# **NPS Simulation Status**

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NPS Collaboration Meeting 2019

### • NPS Geant4 simulation validity check

- Background comparison with Pavel's
- Magnetic field comparison with Bogdan's
- Dose rate comparison with Hamlet's in PR12-13-010

#### NPS energy resolution simulation

- Decision of the design of the calorimeter
- NPS offline software reconstruction and acceptance calculation
  - Work in progress

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### **Background Distribution Comparison**



- Simplest & most essential validity check
  -Compare with Pavel Degtiarenko's
  background rates calculations
  - Geometry  $-\phi 5 \times 15 cm^2$  liquid hydrogen target  $-125\mu$ m Al cover  $-4\pi$  acceptance (pseudo) detector

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## Background Distribution Comparison

Energy distribution

Upper part : Pavel's





 $e + H \rightarrow e^{-} + X$  at  $E_{a} = 11 \text{ GeV}$ , liq.H<sub>2</sub> in 125µm Al,  $\varnothing$ 5×15 cm

#### Pavel's simulation :

Energy cut at 10keV

- Particles with very low energy are not very welly simulated
- However, they should be absorbed by any thickness of material

Lower part : Geant4

(d) Geant4 gamma

#### (e) Geant4 positron

#### (f) Geant4 electron

#### **Background Distribution Comparison** Angular distribution $e + H \rightarrow e^{-} + X$ at $E_{e} = 11$ GeV, liq.H<sub>2</sub> in 125µm Al, Ø5×15 cm $e + H \rightarrow \gamma + X$ at $E_a = 11$ GeV, liq.H<sub>2</sub> in 125µm Al, Ø5×15 cm $e + H \rightarrow e^+ + X$ at $E_e = 11$ GeV, liq.H<sub>2</sub> in 125µm Al, Ø5×15 cm (1) T > 0.01 Me (1) -T > - 0.01 MeV -(1) -T-> - 0:10-MeV -(2) T > 0.10 MeV -(2) T > 0.32 MeV -(2) T > 0.10 MeV Right scale: Detector Load (events/sec) Scattered particle Right scale: Detector Load (events/sec) Right scale: Detector Load (events/sec) -(3) T > 0.32 MeV -(3) T > 1.00 MeV -(3) T > 0.32 Me Assuming beam current 10 µA Assuming beam current 10 µA -(4) T > 3.16 MeV Assuming beam cuirent 10 uA -(4) T > 1.00 MeV -(4) T > 1.00 MeV ָר<u>ק</u> S 10 -(5) T > 3.16 Me and detector solid angle 0.1 sr and detector solid angle 0.1 sr (5) T > 3.16 MeV and detector solid angle 0.1 sr (7) T > 31.62 MeV (7) T > 31.62 MeV (7) T > 100.00 MeV (8) T > 100.00 MeV -(8) T > 100.00 MeV -(8) T > 316.23 MeV ele -(9) T > 1000.00 MeV (9) T > 316.23 MeV -(9) T > 316.23 MeV ----(10)T > 1000.00 MeV -(10)T > 3162.28 MeV (10)T > 1000.00 MeV ဌ <sup>10</sup> Target Beam direction Sb Žp 10 Ъ ⊤ 10 2ຶ<sub>10</sub> T 10 z° <sub>10</sub> 10 10 10 10 Upper part : Pavel's 10 10 40 100 120 140 160 120 160 20 60 0 20 100 120 140 160 180 0 20 40 100 140 180 40 Θ (degrees) Θ (degrees) Θ (degrees) (a) RadCon gamma (b) RadCon positron (c) RadCon electron Lower part : Geant4 e + H -> pos + X at E = 11GeV, 15cm target, field off e + H -> gamma + X at E = 11GeV, 15cm target, field off e + H -> elec + X at E = 11GeV, 15cm target, field off — T > 0.01 MeV - T>0.10 MeV T > 0.01 Me 10 $10^{3}$ T > 0.10 MeV T > 0.10 MeV - T > 0.32 MeV T > 0.32 MeV T > 0.32 MeV 10<sup>2</sup> 10<sup>2</sup> T > 1.00 MeV 10<sup>2</sup> T > 1.00 MeV T > 1.00 MeV - T > 3.16 MeV T > 3.16 MeV T > 3.16 MeV 10 10 T > 10.00 MeV 10 T > 10.00 MeV T > 10.00 MeV T > 31.62 MeV T > 31.62 MeV T > 31.62 MeV – T > 100.00 MeV - T > 100.00 MeV T > 100.00 MeV T > 316.23 MeV T > 316.23 MeV T > 316.23 MeV 10-10-T > 1000.00 MeV T > 1000.00 MeV T > 1000.00 MeV T > 3162.28 MeV 10--T > 3162.28 MeV 10-2 T > 3162.28 MeV $10^{-3}$ 10-10-10-Geant4's background generation is 10<sup>-5</sup> 10- $10^{-6}$ 10 reliable 10-10 10 10 0 20 40 60 80 100 120 140 160 180 100 120 140 160 0 20 40 60 140 160 180 20 60 80 120 theta (degrees) theta (degrees) theta (degrees) 01/02/2019 NPS Collaboration Meeting 2019 6

(f) Geant4 electron

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10

<u>e</u> 10

Gb

Zp 10

10

 $10^{3}$ 

10-

10-

10-

10-

10-

10

10-

10<sup>-8</sup>

10-1

(d) Geant4 gamma

(e) Geant4 positron

### Sweeping Magnet's Magnetic Field Comparison

<<pre><<picture : stp. file. Mike Fowler>>



#### 1cm grid magnetic field table was used for the simulation







### **NPS Dose Rate Comparison**





1µA beam in 15cm Liquid hydrogen target (approximate luminosity :  $\sim 2 \times 10^{36} cm^{-2} s^{-1}$ ) NPS placed 4m away from the target

#### Sweeping magnet :

 Reduces the dose rate about an order magnitude

#### 

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### NPS Dose Rate Comparison

Dose rate on NPS with field on off





#### Sweeping magnet :

- Reduces the dose rate about an order or more of magnitude
- Structure exists in dose rate (Field ON)
  - Speculations
    - Physical volumes in simulation
    - Relative positions of crystals to the magnet's
    - Realistic magnetic field

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## NPS Energy Resolution Simulation Result



### NPS Energy Resolution Simulation Result



#### Based on the simulation result : No material in the middle part of the crystal

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 $\rightarrow$  Example of simulation usage

- NPS offline software reconstruction and acceptance calculation
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### (Near) Future Plan

#### • Offline software reconstruction and NPS acceptance calculation

- Simulation package is functional
- Offline reconstruction software is not yet very advanced
  - Copy Hall A DVCS experiment software & adapt it to Hall C
    - Should be done quickly

### Summary

### • NPS Geant4 simulation validity check

- Background comparison with Pavel's
- Magnetic field comparison with Bogdan's
- Dose rate comparison with Hamlet's in PR12-13-010
  - Geant4 setup is ready
- NPS energy resolution simulation
  - Decision of the design of the calorimeter
    - Detector structure : 1mm carbon material only in the front and the back side of the crystals
- NPS offline software reconstruction and acceptance calculation
  - Work in progress
    - Sould be done quickly



### Dose rate calculation with only target & NPS



### Dose rate of each crystals

#### dose rate on each crystals, field off



dose rate on each crystals, field on



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Figure A.3: Energy deposition. Number of photons collected at the PMT. Gap : 1mm

### Energy resolution with Carbon gap



Figure B.3: Energy deposition. Number of photons collected at the PMT. Gap : 1mm