-06-09)



Bibliography: talks by AM, Stephane or Genki in spring & summer 2015

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https://espace.cern.ch/na58-mgt-tb/Technical%20Board/Lists/Agenda/Attachments/653/DCs_Saclay_tb_150204.pdf
https://espace.cern.ch/na58-mgt-tb/Technical%20Board/Lists/Agenda/Attachments/662/Platchkov-TB-150401_1.pdf
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https://twiki.cern.ch/twiki/pub/Compass/Drell_Yan/Subgroupmeeting/Genki_Efficiency_vs_Hit_rate_DC00.pdf

After removal of 2nd layer of Li sheet (June 10, 2015)