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LAMPIRAN

Lampiran 1 : Daftar Persebaran Pesawat Linac di Indonesia

| Wilayah | Rumah Sakit | Jumlah Linac |
|-------------------------|---|--------------------------------------|
| NAD | - | - |
| Sumatera Utara | 1. RSUP H. Adam Malik 2. RS Grandmed Lubuk Pakam, Sumatera | 2 1 |
| Riau | 1. RSUD Arifin Achmad 2. RS Awal Bros | 1 1 |
| Jambi | - | - |
| Kep. Riau | - | - |
| Sumatera Barat | 1. RS Universitas Andalas | 1 |
| Sumatera Selatan | 1. RSUP Dr. Mohammad Hoesin Palembang | 1 |
| Bengkulu | - | - |
| Bangka Belitung | - | - |
| Lampung | RSUD Dr. H. Abdul Moeloek | 1 |
| DKI Jakarta | 1. MRCCC Siloam Hospitals Semanggi 2. RSPAD Gatot Soebroto 3. RSUPN Dr. Cipto Mangunkusumo 4. RS kanker Dharmais 5. RSUD Pasar Minggu 6. Siloam Hospitals TB Simatupang 7. Rumah Sakit Pusat Pertamina 8. RSUP fatmawati | 2 1 6 2 1 1 1 1 |
| Banten | Mayapada Hospital Tangerang | 1 |
| Jawa Barat | 1. RSUD Al-Ihsan Prov. Jawa Barat 2. RSUP Dr. Hasan Sadikin Bandung 3. RS Mitra Keluarga Bekasi Timur 4. RS Hermina Bekasi 5. Santosa Hospital Bandung Kopo | 1 1 1 1 1 |
| Jawa tengah | 1. RS Indriati Solo 2. RS ken Saras 3. RSUP Dr. Kariadi 4. RS PKU Muhammadiyah Gombong 5. RSU Dadi Keluarga Purwokerto | 2 1 3 2 1 |

| | | |
|---------------------------|--|---|
| | 6. RS PARU Dr. ario wirawan Salatiga | 1 |
| | 7. RS Moewardi Solo | 1 |
| Yogyakarta | 1. RSUP Dr. Sardjito | 3 |
| | 2. RS Jogja Internasional Hospital (Jogja) | 1 |
| Jawa Timur | 1. RS Lavalette | 1 |
| | 2. RSUD Dr. Soetomo | 1 |
| | 3. RSAL Dr. Ramelan Surabaya | 1 |
| | 4. RS Adi Husada Cancer Centre (AHCC) | 1 |
| | 5. RS Mitra Keluarga Surabaya | 1 |
| Bali | 1. RSUD Bali Mandara | 1 |
| | 2. RS Prof. IGNG Ngoerah | 1 |
| NTB | 1. RSUD Prov. NTB | 1 |
| NTT | - | - |
| Kalimantan Barat | RS Soedarso Pontianak | - |
| Kalimantan Tengah | - | - |
| Kalimantan Selatan | - | - |
| Kalimantan Timur | 1. RSUD Kanujoso Djatiwibowo | 2 |
| | 2. RSUD Abdoel Wahab Sjahranie Samarinda | 1 |
| Sulawesi Utara | - | - |
| Sulawesi Tengah | - | - |
| Sulawesi Selatan | - | - |
| Sulawesi Tenggara | - | - |
| Gorontalo | - | - |
| Sulawesi Barat | - | - |
| Maluku | - | - |
| Maluku Utara | - | - |
| Papua | - | - |

Lampiran 2 : Input simulasi PHITS untuk respon absolut detektor terhadap energi neutron (sumber monoenergetik, setiap energi diubah pada input 'e0')

[T i t l e]

minimized input file for lecture

[P a r a m e t e r s]

icntl = 0 # (D=0) 3:ECH 5:NOR 6:SRC 7,8:GSH 11:DSH
12:DUMP


```

maxcas = 10000000 # (D=10) number of particles per one
batch

maxbch = 10 # (D=10) number of batches

file(1) = c:/phits # (D=c:/phits) PHITS install folder name
file(6) = phits.out # (D=phits.out) general output file name

e-mode = 2 # (D=0) 0: Normal, 1: Event generator mode

itall = 1 # (D=0) 0:no tally at batch, 1:same,
2:different

negs = 1 # (D=0) =1 EGS photon and electron

[ S o u r c e ]
s-type = 1 # mono-energetic axial source
proj = neutron # kind of incident particle
dir = 1.0 # z-direction of beam [cosine]
r0 = 10 # radius [cm]
z0 = -20 # minimum position of z-axis [cm]
z1 = -20 # maximum position of z-axis [cm]
e0 = 7 # energy of beam [MeV/u]

[ M a t e r i a l ]
mat[1] C 3 H 4 O 2
mat[2] H 2
mat[3] C 2 H 4 10B 0.05
mat[4] Cd 1
mat[5] Pb 1
mat[6] 6Li 0.2 F 0.2
mat[7] 14N -0.77798 15N -2.89e-3 O -0.20949 Ar -9.64E-03
mat[8] Zn 1 S 1

[ S u r f a c e ]
1 rpp -3.81 3.81 -3.81 3.81 -3.81 3.81
2 rcc 0 -3.81 0 0 -1.59 0 2.5
3 rpp -3.81 3.81 -5.4 -3.81 -3.81 3.81
4 rcc 0 3.81 0 0 1.59 0 2.5

```

```

5 rpp -3.81 3.81 3.81 5.4 -3.81 3.81
6 rcc 3.81 0 0 1.59 0 0 2.5
7 rpp 3.81 5.4 -3.81 3.81 -3.81 3.81
8 rcc -3.81 0 0 -1.59 0 0 2.5
9 rpp -5.4 -3.81 -3.81 3.81 -3.81 3.81
10 rpp -5.4 5.4 -5.4 5.4 -5.4 -3.81
11 rpp -5.4 5.4 -5.4 5.4 3.81 5.4
12 rcc 0 0 -0.019 0 0 0.0762 0.955
13 rcc 0 0 0.0572 0 0 0.038 1.420
14 rcc 0 0 0.0952 0 0 0.640 1.270
15 rcc 0 0 0.7352 0 0 4.7 1.450
16 rcc 0 0 5.4352 0 0 8.25 1.450
17 rpp -5.4 5.4 -5.443 -5.4 -5.4 5.4
18 rpp -5.4 5.4 5.4 5.443 -5.4 5.4
19 rpp 5.4 5.443 -5.4 5.4 -5.4 5.4
20 rpp -5.443 -5.4 -5.4 5.4 -5.4 5.4
99 so 30

```

[C e l l]

```

1 1 -1.051 -1 #12 #13 #14 #15
2 2 -0.000089880 -2
3 3 -1.60 -3 #2
4 2 -0.000089880 -4
5 3 -1.60 -5 #4
6 2 -0.000089880 -6
7 3 -1.60 -7 #6
8 2 -0.000089880 -8
9 3 -1.60 -9 #8
10 3 -1.60 -10
11 3 -1.60 -11 #15
12 4 -8.65 -12
13 5 -11.34 -13
14 6 -2.64 -14

```

```

15  0      -15
16  7 0.012 -16
17   5 -11.34 -17
18   5 -11.34 -18
19   5 -11.34 -19
20   5 -11.34 -20
99   0 -99 #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14 #15 #16 #17
#18 #19 #20
999  -1 99

[ T - T r a c k ]
  mesh = xyz          # mesh type is xyz scoring mesh
  y-type = 2          # x-mesh is linear given by xmin, xmax and
nx
  ny = 200           # number of x-mesh points
  ymin = -20         # minimum value of x-mesh points
  ymax = 20          # maximum value of x-mesh points
  x-type = 1          # y-mesh is given by the below data
  nx = 1             # number of y-mesh points
  -0.5 0.5
  z-type = 2          # z-mesh is linear given by zmin, zmax and
nz
  nz = 200           # number of z-mesh points
  zmin = -20.        # minimum value of z-mesh points
  zmax = 20.         # maximum value of z-mesh points
  part = neutron proton alpha 7Li 3H photon
  e-type = 1          # e-mesh is given by the below data
  ne = 1             # number of e-mesh points
  0.0 1000.0
  unit = 1           # unit is [1/cm^2/source]
  axis = yz          # axis of output
  file = sm_yz.out   #file name of output for the above axis
  title = Track Detection using [T-track] tally
  gshow = 3          # 0: no 1:bnd, 2:bnd+mat, 3:bnd+reg 4:bnd+lat

```



```

epsout = 1 # (D=0) generate eps file by ANGEL
[ T-Deposit ]
title = Energy Deposition for each cell
mesh = reg # mesh type is region-wise
reg = 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
unit = 3 # unit is [1/source] : only for output=deposit
letmat = 0 # (D=0) material id for LET, 0: real
material
dedxfnc = 0 # (D=0) user defined multiplier, 0(no), 1,
2
material = all # (D=all) number of specific material
output = deposit # deposit energy distribution
e-type = 2 # e-mesh is linear given by emin, emax and
ne
emin = 0.000000 # minimum value of e-mesh points
emax = 10.00000 # maximum value of e-mesh points
ne = 50 # number of e-mesh points
axis = eng # axis of output
file = deposit.out # file name of output for the above axis
part = proton alpha 7Li 3H electron
y-txt = Response [cm^2]
epsout = 1 # (D=0) generate eps file by ANGEL
dresol = 0.2 # (D=0) width = sqrt(dresol**2 + dfano*E)
dfano = 0.05 # (D=0) width = sqrt(dresol**2 + dfano*E)

[ E n d ]

```

Lampiran 3 : Lembar data hasil output simulasi fungsi respon absolut terhadap energi neutron

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|----------|-------------|-------------|-------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻⁷ | 2 | 0 | 0,00000004 | 0,00000004 | 0 | 0,00000008 | 0,00000023 |
| | 4 | 0 | 0,00000004 | 0,00000002 | 0 | 0,00000006 | |
| | 6 | 0 | 0,00000005 | 0 | 0 | 0,00000005 | |
| | 8 | 0 | 0,00000003 | 0,00000001 | 0 | 0,00000004 | |
| | 3 | 0 | 0,00017902 | 0,00010021 | 0 | 0,00027923 | 0,342318689 |
| | 5 | 0 | 0,00017804 | 0,000099659 | 0 | 0,000277699 | |
| | 7 | 0 | 0,00018061 | 0,00010114 | 0 | 0,00028175 | |
| | 9 | 0 | 0,0001796 | 0,00010041 | 0 | 0,00028001 | |
| | 10 | 0 | 0,21885 | 0,12235 | 0 | 0,3412 | |
| | 11 | 0 | 0,000038307 | 0,000021405 | 0 | 0,000059712 | |
| | 14 | 0 | 2,3005E-06 | 0 | 0,000002853 | 5,1535E-06 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|-------------|-------------|------------|-------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻⁶ | 2 | 0,00000001 | 0,00000007 | 0,00000002 | 0 | 0,0000001 | 0,00000048 |
| | 4 | 0,00000001 | 0,00000006 | 0,00000005 | 0 | 0,00000012 | |
| | 6 | 0,00000003 | 0,00000006 | 0,00000004 | 0 | 0,00000013 | |
| | 8 | 0,00000001 | 0,00000007 | 0,00000005 | 0 | 0,00000013 | |
| | 3 | 4,7876E-06 | 0,00047753 | 0,00026699 | 0 | 0,000749308 | 0,337293098 |
| | 5 | 4,3916E-06 | 0,00047551 | 0,00026591 | 0 | 0,000745812 | |
| | 7 | 4,4651E-06 | 0,00047826 | 0,00026737 | 0 | 0,000750095 | |
| | 9 | 0,000004418 | 0,00047613 | 0,00026615 | 0 | 0,000746698 | |
| | 10 | 0,002701 | 0,21261 | 0,11884 | 0 | 0,334151 | |
| | 11 | 1,0591E-06 | 0,000095631 | 5,3446E-05 | 0,00000005 | 0,000150186 | |
| | 14 | 0 | 0,000022837 | 0 | 0,000028808 | 0,000051645 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|-------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻⁵ | 2 | 0,00000019 | 0,00000025 | 0,00000008 | 0 | 0,00000052 | 0,00000205 |
| | 4 | 0,00000019 | 0,00000024 | 0,00000009 | 0 | 0,00000052 | |
| | 6 | 0,00000026 | 0,00000022 | 0,00000007 | 0 | 0,00000055 | |
| | 8 | 0,00000013 | 0,00000026 | 0,00000007 | 0 | 0,00000046 | |
| | 3 | 0,00023563 | 0,0018286 | 0,0010221 | 0 | 0,00308633 | 0,345086676 |
| | 5 | 0,00023469 | 0,0018248 | 0,0010199 | 0 | 0,00307939 | |
| | 7 | 0,00023187 | 0,0018238 | 0,0010198 | 0 | 0,00307547 | |
| | 9 | 0,000233 | 0,0018269 | 0,001021 | 0 | 0,0030809 | |
| | 10 | 0,03413 | 0,19123 | 0,10689 | 0 | 0,33225 | |
| | 11 | 0,000035896 | 0,00030698 | 0,00017158 | 0,00000013 | 0,000514586 | |
| | 14 | 0 | 0,00013203 | 0,00000001 | 0,00016868 | 0,00030072 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|-------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻⁴ | 2 | 0,00000059 | 0,00000033 | 0,00000021 | 0 | 0,00000113 | 0,0000049 |
| | 4 | 0,00000059 | 0,00000035 | 0,00000023 | 0 | 0,00000117 | |
| | 6 | 0,00000076 | 0,00000053 | 0,00000014 | 0 | 0,00000143 | |
| | 8 | 0,00000065 | 0,00000039 | 0,00000013 | 0 | 0,00000117 | |
| | 3 | 0,00090108 | 0,0036191 | 0,002023 | 0 | 0,00654318 | 0,335176592 |
| | 5 | 0,00090242 | 0,0036259 | 0,0020269 | 0 | 0,00655522 | |
| | 7 | 0,0008981 | 0,0036208 | 0,0020238 | 0 | 0,0065427 | |
| | 9 | 0,00090691 | 0,0036211 | 0,0020246 | 0 | 0,00655261 | |
| | 10 | 0,058905 | 0,15973 | 0,089283 | 0 | 0,307918 | |
| | 11 | 0,000092892 | 0,00062316 | 0,00034839 | 0,00000044 | 0,001064882 | |
| | 14 | 0 | 0,00031667 | 0,00000002 | 0,00040747 | 0,00072416 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻³ | 2 | 0,0000159 | 0,0000062 | 0,0000003 | 0 | 0,00000251 | 0,00000984 |
| | 4 | 0,0000189 | 0,0000057 | 0,0000022 | 0 | 0,00000268 | |
| | 6 | 0,0000172 | 0,0000043 | 0,0000029 | 0 | 0,00000244 | |
| | 8 | 0,0000138 | 0,0000058 | 0,0000025 | 0 | 0,00000221 | |
| | 3 | 0,002 | 0,0050562 | 0,002826 | 0 | 0,0098822 | 0,32374202 |
| | 5 | 0,0019979 | 0,0050499 | 0,0028231 | 0 | 0,0098709 | |
| | 7 | 0,0019937 | 0,0050552 | 0,0028263 | 0 | 0,0098752 | |
| | 9 | 0,0020004 | 0,0050495 | 0,0028228 | 0 | 0,0098727 | |
| | 10 | 0,083413 | 0,12771 | 0,071385 | 0 | 0,282508 | |
| | 11 | 0,00018571 | 0,00099214 | 0,00055472 | 0,00000045 | 0,00173302 | |
| | 14 | 0 | 0,0005013 | 0,00000001 | 0,00064758 | 0,00114889 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 10 ⁻² | 2 | 0,00000314 | 0,00000073 | 2,7999E-07 | 0 | 4,14999E-06 | 1,67099E-05 |
| | 4 | 0,00000303 | 0,00000078 | 0,00000035 | 0 | 0,00000416 | |
| | 6 | 0,00000322 | 0,0000007 | 3,6993E-07 | 0 | 4,28993E-06 | |
| | 8 | 0,00000293 | 0,00000077 | 0,00000041 | 0 | 0,00000411 | |
| | 3 | 0,0035326 | 0,0060294 | 0,00337 | 0 | 0,012932 | 0,31657426 |
| | 5 | 0,00354 | 0,0060202 | 0,0033654 | 0 | 0,0129256 | |
| | 7 | 0,0035415 | 0,0060195 | 0,0033655 | 0 | 0,0129265 | |
| | 9 | 0,0035391 | 0,0060171 | 0,0033633 | 0 | 0,0129195 | |
| | 10 | 0,10675 | 0,099721 | 0,055744 | 0 | 0,262215 | |
| | 11 | 0,00036697 | 0,0014675 | 0,0008206 | 0,00000059 | 0,00265566 | |
| | 14 | 0 | 0,00065963 | 0,00000004 | 0,00085456 | 0,00151423 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 0,2 | 2 | 0,00000958 | 9,2999E-07 | 0,00000043 | 0 | 1,094E-05 | 4,36354E-05 |
| | 4 | 9,4354E-06 | 9,3998E-07 | 0,00000038 | 0 | 1,07554E-05 | |
| | 6 | 0,00000961 | 0,00000088 | 0,00000027 | 0 | 0,00001076 | |
| | 8 | 0,00000981 | 0,00000094 | 0,00000043 | 0 | 0,00001118 | |
| | 3 | 0,011211 | 0,0075738 | 0,0042341 | 0 | 0,0230189 | 0,365385917 |
| | 5 | 0,011186 | 0,0075834 | 0,0042394 | 0 | 0,0230088 | |
| | 7 | 0,011179 | 0,0075718 | 0,0042323 | 0 | 0,0229831 | |
| | 9 | 0,011196 | 0,0075587 | 0,0042259 | 0 | 0,0229806 | |
| | 10 | 0,17273 | 0,058429 | 0,032695 | 0 | 0,263854 | |
| | 11 | 0,0035846 | 0,0038194 | 0,0021356 | 9,1672E-07 | 0,009540517 | |
| | 14 | 0 | 0,00095354 | 0,00000004 | 0,0012412 | 0,00219478 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 0,5 | 2 | 0,00001401 | 0,00000089 | 0,00000053 | 0 | 0,00001543 | 6,40298E-05 |
| | 4 | 0,00001463 | 0,0000009 | 0,00000046 | 0 | 0,00001599 | |
| | 6 | 0,00001508 | 1,0498E-06 | 0,00000043 | 0 | 1,65598E-05 | |
| | 8 | 0,00001465 | 0,00000104 | 0,00000036 | 0 | 0,00001605 | |
| | 3 | 0,018646 | 0,0072456 | 0,0040518 | 0 | 0,0299434 | 0,392311342 |
| | 5 | 0,01864 | 0,0072521 | 0,0040557 | 0 | 0,0299478 | |
| | 7 | 0,01863 | 0,0072446 | 0,0040507 | 0 | 0,0299253 | |
| | 9 | 0,018634 | 0,007253 | 0,0040565 | 0 | 0,0299435 | |
| | 10 | 0,19192 | 0,039201 | 0,021966 | 0 | 0,253087 | |
| | 11 | 0,010626 | 0,0056673 | 0,0031703 | 7,4185E-07 | 0,019464342 | |
| | 14 | 0 | 0,0010015 | 3,0933E-08 | 0,0013042 | 0,002305731 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|------------|------------|------------|------------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 1 | 2 | 0,00001724 | 0,00000073 | 0,00000041 | 0 | 0,00001838 | 7,377E-05 |
| | 4 | 0,00001736 | 0,00000093 | 0,00000038 | 0 | 0,00001867 | |
| | 6 | 0,00001727 | 8,9998E-07 | 0,00000031 | 0 | 1,848E-05 | |
| | 8 | 0,00001727 | 0,00000068 | 0,00000029 | 0 | 0,00001824 | |
| | 3 | 0,02481 | 0,0060563 | 0,0033887 | 0 | 0,034255 | 0,393400996 |
| | 5 | 0,024786 | 0,0060535 | 0,0033862 | 0 | 0,0342257 | |
| | 7 | 0,02476 | 0,0060608 | 0,0033908 | 0 | 0,0342116 | |
| | 9 | 0,024811 | 0,006065 | 0,0033931 | 0 | 0,0342691 | |
| | 10 | 0,18745 | 0,025023 | 0,014039 | 0 | 0,226512 | |
| | 11 | 0,020125 | 0,0062849 | 0,0035168 | 8,9648E-07 | 0,029927596 | |
| | 14 | 0 | 0,00087842 | 4,9637E-08 | 0,0011451 | 0,00202357 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|----------|----------|----------|----------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 3 | 2 | 1.89E-05 | 3.80E-07 | 1.80E-07 | 0.00E+00 | 1.95E-05 | 7.80E-05 |
| | 4 | 1.95E-05 | 3.90E-07 | 1.10E-07 | 0.00E+00 | 2.00E-05 | |
| | 6 | 1.84E-05 | 3.60E-07 | 1.80E-07 | 0.00E+00 | 1.90E-05 | |
| | 8 | 1.88E-05 | 4.40E-07 | 2.80E-07 | 0.00E+00 | 1.95E-05 | |
| | 3 | 2.83E-02 | 3.24E-03 | 1.82E-03 | 0.00E+00 | 3.33E-02 | 3.43E-01 |
| | 5 | 2.82E-02 | 3.23E-03 | 1.81E-03 | 0.00E+00 | 3.33E-02 | |
| | 7 | 2.83E-02 | 3.24E-03 | 1.81E-03 | 0.00E+00 | 3.33E-02 | |
| | 9 | 2.83E-02 | 3.23E-03 | 1.81E-03 | 0.00E+00 | 3.33E-02 | |
| | 10 | 1.40E-01 | 8.31E-03 | 4.68E-03 | 0.00E+00 | 1.53E-01 | |
| | 11 | 4.67E-02 | 5.17E-03 | 2.90E-03 | 5.93E-07 | 5.48E-02 | |
| | 14 | 3.38E-07 | 5.38E-04 | 2.00E-08 | 7.00E-04 | 1.24E-03 | |

| Energi Neutron (MeV) | Detektor | Partikel | | | | Total Partikel | Total Partikel per detektor |
|----------------------|----------|----------|----------|----------|----------|----------------|-----------------------------|
| | | Proton | Alpha | 7Li | Triton | | |
| 7 | 2 | 3.08E-05 | 2.40E-07 | 1.30E-07 | 0.00E+00 | 3.12E-05 | 1.25E-04 |
| | 4 | 3.06E-05 | 2.30E-07 | 8.00E-08 | 0.00E+00 | 3.09E-05 | |
| | 6 | 3.10E-05 | 2.30E-07 | 8.00E-08 | 0.00E+00 | 3.13E-05 | |
| | 8 | 3.15E-05 | 2.60E-07 | 1.10E-07 | 0.00E+00 | 3.18E-05 | |
| | 3 | 2.34E-02 | 1.50E-03 | 8.38E-04 | 0.00E+00 | 2.57E-02 | 2.51E-01 |
| | 5 | 2.33E-02 | 1.50E-03 | 8.40E-04 | 0.00E+00 | 2.57E-02 | |
| | 7 | 2.34E-02 | 1.50E-03 | 8.41E-04 | 0.00E+00 | 2.57E-02 | |
| | 9 | 2.34E-02 | 1.50E-03 | 8.40E-04 | 0.00E+00 | 2.57E-02 | |
| | 10 | 9.03E-02 | 2.82E-03 | 1.57E-03 | 0.00E+00 | 9.47E-02 | |
| | 11 | 4.98E-02 | 2.68E-03 | 1.50E-03 | 2.29E-07 | 5.39E-02 | |
| | 14 | 1.77E-05 | 3.37E-04 | 0.00E+00 | 3.39E-04 | 6.93E-04 | |

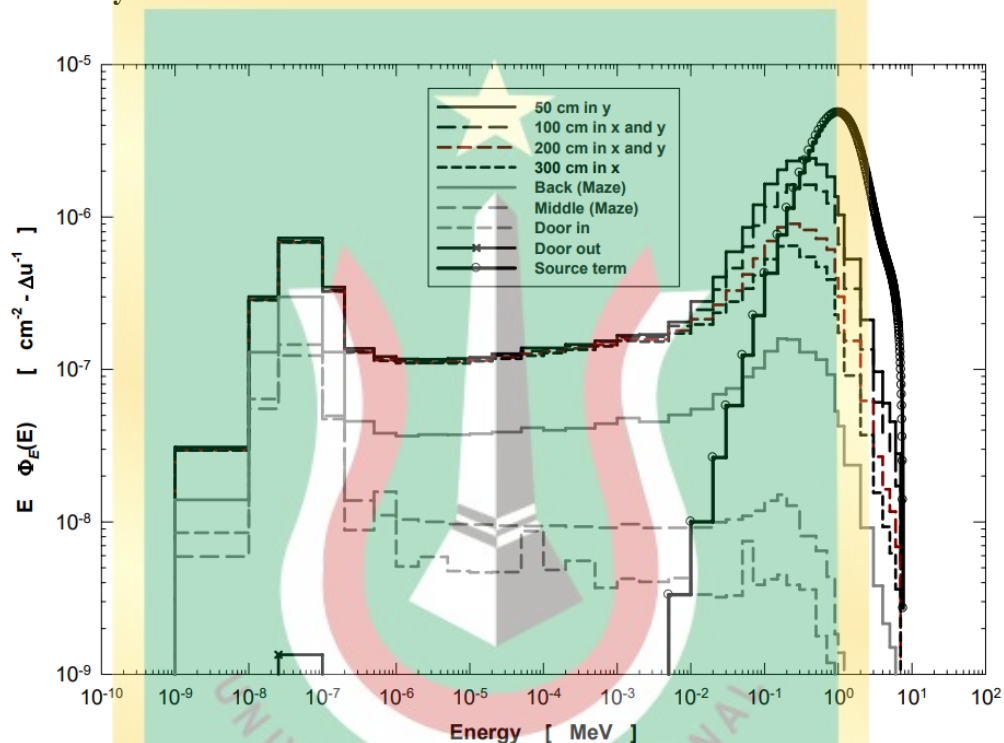
Lampiran 4 : Hasil perhitungan untuk respon absolut terhadap energi termal sampai 1 Mev yaitu penjumlahan total respon detektor BPE dan ⁶Li

| Energi Neutron (MeV) | Respon Detektor (cm ²) | | Total |
|----------------------|------------------------------------|-----------------|----------|
| | BPE | ⁶ Li | |
| 0,0000001 | 0,342318689 | 5,1535E-06 | 0,342324 |
| 0,000001 | 0,337293098 | 0,000051645 | 0,337345 |
| 0,00001 | 0,345086676 | 0,00030072 | 0,345387 |
| 0,0001 | 0,335176592 | 0,00072416 | 0,335901 |
| 0,001 | 0,32374202 | 0,00114889 | 0,324891 |
| 0,01 | 0,31657426 | 0,00151423 | 0,318088 |
| 0,1 | 0,341810509 | 0,002007 | 0,343818 |
| 0.2 | 0.365385917 | 0,00219748 | 0,367581 |
| 0,5 | 0.392311342 | 0,002305731 | 0,394617 |
| 1 | 0,393400996 | 0,00202357 | 0,395425 |

Lampiran 5 : Hasil perhitungan untuk respon absolut terhadap energi cepat (> 1 MeV) yaitu penjumlahan total respon detektor BPE dan H₂

| Energi Neutron (MeV) | Respon Detektor (cm ²) | | Total |
|-------------------------|------------------------------------|----------------|-------|
| | BPE | H ₂ | |
| 3 | 0,343 | 0,78 | 1,123 |
| 7 | 0,251 | 1,25 | 1,501 |

Lampiran 6 : Data sekunder Spektrum Neutron di Bunker Linac 15 MV Pusat Kanker Nayarit



- Sesudah pintu linac

| Energi (MeV) | $\Phi_E(E)$ (cm ⁻² .s ⁻¹) |
|--------------------|--|
| 2x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 3x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 4x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 5x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 6x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 7x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 8x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 9x10 ⁻⁸ | 1.5x10 ⁻⁹ |
| 1x10 ⁻⁷ | 1.5x10 ⁻⁹ |

- Sebelum pintu linac

| Energi (MeV) | $\Phi_E(E)$ (cm ⁻² .s ⁻¹) |
|--------------------|--|
| 1x10 ⁻⁹ | 8x10 ⁻⁹ |

| | |
|--------------------|----------------------|
| 2×10^{-9} | 8×10^{-9} |
| 3×10^{-9} | 8×10^{-9} |
| 4×10^{-9} | 8×10^{-9} |
| 5×10^{-9} | 8×10^{-9} |
| 6×10^{-9} | 8×10^{-9} |
| 7×10^{-9} | 8×10^{-9} |
| 8×10^{-9} | 8×10^{-9} |
| 9×10^{-9} | 8×10^{-9} |
| 1×10^{-8} | 6×10^{-8} |
| 2×10^{-8} | 6×10^{-8} |
| 3×10^{-8} | 1.5×10^{-7} |
| 4×10^{-8} | 1.5×10^{-7} |
| 5×10^{-8} | 1.5×10^{-7} |
| 6×10^{-8} | 1.5×10^{-7} |
| 7×10^{-8} | 1.5×10^{-7} |
| 8×10^{-8} | 1.5×10^{-7} |
| 9×10^{-8} | 1.5×10^{-7} |
| 1×10^{-7} | 5×10^{-8} |
| 2×10^{-7} | 5×10^{-8} |
| 3×10^{-7} | 8×10^{-9} |
| 4×10^{-7} | 8×10^{-9} |
| 5×10^{-7} | 8×10^{-9} |
| 6×10^{-7} | 1.5×10^{-8} |
| 7×10^{-7} | 1.5×10^{-8} |
| 8×10^{-7} | 1.5×10^{-8} |
| 9×10^{-7} | 1.5×10^{-8} |
| 1×10^{-6} | 1.5×10^{-8} |
| 2×10^{-6} | 6×10^{-9} |
| 3×10^{-6} | 6×10^{-9} |
| 4×10^{-6} | 6×10^{-9} |
| 5×10^{-6} | 6×10^{-9} |
| 6×10^{-6} | 4.5×10^{-9} |
| 7×10^{-6} | 4.5×10^{-9} |
| 8×10^{-6} | 4.5×10^{-9} |
| 9×10^{-6} | 4.5×10^{-9} |
| 1×10^{-5} | 4.5×10^{-9} |
| 2×10^{-5} | 4.5×10^{-9} |
| 3×10^{-5} | 4.5×10^{-9} |
| 4×10^{-5} | 4.5×10^{-9} |
| 5×10^{-5} | 4.5×10^{-9} |
| 6×10^{-5} | 8×10^{-9} |
| 7×10^{-5} | 8×10^{-9} |
| 8×10^{-5} | 8×10^{-9} |
| 9×10^{-5} | 8×10^{-9} |
| 1×10^{-4} | 8×10^{-9} |
| 2×10^{-4} | 5.5×10^{-9} |
| 3×10^{-4} | 5.5×10^{-9} |
| 4×10^{-4} | 5.5×10^{-9} |

| | |
|--------------------|----------------------|
| 5×10^{-4} | 5.5×10^{-9} |
| 6×10^{-4} | 3.5×10^{-9} |
| 7×10^{-4} | 3.5×10^{-9} |
| 8×10^{-4} | 3.5×10^{-9} |
| 9×10^{-4} | 3.5×10^{-9} |
| 1×10^{-3} | 3.5×10^{-9} |
| 2×10^{-3} | 4×10^{-9} |
| 3×10^{-3} | 4×10^{-9} |
| 4×10^{-3} | 4×10^{-9} |
| 5×10^{-3} | 4×10^{-9} |
| 6×10^{-3} | 4×10^{-9} |
| 7×10^{-3} | 4×10^{-9} |
| 8×10^{-3} | 4×10^{-9} |
| 9×10^{-3} | 4×10^{-9} |
| 1×10^{-2} | 4×10^{-9} |
| 2×10^{-2} | 3×10^{-9} |
| 3×10^{-2} | 3×10^{-9} |
| 4×10^{-2} | 3×10^{-9} |
| 5×10^{-2} | 3×10^{-9} |
| 6×10^{-2} | 7×10^{-9} |
| 7×10^{-2} | 7×10^{-9} |
| 8×10^{-2} | 3.5×10^{-9} |
| 9×10^{-2} | 3.5×10^{-9} |
| 1×10^{-1} | 3.5×10^{-9} |
| 2×10^{-1} | 4×10^{-9} |
| 3×10^{-1} | 3.5×10^{-9} |
| 4×10^{-1} | 3×10^{-9} |
| 5×10^{-1} | 3×10^{-9} |
| 6×10^{-1} | 3×10^{-9} |
| 7×10^{-1} | 1.1×10^{-9} |
| 8×10^{-1} | 1.1×10^{-9} |
| 9×10^{-1} | 1.1×10^{-9} |

Lampiran 7 : Input simulasi PHITS untuk laju dosis neutron pada posisi di belakang pintu linac 15 MV

[T i t l e]

minimized input file for lecture

[P a r a m e t e r s]

icntl = 0 # (D=0) 3:ECH 5:NOR 6:SRC 7,8:GSH 11:DSH
12:DUMP

maxcas = 10000000 # (D=10) number of particles per one batch

maxbch = 10 # (D=10) number of batches

```

file(1) = c:/phits          # (D=c:/phits) PHITS install folder name
file(6) = phits.out        # (D=phits.out) general output file name
e-mode  =                   2    # (D=0) 0: Normal, 1: Event generator mode
itall   =                   1    # (D=0) 0:no tally at batch, 1:same,
2:different
negs    =                   1    # (D=0) =1 EGS photon and electron

```

[S o u r c e]

```

s-type = 1                  # mono-energetic axial source
proj   = neutron           # kind of incident particle
dir    = 1.0               # z-direction of beam [cosine]
r0     = 10                # radius [cm]
z0     = -20               # minimum position of z-axis [cm]
z1     = -20               # maximum position of z-axis [cm]
e-type = 1                 # energy of beam [MeV/u]
ne     = 81
0      0
1E-9  8E-9
2E-9  8E-9
3E-9  8E-9
4E-9  8E-9
5E-9  8E-9
6E-9  8E-9
7E-9  8E-9
8E-9  8E-9
9E-9  8E-9
1E-8  6E-8
2E-8  6E-8
3E-8  1.5E-7
4E-8  1.5E-7
5E-8  1.5E-7
6E-8  1.5E-7
7E-8  1.5E-7
8E-8  1.5E-7

```

9E-8 1.5E-7
 1E-7 5E-8
 2E-7 5E-8
 3E-7 8E-9
 4E-7 8E-9
 5E-7 8E-9
 6E-7 1.5E-8
 7E-7 1.5E-8
 8E-7 1.5E-8
 9E-7 1.5E-8
 1E-6 1.5E-8
 2E-6 6E-9
 3E-6 6E-9
 4E-6 6E-9
 5E-6 6E-9
 6E-6 4.5E-9
 7E-6 4.5E-9
 8E-6 4.5E-9
 9E-6 4.5E-9
 1E-5 4.5E-9
 2E-5 4.5E-9
 3E-5 4.5E-9
 4E-5 4.5E-9
 5E-5 4.5E-9
 6E-5 8E-9
 7E-5 8E-9
 8E-5 8E-9
 9E-5 8E-9
 1E-4 8E-9
 2E-4 5.5E-9
 3E-4 5.5E-9
 4E-4 5.5E-9
 5E-4 5.5E-9



6E-4 3.5E-9
7E-4 3.5E-9
8E-4 3.5E-9
9E-4 3.5E-9
1E-3 3.5E-9
2E-3 4E-9
3E-3 4E-9
4E-3 4E-9
5E-3 4E-9
6E-3 4E-9
7E-3 4E-9
8E-3 4E-9
9E-3 4E-9
1E-2 4E-9
2E-2 3E-9
3E-2 3E-9
4E-2 3E-9
5E-2 3E-9
6E-2 7E-9
7E-2 7E-9
8E-2 3.5E-9
9E-2 3.5E-9
1E-1 3.5E-9
2E-1 4E-9
3E-1 3.5E-9
4E-1 3E-9
5E-1 3E-9
6E-1 3E-9
7E-1 1.1E-9
8E-1 1.1E-9
9E-1 1.1E-9



[M a t e r i a l]

mat[1] C 3 H 4 O 2

mat[2] H 2

mat[3] C 2 H 4 10B 0.05

mat[4] Cd 1

mat[5] Pb 1

mat[6] 6Li 0.2 F 0.2

mat[7] 14N -0.77798 15N -2.89e-3 O -0.20949 Ar -9.64E-03

mat[8] Zn 1 S 1

[S u r f a c e]

1 rpp -3.81 3.81 -3.81 3.81 -3.81 3.81

2 rcc 0 -3.81 0 0 -1.59 0 2.5

3 rpp -3.81 3.81 -5.4 -3.81 -3.81 3.81

4 rcc 0 3.81 0 0 1.59 0 2.5

5 rpp -3.81 3.81 3.81 5.4 -3.81 3.81

6 rcc 3.81 0 0 1.59 0 0 2.5

7 rpp 3.81 5.4 -3.81 3.81 -3.81 3.81

8 rcc -3.81 0 0 -1.59 0 0 2.5

9 rpp -5.4 -3.81 -3.81 3.81 -3.81 3.81

10 rpp -5.4 5.4 -5.4 5.4 -5.4 -3.81

11 rpp -5.4 5.4 -5.4 5.4 3.81 5.4

12 rcc 0 0 -0.019 0 0 0.0762 0.955

13 rcc 0 0 0.0572 0 0 0.038 1.420

14 rcc 0 0 0.0952 0 0 0.640 1.270

15 rcc 0 0 0.7352 0 0 4.7 1.450

16 rcc 0 0 5.4352 0 0 8.25 1.450

17 rpp -5.4 5.4 -5.443 -5.4 -5.4 5.4

18 rpp -5.4 5.4 5.4 5.443 -5.4 5.4

19 rpp 5.4 5.443 -5.4 5.4 -5.4 5.4

20 rpp -5.443 -5.4 -5.4 5.4 -5.4 5.4


99 so 30

[C e l l]

```

1      1 -1.051  -1 #12 #13 #14 #15
2      2 -0.000089880  -2
3      3 -1.60  -3 #2
4      2 -0.000089880  -4
5      3 -1.60  -5 #4
6      2 -0.000089880  -6
7      3 -1.60  -7 #6
8      2 -0.000089880  -8
9      3 -1.60  -9 #8
10     3 -1.60 -10
11     3 -1.60 -11 #15
12     4 -8.65 -12
13     5 -11.34 -13
14     6 -2.64 -14
15     0      -15
16     7 0.012 -16
17     5 -11.34 -17
18     5 -11.34 -18
19     5 -11.34 -19
20     5 -11.34 -20
99     0 -99 #1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13 #14 #15 #16 #17
#18 #19 #20
999   -1 99

```



[T - T r a c k]

```

mesh = reg
      reg = 2 3 4 5 6 7 8 9 10 11 14
part = neutron proton alpha 7Li 3H photon
e-type = 3          # e-mesh is log given by emin, emax and ne
emin = 1E-10      # minimum value of e-mesh points
emax = 20.00      # maximum value of e-mesh points
ne = 50           # number of e-mesh points

```



```

unit = 1          # unit is [1/cm^2/source]
y-txt= Dose Rate [uSv/h]
axis = eng
file = track_reg.out      #file name of output for the above axis
title = Track Detection using [T-track] tally
gshow = 3             # 0: no 1:bnd, 2:bnd+mat, 3:bnd+reg 4:bnd+lat
epsout = 1           # (D=0) generate eps file by ANGEL
Multiplier = all
Part = neutron
emax = 20
mat = mset1
all (3.6E+0 -200)

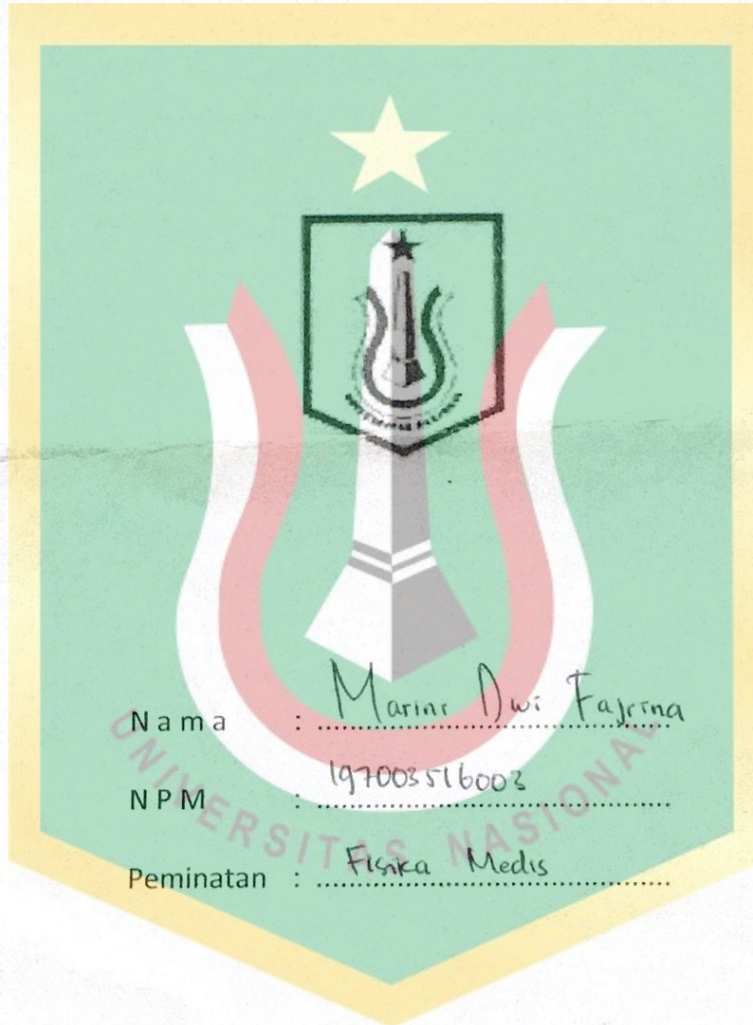
[ T-Deposit ]
title = Energy Deposition for each cell
mesh = reg           # mesh type is region-wise
reg = 3 5 7 9 10 11 14
unit = 0             # Dose [Gy/source]; only for output=dose.
letmat = 0           # (D=0) material id for LET, 0: real
material
dedxfnc = 0         # (D=0) user defined multiplier, 0(no), 1,
2
material = all       # (D=all) number of specific material
output = dose        # deposit energy distribution
axis = reg           # axis of output
file = deposit.out   # file name of output for the above axis
part = proton alpha 7Li 3H electron
y-txt = Dose rate [uSv/h]
epsout = 1           # (D=0) generate eps file by ANGEL
dresol = 0.2         # (D=0) width = sqrt(dresol**2 + dfano*E)
dfano = 0.05         # (D=0) width = sqrt(dresol**2 + dfano*E)

[ Multiplier ]
number= -200

```

Marini

KARTU BIMBINGAN SKRIPSI



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NPM : 197003516003

Peminatan : Fisika Medis

PROGRAM STUDI FISIKA
FAKULTAS TEKNIK DAN SAINS
UNIVERSITAS NASIONAL
JAKARTA

Nama Pembimbing 1 : Drs. Puji Hartoyo, M.Si.



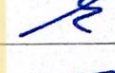
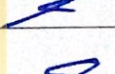
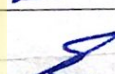

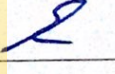
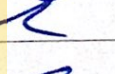
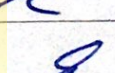
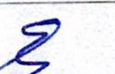
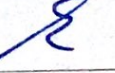

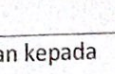
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| Biimbingan ke- | Hari/Tanggal | Materi Bimbingan | Cek Plagiat (%) | Paraf Pembimbing |
|----------------|--------------|-------------------------|-----------------|------------------|
| 1 | 05/04/2023 | konsul ISO 12789 - 2 | | # |
| 2 | 10/04/2023 | konsul Skripsi ke-2 | | # |
| 3 | 01/07/2023 | konsul Online | | # |
| 4 | 07/07/2023 | konsul Online | | # |
| 5 | 10/07/2023 | konsul Offline | | # |
| 6 | 29/07/2023 | konsul online | | # |
| 7 | 20/09/2023 | konsul Bab 1-5 (online) | | # |
| 8 | 28/09/2023 | konsul Bab 1-5 (online) | | # |
| 9 | 29/09/2023 | konsul online | | # |
| 10 | 02/10/2023 | ACC Skripsi | | # |
| 11 | 06/12/2023 | Turnit Skripsi | 23% | # |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |

- CATATAN :**
1. Pada saat bimbingan skripsi kartu bimbingan skripsi ini wajib diserahkan kepada Pembimbing 1 untuk diparaf.
 2. Mahasiswa diperbolehkan mendaftar sidang skripsi bila jumlah bimbingan dengan Pembimbing 1 minimal 10 kali.

Nama Pembimbing 2 : Drs. Bunawas, APV

Instansi : Nuklindo Lab

| Biimbingan ke- | Hari/Tanggal | Materi Bimbingan | Cek Plagiat (%) | Paraf Pembimbing |
|----------------|--------------|---|-----------------|---|
| 1 | 24/03 2023 | Mengenai neutron termal, linac, surveymeter | |  |
| 2 | 14/04 2023 | Proposal BAB 1-3 | |  |
| 3 | 05/05 2023 | Konsul Online | |  |
| 4 | 28/06 2023 | Konsul online | |  |
| 5 | 10/07 2023 | Progress 1 | |  |
| 6 | 19/07 2023 | Progress 2 | |  |
| 7 | 20/07 2023 | Konsul online | |  |
| 8 | 08/08 2023 | Progres 3 | |  |
| 9 | 16/08 2023 | Progres 4 | |  |
| 10 | 06/09 2023 | Konsul online | |  |
| 11 | 15/09 2023 | Progres 5 | |  |
| 12 | 02/10 2023 | Progres 6 & ACC Skripsi | 23% |  |
| 13 | 06/01 2024 | Konsul PPT sidang | |  |
| 14 | | | | |
| 15 | | | | |

- CATATAN :**
1. Pada saat bimbingan skripsi kartu bimbingan skripsi ini wajib diserahkan kepada Pembimbing 2 untuk diparaf.
 2. Mahasiswa diperbolehkan mendaftar sidang skripsi bila jumlah bimbingan dengan Pembimbing 2 minimal 10 kali.

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