FLUKA CNGS Radiation Levels @ RadMon Locations

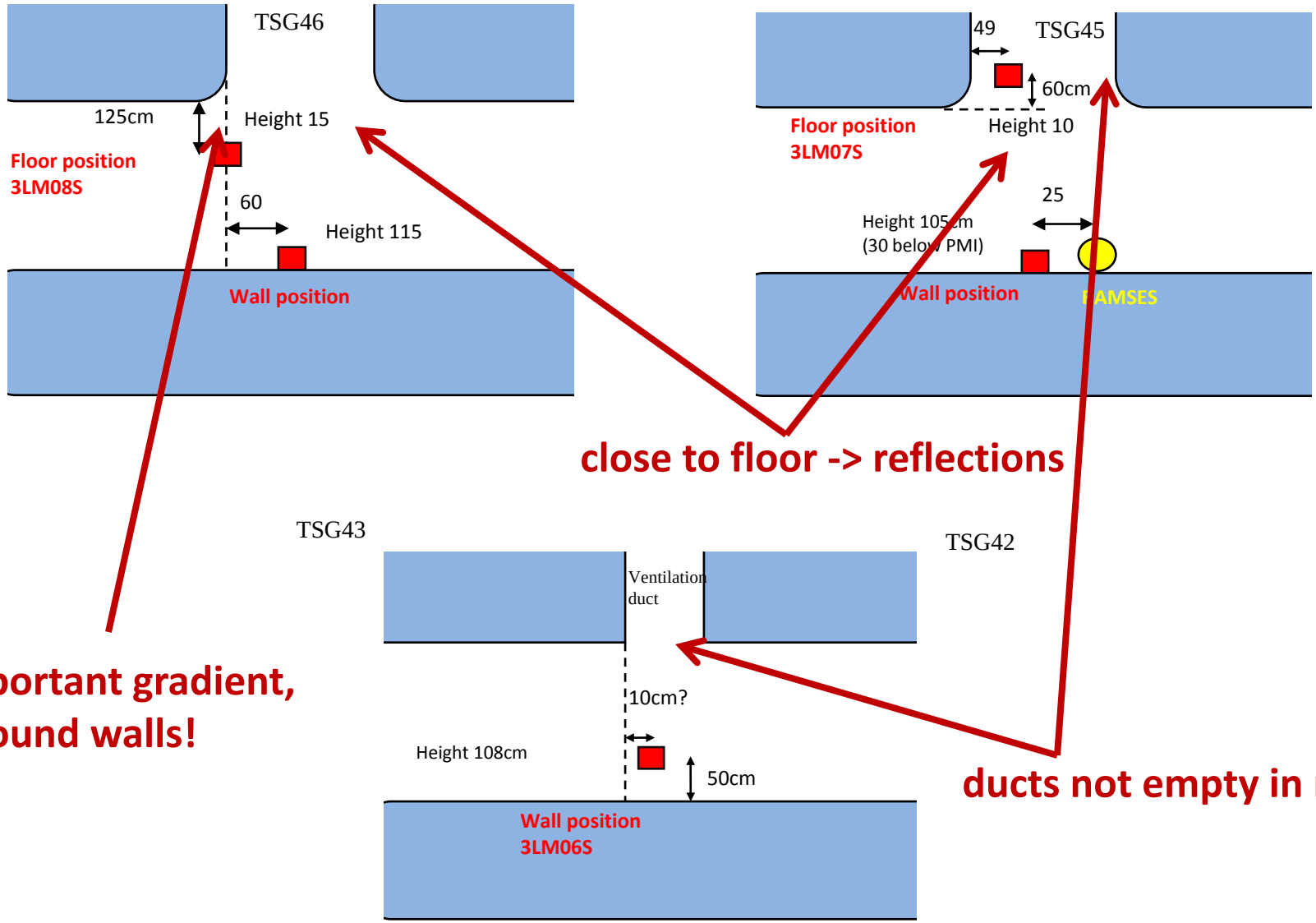
RadWG – April 24th 2009

M. Brugger for 'The FLUKA Team'

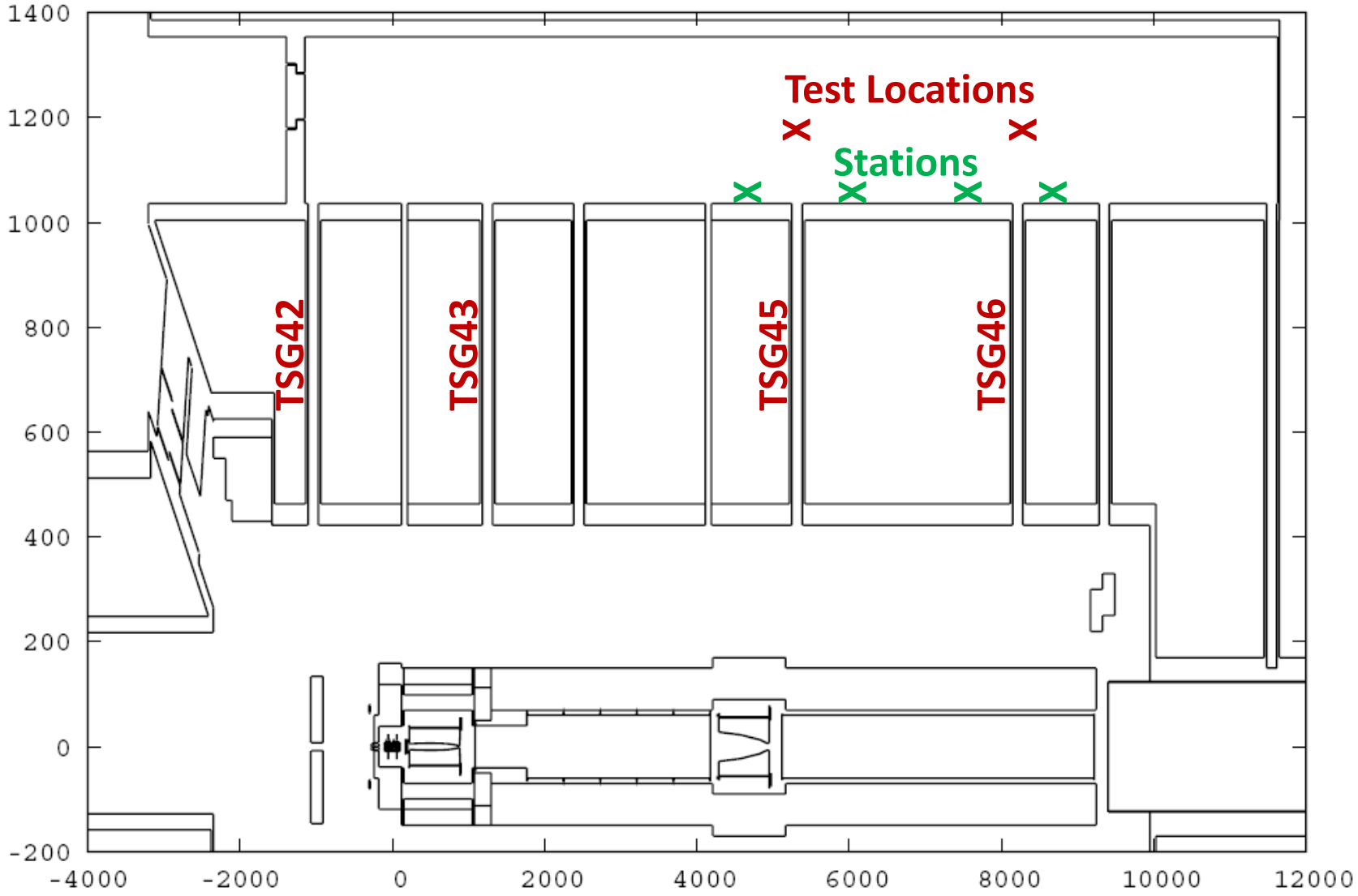
Constraints

- The entire **target area**, **shielding** and **cavern** has to be simulated in order to estimate the radiation levels at the respective test locations
- This complexity requires long calculation time and implies final **uncertainties** of the results
  - **statistical**: ~20-30% (fluctuation can be higher!)
  - **systematic**: **>> larger** due to geometry assumptions (*e.g.*, straight walls) and the simple size of the problem (160m x 30m geometry, loss on target, full cascade, shielding, tunnels and ducts, floor & walls, installed equipment…)
- Particle energy spectra are similar for all radiation test locations, thus quantities of interest (dose, 1MeV-equivalent, high-E fluence) are **linked**
- The test locations don't offer a **homogeneous** radiation field, partly important gradients exist
- The latter becomes more important as soon as one leaves the 'line of sight' with respect to the connection tunnel (TSG…)
- In overall we recommend to include **at least a factor of two to three** in terms of overall uncertainty
- Measurement locations in areas with high-gradients imperatively require a dedicated RadMon

Locations and Limitations



Layout (FLUKA + Test Locations + Stations)



Normalisation - Scaling

- **FLUKA Simulations** provide results per primary proton impinging on the target -> to be scaled by the total number of protons impinging on the CNGS target (p.o.t.) – the graphs in the following use this normalisation
- The actual number of p.o.t. depends on the CNGS operation, but the following can be taken as a rough estimate:
  - ~ 10^{19} p.o.t. per year
    - last year: 1.78x10^{19}, nominal: 4.5x10^{19}
  - ~ 10^{18} p.o.t. per week
    - end of last year: ~2x10^{18}
  - ~ 10^{17} p.o.t. per day
    - end of last year: ~2-3x10^{17}
- For the analysis the exact number of p.o.t. is required!

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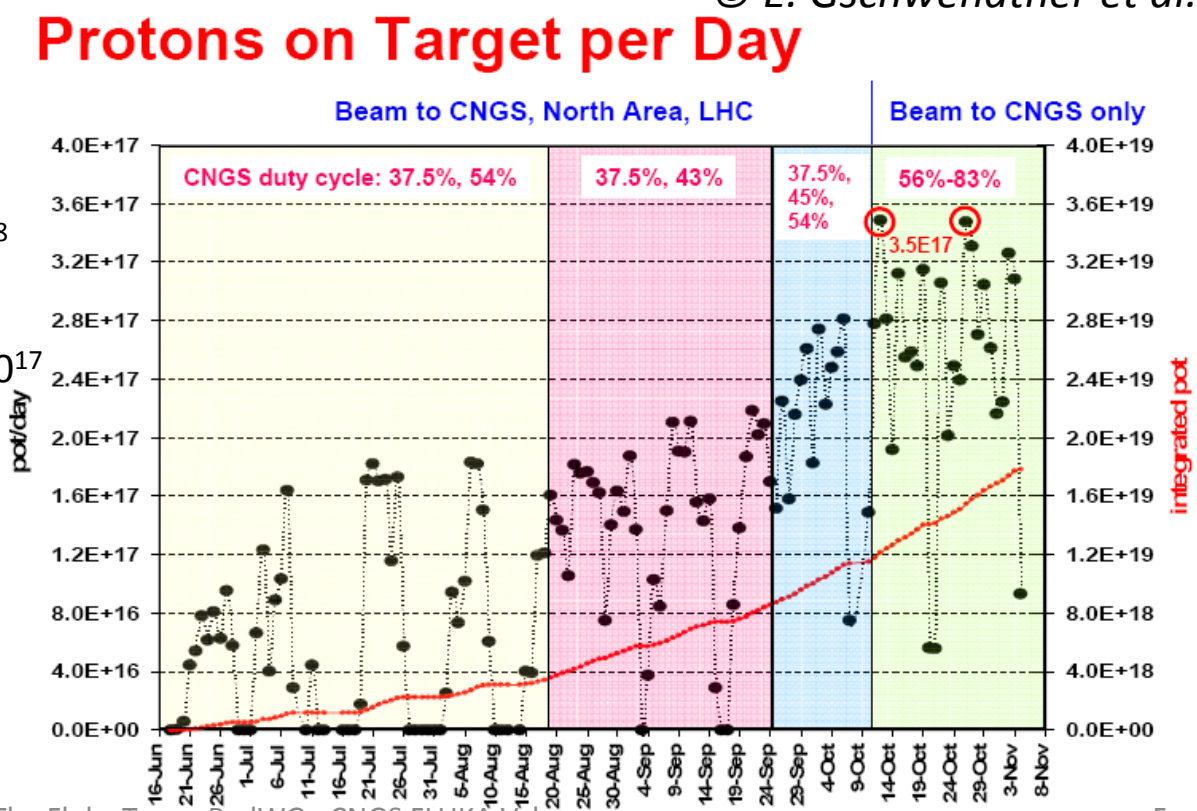
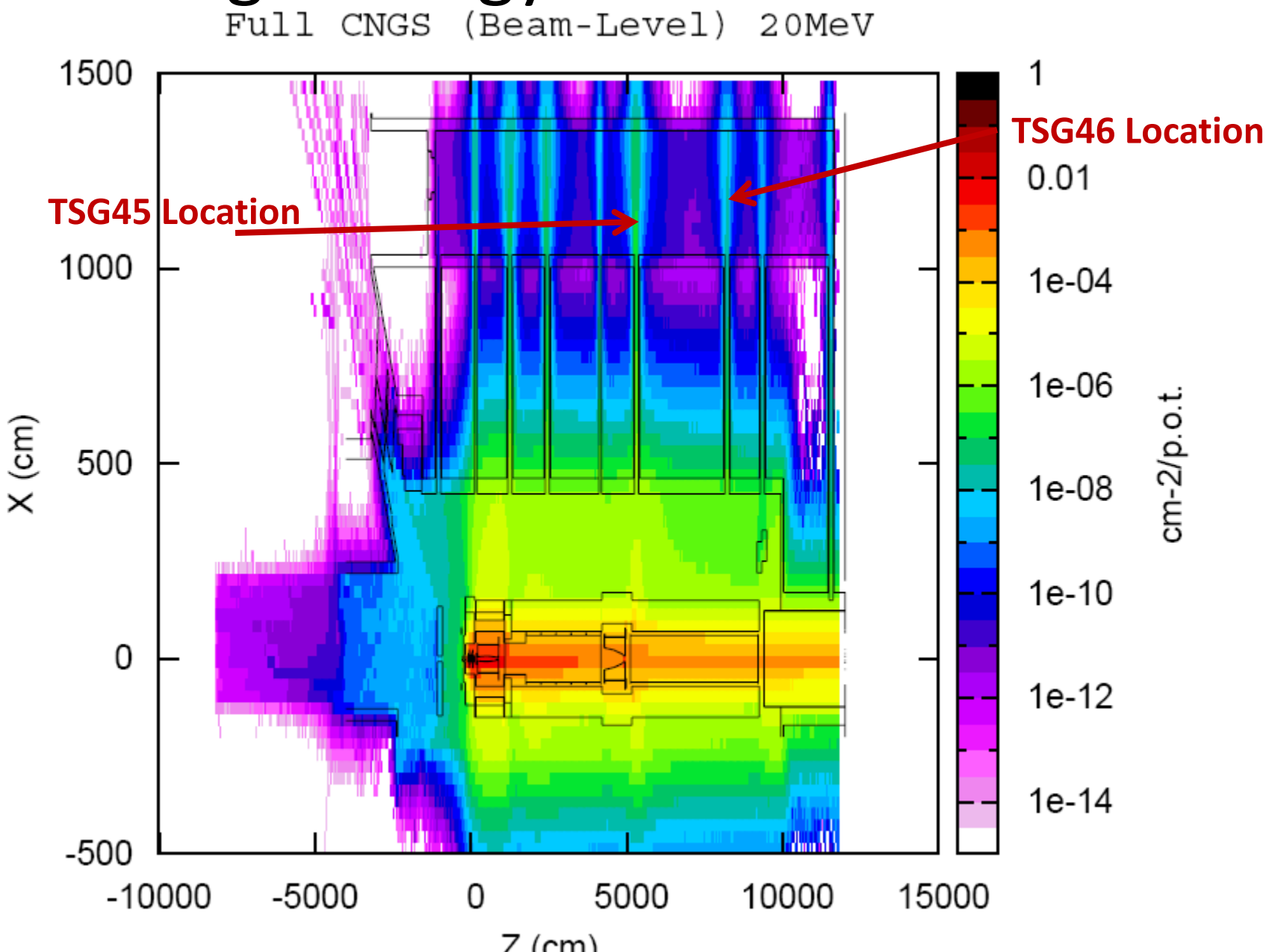
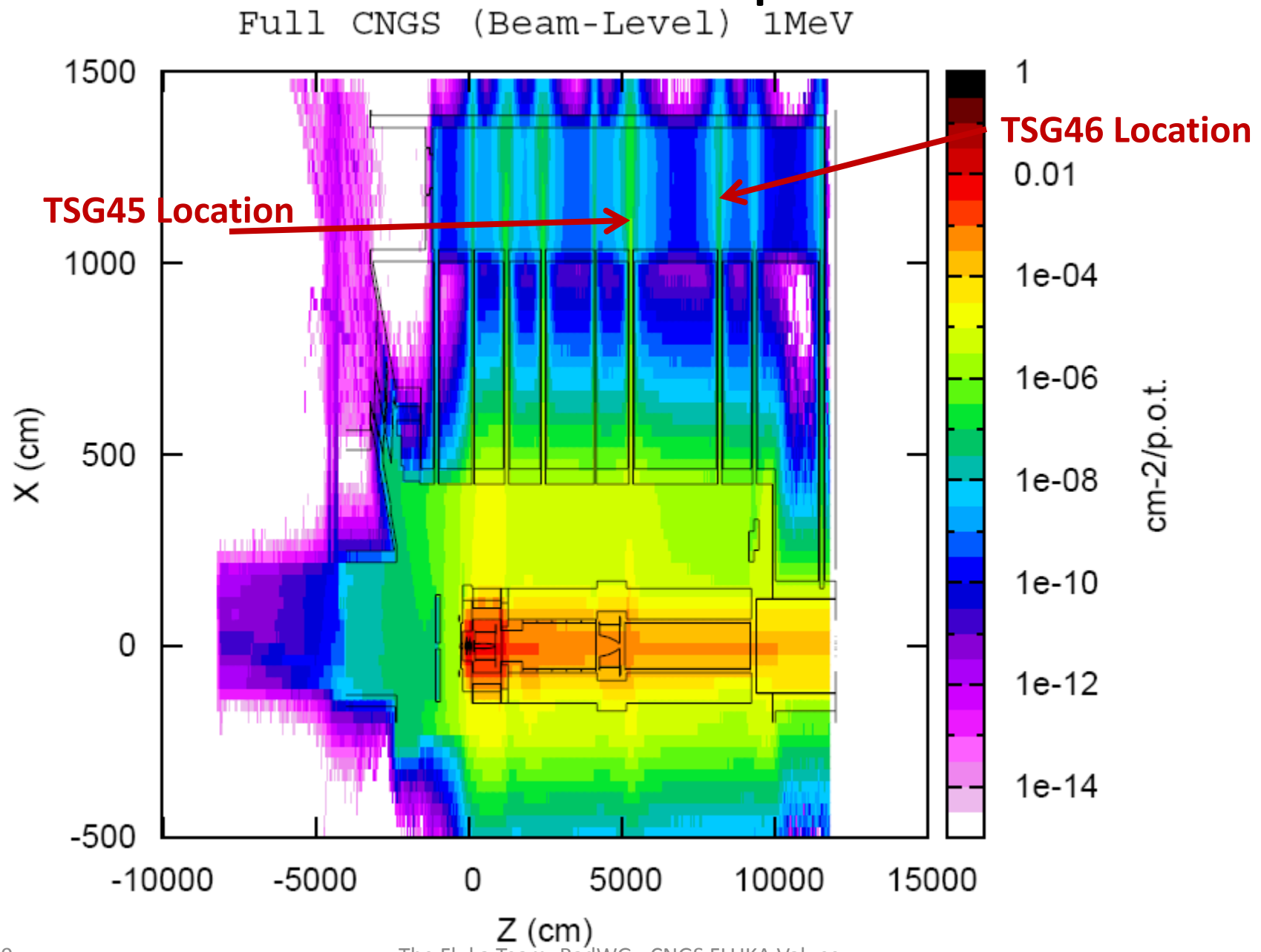


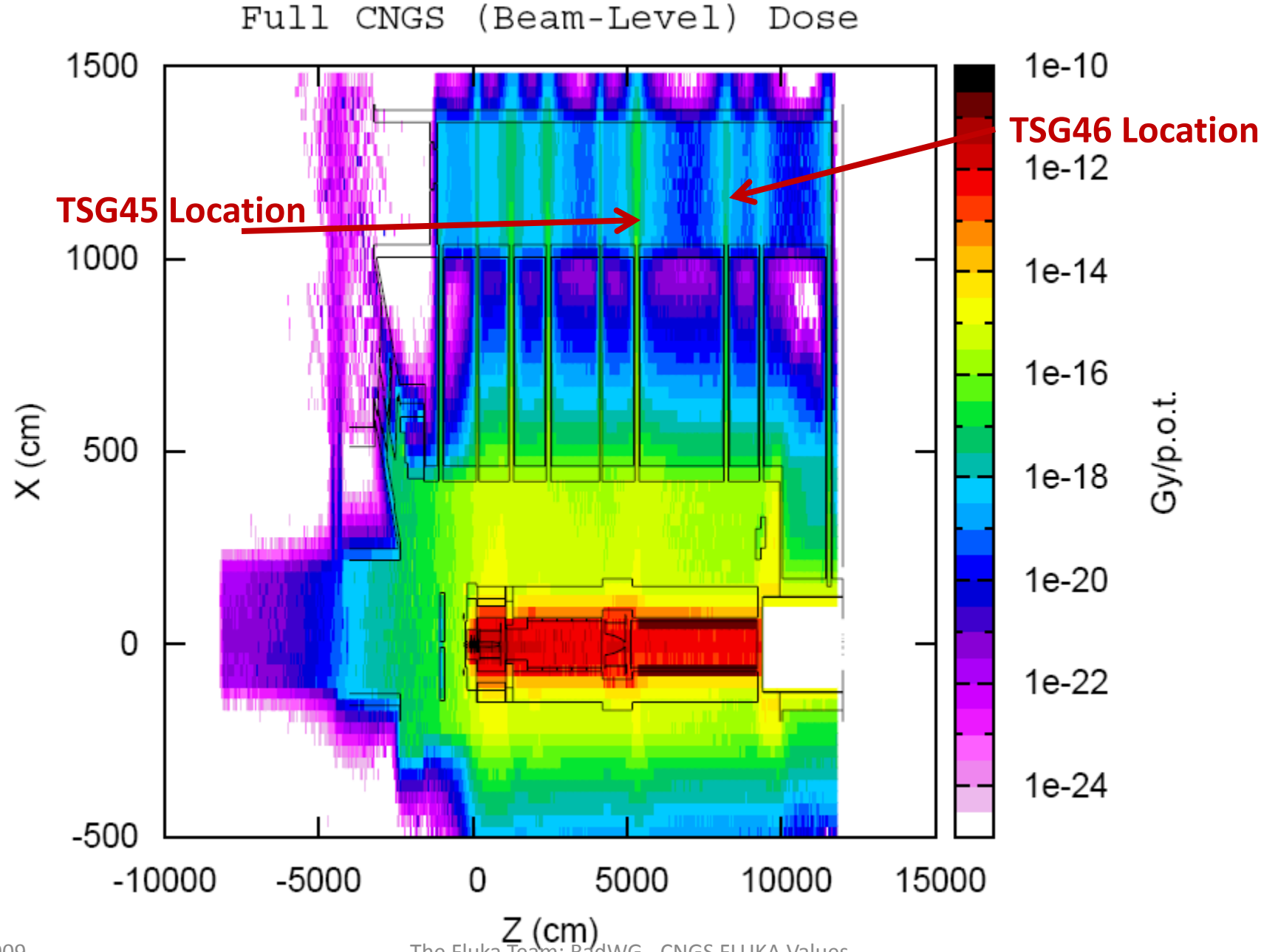
CNGS High-Energy Hadron Fluence Field



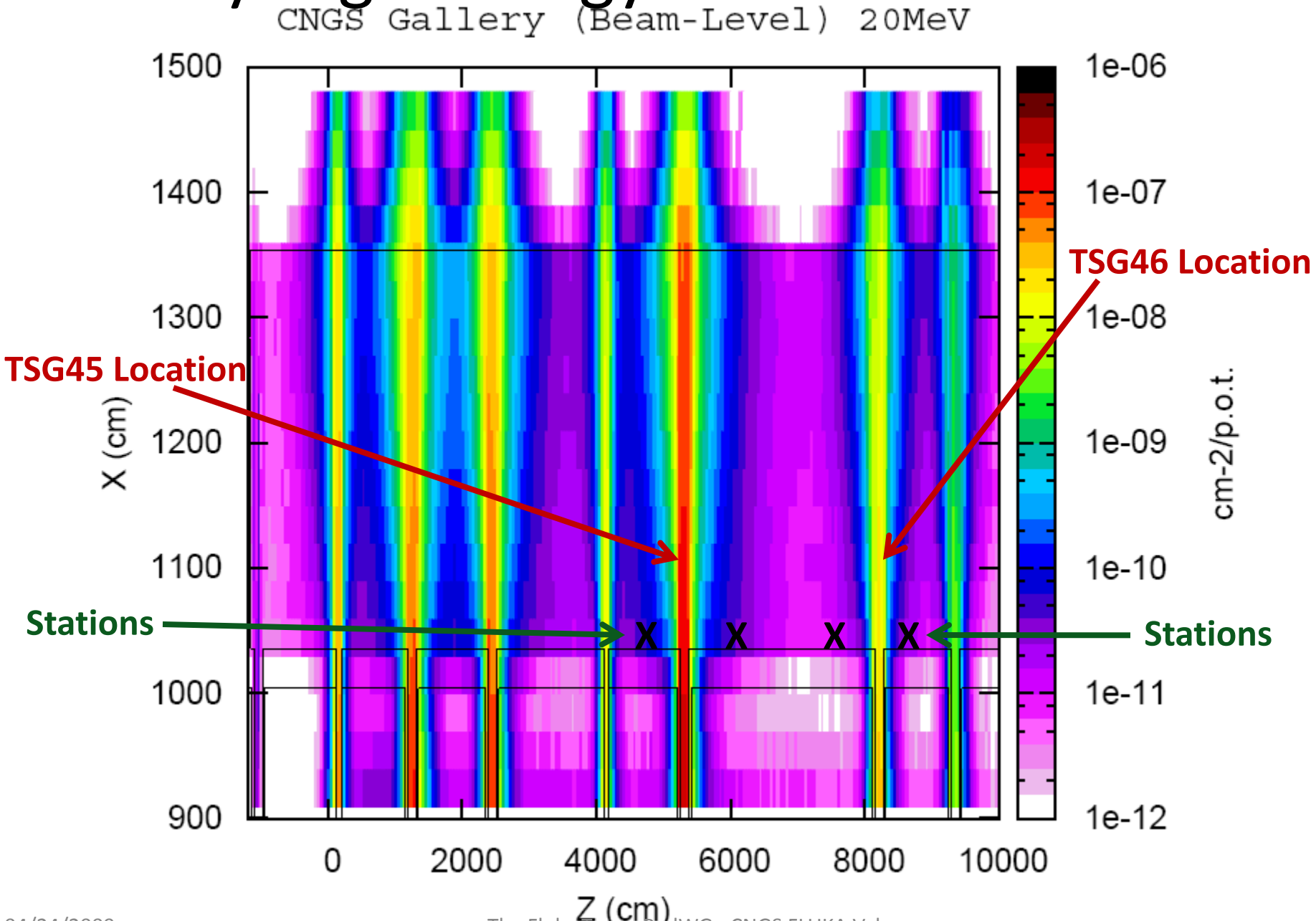
CNGS 1MeV Neutron Equivalent Field



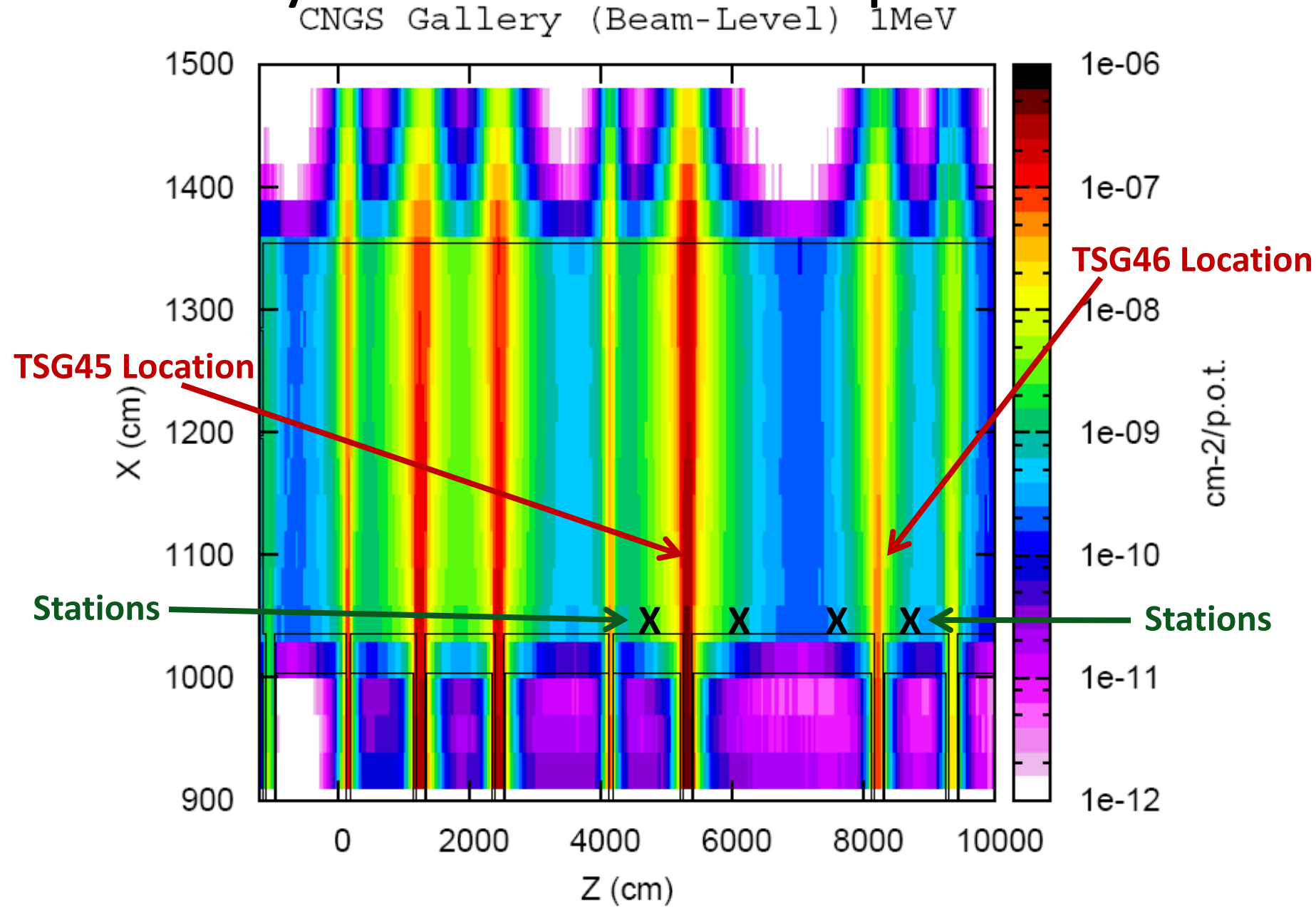
CNGS Dose Distribution



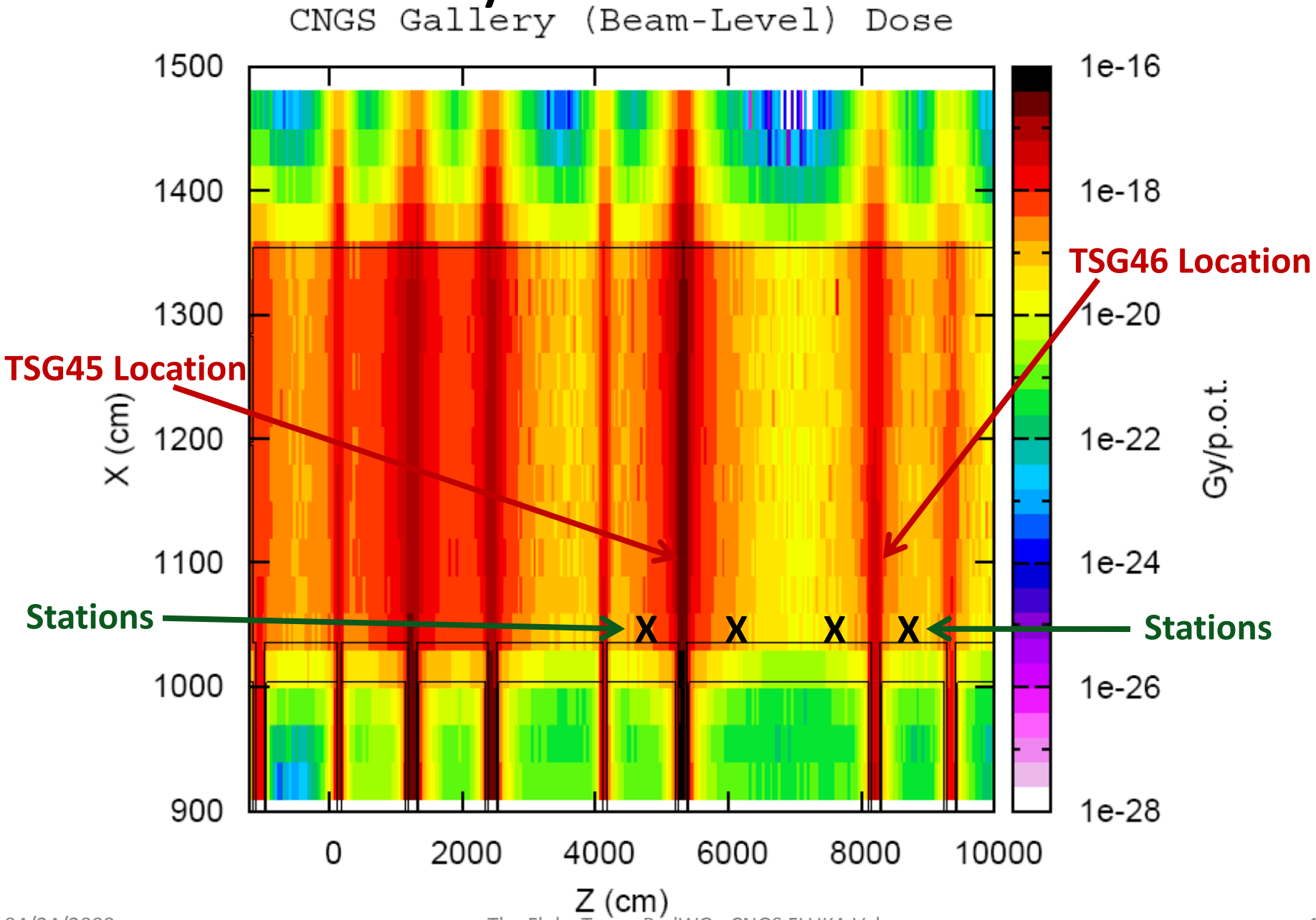
Gallery High-Energy Hadron Fluence Field



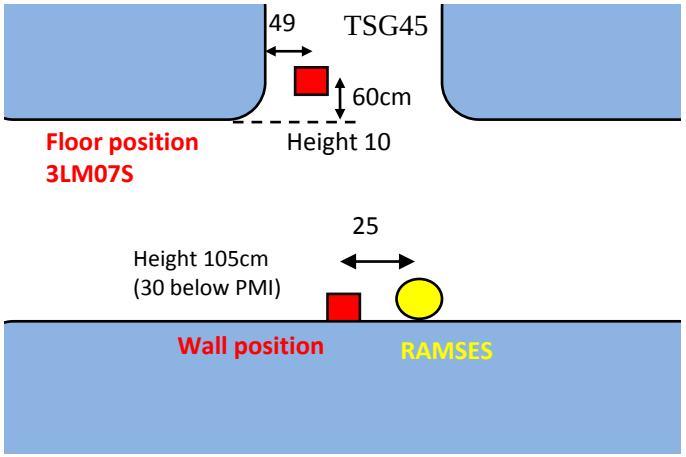
Gallery 1MeV Neutron Equivalent Field



Gallery Dose Distribution

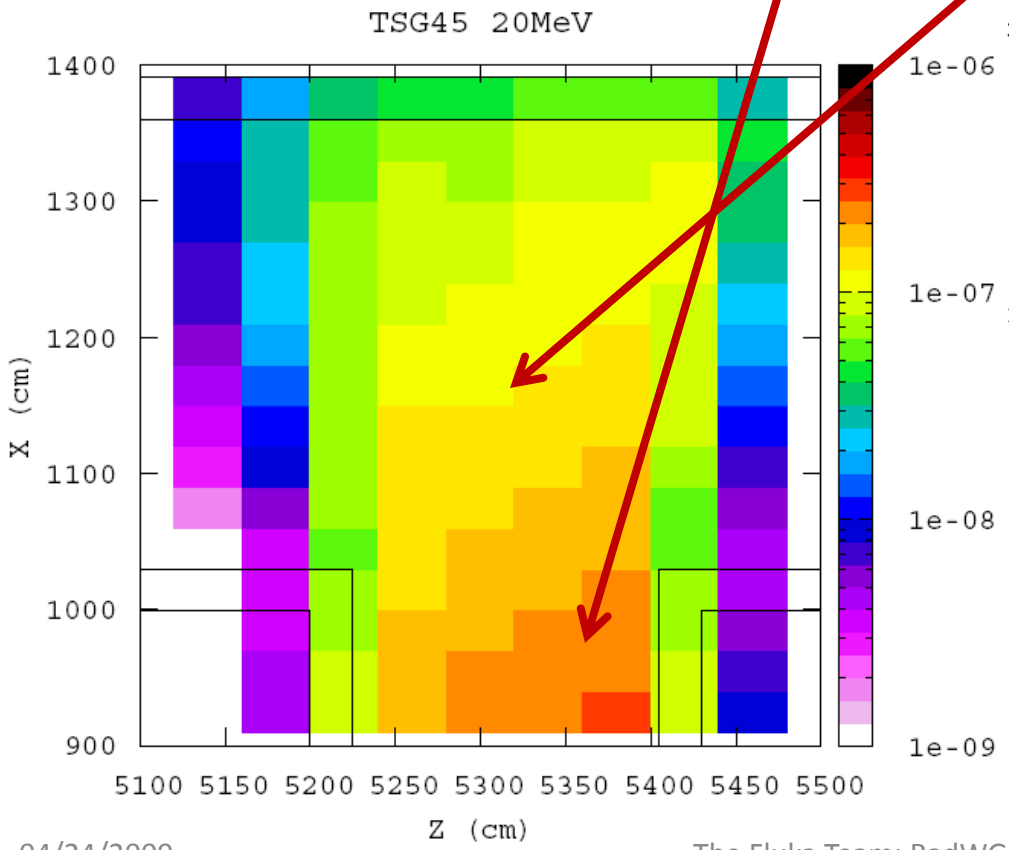


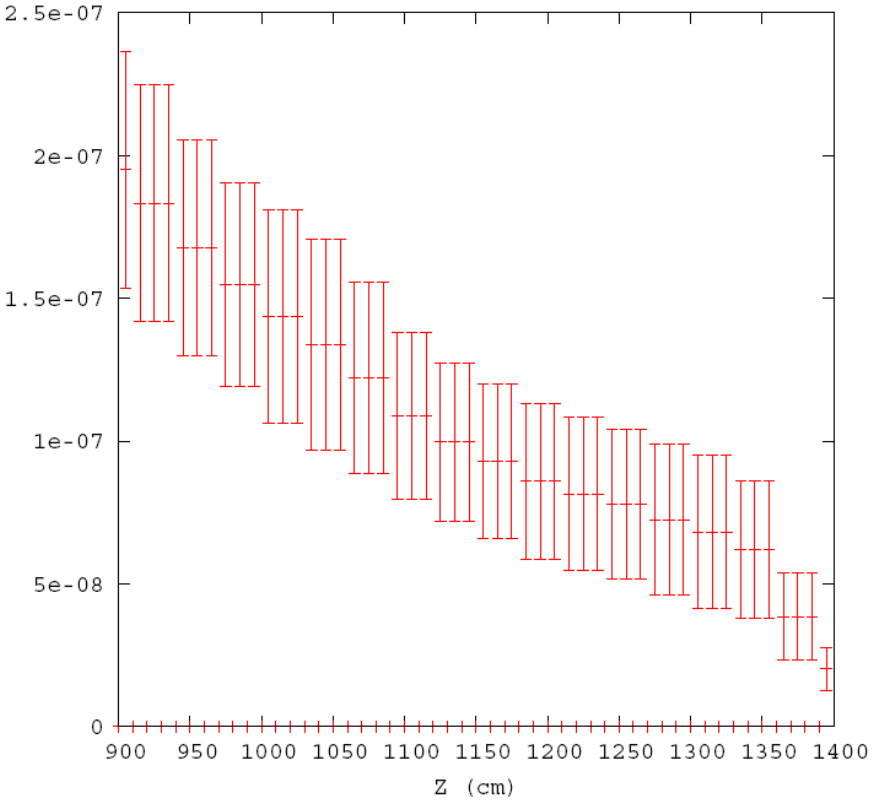
TSG45



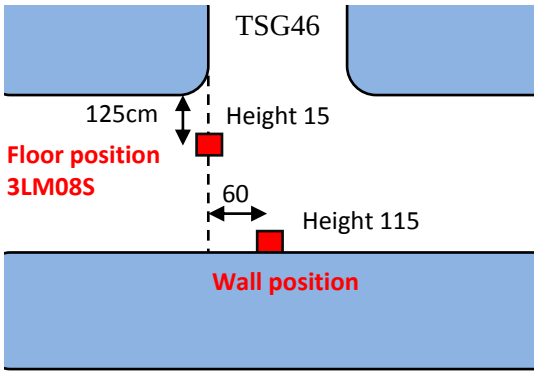
important gradient,
+ round walls
+ duct/tunnel not empty!

Rack Location Important

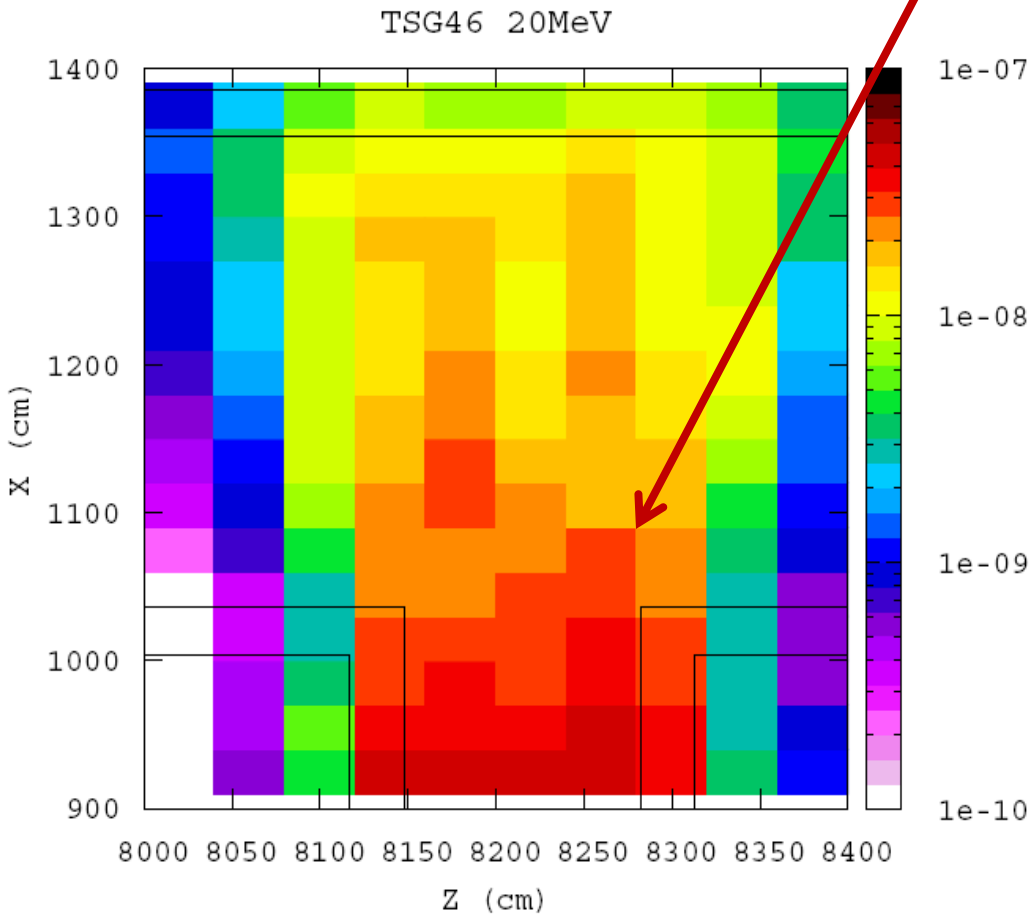


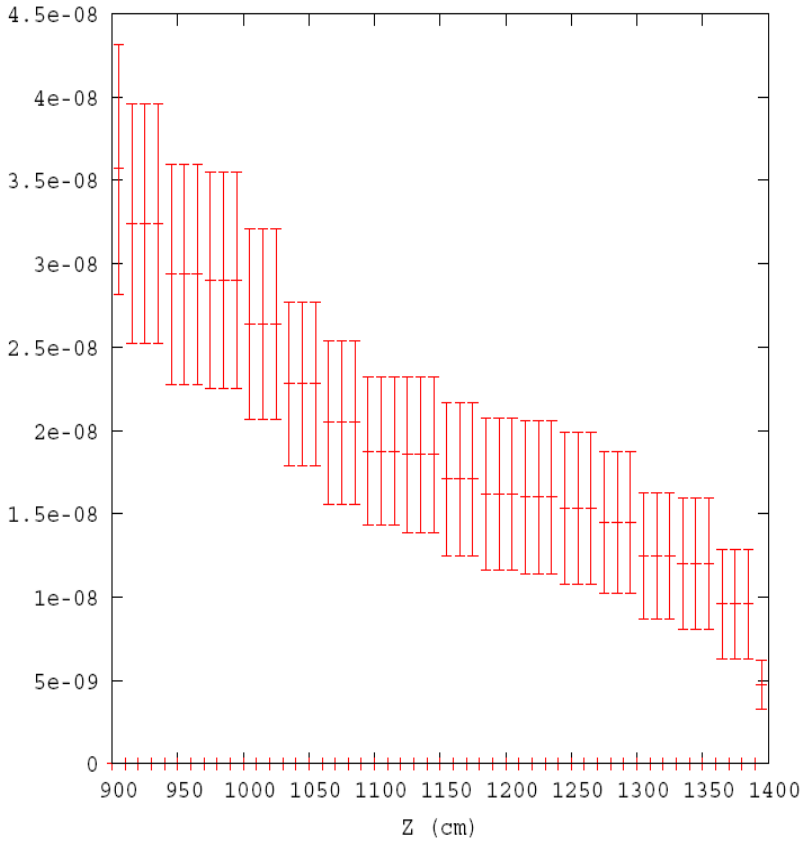


TSG46



important gradient,
+ round walls!





Overview of Values

Location	RESULTS PER PROTON		
	20MeV / cm-2	1MeV / cm-2	Dose / Gy
TSG45	1.2E-07	3.5E-07	2.8E-17
TSG46	1.4E-08	3.9E-08	3.1E-18
*Station 1/2 (rough est.)	1.0E-10	5.0E-09	2.0E-19
*Station 3/4 (rough est.)	1.0E-11	5.0E-08	1.0E-19

Location	RESULTS PER Day (1E17 p.o.t.)		
	20MeV / cm-2	1MeV / cm-2	Dose / Gy
TSG45	1.2E+10	3.5E+10	2.75
TSG46	1.4E+09	3.9E+09	0.31
*Station 1/2 (rough est.)	1.0E+07	5.0E+08	0.02
*Station 3/4 (rough est.)	1.0E+06	5.0E+09	0.01

(*) Values for Stations are a rough estimate only, detailed values depend on exact location and uncertainties are large fro the simulations!

Conclusions

- **Important gradients** exist at measurement locations – for the summary of radiation tests a combination of both, measurements and simulation results at the respective locations shall be considered
- When going '**off-axis**', *i.e.*, to the side of the connection tunnel (TSGs), the **direct RadMon measurement** becomes imperative
- Radiation levels at the location of the **connection stations** are significantly lower, however shall not be neglected – **installed equipment must stand these radiation levels**
- Uncertainties suggest at least a **safety factor of 2-3** to account for all, layout, measurement and simulation uncertainties
- Past evaluation (see presentation) showed a **good comparison within the uncertainties** between RadMons and FLUKA Simulations, more detailed calibrations are still ongoing