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数値解析を用いた微小デブリ衝突の貫通限界曲線の取得状況

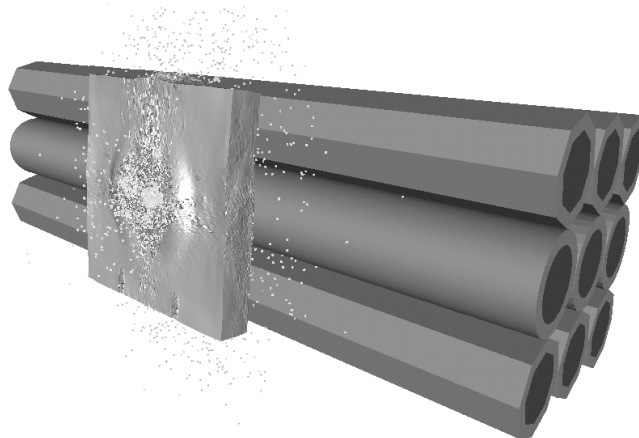
Current Status of the Estimation of the Ballistic Limit Curves by Performing Numerical Analyses of the Small-Size Space Debris Impacts

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1991年、NASA/MSFCのK.B.Hayashidaらは、1960年代にアポロ計画を中心にして検討されたメテオロイド防護技術としての2重板シールドシステム、いわゆる、Whippleバンパーシールドの貫通限界式、及びその後スペースデブリの脅威を踏まえて見直された式について概観した報告書を出している。そこで検討された式は、膨大な数の2段式軽ガス銃を中心とした試験結果に基づいたものであるが、1947年にF. L. Whippleが提案したアイデアを物理的に精査しメカニズムを明らかにすることによって、その防護システムの有効性を確認したものである。筆者らは、JAXA宇宙機設計標準推進委員会デブリ防護設計WGの活動の一環として、「スペースデブリ防護設計マニュアル」の作成を行っているが、その過程で、衛星設計に資するため、実験によるのではなく、数値解析によって貫通限界式の検討を行っている。また、バンパーの他に、電力ケーブルやハニカムパネルに対する検討も実施している。

In 1991, K. B. Hayashida et al. at MSFC/NASA published a report reviewing the ballistic limit equations (BLE's) for the "Double-Plate", so-called Whipple bumper shield, which was investigated as a protection technology for the space vehicle from interplanetary meteoroid impacts mainly for the purpose of the Apollo program in 1960's. The report also reviews the modified equations applicable for the space debris impact, after the space debris problem emerged in 1970's. The BLE's referred to in the report were derived on the basis of vast amounts of hypervelocity impact tests using launchers like two-stage light gas gun, it was confirmed and proven that the Whipple bumper shield is indeed effective for the meteoroid protection by investigating and clarifying the mechanism of it, of which idea was proposed by F. L. Whipple in 1947. The authors have been writing the "Design Manual on Space Debris Protection" as an activity of the Working Group of the Space Debris Protection Design at JAXA, and they tried to derive the ballistic limit curves (equations) of small projectile impacts on the "Double-Sheet" targets, power cables and honeycomb panels only by the numerical analysis, not by the experiment.





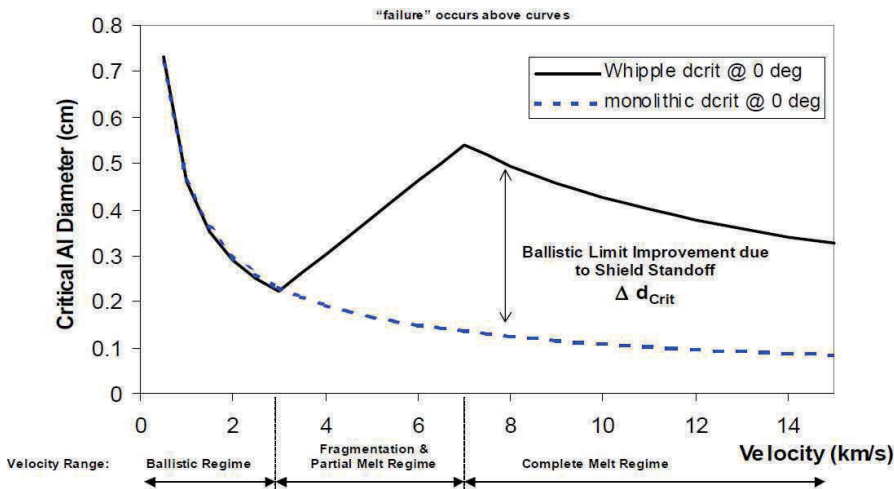
数値解析を用いた微小デブリ衝突の貫通限界曲線の取得状況 Current Status of the Estimation of the Ballistic Limit Curves by Performing Numerical Analyses of the Small-Size Space Debris Impacts

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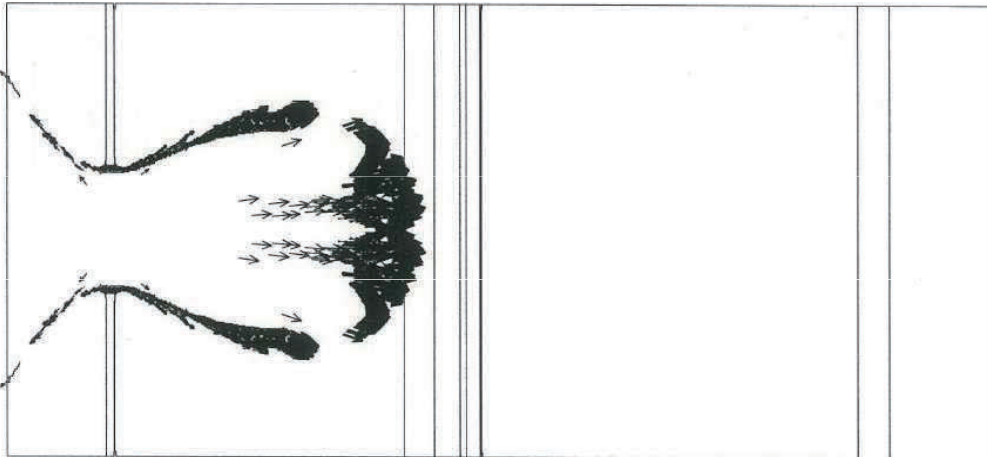
- Ballistic limits for equal mass monolithic target and Whipple shield



Ballistic limits for equal mass monolithic target and Whipple shield

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- Ballistic limit curve for the small-size space debris was estimated by the numerical analysis. A hydrocode: ANSYS AUTODYN was applied to the analysis.



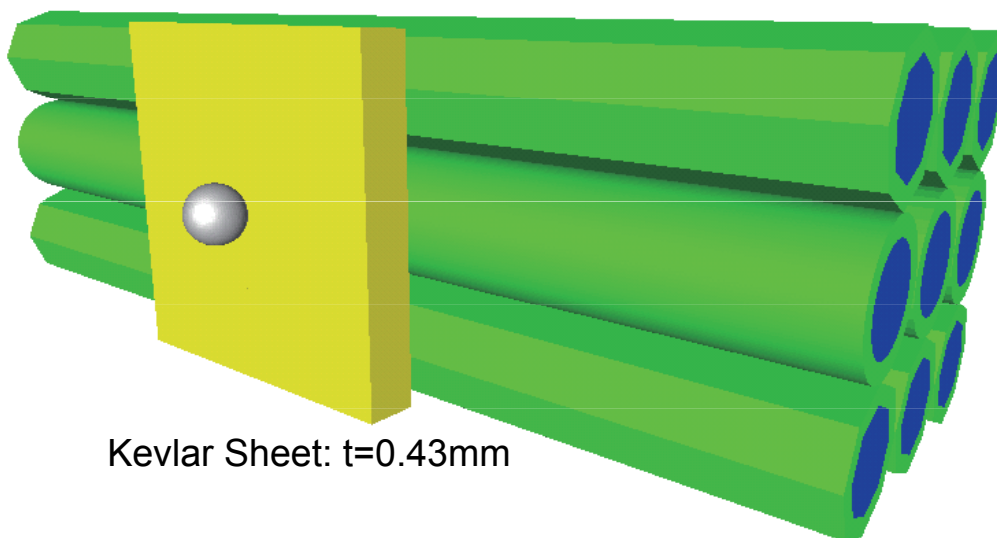
D: 9.5mm V:10km/s

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Power Cables with Kevlar Sheet

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Projectile: D=0.5mm

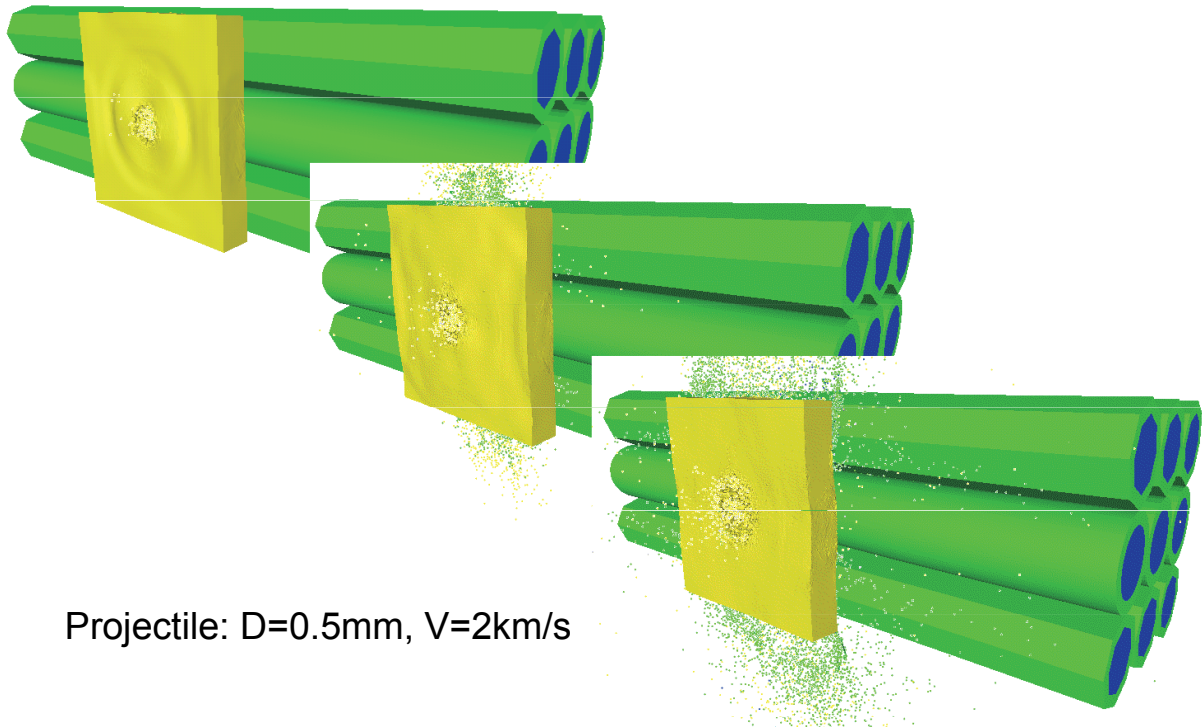


Kevlar Sheet: t=0.43mm

Power Cable

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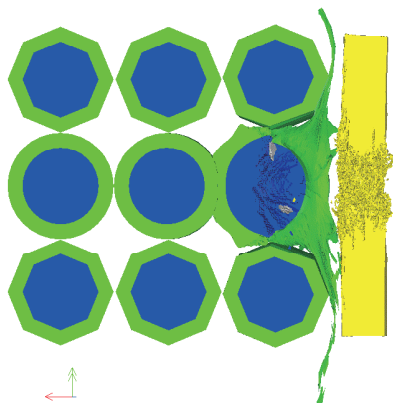
Power Cables with Kevlar Sheet CTC



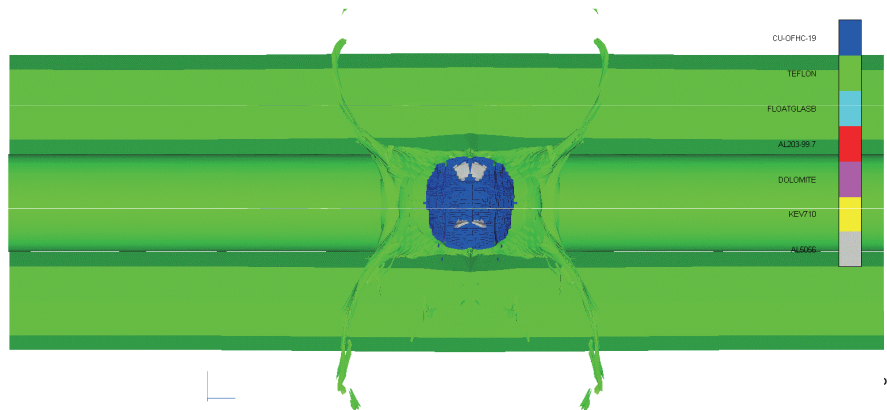
Projectile: D=0.5mm, V=2km/s

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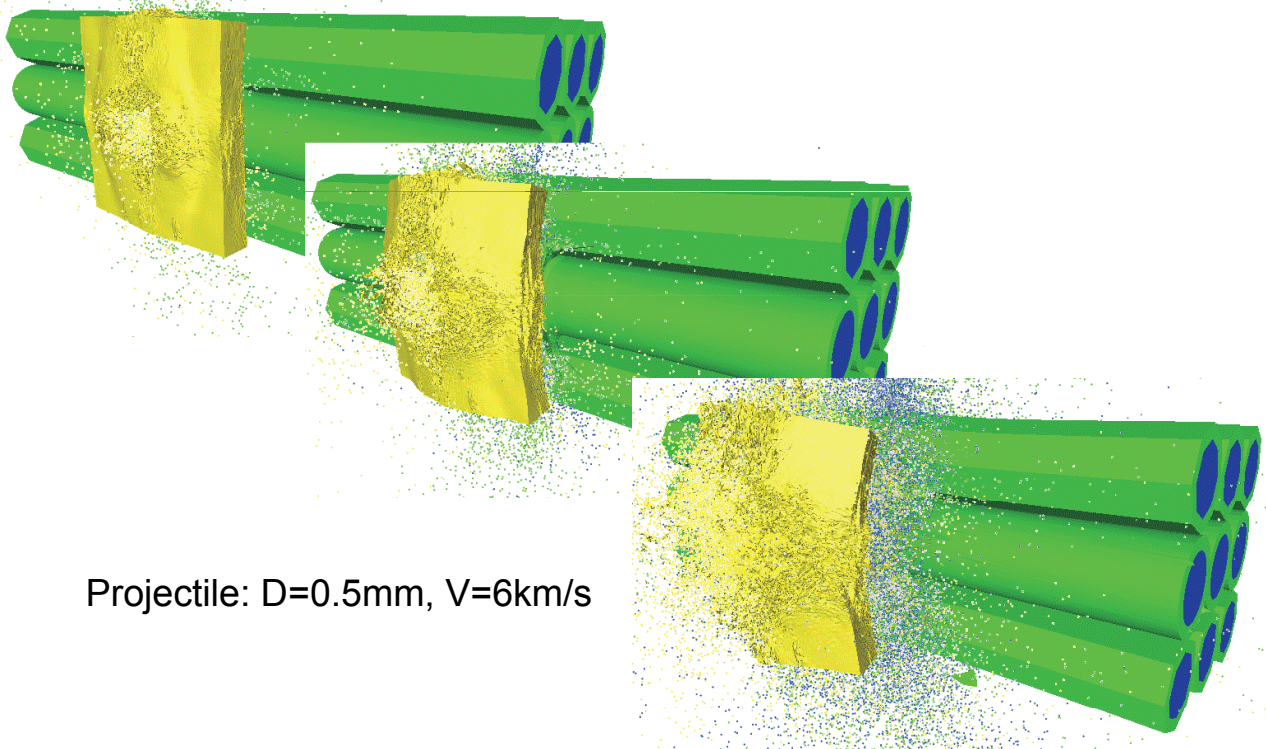
Power Cables with Kevlar Sheet CTC



Projectile: D=0.5mm, V=2km/s

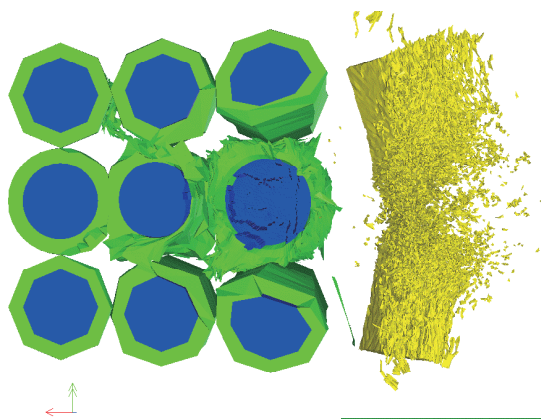


Power Cables with Kevlar Sheet CTC

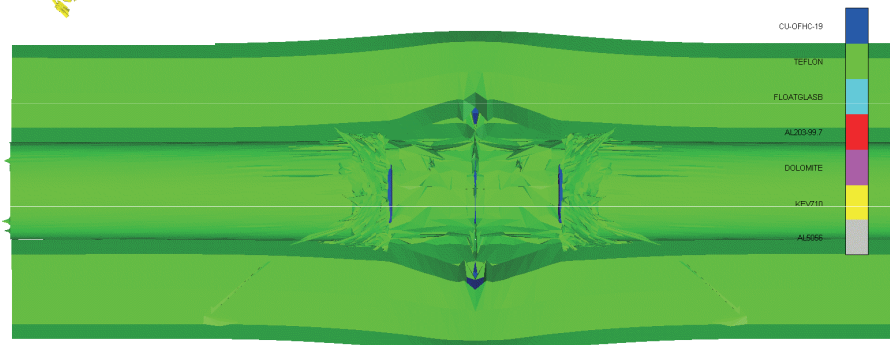


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Power Cables with Kevlar Sheet CTC

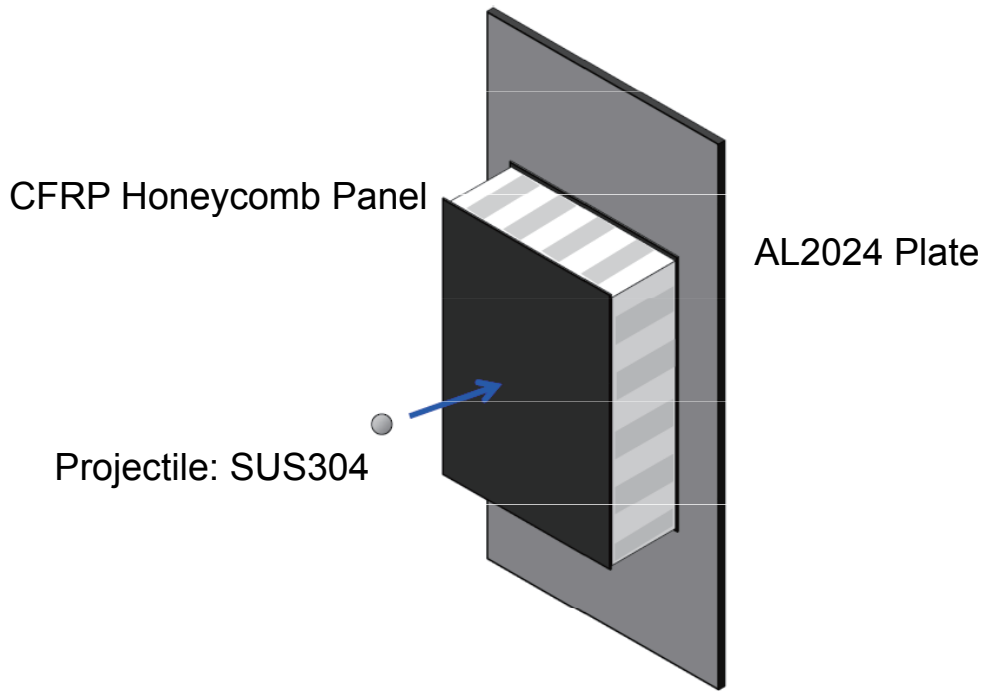


Projectiles: D=0.5mm, V=6km/s



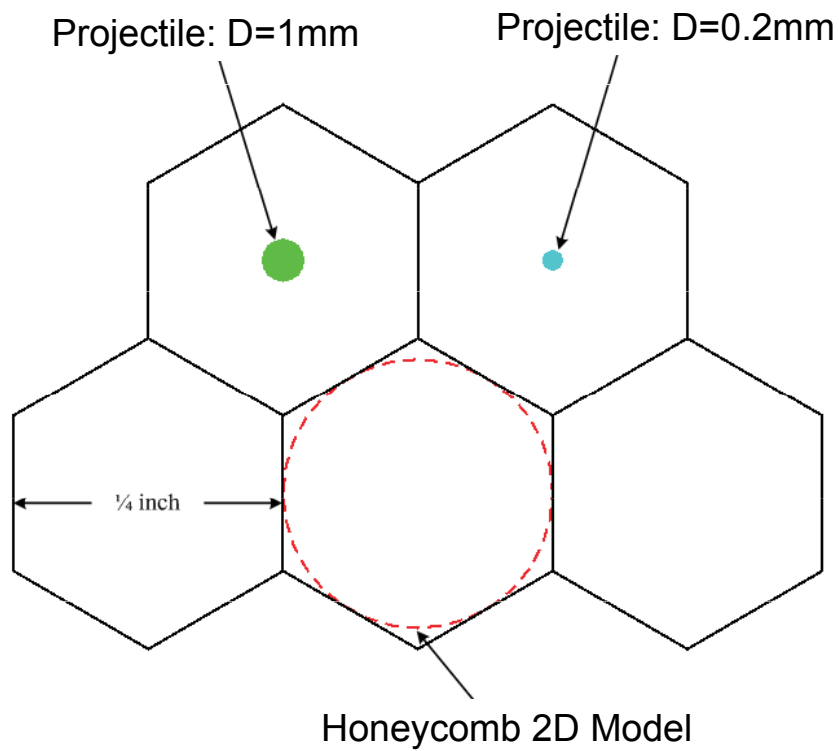
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Honeycomb Panels



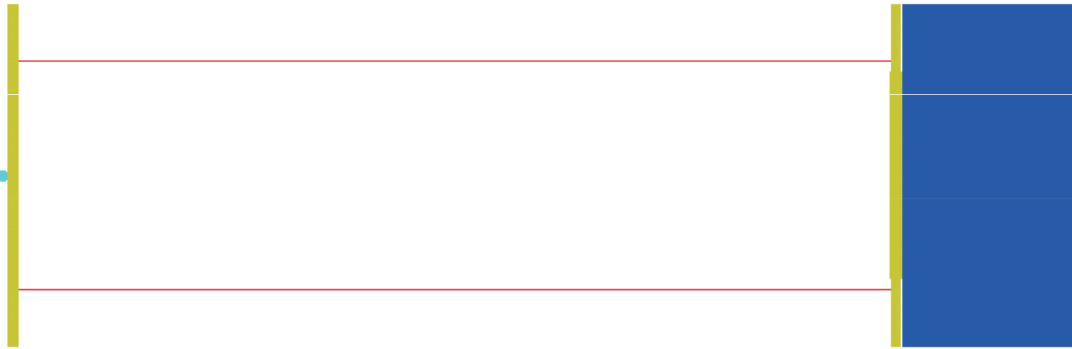
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Honeycomb Panels



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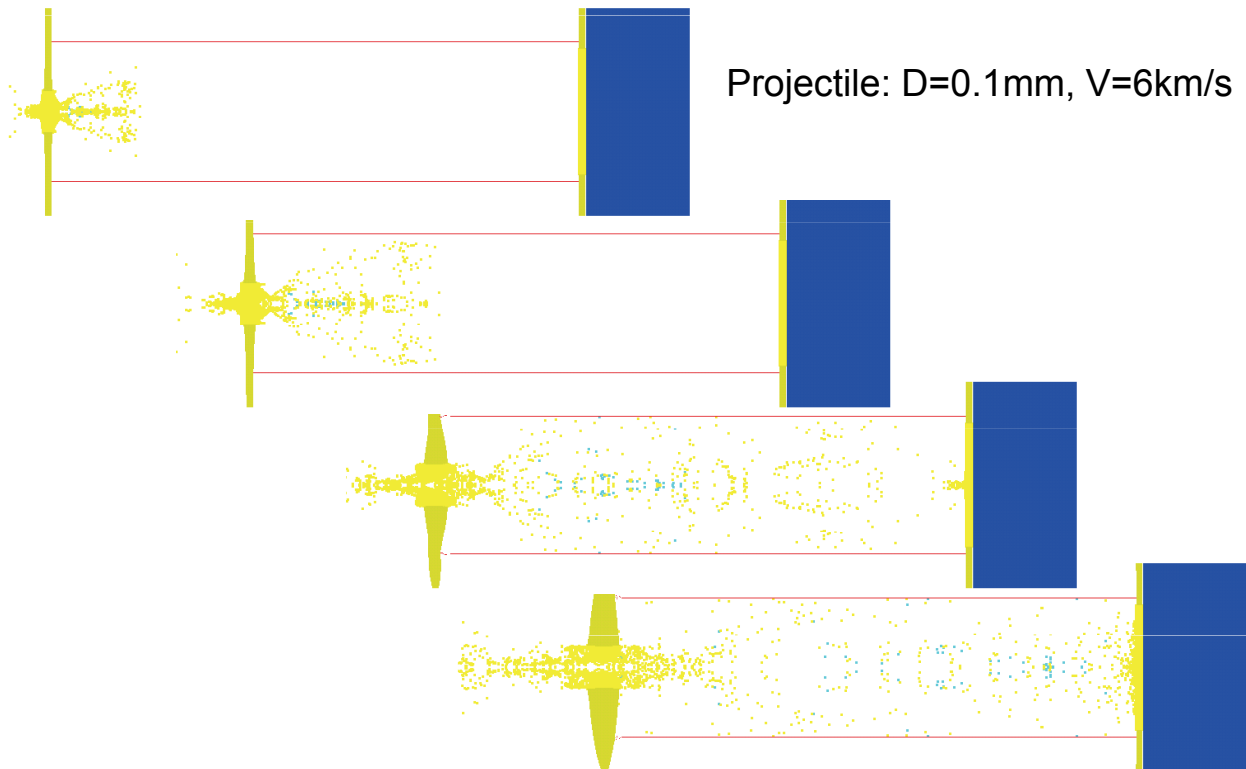
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Numerical Model (2D-axial symmetry)

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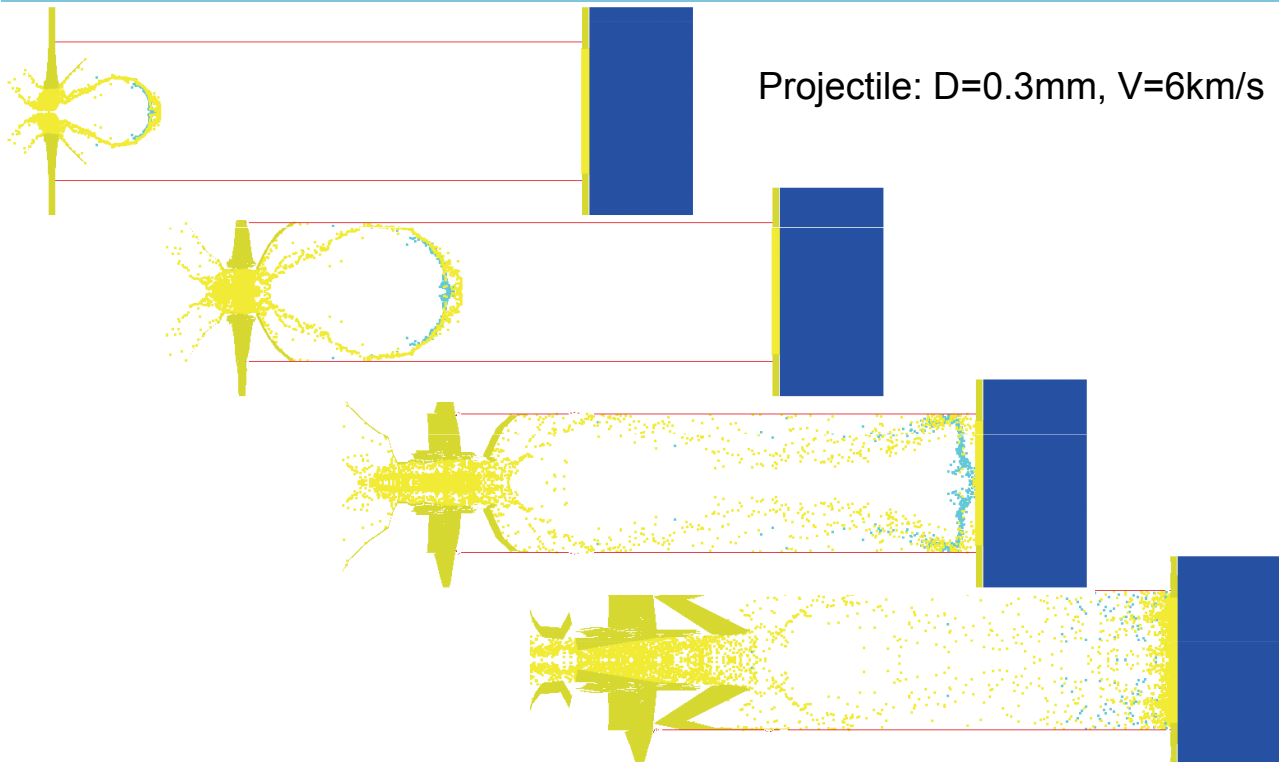
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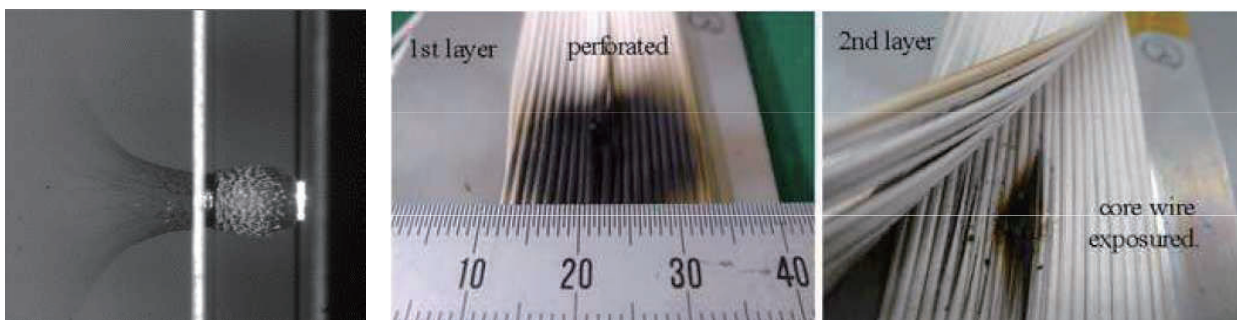


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まとめ、課題

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- An estimation of the ballistic limit curve for power cables and honeycomb panels are still in progress.
- Not only numerical simulation, verification with experimental result will be planned.



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