Impact on Triplet-D1 and experiments from asynchronous beam dump on TCTs

A. Tsinganis, F. Cerutti (EN/STI/FDA)

with R. Bruce (BE/ABP)

6th Annual HiLumi Collaboration Meeting – Paris, November 14-16, 2016

Outline

- Overview
  - Geometry, optics, impact scenarios
- Investigated scenarios
- Results
  - Energy deposition
  - Impact on the triplet
  - Impact on experiment
- Summary and further studies

Introduction and simulation overview

- Accidental beam impact on TCTH4: potential quenching of the triplet, leakage to experiments
- Study already performed for present machine (P. G. Ortega)
  - Different impacts, different collimator materials (Inermet, MoGr, Cu-Diam)
  - Quenches predicted, but values below damage limit
    - https://indico.cern.ch/event/398450/contributions/949713
    - https://indico.cern.ch/event/544856/contributions/2211337

Introduction and simulation overview

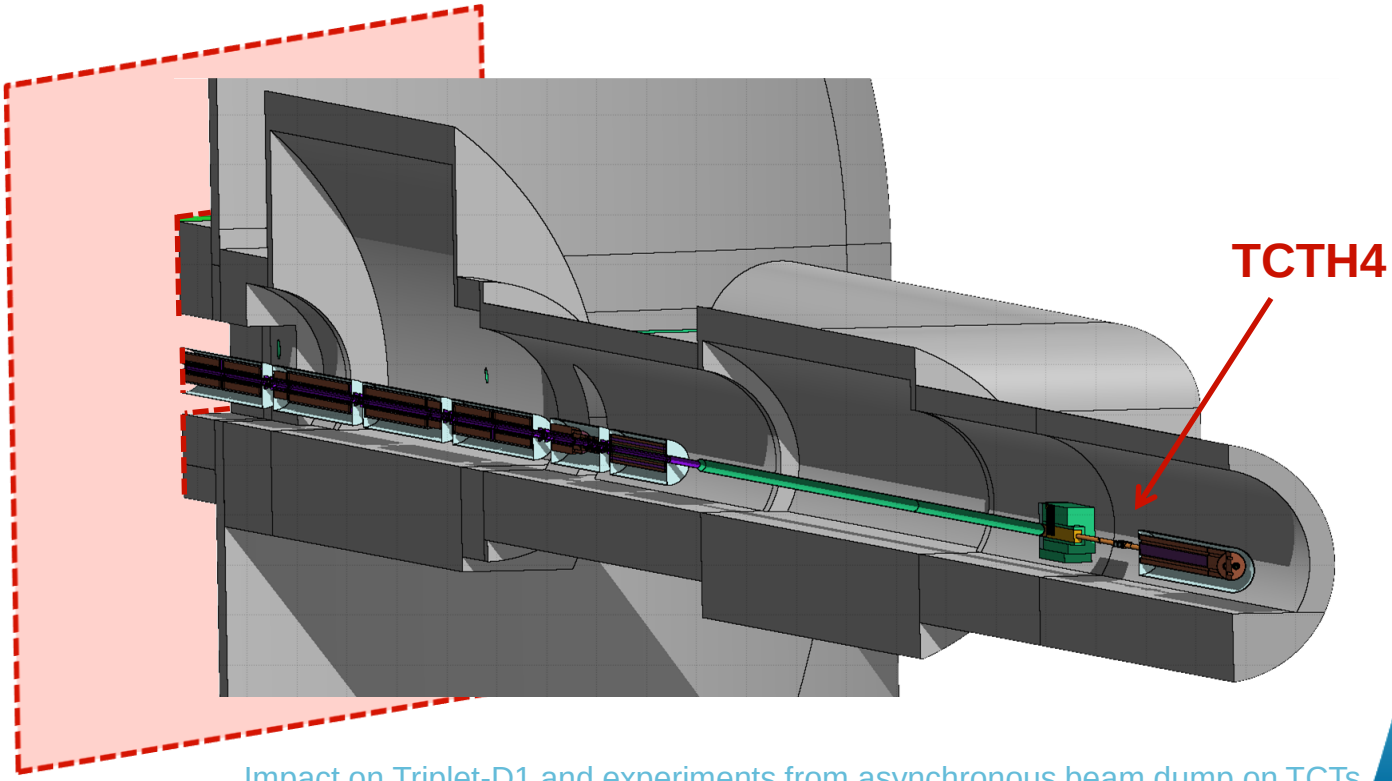
- TCT4 set at 13.3σ – largest setting at which it still shadows the triplet
- Half bunch impact: centre of the bunch at the TCT jaw (~53% of protons / 137kJ impacting)
- Full bunch impact: ~94% of the protons hit the jaw (242kJ impacting)
- SixTrack input loaded in FLUKA and transported
- **Attention:** only one bunch considered
  - A real event might involve more than one bunch
  - Not all the bunches would impact in the same way
  - Therefore, the results of this study are not directly scalable

Introduction and simulation overview

- Optics HL-LHCV1.2, β*=15cm
  - The minor changes in the triplet-D1 region in v.1.3 should not affect these results
  - Of course, v.1.3 has to be used when studying impacts on TCTH.6R5 due to the different Q4
  - Bunch intensity = 2.3×10^{11} protons
- Two materials considered:
  - Inermet
    - heavier, higher local absorption and damage, better protection
  - Molybdenum graphite
    - lighter, lower local absorption and damage, weaker protection
  - Copper-diamond not studied: it represents an intermediate case

Investigated scenarios

- Impact on TCTH.4R5
  1. Half bunch impact on Inermet collimator
  2. Half bunch impact on Molybdenum-Graphite collimator
  3. Full bunch impact on Molybdenum-Graphite collimator



Energy deposition

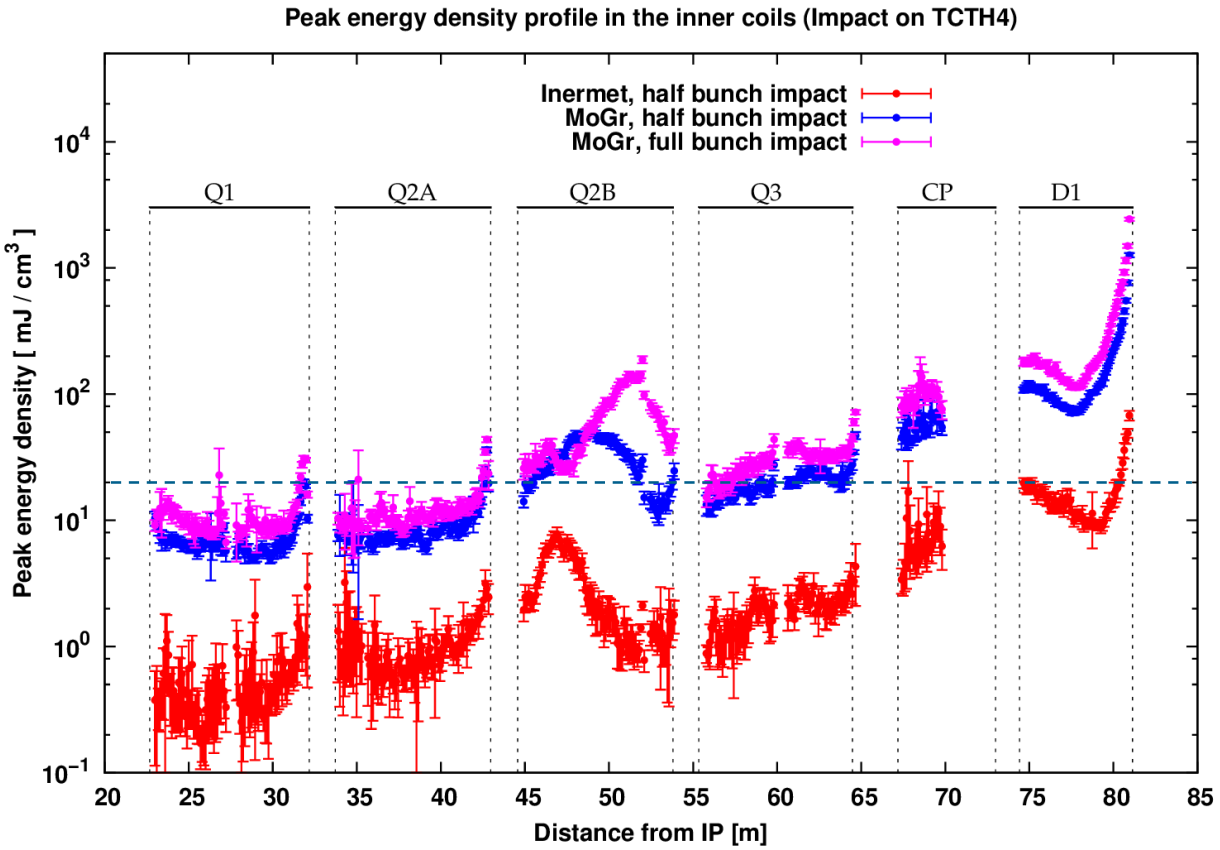
	Inermet half (137kJ)	MoGr half (137kJ)	MoGr full (242kJ)
	Energy deposition (%)		
TCTH4 (1)	46.3	5.6	9.6
TCTV4	2.3 (jaws) 1.8 (tank)	3.2 (jaws) 2.4 (tank)	3.9 (jaws) 3.3 (tank)
TAXN	6.9	11.9	14.0
D1	2.0	15.0	13.9
Triplet	1.2	13.0	11.4
Beam pipe	2.4	10.2	7.2
Crossing@22.6m (2)	4.7 (3.5)	12.9 (4.2)	5.0 (0.5)
Energy to mass	3.9	3.7	3.8
Neutrinos	0.7	0.9	0.9

(1) Jaws only. Tank not included due to integration issues

(2) In parentheses: percentage carried by ~7TeV protons

- Remaining energy (20-30%) mostly in the TCTH tank and the tunnel walls

Peak energy density profile



- All values well below damage limit (~100J/cm^3)
- Only D1 would quench in the Inermet / half bunch scenario
- Values higher by at least a factor of 10 in MoGr case

Impact on experiment

Particle population

- Particles crossing the scoring plane at 22.6m
  - 75-85% photons
  - 10-15% neutrons
  - 0.1-0.5% protons
  - Remainder dominated by electrons and positrons

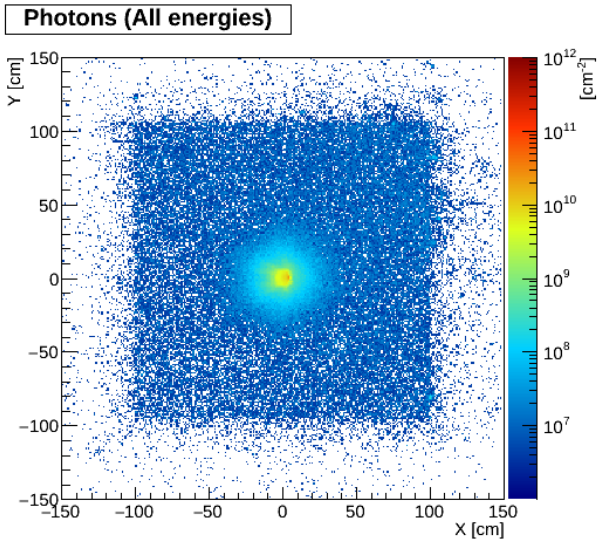
Particle dump: file format

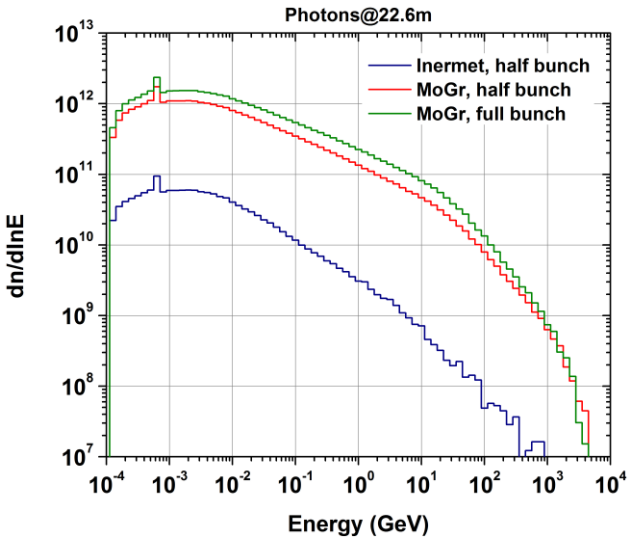
```
# Scoring particles entering Region No  2126
# Col  1: FLUKA run number
# Col  2: primary event number
# -- Particle information --
# Col  3: FLUKA particle type ID
# Col  4: Kinetic energy (GeV)
# Col  5: Statistical weight
# -- Crossing at scoring plane --
# Col  6: x coord (cm)
# Col  7: y coord (cm)
# Col  8: x dir cosine
# Col  9: y dir cosine
# Col 10: Particle age since primary event (sec)
# Col 11: Total energy (GeV)
   0    1    7  1.0685640710268577E-03  1.0000000000000000E+00  5.8040204373064654E+01 -3.6
   0    1    7  2.0869470497192035E-04  1.0000000000000000E+00  6.1410111219202363E+01  4.4
   0    1    8  3.4885316857469206E-11  1.0000000000000000E+00 -8.7361496033804116E+00  8.5
   0    1    7  7.0087267686422025E-02  1.0000000000000000E+00 -4.7746956350640035E+00  1.5
   0    1    8  5.0713988564154988E-11  1.0000000000000000E+00 -7.0645411290578664E+01  9.8
   0    1    7  3.1391604740674895E-03  1.0000000000000000E+00 -3.7325570478160373E+00  1.2
   0    1    7  8.2376767285229514E-03  1.0000000000000000E+00 -4.6377365235985151E+00  6.0
   0    1    4  2.3790418550118337E-02  1.0000000000000000E+00  5.6498051387239085E+00  9.7
   0    1    7  2.0485104425603303E-02  1.0000000000000000E+00 -4.9003375300909688E+00  2.0
   0    1    7  1.1054655441846896E-03  1.0000000000000000E+00  2.4389375814695602E+00 -3.0
   0    1    3  2.2395286454039216E-02  1.0000000000000000E+00  3.6311885130594348E+00 -3.7
```

- At present, data from 30000 primary events are available for each scenario

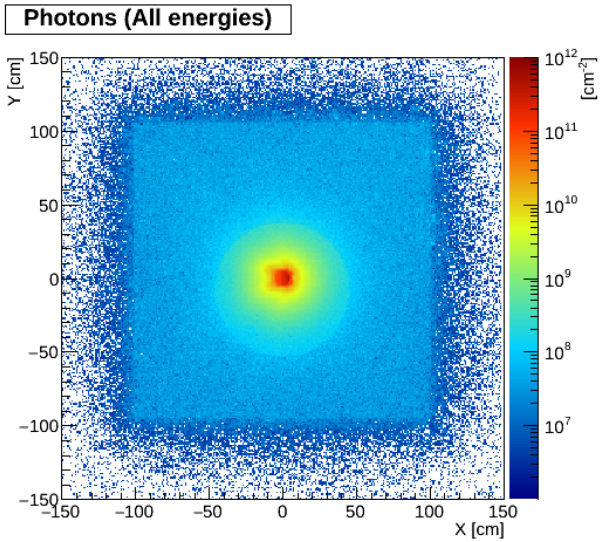
Photons
(transport threshold = 100keV)

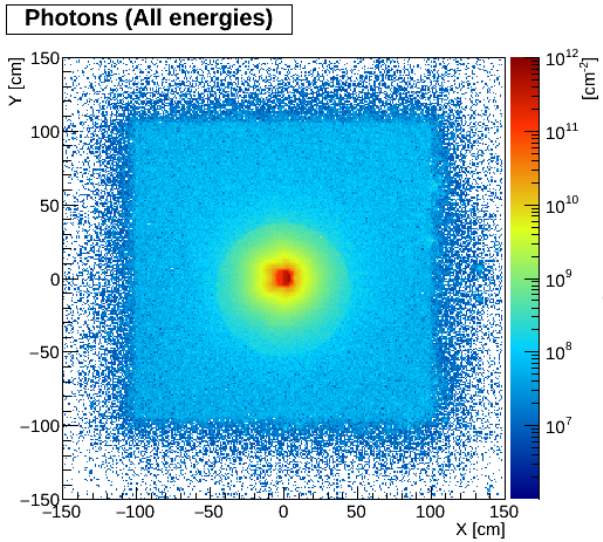
Inermet, half bunch





MoGr, Half bunch

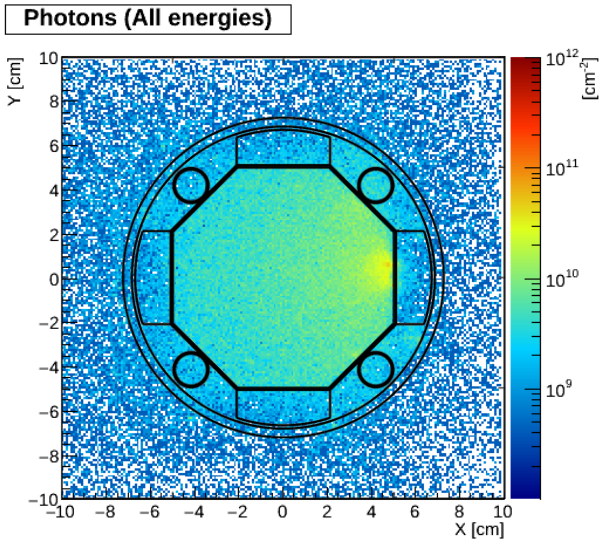


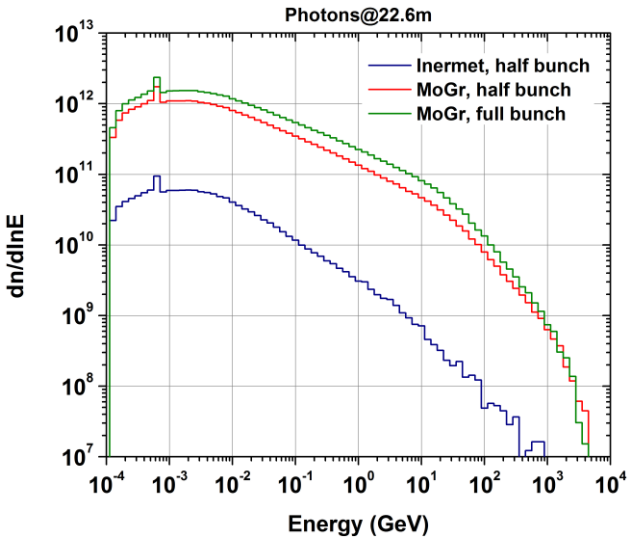


MoGr, full bunch

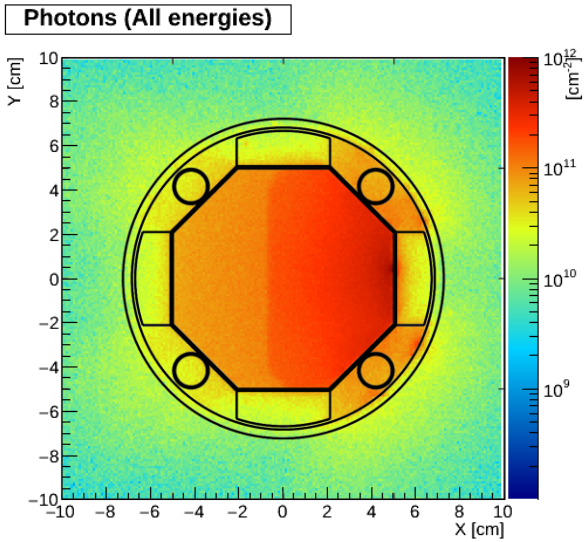
Photons
(transport threshold = 100keV)

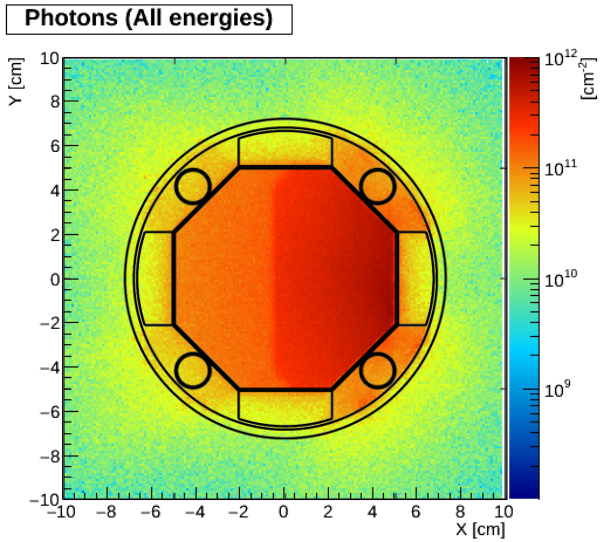
Inermet, half bunch





MoGr, Half bunch

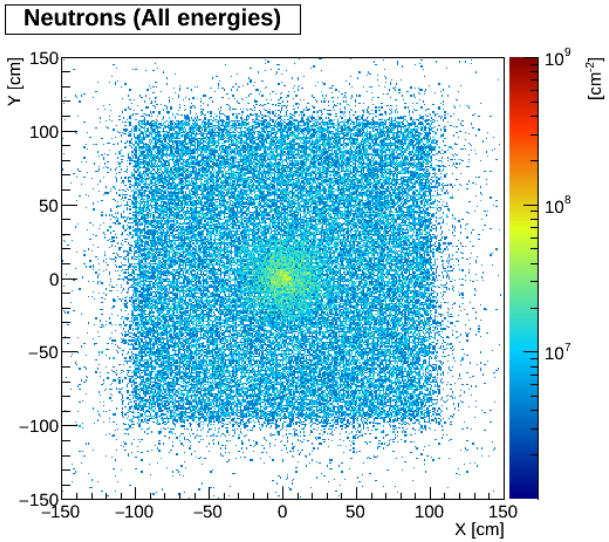


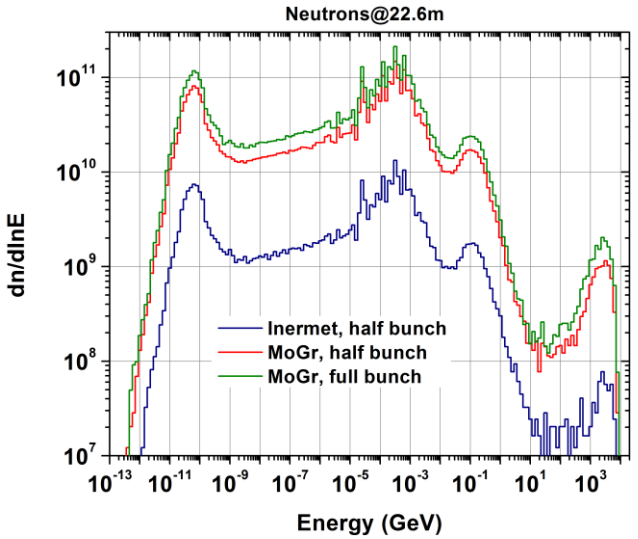


MoGr, full bunch

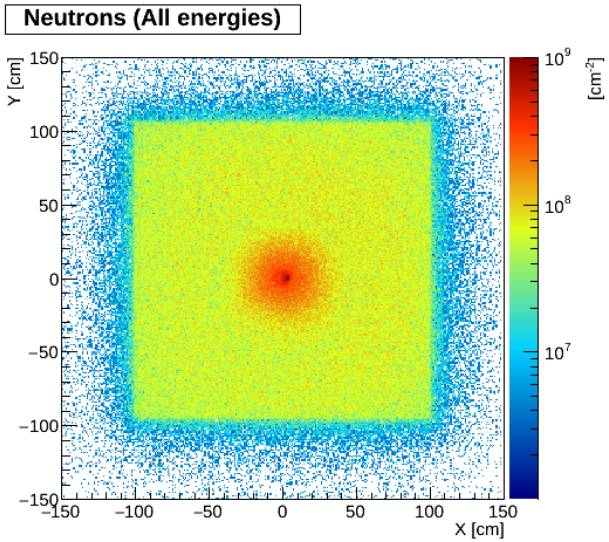
Neutrons

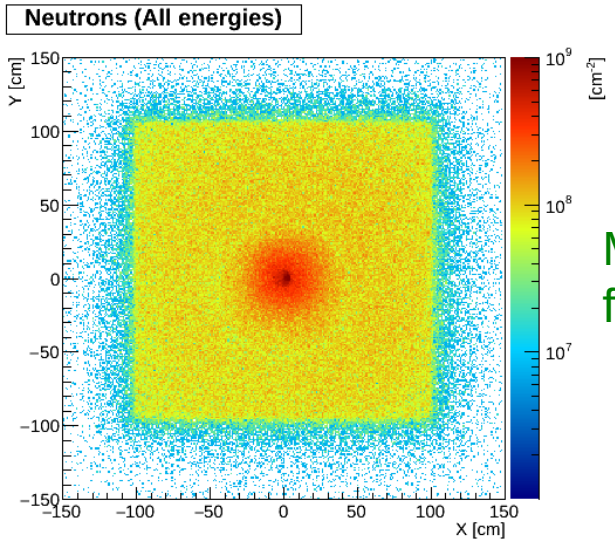
Inermet, half bunch





MoGr, Half bunch

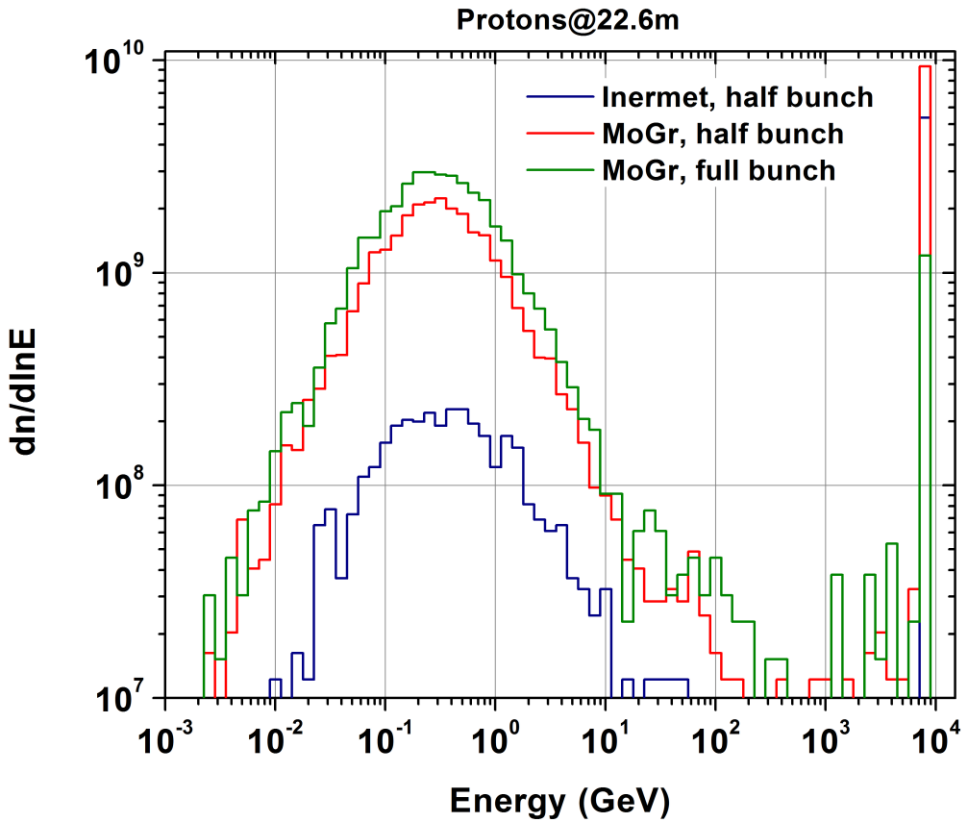




MoGr, full bunch

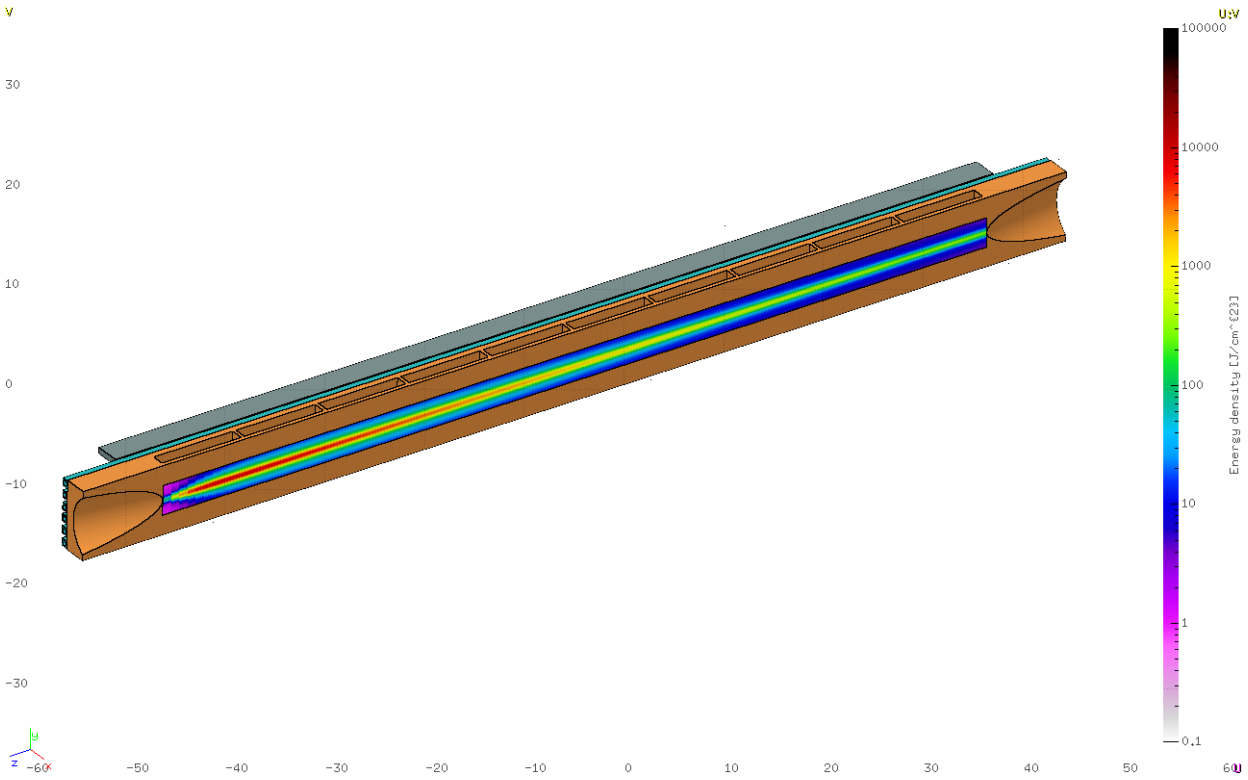
Protons

- Concentrated inside and around beam-pipe



Summary and further studies

- As expected, the use of MoGr leads to a far higher leakage towards the triplet and beyond, independently of the impact scenario (half or full bunch impact)
  - Increase by more than a factor of 10 of neutrons, photons, protons crossing the plane at 22.6m
- Peak energy density values in the triplet remain well below damage limit, but quenches in the triplet (and probably elsewhere, e.g. IP6) are expected in all investigated scenarios
- Further studies:
  - Accidental impact on TCTH.6R5
    - Using optics v.1.3
    - Probable important impact on Q5
    - Q4 also likely to suffer from the restriction of its aperture
    - Masks on incoming beam bore may be beneficial to Q4 and D2


V
30
20
10
0
-10
-20
-30
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
U
U:V
100000
10000
1000
100
10
1
0,1
Energy density [J/cm^(2)]