Shielding design and activation studies

(Vincent Hedberg - Univ. of Lund)

PART 1. SHIELDING

(Mike Shupe & Ian Hooton)

Overview

The new moderator shield

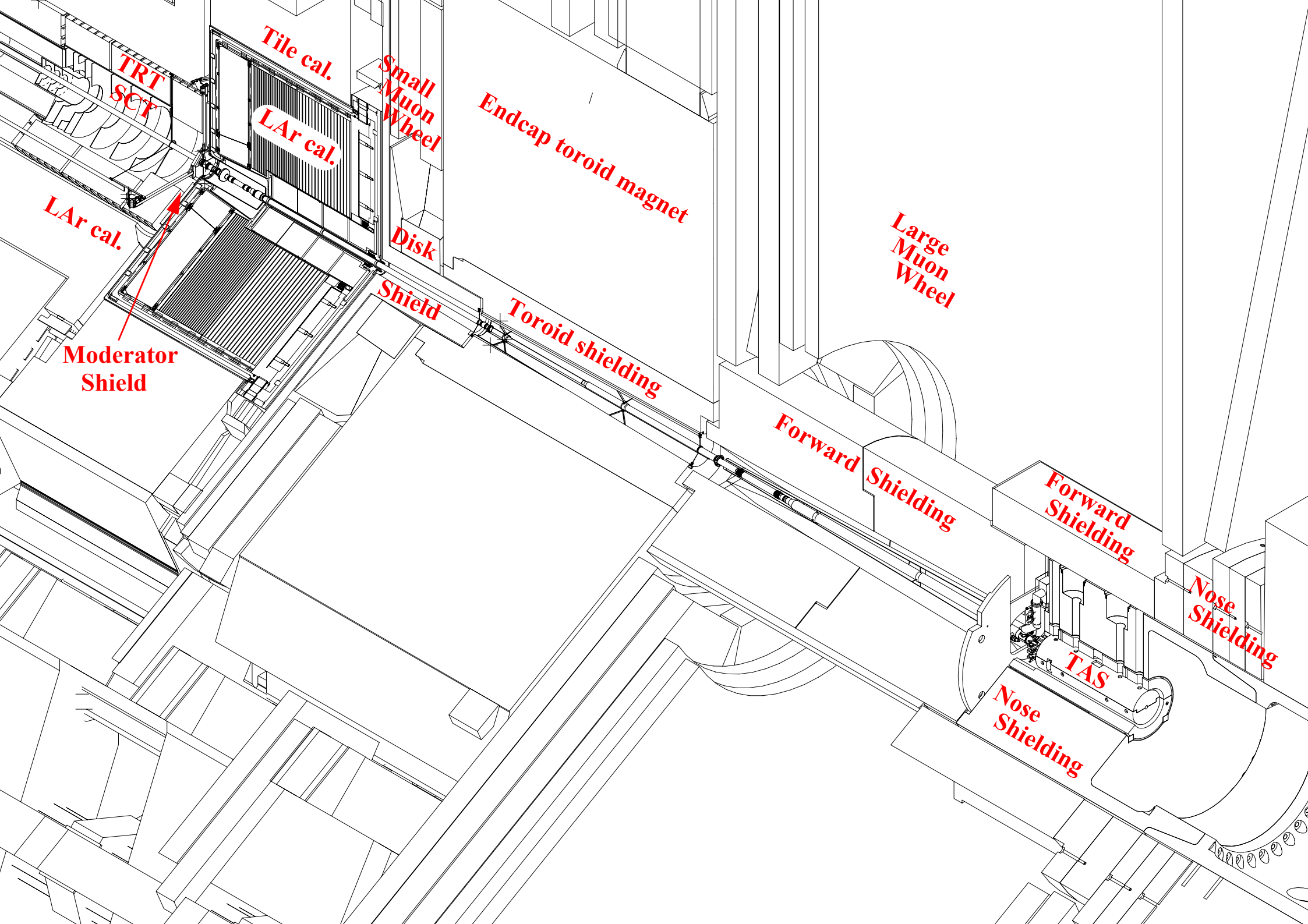
The cladding of the endcap toroid

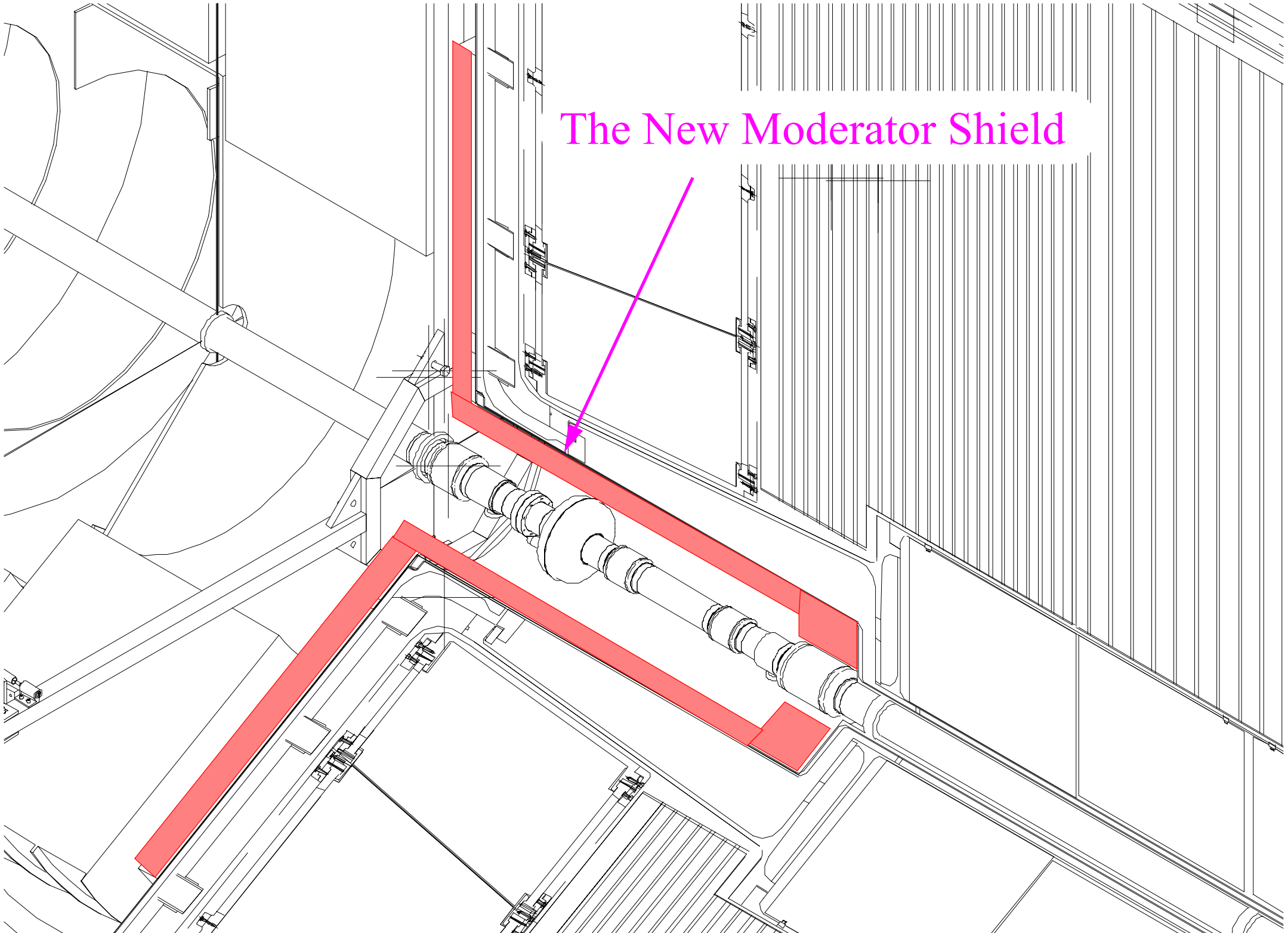
Optimization of the forward shield

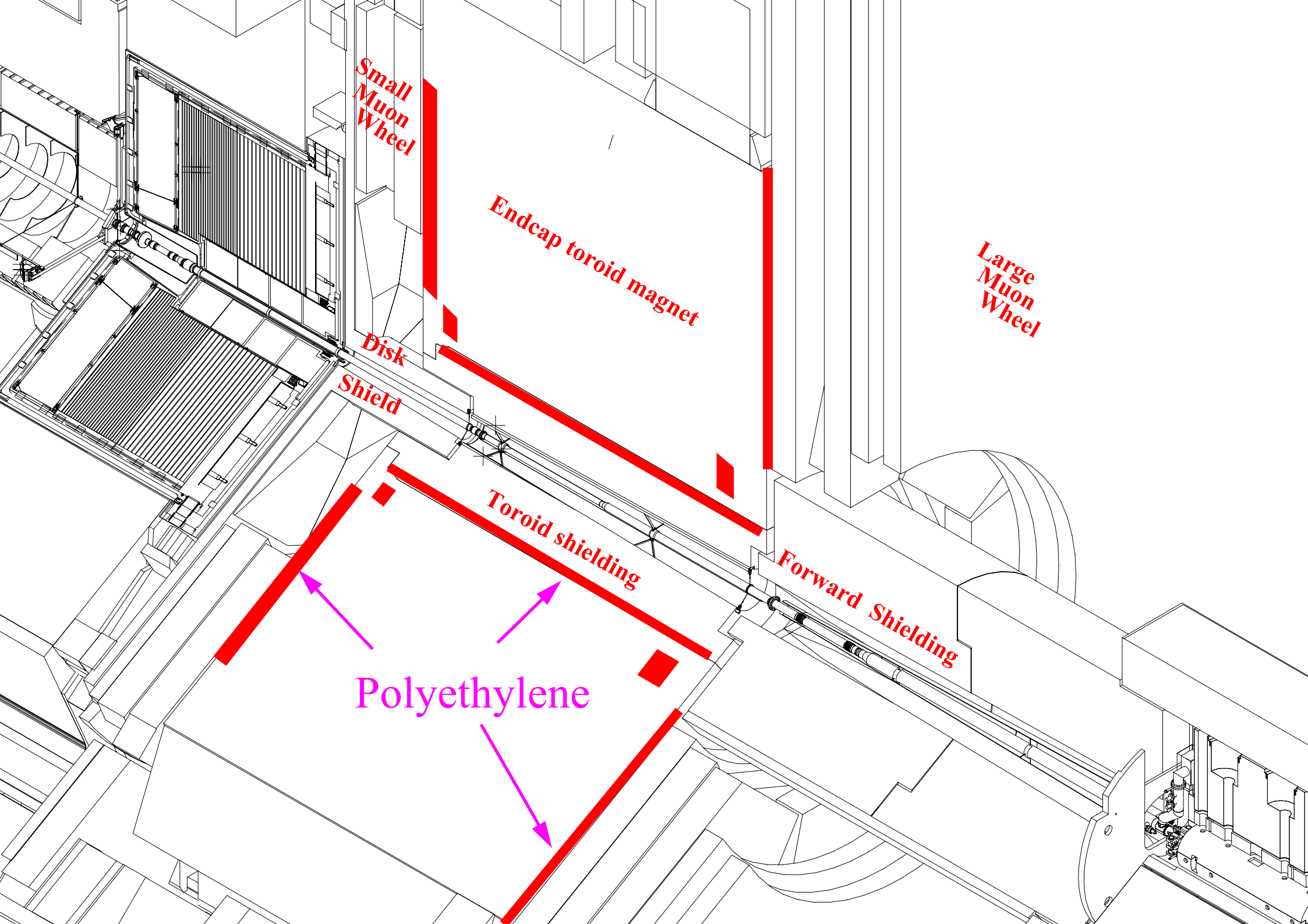
The new forward shield

PART 2. ACTIVATION

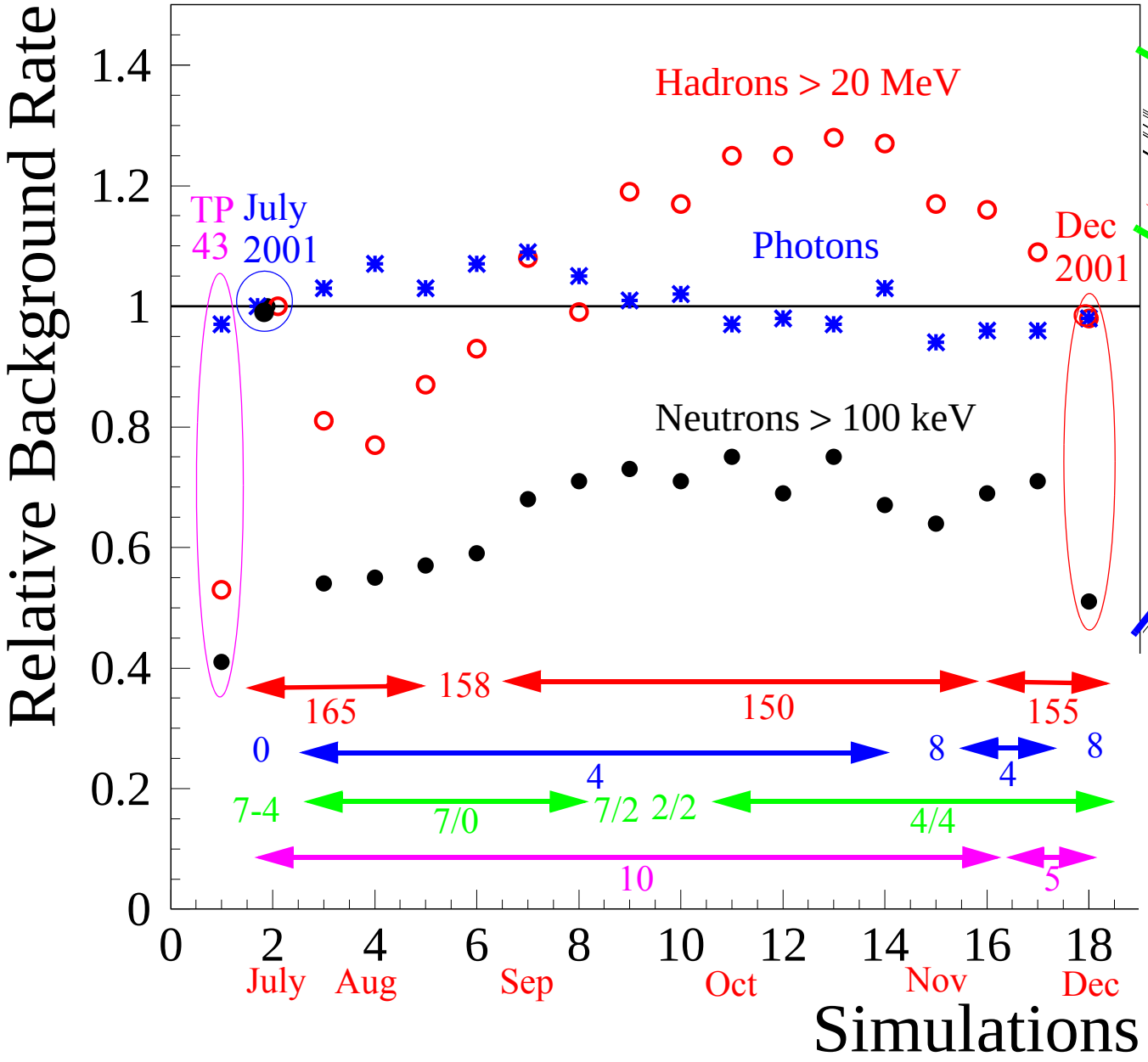
(Misha Morev & Mike Shupe)

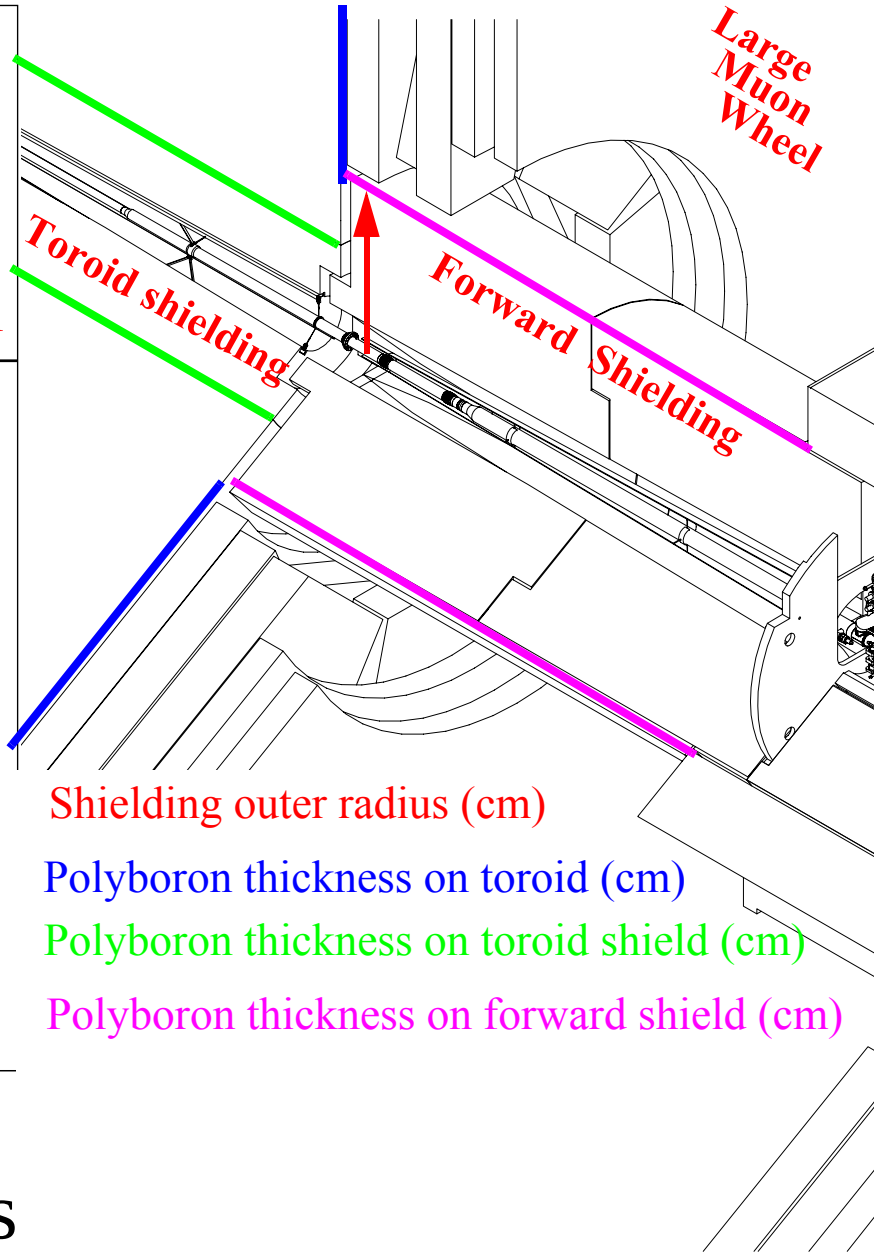

TRT
SCT
Tile cal.
LAr cal.
Small Muon Wheel
Endcap toroid magnet
LAr cal.
Disk
Shield
Toroid shielding
Large Muon Wheel
Moderator Shield
Forward Shielding
Forward Shielding
Nose Shielding
TAS
Nose Shielding

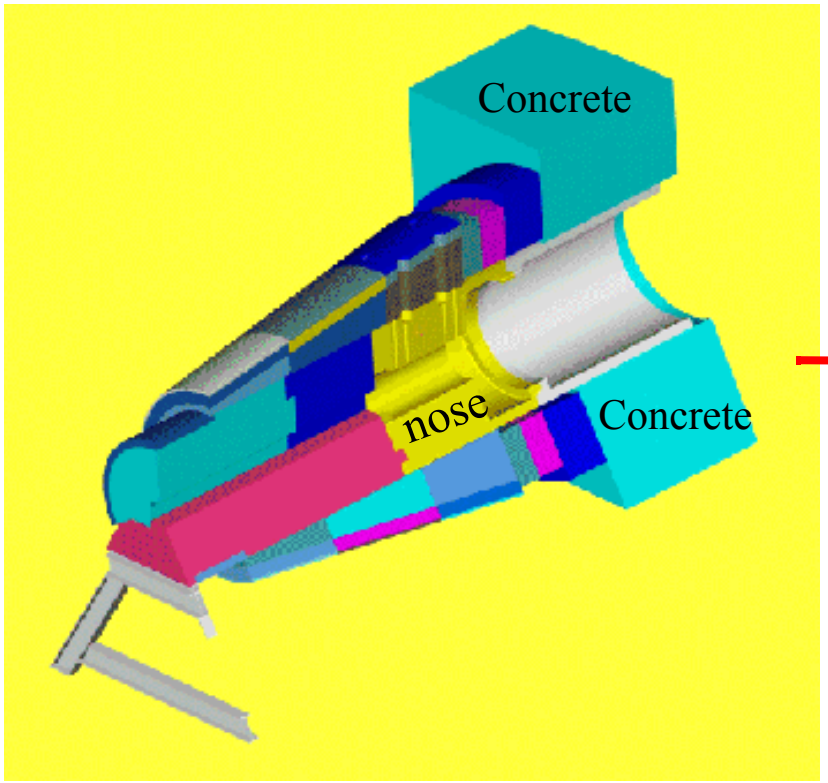

The New Moderator Shield


Small Muon Wheel
Endcap toroid magnet
Large Muon Wheel
Disk Shield
Toroid shielding
Forward Shielding
Polyethylene

Optimization of the forward shield



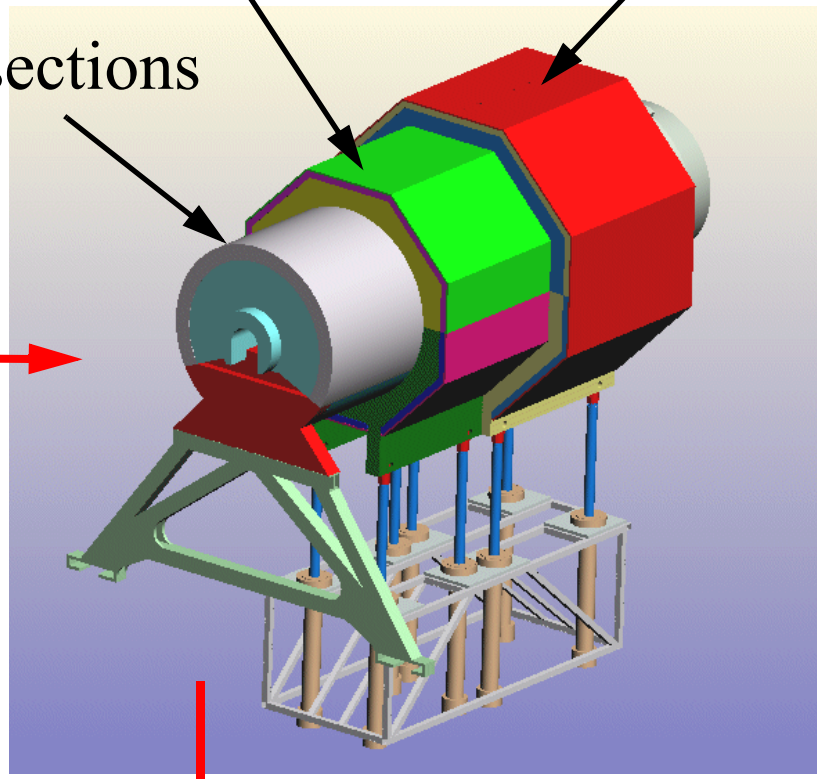




Back octagonal sections

Front octagonal sections

Core sections

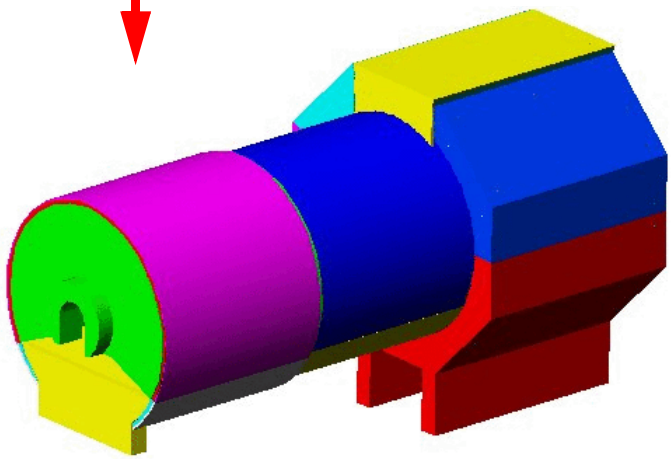


Original design:
(core estimate)

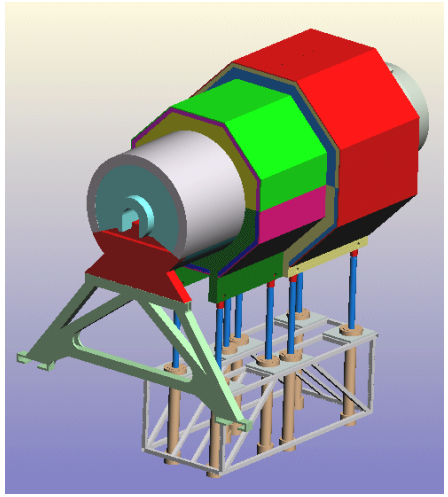
1720 tons of Iron
128 tons of Lead
46 tons of Polyethylene

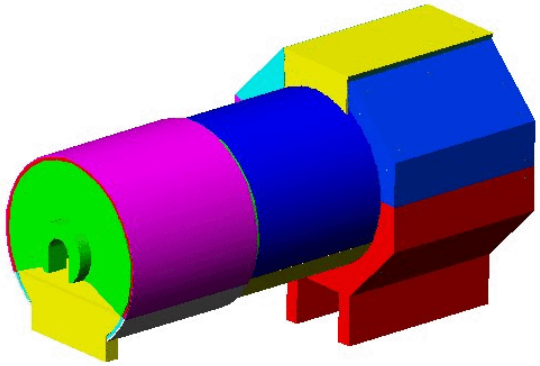
New design:

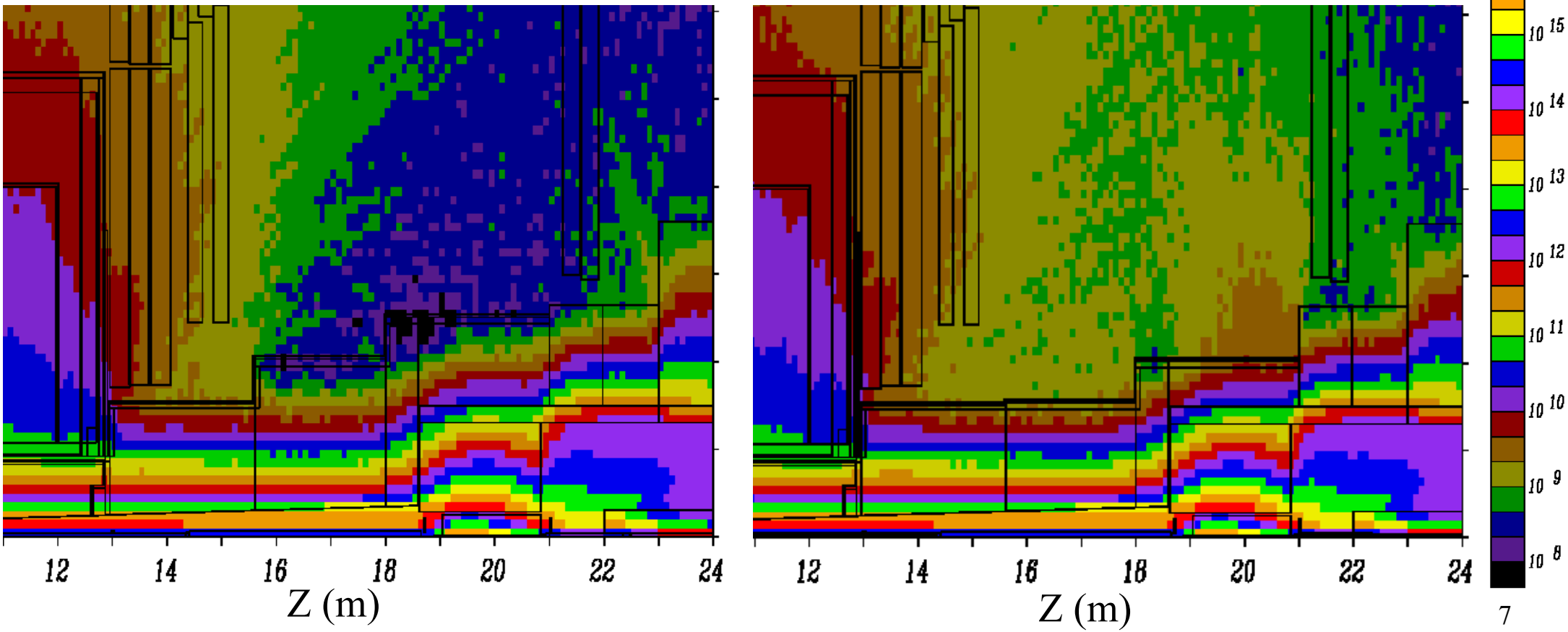
742 tons of Iron
46 tons of Steel
11 tons of Polyethylene



Flux of hadrons (both neutral and charged) > 20 MeV

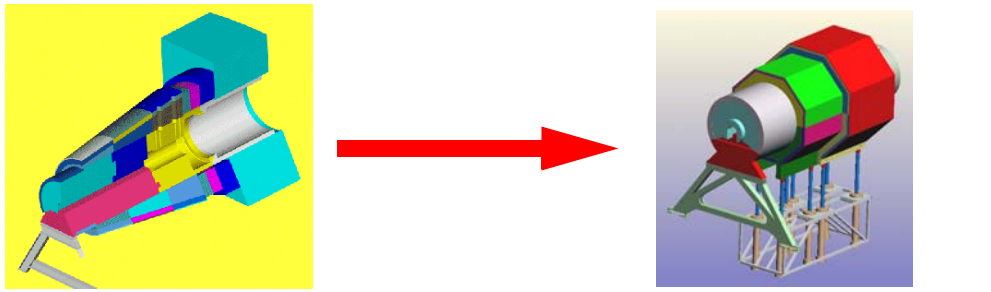


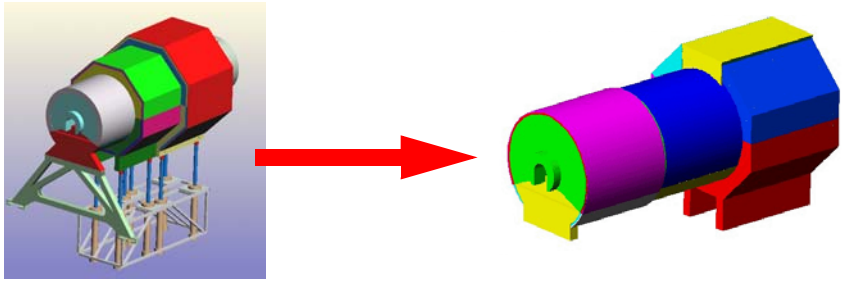


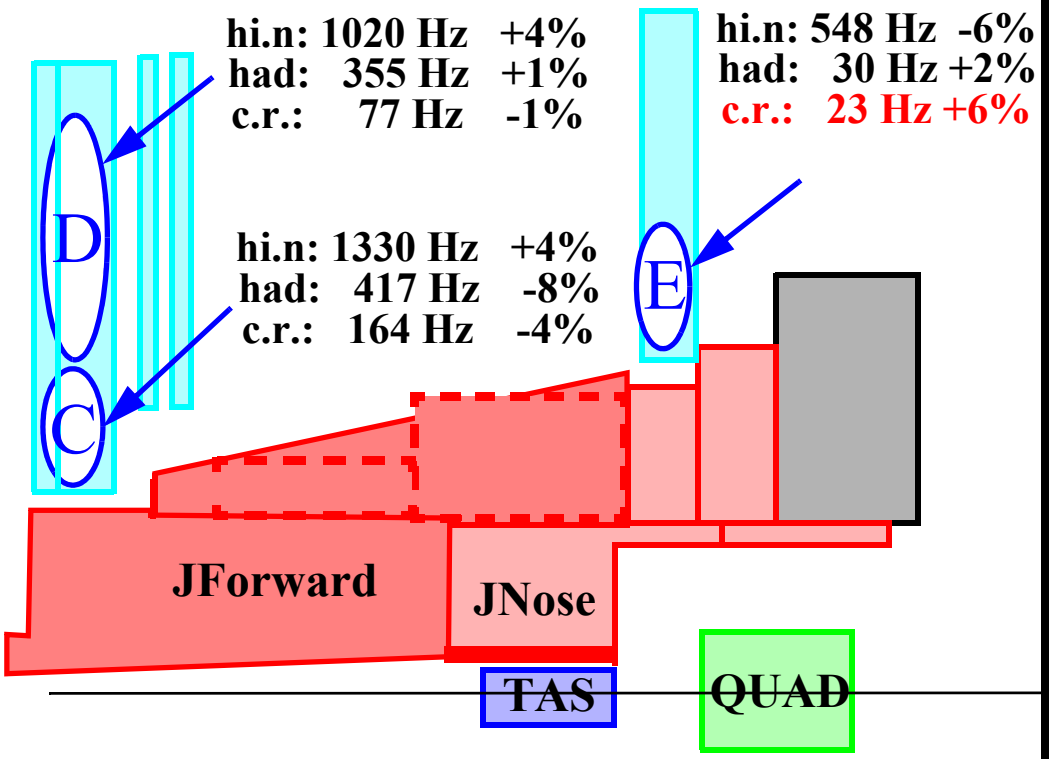


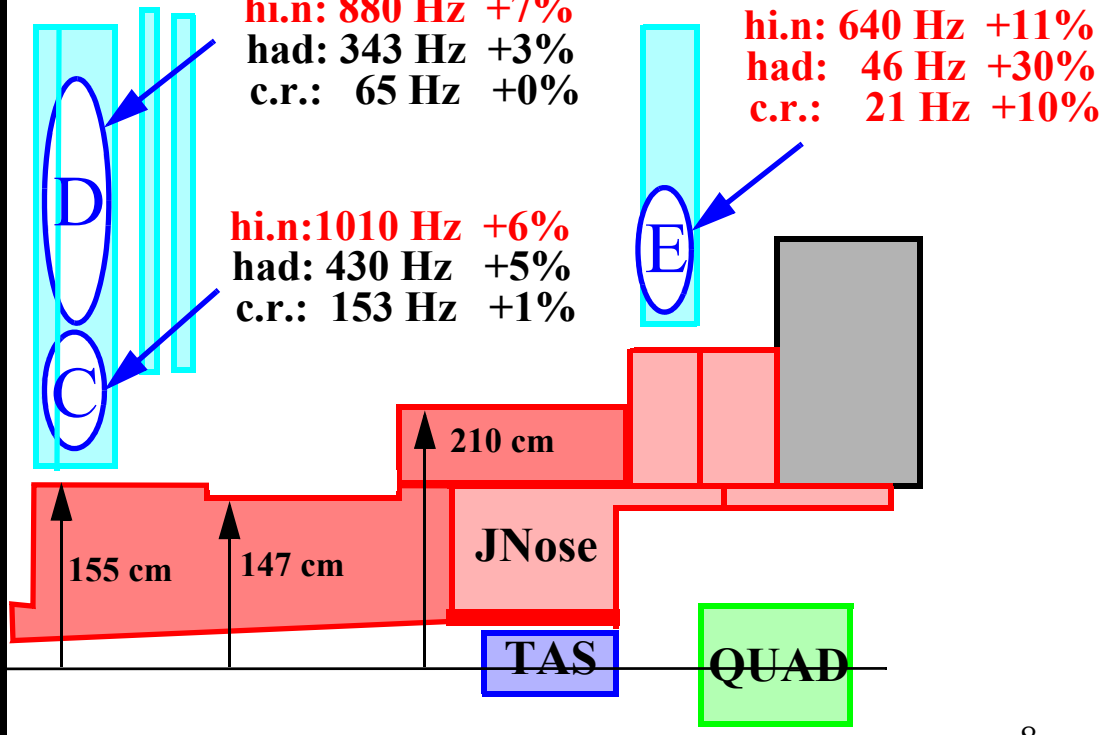
Change in background rate

hi.n: High Energy neutrons (> 100 keV)
had: Charged and neutral hadrons (> 20 MeV)
c.r.: Muon Chamber Counting Rate









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PART 1. SHIELDING

(Mike Shupe & Ian Hooton)

For details about background calculations see

http://atlasinfo.cern.ch/Atlas/TCOORD/Activities/CommonSys/Shielding/Activation/back/background.html

PART 2. ACTIVATION

(Misha Morev & Mike Shupe)

Doserate limits

Health implications

Methods of calculating activation

Standard (short) access and activation

Doserate limits

15 mSv / year	Maximum allowed dose at CERN.
5 mSv / year	Design limit for maintenance operations.

Example:	The maintenance time is counted in
10-100 μSv/h	weeks
100-1000 μSv/h	days
> 1 mSv/h	hours and minutes

500 mSv / year	Maximum allowed dose to hands and forearms.

Some typical doses

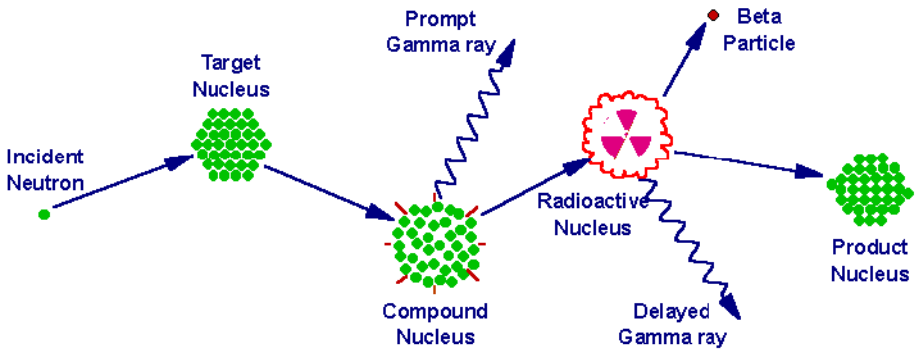
Transatlantic aeroplane flight:	20 μSv
Chest X-ray (local dose):	0.8 mSv
Teeth X-ray (local dose):	6-30 mSv
Background radiation per year:	0.4-4 mSv

Health implications

Increased risk of premature death from

skiing during a 10-day holiday	$0.5 \cdot 10^{-4}$
working in the construction industry during a year	$2 \cdot 10^{-4}$
receiving 10 mSv of radiation	$5 \cdot 10^{-4}$
driving a car 5000 km	$5 \cdot 10^{-4}$
working with mining or fishing during a year	$10 \cdot 10^{-4}$
smoking 20 cigarettes a day during a year	$50 \cdot 10^{-4}$
working as president of the USA during a year	$150 \cdot 10^{-4}$
receiving 10 mSv of radiation per year during the age of 18 to 65	$300 \cdot 10^{-4}$

Activation by thermal neutrons



Example:

Ag-109 (48% of Ag) → Ag-110m

σ = 20000 barns

τ = 250 days

Pb-208 (52% of Pb) → Pb-209

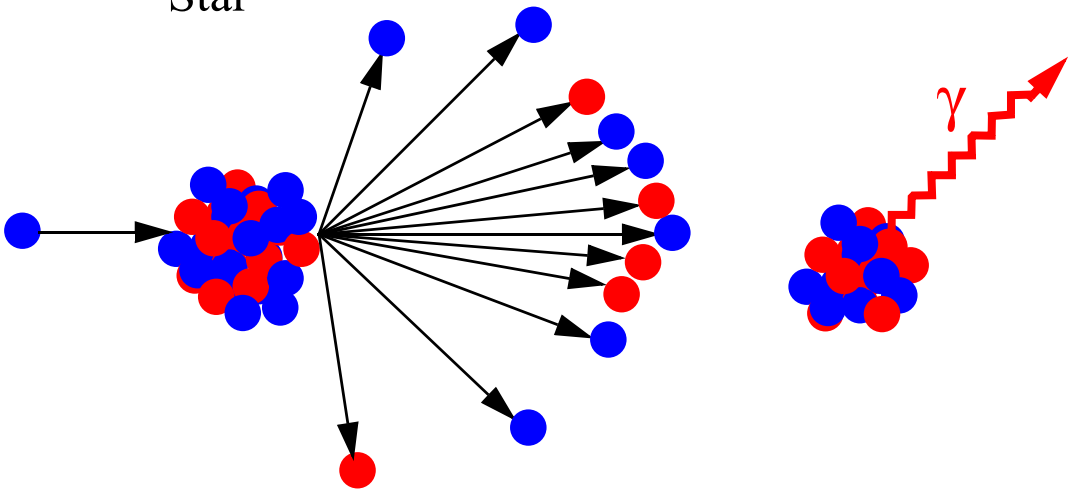
σ = 3 barns

τ = 3.3 hours

Activation by high energy hadrons

Inelastic interaction
"Star"

Radioactive nucleus



The ratio of the doserate from a steel and an aluminium beampipe.

Cooling time	Running time 5000d	1000d	100d	30d
1 d:	4	7	12	12
5 d:	4	8	37	94
30 d:	2	3	12	21

Method 1

(Hedberg - Shupe)

Input:

Stardensity maps calculated with GCALOR

Contact dose rate = ω • Stardensity

30 days irradiation
1 day cooling off

Iron	$1.0 \cdot 10^{-8}$ Sv/h / $cm^{-3}\, s^{-1}$
Copper	1.0
Steel	1.3
Lead	1.5
Tungsten	1.1
Aluminium	0.2
Concrete	0.3
Marble	0.06

Method 2

(Morev et al.)

Input:

Material and geometry description of the experiment

Particle flux maps calculated with GCALOR

Cross sections

Activity:

$$A = n\,(1-e^{-T\lambda})\,e^{-\lambda t}\int \sigma(E)\varphi(E)dE$$

Number of target nuclei

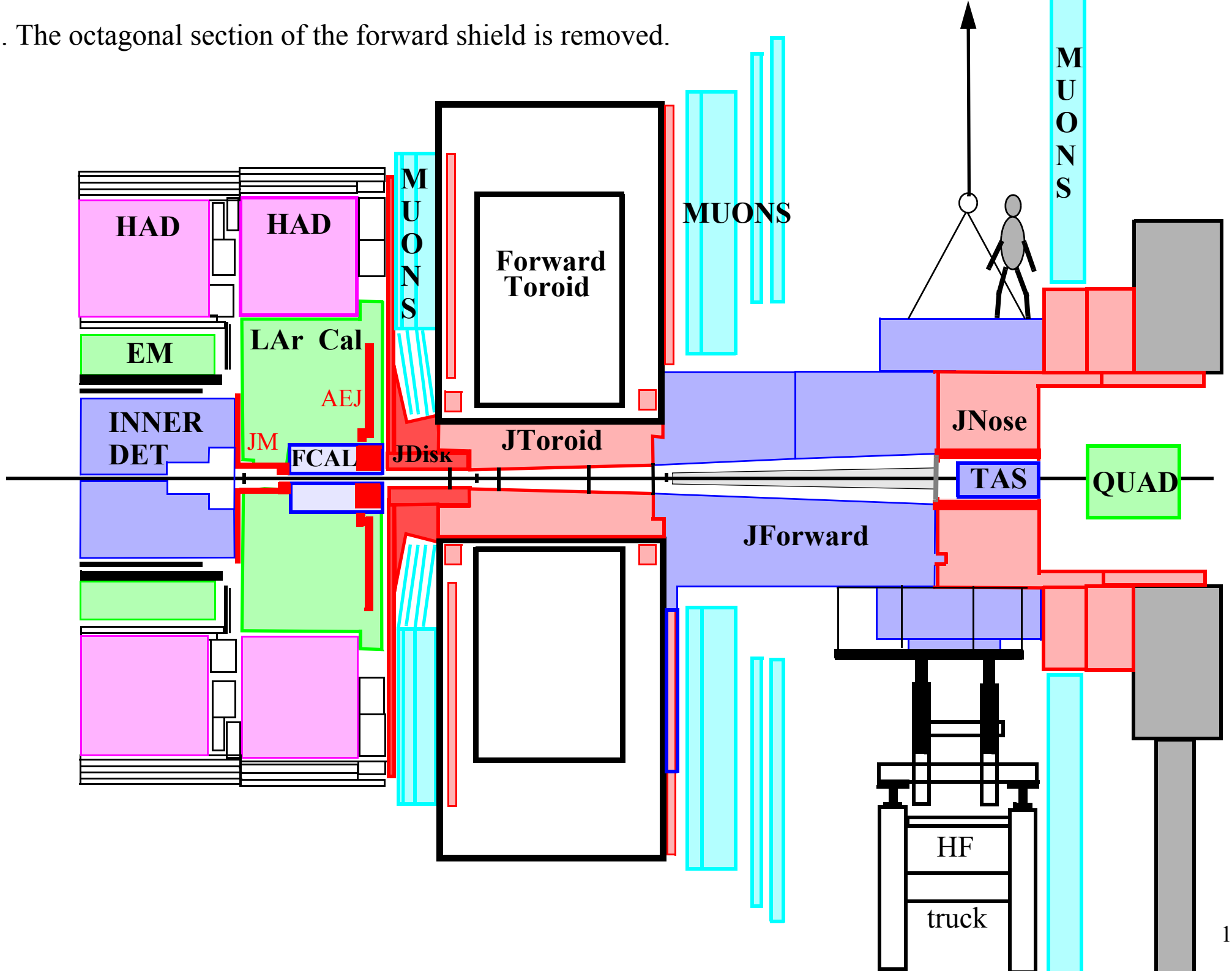
Decay constant

Running time

Cooling-off time

The programs DOT-III and MCNP are used to calculate photon transport.

1. The octagonal section of the forward shield is removed.



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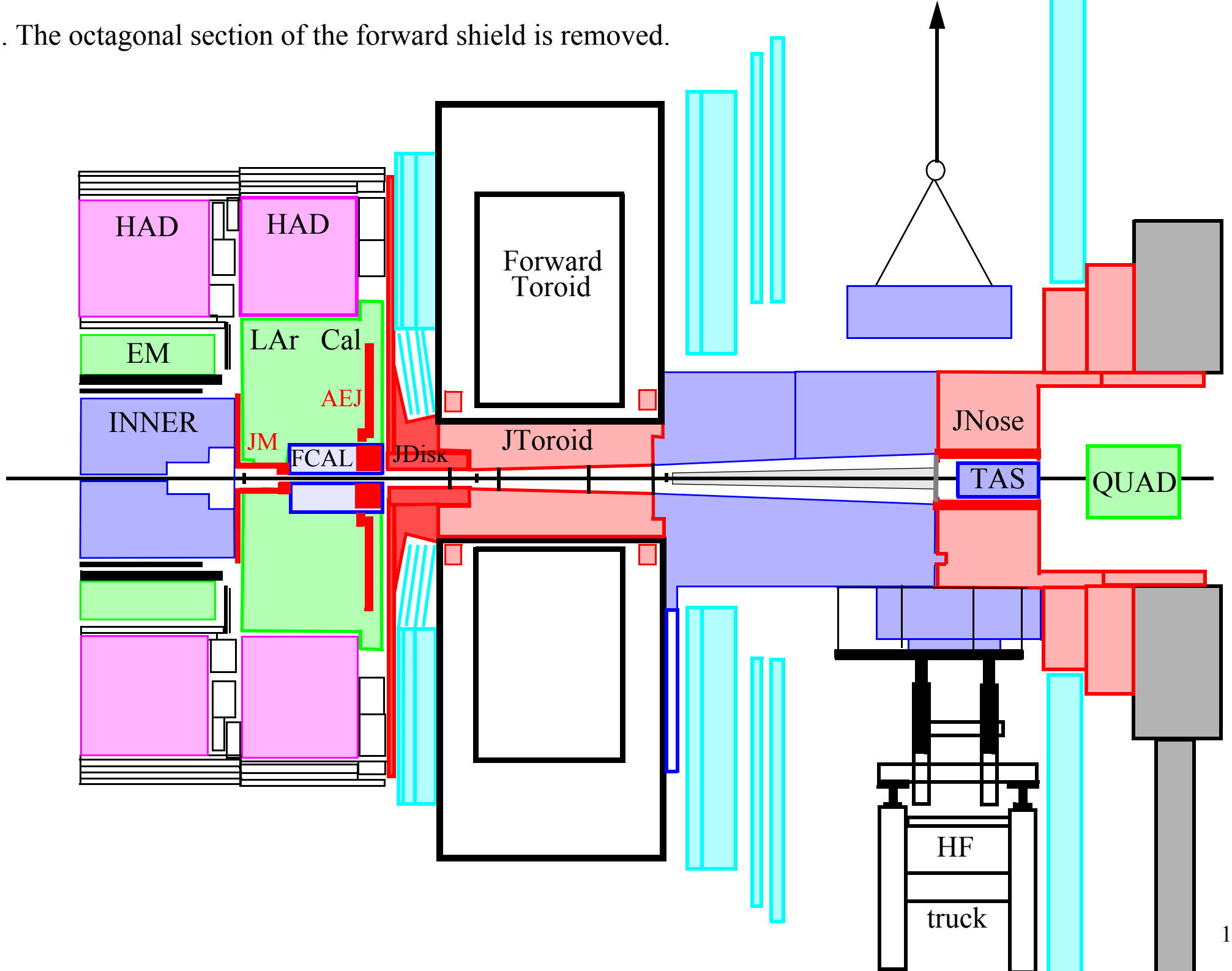

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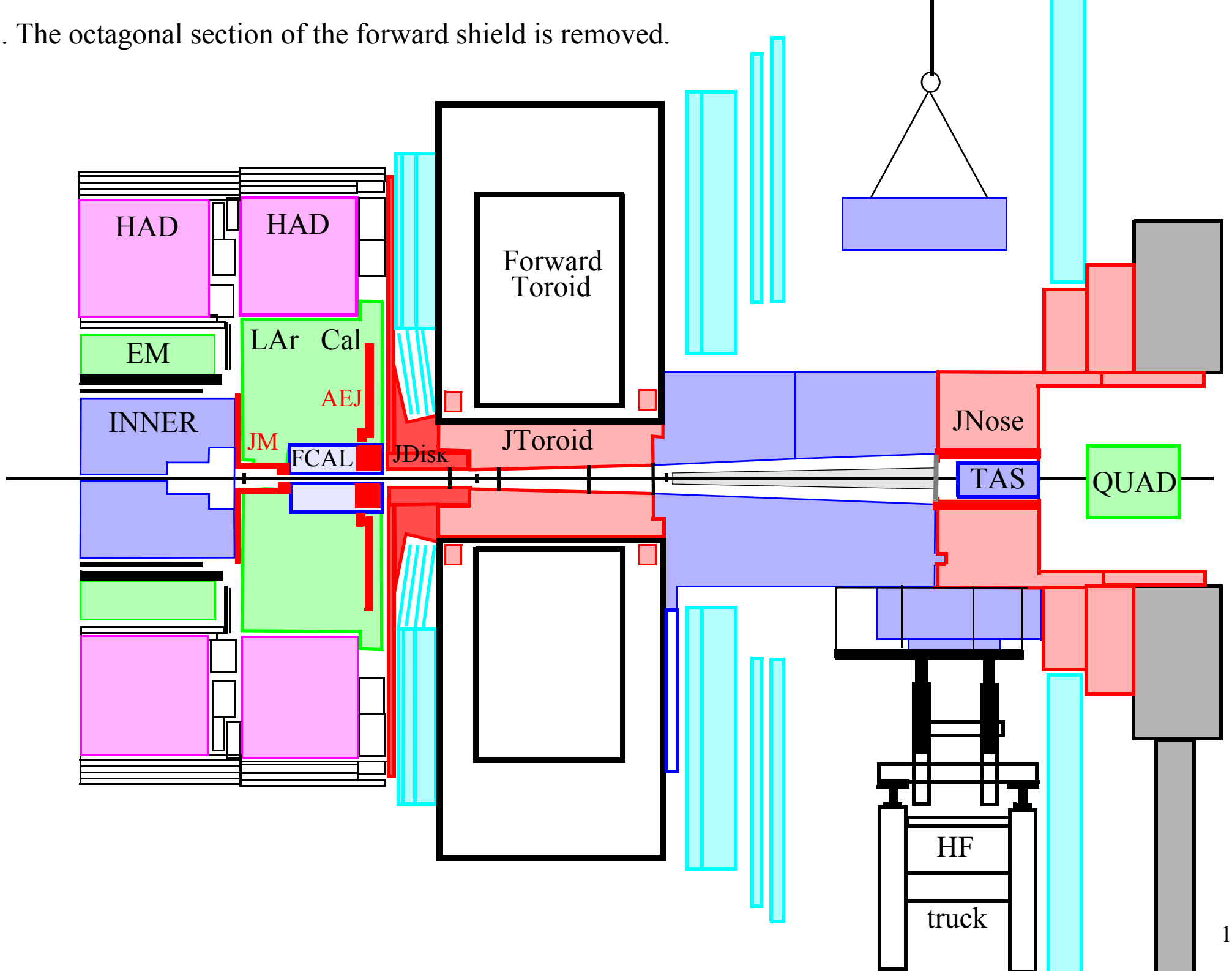

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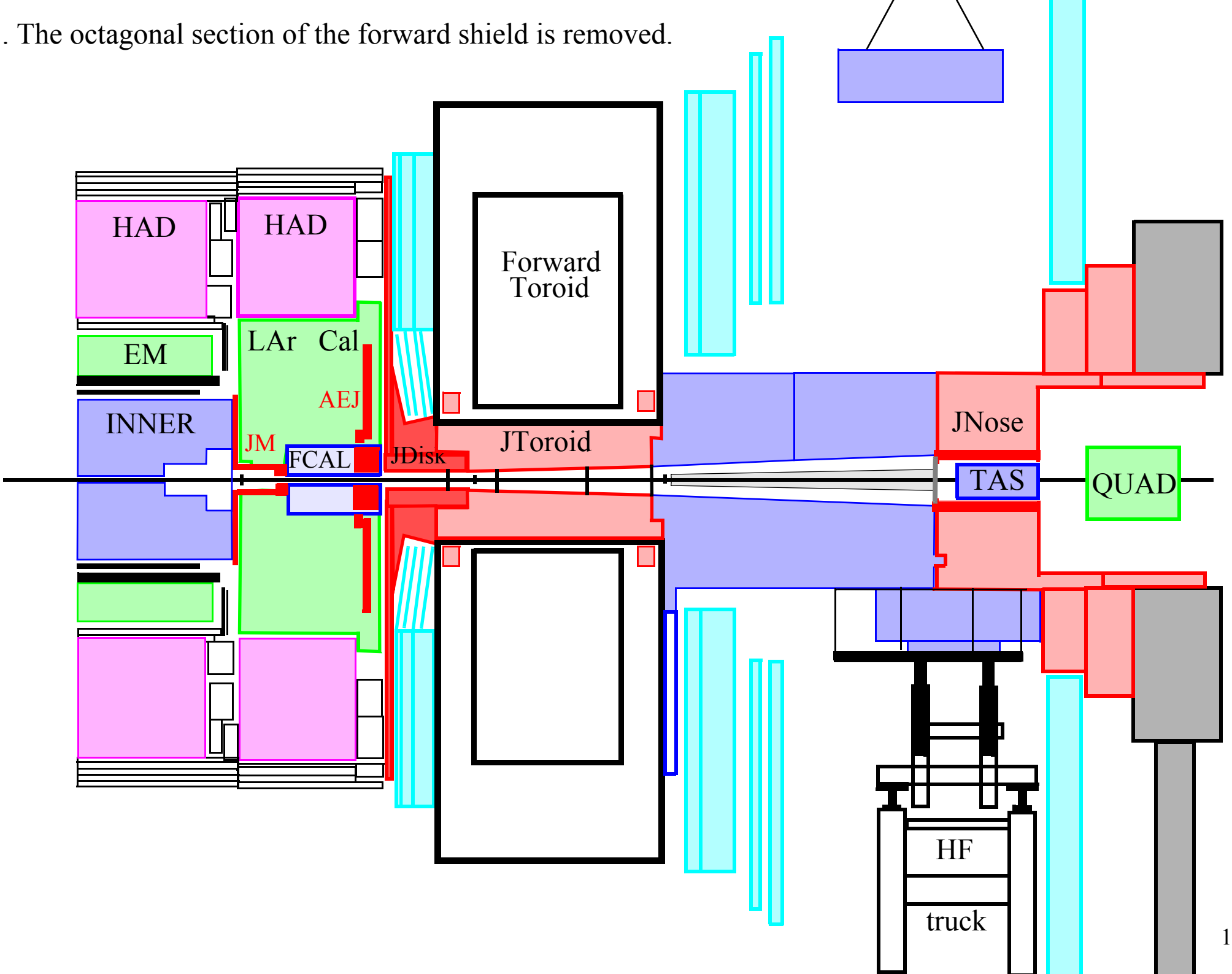

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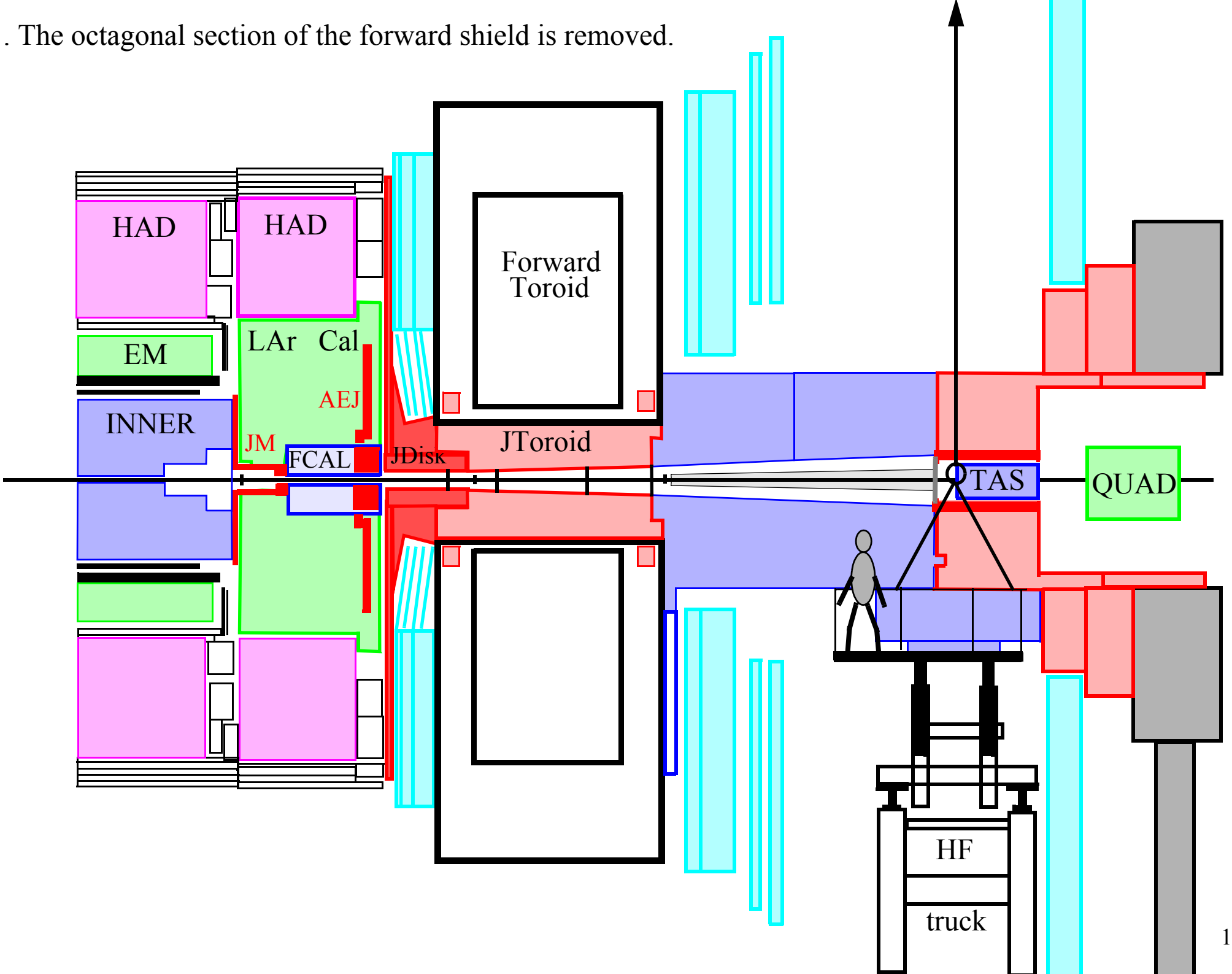

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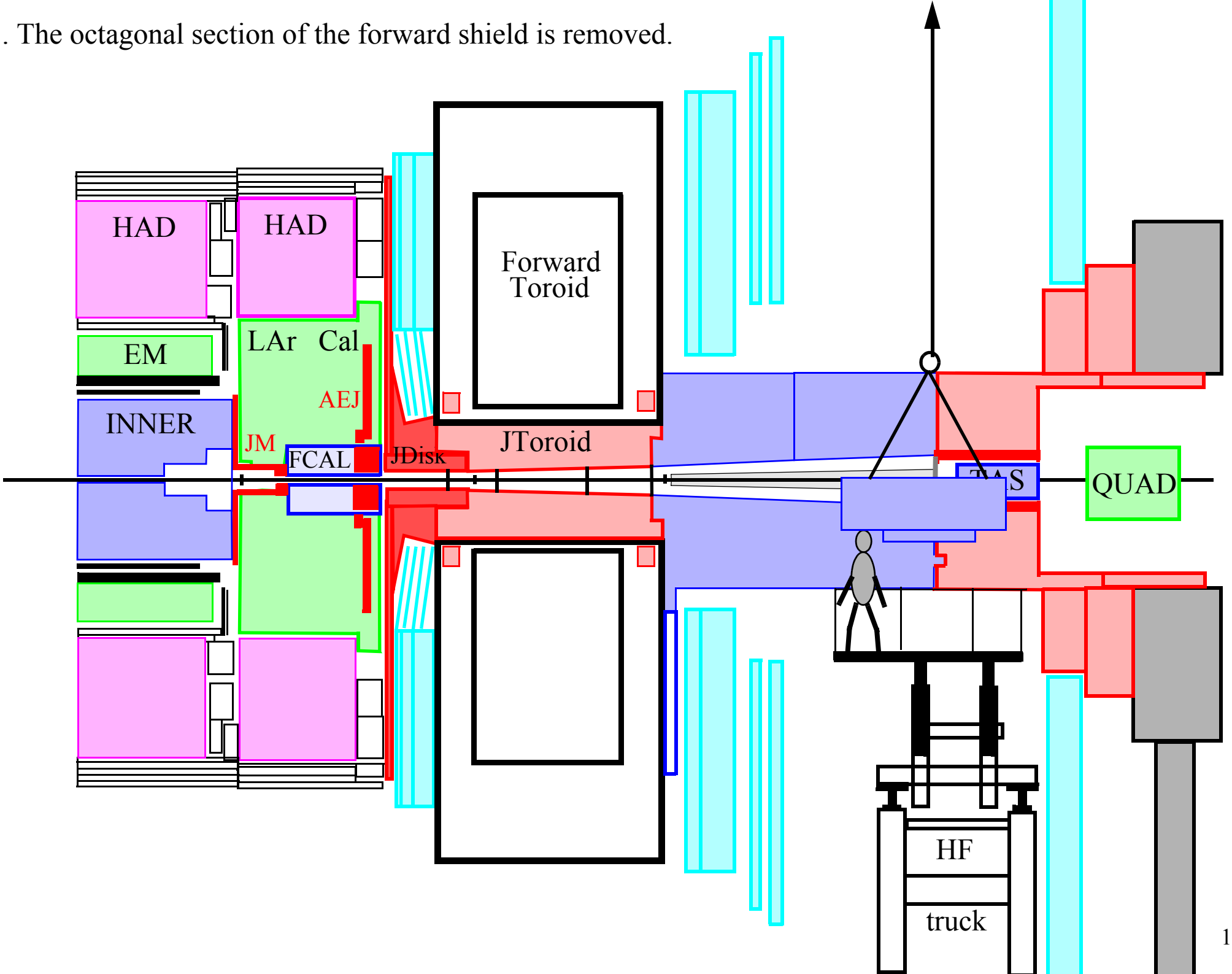

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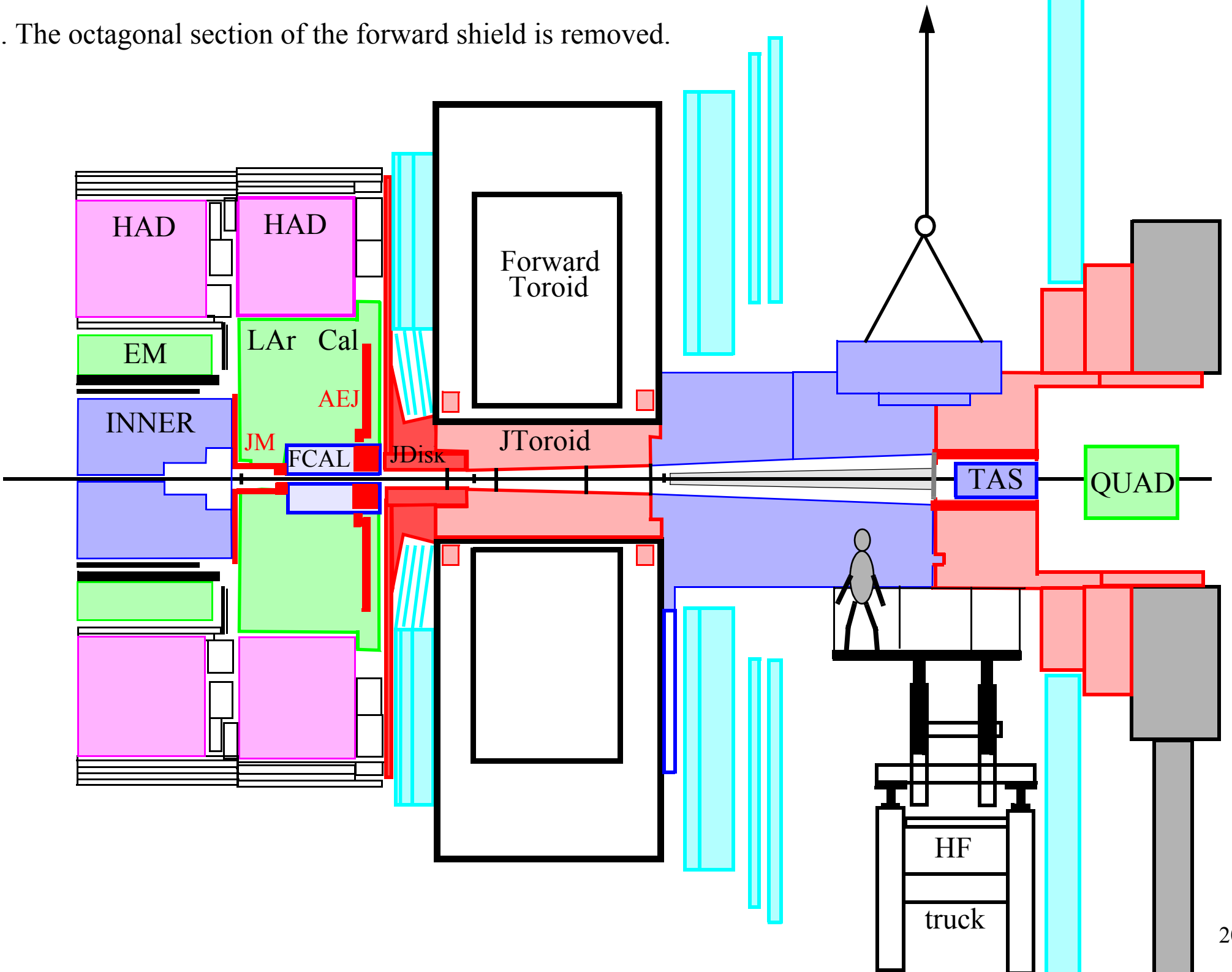

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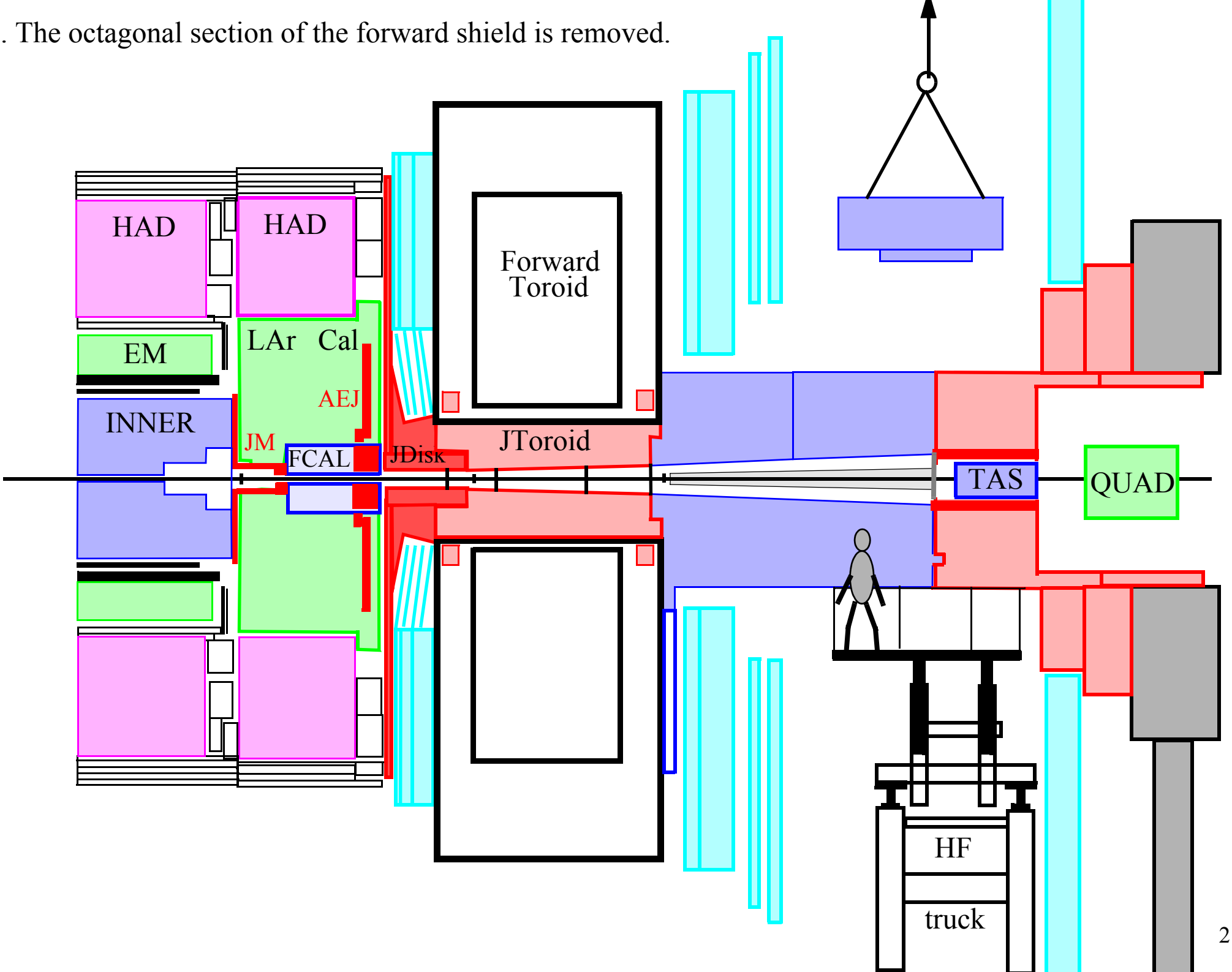

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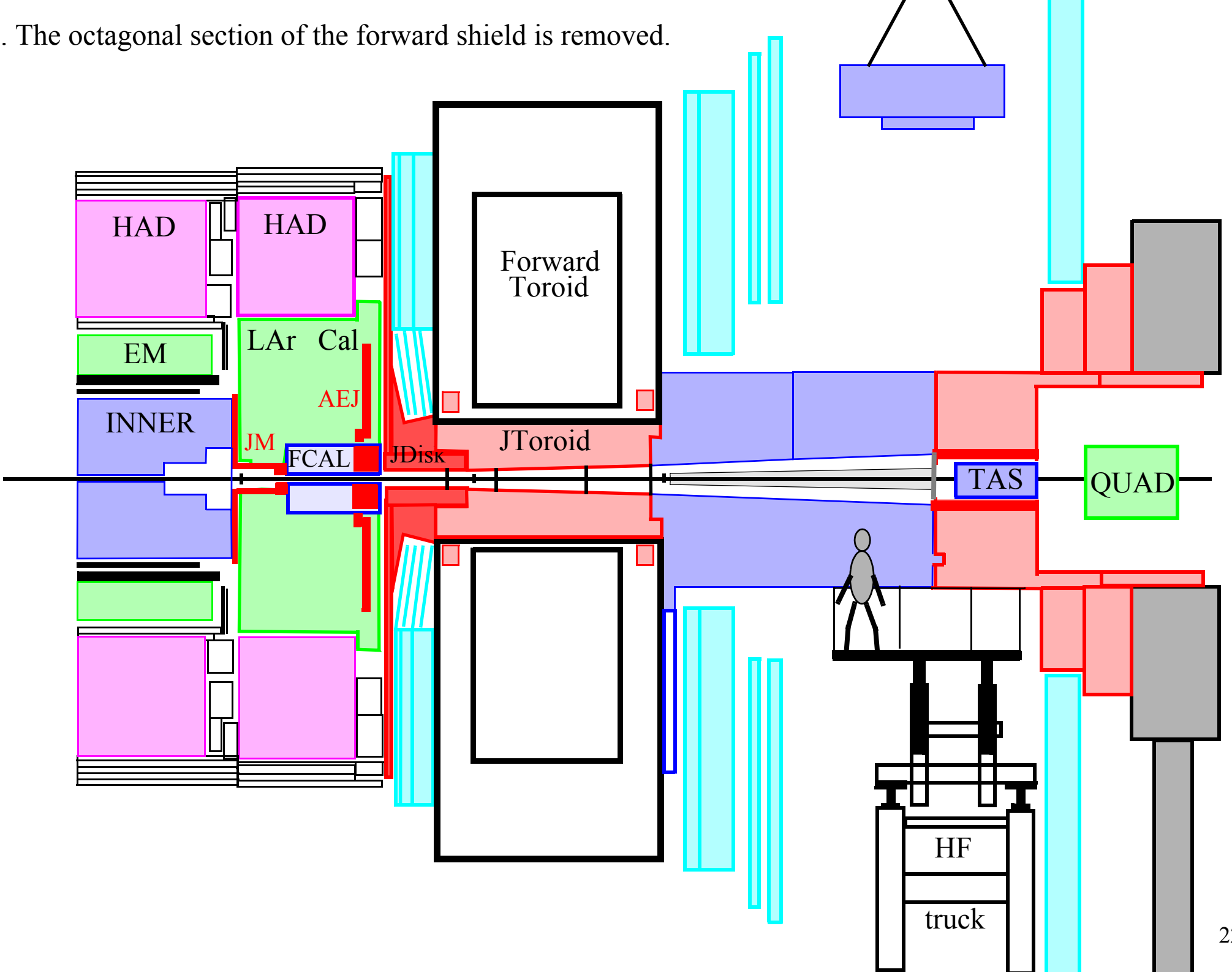
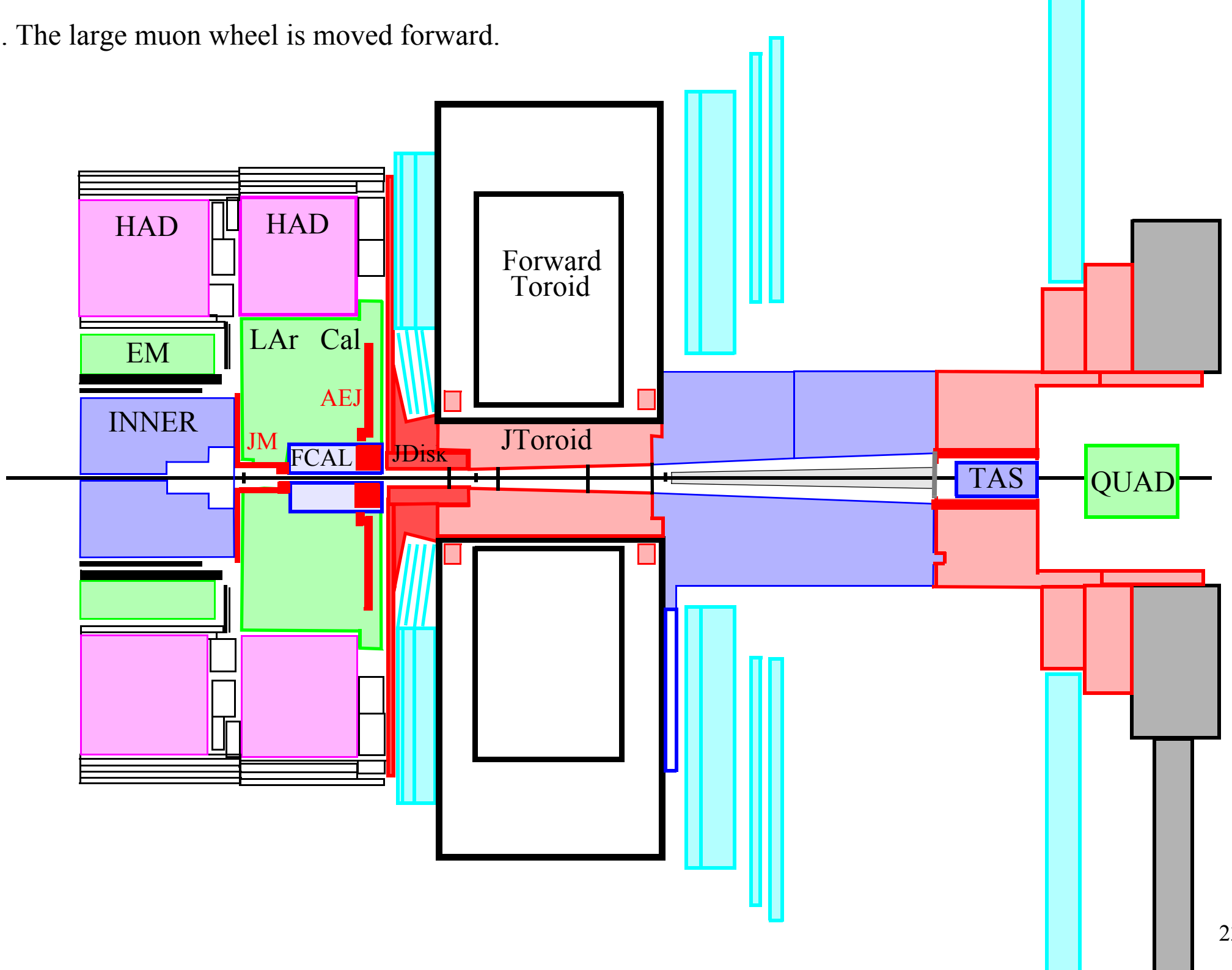


2. The large muon wheel is moved forward.



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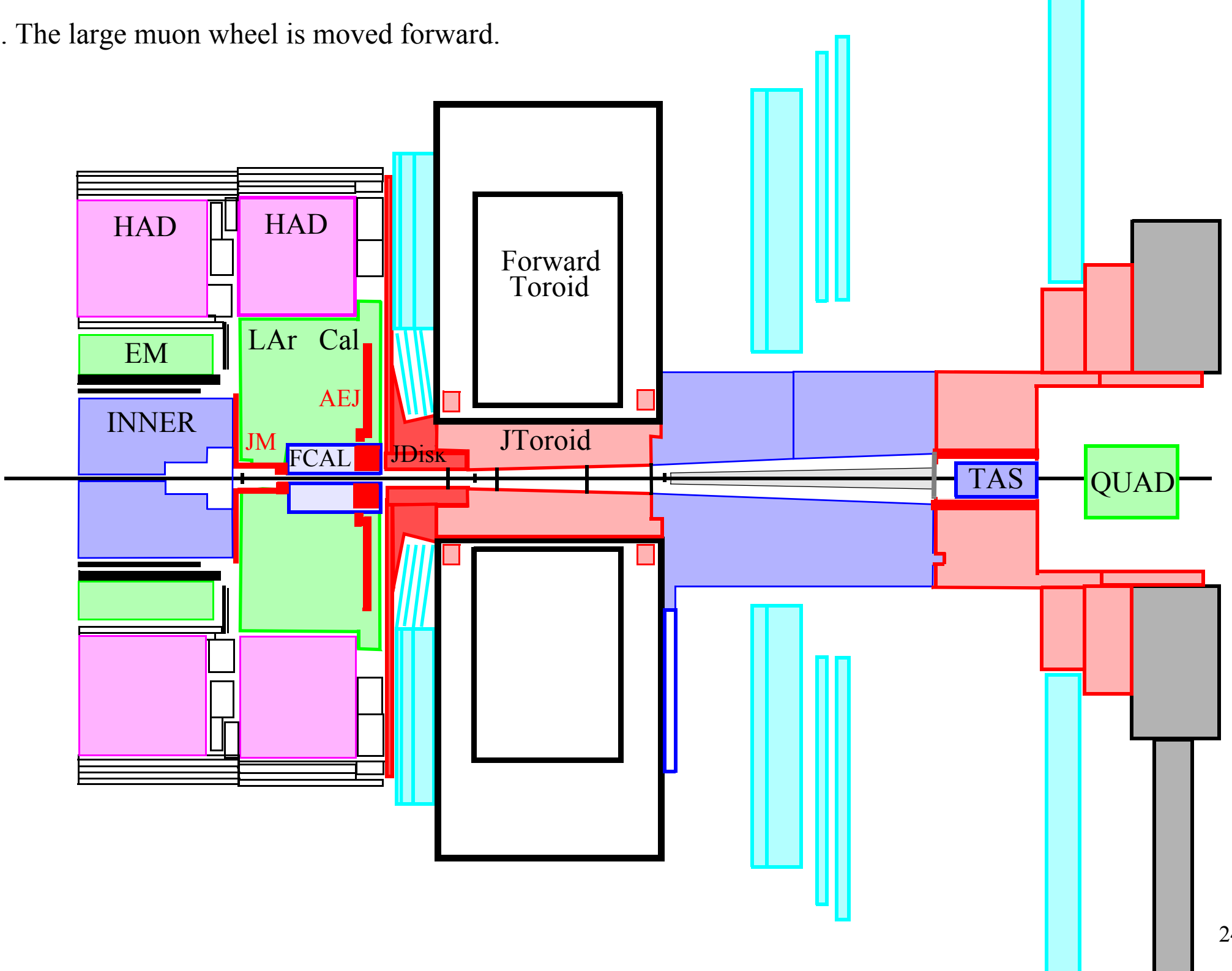

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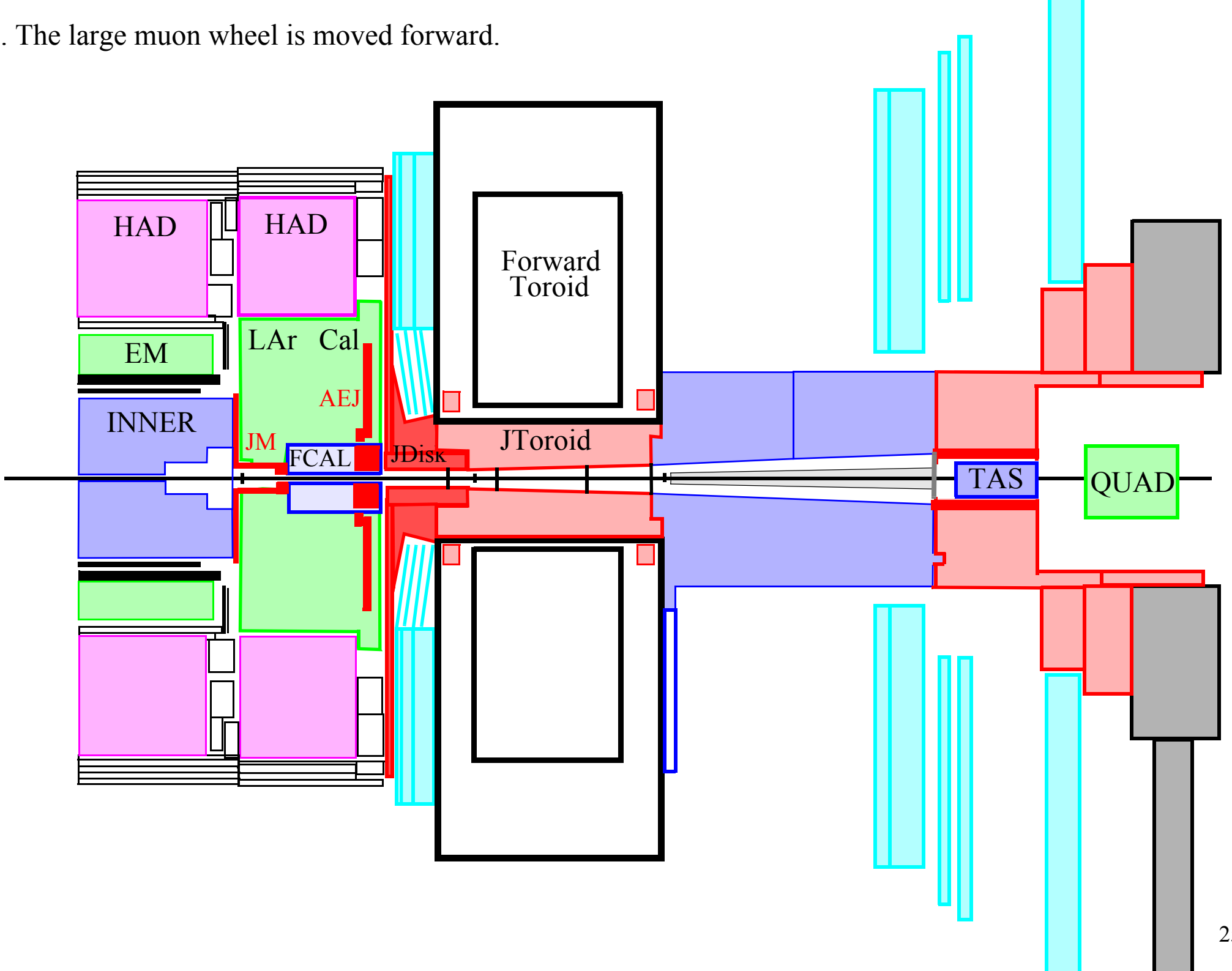

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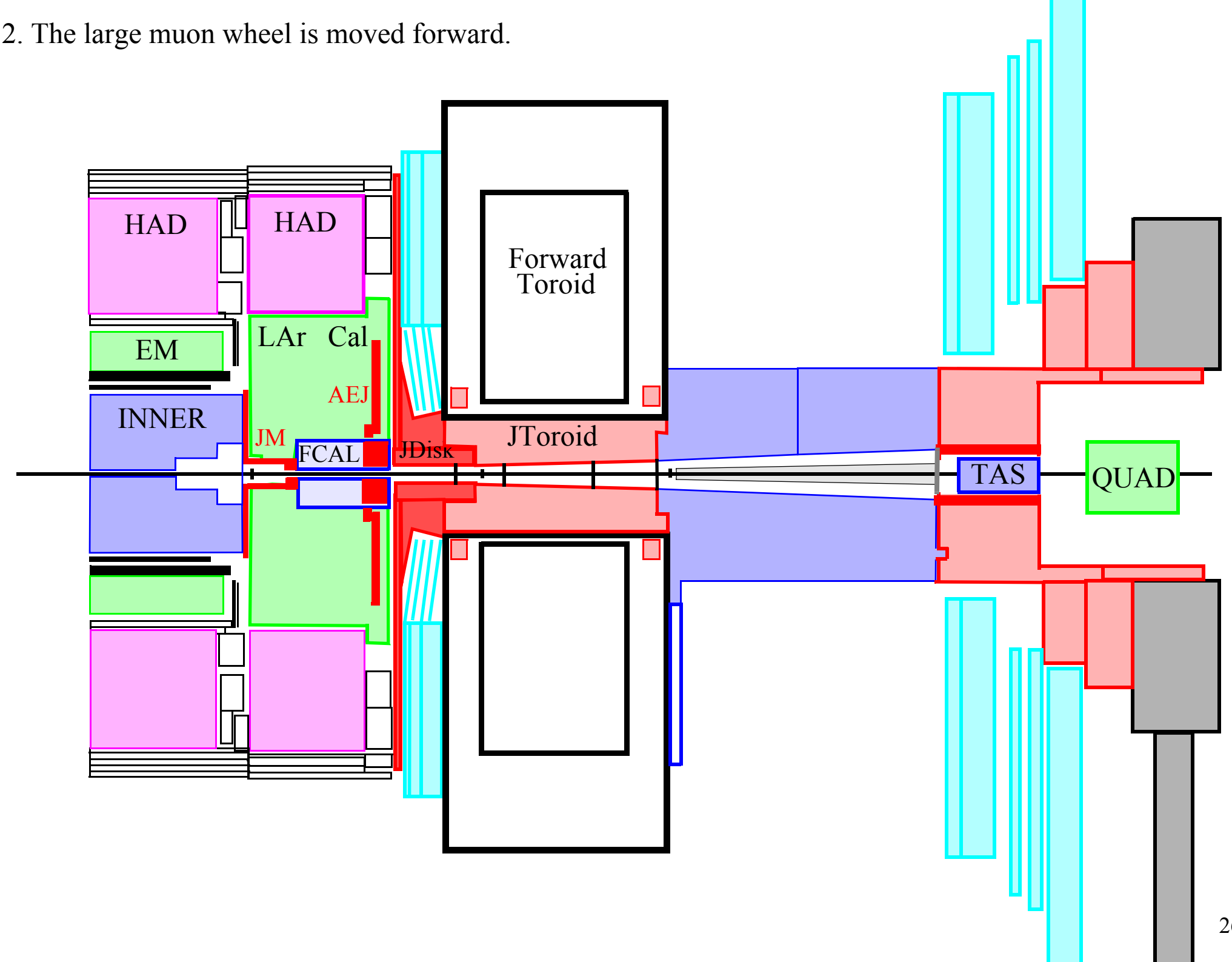
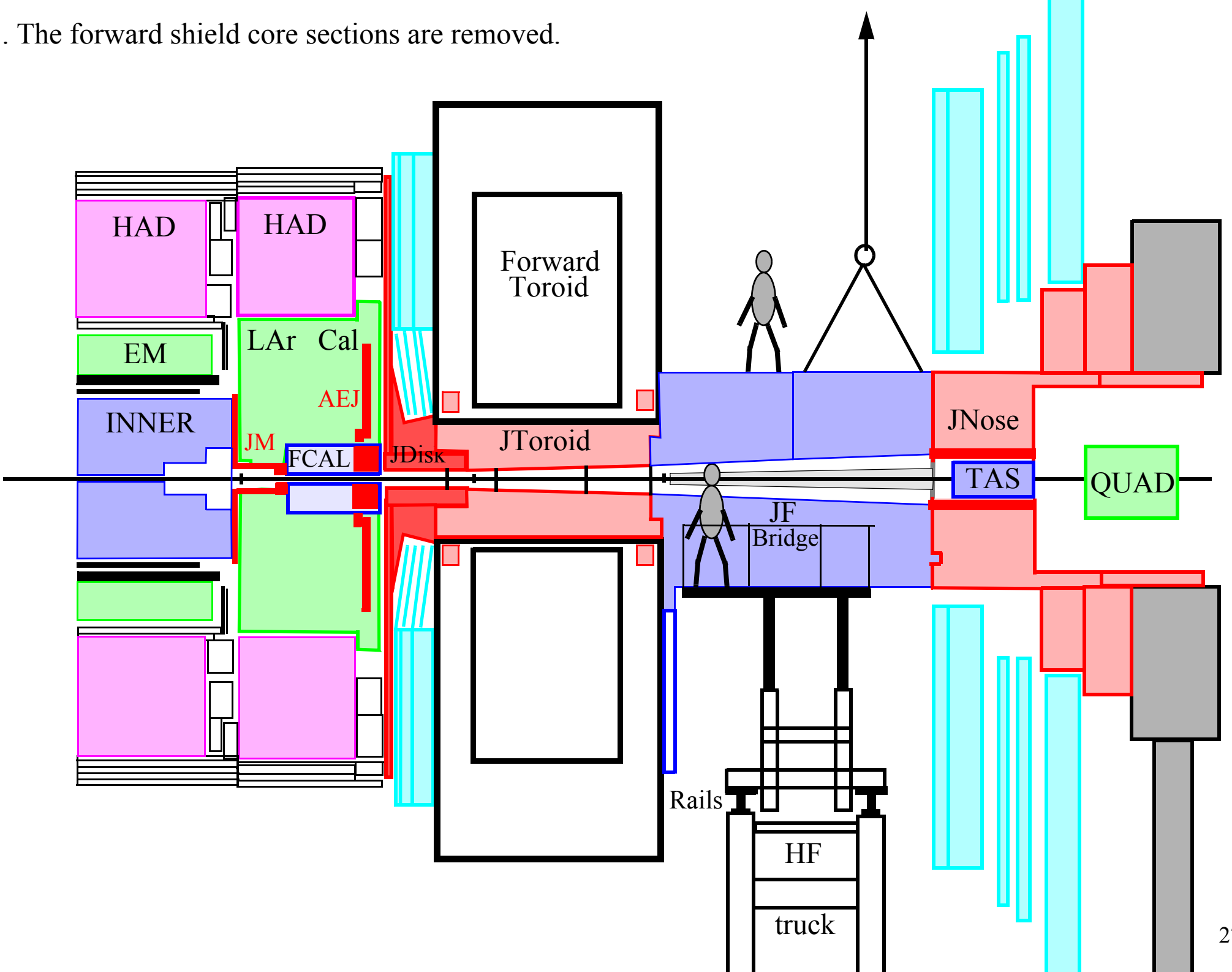


3. The forward shield core sections are removed.



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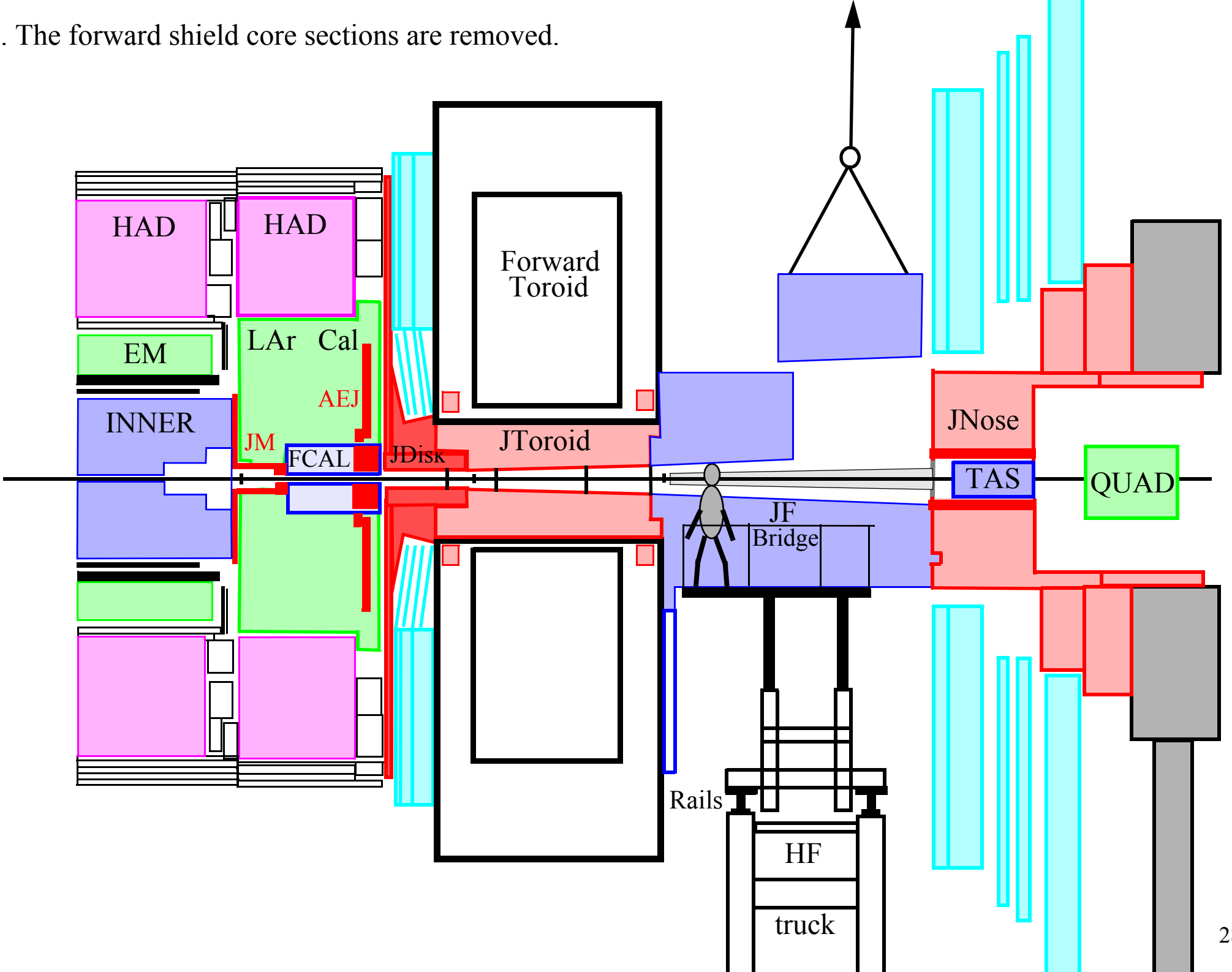

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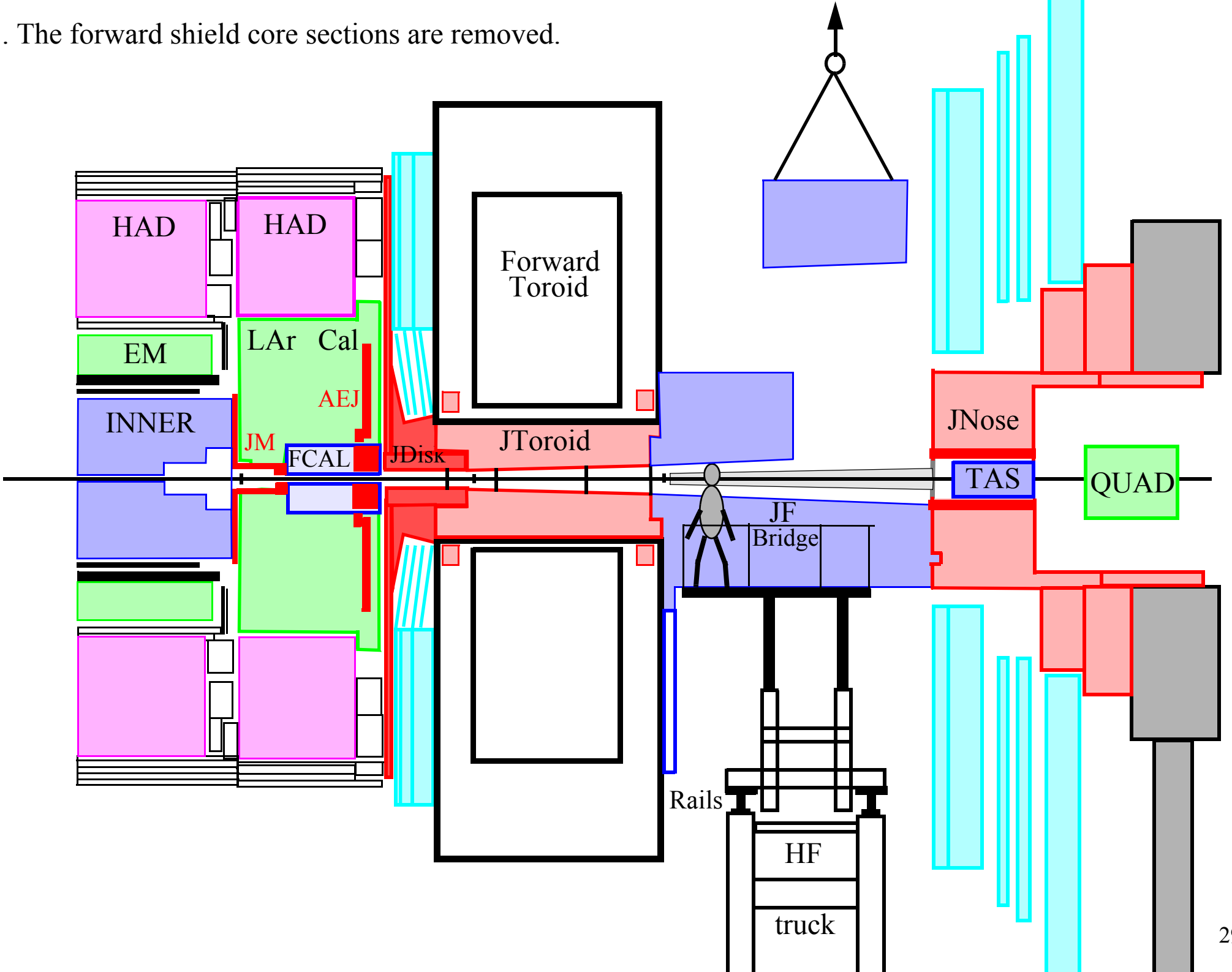

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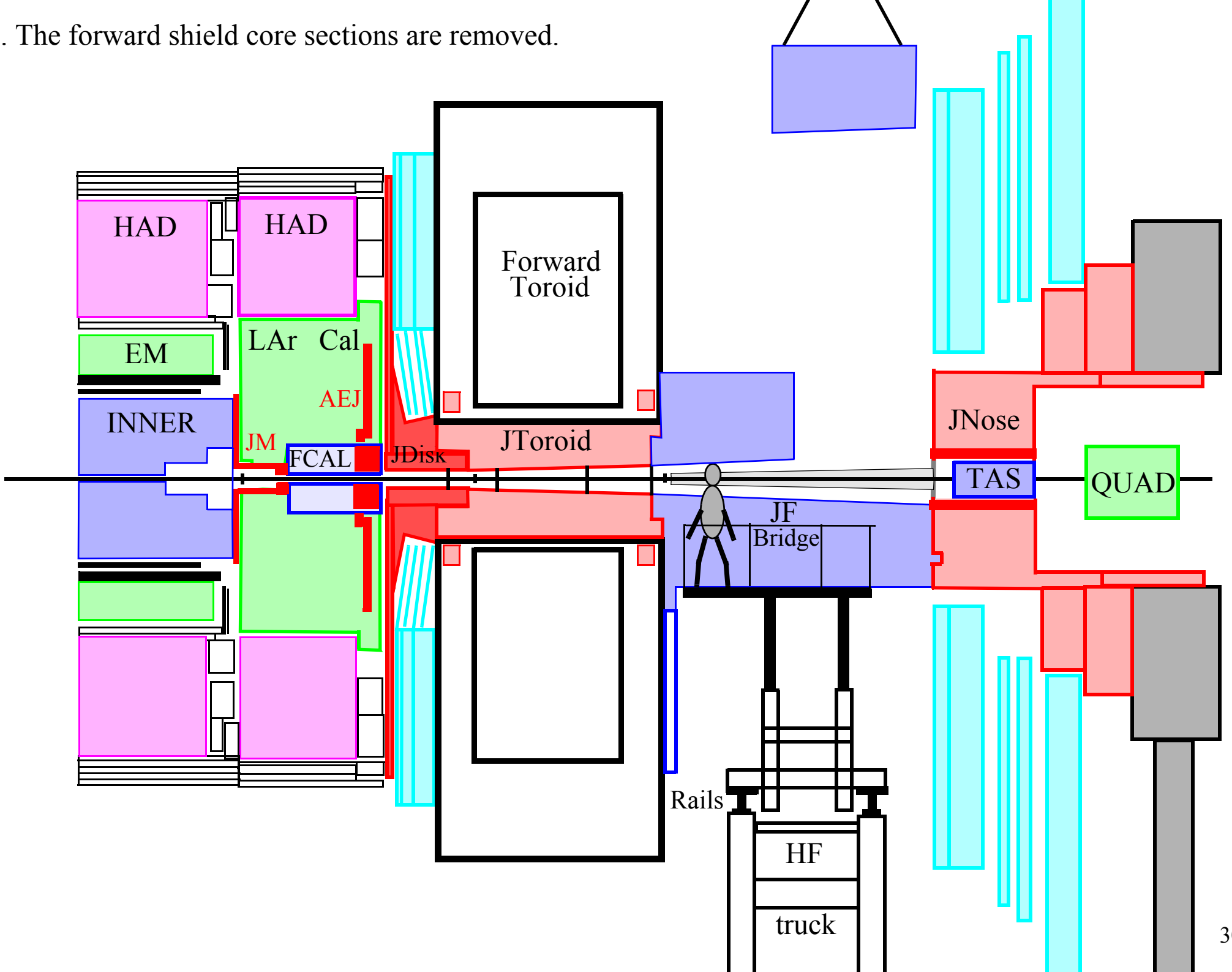

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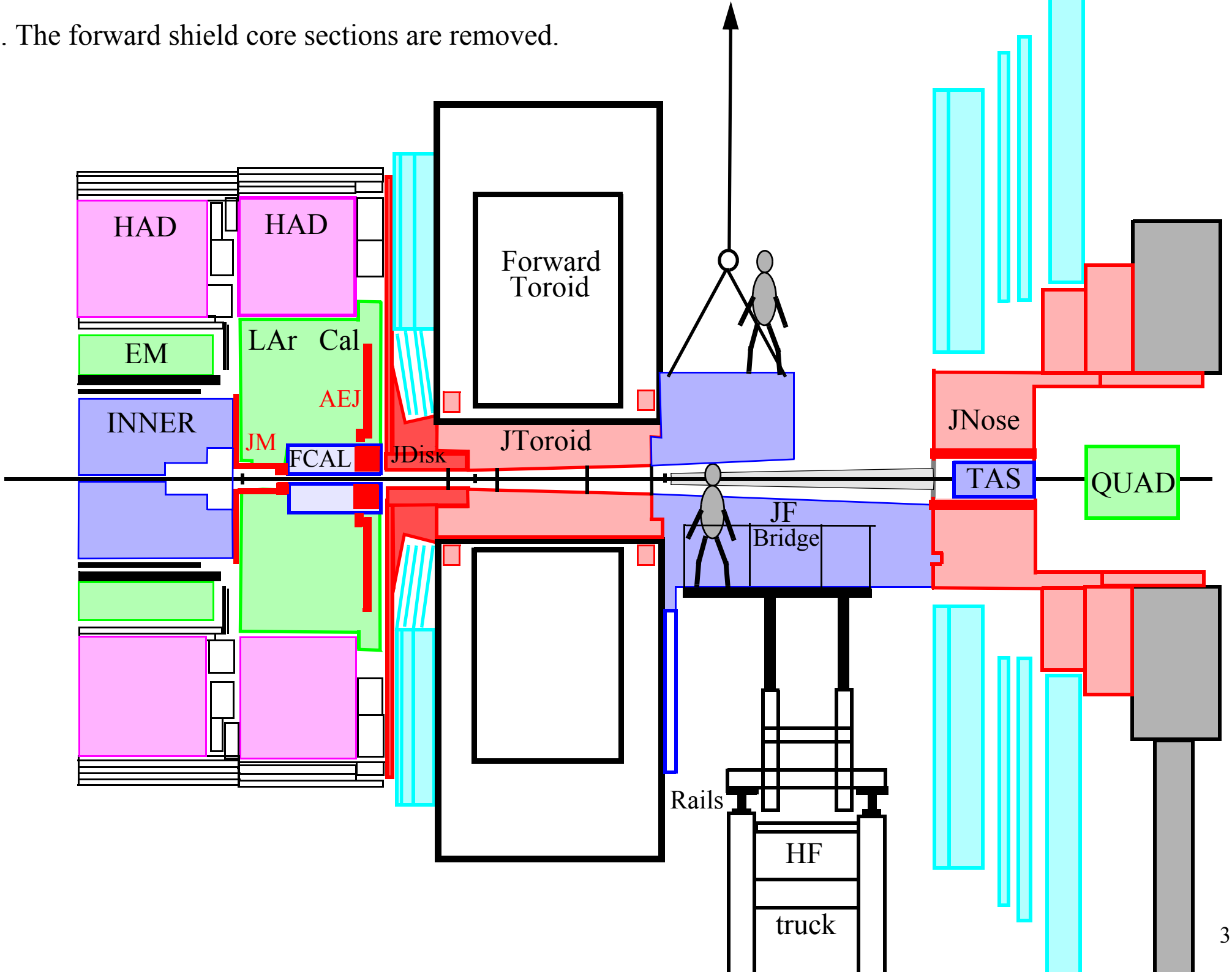
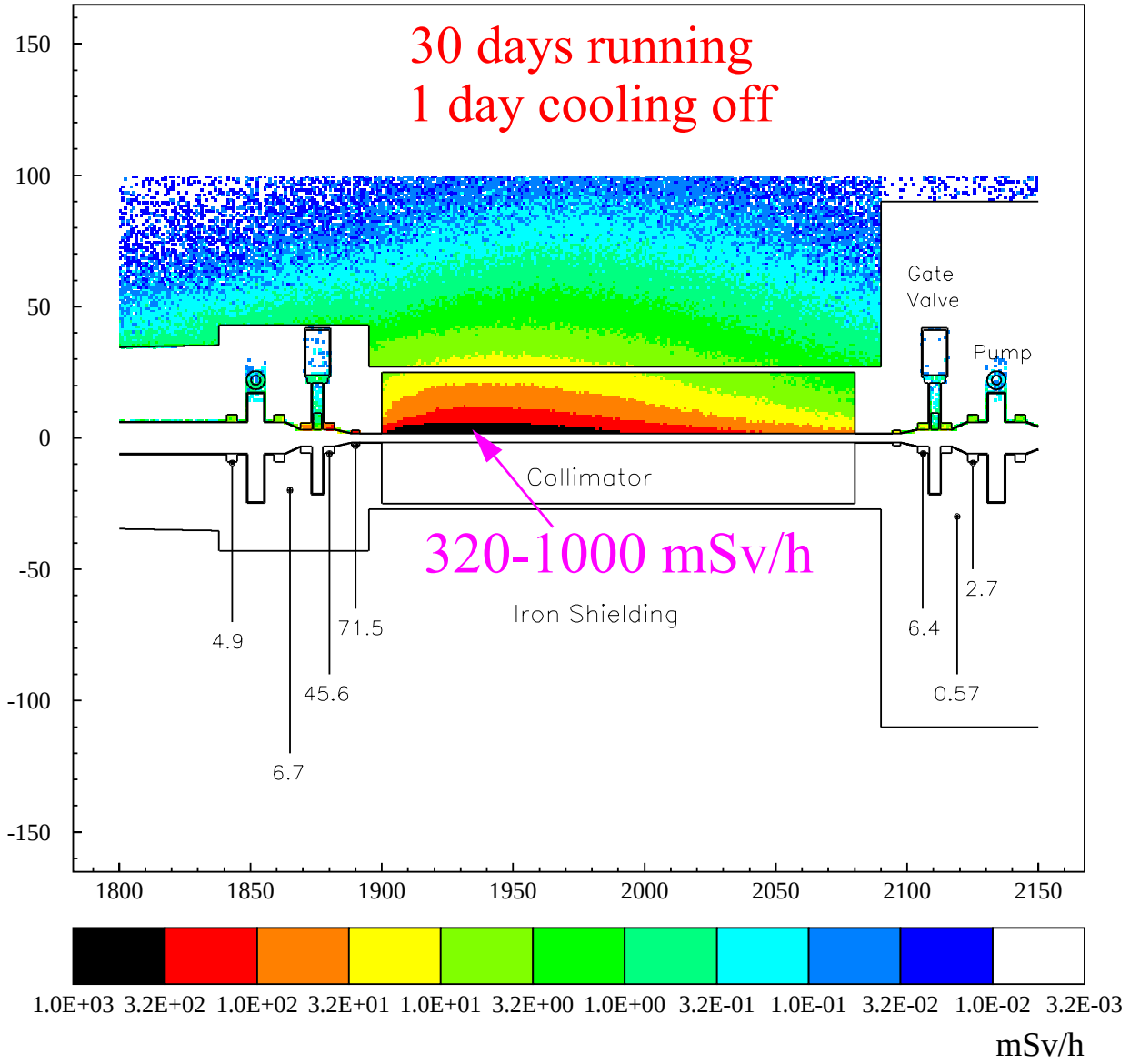


Dose rates in mSv/h around the TAS collimator

(calculation by I. Dawson and G. Stevenson using omega factors)



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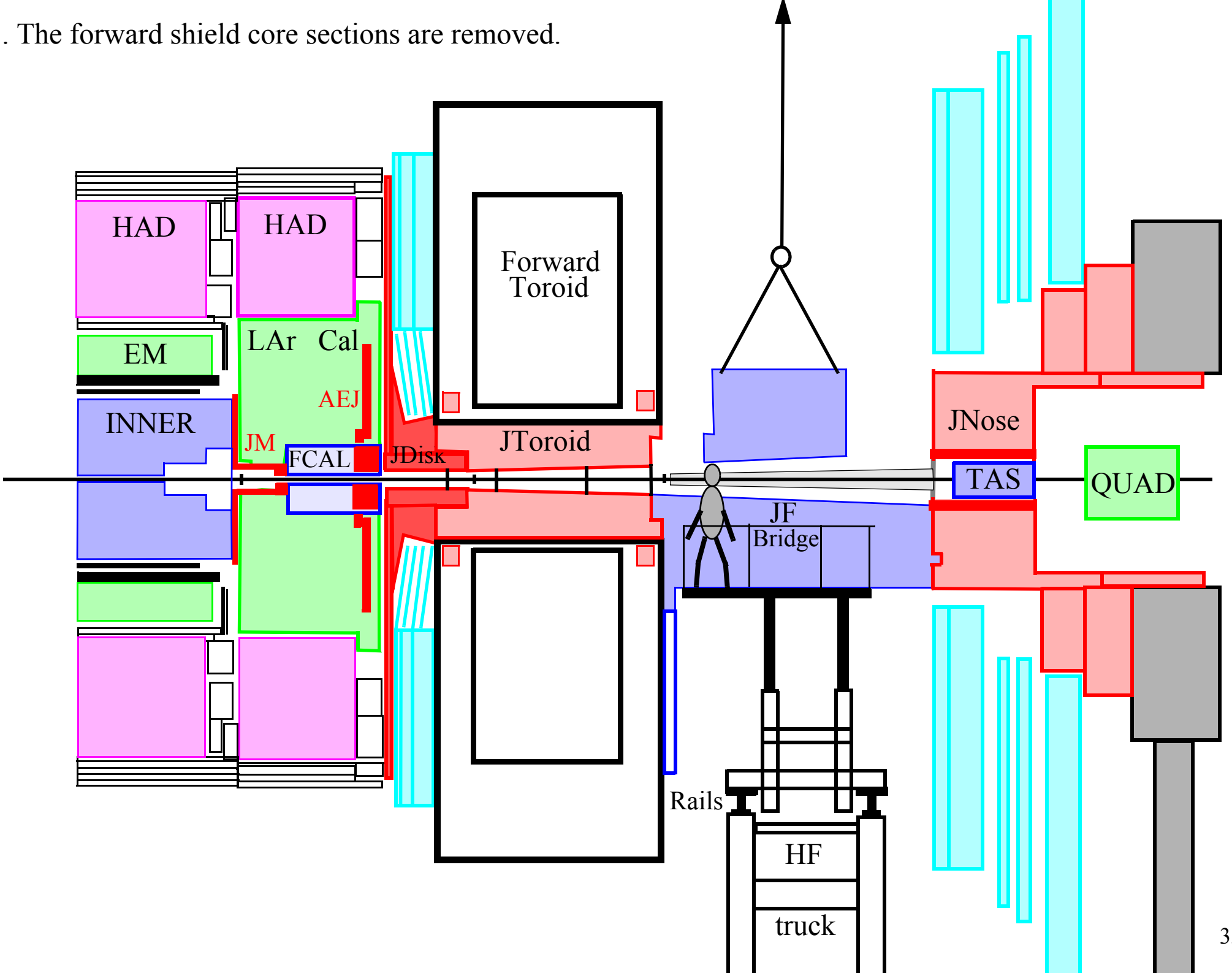

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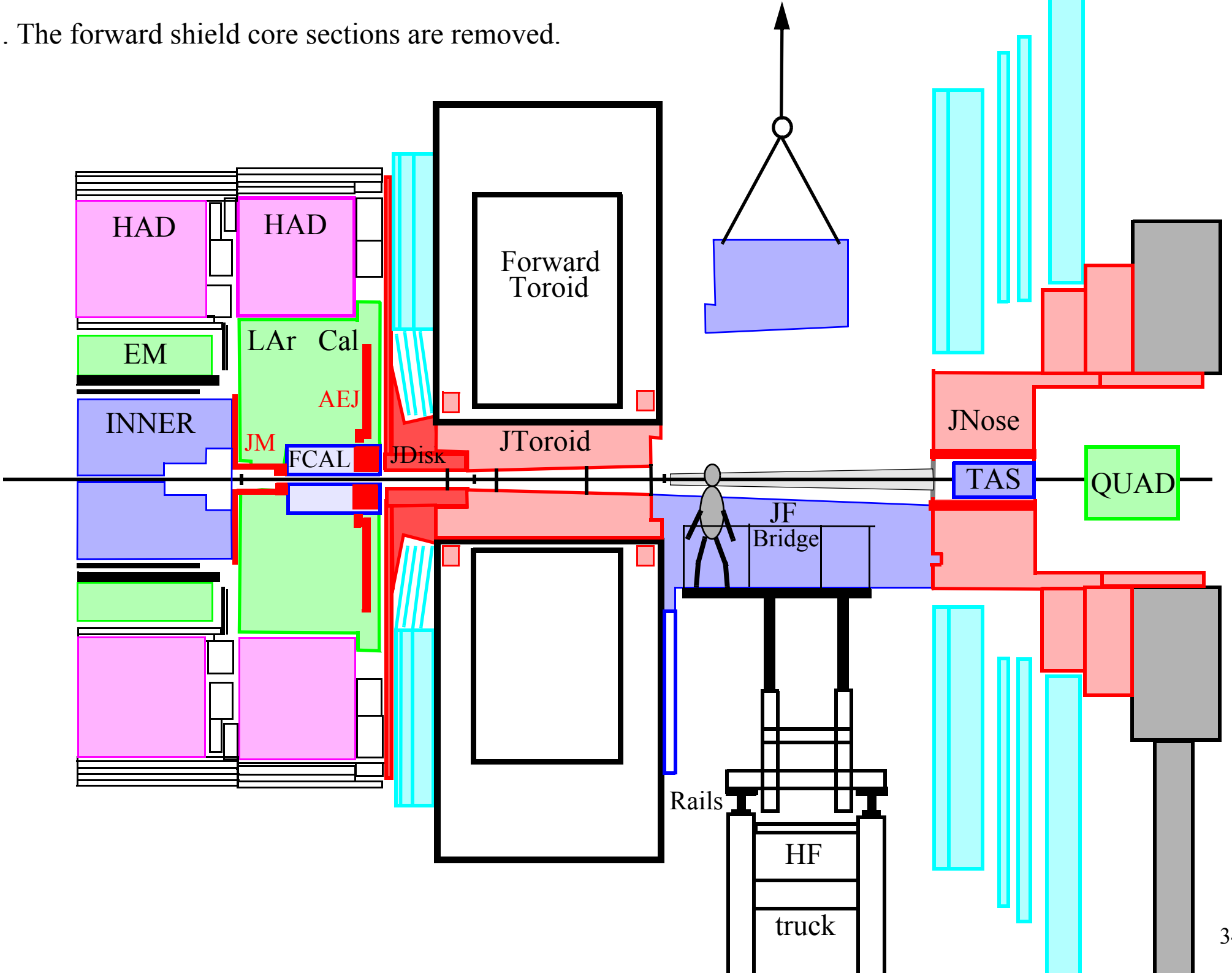

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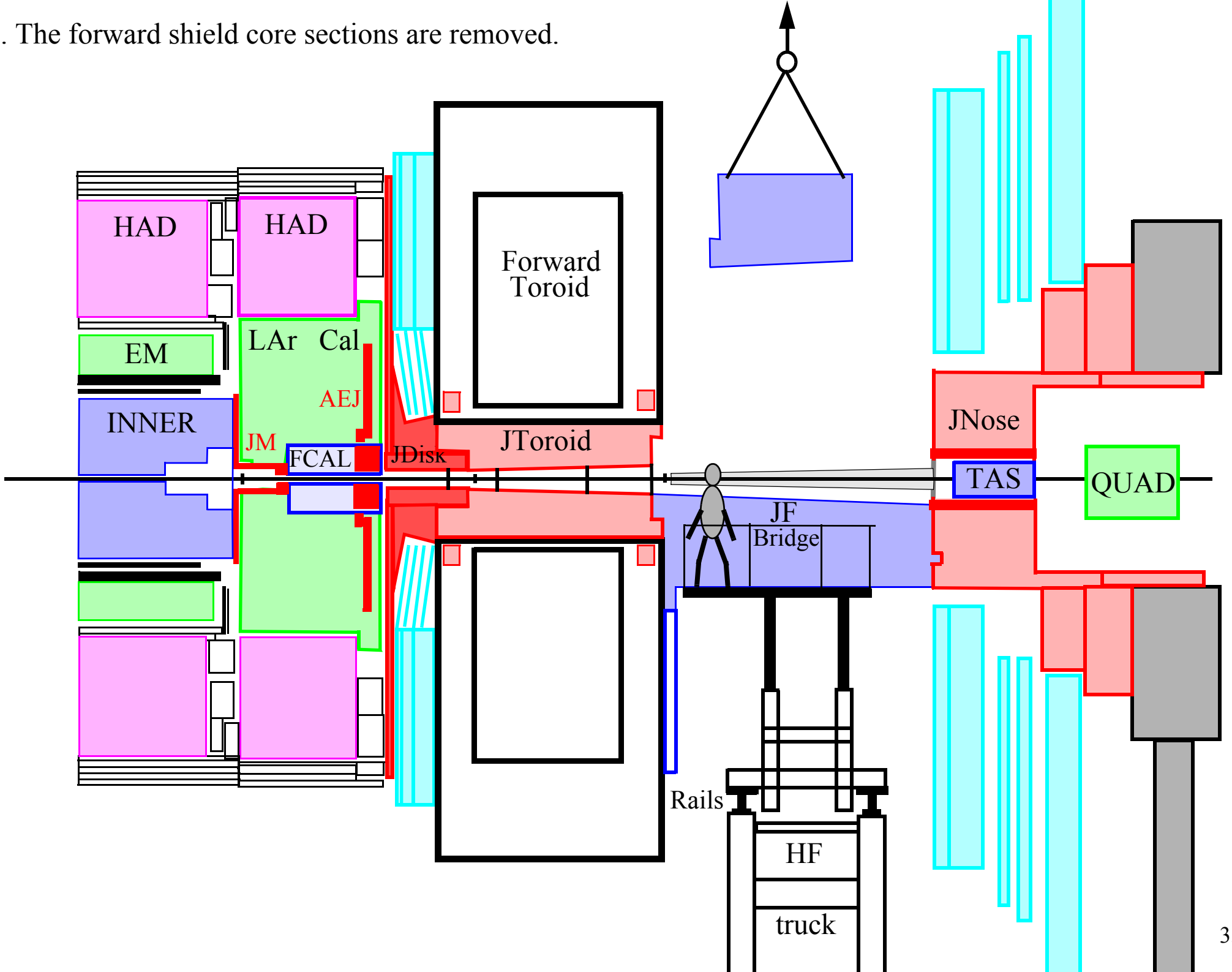

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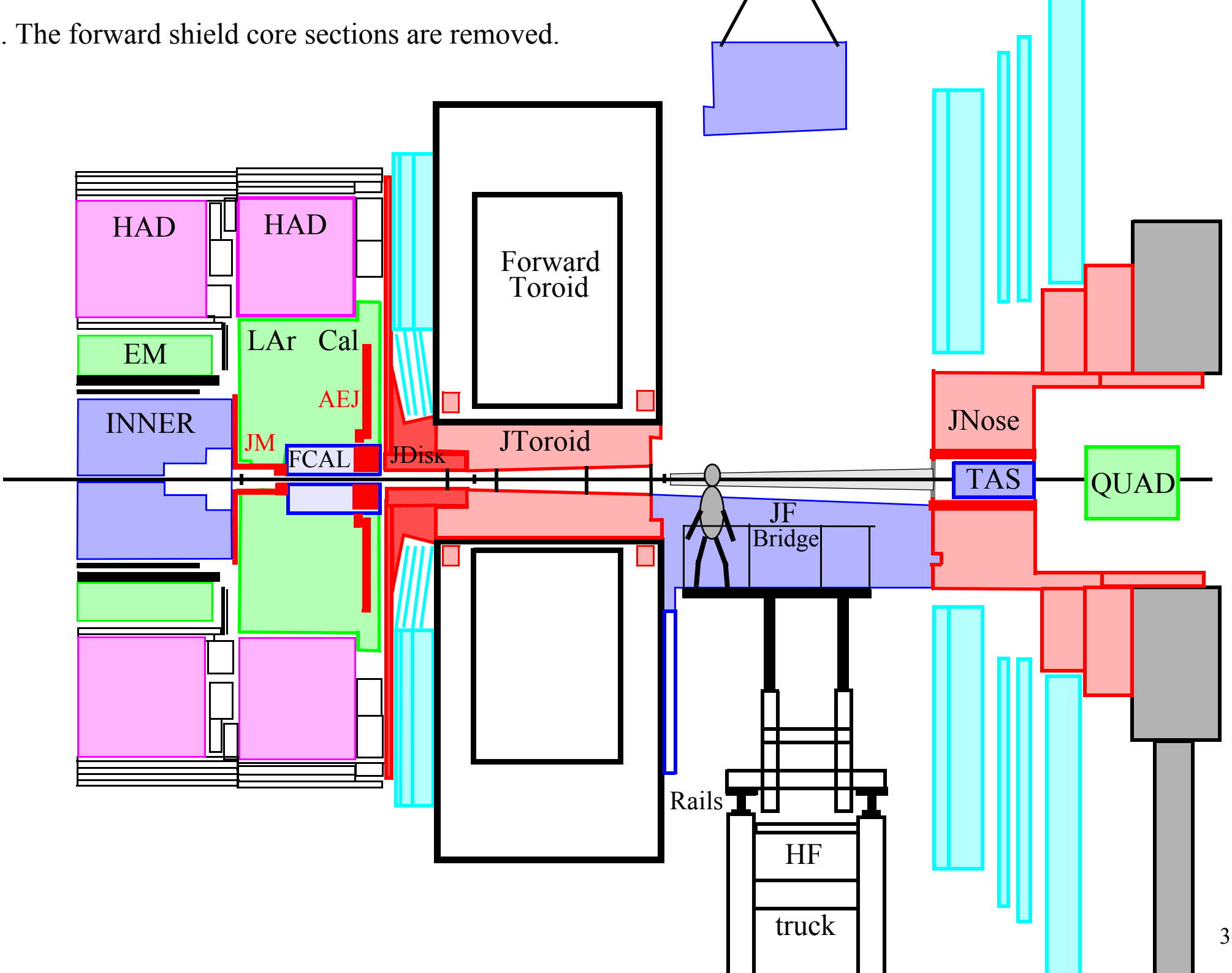

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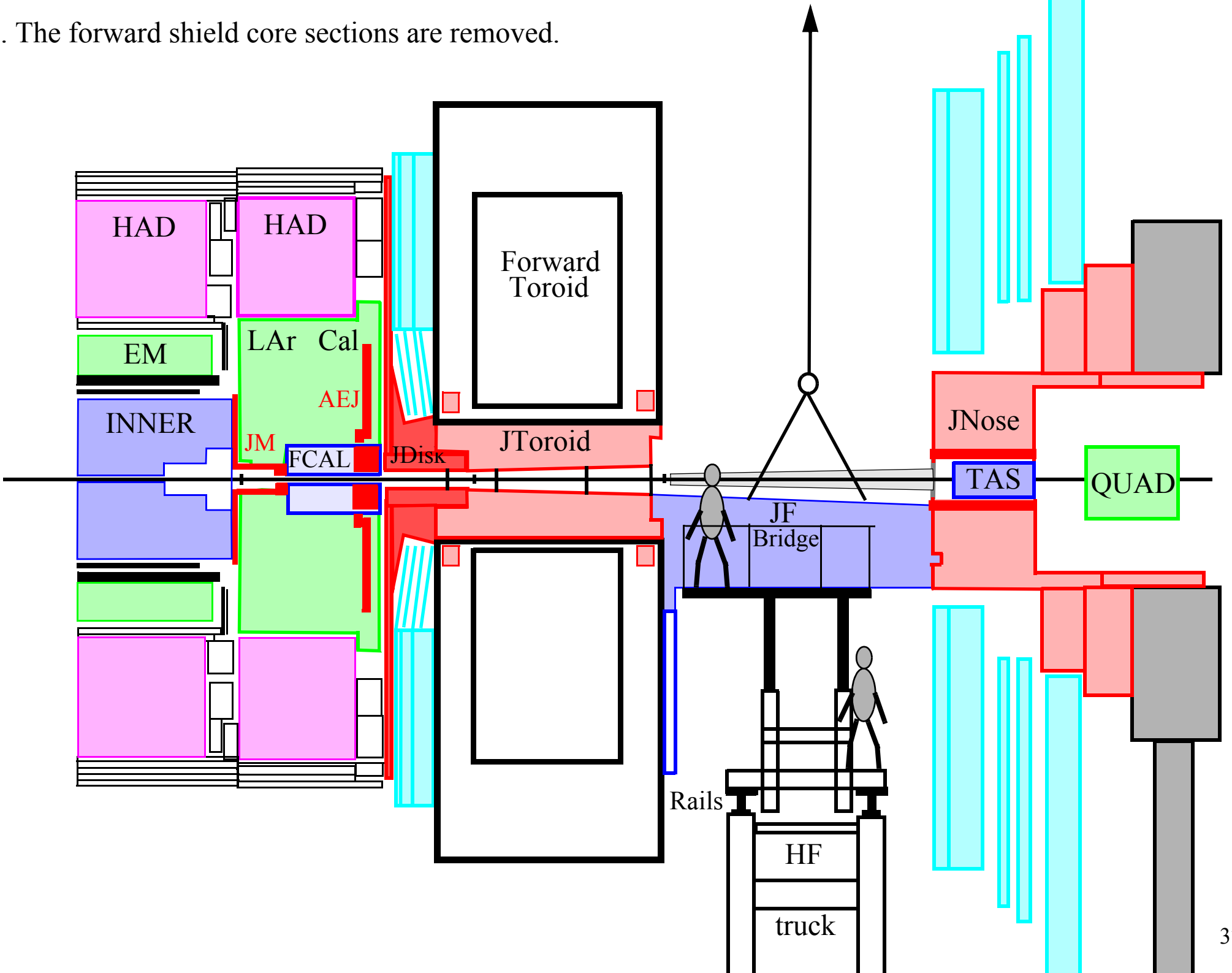
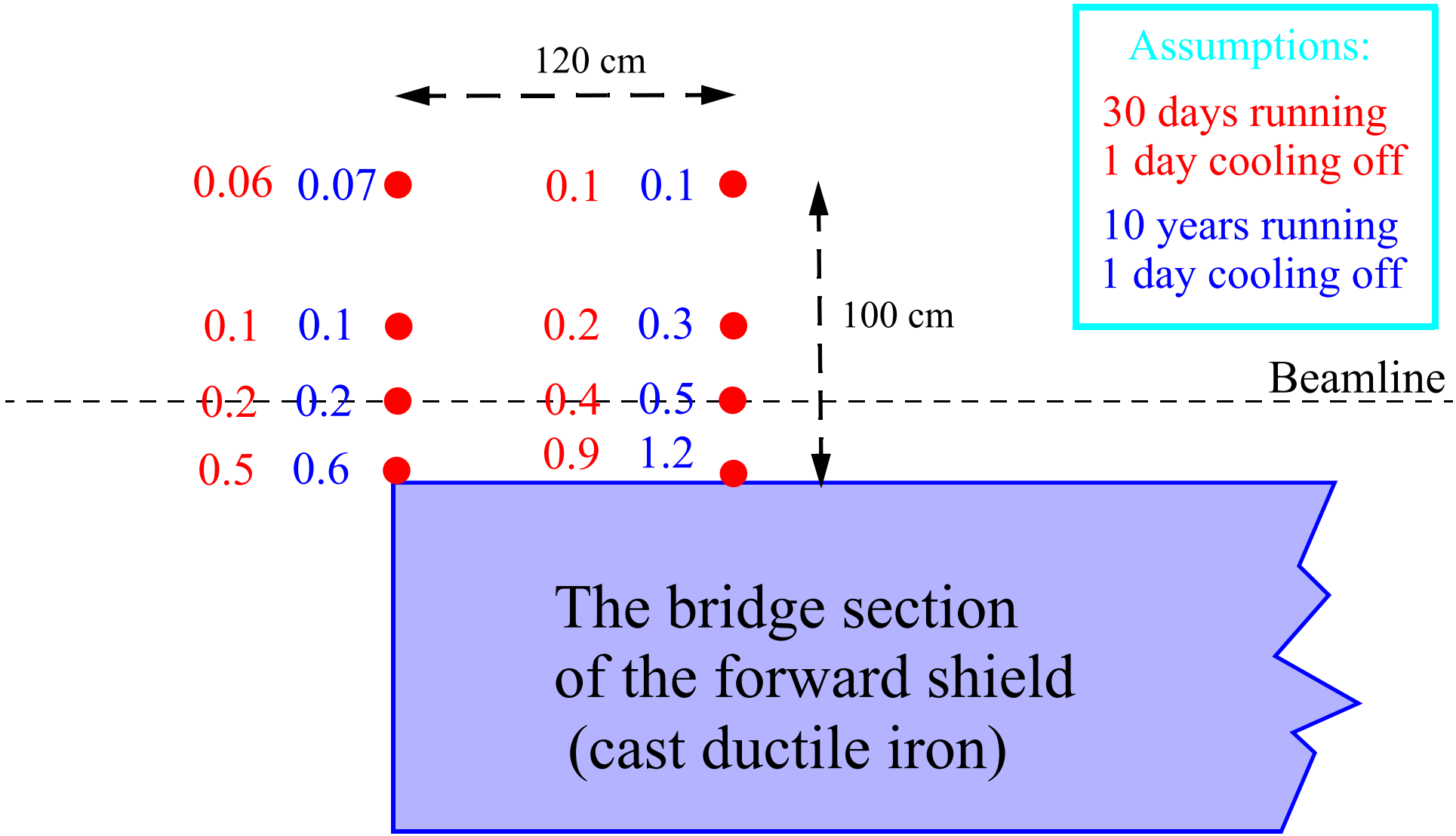


Dose rates in mSv/h around the bridge section of the forward shield. (Calculation by M. Morev)



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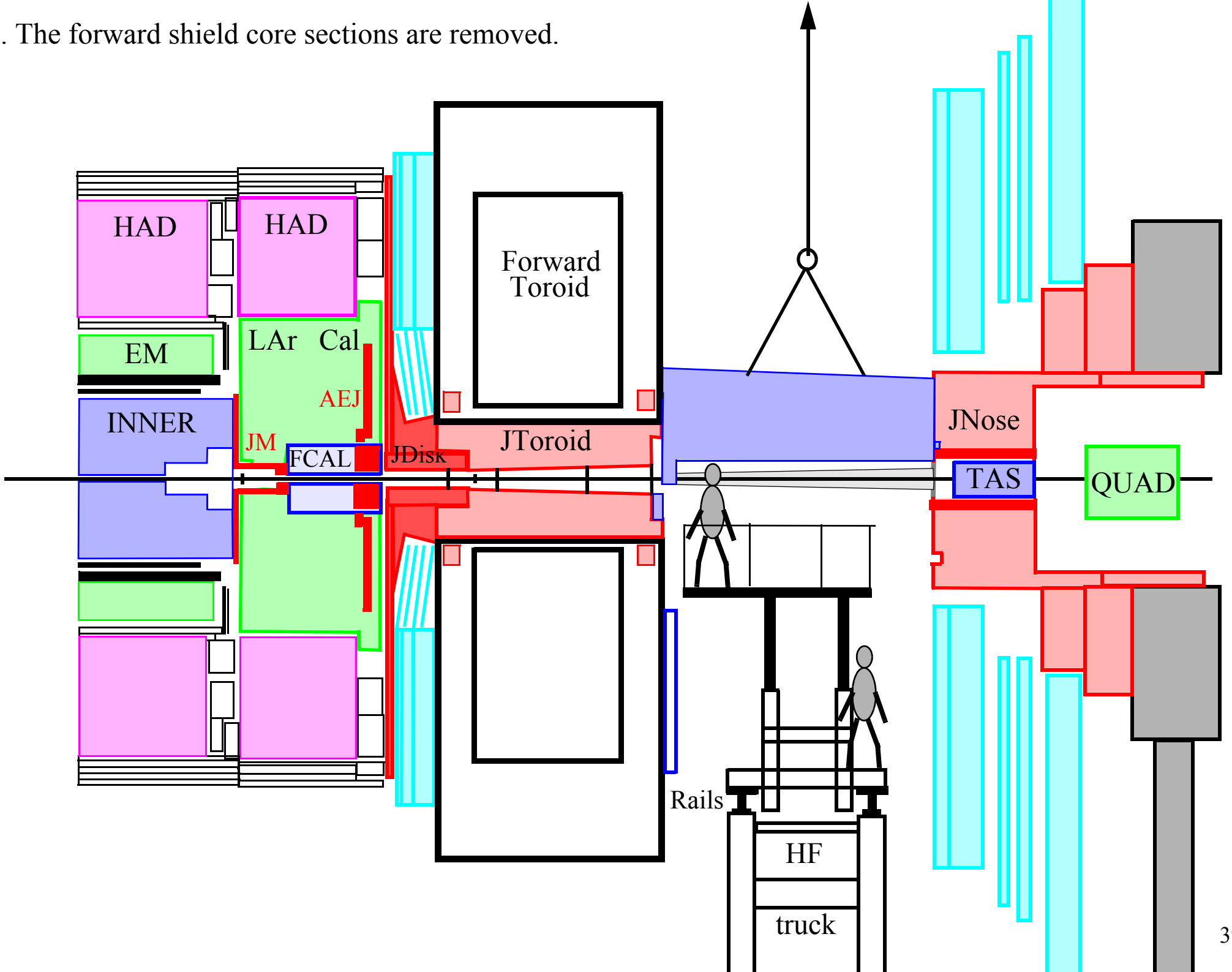

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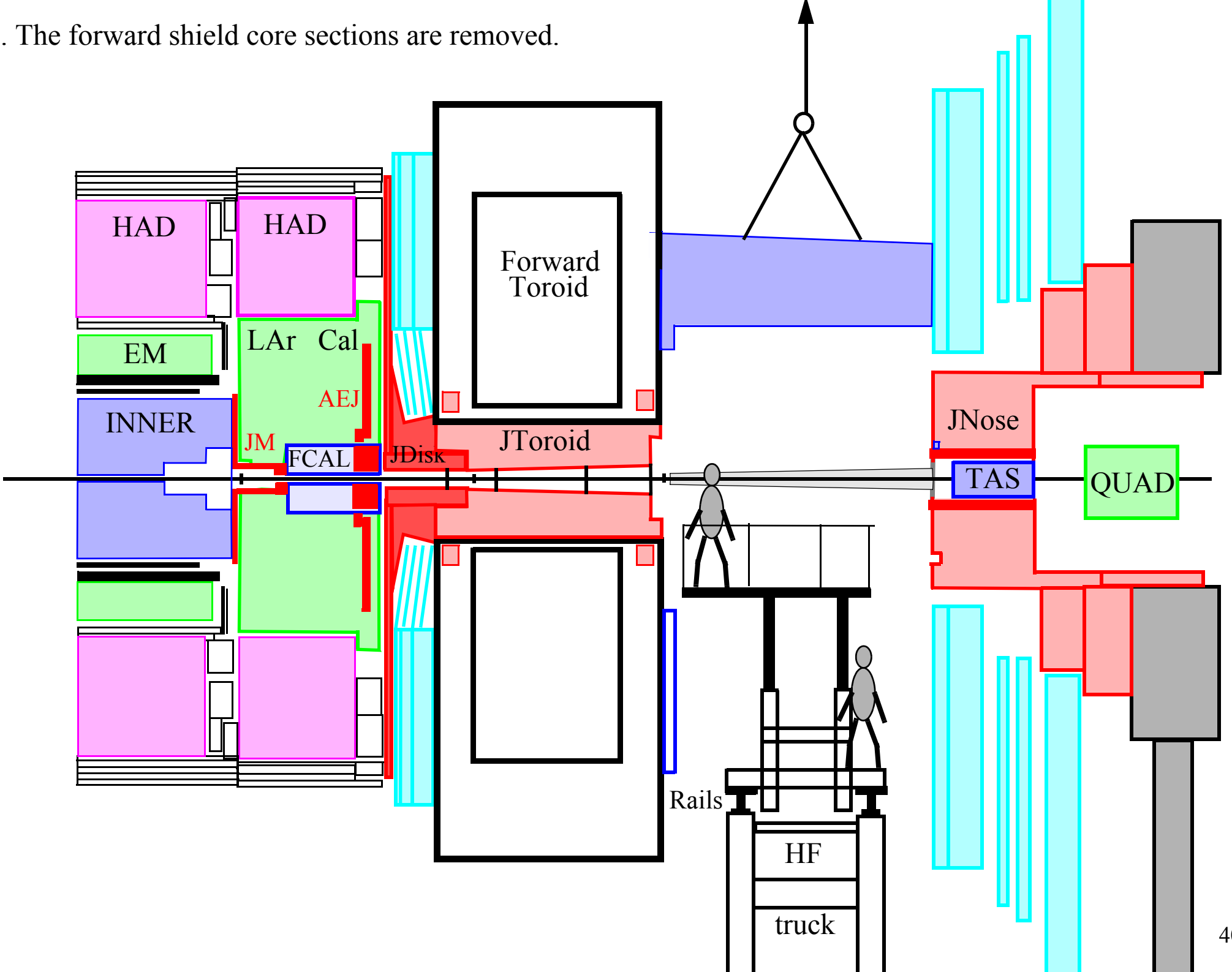

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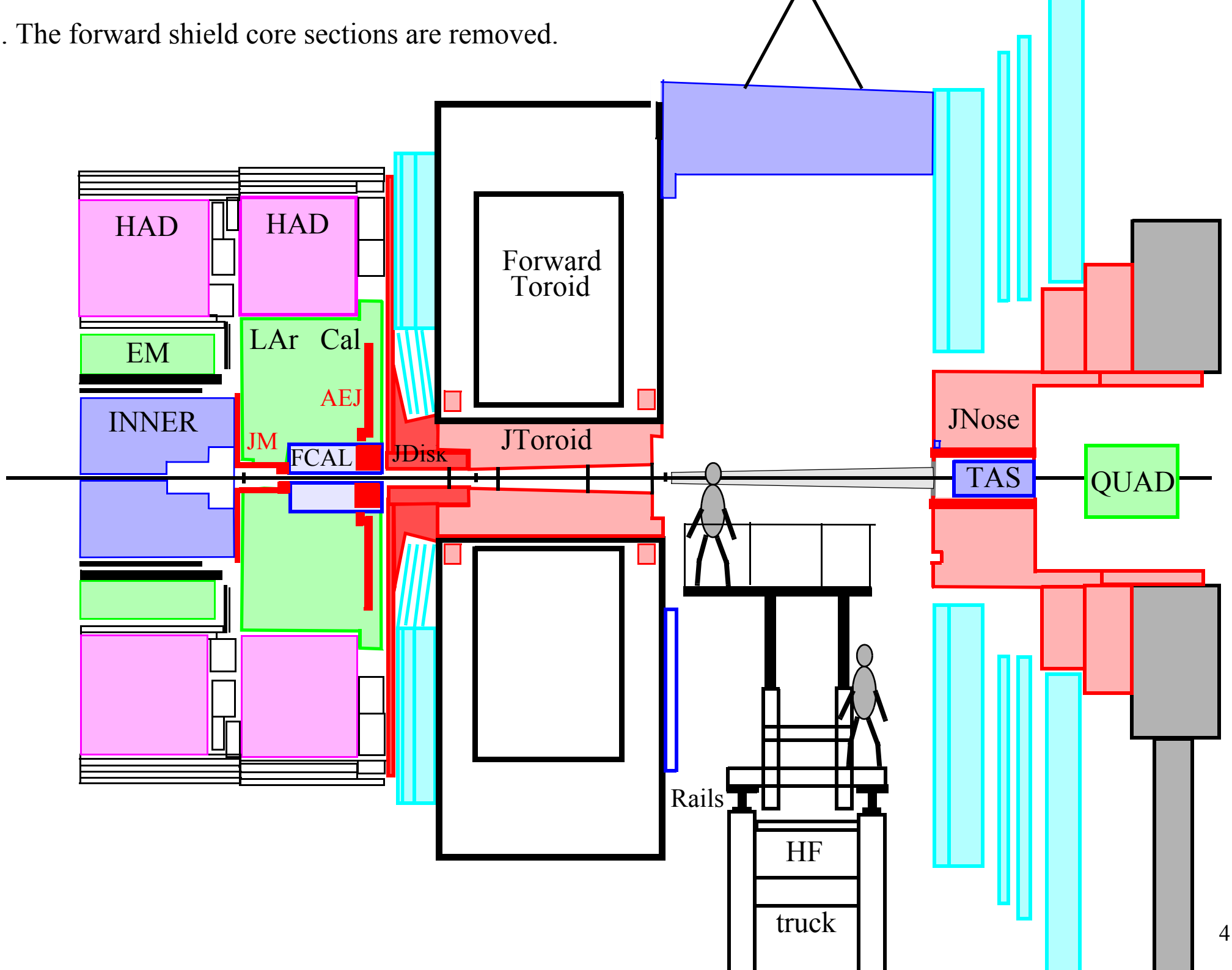
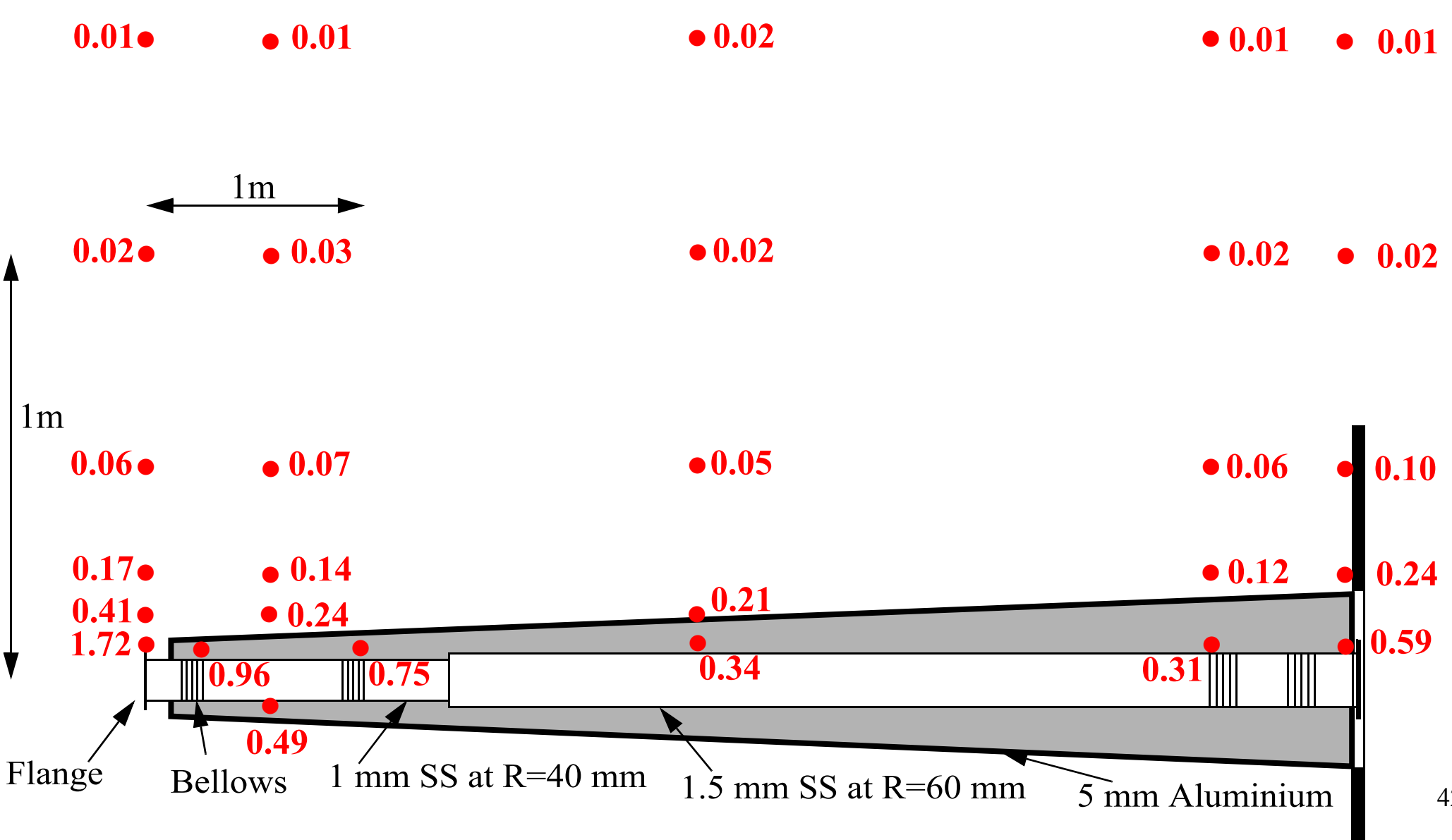


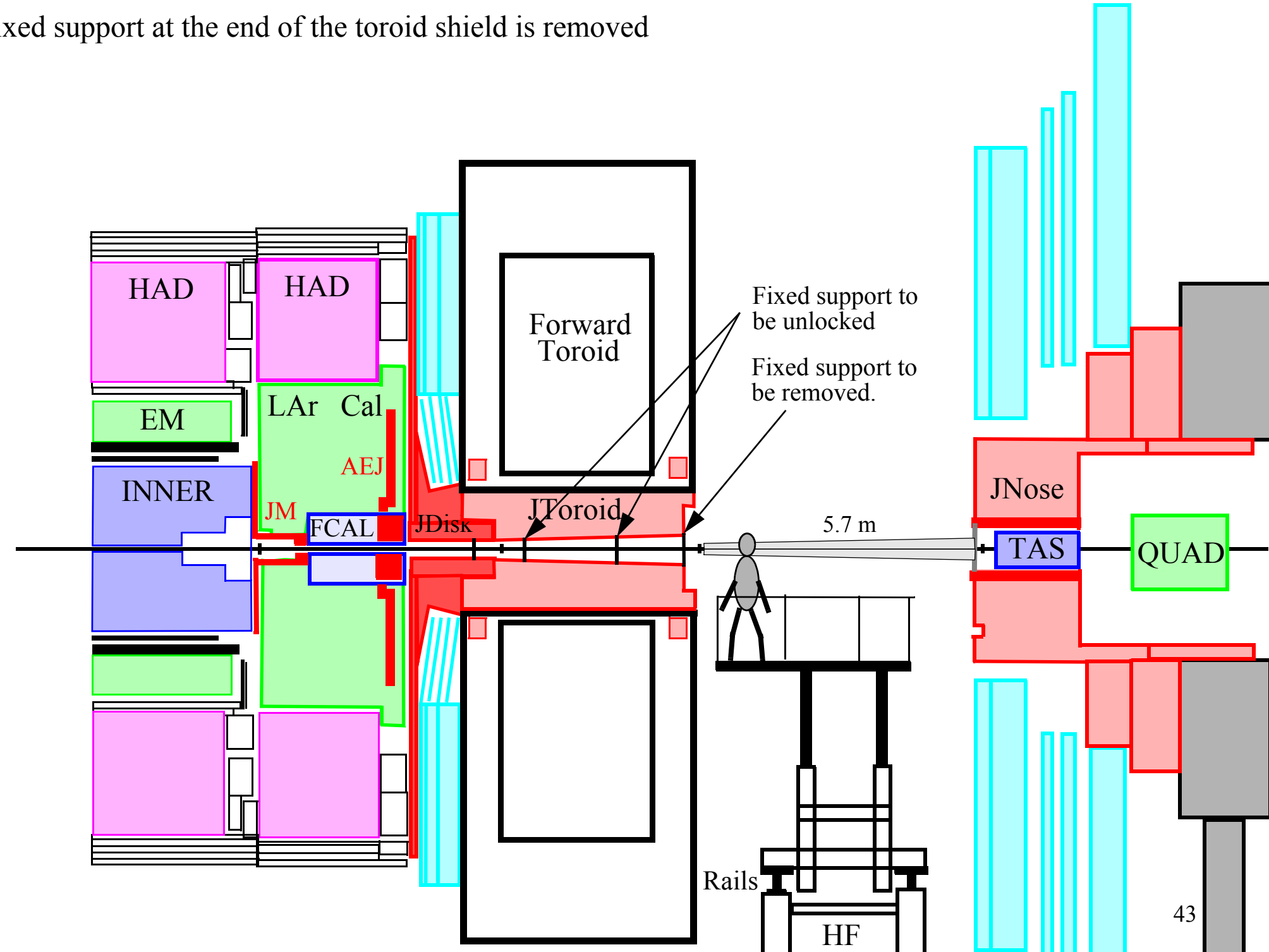
Dose rates in mSv/h after 100 days of running and 1 day of cooling

(M. Morev et al.)

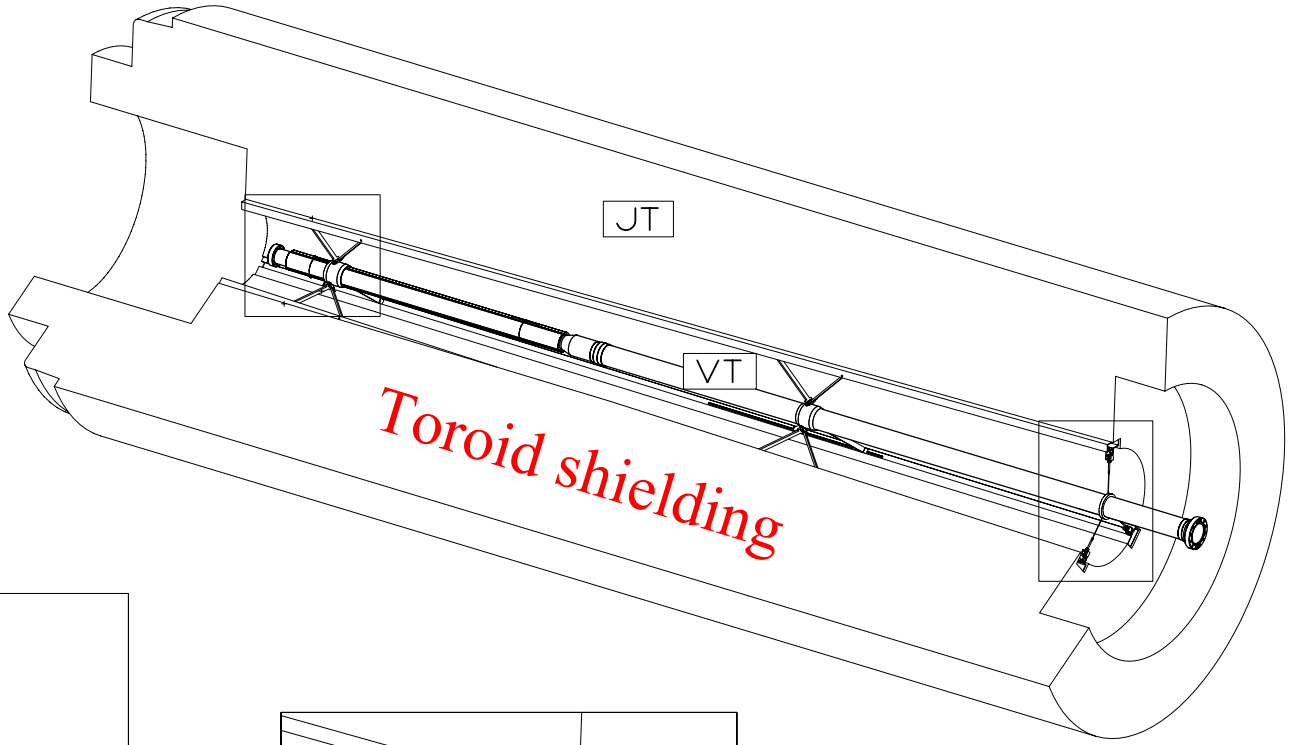
Dose rates from only the VJ beampipe



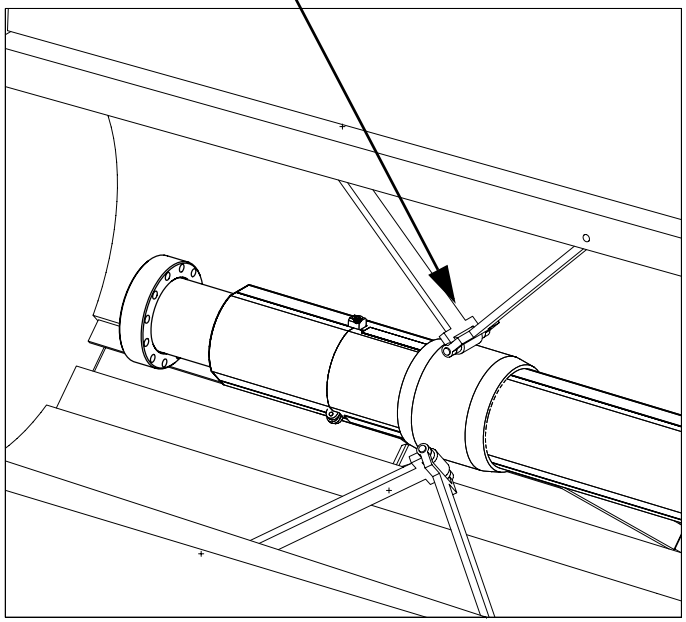
4. The two fixed supports inside the toroid shielding are unlocked
5. The fixed support at the end of the toroid shield is removed

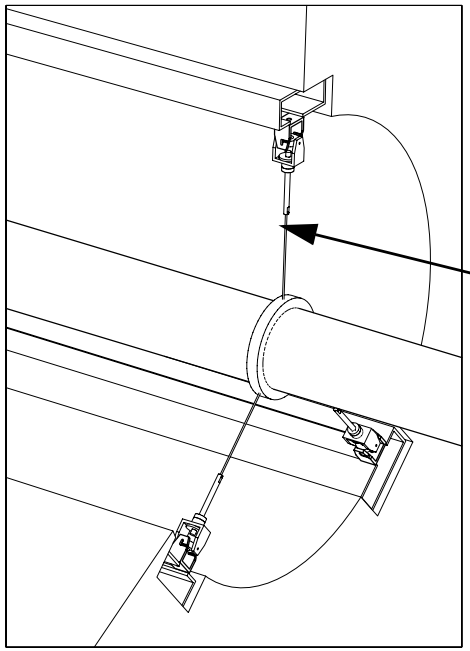


Beampipe supports



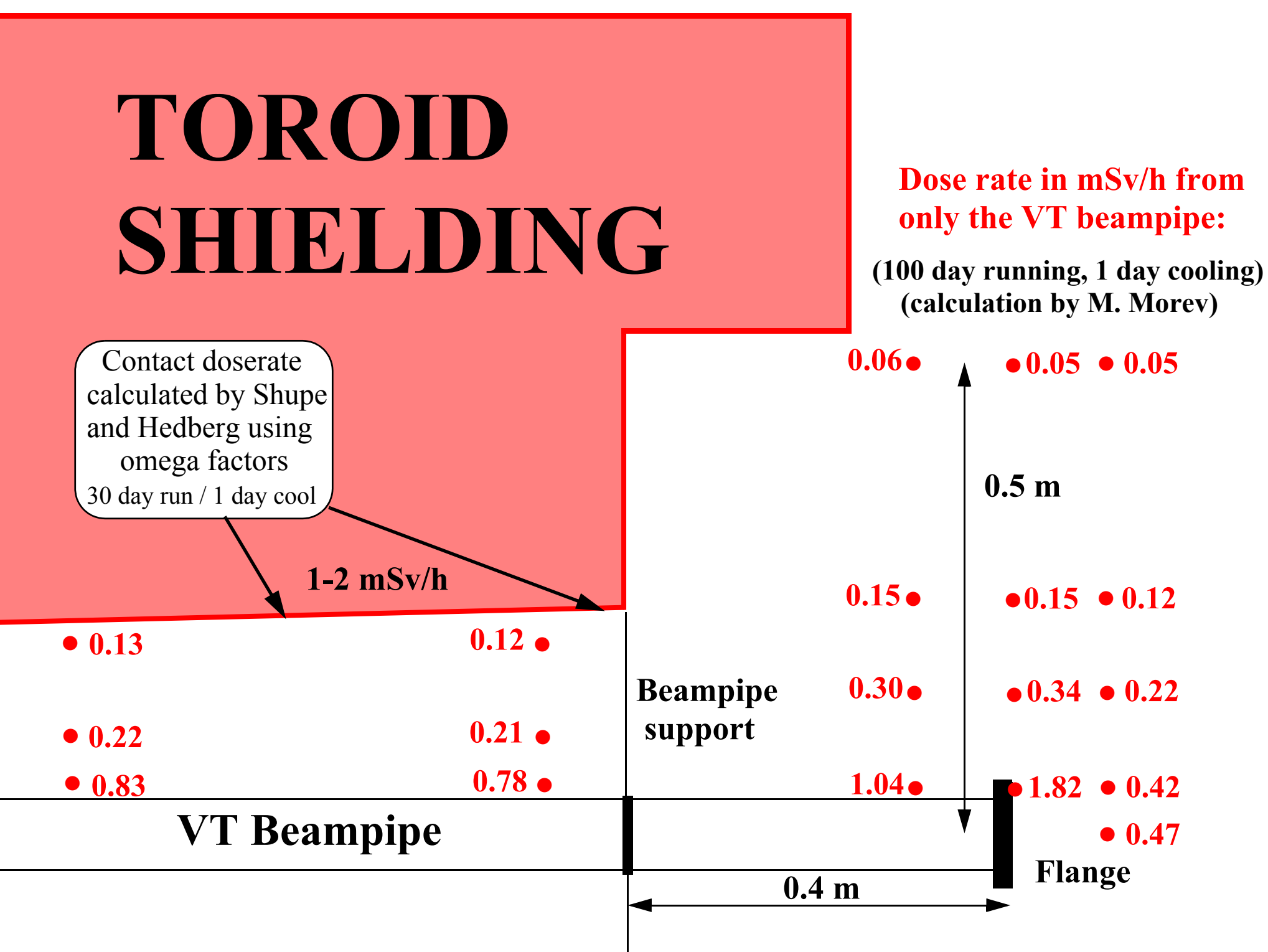
This support has to be retracted.



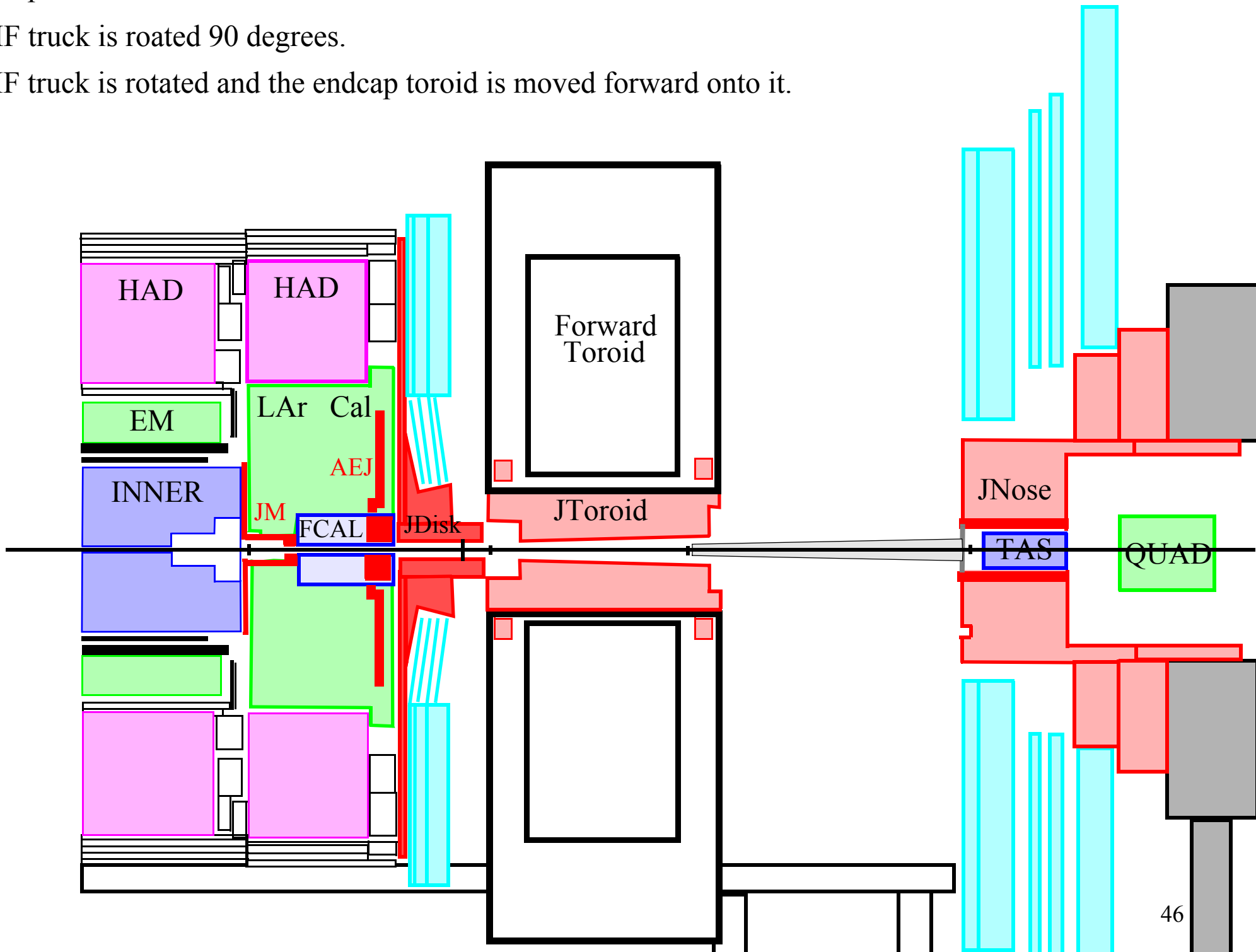


This support has to be removed and replaced by a support that rolls against the shielding.

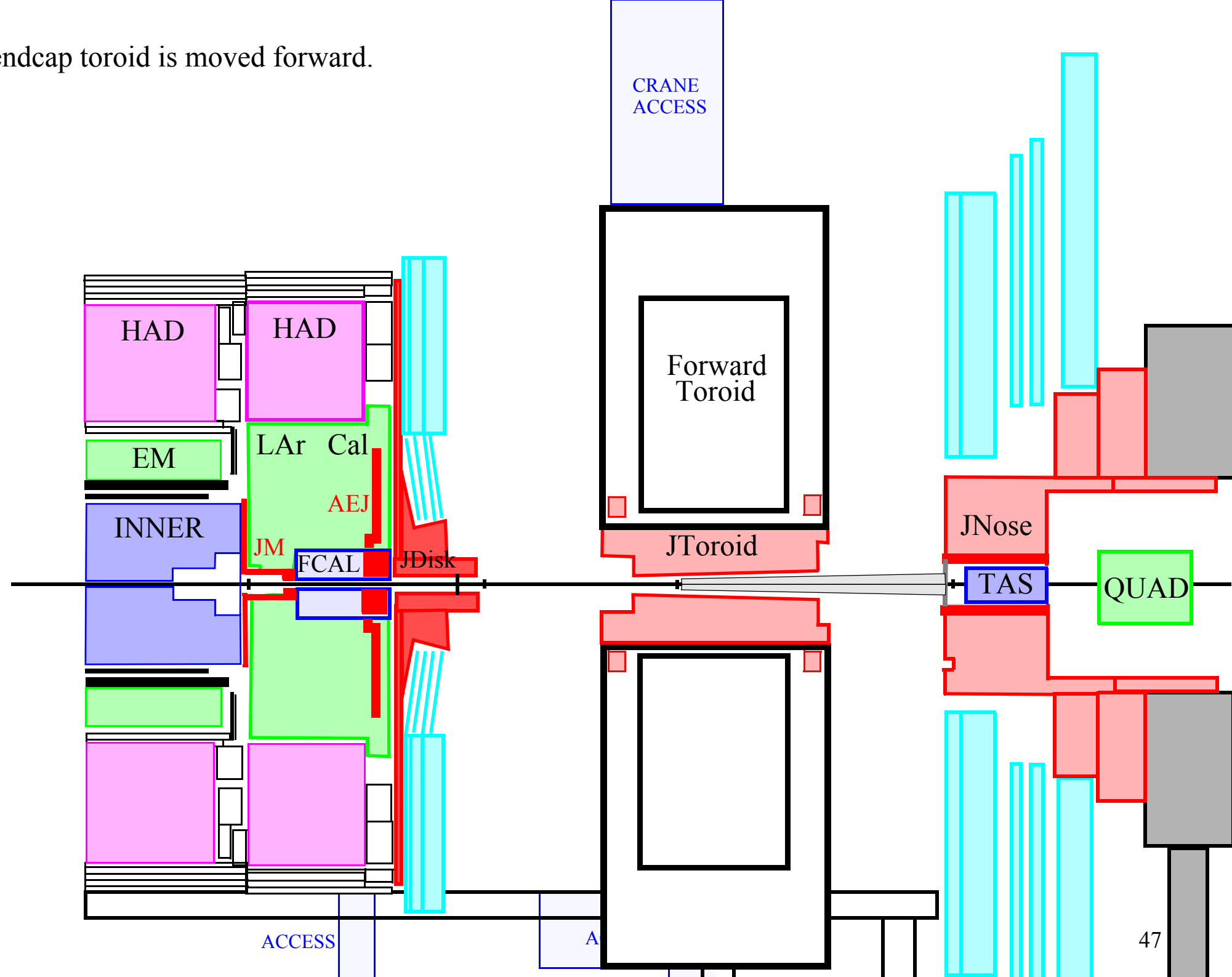
TOROID SHIELDING



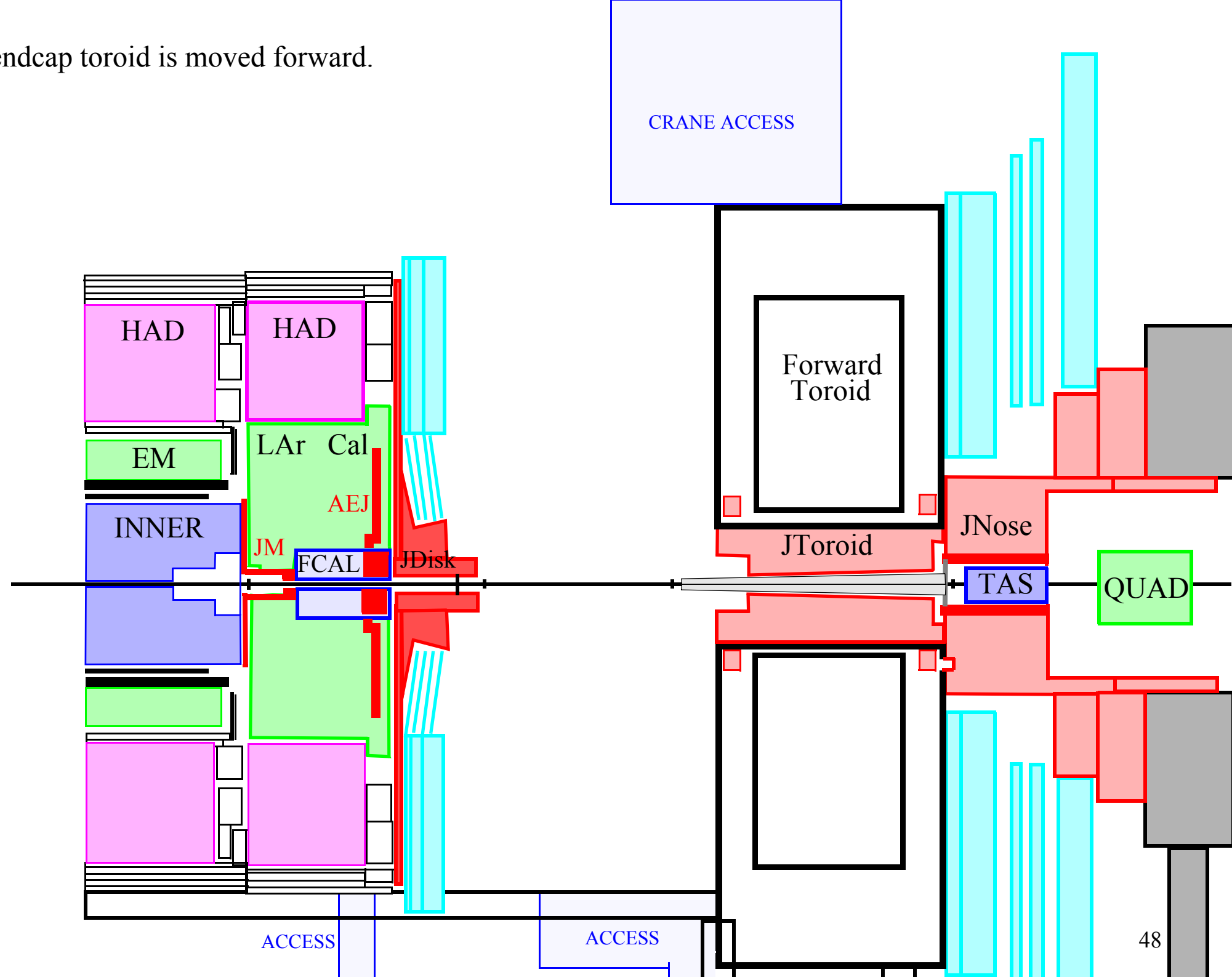
6. The HF platform is removed.
7. The HF truck is roated 90 degrees.
8. The HF truck is rotated and the endcap toroid is moved forward onto it.



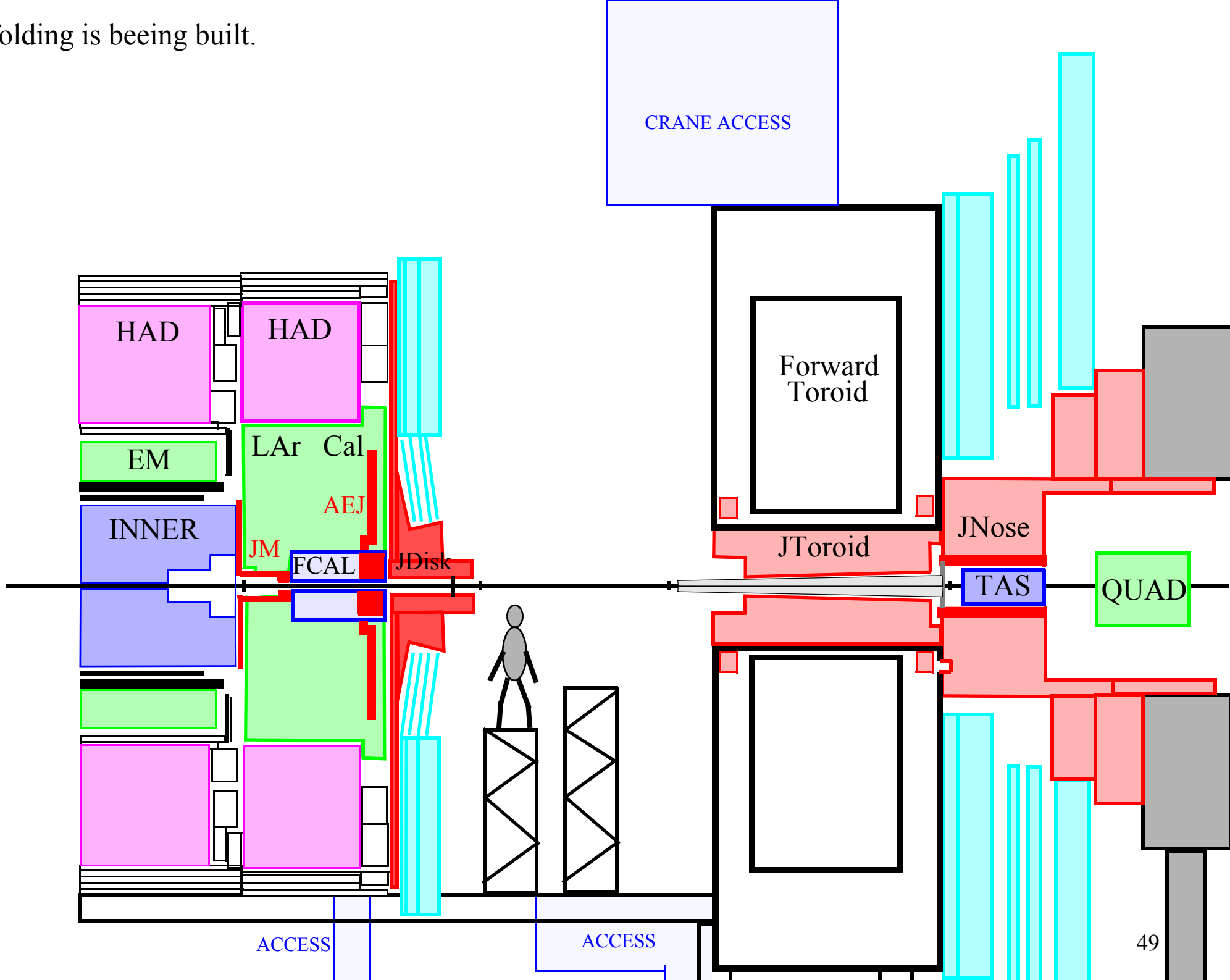
8. The endcap toroid is moved forward.



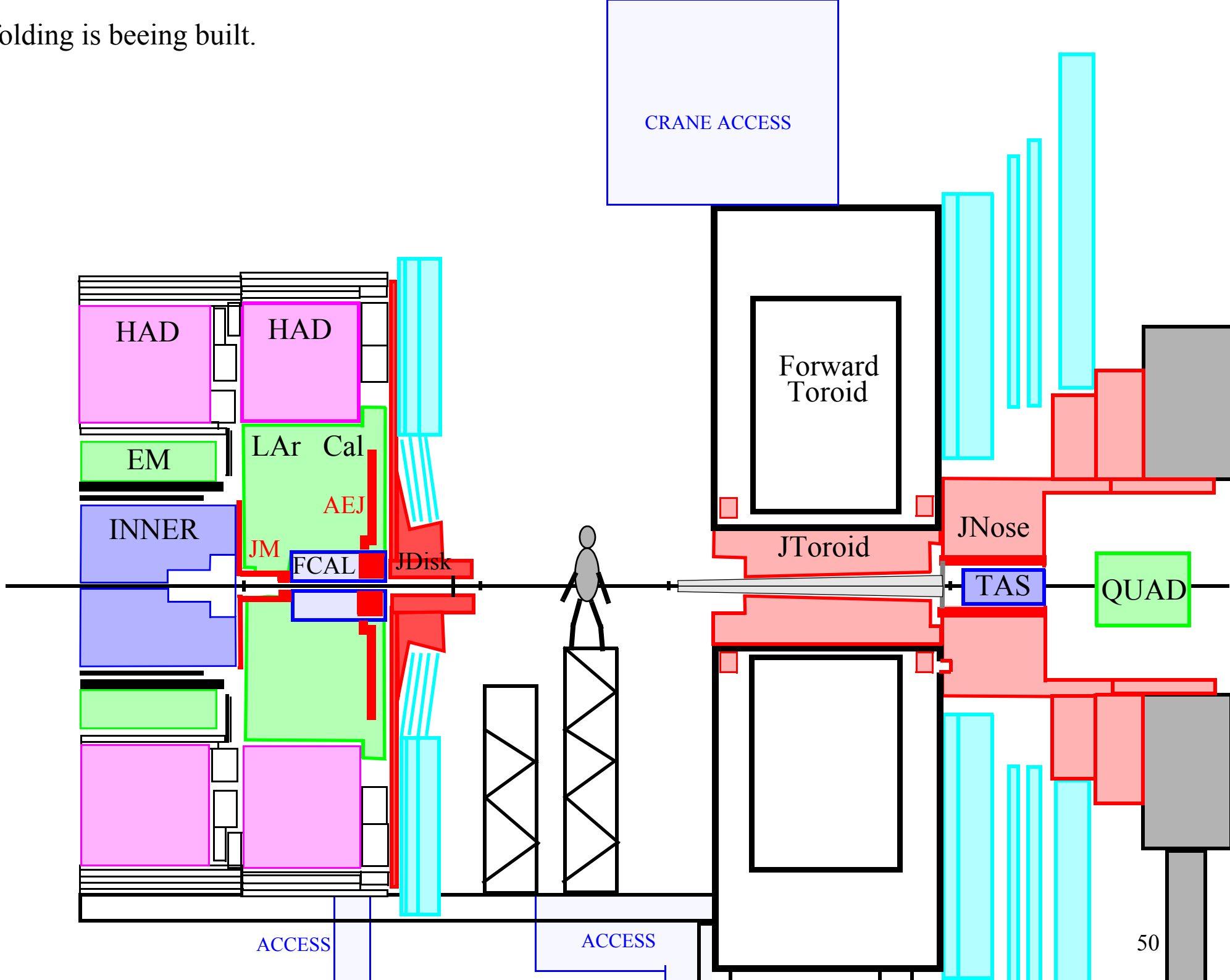
8. The endcap toroid is moved forward.



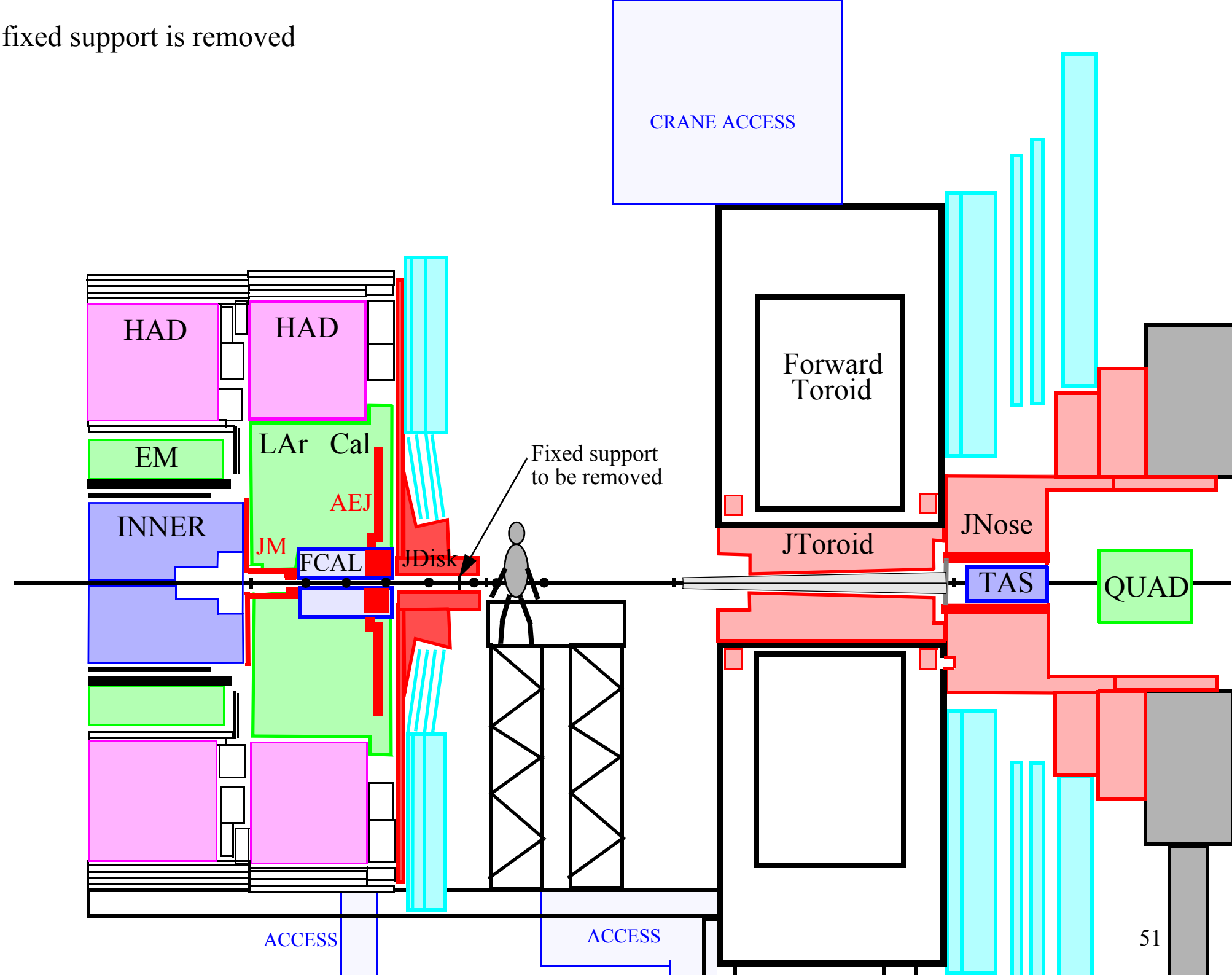
9. Scaffolding is beeing built.



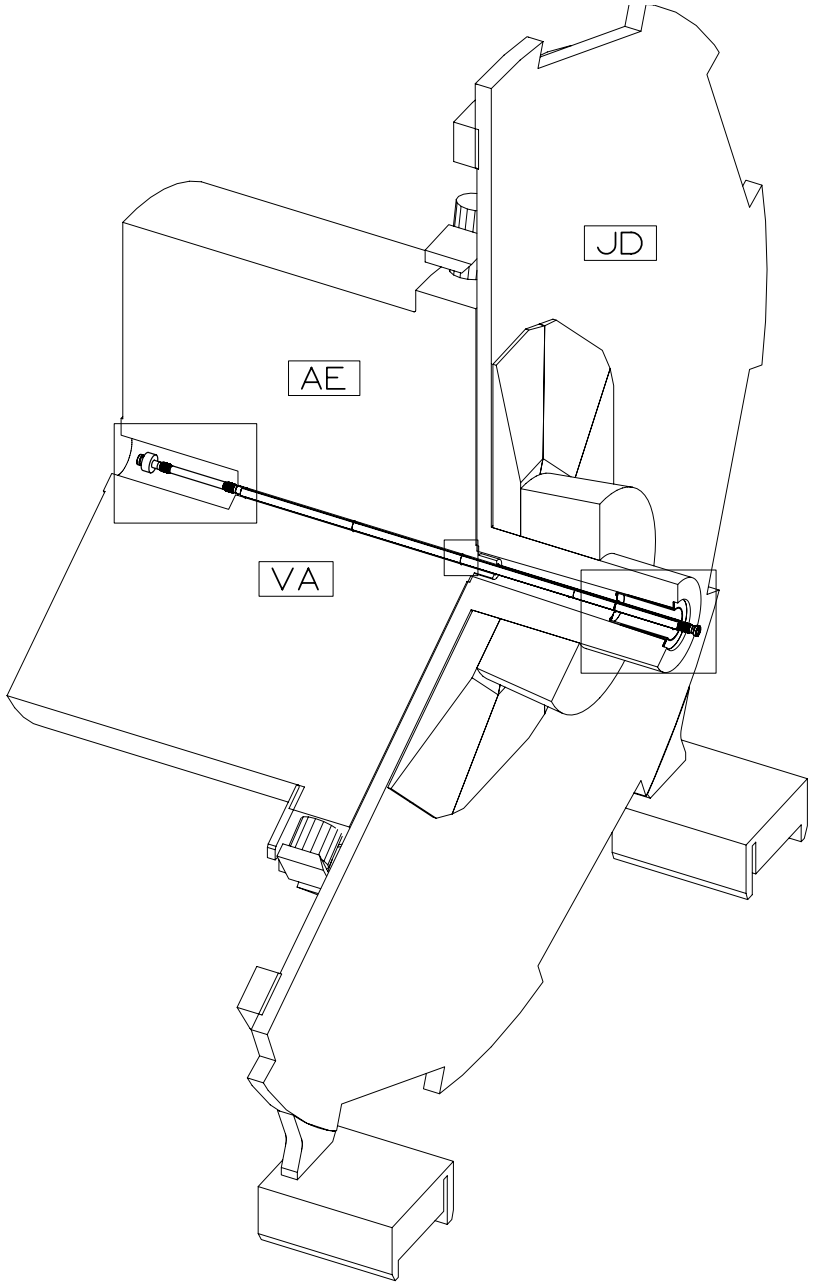
9. Scaffolding is beeing built.

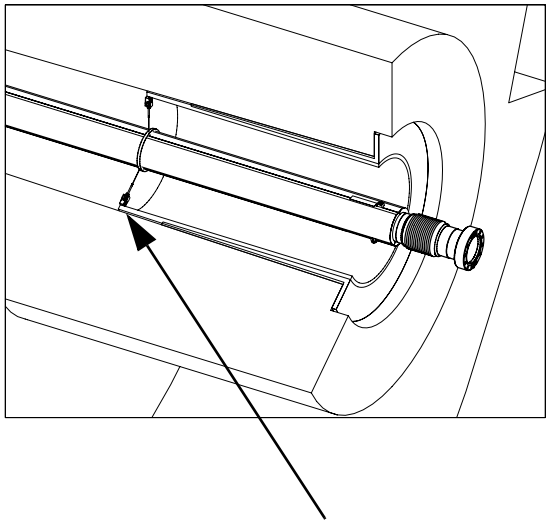


10. The fixed support is removed

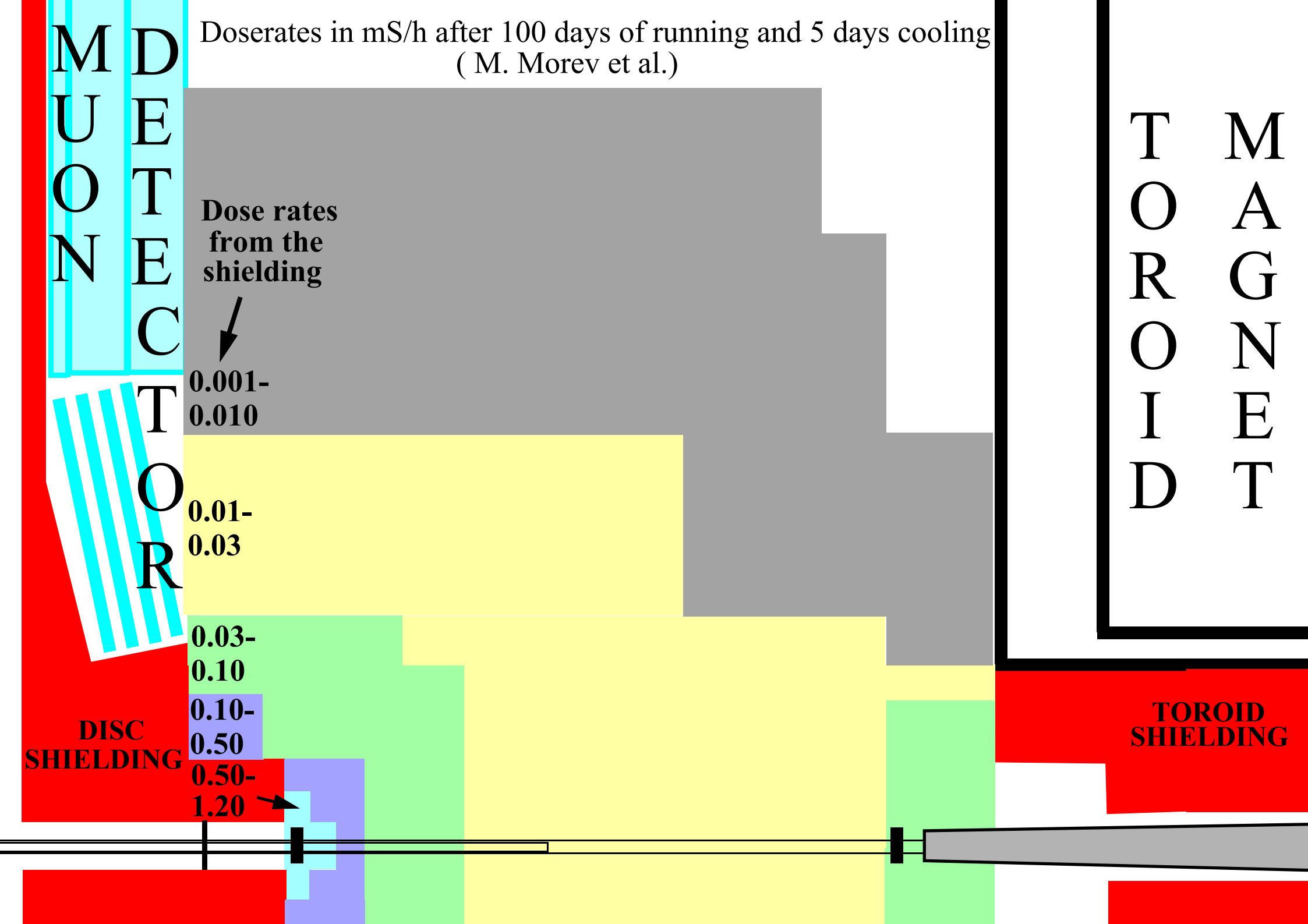


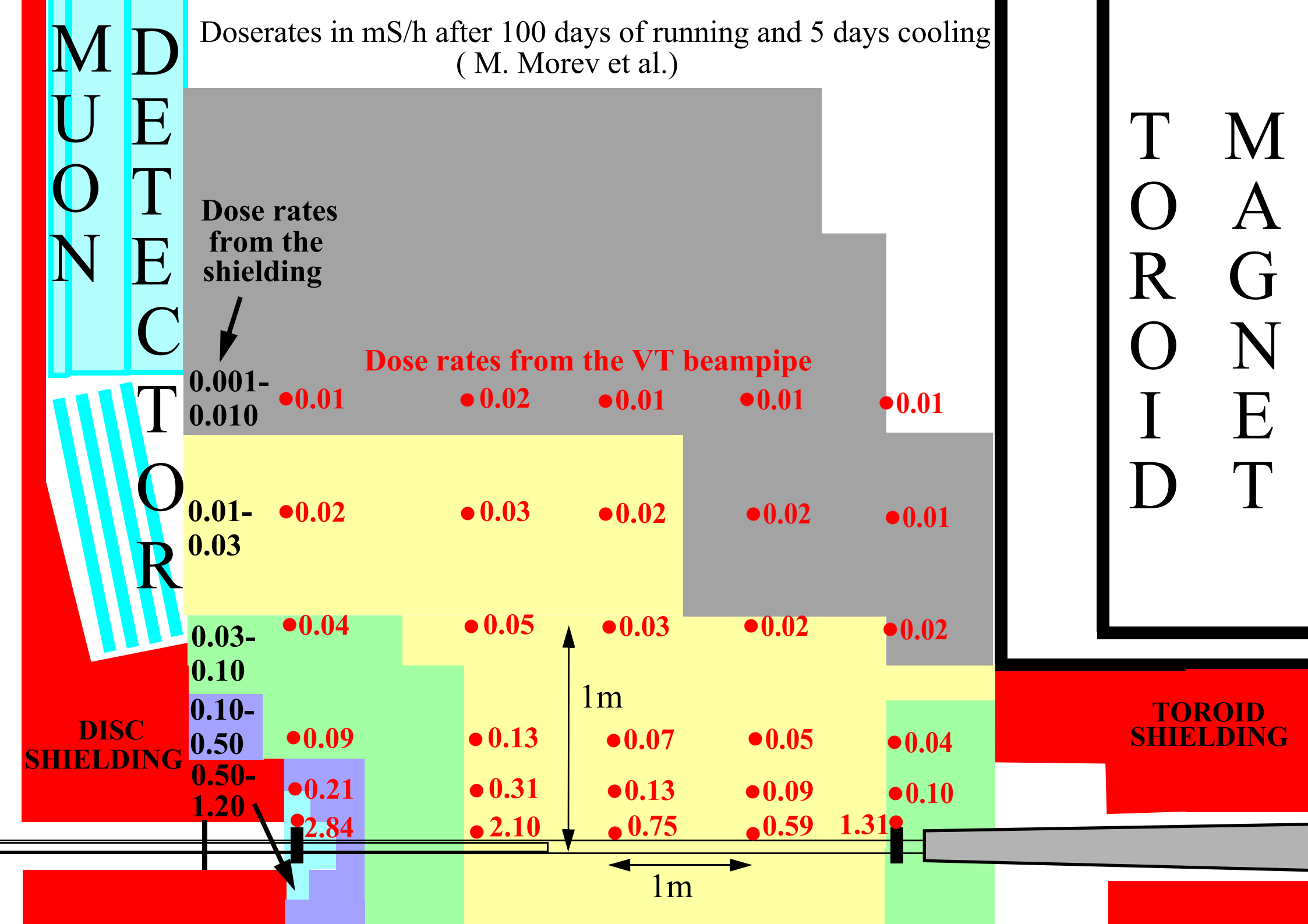
Beampipe supports



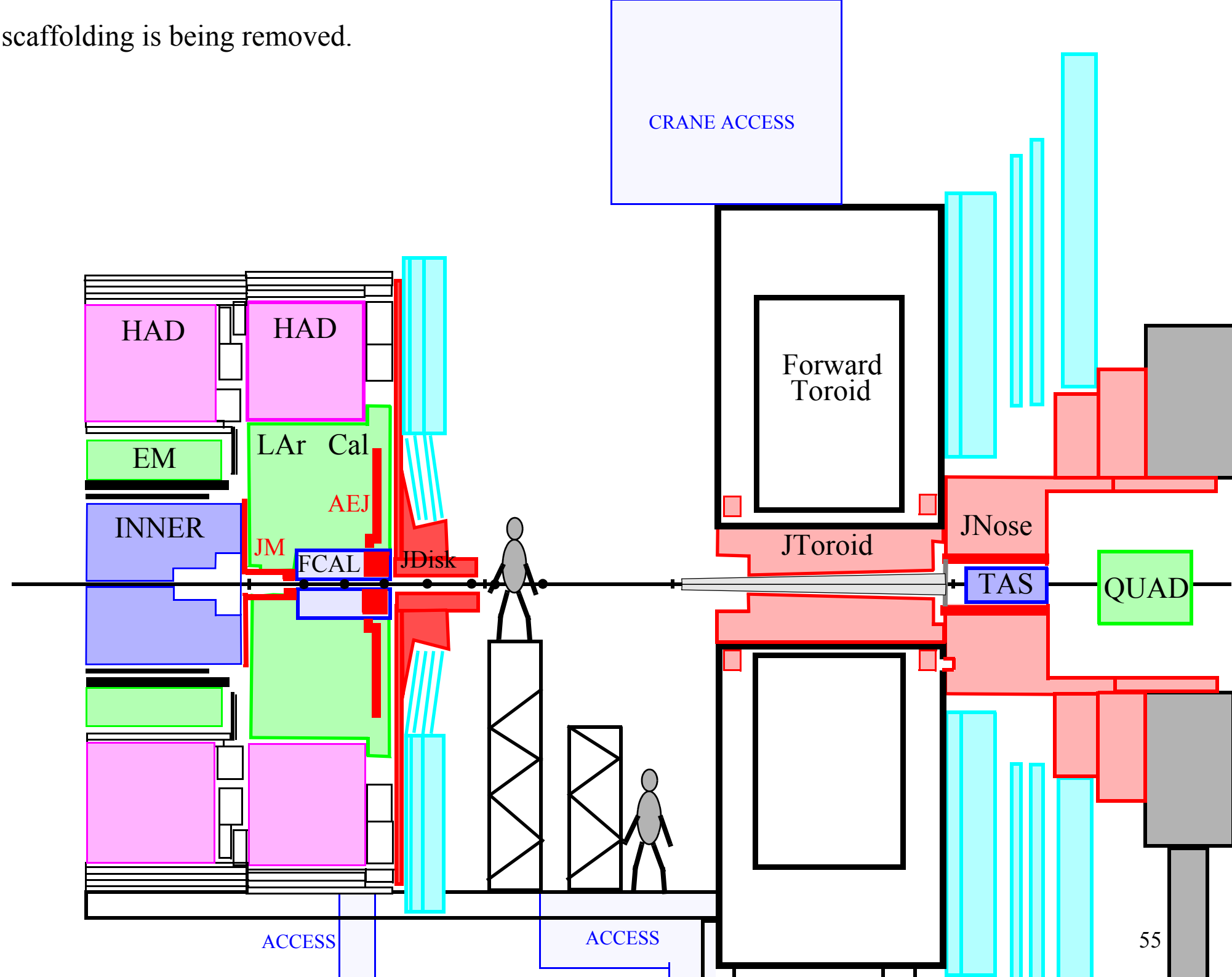


This support has to be removed.

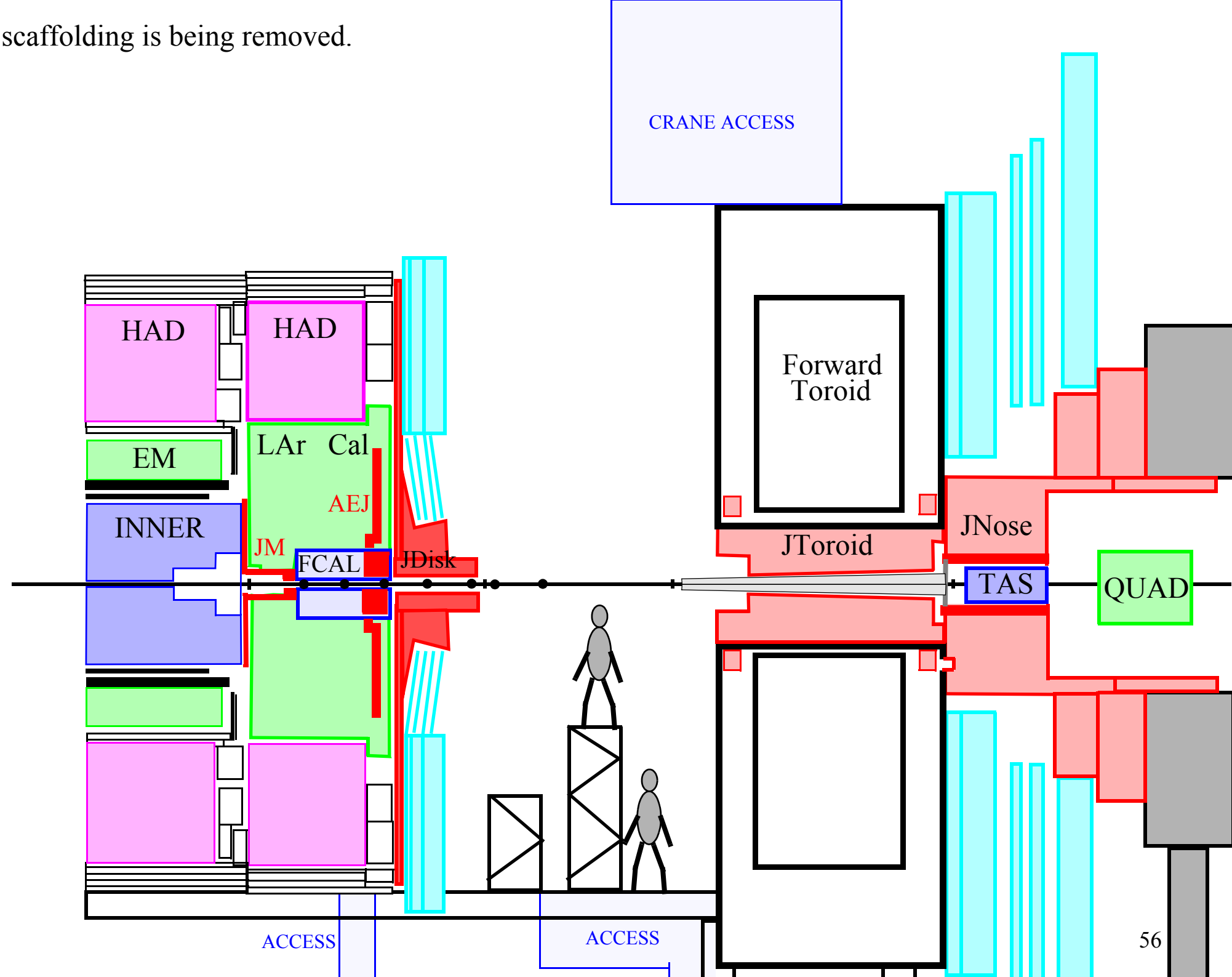

Doserates in mS/h after 100 days of running and 5 days cooling
(M. Morev et al.)
MUON DETECTOR
TOROID MAGNET
Dose rates from the shielding
0.001-0.010
0.01-0.03
0.03-0.10
0.10-0.50
0.50-1.20
DISC SHIELDING
TOROID SHIELDING


Doserates in mS/h after 100 days of running and 5 days cooling
(M. Morev et al.)
MUON DETECTOR
TOROID MAGNET
Dose rates from the shielding
Dose rates from the VT beampipe
0.001-0.010
0.01-0.03
0.03-0.10
0.10-0.50
0.50-1.20
●0.01 ●0.02 ●0.01 ●0.01 ●0.01
●0.02 ●0.03 ●0.02 ●0.02 ●0.01
●0.04 ●0.05 ●0.03 ●0.02 ●0.02
●0.09 ●0.13 ●0.07 ●0.05 ●0.04
●0.21 ●0.31 ●0.13 ●0.09 ●0.10
●2.84 ●2.10 ●0.75 ●0.59 1.31●
1m
1m
DISC SHIELDING
TOROID SHIELDING

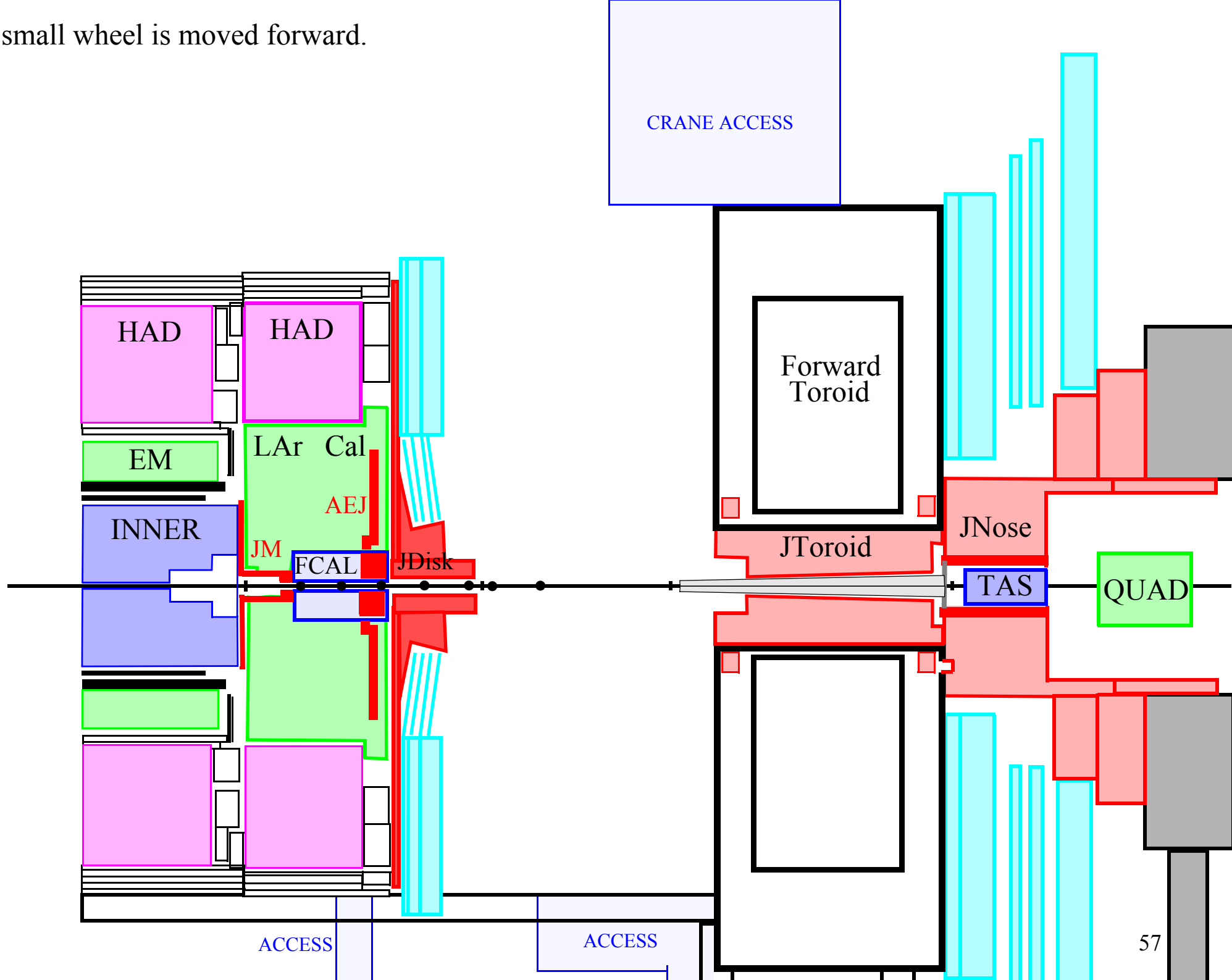
11. The scaffolding is being removed.



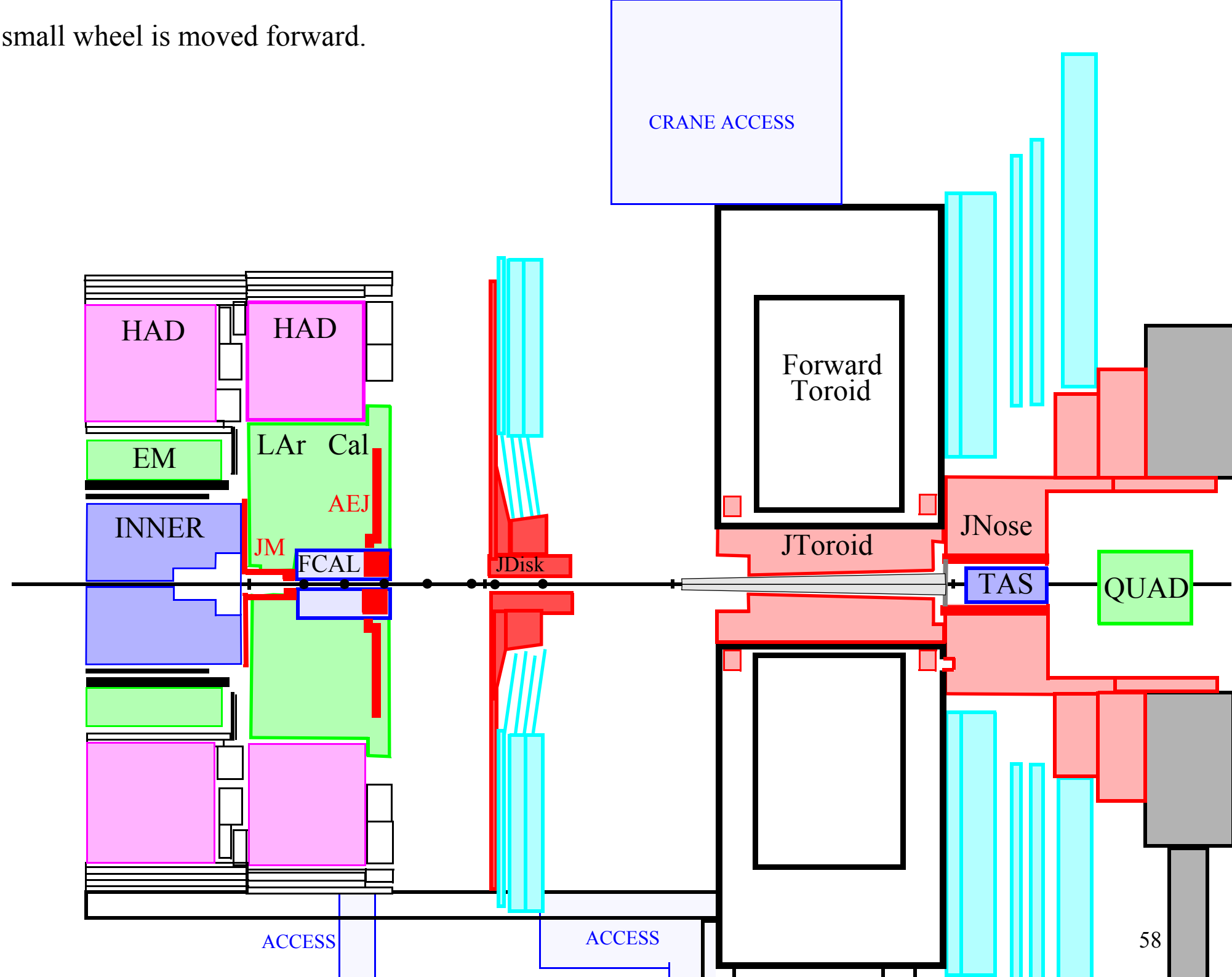
11. The scaffolding is being removed.



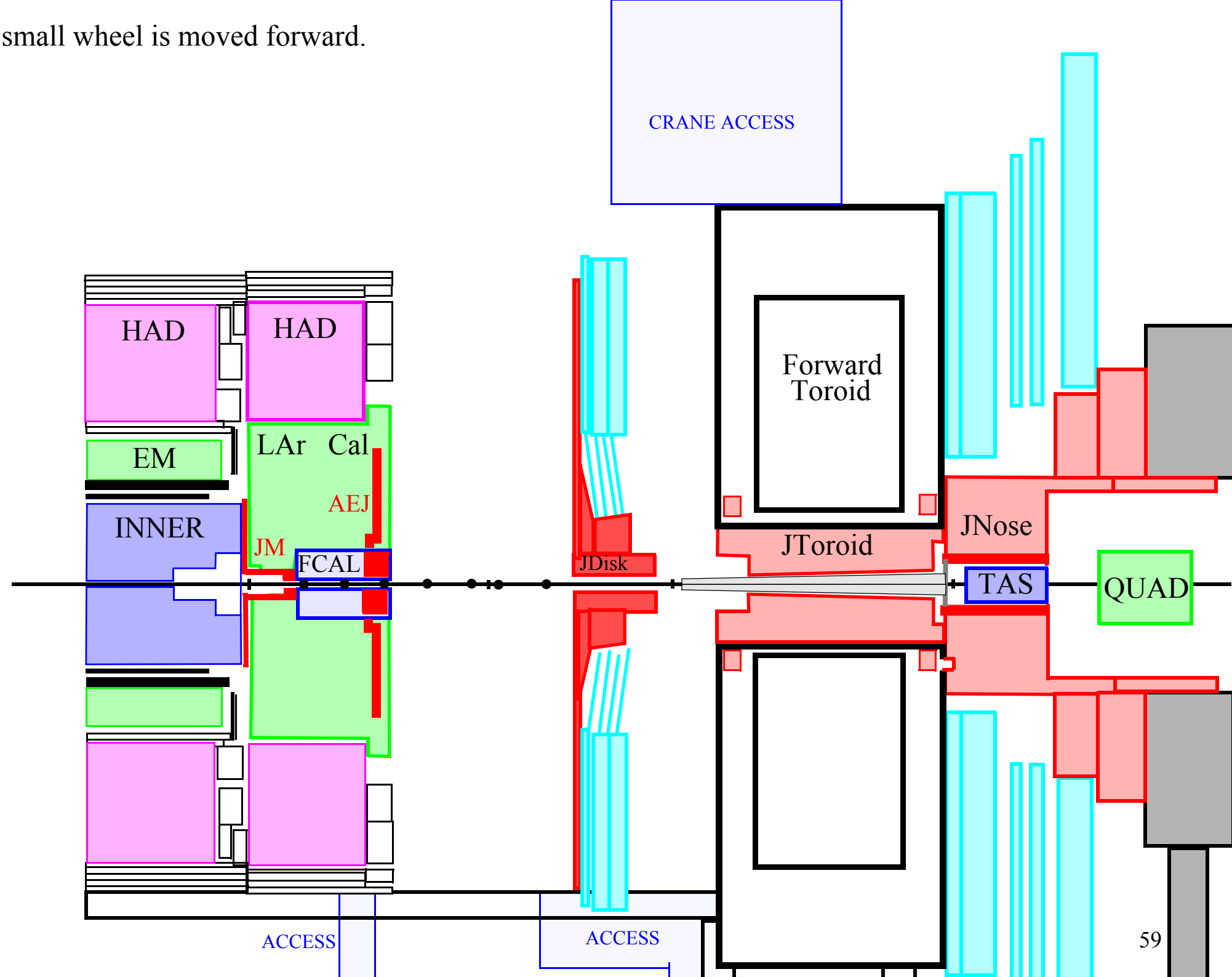
12. The small wheel is moved forward.



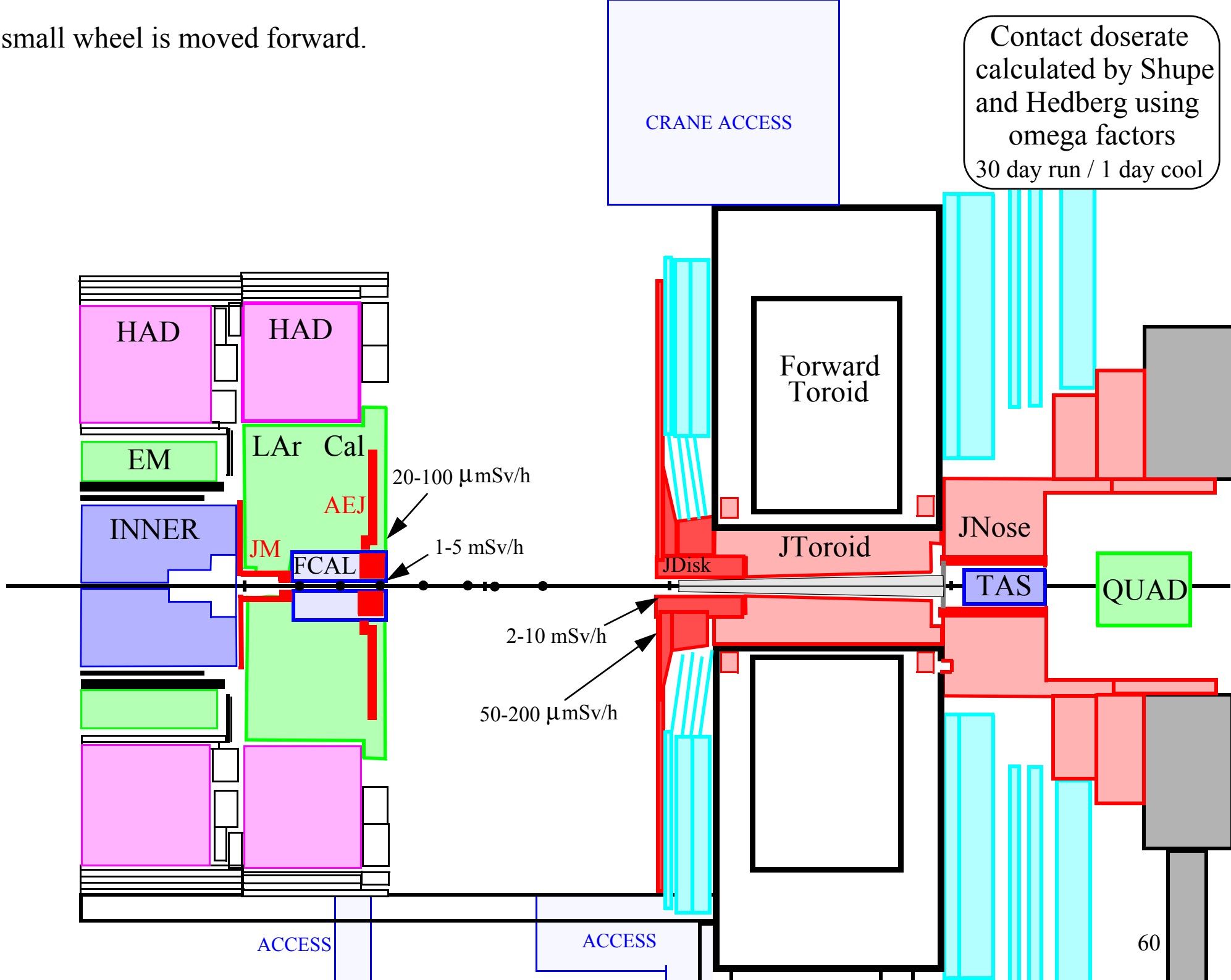
12. The small wheel is moved forward.



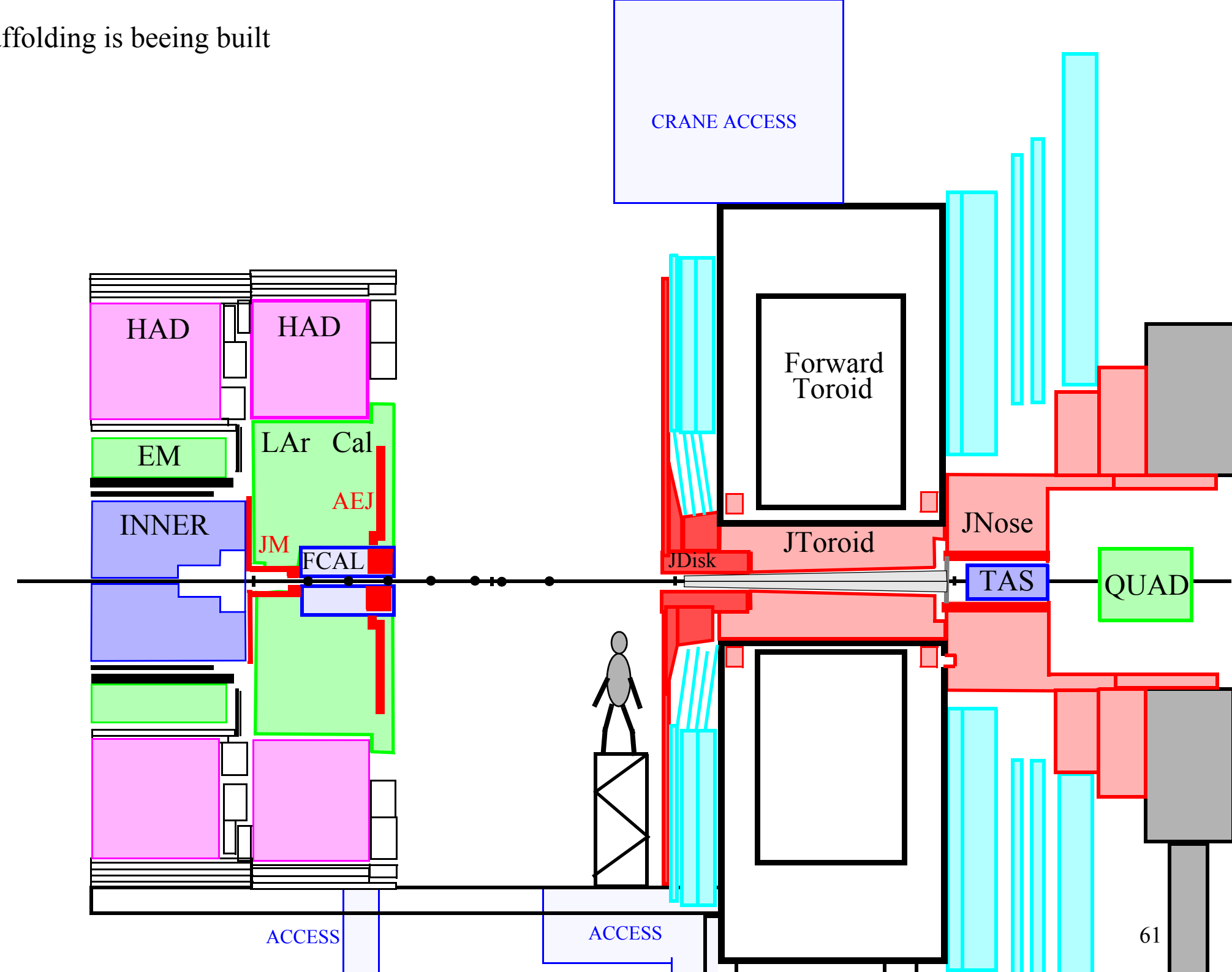
12. The small wheel is moved forward.



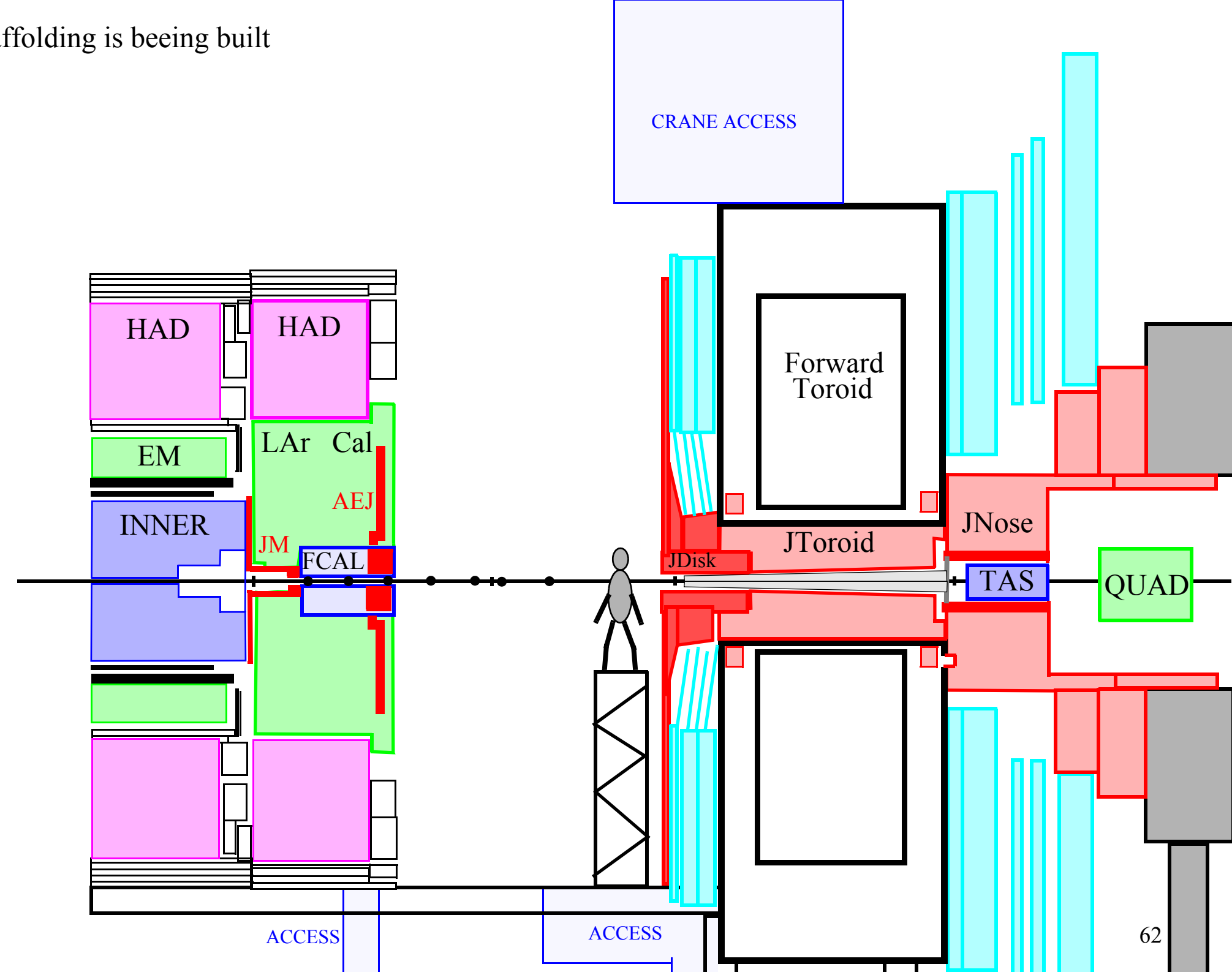
12. The small wheel is moved forward.



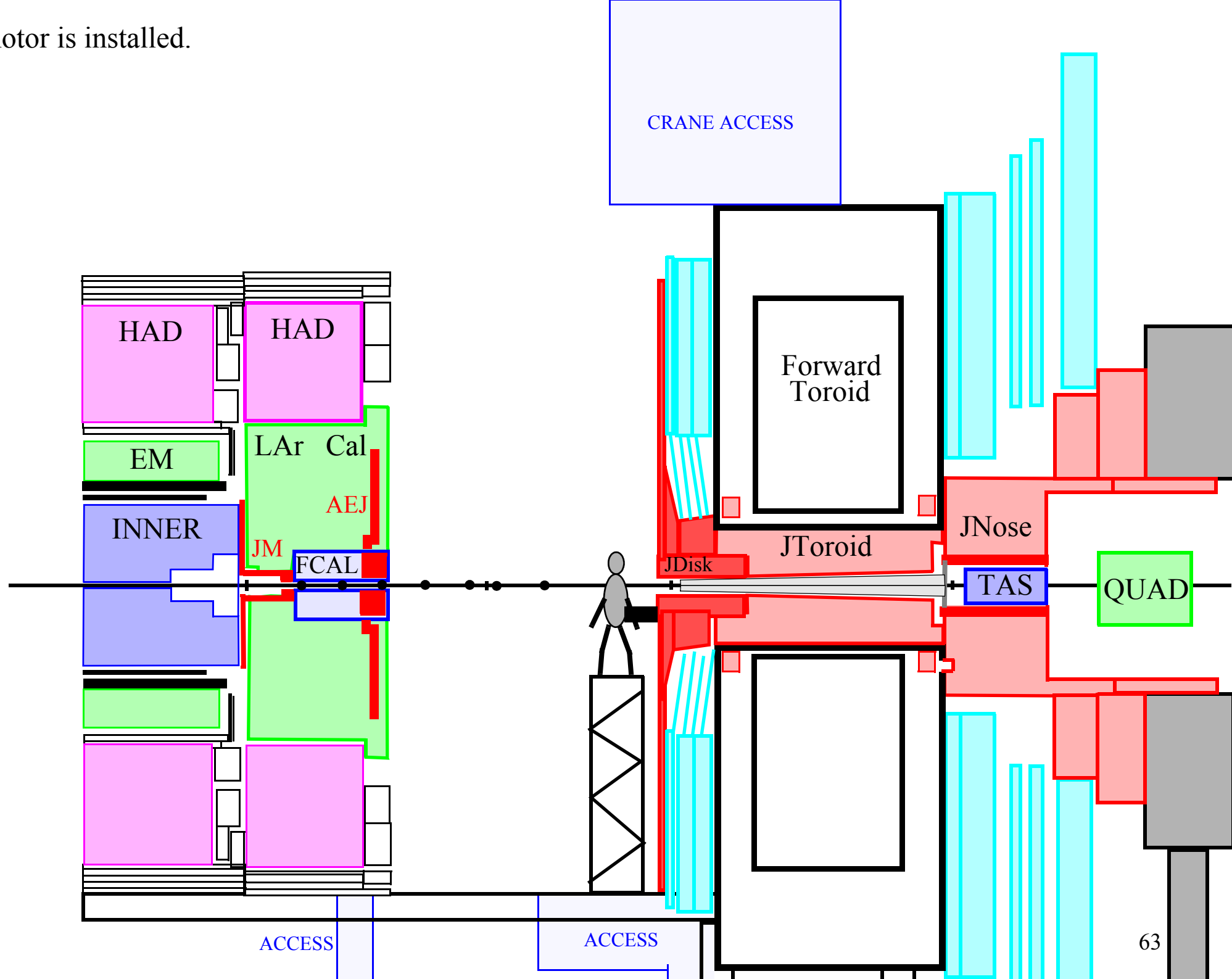
13. Scaffolding is beeing built



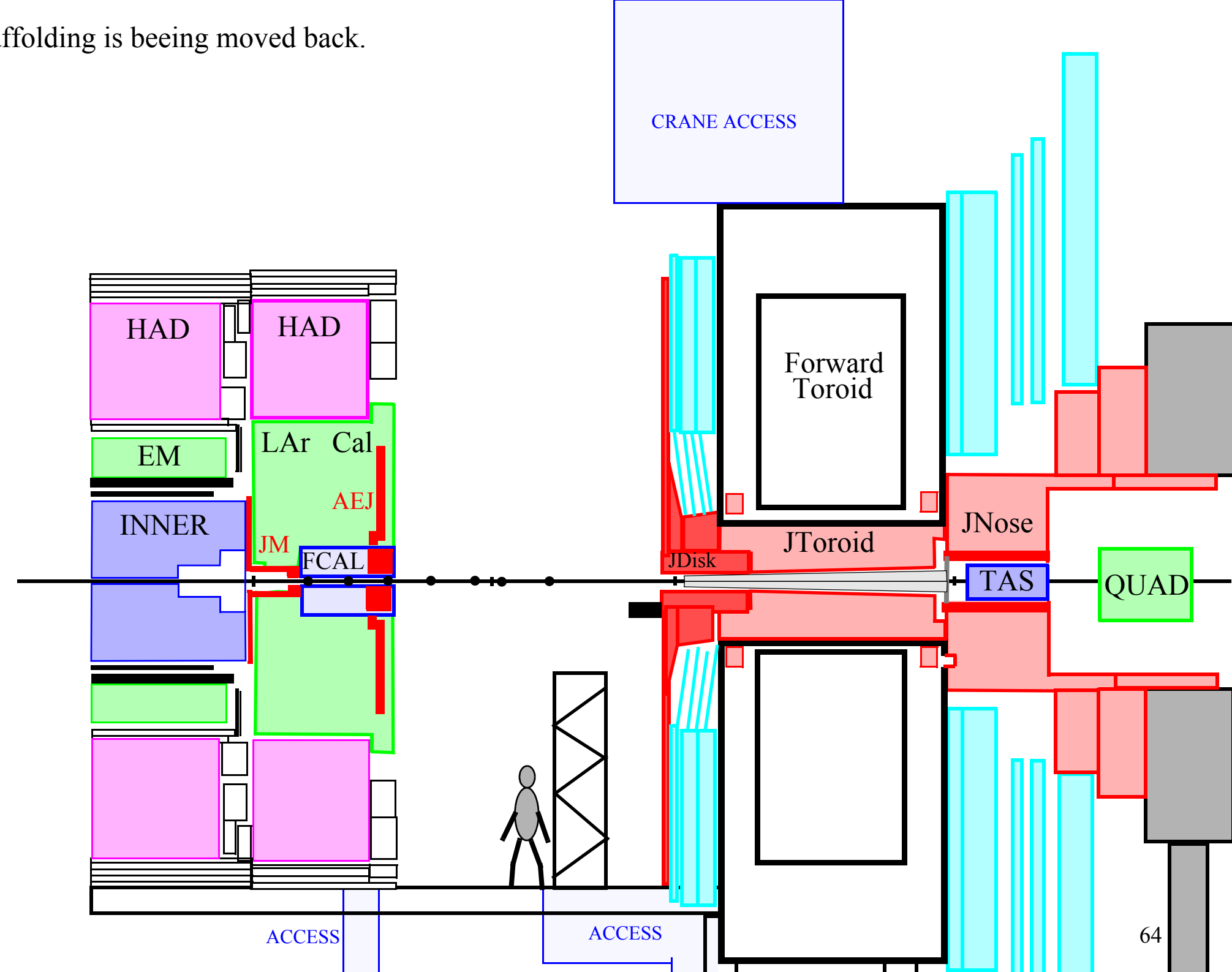
13. Scaffolding is beeing built



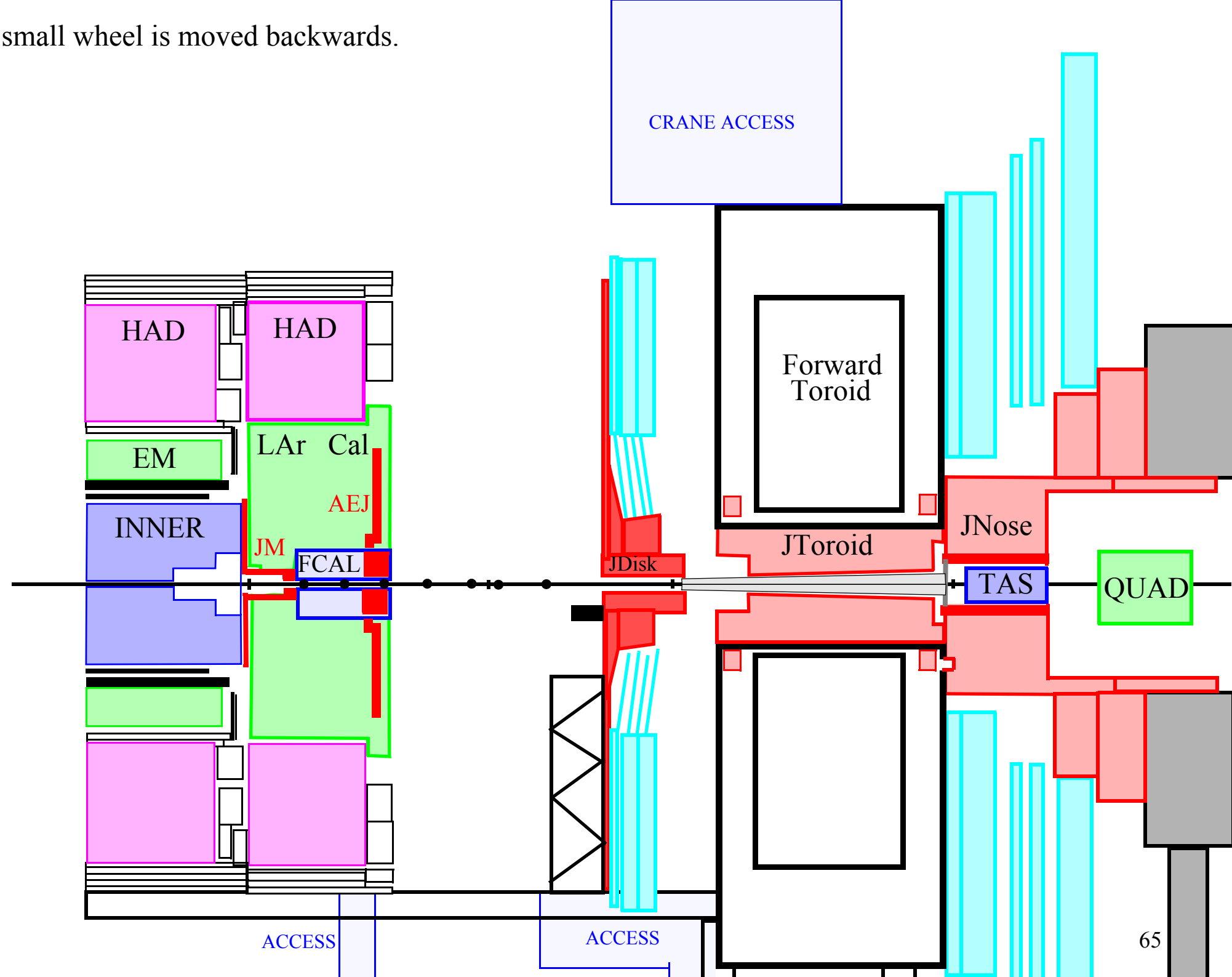
14. A motor is installed.



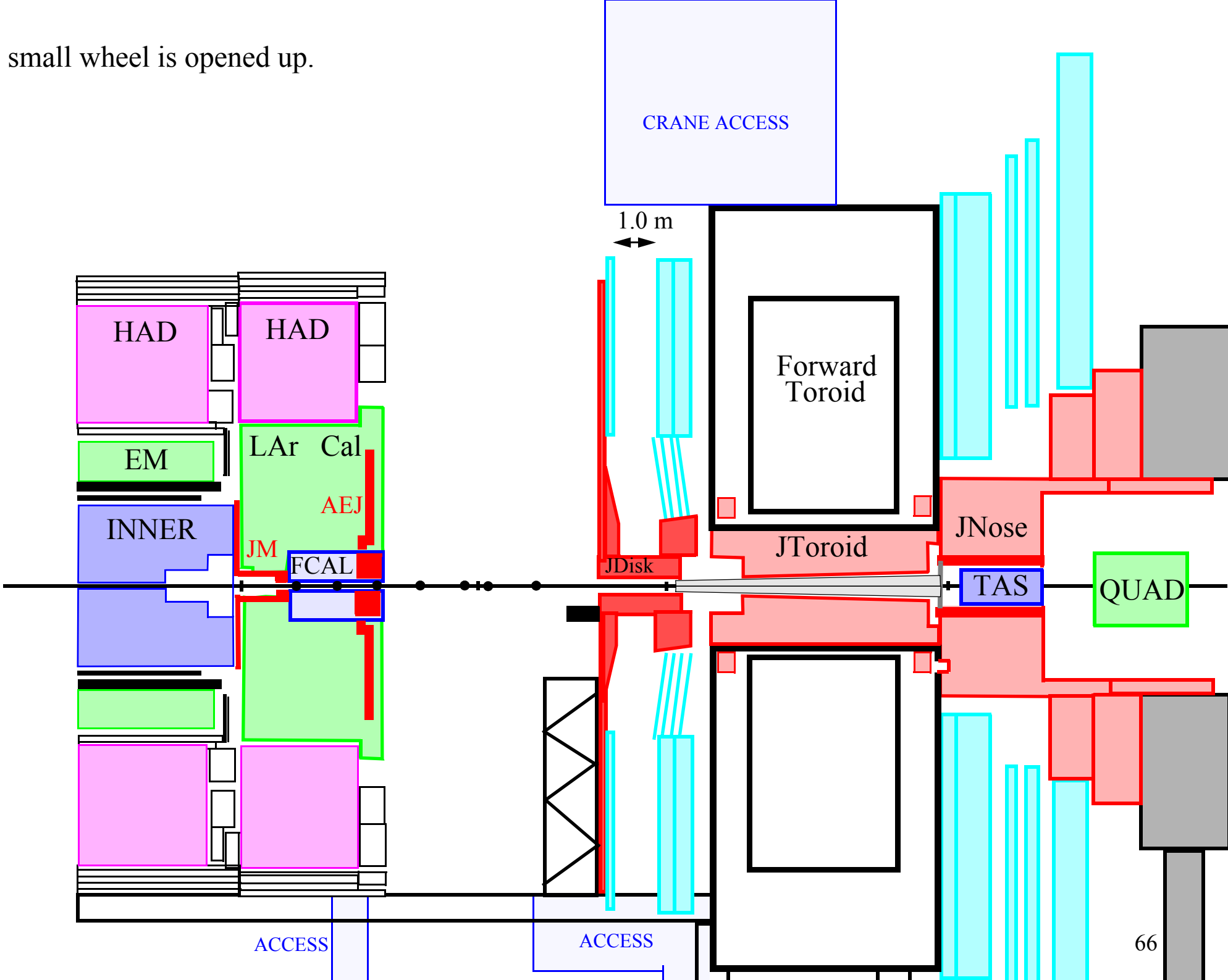
15. Scaffolding is beeing moved back.

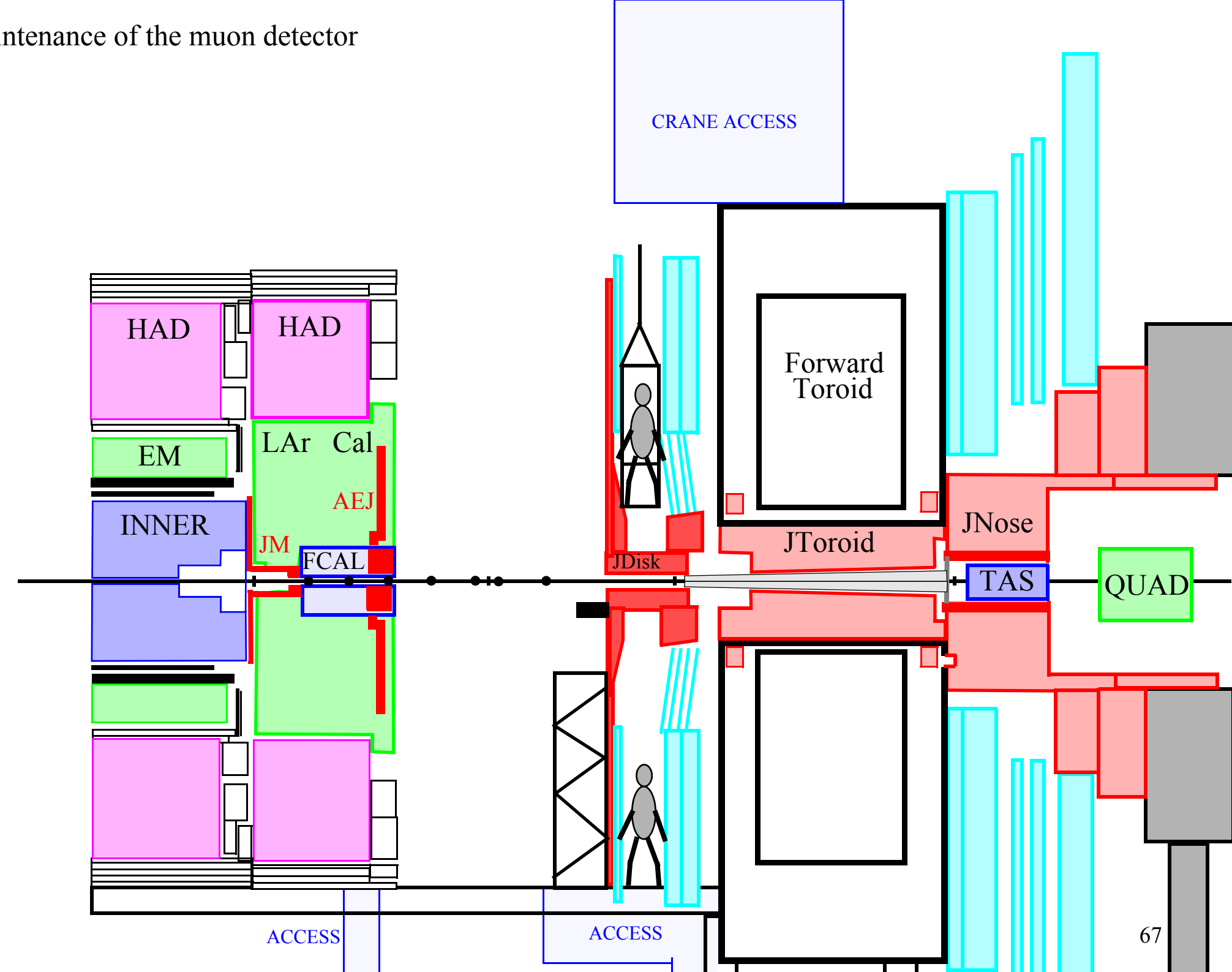


16. The small wheel is moved backwards.

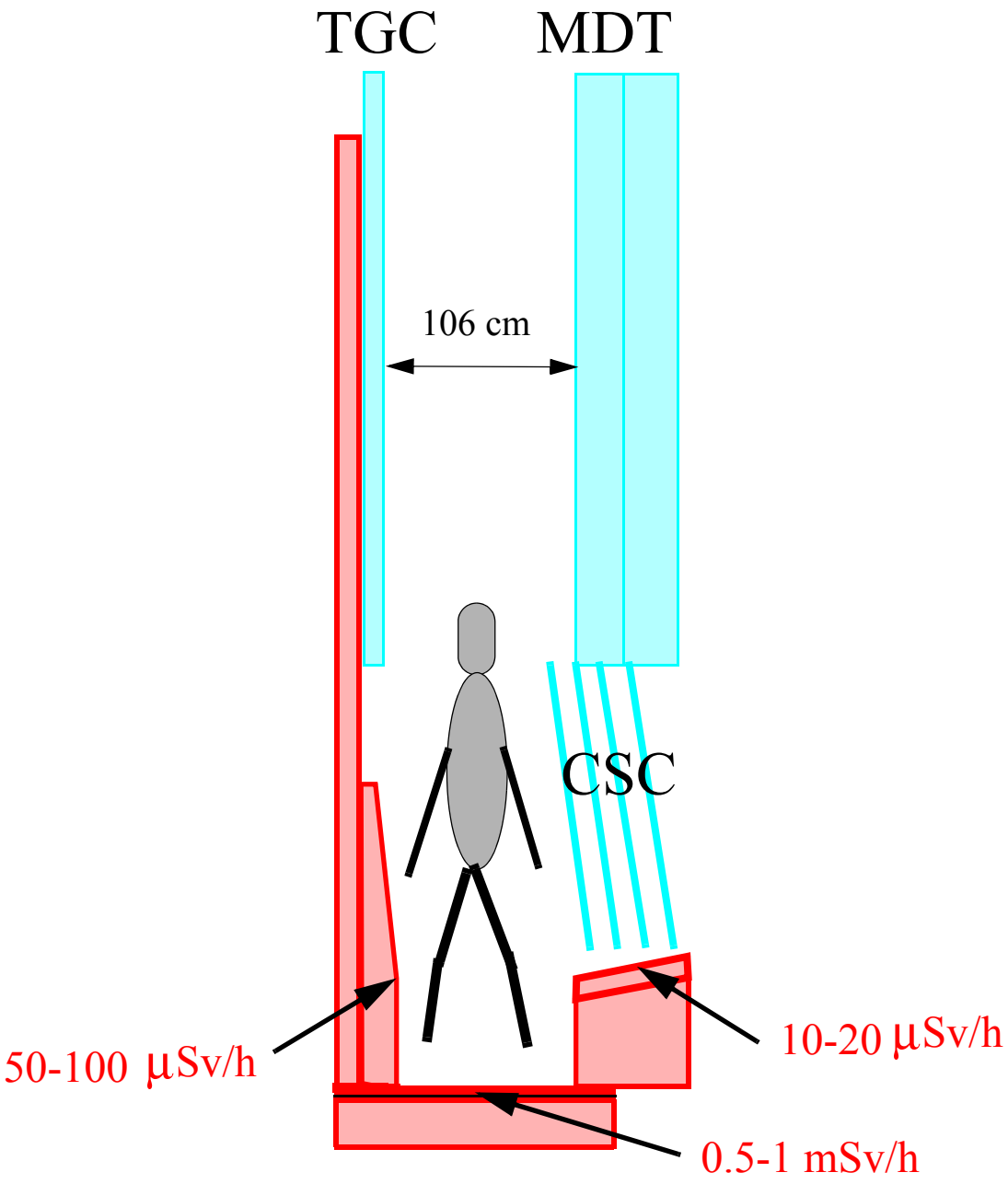


17. The small wheel is opened up.

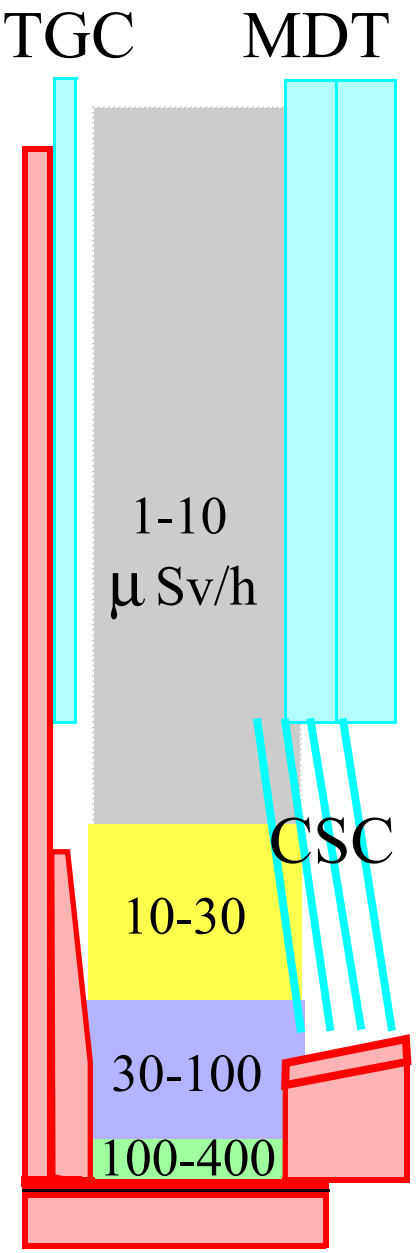



CRANE ACCESS
HAD
HAD
EM
LAr Cal
AEJ
INNER
JM
FCAL
JDisk
Forward
Toroid
JToroid
JNose
TAS
QUAD
ACCESS
ACCESS

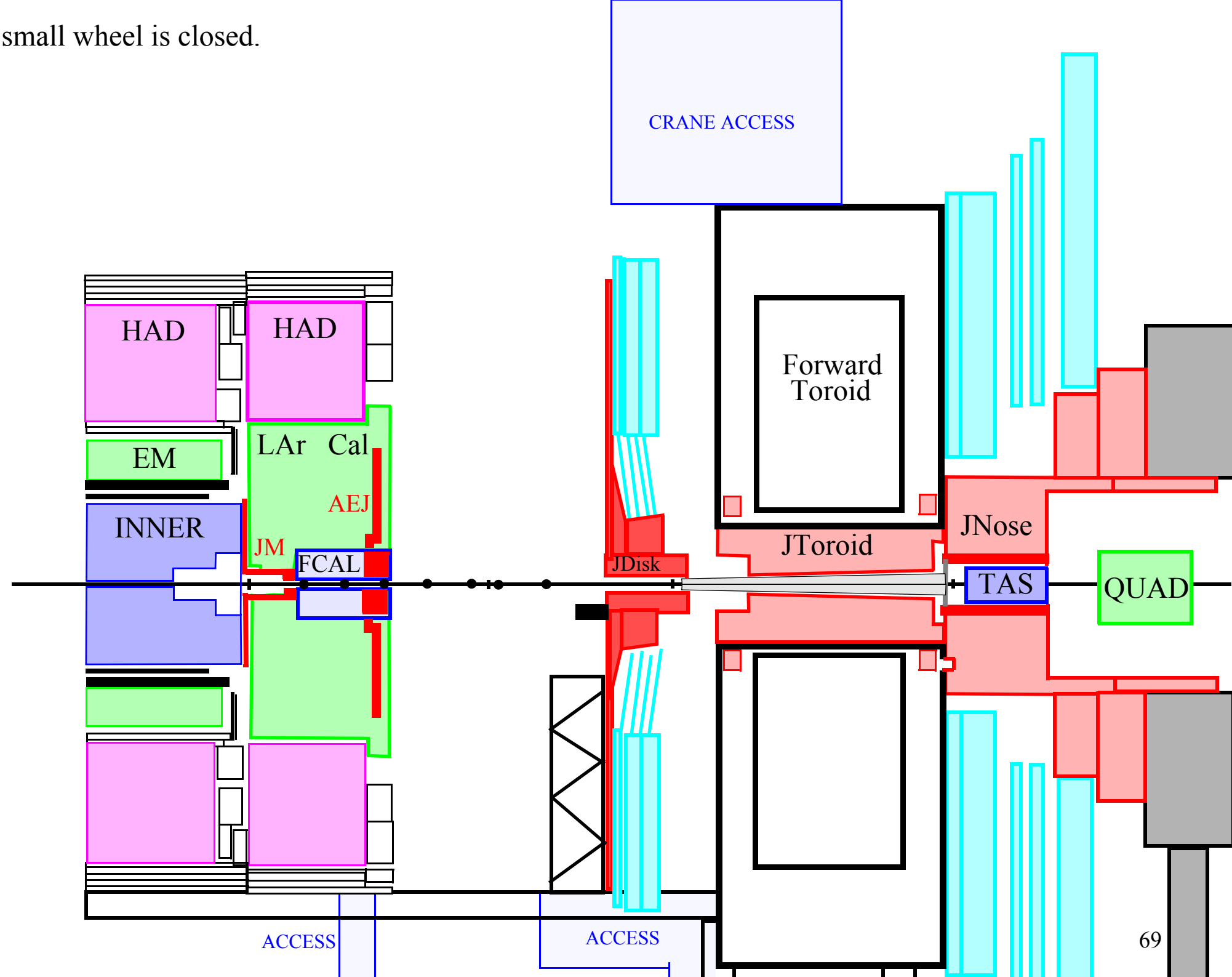
Contact doserate calculated by Shupe and Hedberg using omega factors.
30 day run / 1 day cooling



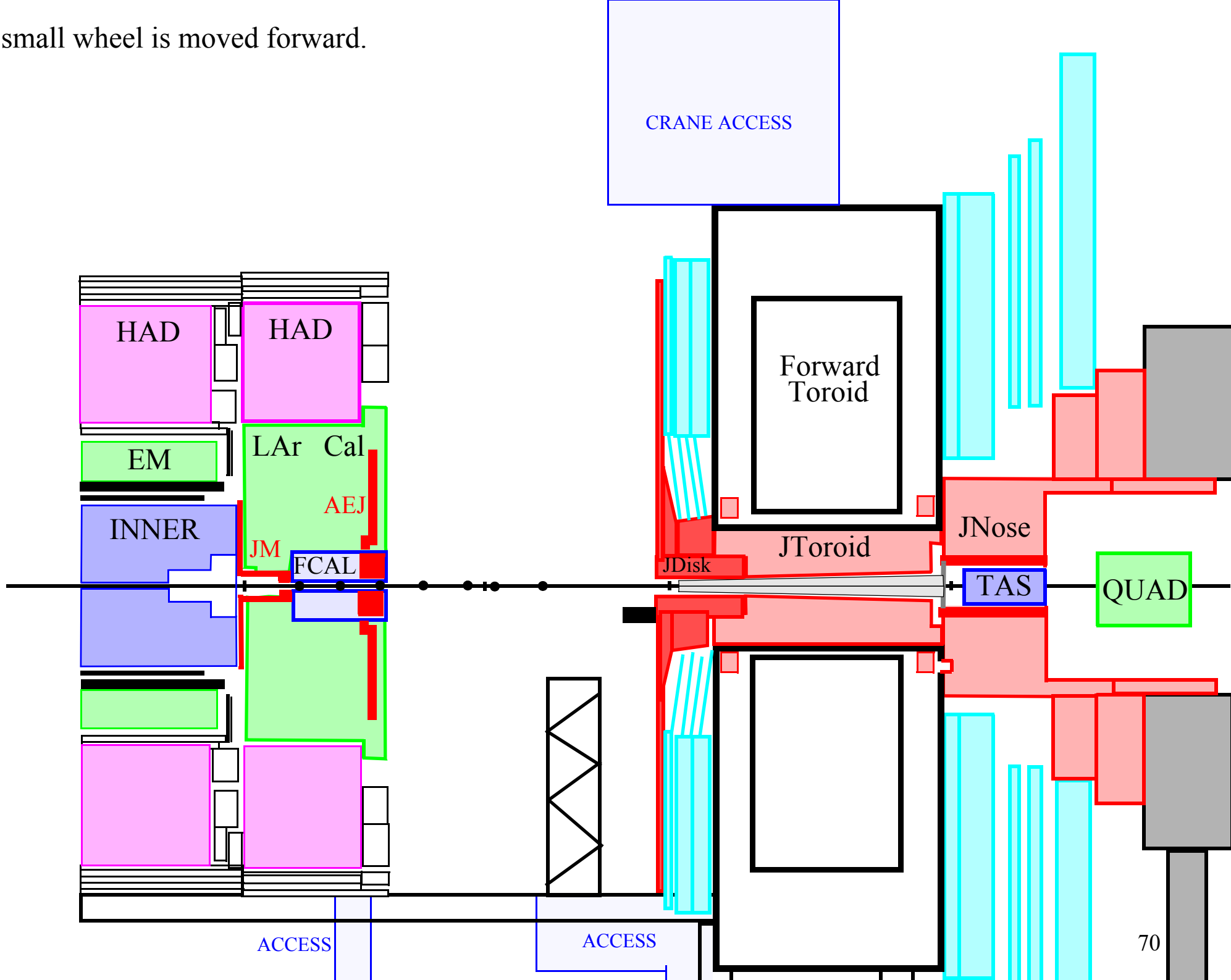
Doserates in the small wheel after 100 days of running and 5 days of cooling.
Calculation by M. Morev.



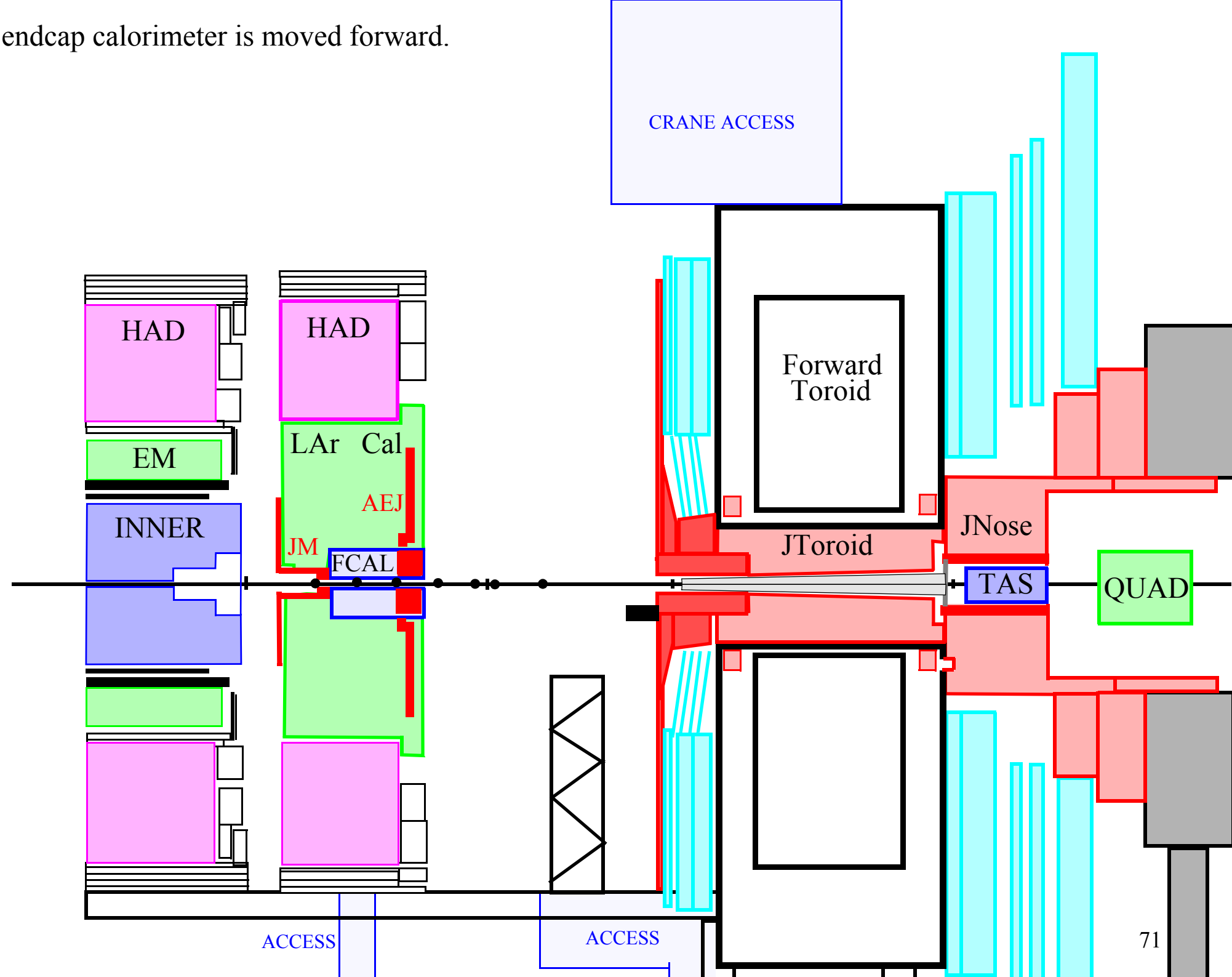
19. The small wheel is closed.



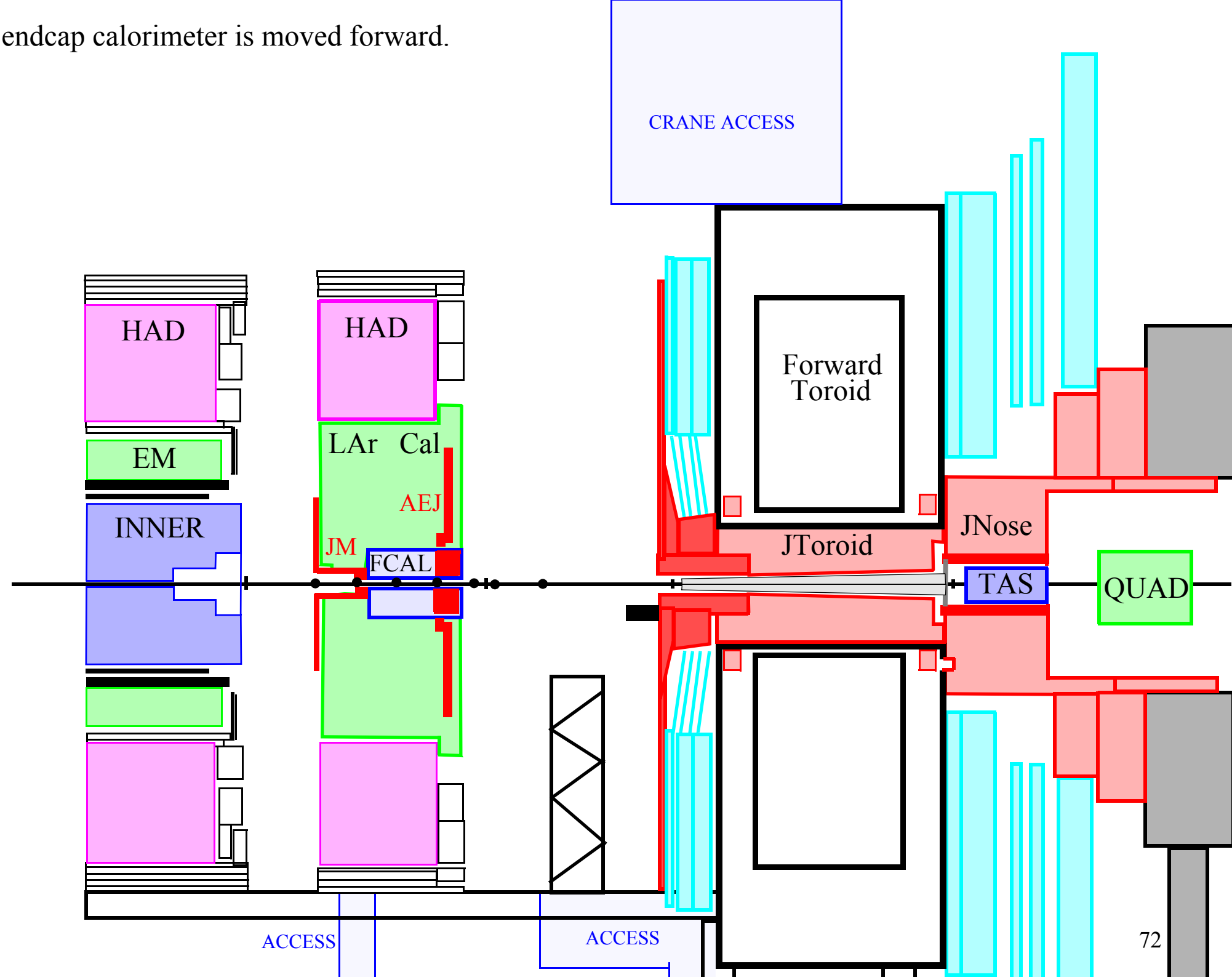
20. The small wheel is moved forward.



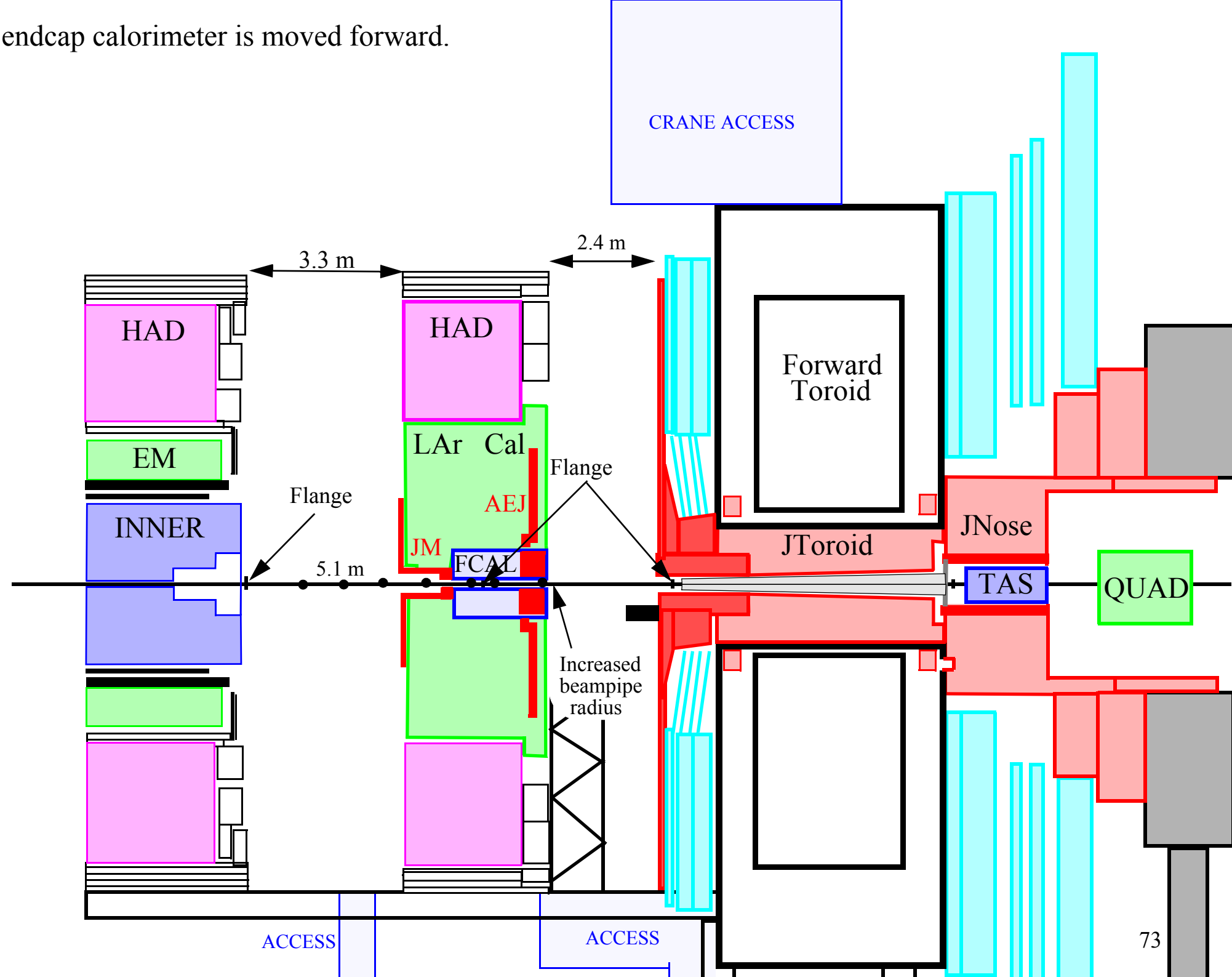
21. The endcap calorimeter is moved forward.



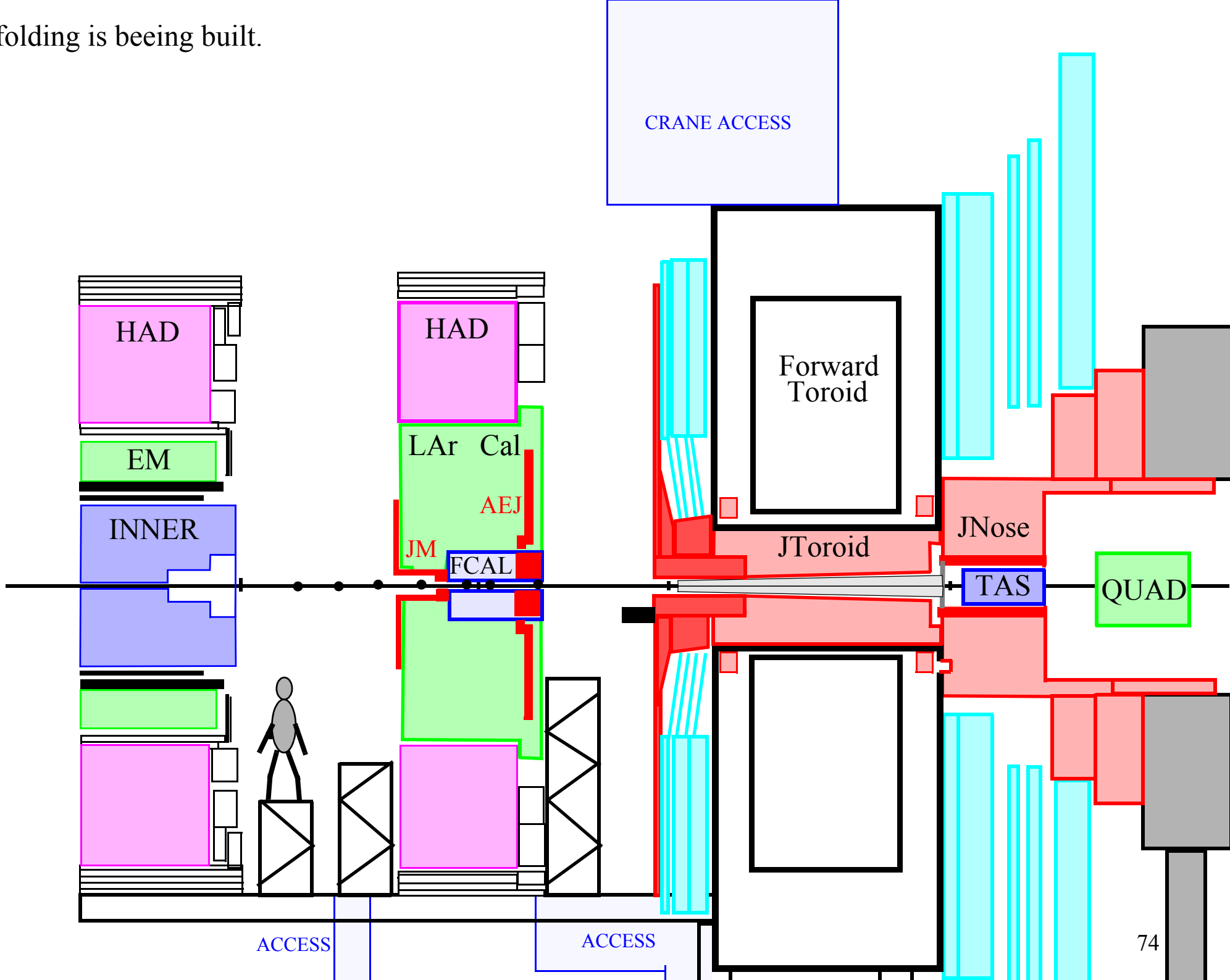
21. The endcap calorimeter is moved forward.



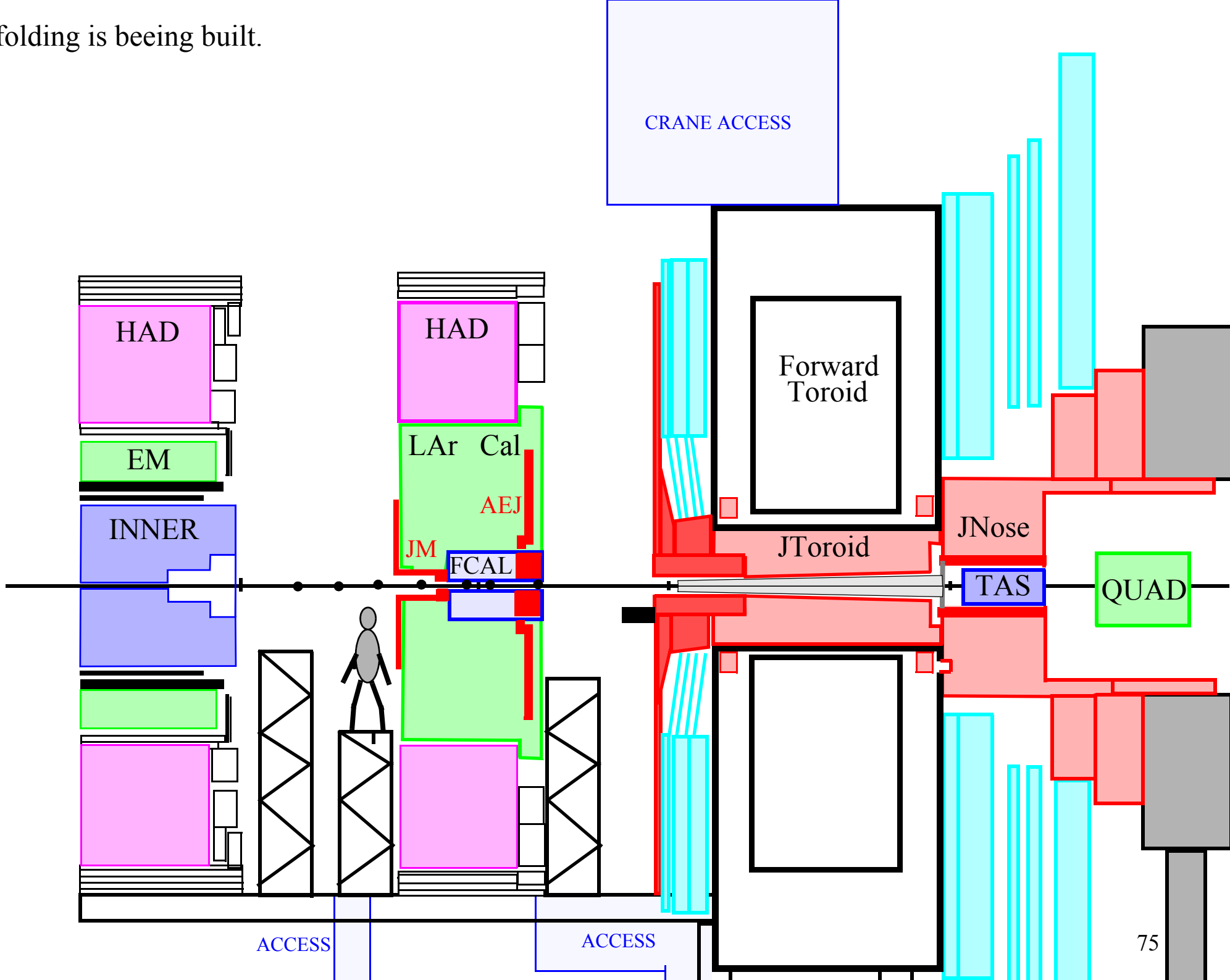
21. The endcap calorimeter is moved forward.



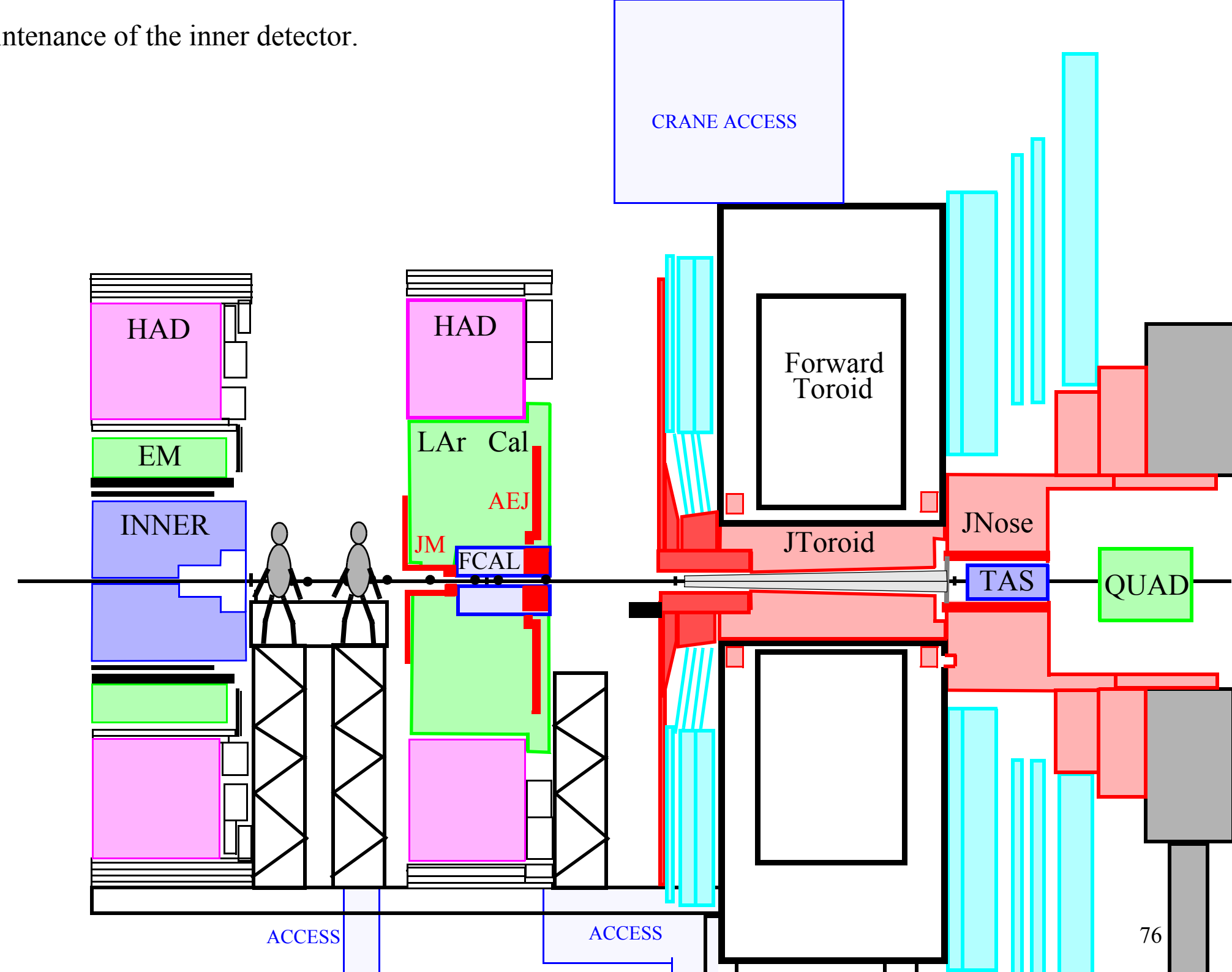
22. Scaffolding is beeing built.



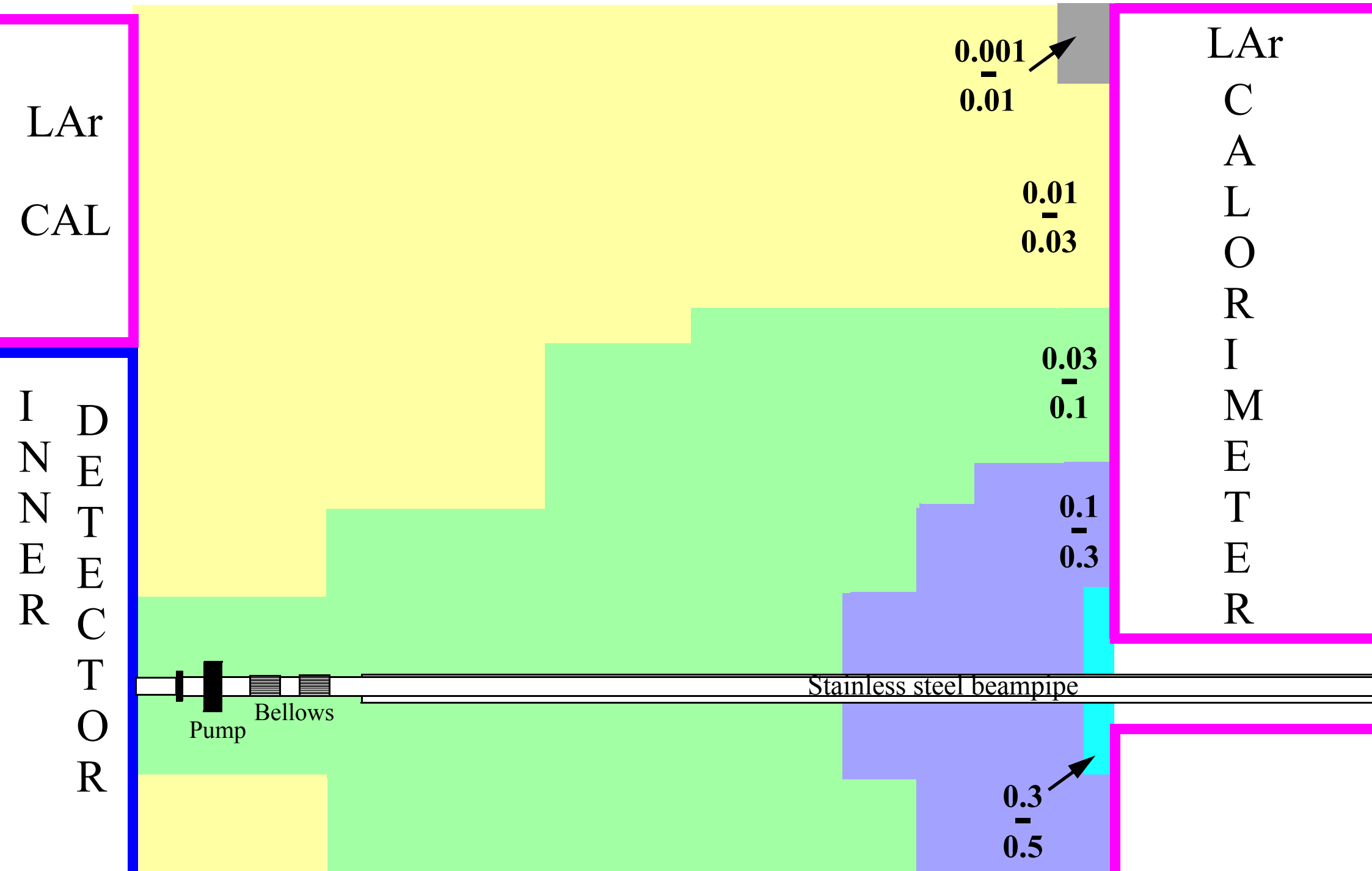
22. Scaffolding is beeing built.



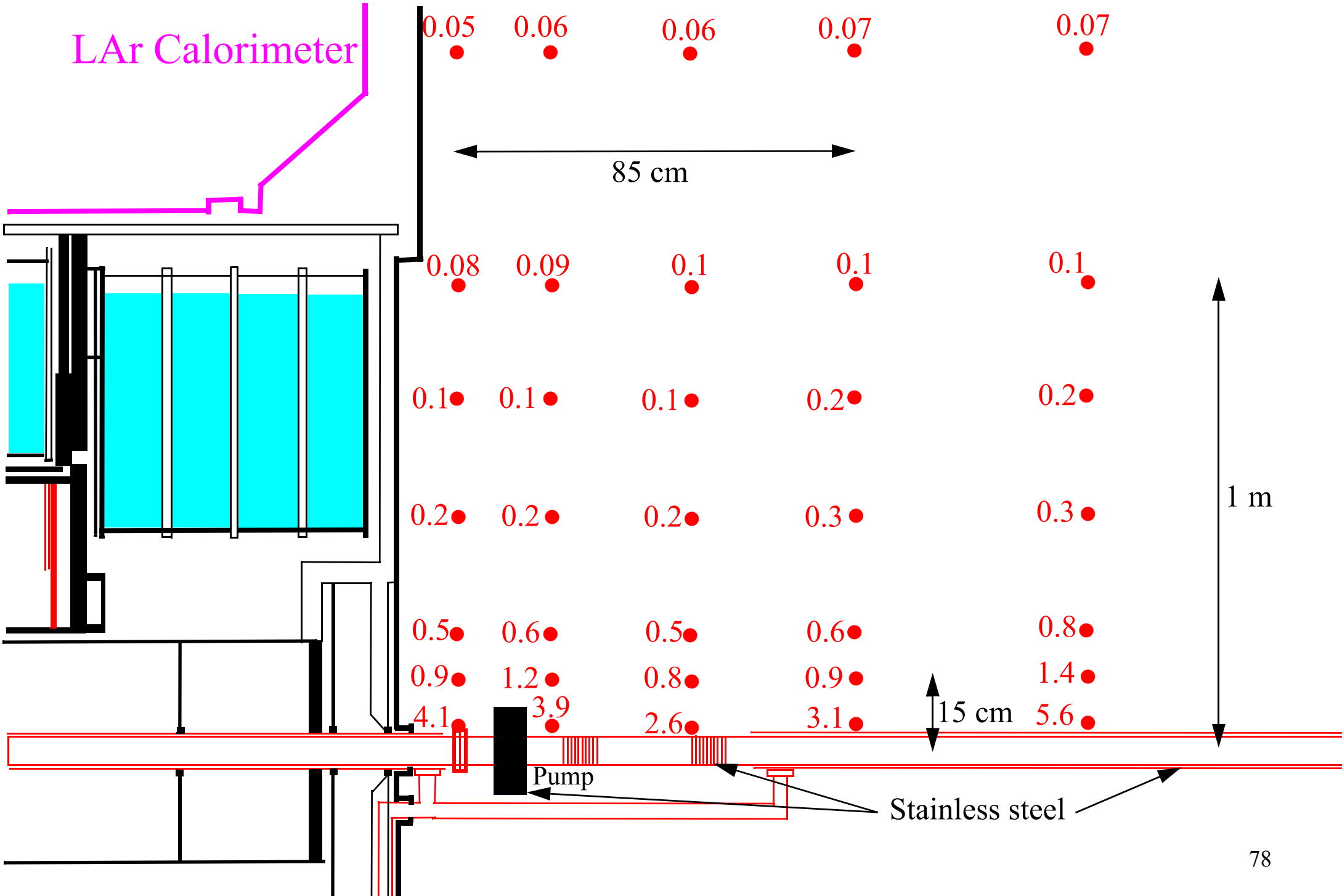
23. Maintenance of the inner detector.



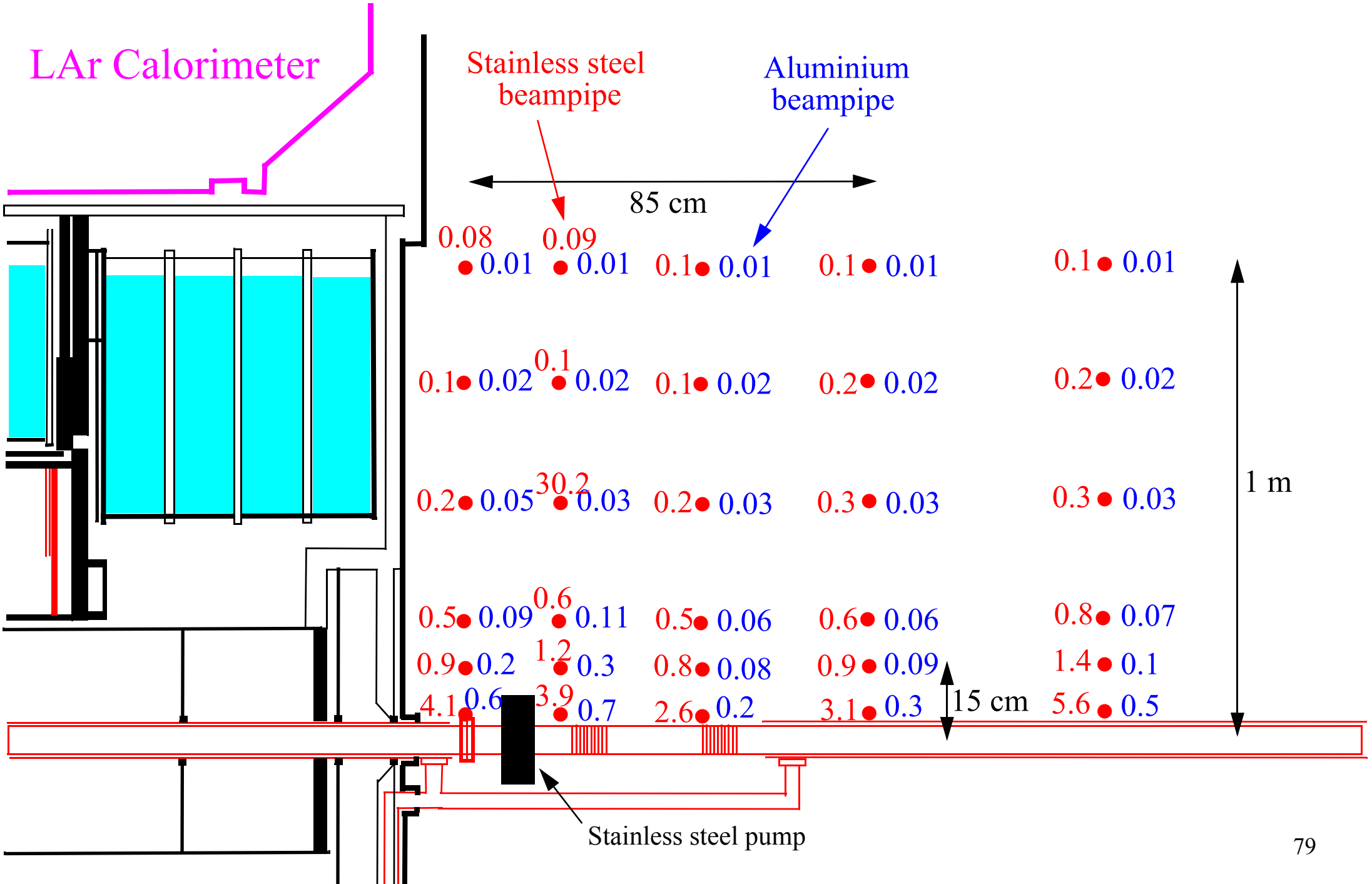
Dose rates after 10 years running and 5 days cooling



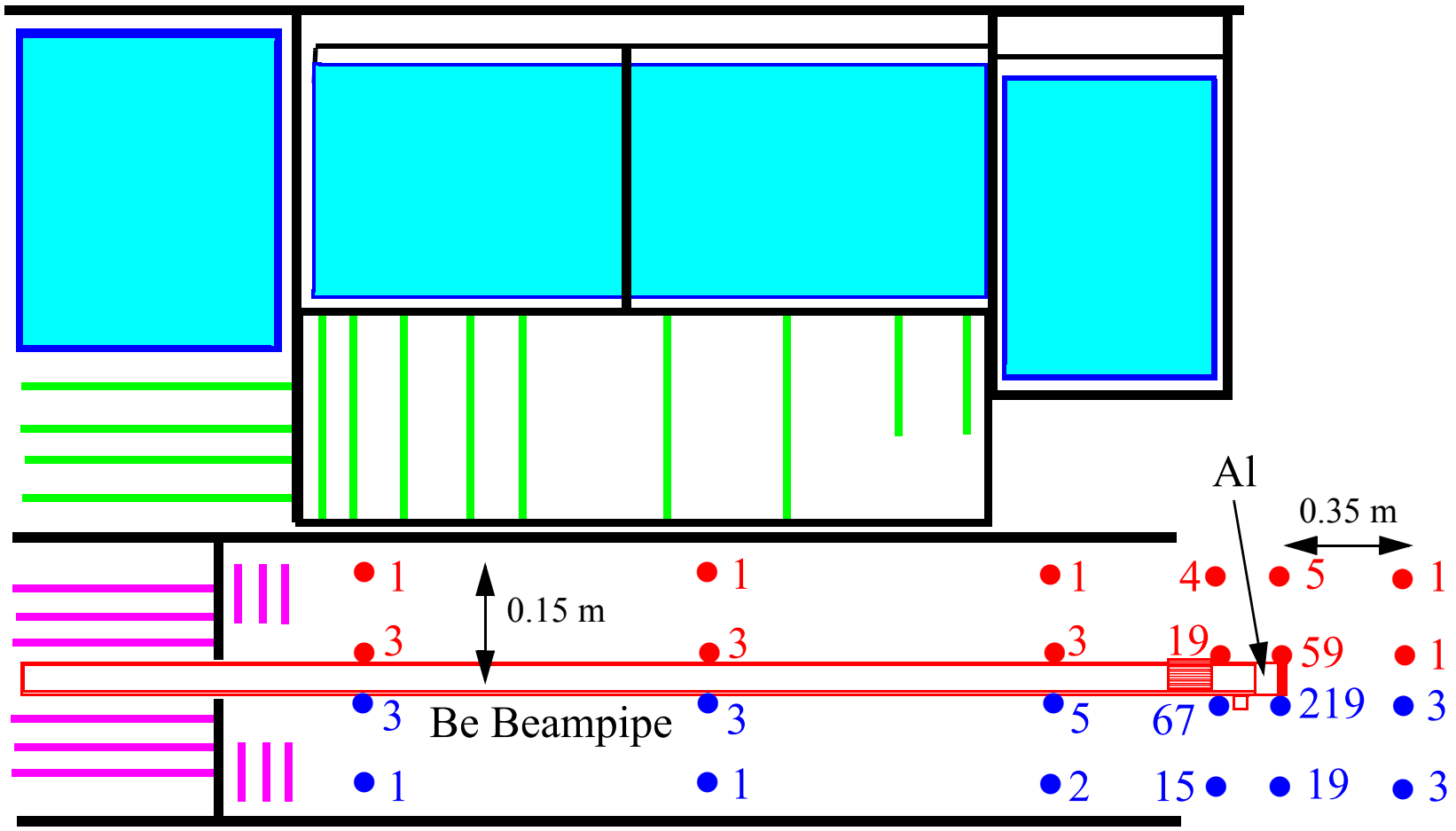
Dose rates in mSv/h from the VA beampipe after 10 years running and 5 days cooling.



Dose rates in mSv/h from the VA beampipe after 10 years running and 5 days cooling.



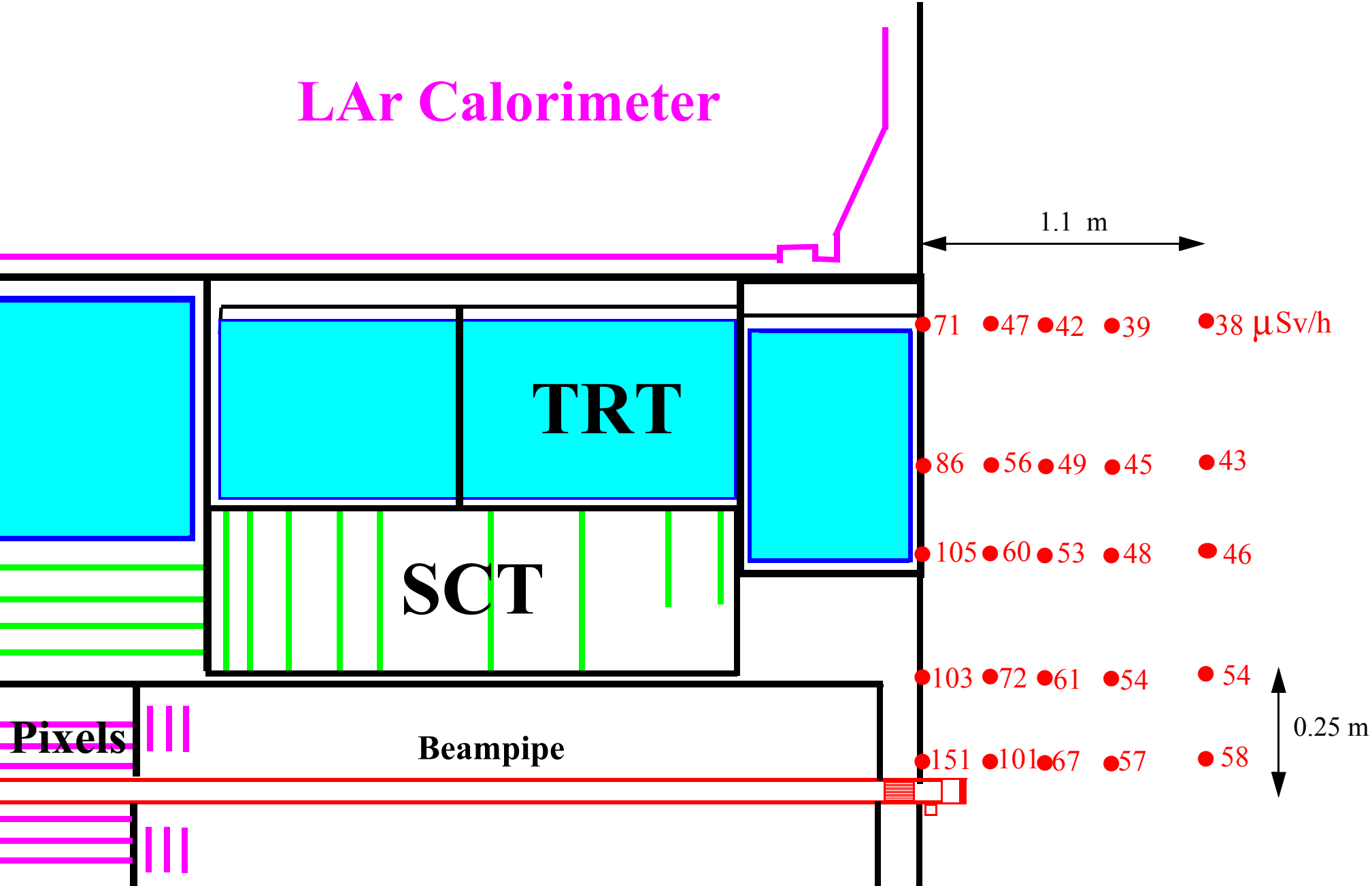
Dose rates in μSv/h from the VI beampipe.
Calculation by M. Morev.



100 days running
5 days cooling

10 years running
5 days cooling

Dose rates in μSv/h from the Pixels+SCT+TRT+LAr cal.+VI beampipe after 10 years of running and 5 days cooling. Calculation by M. Morev.



Activation - Conclusions

Calculations have been made of doserates in many regions of ATLAS.

The stainless steel beampipe is going to be a major problem since it will produce full body doserates in the mSv/h range.

Standard (short) access → All work closer than one meter to the beamline will have to be restricted

Long access → The procedure regarding the removal of the beamline will have to be studied in detail.

A possible improvement could be made by going to an aluminium beampipe.

For details about activation calculations see

http://atlasinfo.cern.ch/Atlas/TCOORD/Activities/CommonSys/Shielding/Activation/activation.html