Compact Photon Source, An Update

Gabriel Niculescu
James Madison University

**2022 Hall C Collaboration Meeting,
JLab (still virtual)**

February 18, 2022

Introduction

Time permitting, I shall talk about...

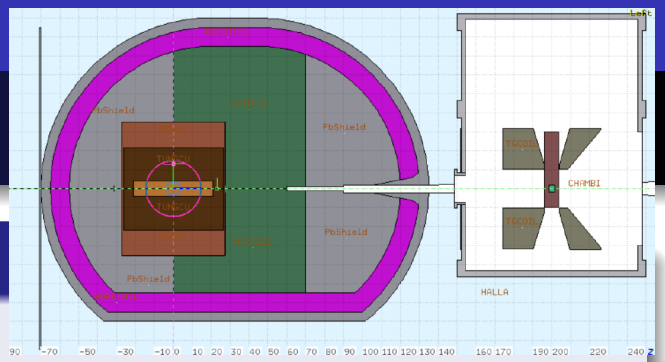
- CPS: what? why? how? (intro/refresher/memento)
- CPS: Design & Optimization
- CPS: Ongoing work.

- Summary & Outlook ("Quo Vadis, CPS?")

Disclaimer ... as usual:

- Lots of ppl contributed to this talk.
- ...and they've done their level best! (and are credited here 🤞)
- Any mistakes/misrepresentations/mis–anything are purely mine!

Enter CPS



what ...is CPS?

- ...as proposed in 2014 (BW)...
- CPS: **C**ompact **P**hoton **S**ource; novel untagged $\vec{\gamma}$ source design.

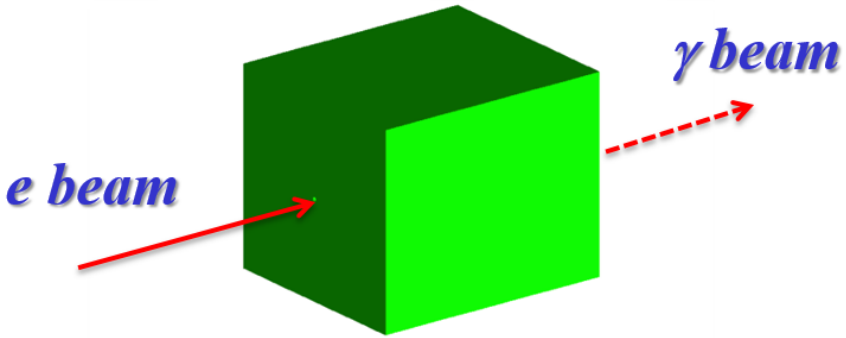
what ...might it be used for?

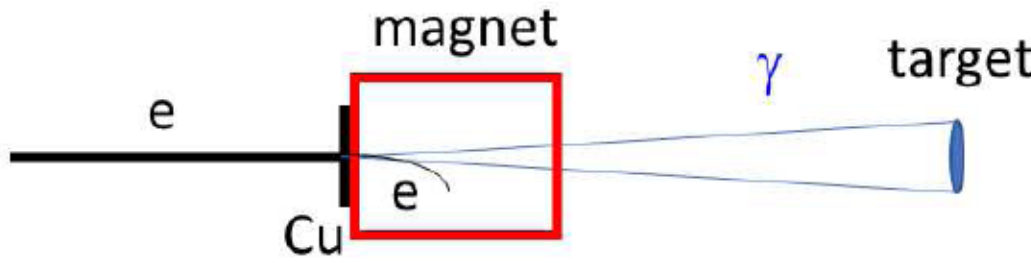
- low cross–section γ–nucleon interactions (such as high s, t WACS)
- narrow photon beam (good 4 identifying exclusive reactions)
- optimized for work w/ polarized NH3–type targets
- high intensity* ($\sim 30\times$ better than alternatives)

Specs?

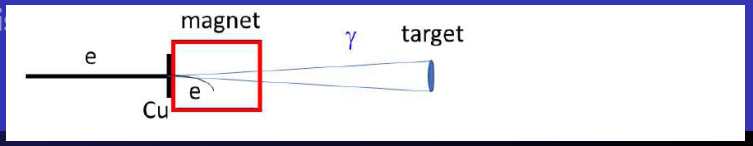
Power:	30 kW	Radiator:	10% rl
Beam size (@ 2 m):	$\sim$1 mm	Lifetime (est.):	1000+ h

How? CPS Concept



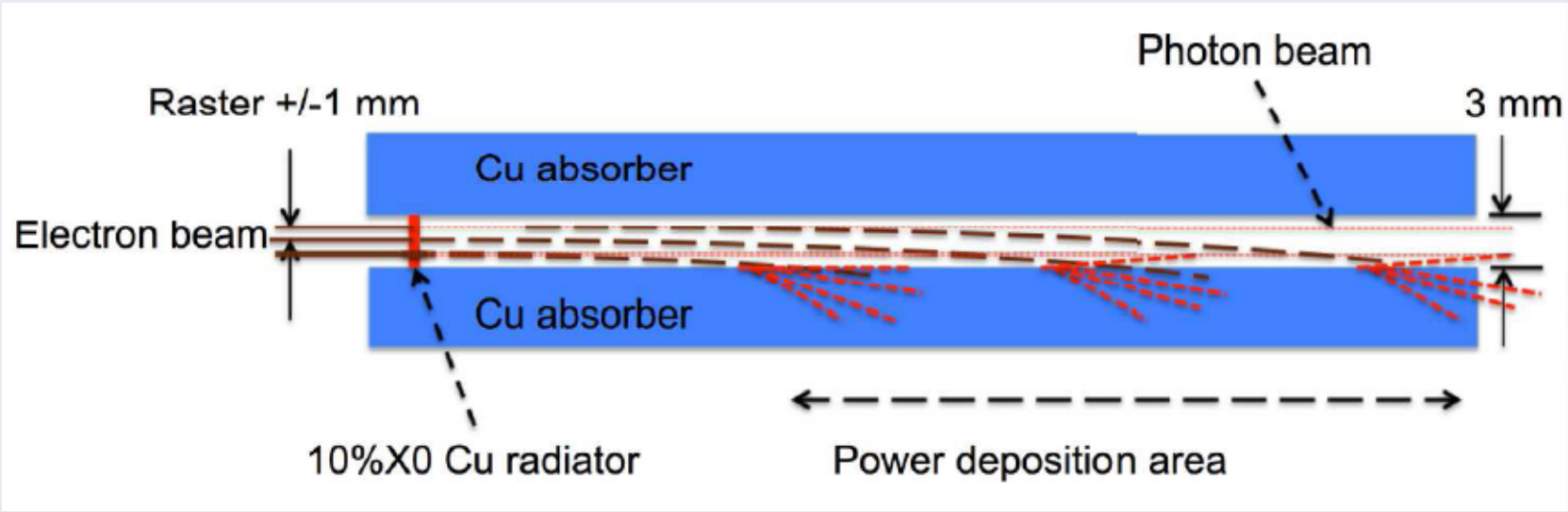


- Traditional γ beam approaches?
  no hermeticity. large. \$\$\$. ("Thank you, next")
- Idea: Use the magnet* both as a beam–shaping and beam–dump device, *ergo*, problem is solved! **How?**



How? (II) CPS Central piece (Power Absorber)

2014 Concept (BW): sliding power absorption...



Back of the envelope calc.

- Radius R for 11 GeV e^- $\sim$10 m
- For 0.3 cm channel power deposition area 17 $\pm$ 12 cm
- Total field integral: $\sim$1000 kG-cm, iron dominated magnet.

mini–Summary

Based on what you've seen thus far... CPS...

- high intensity, untagged, polarized photon source
- narrow beam, compact (in x-y-z space). good for pol. target work.
- suitable for low cross–section γ–nucleon (exclusive) reactions

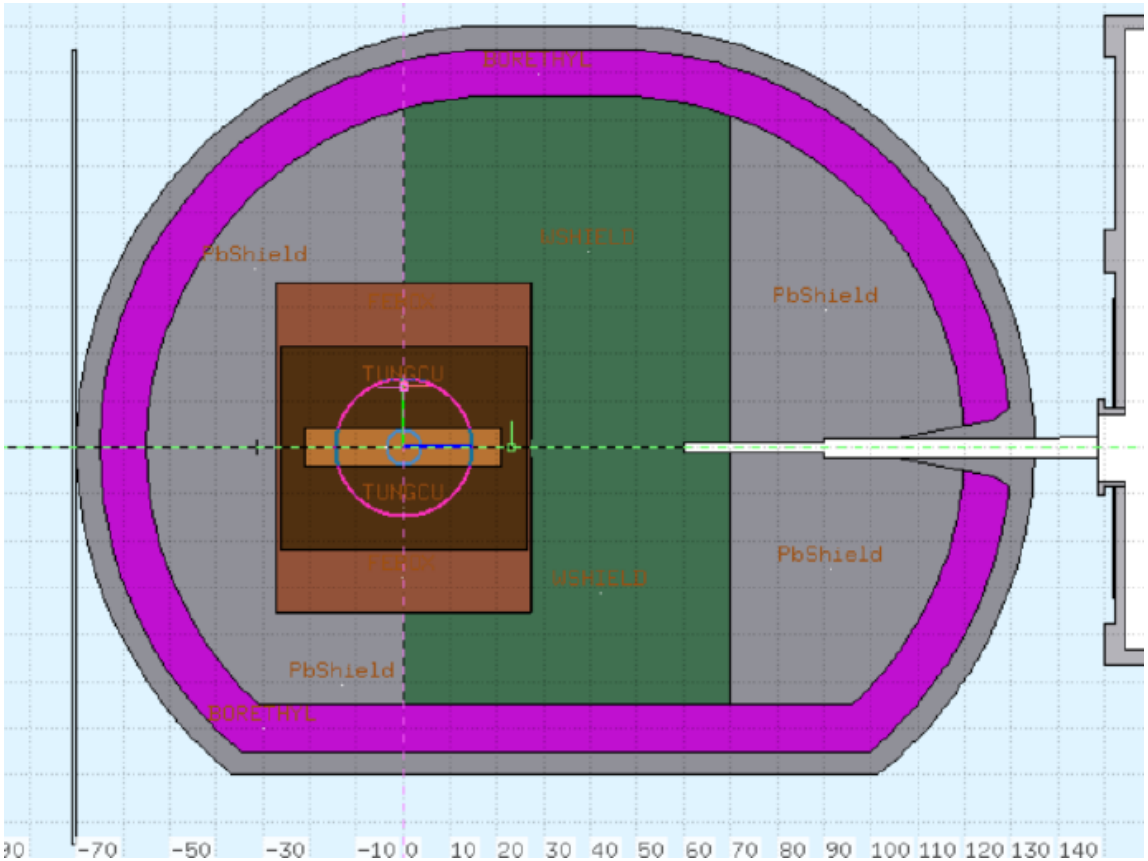
To actually hope to build it... Design & Optimization

- radiation & heat mitigation.
- compactness (in $$$ space). weight too!
- advertise it! (more physics, followers, and (hopefully) funding!)

Then we put it in the hands of the engineers...

- tidy up design.
- coil design & fabrication. *ditto* for center piece, inner section, support.
- shielding procurement & stacking.

Is it safe to use? How about cost & weight?

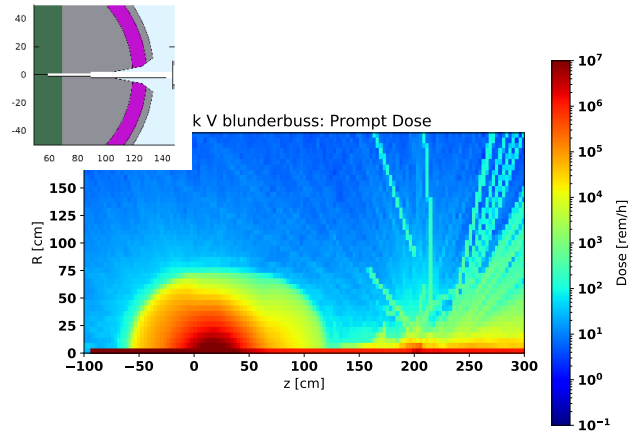


Simulation

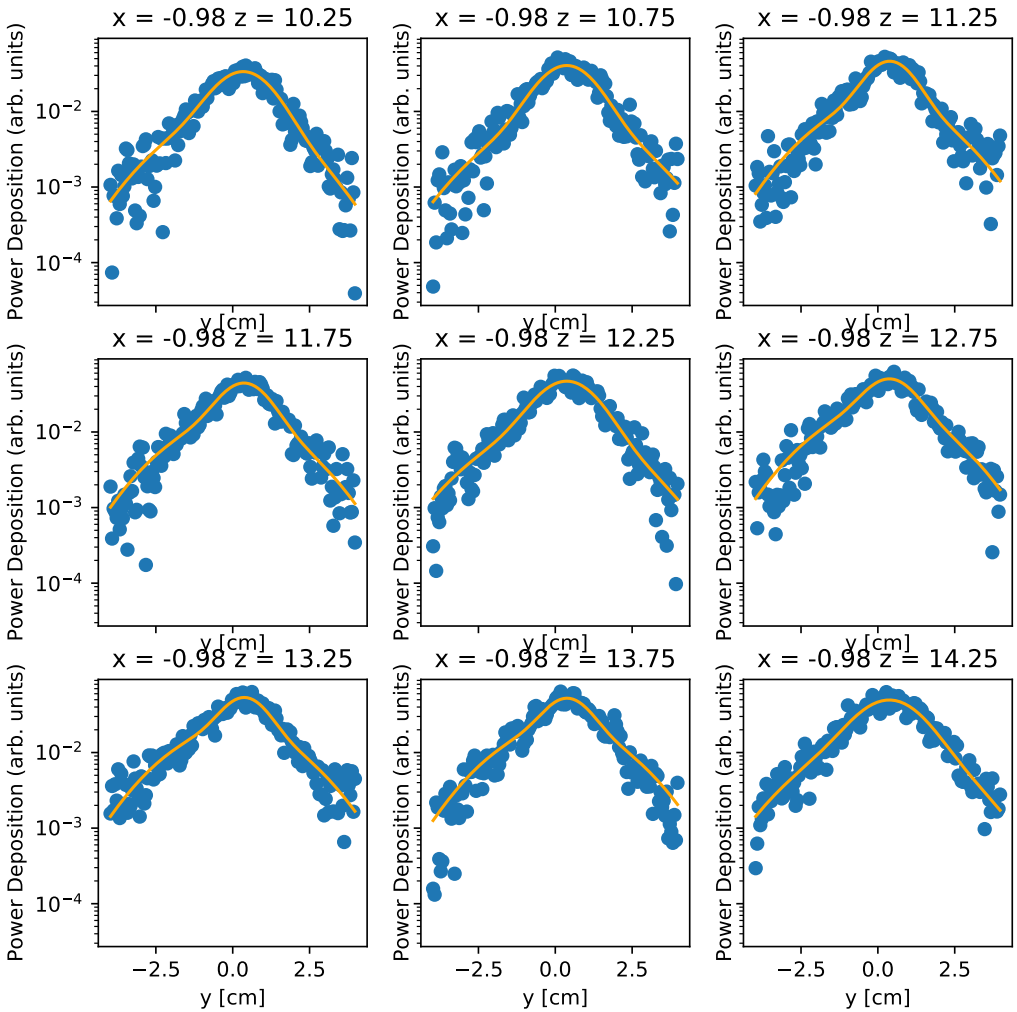
- ...fields, shielding mats.
- prompt/activation dose
- power deposition

...

- substantial savings in weight and $$$
- ... safe to operate.



Power deposition in the Central Piece

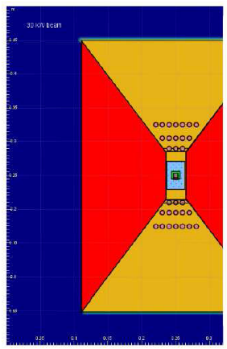


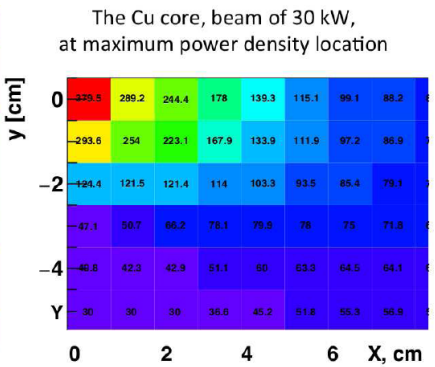
Simulation details...

- 0.5x0.5x5 mm grid
- available as df or param.

Heat Dissipation

- Bogdan: analytic calc.
- GN: 2D simulation
- Amy, Steve: 3D (ongoing)





CPS knowledge dissemination

tell the world...

- CPS concept, design, and simulation results, expected performance, usage, lifetime ... published in NIM, 2020
- also workshops, conference & other professional meeting presentations.

Nucl.Instrum.Meth.A 957 (2020) 163429

A Conceptual Design Study of a Compact Photon Source (CPS) for Jefferson Lab

D. Day,[1] P. Degtiarenko,[2] S. Dobbs,[3] R. Ent,[2] D.J. Hamilton,[4] T. Horn,[5,2,*] D. Keller,[1] C. Keppel,[2] G. Niculescu,[6] P. Reid,[7] I. Strakovsky,[8] B. Wojtsekhowski,[2] and J. Zhang[1]

[1] *University of Virginia, Charlottesville, Virginia 22904, USA*
[2] *Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA*
[3] *Florida State University, Tallahassee, Florida 32306, USA*
[4] *University of Glasgow, Glasgow G12 8QQ, Scotland, United Kingdom*
[5] *Catholic University of America, Washington, D.C. 20064, USA*
[6] *James Madison University, Harrisonburg, Virginia 22807, USA*
[7] *Saint Marys University, Halifax, Nova Scotia, Canada*
[8] *George Washington University, Washington, D.C. 20052, USA*

(Dated: December 17, 2019)

TCS (I)

Timelike Compton Scattering off transversely polarized proton

C12-18-005

PAC 48, August 13th, 2020

Marie Boër (VT), Dustin Keller (UVa), Vardan Tadevosyan (ANSL), et al.

Proposal for Hall C, with NPS and CPS collaborations

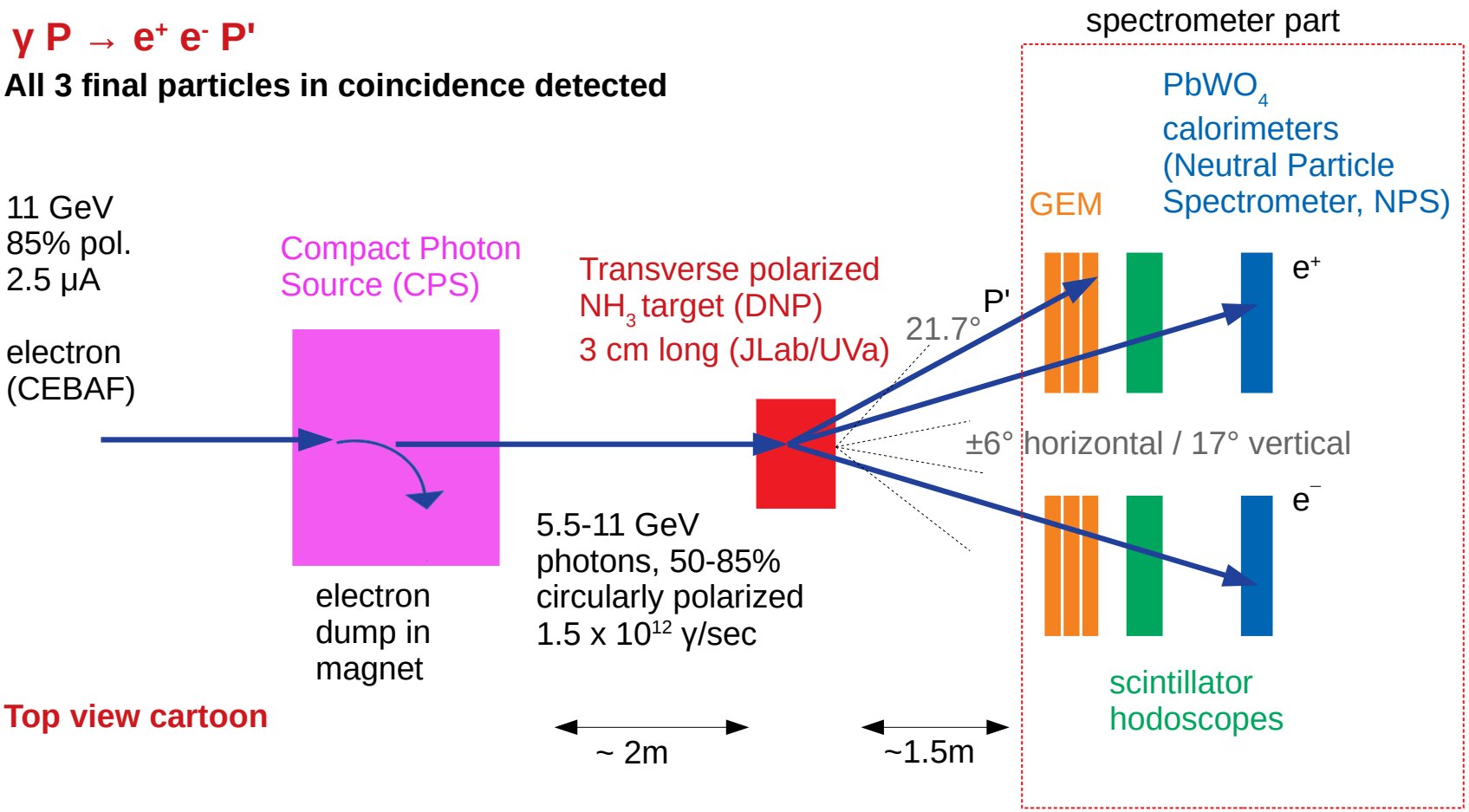
(credit: M. Boer[1] *et al*)

TCS (II)

Experimental setup

$\gamma P \rightarrow e^+ e^- P'$

All 3 final particles in coincidence detected



Trigger: GEMs, hodoscopes, calorimeters (all 3 particles)

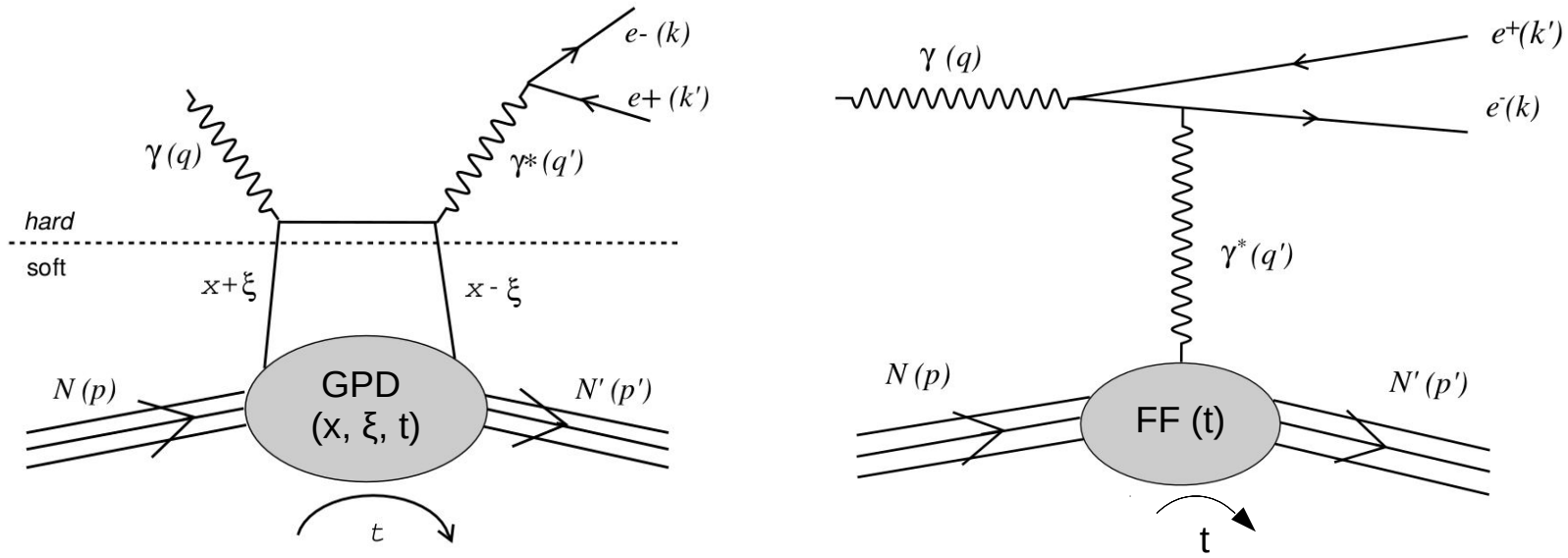
(credit: M. Boer *et al*)

Integrated luminosity: 5.85 x 10^5 pb^{-1} for 30 PAC days of "physics"

TCS (III)

Timelike Compton Scattering

$\gamma P \rightarrow e^+e^- P'$ = TCS + Bethe-Heitler



Why measuring TCS off a transversely polarized proton?

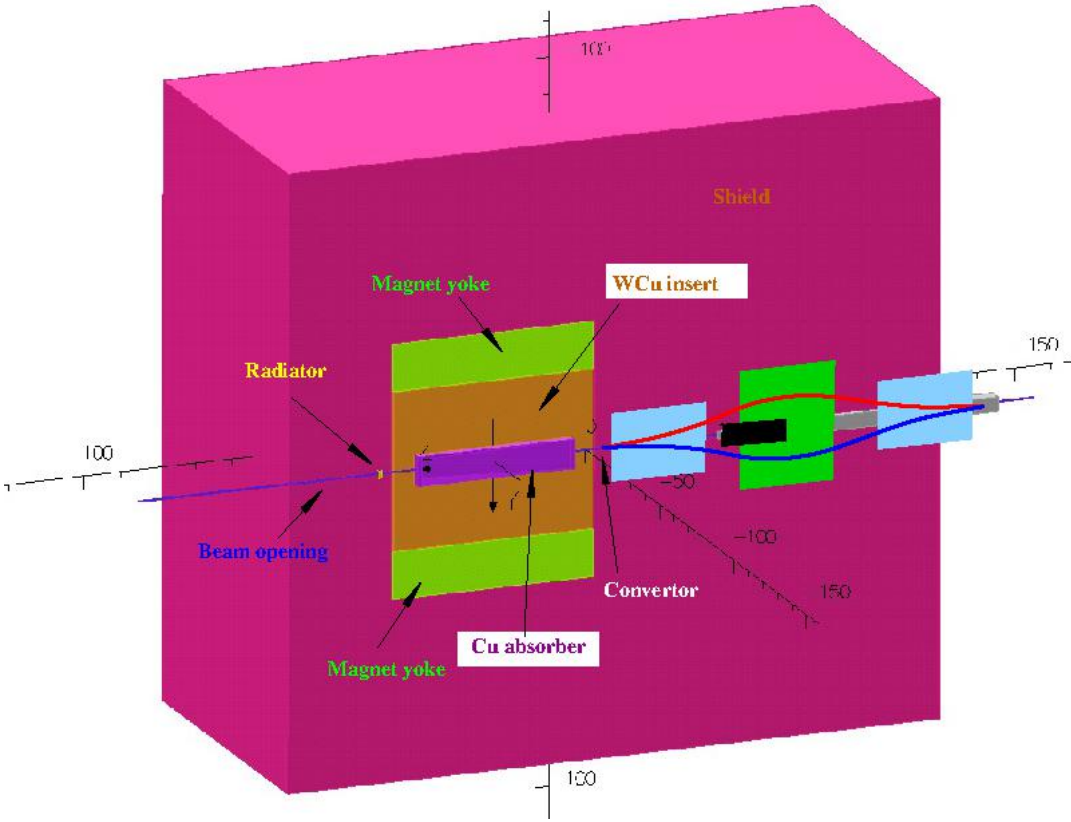
- **Unique access to GPD E of the proton**
- **GPD universality studies (TCS vs DVCS)**
- **Independent observables for GPD data sets and global fits in valence region**
- **Most knowledge on GPDs from DVCS: complex conjugate, TCS access same information**

(credit: M. Boer *et al*)

CPS in EIC era

CPS as a e^+e^- source

- Shed light (!) on the TPE size
- 15x more productive than similar Hall B effort ($2 \times 10^{10}\ e^+/s$)
- Reduced systematics: non–magnetic calorimetry
- Rates @$Q^2 = 3GeV^2$: 0.5/2.5 Hz (∼500 h)
- BSM studies possible (dark photons, etc.)



(credit: DM *et al*, Hall C Future Whitepaper...)

Heat Modeling (credit: Amy C., Steve L. ...)

CPS Prototype

Simulation of low temperature heating using Heat stick

Version D

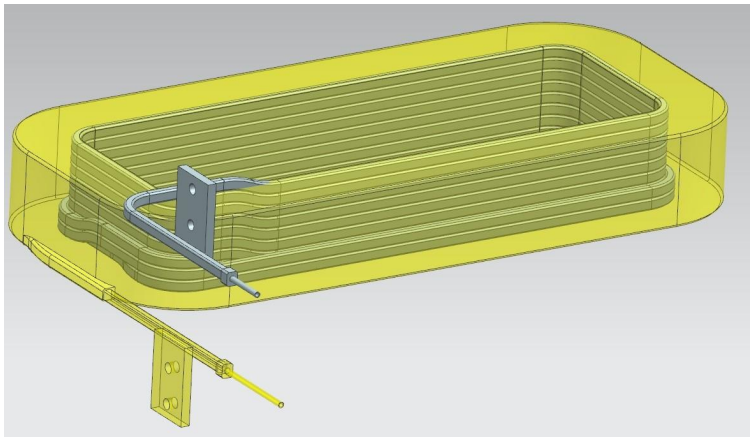
Sept 15, 2021

Coil design & fabrication (credit: Steve, Bert ...)

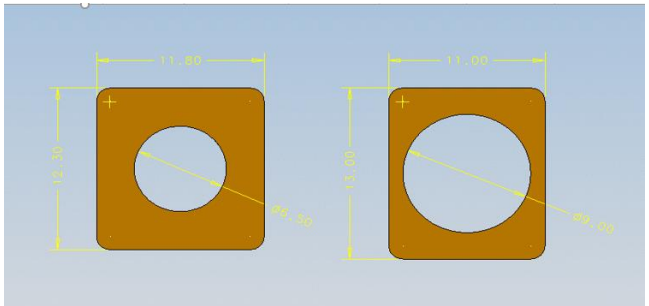
Coils

- Discussion w/ potential vendor NEC/Tokin
- Prototype drawings in process of being signed off for fabrication.
- Design work on CPS/shielding platform and hall layout.

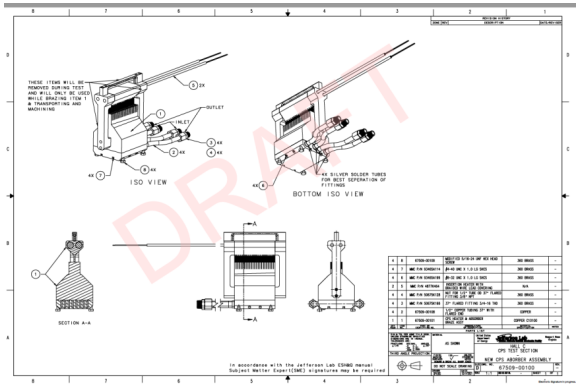
• Continuous Wound Option
Less splices/joints



		JLAB Luvata #6801	TOKIN Luvata #6801	JLAB Luvata #8289	TOKIN Luvata #8289
NI (A.Turns)		42,000	42,000	42,000	42,000
Current	A	764	764	764	764
Voltage	V	14.1	11.2	21.2	10.5
resistance	mOhms	18.5	12.3	27.8	11.3
Power	kW	10.8	8.6	16.2	8
turns		56	55	56	55
weight	kg	102.2	91.8	116.4	70.5
Weight/L	kg/m	0.90	0.90	1.02	1.02
Length	m	113.59	102.00	114.33	69.25
Flow Rate @ (150psi)	L/min	5.40	4.61	12.26	7.89
Temperature Rise	C	28.8	37.5	19.0	27
Temp Max	C	55.4	64.1	45.6	53.6



Heat absorber Blueprints



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Document Number	Revision	Category	Document Number	Drawing Size	Drawing Title	Drawn Date	Native CAD	Notes for Legacy Drawings	SheetNum
67509-00100	-	HALL C	67509-00100	D	NEW CPS ABORBER ASSEMBLY	12/7/21	NX		ALL
67509-00101	-	HALL C	67509-00101	D	CPS SLOT MODIFICATION	01/05/22	NX		ALL
67509-00102	-	HALL C	67509-00102	D	ABSORBER & HEAT ELEMENT BRAZE ASSY	12/212/2021	NX		ALL
67509-00103	-	HALL C	67509-00103	E	NEW ABSORBER	09/14/2021	NX		ALL
67509-00104	-	HALL C	67509-00104	C	NEW COOLING ELEMENT	12/06/2021	NX		ALL
67509-00105	-	HALL C	67509-00105	C	NEW HEATER ELEMENT	12/06/2021	NX		ALL
67509-00106	-	HALL C	67509-00106	C	END CAP, HEATER ELEMENT	12/03/2021	NX		ALL
67509-00107	-	HALL C	67509-00107	B	CONNECTOR BAR, END CAPS	12/03/2021	NX		ALL
67509-00108	-	HALL C	67509-00108	B	TUBING, 1/2" COPPER	12/20/2021	NX		ALL
67509-00109	-	HALL C	67509-00109	B	MODIFIED 5/16-24 UNF HEX HEAD SCREW	12/15/2021	NX		ALL
67509-00110	-	HALL C	67509-00110	C	NEW COOLING ELEMENT BLANK	01/06/2022	NX		ALL
67509-00111	-	HALL C	67509-00111	D	COPPER BLOCK LAYOUT	01/28/2022	NX		ALL
67509-00112	-	HALL C	67509-00112	C	INSULATION SHIELD	02/02/2022	NX		ALL

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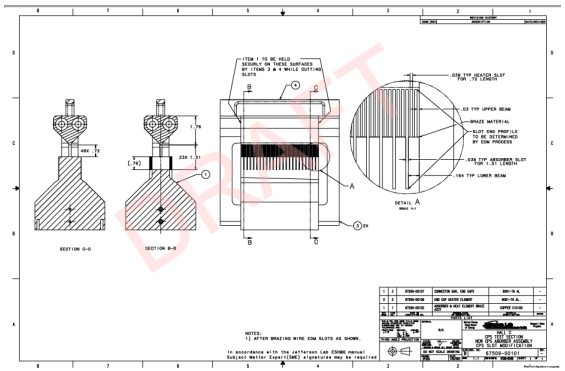
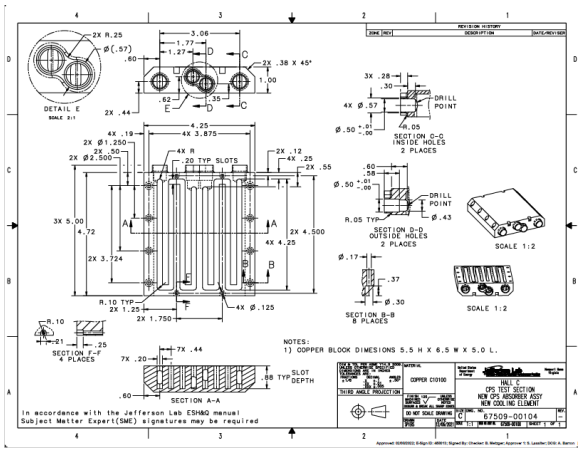
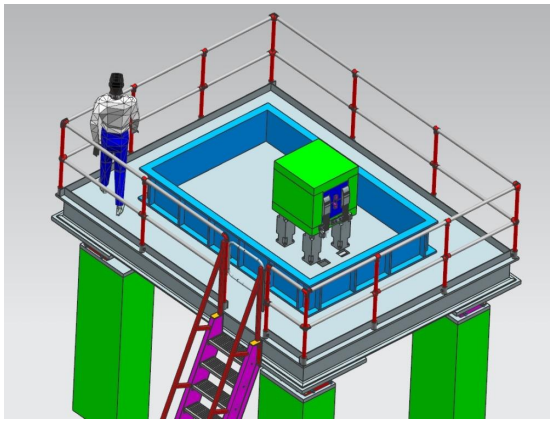
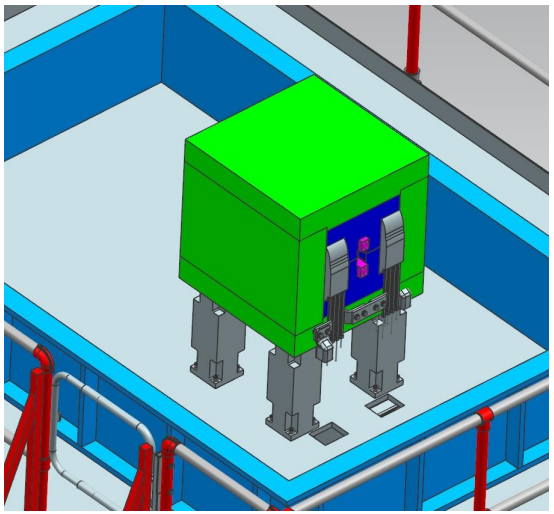


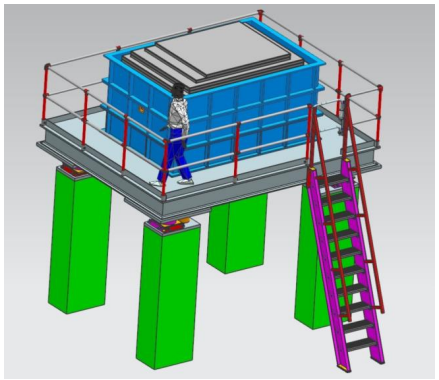


CPS platform (Bert)

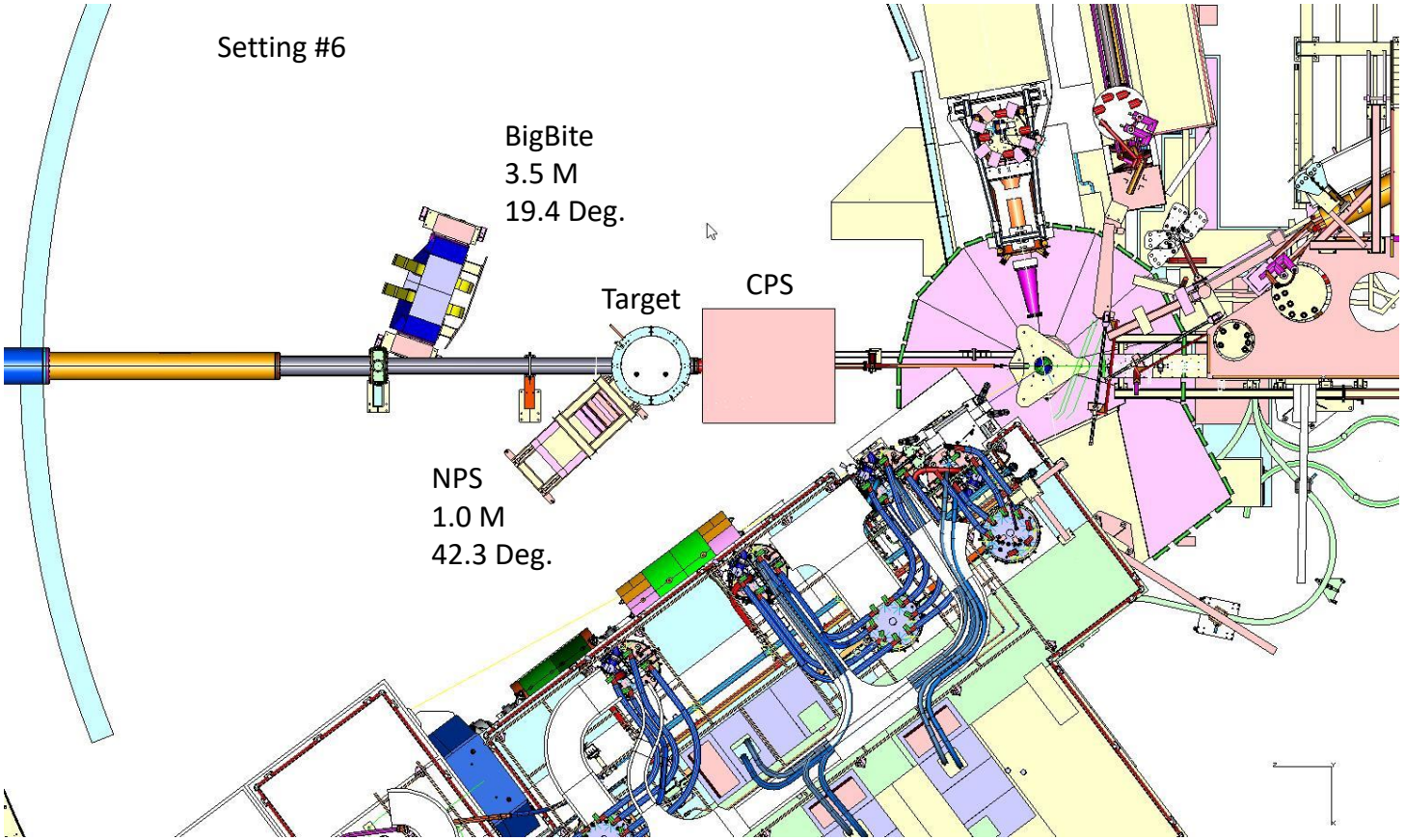
CPS Platform Design







CPS exp Hall layout (Bert)



Identifying & acquiring CPS materials

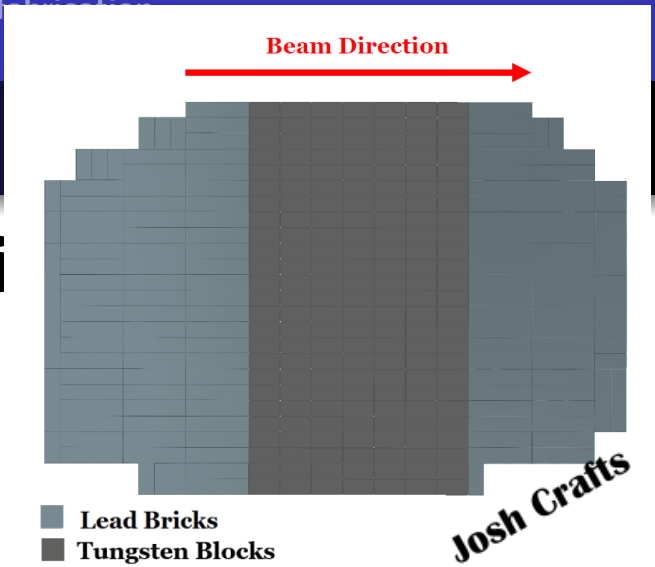
Shielding Materials

- material for inner section of the magnet, WCu (80/20) obtained.
- backward shielding, outer skin Pb: SLAC (20 t) and Bates (8 t) obtained. in shipment.
- material for outer (forward) shield W (high density powder) ordered, first two shipments of blocks on–site.

(credit: Hall A/C eng, BW)

Measure 10x...

CPS Shielding Block Inventory on Si

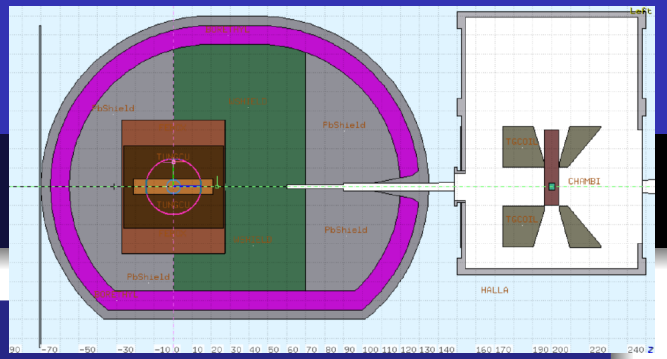


- W80%Cu20% Qty=44 Dimensions 2”x4”x10”

- W90%Ni7%Fe3% Qty=40 Dimensions 2.88”x4”x6” 1st shipment

- W90%Ni7%Fe3% Qty=42 Dimensions 2.88”x4”x6” 2nd shipment

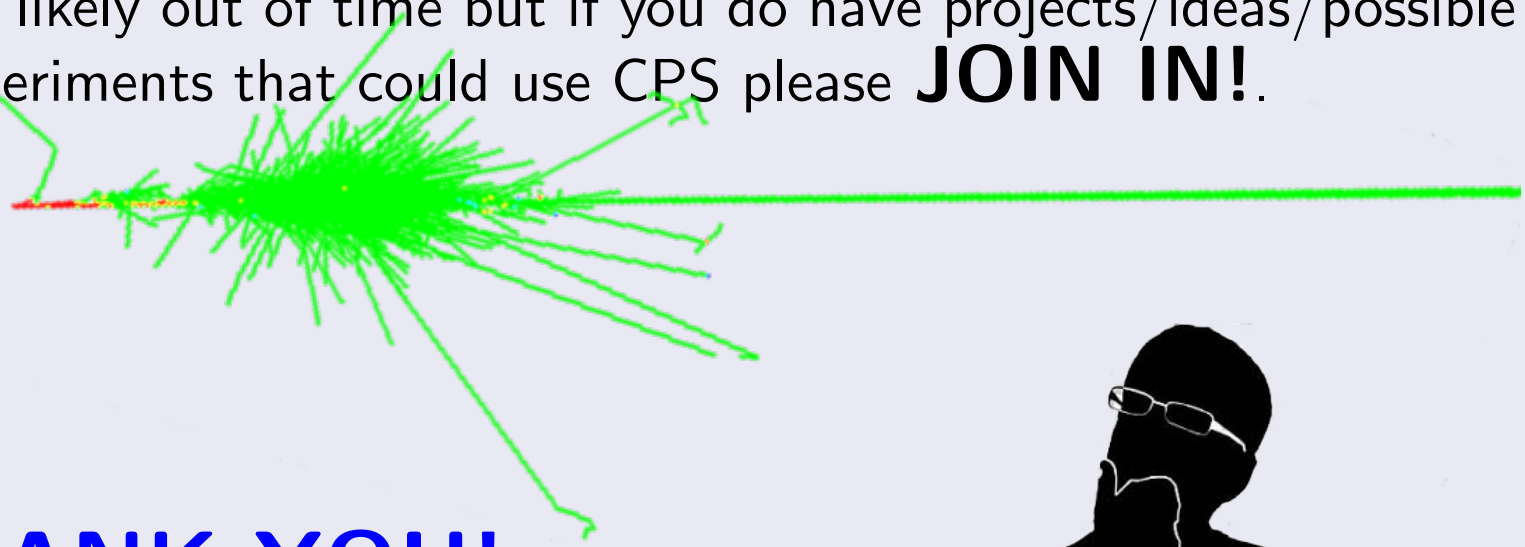
(credit: Steve L.)



Quo Vadis? (Outlook)

I hope I convinced that...

- CPS: novel, efficient tool for (exclusive) photon–nucleon studies.
- Two approved* leading exp., exciting future physics prospects.
- Project at the prototyping, procurement, construction stage.
- I'm likely out of time but if you do have projects/ideas/possible experiments that could use CPS please **JOIN IN!**.



THANK YOU!